CHAPTER XVIII.

ARTS OF COMBINING FLEXIBLE FIBRES.

Theory of Twisting, Rope Making, Hemp Spinning. *Cotton Manufacture*, Elementary Inventions, Batting, Carding, Drawing, Roving, Spinning, Mule Spinning, Warping, Dressing, Weaving, Twilling, Double Weaving, Cross Weaving, Lace, Carpeting, Tapestry, Velvets, Linens. *Woollens. Felting. Paper Making. Bookbinding.*

Theory of Twisting.—The strength of cordage, which is employed in uniting bodies, and the utility of flexible textures, which serve for furniture, or for clothing, depend, principally, upon the friction, or lateral adhesion, produced by the twisting and intermixture of their constituent fibres.

A twisting cord is not so strong as the fibres which compose it, supposing the fibres and cord to be of the same length. The object of twisting is, to connect successive numbers of short fibres, in such a manner, that, besides the mutual pressure which their own elasticity causes them to exert, any additional force, applied in the direction of the length of the aggregate, may tend to bring their parts into closer contact, and augment their adhesion to each other. The simple art of tying a knot, and the

more complicated processes of spinning, rope-making, weaving, and felting, derive most of their utility from this principle.

By considering the effect of a force, which is counteracted by other forces, acting obliquely, it will be seen, that the operation of twisting has a useful effect, in binding the parts of a rope, or thread, together; and also, that it has an inconvenience, in causing the strength of the fibres to act with a mechanical disadvantage. The greater is the obliquity of the fibres, the greater will be their adhesion to each other, but the greater, also, will be their immediate strain, or tension, when a force acts upon them, in the direction of the whole cord. From this, it follows, that, after employing as much obliquity, and as much tension, as is sufficient to connect the fibres firmly together, all that is superfluously added tends to weaken the cord, by overpowering the primitive cohesion of the fibres, in the direction of their length.

The mechanism of simple spinning is easily understood. Care is taken, where the hand is employed, to intermix the fibres sufficiently, and to engage their extremities, as much as possible, in the centre; for, it is obvious, that, if any fibre were wholly external to the rest, it could not be retained in the yarn. In general, however, the materials are, previously, in such a state of intermixture, as to render this precaution unnecessary.

Rope Making.—A single thread of yarn, consisting of fibres twisted together, has a tendency to untwist itself, the external parts being strained, by extension, and the internal parts, by compression; so that the elasticity of all the parts resists, and tends to restore the thread to its natural state. But, if two such threads, similarly twisted, are retained in contact, at a given point of the circumference of each, this point is rendered stationary, by the opposition of the equal forces, acting in contrary directions, and becomes the centre, round which both threads are carried, by the forces which remain; so that they continue to twist round each other, till the new combination causes a tension, capable of counterbalancing the remaining tension of the original threads. Three, four, or more,

threads may be united, nearly in the same manner. A *strand*, as it is called by rope-makers, consists of a considerable number of yarns, thus twisted together, generally from sixteen to twenty-five; a *halser* consists of three strands; a *shroud*, of four; and a *cable*, of three halsers, or shrouds. Shroud-laid cordage has the disadvantage of being hollow in the centre, or else of requiring a great change of form in the strands, to fill up the vacuity; so that, in undergoing this change, the cordage stretches, and is unequally strained. The relative position, and the comparative tension, of all the fibres, in these complicated combinations, are not very easily determined by calculation; but, it is found, by experience, to be most advantageous for the strength of ropes, to twist the strands, when they are to be compounded, in such a direction, as to untwist the yarns, of which they are formed; that is, to increase the twist of the strands themselves; and, probably, the greatest strength is obtained, when the ultimate obliquity of the constituent fibres is least, and the most equable.*

A very strong rope may, also, be made, by twisting five or six strands round a seventh, as an axis. In this case, the central strand, or heart, is found, after much use, to be chafed to oakum. Such ropes are, however, considered unfit for rigging, or for any use, in which they are liable to be frequently bent.

Ropes are most commonly made of hemp; but various other vegetables are occasionally employed. The Chinese even use woody fibres; and the barks of trees furnish cordage to other nations. In spinning the yarn, in the process of rope-making, the hemp is fastened round the waist of the workman; one end of it is attached to a wheel, turned by an assistant, and the spinner, walking backwards, draws out the fibres with his hands. When one length of the walk has been spun, it is immediately reeled, to prevent its untwisting. The machines, employed in continuing the process of rope-making, are mostly of simple construction; but both skill and attention are

* Young's Natural Philosophy, vol. i. Lect. xvi.

required, in applying them, so as to produce an equable texture, in every part of the rope. The tendency of two strands to twist, in consequence of the tension, arising from the original twist of the yarns, is not sufficient to produce an equilibrium, because of the friction and rigidity to be overcome. Hence, it is necessary to employ force, to assist this tendency, and the strands, or ropes, will afterwards retain, spontaneously, the form which has thus been given them. The largest ropes, even, require external force, in order to make them twist at all.

