WEAVING.

The process of weaving consists in interlacing, at right angles, two or more series of flexible materials, of which the longitudinal are called warp and the transverse weft. Weaving, therefore, only embraces one section of the textile industry, for felted, plaited, netted, hosiery and lace fabrics lie outside this definition. Felting consists in bringing masses of loose fibres, such as wool and hair, under the combined influences of heat, moisture and friction, when they become firmly interlocked in every direction. Plaited fabrics have only one series of threads interlaced, and those at other than right angles. In nets all threads are held in their appointed places by knots, which are tied wherever one thread intersects another. Hosiery fabrics, whether made from one or many threads, are held together by intersecting a series of loops; while lace fabrics are formed by passing one set of threads between and round small groups of a second set of threads, instead of moving them from side to side. Notwithstanding the foregoing limitations, woven fabrics are varied in texture and have an enormous range of application. The demands made by prehistoric man for fabrics designed for clothing and shelter were few and simple, and these were fashioned by interlacing strips of fibrous material and grasses, which in their natural condition were long enough for the purpose in hand. But, as he passed from a state of savagery into a civilized being, his needs developed with his culture, and those needs are still extending. It no longer suffices to minister to individual necessities; luxury, commerce and numerous industries must also be considered.

The invention of spinning (q.v.) gave a great impetus to the introduction of varied effects previously; the use of multicoloured threads provided ornament for simple structures, but the demand for variety extended far beyond the limits of cobweb and thread. Materials were employed either separately or conjointly, together with different schemes of interlacing. Eventually the weaver was called upon to furnish articles possessing lustre, softness and delicacy; or those that combine strength and durability with diverse colourings, with a snowy whiteness, or with elaborate ornamentation. In cold countries a demand arose for warm clothing, and in hot ones for cooler materials; while commerce and industry have requisitioned fabrics that vary from normal characteristics to those that exceed an inch in thickness. In order to meet these and other requirements the world has been searched for suitable raw materials. From the animal kingdom in wool, hair, fur, feathers, silk and the pima fibre have long been procured. From the vegetable kingdom, cotton, flax, hemp, jute, ramie and a host of other less known but almost equally valuable materials are derived. Amongst minerals there are gold, silver, copper, brass, iron, glass and asbestos. In addition, strips of paper, or skin, in the plain, gilt, silvered and painted conditions are available as well as artificial fibres. All of the foregoing may be used alone or in combination.

From such varied raw materials it is not surprising that woven fabrics should present an almost endless variety of effects; yet these differences are only in part due to the method of weaving. The processes of bleaching (q.v.), mercerizing (q.v.), dyeing (q.v.), printing (see TEXTILE PRINTING) and finishing (q.v.) contribute almost as much to the character and effect of the resultant product as do the incorporation in one fabric of threads spun in different ways, and from fibres of different origin, with paper, metal, beads or even precious stones.

1 Both these species seem to have been first described and figured in 1600 by Aldrovandus (lib. xv. cap. 22, 23) from pictures sent to him by Ferdinando de’ Medici, duke of Tuscany.
former the same number of warp threads are placed successively above or below each weft thread, and the ribs are of uniform width, as in figs. 3, 4. In the latter more warp threads may be above one

Fig. 3.—Four-thread § Twill. Fig. 4.—Four-thread § Twill.

pick than another, the ribs may vary in width and small ornament may be introduced between the ribs, as in figs. 5, 6 and 7, where the dark squares represent warp upon the surface. Twills may be broken up into zigzags, lozenges, squares and other geometrical designs; all of which may be produced by reversings in the diagonal lines, or by reversing the weave of an unequal twill. Fig. 8 is a zigzag, namely, a twill reversed in one direction. Fig. 9 is a diamond,

Fig. 5.—Upright Twill. Fig. 6.—Reclining Twill.

or a twill reversed in two directions, and fig. 10 is a diaper, or an unequal twill which gives a warp face in one place and a weft face in another. Satins and sateens form another important section of Group 1. In a satin the bulk of the warp, and in a sateen the bulk of the weft, is on the face of a fabric. If perfect in construction both present a smooth, patternless appearance, which is due in part to the scheme of intersections, in part to using fine material for the surface threads and placing it close enough together to render the points of intersection invisible; the threads of the other set being coarser and fewer in number. Satins differ from twills in having each warp thread lifted, or depressed, separately, but not successively. From five to upwards of thirty threads of warp and weft are required to complete the various schemes of intersecting. If the intervals between the intersections are equal the weft is said to be perfect, as in fig. 11, but if the intervals are irregular it is said to be imperfect, as in fig. 12. In Damasks a satin is combined with a sateen weave, and since any desired size and shape of either weave may be produced, great facilities are offered for the development of all kinds of ornamentation. But in combination neither the satin nor the sateen can be perfect in construction, for one requires a preponderance of warp, the other a preponderance of weft; as a consequence every point of intersection is distinctly visible on both surfaces. Brocades are fabrics in which both sets of threads may be floated irregularly upon the surface to produce ornamental effects, and they may be taken as typical of all one warp and one weft fabrics

Fig. 7.—Fancy Twill. Fig. 8.—Zigzag.

that are figured by irregularly floated materials, whether the threads are uniformly or irregularly distributed, and whether one weave or several weaves be employed.

Group 2 includes all backed and reversible fabrics, as well as those ornamented with extra material and compounded. Cloths intended for men’s wear are often backed, the object of which is to give weight and bulk to a thin texture without interfering with the face effects. Either warp or weft may be used as backing; if the former there are two series of warp to one series of weft threads, while in the latter there are two series of weft to one series of warp threads. The face material is superposed upon that of the back, but the ratio of face threads may be one to two or two to one. In order to avoid disturbing the face weave, only those threads are used to bind the backing that are hidden on the face, as in fig. 13, which gives the design and a transverse section of a backed fabric: A is the warp; B back warp, and the circles are warp threads of the latter C, D, are beneath both B and A. This diagram will serve equally as a longitudinal section of a warp-backed fabric, if A represents a thread of the warp, B a thread of back warp and the circles are weft threads. Weft backing is capable of giving a more spongy feel to a fabric than warp, because softer materials may be used, but in these fabrics the length output of loom is reduced by reason of the wefts being superposed. Warp-backed fabrics, whether uniformly coloured or striped, do not materially reduce the output of a loom, for every weft thread adds to the cloth length. Reversible fabrics may have either two series of differently coloured warps or warps to one of the other series, in which event they may be similarly figured on both sides by causing the threads of the double series to change places, as in the design and transverse section, fig. 14; or, by allowing one series to remain constantly above the other, as in backed cloths, both sides may be similar or dissimilar in colour and pattern. Fabrics figured with extra material may have two series of warp or weft threads to one series of the other set, and they may yield reversible or one-sided cloths. A ground texture may have extra material placed above or below it, as in fig. 15, where a design and transverse section of the cloth are given; the waved lines and circles represent a cross-section of plain cloth and A is a thread of extra material; or ordinary and extra material may be used conjointly for figuring. Compound cloths must have at least two textures, and be distinct in character as if woven in separate looms; they have many advantages over backed cloths, thus: the same design and colouring may be produced on both sides; where bulk and weight are required a fine surface texture may be formed over a ground of inferior material, and soft weft be passed between the upper and lower textures. The fabric is more perfect and admits of either simple or elaborate patterns being wrought upon the surface, with simple ones beneath, as in piques and matelassés. One texture may be constantly above the other and connected at the selvages only, as in hose pipes and pillow slips; or at intervals a thread may pass from one texture into the other, in which event both are united, as in many styles of bed-covers and vestings. If differently coloured,

Fig. 9.—Diamond. Fig. 10.—Diaper.

the textures may change places at pleasure, as in Kidderminster carpets; or from three to twelve textures may be woven simultaneously, and united, as in belting cloth. There may be from one to three threads of face warp to one of back, and the wetting may or may not correspond with the warping. Fig. 16 shows the face and

Fig. 11.—Five-thread Satteene. Fig. 12.—Six-thread Satteene.

Fig. 13.—Welt-backed Fabric.

Fig. 14.—Welt Reversible Fabric.

