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(54) Title: RECYCLABLE, THERMOFORMABLE PAPER BASE WEB

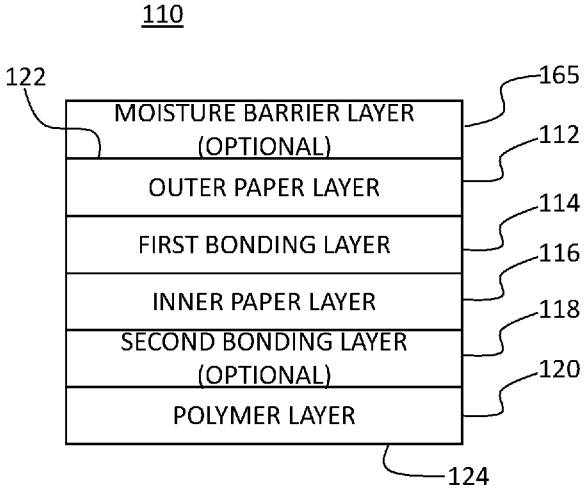

FIG. 1

(57) Abstract: A thermoformable paper base web comprises an outer paper layer having opposing first and second surfaces, the second surface defining an exterior facing surface of the paper base web. An inner paper layer has opposing first and second surfaces, the first surface laminated to the second surface of the outer paper layer. A first bonding layer joins the outer paper layer second surface to the inner paper layer first surface. A polymer layer has opposing first surface and second surfaces, wherein the second surface of the polymer layer defines an interior-facing surface of the paper base web. The first surface of the polymer layer is joined to the second surface of the inner paper layer. The outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

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RECYCLABLE, THERMOFORMABLE PAPER BASE WEB

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of U.S. provisional application no. 63/548,327 filed November 13, 2023. The aforementioned application is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The present disclosure relates generally to the field of thermoformed packaging and, more particularly, recyclable, paper-based, thermoformable base web materials, thermoformed packaging articles made therefrom, and method of forming the same.

[0003] Thermoformed packaging trays have found practical utility in the packaging of various consumable products, including perishable food products such as chilled cooked meats and others. Thermoformed packaging structures made from laminated films of paper and polymer such as polyethylene are known. Such packaging structures may also include a gas barrier layer such as ethylene-vinyl alcohol copolymer (EVOH) to limit the ingress of oxygen into the packaging. Such gas barrier also provides additional moisture resistance by reducing the transmission of moisture vapor transmission through the packaging material.

Such structures have generally provided a functional and cost-effective solution for the containment, transportation, and display of such products. However, existing paper and polymer laminated structures are typically nonrecyclable in paper recycling streams, thereby presenting environmental and sustainability concerns.

[0004] Attempts to create a recyclable, thermoformable paper base web have encountered challenges and limitations. For instance, attempts to increase the paper content and/or reduce the polymer content have resulted in base web materials that cannot be formed to a sufficient depth without the material tearing. Shifting the proportions of paper and polymer to support recyclability while maintaining adequate form depth and structural integrity of the paper base web packaging structure during manufacture and use has, heretofore, not been accomplished.

[0005] The present disclosure provides new and improved paper base webs, thermoformed packaging articles produced therefrom, and methods for making the same, which overcome the above-referenced problems and others.

SUMMARY

[0006] In one aspect, a thermoformable paper base web comprises an outer paper layer having a first surface and a second surface opposite the first surface, wherein the first surface of the outer paper layer defines an exterior-facing surface of the paper base web. An inner paper layer has a first surface and a second surface opposite the first surface, wherein the first surface of the inner paper layer is laminated to the second surface of the outer paper layer. A first bonding

layer is disposed between the outer paper layer and inner paper layer, wherein the first bonding layer joins the second surface of the outer paper layer to the first surface of the inner paper layer. A polymer layer has a first surface and a second surface opposite the first surface, wherein the second surface of the polymer layer defines an interior-facing surface of the paper base web and the first surface of the polymer layer is joined to the second surface of the inner paper layer. The outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

[0007] In a more limited aspect, the first bonding layer is attached directly to the second surface of the outer paper layer and the first surface of the inner paper layer.

[0008] In another more limited aspect, the first bonding layer is selected from the group consisting of an adhesive layer and an extruded resin layer.

[0009] In another more limited aspect, the polymer layer is selected from the group consisting of monolayer film and a multilayer film.

[0010] In another more limited aspect, the polymer layer is attached directly to the second surface of the inner paper layer.

[0011] In another more limited aspect, the thermoformable paper base web further comprises a second bonding layer between the inner paper layer and the polymer layer, the second bonding layer joining the second surface of the inner paper layer to the first surface of the polymer layer.

[0012] In another more limited aspect, the second bonding layer is attached directly to the second surface of the inner paper layer and the first surface of the polymer layer.

[0013] In another more limited aspect, the second bonding layer is an adhesive layer and the inner paper layer is laminated with the polymer layer via the adhesive layer.

[0014] In another more limited aspect, the polymer layer is selected from the group consisting of a barrier film layer and a nonbarrier film layer.

[0015] In another more limited aspect, the outer paper layer and the inner paper layer, which may be the same or different, each comprise paper having a basis weight in the range of 50 GSM to 300 GSM.

[0016] In another more limited aspect, the polymer layer is selected from the group consisting of: (a) a first coextruded film comprising a first polyolefin layer, a second polyolefin layer, and a first barrier layer disposed intermediate the first and second polyolefin layers, wherein the first barrier layer is formed of a material selected from the group consisting of ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene di-chloride (PVcD), polyamide, and polyvinyl alcohol (PVOH); and (b) a second coextruded film comprising a second barrier layer having a barrier outer surface coupled to the second surface of the inner paper layer and a barrier inner

surface opposite the barrier outer surface, and a third polyolefin layer coupled to the barrier inner surface.

[0017] In another more limited aspect, the first and second barrier layers comprise EVOH and the first, second, and third polyolefin layers, which may be the same or different, comprise a polyethylene-based polymer.

[0018] In another more limited aspect, the first bonding layer is selected from the group consisting of: (a) an adhesive layer formed of an adhesive selected from the group consisting of a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C; (b) a high solids content adhesive having a solids content in the range of 15% to 100% by weight; and (c) an extruded polyolefin resin layer.

[0019] In another more limited aspect, the first bonding layer is selected from the group consisting of: (a) a third coextruded film comprising a fourth polyolefin layer, a fifth polyolefin layer, and a third barrier layer disposed intermediate the fourth and fifth polyolefin layers, wherein the third barrier layer is formed of a material selected from the group consisting of ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene di-chloride (PVcD), polyamide, and polyvinyl alcohol (PVOH); and (b) a fourth coextruded film comprising a fourth barrier layer having a barrier inner surface coupled to the first surface of the inner paper layer and a barrier outer surface opposite the barrier inner surface, and a sixth polyolefin layer coupled to the barrier outer surface and the second surface of the outer paper layer.

[0020] In another more limited aspect, the third and fourth barrier layers comprise EVOH and the fourth, fifth, and sixth polyolefin layers, which may be the same or different, comprise a polyethylene-based polymer.

[0021] In another more limited aspect, the paper base web is thermoformable to a depth of between 1 mm to 153 mm.

[0022] In another more limited aspect, said outer and inner paper layers together comprise at least 85% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

[0023] In another more limited aspect, said outer and inner paper layers together comprise at least 90% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

[0024] In another more limited aspect, said outer and inner paper layers together comprise at least 95% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

[0025] In another aspect, a method for producing a thermoformable paper base web comprises laminating an outer paper layer to an inner paper layer with a first bonding layer

therebetween, the outer paper layer having a first surface and a second surface opposite the first surface, wherein the first surface of the outer paper layer defines an exterior-facing surface of the paper base web. In embodiments, the first surface of the outer paper layer defines an exterior-most surface of the paper base web. The inner paper layer has a first surface and a second surface opposite the first surface and the first surface of the inner paper layer faces second surface of the outer paper layer. A polymer layer is attached to the second surface of the inner paper layer, the polymer layer having a first surface and a second surface opposite the first surface, wherein the first surface of the polymer layer is joined to the second surface of the inner paper layer and the second surface of the polymer layer defines an interior-facing surface of the paper base web. In embodiments the second surface of the polymer layer defines an interior-most surface of the paper base web The outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

[0026] In a more limited aspect, the first bonding layer is attached directly to the second surface of the outer paper layer and the first surface of the inner paper layer.

[0027] In another more limited aspect, the first bonding layer is selected from the group consisting of an adhesive layer and an extruded resin layer.

[0028] In another more limited aspect, the first bonding layer is selected from the group consisting of: (a) a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C; (b) a high solids content adhesive having a solids content in the range of 15% to 100% by weight; and (c) an extruded polyolefin resin layer.

[0029] In another more limited aspect, the step of attaching the polymer layer to the second surface of the inner paper layer is performed by a process selected from the group consisting of adhesive lamination and extrusion lamination.

[0030] In another more limited aspect, the step of attaching the polymer layer to the second surface of the inner paper layer includes applying a second bonding layer between the inner paper layer and the polymer layer, the second bonding layer joining the second surface of the inner paper layer to the first surface of the polymer layer.

[0031] In another more limited aspect, the second bonding layer is selected from the group consisting of an adhesive layer and an extruded resin layer.

[0032] In another more limited aspect, the second bonding layer is selected from the group consisting of: (a) a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C; (b) a high solids content adhesive having a solids content in the range of 15% to 100% by weight; and (c) an extruded polyolefin resin layer.

[0033] In another more limited aspect, the second bonding layer is attached directly to the second surface of the inner paper layer and the first surface of the polymer layer.

[0034] In another more limited aspect, the polymer layer is applied to the second surface of the inner paper layer using a method selected from the group consisting of an extrusion coating process and a coextrusion coating process.

[0035] In another more limited aspect, the polymer layer is selected from the group consisting of monolayer film and a multilayer film.

[0036] In another more limited aspect, the polymer layer is selected from the group consisting of a barrier film layer and a nonbarrier film layer.

[0037] In another more limited aspect, the polymer layer is selected from the group consisting of a barrier film layer and a nonbarrier film layer.

[0038] In another more limited aspect, the polymer layer is selected from the group consisting of:

[0039] a first coextruded film comprising a first polyolefin layer, a second polyolefin layer, and a first barrier layer disposed intermediate the first and second polyolefin layers, wherein the first barrier layer is formed of a material selected from the group consisting of ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene di-chloride (PVcD), polyamide, and polyvinyl alcohol (PVOH); and

[0040] a second coextruded film comprising a second barrier layer having a barrier outer surface coupled to the second surface of the inner paper layer and a barrier inner surface opposite the barrier outer surface, and a third polyolefin layer coupled to the barrier inner surface.

[0041] In another more limited aspect, the first and second barrier layers comprise EVOH and the first, second, and third polyolefin layers, which may be the same or different, comprise a polyethylene-based polymer.

[0042] In another more limited aspect, the first bonding layer is selected from the group consisting of: (a) an adhesive layer formed of an adhesive selected from the group consisting of a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C; (b) a high solids content adhesive having a solids content in the range of 15% to 100% by weight; and (c) an extruded polyolefin resin layer.

[0043] In another more limited aspect, the first bonding layer is selected from the group consisting of: (a) a third coextruded film comprising a fourth polyolefin layer, a fifth polyolefin layer, and a third barrier layer disposed intermediate the fourth and fifth polyolefin layers, wherein the third barrier layer is formed of a material selected from the group consisting of ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene di-chloride (PVcD), polyamide, and polyvinyl alcohol (PVOH); and (b) a fourth coextruded film comprising a fourth barrier layer having a

barrier inner surface coupled to the first surface of the inner paper layer and a barrier outer surface opposite the barrier inner surface, and a sixth polyolefin layer coupled to the barrier outer surface and the second surface of the outer paper layer.

[0044] In another more limited aspect, the third and fourth barrier layers comprise EVOH and the fourth, fifth, and sixth polyolefin layers, which may be the same or different, comprise a polyethylene-based polymer.

[0045] In another more limited aspect, the method further comprises modifying one or more of the second surface of the outer paper layer, the first surface of the inner paper layer, the second surface of the inner paper layer, and the inner surface of the polymer layer with a surface treatment selected from the group consisting of flame treatment, corona treatment, ozone treatment, and plasma treatment.

[0046] In a further aspect, a thermoformed packaging article formed from the paper base web in accordance with this disclosure is provided.

[0047] In a more limited aspect, the thermoformed packaging article is a packaging tray.

[0048] In a further aspect, a thermoformed packaging article formed via the method in accordance with this disclosure is provided.

[0049] In another aspect, the present disclosure relates to a paper base web structure comprising, in order, an outer paper layer, a first bonding layer, an inner paper layer, a second adhesive layer, and a polymer layer. Each of the outer paper layer and the polymer layer has an outer surface that are the opposing external surfaces of the paper base web structure. In embodiments, the outer and inner paper layers together represent at least 80% by weight of the paper base web structure and less than 100% by weight of the paper base web structure, so that the paper base web structure is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers together comprise at least 85% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 90% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 95% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less or equal to 95% by weight of the thermoformable paper base web. This paper base web structure is an adhesive lamination embodiment of the present invention.

[0050] In a more limited aspect, the paper base web structure has a basis weight, as measured by a micrometer test method, of 327.8 ± 10% GSM; an oxygen transmission rate (OTR)

as measured utilizing the ASTM D3895 test method at standard test conditions of 23° C and 0% relative humidity (RH) of $\leq 2.2 \pm 5\%$ cc/m^2/24 hours; and a water vapor transmission rate (WVTR) as measured utilizing the ASTM F1249 test method at standard test conditions of 38° C and 90% RH of $\leq 8.9 \pm 5\%$ g/m^2/24 hours.

[0051] In another more limited aspect, each of the outer and inner paper layers has a basis weight of between 50 and 300 GSM, preferably between 100 and 150 GSM.

[0052] In another more limited aspect, the outer and inner paper layers are made of thermoformable paper, meaning the paper layers have been molded with heat and vacuum. The thermoform molding process affects the form depth or draw depth of the paper. Form depth/draw depth is the maximum height that a three-dimensional structure can be formed from a sheet, i.e., its stretchability. The paper base web preferably has a form depth of between 1 and 153 mm, preferably 21 mm.

[0053] In embodiments the thermoformable paper is a stretchable paper having a stretchability of 5% to 25% in a first predetermined direction in the range, and more preferably 10% or more, and a stretchability of 5% to 25% in a second predetermined direction which is perpendicular to the first predetermined direction, and more preferably 13% or more. In embodiments, the first predetermined direction is the machine direction (MD) and the second predetermined direction is the transverse direction (TD)

[0054] Exemplary paper out of which the outer and inner paper layers are formed is sold commercially under the trademark BILLERUD FIBREFORM(TM) (Billerud AB, Solna, Sweden).

[0055] In another more limited aspect, the first bonding layer is comprised of a solvent-free high viscosity adhesive with a centipoise value of between 300 cP and 500,000 cP at 50 degrees C and/or high solids content adhesive, e.g., having a solids content of between 15% and 100%, preferably 30% to 100%, and more preferably 100% or nearly 100%, by weight. An exemplary first bonding layer preferably has 100% solids content and a viscosity of 1000 cP at room temperature.

[0056] In another more limited aspect, the second adhesive layer is a solvent-free adhesive, and may be a low, medium, or high viscosity adhesive.

[0057] In another more limited aspect, the polymer layer is a coextruded film layer that comprises at least, in order, a first polyolefin layer adjacent to the second adhesive layer; a first tie layer; a barrier layer; a second tie layer; and a second polyolefin layer, whose external surface is the external surface of the paper base web structure. The preferred first and second polyolefin layers are polyethylene layers. The barrier layer is preferably an EVOH layer. A preferred coextruded polymer layer has a thickness of 27.8 GSM. A preferred coextruded polymer film

layer is that sold under the trademark VIZELPAS. Polymer layers that are coextrusion layers including a barrier layer are preferred for food, especially meat, packaging applications where oxygen and moisture permeation must be carefully limited.

[0058] In another more limited aspect, the polymer layer is a nonbarrier layer, such as polyethylene, polypropylene, or other suitable polymer material. Nonbarrier polymer layers are advantageously suited for applications that do not involve perishable food packaging or where a high level of protection against gas (e.g., oxygen) permeation is not required.

[0059] During production of the paper base web structures herein, treatments may be applied to the various layers for surface modification. Such treatments may be, non-exclusively, flame, ozone, corona, or plasma treatments and may be deployed to imbue the surfaces with adhesion promotion characteristics.

[0060] In another aspect, the present disclosure relates to a paper base web structure comprising, in order, an outer paper layer, an extrusion layer, an inner paper layer, and a polymer layer. Each of the outer paper layer and the polymer layer has an outer surface that are the opposing outer surfaces of the paper base web structure. In embodiments, the outer and inner paper layers together represent at least 80% by weight of the paper base web structure and less than 100% by weight of the paper base web structure, so that the paper base web structure is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers together comprise at least 85% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 90% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 95% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less or equal to 95% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 85% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 90% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 95% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less or equal to 95% by weight of the

thermoformable paper base web. This paper base web structure is an extrusion embodiment of the present development.

[0061] In another more limited aspect, an extrusion embodiment of the paper base web structure has the following structure: 150 GSM Paper/Extruded 8 GSM PE/100 GSM Paper/16 GSM PE-EVOH-PE coextrusion coating. In this example, the structure has a basis weight of 274 GSM; an OTR as measured utilizing the ASTM D3895 test method at standard test conditions of 23° C and 0% RH of $\leq 2.2 \pm 5\%$ cc/m^2/24 hours; and a WVTR as measured utilizing the ASTM F1249 test method at standard test conditions of 38° C and 90% RH of $\leq 8.9 \pm 5\%$ g/m^2/24 hours.

[0062] In another more limited aspect, each of the outer and inner paper layers has a basis weight of between 50 and 300 GSM. In certain embodiments, the outer paper layer has a basis weight of 150 GSM. In certain embodiments, the inner paper layer has a basis weight of 100 GSM.

[0063] In another more limited aspect, the outer and inner paper layers are made of thermoformable paper. In embodiments, the paper base web has a form depth of between 1 and 153 mm, preferably 21 mm. In embodiments, the paper has a stretch in the range of 5%-25% in the machine direction, preferably 10% or more, and 5%-25% in the transverse direction, preferably 13% or more. Exemplary paper out of which the first and second layers are formed is sold commercially under the trademarks BILLERUD FIBREFORM.

[0064] In another more limited aspect, the extrusion layer is polyethylene having a thickness of 8 GSM.

[0065] In another more limited aspect, the polymer layer is a coextrusion coating layer that comprises at least, in order, a first polyolefin layer adjacent to the inner paper layer; a first tie layer; a barrier layer; a second tie layer; and a second polyolefin layer, whose outer surface defines an outer surface, i.e., interior-facing surface of the paper base web structure. In embodiments, the first and second polyolefin layers are formed of polyethylene. In embodiments, the barrier layer is formed of EVOH layer. In embodiments, the polymer layer coextrusion coating has a basis weight or coating density of 16 GSM.

[0066] In another more limited aspect, the polymer layer is a coextruded film layer that comprises in order, an EVOH barrier layer directly adjacent to the inner paper layer, a polyolefin layer, e.g., polyethylene, and a tie layer. The tie layer is intermediate the EVOH barrier layer and the polyolefin layer. The external surface of the polyolefin layer defines an external surface of the paper base web structure.

[0067] In another more limited aspect, the polymer layer is a nonbarrier layer formed of polyethylene or other suitable polymer. Embodiments having a nonbarrier polymer layer are

advantageously suited for applications that do not involve perishable food packaging or where a high level of protection against gas (e.g., oxygen) permeation is not required.

[0068] In another aspect, a method for producing an adhesive lamination embodiment of the paper base webs as described above is provided. In its most basic form, the method includes the steps of providing the outer and inner paper layers; disposing a first bonding layer, e.g., a high viscosity and/or high solids content adhesive between the outer and inner paper layers to form a paper adhesive lamination; providing a polymer film layer; and disposing a second adhesive between the paper lamination and the polymer layer, where the outer and inner paper layers together comprise at least 80% by weight of the resultant paper base web structure and less than 100% by weight of the paper base web structure. In embodiments, the outer and inner paper layers together comprise at least 85% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 90% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 95% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web. In embodiments, the outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less or equal to 95% by weight of the thermoformable paper base web.

[0069] In another more limited aspect, the method includes the step of modifying one or more of the surfaces to be adhesively bonded of the outer paper layer, the inner paper layer, and/or the polymer layer. This surface modification may be, non-exclusively, through flame, ozone, corona, or plasma treatment to promote adhesion.

[0070] In embodiments, the polymer layer is a coextruded barrier film comprising a first polyethylene layer, a first tie layer, an EVOH layer, a second tie layer, and a second polyethylene layer, i.e., a five layer barrier coextrusion. It will be recognized that other numbers of layers, such as seven layer barrier coextrusions, nine layer coextrusions, and so forth are also contemplated.

[0071] In another more limited aspect, the method includes the optional steps of drying the paper lamination after disposing the high viscosity and/or high solids content adhesive between the outer and inner paper layers and/or drying the paper base web structure after disposing the adhesive between the paper lamination and the coextrusion layer.

[0072] In another more limited aspect, the method includes the steps of compressing the outer and inner paper layers through nip or pressure rollers after disposing the first bonding layer between the outer and inner paper layers.

[0073] In yet another aspect, another method for producing an extrusion embodiment of the paper base web structure, as described above, is provided. In its most basic form, the steps of

this method include: providing outer and inner paper layers; bonding the outer and inner paper layers via extrusion lamination with a polyolefin, e.g., polyethylene; and coating the inner paper layer with a polymer layer via extrusion coating (in the case of a single layer polymer layer) or via coextrusion coating (in the case of a coextruded multilayer polymer layer) to form an extrusion embodiment paper base web structure.

[0074] In another more limited aspect, the polymer layer is a coextrusion coating layer comprising polyethylene, a tie resin, and EVOH forming, e.g., a PE-Tie Resin-EVOH-Tie Resin-PE coextrusion coating, i.e., a five layer barrier coextrusion. It will be recognized that other numbers of layers, such as seven layer barrier coextrusions, nine layer coextrusions, and so forth are also contemplated.

[0075] Certain advantages and benefits of the present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0076] The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating preferred embodiments and are not to be construed as limiting the invention.

[0077] FIG. 1 is a cross-sectional diagram illustrating a composite structure operable to embody the thermoformable paper base web structure of the present disclosure.

[0078] FIG. 2 is a cross-sectional diagram illustrating the layers of an exemplary adhesive lamination embodiment of the paper base web structure.

[0079] FIG. 3 is a cross-sectional diagram of an exemplary adhesive lamination embodiment having a coextruded barrier film polymer layer.

[0080] FIG. 4 is a cross-sectional diagram of an exemplary adhesive lamination embodiment having a nonbarrier polymer layer.

[0081] FIG. 5 is a cross-sectional diagram illustrating the layers of an exemplary extrusion embodiment of the paper base web structure.

[0082] FIG. 6A is a cross-sectional diagram of a first exemplary extrusion embodiment wherein the polymer layer is barrier film coextrusion coating.

[0083] FIG. 6B is a cross-sectional diagram of a first exemplary extrusion embodiment wherein the polymer layer is barrier film coextrusion coating.

[0084] FIG. 7A is a cross-sectional diagram of an exemplary extrusion embodiment wherein the polymer layer is a nonbarrier extrusion coating or coextrusion coating.

[0085] FIG. 7B is a cross-sectional diagram illustrating a first more specific embodiment of the structure appearing in FIG. 7A.

[0086] FIG. 7C is a cross-sectional diagram illustrating a second more specific embodiment of the structure appearing in FIG. 7A.

[0087] FIG. 8A is a cross-sectional diagram of an exemplary extrusion embodiment wherein the polymer layer is a coextruded barrier film polymer layer.

[0088] FIG. 8B is a cross-sectional diagram illustrating a first more specific embodiment of the structure appearing in FIG. 8A.

[0089] FIG. 8C is a cross-sectional diagram illustrating a second more specific embodiment of the structure appearing in FIG. 8A.

[0090] FIG. 8D is a cross-sectional diagram illustrating a third more specific embodiment of the structure appearing in FIG. 8A.

[0091] FIG. 8E is a cross-sectional diagram illustrating a fourth more specific embodiment of the structure appearing in FIG. 8A.

[0092] FIG. 9A is a cross-sectional diagram illustrating a first exemplary embodiment paper base web having a moisture barrier layer on the exterior side of the outer paper layer.

[0093] FIG. 9B is a cross-sectional diagram illustrating a second exemplary embodiment paper base web having a moisture barrier layer on the exterior side of the outer paper layer.

[0094] FIG. 10 is a flow chart illustrating the steps of an exemplary method for producing an adhesive lamination embodiment of the paper base web structure.

[0095] FIG. 11 is a more detailed flow chart illustrating the steps of the method for producing an adhesive lamination embodiment of the paper base web structure.

[0096] FIG. 12A is a schematic drawing of an exemplary process line for a first step of a two-step process for producing an adhesive lamination embodiment of the paper base web structure.

[0097] FIG. 12B is a schematic drawing of an exemplary process line for a second step of a two-step process for producing an adhesive lamination embodiment of the paper base web structure.

[0098] FIG. 12C is a schematic drawing of an exemplary process line for producing an adhesive lamination embodiment of the paper base web structure in a single step process.

[0099] FIG. 12D is a schematic drawing of an exemplary process line for producing an adhesive lamination embodiment of the paper base web structure in an alternative single step process.

[0100] FIG. 13 is a flow chart illustrating the steps of a method for producing an extrusion embodiment of the paper base web structure.

[0101] FIG. 14A is a schematic drawing of an exemplary process line for a first step of a two-step process for producing an extrusion embodiment of the paper base web structure.

[0102] FIG. 14B is a schematic drawing of an exemplary process line for a second step of a two-step process for producing an extrusion embodiment of the paper base web structure.

[0103] FIG. 14C is a schematic drawing of an exemplary process line for producing an adhesive lamination embodiment of the paper base web structure in a single step process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0104] Reference will now be made in detail to presently preferred embodiments of the invention, one or more examples of which are illustrated in the accompanying drawings. Each example is provided by way of explanation of the invention, not limitation of the invention, which may be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present inventive concept in virtually any appropriately detailed structure. Further, the terms and phrases used herein are not intended to be limiting but rather to provide an understandable description of the present development. In fact, it will be apparent to those skilled in the art that modifications and variations can be made in the present invention without departing from the scope or spirit thereof. For instance, features illustrated or described as part of one embodiment may be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0105] The terms "a" or "an," as used herein, are defined as one or more than one. The term "another," as used herein, is defined as at least a second or more. The terms "including" and/or "having" as used herein, are defined as comprising (i.e., open transition). The term "coupled" or "operatively coupled," as used herein, is defined as indirectly or directly connected.

[0106] The term "directly contacts," "in direct contact with," "directly adhered to," or similar terms as used herein, refers to a layer configuration whereby a first layer is located immediately adjacent to a second layer, the first layer touches the second layer, and no intervening layers, and/or no intervening structures, are present between the first layer and the second layer. The terms "indirectly contacts" or "in indirect contact with," or similar terms as used herein, refers to a layer configuration whereby an intervening layer, or an intervening structure, is present between the first layer and the second layer.

[0107] As used in this application, the terms "front," "rear," "upper," "lower," "upwardly," "downwardly," "left," "right," and other orientation descriptors are intended to facilitate the description of the exemplary embodiment(s) of the present invention and are not intended to limit the structure thereof to any particular position or orientation.

[0108] All numbers herein are assumed to be modified by the term "about," unless stated otherwise. The recitation of numerical ranges by endpoints includes all numbers subsumed within that range (e.g., 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, and 5).

