

PATENT SPECIFICATION

(11) 1382714

1382714

- (21) Application No. 32884/72 (22) Filed 13 July 1972
 (44) Complete Specification published 5 Feb. 1975
 (51) INT CL³ B32B 3/28 29/00 29/06 31/08 31/20 3/30
 (52) Index at acceptance
 B5N 0328 0330 2900 2906 3108 3120



(54) IMPROVEMENTS IN THE PRODUCTION OF MULTI-PLY PRODUCTS

(71) We, KIMBERLY-CLARK CORPORATION, a corporation organised and existing under the laws of the State of Delaware, United States of America, of Neenah, Wisconsin, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to products made of creped paper, particularly absorbent multi-ply paper towels, and to methods of producing such products.

The present invention consists in an multi-ply creped paper sheet comprising opposed outer webs each embossed with lands which border recess areas providing bulked sheet areas between the lands and which recesses are less stressed than the lands, the lands of each outer web projecting toward and crossing transversely the lands of the other outer web and bridging internal recesses of the other web, adhesive being interposed between the lands of the webs to unite and form the webs into the sheet to inhibit extension of the bridged recess areas and to limit sheet extension.

The present invention also consists in a method of producing multi-ply creped paper sheet material which comprises forming a first nip between first and second embossing rolls having a pattern of lands and recesses, rotating the rolls so that lands of one roll extend transversely to and across lands of the other roll in said first nip, feeding a creped paper web in a second nip between a first said embossing roll and a resiliently surfaced roll so that the creped paper web has imparted thereto a pattern of lands and recesses conforming to the embossing roll, feeding a second creped paper web in a third nip formed between a second embossing roll and another resiliently surfaced roll so that the second creped paper web receives a pattern of lands and recesses conforming to the pattern of the second embossing roll, applying adhesive

to lands of at least one of said webs prior to entering the first nip, directing the webs without removal from the embossing rolls to the first nip between embossing rolls so that the lands of the webs project toward and cross transversely each other bridging the internal recesses and the webs are adhesively united in said nip between embossing rolls at cross-overs of said lands. The lands thus provided give the material some structural rigidity. The rigidity is imparted to the material without affecting materially the softness and other desirable qualities provided by creped paper webs. The adhesive is preferably a water-resistant adhesive to prevent ply delamination and complete release of the united structure under wetted conditions, thus enhancing bulk in the wet state.

The material may be used as multi-ply paper towel and it requires a minimum of bonding for adequate ply attachment and has good liquid absorbency, towel bulk, softness, tensile strength and fluid capacity.

The lands and the recess areas, may be provided in creped paper products by roll embossing webs separately and then preserving the embossments until web combination into a multi-ply sheet. For this purpose the webs to be combined may be carried on their embossing rolls to a common nip and adhesively secured in the nip. The embossing rolls, in accordance with the invention, have a sequence of lands and recess areas, and, suitably, web attachment is effected only where lands of cooperating rolls cross each other.

The embossing rolls may take any of a variety of forms but preferably, the cooperating embossing rolls have lands of significant surface area and which lands, in the combining nip, so cross each other as to provide relatively small pressure zones, thus providing for secure but limited attachment of creped paper webs to form the multi-ply sheet structure. For the sake of convenience herein, individual plies are generally referred to as webs while the multi-ply structure is commonly termed a sheet.

The invention will be further described by way of example with reference to the accompanying drawings in which:—

Figure 1 is a schematic representation of apparatus on which multi-ply towelling material or the like of the present invention may be formed;

Figure 2 is a view illustrating in perspective the apparatus of Figure 1, the arrow indicating the direction of sheet travel through the apparatus;

Figure 3 is a schematic plan view, idealized and enlarged, representing particularly adhesive bonding zones of an example of two-ply towelling material in accordance with the invention which may be produced by the apparatus of Figures 1 and 2.

Figure 4 is a fragmentary view partially in section of the two-ply towelling material and with a portion of one ply of the two-ply material removed and the view being much enlarged;

Figure 5 is a sectional view of the two-ply product of Figure 2, enlarged about 13 times, the section being taken transversely to the direction of sheet travel, and in the dry sheet condition;

Figure 6 is a view like that of Figure 5 but taken in the direction of sheet travel;

Figure 7 is a view illustrating the product of Figure 6 after it has been well wetted;

Figure 8 is a view like that of Figure 1 but illustrating production of a three-ply product in accordance with the invention;

Figure 9 is a fragmentary, sectional view like that of Figure 5 of a three-ply product;

Figure 10 is a view like that of Figure 9 but taken looking transversely to that of Figure 9;

Figure 11 is a view of a product similar to that of Figure 10 after it has been wetted;

Figure 12 is a schematic view illustrating particularly common cross-over areas of embossing rolls each having a generally parallelogram pattern and by means of which small zones of bonding are formed in multi-ply towelling material, for example;

Figure 13 is a view like that of Figure 12 but wherein the embossing roll pattern is essentially a sine wave;

Figure 14 is a fragmentary, enlarged view partially in section of a three-ply product produced with embossing rolls having a pattern like that of Figure 12; and

Figure 15 is a fragmentary enlarged view, partially in section, of a three-ply product produced with embossing rolls having a sine wave pattern like that of Figure 13, portions of plies being removed for sake of clarity of illustration.