The constituent ropes of a common cable, when separate, are stronger than the cable, in the proportion of about four to three; and a rope, worked up from yarns, one hundred and eighty yards in length, to one hundred and thirty-five yards, has been found to be stronger, than when reduced to one hundred and twenty yards, in the ratio of six to five. The difference is owing, partly, to the obliquity of the fibres, and, partly, to the unequal tension, produced by twisting.*

Hemp Spinning.—The desideratum of spinning hemp, by machinery, has been attained by Mr. Treadwell, in his machines for that purpose, now at work, at the Charlestown Navy Yard, and elsewhere. By this invention, the hemp is drawn out to the requisite size, by a long series of teeth, fixed upon a revolving belt, and afterwards twisted, by the revolutions of the machine. The equality, or uniform size, of the yarn, is ensured, by a roller, or small wheel, which rests upon the part just twisted, and which rises, or is pushed up, if the twist becomes too large, and moves a comb, which immediately falls, and intercepts the superfluous part of the fibres. On the other hand, if the twist becomes too small, the roller descends, and, in so doing, increases the rapidity of the machine, and causes it to supply the hemp faster.

COTTON MANUFACTURE.

When the fibres of cotton, wool, or flax, are intended to be woven, they are reduced to fine threads, of uniform

* Young's Natural Philosophy, vol. i. Lect. xvi.

size, by the well-known process of *spinning*. Previously to the middle of the last century, this process was performed by hand, with the aid of the common spinning-wheel. Locks of cotton, or wool, previously carded, were attached to a rapidly-revolving spindle, driven by a large wheel, and were stretched or drawn out by the hand, at the same time that they were twisted by the spindle, upon which they were afterwards wound. Flax, the fibres of which are longer, and more parallel, was loosely wound upon a distaff, from which the fibres were selected, and drawn out by the thumb and finger, and, at the same time, were twisted by flyers, and wound upon a bobbin, which revolved with a velocity, somewhat less than that of the flyers.

The manufacture of flexible stuffs, by means of machinery, operating on a large scale, is an invention of the last century. Although of recent date, it has given birth to some of the most elaborate and wonderful combinations of mechanism, and already constitutes, especially in England, and in this country, an important source of national wealth and prosperity.

Elementary Inventions.—The character of the machinery which has been applied to the manufacture of cotton, at different times, has been various. There are, however, several leading inventions, upon which most of the essential processes are founded, and which have given to their authors a greater share of celebrity than the rest. These are, 1. The *spinning-jenny*. This machine was invented by James Hargreaves,* in 1767, and, in its simplest form, resembled a number of spindles, turned by a common wheel, or cylinder, which was worked by hand. It stretched out the threads, as in common spinning of carded cotton. 2. The *water spinning-frame*, invented by Richard Arkwright, in 1769. The essential, and most important, feature in this invention consists in the drawing out, or elongating, of the cotton, by causing it to pass between successive pairs of rollers, which revolve, with different velocities, and which act as

* Mr. Guest, in a late work, attributes the invention, both of the jenny, and water spinning-frame, to Thomas Highs, of Leigh, England

substitutes for the finger and thumb, as applied in common spinning. These rollers are combined with the spindle and flyers of the common flax wheel. 3. The *mule*. This was invented by Samuel Crompton, in 1779. It combines the principles of the two preceding inventions, and produces finer yarn, than that which is spun in either of the other machines. It has now nearly superseded the jenny. 4. The *power-loom* for weaving, by water or steam power, which was introduced about the end of the eighteenth century, and has received various modifications.

The foregoing fundamental machines are used in the same, or different establishments, and for different purposes. But, besides these, various auxiliary machines are necessary, to perform intermediate operations, and to prepare the material, as it passes from one stage of the manufacture to another. The number of these machines, and the changes, and improvements, which have been made in their construction, from time to time, render it impossible to convey, in a work like the present, any accurate idea of their formation, in detail. A brief view, however, of the offices which they severally perform, may be taken, by following the raw material, through the principal changes which it undergoes, in a modern cotton-factory, founded and improved upon the general principles of Arkwright.

Batting.—The cotton, after having been cleared from its seeds, at the plantation, by the operation of *ginning*, described on page 111, Vol. I., is compressed into bags, for exportation, and arrives at the factory, in a dense and matted mass. The first operation to which it is submitted has, for its object, to disentangle the fibres, and restore the cotton to a light, open, and uniform, state. For this purpose, after being weighed out, it is submitted to the operation of a machine, called a *picker*, or of another, denominated a *batter*. In some of these machines, it is subjected to the action of a series of pins ; in others, to a sort of blunt knives, revolving with great rapidity ; the effect of which is, to beat up and separate the fibres, to disengage their unequal adhesions, and to reduce the whole to a very light, uniform, flocculent, mass.

