US 20170241058A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2017/0241058 A1**

**FARR et al.** (43) **Pub. Date: Aug. 24, 2017**

(54) **NON-RIGID MATERIAL MULTI-FRAME MANUFACTURING APPARATUS**

(71) Applicant: **NIKE, Inc.**, Beaverton, OR (US)

(72) Inventors: **TODD R. FARR**, TAICHUNG CITY (TW); **ANDREY BACKARIOV**, Yavne (IL); **GILAD DAMARI**, Yavne (IL); **OFER RICKLIS**, Milpitas, CA (US); **JAEIC KIM**, BUSAN (KR)

(21) Appl. No.: **15/440,422**

(22) Filed: **Feb. 23, 2017**

**Related U.S. Application Data**

(60) Provisional application No. 62/298,685, filed on Feb. 23, 2016.

**Publication Classification**

(51) **Int. Cl.**

***D06C 5/00*** (2006.01)

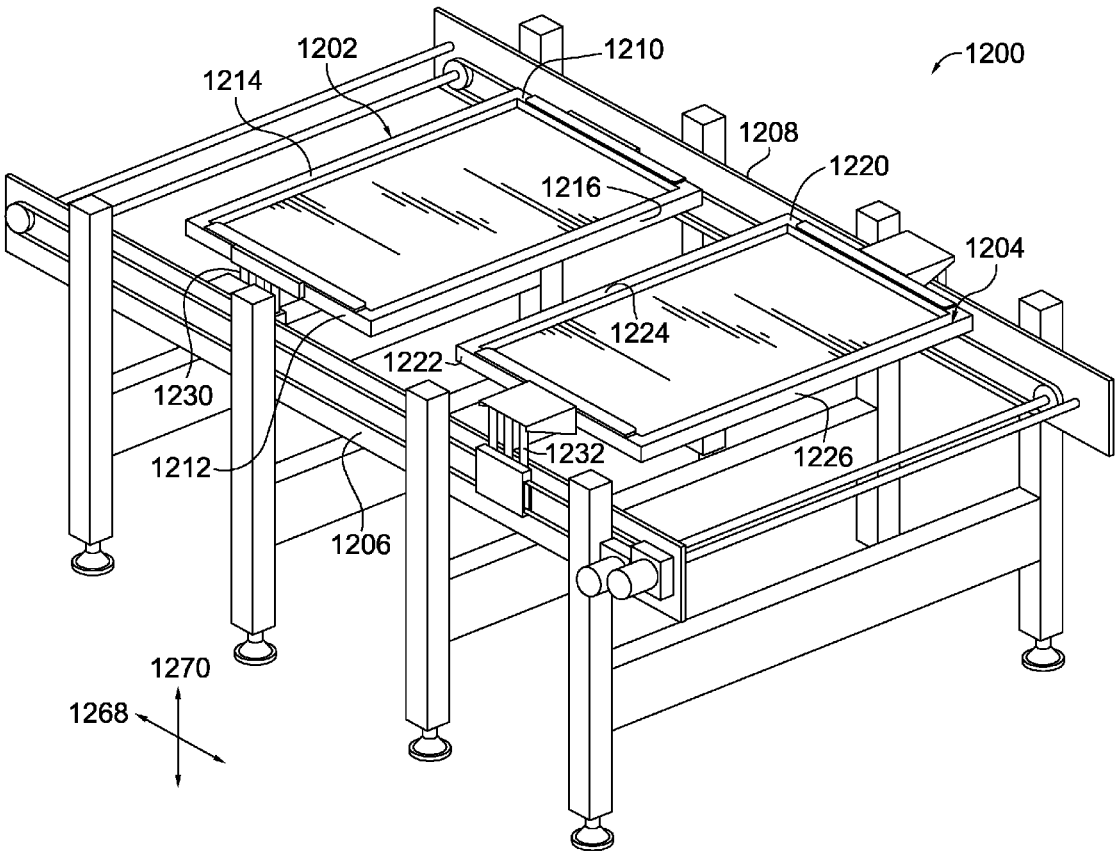
***D06B 11/00*** (2006.01)

(52) **U.S. Cl.**

CPC ..... ***D06C 5/005*** (2013.01); ***D06B 11/0096*** (2013.01)

(57) **ABSTRACT**

Aspects hereof relate to a multi-frame manufacturing apparatus for manufacturing articles from non-rigid materials and methods for manufacturing articles utilizing a multi-frame manufacturing apparatus. The multi-frame manufacturing apparatus includes a plurality of discrete frames, each frame including a movement mechanism that enables it to move between sequentially arranged processing stations. Each movement mechanism permits substantially horizontal movement forward and backward. The movement mechanism for at least one of the frames permits substantially vertical movement both up and down. Actuation of the movement mechanisms for at least two frames may permit the frames to switch their relative positions. Each frame additionally includes at least one gripping mechanism for temporarily securing non-rigid material in place on the framed for processing.



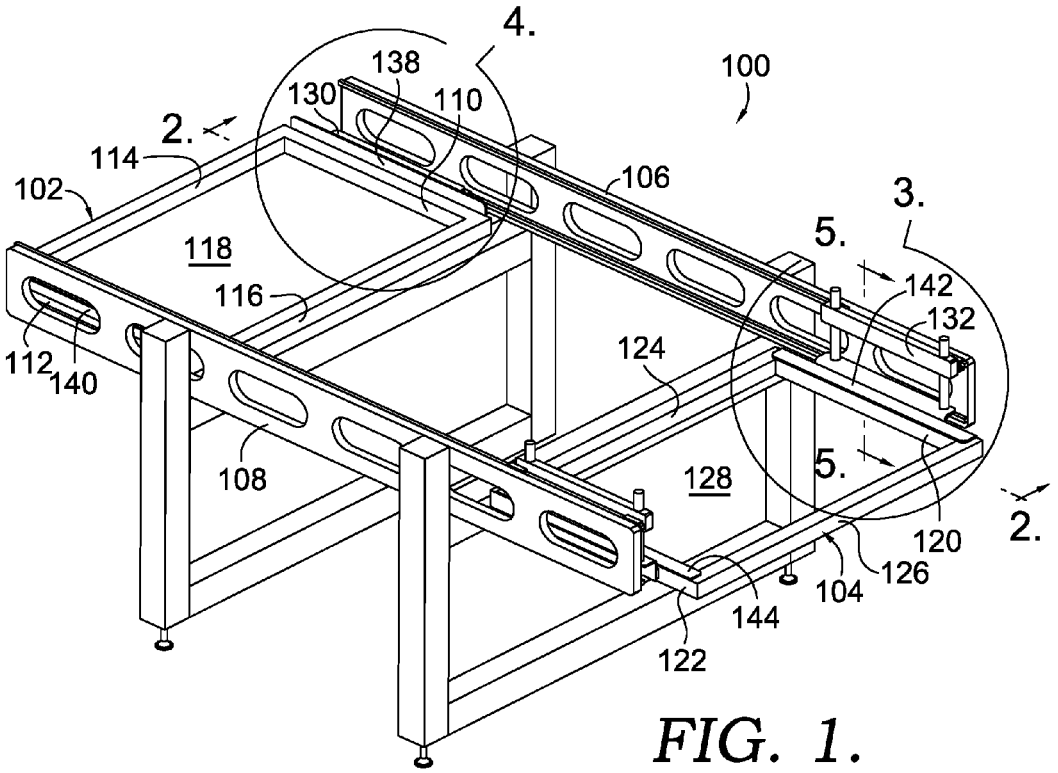

4.
138
130
110
100
2.
114
102
106
3.
5.
118
116
142
132
112
140
124
108
128
5.
2.
120
126
104
144
122

FIG. 1.

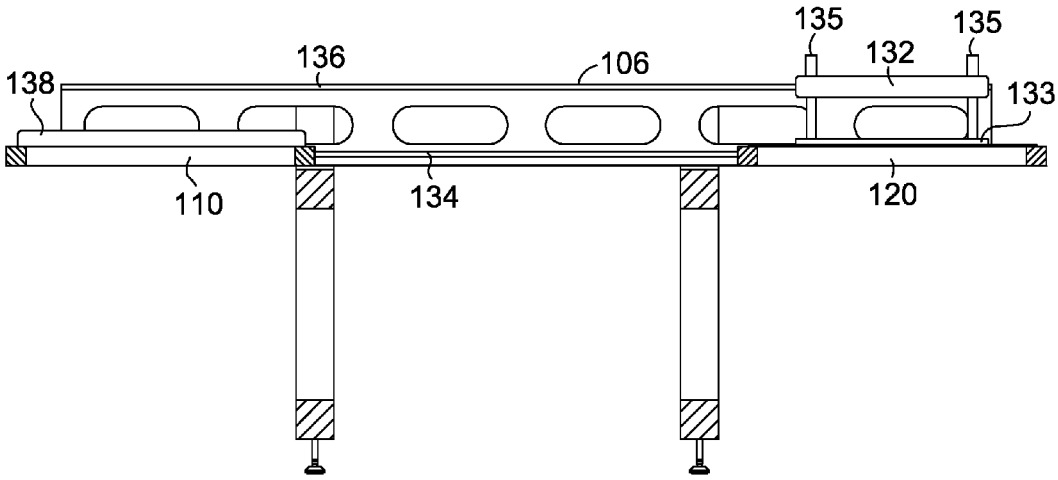

135
135
136
106
132
138
133
110
134
120

FIG. 2.

