

**SILK MANUFACTURE.** This subject naturally divides itself into four parts:—The rearing of the insect which yields the silk; the extrication of the filament in a state fitted for the manufacturer; the spinning and weaving into textile fabrics; and the commercial arrangements arising out of the manufacture. Such portions of the subject will be treated here as have not yet been noticed in the Cyclopædia; for the rest, cross-references will suffice.

*Rearing silk-worms.*—Silk is produced by a small insect, in the manner described in BOMBYCIDÆ, NAT. HIST. DIV. China was undoubtedly the country in which men first availed themselves of the labours of the silk-worm. Serica (the country of the Seres) was a name by which the Macedonian Greeks designated the country which produced the silk that came overland from the north of China. The author of the 'Periplus of the Erythræan Sea' speaks of silk in Malabar as an article imported from countries farther to the east; from which it may be inferred that the culture of the silk-worm and the manufacture of silk had not been introduced even into India four hundred years after silk was known in Europe. In speaking of the country of the Thina, the same author observes that both the raw material and manufactured article were obtained there. The "Median robes," spoken of by the Greek writers of the period of the Persian empire, and extolled for their lustrous beauty and brilliancy, were no doubt silken vestments; as Procopius long afterwards, when silk had been introduced into Europe, states that "the robes which were formerly called Median by the Greeks are now called silken." Aristotle is the first Greek author who mentions the silk-worm ('Nat. Hist.,' v. 19). He states that silk was first spun in the island of Cos, but that the raw material was still an oriental product; and Pliny (xi. 22), in commenting on this passage, states that the silk came from Assyria, and was worked up by the Greek women. It may be remarked that Assyria was, like Media, frequently used in an indefinite sense by ancient writers. The probability is that silk was used in Western Asia before it was known to the Greeks; and that it was in use among the Greeks long before they knew whence the substance came or how it was produced.

Pausanias is perhaps the first who gives precise information respecting the substance from which the Seres formed their cloths. "They have," he says, "a spinning insect, which is kept in buildings, and produces a fine-spun thread, which is wrapped about its feet" (vi. 26). It was not until the sixth century that the obscurity which enveloped this subject was cleared up. At this time silk was an article of general use among the Romans, and was manufactured for them by the inhabitants of Tyre and Berytus in Phœnicia. The Persians monopolised the supply of the raw material, and guarded their trade with so much jealousy, both by land and sea, that travellers from or to China were not allowed to traverse the Persian dominions; and in the time of Justinian, in consequence of some interference with the trade, they had entirely stopped the importation of silk. The trade in silk was in this unsatisfactory state, when two Nestorian monks of Persia, who had travelled to China, acquainted Justinian with the mode of producing silk, and undertook to return and bring back with them some of the eggs of the silk-worm. They were perfectly successful in their expedition; for a quantity of eggs, secured in a hollow cane, were brought in safety to Constantinople, hatched by the heat of a dunghill, and fed with mulberry-leaves. The monks also taught the subjects of Justinian the art of manufacturing silk.

The breeding of silk-worms in Europe was for six centuries confined to the Greeks of the Lower Empire. In the 12th century the art was transferred to Sicily; in the 13th century the rearing of silk-worms and the manufacture of silk were introduced into Italy, and from thence successively introduced into Spain and France.

James I. was solicitous to promote the breeding and rearing of silk-worms in England; and in 1608 issued circular letters, which were addressed to persons of influence throughout the country, recommending the subject to them; but the experiment was unsuccessful. Most of the old mulberry trees found in the neighbourhood of ancient mansions in England at the present day were planted at this period. The experiment has also failed, though several times attempted, in North America.

The production of raw silk is fast extending in British India, and the quality has been for some years gradually improving. In Graham's 'India,' it is said that in the Deccan the mulberry-trees may be deprived of their leaves six times a year, and that six crops of worms may be obtained with ease in the same period. The Chinese method

of rearing silk-worms, and their mode of treating the mulberry-tree (described in Davis's 'China,' p. 280), were introduced at St. Helena, under the auspices of the East India Company; but on the expiration of their charter the establishment was given up. Some of the silk produced in France is believed to be better than that of any other country in the world. The Italian silk is also highly esteemed.