Fig. 15.—Figuring with Extra Weft.
back weaves, the design, and a transverse section of a compound cloth with two threads of face warp and weft to one of back, and both are stitched together. The circles cut by lower lines represent face and back warps respectively, and A, B, C, D are weft threads placed in the upper and lower textures. **Loom-made taperies** and figured repus form a section of Group 2. As compared with true tapeties, the loom-made articles have more limited colour schemes, and their figured effects may be obtained in many ways, as well as warp as well as weft, whether interlaced to form a plain face, or left floating more or less loosely. Every weft thread, in passing through the selvage to selvage, may be brought to the surface where required, the other portions being bound at the back. Some specimens are reversible, others are not, but, however numerous the warps and wefts only one texture is produced. When an extra warp of fine material is used to bind the wefts firmly together a plain or twill weave shows on both sides. If a single warp is employed, two or more wefts form the figure, and the warp seldom floats upon the surface. Where warps do assist to form figure it rarely happens that more than three can be used without overcrowding the reed.

Fig. 17.—*Tapetry with Two Warps and Two Wefts.*

Fig. 18.—*Velveteen.*

Fig. 19.—*Utrecht Velvet.*

Fig. 20.—*Double Plush.*

Fig. 21.—*Brussels Carpet.*

Fig. 22.—*Plain Gauze.*

Figs. 16—19.—Compound Fabric.

Fig. 23.—Figured Warp-pile Fabrics are made with regular and irregular cut and looped surfaces. If regular, the effect is due to colour, and this again may be accomplished in various ways, such as (a) by printing several sets of pile threads, (b) by printing a fabric after it leaves the loom; (c) by printing each pile thread before placing it in a loom, so that a pattern shall be formed simultaneously with a pile surface, as in tapestry carpets; (d) by printing several sets of pile threads, no two of which are similar in colour; then, if five sets are available, one-fifth of all the pile must be lifted over each wire, but any one of five colours may be played upon any space, as in Brussels and Wilton carpets. Fig. 23 is the design, and a longitudinal section of a Brussels carpet. The circles represent two tiers of weft, and the lines of pile threads, when lifted over a wire to form loops, are laid between the wefts; the ground warp interfaces with the weft to bind the whole together. When the surface of a pile fabric is irregular, also when cut and looped pile are used in combination, design is no longer dependent upon colour, for in the former case pile threads are only lifted over wires where required, at other places a flat texture is formed. In the latter case the entire surface of a fabric is covered with pile, but the figure is cut and the ground looped the pattern will thus be distinct.

Group 4. Crossed Weaving.—This group includes all fabrics in which the warp threads intersect one another, to give a twined effect between ordinary wefting and lace, as in gauzes. Also those in which some warp threads are laid transversely in a piece to imitate embroidery, as in lappets.

Plain Gauze embodies the principles that underlie the construction of all crossed woven textiles. In these fabrics the twisting of two warp threads together leaves large interstices between both warp and weft. But although light and open in texture, gauze fabrics are the firmest that can be made from a given quantity and quality of material. One warp thread from each pair is made to cross the other at every pick, to the right and to the left alternately, so that the same threads are above every pick, but since in crossing from side to side they pass below the remaining threads, all are bound securely together. As in fig. 22, where A is a longitudinal section and B a plan of gauze.

Leno is a muslin composed of an odd number of picks of a plain weave followed by one pick of twill, the former being heavier than the latter, and the crisscross farther apart transversely. Fancy Gauze may be made in many ways, such as (a) by using crossing threads that differ in colour or count from the remaining threads, provided they are subjected to slight tensions; (b) by causing some to twist to the right, others to the left simultaneously; (c) by combining gauze with another weave, as plain, twill, satin, brocade or pile; (d) by varying the number of threads that are twisted together; (e) by passing two or more wefts threads in each crossing; and (f) by passing two or more weft threads across each other, and operating any assortment of crossing threads at pleasure.
Lappet weaving consists in diapering the surface of a plain or gauze fabric with simple figures. This is done by drawing certain warp threads into a transverse position and then lifting them over a thread of weft to fix them in the texture; after which they are moved in the opposite direction and lifted over the following pick. The material between one binding point and another must float loosely, and this limits the usefulness of lappet figuring. In fig. 23, the thick lines show a lappet spot upon a plain texture. Notwithstanding diverse structure, intricate mechanisms are not essential to the production of either simple or complex effects; the most elaborate and beautiful specimens of the weaver's art have been manufactured upon simple machinery.

Weaving Machinery.

The longitudinal threads of a fabric are called warp, cane, twist and organize, and the transverse threads are weft, shoot, wool, filling and tram. A loom for intersecting these several threads must provide for: (1) Shedding; namely, raising and lowering the warp threads in a predetermined sequence so as to form two lines between which the weft may be passed. (2) Picking, or placing lines of weft between the divided warp. (3) Beating-up, or striking each weft thread into its appointed position in the fabric. (4) Letting-off, or holding the warp tense and delivering it as weaving proceeds. (5) Taking-up, or drawing away the cloth as manufactured. (6) Temples, for stretching the fabric widthwise in order to prevent the edge threads of a warp from injuring the reed, and from breaking. Power looms require the above-mentioned contrivances to act automatically, and in addition: (7) A weft-kork, to stop a loom when the weft becomes exhausted or breaks. (8) Mechanism for stopping a loom when the shuttle fails to reach its appointed box. (9) For weaving cross striped, multiple shuttle boxes are needed to bring different colors, or counts of weft, into use at the proper time. (10) In some looms a device for automatically ejecting a spent cop, prin or shuttle, and inserting a full one, is requisite. (11) If a weaver has to attend to a greater number of looms than usual, a device for stopping a loom when a warp thread fails is essential.

The Hand-Loom.—During the 17th and the first half of the 18th centuries it was observed that wherever any branch of the textile industry had been carried to a high state of excellence the looms used to manufacture a given fabric were similar in essentials, although in structural details they differed greatly. Prior to the invention of the fly shuttle by John Kay, in 1733, no far-reaching invention had for generations been applied to the hand-loom, and subsequently the Jacquard machine and multiple shuttle boxes represent the chief changes. A hand-loom as used in Europe at the present time (see fig. 24) has the warp coiled evenly upon a beam whose gudgeons are laid in open steps formed in the loom framing. Two ropes are coiled round this beam, and weighted to prevent the warp from being given off too freely. From the beam the thread passes alternately over and under two lease rods, then separately through the eyes of the shedding harness, in pairs between the dents of a reed, and finally they are attached to a cloth roller. For small patterns heads or three-rod looms are used to form sheds, but for large scale a Jacquard machine is required. Heads may be made of twine, of wire or of twine loops into which metal eyes, called mails, are threaded. But they usually consist of a number of strings which are secured above and below upon wooden laths called shafts and each string is passed near the middle to form a small eye. From two to twenty-four pairs of shafts may be employed, but the heads they carry must collectively make up the whole number of threads in the warp. These will be equally or unequally distributed upon the shafts according to the nature of the pattern to be woven, and the threads will be drawn through the eyes in a predetermined order. The upper shafts are suspended from pulleys or livers, and the lower ones are attached directly or indirectly to treadles placed near the floor. The weaver depresses these treadles with his feet in a sequence suited to the pattern, and the scheme of drawing the warp through the heads. When a treadle is pressed down, at least one pair of shafts will be lifted above the others, and the warp threads will ascend or descend with the heads to form a shed for a shuttle, containing weft, to be passed through (see Shuttle). The reed (fig. 25) is the instrument by which weft is beaten into position in the cloth; it also determines the closeness of the warp threads, and guides a moving shuttle from side to side. It is made by placing strips of flattened wire between two half round ribs of wood, and binding the whole together by passing tarred twine between the wires and round the ribs. Such a reed is placed in the lower portion of a batten, which is suspended from the upper framework of the loom. In front of the reed, and immediately below the warp, the projecting batten forms a race for the shuttle to travel upon from side to side. Before Kay's invention a shuttle was thrown between the divided warp and caught at the opposite selvage, but by contrivance the projecting batten on both sides of the warp space, and constructed boxes at each end. Over each box he mounted a spindle, and upon it a driver, or picker. Bands connected both pickers to a stick which the weaver held in his right hand, while with the left hand he controlled the batten. Thus: a treadle is pressed down by one foot to form a shed; the batten is pushed back till a sufficient portion of the shed is brought in front of the reed, and the depressed threads lie upon the shuttle race; a clear way is thus provided for the shuttle. A quick movement of the stick tightens the cord attached to a picker and projects the shuttle from one box to the other. The batten is now drawn forward, and the reed beats the weft left by the shuttle. As the next treadle is depressed to form another division of the warp for the return movement of the shuttle, the last length of weft is enveloped between intersecting warp threads, and the remaining movements follow in regular succession (see fig. 26).

