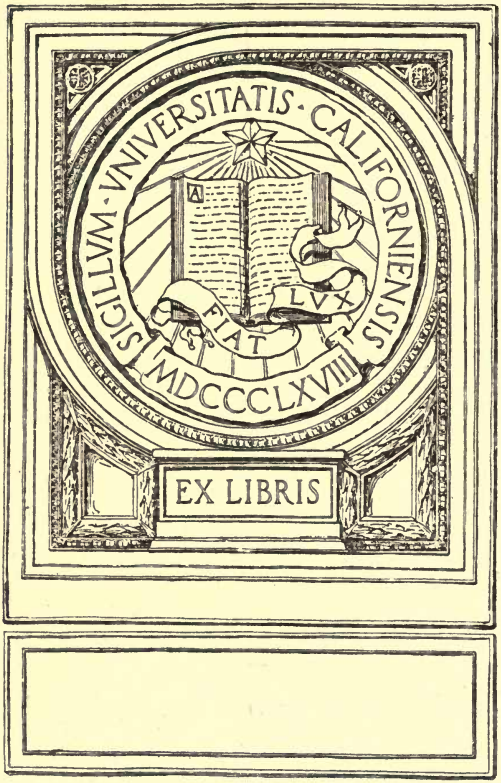
CHEMICAL ASPECTS OF SILK MANUFACTURE

R. L. FERNBACH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THE CHEMICAL ASPECTS

OF

SILK MANUFACTURE

BY

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PREFACE

Five years ago, Mr. Hollins Rayner, in his admirable work, "Silk Throwing and Waste Silk Spinning," gave to the trade the first practical account of the production of a weavable thread from the fiber of the silkworm. De L'Arbousset, Edwards, von Georgeviecs, Hurst, Merritt Matthews, and others have contributed much of importance concerning silk, albeit chiefly in its relation to the other fibers, its culture, or in the form of a compendium of dyeing and printing formulas long since obsolete.

To the deep-rooted fallacy that the problem of silk manufacture is mechanical, confined to the phase of throwing, winding, warping, and weaving, this book owes its existence. In these pages the all-important chemical aspects of the industry — the principles which are the very basis of mechanical practice — are impartially set forth. In publishing the results of an extended practical experience, the author betrays no confidence. He is aware that publications of this type arouse the antagonism of those members of the trade in whose sight all efforts toward enlightenment constitute the unpardonable sin. On the other hand, the author disavows all sympathy with the concoctors of catch-penny tables, who, posing as altruists, are in reality alarmists seeking self-advancement through the exploitation of exploded theories.

The inauguration of a new era, in which rigid scientific control supersedes rule of thumb in silk manufacture, is at hand. The writer of this treatise earnestly hopes that it may assist the manufacturer to a better understanding of the processes to which his material is subjected.

R. Livingston Fernbach.

Chemico-Legal Bureau,
97 Warren Street, N. Y. C.
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THE CHEMICAL ASPECTS OF SILK MANUFACTURE

CHAPTER I

RAW SILK

Varieties of Moth. — It is estimated that Nature has produced from five hundred to six hundred varieties of silk-producing larvæ. Of this great number, however, only a few are of commercial importance; and chief among these is the *Bombyx Mori* which derives its name from the circumstance that its food is principally the leaf of the *Morus Alba* or white mulberry. This is the typical Chinese moth, producing the finest grades of silk in Italy and France as well as in China. The cocoons of the *Bombyx* are all of the closed variety; that is, the threads cover the ends of the cocoons without a break. Its silk being, therefore, entirely reelable, it is the most valuable commercially.

Following in the order of importance comes the Tussah group of silkworms, of which the *Antheria Mylitta*, indigent to China and India, is a characteristic example. The *Mylitta* worm is larger than the *Bombyx* and spins a cocoon of far greater size. In comparison with that of the *Bombyx*, its thread is about $\frac{1}{600}$ inch in diameter, whereas that of the latter is only $\frac{1}{1600}$ of an inch.

The silk produced by the *Antherea* group is distinguished by the tenacity and great resistance of its coloring matter to discharging agents. Although the silk of the *Bombyx* ranges in color from white through yellow, to orange, it is always a pale cream, at worst, after the gum has been boiled off. On the other hand, the original dark color of

Tussah is removable only through the most radical bleaching treatment.

It is interesting to note that the food on which the worm is reared has a direct influence upon the color of the silk spun by the worm. Thus the *Yama Mai*, a Japanese member of the family *Antherea*, feeding on a variety of oak, produces a greenish cocoon, whereas that of the *Attacus Cynthia* of the *Citernia* family, which feeds on ash leaves, is grayish in color. When the *Attacus Cynthia* was introduced into India, where it is known as *Ricini*, it was reared on the Castor Oil plant (whence the latter name) which is responsible for the very deep yellow color of the silks known as Rajah or Bengals.

Some Phases of Sericulture. — We are apprised, from time to time, of attempts to introduce the culture of the silkworm into the United States and it is to be noted that each attempt thus far has failed — although it has been adequately proven that the climate of certain sections of this country is well adapted to the cultivation of the worm for breeding purposes. Similarly, certain varieties of worm, notably the *Antherea Pernyi*, an oak-feeding worm indigent to the Himalayas, have been successfully reared in England. Silkworm culture for breeding purposes is one thing; for the purposes of producing commercial silk, quite another.

Many insurmountable obstacles preclude successful sericulture in the United States. Not only is the high labor a factor, but apart from this we lack the necessary experience — an experience which has an empirical rather than an exact foundation. Success in sericulture seems to be largely a matter of intuition. The faculty, for example, of preventing the spread of disease amongst the worms at the psychological moment must necessarily be inbred of generations of practical experience in the craft.

The great tendency of the worm to disease is indeed the chief obstacle in the way of successful sericulture. The nursing of its voracious appetite is as naught compared with the care necessary to preserve its health. To one gifted with the remotest sense of humor, the study of the habits of the worm is fraught with endless amusement. Certain of his characteristics, to wit, his refusal to work unless his diet is just so, are so human as to be startling. In his general behavior he is a hobo in miniature!

The silkworm is the victim of five diseases each permitting of distinct diagnosis. Of these five, *Lacherie* and *Calcino* are the more important, the latter being most dangerous. Lacherie is a form of malaria. When stricken with this disease the worm becomes indifferent to its food and subsequently spins a weak and worthless fiber. The first symptom of *Calcino*, as that of *Lacherie*, is failure to feed. This is rapidly succeeded, however, by complete inanition and a gradual hardening of the body, when, after 24 hours, it is covered with a chalky coating which gives to the disease its name. Recent research, however, has conclusively proven that the worm is not "ossified" as was originally supposed. The disease has been traced to a parasite of microscopical proportions which feeds on the worm, sapping its vitality with incredible rapidity. Shortly before death ensues the spores of this parasitic fungus burst, covering the body of the worm with their chalk-like contents.

When one considers that disease may have its origin in the tiny eggs, — the size of a pin head — one begins to realize some of the difficulties of sericulture. It is stated that the one reliable method of determining whether the eggs are diseased or not is to place them in boiling water when, if they are in healthy condition, they acquire a purplish tint. Unfortunately, the acquirement of the

favorable hue can be but small satisfaction to the operator, as the treatment kills the embryo within the egg. With these facts in view, it is the more marvelous that the world's production of commercial silk totals its present amount.

At the first sign of disease amongst the worms, drastic measures are perforce adopted. Fumigation of the entire colony by means of the fumes of sulphur is at once resorted to. Just how far this drastic treatment is responsible for deterioration of the fiber subsequently spun by the worm is not known. Opinions on this point differ radically. It is stated by some that fumigation is the ultimate cause of Fiochetti or true lousiness.[1] Others, again, hold the treatment harmless. It is reasonable to assume, however, that certain defects in the ultimate silk fiber must ensue from operations of this kind.

One of the important precautions to be observed in the rearing of silkworms is the ascertaining that the eggs will not hatch before the food for the young worms is ready for their immediate consumption. Without proper sustenance the young worm at once dies. Rayner[2] states that the frequent reports of scarcity of silk owing to frost are accounted for in the fact that the frost, by killing the young mulberry leaves, deprives the newly hatched worms of sustenance and hence they cannot live. He discounts these "early frost" rumors on the ground that they are promulgated by astute brokers in the endeavor to create a better price for the prospective raw silk crop. Be this as it may, scarcity of the raw product may be due to a hundred and one valid causes — the outcome of the many insuperable difficulties encountered in sericulture.

[1] Divisibility of the Silk Fiber. Sir Thomas Wardle, Leek.

[2] Silk Throwing and Waste Silk Spinning, Hollins Rayner (Scott, Greenwood & Co., London).

The relation of the constitution of the food of the worm to the worm itself, and subsequently to the silk fiber, will be better understood from the following approximate analysis of the mulberry leaves and the dried worms fed thereon.

	Worms (dried)	Mulberry Leaf
Mineral matter	9 per cent	12 per cent
Carbon	48 per cent	44 per cent
Hydrogen	7 per cent	6 per cent
Nitrogen	10 per cent	3 per cent
Oxygen	26 per cent	35 per cent

It is readily inferred from these figures that any change in the constitution of the leaves, through blight, frost, or other factor adverse to proper growth, must necessarily bring about a corresponding change in the constitution of the worm and ultimately in the fiber it spins. Indeed, the influence of diet on the character of the product of an animal organism is not confined to the case of the silk-worm. Thus, the oil extracted from the lard of corn-fed hogs is of different character from that extracted from the lard of swill-fed hogs. The latter oil is whiter in color and exhibits, as a rule, less initial free fatty acids than the former and is far more easily "refined"—all this assuming that the extraction and refining process are alike in both instances.

The purpose of the above limited discussion of sericulture is to impress upon the reader the fact that many variations in character of the silk fiber result from *natural* causes. These alone are quite sufficient to necessitate the rigid examination of the raw material in order that its subsequent treatment may be conducted intelligently. The reader will presently see that in addition to these

natural defects, which do not permit of ready control by the silk grower, other defects, purely factitious, are subsequently introduced through ill-advised attempts to impart uniformity to the fiber.

Viewed under the microscope, silk is seen to consist of two parallel cylindrical fibers, one of far greater diameter than the other. This duplex constitution has its origin in the fact that the thread, which is discharged in the fluid state by the worm, emanates from two distinct spinarets, situated close to the worm's under lip. These separate threads unite after they have emerged a short distance and are simultaneously coated with the gum, which rapidly dries and thus maintains a united and single thread.

Of the two initial threads or "brins" as the French call them, the larger is the stronger. It is to be noted that the worm, when diseased, spins a thread in which the smaller brin is imperfect and at times absent. Under these circumstances the single large brin is prone to that splitting or divisibility which is the true cause of Fiochetti or lousiness. This subject is discussed more fully under Chapter III.

Sericin and Fibroin. — The inner or true silk fiber is known technically as *Fibroin* and the gum coating as *Sericin*. Constitutionally these are very similar, consisting approximately of

	Fibroin	Sericin
Carbon	49 per cent	43 per cent
Hydrogen	6 per cent	6 per cent
Nitrogen	19 per cent	16 per cent
Oxygen	25 per cent	35 per cent

A comparison of these figures with those given above as the approximate constitution of the dried worms and mul-

berry leaves will prove an interesting substantiation of the influence of diet upon the animal organism and its product.

In their chemical composition and behavior, Fibroin and Sericin are allied to gelatin and casein. Hence, in the subsequent treatment of the silk fiber, these substances may be employed for "re-animalizing" the silk. Both exhibit characteristic behavior towards certain chemical reagents. Fibroin, for example, possesses, *per se*, the power of reducing the higher chlorides of certain metals to the lower chlorides. It is characterized also by the presence of a nitro group which permits of the development of certain shades within the fiber after adequate diazotation. Thus, a characteristic color is obtained by simply treating the degummed silk fiber with a solution of sodium nitrite in hydrochloric acid, washing and then treating with a developer such as phenol, α or β-naphthol, resorinol, etc.

Both Fibroin and Sericin are markedly hygroscopic, *i.e.*, they rapidly absorb moisture. The normal moisture of silk is estimated at 11%, which figure is invariably added to the absolute dry weight of silk in order to give the conditioned weight. Divers hygroscopic materials have been introduced into the fiber in the course of reeling from the cocoon or of throwing, in order to augment the weighting of the silk through the increased absorption of atmospheric moisture, a practice which is fortunately discouraged through conditioning.

The solubility of Sericin in water is largely theoretical, although a small proportion is soluble in this way. For the complete removal of the gum, however, advantage must be taken of its solubility in soap or alkalies. The latter, save borax, have an injurious effect on the Fibroin. Continuous treatment with hot soda carbonate or caustic

soda, while removing the Sericin, also weakens the fiber, first destroying its elasticity and ultimately tendering the thread.

