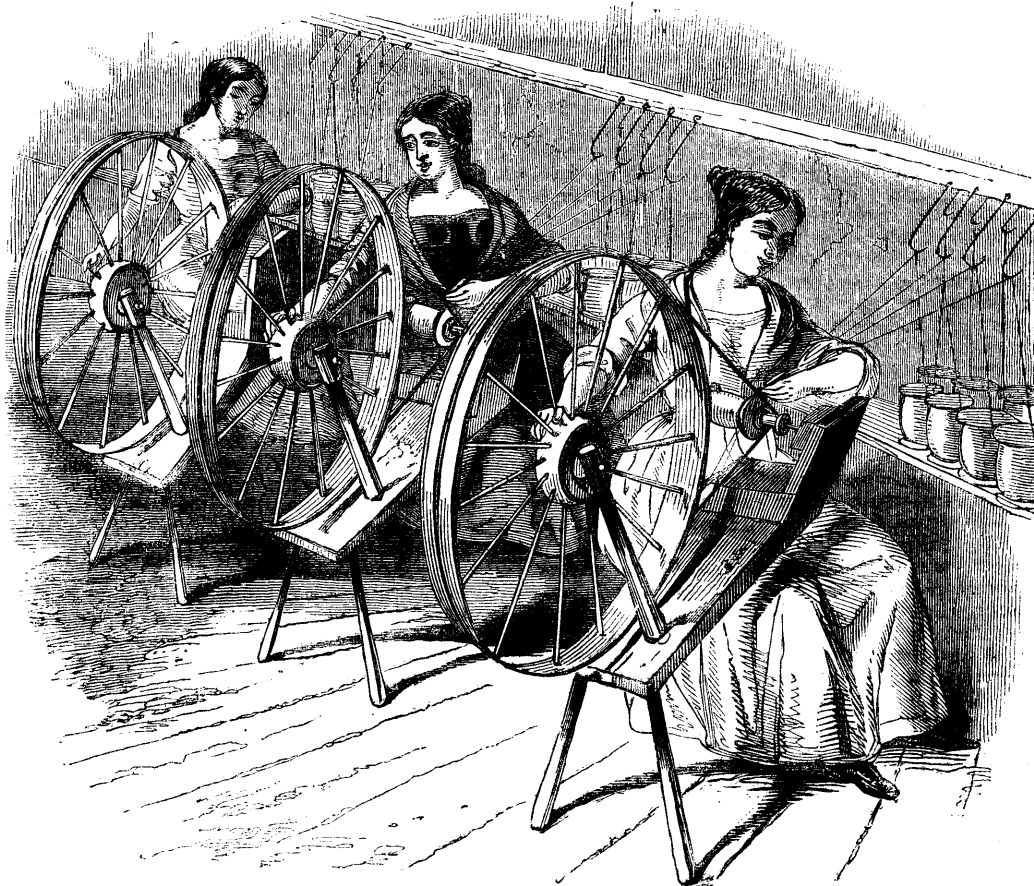


A DAY AT A DERBY SILK-MILL.



[Silk-doublers at work.]

MANUFACTURING industry, as well as polite literature, has its classical spots. The birthplace or the residence of a great inventor, the first factory in any particular department, or the place where the first practical application of a new invention was made, has, in a busy and commercial country like England, a sort of halo around it: it is a mark and object of men's attention, in which we can read records of bygone times; and we can form some estimate of the present, by comparing with it the memento thus presented to us of the past.

Such a memento is the Old Silk-Mill at Derby. When, standing on the bridge which crosses the Derwent near the northern end of the town, we look down the stream and glance at the long brick building on the right-hand, or western bank; and when we are told that this was Lombe's Silk-Mill, we are tempted to ask, "Is this the *real* mill? Is this the veritable building erected by John Lombe more than a hundred and twenty years ago, and at which William Hutton went to work in 1730?" We find that it is so; and that it has never ceased to be worked from that day to the present. Nay, the original water-wheel, which was such a marvel at the time of its erection, has been at work until within a very few years; and the old dusky-red pile of buildings, with its hundreds of win-

dows, still stands isolated from all other buildings, on the little island which Lombe rented from the Derby Corporation.

But before noticing the internal features of the Old Mill, it may be well to speak of the raw material brought thither to be manufactured, and of the source whence that material is obtained.

A silk-mill, in manufacturing phraseology, is the building in which raw silk, as imported, is prepared for the weaver, the stocking-maker, or the seamstress, by spinning or twisting, and other processes. A subdivision is sometimes made between a 'silk-throwing mill' and a 'silk-spinning mill;' the former being for the manufacture from good and perfect raw silk, and the latter from waste and inferior silk; but both are alike dependent on foreign countries for the supply of the raw materials. The silk arrives at the mill in the form of a filament or thread, and it leaves the mill also as a thread; but the difference between the two forms, as to thickness, compactness, and strength, is considerable. We may even go farther back, and state that the imported threads are themselves formed of other threads made abroad; so that in fact we cannot rightly understand the matter without tracing the routine back to the silkworm itself.

