United States Patent [19]

Brown, Jr.

[11] **3,749,544**

[45] **July 31, 1973**

[54] **PREFORM RESHAPING MEANS HAVING WEB DISTORTION CONTROL DEVICE**

[75] Inventor: **Fred P. Brown, Jr.**, Centerville, Mass.

[73] Assignee: **Packaging Industries, Inc.**, Hyannis, Mass.

[22] Filed: **Aug. 20, 1971**

[21] Appl. No.: **173,371**

[52] **U.S. Cl.** **425/397**, 226/108, 226/185

[51] **Int. Cl.** **B29c 17/04**

[58] **Field of Search** 425/397, 455; 226/108, 185, 187

[56] **References Cited**

UNITED STATES PATENTS

2,830,810	4/1958	Colburn et al.	226/185 X
3,613,980	10/1971	Kulig et al.	425/397 X
3,396,890	8/1968	Fulton	226/187 X
3,619,864	11/1971	Birch	425/397 X
3,664,791	5/1972	Brown	425/397 X

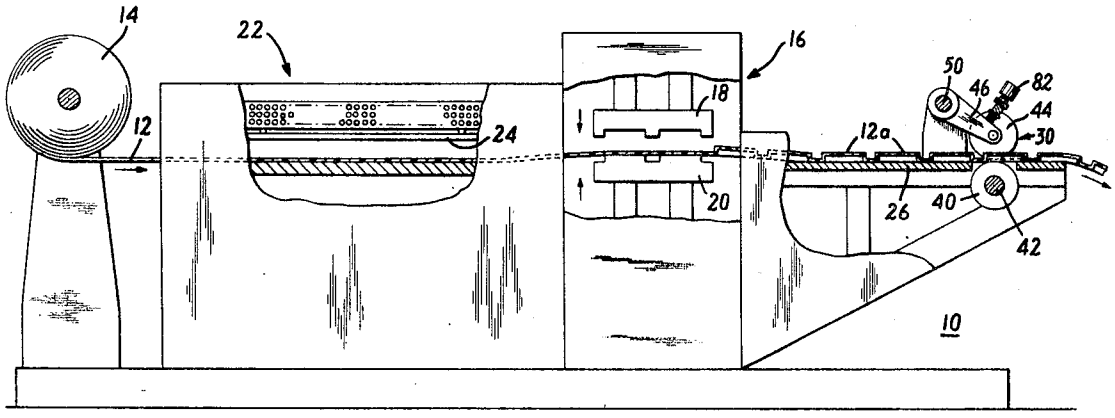
Primary Examiner—R. Spencer Annear

Attorney—Granville M. Brumbaugh, Donald S. Dowden et al.

[57] **ABSTRACT**

An apparatus for the forming of articles from a continuous web of plastic material is described. Certain of such materials are subject to longitudinal shrinkage, causing deformation of the finished articles, and means are provided for applying longitudinal tensions to the web to counteract the shrinkage effect. The tensioning means comprise a plurality of roller pairs spaced transversely across the path of the web, each pair adapted to frictionally engage the web. The roller speeds are adjusted to exert a constant tension on the web as it is incrementally or intermittently indexed through the forming apparatus and compensate for the deformation resulting from shrinkage.