In cases where the weft forms parti-coloured stripes across a fabric, also where different counts of weft are used, shuttles, equal in number to the colours, counts or materials, must be provided. By Robert Kay's invention of multiple shuttle boxes, in 1760, much of the time lost through changing shuttles by hand was prevented. His drop box consisted of trays or shuttles, and flat boxes for ordinary shuttle boxes. Each tray is capable of holding a shuttle, and by operating a lever and plug with the forefinger and thumb of the left hand, the trays may be raised, or lifted up by a string to bring that shuttle containing the colour next needed into line with the picker.

The Draw Loom.—Large figured effects were formerly produced in the looms of the drawloom, where the weaving machine used five or six separate strings that any assortment could be lifted when required. Thus: to the lower end of each string a dead weight, called a lingoe, was attached, and a few inches above the lingoe a mail was fixed for the
control of a warp thread. The strings passed through a drilled board which held the mails and warp threads facing the proper reed-dents. Still higher up, groups of three or four more connected cards; each group consisted of all strings required to rise and fall together constantly. If, for example, in the breadth of a fabric there were twelve repeats of a design, twelve strings would be tied to the same neck cord, but taken up by the corresponding card on the comb board. The foregoing parts of a drawloom harness are clearly shown in fig. 27: A are linges, and the dots represent mails. B is the comb board; between B and C are mounting stud and neck cords, two strings being attached to each cord; and C is the shoulder harness. Each string after being led through a perforated bottom board C, and over a grooved pulley, was threaded through a hole in the vertical cord called the simple, and passing horizontally to, and tied upon a bar rigidly fixed near the ceiling of the weaving room. The simple cords were similarly attached to a bar placed near the filling end from one hundred to the thousands of neck and simple cords could be used in one harness. The design to be reproduced in cloth was laid into the parallels of the simple by looping a piece of string round each cord that governed warp threads to be lifted. The loops were given shed; after which all the loops were bunched together. By pulling at a bunch of loops the simple cords were rewound, and another combination of strings were defined, so that they caused all warp threads controlled by them to be lifted above the level of those undisturbed. The Jaccard machine is the most important invention ever applied to the hand-loom, but it is not the work of one man; it represents the efforts of several inventors whose labours extended over three-quarters of a century. This apparatus has taken the places of the simple, the loops, the pulleys and the draw-boy of the older shedding motion, but other parts of the harness remain unchanged. In 1725 Basile Bouchon substituted for the bunches of looped string an endless band of perforated paper by which the simple cords could be selected. In 1728 M. Falcon constructed the machine since known as the Jaccard and operated it through the medium of perforated cards, but it was attached to simple cords and required many changes to manipulate it. In 1745 Jacques de Vaucanson united in one machine Bouchon's band of paper and the mechanism of Falcon. He placed this machine where the pulley box previously stood, and invented mechanism for operating it from one centre. It is said that about the year 1801 J. M. Jaccard was called upon to correct the defects of a certain loom belonging to the state, in doing which he assuredly discovered the principle of the mechanism. Hereafter it is applied to the hand-looms, and to the power-looms in a gradually increasing degree. In about 1804 he discarded the simple and all but a few inches of the vertical neck cords; he placed Falcon's apparatus immediately over the centre of the loom and severally attached the upper portions of the neck cords to the hooks; all of which Vaucanson had previously done. He then perforated each face of a quadrangular frame—used by Falcon to guide the cards to the vertical neck cords—into action and another moved away. By means of two treadles placed beneath the warp one weaver could operate the entire loom. The cylinder was controlled with one foot, the selecting parts with the other, and both hands were free to attend to picking and beating-up.

In a Jaccard machine the warp threads are raised by rows of upright wires called hooks. See D, fig. 27. These wires are made to slide horizontally to and fro, and at each outward journey make one-quarter of a revolution. Cards were so held upon this cylinder by pegs that at each half-revolution one wire was moved into action and another moved away. By means of two treadles placed beneath the warp one weaver could operate the entire loom. The cylinder was controlled with one foot, the selecting parts with the other, and both hands were free to attend to picking and beating-up.

The power loom is only one of a series of machines and improvements. Although early inventors of the power loom did much to perfect its various movements, the commercial results were disappointing, chiefly because man had not been devised for picking up and over the spindles. The spindles were a machine. One of the principal improvements in construction, but the majority are furnished with conical shafts, consisting either of slip cups, or of cone rollers mounted upon studs. These are driven by an axle or cone, the base of which rests upon the foot of the draw—a fixed in a box, and the top, or arbor, is mounted in a vertical guiding head. The guiding head leads to the front of the loom, where the pins are fixed, when they become stationary. Hooks are carried by the weavers, and the spindles of the pin are engaged with the arms of the hand and the box. The pin is thus a great length of Which can be placed in a shuttle when pins are used.
**MACHINERY**

Warp winding consists in transferring yarn from cops, ring spools or bobbins, either to warpers, bobbins or cheeses (see COTTON-SPINNING MACHINERY). Machines for this purpose are of two kinds, which are generally referred to as spindle and tube winding. In the latter, the tube is placed on a vertical spindle and rotated by frictional contact; a yarn guide meanwhile rises and falls far enough to lay the threads in even coils between the bobbin flanges. In the latter case, the tube is laid out on the base of the frame, and the warp guide moves laterally to and fro; slowly for a bobbin, but quickly for a tube.

**Mill warping** is the oldest type now in extensive use. A mill warper has a creel in which 50 to upwards of 300 bobbins or cheeses, are supported horizontally upon pegs, and the mill has a variety of guides and cradles to enable it to wind any number of yarns upon any variety of materials. The threads are fastened upon the mill warper by means of a magnet, guide and setter, the warp guide moves laterally to and fro; slowly for a bobbin, but quickly for a tube.

**The number of longitudinal threads in the web vary according to their closeness and its breadth. It is the function of a warper to provide a sufficient number of parallel threads for a web, all of equal length, and to retain their parallelism. Warpers are of two kinds: hand and automatic.**

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**Beam warping** is the system most extensively used in the cotton trade. The creels for these machines have an average capacity of about 200 bobbins, and are very often shaped in plan. In each leg of the V the bobbins are arranged in tiers of 16 to 20, and row behind row. The threads are drawn separately between the spools of an adjustable reel, then under and across a series of rollers; from these they are retained upon separate pegs; this is the lease which enables a weaving to readily fix the position of a broken thread. As the mill rotates, the threads form a rope about 1 in. wide, and the leasing apparatus is set in motion, the threads being pulled from the creel. When the full length of warp has been made the mill is stopped, a hale beer is picked by hand from the divisions formed by the runners, and the other retained upon the pegs; this is the lease which enables the weave to readily fix the position of a broken thread. As the mill rotates, the threads form a rope about 1 in. wide, and the leasing apparatus is set in motion, the threads being pulled from the creel. If the warp reverts its direction of rotation, the threads are folded back upon themselves. Hence, if a reel is 20 yds. in circumference, and 200 threads are in use to make a warp 600 yds. long. The 2000 threads will be bunched. The 2000 threads, if at a speed of (600 + 20 = 30) also to reversals, for each reversal 200 additional threads will be added (2000 + 200 = 10). When a warp is complete, strings are passed through the leases, and it is cooled into a ball, locked into a chain, or drum, and moved to the necessary breadth, in which condition they are coiled upon a boom beam.

