THE WET PROCESSING OF COTTON
SCOURING, BLEACHING, DYEING, & FINISHING

Cotton as received from the gin contains impurities. The chemical composition of raw cotton fibers is as follows: Some cotton may contain more trash. Other impurities may also be picked up during the mechanical processing of the cotton, though one of the purposes of the mechanical processing is to remove some of the trash particles and other loose dirt.

The majority of wet processing of cotton is done on yarn and fabrics either woven or knit.

Cotton yarns contain the impurities as shown above. Knit fabrics contain the above impurities, as well as oil from the knitting machine and sometimes graphite and other dirt picked up from dirty knitting machines. Thus it is imperative that the knitting machines be kept clean and separated from machines knitting colored yarn to prevent colored particles from contaminating other fabrics. Woven fabrics, in addition to the natural impurities, contain a sizing material which must be removed prior to further wet processing.

CHEMICAL COMPOSITION OF RAW COTTON

Constituents	Percent Typical (*Dry Basis)	Low	High
Cellulose	94.0	88.0	96.0
Protein**	1.3	1.1	1.9
Pectic Substances	0.9	0.7	1.2
Ash	1.2	0.7	1.6
Wax	0.6	0.4	1.0
Malic, Citric, & Other Organic Acids	0.8	0.5	1.0
Total Sugars	0.3	-	-
Pigment	Trace	-	-
Other	0.9	-	-

* Moisture regains about 8%.

** Calculated by multiplying the nitrogen content by 6.25.

COTTON YARN

Scouring

- Cotton yarn: Most cotton yarn is processed in the package form due to its ease of handling and the economics involved. Some yarn is processed in the skein form, which is more labor intensive.

  The cotton yarn may be scoured by: Detergent and hot water (90° C) for 15 to 30 minutes. This will assist in removing natural dirt and waxes and some of the other impurities, but it will not remove any trash in the cotton. Additives such as soda ash, caustic soda, sequestering agents, and sometimes a small amount of acetic acid may be added to the scouring liquor.

  Prior to bleaching, the cotton yarn may or may not be scoured. In order to destroy the trash, the cotton yarn is scoured using 4.00% caustic soda on the weight of the yarn. This softens the trash so that in the subsequent bleaching the trash is removed. A more economical method is one step scour and bleach which destroys the trash as well as makes a good white yarn.

  A typical bleach formula may be as follows:
  1.00% Detergent
  4.00% Caustic Soda
  2.00% Sodium Silicate 42° Be
  7.00% Hydrogen Peroxide (35%)

  Bleach at 90°-100° C for 1 to 1½ hours, then hot rinse and neutralize with acetic acid.

  Another popular bleach is the use of sodium hypochlorite which gives a good white and is economical. (0.5-3 grams/liter of available chlorine)

  The purpose of bleaching is two fold. One is to produce a yarn that is trash free and produces a good white, and the other is to produce a trash free yarn that is good for dyeing both light colors and bright colors.

  Another wet process is mercerizing. Mercerizing uses a 20% caustic soda solution. The yarn in skein form is soaked in the caustic solution while under tension. The mercerizing process produces a cotton yarn that is both stronger and lustrous in appearance.

KNIT FABRICS

In addition to the natural impurities that are in the cotton fiber, the knit fabric may pick up oils used in the lubrication of the knitting machine. If the oil is not removed in the scouring process, splotchy dyeing could occur.

Scouring

If the knit fabric is fairly clean, then a detergent scour is done. If the fabric contains knitting oil, then a solvent based detergent scour is necessary. The scouring and bleaching when done in batch form is similar to that done in the yarn form. However, there are machines in which bleaching is done continuously.

WOVEN FABRICS

Desizing, Scouring, Bleaching, and Mercerizing

Since the majority of woven fabrics contain some type of sizing material, it is essential that the fabric be desized prior to scouring and bleaching. The chemicals used in desizing will vary depending upon the type of size used. For starch sizes, an enzyme is used to convert the starch to be water soluble so that it may be washed out of the fabric. Woven fabrics are processed either in the batch form or are processed continuously. A typical sequence for the continuous method would be as follows: brush, singe, desize, scour, and bleach. Mercerization may take place before or after scouring and bleaching.