Referring to the drawings, and particularly to Figure 1, a web 1 of creped paper moves in the direction indicated by the arrow around a resilient rubber roll 2 through a nip 3

formed by the resilient roll 2 and a metal male embossing roll 4. The term "web" as already noted will be used generally herein to indicate a single ply, and the term "sheet" to indicate the composite structure. The web 1 as it proceeds to a combining nip 5 is embossed in the nip 3 by indentation of the resilient rubber roll 2 to provide upstanding embossments having surfaces 6 which are supplied with adhesive 7 by a flexographic type adhesive applicator indicated generally at 8. The web material in the area of the surface 6 will be locally stressed relative to adjacent web areas as the roll 2 forces the web to conform to the pattern on roll 4 as noted more particularly hereinafter. The adhesive applicator 8 includes transfer roll 9, doctor roll 10 and pickup roll 11, all rotating in the direction indicated by the arrows. The rolls 9, 10 and 11 are smooth surfaced rolls and, accordingly, adhesive is applied only to the embossment surfaces 6 as the web proceeds to the nip 5. Such adhesive need only be a very thin film and, accordingly, is not generally visible to the unaided eye.

A second and similar web of creped paper 12 is provided to the nip 5 over similar embossing equipment designated 13 and 14, the embossment surfaces of the traveling web being indicated at 15, and the direction of roll movement being indicated by the arrows. The soft rubber roll 13 forms with the steel roll 14 the embossing nip 16, as clearly shown in Fig. 1, and is effective to cause the crepe tissue 12 to assume the surface contour of the steel roll 14. The stress in web 12 due to the steel-rubber nip action is greater in the area of the surface 15, and the web may locally be stressed beyond the elastic limit of the creped paper. The combined creped paper webs move from the nip 5 in the direction of the arrow to a subsequent conventional in-line converting operation such as equipment designed to produce roll towels or folded products.

Referring now more particularly to Fig. 2, the steel rolls 4 and 14 may be seen to be ribbed rolls. Thus, roll 4 has a series of spirally arranged lands and recesses extending around the axis of the roll, the lands being designated at 24 and the recesses being indicated at 25. A similar roll 14 has a similar series of lands and recesses designated at 26, 27. The lands 24, 26 in the embodiment illustrated are in the form of substantially continuous ribs and they form the surfaces 6, 15 on the webs 1, 12 respectively. The rolls 4, 14 rotate in opposite rotational directions, and the lands of each of the rolls (Fig. 2) extend in crossing relation. Accordingly, a zone of relatively high pressure exists on webs 1 and 12 where the lands of rolls 4 and 14 meet to urge the embossment surfaces 6 and 15 respectively of webs 1 and 12 together. A pattern of pressure and adhesive zones 30

such as that illustrated by the dotted zones in Fig. 3 results. The adhesive, however, is applied to all of the embossment surfaces 6, for example, (Fig. 2) and, accordingly, some areas of the upper web 1 will carry adhesive but will not be bonded to lower web 12 since adhesive contact with the lower web is only intermittent. Thus, adhesive bonding occurs only in the zones 30 (Figs. 3 and 4). This results, in effect, as may be most clearly seen from Fig. 4, in a combination of the two webs 1 and 12, each of which, however, has its own series of lands and recesses. These lands and recesses extend (Fig. 4) generally at 45° to the roll axis and are in contact with one another in the product (Fig. 4). The lands 6 of the web 1 become the internal lands of the upper web 1 coinciding over a short length with internal lands 15 of the lower web 12 to define the zones 30; the recesses 33 of the upper web provide, as do the recesses 34 of the lower web, in effect, open channels. The material forming the lands is pressed and is considerably more stressed than the web material forming the recesses.

