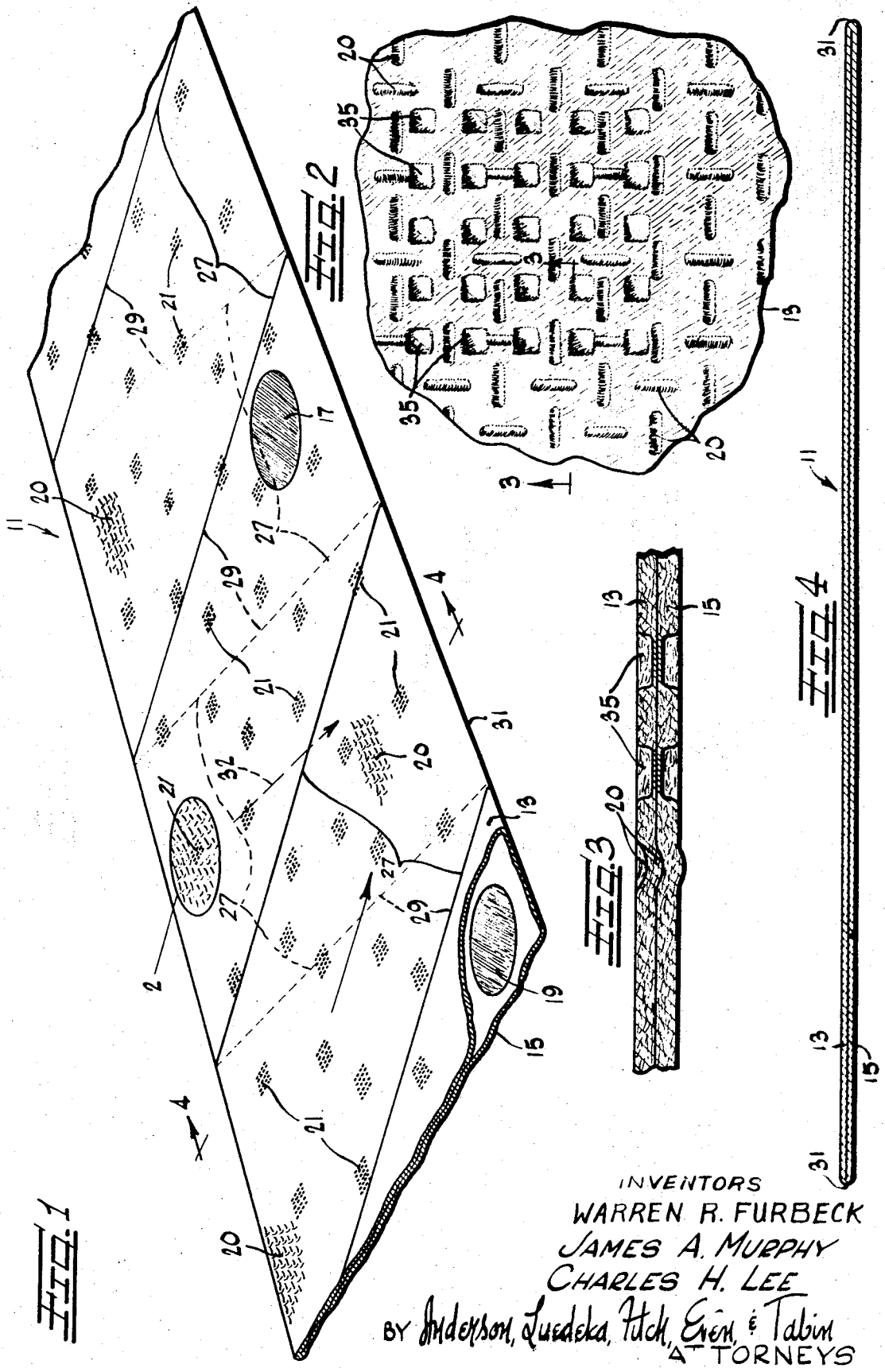
Dec. 1, 1970 J. A. MURPHY ET AL 3,544,420