There has recently been a very earnest attempt made to disseminate the silk-worm culture in various parts of Europe. In 1854 some silk-worm eggs, reared at Assam, were brought from Calcutta to Malta, through the aid of Mr. Piddington. They were not the usual kind, but a variety called the *Bombyx cynthia*, which feeds on the castor-oil plant. Sir William Reid, Governor of Malta, caused these eggs to be carefully tended; 500 of them were hatched, and fed on the castor-oil plant. After some time, portions of the store were sent to Piedmont, France, Algiers, and the West Indies, in order that fair trials might be made in different climates. It is known that the castor-oil plant suffices to give the worms the silk-producing power; for the Assamese make shawls, dhoties, coverlets, coats, turbans, and women's dresses, with silk thus obtained. Early in 1855 it was found that the worms at Malta declined and died off, from some cause not clearly traceable; and the attempt failed, so far as that island was concerned. In 1856, however, some of the eggs reached Prussia; and great endeavours are now being made to foster the culture in Germany, Sweden, and Russia. The silk produced by this kind of worm is not so fine as the mulberry-silk; but is believed to be more easily worked, if the insect can only be made to thrive. As to England, silk-worm rearing has been to the present day, and still is, nothing more than an amusement, or an experiment having no commercial value.

This may be the proper place to say a few words concerning other filaments of the nature of silk. The web of many kinds of caterpillars has been found nearly equal to silk, and gloves and stockings have been made of it; but Reaumur found that 50,000 of the insects were needed to yield 1 lb. of silk, and, moreover, that the caterpillars showed a very unprofitable tendency to kill and eat each other. Some fabrics exquisitely light, others moderately strong, have been made from caterpillar filament, but hitherto without commercial success. The *pinna*, a gigantic kind of mussel found in the Mediterranean and the Indian Ocean, fastens itself to rocks with a kind of cord made of beautiful silky filaments; these filaments may be worked up in the manner of silk; but the supply is too small to render the matter other than a curiosity. Very recently there was landed at Liverpool a small quantity of *pulu* or vegetable silk, obtained from the lower part of the stalk of a fern growing in Sumatra; the stalk is covered with a kind of sparkling golden-brown hair, which can be detached and worked up as silk. About 3 ounces can be obtained from each plant. The substance has not yet attracted much attention in England, but is beginning to be worked in America.

*The Cocoons and Silk Reeling.*—The cocoons [BOMBYCIDÆ, in NAT. HIST. DIV.] average in weight about 3 grains each; the average length of silk upon each, when reeled off, is about 300 yards; and 12 lbs. of cocoons are required to yield 1 lb. of reeled silk—so many are the impurities to be got rid of. About 1 ounce of silk-worm eggs will produce 100 lbs. of cocoons; 16 lbs. of mulberry leaves will afford food sufficient for the production of 1 lb. of cocoons; and each mulberry tree will yield about 100 lbs. of leaves. These figures will afford easy means of calculating the number of insects, eggs, trees, leaves, &c., necessary for the production of 6,000,000 or 8,000,000 lbs. of silk—about the annual consumption of the United Kingdom. *Reeling*, or the drawing off of the silken filament from the cocoon, is usually done only in the countries where the worm is reared. To effect this, the

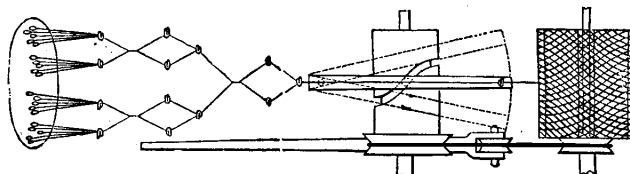


Fig. 1.—Reeling Apparatus (plan).

