CHAPTER IX

THE PRINCIPLES OF FINISHING

Most fabrics are somewhat uncouth and unsatisfactory as taken from the loom. Some few, such as various silks and a few cotton styles, are not markedly changed by the subsequent finishing; others, such as woollen fabrics, are so changed that it is difficult to believe that the harsh, unsightly fabric taken from the loom can be so changed—so improved—by a few simple finishing operations.

Finishing may be varied in three marked ways. Firstly, it may be applied with the idea of making the best of what is present in the cloth under treatment without the addition of any so-called finishing agents; secondly, it may principally consist of adding a finishing agent or "filler" to the fabric, the fabric being merely a foundation to hold the "filler" together; and thirdly, a combination of the two foregoing ideas is possible in which the nature of the fabric is suitably fortified with a not undue allowance of some suitable "filling" agent.

In the first class come most wool fabrics, in which the nature of the wool is, or should be, fully developed by suitable spinning and twisting, suitable weave structure and suitable finishing. The perfect wool texture is only producible by full deference being paid to all these factors. But even in the various all-wool goods a marked difference is observable. The typical woollen cloth is a cloth made in the finishing. The typical worsted cloth is a cloth made in the loom. But between these extremes there is every grade imaginable, from the worsted-serge or vicuna of worsted warp and woollen weft, with a pure woollen finish, to the typical West of England woollen with almost a worsted finish.

In the second class come certain cheap calicoes, and of late certain cheap silks, with a very large percentage of filling. Little exception can be taken to the calicoes. They are sold for what they are, and no one is taken in. With the silks, however, it is quite otherwise. The goods in question are sold as silks, and no reference is made to the percentage of filling, which is sometimes truly astounding. Sometimes the silk spinner or manufacturer imposes upon himself. For example, a silk spinner gives instructions for his yarns to be dyed and loaded up say 40 per cent. Now this yarn in discharging may lose 30 per cent.; so that if the spinner gets back for every 100 lbs. of grey yarn 140 lbs. of dyed yarn, the proportion of filling to silk is—As 70 : 70 or 100 per cent., although it may only be stated at 40 per cent. The ease with which silk can be loaded or filled has enabled unscrupulous silk merchants to take in an all too trusting public. The filling of silk goods has been carried on to such an excess that at the present moment there is a strong reaction against it.

In the third class come some few wool goods and a large variety of cotton, linen and silk goods. Few wool goods can be improved with any filling agent. Meltons and heavy milled cloths may perhaps be improved by a stiffening agent in their interior, and the necessary weight, but no extra value, may be added to worsted coatings by such a weighting agent as chloride of zinc. These, however, may be taken to be the exceptions which prove the rule. Most cotton goods are improved and rendered more sightly by either adding filling or by smoothing down the size already present in the warp yarn. Linen goods specially lend themselves to, one might almost say, "showing-off" a filling agent "starch"—in fact, it is quite questionable whether the goods should not be placed in the second class. Some certainly should; others are not abnormally "filled." Silks, being frequently woven in the "gum," must be discharged in finishing; but it is probable that the presence of a small amount of silk gum in the bath and on the fibre is necessary to preserve the best characteristics of the texture under treatment.

Finishing Processes and Machines.—As many processes and machines are common to all the recognised fabrics, such may be described generally prior to a particular description of the finishing operations necessary for representative fabrics.

Mending, Knotting and Burling.—This consists in repairing the broken threads and picks nearly always present in the fabric as it leaves the loom. It is also advisable to mend pure worsteds after scouring, as the faults are then more easily seen. The mending wage for fine worsteds is frequently equal to the weaving wage. Knotting and burling are also carried out at this stage.

Scouring.—This consists in thoroughly cleansing the fabric prior to proceeding with the finishing proper. Certain cotton, cotton and wool, and silk cloths are so clean on leaving the loom that the finishing proper is at once proceeded with. Many wool goods, however, must be scoured fairly clean in what is known as the "dolly" or on the five-hole machine, before they will satisfactorily take the finish for which they are designed. Again, colours running in the scouring may often be scoured out, while if left in for the milling they will truly "bleed" and permanently stain the neighbouring threads and picks.

Milling.—This operation is equivalent to hammering or squeezing the cloth until it has attained to a sufficient solidity. Wool only of all the textile fibres "felts," as it is termed, so that this operation is practically limited to wool or wool combination goods.

Two machines are employed to effect the required felting, yielding somewhat different results. The milling stocks, imitating the original treading action of the human feet, hammer the cloth (which is placed in a holder or receptacle so shaped that the falling of the hammer not only "mills" or "felts" but also turns the cloth round so that its action is evenly distributed over all its surface). The action of the stocks is obviously of a bursting nature, giving "cover" on the fabric.

The "milling machine" works on the squeezing basis, the cloth to be milled being squeezed up in lengths or in width or both according to requirements. This machine not only gives a more solid cloth, but also enables the miller to control the width and length and consequently the weight per yard.

Crabbing.—This is an operation based upon the fixing qualities of wet heat as applied to various textures, and upon the desirableness of the first shrinking and consequent setting of the fabric being very carefully controlled. The fabric to be "crabbed" is wound dry and perfectly level on to a roller and then under tension wound on to a roller running in hot water. From this roller the fabric may be run to another roller under similar conditions. There are various forms of crabbing machines, but the factors are always the same—wet heat and tension and weight.

A very useful but somewhat dangerous machine is used for finishing certain cotton warp and wool weft goods, consisting of four or five rollers running in scouring and washing-off liquors, round which the fabric is passed, followed by a series of drying rollers, so that the fabric in a sense is continuously scoured, crabbed and dried. This machine is dangerous in that "crimps" are not eliminated as in the case of true crabbing. Of course this machine may be employed in conjunction with the crabbing machine when the above objection does not hold.

A special crabbing machine employed in the woollen and worsted trade simply arranges for steaming while the fabric is being wound on to a true steaming roller upon which the fabric may be steamed and cooled off; or it may be wound on to a roller for "boiling" if necessary.

Steaming.—If the fabric is to be steamed it is run from the last crabbing roller on to the steaming roller—a hollow roller with a large number of holes pierced from its central tube to its periphery—so that steam may be blown right through the piece. The piece is usually re-wound inside out and re-steamed to ensure level treatment. It is then allowed to "cool off." The basis of this treatment appears to be a "setting" action, owing to the great heat employed no doubt partially dissolving or liquefying certain of the constituents of the wool fibre. Prolonged steaming undoubtedly weakens wool fibres.

Dyeing.—From a mechanical point of view dyeing may be conducted on either the "open width" or "rope" method. Cotton goods, for example, must be piece dyed on the "jigger" full width if level shades are to be obtained, while wool goods are usually satisfactorily dyed in rope form. There is no satisfactory theory for this, but practically as fact it is a most important matter. Mercerized cotton has such an affinity for dyes that the utmost difficulty is experienced in finding a restrainer to effect the even distribution of the dye in light shades. Without some restraining influence the first few yards might take up the whole of the colouring matter.

Most goods must be opened out after dyeing, as if allowed to cool in a creased state they retain their creases. The point here to note is that to take out a crease it requires a greater heat than the heat at which the crease was put into the piece.

Washing-off.—This is a simple operation to ensure that all the unfixed colouring matters, etc., are cleaned out of the piece. As the action is mechanical, cold water may be employed.

Drying.—This is usually effected by passing the fabric round a series of steam-heated rollers. Owing to the way in which the fabric is wrapped round these rollers it never rests for long upon one roller, so that it cannot be burnt; again it is wrapped alternately face and back upon the rollers, so that it is really dried in the shortest possible time. In goods which may be worked by a straight pull on the warp either horizontally or vertically arranged drying rollers are ample; but if any extension in width is desired a tentering machine must be employed. As previously explained, these drying rollers are usually arranged in conjunction with another operation—say, continuous scouring and crabbing. Of late there has been a most marked tendency to hot-air dry.

Tentering.—This consists in holding the cloth tightly in the warp direction and widening it in the weft direction. To effect this the cloth is pinned by hand on to two continuous tenter chains, which as they carry the cloth into the machine gradually increase the distance between them, thus tentering out the cloth. The "give" of the cloth is probably due to three factors, viz., give in the fabric structure, in the thread structure, and in the fibre itself. Obviously, unless the cloth is "set" in this position it will more or less shrink after the process. To effect the setting the cloth must be fed into the machine damp; in this condition it must be widened or straightened out, and then in the widened out condition it must be dried. In the most approved tentering machines the expanding chains carry the fabric over gas jets which just supply the necessary heat for drying. A steam-jet pipe is also provided to damp the cloth just prior to or during tentering to give it the necessary plasticity. In the enclosed "steam-pipe" type of machine the efficiency of the machine is often impaired by the difficulty of getting away the hot moisture-charged air, but as drying largely depends upon this and not so much upon the heat developed, this must be done if efficient and economical working is to be attained.

It will be evident that goods "tentering out" will have a tendency to shrink. London tailors are credited with always testing the natural shrinkage of these goods by folding them with a thoroughly wetted and wrung out cloth for a day or two, and then noticing the shrinkage which has taken place. Goods so treated are spoken of as "London shrunk."

Brushing and Raising.—After scouring, milling, etc., most wool goods and some few others present a very irregular face, neither clear nor yet fibrous. If a clear face is desired the few fibres on the face must be raised as much as possible in order that they may be cropped off in the cropping or cutting operation which follows. To effect this the face of the fabric is regularly presented to the action of a circular brush or to the action of "teazles."

Should a fibrous face be desired—technically termed a "velvet" face—the fabric must be raised wet on what is termed the "raising gig" from head to tail, from tail to head, and across if possible, to obtain a sufficiently dense fibre, naturally somewhat irregular in length.

The "raising gig" proper carries teazles, which without damage to the foundation of the fabrics submitted to them raise a sufficiently dense pile. For flannelettes and some other goods a stronger machine is required; in this case wire teeth, specially constructed and specially applied, take the place of the teazles. Teazles themselves vary much in raising qualities; and the experienced raiser knows this and takes advantage of it.

Cropping or Cutting.—To obtain a perfectly level face on fabrics they must be submitted to a "cropping" or "cutting" operation. Formerly cropping was more or less efficiently done with large shears, but to-day much better and more accurate work is done by the circular "cropper," which, working on the principle of the lawn-mower, may be set to leave a pile of any required length, or if desirable to practically leave the fabric bare. The cutting action is due to the combined action of the fixed bed and the spirally arranged revolving blades.

Singeing.—Some fabrics, such as Alpacas, Mohairs, etc., are required to have a clear lustrous face such as no cropping machine can possibly leave. Singeing must here be resorted to. The fabric to be singed is quickly passed face downwards over a semi-circular copper bar heated to almost white heat. The speed of the cloth naturally decides to a nicety the amount of singeing effected, but to avoid damage to the fabric a quick speed is usually adopted and the fabric passed over, say, six times. Gas singeing is not extensively applied save in genapping, *i.e.*, singeing and clearing braid, etc., yarns.

Pressing.—By means of the hydraulic press great weight may be put on to fabrics, and they may thus be more or less permanently consolidated and in some cases lustred. Heat may be applied in the press, thus aiding in the fixing of the fabrics under treatment.

Presses are practically made in three forms: ordinary, intermittent, and continuous. The ordinary press simply receives its charge of cloths in the ordinary cuttled form, heat being introduced through the expanding or contracting press-plates separating individual pieces. Press papers are placed between the cuttles of the pieces to form the surface against which the fabric is pressed.

In the intermittent form about five yards is treated at once, suitably pressed and held stationary in the heated machine for, say, a minute, and then automatically moved on so that the ensuing section of the fabric may be treated in like manner.

In the continuous form the pressing is continuously effected.

The time factor naturally varies in all three forms, and is naturally the factor which decides which is the most efficient machine for particular classes of goods.

Calendering.—This operation simply consists in passing goods through heavily weighted and if desirable heated rollers which it is found break or render less "caky" fabrics passed through them. The probable action is to distribute rigidity or solidity.

Schreinering.—This operation consists in passing suitably constructed cloths between a pair of solid heavily weighted steel rollers, one of which has a plain papier-mâché surface and the other is ruled with extremely fine lines from 190 to 500 to the inch. The effect on the piece is to develop a really wonderful lustre specially applicable to mercerised cotton goods.

Filling.—As already remarked, it may be desirable or necessary to stiffen some goods to increase their utility. Again, some goods are "filled" simply to attain a desired weight.

Soap or other agents may be cracked in pieces or the pieces may be definitely impregnated with some such agent as chloride of zinc. It is hardly necessary to add again that filling is rarely legitimate.

Conditioning.—After fabrics have passed through a process involving the application of dry heat—such as singeing—they are unnaturally dry, and as a consequence are very weak. To give back the natural moisture, goods in such a condition are passed through a machine which "sprays" them and thus causes the fabric to quickly regain the moisture and often the strength lost.

The foregoing are the principal operations in finishing. The secondary operation such as hydro-extracting, burl-dyeing, extracting, etc., are of such minor importance that there is no need to specially refer to them here.

Waterproofing.—Fabrics may be rendered water-proof in three distinct ways. Firstly, the fibres of which they are composed may be rendered moisture-repellent, as, for instance when wool is subjected to the action of super-heated steam. Secondly, the fibres may be charged with a water-repellent substance, which thus prevents the passage of water save under pressure. Oiled fibres, for instance, possess this characteristic. In these two cases the surface tension of the liquid which endeavours to pass through the fabric plays an important part. Thirdly, the fabric may be "plastered" or entirely coated with some such agent as india-rubber.

All three methods are employed, and there are, of course, combinations which are not precisely one or the other.

General Notes.—To give an idea of how the foregoing operations are applied in finishing specific types of fabrics the six following lists are given:—

Woollen Cloth. (All Wool.)	Worsted Cloth. (All Wool.)	Lining Fabric. (Cotton and Wool.)
Mending, Burling, etc.	Mending, Burling, etc.	Mending.
Soaping.	Crabbing.	Crabbing.
Scouring.	Soaping.	Steaming and Setting.
Milling (Stocks).	Scouring.	Dyeing.
Milling (Machine).	Mending.	Washing-off.
Washing-off.	Light-milling.	Tentering and Drying.
Hydro-extracting.	Washing-off.	Singeing (several times).

WOOLLEN CLOTH.
(All Wool.)

Crabbing.
Tentering and Drying.
Brushing and Dewing.
Raising.
Cropping.
Brushing and Steaming.
Cutting.
Pressing.
Steaming.
Cuttling.

WORSTED CLOTH.
(All Wool.)

Hydro-extracting.
Crabbing.
Tentering and Drying.
Dewing or Conditioning.
Brushing and Raising.
Cropping.
Brushing.
Dry Steam Blowing.
Cuttling, Rigging.
Folding and Measuring.
Pressing.

LINING FABRIC.
(Cotton and Wool.)

Washing-off or
Conditioning.
Tentering.
Pressing.

SILK FABRIC.[1]
(Net Silk.)

Singeing or Cropping.
Discharging and Washing.
Drying.
Cylindering.
Damping, or
Dressing and Singeing.
Calendering and Lustring.
Rolling or Plaiting.
Pressing.

COTTON FABRIC.[1]
(Calico.)

Singeing.
Souring.
Washing.
Saturating with Caustic Soda.
Kier Boiling.
Washing.
Chemicing.
Washing.
Souring.
Washing.
Squeezing.
Mangling.
Drying.
Filling.
Drying.
Damping.
Stretching.
Beetling or Calendering.
Making-up.

LINEN FABRIC.[1]
(Standard Style.)

Lime-boiling.
Washing.
Souring.
Washing.
1st Lyre boil.
Washing.
Chemicing.
Washing.
Souring.
Washing.
2nd Lyre boil.
Washing.
Grassing.
Chemicing.
Washing.
Souring.
Washing.
Scalding.[2]
Washing.[2]
Chemicing.[2]
Washing.[2]
Souring.[2]
Washing.[2]
Scutching.
Water-mangling.
Starching and blueing.
Beetling.
Breadthening.
Calendering.
Lapping.

[1] These details are supplied by specialists in the respective branches of the industry. All are preceded by operations equivalent to Mending, Burling, etc.

[2] These processes must be varied in accordance with particular requirements.

The foregoing lists seem fairly comprehensive, but in reality they by no means convey a complete idea of the many different styles of finish. For woollen cloths, for example, some half-dozen typical and distinct finishes could be cited, and the other styles are by no means without their varieties (see Fig. 53F).

There can be no doubt but that more attention to the effects of "finish" is much to be desired. To thoroughly demonstrate the influence of each specific process the best method is to pass a suitable length of fabric through the necessary or desirable operations, and to cut off, say, a yard length from the fabric after each operation as a reference. Thus for a piece-dyed Botany coating reference lengths should be preserved of (*a*) warp and weft; (*b*) grey cloth; (*c*) scoured cloth; (*d*) milled cloth; (*e*) dyed and tentered cloth; (*f*) raised cloth; (*g*) cut cloth; (*h*) steamed cloth; and (*i*) pressed cloth. The record of all the foregoing reference samples should include (1) counts of warp and weft; (2) threads and picks per inch; (3) length and width; (4) weight; and (5) strength. Such records as these have been worked out in the Testing Laboratories of the Bradford Technical College during the past six to eight years, and are found to add most markedly to the efficiency, value and interest of the investigations undertaken.

CHAPTER X

TEXTILE CALCULATIONS

In a general sense most textile calculations have, and should have, reference to the ultimate cloth produced. It is true that there is a distinct "wool" trade, a distinct "top" trade, and a distinct "yarn" trade, each of which is in a sense independent of the cloth trade. It is nevertheless obvious that all nomenclature, designation and indication should be on some basis readily understood and easily applied by the cloth constructor.

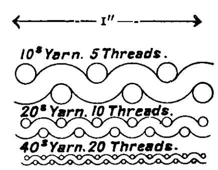

Fig. 49.—Illustrating the Setting of Fabrics; also the Weights of Fabrics.

Unfortunately the "science of cloth construction" was developed so late that not one but many cumbersome methods had long been firmly established, so that to-day a considerable portion of the designer's and cloth-coster's time is wasted on calculations which, with full cognisance of all possible conditions, might easily have been eliminated by the adoption of convenient standard systems for counts of yarn, sets, etc.

Starting from the cloth it is evident that the most useful designation for yarns would be in fractions of the inch (or of a decimeter). Thus 1's yarn would have a diameter of 1 inch, 2's of $\frac{1}{2}$ inch, 3's of $\frac{1}{3}$ inch, 4's of $\frac{1}{4}$ inch, and so on, or that 1, 2, 3, 4, etc., threads might be laid side by side in an inch. The "set" calculations for cloths on this basis would be very simple. On this basis, as shown in Fig. 49, with plain weave, a 10's yarn would be set five threads per inch, a 20's yarn ten threads per inch, and a 40's yarn twenty threads per inch. Moreover, on this system, the weight of the cloth would vary in inverse proportion to the counts, for, as shown, the cloth with 20's count is half the thickness or weight of the cloth with the 10's count, the cloth with 40's count is half the weight of the cloth with 20's count, and *vice versâ*. If the 10's count cloth was a 30 oz. cloth, the 20's count cloth would be a 15 oz. cloth, and so on. Again, the "sets" or threads per inch and picks per inch for any given weave or interlacing would be simplicity itself. As shown in Fig. 50, for example, the threads and picks per inch would be—

$$\frac{\text{Counts of yarn} \times \text{threads in repeat of weave.}}{\text{Threads} + \text{intersections in repeat of weave.}}$$ [1]

Thus with a 60's yarn in $\frac{2}{\quad 2}$ twill the set should be—

$$\frac{60 \times 4}{6} = 40 \text{ threads and picks per inch.}$$

Of course the practical designer would slightly vary the set in accordance with the material he was using; if rough and slackly twisted he would probably put 38 threads per inch, while if smooth, compact and hand-twisted, he might put 42—44 threads and picks per inch. He would also probably take into account the effects of finish, and, of

[1] This is a fairly accurate approximation for ordinary fabrics in which warp and weft bend equally. Note that it is only applicable in this form if count equals the diameter of the yarn.

course, the handle of the ultimate texture he hoped to produce.

Unfortunately this simple system is quite out of count, firstly, because yarn counts designate length and not diameter; and secondly, because yarn and set numbers vary in different localities.

Undoubtedly in the early days of the textile industry yarns were spun very irregularly and to unknown counts in any and every denomination. Then the idea of spinning a definite weight of wool, say 6 lbs., to a given length of yarn, so that a given length of piece could be got out of it, would impress itself upon the more thoughtful spinners. Thus the Leeds "wartern" is 6 lbs., and if the yarn was spun to 1,536 yards, or 1 yard per dram, it was called 1's count, if to 2 yards per dram, 2's count, and so on. In most localities, however, the unit of 1 lb. would be naturally adopted as the weight. Unfortunately there was not the same unanimity with reference to the length. To number 1 yard to 1 lb. 1's count, 2 yards to 1 lb. 2's count, 20 yards to 1 lb. 20's count would be out of the question, as a very thick yarn would then have 256 as its number, and a fine yarn, say, 2,560 as its number. To reduce this count number to thinkable and workable

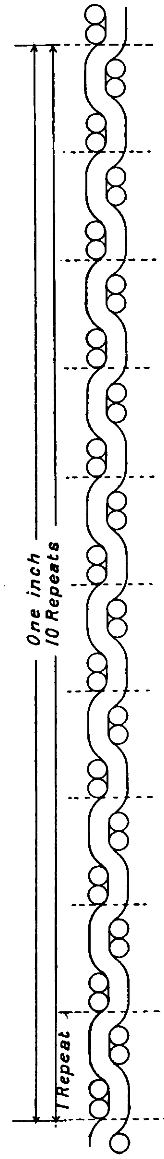

FIG. 50.—Illustrating the Setting of Fabrics.

proportions, in some cases the weight was reduced,[1] and in others the system of "hanking" was resorted to. But the localized character of the various industries unfortunately resulted in a varying weight and a varying number of yards per hank being adopted. In most count systems the hanks per lb. (avoirdupois) indicate the count. Thus 20's count equals 20 hanks per lb., 30's count equals 30 hanks per lb., and so on. But the cotton hank is

LIST IX.—VARIOUS SYSTEMS OF COUNTING YARNS.[2]

Length constant. Weight variable.

System.	Weight.	Length of Hank.	Yards per hank × count, × by gauge point = yards per lb.
Cotton	1 lb.	840 yards	× 1
Worsted	1 lb.	560 yards	× 1
Linen and Hemp	1 lb.	300 yards	× 1
Raw Silk	1 oz.	Number of yards	× 16
Dewsbury	1 oz.	Number of yards	× 16
Yorkshire Skeins Woollen	6 lbs.	1,536 yards	× ·16
Galashiels	24 oz.	300 yards	× ·66
Hawick	26 oz.	300 yards	× ·61
Stirling and Alloa	24 lbs.	Cuts Yds. 48 × 240 (Spindle)	× ·04
West of England	1 lb.	320 yards	× 1
German wool count	½ kilog.	2,200 Berlin ells	
Run (American)	1 oz.	100 yards	× 16
Cut (American)	1 lb.	300 yards	× 1
Metric	1 kilog.	1,000 metres	× ·45
French Metric	½ kilog.	1,000 metres	× ·9

[1] The Yorkshire system may be said to be based upon the yards per dram, and there is also a system based upon yards per ounce, and 1,000 yards per ounce.

[2] See Bradbury's "Calculations in Yarns and Fabrics."

840 yards;[1] the worsted, 560 yards; the linen, 300 yards; Yorkshire woollen skein, 256 yards; West of England, 420 yards; and Galashiels, 300 yards for 24 oz.; so that further complexity has thus been introduced. With the table accompanying, however, the yards per lb. in any denomination may readily be found, and from the yards per lb. any weight or diameter calculation readily worked out.

LIST IXA.—VARIOUS SYSTEMS OF COUNTING YARNS.[2]

Length constant. Weight variable.

System.	Unit of Length.	Unit of Weight.	Count.
Halifax Rural District	80 yards	Dram	Repeats of unit weight in unit length = the counts.
Jute, Heavy Flaxes and Hemp	Cuts Yds. 48 × 300 (Spindle)	lb.	
Denier System . .	Raw silk (476 metres or 520 yards)	Denier	
Dram System . .	1,000 yards	Dram	
International Denier .	500 metres	½ decigramme	
Legal Silk count appd. in Paris, 1900	450 metres	½ decigramme	
American Grain .	20 yards	Grain	

Curious to relate, the √ of the yards per lb. of any material (with a suitable allowance of from 5 to 15 per cent.)

[1] No doubt originating from a reel of a convenient circumference, with a convenient number of warps upon it.

[2] See Bradbury's "Calculations in Yarns and Fabrics."

gives the approximate working diameter of any yarn. Working backwards $diameter^2$ = the area of a square, and the area of a square varies inversely to length; therefore the diameter varies inversely as the $\surd$ of the length, and as count of yarn is in proportion to length therefore *the diameter of a yarn varies inversely as the $\surd$ of the counts* (that is denomination being the same).

This accounts for the relationship of diameter of yarn and lengths or counts, but not for the $\surd$ of the yards per lb. being the actual numerical diameter in fractions of an inch. This coincidence suggests that there is some method in the madness of the English lb., yard and inch, and that they are not merely haphazard standards. If the metric count system is adopted the $\surd$ metres per kilogram $\times$ 2·4 = the threads per decimeter, the decimeter being the most convenient unit to adopt for sets.

The most important systems of counting yarns with length constant and weight variable are given in List IXA.

In the foregoing particulars the inch is taken as the basis. Unfortunately the inch has been taken as the basis in very few manufacturing districts. The reason for this is not far to seek. Bradford, for instance, apparently based its set particulars upon the yard, Leeds upon the ¼ yard or 9 inches; Blackburn upon 1¼ yards; while possibly other districts, owing to French and Flemish immigration, based their sets upon the Flemish ell or French aune—¾ yards or 27 inches—which later possibly being converted into terms of the yard, would create further confusion.

But this is not all. It was evidently found convenient to warp with a given number of threads. In Leeds thirty-eight (termed a "porty") were employed; in Bradford forty (termed a "beer"), and so on. Thus it became customary for the set of a fabric to be defined by the number of times the threads warped with repeated in the standard width. Thus the Leeds "set" is the "porties" per quarter (9 inches)," the Bradford set the "beers per 36 inches or one yard." So little impregnated with scientific method are the textile industries even to this day that these very local standards are still in full use. Thus the man who speaks of threads per inch in Bradford or Leeds mills speaks in an unknown tongue, and is not in the least understood. Of course there is a tendency to reduce these sets to the threads per inch standard. Thus the Bradford man sometimes states the Bradford set as being based upon $1\frac{1}{9}$ threads per inch; but even he is an exception and usually there is not the slightest endeavour to make the inch the standard; in fact, there is antagonism of a somewhat violent character against any change.

The following are the principal set systems with their gauge points for finding the threads per inch (see List X., p. 212).

Some of the most difficult calculations and also some of the easiest possible calculations which the textile designer has to work out have reference to the weight per yard of the fabrics with which he deals. In the worsted coating and the woollen trade the weight per yard (usually 54 inches × 36 inches) is the basis of all dealings; in the stuff, cotton and other trades, although often stated, it is by no means so important. Now under simple conditions of yarns and set there is no difficulty in calculating the weight of a piece. The calculation simply stands—

$$\frac{\text{Yards of yarn in piece}^{1}}{\text{Yards per lb. of yarn employed}} = \text{lbs. weight of piece,}$$

$$\text{and } \frac{\text{lbs. of cloth} \times 16}{\text{length of cloth in yards}} = \text{oz. per yard.}$$

LIST X.—VARIOUS SYSTEMS OF INDICATING THE SET.

Locality and System.		Standard width in inches.	Number of Threads in one Beer, Portie, etc.	Given Set to find ends per inch.
Yorkshire	Bradford	36	40	× 1·11
	Leeds	9	38	× 4·22
	Huddersfield and U.S.A.	1	Splits per inch × ends in splits.	
	Dewsbury	90	38	× ·422
Lancashire	Bolton	24¼	40	× 1·64
	Blackburn	45	40	× ·9
	Manchester	36	2	× ·055
	Stockport	2	2	× 1
Scotch	Glasgow	37	2	× ·054
	Tweed	37	40	× 1·08
Belfast and North of Ireland	Linen Plain, etc.	40	2	× ·05
	,, Damask	30	40	× 1·33
	,, ,,	37	2	× ·054
	,, ,,	Ends per inch × reed width.		
	Silk	Width of fabric, number of ends in each split.		

There are, however, a few complications likely to arise. Yarn counts may be in two or more denominations, threads of various counts or thicknesses may be twisted together

[1] This further extended is:

$$\frac{\text{Threads per inch} \times \text{width in loom} \times \text{yards long of warp}}{\text{Warp counts} \times \text{hanks per lb.}} +$$

$$\frac{\text{Picks per inch} \times \text{width in loom} \times \text{yards long of cloth}}{\text{Weft counts} \times \text{hanks per lb.}} = \text{lbs. of cloth,}$$

to form part or the whole of either warp or weft, warp and weft may be composed of several colours, there may be differences in shrinkage and loss in weight of warp and weft during finishing, and other disturbing influences of a less pronounced type. All the foregoing influences, with one exception, are either so easy of comprehension or are necessarily so dependent upon practical conditions that no attempt need be made to deal further with them here. The exception is the twisting together of yarns of varying thicknesses. For instance, what is the "count" of a 40's cotton twisted with a 40's cotton; a 30's cotton twisted with a 40's cotton, and a 30's cotton twisted with a 60's worsted?

There are really four methods of working out such problems as these.

1st Method.—Base the calculation upon a yard of each material being twisted together.

Thus the first calculation will stand—

$$\frac{1 \text{ lb.}}{40 \times 840} + \frac{1 \text{ lb.}}{40 \times 840} = \frac{1}{16{,}800} \text{ of 1 lb.; } i.e., \text{ 1 yd.} = \frac{1}{16{,}800} \text{ of 1 lb.} \therefore \text{ 1 lb.} = 16{,}800 \text{ yards} = \frac{16{,}800}{840}$$

= 20's cotton counts.

2nd Method.—Work upon the L. C. M. of the number, take this as the length in hanks and proceed as before.

