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UNIFIED PROCESS FOR TREATING WOOL

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This invention relates to an improved method for processing wool. More particularly this invention relates to those steps and treatments which are involved in the conversion of wool from raw stock in fiber form into fulled or felted fabric.

It is an object of this invention to provide a method for a processing wool which will minimize or totally avoid any contact with alkali, soap, and other substances which are injurious to the fiber. Another object is to provide a process which will avoid treatment of wool with soap, mineral oil, or other agents which are difficult to remove from the finished fabric. A further object is to coordinate the chemical treatment of wool at its various stages of mechanical treatment, namely, carding, spinning, weaving and fulling, whereby a single chemical treatment prior to the first stage may suffice for all subsequent treatments. A still further object is to modify the processing of wool in such a manner as to produce a yarn of superior qualities in the intermediate stage, and a finer and all-around superior finished fabric in the end. Numerous other objects and advantages will appear as the description proceeds.

For the purpose of the description which follows, raw stock is to be understood as wool which has been sorted and treated to remove its natural content of grease, suint and dirt, and may or may not have been carbonized, but which has not received any further treatment at this point. This definition, however, is assumed merely to facilitate discussion, for as will be seen from the examples hereinbelow, our invention may, with slight modification in process, be applied successfully also to the treatment of wool which has not been degreased or rid of suint and dirt, and may on the contrary be applied also to wool which has been advanced partially on its way toward finished fabric by any of the various customary procedures such as picking, carding, spinning, weaving, scouring, and carbonizing.

The conversion of wool from the stage of loose hair or fiber into a fulled or felted fabric involves generally the following operations or treatments:

Picking.—A preliminary separation of the wool tufts as they come from the bale, for the purpose of loosening and blending the fibers.

Carding.—Essentially a combing operation to line up the fibers in substantially parallel relation, and to produce roving or roping, which is essentially loose, non-twisted, continuous strands.

Spinning.—In which the roving is mechanically twisted into yarn of substantial strength and relatively small diameter.

Packaging, dressing or winding.—In which the yarn is transferred from the spindles to bobbins, spools or beams of convenient size and form, to supply respectively the warp and filling for the subsequent weaving operation.

Weaving or knitting.—These processes, per se well known, produce a coarse fabric in which the individual threads are separated by visible interstices, blanks and spaces. The structure, weave or grain is plainly visible in such fabrics.

Fulling or felting.—In this operation the woven fabric is shrunk while simultaneously the individual threads open up their fibers which apparently over-lap, interwine or otherwise mingle with the fibers from neighboring threads in such a manner that the entire fabric assumes a continuous, felted appearance, often hiding from view, the individual threads, and giving the entire fabric a soft, pleasing handle and appearance.

In addition to the above, the process involves also several other treatments, of which lubricating the raw stock and further treatment with fulling agents at their respectively proper stages are indispensable, while others are optional or may be interposed at optional stages, these including such treatments as carbonizing, tar removal, degreasing, scouring, dyeing, etc. Other mechanical treatments may also be added, such as napping, pressing, etc.

Our invention is concerned particularly with a process which effects in one treatment the indispensable functions of lubrication of the loose wool prior to carding and addition of fulling agent, and for this reason these functions will now be taken up in greater detail.

The processing of loose textile fibers into yarn for knitting and weaving requires a fiber lubricant. This lubricant must reduce friction between the fibers and those parts of the machines over or thru which the fibers pass in carding, combing, spinning, etc. This might be regarded as external friction. There is also internal friction, that is, friction of fiber against fiber. The lubricant must reduce this internal friction so as to permit every fiber to move freely in relation to other fibers.

Although natural fleece contains fatty components, the best known constituent of which is lanolin, these are not available for the lubrication function since they are generally removed in the scouring and/or degreasing processes to which the wool is subjected prior to processing.

This preliminary degreasing or scouring is essential, since without it, it is not possible to remove in a practical manner the suint and dirt which are also present in natural wool. Furthermore, the natural grease content of the wool is not of a nature or proper quantity to provide good lubrication without clogging the delicate parts of the machinery employed in the processes of carding, spinning and weaving.

Also, in addition to the lubricant proper, it is desirable to introduce a controllable percentage of moisture into the wool, since this plays a definite role in dissipating the static charges accumulating during the working of the wool and increases the pliability of the fiber.

In the fulling operation moisture also plays an important role. But this alone is not sufficient. Fulling agents have to be added, and these have heretofore been confined to two extremes: In the soap-and-alkali fulling process, a high pH naturally results. In the acid-fulling method, on the other hand, sulfuric acid is generally used, resulting in a very low pH. With woolen and worsted goods, it is a reasonable generalization that practically all fulling is based on the use of soap and soda ash.

