March 3, 1970 H. M. ROBINSON ET AL 3,498,737

PROCESS OF PRODUCING SCULPTURED LACE FROM FLAT LACE

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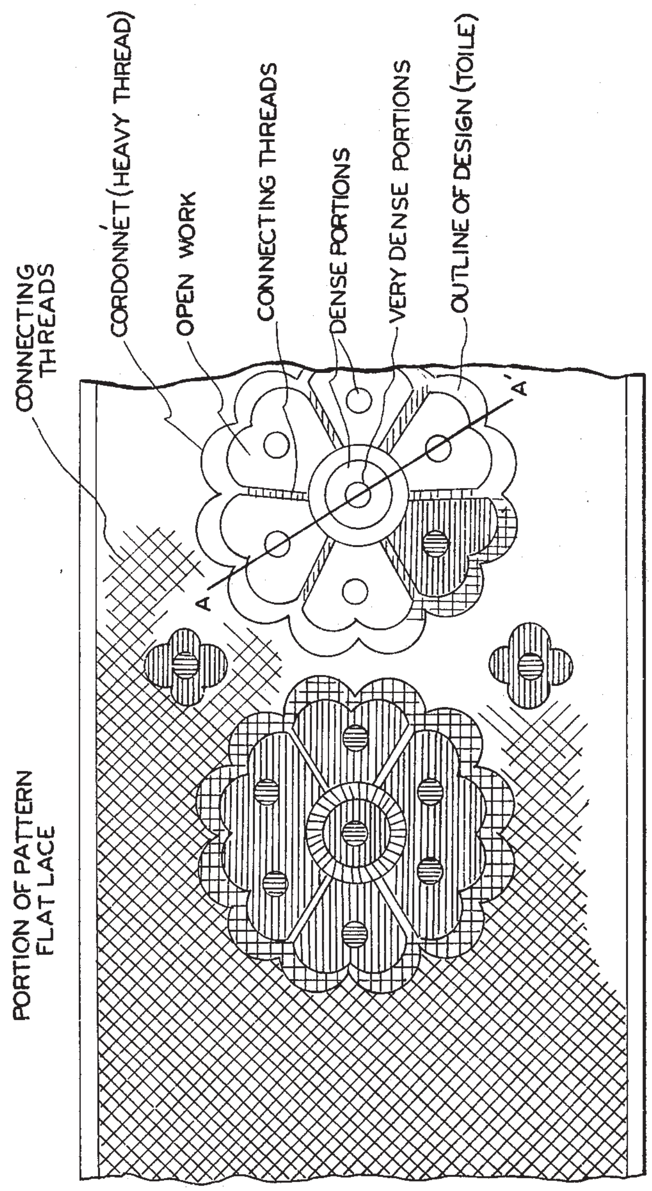

FIG. 1

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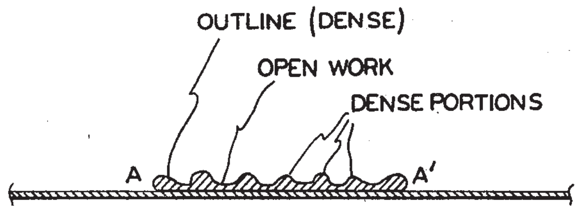
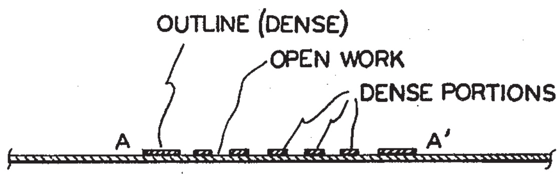


EFFECT OF DIFFERENTIAL SHRINKAGE

FIG. 3



CROSS-SECTIONAL VIEW OF FLAT LACE
LINE A-A'

FIG. 2

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PROCESS OF PRODUCING SCULPTURED LACE FROM FLAT LACE

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U.S. Cl. 8—114.5 **2 Claims**

ABSTRACT OF THE DISCLOSURE

Flat lace, containing cellulose fibers (e.g., cotton) or cellulose-synthetic fiber blends (e.g., nylon), is differentially-shrunk by contact with a swelling agent (e.g., sodium hydroxide) and subsequently treated with a crosslinking agent (e.g., dimethylol carbamate) to effect crosslinking of the cellulose molecules, thereby to produce a dimensionally-stable, easy-care, differential-shrunk, tough, durable lace having a sculptured design.