Thus the second calculation will stand—

L. C. M. of 30 and 40 = 120 hanks as length for combination.

$$\frac{120}{\frac{120}{30} + \frac{120}{40}} = \text{hanks per lb.} = \text{counts.}$$

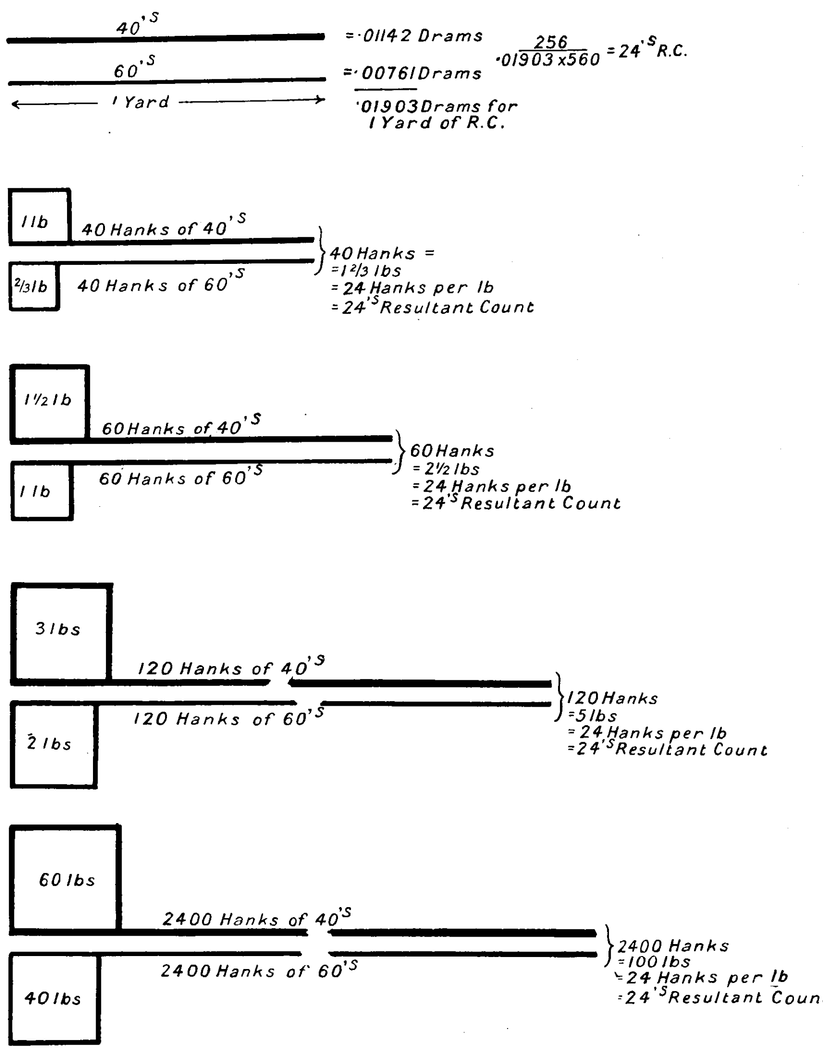

FIG. 51.—Graphic Illustration of the Resultant Counts of Twisting together two Threads of Different Counts.

This is better stated as follows—

Hanks.	lbs.
$120 \div 30 =$	4
$120 \div 40 =$	3

120 weighing 7 = 17 hanks per lb. or 17's counts.

3rd Method.—Work by means of the suitable, if somewhat large numbers, found by multiplying the two count numbers together.

Thus the third calculation will stand—

$$(60\text{'s worsted} = \frac{60 \times 2}{3} = 40\text{'s cotton}),$$

$30 \times 40 = 1{,}200$ hanks.

$$\frac{1{,}200}{\frac{1{,}200}{30} + \frac{1{,}200}{40}} = \text{hanks per lb.} = \text{counts.}$$

The second method seems so much more covenient than the other two that it is most desirable to adopt it whenever possible. Its convenience is all the more marked when the prices of the yarns are given and the price per lb. of the resultant count is required; and again when three or more yarns are to be folded together. Such calculations are so simple in the light of the foregoing that it is not considered necessary to treat them further here (see graphic illustrations).

The changing of the weights of cloths presents one or two features which are somewhat curious and should be specially noted. For instance, to make cloths lighter—(*a*) Warp may be kept the same, and a thinner weft or fewer picks per inch of the same weft may be inserted; or if the cloth is built on the square (*b*) the whole structure of the cloth may be changed and *more* threads and picks per inch may be inserted of a finer yarn. The explanation of this seemingly contradictory method is that to make a cloth lighter it must be made *thinner* (supposing that in the first place it is perfectly constructed), and to make it thinner a smaller *diameter* of yarn must be employed; and with a smaller diameter of yarn more threads per inch, in exact proportion to the decreased diameter of the yarn, must be inserted to maintain the balance of structure. Thus the cloth is lighter because more threads and picks per inch indirectly imply a thinner cloth. Similarly, to make a cloth heavier *fewer* threads and picks must be inserted (see Fig. 49, p. 205).

But these statements and facts are put in terms of the diameters of the yarns. To make it practical then—remembering that $\sqrt{}$ counts is in proportion to the diameter—the rule will be—change the $\sqrt{}$ counts of yarns inversely in proportion to the required change in weight, and change the threads per inch in proportion to the required weight change. An example will well illustrate this—

Example.—A cloth is woven of 2/32's cotton, set 60 threads and picks per inch and is required $\frac{1}{4}$ heavier.

$$\tfrac{4}{4} \text{ to become } \tfrac{5}{4}\text{; proportion} = \text{as } 4:5.$$

As $5 : 4 :: \sqrt{16} : \sqrt{x}$ and $x = 10{\cdot}24$ counts of say 2/20's.

As 5 : 4, or

As $\sqrt{16} : \sqrt{10{\cdot}24} :: 60 : x = 48$ threads and picks per inch.

Proof $$\frac{60 \times 36 \times 1 \times 5}{16 \times 840 \times 4} = \frac{48 \times 36 \times 1}{10{\cdot}24 \times 840}.$$

Another calculation of this type involves a change in weave as well as weight, but as no new principle is involved we refrain from giving it. The varieties of the foregoing calculations are unlimited, but practically all the principles involved have been touched upon; a little common sense and mathematical instinct will lead to a speedy solution of any and all.

The simplification of practical conditions to ensure speedy work may have claim to passing comment.

Example.—A dress cloth when finished contains 88 ends per inch, and 80 picks per inch, is 63 yards long, 48 inches wide, and weighs 14 ounces per yard. It has shrunk 10 per cent. in length, 12 per cent. in width, and lost $\frac{1}{7}$th of its original weight. Ascertain the threads and picks per inch in the loom, length of warp and width of piece as in the loom, weight of material in the grey, and the finished and grey counts of yarn employed.

WARP FINISHED.	WARP IN LOOM.
? Counts of yarn (worsted).	? Counts of yarn.
88 ends per inch.	? Ends per inch.
WEFT FINISHED.	WEFT IN LOOM.
? Counts of yarn.	? Counts of yarn.
80 picks per inch.	? Picks per inch.
Length of warp finished 63 yds.	Length of warp in loom, ?
Width of piece finished, 48 ins.	Width of piece in loom, ?
Weight per yd. finished, 14 oz.	Weight per yd. in loom, ?
$\frac{1}{7}$ loss of original weight.	

To clearly state the problem like this is almost to answer it. For example, the ounces per yard in the loom stands—

14 oz. + $\frac{1}{7}$ of the original weight = 14 oz. + $\frac{1}{6}$ = 16·33 oz. = per yard in loom.

Again:

As 168 (88 + 80 ends and picks per inch) : 88 :: 14 : x = 7·3 oz. of warp, and $\frac{88 \times 48 \times 1 \times 16}{7 \cdot 3 \times 560} = 16 \cdot 5$'s count (if worsted).

Should the manufacturer be engaged in the Continental or South American trade it may be very desirable that he should work in the Metric System. All the foregoing principles may be readily applied in the Metric System by conversion, or, better still, directly by means of the following particulars:—

Worsted counts	÷ ·885	= Metric counts.
Metric counts	× ·885	= Worsted counts.
Cotton counts	÷ ·59	= Metric counts.
Metric counts	× ·59	= Cotton counts.
Yorkshire skeins	÷ 1·939	= Metric counts.
Metric counts	× 1·939	= Yorkshire skeins.
In dram silk 515	÷ counts	= Metric counts.
515 ÷ Metric counts		= Dram silk counts.

Threads or picks per inch × 3·9 = threads or picks per decimeter.

Threads or picks per decimeter ÷ 3·9 = threads or picks per inch.

Bradford set × 4·33 = threads per decimeter.

Threads per decimeter ÷ 4·33 = Bradford set.

Rule to find the threads per decimeter (*i.e.*, fraction of a decimeter occupied) for any metric counts of yarn:

$\sqrt{\text{Metres per kilogram}} \times 2{\cdot}3$ for woollen yarns.[1]

" " " $\times 2{\cdot}4$ for worsted yarns.

" " " $\times 2{\cdot}5$ for cotton yarns.

Rule to find the threads per decimeter for any ordinary weave:

$$\frac{\text{Diameter of yarn in decimeters} \times \text{Thread in repeat of weave}}{\text{Threads} + \text{Intersections in weave.}}$$

$$= \text{Threads per decimeter.}$$

Example:—Find the threads per decimeter for 2/18's cross-bred yarn employing $\frac{2}{\quad 2}$ twill.

$\sqrt{9 \times 1{,}000} \times 2{\cdot}4 = 233$ and

$$\frac{233 \times 4}{6} = 155 \text{ threads per decimeter.}$$

Spinning and Weaving Calculations.—In preparing, combing, and spinning, calculations referring to both the machines employed and the materials passing through these machines frequently occur. The mechanical calculations involved cannot be entered into here. Nearly all spinning calculations involve the principle of drivers and driven, and most weaving calculations involve the principles of leverage, but the application of these simple principles are so varied that no satisfactory treatment of them could be given in the space at our disposal.[2]

The calculations referring to weights of slivers in drawing

[1] The slight differences here are allowances for the relative bulkiness of the materials of which the respective yarns are composed.

[2] See the "Wool Year Book," "Woollen and Worsted Spinning," etc.

and spinning, however, should at least claim passing comment. The ultimate end of spinning is, as we have seen, to produce a strand or thread of a certain count, *i.e.*, of a certain number of yards per pound (this is the simplest denomination). Now, working backwards one would expect the slivers always to be stated and calculated in yards per lb., and if it were so there would be many simplifications of drawing and spinning calculations. But in practice it is found more convenient to reel for fairly fine slivers 40 or 80 yards, and for thick slivers 10 yards. Thus English tops are placed on the market 7 ozs. per 10 yards. Botany tops are placed on the market 4 to 5 ozs. per 10 yards. An English top (say 40's quality) is usually made up in a ball about 230 yards long and weighing about 10 lbs. A Botany top (say 60's quality) is usually made up in a ball about 144 yards long, weighing about 5 lbs. Irrespective of these perhaps unnecessary difficulties drafting calculations are comparatively simple, as a sliver loses in weight exactly in proportion to its extension or draft, and necessarily increases in weight in proportion to the doublings. Thus if 40 yards of a "top" weigh 240 drams, then with drafts 5, 6, 8, 8, 6, 9, 9 and doublings 6, 6, 4, 4, 3, 3, 2, 40 yards roving will weigh

$$\frac{240 \times 6 \times 6 \times 4 \times 4 \times 3 \times 3 \times 2}{5 \times 6 \times 8 \times 8 \times 6 \times 9 \times 9} = 2\tfrac{2}{3} \text{ drams.}$$ [1]

In calculating the drafts necessary to give a total draft a difficulty may occur owing to drafts multipling themselves. Consequently if, say, a total draft of 10,368 is required in seven operations, then logarithms or the slide rule must be

[1] See Buckley's "Worsted Overlookers' Hand-book," and "Woollen and Worsted Spinning," by Barker and Priestley.

resorted to, the $\sqrt{}$ of the total draft being the average draft which may now be varied slightly to suit particular operations. Thus a top weighing 280 drams per 40 yards has to be reduced to 7 drams per 40 yards, at seven operations, the doubling being 6, 6, 4, 4, 3, 3, 2.

$280 \div 7 = 40$ and log. of 40 =	1·602 [1]
log. of 6 =	0·778
,, ,, 6 =	0·778
,, ,, 4 =	0·602
,, ,, 4 =	0·602
,, ,, 3 =	0·477
,, ,, 3 =	0·477
,, ,, 2 =	0·301
	7)5·617
	·802, log. of.

Answer, = 6·3 draft required.

Another calculation often misunderstood is the following: —To find the number of spindles in any part of the drawing or on the spinning frame, to follow any box of the drawing. If the question involved is simply between two boxes, say A and B, immediately following one another, then the weight taken by one spindle head on B divided into the weight given out by all spindle heads on A will be the answer. But should the frames in question be separated by other frames, for example, should the spinning spindles to follow the four-spindle drawing-box be required, then, although the same principle of weight $\div$ weight obtains, in addition the relative thickness, or, in other words, lengths of the respective slivers must be taken into account.

Example:—A drawing-box A with 4-inch front rollers

[1] Log of draft required if there were no doublings.

making 60 revolutions per minute delivers 240 drams per minute. What number of spinning heads B will be required if the diameter of the back rollers is $1\frac{1}{2}$ inches, making 5 revolutions per minute and taking in 8 drams per minute?

If A delivers the same length that B consumes, then

240 inches = 240 drams per minute from A,

$240 \div 8 = 30$ heads or spindles on box B to follow box A.

But B only takes in $7\frac{1}{2}$ inches relative to A giving out 240 inches, so that

$240 \div 7\frac{1}{2} = 32$ times length of B is required to consume length delivered by A.

Thus the total heads or spindles on B to follow A will be compounded of the weight difference and the length difference—

$$30 \times 32 = 960 \text{ spindles.}$$

It will be evident from the foregoing that many most interesting calculations occur in the textile industries. The points involved in these calculations are ordinary mathematical, geometrical, and trigometrical principles, and special principles and variations involved by the conditions obtaining in the industry. Many of the calculations could be materially shortened by the adoption of either the standard inch and pound or the metre and the gramme.

The chief point which stands out, however, is the need for some universally intelligible system. If we in this country are not prepared to adopt our own standard of the inch and yard and the pound of 16 ozs., we must be prepared for the metric agitators to prevail—our weakness will be their strength.

CHAPTER XI

THE WOOLLEN INDUSTRY

THE Wool Industry may be divided into four main classes, viz., the Woollen Industry, the Worsted Industry, the Stuff or Dress Goods and Lining Industry, and the Upholstery or Tapestry Industry. Each of these has several subdivisions : thus the woollen industry may be considered to include the felt industry, the blanket industry, and in part the hosiery trade ; the worsted industry includes also a section of the hosiery trade, and in part the braid trade ; while the stuff or dress goods and lining industry includes many varieties almost attaining to distinct classes. The fourth class includes all pile fabrics of an upholstery type, and carpets and tapestry fabrics of a complex character.

The word "woollen" originally referred to fabrics made of the best Continental wool spun on the spindle-draft system, simply woven, felted, and often highly finished. The old "doeskin" was a typical example of the woollen cloth, and the care and skill required for its production may be gauged by the fact that it frequently took six weeks to finish, and sold up to 30*s*. a yard broad width. The present-day army officers' cloths may also be taken as typical of what was understood by the term woollen "in the olden days." It also seems probable that cotton cloths made from yarn spun upon the spindle-draft system and woven into more or less soft fabrics were sold as woollens. About the year 1813 the re-manufactured materials made their appearance, and very quickly "catching on" became incorporated into the woollen trade, so that to-day the legal definition of a woollen yarn may be taken—as a yarn composed of fibres of any class of materials which may be said to possess two ends, which just possesses the strength necessary to allow the shuttle to lay it in the shed. To-day woollen cloths partake too much of these last named characteristics. Verily our grandfathers would have wept aloud could they have foreseen the degradation which was to overtake their trade and calling. For they were proud of their goods and of their good name for honest dealing. It must not be supposed, however, that the introduction of the re-manufactured materials is entirely a retrograde step. It is surprising what sound goods the Dewsbury and Batley manufacturers can make from low-class raw materials, and we must not forget that thousands of the poorer classes are well clothed by this means who otherwise would have to go very meanly clad indeed. It is the passing of re-manufactured materials as pure wool which must be condemned.

The better class woollen trade is located in the West of England, Huddersfield, Scotland, and Ireland. In the latter country it is not concentrated, but rather distributed.

The medium class woollen trade is largely located in the Leeds district with branches westward into the dales of Yorkshire.

The low class woollen trade is located in the Dewsbury, Batley, and Colne Valley district. The Continental woollen trade is very dispersed. In France, Elbeuf and certain small towns like Sedan in the north are the principal centres. In Germany M.-Gladbach, Cottbus, Forst and Werdau are the main centres for cheap goods for men's wear. Verviers, in Belgium, is the centre of a large woollen spinning district, the yarns produced being shipped to England by the ton. In the north of Italy and in Spain woollen and worsted manufacture is developing, while Austria has a textile industry all too little known and appreciated in this country.

The woollen centre in the United States of America is in the New England States, Philadelphia being the chief city involved.

The supplies of material for these branches of the woollen trade are derived as follows:—For the fine trade Australian, Cape, South American, and Continental fine wools and some few fine cross-breds and English wools are employed; for the medium trade coarser Australian, New Zealand, etc., cross-breds with slipe and skin wool, noils, etc.; and for the low trade shoddy, extract, mungo, etc., scribbled with cotton sweepings, etc., to hold the blend together, are largely employed.

The woollen firm is usually self-contained, *i.e.*, it takes in the raw material and delivers the finished cloth, and also often merchants it. There are a few spinners of woollen yarn who do not weave and finish, and the "Rag Grinders" or "Mungo and Shoddy Dealers" of Dewsbury, Batley, and Ossett, form a distinct class to themselves; but these are the exception, not the rule. Thus a woollen mill will, as a rule, include the following machines or sets of machines:—

Scouring Machines.

Drying Machines.

Willows
Fearnaughts } Placed in the Blending-room.

Scribblers
Intermediates
Condensers } Forming sets of machines to prepare for a given number of spindles.

Mules—pitch and number of spindles to follow cards.
Ring Twisters.
Warping, Dressing, Sizing and Drying Mills, and Machines.
Looms to follow the spinning.
Soaping Machines.
Dollies.
Hydro-Extractor.
Milling Machines.
Stocks.
Crabbing Machines.
Steam-Blowing Machines.
Tentering Machines.
Raising and Brushing Machines.
Cropping Machines.
Presses.

Few mills possess complete sets of scouring bowls—say four or five bowls to the set—as the materials they employ are of such a varied character and comparatively so small in bulk that it pays better to buy bulk lots scoured and to keep a single machine for dealing with the greasy lots. For the same reason the space over the boilers is usually plated as a drying house, although of course the best firms employ drying machines of an approved type, which yield the wool up in a nicely open and dried condition.

The willow is a very rough strong kind of card, which practically tears up and dusts the material, a fan and chimney being connected with it. The fearnaught is a nearer approach to the card, still more finely working the wool and ejecting it as a rule by means of an air blast.

Materials to be blended together are first passed through these machines, then built into a stack, layer by layer, and oiled at the same time, then beaten down with sticks and again passed through the fearnaught. The blend is then allowed to mellow before being passed on to the carding-room. The scribbler card to which the material is subjected opens it out lightly, the intermediate card treats it more severely, while the condensing card ensures a regular film of wool and then divides this film up into a number—say 120 films in 72 inches—of small slivers—count according to count to be ultimately spun to—which are wound on to the condensing bobbin ready for being passed on to the mule. On the mule these condensed slivers are at one operation drafted out to the counts required and twisted, or, if this would be too severe, they are first roved and then finally spun to the required counts. The following particulars respecting the relationships of the cards and mule spindles are useful and interesting (see p. 228).

The operation following spinning and twisting is warping if the yarn is intended for warp. If the yarn is intended for weft it will have been spun directly on to spools fitting the power-loom shuttles ; if for warp, on to cops holding a large quantity, and, if possible, a definite length of yarn to avoid waste in "bits." Warping is best effected on the Scotch warping mill, although the cheese system has by no means fallen into disuse. Upon whatever system the warp

Sets of Woollen Machinery for—

Coarse Work.	*Fine Work.*
Scouring.	Scouring.
Drying	Drying
(Carbonizing).	(Carbonizing).
1 Willow.	1 Willow.
1 Fearnaught.	1 Fearnaught.
Blending Process :—	Blending Process :—
1 treble scribbler—breast and 3 swift, Scotch intermediate feed.	1 double scribbler—breast and 2 swifts.
1 double carding engine—breast and 2 swifts, double-doffer condenser.	1 intermediate—breast and 1 swift, creel intermediate feed.
1 mule of 400 spindles.	1 double carding engine—breast and 2 swifts, tape condenser.
1 ring-twisting frame of 100 spindles.	2 mules, 600 spindles each.
	1 ring-twisting frame of 200 spindles.

is made a regular tension should be placed upon all the threads; if of a coloured pattern, they must be in their correct order; the right length should be accurately obtained, and the correct width for dressing on to the loom beam. Sizing follows, the idea here being to add a certain amount of strength to the yarn and to glue down the strong fibres and so ensure clear weaving conditions. Dressing and twisting follow, and then the warp is mounted in the loom. The favourite loom among woollen manufacturers now is the Dobcross, running at from 80 to 105 picks per minute. Several other firms also make woollen looms of an approved description. It is here interesting to note that in the woollen loom speed does not necessarily mean production, for woollen warps are frequently so tender that running at 80 picks per minute produces more cloth than running at 105 picks per minute. Of course for the cotton warps largely used in the low woollen and flannel trades much quicker looms may be employed, 110 to 120 picks per minute being frequently attained.

As the woollen fabric leaves the loom it is unsightly, rough, and uncouth. But finishing changes all this. Scouring clears off the size, and, if skilfully done, also clears and develops the colours. Milling bursts the thread and gives a full-looking texture; tentering levels the piece, taking out all creases; crabbing fixes and gives lustre to the piece; raising brings a pile on to the surface; cropping levels it; steaming fixes; and wet-raising, boiling, etc., give a finely-developed permanent lustre.

The following example illustrates how all the processes in woollen manufacture must be applied with a definite idea of attaining a particular type of finished fabric:—A Melton cloth is required in which the finished fabric shows little or no trace of threadiness, but is of a felt-like appearance. To begin with, a good, fairly short, felting wool is required; this should be worked with as little drafting as possible, *i.e.*, condensed fine and spun without roving. The warp and weft yarns should be spun with inverse amounts of twist-in and in the same direction, say, open-band. The twill of the weave, should a twill be employed, should run with the twine of the yarn, so that warp and weft "bed" into one another as much as possible. The fabric must not be too closely set, as the fibres must be given room to take a "finish." The thread structure must be cleared in the scouring, broken in the stocks, and consolidated in the milling machine. The surface fibres must be raised up by dry-raising and closely cropped off to leave a bare clear surface without pile. Should stiffening be necessary, this may be effected by washing off the soaped

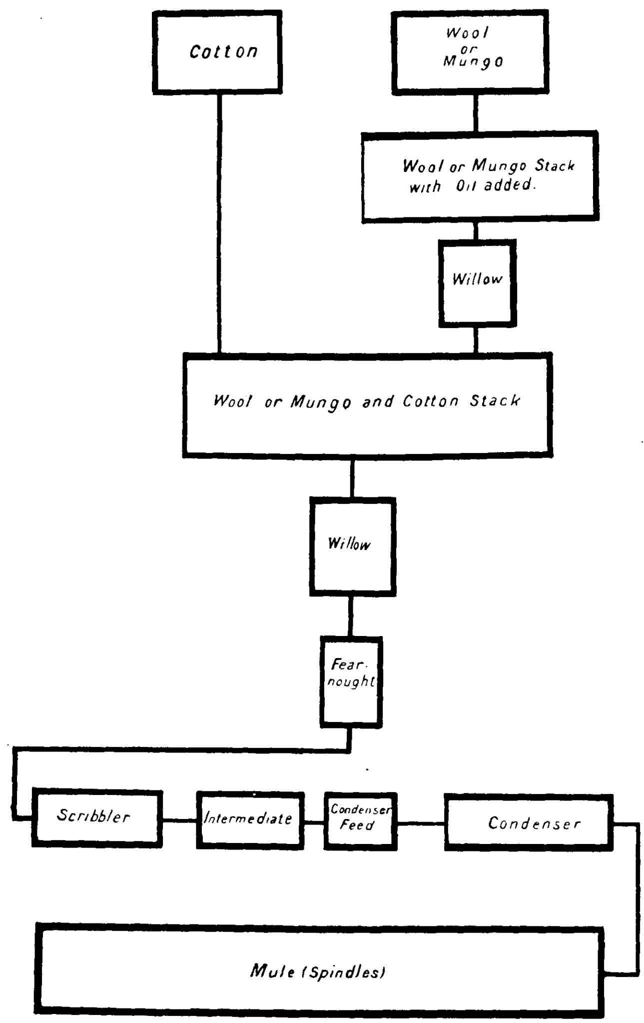

FIG. 52.—Graphic Illustration of the Order of Processes in Woollen Manufacture.

piece with hard water or by adding the necessary stiffening agents. Needless to say, the better piece will be that which requires no stiffening agent. Should the fabric come out of the press too highly glazed, it should be re-steamed to give it the requisite clear but somewhat opaque Melton finish.

Every distinct style of woollen fabric requires special attention in the finishing, as it is the finishing operations which make or mar the piece. A worsted cloth is largely made in the loom, but a woollen cloth is really made in the finishing.

Woollen manufacturers largely merchant their own goods, as distinct from the stuff manufacturers, for example, who cater for the wholesale merchant houses. This is perhaps due to the fact that the woollen trade is largely a home trade, the manufacturing of woollen cloths—no doubt owing to its comparative simplicity—being spread over the world. Japan, for instance, already spins, weaves, and finishes woollens, but buys largely worsted tops and yarns.

In Fig. 52 the relationships of the various processes in woollen manufacturing, one to the other, are shown.

CHAPTER XII

THE WORSTED INDUSTRY

THE worsted industry may be said to have risen with the growth and introduction of colonial wools into England. It may be true that its very name carries us back to an industry located in the village of Worsted, in Norfolk, but it is more than probable that did we enquire into this primitive industry we should find that it was principally based upon the production of fabrics which here will be treated under the heading of "Stuffs." For our present purpose, however, it will be convenient to include in this chapter all combed wool yarns and fabrics made entirely of such yarns, along with possibly a few exceptions in the shape of fabrics made of, say, worsted warp and woollen weft. If this is the division adopted, then it is necessary to point out that there are really two distinct branches of the industry—with, of course, many grades in between. Long wools (mostly English) have been combed and made into what are still known to our women-folk as worsted yarns from time immemorial. St. Blaize, a bishop of the fourth century, was the patron saint of the wool-combers, and for how long the industry had been established before his time it is difficult to say. We are fairly safe in assuming that prior to about 1830 worsted or combed yarns were made from long wool of a somewhat coarse and harsh character, and that the modern "Botany yarn" was unknown. Prior to 1830 fine Continental wools would no doubt be placed on the market as hosiery yarns, but they would be spun on the woollen principle, and were no doubt synonymous with what are to-day termed "merino" yarns. From 1830 onwards the longer colonial merino wools were combed by hand, and about 1840 Lister (Lord Masham) first attempted the combing of short English wools (Southdown), and later of colonial wools, by mechanical means. Prior to this, attempts had been made to comb wool mechanically, but inventors were more concerned with the production of any mechanism which would comb wool, so that we are fairly safe in assuming that the combing attempted was with long wool. Curious to relate, Lister soon abandoned his attempt to comb short wool, becoming more interested in his "nip" comb, which was more suited to the long varieties of wool, leaving the field clear for the Holdens so far as this country was concerned, and Heilmann and the Holdens so far as the Continent was concerned. Thus, from 1850 onwards there has been a steady advance in the capabilities of the machine comb, until to-day the Heilmann and Noble combs will comb wools of, say, 2 inches, which even a few years ago would have been put on one side as being only suitable for clothing purposes. The genesis of the wool comb is illustrated graphically in List I. Every stage therein forms a romance of industry.

It was about the year 1879 that the fine woollen trade was "hit" by the introduction of fine wool "worsteds." Woollen manufacturers, who a few years previously had reckoned their profits in thousands or tens of thousands, either had to change on to the new style of machinery or had to close down. The fine black cloth—the standard clothing of the middle and upper classes—almost became a thing of the past. Thus it came about that the worsted industry, instead of being almost wholly concerned in the rougher sorts of wools, became more and more concerned in the finer wools, so that to-day it is impossible to say whether the prepared, combed, and drawn long wool yarns or the carded, combed, and drawn short wool yarns form the bulk of the trade. But during the past ten years, again owing to the large supply of a suitable medium wool —neither long nor short—what is known as the cross-bred trade has arisen. Cross-bred wools are usually carded, combed, and drawn, but the yarns produced cannot be compared to Botany yarns for softness and delicacy. To-day, owing to the tendency to produce a big carcass sheep, these wools form the bulk sorts of New Zealand and the coastal districts of Australia and South America, and the yarn and cloth trade in these wools is proportionately large.

The worsted "top and yarn" trade is located in Bradford and district, but some few and not unimportant firms are outside this district. Worsted yarns of the fine, cross-bred and long wool type are woven, dyed, and finished in various parts of the country, each district, as it were, making a speciality of a certain style. Thus Huddersfield leads the world in the finest worsteds for men's wear; Bradford and Halifax are pre-eminent for the cheap production of plain style worsteds for both men's and women's wear; and Scotland now consumes large quantities of cross-bred and Botany yarns, which are made into Scotch tweeds and other fancy worsted styles, mostly for men's wear. The corresponding Continental centres are Elbeuf and Aachen. Of course, the correspondence is not exact. Thus, while Elberfeld makes linings similar to Bradford, no combing and spinning of moment is to be found there, and so on. Philadelphia and Jamestown are the corresponding United States centres.

The worsted trade, as distinct from the woollen trade, is organized into several distinct divisions. It is true that in certain parts of the country there are firms who buy wool direct, or at the London sales, scour, comb, spin, weave, and finish it. But these firms are the exceptions, the trade as a whole being organized as follows:—

1. **The Wool Buyers.**—This branch of the trade originally bought the wool from up and down the country or in London and resold it to the combers. Of late years, however, there has been a tendency to combine this trade with the combing.

2. **The Combers.**—This branch takes the raw material, scours it, prepares or cards, combs it, and places it on the market in the "top" form.

3. **The Spinners.**—This branch deals with the "tops" as delivered from the combers, converting them by means of drawing and spinning processes into yarns.

4. **The Warpers and Sizers.**—This branch deals with the warping and sizing of the spinning yarns prior to weaving. Thus, warpers and sizers frequently keep standard qualities of their spinners' yarns, and warp, size, and dress on to the manufacturers' loom beam to order.

5. **The Manufacturers.**—This branch weaves into the required fabrics the yarns, etc., supplied by the spinner or the warper and sizer.