CREPED TISSUE PRODUCT

Filed Sept. 27, 1967 2 Sheets-Sheet 1



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Fig. 5

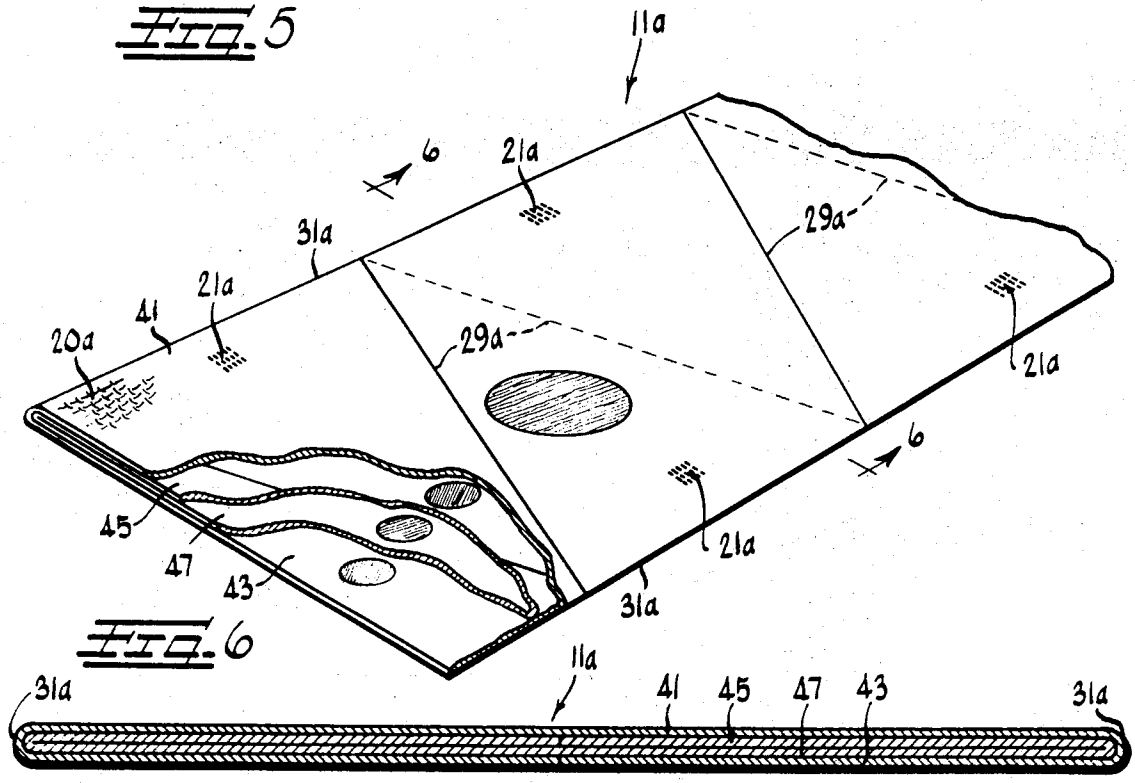


Fig. 6

Fig. 7

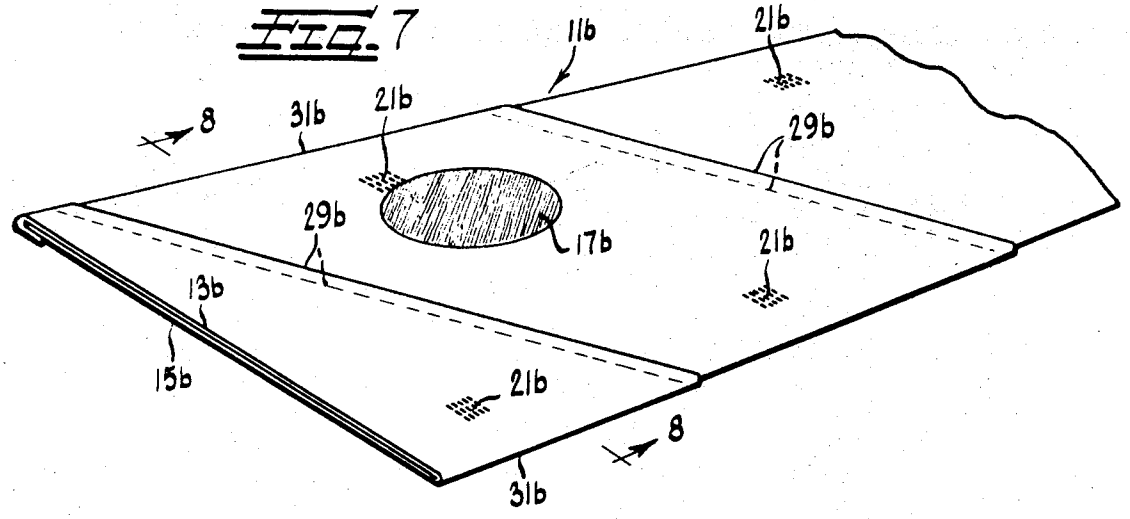
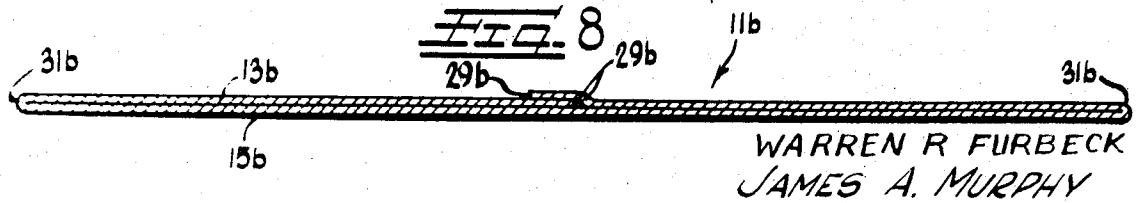


Fig. 8



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3,544,420

CREPED TISSUE PRODUCT

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Int. Cl. B32b 3/00, 29/00
U.S. Cl. 161—129 7 Claims

ABSTRACT OF THE DISCLOSURE

A creped tissue product is formed by at least two superimposed sheets of creped tissue with the lines of creping in one sheet laid at a bias to the longitudinal and transverse direction of the product and disposed to cross the lines of creping in the other sheet. The fibers of one sheet are interlocked with fibers of the other sheet. The resultant product is extensible in both the longitudinal and transverse directions and has unusually good strength and resistance to bursting, particularly in the transverse direction. Preferably, the product is a ribbon formed by collapsing a spirally-wound tube and has interlocked fibers at spaced areas formed by light compression forces which texture the ribbon's surfaces, and by heavy compression forces which glassine the fibers at other areas.

This invention relates to a creped tissue product and more particularly to a multi-ply creped tissue product suitable as an item or a portion of an item which contacts the human skin.

