SILK.

Silk, Manufacture of. In England, where silk is not produced in quantities to be employed by the manufacturers, he must commence his operations upon the raw silk, without other preparation than that of being wound off into skeins or hanks from the balls, or cocoons, which the silk-worms form.

In this state the silk is imported from those countries where it is produced, as Italy, Flanders, Spain, Portugal, Turkey, the East Indies, and China. A thread of this raw silk, drawn from the skein, is found to be composed of an assemblage of several of the fine fibres or threads produced by the worms; the fibres being united together by a natural gum, which is in the silk, and which is soluble in the hot water in which the cocoons are immerged when the silk is wound off.

To prepare this raw silk for use, it is wound from the skeins upon bobbins; the compound thread is then twisted, to unite the constituent fibres more firmly than they can be by the gum alone; and afterwards, being wound again upon fresh bobbins, two or three threads are twisted together to produce a stronger thread, fit for the weaver, who warps and finally weaves the silk into various articles of ornaments or utility, by processes very similar to the weaving of cotton or linen, but more delicately conducted.

In the countries where the silk is produced, the manufacturer may be more properly said to commence with the operation of winding or reeling off the threads into skeins from the cocoons, or balls, in which the worms envelope themselves. These balls become an article of trade, as soon as the insect within them is killed by exposing them to heat, either of the sun, or in an oven, or by the steam of boiling water; and, in general, the breeders of silk-worms sell them, in this state, to persons who make a business of the operation of winding. In Piedmont, where capital silk is produced, it is conducted, as follows, by the aid of the silk reel represented in Plate Silk Manufacture, fig. 1.

The balls are thrown into hot water, contained in a copper basin or boiler, A, which is about eighteen inches in length and six inches deep, full in brick-work, so as to admit a small charcoal fire beneath it; or if a fire of wood is intended to be made, the fire-place must have a small flue or chimney of iron plate to carry off the smoke. At the side of the boiler a is placed the reel, which is very simple. B B marks the wood-framing which supports its parts; there are, the reel D, upon which the silk is wound; the layer e, which directs the thread upon it; and the wheel-work f g, which gives motion to the layer. The reel, D, is nothing more than a wooden spindle, turned by a handle at the end; and within the frame, at each end, it has four arms mortised into it, to support the four battens or rails on which the silk is wound. The rails are parallel to the axis, and at such a distance, that they will form a proper-sized skein by the winding of the silk upon them, (it is usually a yard for each revolution.) One of each of the four arms is made to fold into the middle of its length with hinges, so as to cause the rail, which these two arms support, to fall in or approach the centre, and thus diminish the size of the reel, and admit the skeins of silk to be taken off at the end of the reel when the winding is finished.

Upon the end of the wooden spindle of the reel, and within the frame B, is a wheel of twenty-two teeth, to give motion to another wheel, c, which has about twice the number of teeth, and is fixed upon the end of an inclined axis, c b; this, at the opposite end, carries a wheel, b, of twenty-two teeth, which gives motion to an horizontal cog-wheel of thirty-five teeth. This wheel turns upon a narrow fixed pin in the frame, and has a pin fixed in it, at a distance from the centre, to form an eccentric pin or crank, and give a backward and forward motion to the slight wooden rail or layer a, which guides the threads upon the reel: for this purpose, the threads are pulled through wire-loops or eyes, a, fixed into the layer, and the end thereof opposite the wheel and crank, b, is supported in a mortice or opening made in the frame, B, so that the revolution of the crank will cause the layer to move, and carry the threads alternately towards the right or left. There is likewise an iron bar, a, fixed over the centre of the boiler at c, and pierced with two holes, through which the threads pass to guide them.

To describe the operation of reeling, it should be understood, that if the thread of each ball or cocoon was reeled separately, it would be totally unfit for the purposes of the manufacturer; in the reeling, therefore, the ends or threads of several cocoons are joined, and reeled together out of warm water, which softens their natural gum, and makes the fibres stick together, so as to form one strong smooth thread; and as often as the thread of any single cocoon breaks or comes to an end, its place is supplied by a new one, so that by continually keeping up the same number, the united thread may be wound to any length. The single threads of the newly added cocoons are not joined by any tie, but simply laid on the compound thread, to which they will adhere by their gum; and their ends are so fine, as not to occasion the least perceptible unevenness in the place on which they are laid.

The woman who conducts the reeling is seated before the basin A, and employs a boy or girl to turn the handle of the reel: a fire is lighted beneath the basin A; and when the water becomes nearly boiling hot, the throws into the basin two or three handfuls of cocoons, and leaves them some minutes, to soften that natural gum with which the silk is impregnated; then the flits up or brushes the cocoons with a whisk of birch, or of rice-straw, about six inches long, curling out, like a worn-out broom; the loose threads of the cocoons stick to the whisk, and are drawn out: she then divides these threads from the whisk, and by drawing the ends through her fingers, cleans them from that loose silk which always surrounds the cocoon, till they come off entirely clean: this operation is called la batte; and when the threads are quite clean, she pulls four or more of them, if she intends to wind fine silk, through each of the holes in the thin iron
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iron bar $e$, which is placed horizontally over the centre of the basin $A$; afterwards it twirls the two compound threads (which consist of four cocoons each) twenty or twenty-five times round each other, that the four ends in each thread may the better join together by croffing each other, and that the thread of the silk may be round, which otherwise would be flat.

