Textile Engineering

Roxanna Cody

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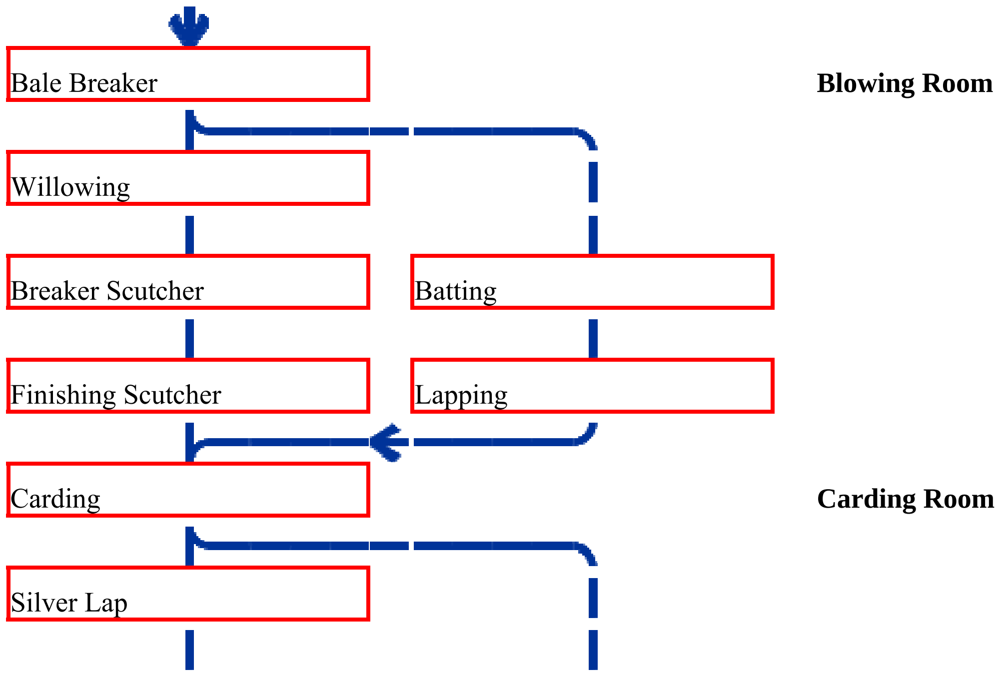
Chapter 1

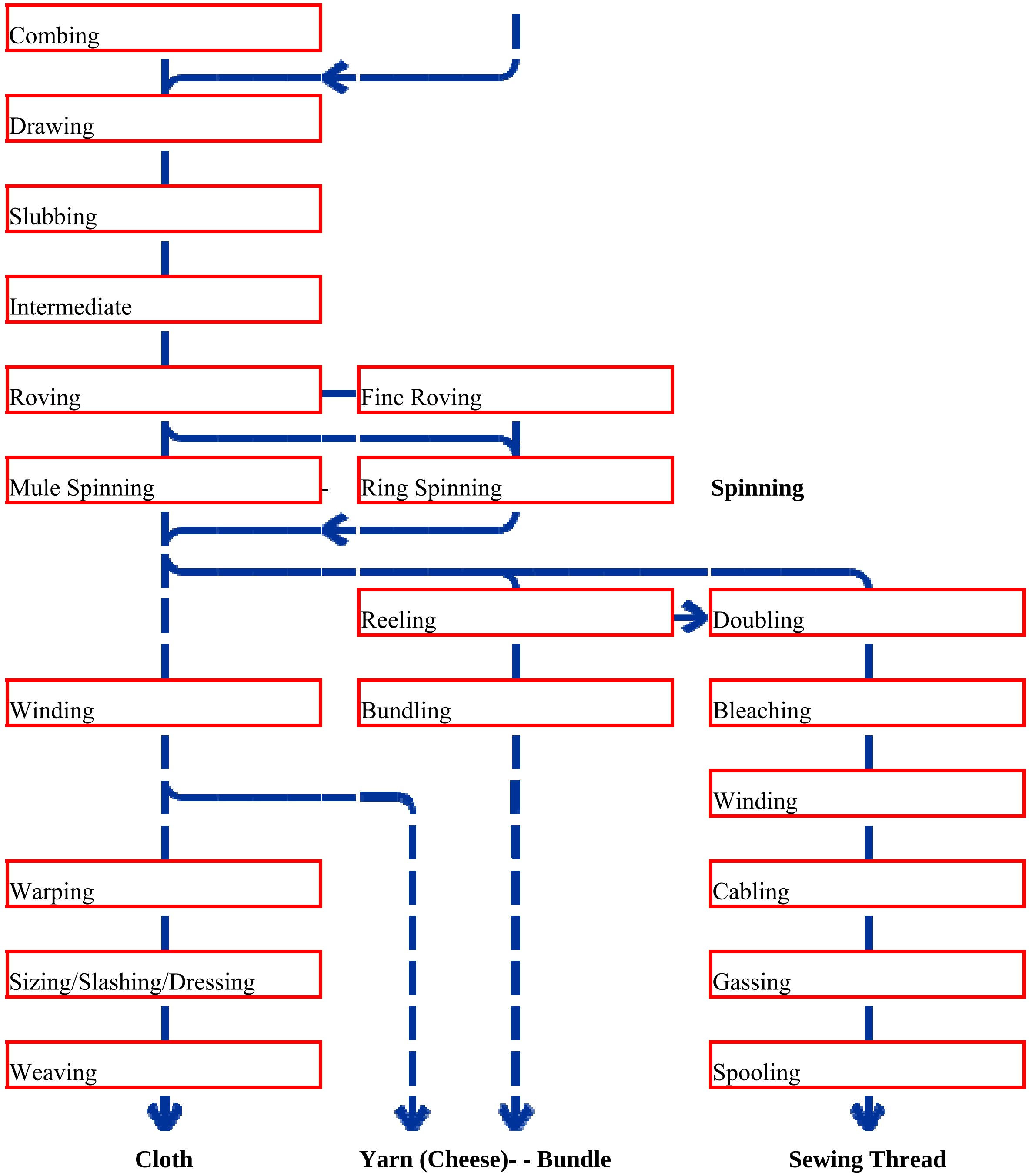
Textile Manufacturing

Textile manufacturing is a major industry. It is based in the conversion of three types of fibre into yarn, then fabric, then textiles. These are then fabricated into clothes or other artifacts. Cotton remains the most important natural fibre, so is treated in depth. There are many variable processes available at the spinning and fabric-forming stages coupled with the complexities of the finishing and colouration processes to the production of a wide ranges of products. There remains a large industry that uses hand techniques to achieve the same results.

Processing of cotton

Cotton Manufacturing Processes (after Murray 1911)





Cotton is the world's most important natural fibre. In the year 2007, the global yield was 25 million tons from 35 million hectares cultivated in more than 50 countries.

There are five stages

- Cultivating and Harvesting
- Preparatory Processes
- Spinning
- Weaving
- Finishing

Cultivating and harvesting

Cotton is grown anywhere with long, hot dry summers with plenty of sunshine and low humidity. Indian cotton, gossypium arboreum, is finer but the staple is only suitable for hand processing. American cotton, gossypium hirsutum, produces the longer staple needed for machine production. Planting is from September to mid November and the crop is harvested between March and May. The cotton bolls are harvested by stripper harvesters and spindle pickers, that remove the entire boll from the plant. The cotton boll is the seed pod of the cotton plant, attached to each of the thousands of seeds are fibres about 2.5 cm long.

- **Ginning**

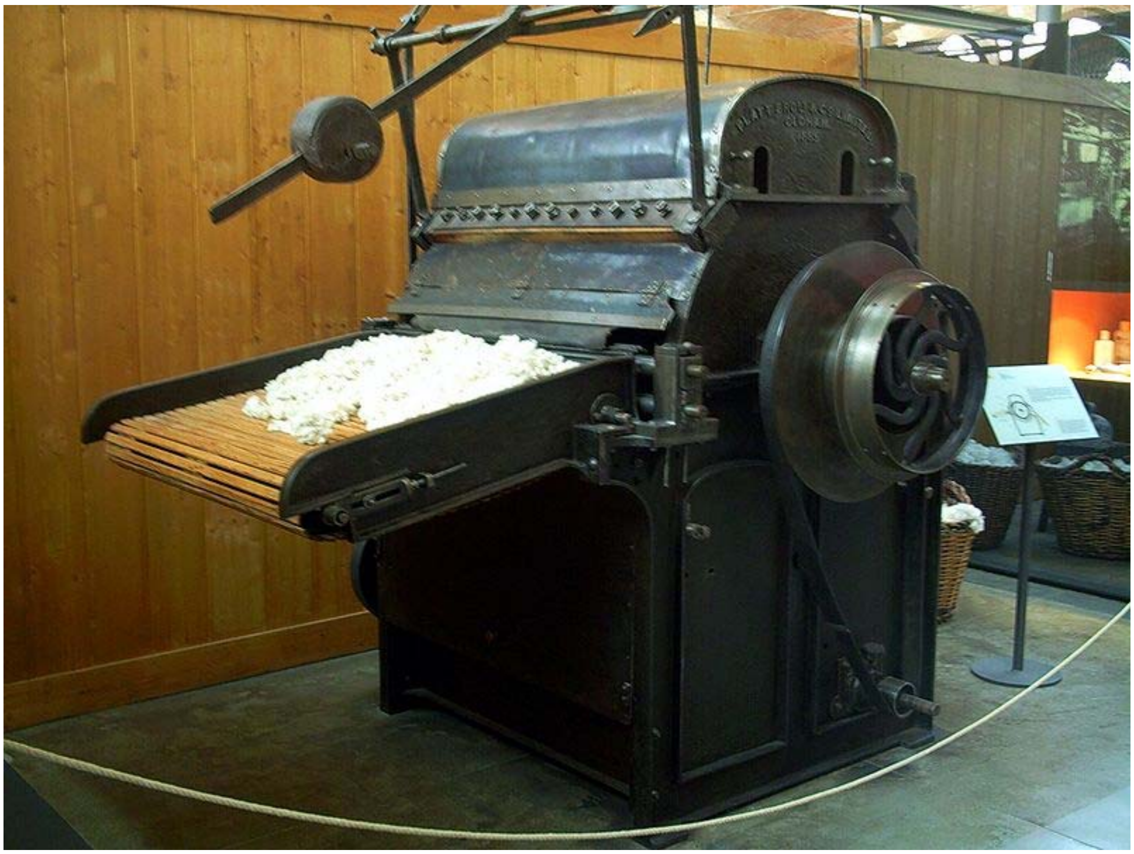
  The seed cotton goes in to a Cotton gin. The cotton gin separates seeds and removes the "trash" (dirt, stems and leaves) from the fibre. In a saw gin, circular saws grab the fibre and pull it through a grating that is too narrow for the seeds to pass. A roller gin is used with longer staple cotton. Here a leather roller captures the cotton. A knife blade, set close to the roller, detaches the seeds by drawing them through teeth in circular saws and revolving brushes which clean them away.
  The ginned cotton fibre, known as lint, is then compressed into bales which are about 1.5 m tall and weigh almost 220 kg. Only 33% of the crop is usable lint. Commercial cotton is priced by quality, and that broadly relates to the average length of the staple, and the variety of the plant. Longer staple cotton (2½ in to 1¼ in) is called Egyptian, medium staple (1¼ in to ¾ in) is called American upland and short staple (less than ¾ in) is called Indian.
  The cotton seed is pressed into a cooking oil. The husks and meal are processed into animal feed, and the stems into paper.

Issues

Cotton is farmed intensively and uses large amounts of fertiliser and 25% of the worlds insecticide. Native Indian variety were rainwater fed, but modern hybrids used for the mills need irrigation, which spreads pests. The 5% of cotton-bearing land in India uses 55% of all pesticides used in India. Before mechanisation, cotton was harvested manually and this unpleasant task was done by the lower castes, and in the United States by slaves of African origin.

Preparatory processes- preparation of yarn

- **Ginning, bale-making and transportation** is done in the country of origin.
- **Opening and cleaning**



Platt Bros. Picker

Cotton mills get the cotton shipped to them in large, 500 pound bales. When the cotton comes out of a bale, it is all packed together and still contains vegetable matter. The bale is broken open using a machine with large spikes. It is called an **Opener**.In order to fluff up the cotton and remove the vegetable matter, the cotton is sent through a picker, or similar machines. A **picker** looks similar to the carding machine and the cotton gin, but is slightly different. The cotton is fed into the machine and gets beaten with a beater bar, to loosen it up. It is fed through various rollers, which serve to remove the vegetable matter. The cotton, aided by fans, then collects on a screen and gets fed through more rollers till it emerges as a continuous soft fleecy sheet, known as a lap.

- **Blending**,

  Mixing & Scutching

Scutching refers to the process of cleaning cotton of its seeds and other impurities. A scutching machine for cotton was first invented in 1797, but didn't get much attention until it was introduced in Manchester in 1808 or 1809. By 1816 it had been generally adopted. The scutching machne worked by passing the cotton through a pair of rollers, and then striking it with iron or steel bars called beaters. The beaters, which turn very quickly, strike the cotton hard and knock the seeds out. This process is done over a series of parallel bars so as to allow the seeds to fall through. At the same time a breeze is blown across the bars, which carries the cotton into a cotton chamber.

- **Carding**

Carding machine

Carding: the fibres are separated and then assembled into a loose strand (sliver or tow) at the conclusion of this stage.

The cotton comes off of the picking machine in laps, and is then taken to carding machines. The carders line up the fibres nicely to make them easier to spin. The carding machine consists mainly of one big roller with smaller ones surrounding it. All of the rollers are covered in small teeth, and as the cotton progresses further on the teeth get finer (i.e. closer together). The cotton leaves the carding machine in the form of a sliver; a large rope of fibres.
Note: In a wider sense Carding can refer to these four processes: Willowing- loosening the fibres; Lapping- removing the dust to create a flat sheet or lap of cotton; Carding- combing the tangled lap into a thick rope of 1/2 in in diameter, a sliver; and Drawing- where a drawing frame combines 4 slivers into one- repeated for increased quality.

- **Combing** is optional,but is used to remove the shorter fibres, creating a stronger yarn.

A Combing machine

- **Drawing** the fibres are straightened

  Several slivers are combined. Each sliver will have thin and thick spots, and by combining several slivers together a more consistent size can be reached. Since combining several slivers produces a very thick rope of cotton fibres, directly after being combined the slivers are separated into rovings. These rovings (or slubbings) are then what are used in the spinning process.
  Generally speaking, for machine processing, a roving is about the width of a pencil.

  - Drawing frame: Draws the strand out
  - Slubbing Frame: adds twist, and winds on to bobbins
  - Intermediate Frames: are used to repeat the slubbing process to produce a finer yarn.
  - Roving frames: reduces to a finer thread, gives more twist, makes more regular and even in thickness, and winds on to a smaller tube.

Spinning- yarn manufacture

- **Spinning**

  The spinning machines take the roving, thins it and twists it, creating yarn which it winds onto a bobbin.
  In mule spinning the roving is pulled off a bobbin and fed through some rollers, which are feeding at several different speeds.This thins the roving at a consistent rate. If the roving was not a consistent size, then this step could cause a break in the yarn, or could jam the machine. The yarn is twisted through the spinning of the bobbin as the carriage moves out, and is rolled onto a cop as the carriage returns. Mule spinning produces a finer thread than the less skilled ring spinning.

  - The mule was an intermittent process, as the frame advanced and returned a distance of 5ft.It was the descendant of 1779 Crompton device. It produces a softer less twisted thread that was favoured for fines and for weft.
  - The ring was a descendant of the Arkwright water Frame 1769. It was a continuous process, the yard was coarser, had a greater twist and was stronger so was suited to be warp. Ring spinning is slow due to the distance the thread must pass around the ring, other methods have been introduced. These are collectively known as Break or Open-end spinning.

  Sewing thread, was made of several threads twisted together, or doubled.

- **Checking**

  This is the process where each of the bobbins is rewound to give a tighter bobbin.

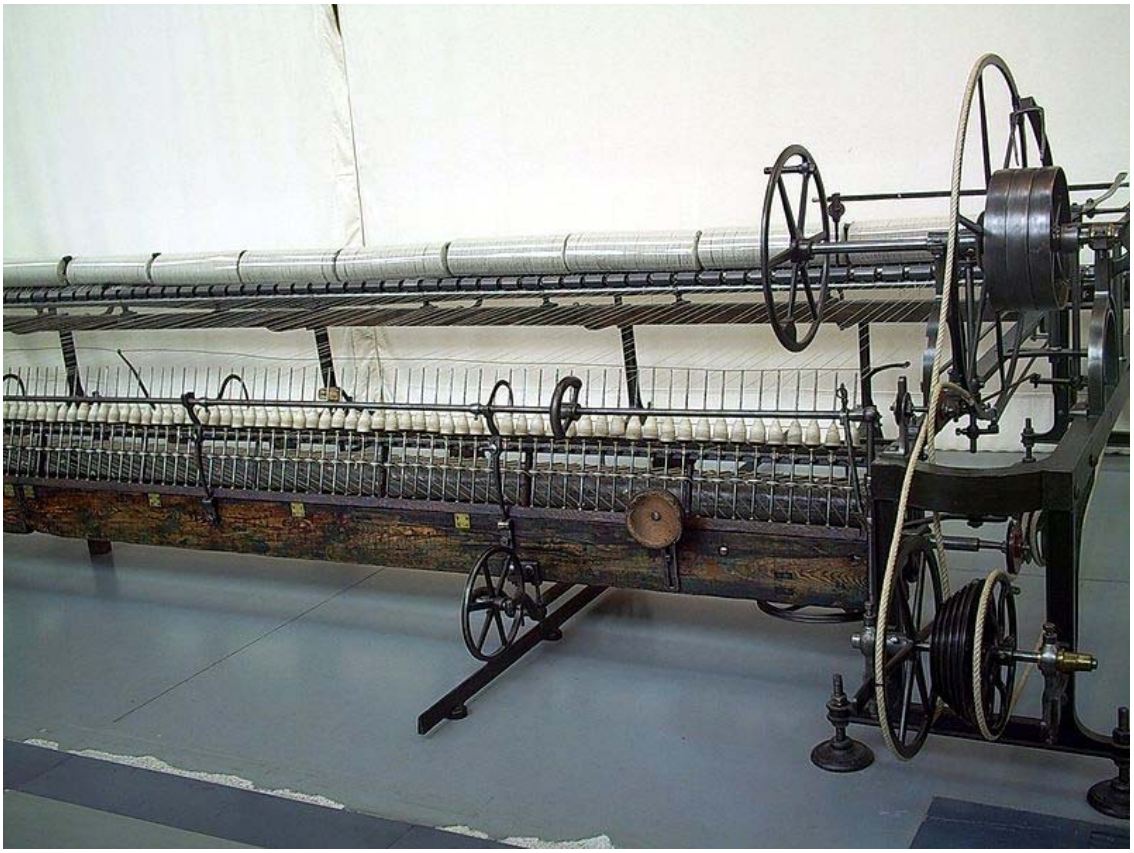
- **Folding and twisting**

  Plying is done by pulling yarn from two or more bobbins and twisting it together, in the opposite direction that in which it was spun. Depending on the weight desired, the cotton may or may not be plied, and the number of strands twisted together varies.

- **Gassing**

  Gassing is the process of passing yarn, as distinct from fabric very rapidly through a series of Bunsen gas flames in a gassing frame, in order to burn off the projecting fibres and make the thread round and smooth and also brighter. Only the better qualities of yarn are gassed, such as that used for voiles, poplins, venetians, gabardines, many Egyptian qualities, etc. There is a loss of weight in gassing, which varies' about 5 to 8 per cent., so that if a 2/60's yarn is required 2/56's would be used. The gassed yarn is darker in shade afterwards, but should not be scorched.

Mule spinning



Mule spinning

Ring spinning

Ring spinning

Measurements

- Cotton Counts: The number of pieces of thread, 840 yards long needed to make up 1 lb weight. 10 count cotton means that 10x840 yd weighs 1 lb. This is coarser than 40 count cotton where 40x840 yards are needed. In the United Kingdom, Counts to 40s are coarse (Oldham Counts), 40 to 80s are medium counts and above 80 is a fine count. In the United States ones to 20s are coarse counts.
- Hank: A length of 7 leas or 840 yards
- Thread: A length of 54 in (the circumference of a warp beam)
- Bundle: Usually 10 lb
- Lea: A length of 80 threads or 120 yards
- Denier: this is an alternative method. It is defined as a number that is equivalent to the weight in grams of 9000m of a single yarn. 15 denier is finer than 30 denier.
- Tex: is the weight in grams of 1 km of yarn.

The worsted hank is only 560 yd

Weaving-fabric manufacture

The weaving process uses a loom. The lengthway threads are known as the warp, and the cross way threads are known as the weft. The warp which must be strong needs to be presented to loom on a warp beam. The weft passes across the loom in a shuttle, that carries the yarn on a pirn. These pirns are automatically changed by the loom. Thus, the yarn needs to be wrapped onto a beam, and onto pirns before weaving can commence.

- **Winding**

  After being spun and plied, the cotton thread is taken to a warping room where the winding machine takes the required length of yarn and winds it onto warpers bobbins

- **Warping or beaming**

A Warper

  Racks of bobbins are set up to hold the thread while it is rolled onto the warp bar of a loom. Because the thread is fine, often three of these would be combined to get the desired thread count..

- **Sizing**

  Slasher sizing machine needed for strengthening the warp by adding starch to reduce breakage of the yarns .

- **Drawing in, Looming**

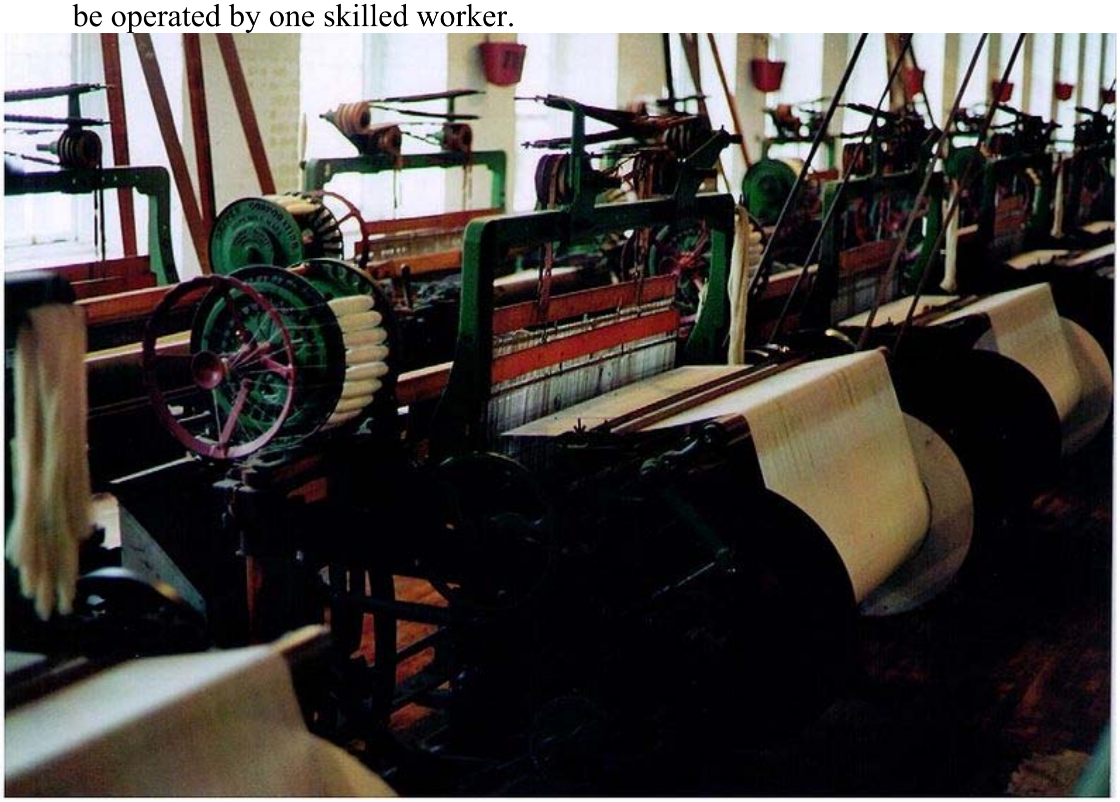
The process of drawing each end of the warp separately through the dents of the reed and the eyes of the healds, in the order indicated by the draft.

- **Pirning (Processing the weft)**

  Pirn winding frame was used to transfer the weft from cheeses of yarn onto the pirns that would fit into the shuttle

- **Weaving**

  At this point, the thread is woven. Depending on the era, one person could manage anywhere from 3 to 100 machines. In the mid nineteenth century, four was the standard number. A skilled weaver in 1925 would run 6 Lancashire Looms. As time progressed new mechanisms were added that stopped the loom any time something went wrong. The mechanisms checked for such things as a broken warp thread, broken weft thread, the shuttle going straight across, and if the shuttle was empty. Forty of these Northrop Looms or automatic looms could be operated by one skilled worker.



A Draper loom in textile museum, Lowell, Massachusetts

The three primary movements of a loom are shedding, picking, and beating-up.

- *Shedding*: The operation of dividing the warp into two lines, so that the shuttle can pass between these lines. There are two general kinds of sheds- "open" and "closed." Open Shed-The warp threads are moved when the pattern requires it-from one line to the other. Closed Shed-The warp threads are all placed level in one line after each pick.

- *Picking*:The operation of projecting the shuttle from side to side of the loom through the division in the warp threads. This is done by the overpick or underpick motions. The overpick is suitable for quick-running looms, whereas the underpick is best for heavy or slow looms.
- *Beating-up*: The third primary movement of the loom when making cloth, and is the action of the reed as it drives each pick of weft to the fell of the cloth.

The Lancashire Loom was the first semi-automatic loom. Jacquard looms and Dobby looms are looms that have sophisticated methods of shedding. They may be separate looms, or mechanisms added to a plain loom. A Northrop Loom was fully automatic and was mass produced between 1909 and the mid 1960s. Modern looms run faster and do not use a shuttle: there are air jet looms, water jet looms and rapier looms.