Creped tissue is a relatively inexpensive material which has enjoyed widespread success in the fields of napkins, facial and toilet tissues and as a major constituent of sanitary napkins and disposable diapers because of its extremely good absorbency—which is a primary consideration in diapers and sanitary napkins—appearance, flexibility, cleanliness and softness. Its strength characteristic has been a secondary consideration, principally because creped tissue has little extensibility in the cross-machine direction and readily bursts or tears when subjected to impacts or tensile forces tending to stretch the creped tissue in the cross-machine direction. Where strength is an important consideration, the creped tissue has been covered by or laminated with additional sheets of more expensive materials to provide strength above and beyond that of the creped tissue, or where it can be tolerated, a large number of creped tissue plies have been formed into a pad to give the desired strength. For instance in both sanitary napkins and disposable diapers, it is quite common to employ a gauze or non-woven fabric to withstand the tensile forces. When an extremely large number of additional creped tissues are formed into a pad, the strength of the creped tissue product is improved, but this renders the product bulky and adds inordinately to the cost of the product. Hence, creped tissue products requiring little bulk have, heretofore, employed additional, expensive reinforcing materials.

With the increasing commercial acceptance of and demand for disposable paper products which come in contact with the human skin, such as, for example, paper clothing, disposable diapers, disposable bed sheets and pillow cases, there is a need for a creped tissue product which is not only inexpensive and can be thrown away, but which also has considerable strength and stretch to withstand movements and impacts from the human body and has good draping qualities.