The threads, after passing through the holes in the iron bar $e$ and being twitted together, are passed through the eyes of the loops, $a$, of the layer, and thence being conducted to the reel, are made fast to one of its arms. The child who turns the reel, gives it the most rapid movement possible; and thus draws off the threads from the cocoons in the basin $A$. The flow traversing motion of the layer prevents the threads laying over each other upon the reel, until it has made so many revolutions in the air as to dry the gum of the silk so far, that the threads will not adhere together. After the reel is covered for about the breadth of three inches, by the gradual progression of the layer, it returns and directs a second course of threads over the first laid, and so on until the required length for the skeins is obtained. The machine winds two skeins at one time. As it is essential to the production of good silk, that the threads should have loft part of its heat and gumminesse before it arrives at the bars of the reel, the Piedmontese are by law obliged to have a distancie of thirty-eight French inches between the guides, $a$, and the centre of the reel, and the layer must also, under a penalty, be moved by cog-wheels instead of an endless cord, which is sometimes used in Italy, and which, if suffered to grow slack, will cause the layer to stop and not lay the threads diffusely, and that part of the skein will be glued together, whereas the cog-wheels cannot fail.

When the skeins are quite dry the reel is removed from the frame, and by the folding of two of its arms the skeins are taken off. A tie is made with some of the refuse filk on that part of each skein where it bore upon the bars of the reel, and another tie on the opposite part of the skein; after which it is doubled into a hank, and usually tied round near each extremity, when it is laid by for use or sale.

This operation appears very simple, but to produce a good thread requires much attention. The reeler must not wait until the thread of a cocoon is entirely exhausted before the joins on another, because the threads near the end have not above a quarter of their full thickness. The cocoons produce a very unequal length; some may be met with which yield 1200 ells, whilst others will scarcely afford 200 ells. In general, the production of a cocoon may be estimated from 500 to 600 ells in length. As often as the cocoons the winds are exhausted, or break, or only diminish, the joins fresh ones to keep up the requisite number, or the proportion; because, as the cocoons wind off, and the thread becomes finer, the must join two cocoons half wound to replace a new one. Thus he can wind three new ones and two half wound, and the filk will be equal to that produced from four to five cocoons. When he would join a fresh thread the must lay one end on her finger, throw it lightly on the other threads which are winding, and the gum will join it immediately, and it will continue to go up with the reel. She must not give the cocoons to the left, because they are near at an end the halfk of the worm joins in with the other threads, and makes the filk foul and gouty. The filk may be wound of any size from one cocoon to 100, but it is difficult to wind more than thirty in a thread.

The nicety of the operation, and that part in which lies the greatest difficulty, is to wind an even thread, because as the cocoon winds off the end is finer, and other cocoons must be joined on to keep up the same size. This difficulty of keeping the filk always even is so great that (excepting a thread of two cocoons, which is called fuch) they do not lay a filk of three, four, or six cocoons; but a filk of three to four, four to five, or six to seven cocoons. In a coarser filk it cannot be calculated even so nearly as to four cocoons more; they lay, for example, from 12 to 15, from 15 to 20, and so on.

During the operation of winding, the woman must always have a bowl of cold water by her, to dip her fingers in, and to sprinkle frequently upon the iron bar $e$, that the heat of the basin may not burn the threads, also to cool her fingers every time she dips them in the hot water, and to pour into the basin when necessary, that is, when the water begins to boil. The water must be just in a proper degree of heat; for when it is too hot, the thread is dead, and has no body; and when too cold, the ends which form the thread do not join well, and form a harsh filk. The heat of the water from which the cocoons are wound, caues that adhesion of the fibres which compose the filk: a thread can with difficulty be wound off when cold water is employed; but in this manner the adhesion is very flight, and the thread breaks with a flight force, or the leaf motes will separate the fibres; but the filk wound from hot water cannot be separated except by hot water.

The old cocoons require the water to be very hot: if the threads break very frequently, it may be concluded that the water is too cold; or, on the other hand, if the filk comes off entangled, and in the state of wool, the water is too hot. When the first parcel of cocoons is finished, the basin, $A$, is cleaned, taking out all the striped worms, as well as the cocoons, on which there remains a little filk: these are thrown into a basket, into which the leaf filk that comes off in making the battue is likewise put as waffe filk, to be carded and spun into threads. The water in the basin must be changed four times a day for coarse filk, and twice only for good cocoons of fine filk: if the water is not changed, the filk will not be so bright and glossy, because the worms contained in the cocoons foul it very considerably. The reeler must endeavour to wind as much as possible with clear water, for if there are too many worms in it, the filk will be covered with a kind of duft, which afterwards attracts moths, which destroys the filk.

From the gummy or viscid material which filk gives out to water when the cocoons are infused in it, Chappe found that he was able to blow up the water into bubbles, or small balloons, far more permanent than those of soap and water, and offering all the colours of the rainbow. So close, indeed, is the texture of these filky bladders, that even the most subtle gas does not penetrate them. Chappe filled many of them, the diameter of each not exceeding three inches, with hydrogen gas, and found several of them continued in a state of fulpension, in an apartment, for considerably more than twenty-four hours. It is not all filk, however, that is sufficiently glutinous for this purpose; that which is of a very deep yellow will not answer the same purpuse. This filk, from its colour, is suppos'd to be produced by the worm in a peculiar dicate, yet this is a flate by no means uncommon.

