New Cotton Textiles

COTTON ALWAYS has been a good mate-
rial for clothing. Now it is even better. It is modified chemically to make tex-
tiles with such chemical and physical properties as wash-wear, stretch, and resistance to water, stains, mildew, shrinking, flame, glow, and heat.

Wash-wear fabrics and garments dry smooth after laundering and resist wrinkling during use. Improvements in the first wash-wear methods have led to the domestic use of more than 2 billion yards of fabric a year.

The smooth-drying and wrinkle-resistant properties are put into cotton by imparting memory to fabric, so that once the fabric is set flat and smooth, it will return to the original condition despite external influences, much as curls put in by a permanent wave return after the hair is washed.

A chemist imparts memory to cotton by reacting the long cellulose mole-
cules with compounds having low molecular weight. The compounds must penetrate the fiber and crosslink the cellulose.

When crosslinking agents tie to-
gether adjacent lamellae in the fiber, the fabric exhibits good wrinkle re-
covery whether wet or dry.

White fabric treated with some of the earlier wash-wear finishes some-
times became yellow or the fibers be-
came weak when it was bleached with common hypochlorite solution. Some of the fabrics tended to soil easily.

The finishes now used on white fabrics are not affected adversely by hypochlorite bleach, and the newer special additives—polyethylene, for example—do not appreciably attract soil. Many of the fabrics do not have to be ironed, but if ironing is considered desirable, the job is quick and easy.

Wash-wear finishes also produce other durable dividends: Very little shrinkage during use, quick drying, and resistance to many micro-orga-

You can dryclean wash-wear goods and launder them at home with detergents, but repeated severe laun-
dering can destroy the wash-wear characteristics of many fabrics. The acid rinse used in commercial laun-
dering does most of the damage.

Some of the better finishes, such as those used on men’s white shirts, can withstand commercial laundering. Wash-wear cotton fabrics can be tumble dried with generally fewer wrinkles than drying them on a line.

Since wash-wear garments tumble dry in about half the time needed for untreated cotton garments, it is more efficient to dry them in a separate load. You therefore should remove the clothes from the dryer as soon as they are dry and hang them so that any wrinkles can straighten out.

Tumbling hot garments after they are dry causes excessive linting and much more abrasion than when wet goods are tumbled.

Durable creases and pleats can be put into wash-wear clothing. Manu-
facturers have several methods of producing such garments, but they are not suitable for use by the home seam-
stress. In each method, creases, shape-
holding, and wash-wear properties are imparted to the cotton by cross-
linking cellulose molecules. The creases are put in after the garments are made.

STRETCH COTTON garments have be-
come popular because of their com-
fort, ease of fitting, and neat appear-
ance.

Commercial methods for producing stretch goods include slack merceriza-
tion of fabric; mechanical compaction
of fabric, followed by resin finishing; elastic core yarns of spandex fiber; a blend of spandex fiber with cotton; and torque-crimp thermoplastic yarn with cotton yarn.

The slack (or tensionless) mercerization method of producing stretch cotton goods, developed by scientists in the Department of Agriculture, is inexpensive and effective. It is used for many types of outer garments, slipcovers, other household items, and industrial commodities.

Woven stretch fabrics are suitable for some household and industrial uses without additional chemical treatment. For use in apparel, however, a wash-wear finish is applied to produce better recovery from stretch as well as smooth drying and wrinkle resistance.

Stretch knit goods, especially cotton socks, can also be made by the slack mercerization process. Such socks have all the desired qualities of cotton and also have good stretch and recovery properties.

Stretch fabrics produced by mechanical compaction followed by a resin treatment have the stretch in the warp (length) in contrast to those produced by slack mercerization, which generally have the stretch in the filling (width), although they can have both warp and filling stretch.

Fabrics produced with about equal amounts of torque-crimp thermoplastic yarns and cotton yarns may have either warp or filling stretch. Fabrics made of yarns containing a spandex fiber core with a cotton sheath or of yarns containing a blend of cotton and spandex can have warp and filling stretch.

These fabrics generally contain at least 90 percent cotton, but their content of elastic spandex fiber requires that they be carefully laundered. Water for washing should be about 100° F. Chlorine bleaches must not be used, because they turn the spandex yellow or brown and degrade the fiber.

Cotton exposed to conditions of high humidity and warmth is readily attacked and destroyed by certain microorganisms (fungi and bacteria) unless they are protected by chemicals.

