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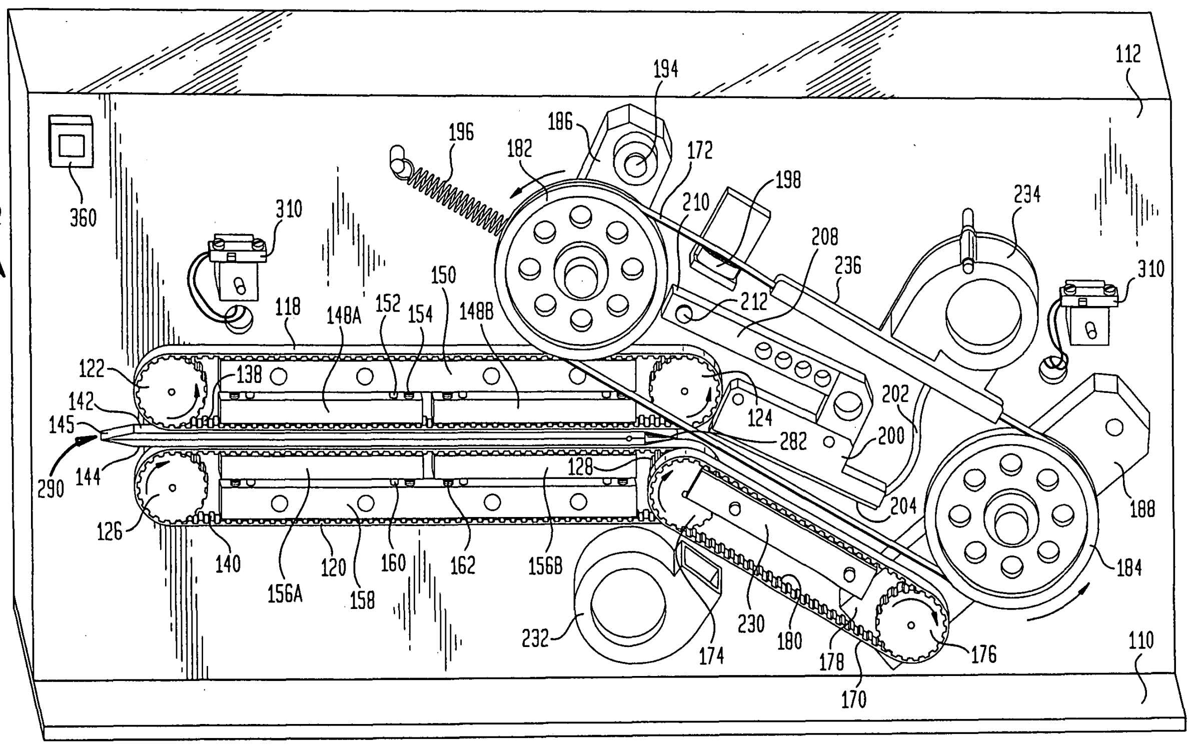
(54) Apparatus and method for forming inflated packaging cushions

(57) An inflation apparatus (100) automatically inflates and seals a plurality of pockets (24) preformed in a film web (10) to form packaging cushions. As the film web is advanced, a stream of inflation gas is directed from an inflation port (282) into each of the pockets. The stream of inflation gas is directed in a flow direction having a component in the direction of travel. A sealing mechanism is positioned as close as possible to the inflation port (282) so that the opening of each pocket is almost entirely closed and sealed while the stream of inflation gas is directed into the pocket. As a result, it is possible to achieve more fully inflated packaging cushions on a consistent basis.

FIG. 2



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to packaging materials and, more particularly, to an improved apparatus for producing inflated cushions for packaging.

[0002] Various apparatus and methods for forming inflated packaging cushions are known. Such inflated cushions are used to package items by wrapping the items in the cushions and placing the wrapped items in a shipping carton, or by simply placing one or more inflated cushions inside of a shipping carton along with an item to be shipped. The cushions protect the packaged item by absorbing impacts that may otherwise be fully transmitted to the packaged item during transit, and also restrict movement of the packaged item within the carton to further reduce the likelihood of damage to the item.

[0003] Conventional apparatus for forming inflated packaging cushions tend to be rather large and complex machines which are expensive and cumbersome to maintain. Because of their large size and complexity, it is difficult to install such apparatus at the manufacturing sites and other locations where packaging takes place. Accordingly, it has been a practice in the past to inflate the cushions at a central location, and then ship the inflated cushions to the packaging site. Because of the volume which these cushions occupy, this practice is grossly inefficient and costly, and creates storage problems at the packaging site.

[0004] To overcome the foregoing problems, inflation apparatus have been developed which are small in size and easy to operate, thereby enabling these machines to be placed directly at packaging sites. As a result, packaging cushions may be inflated at the use site, in many cases immediately prior to their use. While such machines have lowered the cost of inflated packaging cushions and have expanded their use, they often do not reliably inflate the cushions to the level desired.

[0005] Accordingly, there remains a need in the art for a small and simple apparatus which may be placed directly at a packaging site, and which is capable of inflating packaging cushions to a desired level on a consistent and reliable basis.

SUMMARY OF THE INVENTION

[0006] The present invention addresses these needs.

[0007] One aspect of the present invention provides an apparatus for forming inflated cushions, including a film web defining a plurality of preformed pockets, each pocket having an opening; a transport mechanism operable to convey the film web along a transport path in a direction of travel; an inflation mechanism positioned adjacent the transport path and having a first outlet port operable to direct a first stream of inflation gas into each of the pockets to form inflated cushions, the first stream of inflation gas being directed in a flow direction, the flow direction having a component in the direction of travel; and a sealing mechanism operable to seal closed the opening of each pocket. In preferred embodiments, the inflation gas is air, and the apparatus further includes a gas ring compressor for supplying pressurized air to the inflation mechanism.

[0008] Preferably, the flow direction also has a component in a direction orthogonal to the direction of travel. More preferably, the component in the direction of travel is greater than the component in the direction orthogonal to the direction of travel.

[0009] The inflation mechanism may further include a second outlet port operable to direct a second stream of inflation gas into each of the pockets, the second stream of inflation gas flowing in a direction substantially orthogonal to the direction of travel.

[0010] The sealing mechanism may include a pair of opposed members defining a nip therebetween, at least one of the opposed members including a roller, and at least a portion of the first outlet port being positioned between the nip and an imaginary vertical line tangential to the roller.

[0011] Preferably, the flow direction is at an angle to the direction of travel of between about 5° and about 60°, and more preferably between about 5° and about 30°. A flow direction at an angle of about 11° to the direction of travel is highly preferred.

[0012] Another aspect of the present invention provides an apparatus for forming inflated cushions, including a film web defining a plurality of preformed pockets, each pocket having an opening; a transport mechanism operable to convey the film web along a transport path in a direction of travel; an inflation mechanism positioned adjacent the transport path and having a first outlet port operable to direct a first stream of inflation gas into each of the pockets to form inflated cushions; and a sealing mechanism operable to seal closed the opening of each pocket, the sealing mechanism including a pair of opposed members defining a nip therebetween, at least one of the opposed members including a roller, and at least a portion of the first outlet port being positioned between the nip and an imaginary vertical line tangential to the roller.

[0013] Yet another aspect of the present invention provides a method for forming inflated cushions, including providing a film web defining a plurality of preformed pockets, each pocket having an opening; conveying the film web along a transport path in a direction of travel; directing a first stream of inflation gas into each of the pockets to form inflated cushions, the first stream of inflation gas being directed in a flow direction, the flow direction having a component in the direction of travel; and sealing closed the opening of each pocket.

[0014] In preferred methods, the step of sealing closed the opening of a selected pocket is initiated while the first stream of inflation gas is directed into the selected pocket.

[0015] In preferred embodiments of both the apparatus and the method, the film web may be conveyed past the inflation mechanism in the direction of travel and may be conveyed past the sealing mechanism in a direction transverse to the direction of travel. The film web may be conveyed past the inflation mechanism at a first transport speed and may be conveyed past the sealing mechanism at a second transport speed slower than the first transport speed. Additionally, the film web may be conveyed past the inflation mechanism with a first tension and may be conveyed past the sealing mechanism with a second tension less than the first tension.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] A more complete appreciation of the subject matter of the present invention and the various advantages thereof can be realized by reference to the following detailed description in which reference is made to the accompanying drawings in which:

[0017] Fig. 1 is a highly schematic front perspective view of an inflation apparatus in accordance with the present invention;

[0018] Fig. 2 is a highly schematic side perspective view of the inflation apparatus, with the outer shroud removed to show the transport, inflation and sealing mechanisms thereof;

[0019] Fig. 3 is a highly schematic perspective view of the opposite side of the inflation apparatus, with the outer cover removed to show the interior thereof;

[0020] Figs. 4A, 4B and 4C are highly schematic enlarged partial views showing the advancement of the preformed film web through the inflation and sealing mechanisms of the inflation apparatus;

[0021] Fig. 5 is a top plan view of the inflation shoe, partially broken away to show the passageways therein;

[0022] Fig. 6 is a perspective view of a portion of one embodiment of a preformed film web which may be used in connection with the apparatus of Fig. 1;

[0023] Fig. 7 is a highly schematic rear perspective view of the inflation apparatus showing the various components of the material supply section thereof; and

[0024] Fig. 8 is a plan view of a portion of another embodiment of a preformed film web which may be used in connection with the apparatus of Fig. 1.

DETAILED DESCRIPTION

[0025] An apparatus 100 for forming inflated packaging cushions in accordance with the present invention is illustrated in Fig. 1. Generally speaking, apparatus 100 receives a film web 10 preformed with a plurality of open pockets, conveys the web past an inflation zone where the pockets are inflated with a gas, and then seals the pockets closed to entrap the gas therein. Each inflated pocket acts as a cushion for protecting an article packaged in an outer container.

[0026] Film web 10 may be formed from any flexible material that can be manipulated by apparatus 100 and retain a gas as described herein, including various thermoplastic materials, such as polyethylene homopolymer or copolymer, polypropylene homopolymer or copolymer, etc. Non-limiting examples of suitable thermoplastic polymers include polyethylene homopolymers, such as low density polyethylene (LDPE) and high density polyethylene (HDPE), and polyethylene copolymers such as ionomers, EVA, EMA, heterogeneous (Ziegler-Natta catalyzed) ethylene/alpha-olefin copolymers, and homogeneous (metallocene single-site catalyzed) ethylene/alpha-olefin copolymers. Ethylene/alpha-olefin copolymers are copolymers of ethylene with one or more comonomers selected from C_3 to C_{20} alphaolefins, such as 1-butene, 1-pentene, 1-hexene, 1-octene, methyl pentene and the like, in which the polymer molecules comprise long chains with relatively few side chain branches, including linear low density polyethylene (LLDPE), linear medium density polyethylene (LMDPE), very low density polyethylene (VLDPE), and ultra-low density polyethylene (ULDPE). Various other materials are also suitable for use as film web 10 including, for example, polypropylene homopolymer or polypropylene copolymer (e.g., propylene/ethylene copolymer), polyesters, polystyrenes, polyamides, polycarbonates, etc. The film may be monolayer or multilayer and can be made by any known coextrusion process by melting the component polymer(s) and extruding or coextruding them through one or more flat or annular dies.

