SILK

H. T. Gaddum & Company Limited

MACCLESFIELD,

CHESHIRE.

Reeling Raw Silk in 1830
Note the Chambon croisure

SILK

HOW AND WHERE IT IS PRODUCED

H. T. GADDUM & COMPANY
LIMITED

Silk Merchants

MACCLESFIELD
CHESHIRE

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FOREWORD

Little did I think, when putting pen to paper in 1948 with the purpose of recording in permanent form some notes gathered together for a talk to our local branch of the Textile Institute, that these might be serving a useful purpose more than thirty years later, but so it is. Many are the new fibres devised by the ingenuity of chemists during those years, but the charm and the mystic of silk have not been rivalled.

This then is the tenth re-print. In 1954, 1961 and 1968 I introduced revisions in an attempt to keep abreast of new developments and new technology, but on this occasion, apart from up-dating the statistics of Chapter V, I have not interfered with the text.

Never was this publication intended as a text book, but it was hoped that within this small compass silk users and indeed the general public might find something of interest.

P. W. GADDUM

Macclesfield 1979

P. S. It should be noted that the exhibition of sericulture and silk reeling provided for many years by the Lullingstone Silk Farm at Ayot St. Lawrence, as mentioned on p.45, is now open to the public at Compton House, Sherborne, Dorset.

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CHAPTER I

THE ELEMENTS OF SERICULTURE AND RAW SILK REELING

BEFORE embarking upon an account of developments in silk production, it would be well to recount the process from the egg to the skein of raw silk in its simplest form. It is only with some knowledge of the natural cycle of the silkworm and of the elementary processes of reeling that the many variations of method can be appreciated or indeed understood.

SERICULTURE

What is known as *Bombyx Mori* is the species of silkworm that provides by far the most important production of raw silk for the weaving and knitting industries. *Morus* being the Latin word for mulberry (Fr. : *murier*, It. : *gelso*, Jap. : *kuwa*), it follows that it is in fact the mulberry that provides the raw material for the great bulk of silk goods : though *Bombyx Mori* can be raised upon alternative diets, yet he cannot produce from any other leaf the same quality of silk. The mulberry is a hardy plant, growing abundantly in most latitudes. If untended it will assume the proportions of a tree, and its vivid green foliage is a lovely addition to any landscape. The White Mulberry (*Morus Alba*) is the variety most suitable for sericulture.

When the leaves begin to bud in Spring, the eggs of last year's silk-moths, which have been hibernated in a cold dry locality—often in the mountains—are brought into the mulberry districts and subjected to warmth. Amongst primitive peoples this process of incubation is often achieved by women carrying the small packets of eggs about their persons, but a simple stove controlled by a lamp is an improvement adopted in more sophisticated circles. A graduated advance in temperature from 55° to 75°F. over a period of ten to fourteen days should effect a uniform hatching.

The eggs themselves (Fr. : *graine*, It. : *seme bachi*, Jap. : *tane*) are little larger than pin-heads and the baby caterpillar that emerges, leaving the white shell behind, is therefore only a tiny creature, but he has a ravenous appetite. Strips of young mulberry leaf are fed to him at this stage but he increases quickly, and in an existence of only four weeks outgrows his skin four times, ceasing to eat for a while on each occasion, as he discards the skin that has become too tight and assumes another.

This process of moulting is a delicate one, as the silkworm is then particularly susceptible, and any disturbance must be avoided. Having attached the old skin by a strand of silk to a piece of leaf stalk, he remains motionless until the new skin is ready for him to step forth and resume his interrupted life of feeding.

After his fourth and last moult his appetite is quite extraordinary and he becomes an ugly, fat, hairless creature between three and four inches long. In this last stage he actually consumes about four times the weight of leaf he has consumed hitherto: some 36,000 worms hatched from an "ounce" (usually 25 grams) of eggs, which should eventually produce at least 12 lb. of raw silk, may require as much as a ton of foliage, of which only 10 lb. would be consumed before the first moult, 30 before the second, 100 before the third, 300 before the fourth and 1,800 lb. after the fourth moult. An acre ordinarily yields from 3 to 4 tons of leaf (though in Japan an average of 5 tons has been achieved for the whole country with a maximum of nearly 10 tons to the acre in the South). A return of 50 lb. raw silk per acre can thus be considered as a satisfactory result and above the average attained in most countries : often, however, mulberry is planted along verges without interference to other crops, so that a true yield per acre cannot always be computed. The matter is further discussed in Chapter VI.

At last he ceases to eat and looks around for a likely niche in which to build his cocoon. Twigs or straw are provided and he is soon engaged in the remarkable process of spinning a continuous filament of silk into the form of a cocoon, within which he himself is soon lost from sight. Nevertheless he is still working inside, moving his head in figures of eight, and it is again important at this stage to leave him well alone, as disturbance leads to imperfect workmanship or even to the death of the caterpillar before his metamorphosis into a chrysalis has been completed. Atmospheric conditions are of vital importance at this time, as it has been shown how excessive heat or moisture can adversely affect the hardening of the silk as emitted from a viscous state within the worm.

Dependent upon the weather, but usually within ten days, a further change has been effected ; a moth has been perfected within the chrysalis, which on maturity exudes a brown liquid to dissolve the gum in the cocoon of silk, enabling it to push its way back into the outside world as a creature very different from that which spun the cocoon only about a fortnight earlier. This emergence usually occurs at dawn.

The two sexes are now easily discernible (in the worm or larva stage the sexes can be differentiated only by methods analagous to the sex-linking of chickens). The female moth is larger and more rotund than the male ; she is lethargic and makes little attempt to move, being content to perch upon her own empty cocoon or upon that of her nearest neighbour. The male on the other hand is full of zest and, so soon as his wings are dry, he sets off with wings flapping, but on foot (for domesticated moths like domesticated poultry cannot fly) in search of a mate. Mating is usually interrupted after a few hours and the male is then unceremoniously discarded, his work done. Whereupon the female loses no time in depositing her eggs, which in the case of most breeds adhere firmly to the surface upon which they are laid ; by twisting her tail she contrives not to lay one egg upon another.

Like the seeds of most plants, these eggs will not hatch until they have been subjected to a changed condition. Just as vegetable seeds must normally be buried in earth before growth can begin, so silk seed (as silk-worm eggs are often called) must be subjected to severe cold (hibernated) before hatching can be induced by incubation. It is this fact which gives the name of " monovoltine " to the variety of *Bombyx* under description, as its life cycle is completed only once within a year in the normal way. (An account will be found on page 28 of the breeding cycle of polyvoltine silk-worms).

We have now completed the annual cycle and have returned to the Spring, when the mulberries are again budding and the silkworm eggs are taken out of hibernation to be hatched for the coming crop.

For the production of raw silk however, the full cycle is completed only by the very small proportion of insects that are selected as fathers and mothers of next year's crop. In emerging from the cocoon the moth has to force an aperture, which deranges the filament and renders the cocoon difficult, if not impossible, to reel. Such pierced cocoons have a value only as Waste Silk to provide raw material for spinners.

It should here be explained that the term " spinning " is applied in the silk industry to the manufacture of spun or schappe as distinct from raw silk ; spun silk resembles cotton and wool yarns in that it is composed of twisted staple, whilst raw silk (Fr.: *grège*, Jap.: *kitto*) is an amalgamation of continuous filaments.

In order therefore to avoid piercing, it is essential at once to kill the chrysalis, and this is achieved by a number of methods, such as exposure to the sun, stifling by hot air or steam or, less generally, by chemical asphyxiation or freezing. Any of these treatments damages the silk to a greater or lesser degree, and increases the difficulty of unwinding the cocoon filament in the later process known as " Reeling." The killing of the pupa cannot, however, be avoided if cocoons are to be safely stored for more than a week, on account of the danger of moth emergence and consequent piercing.

After effective stifling, cocoons can be stocked theoretically for years, but practically for considerably less on account of the problem of averting damage by rats, mice, ants, mildew and other pests. Moreover, cocoons represent enormous bulk, measuring when baled in the dry condition (which is just about one-third of the fresh weight) up to 700 cubic feet per ton ; no more than two tons of dry cocoons can be loaded on a ten-ton railway wagon.

An old French saying advises *Petites magnaneries grande filature*. *Magnanerie* is the French term for a cocoonery, and it is true that sericulture throughout the world has always been essentially the province of the smallholder : even in Japan the vast production of cocoons is the sum of countless contributions from small farmers whose individual crops average less than 200 lb. each. Large rearings are not only more vulnerable to epidemic disease, but the necessity for a heavy concentration of labour over short periods presents a particular problem in rural areas.

REELING

In building his cocoon the silkworm has emitted through an orifice in his head a continuous filament of silk (in actual fact this filament, proceeding from two separate glands, is already double and is known as a "bave", made up of two "brins"). The process of reeling consists in finding the outside end of this bave, unravelling it and winding it into a hank.

A cocoon is quite a solid object, silk being possessed of a gummy substance known as sericin, which cements the filament as emitted into a solid mass: up to one-quarter of the weight of silk in a cocoon consists of sericin. Before attempting to isolate the filaments therefore, the cocoons must be softened by immersion in hot water to break down the gum and loosen the ends.

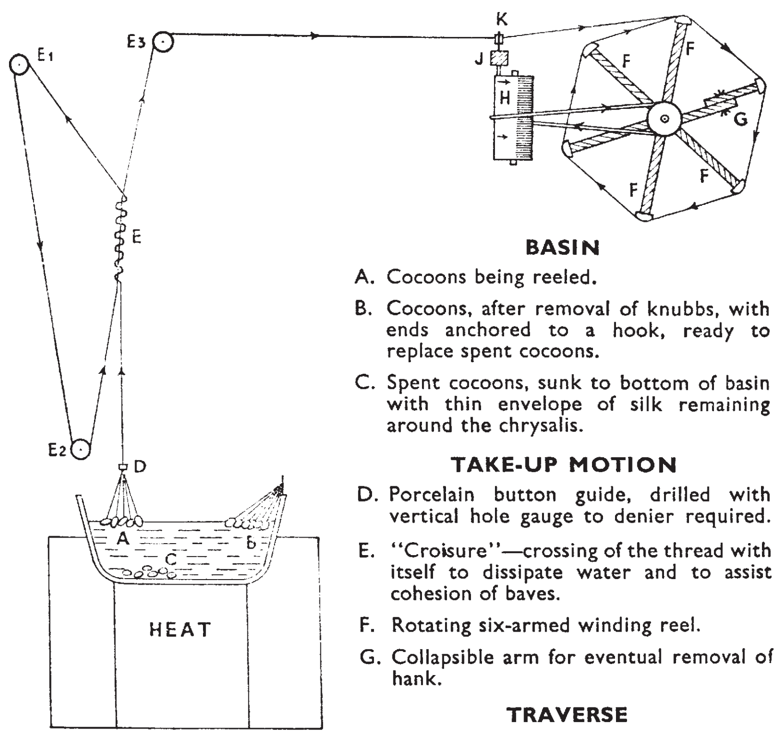
In native practice, a number of cocoons (Fr. : *cocons,* It. : *bozzoli,* Jap. : *mayu*) are placed together in a basin of nearly boiling water, the heat being retained by a fire burning beneath it. Simple boiling does not cause water to penetrate the cocoons, which remain floating (this therefore is termed the floating method as distinct from the sunken or semi-sunken methods, to which reference will be made later). Directly the gum begins to dissolve, the cocoon filaments readily adhere to a small brush or even to a simple rod, by which they are stirred.