This invention relates to sculptured lace. More specifically, it relates to a method of producing sculptured lace from flat lace. Still more specifically, it relates to a method of producing sculptured lace by differential shrinkage of the design portions of essentially flat lace resulting from contact with aqueous solutions of swelling agents. The resultant modified product has exceptional properties of richness-of-beauty and toughness, and when treated with crosslinking agents acquires excellent durability, dimensional stability, and easy-care properties. The aesthetic properties of the lace are greatly enhanced by the treatment and the design is not physically damaged. Laces are widely used for dresses, blouses, collars and cuffs for blouses, lingerie, pajamas, capes, bridal veils, curtains, table cloths, place mats, edging handkerchiefs, and the like.

The term "lace" as used herein may be defined as the artful weaving of holes in a decorative design. It consists of an open-work fabric with a ground of mesh or net on which patterns may be worked at the same time as the ground or applied later and which is made of threads (yarns) by looping, twisting, or knotting either by hand with a needle or bobbin, or by machinery. Because of the patterns, or designs, the yarns are positioned in all directions to conform with the design and are not always normal (perpendicular) to each other, as is usual with fabrics.

"Flat lace" relates to essentially flat or two-dimensional lace which commercially is machine woven.

"Sculptured lace," as used herein, relates to the textured or sculptured product which results when certain portions of the design are raised above the flat plane, thus imparting to the design the appearance of being carved in relief. This effect, usually hand-crafted as by re-embroidering, causes the product to be very expensive.

The term "differential shrinkage" as used herein relates to the differences in shrinkage between the dense, or closely woven, portions of the design and the more open areas of the design. Density as used here does not relate to the number of turns per inch (twist) of the yarn but and wide usage in the United States, cellulosics, parto form the toile (design), or to a single cordonnet (thread or bundle of threads) which may be used.

As noted above, the yarns in lace are positioned to artfully weave holes in a decorative design. Consequently, the threads, or yarns, run in any direction and are not always perpendicular or parallel to the adjacent threads which is usual in most fabrics. The designs comprise a variety of objects including flowers, leaves, animals, geometrical designs, and the like. These threads may be cellulosic, such as cotton, linen, viscose rayon, cuprammonium rayon, and the like; silk; synthetics, such as nylon, Creslan, Dacron, and the like; or wool, mohair, and other natural nitrogenous fibers, or mixtures of any or all of these fibers. Because of its economic importance and wide usage in the United tSates, cellulosics, particularly "cotton," will frequently be used below as the chief component of lace. However, it is to be understood that combinations of cotton with other fibers, including linen and those synthetics which may or may not swell when exposed to aqueous solutions of swelling agents, are within the scope of our invention. Such "swelling agents" and their relation to the fibers involved will be discussed more fully below.

Because of its attractiveness, lace has been used for centuries. Formerly, it was hand-woven and, consequently, very expensive. As a result, its manufacture was largely restricted to those countries in which labor was plentiful and cheap. Frequently, housewives, or women desiring an avocation, spent some of their leisure hours making lace. However, these homemade products seldom find their way into the commercial field. Commercial lace manufacture has been largely restricted to two general types.

In the first type, sometimes referred to as "Leavers," the lace is completely woven on powered weaving-machinery with no additional stitching. As a result, it is competitively priced and is capable of interesting patterning. However, it has the distinct disadvantage of being essentially *flat*.