**Winding on frame.**—After a ball warp has been bleach, dried or sized, the bale beam is laid amongst the teeth of a coarse comb to and fro, so that the necessary breadth, in which condition they are coiled upon a boom beam. The chief parts of a beam warper may be used as a substitute for a mill warper, provided that mechanism is employed to contract the threads to the form of a loose rope and coil them into a cylindrical ball which will be subsequently treated as a mill warp. Of one of these warpers may be furnished with parts which, when the threads are roved, links them loosely into a chain.

**Slasher Dressing.**—For sizing cotton yarns Radcliffe's dressing machine has been adopted by the slasher, but in some branches of the textile industry it is still retained under various modifications. In a slasher the threads from a number of warping beams are first combined into one sheet, then plunged into a trough containing a caustic soda solution. The slasher is set on a rotating steam pipes; and next squeezed between two pairs of rollers mounted in the trough. The surfaces of the sizing rollers are in the size, and the country it is pressed by the gravitation upon the lower ones. On leaving the size trough the sheet of yarn almost encircles two steam-heated cylinders whose diameters are respectively 6 ft. and 4 ft.; these quickly expel the moisture and bring the yarn into the form of a rope of yarn. The yarn minute, passed above and below rods which separate parts of this type that various types of saws have been fastened together by size, smeared with piece of yarn and cooled on a loom beam by means of a slipping friction gear. The last-named is employed so that the surface speed of winding shall not be affected by the increasing diameter of the loaf of yarn, which greatly reduces the velocities of the moving parts, much necessary labour may be performed without actually stopping the machine; this relieves the yarn of strain, and gives better sizing, yet slashed waps are less elastic than beamed ones, and they lack the smoothness of dressed warps.

**Warping** is chiefly employed for coloured yarns and its outstanding features consist in contracting the threads to a ribbon of from 3 in. to 12 in. wide. This ribbon is coiled upon a block placed between flanges, and when completed is set aside until a new block is inserted. The threads have been made in the form of a ribbon which they are slipped upon a shaft and by elongation, converted into a compact mass. All the threads are then collected and transferred in the form of a sheet to a loom beam; each section of the sheet is wound with the threads, and the operations continued until all the sections have been made; after which the yarn is run upon a beam beam. The threads which are left after theotal have been removed from the rollers to the hooks where they are twisted to wind up excess, and force in required size. If sufficient size has not been added by one treatment, when untwisted, the warp-out on a similar machine containing a greater density than the first there to be again treated; if necessary this may be
be followed by a third passage. On the completion of sizing the hanks are removed either to a drying stove or a drying machine. If to the former, they are suspended from fixed, horizontal poles in a specially heated and ventilated chamber. If to the latter, loose pole hanks are dropped into a series of heated troughs, and slowly carried through a large, heated and ventilated box, being partially rotated the while. On reaching the front of the box they are removed, brushed, and made up to bundles. After which the yarn is shipped and transferred to a loom bed for weaving.

Drawing in, or entering, is the operation of passing warp threads through the eyes of a shedding harness, in a sequence determined by the pattern to be woven, and then transferred to the warp harnesses of the several parts. It is effected by passing a hook through each harness eye in succession, and each time a thread is placed in the hook by an attendant; it is drawn into an eye by the withdrawal of the hook.

Twisting or looming consists in twisting, between the finger and thumb, the ends of a new warp separately upon those of an old one, the remains of which are still in the eyes of the shedding harness. The twisted portions adhere sufficiently to permit of all being drawn through the eyes simultaneously.

The Power Loom.—Little is known of the attempts made before the beginning of the 17th century to control all parts of a loom from a central source, but it is certain the practical outcome was inconsiderable. In the year 1661, a loom was set up in Danzig, for which a claim was made that it could weave four or six webs at a time without human aid; but this was probably a ribbon loom. In order to prevent such a machine from injuring the poor people, the authorities in Poland suppressed it, and privately strangled or drowned the inventor. M. de Genne, a French naval officer, in 1670 invented a loom whose chief features consisted in controlling the healds by cams, the batten bycams and the shuttle by a carrier. From 1678 to 1745 little importance appears to have been attached to the mechanical weaving of broad width cloth. But in the last-named year M. Vaucanson constructed a very ingenious, self-acting loom, on which the forerunner of the Jacquard machine was mounted; he also adopted de Genne’s shuttle carrier. All early attempts to employ mechanical power for the weaving of fabric were largely because inventors did not realize that success could only be reached through revolution. Mechanical preparing and spinning machinery had first to be invented, steam was needed for more power, and the industry required more wheels and organization, which induced the abolition of home labour and the introduction of the factory system.

During the last quarter of the 18th century it was generally believed on the expiry of Arkwright’s patents, so many power looms would be erected as to render it impossible to consume at home the yarns thus produced, and to export them would destroy the weaving industry. Many manufacturers also maintained it to be impossible to manufacture cloth in factories, but it proved to be valueless. In the following year, however, he patented another loom which has served as the model for later inventions to work upon. He was conscious that for a mechanically designed loom to become a commercial success, either the machine would have to attend several machines, or each machine must have a greater productive capacity than one manually controlled. The thought and ingenuity bestowed by Dr Cartwright upon the realization of his ideal were remarkable. He added parts which no loom, whether worked manually or mechanically, had previously been provided with, namely, a positive lift-off motion, warp and weft stop motion, and sizing the warp while the loom was in action. With this machine he commenced, at Doncaster, to manufacture fabrics, and by so doing discovered many of its shortcomings, and these he attempted to remedy: by introducing a crank and eccentric wheel; by improving the batten and false shed; by improving the picking mechanism; by a device for stopping the loom when a shuttle failed to enter a shuttle box; by preventing a shuttle from rebounding when in a box; and by stretching the cloth with tippets that act automatically. In 1792 Dr Cartwright obtained his last patent for weaving machinery; this provided the loom with multiple shuttle boxes for weaving checks and cross stripes. But all his efforts were in vain; it became apparent that no mechanism, however perfect, could succeed so long as warps continued to be sized while a loom was stationary. His plans for sizing them while a loom was in operation, and also before being placed in a loom, both failed. So it was that the stateliness and being of the power loom was assured, and means for the attainment of this end were supplied in 1803, by William Radcliffe, and his assistant Thomas Johnson, by their inventions of the beam warper, and the distance motion.

For upwards of thirty years the power loom was worked under numerous difficulties; the mechanism was imperfect, as were also organization, and the preparatory processes. Textile workers were unused to automatic machinery, and many who had been accustomed to labour in their own homes refused employment in mills, owing to dislike of the factory system and the long hours of toil which it entailed, that spinners and manufacturers were compelled to procure assistants from workhouses; this rendered mill life more distasteful than it otherwise would have been to hand spinners and weavers. Their resentment led them to destroy machinery, to burn down mills, to ill-use mill workers and to blame the power loom for the distress occasioned by war and political disturbances. Yet improvements in every branch of the textile industry followed each other in quick successions, and the loom slowly assumed its present shape. By using iron instead of wood in its construction, and centring the batten, or slay, below instead of above the warp line, the power loom became more compact than the hand-loom.