The present invention fulfills this need by providing a creped tissue product which has unusually good tensile

strength and resistance to tearing and rupturing, as contrasted with prior art creped tissue products, without being so bulky as to limit its field of use to those fields where drapery qualities and bulk are not important.

To be a commercially feasible paper product suitable for use in disposable items, the creped tissue product should be of a form which lends itself to high speed manufacturing processes and to simple finishing operations, such as texturing, without requiring extensive handling and other operations. Paper products are most easily handled, if they are to be used as a constituent of a diaper, clothing, bed sheets or the like, when they are formed into a web and wound onto a web supply roll.

In accordance with the present invention, two or more superimposed plies of creped tissue are disposed with their lines of creping at a bias to the longitudinal and transverse directions of the assembled web and with fibers in the respective plies interlocked to each other in a manner that the plies act together and are capable of stretching in either the transverse or longitudinal directions of the combined product. Preferably, the fibers are interlocked by compressing fibers of one ply into fibers of an adjacent ply at spaced areas thereby texturing the fabric, enhancing its integrity and providing a greater surface area for the product. Also, the plies may be interlocked by spaced embossments to assure that the plies assist one another in withstanding and distributing forces. As a result of this interaction between the plies, a low cost, creped tissue product may be made and used in many applications herebefore not thought to be possible or practical, e.g., bed sheets, pillow cases and clothing, where resistance to bursting and tearing are required along with, but not at the sacrifice of good drapery quality. Typically, such products have large unsupported panels or sheets, and unless the product can stretch in all directions, motion or flexing of the human body will tear, burst or rip the panel.

Accordingly, an object of the present invention is to provide multi-ply, creped tissue product in which bias-laid creping and interlocked fibers afford unusually good strength and drapery quality thereby opening up new fields of use for creped tissues.

Other objects and advantages of the invention will become apparent from the detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a fragmentary perspective view of a bias-laid product constructed in accordance with the preferred embodiment of the invention;

FIG. 2 is an enlarged fragmentary portion of FIG. 1 showing the areas of compression for interlocking fibers in the respective plies of the product of FIG. 1;

FIG. 3 is a cross-sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is a cross-sectional view taken along the line 4—4 of FIG. 1;

FIG. 5 illustrates another embodiment of the invention having a four-ply construction;

FIG. 6 is a cross-sectional view taken substantially along the line 6—6 of FIG. 5;

FIG. 7 is a perspective view of another embodiment of the invention; and

FIG. 8 is a cross-section taken substantially along the lines 8—8 of FIG. 7;

As shown in the drawings for purposes of illustration, the invention is embodied in, from a very general standpoint, a creped tissue product in the form of a web or ribbon 11 having at least two plies 13 and 15 of creped tissue disposed in face-to-face relationship with the fibers in one ply being interlocked by spaced areas of compression with fibers in the other ply, the respective crepings 17 and 19 in the respective plies 13 and 15 being disposed

at a bias, i.e., at an angle, to the longitudinal direction of the ribbon **11**. The illustrated web is long and continuous with a longitudinal length greatly exceeding the transverse width of the web. In its preferred form, the ribbon is symmetrically formed with the lines of creping in the two plies disposed at the same angle to the longitudinal dimension to cross each other in opposite directions. In the preferred embodiment of the invention, the fibers of the respective plies are interlocked at depressions **20** formed in the ribbon plies by compression forces which are much lighter than compression forces which interlock the fibers of the webs together at spaced embossed areas **21**. In this instance, the depressions **20** also give a textured surface to the faces of the web.