The second type, frequently referred to as Venice, Aetz, or "Schiffli," is textured, i.e., the flat outlines of the designs are textured, or sculptured, by sewing in an additional heavy cordonnet (thread) to outline parts of the pattern. In other instances, ribbons or tapes are sewed on to outline the toile (design). Even richer-appearing laces are made by appliqueing flowers and leaves and similar figures from the design, overlaying similar figures in the toile. Although this sewing may be accomplished by machines, the machine must be guided by hand and the work is very costly.

Therefore, prior to this present invention there still remained a need for a commercial, suitable process for the modification of essentially flat lace by differential shrinkage of the design portions to produce durable sculptured designs having the appearance of being carved in relief, as well as improved toughness. Such a process should be economical. It should be simple and easily carried out in presently-available commercial equipment. Such a modification should preferably be produced by swelling agents which are easily soluble in aqueous media. Last, but not least important, the sculptured designs should not be physically damaged and, when treated with polyfunctional, or crosslinking, agents have excellent durability, dimensional stability, and easy-care properties.

In order that the invention may be more fully understood, reference is made to the following drawings in which:

FIGURE 1 is a pictorial view of a portion of the design, or pattern, of a flat lace;

FIGURE 2 is a cross-sectional view along the line A–A′ of FIGURE 1 showing the flat characteristic of completely woven Leaver's lace;

FIGURE 3 is a cross-sectional view along the same line A–A′ of FIGURE 1 after the lace has been treated with a swelling agent of the present invention and differential shrinkage has occurred.

In general, the overall process of the present invention may be simply described. Flat lace, either unscoured or scoured (or scoured and bleached) or scoured, bleached and dyed, is subjected to the following operation. Therein, all proportions and percentages are based on the weight of the solutions (OWS), unless otherwise noted. Temperatures are in degrees centigrade, unless otherwise noted.

(a) The flat lace is passed into and through, an aqueous solution of a fiber (thread, yarn) swelling agent.

(b) A period of dwell is maintained during which the flat lace is in contact with the aqueous solution of swelling agent. During this period of dwell differential shrinkage occurs. This will be discussed more fully below.

(c) The swelling agent is then removed, and

(d) The differentially-shrunk lace having a sculptured appearance (design) is dried without tension.

As noted above, it is within the scope of our invention to enhance durability, dimensional-stability, and easy-care properties to the sculptured design by crosslinking the cellulose molecules in the differentially shrunk lace with a cellulose crosslinking agent (polyfunctional reagent). When these improved properties are desired, the following additional steps are included:

(e) Wetting the threads (fibers) thoroughly by passing the dry, differentially-shrunk lace into, and through, an aqueous solution comprising a polyfunctional reagent (crosslinking agent) capable of reacting with the hydroxyl groups of the cellulse molecule to effect covalent crosslinking.

(f) The excess polyfunctional reagent is then removed by hydro-extraction, i.e., by means of a centrifuge.

(g) The hydro-extracted lace is then dried without tension.

(h) The dried product is then heated at a temperature high enough to effect crosslinking of the cellulose molecules by the polyfunctional reagent.

(i) The unreacted polyfunctional reagent (crosslinking agent) is then removed, and

(j) The dimensionally-stable, easy care, differentially-shrunk, tough, durable lace having a sculptured appearance (design) is dried.

As so described, the modification process of the present invention appears deceptively simple. However, each of the several steps is critical. Each involves certain criteria which within certain ranges must be observed. Therefore, each will be more fully discussed in relation to the problem solved thereby, as well as its place in the overall treatment. By the process, the flat lace is converted to a differentially-shrunk product having a sculptured appearance. More important, the sculptured lace is not physically damaged.

As noted above, an advantage of the present process is that it may be carried out using presently-available commercial equipment.

It is another advantage that unscoured flat lace may be first scoured and bleached after which it is differentially shrunk. It is a still further advantage that when unscoured and/or unbleached flat lace is used, a wetting agent may be added to promote wetting of the threads (fibers) by the solution of the swelling agent thereby reducing the time required to obtain differential shrinkage.