6. **The Dyers and Finishers.**—This branch, now largely

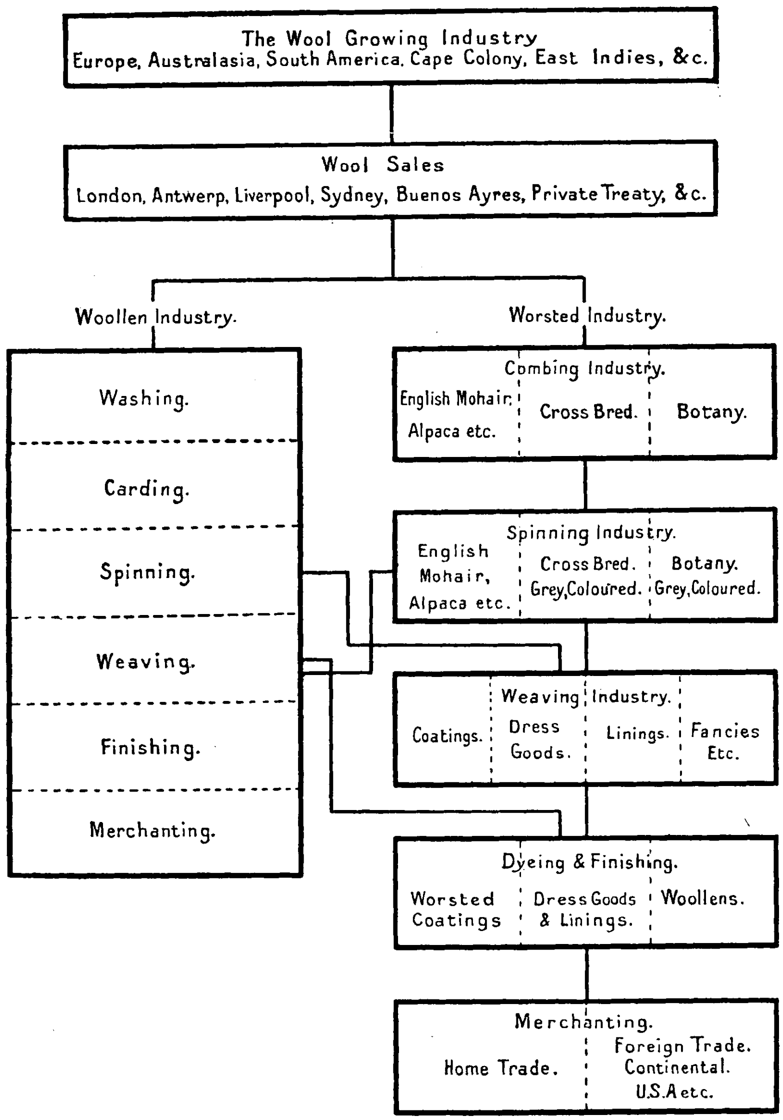

FIG. 53A.—Graphic Illustration of Woollen and Worsted Industries.

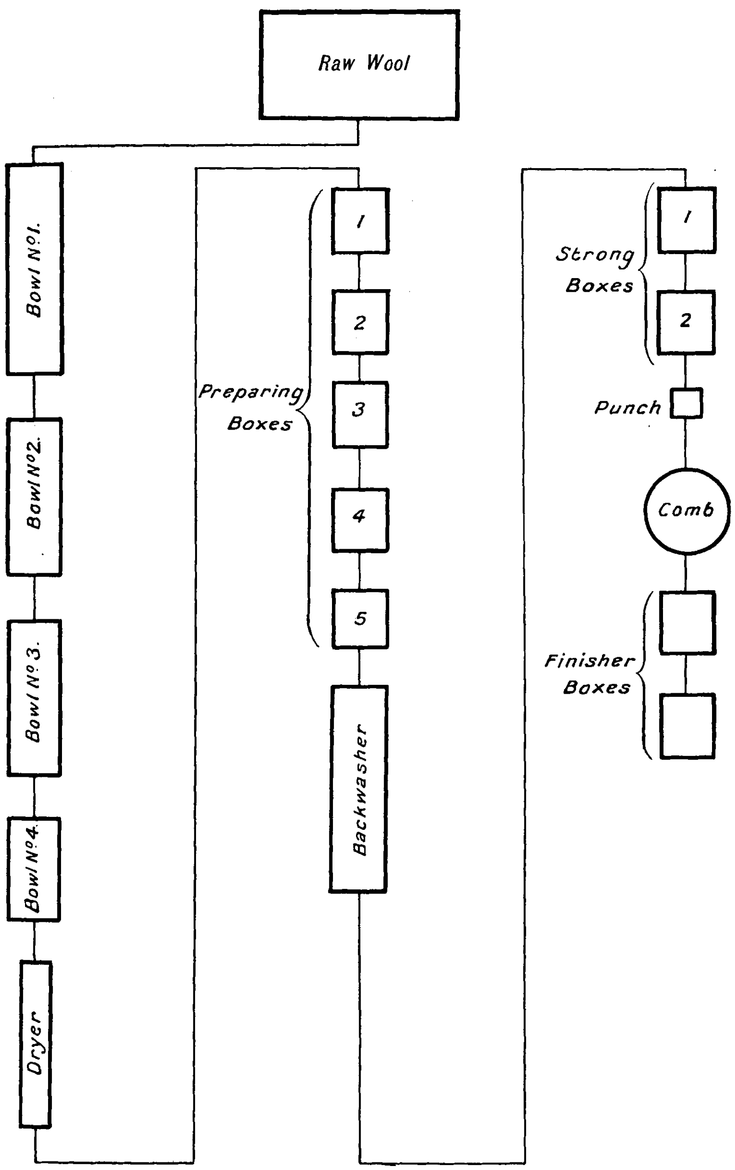

FIG. 53B.—Graphic Illustration of Combing Processes for Long Wool.

organized as a combination under the title of the Bradford Dyers' Association,[1] scours, dyes, and finishes the immense variety of goods forwarded to its various branch works, each of these latter being specialized to deal with particular styles of goods.

7. The Merchants.—The large wholesale houses in Bradford at one time almost controlled—and certainly developed—the Bradford trade. To-day there is manifested a tendency for manufacturing concerns to merchant their own goods, but notwithstanding this the merchanting trade of Bradford is in a very healthy condition.

There are several minor branches of the trade in addition to the foregoing main divisions. Thus there are combmakers, spindle-makers, loom-makers, and the designers and card-cutters.

Sets of Machines from Wool to the Yarn.

Botany.	*English.*
1 Willow.	1 Willow.
1 Four-bowl Scouring Set.	1 Three or four-bowl Scouring Set.
12 Cards.	1 Dryer.
1 Backwasher.	1 Set of six Preparing-boxes.
12 Sets of two Strong boxes.	6 Nip Combs.
12 Noble Combs.	3 Sets of two finishers.
12 Sets of two finishers.	(Backwashing to be added if required.)
About twelve Sets of Botany drawing would be required to follow this, which partly explains why the Combing and Drawing are organized as separate industries.	About six Sets of English Drawing will be required to follow this.

It is not possible to give details of all the machinery employed in the industry, but the above indicated sets

[1] A few not unimportant dyeing and finishing firms are not in this combine.

of machinery for English cross-bred and Botany yarn production, in conjunction with the information given in previous chapters on preparing, spinning, etc., will enable a comprehensive grasp of the subject to be obtained.

In the worsted and woollen industries the type of work is so miscellaneous that weaving machinery is rarely supplied in sets. In the cotton industry, however, sets are most carefully calculated for specific types of fabrics.

Worsted looms may be run much quicker than woollen looms, an additional speed of at least 20 per cent. often being possible. As a rule, a greater shedding or boxing, or both shedding and boxing, capacity, is required in the worsted loom as compared with the woollen loom, as worsted goods are made in the loom, and not in the finishing, as are woollen goods. Extreme fancy woollens, however, are as difficult and complex in the making as fancy worsteds.

The fabrics produced in the worsted trade may usually be classed under the heading of Botanies, cross-breds, or English. The plainer styles in all qualities are woven in $\frac{2}{2}$, $\frac{3}{3}$, $\frac{4}{4}$ twills and other standard weaves. For women's wear, when fashion is favourable, large numbers of jacquard figured styles are produced, while for men's wear backed and double cloths and very complex schemes of interlacing and colouring are regularly to be met with. Special note should be made of the colouring, as the organization of the Botany coloured yarn trade of Bradford and Huddersfield is unequalled elsewhere in the world, unless it be in the Lyons silk trade.

The finishing of worsted goods has been defined in the

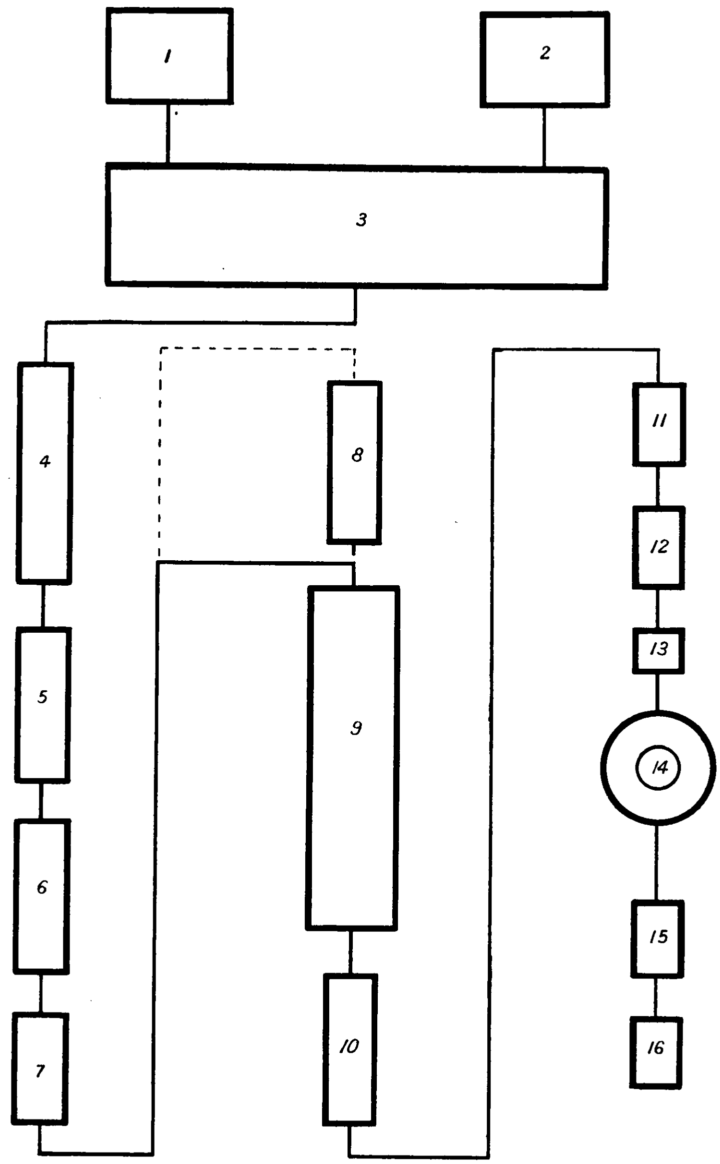

FIG. 53c.—Graphic Illustration of the Combing Processes for Short Wool.—1 and 2, wools to be treated; 3, blend of wools (1) and (2); 4, 5, 6 and 7, washing bowls; 8, dryer (not always used); 9, carder; 10, backwasher; 11 and 12, strong boxes; 13, punch for balling slivers for comb; 14, Noble comb; 15, 1st finisher; 16, 2nd finisher. *Note.*—The balance of machines is not here preserved; thus one set of scouring would keep perhaps twelve combs running (see p. 238).

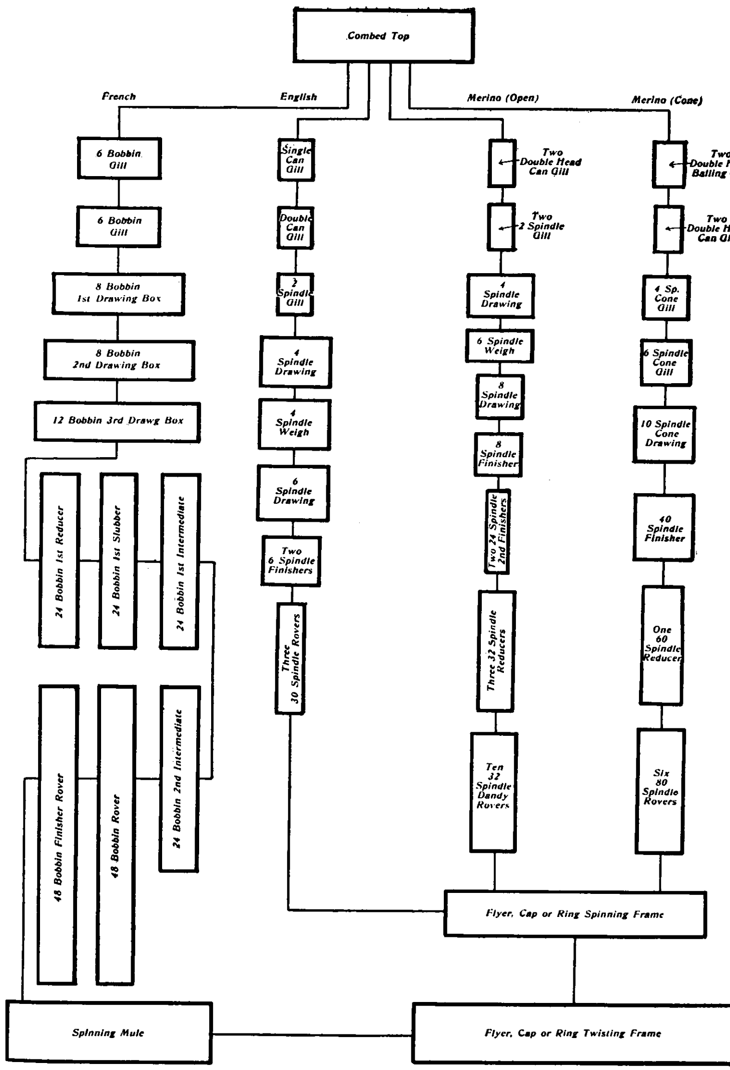

FIG. 53D.—Graphic Illustration of the Drawing and Spinning Processes on the French, English, Merino (Open), and Merino (Cone) Systems.

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chapter on "Finishing." Note should be made, however, of the fact that there are to-day many "worsted finishes." Time was when worsted coatings invariably wore "greasy." Such is not the case to-day—at least, not if the finisher has done his work well. Again, worsteds may be produced soft or crisp at will by maintaining satisfactory conditions. Thus, just as in the case of the woollen cloth, the final product is decided by the primary selection of the raw material, by the way in which that material is prepared and spun, by the way in which the fabric is constructed and woven, and finally by the finishing. It is not one but all these factors which must be considered carefully if characteristic worsted cloths are to be produced.

The merchanting branch of the trade may be conveniently divided into the "home trade" and the "shipping trade." Owing to this division and to the variety of textiles produced, it is questionable whether Bradford should be considered a city of one trade. It is further questionable whether the total trade fluctuation is greater than in a city of recognized diversified trades, such as is Leeds.

The following tables, taken from Mr. F. Hooper's "Statistics of the Worsted and Woollen Trades," convey useful information respecting the "top," yarn, cloth, and dress-stuff trades.

List XI.—Exports of Wool-Waste, Noils, and Tops.

Year.	Total.	
	lbs.	£
1890	21,648,300	1,390,065
1895	31,508,600	1,738,270
1900	37,521,700	2,125,939
1905	58,806,900	3,797,401
1907	57,438,600	4,380,411
1908	55,206,100	3,523,000

List XII.—Exports of Combed or Carded Wool and Tops.

Chief Countries. *To*	1905.		1906.		1907.	
	lbs.	£	lbs.	£	lbs.	£
Russia	1,380,700	100,122	2,400,000	194,834	2,766,600	231,071
Sweden	4,229,400	301,727	4,650,200	366,161	4,806,200	389,818
Germany	15,189,100	1,033,173	16,605,300	1,265,795	13,808,600	1,090,585
Belgium	1,668,500	107,976	1,736,600	139,034	2,322,600	179,421
Spain	1,130,000	93,025	1,347,300	119,161	1,172,600	106,128
Italy	5,189,700	353,016	5,620,900	430,787	4,459,000	364,118
Japan	2,186,000	232,190	2,127,700	257,077	2,253,400	267,511
Total Exports	35,386,300	2,529,395	38,648,600	3,095,664	35,811,300	2,962,893

List XIII.—Woollen and Worsted Yarns.

Year.	Imports.		Exports.	
	Weight in lbs.	Value in £	Weight in lbs.	Value in £
1860	3,007,711	472,363	27,821,378[1]	3,852,998[1]
1865	4,392,090	998,784	31,671,254	5,429,504
1870	10,294,415	1,635,154	36,605,076	5,182,926
1875	12,428,142	1,472,936	36,523,627	6,065,911
1880	14,947,679	1,842,135	33,464,300	4,222,693
1885	15,888,078	1,995,801	55,684,900	5,580,669
1890	16,379,985	1,935,061	54,042,400	5,260,925
1895	19,597,211	2,042,887	78,813,500	7,258,968
1900	20,525,494	2,163,873	72,568,000	6,123,349
1905	28,274,834	2,697,298	70,707,400	6,173,241
1907	27,075,880	2,684,779	82,702,600	8,569,682
1908	22,495,655	2,302,940	71,303,600	6,616,952

[1] Is for 1862, not 1860.

List XIV.—Manufactures of Wool.

Year.	Imports. Value in £	Exports.[1] Value in £
1860	1,673,197	16,847,956
1865	1,910,758	26,669,636
1870	3,096,257	27,664,051
1875	4,134,213	29,081,836
1880	7,079,848	23,934,541
1885	6,868,837	26,571,537
1890	7,938,918	29,175,989
1895	10,183,586	30,594,568
1900	8,504,782	25,946,037
1905	8,697,121	32,239,922
1907	7,007,775	38,121,270
1908	6,129,099	31,804,445

[1] In this column flocks, shoddy, wools, and waste are included.

List XV.—Imports of Wool Dress-stuffs.

Country.	1905.		1906.		1907.	
	Yards.	£	Yards.	£	Yards.	£
From						
France	77,147,636	5,481,166	76,804,595	5,369,811	60,019,751	4,319,932
Germany	5,572,278	400,186	6,160,626	392,767	5,245,820	430,905
Holland	2,518,659	237,848	2,814,818	267,326	2,970,491	291,861
Belgium	5,026,858	549,482	5,240,970	557,370	6,140,638	608,424
Other Countries	10,549	553	14,361	1,134	13,835	1,317
	90,275,980	6,669,235	91,035,370	6,588,408	74,390,535	5,652,439
Less Re-exports	11,957,942	637,838	10,371,554	570,749	10,216,434	606,143
Net Imports	78,318,038	6,031,397	80,663,816	6,017,659	64,174,101	5,046,296

List XVI.—Imports of Wool Cloths.

Country.	1905.		1906.		1907.	
	Yards.	£	Yards.	£	Yards.	£
From						
Germany . .	1,019,749	155,001	771,668	126,195	520,425	89,236
Holland . .	2,623,690	398,825	2,800,665	386,490	2,290,203	295,860
Belgium . .	362,463	50,564	233,163	35,927	227,138	34,457
France . .	52,143	4,769	37,793	3,156	174,018	20,124
Other Countries	49,103	3,180	46,275	4,245	35,418	3,588
	4,107,148	612,339	3,889,564	556,013	3,247,202	443,265
Less Re-exports	283,434	50,009	329,990	60,486	452,744	71,984
Net Imports .	3,823,714	562,320	3,559,574	495,527	2,794,458	371,281

CHAPTER XIII

THE DRESS GOODS, STUFF, AND LININGS INDUSTRY

It is probable that from the earliest days dress goods and fabrics generally destined for women's wear have been very diversified in material, texture, and design. Tapestries might be more elaborate in design and richer in texture, but certainly not so varied in style. It is probable that for centuries wool textures have occupied a leading position for women's ordinary wear. Coarse woollens of the "winsey" type were no doubt manufactured in bulk for the lower classes; somewhat finer fabrics of the serge type would be the bulk sorts for the better classes along with cashmeres; while the upper classes would more largely patronize silks. Linen was of course largely used as an under-wear, and it is more than probable that, prior to the introduction of the cotton frock, linen fabrics would be used for a similar purpose. Our Eastern trade, dating from the seventeenth century resulted in the introduction of fine cotton goods in the shape of muslins, etc.; but it was quite late in the day before we were able to manufacture these and produce somewhat similar styles in wool under the name of "mousseline-de-laine." It is thus quite easy to understand how the Dress Goods trade of to-day has come to be so comprehensive in its employment of nearly every textile fibre and every possible combination of the same.

Prior to about 1837 all wool (woollen or worsted), all silk, all linen, and some few wool, silk, and linen combinations, were the standard styles. With the introduction of cotton warps about this time the possibilities of the combination of various materials was more fully realized, resulting in what is known as the "Stuff Trade." Thus cashmere cloths, which, prior to this period, had been made from wool warp and wool weft, were made with cotton warp and wool weft; the Italian cloth, again a cotton warp and wool weft style, was introduced or re-developed; the use of mohair in conjunction with cotton was exploited, resulting in the discovery of a whole range of fabrics variously spoken of as Sicilians, Brilliantines, Orleans, etc.; and a little later Sir Titus Salt placed his far-famed Alpaca styles upon the market. Thirty years later, and the mercerizing of cotton again upset the commercial equilibrium of Bradford. Mercerized goods in a pure form have partially taken the place of the ordinary botany weft Italian, and in their varieties in the shape of lustred (Schreinered) goods and blistered or crepon styles have made a lasting impression upon the fancy dress goods trade.

Largely owing to being first in the field, and to very successful spinning, Bradford has well maintained its lead in such dress goods as involve the employment of English wools, mohair, alpaca, etc., these being termed hard goods as distinct from the soft Botany styles. With these latter styles the French always seem to have been the most successful, simply because of the style of spinning adopted. Bradford early adopted the Danforth spindle or cap frame,

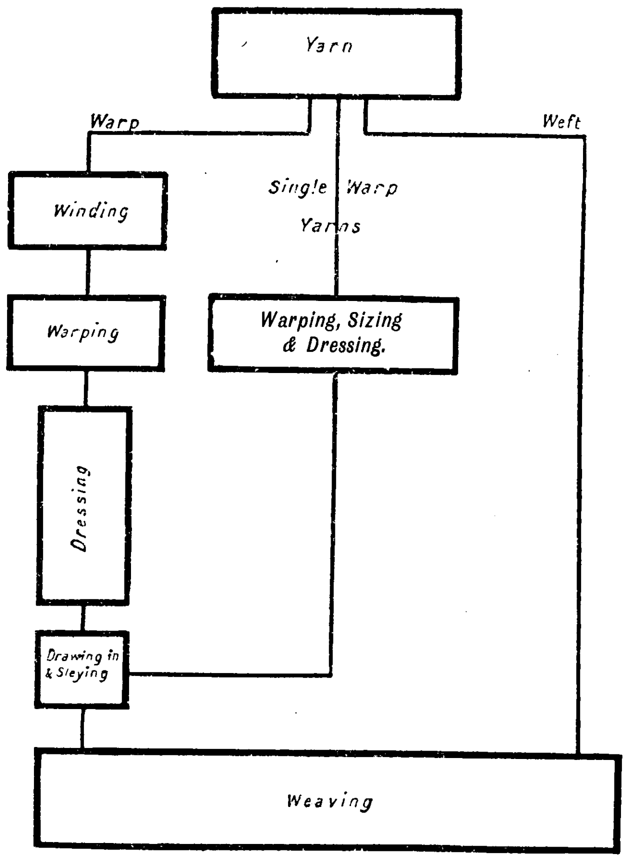

FIG. 53E.—Warping, Sizing, Dressing, etc., Processes.

a spinning machine admirably adapted for the production of sad, solid Botany yarns[1] typically suited to the Italian

[1] Roughness must not be mistaken for fulness. The cap frame can only be considered to spin a "full" yarn in comparison with the flyer frame.

and worsted coating trades. France placed its faith in the mule, and by the time of the Great Exhibition in 1851 had already made a name for soft mule-spun fabrics. From that time to the present, notwithstanding both public and private endeavours, France has well held her own. True it is that when fashion favoured the hard stuffs of Bradford, Roubaix seriously discussed the possibility and advisability of adopting Bradford's method of spinning; but upon the whole they have lost nothing by keeping to the mule. Within the last two years Bradford has again seriously considered the advisability of producing more mule-spun yarns, the Chamber of Commerce taking a strong lead in the deliberations held, and several firms have now successfully overcome the difficulties, both practical and economical, and are placing on the market mule-spun worsted yarns as satisfactory and as cheap as the French yarns. In such goods as Amazons these mule-spun yarns are employed as warp with a woollen yarn as weft. This woollen yarn, of which tons are used in Bradford and Scotland alone, is spun in Belgium and France, no English firm having yet been successful in its economical production. With the success that has attended the attempts to produce mule-spun worsted yarns still markedly in evidence, it will be a strange thing if Bradford does not seriously attempt and succeed in producing this most important woollen yarn.

The Dress Goods, Stuff, and Lining trade is almost wholly located in Bradford and district. In mohairs Bradford still has a practical monopoly, although the piece trade is threatened by the export of "tops" and "yarns" to Continental centres and the United States. In all hard stuffs

Bradford still leads, although both the United States and the Continental centres are gradually becoming proficient in the manipulation of English and cross-bred wools of the long type. Roubaix is the great rival of Bradford, in France, and Gera-Greiz, Tittan, Barmen, Elberfeld, Meerane, and Glauchau in Germany. In the United States the mills are so much engaged in the production of bulk sorts in the local wools that little endeavour has been made to produce Bradford's finest styles, which are thus still imported in fairly large quantities.

The supplies of raw materials are derived as follows:— Oldham and Bolton supply the cotton warps, usually spun from best Egyptian or Sea Island cotton, but sometimes from American; Asia Minor, the Cape, and to a small extent Australia, supply mohair; South America supplies alpaca, vicuna, and llama wool; India supplies cashmere and other wools; England, New Zealand, and South America supply long and cross-bred wool; and Australia, the Cape, and South America supply the fine Botany wools required.[1] Spun silks are now manufactured in Bradford and, close to, at Brighouse, the raw material largely coming from Asia and the latest from the Congo State; while the net silks required are obtained from Macclesfield, the Continent, or China and Japan.

The organization of spinning has been dealt with under the heading of the Worsted Industry. So many and varied are the materials and counts of yarn used by the dress goods manufacturer that it would be an economic impossibility for him to spin the yarns he requires; he must buy on the open market.

[1] Canadian merino wool is just beginning to appear in Bradford.

Cotton warps are delivered in Bradford in the "ball" or "chain" form, and are dressed in the factories on to the loom beam. Mule-spun and delicate wool warps are sized and run directly on to the loom beam by the warpers and sizers, who supply the yarn at a definite price per pound on the loom beam. If it were possible to hank-dye and wind 1-40's cap-spun yarn without undue waste, Bradford would soon develop a coloured dress goods trade. As it is France still retains by far the greater part of this lucrative section of the industry, as Bradford is largely limited to piece-dyeing.

The dress goods manufacturer restricts his energies to the warping and dressing of his yarns and the weaving of the same. His looms may be plain looms, box looms (frequently boxes at one end only), dobby looms or jacquard looms. As the trade is very liable to violent fluctuations from figured styles to plain styles, most fancy manufacturers make arrangements to sling their jacquards up and employ their looms as tappet or dobby looms as occasion demands. The looms used are largely made in the West Riding of Yorkshire. The number of looms in a shed will vary from 50 to 500 or even 1,000 with the accompanying warping, dressing, twisting, weft-room, and grey-room arrangements. The organization is comparatively simple as compared with a combing and spinning mill.

Some so-called manufacturers have no looms at all, getting their goods woven by "commission weavers." These firms are usually very limited in their turnover, although it is but fair to add that there have been some remarkable exceptions.

When figured goods are in fashion the designers and card-cutters form a very important section of the trade.

The larger firms keep their own designing staff and card-cutters, but the smaller firms usually employ one of the independent public designing and card-cutting firms, who supply sketches to select from, point paper designs, and cut cards at a comparatively small price.

The styles of fabrics produced range from plain cloths to elaborate figures. The following particulars respecting (1) a plain lustre fabric; (2) a figured lustre fabric; (3) an all-wool Botany dress serge (cap-spun); (4) an Amazon or soft dress fabric; and (5) a Botany Italian, will give a good idea of the variety of texture to be met with in this trade.

1. *Plain Lustre Fabric:*

Warp.	*Weft.*
All 2/80's Egyptian or Sea Island Black cotton.	All 1/12's Grey Mohair or Lustre English.
40's reed 1's = 40 threads per inch.	46 picks per inch.

Cross-dyed black, lustre finish.

2. *Figured Lustre Fabric: Ground weave plain.*

Warp.	*Weft.*
All 2/100's bleached Egyptian or Sea Island cotton.	All 1/32's White Mohair. 72 to 76 picks per inch.
32's reed 2's or 64's reed 1's = 64 threads per inch.	

Finished White.

3. *All-Wool Serge: Weave* 2/2 *Twill.*

Warp.	*Weft.*
All 2/56's Cap-Spun Botany.	All 1/30's Botany.
16's reed 4's = 64 threads per inch.	64 picks per inch.

Dyed any shade required, and given ordinary serge finish.

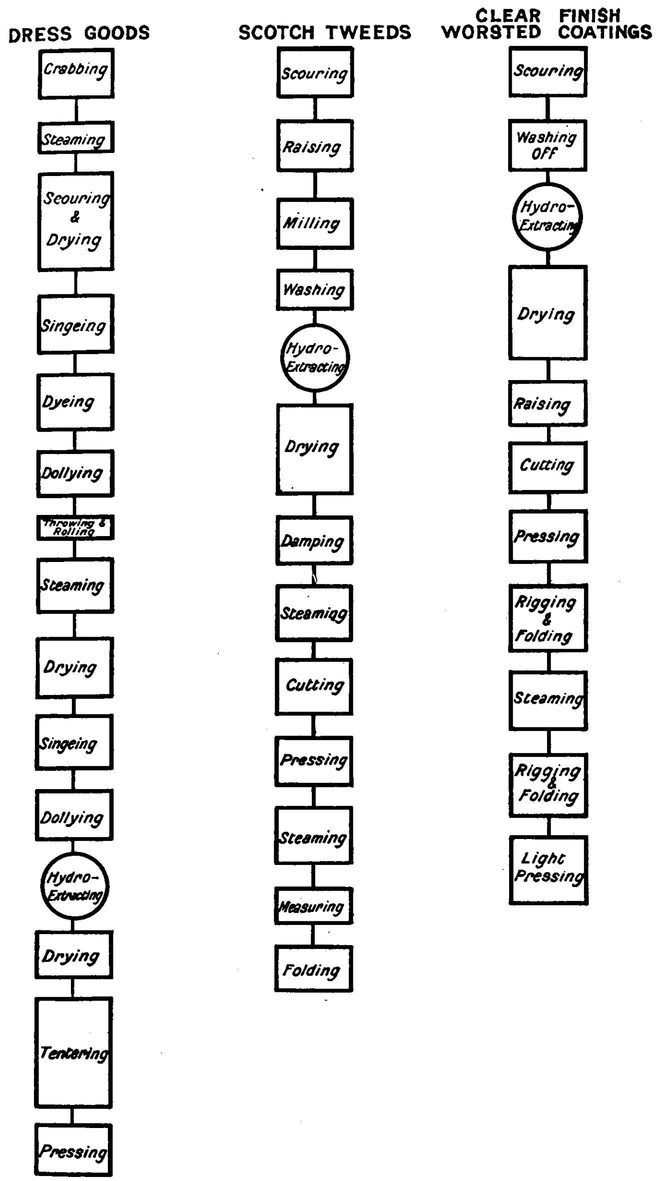

FIG. 53F.—Graphic Illustrations of Dress Goods, Scotch Tweeds, and Worsted Coatings Finishing Processes.