Measurements

- Ends and Picks: Picks refer to the weft, ends refer to the warp. The coarseness of the cloth can be expressed as the number of picks and ends per quarter inch square, or per inch square. Ends is always written first. For example: *Heavy domestics are made from coarse yarns, such as 10's to 14's warp and weft, and about 48 ends and 52 picks.*

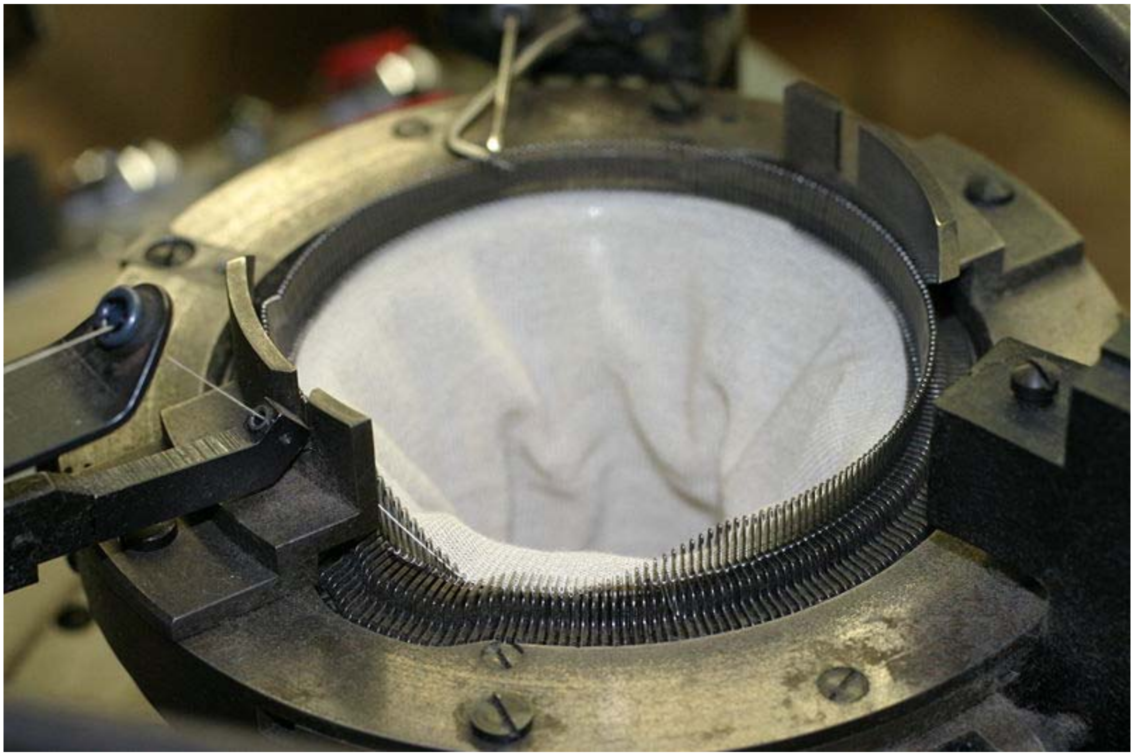
Associated job titles

- Piecer
- Scavenger
- Weaver
- Tackler
- Draw boy
- Pirner

Issues

When a hand loom was located in the home, children helped with the weaving process from an early age. Piecing needs dexterity, and a child can be as productive as an adult. When weaving moves from the home to the mill, children were often allowed to *help* their older sisters, and laws have to be made to prevent child labour becoming established,

Knitting- fabric manufacture



A circular knitting machine.

Close-up on the needles.

Knitting by machine is done in two different ways; warp and weft. Weft knitting (as seen in the pictures) is similar in method to hand knitting with stitches all connected to each other horizontally. Various weft machines can be configured to produce textiles from a single spool of yarn or multiple spools depending on the size of the machine cylinder (where the needles are bedded). In a warp knit there are many pieces of yarn and there are vertical chains, zigzagged together by crossing the yarn. Cotton

Warp knits do not stretch as much as a weft knit, and it is run-resistant. A weft knit is not run-resistant, but stretches more. This is especially true if spools of Lycra are processed from separate spool containers and interwoven through the cylinder with cotton yarn, giving the finished product more flexibility and making it less prone to having a 'baggy' appearance. The average t-shirt is a weft knit.

Finishing- processing of textiles

The **grey cloth**,woven cotton fabric in its loom-state, not only contains impurities, including warp size, but requires further treatment in order to develop its full textile potential. Furthermore, it may receive considerable added value by applying one or more finishing processes.

- **Desizing**

  Depending on the size that has been used, the cloth may be steeped in a dilute acid and then rinsed, or enzymes may be used to break down the size.

- **Scouring**

  Scouring, is a chemical washing process carried out on cotton fabric to remove natural wax and non-fibrous impurities (eg the remains of seed fragments) from the fibres and any added soiling or dirt. Scouring is usually carried in iron vessels called kiers. The fabric is boiled in an alkali, which forms a soap with free fatty acids. (saponification). A kier is usually enclosed, so the solution of sodium hydroxide can be boiled under pressure, excluding oxygen which would degrade the cellulose in the fibre. If the appropriate reagents are used, scouring will also remove size from the fabric although desizing often precedes scouring and is considered to be a separate process known as fabric preparation. Preparation and scouring are prerequisites to most of the other finishing processes. At this stage even the most naturally white cotton fibres are yellowish, and bleaching, the next process, is required.

- **Bleaching**

  Bleaching improves whiteness by removing natural coloration and remaining trace impurities from the cotton; the degree of bleaching necessary is determined by the required whiteness and absorbency. Cotton being a vegetable fibre will be bleached using an oxidizing agent, such as dilute sodium hypochlorite or dilute hydrogen peroxide. If the fabric is to be dyed a deep shade, then lower levels of bleaching are acceptable, for example. However, for white bed sheetings and medical applications, the highest levels of whiteness and absorbency are essential.

- **Mercerising**

A further possibility is mercerizing during which the fabric is treated with caustic soda solution to cause swelling of the fibres. This results in improved lustre, strength and dye affinity. Cotton is mercerized under tension, and all alkali must be washed out before the tension is released or shrinkage will take place. Mercerizing can take place directly on grey cloth, or after bleaching.
Many other chemical treatments may be applied to cotton fabrics to produce low flammability, crease resist and other special effects but four important non-chemical finishing treatments are:

- **Singeing**

  Singeing is designed to burn off the surface fibres from the fabric to produce smoothness. The fabric passes over brushes to raise the fibres, then passes over a plate heated by gas flames.

- **Raising**

  Another finishing process is raising. During raising, the fabric surface is treated with sharp teeth to lift the surface fibres, thereby imparting hairiness, softness and warmth, as in flannelette.

- **Calendering**

  Calendering is the third important mechanical process, in which the fabric is passed between heated rollers to generate smooth, polished or embossed effects depending on roller surface properties and relative speeds.

- **Shrinking (Sanforizing)**

  Finally, mechanical shrinking (sometimes referred to as sanforizing), whereby the fabric is forced to shrink width and/or lengthwise, creates a fabric in which any residual tendency to shrink after subsequent laundering is minimal.

- **Dyeing**

  Finally, cotton is an absorbent fibre which responds readily to colouration processes. Dyeing, for instance, is commonly carried out with an anionic direct dye by completely immersing the fabric (or yarn) in an aqueous dyebath according to a prescribed procedure. For improved fastness to washing, rubbing and light, other dyes such as vats and reactives are commonly used. These require more complex chemistry during processing and are thus more expensive to apply.

- **Printing**

  Printing, on the other hand, is the application of colour in the form of a paste or ink to the surface of a fabric, in a predetermined pattern. It may be considered as localised dyeing. Printing designs on to already dyed fabric is also possible.

Economic, environmental and political consequences of cotton manufacture

The growth of cotton is divided into two segments i.e. organic and genetically modified.. Cotton crop provides livelihood to millions of people but its production is becoming expensive because of high water consumption, use of expensive pesticides, insecticides and fertiliser. GM products aim to increase disease resistance and reduce the water required. The organic sector was worth $583 million. GM cotton, in 2007, occupied 43% of cotton growing areas..

The consumption of energy in form of water and electricity is relatively high, especially in processes like washing, de-sizing, bleaching, rinsing, dyeing, printing, coating and finishing. Processing is time consuming. The major portion of water in textile industry is used for wet processing of textile (70 per cent). Approximately 25 per cent of energy in the total textile production like fibre production, spinning, twisting, weaving, knitting, clothing manufacturing etc. is used in dyeing. About 34 per cent of energy is consumed in spinning, 23 per cent in weaving, 38 per cent in chemical wet processing and five per cent in miscellaneous processes. Power dominates consumption pattern in spinning and weaving, while thermal energy is the major factor for chemical wet processing.

Processing of other vegetable fibres- other processes

Flax

Flax is a bast fibre, which means it comes in bundles under the bark of the Linum usitatissimum plant. The plant flowers and is harvested.

- Retting
- Breaking
- Scutching
- Hackling or combing

It is now treated like cotton.

Jute

Jute is a bast fibre, which comes from the inner bark of the plants of the Corchorus genus. It is retted like flax, sundried and baled. When spinning a small amount of oil must be added to the fibre. It can be bleached and dyed. It was used for sacks and bags but is now used for the backing for carpets.

Now a recent days Jute-Cotton blended fabrics production processes is innovated by Bangladeshi scientists where Jute fibre are blended with cotton and fabricated for the production of various diversified products such as Home Textiles and different decorative fabrics. Dr.Siddique Ullah, Dr. Monjur-e-Khuda and others from BCSIR and BJRI (Bangladeshi Jute Research Institute) improve the chemical treatment method. In addition high value added shutting shirting are made from this fabric with definite woolenising, bleaching, dyeing, printing and finishing. This Jute-Cotton blended fabrics, in the 1970s, were known as Jutton fabrics.

Hemp

Hemp is a bast fibre from the inner bark of Cannabis sativa. It is difficult to bleach, it is used for making cord and rope.

- Retting
- Separating
- Pounding

Other bast fibres

These bast fibres can also be used: kenaf, urena, ramie, nettle.

Other leaf fibres

Sisal is the main leaf fibre used; others are: abacá and henequen.

Processing of protein fibres

Wool

Wool comes from domesticated sheep. It forms two products, woolens and worsteds. The sheep has two sorts of wool and it in the inner coat that is used. This can be mixed with wool that has been recovered from rags. Shoddy is the term for recovered wool that is not matted, while mungo comes from felted wool. Extract is recovered chemically from mixed cotton/wool fabrics.

The fleece is cut in one piece from the sheep.This is then skirted to remove the soiled wool, and baled. It is graded into long wool where the fibres can be up to 15 in, but anything over 2.5 inches is suitable for combing into worsteds. Fibres less than that form short wool and are described as clothing or carding wool.

At the mill the wool is scoured in a detergent to remove grease (the yolk) and impurities. This is done mechanically in the opening machine. Vegetable matter can be removed chemically using sulfuric acid (carbonising). Washing uses a solution of soap and sodium carbonate. The wool is oiled before carding or combing.

- Woollens: Use noils from the worsted combs, mungo and shoddy and new short wool

- Worsteds

Combing: Oiled slivers are wound into laps, and placed in the circular comber. The worsted yarn gathers together to form a top. The shorter fibres or noils remain behind and are removed with a knife.

- Angora

Silk

The processes in silk production are similar to those of cotton but take account that reeled silk is a continuous fibre. The terms used are different.

- Opening bales. Assorting skeins: where silk is sorted by colour, size and quality, scouring: where the silk is washed in water of 40 degrees for 12 hours to remove the natural gum, drying: either by steam heating or centrifuge, softening: by rubbing to remove any remaining hard spots.
- Silk throwing (winding). The skeins are placed on a reel in a frame with many others. The silk is wound onto spools or bobbins.

    - Doubling and twisting. The silk is far too fine to be woven, so now it is doubled and twisted to make the warp, known as organzine and the weft, known as tram. In organzine each single is given a few twists per inch (tpi), and combine with several other singles counter twisted hard at 10 to 14 tpi. In tram the two singles are doubled with each other with a light twist, 3 to 6 tpi. Sewing thread is two tram threads, hard twisted, and machine-twist is made of three hard-twisted tram threads. Tram for the crepe process is twisted at up to 80 tpi to make it 'kick up'.
    - Stretching. The thread is tested for consistent size. Any uneven thickness is stretched out. The resulting thread is reeled into containing 500 yd to 2500 yd. The skeins are about 50 in in loop length.
    - Dyeing: the skeins are scoured again, and discoloration removed with a sulphur process. This weakens the silk. The skeins are now tinted or dyed. They are dried and rewound onto bobbins, spools and skeins. Looming, and the weaving process on power looms is the same as with cotton.

- Weaving. The organzine is now warped. This is a similar process to in cotton. Firstly, thirty threads or so are wound onto a warping reel, and then using the warping reels, the threads are beamed. A thick layer of paper is laid between each layer on the beam to stop entangling.

Processing of man made fibres

Discussion of types of man made fibres

Synthetic fibres are the result of extensive development by scientists to improve upon the naturally occurring animal and plant fibres. In general, synthetic fibers are created by forcing, or extruding, fibre forming materials through holes (called spinnerets) into the air, thus forming a thread. Before synthetic fibres were developed, cellulose fibers were made from natural cellulose, which comes from plants.

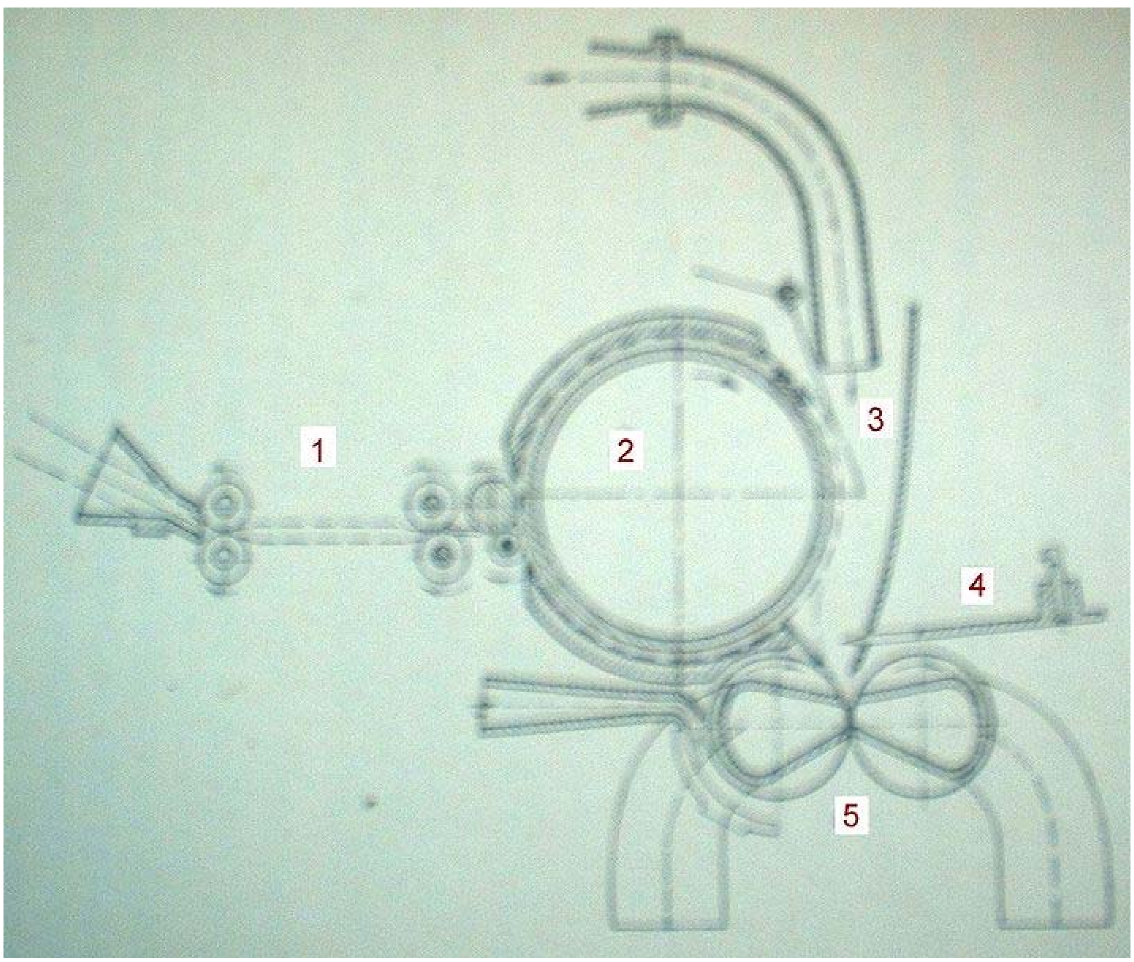
The first artificial fibre, known as art silk from 1799 onwards, became known as viscose around 1894, and finally rayon in 1924. A similar product known as cellulose acetate was discovered in 1865. Rayon and acetate are both artificial fibres, but not truly synthetic, being made from wood. Although these artificial fibres were discovered in the mid-nineteenth century, successful modern manufacture began much later in the 1930s. Nylon, the first synthetic fibre, made its debut in the United States as a replacement for silk, and was used for parachutes and other military uses.

The techniques used to process these fibres in yarn are essentially the same as with natural fibres, modifications have to be made as these fibers are of great length, and have no texture such as the scales in cotton and wool that aid meshing.

Chapter 2

Dref Friction Spinning

Dref Friction Spinning is a textile technology that allows very heavy count yarns and technical core-wrapped yarns to be manufactured. These are most commonly used in mop yarns, flame retardants and high tech fancy yarns such as Raydon and Kevlar.



Schema: Friktionsspinnen

Developer

Dr. Ernst Fehrer invented and patented the DREF friction spinning process in 1973, and named the system after himself. **DR E**rnst **F**ehrer – **DREF**. He had begun work on the development of this alternative to mule, ring and rotor open end spinning at the beginning of the decade with the objective of surmounting the physico-mechanical limits on capacity and yarn engineering and production speeds to which these traditional systems are subject.

Dr. Ernst Fehrer, chairman of Dr. Ernst Fehrer AG, Textilmaschinenfabrick, Linz-Leonding, Austria, died in December 2000 at age 81. Dr. Fehrer's long career in the development of nonwovens and spinning technology had produced more than 1000 patents. He began his career in research, development and inventing at age 14 and received his first patent at age 18. Dr. Fehrer developed the first high-speed needle loom featuring sophisticated counterbalancing technology as well as "Dref", the first commercially successful friction spinning systems. In 1988, Fehrer received the TAPPI Nonwovens Division Award for his outstanding contributions to nonwovens manufacturing technology. In 1994 Dr. Fehrer received Textile World's first Lifetime Achievement Award.

Development

By 1975, Dr. Fehrer already had Dref I in development, a three-head machine undergoing trials and in 1977 the first DREF 2 for the coarse yarn count range came onto the market. In view of its success, Dr. Fehrer then created the DREF 3, which was designed for the medium yarn count range and made its debut at the ITMA ’79 in Hanover, before entering serial production in 1981.

New generations of the DREF 2 followed in 1986 and 1994 and the DREF 3/96 was launched at the ITMA in Milan. The 1999 ITMA in Paris witnessed the arrival of the DREF 2000, the first of which was sold prior to the fair. Full production of the DREF 2000 commenced in the autumn of 1999 in co-ordination with presentations at the ATME, USA and the SIMAT in Argentina. In 2001, the DREF 2000 also went on display in Asia at the ITMA Singapore and in Central America at the EXINTEX, Mexico.

Fehrer entered co-operations with other professional textile companies to develop the technology. Rieter AG in Switzerland Rieter and Oerlikon Schlafhorst in Germany Oerlikon Schlafhorst. With this co-operation the last machine developed by DREF was the DREF 3000, which was available for testing in the new DREF facility at FEHRER headquarters in Linz, Austria in the autumn of 2001. In 2005 Saurer AG Saurer purchased Fehrer AG in 2005. In 2009 Fehrer shut the doors on the DREF factory altogether. The friction spinnning technology is now being developed further by Stewarts of America Stewarts of America, Inc., who manufacture parts for the original Fehrer Dref II, Dref III, Dref 2000 and Dref 3000 friction spinning machines.

DREF I

The first Dref machine, it was a three-headed research and development spinning machine. The fibres were opened with an opening roller and allowed to fall on a single perforated cylindrical drum slot ,which has negative pressure for fibre collection. The rotation of the drum impart twist to fibre assembly. The ratio of perforated drum to yarn surface is very large, hence the drum speed can be kept relatively low, even if one takes the unavoidable slippage into account. Due to the absence of positive control over the fibres assembly, slippage occurred between the fibre assembly and perforated roller, which reduced twist efficiency. Hence this development could not be commercialized.

DREF II

The Dref 2 was exhibited in the year 1975 at ITMA exhibition. The feasibility of using two perforated rotating cylinders, (as fibre collecting means), while at the same time the spinning-in of fibres into yarn occurred. It operates on the basis of mechanical/aerodynamic spinning system with an internal suction and same direction of drums rotation. Drafted slivers are opened into individual fibres by a rotating carding drum covered with saw tooth type wire clothing. The individualized fibres are stripped off from the carding drum by centrifugal force supported by an air stream from the blower and transported into the nip of two perforated friction drums where they are held by suction. The fibres are sub-sequentially twisted by mechanical friction on the surface of the drums. Suction through the perforations of the drums assists this process besides helping in the removal of dust and dirt, thereby contributing to production of cleaner yarn. The low yarn strength and the requirement of more number of fibres in yarn cross-section(minimum 80-100 fibres) were restricted the DREF-2 spinning with coarser counts (0.3–6s Ne).

DREF 2 friction spinning can be used for everything from asbestos substitutes and secondary carpet backing yarns, to technical products such as cartridges for liquid filtration.

At present, around 80 DREF 2 machines are spinning 30,000 t of yarns for liquid filtration. The main markets are Europe and the USA, where approximately 150 million filter cartridges are manufactured with DREF 2 yarns, or 65-70% of global production.

The leading US and European filter producers spin a wide range of DREF 2 PP-yarns at speeds of 160 – 180 m/min. One particular application is for PPFDA washed filters, which are employed in all types of industries including chemicals, pulp, paper, cosmetics, pharmaceuticals, nuclear power and electrical power. The filter is formed using polypropylene Meraklon fda fibre over a supporting core and can withstand up to 5 bar of differential pressure and temperatures of 80 °C. The filters come in all lengths from 4´´-40´´ and have filtration ratings of 1-150 micrometres.

DREF 2 is also used in friction spun yarns for drinking and industrial water, pure water and activated carbon filters. The yarns employed generally consist of PP fibres in the 3.3

dtex, 40 mm range, which are highly resistant to micro-organisms and have a wide scope of chemical applications.

Friction spun yarns offer 20–40% more air volume in the yarn and less flow resistance than flyer yarns, as well as up to twice the service life. The fibre structures are relatively random and subject to high degree of twist. The yarns offer great regularity and increased strength, while their round yarn cross-section ensures limited deformation under transverse load. Production costs can be cut by up to 50% through reduced preparation, spinning and personnel expenses. At present, 8,481 DREF 2 spinning heads manufacture approximately 318,000 metric tons of yarn annually in the Nm 0,5 - Nm 6 (2000 - 167 tex) yarn count range. 230 of these machines, with yearly yarn production of 80,100 metric tons, are employed in the cleaning cloth and mop sector.

Following the world market launch of the DREF 2 in 1977, leading cleaning cloth and mop manufacturers from Europe and overseas began to switch from conventional carded yarn operation to friction spinning.

This decision was influenced by the following notable advantages:

- Savings in material costs due to the use of 100% regenerated fibres, spinning waste and cotton waste blends.
- The economic and problem-free, high-performance processing of extremely short staple materials (10–20 mm staple length) through the feeding of a yarn core (e.g. 167 dtex, texturised, PES sub-standard filament), or of a core-sliver from PES regenerated fibres (instead of a yarn filament core).
- Reductions in personnel costs (simpler preparation as the material passes directly from the card to the spinning machine).
- Increased efficiency (up to 95%) due to greater bobbin weights of up to max. 8 kg and spinning without yarn breaks.
- Considerable increases in performance due to the production of heavier slivers with weights of up to 15 g/m.
- Greatly improved water absorbency capacity and improved retentive volume.
- Higher fabric weights and a cleaner cloth appearance.

Furthermore, DREF allowed the manufacture of both S- and Z-twist yarns with the same machine. This means that the cloth ends do not curl, which is a major advantage with regard to further processing on automatic sewing machines.

DREF cleaning rags and mop yarn production data

Sold spinning heads: 1335 Yarn count: Nm 1.2 Delivery speed: 200 m/min
Production/spinning head: 10 kg/hour Production/1335 spinning heads: 13,350 kg/hour
Production hours/year: 6000 Production/year: 80,100 t

DREF III

The DREF-3 machine was the next version of DREF 2 for improving the yarn quality. It came to the market in the year 1981. Yarns up to 18s Ne. can be spun through this system. This is a core-sheath type spinning arrangement. The sheath fibres are attached to the core fibres by the false twist generated by the rotating action of drums. Two drafting units are used in this system, one for the core fibres and other for the sheath fibres. This system produces a variety of core-sheath type structures and multi-component yarns, through selective combination and placement of different materials in core and sheath. Delivery rate is about 300 m/min.

DREF V

It was developed by Schalafhorst, Suessen and Fehrer Inc. The range of count to be spun from this system is from 16s to 40s Ne. Production speed was up to 200 m/min. The individualized fibres from a single sliver are fed through a fibre duct into the spinning nip at an angle to the yarn axis, so that they are stretched as far as possible, when fed into the nip. This spinning system was not commercialized due to various technical difficulties.

DREF 2000

Was first announced and demonstrated to the open market at ITMA in 1999. The DREF-2000 employs a rotating carding drum for opening the slivers into single fibres and a specially designed system being used for sliver retention. The fibres stripped off from front the carding drum by centrifugal force and carried into the nip of the two perforated spinning drums. The fibres are subsequently twisted by mechanical friction on the surface of the drums, which rotates in the same direction. The process assisted by air suction through the drum perforations. Insertion of twist in X or Y direction is possible without mechanical alterations to the machine. Yarns upto 14.5s Ne can be produced at speeds of 250 m/min.

