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METHOD OF MAKING STRETCHABLE
UNIFIED PAPER

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This application is a continuation-in-part of our co-pending application Ser. No. 749,874, filed on May 22, 1947, and now abandoned.

This invention relates to a new and useful type of stretchable unified paper; to the method of making, which involves the step of severely calendering stretchable creped paper followed by application of a fiber-unifying composition; and to novel adhesive tapes and other products made from such paper.

By "unified paper" is meant paper that has been coated or impregnated with a material which bonds the paper fibers together so as to increase the tensile strength of the paper and its resistance to internal splitting or delamination. By "stretchable paper" is meant paper that has a special structure permitting of a substantial elongation (at least 10%) before rupture when hand pulled; as distinguished from the slight degree of elongation of ordinary paper when strongly pulled to the breaking point (due to slipping of the intermeshed fibers in their flat lay relation, which is a rupture yielding effect).

Creped paper is a well known type of stretchable paper. The wrinkling of the paper permits of elongation by hand pulling to a substantial extent before slipping and yielding of the fibers occurs preliminary to complete rupture. The creping operation also opens up the fiber structure and decreases the density of the paper, and makes the paper more porous and absorbent. The caliper thickness is considerably increased, due both to the wrinkling and to the decrease in density of the body structure. Creped paper can be impregnated with waterproof stretchable compositions so as to result in unified paper that is both stretchable and waterproof.

Unified creped paper of this type is commercially employed on a large scale as backings in pressure-sensitive adhesive masking tapes. The normally tacky and pressure-sensitive adhesive coating causes instant aggressive adhesion on contact with surfaces to which applied by hand, without the need of moistening or heating, and the tape can be dry stripped without internal delamination and without leaving an adhesive residue. Such masking tapes, supplied in roll form, are widely used in connection with painting operations (such as lacquer spraying of automobiles). The stretchable characteristic permits easy conformation to curved or irregular surfaces, and permits the tape to be applied so as to define a curved masking edge when desired. The impregnation of the paper backing prevents penetration by lacquer solvents and the like which

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would soften the adhesive and prevent clean removal of the tape.

The present invention makes possible the production of adhesive masking tapes having improved use characteristics, while at the same time materially reducing the cost of manufacture. This highly desirable goal has been realized by structural changes in the tape obtained as the result of modifying the paper backing structure.

The consequence of the change is not merely to alter the backing but also to alter the relationship of the adhesive coating to the backing, and thereby to obtain a new combination having new and useful properties. Reduction in cost of manufacture is a highly important end in itself but in this case has been accomplished in conjunction with very substantial improvements in the performance characteristics of the product.

While a particularly important accomplishment of the invention thus relates to adhesive masking tapes, the invention also has value in providing a new type of stretchable unified paper that can be used, in one or another specific form, in making other types of products.

This invention has resulted from our discovery of the unexpected results that can be obtained by subjecting porous creped paper to severe calendering, followed by application of a stretchable fiber-unifying composition.

It might well be supposed that severe calendering of porous creped paper would have the effect of greatly reducing the stretch characteristic of the finished masking tape, and would adversely affect its tensile strength; as compared with masking tape made in the usual way with the same creped paper (not calendered). Especially so since severe calendering does materially reduce both the stretch and tensile strength values of the creped paper per se.

We have discovered, however, that severe calendering of the porous creped paper, sufficient to smooth down the creping wrinkles and to reduce the caliper thickness by as much as one-fifth or even one-half or more, does not have the expected result. Indeed, stretch and tensile strength values for the tape product can be obtained which are if anything somewhat higher than would result if the calendering step had been omitted.

We have further discovered that such calendering of the porous creped paper decreases the weight of impregnant per unit area which is required for the same effective unification of the fibers and barrier action to lacquer solvent penetration. We have also discovered that a lower coating weight of pressure-sensitive ad-

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hesive can be used without impairing tape adhesion characteristics. The saving in amounts of impregnant and adhesive needed per unit area for the same performance characteristics, results in a cost saving which is a substantial proportion of the total monetary cost of manufacturing the masking tape. In comparison, the cost of calendering the creped paper is trivial.