Carding.—The cotton next passes to the carding-machines, of which, when there are two, the first is called the *breaker*, and the second, the *finisher*. In this operation, the cotton is carried over the surface of a revolving cylinder, which is covered with card-teeth of wire, and which passes in contact with an arch, or part of a concave cylinder, similarly covered with teeth. From this cylinder, it is taken off by another, called the *doffing* cylinder, which revolves in an opposite direction; and from this, it is again removed, by the rapid vibrating movement of a transverse *comb*, otherwise called the *doffing-plate*, moved by cranks. It then exists in the state of a flat, uniform, fleece, or *lap*, which, after passing the breaker, undergoes the process of *plying*, or doubling, by causing it to perform a certain number of revolutions upon a cylinder, or a perpetual cloth. It is then carded a second time, by the finisher, and the fleece, after being taken off from this machine, is drawn by rollers, through a hollow cone, or trumpet mouth, which contracts it to a narrow band, or *sliver*, and leaves it coiled up in a tin can, ready for the next operation. The process of carding serves to equalize the substance of the cotton, and to lay its fibres somewhat in a more parallel direction.

Drawing.—The slivers of cotton are next elongated, by the process of drawing. This operation is the groundwork, or principle, of Arkwright's invention, and is used in the *roving*, and *spinning*, as well as in the *drawing-frame*. It is an imitation of what is done by the finger and thumb, in spinning by hand, and is performed, by means of two pairs of rollers. The upper roller, of the first pair, is covered with leather, which, being an elastic substance, is pressed, by means of a spring, or weight. The lower roller, made of metal, is fluted, in order to keep a firm hold of the fibres of cotton. Another similar pair of rollers are placed near those which have been described. The second pair, moving with a greater velocity, pull out the fibres of cotton from the first pair of rollers. If the surface of the last pair move at twice, or thrice, the velocity of the first pair, the cotton will be drawn twice, or thrice, finer than it was before. This

relative velocity is called the *draught* of the machine. This mechanism being understood, it will be easy to conceive the nature of the operation of the *drawing-frame*. Several of the narrow ribands, or slivers, from the cards, (sometimes termed *card-ends*,) by being passed through a system of rollers, are thereby reduced in size. By means of a detached, single pair of rollers, the several reduced ribands are *plied*, or united into one sliver.

The operations of drawing and plying serve to equalize, still further, the body of cotton, and to bring its fibres more into a longitudinal direction. These slivers are again combined, and drawn out, so that one sliver of the finished drawing contains many plies of card-ends. Hitherto, the cotton has acquired no twist, but is received into movable tin cans, or canisters, similar to those used for receiving the cotton from the cards.

Roving.—The operation of roving communicates the first twist to the cotton. It is performed by a machine, called the *roving-frame*, or *double-speeder*. The tin cans, containing the slivers of cotton, are placed upon this machine, and are made to revolve, slowly, about their axes, so as to produce a slight degree of twisting. The slivers then pass again, through several pairs of rollers, moving with different speeds, and are thus still further attenuated, by drawing. They are then slightly spun, by the revolution of flyers, and are wound upon the bobbins of the spindles, in the form of a loose, soft, imperfect, thread, denominated the *roving*.

The mechanism of the double speeder is complicated, and interesting, and great ingenuity has been displayed, in overcoming the difficulties of its construction. In order that the yarn, or roving, may be wound upon the bobbins, in even, cylindrical, layers, it is necessary, that the *spindle-rail*, or horizontal bar, which supports the spindles, should continually rise and fall, with a slow alternate motion This is effected by heart-wheels, or cams, in the interio. of the machine. Again, since the collective size of the bobbin is augmented, by the addition of each layer of roving, it is obvious, that, if the axis of the bobbin revolved, always, with the same velocity, the thread of rov

ing would be broken, in consequence of being wound up too fast. To prevent this accident, the velocity of the spindles, and, likewise, the motion of the spindle-rail, is obliged gradually to diminish, from the beginning to the end of an operation. This diminution of speed is effected, by transmitting the motion, both to the spindle-rail, and to the bobbins, through two opposite cones, one of which drives the other with a band, the band being made to pass, slowly, from one end to the other of the cones, and thus continually to alter their relative speed, and cause a uniform retardation of the velocity of the moving parts.* As the roving is not strong enough to bear any violence, the spindles, which support the bobbins, are geared to each other, so as to prevent any deviation from the proper velocity.

A more simple form of the roving-frame has been invented,† in which the gearing is dispensed with, as well as the pair of cones, which regulates the motion of the bobbins. In this machine, the bobbins are not turned by the rotation of their axes, but by friction, applied to their surface, by small wooden cylinders which revolve in contact with them. In this way, the velocity of the surface of the bobbin will always be the same, whatever may be its growth, from the accumulation of roving, so that the winding goes on, at an equable rate. To prevent the roving from being stretched, or broken, in its passage from the drawing rollers to the bobbins, it is made to pass through a tube, which has a rapid rotation, and which twists it, in the middle, into a cord of some firmness. It is again untwisted, as fast as it escapes from the tube, and is wound upon the bobbins, in the form of a dense, even, cord, but without any twist.