All kind of filk which is simply drawn from the cocoons by the reeling, is called raw filk, but is denominated fine or coarse according to the number of fibres of which the thread is compos'd. In general, the raw filk requires dyeing; to prepare for which the thread is very flightly twisted, to render it strong, and more able to bear the action of the hot liquor, without separating the fibres or furrying up. Silk-yarn, which is employed by the weavers for the woof or weft of the stuffs which they fabricate, is compos'd of
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two or more threads of the raw filk, slightly twirled in a machine; and the thread employed by the rocking weaver is of the same quality, but composed of a greater number of threads, according to the thicknes of thread desired. Organize filk is composed of two, three, or four threads of raw filk twirled, and so combined as to obtain the greatest strength: for this purpose, each thread of raw filk is twirled separately upon itself by a mill: the twirt is given in a right-handed direction, and extremely tight. By a second operation of twirling, two of these threads are combined together, the twist being given in a contrary direction, and not above half as tight: this forms a thread similar to a rope. This description of filk, used for the warp of stuffs, is of the utmost importance to the manufacturer, for none of the principal articles can be fabricated without it. The Italians, from whom we formerly imported the filk in the state of organize filk, for a long time kept the art of throwing it a profound secret. It was introduced into this country by the enterprise and skill of Messrs. Thomas and John Lombe, the latter having, at the risk of his life, and with wonderful ingenuity, taken a plan of one of these machines in the kingdom of Sardinia's dominions, from which, on his return, he established a similar set of mills in the town of Derby. (See Derby.) In consideration of the great hazard and expense attending the undertaking, a patent was granted to Sir Thomas Lombe in 1718, for securing to him the privilege of working organize filk for the term of fourteen years; but the construction of buildings and engines, and the instruction of the workmen, took up so much time, that the fourteen years were nearly expired before he could derive any advantage from it; in consequence of which, he petitioned parliament, in 1731, to grant him a further term: but parliament, considering it an object of national importance, granted him the sum of £4,000. on condition that he should allow a perfect model of the machinery to be taken, and deposited in the Tower of London for public inspection. Similar mills were, in course of time, erected in different parts of the country; but owing to the difficulties that were experienced in procuring raw Italian filk of the proper size for organize filk (the exportation of which was prohibited by the Italians), and to the mills having subsequently found employment for other purposes, the quantities worked into organize filk, for many years, bore scarcely any proportion to the imports from Italy; it has however been since revived and improved, in consequence of which it is now carried on to a very considerable extent, as well in other parts of England as at Derby.

The processes which the filk undergoes to bring it into this state it can go to the other machines. The winding-frame is shewn at fig. 2. of the plate, or rather a part of it, which will wind fix threads at once, and by increasing the length it may be made to receive any number. Each of the skeins is extended upon a stick called a swift; it is composed of four small rods, fixed into an axis, and small bands of string are stretched between the arms to receive the skein, but at the same time the bands admit of falling to a greater or less distance from the centre, so as to increase the effective diameter of the reel, according to the size of the skein, because the skeins, which come from different countries, vary in size, being generally an exact yard, or other similar measure, of the country where the filks are produced. The swifts are supported upon wire pivots, upon which they turn freely when the swift is drawn off from them; but in order to cause the thread to draw with a gentle force, a looped piece of string, or wire, is hung upon the axis within the reel, and a small leaden weight, being attached to it, will cause a sufficient friction. B, B, are the bobbins which draw off the threads; they are received in the frame, and are turned by means of a wheel beneath each, the bobbin having a flat rolling surface by which bears its weight upon the circumference of the wheel, and the bobbin is thereby put in motion to draw off the filk from the swift. D is the layer, a small light rod of wood, which has a wire-eye fixed into it, opposite to each bobbin, so as to conduct the thread thereupon; and as the layer moves concentrically backwards and forwards, the thread is regularly spread upon the length of the bobbin. The motion of the layer is produced by a crank fixed upon the end of a cross-spindle, E, which is turned by means of a pair of bevelled wheels from the end of the horizontal axle, upon which the wheels for turning all the bobbins are fixed.

These winding-machines are usually situated in the top building of the mill, the frames being made of great length, and also double, to contain a row of bobbins and swifts at the back as well as in front. Two of these double frames are put in motion by cog-wheels from the vertical shaft, F, which ascends from the lower apartments of the mill, where the twirling-machines are placed. The winding-machines require a constant attendance of children to mend the ends or threads which are broken; or when they are exhausted, they replace them by putting new skeins upon the swifts. When the bobbins are filled they are taken away, by only lifting them up out of their frame, and fresh ones are put in their places.

A patent has been lately taken out by Messrs. Gent and Clarke, for a new construction of the swifts for winding-machines: they are made with fix single arms instead of four double ones; and the arms are small flat tubes, made to contain the items of wire forks, which receive the skein instead of the bands of string in the common swifts. These forks admit of drawing out from the tubes until the swift is sufficiently enlarged to extend it; but as they extend the skein at fix points instead of four, as in the common one, the motion is more regular. Instead of the weight which causes the friction, a spring is used to press upon the end pivot of the axis, and make the requisite resistance.

The twirling of the filk is always performed by a spindle and bobbin, with a flyer, but the construction of the machine which puts the spindle in motion is frequently varied. The limits of our plate do not admit a representation of the great machines, or throwing-mills, such as are used at Derby, and at almost all the other great filk-mills in England. In fig. 3. we have given a drawing of a small machine, which is similar in the parts which act upon the filk; and indeed many mills employ such machines constructed on a large scale,
The one in our plate contains only thirteen spindles, and is intended to be turned by hand, a method which is too expensive for this country, but is common in the south of France, where many artisans purchase their silk in the raw state, and employ their wives or children to prepare it by these machines, which they call ovals, because the spindles $b$, $b$, are arranged in an oval frame $G H$. $B$ is the handle by which the motion is given; it is fixed on the end of the spindle $R$, which carries a wheel, $D$, to give motion to a pinion upon the upper end of a vertical axle $E$: this, at the lower end, has a drum or wheel $F$, to receive an endless f strawberries or band, $a a$, which encompasses the oval frame $G$, and gives motion to all the spindles at once. The spindles $b$, $b$, are placed perpendicularly in the frame $G H$, their points retic in small holes in pieces of glass, which are let into the oval plate $G$; and the spindles are also received in collars affixed to an oval frame $H$, which is supported from the plank, $G$, by blocks of wood $d$ and $e$ are small rollers, supported in the frame $G H$, in a similar manner to the spindles; their use is to confine the strawberries, $a$, to prevent against the rollers of the spindles with sufficient force to keep them all in motion.

The thread is taken up as fast as it is twirled by a reel, $K$, which is turned by a wheel, $b$, and a pinion $i$, upon the end of the principal spindle, $R$. The threads are guided by passing through wire-eyes, fixed in an oval frame, $L$, which is supported in the frame of the machine by a single bar or rail, $l l$, and this has a regular traversing motion backwards and forwards, by means of a crank, or excentric pin, $i$, fixed in a small cog-wheel, which is turned by a pinion upon the vertical axis $E$; the opposite end of the rail, $l$, is supported upon a roller, to make it move easily. By this means the guides are in constant motion, and lay the threads regularly upon the reel $K$, when it turns round, and gathers up the silk upon it, as shown in the figure.