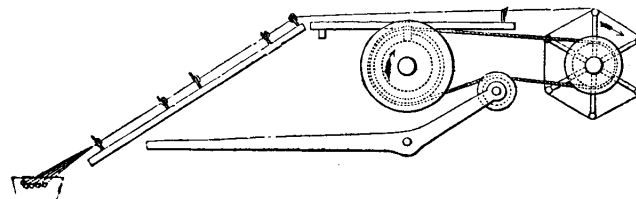


Fig. 2.—Reeling Apparatus (section).

worm is not allowed to die a natural death; the cocoon is exposed to the heat of the sun or of an oven until the insect is stifled. An external soft envelope is removed, constituting *ross silk*; the real silk is wound closely around the cocoon, in an agglutinated mass. The

cocoons are steeped in hot water until the gum is dissolved. The reeler (a woman or girl), with a kind of whisk or brush, detaches the ends of ten or twenty filaments from as many cocoons, winds them two or three together on a reel, then two or three of these groups together, and so on until all form one thread, very much thicker than the original filament, but still exceedingly fine. New cocoons are thrown into the vessel of hot water as fast as the old ones are exhausted, so that the thread is made continuous; and the temperature of the water is such as will enable the cocoons to give off the filaments just as fast as the reeler can wind them. In some districts the reeling is done in a quicker and better way, by aid of the apparatus shown in *fig. 1* (plan), and *fig. 2* (section). From the reel the silk is made up into *hanks*, which present different appearances, according to the countries whence they are obtained. Broussa and China hanks are whiter than the others; Bengal hanks are small; Italian are larger; and Persian are the largest and coarsest of all.

Such is the simple operation of reeling. It has been a conventional opinion that this can only be done in the silk rearing countries; because the cocoons cannot be conveyed long distances safely, and because a clear and warm climate is necessary. The correctness of this opinion is now disputed. Mr. Dickins, a silk dyer at Middleton, and Mr. Chadwick, a silk manufacturer at Manchester, have invented and set to work a system of apparatus for reeling silk in England, and throwing or twisting the silk so reeled. The cocoons are placed for a few minutes in hot soap and water; and then ladled to a trough of clean warm water. The principal end of the silk of each cocoon is drawn out by the fingers; several cocoons, thus treated, are placed in a basin, with the ends of the filaments hanging over the edge; and they are thus taken to the reeling frame when wanted. The machine consists of an iron framework, 12 feet long, 4 feet wide, and 4 feet high. At each side is a row of 30 bobbins, each with a flyer, and with a separate rotary motion. Over the 60 bobbins are 60 copper basins, containing water at 120° Fahr. Into each basin are put 6 cocoons, the filaments from which are wound off by the motion of the bobbins, to which their ends are attached. About 12 inches above each basin is a piece of wire, covered with some soft substance; the filaments pass over these wires on their way from the basins to the bobbins, to cleanse and partially dry them. By this arrangement the winding into hanks, as performed by the silk growers abroad, the winding of bobbins from the hanks, and the usual cleansing process as performed by the throwster, are entirely dispensed with: a twisted thread of silk being furnished at one operation. Threads of different thicknesses may thus be produced, simply by increasing the number of cocoons in each basin. One girl can attend to the cocoons in 30 basins. Whenever a cocoon breaks or comes to an end, a new fastening is instantly made. By an adjustment of the bobbins and flyers, any amount of twist can be imparted to the thread, according to the purpose for which it is intended. The regularity of the movements leads to the production of a thread more free from knots than the ordinary reeled silk. There is no reeling, no hank; the silk is spun at once from the cocoons. The bobbins rotate 3000 times per minute. The principle of the cotton-spindle and flyer being adopted, there is a power of adapting the apparatus to the production of many different kinds of thread; it can either be stopped at the *tram* stage, or advanced to that of *organzine*—terms that will be explained presently. There is said to be a more complete extraction of the silk from the cocoons, a greater regularity in the thread, a thorough extraction of lumps and knots, an avoidance of waste, and a saving in wages. These machines are gradually coming into use in Lancashire and on the continent; but there has not yet been organised an extensive importation of cocoons into England—without which, of course, the machines cannot work.