It is pretty generally known to readers in the present day that silk is a secretion from the silkworm, elaborated through two small holes near the head. How the worm is reared; how it changes its condition with great rapidity; how it is supported by eating vast quantities of mulberry-leaves; and how the Italian peasants prepare for the momentous period when the worms are to produce their silk—are matters upon which there is not room here to enter. Suffice it to say that, when the critical time arrives, the little worm seeks a corner or hollow space in which to form its *cocoon* or nest. Having selected such a spot, it attaches long threads of glutinous matter, or silk, from side to side, to form a support for itself; and upon this support it weaves around itself a hollow envelope of light tissue-like texture. Within this wall it continues to labour, spinning more and more length of filament from the two holes before mentioned, and laying the thread round the interior of its hollow dwelling, gradually thereby increasing the thickness of the inclosing wall. The nest assumes the form of a light egg-shaped ball, very soft and loose on the exterior; but as the worm progresses with its work towards the centre, the structure becomes more dense and compact, from the plies or reduplications of the thread being closer together. At length the working ceases, and we have then a *silk cocoon*, with the worm imprisoned in its centre; the cocoon being from an inch to an inch and a half long, and of a yellow or orange colour.

Now it is important to bear in mind that it is one *continuous thread* thus produced; or in fact it is two threads twisted into one. There are two twin-threads spun out from the two orifices; and the worm, by a peculiar combined movement of its mouth and front-legs, brings these two together, and agglutinates them by a gummy liquid. The worm, if not interrupted, spins out the whole quantity in one unbroken thread of enormous length, composed of the two twin filaments. This circumstance gives rise to one main difference between the cotton and silk manufactures; for cotton comes to us in the form of short fibres, which have to be spun—formerly by hand, but now by machinery—into a continuous thread; whereas in the silk manufacture the little insect performs this spinning process, and presents the material in a continuous form.

But it may next fairly be asked, by what means is the insect removed from its voluntary prison, and how is the continuous thread of silk removed from the cocoons? This is effected in a singular manner. In Italy, from whence a large quantity of silk is brought, the rearing of the silkworms is the occupation of one class of persons, while the winding of the silk is that of another; and the rearers sell the cocoons to the winders as soon as the enclosed insect is killed. Sometimes the cocoons are exposed to the heat of an Italian sun for four or five hours; or if the climate be too cold, they are placed in an oven and there kept till vitality is destroyed. In short, the poor little silk-makers are stifled to death in their egg-shaped envelopes, after having produced the material which man has chosen to appropriate to himself. When the insect is killed, the external soft envelope, which is known as *floss-silk*, is opened, and the hard cocoon is protruded through the opening. This *floss-silk* is to be afterwards brought to a manufactured state by the process of silk-spinning, while the cocoon is appropriated to the silk-throwster.

The vendor of the cocoons separates them into different qualities, to which he applies different names. Thus, the 'good cocoons' are the most perfect; 'pointed cocoons' are apt to break in the winding; 'cocalons' are large, but of a less compact nature than good cocoons; 'dupions,' or doublets, have two threads

confused one with another; 'soufflons' are very imperfect cocoons; and so on, each kind being paid for at a certain price, according to the facility with which it will yield a good silken thread.

When the winder or reeler has purchased the cocoons from the rearer, a woman proceeds as follows:—Into a vessel of warm water a number of cocoons are thrown, and there immersed until the gum, which the insect had used as a kind of cement in forming the cocoon, is so far softened as to permit the thread to come off. The reeler then takes a whisk of fine twigs bound together, and cut off evenly at the ends; and with this she gently presses and stirs the cocoons, till the loose threads are entangled on its points. She then raises her whisk with the threads attached to it, disengages them from it, and draws their ends through her fingers to remove any adhering floss or impurity. Then, supposing the thread which she is about to form is to consist of twenty filaments (the number varying greatly in different circumstances), she collects the threads of twenty cocoons, and passes them through small eyes or loops in a reeling-machine. The first forms, say four groups of five each, each group passing through one eye; then two of these groups are combined into a larger group; and lastly, all of the twenty filaments are brought together in one thread. This combined thread is wound upon a hollow frame or reel; the cocoons, immersed in the warm water, being softened precisely to that state which will admit of their yielding the filaments easily. As fast as any or all of the cocoons become exhausted, others are thrown into the warm water, and their threads united to that of the cocoons previously reeled.

It is thus that the silk leaves the form of cocoons, and assumes that of a hank or skein. Of the quantity thus yielded the following may give some notion. Each cocoon yields on an average about three hundred yards of silk; two hundred and fifty average-sized cocoons weigh about a pound; and eleven or twelve pounds of cocoons give one pound of reeled silk, the other eleven-twelfths being made up of the weight of the chrysalis, or enclosed insect, floss-silk, waste, dirt, &c. From these data it has been estimated that the original silk filament, as elaborated by the insect, would require nearly five hundred miles of length to weigh one pound!

The hanks of silk, thus produced from the cocoon by the silk-reelers of Italy, France, Bengal, China, and other countries, are the commodity which arrives in England under the name of *raw-silk*. That which is imported under the name of *thrown-silk* is the article after having been worked in the silk-mills of foreign countries; and formerly a good deal of this used to be imported into England. But in proportion as the English silk-mills improved in their processes, the English throwsters were able to outweigh certain advantages which used to attach to the Italian throwsters; and the result is thus shown—that while at the opening of the present century the thrown-silk imported was half as much in weight as the raw-silk, in 1839 it was only one-eighteenth part as much, the advantage in change being altogether on the part of the English throwster.