DREF 3000

At the ITMA 2003, the first public appearance of the DREF 3000 was made. The yarn can be spun form 0.3Ne to 14.5Ne.The features of DREF 3000 included a drafting unit and opening head with infinitely variable drive control, spinning units with two infinitely variable suction spinning drums, take-off and winding units with infinitely variable speeds and filament guide with monitoring device. The drafting unit could handle all types of synthetic fibres, special fibres such as aramid, FR and pre-oxidized fibres, polyimides, phenol resin fibres (e.g. Kynol), melamine fibres (e.g. Basofil), melt fibres (e.g. PA, PES, PP), natural fibres (wool, cotton, jute, linen, flax, etc.), as well as glass fibres in blends with other materials. The DREF 3000 processes these fibres in the form of slivers composed of one type of fibre, or using slivers with differing fibre qualities at one and the same time. Slivers with a homogenous fibre mixture ccould also be employed. DREF 3000 core yarns offer high output, breakage-free spinning and weaving mill operation and thus up to 95% efficiency could be achieved with uniform yarn strength and elasticity, not to mention soft yarns with sufficient strength.

DREF 3000 multi-component yarns can be employed for a wide variety of products, which are utilised in the following areas:

- High-strength and FR protective clothing for the civil and military sectors.
- Fire blockers for the aerospace and object sectors.
- Cut-resistant textiles.
- Tent fabrics (military and civil), transport tarpaulins, sacks, covers and sun blinds.
- Fibre composites for the aerospace, automotive, mechanical engineering and construction
- industries.
- Woven filters for dry and wet filtration.
- Transport belts.
- Sealing belts.
- Interlinings for outerwear.
- Elastic yarns.
- Knits
- All types of technical textiles.

The multi-component yarns manufactured using DREF 3000 technology are mainly employed for technical textiles. They provide heat and wear protection, dimensional stability, suitability for dyeing and coating, wearer comfort, long service life and strength. Apart from their strength, DREF 3000 yarns are also notable for their abrasion-resistance, uniformity and excellent Uster values.

How Dref spinning works

Yarn formation in friction spinning system

The mechanism of yarn formation is quite complex. It consists of three distinct operations, namely: Feeding of fibres, Fibres integration and Twist insertion.

Feeding:

The individualized fibres are transported by air currents and deposited in the spinning zone. The mode of fibre feed has a definite effect on fibre extent and fibre configuration in yarn and on its properties. There are two methods of fibre feed 1) Direct feed and 2)Indirect feed. In case of direct feed, fibres are fed directly onto the rotating fibre mass that outer part of the yarn tail. In indirect feed, fibres are first accumulated on the in-going roll and then transferred to the yarn tail.

Fibres Integration:

The fibres through feed tube assembles onto a yarn core/tail within the shear field, is provided by two rotating spinning drums and the yarn core is in between them. The shear causes sheath fibres to wrap around the yarn core. The fibre orientation is highly dependent on the decelerating fibres arriving at the assembly point through the turbulent flow. The fibres in the friction drum have two probable methods for integration of incoming fibres to the sheath. One method, the fibre assembles completely on to perforated drum before their transfer to the rotating sheath. In the other method, fibres are laid directly on to rotating sheath.

Twist insertion:

There has been lot of deal with research on the twisting process in friction spinning. In friction spinning, the fibres are applied twist with more or less one at a time without cyclic differentials in tension in the twisting zone. Therefore, fibre migration may not take place in friction spun yarns. The mechanism of twist insertion for core type friction spinning and open end friction spinning are different,which are described below.

Twist insertion in core-type friction spinning:

In core type friction spinning, core is made of a filament or a bundle of staple fibres is false twisted by the spinning drum. The sheath fibres are deposited on the false twisted core surface and are wrapped helically over the core with varying helix angles. It is believed that the false twist in the core gets removed once the yarn is emerged from the spinning drums, so that this yarn has virtually twist less core. However, it is quite possible for some amount of false twist to remain in the fact that the sheath entraps it during yarn formation in the spinning zone.

Twist insertion in Open end type friction spinning

In open end type friction spinning the fibres in the yarn are integrated as stacked cone. The fibres in the surface of the yarn found more compact and good packing density than the axial fibres in the yarn.

Structure of the yarn tail:

The yarn tail can be considered as a loosely constructed conical mass of fibres, formed at the nip of the spinning drums. It is of very porous and lofty structure.The fibres rotating at very high speed.

Friction-spun yarns properties:

Friction spun yarns DREF yarns have bulky appearance (100-140% bulkier than the ring spun yarns).The twist is not uniform and found with loopy yarn surface. Friction spun yarns with high %age of core have high stiffness. Friction spun yarns are usually weak as compared to other yarns. The yarns possess only 60% of the tenacity of ring-spun yarns and about 90% of rotor spun-yarns. The increased twist and wrapping of the sheath over the core improve the cohesion between the core and sheath and within the sheath.

The breaking elongation ring, rotor and friction spun yarns have been found to be equal. Better relative tenacity efficiency is achieved during processing of cotton on rotor and friction spinning as compared to ring spinning system.

Depending on the type of fibre, the differences in strength of these yarns differ in magnitude. It has been reported that 100% polyester yarns, this strength deficiency is 32% whereas for 100% viscose yarns, it ranges from 0-25%. On the other hand, in polyester-cotton blend, DREF yarns perform better than their ring-spun counterparts. A 70/30% blend yarn has been demonstrated to be superior in strength by 25%. The breaking strength of ring yarns to be maximum followed by the rotor yarn and then 50/50 core-sheath DREF-3 yarn.

DREF yarns have been seen to be inferior in terms of unevenness, imperfections, strength variability and hairiness. DREF yarns occupy an intermediate position between ring-spun and rotor spun yarns as far as short hairs and total hairiness s concerned. For hairs longer than 3mm, the friction spun yarns are more hairy than the ring spun yarns. Rotor spun yarns show the least value in both the values. DREF yarns are most irregular in terms of twist and linear density while ring spun yarns are most even.

Textile technologists have studied the frictional behavior of ring, rotor, friction spun yarns of 59 and 98.4 Tex spun from cotton, polyester, viscose fibres, with varying levels of twist. The yarn to yarn and yarn to guide roller friction was measured at different sliding speeds and tension ratios. However for polyester fibres, the rotor spun yarn showed highest friction, followed by friction and ring spun yarns.

Advantages of Friction spinning system

The forming yarn rotates at high speed compare to other rotating elements. It can spin yarn at very high twist insertion rates (ie.3,00,000 twist/min). The yarn tension is practically independent of speed and hence very high production rates (up to 300 m/min) can be attainable. The yarns are bulkier than rotor yarns.

The DREF II yarns are used in many applications. Blankets for the home application range, hotels and military uses etc. DREF fancy yarns used for the interior decoration, wall coverings, draperies and filler yarn.

Chapter 3

Textile

Simple textile - magnified.

A **textile** or **cloth** is a flexible material consisting of a network of natural or artificial fibres often referred to as thread or yarn. Yarn is produced by spinning raw fibres of wool, flax, cotton, or other material to produce long strands. Textiles are formed by weaving, knitting, crocheting, knotting, or pressing fibres together (felt).

The words **fabric** and **cloth** are used in textile assembly trades (such as tailoring and dressmaking) as synonyms for *textile*. However, there are subtle differences in these terms in specialized usage. *Textile* refers to any material made of interlacing fibres.

Fabric refers to any material made through weaving, knitting, spreading, crocheting, or bonding that may be used in production of further goods (garments, etc.). *Cloth* may be used synonymously with *fabric* but often refers to a finished piece of fabric used for a specific purpose (e.g., *table cloth*).

History

Late antique textile, Egyptian, now in the Dumbarton Oaks collection.

This one has no tunic but is finely pleated, in the Fortuny manner, and falls in long lines, closely following the figure, to the floor"]] The discovery of dyed flax fibres in a cave in the Republic of Georgia dated to 34,000 BCE suggests textile-like materials were made even in prehistoric times.

The production of textiles is a craft whose speed and scale of production has been altered almost beyond recognition by industrialization and the introduction of modern manufacturing techniques. However, for the main types of textiles, plain weave, twill, or satin weave, there is little difference between the ancient and modern methods.

Incas have been crafting quipus (or *khipus*) made of fibres either from a protein, such as spun and plied thread like wool or hair from camelids such as alpacas, llamas, and camels or from a cellulose like cotton for thousands of years. Khipus are a series of knots along pieces of string. They have been believed to only have acted as a form of accounting, although new evidence conducted by Harvard professor, Gary Urton, indicates there may be more to the khipu than just numbers. Preservation of khipus found in museum and archive collections follow general textile preservation principles and practice.

Uses

Textiles have an assortment of uses, the most common of which are for clothing and containers such as bags and baskets. In the household, they are used in carpeting, upholstered furnishings, window shades, towels, covering for tables, beds, and other flat surfaces, and in art. In the workplace, they are used in industrial and scientific processes such as filtering. Miscellaneous uses include flags, backpacks, tents, nets, cleaning devices such as handkerchiefs and rags, transportation devices such as balloons, kites, sails, and parachutes, in addition to strengthening in composite materials such as fibreglass and industrial geotextiles. Children can learn using textiles to make collages, sew, quilt, and toys.

Textiles used for industrial purposes, and chosen for characteristics other than their appearance, are commonly referred to as *technical textiles.* Technical textiles include textile structures for automotive applications, medical textiles (e.g. implants), geotextiles (reinforcement of embankments), agrotextiles (textiles for crop protection), protective clothing (e.g. against heat and radiation for fire fighter clothing, against molten metals for welders, stab protection, and bullet proof vests). In all these applications stringent performance requirements must be met. Woven of threads coated with zinc oxide nanowires, laboratory fabric has been shown capable of "self-powering nanosystems" using vibrations created by everyday actions like wind or body movements.

Fashion and textile designers

Fashion designers commonly rely on textile designs to set their fashion collections apart from others. Armani, Marisol Deluna, Nicole Miller, Lilly Pulitzer, the late Gianni Versace, and Emilio Pucci can be easily recognized by their signature print driven designs.

Sources and types

Traditional Romanian table cloth, Maramureș.

Textiles can be made from many materials. These materials come from four main sources: animal (wool, silk), plant (cotton, flax, jute), mineral (asbestos, glass fiber), and synthetic (nylon, polyester, acrylic). In the past, all textiles were made from natural fibres, including plant, animal, and mineral sources. In the 20th century, these were supplemented by artificial fibres made from petroleum.

Textiles are made in various strengths and degrees of durability, from the finest gossamer to the sturdiest canvas. The relative thickness of fibres in cloth is measured in deniers. Microfibre refers to fibres made of strands thinner than one denier.

Animal textiles

Animal textiles are commonly made from hair or fur.

Wool refers to the hair of the domestic goat or sheep, which is distinguished from other types of animal hair in that the individual strands are coated with scales and tightly crimped, and the wool as a whole is coated with a wax mixture known as lanolin (aka wool grease), which is waterproof and dirtproof. Woollen refers to a bulkier yarn produced from carded, non-parallel fibre, while worsted refers to a finer yarn which is spun from longer fibres which have been combed to be parallel. Wool is commonly used for warm clothing. Cashmere, the hair of the Indian cashmere goat, and mohair, the hair of the North African angora goat, are types of wool known for their softness.

Other animal textiles which are made from hair or fur are alpaca wool, vicuña wool, llama wool, and camel hair, generally used in the production of coats, jackets, ponchos, blankets, and other warm coverings. Angora refers to the long, thick, soft hair of the angora rabbit.

Wadmal is a coarse cloth made of wool, produced in Scandinavia, mostly 1000~1500CE.

Silk is an animal textile made from the fibres of the cocoon of the Chinese silkworm. This is spun into a smooth, shiny fabric prized for its sleek texture.

Plant textiles

Grass, rush, hemp, and sisal are all used in making rope. In the first two, the entire plant is used for this purpose, while in the last two, only fibres from the plant are utilized. Coir (coconut fibre) is used in making twine, and also in floormats, doormats, brushes, mattresses, floor tiles, and sacking.

Straw and bamboo are both used to make hats. Straw, a dried form of grass, is also used for stuffing, as is kapok.

Fibres from pulpwood trees, cotton, rice, hemp, and nettle are used in making paper.

Cotton, flax, jute, hemp, modal and even bamboo fibre are all used in clothing. Piña (pineapple fibre) and ramie are also fibres used in clothing, generally with a blend of other fibres such as cotton. Nettles have also been used to make a fibre and fabric very similar to hemp or flax. The use of milkweed stalk fibre has also been reported, but it tends to be somewhat weaker than other fibres like hemp or flax.

Acetate is used to increase the shininess of certain fabrics such as silks, velvets, and taffetas.

Seaweed is used in the production of textiles. A water-soluble fibre known as alginate is produced and is used as a holding fibre; when the cloth is finished, the alginate is dissolved, leaving an open area

Lyocell is a man-made fabric derived from wood pulp. It is often described as a man-made silk equivalent and is a tough fabric which is often blended with other fabrics - cotton for example.

Fibres from the stalks of plants, such as hemp, flax, and nettles, are also known as 'bast' fibres.

Mineral textiles

Asbestos and basalt fibre are used for vinyl tiles, sheeting, and adhesives, "transite" panels and siding, acoustical ceilings, stage curtains, and fire blankets.

Glass Fibre is used in the production of spacesuits, ironing board and mattress covers, ropes and cables, reinforcement fibre for composite materials, insect netting, flame-retardant and protective fabric, soundproof, fireproof, and insulating fibres.

Metal fibre, metal foil, and metal wire have a variety of uses, including the production of cloth-of-gold and jewelery. Hardware cloth is a coarse weave of steel wire, used in construction.

Synthetic textiles

A variety of contemporary fabrics. From the left: evenweave cotton, velvet, printed cotton, calico, felt, satin, silk, hessian, polycotton.

A synthetic blanket.

All synthetic textiles are used primarily in the production of clothing.

Polyester fibre is used in all types of clothing, either alone or blended with fibres such as cotton.

Aramid fibre (e.g. Twaron) is used for flame-retardant clothing, cut-protection, and armor.

Acrylic is a fibre used to imitate wools, including cashmere, and is often used in replacement of them.

Nylon is a fibre used to imitate silk; it is used in the production of pantyhose. Thicker nylon fibres are used in rope and outdoor clothing.

Spandex (trade name *Lycra*) is a polyurethane product that can be made tight-fitting without impeding movement. It is used to make activewear, bras, and swimsuits.

Olefin fibre is a fibre used in activewear, linings, and warm clothing. Olefins are hydrophobic, allowing them to dry quickly. A sintered felt of olefin fibres is sold under the trade name Tyvek.

Ingeo is a polylactide fibre blended with other fibres such as cotton and used in clothing. It is more hydrophilic than most other synthetics, allowing it to wick away perspiration.

Lurex is a metallic fibre used in clothing embellishment.

Milk proteins have also been used to create synthetic fabric. Milk or casein fibre cloth was developed during World War I in Germany, and further developed in Italy and America during the 1930s. Milk fibre fabric is not very durable and wrinkles easily, but has a pH similar to human skin and possesses anti-bacterial properties. It is marketed as a biodegradable, renewable synthetic fibre.

Production methods

Weaving is a textile production method which involves interlacing a set of longer threads (called the warp) with a set of crossing threads (called the weft). This is done on a frame or machine known as a loom, of which there are a number of types. Some weaving is still done by hand, but the vast majority is mechanised.

Knitting and crocheting involve interlacing loops of yarn, which are formed either on a knitting needle or on a crochet hook, together in a line. The two processes are different in that knitting has several active loops at one time, on the knitting needle waiting to interlock with another loop, while crocheting never has more than one active loop on the needle.

Spread Tow is a production method where the yarn are spread into thin tapes, and then the tapes are woven as warp and weft. This method is mostly used for composite materials; Spread Tow Fabrics can be made in carbon, aramide, etc.

Braiding or plaiting involves twisting threads together into cloth. Knotting involves tying threads together and is used in making macrame.

Lace is made by interlocking threads together independently, using a backing and any of the methods described above, to create a fine fabric with open holes in the work. Lace can be made by either hand or machine.

Carpets, rugs, velvet, velour, and velveteen are made by interlacing a secondary yarn through woven cloth, creating a tufted layer known as a nap or pile.

Felting involves pressing a mat of fibres together, and working them together until they become tangled. A liquid, such as soapy water, is usually added to lubricate the fibres, and to open up the microscopic scales on strands of wool.

Nonwoven textiles are manufactured by the bonding of fibres to make fabric. Bonding may be thermal or mechanical, or adhesives can be used.

Treatments

Woven tartan of Clan Campbell, Scotland.

Embroidered skirts by the Alfaro-Nùñez family of Cochas, Peru, using traditional Peruvian embroidery methods.

Textiles are often dyed, with fabrics available in almost every colour. The dying process often requires several dozen gallons of water for each pound of clothing. Coloured designs in textiles can be created by weaving together fibres of different colours (tartan or Uzbek Ikat), adding coloured stitches to finished fabric (embroidery), creating patterns by resist dyeing methods, tying off areas of cloth and dyeing the rest (tie-dyeing), or drawing wax designs on cloth and dyeing in between them (batik), or using various printing processes on finished fabric. Woodblock printing, still used in India and elsewhere today, is the oldest of these dating back to at least 220CE in China. Textiles are also sometimes bleached, making the textile pale or white.

Textiles are sometimes finished by chemical processes to change their characteristics. In the 19th century and early 20th century starching was commonly used to make clothing more resistant to stains and wrinkles. Since the 1990s, with advances in technologies

such as permanent press process, finishing agents have been used to strengthen fabrics and make them wrinkle free. More recently, nanomaterials research has led to additional advancements, with companies such as Nano-Tex and NanoHorizons developing permanent treatments based on metallic nanoparticles for making textiles more resistant to things such as water, stains, wrinkles, and pathogens such as bacteria and fungi.
More so today than ever before, textiles receive a range of treatments before they reach the end-user. From formaldehyde finishes (to improve crease-resistance) to biocidic finishes and from flame retardants to dyeing of many types of fabric, the possibilities are almost endless. However, many of these finishes may also have detrimental effects on the end user. A number of disperse, acid and reactive dyes (for example) have been shown to be allergenic to sensitive individuals. Further to this, specific dyes within this group have also been shown to induce purpuric contact dermatitis. Although formaldehyde levels in clothing are unlikely to be at levels high enough to cause an allergic reaction, due to the presence of such a chemical, quality control and testing are of utmost importance. Flame retardants (mainly in the brominated form) are also of concern where the environment, and their potential toxicity, are concerned. Testing for these additives is possible at a number of commercial laboratories, it is also possible to have textiles tested for according to the Oeko-tex Certification Standard which contains limits levels for the use of certain chemicals in textiles products.

Chapter 4

Units of Textile Measurement

Fiber/Fibre

Denier

Thread made from two threads

Denier is a unit of measure for the linear mass density of fibers. It is defined as the mass in grams per 9,000 meters. In the International System of Units the **tex** is used instead. The denier is based on a natural standard: a single strand of silk is one denier. A 9,000 meter strand of silk weighs one gram. The term denier is from a French coin of small value (worth 1/12th of a sou). Applied to yarn, a denier was held to be equal in weight to 1/24th oz.

The term micro-denier is used to describe filaments that weigh less than one gram per 9,000 meter length.

One can distinguish between *Filament* and *Total* denier. Both are defined as above but the first only relates to a single filament of fiber (also commonly known as Denier per Filament or D.P.F) whereas the second relates to a yarn, an agglomeration of filaments.

The following relationship applies to straight, uniform filaments:

D.P.F. = Total Denier / Quantity of Uniform Filaments

The denier system of measurement is used on two and single filament fibers. Some common calculations are as follows:

1 denier = 1 gram per 9 000 meters
= 0.05 grams per 450 meters (1/20 of above)
= 0.111 milligrams per meter

In practice measuring 9,000 meters is both time-consuming and wasteful. Usually a sample of 900 meters is weighed and the result multiplied by 10 to obtain the denier weight.

- A fiber is generally considered a microfiber if it is 1 denier or less.
- A 1-denier polyester fiber has a diameter of about 10 micrometers.
- Denier is used as the measure of density of weave in tights and pantyhose, which defines their opacity.

Tex

Tex is a unit of measure for the linear mass density of fibers and is defined as the mass in grams per 1000 meters. Tex is more likely to be used in Canada and Continental Europe, while denier remains more common in the United States and United Kingdom. The unit code is "tex". The most commonly used unit is actually the decitex, abbreviated **dtex**, which is the mass in grams per 10,000 meters. When measuring objects that consist of multiple fibers the term "filament tex" is sometimes used, referring to the mass in grams per 1000 meters of a single filament.

Tex is used for measuring fiber size in many products, including cigarette filters, optical cable, yarn, and fabric.

One can calculate the diameter of a filament given its weight in dtex with the following formula:

$$\varnothing = \sqrt{\frac{4 \times 10^{-6} \cdot \mathrm{dtex}}{\pi \rho}}$$

where ρ represents the material's density in grams per cubic centimeter and the diameter is in cm.

Tex (g/km)	Yield (yards/#)
550	900
735	675
1100	450
1200	413
2000	250
2200	225
2400	207
4400	113

S or super S number

Super S or S number is a direct measure of the fineness of the wool fiber. It is most commonly seen as a label on wool suits and other tailored wool apparel to indicate the fineness of the wool fiber used in the making of the apparel. The numbers may also be found on wool fabric and yarn.

Worsted count

Yarn spinning factory

Worsted count (or spinning count) is an indirect measure of the fineness of the fiber in a worsted wool yarn expressed as the number of 560-yard (1 yard = 0.9144 meters) lengths (hanks) of worsted yarn that a pound (0.45359237 kilograms) of wool yields. The finer the wool, the more yarn and the higher the count. It has been largely replaced by direct measures.

Yield

Similar to tex and denier, **yield** is a term that helps describe the linear density of a roving of fibers. However, unlike tex and denier, yield is the inverse of linear density and is usually expressed in yards/lb.

Yarn and thread

Cotton count

- Cotton Counts: The number of hanks of 840 yds in one pound of weight i.e 10 count cotton means that 10x840 yds weighs = 1 lb. This is coarser than 40 count cotton where 40x840 yards are needed. In the United Kingdom, ones to 40s are coarse counts (Oldham Counts), 40 to 80s are medium counts and above 80 is a fine count. In the United States ones to 20s are coarse counts.
- Hank: A length of 7 leas or 840 yards

One Lea - 120 yds (yarn is strength tested in lea strength) Cotton yarn may be spun is S twist (recverse or Z twist (normal) twist is imparted to produce the strength. To calculate. Length in Yards over weight in grains * 7000 over 840 (7000 grains in a pound - 840 yds in a hank)

Cotton count is an indirect counting system i.e the higher the number the finer the yarn.

- Thread: A length of 54 in (the circumference of a warp beam)
- Bundle: Usually 10 lbs
- Lea: A length of 80 threads or 120 yards
- Denier: this is an alternative method. It is defined as a number that is equivalent to the weight in grams of 9000m of a single yarn. 15 denier is finer than 30 denier.
- Tex: is the weight in grams of 1 km of yarn.

To convert Denier to Cotton Count *5315 - from Tex * 590.5 Tex is 1/9th Denier

Thread

Thread is a cotton yarn measure, equal to 54 inches.

Yarn density conversion

Approx. Yarn Measurement
Comparison

Denier	m/g	Tex	Worsted	Cotton	Woolen(Run)	Linen(Lea)
50	180	5.6	160	106	56	298
75	120	8.3	106	72	37	198
100	90	11.1	80	53	28	149
150	60	16.6	53	35	19	99
200	45	22.2	40	27	14	74
300	30	33.4	27	18	9.3	50
400	22.5	44.4	20	13	7.0	37
500	18	55.5	16	11	5.6	30
700	12.9	77.7	11.4	7.6	4.0	2

1000	9	111	8.0	5.3	2.8	15
1500	6	166	5.3	3.5	1.9	10
2000	4.5	222	4.0	2.7	1.4	7

Fabric

Mommes

Mommes (mm) are units of weight traditionally used to measure the density of silk. It is akin to the use of thread count to measure the quality of cotton fabrics, but is calculated in a very different manner. Instead of counting threads, the Momme is a number that equals the weight in pounds of a piece of silk *if* it were sized 45 inches by 100 yards. This is because the standard width of silk is 45" wide, though silk is regularly produced in 55" widths, and, uncommonly, in even larger widths.

Silk can also be measured by weight in grams. 1 momme = 4.340 g/m^2; 8 momme is close to 1 oz per square yard or 34 g/m^2.

The usual range of momme weight for different weaves of silk are:

- Habutai - 5 to 16 mm
- Chiffon - 6 to 8 mm (can be made in double thickness, i.e. 12 to 16 mm)
- Crepe de Chine - 12 to 16 mm
- Gauze - 3 to 5 mm
- Raw silk - 35 to 40 mm (heavier silks appear more 'wooly')
- Organza - 4 to 6 mm
- Charmeuse - 12 to 30 mm -

The higher the momme, the more durable the weave, and the more suitable it is for heavy-duty use. And, the heavier the silk, the more opaque it becomes. This can vary even between the same kind of silk. For example, lightweight charmeuse is translucent when used in clothing, but 30mm charmeuse is opaque.

Thread count

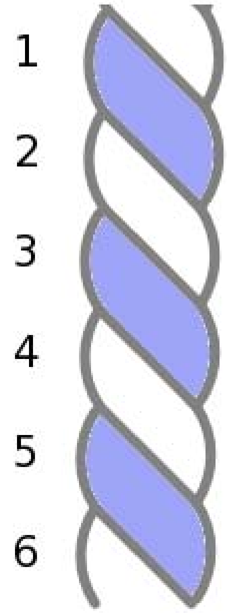


Image showing how to determine the number of twists per inch in a piece of yarn

Thread count is a measure of the coarseness or fineness of fabric. It is measured by counting the number of threads contained in one square inch of fabric or one square centimeter, including both the length (warp) and width (weft) threads. The thread count is the number of threads counted along two sides (up and across) of the square inch, added together. It is used especially in regard to cotton linens such as bed sheets, and has been known to be used in the classification of towels.

Thread count is often used as a measure of fabric quality, so that "standard" cotton thread counts are around 150 while good-quality sheets start at 180 and a count of 200 or higher is considered percale. Some, but not all, of the extremely high thread counts (typically over 500) tend to be misleading as they usually count the individual threads in 'plied' yarns (a yarn that is made by twisting together multiple finer threads). For marketing purposes, a fabric with 250 two-ply yarns in both the vertical and horizontal direction could have the component threads counted to a 1000 thread count although "according to the National Textile Association (NTA), which cites the international standards group ASTM, accepted industry practice is to count each thread as one, even threads spun as two- or three-ply yarn. The Federal Trade Commission in an August 2005 letter to NTA agreed that consumers 'could be deceived or misled' by inflated thread counts. In 2002, ASTM proposed a definition for "thread count" that has been called "the industry's first formal definition for thread count". A minority on the ASTM committee argued for the higher yarn count number obtained by counting each single yarn in a plied yarn and cited as authority the provision relating to woven fabric in the *Harmonized Tariff Schedule of the United States*, which states each ply should be counted as one using the "average yarn number."