Cocoon Reeling. — It is not within the province of this work to deal at length with the commercial forms of raw silk, such as *tsatlees*, *re-reels* or *steam filatures*. The average silk manufacturer is very well informed as to the respective merits of these. To the discriminating weaver, cocoon reeling offers an opportunity for study independent of the facility with which silk may be thrown from the several above-mentioned forms of the raw article. Silk manufacture is somewhat similar to building construction, although the comparison is a trifle broad. Once the foundations are properly laid, the life of the superstructure may be predetermined within close limits. Similarly, once the quality of the raw material is ascertained, the life of the woven silk fabric may be adequately controlled.

It is in cocoon reeling that we see the first evidence of modern commercial rapacity. The softening of the cocoon for the purpose of facilitating the winding of the thread is in reality an extremely simple matter; yet time and skill have been devoted to the introduction of spurious materials in the fiber simultaneous with the softening of the gum, that had been more worthily directed to other channels. A warm solution of weak soap is all that is required to soften the cocoon preparatory to reeling the thread. No restriction applies to the quality of the soap employed, for, while a "good curd soap" has been prescribed as best adapted to the requirement, opinions differ as to what constitutes a good curd soap. With the advent of cheap alkalis, such as sal-soda, has come the opportunity to do away entirely with soap for the softening of the cocoons. Fatty oils, emulsified into partial soaps through the agency of these alkalis, have been found cheaper than soap and

yet as effective for the purpose. Were these efforts towards economy confined to the use of pure vegetable or animal oils, properly emulsified, no danger to the fiber could ensue. Such oils, however, may be cheapened still further through admixture with mineral (petroleum) oils which, once introduced into the fiber, are productive of disastrous results because of the various processes undergone by the silk ere it is in fit state to be woven into the ultimate fabric.

Again, it is possible to cunningly incorporate inert mineral weighting materials through the agency of softening media. The writer has examined many Japanese silks with which there has been incorporated a fine infusorial earth, which was detected only in the course of degumming in the dye-house. True, such adulteration may be roughly detected in the boil-off test of the conditioning house, although the character of adulteration can not be detected in this way. Apart from this, however, the danger to the thread through the abrasive action of crystalline substances thus incorporated is incalculable. It is possible to admix a proportion of the salts of alumina in the course of cocoon softening, which admixture is revealed only on analysis. This fraud is detected with difficulty, owing to the fact that the ash of Bombyx silk contains normally about 11% of alumina. An increase over this percentage can be legitimately ascribed to the above practice.

Many more practices could be cited in support of the contention that he who fails of systematic examination of his raw silk must perforce proceed to the subsequent treatments on an entirely empirical basis. Much evidence exists in proof of the fact that the natives engaged in the production of raw silk in the Far East exercise at times the greatest cunning in disposing of the product. Says

Mr. Hollins Rayner, speaking as an authority on this subject:

"To combat against the well-known cunning practised in the Chinaman's reeling and packing, the European and American shippers at Shanghai and Canton are compelled to have a fully qualified inspector, with assistants, to examine very carefully each book of raw silk before packing into bales and shipping. As far as possible, without damaging the silk, the books are opened to see if there has been any inferior silk packed inside, which is often the case. Sometimes the outside mosses are really first-class silk, and look exceedingly well, being good color, bright and fine in size; but the inside layers have been most cleverly made up of coarser, darker, and inferior silk. There have been cases on record where other material besides silk has been found inside the books to give weight to them, but it is only fair to say that there are some reliable Chinese dealers whose silk can generally be taken to be what it is represented to be."

If the above is true of conditions five or six years ago, what is to be said of the present, in the light of the introduction of Western science and the rapid spread of scientific information through the Far East?

In simple justice, it is necessary to point out that adulteration of raw silk is not confined to the Far East. The writer has examined numerous samples of Italian silks which gave conclusive evidence of tampering for the purpose of deception. He has also examined samples of the so-called European water re-reels which likewise fail to show up well.

Although conditioning has done much to abate these evils, the very fact that conditioning methods cannot possibly determine with exactitude the *nature* of the adulterants has rendered much of the conditioning crusade

abortive. The writer repeats that is it only through chemical analysis that any proper valuation of raw silk may be achieved — a valuation on which depends the intelligent application of the processes through which the silk must go ere it is woven into the finished fabric.

CHAPTER II

SILK THROWING

THE preparation of a weavable thread from the raw silk fiber, ostensibly the simplest of all silk operations, is at the same time the most important. While the problem of silk throwing is chiefly mechanical, involving the proper twist of the raw silk filaments, the necessity of softening the gum of the raw ere it can be wound prior to combining the desired number of filaments with the requisite twist permits of a certain latitude in treating the silk, and at the same time introduces chemical considerations of the utmost importance in view of the operations which the thrown silk subsequently undergoes.

A great increase, during late years, of the number of mills devoted solely to weaving has created a separate industry — that of throwing — of considerable magnitude. This, in turn, has created the opportunity for the purchase of raw materials in the thrown state, ready for dyeing and weaving, of which those manufacturers who regard the average raw silk with suspicion have not been slow to avail themselves. Many, again, refuse to buy thrown silk, preferring to know what chop they are getting and, lacking facilities for preparing organ and tram, send the raw silk to a commission throwster. In either case, it follows that the manufacturer has absolutely no control over his silk at this most important stage. Where silk is thrown "bright," *i.e.*, where it receives no soaping to assist the winding, any ensuing defects are purely mechanical in origin; but where, as is commonly the case,

the silk is first soaked, chemical defects frequently ensue which do not manifest themselves until such time as it is no longer possible to remedy them.

The Commercial Fiber. — Prior to winding, the silk is split into slips of convenient size, as too much material on the swifts causes the thread to break constantly, resulting in an excess of knotted ends in the skein. The raw silk fiber is also frequently cleaned, mechanically, by winding from one bobbin to another, the thread meanwhile passing through a guide or cleaner.

The commercial silk fiber is of three kinds: Organzine, for warp, Tram for weft or filler, and "No-throw." Occasionally, for special goods, "Singles," consisting of the thread as delivered by the cocoon reeler or just sufficiently twisted to resist the operations of stripping and dyeing, is employed.

The chief factor in the preparation of commercial silk yarn is the twist given to the thread, and in this respect organzine and tram differ only in so far that, in the case of organ, the individual thread is given twist as well as the combined threads; whereas, in tram, the single fiber receives no twist whatever, the twist being imparted solely to the combined threads. Both organ and tram may consist of two or more threads, although two-thread organ is the average while three threads constitute the minimum combined in tram. "No-throw" is a thread without twist; just doubled, or at the most given just enough twist to combine the fibers. The amount of twist is controlled by the manufacturer's individual requirement. Organzine is always a much tighter and finer thread than tram and for this reason is never weighted so heavily as tram. The latter, being more open than organ, is usually brighter after weighting and dyeing. It takes up weight far more readily than organ, because of this very openness of the thread.

Throwing Materials and Process. — By far the greater part of thrown silk is softened or soaked before winding — an operation in no wise complicated. In American practice the silk is soaked over night in a bath containing soap (made from olive oil foots), neatsfoot oil and a little borax. A few prefer to use a good grade of olive oil in place of the neatsfoot, although it is generally conceded that pure neatsfoot oil is better for the silk. The quantity of the above materials to be employed is subject to the hardness of the silk gum. This is softest in Japan stock, intermediate in Canton and Italian, and hardest in Bengal. The average formula for soaking 50 lbs. of Japan is:

Soap.....	3 lbs.	in 60 gallons water
Neatsfoot Oil	3 quarts	
Borax.....	2 oz.	

To soften 50 lbs. of Bengal, double this quantity of materials would be required.

Clearance. — Curiously enough, the majority of practices publicly condemned by silk manufacturers are secretly condoned by them and inevitably traceable to their own cupidity. No exception to this rule is the secural of clearance on thrown silks. Since the softening of the silk gum by means of the oil, soap, and borax involves a slight loss of weight through the stripping action of the bath, the throwster is authorized to return an excess of the weight of the raw silk received by him, up to 5%. Thus if 1000 lbs. of silk are thrown, 1050 lbs. may be returned, to which extra 50 lbs. no cost attaches for the throwster's services. We have, in this practice, the very root of the present evils of silk manufacture. It is an ingenious system of "robbing Peter to pay Paul," that, so far from advantaging any one, creates considerable trouble. Normally, this clearance consists of so much extra soap

and oil absorbed by the silk as it soaks, which added weight promptly comes off in the dyer's stripping box. Frequently, it is obtained through the introduction of materials which do not readily strip off, or of partially soluble materials which contaminate the dyer's baths.

Some manufacturers so far delude themselves as to believe that the throwster's clearance gives them an advantage over the dyer in that part of the weight of the thrown silk submitted to the latter is factitious and must be replaced in weighting at the dyer's expense. Such in reality deceive only themselves, as the following will doubtless serve to illustrate.

The manufacturer purchases, let us assume, 1000 lbs. of raw silk, at a cost roughly of $5000. Since some silk boils off as low as 18% and some as high as 30%, the dyer, throughout his operations, assumes an average 25% as the boil-off of all silk. Taking this figure, the 1000 lbs. of raw silk represents 750 lbs. of ultimate silk fiber at a cost of $5000. The silk is thrown and 1050 lbs. are returned, the additional 50 lbs. consisting, we shall assume, of pure soap and oil. All that has happened thus far is the increase of the boil off loss of this silk from 25% to 28½%. The manufacturer has thus far gained not a single ounce of ultimate fiber. Let the weight ordered be 24 oz.

Had, now, 1000 lbs. of thrown silk been sent to the dyer, in the customary number of passes, he would have obtained 24 oz. full and returned 1500 lbs. of weighted silk, of which 750 lbs. would still represent the ultimate fiber. As it is, the dyer receives 1050 lbs. of material and, with the customary number of passes, obtains only a little more than 22 oz. weight. Since the dyer receives exactly the same price whether he puts in the 22 oz. or the 24 oz., it is difficult to comprehend where the manufacturer gains by the operation. As a matter of fact, he is the loser

because of this clearance. Had the normal boil-off of his silk been undisturbed, the manufacturer would have been the gainer by over an ounce to the pound, whereas, with the 1050 lbs., if he insist on full 24 oz., he gets back just so much more tin silico-phosphate, owing to the fact that the dyer must work the silk more to get the weight.

If, on the other hand, the silk is to be dyed pure, the manufacturer neither gains nor loses through the throwster's clearance. The dyer certainly does not lose in any event. If his profit is slightly decreased because of the necessity of further treatment on his part, the manufacturer is a greater loser because of the added weighting materials in his silk. Thus, where 1000 lbs. are submitted and 1500 lbs. returned, one-half of the weighted silk is true fiber; but where 1050 lbs. were submitted, the 50 lbs. being the throwster's clearance, and the dyer obtains full 24 oz., he returns 1575 lbs., of which 750 lbs., *now less than half* of the material, still represents the true silk fiber. What has the manufacturer gained? In the first instance, for a given price the dyer returns 50% silk, 50% weighting. In the second, *for the same price,* the dyer returns 47.6% true silk and 52.4% weighting. The manufacturer has thus lost 2½% of silk fiber. The extra 75 lbs. returned by the dyer is all weight and he is paid for this at the same rate as if it were half fiber and half weight. What has the dyer lost? Nothing. What has the manufacturer gained? An over loaded fiber.

We are not so much concerned in these pages with the commercial fallacy of clearance, but rather with the chemical aspects of the practice—although the latter have considerable bearing on the former.

Influence of Throwing on Subsequent Operations. — It is in the materials employed in throwing that we encounter the first element of danger to the ultimate

woven fabric. Were the soap and neatsfoot oil always pure, and did the throwster always content himself with clearance resulting from the natural absorption of these by the silk, one could scarcely look to throwing as the cause of many of the defects in finished silk. These ingredients, however, are not as a rule pure and are frequently badly contaminated.

True neatsfoot oil is obtained from the hoofs of cattle. Of the neatsfoot oils on the market, only the highest priced are obtained from this source through careful processes of rendering. The true oil is characterized by the absence of the higher fatty acids, such as stearates, exhibiting, in consequence, a very low freezing point or cold-test. Thus, a good neatsfoot oil will not congeal above 12° F. or 20° lower than the freezing point of water. Some have as low a cold test as 4° F. Such oils are, in addition, characterized by the absence of free fatty acids beyond a mere trace. Among the neatsfoot oils coming into the market are those rendered from low greases and animal stock, by treatment with mineral acids and other means. Such, although classified as neatsfoot, are in no sense neatsfoot. These oils have a very high cold-test, usually congealing. at 32° F. and some higher. Left to stand at ordinary room temperature, quantities of stearates separate out. In addition, they are rich in free fatty acids the action of which is described below.

The soap employed by the throwster is usually beyond criticism. It is the same as the dyer uses in stripping and, though occasionally containing unsaponified fats, it is ninety-nine times out of a hundred normal.

The high cost of pure neatsfoot oil does not tempt the average throwster to purchase and use it, and because of his efforts toward economy, without his always being aware of it, he almost constantly endangers the silk entrusted

to him. To secure an oil for throwing at 60¢ per gallon means one of two things. He gets either true neatsfoot mixed down with white petroleum oil, or one of the so-called neatsfoot oils, rich in stearates and free acids. Even these are at times adulterated with petroleum oil. Few, if any, throwsters go to the trouble of having their oils examined for their purity.