The coaction of the superimposed plies results in a redistribution of characteristics such as tensile strength, stretchability and energy absorption thereby making a product with more uniform properties in all directions. As will be explained in greater detail hereinafter, the product resists impacts, splitting, bursting and rupturing, particularly with impacts directed in the transverse direction to an extent not heretofore possible for creped tissue. With exertion of tensile forces in the cross direction, i.e., transversely of the web **11**, the respective lines of creping will extend in the transverse direction so that the composite product is able to withstand tensile forces which heretofore have caused the creped tissue to go immediately beyond its peak tensile strength, whereupon the creped tissue ruptured. By permitting the plies to stretch the tensile forces may be dissipated and distributed over a wider area to the extent that the maximum tensile strength of the plies is not exceeded. Moreover, energy is absorbed when a displacement is permitted, energy being equal to force times displacement. The interlocking of the fibers of one sheet with the fibers of the other sheet combines the strengths and extensibilities to resist rupturing. Moreover, if tensile force do break the fiber-to-fiber bond between plies, they may shift relative one to another in a process whereby additional energy may be absorbed without rupturing the creped tissue plies.

The resulting creped tissue product has excellent drape characteristics because it can be formed of relatively few plies; and in the preferred embodiment of the invention, the drapery qualities are enhanced by texturing the web to produce a fabric-like appearance. The texturing is provided by a pattern of depressions **20** caused by the spaced areas of compression of the creped tissue plies during the formation of the product. This texturing also provides an increased surface area (usually between 10% and 20% more) and provides increased absorptivity to the product.

Proceeding now with the detailed description of the illustrated embodiment of the invention, the upper ply **13** and the lower ply **15** are each formed with a plurality of portions or strips **27** partially defined by a pair of parallel edges **29** running askew of the longitudinal direction of the web between opposite side edges **31** of the ribbon **11**. Preferably, the ribbon **11** is formed by flattening a spirally-wound tube of creped tissue made by wrapping one or more webs of creped tissue about a cylindrical mandrel. Preferably, the tube is formed by a relatively high-speed continuous process, and the tube is stripped from the mandrel and collapsed by moving it through the nip of a pair of rollers to form the flat, two-ply ribbon. Because the spiral tube is made from a continuous web, each of the individual strips **27** is integrally connected along the longitudinal ribbon edges **31** to its opposite, superimposed or underlying strip **27** with which it has a face-to-face contact. To provide a level two-ply thickness throughout the length of the ribbon, each strip abuts its edges **29** against the edges of adjacent strips.

The longitudinal direction of each strip **27** is preferably disposed at a bias angle between 15 to 45 degrees with respect to the transverse direction of the web. This angle may vary from this range and still fall within the purview of the invention, as the invention is not limited

to any particular bias angle or range of bias angles. The bias angle is determined by the angle of inclination of the stock web relative to the cylindrical mandrel as the web is wound spirally on the mandrel. The lines of creping **17** run perpendicular to the longitudinal edges of the stock web and thus perpendicular to the strip edges **29**. As will be understood by those skilled in the art, a creped tissue web possesses strength and stretchability in the machine direction. As shown in FIG. 2, a rectangular grid of depressions **20** is formed by a meshed belt with elongated depressions disposed at right angles to adjacent depressions and spaced from each other by non-compressed areas of creped tissue. The rectangular grid of depressions have depressions of greater depth at the knuckles of the mesh belt than the depressions formed by adjacent wires extending between the knuckles. The lines of creping are reshaped at the indentations. That is, the indentations stretch fibers to break lines of alternating hills and valleys constituting the creping. Since fibers in the respective webs are forced into interlocking contact with fibers of the adjacent webs, these interlocked fibers resist sliding of the strips relative to one another. It is this rearrangement of the lines of creping and the interlocking of fibers which provides increased stretch and strength in the product in excess of that of two similar bias-laid creped tissue sheets which are not bias-laid and do not have their fibers interlocked, as will be explained in greater detail hereinafter.

In the illustrated embodiment of the invention, the plies are further and permanently interlocked together by means such as spaced embossed areas **21** at which heavy pressures are exerted to compress the fibers so that they are welded together, i.e., the fibers of the opposing plies are glassined. As best seen in FIG. 2, the fibers are compressed together very tightly at individual embossments **35** in each area **21** which serve to attach firmly the plies together. The embossments are particularly effective in holding the strips **27** against shifting and separating, i.e., unwinding, with a longitudinally directed pull on the ribbon **11**. With the strips **27** interlocked by the embossments, the web may be easily wound into a supply roll for later use in a product. The fibers may be joined together either solely by embossments, i.e., without any depressions **20**, or on the other hand, solely by the depressions **20**. The preferred product, however, has both. The fiber to fiber bond in this manner improves the hand and drape by giving a flexible and yieldable bond as contrasted with other kinds of bonds which would result in a stiffening of the product.