[0027] As shown in Fig. 6, film web 10 includes a pair of film plies 12 and 14 juxtaposed in substantially coextensive relationship so as to define an open longitudinal edge 16 and a closed longitudinal edge 18. In a preferred arrangement, closed longitudinal edge 18 is formed by folding a single ply of film longitudinally so that the longitudinal edges thereof are brought together or in close proximity to one another. Alternatively, film web 10 may be formed from a pair of separate film plies which are juxtaposed in substantially coextensive relationship and sealed together along one pair of adjacent longitudinal side edges, such as by heat sealing, to form closed longitudinal edge 18.

[0028] As used herein with reference to film web 10, the term "longitudinal" refers to the direction of conveyance of film web 10 through apparatus 100 as indicated in the drawings. The term "longitudinal" also refers to the length direction of film web 10.

[0029] Film web 10 further includes a plurality of spaced apart transverse seals 20 which extend from closed longitudinal edge 18 toward open longitudinal edge 16, but spaced therefrom so as to define a skirt 22 extending continuously in the longitudinal direction adjacent the open longitudinal edge 16 of the film web. Transverse seals 20 may be formed bv gluing, heat sealing or otherwise binding the juxtaposed film plies to one another so as to define a plurality of pre-formed pockets 24, each bounded by a pair of transverse seals 20 and the closed longitudinal edge 18 of film web 10, and each having an opening adjacent the open longitudinal edge of the film web. The size of pockets 24 will depend upon the width of film web 10 between closed longitudinal edge 18 and open longitudinal edge 16, as well as the spacing between transverse seals 20. As the size of pockets 24 will determine the size of the inflated packaging cushions 30 formed by apparatus 100, cushions of any desired size may be formed by selecting a film web 10 having an appropriate width and forming transverse seals at appropriately spaced intervals.

[0030] A perforation 26 or other line of weakness may be provided in film web 10 at each transverse seal 20. Perforations 26 preferably extend from closed longitudinal edge 18 to open longitudinal edge 16 so that one or more inflated cushions 30 may be readily separated from the remainder of film web 10 as desired. When adjacent inflated cushions are separated from one another along a perforation 26, the corresponding transverse seal 20 will be divided in two yet remain in a sealed condition, thereby maintaining the inflation of both of the adjacent cushions.

[0031] Film web 10 is preferably provided in the form of a supply roll 50 consisting of an extended length of the film web wound on a spool. As described more fully below, the spool may be mounted adjacent an inlet end 102 of apparatus 100 so that film web 10 may be fed into and through apparatus 100 in a substantially continuous manner.

[0032] Referring to Figs. 2 and 3, apparatus 100 includes a platform or base 110 and a wall 112 projecting upwardly from base 110 for supporting the various components of the apparatus. A plurality of feet (not shown) may depend from base 110 to support apparatus 100 on a bench, platform or other support surface P.

[0033] Film web 10 is advanced into apparatus 100 by a transport mechanism which includes a pair of timing belts 118 and 120 formed from rubber or other flexible, high friction material. Timing belt 118 is mounted for rotation in a counterclockwise direction around idler gear 122 and driven gear 124. On the other hand, timing belt 120 is mounted for rotation in a clockwise direction around idler gear 126 and driven gear 128. Gears 124 and 128 may be driven at the same speed and in opposite directions by a single drive motor 130 mounted on the opposite side of wall 112. Referring to Fig. 3, a gear 132 may be mounted on a common shaft with gear 124, and a gear 134 may be mounted on a common shaft with gear 128. A gear 136 mounted on the drive shaft of motor 130 is meshed with gear 134 which, in turn, is meshed with gear 132 so that any rotation of the motor drive shaft causes gears 124 and 128 to rotate with one another at the same speed, but in opposite directions.

[0034] Timing belt 118 includes a plurality transverse splines 138 which engage with the teeth of gears 122 and 124 so that, as gear 124 is rotated in the counterclockwise direction, it causes the lower portion of timing belt 118 to move in an advancing longitudinal direction (i.e., toward the right of the drawing in Fig. 2). The movement of timing belt 118 results in a corresponding rotation of idler gear 122. Similarly, timing belt 120 includes a plurality of transverse splines 140 which engage with the teeth of gears 126 and 128 so that, as gear 128 is rotated in the clockwise direction, it causes a corresponding movement of the upper portion of timing belt 120 in the advancing longitudinal direction (i.e., to the right of the drawing in Fig. 2). The movement of timing belt 120 results in a corresponding rotation of idler gear 126.

[0035] As timing belt 118 advances, its lower portion is urged against the upper surface 142 of an inflation shoe 145 by a pair of pressure bars 148A and 148B. Each of pressure bars 148A and 148B is mounted to a fixed support 150 for sliding movement in a vertical direction over a pair of pins 152. A pair of springs 154 interposed between fixed support 150 and each of pressure bars 148A and 148B bias the pressure bars away from the fixed support and against the lower portion of timing belt 118.

[0036] In a similar vein, as timing belt 120 advances, its upper portion is urged against the lower surface 144 of inflation shoe 145 by a pair of pressure bars 156A and 156B. Each of pressure bars 156A and 156B is mounted to a fixed support 158 for sliding movement in a vertical direction over a pair of pins 160. A pair of springs 162 interposed between fixed support 158 and each of pressure bars 156A and 156B bias the pressure bars away from the fixed support and against the upper portion of timing belt 120. Pressure bars 148A, 148B, 156A and 156B may be formed from a lightweight material which is easily biased by springs 154 and 162, respectively, and are preferably coated with a low friction material to facilitate the sliding movement of timing belts 118 and 120 across same. In a preferred embodiment, pressure bars 148A, 148B, 156A and 156B may be formed from aluminum having a polytetrafluoroethylene coating.

[0037] The transport support mechanism of apparatus 100 further includes a timing belt 170 and an opposed metal seal belt 172. Timing belt 170 and metal sealing belt 172 preferably are oriented at a downward angle relative to timing belts 118 and 120, thereby defining a "dogleg" in the path of travel in film web 10. Timing belt 170 is mounted for rotation in the clockwise direction around a driven gear 174 and an idler gear 176. Gear 174 may be mounted on a common shaft with gear 128 and outboard thereof so that rotation of the drive shaft of motor 130 causes both gears to rotate together. Because gear 174 is mounted outboard of gear 128, timing belt 170 will be spaced farther from wall 112 than timing belts 118 and 120. To accommodate this spacing and assure that timing belt 170 is oriented substantially parallel to wall 112, a spacer block 178 may be interposed between gear 176 and wall 112.

[0038] Timing belt 170 includes a plurality of transverse splines 180 which engage with the teeth of gears 174 and 176 so that, as gear 174 is rotated in the clockwise direction, it causes the upper portion of the timing belt to move in an advancing longitudinal direction (i.e., toward the bottom right of the drawing in Fig. 2). The movement of timing belt 170 results in a corresponding rotation of idler gear 176. Thus, by mounting driven gears 128 and 174 on the same shaft for rotation in the same direction and at the same speed as one another, timing belts 120 and 170 are caused to move at the same speed in the same rotational direction.

[0039] Sealing belt 172 may be formed from any metal capable of conducting heat from a heated seal bar 200 to the film web 10 traveling below the sealing belt, while at the same time withstanding the temperatures at which film web 10 is sealed closed, as will be described below. A preferred metal in this regard is steel, with a steel belt coated with low friction polytetrafluoroethylene being highly preferred. Sealing belt 172 is mounted for rotation in a counterclockwise direction around a pair of spaced pulleys 182 and 184. Pulleys 182 and 184 preferably are mounted so as to be spaced from wall 112 by a sufficient distance that sealing belt 172 will be aligned above timing belt 170. This may be accomplished by mounting pulley 182 to a pivotable arm 186, described below, and by mounting pulley 184 to a spacer block 188. A gear 190 may be mounted on the opposite side of wall 112 on a common shaft with gear 176, and a gear 192 may be mounted on the opposite side of wall 112 on a common shaft with pulley 184. Thus, as gear 174 is rotated in the clockwise direction (as seen in Fig. 2), the meshing of the splines 180 of timing belt 170 with the teeth of gears 174 and 176 results in a corresponding rotation of gear 176 in the clockwise direction. This rotation causes gear 190 to rotate in a counterclockwise direction (as seen in Fig. 3), and as a result of the meshing of gears 190 and 192, causes gear 192 to rotate in the clockwise direction (as seen in Fig. 3). The rotation of gear 192 results in a corresponding rotation of pulley 184 in the counterclockwise direction (as seen in Fig. 2), causing the lower portion of sealing belt 172 to move in the advancing direction at the same speed as timing belt 170. To accommodate the expansion of sealing belt 172 as it becomes heated, pulley 182 is mounted to arm 186 which is pivotably connected to wall 112 at pivot point 194. Spring 196 having one end fixedly connected to wall 112 and the other end connected to arm 186 (behind pulley 182) urges pulley 182 in a direction away from pulley 184 so as to continually maintain tension on sealing belt 172. A lubricating pad 198 formed from felt or another suitable material and impregnated with a grease or oil may be connected to wall 112 and positioned so as to apply a light lubricating coating of grease or oil to the inner surface of sealing belt 172. This lubricating coating reduces the friction between sealing belt 172 and heated seal bar 200 when the seal bar is activated during a sealing operation.

[0040] Seal bar 200 is spaced from wall 112 so as to be positioned immediately above sealing belt 172 between pulleys 182 and 184. Seal bar 200 is preferably formed from a high heat-conductive material, such as brass, and includes a resistive heating element (not shown) connected by a power line 202 to a source of electrical power. The resistance heating element heats seal bar 200 to a desired temperature sufficient to heat seal film plies 12 and 14 together. Accordingly, the desired temperature will depend on the type of material forming film web 10. For example, for a film web 10 formed from low density polyethylene, a minimum sealing temperature of about 350°F is desirable in order to obtain a satisfactory seal. To achieve this temperature at film web 10, seal bar 200 preferably is heated to a temperature of about 380-390°F. The surface of seal bar 200 which contacts sealing belt 172 is in the form of a narrow elongated rib 204 which concentrates the heat and pressure exerted on the sealing belt so as to form a narrow seal line 34 (Fig. 1) adjacent the open longitudinal edge 16 of web 10.