10 Claims, 9 Drawing Figures



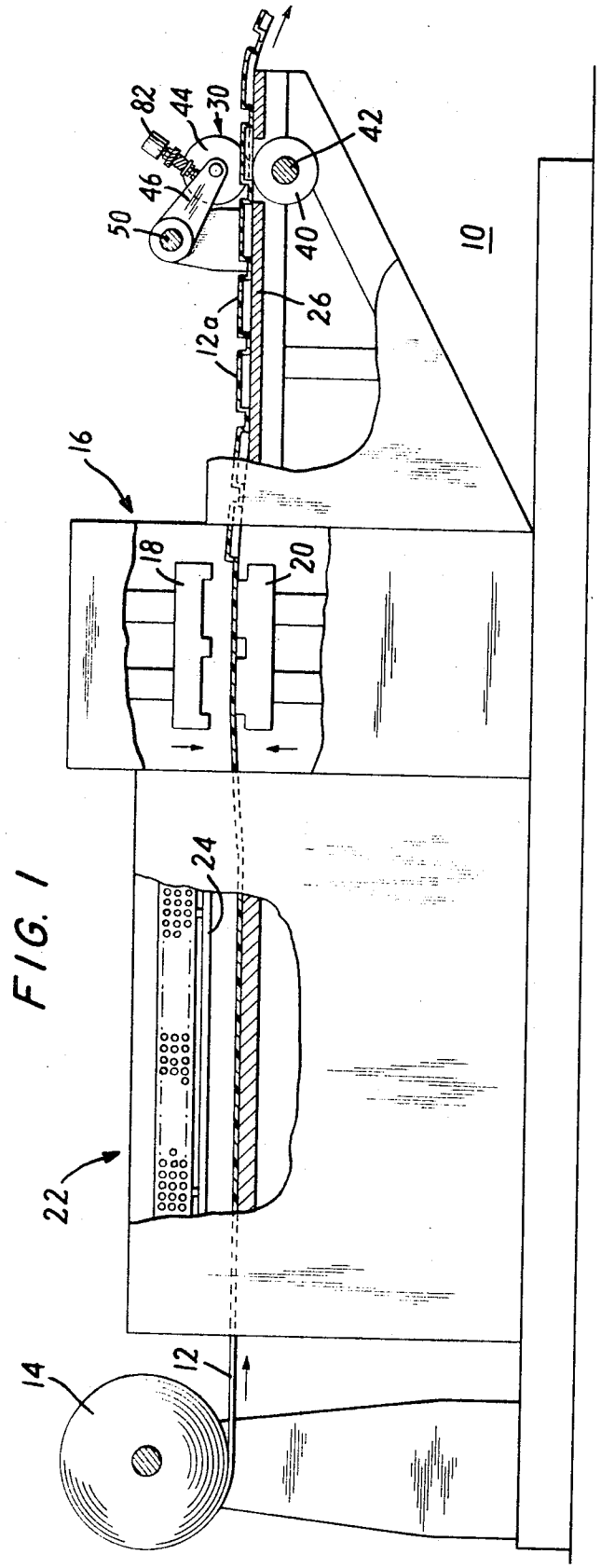

82
44
30
42
46
50
40
10
26
12a
16
18
20
24
22
14
12

FIG. 1

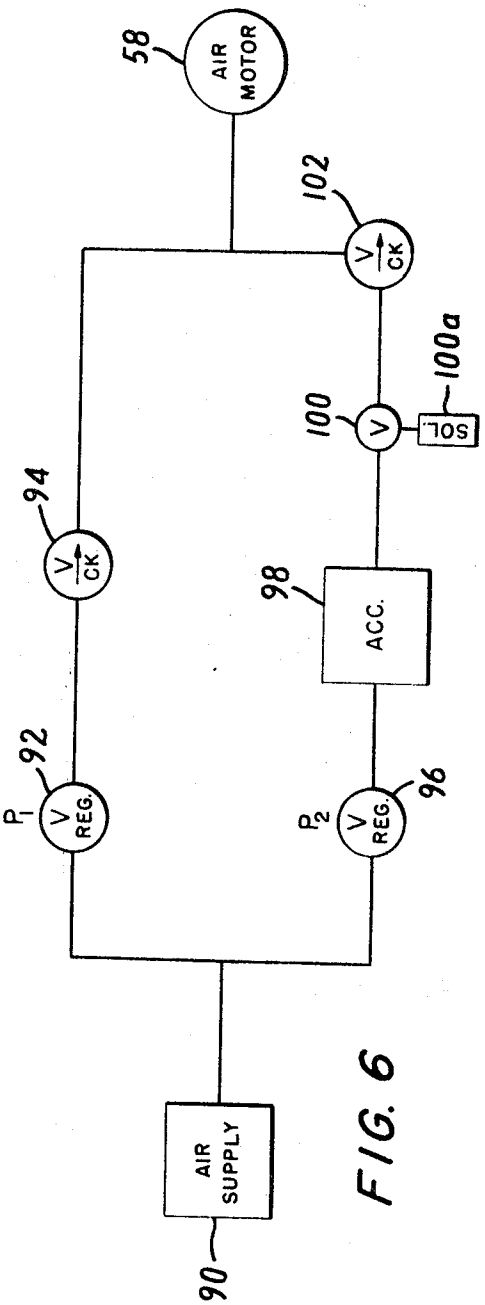

58
AIR MOTOR
102
V CK
100a
100
V
SOL.
94
V CK
98
ACC.
P1
92
V REG.
P2
V REG.
96
AIR SUPPLY
90

FIG. 6

FIG. 2A

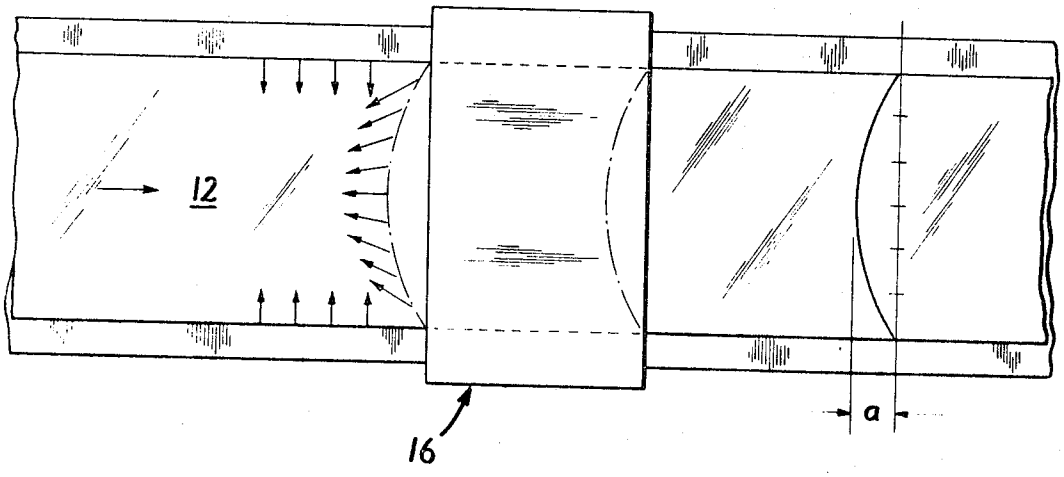
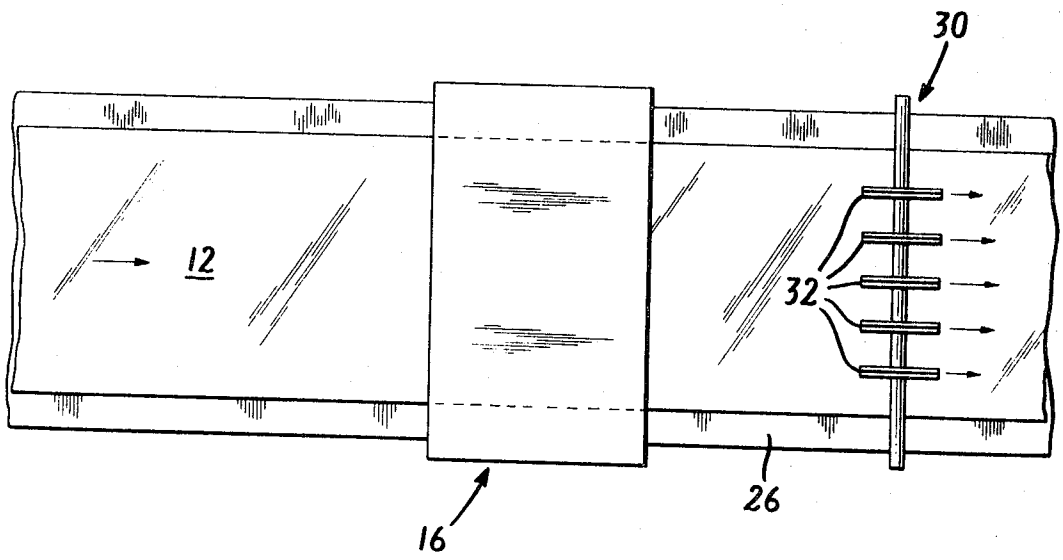