Depending upon the end use and type of fabric the brushing and singeing may not be done as well as bleaching and mercerizing. The two main processes would be the desizing and scouring.

For batch processing, the most common steps in processing would be the desizing and scouring. Bleaching may or may not be done, and mercerization is not usually done on fabrics processed in the batch form.

DYEING

In order to achieve good dyeing, properly prepared yarn or fabric is necessary. Thus it is important to follow the previously discussed procedures so that the dyeing will be uniform with no unlevelness or splotches.

- **Selection of the Dye**

  The end use is usually the determining factor in the selection of the dyes used. There are several classes of dyes used in dyeing cotton. They are as follows:

  A. Direct Dyes
  Fastness Properties: Wash fastness-poor except in light shades where they are satisfactory using mild washing procedures. Light fastness-poor to excellent.
  Uses: Cheap cotton fabrics where fastness is not a concern, light colors in knit fabrics for apparel use, and home furnishing fabrics for upholstery and drapes. Excellent light fastness using selected dyes and fast to dry cleaning and shampooing using a cold procedure.

  B. Reactive Dyes
  Fastness Properties: Wash fastness-good except when chlorine is used in washing. Light fastness is poor to very good.
  Uses: Apparel fabrics where good wash fastness is necessary, able to use reactive dyes where brightness is necessary, for instance, kelly greens, bright purples, reds, and oranges.

  C. Vat Dyes
  Excellent all around fastness properties for both light fastness and wash fastness. Fast to washing in chlorine washing.
  Uses: Apparel fabrics, upholstery fabric, able to produce a complete line of colors but cannot get the brightness obtained from reactive dyes.

  D. Sulfur Dyes
  Good wash and light fastness except when using chlorine in washing.
  Uses: Apparel fabrics, limited range of colors, mainly used for black and navy colors.

Type of Dye	Light Fastness	Wash Fastness
Direct Dye	Poor to Excellent	Poor
Reactive Dye	Fair to Excellent	Good
Sulfur Dye	Good	Good
Vat Dye	Excellent	Excellent

APPLICATION

Direct Dyes

Applied by the exhaust method for the most part. The application of direct dyes to cotton is simple and straight forward. On the prepared cotton, using the exhaust method, the dye is added to the dyebath. The temperature is then raised to 90° C, and common salt is added slowly and run an additional 45 minutes. The dyeing is then rinsed clean.

Reactive Dyes

Applied by the exhaust, semi-continuous, and continuous methods.
Exhaust Method: All in method, add salt, alkali, and dye to the dyebath. Raise the temperature and run for one hour. Rinse clean, then hot wash at 85° C, then rinse clean. The hot wash is required to remove any unreacted dye.

Semi-Continuous Method: The fabric is padded with a pad solution containing dye and alkali, then rolled. Let stand the required amount of time. The time on the roll allows the reactive dye to react with the cellulose. After the required amount of time, the fabric is then rinsed, hot washed, and rinsed.

Continuous Method: The most simple method is to pad the fabric with the dye and alkali, then steam, rinse, hot wash, and rinse.

Vat Dyes

Applied by the exhaust and continuous methods.
Exhaust Method: Vat dyes, being pigment dyes must be solubilized. This is done by the use of caustic soda and a reducing agent, usually sodium dithionite, commonly known as hydro (sodium hydrosulfite). The vat dye is added to the dyebath, then followed by the caustic soda and hydro and brought to the desired dyeing temperature. When the time is complete, the dyeing is rinsed, oxidized with acetic acid and hydrogen peroxide, and then soaped off with a detergent and soda ash.

Continuous Method: Prepare a pad solution with the vat dye, pad, and dry. Then chemical pad with caustic soda and hydro. Steam, wash, oxidize, wash, boil off, wash, and dry.

Sulfur Dyes: These dyes are similar to vat dyes in that they are in the pigment form and must be solubilized by using soda ash and a reducing agent based on sodium sulfide. They may be dyed by both exhaust and continuous methods.

FINISHING

There are two types of finishes done on cotton fabrics: Mechanical and Chemical. Some typical mechanical finishes would be brushing, napping, shearing, and calendering.