Let us suppose, then, that the silkworm-rearers of Asia and Southern Europe have brought into the market cocoons fit for reeling; that the reelers have combined the threads of several cocoons into one, and brought it into the form of hanks; and that these hanks have been imported into England. We shall then be prepared to follow the hanks through the various processes included under the general name of *silk-throwing*, by which they are brought into the proper state for warp and weft threads for the weaver, yarn for the silk-stocking maker, sewing-silk, and

other purposes. Mr. Taylor, the present proprietor of the Lombe Mill at Derby, has kindly permitted us to select that establishment for the object in view.

The circumstance alluded to in the last paragraph, viz., the former prevalence of silk-throwing in Italy, is precisely that which led to the origin of this celebrated mill. Hutton gives a very curious account of the matter, from which we may here condense a few particulars.

The Italians being the silk-throwsters for England, and the taste of the day having set in favour of silks, a Mr. Crotchet of Derby thought it would be a capital speculation to commence silk-throwing in England. He accordingly prepared a small mill at Derby; but, to use Hutton's words, "three engines were found necessary for the whole process: he had but one. An untoward trade is a dreadful sink for money; and an imprudent tradesman is one more dreadful. We often see instances where a fortune would last a man much longer, if he lived upon his capital, than if he sent it into trade. Crotchet soon became insolvent."* It was in the year 1702 that this unsuccessful speculation was set on foot; and a few years thereafter elapsed before the occurrences took place which led to the construction of the present mill, the first one really worked in England.

John Lombe, a good mechanic, a good draughtsman, and a man of tact and energy, went out to Italy with a view of inspecting the machinery employed by the Italians in the process of throwing silk, and of bringing back to England a knowledge of the mode by which the process might be here carried on. As he knew that such an examination would be strictly denied to him, it becomes a very fair question whether such a project was morally or commercially just. We are, of course, well-pleased to see that the silk-manufacture has taken deep root in England; and we are prone to laud the ingenuity of the man who was mainly instrumental in its introduction; but how far such a project deserves to be imitated, when effected by clandestine means, may one day form an item in the ethics of manufactures. However, to proceed, as Lombe could not gain admission to the silk-manufactories by open means, he bribed some of the subordinates, and made frequent secret visits. After each visit he noted down upon paper all the particulars of what he had seen, until by degrees he acquired a general knowledge of the whole routine; but his object being discovered, he fled with the utmost precipitation on board a ship, and narrowly escaped assassination.

On his arrival in England, Lombe determined to fix upon Derby as the scene of his operations; and in the year 1717 he agreed with the Corporation of that town for an island or swamp in the river Derwent, five hundred feet long, and about fifty wide, at a rent of eight pounds per annum. On this spot he erected the mill which is still existing, at an expense of 30,000*l.*; it was built wholly upon huge piles of ash, sixteen or twenty feet long, driven close to each other, and covered with a flooring of masonry to form the foundation of the building. The mode in which he is said to have borne the expense of the gradual erection of this ponderous building was very remarkable. He hired various rooms in Derby, particularly the Town-hall, where he erected temporary engines, worked by hand; and the silk which he manufactured at these engines, though sold at a price which enabled him to compete with the Italian throwsters, yet yielded him so handsome a profit, that he was enabled to advance money by degrees towards the erection of the great mill.

* Knight's Miscellanies: 'Life of William Hutton,' p. 115.

In 1718 Lombe procured a patent for his invention for fourteen years, and carried on his proceedings with vigour, aided by two Italians who accompanied him from Italy. But his death soon ensued under circumstances which Hutton, following the current of popular rumour, thus narrates:—"Alas! he had not pursued this lucrative commerce more than three or four years, when the Italians, who felt the effects from their want of trade, determined his destruction, and hoped that of his works would follow. An artful woman came over in the character of a friend, associated with the parties, and assisted in the business. She attempted to gain both the Italians, and succeeded with one. By these two slow poison was supposed, and perhaps justly, to have been administered to John Lombe, who lingered two or three years in agony, and departed. The Italian ran away to his own country; and madam was interrogated, but nothing transpired, except what strengthened suspicion." The subtleties of "Italian poisoning" have been such a favourite theme for romancers and novelists, that this termination of Lombe's career has been much doubted. There is, however, proof that the Italians were very indignant (and in truth not without justice) at their trade being thus snatched from them; and the King of Sardinia did all he could to prevent the shipment of *raw*-silk from Italy to England; for the raw-silk procured by the English was by them worked up into *thrown*-silk, thereby dispensing with the services of the Italian throwsters.

After the death of John Lombe, the mill became the property of his brother William; but William "being of a melancholy turn, he shot himself," and the property descended to his cousin Thomas, who subsequently became Sir Thomas Lombe. The patent expired in 1732; but Sir Thomas petitioned parliament for a renewal of the patent, on the plea that "the works had taken so long a time in perfecting, and the people in teaching, that there had been none to acquire emolument from the patent." Hutton asserts that Lombe had already accumulated 80,000*l.*, but we know not on what data. Parliament refused to grant a new privilege, but awarded him 14,000*l.* as a reward for his ingenuity; on condition that he would cause an exact model of his machinery to be constructed, and placed in the Tower of London, where it might be open to the inspection of all who sought to erect similar machinery. From that period, a hundred and eleven years ago, silk-throwing became a regular and unrestricted occupation in England.

