June 6, 1967 R. H. BEAUMONT ETAL 3,323,226

SYNTHETIC DRYER BELT

Filed May 28, 1963 3 Sheets-Sheet 1

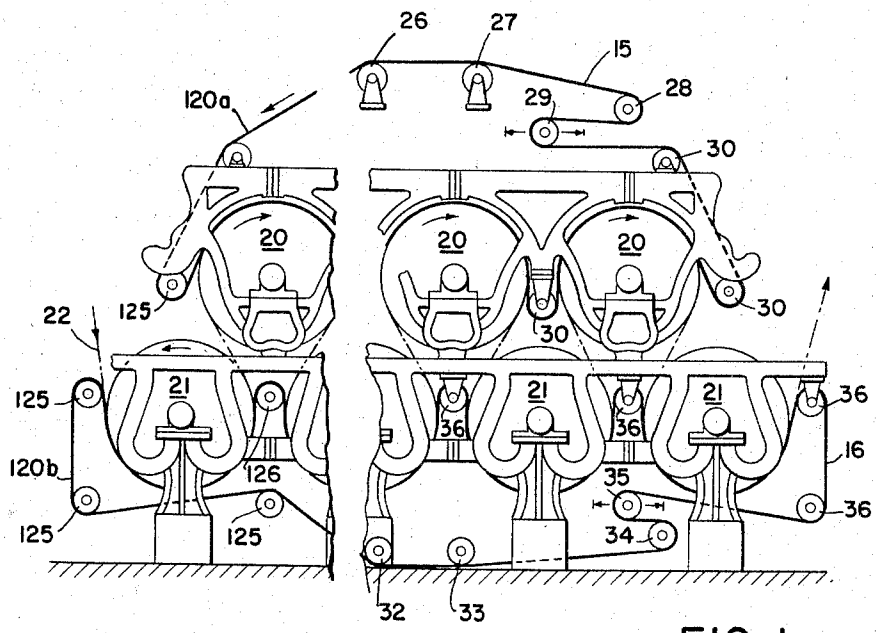


FIG. 1

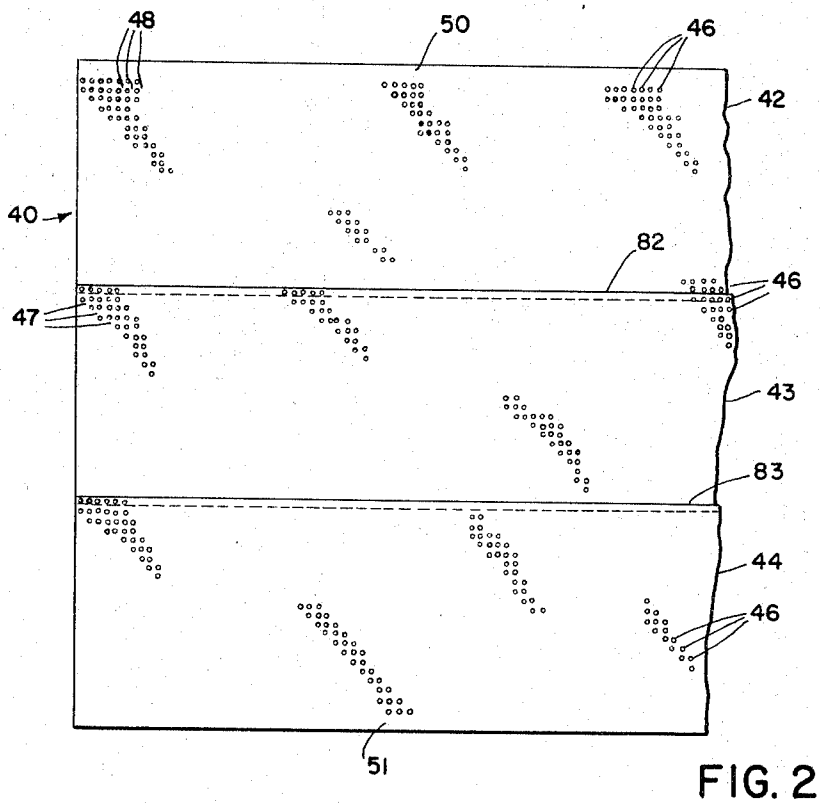


FIG. 2

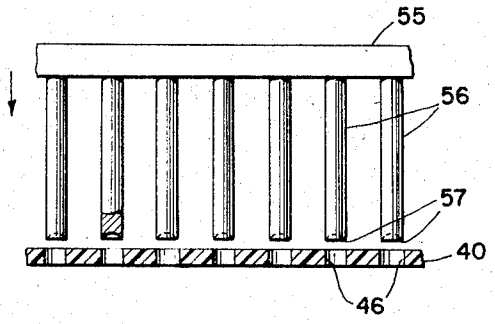


FIG. 3

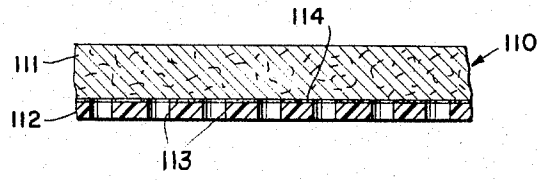


FIG. 4

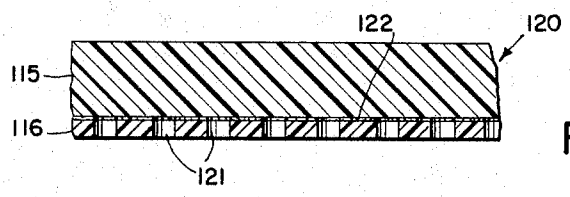


FIG. 5

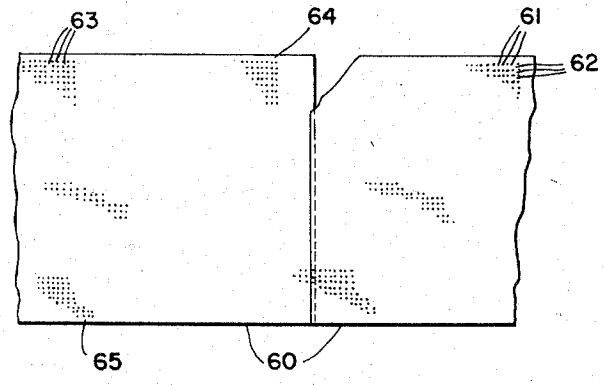


FIG. 6

June 6, 1967 R. H. BEAUMONT ET AL 3,323,226

SYNTHETIC DRYER BELT

Filed May 28, 1963 3 Sheets-Sheet 3

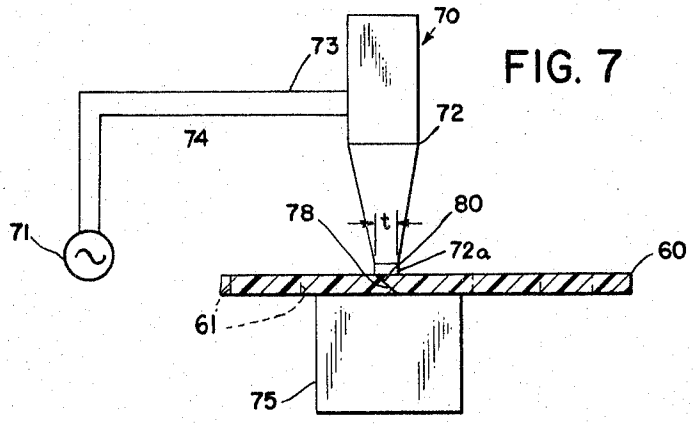


FIG. 7

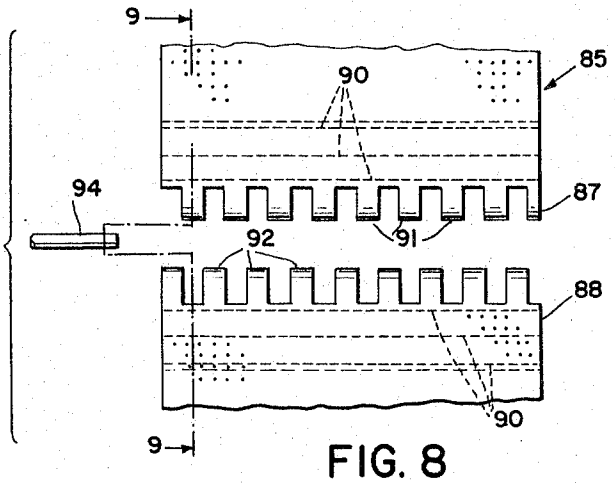


FIG. 8

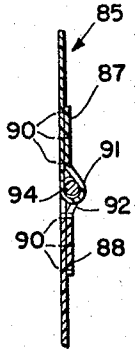


FIG. 9

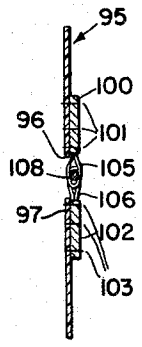


FIG. 11

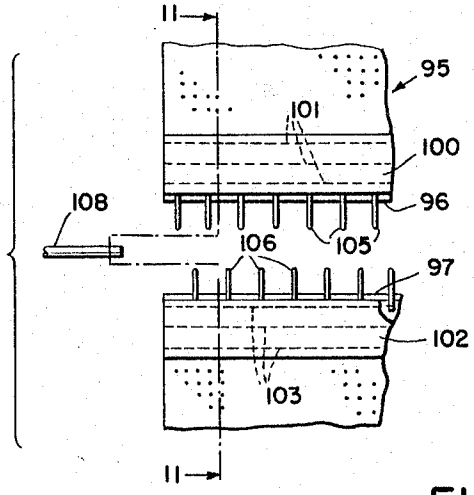


FIG. 10

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Patented June 6, 1967



3,323,226

# SYNTHETIC DRYER BELT

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8 Claims. (Cl. 34—95)

This invention relates to drying machines and more particularly to an improved belt for use in such machines.

Dryer belts of the type to which the present invention is directed, while of general application, are particularly well suited for use in connection with the production of non-woven fibrous products such as paper, paperboard, box-board, etc., in a papermaking machine. As is well known, such machines customarily include a so-called "wet" section and one or more drying sections. The paper product is formed from a web of water-saturated pulp which is transported by one or more papermakers' wet felts through opposed press rolls and other de-watering devices in the wet section of the machine until the moisture content of the web is reduced and its fiber structure compacted to such a point that it may become substantially self-supporting. The web is then received by one or more dryer belts, which heretofore customarily have been in the form of a belt or other woven fabric, and is carried around a series of rotating dryer drums in the drying section of the machine. These drums are arranged to apply heat to the web to remove the remaining moisture.

Papermakers' dryer belts serve to hold the paper web in intimate contact with the heating surfaces of the rotating dryer drums to promote heat transfer and to prevent cockling or wrinkling of the web while being dried. Such belts should be flexible and heat resistant with good dimensional stability and durability under the conditions of tension, temperature, etc., customarily encountered in the drying section of the paper machine. The belts also must have a smooth surface finish appropriate for the particular fibrous product being produced. These characteristics should be realized while at the same time maintaining the cost of the belts to the paper manufacturer at a minimum.