In the illustrated embodiment of the invention, each area **21** is formed with twenty-five individual embossments **35** in the space of about ½ by ½ inch. The embossments **35** are usually square and measure about $\frac{1}{32}$ of an inch on a side. The embossed areas **21** are disposed in longitudinally extending rows and are separated from each other by approximately two inches in the lonitudinal direction. The embossed areas in each longitudinally extending row are offset with respect to the embossed areas in adjacent rows. Other shapes and forms of embossing may be employed to interlock the fibers of the respective plies and fall within the purview of the invention.

In the embodiment of the invention illustrated in FIGS. 5 and 6, a bias-laid ribbon **11*a*** is formed with four plies of creped tissue, but is otherwise like the previously described embodiment of the invention. Like reference characters with the suffix *a* refer to elements corresponding to those previously described. The illustrated ribbon **11*a*** is formed by spirally winding two separate stock webs of creped tissue into concentrically aligned cylindrical tubes spirally wrapped about a cylindrical mandrel so that as tubes are flattened, a four-ply ribbon is produced. In the four-ply ribbon, outer plies **41** and **43** are formed from one stock web, and inner plies **45** and **47** are formed from the other stock web. Usually, the respective stock webs are identical and are laid at the same angle so that the lines of creping in each strip is at the same bias angle to the transverse dimension of the web. In the resulting four-

ply ribbon, each of the plies is bias laid with respect to its adjacent ply. In this embodiment of the invention, the first and third plies have their lines of creping disposed parallel to each other, and likewise, the second and fourth have their respective lines of creping disposed parallel to each other. The four plies are also interconnected by the compressed fibers at the depressions **20***a* and by glassined fibers at the spaced embossment areas **21***a*.

In the embodiment of the invention illustrated in FIGS. 7 and 8, the edges **29***b* of adjacent strips are slightly overlapped during the formation of the spirally-wound, flattened ribbon **11***b* so that a double thickness is present for each ply of the ribbon at what would be the seam of the flattened tube. The overlapped edges provide an area for adhering adjacent strips such as by gluing or embossing. The ribbon **11***b* is otherwise identical to the ribbon **11**, and like reference characters with the suffix *b* refer to elements identical to those previously described.

The surprisingly great physical strength and good stretch characteristics of the multi-ply, bias-laid product of the invention over non-bias-laid and non-interlocked plies of identical creped tissue web stock having their respective lines of creping disposed parallel to each other is evidenced by the results of comparative tests performed on an Instron Universal Testing Instrument, manufactured by Instron Engineering Corporation of Canton, Mass.

For these tests, a web of creped tissue having a width of 16¼ inches was spirally wound at a mandrel having a circumference of about sixteen inches. The web was fed to the mandrel at a lead angle of approximately 30° and then stripped from the mandrel and flattened into an eight inch ribbon. The plies were interlocked by a pattern of indentations. The plies were overlapped slightly more than half their width, producing a thickness equivalent to approximately 4.45 plies. Test specimens were cut randomly from the resulting bias-laid ribbon along its length (machine direction or MD) and at right angles to its length (cross machine direction or CD). The basis weight of these 4.45 ply specimens was 50.8 lbs./ream (for a ream of 2,880 ft.^{2}).

To provide similar test specimens of non-attached, non-bias-laid creped tissue, four plies of the same creped tissue were stacked with their lines of creping aligned. Test strips were then cut parallel to the web's machine direction, its cross machine direction. The combined basis weight of each four-ply strip was 45.48 lb./ream.

The gauge length was held constant at 10 cm. and the jaws of the Instron Test instrument were separated at a speed of 5 cm./min. for all tests with exception of the tests of the four ply, non-bias-laid, creped paper in the cross machine direction, the speed of these latter tests being reduced to 1 cm./min.