4. *Amazon: Weave: reverse 5 Sateen Warp Face.*

Warp.	*Weft.*
All 2/56's Cap-Spun Botany, or 1/30's Mule-Spun Botany. 24's reed 3's = 72 threads per inch.	All 40 Skein Woollen. 36 to 40 picks per inch.

Dyed any shade required, and given a Venetian or Doeskin finish.

5. *Italian: Weave: 5 Sateen Weft Face.*

Warp.	*Weft.*
All 2/50's Black Cotton. 20's reed 4's.	All 1/60's Botany (grey). 120 picks per inch.

Dyed black, and given a solid lustrous Italian finish.

The finishing of dress fabrics, etc., is almost wholly in the hands of the Bradford Dyers' Association, although, as previously remarked, there are a few not altogether unimportant firms outside the combine. If the combine has maintained prices at a high standard, it is but fair to add that they have made most marked advances in the methods of dealing with the large variety of goods continually pouring into their works, and, in addition, have introduced some new finishes of surpassing excellence.

As in the case of the worsted coating industry, there are two marked divisions of the dress goods trade—the home section and the export or shipping section. Again, some firms merchant their own goods, and others work in conjunction with the large merchant houses. Unfortunately, Bradford trade terms are not standardized as are Manchester terms, so that conditions of sale and purchase vary considerably—sometimes for the good of the industry, but, upon the whole, to the detriment of the industry.

The recent development of Bradford's trade in mercerized goods is worthy of more than passing comment. When, between 1890 and 1900, Bradford first took up this trade it was supposed that it would ultimately drift into Lancashire. Although this has partly occurred, Bradford has considerably more than held its own, and to-day is making large quantities of these goods for both the home market and for export. Of course this trade has cut at the spun silk and in part at the Italian industry, but upon the whole the gain has been much greater than the loss.

CHAPTER XIV

THE TAPESTRY AND CARPET INDUSTRY

THE tapestry and carpet industries are frequently but not always allied. It is but natural that we should be able to trace the arts of tapestry and carpet weaving more definitely and perhaps farther back than the art of weaving ordinary fabrics, which, being simpler, did not claim the attention that the production of elaborate tent drapings claimed in the early days of the human race. As already pointed out, it was but natural that elaborate figure weaving should early develop in the family period of the industry, and that elaborate styles of an artistic character, unsurpassed even in these days, were to be met with not only in the eastern but also on the outskirts of the western Roman Empire. The Normans, for example, controlling the labour of England, built cathedrals and churches; in Sicily they not only caused churches to be built, but most elaborate and inspirited tapestries to be woven.

The draw-boy loom was introduced into England from the East during the Middle Ages, and it was no doubt already largely employed on the Continent. This mechanism certainly facilitated the production of large repeating patterns to a very considerable extent. Early in the nineteenth century Jacquard, with some more or less important improvements on the machines of his predecessors and contemporaries, produced what is known as the Jacquard loom, and about 1830 this machine was successfully combined with the power-loom and made almost as complete a success as the ordinary plain power-loom. So little was the success of the Jacquard power-loom known outside the Bradford district, however, that the writer well remembers in the year 1884 or 1885 a supposed authority in the trade questioning whether it ever could be a success as a power-loom, *i.e.*, twenty or thirty years after it was running by the hundred, or perhaps thousand, in the Bradford district. To-day the tapestry loom is a magnificently harmonised combination of Jacquard, dobby or tappets, box motion, letting-off and taking-up motion, and is employed upon the simplest kinds of tapestries, consisting of little more than reversed warp and weft sateens, up to imitations of the Gobelin tapestries. In Fig. 54 a standard tapestry structure is illustrated.

The carpet trade may be divided into three branches, viz., double-structure or Kidder or Scotch carpets, tufted carpets, and true pile carpets. Double-structure carpets, no doubt, had their origin in stoutly woven fabrics to be employed as floor coverings, probably in the first instance for the ladies' apartments of the old baronial castles in the place of rushes, etc. To make a stouter and better-wearing carpet would naturally lead to the weaving of two cloths together, and from this would come the idea of figuring by an interchange of the two cloths—back to face and face to back—the colourings of back and face fabrics being designed to give the utmost value to this change (see Fig. 55). A special form of the Jacquard loom

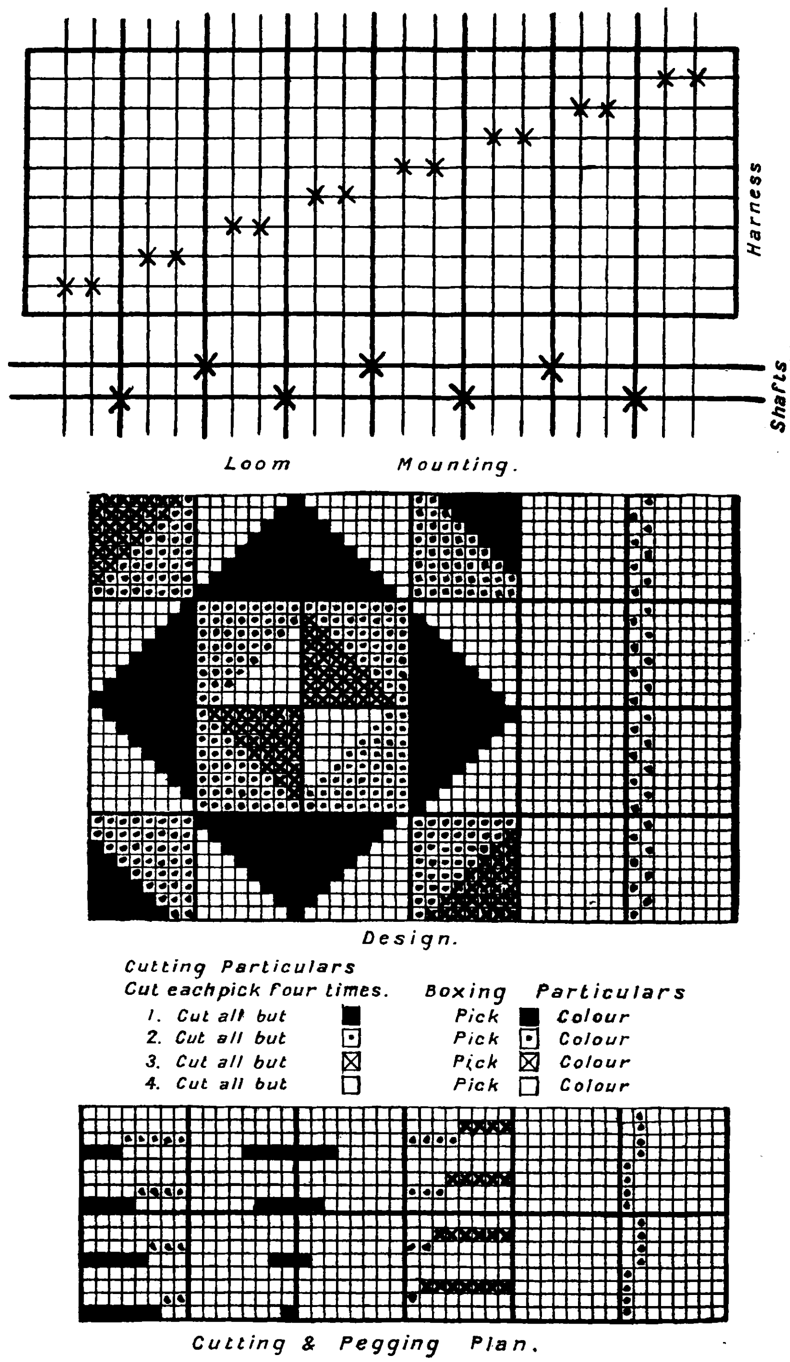

Fig. 54.—Simple Tapestry Structure and Design.

to facilitate the figuring of these goods was also a natural outcome.

Tufted carpets undoubtedly came to us from the East in the first case, Turkey carpets being probably known long before any attempts were made to produce such fabrics in western Europe. Largely owing to the definite endeavours of French statesmen—Colbert, for example—tufted fabrics were made in France during the sixteenth century, and from that date to this the noted Gobelin factory has been turning out most elaborate examples of these fabrics, in many cases reproducing with a most

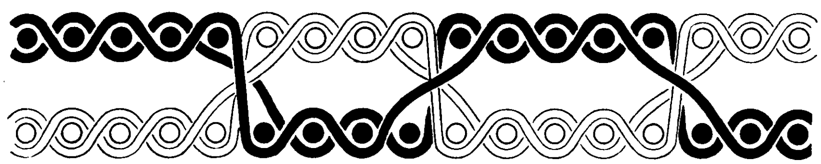

FIG. 55.—Scotch Carpet Structure.

wonderful exactitude the paintings of the most celebrated French artists. A more practical, if somewhat less artistic, hand-loom woven style of tufted carpet was developed during the seventeenth century, and owing to James I., in the seventeenth century, introducing this industry from Flanders into Axminster, in Devonshire, these carpets have become known as Axminster carpets. Briefly, they consist of a firm canvas back or foundation cloth—woven at the same time as the tufts are introduced—into which, row by row, tufts of the colours necessary to produce the pattern are firmly latched in by hand, and cut to the right length. Thus the only limit to this type of design is the number of tufts which it is possible to insert across and lengthwise of the carpet. As these tufts are now introduced mechanically from bobbins held on bars across the "fell" of the piece, and as the number of bars from a practical point of view must be limited, so is the form design limited in both warp and weft direction (see Fig. 56). There is, however, no colour limitation save such as economy imposes. The Axminster power-loom was invented by Mr. Alexander Smith and Mr. Halcyon Skinner in the United States of America about the year 1856, but it took some twenty years to establish itself in this country. Many modifications of Axminster

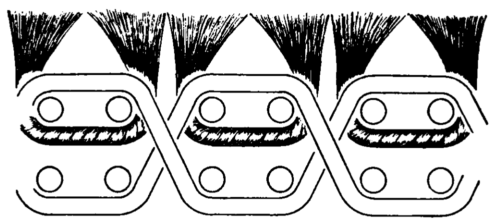

FIG. 56.—Axminster Carpet Structure.

carpets are now placed upon the market. In the most important of these the tufts of colour required in one line across the ultimate carpet are first woven into a gauze thread to form a "chenille" yarn, as many of these variously coloured tufted threads being woven and cut as is necessary to produce the pattern in the carpet, line by line. These are then most exactly woven along with the ground texture of the carpet, the loom throwing in, say, three ground picks, then the coloured chenille pick, and then stopping until the weaver has placed this in "register" to continue exactly the pattern already produced by the previous coloured chenille picks. Then the weaver touches a pedal and the loom again repeats its four picks and stops. There are many varieties of these carpets, but such is the basis of structure and production of all.

How long wire pile carpets—now called Brussels, Wilton and Tapestry carpets—have been in vogue is difficult to estimate. As the name " Brussels " indicates, the industry originally came to us from Flanders, probably being introduced into Wilton in the year 1770, the development of this industry, as in the case of many other industries, being due in part to the definite interference and endeavours of certain of our sovereigns, and in part to the Continental religious persecutions, which drove skilled fugitives to our shores. Once here, it naturally spread, Glasgow, for example, probably receiving its carpet industry from Bristol by sea, just as Glasgow, in the early part of the nineteenth century, came across the Cashmere shawl from its shipping connection with the East, and evolved it as the " Paisley shawl." Of course, the first pile carpets were hand-woven, but in 1844 to 1850 the United States of America, always on the look-out for labour-saving contrivances, brought out the wire-loom (Bigelow's), in which every motion, from the shedding to the insertion of the wire, was controlled mechanically. Messrs. Crossley, of Halifax, soon took up this mechanism, and upon it built up a colossal concern. They were later followed by others, who applied the mechanism in a variety of ways. The three varieties of this structure are formed as follows:—The true looped Brussels is formed by looping wires and distinct coloured threads (or " frames ") for every colour in each row lengthwise of the carpet (see Fig. 57). These coloured threads are lifted over the wires by the Jacquard (*i.e.*, lifted as required for the insertion of the wires) to form the required pattern. The Wilton carpet is but a cut "Brussels" with certain slight modifications—for example, a slightly modified ground structure and a longer pile. The tapestry carpet is produced from but one pile warp, this warp having the required pattern printed on it in an elongated form, so that when the take-up in weaving is effected the right proportions for the true development of the design will result. As would be expected, the pattern is not so clearly

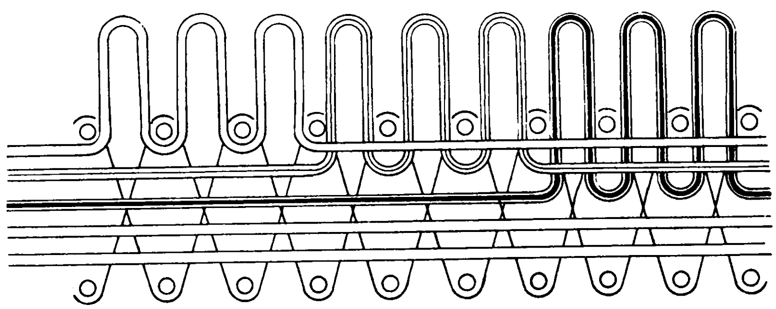

FIG. 57.—Brussels Carpet Structure.

defined as in the Brussels or Wilton carpets, and as it does not contain so much material—having only one pile warp in place of several—it is not so elastic and consequently does not wear so well. The greatest defect of the Brussels or tapestry carpet is the tendency to "sprout," *i.e*, to have long lengths of pile pulled out of them by a nail in a shoe, etc. This, of course, cannot occur with Axminster or Wilton carpets; hence their advantage. Well-woven Brussels carpets, however, should never develop this defect with fair usage. An interesting fact about Brussels, etc., carpets is that if they are not woven in squares they are usually woven in widths of about twenty-seven inches, *i.e.*, the old Flemish ell and French aune.

The tapestry industry is dispersed over the country, being located principally in Halifax, Glasgow, Bradford, Carlisle, and also being instituted as a "home industry" in Ireland and England on very successful lines. On the Continent the centres are Paris, Roubaix, Berlin, Chemnitz, Crefeld and Vienna. In the United States, New York.

The carpet industry is largely located at Halifax, Glasgow, and Kidderminster in this country.

The materials consumed are silk (both net and spun), wool (chiefly English), mohair, hemp, jute, cotton and China grass.

The mill organization is naturally very elaborate and expensive. Messrs. John Crossley & Sons, of Halifax, for example, have premises extending over many acres and employ 5,000 work-people. They produce Brussels, tapestry and Axminster carpets. The firm of Messrs. James Morton & Co., of Carlisle, is remarkable chiefly because it has organized an elaborate Irish home industry for the production of many articles yet unproducible mechanically.

The methods of production, etc., so closely resemble the methods employed in the dress goods and stuffs industries that little further need be added. The designing room is, of course, pre-eminently important. The art of tapestry carpet designing, for example, is that of using the limitations of structure and colour as bases for design. Again, the mixing, printing, and fastening of the colours upon the threads which are to form the pile in the carpet necessarily claim most marked attention.

Two branches, or rather sections, of the textile industry are not dealt with here, the hosiery industry and the ribbon, braid, and trimming industry. The hosiery industry has now attained to such dimensions and is so intimately associated with the stockinette frame and lace machine that it of necessity claims distinct treatment. The ribbon industry is so intimately connected with the bandolier, lace, and other narrow goods industry that it also is of sufficient importance to be considered as a distinct industry.

CHAPTER XV

SILK THROWING AND SPINNING

SILK manufacture has had the advantage during the last ten or twelve years of competent instruction in the technology of the raw material and its manipulation and weaving, together with its relationships to other textile fibres. The technical colleges of Manchester, Bradford, Leeds, and Macclesfield have made special arrangements and facilities for understanding the whole range of study from the production of the cocoon to the weaving of the fabric.

In the scope of a single chapter it is impossible to attempt any detailed description of the various processes of rearing, reeling, throwing or spinning through which this interesting and beautiful fibre passes before it is fitted for the manufacturer, and we must therefore limit it to general characteristics, and especially as an important article of commerce, to the increase and improvement in character, with the causes which have led up to them.

That there has been an expansion will be seen later on by the figures showing the export from the various silk-producing countries, and the amount consumed by each great centre of manufacture. As far as our own country is concerned there is a general impression that silk weaving has materially decreased, and the closing of throwing

FIG. 58.—Silk Reeling, A.D. 1500.

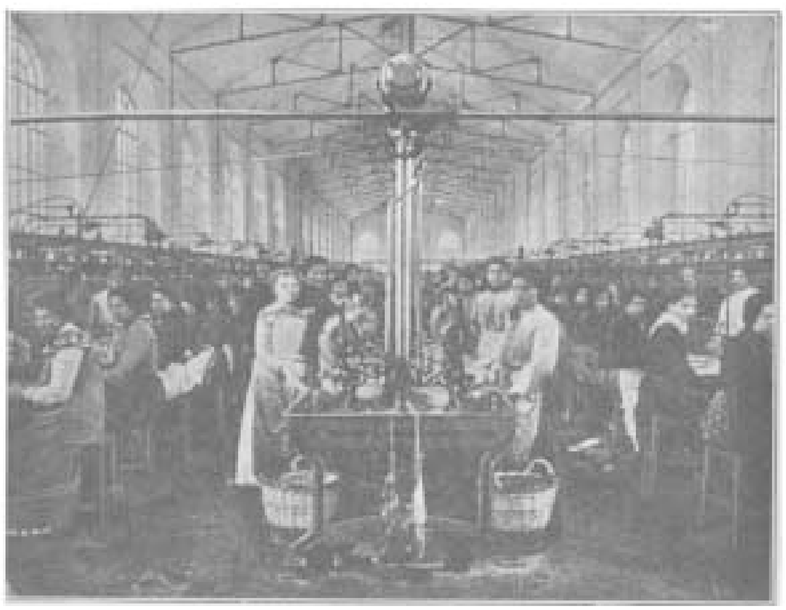

FIG. 59.—Silk Reeling, 1900.
By permission of Messrs. Giov. Battaglio, Luino, Italy.

mills and silk factories in Derby, Nottingham, Coventry, Macclesfield, and other towns gives colour to this conclusion. But it must be remembered that great economic changes have taken place during the last thirty to forty years. London is no longer the port of debarcation for the Eastern silks of China and Japan, and consequently the centre of distribution. The East India Company has ceased to hold responsibility for the importation and sale of our East Indian colony. The shipping companies now disembark their silk freights at Genoa and Marseilles as well as London, and the Japanese send a large contingent of their production across the Pacific to the American continent. Then, again, the evolution of the power-loom and its adaptation for silk weaving has practically displaced the occupation of the old hand-loom weaver, and by its introduction a single operative will be producing four times the amount as in the former days by the older methods. A general desire for cheap fabrics within the purchasing power of the million has greatly stimulated the mixed goods trade, and the looms of Scotland, of Yorkshire, of Lancashire and other districts are now engaged in weaving this textile in combination with others, especially with mercerized cotton and wool. In spinning and throwing, by the introduction of better reeled silks, and the adoption of the faster running gravity spindle, the production has been nearly doubled, and consequently an equal weight is turned out with one half of the labour formerly employed. It is, of course, natural that those countries where the raw material is indigenous will endeavour to take a first place, or where, as in the case of America (a self-contained continent), a desire is manifest to retain the supply of its people in every

The World's Silk Supply

Raw Silk Production and Exportation.	Average for Five Years.			1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
	1876-1880.	1881-1885.	1886-1890.								
France	11,220	13,882	15,224	12,452	14,080	18,744	19,712	17,160	17,248	13,640	12,100
Italy	41,800	60,720	72,842	70,620	65,230	87,648	75,878	68,904	67,826	64,152	65,824
Spain	1,430	1,892	1,584	1,980	1,584	1,694	1,980	2,200	2,244	1,606	1,760
[1] Austria-Hungary	—	3,366	5,830	6,182	4,840	5,346	5,852	6,050	6,468	5,082	5,368
Brutia	1,870	3,080	4,092	2,970	4,532	7,216	7,810	6,600	9,130	6,952	9,064
Syria and Cyprus	3,456	5,170	6,688	6,380	7,700	11,440	10,252	8,250	9,240	10,780	10,230
Salonica and Adrianople	1,782	2,222	2,948	4,180	4,840	5,500	4,070	3,410	3,740	2,530	3,630
[2] Bulgaria, Servia, Roumania	—	—	—	—	—	—	550	792	990	814	748
Greece and Crete	572	418	462	660	770	990	836	924	880	946	880
Caucasus }	6,380	4,510	2,046	4,180	3,960	4,400	3,850	4,070	5,500	5,280	5,060
Exportations: [3] Persia and Turkey }				—	—	—	—	660	1,056	2,310	2,926
Exportations: [4] Shanghai	72,336	53,856	60,676	84,348	89,452	92,730	83,314	93,412	85,470	86,350	102,300
Exportations: Canton	19,514	19,668	28,094	26,422	32,472	28,292	29,788	34,100	37,202	40,920	50,490
Exportations: Japan	22,726	29,920	45,232	65,868	62,876	59,070	67,848	75,020	65,978	77,154	68,684
Exportations: [5] Calcutta and Bombay	11,704	8,932	9,482	5,038	5,500	6,314	4,378	7,480	5,940	6,402	6,050
Total in Bales of 100 lbs.	194,790	207,636	255,200	291,280	297,836	329,384	316,118	329,032	318,912	324,918	345,114

[1] Austria-Hungary before 1881 was included with Italy.
[2] Bulgaria only commenced silk reeling in 1900.
[3] Persia. There were no exportations previous to 1897.
[4] China. Before the year 1890 Tussah Silks were not included in the returns.
[5] Kashmir. From 1905 the production of this province is included with exports from India (shipped from Bombay).

The World's Silk Supply—*contd.*

Raw Silk. Production and Exportation.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
France	12,320	16,192	14,388	12,540	10,428	13,750	13,904	13,310	14,564	14,430	14,830
Italy	73,986	99,792	94,380	98,494	77,572	107,800	97,680	104,390	106,040	98,690	93,520
Spain	1,716	1,848	1,760	1,716	1,892	1,694	1,716	1,232	1,650	1,650	1,760
[1] Austria-Hungary	6,072	6,886	7,150	6,864	6,050	6,930	7,590	7,524	7,920	7,350	8,360
Brutia	10,692	8,360	9,196	11,066	11,572	10,934	14,212	12,188	14,630	13,530	14,960
Syria and Cyprus	10,032	9,900	9,350	11,880	11,220	10,340	10,780	10,340	11,770	10,780	12,650
Salonica and Adrianople	4,620	3,300	4,400	4,180	5,456	5,632	6,160	5,654	7,480	6,270	6,930
[2] Bulgaria, Servia, Roumania	924	1,672	2,112	2,860	2,992	3,366	4,180	4,070	4,730	7,750	6,930
Greece and Crete	748	1,100	1,320	1,430	1,320	1,430	1,540	1,650	1,672	1,430	1,540
Caucasus	6,820	7,700	9,680	10,230	8,800	7,920	6,380	10,010	10,780	7,920	11,880
Exportations. [3] Persia and Turkey	5,412	6,820	5,610	12,100	14,300	9,372	10,120	13,816	13,420	11,570	13,200
Exportations. [4] Shanghai	120,010	101,772	111,408	79,200	93,368	92,730	88,220	93,764	96,360	124,040	112,200
Exportations. Canton	49,500	44,132	47,124	48,818	47,234	46,948	44,000	43,164	49,500	52,320	48,070
Exportations. Japan	77,924	90,750	99,000	104,940	101,376	128,194	101,618	131,824	139,700	166,540	180,400
Exportations. [5] Calcutta and Bombay	7,700	6,160	6,160	6,490	5,390	3,960	6,160	7,150	7,480	5,500	5,170
Total in Bales of 100 lbs.	388,476	406,384	423,038	412,808	398,970	451,000	414,260	460,086	487,696	529,770	532,400

1 Austria-Hungary before 1881 was included with Italy.
2 Bulgaria only commenced silk reeling in 1900.
3 Persia. There were no exportations previous to 1897.
4 China. Before the year 1890 Tussah Silks were not included in the returns.
5 Kashmir. From 1905 the production of this province is included with exports from India (shipped from Bombay).

department of industry in its own hands, which they now do by a heavy protective tariff. The following table of silk production and export of the various countries where sericulture is carried on shows clearly that the weight has been more than doubled during the last thirty years. These figures do not include the silk used by the natives of China, Japan or India, and we know that they retain a very large contingent of their reelings for native manufacture both for home consumption and export of fabrics.

Table showing Silk Production and Export of the various Countries (in Bales of 100lbs. each).

During Years. Average per annum.	From Europe.	Levant.	India.	China.	Canton.	Japan.	Totals. Average per annum.
1870 to 1874	105,250			56,915	19,110	14,400	195,675
1875 to 1879	78,320			67,520	17,666	17,560	181,066
1880 to 1884	109,400			63,050	18,090	24,970	215,510
1885 to 1889	90,700	14,670	17,330	56,715	23,200	41,860	244,475
1890 to 1894	93,580	17,760	5,775	68,585	28,510	58,505	272,715
1895 to 1899	93,820	29,700	7,100	77,900	43,300	72,375	324,195
1900 to 1904	93,525	46,635	6,050	96,435	46,280	98,630	387,555
1905 to 1907	124,905	53,080	5,755	90,250	45,070	120,440	439,500

The above table requires some explanation. Up to the year 1884 statistics of the countries of Europe were grouped with those of the Levant and India, and it is therefore difficult to ascertain which country was best developing its resources. From that period up to the present time the yield in Italy, Austria, and Hungary grouped together has increased 50 per cent. The Levant and Central Asia has trebled its production. India appears to show a decline, owing partly to the withdrawal of the fostering care of the East India Company. From another table, which we append, it will be seen that India manufactures more silk than it exports, so that it is difficult to ascertain its full complement of production. The Chinese, doubtless, retain fully one-half of their out-turn for home consumption, and Japan probably one-third. This last-named together with the Cantonese, owing to their extended cultivation of the mulberry and their improved methods of reeling, account for the largest increase. It is well known that their manufacturing requirements have increased in like proportion. The following table (p. 272), shows the production and consumption of each country at the present period.

The cause of this increased output is not attributable to a single department of its cultivation and manipulation. All along the line Western science has been brought to bear, resulting in improved methods of rearing, reeling, and spinning. In France alone the production, which in the year 1820 reached 1,000,000 lbs., trebled itself during the following decade, and between the years 1840 and 1855 the estimated production was 4,500,000 lbs.; but this excessive development brought in its train serious consequences. The large breeders brought millions of worms together in one room, an overcrowding which induced a serious disease, and nearly threatened the extinction of the species throughout the whole of Southern Europe, and more or less in China and Japan, but without such serious results in these last-named countries.

This catastrophe, however, laid the foundation for greater care in the breeding, and consequently for the better results

Production and Consumption of Raw Silk.

		Production Average of Seasons 1903/04, 1904/05, 1905/06	Consumption of same. Average of years 1902, 1903, 1904.
Europe:	France	12,760	95,194
	Italy	92,334	21,252
	Switzerland	990	35,090
	Spain	1,760	4,026
	Austria	3,608	17,072 (Austria and Hungary)
	Hungary	3,234	
	Russia and Caucasus	8,932	27,962
	Bulgaria, Servia, Roumania	3,432	374
	Greece and Crete	1,386	440
	Salonica, Adrianople	5,742	660
	Germany		62,612
	England		15,598
America:	United States		134,816
Asia:	Brusa	12,078	660
	Syria	11,000	2,420
	Persia (exportation)	5,566	No Estimate. (Persia to Japan)
	Turkestan ,,	6,006	
	China ,,	89,606	
	,, Canton ,,	46,618	
	Japan ,,	111,364	
	India ,,	5,632	7,700
	Tonquin and Annam (exportation)	220	
Africa:	Egypt		4,400
	Morocco		1,540
	Algeria and Tunis		1,430
	Other Countries		1,210
	Bales of 100 lbs.	422,268	434,456

N.B.—Two reasons account for the seeming excess of consumption over production: 1. The figures of production being based upon seasons, and that of consumption upon calendar years, both columns do not refer to exactly the same period. 2. For several years the Italian crop has been officially underestimated.

of which we now reap the benefit. The whole world of sericulture will ever be indebted to M. Pasteur, who in the year 1865 was called to the rescue from what in France was looked upon as a national calamity. After two years of close study and experiment he succeeded in discovering and pointing out the cause of the malady and the means of preventing it. In the first place, healthy seed was imported from Japan, the country which had least suffered, and so the practice of cross-breeding became universal, and amongst the best "graineurs" to-day great care is exercised in the selection of the finest cocoons from the various districts in order to establish new and healthy breeds of silkworms. .The main remedy was effected by the practice of "cellular incubation," viz., the examination of the eggs under the microscope, in order to ascertain if the production of each moth had within it the source of infection for a future race. During the next ten years this method of inspection was adopted by every well-ordered establishment, in every country, with the exception of the Chinese, who still suffer from year to year by their antiquated methods both in quality and quantity of the seasons' yield.

A book recently published by M'Laurent de L'Arbousset, of Alais, France, and translated from the French by Elizabeth Wardle, the talented daughter of the late Sir Thomas Wardle (President of the Silk Association of Great Britain and Ireland), reveals to us other causes of improvement than those of interbreeding and microscopical inspection, important as they are. The mulberry, the staple food of the *Bombyx mori*, is now cultivated under the most methodical and improved conditions, and calculated to afford the highest degree of nutrition. By careful selection of healthy stock plants, grafting, pruning, and judicious gathering of the leaves, especially during the earlier growth, a more succulent and nourishing food is obtained and the trees are better able to resist the fungoid diseases to which they are liable. Magnaneries (rearing sheds) are more carefully warmed and ventilated, the silkworms are better spaced, and by cleanliness and mild fumigations of sulphurous acid or formalin the silkworms are kept freer from the diseases to which they are liable, and consequently spin a more robust cocoon, better in quality and the thread of greater length. In marketing the cocoons they are classified as to quality, and in stoving (with the object of killing the chrysalide) new and improved apparatus has been introduced. The peasants in country districts adopt very primitive means of effecting this. One method described by this writer is that of subjecting them to the baking process. After the bread has been withdrawn from the baker's oven, the bare arm is thrust into it, and, if the heat can be borne without scorching, the cocoons, placed in baskets, are then inserted and retained until the operator is satisfied that life no longer remains. Steaming, however, gives a much better quality of fibre, and in the absence of specially-constructed apparatus they are placed in baskets over a copper of boiling water, and after a complete desiccation spread out in the sun to dry thoroughly.