[0041] Seal bar 200 is mounted to a pivot arm 208 for movement between an inoperative raised position in which the seal bar is spaced above the lower portion of sealing belt 172, and an operative lowered position in which the seal bar contacts and presses against the lower portion of sealing belt 172 to effect the sealing of film web 10. The end 210 of pivot arm 208 is fixedly mounted to a shaft 212 which extends through a bearing (not shown) in wall 112. On the opposite side of wall 112, shaft 212 carries a second pivot arm 216 which is fixedly connected thereto so that any pivoting movement of arm 216 results in a corresponding pivoting movement of arm 208. Arm 216 is biased in a downward direction against a cam element 218 by a spring 220, one end of which is fixedly connected to wall 112 and the other end of which is fixedly connected to the free end of arm 216. A stepper motor 222 may rotate cam element 218 incrementally as arm 216 rides over the outer surface thereof. When arm 216 is resting on the smaller diameter portions of cam element 218, arm 216 will be biased to its lowermost position, as will arm 208 which is operatively connected thereto. In this lowermost position of arm 208, seal bar 200 will be in the operative position against the lower portion of sealing belt 172 to effect a sealing operation. On the other hand, when cam element 218 is rotated so that the enlarged lobe 218a thereof contacts arm 216, arm 216 will be pivoted upwardly against the biasing force of spring 220. At the same time, arm 208 will be pivoted upwardly from the operative position in which seal bar 200 contacts the lower portion of sealing belt 172 to the inoperative position in which the seal bar is spaced above the lower portion of sealing belt 172.

[0042] A heat sink 230 may be mounted below the upper portion of timing belt 170 at a spaced distance from wall 112 so as to be positioned substantially below seal bar 200. Heat sink 230 is also preferably formed from a high heat-capacity material, such as brass, so as to absorb any excess heat generated when seal bar 200 is in the operative position. Heat sink 230 also acts as a fixed platen to support timing belt 170 and sealing belt 172 when seal bar 200 is in the operative position. A cooling fan 232 may be mounted to wall 112 so as to direct a stream of air against the lower portion of timing belt 170, thereby preventing timing belt 170 from overheating. A second cooling fan 234 may be mounted to wall 112 so as to direct a stream of air against the upper portion of sealing belt 172, thereby preventing the sealing belt from becoming overheated. A generally U-shaped tray 236 may be mounted to wall 112 between the upper portion of sealing belt 172 and seal bar 200. Tray 236 acts to shield seal bar 200 from the air stream generated by cooling fan 234 so that the seal bar maintains its desired temperature. Tray 236 also serves to draw heat away from sealing belt 172, preventing the sealing belt from overheating and, in turn, overheating film web 10 so as to produce an inferior seal 34. In that regard, tray 236 is preferably formed from a high heat capacity material such as, for example, aluminum.

[0043] Timing belt 170 and seal belt 172 are mounted so as to define a very narrow gap therebetween. As seal bar 200 is lowered to the operative position, rib 204 will contact sealing belt 172, deflecting it toward interceding film web 10 and timing belt 170. The deflection of sealing belt 172 toward timing belt 170 causes an entry nip 240 to be defined between the belts adjacent gear 174. Similarly, an exit nip 242 is formed between the belts adjacent gear 176. As will be explained below, film plies 12 and 14 are brought into contact with one another as film web 10 leaves inflation shoe 145 and enters nip 240. In an inflation zone just upstream of nip 240, pockets 24 in film web 10 are filled with a gas, and in the sealing zone just downstream of nip 240, i.e., between seal bar 200 and heat sink 230, plies 12 and 14 are heat-sealed together adjacent the open longitudinal edge 16 of the web to retain the gas therein.

[0044] As noted above, inflation shoe 145 is mounted to wall 112 so as to be disposed between upper pressure bars 148A, 148B and lower pressure bars 156A, 156B. Inflation shoe 145 is further mounted to wall 112 so that an air inlet 250 (Fig. 5) at one end thereof is aligned with an aperture (not shown) in wall 112 for receiving the pressurized gas used to inflate pockets 24 of film web 10. Pockets 24 may be inflated with a pressurized gas of any type. However, the description which follows will refer to the use of pressurized air as the pressurized gas in view of its ready availability and minimal cost. Pressurized air may be supplied from any suitable source, including a compressor external to apparatus 100, a blower motor mounted within apparatus 100, a line source within a factory, etc. In a particularly preferred embodiment, pressurized air at a high pressure (about 89 mbars) and sufficient flow rate may be supplied by a gas ring compressor 260. A suitable gas ring compressor for use in apparatus 100 is available from Nash Elmo Industries GmbH of Saale, Germany as Model No. 2BH1000-0AB32. The outlet 262 of gas ring compressor 260 may be connected to a muffler 264 through elbow 266. The outlet of muffler 264 may, in turn, be connected by a length of tubing (not shown) to a tube connector (not shown) mounted to wall 112 in alignment with the aperture therein. As a result, compressed air from gas ring compressor 260 will pass through muffler 264 and into air inlet 250 of inflation shoe 145.

[0045] Referring to Fig. 5, the air entering the air inlet 250 in inflation shoe 145 travels through an internal passageway 280 and exits through two outlet ports. The majority of the inlet air exits through an inflation port 282 oriented at an oblique angle to the longitudinal direction of inflation shoe 145 and disposed at an end 284 thereof. As a result, the flow direction of the air exiting the inflation port will have a first component in the direction of travel of film web 10 and a second component orthogonal thereto. Preferably, inflation port 282 is oriented so that the flow direction of the stream of inflation air will be at an angle of between about 5° and about 60° to the direction of travel of film web 10. More preferably, the flow direction of the stream of inflation air will be at an angle of between about 5° and about 30° to the direction of travel of film web 10. In a highly preferred arrangement, inflation port 282 will be oriented so as to produce a stream of inflation air at an angle of about 11° to the direction of travel of film web 10. Because the angle between the flow direction of the inflation air and the direction of travel of film web 10 is small, the component of air flow in the direction of travel will be significantly larger than the component of air flow in the direction orthogonal thereto.

[0046] The remainder of the inlet air exits from a preinflation port 288 oriented substantially orthogonal to the longitudinal direction of inflation shoe 145 (i.e., substantially orthogonal to the direction of travel of film web 10) and disposed at a spaced distance from the end 284 of the inflation shoe. Preinflation port 288 preferably has a diameter which is significantly less than the diameter of inflation port 282. For example, in a preferred embodiment, preinflation port 288 may have a diameter of about 0.125" while inflation port 282 may have a diameter of about 0.170". However, the diameters of inflation port 282 and preinflation port 288 will ultimately depend upon the type and size of the cells or cushions being inflated in film web 10. As a result of the size difference between inflation port 282 and preinflation port 288, a significantly greater volume of air will exit from the inflation port than will exit from the preinflation port. Preinflation port 288 is merely intend to provide each of pockets 24 with a small quantity of air to separate film plies 12 and 14 and thereby facilitate the full inflation of the pockets via inflation port 282.

[0047] As will be appreciated from the discussion below on the operation of machine 100, inflation port 282 is sized and positioned relative to nip 240 so as to maintain the inflation pressure on pockets 24 until the last possible moment before film plies 12 and 14 are pressed together between timing belt 170 and sealing belt 172. In that regard, the upper surface 142 and lower surface 144 of inflation shoe 145 preferably taper toward one another at end 284 so that the end of the inflation shoe can be positioned as close as possible to nip 240. As can be seen in Fig. 2, inflation shoe 145 is positioned so that at least a portion of inflation port 282 is located between nip 240 and an imaginary vertical line passing tangentially to gear 174. The size, position and orientation of inflation port 282 enable pockets 24 to be inflated to a pressure greater than ambient pressure. A similar taper may be formed at the opposite end 290 of inflation shoe 145 so as to eliminate any sharp edges which could snag film plies 12 or 14 as they pass on either side of the inflation shoe. Inflation shoe 145 may further include one or more longitudinal recesses or grooves (not shown) extending along the upper surface 142 and lower surface 144 thereof. These recesses or grooves may facilitate the tracking of timing belts 118 and 120, respectively, along inflation shoe 145 and may provide a tighter seal for film web 10 between the timing belts and the inflation shoe.

[0048] The transport mechanism, inflation zone and heat sealing zone of apparatus 100 may be enclosed by a shroud 300. In a preferred arrangement, apparatus 100 may be supported on a platform P and shroud 300 may be pivotally connected to platform P for movement between open and closed positions. In the open position, shroud 300 may pivot below the upper surface of platform P, providing complete access for loading film web 10 into the transport mechanism of apparatus 100. In the closed position, shroud 300 defines an entrance opening 302 at one end thereof for introducing film web 10 into apparatus 100, and an enlarged exit opening 304 at its opposite end permitting the inflated cushions 30 to exit from apparatus 100. One or more microswitches 310 mounted to wall 112 may be actuated when shroud 300 is in the closed position, assuring that apparatus 100 does not operate unless the shroud is fully closed.

[0049] As noted above, film web may be provided in the form of a supply roll 50 positioned adjacent the inlet end 102 of apparatus 100. More particularly, apparatus 100 may include a material supply section 400, shown in Fig. 7, adapted to support roll 50 and supply film web 10 to apparatus 100 in a controlled manner. Supply section 400 may include a pair of spaced yokes 402 and 404, each of which may have one or more bearings 406 for supporting the opposite ends of a spindle 408 on which supply roll 50 is mounted. Yoke 402 may be connected to apparatus 100 by a connecting bar 410, and may be connected to yoke 404 by a cross member 412, thereby fixing the position of supply section 400 relative to apparatus 100. A pair of bearings 414 and 416 formed from nylon or other suitable material may be positioned on spindle 408 on either side of yoke 402 so as to maintain film roll 50 in proper alignment with apparatus 100. Spindle 408 is freely rotatable in yokes 402 and 404 so as to freely deploy film web 10 from supply roll 50.

[0050] It is desirable that film web 10 be deployed from supply roll 50 and fed into apparatus 100 with the proper tension. If the tension is too low, as may be the case if the film web is deployed too rapidly, excess slack may result in misfeeding of the web into apparatus 100. On the other hand, too high a tension in film web 10 may make it difficult for inflation gas to enter pockets 24, resulting in cushions 30 which are not fully inflated. To ensure that film web 10 is fed properly, supply section 400 may further include a braking mechanism 420 to slow the rotation of spindle 408 and assure an appropriate tension on film web 10 as it enters apparatus 100. Braking mechanism 420 includes a brake arm 422 pivotally mounted to yoke 402 by a shaft 424. Brake arm 422 is provided at one end 422a with a brake pad 426 which is positioned so as to contact a brake disk 428 fixedly mounted on spindle 408. Brake pad 426 is preferably formed a machinable plastic exhibiting good wear resistance and toughness so as to not crack or fracture when pressed against brake disk 428. A preferred material in this regard is a resinous plastic material available from E. I. duPont de Nemours and Company under the trademark Delrin.