Each of these changes contributes to the improved performance characteristics of the finished masking tape. Adhesive tape can readily be produced which has a total caliper thickness less than one-half of what it would have if made from the same creped paper (not calendered) with the normal impregnation and adhesive coating. Tape rolls are made smaller in diameter. The improved tape has a softer and more pliant feel and handles better in applying it to objects being taped. Yet there is no sacrifice of stretch and tensile strength values.

A particularly noteworthy advantage is that the tape is flatter and has a thinner edge. In painting operations (both spray painting and brush painting) this means that a cleaner and sharper line of demarcation is obtained at the juncture of the painted and masked surface areas. There is less tendency for the fluid paint or lacquer to seep under the tape or to build up on the edge of the tape, but at the same time the paint or lacquer coating is more certain to uniformly cover the surface up to the surface-contacting edge of the adhesive layer.

The invention also permits of using creped paper which would not be regarded as suitable when employed for making masking tape in the customary way. Thus a creped paper having a high degree of creping and stretch and a relatively high caliper thickness, can be calendered down to a reduced caliper thickness and the paper will be relatively flat. By using this calendered creped paper in place of an uncalendered creped paper of the same caliper thickness as the calendered paper, a finished masking tape can be made which has no greater total caliper thickness and yet has much higher stretch and tensile strength values, and the adhesive coating has a flatter surface.

Thus stronger and stretchier masking tapes can be made without increase of caliper thickness; or substantially thinner and more economical tapes can be made without sacrifice of strength and stretchiness; and the manufacturer thus has greater latitude in designing different types of masking tapes for various customer preferences.

The term "porous creped paper" is used by us in the strict sense and designates porous paper that has been crinkled, as by crowding a wet adherent sheet on a roll by means of a doctor blade, or by some equivalent operation, so as to produce an irregular wrinkling. The term does not embrace pleated papers or corrugated papers, which are entirely different, and are so recognized in the trade. The rolling down of corrugated paper so as to produce a pleated formation (wherein portions of the paper are folded over flatwise upon themselves, so that a cross-section of the folded portion shows three layers of paper in superposed relation), results in a paper that is so entirely different in appearance and structure from calendered creped paper that no one could fail to distinguish them. The crushing of corrugated creped paper also results in an entirely different type of sheet, since folds or pleats are produced which are large compared to the crep-

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ing wrinkles and the latter are not smoothed down; the caliper thickness is much greater than that of the pre-corrugated creped paper; and a relatively flat and smooth type of surface does not result. The calendered creped paper to which we refer consists of a single thickness of paper, free from folds or pleats, and in this sense is "flat" paper.

The severe calendering of porous creped paper to which previous reference has been made will now be explained in more detail with particular reference to the alteration in structure of the paper which is produced.

The creping of porous paper produces a multiplicity of fine wrinkles per inch and the over-all length of the web is materially reduced. The fibers are bent at the creases and are set so as to hold the crepe in the dry paper. The creping operation also opens up the fiber structure so that the body of the paper is less dense and hence is made more porous and absorptive. The degree of creping and stretch can be reduced by pulling out the paper during the making operation. Thus from the same paper and creping operation there can be produced a variety of creped papers having different degrees of residual stretch. This pulling out of creped paper causes elongation equal to the reduction in stretch value and decreases the caliper thickness (due to lessening the height of the ridges), but it does not increase the density of the body structure. The crepe wrinkles remain clear cut and plainly evident to sight and touch.