FIG. 2B



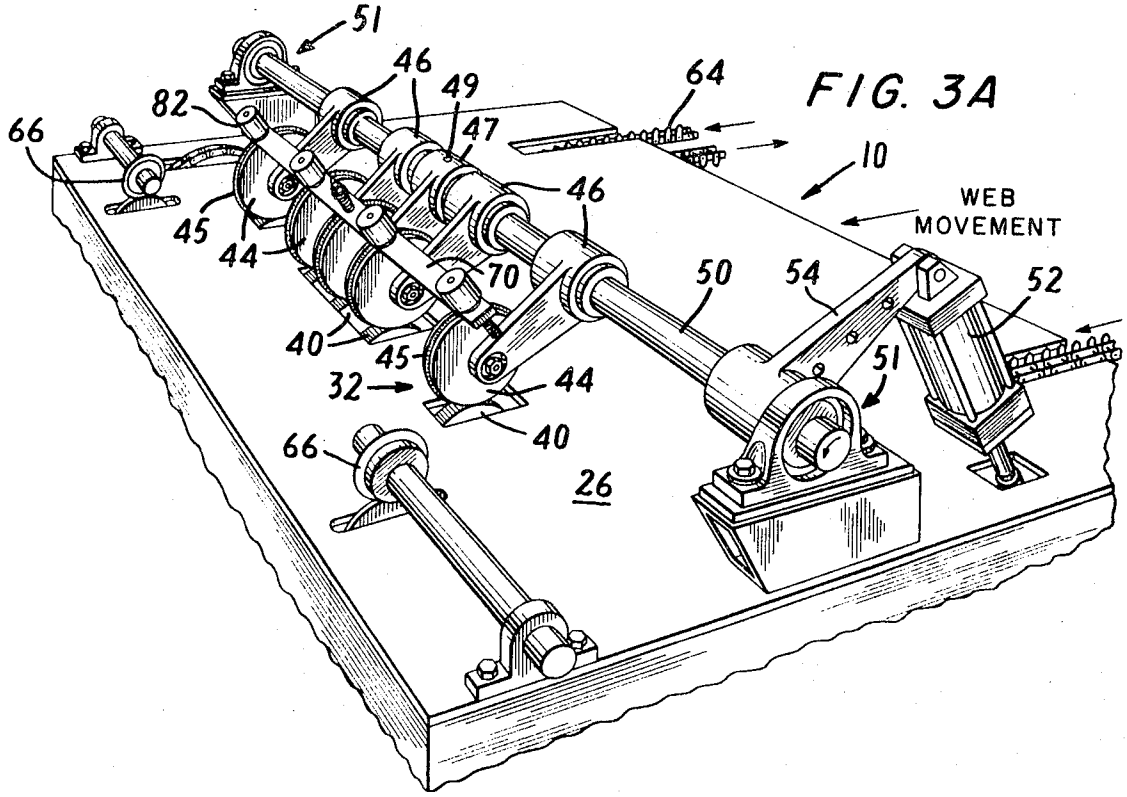

51
46
49
64
82
66
47
10
WEB
MOVEMENT
46
45
44
70
50
54
52
40
45
51
32
44
40
66
26

FIG. 3A

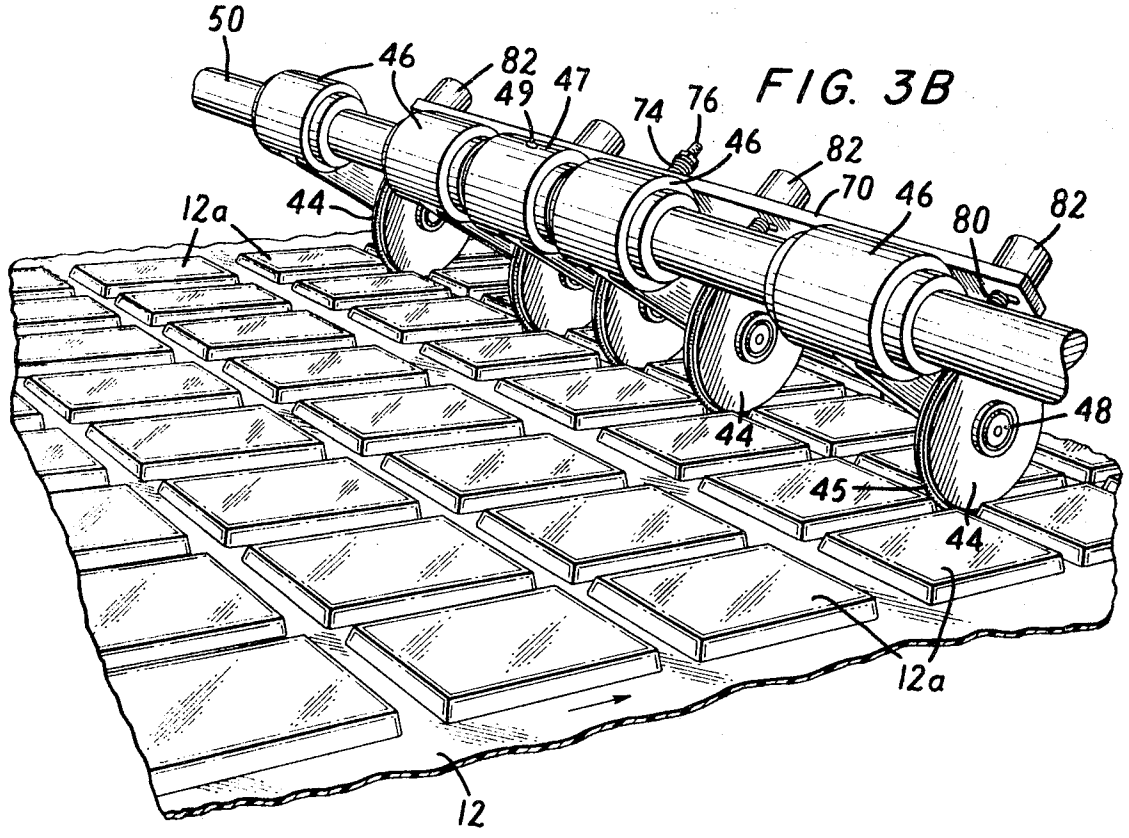

50
46
82
49
47
74
76
46
82
70
46
80
82
12a
44
48
44
45
44
12a
12

FIG. 3B

FIG. 4A

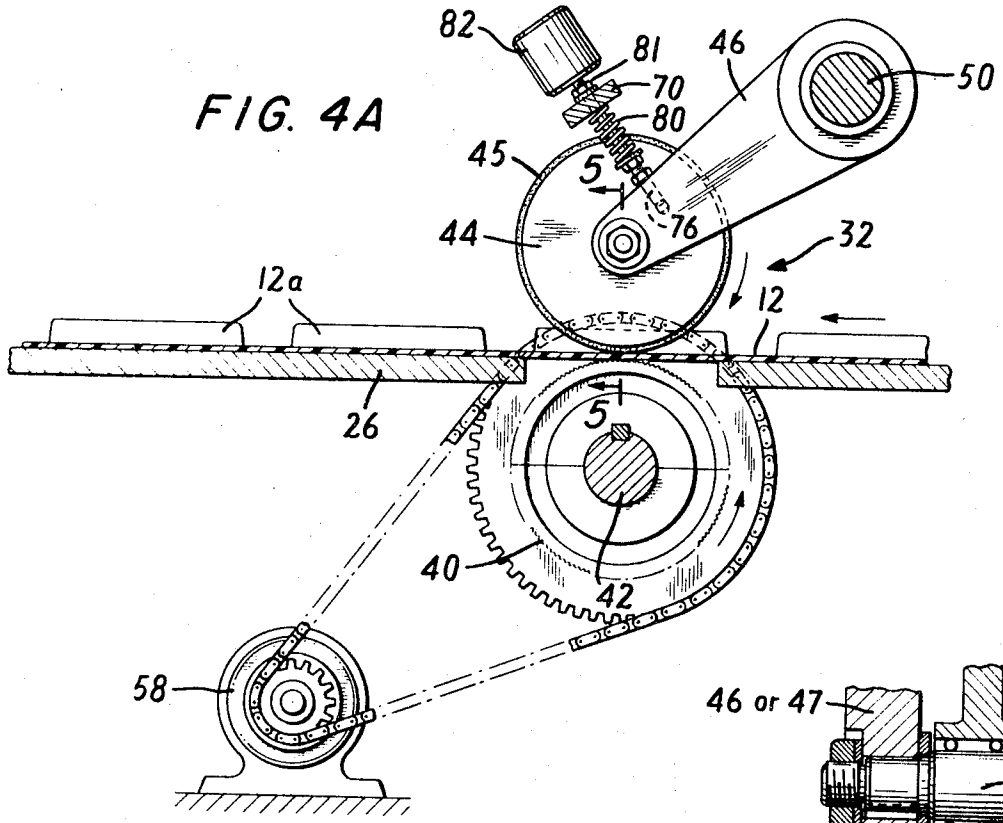


FIG. 5

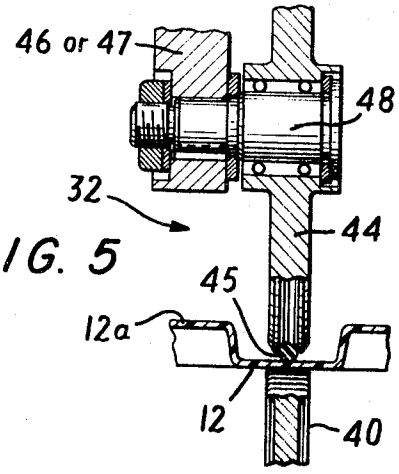
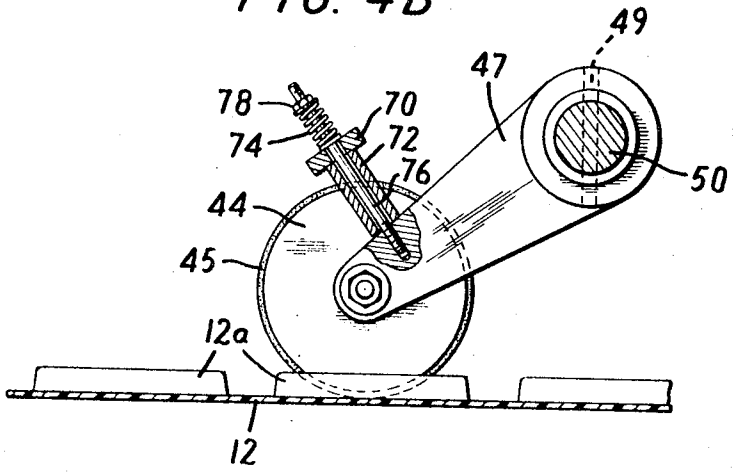


FIG. 4B



PREFORM RESHAPING MEANS HAVING WEB DISTORTION CONTROL DEVICE

BACKGROUND OF THE INVENTION

This invention relates to web handling apparatus and more particularly means for maintaining a desired degree of longitudinal tension on a shrinkable web during its movement through a treatment apparatus.

The feeding of a continuous length of sheet material, e.g., from a roll to utilization apparatus, ordinarily requires that relatively precise control of longitudinal movement be maintained throughout its path of travel. This is particularly true in instances where the nature of the treatment to which the web is subjected requires exact registry of a given segment of the web at several longitudinally spaced positions. Applications of this type occur frequently in the production of plastic articles where successive segments of a continuous web the first formed to produce a multiplicity of articles, such as cups or trays, and then blanked or cut to separate them into the individual articles. Other steps such as imprinting or embossing may also be incorporated in the fabrication process.

Economical mass production of uniformly shaped plastic articles from a continuous web requires that the longitudinal position of the web be carefully controlled during the succession of forming operations. To achieve the necessary accurate positioning, plastic forming machinery has been developed in which the web feeding means and the several treatment stations of the apparatus are precisely synchronized. Apparatus of this type, such as the package forming arrangement disclosed in copending application of Fred P. Brown, Ser. No. 815,292, filed Apr. 11, 1969, for "Method and Apparatus for Forming Containers," assigned to the present assignee, now U.S. Pat. No. 3,647,335, are quite effective where the web material being employed exhibits negligible tendency to deform in the direction of feed. Foamed polystyrene sheet, widely used for food trays, egg cartons, etc., is one such material.