It is a still further advantage that various portions of the designs of these laces may be made from yarns that are unscoured, scoured, bleached, dyed and/or otherwise chemically finished prior to the differential shrinkage-type treatment so long as the prior chemical finishing treatment does not negate the swelling and shrinkage action of the cellulosic fibers when subsequently treated with a suitable swelling-type reagent as described herein. These and other advantages will be discussed more fully below.

It is also within the scope of the process of this invention that the flat lace may be designed to provide particular sculptured effects which are apparent only after the flat lace is treated with aqueous solutions of swelling agents and differential shrinkage results.

Flat lace

Any suitable machine-woven or knitted, commercially available flat lace comprising cellulosic threads may be used. In many instances the entire lace consists of cellulosic threads, such as cotton, linen, viscose rayon, cuprammonium rayon, etc. However, many so-called cellulosic laces contain fibers other than cellulosics, such as nylon, Dacron, Orlon, Creslan, and the like. These synthetics are useful in forming the cordonnet and other details of the pattern, or toile. As noted above, the cellulosic threads employed in the manufacture of the flat lace may be scoured and bleached, or they may be unscoured and unbleached, depending upon the particular purpose for which the lace is to be used.

It is within the scope of this invention to employ machine-sculpture lace of the Schiffli type and other laces such as ribbon or tape laces wherein the sculptured effect is still further enhanced by the differential shrinkage imparted to the lace by contact with the swelling agents. When such differentially-shrunk lace is treated with a crosslinking agent of the polyfunctional type, dimensional-stability and easy-care properties as well as improved durability and toughness are imparted to the lace.

Swelling agent

Swelling agents soluble in aqueous solutions which are useful in the practice of this invention are metallic hydroxides, such as sodium, potassium, or lithium hydroxide, liquid ammonia under pressure or at low temperatures, cuprammonium hydroxide, cupriethylene diamine hydroxide (cuene), hexamethylene diamine, ethylamine, ethylene diamine, and the like. Certain metallic thiocyanates, for example, sodium, potassium, or lithium thiocyanates, also may be used. We prefer to use sodium hydroxide because it is commercially-available to the textile industry, and is not expensive.

The concentration of sodium hydroxide may range from about 12–50 weight percent on the weight of the solution (OWS).

Temperatures may range from 0° to 60° C. The lower the concentration of the sodium hydroxide, the lower the temperature required, maximum swelling occurring at about 13 weight percent sodium hydroxide (OWS) at 0° C. We prefer using 15–25 weight percent sodium hydroxide (OWS) at or about 20–30° C.

Period of dwell

The dwelling-time, or period of dwell, is determined by several factors, the principal factor being the rate of absorption of the swelling agent by the fiber. It is a critical feature of this invention that the fiber be completely penetrated by the swelling agent.

The rate of absorption is largely determined by the removal of impurities from the original cellulosic fibers. For those fibers which have not been scoured, or scoured and bleached, longer periods of dwell are required. A suitable wetting agent, such as the cresylic acid types, increases the rate of wetting.

For most cellulosic laces, a period of dwell of at least 30 seconds at the preferred temperature of about 20°–30° C. is required. Dwelling times of from 5 minutes or more may be used without damage to the cellulosic material. We prefer to use a dwelling time of from about 2–5 minutes at about 20°–30° C. to insure complete wetting and maximum swelling.

It has been known that tightly twisted yarns, when wet with swelling agents, swell more than loosely twisted yarns. However, in laces in which the threads forming the open and dense portions of the pattern or design have the same twist (i.e., turns per inch), the more open part of the design swells more when it is wet with a swelling agent than the denser portions. *This was unexpected.* This difference in swelling causes differential shrinkage to occur, resulting in a change of the essentially flat lace to a lace having a sculptured appearance. *This also was unexpected.* These sculptured effects may be accentuated by selectively weaving laces that have patterns of dense and open structures, or by varying the textile composition of the structures. For example, an open structure consisting of cellulosic threads and denser structure comprising cellulosic and/or synthetic threads causes the denser portion to "puff out," thereby increasing the sculpture effect.