When porous creped paper is severely calendered by being passed through the steel or other rigid rolls of a paper calender, it is subjected to a wedging and squeezing action at the nip which is of short duration. The curved calender roll surfaces move down into and then up from the paper, as it goes through the nip, and the fiber body structure has room to yield or give at each side of the center of the nip. However, the radius of curvature of the calender rolls is too large to permit of the nip surfaces getting into the valleys of the creping in such a way as to cause elongation of the paper and decreping. The effect is to roll down the creping wrinkles so that the paper surface becomes relatively flat, and has a much softer and smoother feel to the touch of a finger rubbed across the flattened remains of the wrinkles. The change in visual appearance is striking. In addition, the squeezing action of the rigid rolls compresses and compacts the body structure of the paper. These two types of compaction (reduction of wrinkles and compression of body structure) are both involved in what we refer to as severe calendering of the creped paper. Thus a greater caliper reduction is obtained than would result from merely pulling out the creped paper; and the density of the paper is increased, thereby reducing porosity. The paper is not substantially elongated by the calender squeezing action.

As an illustration, a 27 pound per ream creped kraft paper (similar to towelling paper), having a normal caliper thickness of 7.0 mills and a stretch of 12.5%, was calendered to a caliper thickness of 3.8 mills with an elongation of only 1.0%, and a reduction in stretch to 10.0%. The lengthwise tensile strength of the uncalendered paper was 4.6 lbs. per inch width, which the calendering reduced to 3.25 lbs. The density was compared by before and after measurements of air porosity on a Gurley densometer. In this measurement two thicknesses of paper are

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clamped across a circular orifice ($1\frac{1}{8}$ " diameter) and 400 cc. of air is forced through under constant pressure, and the required time is measured. The greater the time required, the more dense and less porous is the paper. In this case the density value was increased from 4.8 seconds to 9.6 seconds, thus demonstrating the substantial compaction of the body structure. The caliper thickness of calendered creped paper was approximately the same as that of the original paper prior to creping, but the density was only about half as great. The original paper prior to creping would elongate about 1 to 2% when pulled to the rupture point; but this represents a yielding or pulling apart of the fiber structure preliminary to breaking, as distinguished from the substantial stretch of creped paper obtained by hand pulling with a force insufficient to cause incipient rupture.

A further demonstration of the change in physical properties produced by severe calendering of porous creped paper, can be easily made by subjecting samples of non-calendered and calendered creped papers to successively increased pull stresses in a tensile testing machine, and measuring the required tensile stress for each of various percentages of elongation (up to the breaking point) and the caliper thickness at each step. An experiment of this type on absorbent creped kraft paper having a caliper thickness of 8-9 mils, reduced to 5 mils by calendering, showed that the calendered paper maintained the same thickness even to the breaking point, whereas the non-calendered paper underwent a caliper reduction proportionate to elongation so that at the breaking point the caliper was reduced to 6 mils. This experiment also demonstrated the increase in body density of the calendered paper, since the ultimate caliper of the stretched calendered paper was 5 mils as against 6 mils for the non-calendered paper. This same experiment also demonstrated the change in the stress-strain characteristic. A somewhat greater pulling force (stress) was required to produce the same degree of elongation of the calendered paper as compared with the non-calendered paper. For example, a pull of 8.4 lbs. per inch width was required to produce a 5% elongation of the calendered paper, as compared to 6.9 lbs. for the non-calendered paper.

Calendering of the porous creped paper involves a reversible change of structural state. The squeezing action bends and curls the fibers, and compacts them, but within limits of elastic regain or reversion. Thus the fibers are not cut, broken or damaged and this makes possible the production of finished masking tape having substantially as high stretch and tensile strength values as would be obtained if the creped paper had not been calendered; despite the fact that these values are substantially lowered by the calendering in respect to the paper as it exists prior to coating with the pressure-sensitive adhesive. This was an unexpected discovery on our part and is an important feature of our invention as applied to the manufacture of masking tapes and the like.

The reversible nature of the calendering action can be easily demonstrated by moistening a sheet of the calendered creped paper and air drying, which causes it to revert to a normal creped paper substantially identical in appearance, feel, and physical properties, to the original creped paper (not calendered).