In some processes, the lubricant is removed after weaving and prior to fulling, by scouring the fabric with soap and alkali or by solvent extraction. In other processes, where fulling is done "in the grease," the lubricant is left in the fabric until after the fulling operation. In either case, as will be readily apparent, soap and alkali have heretofore played major roles in the process either as fulling agents or as both fulling and scouring agents.

Soap and alkali, however, are agents injurious to wool. Alkali, as is well known, acts chemically on wool fiber, and gradually dissolves it. Soap on the contrary has a strong affinity for wool fiber, so that complete removal of it from the fiber is almost impossible to achieve. On the other hand, the part of it that remains on the fiber gradually undergoes chemical change resulting in a disagreeable odor and discoloration of the wool. Furthermore, when hard water is employed, the soap forms a precipitate which coagulates and sticks to the wool constituting in effect a local resist against dyeing, as a result of which the subsequent dyeing of the fabric is apt to be uneven and spotty.

The oil employed in the lubricating step also brings with it numerous complications and problems. Heretofore, the lubricant was selected from among the numerous oils and fats of animal, vegetable and mineral origin, employed individually or in various blends. The amount used would vary from 1% to 8% or even 10% on the weight of the stock and would depend on several factors such as quality of wool, fineness of yarn, mechanical equipment, etc. After the yarn has been woven or knitted into cloth the lubricant has served its purpose and generally must be removed to make a saleable fabric. In conventional procedure this has been accomplished heretofore by scouring with solutions of soap and alkali. These, as already indicated, are themselves objectionable and are difficult to remove from the fabric. Furthermore, removal of the oil is often incomplete, and residual quantities thereof in the fabric tend to develop in it an unpleasant odor and discoloration.

Removal of the lubricant has thus always presented difficulties and much work has been done to overcome them. In many cases very costly oils have been used solely because it was claimed that they are easily removed in water media. Such expensive oils, however, are economically prohibitive in the case of woolen fabrics, and the choice is therefore limited to the cheaper mineral oils and blends.

Many non-oily water soluble substances have been tried but with little success.

Within recent years there was developed a method for removal of the lubricant by extraction with a volatile solvent, but this obviously requires special apparatus, machinery and operations for extraction and for recovery of the solvent.

An additional and most serious disadvantage of mineral or blended oils is that their emulsions tend to enhance the natural hygroscopicity of the wool. Roving treated with mineral oil emulsion will vary in weight according to the relative humidity of the atmosphere. Since the setting of the spinning machine is determined by the weight of the roving per unit length, it is impossible to set the machine so as to obtain a uniform yarn from hour to hour and from day to day. As a result, yarn made from such roving is relatively replete with "twits" (weak spots) and "nibs" (coarse spots). This is a very serious factor when one considers that the winding and weaving machines work on hundreds of "ends" simultaneously, and must of necessity be so designed and set that rupture of a single "end" shall automatically stop the machine.

Now according to this invention, we have solved many of the above difficulties and improved the process in numerous other respects by the application of a chemical treating agent which performs both as a lubricating agent and as a fulling agent; washes out readily from the fabric without the aid of either soap or alkali; is of substantially neutral reaction; is harmless to the fiber; and traces of it, if any be left in the fabric, do not decompose into rancid by-products or discoloration.

Mixtures of high-molecular, saturated, neutral organic compounds with the neutral sulfonates of high-molecular, saturated, neutral organic compounds answer the above qualifications in a satisfactory manner, especially if the proportion of the sulfonate in the mixture is sufficiently high to render the whole readily soluble or dispersible in water. Such mixtures may be prepared most conveniently by reacting with a mixture of sulfur dioxide and chlorine in the presence of actinic light, as in U. S. Patents Nos. 2,202,791 and 2,334,764, upon high-molecular, aliphatic or cycloaliphatic hydrocarbons, alcohols or esters, having at least 16 C-atoms per molecule, or upon mixtures of such high-molecular compounds, until the increase in weight shows that on the average about 30 to 70 out of every initial 100 molecules have been converted into SO_2Cl derivatives, and then hydrolyzing the resulting mixtures with alkalis to convert the SO_2Cl groups into the corresponding neutral-sulfonates, for instance into SO_3Na groups where caustic soda is the hydrolyzing agent.

Especially remarkable qualities for our purpose have been discovered by us in a reagent prepared by reacting with sulfur dioxide and chlorine according to U. S. Patent No. 2,334,764, upon a mixture of paraffin wax and petrolatum, as employed for instance in Example 4 of said patent, until about 50% of the saturated hydrocarbons started with have been converted into SO_2Cl derivatives,

followed by neutralization with sodium hydroxide as described in the mentioned example.

The actinic reaction results in a mixture of compounds containing SO_2Cl groups and to some extent Cl atoms, with a considerable quantity of unreacted initial material and, probably, partially chlorinated hydrocarbons which are free of SO_2Cl. Upon treatment with sodium hydroxide, the SO_2Cl groups become converted into SO_3Na groups, and the entire composition, having a pasty consistency, becomes soluble or uniformly dispersible in water.