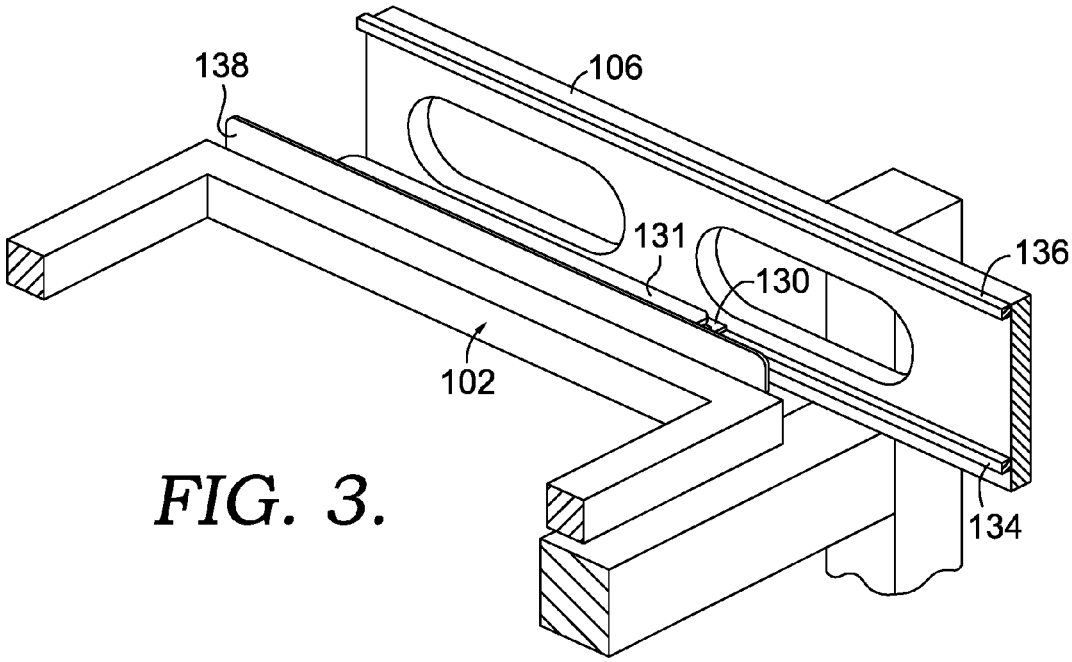



FIG. 3.

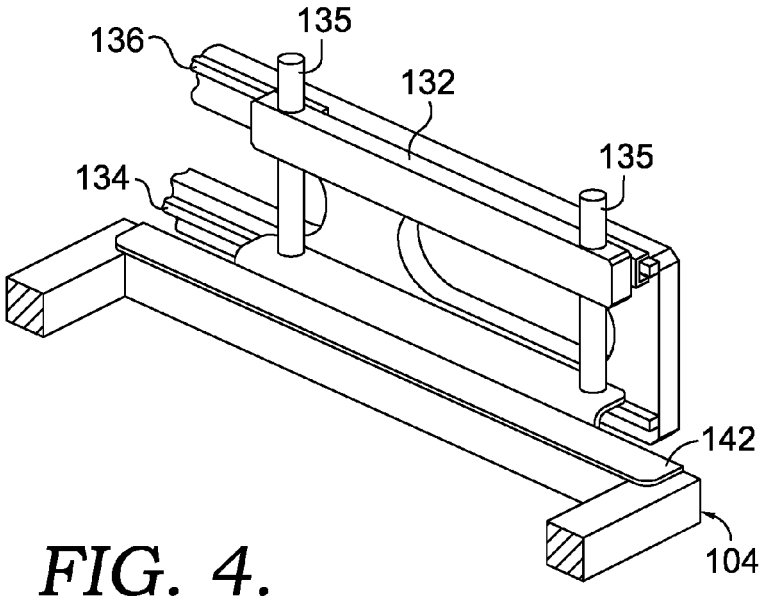



FIG. 4.

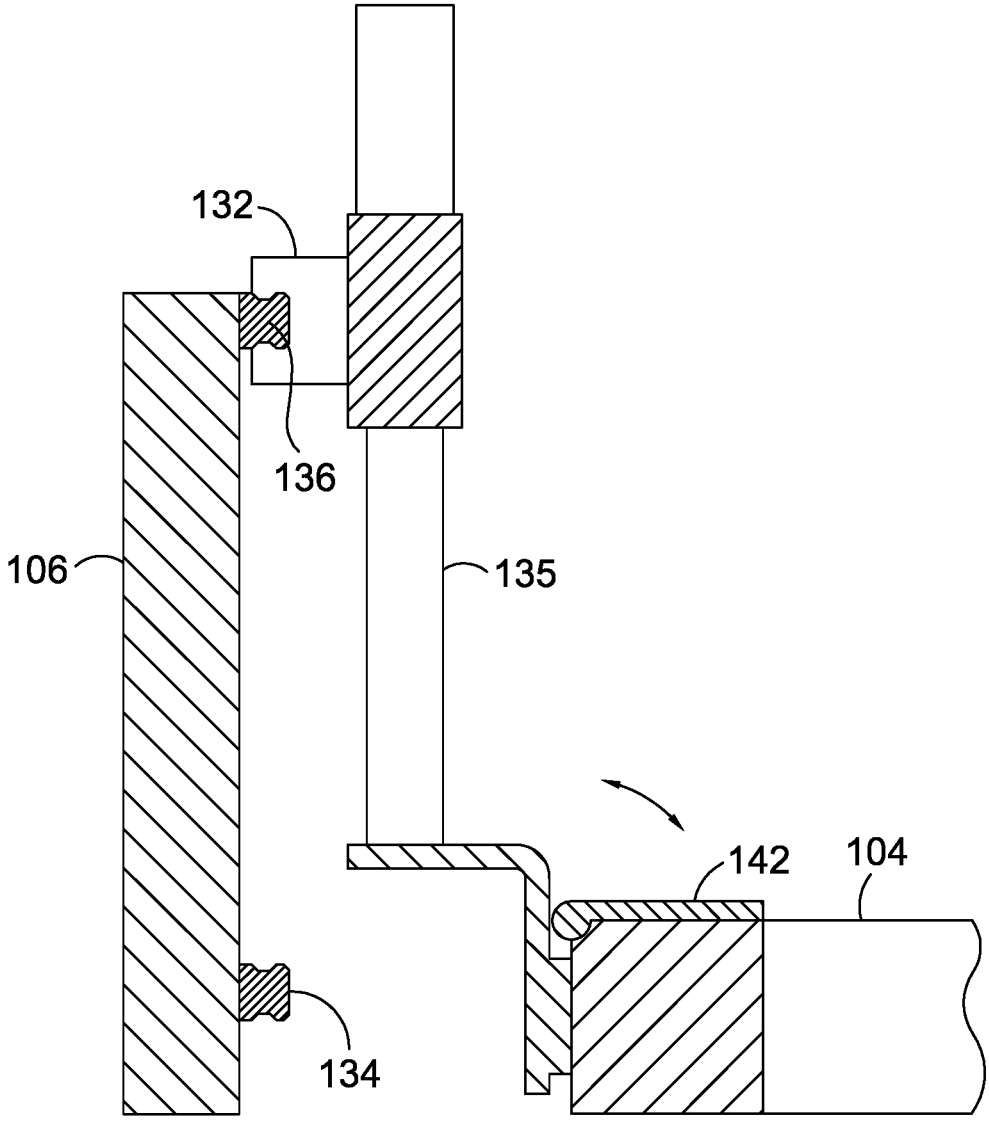



*FIG. 5.*

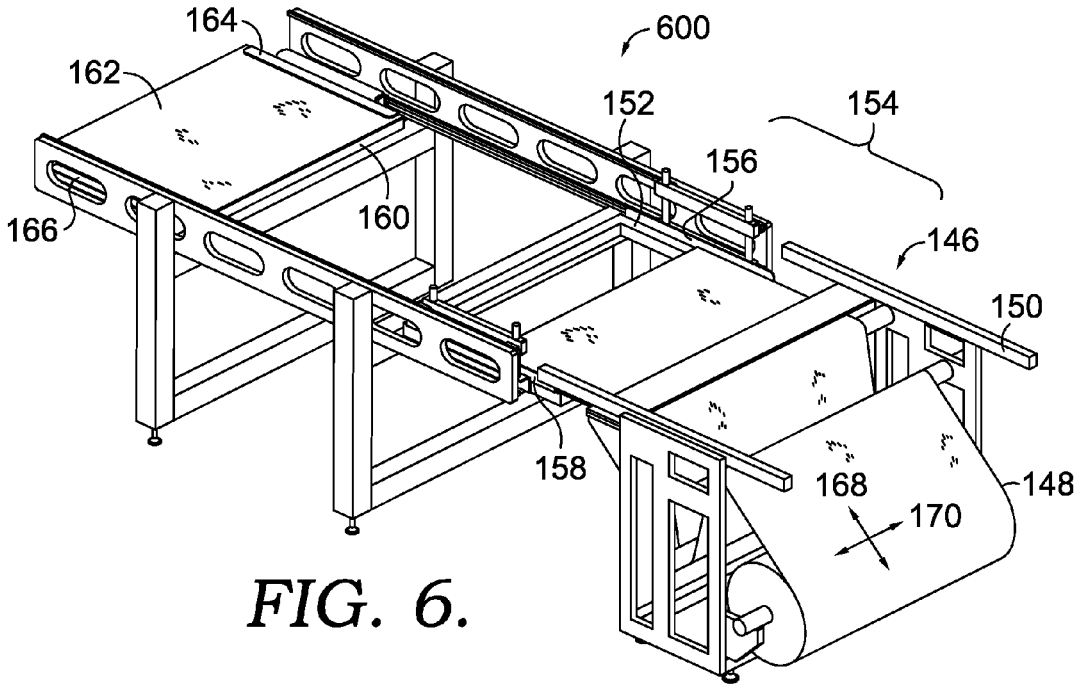

164
600
162
152
154
156
160
166
146
150
158
168
148
170

FIG. 6.