Ends per inch

Ends per inch (or e.p.i.) is the number of warp threads per inch of woven fabric. In general, the higher the ends per inch, the finer the fabric is.

Ends per inch is very commonly used by weavers who must use the number of ends per inch in order to pick the right reed to weave with. The number of ends per inch varies on the pattern to be woven and the thickness of the thread. Plain weaves generally use half the number of wraps per inch for the number of ends per inch, whereas denser weaves like a twill weave will use a higher ratio like two thirds of the number of wraps per inch. Finer threads require more threads per inch than thick ones, and thus result in a higher number of ends per inch.

The number of ends per inch in a piece of woven cloth varies depending on what stage the cloth is at. Before the cloth is woven the warp has a certain number of ends per inch, which is directly related to what size reed is being used. After weaving the number of ends per inch will increase, and it will increase again after being washed. This increase in the number of ends per inch (and picks per inch) and shrinkage in the size of the fabric is known as the **take-up**. The take-up is dependent on many factors, including the material and how tightly the cloth is woven. Tightly woven fabric shrinks more (and thus the number of ends per inch increases more) than loosely woven fabric, as do more elastic yarns and fibers.

Picks per inch

Picks per inch (or p.p.i.) is the number of weft threads per inch of woven fabric. A pick is a single weft thread, hence the term. In general, the higher the picks per inch, the finer the fabric is.

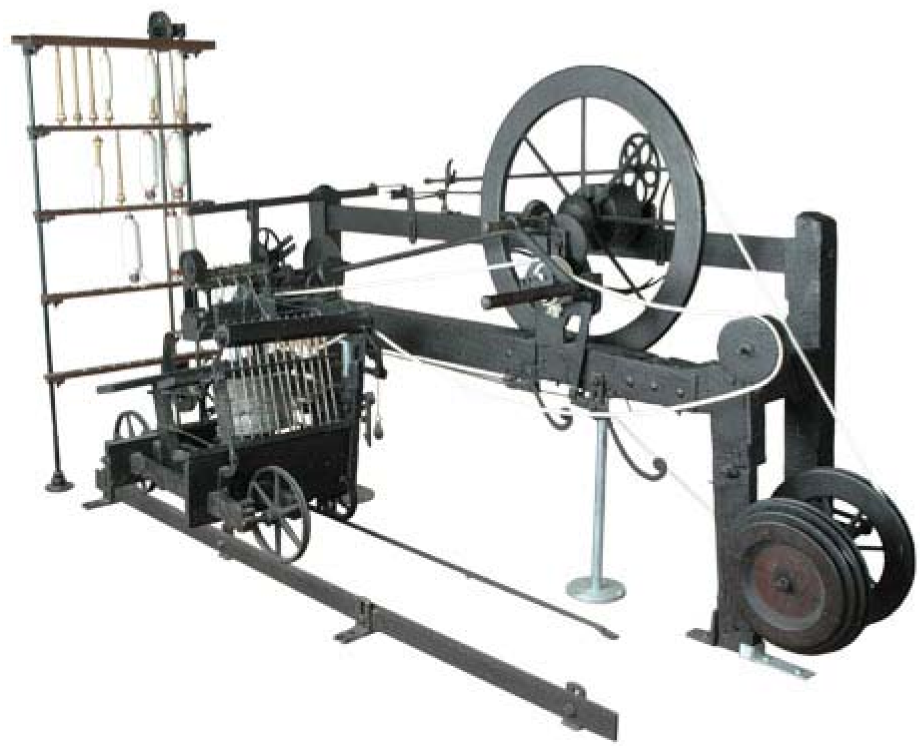
Chapter 5

Textile Manufacture during the Industrial Revolution

The industrial revolution changed the nature of work and society. Opinion varies as to the exact date when it took place but place the First Industrial Revolution between 1750 and 1850, and the second phase or Second Industrial Revolution between 1860 and 1900. The three key drivers in these changes were textile manufacturing, iron founding and steam power. The geographical focus of **Textile manufacture during the Industrial Revolution** in Britain was Greater Manchester and the small towns of the Pennines and southern Lancashire. In the United States it was New England.

Prior to the 17th century, the manufacture of goods was performed on a limited scale by individual workers. This was usually on their own premises (such as weavers' cottages) – and goods were transported around the country by horse, or by river. Rivers navigations has been constructed, and some contour following canals, and, in the early 18th century, artisans were inventing ways to become more productive. Silk, Wool, Fustian, were being eclipsed by Cotton which was becoming the most important textile. This set the foundations for the changes. Historians agree that the Industrial Revolution was one of the most important events in history.

Elements of the Industrial Revolution



The only surviving example of a Spinning Mule built by the inventor Samuel Crompton

The commencement of the Industrial Revolution is closely linked to a small number of innovations, made in the second half of the 18th century:

- **Textiles** – Cotton spinning using Richard Arkwright's water frame, James Hargreaves's Spinning Jenny, and Samuel Crompton's Spinning Mule (a combination of the Spinning Jenny and the Water Frame). This was patented in 1769 and so came out of patent in 1783. The end of the patent was rapidly followed by the erection of many cotton mills. Similar technology was subsequently applied to spinning worsted yarn for various textiles and flax for linen.
- **Steam power** – The improved steam engine invented by James Watt and patented in 1775 was initially mainly used for pumping out mines, but from the 1780s was applied to power machines. This enabled rapid development of efficient semi-automated factories on a previously unimaginable scale in places where waterpower was not available.
- **Iron founding** – In the Iron industry, coke was finally applied to all stages of iron smelting, replacing charcoal. This had been achieved much earlier for lead and copper as well as for producing pig iron in a blast furnace, but the second stage in the production of bar iron depended on the use of potting and stamping (for which a patent expired in 1786) or puddling (patented by Henry Cort in 1783 and 1784).

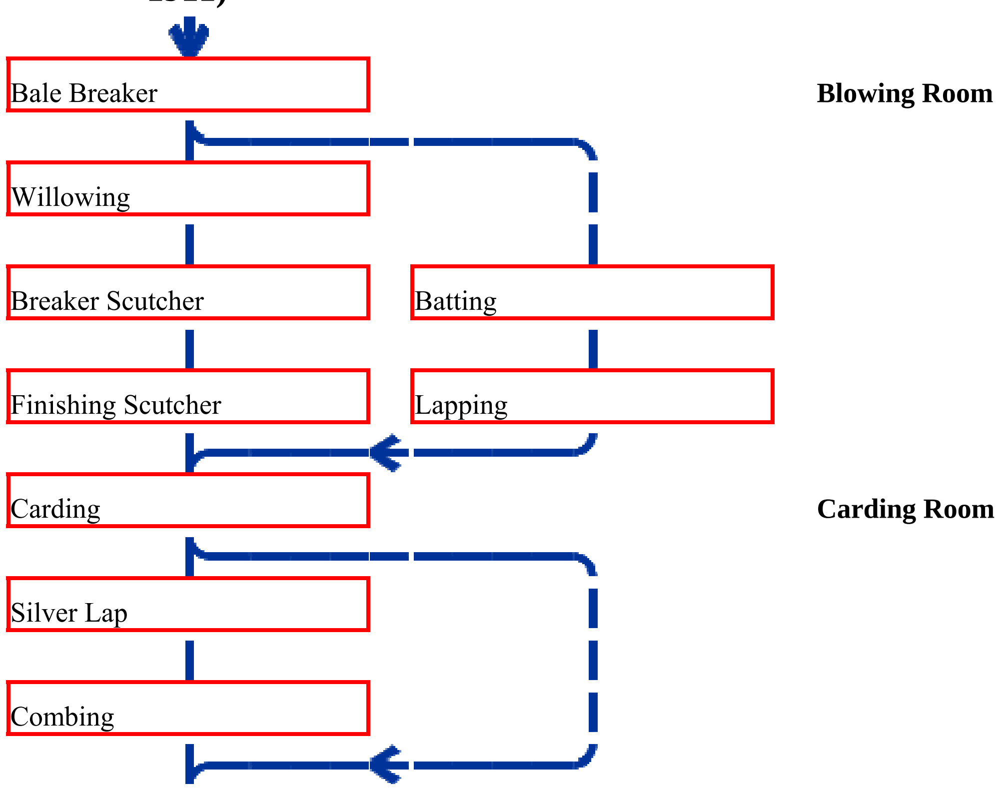
These represent three 'leading sectors', in which there were key innovations, which allowed the economic take off by which the Industrial Revolution is usually defined. This is not to belittle many other inventions, particularly in the textile industry. Without some earlier ones, such as the spinning jenny and flying shuttle in the textile industry and the smelting of pig iron with coke, these achievements might have been impossible. Later inventions such as the power loom and Richard Trevithick's high pressure steam engine were also important in the growing industrialisation of Britain. The application of steam engines to powering cotton mills and ironworks enabled these to be built in places that were most convenient because other resources were available, rather than where there was water to power a watermill.

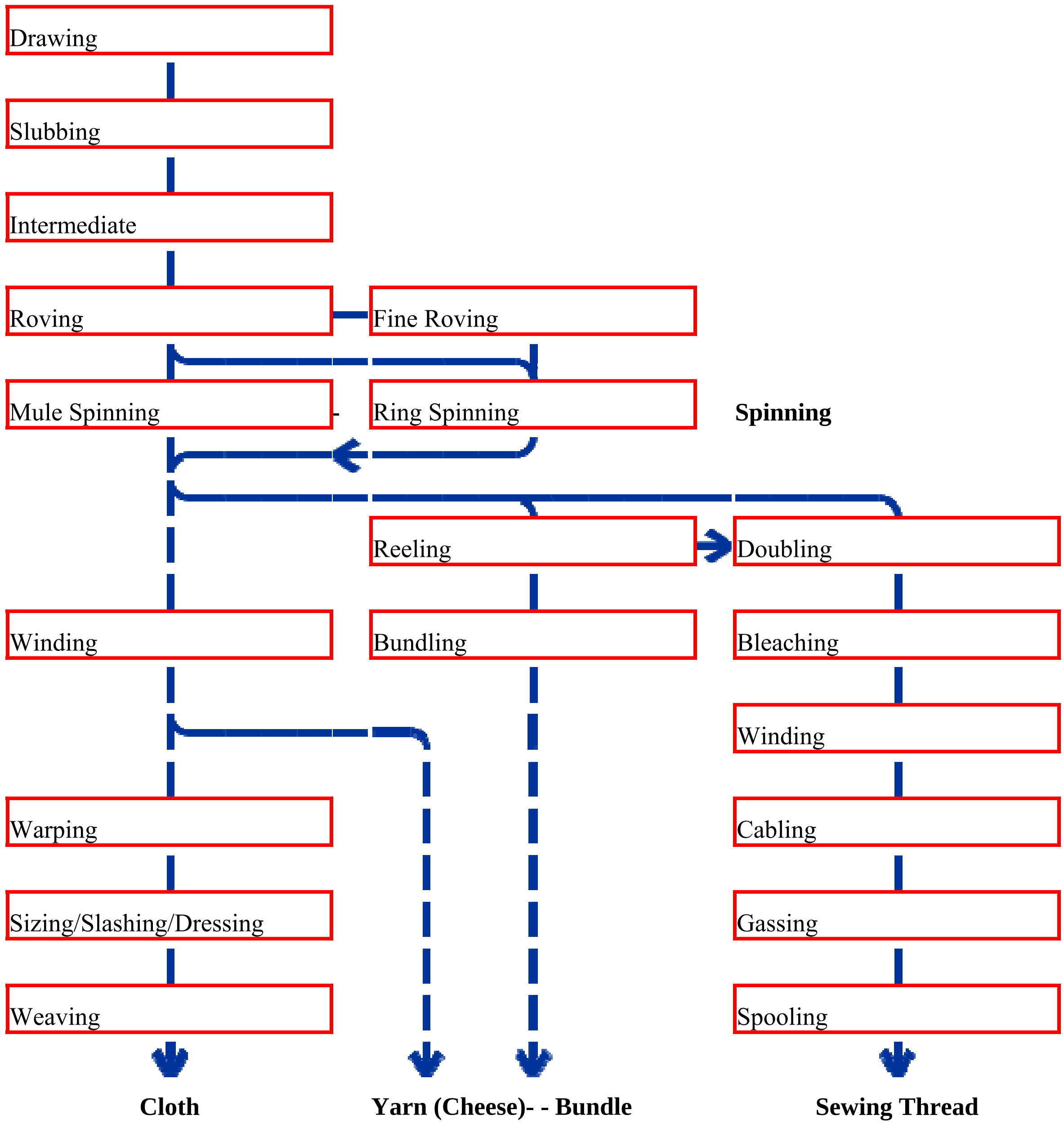
In the textile sector, such mills became the model for the organisation of human labour in factories, epitomised by Cottonopolis, the name given to the vast collection of cotton mills, factories and administration offices based in Manchester. The assembly line system greatly improved efficiency, both in this and other industries. With a series of men trained to do a single task on a product, then having it moved along to the next worker, the number of finished goods also rose significantly.

Also important was the 1756 rediscovery of concrete (based on hydraulic lime mortar) by the British engineer John Smeaton, which had been lost for 13 centuries.

Processing of cotton

Cotton Manufacturing Processes (after Murray 1911)





Cotton is the world's most important natural fibre. In the year 2007, the global yield was 25 million tons from 35 million hectares cultivated in more than 50 countries.

There are five stages

- Cultivating and Harvesting
- Preparatory Processes
- Spinning
- Weaving
- Finishing

Industry and Invention

The reasons for this succession of events are interlinked. Partly through good fortune and partly through conscious effort, Britain by the early 18th century possessed the combination of skills, social needs and social resources needed for commercially successful innovation and a social system capable of sustaining the processes of rapid technological change once they had started.

Before the 1760s, textile production was a cottage industry using mainly flax and wool. In a typical house, the girls and women could make enough yarn for the man's loom. The knowledge of textile production had existed for centuries, and the manual methods had been adequate to provide enough cloth. Cotton started to be imported and the balance of demand and supply was upset.

Two systems had developed for spinning: the Simple Wheel, which used an **intermittent** process and the more refined Saxony wheel which drove a differential spindle and flyer with heck, in a **continuous** process. But neither of these wheels could produce enough thread for the looms after the invention by John Kay of the flying shuttle (which made the loom twice as productive). The first moves towards manufactories called mills were made in the spinning sector, and until the 1820 cotton, wool and worsted was spun in mills, and this yarn went to outworking weavers who continues to work in their own homes.

Early Inventions

In 1734 in Bury, Lancashire, John Kay invented the flying shuttle — one of the first of a series of inventions associated with the cotton industry. The flying shuttle increased the width of cotton cloth and speed of production of a single weaver at a loom. Resistance by workers to the perceived threat to jobs delayed the widespread introduction of this technology, even though the higher rate of production generated an increased demand for spun cotton.

Shuttles

In 1738, Lewis Paul (one of the community of Huguenot weavers that had been driven out of France in a wave of religious persecution) settled in Birmingham and with John Wyatt, of that town, they patented the Roller Spinning machine and the flyer-and-bobbin system, for drawing wool to a more even thickness. Using two sets of rollers that travelled at different speeds yarn could be twisted and spun quickly and efficiently. This was later used in the first cotton spinning mill during the Industrial Revolution.

1742: Paul and Wyatt opened a mill in Birmingham which used their new rolling machine powered by donkey; this was not profitable and was soon closed.

1743: A factory opened in Northampton, fifty spindles turned on five of Paul and Wyatt's machines proving more successful than their first mill. This operated until 1764.

1748: Lewis Paul invented the hand driven carding machine. A coat of wire slips were placed around a card which was then wrapped around a cylinder. Lewis's invention was later developed and improved by Richard Arkwright and Samuel Crompton, although this came about under great suspicion after a fire at Daniel Bourn's factory in Leominster which specifically used Paul and Wyatt's spindles. Bourn produced a similar patent in the same year.

1758: Paul and Wyatt based in Birmingham improved their roller spinning machine and took out a second patent. Richard Arkwright later used this as the model for his water frame.

Start of the Revolution

In 1761, the Duke of Bridgewater's canal connected Manchester to the coal fields of Worsley and in 1762, Matthew Boulton opened the Soho Foundry engineering works in Handsworth, Birmingham. His partnership with Scottish engineer James Watt resulted, in 1775, in the commercial production of the more efficient Watt steam engine which used a separate condensor.

In 1764, James Hargreaves is credited as inventor of the spinning jenny which multiplied the spun thread production capacity of a single worker — initially eightfold and subsequently much further. Others credit the original invention to Thomas Highs. Industrial unrest and a failure to patent the invention until 1770 forced Hargreaves from Blackburn, but his lack of protection of the idea allowed the concept to be exploited by others. As a result, there were over 20,000 Spinning Jennies in use by the time of his death. Again in 1764, Thorp Mill, the first water-powered cotton mill in the world was constructed at Royton, Lancashire, England. It was used for carding cotton.

Arkwright's Cromford Mill.

Richard Arkwright used waterwheels to power textile machinery. His first spinning mill, Cromford Mill, Derbyshire, was built in 1771. It contained his invention the water frame. Frame is another name for the machinery for spinning or weaving. The water frame was developed from the spinning frame that Arkwright had developed with (a different) John Kay, from Warrington. The original design was again claimed by Thomas Highs, which he claimed he had patented in 1769. Initial attempts at driving the frame had used horse power, but the innovation of using a waterwheel demanded a location with a ready supply of water, hence the mill at Cromford. This mill is preserved as part of the Derwent Valley Mills in some ways it was modelled on Matthew Boulton and John Fothergill's Soho Manufactory. Arkwright protected his investment from industrial rivals and potentially disruptive workers. He generated jobs and constructed accommodation for his workers, this led to a sizeable industrial community. Arkwright expanded his operations to other parts of the country.

Samuel Crompton of Bolton combined elements of the spinning jenny and water frame in 1779, creating the spinning mule. This mule produced a stronger thread than the water frame could. Thus in 1780, there were two viable hand operated spinning system that could be easily adapted to run by power of water.As early mules were suitable for producing yarn for use in the manufacture of muslin, and which were known as the muslin wheel or the Hall i' th' Wood (pronounced Hall-ith-wood) wheel. As with Kay and

Hargreaves, Crompton was not able to exploit his invention for his own profit, and died a pauper.

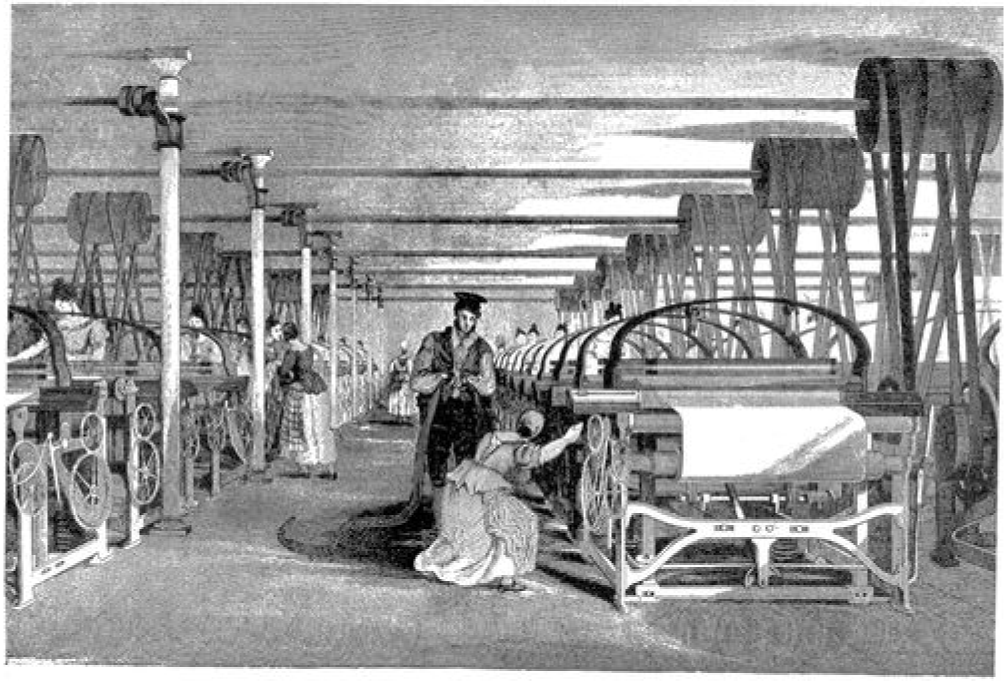
In 1783 a mill was built in Manchester at Shudehill, at the highest point in the city away from the river. Shudehill Mill was powered by a 30 ft diameter waterwheel. Two storage ponds were built, and the water from one passed from one to the other turning the wheel. A steam driven pump returned the water to the higher reservoir. The steam engine was of the atmospheric type. An improvement devised by Joshua Wrigley, trialled in Chorlton-upon-Medlock used two Savery engines to supplement the river in driving on overshot waterwheel.

In 1784, Edmund Cartwright invented the power loom, and produced a prototype in the following year. His initial venture to exploit this technology failed, although his advances were recognised by others in the industry. Others such as Robert Grimshaw (whose factory was destroyed in 1790 as part of the growing reaction against the mechanization of the industry) and Austin – developed the ideas further. In 1803, William Radcliffe invented the dressing frame which was patented under the name of Thomas Johnson which enabled power looms to operate continuously.

Later developments

With the Cartwright Loom, the Spinning Mule and the Boulton & Watt steam engine, the pieces were in place to build a mechanised textile industry. From this point there were no new inventions, but a continuous improvement in technology as the mill-owner strove to reduce cost and improve quality. Developments in the transport infrastructure; that is the canals and after 1831 the railways facilitated the import of raw materials and export of finished cloth.

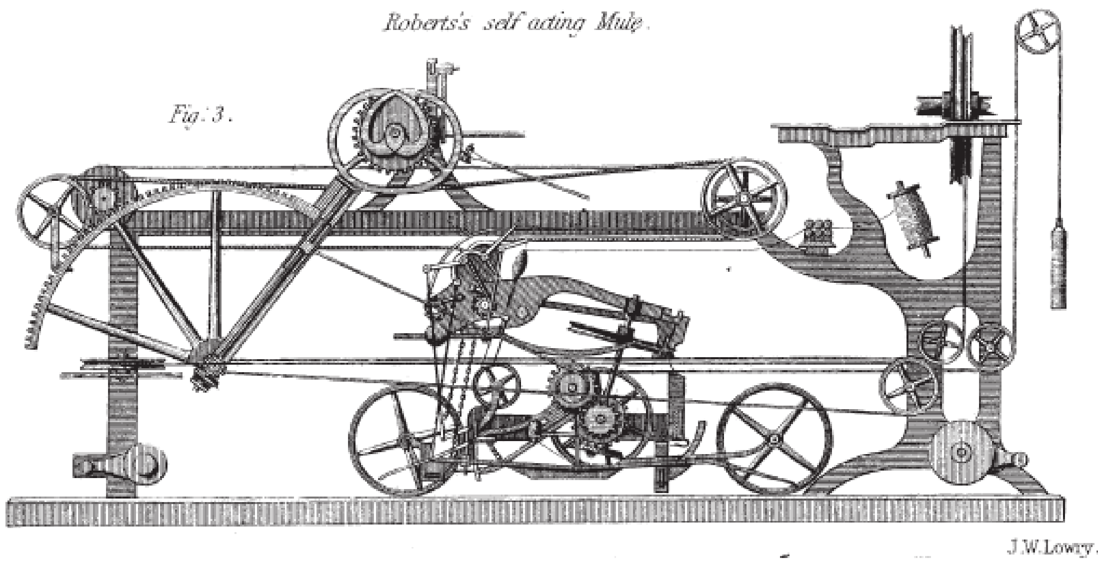
Firstly, the use of water power to drive mills was supplemented by steam driven water pumps, and then superseded completely by the steam engines. For example Samuel Greg joined his uncle's firm of textile merchants, and, on taking over the company in 1782, he sought out a site to establish a mill.Quarry Bank Mill was built on the River Bollin at Styal in Cheshire. It was initially powered by a water wheel, but installed steam engines in 1810.In 1830, the average power of a mill engine was 48 hp, but Quarry Bank mill installed an new 100 hp water wheel. This was to change in 1836, when Horrocks & Nuttall, Preston took delivery of 160 hp double engine. William Fairbairn addressed the problem of line-shafting and was responsible for improving the efficiency of the mill. In 1815 he replaced the wooden turning shafts that drove the machines at 50rpm, to wrought iron shafting working at 250 rpm, these were a third of the weight of the previous ones and absorbed less power.



A Roberts loom in a weaving shed in 1835. Note the wrought iron shafting, fixed to the cast iron columns

Secondly, in 1830, using a 1822 patent, Richard Roberts manufactured the first loom with a cast iron frame, the Roberts Loom. In 1842 James Bullough and William Kenworthy, made the Lancashire Loom . It is a semi automatic power loom. Although it is self-acting, it has to be stopped to recharge empty shuttles. It was the mainstay of the Lancashire cotton industry for a century, when the Northrop Loom invented in 1894 with an automatic weft replenishment function gained ascendancy.

Number of Looms in UK					
Year	1803	1820	1829	1833	1857
Looms	2400	14650	55500	100000	250000



Roberts self acting mule with quadrant gearing

Thirdly, also in 1830, Richard Roberts patented the first self-acting mule. Stalybridge mule spinners strike was in 1824,this stimulated research into the problem of applying power to the winding stroke of the mule. The draw while spinning had been assisted by power, but the push of the wind had been done manually by the spinner, the mule could be operated by semiskilled labour. Before 1830, the spinner would operate a partially-powered mule with a maximum of 400 spindles after, self-acting mules with upto 1300 spindles could be built.

Workers

Working conditions in some early British textile factories were unfavorable relative to modern standards. Children, men, and women regularly volunteered for 68-hour work weeks. Factories often were not well ventilated and became very hot in the summer. Worker health and safety regulations were non-existent. Textile factories organized workers' lives much differently from craft production. Handloom weavers worked at their own pace, with their own tools, and within their own cottages. Factories set hours of work, and the machinery within them shaped the pace of work. Factories brought workers together within one building to work on machinery that they did not own. Factories also increased the division of labor. They narrowed the number and scope of tasks and included children and women within a common production process. As Manchester mill owner Friedrich Engels decried, the family structure itself was "turned upside down" as women's wages undercut men's, forcing men to "sit at home" and care for children while the wife worked long hours. Factories flourished over manual craftsmanship because they had more efficient production output per worker, keeping prices down for the public, and they had much more consistent quality of product.