It has been recognized heretofore that this reagent, hereinafter referred to for brevity as a substantially neutral, hydrocarbon:hydrocarbon-sulfonate composite, has the property of softening textile fiber, especially cotton. But it has not been recognized or known that this composite has the qualities of both a lubricant and fulling agent for wool fibers. As a general proposition there is no relation between fulling agents and softening agents, the former relating exclusively to wool, while the latter are spoken of chiefly in connection with cotton. Nor is there any generally recognized relation between lubricants for wool and fulling agents, for as we have seen the former have always been selected from among the oils and fats, while the latter were generally satisfied by soaps and alkaline-reacting compounds.

Now, by the selection of a composite reagent of the type above indicated, the entire procedure of converting raw wool into finished fabric becomes susceptible of arrangement in a continuous sequence of steps without superfluous intermediate scouring steps or costly solvent-recovery procedures. The sequence of steps of our improved process may be summarized in the following continuous procedure.

The raw stock is picked and then impregnated with an aqueous dispersion of the hydrocarbon: hydrocarbon-sulfonate composite in such quantity and concentration as to deposit about 2 lbs. of the composite on each 100 lbs. of raw stock. Incidentally, there is a noteworthy improvement at this very point of procedure, inasmuch as with conventional wool oils in the manufacture of woolen fabrics the more common practice was to use 5 to 10 lbs. of the lubricant per 100 lbs. of raw stock.

The stock is then subjected in usual manner to the well established procedure of carding and spinning. A strong, uniform yarn is obtained, relatively free of twits and nibs.

The yarn is then dressed for weaving and woven on a loom. Substantial improvement in quality of the greige fabric (fabric as obtained off the loom) has been noted at this point in many instances. The greige fabric resulting from our process is remarkably free of knots, has fewer broken threads, and is generally more uniform. Following the loom, the goods are now ready for wet processing. With fabrics which do not require carbonizing before fulling the woven fabric needs only impregnation with water to add moisture to the fiber. Additional quantities of the hydrocarbon:hydrocarbon - sulfonate composite may, however, be added at this point, if desired, to build up the total quantity of this agent in the fiber.

With some fabrics, such as blanket material, carbonizing is desirable before fulling. Carbonizing is a treatment with sulfuric acid or aluminum chloride and hydrochloric acid, for the purpose of carbonizing or charring any cellulosic impurities present in the wool. After impregnation, the fabric is successively dried (about 160 to 200° F.) and baked (about 220 to 260° F.). This operation may remove part of the hydrocarbon:hydrocarbon-sulfonate composite deposited on the fiber in the first step of procedure. In such event, it is advisable to add to the fabric an additional quantity of this reagent, in the form of an aqueous solution, prior to fulling.

Where it is found necessary or desirable to remove tarry impurities from the wool, it is advisable at this point to treat the fabric further with an aqueous emulsion of an organic solvent such as xylol. Since, however, this step is per se old, it neither adds to nor subtracts from the merits of our simplified process.

The fabric is then subjected to fulling in customary manner, until the desired degree of shrinkage has been obtained. A shrinkage of 8 inches per yard in each dimension is typical of customary practice.

The fabric is then subjected to scouring, which in our improved process need consist of nothing more severe than a continuous dipping in hot water (about 110° F.) for a period of about 30 minutes to 1 hour, depending upon the weight of the fabric. No soap or soda ash need to be added. As contrasted with this, the standard soap-and-alkali scouring requires treatment for 1½ to 4 hours or more, because of the strong tendency of wool to absorb and hold soap and soda ash. In this old process it is extremely important that the goods be rinsed to a pH of 7 or as close thereto as possible.

The fabric is now finished as far as our invention is concerned, but may be subjected to further optional treatments such as carbonizing (if the latter step had not been done prior to fulling), neutralizing, dyeing, napping and other dry-finishing treatments.

The following detailed examples will serve additionally to illustrate our invention, but it is understood that no limitation is intended thereby.

Example 1.—Preparation of cloth for blankets

Two lbs. of a substantially neutral hydrocarbon:hydrocarbon-sulfonate composite (prepared from a mixture of paraffin wax and petrolatum according to U. S. Patent 2,334,764, Example IV, and consisting substantially of equal molecular proportions of the sulfonated and unsulfonated compounds) are dispersed in water at the boil and made up with water at 110 to 140° F. to a total volume of 3 gallons. 100 lbs. of scoured raw wool (i. e. wool which has undergone only the operations of sorting, degreasing and removal of suint and dirt) are mixed in a picker and simultaneously impregnated with the aforegoing aqueous emulsion. The wool is then subjected to carding and spinning in regular fashion, except that the yarn weight may be reduced, about 3%, if desired, to compensate for the lower dead loss in finishing. Weaving is next carried out in regular fashion. The greige thus obtained may now be put directly in the fulling machine, with only water and tar-remover being added to it in the fulling machine. On the other hand, if desired, additional quantities of the above composite reagent may be added, according to the following formula:

An aqueous dispersion of the hydrocarbon:hydrocarbon-sulfonate composite is made up as above and diluted with water to a concentration of 2 to 4 ounces per gallon. 12 to 15 gallons of the dilute dispersion are added to each 100 lbs. of wool fabric (on dry basis) in the fulling mill.