[0109] As used herein, the term "about," when referring to a value can encompass variations of, in some embodiments ±20%, in some embodiments ±10%, in some embodiments ±5%, in some embodiments ±1%, in some embodiments ±0.5%, in some embodiments ±0.1%, and in some embodiments to ±0.01%, from the specified amount, as such variations are appropriate in the disclosed materials and methods.

[0110] The terms "exterior" and "interior" are used herein to refer to a position in relation to a product to be packaged using the multilayer packaging structures herein, while the terms "outer" and "inner" are used herein to refer to a position in relation to other layers of the multilayer packaging structures herein.

[0111] As used herein, the term "exterior layer" refers to a layer of a multilayer packaging structure which is furthest from the product to be packaged in relation to the other layers of the multilayer structure. The term "exterior facing surface" of a layer of a multilayer packaging structure is the surface of such layer that faces away from the product being packaged within a multilayer packaging structure herein or a packaging article formed thereof. Likewise, the term "exterior surface" of a multilayer packaging structure is the surface of the structure that is intended to face away from a product being packaged within the structure. The term "exterior-most surface" refers to the surface of the outer paper layer that is intended to be the furthest away from a packaged product when the paper base web is formed into a packaging article. In embodiments, the exterior surface of the outer paper layer is the outermost surface of the paper base web. In certain embodiments, a moisture barrier layer may be disposed on the exterior surface of the outer paper layer.

[0112] As used herein, the term "interior layer" refers to a layer of a multilayer packaging structure which is closest to or is intended to contact the product to be packaged within a multilayer structure herein in relation to the other layers of the multilayer structure. The term "interior facing surface" of a layer of a multilayer packaging structure herein is the surface of such layer that faces toward the product being packaged within a multilayer packaging structure herein or a packaging article formed thereof. Likewise, the term "interior surface" of a multilayer packaging structure herein is the surface of the structure that faces toward or is intended to face toward or contact a product being packaged within the structure. The term "interior-most surface" refers to the surface of the polymer layer that is intended to be closest to a packaged product when the paper base web is formed into a packaging article.

[0113] As used herein, the term "inner layer" refers to a layer within a multilayer packaging structure that is not exposed to handling and the environment. Inner layers may provide functionality as needed for particular applications. For example, inner layers may provide barrier protection and/or structural strength. As an example, an exemplary inner layer provides protection to packaged food or other product for freshness and/or a barrier to moisture and/or oxygen, and/or a barrier to migration of moisture, oils, and the like from packaged food or other product from the interior surface of the multilayer packaging structure to the exterior surface of the multilayer packaging structure. As another example, an inner layer may also be a structural layer which provides one or more properties including but not limited to general durability, puncture strength, resistance to curling, tear or flex crack resistance, and the like.

[0114] As used herein, the term "outer layer" refers to a layer which comes in immediate contact with the outside environment or atmosphere. Therefore, the multilayer packaging structures herein have two outer layers, namely, the interior layer and the exterior layer.

[0115] As used herein, "recyclable" may refer to a paper-based product that is eligible for acceptance into paper recycling programs, including curbside collection programs and recycling programs that use drop-off locations, including products that comply with one or more promulgated standards or guidelines for recyclability, and including materials that are sufficiently free of plastic materials, such as polyethylene, nylon, polypropylene, polyester, and others which would impede recyclability.

[0116] As used herein, "repulpable" may refer to a product that can be reused or remade into paper (e.g., at a paper mill), including products that comply with one or more promulgated standards or guidelines for repulpability, and including materials that are sufficiently free of plastic materials, such as polyethylene, nylon, polypropylene, polyester, and others which would impede repulpability.

[0117] As used herein, the terms "grease resistant" or "grease resistance" refer to the character of the barrier layer in blocking or impeding the absorption or transmission of grease or oil in any significant quantity.

[0118] As used herein, the term "extrusion" is used with reference to the process of forming shapes such as a melt curtain by forcing a molten plastic material through a die, followed by cooling or chemical hardening. Immediately prior to extrusion through the die, the polymeric material is fed into a rotating screw, i.e., an extruder that forces the polymeric material through the die. The term "continuous extrusion" refers to an extrusion process wherein the die is designed to produce a continuous flow or curtain of molten polymer without breaks or gaps. The term "discontinuous extrusion" refers to an extrusion process wherein the die is designed to produce a patterned or otherwise discontinuous flow or curtain of molten polymer. For example, the die

may have multiple orifices that allow the polymer to be extruded in a pattern or with gaps in between extruded portions.

[0119] As used herein, the term "extrusion coating" is used in reference to a process wherein a molten polymer is extruded through a die and applied as a coating onto a substrate to form a coated substrate.

[0120] As used herein, the term "extrusion lamination" is used in reference to a process where a molten polymer is extruded through a die and then immediately laminated onto a first substrate and passes through a nip between the extrusion die and a second substrate, wherein the molten polymer forms an extrusion interlayer and bonds the two substrates together to form a laminated structure.

[0121] As used herein, the term "coextrusion" refers to the process of extruding two or more materials through a single die with two or more orifices arranged so that the extrudates merge and weld together into a laminar structure before chilling, i.e., quenching.

[0122] As used herein, the term "surface treatment" means a surface modification treatment to increase the surface energy of a material, which can improve adhesion between two surfaces.

[0123] As used herein, the term "packaging structure" means a web of sheet material having a structure as disclosed herein, as well as a packaging article manufactured therefrom, including sheets or wraps, bags, pouches, and the like.

[0124] As used herein "fiber components" refers to the paper material in a composite, including any cellulose fibers or pulp.

[0125] As used herein, "non-fiber components" refers to non-paper material in a composite, including any polymer films, coatings, lamination adhesives, or any other non-paper elements in the composite.

[0126] All compositional percentages used herein are presented on a "by weight" basis, unless specifically stated otherwise.

[0127] Referring now to the drawings, like reference numerals are used to describe like or analogous items in which the hundreds digit has been increased to correspond to the figure number (e.g., the outer paper layer **112** in FIG. 1 corresponds to the outer paper layer **212** in FIG. 2, which corresponds to the outer paper layer **312** in FIG. 3, and so forth). The description in reference to any given reference numeral herein is equally applicable to other reference numerals that differ only in the hundreds digit, unless specifically stated otherwise.

[0128] Referring now to FIG. 1 there is illustrated a cross-sectional view of a general embodiment of a paper base web structure **110**. The structure **110** includes an outer paper layer **112** and an inner paper layer **116**. The outer paper layer **112** defines an outward facing surface

122 of the structure **110**. A first bonding layer **114** is disposed between the inner and outer paper layers **112**, **116**. In embodiments the first bonding layer **114** may be an adhesive layer or an extruded resin layer, as described in greater detail below. The inner and outer paper layers **112**, **116** may be brought together via an adhesive lamination process or an extrusion lamination process.

[0129] A polymer layer **120** is attached to the inner paper layer **118**. The polymer layer **120** defines an interior facing surface **124** of the structure **110**. The polymer layer **120** may be a monolayer film structure or a multiplayer film structure. The polymer layer **120** may be a barrier film structure comprising a gas barrier layer or a non-barrier film structure, depending on the desired application. In certain embodiments, the structure **110** includes an optional second bonding layer **118** for joining the polymer layer **120** to the inner paper layer **116**. In embodiments the optional second bonding layer **114** may be an adhesive layer or an extruded resin layer. The polymer layer **120** and inner paper layer **116** may be brought together via an adhesive lamination process or an extrusion lamination process. In alternative embodiments, the optional second bonding layer **118** is omitted and the polymer layer **120** is bonded directly to the inner paper layer **116**, e.g., via a coating process, an extrusion coating process, or a coextrusion coating process. Optionally, a moisture barrier layer **165** may be provided on the exterior facing surface of the outer paper layer **112**, as will be described in greater detail below.

[0130] Referring now to FIGS. 2-7, which show some of the presently preferred embodiments, FIG. 2 is a cross-sectional view of a first embodiment paper web base **210**. The paper base web **210** comprises an outer paper layer **212**. The outer paper layer **212** has an exterior facing surface **222** of the paper base web **210** when the paper base web **210** is used to form a thermoformed packaging tray. Printed indicia or graphics comprising inks and associated varnishes and lacquers may be provided on the exterior facing surface **222** of the outer paper layer **212**.

[0131] The outer paper layer **212** is adhesively laminated to a first major surface of an inner paper layer **216** with a first adhesive layer **214**. In embodiments, the first adhesive layer **214** is a high viscosity adhesive. A second major surface of the inner paper layer **216**, in turn, is adhesively laminated to a polymer layer **220** with a second adhesive layer **218**. In embodiments, the second adhesive layer **218** is a high viscosity adhesive. The polymer layer **220** has an interior facing surface **224** which is configured to contact or face a packaged product when the paper base web **210** is used to form a thermoformed packaging tray.

[0132] In embodiments, the outer and inner paper layers **212**, **216** together comprise at least 80%, e.g., 80% to 99%, e.g., 80%, 81%, 81%, 83%, 84%, 85%, 86%, 87%, 88%, 89% 90%,

91%, 91%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% of the paper base web structure **210** by weight, so that the paper base web structure **210** is recyclable in paper recycling streams.

[0133] Each of the outer paper layer **212** and the inner paper layer **216**, which may be the same or different, may be any suitable paper type having a basis weight in the range of from about 50 grams per square meter (GSM) to about 300 GSM, e.g., 50 GSM, 60 GSM, 70 GSM, 80 GSM, 90 GSM, 100 GSM, 110 GSM, 120 GSM, 130 GSM, 140 GSM, 150 GSM, 160 GSM, 170 GSM, 180 GSM, 190 GSM, 200 GSM, 210 GSM, 220 GSM, 230 GSM, 240 GSM, 250 GSM, 260 GSM, 270 GSM, 280 GSM, 290 GSM, or 300 GSM. In embodiments, each of the outer paper layer **212** and the inner paper layer **216**, which may be the same or different, have a basis weight in the range of from about 100 GSM to about 200 GSM. In embodiments, each of the outer paper layer **212** and the inner paper layer **216**, which may be the same or different, have a basis weight of about 150 GSM.

[0134] The polymer layer **220**, which may be a monolayer structure or a multilayer structure comprises any suitable polymer composition, including homopolymers, copolymers, and polymer blends. In embodiments, the polymer layer **220** comprises a polyolefin polymer. In embodiments, the polymer layer **220** comprises a polyolefin polymer. In embodiments, the polymer layer **220** comprises a polyethylene or polypropylene polymer. In embodiments, the polymer layer **220** comprises a polyethylene polymer. Exemplary polyolefin polymers include, for example, homopolymers, copolymers, and terpolymers of ethylene, high density polyethylene (HDPE), medium density polyethylene (MDPE), linear medium density polyethylene (LMDPE), low density polyethylene (LDPE), linear low density polyethylene (LLDPE), very low density polyethylene (VLDPE), metallocene linear low-density polyethylene (mLLDPE), and homopolymers, copolymers, and terpolymers of polypropylene. Exemplary polyolefin copolymers include ethylene-vinyl acetate copolymer (EVA), ethylene-methyl acrylate copolymer (EMA), ethylene-methyl acrylate-acrylic acid copolymer (EMAA), SURLYN(TM) or other ionomer resin including ethylene-based ionomer resins and ethylene-methacrylic acid ionomer resins.

[0135] In certain embodiments the polymer layer **220** is a high barrier coextruded layer, an exemplary embodiment of which appears in FIG. 3. In alternative embodiments, the polymer layer **220** is a nonbarrier layer, an exemplary embodiment of which appears in FIG. 4. It will be recognized that multilayer polymer structures **220** may be achieved through a single coextrusion process or through successive extrusion lamination, extrusion coating, or other types of coating operations.

[0136] In preferred embodiments, the first adhesive layer **214** comprises a high viscosity adhesive. Unless stated otherwise, all viscosity values herein are at 50 °C (122 °F). In

embodiments, the first adhesive layer **214** comprises solvent-free adhesive having a centipoise value of between 300 cP and 500,000 cP, preferably between 1,000 cP and 300,000 cP, and more preferably between 3,000 cP and 200,000 cP. Exemplary high-viscosity adhesives have a viscosity of 300 cP, 1,000 cP, 2,000 cP, 3,000 cP, 4,000 cP, 5,000 cP, 6,000 cP, 7,000 cP, 8,000 cP, 9,000 cP, 10,000 cP, 11,000 cP, 12,000 cP, 13,000 cP, 14,000 cP, 15,000 cP, 16,000 cP, 17,000 cP, 18,000 cP, 19,000 cP, 20,000 cP, 21,000 cP, 22,000 cP, 23,000 cP, 24,000 cP, 25,000 cP, 26,000 cP, 27,000 cP, 28,000 cP, 29,000 cP, 30,000 cP, 31,000 cP, 32,000 cP, 33,000 cP, 34,000 cP, 35,000 cP, 36,000 cP, 37,000 cP, 38,000 cP, 39,000 cP, 40,000 cP, 41,000 cP, 42,000 cP, 43,000 cP, 44,000 cP, 45,000 cP, 46,000 cP, 47,000 cP, 48,000 cP, 49,000 cP, 50,000 cP, 51,000 cP, 52,000 cP, 53,000 cP, 54,000 cP, 55,000 cP, 56,000 cP, 57,000 cP, 58,000 cP, 59,000 cP, 60,000 cP, 61,000 cP, 62,000 cP, 63,000 cP, 64,000 cP, 65,000 cP, 66,000 cP, 67,000 cP, 68,000 cP, 69,000 cP, 70,000 cP, 71,000 cP, 72,000 cP, 73,000 cP, 74,000 cP, 75,000 cP, 76,000 cP, 77,000 cP, 78,000 cP, 79,000 cP, 80,000 cP, 81,000 cP, 82,000 cP, 83,000 cP, 84,000 cP, 85,000 cP, 86,000 cP, 87,000 cP, 88,000 cP, 89,000 cP, 90,000 cP, 91,000 cP, 92,000 cP, 93,000 cP, 94,000 cP, 95,000 cP, 96,000 cP, 97,000 cP, 98,000 cP, 99,000 cP, 100,000 cP, 101,000 cP, 102,000 cP, 103,000 cP, 104,000 cP, 105,000 cP, 106,000 cP, 107,000 cP, 108,000 cP, 109,000 cP, 110,000 cP, 111,000 cP, 112,000 cP, 113,000 cP, 114,000 cP, 115,000 cP, 116,000 cP, 117,000 cP, 118,000 cP, 119,000 cP, 120,000 cP, 121,000 cP, 122,000 cP, 123,000 cP, 124,000 cP, 125,000 cP, 126,000 cP, 127,000 cP, 128,000 cP, 129,000 cP, 130,000 cP, 131,000 cP, 132,000 cP, 133,000 cP, 134,000 cP, 135,000 cP, 136,000 cP, 137,000 cP, 138,000 cP, 139,000 cP, 140,000 cP, 141,000 cP, 142,000 cP, 143,000 cP, 144,000 cP, 145,000 cP, 146,000 cP, 147,000 cP, 148,000 cP, 149,000 cP, 150,000 cP, 151,000 cP, 152,000 cP, 153,000 cP, 154,000 cP, 155,000 cP, 156,000 cP, 157,000 cP, 158,000 cP, 159,000 cP, 160,000 cP, 161,000 cP, 162,000 cP, 163,000 cP, 164,000 cP, 165,000 cP, 166,000 cP, 167,000 cP, 168,000 cP, 169,000 cP, 170,000 cP, 171,000 cP, 172,000 cP, 173,000 cP, 174,000 cP, 175,000 cP, 176,000 cP, 177,000 cP, 178,000 cP, 179,000 cP, 180,000 cP, 181,000 cP, 182,000 cP, 183,000 cP, 184,000 cP, 185,000 cP, 186,000 cP, 187,000 cP, 188,000 cP, 189,000 cP, 190,000 cP, 191,000 cP, 192,000 cP, 193,000 cP, 194,000 cP, 195,000 cP, 196,000 cP, 197,000 cP, 198,000 cP, 199,000 cP, 200,000 cP, 201,000 cP, 202,000 cP, 203,000 cP, 204,000 cP, 205,000 cP, 206,000 cP, 207,000 cP, 208,000 cP, 209,000 cP, 210,000 cP, 211,000 cP, 212,000 cP, 213,000 cP, 214,000 cP, 215,000 cP, 216,000 cP, 217,000 cP, 218,000 cP, 219,000 cP, 220,000 cP, 221,000 cP, 222,000 cP, 223,000 cP, 224,000 cP, 225,000 cP, 226,000 cP, 227,000 cP, 228,000 cP, 229,000 cP, 230,000 cP, 231,000 cP, 232,000 cP, 233,000 cP, 234,000 cP, 235,000 cP, 236,000 cP, 237,000 cP, 238,000 cP, 239,000 cP, 240,000 cP, 241,000 cP, 242,000 cP, 243,000 cP, 244,000 cP, 245,000 cP, 246,000 cP, 247,000 cP, 248,000 cP, 249,000 cP, 250,000 cP, 251,000 cP,

252,000 cP, 253,000 cP, 254,000 cP, 255,000 cP, 256,000 cP, 257,000 cP, 258,000 cP, 259,000 cP, 260,000 cP, 261,000 cP, 262,000 cP, 263,000 cP, 264,000 cP, 265,000 cP, 266,000 cP, 267,000 cP, 268,000 cP, 269,000 cP, 270,000 cP, 271,000 cP, 272,000 cP, 273,000 cP, 274,000 cP, 275,000 cP, 276,000 cP, 277,000 cP, 278,000 cP, 279,000 cP, 280,000 cP, 281,000 cP, 282,000 cP, 283,000 cP, 284,000 cP, 285,000 cP, 286,000 cP, 287,000 cP, 288,000 cP, 289,000 cP, 290,000 cP, 291,000 cP, 292,000 cP, 293,000 cP, 294,000 cP, 295,000 cP, 296,000 cP, 297,000 cP, 298,000 cP, 299,000 cP, 300,000 cP, 301,000 cP, 302,000 cP, 303,000 cP, 304,000 cP, 305,000 cP, 306,000 cP, 307,000 cP, 308,000 cP, 309,000 cP, 310,000 cP, 311,000 cP, 312,000 cP, 313,000 cP, 314,000 cP, 315,000 cP, 316,000 cP, 317,000 cP, 318,000 cP, 319,000 cP, 320,000 cP, 321,000 cP, 322,000 cP, 323,000 cP, 324,000 cP, 325,000 cP, 326,000 cP, 327,000 cP, 328,000 cP, 329,000 cP, 330,000 cP, 331,000 cP, 332,000 cP, 333,000 cP, 334,000 cP, 335,000 cP, 336,000 cP, 337,000 cP, 338,000 cP, 339,000 cP, 340,000 cP, 341,000 cP, 342,000 cP, 343,000 cP, 344,000 cP, 345,000 cP, 346,000 cP, 347,000 cP, 348,000 cP, 349,000 cP, 350,000 cP, 351,000 cP, 352,000 cP, 353,000 cP, 354,000 cP, 355,000 cP, 356,000 cP, 357,000 cP, 358,000 cP, 359,000 cP, 360,000 cP, 361,000 cP, 362,000 cP, 363,000 cP, 364,000 cP, 365,000 cP, 366,000 cP, 367,000 cP, 368,000 cP, 369,000 cP, 370,000 cP, 371,000 cP, 372,000 cP, 373,000 cP, 374,000 cP, 375,000 cP, 376,000 cP, 377,000 cP, 378,000 cP, 379,000 cP, 380,000 cP, 381,000 cP, 382,000 cP, 383,000 cP, 384,000 cP, 385,000 cP, 386,000 cP, 387,000 cP, 388,000 cP, 389,000 cP, 390,000 cP, 391,000 cP, 392,000 cP, 393,000 cP, 394,000 cP, 395,000 cP, 396,000 cP, 397,000 cP, 398,000 cP, 399,000 cP, 400,000 cP, 401,000 cP, 402,000 cP, 403,000 cP, 404,000 cP, 405,000 cP, 406,000 cP, 407,000 cP, 408,000 cP, 409,000 cP, 410,000 cP, 411,000 cP, 412,000 cP, 413,000 cP, 414,000 cP, 415,000 cP, 416,000 cP, 417,000 cP, 418,000 cP, 419,000 cP, 420,000 cP, 421,000 cP, 422,000 cP, 423,000 cP, 424,000 cP, 425,000 cP, 426,000 cP, 427,000 cP, 428,000 cP, 429,000 cP, 430,000 cP, 431,000 cP, 432,000 cP, 433,000 cP, 434,000 cP, 435,000 cP, 436,000 cP, 437,000 cP, 438,000 cP, 439,000 cP, 440,000 cP, 441,000 cP, 442,000 cP, 443,000 cP, 444,000 cP, 445,000 cP, 446,000 cP, 447,000 cP, 448,000 cP, 449,000 cP, 450,000 cP, 451,000 cP, 452,000 cP, 453,000 cP, 454,000 cP, 455,000 cP, 456,000 cP, 457,000 cP, 458,000 cP, 459,000 cP, 460,000 cP, 461,000 cP, 462,000 cP, 463,000 cP, 464,000 cP, 465,000 cP, 466,000 cP, 467,000 cP, 468,000 cP, 469,000 cP, 470,000 cP, 471,000 cP, 472,000 cP, 473,000 cP, 474,000 cP, 475,000 cP, 476,000 cP, 477,000 cP, 478,000 cP, 479,000 cP, 480,000 cP, 481,000 cP, 482,000 cP, 483,000 cP, 484,000 cP, 485,000 cP, 486,000 cP, 487,000 cP, 488,000 cP, 489,000 cP, 490,000 cP, 491,000 cP, 492,000 cP, 493,000 cP, 494,000 cP, 495,000 cP, 496,000 cP, 497,000 cP, 498,000 cP, 499,000 cP, 500,000 cP, or within any subrange between any of the foregoing viscosity values.

[0137] In embodiments, the first adhesive layer **214** comprises a high viscosity adhesive having a solids content of between 15% and 100%, preferably 30% to 100%, and more preferably 100% or close to 100%. In embodiments, the adhesive first adhesive layer **214** comprises a high viscosity adhesive having a solids content in the range of 15-30%. In embodiments, the adhesive first adhesive layer **214** comprises a high viscosity adhesive having a solids content in the range of 30-50%. In embodiments, the adhesive first adhesive layer **214** comprises a high viscosity adhesive having a solids content in the range of 50-60%. In embodiments, the adhesive first adhesive layer **214** comprises a high viscosity adhesive having a solids content in the range of 60-80%. In embodiments, the adhesive first adhesive layer **214** comprises a high viscosity adhesive having a solids content in the range of 70-90%. In embodiments, the adhesive first adhesive layer **214** comprises a high viscosity adhesive having a solids content in the range of 90-100%. All percentages given herein are by weight unless specifically stated otherwise.

[0138] Exemplary adhesives suitable for the first adhesive layer **214** include single component adhesives, two component adhesives, solvent-based adhesives, solventless adhesives, water-based adhesives, acrylic adhesives, extruded polyethylene or polypropylene adhesive systems, electron beam curable adhesives, and ultraviolet radiation (UV) curable adhesives, and the like, as would be understood by persons skilled in the art.

[0139] It has been found that the use of a high viscosity adhesive as the first adhesive layer **214** allows for a thermoformable, laminated, paper base web structure **210** with a single polymer layer **220**, thereby eliminating additional, i.e., inner, polymer layer(s) of the prior art base web structures to provide a recyclable structure while retaining draw forming capabilities, e.g., 1 mm to 153 mm form depth, preferably up to 21 mm form depth, without ripping on the production line.

[0140] The second adhesive layer **218** may comprise any suitable lamination adhesive. In embodiments, the second adhesive layer **218** comprises a solvent free adhesive, solvent-based adhesive, or water based adhesive. In embodiments, the second adhesive layer **218** comprises low or medium viscosity adhesive. In embodiments, the second adhesive layer **218** is applied at a coating weight of 0.9 lb to 5 lb per 3000 square foot ream.

[0141] Exemplary adhesives suitable for the second adhesive layer **218** include single component adhesives, two component adhesives, solvent-based adhesives, solventless adhesives, water-based adhesives, acrylic adhesives, extruded polyethylene or polypropylene adhesive systems, electron beam lamination adhesives, and UV lamination adhesives, as would be understood by persons skilled in the art.

[0142] Now referring to FIG. 3, there is shown an exemplary paper base web embodiment **310**, which is generally as shown and described above by way of reference to FIG. 2, wherein the

polymer layer **220** comprises a multilayer gas and/or moisture layer **320**. The multilayer gas and/or moisture barrier layer **320** is formed via a coextrusion process.

[0143] An outer paper layer **312** defines an exterior surface **322** of the paper base web **310** and is laminated to an inner paper layer **316** via an adhesive layer **314** (preferably a high viscosity adhesive). The inner paper layer **316** is laminated to the coextruded layer **320** via an adhesive layer **318** (preferably a low or medium viscosity adhesive).

[0144] It is to be understood that in embodiments where adjacent polymer layers may be incompatible, an optional tie layer can be provided, e.g., between a barrier layer and any adjacent layer(s), as would be recognized by a person skilled in the art to promote adhesion and improve interlayer bonding. It is to be further understood that where tie layers are shown in the drawings and/or described herein in detail, such tie layers are provided for illustrative purposes and are considered optional.

[0145] The coextruded layer **320** comprises a first polyolefin layer **326** directly adjacent the adhesive layer **318**. A first tie layer **328** is adjacent to the first polyolefin layer **326**, opposite the adhesive layer. A barrier layer **330** is adjacent to the first tie layer **328** and a second tie layer **332** is adjacent the barrier layer **330** opposite the first tie layer **328**. A second polyolefin layer **334** is adjacent the second tie layer **332** and defines an interior-facing surface **324** of the base web **310**. In embodiments, the inner and outer paper layers **312**, **316** together represent at least 80% by weight of the paper base web structure **310** and less than 100% by weight of the paper base web structure **310** so that the paper base web structure **310** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **312**, **316** together comprise at least 85% by weight of the thermoformable paper base web **310** and less than 100% by weight of the thermoformable paper base web **310**. In embodiments, the outer and inner paper layers **312**, **316** together comprise at least 90% by weight of the thermoformable paper base web **310** and less than 100% by weight of the thermoformable paper base web **310**. In embodiments, the outer and inner paper layers **312**, **316** together comprise at least 95% by weight of the thermoformable paper base web **310** and less than 100% by weight of the thermoformable paper base web **310**. In embodiments, the outer and inner paper layers **312**, **316** together comprise at least 80% by weight of the thermoformable paper base web **310** and less or equal to 95% by weight of the thermoformable paper base web **310**.

[0146] In certain embodiments, the first and second polyolefin layers **326**, **334** are formed of polyethylene. In certain embodiments, the barrier layer **330** is formed of EVOH (with or without compatibilizer additives). Other polymer barrier layers **330** include polyvinylidene dichloride (PVcD), polyamides (such as nylons), polyvinyl alcohol (PVOH). Exemplary tie layers **328**, **332** include maleic anhydride (MAH) or other tie resin or adhesion promotor as would be

known by persons skilled in the art. Although a five-layer multilayer film structure **320** is shown, it will be recognized that other numbers of layers, including seven-layer, nine-layer, and others are also contemplated.

[0147] The high barrier properties provided by the coextruded layer **320** allow for forming packages for consumable products. In particular, the base web **310** may advantageously be used to manufacture thermoformed trays for packing chilled cooked meats, while maintaining the required commercial shelf life of the product.

