

Weaving: the act or art of forming from threads or filaments any textile fabric. These fabrics are formed in the machine called a LOOM (*q. v.*), and in a general way may be said to be formed of two series of threads or filaments interlaced at right angles, technically known as warp and filling. In the length of the fabric the threads are warp, and those which interlace with the warp are the filling threads. Notwithstanding the great variety of textile fabrics, there are but three underlying principal movements in their formation—that is, in weaving; these may be arrived at in various manners and by many different mechanisms, but are, without exception, to be found in the following order: “shedding,” “picking,” and “beating up.” The warps may be arranged in the looms differently; they may be on a single warp-beam at the back, or on more than one; the warp-threads are drawn through the eyes of the various loom-harness and through the reed—usually before the warp is placed in the loom—then fastened to the cloth-roll at the front, and the warp is ready to be woven. The first movement is to form a shed; this is accomplished by raising some of the loom-harness and depressing others, thereby raising a part of the warp-threads and lowering the remainder; the space between these two parts of the divided warp is the shed. The second movement is to pass through this shed the filling, after which the third movement, to complete the formation, is to beat up the filling-thread toward the cloth-roll. Another shed is formed, as before, a new filling-thread picked—that is, thrown across and through the shed—this thread beaten up against the one which preceded it, and these three movements, continually repeated, produce the fabric and constitute the operation of weaving.

Origin of the Art.—It is not known who were the first to practice weaving, when it was first practiced, or what fabric was first produced; yet the art is well classed as one of the earliest. The Chinese claim that they have certain documents or records which show silk-weaving to have been practiced over twenty-five centuries before the Christian era. By some archæologists Egypt is credited with being the mother of the invention. Joseph Strutt says in *View of the Dress and Habits of the People of England*, “The Egyptians put a shuttle in the hands of their goddess Isis to signify that she was the inventress of weaving.” Several references in the Bible narrative (Lev. xiii. 47–59, etc.) to “warp and woof” show that in the fifteenth century before Christ the Israelites were familiar with the art. It is very evident that among the Hindus, Chinese, and Egyptians the art has been practiced for many centuries. The fact that several countries widely separated seem to have practiced weaving extensively as far back as history or tradition goes, and also that in principle the practice of weaving to-day is not different from that of the most remote methods reported, would help to substantiate the belief that mechanisms for weaving may have been invented independently by several races.

Weaving in India.—Even to the present time many Hindus hold to their primitive mode of making textiles, and cause much wonder by producing fabrics of great delicacy and beauty. They have acquired by their continued application to old customs patience, alacrity, and a great delicacy of touch, enabling them to equal, except in quantity, the output of some of the best modern looms, and all with the simplest of appliances. These are described in the

Circle of Mechanic Arts by Martin, as follows: "The loom consists merely of two bamboo rollers, one for the warp and the other for the web" (woven cloth) "and a pair of gears. The shuttle performs the double office of shuttle and batten, and for this purpose is made like a huge netting-needle, and of a length somewhat exceeding the breadth of the cloth. This apparatus the tanty (weaver) carries to a tree, under which he digs a hole large enough to contain his legs and the lower part of the gear. He then stretches his warp by fastening his bamboo rollers at a due distance from each other on the turf by wooden pins. The balance of the gear he fastens to some convenient branch of the tree over his head. Two loops underneath the gear, in which he inserts his great toes, serve instead of treadles, and his long shuttle, which also performs the office of batten, draws the weft through the warp, and afterward strikes it up close to the web."

Growth of the Art.—History discloses the fact that the manufacture of fabrics kept moving westward from Egypt and Asia, as did civilization. Italy seems to have been the first European country to enter into woolen and cotton manufacturing, and it was from Italy that the other European countries obtained a knowledge of the art. In the tenth century Flanders led in the manufacture of woolens. "The art of weaving seems to be a gift bestowed upon them by nature," one author states in writing of the Flemings; and another, that "all the world was clothed from English wool wrought in Flanders." This was up to the eleventh century, and during that century, while William the Conqueror was King of England, the Flemings came into England in large numbers, and introduced wool-manufacturing. Later, in the early part of the twelfth century, in the reign of Henry I, many more immigrated into England, and the beginning of one of her principal industries was made. Just when cotton fabrics were first produced in England is not known, but early in the seventeenth century, Roberts, in *Treasures of Traffic*, in speaking of Manchester, says, "they buy cotton wool in London that comes from Cyprus and Smyrna, and work the same into fustians, vermilions, and dimities, which they return to London." The art may be said to have been introduced into America by the Puritan settlers of New England early in the seventeenth century.