As noted above, it is within the scope of this invention to weave designs in flat lace which, upon differential shrinkage, acquire a symmetrical pattern thereby enhancing the pleasing effect of the resultant sculptured lace. Symmetry of the differentially-shrunk material is readily obtained by the application of controlled warp and filling tension either during the drying step (Step (d) or Step (g)) when the dimensionally shrunk lace is dried after treatment with a polyfunctional agent to obtain dimensionally-stable, easy-care properties.

Removing the swelling agent

Best results are obtained by first mechanically extracting most of the swelling agent and subsequently washing out the remainder. Mechanical extraction may be accomplished by a padder roll, or by a hydro-extractor. We prefer to use the hydro-extractor. Water-washing may be carried out in water at all temperatures from ambient room temperature to the boil. We prefer hot water-washing at about 70° to 100° C., after which the washed lace is scoured (neutralized) with an inorganic, or an organic acid. We prefer to use an organic acid, such as acetic acid, because it has less corroding effect upon commercially-available textile equipment at the higher temperatures. Further, it has less degrading action on the cellulosic material, especially at higher temperatures. The acetic acid is then removed by rinsing in hot water, preferably at a temperature of 70° to 100° C., after which the excess rinse water is again removed mechanically, prior to air drying.

When desired, the neutralization with acetic acid (or commercially-available mineral acids such as sulphuric acid) and the subsequent rinsing operation may be carried out at ambient room temperatures.

Drying the differentially-shrunk lace

Various types of commercially-available drying equipment may be used, such as a "net" dryer and "drum" dryers conventionally used for drying knit goods. If a specific width is required, the lace may be dried and "framed" (stretched to a uniform width) on an overfeed, pin-tenter frame. The dried material may then be packaged and sold as a sculptured lace, or it may be converted into a sculptured lace having dimensional stability and easy-care properties. This is accomplished by further treatment with a polyfunctional reagent frequently referred to herein as a crosslinking agent.

Treatment with crosslinking agents

Any polyfunctional reagent that will react with the hydroxyl groups in cellulose to form a covalent link between molecules of the cellulose fiber may be used in the crosslinking treatments. Examples are tris-(1-aziridinyl) phosphine oxide, methylol melamine, dimethylol ethylcarbamate, dimethylol ethyleneurea, and the like. We prefer to use the dimethylol ethylcarbamate because it has exceptional stability to laundering conditions. However, we are not limiting our invention to the use of this polyfunctional or crosslinking agent. The use of about 2 to 7 weight percent of the crosslinking agents (solids) on the weight of the fiber (OWF) is a good practice.

The crosslinking agent is dissolved in aqueous solutions along with a catalyst to catalyze (activate) the crosslinking agent. Catalysts useful in the practice of this invention are largely determined by the particular polyfunctional agent used in the crosslinking process. For example, when tris-(1-aziridinyl) phosphine oxide is used, zinc fluoborate is preferred; when methylol melamine is used, zinc nitrate or an amine hydrochloride gives satisfactory crosslinking; when dimethylol ethylcarbamate or dimethylol ethyleneurea are used, magnesium chloride or zinc nitrate causes good results to be obtained.

Amounts of the above catalysts to be used may range from about 5 to 50 weight percent on the weight of the polyfunctional agent, the higher percentages being preferred for delayed cures.

The addition of a softening agent such as an emulsifiable polyethylene, which is commercially available, also may be desirable. Amounts ranging from about 0.5 to 2.0 weight percent (OWF) causes excellent results to be obtained. The crosslinking agents referred to above are those usually catalyzed (activated) with a Lewis acid (sometimes called Lewis-type acid).

It is also within the scope of this invention to use crosslinking agents (reagents) that are catalyzed (activated) with Lewis bases.