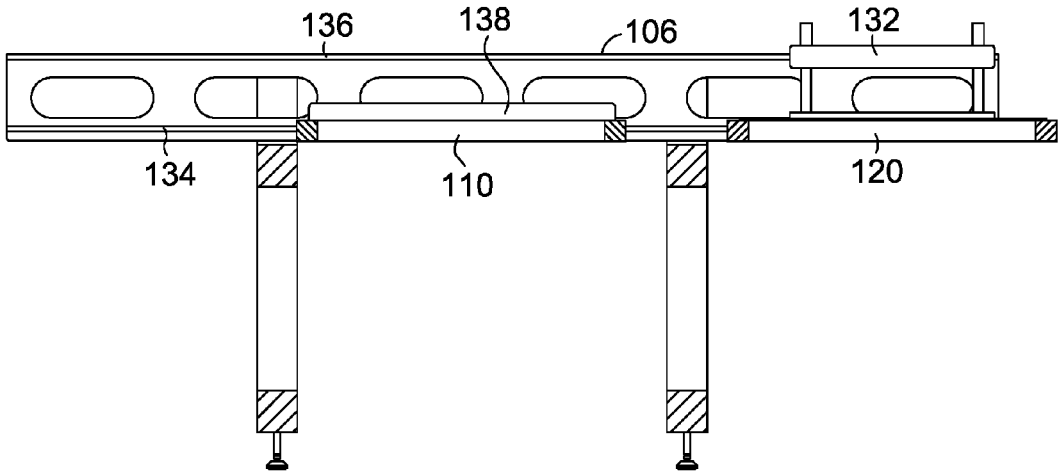

136
138
106
132
134
110
120

FIG. 7.

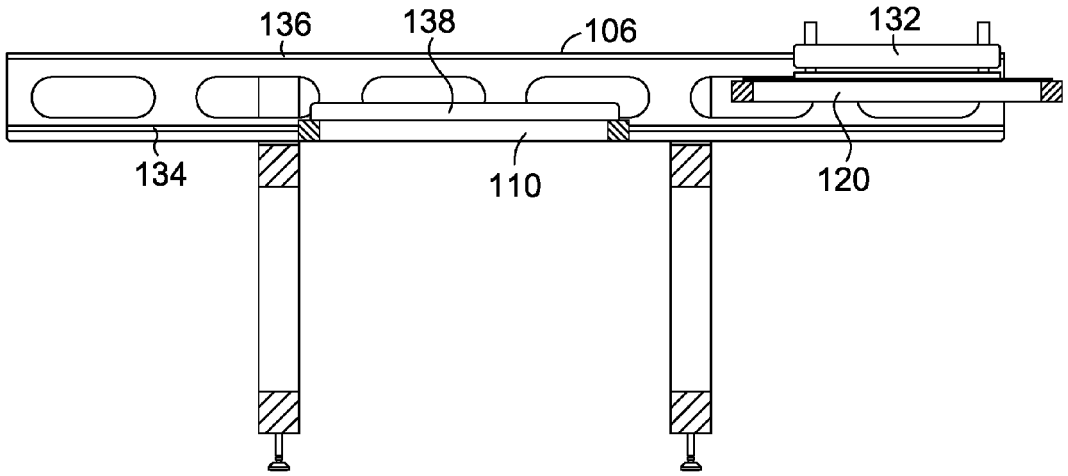



FIG. 8.

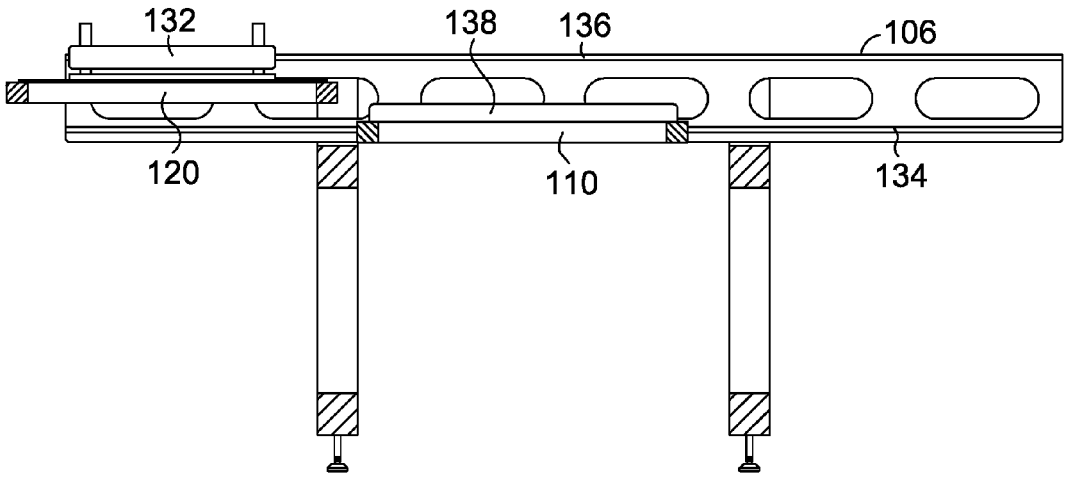



FIG. 9.

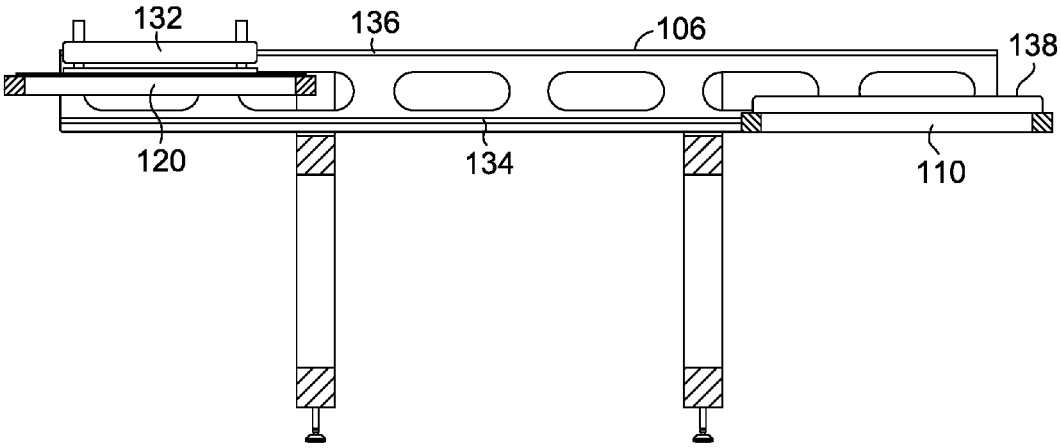



FIG. 10.

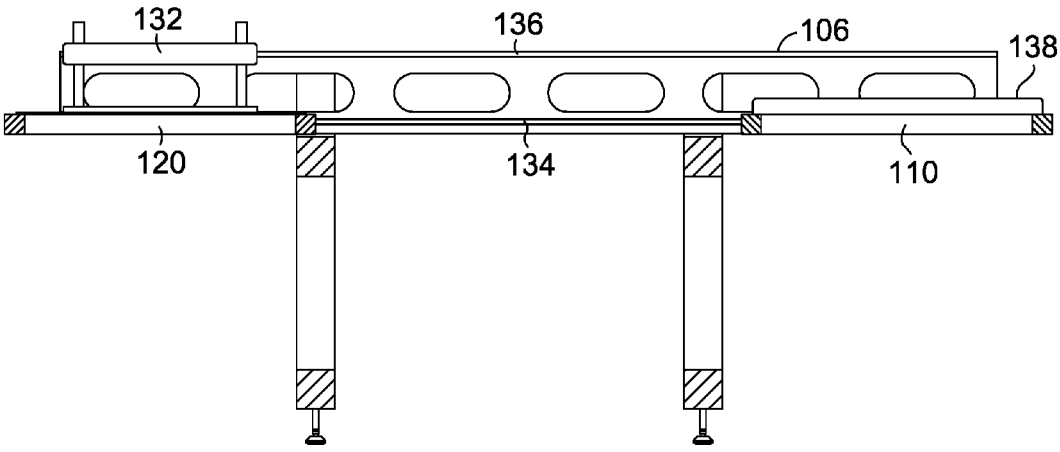



FIG. 11.