Of course it is possible to load the calender

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so as to exert so great a pressure as would break down the structure to an undesirable extent. However, such action does not appear to take place unless the resultant caliper reduction substantially exceeds one-half.

Reversion of the calendered creped paper upon subsequent coating or impregnating can be prevented by avoiding the use of water-vehicle coating and impregnating compositions which would result in water absorption by the paper body fibers. Organic solvents are suitable. Also, the calendered creped paper should be unified before reversion takes place as the result of unduly long storage.

The calendered creped paper is stabilized by coating or impregnating with a binder material which bonds the fibers together. This unification treatment also increases the tensile strength. The unifying composition should be of a stretchable kind, such as a rubbery base material, in order to permit of stretching the paper. It should preferably be of a kind that adheres or bonds to cellulose fibers in order to cement the fibers as distinguished from merely encasing them, in order to obtain a high increase in tensile strength.

An illustration of a commercially employed impregnation treatment for porous creped paper used for masking tape backings, is the saturation of the paper with a solution in a volatile hydrocarbon solvent of a fluxed blend of broken-down rubber (natural or synthetic), a compatible tack-producing resin (such as rosin) adapted to increase adhesion of the impregnant to the paper fibers, and a reinforcing pigment (such as zinc oxide). Following impregnation, the paper is heated in an oven to remove the solvent. This same treatment can be used for unifying calendered creped paper. While calendering decreases the porosity of the paper, yet the decrease is not sufficient to prevent adequate penetration of the impregnant solids. As previously mentioned, calendering makes it possible to employ a substantially smaller weight of impregnant solids per unit area and yet obtain a finished masking tape having the same tensile strength. For further details on the above-mentioned type of rubber-resin impregnation treatment, see Drew Patent No. 2,236,527 (issued April 1, 1941), and Kellgren Patent No. 2,410,078 (issued October 29, 1946); and the "Example" set forth hereinafter.

In making masking tape, the thus unified paper may be given a thin coating of shellac on the back side to facilitate unwinding of the tape from rolls; and is coated on the face side with a pressure-sensitive adhesive, such as the rubber-resin type, which is aggressively tacky, stretchable, water-proof, and more highly cohesive than adhesive. The adhesive sheeting is then slit and wound into rolls of finished masking tape.

In making certain types of pressure-sensitive adhesive tapes it is not necessary that the calendered creped paper be unified to the extent of saturation throughout its thickness by an impregnant. The paper backing may be given a coating which suffices to prevent delamination upon unwinding of the adhesive tape, and sufficiently prevents or delays the previously mentioned reversion effect in the paper (especially when the tape is wound in rolls). The back surface of the backing sheet may be provided with a low-adhesion film coating which presents a back surface toward which the pressure-sensitive adhesive has a low affinity so that a much reduced

force is exerted in unwinding the tape from a roll. Examples of such low adhesion compounds are the cellulose tristerate, tripalmitate and tri-laurate esters.

The invention is not limited to the ordinary type of creped paper wherein the wrinkles extend transversely across the web. X-creped papers may be used, wherein a combination of creping wrinkles running crosswise of each other results in a two-way stretch characteristic (i. e. the creped paper web has a crepe stretch both lengthwise and crosswise).

Creped tissue papers find application in certain types of adhesive tape constructions, particularly tissue papers made from long hemp or rope fibers, and these may advantageously be calendered.

Further examples of rubbery, stretchable, waterproof unifying compositions suitable for coating and impregnation, which bond to the cellulose fibers to provide added tensile strength, and which may be applied as a solution in a volatile organic solvent, are the polyacrylate elastomers, such as methyl acrylate polymers, ethyl acrylate polymers, and copolymers of methyl and ethyl acrylates. These can be dissolved in volatile solvents such as acetone and ethylene dichloride.