Heretofore, the most widely used dryer belts have been woven from either natural or synthetic yarns to form a relatively bulky fabric. It was generally considered necessary that the fabric have good absorbent characteristics and high porosity to enhance the removal of moisture from the web of material being dried. While smooth surface finish was recognized as a desirable property, it was felt that the fabric should have sufficient roughness so that it could be easily driven and guided during its movement around the dryer drums of the machine.

In the manufacture of dryer belts of the type previously employed, difficulties were encountered in the realization of belts having the optimum drying characteristics. For example, particularly in cases in which the belts were of woven construction, comprises had to be made between what was desired in the way of dimensional stability, durability, surface finish, porosity, etc., because emphasis upon certain of these characteristics necessitated the sacrifice of others. As an illustration, for applications in which it was felt that the belts should have high porosity, a comparatively open weave fabric was employed, with the attendant reduction in dimensional stability, durability and surface finish. To improve these latter characteristics, the yarns were woven closer together to form a comparatively dense fabric, with the result the range of available porosities often was too slow. Moreover, primarily because of the highly absorbent, deformable nature of many prior belts, the belts exhibited a tendency to rewet the sheet being dried and were difficult to keep clean. In addition, even though dryer belts of the type used hereto frequently included asbestos or other heat resistant fibers, their resistance to the heat from the dryer drums in many cases proved deficient. Furthermore, difficulties frequently were encountered heretofore in the joining of the ends of the belts to provide an endless construction.



The difficulties experienced with dryer belts of traditional construction were often compound by their comparatively high cost. In many cases, the belts required expensive textile processing operations, including the use of large and costly looms. Also, substantial quantities of relatively expensive fibers were needed, the cost of which was further increased when fibers having good heat resistant properties were employed.

One general object of this invention, therefore, is to provide a new and improved belt for use in a drying machine.

More specifically, it is an object of this invention to provide a belt of the character indicated in which the belt exhibits broadened porosity characteristics, greater dimensional stability, increased durability and good finish properties in much broader ranges of combination than dryer belts heretofore available.

Another object of this invention is to provide such belt in which the amount of moisture absorbed by the belt material is substantially reduced and in some cases eliminated.

Another object of the invention is to provide a belt for the drying section of a paper machine which exhibits greater resistance to heat and chemical deterioration than many types of dryer belts employed heretofore.

Still another object of the invention is to provide a dryer belt for a paper machine in which the tendency of the belt to fill up and thus require frequent cleaning is substantially reduced.

A further object of the invention is to provide an improved connection between the ends of the belt.

A still further object of the invention is to provide a belt which is extremely economical to manufacture and thoroughly reliable in operation.

In one illustrative embodiment of the invention, there is provided a belt for the paper web in the drying section of a paper machine which includes a plurality of perforations substantially entirely throughout its surface area. The belt is fabricated from oblong, rectangular sheets of synthetic, non-woven material which are positioned in side-by-side relationship with each other. The ends of the perforated sheets are connected together to form a seamed or endless belt which is arranged in an operative position around the dryer drums of the machine.

In accordance with one feature of the invention, the belt is manufactured from sheets of a polymeric material which is substantially non-deformable in thickness and has a substantially crystalline structure, for example, polyethylene terephthalate. The material preferably has softening and melting points at comparatively high temperature levels and exhibits good durability and dimensional stability under the conditions of tension, temperature, flexure, etc., in the drying section of the machine. In certain particular advantageous arrangements, the material is substantially non-absorbent, thereby further improving the drying action by reducing the possibility of transmitting unevenly absorbed moisture in the form of wet streaks, etc., back to the paper web.

In accordance with another feature of certain embodiments of the invention, the perforations in the belt material are of a size and orientation sufficient to enable extremely efficient transmission of moisture through the

belt from the paper web. In some embodiments, the perforation arrangement is such that uninterrupted paths of the material extend in a lengthwise or machine direction, thereby further preserving the material's good durability characteristics.

In accordance with still another feature of the invention, in some particularly advantageous embodiments, the incompressible belt includes a lamination of compressible material in position to contact the web of paper. In some cases, the compressible material comprises a batt of either natural or synthetic fibers, while for other applications a layer of open-cell foam is secured to the belt. The laminated belt is particularly advantageous at the infeed or wet end of the dryer section and serves to provide an exceedingly smooth surface adjacent the paper web while further enhancing the drying action.

In accordance with still another feature of the invention, in several good arrangements, the various seals between the sheets of material forming the belt are accomplished by ultrasonic means, as is the seal joining the ends of the belt. Such seals provide an extremely strong joint and further reduce the possibility of finish markings on the paper product.

In accordance with a further feature of certain embodiments of the invention, the belt material is preconditioned while under tension by the application of heat thereto for a predetermined time.

The present invention, as well as further objects and features thereof, will be understood more clearly and fully from the following description of certain preferred embodiments, when read with reference to the accompanying drawings, in which:

FIGURE 1 is a side elevational view, partially broken away, of portions of the drying section of a paper machine, together with representative web-carrying belts in accordance with the invention;

FIGURE 2 is an enlarged plan view of a portion of a web-carrying belt in accordance with one illustrative embodiment of the invention;

FIGURE 3 is an enlarged vertical sectional view of the belt shown in FIGURE 2, together with a schematic representation of suitable perforating apparatus;

FIGURE 4 is an enlarged vertical sectional view of a portion of a laminated belt in accordance with another illustrative embodiment of the invention;

FIGURE 5 is an enlarged vertical sectional view of a portion of a laminated belt in accordance with a further illustrative embodiment of the invention;

FIGURE 6 is a plan view, partially broken away, of the ends of a web-carrying belt showing a representative connection therebetween;

FIGURE 7 is an enlarged vertical section view of a portion of the belt shown in FIGURE 6, along with a schematic illustration of representative apparatus for effecting various seals;

FIGURE 8 is an exploded plan view of the ends of a web-carrying belt showing another representative connection therebetween;

FIGURE 9 is a longitudinal sectional view taken generally along the line **9—9** in FIGURE 8;

FIGURE 10 is an exploded plan view in general similar to FIGURE 8 but showing a third representative connection between the ends of the belt; and

FIGURE 11 is a longitudinal sectional view taken generally along the line **11—11** in FIGURE 10.