Such was the origin of the Old Silk-mill at Derby, to which we will forthwith pay a visit. From the market-place a street called Full Street leads in a northerly direction; and out of this street on the right hand branches a narrow lane descending towards the river Derwent. This lane has the appellation of 'Silk-Mill Lane,' one which sufficiently designates its origin and locality. Proceeding down this lane, we see the old red-brick mill before us, speckled around with its four hundred and eighty windows. We have said that the mill stands upon a little island; and to reach this we must cross a bridge which separates the island from the main town. While on the bridge, we can see at a glance that the portion of the river that flows through the narrow channel between the island and the main bank has force enough to turn a mill-wheel: this is, indeed, the portion of the river employed for this purpose; for on looking northward, we see a large wooden wheel which, receiving its motive-power from the descending stream, works some of the machinery within the factory. Until within six or eight years back, the original water-wheel, erected by John Lombe about 1720, continued working in its original position; but it was at length replaced by a new one. We

believe that this "old stager" was not actually destroyed till a year or two ago.

At the eastern extremity of the bridge a pair of iron gates gives entrance to a small court-yard in front of the factory; on entering which it is seen that the mill consists of two piles of buildings, one northward and the other southward of the entrance gates. Each pile is five stories in height; and the two extend to a length of about a furlong, bounded on all sides by the river Derwent.

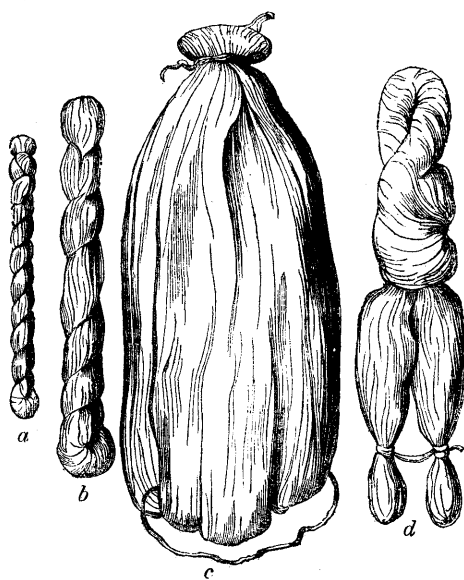
The floors or ranges of each pile are of great length, and lighted on both sides by windows. Generally speaking, one floor is devoted to some one particular department of the silk manufacture, and is fitted up with machines pertaining to that branch. In a kind of warehouse near the entrance is a curious memento of John Lombe, which has probably occupied its present position undisturbed for more than a century. It is an old box or trunk, six or seven feet long, and between two and three wide and deep. It is made of a very hard kind of wood, and is carved all over with curious devices. We have been informed that it still contains numerous documents, once probably belonging to the Lombe family, but the nature of which is not at present known. Indeed the intermediate history of the factory, from Lombe's time, till the present proprietor came into possession of it, is not very clearly to be traced.

In some of the floors the machines employed are such as little girls can attend to; in others, elder girls or women are necessary; in some, boys and men form the principal workpeople; but in all silk-mills the larger number of those employed are females. In the rooms where girls and women are engaged, a song is not an unfrequent accompaniment to the clack, and thump, and humming of the machinery. We do not know in what department of the silk-throwing processes William Hutton, when a boy, was employed; but he tells us in his Autobiography, that he went to the Lombe mill in 1730, when about seven years of age. He says that, when his parents thought he ought to begin to work for himself, "the silk-mill was proposed. One of the clerks remarked to the person who took me there, that the offer was needless, I was too young. However, the offer was made; and as hands were wanted in the infant state of this work, I was accepted. It was found, upon trial, that nature had not given me length sufficient to reach the engine; for, out of three hundred persons employed at the mill, I was by far the least, and the youngest. It is happy for man that his invention supplies the place of want. The superintendents wisely thought if they lengthened one end it would affect both. A pair of high *pattens* were therefore fabricated, and tied fast about my feet, to make them steady companions. They were clumsy companions, which I dragged about one year, and with pleasure delivered up.

The best way for us to see how the various floors of the building are occupied with machinery, and what is the nature of the processes at which the workpeople are engaged, is to trace a hank of silk through the various processes, till it assumes the form of yarn or hosiery silk, warp and weft, or sewing-silk. And it may be well here to remark, that we have selected the old Derby mill for illustration, not for the modern character of the machinery fitted up there, but for the associations which bind it so indissolubly with the history of the silk manufacture in England. Modern improvement has wrought many changes in the mode by which machinery has been brought to bear on the manufacture; but the general principle, so far as the effect to be produced, is alike in all; and a general reader will understand the process better, the less refined and complex is the machinery employed.

First, then, we have to understand that the hanks of

raw yellow silk are brought to the factory in bales or bundles. The appearance of these bales, when opened, is remarkably beautiful, from the glossy richness of the material. The silk has different tints of colour, and different delicacy of texture, according to the country whence it has been brought. For instance, the Broussa silk and the Chinese silk are whiter than most of the other kinds. The bales of Bengal silk are made up to a weight of about a hundred and fifty pounds, and consist of hanks or 'heads' of small size. The Italian silk is made up into rather larger bales, and consists of larger hanks. The Persian silk, which is of inferior quality, is in still larger hanks, weighing about a pound each. The various qualities of raw silk are now purchased in the market at from ten to twenty shillings per pound. The annexed cut will show the general form of the hanks.



[Hanks of Silk.]