As shown in Fig. 4 where a portion of upper web 1 is removed, internal lands 6, 15 of the two webs extend in opposed crossing relation bridging the recesses 33, 34 to restrict extension of the material in these areas. Also, the abutment of the lands provides for an overall thickness of sheet where lands cross which is dependent upon substantially the sum of the heights of the original web embossments. Also, it is to be noted that, though the webs are plied as is customary with both webs extending longitudinally in the machine direction (indicated by the arrows in Figs. 3 and 4), the bonded zones and the internal lands and recesses project at 45° to the axis in this instance. Such a 90° relationship of the lands is not necessary but the lands should not mate and, preferably, the crossing angle is close to 90°.

As clearly indicated in Fig. 5, which is based on a much enlarged (13 times) photograph of a two-ply sheet in accordance with the invention, the spacing 37 between the two webs is well open on either side of the bonded zones 30. In this two-ply structure, as may be seen from Fig. 6, which is a view transverse to that of the sheet of Fig. 5, also enlarged 13 times, the structure is quite symmetrical, the bonding zones 30 being regularly spaced (Fig. 3) to provide the combination of webs 1, 12 in a symmetrical arrangement (Fig. 2). Such multi-ply sheet, when wetted as indicated by Fig. 7, which is also an enlargement 13 times of the view similar to that of Fig. 6, the webs 1, 12 collapse on each other, retaining, however, a crepe type configuration and exhibiting good bulk.

A further embodiment of the product of the invention, illustrated in Figs. 9, 10 and 11, may be formed with the apparatus of Fig.

8. In Fig. 8 a second flexographic adhesive type applicator, indicated generally at 17, is provided for application of adhesive 21 by rolls 18, 19 and 20 to embossment surfaces 15. A third web 22 is fed directly to the nip 5 between webs 1 and 12 and is secured to the outer webs by the adhesives 7 and 21. The Fig. 9 view is taken looking in the machine direction (indicated by the arrow, Fig. 8) and, consequently, little of the actual crepe structure is apparent. However, the third and intermediate ply 22 is shown to separate the outer plies 1, 12 and to divide the open spacing into intermediate spaces 39, 40. The crepe structure, particularly the high creped intermediate ply 22, is more clearly shown in Fig. 10, this view being taken looking in the cross direction. Fig. 11 illustrates the product of Fig. 10 in the wetted condition and clearly indicates that the high stretch center ply serves to space the outer plies 1, 12 providing wet bulk in the product.

Various patterns of bonding of the two or three ply structure may be employed. We prefer to utilize the arrangement shown in Fig. 1 wherein the lands and recesses or grooves of the two rolls 4, 14 are each similar in dimension, extend continuously in a spiral the length of and around the roll at a constant angle with the axis of the roll, and are so presented to each other in their nip that the lands of one cross the other at a significant angle, suitably 90° as in Figs. 1 and 2. However, it is not necessary that both rolls have the same configuration of lands and recesses, nor is it necessary that the lands and grooves cross each other to form the 90° arrangement of Fig. 3 where the adhered zones 30 are small diamond-shaped areas. Additionally, it is not necessary that the lands extend continuously; in accordance with the invention the lands need only be of sufficient length to bridge a recess of another web and be secured to lands of that web bordering the recess.

In Fig. 12 the pattern of adhesive attachment of a two-ply towel product, for example, is formed by cooperating embossing rolls having lands respectively as at 42, 43 in the shape of parallelograms. The lands 42 of one roll are indicated in solid lines and the lands 43 of the other roll are represented by dash lines. The zone 44 in which adhesive attachment of sheets carried on the rolls would occur appears as small diamond areas 44.

In Fig. 13 the illustration is of a pattern resulting from cooperating embossing rolls each of which has lands as designated at 46, 47 by solid and dash lines respectively. The zones of contact in roll rotation which would provide adhesive zones are indicated at 48.

Fig. 14 is illustrative of a three-ply product formed with outer webs 51, 52 em-

bossed on rolls of the type shown in Fig. 12. The intermediate ply which suitably is creped paper also, but not embossed, is designated at 53 and may, of course, be eliminated, if desired. The parallelogram type recess embossments of the webs 51, 52 are indicated respectively at 54, 55. These embossments in each web are oriented angularly to the machine direction of the sheets as indicated by the arrow, and the embossments are themselves disposed so that the inner lands 56, 57 of the webs 51, 52 completely border or surround each recess. Adhesive bonding zones as at 58 provide for the adhesive attachment of the inner lands of the outer plies to the central web 53 or, in the case of a two-ply structure, to bond the outer webs to each other.

Fig. 15 is illustrative of another embodiment in accordance with the invention and, as shown, includes an upper web 60, a lower web 61, and an intermediate ply 62. The intermediate ply suitably is an unembossed crepe tissue web and may be eliminated, if desired. The sinusoidal wave type embossments, or internal land 63 of web 60 and internal land 64 of web 61 extend at substantially right angles to the machine direction of the webs indicated by the arrow, and the zones of adhesive, as indicated at 65, define zones which secure the outer webs to the inner. In the absence of an intermediate ply 62 the adhesive, as at 65, carried on one web is useful to secure the two embossed webs together.