Spinning.—The bobbins, which contain the cotton, in a state of roving, are next transferred to the spinning-frame. It is here once more drawn out by rollers, and twisted by flyers, so that the spinning is little more than

* Instead of band cones, an ingenious mode of using geared cones, now introduced in several American factories, has already been described, page 60.

† By Mr. Danforth, of Massachusetts.

a repetition of the process gone through, in making the roving, except that the cotton is now twisted into a strong thread, and cannot any longer be extended, by drawing. The flyers of the spinning-frame are driven by bands, which receive their motion, in some cases, from a horizontal fly-wheel, and, in others, from a longitudinal cylinder.* As the thread is sufficiently strong not to break with a slight force, the resistance of the bobbins, by friction, is relied on to wind it up, instead of having the spindles geared together, and turned with an exact velocity, as they are in the common double-speeder. In the spinning frame, the heart-motion is retained, to regulate the rise and fall of the rail; and, in those frames which spin the woof, or filling, it is applied, by a progressive sort of cone, the section of which is heart-shaped, and which acts, remotely, to distribute the thread, in conical layers, upon the bobbins, that it may unwind the more easily, when placed, afterwards, in the shuttle.

Mule Spinning.—The processes of water-spinning, already described, are adequate to produce yarns, of sufficient fineness for ordinary fabrics. But, for producing threads of the finest kind, another process is necessary, which is called *stretching*, and which is analogous to that which is performed, with carded cotton, upon a common spinning-wheel. In this operation, portions of yarn, several yards long, are forcibly stretched, in the direction of their length. It differs, therefore, from the operation of drawing, in which a few inches, only, are extended at a time. The stretching is performed, with a view to elongate and reduce those places in the yarn, which have a greater diameter, and are less twisted, than the other parts so that the size and twist of the thread may become uniform throughout. To effect the process of stretching, the spindles are mounted upon a carriage, which is moved, back and forwards, across the floor; receding, when the threads are to be stretched, and returning, when they are to be wound up. The yarn, produced by mule-spinning, is more perfect than any other, and is employed in the

* The latter method, which had gone into disuse, is beginning to be revived, and to be considered most advantageous.

fabrication of the finest articles. The sewing-thread, spun by mules, is a combination of two, four, or six, constituent threads, or plies. Threads have been produced, of such fineness, that a pound of cotton has been calculated to reach one hundred and sixty-seven miles.

Warping.—The first step, preparatory to weaving, is to form a *warp*, which consists of parallel threads, continued through the whole length of the intended piece, and sufficient, in number, to constitute its breadth. It was, formerly, the practice to attach the threads to as many pins, and to draw them out, to the required length. But, as this method required too much room, a warping machine was subsequently used, in which the mass of threads, intended to constitute a warp, was wound in a spiral course, upon a large revolving frame, which rose and fell, so as to produce the spiral distribution.

These methods are now superseded, in this country, by Moody's warping-machine,* an ingenious piece of mechanism, in which a number of bobbins, equal to one eighth part of the number of threads in the intended warp, are arranged upon the surface of a concave frame. The threads pass through a reed, which separates the alternate threads, as they are to be kept in the loom; after which, they are wound upon a beam, with rods interposed at the end, to preserve the separation. But the most interesting part of the mechanism is a contrivance for stopping the machine, if a single thread of the warp breaks. To effect this object, a small steel weight, or flattened wire, is suspended, by a hook, from each thread, so that it falls, if the thread is broken. Beneath the row of weights, a cylinder revolves, furnished with several projecting ledges, extending its whole length, parallel to the axis. When one of the weights falls, by the breaking of its thread, it intercepts one of the ledges, and causes the cylinder to exert its force upon an elbow, or toggle-joint, which disengages a clutch, and stops the machine. After the thread is tied, and the weight raised, the machine proceeds.

* Mr. Paul Moody, formerly of Waltham, and now of Lowell, is the inventor of this machine; likewise of the spinning-frame, which winds the woof in conical layers; and of great improvements in the roving frame, the dressing-frame, &c.

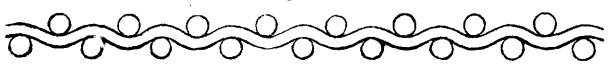
Dressing.—As the threads, which constitute the warp, are liable to much friction, in the process of weaving, they are subjected to an operation, called dressing, the object of which is, to increase their strength and smoothness, by agglutinating their fibres together. To this end, they are pressed between rollers, impregnated with mucilage, made of starch, or some gelatinous material, and, immediately afterwards, brought in contact with brushes, which pass repeatedly over them, so as to lay down the fibres in one direction, and remove the superfluous mucilage from them. They are then dried, by a series of revolving fans, or by steam-cylinders, and are ready for the loom.