*Silk Throwing and Weaving.*—Except under the system just described, silk is imported in hanks, not in the cocoons. The silk in the hanks has simply been reeled, without regular twisting. In China and India the silk is reeled very unequally; there may be as few as five, or as many as fifteen filaments in each thread, without any regard to uniformity. Italian silk is better reeled. In the *throwing* mills, situated chiefly in Lancashire and Derbyshire, the silk is doubled, twisted, and hardened. John and Thomas Lambe introduced the art from Italy early in the last century. The silk is made into *dumb singles*, for weaving into gauze and other light fabrics; into *thrown singles*, which, when wound, cleaned, and thrown, is used for weaving into ribbons and common silks; into *tram*, which is doubled as well as thrown, and is used for the weft of the best kinds of goods; into *organzine*, used for the warp; and into *sewing silk*, which is the thickest and best of all. These kinds are produced by the processes of *winding*, *cleaning*, *doubling*, and *twisting*, carried to a greater or less extent. The *winding* is the transference of the silk to bobbins. The hanks are opened, and put upon light frames called *swifts*; and while these are rotating, a series of rotating bobbins draw off the silk from the swifts. *Fig. 3* shows one form of apparatus for effecting this transfer. The *cleaning* is effected by passing the filament through a cleft in a piece of steel, whereby impurities and irregularities are removed. The *doubling* and *twisting* are processes in which two or more threads are twisted round each other; the machinery for effecting this is very varied; but a reference to COTTON MANUFACTURE will afford means for judging of the general principle, although the details are different. *Fig. 4* will illustrate the action of one form of twisting or throwing machine.

When silk is required to be made very thick, strong, and densely twisted, it is sometimes twisted in the manner of rope, in a long alley

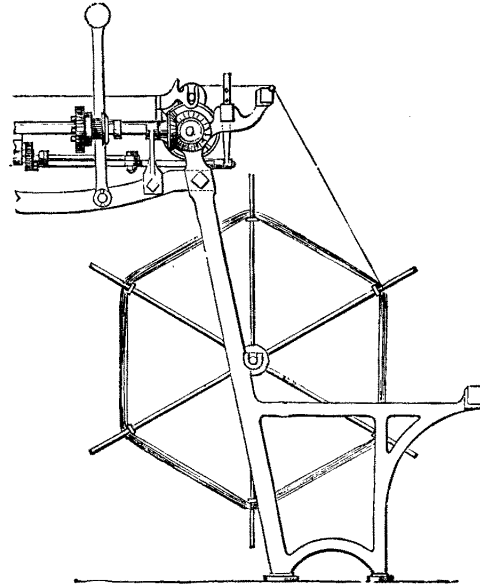


Fig. 3.—Silk Engine or Swift.

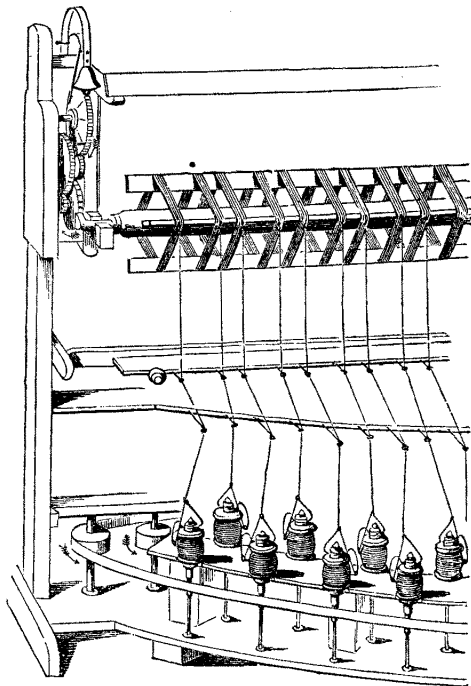


Fig. 4.—Twisting or Throwing Machine.

or avenue (*fig. 5*). *Silk spinning* is comparatively a modern process. It is a mode of using up floss silk, and any waste that may result from the other processes. However unfitted silk may be to be thrown and twisted in the usual way, it may be spun into a continuous thread by carding, drawing, roving, and spinning, almost in the same manner as cotton. The thread produced is of inferior character, and is used for the cheaper kinds of goods.