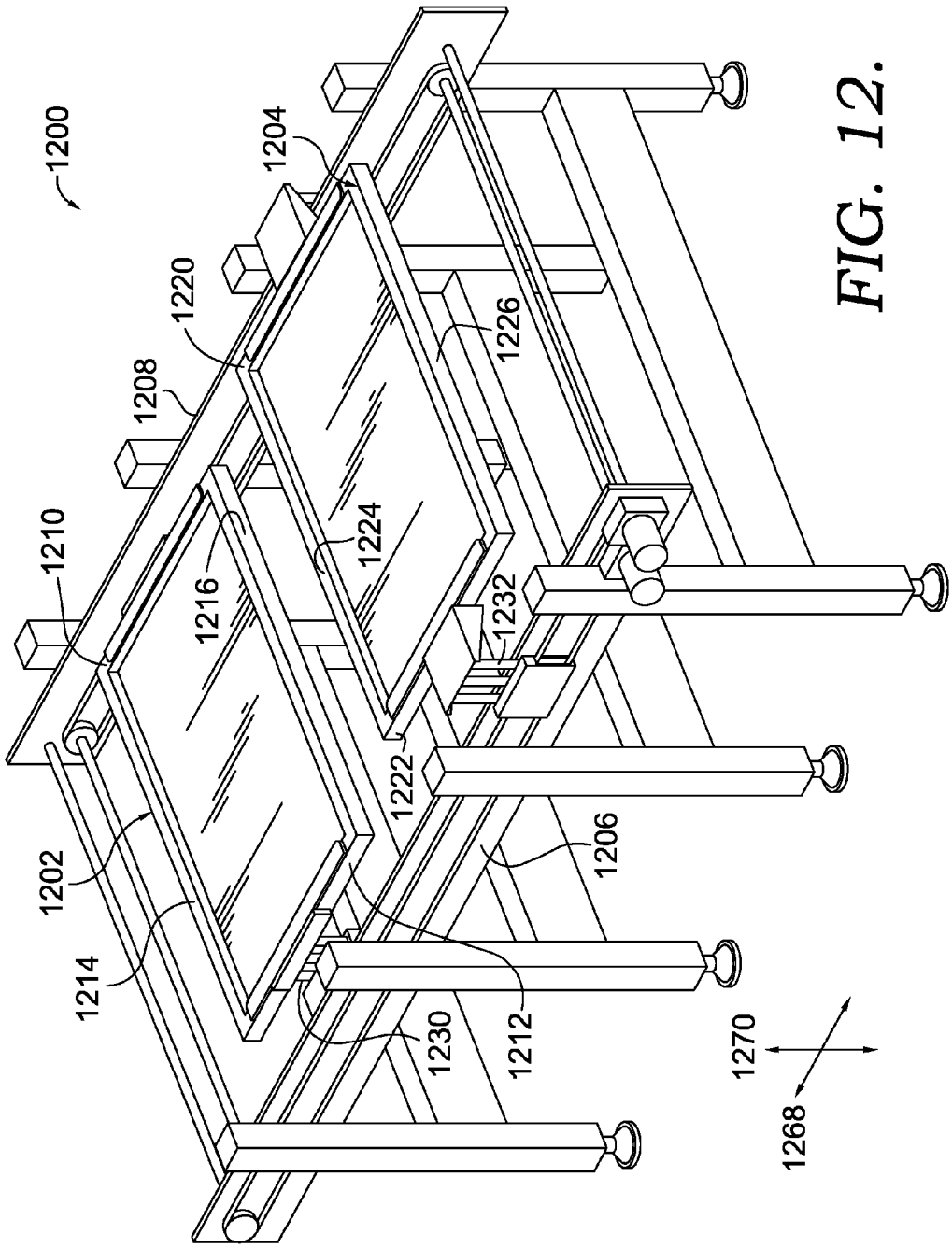

1200
1204
1220
1208
1210
1216
1224
1226
1232
1222
1206
1202
1214
1230
1212
1270
1268

FIG. 12.

# NON-RIGID MATERIAL MULTI-FRAME MANUFACTURING APPARATUS

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority to U.S. Provisional Patent Application 62/298,685 filed Feb. 23, 2016 and entitled "Non-Rigid Material Multi-Frame Manufacturing Apparatus," which application is hereby incorporated by reference as if set forth in its entirety herein.

## TECHNICAL FIELD

**[0002]** Aspects hereof relate to multi-frame manufacturing apparatus for manufacturing articles. Aspects further relate to methods of manufacturing articles utilizing a multi-frame manufacturing apparatus.

## BACKGROUND

**[0003]** Non-rigid materials may be fed into an assembly-line- or conveyor-type manufacturing system or machine from a material stock including a large roll or continuous web. Working with such large sections of material can be cumbersome. This is particularly true as non-rigid materials generally are stretchable in at least one direction when placed under tension. Attempting to process non-rigid materials in a tensioned state causing stretch of the material may lead to manufactured articles that have mistakes or deformities and are consequently unusable.

## BRIEF SUMMARY

**[0004]** Aspects hereof relate to a multi-frame manufacturing apparatus for manufacturing articles, (e.g., garments, sock liners, and the like) from non-rigid materials. The multi-frame manufacturing apparatus includes a plurality of discrete frames. Each frame includes a movement mechanism that enables it to move between sequentially arranged processing stations in an assembly-line- or conveyor-type manufacturing system. Each movement mechanism permits substantially horizontal movement both forward and backward. The movement mechanism for at least one of the plurality of frames additionally permits substantially vertical movement both up and down. Actuation, synchronous or asynchronous, of the movement mechanisms for at least two of the plurality of frames may permit the frames to switch their relative positions among the processing stations in the manufacturing system.

**[0005]** Each frame includes at least one gripping mechanism that includes an open material-receiving position and a closed material-gripping position. When a non-rigid material is loaded onto one of the frames, the gripping mechanism of the frame is in the open material-receiving position. Once the material is in place and in a non-tensioned state (that is, taut but not stretched, such that the material is not substantially distorted in any direction), the gripping mechanism closes into the closed material-gripping position such that it temporarily secures the non-rigid material in place on the frame for processing. If the material stock from which the material is loaded onto the frame is more than the quantity desired for processing as a single processing unit, the gripped portion of the material may be cut or otherwise separated from the larger quantity of material such that it may be processed more manageably.

**[0006]** Aspects hereof further relate to methods of manufacturing articles utilizing a multi-frame manufacturing apparatus included in a manufacturing system having a plurality of sequentially arranged processing stations in an assembly-line- or conveyor-type arrangement. A non-rigid material is loaded in a non-tensioned state onto the first of a plurality of frames. The first frame includes at least one gripping mechanism that, once the material is in place on the first frame, is actuated such that it closes and temporarily holds the non-rigid material in place on the frame for processing. The non-rigid material secured to the first frame is in a taut condition but not stretched such that distortion of the material results. A movement mechanism coupled with the first frame causes the frame, with the material in place, to move at least substantially horizontally in a first direction. Synchronously or asynchronously, a second movement mechanism associated with a second frame is caused to move substantially horizontally in an opposing direction and substantially vertically causing the first frame and the second frame to switch their respective positions among the plurality of processing stations.

**[0007]** This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** Illustrative aspects hereof are described in detail below with reference to the attached drawing figures, which are incorporated by reference herein and wherein:

**[0009]** FIG. **1** depicts an exemplary multi-frame manufacturing apparatus, in accordance with exemplary aspects hereof;

**[0010]** FIG. **2** depicts a cross-sectional view of the multi-frame manufacturing apparatus of FIG. **1** taken along line **2**.-**2**. thereof, in accordance with exemplary aspects hereof;

**[0011]** FIG. **3** depicts a view of the area encircled by line **3** in FIG. **1**, in accordance with exemplary aspects hereof;

**[0012]** FIG. **4** depicts a view of the area encircled by line **4** in FIG. **1**, in accordance with exemplary aspects hereof;

**[0013]** FIG. **5** depicts a cross-sectional view of the second movement mechanism of FIG. **1** taken along line **5**.-**5**. thereof, in accordance with exemplary aspects hereof;

**[0014]** FIG. **6** depicts an exemplary multi-frame manufacturing apparatus having a loading mechanism in cooperation therewith, in accordance with exemplary aspects hereof;

**[0015]** FIGS. **7**-**11** are cross-sectional views depicting sequential movement and place switching of two frames according to a first frame switching mechanism, in accordance with exemplary aspects hereof; and

**[0016]** FIG. **12** depicts an exemplary multi-frame manufacturing apparatus having a second frame switching mechanism, in accordance with additional aspects hereof.

## DETAILED DESCRIPTION

**[0017]** The subject matter herein is described with specificity to meet statutory requirements. However, the description itself is not intended to limit the scope of this patent. Rather, the inventors have contemplated that the claimed subject matter might also be embodied in other ways, to include different elements or combinations of elements

similar to the ones described in this document, in conjunction with other present or future technologies.

**[0018]** Aspects hereof contemplate a multi-frame manufacturing apparatus (e.g., a manufacturing apparatus having at least two discrete processing frames) for manufacturing articles, for instance, sock liners, from non-rigid materials. The multi-frame manufacturing apparatus provides for manageably handling discrete portions of a large material stock of non-rigid material in a non-tensioned state (i.e., taut but not stretched, such that the material is not substantially distorted in any direction). For instance, the multi-frame manufacturing apparatus, in exemplary aspects, temporarily secures discrete portions of non-rigid material to the frames for processing. In aspects, the non-rigid material is secured to the frames along the stretch direction (that is, the direction along which the non-rigid material has the greatest relative ability to stretch or deform from its relaxed, taut, but non-stretched state). In this way, waste occasioned by the manufacture of deformed or otherwise misshapen articles is reduced as the non-rigid material is secured in its non-tensioned state during processing to prevent such deformity thereof. Further, discrete non-rigid material portions may be handled more manageably than processing continuously from a large material stock.