The dryer belts described herein preferably are fabricated from thermoplastic polymeric sheet materials having a substantially crystalline structure and a comparatively high softening or distortion point. Such materials are substantially non-deformable in thickness and exhibit little or no compressibility, either in their unstressed condition at room temperature or under the conditions of tension, temperature and flexure customarily encountered in the drying section of a paper machine. In the operation of some types of machines, the temperature of the dryer drums may approach about 300° F., and in these cases the softening point of the material should be well in excess of this temperature. In addition, the material advantageously is substantially non-absorbent. As a result, the moisture from the paper web passes through the perforations and is not retained within the material, thereby reducing the possibility of transmitting moisture from the material back to the web.

One illustration of an incompressible polymeric sheet material which is of particular utility in connection with the invention is polyethylene terephthalate. This material is exemplified by the line of products commercially available from E. I. du Pont de Nemours and Company, Wilmington, Del., and sold under its trademark Mylar. Such products are referred to herein as Mylar polyester film and are characterized by their crystalline structure, high heat resistance, extremely smooth surface finish and good tensile strength. The melting and distortion points lie within the range of from about 380° F. to 490° F., well above the temperatures encountered in the drying sections of conventional paper machines. Because conventional sealing operations have little utility when applied to Mylar polyester film, difficulties heretofore were encountered in joining the ends of the material to form an endless belt, and these difficulties were of special moment in cases in which a smooth surface was desired in the vicinity of the joint. However, because of the unique joining means described hereinafter, exceedingly smooth belt surfaces are provided which substantially reduce any possibility of marking the paper web.

Of the various types of Mylar polyester film presently available, Type A and Type T have exhibited particular utility as dryer belts. Type A is biaxially oriented, having substantially equal properties in both the longitudinal or machine direction and in the transverse or cross direction. It has extremely good dimensional stability and exhibits little or no elongation or shrinkage under the widely varying conditions of tension, temperature and pressure in the drying section of the machine. Type T has unusually high tensile strength in the machine direction and is particularly useful in cases in which the machine is operated at high speed or in the manufacture of some of the heavier paper products such as paperboard, for example.

Mylar polyester film customarily ranges in thickness from about 0.25 mil to about 14.0 mils for single ply construction. However, when used as dryer belts in accordance with several advantageous embodiments of the invention, it has been found that two or three plies often are advantageous and that the thickness of the belts should range between about 5.0 mils and 28.0 mils for optimum operating characteristics, and preferably between about 7.5 mils and 14.0 mils.

Other polymeric materials useful in the formation of dryer belts in accordance with the invention include polyamide polymers, e.g., the nylons designated as Type 6, Type 66 and HT–1 various polycarbonate polymers, vinyl polymers such as polyvinyl fluoride or polytetrafluoroethylene, for example, and various varieties of vinylidene polymers. Representative of suitable polymers of this latter class are polymers of vinylidene bromide, vinylidene chlorobromide, vinylidene cyanide and vinylidene halocyanide. These and other monomers also may be co-polymerized to form copolymers such as vinylidene chloride-vinyl chloride, for example.

As best shown in FIGURE 1, rectangular sheets of Mylar polyester film are aranged to form a top belt **15** and a bottom belt **16** in the drying section of a paper machine. The belt **15** extends over a plurality of upper tier dryer drums or cans **20**, while the belt **16** is trained around a series of lower tier dryer cans **21**. These belts serve to hold a running web **22** of paper against the cans **20** and **21** during its passage through the drying section. The cans **20** and **21** are internally heated by steam under pressure to a temperature which in many machines may be about 300° F. As will be understood, at the time the paper

web 22 enters the infeed or wet end of the drying section (that is, the left end, as viewed in FIGURE 1), the web has been formed in the forming section of the machine and has been conducted through various de-watering devices in the wet section. In the drying section, the belts 15 and 16 hold the web in contact with the cylindrical surfaces of the cans 20 and 21, thereby enhancing the transfer of heat therefrom and preventing the web from wrinkling or cockling as is dries. At the time the web reaches the outfeed end of the dryer, it customarily has a moisture content which is under ten percent, wet basis, and in most cases is substantially in its finished form. By percent moisture content "wet basis" is meant the weight of the water in the web as it leaves the dryer section divided by the total weight of a water saturated web times 100, as determined by the procedure described in ASTM Standards for Textile Materials, Tentative Methods for Quantitative Analysis of Textiles, ASTM designation D629–59T, pages 317–8, 31st ed., published November, 1960.

The belts 15 and 16 are of endless construction and are supported by a series of guide rolls, stretch rolls and carrying rolls in the drying section of the paper machine. Thus, the top belt 15 is disposed over a pair of guide rolls 26 and 27, around two stretch rolls 28 and 29 and over a series of carrying rolls 30. The pillow block and shaft bearing (not visible in FIGURE 1) at one end of each of the guide rolls 26 and 27 are movable in the usual manner to change the angularity of the roll and thus guide the travel of the belt, the block and bearing for the guide roll 26 being manually movable and those for the guide roll 27 being movable by mechanical means. The stretch roll 29 is arranged for movement in a longitudinal or machine direction to increase or decrease the tension in the belt 15. The lower reach of the belt extends over the upper portions of the cylinder surfaces of the top tier dryer cans 20, and these cans are continuously rotated (by means not shown) in a clockwise direction, as viewed in FIGURE 1, thereby driving the belt in an opposite or counterclockwise direction, as viewed in this figure.