The borax used to emulsify the soap and oil is usually standard, although it has been adulterated at times with common salt and even caustic soda, which latter has a drastic weakening action on the thread.

Taken all in all, uncontrolled throwing is a serious menace to the quality of the ultimate fabric. If the throwster's oil contains stearates and free fatty acids, these permeate the fiber and are with difficulty removed in stripping. Indeed, unless the dyer is aware of their presence they practically defy removal, requiring as they do an excess of soda in the stripping bath, which weakens the thread in order to saponify them and render them water-soluble. Unless they are removed, they combine with the ingredients of the weighting bath, forming insoluble soaps, which refuse to dye evenly, frequently remaining sticky and hindering the winding of the dyed silk and even, at times, causing chalkiness of the dyed silk.

Even more serious than this is the menace of petroleum oil once introduced into the silk fiber. The exact action of this is fully described in Chapters III, V and VI. The following is a case in point.

As is well known, souple silk is prepared by simply softening the gum and not stripping it off. This was formerly done by means of tartaric acid. More recently, the silk is subjected to a bath of mixed sulphuric and sulphurous acids until the gum has swollen to the requisite degree, when the "honeycombing" is filled by means

of cane sugar, or better and cheaper still, glucose. After weighting and dyeing, the stiffness is removed on a breaking machine.

In June of this year, the writer was called upon to determine the cause of black streaks, greasy in nature, in some heavily weighted taffeta for petticoats. The facts in the case were these. The silk, several thousand pounds, had been dyed by a prominent commission dyer in February, 1908. Part of the tram was dyed bright *i.e.*, the gum boiled off, and part was dyed souple. All was weighted 24 oz. full. The silk was returned to the manufacturer who wove it on a rush order, which order was countermanded when the silk was ready for delivery. The silk was accordingly stored away in the vaults. Seventeen months later it was taken out preparatory to delivery on another order, and when examined so much as was woven from the soupled tram was found to be full of black streaks running through the goods in the direction of the filler. Goods that had been woven with bright tram were faultless. It is to be noted that the goods, immediately they were woven, seventeen months previous, had been examined and pronounced perfect.

Of course, the inevitable claim was lodged against the dyer, who contended that the fault was not his. The spots were proven to be grease of some kind and for a while it was thought that they were the result of the casein combined with the phosphate bath. In fact, superfatted casein applied to the silk produced spots or streaks identical with those complained of. It is to be noted, however, that the bright tram in the other goods, although it had received the casein treatment at the same time as the souple, exhibited none of the defects of the latter.

Experience with similar complaints led the writer to direct his investigation elsewhere, with the result that the

streaks were found to consist essentially of petroleum or mineral oil. This view was subsequently confirmed by the laboratory at Milan, Italy, to whom the matter was ultimately referred for a final opinion. It is not at all difficult to trace the action of the mineral oil, introduced by the throwster in this case. In the case of the bright tram, the bulk was removed in the stripping. In that which was soupled, however, the combination of neatsfoot and mineral oils, employed by the throwster, was practically permanently fixed in the fiber by the combined acids of the soupling bath. Subsequently weighted with tin, the latter formed partial tin soaps within the fiber. For the dissociation of these both time and heat are required. These factors were secured by storing the silk when, as is well known, considerable heat develops in weighted silk — so much so that insurance companies refuse heavily weighted silks as a risk. The storing of the silk, then, supplied all that was necessary for the gradual dissociation of the metallic soaps within the fiber and the ultimate sweating out of the grease, which was heaviest wherever the silk was folded, *i.e.*, where the greatest heat was generated. Need anything more be said to convince the manufacturer of the necessity of determining what is in the thrown silk before sending it to the dyer?

To return to the subject of clearance. No possible good from this accrues to the manufacturer where this consists of an excess of pure soap and oil. Where these are impure manifest harm results — so much more dangerous impurities introduced into the silk, than is necessary. Where, to stimulate the absorption by the silk of the oil emulsion, the throwster employs salt, the menace is increased. It is useless to occupy the reader's time with a discussion of the possibility of introducing insoluble materials in the silk, thus obtaining a clearance which is permanent. Such

practices are fortunately rare and are readily detected. The menace of the use of adulterated materials by the throwster is sufficiently great without stopping to inquire if he resorts to downright trickery, which is extremely doubtful.

Those weavers who do their own throwing and dyeing, although in far better case than those who have to resort to the commission throwster, inasmuch as clearance is not an item with them, are still not immune to the danger of adulterated throwing materials.[1] Yet they are in somewhat better position to check these even though roughly, inasmuch as many untoward conditions in the dye-house can be traced back to the throwing department as fast as they arise. On the other hand, the manufacturer who is dependent upon both commission throwster and commission dyer for the treatment of his silk at stages of the utmost importance, frequently courts disaster and is at best the recipient of mediocre results through his failure to inform himself of the constitution of the raw silk before it goes to the throwster, and that of the thrown silk before he sends it to the dyer.

[1] See case described in Chapter III, page 29.

CHAPTER III

SILK STRIPPING

Silk stripping or degumming is the first of a series of operations for the success or failure of which the dyer is, under normal conditions, responsible. Assuming that the silk which comes to him to be dyed has not suffered the various questionable practices in cocoon reeling or throwing that have been described in the foregoing pages, it rests with the dyer whether the silk shall leave his works in good condition or not. In view of the extent of these questionable practices at the present time, it is doubtful if the dyer is responsible for the majority of the defects commonly complained of in the finished silk.

Hardness of Sericin. — Gum hardness varies with the different kinds of silk. Japan has about the softest gum of all; Bengal the hardest. Intermediate are Canton, China, and the Italian silks — yellow and green. The relative hardness of the gum naturally receives consideration in the boil-off, controlling the temperature at which the operation is conducted as well as its duration.

Steam Stretching. — Prior to boiling off the silk, it may, where extra brilliance or luster is desired, be stretched in the gum. Opinion differs as regards the advisability of this practice. In our larger dye-houses it has been superseded by the so-called metallicing machines the operation of which is fully described in Chapter VI.

It is contended that gum stretching tends to weaken the silk, lessening its elasticity. The writer grants that such danger exists where the process is carelessly carried

out. Taken all-in-all, however, it is the safest of all the processes designed to produce extra brilliance. In the first place it is effected at a stage where the silk has been only lightly treated — where, under *normal* conditions, no extraneous materials other than pure oil, pure soap, and a trifle of borax have entered the fiber; whereas, in the case of metallicing after dyeing, the silk has undergone numerous complex operations. Secondly, the luster produced by gum stretching is *permanent* so long as succeeding operations are correctly executed, while the luster of metallicing does not always endure.

Prior to gum stretching, the thrown silk is softened over night in a lukewarm bath containing 10% of the weight of the silk in soap and just enough water to cover the silk. The following morning the excess of soap-water is removed by whizzing in the hydro-extractor and the silk must then be stretched *at once*.

The stretching apparatus varies in construction. The simplest, *which happens to be the best*, consists of a small chamber containing two metal pins, the upper permanent, the lower movable at will. Over these a limited number of skeins is put. The chamber is then closed and, simultaneous with a blast of high-pressure steam, the under pin is lowered the desired distance, allowed to rest for an instant and the tension released, at the same time cutting off the steam. The batch is then removed and a fresh batch entered. The simultaneous stretching and steaming presupposes considerable skill on the part of the operator. The steam must be free from moisture, else the silk is degummed in spots which are over-stripped in the subsequent degumming bath. (See Fiochetti below.)

Materials Employed. — The chief of these is, of course, soap; and the soap employed is usually that made from olive oil foots (the so-called sulphur oil). The constitu-

tion of this soap is important. If the soap be too neutral or exhibit free unsaponified fats, its stripping action is retarded and the treated silk apt to be greasy. (See same problem in throwing.) If, on the other hand, the soap contains a marked excess of free caustic alkali, it is apt to tender the thread. A soap that is on the alkaline side, but showing not more than one-half of one per-cent free caustic alkali, is best for stripping.

To insure the alkalinity of the stripping bath, or, where hard water alone is available, it has been customary to employ carbonate of soda (sal soda or soda ash) in addition to the soap. This practice is somewhat risky, as solutions of soda at the temperature obtaining in this process have a decided weakening tendency on the thread. Borax might be employed with greater safety, but its cost is practically prohibitive.

When these alkalies are employed, or where too alkaline a soap is used, not only does the silk suffer this weakening action, but the sodium salts remaining in the fiber because of inadequate washing are apt to cause considerable mischief in the "dynamite" bath. The best stripping practice presupposes the use of only soap which is just alkaline enough in constitution, and of this there is used from 25 to 30% based on the weight of the silk worked.

The Stripping Process. — The silk is placed on the sticks and is worked in the bath, being given the requisite number of turns (three in all), until all the gum is off. Apparently a matter of extreme simplicity, in reality considerable skill is involved in silk stripping. The selection of a box that is neither too large nor too small to accommodate the lot, and yet permits of free movement of the skeins, involves some judgment. The skeins are moved very slowly, as quick action tends to "fuzz" the goods.

Assuming that one hundred pounds are being worked the stripping consumes two hours. After the gum has been dissolved, the silk is washed several times and finally receives a bath of acetic acid.

In stripping, mill dye-house practice naturally differs from that obtaining in commission dye-houses. In the former, it is possible to separate the boiled-off liquor from colored gum silks from that which results from stripping white gum silk. This is not always expedient in commission dye-houses. Here, because of the great amount of work to be done in a given time, and the necessity for economizing in materials consumed, as well as labor, it is frequently necessary to first strip white silk, then re-strengthen the bath and at once strip yellow silk. In this way the liquors are mixed.

It is commonly known that the bath, containing the gum from the stripped silk, constitutes the basis of the dye-bath after adequate dilution with water. (See Chapter VI.) Where the various colored liquors may be kept separate, the dyeing of light shades is simplified, as none but the boil-off liquor from white gum silks is used for this purpose, that from the yellow being employed for the dark shades. Where the liquors are mixed, at the outset of stripping, as is the case in some commission dye-houses, it is not possible to obtain the same clearness of light shades as can be obtained if the liquors are kept separate as described.

Again, in some of the small commission dye-houses, the simultaneous stripping of Japan, yellow Italian, and Canton is frequently attempted. The fallacy of this practice becomes manifest upon study of the influence of temperature on stripping. When these three are worked in the same bath, if the Italian is stripped, the Japan and Canton are bound to be over-stripped. If the Japan is prop-

erly degummed, the Canton will be too much so and the Italian only partially so. When the Canton is stripped, neither the Japan nor the Italian will be fully stripped. Again, the yellow gum of the Italian is apt to stain the other two, with the result that, if they are to be dyed white, an excess of blue is required, imparting a bluish cast; and they will not be clear if dyed into intermediate light shades. For the darker shades this practice does not interfere to any extent.

Influence of Temperature. — According as the hardness of the silk gum varies, so is the temperature at which the stripping bath is maintained regulated, as well as the time between "turns." Thus in stripping Japan stock, the bath, once brought to the boiling point, is permitted to cool gradually after the silk has been entered, and only twenty to twenty-five minutes are given between turns. On the other hand, for yellow Italian silk (particularly organzine which has a tight twist), the bath is maintained at as near the boiling point, throughout the entire operation, as is possible without creating actual ebullition. Again, when Canton is stripped, the temperature should not exceed 180° F., as greater heat promotes this silk's exasperating tendency to "fuzz."

Influence of Water. — The character of the water employed is most important. This should be very soft, else there are at once introduced into the silk, in stripping, very harmful substances that emanate from the same source as in throwing.

Unless the water be soft, the silk will not emerge from the strip with adequate luster; and the luster cannot be restored in subsequent processes without radical danger to the thread.

Souple. — The preparation of souple has already been

described in connection with the use of mineral oils in throwing. (See p. 18.)

Stripping Tussah. — Tussah should never be stripped on soap, as this tends to permanently bind the coloring matter in the fiber and renders bleaching extremely difficult if not actually impossible. Accordingly, Tussah is stripped in a bath containing 25% of its weight of silicate of soda. The temperature and modus operandi are the same as in regular stripping save that more acid is required to rid the fiber of all traces of silicate.

Fiochetti or "Lousiness." — The phenomenon, only recently explained,[1] of the appearance of white specks on the thread of dyed silks, which specks interfere with weaving, long constituted a puzzle to dyer and weaver alike. It was long known that diseased worms spun a fiber which, when dyed, exhibited this defect, commonly termed "lousiness"; but because of the paucity of information on the subject, this defect was invariably ascribed to "lousiness" where recent research has proven conclusively that a similar phenomenon, and one readily mistaken for the original, has its origin in the initial treatment of the silk fiber, and that ninety-nine out of a hundred cases of so-called lousiness are due to factors other than disease of the worm.

After years of patient and exhaustive research, the late Sir Thomas Wardle, long time president of the Silk Association of Great Britain, his observations subsequently confirmed by the researches of the Società Cooperativa del Sete, of Milan, demonstrated that conditions at intervals obtain beyond the control of sericulturists which induce the worm to spin a thread characterized by its divisibility once the gum is removed. Such a thread splits

[1] For a description of the cause of true lousiness, see "Divisibility of the Silk Fiber," Sir Thomas Wardle, Leek.

into tendrils, or fine fibers, viewed clearly only with the microscope, which tend to bunch together on the main fiber. To the naked eye these become visible only after the silk is dyed.

Owing to the fact that the form and constitution of these fibrillæ is changed because of disease in the worm, with the result that, under the lens of the microscope, they appear flat and segmented like cotton, an ingenious theory as to their origin was promulgated some years ago. It was claimed that fine fibrils of wood (cellulose) were detached from the stripping box by the constant action of the hot soap (this despite the fact that stripping boxes, as well as others of wood employed in the dye-house, are all canvas lined), and, attaching themselves to convenient places in the silk, became more firmly lodged in the course of treating the silk, ultimately forming these minute fibrillæ.

The absurdity of this contention becomes at once manifest if we pause to reflect that, even were it possible for minute slivers of the wood to attach themselves to the silk, they would be dyed more or less the same shade as the silk and hence pass detection; or, if observed at all, they would be regarded as fuzz caused by over-stripping or some such error in manipulating the silk. It is well known, however, that the minute "nests" of fibrillæ which are true fiochetti or "lousiness" are incapable of absorbing any dye-stuff and hence appear as pure white specks upon the dyed fiber. The writer does not contend that specks of this character do not frequently appear on dyed silks. He asserts, however, that, in the majority of cases, the origin of these specks is traceable to factors other than disease in the worm.

A defect very similar in appearance to fiochetti may result from the following:

1. Faulty practice in gum stretching. Unless the silk is stripped immediately after it is stretched in the gum, the latter will harden in spots, causing these to over-strip by the time of their complete removal in the soap bath, Again, if the silk is stretched too much in the gum, the latter becomes firmly embedded in the fiber in spots, with the same result.

2. Over-stripping. The too rapid movement of the silk in the soap bath or its retention for too long a time in the bath. The permitting of actual ebullition of the bath while the silk is immersed therein.

3. The use of very hard water for stripping. The lime and magnesia (and at times, iron), in hard water unite to form lime, magnesia, or iron soaps as the case may be, with the soap of the bath. These insoluble metallic soaps form within the fiber and are rarely if ever split up. They do not dye readily and hence, wherever formed, have the specky appearance of lousiness.

4. The use of petroleum oil in throwing. This is by far the commonest cause of speckiness of the dyed fiber, producing a result so akin to true lousiness as to puzzle experts. That this may be caused by the above oil is, however, indisputable.

Four years ago the writer was called upon to determine the cause of speckiness of some silk dyed pink and light blue. In addition to exhibiting specks, a fuzzy coating was scraped off as the silk passed through the loom, clogging the reed-harness and practically stopping the loom. The manufacturer at once reached the conclusion that the silk was lousy and prepared to lodge a claim against the raw silk dealer from whom this lot had been purchased. Indeed, careful examination of the fiber under the microscope revealed characteristic nests of fibrillæ. This evidence, otherwise conclusive, was offset by the fact that

some of the same lot of silk, dyed three or four days previous to the trouble, was satisfactory in all respects. The mill experiencing the trouble does its own throwing as well as dyeing.

In view of the fact that part of the silk was all right, the writer's investigations led him to the dye-house of the mill. Here it was discovered that a thick scum was forming on the boiled-off liquors used for dyeing. It was learned that this liquor was from the strip of some silk received from the throwing department only two days before, and that the silk complained of had been dyed on this liquor, although it had, of itself, yielded a perfect gum soap when stripped. Here then was the clue to the mystery. Analyses of the scum on the gum soap showed the presence of considerable petroleum oil, which must have been in the fiber of the second lot of silk. This oil, in the stripping bath, held in suspension considerable fat soap. The silk subsequently dyed in this liquor, upon being washed with the customary hard water, became charged with lime and magnesia soaps which caused the mischief. Analysis of the fuzz scraped off in the loom showed this to consist entirely of such metallic soaps. The crowning piece of evidence was obtained in the admission of the head of the throwing department that he had sought to reduce expenses by purchasing cheaper neatsfoot oil. *This oil proved to be badly adulterated with petroleum oil.*

It is readily seen that, had the dyeing been done outside of the mill, the dyer would have been made responsible for a defect for which he was in no wise to blame, and would doubtless have been mulcted of a large sum in settlement of the "claim." How many claims of this kind are charged to the dyer in the course of, say, a year? And who, in reality, is responsible for the trouble?

CHAPTER IV

SILK BLEACHING

The bleaching of true or Bombyx silk has for its object the elimination of the last trace of color left after stripping, in order that an absolutely pure white silk may be procured. White-dyeing is effected simply by working the silk in a rich bath of fresh soap to which just a spot or touch of blue dyestuff has been added. The infinitesimal quantity of the blue that attaches itself permanently to the fiber suffices to produce a white thread. For certain silk, it is not necessary to bleach before dyeing. Others, again, must be bleached if a good white is to result. Silks that do not strip absolutely clear require considerable blue to nullify the yellow or cream tinge that remains after stripping, with the result that they retain a bluish cast which is undesirable.

Since time immemorial, the bleaching agent for silk has been sulphur, inasmuch as the reducing action of its fumes has qualified it as best adapted to the removal of the organic coloring matter in the fiber. Its use has been attended by one disadvantage, to wit, that, since it bleaches by reduction, *i.e.*, by the removal of oxygen, unless reduction is complete, some traces of the color may return upon subsequent exposure of the silk to the oxidizing action of the air. Before the advent of the modern peroxides, however, the oxidizing treatment of silk for bleaching was impractical, owing to the fact that chlorine gas, the only oxidizing bleach previously known, could not be employed because of its drastic solvent action on the thread.

Stoving. — The treatment of silk by stoving is now practically obsolete. The silk skeins, dampened to the requisite degree, were hung on poles in a chamber which permitted of sealing. In the center of the room stood a small stove in which the sulphur was burned, the resultant fumes permeating the fiber. The process suffered the disadvantage of being incapable of regulation and more times than not the silk was over-bleached and the thread tendered.

The Sulphurous Acid Process. — The modern sulphurous acid method of bleaching is merely an amplification of the old stoving practice, yet a distinct improvement over the latter in that it eliminates all guess work. In the former, as in the latter method, sulphur is still burned in a small stove, but the fumes, instead of being permitted to react directly upon the silk, are conducted through water contained in a rectangular wooden vat, in order to produce a solution of sulphurous acid of a known degree of strength. In this bath, the silk is worked on sticks, being turned until the requisite state of color-discharge has been achieved. In this way it is possible to control the process completely.

Hydrogen and Sodium Peroxides — Tussah Bleaching. — The peroxides of hydrogen and sodium constitute satisfactory media for the bleaching of all silks in place of sulphurous acid, but owing to their increased cost over the latter are not used extensively for the purpose. On the other hand, without them it would be impossible to bleach Tussah. Attention has already been directed to the peculiar tenacity of the coloring principle of the fiber spun by the *Antheria* family; yet, because of its cheapness compared with true silk and because of the size of the thread, Tussah makes a most desirable filler for woven fabrics. It was not, however, until the advent

of the peroxides of hydrogen and sodium and their cost reduction within commercial limits, that Tussah bleaching became an accomplished fact.

A peculiarity of Tussah, not known to the average, is that, once brought into contact with a soap solution, its coloring matter is rendered absolutely permanent, and all attempts at subsequent bleaching are unavailing. Accordingly, instead of being stripped on soap, Tussah is stripped on a bath of silicate of soda, containing 25% of silicate, based on the weight of the silk manipulated. The small amount of gum once removed, the silk is bleached by means of sodium peroxide or, if the Tussah is old stock, by means of hydrogen peroxide.

The rapidity with which these peroxides give up their oxygen has led to a modification of the original method of using them. In the latest practice, the bath consists of sulphate of magnesia (Epsom salt) to which sulphuric acid and then the peroxide have been added. The resultant magnesium peroxide is easier of regulation than the sodium or hydrogen peroxide, giving up its oxygen more slowly and producing more uniform results. In bleaching Tussah piece goods, the same methods obtain and, occasionally, through faulty practice, tiny holes are burned in the goods.

Again, unless all traces of the silicate of soda are removed from the thread after stripping, the fibers are apt to stick together and prevent good winding. Indeed, the dyed material is apt to exhibit, under these circumstances, a chalky excrescence, making the dyeing uneven and coming off in a powder in the looms, clogging the harness reeds.

The incomplete removal of silicate of soda after weighting is the direct cause of chalky threads. It is to the dyer's advantage to use his baths over and over again

as many times as possible. Under proper strengthening and correction this is feasible with the tin and with the phosphate bath; but the silicate bath, once it "breaks" or becomes milky, must be thrown away. The careful dyer sees to this regularly, but his less careful brethen, actuated by a spirit of economy, at times keep on using "broken" silicate, with the result that a chalky condition of the thread ensues.

The bleach-house of a dyeing plant is maintained, wherever possible, in a building separate from the main works. In addition to bleaching silk the sulphurous acid bath is frequently used for the preparation of souple, as described in the preceding chapter. In those plants where it has been impossible to separate the sulphuring room from the main buildings, the dyeing work has at times suffered the handicap of being subjected to the fumes of sulphur, which escape from the room occasionally. It is at times possible to account for spottiness in dyeing in this way.

Influence of Stripping on Bleaching. — To say that unless stripping is complete, bleaching will be unsatisfactory, is to cite an axiom. Indeed, unless the materials employed in the cocoon reeling and throwing are of such solubility as to insure their complete removal in the stripping bath, defects of the fiber must be created in the course of sulphuring the silk.

Where, as is too often the case, the materials alluded to are cheap and greasy substitutes for soap, containing various percentages of mineral oil; or where, as frequently occurs, the throwster employs a stripping soap containing an excess of unsaponified fats, these remain in the fiber after stripping, and once subjected to the action of the sulphurous acid become permanently embedded in the silk.

This is the main cause of uneven bleaching and, in turn, of uneven dyeing. Where such silk is weighted after bleaching and before dyeing, these defects are radically augmented and will account for many of the common complaints as regards the finished silk, which the reader will find enumerated in Chapter V. In this stage of silk treatment, as in all the others, eternal vigilance is the price of safety. It is again to be remarked that, once the purity of the raw and thrown silk is assured, the chances are most overwhelmingly in favor of securing a satisfactorily weighted and dyed thread. It is to be noted that the dyer, although capable of erring, seldom actually errs in his treatment of the silk. It is in reality the manufacturer's carelessness and neglect that are primarily responsible for defects in dyed silk.

CHAPTER V

SILK WEIGHTING

Weighted vs. Pure Dye Silks. — Many distributors of silk contend that silk weighting is tantamount to adulteration. It must be conceded that where the modern weighting process is improperly or imperfectly carried out, there is some foundation for this contention. On the other hand, where the process is properly effected the silk, so far from being adulterated, is actually improved. The increasing popularity of mixed fabrics, the stability of silks woven in the piece and dyed pure, the periodic recurrence of the depression of the market for goods woven from the treated skein, are perhaps responsible for the advocacy of the adulteration theory. Its advocates, however, are either ignorant of or overlook the fact that mixed goods are as far from being pure fiber as tin-weighted silks. The cotton which enters into the composition of the former is radically treated in the spinning and in the dyeing. Not only does it receive augumentation in the slashing through the agency of tallow, starch, and talc or allied ingredients, but it is also frequently treated with muriate of tin in the dyeing, which, ostensibly a mordant for certain of the colors, is nevertheless effective as a weighting medium. Similarly, woolen yarns may be bulked by complex treatment frequently applied.

It would seem, then, that the treatment applied to a fiber to impart desirable properties has little or nothing to do with the marketability of the fabric woven therefrom, *provided the treatment is carried out intelligently.*

And it will further be seen that the intelligent treatment of silk in this respect is dependent upon certain factors not within the control of the dyer, but strictly within control of the manufacturer.

The very term "pure dye" is a misnomer. Colored silks of this class indeed contain nothing but the silk fiber plus the dye. Pure dye blacks and some darker colors are in reality weighted silks, albeit the weighting is effected with substances other than tin or the derivatives of tin, and they are not so heavily weighted as the "dynamited" silks. In preparing pure dye silks, advantage is taken of the affinity of the silk fiber for tannin, and they are accordingly processed by means of galls, sumac, etc., which not alone form the mordant for the old-fashioned dyestuffs still in vogue for this class of work, but, by increasing the bulk of the silk, impart to it a handle without which it would be practically unsalable. Black pure dyes are processed with the salts of the metal iron, by means of which the silk is made to absorb far more tannin than it is ordinarily capable of doing; and on this mordant, iron tannate, the desired black is produced. Wash silks, classified as pure dyes, are in reality weighted to a limited extent through the agency of the chromium salts employed as a mordant for the alizarin colors employed to dye them.

It is many years since it was first conceded that silk does not make a desirable woven fabric unless it is subjected to processes tending to increase certain characteristics. Since the proper weighting of the silk assuredly increases its luster, handle, and elasticity, it cannot be legitimately regarded as adulteration.

Older Methods. — The above-described methods for the production of pure dye silks were formerly in general vogue, and then, as now, relied upon to impart factitious

weight to the fiber. For colors, they were superseded by the forerunner of the present "dynamite" process, which consisted in treating the silk with ammonio-stannate, or pink salt as it was better known, a preparation of tin which was subsequently modified within the fiber. Since the process is now obsolete, it need not be discussed here.

Before passing to a description of the weighting process now in use at all of our dye-houses, it is necessary to point out that the influence of silk weighting has proven pernicious, chiefly in that it has been responsible for attempts, from time to time, on the part of the throwster to obtain a factitious clearance by subjecting the silk to certain of the baths employed in the weighting process. This has introduced factors exercising a decidedly adverse influence on the proper degumming and weighting of the silk; and for some strange reason the responsibility for these factors has been attributed to the dyer's carelessness rather than to the throwster's malpractice.

The "Dynamite" Process. — So much depends upon the proper weighting of the silk, and so closely are the previous processes to which the silk is subjected interlinked with its success, that I feel justified in appending here an exposition of the theory of silk weighting in addition to the very necessary description of the modus operandi of the process. Chemists differ radically in their opinions of the changes undergone by the silk fiber in the course of weighting, and there is much to support each theory advanced. To Mr. George H. Hurst,[1] the English silk expert, belongs the credit of advancing the most rational explanation of all, which I now outline.

Silk is weighted by means of bichloride of tin, which is in reality stannic chloride of the formula $SnCl_4$, which is

[1] Silk Dyeing, Printing & Finishing, by G. H. Hurst. (Scott, Greenwood & Co., London.)

subsequently converted into phosphate and then silico-phosphate of tin, by means first of a bath of phosphate of soda and then one of silicate of soda. Before this conversion takes place, however, the stannic chloride is reduced *by the silk itself* to stannous chloride of the formula $SnCl_2$. Attention is particularly called to this reduction as it is the basic principle of silk weighting. Silk itself possesses the chemical property of reducing a higher form of chemical salt to a lower form.

Were it not necessary to employ a complex chemical salt to be reduced by the silk to a lower form as above illustrated, such substances as chloride of barium could be employed. This latter may be converted into a silico-phosphate of transparency equal to that of tin silico-phosphate. It is to be noted, however, that the barium chloride does not stay on the fiber and hence gives no basis for weight, whereas bichloride of tin or any higher chloride of any metal such as iron or chromium which may be reduced by the silk to the lower form of chloride does remain in the fiber in its reduced form. The chlorides of iron and chromium, however, impart a direct color to the silk and hence cannot be used for weighting save for very dark shades or blacks. Accordingly, the only available commercial salt for this purpose is the higher chloride of tin.

It is thus seen that the silk fiber, so far from being inert, possesses marked chemical characteristics. In addition to the reducing power above outlined, silk of itself contains a nitro group which permits of the diazotation and development of certain shades on the fiber, without first dyeing it with a color that permits of diazotation as is the case with cotton and wool. Chemical activity is not confined to silk among the textile fibers; both cotton and wool exhibit marked characteristics upon treatment with certain reagents; but it is to be noted that the latter

permit of more drastic treatment than silk, because they are hardier constitutionally.

Weighting for Colors. — A bath of tin bichloride is prepared of a strength 30° Bé. This bath is kept constantly at a temperature of 60° F. In this the silk is immersed for one hour. It is then removed, whizzed in a hydro-extractor in order to recover the excess of tin solution, which is returned to the main bath and the silk is then washed on a suitable machine. This washing is not merely for the purpose of removing any excess of tin solution that has not been whizzed off. The water has a definite chemical action on the tin in the fiber, reducing it to the form of hydrate, which is subsequently converted to the form outlined above by the phosphate and silicate baths.

At this juncture the silk is again immersed in the tin bath or not, according to the weight desired. It is to be noted that:

To secure 16–18 oz. the silk is given one bath of tin, one bath of phosphate, and one bath of silicate, with suitable washings in between and after the various baths.

To secure 18–20 oz. the silk is given one hour in tin, then washed, then one hour in phosphate, then washed, then again an hour in the tin, then washed, again an hour in the phosphate, then washed, and finally one hour in the silicate of soda, after which it is suitably soaped and finished as noted below.

To secure 22–24 oz. the silk is given one hour in tin, washed, one hour in phosphate, washed, one hour in tin, washed, one hour in phosphate, washed, a third hour in tin, washed, a third hour in phosphate, washed, and finally one hour in the silicate, after which it is soaped and finished.

The phosphate bath employed in weighting stands at

a strength of about 6° Bé., and is heated to about 140° F. The silicate of soda bath is made to the same strength as the phosphate bath and utilized at practically the same temperature.

After the silk has been treated with silicate of soda, it is worked on a rich soap bath for one hour at 150° F., for the purpose of removing all silicate. It is then washed at least twice on warm water and the last trace of soap removed by treatment with water containing a small percentage of acid.

Were the weighting confined to the form of tin silicophosphate, far less danger would accrue to the process than is normally experienced. Unfortunately, through the persistent demands of the manufacturer for a *big thread,* other ingredients enter into the weighting of the fiber. For example, sulphate of alumina, although not so much in vogue now as formerly, is successfully employed for reducing the number of "passes" necessary to produce a given weight. Through its use it is possible to obtain:

20 oz. full in one pass, *i.e.*, 1 tin, 1 phosphate, 1 alumina, 1 phosphate, and 1 silicate.

24 oz. full in two passes, *i.e.*, 1 tin, 1 phosphate, 1 tin, 1 phosphate, 1 alumina, 1 phosphate, and 1 silicate.

If the reader will compare these figures with those given above for obtaining similar weights with just tin, phosphate, and silicate, the saving of materials will be seen.

Thus, to obtain 24 oz. full normally presupposes:

3 hours in the tin bath
3 hours in the phosphate bath
1 hour in the silicate bath
1 hour in the soap
5 hours for the various washings

or a total of 13 hours, whereas, to obtain the same weight using sulphate of alumina we require:

2 hours in the tin bath
3 hours in the phosphate bath
1 hour in the alumina bath
1 hour in the silicate bath
1 hour in the soap
5 hours for the various washings

or a total of 13 hours.

It will be seen that while the use of the alumina saves neither time nor labor, it results in the saving of tin, the most expensive ingredient in the process, by reducing the required number of tin immersions. Another advantage is the increase in the size of the thread through its use.

Sulphate of alumina has been more recently superseded by sulphate of zinc and in rare instances chloride of zinc, although the use of the last named is exceedingly dangerous, owing to its solvent action on the silk. In order that the fiber may withstand the burden imposed by these extra treatments, it is customary to incorporate a certain amount of glue, or better, casein with the phosphate of soda bath, which serves to "re-animalize" the fiber.

Weighting for Blacks. — The weighting in black organzine as well as in black souple is not effected by means of tin. On the other hand, the weighting in black tram is part tin and part tannin. Thus, to produce a black tram weighing 32 oz., we proceed as follows:

24 oz. weight are put in by means of tin, that is to say, the silk receives three tins and three phosphates and finally the silicate. After the silk has been finished from the silicate, it is either immersed over night in a bath of gambier of about 8° Bé. strength, or it is slowly worked for ten hours in such a bath, starting with the bath at 180° F.

and allowing it to cool gradually as the silk is worked. Not only does the gambier put in the additional 8 oz. weight required, but it also forms the basis for the black, and for this reason there is incorporated with the bath about 2% of ordinary sulphate of iron or copperas, which forms a mordant, tannate of iron. Tin crystals are sometimes employed to force the weight. After the treatment with the gambier, the silk is suitably soaped and washed and is then dyed on a bath containing 100% of soap and from 25% to 40% of hæmatine (logwood). This combines with the tannate of iron in the silk fiber to form what is practically an ink, which is the required black.

Black organzine and black souple, however, are weighted and dyed by the following process. The basic weighting material is copperas nitrate of iron, popularly known as red iron. This is made up into a bath of about 30° Bé. and is used much the same as the tin bath. That is to say, the silk is given one or more immersions in the red iron according to the weight desired. Between each immersion in the red iron, the silk is properly soaped. The next step is what is known as blue-bottoming. This consists of treating the silk which has been immersed in the red iron to a suitable bath of ferrocyanide of potassium, commonly known as the yellow prussiate of potash. This combines with the iron to form the color known as Prussian blue. The silk, after blue-bottoming, is dyed on a bath of soap and logwood similar to that employed for black tram. The blacks so produced may be further improved by topping with a black anilin dye.

Influence of Prior Processes on Weighting. — The above exposition of the essentials of the methods of silk weighting will be of use to the reader only if he pauses to review and consider the possible detrimental effects

which may ensue through the weighting of the silk, because of his neglect to become acquainted with its initial characteristics. Unless the silk is in good shape at the outset it will turn out poorly. It is undoubtedly true that much of the responsibility for the ultimate good quality of the silk devolves upon the dyer. On the other hand, it must not be overlooked for a moment that an equal measure of responsibility devolves upon the owner of the silk, with which responsibility it is manifestly unfair to burden the dyer in addition to his own.

The major defects complained of in dyed and finished silk are:

1. Weakness of thread.
2. Shadiness of the color.
3. Absence of adequate luster.
4. Poor winding qualities, such as stickiness.
5. Chalkiness and brittleness of the thread.

These are the defects commonly complained of. The question logically arises, is the responsibility for these defects entirely the dyer's? Not necessarily. It is absolutely true that the dyer working on silk of good quality which has been properly treated in the throwing may, through his carelessness in carrying out the various weighting processes or in attempting new and experimental treatments, utterly ruin the silk. With this in view, the Silk Association of America has formulated stringent rules affecting the acceptance or rejection of dyed silks. It is equally true that the dyer may without error carry out the processes required for the production of the weight ordered by the manufacturer and yet the silk be anything but acceptable. Whence arises the cause of this latter contingency? Is the responsibility for making or marring the quality of the silk entirely the dyer's? Let us see.

We have already seen that, in the initial reeling of the

thread from the cocoon, it is possible to employ softening media which may impart a factitious bulk to the thread. The soaps employed for the softening of the cocoon at times contain petroleum oil. If we assume such to be the case for the purpose of a hypothetical illustration, we may then trace the behavior of the thread through subsequent operations. No adverse factor will be noticeable until such time as the thread reaches the dyer to be degummed. The presence of the mineral oil in the fiber will account for the holding in suspension, within the fiber, of a proportion of the soap from the degumming bath, which suspended soap does not wash out. The silk will then enter the tin bath where the metal will immediately combine with the fat of the soap to form an insoluble tin soap, sticky and greasy, which is further accentuated as the silk passes through the subsequent weighting baths. The result may be any or all of the above outlined complaints. It may result not only in the tendering of the thread in spots, but will account for much of the stickiness at times experienced in winding as well as shady dyeing. The exact results of the presence of certain impurities originating in the initial processes of silk treatment have already been outlined in the discussion of the so-called lousiness of silk under Chapter III. In view of the fact that silk treatment consists of closely interlinked processes, the success of each dependent upon the proper effectment of the preceding, the author feels justified in constantly reverting to the possibility of the introduction of defects at stages before the silk reaches the dyer.

If the manufacturer would take the trouble to have his raw silk or thrown silk assayed, many of the difficulties of silk weighting would be minimized. The writer does not exaggerate when he states that in those mill dye-houses where no baths are employed other than the customary

tin, phosphate, and silicate, and where all materials including the raw silk are subject to proper supervision, "dynamite" results may be safely guaranteed for two if not for three years. If this can be brought about in one class of dye-house, there is absolutely no reason why it should not be brought about in all. That it is not brought about is due more to the manufacturers' utter disregard of elementary principles than to any carelessness on the part of the dyer. The dyer's duty is to supply the weight ordered by the manufacturer independent of the quality of the silk submitted, and so long as the manufacturer continues to order heavy weighting without regard to whether or not the silk he submits can stand this weighting, so long will complaints continue. It may be stated without reserve that did the manufacturer acquaint himself with the initial characteristics of his silk he would be enabled to so order his dyeing as to permit him to guarantee, without fear, the life of his silk for a definite period.

CHAPTER VI

SILK DYEING

Unlike the dyeing of cotton and wool, silk dyeing does not admit of the use of exact formulæ. It is possible to achieve a given shade on the two former through the use of just so much dyestuff per hundred pounds manipulated and by heating the bath to an exact degree, giving the goods a definite number of turns and working them for a given time. In silk dyeing, however, apart from certain fundamental rules observed in common by dyers, the procedure is largely empirical, demanding considerable ingenuity on the part of the operator and affording a wide latitude for his exercise thereof. Your silk dyer must trust to his eye for color, rather than to exact weights of materials, in order to dye the goods to shade.

While it is sought to produce colors on cotton and wool that are fast to strong soaping, no such solicitude enters into the dyeing of silk save for some few special requirements. The very nature of the silk fiber, together with the necessity for preserving its natural luster, elasticity and scroop, precludes the drastic treatments applied to cotton and to wool in dyeing. Cotton does not suffer much from prolonged heating in the dye bath; silk does, especially if it has been weighted before dyeing. Overworking silk in the dye bath is responsible for poor winding, assuming all other factors to be normal. Accordingly, the most skilful silk dyer is he who obtains his shade with the least number of boils and turns, — a condition which

presupposes the absolute purity of the silk fiber as well as the proper effectment of processes prior to dyeing.

Color Dyeing. — In the dyeing of any textile fiber, it is necessary to distinguish between the *coloring* of the fiber and true *dyeing*. Immerse any fiber in a solution of dyestuff, and it will assume the color of the bath to a greater or less extent, dependent upon the nature of the fiber itself. It does not follow, however, that the fiber is *dyed* by the operation. Dyeing, as distinguished from coloring, is the more or less permanent chemical combination of the dyestuff with the fiber; coloring, the mere temporary mechanical permeation of the fiber by the dyestuff.

Modern coloring materials may be roughly divided into two general classes. A, basic or substantive colors, and B, acid colors. Class A have the property of combining directly with certain fibers to form a dye, without the aid of an intermediate chemical substance termed a *mordant*. They are salts of a coloring principle which behaves as a base. Thus, *fuchsine*, a basic color, sometimes employed in silk dyeing, is the hydrochloride of the base pararosaniline, just as common salt is the chloride of the base sodium. Class B, on the other hand, behave like acids and will not combine with the fiber without the interposition of a third basic substance or mordant. The behavior of these various colors depends largely on the fiber with which they are expected to combine. We are concerned solely with their behavior towards silk.

Both classes of colors are adapted to silk dyeing, although few of the basic are now used except for special work. The earliest chemical researches into the dyeing of silk revealed the fact that a bath containing a basic color together with a quantity of acetic acid could be exhausted of its coloring matter by immersing sufficient silk which was permanently dyed thereby. Prior to the advent of the coal-tar colors,

silk was dyed by means of vegetable coloring matters such as logwood, Brazil wood, archil, safflower, madder, etc., and certain animal products such as cochineal. Much profit and enjoyment may be derived from a perusal of the treatise,[1] first published in 1789, by three French pioneers in the domain of the chemistry of dyeing, from which the reader will obtain an excellent idea of the difficulties encountered in silk dyeing one hundred and twenty years ago. Although these materials have been supplanted by the coal tar dyes, some of the former are still in use on special work; and it is curious to note that while modern machinery has greatly simplified the problem, the essentials of silk dyeing are the same to-day as they were then.

As has already been pointed out, of late years the acid colors have come into greater use than the basic for silk dyeing, for the reason that the bulk of the silk now woven is tin weighted. The use of basic colors on top of tin is attended by numerous difficulties. The tin silico-phosphate in the weighted fiber acts as a partial mordant for the acid colors, causing them to penetrate the fiber very rapidly in the presence of sulphuric acid. For silk printing of certain kinds, however, the basic colors possess considerable advantage over the acid colors.

One of the great difficulties in silk dyeing lies in the fact that, if the best results are to be obtained, a given shade cannot be achieved by means of a single dyestuff. In cotton and wool this is quite feasible. Take, for example, the common pink cord with which every one is familiar. This shade may be obtained with exactitude time and time again by using just so much rose bengal in the dye bath together with just so much sodium sulphate for mordant and heating the bath to a given temperature. To obtain

[1] Art of Dyeing Silk, Wool and Cotton, by M. Hellot, M. Macquer and M. Le Pileur D'Appligny. (D. Van Nostrand Co., New York.)

the same shade on silk would require at least two separate colors; fast red for the body of the color and rhodamine for topping to shade. Indeed, all silk dyeing is based on the combination of the elementary colors of the solar spectrum. Thus, browns are produced by combining yellow, red, and green; grays, by combining weak blue-black (nigrosine) with yellow and a little red and blue. Greens are obtained by combining blue and yellow; and where green itself is the basis of the bath, as in olive shades, the shade is rendered more blue or more yellow as may be required by adding one or the other of these colors to the dye bath. It is thus readily seen that, to cause the proper proportion of each color necessary to a given shade to go onto the fiber, is no small matter. It is because of this difficulty that the dyer is afforded wide latitude for the exercise of his ingenuity.

The dye bath once prepared and brought to the boil, the silk is entered and given five turns. It is then laid up and the bath reboiled, when it is re-entered and given another five turns and so on until the silk is dyed to shade. The skilful dyer, assuming that all previous processes are properly carried out, will get the shade in 15 turns, — that is, three boils. A less skilful will have to give the silk anywhere from 20 to 30 turns or from 4 to 6 boils. As the dye bath for weighted silks invariably contains a slight excess of sulphuric acid added to facilitate the dyeing, it is not difficult to comprehend that prolonged working of the silk in dyeing is to be avoided. It interferes with the winding of the silk, for one thing; for another, it tends to disturb the chemical balance of the weighting materials in the fiber, with the result that the tin may subsequently oxidize and the woven silk rot.

The boiled-off liquor, containing the gum from the strip, is extensively used in dyeing. It is practically indispen-

sable for dark shades on weighted silks. The tin salts in the fiber, once the bath has been broken with the sulphuric acid, tend to draw certain of the colors too rapidly into the fiber, resulting in uneven dyeing. The silk gum, on the other hand, tends to retard the absorption of the colors by the fiber and a medium rate of absorption is accordingly achieved by the addition of a slight excess of sulphuric acid to the bath, certain shades requiring more acid than others. The boiled-off liquor is used also for pure dye, although for this class of work it may be dispensed with and a dye bath based on sulphuric acid and sulphate of soda substituted. Indeed, where there is a shortage of gum soap, this same bath is used for the lighter shades on tin weighted silk, although the silk thus dyed has a tendency to harshness of feel.

Once the silk is dyed to shade, it is washed several times with hard water and then given a bath of acetic acid to restore the "scroop." Owing to the fact that the bulk of silk sent to be weighted and dyed is far from pure, initially, with the result that a large number of boils is required to dye it to shade, the silk becomes slightly fuzzy from overworking and it is then customary to finish it with an emulsion of olive oil, soda, and acetic acid, which serves to lay the fuzz on the fiber. Dyers avoid this treatment wherever possible, as the oil thus put on the fiber deadens the scroop of the silk and may sooner or later sweat out in greasy spots if used to excess. It is not always feasible to obtain the shade in 15 turns; but where reasonable care is exercised, it may be obtained in 20, in which case it is not necessary to use the above finishing emulsion.

Black Dyeing. — A full description of the processes in vogue for this class of work will be found on pages 42 and 43.

Fast Colors. — Ordinarily, dyed silks are not fast to

strong soaping. In this we have conclusive proof that the tin salts in the weighted fiber act only as a weak or partial mordant. Indeed, where silk weighting is properly done, the combination of tin, phosphate, and silicate is practically inert. Were it otherwise, it is to be presumed that the silk would speedily go to pieces owing to the reversion of the tin to the form of oxide, in which form it is decidedly inimical to the life of the fiber. Hence, if the combination is permanent, as it should be, it is not to be expected that the tin itself is free to combine with the colors.

The production of fast colors is confined to wash silks (art embroidery silks, etc.) These are dyed pure in so far as they are free from tin weighting. The colors employed are the alizarin (artificial madder) derivatives and these are mordanted by means of chromium chloride. This class of coloring material might be used for the production of fast colors on pure organzine and tram; but the number of shades is small and they are apt to be dull unless the silk undergoes special treatment. They are used to advantage, however, in re-dyeing ribbons in the piece.

Developed Colors. — Save for rare shades on wash silks, this method of dyeing is not practised in silk manufacture. It is worthy of limited mention, however, because of its possibilities. The reader's attention has been several times directed to the fact that silk contains a nitro group which admits of direct diazotation and development. Were it not for the time and labor involved, the dyeing by diazotation and development as now practised for cotton would assuredly be applied to silk.

In dyeing by these methods, the fiber is first dyed with a color containing the necessary nitro group. This is subsequently diazotized by a bath of sodium or potassium nitrite in hydrochloric acid. Finally, the fiber is placed in a developing bath which produces a shade utterly dif-

ferent from the one initially dyed. Such colors are created chemically within the fiber and hence offer great resistance to soaping and light. It may interest the reader to learn that many of the highly praised blacks of European production are dyed by this method; and in view of the threatened competition with European interests in the very near future, it is probable that the American dyer will not be slow to adopt it.

Piece Dyeing. — The *modus operandi* of piece dyeing differs radically from that of skein. Its success is as much dependent upon adequate machinery for handling the goods as upon the chemical principles involved, as the latter are not so complex as in skein dyeing. This statement, however, holds good only so long as piece goods are dyed pure, which is the case to date. It is reported that European dyers have recently perfected machinery and process for weighting goods in the piece and we shall doubtless ere long witness the introduction of the method into the United States — a possibility which is to be sincerely deplored.

Gum soap is seldom used in piece dyeing. The ease with which the colors penetrate the woven fabric, once it has been boiled off, whether the goods are all silk, silk and cotton, silk and schappe, or silk and wool, permits of dyeing on a bath of mixed acetic and sulphuric acids with the addition of sodium sulphate.

In view of the marked impurities of manufactured cotton, cotton-backs receive a more drastic scouring prior to dyeing than could be safely applied to all-silks. Similarly, goods woven of silk and schappe or silk and wool require special treatment before dyeing. It is not within the province of this work to deal extensively with the fermentation treatments applied to the various silk wastes ere they can be spun into a workable fiber. Suffice it

to say that their complexity is such as to be responsible for seriously adverse chemical factors which must be specially dealt with in dyeing goods containing schappe.

In the dyeing of goods in the piece, many processes inapplicable to skein dyeing are successfully used. The conditions obtaining are rather similar to those encountered in cotton and wool dyeing.

Influence of Prior Processes on Dyeing. — Since the boiled-off liquor containing the silk gum is essential to skein dyeing, and since all impurities entering into the raw or thrown silk must contaminate the boiled-off liquor, the connection between cocoon reeling as well as throwing and dyeing, is readily seen. Adulteration of the throwster's materials simply means trouble in the dyeing either directly or through conditions arising from this adulteration in the course of weighting the silk. This subject must be dealt with at length a little further on; and there is hence no necessity for straining the reader's patience with its discussion at this juncture.

CHAPTER VII

SILK PRINTING AND FINISHING

THE chemical principles involved in printing any textile fabric, like the mechanical principles, are very similar. Just as in dyeing, the selection of the colors and the preparation of printing media are controlled by the natural characteristics of the fiber to be printed. The production of the design on rollers and the type of machine used for actual printing are the same whether the fabric be silk, cotton, or wool. That is, the basic principles are the same; some slight modification of the depth of the engraved lines being made in the case of silk. The silk fabric is somewhat flimsier than the corresponding cotton or wool fabrics, and hence the printed design on silk must lie at the surface as much as possible and not bleed through to the reverse side to any extent. The secural of the result is dependent as much on mechanical factors as chemical.

As a rule, silk printing is confined to fabrics woven of pure silk dyed in the piece, although it is quite feasible to produce designs on weighted silks woven from the dyed skein. Again, the design is frequently printed upon warps before weaving. The great latitude of silk printing procedure is responsible for the many attractive novelties now on the market; nor is the possibility of producing new effects by any means exhausted, not only because of the yearly advent of new colors permitting of new treatments and effects, but because of the great number of possible combinations of a given design.

Print Colors and Thickeners. — In printing all textiles, it is sought to incorporate the color with the fiber as far as possible. In the case of wall paper, this is effected mechanically or physically, the glue used to size the pulp colors binding these to the paper. In the case of wool, cotton, and silk, however, this incorporation is effected by actually mordanting the colors within the fiber. Accordingly, the colors chiefly selected for silk printing are the basic colors described in the last chapter. These are all precipitable by means of tannic acid, and once precipitated are practically fast to warm soaping. It is thus seen that, as regards the selection of colors, silk printing is the antithesis of silk dyeing.

Nor can the aqueous solution of these colors, or of any color for that matter, be at once applied to the fabric. They must first be thickened in order that they will print evenly from the rollers and not merely splash over the surface of the silk and bleed in all directions through the goods. The thickening of the colors may be accomplished by means of a number of materials. The most frequently employed is a high grade of gum tragacanth, a vegetable gum of considerable purity, possessing the property of absorbing a great quantity of water in the cold and at the same time dissolving to form a semi-fluid paste. In the best printing practice this gum is used by itself. Its high cost, however, frequently prompts the printer to mix with it cheaper media such as gum la biche, developed starches and others. Egg and blood albumin are well adapted to color thickening, although the dark color of the latter debars it from certain classes of work. Both these substances are closely allied in constitution to silk itself and hence are regarded with considerable favor as thickening media. Their preparation is attended by certain difficulties not involved in the use of gum traga-

canth. Casein, derived from milk, is a cheap and effective color thickener. It is not used extensively because of the difficulty of preserving its solution against fermentation.

The color base or thickener prepared, the color itself is added. Since absolute clearness of the colors is a prerequisite of silk printing, and since colors dissolve to a clearer solution in alcohol than in water, wood alcohol is extensively employed for the purpose. Next, a proportion of tannic acid, previously dissolved in alcohol, is added to the mass. This does not at once react with the colors, but by the time the silk is printed, serves to mordant them upon the fiber.

Direct Printing. — In this mode of printing, the silk is brought in contact with the engraved rollers inked with the colors. After the design is on the silk, the fabric is washed to remove the color thickener, else the printed portions would dry stiff. The silk is then hung upon an extending rack to dry.

Resist Printing. — Of late years this mode of printing has not been practised for silk, although commonly employed on cotton and wool. The method is based upon the fact that the fiber, when impregnated with certain chemicals, will not take up any color whatever, or, if the resist materials be modified, will take up only certain colors. The design is printed on the goods in blank, the color thickener containing simply the resist media. The fabric thus printed is then dyed either in a bath of a single dyestuff, when the design does not dye and the ground alone assumes the color, or in a dye bath of mixed colors, when the ground assumes one shade and the resist-printed portion another. This method of printing is anything but new, having been practised as long ago as 1845 when the resist consisted of a mixture of rosin and tallow, printed

on the silk from heated rollers. The silk was then dyed and the resist subsequently removed by treatment with a weak alkaline bath.

Discharge or Extract Printing. — This method has for its foundation the fact that certain colors are completely dissipated when treated with reducing agents and subsequently aged to prevent the return of the color through the oxidizing action of the atmosphere. The method is not difficult of operation, permitting the production of a design in pure white on a colored ground or "blotch." The small white polka dots on silks are produced by this method. The large ones are not, being printed on by means of zinc white in gum tragacanth. To produce the small white dots, a color thickener is mixed with the discharge agent, commonly known as hydrosulphite. The dots are printed with this mixture from a suitably engraved roller. A certain interval is permitted to elapse in order that the hydrosulphite may discharge the ground-color of the silk and the piece is then "aged" by subjecting it to superheated steam. To guard against return of temporarily discharged colors, the basic dyestuffs are as a rule employed for the ground-color of the silk.

Silk Finishing. — This branch of the industry has for its object the restoration of elasticity to the woven fiber, the increase of luster and handle or, as is too frequently the case, the covering over of defects in the thread or fabric.

Silk finishing is first attempted in the dye-house, either through the use of the emulsion described in the last chapter, the use of such materials as *diastofor* (a concentrated malt preparation valuable for its content of *diastase*, the fermentive principle of malt), which serves to strengthen the thread temporarily if weakened by faulty treatment in

dyeing, or by the metallicing process for the production of extra brilliance. This last is worthy of some attention. The dyed silk, still damp, is placed upon a buckling apparatus and stretched as it dries at a high temperature. The apparatus is so devised that the skeins may be turned uniformly as they receive treatment. This treatment is at best a precarious one. As has been previously stated, stretching the silk in the gum before stripping is productive of as great luster and one of greater duration without one iota of the risk involved in metallicing. On the other hand, metallicing has the advantage in that it lays the fiber, producing a better looking and a better winding silk, assuming, of course, that the treatment does not overtax the thread, which is a matter of extreme doubt. If no impurities enter the thread in the course of reeling and throwing, and if all dyeing operations are correctly carried out subsequently, then steam stretching in the gum yields most satisfactory results without danger to the thread.

Finishing Media. — Certain of the materials employed as color thickeners in printing are applicable as finishing media. Of these, gum tragacanth is extensively employed for silk finishing in combination with waxes. Glue and dextrine are also commonly used for finishing. With the exception of dextrine, no single material is applied to the silk, a definite combination being necessary to secure the desired result. Glue jelly must be softened with soluble castor oil. Waxes must be emulsified with alkali. According as these treatments are carefully carried out or not, so will the silk be well or poorly finished.

The extensive use of glue, coupled with the fact that glues frequently are far from pure, will account for occasional defects in finished silks which are ascribed to the dyer's carelessness. The writer recalls an instance where

broad goods that had been dyed the shade known as "Alice blue," some months after weaving developed red spots akin to those that result from mistakes in silk weighting, and accompanied by a similar tendering of the goods wherever the spots appeared. Of course, the trouble was laid to the dyer, until it was shown that, in finishing the silk, a glue containing an excess of sulphurous acid had been used and that this had discharged the colors save the body of fast red which is very difficult to dislodge. Hence the red spots.

The glues finding the greatest favor with silk finishers are the imported, characterized by transparency and light color. In these glues, the transparency is frequently accomplished by treating the glue liquors, in the course of manufacture, with alum; and paleness of color by subsequently bleaching the liquors with sulphurous acid or its derivatives. Not all light glues are so bleached. The higher and (hence) more expensive grades owe their paleness to the careful selection of the stock from which they are boiled. It is to the finisher's advantage as well as the manufacturer's, to keep the cost of his materials as low as possible. Hence the possibility of defects in finished silk ensuing from impurities in the finishing media. These may not be due to the glue directly, but might enter from acidity or alkalinity of the soluble oils used for softening the glue jelly.

Thread Finishing.— Although this method was originally devised in order that the manufacturer might impart certain desirable properties to the thread before weaving, its object of late has been rather to gloss over defects in the initial silk fiber or ensuing from careless handling by the dyer. It is true that certain finishing media applied to the dyed thread impart remarkable strength thereto; but this is only temporary at best, and it certainly does

not follow that the life of the woven silk will be prolonged to any extent thereby. The contrary is more often the case.

In thread finishing, the silk is first wound from the skein onto bobbins. It is then re-wound from these upon a second set, passing meanwhile through a bath containing the finishing media, then through a series of brushes which remove any excess of finish, and finally over a heated metal plate which dries the thread ere it reaches the receiving bobbins. Weak threads thus treated acquire an amazing strength which doubtless renders them easy of warping and weaving where they otherwise would cause considerable trouble. Unless, however, the weighting materials in the thread so treated are properly combined, this heating tends to upset their balance so that the silk will rot a short while after it has passed the looms.

Piece Finishing. — Successful piece finishing is as much a matter of adequate machinery as of media employed. Piece goods may be finished without the use of glue or gums, etc., by simply passing the goods through a heated copper calender. Again, a light treatment with dextrine may be applied and the goods then similarly calendered; or the goods may receive full treatment with softened glue. To distinguish between goods that have been finished and those that have not, it is necessary to crumple a small piece in the hand and then suddenly release it. If the goods have been finished, they will spring out into shape; if not, they will remain crumpled.

It may be safely asserted that where all other processes have been properly carried out, little danger arises from the practice of finishing save in those instances where the finishing media are impure.

CHAPTER VIII

SILK CONDITIONING

Chemical Analysis Versus Conditioning

The rapid growth of silk conditioning in the United States during the past few years renders it a topic worthy of intimate discussion. The movement, on the whole, is not a new one. As early as 1896 a conditioning house was established in New York. Up to two or three years ago, its services were not in noticeable demand. The establishment, then, of a rival and better equipped institution, vested with the authority of the Silk Association of America, led to a campaign of education amongst silk manufacturers as to the benefits accruing from silk conditioning in accordance with European practice.

Too much credit cannot be accorded the instigators of any movement tending to reduce an industry to an exact basis. The erstwhile empiricism, tantamount to a condition of chaos, characterizing the silk industry, certainly cried for reform. It is a curious commentary, however, that American industry with its wide latitude for the exercise of initiative should, because of the false premises assumed by those desirous of bettering existing conditions, long defer the adoption of remedial procedure only to adopt, in the end, European methods which, no sooner are they adopted, are greatly modified or even discarded by our continental contemporaries themselves. This is the exact status of American Silk Conditioning.

Lest the author appear unduly prejudiced in favor of

his own system of silk valuation, he hastens to avow his recognition of the considerable good thus far achieved by conditioning. In so far as mechanical tests are concerned, the system is practically perfect. For determining true invoice weights, it is practically indispensable. It is to be noted, however, that, apart from the necessary drying ovens for the assay of this last, it has been within the power of every manufacturer for years past to determine the count, size, and twist of his silk with accuracy equal to that of the conditioning house, by means of suitable apparatus installed in his own mill. A certain value, however, seems to attach to tests conducted under a separate roof without danger of bias.

With the determination of the true conditioned weight of the raw silk, the usefulness of the conditioning house ends. Great stress, indeed, has been laid upon the value of the "boil-off" test, as a panacea for all silk ills. Unfortunately, the claims made for this test are but illy founded. It is a reliable check for the throwster's clearance, but that is all. The contention that it may be made the basis for ordering weighting and dyeing is absurd, despite the numerous "statistics" advanced in support of the theory. Since it is usually at the weaver's behest or, at best, with his tacit consent, that the throwster overloads the silk with soap and oil, if not more dangerous substances, the weaver's subsequent curiosity to discover if clearance has been put in is, to say the least, ludicrous. It is a waste of both time and money for him to apply to the conditioning house for this information. The weaver is concerned, not with the amount of clearance, since this costs him nothing, but with the *nature* of the clearance which may prove costly in the end. Conditioning cannot supply this information. Chemical analysis can.

Unless followed by chemical analysis of the silk, condi-

tioning house boil-off tests are worthless. Says Sig. Giuseppi Corti, of the Milan Conditioning House, writing on this head to the American Silk Journal:

"Until recently the boil-off test, as made uniformly at all conditioning houses, was the only means of determining the intrinsic value of a silk as well as the amount of weighting it had received during reeling or throwing. But appraising the value of silks by the loss in boil-off, having regard only to the amount of foreign substances they may contain, is not always exact. The well-known inequalities in the amount of pure silk fiber found in the same lot of silk entirely free from foreign substances make it impossible to determine with exactitude from the loss of weight in boil-off whether it was weighted when in the hands of the throwster and to what extent.

"Even when one exercises the greatest care in taking samples, the boil-off tests often show differences of from 1 to 1.50%. These differences sometimes become even more marked when heavily weighted silks are being tested because of the volatilization of a portion of the overweighting during conditioning. It is only when the raw silk is boiled off simultaneously with the thrown silk that the differences between the results obtained represent pretty nearly the amount of weighting added by the throwster.

"On account of these different causes of inequality it has sometimes been sought to prove that thrown silks, in which a light weighting had been introduced to facilitate the winding, would lose less in boil-off than the corresponding raw silk, instead of showing a greater loss.

"From the above the necessity of having recourse to chemical analysis whenever it is desired to determine with exactitude the weighting of a raw silk is most evident. The process of washing with distilled water heated to 50°, which is still used in some silk conditioning houses, is

certainly an improvement over the boil-off method, but evidently does not carry with it the guarantee of an exact chemical analysis, because if the weighting is composed of substances insoluble in water, the washing will sometimes give inexact results.

"The Milan Silk Conditioning House (Societa Anonima Co-operative per la Stagionatura e l'Assaggio delle sete ed Affini in Milano) realizing the great value of the method of chemical analysis pursued by its Laboratory for the Experimental Study of Silk, and aiming to facilitate the employment of methods truly scientific in place of those in use at present, has decided to place its service for the regulation of the purity of raw silks on a commercial basis by reducing the charge for analysis to four francs ($1.00) per sample."

So long, of course, as the silk dyer is to be made responsible for defects not within his control, the present system of silk valuation will suffice. A system of silk valuation, however, that furnishes absolutely no data on which to base the ordering of dye-house treatment cannot endure for long. As a practical example of the utter futility of conditioning house tests with respect to this latter contingency, let us consider the following.

Since the early eighties, fat has been used for adulteration of raw silk, rendering degumming very difficult. In Italy there has long been employed, for this purpose, a mixture consisting of salt, soap, unsaponified grease, mineral oil and gelatine — a compound containing the organic elements of silk itself and which increases its weight but not its volume or strength.

We shall assume that silk, so adulterated, has been purchased by the manufacturer, who sends it to the conditioning house for assay. Note that, in this instance, the figure for conditioned weight obtained by drying the silk

and adding 11 % for average moisture in no sense represents the true silk in the shipment. The silk is now subjected to the boil-off test. Since the character of the adulteration precludes the normal degumming of the silk, very little gum comes off, with a result that *the conditioning house certificate will indicate that this is a low-boiling silk and hence one of good quality!* Let us go a step further and assume that the silk is now thrown and returned for boil-off to the conditioning house. The test will simply show that additional soap and oil has been put in by the throwster. Since the manufacturer orders this done, the result of the test must be of considerable comfort to him! Let the reader carefully observe, however, that at no time have the tests revealed the presence of the dangerous ingredients in the silk. The silk now goes to the dyer. It contaminates his boiled-off liquor. Once in the tin bath, the fats remaining in the silk combine with the former to form metallic insoluble soaps. These prevent even dyeing; create chalkiness of the thread and weaken it, and the dyer, in order to produce anything like a normal result, must subject this silk to abnormally drastic treatments throughout, so that by the time the silk has passed the looms it is short-lived. Now, what has conditioning availed the owner of this silk? The sellers, aware of its questionable character, doubtless secretly congratulate themselves on not only the impossibility of detection by conditioning house tests, but also on the fact that the very figure for conditioned weight is fallacious! And since the bulk of raw silk coming to the American market is more or less adulterated, just what is gained by conditioning tests? What shall it avail a manufacturer to know the exact size, twist, or count of his silk, to be told that the throwster has done just what he has ordered him to do and yet remain in utter ignorance of those factors upon which

depend the success of dyeing operations and the life of the woven silk?