[0051] At its opposite end 422b, brake arm 422 includes a tension bar 430 connected thereto in a cantilevered fashion and extending substantially entirely across the width of film web 10. As film web 10 is fed into apparatus 100, it is first passed below tension bar 430. Tension bar 430 is positioned at a height lower than the height of both spindle 408 and the entrance to apparatus 100 so that, as the advancing film web 10 is pulled from supply roll 50, it will exert an upward force on the tension bar. A spring 432 connected at one end to end 422b of brake arm 422 and at the other end to a collar 434 disposed on connecting bar 410 biases brake arm 422 in a downward direction. The amount of biasing force exerted by spring 432 may be adjusted by adjusting the position of collar 434 on connecting bar 410. Thus, positioning collar 434 closer to apparatus 100 will result in a lower biasing force on brake arm 422, and thus a lower tension in film web 10, while positioning collar 434 farther from apparatus 100 will result in a greater biasing force on brake arm 422, and thus a greater tension in the film. Once a desired film tension has been achieved, collar 434 may be affixed to connecting bar 410 by a set screw 436.

[0052] As film web 10 is advanced from supply roll 50 into apparatus 100 under tension, it causes an upward force on tension bar 430 sufficient to overcome the biasing force of spring 432. As a result, end 422b of brake arm 422 will move upwardly, with end 422a moving downwardly to space brake pad 426 away from brake disk 428, permitting spindle 408 to rotate freely as the film web is dispensed into apparatus 100. However, should film web 10 be deployed too quickly from supply roll 50, slack will develop in the web, whereupon tension bar 430 will be free to move downwardly by virtue of the biasing force of spring 432. This downward movement will cause end 422b of brake arm 422 to move downwardly and end 422a of the brake arm to move upwardly until brake pad 426 presses against brake disk 428. The friction between brake pad 426 and brake disk 428 will slow the rotation of spindle 408 and thus the deployment of film web 10 therefrom. The continued advancement of film web 10 into apparatus 100 will eventually remove the slack from the film web until the appropriate tension is again created in the web and the braking action is terminated.

[0053] It will be appreciated that brake mechanism 420 is but one system for controlling the tension in film web 10. Thus, other such systems are contemplated herein, including the use of a stationary band in frictional contact with a friction wheel which rotates along with the film supply roll, or other friction members which either directly or indirectly engage the spindle 408 or the supply roll 50 itself. Also contemplated is a motorized deployment system having a feedback circuit which controls the speed of the motor and thus the speed of film deployment.

[0054] The operation of apparatus 100 is generally controlled by various switches disposed on the front panel 320 thereof. Thus, as shown in Fig. 1, front panel 320 includes a power switch 330 for supplying power to apparatus 100, a start button 332 for commencing the inflation and sealing process, and a stop button 334 for terminating the inflation and sealing process. A sensor mode switch 340 may be used to switch apparatus 100 between a batch mode of operation and an automatic replenishment mode of operation, both of which are described more fully below. A full bin sensor 342 disposed near the bottom of front panel 320 senses when a receiving bin (not shown) has been filled with inflated cushions 30. Apparatus 100 may further be provided with a cooling fan 350 to draw air into the interior of the apparatus to cool the components and circuitry therein. In addition to the front panel controls, apparatus 100 may include a film loading button 360 mounted on wall 112 and accessible only when shroud 300 is pivoted to the open position.

[0055] The following will describe the operation of apparatus 100 to form packaging cushions 30 through the inflation and sealing of film web 10. To begin, power switch 330 is turned to the "on" position. The actuation of power switch 330 supplies power to seal bar 200, causing it to begin to heat up. While seal bar 200 is heating, a light in start button 332 may blink to signal the heating process. When seal bar 200 reaches the desired temperature, the light in start button 332 may change to a solid "on" state, indicating that apparatus 100 is ready for operation.

[0056] As seal bar 200 is heating, or before or after the heating step, the free end of film web 10 may be advanced from supply roll 50 under tension bar 430 and into apparatus 100. The upper film ply 12 is guided above inflation shoe 145 and into the nip formed between timing belt 118 and the upper surface 142 of the inflation shoe, while the lower film ply 14 is guided into the nip formed between timing belt 120 and the lower surface 144 of the inflation shoe. Film loading button 360 may then be depressed to jog drive motor 130 and advance timing belts 118 and 120. As timing belt 118 advances, film ply 12 is drawn between the timing belt and the upper surface 142 of inflation shoe 145. Similarly, the advancement of timing belt 120 draws film ply 14 between the timing belt and the lower surface 144 of inflation shoe 145, with the inflation shoe positioned within the skirt 22 formed in film web 10. Once the leading edge of film web 10 has been securely grasped between inflation shoe 145 and timing belts 118 and 120, respectively, shroud 300 may be pivoted to the closed position and start button 332 may be depressed to begin commencement of the inflation and sealing process. Actuation of start button 332 actuates motor 130, gas ring compressor 260 and cooling fans 232 and 234. Actuation of start button 332 also causes stepper motor 222 to rotate to a position in which seal bar 200 is in the operative position against sealing belt 172.

[0057] Film web 10 will advance with inflation shoe 145 positioned within skirt 22 and film plies 12 and 14 on opposite sides of the inflation shoe, as shown in Fig. 4A. As the first pocket 24 reaches preinflation port 288, a small amount of air will flow from the preinflation port into the pocket, separating plies 12 and 14 from one another. With the continued advancement of film web 10, the first pocket 24 will reach inflation port 282, as shown in Fig. 4B. At this point, air will travel from both inflation port 282 and preinflation port 288 to quickly fill pocket 24, causing plies 12 and 14 to bulge outwardly away from one another.

[0058] As film web 10 continues to advance, the leading portion of pocket 24 will enter the nip 240 between timing belt 170 and sealing belt 172. On entering nip 240, film plies 12 and 14 will be squeezed tightly together between sealing belt 172 and timing belt 170, thereby preventing the escape of any air from the forward portion of pocket 24 while at the same time air pressure is being maintained on the rearward portion of the pocket by air flowing from inflation port 282. Air pressure will continue to be maintained on pocket 24 from inflation port 282 as more and more of the open edge of the pocket is pinched closed between timing belt 170 and sealing belt 172.

[0059] As film web 10 enters the zone between seal bar 200 and heat sink 230, the heat from seal bar 200, and particularly the elongated rib 204 thereof, will be conducted through sealing belt 172 so as to heat seal film plies 12 and 14 together along a seal line 34 adjacent the open edge of pocket 24. Seal line 34 is formed inwardly of longitudinal edge 16 by an amount sufficient to intersect with transverse seals 20, thereby fully enclosing pocket 24 so as to entrap the air therein in the form of an inflated cushion 30. On the continued advancement of film web 10, successive pockets 24 will be inflated via preinflation port 288 and inflation port 282 and sealed closed by seal bar 200 to form cushions 30. The inflated cushions may then be fed out from apparatus 100 through the enlarged exit opening 304 defined by shroud 300.

[0060] The inflated cushions 30 exiting apparatus 100 may be collected in a receiving bin (not shown) positioned in front of front panel 320. Apparatus 100 may continue to produce inflated cushions 30 and deposit them in the receiving bin until the level of inflated cushions in the receiving bin reaches a predetermined height detected by full bin sensor 342. When sensor 342 determines that inflated cushions 30 have reached the predetermined height, it sends a signal which stops the operation of apparatus 100. That is, a signal is sent terminating the operation of motor 130, gas ring compressor 260 and cooling fans 232 and 234, and actuating stepper motor 222 to rotate cam element 218 to a position in which seal bar 200 is in the inoperative position spaced from sealing belt 172. Once this occurs, if apparatus 100 is in a batch mode of operation, it may be restarted simply by clearing cushions 30 from full bin sensor 342 and actuating start button 332 to again start the inflation and sealing processes. On the other hand, if apparatus 100 is in the automatic replenishment mode of operation, simply clearing cushions 30 from full bin sensor 342 will automatically restart the inflation and sealing processes. Of course, the inflation and sealing processes may be terminated at any time by actuating stop button 334. Upon termination of the inflation and sealing operations, either by actuation of full bin sensor 342 or stop button 334, power to apparatus 100 preferably will be maintained, such that seal bar 200 will remain in a heated condition.

[0061] Cushions 30 exit apparatus as a continuous strip of indefinite length, with adjacent cushions joined together along perforations 26. Hence, either a single cushion or a number of interconnected cushions, depending on the particular packaging application, may be separated from the strip by tearing along an appropriate perforation 26.

[0062] Although the invention herein has been described in connection with the inflation and sealing of film web 10 to provide a plurality of inflated packaging cushions, the invention is equally applicable to the inflation and sealing of film webs configured to produced other inflated shapes. Thus, film webs may be used which are preformed to produce packaging cushions having shapes other than the rectangular shapes produced from film web 10.

[0063] Additionally, film webs may be used which are sealed together in a pattern defining a plurality of cells connected in series across the width of the film web, such as those described U.S. Patent Publication No. 2002/0166788. One such web is indicated at 500 in Fig. 8. Film web 500 includes two film plies 512 and 514 sealed to each other in a pattern of seals 516 defining a series of inflatable chambers 518 of predetermined length "L". Length L may be substantially the same for each of the chambers 518, with adjacent chambers being off-set from one another as shown in order to arrange the chambers in close proximity to one another. The pattern of seals 516 that defines the inflatable chambers 518 is such that each of the chambers has at least one change in width over its dimension in the direction of length L. That is, seals 516 may be patterned to provide in each chamber 518 a series of cells 520 of relatively large width connected by relatively narrow passageways 522. When inflated, cells 520 may provide essentially spherical bubbles in film web 500 by symmetrical outward movement of those sections of film plies 512 and 514 forming the walls of cells 520. This would generally occur when film plies 512 and 514 are identical in thickness, flexibility and elasticity. Film plies 512 and 514 may, however, be of different thickness, flexibility or elasticity such that inflation will result in different displacement of film plies 512 and 514, thereby providing hemispherical or asymmetrical bubbles.

[0064] Seals 516 are also patterned to provide inflation ports 524, which are located at the proximal end 526 of each of inflatable chambers 518 in order to provide access to each chamber so that the chambers may be inflated. Opposite the proximal end 526 of each chamber is a closed distal end 528. As shown, seals 516 at proximal end 526 are intermittent, with inflation ports 524 being formed therebetween. Preferably, inflation ports 524 are narrower in width than the inflatable cells 520 of relatively large width in order to minimize the size of the seal required to close off each chamber 518 after inflation thereof.