[0148] In reducing the embodiment appearing in FIG. 3 to practice, inner and outer paper layers (Billerud FiberForm(TM), available from Billerud AB, Solna, Sweden), each having a basis weight of 150 GSM, were adhesively laminated using MORCHEM(TM) XPL 531300 adhesive to form a paper adhesive lamination. A coextruded film comprising having a structure: PE-Tie Layer-EVOH-Tie Layer-PE (available from Vizelpas - Flexible Films, S.A. (Vilarinho, Santo Tirso, Portugal)) having a basis weight of 27.8 GSM was then adhesively laminated to the paper adhesive lamination with MORCHEM(TM) PL 278 - CF 744 adhesive. The resulting base web structure had the properties shown in the table below:

	Test Method	**Value**	**Tolerance**	**Unit**
Basis Weight	Micrometer	327.8	± 10%	GSM
Oxygen Transmission Rate (23°C/0%RH)	ASTM D3895	≤2.2	± 5%	$cc/m^2/24hrs$
Water Vapor Transmission Rate (38°C/90%RH)	ASTM F1249	≤8.9	± 5%	$g/m^2/24hrs$

[0149] Now referring to FIG. 4, there appears an alternative base web embodiment **410**, which is generally as shown and described above by way of reference to FIG. 2, wherein the polymer layer **220** comprises a nonbarrier polymer layer. The base web **410** is advantageously used for the manufacture of thermoformed trays for products that are not sensitive to oxygen, moisture, or other gas intrusion. An outer paper layer **412** defines an exterior surface **422** of the paper base web **410** and is laminated to an inner paper layer **416** via an adhesive layer **414** (preferably a high viscosity adhesive). The inner paper layer **416** is laminated to the nonbarrier polymer layer **420** via an adhesive layer **418** (preferably a low or medium viscosity adhesive).

[0150] The nonbarrier polymer layer **420** is a monolayer structure or multilayer structure. The layer **420** may comprise any suitable polymer composition, including homopolymers, copolymers, and polymer blends. When the nonbarrier polymer layer **420** is a multilayer structure, each layer within the multilayer structure can be the same or different. In certain embodiments, the nonbarrier polymer layer **420** comprises a polyolefin, preferably polyethylene. In

embodiments, the inner and outer paper layers **412**, **416** together represent at least 80% by weight of the paper base web structure **410** and less than 100% by weight of the paper base web structure **410** so that the paper base web structure **410** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **412**, **416** together comprise at least 85% by weight of the thermoformable paper base web **410** and less than 100% by weight of the thermoformable paper base web **410**. In embodiments, the outer and inner paper layers **412**, **416** together comprise at least 90% by weight of the thermoformable paper base web **410** and less than 100% by weight of the thermoformable paper base web **410**. In embodiments, the outer and inner paper layers **412**, **416** together comprise at least 95% by weight of the thermoformable paper base web **410** and less than 100% by weight of the thermoformable paper base web **410**. In embodiments, the outer and inner paper layers **412**, **416** together comprise at least 80% by weight of the thermoformable paper base web **410** and less or equal to 95% by weight of the thermoformable paper base web **410**.

[0151] Now referring to FIG. 5, there is shown a further embodiment paper base web **510** comprising a paper-based extrusion lamination **536** and an extrusion or coextrusion coating layer **520**. The paper-based extrusion lamination **536** includes an outer paper layer **512** which is extrusion laminated to an inner paper layer **516** via a polyolefin layer **538**. The outer paper layer **522** includes an exterior facing surface **522** which is configured to face away from a product to be packaged when the paper base web **510** is formed into a packaging tray.

[0152] The extrusion coating or coextrusion coating layer **520** is disposed on an interior facing surface of the inner paper layer **516**. The extrusion coating or coextrusion coating layer **520** has an inner facing surface **522** which is configured to contact or face toward a product to be packaged when the paper base web **510** is formed into a packaging tray. In embodiments, the inner and outer paper layers **512**, **516** together represent at least 80% by weight of the paper base web structure **510** and less than 100% by weight of the paper base web structure **510** so that the paper base web structure **510** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **512**, **516** together comprise at least 85% by weight of the thermoformable paper base web **510** and less than 100% by weight of the thermoformable paper base web **510**. In embodiments, the outer and inner paper layers **512**, **516** together comprise at least 90% by weight of the thermoformable paper base web **510** and less than 100% by weight of the thermoformable paper base web **510**. In embodiments, the outer and inner paper layers **512**, **516** together comprise at least 95% by weight of the thermoformable paper base web **510** and less than 100% by weight of the thermoformable paper base web **510**. In embodiments, the outer and inner paper layers **512**, **516** together comprise at least 80% by weight of the thermoformable paper base web **510** and less or equal to 95% by weight of the thermoformable paper base web **510**.

[0153] Referring now to FIG. 6A, there is shown a paper base web embodiment **610a**, which is generally as shown and described by way of reference to the paper base web embodiment **510** appearing in FIG. 5, wherein the extrusion or coextrusion coating layer **520** of FIG. 5 is a barrier coextrusion coating layer **620a**.

[0154] The coextrusion coating layer **620a** comprises a first polyolefin layer **626** directly adjacent the inner paper layer **616**. A first tie layer **628** is adjacent to the first polyolefin layer **626**, opposite the inner paper layer **616**. A barrier layer **630** is adjacent to the first tie layer **628** and a second tie layer **632** is adjacent the barrier layer **630** opposite the first tie layer **628**. A second polyolefin layer **634** is adjacent the second tie layer **632** and defines an interior-facing surface **624** of the base web **610a**.

[0155] In embodiments, the first and second polyolefin layers **626**, **634** are formed of polyethylene. In certain embodiments, the barrier layer **630** is formed of EVOH (with or without compatibilizer additives). Other polymer barrier layers **630** include polyvinylidene di-chloride (PVcD), polyamides (such as nylons), polyvinyl alcohol (PVOH). Exemplary tie layers **628**, **632** include maleic anhydride (MAH) or other tie resin or adhesion promotor as would be known by persons skilled in the art. Although a three-resin, five-layer multilayer film structure **620a** is shown, it will be recognized that other numbers of layers, including seven-layer, nine-layer, and others are also contemplated. In embodiments, the inner and outer paper layers **612**, **616** together represent at least 80% by weight of the paper base web structure **610a** and less than 100% of the paper base web structure **610a** so that the paper base web structure **610a** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **612**, **616** together comprise at least 85% by weight of the thermoformable paper base web **610a** and less than 100% by weight of the thermoformable paper base web **610a**. In embodiments, the outer and inner paper layers **612**, **616** together comprise at least 90% by weight of the thermoformable paper base web **610a** and less than 100% by weight of the thermoformable paper base web **610a**. In embodiments, the outer and inner paper layers **612**, **616** together comprise at least 95% by weight of the thermoformable paper base web **610a** and less than 100% by weight of the thermoformable paper base web **610a**. In embodiments, the outer and inner paper layers **612**, **616** together comprise at least 80% by weight of the thermoformable paper base web **610a** and less or equal to 95% by weight of the thermoformable paper base web **610a**.

[0156] In reducing the present development to practice, the embodiment appearing in FIG. 6A was produced using an outer paper layer having a basis weight of 150 GSM and an inner paper layer having a basis weight of 100 GSM. The inner and outer paper layers were extrusion laminated with a polyethylene extrusion layer. The polyethylene extrusion layer had a basis weight of 8 GSM. Next, the inner paper layer was surface treated with flame and corona and a 5

layer coextrusion coating comprising PE-Tie Resin-EVOH-Tie Resin-PE was brought on to the treated surface of the inner paper layer **616**. The coextrusion coating had a basis weight of 16 GSM.

[0157] Referring now to FIG. 6B, there is shown a paper base web embodiment **610b**, which is generally as shown and described by way of reference to the paper base web embodiment **610a** appearing in FIG. 6A, wherein the extrusion or coextrusion coating layer **620a** of FIG. 6A is replaced with a barrier coextrusion coating layer **620b**.

[0158] The coextrusion coating layer **620b** comprises a barrier layer **630** formed of an extrudable barrier polymer material which is directly adjacent the inner paper layer **616**. A polyolefin layer **634** is adjacent the barrier layer **630** and defines an interior-facing surface **624** of the base web **610b**.

[0159] In embodiments, the polyolefin layer **634** is formed of polyethylene. In embodiments, the barrier layer **630** is formed of EVOH (with or without compatibilizer additives). Other polymer barrier layers **630** include polyvinylidene di-chloride (PVcD), polyamides (such as nylons), polyvinyl alcohol (PVOH). In embodiments, the inner and outer paper layers **612**, **616** together represent at least 80% by weight of the paper base web structure **610b** and less than 100% by weight of the paper base web structure **610b** so that the paper base web structure **610b** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **612**, **616** together comprise at least 85% by weight of the thermoformable paper base web **610b** and less than 100% by weight of the thermoformable paper base web **610b**. In embodiments, the outer and inner paper layers **612**, **616** together comprise at least 90% by weight of the thermoformable paper base web **610b** and less than 100% by weight of the thermoformable paper base web **610b**. In embodiments, the outer and inner paper layers **612**, **616** together comprise at least 95% by weight of the thermoformable paper base web **610b** and less than 100% by weight of the thermoformable paper base web **610b**. In embodiments, the outer and inner paper layers **612**, **616** together comprise at least 80% by weight of the thermoformable paper base web **610b** and less or equal to 95% by weight of the thermoformable paper base web **610b**.

[0160] In embodiments, the paper base web **610b** appearing in FIG. 6B is produced using an outer paper layer having a basis weight of 150 GSM and an inner paper layer having a basis weight of 100 GSM. The inner and outer paper layers are extrusion laminated with a polyethylene extrusion layer. The polyethylene extrusion layer has a basis weight of 8 GSM. Next, the inner paper layer is surface treated with flame and corona and a 2 layer coextrusion coating comprising EVOH-PE is brought onto the treated surface of the inner paper layer **616**.

[0161] Now referring to FIG. 7A, there appears a paper base web embodiment **710a**, which is generally as shown and described by way of reference to the paper base web embodiment

510 appearing in FIG. 5, wherein the extrusion or coextrusion coating layer **520** of FIG. 5 is a nonbarrier extrusion coating or coextrusion layer **720**. The base web **710a** is advantageously used for the manufacture of thermoformed trays for products that are not sensitive to oxygen, moisture, or other gas intrusion.

[0162] A paper based extrusion lamination **736** comprises an outer paper layer **712**, which defines an exterior surface **722** of the paper base web **710a**, and which is extrusion laminated to an inner paper layer **716** via a polyolefin layer **738**. In certain embodiments, the polyolefin layer **738** is polyethylene. The extrusion lamination **736**, in turn, is extrusion coated or coextrusion coated with a nonbarrier polymer layer **720**.

[0163] In certain embodiments, the nonbarrier polymer layer **720** is a single layer, extruded coating layer. In certain embodiments, the nonbarrier polymer layer **720** is a multilayer, coextruded coating layer. The extrusion coated or coextrusion coated nonbarrier polymer layer **720** may comprise any suitable polymer composition, including homopolymers, copolymers, and polymer blends. When the nonbarrier polymer layer **720** is a multilayer coextrusion coating, each layer within the multilayer structure can be the same or different. In certain embodiments, the nonbarrier polymer layer **720** comprises a polyolefin, preferably polyethylene. In embodiments, the inner and outer paper layers **712**, **716** together represent at least 80% by weight of the paper base web structure **710a** and less than 100% by weight of the paper base web structure **710a** so that the paper base web structure **710a** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 85% by weight of the thermoformable paper base web **710a** and less than 100% by weight of the thermoformable paper base web **710a**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 90% by weight of the thermoformable paper base web **710a** and less than 100% by weight of the thermoformable paper base web **710a**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 95% by weight of the thermoformable paper base web **710a** and less than 100% by weight of the thermoformable paper base web **710a**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 80% by weight of the thermoformable paper base web **710a** and less or equal to 95% by weight of the thermoformable paper base web **710a**.

[0164] Now referring to FIG. 7B, there appears a paper base web embodiment **710b**, which is generally as shown and described by way of reference to the paper base web embodiment **710a** appearing in FIG. 7A, wherein the polyolefin layer **738** is a barrier coextrusion layer which bonds the outer paper layer **712** to the inner paper layer **716**. The base web **710b** is advantageously used for the manufacture of thermoformed trays for products that are sensitive to oxygen, moisture, or other gas intrusion.

[0165] The base web **710b** includes a paper based extrusion lamination **736** which comprises the outer paper layer **712**, which defines an exterior surface **722** of the paper base web **710b**, and which is extrusion laminated to the inner paper layer **716** via the polyolefin barrier coextrusion layer **738**. The extrusion lamination **736**, in turn, is extrusion coated or coextrusion coated with a nonbarrier polymer layer **720**.

[0166] The polymer layer **738** comprises a core barrier layer **730o** disposed intermediate an outer polyolefin layer **726o** and an inner polyolefin layer **734o**. Optionally, a first tie layer **728o** is disposed intermediate the outer polyolefin layer **726o** and the core barrier layer **730o** and an optional second tie layer **732o** is disposed intermediate the inner polyolefin layer **734o** and the core barrier layer **730o** to enhance adhesion and compatibility between the layers. The outer polyolefin layer **726o** is positioned on the exterior side of the barrier layer **730o** to protect the barrier layer **730o** from mechanical stress, punctures, etc. during handling.

[0167] In certain embodiments, the nonbarrier polymer layer **720** is a single layer, extruded coating layer. In certain embodiments, the nonbarrier polymer layer **720** is a multilayer, coextruded coating layer. The extrusion coated or coextrusion coated nonbarrier polymer layer **720** may comprise any suitable polymer composition, including homopolymers, copolymers, and polymer blends. When the nonbarrier polymer layer **720** is a multilayer coextrusion coating, each layer within the multilayer structure can be the same or different. In certain embodiments, the nonbarrier polymer layer **720** comprises a polyolefin, preferably polyethylene. In embodiments, the inner and outer paper layers **712**, **716** together represent at least 80% by weight of the paper base web structure **710b** and less than 100% by weight of the paper base web structure **710b** so that the paper base web structure **710b** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 85% by weight of the thermoformable paper base web **710b** and less than 100% by weight of the thermoformable paper base web **710b**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 90% by weight of the thermoformable paper base web **710b** and less than 100% by weight of the thermoformable paper base web **710b**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 95% by weight of the thermoformable paper base web **710b** and less than 100% by weight of the thermoformable paper base web **710b**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 80% by weight of the thermoformable paper base web **710b** and less or equal to 95% by weight of the thermoformable paper base web **710b**.

[0168] Now referring to FIG. 7C, there appears a paper base web embodiment **710c**, which is generally as shown and described by way of reference to the paper base web embodiment **710b** appearing in FIG. 7B, except that the inner polyolefin layer **734o** and optional second tie layer

732o of the polymer layer **738** are omitted. The outer polyolefin layer **726o** is positioned on the exterior side of the barrier layer **730o** to protect the barrier layer **730o** from mechanical stress, punctures, etc. during handling. In addition, omitting the inner polyolefin layer **734o** and optional second tie layer **732o** from the polymer layer **738** decreases the overall polymer content in the base web **710c**, thus increasing the relative proportion of paper content in the base web **710c** and enhancing recyclability within paper recycling streams. In embodiments, the inner and outer paper layers **712**, **716** together represent at least 80% by weight of the paper base web structure **710c** and less than 100% by weight of the paper base web structure **710c** so that the paper base web structure **710c** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 85% by weight of the thermoformable paper base web **710c** and less than 100% by weight of the thermoformable paper base web **710c**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 90% by weight of the thermoformable paper base web **710c** and less than 100% by weight of the thermoformable paper base web **710c**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 95% by weight of the thermoformable paper base web **710c** and less than 100% by weight of the thermoformable paper base web **710c**. In embodiments, the outer and inner paper layers **712**, **716** together comprise at least 80% by weight of the thermoformable paper base web **710c** and less or equal to 95% by weight of the thermoformable paper base web **710c**.

[0169] Now referring to FIG. 8A, there appears a paper base web embodiment **810a**, which is generally as shown and described by way of reference to the paper base web embodiment **710a** appearing in FIG. 7A except that the polymer layer **720** is a coextrusion coated barrier layer **820**. The base web **810a** is advantageously used for the manufacture of thermoformed trays for products that are sensitive to oxygen, moisture, or other gas intrusion. In embodiments, the inner and outer paper layers **812**, **816** together represent at least 80% by weight of the paper base web structure **810a** and less than 100% by weight of the paper base web structure **810a** so that the paper base web structure **810a** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 85% by weight of the thermoformable paper base web **810a** and less than 100% by weight of the thermoformable paper base web **810a**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 90% by weight of the thermoformable paper base web **810a** and less than 100% by weight of the thermoformable paper base web **810a**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 95% by weight of the thermoformable paper base web **810a** and less than 100% by weight of the thermoformable paper base web **810a**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 80% by weight of the thermoformable paper base web **810a** and less or equal to 95% by weight of the thermoformable paper base web **810a**.

[0170] Now referring to FIG. 8B, there appears a paper base web embodiment **810b**, which is generally as shown and described by way of reference to the paper base web embodiment **810a** appearing in FIG. 8A, wherein the polyolefin layer **838** is a barrier coextrusion layer which bonds the outer paper layer **812** to the inner paper layer **816**. The base web **810b** is advantageously used for the manufacture of thermoformed trays for products that are sensitive to oxygen, moisture, or other gas intrusion.

[0171] The base web **810b** includes a paper based extrusion lamination **836** which comprises the outer paper layer **812**, which defines an exterior surface **822** of the paper base web **810b**, and which is extrusion laminated to the inner paper layer **816** via the polyolefin barrier coextrusion layer **838**. The extrusion lamination **836**, in turn, is extrusion coated or coextrusion coated with a barrier polymer layer **820**, as described below.

[0172] The polymer layer **838** comprises a core barrier layer **830o** disposed intermediate an outer polyolefin layer **826o** and an inner polyolefin layer **834o**. Optionally, a first tie layer **828o** is disposed intermediate the outer polyolefin layer **826o** and the core barrier layer **830o** and an optional second tie layer **832o** is disposed intermediate the inner polyolefin layer **834o** and the core barrier layer **830o** to enhance adhesion and compatibility between the layers. The outer polyolefin layer **826o** is positioned on the exterior side of the barrier layer **830o** to protect the barrier layer **830o** from mechanical stress, punctures, etc. during handling.

[0173] The polymer layer **820** comprises a core barrier layer **830i** disposed intermediate an outer polyolefin layer **826i** and an inner polyolefin layer **834i**. Optionally, a first tie layer **828i** is disposed intermediate the outer polyolefin layer **826i** and the core barrier layer **830i** and an optional second tie layer **832i** is disposed intermediate the inner polyolefin layer **834i** and the core barrier layer **830i** to enhance adhesion and compatibility between the layers. In certain embodiments, the polyolefin layers **826o**, **834o**, **826i,** and **834i** comprise polyethylene. In certain embodiments, the barrier layers **830o** and **830i** comprise EVOH.

[0174] In embodiments, the inner and outer paper layers **812**, **816** together represent at least 80% by weight of the paper base web structure **810b** and less than 100% by weight of the paper base web structure **810b** so that the paper base web structure **810b** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 85% by weight of the thermoformable paper base web **810b** and less than 100% by weight of the thermoformable paper base web **810b**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 90% by weight of the thermoformable paper base web **810b** and less than 100% by weight of the thermoformable paper base web **810b**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 95% by weight of the thermoformable paper base web **810b** and less than 100% by weight of the thermoformable paper

base web **810b**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 80% by weight of the thermoformable paper base web **810b** and less or equal to 95% by weight of the thermoformable paper base web **810b**.

[0175] Now referring to FIG. 8C, there appears a paper base web embodiment **810c**, which is generally as shown and described by way of reference to the paper base web embodiment **810b** appearing in FIG. 8B, except that the outer polyolefin layer **826i** and optional first tie layer **828i** of the polymer layer **820** are omitted. Omitting the outer polyolefin layer **826i** and optional first tie layer **828i** from the polymer layer **820** decreases the overall polymer content in the base web **810c**, thus increasing the relative proportion of paper content in the base web **810c** and enhancing recyclability within paper recycling streams. In embodiments, the inner and outer paper layers **812**, **816** together represent at least 80% by weight of the paper base web structure **810c** and less than 100% by weight of the paper base web structure **810c** so that the paper base web structure **810c** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 85% by weight of the thermoformable paper base web **810c** and less than 100% by weight of the thermoformable paper base web **810c**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 90% by weight of the thermoformable paper base web **810c** and less than 100% by weight of the thermoformable paper base web **810c**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 95% by weight of the thermoformable paper base web **810c** and less than 100% by weight of the thermoformable paper base web **810c**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 80% by weight of the thermoformable paper base web **810c** and less or equal to 95% by weight of the thermoformable paper base web **810c**.

[0176] Now referring to FIG. 8D, there appears a paper base web embodiment **810d**, which is generally as shown and described by way of reference to the paper base web embodiment **810b** appearing in FIG. 8B, except that the inner polyolefin layer **834o** and optional second tie layer **832o** of the polymer layer **838** are omitted. The outer polyolefin layer **826o** is positioned on the exterior side of the barrier layer **830o** to protect the barrier layer **830o** from mechanical stress, punctures, etc. during handling. In addition, omitting the inner polyolefin layer **834o** and optional second tie layer **832o** from the polymer layer **838** decreases the overall polymer content in the base web **810d**, thus increasing the relative proportion of paper content in the base web **810d** and enhancing recyclability within paper recycling streams. In embodiments, the inner and outer paper layers **812**, **816** together represent at least 80% by weight of the paper base web structure **810d** and less than 100% by weight of the paper base web structure **810d** so that the paper base web structure **810d** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 85% by weight of the thermoformable paper base

web **810d** and less than 100% by weight of the thermoformable paper base web **810d**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 90% by weight of the thermoformable paper base web **810d** and less than 100% by weight of the thermoformable paper base web **810d**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 95% by weight of the thermoformable paper base web **810d** and less than 100% by weight of the thermoformable paper base web **810d**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 80% by weight of the thermoformable paper base web **810d** and less or equal to 95% by weight of the thermoformable paper base web **810d**.

[0177] Now referring to FIG. 8E, there appears a paper base web embodiment **810e**, which is generally as shown and described by way of reference to the paper base web embodiment **810b** appearing in FIG. 8B, except that the outer polyolefin layer **826i** and optional first tie layer **828i** of the polymer layer **820** are omitted and the inner polyolefin layer **834o** and optional second tie layer **832o** of the polymer layer **838** are omitted. The outer polyolefin layer **826o** is positioned on the exterior side of the barrier layer **830o** to protect the barrier layer **830o** from mechanical stress, punctures, etc. during handling. In addition, omitting the outer polyolefin layer **826i** and optional first tie layer **828i** of the polymer layer **820** and the inner polyolefin layer **834o** and optional second tie layer **832o** of the polymer layer **838** decreases the overall polymer content in the base web **810e**, thus increasing the relative proportion of paper content in the base web **810e** and enhancing recyclability within paper recycling streams. In embodiments, the inner and outer paper layers **812**, **816** together represent at least 80% by weight of the paper base web structure **810e** and less than 100% by weight of the paper base web structure **810e** so that the paper base web structure **810e** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 85% by weight of the thermoformable paper base web **810e** and less than 100% by weight of the thermoformable paper base web **810e**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 90% by weight of the thermoformable paper base web **810e** and less than 100% by weight of the thermoformable paper base web **810e**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 95% by weight of the thermoformable paper base web **810e** and less than 100% by weight of the thermoformable paper base web **810e**. In embodiments, the outer and inner paper layers **812**, **816** together comprise at least 80% by weight of the thermoformable paper base web **810e** and less or equal to 95% by weight of the thermoformable paper base web **810e**.

[0178] The paper base web structures in accordance with this disclosure may optionally include a moisture barrier layer disposed on the exterior-facing surface of the outer paper layer to enhance moisture resistance, especially in embodiments where the paper base web includes a moisture-sensitive gas/oxygen barrier layer, such as EVOH, PVOH, nylon, or the like. The

optional moisture barrier layer serves to protect the gas/oxygen barrier properties of the barrier layer from degradation due to exposure to external moisture or humidity. The optional exterior moisture barrier layer is particularly advantageous, for example, when the gas barrier layer is attached directly to the inner paper layer or outer paper layer and there is no moisture barrier layer in the base web structure disposed exterior to the barrier layer to protect the gas/oxygen barrier from moisture and humidity. FIGS. 9A and 9B illustrate some illustrative embodiments of paper base web structures in accordance with this disclosure employing an exterior moisture barrier layer. It will be recognized, however, that the moisture barrier layer may also be employed with any of the paper base web structures disclosed herein, including the structures shown in FIGS. 1-5, 6A, 6B, 7A-7C, 8A-8D, and others, to achieve improved moisture resistance as desired.

[0179] Referring now to FIG. 9A, there appears a paper base web embodiment **910a**, which is generally as shown and described by way of reference to the paper base web embodiment **710b** appearing in FIG. 7B, wherein the polyolefin layer **726o** and optional tie layer **728o** have been omitted so that a barrier layer **930** is attached directly to the outer paper layer **912**. The polyolefin layer **938** is thus a barrier coextrusion layer which bonds the outer paper layer **912** to the inner paper layer **916**. The base web **910a** is advantageously used for the manufacture of thermoformed trays for products that are sensitive to oxygen, moisture, or other gas intrusion.

[0180] The base web **910a** includes a paper based extrusion lamination **936** which comprises the outer paper layer **912**, which defines an exterior surface **922** of the paper base web **910a**, and which is extrusion laminated to the inner paper layer **916** via the polyolefin barrier coextrusion layer **938**. The extrusion lamination **936**, in turn, is extrusion coated or coextrusion coated with a nonbarrier polymer layer **920**.

[0181] The polymer layer **938** comprises the barrier layer **930** disposed intermediate the outer paper layer **912** and an inner polyolefin layer **934**. Optionally, a tie layer **928** is disposed intermediate the polyolefin layer **926** and the barrier layer **930** to enhance adhesion and compatibility between the layers. The polyolefin layer **934** is positioned on the interior side of the barrier layer **930**. To protect the barrier layer **930** from external moisture and humidity which will degrade is gas barrier properties, a moisture barrier layer **965** is disposed on the exterior side of the outer paper layer **912**.

[0182] In embodiments, the moisture barrier layer **965** comprises a monolayer or multilayer structure comprises any suitable polymer composition with moisture resistance, including homopolymers, copolymers, and polymer blends. In embodiments, the moisture barrier layer **965** comprises a polyolefin polymer. In embodiments, the moisture barrier layer **965** comprises a polyolefin polymer. In embodiments, the moisture barrier layer **965** comprises a polyethylene or polypropylene polymer. In embodiments, the moisture barrier layer **965**

comprises a polyethylene polymer. Exemplary polyolefin polymers include, for example, homopolymers, copolymers, and terpolymers of ethylene, high density polyethylene (HDPE), medium density polyethylene (MDPE), linear medium density polyethylene (LMDPE), low density polyethylene (LDPE), linear low density polyethylene (LLDPE), very low density polyethylene (VLDPE), metallocene linear low-density polyethylene (mLLDPE), and homopolymers, copolymers, and terpolymers of polypropylene. Exemplary polyolefin copolymers include ethylene-vinyl acetate copolymer (EVA), ethylene-methyl acrylate copolymer (EMA), ethylene-methyl acrylate-acrylic acid copolymer (EMAA), SURLYN(TM) or other ionomer resin including ethylene-based ionomer resins and ethylene-methacrylic acid ionomer resins.

[0183] In embodiments, the moisture barrier layer **965** comprises a dried polymer dispersion, wherein the moisture barrier layer is applied as a coating in the form of an aqueous or non-aqueous solvent-based polymer dispersion and then dried. Exemplary solvents include water, ethanol, and isopropanol. Exemplary polymers include polyacrylates, latex, waxes (e.g., animal waxes, vegetable waxes, mineral waxes, and petroleum waxes), polystryenes, and polyolefins (e.g., polyethylenes and polypropylenes). The aqueous or non-aqueous solvent-based polymer dispersion is applied by a suitable coating technique, such as roll coating, roll-to-roll coating, various types of gravure coating, flexographic coating, bar coating, doctor blade coating, comma coating, spraying, or brush coating. The solvent is removed using heat, vacuum, forced hot air, drying oven, or the like.