By the adoption of the foregoing methods the net yield from one ounce of graine, or eggs, has during the last twenty-five or thirty years been trebled, and in many instances quadrupled. It is now calculated that from this incubation of healthy and carefully-selected seed seventy kilos of cocoons may be produced, 90 per cent. of which are of the first quality. But we pass on to note the stages by which the reeling has been brought up to its present standard of efficiency in the improvement of the reeled silk and the lowered cost of production. In the year 1820 a

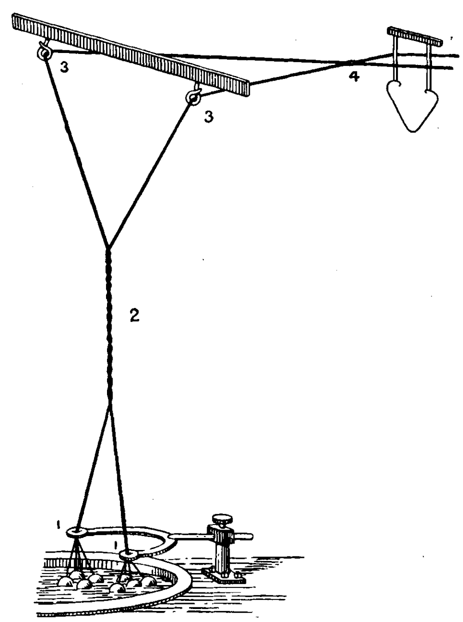

FIG. 60.—Croissure by the System Chambon.

French inventor, Gensoul, of Bagnols-sur-Lèze, introduced the process of heating the reeling basins by steam, which, by removing a separate oven for each basin and the driving of each reel separately by hand, enabled the workers to be placed nearer together on one table, and by one driving-wheel the whole line of reels are worked by the same motive power.

In 1828 a further improvement was introduced by Chambon, of Alais, which established the universal use of the Croissure which improved the reeled threads by making them rounder and more compact and homogeneous. Unfortunately this apparatus gave rise to what is known in the

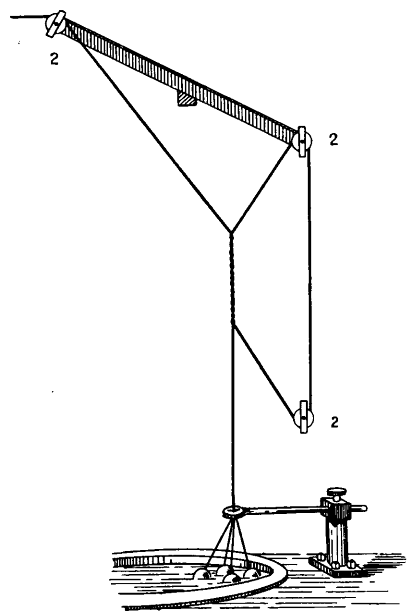

Fig. 61.—Croissure by Tavalette.

trade as "mariages," or double threads running parallel together on the reel and needing separation in the winding and throwing of the silk for manufacture. This has been obviated by the use of the Tavalette croissure, each separate thread being crossed upon itself (with thirty to forty turns), and is carried singly by means of small pulleys on to the reel. The waste material on the outside of the cocoon, which had to be removed by the whisking of a brush in a separate basin, and by hand, is now effected by automatic machinery. The work of one reeler was under the older system confined to two sets of cocoons. (From four to six threads or cocoons are combined to make one thread of

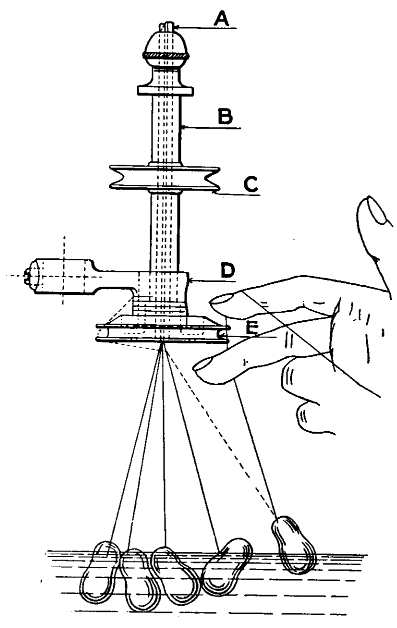

FIG. 62.—The Jette-bout, combining Five Cocoons in One Thread.

raw silk.) Now, under the new conditions, the reeler can easily superintend in one enlarged basin from four to six sets of cocoons, in addition to which the reels can be driven faster. In spite of the mechanical improvements in the apparatus used, it is necessary that great care should be exercised in order to avoid those defects which would impair

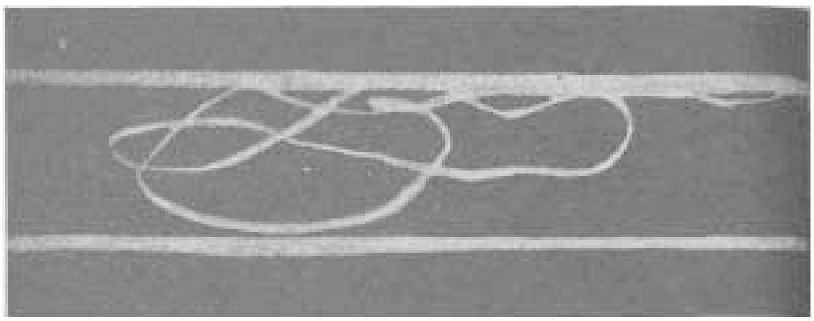

FIG. 63.—Duvet.

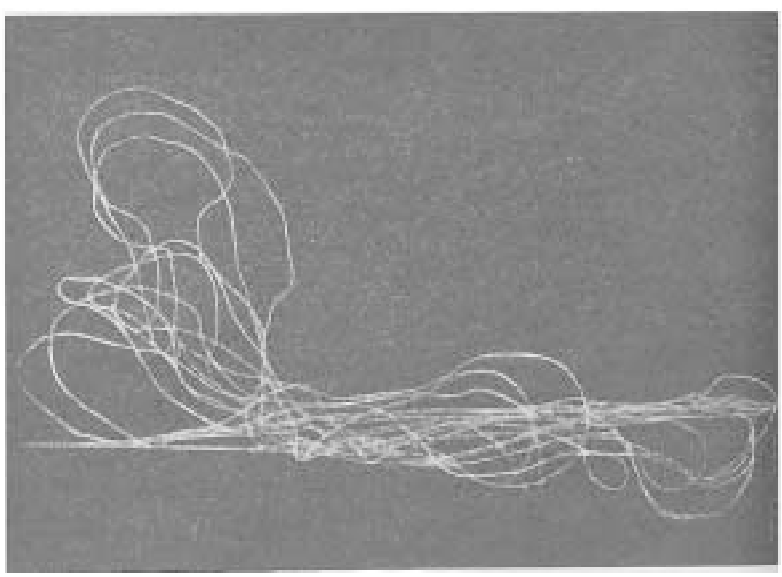

FIG. 64.—Bouchons or Slubs.

the quality or cause trouble in the weaving. A few of the imperfections to which bad reeling gives rise may be indicated. First, *Duvet* gives the appearance of short fibres thrown off from the main continuous thread. This was attributed formerly to the silkworm spinning an imperfect bave on the cocoon; but while there may be variation in thickness between the first and last end of the spun thread, there is no mechanical imperfection caused naturally. The microscope reveals to us the real cause, either frequent and

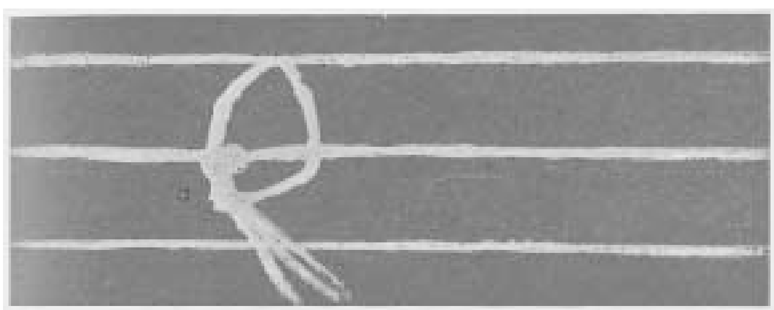

FIG. 65.—Knots.

imperfect joinings as the cocoons become attached to the main thread, or still more by an uneven temperature in the reeling basin (which should be kept at 140° to 160° Fahr.), thus causing the silk to unwind itself unevenly and cause small loops. Secondly, *Foul* or *Slubs* (bouchons) present a more aggravated form of the above-named defect, the layers of the thread on the cocoon coming off *en masse*. There are few productions actually free from this fault, and the native reelers of China silks are so careless that it is only by passing the thread through cleaners (steel blades closed so as to stop the bouchons) that their productions can be utilized. Thirdly, *Knots* are unavoidable, but by careful oversight they may be minimized, and under any circumstances be neatly made. Fourthly, *Baves* imperfectly joined together give the thread an open and soft appear-

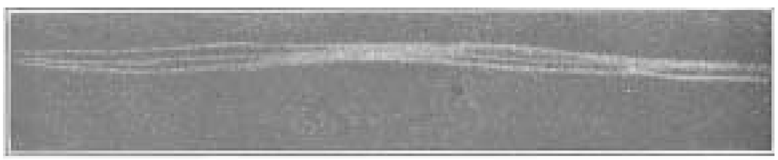

Fig. 66.—Baves imperfectly Joined.

ance. They are mainly caused during a temporary stoppage of the reeling, some of the threads from the cocoon drying more quickly than others. Fifthly, *Vrilles* give the thread a crêped appearance, and are produced by the breakage of one of the baves when it is necessary to reduce the number of the cocoons.

Fig. 67.—Vrilles.

Most of these faults may be discerned while the silk is in the raw or gum state. During the last decade a much graver imperfection (but not new by any means) has formed the subject of controversy amongst experts. It is known as *silk louse*, causing an appearance when discharged or dyed and wound on the bobbin of specks of dust. When placed under a high power of the microscope these minute specks present the appearance of numberless fibrils indicating a rupture and division of the original bave and brin of the silk. It has been variously attributed to (*a*) the use of disinfectants in the rearing sheds chemically disin-

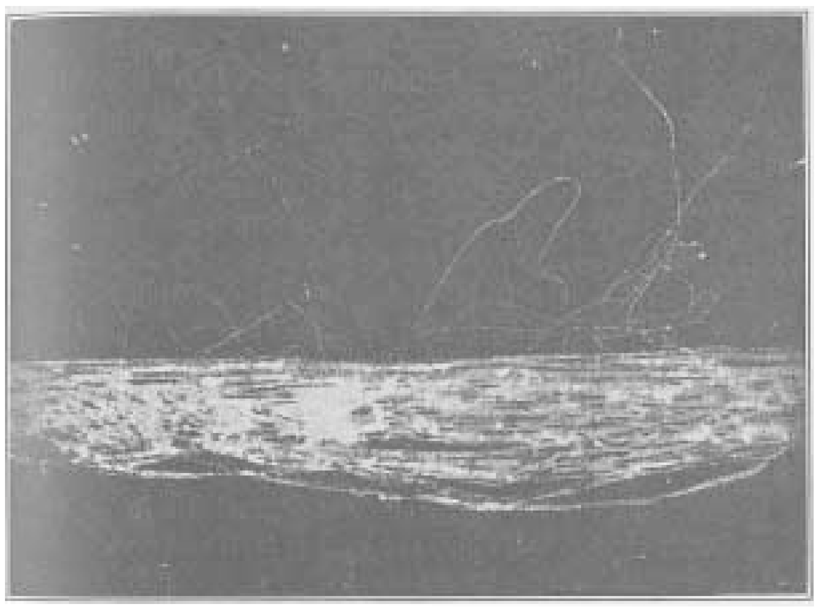

FIG. 68.—Silk-louse.

tegrating the fibre; (*b*) an imperfect croissure, the reeler failing to give the necessary number of turns of the thread upon itself; (*c*) undue punishment in the process of boiling, dyeing, or lustreing, specially the latter. So far no satisfactory solution has been arrived at, and it is most probable that it may arise from a combination of causes.

Certain it is that some classes of silk are more liable to it than others, and as the appearance is only spasmodic there may be certain seasons and countries where the conditions of rearing and reeling are unfavourable.

In the production of a good weaving thread it is equally necessary that the throwster should take every precaution either to minimize by cleaning the reeling defects of the raw silk, or, by good machinery and careful oversight in his own processes, avoid the production of faults incidental to this particular process of manipulation. A brief *résumé* of the work of the throwster may not be out of place. In dealing with the raw silk for throwing, the treatment should be varied according to quality. The filature silks of Italy, China, and Japan are fairly even in size, and the skeins are reeled in hanks suited for winding without separation, whereas those of China reeled by the natives come to us in mosses or hanks weighing nearly 1 lb., and require very carefully splitting into smaller hanks. They are usually so uneven in the thickness of the thread that it is necessary to classify them, otherwise the union of a thick and thin thread produces in the two-folded tram or organzine a loopy or crinkled appearance, which is a serious fault and drawback to the after-processes in the manufacture. Where the silk in reeling has touched the arms of the reel a hard gum is formed, and requires carefully softening either by the immersion of that portion of the skein in a softening emulsion or by a complete washing of the bulk in a soap bath. The cost of winding varies according to the method of reeling. Those silks produced in well-equipped filatures or factories are as nearly perfect as possible, and one worker can superintend 80 to 100 spindles, the bobbin taking up

50 metres per minute, as against inferior native silks 20 to 25 spindles, and the waste caused by these latter is much heavier. In the next process of cleaning equal care is required, so that all the bouchons or foul may be eliminated,

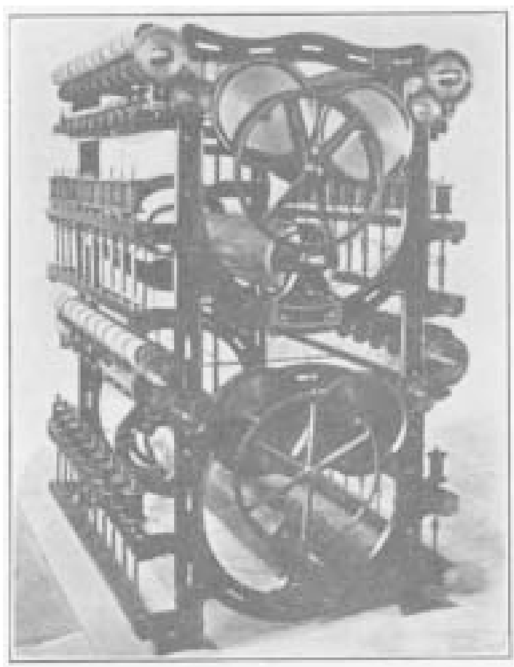

FIG. 69.—The Ritson Spinning Mill.

and where tied out a neat knot should be made and the ends cut off shortly. The process of doubling two or more threads together requires equal vigilance. Two ends of equal size should be run together, the tensions on each carefully adjusted, and each thread passed through an automatic faller or eye, so that one thread cannot pass on to the

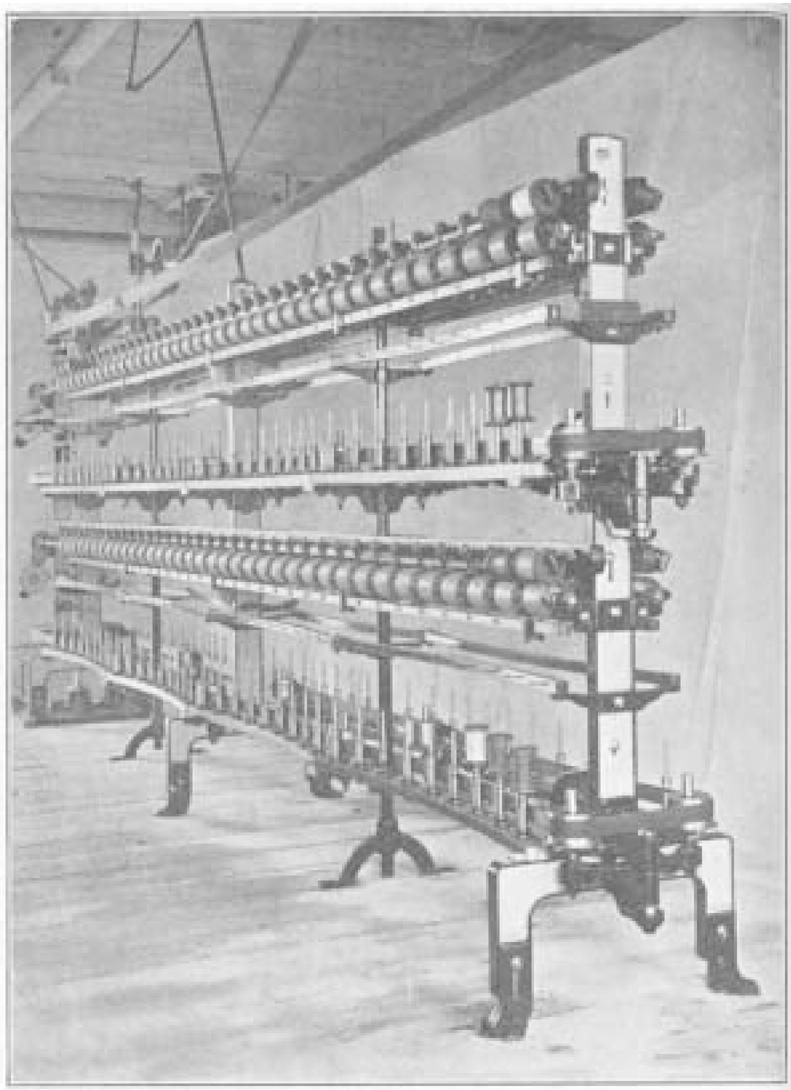

Fig. 70.—Spinner (new type).

bobbin singly. In spinning, doubling, and twisting marked improvements have been effected in late years by better and faster-running machinery. The Ritson spinning mill, introduced in 1830, with a separate cotton band for each spindle driven by a cylinder, was only capable of doing

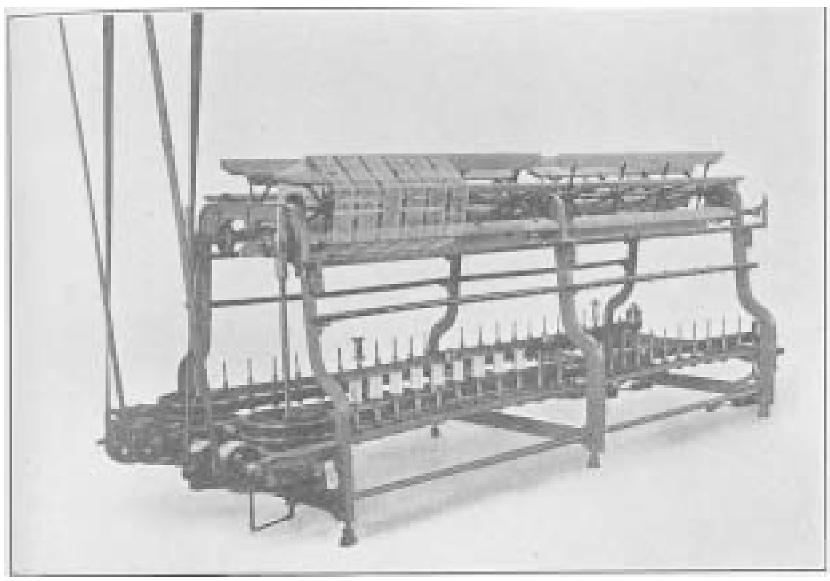

FIG. 71.—Throwing Mill, Twisting and Reeling Combined.

effective work at 3,000 to 4,000 revolutions of the spindle per minute.

This has been superseded by machinery furnished with gravity spindles, which are successfully run at the rate of 8,000 to 10,000 revolutions per minute. In addition to this advantage the machine only takes up two-thirds of the room of the older type. In some cases the final twist is given

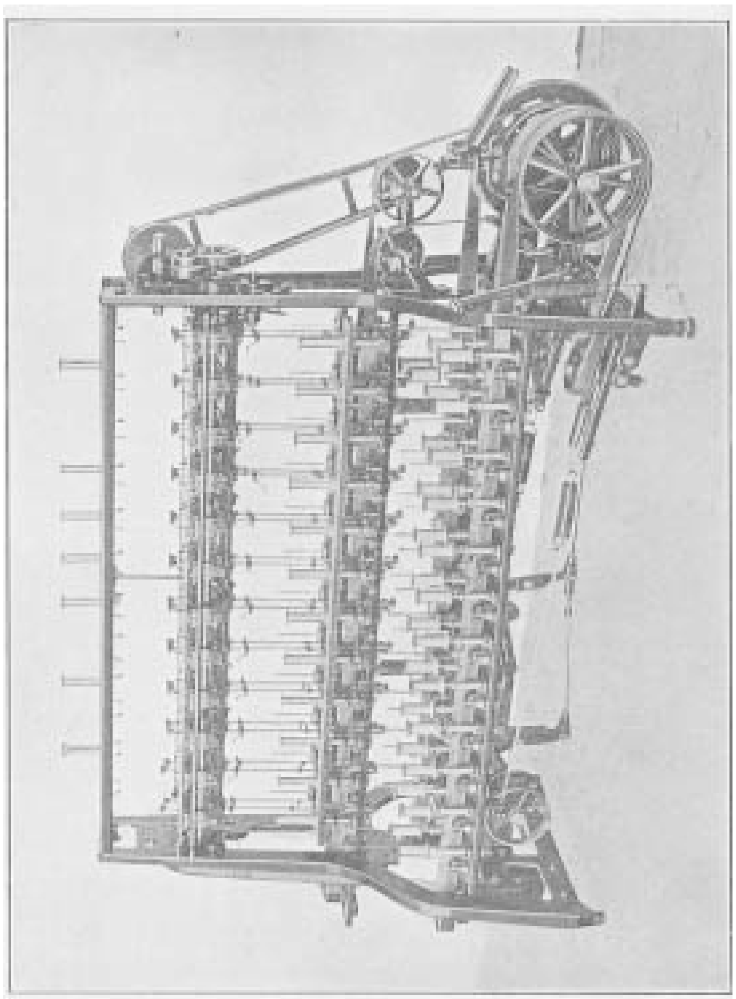

FIG. 72.—The Bradley Spinner Compound Processes.

on the same type of machine and the doubled thread reeled on a separate reeling machine with automatic stop motion, so that each skein is of an equal length. The more modern and equally effective method is to twist and reel at the same time. A twisting frame built on similar lines to that of the spinning mill, but with reels instead of take-up bobbins can be driven at the rate of 6,500 revolutions per minute. The latest American machine provides for spinning, doubling, and twisting in one process, but so far it can only be adapted for the most perfectly reeled silks of Italy and Japan of 14 to 16 deniers in the thread. Finer reeled silks and those of a commoner description would suffer in quality, and little if any advantage in cost would be gained by the adoption of so compounding the processes. One of the greatest advantages of late years has been gained by the process of cross-reeling known as the Grant system, by which a length of 5,000 to 10,000 yards can be reeled in one skein. The silk is kept straighter in the dyeing process, and the winding is facilitated, and at one-half of the original cost as against the smaller hanks.

As compared with other textiles made from short fibres, net silk has distinctive qualities which give to it a precedence over them. For instance, its natural brilliancy, transparency, and absorbent character enables the dyer to incorporate with it tannic acids or metallic salts, in some cases up to double its original weight, and increasing bulk up to 50 to 100 per cent., without in any way impairing its natural lustre, and at the same time so incorporating itself as part of the original thread that it is perfectly homogeneous, and not, as in some cases, appearing as an accretion outside of the thread or fibre itself. The properties of elasticity and tenacity are also important factors, specially for weaving in the single thread without twist, as also those combinations where a strain is put upon the warp threads to produce certain effects.

Careful assays are made in what is known as conditioning houses to ensure to the buyer an article specially suited to his purpose. The absorbent quality admits of too great a percentage of moisture or water being incorporated with it when sold, in fact, up to 5 or 6 per cent. over the normal, without in any way appearing fraudulent. To arrive at a fair condition 500 or 600 grammes are carefully weighed, and afterwards enclosed for fifteen or twenty minutes in a specially constructed apparatus or oven, superheated up to about 300° Fahr. It is then weighed and 11 per cent. added to the absolute dry weight, by which percentage it is supposed that we arrive at the proper normal condition. A further test is added by decreusage or boiling off the gum in order to ascertain that no undue weighting of fatty or other matter has been added to increase the weight of silk beyond its original condition in the raw state. The tavelle, or winding test, is only applied in the case of raw silk as a guide to the silk throwster. Five hanks are placed on the winding swifts and run for two hours at the rate of 50 metres per minute on the take-up bobbin. The number of breakages during the time are carefully tabulated, and the resultant divided into 800 gives the number of spindles one worker can superintend. Tests for elasticity and tenacity are conducted on a special apparatus called the serimetre. The normal amount of elasticity indicating a silk of good quality should not be less than 25 per cent. of its length. Tenacity or amount of strain before breakage is considered to be satisfactory if the weight borne in grammes is four times the denier or size of the thread. For example, a 10-12 denier raw silk should bear a strain of 40-50 grammes in weight (equivalent to about 1 oz. avoirdupois), and so on in proportion with all other sizes.

Assays for size or count are made by reeling 20 skeins of a given length, weighing each separately, which will indicate the range or variation, and thus showing the comparative evenness of the thread, or otherwise, and by striking a mean average of the totals the size or count will be ascertained, by which calculations may be built up for the manufacturer. An international metric count has been established in all silk centres as approved by the Paris Convention of 1900. This is based upon the metre for length, and the gramme for the weight—*e.g.*, No. 100, means that 100 metres will weigh one gramme. What is known as the legal count for raw and thrown silks is based upon the number of half decigrammes per 450 metres, and corresponds very nearly to the former method of weighing by the denier ($33\frac{1}{3}$ deniers = 1 dram avoirdupois) per 476 metres. The nomenclature for counts and sizes for various textiles is so varied that the student or manufacturer should furnish himself with the small handbook of "International Yarn Tables," compiled and arranged by McLennan, Blair & Co., of Glasgow, an absolutely indispensable office guide.

The question of quality of the silks of various countries is equally varied, according to climate, soil, rearing, reeling, etc., and can only be assessed either by actual practice or a long experience in their manipulation. A few details respecting them may not be uninteresting.

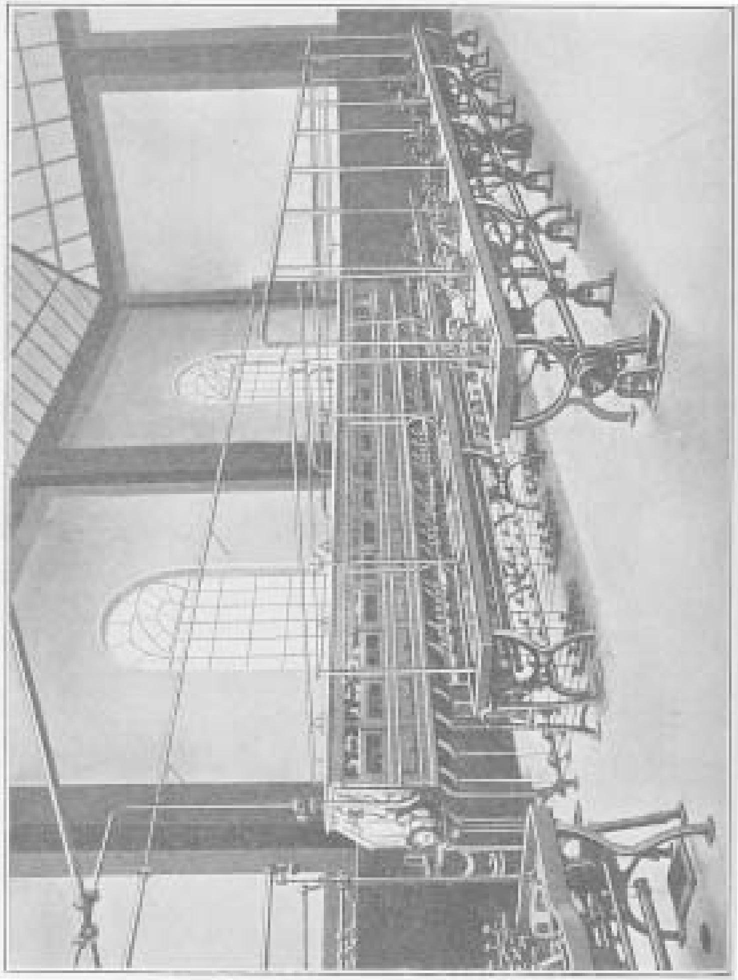

Fig. 73.—Silk Reeling Machinery at the Italian Exhibition of 1906.

French and Italian.—These are mostly yellow gum silk, in fact the yellow breeds of cocoons are indigenous, and the eggs of the white races of the far East after a few years' breeding revert to the yellow silks peculiar to these countries. Great care is exercised in the reeling to produce a well-formed and even thread. They are usually reeled in sizes of 9-11 to 12-14 deniers, according to the number of cocoons combined in one thread, and are adapted for either organzine (warp) or tram (weft) for the production of broad goods, for which they are admirably suited. The loss in boiling is 25 per cent., and great care is required in discharging the gum so as to prevent the appearance of duvet or silk-louse, to which they are somewhat liable. Some of these silks are reeled from 20 to 30 deniers in size for weaving in the gum with the single thread, and specially for the production of the network in silk lace. The productions of Spain, Austria, and Hungary may be classed with those of France and Italy.

Syrian, Brutian, Bulgarian, and Persian Silks are also carefully reeled, and in similar sizes to those before named. They are, however, of a softer nature, and not so well fitted for organzines as for tram silks. The coarser sizes of Brutian silks are largely used for weaving in the gum (single thread), and the finer sizes of Brutian and Persian silks doubled two or three fold make an excellent weft when twisted heavily for the manufacture of crêpe de chine.

Kashmir Silk is comparatively a new production. In 1897 it was non-existent. The Durbar of that province is indebted to the late Sir Thomas Wardle for its initiation and development. In the year 1900 the annual production was 57,921 lbs., and by the year 1906 it had increased to

Fig. 74.—Interior of Kashmir Reeling Factory.