As will be noted from the foregoing, in each instance the resilient roll urges the web to conform to the pattern on the steel embossing roll locally stressing the web in the area of the land of the embossing roll; this stressed web area then in each instance becomes an internal land of the multi-ply sheet and the internal land in each instance borders a less stressed recess area of its own web. Each internal land also bridges a lower stressed recess area of the other web.

The recess areas are then prevented from extending during sheet use or upon water wetting to a large degree, depending on the residual stretch or crepe remaining in the embossed web, since the adhered internal lands restrict such movement.

In more detail, towelling material for conventional household uses may be conveniently made on conventional papermaking equip-

ment from a pulp furnish of wood pulp such as follows:—

40% by weight of bleach softwood kraft
50% by weight of bleach softwood sulfite
10% by weight of bleached hardwood kraft

Such furnish is not critical, as other wood pulp constituents and in other proportions may be substituted with only generally minor product characteristics insofar as the practice of the present invention is concerned. Suitably, however, such furnishes do contain a wet strength agent to the extent of between about 0.25 to 0.75 per cent by weight of the fiber of the furnish and the webs are creped in usual manner. In some instances a quantity of short synthetic fibers may be included in the furnish to provide special characteristics.

The webs in two-ply product manufacture are fed to the equipment of Fig. 1 as already described, and the ribs of the rolls impart the rib pattern to the webs. Other similar roll design arrangements in which the co-operating embossing rolls have ribs which cross each other in the roll nip at large angles may, of course, be employed. The ribs need not be substantially straight but may be irregular, and, also, they need not be continuous but are of a length greater in magnitude than the sum of the width of the rib or raised land and the width of a recess area. The greater the length to width ratio of the rib, the less critical is registration of the metal embossing rolls. This is in distinct contrast to peg-on-peg type embossing where mated registration of identical embossments is required and at substantial speed, roll and peg wear are an ever present problem.

Example 1

A very suitable towelling material is produced as follows: creped paper outer webs each having a dry basis weight of about 10.8 lbs per 2880 sq. ft., a stretch at break of about 32%; dry tensile strength (per 3" width) of about 1900 grams in the machine direction and about 1200 grams in the cross direction, a wet tensile strength (per 3" width) of about 640 grams in the machine direction and about 310 grams in the cross direction, and with polyvinyl alcohol as the adhesive bonding agent, are formed into a two-ply sheet on the equipment of Fig. 1, with the spiral rib pattern and had characteristics as follows:

	Basis weight—lbs/2880 sq. ft.		23.8
	Sheet thickness—inches at:	0.2 lb/sq. in.	0.023
		0.4 lb/sq. in.	0.021
5	Tensile strength (gm/3''):	MD dry	3500
		CD dry	1950
		MD wet	1000
		CD wet	540
	% Stretch		19
	Absorbent rate—sec.		10.2
10	Absorbent capacity—gms/16 sq. in.		2.01
	Handle-O-Meter (gms)	MD	6.3
		CD	10.4
	Compressive Modulus		415

15 The spiral pattern used in producing the above had a depth of 0.070". The lands of the pattern were 0.30" wide and extended continuously at a 45° angle with respect to the axis of the roll. The distance between adjacent lands or ribs was 0.070".

20 The above data, that is, the sheet thickness, tensile strength and stretch values, were obtained with an Instron tester (Model TM-1). (Instron being a Registered Trade Mark). The absorbent rate test was made by placing a 0.1 ml. drop of water on the test sample and measuring the time for the gloss to disappear, which is the end point for the absorption of water by the sample. The absorbent capacity test was performed by weighing a 4"×4" dry sample, soaking it with water for 3 minutes, hanging it by one corner for 1 minute to allow excess water to be drained off, and re-weighing. The difference in the wet and dry weight is the water pick-up of the sample.

35 The Handle-O-Meter values were obtained by using a common Thwing-Albert Handle-O-Meter test. For testing Handle-O-Meter in the machine direction, 2-1/2" wide by 6" long samples were used, and for cross direction samples were 2-1/2" wide by 3-1/2" long. The Handle-O-Meter values give an indication of sheet stiffness and lower values indicate better handle and less stiffness. By this test procedure, two-ply sheets produced as described and conventional creped tissue

towel products have Handle-O-Meter values generally in the range of about 1—25 in each direction (machine and cross-direction).