Chemical Finishing

Softeners and lubricants are added to the final rinse bath in yarn dyeing so that the yarn is easier to knit. On fabrics, softeners and lubricants may be added for fabrics that are to be napped. Also, starches may be applied to fabrics that are to be calendered to produce a better sheen and hand.

One of the most used chemical finishes is the use of resins to improve the wrinkle resistance of cotton fabrics so that they may be washed and dried without wrinkling and do not have to be ironed.

Chemical finishing may be used to give a soft hand to the fabric, a stiffer hand, or give more body to the fabric. It may also be used to produce wrinkle resistant wash and wear fabrics. Fabrics may be treated for soil and oil resistance in upholstery, fabrics, and work clothes. The most commonly used type of chemical for this type of treatment are the fluoro chemicals such as Scotchguard made by the 3M Company.

Cotton also may be chemically treated for water proofing and flame proofing.

Thus, we can see cotton is a versatile fiber where it can be scoured, bleached, dyed, and finished for a variety of end uses from cotton balls to industrial fabrics.

WET PROCESSING OF COTTON

The majority of wet processing of cotton is done on :

A. Yarn: Scour, Bleach, Mercerize.

B. Knit Fabric: Alkali Scour, Bleach, Mercerize.

C. Woven Fabrics: Desize, Alkali Scour, Bleach, Mercerize.

CHEMICAL USED IN WET PROCESSING

1. Detergent (Scouring and Wetting Agents)
2. Enzymes (Desizing Agents)
3. Alkalis (Soda Ash, Caustic Soda)
4. Hydrogen Peroxide, Sodium Hypochlorite, Sodium Silicate, Stabilizer

WET PROCESSING PREPARATION

1. **Woven Fabric**

Desize: X % Detergent
X % Enzyme (for starch sizes)
Hot water 90° C for 30 minutes
Rinse

Scour: X % Detergent
X% Caustic Soda, Soda Ash, or just detergent
Hot water 90° C for 30 minutes to 1 hour
Rinse

Bleach: (If desired) Typical Bleach Formula
1.0% Detergent
4.0% Caustic Soda
2.0% Sodium Silicate 42° Be (Stabilizer)
7.0% Hydrogen Peroxide (35°)
Bleach at 90° C for 1 to 1½ hours
Hot rinse and neutralize with acetic acid

Bleach: Sodium Hypochlorite
1.0% Detergent
.5-3 grams per liter of available chlorine
40° C to 75° C for 30-45 minutes

2. **Knit Fabric**
As above, but no desizing necessary.

3. **Yarn**
As above, but no desizing necessary.

MERCERIZATION

The fabric or yarn is soaked in a 20% caustic soda solution while under tension. This will produce a stronger and lustrous appearance of the yarn or fabric.

SELECTION OF DYES

There are several classes of dyes used in dyeing cotton. The end use is usually the determining factor in the selection of the dye used. The most common are:

- Direct Dyes
- Reactive Dyes
- Vat Dyes
- Sulfur Dyes

CHEMICALS USED IN DYEING

1. Detergents (wetting and leveling)
2. Salts (sodium sulfate)
3. Alkalis (soda ash, caustic soda, phosphate)
4. Lubricants
5. Acids (acetic acid)
6. Oxidizing Agents (hydrogen peroxide)
7. Reducing Agents (sodium hydrosulfate)

FINISHING

There are two types of finishes done on cotton fabrics.

Mechanical:

- Brushing
- Napping
- Shearing
- Calendering

Chemical:

- Softeners, lubricants (final rinse)
- Starch for fabrics that have to be calendered for better sheen and better hand
- Wrinkle resistant chemicals
- Water proofing
- Flame proofing or retardants