In a similar manner the bottom belt 16 extends around two guide rolls 32 and 33, a pair of stretch rolls 34 and 35 and a series of carrying rolls 36. The upper reach of the belt 16 is in contact with the lower portions of the cylindrical surfaces of the lower tier dryer cans 21. These latter cans are driven in a counterclockwise direction, as viewed in FIGURE 1, thereby rotating the belt 16 clockwise. The angularity of the guide rolls 32 and 33 is adjustable, in a manner similar to that described above, and the stretch roll 35 is movable in the machine direction to vary the tension in the belt.

Referring to FIGURE 2, there is shown a dryer belt 40 which is representative of the belts 15 and 16. The belt 40 is fabricated from three oblong sheets 42, 43 and 44 of Mylar polyester film. These sheets are ultrasonically sealed in side-by-side relationship with each other, in a manner that will become more fully apparent hereinafter, to provide smooth continuous belt surfaces. The belt 40 is provided with a plurality of perforations 46 substantially entirely throughout its surface area. The perforations 46 are aligned in rows which extend in the longitudinal or machine direction of the belt and also in the transverse or cross direction. The spacing betwen adjacent rows of perforations is substantially equal to the diameter of each perforation and provides uninterrupted longitudinal paths 47 and transverse paths 48 of the belt material. Particularly because of the longitudinal paths 47, the reduction in the tensile strength of the material occasioned by the perforations is considerably less than would otherwise be the case.

The outermost sheets 42 and 44 of the belt 40 include imperforate, longitudinally extending areas 50 and 51, respectively. The areas 50 and 51 extend along the outer edges of their respective sheets and serve to minimize the possibility of fraying or rupture at these edges after repeated usage.



As a result of the perforations 46, the available ranges for the porosities of dryer belts in accordance with the various illustrated embodiments of the invention are considerably greater than those for the woven belts heretofore available. At the time the wet paper web comes in contact with each dryer can, much of the water and other liquid in the web is rapidly vaporized. With conventional, relatively bulky belts, even those of comparatively open weave construction, the belts have exhibited a blanketing effect which greatly restricted the free passage of vapor therethrough from the web to the atmosphere. The perforations in the belts 15, 16 or 40, on the other hand, are such that the vapor is quickly discharged to the atmosphere.

The deleterious blanketing effect of many of the conventional dryer belts has been further augmented by their highly absorbent characteristics. Although the absorbency of the prior belts in some respects has been considered advantageous, it has been found that the accumulated moisture absorbed by the belt, unless removed, has a wetting effect on the paper web in contact with the dryer cans. Because of the substantially non-absorbent nature of the polymeric material used for the belts 15, 16 or 40, for example, much of the moisture that would otherwise be retained within the belt is discharged to the atmosphere through the perforations 46.

For certain paper machines, particularly in cases in which considerations other than the rapid passage of moisture through the belt are of primary concern, are perforations 46 may be omitted without departing from the spirit or scope of the invention.

In the embodiment shown in FIGURE 2, each of the perforations 46 in the belt 40 is .045 inch in diameter, and 225 perforations are provided in each square inch of the material, giving an open area of thirty-six percent. With this arrangement, the air permeability of the belt is over 700 cubic feet per minute per square foot at 0.5 inch water, as measured under ASTM Standard Test Procedure No. D737–46 for Air Permeability of Textiles. For comparison purposes, the air permeability of representative conventional belts woven from synthetic yarns in most cases is under 300 cubic feet per minute per square foot at 0.5 inch water.

In several advantageous embodiments, the size and orientation of the perforations 46 is within well defined limits to enable the efficient transmission of moisture through the belt from the paper web. Although the perforation size and orientation varies widely in accordance with the type of paper machine and the particular papermaking operation being performed, for many applications the diameter of each perforation advantageously is within the range of from about 0.01 inch to about 0.25 inch, while the number of perforations per square inch ranges from about 6000 to about 10. In other arrangements, good results are obtained with perforations of a size and orientation outside these ranges. In addition, the individual perforations may be of various shapes, other than the circular form shown, without departing from the spirit or scope of the invention.

The perforations 46 are formed by punching apparatus indicated schematically at 55 (FIGURE 3). The apparatus 55 includes a series of cylindrical, downwardly extending punches 56 which are movable in directions perpendicular to the plane of the polymeric sheet. The lower surfaces of the punches 56 are recessed to form comparatively sharp cutting edges 57. Upon movement of the punches into the sheet of material, the material is cut away to form the perforations. In most cases, the punches are at a temperature which is well below the softening point of the material, and preferably at substantially room temperature. With this arrangement, the material to be removed from the sheet is cut cleanly, thus substantially eliminating the possibility of forming small lumps or beads of material on the sheet surfaces which might mar the paper web.

In the embodiment shown in FIGURE 2, the perforations 46 advantageously are formed after the sheets 42, 43 and 44 have been sealed in side-by-side relationship with each other. The perforations extend across the seals without interruption and are arranged substantially entirely throughout the surface area of the belt 40. In other good arrangements, the sheets are perforated before the sealing operation. The perforations either terminate prior to the inside edges of the sheets, to provide imperforate, longitudinally extending areas of material adjacent each seal, or extend in close proximity therewith.