[0184] In certain embodiments, the nonbarrier polymer layer **920** is a single layer, extruded coating layer. In certain embodiments, the nonbarrier polymer layer **920** is a multilayer, coextruded coating layer. The extrusion coated or coextrusion coated nonbarrier polymer layer **920** may comprise any suitable polymer composition, including homopolymers, copolymers, and polymer blends. When the nonbarrier polymer layer **920** is a multilayer coextrusion coating, each layer within the multilayer structure can be the same or different. In certain embodiments, the nonbarrier polymer layer **920** comprises a polyolefin, preferably polyethylene. In embodiments, the inner and outer paper layers **912**, **916** together represent at least 80% by weight of the paper base web structure **910a** and less than 100% by weight of the paper base web structure **910a** so that the paper base web structure **910a** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **912**, **916** together comprise at least 85% by weight of the thermoformable paper base web **910a** and less than 100% by weight of the thermoformable paper base web **910a**. In embodiments, the outer and inner paper layers **912**, **916** together comprise at least 90% by weight of the thermoformable paper base web **910a** and less than 100% by weight of the thermoformable paper base web **910a**. In embodiments, the outer and inner paper layers

912, **916** together comprise at least 95% by weight of the thermoformable paper base web **910a** and less than 100% by weight of the thermoformable paper base web **910a**. In embodiments, the outer and inner paper layers **912**, **916** together comprise at least 80% by weight of the thermoformable paper base web **910a** and less or equal to 95% by weight of the thermoformable paper base web **910a**.

[0185] Referring now to FIG. 9B, there appears a paper base web embodiment **910b**, which is generally as shown and described by way of reference to the paper base web embodiment **810b** appearing in FIG. 8B, except that the outer polyolefin layer **826o** and the optional first tie layer **828o** are omitted. The paper base web **910b** includes a polyolefin layer **938** which is a barrier coextrusion layer that bonds the outer paper layer **912** to the inner paper layer **916**. The base web **910b** is advantageously used for the manufacture of thermoformed trays for products that are sensitive to oxygen, moisture, or other gas intrusion.

[0186] The base web **910b** includes a paper based extrusion lamination **936** which comprises the outer paper layer **912**, which defines an exterior surface **922** of the paper base web **910b**, and which is extrusion laminated to the inner paper layer **916** via the polyolefin barrier coextrusion layer **938**. The extrusion lamination **936**, in turn, is coextrusion coated with a barrier polymer layer **920**, as described below.

[0187] The polymer layer **938** comprises a barrier layer **930o** disposed intermediate the outer paper layer **912** and an inner polyolefin layer **934o**. Optionally, a tie layer **932o** is disposed intermediate the inner polyolefin layer **934o** and the barrier layer **930o** to enhance adhesion and compatibility between the layers. The inner polyolefin layer **934o** is positioned on the interior side of the barrier layer **930o**. To protect the barrier layer **930o** from external moisture and humidity which will degrade is gas barrier properties, a moisture barrier layer **965** is disposed on the exterior side of the outer paper layer **912**. The moisture barrier layer **965** may be as described above by way of reference to FIG. 9A.

[0188] The polymer layer **920** comprises a core barrier layer **930i** disposed intermediate the inner paper layer **916** and an inner polyolefin layer **934i**. Optionally, a tie layer **932i** is disposed intermediate the inner polyolefin layer **934i** and the barrier layer **930i** to enhance adhesion and compatibility between the layers. In certain embodiments, the polyolefin layers **934o** and **934i** comprise polyethylene. In certain embodiments, the barrier layers **930o** and **930i** comprise EVOH.

[0189] In embodiments, the inner and outer paper layers **912**, **916** together represent at least 80% by weight of the paper base web structure **910b** and less than 100% by weight of the paper base web structure **910b** so that the paper base web structure **910b** is recyclable in paper recycling streams. In embodiments, the outer and inner paper layers **912**, **916** together comprise

at least 85% by weight of the thermoformable paper base web **910b** and less than 100% by weight of the thermoformable paper base web **910b**. In embodiments, the outer and inner paper layers **912**, **916** together comprise at least 90% by weight of the thermoformable paper base web **910b** and less than 100% by weight of the thermoformable paper base web **910b**. In embodiments, the outer and inner paper layers **912**, **916** together comprise at least 95% by weight of the thermoformable paper base web **910b** and less than 100% by weight of the thermoformable paper base web **910b**. In embodiments, the outer and inner paper layers **912**, **916** together comprise at least 80% by weight of the thermoformable paper base web **910b** and less or equal to 95% by weight of the thermoformable paper base web **910b**.

[0190] Now referring to FIG. 10, a flow chart illustrating the steps of an exemplary method **1001** for producing an adhesion lamination embodiment paper base web structure as shown in FIGS. 2-4 is provided. Along the top are the steps of method **1001** in its most basic form: providing inner and outer paper layers (step **1011**); disposing high a first adhesive layer (e.g., comprising a high viscosity and/or high solids content adhesive) between the inner and outer paper layers and laminating the inner and outer paper layers to form a paper adhesive lamination (step **1013**); providing a polymer layer, which may be a single layer or multilayer nonbarrier film or a coextruded barrier film layer (step **1015**) and disposing a second adhesive layer between the paper lamination and the polymer layer and laminating the paper lamination and the polymer layer (step **1017**) to form a paper base web. In embodiments, the resultant paper base web structure is at least 100% paper by weight based on the weight of the paper base web structure.

[0191] In certain embodiments, between providing the inner and outer paper layers at step **1011** and disposing a high viscosity adhesive between the inner and outer paper layers to form a paper lamination at step **1013**, a step **1019** of modifying the surfaces of the inner and/or outer paper layers occurs at a step **1041**. This surface modification may be, non-exclusively, through flame, ozone, corona, or plasma treatment. In embodiments, surfaces of both of the inner and outer paper layers, between which the first adhesive is disposed, are so treated.

[0192] In certain embodiments, between the steps of disposing the first adhesive between the outer and inner paper layers to form a paper lamination at step **1013** and providing the polymer layer at step **1015**, a step **1021** of drying the paper lamination occurs. In certain embodiments, after the step of disposing the second adhesive between the paper lamination and the polymer layer at step **1017**, a step **1023** of drying the resultant laminated paper base web structure occurs.

[0193] Now referring to FIG. 11, a more detailed flow chart illustrating the steps of a method **1101** in accordance with a preferred embodiment is provided. The method **1101** includes a step **1125** of unspooling the inner and outer paper layers. Optionally, one or both of the surfaces of the inner and outer paper layers to be bonded is surface treated to improve adhesion at step

1127. At step **1129**, a first adhesive, e.g., a high viscosity and/or high solids content adhesive, is applied to the inner paper layer.

[0194] In the context of adhesively laminating two webs, it should be understood that the descriptions and examples provided herein are not limited to specific configurations of adhesive application. While certain embodiments may depict adhesive being coated onto a specific web and subsequently bonded to another, this disclosure is intended to encompass a broad spectrum of adhesive application methods. For example, where it is specified that an adhesive is applied to the inner paper web and that the inner web is subsequently bonded to the outer paper web, it will be recognized that this disclosure is additionally intended to encompass application of the adhesive to the outer paper web for subsequent bonding to the inner paper web. Likewise, where it is specified that an adhesive is applied to the polymer web and that the polymer web is subsequently bonded to the paper lamination, it will be recognized that this disclosure is additionally intended to encompass application of the adhesive to the paper lamination for subsequent bonding to the polymer web. Moreover, variations are also contemplated wherein adhesive is applied to both of the facing surfaces of the webs to be laminated to achieve adhesion. Still further variations are contemplated where the order of performing the lamination is varied. For example, where it is disclosed that the inner and outer paper webs are adhesively laminated to form a paper lamination and then the paper lamination is subsequently adhesively laminated to the polymer layer to form the base web, it is also contemplated and this disclosure is intended to encompass variations wherein the inner paper web and the polymer web are first adhesively laminated to form a paper/polymer lamination and then the paper/polymer lamination is subsequently adhesively laminated to the outer paper layer to form the base web. This flexibility in adhesive application is applicable to the examples and embodiments provided throughout this document, allowing for the adaptation of methods and techniques to suit specific requirements and preferences in adhesively laminating the paper and polymer webs.

[0195] With continued reference to FIG. 11, at a step **1131**, the paper layers are bonded to form a resultant paper lamination, e.g., by the application of roller pressure. Optionally, the paper lamination is dried at step **1133**. At step **1135**, the paper lamination is spooled on a roll for subsequent processing. At step **1137**, the paper lamination is unspooled. At step **1139** the polymer layer (i.e., barrier or nonbarrier) is unspooled. At steps **1141** and **1143**, the surfaces of the paper lamination and/or the polymer layer, respectively, are optionally modified to promote adhesion, e.g., via flame, corona, ozone, or plasma treatment. A second adhesive is applied to the polymer layer at step **1145**. The paper lamination and polymer layer are bonded, e.g., through application of roller pressure at step **1147**. Optionally, the resultant paper base web structure is dried at step **1149** and wound up on a finished product roll at step **1151**. These steps may be performed in a

single process. Alternatively, the steps may be performed in two processes where, the first process ends after the step of drying the paper lamination **212** with an additional step of spooling the paper lamination **222**. The second process begins with unspooling the paper lamination **224**. Variations on these processes are further illustrated with respect to FIGS. 12A-12D.

[0196] The step **1125** of unspooling the outer and inner paper layers is a preferred execution of the step of providing outer and inner paper layers. The step **1129** of applying the high viscosity and/or high solids content adhesive to the outer paper layer is a preferred execution of the step of disposing high viscosity and/or high solids content adhesive between the outer and inner paper layers to form a paper lamination. The step **1139** of unspooling the polymer layer is a preferred execution of the step of providing a polymer layer. The step **1145** of applying the adhesive to the polymer layer is a preferred execution of the step of disposing the second adhesive between the paper lamination and the polymer layer.

[0197] Referring now to FIG. 12A, there is shown an exemplary process line suitable for performing a first step of a two-step process for forming the base web structures appearing in FIGS. 2-4. An outer paper layer **1212** is unrolled from a feed roll **1240** and fed toward an adhesive lamination station **1242**. Optionally, on the way to the adhesive lamination station **1242**, the outer paper layer **1212** is fed past a surface treater **1244**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper layer **1212** to improve adhesion.

[0198] An inner paper layer **1216** is unrolled from a feed roll **1246** and fed toward an adhesive coating station **1248**. Optionally, on the way to the adhesive coating station **1248**, the inner paper layer **1216** is fed past a surface treater **1250**. At the adhesive coating station **1248**, an adhesive coating **1214** is applied to the facing surface of the inner paper layer **1216**. In embodiments, the adhesive coating station **1248** comprises a roll coater, spray coater, slot-die coater, gravure coater, flexographic coater, or the like. The coated paper layer **1216** then continues to the adhesive lamination station **1242**.

[0199] At the adhesive lamination station **1242**, the outer paper layer **1212** and the adhesive coated inner paper layer **1216** come together and pass through a series of rollers, e.g., **1252a**, **1252b**, **1252c**, that apply pressure to bond the outer paper layer **1212** and the inner paper layer **1216** together for forming a paper adhesive lamination **1236**. In embodiments, the rollers **1252a**, **1252b**, **1252c** are heated to activate the adhesive and ensure a strong bond. Optionally, the paper adhesive lamination **1236** passes through a dryer **1254**, which may include a plurality of rollers **1256** and may include heating elements, fans, and so forth. The paper adhesive lamination **1236** is then wound onto a wind up roll **1258**.

[0200] Referring now to FIG. 12B, there is shown an exemplary process line suitable for performing a second step of a two-step process for forming the base web structures appearing in

FIGS. 2-4. The paper lamination **1236** is unrolled from the roll **1258** and fed toward an adhesive lamination station **1260**. Optionally, on the way to the adhesive lamination station **1260**, the paper lamination **1236** is fed past a surface treater **1262**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper lamination **1236** to improve adhesion.

[0201] A polymer layer **1220**, which may be a barrier or nonbarrier polymer layer as described above, is unrolled from a feed roll **1264** and fed toward an adhesive coating station **1266**. Optionally, on the way to the adhesive coating station **1266**, the polymer layer **1220** is fed past a surface treater **1268**. At the adhesive coating station **1266**, an adhesive coating **1218** is applied to the facing surface of the polymer layer **1220**. In embodiments, the adhesive coating station **1266** comprises a roll coater, spray coater, slot-die coater, gravure coater, flexographic coater, or the like. The coated paper layer polymer layer **1220** then continues to the adhesive lamination station **1260**.

[0202] At the adhesive lamination station **1260**, the adhesive coated polymer layer **1220** and the paper lamination **1236** come together and pass through a series of rollers, e.g., **1270a**, **1270b**, **1270c**, that apply pressure to bond the paper lamination **1236** and the polymer layer **1220** together for forming a base web **1210**. In embodiments, the rollers **1270a**, **1270b**, **1270c** are heated to activate the adhesive and ensure a strong bond. Optionally, the base web **1210** passes through a dryer **1272**, which may include a plurality of rollers **1274** and may include heating elements, fans, and so forth. The paper web base **1210** is then wound onto a finished product up roll **1276**.

[0203] Referring now to FIG. 12C, there is shown an exemplary process line suitable for performing a one-step process for forming the base web structures appearing in FIGS. 2-4. An outer paper layer **1212** is unrolled from a feed roll **1240** and fed toward an adhesive lamination station **1242**. Optionally, on the way to the adhesive lamination station **1242**, the outer paper layer **1212** is fed past a surface treater **1244**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper layer **1212** to improve adhesion.

[0204] An inner paper layer **1216** is unrolled from a feed roll **1246** and fed toward an adhesive coating station **1248**. Optionally, on the way to the adhesive coating station **1248**, the inner paper layer **1216** is fed past a surface treater **1250a** and/or **1250b**. At the adhesive coating station **1248**, an adhesive coating **1214** is applied to the facing surface of the inner paper layer **1216**. In embodiments, the adhesive coating station **1248** comprises a roll coater, spray coater, slot-die coater, gravure coater, flexographic coater, or the like. The coated paper layer **1216** then continues to the adhesive lamination station **1242**.

[0205] A polymer layer **1220**, which may be a barrier or nonbarrier polymer layer as described above, is unrolled from a feed roll **1264** and fed toward an adhesive coating station

1266. Optionally, on the way to the adhesive coating station **1266**, the polymer layer **1220** is fed past a surface treater **1268**. At the adhesive coating station **1266**, an adhesive coating **1218** is applied to the facing surface of the polymer layer **1220**. In embodiments, the adhesive coating station **1266** comprises a roll coater, spray coater, slot-die coater, gravure coater, flexographic coater, or the like. The coated paper layer polymer layer **1220** then continues to the adhesive lamination station **1260**.

[0206] At the adhesive lamination station **1242**, the outer paper layer **1212**, the adhesive coated inner paper layer **1216**, and the adhesive coated polymer layer **1220** come together and pass through a series of rollers, e.g., **1252a**, **1252b**, **1252c**, that apply pressure to bond the outer paper layer **1212**, the inner paper layer **1216**, and polymer layer **1220** together for forming the web base structure **1210**. In embodiments, the rollers **1252a**, **1252b**, **1252c** are heated to activate the adhesive and ensure a strong bond. Optionally, the web base structure **1210** passes through a dryer **1254**, which may include a plurality of rollers **1256** and may include heating elements, fans, and so forth. The web base structure **1210** is then wound onto a finished product wind up roll **1276**.

[0207] Referring now to FIG. 12D, there is shown an alternative exemplary process line suitable for performing a one-step process for forming the base web structures appearing in FIGS. 2-4. An outer paper layer **1212** is unrolled from a feed roll **1240** and fed toward an adhesive lamination station **1242**. Optionally, on the way to the adhesive lamination station **1242**, the outer paper layer **1212** is fed past a surface treater **1244**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper layer **1212** to improve adhesion.

[0208] An inner paper layer **1216** is unrolled from a feed roll **1246** and fed toward an adhesive coating station **1248**. Optionally, on the way to the adhesive coating station **1248**, the inner paper layer **1216** is fed past a surface treater **1250a** and/or **1250b**. At the adhesive coating station **1248**, an adhesive coating **1214** is applied to the facing surface of the inner paper layer **1216**. In embodiments, the adhesive coating station **1248** comprises a roll coater, spray coater, slot-die coater, gravure coater, flexographic coater, or the like. The coated paper layer **1216** then continues to the adhesive lamination station **1242**.

[0209] At the adhesive lamination station **1242**, the outer paper layer **1212** and the adhesive coated inner paper layer **1216** come together and pass through a series of rollers, e.g., **1252a**, **1252b**, **1252c**, that apply pressure to bond the outer paper layer **1212** and the inner paper layer **1216** together for forming a paper adhesive lamination **1236**. In embodiments, the rollers **1252a**, **1252b**, **1252c** are heated to activate the adhesive and ensure a strong bond. The paper lamination **1236** is fed toward a second adhesive lamination station **1260**. Optionally, on the way to the adhesive lamination station **1260**, the paper lamination **1236** is fed past a surface treater

1262, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper lamination **1236** to improve adhesion.

[0210] A polymer layer **1220**, which may be a barrier or nonbarrier polymer layer as described above, is unrolled from a feed roll **1264** and fed toward an adhesive coating station **1266**. Optionally, on the way to the adhesive coating station **1266**, the polymer layer **1220** is fed past a surface treater **1268**. At the adhesive coating station **1266**, an adhesive coating **1218** is applied to the facing surface of the polymer layer **1220**. In embodiments, the adhesive coating station **1266** comprises a roll coater, spray coater, slot-die coater, gravure coater, flexographic coater, or the like. The coated paper layer polymer layer **1220** then continues to the adhesive lamination station **1260**.

[0211] At the adhesive lamination station **1260**, the adhesive coated polymer layer **1220** and the paper lamination **1236** come together and pass through a series of rollers, e.g., **1270a**, **1270b**, **1270c**, that apply pressure to bond the paper lamination **1236** and the polymer layer **1220** together for forming a base web **1210**. In embodiments, the rollers **1270a**, **1270b**, **1270c** are heated to activate the adhesive and ensure a strong bond. Optionally, the base web **1210** passes through a dryer **1272**, which may include a plurality of rollers **1274** and may include heating elements, fans, and so forth. The paper web base **1210** is then wound onto a finished product up roll **1276**.

[0212] It will be recognized that the process lines appearing in FIGS. 12A-12D are exemplary only and that the order of performing the adhesive lamination step and/or which of the facing surfaces to which the adhesive is applied can be modified.

[0213] Now referring to FIG. 13, a flow chart illustrating the steps of an exemplary method **1301** for producing an extrusion embodiment paper base web structure as illustrated in FIGS. 5-7. The method **1301** include of feeding inner and outer paper layers to an extrusion lamination station at step **1353**. At step **1355**, as the inner and outer paper layers converge, molten polyolefin is extruded to form a continuous melt curtain between the inner and outer paper layers to form a paper extrusion lamination. After lamination, the combined paper layers with the molten polyolefin layer may pass through a cooling station where cool air, one or more chill rollers, or other cooling mechanisms are applied to solidify the molten polyolefin. At step **1357**, the paper extrusion lamination is fed to an extrusion coating station or coextrusion coating station, as the case may be.

[0214] In the case of a monolayer extrusion coating, the polymer layer is applied as an extrusion coating onto the surface of the inner paper layer to form the base web. The base web may be passed to a cooling station for cooling and solidification.

[0215] In the case of a multilayer coextrusion coating, multiple materials, e.g., polyolefin, a barrier resin, tie resins, etc., are extruded simultaneously onto the surface of the inner paper layer. The base web may be passed to a cooling station for cooling and solidification.

[0216] Now referring to FIG. 14A, there is shown an exemplary process line suitable for performing a first step of a two-step process for forming the base web structures appearing in FIGS. 5-7. An outer paper layer **1412** is unrolled from a feed roll **1440** and fed toward an extrusion lamination station **1480**. Optionally, on the way to the extrusion lamination station **1480**, the outer paper layer **1412** is fed past a surface treater **1444**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper layer **1412** to improve adhesion.

[0217] The inner paper layer **1412** is unrolled from a feed roll **1446** and fed toward the extrusion lamination station **1480**. Optionally, on the way to the extrusion lamination station **1480**, the inner paper layer **1416** is fed past a surface treater **1450**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper layer **1412** to improve adhesion.

[0218] The extrusion lamination station **1480** includes a hopper **1482** containing polyolefin, e.g., polyolefin pellets. The hopper **1482** feed the polyolefin into the barrel of an extruder **1484**, which includes heating elements and means for conveying the polyolefin resin through the extruder barrel. Molten polyolefin exits a die **1486** as a uniform curtain of molten polyolefin **1438** at a point just before the paper webs **1412**, **1416** come together at the nip between a pressure roller **1488** and a chill roller **1490**. The resultant paper extrusion lamination **1436** is rolled up onto a take up roll **1458**.

[0219] Now referring to FIG. 14B, there is shown an exemplary process line suitable for performing a second step of a two-step process for forming the base web structures appearing in FIGS. 5-7. The paper extrusion lamination **1436** is unrolled from the feed roll **1458** and fed toward a coextrusion coating station **1492**. Optionally, on the way to the extrusion coating station **1492**, the paper extrusion lamination **1436** is fed past a surface treater **1462**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper extrusion lamination **1436** to improve adhesion.

[0220] The extrusion coating station **1492** includes hoppers **1494a**, **1494b**, and **1494c**, etc., containing the resins to be coextruded, e.g., polyolefin, EVOH, and tie resin in the depicted embodiment. It will be recognized that other coextrusion structures and compositions are contemplated. The hoppers **1494a-1494c** feed the resins into the barrels of respective extruders (not shown). The molten materials from the extruders are combined in a feed block **1496** which arranges the molten resins in the desired layered arrangement and are directed to a coextrusion die **1498**. The molten resins exit the die **1498** as a uniform, layered melt curtain at a point just before

the lamination **1436** enters the nip between a pressure roller **1493** and a chill roller **1495**. The resultant paper web base **1410** is rolled up onto a take up roll **1476**.

[0221] Referring now to FIG. 14C, there is shown an exemplary process line suitable for performing a one-step process for forming the base web structures appearing in FIGS. 5-7. The outer paper layer **1412** is unrolled from a feed roll **1440** and fed toward an extrusion lamination station **1480**. Optionally, on the way to the extrusion lamination station **1480**, the outer paper layer **1412** is fed past a surface treater **1444**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper layer **1412** to improve adhesion.

[0222] The inner paper layer **1412** is unrolled from a feed roll **1446** and fed toward the extrusion lamination station **1480**. Optionally, on the way to the extrusion lamination station **1480**, the inner paper layer **1416** is fed past a surface treater **1450**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper layer **1412** to improve adhesion.

[0223] The extrusion lamination station **1480** includes a hopper **1482** containing polyolefin, e.g., polyolefin pellets. The hopper **1482** feed the polyolefin into the barrel of an extruder **1484**, which includes heating elements and means for conveying the polyolefin resin through the extruder barrel. Molten polyolefin exits a die **1486** as a uniform curtain of molten polyolefin **1438** at a point just before the paper webs **1412**, **1416** come together at the nip between a pressure roller **1488** and a chill roller **1490**.

[0224] The resultant paper extrusion lamination **1436** is fed toward a coextrusion coating station **1492**. Optionally, on the way to the extrusion coating station **1492**, the paper extrusion lamination **1436** is fed past a surface treater **1462**, such as a flame treater, corona treater, plasma treater, or ozone treater that treats the surface of the paper extrusion lamination **1436** to improve adhesion.

[0225] The extrusion coating station **1492** includes hoppers **1494a**, **1494b**, and **1494c**, etc., containing the resins to be coextruded, e.g., polyolefin, EVOH, and tie resin in the depicted embodiment. It will be recognized that other coextrusion structures and compositions are contemplated. The hoppers **1494a-1494c** feed the resins into the barrels of respective extruders (not shown). The molten materials from the extruders are combined in a feed block **1496** which arranges the molten resins in the desired layered arrangement and are directed to a coextrusion die **1498**. The molten resins exit the die **1498** as a uniform, layered melt curtain at a point just before the lamination **1436** enters the nip between a pressure roller **1493** and a chill roller **1495**. The resultant paper web base **1410** is rolled up onto a take up roll **1476**.

[0226] The process line embodiments appearing in FIGS. 14A-14C illustrate a preferred embodiment, wherein the polymer layer **1420** is a coextruded barrier layer. In alternative

embodiments, the polymer layer **1420** may be a monolayer, wherein the coextrusion coater **1492** is replaced with an extrusion coater. In embodiments, the polymer layer **1420** may be a nonbarrier layer, an exemplary embodiment of which appears in FIG. 7A. It will be recognized that other multilayer polymer structures **1420** may be achieved through a single coextrusion process or through successive extrusion lamination, extrusion coating, or other types of coating operations.

[0227] Particular aspects of the disclosure are described below in the following sets of interrelated Clauses:

[0228] Clause 1. A paper base web structure comprising:

[0229] an outer paper layer having a paper external surface and a paper internal surface;

[0230] a first adhesive layer adjacent to said paper internal surface;

[0231] an inner paper layer adjacent to said first adhesive layer;

[0232] a second adhesive layer adjacent to said inner paper layer; and

[0233] a coextruded film layer having a coextrusion external surface and a coextrusion internal surface, wherein said second adhesive layer is adjacent to said coextrusion internal surface;

[0234] wherein said outer and inner paper layers together comprise at least 80% by weight of said paper base web and less than 100% by weight of said paper base web.

[0235] Clause 2. The paper base web of Clause 1, wherein said outer and inner paper layers are comprised of thermoformable paper with greater than 5% stretch.

[0236] Clause 3. The paper base web of Clause 2, wherein said outer and inner paper layers are comprised of thermoformable paper with between 10% and 30% stretch.

[0237] Clause 4. The paper base web of Clause 3, wherein said outer and inner paper layers are comprised of thermoformable paper with between 10% and 20% stretch.

[0238] Clause 5. The paper base web of Clause 4, wherein said outer and inner paper layers are comprised of thermoformable paper with 13% stretch.

[0239] Clause 6. The paper base web of Clause 1, wherein said first adhesive layer is comprised of a high viscosity adhesive.

[0240] Clause 7. The paper base web of Clause 6, wherein said high viscosity adhesive has a centipoise value between 300 cP and 500,000 cP at 50 degrees C.

[0241] Clause 8. The paper base web of Clause 7, wherein said high viscosity adhesive has a centipoise value of 2000.

[0242] Clause 9. The paper base web of Clause 1, wherein said first adhesive layer has a solids content of between 15% and 100% by weight.

[0243] Clause 10. The paper base web of Clause 9, wherein said first adhesive layer has a solids content between 99% and 100% by weight.

[0244] Clause 11. The paper base web of Clause 1, wherein said first and second adhesive layers are solvent-free adhesives.

[0245] Clause 12. The paper base web of Clause 1, wherein said outer and inner paper layers each has a basis weight between 50 GSM and 300 GSM.

[0246] Clause 13. The paper base web of Clause 12, wherein said outer and inner paper layers each has a basis weight of 150 GSM.

[0247] Clause 14. The paper base web of Clause 1, wherein said paper base web has a thickness as measured by a micrometer test method of 327.8 ± 10% GSM.

[0248] Clause 15. The paper base web of Clause 1, wherein said paper base web has an OTR as measured utilizing the ASTM D3895 test method at standard test conditions of 23° C and 0% RH of $\leq$2.2 ± 5% cc/m^2/24 hours.