In the nineteenth century weaving as an industry has taken wonderful strides. This was and is due to the improvements in the loom. Up to 1785 the power-loom was unknown, nor was it a success until the beginning of the nineteenth century. Hand-weaving had alone been practiced, and the weaving was done by the operators in their own homes, they having in most cases spun their own yarns. The development of machinery for preparing yarns, beginning about the middle of the eighteenth century, was a step which greatly increased the demand for an improved loom, a loom that would automatically produce the movements then made by the hands and feet of the weaver. The hand-loom in use in the eighteenth century was still very simple, the first improvement of note being that of the shuttle motion. The shuttle, until the invention of the "fly-shuttle" by Kay in 1733, was thrown through the shed from and by the hand of the weaver; by an arrangement of springs and straps, it was now driven from a box at one end of the batten or lathe through the shed, to a box at the opposite end; the propelling power was the hand still, but imparted to the shuttle through the strapping. Soon after this the rising and falling shuttle-box was introduced, which allowed the entrance of various colored filling-threads without stopping the loom. Even with this improvement, weaving was not an easy or rapid operation; the shed for all that had to be formed by the depressing of the treadles connected with the harness by the weaver, and the filling must be beaten up against the woven cloth by hand.

Cartwright, in 1785, having never seen any one weave, and though not a mechanic, but a minister of the Church of England, conceived the idea of producing textile fabrics automatically, and after one or two attempts gave to the world a loom approaching very nearly in form as well as principle the modern plain loom. On the foundation thus laid other inventors have built, until to-day the loom combines some of the most wonderful mechanical inventions, and produces fabrics automatically and with rapidity, which equal if not excel the most beautiful made by hand.

Ribbon-weaving.—As early as 1745 John Kay, with an associate, secured patents for a ribbon-loom which could be run by power; the loom was really only the "Dutch engine loom" remodeled and improved; and from all available re-

ports the improved loom seems to have been very similar in construction to the ribbon-loom of to-day except that the speed was much slower and the movements of the various harness very limited.

Ribbon-weaving is accomplished in a compound loom, having but one set of harness and one lathe or batten, yet a series of warp-beams and individual rollers for the woven ribbon, each warp also having its own shuttles. These shuttles work positively—that is, are not thrown across, but are passed through the sheds of their respective warps by a rack-and-pinion arrangement, the shuttle passing through one warp taking the place of the shuttle which simultaneously passes in the same direction through the shed of the next adjoining warp, and so back again as the shuttles move in the opposite direction. By this arrangement as many as thirty or forty ribbons or tapes may be woven at once in the same loom. The application of the Jacquard machine to the ribbon-loom, and the box-motion, allowing the use of five or six different shuttles, have so developed ribbon-weaving that some of the most beautiful textiles are these narrow fabrics. The early application of power to the ribbon-loom seems to have had no connection with the development of the modern power-loom, however.

Weaving by Power.—The application of power to the loom necessitated, among the many attachments, an arrangement whereby the loom would stop if the filling should become exhausted in the shuttle or should break; an attachment to wind up the cloth-roll automatically and keep the warp at an even tension; also a mechanism to stop the loom if the shuttle failed to reach its destination. Should the shuttle get caught in the shed, without something to stop the loom before the stroke of the lathe the warp would be broken out. After numerous improvements and many different inventions toward the same end, the weaver has reached a point where he has but little to do with a single loom. On plain white fabrics of cotton, as sheetings and shirtings, one weaver can run from six to eight looms, running from 180 to 250 picks a minute, and on heavy woolen or worsted suitings, woven on broad looms, one weaver can keep two running with a speed of ninety to ninety-five picks. Comparing this speed and the increased production with the varying production of the hand-loom, one weaver to a loom, the product of which was governed by his physical ability and endurance, the wonderful advance made during the nineteenth century will be readily understood.