Finishing Formula for Cotton Fabric

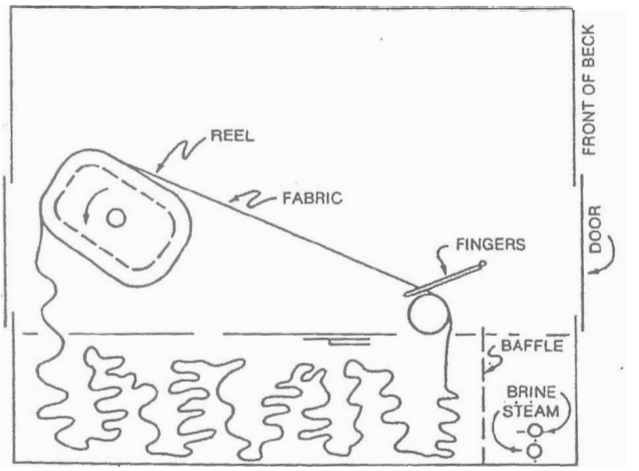
0.25%	Wet Aid Tergitol NP - 9
12.0%	Permafresh ULF (Durable Press Finish)
6.0%	Prym 119 (Stain Release)
2.0%	Sequa Soft 69 (Softener)
3.0%	Catalyst 531

NOTE: All percents are on the weight of the fabric - then bring up the total weight with the water.

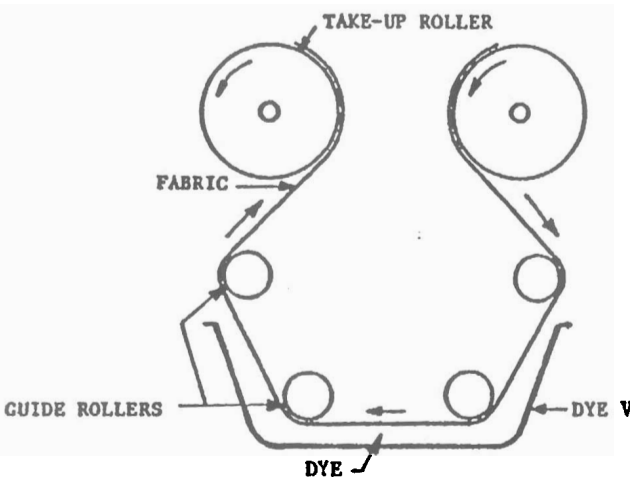
Finishing Formula for Cotton/Wool Fabric

0.25%	Wet Aid Tergitol NP - 9
12.0%	Permafresh ULF (Durable Press Finish)
4.0%	Sequa Soft 69 (Softener)
3.0%	Mykon HD (Provides excellent sewability and improves abrasion)
3.0%	Mykon 39 Softener
3.0%	Catalyst 531

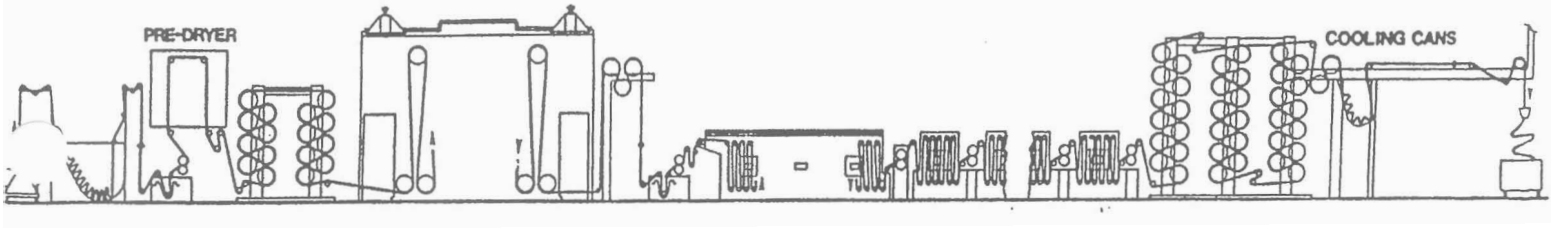
Pad at 3 psi
Dry at 110° C
Cure at 150° C



Dye Beck Schematic



Schematic of a jig machine.