**[0019]** Aspects hereof relate to a multi-frame manufacturing apparatus for manufacturing articles, e.g., sock liners, garments or garment portions, from non-rigid materials. Non-rigid materials may include, by way of example and not limitation, knit materials, woven materials, mesh materials, non-woven materials, leather materials, foamed materials, and the like. Non-rigid materials utilized in the manufacture of articles often are fed, by way of example only, from material stock (e.g., material rolls or webs) having large quantities of material. Material from a material stock may be fed into a manufacturing system at an appropriate processing station of a plurality of processing stations sequentially arranged in an assembly line. Non-rigid materials generally include a direction (referred to herein as the "stretch direction") along which the material has the greatest relative ability to stretch or deform from its relaxed, taut, but non-stretched state when the material is in a state of tension or strain (e.g., a stretched state). Such tension may cause deformity of the non-rigid material during processing resulting in deformed or misshapen manufactured articles. As such, in exemplary aspects, maintaining placement of non-rigid materials in a non-tensioned state during processing (i.e., taut but not stretched, such that the material is not substantially distorted in any direction) may be desirable to reduce waste occasioned by production of deformed, and consequently unusable, articles or portions of articles.

**[0020]** As will be discussed throughout, it is contemplated that a multi-frame manufacturing apparatus in accordance with aspects hereof may include at least two discrete frames configured for receiving a non-rigid material and for moving the non-rigid material through a plurality of sequentially arranged processing stations positioned in a conveyor- or assembly-line-type of arrangement. In exemplary aspects, the frames may be substantially rectangular and movably positioned between a pair of side rails. As used herein, it is contemplated that "substantially rectangular" refers to frames having a first pair of sidewalls positioned opposite one another and a second pair of sidewalls positioned opposite one another and perpendicular to the first pair of sidewalls. The sidewalls may be formed from one or more wall portions that collectively form a substantially rectangular perimeter sidewall surrounding a central void. When multiple wall portions are assembled to form the substantially rectangular perimeter sidewall, aspects hereof contemplate that those wall portions requiring attachment to one another may have end portions cut at angles of about forty-five degrees (45°) to allow the wall portions to be mitered to form a rectangular structure. It will be understood that angles slightly off of 45° are contemplated and are intended to be within the scope of aspects hereof. Further aspects hereof contemplate the joining of wall portions having abutting attachment surfaces at about ninety (90°) relative to one another or any other angle permitting attachment to form a rectangular structure. Any and all such variations, and any combination thereof, are contemplated to be within the scope of aspects hereof. Mechanisms for fastening the wall portions may include various screws or other fastening mechanisms known to those having ordinary skill in the art.

**[0021]** Each frame may include a movement mechanism that permits substantially horizontal movement both forward and backward between the pair of side rails. As used herein, the terms "forward" and "backward" refer to opposing movements in the longitudinal direction of the side rails between which movement is permitted. In aspects, the pair of side rails may be positioned parallel to one another and spaced apart from one another by a distance sufficient to permit functional receipt of the frames. As used herein, "substantially horizontal movement" refers to horizontal movement in the longitudinal direction of the side rails that may or may not also include vertical movement to a lesser extent than the horizontal movement. Substantially horizontal movement results in a discernible horizontal progression either forward or backward and may include, but does not necessarily include, a concurrent discernible vertical progression. The movement mechanism for at least one of the two frames additionally permits substantially vertical movement both up and down. As used herein, "up" and "down" refer to opposing movements in the latitudinal direction of the side rails between which movement is permitted As used herein, "substantially vertical movement" refers to vertical movement in the latitudinal direction of the side rails that may or may not also include horizontal movement to a lesser extent than the vertical movement. Substantially vertical movement results in a discernible vertical progression either up or down and may include, but does not necessarily include, a concurrent discernible horizontal progression. In aspects, the movement mechanism for each of the two frames permits both substantially horizontal movement and substantially vertical movement.

**[0022]** Aspects hereof contemplate that actuation of the movement mechanisms for two frames of the multi-frame manufacturing apparatus may permit the two frames to switch positions with one another relative to the conveyor- or assembly-line processing stations. Processing stations may include, by way of example and not limitation, stations for cutting, pressing, molding, adhering, and the like. By way of example only, if a first of the two frames is at a first processing station and a second of the two frames is at a second processing station, the first and second processing stations being sequentially arranged with respect to one another, actuation of the movement mechanisms for both frames may permit the first frame to proceed to the second processing station (via substantially horizontal movement or

both substantially horizontal and substantially vertical movement) and the second frame to proceed to the first processing station (again, via substantially horizontal movement or both substantially vertical and substantially horizontal movement). As will be understood and appreciated by those having ordinary skill in the art, when it is stated herein that the two frames "switch positions," it is contemplated that the two frames do not necessarily switch to the exact same positions but that the two frames change their relative position in the manufacturing process. For instance, if the first frame was at a sequentially later processing station in the manufacturing process than the second frame, it is contemplated that the two frames have switched positions if after the switch, the second frame is at a sequentially later processing station in the manufacturing process than the first frame. In exemplary aspects, the switching of frames relative to the processing stations of the manufacturing process permits processing of material associated with one frame while material is being loaded onto another frame. This increases speed of manufacture and efficiency as processing does not cease when new material is loaded into the processing system.

**[0023]** In aspects, each frame may include one or more gripping mechanisms configured to temporarily secure the non-rigid material on the frame in a non-tensioned state for processing, that is, in a state wherein the material is taut but not stretched, such that the material is not substantially distorted in any direction. If the frame is a substantially rectangular frame, aspects hereof contemplate gripping mechanisms coupled with (e.g., pivotally connected with) each of two opposing sidewalls thereof. Each gripping mechanism may be configured as a clamping mechanism and may include an open material-receiving position and a closed material-gripping position. When a non-rigid material is loaded onto the frame, the gripping mechanisms of the frame may be in the open material-receiving position. Once the material is in place and in a non-tensioned state, the gripping mechanisms may close into the closed material-gripping position such that they temporarily secure the non-rigid material in place on the frame for processing. In aspects, the gripping mechanisms grip the non-rigid material along the stretch direction (that is, the direction along which the non-rigid material has the greatest relative ability to stretch or deform from its relaxed, taut, but non-stretched state). If the material stock from which the material is loaded onto the frame is more than the quantity desired for processing on the frame, the gripped portion of the material may be cut or otherwise separated from the larger quantity of material such that it may be processed more manageably.

**[0024]** As will be discussed throughout, it is contemplated that aspects provided herein also are directed to a method of manufacturing articles (or portions thereof) formed from non-rigid materials utilizing a multi-frame manufacturing apparatus. Articles may include, by way of example and not limitation, apparel, outerwear, sock liners, other portions of footwear, and the like. In exemplary aspects, a quantity of non-rigid material is loaded onto a first frame from a material stock utilizing a material loading mechanism. The non-rigid material is loaded onto the first frame at a loading station that is one of a plurality of sequentially-arranged processing stations positioned in a conveyor- or assembly-line-type of arrangement. Aspects hereof contemplate that the first frame may be substantially rectangular and movably positioned between a pair of parallel side rails.

**[0025]** In aspects, the first frame may include one or more gripping mechanisms configured to temporarily secure the non-rigid material on the first frame in a non-tensioned state for processing (i.e., in a state where in the material is taut but not stretched). When the first frame is substantially rectangular, aspects hereof contemplate gripping mechanisms coupled with each of two opposing sidewalls, the two opposing sidewalls being adjacent the parallel side rails. Each gripping mechanism may be configured as a clamping mechanism and include an open material-receiving position and a closed material-gripping position. When the non-rigid material is loaded onto the first frame at the loading station, the gripping mechanisms of the first frame may be in the open material-receiving position. Once the material is in its desired manufacturing location and in a non-tensioned state, the gripping mechanisms may close into the closed material-gripping position temporarily securing the non-rigid material on the first frame for processing. In aspects, the non-rigid material is gripped along the stretch direction (i.e., the direction having the greatest relative ability to stretch or deform). If the material stock from which the non-rigid material is loaded onto the frame is more than the quantity desired for processing as a single processing unit, the gripped portion of the material may be cut or otherwise separated from the larger quantity of material.

**[0026]** The first frame may include at least one movement mechanism coupled therewith that permits substantially horizontal movement both forward and backward between the pair of parallel side rails. In aspects, the parallel side rails are spaced apart from one another by a distance sufficient to permit movement of the first frame there between. In aspects, the movement mechanism may be actuated causing the first frame, with the material in place, to move substantially horizontally in a first direction while, synchronously or asynchronously, a second movement mechanism associated with a second frame, also substantially rectangular and movably positioned between the pair of parallel side rails in accordance with aspects hereof, is caused to move substantially horizontally in an opposing direction and substantially vertically causing the first frame and the second frame to switch positions. In additional aspects, the movement mechanism may be actuated causing the first frame, with the material in place, to move substantially horizontally in a first direction and substantially vertically while, synchronously or asynchronously, a second movement mechanism associated with a second substantially rectangular frame (movably positioned between the pair of parallel side rails in accordance with aspects hereof) is caused to move substantially horizontally in a direction opposing the first direction and substantially vertically such that the first frame and the second frame cooperate to switch their relative positions. It will be understood and appreciated by those having ordinary skill in the art that that the first frame and the second frame have switched positions in accordance with aspects hereof when the first and second frames have changed their relative positions in the manufacturing process.