Mildew is a common term for the fungi responsible for most cotton degradation.

Micro-organisms do not subsist on cotton itself. Instead, they secrete enzymes that hydrolyze cotton cellulose to produce water-soluble products and then feed upon the soluble material. Most of the spores from fungi do not germinate when the temperature is below 65° and the relative humidity is less than 40 percent.

Bacteria can flourish and rot cotton only when it is nearly soaking wet.

Cotton is subject to degradation by micro-organisms in end uses that include tents, tarpaulins, shoe linings, sandbags, boat covers, ditch liners for irrigation, and fishing equipment. The degradation can be retarded or prevented by treatment with additive finishes, such as copper-quinolinolate, copper naphthenate, and phenyl mercury esters.

Workers in the Department of Agriculture discovered that zirconium acetate and zirconium ammonium carbonate solutions solubilize many biocides and make it easier (and sometimes more effective) to apply them to cotton.

Other useful additives are pentachlorophenol and quarternary ammonium compounds. The most effective and durable treatments for cotton include acetylation, cyanoethylation, and deposition of polymers of melamine or of acrylonitrile. These agents give excellent rot resistance in sandbags, ditch liners, and other products in which the fabric touches soil.

Cotton has some natural resistance to degradation by sunlight, but it must be protected when it is exposed for long periods, as in tents, tarpaulins, awnings, truck covers, and beach umbrellas.

The damage to cotton by solar radiation is largely through photosensitization. In this process, some substance in the cotton—an impurity
or an additive, such as a dye—absorbs light and then makes the absorbed energy available for rupture of the cellulose molecules. These degrading effects of sunlight vary with temperature, season, latitude, humidity, and contaminants in the air.

Cotton is protected from degradation by sunlight by removing or deactivating photosensitizers. To do that, materials are used that screen or scatter light or by substances that utilize solar energy themselves without transmitting degrading effects to the cotton.

Protective materials include certain pigments, inorganic compounds, and amino resins.

Pigments are the most effective and generally are inexpensive. Some of them provide outstanding protection. A weight increase as little as 2 to 4 percent can more than double the life of a fabric. Larger amounts often extend the life up to fourfold.

Pigments and some inorganic compounds must be bound to fabric with a polymeric substance that penetrates the interstices of the fabric or merely coats one side, as for awnings.

Fabrics protected against sunlight are also generally treated to make them resistant to mildew, rot, and water and sometimes resistant to flame.

**Water- and stain-repellent fabrics** are used widely.

A fabric is termed water-repellent if it resists wetting and penetration. Water-repellent fabrics are needed for raincoats, sport coats, jackets, umbrellas, and other items.

Stain repellency is desired in some of these items but is especially needed for tablecloths, upholstery, and party dresses.

Water and stain repellency are imparted to cotton by chemicals that interact with the surface of the individual fibers and lower the surface energy of the fabric.

Three general classes of water repellents are those based on metallic salts and oxides, those based on polymers deposited on or in the fibers, and those based on some chemical in which there is union between the repellent and the cotton.

A water-repellent fabric is different from a waterproof fabric in that its interstices are not closed, so that it is permeable to air and water vapor.

In waterproof fabrics, the interstices are filled and function like plastic films in that they do not allow free passage of water vapor and air. Waterproof fabrics and plastic films thus are less comfortable than water-repellent fabrics in garments.

An easy test for water repellency is to place a drop of water on a flat surface of the fabric. If it takes on a spherical shape, it has not wet the surface. If it flattens out, it has wet the surface, and the fabric is not water repellent.

Most water-repellent fabrics are also repellent to waterborne stains and spots, such as those caused by coffee, tea, fruit juices, and soft drinks. The repellents containing silicones or fluorocarbons are most effective against waterborne stains.

Fabrics containing fluorocarbons may also be resistant to greasy stains. A test is to place a drop of cooking oil on the surface of the fabric. If it takes on a spherical shape, the fabric has repellency to grease.

**Oily or greasy products** should be removed from a garment by blotting with an absorbent cloth. Rubbing causes greater penetration and makes removal difficult.

Water- and stain-repellent finishes applied to fabrics used in garments are durable to at least three to seven mild launderings or drycleanings.

Sometimes silicone-finished garments appear to have lost their water repellency during laundering, but generally it can be revived by a more thorough rinsing to remove all the detergent. Ironing also helps revive the repellency. The water and stain repellents generally used on upholstery fabrics are not durable to repeated laundering, however.
A **flame-resistant** fabric is one that does not continue to flame when it is removed from the source of ignition.