Motion is communicated to all the working parts from a main shaft A (fig. 28), upon which two cranks are bent to cause the slay B to oscillate; by toothed wheels this shaft, driven a second shaft, C, at half its own speed. For plain weaving four tappets are fixed upon the second shaft, two, D, for moving the shuttle to and fro, and two others, E, for moving the healds, L, up and down through the loom. From M. M. M. Further rows of weaving sheds and shedding tappets are more numerous, and are either loosely mounted upon the second shaft, or fixed upon a separate one. In either event they are driven by additional gearing, for the revolutions of the tappets to those of the crank shaft must be as one is to the number of picks in the repeat of the pattern to be woven. Also, when two or more shuttles are driven successively from the same side of a loom, if the picking tappets are with the second shaft, those tappets must be free to slide axially in order to keep one out of action so long as the other is required to act. The warp beam F is often put under the control of chains instead of ropes, as used in hand looms, and the chains are attached to adjustable weighted levers, G, whereby the effectiveness of the weights may be varied at pleasure. In the manufacture of heavy fabrics, however, it may be necessary to deliver the warp by positive gearing, which is either connected, or connected to the taking-up motion. The cloth is drawn forward regularly as it is manufactured by passing it over the rough surface of a roller, I, and imparting to the roller an intermittent motion on each pick of the fabric. This motion is derived from the oscillating slay, and is communicated through a train of wheels. The loom is stopped when the weft falls by a fork and grid stop motion, which depends for its action on the lightly balanced weights of a fork, N. The prongs come in contact with the weft, between the selvage of the web and the shuttle box each time the shuttle is shot to the side at which the apparatus is fixed. If the prongs meet no thread they are not actuated, and being unmoved a connection is formed with a vibrating lever, J; the latter draws the fork forward, and with it a second lever O, by which the loom is stopped. On the other hand, if the prongs are tilted, the loom continues in action. If more than one fork is fitted to the loom it may be necessary to feed for each, instead of alternate threads of weft. In such cases a fork is placed beneath the centre of the cloth and lifted above a moving shuttle; if in falling it meets with weft it is arrested, and the loom continues in motion, but if the weft is absent the prongs fall far enough beneath the
shuttle race for a stop to act upon a lever and bring the loom to a stand. To prevent a complete wreck of the warp it is essential to act quickly when a shuttle stops, as the effect of the Rebel's action upon the shuttle box is greatly increased, due to the time it remains in the warp, thus relieving its tension, for the time being, of its function of bearing up the web. On the release of a reed from the motion of the loom, a dagger stops the loom. Temples must keep a firm pressure on the breadth of the web, and the reeds are actuated by a reed head which can be set at any position. This actuated by either by leg, is a horizontal bar that set in motion all parts of the machine. The machine is an inverted U, so arranged that the bands are turned by a gear, and, in this way, the threads are drawn through the reed and beaten by a band, but later by a rack and pinion arrangement, in which action the shuttle shoots simultaneously across a web, to the right and left of the loom, and the weaving is then taken over by the new section of the web, which is transferred to the next shed. One small warp beam is required for each shed. Weft bobbins, or Jaccard bobbins, are available for dividing the threads. Where differently coloured wefts are needed in one web the shuttles are mounted in tiers and all raised or lowered at once to bring the proper colour in line with the shed.

In Sticked Weaving similar shuttles are added to the battens of broad looms in order to diessel small figure effects, in different colours or materials, over the surface of broad looms.

Pile Weaving.—Looms for weaving piled fabrics differ in certain important respects from those employed for ordinary weaving; a man to differ from each other to suit the type of fabric to be manufactured, as, for example, double and single, plain and figured, textures.

In Double Pile Looms the special features are those that control the motion of the pile threads, which are wound on a separate pile, on the back of the warp. Two ground warps are required, and unless they are kept uniform in distance apart the wired effect will be irregular. For plain goods the pile threads are wound on two or more beams, and, as they are wound in single rows, they are individually sheared to their correct fixed lengths. Meanwhile, a shuttle passes twice in succession through each ground warp, and the pile threads in moving above or beneath the wefts are bound securely. Both fabrics are furnished with two rows of pile bobbins which draw the pieces apart and so produce the effect that the unifying pile in front of a knife, which severs it, thus forming two pieces at once. A knife may consist of a short blade that merely slits the pile web, or of a group of blades, or of a single blade mounted in a needle, which, in moving from side to side, is inserted in the pile, either case it is automatically sharpened. But if a knife is longer than the breadth of a fabric it receives only a slight lateral movement, and is therefore periodically removed for sharpening. In plain and printed goods healds control all the warps; but in figured goods, other than those made from printed warps, a Jaccard is needed to lift, and a reed to hold, the pile threads.

Single Pile Looms.—The chief feature which renders most single pile looms dissimilar from others is the mechanism by which the wires are wound upon, and withdrawn automatically, from a ground warp, when the pick of the pile is being formed, and then returned, without and with knives; the former, being flattened and somewhat reduced. They are placed above the weft of a ground texture, but beneath the pile, hence, by withdrawing them, looped pile is formed. A wire terminating in a knife or blade, or a series of blades, or of a group of blades, or of a single blade mounted on a needle, or of a group of blades, or of a single blade mounted upon a needle, which, in moving from side to side, is inserted in the pile, either case it is automatically sharpened. But if a knife is longer than the breadth of a fabric it receives only a slight lateral movement, and is therefore periodically removed for sharpening. In plain and printed goods healds control all the warps; but in figured goods, other than those made from printed warps, a Jaccard is needed to lift, and a reed to hold, the pile threads.

Terry Looms.—Looms for weaving piled textures, of the Turkish towel type, have the reed placed under the control of parts that prevent it from advancing its full distance for two picks out of every
series that separate one line of loops from another. At such times the weft is not beaten home, but a broad crack is formed. So soon as the reed again moves through its normal space three picks of weft are simultaneously driven home, thus closing the gap, and causing part of the pile to loop upward, the remainder downward. The system is available for plain and figured effects.

Gauze Textures are woven in looms having a modified shedding harness, which, at predetermined intervals, draws certain warp threads crosswise beneath others, and lifts them while crossed. Also, a tensioning device to slacken the crossed threads and thus prevent breakages due to excessive strain. At other times the shedding is normal.

Lapill Looms have a series of needles fixed upright in lathe, and placed in a groove cut in the slay, in front of the reed. Each needle carries a thread which does not pass through the reed, hence, by giving the lathe an endless movement of varying extent, and lifting the needles for each pick, their threads are laid crosswise in the web to pattern.

ARCHAEOLOGY AND ART

The archaeology of shuttle-weaving shows that for ages the use of a loom for weaving plain, as distinct from ornamental or figured textiles, whether of fibres or of spun threads, has been practically universal, whilst the essential points of its construction have been almost uniform in character. An early stage in its development, anterior probably to that when the spinning of threads had been invented, is represented by the loom or frame (see fig. 29) used by a native of Sarawak to make a textile with shreds of grass. As will be seen, the shreds of grass for the warp are divided into groups by a flat sword-shaped implement which serves as the batten (Latin spatha). The shuttle is passed above it, leaving a weft of grass in between the warp; the batten is then moved upwards and compresses the weft into the warp; this method of pressing the weft upwards was usually employed by Egyptian and Greek weavers for their linen textiles of beautiful quality. Fig. 30 gives us an Indian

Fig. 29.—Loom from Sarawak.

Mountain tribesman weaving with spun threads; but here we find the loom fitted with rudely constructed heads, by which the weaver lifts and lowers alternate ranks of warp threads so that he may throw his shuttle-carried weft across and between them. Besides the heads there is a hanging reed or comb, and between

the reeds of it the warp threads are passed and fastened to a roller or cylinder. After throwing his shuttle once or twice backwards and forwards, the weaver pulls the comb towards himself, thereby pressing his weft and warp together, thus making the textile which he gradually winds from time to time on to the roller. This advance in the construction of the loom is also virtually of undatable age; and except for more substantial construction, there is little difference in main principles between it and the medieval loom of fig. 31. With such looms, and by arranging coloured warp threads in a given order and then weaving into them coloured shuttle or weft threads, simple textiles with stripes and chequer patterns could be, and were, produced; but textiles of complex patterns and textures necessitated the more complicated apparatus that belongs to a later stage in the evolution of the loom. Fig. 32 is from a Chinese drawing illustrating the description given in a Chinese book published in 1210 on the art of weaving intricate designs. The traditions and records of such figured weavings are far older than the date of this book. As spun silken threads were brought into use, so the development of looms with increasing numbers of heads and other mechanical facilities for this sort of weaving seems to have started. But as far back as 2600 B.C. the Chinese were the only cultivators of silk, 1 the delicacy and fineness of which must have postulated possibilities in

Fig. 30.—Indian Hill Tribesman's Loom.