However, in recent years, biaxially oriented plastic sheet materials have become available. These materials exhibit superior tensile strength properties, flexibility and toughness, as well as a high degree of optical clarity, all of which make them admirably suited for use in packaging applications where the contents of the finished package are to be made visible to the purchaser. Biaxially oriented polystyrene film, usually referred to as oriented polystyrene or OPS, is of particular attractiveness in the food packaging area since, in addition to the above-mentioned properties, it "breathes" at a rate comparable to many food products, thereby permitting a proper oxygen and water balance to be maintained in the packaged product, preserving its freshness and extending its life. As a result of this compatability, OPS has become more and more popular in the food packaging industry.

Until now however, the use of OPS has been somewhat limited because of difficulties encountered in its utilization in high speed packaging machinery. In such machines, the segment of the film or web about to enter the forming station is preheated to facilitate the forming operation. Since the biaxial orientation of the film results in shrinkage when heated, it is necessary to firmly hold the sheet along its edges as it is fed through the machine. This prevents shrinkage in a direction transverse to the direction of feed but permits shrinkage in the longitudinal direction. Thus, after a segment of the web has been formed and the mold section opened to release the formed section or "shot," the forces in the heated portion of the web about to enter the forming station tend to pull back the just formed shot in a direction opposite to the machine direction. This causes distortion of the shot, interfering with precise registration in the succeeding stages in the packaging operation. This problem becomes more acute as the width of the web increases.

SUMMARY OF THE INVENTION

The present invention overcomes the longitudinal deformation problem described above in a simple and effective way, thereby avoiding the registry and handling problems heretofore encountered. Briefly, in accordance with the present invention, means are provided on a forming machine for uniformly compensating for the deformation forces acting on the web as it passes through the machine. This tensioning means comprises a plurality of independently adjustable tensioning units disposed transversely of the web at a location subsequent to the forming station, so as to exert a longitudinal pull on the web counter to the forces due to shrinkage. These units comprise a series of pairs of rollers engaging the web at different points across its width, each pair of rollers consisting of a driven roller on one side of the web and an idler roller on the other side of the web. Motor means are coupled to the driven rollers and control the speed of these rollers in conjunction with the speed of the web movement. The tension forces are applied to the web by frictionally engaging the opposite surfaces thereof between the driven rollers on one side and respective idler rollers on the other side. Means are provided to adjust roller speed so that each roller pair develops constant torque and maintains the portion of the web which it engages under constant tension as the web is intermittently indexed through the forming machine. Each roller pair engages opposite sides of the web with sufficient force that there is no slippage or substantially no slippage between web and rollers at any time. The longitudinal tension applied to the web by each such tensioning unit (idler roller and its associated driven roller) is ordinarily greater at the center of the web and decrease towards either edge. This is because web deformation is ordinarily greater at the center of the web and decreases towards either edge. As a result of the features described above, the deformation of the web that would otherwise occur because of the heating operation is prevented. Thus, a physical or imaginary straight line drawn on the web upstream of the web-heating station in a direction perpendicular to the direction in which the web advances through the forming machine remains straight subsequent to the heating operation and does not become bowed as would otherwise be the case.

BREIF DESCRIPTION OF THE DRAWING

The foregoing advantages and features of the invention will become more readily apparent from the following detailed description thereof, when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a side elevation view in simplified form of a package forming machine incorporating the present invention;

FIG. 2A is a schematic partial plan view of the apparatus of FIG. 1, illustrating the distortion that occurs in the web in the absence of the present invention;

FIG. 2B is a partial plan view similar to FIG. 2 illustrating how the present invention corrects the distortion;

FIGS. 3A and 3B are perspective views illustrating the tensioning means of the present invention from two different aspects;

FIG. 4A is a vertical section view taken through the tensioning means of the present invention illustrating the roller elements of the tensioning means;

FIG. 4B is a partial vertical section similar to FIG. 4A showing a portion of the tension control means;

FIG. 5 is a partial section taken along the lines 5—5 of FIG. 4A, showing the roller construction; and

FIG. 6 is a schematic diagram of the pneumatic control circuit for an air motor drive usable in the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to the drawings, FIG. 1 illustrates, in simplified form, apparatus for forming three dimensional hollow articles, e.g., shallow rectangular trays, from a continuous web of plastic film in which a preferred embodiment of the present invention is incorporated. This apparatus is representative of the type of machinery employed for fabricating trays, cups and other containers for the packaging industry and is of the same general configuration as the apparatus described in the aforementioned copending application Ser. No. 815,292, now U.S. Pat. No. 3,647,335. From the ensuing description, it will be apparent that the principles of the present invention are equally applicable to other web handling applications in which longitudinal shrinkage of the web during treatment presents a deformation problem.

In the apparatus of FIG. 1, a continuous web of material 12, such as a film of OPS, is supplied from a roll 14 to the mating dies 18, 20 of the forming station 16 of the machine. The mating dies 18, 20 are shown by way of illustration of a typical forming means. It is, of course, within the scope of the invention to employ any suitable means for forming the material 12. For example, as those skilled in the art are aware, a single die can be employed in combination with means for blowing a fluid such as air against the material 12 to force the material 12 against the die during the forming operation. Or, a single die can be employed in combination with suction means whereby atmospheric pressure forces the material 12 against the die during the forming operation. Ordinarily, the web would pass through a heating station 22 prior to reaching the forming die or dies so that the plastic web may be preheated and softened prior to forming. The heating element, which may be of the electrical resistance type or any other suitable type, is denoted by the numeral 24 and may be controlled as to temperature the positioning over the web path by appropriate means (not shown).