One of the spindles is shown at $r$ without a bobbin, but all the others are represented as being mounted and in action. A bobbin, $e$, is fitted upon each spindle, by the hole through it being adapted to the conical form of the spindle, but in such manner, that the bobbin is at liberty to turn freely round upon the spindle; a piece of hard wood is stuck fast upon each spindle, just above the bobbin, and has a small pin emerging into a hole in the top of the spindle, so as to oblige it to revolve with the spindle; this piece of wood has the wire-flyer, $b$, fixed to it: the flyer is formed into eyes at the two extremities; one is turned down, so as to stand opposite the middle of the bobbin $e$; and the other arm, $b$, is bent upwards, so that the eye is exactly over the centre of the spindle, and at a height of some inches above the top of the spindle. The thread from the bobbin, $e$, is passed through both the eyes of this wire, and must evidently receive a twist when the spindle is turned; and at the same time, by drawing up the thread through the upper eye, $b$, of the flyer, it will turn the bobbin round and unwind therefrom. The rate at which the thread is drawn off from the bobbin, compared with the number of revolutions which the flyers make in the same time, determines the twist to be hard or soft; and this circumstance is regulated by the proportion of the wheel, $b$, to the pinion $i$, from which it receives motion; and when it is required to spin different kinds of silk. The operation of the machine is very simple; the bobbins filled with silk in the winding-machine, fig. 1, are put loose upon the spindles at $e$, and the flyers are stuck fast upon the top of the spindles; the threads are conducted through the eyes of the flyers $b$, and of the layers $L$, and are then made fast to the reel $K$, upon which it will be seen that there are double the number of skeins to that of the spindles represented, because one half of the number of the spindles is on the opposite side of the oval frame, so that they are hidden. With this preparation the machine is put in motion, and continues to spin the threads by the motion of the flyers, and to draw them off gradually from the bobbins, until the skeins upon the reel are made up to the requisite lengths. This is known by a train of wheel-work at $a a$, confining of a pinion, $i$, fixed upon the principal spindle $K$, turning a wheel $o$, which has a pinion fixed to it, and turning a larger wheel $p$; this has another wheel upon its spindle, with a pin fixed in it, which at every revolution raises a hammer, and strikes upon a bell, $s$, to inform the attendant that the skeins are made up to a proper length. When this machine is employed for the first operation of twirling the organzine, the wheel, $b$, must be larger, and the pinion, $i$, smaller than represented, in order that the reel, $K$, may be turned slowly, and the threads will therefore receive a stronger and closer twist. Also, the handle $B$ is turned in an opposite direction to that in which it must move for the final throwing off the two or three twisted threads together; and as it must also move for twisting the raw threads together for the warp of silk-stuffs, and for weaving flockings, this reverser movement makes no alteration in the machine, except that it will give twist in a contrary direction; for it is always necessary, when two or more twisted threads are combined by twisting, that the twist of the original threads shall be in the opposite direction to that twist which unites them into one thread, in the same manner as for making ropes, organzine silk being in fact small rope, and flocking-silk or warp being only yarn. The silk which is intended to be dyed, is previously twisted very slightly in this machine, and of course in that direction which will suit the purpose for which it is ultimately intended; viz. whether for yarn or organzine.

The great mills for twisting silk, originally introduced by Messrs. Lombe, though very complicated, are simple in their operation, because the complexity arises from the great number of spindles which are actuated by the same movement, every one of which produces its effect independent of the others, and in the same manner as the oval which we have described. A machine is contained in a circular frame, of which the diameter varies from 4 to 5, 15, and even 17 feet; but 15 feet is the general size of the original Piedmontese machines. In the centre of the frame is a perpendicularly axis or spindle, coming up through the floor of the chamber, and rising to the ceiling; it is put in motion by a communication of wheel-work from a water-wheel, or otherwise from a horse-wheel. The axis has upon it two, three, or four horizontal wheels, according to the height of the machine, which revolve with it, and are of a sufficient size to fill nearly all the interior of the circular frame, and act upon the pulleys or rollers of the spindles, which are supported vertically in the frame, and arranged round the machine, at equal distances, in a circle, the number being proportioned to the dimensions of the machine. The spindles are also arranged in as many different stages of height as there are wheels upon the vertical spindle; for the circumference of each wheel precludes against the rollers of the spindles which are arranged round it; and thus, when the wheel revolves, it gives a very rapid motion to all the spindles at once, by the contact of the edge of the wheel, but without any twist, in the oval. Each spindle has a bobbin, filled with silk, fitted upon the top of it, and from this the silk is carried up to a horizontal reel, which is turned round slowly by the machine, and draws off the thread gradually from the bobbin: the flyer, being all the while in rapid motion, twirls the thread upon itself, or, if two or three threads are previously wound together upon the bobbin, they will be twisted
twisted round each other. Each reel serves to take up the thread from several spindles which are situated beneath it; thus, in a mill of fifteen feet diameter, there will be six spindles beneath each reel.

To explain this machine more clearly, we will give a description of one of thirteen feet diameter, which has four large wheels and flanges of spindles, two of which are for giving the first preparation to the organzine, the spindles revolve in a direction from right to left. The spindles of the other two flanges are for the finishing the twist; and also for twisting the single threads which are to be used for Warwick or flossing-weaving: they revolve in a contrary direction to the former. The frame of the machine consists of two wooden circles of thirteen feet diameter, one placed upon the floor of the mill, and the other at a height of fifteen feet above, the two being united by fourteen upright pillars of wood, which altogether compose a large cylindrical frame or lantern. Each flange contains eighty-four iron spindles, placed vertically, and supported in the flange, which is formed of two wooden circles, extended round between the fourteen uprights of the lantern, and fixed one above the other, at a distance of four inches apart, so as to support the spindles between them, in the same manner as the pieces, G, H, of the oval last described.