[0249] Clause 16. The paper base web of Clause 1, wherein said paper base web has a WVTR as measured utilizing the ASTM F1249 test method at standard test conditions of 38° C and 90% RH of $\leq$8.9 ± 5% g/m^2/24 hours.

[0250] Clause 17. The paper base web of Clause 1, wherein the paper base web is thermoformable to a form depth of between 1 mm and 153 mm.

[0251] Clause 18. The paper base web of Clause 17, wherein the paper base web is thermoformable to a form depth of 21 mm or greater.

[0252] Clause 19. The paper base web of Clause 1, wherein said coextruded film layer has a thickness of 27.8 GSM.

[0253] Clause 20. The paper base web of Clause 1, wherein said coextruded film layer comprises at least:

[0254] a first polyolefin layer adjacent to said second adhesive layer;

[0255] a first tie layer;

[0256] an EVOH barrier layer;

[0257] a second tie layer; and

[0258] a second polyolefin layer.

[0259] Clause 21. The paper base web of Clause 20, wherein said first and second polyolefin layers of said coextruded film layer comprise polyethylene.

[0260] Clause 22. A paper base web structure comprising:

[0261] an outer paper layer;

[0262] an extrusion layer;

[0263] an inner paper layer; and

[0264] a coextrusion coating layer;

[0265] wherein said outer and inner paper layers comprise at least 80% by weight of said paper base web and less than 100% by weight of said paper base web.

[0266] Clause 23. The paper base web of Clause 1, wherein said outer and inner paper layers each has a basis weight of 50 GSM to 300 GSM.

[0267] Clause 24. The paper base web of Clause 23, wherein:

[0268] said outer paper layer has a basis weight of 150 GSM; and

[0269] said inner paper layer has a basis weight of 100 GSM.

[0270] Clause 25. The paper base web of Clause 22, wherein said coextrusion coating layer has a coating density of 16 GSM.

[0271] Clause 26. The paper base web of Clause 22, wherein said extrusion layer has a basis weight of 8 GSM.

[0272] Clause 27. The paper base web of Clause 22, wherein said extrusion layer is comprised of polyethylene.

[0273] Clause 28. The paper base web of Clause 22, wherein said coextrusion coating layer comprises at least:

[0274] a first polyolefin layer adjacent to said second adhesive layer;

[0275] a first tie layer;

[0276] an EVOH barrier layer;

[0277] a second tie layer; and

[0278] a second polyolefin layer.

[0279] Clause 29. The paper base web of Clause 28, wherein said first and second polyolefin layers of said coextrusion coating layer comprise polyethylene.

[0280] Clause 30. A method for producing a paper base web structure, said method comprising the steps of:

[0281] providing first and second layers of paper;

[0282] disposing a first adhesive selected from the group consisting of a high viscosity adhesive, a solids content adhesive, or both, between the first and second layers of paper to form a paper lamination;

[0283] providing a coextrusion layer; and

[0284] disposing a second adhesive between the paper lamination and the coextrusion layer;

[0285] wherein:

[0286] said coextrusion layer comprises a first polyethylene layer, a first tie layer, an EVOH barrier, a second tie layer, and a second polyethylene layer; and

[0287] the paper base web formed thereby comprises at least 80% paper by weight.

[0288] Clause 31. The method of Clause 30, further comprising the step of modifying a surface of the first layer of paper before said step of disposing the first adhesive.

[0289] Clause 32. The method of Clause 30, further comprising the step of modifying a surface of the second layer of paper before said step of disposing the first adhesive.

[0290] Clause 33. The method of Clause 31, wherein said step of modifying a surface of the first layer of paper comprises flame treating a surface of the first layer of paper.

[0291] Clause 34. The method of Clause 31, wherein said step of modifying a surface of the first layer of paper comprises ozone treating a surface of the first layer of paper.

[0292] Clause 35. The method of Clause 31, wherein said step of modifying a surface of the first layer of paper comprises corona treating a surface of the first layer of paper.

[0293] Clause 36. The method of Clause 32, wherein said step of modifying a surface of the second layer of paper comprises flame treating a surface of the second layer of paper.

[0294] Clause 37. The method of Clause 32, wherein said step of modifying a surface of the second layer of paper comprises ozone treating a surface of the second layer of paper.

[0295] Clause 38. The method of Clause 32, wherein said step of modifying a surface of the second layer of paper comprises corona treating a surface of the second layer of paper.

[0296] Clause 39. The method of Clause 30, wherein:

[0297] said step of providing a first and second layer of paper is unrolling the first and second layer of paper from first and second spools; and

[0298] said step of disposing the first adhesive between the first and second layers of paper comprises coating one of a group consisting of the first layer of paper, the second layer of paper, and the first and second layers of paper with the first adhesive; and

[0299] said method further comprises, after said step of disposing the first adhesive between the first and second layers of paper, compressing the first and second layers of paper together through a first set of nip rollers.

[0300] Clause 40. The method of Clause 30, further comprising the step of drying the outer and inner paper layers after said step of disposing the first adhesive between the first and second layers of paper.

[0301] Clause 41. The method of Clause 30, further comprising the step of rolling the paper lamination into a third spool after said step of disposing the first adhesive between the first and second layers of paper.

[0302] Clause 42. The method of Clause 30, wherein said step of providing a coextrusion layer comprises unrolling the coextrusion layer from a fourth spool.

[0303] Clause 43. The method of Clause 30, wherein said method further comprises the step of modifying a surface of the paper lamination before said step of disposing the second adhesive between the paper lamination and the coextrusion layer.

[0304] Clause 44. The method of Clause 30, further comprising the step of modifying a surface of the coextrusion layer before said step of disposing the second adhesive between the paper lamination and the coextrusion layer.

[0305] Clause 45. The method of Clause 43, wherein said step of modifying a surface of the paper lamination comprises flame treating a surface of the paper lamination.

[0306] Clause 46. The method of Clause 43, wherein said step of modifying a surface of the paper lamination comprises ozone treating a surface of the paper lamination.

[0307] Clause 47. The method of Clause 43, wherein said step of modifying a surface of the paper lamination comprises corona treating a surface of the paper lamination.

[0308] Clause 48. The method of Clause 44, wherein said step of modifying a surface of the coextrusion layer comprises flame treating a surface of the coextrusion layer.

[0309] Clause 49. The method of Clause 44, wherein said step of modifying a surface of the coextrusion layer comprises ozone treating a surface of the coextrusion layer.

[0310] Clause 50. The method of Clause 44, wherein said step of modifying a surface of the coextrusion layer comprises corona treating a surface of the coextrusion layer.

[0311] Clause 51. The method of Clause 30, wherein:

[0312] said step of disposing the second adhesive between the paper lamination and the coextrusion layer comprises coating one of a group consisting of the paper lamination, the coextrusion layer, and the paper lamination and the coextrusion layer; and

[0313] said method further comprises the step, after said step of disposing the second adhesive between the paper lamination and the coextrusion layer, of compressing the paper lamination and the coextrusion layer together through a second set of nip rollers.

[0314] Clause 52. The method of Clause 30, further comprising the step of drying the paper lamination and the coextrusion layer after said step of disposing the second adhesive between the paper lamination and the coextrusion layer.

[0315] Clause 53. The method of Clause 30, further comprising the step of rolling the paper lamination and the coextrusion layer into a fifth spool after said step of disposing the second adhesive between the paper lamination and the coextrusion layer.

[0316] Clause 54. A method for producing a paper base web structure, said method comprising the steps of:

[0317] providing outer and inner paper layers;

[0318] extrusion laminating the outer and inner paper layers with an extruded polyethylene layer to form a paper lamination;

[0319] chilling the paper lamination;

[0320] coating the inner paper layer of the paper lamination with a polymer coextrusion coating to form the paper base web structure; and

[0321] chilling the paper base web structure.

[0322] Clause 55. The method of Clause 54, wherein said step of extrusion laminating comprises the steps of:

[0323] passing a polyethylene resin through an extruder and through an extrusion die as a melt curtain.

[0324] Clause 56. The method of Clause 54, wherein said step of providing the coextrusion coating comprises the steps of:

[0325] supplying polyethylene, a tie resin, and EVOH to a coextrusion feed block to form a PE-EVOH-PE multilayer coextrusion; and

[0326] bringing the PE-EVOH-PE multilayer coextrusion onto the paper lamination.

[0327] Clause 57 A thermoformable paper base web comprising:

[0328] an outer paper layer having a first surface and a second surface opposite the first surface, wherein the first surface of the outer paper layer defines an exterior-facing surface of the paper base web;

[0329] a first bonding layer directly adjacent to the second surface of the outer paper layer;

[0330] an inner paper layer having a first surface and a second surface opposite the first surface, the first surface of the inner paper layer directly adjacent to the first bonding layer;

[0331] a polymer layer having a first surface and a second surface opposite the first surface, wherein the second surface of the polymer layer defines an interior-facing surface of the paper base web, and wherein the first surface of the polymer layer is attached directly to:

[0332] the second surface of the inner paper layer; or

[0333] a second adhesive layer, wherein the second adhesive layer is attached directly to the second surface of the inner paper layer;

[0334] wherein said outer and inner paper layers together comprise at least 80% by weight of the paper base web and less than 100% by weight of the paper base web.

[0335] Clause 58. The thermoformable paper base web of Clause 57, wherein the polymer layer comprises a barrier film.

[0336] Clause 59. The thermoformable paper base web of Clause 57, wherein the outer paper layer and the inner paper layer, which may be the same or different, each comprise paper having a basis weight in the range of 50 GSM to 300 GSM.

[0337] Clause 60. The thermoformable paper base web of Clause 57, wherein:

[0338] the first surface of the polymer layer is attached directly to the second adhesive layer.

[0339] Clause 61. The thermoformable paper base web of Clause 60, wherein the polymer layer comprises a coextruded film comprising a first polyethylene layer, a second polyethylene layer, and an ethylene-vinyl alcohol copolymer (EVOH) layer disposed intermediate the first and second polyethylene layers.

[0340] Clause 62. The thermoformable paper base web of Clause 60, wherein the first adhesive layer is selected from the group consisting of a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C, a high solids content adhesive having a solids content in the range of 15% to 100% by weight, or both.

[0341] Clause 63. The thermoformable paper base web of Clause 57, wherein the first surface of the polymer layer is attached directly to the second surface of the inner paper layer.

[0342] Clause 64. The thermoformable paper base web of Clause 63, wherein the first adhesive layer is an extruded polyolefin layer bonding the second surface of the outer paper layer to the first surface of the inner paper layer.

[0343] Clause 65. The thermoformable paper base web of Clause 63, wherein the polymer layer comprises a barrier layer.

[0344] Clause 66. The thermoformable paper base web of Clause 63, wherein the polymer layer comprises a coextrusion coating comprising a first polyethylene layer, a second polyethylene layer, and an ethylene-vinyl alcohol copolymer (EVOH) layer disposed intermediate the first and second polyethylene layers.

[0345] Clause 67. The thermoformable paper base web of Clause 57, wherein the paper base web is thermoformable to a depth of between 1 mm to 153 mm.

[0346] Clause 68. A method for producing a paper base web, comprising:

[0347] laminating an outer paper layer to an inner paper layer with a first adhesive layer, the outer paper layer having a first surface and a second surface opposite the first surface, wherein the first surface of the outer paper layer defines an exterior-facing surface of the paper base web, and wherein the first adhesive layer is directly adjacent to the second surface of the outer paper layer;

[0348] the inner paper having a first surface and a second surface opposite the first surface, the first surface of the inner paper layer directly adjacent to the first adhesive layer;

[0349] attaching a polymer layer to the second surface of the inner paper layer, the polymer layer having a first surface and a second surface opposite the first surface, wherein the

second surface of the polymer layer defines an interior-facing surface of the paper base web, and wherein the first surface of the polymer layer is attached directly to:

[0350] the second surface of the inner paper layer; or

[0351] a second adhesive layer, wherein the second adhesive layer is attached directly to the second surface of the inner paper layer;

[0352] wherein said outer and inner paper layers together comprise at least 80% by weight of the paper base web and less than 100% by weight of the paper base web.

[0353] Clause 69. The method of Clause 68, wherein the polymer layer comprises a barrier film.

[0354] Clause 70. The method of Clause 68, wherein the outer paper layer and the inner paper layer, which may be the same of different, each comprise paper having a basis weight in the range of 50 GSM to 300 GSM.

[0355] Clause 71. The method of Clause 68, wherein the step of attaching the polymer layer to the second surface of the inner paper layer comprises adhesively laminating the first surface of the polymer layer to the second surface of the inner paper layer.

[0356] Clause 72. The method of Clause 71, wherein the polymer layer comprises a coextruded film comprising a first polyethylene layer, a second polyethylene layer, and an ethylene-vinyl alcohol copolymer (EVOH) layer disposed intermediate the first and second polyethylene layers.

[0357] Clause 73. The method of Clause 71, wherein the first adhesive layer is selected from the group consisting of a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C, a high solids content adhesive having a solids content in the range of 15% to 100% by weight, or both.

[0358] Clause 74. The method of Clause 68, wherein the first surface of the polymer layer is attached directly to the second surface of the inner paper layer.

[0359] Clause 75. The method of Clause 74, wherein the first adhesive layer is an extruded polyolefin layer bonding the second surface of the outer paper layer to the first surface of the inner paper layer and wherein the step of laminating an outer paper layer to an inner paper layer is performed by extrusion lamination.

[0360] Clause 76. The method of Clause 74, wherein the polymer layer is attached directly to the second surface of the inner paper layer by extrusion coating or coextrusion coating.

[0361] Clause 77. The method of Clause 76, wherein the polymer layer is attached directly to the second surface of the inner paper layer by coextrusion coating a first polyethylene layer, a second polyethylene layer, and an ethylene-vinyl alcohol copolymer (EVOH) layer disposed intermediate the first and second polyethylene layers.

[0362] Clause 78. The method of Clause 68, further comprising modifying one or more of the second surface of the outer paper layer, the first surface of the inner paper layer, the second surface of the inner paper layer, and the inner surface of the polymer layer with a surface treatment selected from the group consisting of flame treatment, corona treatment, ozone treatment, and plasma treatment.

[0363] Clause 79. A thermoformed packaging article formed from the paper base web or method of any of the preceding Clauses.

[0364] The invention has been described with reference to the preferred embodiment. Modifications and alterations will occur to others upon a reading and understanding of the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

CLAIMS

What is claimed is:

1. A thermoformable paper base web, comprising:

an outer paper layer having a first surface and a second surface opposite the first surface, wherein the first surface of the outer paper layer defines an exterior-facing surface of the paper base web;

an inner paper layer having a first surface and a second surface opposite the first surface, the first surface of the inner paper layer laminated to the second surface of the outer paper layer;

a first bonding layer between the outer paper layer and inner paper layer, the first bonding layer joining the second surface of the outer paper layer to the first surface of the inner paper layer;

a polymer layer having a first surface and a second surface opposite the first surface, wherein the second surface of the polymer layer defines an interior-facing surface of the paper base web, and wherein the first surface of the polymer layer is joined to the second surface of the inner paper layer; and

said outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

2. The thermoformable paper base web of claim 1, wherein the first bonding layer is attached directly to the second surface of the outer paper layer and the first surface of the inner paper layer.

3. The thermoformable paper base web of claim 1, wherein the first bonding layer is selected from the group consisting of an adhesive layer and an extruded resin layer.

4. The thermoformable paper base web of claim 1, wherein the polymer layer is selected from the group consisting of monolayer film and a multilayer film.

5. The thermoformable paper base web of claim 1, wherein the polymer layer is attached directly to the second surface of the inner paper layer.

6. The thermoformable paper base web of claim 1, further comprising:

a second bonding layer between the inner paper layer and the polymer layer, the second bonding layer joining the second surface of the inner paper layer to the first surface of the polymer layer.

7. The thermoformable paper base web of claim 6, wherein the second bonding layer is attached directly to the second surface of the inner paper layer and the first surface of the polymer layer.

8. The thermoformable paper base web of claim 6, wherein the second bonding layer is an adhesive layer and the inner paper layer is laminated with the polymer layer via the adhesive layer.

9. The thermoformable paper base web of claim 1, wherein the polymer layer is selected from the group consisting of a barrier film layer and a nonbarrier film layer.

10. The thermoformable paper base web of claim 1, wherein the outer paper layer and the inner paper layer, which may be the same or different, each comprise paper having a basis weight in the range of 50 GSM to 300 GSM.

11. The thermoformable paper base web of claim 1, wherein the polymer layer is selected from the group consisting of:

a first coextruded film comprising a first polyolefin layer, a second polyolefin layer, and a first barrier layer disposed intermediate the first and second polyolefin layers, wherein the first barrier layer is formed of a material selected from the group consisting of ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene di-chloride (PVcD), polyamide, and polyvinyl alcohol (PVOH); and

a second coextruded film comprising a second barrier layer having a barrier outer surface coupled to the second surface of the inner paper layer and a barrier inner surface opposite the barrier outer surface, and a third polyolefin layer coupled to the barrier inner surface.

12. The thermoformable paper base web of claim 11, wherein the first and second barrier layers comprise EVOH and the first, second, and third polyolefin layers, which may be the same or different, comprise a polyethylene-based polymer.

13. The thermoformable paper base web of claim 11, wherein the first bonding layer is selected from the group consisting of:

an adhesive layer formed of an adhesive selected from the group consisting of a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C;

a high solids content adhesive having a solids content in the range of 15% to 100% by weight; and

an extruded polyolefin resin layer.

14. The thermoformable paper base web of claim 11, wherein the first bonding layer is selected from the group consisting of:

a third coextruded film comprising a fourth polyolefin layer, a fifth polyolefin layer, and a third barrier layer disposed intermediate the fourth and fifth polyolefin layers, wherein the third barrier layer is formed of a material selected from the group consisting of ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene di-chloride (PVcD), polyamide, and polyvinyl alcohol (PVOH); and

a fourth coextruded film comprising a fourth barrier layer having a barrier inner surface coupled to the first surface of the inner paper layer and a barrier outer surface opposite the barrier inner surface, and a sixth polyolefin layer coupled to the barrier outer surface and the second surface of the outer paper layer.

15. The thermoformable paper base web of claim 14, wherein the third and fourth barrier layers comprise EVOH and the fourth, fifth, and sixth polyolefin layers, which may be the same or different, comprise a polyethylene-based polymer.

16. The thermoformable paper base web of claim 1, wherein the paper base web is thermoformable to a depth of between 1 mm to 153 mm.

17. The thermoformable paper base web of claim 1, wherein said outer and inner paper layers together comprise at least 85% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

18. The thermoformable paper base web of claim 1, wherein said outer and inner paper layers together comprise at least 90% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

19. The thermoformable paper base web of claim 1, wherein said outer and inner paper layers together comprise at least 95% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

20. A method for producing a thermoformable paper base web, comprising:

laminating an outer paper layer to an inner paper layer with a first bonding layer therebetween, the outer paper layer having a first surface and a second surface opposite the first surface, wherein the first surface of the outer paper layer defines an exterior-facing surface of the paper base web;

the inner paper layer having a first surface and a second surface opposite the first surface, the first surface of the inner paper layer facing second surface of the outer paper layer; and

attaching a polymer layer to the second surface of the inner paper layer, the polymer layer having a first surface and a second surface opposite the first surface, wherein the first surface of the polymer layer is joined to the second surface of the inner paper layer and the second surface of the polymer layer defines an interior-facing surface of the paper base web;

wherein the outer and inner paper layers together comprise at least 80% by weight of the thermoformable paper base web and less than 100% by weight of the thermoformable paper base web.

21. The method of claim 20, wherein the first bonding layer is attached directly to the second surface of the outer paper layer and the first surface of the inner paper layer.

22. The method of claim 20, wherein the first bonding layer is selected from the group consisting of an adhesive layer and an extruded resin layer.

23. The method of claim 20, wherein the first bonding layer is selected from the group consisting of:

a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C;

a high solids content adhesive having a solids content in the range of 15% to 100% by weight; and

an extruded polyolefin resin layer.

24. The method of claim 23, wherein the step of attaching the polymer layer to the second surface of the inner paper layer is performed by a process selected from the group consisting of adhesive lamination and extrusion lamination.

25. The method of claim 20, wherein the step of attaching the polymer layer to the second surface of the inner paper layer includes applying a second bonding layer between the inner paper layer and the polymer layer, the second bonding layer joining the second surface of the inner paper layer to the first surface of the polymer layer.

26. The method of claim 25, wherein the second bonding layer is selected from the group consisting of an adhesive layer and an extruded resin layer.

27. The method of claim 25, wherein the second bonding layer is selected from the group consisting of:

a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C;

a high solids content adhesive having a solids content in the range of 15% to 100% by weight; and

an extruded polyolefin resin layer.

28. The method of claim 26 wherein the second bonding layer is attached directly to the second surface of the inner paper layer and the first surface of the polymer layer.

29. The method of claim 28 wherein the polymer layer is applied to the second surface of the inner paper layer using a method selected from the group consisting of an extrusion coating process and a coextrusion coating process.

30. The method of claim 20, wherein the polymer layer is selected from the group consisting of monolayer film and a multilayer film.

31. The method of claim 20, wherein the polymer layer is selected from the group consisting of a barrier film layer and a nonbarrier film layer.

32. The method of claim 20, wherein the polymer layer is selected from the group consisting of a barrier film layer and a nonbarrier film layer.

33. The method of claim 20, wherein the polymer layer is selected from the group consisting of:

a first coextruded film comprising a first polyolefin layer, a second polyolefin layer, and a first barrier layer disposed intermediate the first and second polyolefin layers, wherein the first barrier layer is formed of a material selected from the group consisting of ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene di-chloride (PVcD), polyamide, and polyvinyl alcohol (PVOH); and

a second coextruded film comprising a second barrier layer having a barrier outer surface coupled to the second surface of the inner paper layer and a barrier inner surface opposite the barrier outer surface, and a third polyolefin layer coupled to the barrier inner surface.

34. The method of claim 33, wherein the first and second barrier layers comprise EVOH and the first, second, and third polyolefin layers, which may be the same or different, comprise a polyethylene-based polymer.

35. The method of claim 33, wherein the first bonding layer is selected from the group consisting of:

an adhesive layer formed of an adhesive selected from the group consisting of a high viscosity adhesive having a viscosity in the range of 300 cP to 500,000 cP at 50 degrees C;

a high solids content adhesive having a solids content in the range of 15% to 100% by weight; and

an extruded polyolefin resin layer.

36. The method of claim 33, wherein the first bonding layer is selected from the group consisting of:

a third coextruded film comprising a fourth polyolefin layer, a fifth polyolefin layer, and a third barrier layer disposed intermediate the fourth and fifth polyolefin layers, wherein the third barrier layer is formed of a material selected from the group consisting of ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene di-chloride (PVcD), polyamide, and polyvinyl alcohol (PVOH); and

a fourth coextruded film comprising a fourth barrier layer having a barrier inner surface coupled to the first surface of the inner paper layer and a barrier outer surface opposite the barrier inner surface, and a sixth polyolefin layer coupled to the barrier outer surface and the second surface of the outer paper layer.

37. The method of claim 36, wherein the third and fourth barrier layers comprise EVOH and the fourth, fifth, and sixth polyolefin layers, which may be the same or different, comprise a polyethylene-based polymer.

38. The method of claim 20, further comprising modifying one or more of the second surface of the outer paper layer, the first surface of the inner paper layer, the second surface of the inner paper layer, and the inner surface of the polymer layer with a surface treatment selected from the group consisting of flame treatment, corona treatment, ozone treatment, and plasma treatment.

39. A thermoformed packaging article formed from the thermoformable paper base web of claim 1.

40. A thermoformed packaging article formed by the method of claim 20.

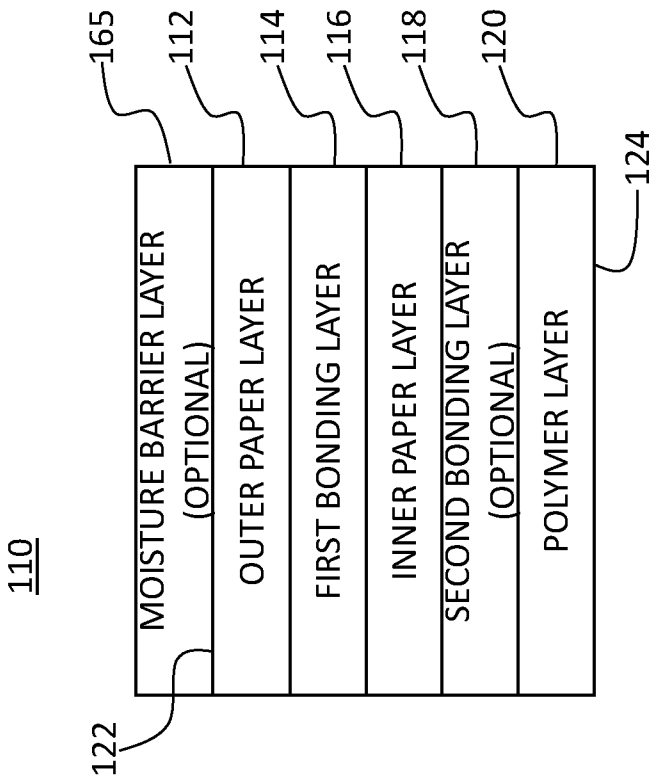

110
MOISTURE BARRIER LAYER (OPTIONAL)
OUTER PAPER LAYER
FIRST BONDING LAYER
INNER PAPER LAYER
SECOND BONDING LAYER (OPTIONAL)
POLYMER LAYER
165
112
114
116
118
120
122
124

FIG. 1

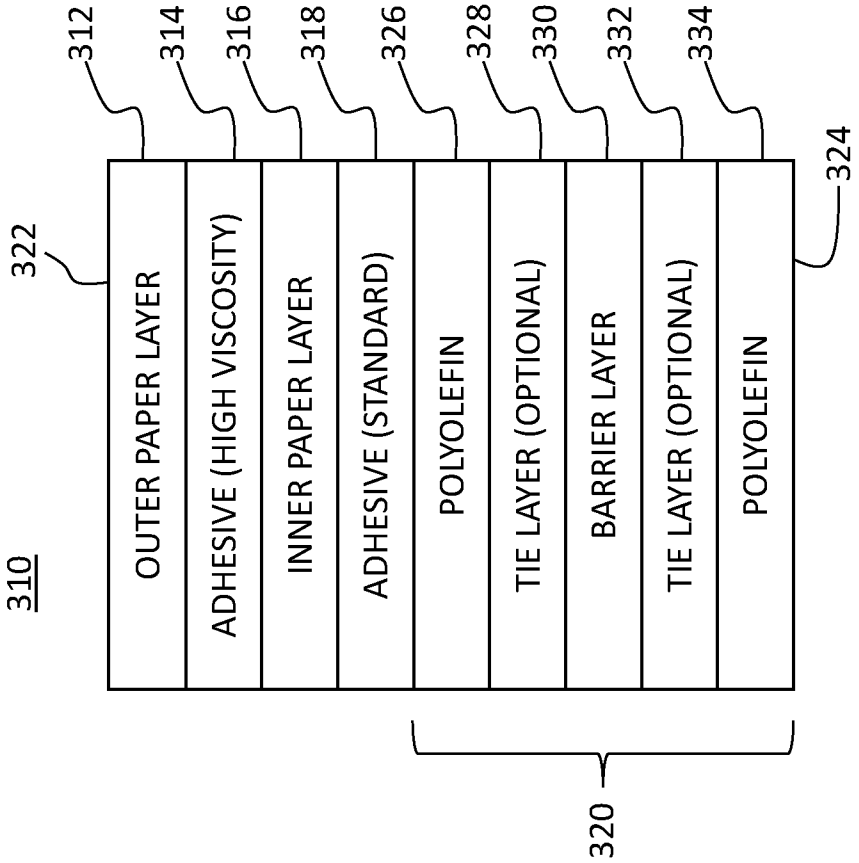

310
322
312
314
316
318
326
328
330
332
334
324
OUTER PAPER LAYER
ADHESIVE (HIGH VISCOSITY)
INNER PAPER LAYER
ADHESIVE (STANDARD)
POLYOLEFIN
TIE LAYER (OPTIONAL)
BARRIER LAYER
TIE LAYER (OPTIONAL)
POLYOLEFIN
320