When the silkworm started to build his cocoon, his early efforts were imperfect and the outside layer of silk is of a lower standard than that which lies beneath. The reeler having stirred the cocoons and plenty of material having stuck to the brush, the ends can now be grasped and jerked off the cocoons by a series of upward movements, until this outer layer known as "knubbs" (and more fully explained in Chapter IV) has been removed and only a single bave is running from each individual cocoon.

All is now ready for reeling. The size or denier of a single cocoon being too fine to be of any commercial use (1,000 miles of single baves of 2½ deniers would weigh only 1 lb.), it must be decided at this stage what size of raw silk is required and consequently how many cocoons are to be reeled as one. Cocoons reeled together in hot water, when the gum is soft and sticky, will form what to the naked eye cannot be distinguished from a single thread.

To ensure the union of the individual cocoon-baves reeled into a single end of raw silk, it is usual to run the

ELEMENTARY PRINCIPLES OF RAW SILK REELING



BASIN

A. Cocoons being reeled.

B. Cocoons, after removal of knubbs, with ends anchored to a hook, ready to replace spent cocoons.

C. Spent cocoons, sunk to bottom of basin with thin envelope of silk remaining around the chrysalis.

TAKE-UP MOTION

D. Porcelain button guide, drilled with vertical hole gauge to denier required.

E. "Croisure"—crossing of the thread with itself to dissipate water and to assist cohesion of baves.

F. Rotating six-armed winding reel.

G. Collapsible arm for eventual removal of hank.

TRAVERSE

H. Drum rotated by belt from winding reel.

J. End of sliding rod, pinned eccentrically to drum top, causing to and fro movement across the direction of the thread.

K. Guide eye, set on sliding rod, to spread the ends and so give width to the hank.

thread through a system of small pulleys so arranged that the thread is crossed at one point either with itself or with a neighbour (termed respectively the Tavelette and Chambon systems), while still wet, so binding the filaments together. This crossing is known by the French term *croisure* and is of importance from the point of view of cohesion. It also dissipates surplus water.

If the required size is 20/22 deniers and the individual baves of the parcel of cocoons to be reeled are found for simplicity's sake to be 3 deniers, it is clear that 7 cocoons must be reeled together. The ends of seven cocoons are therefore run through a guide, round the croisure and attached to a frame revolved either by an assistant or by a treadle, leaving the reeler with his hands free to tend the basin. As and when a cocoon drops off, whether on account of a breakage or because its silk is exhausted, another must be substituted at once, as it is evident that the size of raw silk reeled will in the meanwhile drop to 18 deniers.

The skill with which an experienced reeler adds another cocoon to those already reeling is fascinating to watch. Placing the filament of a new cocoon over the index or little finger of his hand, he lightly touches the multiple thread rising from the remaining six ; the sticky gum instantaneously effects a union, and the new cocoon is soon bobbing about on the surface of the water with its fellows, as its silk is unravelled.

It is the reeler's art to maintain a regular size, and a little thought must convince the critical user of the difficulty of the task, which is in practice not so easy as was made to appear in the foregoing simple example, as the individual baves themselves vary in size, tending to become finer towards the inside of the cocoon. Moreover he (or more often she) is asked to tend many more than a single end, often running at over 100 yards per minute. Some of the devices that have been evolved to facilitate and to perfect reeling will be told later, but the above is an outline of reeling as still practised to some extent by natives of all silk-producing countries.

CHAPTER II

SILK IN RECENT TIMES

LET it not be thought that the silk industry of today bears more than a basic parallel to the simple tale told in the first chapter. As with all natural products much has been done and is being done to take full advantage of modern science. Man's mastery of nature is extending into every field of industry and not least into agriculture; cows have been jockeyed into yielding 2,000 gallons of milk a year and hens into laying 300 eggs. Over the past 3 or 4 decades the production of silk per acre has been increased by 2½ times and plans are afoot to raise this ratio significantly. Silk reeling too has achieved a high degree of automation; the productivity of a silk reeler has been increased by 300% and raw silk may soon be available in a form, which will reduce initial costs to the throwster and manufacturer and so help further to cheapen fabric.

The production of silk is essentially an agricultural process in which an animal serves to convert vegetation to protein, just as cattle, poultry and sheep serve to do for milk, eggs and wool. Man has not yet altogether contrived to by-pass the use of the animal kingdom for this purpose. Maybe this will come and certainly the creation of "Artificial Silk" was an early sortie in this direction: it was based upon the spinnerets of the silkworm—hence the name. This led logically to the man-made fibres, spun by forcing a viscous substance through spinnerets in the same way as the silkworm has been doing for thousands of years. New and wonderful fibres have been evolved on these lines, but none with properties quite akin to those of silk.

What then has been done to rationalise the production of silk? The answer to this question involves both the sericulturist, who is a farmer and the reeler who is an industrialist and the sub-headings of the previous chapter will therefore be repeated here. The overall target is to produce a maximum weight of silk thread from an acre of land and towards this both parties have made their contributions.

SERICULTURE

Mulberry is a leaf crop such as tea or tobacco. As has been mentioned, it was at one time grown as a tree, often pollarded but nevertheless too difficult of access to be an economic proposition. The consumption of mulberry by silkworms in their two last ages (or instars) before the spinning of their cocoons is enormous and continuous throughout the 24 hours. Stripping leaves and branches from trees, of which many may be at some distance from the farm, is a slow and arduous job, calling for considerable strength and stamina, and extra casual labour is not ordinarily available to farmers for short periods for such intensive work. The answer has been to plant fields of bushes as a crop in themselves, cut down each year to ground level. A great deal of work has been done on developing the best type of mulberry for the job and the whole science of manuring and spacing has been the subject of specialized agricultural research. (Incidentally, why in the nursery rhyme is it a mulberry bush rather than a tree round which we go on a cold and frosty morning? mulberry in the form of a bush must be of rare occurrence in Britain).

The achievement of a maximum yield of leaf per acre is but a first step and leads us to what has perhaps been the most important advance made in the rationalization of silk culture in recent times. Outside the tropics silk has ordinarily been produced from a monovoltine species of Bombyx Mori and it has been explained on page 12 that in the natural state hibernation is essential before the eggs of one generation can be used for the next, which is Nature's way of preserving seed from sprouting until suitable conditions return in the Spring.

After harvesting the Spring crop of mulberry foliage, the plant leafs again and the second leafing has in the past gone to waste or been put to other uses. It was discovered that treatment with a mild solution of hydrochloric acid (a solution of 1.1 s.g. at 114°F. is a typical formula) could affect silkworm eggs in the same way as " hibernation ", and the Spring monovoltine eggs could thereby be hatched out at will and in time to make use of the second crop of mulberry leaf. This discovery was a major breakthrough and has increased the production of cocoons per acre, not by double, but by something like one and a half times by the introduction of Summer and Autumn crops.

An extension of this idea is now undergoing test in Japan. It is hoped that mulberry leaf can be dried and pulverized for the continuous rearing of silkworms throughout the year, which would represent another big step towards cheapening costs, as such a unit could afford to employ skilled labour on a permanent basis and replace the small farmer and his family. It is analogous to the year-round production of milk.

Despite the supposed omniscience of modern chemistry, it cannot yet be said just what is the property possessed uniquely by the mulberry that enables the silkworm to create silk. It is not enough to present him with a synthetic concoction—it must at the same time be appetizing.

There has always been a big wastage of leaf due to disease or weakness of the silkworm. Such a disease as pebrine brings death to the worm just before spinning, when he has consumed his ration of leaf and finally produces no silk. This menace was tackled by Louis Pasteur 100 years ago and was one of his major triumphs. As a result of his work pebrine has been largely overcome, but there are other factors and other diseases which contribute largely to mortality such as muscardine, flacherie and grasserie.

It is during his first three instars that the worm is highly susceptible to infection and to improper diet. Up to this stage too his requirements are small: his consumption of leaf is only 5% of what he will eventually consume and the need for labour and floor space are correspondingly low. The introduction therefore of co-operative rearing of young silkworms, for what may be the first 11 of a 25 day life, was not difficult and has proved of great value in reducing wastage. Trained experts are often available to supervise the village cocoonery and silkworms, already safely through the first two moults, are then distributed to the individual farms for the last intensive fortnight.

Many factors have contributed to the improved economy of sericulture—the careful handling of the eggs, especially in hibernation whether natural or stimulated: precise methods of incubation to ensure uniform hatching: sophisticated routines for disinfection: the provision of proper frames in which each cocoon can be built in a separate partition and then easily harvested: all these have made their contribution to what has amounted within a few decades to a revolution in the practice of growing a crop of silk cocoons.

REELING

The process of silk reeling—that is the unwinding of the continuous filament of thread, which the caterpillar has wrapped around himself to form a cocoon in which the larva can safely become a moth—has altered vastly. The first major step towards the refinement of silk reeling was the introduction in nineteenth century Europe of what came to be known as Steam Filatures. One of the great drawbacks to the native method of reeling is the wide fluctuation of water temperature inseparable from a simple basin heated directly by a small fire, and good reeling demands careful control of this item. Another desideratum is a constant speed for the revolution of the reeling frame to ensure that the unravelling of the cocoons is maintained at an even tension, especially so that jerking may be avoided. Whilst offering many other incidental improvements, the

Steam Filature was primarily the answer to these two defects. A steam boiler enabled the reeler to control the temperature of the water by means of a steam cock in the reeling basin, and a steam engine gave uniform speed to the revolutions of the reels.

The provision of these innovations entailed bringing the workers under one roof, which enabled supervision of their work; and more or less accurate sizes such as 16/20 and 20/24 deniers then became a possibility. Modifications came along throughout the years and several original patents began to make an appearance at the turn of the century, but it was not until the 1930's that the next fundamental change took place. This is associated with the name of Minorikawa (though in fact the outcome of many individual patents) and came into extensive use in Japan during the hey-day of silk stockings.

Hitherto cocoons floated in the reeling basin. They are very light and, unless fair speed is maintained during reeling, will cease to unravel and tend to rise out of the water to be caught on the initial guide eye. Evidently the greater the speed the greater the length of silk reeled before the operative can replace a dropped cocoon and Minorikawa's objective was therefore to find a means of reducing speed and thereby greatly improve evenness, which was an essential for the silk stocking trade. His answer was to saturate the cocoons with water and so there arrived the sunken, multi-end or cool-water type of reeling. Under this system the cocoon boiling and reeling became two distinct processes. Sorted cocoons are placed in small metal cages attached to an endless belt, moving across the top of a long trough. They are first subjected to steam, but the turn of the belt at the end of the machine has the effect of plunging them into cool water. They then return along the lower part of the trough, passing through water of varying temperatures. At the far end they are tipped out of the cages into a bucket ready for conveyance to the reeler. As a result of this process, requiring from 15 to 25 minutes, the cocoons emerge full of water.

The reeling basin has as many as twenty ends, tended by a single operative, but the weight of water within the cocoons makes it possible to maintain necessary tension while reeling at speeds as low as 40 yards per minute. Each individual end is fitted with a stop motion working in conjunction with a fine porcelain eye, gauged to the denier required and designed to catch thick places. Moreover, the water need only be tepid, which is a boon to the reeler's fingers.