At times, the workers rebelled against poor wages. The first major industrial action in Scotland was that of the Calton weavers in Glasgow, who went on strike for higher wages in the summer of 1787. In the ensuing disturbances, troops were called in to keep the peace and three of the weavers were killed. There was continued unrest. In Manchester in May 1808, 15,000 protesters gathered on St George's Fields and were fired on by dragoons, with one man dying. A strike followed, but was eventually settled by a small wage increase. In the general strike of 1842, half a million workers demanded the Charter and an end to pay cuts. Again, troops were called in to keep the peace, and the strike leaders were arrested, but some of the worker demands were met.

The early textile factories employed a large share of children, but the share declined over time. In England and Scotland in 1788, two-thirds of the workers in 143 water-powered cotton mills were described as children. Sir Robert Peel, a mill owner turned reformer, promoted the 1802 Health and Morals of Apprentices Act, which was intended to prevent pauper children from working more than 12 hours a day in mills. Children had started in the mills at around the age of four, working as scavengers under the working machinery until they were eight, they progressed to working as little piecers which they did until they were 15. During this time they worked 14 to 16 hours a day, being beaten if they fell asleep. The children were sent to the mills of Derbyshire, Yorkshire and Lancashire from the workhouses in London and other towns in the south of England. A well documented example was that of Litton Mill. Further legislation followed. By 1835, the share of the workforce under 18 years of age in cotton mills in England and Scotland had fallen to 43%. About half of workers in Manchester and Stockport cotton factories surveyed in 1818 and 1819 had begun work at under ten years of age. Most of the adult workers in cotton factories in mid-19th century Britain were workers who had begun work as child labourers. The growth of this experienced adult factory workforce helps to account for the shift away from child labour in textile factories.

A representative early spinning mill 1790-1825

Cromford Mill was an early Arkwright mill and was the model for future mills The site at Cromford had year-round supply of warm water from the sough which drained water from nearby lead mines, together with another brook. It was a five storey mill. Starting in 1772,the mills ran day and night with two 12 hour shifts.

It started with 200 workers, more than the locality could provide so Arkwright built housing for them nearby, one of the first manufacturers to do so. Most of the employees were women and children, the youngest being only 7 years old. Later, the minimum age was raised to 10 and the children were given 6 hours of education a week, so that they could do the record keeping their illiterate parents could not. Initially the first stage of the process was hand carding, but in 1775 he took out a second patent for a water-powered carding machine and this led to increased output. He was soon building further mills on this site and eventually employed 1,000 workers at Cromford. By the time of his death in 1792, he was the wealthiest untitled person in Britain.

Gateway to Arkwright's Mill

The gate to Cromford Mill was shut at precisely 6am and 6pm every day and any worker who failed to get through it not only lost a day's pay but was fined another day's pay. In 1779, Arkwright installed a cannon, loaded with grapeshot, just inside the factory gate, as a warning to would-be rioting textile workers, who had burned down another of his mills in Birkacre, Lancashire. The cannon was never used.

A representative mid-century spinning mill 1840

Brunswick Mill, Ancoats is a cotton spinning mill in Ancoats, Manchester, Greater Manchester. It was built around 1840, part of a group of mills built along the Ashton Canal, and at that time it was one of the countries largest mill. It was built round a quadrangle, a seven storey block faced the canal. It was taken over by the Lancashire

Cotton Corporation in the 1930s and passed to Courtaulds in 1964. Production finished in 1967.

The Brunswick mill was built around 1840 in one phase. The main seven storey block that faces the Ashton Canal was used for spinning. The preparation was done on the second floor and the self-acting mules with 400 spindles were arranged transversely on the floors above on the upper floor. The wings contained some spinning and ancillary processes like winding. The mill is of fireproof construction and was built by David Bellhouse, but it is suspected that William Fairbairn was involved in the design. Is was powered by a large double beam engine.

In 1850 the mill had some 276 carding machines, and 77,000 mule spindles, 20 drawing frames, fifty slubbing frames and eighty one roving frames.

Export of technology

While profiting from expertise arriving from overseas (e.g. Louis Paul), Britain was very protective of home-grown technology. In particular, engineers with skills in constructing the textile mills and machinery were not permitted to emigrate — particularly to the fledgeling America.

Horse power (1780–1790)

The earliest cotton mills in the United States were horse powered. The first mill to use this method was the Beverly Cotton Manufactory, built in Beverly, Massachusetts. It was started August 18, 1788 by entrepreneur John Cabot and brothers. It was operated in joint by Moses Brown, Israel Thorndike, Joshua Fisher, Henry Higginson, and Deborah Higginson Cabot. The Salem Mercury reported that in April of 1788 that the equipment for the mill was complete, consisting of a spinning jenny, a carding machine, warping machine, and other tools. That same year the mill's location was finalized and built in the rural outsets of North Beverly. The location had the presence of natural water, but it was cited the water was used for upkeep of the horses and cleaning of equipment, and not for mass-production.

Much of the internal designs of the Beverly mill were hidden due to concerns of competitors stealing designs. The beginning efforts were all researched behind closed doors, even to the point that the owners of the mill set up milling equipment on their estates to experiment with the process. There were no published articles describing exactly how their process worked in detail. Additionally, the mill's horse powered technology was quickly dwarfed by new water-powered methods.

Slater

Following the creation of the United States, an engineer who had worked as an apprentice to Arkwright's partner Jedediah Strutt evaded the ban. In 1789, Samuel Slater took his skills in designing and constructing factories to New England, and he was soon engaged in reproducing the textile mills that helped America with its own industrial revolution.

Local inventions spurred this on, and in 1793 Eli Whitney invented and patented the cotton gin, which sped up the processing of raw cotton by over 350 times.

Chapter 6

Spinning (Textiles)

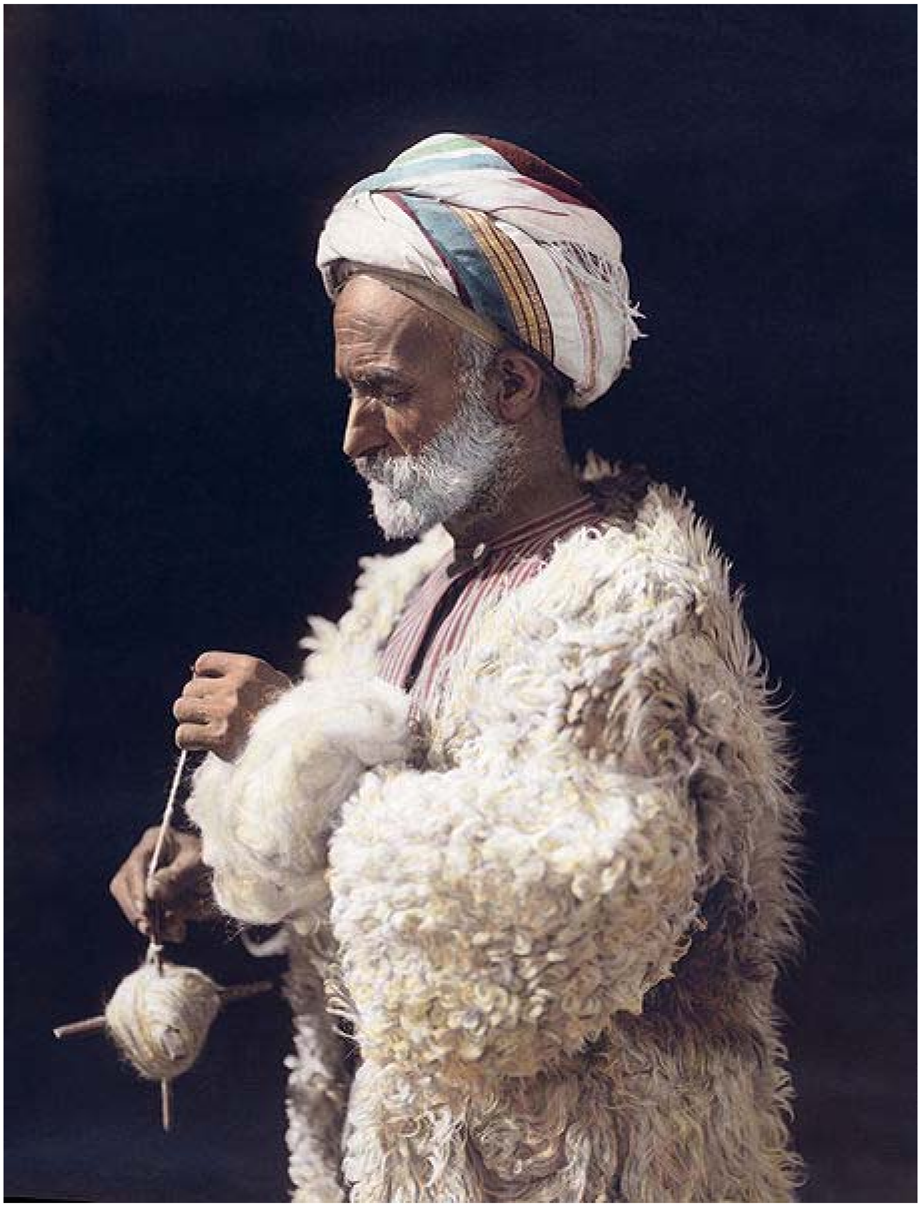
Spinning is an ancient textile art in which plant, animal or synthetic fibers are twisted together to form yarn. For thousands of years, fiber was spun by hand using simple tools, the spindle and distaff. Only in the High Middle Ages did the spinning wheel increase the output of individual spinners, and mass-production only arose in the 18th century with the beginnings of the Industrial Revolution. Hand-spinning remains a popular handicraft.

Characteristics of spun yarn vary according to the material used, fiber length and alignment, quantity of fiber used, and degree of twist.

History

Hand spinning

Woman spinning. Detail from an Ancient Greek Attic white-ground oinochoe, ca. 490 BC, from Locri, Italy. British Museum, London.



A man from Ramallah spinning wool. Hand-tinted photograph from 1919, restored.

Modern top-whorl drop spindles

The origins of spinning fiber to make string or yarn are lost in time, but archaeological evidence in the form of representation of string skirts has been dated to the Upper Paleolithic era, some 20,000 years ago. In the most primitive type of spinning, tufts of animal hair or plant fiber are rolled down the thigh with the hand, and additional tufts are added as needed until the desired length of spun fiber is achieved. Later, the fiber is fastened to a stone which is twirled round until the yarn is sufficiently twisted, whereupon it is wound upon the stone and the process repeated over and over.

The next method of twisting yarn is with the spindle, a straight stick eight to twelve inches long on which the thread is wound after twisting. At first the stick had a cleft or split in the top in which the thread was fixed. Later, a hook of bone was added to the upper end. The bunch of wool or plant fibers is held in the left hand. With the right hand the fibers are drawn out several inches and the end fastened securely in the slit or hook on the top of the spindle. A whirling motion is given to the spindle on the thigh or any convenient part of the body. The spindle is then dropped, twisting the yarn, which is wound on to the upper part of the spindle. Another bunch of fibers is drawn out, the spindle is given another twirl, the yarn is wound on the spindle, and so on.

The distaff was used for holding the bunch of wool, flax, or other fibers. It was a short stick on one end of which was loosely wound the raw material. The other end of the distaff was held in the hand, under the arm or thrust in the girdle of the spinner. When held thus, one hand was left free for drawing out the fibers.

A spindle containing a quantity of yarn rotates more easily, steadily, and continues longer than an empty one; hence, the next improvement was the addition of a weight called a spindle whorl at the bottom of the spindle. These whorls are discs of wood, stone, clay, or metal with a hole in the center for the spindle, which keep the spindle steady and promote its rotation. Spindle whorls appeared in the Neolithic era.

In mediæval times, poor families had such a need for homespun yarn to make their own cloth and clothes, that practically all girls and unmarried women would keep busy spinning, and spinster became synonymous with an unmarried woman. Subsequent improvements with spinning wheels and then mechanical methods made hand-spinning increasingly uneconomic, but as late as the twentieth century hand-spinning remained widespread in poor countries: in conscious rejection of international industrialization, Gandhi was a notable practitioner.

Industrial spinning

A mule spinning machine at Quarry Bank Mill, UK

Modern powered spinning, originally done by water or steam power but now done by electricity, is vastly faster than hand-spinning.

The spinning jenny, a multi-spool spinning wheel invented c. 1764 by James Hargreaves, dramatically reduced the amount of work needed to produce yarn of high consistency, with a single worker able to work eight or more spools at once. At roughly the same time, Richard Arkwright and a team of craftsmen developed the spinning frame, which produced a stronger thread than the spinning jenny. Too large to be operated by hand, a spinning frame powered by a waterwheel became the water frame.

In 1779, Samuel Crompton combined elements of the spinning jenny and water frame to create the spinning mule. This produced a stronger thread, and was suitable for mechanisation on a grand scale. A later development, from 1828/29, was Ring spinning.

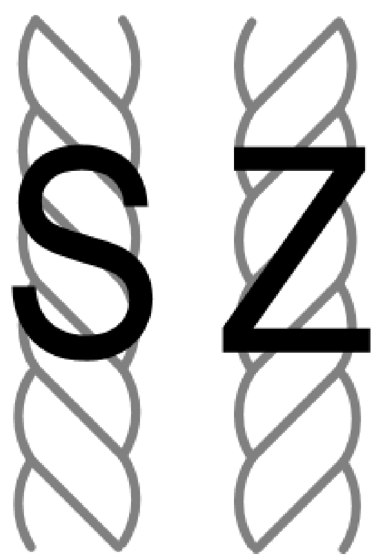
In the 20th century, new techniques including Open End spinning or rotor spinning were invented to produce yarns at rates in excess of 40 meters per second.

Characteristics of spun yarns

Materials

Yarn can be, and is, spun from a wide variety of materials, including natural fibers such as animal, plant, and mineral fibers, and synthetic fibers. It was probably first made from plant fibers, but animal fibers soon followed.

Twist and ply



S-twist and Z-twist yarns

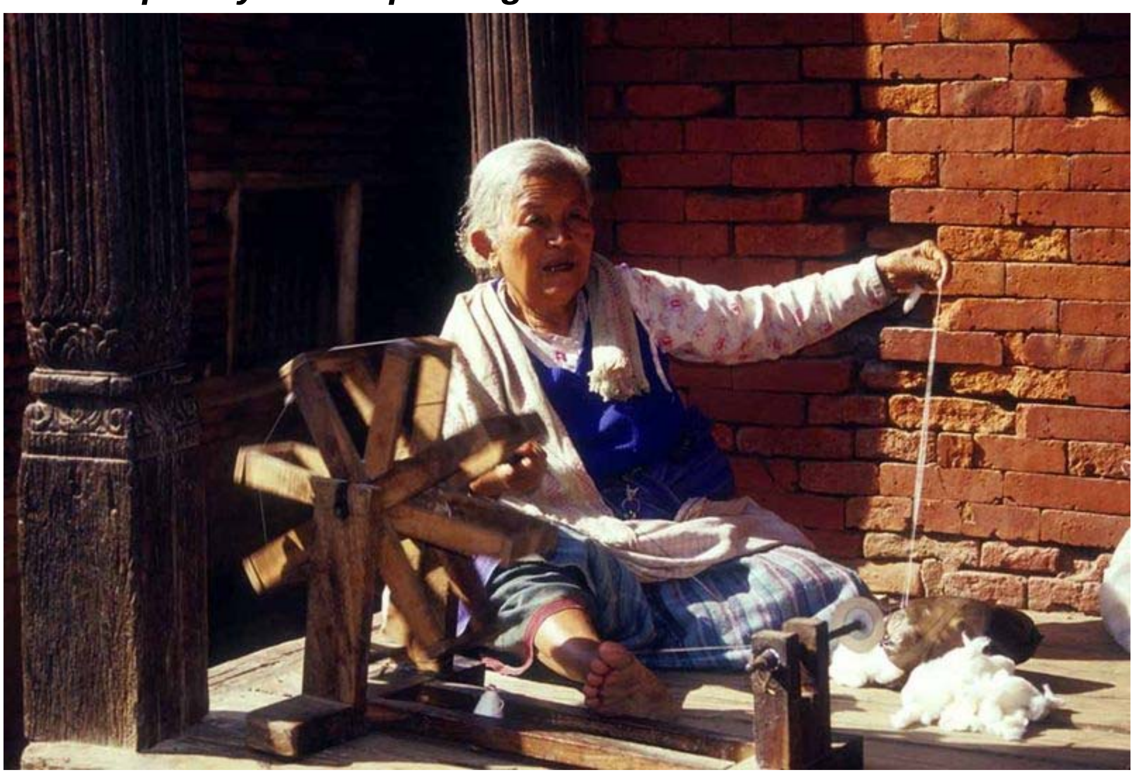
The direction in which the yarn is spun is called *twist*. Yarns are characterized as S-twist or Z-twist according to the direction of spinning. Tightness of twist is measured in TPI (twists per inch or turns per inch).

Two or more spun yarns may be twisted together or *plied* to form a thicker yarn. Generally, handspun single plies are spun with a Z-twist, and plying is done with an S-twist.

Plying methods

Yarns can be made of two, three, four, or more plies, or may be used as *singles* without plying. Two-ply yarn can also be plied from both ends of one long strand of singles using Andean plying, in which the single is first wound around one hand in a specific manner that allows unwinding both ends at once without tangling. Navajo plying is another method of producing a three-ply yarn, in which one strand of singles is looped around itself in a manner similar to crochet and the resulting three parallel strands twisted together. This method is often used to keep colors together on singles dyed in sequential colors. Cabled yarns are usually four-ply yarns made by plying two strands of two-ply yarn together in the direction opposite to the plying direction for the two-ply yarns.

Contemporary hand spinning



An Nepali charka in action

Hand-spinning is still an important skill in many traditional societies. Hobby or small scale artisan spinners spin their own yarn to control specific yarn qualities and produce yarn that is not widely available commercially. Sometimes these yarns are made available to non-spinners online and in local yarn stores. Handspinners also may spin for self-sufficiency, a sense of accomplishment, or a sense of connection to history and the land. In addition, they may take up spinning for its meditative qualities.

Within the recent past, many new spinners have joined into this ancient process, innovating the craft and creating new techniques. From using new dyeing methods before spinning, to mixing in novelty elements (Christmas Garland, eccentric beads, money, etc.) that would not normally be found in traditional yarns, to creating and employing new techniques like coiling, this craft is constantly evolving and shifting.

To make various yarns, besides adding novelty elements, spinners can vary all the same things as in a machined yarn, i.e., the fiber, the preparation, the color, the spinning technique, the direction of the twist, etc. A common misconception is yarn spun from rolags may not be as strong, but the strength of a yarn is actually based on the length of hair fiber and the degree of twist. When working with shorter hairs, such as llama or angora rabbit, the spinner may choose to integrate longer fibers, such as mohair, to prevent yarn breakage. Yarns made of shorter fibers are also given more twist than yarns of longer fibers, and are generally spun with the short draw technique.

The fiber can be dyed at any time, but is often dyed before carding or after the yarn has been spun.

Wool may be spun before or after washing, although excessive amounts of lanolin may make spinning difficult, especially when using a drop-spindle. Careless washing may cause felting. When done prior to spinning, this often leads to unusable wool fiber. In washing wool the key thing to avoid is too much agitation and fast temperature changes from hot to cold. Generally, washing is done lock by lock in warm water with dish-soap.

Techniques

A handspinner using the short draw technique to spin wool

A tightly spun wool yarn made from fiber with a long staple length in it is called worsted. It is hand spun from combed top, and the fibers all lie in the same direction as the yarn. A woolen yarn, in contrast, is hand spun from a rolag or other carded fiber (roving, batts), where the fibers are not as strictly aligned to the yarn created. The woolen yarn, thus, captures much more air, and makes for a softer and generally bulkier yarn. There are two main techniques to create these different yarns: short draw creates worsted yarns, and long draw creates woolen yarns. Often a spinner will spin using a combination of both techniques and thus make a semi-worsted yarn.

Short draw spinning is used to create worsted yarns. It is spun from combed roving, sliver or wool top. The spinner keeps his/her hands very close to each other. The fibers are held, fanned out, in one hand, and the other hand pulls a small number from the mass. The twist is kept between the second hand and the wheel. There is never any twist between the two hands.

Long draw is spun from a carded rolag. The rolag is spun without much stretching of the fibers from the cylindrical configuration. This is done by allowing twist into a short section of the rolag, and then pulling back, without letting the rolag change position in one's hands, until the yarn is the desired thickness. The twist will concentrate in the thinnest part of the roving; thus, when the yarn is pulled, the thicker sections with less twist will tend to thin out. Once the yarn is the desired thickness, enough twist is added to make the yarn strong. Then the yarn is wound onto the bobbin, and the process starts again.

Spinning in the grease

Irreler Bauerntradition shows carding, spinning and knitting in the Roscheider Hof Open Air Museum

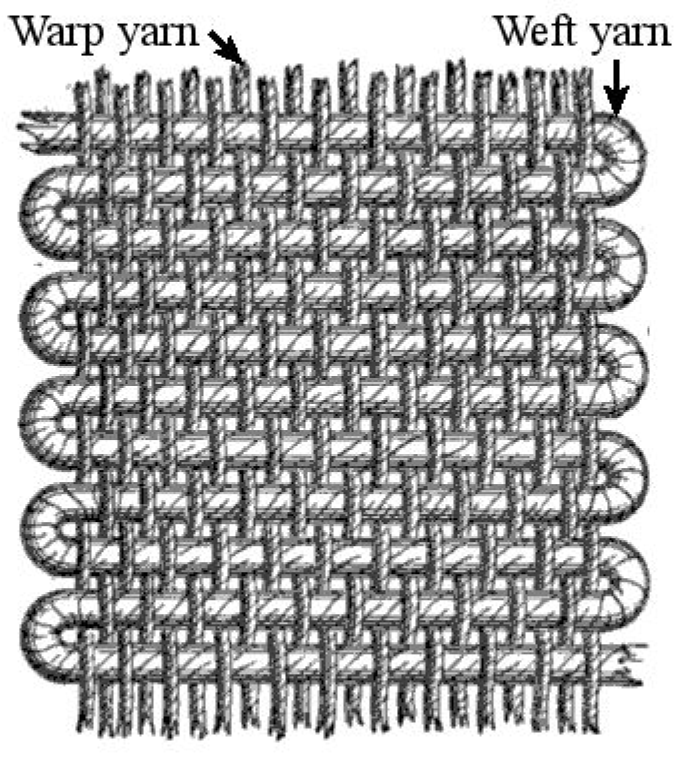
Handspinners are split, when spinning wool, as to whether it is better to spin it 'in the grease' (with lanolin still in) or after it has been washed. More traditional spinners are more willing to spin in the grease, as it is less work to wash the wool after it is in yarn form. Spinners who spin very fine yarn may also prefer to spin in the grease as it can allow them to spin finer yarns with more ease. Spinning in the grease covers the spinner's hands in lanolin and, thus, softens the spinner's hands.

Spinning in the grease only works really well if the fleece is newly sheared. After several months, the lanolin becomes sticky, which makes it harder to spin using the short draw technique, and almost impossible to spin using the long draw technique. In general, spinners using the long draw technique do not spin in the grease.

Spinners who do not spin in the grease generally buy their fibers pre-washed and carded, in the form of roving, sliver, or batts. This means less work for the spinner, as they do not have to wash the lanolin out. It also means that one can spin predyed fiber, or blends of fibers, which are very hard to create when the wool is still in the grease. As machine carders cannot card wool in the grease, pre-carded yarn generally is not spun in the grease. Some spinners, however, use spray-on lanolin-like products to get the same feel of spinning in the grease with this carded fiber.

Chapter 7

Weaving



Warp and weft in plain weaving

Weaving is a textile craft in which two distinct sets of yarns or threads are interlaced to form a fabric or cloth. The threads which run lengthways are called the warp and the threads which run across from side to side are the weft or filling.

Cloth is usually woven on a loom, a device that holds the warp threads in place while filling threads are woven through them. *Weft* is an old English word meaning "that which is woven". A fabric band which meets this definition of cloth (warp threads with a weft thread winding between) can also be made using tablet weaving techniques.

The way the warp and filling threads interlace with each other is called the weave. The majority of woven products are created with one of three basic weaves: plain weave, satin weave, or twill. Woven cloth can be plain (in one colour or a simple pattern), or can be woven in decorative or artistic designs, including tapestries. Fabric in which the warp and/or weft is tie-dyed before weaving is called ikat.

Though traditional handweaving and spinning remain popular crafts, nowadays the majority of commercial fabrics in the West are woven on computer-controlled Jacquard looms. In the past, simpler fabrics were woven on dobby looms, while the Jacquard harness adaptation was reserved for more complex patterns. Some believe the efficiency of the Jacquard loom, with its Jacquard weaving process, makes it more economical for mills to use them to weave all of their fabrics, regardless of the complexity of the design.

Process and terminology

An Indian weaver preparing his warp

A woman weaving with a manual loom

In general, weaving involves the interlacing of two sets of threads at right angles to each other: the warp and the weft (older *woof*). The warp are held taut and in parallel order, typically by means of a loom, though some forms of weaving may use other methods. The loom is warped (or dressed) with the warp threads passing through heddles on two or more harnesses. The warp threads are moved up or down by the harnesses creating a space called the shed. The weft thread is wound onto spools called bobbins. The bobbins are placed in a shuttle that carries the weft thread through the shed.

The raising and lowering sequence of warp threads gives rise to many possible weave structures:

- plain weave,
- twill weave,
- satin weave, and
- complex computer-generated interlacings.

Both warp and weft can be visible in the final product. By spacing the warp more closely, it can completely cover the weft that binds it, giving a *warp faced* textile such as rep weave. Conversely, if the warp is spread out, the weft can slide down and completely cover the warp, giving a *weft faced* textile, such as a tapestry or a Kilim rug. There are a variety of loom styles for hand weaving and tapestry. In tapestry, the image is created by placing weft only in certain warp areas, rather than across the entire warp width.