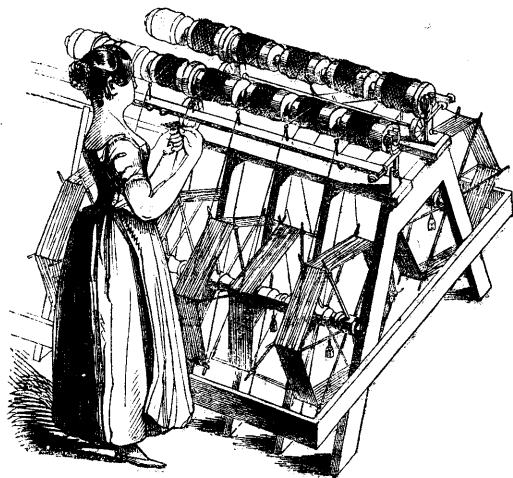
a, Bengal; b, Italian; c, Persian; d, Broussa.

The processes which these different kinds of silk undergo, in their passage through the silk-mill, depend on the purposes to which the silk is to be applied. Thus, there is a kind called *dumb singles*, which consists of silk merely wound and cleaned: this is used in the weaving of gauze and other thin fabrics. Another manufactured variety, called *thrown singles*, is silk which has been wound, cleaned, and thrown, and is then used in the weaving of ribbons and common silks. *Tram* is silk which, besides being wound, cleaned, and thrown, is 'doubled,' that is, two or more thicknesses of thread are combined into one, and twisted together; this is used for the weft or cross threads of Gros de Naples, velvets, flowered silks, and the best varieties of silk goods. Another kind, called *organzine*, besides being wound, cleaned, and doubled, is twisted or thrown twice; the first twist being like the yarns which form a strand, and the second like the strands which form a rope: this forms a hard and compact thread, and is used as the warp or long threads for the same kind of goods as those which have *tram* in the weft. Lastly, *sewings* are compound threads of silk, wound, cleaned, doubled, and thrown, with especial reference to their ultimate use as sewing-silk.

It will thus be seen that the operations to which the silk is submitted differ in complexity, according to the purposes to which it is to be applied. Some are only wound and cleaned; others wound, cleaned, and

twisted once; others wound, cleaned, doubled, and twisted once; others wound, cleaned, twisted, doubled, and twisted again. In point of fact, therefore, the main operations may be classified as *winding*, *cleaning*, *doubling*, and *twisting* or *throwing*; with a few others subordinate to them.

After a slight washing or soaking, comes the process in which the *winding-engine*, sketched in the accompany-



[Winding-Machine.]

ing out, is brought into requisition. The winding-room at the old mill is a busy, bustling place, filled with machines, the construction and arrangement of which may be thus briefly described. Across the width of the room, from side to side, extend the machines, in parallel rows, leaving a clear passage on either side of the room. The machines are sufficiently far apart to allow the workwomen and girls to pass between them; and these females we see walking to and fro, adjusting the different parts of the apparatus, removing bobbins when they are filled with silk, replacing them with other bobbins to be similarly filled, and providing a supply of the material which is to be wound.

The term 'winding,' as here applied, refers to the original skeins or hanks of silk, which are to be wound on bobbins four or five inches in length before the silk can go through the processes of manufacture. Any one who has sat at a domestic fireside, and has seen the process of winding a skein of silk on a small wooden reel, or round a roll of paper, will be prepared in some degree to understand how the winding in a silk-mill is effected, so far as the change of form in the silk is concerned. It will be recollected that we explained, in a former paragraph, how the silk-reelers of Italy transfer the silk to a hollow framework or reel, as they draw it from the cocoons; and it will be obvious that the circumference of the framework will determine the size of the skein or hank produced. Then, in order to wind from the hank, the latter must be stretched out over a support of some kind or other: a lady employs her sister, or friend—or perhaps her lover—to hold a skein of silk stretched between the two hands during the process of winding; but the manufacturer employs a dumb agent to perform a similar service.

Understanding this, then, we may say that this dumb agent, in the winding-machine, is called a *swift*—some-what unfittingly, perhaps, for its movements are very slow compared with those of the bobbins. It is a hexagonal frame, or, if we may use such a term, a six-sided hoop, whose circumference equals the circumference

of the skeins of raw silk. The skeins or hanks, as imported from different countries, are not always the same size; and therefore 'swifts' of different diameters are provided. The swifts are also made in a light and elastic manner, so as to adapt themselves readily to small differences of dimensions. The hanks of silk are opened and separated, and the skeins spread on the circumference of these swifts. These swifts are ranged in parallel rows of several dozen each, on either side of every winding-engine; so that a common axle, running through the centres of them all, will permit them all to rotate.

Next for the bobbins to which the silk is to be transferred. These are ranged in a row above the swifts, one bobbin to each swift; and all the bobbins revolve together on a horizontal axis. Now when one end of the thread of any given skein is carried up from the swift to the bobbin above, and attached to it, the rotation of the bobbin will cause all the silk to be gradually unwound from the swift on to the bobbin. The swift rotates solely by the pulling-force of the silken thread, as the latter becomes wound up, and this rotation causes the silk to be freely given off from the swift. If no further provision were made than is here indicated, the silk would be wound in an irregular heap on the bobbin; but it is made to distribute itself in a parallel and equable layer, by passing through an eye before it reaches the bobbin, which eye is fixed in a bar that oscillates or traverses to and fro sideways, so as to bring the thread successively in front of every different part of the length of the bobbin.