In Steam Filatures the thread was reeled from the basin through the croisure direct on to a six-armed collapsible frame mounted in a chamber heated by steam pipes, designed to dry the thread and so avoid the matting of the hank as the gummy sericin, just softened in hot water, now hardens. It seems impossible however, altogether to prevent the gum setting hard on the corners of the frame, and the new system adopted re-reeling as the answer to this difficulty. The original reeling is taken up on light metal rollers of about 8 inches diameter and is then transferred to another department, where the silk is ballooned off vertically from the rollers into standard 1½ metre hanks, with a pronounced diamond traverse. There would seem to be no insuperable difficulty at this stage in winding on to cones instead of hanks: it is on cones or other similar packages that most other fibres are supplied to manufacturers nowadays.

The great bulk of this development took place during the 1930's and was the reelers' reply to the demand for superlative evenness for the manufacture of stockings, which was at that time big business. Other properties of silk had however to be sacrificed: slow reeling in tepid water does not give good cohesion, the baves composing the single end of raw silk being less firmly welded together, with resultant fraying and split ends in weaving, due in some degree also to the difficulty of inserting an adequate croisure on account of the increased tension from the basin end. A curious but real criticism raised was the ability of

Minorikawa reeling to produce a good seriplane test from second rate cocoons.

In the years that followed the 1939/45 war silk has been progressively superseded by the synthetics for the manufacture of stockings until it is now virtually only the weaving industry that remains as a large-scale customer for raw silk. The quality requirements of weavers differ from those of hosiery manufacturers, the latter demanding evenness over comparative short lengths, whilst the former need a silk which conforms accurately throughout to a specific denier.

Automatic reeling was the answer found, not only to this problem but at the same time to reduce costs and economise in the use of labour at a time when competition was becoming fierce and the army of girls, who had so long played a major and magnificent part in the delicate process of reeling, were beginning to find more congenial and perhaps more remunerative jobs in the towns.

There was nothing novel in the idea of automatic reeling and in fact Sir Thomas Wardle wrote in 1887 of a machine patented at that time in New York, evidently on very similar lines. " It appears to do what Mr. Serrell claims for it, and I commend it to those interested for thorough investigation of its capabilities ". Just why Serrell's machine did not find a market, we do not know.

It was in 1949 that Japan was first able to embark upon the use of automatic reeling machines on a commercial scale, but it was not until 1956 that real success was achieved, due largely to the introduction by the National Sericultural Experimental Station of an effective denier gauge. In 1956, 12% of raw silk produced in Japan was already being reeled on automatic machines, but by 1959 this figure had risen to 52%. It has now virtually superseded the older methods.

On these machines the principle of maintaining a correct number of cocoons per end is unchanged, but the job is taken over by a mechanical contrivance. Quite simply the raw silk end passes through an electronic gauge set to the required denier. Every few seconds a conveyer belt carrying new cocoons, already soaked and with their ends already in position, passes the reeling basin. If the gauge registers the denier of the raw silk thread to have dropped by 1½ or 2 deniers, it sets in motion a mechanism which picks up another cocoon from the conveyer and so adjusts the evenness. If it fails to do so, some seconds will elapse before another cocoon is presented and it can happen that the mechanism, which is a remarkably delicate balance, jams or jibs and so we get the curse of modern silk—fine ends, which may run sometimes for a hundred yards or more.

So far the reeling of silk finer than 20/22 denier has not been successful by automatic reeling, which is the only reason why the old method is almost and not completely obsolete, and such sizes as 13/15 denier have become scarce. Throwsters and weavers have been forced to reconstruct cloths to suit supply and the disappearance of odd sizes has been a feature of silk manufacture in modern times. The streamlining of filature methods has enforced streamlining throughout the industry. Mass production has overtaken craftsmanship and silk has perforce adapted itself to modern needs.

It remains however an expensive fibre. Will the public pay for comfort and elegance or have we in the rat race of modern life ceased to appreciate such things? Drip-dry and non-ironing save time and so enable us to look a little longer at the television. It was Aristotle who said, "To be always seeking after utilities does not become free and elevated souls", but that was more than 2,000 years ago.

May it be that the time will come when higher incomes and greater leisure will bring with them a reversion to gracious living—and what could not be done for silk if there were available but a tithe of the money spent on the promotion of other fibres?

CHAPTER III

THE SILK PRODUCING COUNTRIES

ALL the world knows that silk reeling had its origin in China. In modern times it has been pre-eminently in Japan that the latest developments have taken place, and it will be convenient therefore if in this review we begin in China, move westwards and so end with Japan.

CHINA

Many text-books begin their history of silk with mention of the famous Chinese Empress Hsi Ling Shi, who gave the industry royal patronage about the year 2640 B.C., but the author of *An Essay upon the Silkworm*, published in London in 1719, is content with nothing so recent. After reviewing the evidence of sericulture in antediluvian times and finding it rather scanty, he propounds a most plausible theory as to its extension since the Flood. Starting from the point where the male and female silkworms (or moths) left Noah's Ark, when it finally came to rest on Mt. Ararat in Armenia, he squarely faces the natural question " How then did it come to pass that silk originated so far away as in China ?"

The Book of Genesis is strangely reticent about Noah after the Flood, apart from remarking that he lived another 350 years. Plenty is told of his three sons, none of whom appear to have journeyed as far East as China. How then did China become so populous in such early times ? Does not the very fact that Noah's last 350 years are wrapped in mystery indicate that he travelled far, and is it not likely that he travelled to China and founded a new family there, taking the silkworms with him ?

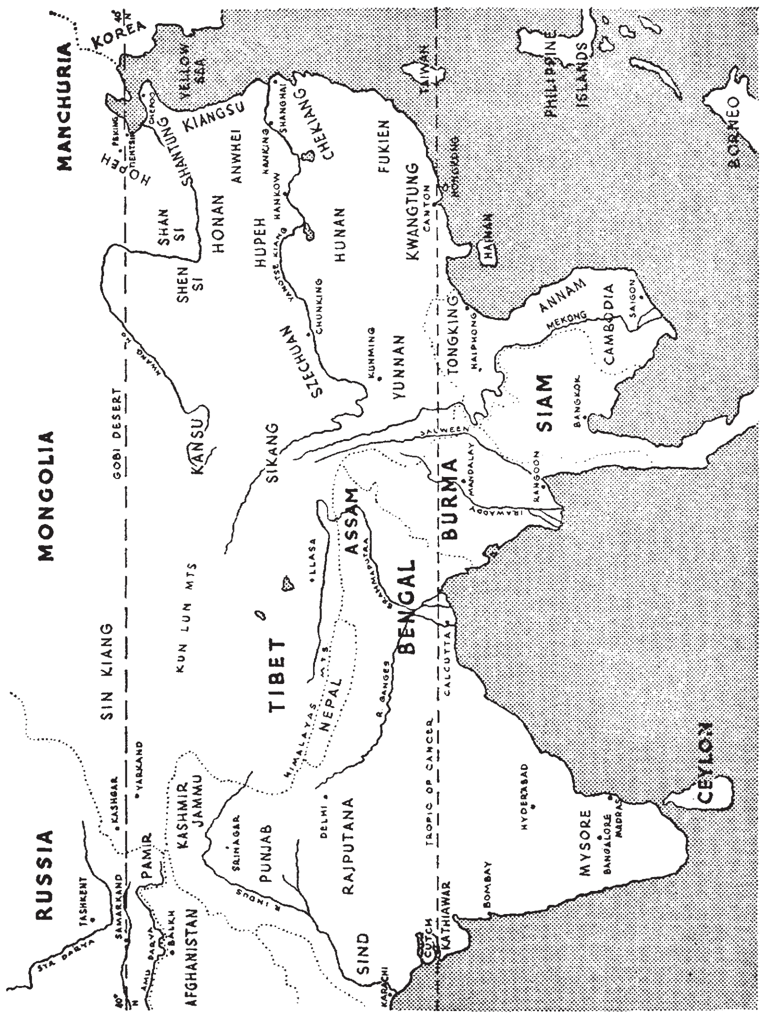
A curious item of evidence brought out by the author is the singularity of the Chinese language and of their manner of writing, which is "at so vast a distance from those which the confusion of Babel introduced that it cannot well be derived from thence nor from any of those patriarchs whose posterity was there divided into the several parts of the world . . . . all of which persuades me that as we are the offspring of Shem, Ham and Japhet, whose sons were scattered from Babel, so are the Chinese of Noah who was in no way interested or concerned in that dispersion."

Lest any doubt should remain in the reader's mind, it is further proved that the date of the death of Fo Hi, the first Emperor of China, happens to coincide with that of Noah's death. Moreover, Fo Hi is reputed to have appeared from nowhere, and is traditionally said to have been conceived beneath a rainbow.

Whatever explanation is accepted for the difficulty of Mt. Ararat, there can be little doubt that it was in China that silk was first reeled from the cocoon. The Chinese word for silk is "sse," and from it the Greeks took their name "ser," which European languages have since adapted to their own forms.

The account given in Chapter I of elementary reeling is true enough of the raws which were known in China as Tsatlees. As western buyers mechanised and accelerated their throwing and weaving methods, trouble was experienced with the diversity of sizes and skein formations in which Tsatlees were obtainable : in primitive apparatus the simplest form of gearing is by enlarging or reducing the circumference of the reeling frame to give greater or lower speeds (compare the Penny Farthing bicycle). Shanghai dealers therefore found it worth their while to sort the native silk and to re-wind it into uniform skeins. Hence we got Tsatlee Re-reels, which later became known simply as Re-reels, a name that has since become confusing in view of the re-reeling of Steam Filatures.

Tsatlee reeling was usually confined to the cocoon season, when by staggering a series of harvests it was possible to dispense with the stifling process, reeling only live cocoons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SHANGHAI
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CHEKIANG
FUKIEN
KWANGTUNG
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CHUNKING
YUNNAN
KUNMING
TONGKING
HAIPHONG
HAINAN
TAIWAN
PHILIPPINE ISLANDS
BORNEO
ANNAM
MEKONG
CAMBODIA
SAIGON
SIAM
BANGKOK
SALWEEN
BURMA
MANDALAY
RANGOON
IRAWADDY
ASSAM
LLASA
BRAHMAPUTRA
BENGAL
CALCUTTA
R. GANGES
HIMALAYAS MTS
NEPAL
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TASHKENT
SYR DARYA
SAMARKAND
AMU DARYA
BALKH
AFGHANISTAN
PAMIR
KASHGAR
YARKAND
KASHMIR JAMMU
SRINAGAR
PUNJAB
R. INDUS
DELHI
RAJPUTANA
SIND
KARACHI
CUTCH
KATHIAWAR
BOMBAY
HYDERABAD
MYSORE
BANGALORE
MADRAS
CEYLON

which produce a brilliant silk. Stifling is a necessity, if cocoons are to be stored and reeled throughout the year, and the particular lustre of Tsatlees is an illustration of what is sacrificed for this convenience.

The brilliant white silk most generally associated with China came traditionally from the provinces of Kiangsu, Anhwei and Chekiang with its centre in the neighbourhood of Shanghai, whilst the tropical province of Kwantung in the south was associated with the production of polyvoltine cocoons.

Polyvoltine silk moths differ fundamentally from the monovoltine variety, whose life cycle was outlined in Chapter I, in that their eggs require no hibernation and will hatch under normal conditions within a fortnight of laying : the cycle of a typical polyvoltine species occupies only 52 days—30 days as a caterpillar, 7 as a cocoon and another 15 days between the emergence of the moth and the hatching of her eggs. Thus seven cycles are completed within a year.