Such fabrics are needed in garments worn by workers exposed to flames or sparks; in combat clothing, tents, awnings, draperies, and upholsteries used in places of public assembly; hospital bed linens; and in clothing for children and elderly persons who live in homes that are heated with open flames.

When cotton burns, the cellulose is broken down into volatile liquids or tar and gases that support the flame. Cotton is made flame resistant by chemicals that alter the course of the decomposition and produce less flammable volatile material and more char. A flame-resistant fabric should also be glow-resistant, but all are not. Certain phosphorous compounds are outstanding antiglow agents for cellulose as well as excellent flame retardants. A good flame and glow retardant should not reduce the strength of fabric or adversely affect drape, color, or abrasion resistance.

**Flame retardants** are nondurable or durable. The nondurable ones must be reapplied after treated fabrics are laundered, dry cleaned, or exposed to water leaching.

Two good nondurable flame-retardant formulations are 7 ounces of borax and 3 ounces of boric acid dissolved in 2 quarts of warm water; 12 ounces of diammonium phosphate dissolved in 2 quarts of water. Flame resistance is imparted by wetting cotton fabrics with either solution and then drying them.

(Details for the preparation and application of nondurable flame retardants can be obtained from the Department of Agriculture by writing for leaflet number 454.)

A type of durable flame retardant used extensively for tents and tarpaulins contains antimony oxide and chlorinated paraffins. They generally glow for about a minute or longer unless a phosphorous compound is added. The formulations also generally contain pigments to provide color and screen light, a biocide, and a water repellent. Flame retardants of this type increase the weight of the fabric about 60 percent or more.

Scientists in the Department of Agriculture developed a number of durable flame retardants based on the use of tetrakis (hydroxymethyl) phosphonium chloride, which is usually referred to as THPC.

Processes based on THPC are suitable for cotton apparel, such as uniforms, work clothes, ladies' and children's clothes, and for household and institutional products, such as draperies, sheets, and pajamas.

In the best processes, a nitrogenous compound is used to react with THPC to improve the efficiency and durability of the flame-retardant finish. These flame retardants are durable to laundering and to dry cleaning. Some impart a moderate degree of dimensional stability and wash-wear properties. Most impart mildew and rot resistance. All of them have antiglow properties.

An outstanding flame retardant is based on THPC in combination with tris (1-aziridinyl) phosphine oxide (APO), referred to as APO–THPC flame retardant. Some fabrics, such as those in work uniforms, can be made flame resistant with as little as 12 percent weight increase of APO–THPC, whereas about 16 percent is required on the same type of fabric for the THPC finish. APO–THPC can also be used on lightweight goods, such as fabrics used in pajamas or sheets.

**Heat-resistant** cotton fabrics resist scorching when heated at temperatures that normally scorch cotton fabrics, but they are not flame resistant. Moist heat causes more degradation than dry heat, but a completely wet fabric is degraded least of all.

Heat-resistant fabrics are needed for ironing board covers, for hot-head presses, and for other industrial uses. One way of making cotton resistant to
heat is by chemically blocking some of the hydroxyl groups in the cellulose.

At present, this method provides two chemically modified cottons with outstanding heat resistance. One is acetylated cotton. The other modified cotton is cyanoethylated cotton. Ironing board and commercial laundry press covers made of acetylated cotton fabric last three to five times longer than covers made from untreated cotton. The acetylated cotton does not stick to an iron and does not require special care.

Moderate heat resistance is exhibited by most easy-care or wash-wear cottons and by fabric treated with various additive-type chemicals, such as dicyandiamide. They are generally less expensive than the acetylated cotton but wear out sooner.

Warm garments that weigh less are welcomed by almost everyone. This advantage is one of several provided by foamback fabrics.

Textile goods composed of a rubbery foam, usually polyurethane, bonded to a fabric or between two fabrics are called foamback fabrics. Because of the construction, they are sometimes called two-faced fabrics, sandwich laminates, and bonded foam fabrics.

The polyurethane foam can vary in density, flexibility, and thickness. It is resilient and elastic. It is dimensionally stable.

Cotton, cotton blends, and almost any other textile fiber may be bonded to polyurethane foam. The fabrics may be knit or woven goods. They are bonded to the foam by an adhesive or by the foam itself after it is softened by heating.