Fig. 32.—Chinese Loom for Figured Weaving (Photo).

weaving far beyond those of looms in which grasses, wools and flax were used. It therefore is probably correct to credit the Chinese with being the earlier inventors of looms for weaving figured silks, which in course of time other nations (acquainted only with wool and flax textiles) saw with wonder. At the comparatively modern period of 300 B.C. Chinese dexterity in fine-figured weaving had become matured and was apparently in advance of any other elsewhere. Designs were being woven by the Chinese of the earlier Han Dynasty 206 B.C. as elaborate almost

1 E. Pariset, Histoire de la soie (Paris, 1862).
as those of the present day, with dragons, Phoenixes, mystical bird forms, flowers and fruits. At that time even Egypt, Assyria or Babylonia, Greece and Rome, seem to have been only learning of the fact that there was such a material as silk. Their shuttle-weaving had been and was then concerned with spun wool and flax and possibly some cotton, whilst the ornamentation of their textiles, although sparkling on occasion with golden threads, was done apparently not by shuttle-weaving but by either embroidery or a sort of compromise between darning and weaving from which tapestry weaving descended (see TAPESTRY). The range of their colours was limited, reds, purples and yellows being the chief, and their shuttle-weaving was principally concerned with plain stuffs, and in a much smaller degree with striped, spotted and chequered fabrics. Remains of these, whether made by Egyptians thousands of years B.C., by Scandinavians of the early Bronze Age, by lake dwellers, by Aztecs or Peruvians long before the Spanish Conquest, display little if any technical difference when compared with those woven by nomads in Asia, hill tribes in India and natives in Central Africa and islands of the Pacific. Such ornamental effect as is seen in them depends upon the repetition of stripes or very simple crossing forms, still this principle of repetition is a prominent factor in more intricate designs which are shuttle-woven in broad looms and lengths of stuff.

The world's apparent indebtedness to the Chinese for knowledge of figured shuttle-weaving leads to some consideration of their early overseas commerce westwards. About 200 B.C. during the Han Dynasty Chinese trade had extended beyond inner Asia to the confines of the Graeco-Parthian empire, then at its zenith, and the protection of the route by which the Seres (Chinese) sent their merchandise was a matter of importance. Seven years later the emperor of China sent a certain Chang Kien on a mission to the Indo-Scythians; and according to his records the people as far west as Bactria (adjacent to the Graeco-Parthian territory) were knowing traders, and amongst other things understood the preparation of silk. Chinese weavings had for some time been coming into Persia, and doubtless instigated the more skilled weavers to adapt their shuttle looms in course of time to the weaving of stuffs with greater variety of effects than had been hitherto obtained by them; and into Persian designs were introduced details taken not only from Chinese textiles, but also from sculptured, embroidered and other ornament of Graeco-Parthian and earlier Babylonian styles. In A.D. 97 Chinese enterprise in still furthering their trade relations with the Far West is at least suggested by the fact that envoys from the emperor of Chisa to Rome actually reached the eastern shores of the Mediterranean, but turned back frightened by the Parthian accounts of the terrors of the sea voyage.

Early in the 3rd century A.D. Heligabalus is reputed to have been amongst the first of the Roman emperors to wear garments entirely of silk (holosericum), which, if figured (as is not unlikely), were probably of Syrian or Persian manufacture. Sidonius Apollinaris (A.D. 439) writes of Persian pattern stuffs.— "Picturos fauces brilliancet couches and stuffs on which, produced by a miracle of art, we behold the fierce Parthenian with his head turned back on a prancing steed; now escaping, now turning to hurl his spear, by turns fleeing from and putting to flight wild animals whom he pursues"— a description quite appropriate to such silk weaving as that in fig. 33. A number of kindred pieces have been discovered of late years from Egypt, in burial-places of the Roman period. The Persians of the Sasanian dynasty (3rd to 7th century) traded in silks with Romans and Byzantines; King Chosroes (about 570) encouraged the trade, and ornamental weaving seems to have been an industry of some standing at Bagdad and other towns north, east and south of Hamadan, Kazvin, Kashan, Zeyre Persepolis, &c. To the north-west of Persia and north of Syria lay the Byzantine region of Anastolia (now the Black Sea) Minor, some towns in which became noted for their fine weavings; the mass of the population there was well off in the 6th century, the country highly cultivated and prosperous, and justice fairly administered, thus affording favourable conditions for an industry in ornamental weaving, which had been and was prospering in neighbouring Syrian districts.

2 Aristotel describes the silk-worm's and its cocoon. Virgil-Martial and late Roman writers (including Pliny) throw scarcely more light upon the use of silken stuffs than that they were of rarity and great value to the opulent Romans (there is a "silken garments of varied tissue," and of Cynthia that it "perchance she glistens in Arabian Silk.

W. M. Ramsay, Studies in the History and Art of the Roman Empire (University of Aberdeen, 1906).

3 See Codex Theodosius, lib. vi. tit. 21, lex 3).

4 In 569 by order of the emperors Valens and Valentinian the making of textiles in which gold and silver threads were introduced was limited to women's workshops or gynaeia (see Codex Theodosius, lib. vi. tit. 21, lex 3).

Fig. 33.—Syrian or Persian Silk Weaving of the 5th Century.

Fig. 34.—Syrian and Coptic Flax Weaving of the 5th and 6th Century.
or Alexandria or other towns in Lower Egypt as well as in Syria. Contemporaneously the development of similar weaving appears to have been proceeding in Byzantine provinces, though perhaps not in so marked a way as when Justinian systematized sericulture and still further stimulated shuttle-weaving in the town of Byzantium (Constantinople) itself in A.D. 552.

For examples of the elaborate figure weavings at that time we have to rely upon such as have been rescued in the service of archaeology from the oblivion of tombs and burial-places. The dates of some specimens can be fixed with almost certainty, by means of nearly contemporary records, e.g. those of Sidonius Apollinaris and later Anastasius the Librarian; comparison and classification lead to almost conclusive inferences as to the dates of other examples. Broadly speaking, the earlier of these remains (i.e. from about the 4th to the 7th century) seem to be either of Persian (Sassanian) manufacture and design, or of Syrian and possibly Alexandrian make. Christian subjects were occasionally introduced into the designs. Between the 7th and the 13th centuries Byzantine manufactures come to the fore, and it is difficult if not impossible now to draw a clear line between those of Roman-Byzantine, Perso-Byzantine and Moslem styles, though one may do so in respect of certain Moslem (Moorish and Saracenic) weavings, which have distinctive features of design, and were produced in the south of Spain and in Sicily about a period from the 10th century to the 13th.

Fig. 37.—Part of Silk Wrapping of the Emperor Charlemagne, possibly of Baghdad manufacture, 9th Century, with Fanciful Elephant and Sacred Tree device in a Roundel.

Fig. 38.—Fragment of Byzantine Silk, 12th Century, with Ogival Framing about pairs of Birds, &c.

Anatolian: of the same date are pieces with scenes of the Annunciation repeated in roundels, and with artistic birds and lions, in the treasury of the Sancta Sanctorum of the Chapel of St Lawrence in

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1 This virtually was the starting of sericulture in Europe.
the old Lateran Palace, Rome. Scriptural subjects seem to be typical of those which were condemned by Anatolian and Syrian fathers of the Christian church as early as in the late 4th century, and Asterius, bishop of Amassus, in denouncing the luxury of the rich in flaunting themselves in such inappropriately decorated silks, has left a most useful description of the subjects decorating them. A scheme long maintained in Syrian and Byzantine patterns was that of repeated roundels, within which other than scriptural subjects were wrought, e.g. hunters on horseback (as in fig. 33), fantastic animals and birds, singly or in pairs, confronting one another or back framing, composed of animals, birds and the like, formally treated and repeated vertically and horizontally, as in fig. 36, which is from a silk and gold thread shuttle-woven class of the 11th century manufacture. But this style of composition also occurs in a Sassanian or Syrian silk of the 5th century at Le Mans, and again in the Cope of St. Maxim at Chintor, which is powdered with panthers. Conventional eagles (reminiscent of Roman Eagle), with scale patterns on their breasts and wings, are woven in the wrappings reputed to have been given by the Empress Placidia for the corpse of St. Germanus (449) preserved at the church of St. Eusebius at Auxerre. Some remains in style may be detected between these latter and a fragment of one of the wrappings of the bishop of Durham, though in this case the elaborate ornamentation is set within a roundel. Prior to the discovery of woven silks in the British cemeteries, the periods to which tradition and association had ascribed the Auxerre and Durham specimens were considered too early; but there now seems to be far less reason to question that ascription. Fig. 37 is from part of a silk cord from Aix-la-Chapelle. It bears a Greek inscription of the name of Peter, governor of Negropont, and a priest of the Imperial Chambers, and this is taken by some authorities as evidence that the weaving was made at Byzantium. On the other hand, Charlemagne's secretary, has written of gifts, including rich textiles presented in his day by Haroun al Raschid to the emperor, and a fabric like that in question might have been made quite possibly even at Baghdad in the 9th century. In the 11th century amongst the handicrafts of the city of Byzantium were many skilful native and foreign weavers, and the designs generally appear to reflect the style of earlier Persian and Syrian taste.