Such cocoons cannot be classed with those of the monovoltine moth for quality ; they are small, fluffy, usually pointed at the ends and contain no more than 3/400 yards of reelable silk, which is less than half that of average monovoltines. On the other hand, they have qualities of their own, Cantons having been at one time particularly in demand for the manufacture of mourning crepe. The fineness of the filaments (about 2 deniers) can of itself be a merit.

The Chinese Government has now introduced to the province of Kwantung white monovoltine silk of the Shanghai type. Mulberry silk is also produced in Honan and Shangtung, but the latter province together with Manchuria still farther to the north, is chiefly known for exports of Tussah, which is a wild variety involving a rather different process.

Silk is in fact to be found throughout China. Szechuan in the west has always been a silk producer, but until recent times its native silk was yellow and its exports were for the most part confined to the Lyons market. However, white silk of the Wusih breed for which Shanghai had become famous, has been successfully introduced and Szechuan raws are being accepted today by most manufacturers as the equivalent of Shanghai.

INDIA AND PAKISTAN

Turning west from China, the first important silk country is found in the Brahmaputra basin, situated for the most part in ASSAM.

Hitherto we have confined ourselves to mulberry silk, but Assam is a country rich in other races of silk-producing moths, which have not been domesticated to the extent of losing the power of flight and are cultivated in the wild state. Interest was first taken in the possibilities of this type of silk in the middle of the nineteenth century, when supplies of mulberry silk were suddenly decimated as a result of widespread disease.

The most important is undoubtedly the Tussah moth, which indeed occurs in many parts of India other than Assam and is closely related to the Tussah of northern China, mentioned above. It is a handsome creature with a wing span of six inches (*Bombyx Mori* can boast of only two inches) and emerges from a cocoon quite unlike that of other species. The cocoon is oval and its surface is as hard as that of an egg-shell, its oddest feature being a tough stalk, composed of silk and gum, ending in a loop by means of which it is hung from the twigs of trees.

In the early part of the season, cocoons are collected in the jungle, and eggs from the moths that emerge are gummed on long strips of paper, which are then hung on suitable trees, where they hatch quite naturally. A barrier of some sort is coiled round the trunks to prevent the caterpillars from wandering, and here they collect when a tree has been stripped of foliage, to be removed to another by the peasants. During the larval stage, which occupies up to seven weeks, guard is kept against the insect's natural enemies such as bats, birds and beetles, and on completion the cocoons are harvested like fruit.

Tussah is of a brownish colour, varying considerably between one locality and another (probably in accordance with its diet, as the Tussah silkworm does not confine its feeding to one type of leaf), and the filament is coarser than that of mulberry silk. Its outstanding merits are strength and durability, to which any user of fabric woven from Tussah can testify.

Another wild silk of Assam is Muga, which is of the same family as Tussah, but the Muga cocoon is not hard like that of its cousin and the filament is finer and more brilliant. The third species of wild silk that must be mentioned here is the Eri moth ; characteristics of Eri are its fondness for the leaf of the castor oil plant and the fact that in building the cocoon an opening is left for the emergence of the moth. Cassilk is a name given commercially to certain of these fibre.

Though many of these wild silks can be reeled, in India the usual process employed is a primitive form of spinning, the cocoons being first softened by boiling in an alkali solution and then pulled out by hand into a coarse thread.

There can be no doubt that Tussah, Muga, Eri and other wild moths are indigenous to India, and the tradition which tells of the introduction of silk to India in the head-dress of a Chinese princess in the fourth century must therefore relate only to mulberry silk.

Bengal has an important production of polyvoltine mulberry silk, which must date back a very long time, though it was not until the middle of the eighteenth century that the East India Company recognised its importance and set about its development. Experts were sent out to Bengal in 1772 with a view to the introduction of the technique then practised in Italy. Unfortunately, they struck one of the periodic famines to which Bengal is subject, and no progress was possible until 1776. Their efforts were, however, eventually so successful that exports of raws from Bengal rose over a period of years from 500,000 lbs. to 1,500,000 lbs. annually, replacing to some extent Italian and Turkish silk, which were then the vogue of the British market.

In India, native-reeled silk is known as "charka," the local demand for which, for sarees and other garments, has always provided keen competition to the steam filatures. While cocoon production has probably declined but little in Bengal, filatures (once largely French-owned) have been greatly reduced in number, until in 1940 two only remained. During the 1939/45 war, officially-sponsored efforts were made with a view to increasing and improving Bengal filature silk for parachute manufacture, but the quality of the cocoons and the standard of local workmanship presented difficulties that could not immediately be overcome.

The native moth, known as Nistari, is polyvoltine, and five principal crops are raised in the course of a year, the most important being the November/December " bund." The cocoons are small, weighing fresh as many as 600 to the pound (against a monovoltine average of between 200 and 300), and it is evident that this is a great detriment to reeling, necessitating very much more frequent replacements of exhausted cocoons : running at 180 yards per minute, not at all unusual in Bengal, even good cocoons will reel for only two minutes and the reeler is forced to resort to the pernicious practice of presenting two cocoons simultaneously. Moreover, the habit of sun-drying cocoons renders the silk brittle. The labour is male, recruited from workers experienced in charka reeling, which is such a very different matter from the reeling of accurate deniers. Towards the end of the last century, Sir Thomas Wardle wrote of the native reelers—" I visited many of these and found the appliances very rough and rude, the reeling by them varying from 10 to 20 cocoons in almost as many seconds."

Steps have been taken to counter both these deficiencies. Hybrids (Nismo and Nistid) crossed with monovoltines, have been developed, and improved apparatus based upon the Japanese system of re-reeling has been introduced.

Another area of silk production lies in Southern India, chiefly in MYSORE but extending eastwards into the province of MADRAS. Although also polyvoltine, this silk differs from that of Bengal, being of remarkable lustre and of light greenish colour. Bengal silk is yellow—or more accurately it should be said that its sericin is yellow, as the distinctive colouring of Bombyx cocoons is confined to the gum content and disappears after boiling.

The Government of Mysore turned its attention seriously to sericulture in 1914, when a department was set up to arrest the decline of the industry and to institute research towards its betterment. Within ten years much had been achieved and experiments were under way for the creation of an improved hybrid cocoon. French filatures had existed in Bangalore and in Mysore City, but it was not until 1937 that Steam Filature reeling can be said to have become established. Profiting from the special demand for silk during the War, much progress was made, and by 1943 as many as 700 basins were in operation and some 16 well-equipped sericultural stations were active throughout the State, maintaining supplies of disease-free eggs of a first generation cross between the local female and an imported monovoltine male.

Present day sericulture in KASHMIR and JAMMU can be said to date from a visit of Sir Thomas Wardle in 1891. Silk was grown here much before that time, as is witnessed by the size of the mulberry trees, said to have been planted by the Moguls, which stand 30 to 40 ft. high, and in winter at least have the appearance almost of English elms. Wardle introduced French-bred silkworm eggs, and imports of eggs from France continued for many years to supply about two-thirds of what is incubated each year. Some idea of the success of Wardle's work is shown by the fact that cocoon production in 1910 was just four times as great as in 1900.

Dependence upon foreign stock has, however, its weaknesses, especially as imports have not been confined to a single variety, with the result that local breeders have evolved quite irresponsible crosses, and it is realized by the authorities that the time has come to start afresh and to establish a pure Kashmir breed. The need for this was emphasized in war-time, when contact was lost with the important egg-producing establishments both of France and of Italy.

Denier reeling is confined to filatures of 740 basins at Srinagar and another of 150 basins at Jammu. Both are equipped and run on European lines, but the cocoons are not first-class, about 80 per cent of the crop being sun-dried (the most damaging of all stifling processes) on account of the difficulty of transport over wide areas to the filature stifling plants.

IRAN

The days when the country now contained within the borders of Iran and Northern Afghanistan gained huge profits from silk were those of the grand era of Chinese monopoly. The caravan route from China had its terminus in the Pamir mountains to the East of Balkh, and it was thus that as middlemen the Bactrians and the peoples lying along the extended route to the Mediterranean were able to earn vast sums on re-selling to the West, especially in the prodigal period of the Roman Empire, when silk was a luxury for which any fancy price was readily paid.

It is perhaps odd, therefore, that according to Gibbon, it should have been two Persian monks that were bribed by the Emperor Justinian to smuggle from China the secret of her 3,000 years monopoly. The story of how they succeeded in bringing out silkworm eggs concealed in their hollow pilgrim canes is well known, and it was from that date (A.D. 552) that the great entrepôt trade in Chinese silks began to decline, as sericulture became established within the Byzantine Empire itself.

Today, cocoons are grown along the shores of the Caspian Sea with a centre at Resht, and extending north into Russian territory. The breed most favoured is Baghdad White, a large cocoon of good white colour, and new stock is yearly introduced from France.

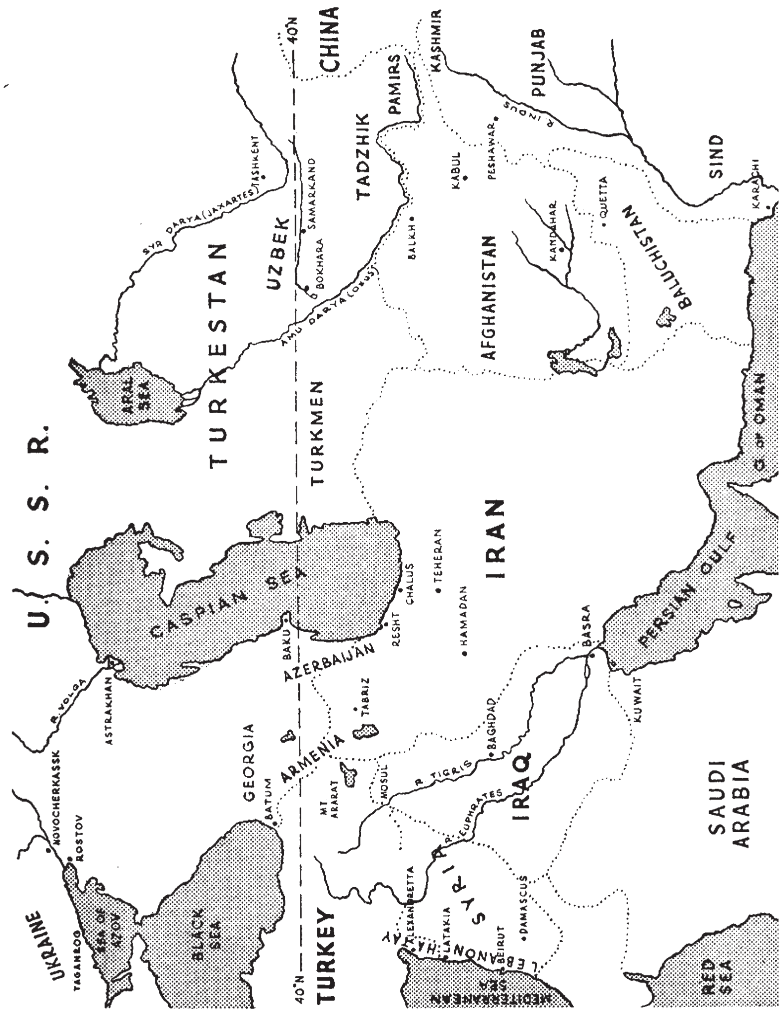
The late Shah Reza Khan created a royal monopoly in silk, and built at Chalus on the Caspian, north of Teheran, a factory to undertake all operations from the cocoon to the printed scarf or pair of stockings. No expense was spared and the leading textile machinists of the world were given a free hand to set up a comprehensive plant. It cannot be said that this venture has proved a commercial success.