Weaving.—Woven textures derive their strength from he same force of lateral adhesion, which retains the twised fibres of each thread in their situations. The manner, in which these textures are formed, is readily understood. On inspecting a piece of plain cloth, it is found to consist of two distinct sets of threads, running perpendicularly to each other. Of these, the longitudinal threads constitute the *warp*, while the transverse threads are called the *woof*, *weft*, or *filling*, and consist of a single thread, passing backwards and forwards. In weaving with the common loom, the warp is wound upon a cylindrical beam, or roller. From this, the threads pass through a *harness*, composed of movable parts, called the *heddles*, of which there are two or more, consisting of a series of vertical strings, connected to frames, and having loops, through which the warp passes. When the heddles consist of more than one set of strings, the sets are called *leaves*. Each of these heddles receives its portion of the alternate threads of the warp; so that, when they are moved, reciprocally, up and down, the relative position of the alternate threads of the warp is reversed. Each time that the warp is opened, by the separating of its alternate threads, a *shuttle*, containing the woof, is thrown across it, and the thread of a woof is immediately driven into its place, by a frame, called a *lay*, furnished with thin reeds, or wires, placed among the warp, like the teeth of a comb. The woven piece, as fast as it is completed, is wound up on a second beam, opposite to the first.

Power looms, driven by water, or steam, although a late invention, are now universally introduced into manufactories of cotton and woollens. As the motions of the loom are, chiefly, of a reciprocating kind, they are produced, in some looms, by the agency of cranks, and in others, by cams, or wipers, acting upon weights, or springs.

Twilling.—In the mode of plain weaving, last described, it will be observed, that every thread of the warp crosses at every thread of the woof, and *vice versa.* In articles, which are *twilled*, or *tweeled*, this is not the case; for, in this manufacture, only the third, fourth, fifth, sixth, &c., threads cross each other, to form the texture. In the coarsest kinds, every third thread is crossed; but, in finer fabrics, the intervals are less frequent, and, in some very fine twilled silks, the crossing does not take place, till the sixteenth interval. In Fig 178, is shown a magnified

Fig. 178.



section of a piece of plain cloth, in which the woof passes, alternately, over and under every thread of the warp. In Fig. 79, is a piece of twilled cloth, in which the thread

Fig. 179.

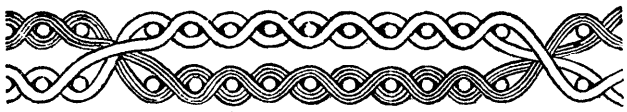
of the woof passes, alternately, over four, and under one, of the threads of the warp, and performs the reverse, in its return. To produce this effect, a number of leaves of heddles are required, equal to the number of threads contained in the interval, between each intersection, inclusive. By the separate movements of these, the warp is placed in the requisite positon, before each stroke of the shuttle. A loom, invented in this country, by Mr. Batchelder, of Lowell, has been applied to the weaving of twilled goods, by water-power.

Twilled fabrics are thicker than plain ones, when of the same fineness, and more flexible, when of the same thickness. They are also more suceptible of ornamental va

rnations. Jeans, dimities, serges, &c., are specimens of this kind of texture.

Double Weaving.—In this species of weaving, the fabric is composed of two webs, each of which consists of a separate warp, and a separate woof. The two, however, are interwoven, at intervals, so as to produce various figures. The junction of the two webs is formed, by passing them, at intervals, through each other; so that each particular part of both is sometimes above, and sometimes below. It follows, that, when different colors are employed, as in carpeting, the figure is the same, on both sides, but the color is reversed. A section of double cloth is shown in Fig. 180.

Fig. 180.



The weaving of double cloths is commonly performed, by a complicated machine, called a *draw-loom*, in which the weaver, aided by an assistant, or by machinery, has the command of each particular thread, by its number. He works by a pattern, in which the figure before him is traced, in squares, agreeably to which the threads to be moved are selected, and raised, before each insertion of the woof. Kidderminster carpets, and Marseilles quilts, are specimens of this mode of weaving.

Cross Weaving.—This method is used, to produce the lightest fabrics, such as gauze, netting, catgut, &c. In the kinds of weaving which have been previously described, the threads of the warp always remain parallel to each other, or without crossing. But, in gauze-weaving, the two threads of warp, which pass between the same splits of the reed, are crossed over each other, and partially twisted like a cord, at every stroke of the loom. They are, however, twisted to the right and left, alternately, and each shot, or insertion of the woof, preserves the twist which the warp has received. A great variety of fanciful textures are pro-

duced, by variations of the same general plan. Fig. 181, represents the cross-weaving, used in common gauze.

Fig. 181.

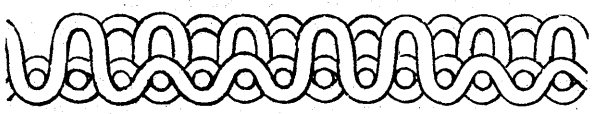
Lace.—Lace is a complicated, ornamental, fabric, formed of fine threads of linen, cotton, or silk. It consists of a net-work of small meshes, the most common form of which is hexagonal. In perfect thread-lace, four sides of the hexagon consist of threads which are twisted, while, in the remaining two, they are simply crossed. Lace has been commonly made upon a cushion, or pillow, by the slow labor of artists. A piece of stiff parchment is stretched upon the cushion, having holes pricked through it, in which pins are inserted. The threads, previously wound upon small bobbins, are woven round the pins, and twisted, in various ways, by the hands, so as to form the required pattern. The expensiveness of the different kinds of lace is proportionate to the tediousness of the operation. Some of the more simple fabrics are executed with rapidity, while others, in which the sides of the meshes are plaited, as in the Brussels lace, and that made at Valenciennes, are difficult, and bear a much greater price.