The calendered creped paper may be directly coated or impregnated with a pressure-sensitive tape adhesive of the rubbery base or rubber-resin type. Thus if such adhesive, in solution in a volatile organic solvent, is applied to both faces of a calendered creped paper, there will be a certain degree of penetration of the paper structure (depending on the type of solution and technique employed), resulting in fiber-unification, and a double-coated adhesive sheet will be obtained which is normally tacky on both sides. A highly porous calendered creped tissue paper can readily be saturated throughout its thickness with the adhesive, and will serve as a stretchable reinforcement within the body of a stretchable pressure-sensitive adhesive layer. The adhesive-paper sheet, normally tacky on both sides, can be laminated to a stretchable non-fibrous film backing (such as a film of rubber hydrochloride), for making stretchable film-backed adhesive tapes which have increased tear-resistance and tensile strength on account of the fibrous paper reinforcement.

The porous creped paper may be fully calendered in a single step or may be subjected to successive calendering operations. In a single step procedure, a single pair of calender rolls is used, the paper passing around one roll and then through the nip. The pressure loading of the rolls is adjusted to result in sufficient squeezing of the creped paper to produce the desired caliper reduction (at least one-fifth) and compaction of the body structure of the paper. The rolls are driven and the paper moves through the nip with the same velocity as the roll surfaces. The calendered paper is drawn to the windup roll without using sufficient pull tension to draw out the paper. A calender stack having three or more rolls may be used for calendering the paper in two or more successive steps, the final nip pressure being such as to produce the desired ultimate caliper reduction.

The present calendering procedure is clearly distinguishable from the use of draw rolls having resilient surfaces of soft rubber or felt, which are employed in the manufacture of creped paper for drawing out the creping of creped paper to reduce the degree of creping and stretch and to even the creped paper. The paper web is elongated in

proportion to the reduction in stretch, and there is no rolling down of the wrinkles and compaction of the body structure. The product is still creped paper, and requires calendering as herein described to result in the distinctive calendered creped paper to which we refer. Likewise the present effect is not produced by the use of evening rolls as employed in the manufacture of creped paper.

It is not necessary to employ hot calendering, i. e. the calender rolls may be unheated or merely warm (say 120° F.). The calendering operation is a dry one, i. e. the paper is not wetted or soaked so as to contain free water like water in a sponge. A creped paper having the degree of dryness resulting from storage under normal room conditions in average humidity air, can be calendered to produce the desired change and will hold the change for a sufficient number of days, without substantial reversion under storage, to avoid the necessity of immediate coating or impregnation. However, a better and more permanent set can be secured by humidifying the creped paper, especially if it has been stored in relatively dry air, so as to increase the moisture content. This can be done by passing the creped paper through a high-humidity chamber, or by steaming it, prior to calendering. If the moisture content is substantially higher than that which the calendered paper would have upon storage, the calender rolls can be heated sufficiently to dry the paper down to an average moisture content.

The present calendering procedure is, as previously made clear, a dry operation performed on porous creped paper in the absence of free water. The squeezing of a wet creped paper which has been impregnated in an aqueous glue bath (as in Drew patents Nos. 1,760,820 and 1,814,132), so as to squeeze out the surplus impregnant and water, is not a calendering operation and is not the equivalent of the present method, not only because the desired structural alteration and caliper reduction are not obtained, but also because the presence of free water causes a reversion of structure so as to restore the original creping.

Example

This example illustrates a complete procedure for preparing unified calendered creped paper, useful for making adhesive masking tapes and for other purposes, and the beneficial results of the calendering operation in the manufacture of masking tape.

The paper used was a regular commercial creped paper that has been commercially used in the manufacturing of masking tapes. It was an absorbent creped paper (made from a bleached and purified kraft paper) having a ream weight of 27 lbs. (weight of 320 square yards), a caliper thickness of 7.0 mils (0.0070 in.), a stretch of 12.5%, and a lengthwise tensile strength of 4.6 lbs. per inch width. It had been stored in stock rolls at room temperature, at a relative humidity of about 35-50%, and was not moistened or humidified prior to calendering.