**[0027]** In aspects, one or more of the movement mechanism for the first frame, the movement mechanism for the second frame and the gripping mechanisms may be manually actuated. In aspects, one or more of the movement mechanisms and the gripping mechanisms may be actuated by coordination with a computing device (not shown) that is functionally and/or logically coupled with at least one of the multi-frame manufacturing apparatus, the processing sta-

tions, and the frames. Any and all such variations, and any combination thereof, are contemplated to be within the scope of aspects hereof.

**[0028]** Referring now to FIG. **1**, an exemplary multi-frame manufacturing apparatus **100** is depicted in accordance with aspects hereof. The multi-frame manufacturing apparatus **100** includes a first frame **102**, a second frame **104**, and first and second parallel side rails **106**, **108**. It is understood that additional elements may be included in alternative aspects. Further, it is understood that one or more of the listed elements of the multi-frame manufacturing apparatus **100** may be omitted in alternative exemplary aspects. Further, the multi-frame manufacturing apparatus **100** is depicted for illustrative purposes and may have alternative configurations, shaping, sizing, and arrangements.

**[0029]** Each of the first and second frames **102**, **104** is discrete from one another and, as more fully described below, is configured to temporarily secure a discrete portion of a non-rigid material and to move the portion of the non-rigid material through a plurality of sequentially arranged processing stations positioned in a conveyor- or assembly-line-type of arrangement. The first frame **102** includes a first pair of sidewalls **110**, **112** positioned opposite one another and a second pair of sidewalls **114**, **116** positioned opposite one another and perpendicular to the first pair of sidewalls **110**, **112** to form a substantially rectangular structure. The sidewalls **110**, **112**, **114**, **116** may be formed from one or more wall portions that collectively form a substantially rectangular perimeter sidewall surrounding a central void **118**. The central void **118** provides a material processing area that is void of interference by the first frame **102**. In exemplary aspects, the sidewalls **110**, **112**, **114**, **116** each may be discrete wall portions having end portions cut at about 45° angles in an arrangement permitting them to be mitered to form the substantially rectangular perimeter sidewall structure of the first frame **102**. In exemplary aspects, the sidewalls **110**, **112**, **114**, **116** each may be discrete wall portions having attachment surfaces that abut one another at about 90°, or any other angle permitting attachment to one another to form a rectangular structure. Any and all such variations, and any combination thereof, are contemplated to be within the scope of aspects hereof.

**[0030]** Mechanisms for fastening the wall portions together may include various screws or other fastening mechanisms known to those having ordinary skill in the art. It will be understood that the rectangular perimeter sidewall collectively formed from the first and second pairs of sidewalls **110**, **112**, **114**, **116** may be formed as a continuous structure or from any number of wall portions. Further, any mechanism for fastening wall portions to one another may be utilized within aspects hereof. The formation of the first frame **102** and/or the mechanism for securing wall portions comprising the first frame **102** are not intended to limit aspects hereof in any way. Still further, it is understood that frames having other than a substantially rectangular structure may be utilized in accordance with aspects hereof. Any and all such variations, and any combination thereof, are contemplated to be within the scope of aspects hereof.

**[0031]** Similar to the first frame **102**, the second frame **104** includes a first pair of sidewalls **120**, **122** positioned opposite one another and a second pair of sidewalls **124**, **126** positioned opposite one another and perpendicular to the first pair of sidewalls **120**, **122** to form a substantially rectangular structure. The sidewalls **120**, **122**, **124**, **126** may be formed from one or more wall portions that collectively form a substantially rectangular perimeter sidewall surrounding a central void **128** that provides a processing area free from interference by the second frame **104**. When a plurality of wall portions is assembled to form the substantially rectangular perimeter sidewall, the wall portions may include attachment surfaces that abut one another at 45°, 90°, or any other desired angle, to allow the wall portions to be joined to form a rectangular structure. Mechanisms for fastening the wall portions together may include various screws or other fastening mechanisms known to those having ordinary skill in the art. It will be understood and appreciated that the rectangular perimeter sidewall collectively formed from the first and second pairs of sidewalls **120**, **122**, **124**, **126** may be formed as a continuous structure or from any number of wall portions. Further, any mechanism for fastening wall portions to one another may be utilized within aspects hereof. The formation of the second frame **104** and/or the mechanism for securing wall portions comprising the second frame **104** are not intended to limit aspects hereof in any way. Still further, it is understood that frames having other than a substantially rectangular structure may be utilized in accordance with aspects hereof. Any and all such variations, and any combination thereof, are contemplated to be within the scope of aspects hereof.

**[0032]** Though the multi-frame manufacturing apparatus **100** of FIG. **1** includes two frames **102**, **104**, aspects hereof contemplate any quantity of frames. For instance, aspects hereof are equally applicable to a multi-frame manufacturing apparatus having three frames, four frames, five frames, etc. The quantity of frames comprising a multi-frame manufacturing apparatus as described throughout is not intended to limit the scope of aspects hereof.

**[0033]** As previously set forth, each of the first frame **102** and the second frame **104** is configured for moving a quantity of non-rigid material through a plurality of sequentially arranged processing stations positioned in a conveyor- or assembly-line-type of arrangement. As such, the first frame **102** includes a first movement mechanism **130** coupled therewith and the second frame **104** includes a second movement mechanism **132** coupled therewith. Each of the first movement mechanism **130** and the second movement mechanism **132** permits substantially horizontal movement both forward and backward between the pair of parallel side rails **106**, **108**, e.g., in the longitudinal direction **168** (see FIG. **6**) thereof. The second movement mechanism **132** further permits substantially vertical movement of the second frame **104** both up and down, e.g., in the latitudinal direction **170** (see FIG. **6**) of the side rails **106**, **108**. As more fully described below, FIG. **12** illustrates an aspect hereof wherein both a first movement mechanism and a second movement mechanism permit substantially horizontal movement and substantially vertical movement.

**[0034]** Turning now to FIG. **2**, a cross-sectional view of the multi-frame manufacturing apparatus **100** of FIG. **1** is illustrated, the cross-section being taken along line **2**.-**2**. of FIG. **1**. As illustrated, the first parallel side rail **106** includes a first track **134** and a second track **136**. The first track **134** is positioned vertically beneath the second track **136** in the latitudinal direction **170** (see FIG. **6**) thereof. It will be understood by those having ordinary skill in the art that, while shown only with respect to the first side rail **106**, the second side rail **108** includes similar and opposing structure

to the first track **134** and the second track **136** illustrated in association with the first side rail **106**.

**[0035]** The first movement mechanism **130** (visible with reference to FIG. **1** and FIG. **3**) is coupled with each of the first pair of opposing sidewalls **110**, **112** of the first frame **102** and is configured to movably cooperate with the first track **134**. In aspects, the first movement mechanism **130** may include a movement actuating device **131**, e.g., a linear actuator, motor, or the like, that cooperates with the first track **134** to propel the first frame **102** substantially horizontally in the forward and backward directions. The second movement mechanism **132** (visible with reference to FIGS. **1**, **2** and **4**) is coupled with each of the first pair of opposing sidewalls **120**, **122** of the second frame **104** and is configured to movably cooperate with the second track **136**. With reference to FIG. **5**, a cross-sectional view is depicted showing the second movement mechanism **132** in cooperation with the second track **136** of the first parallel side rail **106**, the cross-section taken along line **5**.-**5**. of FIG. **1**. In aspects, the second movement mechanism **132** may include a movement actuating device **133**, e.g., a linear actuator, motor, or the like, that cooperates with the second track **136** to propel the second frame **104** substantially horizontally in the forward and backward directions. In exemplary aspects hereof, the second movement mechanism **132** also may include at least one piston **135** that cooperates with the second frame **104** to propel the second frame **104** substantially vertically in the up and down directions. As more fully described below, the illustrated arrangement permits the second frame **104** to pass vertically over the first frame **102** as the two frames move in opposing horizontal directions such that their relative position with respect to the manufacturing apparatus **100** is switched when the first movement mechanism **130** and the second movement mechanism **132** are actuated.

**[0036]** Referring back to FIG. **2**, illustrated is a cross-section of the multi-frame manufacturing apparatus **100** of FIG. **1** taken along line **2**.-**2**. thereof. The first parallel side rail **106** includes a first track **134** and a second track **136**, the first track **134** being positioned vertically beneath the second track **136**. The first movement mechanism **130** (visible with reference to FIG. **1** and FIG. **3**) is coupled with the opposing sidewall **110** of the first frame **102** and is configured to movably cooperate with the first track **134**. The second movement mechanism **132** is coupled with the opposing sidewall **120** of the second frame **104** and is configured to movably cooperate with the second track **136**.

**[0037]** In aspects, actuation of the first movement mechanism **130** and the second movement mechanism **132** may cause the first frame **102** and the second frame **104** to switch positions with one another relative to the sequentially arranged processing stations. An exemplary process in which such position switching may occur is illustrated with reference to FIGS. **7**-**10**. With reference to FIG. **7**, the first frame is illustrated as having moved substantially horizontally in a first direction, the discernible horizontal progression relative to the position of the first frame **102** in FIG. **2** being visible. With reference to FIG. **8**, the second frame **104** is illustrated as having moved substantially vertically in an upward direction. With reference to FIG. **9**, once positioned to clear the first frame **102**, the second frame **104** is caused to move substantially horizontally in the horizontal direction opposite of the horizontal direction in which the first frame **102** was caused to move. As shown in FIG. **10**, synchronously, the first frame **102** is illustrated as having continued its horizontal progression in the first direction. As illustrated in FIG. **11**, the second frame **104** is illustrated as having moved substantially vertically in a downward direction such that the first and second frames **102**, **104** have switched their relative places in the sequential arrangement of the processing stations.