The cheaper kinds of lace have long been made by machinery; and, recently, the invention of Mr. Heathcoat's lace-machine has effected the fabrication of the more difficult, or twisted lace, with precision and despatch. This machine is exceedingly complicated and ingenious, and is now in operation in this country, and in France, as well as in England.

Carpeting.—Carpets are thick textures, composed, wholly or partly, of wool, and wrought by several dissimilar methods. The simplest mode is that used in weaving the *Venetian* carpets, which is a plain texture, composed of a striped woollen warp, on a thick woof of linen thread. *Kidderminster* carpeting is composed by two woollen webs, which intersect each other, in such a manner, as to produce definite figures. *Brussels* carpet

ing has a basis, composed of a warp and woof, of strong linen thread. But, to every two threads of linen, in the warp, there is added a parcel of about ten threads of woollen, of different colors. The linen thread never appears on the upper surface; but parts of the woollen threads are, from time to time, drawn up in loops, so as to constitute ornamental figures, the proper color being, each time, selected from the parcel to which it belongs. A sufficient number of these loops is raised, to produce a uniform surface, as seen in Fig. 182; and to render them

Fig. 182.



equal, each row passes over a wire, which is subsequently withdrawn. In some cases, the loops are cut through with the end of the wire, which is sharpened for the purpose, so as to cut off the threads, as it passes out. In forming the figure, the weaver is guided by a pattern, which is drawn in squares, upon a paper. *Turkey* carpets appear to be fabricated upon the same general principles, as the Brussels, except that the texture is all woollen, and the loops larger, and always cut.

Tapestry.—The name of tapestry is given to certain delicate and complicated fabrics, in which the forms and colors of natural objects are produced, with such accuracy, as to resemble fine paintings. The mode of texture used, to produce this effect, is, in many respects, analogous to that by which the finer carpetings are made. The minuteness, however, of the constituent parts, causes the sight of the texture to be lost, in the general effect of the piece. The fabrication of tapestry is slow, intricate, and very expensive. The most celebrated manufactory is that established by the family of Gobelins, and kept up by their successors, at Paris.

Velvets.—The fine soft nap, by which velvet is covered, is produced by a method, not unlike that which is used in carpeting and tapestry. It is formed of a part

of the threads of the warp, which the workman puts, in loops, on a long, channelled wire. Before the wire is withdrawn, the row of loops is cut open, by a sharp steel instrument which is drawn along the channel of the wire. Various other fabrics of silk, cotton, and wool, such as thicksets, plushes, corduroys, velveteens, &c., are cut in a similar manner.

Cotton counterpanes are woven with two shuttles, one containing a much coarser woof than the other. The coarser of the threads is picked up, at intervals, with an iron pin, which is hooked at the point, thus forming knobs, which are made to constitute regular figures.

In cotton fabrics, the web, when taken from the loom, is covered with an irregular nap, or down, formed by the projecting ends of the fibres. This is removed, in the finest articles, by burning it off, the heat being so managed, as not to injure the texture of the cloth. The operation is performed, by drawing the web, very rapidly, over an iron cylinder which is kept constantly red hot, by a fire within it. The velocity of the cloth prevents it from burning, while the loose filaments, which constitute the nap, are singed off. The flame of coal-gas has, of late, been applied to the same purpose.

Linens.—This name belongs to fabrics, which are manufactured from flax; but those made of hemp are similar in their properties, except in fineness. The length and comparative rigidity, of the fibres of flax, present difficulties, in the way of spinning it, by the machinery which is used for cotton and wool. It cannot be prepared, by carding, as these other substances are, and the rollers are capable of drawing it but very imperfectly. The subject of spinning flax, by machinery, has attracted much attention, and the Emperor Napoleon, at one time, offered a reward of a million of francs, to the inventor of the best machine, for this purpose. Various individuals, both in this country, and in Europe, have succeeded in constructing machines, which spin coarse threads of linen, sufficiently well, and with great rapidity. But the manufacture of fine threads, such as those used for cambrics and lace, continues to be performed, by hand, upon the ancient spinning-wheel.

Linen was manufactured by the Egyptians, probably, one thousand five hundred years before Christ. Some of it was of exceeding fineness. Vast quantities, in the form of mummy-cloths, still remain.

WOOLLENS.