Simultaneously, a tar-remover solution is made up by mixing 6 ounces of the diethyl-cyclohexylamine salt of lauryl-sulfuric acid with 1 gallon of xylol and adding 6 quarts of water. It will be noted that the xylol emulsion is thus prepared without the aid of soap or alkali. 5 to 10 quarts of the resulting aqueous dispersion are applied to each 100 lbs. of wool fabric (dry basis) in the fulling mill. The xylol dispersion and the aforegoing aqueous dispersion of the composite re-agent may be mixed together and entered as a single spray to the cloth in the fulling machine. The duration of fulling and other details may follow customary procedure, and will depend of course on the weight of the fabric and on the amount of shrinkage desired.

After fulling, the fabric is subjected to scouring in a suitable washer. Without addition of any further agents, the fulled fabric is treated with water for 15 to 20 minutes at 120° F. It is then rinsed for ½ to ¾ hour with warm water, and extracted.

Carbonization and dry milling are next carried out in regular fashion, followed by neutralization and, if desired, dyeing and various additional dry-finishing operations such as napping, shearing, brushing, steaming, pressing, decating, etc.

The woolen fabric thus obtained is characterized by good handle, freedom from odor and by level dyeing qualities, and does not undergo the discoloration typical of residual soap and mineral oil.

Example 2.—Spinning warp yarn for blankets

A stock mixture of 2000 lbs. of wool was made up by mixing together stock-dyed, scoured wool (48's to 56's) as follows:

	Per cent
White wool, undyed	23
Wool, dyed khaki	40
Wool, dyed brown	17
Wool, dyed olive	20

A lubricating solution was then made up by dissolving 40 lbs. of the hydrocarbon:hydrocarbon-sulfonate composite set forth in Example 1 in 15 gallons of water at the boil, and diluting with water to a total volume of 60 gallons at 100–120° F.

The stock mixture was fed into a picking machine to effect blending, and simultaneously the above prepared lubricant solution was applied to it by a revolving brush at the rate of 3 gallons per 100 lbs. of stock. The stock was then given a second run thru the picker to blend it thoroughly. It was then fed thru a carding machine which was adjusted to deliver roving of 160 grains per 50 yards. The resulting roving was found uniform, smooth and round. The "fly" at the "fancy" rolls on the card was negligible.

Spinning was next carried out on a ring or frame system, adjusted to produce 1¾ run yarn, (i. e., 125 grains per 50 yards), and 22% draft. Draft is defined or measured by the difference in weight per unit length between the card roving and yarn divided by the weight of the card roving and multiplied by 100.

The yarn resulting above was smooth, uniform, strong and elastic. Its tensile strength was 170 lbs. "per 50 yards" (i. e., per 100 strands), whereas the same style yarn produced in the same mill by the same method except for employing a lubricating solution made up of 20 gallons of conventional lubricant (predominantly mineral oil) and 45 gallons of water, had been exhibiting an average tensile strength of but 135 lbs. per 50 yards.

Example 3.—Producing an 18 oz. fabric for men's top coats

A stock blend of 3380 lbs. total weight was prepared by mixing 1352 lbs. of cut worsted top dyed a pearl color and 2028 lbs. of similar top dyed black. A lubricating solution was then prepared by dissolving 64 lbs. of the composite reagent mentioned in Example 1 in 40 gallons of water at the boil, and diluting with water to a total volume of 142 gallons at 110–120° F. (This lubricant replaces the heretofore employed regular lubricant made up of 32 gallons of wool oil and 141 gallons of water.) The lubricant solution was applied by hand with a sprinkler can to several layers of the stock spread on the floor. The impregnated stock was passed thru a mixing picker three times to effect thorough blending.

Carding was next carried out with the cards adjusted to deliver roving of 94 grains per 50 yards. A smooth, uniform and round roving was obtained.

Spinning was done on a mule system adjusted to produce 3 run warp yarn, i. e., 73 grains per 50 yards. The resulting yarn was smooth, uniform, strong and elastic. Yarn produced by the old process using wool oil under the same conditions would have an average strength of 75 lbs. per 50 yards. The yarn produced in the above example averaged 80–85 lbs. per 50 yards. A filling yarn of 3½ run, i. e., 63 grains per 50 yards was likewise spun on the mule.