The web 12 is moved through the apparatus by feeding means including a pair of endless belts or chains 64 disposed on either side of the web along the web supporting surfaces of the apparatus (see FIG. 3A). These transporting loops generally consist of a series of articulated elements, each of which includes means for firmly engaging an edge of the web. The engaging means may be clamps, teeth, or any other suitable means. Teeth are illustrated in FIG. 3A, by way of example. The teeth cooperate with corresponding holes (which are either preformed or formed by the teeth themselves) in the edge of the web, in the manner of a sprocket drive for a film strip.

As will be appreciated, the movement of the web must be halted during the forming step, i.e., when the dies 18 and 20 or other forming means are acting on a segment of the web to form the desired articles. Consequently, the web is transported or "indexed" incrementally or intermittently, so that after a fixed length of the web is moved into forming position, movement of the web is stopped until the forming operation is completed and the dies are again separated. In this manner, successive segments of the web are formed with essentially no wasted material therebetween. Any suitable drive control means, such as that described in the aforementioned copending application, may be used to provide the incremental movement of the web.

As shown in FIG. 1, upon leaving the forming station 16, the web is shaped with a plurality of three-dimensional hollow articles 12*a*, each joined to the other by an integral strip of plastic. The number of such individual articles formed in one forming operation will vary with the size of the article to be formed and the number of segments on the dies. As indicated by way of example in FIG. 3B, the width of the dies may be such as to produce eight or more separate articles transversely of the web.

The foregoing structure is described merely by way of background to explain the operaion of the web tensioning means 30 which forms the essence of the present invention. Details of such forming apparatus may be found in the aforementioned copending application.

FIGS. 2A and 2B are helpful in understanding the operation and function of the web tensioning means 30. FIG. 2A represents, in schematic form, a top view of the apparatus of FIG. 1 with all but the forming station 16 removed, the web moving from left to right through the apparatus. Assuming that the web 12 is of shrinkable material, it will be seen that shrinkage tends to pull on the web in the directions of the arrows immediately to the left of the forming station 16. Since the web is firmly constrained along its edges by the feeding means, shrinkage in the lateral direction is resisted and is negligible. Moreover, during the forming process, when the dies 18 and 20 are firmly closed on the web, shrinkage is also limited in the longitudinal direction.

However, as soon as the forming dies are opened in preparation for the next incremental movement or index of the web, the longitudinal restraint on the web is relieved and the shrinkage forces are free to pull in the longitudinal direction. The result is to pull back on the web in the direction opposite to that of movement through the machine, resulting in deformation of the segment of the web just leaving the forming station. As indicated by the curved dot-dash lines, the deformation tends to be greatest at the center of the web, i.e., farthest from the clamped edges, and decreases from the center towards the respective edges. The maximum deformation, indicated by the letter *a* in the drawing, will depend on the nature of the web material, the width of the web, and the configuration of the formed articles.

Oriented polystyrene, or OPS, a material highly desirable for use in food packaging because of its chemical and physical characterisitcs, exhibits relatively high

shrinkage when heated. Moreover, when using OPS in a package forming apparatus, such as shown in FIG. **1**, it is desirable for optimum forming action to heat the successive segments of OPS before they reach the forming station. Consequently, the shrinkage under heat exhibited by OPS is to be expected and unless means are provided to compensate or counteract the shrinkage, the formed articles will be subject to substantial deforming forces after the dies are separated and the next segment of the web is being fed to the forming station. Such deformation distorts the formed articles and makes it difficult to accurately align subsequent operations such as blanking, printing, etc. It interferes also with the proper nesting of the blanked articles, making subsequent use of the articles, particularly by automated means, more difficult.

In accordance with the present invention, the above described deformation is avoided by means of the web tensioning means **30.** As illustrated schematically in FIG. 2B, the tensioning means **30** is disposed transversely of the web at a location subsequent to or downstream of the forming station **16** and consists of a plurality of individual tensioning units **32,** each adapted to exert a tensioning force on the web in the direction of the associated arrow and of a magnitude represented by the length of the arrow. It will be seen that if the tensioning forces applied by the units **32** are equal and opposite to the deforming forces applied to the web as a result of the shrinkage of the film, the deforming forces will be counteracted and there will be no distortion of the finished articles.

FIGS. 3A, 3B, 4A, 4B and **5** illustrate the tensioning means **30** in greater detail. As seen best in FIG. 4A, each of the tensioning units **32** includes a pair of rollers arranged on opposite sides of the web **12.** The lower or driven roller **40** is keyed or otherwise fixed to a shaft **42** to be rotated thereby. The upper or idler roller **44** is journaled at the end of a hold-down lever **46** by means of a sprag or one-way clutch mechanism **48** (FIG. **5**) which permits it to rotate only in the direction indicated by the arrow, i.e., in the direction of movement of the web. It is, of course, within the scope of the invention to interchange the positions of the driven and idler rollers.

Referring now to FIG. 3A, the five tensioning units of the preferred embodiment are illustrated in position at the output end of the apparatus **10.** The driven rollers **40** are only partially shown, being located beneath the table surface **26.** Each of the idler rollers **44** is shown in place at the end of its respective hold-down lever.

Of the five tensioning units shown, four of them are provided with hold-down levers **46** which are mounted for free rotation about a common shaft **50.** The hold-down lever **47** of the fifth tensioning unit is fixed to the shaft **50** as by means of a pin **49** (see FIG. 4B) so that the lever rotates with the shaft **50.** In other respects, the lever **47** and the roller which it carries is similar to the remaining four tensioning units.

The shaft **50** is supported at each end in suitable bearing blocks **51** secured to the outer edges of the table **26.** A lever arm **54** is keyed to one end of the shaft **50,** and pivotally connected to a pneumatic piston-cylinder unit **52.** Upon application of pressurized air, the pneumatic unit extends to rotate the shaft **50** in the direction shown by the arrow at its near end and force the hold-down lever **47** and its associated idler roller **44** downwardly towards the lower roller **40.** The force thus exerted on the web is proportional to that supplied by the pneumatic unit and establishes a reference force to be applied to the film by the tensioning means.