190,736 lbs., and year by year promises a like progressive increase; the silkworm eggs are distributed to 15,784 village householders, and, reckoning an average of four persons to each family, it will be seen that some 60,000 to 70,000 persons, young and old, are engaged in this industry, which has proved very remunerative to all concerned. Factories have been established for the reeling, in addition to which some 200 hand-looms have been sent out from this country for the weaving of fabrics. The seed is imported annually from Europe, the race is univoltine, viz., one crop per annum, and the silk is therefore much superior to the ordinary silks of India from the eastern provinces. It is mostly reeled in 10-12 denier size, and finds a ready market in Lyons for throwing into weft silks, for which it is specially adapted.

Bengal Silks for export are somewhat limited. Although there are three crops or bunds per annum, the supply does not exceed 4,000 to 5,000 bales per annum. The filatures are in the hands of about four or five (European) companies, who give their productions names according to the districts from which the cocoons are obtained. Those known as Surdah, Rangamatty, Gonatea, Banjetty, Cossimbuzar, and Rose filature are among the best, and from these second and third selections are made under different titles too numerous to include in these notes. Some of the native reels are worthy of inclusion as silks of good quality, but the great bulk are of an inferior order and used by the native manufacturers for the fabric known as Pongees. The silks of the Bengal province being multivoltine, the bave is finer, and the cocoon only yields two-thirds the length of the univoltine species. The thread is softer and more liable to duvet, but yields a bright thread after dyeing, and is especially suited for weft, particularly when dyed black. The sizes run from 10-14 to 16-20 deniers.

Cantons.—These also are the produce of multivoltines. The Cantonese produce six crops annually. The silk is similar in quality to the Bengals, but as the colour is a creamy white it lends itself to the lighter shades of colouring, and when well reeled is adapted particularly for crêpe de chine weft. Formerly this silk was all in the hands of native reelers, and very coarse and uneven. European enterprise and capital has established numberless filatures, and both for size and winding properties they compete favourably with the filature silks of other countries. There are still some native-reeled silks, but even these are of much better type than the exportations of, say, fifteen to twenty years ago. The worst fault of these native reels is that of *mariages* or double threads.

Japans have vastly improved during the last ten years, both for colour, reeling, and general characteristics. They are good winding, fairly even, firm in the thread, and capable of being dyed and weighted (especially in colours) to double their original weight when boiled off. The sizes run from 9-10 to 13-15 deniers in the single thread, so that they can be utilized for fine organzine and tram silks. The American manufacturers use these silks more extensively than those of any other province or country. One special characteristic of Japan silks is the minimum percentage of gum. The loss in boiling does not exceed 18 to 20 per cent., as against European silks and those of India and Canton 25 per cent.

Tussah Silks are the produce of the family of *Saturnides.*

In India the Antherea Mylitta produces a bave of at least 8 deniers in size, and in China the Antherea Pernyi produces a bave of about 5 deniers, as against the bave of the Bombyx Mori silks of 2 to $2\frac{1}{2}$ deniers. Consequently, the original thread is flatter and more uneven, and a less number of cocoons can be combined to produce a given size. The quality is very varied. Some of the filature-reeled silks of northern China (Chefoo district) are fairly workable, but unfortunately they vary from year to year, and many chops or trade-marks in favour a few years ago are now little better than those of the native reelers. The filatures usually run 35-40 deniers in size, and those of the natives 50-60 deniers. A large proportion of the silk in China in the province of Shantung is reserved for the native manufacture of fabrics bearing that name.

China Silks cover so wide an area, and are so varied in qualities and sizes, that only a few general details can be included here, so we must confine our remarks to a general classification. (1) Filature silks produced in factories in the neighbourhood or within a fifty-mile radius of Shanghai are reeled under European supervision and take a first place in the world's productions. They are white in colour, even in size, of a firm texture, and possess great tensile strength, so that for some purposes they are preferred to any other silks, and consequently command a high price. 10,000 to 15,000 bales are now annually produced and exported, principally for Europe and America.

(2) *Re Reels.*—These silks are very similar to the native-reeled silks both as to size and quality. In fact, they are the native-reeled silks, wound by Chinese women, carefully cleared of some of the bouchons or foul by passing

through the fingers, and by re-reeling a better winding is obtained. The finer portions of the silk are selected for this purpose, so that part of the cost of manipulation in silk-throwing is saved, a great *desideratum* where the cost of manual labour is comparatively at a premium. During the last 10 to 15 years the export of these silks has been on the increase. During the season 1906-1907 they reached nearly 13,000 bales, nearly equal in quantity to those of the ordinary white native-reeled silks.

(3) *Native Reels.*—These include Tsatlees, Kahings, Hainins, Hangchows in the white silks, and the yellow silks of the Seychuen districts. Owing to the selection of the best and finest hanks for re-reeling purposes the white silks of China have greatly deteriorated. Naturally, the cocoon of the white China species is second to none; in fact, if it could be produced under the same scientific conditions as those of Europe and Japan, for strength, lustre, etc., it would be the very best. In the districts where the rearing takes place there is no microscopic selection of healthy graine or eggs, and consequently liable to the ravages of diseases to which the silkworm is subject. It is to be hoped that Western education and contact with their near neighbours the Japanese will so leaven the commercial spirit of this country that ultimate improvement may be the result. The yellow silks especially are of little utility for the English or Continental markets beyond that of coarse fabrics, or heavy sewings, or embroidery threads.

So far we have only dealt with the silk in the net or raw state, and its manipulation in the processes of reeling and throwing, but in these stages it is estimated that an equal quantity of waste is produced, and which is now utilized for silk spinning. In the rearing of the cocoons the blaze or fine silken fibres thrown off by the silkworm on the bush as a nest on which to form its cocoon is collected, and China alone has exported 240,000 lbs. annually of this product. Imperfect and pierced cocoons which cannot be used for reeling form another source of supply. In the reeling process, before a perfect thread can be obtained for continuous running the outside threads are brushed off by an automatic process, and at least 25 to 30 per cent. of the total weight of the cocoon goes into the waste basket. To this may be added the waste made by the silk throwster in the processes of winding, cleaning, and doubling. Doubtless some portions of these waste materials were used by the ancients for all time, but under earlier conditions were combed and spun by hand. In the regulations of the thirteenth and fourteenth centuries in France mention is made of galette flourin and filoselle, productions of hand spinning, and in 1815 a society was formed in Paris for the encouragement of the industry on a larger scale and by mechanical means. At this period the waste was cut into short lengths and spun on lines similar to those then existent in the cotton spinning, but in 1830 special machinery was introduced for dealing with longer fibres, on the basis of the present system of the silk-spinning industry of to-day. To a paper read by Joseph Boden, Esq., silk merchant, of Manchester, before the Silk Association in February, 1905, we are indebted for information as to the rise and progress of this branch of textile industry in our own country. It appears that the first spinning mill established in England was in the year 1792, at Galgate, near Lancaster, but a quarter of a century elapsed before this example was followed to any extent by other firms.

On the Continent operations were commenced in Bâle about the year 1822, and from that period both at home and abroad it has made considerable progress and development. It may be interesting to know that an approximate estimate of the spun-silk spindles in the whole world may be put at about 660,000, spread over France, Switzerland, Italy, Germany, Austria, England, America, China, Japan, and India. The production may be taken roughly at 15,500,000 lbs. per annum, of which about 11,000,000 are produced on the Continent, 3,000,000 in England, and the remainder in other countries.

The predominance gained by the Continent may be partly accounted for by the cheaper labour employed, and an abundant water supply, so necessary for the purpose of schapping, and also more favourable treatment by the absence of restrictive factory regulations. By the method of schapping, in which a portion of the gum is retained, the processes are somewhat cheapened, a larger yield is obtained, and for some purposes, specially where required for black dyeing, the yarn has a wider scope of utility for the manufacturer. The gum is partially removed by the process of maceration and fermentation or by chemical means. The English spinners succeed in spinning brighter and whiter yarns which, although higher in price, command a sale for purposes for which the Continental yarns are less suited, specially where brilliancy and clearness of colouring is desired for delicate tintings and for whites. The methods employed for schapping, for long spinning, and for what is known as shortspuns involve different treatment and special machinery, the details of which are so varied that a special chapter would be necessary to describe them even in the most general outline. My purpose has been to show the evolution of the silk industry from the smallest and crudest beginnings up to its present conditions of expansion and improvement.

By permission of Messrs. Sulzer, Rudolph & Co., of Zurich, silk merchants, we append a complete classification of the Chinese white silks and those of Tussah filatures; also a classification of Tussah native reels by Messrs. Puthod.

CLASSIFICATIONS.

Steam Filatures.

Marks Classic.	
Best Chops.	
Ewo	best 1, 2
Sinchong: Factory	Extra 1, 2
Soylun: Anchor	Extra 1, 2, 3
Jinchong: Crown	Extra 1, 2
Good Chops.	
Lunwha: Double Dragon	1, 2, 3
Denegri: Rose	Extra 1, 2
Chuezen: Diamond	Extra 1, 2
Jeaykhong: Sans Pareil	1, 2, 3
Yang: Rayon d'or	1, 2, 3

Steam Filatures—*continued.*

Good Marks A.

Soyzun: Eagle	Extra 1. 2. 3
Yahwo: Soleil	Extra 1. 2
Chuntsiang: Flying Lizards	1. 2. 3
Yungtai: Double Gold Deer	1. 2. 3
Yatchong: Gold Watch	Extra 1. 2
Yahlung: Trois Etoiles	1. 2. 3
Dahlun: Stork	1. 2. 3
Yuezung: Gold Elephant	1. 2. 3
Yuenlung: Dragon	1. 2. 3
Keechong: Flag	1. 2. 3
Yuenchong: Star and Dragon	1. 2. 3
Hunkee: Tiger	1. 2. 3
Dong Yah Dzang	Extra 1. 2
Shingtze: Lion	1. 2. 3
Tsunwo: Mulberry Tree and Web	1. 2. 3
Chingwha: Worm, Leaf and Cocoons	1. 2. 3
Poa Woo: Lighthouse	1. 2. 3
Yue Lun: Tramcar	1. 2. 3
Sooking: Centaur	1. 2. 3
Lungwha: Single Dragon	1. 2. 3
Hahiho: Two Gods	1. 2. 3
Sung Mu: Médaille	1. 2. 3
Tschenglung: Flying Tiger	Extra 1. 2
Nee Chong: Bell	Extra 1. 2
Kinglung: Excelsior	1. 2. 3
Soylum: Gold Star	1. 2. 3

Good Marks B.

Yungtah: Gold Globe	1. 2. 3
Yue Chong: Snow Hill and Pagoda	1. 2. 3
Lun Chong: Flying Horse	Extra 1. 2
Jeaykhong: Black Lion	1. 2. 3
Soyzun: Cock	1. 2. 3
Sooking: Woman and Loom	1. 2. 3
Darkin: Double Phœnix	1. 2. 3
Zunchong: Double Cocks	Extra 1. 2
Whafong: Two Riding Josses	1. 2. 3
Wooshing: Sun	1. 2. 3
Tsunchong: Double Anchor	1. 2. 3
Soochow: Double Gold Pagoda	1. 2. 3
Keechong: Star and Pagoda	1. 2. 3
Yae Kih: Joss and Unicorn	1. 2. 3

STEAM FILATURES—*continued.*

Marks Current A.

Dong Yah Chang: Double Lions	1. 2. 3
Chiankee: Double Tiger	1. 2. 3
Jinchong: Red Star	1. 2. 3
Kinglun: Railway and Train	1. 2. 3
Young Lee: Three Sheep	1. 2. 3

Marks Current B

Chang Shing: Five Tigers	1. 2. 3
Wayuen: Steamboat	1. 2. 3
Tsuncheong: Gold Star	1. 2. 3
Sung Tai: Red Cross	1. 2. 3
Kinglun: Double Gold Horse	Extra 1. 2
Yung Tai: Moon and Rabbit	1. 2

Hupeh: Imperial Dragon	1. 2. 3
Shantung: Gold Flying Bear	1. 2. 3

SHANGHAI RE-REELS FOR NEW YORK.

Best Chops.

{ Gold Dragon	Extra 1. 2
{ Gold Pagoda	1. 2. 3

Value 10/15 Taels less than Gold Dragon.

{ Dragon Flag	Extra 1. 2
{ Wild Man	Extra 1. 2
{ Stars and Stripes	1. 2. 3
{ Red Indian	1. 2. 3
{ Solstice	A. B. C.
{ Gold Globe	A. B. C.
{ Lion and Scale	1. 2. 3
{ Sheep and Flag	1. 2. 3
{ Gold Dollar	Extra 1. 2
{ Fountain	Extra 1. 2
{ Blue Dragon	Extra 1. 2
{ Flying Horse	Extra 1. 2

Shanghai Re-reels for New York—*continued.*

Value 10/15 Taels less than Gold Dragon—*continued.*

{ Red Almond Flower	Extra	1.	2	
{ Green Almond Flower	Extra	1.	2	
{ Five Lions	Extra	1.	2	
{ Leopard	Extra	1.	2	
{ Old Man		1.	2.	3
{ Two Men		1.	2.	3
{ Ironclad	Extra	1.	2	
{ Torpedo Boat		1.	2.	3
{ Gold Double Eagle	Extra	1.	2	
{ Silver Double Eagle	Extra	1.	2	
{ Gold Motor Car	Extra	1.	2	
{ Silver Motor Car	Extra	1.	2	
{ Gold Peacock	Extra	1.	2	
{ Silver Peacock	Extra	1.	2	
{ Gold H (Mark)		1.	2.	3
{ Silver H (Mark)		1.	2.	3
{ Cloud Lion		1.	2.	3
{ Flying Stork		1.	2.	3
{ Gold Flying Dragon	Extra	1.	2	
{ Silver Flying Dragon	Extra	1.	2	
{ Gold Flying Kite	Extra	1.	2	
{ Silver Flying Kite	Extra	1.	2	
{ Shield and Flags	Extra	1.	2	
{ Arrows and Bow	Extra	1.	2	
{ Three Gold Josses	Extra	1.	2	
{ Three Silver Josses	Extra	1.	2	

15/20 Taels less than Gold Dragon.

{ Galley		1.	2.	3
{ Dragon Boat		1.	2.	3
Cloud and Dragon	Extra	1.	2	
{ Flying Eagle		1.	2.	3
{ Horse		1.	2.	3
{ Gold Zebra	Extra	1.	2	
{ Silver Zebra	Extra	1.	2	
{ Gold Riding Horse		1.	2.	3
{ Silver Riding Horse		1.	2.	3
{ Gold Sycee and Boy	Extra	1.	2	
{ Silver Sycee and Boy	Extra	1.	2	
{ Gold Double Swallow		1.	2.	3
{ Silver Double Swallow		1.	2.	3
{ Gold Hand	Extra	1.	2	
{ Silver Hand	Extra	1.	2	

Shanghai Re-reels for New York—*continued.*

25/30 Taels less than Gold Dragon.

Crown		1. 2. 3
Woman and Loom		1. 2. 3
(Red Mark) Sun E Tah		A. B. C.
Gold Winding Mill	Extra	1. 2
Tiger	(gold) Extra	(silver) (black) 1. 2
Gold Phœnix		1. 2. 3

110/120 Taels less than Gold Dragon.

Columbia		1. 2. 3
Black Lion		1. 2. 3
Wild Dragon		1. 2. 3
Small Buffalo		1. 2. 3
Three Gold Foxes		1. 2. 3
Woman and Loom (Tarkong)		1. 2. 3
,, ,, ,, (Yuenlee)		1. 2
Three Arrows		1. 2. 3
Gold Kangaroo	Extra	1. 2
Red Peacock	Extra	1. 2
Black Peony		1. 2. 3
Carriage	Extra	1. 2
Gold Eagle and Skein		1. 2. 3
Medal		1. 2. 3
Gold Stork		1. 2. 3
Blue Zebra	Extra	1. 2
Gold Buffalo		1. 2. 3
Three Men		1. 2. 3
Oregon	Extra	1. 2
Black Double Guns		1. 2. 3
Black Hand	Extra	1. 2
Red Double Swallow		1. 2. 3
Blue Mark (Sun E Tah)		A. B. C.
Red Elephant		1. 2. 3
Blue Stork	Extra	1. 2
Silver Double Rabbit		1. 2. 3
Gold Peony		1. 2

Shanghai Re-reels for New York—*continued.*

120/130 Taels less than Gold Dragon.

Red Riding Horse	1. 2. 3
Bell	1. 2. 3
Double Fish	Extra 1. 2

10/15 Taels less than Columbia.

Yellow Lion	1. 2. 3
Gold Cash	1. 2
Red Stork	1. 2
Gold Tiger	Extra 1
Silver Stork	1. 2. 3
(Taels 20.—Dearer than Tsatlee Filature cross S. S. S. Mars)	
Mars S. S. S.	1. 2
Blue Riding Horse	1. 2. 3

Haining improved Re-reels.

{ Shield and Flags	Extra 1. 2
{ Arrows and Bow	Extra 1. 2
Green Flying Stork	1. 2. 3

Haining Filatures Cross-reeled for New York.

Best Chops.

Blue Dragon	Extra 1. 2
Fighting Cock	A. B. C.
Gold Butterfly	1. 2. 3
Watermark	1. 2. 3
Balloon	Extra 1. 2

Haining Filatures Cross-reeled for New York—*contd.*

Good Chops.

Flying Horse	Extra 1. 2
Cock and Centipede	1. 2. 3
Butterfly and Almond Flower	1. 2. 3
Blue Lion	1. 2. 3
Gold Flying Dragon	Extra 1. 2. 3

Middling Chops.

Pegasus	Extra 1. 2. 3
Buffalo	Extra A. B. C.
Black Horse	Extra 1. 2. 3
Bicycle	Extra 1. 2. 3
Grasshopper	Extra A. B. C.
Hankonshing	Extra 1. 2. 3
Mountain and Pagoda	1. 2. 3
Gold Double Rabbit	Extra 1. 2
Red Pagoda	Extra 1. 2
Gold Lion	Extra 1. 2
Fisherman	Extra 1. 2
Gold Dollar	A. B. C.

Inferior Chops.

Double Fish	Extra 1. 2
Small Buffalo	Extra 1. 2
Eagle and Skein	Extra 1. 2
Gold Mars (Chuntah)	Extra 1. 2
Mars (Sze She Shing)	Extra 1. 2
,, (Saw E Kee)	Extra 1. 2
,, (Kunchee)	Extra 1. 2
Cupid	1. 2
Green Flying Horse	1. 2
Shanghai Bund	1. 2
Double Birds	1. 2

Tsatlée Filatures Cross-reeled for New York.

Best Chops.

Blue Dragon	Extra 1. 2
Blue Monster	Extra 1. 2
Fighting Cock	A. B. C.
Gold Butterfly	1. 2. 3
Old Man	Extra 1. 2
Stork and Cloud	Extra 1. 2
Balloon	Extra 1. 2. 3

Good Quality.

Flying Horse	Extra 1. 2
Race Horse	Extra 1. 2
Cock and Centipede	1. 2. 3
Butterfly and Almond Flower	1. 2. 3
Double Men	1. 2. 3
Blue Lion	1. 2. 3
Gold Flying Dragon	Extra 1. 2. 3
Atlas	Extra 1. 2. 3
Plough	1. 2. 3
Gold Cock	1. 2. 3
Gold Butterfly (Cat and Bee)	Extra 1. 2. 3

Medium Quality.

Pegasus	Extra 1. 2. 3
Buffalo	Extra A. B. C.
Black Horse	Extra 1. 2. 3
Red Pagoda	Extra 1. 2. 3
Bicycle	Extra 1. 2. 3
Grasshopper	Extra A. B. C.
Cloud and Bridge	Extra 1. 2. 3
Blue Phœnix (Sun E Tah)	Extra 1. 2
Blue Mark (Sun E Tah)	A. B. C.
Red Eagle	Extra 1. 2. 3

TSATLÉE FILATURES CROSS-REELED FOR NEW YORK—*contd.*

Value 5/10 Tales less than Pegasus Extra.

Green Pine and Stork	Extra 1. 2. 3
Gold Goat	Extra 1. 2. 3
Double Cock	Extra A. B. C.
Monkey and Bee	Extra 1. 2
Zee May Zee	1. 2. 3
Gold Lion (Yao-ta-zung) . . .	Extra 1. 2. 3

15/20 less than Pegasus Extra.

Worm and Leaf	1. 2. 3
White Horse	Extra 1. 2. 3
Sun and Cloud	Extra 1. 2
Gold Double Rabbit	Extra 1. 2

Quality Inferior.

Double Fish	Extra 1. 2
Gold Dragon	1. 2
Gold Buffalo	Extra 1. 2
Small Buffalo	Extra 1. 2
Black Tiger	Extra 1. 2
Eagle and Skein	Extra 1. 2
Gold Mars (Chuntah) . . .	Extra 1. 2
Gold Mars (Pee Va May) . . .	1. 2
Gold Dollar	A. B. C.
Oregon	Extra 1. 2
Gold Unicorn	Extra 1. 2
Black Unicorn	Extra 1. 2
Mars S. S. S.	Extra 1. 2
Mars Tokong	Extra 1. 2
Mars S. Y. K.	Extra 1. 2
Double Birds	1. 2
Mercury	Extra 1. 2
Tower	A. B. C.
Fan	1. 2. 3
Gold Pony	Extra 1. 2
Gold Clock	1. 2
Gold Lion (Taikee)	1. 2
Blue Phœnix (Yao-ta-zung) . .	1. 2
Mars (Kungkee)	1. 2
Steamboat	Extra 1. 2

Tsatlée Filatures Cross-reeled for New York—*contd.*

Quality Inferior—*continued.*

Genet	1. 2
Blue Eagle	1. 2
Flag Keechong	1. 2
Locomotive	1. 2

Tsatlées Filatures (Ordinary).

Best Chop.

Crown	1. 2. 3

Good Quality.

Buffalo	A. B. C. D.
Pegasus	1. 2. 3. 4
Black Horse	1. 2. 3. 4
Red Eagle	1. 2. 3. 4
Mountain and Pagoda	1. 2. 3. 4
Blue Pheasant	1. 2. 3
Grasshopper	A. B. C. D.
Red Dragon	1. 2. 3. 4
Red Pagoda	1. 2. 3. 4
Bicycle	Extra 1. 2. 3. 4
Blue Lion	1. 2. 3. 4
Black Lion	A. B. C. D.

Medium Quality.

Gold Flying Eagle	1. 2. 3. 4
Gold Stork	1. 2. 3. 4
Gold Goat	1. 2. 3. 4
Blue Goat	1. 2. 3
Double Cock	A. B. C. D.
Green Pine and Stork	1. 2. 3. 4
Black Eagle	1. 2. 3
White Horse	1. 2. 3
Gold Mandarin Duck	1. 2. 3. 4
Yellow Tiger	1. 2. 3. 4
Triton	A. B. C.
Fan	1. 2. 3
Gold Eagle	1. 2. 3

Tsatlées Filatures (Ordinary)—*continued.*

Inferior Quality.

Small Buffalo	1. 2
Double Fish	Extra 1. 2. 3
S. S. S. Mars	1. 2
S. E. K. Mars	1. 2
Gold Dollar	A. B.
Cupid	1. 2
Black Unicorn	1
Evergreen	1. 2
Blue Phœnix (Yao ta Zung)	1. 2
Gold Phœnix	1. 2. 3
Shanghai Bund	1. 2
Pee Va May Gold Mars	1. 2
Chuntah Gold Mars	1. 2
Mercury	1. 2
Eagle and Skeins	Extra 1. 2. 3
Red Stork	1. 2
Gold Unicorn	1. 2
Gold Flying Tiger	1. 2. 3
Flag	1. 2. 3
Double Birds	1. 2
Kunchee Mars	1. 2
Blue Eagle	1. 2
Genet	1. 2
Steamboat	1
Gold Lion	1. 2. 3
Star and Cloud	1. 2

Haining Filatures (Ordinary).

Best Chop.

Crown	Extra 1. 2. 3

Good Quality.

Han Kon Shing	Extra 1. 2. 3. 4
Mountain and Pagoda	Extra 1. 2. 3. 4
Gold Pheasant	A. B. C. D.
Grasshopper	A. B. C. D.
Pegasus	Extra 1. 2. 3. 4

Haining Filatures (Ordinary)—*continued.*

Good Quality—*continued.*

Bicycle	1. 2. 3
Black Horse	Extra 1. 2. 3. 4
Red Dragon	1. 2. 3. 4
Gold Flying Eagle	1. 2. 3. 4
Buffalo	Extra A. B. C. D.
Red Pagoda	Extra 1. 2. 3. 4
Fisherman	Extra 1. 2. 3. 4
Kangaroo	Extra 1. 2. 3
Black Lion	1. 2. 3. 4
Red Peony	1. 2. 3
Gold Double Rabbits	1. 2. 3
Sun and Phœnix	Extra 1. 2. 3
Gold Mandarin Duck	1. 2. 3. 4
White Horse	Extra 1. 2. 3. 4

Inferior Quality.

S. S. S. Mars	1. 2
Pee Va May Gold Mars	1. 2
Evergreen	1. 2
Green Lion	1. 2
Kunchee Mars	1
Star and Cloud	1. 2

Haining Books.

	Best Chops.	Good Chops.
Extra	Mountain and Pagoda. Hankonshing. Pegasus. Grasshopper.	Sun and Phœnix. Fisherman.
1	Mountain and Pagoda. Hankonshing. Pegasus. Grasshopper. Gold Double Rabbit. Double Pagoda. Black Lion. Gold Flying Eagle.	Sun and Phœnix. Fisherman. Gold Mandarin Duck.

HAINING BOOKS—*continued.*

	Best Chops.	Good Chops.
2	Mountain and Pagoda. Hankonshing. Pegasus. Grasshopper. Gold Double Rabbit Double Pagoda. Black Lion. Gold Flying Eagle.	Sun and Phœnix. Fisherman. Gold Mandarin Duck.
3	Mountain and Pagoda. Hankonshing. Pegasus. Grasshopper. Gold Double Rabbit. Double Pagoda. Black Lion. Gold Flying Eagle.	Sun and Phœnix. Fisherman. Gold Mandarin Duck.
4	Mountain and Pagoda. Hankonshing. Pegasus. Grasshopper. Black Lion.	Fisherman. Gold Mandarin Duck.

KAHING (GREEN).

	Best Chops.	Good Chops.	Market Chops.
Extra	Fish and Man Extra.		
1	Fish and Man 1. Swan 1. Mandarin Duck M.	Woman and Loom 1. Gold Swallow 1. Gold Eagle Extra.	
2	Swan 2. Mandarin Duck M M.	Woman and Loom 2. Gold Swallow 2. Gold Eagle 1.	
3	Swan 3. Mandarin Duck M M M.	Woman and Loom 3 Gold Eagle 2.	Almond Flower 1.
4	Swan 4. Mandarin Duck M M M M.		Almond Flower 2. Gold Star 1.

HAINING BOOKS—*continued.*

	Best Chops.	Good Chops.
2	Mountain and Pagoda. Hankonshing. Pegasus. Grasshopper. Gold Double Rabbit Double Pagoda. Black Lion. Gold Flying Eagle.	Sun and Phœnix. Fisherman. Gold Mandarin Duck.
3	Mountain and Pagoda. Hankonshing. Pegasus. Grasshopper. Gold Double Rabbit. Double Pagoda. Black Lion. Gold Flying Eagle.	Sun and Phœnix. Fisherman. Gold Mandarin Duck.
4	Mountain and Pagoda. Hankonshing. Pegasus. Grasshopper. Black Lion.	Fisherman. Gold Mandarin Duck.

KAHING (GREEN).

	Best Chops.	Good Chops.	Market Chops.
Extra	Fish and Man Extra.		
1	Fish and Man 1. Swan 1. Mandarin Duck M.	Woman and Loom 1. Gold Swallow 1. Gold Eagle Extra.	
2	Swan 2. Mandarin Duck M M.	Woman and Loom 2. Gold Swallow 2. Gold Eagle 1.	
3	Swan 3. Mandarin Duck M M M.	Woman and Loom 3 Gold Eagle 2.	Almond Flower 1.
4	Swan 4. Mandarin Duck M M M M.		Almond Flower 2. Gold Star 1.

TSATLEES.

No.	Best Chops.	Good Chops.	Market Chops.	Inferior Chops.
4	Black Lion $3\frac{1}{2}$.	Red Elephant.		
		Mountain 1.		
	Buffalo 2.	Red Pagoda 2.		
$4\frac{1}{2}$	Black Lion 4.	Mountain 2.		
		Bird Fongling.		
	Buffalo 3.	Red Pagoda 3.		
$4\frac{3}{4}$	Black Lion $4\frac{1}{2}$.	Blue Elephant.		
		Mountain 3.		
		Siefong.		
		Bird Chunling.		
		Buffalo 4.		
		Red Pagoda 4.		
5 Best	Mountain 4.	Yellow Elephant.		
	Gold Elephant.	Red Pagoda 5.		
5 Bonnes	Mountain 5.	Bird Yuenling.		
	Gold Lion Kintze.			
	Double Silver Elephant.	Sœyfong.		
5 Courantes	Gold Kiling.		Mandarin Duck 1.	
			Stork Foling.	
5 Ordinary	Double Blue Elephant.	Bird Seeling.	Cocoon Quanfong.	
		Jeahfong.		
		Green Elephant.	Mandarin Duck 2.	
		Blue Phœnix Lanfong.		
5 Infér.	Blue Stork Choiling.	Triple Pagoda.	Cocoon Choeyfong.	Almond Flower Siemay
	Chœy Kiling.	Bird Teayling.	Mandarin Duck 3.	Almond Flower Sielye
			Stork Cheangling.	Double Pagoda.
				Running Deer.

KAHING (WHITE).

Extra.	1	2	3	4
Gold Lily Flower Extra.	Gold Lily Flower 1.	Gold Lily Flower 2.	Gold Lily Flower 3.	Gold Lily Flower 4.
Tsu Kee Yuen Gnaling.	Tsu Kee Yuen Kinling.	Tsu Kee Yuen Fongling.	Tsu Kee Yuen Sueling.	

HANGCHOW TSATLÉES.

	Best Chops.	Good Chops.	Market Chops.
1 Best	Lily Flower Lantyar. Pagoda Tingfong. Peony and Phœnix Extra.	Blue Lion Extra.	Stork and Tree Extra.
1	Lily Flower Laegno. Pagoda Layfong. Peony and Phœnix 1.	Blue Lion 1.	Stork and Tree 1.
2	Lily Flower Laebing. Pagoda Deahow. Peony and Phœnix 2.	Blue Lion 2.	Stork and Tree 2.
3	Peony and Phœnix 3. Lily Flower Laeling.		

CHINCUMS.