Weaving was done on a loom to a width of 74 inches and 40 picks (filling threads per inch). A considerably improved loom efficiency was observed owing to the greater strength and elasticity of the yarn. These qualities increase the ability of the yarn to withstand abrasion and constant flexing in the loom. The cloth taken off the loom was clear and smooth, and had an average weight of 22 ozs. per lineal yard.

Fulling was next carried out in an ordinary fulling mill, running 4 pieces on each side, tacked face in. The cloth, approximately 720 lbs. in weight, was impregnated in the fulling mill with a solution of 12 lbs. of the composite reagent defined in Example 1, and 10 lbs. of soda ash, made up with water to 80 gallons at 100–120° F.

NOTE.—The stock employed in this example having been dyed with after-chrome dyes, it contained appreciable amounts of acid in the fiber. The soda ash above was calculated to bring the cloth approximately to the neutral point. In prior practice in the same production a fulling solution was employed made up of 35 lbs. of soap and 25 lbs. of soda ash and water to a total of 80 gallons.

When the fulling solution was completely and uniformly applied to the cloth, fulling was continued for 2 to 2½ hours, or until the width had shrunk from 74 inches to 59 inches. Simultaneously, the length shrank from 68 yards to 65 yards per piece.

Scouring was next carried out in a dolly washer containing 1500 gallons of water at 110–120° F. The cloth was worked in this bath for 15 minutes, then rinsed for 20 minutes with warm water and for 20 more minutes with cold water until the wash water showed a pH of 7.5 to 8.0. The cloth was then extracted by passing thru squeeze rolls, rolled up, and allowed to stand 24 hours. It was then finished by passing it twice over a wet gig, face and back; it was dried on a pin tenter; brushed face and back, sheared on the face, and decated.

The finished fabric was clean, lofty, and had a very kind handle.

Example 4.—12 oz. Shetland ladies' wear

Stock blend:

White wool, 64's to 70's, clean scoured	percent	40
Card waste	do	15
Bradford noil	do	32
French noil	do	5
Cut worsted top	do	8
Total weight of blend	lbs.	2500

Fiber lubricant:

50 lbs. composite reagent as defined in Example 1, dissolved in 25 gallons water at the boil, and diluted with water to a total volume of 87 gallons at 110–120° F.

The fiber lubricant was applied at the rate of 3½ gallons per 100 lbs. of stock by spraying same on even layer of stock as the latter was being fed into the mixing picker. The stock was then given a second pass thru picker to blend thoroughly.

Carding was next done to produce roving of 116 grains per 50 yards. The roving was spun to produce yarn for both warp and filling of 2% run, (i. e., 76 grains per 50 yards), with a draft of 34%. The yarn obtained was smooth, uniform, elastic and strong, and averaged 10 to 15% higher in strength than regular yarn processed under the same conditions with conventional wool lubricant.

The yarn was then "dressed," that is wound from the spools unto loom beams, to make it ready for weaving. Ordinarily 35 to 40 ends break in making up the beam for 16 pieces of fabric. With the yarn obtained above there were only 9 breaks. Weaving was effected with 1860 warp ends and 28 picks (filling threads per inch). Average weight of woven cloth was 14 ozs. per lineal yard.

Fulling was effected in a regular mill, working on 8 pieces of fabric: 4 pieces on each side of fulling mill. Before entering the fulling mill, however, the fabric was impregnated with a solution of 10 lbs. of a neutral fatty alcohol detergent (sodium salt of a higher alcohol sulfuric ester) and 40 lbs. of a tar-remover as in Example 1, made up with water to a total of 150 gallons at 100–120° F. (The function of the detergent was to assist in removing oils contained in the noils and card waste as purchased by the mill.) The 8 pieces, originally weighing about 536 lbs., absorbed about 60 gallons of this solution.

Fulling was then carried out for 45 to 50 minutes, until the goods shrunk in width from 76" to 60". The shrinkage in length was from 74 yards to 69 yards.

Scouring was next done in a dolly washer in about 1000 gallons of water at 110-120° F. The goods were worked in this bath for about 15 minutes, then rinsed 20 minutes with warm water, and 20 minutes further with cold water. Total time in dolly washer was 55 minutes. The same style fabric processed with conventional wool lubricant and fulled with soap and soda ash requires 2 to 2½ hours of scouring and rinsing to remove the fiber lubricant and soap and to bring the wash water to pH of 7.0–7.5.

Carbonizing, neutralizing, dyeing and finishing (napping, brushing, shearing and pressing) were then effected in conventional manner.

Example 5.—Application to clips before picking

This example demonstrates complete process for stock blend of reworked and reprocessed wool for the filling of a cotton-warp lining fabric.