Each result reported herein is the average of ten separate measurements and, as will be described in more detail, results were obtained for the maximum breaking load, the percent of elongation at maximum load, and the amount of tensile energy absorption to maximum load. The maximum tensile strength for a bias-laid specimen was recorded when the first one of its plies failed and the amount of energy absorption to this load was also measured. The energy absorption figure is an integrated reading equal to the area under the curve of force plotted rectilinearly as a function of elongation.

It was observed in these tests that the tensile strength in the cross direction of the bias ribbon is increased by about ⅓, but more significantly that the ability of the ribbon to absorb tensile energy without failing is increased nine times, i.e., from .33 kg. cm. to 2.78–3.05 kg. cm. This manyfold increase in energy absorption is primarily due to the increased elongation (26% vs. 4%) permitted by expansion of the creping before the failure of any of the creped tissue plies. Even with failure of one of the plies of the bias-laid specimens, the other plies remained integral and provided an integral product unlike the non-bias-laid specimens in which all four of the plies broke substantially simultaneously, thereby forming two separated portions.

Although the tensile strength and energy absorption for the bias-laid specimens were reduced in the machine direction from that in the non-bias-laid specimens, the machine tensile strength remained quite high at 1,550–1,760 g./in. as compared to 1,270 g./in. for the other specimens. The bias-laid specimens had a minimum energy absorption to maximum load of 0.77–0.85 kg. cm. which was better than twice the minimum value of 0.33 for the non-bias creped tissue. Also, the bias-laid specimen's elongation of about 7% to maximum load is significantly greater than 4% elongation for the non-bias-laid product. While such tests are helpful to gain an understanding of how the bias-laid product will perform in use, these tests do not duplicate actual working conditions and do not reveal the full import of the increased strength and resistance to bursting of the bias-laid product. For example, the tests were made with uniform loading with small width, e.g., one inch wide, specimens. When used on humans, however, it is contemplated the bias-laid product will be in the form of relatively large sheets and panels which will be non-uniformly loaded so that the force being applied will be redistributed to other of the plies which can move to relieve some of the local stress being applied. This will bring other plies into play to elongate and absorb the force without tearing the product.

It should also be noted that the test results reported herein relate to elongation and energy absorption to maximum load. In the case of the bias-laid product, this occurs just prior to the failure of the ply or plies having their lines of creping running most nearly in the direction of the tensile forces. Failure of such plies does not constitute failure of the bias-laid product as a whole as the remaining plies remain intact and continue to stretch and absorb energy. Further, the remaining plies, being intimately connected to the other plies, redistribute the load and withstand tensile forces remaining after the tensile forces producing the failure have been relieved by the failure.

As stated earlier, the bias angle may be changed considerably from the 30° angle used in the product tested as reported above, but the general results of greater elongation, tensile strength and energy absorption in the cross machine direction will still be obtained over a comparable multi-ply, non-bias-laid ribbon.

The increase in the transverse strength and elongation is of particular importance as it provides a greater bidimensional strength and resistance to tear which is more closely akin to woven cloth. This bidimensional strength, together with the qualities of drape, appearance and feel to the human skin makes possible new use for the creped tissue.

The bias-laid product has been found to have added surprising resistance to splitting with transversely directed tensile forces applied to disposable diapers of the kind illustrated in copending Murphy and Lee application Ser. No. 671,078 filed of even date and entitled "Disposable Diaper." Forces so directed have previously been found to be the most troublesome and most likely to cause failure of diapers not including the bias-laid product of this invention.

In other end uses of the product, such as, for example, long unsupported areas of bed sheets or clothing, it may be desirable to incorporate reinforcement threads in the bias-laid product to provide additional tensile strength. It will be appreciated that the bias-laid creped tissue will give increased strength against bursting and tearing in the space between threads as contrasted with creped tissue products which are not produced in accordance with the invention. Thus, the bias-laid product incorporating the threads will retain its integrity as it absorbs and stretches with impacts. It is also contemplated that the creped tissue product **11** will be used as an intermediate

layer between cover plies, as in the diaper, or in between cover plies in a bed sheet.