Polyfunctional reagents which may be used include dimethylol urea, bis(hydroxyethyl) sulfone, vinyl cyclohexene diepoxide, epichlorohydrin, tris-(sulfatoethyl)-sulfonium inner salt, and the like. Solution concentrations of the crosslinking agents are generally similar to those catalyzed with Lewis acids, that is the concentration of the crosslinking agent and the wet pickup should be sufficient to give a dry solids add-on of about 2 to 7 weight percent (OWF).

Lewis bases which may be used to catalyze these polyfunctional agents are alkalies, alkali carbonates, and alkali bicarbonates. The amount of Lewis base catalyst to be used will range from about 5 to 50 weight percent on the weight of the polyfunctional agent, the higher percentages being preferred for delayed cures and when higher percentages of crosslinking agents are used.

Drying the lace containing the crosslinking agent

This may be accomplished in any of the equipment described above under the heading, "Drying the Differentially-Shrunk Lace." However, since at this stage of the operation, a uniform width is desirable, we prefer to use the overfeed pin-tenter frame.

It is an advantage of this drying operation that the warp, or long direction, of the lace may also be stretched to improve the symmetry of the design, should such stretching be necessary. This may also be accomplished on the overfeed pin-tenter frame.

Crosslinking the sculptured lace

Crosslinking between the hydroxyl groups in the dry cellulosic molecule is accomplished by a heat treatment at about 160° C. for about 2–3 minutes. It is a critical feature in this heating operation that the lace be in a relaxed condition.

It is within the scope of our invention that drying and crosslinking of the treated lace may be accomplished in one continuous operation. The treated lace, in a relaxed condition, is exposed to hot air having a temperature of about 160° C. During the drying, the temperature of the lace is held to about 80°–85° C. due to evaporation of the aqueous media. As drying occurs, the temperature of the lace gradually rises to about 160° C. and crosslinking is effected.

Removing unreacted crosslinking agent

This is readily accomplished by means of a hot-water wash at about 70° to 100° C. Best results are obtained when the washing operation is carried out with the lace in a relaxed condition. The washed material is then hydro-extracted to remove excess wash-water.

Drying the crosslinked, differentially-shrunk, tough, durable lace having a sculptured design

This final drying may be carried out by one of two methods: (1) drying the lace to a specific finished-width on an overfeed, pin-tenter frame. We prefer this method. Or, (2) the crosslinked, differentially-shrunk lace may be dried on a net dryer, or on drum dryers conventionally used to dry knit goods. When Method 2 is used, it may be necessary to frame the finished product on a tenter frame after light steaming to give the desired uniform width.

Regardless of the method of drying employed, the process for preparing the crosslinked, differentially-shrunk, tough, durable lace, having a sculptured design, is completed and the lace is ready to be packaged.

The following examples are presented to illustrate in greater detail certain features involved in the practice of the present invention. However, it is apparent that many modifications can suitably be made. The scope of the invention is defined by the claims and is not to be construed as being limited to the particular materials and conditions employed in the examples. Parts and percentages are based on the weight of the solution (OWS) or on the weight of the fiber (OWF). Degrees are in centigrade, unless otherwise noted.

Toughness of the threads (yarns) is determined by breaking tests on an Instron Tensile Tester using 3" x 9" sections from both warp and filling. The Toughnes Index is defined as Breaking Strength x Elongation and is described in Textiles, Fibers, Yarns, and Fabrics, by E. R. Kaswell, Reinhold (New York) 1953.

Dimensional-stability is defined as the amount of area shrinkage resulting from the treatment. In the case of lace, this is the average area from the measurements of at least six different samples selected from varying sections of the designs.

Growth is the increase in length after 15% elongation and then relaxed for five minutes. Slack mercerized and crosslinked fabric stretches more but recovers more.

Area shrinkage is determined by measurement of the sample area before and after washing in an automatic washing machine and tumble drying in an automatic dryer. The calculation is as follows:

$$\frac{\text{Area of original sample} - \text{Area of washed sample}}{\text{Area of original sample}} \times 100$$

equals percent shrinkage.