The circles of the flange are of a rather less diameter than the two circles which compose the top and bottom of the lantern; so that the spindles will be rather within the circle of the frame of the lantern, and admit the wheels of the central axis to act upon them. For this purpose, each of the circles of the flange is made up by fourteen segments fixed between the uprights, and each segment supports six spindles, making up the number of eighty-four in the whole circle. The spindles, like those of the oval, are sharpened at the lower end, and the points rest in small holes made in pieces of glafs, which are let into the lower circle of the flange, whilst the upper circle fulfills the spindles at a height of four or five inches above the point, leaving full one-third of the length of the spindle projecting above, for the purpose of fitting the bobbin upon it. The upper circle of the flange is rather smaller than the lower, because the spindles do not pass through it, but through holes in small pieces of hard wood, which project from it, so as to be exactly above the pieces of glafs which fulfills the positions in a direction from right to left. Each spindle has a small roller fixed upon it in the space between the two circles of the flange, and it is the contact of the rim of the great wheel upon that which causes the revolution of the spindles when the wheel revolves. In order to make the contact certain, the exterior rim of the great wheel is made in several segments, and each segment has a constant tendency to recede from the central axis by the action of a weight, and thus press against the rollers of the spindles. In order to give the reverse movement of the spindles, which we have before spoken of in the description of the oval, the great wheels for two of the flanges are made differently from those which we have just described, so that the segments of the rim will act upon the outsides of the rollers of the spindles, instead of the insides: for this purpose the wheels are made larger than the flanges in which the spindles are placed, and from the rim of the wheel small pillars rise up to support the segments, which act upon the rolls of the spindles in front or without the insides, instead of the inside, as is the case with the other flanges, in consequence of which the spindles of these flanges turn in opposite directions. The reels are placed over the bobbins, to take up the threads when twisted; and the rollers of the different spindles are made smaller or larger, as is required, to give more or less twist to the filk operated upon by them; for the velocity with which the spindles revolve, compared with the rate at which the reels take up the thread, determines the degree of twist which the thread will have; and to render this equal, the reels which draw off the filk from the bobbins of the spindles are turned regularly with the motion of the machine by means of wheel-work, which is more easily conceived than described: it is sufficient to state that it receives its motion from the central vertical axis. There is also a layer adapted to each reel, with a wire-eye to receive each thread, and the layers having a slow reciprocating motion, distribute the threads regularly upon the reels, in a similar manner to that first described for the oval. One of these reels is placed between each of the uprights of the machine, so as to make fourteen reels in the whole circle of each flange, and every reel serves to take the filk from the bobbins of six spindles. The whole machine in the four flanges contains 536 spindles.

A machine of four flanges is so high, as to reach through two floors of the mill, and for this purpose the upper floor is made with a large round opening, to admit the machine: this floor serves the people who attend the machine, and change the bobbins when exhausted, and also remove the finished filk from the reels.

The spindles in the upper flanges are usually devoted to the first twirling of the single threads for the organzine, and therefore turn the reverse way, as before mentioned; and as the filk is afterwards to be thrown, or re-twirled, they are drawn off from the bobbins by large bobbins of three inches diameter, and four inches long, instead of the reels. These bobbins are fluck fiex together upon a long spindle, situated horizontally, and turned by similar wheel work, to that which actuated the reels; they have similar layers to conduct the filk regularly upon the bobbins from one end to the other, so that the operation is not at all different.

In many of the best silk-mills, they have abandoned the original method of turning the spindles, for the preparation of organzine, the reverse way, by making the action of the wheels upon the outside, instead of the inside, of the circle of spindles. Instead of them they employ two different machines, one for the first operation on organzine, and the other for the second operation, both of them constructed with the wheels within: but the motion of the two machines is reversed to each other.

Fig. 5, represents a single spindle of a throwing machine, which, though the same in its action as the great mill, is different in its construction. G and H represent portions of the rails or circles of the flange which support the spindle, and a a is a part of the rim of the great wheel of the central axle. This wheel is not made in segments, as before described, but made very truly circular, and covered with leather on the edge, so that it may act with more force to turn the roller, t, of the spindle. The point of the spindle rests in a glafs cap, supported by the rail G, and the roller, t, is always made to press against the rim of the great wheel, a a, by a small lever, d, and a spring, which, after turning over a pulley, has the weight, e, made fast to it, so press the spindle always towards the wheel. In this machine, instead of the reel, the thread is taken up by a bobbin, K, is put into a frame, m, which moves on pivots, and by a weight, n, is pressed down so as to make the bobbin bear upon the edge of a wheel, b, which is kept in constant and regular motion, by the same kind of movement which turns the reels of the great machine. The intention of this is, that the action of the wheel, b, to turn the bobbin, being communicated by preffure against the part upon which the silk is to wind, will be con-
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faint, and will not draw more when the bobbin is large and full, or less when it is empty, as must be the case when the motion is given to the axis of the bobbin.