All of the lower or driven rollers **40** of the respective tensioning units are keyed to a common shaft **42** which is rotated, as through a chain and sprocket drive, by a motor **58.**

FIGS. 4A and **5** best illustrate the manner in which the tensioning units apply tension to the web as it passes between the roller pairs. As indicated in FIG. **5,** the outer periphery of the driven roller **40** is roughened, such as by straight knurling and the idler roller **44** is provided with an outer friction surface in the form of an elastomeric O-ring **45** snugly received in a circumferential groove around the outer edge of the roller. The combination of the knurled surface and the O-ring is effective to firmly grasp an intermediate web without allowing slippage to occur and without damage to the web. It is, of course, within the scope of the invention to interchange the knurled and O-ring surfaces or to use other surfaces with a suitable coefficient of friction. It is also within the scope of the invention to employ any other means for applying a controlled longitudinal tension to the web, including a sprocket-type drive or a drive similar to the feeding mechanism **64** (see FIG. 3A).

With the idler roller **44** urged downwardly against the upper surface of the web **12** and in turn pressing the web against the associated peripheral surface of the lower wheel **40,** the web is frictionally engaged by the peripheral surfaces of the rollers with a force dependent upon the downward force applied by the idler roller. As a consequence, rotation of the driven wheels **40** tends to pull the web in the direction of rotation, and each of the tensioning units applies tension to the web in its direction of movement. Referring back to FIGS. 2A and 2B, it will be seen that if these forces are of appropriate magnitudes, they compensate for the longitudinal shrinkage forces acting in the opposite direction. The appropriate magnitudes automatically result in accordance with the invention since the web and all of the tensioning units where they are tangent to the web all move at the same speed, there being no slippage. The forces with which the rollers of each roller pair are urged towards each other can be individually adjusted by means described below in connection with FIGS. 4A and 4B.

Returning now to FIG. 3A, in which the web is omitted for purposes of clarity, each formed segment of the web is moved in the direction of the arrow from the forming station **16** (not shown in FIG. 3A) by the web feeding means **64** or other suitable web feeding means. As the web reaches the series of tensioning units **32,** it is grasped by the respective pairs of rollers and longitudinal forces tending to tension the web are applied at spaced transverse locations. The magnitudes of the respective forces with which the paired rollers of the tensioning means **32** are urged towards each other may be independently adjusted, as will be described below, so that the tensioning forces may compensate as nearly as possible for the shrinkage forces to which the web is subjected. After leaving the tensioning means, the edges of the web may be trimmed by means of rotating cutter knives **66** adjacent both edges of the table.

The transverse spacing and number of tensioning units required will depend upon the width of the web

being processed, its shrinkage characteristics, and the configuration of the articles being formed. As seen in FIG. 3B, the web may be formed into a series of generally rectangular trays 12*a*, eight across the width of the web. With the expected deformation as illustrated in FIG. 2A, the greater tensioning forces are required towards the center of the web. Therefore, three tensioning units are located in the center area of the web with two additional ones on either side of the web near, but not at, the edges. To avoid damage to the finished articles, these tensioning units are arranged so that the rollers frictionally engage the web in the spaces between rows of the formed articles. This of course is but one example of the number and location of such tensioning means and they may be varied to suit the particular application.

Independent control of the forces applied by each of the tensioning units is effected by means of the tension control bar **70** which bridges all of the roller hold-down levers **46** and **47.** As shown in FIG. **4B**, the tension control bar is fixed in spaced relation to the lever **47** by means of a spacer sleeve **72** and spring **74.** The bar **70** is snugly retained in spaced relation to the lever **47** by the rod **76** which threadedly engages the arm **47** and the nut **78** and passes through the spring **74.** As described hereinabove, the pneumatic unit **52** and lever arm **54** apply a predetermined torque to the shaft **50** tending to urge the hold-down lever **47** and its idler roller downwardly with a force dependent upon the air pressure in the pneumatic cylinder. Since the tension control bar **70** is fixed to the lever arm **47,** it thereby establishes a reference pressure from which the remaining lever support arms **46** may be adjusted. In the event the configuration of the formed articles is such that tensioning forces are not to be applied along the center of the web, the roller **44** on the lever **47** may be removed. Without the roller, the lever **47** still serves the function of establishing a reference pressure for the active tensionsing units.

Turning to FIG. **4A**, the adjustable coupling of the tension control bar to each of the hold-down levers **46** is illustrated. As in the case of lever **47,** a rod **76** is also threadedly received in the lever **46.** A compression spring **80** is retained between the lower surface of the bar **70** and a retaining nut **81** on the rod **76,** and a weight **82** is threaded onto the upper end of the rod. As the retaining nut **81** is turned, it will either pull the arm **46** towards the bar **70** or push it further away. In either case, the force with which the roller **44** is urged downwardly against the lower roller **40** is charged. Further control of the downward force exerted by the roller may be effected by means of the weight **82,** which adds an increment of downward force on its associated hold-down lever. The weight **82** may be dispensed with entirely or it may be used in place of the retaining nut **81** where it is able to provide the requisite downward force.

In adjusting the tensioning mechanism heretofore described, the operation of the forming apparatus is stopped shortly after the beginning of the run and the amount of deformation observed. The maximum downward force on the lever **47** is then applied through the pneumatic unit **52** and the adjustable couplings on the remaining hold-down levers **46** actuated to relieve the gripping forces to the desired extents. Some further adjustment may be necessary as the run progresses to effect accurate control of the tensioning forces.

The best mode contemplated by the inventor for adjusting roller forces is that described above. The advantages, in addition to those already indicated, include the further fact that compensation is automatically made for slight differences among the rollers (slightly different diameters resulting from different degrees of wear, for example) and for slight variations in the thickness of the web of material **12** at different points, plus the fact that roller pressures can be individually adjusted to take into account variations in the degree of orientation of the polystyrene across the width of the web. However, it is within the scope of the invention to mount the driven rollers coaxially with respect to a common shaft and the idler rollers coaxially with respect to a second common shaft, when the nature of the material **12** and other conditions permit, thereby achieving a certain economy of machine construction at the cost of a loss of flexibility as regards the individual adjustments that are facilitated by the preferred mode described above.