In the following example, cotton flat lace is treated with sodium hydroxide solution without tension.

Example 1

Scoured cotton flat lace is immersed in 23 weight percent aqueous sodium hydroxide solution for 15 minutes at ambient room temperature without tension. The excess swelling agent is then removed by first hydro-extracting to about 50 weight percent pickup (on the weight of the lace) after which it is washed in hot water, and soured (neutralized) in acetic acid and rinsed in warm water. It is then dried with hot air.

The resultant lace has a sculptured appearance due to differential shrinkage, the open portions of the design having shrunk more than the denser portions.

Example 2

A. Another portion of the same scoured cotton lace used in Example 1 is immersed in 15 weight percent sodium hydroxide solution for 30 minutes, without tension. It is then hydro-extracted to remove the excess swelling agent after which it is washed in very hot running water, soured in acetic acid, and then washed in ambient temperature water to remove the acetic acid, after which it is air-dried.

B. Another portion of the same scoured cotton lace is treated in 15 weight percent sodium hydroxide solution (OWS), without tension. Without hydro-extracting, the

swelling agent is removed by washing in very hot water (circa 190° F.) for one hour, soured in one weight percent acetic acid (OWS) for half an hour, and then washed in ambient temperature water until the acetic acid is removed, after which it is air-dried.

C. A third portion of the scoured cotton lace is immersed in 25 weight percent sodium hydroxide solution (OWS) for 15 minutes without tension, after which it is hydro-extracted to remove the excess swelling agent. The hydro-extracted lace is then washed, soured, and washed until neutral, after which it is air-dried.

In each of the procedures, A, B, and C, the dried lace has a sculptured appearance due to differential shrinkage, the open portions of the design having shrunk more than the denser portions.

Example 3

Scoured cotton lace is passed through 23 weight percent sodium hydroxide (OWS) and the excess swelling agent removed by passing the wet lace through a two-bowl padder to give a wet pickup of about 100 weight percent (OWF). The fabric is then passed directly from pad to jig for washing in boiling water. After several washings to remove the sodium hydroxide, the lace is washed with acid to neutralize the remaining swelling agent, after which it is again washed to remove the acid. The washed lace is then passed through a padder to remove the excess wash water after which the lace is dried on a tenter frame with a minimum of lateral and longitudinal tension.

The resultant lace has uniform width and a sculptured appearance due to differential shrinkage, the open portions of the design having shrunk more than the denser portions.

Example 4

The procedure of Example 1 is repeated, except the lace is unscoured.

The resultant lace has a sculptured appearance, due to the differential shrinkage, the open portions of the design having shrunk more than the denser portions.

Example 5

Tho procedure of Example 1 is repeated except the denser portions of the scoured lace consist of a hydrophobic, synthetic fiber.

After the treatment, the open portions of the lace, which consist of cellulosic material, have shrunk and caused the denser portions, consisting of the hydrophobic, synthetic fiber to puff up, causing the lace to have a sculptured appearance.

Example 6

A portion of the differentially-shrunk lace of Example 1 is then cross linked by immersion in an aqueous solution of a crosslinking agent comprising ten weight percent dimethylol ethylcarbamate and 0.6 weight percent zinc nitrate hexahydrate, both percentages based on the weight of the solution.

The treated lace is then hydro-extracted to about 50 weight percent pickup (giving an add-on of five weight percent of the dimethylol ethylcarbamate) and air-dried. It is then framed to the same width as the starting material in Part B and heated at 160° C. for three minutes to effect crosslinking. The heat-treated lace is then washed in a detergent solution to remove unreacted crosslinking agent, thoroughly rinsed, and dried.

The dried material has a sculptured appearance and is dimensionally stable.

Example 7

The procedure of Example 6 is repeated except the aqueous solution of crosslinking agent comprises five weight percent dimethylol ethylcarbamate and 0.3 weight percent zinc nitrate hexahydrate (OWS). The wet pickup is 55 weight percent after hydro-extraction (2.75 weight percent add-on of the dimethylol and ethylcarbamate).