The laboratory calender employed had a pair of polished steel rolls, diameter 6 in., both positively driven, and the roll speed was 12 R. P. M. The nip spacing was adjustable to provide positive spacing of desired magnitude. The rolls were not heated. Three lots of creped paper were calendered at different pressures to secure different degrees of caliper reduction, and are designated hereinafter as I, II and III. One lot

of creped paper was not calendered and was used as a control, to provide a comparison with the results obtained in making regular masking tape. The calendered papers each had reduced stretch and tensile values as compared to the non-calendered creped paper.

These papers were then unified by saturation with a rubber-resin type impregnant solution, followed by heating to remove the solvent and vulcanize the rubber, as described hereinafter in more detail. The following table shows the caliper thicknesses of the calendered paper (prior to impregnation), the weight of the impregnant (dry solids in grains per 24 sq. in.), and the lengthwise tensile and stretch values of the impregnated papers.

Paper	Caliper (mils)	Impregnant Weight (grains)	Tensile (lbs.)	Stretch, Percent
Control	7.0	18.5	17.5	17.5
Cal. I	5.5	15.0	10.9	13.7
Cal. II	4.5	12.0	11.4	13.2
Cal. III	3.5	10.0	10.4	12.5

The impregnation increased the stretch and tensile values in each case.

The impregnated papers were given a back-sizing coating of shellac and were then coated on the face side with a solution of pressure-sensitive tape adhesive having the formula:

Parts by weight

Natural rubber	100
Zinc oxide	50
Anti-oxidant (condensation product of acetone and aniline)	1
(The above were combined on a rubber mill, with milling for 20 minutes, and then were churn-mixed with the following to provide the adhesive solution.)	
Wood rosin	50
Lanolin	12
Ethyl alcohol (denatured)	7
Heptane (volatile solvent)	410

The sheetings were dried in an oven to remove the solvent from the adhesive coatings, and were slit and wound in rolls.

The finished tapes had the following measured properties:

	Caliper	Tensile	Stretch, Percent
Control	11.5	19.5	18.1
Cal. I	7.5	20.5	18.8
Cal. II	6.5	21.0	16.9
Cal. III	5.5	21.0	17.2

The above table shows that a substantial reduction in caliper of the finished tape was obtained without sacrifice of tensile and stretch values, notwithstanding that the unified calendered creped papers had materially lower tensile and stretch values, and that a substantial saving of the impregnant weight has been obtained.

The increase in tensile strength of the adhesive coated unified papers cannot be attributed to a mere additive effect, since the pressure-sensitive adhesive coatings, while very stretchable, have only a slight tensile strength per se (as measured in the form of free films thereof). There is some kind of combination effect, the nature of which is not fully understood, that results when the adhesive is coated on the unified paper, and causes the substantial increase in tensile strength

of the product. It will be noted that the stretch values have also been substantially increased as the result of coating with the pressure-sensitive adhesive.

Experiments made with unified calendered creped paper of the II type (see first table), using different coating weights of pressure-sensitive adhesive, have shown that 13-14 grains per 24 sq. in. (dry weight) results in a masking tape having an adhesion performance that satisfactorily duplicates that obtained by a 17-19 grain coating on the unified non-calendered (control) creped paper. This demonstrates the substantial saving in adhesive that can be obtained.

A description will now be given of the impregnation treatment employed for unifying the papers of this example.

The compounding formula of ingredients (other than the vulcanizing agent) was as follows:

Parts by weight

Natural rubber	100
Zinc oxide	100
Wood rosin	160
Beta naphthol	1
Oleum spirits (volatile petroleum hydrocarbon solvent of 306-424° F. boiling range)	210

The rubber and zinc oxide were mixed on a rubber mill for 30 minutes, thereby thoroughly dispersing the latter in the rubber. Further compounding was done in an internal mixer having a jacket for steam heating and water cooling. With the mixer warmed up with 60# steam in the jacket, the mixed rubber and zinc oxide base, together with 4 parts of the rosin, were added; after 10 minutes of mixing, 19 additional parts of the rosin were added and mixing was continued for 8 hours with 60# steam in the jacket. The balance of the rosin was then gradually added during a period of 1 hour with continued mixing. The steam was then turned off and cooling water was sent through the jacket. The beta naphthol was added and then the oleum spirits solvent was added over a period of one-half hour, with continued mixing. The batch was completed, and dumped from the mixer, 10 hours from the start.