	Best Chops.	Good Chops.	Market Chops.
I.	Tiger Extra Best.	Peach, Tree and Nut 1 Gnoling.	Fighting Cock 1. Blue Flying Dragon 1. Double Lion 1. Gold Pagoda Extra.

WOOZIES.

	Best Chops.	Good Chops.	Market Chops.	Inferior Chops.
Extra	Gold Pheasant. Green Horse 1. Green Stork Extra.	Gold Butterfly.	Deer and Stork 1.	
1	Blue Pheasant. Green Horse 2. Green Stork 1.	Single Butterfly. Double Horse 1. Double Dragon 1.	Deer and Stork 2.	
2 Best	Blue Pheasant 2. Green Horse 3. Green Stork 2.	Double Butterfly 1. Double Horse 2. Double Dragon 2.	Deer and Stork 3.	
2 Market	Blue Pheasant 3. Green Horse 4. Green Stork 3.	Double Butterfly 2. Double Horse 3. Double Dragon 3.	Deer and Stork 4.	
3	Green Horse 5. Green Stork 4.	Double Dragon 4.		Gold Bear Extra. Gold Bear No. 1.

CHINCUMS—*continued.*

	Best Chops.	Good Chops.	Market Chops.
II.	Tiger Extra.	Peach, Tree and Nut 2 Gnoling.	Fighting Cock 2. Blue Flying Dragon 2. Double Lion 2. Gold Pagoda 1.
III.	Tiger No. 1.	Peach, Tree and Nut 3 Gnoling.	Fighting Cock 3. Blue Flying Dragon 3. Double Lion 3. Gold Pagoda 2. Gold Stork 4. Blue Flying Eagle 4.

SKEINS.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Double Men 1. Lucky Twins 1. Three Men 1.	Double Men 2. Lucky Twins 2. Three Men 2.	Double Men 3. Lucky Twins 3. Blue Monster 1. Old Man 1. Green Monster 1.	White Stork Extra. Blue Monster 2. Old Man 2. Green Monster 2.	White Stork 1. Red Monster. Old Man 3.

SHANTUNG (FINE).

1 Best.	2 Best.	3 Best.	4 Best.
Gold Buffalo. Double Dragon 1. Lily Flower 1. Double Almond Flower 1. Black Triple Lion 1.	Gold Elephant. Double Dragon 2. Lily Flower $1\frac{1}{2}$. Double Almond Flower 2. Black Triple Lion 2.	Double Dragon 3. Double Almond Flower $2\frac{1}{2}$. Black Triple Lion 3.	Blue Goat. Double Dragon 4. Blue Stork.

SHANTUNG (COARSE).

Extra.	Best.
Gold Stork Lay Vo.	Gold Stork Lert Cee.
Silver ,, ,,	Silver ,, ,,
Blue ,, ,,	Blue ,, ,,
Gold Stag ,,	Gold Stag ,,
Silver ,, ,,	Silver ,, ,,
Blue ,, ,,	Blue ,, ,,

1	2	3
Gold Stork Charpar.	Gold Stork Mar Deu.	Gold Stork Quay Lee.
Silver ,, ,,	Silver ,, ,,	Silver ,, ,,
Blue ,, ,,	Blue ,, ,,	Blue ,, ,,
Gold Stag ,,	Gold Stag ,,	Gold Stag ,,
Silver ,, ,,	Silver ,, ,,	Silver ,, ,,
Blue ,, ,,	Blue ,, ,,	Blue ,, ,,
Gold Stork Chuntong (Tungloo).		
Silver ,, ,,		
Blue ,, ,,		
Gold Stag ,,		
Silver ,, ,,		
Blue ,, ,,		

YELLOW SILKS FROM THE SEYCHUEN DISTRICT.

Minchew	Extra	Good I.	Market I.	Best II.	No. 2 Common
Kopun	Extra	Good I.	Market I.	No. $1\frac{1}{2}$	No. 2
Meeyang					
Yellow	Market I.	No. $1\frac{1}{2}$	No. 2		
White	Best I.	Market I.	No. $1\frac{1}{2}$	No. 2	
Fooyung					
Yellow	Bèst I.	Market I.			
White	Best I.	Market I.	No. $1\frac{1}{2}$	No. 2	
Wongyi	Best I.	Market I.	No. $1\frac{1}{2}$	No. 2	
Wangchew	Best I.	Market I.	No. 2		
Songtsan	No. 1				
Szechong	Best I.	Market I.	No. $1\frac{1}{2}$	No. 2	

TUSSAH FILATURES.

True Filatures.
Whafong: Worm and Leaf 1 and 2. Yee Foong: Gold Double Dragon ,, Whatai: Flag 1, Blue Cross 2.

Best.	Good A.
Spinning Girls 1.	Spinning Girls 2.
Black Pagoda 1.	Black Pagoda 2.
Sun and Pagoda 1.	Sun and Pagoda 2.
Gold Bell.	Silver Bell.
Black Monkey 1.	Black Monkey 2.
Peony 1.	Peony 2.
Gold Flying Fish.	Gold Toad.
Black Cowboy 1.	Black Cowboy 2.
Gold Unicorn 1.	Gold Unicorn 2.
White Double Elephant 1.	White Double Elephant 2.
Japanese Woman.	American and Chinese Flag 2.
American and Chinese Flag 1.	Black Double Magpie.
Black Double Magpie 1.	Wong Lie Soo.
Gold Stork.	Gold Single Man.
Black Leopard 1.	Gold Mars.
Black Pony.	Gold Woman.
Commercial Flag.	Black Single Deer.
Black Double Horses.	Black Single Goat.
	Almond Tree.
	Mandarin Horse.
	Gold Single Cock.
	Black Zebra.
	Sun.
	Gold Ostrich.
	Black Nine Ladies.
	Gold Eagle.
	Red Unicorn.
	Black Leopard No. 2.
	Double Mandarin Duck.
	Blue Butterfly.
	Gold Snake.
	Policeman.
	Black Double Lion.
	Black Flying Horse.

TUSSAH FILATURES—*continued.*

Good B.	Good B.
Gold Single Peach. Gold Double Rabbits. Gold Horse. Black Firtree. Black Riding Horse. Black Seven Stars. Red Double Wild Geese. Silver Woman.	Silver Ostrich. Silver Eagle. Silver Cock. Tramway. Gold Double Horse. Black Flying Dragon. Piano Girl.

Current A.	Current B.
Pluck Mulberry. Gold Phœnix. Gold Cash. Gold Double Men. Red Woman. Black Three Elephants. Red Cock. Red Ostrich. Red Eagle. Black Steamship. Red Nine Ladies. Black Double Goats. Gold Tiger. Blue Double Wild Geese. Gold Double Peach. Black Double Rabbit. Silver Single Peach. Moon. Black Locomotive.	Gold Three Men. Blue Cash. Silver Phœnix. Gold Double Pony. Silver Double Peach. Silver Double Rabbits. Green Woman. Gold Mountain. Green Locomotive. Gold Sampan. Gold Double Birds. Black Double Deer. Black Double Wild Geese. Blue Eagle. Blue Phœnix. Green Phœnix. Bicycle.

No. 2.	No. 2 Inferior.	No. 3.
Black Fan. Silver Mountain. Gold Fox. Three Deers. Red Sampan. Blue Sampan.	Gold Lion.	Gold Dog.

Classification of Native Reeled Tussahs.
By Messrs. A. Puthod & Co. (Importers).

Best.	Market No. 1.	Market No. 1½.	Market No. 2.	No. 3 and Inferior.
Gold Dragon "Extra." (Ching Cheong)				
Gold Star "Extra."	Gold Star.	Silver Star.	Red Star.	Golden Vase.
Greyhound I.	Greyhound II.	Greyhound III.	Greyhound IV.	
Gold Anchor "Extra."	Gold Anchor.	Silver Anchor.	Red Anchor.	
Gold Bird "Extra."	Gold Bird.	Silver Bird.	Red Bird.	Black Bird.
Gold Cock and Flag, Best I.	Cock and Flag Gold I.	Cock and Flag Gold II.	Cock and Flag Gold III.	Cock and Flag Gold IV.
Blue Horse "Extra."	Blue Horse.	Red Horse.	Green Horse.	Yellow Horse.
Gold Lyre.	Gold Teapot.	Silver Teapot.	Red Teapot.	Gold Cat and Tree. Blue Cat and Tree.
Gold Parrot.	Gold Eagle.	Gold Pelican.	Gold Fish.	Silver Fish. Red Fish.
Blue Mountain.	Gold Mountain.	SilverMountain.	Red Mountain.	Green Mountain.
	Gold Railway.	Silver Railway.	Red Railway.	Black Railway.
	Gold Basilisk.	Silver Basilisk.	Red Basilisk.	Blue Basilisk.
Gold Cross.	Silver Cross.	Blue Cross.	White Cross.	Red Cross.
Moon "Extra."	Moon I.	Moon II.	Moon III.	Moon IV.
Gold Pheasant.	Gold Fairy and Deer.	Silver Fairy and Deer.	Red Fairy and Deer.	Blue Fairy and Deer. Yellow Fairy and Deer.
Yellow Ticket.	White Ticket.	Blue Ticket.	Red Ticket.	Ticket No. III.
	Gold Boudha.	Silver Boudha.	Red Boudha.	
Gold Temple "Extra."	Gold Temple.	Silver Temple.	Red Temple.	Black Temple. No. 3 Temple.
Gold Mandarin Extra Best.	Gold Mandarin Extra.	Gold Mandarin I.	Gold Mandarin II.	Gold Mandarin III.
	Gold Swallow.	Silver Swallow.	Red Swallow.	Blue Swallow. Yellow Swallow.
Gold Elephant "Extra." (Ching Cheong)	Gold Elephant.	Silver Elephant.	Red Elephant.	
Gold Phœnix "Extra."	Gold Phœnix I.	Gold Phœnix II.	Gold Phœnix III.	Gold Phœnix IV.
Double Magpie Gold "Extra."	Double Gold Magpie I.	Double Gold Magpie II.		
Gold Peacock "Extra."	Gold Peacock I.	Gold Peacock II.	Gold Peacock III.	

CHAPTER XVI

THE COTTON INDUSTRY

(By William H. Cook, of Manchester)

The cotton branch of the textile industry has increased at such a rate during the last century in all parts of the world, and has now arrived at such proportions, that it may safely be said to occupy the foremost position among the industrial arts.

It has more money invested in buildings, plant, and stock, and employs more workpeople, directly and indirectly, than any other manufacturing branch of trade in this, or probably any other country.

It is supposed that the manufacture of cotton originated in India about 1100 B.C., and the methods then used have practically remained the same, until within a comparatively recent date. The Hindoos spun yarn and manufactured material of as fine a quality as can be produced to-day in any Lancashire mill, equipped with the best and most modern machinery. In the course of ordinary events the trade in cotton and cotton goods spread westwards, until we find it in Italy in the fourteenth, Germany, Prussia, and England in the sixteenth, France in the seventeenth, and in Russia in the eighteenth century.

The first reported importation of cotton into England was in the year 1298, and it was mainly used for candle-wick. Manchester goods, which were principally made from a mixture of woollen and cotton, or linen and cotton, were first heard of in the year 1352.

The weight and value of the cotton used has reached an enormous amount, as will be seen from Table I., which has been compiled by the Cotton Spinners' Federation.

TABLE I.

COUNTRY.	Number of Spindles.	Cotton Used. All Kinds.
		Bales.
Great Britain . .	43,154,713	3,462,823
Germany . .	9,191,940	1,661,180
France . . .	6,603,105	923,423
Austria . . .	3,584,434	705,007
Italy . . .	2,867,862	731,357
Switzerland . .	1,413,896	89,360
Belgium . . .	1,110,600	190,756
Japan . . .	1,356,713	1,068,000
Spain . . .	1,387,500	255,754
Portugal . .	388,000	86,936
Russia . . .	2,361,513	548,892
Holland . . .	395,678	73,870
Sweden . . .	326,860	76,559
Norway . . .	65,776	10,647
Denmark . .	48,104	20,143
Levant . . .	23,184	13,100
Egypt . . .	39,200	4,386
United States of America . .	26,242,000	4,987,000
Total . .	100,561,078	14,909,193

These returns do not include China and some other small producing countries.

It will be noticed that the consumption per spindle varies very considerably in the different countries; this, in most cases, arises from the difference in the counts spun.

It will be seen also that 43 per cent. of the total spindles are in the United Kingdom.

The greater part of the cotton used is American, as out of the total of 14,909,193 bales used, 11,668,575 bales are of this variety.

The total production of American during the last season was 6,500,000,000 lbs. It is interesting to know that a little over a century ago an American ship which imported eight bags of cotton into Liverpool was seized on the grounds that so much cotton could not be produced in the United States.

The total world's production during the last twelve months is estimated at 8,000,000,000 lbs.

Particulars as to the number of looms and the amount of cloth produced in the various countries are not easy to obtain, but Table II. gives the fullest information obtainable in regard to the increases in production and reductions in wage costs of both cloth and yarn in the United Kingdom in the years 1856, 1880, and 1905.

Table II. is very interesting, as it shows that during the last half-century the weight of yarn produced has increased by 886·7 million lbs.

The hours worked have decreased by 7·5 per cent., and the labour cost per lb. of yarn has decreased by 55·8 per cent.

The production of cloth has increased by 7,950 million yards; the hours worked have decreased by 7·5 per cent., and the labour cost per yard has decreased by 24·36 per cent.

During the time these changes have been taking place the average wages of the operatives have increased by 94 per cent., as shown in Table III.

Table II.

Production and Costs of Cotton Yarns and Cloths in the United Kingdom.

	1856.	1880.	1905.
Raw Cotton Imports, millions of lbs.	1,023·8	1,629·2	2,203·5
Raw Cotton Exports, millions of lbs.	146·6	224·6	283·1
[1] Yarn Production, millions of lbs., average counts	745·6	1,194·0	1,632·3
Yarn Exported, millions of lbs.	182·0	215·7	205·0
Yarn for Home Consumption, millions of lbs., average counts	563·6	978·3	1,427·3
Cloth Production, millions of yards, average width	3,600·0	7,737·0	11,550·0
Cloth Exported, millions of yards	2,036·5	4,496·3	6,198·2
Number of Spindles	28,000,000	42,000,000	50,000,000
,, Looms	300,000	550,000	700,000
,, Operatives in weaving mills	175,000	246,000	306,000 [2]
,, Operatives in spinning mills	205,000	240,000	211,000 [2]
Working Hours per Week	60	56½	55½
Average Weekly Wages, 17 classes of operatives	14*s.* 6*d.*	19*s.* 10*d.*	26*s.* 2*d.*
Operatives per 1,000 Spindles	7·3	5·7	4·2
Production of Yarn per operative per year, lbs.	3,637·0	4,975·0	7,736·0
Production of Cloth per Operative, yards	20,580	31,860	37,740
Production of Yarn per Spindle per Year, lbs., average counts	27·0	28·5	32·6
Production of Cloth per Loom per Year, yards, average width	12,000	14,250	16,500
Labour Cost per lb. of Yarn, average counts	2·4*d.*	2·0*d.*	1·06*d.*
Labour Cost per Yard of Cloth, average width	·55*d.*	·447*d.*	·416*d.*

[1] Taking an average of 15 per cent. waste. Stocks not taken into account.
[2] From latest published Blue Books, 1903.

Table III.

Average Weekly Wages of Cotton-Mill Operatives, Manchester and Oldham Districts.

	1856. 60 hours per week.		1880. $56\frac{1}{2}$ hours per week.		1905. $55\frac{1}{2}$ hours per week.	
	s.	d.	s.	d.	s.	d.
Scutcher	8	0	13	8	24	6
Card-room Overlooker	28	0	38	6	50	0
Drawing-frame Tenter	9	0	15	0	19	0
Spinners' Overlooker	26	0	40	0	50	0
Mule Spinners (average of fine, medium, and coarse)	24	1	33	6	45	0
Mule Piecers (average of fine, medium, and coarse)	8	3	10	8	14	10
Throstle Spinners	9	0	14	0	16	0
Doffers	6	0	9	0	8	0
Reelers	9	0	12	0	17	0
Winders	9	0	14	2	18	0
Warpers	23	0	33	0	45	0
Beamers	22	0	24	9	22	0
Doubling Overlookers	28	0	24	0	35	0
Doublers	9	0	12	0	16	0
Gassers	9	6	13	0	20	0
Weavers (average number of looms)	11	2	15	3	24	0
Average of above seventeen classes of Operatives	14	6	19	10	26	2
Comparison, calculated for number of hours worked	100		144		194	

The altered conditions of the operatives are further seen by a comparison of the cost of living during the periods given in Tables II. and III. The particulars regarding cost of food have been obtained from the books of one of the large Manchester hospitals, no other data being to hand.

TABLE IV.

COMPARATIVE CONDITIONS OF COTTON MILL OPERATIVES IN THE UNITED KINGDOM.

	1856.	1880.	1905.
Total number of Operatives employed in Cotton Mills	380,000	486,000	523,000[1]
Number of Half-time Operatives	10,050	51,000	21,000[1]
Age of Children admitted to work Half Time	9 years.	10 years.	12 years.
Age of Children admitted to work Full Time	13 years.	13 years.	13 years.
	s. d.	s. d.	s. d.
Average House Rents	3 0	5 0	6 0
Paid by one of the Manchester Hospitals:—			
Meat, per lb.	0 7½	0 8	0 6
Flour, per doz. lbs.	2 6	2 0	1 2
Bread, per 4 lb. loaf	0 8½	0 7½	0 5½
Sugar, per lb.	0 7	0 3½	0 1¾
Tea, per lb.	4 6	2 0	1 4
Butter, per lb.	1 2	1 0	0 11

[1] From latest published Blue Books, 1903.

One very satisfactory feature in this table is the increase in the age at which children are allowed to commence work as half-timers. It is very probable that at a near date the system of half-time working will be abolished in the cotton trade, as has been done for some years in the engineering trade.

These increases in production have not arisen through any great mechanical invention, seeing that all the radical patents for spinning and weaving machinery are dated prior to 1825, with perhaps one or two exceptions, such as the Heileman Comber, the automatic feeder for openers and scutchers, or the piano feed-motion regulator.

Wyatt invented the drawing frame, and Kay the fly shuttle in 1738; Lewis Paul the card in 1748, and the clever doffing comb mechanism about 1750.

Hargreaves invented the spinning jenny in 1764, and Crompton the mule in 1779.

The scutcher was invented in 1797, to be improved by the addition of the lap-end by Mr. Creighton fifty years later, and the piano-feed regulator by Mr. Lord in 1862.

Holdsworth brought out his wonderful differential motion in 1830. It is so far back as 1825 that Richard Roberts invented his self-acting mule, and even the ring frame, which has made such tremendous strides during the last thirty years, was invented more than eighty years ago.

There has, however, been a steady improvement in the details of the various machines, and in the methods of production by the machine-makers, so that it is possible to run at much higher speeds, and for the operative to attend a much larger number of spindles than formerly.

A few of these improvements may be briefly mentioned:—

(1) The revolving flat card, in which the old rollers and clearers of the roller and clearer card, with the inconvenience and dirt, are replaced by a travelling apron of flats or combs. This machine has taken many years to secure universal adoption, but on account of the cleaner work produced and the less cost for attention it is now used in almost every case except for very low counts and waste; but it must be said that there are still many people who contend that the greater amount of waste made more than counteracts the saving in labour.

The percentage of waste in the roller and clearer card is generally about 2, whereas in the revolving flat card it is 5.

(2) Another great improvement is the presser used in connection with preparation frame spindles. This is a very simple but most effective addition to the spindle, and consists of the addition to the old flyer of a loose leg, to which is added a foot called a presser. The outer part, or leg, is heavier than the inner part, or foot, and during revolution the centrifugal force of the leg being greater than that of the foot causes an inward pressure on the bobbin, thus enabling the machine to make a bobbin which is not so liable to damage in the after-process, and also contains a much greater length of material. This improvement has tended, in a great degree, to the reduction of cost in the preparatory stages of spinning.

(3) The piano-feed regulator, patented in 1862 by Mr. Lord, is also worthy of notice. This invention has for its object the regulating of the lap. It consists of a number of pedals like the keys on a piano. These pedals "feel" the cotton, and if it is too thick or too thin they put into action a motion which decreases or increases the rate of feed, thus automatically adjusting the volume of cotton in accordance with the weight per yard decided upon.

(4) Another patent of importance is the "Rabbeth" spindle for ring spinning and doubling frames. When the ring frame was first introduced it had top and bottom bearings for the spindle, which required oiling every day. This, besides being troublesome, was liable to cause dirty yarn, and it was not possible to run the spindle at a greater speed than 5,000 revolutions per minute, whereas the "Rabbeth," or self-contained gravity spindle, only requires oiling about every two months, and even with an unbalanced bobbin will run steadily at 20,000 revolutions per minute,

a speed much higher than is required, the maximum speed at which the worker can attend to the frame being about 10,000 revolutions. It will readily be seen what a great effect this patent has had in increasing the production of yarn.

(5) Another patent is the cross-winding frame. This machine was rendered necessary mainly on account of the changes in the location of the spinning and the weaving mills, and to meet the different conditions existing between mule and ring spinning mills, as also the hostile foreign tariffs. These varied conditions made it necessary to be able to send the yarn from place to place with the smallest possible amount of tares.

(6) Then of late years we have had the introduction of the automatic feeder into the blowing-room. This machine automatically regulates the supply of cotton to the cylinder or beater of the opener, and thus more regular laps of cotton are produced than formerly, besides reducing the cost of attention 50 per cent.

(7) For certain classes and qualities the yarn spun on the mule is still considered to be superior to that produced on the ring spinning frame, especially for the very fine counts. Although the self-acting mule was invented and introduced some considerable time previous to 1856, the main principles are still the same, and the same facts hold good that this machine has only been improved in its detail parts. One of the main advances is concerning the number of spindles per mule. In 1856 and 1905 they were 500 and 1,300 respectively.

(8) Finally, there is the introduction of the various new types of looms. Previous to these there had been no radical alterations in the design of the loom for more than

fifty years. The automatic loom has made rather slow progress in England up to the present time, but there is no doubt they have come to stay. When it is borne in mind that a weaver can only attend to six looms of the old type, as a maximum, whereas he can attend to twenty-four or more of the new type, it will be seen that these automatic looms have a future before them.

In 1856, the earliest period in the tables of comparison, on page 323, the average spinning mill was constructed on very unsatisfactory principles, and it would contain about 30,000 spindles.

The mills generally had narrow, low, dark and ill-ventilated rooms, and the sanitary arrangements were exceedingly poor and unsatisfactory.

The power was in some cases transmitted by means of a water wheel, but steam engines were more generally adopted. These engines were of the beam type, single condensing, with cylinders up to 60 ins. diameter, and 8 ft. stroke, running 20 to 30 revolutions per minute. The steam pressure was from 20 to 60 lbs. per square inch, and the consumption about 25 lbs. of steam, and 3½ to 5 lbs. of coal per indicated horse-power.

The power was transmitted to the various rooms by means of spur gearing.

The spinning spindles were either of the mule or flyer type, running at 6,000 and 3,500 revolutions per minute, and producing ·52 lbs. and ·4 lbs. of yarn average counts, 32*s*. per spindle per week of 60 hours respectively.

The cost of such a mill was from 45*s*. to 50*s*. per spindle, including buildings, boilers, engines, machinery, and accessories. The cost of a weaving shed was £15 per loom.

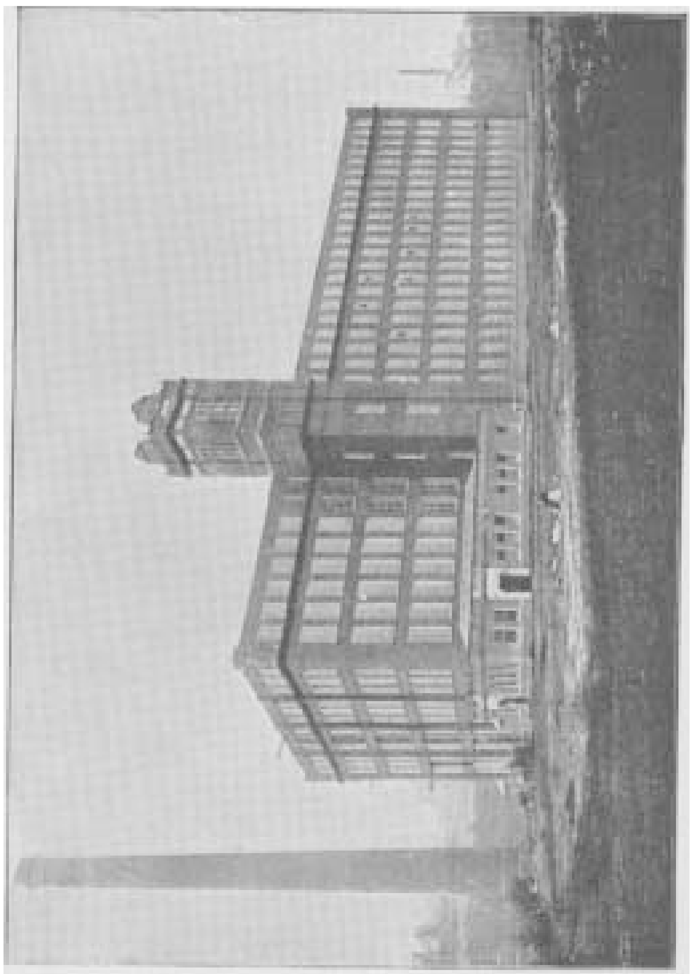

FIG. 75.—Modern Ring Spinning Mill.

At the present time the average mill contains about 80,000 spindles, and the yarn produced may be taken at an average of 40*s*. counts. The buildings are of the most approved design for cheap production and economical driving, and the sanitary arrangements are of the latest.

The machinery is so arranged that the raw cotton from the bale passes through the various machines until it arrives in the warehouse in the form of yarn, without traversing the same ground twice; that is, it pursues the shortest course possible to save cost in handling.

This is clearly shown on Fig. 75, which gives the arrangement of one of the most modern ring spinning mills, built in the shed form. This type has been adopted here because the whole of the processes in spinning and weaving can be clearly shown. In Fig. 76 a plan of a mill taking the cotton from the raw state to the finished product is given.

The power is mostly transmitted by steam engines, although great efforts are at present being made to introduce driving by electricity. Many mills in foreign countries have been arranged with this drive, particularly where there is a plentiful supply of water, which enables the engineer to install water turbo-generators, and to produce the electrical power much more cheaply than where steam is used.

Several mills have been fitted up in England recently with electrical driving, but the results have not yet been made public, so that it is not possible to say what prospects there are for this type of driving.

Steam turbines have also been installed into several mills with very satisfactory results.

Where steam engines are used they are of the recipro-

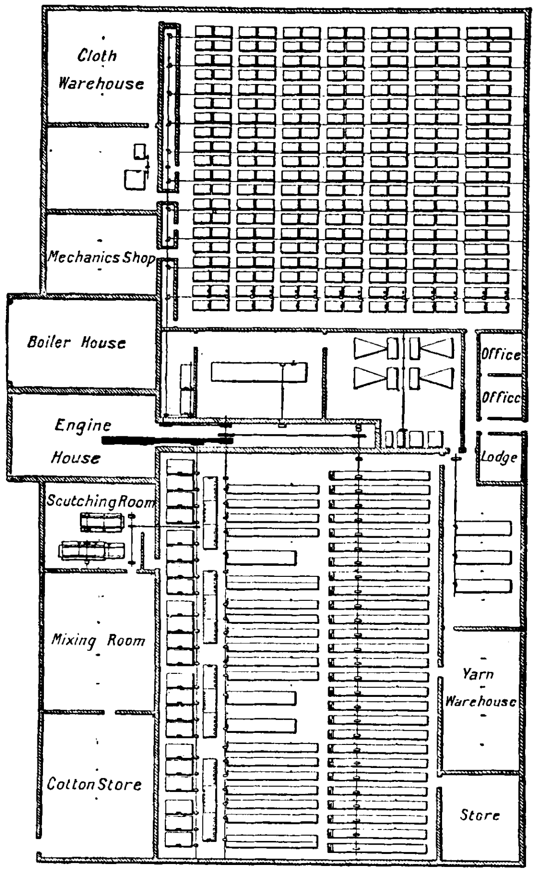

FIG. 76.—Plan of Cotton Mill.

cating type, either vertical or horizontal, with double, triple, and in some cases quadruple expansion, and of powers up to 2,500 indicated horse-power. The cylinders are made up to 66 in. diameter, with stroke up to 6 ft.

The crank shafts make 60 to 80 revolutions per minute, and are fitted with fly-wheels in the form of rope pulleys up to 30 ft. diameter, prepared to receive as many as fifty ropes of $1\frac{5}{8}$ in. diameter for driving the main shafts in the various rooms, thus dispensing with all spur gearing, giving greater freedom from breakdown, and much smoother and quieter running.

The steam consumption is from 12 to 16 lbs. of steam, and the coal consumption about $1\frac{1}{2}$ to 2 lbs. per indicated horse-power.

In cases where superheated steam is used the compound engine is about as economical as the triple expansion working under ordinary conditions.

The present mill hours are $55\frac{1}{2}$ per week.

The flyer frame has become almost obsolete, and the mills are either filled with ring or mule spindles, or in some cases both types of spinning machinery.

The speed of the spindles is—mule 11,000 revolutions, ring 9,500; and the production ·75 lbs. mule, and 1 lb. ring average counts 40*s*. per spindle per week respectively.

The various processes through which the cotton passes from the bales to the yarn or cloth are shown in the form of a diagram on page 334 (Fig. 77).

The cost of a mule mill is about 23*s*. per spindle, and the cost of a ring mill from 38*s*. to 42*s*. per spindle inclusive.

The cost of a modern weaving shed is about £26 per loom.

Most of the extra cost per spindle in the ring mill arises from the greater production per spindle, which, as a consequence, requires more preparation machinery.