[0065] Film web 500 further includes a skirt 530 formed by a portion of each of film plies 512 and 514 that extends beyond inflation ports 524 and seals 516. Skirt 530, in conjunction with ports 524 and seals 516, constitute an open inflation zone in web 500 configured to provide rapid and reliable inflation of chambers 518.

[0066] Preferably, the pattern of seals 516 provides uninflatable planar regions between chambers 518. These planar regions serve as flexible junctions that may be used to bend or conform the inflated web about a product in order to provide optimal cushioning protection. In another embodiment, the seal pattern can include relatively narrow seals that do not provide planar regions. These seals serve as the common boundary between adjacent chambers. The seals 516 may be heat seals between the inner surfaces of film plies 512 and 514. Alternatively, film plies 512 and 514 may be adhesively bonded to one another.

[0067] It will be appreciated that various modifications may be made to apparatus 100 without affecting the operation thereof. For example, gears 122, 124, 126, 128, 174 and 176 may be replaced with conventional pulleys or other types of rollers, and timing belts 118, 120, and 170 may be replaced with generally flat belts or bands, i.e., not having any splines therein. Alternatively, combinations of gears and pulleys or other types of rollers may be employed. In addition, pulleys 182 and 184 may be replaced with other structures capable of guiding the movement of sealing belt 172.

[0068] In another variant of the present invention, apparatus 100 may be arranged so that film web 10 travels through the heat sealing zone at a slower speed than it travels through the inflation zone. Thus, for example, by providing a gear 174 with a smaller diameter than gear 128, each revolution of gear 174 will cover a smaller arcuate distance than each revolution of gear 128, such that timing belt 170 will move at a slower rate of speed than timing belts 118 and 120. The slower movement of timing belt 170 will, in turn, result in a slower movement of sealing belt 172. As a result of this difference in speed, the tension in film web 10 will be reduced once the film web reaches the tapered portion at end 284 of inflation shoe 145 and is no longer being pressed against inflation shoe 145 by pressure bars 148A, 148B, 156A and 156B. The reduced tension in film web 10 from this point until the film enters nip 240 relaxes film plies 12 and 14, thereby enabling a greater amount of pressurized air to enter pockets 24. In a preferred arrangement, the diameter of gear 174 may be sized so as to provide up to about a 10% reduction in the speed of timing belt 170 and sealing belt 172 relative to timing belts 118 and 120. A speed reduction of about 6% is highly preferred.

[0069] Although the invention herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the present invention as defined by the appended claims.

Claims

1. An apparatus for forming inflated cushions, comprising:

a film web defining a plurality of preformed pockets, each pocket having an opening;
a transport mechanism operable to convey the film web along a transport path in a direction of travel;
an inflation mechanism positioned adjacent the transport path and having a first outlet port operable to direct a first stream of inflation gas into each of the pockets to form inflated cushions, the first stream of inflation gas being directed in a flow direction, the flow direction having a component in the direction of travel; and
a sealing mechanism operable to seal closed the opening of each pocket.

2. The apparatus as claimed in claim 1, wherein the flow direction has a component in a direction orthogonal to the direction of travel.

3. The apparatus as claimed in claim 2, wherein the component in the direction of travel is greater than the component in the direction orthogonal to the direction of travel.

4. The apparatus as claimed in claim 1, wherein the inflation mechanism further includes a second outlet port operable to direct a second stream of inflation gas into each of the pockets, the second stream of inflation gas flowing in a direction substantially orthogonal to the direction of travel.

5. The apparatus as claimed in claim 1, wherein the sealing mechanism includes a pair of opposed members defining a nip therebetween, at least one of the opposed members including a roller, and at least a portion of the first outlet port being positioned between the nip and an imaginary vertical line tangential to the roller.

6. The apparatus as claimed in claim 1, wherein the inflation gas is air, the apparatus further comprising a gas ring compressor for supplying pressurized air to the inflation mechanism.

7. The apparatus as claimed in claim 1, wherein the flow direction is at an angle to the direction of travel of between about 5° and 60°.

8. The apparatus as claimed in claim 7, wherein the angle is between about 5° and about 30°.

9. The apparatus as claimed in claim 8, wherein the angle is about 11°.

10. The apparatus as claimed in claim 1, wherein the transport mechanism includes a first portion operable to convey the film web past the inflation mechanism in the direction of travel and a second portion operable to convey the film web past the sealing mechanism, the first portion being different than the second portion.

11. The apparatus as claimed in claim 10, wherein the first portion conveys the film web at a first transport speed, and the second portion conveys the film web at a second transport speed slower than the first transport speed.

12. The apparatus as claimed in claim 10, wherein the second portion conveys the film web in a direction transverse to the direction of travel.

13. The apparatus as claimed in claim 10, wherein the first portion conveys the film web with a first tension and the second portion conveys the film web with a second tension less than the first tension.

14. An apparatus for forming inflated cushions, comprising:

a film web defining a plurality of preformed pockets, each pocket having an opening;
a transport mechanism operable to convey the film web along a transport path in a direction of travel;
an inflation mechanism positioned adjacent the transport path and having a first outlet port operable to direct a first stream of inflation gas into each of the pockets to form inflated cushions; and

a sealing mechanism operable to seal closed the opening of each pocket, the sealing mechanism including a pair of opposed members defining a nip therebetween, at least one of the opposed members including a roller, and at least a portion of the first outlet port being positioned between the nip and an imaginary vertical line tangential to the roller.

15. The apparatus as claimed in claim 14, wherein the inflation mechanism further includes a second outlet port operable to direct a second stream of inflation gas into each of the pockets, the second stream of inflation gas flowing in a direction substantially orthogonal to the direction of travel.

16. The apparatus as claimed in claim 14, wherein the transport mechanism includes a first portion operable to convey the film web past the inflation mechanism in the direction of travel and a second portion operable to convey the film web past the sealing mechanism in a direction transverse to the direction of travel.

17. The apparatus as claimed in claim 14, wherein the transport mechanism includes a first portion operable to convey the film web past the inflation mechanism at a first transport speed and a second portion operable to convey the film web past the sealing mechanism at a second transport speed slower than the first transport speed.

18. The apparatus as claimed in claim 14, wherein the transport mechanism includes a first portion operable to convey the film web past the inflation mechanism with a first tension and a second portion operable to convey the film web past the sealing mechanism with a second tension less than the first tension.

19. A method for forming inflated cushions, comprising:

providing a film web defining a plurality of preformed pockets, each pocket having an opening;
conveying the film web along a transport path in a direction of travel;
directing a first stream of inflation gas into each of the pockets to form inflated cushions, the first stream of inflation gas being directed in a flow direction, the flow direction having a component in the direction of travel; and
sealing closed the opening of each pocket.

20. The method as claimed in claim 19, wherein the step of sealing closed the opening of a selected pocket is initiated while the first stream of inflation gas is directed into the selected pocket.

21. The method as claimed in claim 19, wherein the flow direction has a component in a direction orthogonal to the direction of travel.

22. The method as claimed in claim 21, wherein the component in the direction of travel is greater than the component in the direction orthogonal to the direction of travel.

23. The method as claimed in claim 19, further comprising directing a second stream of inflation gas into each of the pockets, the second stream of inflation gas flowing in a direction substantially orthogonal to the direction of travel.

24. The method as claimed in claim 19, wherein the flow direction is at an angle to the direction of travel of between about 5° and about 60°.

25. The method as claimed in claim 24, wherein the angle is between about 5° and about 30°.

26. The method as claimed in claim 25, wherein the angle is about 11°.

27. The method as claimed in claim 19, wherein the conveying step includes conveying the film web past the inflation mechanism in the direction of travel and conveying the film web past the sealing mechanism in a direction transverse to the direction of travel.

28. The method as claimed in claim 19, wherein the conveying step includes conveying the film web past the inflation mechanism at a first transport speed and conveying the film web past the sealing mechanism at a second transport speed slower than the first transport speed.

29. The method as claimed in claim 19, wherein the conveying step includes conveying the film web past the inflation mechanism with a first tension and conveying the film web past the sealing mechanism with a second tension less than the first tension.