50 The compressive modulus value is given in inch-grams per cubic inch and is an indication of sheet softness, with low values indicating more compressible and softer products. In general, two-ply sheets produced as described and conventional creped tissue toweling material have modulus values in the range of 200—1400. These values are obtained by using an Instron tester, with a sample between compression plates having an area of four square inches. Loading of the compression plates at a rate of about 0.02 inch per minute provides a stress-strain curve from the slope of which the modulus value is derived at a loading of 100 gms/sq. in.

65 In the example above described, and preceding examples, ply attachment was in the range of 40—50 gms. per 4" width. This ply attachment test was made by cutting a four-inch wide sample by about six inches long, separating the two outer webs on a portion of the sample, and then placing those four-inch wide separated web portions in an Instron tester to measure the force (grams) required for ply separation. Values for conventional multi-ply towel materials are generally at least 10 gms. or more. Values of 25 gms. or more is considered very satisfactory ply attachment.

Example 2

80 A three-ply product was produced employing the same outer webs as in Example 1 as the outer webs and using as the center a web having: a dry basis weight of about 7.7 lbs./2880 sq. ft.; a stretch level of about 92%; a dry tensile strength (per 3" width) of about 1200 gms. in the machine direction and about 500 gms. in the cross-direction; a wet tensile strength (per 3" width) of about 510 grams in the machine direction and about 135 grams in the cross-direction; and polyvinyl alcohol was employed as the adhesive bonding agent of each outer web. A three-ply sheet formed with the spiral rib pattern had characteristics as follows:

	Basis weight—lbs/2880 sq. ft.		38.8
	Sheet Thickness—inches at:	0.2 lb/sq. in.	0.026
		0.4 lb/sq. in.	0.023
5	Tensile strength (gms/3'')	MD dry	4120
		CD dry	2530
		MD wet	1175
		CD wet	770
	% Stretch		18
	Absorbent rate—sec.		7.1
10	Absorbent capacity—gms/16 sq. in.		4.77
	Handle-O-Meter (grams)	MD	11.5
		CD	17.6
	Compressive modulus		1272

Examples 3 and 4

- 15 Employing the same outer webs and process as in Examples 1 and 2, except using the parallelogram embossing pattern (Fig. 12), corresponding two and three-ply sheets had characteristics as follows:—

			2-Ply	3-Ply
20	Basis weight—lbs/2880 sq. ft.		24.0	38.5
	Sheet thickness—In.	0.2 lbs/sq. in.	0.029	0.037
		0.4 lbs/sq. in.	0.022	0.029
	Tensile strength (gms/3'')	MD dry	3550	4200
		CD dry	1380	2600
		MD wet	1090	830
25		CD wet	500	650
	% Stretch		18	18
	Absorbent rate—sec.		11.4	2.4
	Absorbent capacity—gms/16 sq. in.		2.11	3.95
	Handle-O-Meter (gms)	MD	6.9	7.0
30		CD	5.2	8.3
	Compressive modulus		345	329

- The parallelogram pattern used in producing Examples 3 and 4 had a pattern depth of about 0.070" and the width of the lands was 0.020". Opposing acute and obtuse angles of one enclosed parallelogram of the pattern were 60° and 120°, respectively.
- 35 Enclosed opposing sides of each parallelogram were 1/8" and 1/4".

Examples 5 and 6

Employing the same outer webs and process as in Examples 1 and 2, except using the wave embossing pattern (Fig. 13), corresponding two and three-ply sheets had characteristics as follows:—

40			2-Ply	3-Ply
	Basis weight—lbs/2880 sq. ft.		23.1	38.6
	Sheet thickness—In. at	0.2 lbs/sq. in.	0.023	0.039
		0.4 lbs/sq. in.	0.018	0.013
45	Tensile strength (gms/3'')	MD dry	2500	2400
		CD dry	1300	2020
		MD wet	950	710
		CD wet	420	580
	% Stretch		17	16
	Absorbent rate—sec.		8.6	12.2
50	Absorbent capacity—gms/lb. sq. in.		2.09	4.43
	Handle-O-Meter (gms)	MD	5.7	7.8
		CD	8.0	14.9
	Compressive modulus		276	705

The wave embossing pattern used in producing Examples 5 and 6 had a pattern depth of about 0.050" and the width of the continuous lands was 0.030". Each sinusoidal portion of the continuous transverse lands had a parallel length with respect to the axis of the embossing roll of 0.420". Each sinusoidal portion consisted of two half-circles having a radius of 0.09" to the inside of the raised land and the maximum distance between adjacent continuous lands was 0.180".