FIG. 3

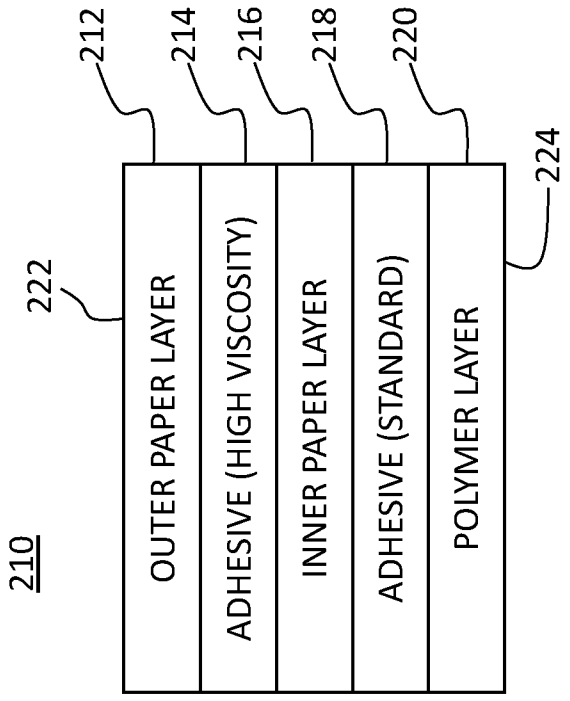

210
222
212
214
216
218
220
224
OUTER PAPER LAYER
ADHESIVE (HIGH VISCOSITY)
INNER PAPER LAYER
ADHESIVE (STANDARD)
POLYMER LAYER

FIG. 2

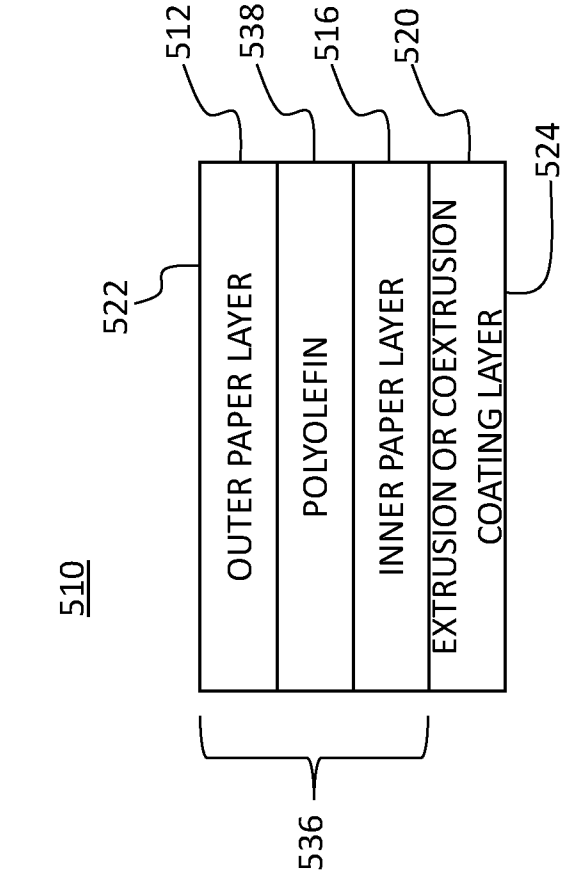

512
538
516
520
522
OUTER PAPER LAYER
POLYOLEFIN
INNER PAPER LAYER
EXTRUSION OR COEXTRUSION COATING LAYER
524
510
536

FIG. 5

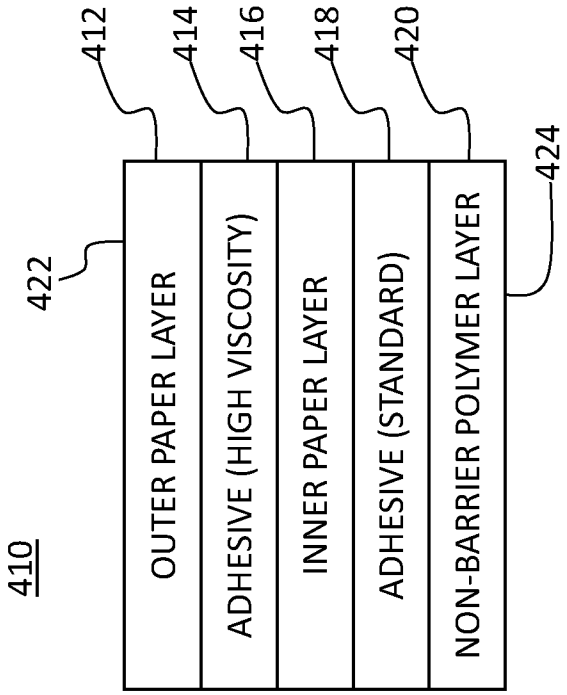

412
414
416
418
420
422
OUTER PAPER LAYER
ADHESIVE (HIGH VISCOSITY)
INNER PAPER LAYER
ADHESIVE (STANDARD)
NON-BARRIER POLYMER LAYER
424
410

FIG. 4

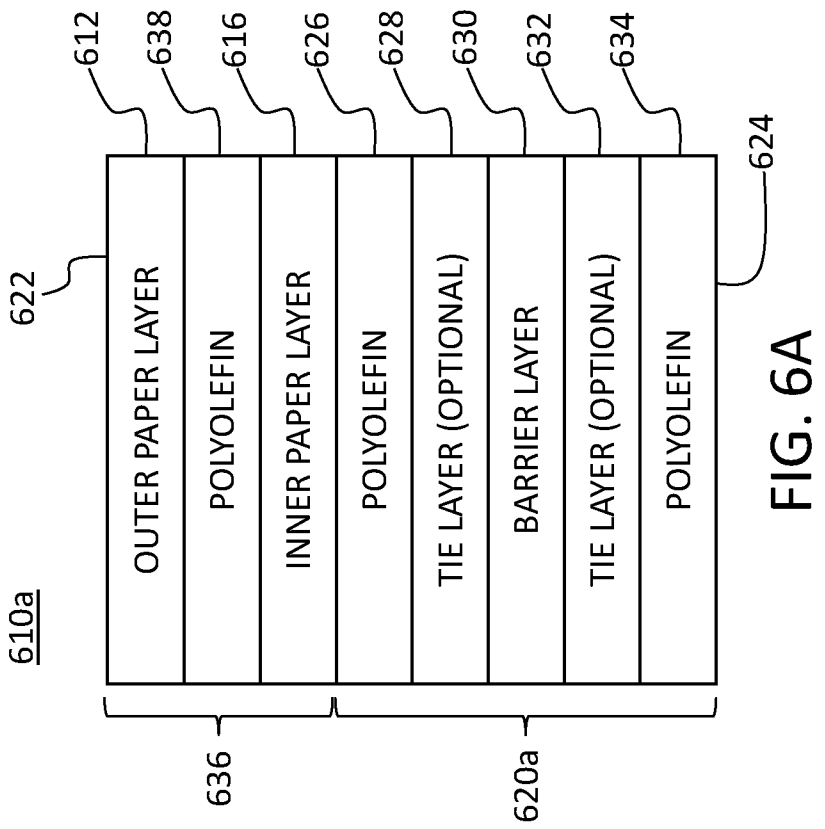

610a
622
612
638
616
626
628
630
632
634
624
OUTER PAPER LAYER
POLYOLEFIN
INNER PAPER LAYER
POLYOLEFIN
TIE LAYER (OPTIONAL)
BARRIER LAYER
TIE LAYER (OPTIONAL)
POLYOLEFIN
636
620a

FIG. 6A

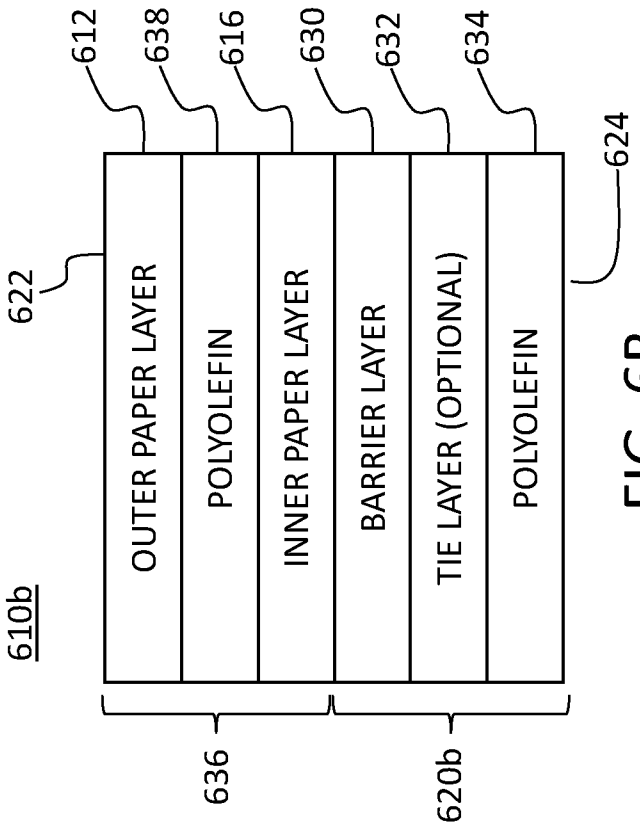

610b
622
612
638
616
630
632
634
624
OUTER PAPER LAYER
POLYOLEFIN
INNER PAPER LAYER
BARRIER LAYER
TIE LAYER (OPTIONAL)
POLYOLEFIN
636
620b

FIG. 6B

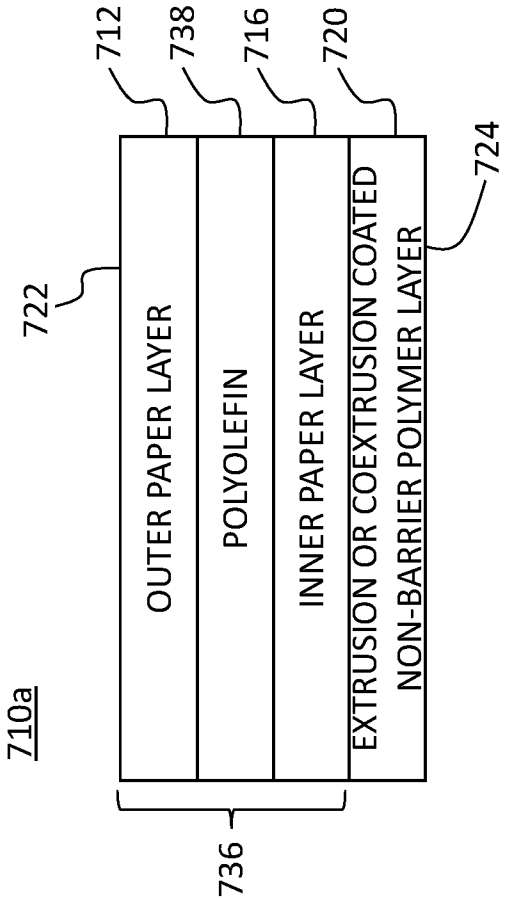

712
738
716
720
724
722
OUTER PAPER LAYER
POLYOLEFIN
INNER PAPER LAYER
EXTRUSION OR COEXTRUSION COATED
NON-BARRIER POLYMER LAYER
710a
736

FIG. 7A

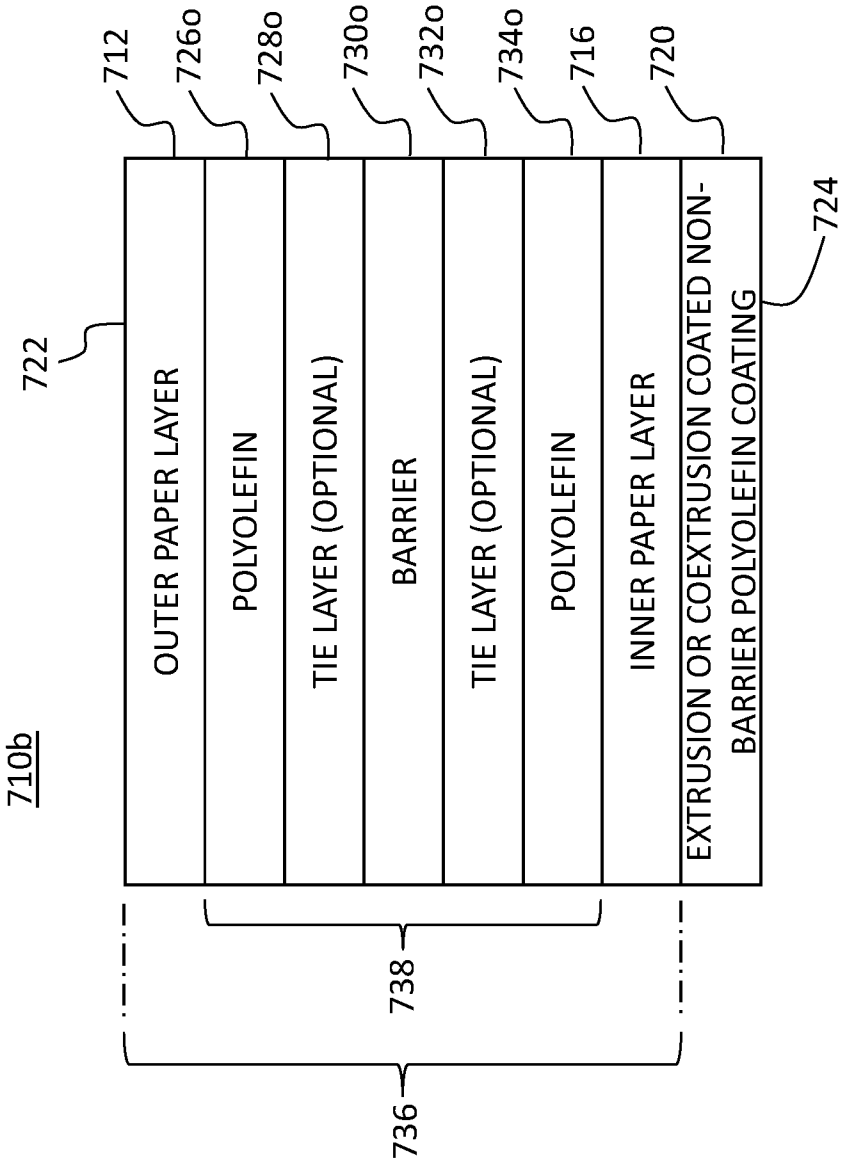

710b
722
712
726o
728o
730o
732o
734o
716
720
724
OUTER PAPER LAYER
POLYOLEFIN
TIE LAYER (OPTIONAL)
BARRIER
TIE LAYER (OPTIONAL)
POLYOLEFIN
INNER PAPER LAYER
EXTRUSION OR COEXTRUSION COATED NON-BARRIER POLYOLEFIN COATING
738
736

FIG. 7B

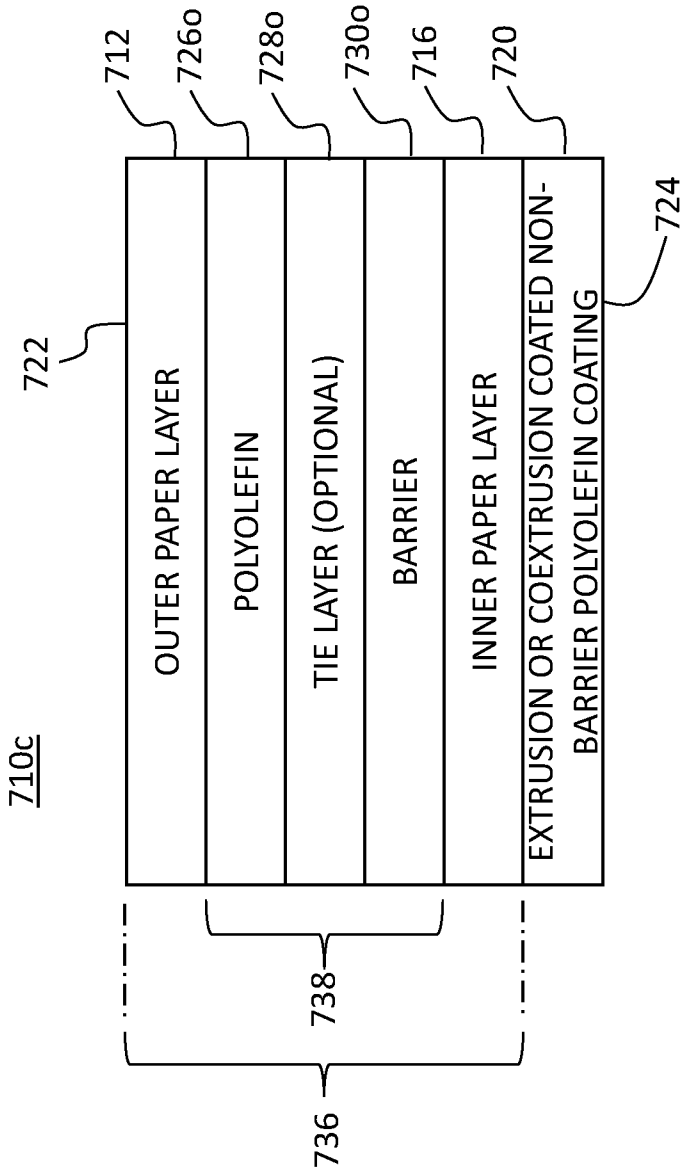

710c
722
712
726o
728o
730o
716
720
724
OUTER PAPER LAYER
POLYOLEFIN
TIE LAYER (OPTIONAL)
BARRIER
INNER PAPER LAYER
EXTRUSION OR COEXTRUSION COATED NON-BARRIER POLYOLEFIN COATING
738
736

FIG. 7C

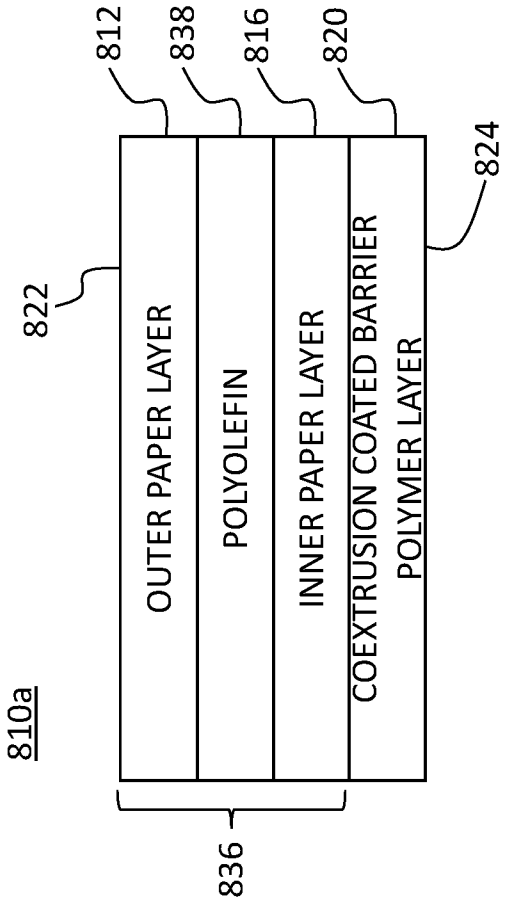

812
838
816
820
824
822
OUTER PAPER LAYER
POLYOLEFIN
INNER PAPER LAYER
COEXTRUSION COATED BARRIER
POLYMER LAYER
810a
836

FIG. 8A

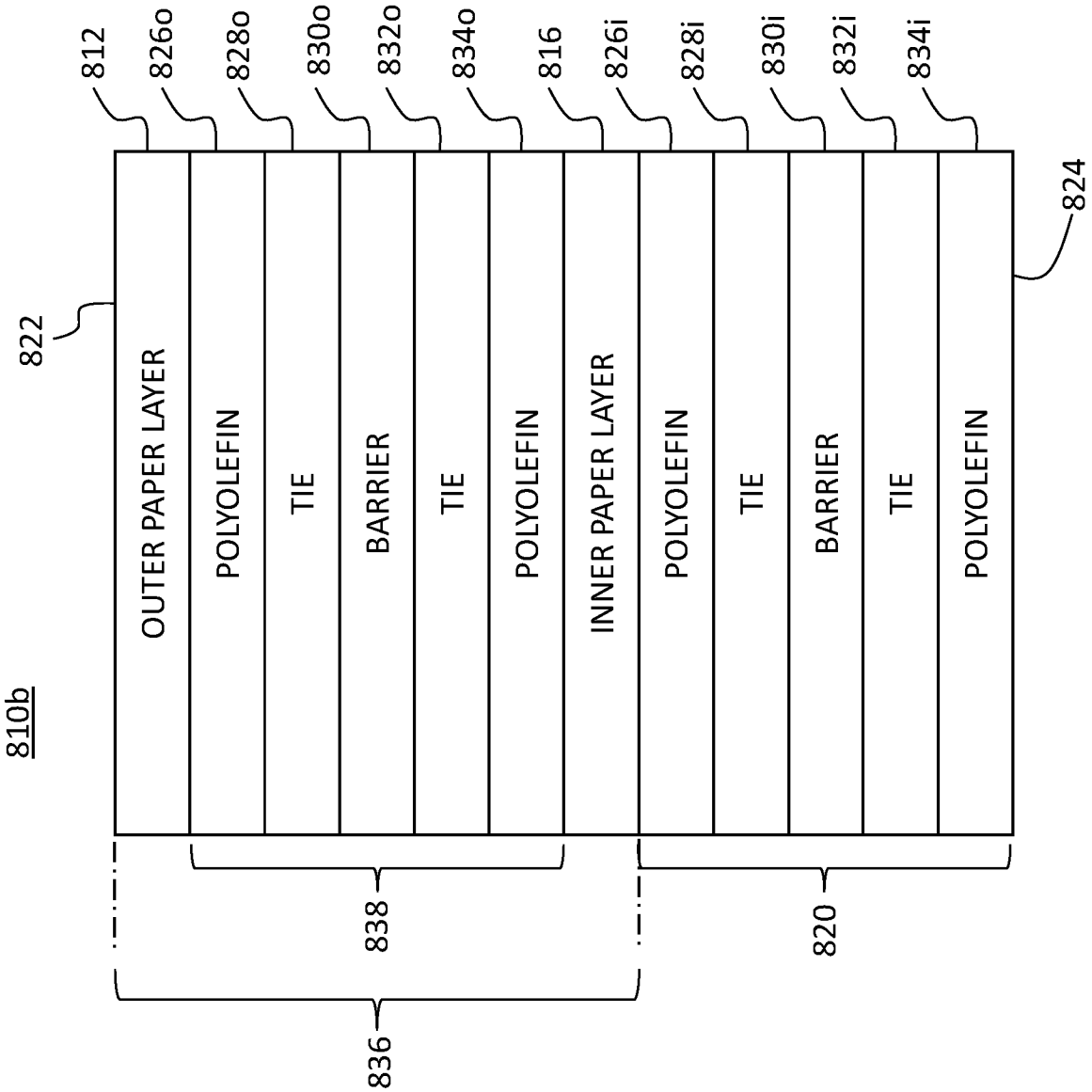

810b
822
812
826o
828o
830o
832o
834o
816
826i
828i
830i
832i
834i
824
OUTER PAPER LAYER
POLYOLEFIN
TIE
BARRIER
TIE
POLYOLEFIN
INNER PAPER LAYER
POLYOLEFIN
TIE
BARRIER
TIE
POLYOLEFIN
838
820
836

FIG. 8B

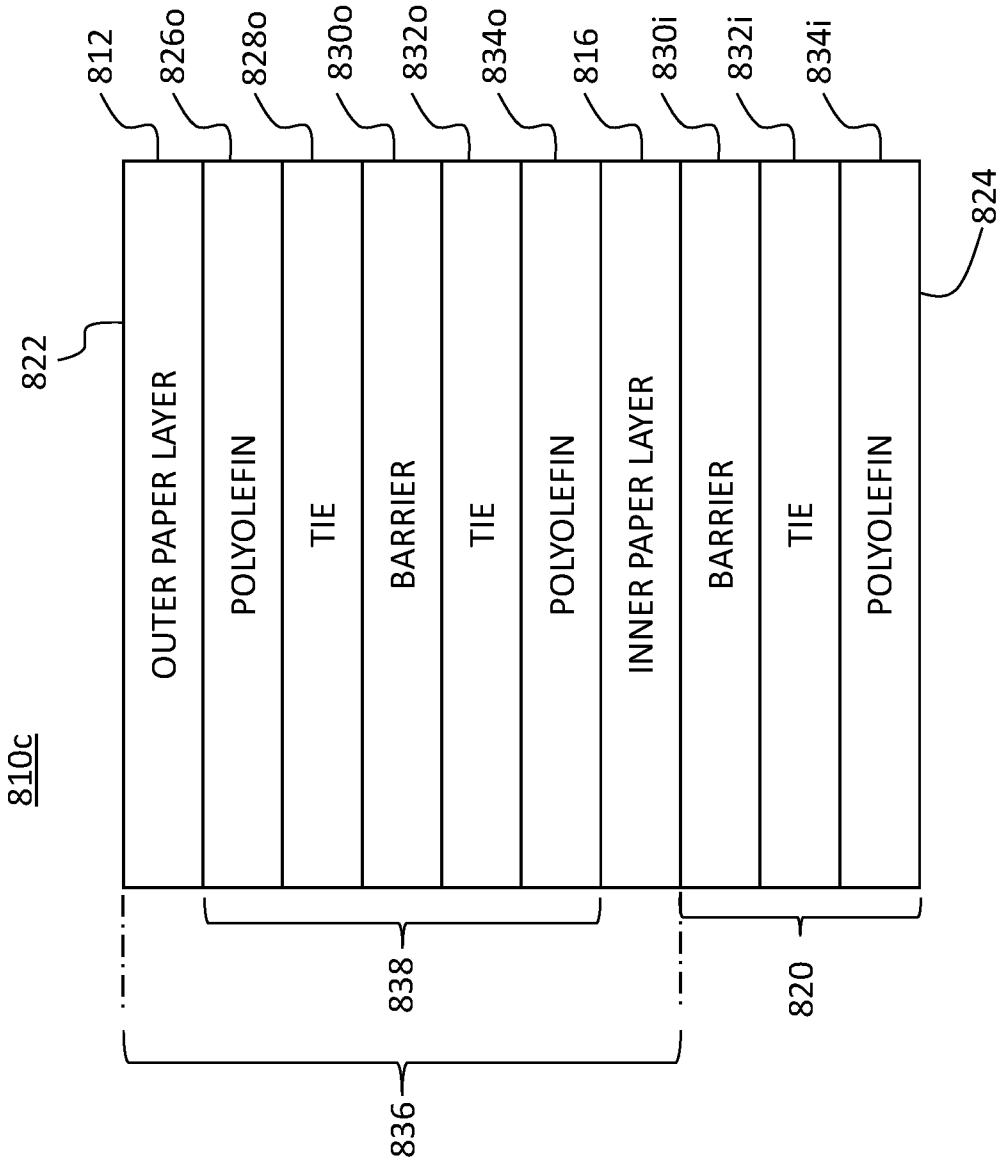

810c
822
812
826o
828o
830o
832o
834o
816
830i
832i
834i
824
OUTER PAPER LAYER
POLYOLEFIN
TIE
BARRIER
TIE
POLYOLEFIN
INNER PAPER LAYER
BARRIER
TIE
POLYOLEFIN
838
820
836