After the silk is twisted in a right-hand direction, if it is intended for yarn, or for dyeing; or in a left-hand direction, if it is prepared for organizing; it must be wound on fresh bobbins, with two or three threads together, preparatory to twitting them into one thread. In the original machines at Derby this was done by women, who, with hand-wheels, wound the threads from two or three of the large bobbins, upon which the silk is gathered instead of the reels, and assembled them two or three together upon another bobbin, of a proper size to be returned to the twisting mill. We have seen an attempt for a machine to perform the doubling, which is slightly represented in fig. 4. The whole machine itself is very similar to the winding-machine, fig. 2, but instead of the twist, the bobbins from the twitting-mill are placed in front at A, fig. 4, two or three in rows, the threads from these being passed over the rail m, and beneath a piece of wood, n, both which, being covered with cloth, have the same effect to clean the silk by drawing through them, as the fingers of the winder. B is the bobbin upon which the two or three threads are to be wound together; it is turned by a wheel, F, upon which it revolves, the fame as the bobbins of the winding-machine; and D is the layer, which, for convenience, is in this cafe placed behind the bobbin, B; and the wire-eye, d, which receives the three threads, is made to reach over the front. The additional apparatus consists of a small piece of wood, e, which slides freely up and down, in a hole through a fixed board, f. On the top of the slider, e, is an eye of wire, through which one of the single threads of silk passes in its passage from between the pieces m, n, to the bobbin B; there is one of these slides, e, to each of the three threads; t is a lever moving on the centre w; the end t is immediately beneath the small sliders, e, and the end v is formed to a hook, to catch into the notches which are made in the end of the bobbin B. A small counter weight, s, always cauls the hook, v, of this lever to recede from the bobbin; but if any one of the three threads breaks, it suffers the slider, e, which belongs to it, to descend upon the end, i, of the lever, and depresses the end of the lever, so as to bring the hook, v, in a situation to catch a tooth of the bobbin B, and stop its motion. By this means the winding of the threads from all these bobbins together is rendered absolutely certain with the winding of one; for when any one breaks, the operation of winding on that bobbin stops, until the attendant repairs the broken thread, and puts the machine again in motion. We have lately been informed, that a machine for winding two and three threads together is becoming common in the silk-mills, but we do not know if it is the same with this one, which however is not evidently impracticable.

There is a variety of these thus filled with double or triple threads, are carried back to the throwing machine, and are there spun or twisted together, the manner of doing which does not differ from the operation which we have before described. In this second operation the silk is taken up by reels instead of bobbins, and is thus made up into skeins. The degree of twist varies with the purpose for which the silk is intended; and the wheels which give motion to the reels are for this purpose adapted to the degree of twist which the silk is desired to have. The silk, being now spun, requires only the preparation of boiling to discharge the gum, and render the silk fit to receive the dye, and also to render it soft and glossy. The silk is boiled for about four hours, in a boiler filled with water, into which a small quantity of soap is put; this operation dissolves the gum, which before could be felt upon the silk, and rendered it harsh. After the boiling, it is well washed in a current of clear water, and when dried, will be found to have lost about one-fourth of its weight; at the same time the volume of the silk is sensibly increased, and it has acquired that soft texture and glossiness, which are the principal beauties of silk. This change is produced by the diffusion of the gum, which, in the first instance, was the only adherence of the fibre to form a thread, but by the operation of the twisting the fibres are firmly united, and no longer require the gum. It is also necessary, in order to give a fine dye to the silk, that the gum should be removed, because it would prevent the entrance of the dyeing matter to the centre of the thread, and thus impair the beauty of the colour. If the silk was thus boiled before the twitting, nothing but a fine entangled down or wool would be obtained, and it would require spinning, by a similar process to that of cotton, before a thread could be obtained. This, indeed, is the case for that portion of waffle silk which is drawn from the cocoons in the first operation of reeling; also for those cocoons which are reserved for breeding, and from which the moths eat their way out by holes, which render it impracticable to wind off the silk. This waffle silk, when carefully spun by a spinning-wheel, is called spun silk, and the thread is not inferior to the regular silk which is wound off; indeed, the winding off the silk into a thread united by its gum, is of no advantage farther than as a preparation for spinning, from which proceeds the thread obtains its strength.

The silk is now in a state for use: if it is for flocking, weaving, or fowling, or if intended for weaving into stuff, it only requires warping to be put into the loom. The operation of warping is to put together all the threads which are to compose the warp of the intended piece of stuff, and lay them parallel, so that the warp, being put into the loom, will have no slack threads, nor any which are strained too tight. Formerly, this operation was performed by stretching the threads out at length in a field, or by extending them in a frame, and winding them backwards and forwards over pegs. The warping machine now universally employed is shown in fig. 6, where AA is a trestle or floor, which supports the small bobbins b, b, upon which the silk is wound. The number of these is equal to the number of threads which the warp of the intended piece of stuff is to have in its breadth. The threads which are from in front of the bobbins, and are then all brought together, and passed through an opening in a piece of wood D; this conducts the threads all together upon a large reel E, which is supported in a frame F, F, and turned round by means of a pulley at the lower end of its axle, from which an endless band is continued to a second wheel G, mounted on a spindle, and turned by a handle. This latter spindle is supported in a fork of rood H, upon which a child is needed, and at the same time turns the handle and puts the reel in motion, so as to draw the warp or assemblage of threads off from the several bobbins, and lay it upon the reel E. The piece of wood D is fitted upon one of the upright pieces, F, of the frame, to slide freely up and down upon it, and is supplied by a cord, which, after passing over a pulley j, is wrapped round the spindle of the machine at e; by means of this, the motion of the reel, E, draws the cord, and raises up the piece D, as to lay the warp upon the circumference of the reel, in a regular spiral, from one end to the other, and prevent the coils lapping one upon another. When the required length of warp is wound upon the reel, the ends of all the threads are cut off, tied together, and thus drawn off from the reel and rolled up into a large ball,
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in which state the weaver takes it, and mounts it in his loom.

For the subsequent operations of weaving we shall refer to the article Weaving, because the weaving of silk goods is the same as for any other, except that finer and more beautiful articles are produced in this fabric than in any other. Some information on the details of weaving mechanism will be found under our articles Draught of Looms, Draw-Loom, Diaper, Dimity, and Dornock; and though these are rather the weaving of linen and cotton than silk, the same principles apply to silk, as will be more fully explained under Weaving; where a description of weaving ribbons and figured silks will be given.