Foamback fabrics have great possibilities, particularly for winter garments. They generally have wrinkle resistance, dimensional stability, shape retention, and insulating properties and can provide additional body without much increase in weight.

Some of the sandwich-type structures have a knit fabric on one side and a woven fabric on the other, with the foam in between. One side may even be a fleece fabric. Bonding stretch fabrics to the elastic foam produces particularly attractive apparel.

Polyurethane foams have been used as backing for carpets and rugs. Newer uses for foambacks include tablecloths, mats, and slipcovers for furniture.

You may have noticed the new and brighter colors of apparel. They are produced by new classes of dyes that can react with cellulose to form primary valence bonds. Older coloring substances are held in the cotton by various other means, such as by hydrogen bonds, by deposition of insoluble particles, and by resin bonding of pigments.

The new colors are used extensively. They are less resistant to fading by light than some of the older and duller colors are, but they have adequate resistance for the life of most garments.

Fluorescent brightening agents, which are chemicals closely related to dyes, are used on cotton fabrics to make white fabric whiter and colored clothes brighter. These brightening agents are added to most laundry detergents. They reduce the amount of bleach needed in the laundering of white goods.

Stretch cotton lace can be made by slack mercerization, which converts inexpensive lace into goods having much more three-dimensional character as well as good stretch and recovery. This is a timely development for cotton, because lace is again becoming fashionable.

Laboratory methods have been developed for the production of stretch yarn that can be woven or knit into items such as sweaters.

Fabrics that soil less and are more easily cleaned are being developed to make household chores easier. For example, the factor most conducive to reduced soiling and easier soil removal is the attachment of anionic groups to cellulose.

Also of value to most consumers is
cotton with more luster. Progress has been made: New laboratory products exhibit a desirable degree of luster, but more basic research and developmental work must be completed before we can expect to see this development in wide use.

Fabrics with bactericidal properties are becoming available, especially for apparel and bed linens used in hospitals. This property is imparted by treating fabrics with bactericides that are slowly released during use.

Research has begun to develop bulky, warm cotton fabrics for fall and winter use. The bulk would be obtained by modifying yarn and fabric structures rather than by bonding the fabric to a polyurethane foam. (Wilson A. Reeves)

Wool

Cloth and clothing made of wool are good looking, soft, comfortable, relatively soil resistant, easy to clean and tailor, and flame resistant.

Nevertheless, manmade—synthetic—fibers have become popular because they are easy to care for, resistant to shrinkage and moths, more resistant to wear, and quick to dry.

Because wool is a major agricultural product, we in the Department of Agriculture naturally would like to see wool keep its proper share of the textile market. We therefore have developed new knowledge of the structure and properties of wool. We have developed ways to treat and modify it with new and cheaper chemicals that build superior and durable properties into wool with relatively little treatment and little sacrifice of its natural qualities.

One development is the Wurlan treatment, which was designed primarily to reduce the amount of shrinkage in machine laundering. The treated fabrics also are more resistant to pilling and abrasive wear. They are stronger and more dye-fast than wools treated by earlier shrink-proofing treatments.

The first part of the word "Wurlan" are the initials of the Western Utilization Research and Development Division of the Department of Agriculture, where the process was discovered.

Wurlan-treated woven fabrics have come into large-scale commercial use as machine launderable yard goods, men’s sport shirts, and women’s and children’s wear. The name "Wurlan" does not appear on any wool product on the market, because manufacturers prefer to use their own labels.

Like chemically modified cottons, Wurlan-treated fabrics are slightly altered in the feel to the hand. The change is described as "slightly more crisp." The amount of change depends on the level of treatment given, and that depends on the weave of the fabric.

The Wurlan treatment employs the same chemicals used to make nylon fibers. The basic principle used is called interfacial polymerization.

The chemicals react to form ultra-thin resin films, surrounding and chemically grafted to each wool fiber so that they withstand washing and drycleaning.

Even though the total weight added to the wool by the film is generally 1 percent or less, the resistance to felting shrinkage on laundering of the treated wools is comparable to that of blends containing at least 50 percent of manmade fibers.

Obviously, the small amount of chemicals in the modified wools is an advantage for wool. Since the films anchored to the wool are so thin, there is relatively little change in the desirable properties of wool. For example, the moisture uptake of treated wools is essentially the same as that of normal wool.

Garments made from treated goods