THERMOSOL DYE RANGE

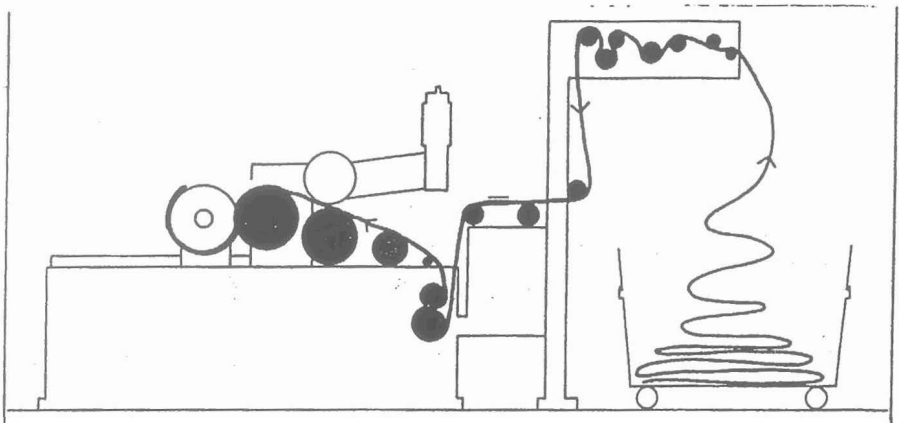


Fig. 1. Pad/batching unit.

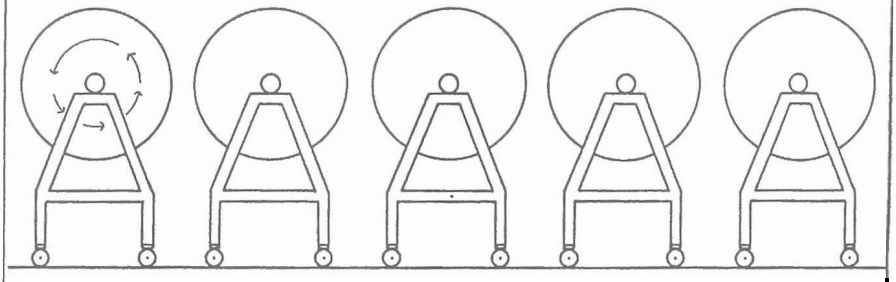


Fig. 2. Beam storage frames.

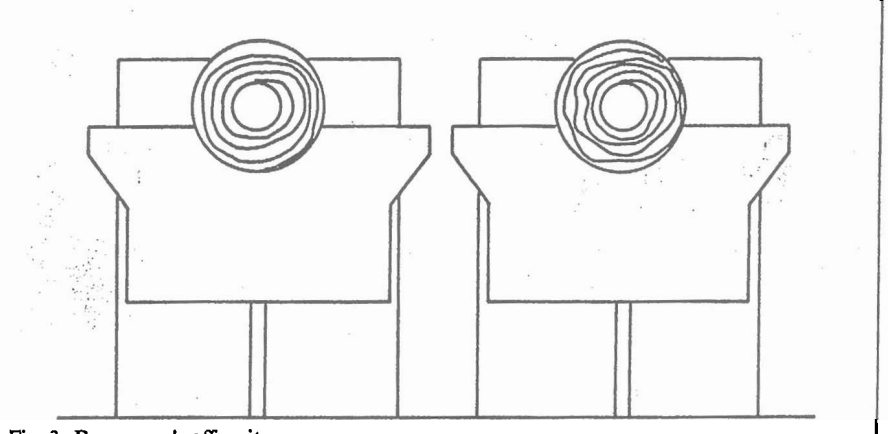


Fig. 3. Beam wash-off units

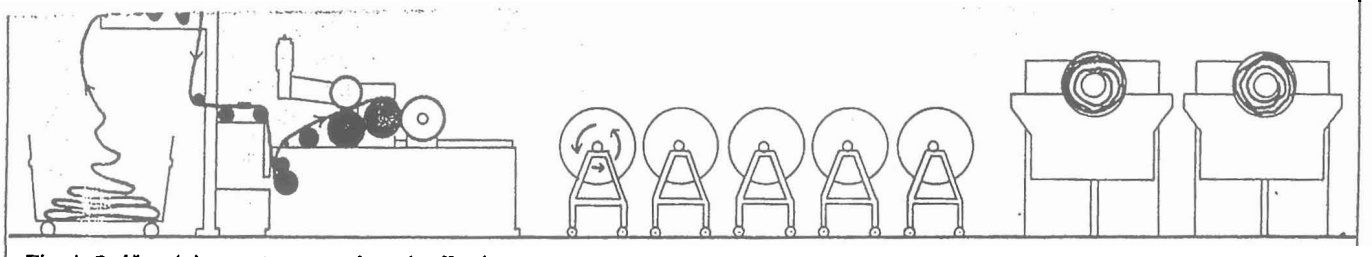


Fig. 4. Pad/batch-beam storage and wash-off unit.