RUSSIA

Both to the north-west and to the north-east of Iran lie the silk districts of the Soviet Union, one-third of the crop being raised in Russian Azerbaijan, Armenia, Georgia and the Ukraine (there are sericultural stations at Novocherkassk and at Taganrog), while the territory once known as Russian Turkestan to the east of the Caspian and Aral Seas is responsible for the other two-thirds of the present Soviet output. The State of Uzbek, with the famous old silk markets of Bokhara and Samarkand on the Zerafshan River and of Tashkent in the valley of Syr Darya (Jaxartes), alone contributes more than half of the production of the whole Union.

THE LEVANT

Silk has been grown in the mountains of the Levant coast probably since the introduction of sericulture to the Near East in the sixth and seventh centuries. The area extends from Anatolia in the north to Sidon and nearly to the borders of Palestine in the south, crossing the modern political frontiers of Turkey, Syria and Lebanon. The whole was stocked with breeds of yellow cocoons, introduced from France.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ASTRAKHAN
R. VOLGA
CASPIAN SEA
BAKU
AZERBAIJAN
ARMENIA
MT ARARAT
TABRIZ
RESHT
CHALUS
TEHERAN
HAMADAN
IRAN
TURKESTAN
TURKMEN
ARAL SEA
UZBEK
BOKHARA
SAMARKAND
TASHKENT
SYR DARYA (JAXARTES)
AMU DARYA (OXUS)
TADZHIK
PAMIRS
40°N
CHINA
KASHMIR
PUNJAB
R. INDUS
PESHAWAR
KABUL
BALKH
AFGHANISTAN
KANDAHAR
QUETTA
BALUCHISTAN
SIND
KARACHI
G. OF OMAN
PERSIAN GULF
BASRA
KUWAIT
SAUDI ARABIA
IRAQ
BAGHDAD
R. TIGRIS
MOSUL
EUPHRATES
SYRIA
ALEXANDRETTA
LATAKIA
BEIRUT
DAMASCUS
LEBANON
MEDITERRANEAN SEA
RED SEA

After the break-up of the Turkish Empire in 1919 the Ottoman Debt Commission took steps to augment exports of silk from the Levant, introducing measures to propagate mulberry and to control silkworm diseases. A certain success was achieved and shipments of cocoons were made from Alexandretta, Latakia and Beirut to Marseilles.

At the time of the outbreak of the 1939–45 War, the country possessed many filatures, a few of which (mostly French in origin) were of European design, but in addition there remained a large number scattered throughout the mountains of Lebanon, wherever a plentiful supply of water was to be found, with anything down to a dozen basins each.

Cocoon output was fast declining, but the closing of filatures had strangely lagged behind, with the result that smaller filatures with inadequate capital to acquire sufficient cocoons for cash during the single crop had adopted the habit of working for only a few months out of every twelve.

After the Pearl Harbour incident in December 1941, the Western Allies found themselves denied all their normal supplies of silk which was then still imperative for the manufacture of parachutes. The situation in Lebanon enabled the cocoon surpluses of Iran and Turkey, which would have found their way under normal circumstances to France and Italy, to be reeled here, and all filatures both of Syria and Lebanon worked full time from 1942 to 1945 in support of the war effort. Monopolies of their own cocoon crops were accorded to the Allies, and by thus establishing unity of control an opportunity was afforded for standardisation and improvement, if only of a temporary nature.

CYPRUS

During the colonial government of Cyprus, efficient measures were taken to foster and control sericulture in the Island. Being an island, Cyprus had perhaps a better chance than other Near Eastern countries to eliminate disease and to maintain sound stock. This she accomplished, and the standard of her silkworm egg production came to bear favourable comparison with that of the old-established firms of France and Italy.

For centuries Cyprus reeled and wove her silk on native machines, but in 1928 a modern filature was set up, with the encouragement of the Imperial Institute, at Paphos in the south-west corner of the island. The timing of this venture was unfortunate as it encountered in its first years the slump in silk prices, which was such a feature of the early thirties. Moreover it came up against local merchants, who had long been engaged in the export of cocoons to Europe and who were able, partly on account of subsidies paid to reelers in foreign countries, to pay better prices for the Cypriot cocoons than could the local filature.

Through a combination of such circumstances, the filature closed in 1933 and the Island is no longer of any importance as a supplier of silk.

TURKEY

Mention has already been made of the production of yellow cocoons in the Hatay with its centre at Alexandretta, but the most important output of cocoons within modern Turkey comes from the neighbourhood of Brutia on the southern shores of the Sea of Marmara in north-west Anatolia. Steam filature reeling was introduced here as long ago as 1844.

It is perhaps not entirely a coincidence that silk production tends to prefer beautiful country, but Brutia is certainly a striking example of this—so also is Lebanon the loveliest of her neighbours, and the shores of the Caspian are of a verdure most refreshing to eyes accustomed to the dust of southern Persia ; Kashmir is widely renowned for the magnificance of its scenery, and Mysore is among the pleasantest of the lands of India.

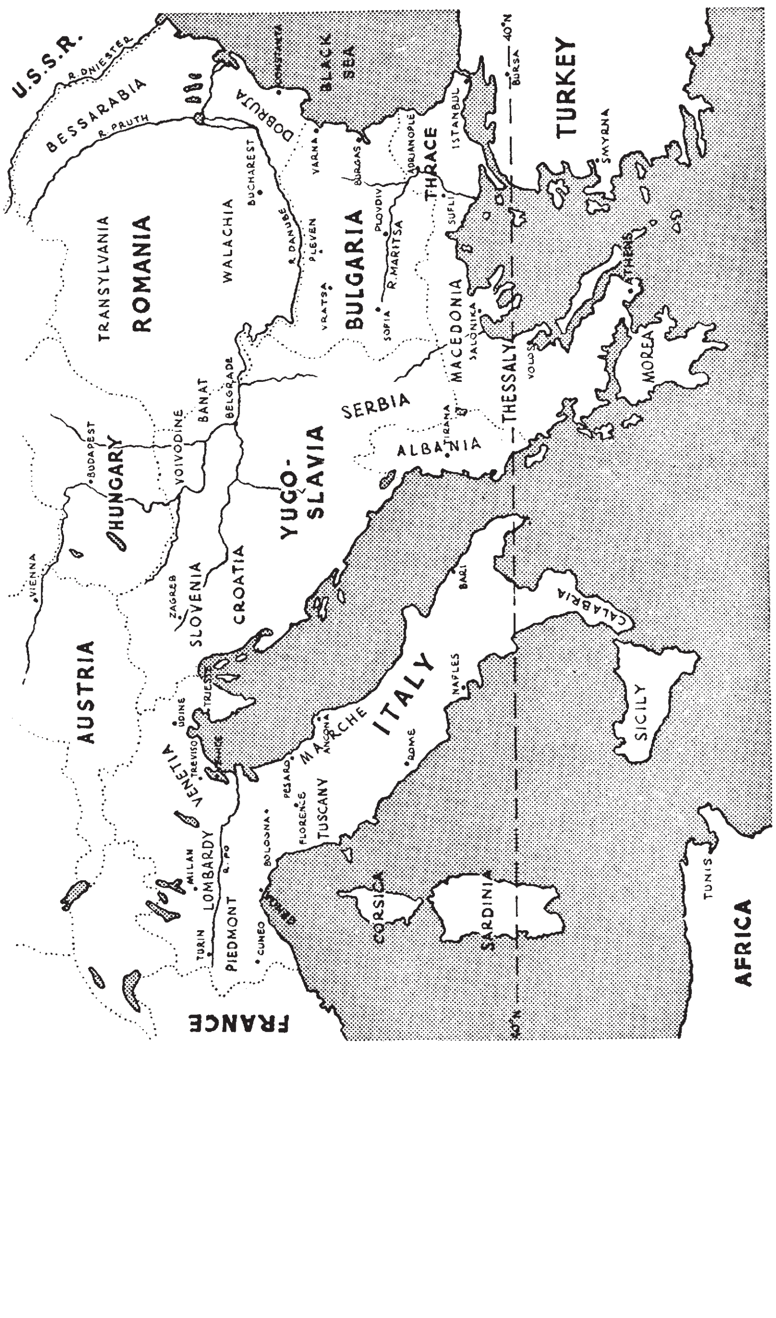
In Brutia (or Bursa as it is now spelled) the crop is white and the cocoons of good quality, but since the 1914/18 war sales of raw silk have been confined to local demand and the reeling industry, which suffered heavily from the expulsion of Christians in 1920, has not shared in recent progress. Turkey became content to sell her cocoon surplus to Europe and much of the raw silk, once loosely known in the United Kingdom as "White Italian," had its origin in Brutia cocoons.

On the European side of the Bosphorus is another area of white cocoon production, associated with the name of Adrianople. These cocoons have long been famous for good bony texture and have been considered especially suitable for the manufacture of bolting cloth. Since the decline of the Ottoman Empire, political frontiers in this part of the world have been the subject of much change, and today little of this production lies within Turkey.

THE BALKANS

The most intensive area of cocoon cultivation in the Balkans is the watershed of the river Maritsa, which runs through Plovdiv (Philippopolis) in Bulgaria, past Adrianople in European Turkey and reaches the Aegean Sea through Grecian Thrace : within ten miles of the point where these three countries meet lies Svilengrad, meaning " silk town." Here production is largely devoted to the white Adrianople cocoon, but certain areas have been allocated by the Bulgarian Government to the production of what is known as the Improved Bulgarian cocoon.

Greece, Bulgaria, Yugoslavia, Hungary and Romania can all lay claim to silk production, but the two first are the most important, Greece being responsible for more than half of the total Balkan crop and Bulgaria nearly one-third. From the important centre of Thrace a belt of silk country runs westward through Macedonia, turning north into Serbia and south into Thessaly. The Peloponnesus too, produces cocoons, and claims to be the oldest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CONSTANTA
BLACK SEA
VARNA
BURGAS
PLEVEN
VRATSA
BULGARIA
SOFIA
PLOVDIV
R. MARITSA
ADRIANOPLE
THRACE
ISTANBUL
SUFLI
BURSA
40°N
TURKEY
SMYRNA
MACEDONIA
SALONIKA
THESSALY
VOLOS
ATHENS
MOREA
SERBIA
TIRANA
ALBANIA
BELGRADE
BANAT
VOIVODINE
BUDAPEST
HUNGARY
YUGO-SLAVIA
VIENNA
AUSTRIA
ZAGREB
SLOVENIA
CROATIA
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TURIN
PIEDMONT
CUNEO
GENOA
BOLOGNA
FLORENCE
PESARO
TUSCANY
MARCHE
ANCONA
ITALY
ROME
NAPLES
BARI
CALABRIA
SICILY
CORSICA
SARDINIA
TUNIS
AFRICA
FRANCE

sericultural district of Europe, the name Morea having supposedly been derived from the classical word for the mulberry.

Another cocoon district of the Balkans is to be found in the north-west corner of Bulgaria, south of the Danube with markets at Vratsa and Pleven. Higher up the river and on its northern bank, lie the producing areas of what was once Hungary, but which by the Treaty of Trianon were incorporated in Yugoslavia and in Romania, the former taking Voivodine and the latter taking parts of Banat and of Transylvania. What remains to modern Hungary is reserved as a state monopoly. There is some production also in Croatia and Slovenia, but this is indeed an outcrop of the important Italian belt.