Upon the formation of the perforations in the belt material, the material preferably is pre-conditioned by the application of heat to reduce the possibility of shrinkage during the papermaking operation and also to relieve any stresses that may have developed during the formation of the perforations. The ends of the material are first temporarily connected, as by suitable staples (not shown), and the belt is then installed under tension around a portion of the cylindrical surface of one or more dryer cans, such as the can 20 or 21 (FIGURE 1), for example in a pre-conditioning dryer. The temperature of the cans is such that the belt is heated to a pre-conditioning temperature which is at least as great as that expected in its end use but is below the softening point of the material. In certain good arrangements, the belt is pre-conditioned at a temperature of about 300° F. and is maintained at that temperature for a length of time sufficient to substantially eliminate the possibility of any residual shrinkage on the paper machine. In most cases, the pre-conditioning time is relatively short and illustratively is of the order of about five minutes. Thereafter, the staples are removed, and the belt is cut to the appropriate length preparatory to its installation on the machine.

In other embodiments, particularly when Type A Mylar polyester film is used as the belt material, the possibility of substantial belt shrinkage on the machine is so slight that the pre-conditioning step is eliminated.

For paper machines of comparatively small size in which the paper web being produced is relatively narrow, a single sheet of incompressible polymeric material is employed as a web-carrying belt. Thus, as best shown in FIGURE 6, there is provided a belt 60 of Mylar polyester film which includes perforations 61 substantially entirely throughout the same. The perforations 61 are arranged in a manner similar to the perforations 46 (FIGURE 2) described heretofore, and the belt is provided with uninterrupted lengthwise paths 62 and transverse paths 63 between the rows of perforations. In addition, the edges of the belt form longitudinally extending imperforate areas 64 and 65. The perforations are formed and the belt is pre-conditioned in the manner discussed above with respect to the belts 15, 16 and 40.

The opposite longitudinal ends of the rectangular sheet material are joined to form endless dryer belts by ultrasonic welding apparatus indicated generally at 70 (FIGURE 7). The apparatus 70 includes a sine wave voltage source 71 which is connected to a transducer 72 by two conductors 73 and 74. The transducer 72 is of conventional construction and is arranged to impart vibratory mechanical motion at a fixed ultrasonic frequency to a welding element or horn 72*a*. The thickness of the portion of the horn 72*a* adjacent the belt, when measured in a longitudinal direction with respect thereto (the thickness *t* in FIGURE 7), preferably is approximately equal to the thickness of the belt. The horn 72*a* is disposed in juxtaposition with one side of the belt material, while the opposite side rests on a stationary table 75.

The apparatus 70 is arranged to join opposite ends of either a multi-sheet belt, such as the belt 40 shown in FIGURE 2, for example, or a single sheet belt, such as the belt 60 of FIGURES 6 and 7. In some embodiments, each end of the belt to be joined is provided with a forty-five degree bevel 78. The ends are then clamped on a movable fixture (not visible in FIGURE 7), and the belt is moved along the table 75 in a transverse direction. The vibratory motion of the horn 72*a* forms a permanent weld or seal 80 along the beveled edges of the belt with little or no interruption in the smooth continuity of the belt surfaces.

Particularly for comparatively long seals, the belt may be held stationary, and the apparatus 70 moved in a transverse direction to form the seal. In addition, in some cases the bevels 78 are omitted, and the belt ends are placed in overlapping relationship with each other prior to sealing. In these latter situations, the amount of overlap preferably is at least equal to the thickness of the belt.

The ultrasonic sealing apparatus 70 also is effective to form longitudinal seals, such as the seals 82 and 83 (FIGURE 2) between the three oblong sheets 42, 43 and 44 of the belt 40. The seals 82 and 83 are of the overlapping type and are formed by moving the sheets relative to the apparatus 70 in a manner similar to that described heretofore. In addition, the apparatus is advantageous in the formation of transverse or oblique seals between adjacent sheets, as in cases in which the belt comprises successive side-by-side sheets which extend in the cross machine direction, for example.

Although the use of ultrasonic sealing apparatus is advantageous in the formation of dryer belts in accordance with several embodiments of the invention, in other good arrangements the polymeric material is adhesively interconnected or is joined by lamination or other suitable techniques. As an illustration, particularly for comparatively low-temperature dryers, a polyester tape of the type available commercially from the G. T. Schjeldahl Company, Northfield, Minn., may be used to unite the ends of a single sheet belt, for example, or to hold adjacent sheets of a multi-sheet belt in side-by-side relationship with each other.

FIGURES 8–11 are illustrative of various alternative connections between the ends of dryer belts in accordance with the invention. In FIGURES 8 and 9 there is shown a perforated dryer belt 85 of Mylar polyester film. The ends 87 and 88 of the belt 85 are folded back upon themselves and are each held in place by three transverse rows of stitching 90. The folds in the ends 87 and 88 are notched to provide integrally formed loops 91 and 92, respectively, which are positioned in interleaved relationship with each other. An elongated rod or pintle 94 is inserted through the loops 91 and 92 to connect the ends of the belt and thereby form an endless construction.

Referring to FIGURES 10 and 11, there is provided a perforated belt 95 of Mylar polyester film having substantially flat end portions 96 and 97. The end portion 96 includes a transversely extending web 100 of woven material, such as Dacron, for example, which is held in place by stitching 101. The end portion 97 similarly includes a woven web 102 secured to the belt by stitching 103. A plurality of clipper hooks 105 are sewn into the web 100 and are interleaved with corresponding clipper hooks 106 in the web 102. The hooks 105 and 106 accommodate a pintle 108 to hold the ends of the belt in fixed but flexible relationship with each other.

In several advantageous embodiments, after the ends of the polymeric sheet material have been interconnected to form an endless dryer belt, the belt is inserted in an operative position around the dryer drums 20 or 21 (FIGURE 1) of the paper machine. Certain of the rolls in the drying section are either removed or temporarily supported during the removal of appropriate portions of the machine frame, and the belt is trained around the dryer drums and the remaining rolls. The removed rolls and frame portions are then replaced, and the corresponding stretch roll 29 or 35 is adjusted to place the belt under proper tension.

in the web 102. The hooks 105 and 106 accommodate a

In other good arrangements, the belt is positioned around the dryer drums and rolls prior to the joining of its ends to provide an endless construction. In these latter situations, the belt is threaded through the dryer

section, and the ends are then ultrasonically sealed or otherwise interconnected in the manner described above. The stretch rolls are adjusted in the usual manner to place the proper tension on the belt.