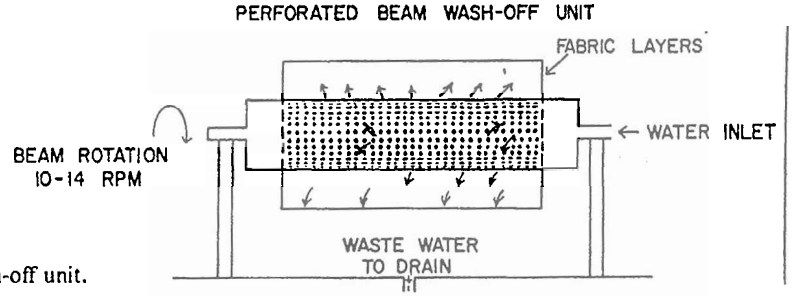
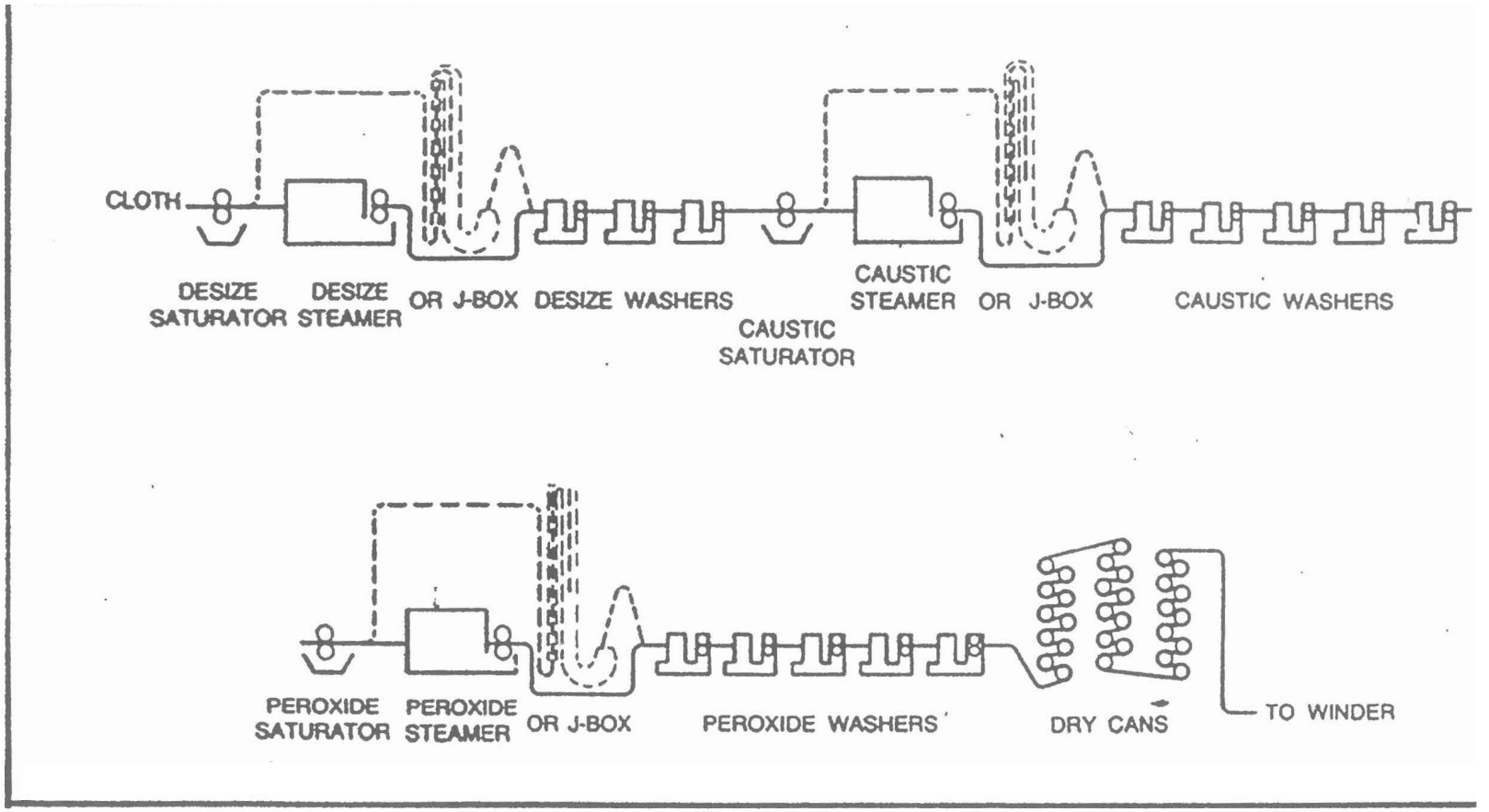