Reeling has not hitherto reached great importance in the Balkan countries which have provided a supplementary supply of cocoons for Italian filatures. However, the Bulgarian Government in particular is anxious to foster the industry, and there are today more than 1,000 basins in operation in the country, which consume a large share of the fine Adrianople cocoons, so much in demand by Italy before the War.

ITALY

Italy has been producing silk on a large scale for more than six centuries and is today the only significant source of supply remaining in Europe.

It is in the Venetian provinces that over half of the Italian crop is raised, the most important districts being around Udine (the principal market for Friuli) and Treviso at the head of the Adriatic Sea. Lombardy and Piedmont account for another 40 per cent. of the total, leaving only about 10 per cent. to be shared between Emilia, Tuscany, Marche, Calabria and Sicily.

The Italian crop was once wholly yellow, but efforts made to introduce Japan white silk have proved successful; the raising of the traditional Italian yellow cocoon has virtually disappeared. Egg production is controlled by Government stations at Padua in the North and at Ascoli Piceno in Central Italy. Importance has always been attached to the creation of breeds that will yield a maximum weight of fresh cocoons per ounce of eggs (official statistics quote kilograms of cocoons per ounce of seed in the various provinces) rather than to the more pertinent factor of raw silk per acre of mulberry : more prominence is attached to this consideration than to the worth of such cocoons to the reeler and the supreme importance of furnishing a type of raw silk to compete in the markets of the world.

Both in sericulture and in reeling Italy was slow to follow her Far Eastern competitors. The importance of rearing a second crop by modern methods of artificial hibernation, and the advantages of slow, cool-water and automatic reeling, pioneered in Japan, were slow to be adopted. Italian cocoon production declined steadily over recent years, but it is significant that today the Common Market Commission is sudsidising Italian sericulture with a view to greatly increasing production.

Reeling is distributed throughout the cocoon districts, though Lombardy has rather more filatures than her cocoon production would justify. The most important centres are at Bergamo, Brescia, Cremona, Como and Milan in Lombardy ; at Treviso, Vicenza, Udine, Verona and Padua in Venetia ; at Cuneo in Piedmont ; and in the neighbourhoods of Ancona and Pesaro in Marche.

FRANCE

Although her production today is insignificant, France has in the past made fundamental contributions both to sericulture and to filature technique.

Outstanding among these must be considered the work of Louis Pasteur for the elimination of pebrine, the most deadly of all silkworm diseases. In the early part of the nineteenth century French sericulture had been booming, and by 1853 the crop had progressivelv risen to 28,000 tons of cocoons, which represented an important revenue to the economy of the country. Within the twelve following years this figure had dropped to 4,000 tons, and in 1865 Pasteur was persuaded to turn his attention to the study of a problem that was proving disastrous to France.

By a series of exhaustive experiments on healthy and diseased worms, he was able to prove that pebrine was hereditary, and his cure was therefore directed to the careful selection of disease-free moths for the provision of next season's supply of eggs. The method advocated by Pasteur (known as " cellular ") is still the foundation of present-day practice and must be outlined here.

As already described, mating of male and female moths immediately follows emergence from the cocoon : the male is discarded and the female proceeds to the depositing of her fertilised eggs. Under the cellular method she is confined for this purpose either within a small cotton bag or within the compass of a device that could be compared with a slightly conical brass napkin ring, placed upon a card (usually 28 moths to the card). Here she dies, leaving her eggs at once identifiable with the body from which they emanated. The " graineur " crushes a part of each body, using a small mortar and pestle, and examines the corpuscles under a microscope : pebrine infection can be recognised in the form of minute oval bodies in the vital juices and, in the event of finding such, the infected moth and her eggs are at once destroyed. In Japan the whole card of 28 layings is destroyed if any one of the mother moths is found to be diseased.

So the scourge of pebrine was arrested in France, and from that time all countries have adopted some such method, prohibiting by legislation indiscriminate reproduction of silkworm eggs. Where only a single crop is raised the graineur has the autumn months in which to examine the moths, as there is no danger of hatching until the eggs have been subjected to temperatures as low as 40°F., but in polyvoltine countries where crops succeed each other without pause, a number of time-saving devices have been evolved to speed the work, which is in many cases undertaken only under Government auspices.

There remains in France a production of cocoons, aided by Government subsidy. The best known source of these is in the Cevennes mountains, and it is in fact at Alès in the Départment du Gard, still the most important Sericultural district of France, that a statue was raised to Louis Pasteur with the simple inscription *A Pasteur la sériculture et l'industrie de la soie reconnaissantes.*

SPAIN

Sericulture was introduced into Spain with the invasions of the Moors in the ninth century, and continues today in the south-east in Andalusia and particularly in Murcia. Here a speciality is the manufacture of silkworm gut.

When a silkworm has passed through his fourth moult and is about to spin his cocoon, he may be taken and immersed in a solution of vinegar and salt for a few hours. The body is then opened and the two silk glands carefully extracted : taking an end in each hand the glands are drawn out to their full extent and plunged into cold water. They are then left for some days in a mild solution of brine and lemon juice before finally washing and drying.

In Spain this simple practice has been raised to a fine art, and imitators of Spanish gut have never succeeded in equalling the genuine article. Fishermen know of its uses.

BRITISH ISLES

Though never yet an important silk producing country, it is interesting to recall attempts that have been made here from time to time to raise cocoons.

James I was among the first enthusiasts. Jealous of the successful development of sericulture in France under Henri IV, James issued a circular in 1608 to all the counties of England, directing that opportunities afforded by Quarter Sessions and other public gatherings be taken to "persuade and require all who were able to distribute 10,000 mulberry plants to be procured from London at ¾d. per piece." Some interest was shown, "but notwithstanding the royal countenance the attempt was never attended by even partial success."

The cause of this failure has been attributed to too short a period having been allowed to elapse between the mulberry planting and an attempt to raise a cocoon crop, but a perhaps more cogent reason lies in the fact that the wrong variety of mulberry was distributed. Many mulberry trees remain throughout the country which evidently date from early attempts at sericulture, and are all the black mulberry (*Morus Nigra*) which can be grown in northern latitudes more readily than can the white mulberry which, as already noted, is the species preferred by silkworms. The white mulberry suffers from a Spring precocity which often leads to the destruction of the buds or young foliage by late frost. As those engaged in the buying and selling of raw silk well know, this is only too common an occurrence even in the big silk producing countries.

In 1629 there occurs a reference to a grant being made to a Walter Aston for "the custody of the garden, mulberry trees and silkworms near St. James's in the county of Middlesex," which may relate to some personal venture of the late King James.

In 1718 an ambitious undertaking was launched for the propagation of British sericulture, when a patent was granted to a certain John Appleton, and two thousand mulberries were planted in Chelsea Park. It was as a prospectus to this venture that Barham published his *Essay upon the Silkworm*, which has already been quoted in connection with Noah's introduction of silk to China. This scheme ended in disaster as did many another at that time, the most notorious of which was the South Sea Bubble, which failed in 1720.

A century later a company known as the British, Irish and Colonial Silk Company planted 80 acres in County Cork and another 19 acres "of fine, rich soil near Slough," but in neither of these sites does the venture appear to have flourished, the promoters later turning their attention to Malta and St. Helena.

It was however, at about this time (1825) that John Heathcoat made certain valuable contributions to the development of filature machinery, designed from experience gained in reeling cocoons in Devonshire; his ideas were more fully exploited later in Sicily.

Mention must here be made of the Lullingstone Silk Farm at Ayot St. Lawrence, where silkworms are today being raised and cocoons reeled under the direction of Zoë, Lady Hart Dyke. This establishment affords a unique opportunity within this island today of gaining at first hand a knowledge of these processes, and a visit is very well worth while. Propagation of the Osigian mulberry is here a speciality.

AFRICA

Monovoltine mulberry cocoons have been successfully raised in the Eastern Congo (Ituri) north of Lake Albert and within 50 miles of the convergence of the Sudan and Uganda borders but, apart from this development, the African continent can make no serious claim to silk production, excepting certain wild silks which are unique and interesting.

Of these it is only the product of the Anaphe moth that has been exported in bulk. Throughout a belt of equatorial Africa this insect abounds, breeding and developing with great rapidity. Instead, however, of forming individual cocoons for the metamorphosis from caterpillar to moth, a number of caterpillars group together to spin a nest, from which the moths fly on emergence, and it is these empty nests that are collected as raw material for the spinning industry.

WESTERN HEMISPHERE

Certain wild silks are indigenous to America, but have not been commercially exploited. Repeated attempts have, however, been made to initiate mulberry breeds.

Having failed in his efforts to develop sericulture at home, James I in 1622 issued strict injunctions to his colonists in Virginia that " they should apply themselves diligently and promptly to the breeding of silkworms, bestowing their labours rather in producing this rich commodity than in the growth of that pernicious and offensive weed, tobacco." Then, as now, slogans were employed to promote Government policy, and the following is an example of the use of verse to this end :

> " Where worms and food do naturally abound,
> A gallant silken thread must there be found.
> Virginia excels the World in both,
> Envy nor malice can gainsay this troth."

But Virginian tobacco is better known today than is Virginian silk.

In 1732 in the earliest infancy of the settlement of Georgia mulberries were planted and cocoons were raised. This met with some success and extended into South Carolina. With a view to fostering its development, the Home Government in 1749 exempted the raw silk of these colonies from duty, but sericulture finally succumbed to cotton cultivation, which was proving so profitable to the planters.

Many another attempt has been made across the Atlantic, often sponsored by emigrants from silk countries. In 1838 there was in Pennsylvania a short-lived but particularly violent wave of enthusiasm for the planting of mulberry.

In recent times a large-scale enterprise was inaugurated at Mineral Wells in Texas, and a number of the Central American republics (notably Mexico, where sericulture is said to have been introduced in the 16th century by the Conquistadores) have given silk a trial. In the West Indies mulberry has been shown to prosper and there is no longer any reason why first class silk should not be produced in these tropical and sub-tropical areas.

In the 1930's, Brazil met with considerable success in silk culture. Cocoon cultivation took root, especially in the Province of Sao Paulo, where emigrants from Japan, Italy and Syria were officially encouraged and assisted by the Government to develop the industry. Expansion was rapid and it will be seen from figures quoted in Chapter V that the contribution of Brazil to world production is considerable.

JAPAN

Traditions vary as to the introduction of sericulture into Japan. One legend tells of how an unwanted princess was cast adrift on the ocean in the hollow trunk of a mulberry tree, and at length reached the shores of Japan in the guise of a silkworm, but a more credible story is of a secret mission which penetrated into China in the third century and succeeded in capturing four Chinese girls and a supply of silkworm eggs.

It was at any rate in very early times that the Japanese learned the use of silk, and the Yamamai cocoon is almost certainly indigenous, but for many centuries the industry was confined to manufacture for local use.

The first serious entry of Japan into the export field was about the year 1855, when it will be remembered that pebrine was ravaging the silk production of Central Asia and of Europe. The islands of Japan seem to have escaped this disaster and a heavy demand sprang up for eggs to replenish stock in the West. Up to 1873 egg production experienced a boom, followed abruptly by a slump, which by 1885 had brought the export of eggs from Japan to a standstill. It was at this juncture that Japan turned her attention to the possibilities of her own sericulture with a view to export.