Stock blend for filling yarn:

Cotton card waste	per cent	18
New mixed worsted clips	do	23
New dark polo clips	do	33
Wool card waste	do	16
New wool tweed clips	do	10
Total weight of lot	lbs.	1000

NOTE:—"Clips" are irregularly sized and shaped pieces of cloth discarded by the garment manufacturer when cutting up the cloth. The term "clips" differentiates the material from "rags" which are salvaged from worn garments.

The different clips above are piled together and sprayed with a lubricant solution, made up as in the aforegoing examples in the proportion of 1 lb. of the hydrocarbon:hydrocarbon-sulfonate composite per gallon of water. 4 gallons of this solution are used per 100 lbs. of clips. The sprayed clips are then put through a rag picker to reduce them to loose wool. The cotton card waste and wool card waste are then added and the whole mass is then passed through a mixing picker to effect blending. Carding, spinning, weaving and fulling then follow as in the other examples. Water is added in the fulling machine, but no additional composite reagent need to be added in this case, in view of the larger proportion thereof sprayed on the clips as lubricants.

It will be clear that the above examples are merely illustrative, and that the details thereof may be varied within the skill of those engaged in this art.

Thus instead of the particular composite reagent produced according to Example 4 of U. S. Patent No. 2,334,764, and containing roughly a 50:50 ratio (in moles) of unsulfonated and sulfonated hydrocarbons, equivalent mixtures produced by mechanical admixture of the two principal components (sulfonated and unsulfonated paraffins) may be employed. In either event, the proportions of the said two principal ingredients may be varied within substantial limits. For instance, the proportion of the sulfonated compound may be as low as 30% or as high as 70% by molal count. Furthermore, in lieu of the product obtained by reacting with sulfur-dioxide and chlorine on a mixture of paraffin-wax and petrolatum, one may employ products similarly prepared from any other saturated (hence, non-aromatic) hydrocarbon having at least 16 carbon atoms per molecule, or from a high-molecular (in the above sense) saturated alcohol, or from a saturated carboxylic acid ester having a long chain in the alcoholic or acid radical or both.

The length of carbon-chain in the saturated organic compound selected for partial sulfonation has an important bearing. In the specific examples above we used a composite derived from a mixture of paraffin wax and petrolatum. It is estimated that the chain length of the hydrocarbon in the paraffin wax employed varies from 20 to 35 C-atoms. The petrolatum is probably of a naphthenic nature (cycloaliphatic), and its range of molecular weight is not known definitely. Shorter-chain hydrocarbons, say even as low as 16 carbon atoms may be employed. It is essential that the initial organic compound be saturated, so as to avoid oxidation or polymerization if any of it is left on the fiber. It need not, however, be a straight-chain compound.

Branched-chain hydrocarbons and cycloaliphatic hydrocarbons containing 16 to 50 C-atoms per molecule (or even higher) may be employed. Synthetic organic compounds, for instance hydrocarbons obtained by Fischer-Tropsch synthesis, may likewise be resorted to.

The proportion of treating agent recommended by the above examples is about 2% to 4% by weight of the raw stock. Larger proportions are wasteful but do no harm, except that if unduly large quantities are employed, say 8%, they are apt to accumulate a waxy deposit and cause clogging of the card-clothing, the shuttles of the loom and the combing and winding machinery. Lower quantities than 2% may in some cases be successfully employed, particularly in worsted processing.

The temperature of the final wash-waters, the duration of the scouring, the duration of the fulling, etc., may vary within wide limits and are best controlled by the judgment and accumulated experience of the persons actually running the mill, as well as by the quality of the results desired.

Although we have illustrated our invention above with particular reference to a process producing a woven fabric, it will be clear that our improvement is equally applicable to a process wherein the fabric is produced by knitting. Likewise, although we have employed in the discussion above a process of producing woolen fabrics (using this term in the narrow sense as it is employed in the trade), our invention may be applied successfully also to the production of worsted fabrics. In that event, of course, operations peculiar to the worsted process are interposed at their proper places in the procedure above outlined. Our improvement is also applicable to the processing of mixed fibers of which the dominant constituent is wool, for instance blends of wool with cotton, rayon, tussah silk, etc.

Again, where we talk about fulling, it is clear that the discussion is equally applicable to what is often called "felting." This term is used generally in connection with hat felts, paper makers' felts and other felted material and in a sense is nothing but a fulling operation carried to a higher degree. Consequently, in the claims below where we speak of "felting" the term should be construed in a broad sense to include "felting," "milling" and other synonymous or related operations.

The term "wool" which we employ likewise should be construed in a generic sense inclusive of the corresponding worsted yarns and fabrics, reprocessed wool, shoddy, and also fibers which are designated in the trade as "hair," such as mohair, camel's hair, alpaca, etc.

The advantages of our improved procedure for processing wool will now be readily apparent.