The silk, then, has been, we will suppose, wound upon bobbins, and is ready for the subsequent operations. That which is termed *cleaning* is simply the removal of all impurities or irregularities, by which the diameter of the thread may be rendered unequal. Sometimes this is effected in the same machine by which other parts of the process are carried on; while in other factories a separate machine, called the 'cleaning-machine,' is employed. However, the principle is the same in both cases, and consists merely in passing the silken thread through a cleft in a piece of steel, so adjusted in size as to allow the thread, in its proper state of thickness, to pass freely through, but to detain and remove all asperities, roughnesses, and irregularities of surface.

If the preceding details be borne in mind, it will be understood that the next process will depend on the purpose to which the silk is to be applied: whether the thread is to be used as 'dumb-singles,' 'thrown singles,' 'tram,' 'organzine,' or 'sewings.' But it will suffice if we deem the 'twisting' or 'throwing' to be the next process, as it is, indeed, in most cases.

There does not seem to be any very definite distinction, among silk-throwsters, between the terms *spinning*, *twisting*, and *throwing*; or at least, the difference existing is not such as can be understood by general readers. All these terms refer to the formation of a rope-like twist of the silken filaments, for the purpose of strength. In the 'filatures,' or reeling-houses in Italy, where the threads of many cocoons are united into one compound thread, this thread coheres merely by the glutinous gum which envelopes the threads, and not by an actual *twisting* of the threads: this twisting is reserved till the silk reaches the throwing-mill.

We follow the silk, therefore, to the throwing or twisting room, where machines called 'spinning-machines' (represented in p. 166) are at work. This is an inconvenient confusion of terms, for spinning is properly the combination of a number of *short* fibres into a continuous thread, such as takes place in the cotton, woolen, and linen manufactures, and also in the silk-spinning from waste silk: in a silk-throwing mill the term spinning ought not in strictness to be admitted at all,



[Spinning-Machine or Engine.]

since there are no short fibres to be combined into a continuous thread. Be it a 'twisting' or a 'spinning' machine, however, the action is both simple and beautiful. The floor or story in which these machines are congregated exhibits them ranged one behind another in two rows; and the eye is at once struck with the thousands of little spindles and bobbins which are whirling round at a very rapid rate, some yielding the silk which is to be twisted before reaching the others.

There is, to every machine, a set of bobbins whose axes are horizontal, and another set whose axes are vertical, and the twisting takes place while the silken thread is passing from the former to the latter. The vertical bobbins do not revolve, but they are placed upon steel spindles which pass through their centres; and these spindles, together with a kind of loop or eye attached to one end, revolve rapidly. The silken thread being passed from the horizontal bobbin through the eye or loop, and fastened to the stationary vertical bobbin, and motion being given to the apparatus, the thread becomes wound on the vertical bobbin by the rotation of the little loop apparatus, called the 'flyer,' round this bobbin; and a twist is at the same time imparted to the thread.

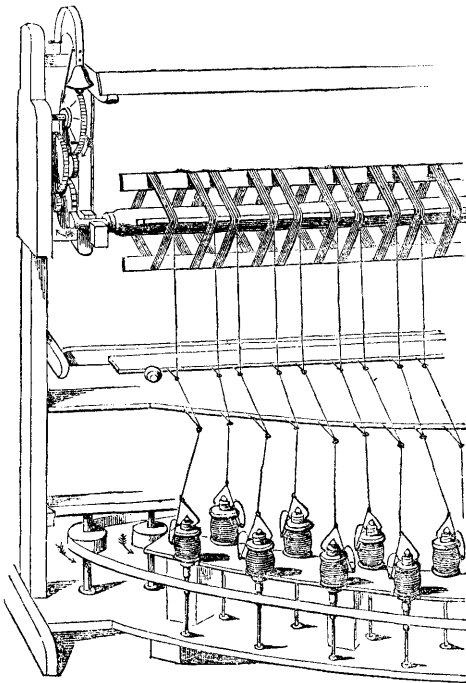
We have said nothing of the comparative velocity with which the two parts of the apparatus revolve; but it will be seen that a change in this relation produces a curious effect. If, while the bobbin maintains a uniform rate of movement, the flyer rotates more rapidly, the *hardness of twist* is increased, or there are more spiral turns in a given length of thread. If, on the other hand, the velocity of the flyer decreases while that of the bobbin remains uniform, or that of the flyer remains uniform while that of the bobbin increases, the twist becomes slackened, or there are fewer turns in a given length. The silk-throwster can therefore give any degree of hardness or closeness

to the twist, by varying the relative velocities of the two moving parts.

However complex the twisting-machine may seem at first sight, it is but a repetition of similar parts, each of which acts in the manner just noticed. All the horizontal bobbins are made to rotate by one piece of mechanism, while all the spindles owe their motion to another. The foreman or superintendent of the department regulates the relative velocities which the two movements shall bear to each other, according to the hardness of the twist to be given to the thread; but, when this is adjusted, women and girls attend the machines, replacing the lower bobbins when emptied, and the upper ones when filled, and also joining the ends of broken threads.