The fibres of wool, being contorted and elastic, are drawn out and spun, by machinery, in some respects similar to that used for cotton, but differing in various particulars. Independently of the quality of fineness, there are two sorts of wool, which afford the basis of different fabrics, the *long* wool, and the *short*. Long wool is that, in which the fibres are rendered parallel, by the process of combing. It is also known by the name of *worsted*, and is the material, of which camlets, bombazines, &c., are made. Short wool is prepared, by carding, like cotton, and is used, in different degrees of fineness, for broadcloths, flannels, and a multitude of other fabrics. This wool, when carded, is formed into small, cylindrical rolls, which are joined together, and stretched, and spun, by a *slubbing*, or roving, machine, and a jenny, or mule; in both of which, the spindles are mounted on a carriage, which passes backwards and forwards, so as to stretch the material, at the same time that it is twisted. On account of the roughness of the fibres, it is necessary to cover them with oil, or grease, to enable them to move freely upon each other, during the spinning and weaving. After the cloth is woven, the oily matter is removed, by scouring, in order to restore the roughness to the fibres, preparatory to the subsequent operation of fulling.

In articles which are made of long wool, the texture is complete, when the stuff issues from the loom. The pieces are subsequently dyed, and a gloss is communicated to them, by pressing them between heated metallic surfaces. But, in cloths made of short wool, the weaving cannot be said to have completed the texture. When the web is taken from the loom, it is too loose and open, and, consequently, requires to be submitted to another operation, called *fulling*. This is performed by a fulling-mill, in which the cloth is immersed in water, and subject-

ed to repeated compressions, by the action of large beaters, formed of wood, which repeatedly change the position of the cloth, and cause the fibres to felt, and combine more closely together. By this process, the cloth is reduced in its dimensions, and the beauty and stability of the texture are greatly improved. The tendency to become thickened, by fulling, is peculiar to wool and hair, and does not exist in the fibres of cotton, or flax. It depends on a certain roughness of these animal fibres, which permits motion, in one direction, while it retards it, in another. It thus promotes entanglements of the fibres, which serve to shorten and thicken the woven fabric. Before the cloth is sent to the fulling-mill, it is necessary to cleanse it from all the unctuous matter, which was applied, to prepare the fibres for spinning.

The nap, or downy surface, of broadcloths, is raised, by a process, which, while it improves the beauty, tends somewhat to diminish the strength, of the texture. It is produced, by carding the cloth, with a species of burrs, the fruit of the common teazle, (*Dipsacus fullonum*,) which is cultivated for the purpose. This operation extricates a part of the fibres, and lays them in a parallel direction. The nap, composed of these fibres, is then cut off, to an even surface, by the process of *shearing*. This is performed in various ways; but in one of the most common methods, a large spiral blade revolves, rapidly, in contact with another blade, while the cloth is stretched over a bed, or support, just near enough for the projecting filaments to be cut off, at a uniform length, while the main texture remains uninjured.

FELTING.

The texture of modern hats, which are made of fur and wool, depends upon the process of *felting*, which is similar to that of fulling, already described. The fibres of these substances are rough, in one direction only; a circumstance which may be perceived, by passing a hair through the figures, in opposite directions. This roughness allows the fibres to glide among each other, so that, when the mass is agitated, the anterior extremities slide

forward, in advance of the body, or posterior half of the hair, and serve to entangle, and contract, the whole mass together. The materials, commonly used for hat-making, are the furs of the beaver, seal, rabbit, and other animals, and the wool of sheep. The furs of most animals are mixed with a longer kind of thin hair, which is obliged to be first pulled out, after which, the fur is cut off, with a knife. The materials to be felted are intimately mixed together, by the operation of *bowing*, which depends on the vibrations of an elastic string; the rapid alternations of its motion being peculiarly well adapted to remove all irregular knots and adhesions, among the fibres, and to dispose them in a very light and uniform arrangement. This texture, when pressed under cloths and leather, readily unites into a mass of some firmness. This mass is dipped into a liquor, containing a little sulphuric acid; and, when intended to form a hat, it is first moulded into a large conical figure, and this is afterwards reduced in its dimensions, by working it, for several hours, with the hands. It is then formed into a flat surface, with several concentric folds, which are still further compacted, in order to make the brim, and the circular part of the crown, and forced on a block, which serves as a mould, for the cylindrical part. The nap, or outer portion of the fur, is raised with a fine wire brush, and the hat is subsequently dyed and stiffened, on the inside, with glue.

An attempt has been made, and, at one time, excited considerable expectation in England, to form woollen cloths by the process of felting, without spinning or weaving. Perfect imitations of various cloths, were produced; but they were found deficient in the firmness and durability, which belongs to woven fabrics.

PAPER-MAKING.