After heat-treating, the lace has a sculptured appearance and is dimensionally stable.

Example 8

The procedure of Example 6 is repeated except the aqueous solution of crosslinking agent comprises 15 weight percent dimethylol ethylcarbamate and .09 weight percent zinc nitrate hexahydrate. After hydro-extraction, the wet pickup is 48 weight percent and the add-on is 7.0 weight percent (on the weight of the lace) of the dimethylol ethylcarbamate.

After heat-treating, the crosslinked lace has a sculptured appearance and is dimensionally stable.

Example 9

In the following example, the Toughness Index Growth and Area Shrinkage of untreated lace (control), a portion of the same lace used as a control which has been slack mercerized by the procedure of Example 1, and a portion of the same lace which has been slack mercerized by the procedure of Example 1 and then crosslinked by the procedure of Example 6 are determined. The results follow:

	Toughness index		Growth 5 min. after cycling to 15% stretch (percent)		Area shrinkage (percent) after home wash and tumble dry (percent)
	Warp	Fill	Warp	Fill	
Control (untreated)	1,239	899	5.4	6.2	28.3
Slack merc. (Example 1)	2,359	3,423	4.9	3.3	17.9
Slack merc. and resin treated by Example 6	1,402	2,161	4.7	2.4	10.8

It will be noted that the Toughness Index of the resin-treated lace in both warp and fill is greater than in the original untreated lace (control). It is well known in the industry that the application of crosslinking agents to lace in the past produces commercially unacceptable laces because of reduced physical properties, particularly "toughness."

It will also be noted that the "growth" is reduced by each of the two successive treatments. This shows that any deformation of the lace after wear would be more completely recoverable to the original dimensions as a result of these treatments.

It will also be noted that the area of shrinkage is reduced by each of the chemical treatments when compared with the area of shrinkage of untreated lace. This is extremely important in the manufacture of garments made from lace, since it is necessary to compensate for shrinkage after laundering to obtain a particular size garment.

We claim:

1. A process for producing a dimensionally stable sculptured lace from a conventional flat lace containing cellulosic fibers comprising the steps:

(a) wetting the flat lace with an aqueous solution of 15 to 25 weight percent sodium hydroxide at a temperature of about from 20° to 30° C., to induce swelling of the cellulose fibers;

(b) maintaining a period of dwell of the flat lace in the said aqueous solution for about from 2 to 5 minutes at a temperature of about from 20–30° C., during which period swelling of the cellulosic fibers and attendant differential shrinkage of the lace occurs;

(c) removing the sodium hydroxide from the product of step (b) by mechanically extracting the lace to remove most of the sodium hydroxide, then hot water-washing the extracted lace at a temperature of about from 70° to 100° C., to remove most of the remaining sodium hydroxide, then washing the water-washed lace with acetic acid to neutralize any residual sodium hydroxide, and finally hot water-washing the resulting product at a temperature of about from 70° to 100° C., to remove any excess acetic acid;

(d) drying the product of step (c) without tension in hot air to produce a differentially shrunk sculptured lace;

(e) wetting the dried product of step (d) to a pick-up of about 50% by weight with an aqueous solution containing about 10% by weight of dimethylol ethyl carbamate and about 0.6% by weight of zinc nitrate hexahydrate;

(f) drying the product of step (e) without tension in hot air;

(g) heating the product of step (f), while in a relaxed condition, for about from 2 to 3 minutes at a temperature of about 160° C., to effect crosslinking reaction between the cellulosic fibers and the dimethylol ethylcarbamate;

(h) washing the product of step (g) with hot water at a temperature of about from 70° to 100° C., to remove unreacted dimethylol ethylcarbamate and zinc nitrate hexahydrate; and

(i) drying the washed product of step (h) to produce a dimensionally stable, sculptured lace.

2. The dimensionally stable sculptured lace produced by the process of claim **1.**

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U.S. Cl. X.R.

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