We may now dismiss the twisting of the single threads, and speak of the *doubling*, which takes place in the manufacture of tram, organzine, and sewing-silk. This is a combination of two or more threads into one, to increase the strength and thickness, and may be deemed analogous to the combination of the threads from many cocoons into one in the foreign reeling-houses. The number thus combined varies generally from three to twelve, and it is a mere combination or laying together, without twisting. This is effected in two different ways; either by a kind of hand-wheel something like a spinning-wheel, or by a modern automatic machine of greater complexity; but it will be more readily understood if we speak of the hand-method only. In one of the rooms of the factory are a large number of women, each sitting on a low stool and having before her a small wheel, which she turns with the right hand. Each woman has, fixed up in a small frame near her, as many bobbins as there are to be threads doubled together. From each of these bobbins she takes the loose end of silk, and, combining them all into one, passes them through a kind of loop, and thence attaches them to her wheel. Then, turning the wheel with the right hand, she unwinds all the thread from all the bobbins, and obtains a thicker but untwisted thread therefrom. It generally happens that while some of the women are doubling two threads together, others are doubling three, others four, and so on, to suit different qualities of goods. The women arrange their simple machines obliquely, one behind another, for economy of space, having two bobbins of single silk placed on upright spindles, and which they can rotate with facility. Our frontispiece was sketched in this 'doubling-room.'

The doubled threads, whatever be their number, are as we before observed, merely laid side by side in a parallel group, without any intimate combination. The combination is the result of the next process called *throwing*, by which the two, three, five, or a dozen threads are twisted firmly one around another. The 'throwing-machine' here represented, for twisting doubled threads, is almost exactly the same in principle as the 'spinning-machine' for twisting singles, although differing in some of the details. In both cases the thread to be twisted is wound on a horizontal bobbin or reel, while the bobbin for receiving it is in a vertical position. In both cases the twist is given by a 'flyer' revolving rapidly round the vertical bobbin and carrying with it the thread through an eye or loop. In both cases the hardness or closeness of the twist is regulated by the ratio between the velocities of the two parts of the apparatus. But in the one case a single thread is twisted around itself; while in the other several are twisted round one another, like the yarns in a rope; or rather, if we may compare the elementary cocoon filaments of the silk with the elementary hempen fibres of a rope, we may say that, in the first stage, the filaments are combined and twisted into 'singles,' while the hempen fibres are combined



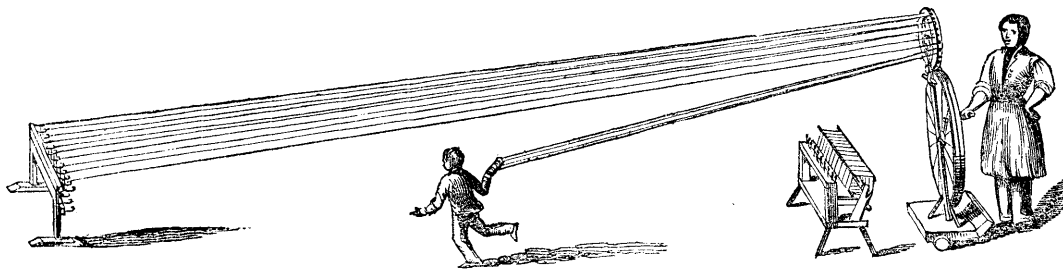
[Throwing-Machine.]

and twisted into 'yarns;' and that, in the second stage, the singles are combined and twisted into 'warp-threads,' while the yarns are combined and twisted into 'strands' or 'ropes.' Nay, the analogy between ropes and thrown-silk is yet closer, and may be studied instructively. We find that while the fibres of a yarn are twisted in one direction, the yarns of a rope are twisted in the opposite direction; and the like is observable in the twisting of silk, so far as regards organzine, sewing-silk, and other kinds in which strength is required. The matter may be thus expressed:—For 'singles,' after the raw silk has been wound, it is thrown or twisted *to the right*; for 'tram,' the silk is not twisted immediately after being wound, but the raw silks are doubled, and then twisted *to the*

right; for 'organzine,' the raw silk, after being wound, is twisted *to the left*, then doubled, and the doubled thread finally twisted *to the right*. This rope-like texture gives great firmness to the organzine; while the lesser amount of twisting in the tram gives it a more floss-like texture, better suited to some purposes than the organzine.

There is, in some parts of the processes now described, a very pretty little contrivance, which has often been noticed as one example among many which our manufactures afford, of certainty and precision in mechanical operations. It is a piece of mechanism which refuses to work when anything is going wrong; it is a tell-tale, an overseer, a warning, which immediately informs the workwoman that something requires her attention. When the delicate threads of silk are passing from one revolving bobbin to another, if the thread happens to be defective at any particular part, it is likely to break; and in many cases a breakage would seriously injure the manufactured article, if not immediately attended to. For instance, if four threads are being doubled into one, and one of the four break, the other three, if not instantly stopped, would continue to form a threefold thread, which would not correspond with the fourfold previously made. The contrivance acts by stopping all the bobbins of one group instantly, when any one of the threads breaks. Each thread passes through an eye in the end of a short lever; and, when a thread breaks, the lever loses a temporary support, drops, and by means of a sort of catch or detent stops the movement of the bobbin on which the doubled thread is being wound. The stoppage of the movement instantly attracts the notice of the attendant, who mends the broken thread, and puts the apparatus again into motion.