Referring now to FIGURE 4, there is shown a dryer belt **110** which comprises a non-woven fibrous batt **111** laminated to a sheet **112** of Mylar polyester film. The batt **111** is deformable and is formed from either natural or synthetic fibers, such as various heat resistant cottons, for example, or nylon or other synthetic fibers, or from blends of natural and synthetic fibers. In some cases, the batt is preformed, as by needling, felting, chemical bonding, etc., or other conventional process. Particularly in cases in which the fibers forming the batt are to be given a predetermined orientation, however, the individual fibers are deposited electrostatically on the sheet **112**. A suitable adhesive **114**, such as one of the polyurethane resins, for example, is used to secure the batt **111** to the sheet **112**. A polyurethane resin which has been found to be particularly useful for this purpose is Unithane Resin 390T, which is a trade name of the Thiokol Chemical Corporation, Trenton, N.J.

The sheet **112** includes a series of perforations **113** therein and is generally similar to the various dryer belts described heretofore. Upon the application of the batt **111** thereto, the ends of the sheet are joined ultrasonically or otherwise interconnected to provide an endless construction. In cases in which ultrasonic seals are employed, the ends preferably are left bare until the completion of the seal and are then provided with a suitable strip of the batt material.

FIGURE 5 is illustrative of a deformable layer **115** of open-cell plastic foam which is laminated to a sheet **116** of Mylar polyester film to form a dryer belt **120**. The layer **115** preferably comprises a polyurethane resin, the polyether resins of this type having exhibited particular utility in this regard. The sheet **116** is substantially the same as the dryer belts **40** or **60**, for example, and includes perforations **121** arranged in a manner similar to that discussed above. A suitable adhesive **122**, such as Unithane Resin 390T, for example, is employed to secure the foam **115** to the sheet **116**.

The laminated belts **110** and **120** are used as the paper web carrier in the drying section of a paper machine in a manner generally similar to the belts **15** and **16** (FIGURE 1) described heretofore. The belts **110** and **120** are particularly advantageous at the infeed or wet end of the drying section, prior to the time the paper web reaches its critical moisture point, and in some cases are followed by non-laminated belts such as the belts **15** and **16**. Thus, as best shown in FIGURE 1, the infeed end of the drying section is provided with a top belt **120***a* and a bottom belt **120***b*, of the type shown in FIGURE 5, for example. These belts are trained around suitable rollers **125** and **126** with the foam **115** thereon in contact with the paper web **22**.

The laminated belts **110** and **120** have exhibited comparatively high insulating properties. These properties are particularly important as the paper web is advanced toward the hot press rolls sometimes provided adjacent the wet end of the drying section and greatly facilitate the retention of heat by the web. In the dry or outfeed portion of the drying section, the increased porosity of the non-laminated belts **15** and **16** further enhance the drying action.

In order to describe more clearly the nature of the present invention, the following examples illustrating the invention are disclosed. It should be understood, however, that this is done solely by way of example and is intended neither to delineate the scope of the invention nor limit the ambit of the appended claims.

*Example I*

Dryer belts were prepared from sheets of Type A Mylar polyester film having a thickness of 10 mils and were perforated substantially entirely throughout their surface area by the application of punches at substantially room temperature. The perforations were oriented in the manner shown in FIGURE 2, with uninterrupted paths of the belt material extending in both the machine direction and in the cross machine direction. The diameter of each perforation was 0.045 inch and there were 225 perforations per square inch, giving an open area of thirty-six percent and an air permeability of over 700 cubic feet per minute per square foot at 0.5 inch water when measured under the conditions referred to heretofore. The perforated sheets were arranged in pairs which were ultrasonically sealed in side-by-side relationship with each other to form belts 50 inches wide. Each belt was maintained under tension at a pre-conditioning temperature of 250° F. for five minutes, during which time the transverse dimension of the belt was reduced by 0.375 inch.

The ends of the belts were interconnected by pintles and clipper hooks of the type shown in FIGURES 10 and 11, and the belts were mounted in the second drying section of an experimental paper machine located at the State School of Forestry, Syracuse University, Syracuse, N.Y. The arrangement of the belts was substantially as shown by the top belt **15** and the bottom belt **16** in FIGURE 1. The length of the top belt was 57.5 feet and that of the bottom belt was 51.5 feet. The stretch rolls for each belt were adjusted until the belt tension approximated 10 pounds per linear inch. The steam pressure in the dryer cans ranged between 10 pounds per square inch and 20 pounds per square inch, and the maximum temperature of the cans was 240° F.

A web of medium grade bond paper was threaded through the machine, and the machine was operated at a speed of 185 feet per minute. Upon entering the drying section, the web had a consistency of 71.1 percent. At the time the web was discharged, its consistency was 96.8 percent, 0.370 pound of water having been removed per pound of paper. The dried web was of high quality with no evidence of surface markings.

*Example II*

As another example of the effectiveness of the method and apparatus of the invention, perforated sheets of Type A Mylar polyester film were prepared and pre-conditioned in accordance with Example I. An open-cell polyurethane foam, available commercially from the General Foam Corporation, New York, N.Y., under its trade name Polyurethane Foam GF–30, was laminated to each sheet and was adhesively secured in place through the use of Unithane Resin 390T. The density of the foam was 2 pounds per cubic foot, and its thickness was 0.25 inch. The air permeability of the assembled belts was 101 cubic feet per minute per square foot at 0.5 inch water, measured in accordance with the above-noted procedure.