**[0038]** With reference back to FIG. **1**, each of the first frame **102** and the second frame **104** includes one or more gripping mechanisms configured to temporarily secure the non-rigid material in the respective frame **102**, **104** in a non-tensioned state for processing. As illustrated, the first frame **102** includes first and second gripping mechanisms **138**, **140** coupled with its opposing first pair of sidewalls **110**, **112**, those sidewalls **110**, **112** that are adjacent the first and second parallel side rails **106**, **108**. Similarly, the second frame **104** includes first and second gripping mechanisms **142**, **144** coupled with its opposing first pair of sidewalls **120**, **122**. In aspects, the gripping mechanisms **138**, **140**, **142**, **144** may be pivotally connected with the frame (as shown with respect to gripping mechanism **142** of FIG. **5**). Each of the first and second gripping mechanisms **138**, **140** of the first frame **102** and the first and second gripping mechanisms **142**, **144** of the second frame **104** may be configured as a clamping mechanism (as shown) and include an open material-receiving position and a closed material-gripping position. The first and second gripping mechanisms **138**, **140** of the first frame **102** are illustrated in the open material-receiving position (best seen at the first gripping mechanism **138** as the second parallel side rail **108** largely obscures the view of the second gripping mechanism **140**). In the open material-receiving position, the first and second gripping mechanisms **138**, **140** are in a released state and do not substantially obscure the top surface of the first frame **102**. In this way, the first frame **102** may receive a non-rigid material freely over the central void **118** and around the perimeter sidewall formed from the first pair of sidewalls **110**, **112** and the second pair of sidewalls **114**, **116**, as more fully described below. The first gripping mechanism **138** of the first frame **102** in its open material-receiving position additionally is shown in the cross-sectional view of FIG. **2**, as well as in the view of FIG. **3**.

**[0039]** Once the desired material is in place and in a non-tensioned state (i.e., in a state where in the material is taut but not stretched) over the desired frame, the gripping mechanisms may be closed or clamped to temporarily secure the non-rigid material into place and prevent misshaping or other deformity. In FIG. **1**, the first and second gripping mechanisms **142**, **144** of the second frame **104** are illustrated in the closed material-gripping position. In the closed material-gripping position, the first and second gripping mechanisms **142**, **144** are in an actuated state and temporarily hold the non-rigid material over the central void **128** and to the top surface of the first pair of sidewalls **120**, **122** of the second frame **104** until such time as the first and second gripping mechanisms **142**, **144** are released. The first gripping mechanism **142** of the second frame **104** in its closed material-gripping position additionally is shown in the cross-sectional view of FIG. **2** as well as in the view of FIG. **4**.

**[0040]** Exemplary aspects hereof also are directed to a method of manufacturing articles (or portions thereof) formed from non-rigid materials utilizing a multi-frame manufacturing apparatus (for instance, a two frame manu-

facturing apparatus) arranged for moving the non-rigid material through a plurality of sequentially arranged processing stations positioned in a conveyor- or assembly-line-type of arrangement. Turning to FIG. **6**, a perspective view is depicted of an exemplary multi-frame manufacturing apparatus **600** in cooperation with a material loading mechanism **146**. The illustrated material loading mechanism **146** includes a roll **148** of non-rigid material and a loading frame **150** that is configured to facilitate loading of the non-rigid material onto a first frame **152** at a material loading station **154** (e.g., the first station in a series of sequentially positioned processing stations in a conveyor- or assembly-line-type arrangement). The non-rigid material includes a non-stretch direction **168** (i.e., a direction of relatively less stretch or give when the material is in a tensioned state) and a stretch direction **170** (i.e., a direction of relatively more stretch or give when the material is in a tensioned state). In exemplary aspects, a portion of non-rigid material from the material roll **148** may be loaded onto the first frame **152** at the material loading station **154** when first and second gripping mechanisms **156**, **158** for the first frame **152** are in their open material-receiving position, as shown. Once the material has reached its desired placement with respect to the first frame **152**, the first and second gripping mechanisms **156**, **158** for the first frame **152** may be closed into their closed material-gripping position, temporarily securing a portion of the non-rigid material to the first frame **152**. A second frame **160** is illustrated in FIG. **6** with a portion of material **162** secured thereto by closed first and second gripping mechanisms **164**, **166**. In aspects, once a material portion is secured on a frame, it may be cut or otherwise separated from the material roll **148** and the loading frame **150** may return to a position of disengagement with the frame.

**[0041]** As previously set forth with reference to FIGS. **7-11**, supra, in accordance with aspects hereof, movement mechanisms respectively associated with each of the first frame **152** and the second frame **160** may cause the first frame **152** to move substantially horizontally in a first direction while synchronously the movement mechanism associated with the second frame may cause the second frame **160** to move substantially horizontally in an opposing direction and substantially vertically such that the first frame **152** and the second frame **160** switch or change positions. In this way, manufacturing with respect to one of the first and second frames **152**, **160** may continue while non-rigid material is being loaded onto the other of the first and second frames **152**, **160**.

**[0042]** Referring now to FIG. **12**, an exemplary multi-frame manufacturing apparatus **1200** having first and second movement mechanisms that both permit substantially horizontal movement and substantially vertical movement is depicted in accordance with aspects hereof. As with the multi-frame manufacturing apparatus of FIGS. **1-11**, the multi-frame manufacturing apparatus **1200** includes a first frame **1202**, a second frame **1204**, and first and second parallel side rails **1206**, **1208**. It is understood that additional elements may be included in alternative aspects. Further, it is understood that one or more of the listed elements of the multi-frame manufacturing apparatus **1200** may be omitted in alternative exemplary aspects. Further, the multi-frame manufacturing apparatus **1200** is depicted for illustrative purposes and may have alternative configurations, shaping, sizing, and arrangements.

**[0043]** Each of the first and second frames **1202**, **1204** is discrete from one another and is configured to temporarily secure a discrete portion of a non-rigid material and to move the portion of the non-rigid material through a plurality of sequentially arranged processing stations positioned in a conveyor- or assembly-line-type of arrangement. The first frame **1202** includes a first pair of sidewalls **1210**, **1212** positioned opposite one another and a second pair of sidewalls **1214**, **1216** positioned opposite one another and perpendicular to the first pair of sidewalls **1210**, **1212** to form a substantially rectangular structure. The sidewalls **1210**, **1212**, **1214**, and **1216** may be formed from one or more wall portions that collectively form a substantially rectangular perimeter sidewall surrounding a central void (not shown). The central void (not shown) provides a material processing area that is void of interference by the first frame **1202**.

**[0044]** In exemplary aspects, the sidewalls **1210**, **1212**, **1214**, **1216** each may be discrete wall portions having end portions cut at any other angle permitting attachment to one another to form a rectangular structure. Mechanisms for fastening the wall portions together may include various screws or other fastening mechanisms known to those having ordinary skill in the art. It will be understood that the rectangular perimeter sidewall collectively formed from the first and second pairs of sidewalls **1210**, **1212**, **1214**, **1216** may be formed as a continuous structure or from any number of wall portions. Further, any mechanism for fastening wall portions to one another may be utilized within aspects hereof. The formation of the first frame **1202** and/or the mechanism for securing wall portions comprising the first frame **1202** are not intended to limit aspects hereof in any way. Still further, it is understood that frames having other than a substantially rectangular structure may be utilized in accordance with aspects hereof. Any and all such variations, and any combination thereof, are contemplated to be within the scope of aspects hereof.

**[0045]** Similar to the first frame **1202**, the second frame **1204** includes a first pair of sidewalls **1220**, **1222** positioned opposite one another and a second pair of sidewalls **1224**, **1226** positioned opposite one another and perpendicular to the first pair of sidewalls **1220**, **1222** to form a substantially rectangular structure. The sidewalls **1220**, **1222**, **1224**, **1226** may be formed from one or more wall portions that collectively form a substantially rectangular perimeter sidewall surrounding a central void (not shown) that provides a processing area free from interference by the second frame **1204**. When a plurality of wall portions is assembled to form the substantially rectangular perimeter sidewall, the wall portions may include attachment surfaces that abut one another at any desired angle, to allow the wall portions to be joined to form a rectangular structure. Mechanisms for fastening the wall portions together may include various screws or other fastening mechanisms known to those having ordinary skill in the art. It will be understood and appreciated that the rectangular perimeter sidewall collectively formed from the first and second pairs of sidewalls **1220**, **1222**, **1224**, **1226** may be formed as a continuous structure or from any number of wall portions. Further, any mechanism for fastening wall portions to one another may be utilized within aspects hereof. The formation of the second frame **1204** and/or the mechanism for securing wall portions comprising the second frame **1204** are not intended to limit aspects hereof in any way. Still further, it is understood that frames having other than a substantially rectan-

gular structure may be utilized in accordance with aspects hereof. Any and all such variations, and any combination thereof, are contemplated to be within the scope of aspects hereof.

**[0046]** Though the multi-frame manufacturing apparatus **1200** of FIG. **12** includes two frames **1202**, **1204**, aspects hereof contemplate any quantity of frames. For instance, aspects hereof are equally applicable to a multi-frame manufacturing apparatus having three frames, four frames, five frames, etc. The quantity of frames comprising a multi-frame manufacturing apparatus as described throughout is not intended to limit the scope of aspects hereof.