There are some kinds of twisted silk more dense, thick, and strong than the ordinary varieties, which are prepared by hand-twisting in a mode that cannot fail to strike the attention of a visitor, and which, to one unaccustomed to the inspection of machinery, exhibits the true nature of the twist in a clearer manner. In one of the long rooms or ranges of the mill a number of young active boys are seen running to and fro with untiring industry, carrying or supporting silken threads in their hands; these boys are assisting to form twisted silk, much on the same principle as twine is spun in a rope-walk. At one end of the room is a large wheel turned by a handle. On one face of the



[Throwing or spinning by hand.]

wheel, near the circumference, are about a dozen hooks, ranged in a circle. Several threads of silk, twelve or a lesser number, are fastened to these hooks, and the other ends of the whole twelve are carried to the distant end of the room by the boys. At that end they are fastened to hooks attached to a machine capable of travelling slowly along the floor. Matters being thus prepared, the handle of the wheel is set in motion, by which the hooks are made to rotate with great rapidity, and the threads fastened on them be-

come thereby twisted one around another with great closeness. It bears in fact a very close resemblance—not so much to the spinning of yarn from hempen fibres—as to the twisting of strands or cords from yarns in a rope-yard. The silk-twisting is, however, effected with great quickness; and the little boys are incessantly engaged running to and fro, attaching and detaching the remote ends of the silken threads. We were informed that this running amounts sometimes to as much as thirty miles a day, and forms a striking

contrast to the stillness and fixedness of many departments of factory labour. All the boys at one frame or wheel are under the control or orders of the man who superintends the wheel, and who is responsible for the work produced.

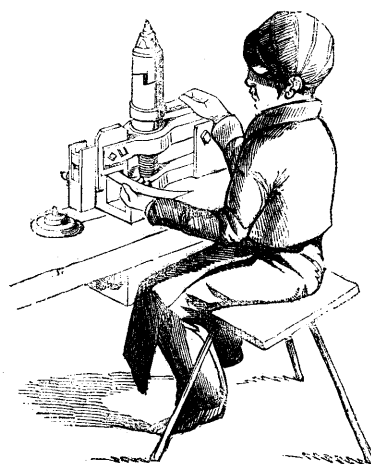
All silk is either dyed or bleached at some stage or other of its progress, and this is generally effected, we believe, immediately or soon after the twisting is finished. But before it is dyed, it is made up into convenient hanks, and 'scoured,' to remove the gum which may still adhere to the silken filaments. Before this scouring the silk is harsh to the touch, and is unfit to receive the dye. It is boiled for three or four hours in strong soap and water, by which the gum is dissolved, and the silk rendered soft and glossy. This scouring, together with the waste which occurs in the preceding departments of the manufacture, reduces the weight of the silk four or five ounces in the pound. The silk is washed in a current of clear water to remove the soap, and it is then seen that, although the weight is so much reduced, its bulk is greater than before, and it presents the soft, rich, and delicate gloss which is the characteristic of silk.

The processes of silk-throwing, or 'throwsting,' considered as a general whole, may now be said to be finished, and the silk-thrower has nothing further to do with the material: he supplies the silk in this state to those who wish to use it as warp and weft for weaving, as yarn or thread for hosiery and gloves, as sewing-silk, or to any of the numerous purposes to which thrown silk is applied.

We have said that the Old Mill at Derby exhibits processes arising out of, but not exactly pertaining to, the occupation of silk-throwing; that is, some of the thrown silk is there manufactured into finished articles. To this extent, therefore, it is something besides a silk-throwing mill; but these additional features we can notice only in a very brief manner.

In some rooms, by a kind of workmanship intermediate between, or a sort of combination of, weaving and twisting, there are various descriptions of silk cords, laces, and lines manufactured. The rage for cheapness in the present day has led to a curious exercise of ingenuity in this department of manufacture by the invention of a process termed 'plating,' which bears the same relation to the real silk manufacture as metal 'plating' does to manufactures in silver. It consists in putting a coating of silk on a substratum or foundation of cotton, by which the more costly material is only used in those parts which meet the eye. The history of our textile manufactures within the last dozen years is full of examples of this kind, in which the manufacturer endeavours, by economizing the more costly materials, to bring his wares within the purchasing capacity of an increased range of customers. The inventive ingenuity called for in these adaptations is often exceedingly great, and it has occasionally happened that new productions which have owed their origin to motives of this kind have created a new market by their beauty as well as their cheapness.

One very remarkable article of manufacture—remarkable, at least, in respect to one department—produced at this establishment is that of silk boot-laces with brass tags. The laces themselves are made by a kind of braiding or twisting process, in some degree analogous to that of whip-making. The tags which form the rigid end to each lace are made by two small machines, placed upon low benches, and worked by boys. In the first of these machines, here sketched, a boy takes in his hand a strip of brass, whose width equals the intended length of the tag; and, placing this in a kind of groove, he brings down a cutting-edge to act upon it, which cuts the brass to the required size. The groove into which the brass is placed is at the same time



[Machine for cutting and hollowing tags.]

so formed, that the little piece of brass, as it is cut off, is at the same time bent into an angular or semicircular shape. The pieces of brass thus prepared are transferred to another bench, where other boys are working on machines which fix the tags to the laces. The tags



[Machine for fixing tags to the laces.]

are dropped one by one into a little recess; and the end of a lace being laid in the hollow of the tag, a lever is brought down with the left hand, by which the tag is made to embrace the lace firmly, enclosing it all round. This is done with astonishing rapidity, and forms a curious instance of the dexterity which is acquired by long practice. No less dexterous is the way in which a hole or two are made in each tag, to pin it more effectually to the lace.

We may remark, in conclusion, that the floss-silk forming the outer covering of the cocoons, the defective cocoons, and the waste produced in the filature and throwing of good silk, are the materials which are sent to the silk-spinning mills to be manufactured into yarn for shawls, bandana handkerchiefs, and other coarse articles made of 'spun silk' by a process nearly resembling cotton-spinning. This department of the silk-manufacture has extended in a remarkable degree within the last few years.