About the 12th century the well-used pattern scheme of roundels became more or less superseded by one of continuous ovals, of ogival framings (see fig. 38), contemporaneous with which are Saracen patterns based on hexagonal and star-shape frames. Within these new varieties of pattern framings recur the Byzantine and Persian pairs of birds, animals, &c. But distinct from these is the more restricted style which has been mentioned. It had arisen under the influence for the most part of the Fatimy khans, not only in Syria and Alexandria but also in Sicily and southern Spain. Patterns of this Moslem or Saracenic type are usually composed of a succession of parallel bands—narrow and wide—containing Kufic inscriptions, groups of small intricate geometrical devices, and occasionally wrappings of Chinese animals and birds. A 12th-century example of this class of pattern has been given elsewhere (see Brocade, fig. 1).

Almeria, Malaga, Granada, and Seville were notable Moorish weaving places in Spain for such patterned silks and stuffs as these; and even after the Christian conquest of Granada at the end of the 15th century this city retained its celebrity for silks woven "la Moreysa.

In Sicily no similar survival of Saracenic influence seems to have been as strongly maintained, notwithstanding the Saracen weavers at work in the island for years before the Royal factory for silk weaving came to be organized at Palermo under Norman supremacy. According to the usual story, Roger of Sicily, or Roger Guiscard, who in 1117 made a raid into Attica, and took Athens, Thebes and Corinth, carried off as prisoners a number of Greek (Byzantine) weavers and settled them at Palermo in the factory known as the Hôtel des Tissus. A mixture of Byzantine weavers

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1 The silken wrappings of St. Willibald (700–786), a founder of the church at Eichstatt, where they are still preserved, are cloth between two lions, and are perhaps Byzantine of the 8th century.

2 See Sir George Birdwood's chapter on Knop and Flower pattern in his Industrial Arts of India, in which this device of ancient Assyrian art is discussed as well as its relation and that of the horn, a fanlike symbol, to cognate ornament in Greek, Roman and even Renaissance art.

3 See Abbé de l'archéologie (June 1854).

4 Recherches, &c., by Francisque Michel, i. 40.
and Saracenic styles of textile patterns ensued; and this peculiarity is demonstrated in many of the rich fabrics attributed to south and north Italian weavers from the 12th century onwards. From Palermo, the art of ornamental weaving in this style soon extended into the mainland, and from Apulia a bishop of St Evroul in Normandy is mentioned as having obtained a number of silken goods in the 12th century. From the 13th century onwards, Lucca, Florence, Milan, Genoa and Venice became important centres, using not only imported silk, but also such as was being then cultivated in Italy, for sericulture had become an Italian industry early in the 13th century. Wandering Saracen and Byzantine weavers even before that time had strayed or been taken to work at places in Germany, France and Britain, but the output of their productions in northern countries was almost infinitesimal as compared with that of the far greater Italian output, nevertheless they were sowing the seeds of a harvest to be reaped centuries later by these more northerly European countries.

To the influence of these early sporadic weavings we seem to trace a distinctive class of work, which was done by inmates of monasteries and convents as well as by devout ladies, in little looms, for use as stoles, mantles, orphreyes and similar narrow bands. A rhyming chronicle of the 13th century paraphrases the older record by Eginhard of the skill of Charlemagne’s weavers in silk weaving, “ceuvres en soie et tauliele” or small looms.1 The illustrations in fig. 39 give varieties of this class of work between the 7th and 12th centuries, for which Cologne especially seems to have become famous in the 12th century. Venice also made work of corresponding character: and the designs were evidently furnished by or directly adapted from the compositions of such artists as those who produced the notable German and Venetian woodcuts of the 15th century (fig. 40).

While the bulk of the Italian patterned stuffs issuing in great lengths from large looms were of silk, a good many also were woven in wools, or woolls intermixed with silks. The earlier of the silk textiles—Persian, Syrian, and Byzantine—were of the nature of sarcenet and taffetas; later in development are satins, damask satins, brocades, and still later (i.e. about the end of the 14th century) come Italian velvets and cloths of gold, which quite transcended the ancient and less substantial artistic cloths of the early Roman period. Medieval inventories and records contain many names of textiles, but the exact technical meaning of several of them is uncertain. Centav, Sendal, Sndanam seem to relate to such materials as sarcenet or taffeta: setani, from low Latin, is held by some writers to be of the same class as samit or examile, so called because the weft threads were only caught at every sixth thread of the warp; damask, now regarded as a special class of textile, the ornamentation of which depends upon contrasting sheens in the surface of the stuff, whether of silk or linen, got its name from Damascus, much in the same way as Baudakin comes from Baldak or Baghdad. Baudakin, and an apparently somewhat earlier word ciclaton, seem to have been general terms for rich-looking textiles, in which gold thread played an im-

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1 See Recherches, &c., by Franciscus Michel, i. 93-94.
well-known and kindred textiles. Frequently one meets with odd phrases such as "silk of Bridge" (Bruges), "silk dorne" (from Dorneck), "sheets of raynes" (Rheims), and "fuscan in Appules" (Naples Fustian). Many of the foregoing stuffs are identifiable by textures peculiar to them; this is, however, not so as regards their ornamental patterns, for these are frequently interchanged, the same class of patterns appearing in satin damasks, velvets and brocades. This is particularly the case with 14th and 15th-century Italian stuffs. In the patterns of these, as previously suggested, are strong traces of Saracen and Byzantine motives, intermingled with badges, heraldic devices, human figures, eagles, falcons, bound male, hawks, boards, leopards, rays of light, Persianque pines and cloud forms, and even Chinese mystical birds, symmetrically distributed, without framing, as a rule, though elaborations of the ogival frame or scheme are also met with, but less frequently (see fig. 41). Such fabrics, made in the main by Lucchese weavers, appear to have been traded in with other European countries. But besides trade records, there are others relating to Lucchese weavers who left their own town under stress of circumstances, civil wars and the like, to settle and work elsewhere in France and Flanders, during the 15th century. Nevertheless the northern parts of Italy were the fertile places for producing fine types of patterned textiles used by Italian and other

carnations and hyacinths depicted on a smaller scale are unmistakably Ottoman. Persian fabrics of rather thin silk material or taffetas like that of the original of this were also being woven with varieties of floral designs, as well as others portraying Persian stories. At this period there was considerable activity in weaving Persianque and other similar stuffs at Broussa and Constantinople (fig. 44). Arabic and Turkish weavers often came over to be employed in Venice, blending Italian and Oriental characteristics into their designs. Again during the early 16th century, we have traces of Hispano-Moresque influence in the overlapping and interlocking nondescript forms; but Spanish weavings are hardly comparable in quality with the Italian of the same time. In a middle of this century clothes of gold or silver, and brocades made of similar formal design were made in greater quantities in Venice. For as costumes of men and women. The frequent basis of most of the designs is a quatrefoiled framework already referred to, but it is much elaborated with detail and combined with cable device of a previous century. The ornamentation of this style is purely conventional throughout, the various devices having little of the appearance of actual objects like fruit, leaves, &c.