Shortly before use for saturating the paper, there was added to the solution a rubber vulcanizing agent, namely, 3.5 parts of dipentamethylene-thiuram-tetrasulfide. This is a self-vulcanizing organic accelerator which releases nascent sulfur.

After saturation treatment with this solution, the impregnated paper was oven-dried for 5 hours at 212° F. to remove the solvent and vulcanize the rubber.

Use can also be made of towelling-type absorbent creped papers which are of the "wet-strength" kind, due to inclusion of a minute proportion of a suitable synthetic resin material such as urea-formaldehyde or melamine, which greatly increases the wet strength of the paper but without materially changing its porosity and absorbency. An illustration is a creped paper having a ream weight of 30 lbs., an initial stretch value of 12%, and an initial caliper of 8 to 9 mils, which is reduced to 5 mils by the calendering operation.

Creped papers having unusually high stretch values can be employed. An illustration is a creped paper having a ream weight of 30 lbs., an initial stretch value of 20%, and an initial caliper

of 8 to 9 mills, which is reduced to 5 mills by the calendering operation.

We claim:

1. The method of making a new and useful type of stretchable unified paper which comprises severely calendering a flat, porous and stretchable creped paper, in the absence of free water, so as to roll down the creping wrinkles, decrease the caliper thickness by at least one-fifth, and substantially increase the density of the body structure, the calendered paper being capable of reversion; and thereafter, without allowing reversion to the pre-calendered creped state, unifying the paper by application of a flexible and stretchable fiber-bonding composition which prevents reversion, the unified paper having a stretch value of at least 10%.

2. The method of making a new and useful type of stretchable unified paper which comprises severely calendering a flat, porous and stretchable creped paper, in the absence of free water, so as to roll down the creping wrinkles, decrease the caliper thickness by at least one-fifth, and substantially increase the density of the body structure, the calendered paper being capable of reversion; and thereafter, without allowing reversion to the pre-calendered creped state, unifying the paper by application of a water-insoluble flexible and stretchable fiber-bonding composition which results in the unified paper having substantially higher stretch and tensile strength values than does the pre-unified calendered paper, the unified paper having a stretch value of at least 10%.

3. The method of making a new and useful type of stretchable unified paper which comprises severely calendering a flat, porous and stretchable creped paper, in the absence of free water, so as to roll down the creping wrinkles, decrease the caliper thickness by at least one-fifth, and substantially increase the density of the body

structure, the calendered paper being capable of reversion; and thereafter, without allowing reversion to the pre-calendered creped state, unifying the paper by impregnating it substantially throughout its thickness with a stretchable rubbery base unifying composition containing a resin adapted to increase the cementing action upon the fibers of the paper, deposited from solution in an organic solvent, the unified paper having a stretch value of at least 10%.

4. The method of making a new and useful type of stretchable unified paper which comprises severely calendering a flat, porous and stretchable creped paper, in the absence of free water, so as to roll down the creping wrinkles, decrease the caliper thickness by at least one-fifth, and substantially increase the density of the body structure, the calendered paper being capable of reversion; and thereafter, without allowing reversion to the pre-calendered creped state, unifying the paper by impregnating it substantially throughout its thickness with a water-insoluble flexible and stretchable fiber-bonding organic polymer, deposited from solution in an organic solvent, the unified paper having a stretch value of at least 10%.

WALDO KELLGREN.
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The following references are of record in the file of this patent:

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