Ancient and traditional cultures

There are some indications that weaving was already known in the Palaeolithic era. An indistinct textile impression has been found at Pavlov, Moravia. Neolithic textiles are well known from finds in pile dwellings in Switzerland. One extant fragment from the Neolithic was found in Fayum, at a site dated to about 5000 BCE. This fragment is woven at about 12 threads by 9 threads per cm in a plain weave. Flax was the predominant fibre in Egypt at this time and continued popularity in the Nile Valley, even after wool became the primary fibre used in other cultures around 2000 BCE. Another Ancient Egyptian item, known as the Badari dish, depicts a textile workshop. This item, catalogue number UC9547, is now housed at the Petrie Museum and dates to about 3600 BCE. Enslaved women worked as weavers during the Sumerian Era. They washed wool fibers in hot water and wood-ash soap and then dried them. Next, they beat out the dirt and carded the wool. The wool was then graded, bleached, and spun into a thread. The spinners pulled out fibers and twisted them together. This was done either by rolling fibers between palms or using a hooked stick. The thread was then placed on a wooden or bone spindle and rotated on a clay whorl, which operated like a flywheel.

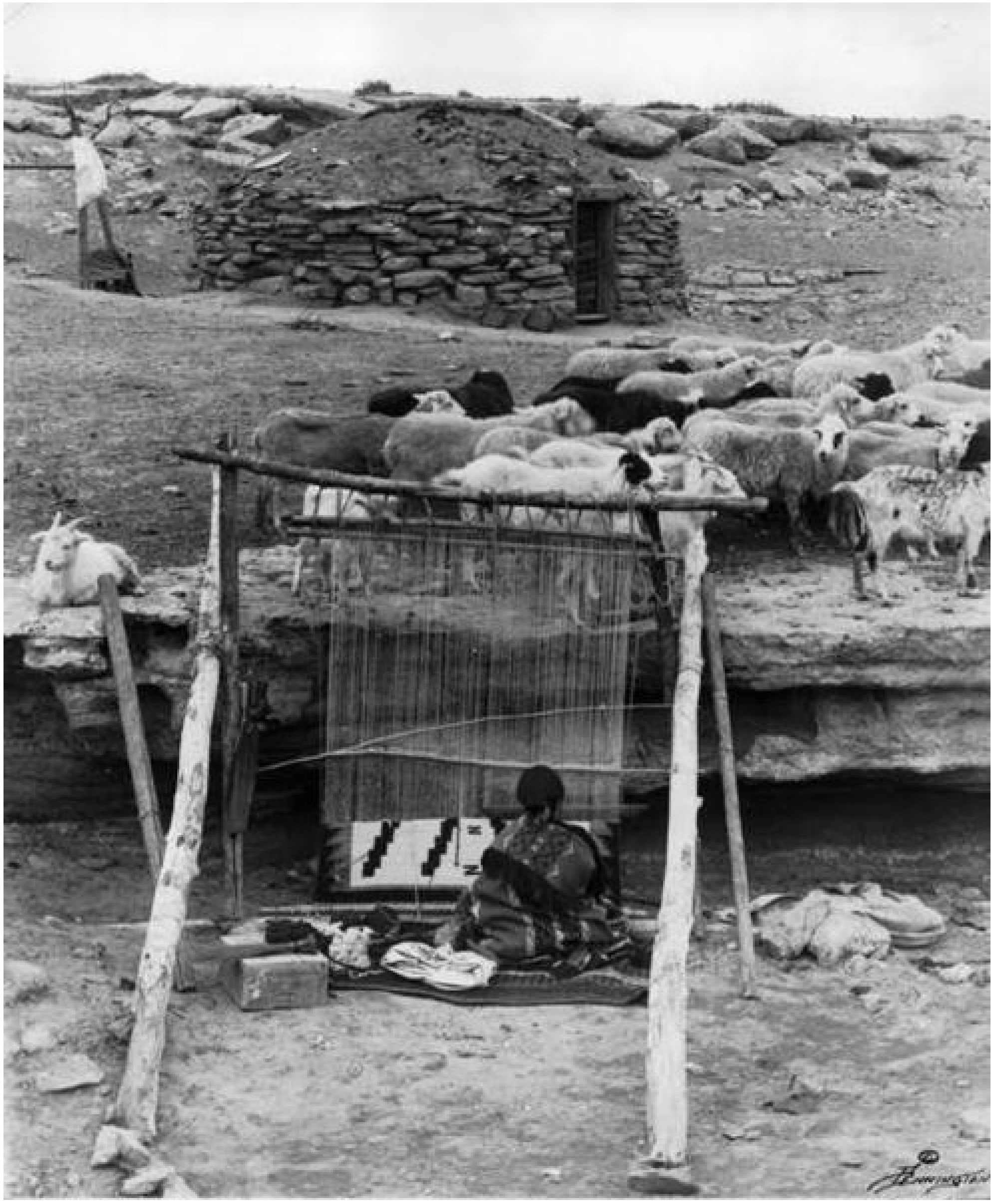
The slaves then worked in three-woman teams on looms, where they stretched the threads, after which they passed threads over and under each other at perpendicular angles. The finished cloth was then taken to a fuller.

Easton's Bible Dictionary (1897) refers to numerous Biblical references to weaving in ancient times:

Weaving was an art practised in very early times (Ex 35:35). The Egyptians were specially skilled in it (Isa 19:9; Ezek 27:7), and some have regarded them as its inventors.

In the wilderness, the Hebrews practised weaving (Ex 26:1, 26:8; 28:4, 28:39; Lev 13:47). It is referred to subsequently as specially the women's work (2 Kings 23:7; Prov 31:13, 24). No mention of the loom is found in Scripture, but we read of the "shuttle" (Job 7:6), "the pin" of the beam (Judg 16:14), "the web" (13, 14), and "the beam" (1 Sam 17:7; 2 Sam 21:19). The rendering, "with pining sickness," in Isa. 38:12 (A.V.) should be, as in the Revised Version, "from the loom," or, as in the margin, "from the thrum." We read also of the "warp" and "woof" (Lev. 13:48, 49, 51–53, 58, 59), but the Revised Version margin has, instead of "warp," "woven or knitted stuff."

American Southwest



Weaving a traditional Navajo rug

Textile weaving, using cotton dyed with pigments, was a dominant craft among pre-contact tribes of the American southwest, including various Pueblo peoples, the Zuni, and the Ute tribes. The first Spaniards to visit the region wrote about seeing Navajo blankets. With the introduction of Navajo-Churro sheep, the resulting woolen products have become very well known. By the 18th century the Navajo had begun to import yarn with their favorite color, Bayeta red. Using an upright loom, the Navajos wove blankets and then rugs after the 1880s for trade. Navajo traded for commercial wool, such as Germantown, imported from Pennsylvania. Under the influence of European-American settlers at trading posts, Navajos created new and distinct styles, including "Two Gray Hills" (predominantly black and white, with traditional patterns), "Teec Nos Pos" (colorful, with very extensive patterns), "Ganado" (founded by Don Lorenzo Hubbell), red dominated patterns with black and white, "Crystal" (founded by J. B. Moore), Oriental and Persian styles (almost always with natural dyes), "Wide Ruins," "Chinlee," banded geometric patterns, "Klagetoh," diamond type patterns, "Red Mesa" and bold diamond patterns. Many of these patterns exhibit a fourfold symmetry, which is thought to embody traditional ideas about harmony, or *hózhó*.

Amazonia

In Native Amazonia, densely woven palm-bast mosquito netting, or tents, were utilized by the Panoans, Tupí, Western Tucano, Yameo, Záparoans, and perhaps by the indigenous peoples of the central Huallaga River basin (Steward 1963:520). Aguaje palm-bast (Mauritia flexuosa, Mauritia minor, or swamp palm) and the frond spears of the Chambira palm (Astrocaryum chambira, A.munbaca, A.tucuma, also known as Cumare or Tucum) have been used for centuries by the Urarina of the Peruvian Amazon to make cordage, net-bags hammocks, and to weave fabric. Among the Urarina, the production of woven palm-fiber goods is imbued with varying degrees of an aesthetic attitude, which draws its authentication from referencing the Urarina's primordial past. Urarina mythology attests to the centrality of weaving and its role in engendering Urarina society. The post-diluvial creation myth accords women's weaving knowledge a pivotal role in Urarina social reproduction. Even though palm-fiber cloth is regularly removed from circulation through mortuary rites, Urarina palm-fiber wealth is neither completely inalienable, nor fungible since it is a fundamental medium for the expression of labor and exchange. The circulation of palm-fiber wealth stabilizes a host of social relationships, ranging from marriage and fictive kinship (*compadrazco*, spiritual compeership) to perpetuating relationships with the deceased.

Islamic world

Girls weaving a Persian rug, Hamadan, circa 1922. Note the design templates (called 'cartoons') at top of loom.

Hand weaving of Persian carpets and kilims has been an important element of the tribal crafts of many of the subregions of modern day Iran. Examples of carpet types are the Lavar Kerman carpet from Kerman and the Seraband rug from Arak.

An important innovation in weaving that was developed in the Muslim world during the Islamic Golden Age was the introduction of foot pedals to operate a loom. The first such devices appeared in Syria, Iran and Islamic parts of East Africa, where "the operator sat with his feet in a pit below a fairly low-slung loom." By 1177, it was further developed in Al-Andalus, where having the mechanism was "raised higher above the ground on a more substantial frame." This type of loom spread to the Christian parts of Spain and soon became popular all over medieval Europe.

Europe

Dark Age and Medieval Europe

Weighted-warp looms were commonplace in Europe until the development of more advanced looms around the 10th–11th centuries. Especially in colder climates, where a large floor loom would take up too much valuable floor space, the more primitive looms remained in use until the 20th Century to produce "homespun" cloth for individual family needs. The primary material woven in most of Europe was wool, though linen was also common, and imported silk thread was occasionally made into cloth. Both men and women were weavers, though the task often fell to the wife of a farming household. Fabric width was limited to the reach of the weaver, but was sufficient for the tunic-style garments worn in much of Europe at the time. A plain weave or twill was common, since professional weavers with skills to produce better fabrics were rare.

Weaving was a strictly local enterprise until later in the period, when larger weaving operations sprung up in places like Brugges, in Flanders. Within this setting, master weavers could improve their craft and pass skills along to apprentices. As the Middle Ages progressed, significant trade in fine cloth developed, and loom technology improved to allow very thin threads to be woven. Weaver's guilds (and associated craft guilds, like fullers) gained significant political and economic power in some of the bigger weaving cities.

In the medieval period, weaving was considered part of the set of *seven mechanical arts*.

Colonial America

Colonial America was heavily reliant on Great Britain for manufactured goods of all kinds. British policy was to encourage the production of raw materials in colonies. Weaving was not prohibited, but the export of British wool was. As a result many people wove cloth from locally produced fibers in Colonial America.

In Colonial times the colonists mostly used wool, cotton and flax (linen) for weaving, though hemp fiber could be made into serviceable canvas and heavy cloth also. They could get one cotton crop each fall, but until the invention of the cotton gin it was a labor-intensive process to separate the seeds from the cotton fiber. Flax and hemp were harvested in the summer, and the stalks rendered for the long fibers within. Wool could be sheared up to twice yearly, depending on the breed of sheep. The relative ease of processing wool, and its durability, meant that a great proportion of weaving was wool cloth.

A plain weave was preferred in Colonial times, and the added skill and time required to make more complex weaves kept them from common use in the average household. Sometimes designs were woven into the fabric but most were added after weaving using wood block prints or embroidery.

Industrial Revolution

Before the Industrial Revolution, weaving was a manual craft, usually undertaken part-time by family craftspeople. Looms might be broad or narrow; broad looms were those too wide for the weaver to pass the shuttle through the shed, so that the weaver needed an assistant (often an apprentice). This ceased to be necessary after John Kay invented the flying shuttle in 1733, which also sped up the process of weaving.

Great Britain

Edmund Cartwright was the first to attempt to mechanise weaving from 1785. He built a factory at Doncaster and obtained a series of patents between 1785 and 1792. In 1788, his brother Major John Cartwight built Revolution Mill at Retford (named for the centenary of the Glorious Revolution. In 1791, he licensed his loom to the Grimshaw brothers of Manchester, but their Knott Mill burnt down the following year (possibly a case of arson). Edmund Cartwight was granted a reward of £10,000 by Parliament for his efforts in 1809. However, success in power-weaving also required improvements by others, including H. Horrocks of Stockport. Only during the two decades after about 1805, did power-weaving take hold. Textile manufacture was one of the leading sectors in the British Industrial Revolution, but weaving was a comparatively late sector to be mechanised. The loom became semi-automatic in 1842 with Kenworthy and Bulloughs Lancashire Loom. The various innovations took weaving from a home-based artisan activity (labour intensive and man-powered) to steam driven factories process. A large metal manufacturing industry grew to produce the looms, firms such as Howard & Bullough of Accrington, and Tweedales and Smalley and Platt Brothers. Most cotton weaving took place in weaving sheds, in small towns circling Greater Manchester and worsted weaving in West Yorkshire – men and women with weaving skills emigrated, and took the knowledge to their new homes in New England, in places like Pawtucket and Lowell.

The invention in France of the Jacquard loom in about 1803, enabled complicated patterned cloths to be woven, by using punched cards to determine which threads of coloured yarn should appear on the upper side of the cloth.

America, 1800–1900

Jacquard loom

The Jacquard loom attachment was perfected in 1801, and was becoming common in Europe by 1806. It came to the US in the early 1820s, some immigrant weavers bringing jacquard equipment with them, and spread west from New England. At first it was used with traditional human-powered looms. As a practical matter, previous looms were mostly limited to the production of simple geometric patterns. The jacquard allowed individual control of each warp thread, row by row without repeating, so very complex patterns were suddenly feasible. woven coverlets (bedspreads) became popular by mid-century, in some cases being custom-woven with the name of the customer embedded in the programmed pattern. Undyed cotton warp was usually combined with dyed wool weft.

Natural dyes were used until just before the American Civil War, when artificial dyes started to come into use.

Weaving can also refer to a person such as weave hair styles. Weaving or the term "weaver" can also refer to ones last name.

Chapter 8

Textile Bleaching and Dyeing

Textile bleaching

Textile bleaching is one of the stages in the manufacture of textiles. All raw textile materials, when they are in natural form, are known as 'greige' material(pronounced grey-sh). This greige material will be with its natural color, odour and impurities that are not suitable for clothing materials. Not only the natural impurities will remain on the greige material but also the add-ons that were made during its cultivation, growth and manufacture in the form of pesticides, fungicides, worm killers, sizes, lubricants, etc.

The removal of these natural coloring matters and add-ons during the previous state of manufacturing is called scouring and bleaching.

Scouring

Scouring is the first process carried out with or without chemicals, at room temperature or at suitable higher temperatures with the addition of suitable wetting agents, alkali and so on. Scouring removes all the waxes, pectins and makes the textile material hydrophilic or water absorbent.

Bleaching

The next process of decolorization of greige material in to a suitable material for next processing is called bleaching. Bleaching of textiles can be classified in to oxidative bleaching and reductive bleaching.

Oxidative bleaching

Generally oxidative bleachings are carried out using sodium hypochlorite, sodium chlorite or hydrogen peroxide. Natural fibres like cotton, ramie, jute, wool, bamboo are all generally bleached with oxidative methods.

Reductive bleaching

Reductive method of bleaching is done with Sodium hydrosulphite, a powerful reducing agent. Fibres like Polyamide, Polyacrylics and Polyacetates can be bleached using reductive bleaching technology.

Optical whiteners

After scouring and bleaching, Optical Brightening Agents (OBA), are applied to make the textile material to appear more brilliant whites. These OBA are available in different tints such as blue, violet and red.

Dyeing

Pigments for sale at a market in Goa, India.

Cotton being dyed manually in contemporary India.

Dyeing is the process in order to dye textile production like fibers, yarns, fabrics. Dyeing is normally done in a special solution containing dyes and particular chemical material. After dyeing, dye molecules have uncut Chemical bond with fiber molecules. The temperature and time controlling are two key factors in dyeing. There are mainly two classes of dye, natural and man-made.

Dye types

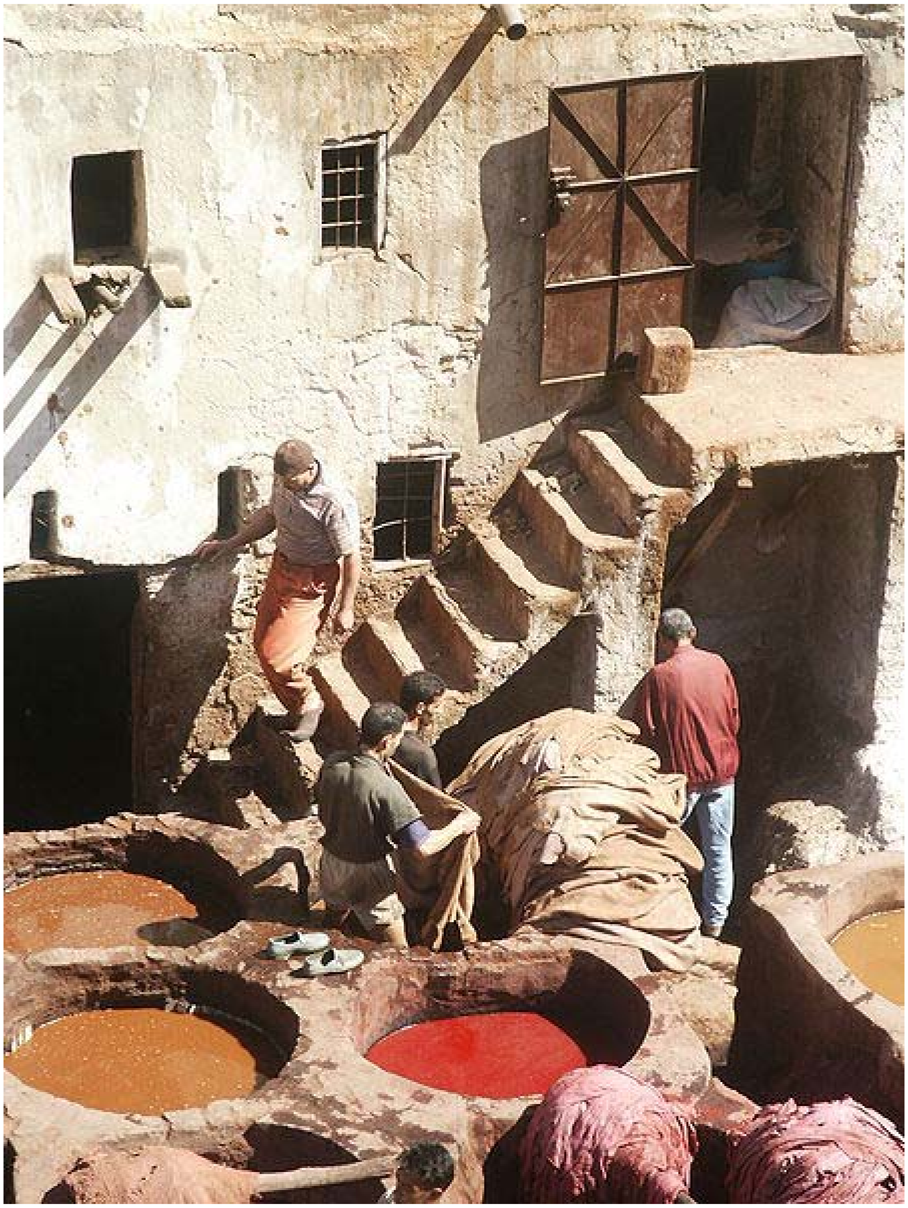
For most of the thousands of years in which dyeing has been used by humans to decorate clothing, or fabrics for other uses, the primary source of dye has been nature, with the dyes being extracted from animals or plants. In the last 150 years, humans have produced artificial dyes to achieve a broader range of colors, and to render the dyes more stable to resist washing and general use. Different classes of dyes are used for different types of fiber and at different stages of the textile production process, from loose fibers through yarn and cloth to completed garments.

Acrylic fibers are dyed with basic dyes, Nylon and protein fibers such as wool and silk are dyed with acid dyes, polyester yarn is dyed with disperse dyes. Cotton is dyed with a range of dye types, including vat dyes, which are similar to the ancient natural dyes, and modern synthetic reactive and direct dyes.

History

Archaeologists have found evidence of textile dyeing dating back to the Neolithic period. In China, dyeing with plants, barks and insects has been traced back more than 5,000 years. Early evidence of dyeing comes from Sindh (Pakistan), where a piece of cotton dyed with a vegetable dye has been recovered from the archaeological site at Mohenjo-daro (3rd millennium BCE). The dye used in this case was madder, which, along with other dyes such as indigo, was introduced to other regions through trade. Contact with Alexander the Great, who had successfully used dyeing for military camouflage, may have further helped aid the spread of dyeing from India. Natural insect dyes such as Tyrian purple and kermes and plant-based dyes such as woad, indigo and madder were important elements of the economies of Asia and Europe until the discovery of man-made synthetic dyes in the mid-19th century. The first synthetic dyes was William Perkins's mauveine in 1856, derived from coal tar. Alizarin, the red dye present in madder, was the first natural pigment to be duplicated synthetically, in 1869, a development which led to the collapse of the market for naturally grown madder. The development of new, strongly colored synthetic dyes followed quickly, and by the 1870s commercial dyeing wth natural dyestuffs was disappearing.

Methods



Dyeing in Fes, Morocco.

Dyes are applied to textile goods by dyeing from dye solutions and by printing from dye pastes.

Direct application

The term "direct dye application" stems from some dyestuff having to be either fermented as in the case of some natural dye or chemically reduced as in the case of synthetic vat and sulfur dyes before being applied. This renders the dye soluble so that it can be absorbed by the fiber since the insoluble dye has very little substantivity to the fiber. Direct dyes, a class of dyes largely for dyeing cotton, are water soluble and can be applied directly to the fiber from an aqueous solution. Most other classes of synthetic dye, other than vat and surface dyes, are also applied in this way.

The term may also be applied to dyeing without the use of mordants to fix the dye once it is applied. Mordants were often required to alter the hue and intensity of natural dyes and improve their color fastness. Chromium salts were until recently extensively used in dying wool with synthetic mordant dyes. These were used for economical high color fastness dark shades such as black and navy. Environmental concern has now restricted their use, and they have been replaced with reactive and metal complex dyes which need no mordant.

Yarn dyeing

There are many forms of yarn dyeing. Common forms are the at package form and the at hanks form. Cotton yarns are mostly dyed at package form, and acrylic or wool yarn are dyed at hank form. In the continuous filament industry, polyester or polyamide yarns are always dyed at package form, while viscose rayon yarns are partly dyed at hank form because of technology.

The common dyeing process of cotton yarn with reactive dyes at package form is as follows:

1. The raw yarn is wound on a spring tube to achieve a package suitable for dye penetration.
2. These softened packages are loaded on a dyeing carrier's spindle one on another.
3. The packages are pressed up to a desired height to achieve suitable density of packing.
4. The carrier is loaded on the dyeing machine and the yarn is dyed.
5. After dyeing, the packages are unloaded from the carrier into a trolly.
6. Now the trolly is taken to hydro extractor where water is removed.
7. The packages are hydro extracted to remove the maximum amount of water leaving the desired color into raw yarn.
8. The packages are then dried to achieve the final dyed package.₪

After this process, the dyed yarn packages are packed and delivered.

Removal of dyes

In order to remove natural or unwanted colour from material, the opposite process of bleaching or discharging is carried out.

If things go wrong in the dyeing process, the dyer may be forced to remove the dye already applied by a process that is normally known as stripping. This normally means destroying the dye with powerful reducing agents (sodium hydrosulphite) or oxidizing agents (hydrogen peroxide or sodium hypochlorite). The process often risks damaging the substrate (fiber). Where possible, it is often less risky to dye the material a darker shade, with black often being the easiest or last option.

Chapter 9

Textile Printing

Design for a hand woodblock printed textile, showing the complexity of the blocks used to make repeating patterns. *Evenlode* by William Morris, 1883.

Evenlode block-printed fabric.

Textile printing is the process of applying colour to fabric in definite patterns or designs. In properly printed fabrics the colour is bonded with the fiber, so as to resist washing and friction. Textile printing is related to dyeing but, whereas in dyeing proper the whole fabric is uniformly covered with one colour, in printing one or more colours are applied to it in certain parts only, and in sharply defined patterns.

In printing, wooden blocks, stencils, engraved plates, rollers, or silkscreens are used to place colours on the fabric. Colourants used in printing contain dyes thickened to prevent the colour from spreading by capillary attraction beyond the limits of the pattern or design.

Traditional textile printing techniques may be broadly categorised into four styles:

- Direct printing, in which colourants containing dyes, thickeners, and the mordants or substances necessary for fixing the colour on the cloth are printed in the desired pattern.
- The printing of a mordant in the desired pattern prior to dyeing cloth; the color adheres only where the mordant was printed.
- Resist dyeing, in which a wax or other substance is printed onto fabric which is subsequently dyed. The waxed areas do not accept the dye, leaving uncoloured patterns against a coloured ground.
- Discharge printing, in which a bleaching agent is printed onto previously dyed fabrics to remove some or all of the colour.

Resist and discharge techniques were particularly fashionable in the 19th century, as were combination techniques in which indigo resist was used to create blue backgrounds prior to block-printing of other colours. Most modern industrialised printing uses direct printing techniques.

Origins

Woodblock printing is a technique for printing text, images or patterns used widely throughout East Asia and probably originating in China in antiquity as a method of printing on textiles and later paper. As a method of printing on cloth, the earliest surviving examples from China date to before 220, and from Egypt to the 4th century.

Textile printing was known in Europe, via the Islamic world, from about the 12th century, and widely used. However, the European dyes tended to run, which restricted the use of printed patterns. Fairly large and ambitious designs were printed for decorative purposes such as wall-hangings and lectern-cloths, where this was less of a problem as they did not need washing. When paper became common, the technology was rapidly used on that for woodcut prints. Superior cloth was also imported from Islamic countries, but this was much more expensive.

The Incas of Peru, Chile and the Aztecs of Mexico also practiced textile printing previous to the Spanish Invasion in 1519; but, owing to the imperfect character of their records before that date, it is impossible to say whether they discovered the art for themselves, or, in some way, learned its principles from the Asiatics.

During the latter half of the 17th century the French brought directly by sea, from their colonies on the east coast of India, samples of Indian blue and white resist prints, and along with them, particulars of the processes by which they had been produced, which produced washable fabrics.

Technology

Textile printing was introduced into England in 1676 by a French refugee who opened works, in that year, on the banks of the Thames near Richmond. Curiously enough this is the first print-works on record; but the nationality and political status of its founder are sufficient to prove that printing was previously carried on in France. In Germany, too, textile printing was in all probability well established before it spread to England, for, towards the end of the 17th century, the district of Augsburg was celebrated for its printed linens, a reputation not likely to have been built up had the industry been introduced later than 1676.