The towelling material made as described results in high bulk, good absorbency, and softness qualities. These product attributes, as noted in the examples, can be altered depending on the embossing pattern and number of plies in the finished product. As may be noted, the high stretch center web of the three-ply examples increases the basis weight of the finished product above that of the two-ply examples. The highest bulk with two-ply samples occurred with the parallelogram pattern, while bulk was highest with the wave pattern on three-ply samples.

The tensile strength of the examples is mainly affected by the embossing pattern. In particular, it will be noted that the machine direction strength is changed little for the two and three-ply examples embossed with the same pattern, but cross-direction strength shows a significant increase for the three-ply. This is because the high stretch center web contributes very little to the breaking tensile strength of the two lower stretch outer webs in the three-ply examples. The center web does contribute to the cross-direction strength since stretch characteristics in this direction are very similar for all webs. Of the patterns used in the examples, the least tensile strength was obtained with the wave pattern.

One of the major quality differences between the two and three-ply examples is the much higher absorbent capacity of the latter. This increase in capacity is greater than the basis weight differences would indicate and is due to the three-ply product design, i.e., having a higher stretch center web than the outer webs, which, when wet, creates greater thick-

ness and fluid holding capacity than the two-ply design. Thereby it is less subject to the degree of collapse that occurs in a two-ply design in which both plies are of the same weight and stretch characteristics.

Handle-O-Meter values show that the spiral rib examples are slightly stiffer than those with the other patterns. Also, the three-ply examples are slightly stiffer than the two-ply examples in the cross-direction as would be expected. However, these values are well within the acceptable limpness range suitable for towelling.

The two-ply examples are slightly more compressible than the three-ply examples, as shown by the compressive modulus values. The lowest values were obtained on the parallelogram pattern examples. All values are, however, within the range for good towelling.

Besides the embossing pattern and the number of webs in the product design, the product characteristics given for the examples above can also be altered depending on the embossing pressures employed and the characteristics of the base webs used for the outer and center plies, such as the dry basis weight, fineness of crepe, level of stretch and tensile strength. For example, two and three-ply products have been produced by making some of these changes that result in absorbent capacity values in the range of 2.0—7.0 gms/16 sq. in. For towelling, the dry basis weight range of the outer webs in the product design that are applicable are in the 7—15 lb/2880 sq. ft. range per web, with a 9—11 lb/2880 sq. ft. preferred range. Outer web stretch levels applicable are in the 15—45% range, with a level of 25—35% preferred. For product designs of more than two webs, center webs having a dry basis weight and stretch level range of 5—11 lbs/2880 sq. ft. and 20—120%, respectively, are applicable. Preferred ranges are 6—8 lbs/2880 sq. ft. and 60—80% stretch. The preferred ranges for dry basis weight and stretch result in the following finished product weights (lbs/2880 sq. ft.) and stretch:—

	2-Ply	3-Ply
Finished basis weight	20—30	30—45
Stretch level	5—25	5—25

Sheets produced in accordance with the invention are characterized generally by distinctly contoured raised areas corresponding with the channels or recesses of the embossing patterns of the rolls. For towelling purposes the bulk of the sheets as measured in well raised areas is for two-ply material between about 0.015 and 0.040" thickness at a pressure or loading of about 0.2 pounds per sq. in.; a three-ply towelling material may bulk to 0.080" depending upon the nature of the

plies, the graphics of the embossments and the like. The pressure applied by the embossing rolls is most suitably between about 100 and 300 pounds per lineal inch; higher embossing pressures lead to greater bulk and bulked areas of the final product measuring 0.020" to about 0.050" are generally preferred. Too high an embossing pressure may lead to web breakage by a forcing of the web too severely into the channels or recesses of the embossing rolls. An embossing roll pat-

tern depth of 0.030" to 0.080" is generally satisfactory although a range of 0.040" to about 0.060" is preferred for towelling uses. To provide for ready conformance of the rubber roll with the embossing roll, we have found a cover thickness of about 1/4" to 1" to be satisfactory while generally we prefer a thickness in the range of 1/2" to 5/8". The hardness of such rolls is usefully in the range of 30 to 60 Shore Durometer A, and preferably 35 to 45.

Generally, we prefer to provide the male embosser rolls of the web combining nip at a fixed clearance sufficient to attain the degree of ply adhesion for the purpose. The area of pressure application in the combining nip corresponds to the cross-over areas of the internal lands of the sheet product. The width of the land for towelling purposes we prefer to keep in the range of 0.010" to 0.050", with about 0.030" generally optimum. The bulked area has suitably a width generally at least one or more times that of the internal land width, and the pressed area in the combining nip would, therefore, consist of about a maximum of 25% of the sheet area. Depending on the graphics of the sheet, the bulked area may be as much as 25 times that of the internal land area, and the pressed cross-over area in the combining nip might then constitute less than 1% of the sheet area.