Silk is distinguished by different names according to its different states. Thus,

Silk, Span is that taken from the ball, without fire, and spun into thread without any coating; such as is molt, if not all, that is brought into England from the Levant; i.e. from Persia by the way of Turkey, from Bengal in India, and from China. The raw spun silk is commonly worked up into two forts, called organiz and tram; the former is made by giving a throw or twist to each thread of raw spun silk filigree, and then doubling over these twisted threads together, and winding them firmly together; this forms the warp or length of a piece when manufactured. The tram, or float, which makes the breadth of the piece, is formed by twisting two or more threads of raw silk flax. The waste raw silk, or refuse in reeling, &c. is collected, carded, and spun, and called fiesilk; this is doubled and thrown, and often made into a cheap sort of silk-rocking, which are very strong and durable.

In the French silk-works, the greatest part of this raw silk passes for little better than a kind of fine fiorette; yet, when spun, it makes a bright thread, and serves for the manufacture of stuffs of moderate value and lustre. But the spun silks of the Levant, which most of our com is, are exceedingly fine and beautiful. The difference arises hence, that in France, the best balls are reeled off in boiling water, and only the refuse made into spun silk; whereas, in the Levant, there is no such thing as reeling or winding on the fire, but the filks are all fent in bales, or packs, as they are drawn from off the balls; so that they are only distinguished by their quality of fine, middling, and coarse.

Silk, Boiled, is that which has been boiled in water, to facilitate the spinning and winding. This is the finest of all the forts of silk manufactured in France, and is seldom used but in the richest stuffs; as velvets, taffeties, damaskes, brocades, &c.

There is also another kind of boiled silk, which is prepared by boiling, to be milled; and which cannot receive that preparation, without being first passed through hot water. By the laws of France, it has been prohibited to mix raw with boiled silk; both as such a practice spoils the dyeing, and as the raw silk corrupts and cuts the boiled.

Silks, threaded or twizzed, are such as, besides their spinning and winding, have received their milling or throwing.

This they receive in a different degree, as they are passed oftener or colder than over the mill; properly, however, threaded silks are those in which the threads are really thick-throved, and twizzed several times.

The thrown silk comes to us chiefly from Leghorn, Genoa, Naples, and Messina.

Silks, Black, are such as are not twizzed, but are prepared, and dyed for tapestry, and other works with the needle.

Silk, Eastern or East Indian. That popularly thus called is not twizzed of the filk-worm, but comes from a plant that produces it, in pods, much like those of the cotton-tree. The matter this pod contains is extremely white, fine, and moderately glossy; it spins easily, and is made into a kind of silk, that enters the manufacture of several Indian and Chinese stuffs.

Silks, French. It is only in the most southern provinces of France that silk is cultivated, mulberry-trees planted, and worms bred. The principal places are Languedoc, Dauphiné, Provence, Avignon, Savoy, and Lyons. This last place, indeed, furnishes very few silks of its own growth; but it is the great staple whence the merchants of Paris, and the other cities, are to fetch them. At least, they are obliged to have them pass through Lyons, if they bring them from other places, either by land or sea. There have been computed to enter Lyons, committus annis, fix thousand bales; the bale valued at one hundred and sixty pounds weight; of which fix thousand bales, there are one thousand four hundred from the Levant, one thousand fix hundred from Sicily, one thousand five hundred from Italy, three hundred from Spain, and one thousand two hundred from Languedoc, Provence, and Dauphiné.

At the time when the manufactures of Lyons were in their prosperity, there were reckoned to be eighteen thousand looms employed in the silk manufacture; but in 1508, there were not reckoned four thousand. However, this manufacture afterwards revived, and a great part of Europe has been supplied from hence with brocade and rich silks. The decay has not been less notable at Tours; they had formerly there eight hundred mills for winding and preparing the silks; eight thousand looms to weave them; and forty thousand perfons employed in the preparation and manufacturing of them; but these have been reduced to seventy mills, twelve hundred looms, and about four thousand perfons. The revolution has, however, made such an alteration in the manufactures and trade of France, and they are still (1816) in so unfettled a state, that no correct estimate of them can be obtained.

Silks, Sicilian. The commerce of the silks of Sicily has been very considerable; and the Florentines, Genoese, and Lucceze, are the people who have chiefly availed themselves of it. Great quantities were yearly brought thence, especially from Messina; part of which they used in their own manufactures, and sold the rest to their neighbours the French, &c. with profit. The Italians had this advantage, especially the Genoese, over other people, that, having large establishments in the island, they were reputed as natives, and paid no duty for the export.

Part of the Sicilian silks is raw, the rest are spun and milled; of which last kind, those of St. Lucia and Messina are the most valued. The raw unwrought silks were always sold for ready money; the others, sometimes, in exchange for other goods. See Sicily.

Silks, Spanish, are all raw; and are spun, milled, &c. in England, according to the several works in which they are to be used.

Silks, Turkish, are all raw. One advantage we have in the commerce of the Levant, in silks, is owing in those of Sicily, is, that the latter are confined to a particular season of the year; whereas the former are bought at all times. They
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They are brought from Aleppo, Tripoli, Sayda, and from the isle of Cyprus, Candia, &c. But the principal place of commerce, especially for the filks of Persia, is Smyrna. The filks are brought either in caravans, from the month of January to September. The caravans from January are loaded with the finest filks; those of February and March being indifferent ones; the rest, the coarsest. They all come from several provinces of Persia, chiefly those of Ghilan and Shirvan, and the city of Schamachia, sittuate near the edge of the Caipian sea; from which three places, a Dutch author affirms us, there have not come less than thirty thousand bales of silk in a year. Ghilan produces the belt and greatest quantities of filk; next to this are Shirvan and Erivan, then Mazanderan, and lastly Attrabad; but the latter is much inferior, serving only for a manufacture mixed with cotton; that of Mazanderan and Attarabad is seldom or ever exported.

Ardeuil, or Ardabil, is another city of Persia, not far distant from these silk countries, is the place where the silk are laid up, and whence the caravans set out for Smyrna, Aleppo, Scanderban, and Constantinople; and it is this city, with Schamachia, that have always been esteemed the centre of the filk trade; which has been several times attempted to be removed from Smyrna, and the Mediterranean, in favour of Archangel, and the White sea, by carrying them across Mulcovy, by the Volga and Dwina, two rivers that traverse the principal provinces of that vast empire.