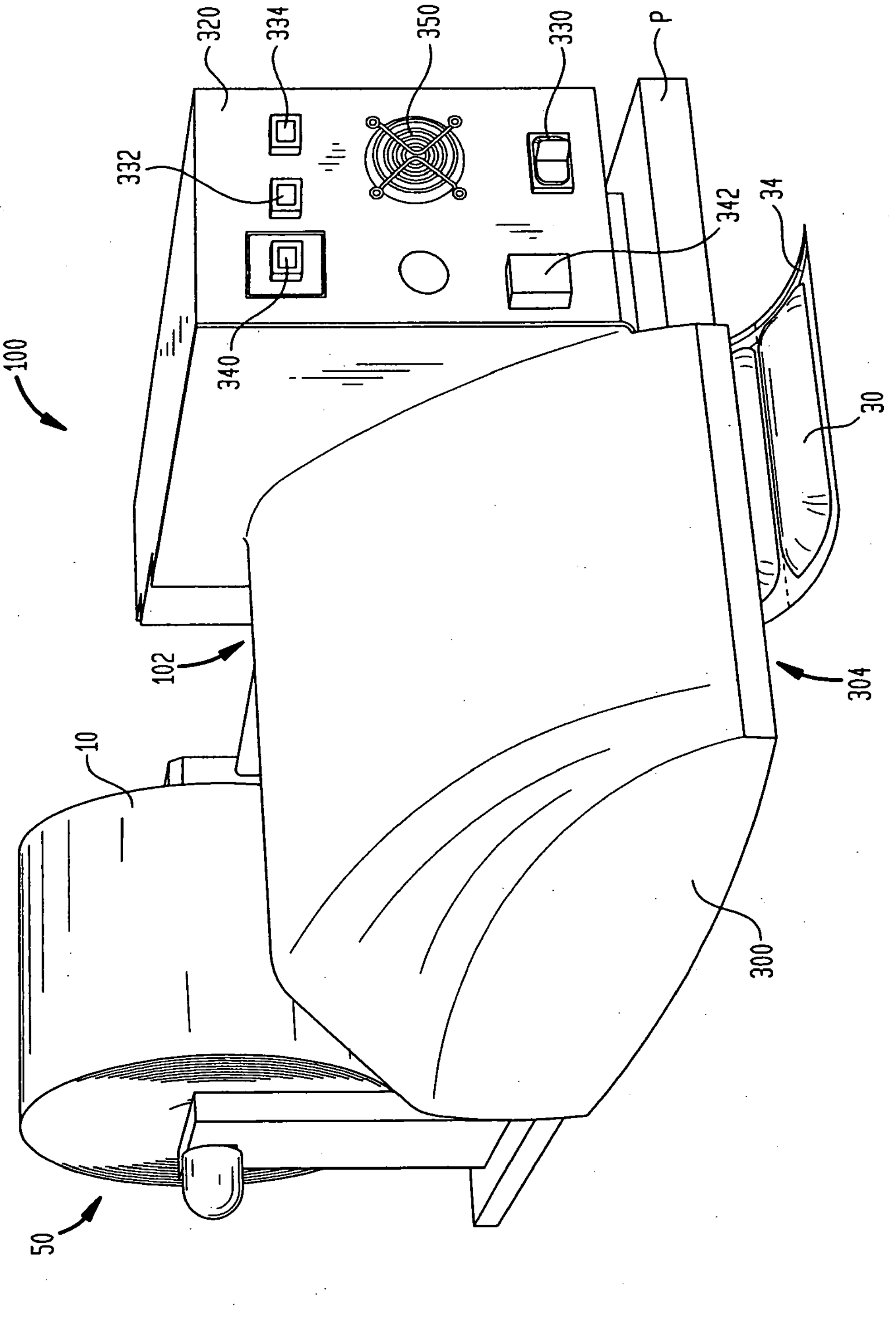

FIG. 1

FIG. 2

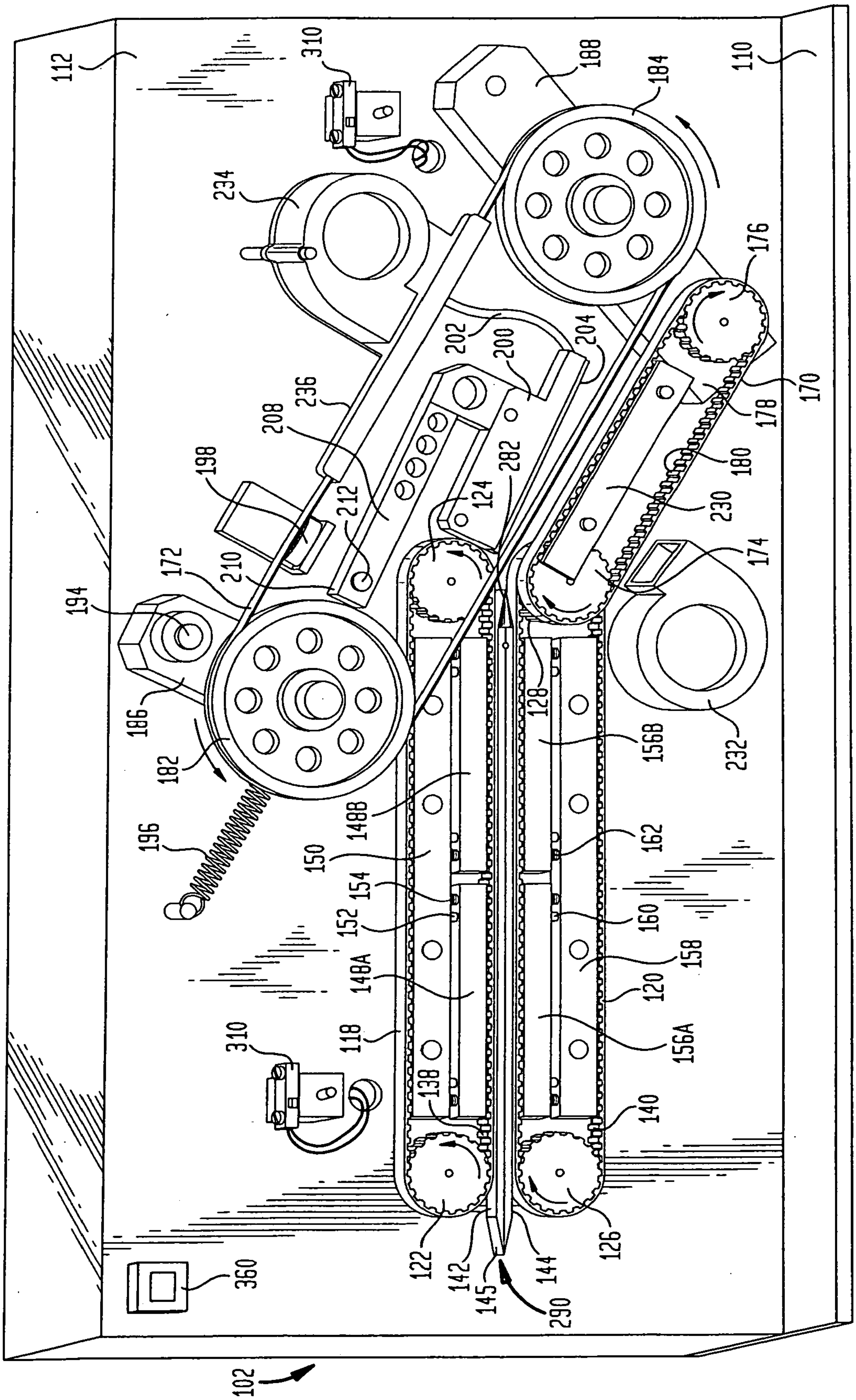
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FIG. 3

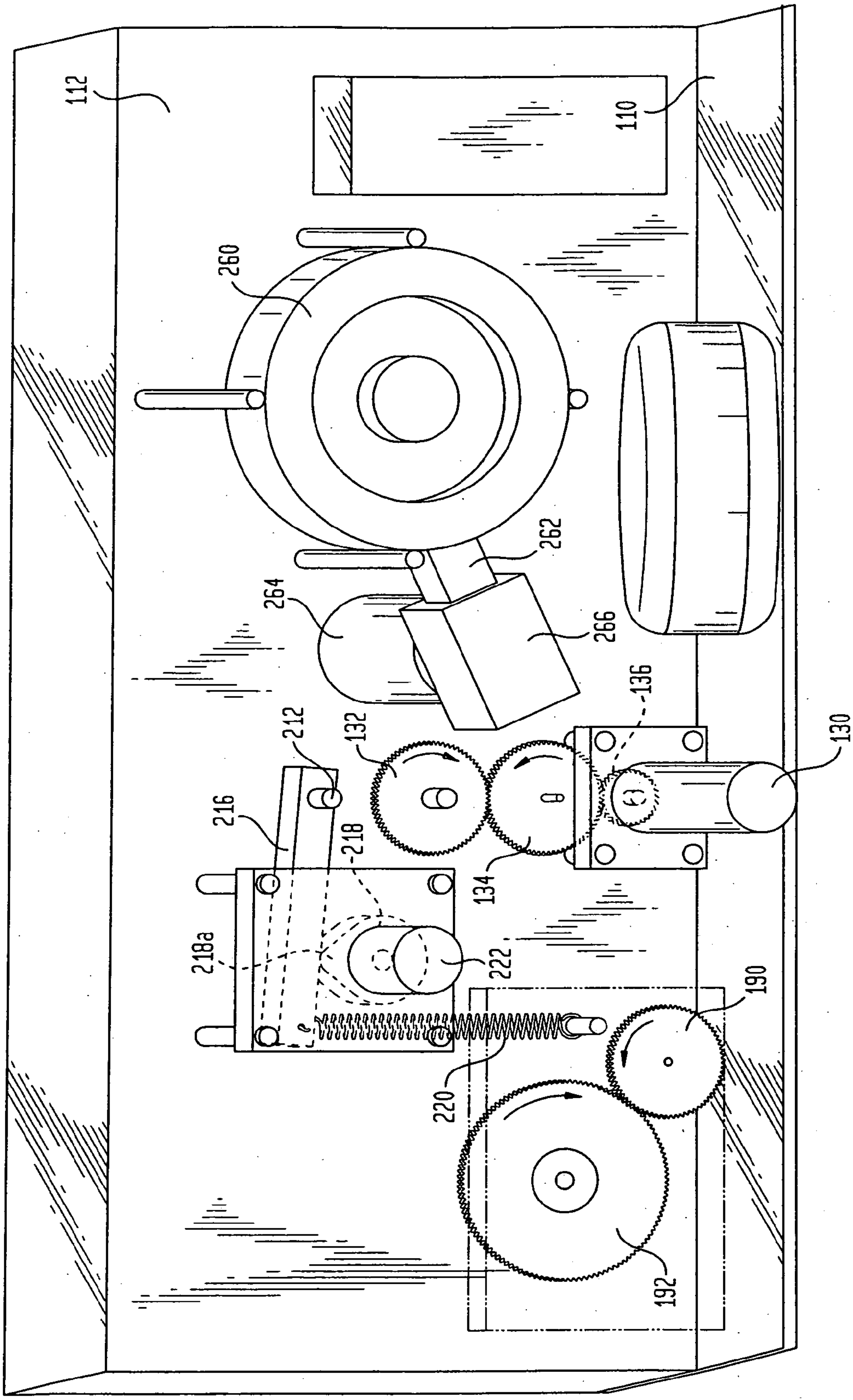

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FIG. 4A

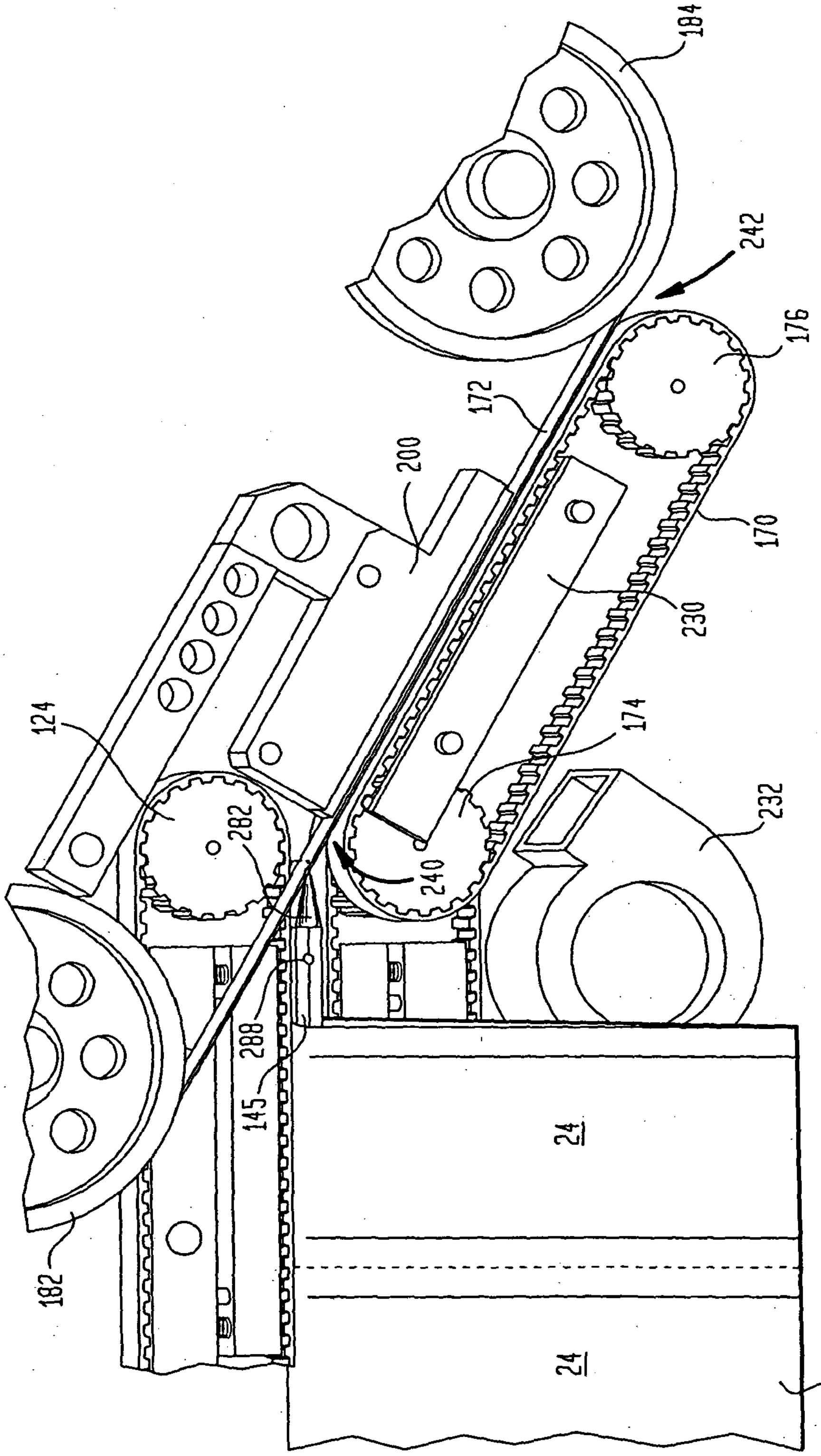
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FIG. 4B