The products of our method are, for towelling purposes, very absorbent, soft, strong and controllably so. Conventional furnishes are suitable for the purpose. For altering some characteristics such as the degree of softness or to attain a particular "feel" of the sheet to a hand of a user, we contemplate that some other fibres may be employed with the conventional wood pulp fibres. For example, a weight % of synthetics fibres, such as 10% or more by weight of short rayon, may be included to achieve a very soft feeling product.

Certain variations of the specifically described procedures may be practiced to provide towel, napkin and like products in accordance with the invention. For example, while we have referred specifically to the feeding of a single creped paper web to each of the rubber-metal nips of the roll apparatus (and to the steel-steel nip in 3-ply products) webs in superposition may, of course, be fed to the nips, and such superposed webs may vary in weight, stretch and degree of openness to achieve particular characteristics. Consequently, the outer plies of the sheet or the inner ply may itself be a composite.

In all cases for towelling purposes, however, the sheets have rounded smooth-feeling, rather gross sized bulked protrusions occupying 50% or more of the sheet surface area; generally, in towelling usage the bulked area will be much in excess of the pressed area

of the total sheet, up to 25 times that of the internal land area, as already noted.

WHAT WE CLAIM IS:—

1. A multi-ply creped paper sheet comprising opposed outer webs each embossed with lands which border recess areas providing bulked sheet areas between the lands and which recesses are less stressed than the lands, the lands of each outer web projecting toward and crossing transversely the lands of the other outer web and bridging internal recesses of the other web, adhesive being interposed between the lands of the webs to unite and form the webs into the sheet to inhibit extension of the bridged recess areas and to limit sheet extension.

2. A multi-ply paper sheet according to Claim 1 in which the sheet is two ply and the internal lands are united only by adhesive.

3. A multi-ply sheet according to Claim 1 in which the means uniting the outer webs includes at least one web interposed between the lands and adhesive joins the lands of each web to the central web.

4. A multi-ply sheet according to any of the preceding claims in which the lands of the webs of the paper sheet are in the form of ribs and the recesses of each web extend substantially continuously and border the ribs for the width of the web.

5. A multi-ply sheet according to Claim 4 in which the lands of the webs are continuous ribs extending the width of the sheet.

6. A multi-ply sheet according to Claim 4 in which the ribs are sinusoidal and the recesses between the ribs are longer in the direction of the sheet length than the length of the lands in the same direction.

7. A multi-ply sheet according to Claim 1 in which the web recesses are individual depressions and provide individual separate protrusions extending from the lands of the sheet to the sheet surface.

8. A multi-ply paper sheet according to Claim 1 in which the recesses form channels extending completely through the sheet.

9. A multi-ply sheet as claimed in any of the preceding claims in which the recesses form, on the outer surfaces of the webs, bulked areas and the bulked areas have generally a width which is at least that of the width of the lands.

10. A multi-ply material according to Claim 9 in which the total bulked area of the sheet surface is between 1 and 25 times the area of the lands.

11. A multi-ply absorbent paper towel material according to Claim 9 in which the width of the lands is between 0.010 inch and 0.050 inch.

12. A multi-ply creped paper sheet as claimed in claim 1 wherein recess areas provide a series of raised, rounded bulked areas



tern depth of 0.030" to 0.080" is generally satisfactory although a range of 0.040" to about 0.060" is preferred for towelling uses. To provide for ready conformance of the rubber roll with the embossing roll, we have found a cover thickness of about 1/4" to 1" to be satisfactory while generally we prefer a thickness in the range of 1/2" to 5/8". The hardness of such rolls is usefully in the range of 30 to 60 Shore Durometer A, and preferably 35 to 45.

Generally, we prefer to provide the male embosser rolls of the web combining nip at a fixed clearance sufficient to attain the degree of ply adhesion for the purpose. The area of pressure application in the combining nip corresponds to the cross-over areas of the internal lands of the sheet product. The width of the land for towelling purposes we prefer to keep in the range of 0.010" to 0.050", with about 0.030" generally optimum. The bulked area has suitably a width generally at least one or more times that of the internal land width, and the pressed area in the combining nip would, therefore, consist of about a maximum of 25% of the sheet area. Depending on the graphics of the sheet, the bulked area may be as much as 25 times that of the internal land area, and the pressed cross-over area in the combining nip might then constitute less than 1% of the sheet area.

The products of our method are, for towelling purposes, very absorbent, soft, strong and controllably so. Conventional furnishes are suitable for the purpose. For altering some characteristics such as the degree of softness or to attain a particular "feel" of the sheet to a hand of a user, we contemplate that some other fibres may be employed with the conventional wood pulp fibres. For example, a weight % of synthetics fibres, such as 10% or more by weight of short rayon, may be included to achieve a very soft feeling product.