In the first place we have eliminated or reduced to a minimum all contact of the wool with alkali in the process of transition from raw stock into finished fabric. Alkalis are injurious to wool. Their use upon wool in any process must be considered as an emergency measure, and the treatment even with soda ash and for short durations may leave its injurious imprint on the fiber. Secondly, we have eliminated the use of soaps, mineral, and blended oils, all of which are difficult to remove from the fabric. The inherent difficulties in the removal of these products cause uneven dyeing of the fabric and are also apt to give it an unpleasant handle and odor in the course of time. Removal of the soap, alkali and oils requires prolonged scouring and rinsing with water, for a total period of 1½ to 4 hours or longer. These longer periods cannot help degrading the fabric because of prolonged treatment. In our process, the fulled fabric requires only a rinsing in water for a relatively short period.

In the case of the particular composite reagent defined in Example 1 above, we have discovered the remarkable and unpredicted additional advantage that the yarn resulting from our process is more uniform and generally stronger than that obtained when mineral and blended oils are employed as the lubricant.

With said earlier lubricants, it has been the annoying experience of the trade that on humid days production of the carding and spinning machines would drop because of repeated breaks of the roving or yarn. This effect has been ascribed to the hygroscopicity of the fiber, which causes the roving to change in weight in relation to atmospheric humidity. Without fully understanding the reason, we have found that when a hydrocarbon:hydrocarbon-sulfonate composite as hereinabove described is employed as lubricant, the roving and resulting yarn are uniform in strength, do not vary in weight from day to day and from hour to hour, and the output of the machines remains at a high standard without regard to the weather.

Yarns lubricated with mineral oil cannot be stored for long periods, due to the tendency of the oil to oxidize. Storage then would substantially destroy the lubricating properties necessary for further processing, would convert the oil on the fiber into difficultly soluble polymers, and would incidentally tend to develop heat in the process, creating a fire hazard. Yarn according to our invention is free from the above objections, and is as ready for further processing after several months of storage as when freshly treated. Consequently, our invention enables us to convert the intermediate yarn into an article of commerce. It may be shipped from place to place, and may be prepared by one manufacturer and then sold for further treatment in a different mill.

Heretofore, if the yarn to be woven or knitted was obtained from an outside source, the fabric manufacturer encountered difficulty in the removal of the lubricant in his normal process and also had often the problem of guessing the nature of the lubricant employed and fitting the scouring process thereto. With yarn treated by our process, this guess-work is eliminated, because the lubricant washes out easily in any event. In many cases only the residual hydrocarbon:hydrocarbon-sulfonate composite carried over from the lubrication step constitutes the fulling agent, while in the case of heavier goods only relatively small additions of this agent are needed if at all. Consequently, if the fabric is to be fulled before carbonizing, it needs, in most cases, to have only water added thereto in the fulling machine.

In the old, two-treatment processing of wool, the fulling was carried out under either highly alkaline or highly acid conditions. In our process the fulling is done substantially at the neutral point (within the limits of error under practical working conditions), hence under conditions less injurious to the fiber. It will thus be recognized that although our invention offers the maximum combination of advantages if embodied in a continuous, correlated, single-treatment process wherein the hydrocarbon:hydrocarbon-sulfonate composite is added at the very beginning, prior to

carding, it nevertheless possesses considerable merit even if limited to the step of fulling. In other words, one may start with a fabric where the wool has been treated with an ordinary lubricant and then solvent-cleansed, and one may treat it with our preferred composite reagent in the fulling mill. The advantages one will reap then are that the fulling is done substantially at the neutral point, that the subsequent scouring operation is relatively short, that no alkalis contact the wool either in the fulling step or in the subsequent scouring step, and that traces of the fulling agent which may intentionally or incidentally be left in the fiber will not produce uneven dyeing or rancidity.

Not all wools that are processed as outlined above start from the clean wool stage. A considerable percentage of the woolen cloth now being manufactured is dyed in the form of raw stock or tops and then the process is similar to that above outlined. Many dyes that are otherwise applicable to wool are sensitive to alkali, and therefore great care must be taken in the selection of the color for these special processes, and further care must be taken particularly that the shade be not disturbed in the fulling and scouring.

It has been our experience that in using the above-defined composite reagent as a lubricant and subsequent fulling agent and where this operation is performed in a substantially neutral bath, there is almost complete elimination of bleeding of the colors into adjacent white or colored wool in the same piece. Thus, for example, in a fabric which contains a considerable portion of white wool, this white wool is left clean and the colors retain their original hues.

The composite reagent employed in our process is also harmless to the skin and gives a soft, pleasant feel to the hands of those handling it.