Fig. 5. Perforated beam wash-off unit.


CLOTH
DESIZE SATURATOR
DESIZE STEAMER
OR J-BOX
DESIZE WASHERS
CAUSTIC SATURATOR
CAUSTIC STEAMER
OR J-BOX
CAUSTIC WASHERS
PEROXIDE SATURATOR
PEROXIDE STEAMER
OR J-BOX
PEROXIDE WASHERS
DRY CANS
TO WINDER

Water-cooled stainless steel rolls maintain the fabric in a flattened state as well as under control and parallel to the burners. Sparks and flames on the fabric are snuffed out as the rolls cool the fabric after each impingement. The rolls are adjustable in order to provide proper distances between the fabric and burners required to fulfill the process conditions for a given fabric.

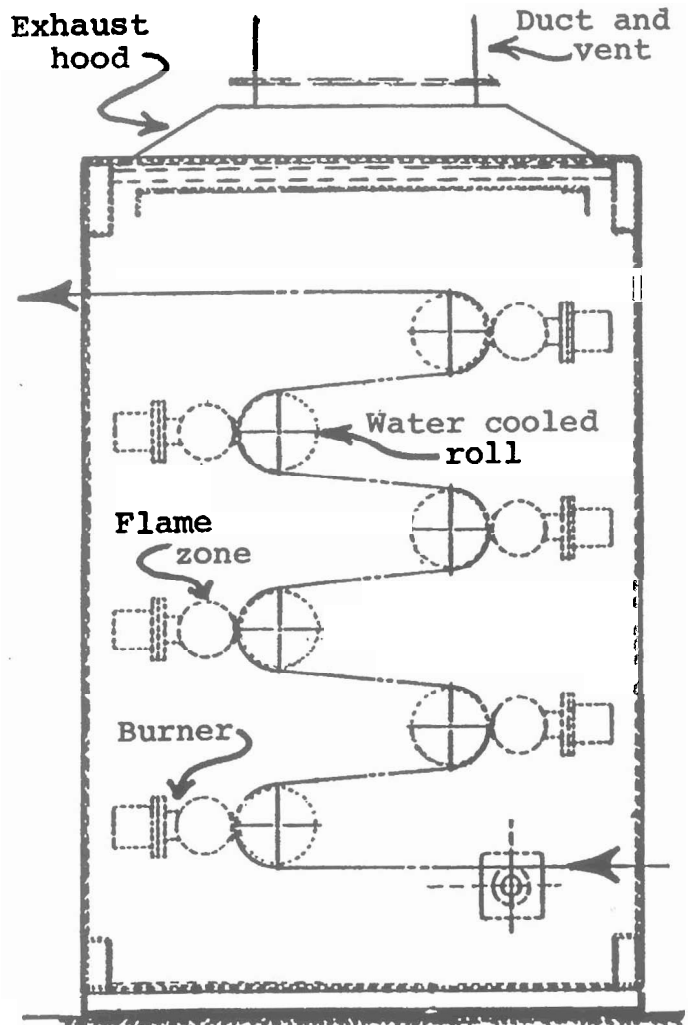


Figure 7.1: Schematic diagram of a singer showing its components and fabric travel. (Courtesy of Menzel Inc.)