Certain variations of the specifically described procedures may be practiced to provide towel, napkin and like products in accordance with the invention. For example, while we have referred specifically to the feeding of a single creped paper web to each of the rubber-metal nips of the roll apparatus (and to the steel-steel nip in 3-ply products) webs in superposition may, of course, be fed to the nips, and such superposed webs may vary in weight, stretch and degree of openness to achieve particular characteristics. Consequently, the outer plies of the sheet or the inner ply may itself be a composite.

In all cases for towelling purposes, however, the sheets have rounded smooth-feeling, rather gross sized bulked protrusions occupying 50% or more of the sheet surface area; generally, in towelling usage the bulked area will be much in excess of the pressed area

of the total sheet, up to 25 times that of the internal land area, as already noted.

WHAT WE CLAIM IS:—

1. A multi-ply creped paper sheet comprising opposed outer webs each embossed with lands which border recess areas providing bulked sheet areas between the lands and which recesses are less stressed than the lands, the lands of each outer web projecting toward and crossing transversely the lands of the other outer web and bridging internal recesses of the other web, adhesive being interposed between the lands of the webs to unite and form the webs into the sheet to inhibit extension of the bridged recess areas and to limit sheet extension.

2. A multi-ply paper sheet according to Claim 1 in which the sheet is two ply and the internal lands are united only by adhesive.

3. A multi-ply sheet according to Claim 1 in which the means uniting the outer webs includes at least one web interposed between the lands and adhesive joins the lands of each web to the central web.

4. A multi-ply sheet according to any of the preceding claims in which the lands of the webs of the paper sheet are in the form of ribs and the recesses of each web extend substantially continuously and border the ribs for the width of the web.

5. A multi-ply sheet according to Claim 4 in which the lands of the webs are continuous ribs extending the width of the sheet.

6. A multi-ply sheet according to Claim 4 in which the ribs are sinusoidal and the recesses between the ribs are longer in the direction of the sheet length than the length of the lands in the same direction.

7. A multi-ply sheet according to Claim 1 in which the web recesses are individual depressions and provide individual separate protrusions extending from the lands of the sheet to the sheet surface.

8. A multi-ply paper sheet according to Claim 1 in which the recesses form channels extending completely through the sheet.

9. A multi-ply sheet as claimed in any of the preceding claims in which the recesses form, on the outer surfaces of the webs, bulked areas and the bulked areas have generally a width which is at least that of the width of the lands.

10. A multi-ply material according to Claim 9 in which the total bulked area of the sheet surface is between 1 and 25 times the area of the lands.

11. A multi-ply absorbent paper towel material according to Claim 9 in which the width of the lands is between 0.010 inch and 0.050 inch.

12. A multi-ply creped paper sheet as claimed in claim 1 wherein recess areas provide a series of raised, rounded bulked areas

and the lands are adjacent pressed areas, said sheet having a thickness of between 0.015 inch and 0.080 inch overall, a basic weight of between 20 and 45 pounds per 2880 sq. ft. and a stretch of between 5 and 25%.

- 5 13. A process of producing multi-ply creped paper sheet material which comprises forming a first nip between first and second embossing rolls having a pattern of lands and recesses, rotating the rolls so that lands of one roll extend transversely to and across lands of the other roll in said first nip, feeding a creped paper web in a second nip between a first said embossing roll and a resiliently surfaced roll so that the creped paper web has imparted thereto a pattern of lands and recesses conforming to the embossing roll, feeding a second creped paper web in a third nip formed between a second embossing roll and another resiliently surfaced roll so that the second creped paper web receives a pattern of lands and recesses conforming to the pattern of the second embossing roll, applying adhesive to lands of at least one of said webs prior to entering the first nip, directing the webs without removal from the embossing rolls to the first nip between embossing rolls so that the lands of the webs project toward and cross transversely each other bridging
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the internal recesses and the webs are adhesively united in said nip between embossing rolls at cross-overs of said lands.

14. A process according to Claim 13 in which a third web is directed between the first and second webs in the first nip between embossing rolls.

15. The process according to Claim 13 in which each resiliently surfaced roll has a Shore Durometer A of between 30 and 60.

16. Multi-ply creped paper sheet material produced by a method as claimed in any of Claims 13—15.

17. Multi-ply creped paper sheet material substantially as hereinbefore described with reference to Figures 3—7; 9—11; 14 or 15.

18. A process for producing multi-ply creped paper sheet material substantially as hereinbefore described with reference to Figures 1—2 or 8 of the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1975.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