The combination of flexible fibres, by which paper is produced, depends on the minute subdivision of the fibres, and their subsequent cohesion. Linen and cotton rags are the common material, of which paper is made; but hemp, and some other fibrous substances, are used for the coarser kinds. These materials, after being washed,

are subjected to the action of a revolving cylinder, the surface of which is furnished with a number of sharp teeth, or cutters, which are so placed, as to act against other cutters, fixed underneath the cylinder. The rags are kept immersed in water, and continually exposed to the action of the cutters, for a number of hours, till they are minutely divided, and reduced to a thin pulp. During this process, a quantity of chloride of lime is mixed with the rags, the effect of which is to *bleach* them, by discharging the coloring matter, with which any part of them may be dyed, or otherwise impregnated. Before the discovery of this mode of bleaching, it was necessary to assort the rags, and select only those which were white, to constitute white paper. If, however, the bleaching process be carried too far, it injures the texture of the paper, by corroding and weakening the fibres.

The pulp, composed of the fibrous particles, mixed with water, is transferred to a large vat, and is ready to be made into paper. The workman is provided with a *mould*, which is a square frame, with a fine wire bottom, resembling a sieve, of the size of the intended sheet. With this mould, he dips up a portion of the thin pulp, and holds it in a horizontal direction. The water runs out through the interstices of the wires, and leaves a coating of fibrous particles, in the form of a sheet, upon the bottom of the mould. The sheets, thus formed, are subjected to pressure, first between felts, or woollen cloths, and afterwards alone. They are then *sized*, by dipping them in a thin solution of gelatin, or glue, obtained from the shreds and parings of animal skins. The use of the size is to increase the strength of the paper, and, by filling its interstices, to prevent the ink from spreading among the fibres, by capillary attraction. In *blotting* paper, the usual sizing is omitted.

The paper, after being dried, is pressed, examined, selected, and made into quires and reams. *Hot-pressed* paper is rendered glossy, by pressing it between hot plates of polished metal.

Paper is also manufactured by machinery; and one of the most ingenious methods is that invented by the

Messrs. Fourdrinier. In this arrangement, instead of moulds, the pulp is received in a continual stream, upon the surface of an endless web of brass wire, which extends round two revolving cylinders, and is kept in continual motion forwards, at the same time that it has a tremulous, or vibrating, motion. The pulp is thus made to form a long, continual sheet, which is wiped off from the wire web, by a revolving cylinder, covered with flannel, and, after being compressed between other cylinders, is finally wound into a coil, upon a reel, prepared for the purpose.

Another machine for making paper, consists of a horizontal revolving cylinder of wire web, which is immersed in the vat, to the depth of more than half its diameter. The water penetrates into this cylinder, being strained through the wire web, at the same time depositing a coat of fibrous particles on the outside of the cylinder, which constitute paper. The strained water flows off, through the hollow axis of the cylinder, and the paper is wound off, from the part of the cylinder which is above water, in the form of a continued sheet.

As a specimen of the rapidity with which paper may now be manufactured, Mr. Passey, of Birmingham, has in his possession, a document, the material of which was in a state of rags, was made into paper, dried, and printed, in the space of five minutes, in the presence of many witnesses.

Bookbinding, according to the present mode, is performed in the following manner. The sheets are first folded into a certain number of leaves, according to the form in which the book is to appear; viz., two leaves for folios, four for quartos, eight for octavos, twelve for duodecimos, &c. This is done with a slip of ivory or boxwood, called a folding-stick. In the arrangement of the sheets, the workmen are directed by catchwords or signatures, at the bottom of the pages. When the leaves are thus folded, and arranged in proper order, they are usually beaten upon a stone, with a heavy hammer, to make them solid and smooth, and are then condensed in a press, or by passing through iron rollers. After this preparation, they are sewed in a sewing-press, upon

transverse cords, or packthreads, called bands, to receive which, notches are previously sawed in the back.

The number of bands is usually six to a folio, and five for quartos, or any smaller size. The backs are now brushed over with glue, and the ends of the bands opened, and scraped with a knife, that they may be more conveniently fixed to the pasteboard sides; after which, the back is turned with a hammer, the book being fixed in a press, between boards, called backing-boards, in order to make a groove, for admitting the pasteboard sides.

When these sides are applied, holes are made in them, for drawing the bands through, the superfluous ends are cut off, and the parts are hammered smooth. The book is next pressed, for cutting, which is done by a particular machine, called the plough, to which is attached a knife. It is put into a press, called the cutting-press, betwixt two boards, one of which lies even with the press, for the knife to run upon; and the other above, for the knife to cut against. After this, the pasteboards are cut square, with a pair of iron shears; and the colors are sprinkled on the edges of the leaves, with a brush, made of hog's bristles.

The pasteboard sides are now covered, by pasting upon them leather, or whatever other material is intended to form the outside. The sprinkling, or marbling, of the covers is performed, with a brush and a coloring liquid. The covers are glazed, by applying to them the white of an egg, and rubbing them with a heated steel-polisher. A thin piece of morocco is glued upon the back, to receive the lettering, which is impressed with gold-leaf and heated types.

Cloth Binding is a recent improvement, in which a piece of cloth, usually dyed cotton, is embossed with ornamental figures, by passing it through a roller-press, between engraved steel cylinders. It is afterwards pasted upon the volume, in the same manner as leather. Cloth binding is executed with more despatch, and at less expense, than that with leather.

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