Since certain standard methods obtain for the treatment of silk in the dye-house, the manufacturer is concerned solely with the question whether the raw silk he purchases is in a fit state to go to the dyer and be returned in good condition, after throwing. Once he determines to have his raw silk regularly assayed, his thrown silk examined, he is then in a position to determine the exact degree of the dyer's responsibility. How can he justly declare that defects in the dyed silk are due to the dyer's carelessness unless he has previously determined whether or not the thrown silk contained impurities which interfered with dyeing processes? Again, why should he accuse the throwster of malpractice unless he is confident beyond peradventure of doubt that the raw silk was pure? By all means let him avail himself of means preventive of his purchasing excess moisture. Let him surround himself with every system that safeguards his finances and protects his profit; but let him apply an equal measure of common sense to the treatment of his raw material at its most important stage!

A *rational* system of silk valuation presupposes the following:

1. The determination of the conditioned weight; *i.e.*, absolute dry weight plus 11 %.
2. The complete chemical analysis of the raw silk.
3. The complete chemical analysis of the thrown silk.
4. The complete chemical analysis of the dyed silk.

The first is indispensable to the proper checking of raw silk invoices.

The second is a prerequisite to the ordering of all subsequent treatments of the silk. If the raw silk is found to be free of adulteration, then, —

The third serves as an absolute check on the work of the throwster. No insoluble materials employed to obtain factitious clearance can escape detection.

The raw and thrown silks found to be normal, responsibility for the quality of the silk now rests with the dyer. The amount of weighting can now be *rationally* ordered and the analysis of the dyed silk checks not only the *amount* of weighting but the *character* as well. In this way it is possible to forecast, within close limits, the life of the woven silk *before the dyed silk has passed through the looms*, i.e., *at a time when a claim against the dyer, for mistakes on his part, may be safely prosecuted.* The substantiation of such cases must, however, *rest upon the certain knowledge that the silk contained no abnormal ingredients before it reached the dyer.*

Any other system of silk valuation must fail of adequate protection to the manufacturer. It is unsafe for him to take constant refuge behind the legal maxim "caveat emptor"; for while the law does distinguish between visible and latent defects, the defects in silk are easily proven to be latent, and for him who shall take the initiative in litigation involving the quality of silk exists the possibility of mulcting the manufacturer of heavy damages.

APPENDIX

Influence of Prior Processes on Winding and Weaving

That silk which winds well is readily warped and woven is virtually an axiom. Silk winding is the *bête noir* of the manufacturer, and responsibility for the difficulties he experiences at this stage is invariably laid at the dyer's door, frequently with justice although not always so.

It is worthy of notice that concerns operating their own dye-houses do not suffer the inconveniences of poor-winding silk as frequently as those who are dependent upon the commission dyer. This would, at first blush, appear to prove the thesis that the dyer is responsible for the winding qualities of the silk. Let us subject the matter to a little closer scrutiny, lest we form an erroneous opinion. Conditions prevailing in mill dye-houses differ radically from those obtaining in commission dye-houses. The silk run in the former is usually of good quality. Much of the silk treated in the latter is inferior if not altogether worthless. The weighting demanded by manufacturers equipped with dyeing facilities is always kept within rational limits; the weighting demanded of the commission dyer is frequently so far in excess of what the silk can normally stand and the dyer is so often forced to subject the silk to many unusual processes that it is small wonder that difficulty is subsequently experienced in winding.

Poor winding is due either to stickiness, tenderness of the thread or its brittleness. It is necessary to distinguish

carefully between these defects. All may be brought about through the following errors on the dyer's part:

1. Over-stripping the silk (stickiness).
2. Insufficient washing after stripping (stickiness).
3. The use of oxidized tin liquors (tenderness).
4. Insufficient washing after phosphate (stickiness).
5. The use of " broken " silicate baths (brittleness).
6. An excess of casein in the phosphate (stickiness).
7. The use of zinc chloride after phosphate (tenderness).
8. The use of hard water after certain baths (brittleness).

All of these conduce to the bad winding of the silk. Some, in addition, are responsible for loss of luster.

The reader must bear in mind, however, that initial adulterations in raw and thrown silk are as likely to create the above defects after silk has been weighted and dyed as any carelessness on the dyer's part.

Effect of Moisture on Weaving — Humidification

Recent developments in the humidification of weavesheds, with a view to the elimination of the frictional electricity of yarns, claim the interest of the investigator. Numerous " systems " of humidifying have come into the market. From a comparatively simple matter, the movement has assumed complex proportions involving, at this writing, such features as the removal of disease germs!

A word or two of comment may not be altogether irrelevant. In the first place, the apparatus, as now put on the market, is in every instance unnecessarily elaborate. One of the most successful " systems " coming within the observation of the writer consists of a pipe which inducts exhaust steam into a corner of the weaving room, which pipe is backed by a small fan. Simple as this seems, it accomplishes all that can possibly be required in the way of humidification.

It is, indeed, questionable if anything elaborate in the way of " humidifying " is required in the case of silk weaving. True, it is desirable that the humidity of the room in which the looms are installed shall be as nearly constant as possible throughout the year. It is not to be denied that moisture has a definite effect upon the facility with which certain yarns are woven. In the case of silk, however, it is extremely doubtful if the effect is genuinely advantageous.

Silk is practically the most hygroscopic of textile fibers. Rational treatment, in the way of weighting, does not reduce its hygroscopicity. Properly treated silks have woven well, without humidification, since time immemorial. On the other hand, where silk is workable only with difficulty, it is usually due to innate defects or defective dyeing treatment in which latter event the subjection of the silk to excess moisture so far from permanently overcoming these defects is positively harmful in that it still further dissociates illy-combined weighting ingredients within the fiber and practically insures the rapid dissolution of the silk.

Viewed exclusively from the commercial standpoint, whenever a silk manufacturer installs a system of humidifying, he gives his dyer an advantage over him. Silks which would wind poorly because of brittleness or other defects, now have their elasticity temporarily augmented with a result that they will pass the looms unchecked. Since the manufacturer is responsible financially for the quality of the silk he weaves, this phase of the question becomes worthy of his serious consideration. It were safer for him to dispense with what is at best a temporary fad in favor of the rational examination of his raw and dyed silks thereby affording himself unlimited protection with reference to the above-cited contingency.

Classification of Raw Silks

Adopted by Division A, June 15, 1908.

At the request of the Board of Managers of the Silk Association of America, Division A. has carefully considered the classification names to apply to the various qualities of European Silk and Japan Filatures, Re-reels and Kakedas dealt in on the New York market and have adopted the following:

European Silks

Grand Extra	Best No. 1
Extra Classical	No. 1
Best Classical	Realina
Classical	

Japan Silks

FILATURES	RE-REELS
Double Extra	Extra
Extra	No. 1
Sinshiu Extra	No. 1–1½
Best No. 1 to Extra	No. 1½
Best No. 1	No. 1½–2
Hard Nature No. 1	No. 2
No. 1, of the grade of	No. 2–2½
Sinshiu Okaya (Chicken)	No. 2½
Summer reeling Season 1908–9	No. 3
	KAKEDA
No. 1–1½	Best Extra
No. 1½	Extra
No. 1½–2	No. 1
No. 2	No. 2
	No. 3

The Board of Managers of the Silk Association of America at a meeting on June 10, 1908, approved the foregoing classification with the recommendation that the Raw Silk Division of the Association consider the feasibility of

tabulating a set of descriptions with samples of raw silk to represent the agreed-upon classification at the opening of each silk season.

On June 15, 1908, the Raw Silk Division voted to endeavor to adopt a standard for No 1 filatures and re-reels as soon after the opening of each silk season as sufficient silk shall have arrived in New York to give a fair representation of the average quality of the season's summer reelings, and this matter is now under consideration by them.

It is believed that the deposit with the Silk Association of America at the opening of each silk season of a set of samples representing say five grades of silk would bring within the reach of both buyer and seller a standard to which offerings of parcels could be compared; thereby avoiding existing uncertainty and misapprehension as to qualities.

Customs Prevailing in the Skein Silk Dyeing Trade of the United States.[1]

Storage and Insurance

The dyer provides safe and suitable storage for silk sent to him to dye, without charge to the customer, assumes liability for the loss, theft, or destruction of silk while in his possession, and keeps it fully insured.

Transportation Charges

The dyer pays the transportation charges on the silk sent him to dye, unless otherwise agreed, and he delivers the dyed silk free within a short radius of his dye-house. Transportation charges on dyed silk, shipped to a considerable distance, to be paid by the customer.

[1] Quoted from "The Value of Conditioning."

Packing

The dyer when shipping the dyed silk is to have it safely and suitably packed, using such quality of paper, cords, and bagging as will insure the proper protection of the silk.

Withdrawals of Undyed Silk

Should the customer order silk to be sent by the dyer to some other dye-house, or to be returned to him undyed, he must reimburse the dyer for any money that has been expended by him for transportation charge, insurance, or storage of such silk.

Time of Delivery of Order

Dyer must execute order with reasonable promptness. If silk is on hand at the dyer's, shipment back of the dyed silk may be expected in from one to three weeks (according to circumstances and the nature of the work) from receipt of the order.

Prices, Discounts and Terms

Prices, discounts, and terms, are matters of mutual arrangement. A standard printed price-list is generally used as a basis for prices. Bills are rendered at the end of each month, a common basis of settlement being cash within 30 days.

Orders for Weighting

The dyer is obligated to deliver silk within the limits of the weighting ordered. Thus, 20–22 oz. is supposed not to run below 20 oz. and, unless by special agreement, a greater weight than 22 oz. cannot be claimed. If the weight comes less than 20 oz. the customer can claim the

price corresponding with what it weighs. If, however, it runs over 22 oz., even when not specially agreed on, the dyer cannot charge more for the extra weight.

Weighting of Silks with Varying Boil-offs

Whether the dyer treats silk having either a light or a heavy boil-off, his price is the same.

Matching Colors

The dyer does not undertake to guarantee an exact match to sample, but does undertake to furnish a commercial match, that is, a shade so close that fabrics made of it can be properly delivered as that color. If the customer finds on examination of dyed silk that same is off shade, or too dark, or too light, the dyer will make the necessary modification of the color, if it can be done without injury to the working qualities of the silk, without extra charge.

If, through his error, the dyer puts on the silk the wrong color or weighting, the customer may use the lot if he chooses to do so to the best advantage, charging the dyer the loss, if any. If this is impossible the dyer may be required to pay for the silk at current market prices.

Shady Silk

Should silk be found to be shady to an uncommercial degree and the defect be found not due to the nature of the silk the dyer must try and rectify the trouble at his own expense, and should this be impossible he may be required to keep and pay for the lot.

Should the customer, before knowing of the trouble, have put such silk in work the dyer may not only be required to make right, or to take back and pay for, the silk,

as already stated, but he should reimburse the customer for money actually spent in the winding, warping, quilling, etc., of such defective lot.

He is not, however, to be held liable for damaged cloth, woven from such material, past the point where the defect should have become apparent, as the weaving of visibly imperfect goods should not be proceeded with.

The consequential damages in such cases due to standing looms, goods late for delivery, etc., fall upon the customer.

Rotten Silk

Should silk, originally sound, be returned from the dyer rotten, or seriously defective in strength, or should it while remaining in stock for a reasonable time after dyeing, and under proper conditions of storage, develop such trouble, the dyer can be called on to take back and pay for the silk.

If, however, the weighting ordered is beyond the bounds of prudence and the limitations of good practice, the dyer should promptly notify the customer to that effect, before proceeding with the order, and should the customer then direct that the work be proceeded with, any loss that may arise if the silk turns out unsound must be borne by the owner.

Fast Colors

Dyers are supposed to make their colors commercially fast for such ordinary purposes as the goods are used for. Customers wanting colors fast, *i.e.*, not liable to change by light, washing, perspiration, or what not, must so specify in ordering, and charge for the work is made accordingly.

If the silk is ordered " fast " for certain uses, and is paid for on that basis, and claims should come upon the

manufacturer for a deficiency in this report when the fabric has been used under reasonable conditions, the dyer may properly be called on to make good such claims as the manufacturer has had to allow.

Mixed Silk

Should the dyer mix one customer's silk with another's, or different lots of the same customer's silk, he is chargeable with the loss that may result.

Bad Winding

When properly thrown silk is so handled in the dyeing that it is difficult to wind, and when in consequence the customer has to pay extra wages for the winding of it, and when excessive waste may be caused thereby, such loss in wages and waste is properly chargeable to the dyer.

As souple dyed silks generally wind poorly, specific arrangement with dyer should be made regarding same.

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