FIG. 8C

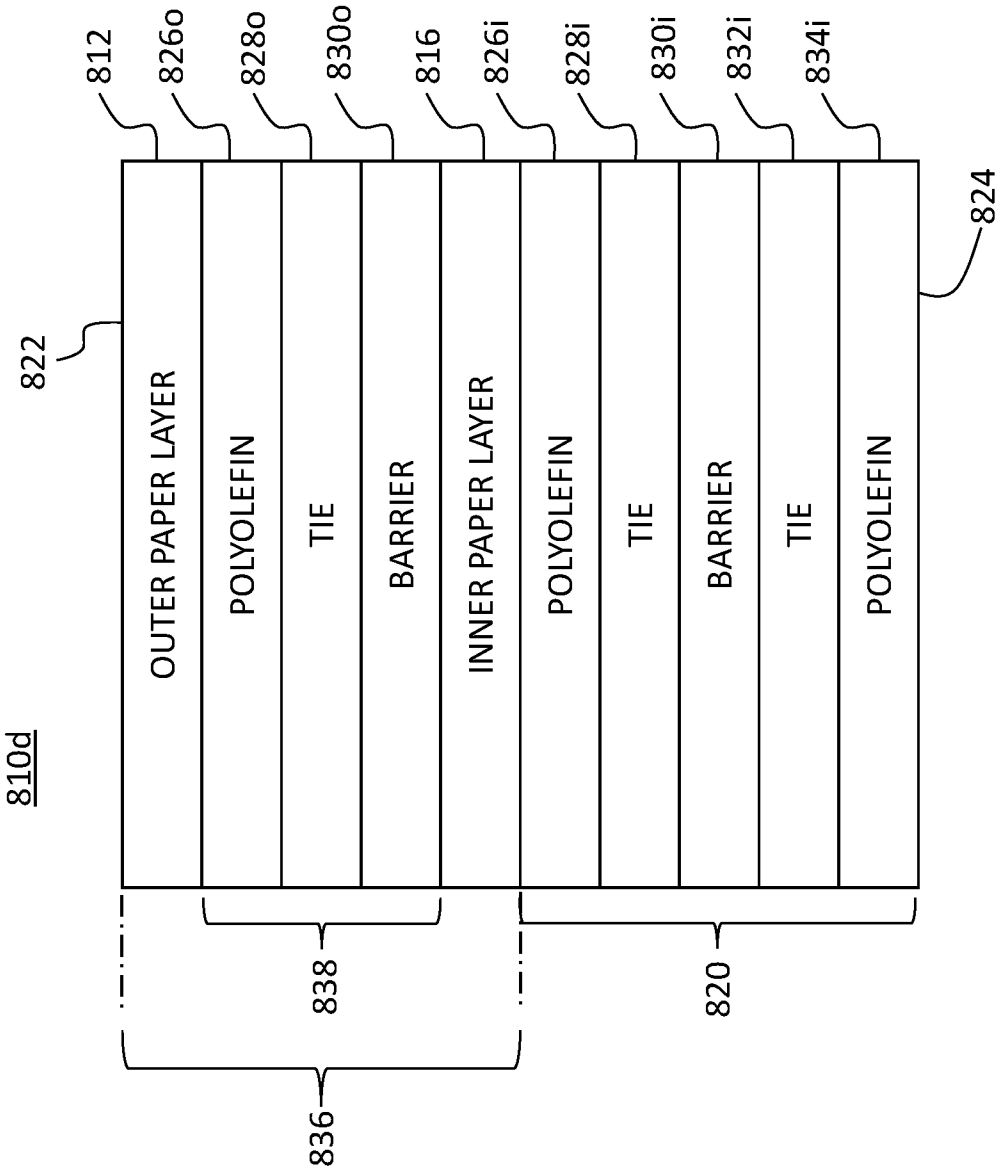

810d
822
812
826o
828o
830o
816
826i
828i
830i
832i
834i
824
OUTER PAPER LAYER
POLYOLEFIN
TIE
BARRIER
INNER PAPER LAYER
POLYOLEFIN
TIE
BARRIER
TIE
POLYOLEFIN
838
820
836

FIG. 8D

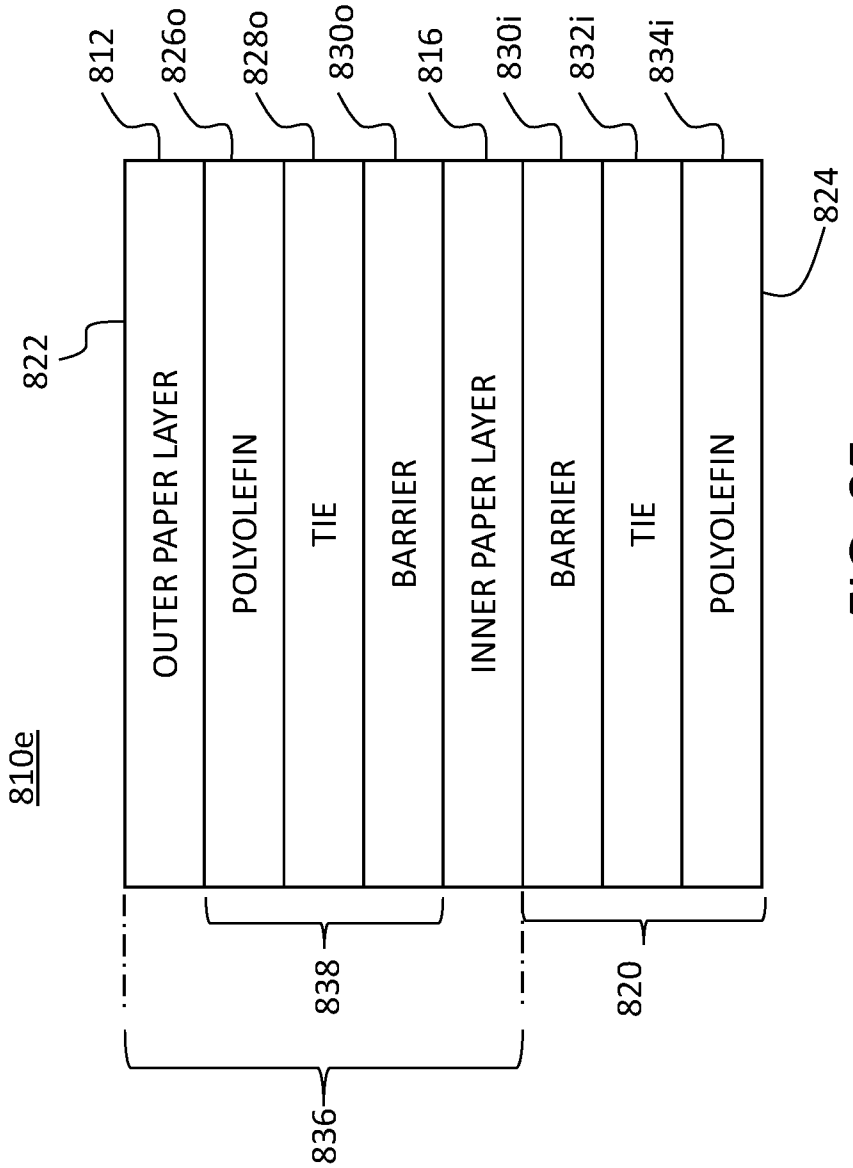

810e
822
812
826o
828o
830o
816
830i
832i
834i
824
OUTER PAPER LAYER
POLYOLEFIN
TIE
BARRIER
INNER PAPER LAYER
BARRIER
TIE
POLYOLEFIN
838
820
836

FIG. 8E

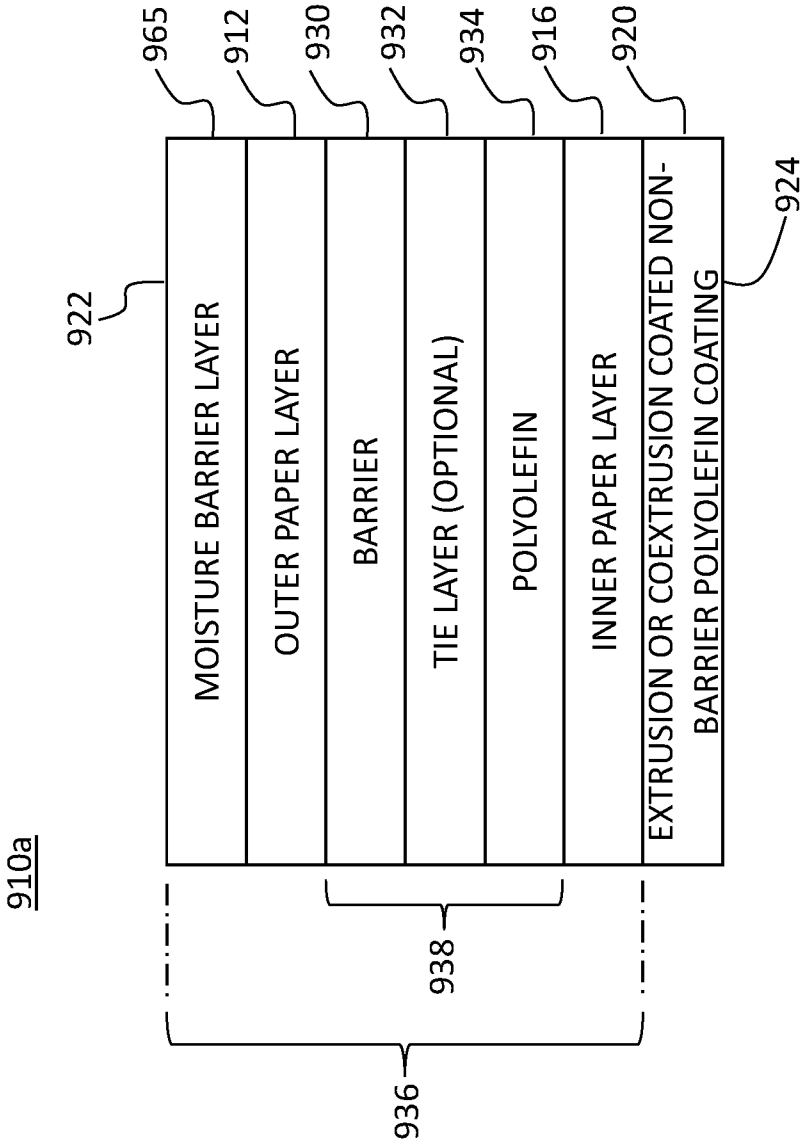

910a
922
965
912
930
932
934
916
920
924
MOISTURE BARRIER LAYER
OUTER PAPER LAYER
BARRIER
TIE LAYER (OPTIONAL)
POLYOLEFIN
INNER PAPER LAYER
EXTRUSION OR COEXTRUSION COATED NON-BARRIER POLYOLEFIN COATING
938
936

FIG. 9A

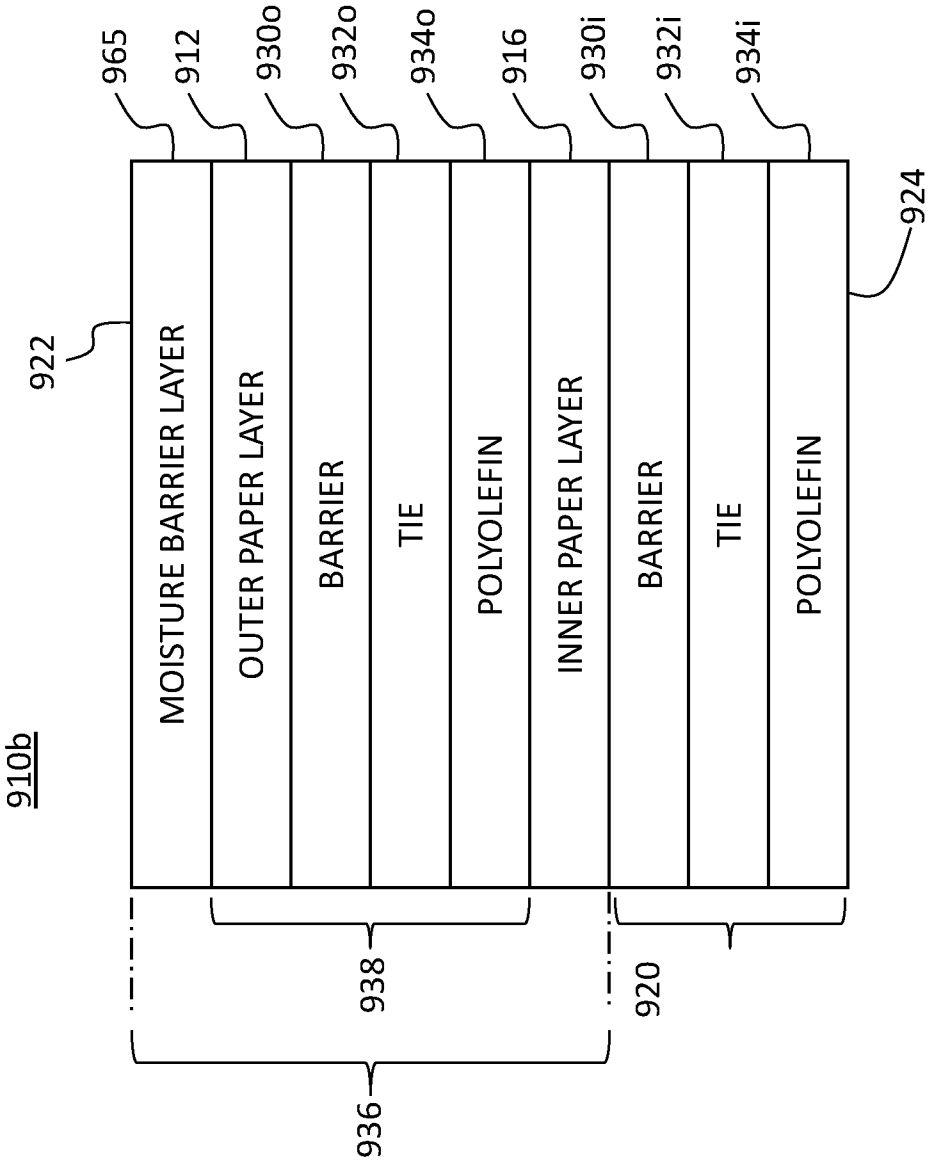

910b
922
MOISTURE BARRIER LAYER
OUTER PAPER LAYER
BARRIER
TIE
POLYOLEFIN
INNER PAPER LAYER
BARRIER
TIE
POLYOLEFIN
924
965
912
930o
932o
934o
916
930i
932i
934i
938
920
936

FIG. 9B

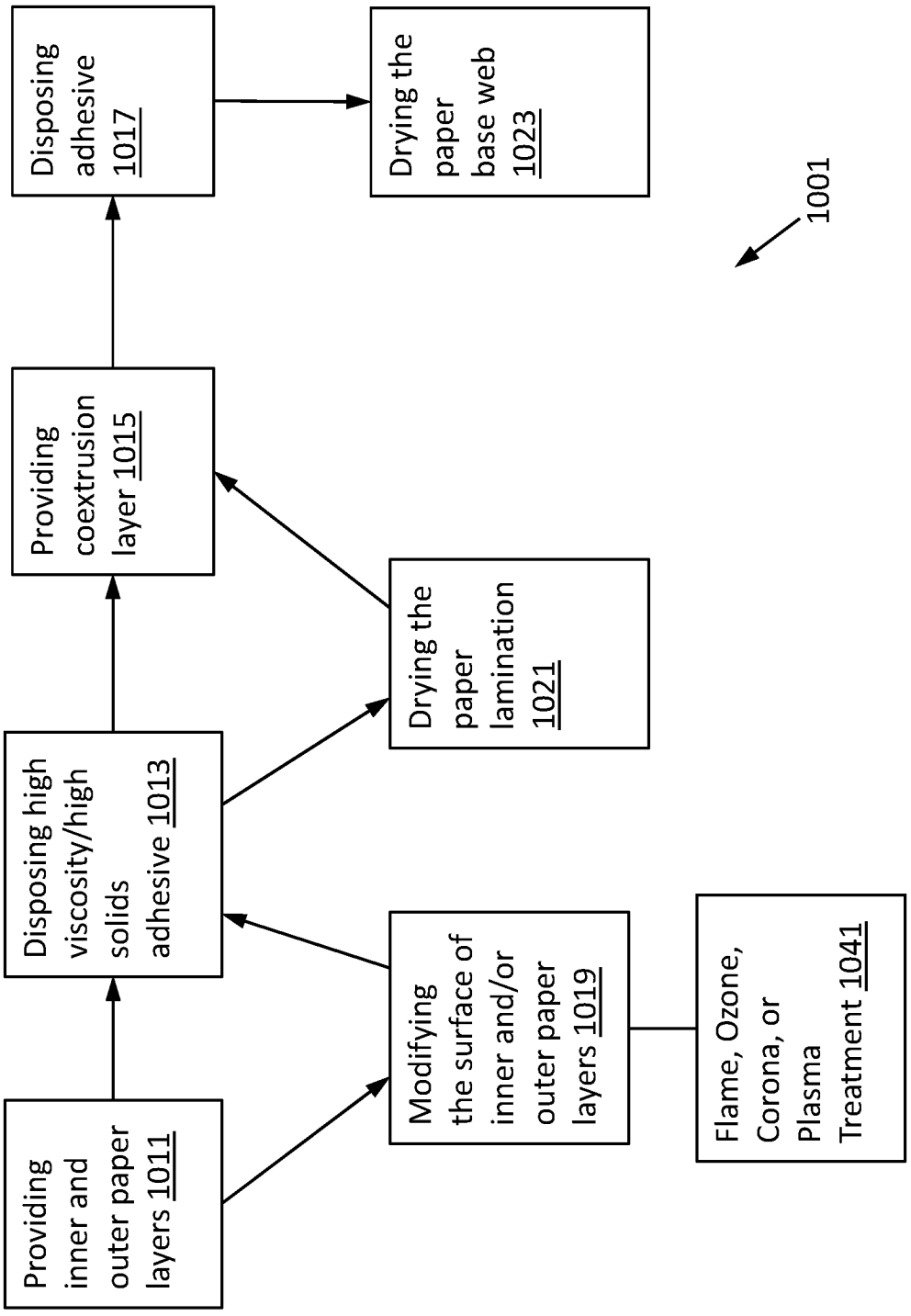

Providing inner and outer paper layers 1011
Disposing high viscosity/high solids adhesive 1013
Providing coextrusion layer 1015
Disposing adhesive 1017
Modifying the surface of inner and/or outer paper layers 1019
Drying the paper lamination 1021
Drying the paper base web 1023
Flame, Ozone, Corona, or Plasma Treatment 1041
1001

FIG. 10

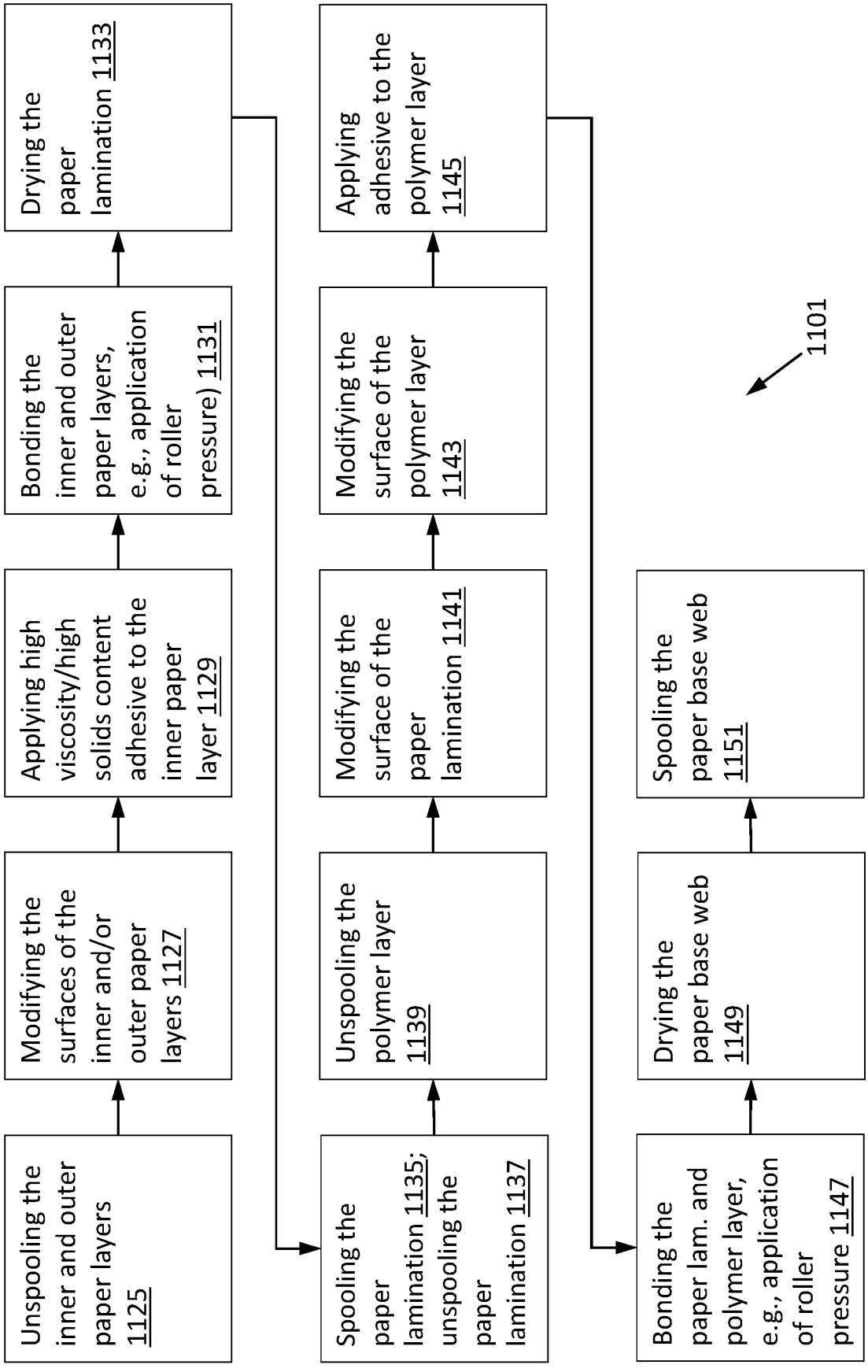

Unspooling the inner and outer paper layers 1125
Modifying the surfaces of the inner and/or outer paper layers 1127
Applying high viscosity/high solids content adhesive to the inner paper layer 1129
Bonding the inner and outer paper layers, e.g., application of roller pressure) 1131
Drying the paper lamination 1133
Spooling the paper lamination 1135; unspooling the paper lamination 1137
Unspooling the polymer layer 1139
Modifying the surface of the paper lamination 1141
Modifying the surface of the polymer layer 1143
Applying adhesive to the polymer layer 1145
Bonding the paper lam. and polymer layer, e.g., application of roller pressure 1147
Drying the paper base web 1149
Spooling the paper base web 1151
1101