The expansion thereafter was very rapid. A production of 50,000 tons of cocoons in 1892 rose to 100,000 in 1907, to 200,000 in 1920, to 300,000 in 1924, and reached a peak of 380,000 tons in 1930. Production is distributed throughout the islands south of the 39th parallel, but more than half of the crop is raised within 150 miles of Tokyo.

Full credit must be accorded to the Japanese for a remarkable achievement. The task set was to produce a maximum weight of raw silk per acre, involving firstly increased foliage per unit of plantation, secondly increased fresh cocoons per unit of foliage, and thirdly increased yield of raw silk per unit of cocoons. Advances were made in all respects and costs of production were thereby reduced well below that of any competitor. In fact the advances recorded in Chapter II emanated one and all from Japan.

The graph appearing on page 49 illustrates the extent of this success over the pertinent decades. Within forty years the yield of raw silk per acre of mulberry was increased 2½ times.

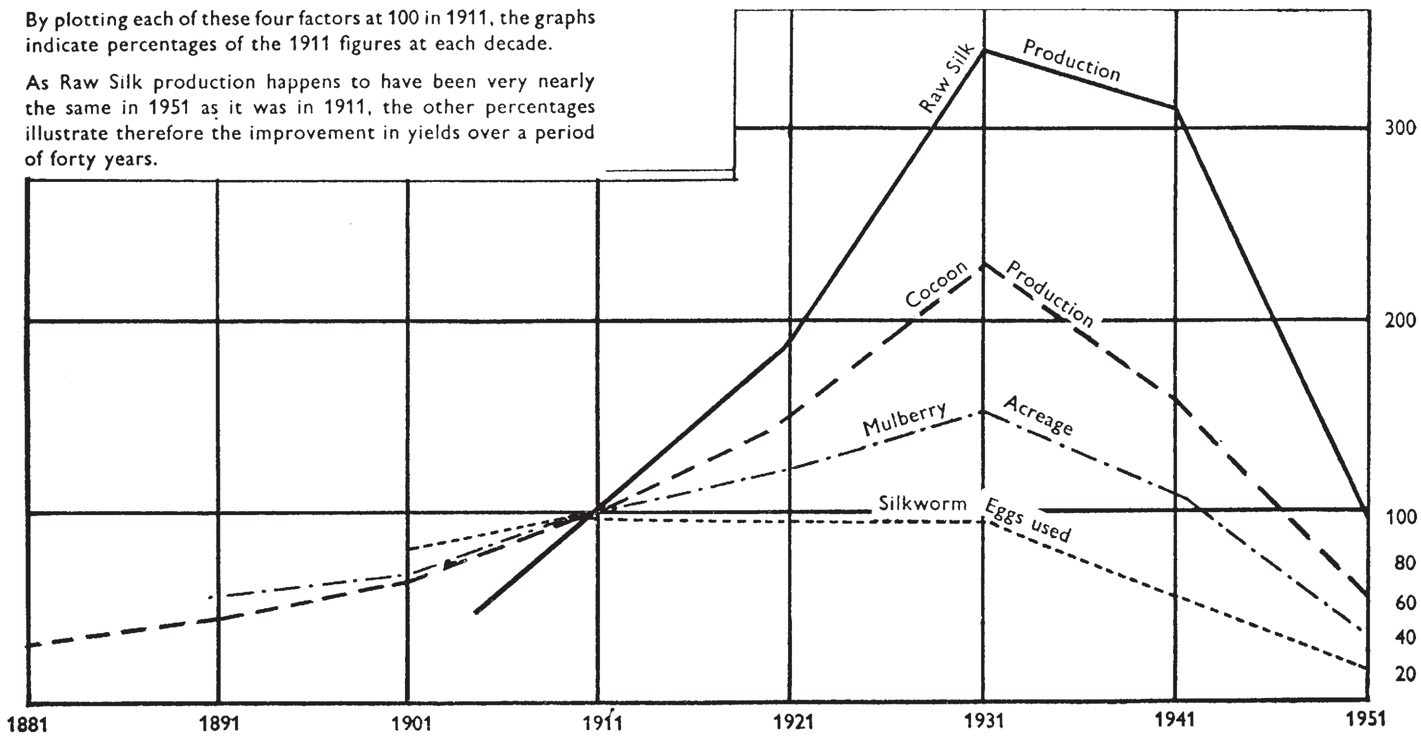
Energetic application of State-subsidised research was the basis of success, nor has this since been relaxed despite changed circumstances. Today their hope of a further big stride forward rests upon work now being done on the possibility of silkworm rearing under controlled conditions on a processed diet throughout the twelve months. Many obstacles have still to be surmounted but progress continues to be made. Success in this project would revolutionise and could revitalise the whole industry.

It was just a century ago (1868) when filature reeling was first brought to Japan by a Swiss expert. Throughout the years the Japanese have given a lead to the world—not only as a producer, but as a consumer. No nation appreciates better than they the virtues of silk for apparel of prestige and of comfort.

GRAPH ILLUSTRATING YIELD INCREASES IN JAPAN

By plotting each of these four factors at 100 in 1911, the graphs indicate percentages of the 1911 figures at each decade.

As Raw Silk production happens to have been very nearly the same in 1951 as it was in 1911, the other percentages illustrate therefore the improvement in yields over a period of forty years.



KOREA

During its occupation by Japan (1910/1945) sericulture in Korea developed along lines similar to those of the Japanese islands, and there is little therefore to add. The country is now divided politically and South Korea has become a useful source of supply to the United States.

Korea is also a big Tussah producer and was the primary source (Manchuria being second in importance) of the large quantities of this silk once imported into Japan for the manufacture of pongees.

OTHER COUNTRIES

The foregoing by no means provides a comprehensive list of the silk countries ; nor even are those included the most important, as Indo-China and Burma can be taken as examples of producers very much more prolific in silk than some of those mentioned. In India only three areas were described, but silk, chiefly of wild varieties, abounds in many districts. Thai silks from the country once known as Siam are now becoming widely known in the shops.

During the 1939/1945 war, Germany made an attempt to introduce sericulture in the Hanover region, and two filatures were erected at Celle and at Peine in that neighbourhood. Other European countries include Czecho-Slovakia, Poland, Holland and Portugal, all of which have produced silk: there are in fact few suitable areas of Europe in which sericulture has not been attempted at some time or another.

In America, mention could be made of California, Venezuela, Argentine and others, but data is not always available, and we must conclude by asking the indulgence, both of those inadvertently omitted and of those incompletely or perhaps incorrectly described.

CHAPTER IV

WASTE SILK AND BY-PRODUCTS

THROUGHOUT all processes of sericulture and of reeling, some waste occurs, but use is found for all by-products and in sum they represent a considerable item against costs : under certain circumstances, it is possible to have cocoons reeled on commission without charge, the reeler retaining all but the raw silk.

Types of waste silk originating in the many silk producing countries are legion, and the International Silk Association made an attempt in 1959 to evolve a dictionary of silk waste terms, detailing the many qualities available with equivalent nomenclature in French, Italian, English and Japanese.

Waste arises firstly in sericulture, secondly during the preliminary sorting of cocoons, thirdly in the filature, and fourthly during subsequent processes. It would be convenient to take these in sequence.

SERICULTURE

In harvesting, a quantity of fluffy material is found enveloping each cocoon. In starting to spin, the silkworm must get a purchase on some solid object (usually twigs, straw or bamboo matting are provided) and he casts out pilot threads to form a rough structure within which to build the cocoon proper. In some districts this material, known as Blaze (It.: *Spelaia*, Jap.: *Keba*) is kept by the grower and in others it is left to be removed at the filature. The quantity is small and the quality poor, being usually full of twigs or straw, but it has a value for noil spinning. The blaze, even of yellow cocoons, is white.

An unexpected residue of sericulture, which commands a price, is the litter from the silk-worm beds, containing droppings, rich in undigested material, and crumbs of foliage, which is dried and used as winter feed for cattle.

Undoubtedly the most important of the by-products of sericulture are the pierced cocoons (Fr.: *cocons percés*, It.: *sfarfallati*, Jap.: *degara*) derived from breeding establishments where the moths are permitted to emerge. These contain the complete silk output of the worm with no other matter, apart from the flimsy chrysalis shell and the caterpillar's last skin. A certain amount of accidental piercing occurs also outside the breeding industry, often owing to a breakdown of transport on the way to the stifling plants.

In China and Japan these cocoons are boiled, turned inside out to remove the remains of animal matter and opened to provide wadding (*Mawata*) for quilted winter wear. They also provide good material for spinners, as the quality has been impaired neither by stifling nor by previous boiling.

SORTING

In any parcel of cocoons a percentage of deformed, irregular and imperfect specimens is certain to occur, and sorting is an essential process that must always precede filature reeling.

It happens, particularly where space has been unduly cramped at the mounting stage, that two worms unite to spin a single cocoon, which is therefore composed of two baves: it might well be supposed that the tangle would be inextricable, but such double cocoons, which may represent as much as 7 per cent. of a crop, can be reeled into a coarse slubby thread, known by the French term *douppion* (Jap.: *tamaito*). This type of reeling is a speciality, which has been much improved of late, douppions being now available in sizes as fine as 19/24 deniers in Japan. Polyvoltine breeds are very much less liable to this abnormality than are monovoltines, and of the latter Europeans less than Asiatics.

A not infrequent occurence is the death of the caterpillar either in the very early stages of spinning or actually within the completed cocoon. In the first case it is likely that the decomposing body will foul adjacent and otherwise perfect cocoons which become stained and must be sorted as sub-standard. In the second case, the dead body adheres to the inside wall of the cocoon and the normal rattle cannot be heard when shaken ; it is on this account that dead cocoons (Fr. : *fondus*, It. : *scarti*, Jap. : *shinigomori*), are expressively termed " deaf " in Arabic.

Others that must be relegated to the sub-standard class in sorting are the very flimsy cocoons spun by sickly caterpillars (Fr.: *faibles*, Jap.: *usukawa*). Yet another deformity, very much less usual, is represented by cocoons into which a twig or other foreign body has been spun. All such are usually reeled in the native style and are not used in the filatures.

The above irregularities are due to faulty workmanship on the part of the silk-worm, but a sorter will also find cocoons once perfect but damaged since harvesting. The most prevalent in this category are those which have been punctured by a parasitic maggot and are known in French as *mités* (It. : *tarmati*, Jap. : *ujide*) : to the untrained eye this fault is not easy to spot, the maggot making but a tiny boring through the silk, but the affected cocoon cannot ordinarily be reeled as the filament has been severed. There is, however, no difficulty in spotting cocoons attacked by rodents: cocoons have an irresistible attraction for rats and mice, which gnaw through the silk to eat the chrysalis within, leaving a sorry mess behind them (Jap.: *nezumikui*).

Apart from eliminating such as the above, a sorter must grade the reelable cocoons, but those of Second Choice are inferior only in texture, and cannot be considered under the heading of Waste. For the selection of cocoons according to size a grill is used, through which first the small and then the medium drop, leaving the large: this is important, not because the small are inferior to the large, but those of like size will contain baves of like denier, so facilitating the reeling of a regular count.

FILATURE WASTE

A description was given in Chapter I of the boiling of cocoons preparatory to reeling and of the way in which the loosened ends sticks to a brush until they can be gripped in the reeler's hand and the outer layer jerked off. This is continued until the single baves are isolated and the cocoons are ready for reeling.