Of the subsequent processes in the silk manufacture, little need be said here. A reference to the articles CRAPE, DYEING, EMBROIDERY, GAUZE, JACQUARD APPARATUS, RIBBON, and WEAVING, will supply the requisite details. Brocade and damask, the most sumptuous articles of silk manufacture a century ago, are now comparatively unknown. Persian, sarsnet, gros-de-Naples, ducales, satin, and levantines, are the names given to plain silks, which vary from one another only in texture, quality, or softness. Satin derives its lustre from the great proportion of the threads of the warp being left visible, and the piece being afterwards passed over heated cylinders. Other varieties of silk goods are produced by mechanical arrangements in the loom, such as using

different shuttles with threads of various quality, &c. The pile which constitutes the peculiarity of velvet is produced by the insertion of short pieces of silk thread, which cover the surface so entirely as to conceal the interlacing of the warp and woof. The process of weaving

velvet is slow, and it is paid for at several times the rate of plain silks. There are several sorts of goods in which silk is employed with woollen materials, such as poplins and bombazines. The Chinese make a species of washing silk, called at Canton ponge, which becomes



Fig 5.—Silk Spinning by hand.

more soft as it is longer used. Their crapes have never yet been perfectly imitated; and they particularly excel in the production of damasks and flowered satins.

*Silk Trade.*—The making of ribbons and small articles in silk long preceded in England that of broad silk. The trade was principally in the hands of women; and, like a sickly plant of foreign growth, it appears to have constantly demanded props and support. Repeated statutes and orders were made, discouraging the use of silk goods from abroad. An act passed in the reign of Edward IV. contained a sort of apology, which, if good for anything, made the prohibition unnecessary. The act states that not only were the artificers, men and women "greatly impoverished, hindered of their worldly increase and daily living, by these wares and chaffres being brought in fully wrought and ready for sale by strangers, the king's enemies, and other," but that "the greatest part in substance was deceitful, and nothing worth in regard of any man's occupation and profit." The law against the importation of ribbons, &c. was renewed at successive intervals until the 19 Henry VII., when it was made perpetual. Foreign ribbons notwithstanding still made their way over. The silk-throwsters were incorporated by a charter obtained 5 Charles I., about ten years after the establishment of the broad-silk manufacture in the reign of James I.: the silk-weavers were already included in the great company of weavers. Towards the end of the reign of Charles II., the silk manufacture, which had hitherto been almost confined to London, was carried into several other large towns of the kingdom by the French Protestants, who took refuge in this country, to the number, it is said, of 70,000, after the revocation of the Edict of Nantes in 1685; and amongst the rest to Coventry. The ribbon trade, of which Coventry has since become the chief seat in England, was introduced early in the last century by Mr. Bird, assisted probably by some of the French emigrants: the number of French terms still used in the manufacture proves that its origin was, in part at least, foreign. After the treaty of Utrecht, in 1713, French and Italian manufactured silks were admitted under considerable duties; but in 1765 the ribbon and other silk manufacturers procured the re-establishment of the prohibitory system, which was thenceforward maintained for sixty years, enforced by heavy penalties. With the increase of population and the greater demand for luxuries, the home market increased; but an export trade, principally to America, gradually decayed, in consequence perhaps of the heavy duties on raw and thrown silk. During the period of restriction, ribbon-weaving seems to have degenerated in this country as regards the superior branches. In 1824 the government determined to try the effect of an approach to free trade upon the silk manufacture. As a preliminary step, the duties on raw silk were reduced from 4*d.* per lb. to 3*d.*, and afterwards to 1*d.*; and on thrown, from 1*s.* 8*d.* to 7*s.* 6*d.*, and afterwards to 3*s.* 6*d.*, 2*s.*, and 1*s.* 6*d.*, according to quality; with a drawback to the amount of the duty allowed on any manufactures of silk exported, whether they were or were not made of the foreign thrown silk which had paid the duty. Two years were allowed after the lowering of these duties to prepare for the admission of foreign manufactured silk at a duty of 30 per cent. But this step was strongly opposed by the ribbon manufacturers of Coventry, who were unanimous in demanding a total prohibition of foreign ribbons; they succeeded in procuring, in 1832, the appointment of a committee of the House of Commons to inquire into the state of the silk trade. Nothing short of this (they said) could enable them to make ribbons at all. This inquiry led to no alteration in the system which the government had adopted; and subsequent remonstrances made by the same parties had a similar result.

Without tracing in detail the progress of the trade and the alterations in the duties, it will suffice to give a few figures relating to the last few years. Sir Robert Peel wholly removed the import duty on raw silk in 1845; and since that year every part of the trade has extended. The raw silk imported between 1844 and 1860, varied from 4,133,000 lbs. (in 1844) to 12,078,000 lbs. (in 1857). But the last-named year was an exceptional one, in regard to the largeness of the import; the import for the last seven years has averaged about 8,000,000 lbs.

per annum. The above is *raw* silk, in the hank. The *thrown* silk, ready for the weaver, is imported in much smaller quantity, varying from 300,000 lbs. to 1,000,000 lbs. per annum. Manufactured silk goods imported are entered by the *lb.* or by the *piece*, according to their character—that is, European goods by the *lb.*, and India goods by the *piece*. About 300,000 lbs. of broad silks and 400,000 lbs. of ribbons, from the continent, together with half a million pieces of India goods (Bandanas, Corahs, Choppas, Tussire cloths, Romals, and Taffetas)—have been about the average quantities within the last few years. Omitting all years but 1859, we will give the exact figures for that date:—

Raw silk, from China . . . . .	3,192,632	} 9,920,891 lbs.
" " India and Egypt . . . . .	5,805,487	
" " other countries . . . . .	922,772	
Waste, knubs, and husks . . . . .		20,808 cwt.
Thrown silk, from France . . . . .	155,872	} 327,462 lbs.
" " other countries . . . . .	171,590	
European blond, silk, and satin . . . . .	305,523	} 987,080 lbs.
" gauze, crape, and velvet . . . . .	41,918	
" ribbons . . . . .	479,106	
" plush for hats . . . . .	160,533	
India piece goods . . . . .		343,034 pieces.

The *exports* of course do not comprise any *raw* silk. Of *thrown* silk, in the various forms of thread and yarn, the quantity exported from 1844 to 1860, varied from about 200,000 lbs. (in 1848) to 1,400,000 lbs. (in 1856). Of woven silk goods the quantity varied from 600,000 lbs. (in 1848) to 3,000,000 lbs. (in 1856). Taking one particular year (1853) as a fair average for seven recent years, we find that the computed real value of all the silk and silks imported was about 8,000,000*l.*; and that the declared value of the silk and silks exported was about 2,000,000*l.* Raw silk is imported duty free; manufactured goods pay an import duty, which in 1853 amounted to about 900,000*l.* By the new commercial treaty with France, England has given up about 300,000*l.* a year, that having been the produce of duties laid on French silk and silk goods.

Without going into details, it may suffice to state that the quantity of silk imported in 1860, whether raw, waste, or thrown, was less than in 1859; but greater in reference to manufactured silk. The export of silk goods woven in England was smaller in 1860 than in 1859; but of silk-thread and yarn, it was higher.

Mr. Winkworth, a Spitalfields manufacturer, estimated in 1857 that 50 millions sterling are sunk in the United Kingdom in the silk manufacture, and that 1,000,000 persons are supported by it. For the number of mills, see FACTORIES.