FIG. 11

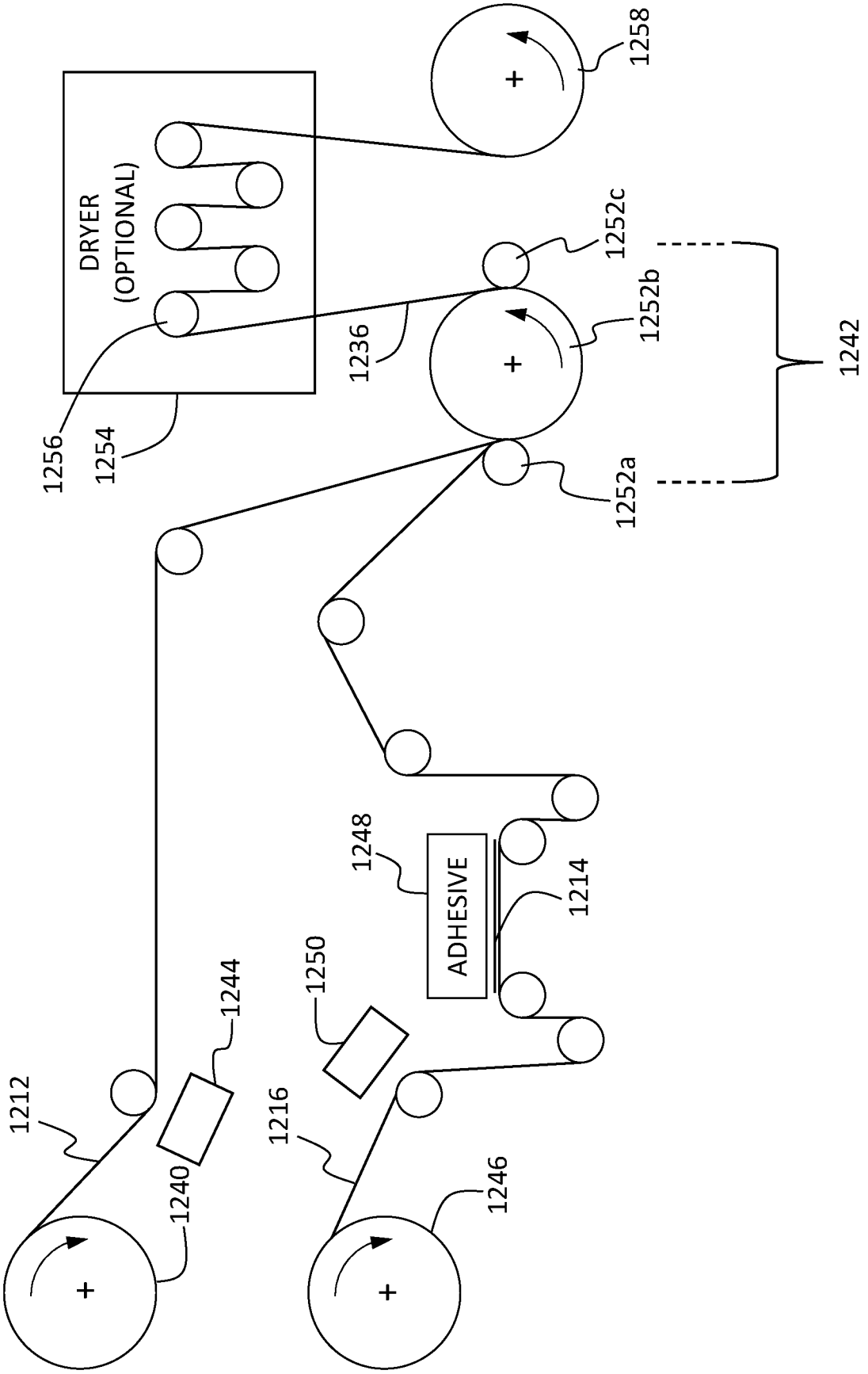

1212
1240
1244
1216
1250
1246
ADHESIVE
1248
1214
1252a
1252b
1252c
1242
1236
1254
1256
DRYER
(OPTIONAL)
1258

FIG. 12A

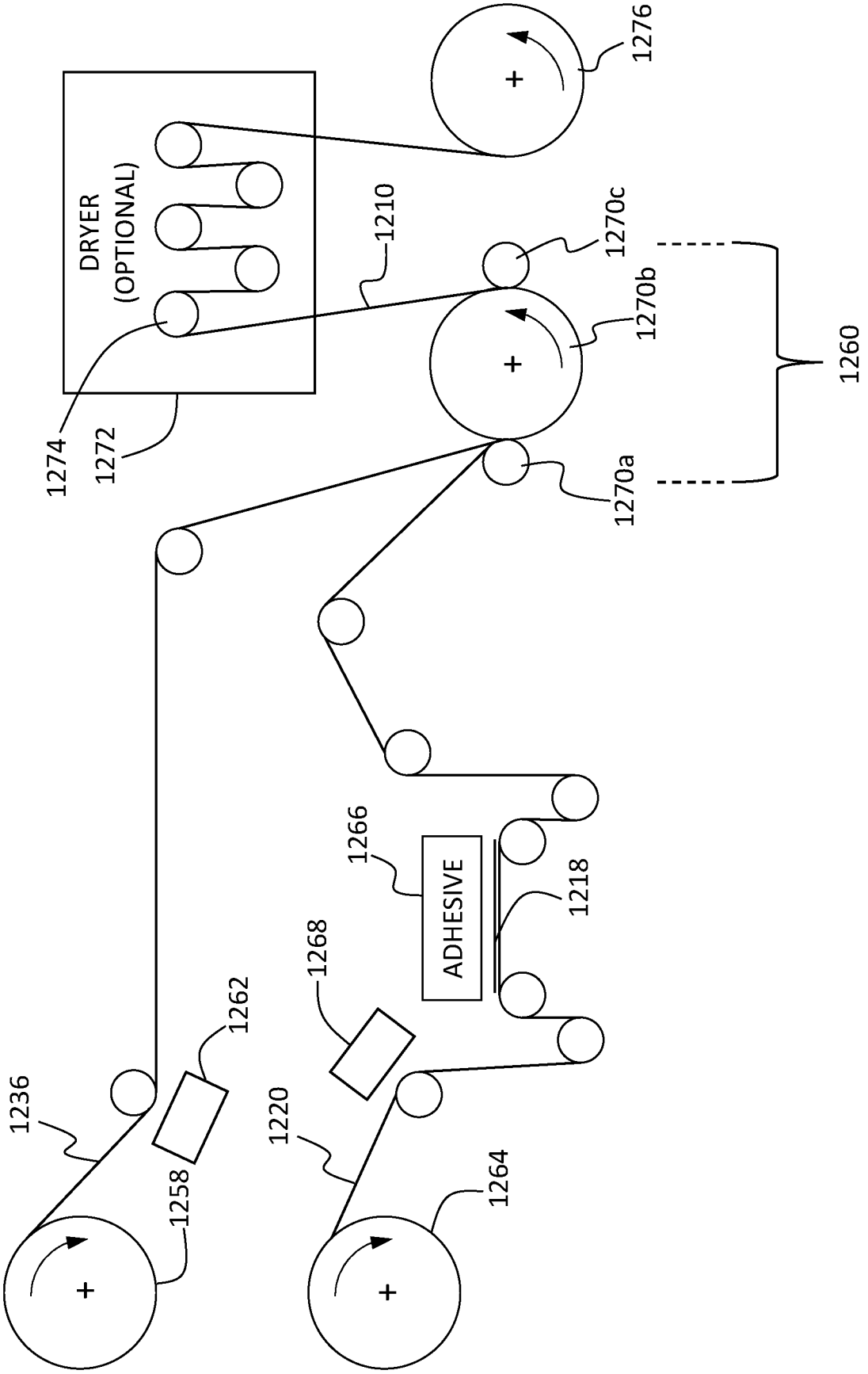

1276
DRYER
(OPTIONAL)
1210
1270c
1270b
1260
1274
1272
1270a
1266
ADHESIVE
1218
1268
1262
1236
1220
1258
1264

FIG. 12B

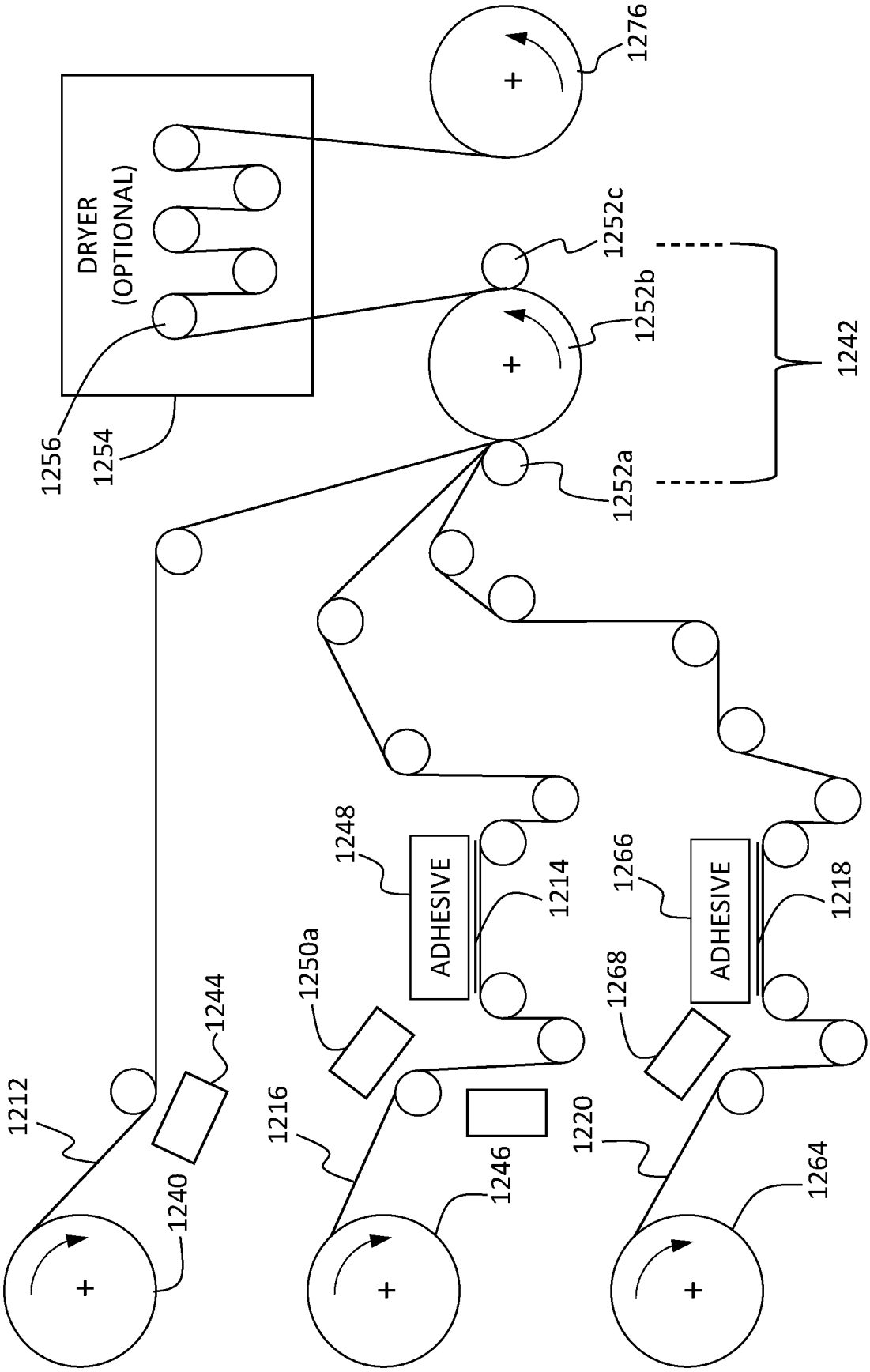

DRYER
(OPTIONAL)
1256
1254
1276
1252c
1252b
1252a
1242
1212
1240
1244
1216
1246
1250a
1248
ADHESIVE
1214
1220
1264
1268
1266
ADHESIVE
1218

FIG. 12C

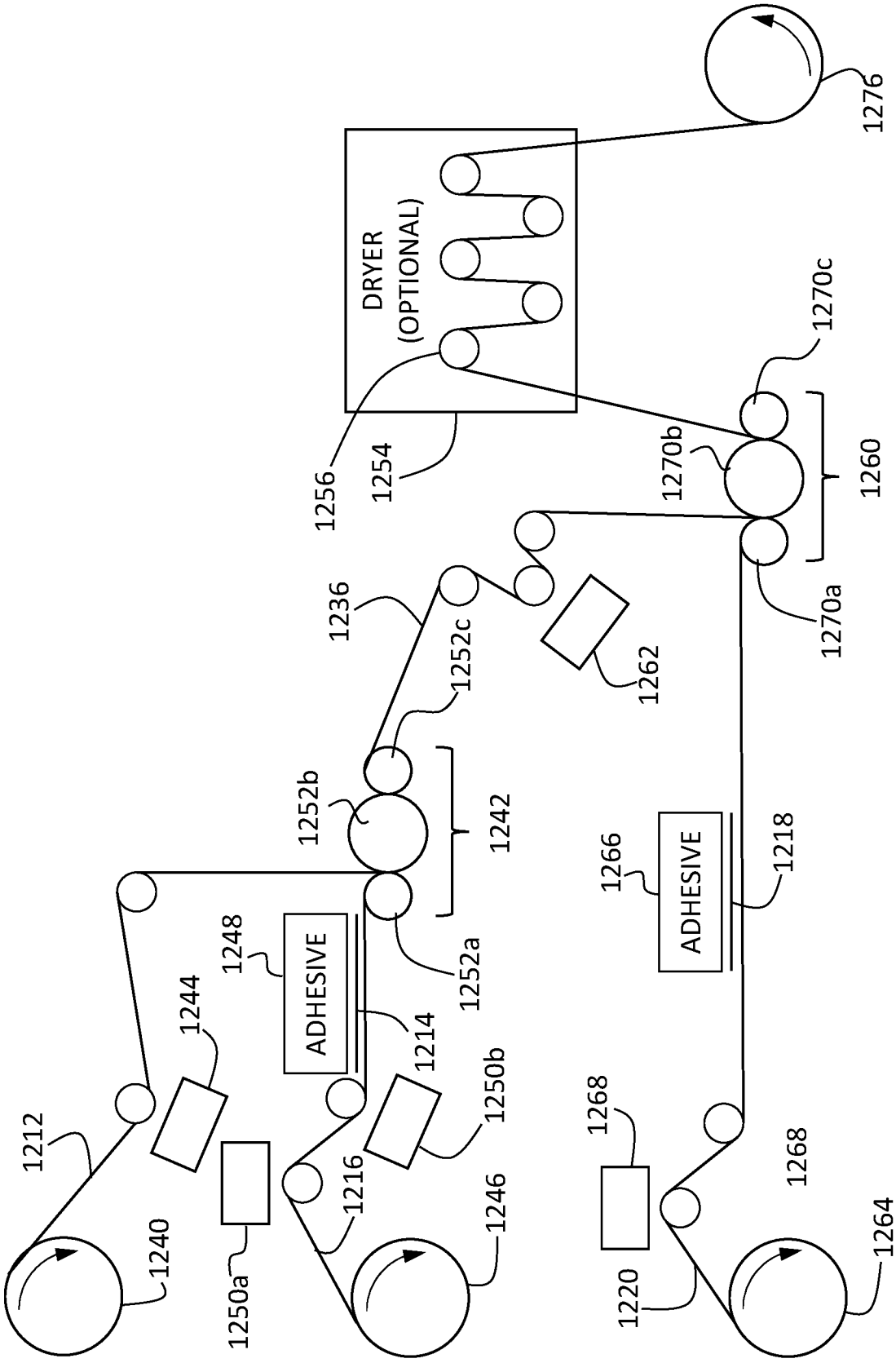

1212
1240
1250a
1244
1248
ADHESIVE
1214
1216
1246
1250b
1252a
1252b
1242
1236
1252c
1262
1256
1254
DRYER
(OPTIONAL)
1276
1270c
1270b
1260
1270a
1266
ADHESIVE
1218
1268
1220
1268
1264

FIG. 12D

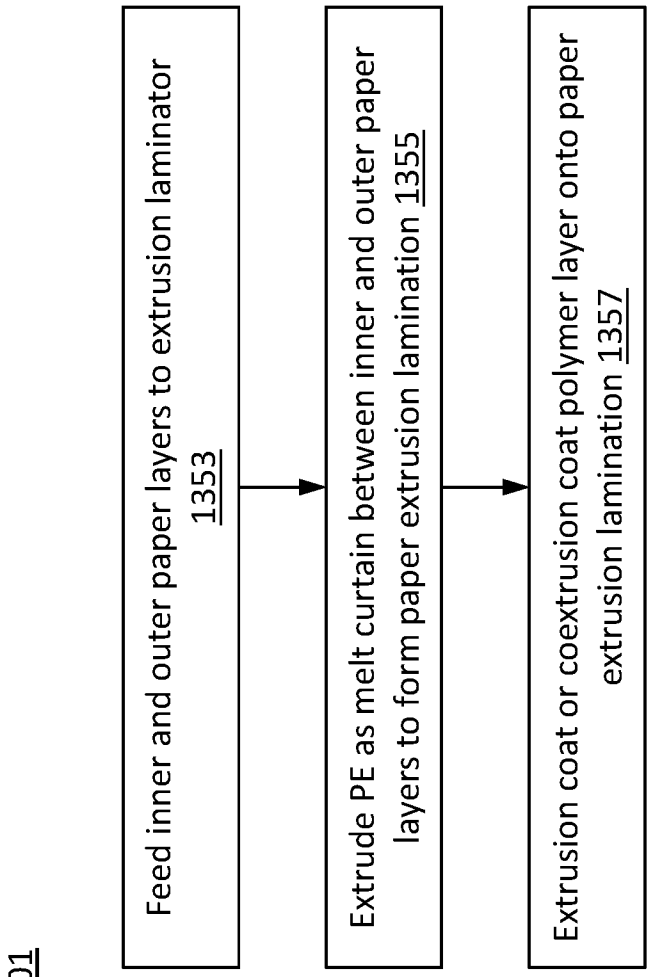

1301
Feed inner and outer paper layers to extrusion laminator 1353
Extrude PE as melt curtain between inner and outer paper layers to form paper extrusion lamination 1355
Extrusion coat or coextrusion coat polymer layer onto paper extrusion lamination 1357

FIG. 13

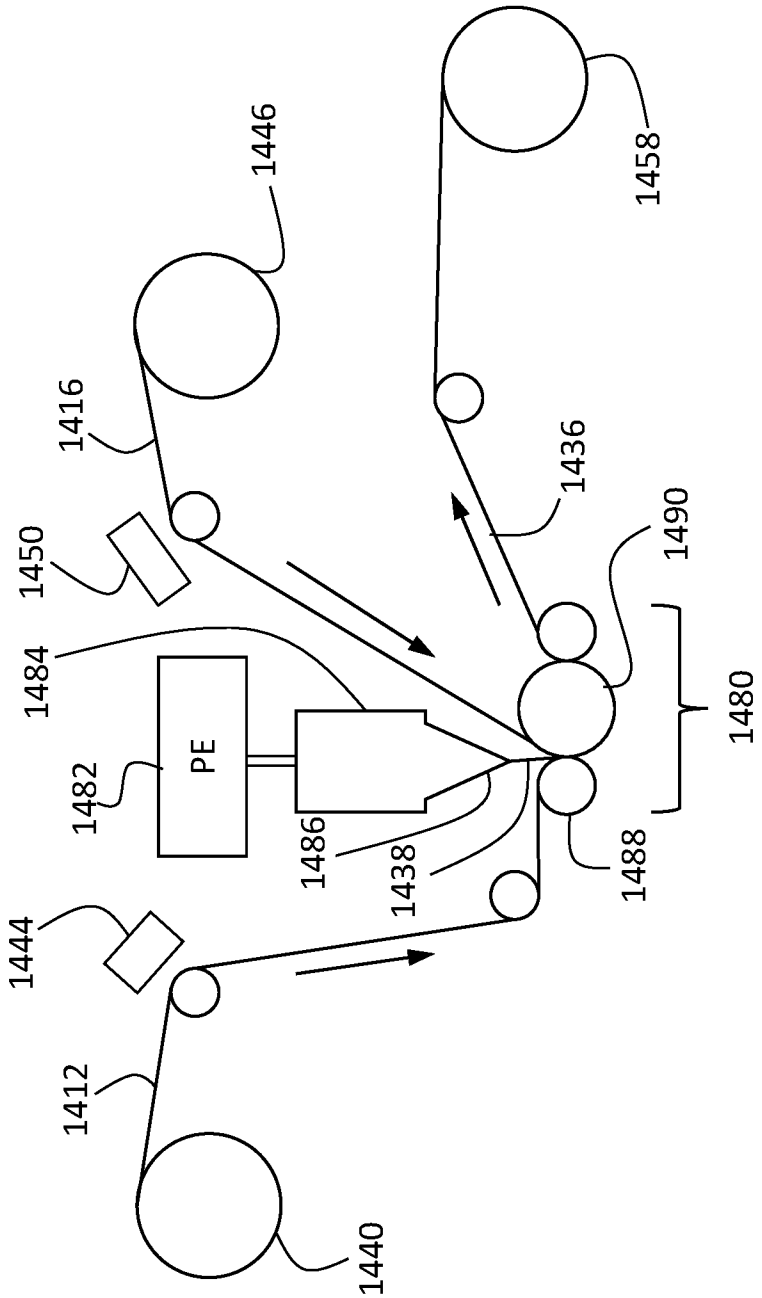

1446
1458
1416
1436
1450
1490
1484
1480
PE
1482
1486
1438
1488
1444
1412
1440

FIG. 14A

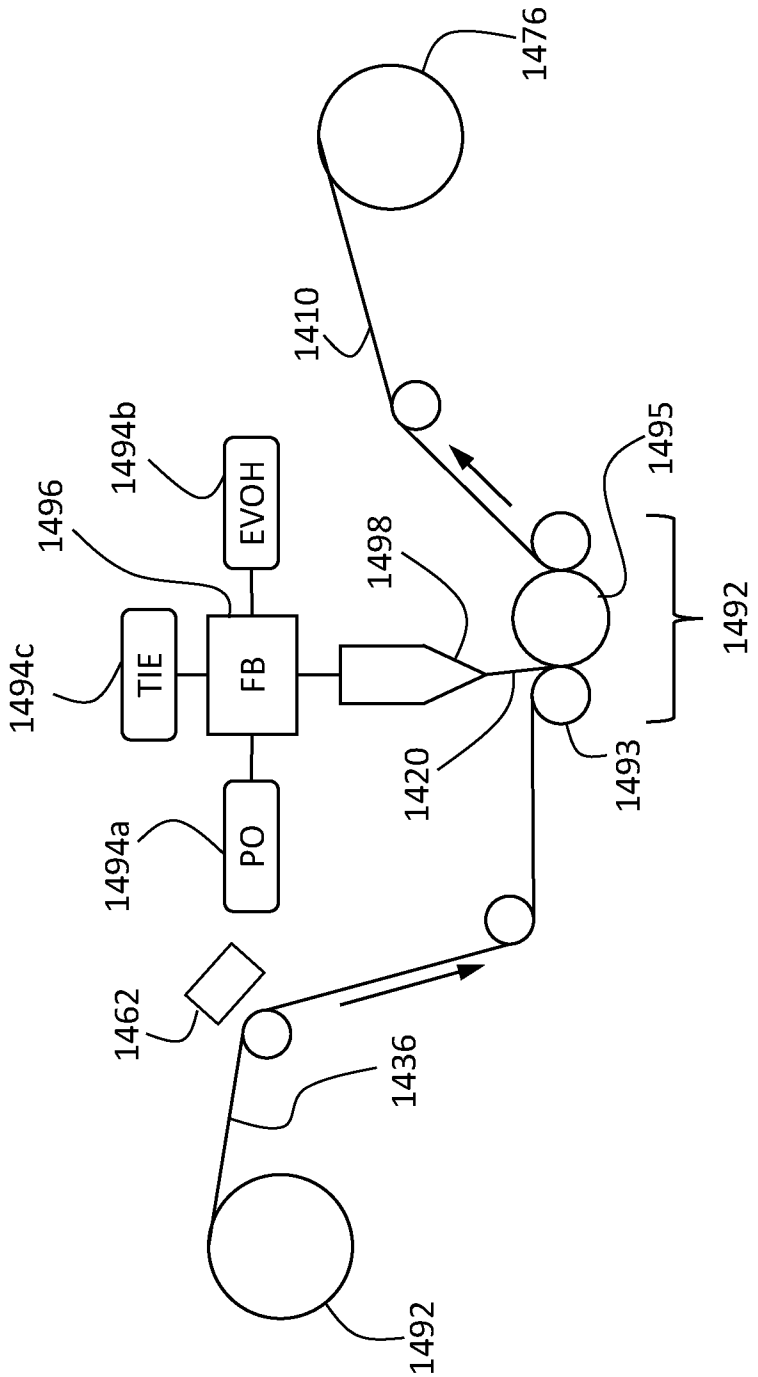
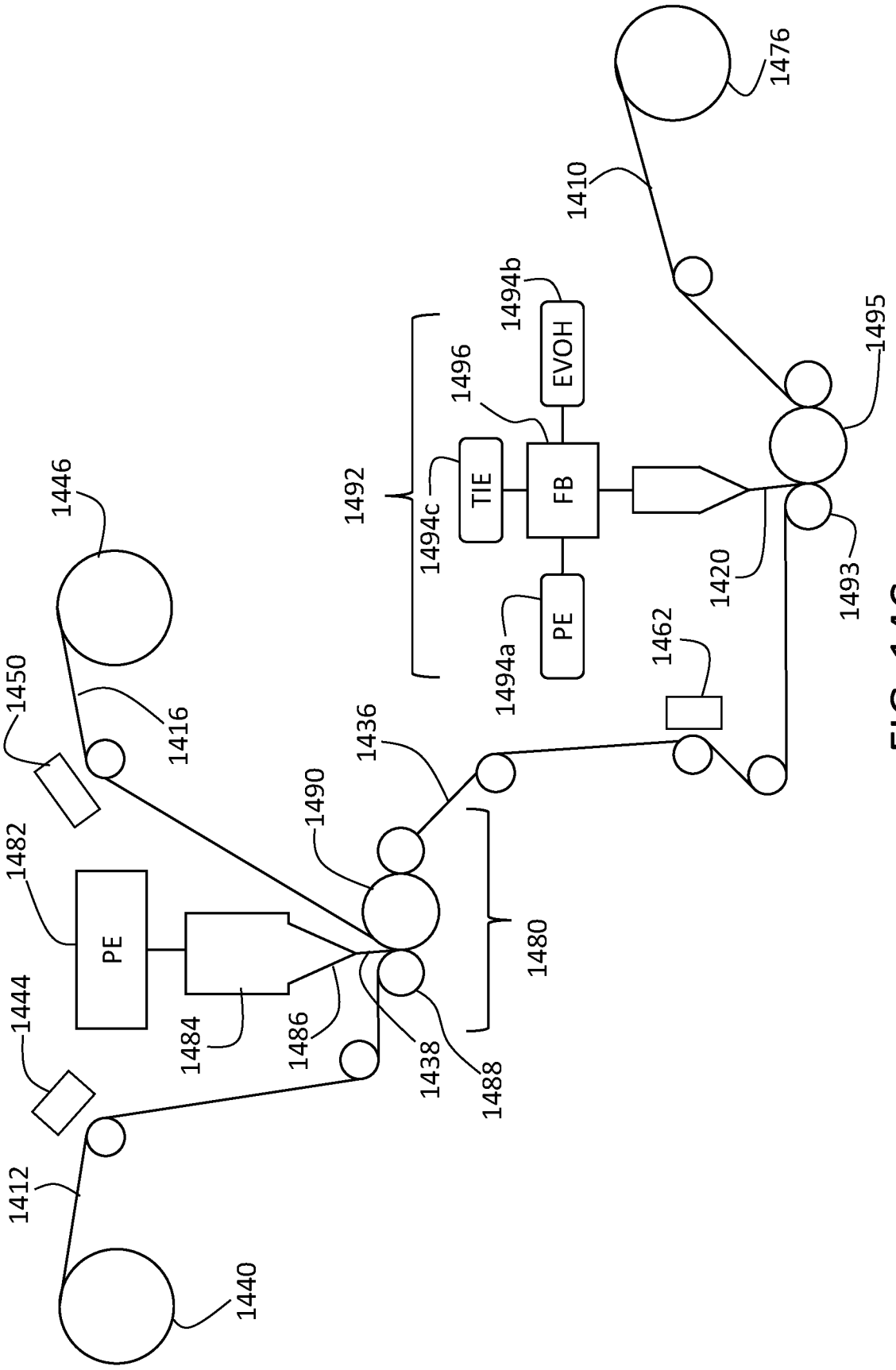

1476
1410
1494b
EVOH
1496
1498
1495
1494c
TIE
FB
1492
1420
1493
1494a
PO
1462
1436
1492

FIG. 14B


1476
1410
1495
1496
1494b
EVOH
TIE
FB
1492
1494c
1420
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1462
1494a
PE
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FIG. 14C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/054518

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***B32B 9/06*** (2025.01); ***B32B 27/32*** (2025.01); ***B32B 27/30*** (2025.01); ***B29C 48/16*** (2025.01); ***B65D 65/40*** (2025.01); *B32B 29/00* (2025.01)

CPC: ***B32B 29/005; B32B 9/06; B32B 27/32; B32B 27/30; B32B 29/002; B29C 48/16; B65D 65/40;*** *B32B 29/00; B29K 2023/086; B32B 2250/00; B32B 2307/7242*

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)

See Search History Document

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

See Search History Document

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

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2018/0119358 A1 (BILLERUDKORSNAS AB) 03 May 2018 (03.05.2018) The entire document, and more specifically: para [0001], [0005], [0056]-[0059], [0062], [0073], [0087], [0109]-[0115], [0118], [0122]-[0124], [0131]; figures 1A-1D and 5A-5B; abstract; title	1-10, 16-28, 30-32 and 39-40
Y	US 2018/011935 A1 (BILLERUDKORSNAS AB) 03 May 2018 (03.05.2018) The entire document, and more specifically: para [0001], [0005], [0056]-[0059], [0062], [0073], [0087], [0109]-[0115], [0118], [0122]-[0124], [0131]; figures 1A-1D and 5A-5B; abstract; title	11-15, 29 and 33-38
Y	US 2010/0200596 A1 (WALLACE) 12 August 2010 (12.08.2010) The entire document, and more specifically: para [0079], [0084]-[0085]; abstract; title	38
A	US 2013/0101855 A1 (FRITO-LAY NORTH AMERICA, INC.) 25 April 2013 (25.04.2013) The entire document	1-40

☑ 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
"D" document cited by the applicant in the international application
"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
05 March 2025 (05.03.2025)	**14 March 2025 (14.03.2025)**

Name and mailing address of the ISA/US	Authorized officer
COMMISSIONER FOR PATENTS **MAIL STOP PCT, ATTN: ISA/US** **P.O. Box 1450** **Alexandria, VA 22313-1450** **UNITED STATES OF AMERICA**	**KARI RODRIQUEZ**
Facsimile No. **571-273-8300**	Telephone No. **PCT Help Desk: 571-272-4300**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2022/048876 A1 (SOCIÉTÉ DES PRODUITS NESTLÉ S.A.) 10 March 2022 (10.03.2022) The entire document	1-40
A	US US 2016/0067950 A1 (WIPAK WALSRODE GMBH & CO. KG) 10 March 2016 (10.03.2016) The entire document	1-40
Y	MOUNT III, "Coextrusion equipment for multilayer flat films and sheets"; Multilayer Flexible Packaging (Second Edition), Chapter 6 (April 2016), pg 75-95 pg 75, col 2, para 2; pg 76, col 1, para 3; pg 76, col 2, para 1; pg 77, col 1, para 1; title	11-15, 29 and 33-37

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/054518

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1.

Group I: claims 1-19 and 39, directed to a thermoformable paper base web, with two paper layers and a polymer layer.

Group II: claims 20-38 and 40, directed to a method for producing a thermoformable paper base web.

1. ☑ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☑ No protest accompanied the payment of additional search fees.