This new course of the Perisan filks into Europe was first proposed by Paolo Centurio, a Genoese, to the tsar Basil, under the posticat of Leo X. The French had the same design in 1628. The duke of Holstein, in 1633, sent ambassadors to the court of Persia, purely with the same view. And in 1668, the tsar Alexis Michael attempted the thing himself; but he was disappointed by the rebellion of the Cossacks, and the surplice of Astrakhan.

In 1688, the commerce of Perisan filks had nearly been removed from Smyrna by an earthquake, which almost overturned the whole city; and, doubtfull, the removal had been effected, but for the vigorous means used by the Turks to prevent it. Smyrna, however, still remains in its ancient possession; and the several nations of Europe continue every year to send their fleets, to fetch away the filks.

SILKS, China, Japan, and Indian. Several provinces of China are fo fertile in mulberry-trees, and their climate is so agreeable to the nature of filk-worms, that the quantity of filks there produced is incredible; the Angi province of Tcheching might suply all China, and even a great part of Europe, with this commodity. The filks of this province are the most esteemed, though those of Nankin and China be excellent.

The filk-trade is the principal in China, and that which employs the most hands; but the European merchants who deal in it, especially in wrought filks, are to be careful of the spinning, &c., the work being usually very great, as the French East India company have found to their cost.

Japan would not afford fewer filks than China; but that the Japanese, a barbarous and disfrutiful people, have interfered all commerce with strangers, especially with Europeans, excepting with the Dutch; who are laid to be admitted on certain impious terms, related by Tavernier, but which, we must own, we cannot credit. The Dutch have endeavoured to vindicate themselves from these by the pens of several famous writers.

Great quantities of both raw and wrought filks are furnished by other parts of Bengal, and by several provinces of Hindoostan, which partly supply the natives, and afford a very considerable exportation to Europe. Several thousand bales of raw filk are annually imported from Bengal and China; some of which is, in this state, used for making Camels' fluffs, but the greater part is prepared for the manufacturers by the filk-throwers.

SILK, Laws relating to. The duties on filks and callicoes being under the same regulations with those on printed linens, the laws respecting them is inferred under the article LINEN. By the 13 & 14 Car. II. c. 15. f. 2. no person shall exercise the trade of a filk-thrower, unless he hath served seven years' apprenticeship, on pain of 400. a month, half to the king, and half to him that shall sue in any court of record, or as the aifizes, or quarter-judicats of the peace. By the 9 & 10 W. c. 43. no foreign filks, called alamodes or lutefirings, shall be imported but in the port of London, on notice first given to the commissioners of the customs, and licence had from them, on pain of forfeiture, or the value; and they shall be folded, and exported again; and the offender for importing, and also the receiver and person offering to sell the same, shall forfeit 500l. Being marked and sealed by order of the commissioners, any persons who shall counterfeit the custum-bonheur seal, or that of the lutefirring company, shall forfeit 500l., and be set in the pillory for two hours. And any person who shall buy and sell, and have in his custody, any alamodes or lutefirings, sealed or marked with a counterfeit seal or mark, shall forfeit the same and 100l. However, none but custum-bonheur officers, or persons deputed by the lutefirring company, and having written of affiliation under the seal of the exchequer, shall feixe lutefirings or alamodes within the bills of mortality. (5 Ann. c. 20.) The penalties shall be two-thirds to the king, and one-third to him that shall seize or sue in any court of record.

By 3 Geo. III. c. 21. and 5 Geo. III. c. 48, if any person shall import any ribbons, laces, or girdles, not made in Great Britain, whether the same shall be wrought of silk alone, or mixed with other materials, the same shall be forfeited, and may be seized by any officer of the customs, in whatever importers', venders', or retailers' hands they may be found; and the importer, and every person afflating therein, and the venders and retailers in whole custody they shall be found, or who shall sell or expose the same to sale, or concealing with intent to prevent the forfeiture, shall forfeit respectively 200l., with costs. Half the said penalties to be to the king, and half to the officer who shall inform and prosecute.

But if any officer of the customs shall neglect or refuse, for one month after condemnation, to prosecute to effect any person for any of the said pecuniary forfeitures, any other person may sue for and recover the same; half thereof to go to the king in like manner, and half to him who shall sue.

And when the goods feized (being out of the limits of the bills of mortality) shall not exceed the value of 20s., two justices, on information before them that such goods were feized, as unduly imported, may hear and determine the same, and proceed to condemnation or discharge.

After feizing, until condemnation or discharge, the said goods shall be deposited in one of the king's warehouses, if the feize be within the bills of mortality; elsewhere, in the hands of the chief magistrate or constable, and the said goods shall be free to inspection, with leave of the court, judge, or justices, before whom the prosecution shall be.

And after condemnation, the said goods shall be publickly sold by the candle for exportation; half of the produce by
such sale to be to the king, and half to the officer who shall seize and secure the same; and the same goods shall not be delivered out of the warehouse, till security shall be given for exportation, and that the same shall not be landed again in any part of his majesty’s dominions.

By 5 Geo. III. c. 48, if any foreign manufactured silk-stockings, silk-mitts, or silk-gloves, shall be imported into this kingdom, or any part of the British dominions, the same shall be forfeited, and liable to be searched for and seized as other uncustomed goods; and every person who shall import the same, or be assisting therein, and the vendors and retailers in whose custody they shall be found, or who shall sell or expose the same to sale, or conceal with intent to prevent the forfeiture, shall, over and above the forfeiture of the goods, forfeit 200l., with costs; half to the king, and half to the officer who shall inform and prosecute.

And when the goods seized (being out of the limits of the bills of mortality) shall not exceed the value of 20l., two justices may proceed to the condemnation thereof. And the proceedings, in all other respects, shall be in like manner as in the case of ribbands and laces above mentioned.