On the continent of Europe the commercial importance of calico printing seems to have been almost immediately recognized, and in consequence it spread and developed there much more rapidly than in England, where it was neglected and practically at a standstill for nearly ninety years after its introduction. During the last two decades of the 17th century and the earlier ones of the 18th new works were started in France, Germany, Switzerland and Austria; but it was only in 1738 that calico printing was first, practiced in Scotland, and not until twenty-six years later that Messrs Clayton of Bamber Bridge, near Preston, established in 1764 the first print-works in Lancashire, and thus laid the foundation of what has since become one of the most important industries of the county and indeed of the country. At the present time calico printing is carried on extensively in every quarter of the globe, and it is pretty safe to say that there is scarcely a civilized country in either hemisphere where a print-works does not exist.

From an artistic point of view most of the pioneer work in calico printing was done by the French; and so rapid was their advance in this branch of the business that they soon came to be acknowledged as its leading exponents. Their styles of design and schemes of colour were closely followed-even deliberately copied by all other European printers; arid, from the early days of the industry down to the latter half of the 10th century, the productions of the French printers in Jouy, Beauvais, Rouen, Alsace-Lorraine, &c., were looked upon as representing all that was best in artistic calico printing. This reputation was established by the superiority of their earlier work, which, whatever else it may have lacked, possessed in a high degree the two main qualities essential to all good decorative work, viz., appropriateness of pattern and excellency of workmanship. If, occasionally, the earlier designers permitted themselves to indulge in somewhat bizarre fancies, they at least carefully refrained from any attempt to produce those pseudo-realistic effects the undue straining after which in later times ultimately led to the degradation of not only French calico printing design, but of that of all other European nations who followed their lead. The practice of the older craftsmen, at their best, was to treat their ornament in a way at once broad, simple and direct, thoroughly artistic and perfectly adapted to the means by which it had to be reproduced. The result was that their designs were characterized, on the one hand, by those qualities of breadth, flatness of field, simplicity of treatment arid pureness of tint so rightly prized by the artist; and, on the other, by their entire freedom from those meretricious effects of naturalistic projection and recession so dear to the modern mind and so utterly opposed to the principles of applied art.

Methods of printing

There are seven distinct methods at present in use for producing coloured patterns on cloth:

Hand block printing

Woman doing Block Printing at Halasur village, Karnataka, India.

This process, though considered by some to be the most artistic, is the earliest, simplest and slowest of all methods of printing.

In this process, a design is drawn upon, or transferred to, a prepared wooden block. A separate block is required for each distinct colour in the design.

A blockcutter carves out the wood around the heavier masses first, leaving the finer and more delicate work until the last so as to avoid any risk of injuring it during the cutting of the coarser parts. When finished, the block presents the appearance of flat relief carving, with the design standing out.

Fine details are very difficult to cut in wood, and, even when successfully cut, wear down very rapidly or break off in printing. They are therefore almost invariably built up in strips of brass or copper, bent to shape and driven edgewise into the flat surface of the block. This method is known as coppering.

To print the design on the fabric, the printer applies color to the block and presses it firmly and steadily on the cloth, ensuring a good impression by striking it smartly on the back with a wooden mallet. The second impression is made in the same way, the printer taking care to see that it fits exactly to the first, a point which he can make sure of by means of the pins with which the blocks are provided at each corner and which are arranged in such a way that when those at the right side or at the top of the block fall upon those at the left side or the bottom of the previous impression the two printings join up exactly and continue the pattern without a break. Each succeeding impression is made in precisely the same manner until the length of cloth is fully printed. When this is done it is wound over the drying rollers, thus bringing forward a fresh length to be treated similarly.

If the pattern contains several colours the cloth is usually first printed throughout with one, then dried, and printed with the second, the same operations being repeated until all the colours are printed.

Block printing by hand is a slow process it is, however, capable of yielding highly artistic results, some of which are unobtainable by any other method.

Perrotine printing

The perrotine is a block-printing machine invented by Perrot of Rouen in 1834, and practically speaking is the only successful mechanical device ever introduced for this purpose. For some reason or other it has rarely been used in England, but its value was almost immediately recognized on the Continent, and although block printing of all sorts has been replaced to such an enormous extent by roller printing, the perrotine is still largely employed in French, German and Italian works.

The construction of this ingenious machine is too complex to describe here without the aid of several detailed drawings, but its mode of action is roughly as follows: Three large blocks (3 ft. long by 3 to 5 in. wide), with the pattern cut or cast on them in relief, are brought to bear successively on the three faces of a specially constructed printing table over which the cloth passes (together with its backing of printers blanket) after each impression. The faces of the table are arranged at right angles to each other, and the blocks work in slides similarly placed, so that their engraved faces are perfectly parallel to the tables. Each block is moreover provided with its own particular colour trough, distributing brush, and woolen colour pad or sieve, and is supplied automatically with colour by these appliances during the whole time that the machine is in motion. The first effect of starting the machine is to cause the colour sieves, which have a reciprocating motion, to pass over, and receive a charge of colour from, the rollers, fixed to revolve, in the colour troughs. They then return to their original position between the tables and the printing blocks, coming in contact on the way with the distributing brushes, which spread the colour evenly over their entire surfaces. At this point the blocks advance and are gently pressed twice against the colour pads (or sieves) which then retreat once more towards the colour troughs. During this last movement the cloth to be printed is drawn forward over the first table, and, immediately the colour pads are sufficiently out of the way, the block advances and, with some force, stamps the first impression on it. The second block is now put into gear and the foregoing operations are repeated for both blocks, the cloth advancing, after each impression, a distance exactly equal to the width of the blocks. After the second block has made its impression the third comes into play in precisely the same way, so that as the cloth leaves the machines it's fully printed in three separate colours, each fitting into its proper place and completing the pattern. If necessary the forward movement of the cloth can be arrested without in any way interfering with the motion of the block, san arrangement which allows any insufficiently printed impression to be repeated in exactly the same place with a precision practically impossible in hand printing.

For certain classes of work the perrotine possesses great advantages over the hand-block; for not only is the rate of production greatly increased, but the joining up of the various impressions to each other is much more exacting fact, as a rule, no sign of a break in continuity of line can be noticed in well-executed work. On the other hand, however, the perrotine can only be applied to the production of patterns containing not more than three colours nor exceeding five inches in vertical repeat, whereas hand block printing can cope with patterns of almost any scale and continuing any number of colours. All things considered, therefore, the two processes cannot be compared on the same basis: the perrotine is best for work of a utilitarian character and the hand-block for decorative work in which the design only repeats every 15 to 20 in. and contains colours varying in number from one to a dozen. -

Engraved copperplate printing

The printing of textiles from engraved copperplates was first practiced in the United Kingdom by Thomas Bell in 1770.

The presses first used were of the ordinary letterpress type, the engraved plate being fixed in the place of the type. In later improvements the well-known cylinder press was employed; the plate was inked mechanically and cleaned off by passing under a sharp blade of steel; and the cloth, instead of being laid on the plate, was passed round the pressure cylinder. The plate was raised into frictional contact with the cylinder and in passing under it transferred its ink to the cloth.

The great difficulty in plate printing was to make the various impressions join up exactly; and, as this could never be done with any certainty, the process was eventually confined to patterns complete in one repeat, and was made obsolete by roller printing.

Roller printing, cylinder printing, or machine printing

This elegant and efficient process was patented and worked by Bell in 1785 only fifteen years after his application of the engraved plate to textiles. Bell's first patent was for a machine to print six colours at once, but, owing probably to its incomplete development, this was not immediately successful, although the principle of the method was shown to be practical by the printing of one colour with perfectly satisfactory results. The difficulty was to keep the six rollers, each carrying a portion of the pattern, in perfect register with each other. This defect was soon overcome by Adam Parkinson of Manchester, and in 1785, the year of its invention, Bells machine with Parkinson's improvement was successfully employed by Messrs Livesey, Hargreaves, Hall & Co., of Bamber Bridge, Preston, for the printing of calico in from two to six colours at a single operation.

The advantages possessed by roller printing over other contemoporary processes were three: firstly, its high productivity, 10,000 to 12,000 yards being commonly printed in one day of ten hours by a single-colour machine; secondly, by its capacity of being applied to the reproduction of every style of design, ranging from the fine delicate lines of copperplate engraving and the small repeats and limited colours of the perrotine to the broadest effects of block printing and to patterns varying in repeat from I to 80 in.; and thirdly, the wonderful exactitude with which each portion of an elaborate multicolour pattern can be fitted into its proper place without faulty joints at its points of repetition.

Stencil printing

The art of stenciling is very old. It has been applied to the decoration of textile fabrics from time immemorial by the Japanese, and, of late years, has found increasing employment in Europe for certain classes of decorative work on woven goods for furnishing purposes.

The pattern is cut out of a sheet of stout paper or thin metal with a sharp-pointed knife, the uncut portions representing the part that is to be reserved or left uncoloured. The sheet is now laid on the material to be decorated and colour is brushed through its interstices.

It is obvious that with suitable planning an all over pattern may be just as easily produced by this process as by hand or machine printing, and that moreover, if several plates are used, as many colours as plates may be introduced into it. The peculiarity of stenciled patterns is that they have to be held together by ties, that is to say, certain parts of them have to be left uncut, so as to connect them with each other, and prevent them from falling apart in separate pieces. For instance, a complete circle cannot be cut without its center dropping out, and, consequently, its outline has to be interrupted at convenient points by ties or uncut portions. Similarly with other objects. The necessity for ties exercises great influence on the design, and in the hands of a designer of indifferent ability they may be very unsightly. On the other hand, a capable man utilizes them to supply the drawing, and when thus treated they form an integral part of the pattern and enhance its artistic value whilst complying with the conditions and the process.

For single-colour work a stenciling machine was patented in 1894 by S. H. Sharp. It consists of an endless stencil plate of thin sheet steel that passes continuously over a revolving cast iron cylinder. Between the two the cloth to be ornamented passes and the colour is forced on to it, through the holes in the stencil, by mechanical means.

Screen-printing

Screen printing is by far the most used technology today. Two types exist: rotary screen printing and flat (bed) screen printing. A blade squeezes the printing paste through openings in the screen onto the fabric.

Digital textile printing

Digital textile printing, also known as direct to garment printing, DTG printing, and digital garment printing is a process of printing on textiles and garments using specialized or modified inkjet technology. Inkjet printing on fabric is also possible with an inkjet printer by using fabric sheets with a removable paper backing. Today major inkjet technology manufacturers can offer specialized products designed for direct printing on textiles, not only for sampling but also for bulk production.

Other methods of printing

Although most work is executed throughout by one or other of the seven distinct processes mentioned above, combinations of them are not infrequently employed. Sometimes a pattern is printed partly by machine and partly by block; and sometimes a cylindrical block is used along with engraved copper-rollers in the ordinary printing machine. The block in this latter case is in all respects, except that of shape, identical with a flat wood or coppered block, but, instead of being dipped in colour, it receives its supply from an endless blanket, one part of which works in contact with colour-furnishing rollers and the other part with the cylindrical block. This block is known as a surface or peg roller. Many attempts have been made to print multicolour patterns with surface rollers alone, but hitherto with little success, owing to their irregularity in action and to the difficulty of preventing them from warping. These defects are not present in the printing of linoleum in which opaque oil colours are used, colours that neither sink into the body of the hard linoleum nor tend to warp the roller.'***Inkjet Printing on Fabric'***is a way anyone can print on fabric using their home printer. Specially treated Cotton as well as various types of Silk fabric sheets are available in various sizes. The fabric sheets have a paper backing which enable the fabric to go through the printer. Family photos printed on fabric are used to make memory quilts, pillows, notebook covers, wall hangings and many other products.

The printing of yarns and warping is extensively practiced. It is usually carried on by a simple sort of surface printing machine and calls for no special mention.

Lithographic printing, too, has been applied to textile fabrics with somewhat qualified success. Its irregularity and the difficulty of printing all over patterns to repeat properly, have restricted its use to the production of decorative panels, equal in size to that of the plate or stone, and complete in themselves.

Pad printing has been recently introduced to textile printing for the specific purpose of printing garment tags (care labels).

Preparation of cloth for printing

Goods intended for calico printing ought to be exceptionally well-bleached, otherwise mysterious stains, and other serious defects, are certain to arise during subsequent operations.

The chemical preparations used for special styles will be mentioned in their proper places; but a general prepare, employed for most colours that are developed and fixed by steaming only, consists in passing the bleached calico through a weak solution of sulfated or turkey red oil containing from 21/2 per cent, to 5 per cent, of fatty acid. Some colours are printed on pure bleached cloth, but all patterns containing alizarine red, rose and salmon shades, are considerably brightened by the presence of oil, and indeed very few, if any, colours are detrimentally affected by it.

Apart from wet preparations the cloth has always to be brushed, to free it from loose nap, flocks and dust that it picks up whilst stored. Frequently, too, it has to be sheared by being passed over rapidly revolving knives arranged spirally round an axle, which rapidly and effectually cuts off all filaments and knots, leaving the cloth perfectly smooth and clean and in a condition fit to receive impressions of the most delicate engraving. Some figured fabrics, especially those woven in checks, stripes and crossovers, require very careful stretching and straightening on a special machine, known as a stenter, before they can be printed with certain formal styles of pattern which are intended in one way or another to correspond with the cloth pattern. Finally, all descriptions of cloth are wound round hollow wooden or iron centers into rolls of convenient size for mounting on the printing machines.

Preparation of colours

The art of making colours for textile printing demands both chemical knowledge and extensive technical experience, for their ingredients must not only be properly proportioned to each other, but they must be specially chosen and compounded for the particular style of work in hand. For a pattern containing only one colour any mixture whatever may he used so long as it fulfils all conditions as to shade, quality and fastness; but where two or more colours are associated in the same design each must be capable of undergoing without injury the various operations necessary for the development and fixation of the others.

All printing pastes whether containing colouring matter or not are known technically as colours, and are referred to as such in the sequence.

Colours vary considerably in composition. The greater number of them contain all the elements necessary for the direct production and fixation of the colour-lake. Some few contain the colouring matter alone and require various after-treatments for its fixation; and others again are simply mordants thickened. A mordant is the metallic salt or other substance that combines with the colouring principle to form an insoluble colour-lake, either directly by steaming, or indirectly by dyeing.

All printing colours require thickening, for the twofold object of enabling them to be transferred from colour-box to cloth without loss and to prevent them from running or spreading beyond the limits of the pattern.

Selecting thickening agents

The printing thickeners used depend on the printing technique and fabric and dyestuff used. Typical thickening agents are starch derivatives, flour, gum arabic, guar gum derivatives, tamarind, sodium alginate, sodium polyacrylate, gum Senegal and gum tragacanth, British gum or dextrine and albumen.

Hot water soluble tickening agents as native starch are made into pastes by boiling in double or jacketed pans, between the inner and outer casings of which either steam or water may be made to circulate, for boiling and cooling purposes. Mechanical agitators are also fitted in these pans to mix the various ingredients together, and to destroy lumps and prevent the formation of lumps, keeping the contents thoroughly stirred up during the whole time they are being boiled and cooled to make a smooth paste. Most tickening agents used today are cold soluble and require only extensive stirring.

Starch paste

This is made from wheat starch, cold water, and olive oil, and boiled for thickening.

Non modified Starch was the most extensively used of all the thickenings. It is applicable to all but strongly alkaline or strongly acid colours. With the former it thickens up to a stiff unworkable jelly, while mineral acids or acid salts convert it into dextrine, thus diminishing its viscosity or thickening power. Acetic and formic acids have no action on it even at the boil. Today mostly modified carboxymethylated cold soluble starches are used which have a stable viscosity and are easier to rinse out of the fabric and give reproducible "short" pasty rheology.

Flour paste is made in a similar way to starch paste. At the present time it is rarely used for anything but the thickening of aluminum and iron mordants. In the impressive textile traditions of Japan, several techniques using starch paste resists of rice flour have been perfected over several centuries.

Gums

Gum arabic and gum Senegal are both very old thickenings, but their expense prevents them from being used for any but pale delicate tints. They are especially useful thickenings for the light ground colours of soft muslins and sateens on account of the property they possess of dissolving completely out of the fibers of the cloth in the washing process after printing and have a long flowing, viscous rheology, giving sharp print and good penetration in the cloth. Today guar gum and tamarind derivates offer a cheaper alternative.

British gum or dextrin is prepared by heating starch. It varies considerably in composition sometimes being only slightly roasted and consequently only partly converted into dextrine, and at other times being highly torrefied, and almost completely soluble in cold water and very dark in colour. Its thickening power decreases and its gummy nature increases as the temperature at which it is roasted is raised. The lighter coloured gums or dextrines will make a good thickening with from 2 to 3 lb of gum to one gallon of water, but the darkest and most highly calcined require from 6 to lb per gallon to give a substantial paste. Between these limits all qualities are obtainable. The darkest qualities are very useful for strongly acid colours, and with the exception of gum Senegal, are the best for strongly alkaline colours and discharges. Like the natural gums, neither light nor dark British gums penetrate as well into the fiber of the cloth so deeply as pure starch or flour, and are therefore unsuitable for very dark strong colours.

Gum tragacanth, or Dragon, is one of the most indispensable thickening agents possessed by the textile printer. It may be mixed in any proportion with starch or flour and is equally useful for pigment colours and mordant colours. When added to starch paste it increases its penetrative power, adds to its softness without diminishing its thickness, makes it easier to wash Out of the fabric and produces much more level colours than starch paste alone. Used by itself it is suitable for printing all kinds of dark grounds on goods that are required to retain their soft clothy feel. A tragacanth mucilage may be made either by allowing it to stand a day or two in contact with cold water or by soaking it for twenty-four hours in warm water and then boiling it up until it is perfectly smooth and homogeneous. If boiled under pressure it gives a very fine, smooth mucilage (not a solution proper), much thinner than if made in the cold.

Starch always leave on the printed cloth somewhat harsh in feel (unless modified carboxymethylated starches are used) but are well suited to obtain very dark colours. Gum Senegal, gum arabic or modified guar gum thickening are yielding beautifully clear and perfectly even tints comparing to starch, but give lighter colours and are washedaway too much during the rinsing or washing of the printed fabric and are thuss less suited for very dark colours. (The gums are apparently preventing the colours from combining fully with the fibers.) So a printing stock solution is mostly a combination of modified starch and gum stock solutions usually made by dissolving 6 or 8 lb of either in one gallon of water.

Albumen

Albumen is both a thickening and a fixing agent for insoluble pigments such as chrome yellow, the ochres, vermilion and ultramarine. Albumen is always dissolved in the cold, a process that takes several days when large quantities are required. The usual strength of the solution is 4 lb per gallon of water for blood albumen, and 6 lb per gallon for egg albumen. The latter is expensive and only used for the lightest shades. For most purposes one part of albumen solution is mixed with one part of tragacanth mucilage, this proportion of albumen being found amply sufficient for the fixation of all ordinary pigment colours. In special instances the blood albumen solution is made as strong as 50 per cent, but this is only in cases where very dark colours are required to be absolutely fast to washing. After printing, albumen thickened colours are exposed to hot steam, which coagulates the albumen and effectually fixes the colours.

Printing thickeners and the dye system

Combinations of cold water soluble carboxymethylated starch, guar gum and tamarind derivatives are most commonly used today in disperse screen printing on polyester, for cotton printing with reactive dyes alginates are used, sodium polyacrylates for pigment printing and with vat dyes on cotton only carboxymethylated starch is used.

Printing paste preparation

Formerly colours were always prepared for printing by boiling the thickening agent, the colouring matter and solvents, &c., together, then cooling and adding the various fixing agents. At the present time, however, concentrated solutions of the colouring matters and other adjuncts are often simply added to the cold thickenings, of which large quantities are kept in stock.

Colours are reduced in shade by simply adding more stock (printing) paste. For example, a dark blue containing 4 oz. of methylene blue per gallon may readily be made into a pale shade by adding to it thirty times its bulk of starch paste or gum, as the case may be. Similarly with other colours.

Before printing it is very essential to strain or sieve all colours in order to free them from lumps, fine sand, &c., which would inevitably damage the highly polished surface of the engraved rollers and result in bad printing. Every scratch on the surface of a roller prints a fine line in the cloth, and too much care, therefore, cannot be taken to remove, as far as possible, all grit and other hard particles from every colour.

The straining is usually done by squeezing the colour through filter cloths as artisanal fine cotton, silk or industrial woven nylon. Fine sieves can also be employed for colours that are used hot or are very strongly alkaline or acid.

Silk printing

Silk printing calls for no special mention. The colours and methods employed are the same as for wool, except that in the case of silk no preparation of the material is required before printing and the ordinary dry steaming is preferable to damp steaming.

Both acid and basic dyes play an important role in silk printing, which for the most part is confined to the production of articles for wearing apparel dress goods, handkerchiefs, scarves, articles for which bright colours are in demand. Alizarine and other mordant colours are mainly used, or ought to be, for any goods that have to resist repeated washings and prolonged exposure to light. In this case the silk frequently requires to be prepared in alizarine oil, after which it is treated in all respects like cotton steamed, washed and soaped the colours used being the same.

Silk is especially adapted to discharge and reserve effects. Most of the acid dyes can be discharged in the same way as when they are dyed on wool; and reserved effects are produced by printing mechanical resists, such as waxes and fats, on the cloth and then dyeing it up in cold dye-liquor. The great affinity of the silk fiber for basic and acid dyestuffs enables it to extract colouring matter from cold solutions, and permanently combine with it to form an insoluble lake. After dyeing, the reserve prints are washed, first in cold water to get rid of any colour not fixed on the fibre, and then in hot water or benzene, to dissolve out the resisting bodies.

As a rule, after steaming, silk goods are only washed in hot water, but, of course, those printed entirely in mordant dyes will stand soaping, and indeed require it to brighten the colours and soften the material. (E. K.)

Glossary of Textile Manufacturing

The **manufacture of textiles** is one of the oldest of human technologies. To make textiles, the first requirement is a source of fibre from which a yarn can be made, primarily by spinning. The yarn is processed by knitting or weaving, which turns yarn into cloth. The machine used for weaving is the loom. For decoration, the process of colouring yarn or the finished material is dyeing.

A

Absorbency
: A measure of how much water a fabric can absorb.

Acetate
: Acetate is a synthetic fiber.

Acrylic
: Acrylic fiber is a synthetic polymer fiber that contains at least 85% acrylonitrile.

Aida cloth
: Aida cloth is a coarse open-weave fabric traditionally used for cross-stitch.

Alnage
: Alnage is the official supervision of the shape and quality of manufactured woolen cloth.

Alpaca
: Alpaca is a name given to two distinct things. It is primarily a term applied to the wool of the Peruvian alpaca. It is, however, more broadly applied to a style of fabric originally made from alpaca fiber but now frequently made from a similar type of fiber.

Angora
: Angora refers to the hair of the Angora rabbit, or the fabric made from Angora rabbit fur. (Fabric made from angora goat is mohair.)

Appliqué
: Appliqué is a sewing technique in which fabric shapes, lace or trim, are sewn onto a foundation fabric to create designs.

Aramid
: Aramid fiber is a fire-resistant and strong synthetic fiber

Argyle
: An argyle pattern is one containing diamonds in a sort of diagonal checkerboard pattern.

B

Backstrap loom

Backstrap looms, as the name implies, are tied around the weaver's waist on one end and around a stationary object such as a tree, post, or door on the other. Tension can be adjusted simply by leaning back. Backstrap looms are very portable, since they can simply be rolled up and carried.

Baize

Baize is a coarse woollen or cotton cloth, often coloured red or green.

Ballistic nylon

Ballistic nylon is a thick, tough synthetic fabric used for a variety of applications.

Batik

Batik is an Indonesian traditional word and refers to a generic wax-resist dyeing technique used on fabric.

Bedford-Cord

Combination of two kinds of Weave, Namely Plain and Drill.

Bias

The bias direction of a piece of woven fabric, usually referred to simply as "**the bias**", is at 45 degrees to its warp and weft threads. Every piece of woven fabric has two biases, perpendicular to each other.

Binding

In sewing, binding is used as both a noun and a verb to refer to *finishing* a seam or hem of a garment, usually by rolling or pressing then stitching on an edging or trim.

Blend

A Blend is a fabric or yarn made up of more than one type of fiber.

Bobbin lace

Bobbin lace is a delicate lace that uses wound spools of thread (the bobbins) to weave together the shapes in the lace.

Bobbinet

Bobbinet is a tulle netting with hexagonal shaped holes, traditionally used as a base for embroidery and lingerie.

Bombazine

Bombazine is a fabric originally made of silk or silk and wool, and now also made of cotton and wool or of wool alone. It is twilled or corded and used for dress-material.

Braid

To braid is to interweave or twine three or more separate strands of one or more materials in a diagonally overlapping pattern.

Broadcloth

Broadcloth -material of superior quality.

Brocade

Brocade is the term for forming patterns in cloth with a supplementary weft.

Buckram

Buckram is a stiff cloth, made of cotton or linen, which is used to cover, and protect, a book, and although is more expensive than its look-a-like, Brella, is stronger and resistant to cockroaches eating it. Buckram can also be used to stiffen clothes.

Burlap

Burlap is a type of cloth often used for sacks.

C

Calico

Calico is a type of fabric made from unbleached, and often not fully processed, cotton. Also referred to a type of Printing.

Cambric

Cambric is a lightweight cotton cloth used as fabric for lace and needlework.

Camel's Hair

Camel's Hair is a natural fiber from the camel. Camel hair can produce a variety of different coarseness of yarn. This fiber is a novelty fiber spun by hand-spinners.

Canvas

Canvas is an extremely heavy-duty fabric used for making sails, tents, marquees, and other functions where sturdiness is required. It is also popularly used on fashion handbags.

Canvas work

Canvas work is embroidery on canvas.

Carding

Carding is the processing of brushing raw or washed fibers to prepare them as textiles.

Carpet

A carpet' is any loom-woven, felted textile or grass floor covering.

Cashmere

Cashmere is wool from the Cashmere goat.

Cellulose

Cellulose; this fiber processed to make cellophane and rayon, and more recently Modal, a textile derived from beechwood cellulose.

Cheesecloth

Cheesecloth is a loosewoven cotton cloth, such as is used in pressing cheese curds.

Chiffon

Chiffon is a sheer fabric made of silk or rayon.