Filling Stop-motion.—While there are many different stop-motions used by weavers and loom-builders, the description of one may answer for all. The object being to stop the loom when the shuttle leaves no thread in the shed as it passes through, a "filling-fork" is arranged on the loom-lathe in connection with a series of levers which control the driving motion of the loom; this fork is held in such a position by the filling-thread that it can not touch the levers, but so soon as the shuttle passes without leaving a filling-thread, the fork, having nothing to hold it away from the levers, comes in contact with them and immediately stops the loom. For extremely fine fabrics this stop-motion must be very delicate and carefully adjusted.

Shuttle Protector.—In 1796 an invention, still used, was made, called the "stop-rod motion," designed to stop the loom when the shuttle fails to pass entirely through the shed. It consists of an iron rod which runs the width of the loom on the face of the lathe, having a dagger projecting toward the breast-beam at the front of the loom, and fitted with an arm at each end, these arms being in contact with certain fingers on the shuttle-boxes at either end of the lathe. When the shuttle enters the box the finger is pressed outward and the arm in contact with it gives a vibrating motion to the rod just as the filling is being beaten up; should the shuttle not enter the box, however, the rod is left in such a position that the dagger strikes a lever so arranged as to immediately stop the loom and hold the lathe at a distance, so that none of the warp-thread may be broken, even in case the shuttle is in the shed at the time.

Another means to prevent the breaking of the warp, used principally in silk-weaving, is the "loose reed." The reed is hinged at the top and is held firmly as the lathe beats up; so long as the shuttle is in the shuttle-box, but is released at the bottom and swings away from the cloth should the shuttle not reach the box, stopping the loom.

Jacquard Weaving.—More than to any other invention the artistic quality of textiles is due to the Jacquard machine (see Loom) and to its subsequent development. The machine may be attached to a great variety of looms, from

those weaving narrow brocade ribbons to those immense looms weaving rugs, tapestries, art-squares, etc., some 8 or 10 yards broad. This class of weaving requires great skill in adjusting the mechanism of the loom and likewise great care and skill on the part of the weaver, though the machine has been brought to such a state of perfection that it may be handled with the ease of much simpler looms.

Pile Weaving.—Under this head would come the weaving of all pile carpetings, velvets, plushes, etc. The general construction of each is similar; a body-warp and a pile-warp are bound together by a single filling which interlaces with the body-warp. A shed is formed with the warp thread for the pile raised, and a small wire rod is inserted and beaten up, the pile-warp is lowered, and the filling interlaces again with the body-warp, binding the pile-warp into the body of the fabric; this arrangement continues, and after ten or twelve loops have been formed the wires, which have been left in the loops they have helped to form, are withdrawn one at a time, and again inserted in succeeding sheds to form other loops. For the Brussels carpet and all loop-pile fabrics the wires are round, but for fabrics with a cut pile they are fitted with a knife at one end which cuts the loop as the rod is withdrawn; or the rods may be grooved on one side, as for velvet-weaving, and the cutting be done by running a trivet—a small knife made for the purpose—along the groove in the rod and under the loops.

Much of interest could be said of gauze-weaving, for which the warps are mounted specially in the loom, and are usually woven from more than one warp-beam, and terry-weaving—the production of Turkish towels—woven both on the pile-fabric principle and in specially arranged looms. The weaving of glass-cloth is particularly interesting. The fabric is formed as if it were silk, with each third or fourth pick of spun glass; the loom stops on the shed for the glass filling, and this is inserted by hand, the strand of spun glass being placed on a narrow flat strip of wood which is passed through the shed and deposits the glass strand between the warp-thread; the strip of wood is removed, the glass filling beaten up, three or four picks of silk inserted to bind it, another glass thread placed in its shed, and so on. There are also hair-cloth-weaving, upholstery-weaving, the weaving of wire-cloths, and the weaving of many specially constructed fabrics on looms built purposely to produce them, or by means of adjustments of the ordinary looms. See COTTON MANUFACTURES, TEXTILE-DESIGNING, and TEXTILE FABRICS.

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