The material collected in the hand during this process is known as knubbs (Fr.: *frisons*, It.: *strusa*, Jap.: *kibizzo*) and provides the bulk of all waste silk bought by spinners. A careful reeler will remove only a minimum and thus greatly increase the yield of raw silk from the cocoons, but in careless reeling a great deal of silk is lost in the knubbs, which could and should have been reeled as raw. It follows that the most valuable waste tends to come from countries where the importance of the yield factor is not too greatly stressed.

Methods of dealing with this material differ considerably between producing countries, but a common practice is to delegate one or more specialised workers to collect the knubbs from the reelers regularly throughout the day and to pull them out into straight lengths before the gum hardens. It will be appreciated that in the creation of knubbs, the reeler (or often a child assistant) crumples them up into the palm of the hand; if left, they will harden into solid balls, as is the case in Persian native reeling, and provide a nasty problem to the spinner at a later stage. It is customary therefore to unfold them and to hang them to dry with the flowers and roots (terms applied to the inside and outside ends) all lying parallel.

A notable variation of this practice is in Bengal where knubbs (or *chassums* as they are there called) are formed into hard tapes by wrapping round the reeler's hand. It has already been indicated how Persian Balls (*boules de Perse*) are produced. In China the product of Tsatlee reeling was sold in a form known as Curlies. Italian filatures have adopted the custom of separating the individual knubbs before drying, but not pulling them out into lengths—hence the expression *non tirata*. There is in fact a diversity of local practice in presenting the material for sale but inherently it remains the same.

In the production of 100 lb. of raw silk, 20 to 30 lb. of knubbs may result, but this figure fluctuates widely on account not only of the quality of the cocoons but of the care exercised by the reeler.

A filature waste, considerably less in quantity and lower in quality, is provided from the basin. Certain cocoons refuse to reel, sometimes through a defect overlooked by the sorter but more often on account of poor construction; cocoons with pointed ends are particularly apt to open up, fill with water and to sink. Even perfect cocoons sink before the last yards of silk have been unravelled, leaving thin envelopes or husks enwrapping the now visible chrysalis (*pupa*) within.

This Basin Waste is everywhere treated differently. Some producers sort the complete but unreelable cocoons (Fr.: *Bassinés*, It.: *Galettame*, Jap.: *Agari*) from the husks (Fr.: *Pelettes*, It.: *Galettamini*, Jap.: *Bisu*, *Yoshin*) and sell them as such. Others reboil the entire residue of the basin and beat out the chrysalises. Others again dispose of the chrysalis without salvaging the husk. This is not first class spinning material, and it would be tedious to attempt a description of the forms in which it is marketed.

Gum Waste (Fr.: *Bourres de Soie*, It.: *Strazza*), the bulk of which results from subsequent processes such as throwing and weaving, must also be mentioned. It is better described as Thread Waste, consisting only of silk damaged and discarded after passing into the form of raw silk. In the filature, ends break and have to be pieced up, causing some yards of waste, but it is chiefly in the re-reeling department that this occurs in any quantity. Such filature waste contains no twist and provides the most valuable of all raw materials to a silk spinner.

CHRYSALIS

In reeling 100 lb. of raw silk, something between 110 and 150 lb. of chrysalis will result and many are the purposes to which this is eventually put. In the Far East it is general to feed it to carp and eels, and at Chalus it is thrown to sturgeons lying in the river as it runs into the Caspian Sea.

In some parts it is considered as a delicacy by the peasants. It also provides a very efficacious manure for farmers. The modern method is to extract the animal oil for the manufacture of soap and to employ the residue as agricultural fertilizer.

CHAPTER V

PRODUCTION FIGURES

UNTIL 1939, statistics were generally available of sufficient accuracy to make a fair estimate of the distribution of the world production of silk, and the first edition of this book included a table shewing the fresh cocoon crop in each silk centre in 1938, together with an approximate equivalent in terms of raw silk.

These figures in a somewhat abbreviated form are repeated below, together with an estimate for the year 1977. No claim to accuracy is made, and it is intended only to indicate the relative importance of the producing areas both then and now. For countries which export cocoons the figures given include such exports in terms of raw silk.

In view of the loss by silk of the stocking trade, it is remarkable that the total world production has dropped by less than one eighth during the forty years, in which so many new synthetic fibres have come on to the market.

*Estimated production of **Raw Silk** (metric tons)*

			1938	*1977*
CHINA	North	210		
	Central	2,800		
	West	790		
	South	1,200		
			5,000	15,000
INDO-CHINA, BURMA & SIAM			210	260
INDIA & PAKISTAN	Bengal	150		
	Mysore & Madras	470		
	Kashmir	72		
	Jammu	22		
			714	3,200
IRAN			140	250
RUSSIA	TURKESTAN	1,200		
	Caucasia	600		
			1,800	3,000
	Carry forward		7,864	21,710

			Estimated production of Raw Silk (Metric tons) 1938	1977
	Brought forward		7,864	21,710
LEVANT	Syria	45		
	Lebanon	80	125	25
TURKEY	Hatay	27		
	Brutia	170	197	220
CYPRUS			17	—
GREECE	Thrace	95		
	Macedonia	105		
	Other	100	300	40
BULGARIA	Maritsa Valley	115		
	Danube Valley	45	160	230
YUGOSLAVIA			32	10
HUNGARY			20	10
ROMANIA			7	15
ITALY	Venetia	980		
	Lombardy	530		
	Piedmont	200		
	Emila & Marche	110		
	Tuscany	24		
	Calabria & Sicily	38		
	Other	18	1,900	40
FRANCE			52	1
SPAIN			15	10
BRAZIL			35	930
JAPAN	Honshu	31,000		
	Shikoku	2,500		
	Kyushu	4,500	38,000	16,000
KOREA			1 850	5,500
TOTAL			50,574	44,741

CHAPTER VI

SOME FACTS AND FIGURES

THOUGH never intended for reference, this booklet has been consulted by some for detailed information about silk, and this chapter has therefore been added as a sort of ready reference.

A Denier is the unit used to express the size or count of net silk; it is the weight in half-decigrams of a measured length of 450 metres, so that the lower the denier the finer is the thread. This is contrary to the practice of the cotton, woollen and spun silk industries, where counts are expressed according to the length of a standard weight, so that in those yarns the lower the count the coarser is the thread.

An attempt is at present being made to introduce a universal count system to supersede the many that are at present in use. *Tex* is the weight in grams of 1,000 metres of yarn, and is therefore just one ninth of a denier.

Yields of Mulberry Foliage, Cocoons, Raw Silk and By-Products. There is considerable disparity between yields in different countries, but in Japan the following hypothetical figures have been quoted.

1 acre of fully-grown mulberry should produce 4·5 tons foliage per season.

4·5 tons mulberry foliage should produce 540 lb. fresh cocoons.

540 lb. fresh cocoons should produce 85 lb. raw silk.

On page 10 it was suggested that 50 lb. raw silk per acre might be considered a satisfactory return in most countries, but from the above it would seem that Japan expects as much as 85 lb. This, however, is not so for the country as a whole, and for planning purposes the Japanese authorities have calculated upon an average acre yielding 450 lb. fresh cocoons and 66 lb. raw silk.

Similarly the hypothetical ratio of fresh cocoons to raw silk is higher than actual averages obtainable. The above target figures for the country as a whole were calculated on a yield of 6·8 to one, but 6·25 to one is considered no more than ordinary nowadays: 6·25 lb. fresh cocoons should produce 1 lb. raw silk, 5 lb. chrysalis and $\frac{1}{4}$ lb. waste.

Confusion sometimes arises in discussing fresh cocoon yields, as it is of course usually dry cocoons that go to the reeling basin. As already mentioned (p. 13) dry cocoons weigh only one-third of their fresh weight and this loss is confined almost entirely to the chrysalis, which is reduced from a fat grub to a shrivelled carcase in the process of stifling. If therefore, the above 6·25 lb. fresh cocoons were reduced to 2·08 lb. (*i.e.*, one-third) after drying, and if this loss of 4·17 lb. were confined wholly to the chrysalis, reeling would still result in 1 lb. raw silk and ·25 lb. waste, but the weight of chrysalis would be ·83 instead of 5 lb. This is not mathematically exact as there is, of course, some weight lost also from the silk content of the cocoon, but it explains the principle and what might otherwise appear contradictory in the figure given on p. 56 as the weight of chrysalis resulting from the reeling of 100 lb. raw silk.

Cocoon weight and measure. It is often asked what length of silk does a cocoon provide, to which the answer could be anything from 500 to 2,000 yards. So wide a range would hardly satisfy the curious, and it would perhaps be interesting, therefore, to compute from figures already quoted what is an average length of bave reeled from a cocoon.

It was said on page 14 that 1 lb. weight of cocoon ends (baves) would measure 1,000 miles: this was based on a mean size of 2·5 deniers, but post-war Japanese cocoons run rather coarser than this, and for the present purpose it would be well to reckon on 2·8 deniers, which would give a length of about 900 miles per lb. Taking 200 fresh cocoons to weigh 1 lb. (see p. 31) and taking 6·8 lb. cocoons to yield 1 lb. raw silk (see above), it follows that it would require $6{\cdot}8 \times 200 = 1{,}360$ cocoons to reel a single end of

900 miles. The length reeled from each would average, therefore, 900÷1,360 or rather less than two-thirds of a mile—say 1,100 yards.

What does "Kake" or "Kakeme" mean? Reports from Japan about the cocoon markets frequently use one or other of these expressions, and an explanation of their meaning here may be found useful.

Cocoons can vary widely in their yield of raw silk, and to obviate the difficulties thereby involved, the buyer offers the producer so many Kake instead of so many Yen. Kake is in effect the price divided by the yield, so that the price actually paid equals Kake × Yield.

Suppose a unit of cocoons from one farmer yields ·15 units of raw silk, while that of another farmer yields only ·12 units. If the Kake price agreed in both cases is 8,000 Kake, then the first man will receive 8,000 × ·15 or 1,200 Yen, and the second 8,000 × ·12 or 960 Yen per unit.

As the unit used in Japan is what is known as a "Kan", which is one-sixteenth of the weight of a bale, then the Kake price × 16 equals the cost of cocoons to produce one bale of raw silk, to which must, of course, be added the cost of reeling. Under normal circumstances the cost of reeling works out at about one-third of the total cost of raw silk. Until recently it was customary to quote raw silk in Japan as Yen per bale of 60 kilograms, but Bourse prices are now in terms of Yen per one kilogram.

Classification. Raw silk is sold in the consuming markets on the basis of a classification system, drawn up by the International Silk Association and under continual revision to suit changing requirements.

The major tests are for Evenness, Neatness and Cleanness, for which purpose a contrivance known as a Seriplane is employed. This winds the silk at prescribed spacing on to a blackboard, where it is inspected under powerful lights. For Evenness and Neatness the panels of silk are compared with standard photographs; for Cleanness each fault is counted, the silk being penalised accordingly.

Lengths of 450 metres of the silk are then wound into small skeins and weighed accurately for denier. The divergences of these from the average or mean denier are recorded and used in what are known as the Size Deviation tests.

Other tests are made for tenacity, elongation and cohesion, and note is also taken of the number of times the thread breaks in winding. All results are eventually grouped together and by a process of degrading for shortcomings on each score the raw silk finally falls into its proper grading. This system has worked well for many years, but thought is now being given to the introduction of modern electronic instruments for the accurate assessment of quality.

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.Page numbers printed in heavy type denote passages where the indexed item occurs as the subject of the text rather than as an incidental reference.

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