We are aware that it has been suggested to employ solubilized paraffin as an assistant in fulling. The talk there, however, concerned paraffins which have been fully transformed into SO_3H and Cl derivatives, without any substantial quantities of residual hydrocarbons. Also, the intention there was to employ these either as assistants in the alkaline fulling process, hence in addition to soda ash or other alkalis, or in an acid-fulling procedure, hence they were to be employed in free SO_3H form or in conjunction with the mineral acid carried over by the fabric from the carbonizing step. Thus, the proposal did not vary from the traditional practice of operating at extreme pH values (over 10 or under 2), and in general taught nothing more revolutionary than replacing the customary soap by its equivalent of the sulfonated paraffin reagent.

Under our improved process, the fulling step is carried out under substantially neutral conditions, although it does not exclude the option of adding acid if desirable under particular conditions. The composite reagent employed by us is not used as an assistant to either alkali or acid, nor can it be considered a mere substitute for soap since it is capable of acting by itself, without the aid of other agents. As a matter of fact, we are not aware of a single case wherein the above referred to suggestion concerning solubilized paraffin has been actually adopted in practice, and judging from the low viscosity of aqueous solutions of fully sulfonated paraffins, it is a foregone conclusion that they could not by themselves operate in a practical process to achieve both lubrication and fulling in a single treatment of the wool as it is effected by our process.

We claim:

1. A unified process for converting loose wool into a finished fabric, which comprises the steps of impregnating the loose wool with a substantially neutral and soap-free composite reagent consisting predominantly of saturated petroleum hydrocarbons having not less than 16 carbon atoms per molecule and the sulfonates of saturated petroleum hydrocarbons having not less than 16 carbon atoms per molecule, said sulfonates being present in sufficient quantity to render the whole dispersible in water while the said unsulfonated hydrocarbons are present in quantity sufficient to impart to the mixture lubricating qualities; subjecting the loose wool to carding, spinning and formation into fabric; adding water to the fabric, and fulling the same under substantially neutral conditions in the absence of soap; and finally scouring the fulled fabric with water which is free of soap and alkali to remove the composite reagent.

2. A process as in claim 1, wherein further quantities of said composite reagent and water are added to the fabric in the fulling step but wherein the fulling is nevertheless carried out in the absence of any substantial amounts of soap and alkali.

3. A process as in claim 1, wherein the fabric is subjected further to carbonizing and neutralizing before fulling, and wherein additional quantities of said composite reagent and water are added to the fabric in the fulling step, to compensate for any losses during the carbonizing and neutralizing steps, but wherein the fulling is nevertheless carried out in the absence of any substantial amounts of soap and alkali.

4. A process as in claim 1, wherein an aqueous emulsion of a tar-removing solvent is added to the fabric in the fulling step, but wherein the fulling is nevertheless carried out in the absence of any substantial amounts of soap and alkali.

5. A unified process for converting loose wool into a finished fabric, which comprises the steps of impregnating the loose wool with a substantially neutral and soap-free composite reagent consisting predominantly of saturated petroleum hydrocarbons having between 16 and 50 carbon atoms per molecule and the sulfonates of the same saturated petroleum hydrocarbons, said sulfonates being present in sufficient quantity to render the whole dispersible in water while the said unsulfonated hydrocarbons are present in quantity sufficient to impart to the mixture lubricating qualities; subjecting the loose wool to carding, spinning and formation into fabric; treating the fabric in a carbonizing bath, followed by drying, baking and neutralizing the acid absorbed by the fiber during the carbonizing step; adding to the fabric a further quantity of the composite reagent hereinabove defined together with water, fulling the impregnated fabric under substantially neutral conditions in the absence of soap; and finally scouring the fulled fabric with water which is free of soap and alkali to remove the composite reagent.

6. A unified process for converting loose wool into a finished fabric, which comprises impregnating the loose wool with an aqueous dispersion of a substantially neutral and soap-free composite reagent obtained by subjecting a mixture of paraffin wax and petrolatum to the action of sulfur dioxide and chlorine under the influence of actinic light until about 50% of the hydrocarbon molecules have been converted into SO_2Cl derivatives and then reacting upon the mixture with

alkali to convert the SO_2Cl groups into alkali-metal sulfonate radicals; subjecting the loose wool to carding, spinning and weaving into fabric; adding water to the fabric and fulling the same under substantially neutral conditions in the absence of soap; and finally scouring the fulled fabric with water to which no soaps and alkalis have been added, to remove the composite reagent.

7. A process as in claim 6, wherein additional quantities of said composite reagent and water are added to the fabric in the fulling step, to compensate for any losses of said composite reagent during any previous operation, but wherein the fulling is nevertheless carried out in the absence of soap and alkali.

8. A process as in claim 6, wherein the formed fabric is subjected further to carbonizing and neutralizing before fulling, and wherein additional quantities of said composite reagent and water are added to the fabric in the fulling step, to compensate for any losses of said composite reagent during the carbonizing and neutralizing steps, but wherein the fulling is nevertheless carried out in the absence of soap and alkali.

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