Chino cloth

Chino cloth is a kind of twill fabric, usually made primarily from cotton.

Chintz

Chintz is calico cloth printed with flowers and other devices in different colors. It was originally of Eastern manufacture.

Coir

Coir is a coarse fibre extracted from the fibrous outer shell of a coconut.

Colorfast (Colourfast)

A term used to describe whether the colors bleed or not in washing.

Cord

Cord is twisted fibre, usually intermediate between rope and string. It is also used as a shortened form of corduroy.

Corduroy

Corduroy is a durable cloth.

Cotton

Cotton is a soft fibre that grows around the seeds of the cotton plant, a shrub native to the tropical and subtropical regions of both the Old World and the New World. The fibre is most often spun into thread and used to make a soft, breathable textile.

Crepe

Crepe is a silk fabric of a gauzy texture, having a peculiar crisp or crimpy appearance.

Crazy quilt

Crazy quilting is often used to refer to the textile art of patchwork and is sometimes used interchangeably with that term.

Crinoline

Crinoline was originally a stiff fabric with a weft of horse-hair and a warp of cotton or linen thread. The fabric first appeared around 1830.

Cross-stitch

Cross-stitch is a popular form of counted-thread embroidery in which X-shaped stitches are used to form a picture.

Crochet

The word crochet describes the process of creating fabric from a length of cord, yarn, or thread with a hooked tool.

Crochet hook

A crochet hook is a type of needle, usually with a hook at one end, used to draw thread through knotted loops.

Cro-hook

The cro-hook is a special double-ended crochet hook used to make double-sided crochet. Because the hook has two ends, two colours of thread can be handled at once and freely interchanged.

D

Damask

Damask is a fabric of silk, wool, linen, cotton, or synthetic fibers, with a pattern formed by weaving. Today, it generally denotes a linen texture richly figured in the weaving with flowers, fruit, forms of animal life, and other types of ornament.

Darning mushroom

A darning mushroom is a tool which can be used for darning clothes, particularly socks. The sock can be stretched over the top of the (curved) mushroom, and gathered-tightly-around the stalk.

Denim

Denim denotes a rugged cotton twill textile.

Dimity

Dimity is a lightweight, sheer cotton fabric having at least two warp threads thrown into relief to form fine cords.

Dobby loom

Dobby loom is a loom in which each harness can be manipulated individually. This is in contrast to a treadle loom, where the harnesses are attached to a number of different treadles depending on the weave structure.

Double weave

Double weave is a type of advanced weave. It is done by interlacing two or more sets of warps with two or more sets of filling yarns.

Dowlas

Dowlas is the name given to a plain cloth, similar to sheeting, but usually coarser.

Durability

how durable a fabric or yarn is.

Dyes

Dye is used to color fabric. There are two main types: Natural dyes and synthetic dyes. The process is called dyeing.

Dye lot

Dye lot is a number that identifies yarns dyed in the same vat at the same time. Subtle differences can appear between different batches of the same color yarn from the same manufacturer.

E

Embroidery

Embroidery is an ancient variety of decorative needlework in which designs and pictures are created by stitching strands of some material on to a layer of another material.

Epinglé fabric

A type of velvet fabric woven on a wire loom or épinglé loom. The épinglé velvet is specific by the fact that both loop pile and cut pile can be integrated into the same fabric. The art of épinglé weaving in Europe originates from Lucca (Italy) and later Venice and Genua. Actually the term 'Genua velvet' is still in use. The Flemish region of Kortrijk and Waregem (Belgium) is the area whereupon today the technique of épinglé weaving is still very actual. The fabric finds it application mostly in upholstery, although in medieval times is was used as apparel for princes and kings as well as for bishops, cardinals and the pope.

Even-weave

Even-weave or evenweave fabric is used in counted-thread embroidery and is characterized by Warp and weft threads of the same size.

Eyelet

Grommets and eyelets are metal, plastic, or rubber rings that are inserted into a hole made through another material. They may be used to reinforce the hole, to shield something from the sharp edges of the hole, or both.

F

Felt

Felt is a non-woven cloth that is produced by matting, condensing and pressing fibers. The fibers form the structure of the fabric.

Felting

The process of making felt is called felting.

Fiber

Fiber or **fibre** is a class of materials that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. Fibers are often used in the manufacture of other materials. They can be spun into filaments, thread, or rope. They can be used as a component of composite materials. They can also be matted into sheets to make products such as paper or felt.

Filament

A filament is a fine, thinly spun thread, fiber, or wire.

Finishing

Finishing refers to any process performed on yarn or fabric after weaving to improve the look, performance, or "hand" (feel) of the finished textile.

Fishnet

Fishnet is a material with an open, diamond shaped knit.

Flannel

Flannel is a cloth that is commonly used to make clothing and bedsheets. It is usually made from either wool, wool and cotton, or wool and synthetic fabric.

Flax

Flax fiber is soft, lustrous and flexible. It is stronger than cotton fiber but less elastic. The best grades are used for linen fabrics such as damasks, lace and sheeting. Coarser grades are used for the manufacturing of twine and rope.

Frieze

Frieze is a coarse woollen cloth with a nap on one side, that was raised by scrubbing it to raise curls of fibre (French: frisé). In the 19th century rough cheap frieze was made of wool mixed with shoddy.

Fulling

Fulling is a step in clothmaking which involves the cleansing of cloth (particularly wool) to get rid of oils, dirt, and other impurities.

Fustian

Fustian is a term for a variety of heavy twilled woven cotton fabrics, chiefly prepared for menswear. Usually dyed in a dark shade. Declined in popularity from 1813, being replaced by harder wearing and better quality wool cloths.

G

Gabardine

Gabardine is a tough, tightly woven fabric often used to make suits, overcoats and trousers. The fibre used to make the fabric is traditionally worsted (a woolen yarn), but may also be cotton, synthetic or mixed. The fabric is smooth on one side and has a diagonally ribbed surface on the other.

Gauge

A gauge is a set number of rows per inch (in knitting) or the thread-count of a woven fabric that helps the knitter determine whether they have the right size knitting needles or a weaver if the cloth is tight enough.

Gante

Gante is a cloth made from cotton or tow warp and jute weft. It is largely used for bags for sugar and similar material, and has the appearance of a fine hessian cloth.

Gauze

A very light, sheer, fine woven fabric.

Genova velvet

A type of velvet where in Jacquard patterns are woven into the ground fabric and where the pile is made of a combination of cut and uncut (loop) pile. This fabric is also known as Venetian velvet, or more generally, as épinglé velvet. In the actual terminology of furnishing fabrics it is mostly named with its French name "velours de Gênes".

This kind of fabric is made on a wire loom or épinglé loom.

Geotextile

A geotextile is a synthetic permeable textile.

Gingham

Gingham is a fabric made from dyed cotton yarn.

Glass fiber (**fibre**)

Fiberglass is material made from extremely fine fibers of glass. It is widely used in the manufacture of insulation and textiles.

Gossamer

A gossamer is a very light, sheer, gauze-like fabric, popular for white wedding dresses and decorations.

Grogram

Grogram is a coarse fabric of silk mixed with wool or with mohair and often stiffened with gum.

H

Heddle

Common component of a loom used to separate warp threads for passage of the weft. Commonly made of cord or wire.

Hem

To hem a piece of cloth (in sewing), a garment worker folds up a cut edge, folds it up again, and then sews it down. The process of hemming thus completely encloses the cut edge in cloth, so that it cannot ravel.

A hem is also the edge of cloth hemmed in this manner.

Hemp

The main uses of hemp fibre are rope, sacking, carpet, nets and webbing. Hemp is also being used in increasing quantities in paper manufacturing. The cellulose content is about 70%.

Huckaback

Huckaback is a type of coarse absorbent cotton or linen fabric used for making towels.

I

Ikat

Ikat is a style of weaving that uses a tie-dye process on either the warp or weft before the threads are woven to create a pattern or design. A **Double Ikat** is when both the warp *and* the weft are tie-dyed before weaving.

Intarsia

Intarsia is a knitting technique used to create patterns with multiple colours.

Interfacing

Interfacing is a common term for a variety of materials used on the unseen or "wrong" side of fabrics in sewing.

J

Jacquard loom

The Jacquard loom was the first machine to use punched cards. It uses punched cards to control the pattern being woven. It is a form of dobby loom, where individual harnesses can be raised and lowered independently.

Jamdani

Jamdani is a kind of fine cloth made in Bangladesh.

Jute

Jute is a long, soft, shiny plant fibre that can be spun into coarse, strong threads. Jute is one of the cheapest natural fibres, and is second only to cotton in amount produced and variety of uses. Jute fibres are composed primarily of the plant materials cellulose and lignin.

K

Knit fabrics

Knit fabrics are fabrics that were produced through the process of knitting.

Knitting needle gauge

A knitting needle gauge makes is used to determine the size of a knitting needle. Some also double for crochet hooks. Most needles come with the size written on the needle, but many needles (like double-pointed needles) tend to not be labeled. Also, with wear and time the label often wears off.

Needle gauges can be made of any material, and are often made for metal and plastic. They tend to be about 3 by 5 inches. They contain holes of various sizes, and often have a ruler along the edge for determining the gauge of a sample.

L

Lace

Lace-making is an ancient craft. A lace fabric is lightweight openwork fabric, patterned, either by machine or by hand, with open holes in the work. The holes can be formed via removal of threads or cloth from a previously woven fabric, but more often lace is built up from a single thread and the open spaces are created as part of the lace fabric.

Lamé

Lamé is a type of brocaded clothing fabric with inwoven metal threads, typically of gold or silver, giving it a metallic sheen.

Lawn

Lawn is a fine linen or cotton cloth.

Linen

Linen is a material made from the fibers of the flax plant. Linen produced in Ireland is called Irish linen. Linens are fabric household goods, such as pillowcases and towels.

Loden

Loden is water-resistant material for clothing made from sheep wool.

Loom

The Loom is a machine used for weaving fabric.

Lucet

Lucet is a method of cordmaking or braiding which is believed to date back to the Viking era. Lucet cord is square, strong, and slightly springy. It closely resembles knitted I-cord or the cord produced on a knitting spool. Lucet cord is formed by a series of loops, and will therefore unravel if cut.

M

Macramé

Macrame or **macramé** is a form of textile-making using knotting rather than weaving or knitting. Its primary knots are the square knot and forms of hitching (full hitch and double half hitches).

Mercerized cotton

Mercerization is a treatment for cotton fabric and thread mostly employed to give cotton a lustrous appearance.

Merino

Merino is the Spanish name for a breed of sheep, and hence applied to a woolen fabric.

Mesh

A mesh is similar to fabric or a web in that it has many connected or weaved pieces. In clothing, a mesh is often defined as fabric that has a large number of closely-spaced holes, such as is common practice for modern sports jerseys.

Metallic fiber (fibre)

Metallic fibers are fibers used in textiles which are either composed of metal, or fibers of other materials with a metal coating.

Their uses include decoration and the reduction of static electricity.

Microfibre (fiber)

Microfibre is a term for fibres with strands thinner than one denier. Fabrics made with microfibres are exceptionally soft and hold their shape well.

Millinery

Millinery is women's hats and other articles sold by a milliner, or the profession or business of designing, making, or selling hats for women.

Mocado

Mockado is a woollen pile fabric made in imitation of silk velvet.

Modal

Modal is a cellulose fiber made by spinning reconstituted cellulose from beech trees.

Mohair

Mohair is a silk-like fabric made from the hair of the Angora goat. It is durable, light and warm, although some people find it uncomfortably itchy.

Mungo

Fibrous woollen material generated from waste fabric, particularly tightly woven cloths and rags.

Muslin

Muslin is a type of finely-woven cotton fabric, introduced to Europe from the Middle East in the 17th century. It was named for the city where it was first made, Mosul in what is now Iraq.

N

Nainsook

Nainsook is a fine, soft muslin fabric, often to used to make babies clothing.

Nap

Nap is a term for the raised surface of certain cloth, such as flannel.

Needlepoint

Needlepoint is a form of canvas work created on a mesh canvas. The stitching threads used may be wool, silk, or rarely cotton. Stitches may be plain, covering just one mesh intersection with a single orientation, or fancy, such as Bargello. Plain stitches, known as Tent stitches, may be worked as basketweave or half cross.

Needlework

Needlework is another term for the handicraft of decorative sewing and textile arts. Anything that uses a needle for construction can be called needlework.

Net

Net is a device made by fibers woven in a grid-like structure, as in fishing net, a soccer goal, a butterfly net, or the court divider in tennis

Nonwoven fabric

Non-woven textiles are those which are neither woven nor knit, for example felt. Non-wovens are typically not strong (unless reinforced by a backing), and do not stretch. They are cheap to manufacture.

Nylon

Nylon is a synthetic polymer, a plastic. Nylon fibres are used to make many synthetic fabrics and women's stockings.

O

Oilcloth

Oilcloth was, traditionally, heavy cotton or linen cloth with a linseed oil coating: it was semi-water-proof. The most familiar use was for brightly printed kitchen tablecloths. Dull colored oilcloth was used for bedrolls, sou'westers, and tents. By the late 1950's, oilcloth became a synonym for vinyl (polyvinyl chloride) bonded to either a flanneled cloth or a printed vinyl with a synthetic non woven backing.

Organdy

Organdy or organdie is the sheerest cotton cloth made. Combed yarns contribute to its appearance. Its sheerness and crispness are the result of an acid finish on greige (unbleached) lawn goods. Because of its stiffness and fiber content, it is very prone to wrinkling.

Organza

Organza is a thin, plain weave, sheer fabric traditionally made from silk, the continuous filament of silkworms. Nowadays, though many organzas are woven with synthetic filament fibers such as polyester or nylon, the most luxurious organzas are still woven in silk

P

Paisley

Paisley is a droplet-shaped vegetal motif, similar to half of the T'ai Chi symbol, the Indian bodhi tree leaf, or the mango tree. The design originated in India and spread to Scotland when British soldiers brought home cashmere shawls.

Patchwork

Patchwork is a form of needlework or craft that involves sewing together small pieces of fabric and stitching them together into a larger design, which is then usually quilted, or else tied together with pieces of yarn at regular intervals, a practice known as tying. Patchwork is traditionally 'pieced' by hand, but modern quiltmakers often use a sewing machine instead.

Percale

Percale refers to a closely woven, high thread count, cotton fabric often used for sheets and clothing.

Persian weave

Persian weave is a method of weave used in jewelry and other art forms.

Pile Wire

A steel rod which is inserted in between the base fabric and the pile ends in a pile fabric woven on a wire loom or épinglé loom. The height and thickness of the rod determine the size of the loop. A pile wire can be a simple rod - in which case the pile yarns will form a 'loop' pile. If the pile wire is equipped with a blade holder and cutting blade at the tip it will cut the pile loops during extraction thus producing cut pile.

Plaid

From a Scots language word meaning *blanket*, plaid usually referring to patterned woollen cloth otherwise known as tartan.

Plain weave

Plain weave

Plied yarn

Plied yarn is yarn that has been plied, with the process called plying.

Plush

Plush is a fabric having a cut nap or pile the same as fustian or velvet.

Polyester

Polyester is a synthetic fiber

Poplin

Poplin is a heavy, durable fabric that has a ribbed appearance. It is made with wool, cotton, silk, rayon, or any mixture of these. The ribs run across the fabric from selvage to selvage. They are formed by using coarse filling yarns in a plain weave.

Purl stitch

a commonly used stitch in knitting

Q

Qalamkari
: Qalamkari is a type of hand-painted or block-printed textile, produced in various places in India.

Qiviut
: Qiviut is the wool of the musk ox.

Quilt
: Quilting is a method of sewing or tying two layers of cloth with a layer of insulating batting in between. A bed covering or similar large rectangular piece of quilting work is called a quilt.

R

Rayon
: **Rayon** is a transparent fibre made of processed cellulose. Cellulose fibres from wood or cotton are dissolved in alkali to make a solution called viscose, which is then extruded through a nozzle, or spinneret, into an acid bath to reconvert the viscose into cellulose. A similar process, using a slit instead of a hole, is used to make cellophane.

Rolag
: A rolag is a loose woolen roll of fibers that results from using handcards.

Roving
: A roving is a long rope of fibers where all of the fibers are going parallel to the roving.

Rug
: A rug is a form of carpet. It is usually smaller than a carpet.

S

Sateen
: Sateen is a fabric formed with a satin weave where the floats are perpendicular to the selvage of the goods.

Satin
: A Satin is a cloth that typically has a glossy surface and a dull back. It is formed by a sequence of broken twill floats in either the warp or weft system, which respectively identify the goods as either a satin or a sateen.

Satin weave
: A satin is a broken twill weaving technique that forms floats on one side of the fabric. If a satin is woven with the floats parallel to the selvedge of the goods, the corresponding fabric is termed a "satin." If the floats are perpendicular to the selvedge of the goods, the fabric is termed a 'sateen.'"

Seam
: A seam, in sewing, is the line where two pieces of fabric are held together by thread.

Seam ripper
: A seam ripper is a small tool used for unpicking stitches.

Selvage or Selvedge

The woven edge portion of a fabric parallel to the warp is called selvage.

Serge

Serge is a type of twill fabric that has diagonal lines or ridges on both sides, made with a two-up, two-down weave. The worsted variety is used in making military uniforms, suits, great and trench coats. Its counterpart, silk serge, is used for linings. French serge is a softer, finer variety. The word is also used for a high quality woolen woven.

Serging

Serging is a sewing term, the binding off of an edge of cloth.

Sewing

Sewing is an ancient craft involving the stitching of cloth, leather, animal skins, furs, or other materials, using needle and thread. Its use is nearly universal among human populations and dates back to Paleolithic times (30,000 BC). Sewing **predates the weaving of cloth.**

Shag

Shag (fabric) is typically used to make a deep-pile carpets. This is the oldest use of the term. Shag carpet is sometimes evoked as an example of the aesthetic from the culture of the U.S. 1970s. Also used to make carpets for mariners.

Shed

In weaving, the shed is the gap between yarns on a loom when one or more, but not all, of the harnesses are raised.

Sheer

Sheer is a semi-transparent and flimsy cloth.

Shoddy

Recycled or remanufactured wool which is of inferior quality compared to the original wool. Historically generated from loosely woven materials. Benjamin Law invented shoddy and mungo, as such, in 1813. He was the first to organise, on a larger scale, the activity of taking old clothes and grinding them down into a fibrous state that could be re-spun into yarn. The shoddy industry was centred on the towns of Batley, Morley, Dewsbury and Ossett in West Yorkshire, and concentrated on the recovery of wool from rags. The importance of the industry can be gauged by the fact that even in 1860 the town of Batley was producing over 7000 tonnes of shoddy. At the time there were 80 firms employing a total of 550 people sorting the rags. These were then sold to shoddy manufacturers of which there were about 130 in the West Riding.

Shot

The opal effect achieved on a fabric by dyeing the warp and weft threads different colours. The yarns are dyed first and then woven. When looking at the fabric from various angles it appears to alter in colour, this is more obvious in lustrous fabrics and more so in certain types of weaves.

Shuttle

A shuttle in weaving is a device used with a loom that is thrown or passed back and forth between the threads of the warp to weave in the weft.

Silk

Silk is a natural protein fiber that can be woven into textiles. It is obtained from the cocoon of the silkworm larva, in the process known as *sericulture*, which kills the larvae. The shimmering appearance for which it is prized comes from the fibres triangular prism-like structure, which allows silk cloth to refract incoming light at different angles.

Sisal

Sisal or sisal hemp is an agave *Agave sisalana* that yields a stiff fiber used in making rope. (The term may refer either to the plant or the fiber, depending on context.) It is not really a variety of hemp, but named so because hemp was for centuries a major source for fiber, so other fibers were sometimes named after it.

Skein

Skein is when a length of yarn is bundled in a loose roll rather than put on a cone (as you would purchase from store)- usually done if yarn is going to a dye vat or needs a treatment in a manufacturing/knitting mill environment.

Spandex fiber

Spandex or elastane is a synthetic fiber known for its exceptional elasticity (stretchability). It is stronger and more durable than rubber, its major plant competitor. It was invented in 1959 by DuPont, and when first introduced it revolutionized many areas of the clothing industry.

Spinning

Spinning is the process of creating yarn (or thread, rope, cable) from various raw fiber materials.

Spread Tow Fabrics

Spread Tow Fabrics is a type of lightweight fabric. Its production involves the steps of spreading a tow of higher count, e.g. 12k, into thin-and-wide spread tow tape (STT) and weaving them into a lightweight fabric by employing the novel tape-weaving technique.

Staple

Staple is the raw material, or its length and quality, of fiber from which textiles are made.

Stitch

A stitch is a single turn or loop of the thread or yarn in sewing, knitting, and embroidery.

Stuff

Stuff is a coarse cloth, sometimes made with a linen warp and worsted weft.

Super

The Super grading system is used to grade the quality of wool fabric. The higher the number, the more yarn is packed in per square inch, therefore all things being equal a super 120s yarn is better than super 100s.

T

Tablet weaving

Tablet weaving is a process of weaving where tablets, also called 'cards', are used to create the shed that the weft is passed through. It is generally used to make narrow work such as belts or straps.

Tactel

Tactel is the brand name of a man-made fibre made from nylon.

Taffeta

Taffeta is a type of fabric, often used for fancy dresses.

Tapestry

Tapestry is a form of textile art. It is woven by hand on a weaving-loom. The chain thread is the carrier in which the coloured striking thread is woven. In this way, a colourful pattern or image is created. Most weavers use a naturally based chain thread made out of linen or wool. The striking threads can be made out of silk, wool, gold or silver, but can also be made out of any form of textile.

Tarlatan

Tarlatan is a starched, open-weave fabric, much like cheese cloth. It is used to wipe the ink off a plate during the intaglio inking process. The open weave allows for the tarlatan to pick up a large quantity of ink. The stiffness imparted by the starch helps prevent the fabric from taking the ink out of the incised lines.

Tassel

A tassel is a ball-shaped bunch of plaited or otherwise entangled threads from which at one end protrudes a cord on which the tassel is hung, and which may have loose, dangling threads at the other end.

Tatting

Tatting is a technique for handcrafting lace that can be documented approximately to the early 19th century.

Terry cloth

Terry cloth is a type of cloth with loops sticking out. Most bath towels are examples of Terry cloth.

Thimble

A thimble is a protective shield worn on the finger or thumb.

Threads per inch (TPI)

Threads per inch is the measurement of the number of threads per inch of material, such as fabric, or metal in the case of screws and bolts.

Thread count

The thread count is the number of warp threads per inch plus the number of weft threads.

Tissue

Tissue is a fine woven fabric or gauze.

Trim

Trim or **trimming** in clothing and home decorating is applied ornament such as gimp, passementerie, ribbon, ruffles, or, as a verb, to apply such ornament.

Tulle

Tulle is a netting, which is often starched, made of various fibers, including silk, nylon, and rayon, that is most commonly used for veils, gowns (particularly wedding gowns) and ballet tutus.

Tweed

Tweed is a type of fabric using the twill weave.

Twill tape

Twill tape is a flat twill-woven ribbon of cotton, linen, polyester, or wool.

Twill weave

Twill is a type of fabric woven with a pattern of diagonal parallel ribs. It is made by passing the weft threads over one warp thread and then under two or more warp threads. Examples of twill fabric are gabardine, tweed and serge.

V

Velour

Velour is a textile, a knitted counterpart of velvet.
It combines the stretchy properties of knits such as spandex with the rich appearance and feel of velvet.

Velvet

Velvet is a type of tufted fabric in which the cut threads are very evenly distributed, with a short dense pile, giving it its distinct feel. Velvet can be made from any fiber. It is woven on a special loom that weaves two piece of velvet at the same time. The two pieces are then cut apart and the two lengths of fabric are wound on separate take-up rolls.

Velveteen

Velveteen is a cotton cloth made in imitation of velvet. The term is sometimes applied to a mixture of silk and cotton. Some velveteens are a kind of fustian, having a rib of velvet pile alternating with a plain depression. The velveteen, trade varies a good deal with the fashions that control the production of velvet.

Viscose

Viscose is an artificial cellulose-based polymer, sometimes used as a synonym for Rayon

W

Warp

The warp is the set of lengthwise threads attached to a loom before weaving begins, and through which the weft is woven.

Warp knit

Knit fabric in which intermeshing loops are positioned in a lengthwise, or warp, direction. The fabric has a flatter, closer, less elastic structure than most weft knits and is run-resistant.

Weaving

Weaving is an ancient textile art and craft that involves placing two sets of threads or yarn made of fibre called the warp and weft of the loom and turning them into cloth. This cloth can be plain (in one color or a simple pattern), or it can be woven in decorative or artistic designs, including tapestries.

Weft

The weft is the yarn that is woven back and forth through the warp to make cloth.

Wilton Carpet

Wilton carpet is produced on a specific type of weaving machine called wire loom. Wilton carpets are pile carpets whereby the pile is formed by inserting steel rods in the pile warps of the fabric. After extraction of the rods the pile is looped (in case straight wires have been used) or cut (in case cutting wires are used). Wilton carpet is generally considered as high quality and is used for heavy duty applications.

Wire loom,

Weaving machine for pile fabrics or velvets whereby the pile is made by weaving steel rods or wires into the fabrics. When the wires are extracted the warp ends that have been woven over the wires remain as loops on top of the fabric or will form cut pile if the wire is equipped with a cutting blade. This technique is also known as "épinglé weaving". A wire loom in a much wider version (up to 5 meters of width) and in heavier construction is used for the manufacturing of carpets is called a "WILTON" loom, and the carpets made on such a loom are known as "Wilton Carpets"

Woof

The woof is the same thing as the weft.

Wool

Wool is the fiber derived from the hair of domesticated animals, usually sheep.

Woolen

Woolen or **woollen** is the name of a yarn and cloth usually made from wool.

Worsted fabric

Worsted is the name of a yarn and cloth usually made from wool. The yarn is well twisted and spun of long staple wool (though nowadays also medium and short fibres are used). The wool is combed so that the fibres lie parallel.

Woven fabric

A woven fabric is a cloth formed by weaving. It only stretches in the bias directions (between the warp and weft directions), unless the threads are elastic. Woven cloth usually frays at the edges, unless measures are taken to counter this, such as the use of pinking shears or hemming.

Y

Yarn

Yarn is a long continuous length of interlocked fibers, suitable for use in the production of textiles, sewing, crocheting, knitting, weaving and ropemaking. Yarn can be made from any number of synthetic or natural fibers.

Z

Zibeline

Zibeline is a thick, soft fabric with a long nap.