The ends of the laminated belts were sealed ultrasonically, and the belts were arranged in an operative position in the second section of the experimental paper machine used for Example I. A moist paper web was run through the machine under substantially the same conditions. The consistency of the web as it entered the drying section was 54.65 percent and on leaving the dryer section was 92.45 percent; 0.748 pound of water were removed per pound of paper. No evidence of sheet marking was observed.

In cases in which laminated belts are employed in the dryer section of a paper machine, in some embodiments various constructions other than the fiber or foam laminations described heretofore may be used with good effect. For example, a plurality of polymeric material may be laminated together to form various sandwich constructions. Also, a wide variety of coating materials may be applied to one or both surfaces of the assembled belt to further enhance the belt's resistance to heat, hydrolysis, soiling, etc.

When used in the initial portion of the drying section of a papermaking machine, dryer belts in accordance with some embodiments of the invention may be employed to carry the paper web between certain of the press rolls in the wet section of the machine before being led around the dryer drums. As an illustration, the endless paths for the laminated belts **120***a* and **120***b* (FIGURE 1), for example, may be such that the belts extend around the last press rolls in the wet section and serve to carry the paper web between these rolls and to then transfer the web to the drying section. Also, in those types of machines which employ an initial or predrying section followed by opposed hot press rolls, the laminated belts advantageously may extend between these latter rolls on opposite sides of the web.

Although the invention has been shown and described as having particular utility when used in the drying section of a paper machine, it will be apparent to those skilled in the art that the invention also may be employed advantageously for other drying applications. Thus, for example, the invention may be used effectively in Palmer-type units for drying fabrics or other sheet materials.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described, or portions thereof, it being recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

**1.** A synthetic belt for the paper web in the drying section of a paper machine comprising, in combination, a rectangular sheet of nonwoven polymeric material which is substantially nondeformable in thickness, said sheet having two end portions and a plurality of spaced perforations substantially entirely throughout the same but with uninterrupted paths of said material extending in a lengthwise direction, the diameter of each of said perforations being within the range of from about 0.01 inch to about 0.25 inch and the number of perforations per square inch ranging from about 6000 to about 10, to enable the efficient transmission of moisture through said sheet from said web, and means for ultrasonically joining the end portions of said sheet.

**2.** A belt of the character set forth in claim **1**, in which said perforated sheet comprises a polyethylene terephthalate film.

**3.** A synthetic belt for the paper web in the drying section of a paper machine comprising, in combination, a sheet of nonwoven polymeric material which is substantially nondeformable in thickness, said sheet having two end portions and a plurality of spaced perforations substantially entirely throughout said sheet, the diameter of each of said perforations being within the range of from about 0.01 inch to about 0.25 inch and the number of perforations per square inch ranging from about 6000 to about 10, to enable the efficient transmission of moisture through said sheet from said web, and means for joining the end portions of said sheet.

**4.** A synthetic belt for a drying machine comprising, in combination, a sheet of nonwoven polymeric material which is substantially nondeformable in thickness, said sheet having two end portions and a plurality of spaced perforations substantially entirely throughout said sheet, the diameter of each of said perforations being within the range of from about 0.01 inch to about 0.25 inch and the number of perforations per square inch ranging from about 6000 to about 10, to enable the efficient transmission of moisture through said sheet from said web, a layer of fibrous material laminated to one surface of the perforated sheet, and means for joining the end portions of said sheet.



**5.** A synthetic belt for the paper web in the drying section of a paper machine comprising, in combination, a pair of rectangular sheets of nonwoven thermoplastic polymeric material, each of said sheets being substantially nondeformable in thickness and having a plurality of spaced perforations substantially entirely throughout the same but with uninterrupted paths of the sheet material extending in a lengthwise direction, the diameter of each of said perforations being within the range of from about 0.01 inch to about 0.25 inch and the number of perforations per square inch ranging from about 6000 to about 10, to enable the efficient transmission of moisture through said sheets from the paper web, a first ultrasonic seal for maintaining said sheets in side-by-side relationship with each other, and a second ultrasonic seal for joining opposite ends of said sheets.

**6.** A belt for the character set forth in claim **5**, in which the thickness of each of said elongated sheets is within the range of from about 5.0 mils to about 28.0 mils.

**7.** A synthetic belt for a drying machine comprising, in combination, a sheet of nonwoven polymeric material which is substantially nondeformable in thickness, said sheet having two end portions and a plurality of spaced perforations substantially entirely throughout said sheet, the diameter of each of said perforations being within the range of from about 0.01 inch to about 0.25 inch and the number of perforations per square inch ranging from about 6000 to about 10, to enable the efficient transmission of moisture through said sheet from said web, a layer of open-cell foam laminated to one surface of the perforated sheet, and means for joining the end portions of said sheet.

**8.** A synthetic belt of the character set forth in claim **3**, in which said nonwoven polymeric sheet consists substantially entirely of at least one material selected from the group consisting of polyesters, polyamides, polycarbonates, vinyl polymers, vinylidene polymers and their copolymers.


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# UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 3,323,226 June 6, 1967

Ralph H. Beaumont et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 59, for "comprises" read -- compromises --; line 71, after "result" insert -- that --; same line 71, for "slow" read -- low --; column 2, line 4, for "hereto" read -- heretofore --; line 11, for "compound" read -- compounded --; line 64, for "particular" read -- particularly --; column 5, line 36, for "cylinder" read -- cylindrical --; column 6, line 29, for "are", second occurrence, read -- the --; column 8, line 71, strike out "in the web 102. The hooks 105 and 106 accommodate a"; column 10, line 70, after "plurality" insert -- of sheets --.

(SEAL) Signed and sealed this 18th day of June 1968.

Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents