THE STORY OF SILK & CHENEY SILKS

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The First Silk Culture

THE STORY OF SILK & CHENEY SILKS

THE FIRST SILK CULTURE

Mediaeval China
Killing Cocoons by
Steaming

CHINESE myths date the culture of silk back to 2640 B. C., almost 3,200 years before its nature was understood in Europe.

One of the three emperors to whom the Chinese ascribe the beginning of their ancient customs was Huang-Ti, who is said to have invented the making of garments, which possibly means an improvement in weaving. He instructed his Empress, Si-Ling-Chi, to experiment with the wild silk worms, which lived on the mulberry trees, to see if they could be raised by the people.

Whether the silk in their cocoons had previously been, like linen or wool, not reeled, but spun, and then made into cloth, is not stated, but seems probable. The Empress collected a large number of the worms from the mulberry trees, learned how to feed and raise them, and what is much more important, how to reel or unwind the silk filaments from their cocoons.

Immemorial Customs

While this account is only a legend, it emphasizes the fact that silk culture was known in China from time immemorial. A number of notices concerning it in the oldest Chinese books confirm this statement. Confucius, for example, about 500 B. C., noted that the emperor and his vassals maintained, near a brook, a government nursery for mulberry trees and silk worms. It was then the custom for lots to be drawn by the ladies of the three palaces, and for the lucky ones thus chosen to be sent to the nursery to care for the worms.

In the last spring month the young empress was wont to purify herself and offer a sacrifice to the goddess of the silk worms. She herself would go to the fields and gather mulberry leaves. The raising of the silk worms was so important that at this season she would dispense with the waiting women who sewed and embroidered for her, and forbid similar work for the noble ladies and ministers' wives in order that all might give their attention to the culture of the worms. As this suggests, the silk industry in ancient China was considered so vital to the prosperity of the people as to be interconnected with various religious rites.

Earliest Records of Silk Culture

From a compilation made by the Chinese government of the early notices and rules in regard to silk culture, it is possible to get a very good idea of the methods they employed even in the earliest, as well as mediaeval, times. There are also several paintings on antique porcelains and a number of quaint wood cuts by ancient Chinese artists, which serve to visualise the industry and give something of its atmosphere as it existed in those far off days. Low-Show, for example, in 1210 produced a whole series of 46 wood cuts showing the processes of agriculture and silk culture which had already been in use from time immemorial.

Ancient China—Gathering Mulberry Leaves

The Ancient Chinese Industry

The industry naturally fell into the great divisions of raising the mulberry trees, producing cocoons, reeling, and weaving the silk.

The Mulberry Tree

It was early recognized that there were two great species of mulberry trees,—the loo, or large mulberry, which was common in the north, and the king, or dwarf mulberry, which was native to the south. The king was more hardy, but the loo had larger and more abundant leaves. For this reason the Chinese early learned to graft a slip from the large on to one from the dwarf mulberry, and to raise the trees from such slips, with the dwarf one furnishing the root. Oil cakes and decayed fish were used for fertilizer. As the tree grew it was carefully pruned by cutting off the central branches, so as to make it spread and increase the foliage.

Raising the Silkworm The briefest outline of the ancient Chinese rules for the raising of the silk worm will suggest what patient, painstaking care the industry demanded.

Care of the Eggs In the spring the eggs, when the moths were through laying them on sheets of paper which had been supplied for the purpose, were hung up until dried. The sheets were then sprinkled with ashes, rolled up and deposited for the summer in a cool place away from damp or smoke. At the beginning of autumn, the ashes were removed. In the middle of January the eggs were soaked for a quarter of an hour in cool juice steeped from mulberry leaves, and perhaps salt. When dry they were again rolled up and laid away.

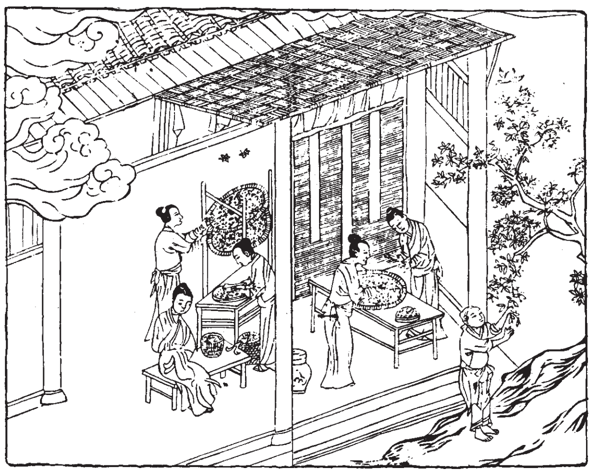
Hatching In the beginning of April, or as soon as the leaves began to sprout on the mulberry trees, the sheets of eggs were bathed in pure water for a quarter of an hour and spread out in an airy place until dry. They were then wrapped in paper and covered with cotton or blankets to receive warmth enough to hatch them. They were sometimes given the warmth required for hatching by being carried next the breast. In seven days the silk raiser examined the eggs, and, if they had begun to change from slaty gray to pea green, watched them carefully for the coming of the worms. If a few came out before the others, such galloping worms, as they were called, were brushed off as useless, because it was considered very important to have the whole culture the same age. When even a third were hatched, they were still wrapped up in paper as before. But the next day the sheets were taken out and spread in a warm spot so as to make the rest of the eggs all hatch together. If some did not do so, they were either kept separate or thrown away.

When the grubs were out, shredded mulberry leaves were sprinkled over them, and as they clung they were delicately removed by silk-worm nippers to the place selected. The fingers could not be used, and even goose feathers were considered too harsh for handling the worms at this stage.

Weighing The cards were weighed with the newly hatched grubs on them, and alone after their removal, so that the exact weight of the grubs could be noted. For every ounce of grubs, the warning was given that the worms, before they spun their cocoons, would require 20 peculs, or 2,660 pounds of mulberry leaves, and it was estimated that they should produce from 150 to 160 ounces of silk.

Raising the Worms The most minute attention was paid to raising the worms. In the course of their life, until they begin to spin their cocoons, the worms change their skin four times, or in the case of some species, only three times, each change being preceded by a period of torpor. For each stage the Chinese had directions for care far too detailed to be repeated.

The worms were said to love quiet and abhor noise; to love cleanliness and abhor dirt; to like warmth and dryness, but to hate dampness, and live without drinking; to hate smoke, wine or vinegar, smells of musk or grease, and mourning women.



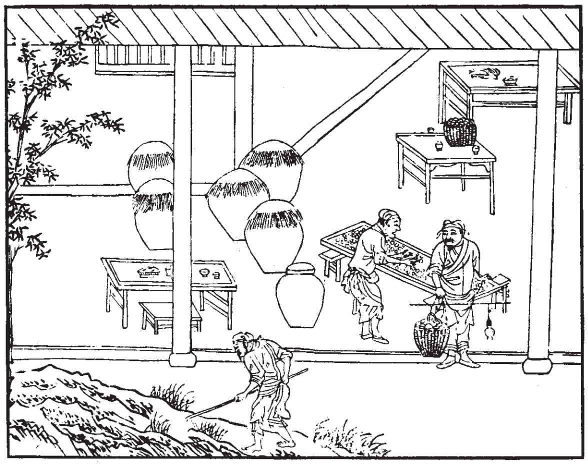
Ancient China—Feeding the Young Worms

It was essential, not only to have the eggs hatched together as described, but for the worms to go into each torpor together and to begin to spin their cocoons together.

Feeding The feeding was in care of the women, the chief of whom was called the matron of the worms. The worms were fed five or six times a day with finely chopped mulberry leaves. It was directed that the hands should be washed before each feeding, and that while feeding, the worms should be placed inside a curtain to keep out the wind and cold.

Care of the Worms The temperature was kept as even as possible by little charcoal fires. If too cold, the worms would be too slow, if too hot, they would dry and shrivel. But if the room were heated too suddenly, the yellow sickness would develop. If the room were cooled too suddenly, the worms would become white and die. Damp leaves for feeding would make them white, while hot ones would make their heads too large and they would not develop into cocoons.

The trays were cleaned every day of all refuse. This in itself required the most delicate handling of the worms. Leaves were spread over them, and when the worms clung to them they were placed on another tray. After the third or fourth torpor they were removed, during cleaning, by means of a silkworm net to which they would cling. When the worms began to look bright yellow, it signified that a period of torpor was approaching. The first one usually took place in six days after hatching. In order to make all molt at once, the food was diminished in proportion to the number that were yellow. Those not falling to sleep were rejected. The first worms to cast off their skins were allowed to remain without eating until all had molted. After that they were fed systematically again. They now increased in size daily, and had to be placed farther apart after each cleaning. The worms were thus raised through four torpors, during which they each increased in size from a quarter of an inch to 3½ inches in length. A batch which at hatching would be no larger over than a checker, after the first molting would require two trays, and after the fourth twenty trays, their weight being multiplied probably 5,000 times. After the fourth torpor the worms were fed all they could eat, in order to increase the flow of silk.



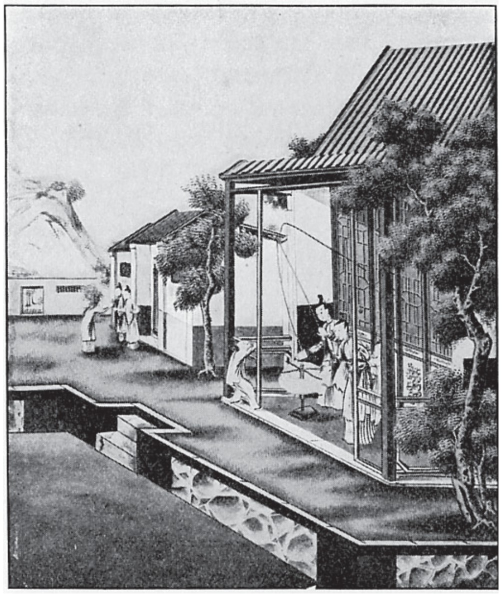
Ancient China—Preserving Cocoons by Salting Down in Clay-Stopped Jars

Spinning the Cocoons

When ready to spin their cocoons, the worms would stop eating, raise their heads, and evince a desire to climb. They were then placed upon a spinning trellis constructed of bamboo and rushes, with branches of rice straw to hold the cocoons. From the first hatching to the spinning required about thirty days. When the worm was placed on the trellis for spinning, it would discharge two silk filaments in the form of a gummy liquid from two minute tubes in its lower jaw, fastening these filaments to a number of straws. On being exposed to the air they would at once harden and act as supports for the cocoon. The worm would then double itself on its back, almost like a horseshoe, with its legs on the outside, and, emitting the filament from its tubes, wind it round and round its body with rapid circles of its head.

Modern estimates are that its head describes about one ellipse a second, and some 300,000 in making the cocoon.

On the fourth day all the silk would be expended, and the worm



Ancient Chinese

within the cocoon would become a dull white, its ten hind legs would wither, the six fore legs would draw together and become black, the skin would wrinkle and be pushed down toward the end, and the chrysalis would appear between the rents of the skin.

Changing to a Moth The chrysalis would at first be white, but later turn to a brownish red. If not interfered with, it would remain in the pupa state from fifteen to seventeen days, then change to a moth and break through the cocoon. The moths would mate immediately, and in the course of the next three days the female would lay some 350 eggs on a sheet of paper already arranged for her. The eggs at first would be yellow, then brown, and finally turn gray. The moths would live only ten or twelve days and eat nothing.

Preserving the Cocoons The Chinese discovered, however, that in order to reel the silk it was necessary to do so before the cocoon was pierced by the chrysalis, as this fractured the threads. Hence, only a few of the best cocoons were left for breeding.

From two to five days after the spinning, they would take down the cocoons for reeling, and either reel them at once or preserve them by killing the chrysalis. A very early method of doing this was by salting them down in air-tight earthen jars. Another was to kill the chrysalides by exposing the cocoons in the hot sunshine, but the results of this were more uncertain. A somewhat later method was to steam the cocoons over hot water and afterward dry them before putting away until used.

The invention of a method of preserving the cocoons for future reeling was very important, as it was absolutely impossible to carry on the slow process of unwinding the silk from them as fast as they were spun by the worms, or before they were spoiled for reeling by the moths breaking through them.

Reeling the Silk from the Cocoons

The ancient Chinese method of reeling required the utmost patience and was inexpressibly tedious.

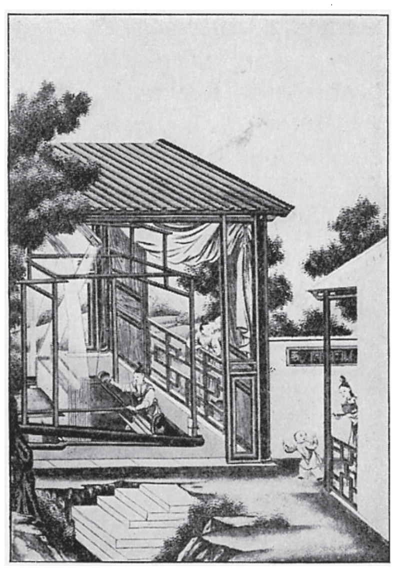
A little furnace was built of bricks and clay, and heated with charcoal or dried dung. Over the furnace the cocoons were placed in a pan of hot water. If the water were too hot the cocoons rose to the surface, if it were too cold they sank to the bottom.

The reeler then stirred the cocoons and searched for the loose ends that had been fastened to the spinning trellis. When these were found, he jerked off the coarse threads on the outside of the cocoon, disclosing the fine silk below. This was the part he sought for reeling.

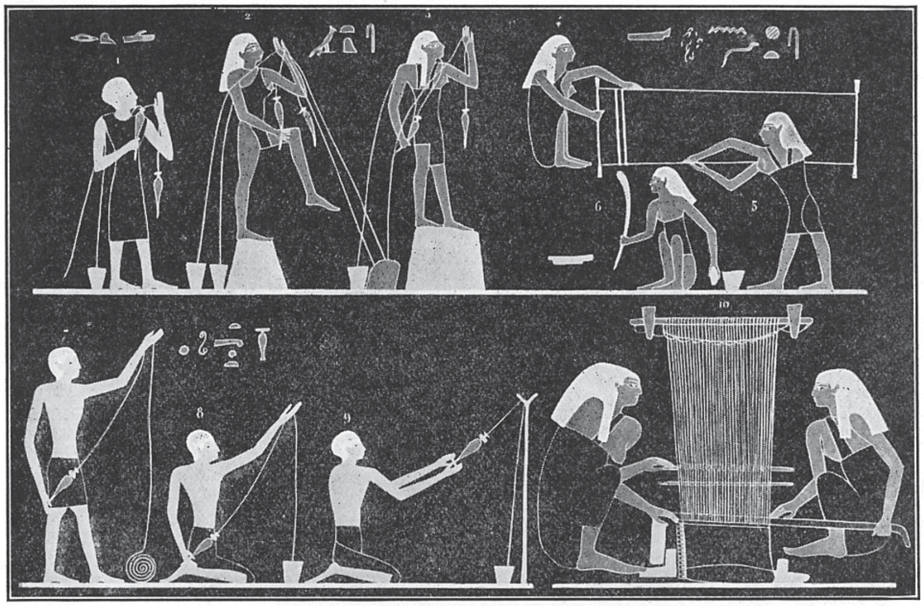
The filament of one cocoon was much too fine to reel. It was discovered that several filaments from as many cocoons could be joined together and reeled at the same time. This not only gave a much stronger thread, but reduced the labor in proportion to the number that were handled at once.

In unwinding several cocoons at a time, the filaments were joined by being drawn through small holes or eyes, their natural gumminess when they first came out of the water causing these filaments to adhere as soon as they came in contact. The thread was then drawn over spools, and wound upon the reel. This was at first turned by hand, but later by foot power. The thread had to be kept a regular thickness by adding a filament for each one that was exhausted, which was indicated by the chrysalis being drawn to the surface of the water. If the filament broke, another was added to take its place. During the reeling the hot water for the cocoons was frequently changed, a third at a time. Each cocoon would furnish from 400 to 600 yards of filament, besides the coarse threads discarded in the beginning and a portion at the end too fine to pay for reeling.

The process of reeling not only demanded the greatest care, but was very ineffective. Working from daylight till dark, the ancient Chinese reeler could reel only from one to two pounds of thread a week.



Mediaeval Chinese Weaving



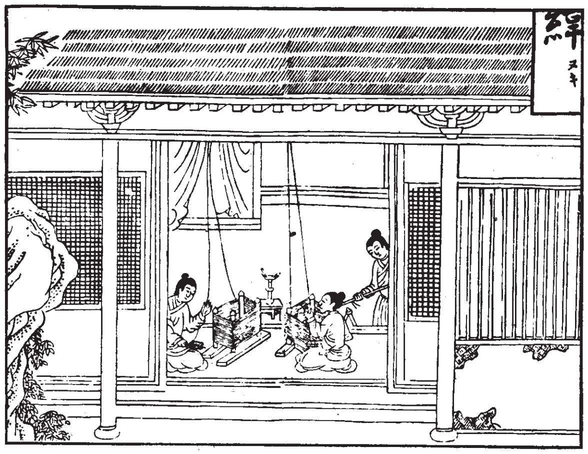
See page 15 The Earliest Picture of Weaving and Spinning

Spinning Silk Besides thus reeling silk, the Chinese, even in ancient times, used to spin silk,—in fact, this was probably the original method of utilizing it, though it fell into comparative disuse for silk after reeling was perfected. The distinction between spinning and reeling is absolute. Reeling is simply unwinding the silk from the cocoons which the silkworms have already spun. In making spun silk, the shorter fibres combed out from the tangled or broken silk made in reeling the pierced cocoons, and what other silk cannot be reeled or would otherwise be wasted, is twisted or spun into thread just as cotton or wool is spun.

The cocoons from the wild silkworms for this purpose were hunted for in the trees where they abounded. Some of them could be reeled, but many of them had to be spun, either because already pierced or too tangled for reeling.

The earliest method of spinning was to draw out with the hand a few filaments from the mass, and, having fastened the end on a round or pear shaped piece of heavy wood or stone, to keep whirling this spindle in order to twist the filaments, as fast as supplied, into a thread.

Preparing for Weaving To prepare either the reeled or spun silk for weaving, it was twisted, doubled, and then twisted again as many times as necessary to give the desired



China, A. D. 1210—Winding Spools

weight. In early days this was all done by hand,—the thread being run off from the reel into skeins and upon spools. As already mentioned, the raw silk was very gummy, but just how much of this gum was in ancient times abstracted before spinning, twisting, weaving, or dyeing, it is impossible to state.

Weaving The earliest method of weaving was almost as crude as was spinning. The threads to form the warp were stretched between the two ends of a frame which were as wide as the cloth was to be. For the simplest texture the threads for the weft or woof were drawn alternately in and out between those of the warp. This was at first done solely by hand, with the warp threads fastened to a large needle or rod with a hook at the end. Ancient pictures show that two rods were used, which were run between the alternate threads of the warp, to hold it in place. When the woof was run through, it was pressed against the woven portion with another rod.

Whether this was the crude loom accredited in the Chinese legend to Huang-Ti or not is, of course, uncertain, but such a loom, together with the hand spinning already described, appears in Egyptian pictures as early as 3000 B. C., where it was used especially for linen, silk being then unknown in Egypt.

The Chinese had already in ancient times taken the next great step in the development of the loom, which was to run the threads of the warp through eyes which were joined to rods, so that when one rod or heddle was lowered one set of warp threads would be lowered to let the woof go above them and below the other set, while, when the other rod was lowered the alternate set of warp threads would be lowered to let the woof pass above them.

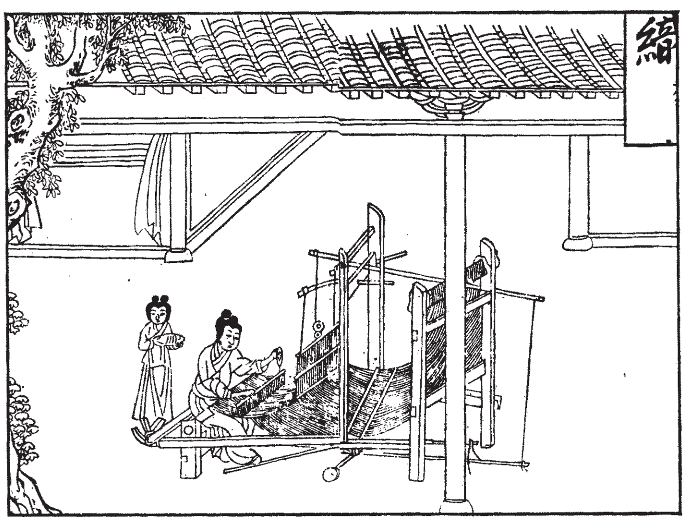
An early device was the use of a foot treadle to lower the rods. Another improvement was the development of the needle for running the woof. The first step was probably the use of a spindle or spool with thread for the woof on it; the next step, which seems to have been delayed until the Roman Era, was to enclose the spool, as a bobbin in a shuttle.

From various sources it is known that ancient silk was woven in many different patterns and colors rivalling the flowers of the meadows. Sixteenth century pictures show the Chinese using a draw loom for this purpose.

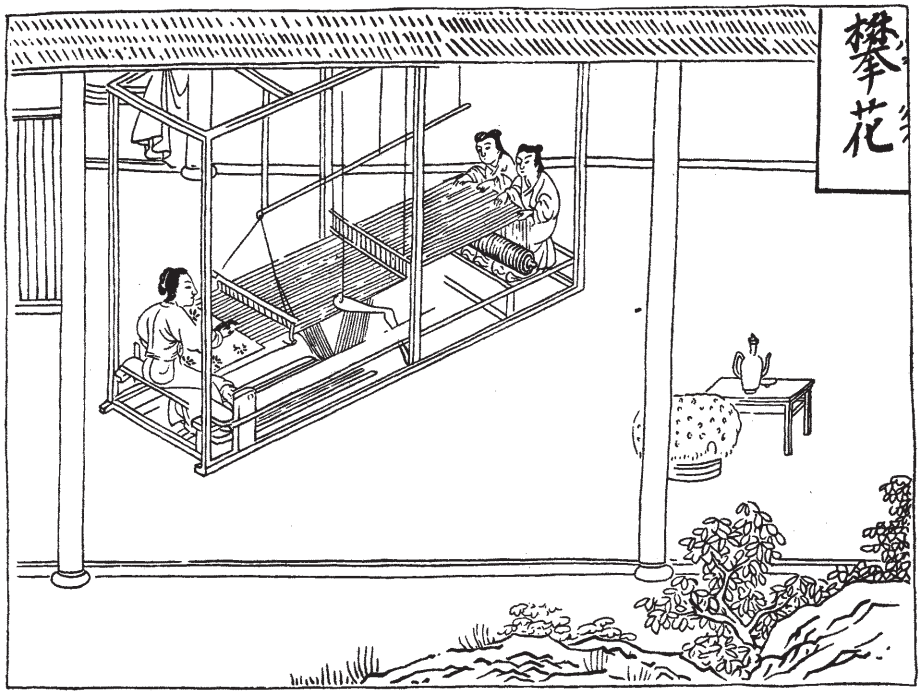
Dyeing and Printing

There are old Chinese pictures in existence showing the dyeing both of silk thread in skeins and of silk cloth in the piece.

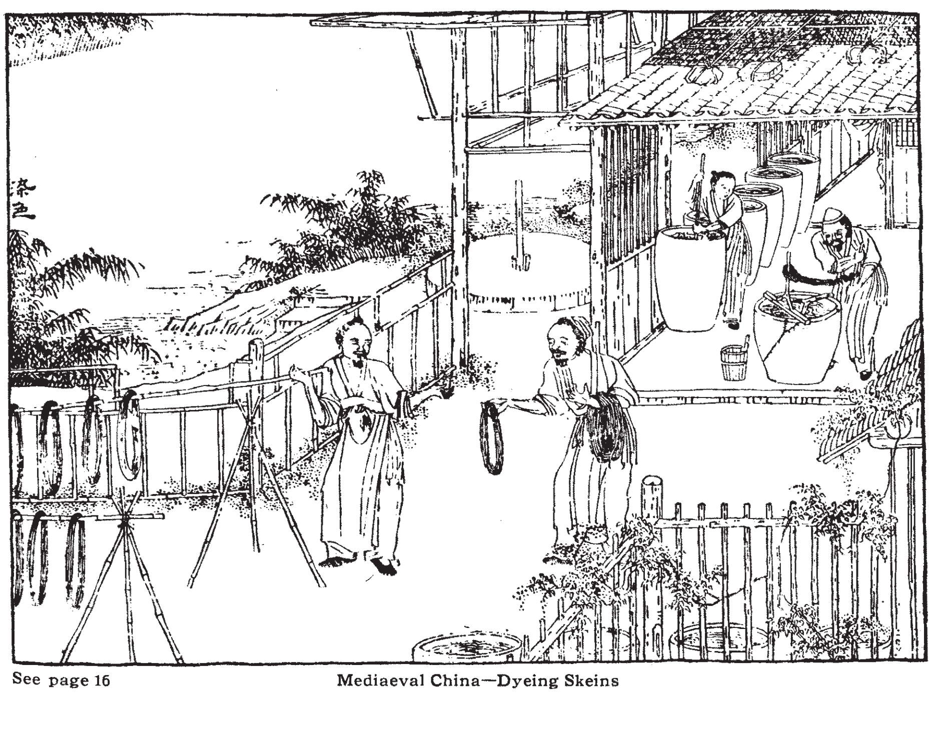
After the Chinese learned to make blocks with which to print their alphabet, before the Christian Era, they applied this method of printing to silk. Another very early method of printing was by means of painting over a pattern cut out in japanned ware, or, as we would say, a stencil.



See page 15 Ancient China—Weaving



See page 15 China, A.D. 1210—Weaving Pattern



See page 16 Mediaeval China—Dyeing Skeins

Silk Culture in Ancient Europe

See page 23

Delivering the Eggs of the Silk Worms to Justinian

SILK IN ANCIENT EUROPE.

AT how early a date silks were first imported into the countries around the Mediterranean we shall probably never know.

Aristotle and Pliny say that Pamphila, the daughter of Plateos, king of the Island of Cos, was the first one who discovered the art of unravelling the heavy silks imported from the East, and re-weaving from them a tissue so translucent as to reveal and yet conceal a woman's charms.

This implies that silks were imported before 400 B. C. But for nine centuries after this, the only manufacture of silk in the Western World was such an unravelling and re-weaving of foreign goods.

There was, of course, no direct trade between the Mediterranean and China. Even the Romans bought their silks from the Persians, who in turn got them from northern India, or from some other point to which they were carried from China, while the Chinese themselves did all they could to keep the process of silk production a secret.

Prohibitive Expense The fact that all silks were imported over difficult and dangerous routes totalling thousands of miles, made them extravagances even for emperors.

Nearchus, one of Alexander's generals, was said to have been the first Greek to don an all-silk garment. Silk was introduced into Rome after the Parthian wars, 54 B. C., but remained rare and costly. Marcus Antonius sent an embassy to the Seres to make a treaty about importing silk, but without results, and it continued to be supplied through the Persians. The first Roman to wear pure silk robes was Heliogabalus, the Emperor (222 A. D.) and he was considered extremely self-indulgent for so doing.

The Emperor Aurelian (273 A. D.) refused to allow his wife to buy a silk shawl, because it was priced at literally its weight in gold.

The Emperor Tacitus made it unlawful to wear silk unless mixed with other materials.

Silk a Mystery to Europe The source and nature of silk itself continued always a mystery, and writer after writer referred to it in terms which show his misconception of its character.

The first statement in the West concerning the silk worm is found in the "History of Animals," by Aristotle, who probably heard of it when he accompanied Alexander in his conquest of Persia.

Virgil, in his line, "Seres comb their fleece from silken leaves," seems to have confused silk with cotton.

Dionysius thought that the Seres combed the variously colored flowers of their desert land to make precious figured garments rivalling the spider's web. This is, at least, evidence that the silks imported had fine threads and were strikingly dyed.

In the First Century A. D., Seneca wrote that the shining thread was gathered by the Seres from the boughs.

Pausanius, the traveller and geographer, fancied that silk came from an animal twice the size of a large beetle, but resembling a spider, and that the Seres fed it upon green reeds until it burst, whereupon most of the thread was found in its body.

In the second century, Tertullian imagined it came from a worm, which spread a web, floating through the air like a spider's, and then devoured it, after which, when it was killed, one could roll living threads from its stomach.

Ammianus Marcellinus, in the fourth century, declared that the soil furnished the Seres so soft a wool that after being sprinkled with water and combed, it formed cloths such as silks.

All of these grotesquely mistaken ideas serve to emphasize how great a mystery the production of silk really was, which thus baffled the investigation and even the imagination of the Mediterranean world for so many centuries.

The Culture Spreading The knowledge of its culture was, however, gradually spreading. About 289 A. D., it was carried to Japan along with Buddhism. It is said that there were imported four Chinese girls, who taught the Japanese the intricacies of silk culture,—a service which was considered so great that temples were raised in their honor.

Under the twenty-first Mikado (459-479 A. D.) the planting of mulberry trees was introduced, and the whole culture seems to have been well established by 550 A. D.

India, it is said, first learned the raising of silkworms from a Chinese princess (300 A. D.), who, at the time of her marriage, carried the eggs with her in her head dress. At any rate, it seems to have been introduced overland from China. From India it slowly spread to Persia and central Asia.

But as late as 500 A. D., after the fall of Rome, it was still unknown in Constantinople or elsewhere in the Roman Empire of the East. Justinian, who was Emperor from 527 A. D. to 565 A. D., decreed that the price of silk should not be over 8 aurei, or about $23 a pound. This, however, was less than the merchants had paid for it, and they began to quit the business, selling the silks on hand for what they would bring. The Empress Theodora thereupon, in accordance with the decree, fined the merchants and confiscated the goods, the Emperor, himself, assuming control of the trade.

Up to this time most of the silk had come through the Persians, but the wars which were now waged between them and the Empire (529-549 A.D.) cut off the supply. Justinian tried to make arrangements to procure silks through other routes, and let it be known that he was very anxious to break the Persian monopoly of the trade.

The Mystery Solved

Just at this moment, according to Propocius, two Nestorian monks arrived from Serinda, and learning Justinian's desire, went to him and said that they had long resided in the country called Serinda, and had carefully informed themselves of the method by which raw silk might be produced in the Roman Empire. In reply to minute questioning by the Emperor, they explained that raw silk is a product of silkworms. They said that it would be impossible to bring the worms alive to Byzantium, but that each silk moth produces numberless eggs, which long afterwards caretakers cover with fertilizer and hatch by warming. They declared that if the eggs could be procured, the raising of the worms would not be over-difficult.

The First Silk Culture in Europe

The Emperor promised the monks a handsome reward if they could put their plan in execution. Thereupon they retraced the long journey to Serinda, and although their act was punishable by death, having secreted a good supply of the silk moth's eggs in hollow wands or staves such as were occasionally carried by pilgrims, returned with them in safety to Constantinople. Here they hatched the eggs by the methods they had learned abroad, and raised the worms by feeding them upon the leaves of the black mulberry tree, which was native to Greece.

Justinian reserved a monopoly of the trade, and kept the monks at the head of the sericulture of the State, and as instructors for his subjects, among whom he tried to encourage the extension of the industry.

The progress made was scarcely encouraging, the price of silk rising to several times that formerly asked for the imported product.

The wars with the Mohammedans, however, cut off importations from the East, and tended to stimulate silk culture in Greece. The same effect was produced when the Chinese rebel, Baichu, in 877 A. D., destroyed Canfu, the principal Chinese city from which silks were exported.

But in spite of great encouragement, the silk industry spread but slowly from Constantinople throughout Greece, and, along with the Mohammedans, into northern Africa. As late as 1146 A. D. there seems

Italian Filature of 1500

to have been no silk produced in Europe outside of the Greek Empire, except, perhaps, by the Saracens in Sicily and southern Spain.

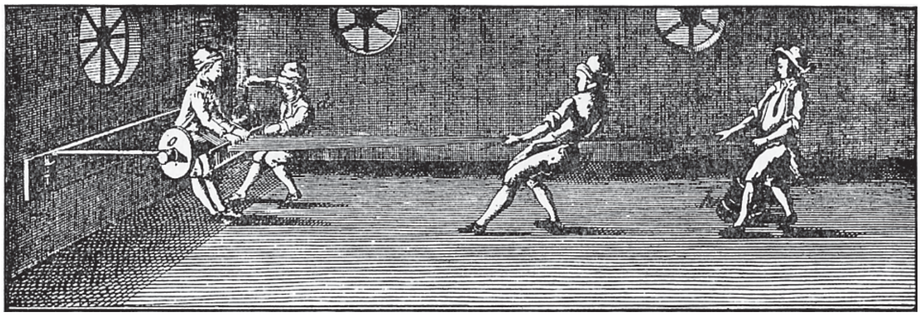
In Southern Europe The successful introduction of silk into the rest of southern Europe was largely the result of several wars. In 1146 Roger, the first Norman king of Sicily, waged a campaign against the Greek Empire, and during its progress carried off a large number of silk raisers and weavers to Palermo in Sicily. Silk had already been introduced there by the Saracens, but the influx of skilled hands gave a great impulse to the industry.

In a similar manner the Venetians, in 1203, through means of their victories over the Greek Empire, acquired a number of the best silk districts of Greece. Silk culture was considered so highly that even the noble families there could engage in it without degradation. Through Venice, the industry was carried to Italy, and in the next century spread there so that by 1300 there were several thousand engaged in it at Florence, and it was highly important in other cities such as Genoa, Modena, and Bologna.

The only successful throwing mill for twisting silk in Italy, and, for that matter, in Europe, outside of Greece, was in Bologna, and it remained so until 1500.

During the Dark Ages of Europe, a great improvement in weaving seems to have been invented in the East. This was the draw loom, which made much easier the repetition of a pattern. The principle made use of, was to divide the number of threads of the warp into as many equal sections as the pattern was to be repeated in a width of the goods, and fasten all the similarly numbered threads of each section to one cord. When this cord was drawn, all the corresponding threads would be lifted at once. At that time a helper was necessary to draw the cords governing the warp, but this was later done by machinery.

The draw loom seems to have been found in use at Damascus, by the Crusaders, and the idea brought back by them to the West.



Putting Warp on Roller, A. D. 1750

IN FRANCE.

IN France the silkworm was known and experimented with several centuries before its culture was successful there. It is believed that the first white mulberry tree to be planted in France, was brought from Syria by Guiappe de St. Aubon, on his return from the second Crusade about 1147 A. D. It was planted near Montmeliart, and, what seems very remarkable, was still standing in 1810.

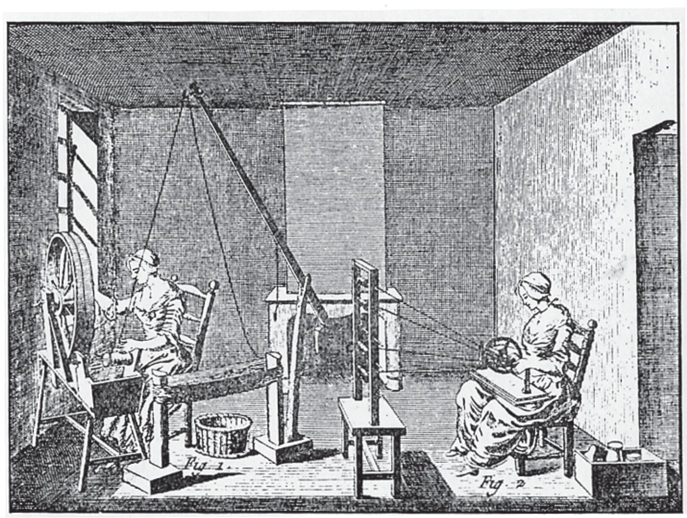
The weaving of silk seems to have been begun in Lyons and Tours not long after 1200. There was, however, no silk as yet produced there. In 1480 Louis XI brought silkworms from Genoa, Venice, and Florence, which were then under his power. Charles VIII in 1494 renewed the effort to raise mulberry trees. In 1521 Francis I brought a large number of silk weavers from Milan, which was then held by France, to Lyons, and also attempted to grow mulberry trees.

The first nursery of white mulberry trees was set out by Fraucot, at Nimes, in 1564, but was only partially successful. In 1603 Henry IV (of Navarre) really established sericulture in France. He brought Ollivier de Serres, who was experienced in the industry, to his aid, and the people were encouraged to raise both mulberry trees and silk worms. Their first attempts, however, failed because the intricacies of the culture were not widely enough understood. The worms died, the cocoons were pierced, and the whole attempt seemed about to end in disaster, but Henry IV established his own nursery, under experienced silk growers, and through their careful attention soon produced an abundance of silk. Instructors were supplied for the people, who, when they saw a successful example before them, again took up the culture. The experiments at this time cost 1,500,000 livres, but established the industry.

Colbert, the chief minister under Louis XIV, also did a great deal for the development of silk culture, and the textures of Lyons and Tours became famous.

The industry was, however, hard hit by the Revocation of the Edict of Nantes in 1685. This drove some 400,000 Huguenots from France, many thousand of whom were engaged in the production and weaving of silk. It is said to have reduced the working looms of Lyons from 18,000 to 4,000, and at Tours, from 11,000 to 1,200. It was thirty years before the industry recovered from the blow.

Many thousands of the Huguenots settled in other countries, notably England, Switzerland, and Germany, and gave a tremendous impetus to the growth of silk manufacture there.



Winding on Spools, 1750

IN ENGLAND.

SILK was manufactured in England as early as 1251. At the marriage of the daughter of Henry III a thousand knights appeared with silk garments. In 1455 a committee of silk women protested against the importation of Italian silks. There was a guild of silk throwers at Spitalfields, London, in 1562. John Tice, in 1573, claimed to have perfected the making of tufted taffetas and wrought velvets. The first large manufacture of silk dates from about 1585, when Flemish weavers settled there, fleeing, after the capture of Antwerp, during the revolt of Flanders from Spain. Queen Elizabeth was greatly pleased with silk, instead of the previous cloth stockings, and was much disappointed because Lee's stocking machine, invented in 1589, knitted only wool stockings. Nine years later, however, he succeeded in knitting silk, and presented her with a pair.

James I was tremendously enthusiastic over silk, and just as fanatical against tobacco. He made a number of attempts to encourage the raising of silkworms in England, but after fourteen years of failure there, partly because of too damp a climate, shifted his efforts to the Colonies.

A number of notable inventions marked the close of the Seventeenth Century.

In 1671 Edmund Blood obtained a patent for carding and spinning waste silk, which was probably the first successful attempt in Europe to do so. A patent of 1687 was to use a device instead of a helper to draw the cords controlling the warp on a draw loom. In 1693 one was given Francis Pousset for weaving silk crepe. In fact, the influx of the Huguenot weavers in 1685 fairly established that branch of the trade.

There was as yet no thoroughly successful mill for throwing or twisting silk in England. But in 1718 John Lombe, of Derby, went to Italy and got a job in the guise of a common laborer in one of the great Italian silk throwing mills, besides bribing two workmen to let him in after hours. He studied the process, made drawings of the machines by night, and corrected them again from his observations in the mill. The three were discovered and he escaped to a ship at peril of his life. On his return to England, he built the first great silk throwing mill there.

The New Inventions for Textiles

The Eighteenth Century was marked by still more epoch-making inventions for the better production of textiles. They marked the real beginning of the factory system, and ushered in the revolution that followed the application of power to industry.

In 1733 Kay obtained a patent for a flying shuttle to be used in weaving. This placed a shuttle box at each end of the reed, or bed, along which the shuttle had previously been slid by hand. In each box was a picker or hammer, which was fastened by a cord to the picking stick. When the stick was jerked, the picker or hammer struck the shuttle and sent it flying across its bed, or shuttle race, between the threads of the warp, into the other shuttle box. Each shuttle was about ten inches long and contained a bobbin, or quill, wound with woof, so that Kay's invention made the action of weaving almost continuous. It was a number of years, however, before it was extensively used in silk weaving.

Jedidiah Strutt, in 1758, patented his ribbed stocking frame, the use of which enabled him to establish his large hosiery mills at Derby.

Hargreave's spinning jenny (1770), Arkwright's roller spinning (1771), and Crompton's mule (1776), or combination of the two, by 1800 changed spinning from a hand to a machine operation.

Crawford, a London merchant, patented, in 1780, a silk doubling frame, which is notable because it included the first attempt to have a machine stop automatically when a thread was broken. Another invention of that year was printing from plates, by Bell, who developed this into roller-printing in 1785.

Cartwright, in 1774, constructed his power loom to apply either water power or steam to weaving. It was not at first a success, but improvements, in 1803, by Thomas Johnson, in dressing warp before it was put into the loom, and his devices to take up the slack in the cloth, eventually made the power loom practical. It became generally used in the cotton industry by 1815, though it did not make much headway in woolen or silk before 1835.

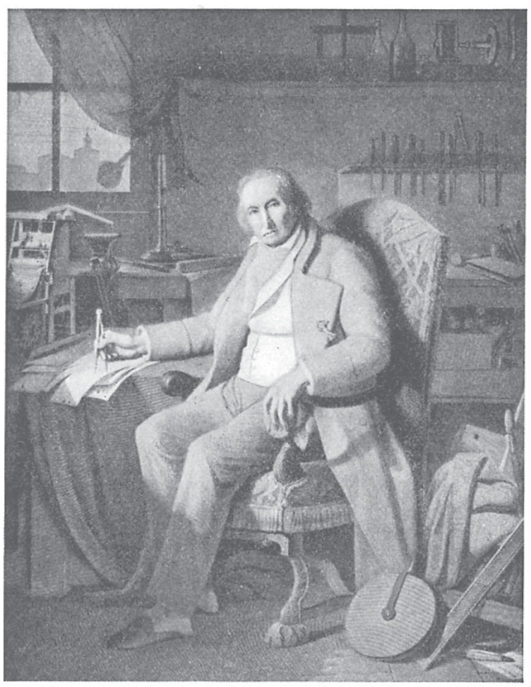
In 1801 Joseph Marie Jacquard, of Lyons, France, exhibited at the French Exposition, his machine for weaving patterns.

Jacquard, in his machine, passed each thread of the warp through an independent eye on a cord of its own. As in the draw loom, a number of these cords, one from each repeat of the pattern, are gathered into one, known as a lash, which is fastened to a hook. These hooks are controlled by paper cards with holes in them, on the same principle as the playerpiano. Where the hole is punched, it allows the hook and thread of the warp to be lifted; where it is not punched, the warp thread remains down and the weft is woven over it. The cards of the Jacquard machine took the place of the system of cords and complicated tie-up of the draw loom.

Jacquard suffered from the hostility met with by many inventors. He was mobbed in Lyons, burned in effigy, and his machine smashed by the crowd. But today most figured designs are woven on the Jacquard machine.

Sir Robert Peel, in 1802, first began to use the method of printing textiles on the resist system. This was an idea thought of by a commercial traveller, named Grouse, and sold for £5. The principle was to print textiles with wax or some other preparation that would resist the dye, so that after dyeing, when the wax was removed, the figures where it had been would remain white.

Asa Arnold patented, in 1823, a bevel wheel for twisting, in order to keep the twist more uniform by keeping the tension on the thread more even.



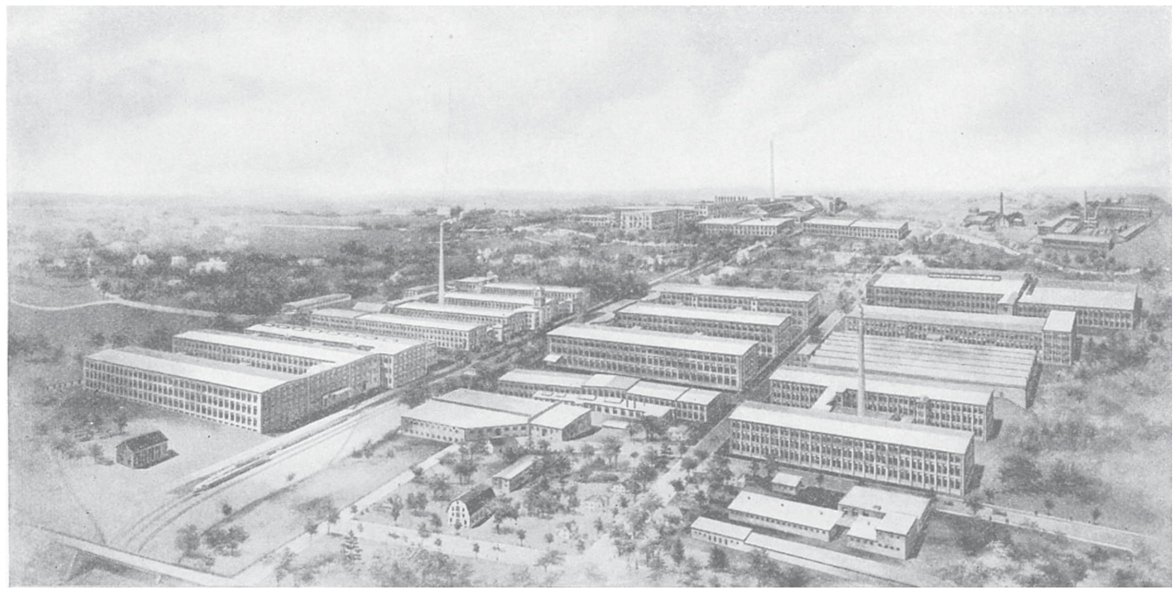
Joseph Marie Jacquard (1752-1834)
Inventor of the Jacquard Loom

In 1824 a method, now common, of weaving velvets double, face to face, and immediately cutting them apart, was patented by Stephen Wilson.

These inventions will give a conception of the furthest advance of the textile industry just before the manufacture of silk was established in America. But it must be remembered that, inasmuch as silk required much more delicate handling than either cotton or woolen, most of these inventions were in use in the cotton mills on an average of twenty years before it was found possible to apply them successfully to silk.

Silk Culture in America

Office Dyeing and Finishing Mills Box Factory



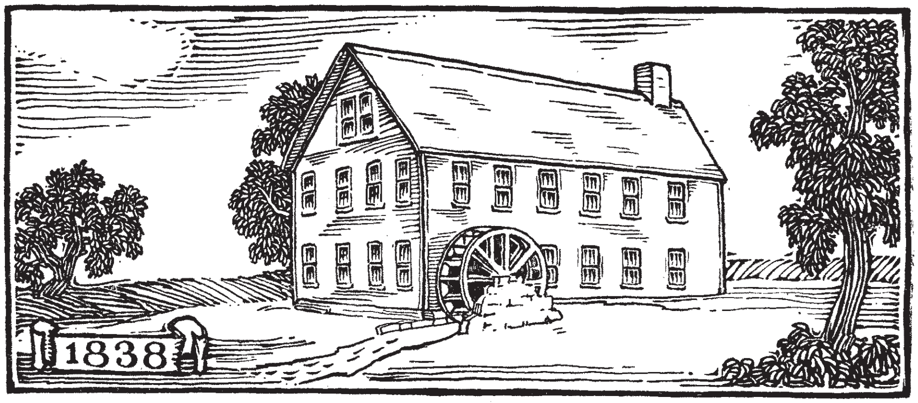
Spun Silk Mills, Length 310 ft.
Throwing Upholstery and Dress Goods Weaving Mills
Length 330 ft

Velvet Mills, Length 300 ft.
Store House Machine Shop

Spun Silk Dressing Mill, Length 496 ft.
Yarn Dye House, Length 372 ft.
Velvet Weave Shed, Length 320 ft.
Ribbon Mills, Length 300 ft.

Total Area of Floor Space, 35¼ Acres

Cheney Brothers' Factory, South Manchester, Connecticut



Original Cheney Mill

SILK CULTURE IN AMERICA.

THE story of the silk industry in America exhibits every phase from the wildest speculation to the utmost failure in one of its branches, and from the crudest beginnings to the most splendid success in another.

The first effort in America toward silk production, was when James I tried to compel the planters of Virginia to stop the cultivation of tobacco, and go to raising mulberry trees and silkworms to supply raw silk for the English factories. In 1623 it was decreed that any Virginia planter should be fined £10 if he did not cultivate at least ten mulberry trees for each hundred acres of his estate.

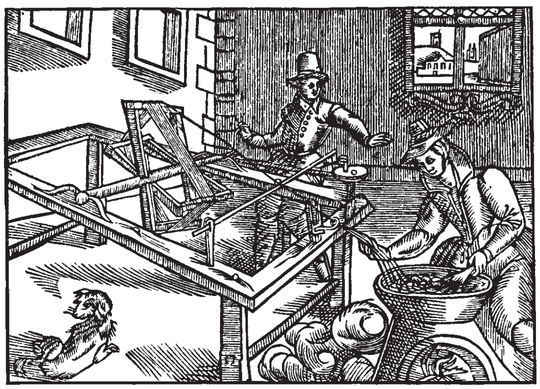
The raising of silkworms was encouraged in 1657, when the Virginia Assembly offered 10,000 pounds of tobacco to any planter who should export £200 worth of raw silk or cocoons in a single year; 5,000 pounds of tobacco to anyone producing 1,000 pounds of raw silk; or 4,000 pounds of tobacco to anyone producing silk exclusively.

The bounty was withdrawn in 1666 and renewed in 1669, but it was never claimed.

The fact was, that silk culture was not profitable in comparison with the raising of tobacco. It suffered from bad weaving, inexpert throwing or twisting, and inadequate cleaning. It was the policy of Parliament not to encourage the manufacture of silk in the Colonies, but only the raising, and the little silk cloth made was fuzzy, stiff, and of poor color and lustre.

In Georgia, in 1732, a nursery of white mulberry plants was set out, and a clergyman experienced in silk culture was sent there to instruct the colonists. Land was given to settlers who would plant 100 mulberry trees for each 10 acres. In 1735 eight pounds of raw silk were sent to England and there thrown, woven and presented to the Queen. Parliament, in 1749, exempted silk produced in Georgia or Carolina from duty. In the same year a filature for reeling silk from the cocoons was built in Savannah in order to overcome the difficulty the individual growers had with this operation.

Silk culture undoubtedly made considerable progress in the Colony, as evinced by the fact that in 1759, 10,000 pounds of cocoons were received at the filature.


Silk Reeling in Colonial Virginia

But just as silk culture could not compete with tobacco in Virginia, so, after the English price was reduced, it failed in competition with cotton in Georgia. This was especially true after the invention of the cotton gin reduced the labor of separating cotton from the seeds to far less than that of reeling the silk.

South Carolina was the next Colony to attempt the raising of the mulberry tree and silkworm. In 1755, Mrs. Pinckney carried with her to England, enough silk of her own raising to weave three dresses, one of which was presented to the Princess Dowager of Wales. The dress retained by herself was still in existence in 1809. The fact that a dress from this silk was considered worthy of such a presentation is boomerang-like evidence that South Carolina silk was still a novelty.

In the North, Governor Leete, of Connecticut, who died in 1683, had some years previously raised silk, and had a suit made for himself from it.

The mulberry was mentioned in legislation in Connecticut in 1732. Dr. N. Aspinwall sent trees to New Haven and Mansfield, together with the eggs of the silkworm, in 1762.

The Connecticut Assembly, in 1763, offered 10 shillings bounty for each hundred mulberry trees planted and kept in good condition for three years; and another of 3 pence for each ounce of raw silk produced. In order to spread the culture, half an ounce of mulberry seed was sent to each parish of the Colony. The bounty was continued for several years, and the culture grew to really important proportions.

Dr. Stiles, president of Yale, was an enthusiastic silk grower from about 1758, and kept a diary of his experiences in silk culture between 1763 and 1790. A woman and three children could make 10 pounds of raw silk worth $50 in five weeks. As late as 1810 the three chief silk counties of Connecticut produced $28,500 worth of raw and sewing silk, besides half that value of waste silk for spinning.

Dr. Aspinwall also introduced the mulberry tree into Pennsylvania in 1767 or 1768. About 1770 there was built in Philadelphia, by popular subscription, a filature for reeling the silk from the cocoons which were to be raised by the silk growers.

A Wild Speculation In the first part of the Nineteenth Century, silk culture in the United States, while not exactly prosperous, continued apparently to promise possibilities of development,—sufficiently so, at least, to be the basis of a tremendous speculation in the thirties.

The boom was built upon the morus multicaulis tree. This was one of the varieties of the mulberry raised in China for silk culture, whence it had been introduced, by way of the Philippines, into France. The first one in the United States is said to have been planted by Gideon B. Smith of Baltimore in 1826. It was soon discovered that, in comparison with the black, or Italian white mulberry, its growth was much more rapid and its leaves several times larger.

When news of these virtues spread, the nurserymen began to get calls for it from widely scattered sources. The demand soon exceeded the supply and a wild rush for the young plants took place.

Several of the Cheney Brothers had begun experimenting with silk culture about 1833. Family diaries and silk culture papers of the next few years give not only a vivid idea of the morus multicaulis speculation, but of other conditions of the period too interesting to be passed over.

The first nursery established by the Cheney Brothers was at South Manchester, Connecticut. An item of the time shows that morus multicaulis trees, the price of which in 1834 was only about $4 a hundred, rose in 1835 to $10, and in the beginning of 1836 to $30 a hundred at the nurseries.

A Norwegian bark arriving in April, 1836, had started from Marseilles with 70,000 of these Chinese mulberry trees, but on the way all perished except some 15,000, which were consigned to Cheney Brothers. It was added that this was the last shipment which could be received until autumn.

The possibilities of the venture were shown by the fact that on May 12th, Ward Cheney had laid 300 trees horizontally, six inches deep in the ground, from which 3,700 shoots had sprung up. The leaves from these, as early as June 25th, he had commenced feeding to some 6,000 silkworms, which produced three bushels of cocoons. By August 1st the shoots were 2½ feet high. With such a multiplication of trees and such quick production of silk, it is no wonder that the boom spread like wildfire.

In November, 1836, the Cheneys leased, for $400 per year, 117 acres at Burlington, New Jersey. They established here a nursery and cocoonery and later another near Cincinnati, Ohio.

It is an interesting detail that the trip from New York to Philadelphia at this time required from 10 A. M. to 5.30 P. M., and was made via a steamer from New York to South Amboy, a train to Bordentown, and another steamboat to Philadelphia.

In October, 1837, the Cheneys had sold about $14,000 worth of trees from Burlington, N. J., and had about 50,000 on hand. The trees at this time brought about $30 a hundred. Silkworm eggs were $5.50 an ounce.

Most of those who got in early, got big returns at first. A Monmouth, New Jersey, man had made a clean profit of $3,000 from a $400 investment in the trees. With the multiplication of such instances of results, the rage for the multicaulis spread all over the country, and the price mounted still higher.

In January, 1839, trees brought from a dollar to two dollars apiece, and in isolated cases soon reached as high as $300 and even $500 a hundred.

But all of this speculation had been going on in spite of the panic of 1837. During 1839 the hard times, which had already affected other fields, spread to the nurserymen and silk culture. At almost the same instant came the realization that the morus multicaulis was not hardy enough to be raised without difficulty in the North, and that, even if it could be, Americans would not take the trouble and pains necessary to the successful culture of silkworms.

By 1840 the crash was complete. The silk growers had wasted their money. The nurserymen were left with great quantities of the trees on hand, which had cost them heavily and were now worth next to nothing. Importers could not even pay the freight on their shipments from abroad. The trees were sold for such humble uses as pea brush, or unceremoniously uprooted and burned. Practically everyone in the business bore his share of the loss.

This shock to silk culture was followed by another disaster, which was unavoidable, and an ever-present risk of the silk producer.

Difficulties of Silk Culture Here

In 1844 a fatal blight affected almost all of the mulberry trees in the country. This caused the loss of all the multitudes of silkworms, and practically drove the growers out of business. Even at Mansfield, Connecticut, where it had been most prosperous, the culture was finally abandoned.

Although several other attempts have been made to revive the production of raw silk in the United States, none of them has been sufficiently successful to make a repetition advisable.

The fundamental reason for this is, not that mulberry trees and silkworms cannot, though with difficulty, be raised in this country, but that the production of raw silk is essentially a household and hand process, still requiring, as in the days of ancient China, infinite patience and an altogether disproportionate amount of human labor. Even in Italy, during the silkworm season, the whole house, including the bedrooms and beds, is given over to the worms, upon which the women lavish every attention from daylight until late at night,—and for all this trouble and work, they net only six or seven cents a day. In Japan and China such household labor may bring as low as two or three cents a day.

Silk cannot be grown by the highly paid labor of the United States in competition with such meagrely rewarded Oriental drudgery, nor can household hand labor compete here with other industries in which most of the energy is furnished by power and most of the work done by machinery.

But the manufacture of silk goods has in recent years, along with all other textiles, been so revolutionized by the application of inventions and power, that the silk manufacturers of the United States, which is essentially the home of the machine, not only include some of the greatest concerns, but produce much of the best silk in the world.

Silk Manufacturers in America

In Colonial days, whatever silk was manufactured here, was made entirely in the home. It was reeled by hand, thrown, or twisted and doubled by hand, and woven on the crude foot-power loom of the period by the women of the family. The early attempts at silk manufacture were all failures.

Silk Worms on Mulberry Leaves

The first silk mill in the United States seems to have been started by Rodney and Horatio Hanks, at Mansfield, Connecticut, in 1810. The mill was but 12 x 12 feet in size, and was intended to make sewing silk and twist on a machine of their own, which was run by water power. This mill and two others, with which they were later connected, were abandoned by 1828, largely because the machinery was too crude to produce satisfactory results. In 1815, William H. Hortsmann, in Philadelphia, built a mill for trimmings and ribbons in which he attained partial success with machines for plaiting, braiding, and fringe cutting. A Jacquard loom was imported by him in 1824. The Mansfield Silk Company, which was begun in the center of the silk growing district, made use of water power for reeling, but was unsuccessful in its attempts at weaving, and failed as a result of its speculations in the morus multicaulis.

The first really successful silk manufacturers in the United States were the Cheney Brothers. Their original mill was started as the Mt. Nebo Silk Mills, at South Manchester, Connecticut, in January, 1838, and, although somewhat neglected during the wild speculation in the morus multicaulis, it is the only mill established before that date that has been permanently successful.

Crude Beginnings

The story of the Cheney silk mills is typical of the growth of the industry, and, even more than that, of the development of the United States from an agricultural to a manufacturing country. A number of details which have been preserved in old diaries, show how crude was their beginning, and, in fact, the start of most factories at that period.

Ralph, Ward, and Frank Cheney, together with E. H. Arnold, agreed in November of 1837 to form a company for silk manufacture. Their first idea was to adapt the barn for a mill. The machinery was ordered in December, to be completed April 1st. The company was actually formed, January 2, 1838, with a capital stock of $50,000.

It was decided not to try to use the barn, but to build a factory. The size was only 32 x 45. A deal was made to have the timber hewn out at four cents a foot, while the joiner's work was contracted for at $262. An old-fashioned bee was held on March 31st for the raising of the mill.

The power for the silk factory was taken from the bottom of the tail-race of a mill which served at different times for paper making, grist grinding, and distilling. A little undershot wheel was used, and there was altogether only a six-foot fall. When the mill above was not running, the water supply was shut off from the silk factory. The Cheney factory was at the end of a road, the track of which was changed at the pleasure of the driver. Beyond the mill was a rather sandy pasture, full of huckleberry bushes.

An Important Improvement

One important feature of the factory was the use, in doubling and twisting, of the new Rixford roller made for the Cheneys. This was turned only by friction, and hence would give a little in drawing out the silk, and thus avoid breaking it, as the former fixed rollers had been constantly doing.

As this principle is well-nigh essential in working silk, the Cheney factory, even at its very inception, introduced an almost revolutionary improvement.

Details of the Forties

The first energies of the company were devoted chiefly to sewing silk, which was made almost entirely from raw silk imported from the East.

Records of 1843 show that the average pay in the silk mill, employing both men and women, was only fifty-one cents a day.

In 1844, Ward Cheney learned the main points of silk dyeing from a Mr. Valentine, of Northampton, Massachusetts, and they were soon applied to the business, though at considerable cost for experimenting. In this year sewing silk was sold to their agent in Philadelphia at from $6.50 to $7.50 a pound.

The first practical machine for making sewing silk was patented by Frank Cheney in 1847. The success of the machine in doubling, twisting, and winding, depended largely upon the use of live or moving spindles on a carriage which ran back and forth on tracks in the second story of the mill.

It is an interesting sidelight, that the employees used to take up the track for dances at night and relay it when the dance was over. The children were often brought along and encouraged to sleep on the benches while the parents danced. Other entertainments, including private theatricals, were not infrequently given in this improvised hall.

In 1848 the wages of the men averaged $1.14 a day; of the women, 63 cents a day. The total average was 72 cents.

It is a curious fact that the Public Library of the town developed from the books which were read to the girls in the skein room while they worked. At that time no machinery was employed in this room, and the girls used to bring books of their own, which were supplemented by others from the concern, to be read aloud there. These were afterwards brought together and formed the nucleus of the library.

Frisons After Washing
Cheney Brothers' Factory

Influence of the Sewing Machine

The invention of the sewing machine greatly increased the call for sewing silk, and created a demand for stronger and more even thread than had been used in hand sewing. Whereas in hand sewing the thread had been twice doubled and twisted, it was found valuable for machine sewing to combine three threads. The manufacture of machine twist was begun by the Cheneys as early as 1852, and soon developed into an important department.

A New Field of Industry

Hitherto the greater part of the cocoons, from which the silk moths had emerged, and of the raw silk which was too tangled to be reeled, had been practically wasted. Attempts had been made to spin it, as was done with wool or cotton, but without notable success. In 1855, however, the Cheneys began the spinning of such waste silk in an important way. The only machines they could get at first for this purpose were those used for cotton or wool. These required many modifications and an expenditure of some thirty thousand dollars before they could be adapted successfully to silk. It is not too much to say that in utilizing this great waste product, the Cheneys created an entirely new branch of the silk industry in this country, although silk had already been crudely spun in factories in Europe.

To supply the growing business, another mill had already been built at South Manchester, and, in 1854, mills were established in Hartford, which were used chiefly for ribbon making. The name was changed in 1854 to the Cheney Brothers Silk Manufacturing Company, and the capital stock was increased in 1855 to $400,000.

The Process in the Fifties

In the cornerstone of the old office building, which was built in 1857, was deposited, among other papers, a brief description of the state of the business, extracts from which may give an idea of industrial conditions at the time. The buildings were still of wood. The power still came chiefly from the brook and was furnished by two turbine wheels of 20-horse power, each 26 inches in diameter. Steam was supplied for the dyehouse from two locomotive boilers.

An invention of the Fifties, made in the factory, greatly simplified spooling. It had previously required one girl to attend to each machine.

Frank Cheney and Grant, after only three months' experimenting, evolved a spooling machine which enabled one girl to attend to three machines.

A Part in the War

The Cheneys took a rather important part in the War of Secession. C. M. Spencer, who had been employed at the mills since 1847, had, even before the war began, conceived the idea for the Spencer repeating carbine. He had constructed one in the machine shop of the mill, and had taken out a patent on it March 6, 1860. When the war came, the Cheneys arranged with him to manufacture it. Charles Cheney, after exhibiting it at Washington, got a trial order from the Navy Department for 1,000. The Cheneys realized that a silk mill offered very poor facilities for rifle manufacture, and leased part of the Chickering piano factory at Boston for the purpose. A great deal of difficulty was experienced in convincing the War Office of the practicability of a repeating rifle. General Ripley, the Chief of Ordnance, had little use for what he called such "new-fangled jimcracks," while one of the secretaries declared it a "damphool contraption to use up ammunition." James G. Blaine, however, got the concern an order for 10,000 from Gideon Welles of the War Department, but this was very far from enough to pay for the new machinery necessarily constructed to manufacture them.

A rifle was presented to President Lincoln, personally, by Mr. Spencer, who, at the President's request, took it all apart and put it together again with only a screw-driver. An engagement was made to test it the next day, August 19, 1863. President Lincoln's seven shots at the target were so good, although somewhat bettered by Mr. Spencer's, that the Government ordered practically all the rifles the company could make. Some 200,000 were completed by the end of the war, after which the plant was sold to the Winchester Arms. It was not a profitable venture.

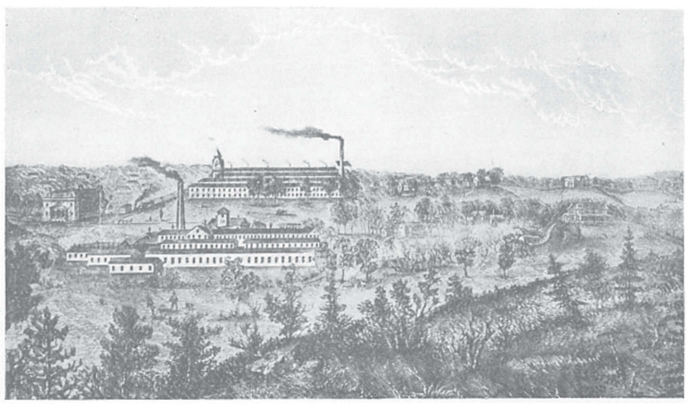
Influence of the Tariff

The tariff that was put on silk goods during the war made it possible to develop the weaving of silk far more extensively in this country.

Cheney Brothers took up the weaving of ribbons on a considerable scale in 1861, and of grosgrains in 1866. It is a striking fact that, whereas the price of grosgrains in 1869 was $1.96 a yard, over three times what it is at present, the average wages of the time were only $1.49 paper, worth not more than one-third of the present wages.

In the silk, as well as other manufacturing industries, it is indisputable that while inventions have multiplied wages, these same inventions and competition have even more remarkably lowered prices, in spite of the fact that the protective tariff rate has remained comparatively level. And in many cases it is only the tariff that has made the development of the industry possible at all in this country.

The growing prosperity of the company is shown by the construction of separate spinning mills in 1872. In 1873 the name was changed from the Cheney Brothers Manufacturing Company to simply Cheney Brothers. The Cheney mills, in 1880, took up extensively the weaving of plush and velvet, for which it was considered necessary to import two looms from Germany. The velvet looms, now in general use, were invented in 1892 by Richard Monners in the Cheney Mills.



Cheney Brothers' Factory, 1876

The Grant Reel

In 1882 another far-reaching invention was made in these mills. This was the Grant reel.

Up to that time there had always been a great deal of difficulty and waste caused by the snarling in skeins of silk. Grant, who had been employed in the factory since 1840, invented an improvement by which a bar moving slowly a few inches sidewise and back between the feeding spool and the thread, directed it so that the skein was wound on the reel overhanded, somewhat as a boy winds a kite cord. Where the threads crossed could then be tied with a string, so as to make snarling almost impossible.

This invention made a practical revolution, not only in silk, but in cotton and worsted winding throughout the world.

Rapid Expansion It is unnecessary to follow the further progress of the Cheney Brothers in detail.

The mills have not merely increased wonderfully in number and size, but have been improved with the introduction of every up-to-date machine and process that seemed to promise greater efficiency. At the present time they include over 36 acres of floor space.

Experience and Efficiency The long history of the Cheney mills is not only evidence that their products have for many years been the standard of the country, but so extensive an experience, concentrated in one family, necessarily evolves a far higher quality of management. When this is supplemented by the similarly long experience of individual employees, the result is an unequaled and uniformly high character of work.

In establishing a pension system for their employees, it was necessary to make out a table showing the number of years each had been with the concern. The statistics of 1914 are as follows:

CHENEY BROTHERS

Employment Bureau Statistics, 1914

Length of Employment.	Male Employes.	Female Employes.	Totals.
0- 5 years	1153	1070	2223
5-10 "	514	389	903
10-15 "	285	183	468
15-20 "	166	85	251
20-25 "	112	52	164
25-30 "	109	43	152
30-35 "	72	30	102
35-40 "	27	11	38
40-45 "	30	18	48
45-50 "	10	4	14
50-55 "	3	0	3
55-60 "	2	0	2
Totals	2483	1885	4368

5 years or over, 2145.

The figures show that some of the employes have been with the firm for fifty years and that practically half of them have had over five years' experience in the Cheney mills.

Growth of the Industry

To view the development of the silk industry in a broader light, the Cheneys have seen silk manufacture grow in America under the tariff from almost nothing to tremendous proportions, while during the same period it has actually decreased in England under free trade. Thus in the United States the value of manufactured silk increased from $6,600,000 in 1860 to $197,000,000 in 1910, while the number of employes rose from 5,000 to 120,000. Importations of manufactured silk amounted to about $33,000,000 in 1861, and have remained about constant. Thus the home manufacturers have supplied the greater demand due to increased population and higher prosperity.

In Great Britain, however, where there was an import duty till 1861, upon the removal of that duty the imports of manufactured silk rose from £6,000,000 in 1861 to £13,000,000 in 1911, but silk manufacture there decreased so greatly that where it busied 116,000 in 1861, it employed only 37,000 in 1901.

The United States the Greatest Silk Manufacturing Country

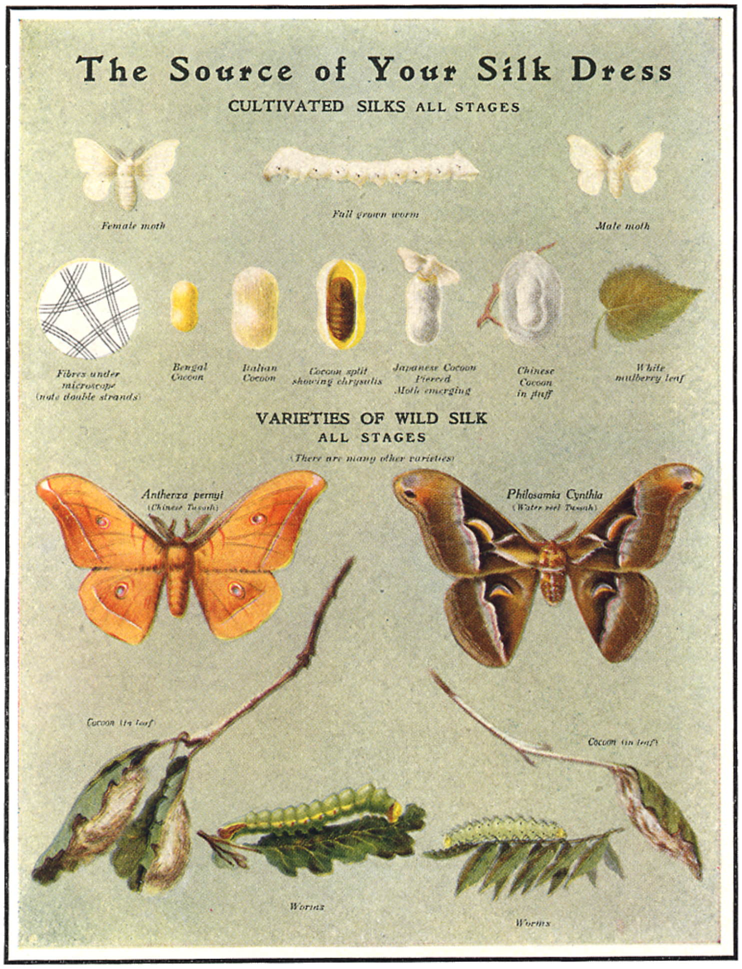
In 1913 the United States consumed as much raw silk in manufacturing silk goods as France, Germany, Italy, and England put together. The 1913 statistics of the production and consumption of silk in the world were as follows:

Production, 1913

Japan, Export	11,000,000 kl.
Shanghai and Canton, Export	8,750,000
Europe	4,000,000
Levant and Central Asia	2,250,000
	26,000,000

Consumption, 1913

United States	10,700,000 kl.
France	4,400,000
Germany	3,600,000
Switzerland	1,700,000
Russia	1,700,000
Italy	1,700,000
Austria-Hungary	1,100,000
England	800,000
Other Countries	600,000
Kilo is 2.2 pounds.	26,300,000



Colored insert showing various stages in the development of the silk worm to adult moth. Because of the minuteness of reproduction, the eggs are not illustrated. The silk worms, cocoons and moths illustrated above are one-third actual size

Gathering Mulberry Leaves for the Silk Worms, Japan

The Cheney Silk Mills the Greatest in the World

Just as the United States is the greatest silk manufacturing country in the world, so the Cheney Brothers are the largest silk manufacturers both in the United States and in the world. They are the only concern in any country that carries silk manufacture completely through all its different processes from the raw silk to the finished goods.

These processes are so interesting and so characteristic of the revolution from the ancient hand to the modern methods of machine manufacture as to be well worth following more in detail. First, however, we must mention the few chief improvements in modern silk-worm culture over the ancient Chinese methods already described.

Modern Improvements in Silk Culture

As an exporter of raw silk, Japan has passed China, though the total Chinese production for home consumption is probably the greater.

The best silkworms are still considered those that spin once a year, although toward the tropics silkworms spinning two, three, or even more times annually are also cultivated. Wild or tussah silkworms of various kinds are now used to some extent, especially since the development of silk spinning, and of modern methods for bleaching and dyeing their silks. Their cocoons, which are spun in the trees where they feed, must be hunted for and gathered. Some of them can be reeled after being softened with an alkali, but others can only be spun.

While silk culture among the peasants is practically the same as it has been for thousands of years, modern improvements are being made use of in cocooneries and filatures.

Cold storage now enables the eggs to be kept with greater certainty until they are to be hatched. For hatching they are placed in incubators, where they are kept at an even temperature for from 25 to 30 days.

In Japan a dwarf mulberry only four or five feet high is popular for feeding.

Feeding Mulberry Leaves to the Voracious Young Silk Worms, Japan

Reeling Raw Silk—Japan

In caring for the worms, the chief modern innovation seems to be a microscopic examination that enables diseased worms to be destroyed before the plague spreads. One of the greatest achievements of Pasteur was the discovery of the germ that caused the silkworm disease in France.

After the cocoons have been spun, they are suffocated usually by hot, dry air.

In reeling, the better filatures now employ steam power. The water in the basins where the cocoons float is kept hot, 60 degrees centigrade, by steam. Automatic cocoon beaters, revolving in the basins, are used to brush off the frisons, or first threads of the cocoons, before they are reeled. While six cocoons are most commonly reeled at a time, the number may run anywhere from two to twelve, or more. The filaments are joined by passing them through a glass button.

The silk is cleaned and twisted in reeling much better than formerly, either by bringing the thread back and passing it around itself some 200 times in a seven-inch spiral, or by twisting the threads of two different basins around each other before they are passed on to separate reels. The filament is dried before going on the reel by steam-heated tubes running along the travellers. The reels are run at from 80 to 100 revolutions a minute.

In Italy the girls may get as high as 22 to 25 cents a day for eleven hours' work.

In Japan they work from 5 o'clock in the morning to 11 o'clock at night, though two hours are taken out for tea and meals. For these 16 hours of labor they receive from 15 to 22 cents a day.

Both in Italy and Japan the women who do reeling at home earn only about a half of these amounts.

When reeled, the raw silk is done up into hanks of from 80 to 100 grams each for export. The best raw silk is worth from $4.50 to $6 a pound, which is not far from the price it brought 100 years ago.

The silk that cannot be reeled, including the frisons or first threads, and the pierced cocoons, is packed in bales and exported in that form.

The value of this so-called waste silk runs from 40 cents to $1.25 a pound.

Significant Figures

Before leaving the subject of raw silk, a few significant figures may be interesting.

To make a pound of raw silk requires from 2,500 to 3,000 cocoons, each cocoon furnishing a filament of perhaps 600 yards in length. Thus, if the cocoons were reeled separately, which, because of their fineness, is practically impossible, it would require about 1,800,000 yards or a thousand miles of single silk filament to weigh a pound.

Weighing Raw Silk on Delicate Scales—Japan

Ordinarily some six or seven cocoons are reeled together, producing the size known as 13-15 deniers. A denier is a French weight, of which it requires 533 1-3 to make an ounce avoirdupois. The ordinary hank or skein is 400 French ells, or 520 yards. The number of deniers which a hank weighs is spoken of as the "count" of the yarn.

We have now arrived at the stage in the preparation of raw silk, at which, in the form either of reeled or waste silk, it comes into the Cheney mills. To follow it further we must go through the plant itself.

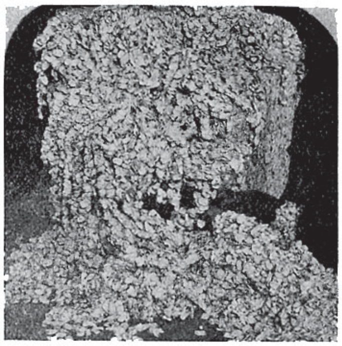
A Day at the Cheney Mills

A visit to the Cheney mills is well worth making, not merely because it will show the many steps passed through by the cocoons and raw silk before they emerge in perhaps the most lavishly brocaded velvet, but because it may give one a sense of the intricacies of present-day manufacture, and help one to realize that the application of power to machinery has produced, within the life of this one firm, greater changes than occurred in all the previous 5,000 years of recorded history.

Such a journey through the mills requires all of one well-filled day, but only a summary can be given in the space at our disposal.

Anyone who expects, on a visit to South Manchester, Connecticut, to see an ordinary manufacturing town, or mills crowded into the midst of the usual huddled-together manufacturing district, will be most pleasurably surprised.

The various mills are nestled in the midst of great stretches of rolling



The Pierced Cocoons as They Arrive in Bales—Cheney Brothers' Factory

green lawns, shaded with wide-spreading colonial oaks. The nearest residences are those of the Cheneys themselves. This fact alone eliminates the evils that occasionally arise where absentee proprietors live so far away as to get out of touch with conditions in their plants.

The several mills include 36 acres of floor space, and have about 4,500 employees. The investment in the plant is now capitalized at $7,000,000.00. The value of the raw stock required to keep the mills running for a year is almost $4,000,000.00.

The Waste Silk

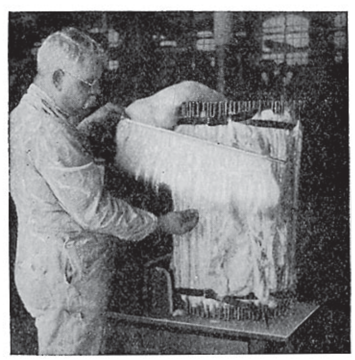
Much of the raw stock comes in as waste silk, and the first requirement is to bring this to the point already reached by reeled silk, or, in other words, to spin it into yarn.

Both the pierced cocoons and frisons, in order to have their natural gum removed, are boiled in soap suds, and dried in a revolving extractor, which throws out the water by centrifugal force. Chemical reagents, rotting, and maceration may also be used for ungumming.

The Dressing Mill

In the dressing mill the cocoons are opened by being fed through rollers against a revolving cylinder, studded with innumerable wire hackles or needles which pull the fibres into sheets or laps. These sheets, and the frisons, which have been similarly pulled out, are run through a picking machine which still further draws out the sheet and cuts it into nine-inch lengths, which the machine itself hangs like flags over small rods.

These rods are put into a dressing machine with revolving drums covered with teeth, where the silk is combed and cleaned from much of its dirt and the remains of the chrysalides which have clung to it. The flags of silk wound around the rods, are carried to a machine which divides them into four or five short laps.



Flag from Dressing Machine Cheney Brothers' Factory

The silk is then inspected and cleaned by being placed over long glass tables with the light shining through them from below.

The laps are run together on a machine

into longer laps measuring from seven to nine feet, and weighing possibly 4½ ounces. They are now ready to be taken to the spinning mill.

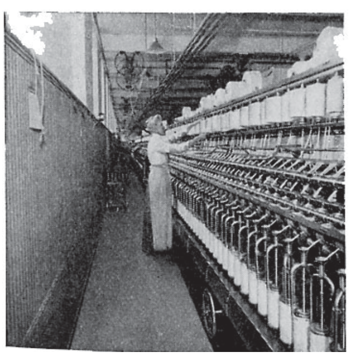

Drawing Frame—Cheney Brothers' Factory

Spinning the Waste Silk In the spinning mills the lap is drawn out into what is called a sliver, approximately the size of a finger, by being run through the rollers of drawing frames, the second of which turns considerably faster than the first. In order to get the fibres even several of these slivers, after being combed, are drawn out again into another sliver, and the process may be repeated several times. The sliver is now passed through roving frames, which wind it on bobbins, where it may be said first to take the form of thread. From here it is run through a spinning frame where it receives a partial twisting. It is now known as a single, and for some purposes may be used in this form.

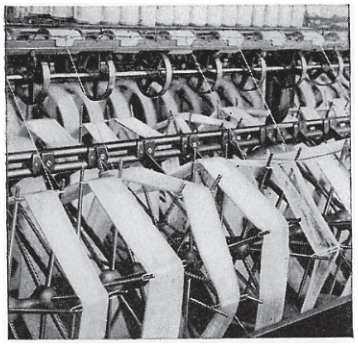
The cleaning of the silk thread is done in what is called the gasing room. It passes through several flames of gas which singe off the extra fuzz, but travels too rapidly to be itself burned. It is cleaned by being run around small cylinders, which are turned by friction.

The thread, in order to be made uniform, now goes to the controlling room, where many threads are run through the controller at once for the removal of knots.

It is then taken to a Grant reel, where it is wound off, as previously explained, into a skein, the threads of which are so criss-crossed, that, after being tied where they cross, they will not tangle. These skeins of silk weigh from four to five ounces. After being inspected they are bundled up and sent to the warehouse, from which they may be sold as they are, sent to the dye house to be dyed, or the weaving mill to be woven undyed into goods.


Spinning—Cheney Brothers' Factory

All of this labor, it must be borne in mind, has been necessary to produce in the



Winding Thread from Skeins to Bobbins—Cheney Brothers' Factory

spun silk comparatively the same kind of single thread as is produced in cotton spinning.

Throwing the Reeled Silk The reeled silk must be carefully distinguished from the spun silk. The reeled silk "single," or the raw silk goes to what has long been termed the throwing mill. Throwing is taken from an old Anglo Saxon word, "thrawn," meaning to twist, and the purpose of the mill is to twist, double, twist and combine again as often as necessary to produce the thread desired. Although this sounds comparatively simple, it will be remembered that it was several centuries before the English learned to throw silk well enough to compete with the Italians.

The skeins of reeled silk are put on a light skeleton reel, called a swift, which can be changed in size to fit various skeins. The silk is wound off of this reel upon a bobbin simply by the friction caused by the turning of a lead cylinder against the bobbin,—a method which, as already mentioned, avoids breaking the threads.

The reeled silk is often cleaned at this stage by running it between carefully set knives.

The principle of twisting consists of running a horizontal bobbin off on a vertical one that turns at a faster speed. The yarn runs through the eye of a little metal flyer on the top of the first bobbin, and the difference in speed between the two bobbins regulates the amount of twist. Singles are sometimes given 60 twists to the inch.

The doubling is done by running the two threads together through the single eye of a guiding bar onto another bobbin. It is very important to have the machine stop if a thread breaks. For this purpose, before they are joined, each thread holds up one end of a separate lever. If the thread breaks the other end of the lever falls and stops the bobbin.

After doubling, the thread may be again twisted,—in the case of organzine, in an opposite direction. It may be steamed to set the twist.

The Cheney mills run some 30,000 spindles in the throwing department, and 8,000 more in winding and spooling.

Trade Usages Before leaving the subject of yarn or thread there are a few trade usages that need explaining.

Spun silk is numbered on either the English or French system. On the English system the number of 840-yard hanks required to weigh a pound avoirdupois decides the number of the yarn, while a sub-number tells whether the yarn is single or of two or three threads. Thus number 50-2 is a two-cord yarn requiring 50 hanks or 42,000 yards to the pound.

On the French system the thousands of meters of the single thread required to weigh a kilogram designates the number of the yarn, while the smaller figure tells the number of threads, but a two-ply weighs twice as much as the same number single. Thus 2-100 is made up of two number 100 singles, and runs 50,000 meters per kilogram.

Raw silk singles with the gum still in them are often used as warp for goods which are not dyed until woven.

In yarn dyed goods the usual warp is organzine, which consists of two or more raw silk threads well twisted, both in the singles and after doubling.

The weft and filling of both yarn dyed and piece dyed goods, is commonly tram, which consists of two or more threads scarcely twisted at all before doubling, and generally only slightly twisted after doubling.

For crepe or chiffon, however, the yarn used is a tram that is given a very hard twist, from 40 to 80 turns an inch.

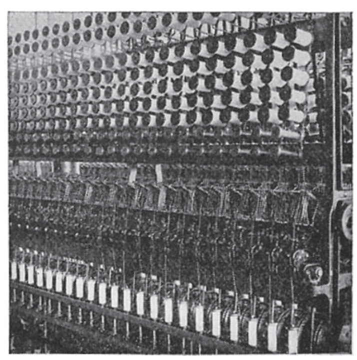
Floss silk generally consists of a large number of singles very slightly twisted. It is not used in weaving.

Embroidery silk consists of a large number of slackly twisted singles, doubled and again slightly twisted in the reverse direction.

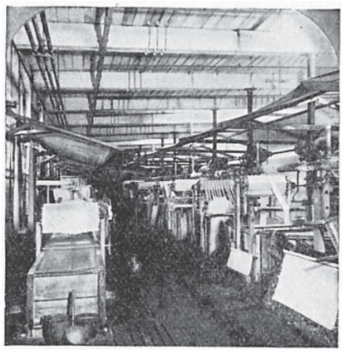
Hand sewing silk is made by winding and doubling the raw silk, giving it a hard twist, doubling and twisting again in the reverse direction under a strong tension.

Machine twist is made in a similar way, except that it has a three-ply, instead of a two-ply thread.

Yarn Dyeing One great class of goods is dyed in the yarn before weaving, while the other class is not dyed or printed until after weaving. The first is called yarn dyed, the second piece dyed or printed goods.



High Speed Spinner—Cheney Brothers' Factory



Vats for Dyeing Cloth in the Piece—
Cheney Brothers' Factory

We are now at the point where part of the yarn is sent to the dye house to be colored in that form.

The gum has already been taken out of spun silk yarn, but still remains in the yarn made from reeled silk. In order to take the dye, the reeled silk is usually ungummed by being boiled in soap and water and rinsed in cold water. The loss of the gum reduces the weight approximately a quarter. A few yarns, such as are used in cheaper ruchings, may be dyed with the gum in, and some, known as souples, with part of the gum in.

Before dyeing, the silk may be soaked in mordants, the object of which is to make the yarn take the color better, but they are not as necessary as in the case of cotton, because silk has a stronger affinity for dyes.

In the old method, the yarn was hung over rods and let fall into the bark, or vat, of hot dye stuff. Workmen had constantly to turn the skeins to keep the color even and avoid a streak where the skein rested on the rod.

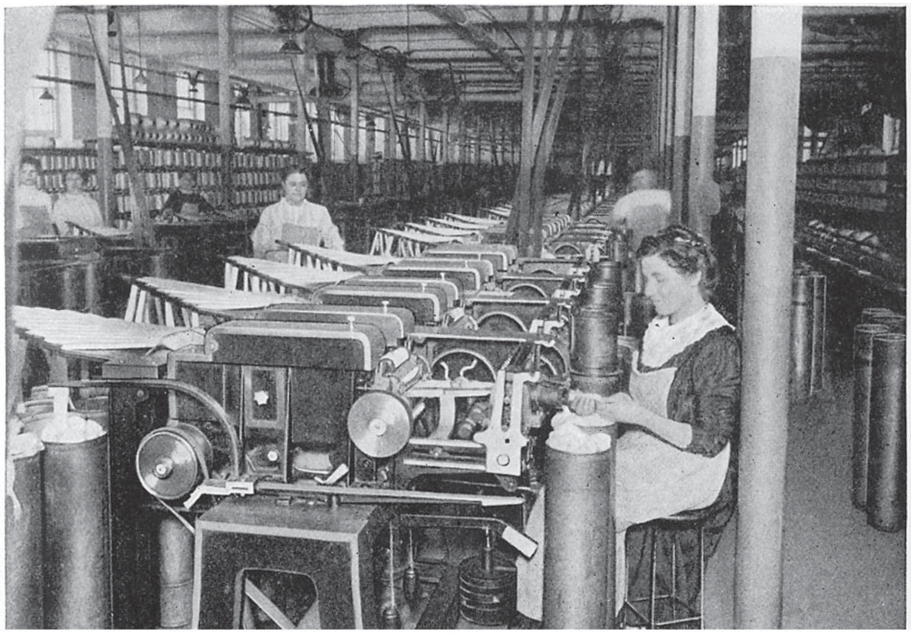
The machine now used for the purpose consists of a large reel, similar to a small Ferris wheel, on the rounds of which are hung the skeins. When the reel revolves, not only are the skeins dipped periodically into the dye, but each round of the wheel is itself turned automatically so as to keep the skeins turning and avoid a streak in any particular spot. The dye is kept at the right temperature by steam.

After dyeing, the yarn was formerly hung over a peg in the wall, and wrung as much as possible by turning a smooth stick which had been run through the other end of the skein. The present method uses a revolving cylinder or extractor that drives out the water by centrifugal force. The lustre formerly added by hand wringing is now given by stretching the yarn under steam pressure.

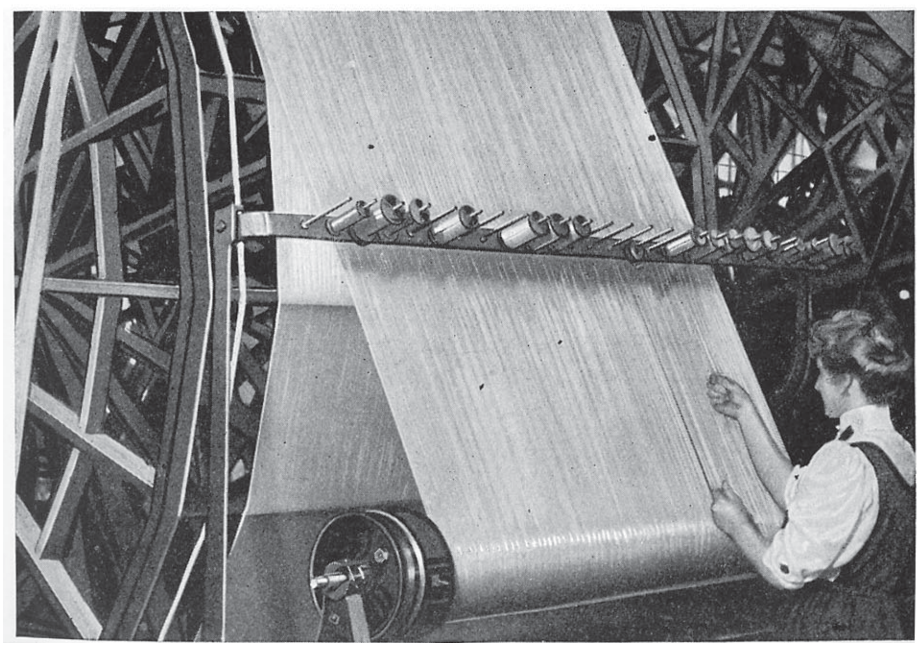
Yarns are not only dyed before being made up into goods, but the warp itself is sometimes printed.

The Weaving Department

We are now prepared to follow the dyed and undyed yarns together through the weaving department. The first step is to make the warp, which consists of the long and comparatively strong threads that run lengthwise in the goods.



See page 49 Drawing Machines — Cheney Brothers' Factory



See page 52 Beaming Off Warp — Cheney Brothers' Factory

Preparing the Warp The organzine or yarn for the warp comes into the warping room on spools or bobbins. The warp is usually, though not always, made in sections. As many spools as there are to be threads in a section are placed on the iron pegs of a rack, which commonly stands up vertically. In order to keep the threads separate and make them spread evenly on the reel, each thread is first passed between two teeth of one or more reeds, which resemble a fine comb, though closed at both ends. Drawing the warp through the reed at this stage is still usually a hand process requiring much care and labor. From the reed the threads are run upon a large reel forming an even spaced band, the width of which depends on the number of threads, and the length of which may be anything up to five or six hundred yards.

Enough sections are made on the reel to give the number of threads required for the width of the goods.

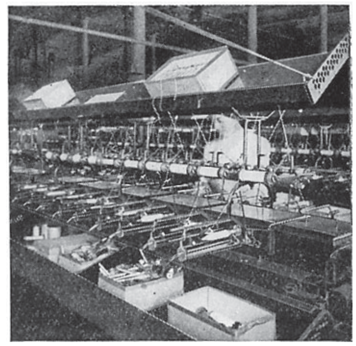
From the warping reel the warp is run off upon the cylinder or beam that is to be placed in one end of the loom.

Each thread of the warp must now be run through what is called the harness, which consists of a number of shafts, from each of which are suspended the heddles. As previously explained, these are cords strung between the top and bottom of each shaft with a loop or eye in the center of each cord.

The threads of the warp are each drawn, one at a time, through its own eye. This operation must be done with absolute correctness, for if an eye is skipped or a thread misplaced it will show throughout the whole piece of goods. Drawing through the heddles is still done to a large extent by hand and is a tedious process.

A Mechanical Twister at Work
Cheney Brothers' Factory

When a harness is on hand with the ends of an old warp in it properly arranged for a new piece of goods, there is a method of saving the trouble of drawing through the heddles by joining or twisting a thread of the new warp to each thread of the old. This twisting may be done by hand or by a mechanical twister. To each shaft are fastened the heddles that in weaving must be lifted at the same time, allowing the shuttle to pass beneath them, for forming that particular pattern or weave. There may be from two to thirty shafts.



Quilling—Cheney Brothers' Factory

After passing through the heddles, the warp is run through the weaving reed. It is often drawn between the teeth of this reed by hand, which requires a long time, but may be inserted with a machine. One or more threads may be passed through each dent.

The loom beam, harness and reed are then placed in the loom ready for weaving in the weft or filling.

The Weft The weft or woof consists usually of tram or slackly twisted yarn and is frequently of spun silk. This is wound by a quilling machine from the spools upon a quill, so called from its shape, which is placed inside a shuttle, and will let the weft unwind as fast as the shuttle flies.

The Weaving Room The first thing that strikes one on entering the weaving room is the resounding racket, like the constant rattle of musketry.

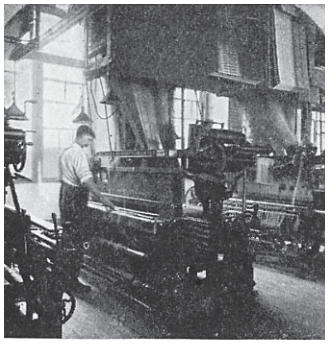
Silk weaving is still far from automatic. The weaver must keep the shuttle filled, clean the warp, keep the threads straight, and see that there are no imperfections.

The loom itself lifts the warp threads, drives the shuttle flying through, pushes the reed against the woven goods to crowd the filling into place, lifts the next set of warp threads, lets the warp off its beam as required, and takes up the goods.

The arrangement of the heddles on the shafts will give almost an endless variety of weaves. One of the simplest is taffeta, where the weft may be run merely over one thread and under the next, returning over and under the alternate threads. In satin, the woof is used merely for tying together the warp, most of which is left to show on the surface.

Jacquard Weaving Where the pattern is very complicated the Jacquard machine is employed. As already noted, on this system each heddle or eye, through which the warp runs, hangs from its own cord. One cord from each repeat of the pattern forms the lash which is fastened to a hook, the lifting of which before each pick or trip of the shuttle depends on whether there is or is not a hole in a given position on one of the cardboards that hang in festoons above the loom.

There are usually from 600 to 1,280 spaces for holes on the



Jacquard Loom at Work
Weaving Brocade
Cheney Brothers' Factory

Jacquard card or as many as the number of lashes or the threads in a repeat of the pattern. More warp threads may be handled by joining two or three cords before they pass through the card. This doubles or triples the pattern in one width of the goods.

There are as many Jacquard cards in the set as there are threads of the filling required before the pattern is completed. To repeat the pattern lengthwise, the endless chain of cards looped above the loom, is simply run over and over. The designs to be transferred to the Jacquard cards are on paper ruled into small squares, each of which represents a thread, and the cards are punched by a machine, directed by hand, in accordance with this pattern.

Ribbon and Necktie Weaving

The most striking difference between ribbon and broadgoods weaving is that, because of their narrowness, from 20 to 30 ribbons may be woven on the same loom at once. Each ribbon has, however, its own shuttle, but, instead of being more than a foot long, as in the case of broadgoods, it is only five or six inches long. It is carried by a rack and pinion, back and forth, practically in plain sight, from one side of the narrow warp to the other.

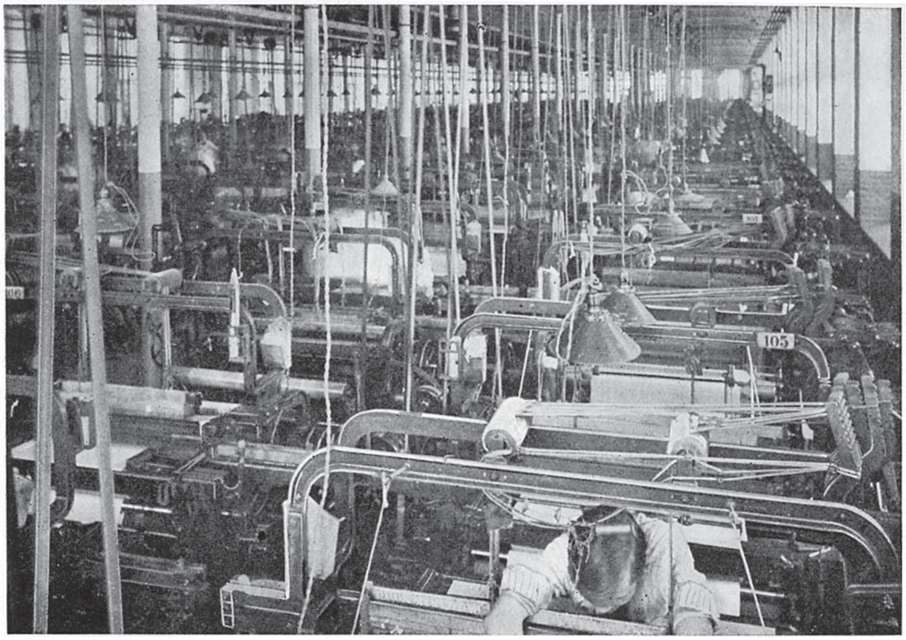
The same principles are applied to ribbon as to broadgoods weaving, but the warp and cloth beams are only large spools, while the shuttle seems diminutive in comparison.

The weaving of tubular neckties gives much the same general impression as that of ribbon, but with a few unique exceptions.

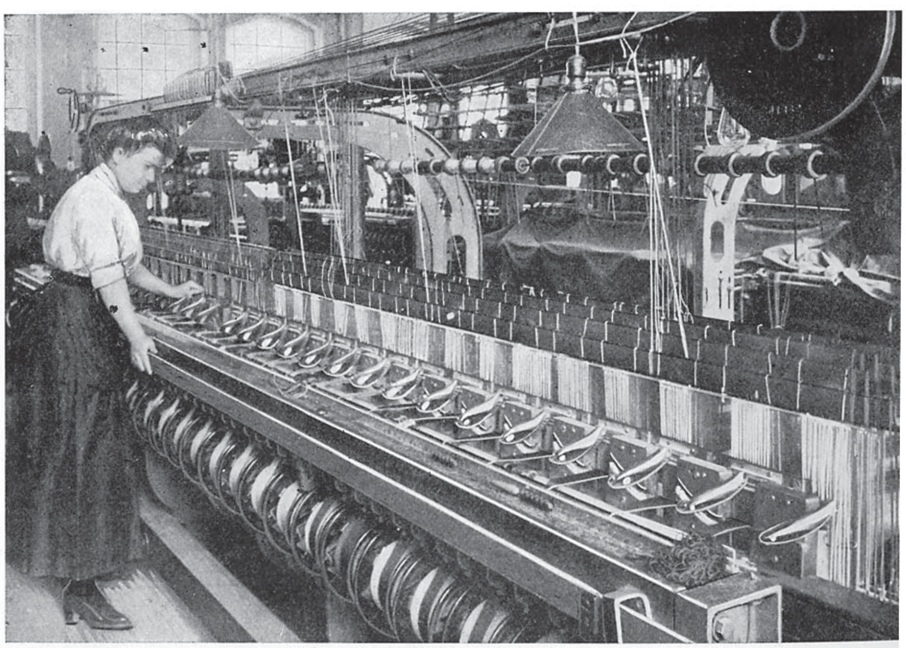
The tie is woven smaller in the neck by having the reed narrower at the bottom than at the top and weaving the neck through the narrow part. The neck is also made softer with fewer picks of the shuttle per inch.

Probably the most remarkable product of necktie weaving is the Cheney tubular tie. This is a tie woven in a complete tube, without a seam. It may be worn either side front, or turned inside out, and again exhibited either face to the world.

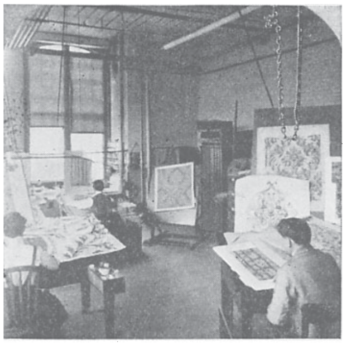
Ties are also knitted on machines which regulate the different designs by a pattern wheel. Others are cut out of broad silk and sewed.



See page 55 General View of Weaving Room—Cheney Brothers' Factory



See page 56 Ribbon Loom Weaving Neckties—Cheney Brothers' Factory


Designing Room for Silk to be Woven on Jacquard Looms
Cheney Brothers' Factory

Velvet Weaving and Finishing

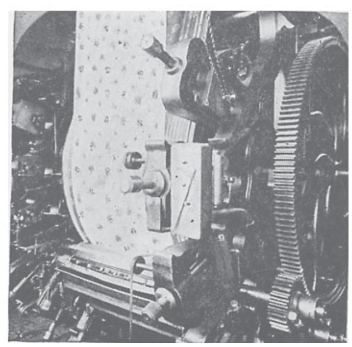
Cheney Brothers are the largest manufacturers of velvets in the United States. Their velvets are made in almost five hundred different colors and shades.

Velvets were formerly woven over wires in such a way that on the face of the cloth loops were formed, which could be cut open by hand to make the pile. They are now woven with two pieces, face to face, with the pile threads running up and down between them. As fast as woven a sharp knife travels back and forth between the two pieces cutting the pile threads in the center so as to leave the ends standing up straight for the pile.

If the dyeing has already been done in the yarn, the velvets are sent, after weaving, to the shearing room. Here they are run over the large revolving cylinders of machines which clean them, and pull up, and carefully shear, or even off, the pile.

In the sizing room it is stretched to uniform width on a tentering frame, sized or starched, and ironed on the back. In the finishing room, the velvet is measured on a cylinder with a length indicator, split into two widths, put through another brushing machine, dried if necessary, and softened in a breaking machine. For shipping, panne velvet is rolled up, plain velvet is folded, and both are stitched to prevent slipping and wrinkling.

In the wet finishing room, chiffon velvets are wet sprayed, run through a carder to pick up the pile, cleaned on a brushing frame, dried in a great heat box, again atomized, recarded, dried, steamed and dried again.


Machine Printing
Cheney Brothers' Factory

One of the most striking impressions about silk manufacture, is the very multiplicity of processes which a piece of goods must undergo after weaving before it is ready to lay on the counter. A piece may be run over as many as one hundred and fifty times in various processes after it comes from the loom before ready for shipment.

Piece Dyeing One large class of silk goods is not dyed until after weaving. Such goods are usually woven with the gum still in the silk, and as a preparation for dyeing must be boiled from 20 minutes to two hours in olive soap and water. After the gum is out, they are rinsed by being run over rollers through the many boxes of a big washing machine, and dried over a hot cylinder or in an extractor.

The dyeing may be done by hand in large barks or vats filled with dye, or by being run over large reels which carry the goods from one bark to another.

Printing Many varieties of silk goods are now machine printed. The color laboratory has on hand several thousand samples of probably a thousand different shades which it has tested for dyeing and printing.

The designs are sketched on white paper, then enlarged, traced on zinc, and cut in by hand. A pantograph then transfers all of the design that is in one color, in the proper size, upon a copper cylinder, into which it is etched by a solution of acid.

Each color requires a separate cylinder, and the set of cylinders must be exactly the same size.

The cylinders are placed on the printing machine, which supplies the etched parts with color thickened with gum, scrapes the extra color entirely off the cylinder, except where etched, by a very true knife blade, and prints the goods as it revolves.

After printing, the goods are steamed in a steam box to set their color, then heated with dry heat to age it. In order to take out the gum used to thicken the color, they are well washed. If necessary the color is touched up.

Finishing Like other goods, printed silks must be put through a numerous variety of finishing processes.

To stretch the piece to a uniform width, a great so-called tenter catches the cloth between clamps and carries it along through steam heat perhaps a hundred feet. The silk may be stiffened with sizing as it is run through rollers, pressed out and dried on a calender, and expanded on a barrel spreader to take out the wrinkles. It may be run through gas flames to singe off any loose fuz, or through machines for embossing or watering.

Very delicate material is wound in paper, heated over hot cylinders and left for a day until the paper cools. Other goods, after being folded between heavy paper, are, like satin, put under a hot pressure of several thousand pounds and left over night until cool.

A serious objection to piece dyed and printed goods used to be their liability to spot with water. In the case of the Cheney goods, this has been eliminated by the invention of the Cheney shower-proof silks, the process for which prevents rain-spotting while retaining absolutely the strength and feel of the goods.

A Pause in the Story Here the history of silk pauses,—not ends. It began ages ago with a humble worm in far eastern China, and has reached its climax on this Western Hemisphere in the greatest silk mills in the world.

But this is only a pause in the story: its sequel is embodied in the wonderful fabrics into which silk is wrought; in their brilliancy, elegance and lightness,—and the pleasure and comfort they assure.

INDEX

INDEX

INDEX OF ILLUSTRATIONS