The time, however, was close at hand when a more general reaction was to set in, in the direction of designs representing forms very nearly as they actually look, an example of which occurs in fig. 45, with its leaf forms and crowns. This from a class of silk damask or lampas, which is kindred to brocatelle; a feature in lampas is that its ground is different in colour from that of the ornament on it, and as in the case of portions of brocailles its texture is of taffeta or sarcenet quality. At the end of the 16th century a peculiar type of pattern consists of repetitions of different positions of the same detail treated realistically or purely ornamentally, little if anything of quite the same character having been previously designed. Of such fig. 46, with its repeated realistic leafy foliages variously placed, is an example. The chief rule in the composition of these patterns, but with a greater variety of conventional detail, is followed in French 17th century examples. However, as soon as this period French figured stuffs seem to surpass those of other countries. "If," writes Monsieur Pariset, "any account is to be taken of the weavers during the 14th and 15th centuries who made brocatelles of silk in Paris, Rouen, Lyons, Nimes and Avignon must be remembered that they were almost solely Italian emigrants from Lucca and Florence, who had fled their towns during troublous times." By a charter granted by Francis I. to Lyons, foreign and native weavers were encouraged to promote the city's interests in trade and manufacture; still, it is not until the 17th century that Lyons really asserts herself in producing fabrics possessing French taste and ornamentation. The more important designs were supplied by a group of influential artists of the time, including Rebeyval, a pupil of Le Brun, the first principal of the Académie des Beaux Arts founded by Colbert in Paris in 1648, Pilenot and Philippe de la Salle in the 18th century, may be

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**Fig. 42.—Damask and Brocade Silk Fabric. Italian manufacture of the 15th century.**

European courts and nobles: and if the art seriously dwindled in the town of Lucca, it flourished conspicuously, from the end of the 14th century and up to the beginning of the 15th century; in Venice, Bologna, Genoa, Florence and Milan. There was nothing similar to compete with it in France, Germany or England. The identification of its splendid varieties is made possible upon referring to contemporary paintings by Orcagna, Crovelli, Spinello Aretino and later Italian masters, as well as to those of the Flemish School, Germain David, Mabuse, &c.

Of a specially distinct class, very dignified in effect, are patterns of a very basalt upon the repetition of conventional pentagonally constructed leaf panels, clearly defined in outline, each encircling a pomegranate or corn form around which radiate small leaves or blossoms; though they were more richly developed in Sweden. The leaves of this pattern were in most cases, shaded with rust or gold, for which Florence, Venice and Genoa were famed, this type of design is also woven in less costly materials. A composite unusual and beautiful design of another kind is given in fig. 42. Repeated leafy shapes can just be detected in it, but more remarkable are the bunches of radiating stalks of wheat ears and cornflowers within them, whilst about them, arranged in hexagonal trellising, are leafy bars, small birds, crowns, pomegranate and corn-like depicted plant forms. This and damask combined with brocades is of late 15th century manufacture: and after the opening of the next century the freedom towards realistic treatment, which we find here, enters into many of the Italian pattern. In some of them, as in fig. 43 a figured silk which is considered to have been made in Venice. The chained dogs and birds in this design recall the rather more formal ones in Luccese patterns of a hundred years earlier, whereas the lengthy serrated leaves and elongated flower devices charged with

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**Fig. 45.—Piece of Venetian Silk Weaving showing Ottoman influence in the arabesque design (16th century).**

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1 See Ornament in European Silks (London, 1889), p. 15.
named. Their influence in the domain of fanciful, and at times extravagant realistic, floral patterns was widespread. Soon after the revocation of the Edict of Nantes, in consequence of which thousands of Protestant weavers left France, factories for weaving silks and mixed materials with patterns imitating the successive French phases became organized at Spitalfields, in Cheshire, Yorkshire, Norfolk and elsewhere in England, as well as in Germany at Crefeld, Elberfeld, Barmen and Weissen. Entirely distinct from what has already been discussed is a branch of artistic weaving concerned with the decoration of linens, that flourished notably in Italy towards the end of the 15th century and in the 16th century. From early times long and narrow Italian tablecloths were enriched with ornament of linen or cotton threads of a single colour, and Signora Isabella Erera has written at some length about them, illustrating the result of her investigations with several examples culled from paintings by Pietro Lorenzetto of Siena (1490), by Ghirlandaio (1449-1499), &c. In Leonardo da Vinci’s painting of the Last Supper, now in the Louvre, the border of the tablecloth is very like many examples of this sort of textile in the Victoria and Albert Museum, South Kensington. Their characteristic ornament, in rather heavy blue thread, consists of quaint animals and birds in pairs, which are evident derivations of those so often seen in Italo-Byzantine and Lucchese silks and brocades. Besides animals and birds, reversed names and words were sometimes introduced, e.g., “Amor” for “Roma,” “Amorzaroardo” for “Gratiosa,” and “Eroma” for “Amore,” &c. The simpler of these tablecloth patterns probably date from before the 14th century, whilst the fuller ones were certainly made in considerable quantities in the 15th century. An inventory dated 1512 has an entry of two napkins or cloths woven in cotton with bands of dragons and lions à la Pérusian, which is suggestive that this type of weaving was associated particu

With Perugia. In the 16th century, work of similar style was produced, but it was lighter and flatter in texture and often done with red or yellow silk, and embroidery was sometimes added to the weaving. The most important and probably the best known class of later ornamental linen weaving is that of damask household napery, which, as a reflection of satire on dress, was developed in the fast-growing regions of Saxony, Flanders and North France, during the late 15th or early 16th century; it was then rare and acquired for use by wealthy persons only. The style of design in the better of the old linen damasks has some kinship with that of bold 15th- and 16th-century woodcuts of the Flemish or German schools. To some extent these damask figure subjects recall those of the coloured Cologne and Venetian engravings for copies and separations for dalmatics. The early history of linen damask is obscure, but a great many of its results are preserved in England. A napkin with the royal shield of Henry VII., the supporters within the garter surmounted by the crowns, is in the Victoria and Albert Museum where it is called Flemish. On the other hand it is possible the work of Flemings in England, since from the time of Edward I. and for a hundred years a constant stream of emigrants passed from Flanders to England. The Victoria and Albert Museum contains an early 16th-century tablecloth in damask linen of German or Flemish manufacture with various subjects, chiefly religious and moral: Gideon being shown as a kneeling knight, the fleece of wool on the ground being near him, while from above the dew falls on it; below Gideon is the Virgin Mary and the unicorn, and lower down an angel with seven dogs' heads typifying different virtues as shown in the lettering—Fidelis, Invicta, Charitas, &c. In another which was probably made in England (at Norwich?) by Flemings during the second half of the 16th century, we find St George and the Dragon, the royal arms of Queen Anne Boleyn, the badges of Queen Anne Boleyn and Queen Elizabeth, the crowned Tudor Rose, and repeated portraits of Queen Elizabeth, with the legend below, “God save the Queen.” This specimen is also in the Victoria and Albert Museum. A hundred years later in date is a tablecloth on which is a view of old St Paul’s (burnt in 1666), while above and below occurs the wreathed shield of the City of London. A different class of linen, with the design done in blue, was evidently, from the inscriptions on it, the work of a German or Flemish, and probably woven in Germany about 1730. Here we find the wreathed arms of the City of London, a view of London, and “George der H. König in Engeland” mounted on horseback. In this specimen the design is repeated, and

1 See the Italian monthly art review, Emportum, vol. xiii. (1906).

2 The earl of Northumberland (1512) is said to have had but eight linen cloths for his personal use, while his large retinue of servants had but one, which was washed once a month. (See notes by Rev. C. H. Evelyn White on damask linen, Proceedings of Society of Antiquaries, second series, vol. xx. p. 132.)

not reversed, as in the case with the earlier pieces. A large collection of this German damask weaving with coloured thread was formed under the auspices of the Royal Kunstgewerbe Museum at Dresden. The north-eastern Irish industry of damask weaving owes much to French Protestant refugees, who settled there towards the close of the 17th century, though linen manufacture had been established in the district by a colony of Scots in 1634. Dunfermline in Scotland is said to produce as much damask as the rest of Europe, but there are important manufactories of it at Courtrai and Liège in Belgium, in Silesia, Austria and elsewhere.


(A.S.C.)