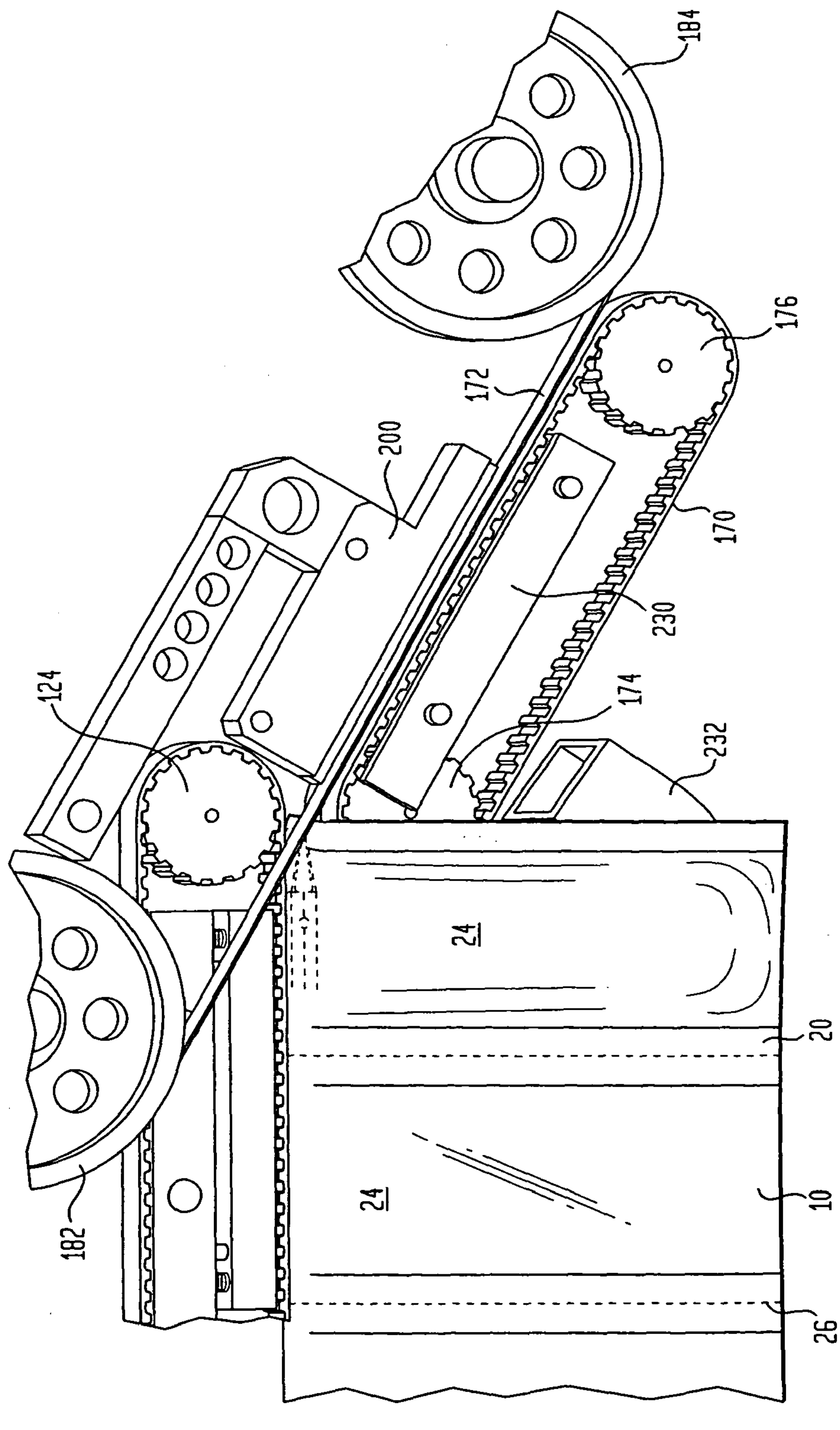
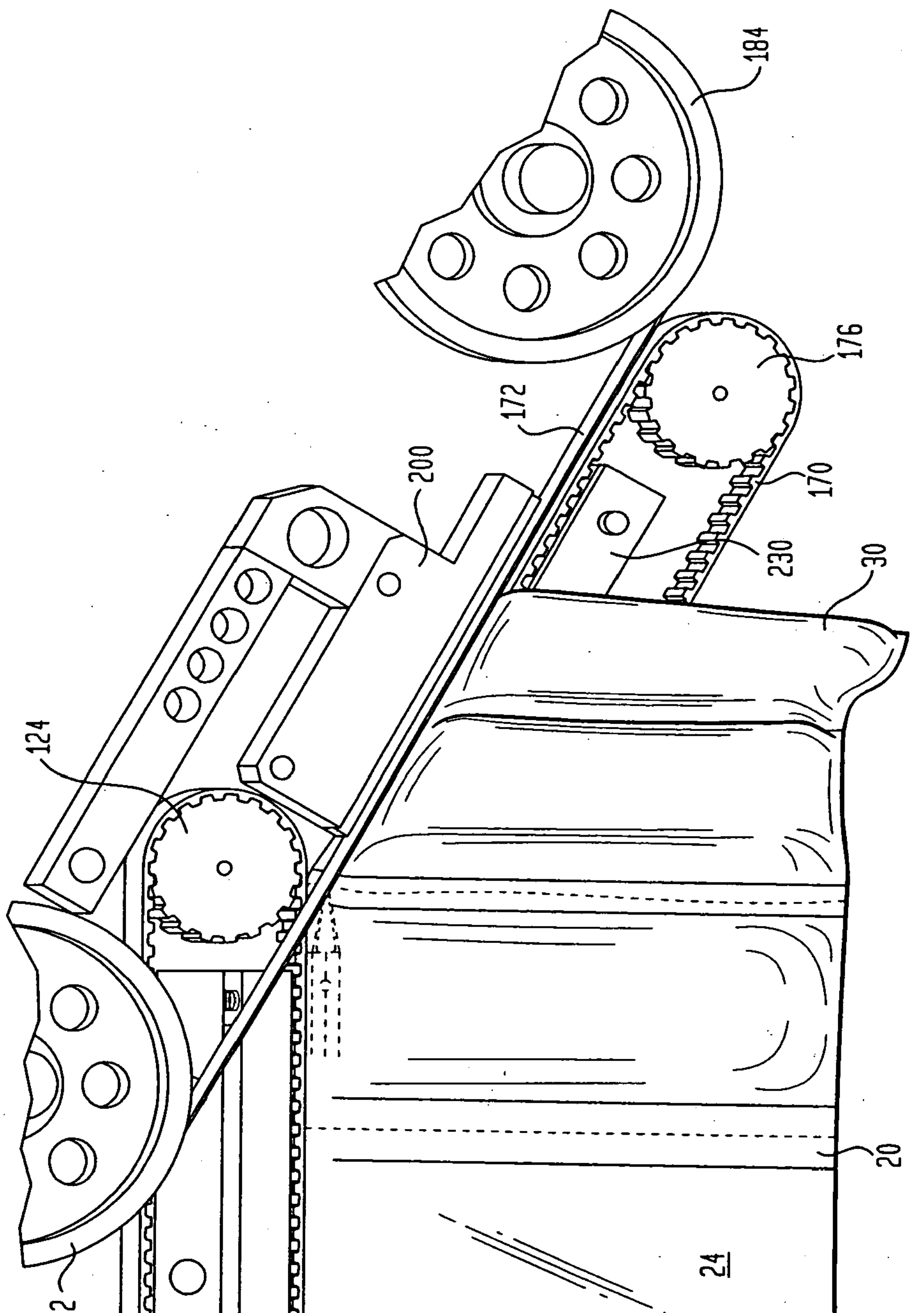