**[0047]** As previously set forth, each of the first frame **1202** and the second frame **1204** is configured for moving a quantity of non-rigid material through a plurality of sequentially arranged processing stations positioned in a conveyor- or assembly-line-type of arrangement. As such, the first frame **1202** includes a first movement mechanism **1230** coupled therewith and the second frame **104** includes a second movement mechanism **1232** coupled therewith. Each of the first movement mechanism **1230** and the second movement mechanism **1232** permits substantially horizontal movement both forward and backward between the pair of parallel side rails **1206**, **1208**, e.g., in the longitudinal direction **1268** thereof. Each of the first movement mechanism **1230** and the second movement mechanism **1232** further permits substantially vertical movement of the first frame **1202** and the second frame **1204**, respectively, both up and down, e.g., in the latitudinal direction **1270** of the side rails **1206**, **1208**.

**[0048]** The first movement mechanism **1230** is coupled with each of the first pair of opposing sidewalls **1210**, **1221** of the first frame **1202** and with opposing side rails **1206**, **1208** and is configured to movably cooperate with the first and second side rails **1206**, **1208**. In aspects, the first movement mechanism **1230** may include one or more movement actuating devices, e.g., a linear actuators, motors, or the like, that cooperate with the first and second side rails **1206**, **1208** to propel the first frame **1202** substantially horizontally in the forward and backward directions, as well as substantially vertically in the up and down directions. The second movement mechanism **1232** is coupled with each of the first pair of opposing sidewalls **1220**, **1222** of the second frame **1204** and with the opposing side rails **1206**, **1208** and also is configured to movably cooperate with the first and second side rails **1206**, **1208**. In aspects, the second movement mechanism **1232** may include one or more movement actuating devices, e.g., a linear actuators, motors, or the like, that cooperate with the first and second side rails **1206**, **1208** to propel the second frame **1204** substantially horizontally in the forward and backward directions, as well as substantially vertically in the up and down directions. The illustrated arrangement permits the second frame **1204** to pass vertically over the first frame **1202** and/or the first frame **1202** to pass vertically over the second frame **1204** as the two frames move in opposing horizontal directions such that their relative position with respect to the manufacturing apparatus **1200** is switched when the first movement mechanism **1230** and the second movement mechanism **1232** are actuated.

**[0049]** In aspects, actuation of the first movement mechanism **1230** and the second movement mechanism **1232** may cause the first frame **1202** and the second frame **1204** to switch positions with one another relative to the sequentially arranged processing stations. It will be understood by those having ordinary skill in the art that gripping mechanisms as described with respect to aspects illustrated in FIGS. **1-11** are included in the multi-frame manufacturing apparatus **1200** of FIG. **12** and function as previously set forth.

**[0050]** As can be seen, aspects hereof relate to a multi-frame manufacturing apparatus for manufacturing articles, for instance, sock liners, formed of a non-rigid material. Aspects hereof further relate to a method of manufacturing articles, for instance, sock liners, utilizing a multi-frame manufacturing apparatus. A multi-frame manufacturing apparatus having a structure as described herein permits interchangeability of the position of multiple manufacturing frames enabling processing of one or more articles to progress while material for another article is being loaded onto the apparatus. A multi-frame manufacturing apparatus having a structure as described herein further permits processing of a portion of a non-rigid material separated from a larger material stock, the portion being held in a non-tensioned state during processing and, accordingly, reducing waste occasioned by deformed and consequently unusable articles.

**[0051]** Although the multi-frame manufacturing apparatus and method of manufacturing articles formed from non-rigid materials utilizing a multi-frame manufacturing apparatus are described above by referring to particular aspects, it should be understood that modifications and variations could be made without departing from the intended scope of protection provided by the following claims. It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of the claims.

**[0052]** While specific elements and steps are discussed in connection to one another, it is understood that any element and/or steps provided herein is contemplated as being combinable with any other elements and/or steps regardless of explicit provision of the same while still being within the scope provided herein. Since many possible aspects may be made of the disclosure without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

What is claimed is:

**1**. A manufacturing tool comprising:

a first rectangular frame having at least one perimeter sidewall surrounding a first central void; and

a second rectangular frame having at least one perimeter sidewall surrounding a second central void,

wherein two opposing sides of each of the first and second rectangular frames include a gripping mechanism that temporarily grips a non-rigid material and a movement mechanism that permits at least one of horizontal movement and vertical movement between first and second parallel side rails.

**2**. The manufacturing tool of claim **1**, wherein the gripping mechanism is a clamping mechanism that has an open material-receiving position and a closed material-gripping position.

**3**. The manufacturing tool of claim **1**, wherein the non-rigid material includes a stretch direction and a non-stretch direction, and wherein the gripping mechanism grips the non-rigid material along the stretch direction.

**4**. The manufacturing tool of claim **1**, wherein each of the first and second parallel side rails includes a first track and

a second track, wherein the movement mechanism of the first rectangular frame is coupled with the first track such that horizontal movement is permitted, and wherein the movement mechanism of the second rectangular frame is coupled with the second track such that horizontal and vertical movement are permitted.

**5**. The manufacturing tool of claim **4**, further comprising at least one linear actuator that causes the horizontal movement of the first rectangular frame and the second rectangular frame.

**6**. The manufacturing tool of claim **5**, further comprising at least one piston that causes the vertical movement of the second rectangular frame.

**7**. The manufacturing tool of claim **6**, wherein the at least one linear actuator and the at least one piston cooperate with one another to permit the first rectangular frame and the second rectangular frame to switch positions.

**8**. The manufacturing tool of claim **1**, further comprising a material loading mechanism that loads the non-rigid material onto one of the first rectangular frame and the second rectangular frame.

**9**. A manufacturing tool comprising:

a first frame having a first pair of sidewalls positioned opposite one another and a second pair of sidewalls positioned opposite one another and perpendicular to the first pair of sidewalls to form a first rectangular structure;

a second frame having a first pair of sidewalls positioned opposite one another and a second pair of sidewalls positioned opposite one another and perpendicular to the first pair of sidewalls to form a second rectangular structure; and

first and second parallel side rails spaced apart from one another at a distance sufficient for the first and second frames to be movably positioned between the first and second parallel side rails;

wherein the first frame and the second frame are movably positioned between the first and second parallel sidewalls such that substantially horizontal movement is permitted forward and backward,

wherein at least one of the first frame and the second frame is movably positioned between the first and second parallel sidewalls such that substantially vertical movement is permitted up and down,

and wherein each sidewall of the first pair of sidewalls of the first frame and each sidewall of the first pair of sidewalls of the second frame includes a gripping mechanism for temporarily gripping a non-rigid material.

**10**. The manufacturing tool of claim **9**, wherein the gripping mechanisms of each of the first pair of sidewalls of the first frame and the first pair of sidewalls of the second frame is a clamping mechanism that has an open material-receiving position and a closed material-gripping position.

**11**. The manufacturing tool of claim **9**, wherein the non-rigid material includes a stretch direction and a non-stretch direction, and wherein the gripping mechanism grips the non-rigid material along the stretch direction.

**12**. The manufacturing tool of claim **9**, wherein each of the first and second parallel side rails includes a first track and a second track, and wherein each sidewall of the first pair of sidewalls of the first frame includes a first movement mechanism coupled with the first track of each of the first and second parallel side rails such that horizontal movement is permitted, and wherein each sidewall of the first pair of sidewalls of the second frame includes a second movement mechanism coupled with the second track of each of the first and second parallel side rails such that horizontal and vertical movement are permitted.

**13**. The manufacturing tool of claim **9**, further comprising at least one linear actuator that causes substantially horizontal movement of the first frame and the second frame.

**14**. The manufacturing tool of claim **13**, further comprising at least one piston that causes substantially vertical movement of the at least one of the first frame and the second frame.

**15**. The manufacturing tool of claim **14**, wherein the at least one linear actuator and the at least one piston cooperate with one another to permit the first frame and the second frame to switch positions.

**16**. The manufacturing tool of claim **9**, further comprising a material loading mechanism that loads the non-rigid material onto one of the first frame and the second frame.

**17**. A method of manufacture utilizing a multi-frame manufacturing apparatus, comprising:

loading a non-rigid material onto a first rectangular frame at a loading station, the first rectangular frame having opposing sides that each include a gripping mechanism and a first movement mechanism;

causing the gripping mechanisms to temporarily grip the non-rigid material onto the first rectangular frame;

causing the first movement mechanism to move the first rectangular frame substantially horizontally in a first direction while synchronously causing a second movement mechanism associated with a second rectangular frame to move substantially horizontally in an opposing direction and substantially vertically such that the second rectangular frame and the first rectangular frame change positions.

**18**. The method of claim **17**, wherein the gripping mechanism is a clamping mechanism that has an open material-receiving position and a closed material-gripping position.

**19**. The method of claim **17**, wherein the non-rigid material includes a stretch direction and a non-stretch direction, and wherein the gripping mechanisms grip the non-rigid material along the stretch direction.

**20**. The method of claim **17**, wherein the first movement mechanism comprises at least one linear actuator that causes the horizontal movement of the first rectangular frame, and wherein the second movement mechanism comprises at least one linear actuator that cause the horizontal movement of the second rectangular frame and at least one piston that causes the vertical movement of the second rectangular frame.

* * * * *