As described above, during the operation of the forming machine, the web is fed to the forming station incrementally or intermittently rather than continuously. In order to maintain the tensioning forces at the proper level and to avoid tearing or crumpling the web, the speed of the driven rollers is controlled in synchronism with the movement of the web so that the tension is constant whether the web is stationary, i.e., during actuation of the dies, or moving. An air motor is at present preferred for this purpose, but it is also within the scope of the invention to employ any other suitable motive means that can develop a constant output torque over an adequate speed range including a stalled condition, for example a gas motor, an electric motor of the type used in servo-systems, or any motor coupled to the load through a suitable clutch, such as a clutch that engages and disengages smoothly and continuously as a function of a variable control voltage.

In the preferred embodiment illustrated in FIG. **6,** the motor **58** employed to drive the rollers **40** is of the compressed air operated type. Such motors are capable of good speed control and provide slippage without damage or overheating. A suitable type of such an air motor is the Model 16AM made by the Gast Manufacturing Company.

To control the speed of the motor, compressed air from a supply **90** is fed through two parallel paths to the air motor. The first of these paths includes a pressure regulating valve **92** set to limit the air pressure delivered to a maximum pressure **P1.** A check valve **94** prevents return air flow. The second path includes a pressure regulator valve **96** set at a pressure **P2** substantially higher than the pressure **P1.** An accumulator tank **98** maintains a constant pressure **P2** available at all times. Finally, the application of air at pressure **P2** to the motor is controlled by the solenoid valve **100** and a check valve **102.**

As indicated hereinabove, in order to maintain constant tension on the web at all times, it is necessary that the driven rollers **40** rotate at a speed equal to the movement of the web in order not to tear or mutilate the web (which alternately starts and stops). Thus, during the indexing or movement period of the web, the motor should be operating at a relatively high rate of speed while during the forming operation, the motor should be stalled while maintaining constant tension on the web. The pneumatic circuit of FIG. **6** insures that

these conditions are met. During the forming operation, the solenoid **100***a* associated with the solenoid valve **100** is unenergized and the valve is closed, thereby preventing delivery of high pressure air to the air motor **58.** Consequently, there is an open path for air at low pressure P1 established by the regulator valve **92** to be delivered to the air motor. With low pressure air supplied to it, the motor operates at a stall, while maintaining constant tension on the web.

Just prior to opening of the forming dies and indexing of the web, the solenoid valve is actuated to open the valve **100** and allow high pressure air from the accumulator **98** to reach the motor **58.** By the time the web is being indexed, the motor is thus operating at its higher speed and the same requisite tension on the web is maintained. When the web is stopped for the next forming operation, the solenoid valve is deenergized again and the low pressure air through valve **92** is returned to the air motor so that it stalls while maintaining the same requisite tension. Acuation of the solenoid valve is thus synchronized with the movement of the web and preferably is under control of the same timing mechanism.

It will be seen from the foregoing that a novel and effective means has been provided for overcoming the shrinkage and deformation problems encountered in the treatment of shrinkable web materials. Although in the preferred embodiment, the use of the invention in connection with OPS in a package forming machine has been described, it will be realized that the teachings of the invention are applicable as well to other applications where similar problems are encountered. Moreover, the particular form and details of the tensioning means illustrated may be modified in various respects without departing from the spirit of the invention, as will be appreciated by those skilled in the art.

I claim:

1. In apparatus for producing hollow three dimensional articles from an elongated web of shrinkable material including pressure forming means adapted to shape one or more of the desired articles in said web at one time and means for feeding said web to said forming means and removing it therefrom after actuation of said forming means, said feeding means including transport means adapted to move along a path passing said forming means and firmly engaging said web along both edges thereof, the improvement comprising web distortion control tensioning means engaging said web at a location subsequent to said forming means for applying longitudinal tension to said web between the edges thereof as it moves through said apparatus to prevent said web from becoming distorted by shrinkage.

2. Apparatus as set forth in claim **1** above for producing said articles from a web of biaxially oriented plastic material, further comprising means for heating said web prior to its reaching said forming means.

3. Apparatus as set forth in claim **1** wherein said tensioning means comprises a plurality of tensioning units disposed transversely of the path of said web, and means for individually controlling the tension applied to said web by each of said tensioning units.

4. Apparatus as set forth in claim **3** above wherein each of said tensioning units includes first and second rollers respectively disposed on opposite sides of said web as it moves through said apparatus, the peripheral surfaces of said rollers being arranged to frictionally engage the web therebetween, means for driving one of said rollers to rotate at a plurality of predetermined speeds in the direction of movement of said web, and means for urging the other of said rollers towards said one roller thereby to frictionally engage the web therebetween substantially without slippage between said rollers and said web and apply substantially constant tension forces to said web.

5. Apparatus as in claim **4** wherein said driven roller has a substantially unyielding, knurled peripheral surface and said other roller has a peripheral contact surface provided by an elastomeric O-ring retained in a circumferential groove in said other roller.

6. Apparatus as in claim **5** further comprising a common driving shaft for the driven rollers of all of said tensioning units, motor means for rotating said common shaft, and common support means for said other rollers of all of said units, each of said urging means for said other rollers being independently adjustable.

7. Apparatus as in claim **6** wherein each of said other rollers is mounted on said support means by means of a one-way clutch operable to enable said other roller to rotate only in the direction of web movement.

8. Apparatus as in claim **6** wherein said web feeding means is operative to move said web by successive incremental lengths to said forming means, said web being stationary during actuation of said forming means, said apparatus further comprising speed control means for said motor means, said speed control means being operative in synchronism with said web feeding means to increase the speed of said motor during movement of said web and decrease its speed during actuation of said forming means.

9. Apparatus as in claim **8** wherein said motor means comprises a compressed air actuated motor and said speed control means includes a source of compressed air, a plurality of pressure regulating valves coupled to said source, means coupling one of said valves to said motor and means including a solenoid actuated valve coupling the other of said valves to said motor, said solenoid opening its associated valve just prior to the feeding of the next incremental length of web to said forming means and permitting said associated valve to close when said forming means is actuated.

10. Apparatus as in claim **9** wherein said pressure regulating valve coupled to said motor through the solenoid actuated valve supplies air at a higher pressure than the other regulating valve, whereby the speed of said motor is higher during actuation of said solenoid actuated valve.

* * * * *