FIG. 4C



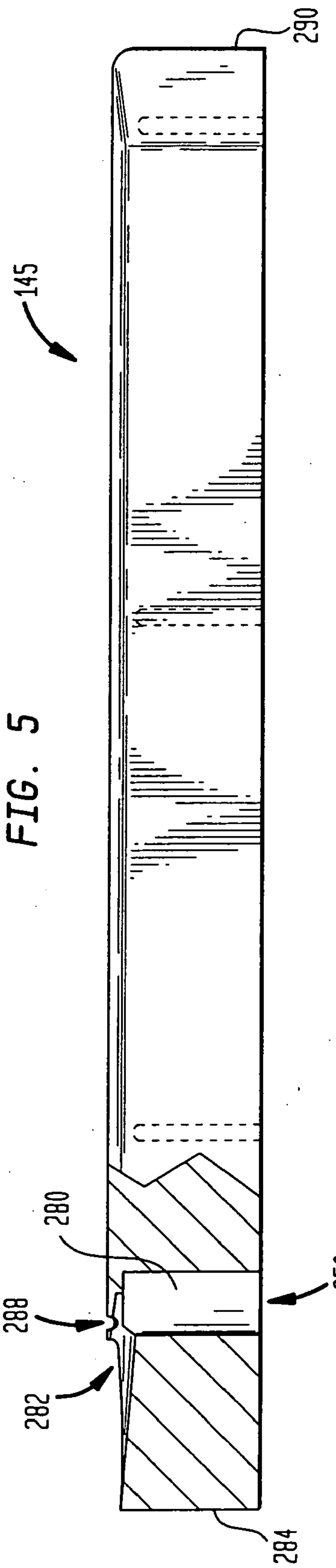


FIG. 5

FIG. 6

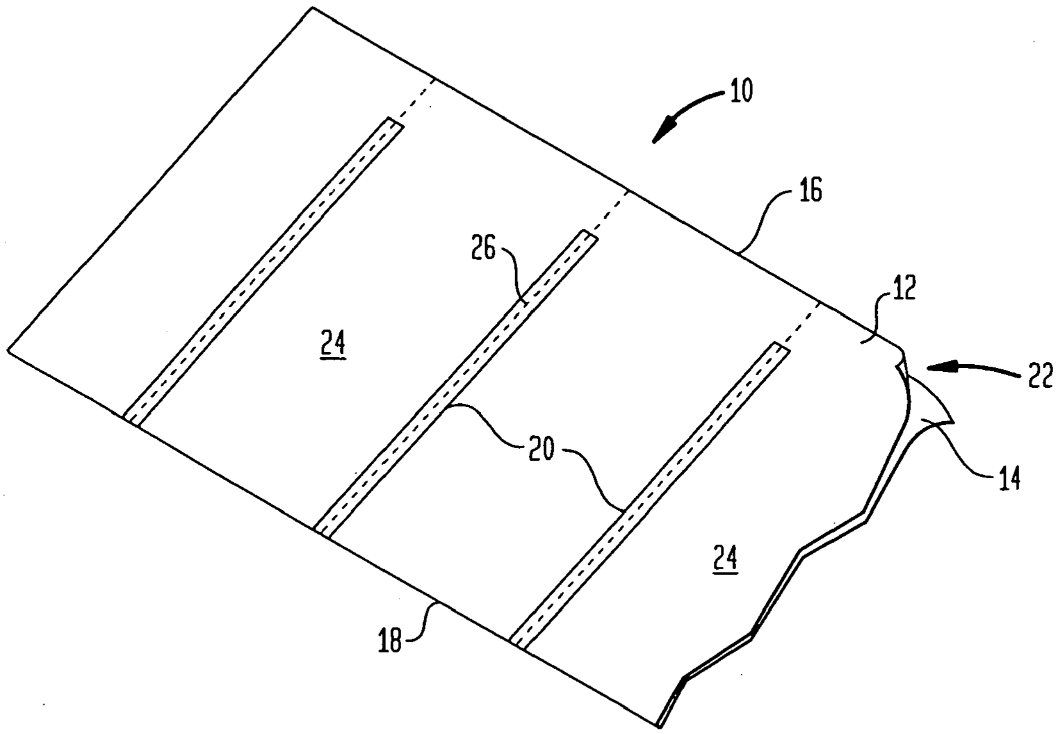
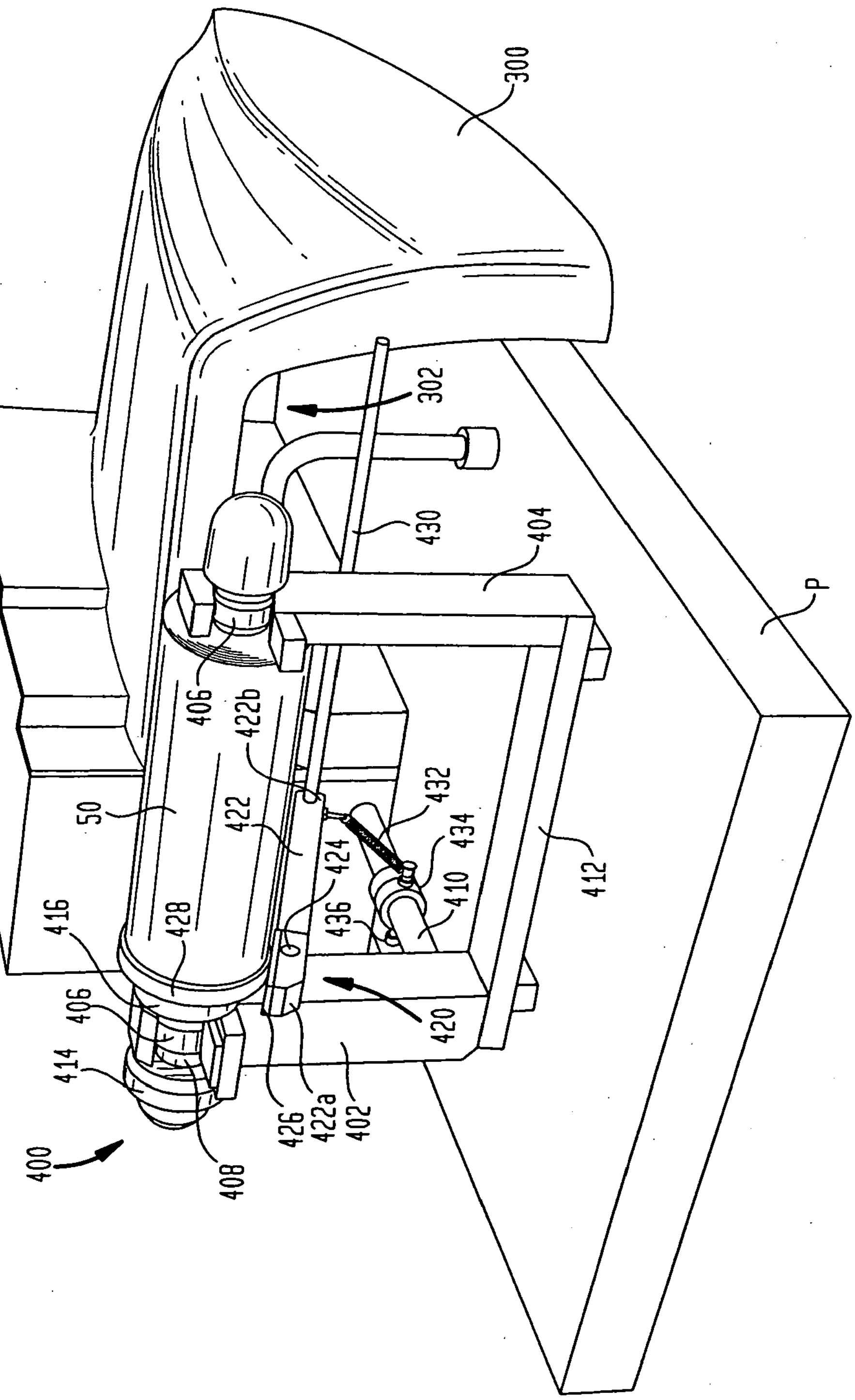


FIG. 7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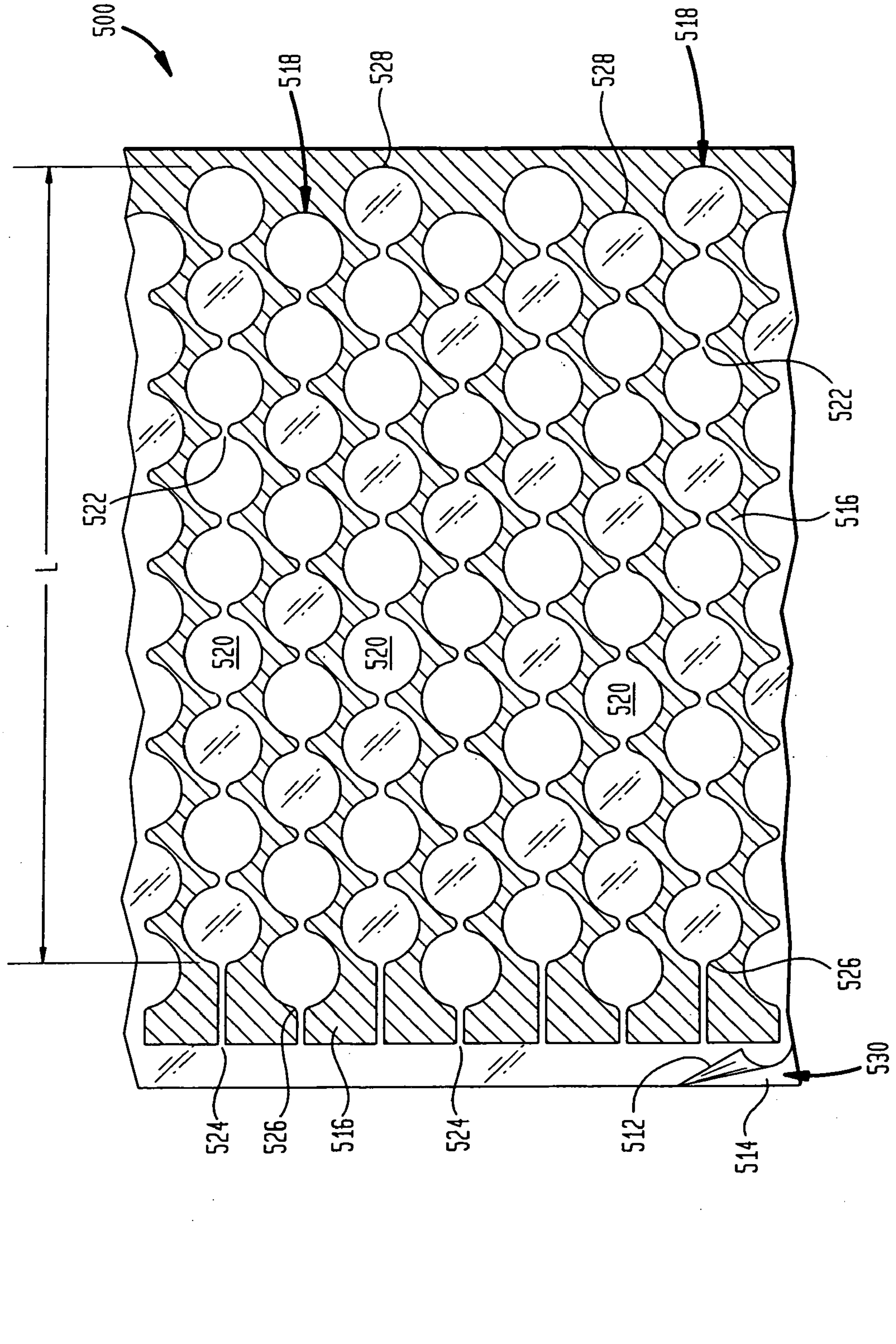
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FIG. 8