From the foregoing it will be seen that the present invention provides a creped tissue product in which resistance to bursting is no longer a secondary consideration but may be a primary consideration in the use of creped tissue. Because of the nature of the association of the respective plies of creped tissue, strength and stretchability are obtained with relatively few plies of creped tissue so that good draping qualities are not compromised. In its preferred form the product is textured and has good hand as well as the usual characteristics of cleanliness and absorptivity making the product advantageously suited for use for or as a part of products which are in contact with the human skin. The product is uniquely formed so as to be produced in mass quantity and rolled into convenient continuous supply rolls for later use with high speed continuous fabricating equipment. Thus, the increased strength, stretch, and general characteristics of the product open up new fields for low cost creped tissue.

While a preferred embodiment has been shown and described, it will be understood that there is no intent to limit the invention by such disclosure, but rather it is intended to cover all modifications and alternate constructions falling within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An article of manufacture comprising at least two sheets of creped tissue disposed face-to-face, a first one of said sheets of crepe tissue having a machine direction with a line of greater strength substantially parallel to its machine direction and having lines of creping disposed substantially normal to said machine direction, said first sheet having greater stretchability in a line substantially parallel to said machine direction than at angles thereto, another one of said sheets of creped tissue superimposed on said first sheet of said crepe tissue with its machine direction crossing the machine direction of said first sheet, said other sheet having a line of greater strength substantially parallel to its machine direction and having lines of creping disposed substantially normal to its machine direction, said other sheet having greater stretchability in its machine direction than at angles thereto, and the fibers of one sheet being compressed into engagement with the fibers of the other sheet at spaced locations whereby the sheets are connected to each other and act together to withstand forces applied to said article.

2. An article of manufacture comprising an elongated composite web having a longitudinal direction and a transverse direction perpendicular thereto, said web comprising a plurality of superimposed plies of creped tissue, said plies of creped tissue each having a basis weight less than about 15 lbs. for a ream of 2,880 ft.^{2}, a first one of said plies of creped tissue having a machine direction with a line of greater strength substantially parallel to its machine direction and having lines of creping disposed substantially normal to said machine direction, said first ply having greater stretchability in a line substantially parallel to said machine direction than at angles thereto, another of said plies of creped tissue superimposed on said first ply of said creped tissue with its machine direction crossing the machine direction of said first ply, said other ply having a line of greater strength substantially parallel to its machine direction and having lines of creping disposed substantially normal to its machine direction, said other ply having greater stretchability in its machine direction than at angles thereto, said plies being disposed obliquely with respect to the longitudinal and transverse directions of said web, and means bonding said plies together at spaced locations along inner facing surfaces thereof whereby the plies act conjointly when subjected to load.

3. An article in accordance with claim **2** in which a plurality of first plies are provided and are in the form of strips disposed obliquely to said longitudinal and said transverse directions with adjacent obliquely extending edges thereof overlapped and bonded together, and in which a plurality of second plies are provided in the form of strips disposed obliquely to said longitudinal and transverse directions with adjacent edges thereof overlapped and bonded together.

4. An article in accordance with claim **2** in which said plies are made from the same web and said first one of said plies is integrally attached along folded, longitudinal extending edges of said composite web to said another of said plies and in which said bonding extends transversely across from one folded edge to an opposite folded edge.

5. An article in accordance with claim **2** in which said composite web is formed with at least four superimposed plies of creped tissue.

6. An article in accordance with claim **2** in which said plies are formed as at least one pair of plies, each such pair of plies consisting of a first ply and a second ply made from the same continuous web of creped tissue folded over at an angle to its machine direction along the longitudinally extending edges of said composite web, said first and second plies being bonded together by said bonding means.

7. An article in accordance with claim **6** having at least two such pairs of plies, the first plies of the respective pairs being disposed adjacent one another with their respective machine directions parallel, and the second plies of the respective pairs being disposed adjacent one another with their respective machine directions parallel.

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U.S. Cl. X.R.

128—284; 161—55, 148, 411