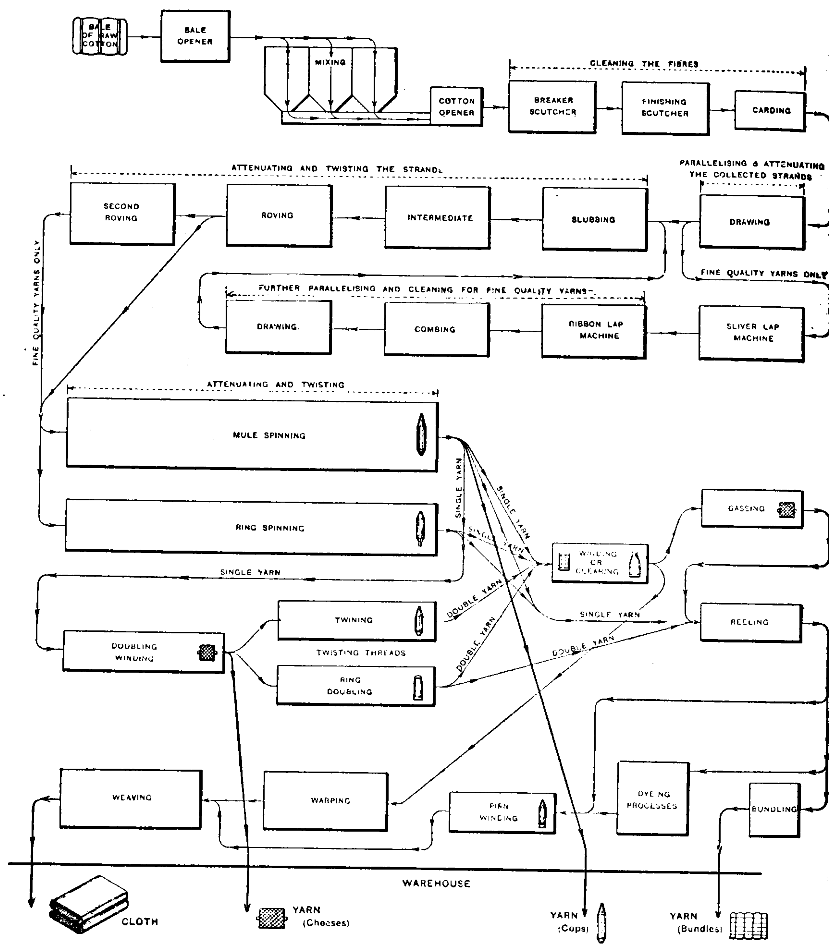

FIG. 77.—Graphic Illustration of Processes in Cotton Manufacture.

The greater cost of the modern weaving shed arises from the far superior manner in which it is fitted up.

The great reduction in the cost of erecting the modern mill is further apparent when it is known that the average wages of the employees in the machine works have increased $12\frac{1}{2}$ per cent., and the hours have been reduced $7\frac{1}{2}$ per cent.

It has only been possible to do this by the introduction of labour-saving machinery of the highest type.

The machine construction branch of the textile industry is now so well organized that even with the heavy duties which are imposed by foreign countries the greater part of the machinery used in all parts of the world is produced in England, and there does not appear to be any reason to fear that for a long time to come England will lose her supremacy in either the machine-making or the spinning or manufacturing branch of the textile industry.

CHAPTER XVII

THE LINEN INDUSTRY HISTORICALLY AND COMMERCIALLY CONSIDERED

By FRED BRADBURY, Professor of Textile Industries, Municipal Technical Institute, Belfast.

THE cultivation of the flax plant, the separation of the fibres from the straw, the preparing and spinning of these same fibres into yarns, and their subsequent manufacture into linen cloth form to-day no insignificant branch of the textile industry, employing, as it does, tens of thousands of persons in the various progressive sections from the sowing of the flax seed to the distribution of the finished woven product.

EARLIEST RECORDS.

The Biblical records testify that flax was cultivated, yarn spun, and linen fabrics woven in the patriarchal times. It is also interesting to know that the manufacture of *fine linens* is spoken of in all classical records, books, and writings from the earliest times.

If the growth of flax, together with all the subsequent processes of preparation and manufacture into cloth, were considered from the point of antiquity alone, it would form an interesting volume, since most people manifest an intense interest in anything which can justly claim to have its foundation in prehistoric times.

Flax.—The first mention in the sacred writings of *flax* by that name occurs in connection with the plagues of Egypt (Ex. ix. 31): "And the *flax* and the barley were smitten, for the barley was in the ear and the flax was bolled." The virtuous woman is described by Solomon as one who "seeketh wool and *flax* and worketh it with her hands. . . . She layeth her hands to the spindle and her hands hold the distaff. . . . She maketh fine linen and selleth it" (Prov. xxxi. 13, 19, 24).

Scriptural Records: Linen.—The first scriptural record of *linen* described by that name is found in Gen. xli. 42: "And Pharaoh took off his ring from off his hand and put it upon Joseph's hand, and arrayed him in vestures of *fine linen*, and put a gold chain upon his neck." This was in 1715 B.C., when Pharaoh exalted Joseph to the second position in the kingdom. Though this is the first reference to *linen* in the Scriptures, it is very evident that linen fabrics were made long before this period, since the reference is to *fine* linen, and *fine* linen can only be manufactured after many efforts and long experience. The sackcloth which Jacob put on (Gen. xxxvii. 34), when Joseph's coat of many colours was brought to him, was in all probability made of coarse linen cloth. Some historians contend that coarse fabrics of flax were produced in the antediluvian age, and that the covering of Jabal's tents (Genesis iv. 20, 3875 B.C.) were made of some coarse flaxen or hempen material.

Linen—Emblematic of Purity.—Wherever cleanliness and purity were required the chosen symbol among fabrics was linen, and in this respect it stands unique among all textile fabrics, and as such is spoken of as being of service in the glorious hereafter. Moses, in enumerating to the people the articles which might be offered for the fitting and completing of the tabernacle, says: "And blue and purple and scarlet and *fine linen* and goat's hair" (Ex. xxv. 4). Later, when Aaron and his sons were set apart as priests unto the people, instructions were given that Aaron's coat was to be embroidered in *fine linen*, and that his sons were to wear *linen* breeches. Further, whenever the Jewish priests entered in at the gates of the inner court of the sanctuary they were to be clothed with linen garments and no wool was to be upon them while they ministered within the gates. They were also to have linen bonnets upon their heads and linen breeches upon their loins during the ceremony, and were not to be girded with anything that causeth sweat (Ezek. xliv. 17, 18). St. John the Divine describes the seven angels as being clothed in pure white linen, and says: "For the fine linen is the righteousness of the saints;" and again: "The armies which were in heaven followed him upon white horses clothed in fine linen, white and clean."

Evolution of the Linen Manufacture.

Egypt—the Birthplace.—Historians generally agree that linen was first manufactured in Egypt. The flax plant was indigenous to the soil of Egypt, the climate and the Nile were favourable to its growth, and there appears to be no doubt as to its extensive cultivation in the earliest history of the country. It is an established fact that linen cloths were made in Egypt more than 4,000 years ago, specimens of the linen having been discovered in the land of the Pharaohs which were proved to be at least that age. Solomon had *linen yarn* brought out of Egypt, and the king's merchants received the *linen yarn* at a price (2 Chron. i. 16).

As already intimated, many of the fabrics woven in those early times have been preserved unto the present day as a result of the practice, then common, of embalming the dead. The choice of linen for this purpose was due to the material being able to resist the development of animal life in a more marked degree than fabrics made from animal fibres, such as wool, which germinate animal life much sooner, and consequently would defeat the end they were intended to serve.

Many of the linens thus preserved were fine in texture, but "set" much closer in the warp than in the weft. This may be largely due to the method then practised of inserting the shuttle into the warp shed with the one hand and then receiving it at the opposite side by the other hand. Then, too, since there was no "lay" for beating up the weft, the operation had to be performed with the aid of a stick, which necessarily meant slow and tedious work, however skilful the weaver might be. Nevertheless, some few of the textures thus woven compare favourably with many modern productions. A specimen among these cloths in plain weave revealed as many as 90 threads per inch in the warp and 45 in the weft; a second contained 150 threads of warp with about 70 shots of weft per inch respectively, involving the use of yarns which exceeded 100 leas of 300 yards each per lb.—a fine yarn and sett! One specimen is recorded to have contained at least 250 double threads per inch, with half the number of weft threads for the same length. The ancient tombs of Egypt reveal by pictures and other hieroglyphics the progressive stages through which the flax passed in those prehistoric times, and, singularly enough, the preparation of the fibre as then practised corresponds in many respects to the present method adopted, especially in Ireland. Some consider this an indication that the origin of the industry in the Emerald Isle was due to the migration of some Egyptians skilled in the art. There are many evidences to show that the Egyptians produced more yarn than their looms could weave and more cloth than the people themselves could consume, which, combined with the fact that they were not a commercial or maritime people, gave an opportunity to the Phœnician traders, who navigated the high seas for thirteen centuries to distribute their yarns and woven products. Much of the latter was first delivered in Tyre, where the inhabitants dyed the fabrics in colours, for which they were famous, and afterwards the Phœnicians re-exported the goods to Persia, Arabia, Palestine, Greece, Italy, Spain and France, etc.

Decline of Linen Manufacture in Egypt.—Eventually, as the years rolled on and Imperial arrogancy and oppression increased with the succeeding decades, the great enterprise hitherto displayed by the Egyptians in the peaceful arts and hereditary skill in textile crafts began to wane and gradually decayed.

Carthage, Babylon, and Greece.—With the advance of time, the renowned city of Carthage conducted the maritime commerce of the world, and discharged the duties of factor in *fine linens* as well as other textile materials. These goods they sent westward into the countries of Europe, including Britain. In Babylon and the whole region of the Euphrates the cultivation of flax was largely carried on, and the manufacture of linen was common in all the cities on the banks of the Tigris; but this industry has long since become extinct in these countries. Greece had also a small share in the growth of flax and manufacture of linen, though she was never much noted in this respect.

Italy—Rome.—It is but natural to expect that Imperial Rome, exercising a world-wide influence, should seek to introduce into her country such a peaceful and profitable art as linen manufacturing. In her earliest days of conquest and supremacy she chiefly imported linens from the East. Subsequently she gave every encouragement to the manufacture of the finest linens in several parts of Italy. The most important step probably ever taken in this respect was when she formed guilds or colleges of the factories which were noted for the manufacture of the best qualities and varieties of linens. In these Imperial factories all kinds of clothing were made for the Emperor's family and court, and also for the officers and soldiers of the army. The guilds were also useful in collecting knowledge pertaining to the weavers' craft and of disseminating it by her legions throughout the whole of the Roman Empire.

Spain.—After the withdrawal of the Roman soldiers from Spain the Moors overran the country, yet it is recorded that they manufactured linens on an extensive scale and exported large quantities.

Germany and Austria.—Ever since the dawn of the seventh century the linen trade has had a home in Germany. It is one of its oldest branches of industry, and formerly ranked amongst its most important. In 1169 the Hanse towns of Hamburg, Lübeck, and Bremen formed a league to protect their trade and commerce, of which linen products formed the most important section. The Hanseatic League existed for several centuries, during which time it distributed the linen manufactures of Germany throughout the chief centres of Europe. In sympathy with German manufacture, Austrian linens date from an early period.

France.—There was an extensive production of linens in Gaul at the time of the Roman domination of that country, and, notwithstanding all the vicissitudes of political fortune and revolution, the people have always carried on a considerable trade in the most delicate and finest of linens and other textile fabrics. This branch of the trade received its greatest check immediately following the Revocation of the Edict of Nantes, 1685, when the persecution of the Protestants became so acute that fully 600,000 skilled artisans, chiefly persons engaged in the textile trades, were obliged to leave their native land and seek refuge on other shores. About 70,000 of these refugees found a home in Great Britain or Ireland, and just as the woollen trade of Great Britain was materially assisted by the influx of these skilled artificers, so the linen trade of Ireland received its greatest impetus by their advent.

Various European Countries.—Other European countries, notably Holland and Belgium, carried on a large and important trade in linen for an extensive period. Belgium has always paid great attention to the cultivation of flax, and as far back as the tenth century she began to be famous for the manufacture of linen goods. On a somewhat smaller scale the flax plant was cultivated and linen cloth manufactured in other countries, notably Portugal, Denmark, Norway, Sweden, Switzerland, Turkey, and Russia.

United States of America.—The United States of America grows much flax, but its manufacture is, and always has been, comparatively small. To-day she is one of the best customers of Irish-made linens. There are signs, however, that the country is about to try the experiment of linen manufacturing. Recent reports intimate the erection of an extensive plant for same in Vermont.

Great Britain and Ireland.

No historical description of the flax industry would be complete, however brief, unless some reference were made to Ireland, where to-day, and for at least half a century, the production of flax yarns and manufacture of linens have stood out pre-eminently. Of necessity this industry in Ireland is inseparably linked to that of England and Scotland. In the traditional records of the "Four Masters" of the fifth century reference is made to "the weaves," "the flax scutching stick," "the distaff," etc.; the inference is left to the reader. The laws of the judges in Ireland, known as the ancient Brehon laws, required the farmers to learn the cultivation of flax.

The earliest authentic accounts of Irish linen manufacture date from the eleventh century, but the cloth made was only for home consumption, for the first exports occur in 1272, when it is recorded that Irish linen was used at Winchester. Generally speaking, England and Scotland acquired the art of linen manufacturing before Ireland. In 1253 Henry III. patronized English linens by ordering 1,000 ells for his wardrobe at Westminster. In the reign of Richard II. and the year 1382 a company of linen weavers, chiefly from the Netherlands, was established in London. But the climate and soil of Ireland were better adapted to the cultivation and growth of flax than those of Great Britain, and consequently she supplied the sister island with the raw material. Later, about the middle of the seventeenth century, we learn that Ireland produced more flax and spun more yarn than she could weave, and as a consequence "The merchants of Manchester bought 'lynne yarne' from the Irish in great quantities, and after weaving it into cloth returned it to Ireland for sale."

About the year 1670 the English Government sought by every means in her power to encourage the linen industry of Ireland in its entirety. At the same time she discouraged the woollen manufacture in the interests of her own manufactures of the same material. The methods, however, by which Lord Strafford (then Lord Lieutenant of Ireland) sought to promote the desired end were not always of the nature best calculated to accomplish that for which he strove; *e.g.*, "Any farmer, weaver, or linen draper who manufactures flax fibre by any other mode than that prescribed shall be punished with the severest penalty the law can inflict." Naturally the people resisted the injunction with a stubbornness that was characteristic of the times. During the year 1685, and resulting from the agitation among English woollen manufacturers, an agreement was made between the Parliaments of England and Ireland which imposed duties upon the exportation of Irish woollens, but sought in a variety of ways to improve and increase the production of Irish linens. It was not, however, until the seventeenth century was well advanced that the Irish linen trade attained any commercial importance. Then, owing largely to the Ulster colonists from Scotland, and later, the influx of the skilled French refugees, especially one—Louis Crommelin, a wealthy Huguenot who was induced to settle at Lisburn, near Belfast—the linen industry of Ireland made rapid progress. Crommelin, on the Revocation of the Edict of Nantes, fled first into Holland, where he became personally acquainted with William, Prince of Orange, afterwards William III. of England, by whose persuasion he was subsequently induced to settle in Ireland. Here he spared no personal expense in introducing improvements for developing the linen industry, notably in regard to the spinning wheel and the loom, and involved himself in an expenditure of £10,000. For these valuable services he received a grant of £800 per annum, but owing to the death of his Royal patron, William III., the grant ceased after the second year. In the year 1712 a Royal Commission was appointed to enquire into the Irish linen trade, and reported that "Louis Crommelin and the Huguenot colony have been largely instrumental in improving and propagating the flaxen manufactures in the north of Ireland, and the perfection to which the same is brought in that part of the country is largely owing to the skill and industry of the said Crommelin." Crommelin's name, together with that of Philip de Gerard, the inventor of the wet-spinning process, is being still further perpetuated on panels in a stained-glass window devoted to the Textile Industries Department in the new Municipal Technical Institute, Belfast.

Linen Board of Ireland.—In 1711 the English Parliament

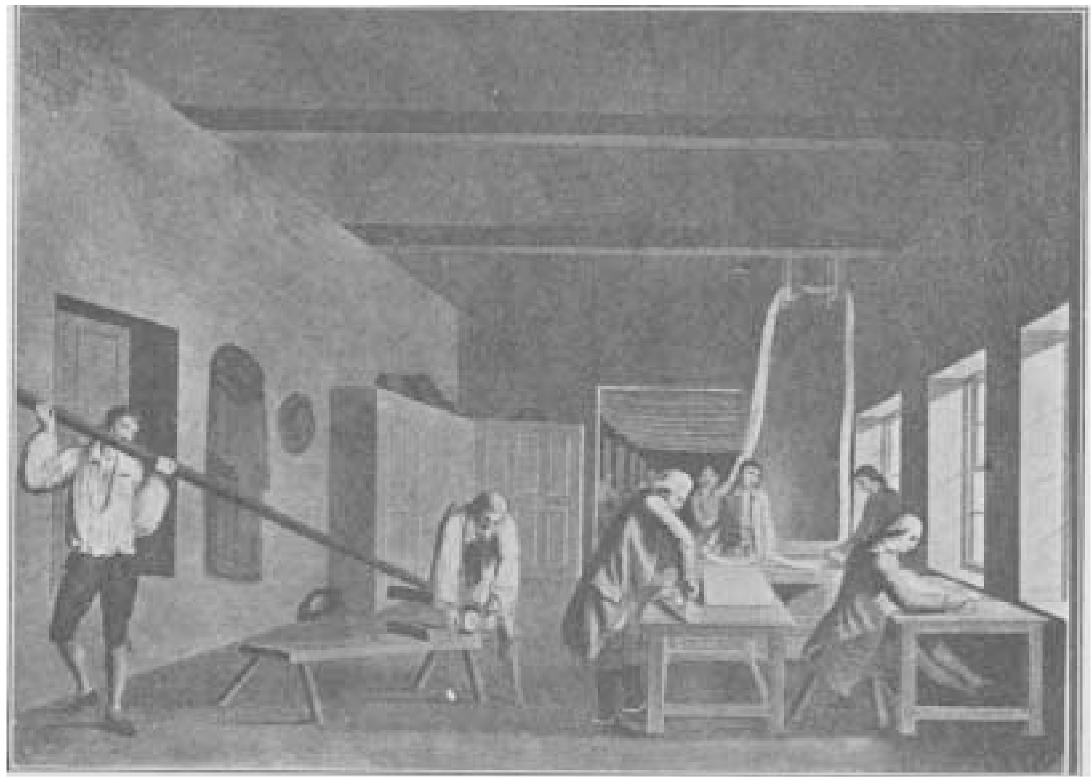

Fig. 78.—Perspective View of a Lapping Room in the olden times showing *measuring*, examining, folding the cloth into lengths, tying in the clips acting by the *mechanical power of the lever to press* the cloth round and firm, and *sealing* it preparatory to *sending it to the Linen Hall*.

created and endowed a Board of Trustees of linen and hempen manufacturers of Ireland to further encourage and develop the linen industry. During its existence the Board expended a sum of nearly £1,750,000 sterling from Imperial taxation for this purpose and the erection of a Linen Hall in Dublin. Upon the dissolution of the Board in 1828, Ireland had established her proud position in the world as an important linen manufacturing centre, and was fast displacing in the markets of the world the products of other linen-producing countries.

Sealing of Linens.—Among the many useful regulations imposed by the *Linen Board* was the introduction of an *Official Seal* for marking *white* linens before being exposed for sale, which resulted in a much-improved and superior-woven fabric. Guaranteeing as it did correctness of length and perfection of make, it inspired public confidence in all buyers of Irish linens. Subsequently the regulation stamp was extended to *brown* linens also with equally beneficial results. (For illustration see Fig. 78.)

Progress in Irish Linens.—By the year 1730 the trade had made such progress that in one month alone Ireland sent to the metropolis three times the length received by London from the whole of Holland; and so much did the linen trade of Ireland prosper that foreign manufacturers of linens became greatly alarmed.

In 1689, when William III. ascended the throne, the export of Irish linens amounted to £12,000; in 1701 the amount reached £14,120; the fifth decade of the same century saw the total at £365,838 12*s.* 3*d.*, so that in less than half a century the trade increased 250 per cent. If to this be added the export value of linen yarns for the same year the total value of linen exports reached half a million sterling.

In 1742 an import duty of 2*s*. 10*d*. per web was imposed on all foreign linens, and a bounty of 1*d*. per yard, later increased to 5*d*. per yard, on all British and Irish linens exported exceeding 1*s*. per yard encouraged the production of the finer fabrics.

Checks and Progress.—The linen trade of Ireland was not, however, of uninterrupted progress, for in the year 1773 about 30,000 people emigrated to America from Ulster alone, owing largely to trade being so bad. Yet statistics record that in the year 1784 the linen exports reached nearly 25 million yards, equal in value to about £1,250,000 and twelve years later the amount was practically double in quantity and value. At this time the finest linen cambrics sold at 25 guineas a web, equal to about one guinea per yard.

Bleaching Linens.—Besides favouring the growth of flax and the spinning of same, the climate of Ireland is well adapted for the bleaching of linens. In the early days this process occupied from two to three months, for it was accomplished by natural means in the open fields. Stealing linens from bleach fields was a common practice, for which offence capital punishment was inflicted until the end of the eighteenth century. Singularly enough, when capital punishment was abolished the evil decreased by 50 per cent. Prior to 1760 buttermilk was the only acid used for bleaching, but during that decade Dr. Fergusson, of Belfast, was awarded £300 for successfully applying lime to the bleaching process. Later, sulphuric acid, potash, and chloride of lime have in their turn produced great changes in this particular branch of the trade.

Modes of Exchange and Value: Eighteenth Century.—At this juncture it may be interesting to briefly consider values and methods of exchange of the period. In the year 1776 brown linens sold at $10\frac{1}{2}d.$ to $11d.$ per yard for 8^{oo}. The weaver sold his web to a draper who usually possessed a bleach green; the cost of bleaching was from $3s.$ to $3s.\ 2d.$ per web, or $90s.$ to £5 per thirty pieces. When fully bleached the draper sent his material to London, the Linen Hall at Dublin, or to Chester. In London seven months' credit was given, in Dublin two to three months, and cash when the fabrics were sold personally and at all the local fairs (see Fig. 79). Spinners were paid $3d.$ to $4d.$ and weavers $10d.$ to $1s.\ 4d.$ per day. The setts ranged from 8^{oo} to 24^{oo}, and the prices paid for weaving were 8^{oo}, $2\frac{1}{2}d.$; 10^{oo}, $3\frac{1}{2}d.$; 13^{oo}, $3\frac{3}{4}d.$; 16^{oo}, $9d.$; 18^{oo}, $10\frac{3}{4}d.$; and 24^{oo}, $1s.\ 7\frac{1}{2}d.$ per yard. The flax spinners were frequently engaged by the drapers at $10s.$ to $12s.$ per quarter, including board and lodging. They had to guarantee to turn off from five to eight hanks per week; usually an average spinner could spin six hanks (3,600 yards per hank) of 72's. lea, *i.e.*, $72 \times 300 = 21{,}600$ yards per lb. The value of this yarn for an 18^{oo} sett was worth approximately $8d.$ per hank, $4s.$ per lb., or $11s.\ 1d.$ per bundle. Belfast had two linen halls in which she conducted her exchanges, viz., the Brown Linen Hall in Donegall Street, originally built by Lord Donegall, and the White Linen Hall, originally built by subscription in Donegall Square, but now replaced by the magnificent City Hall.

Spinning and Weaving by Machinery.—The introduction of spinning and weaving by power, though difficult at first, gradually displaced to a considerable extent the hand method,

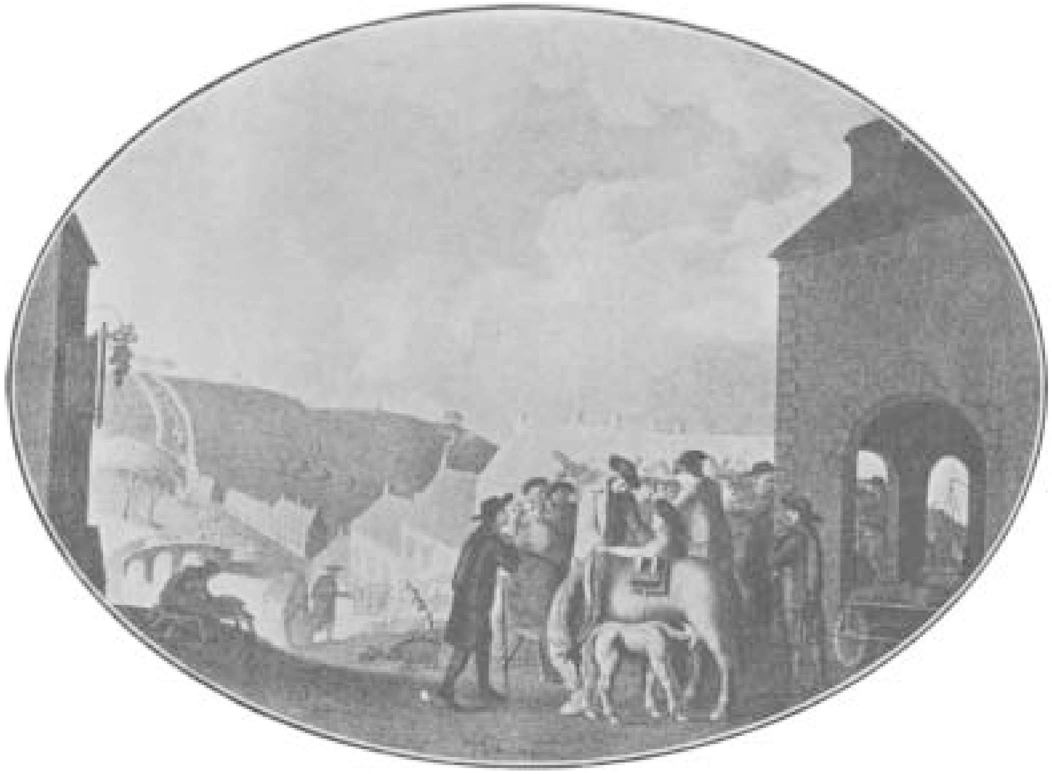

Fig. 79.—The Local Linen Fair at Banbridge, in county Downe, Ireland, in the olden times. The weavers are holding up their webs of linen to view; the bleachers and buyers are elevated on forms examining its quality.

and also centralised the work in mills and factories. The spinning of flax by machinery was attempted in Great Britain fully a decade previous to any similar experiment in Ireland, notwithstanding that the latter country had acquired a considerable reputation for flax spinning. At

FIG. 80.—Loading flax.
From a photograph by A. F. Barker.

first it was only possible to produce by machinery the coarser and lower dry spun numbers of yarn. The first machines for this purpose were started in Cork, and later at Ballymena and Crumlin, in county Antrim, about the year 1787. The Irish Linen Board, which at that time was still in existence, sought to encourage the enterprise by offering 30*s*. per spindle to the owners of all mills who introduced the power method, and by the year 1816 there were 6,369 spindles at work. The hand-spinning method for the finer yarns would, in all probability, have continued to this day but for the discovery of the wet-

FIG. 81.—Retting flax: putting flax in dam.
From a photograph by A. F. Barker.

spinning process by Philip de Gerard, of France, about the year 1826. This process was subsequently and successfully applied by Marshalls of Leeds, Baxter of Dundee, Mulholland of Belfast, and Murland of Castlewellan. In the year 1828 Messrs. Murland started the enterprise, and in the year following Messrs. Mulholland, now the York

Street Flax Spinning Mills, Belfast, adopted the new process, whereby it became possible, with the use of hot water, to soften the gummy matter which holds the flax fibres together, and reduce them to their ultimate length and fineness, and so to draw and spin them into yarn of a

FIG. 82.—Retting flax: taking flax out of dam after, say, ten days.
From a photograph by A. F. Barker.

much greater length and fineness than by the dry-spinning process. Undoubtedly the discovery and practical application of same thoroughly revolutionised the spinning, and eventually exerted an immense influence over the weaving, by causing a greater demand for power looms. Ireland now began more rapidly than ever to acquire the lead over foreign linen-producing countries in the markets of the world; and Belfast, the centre of the Irish linen trade, not only maintained, but increased her proud position among the manufacturing centres, whilst to-day she ranks as both

FIG. 83.—Flax drying.—Stack after retting.
From a photograph by A. F. Barker.

the industrial capital of Ireland and the metropolis of the world's linen industrial centres.

Statistics do not show any considerable adoption of power looms prior to 1850, but the following abbreviated table will give some idea of the development in the spinning and weaving of linen throughout the country since the advent of machinery:—

Year.	Number of Spindles in Ireland.	Number of Power Looms.
1841	250,000	—
1850	326,000	58
1856	567,980	1,871
1866	770,814	10,804
1875	924,817	20,152
1900	843,934	32,245
1906	869,146	34,723
1907	909,999	35,386
1908	913,423	35,386
Feb., 1910	939,732	35,622

The following comparative and latest official returns of spindles and power looms engaged in the linen industry in the United Kingdom and on the Continent will no doubt be interesting:—

Country.	Number of Spindles.	Number of Power Looms.
Ireland	939,732	35,622
France	545,497	18,083
Scotland	160,085	17,185
Germany	325,000	7,557
Russia	300,000	7,312
England and Wales . .	49,941	4,424
Italy	[1] 77,000	3,500
Belgium	[1] 280,000	3,400
Austria-Hungary . .	294,000	3,357
Holland	8,000	1,200
Spain	—	1,000
Norway and Sweden . .	—	406
[2] Total for Europe . .	1,829,497	43,815
,, United Kingdom	1,120,025	56,995

[1] Flax and hemp. [2] Exclusive of the U. K.

The volume of linen *yarn* exported from the United Kingdom in 1906 reached the enormous total of

14,975,500 lbs., bearing a monetary value of £1,008,831. In the year 1840 the respective totals were 28,734,212 lbs. and £1,976,830, from which date there has been a gradual

FIG. 84.—Flax spreading.
From a photograph by A. F. Barker.

decline as far as yarn exported was concerned, but an ever-increasing demand for home productions. The average annual imports of linen yarn into the United Kingdom during the last decade reached 26,311,329 lbs. of declared value £933,426. These yarns are chiefly of the lower numbers. The linen *goods* of all kinds exported for the year 1906 amounted in value to £5,326,744, whilst the total value of linen yarns, threads, and piece goods reached £6,341,216.

FIG. 85.—Inside an Irish Scutching Mill.
From a photograph by A. F. Barker.

These summarised Board of Trade returns, together with the large amount of linen used for home consumption, added to the fact that nearly 250,000 people in Great Britain and Ireland are exclusively engaged in the growth of flax, the preparation and spinning of long vegetable fibres (flax, hemp, and jute), the manufacture and merchanting of linen yarns and fabrics, will afford some idea of the commercial importance to which this industry has now attained.

Linen Varieties.—The varieties of fabrics made from *flax* in respect to structure, design, quality, and finish is much

FIG. 86.—Inside an Irish Scutching Mill.
From a photograph by A. F. Barker.

greater to-day than formerly. These include plains, ducks, hollands, lawns, sheer lawns, cambrics, handkerchiefs, dress linens, and unions in an ever-increasing novelty, vestings, glass cloths, drills and diapers, huckabacks, honeycomb and Turkish towels, d'oyleys, napkins, and damasks. The world-renowned cambrics were first made at Cambrai, in France, and the same country was famous for the initiation and manufacture of lawns, while the town of Ypres, in Belgium, became noted for the manufacture of linen known as diaper—cloth de Ypres—and "holland" received its name through having been first manufactured by the Dutch settlers in Ireland. Napkins were introduced for wiping the hands, being all the more necessary owing to the lack of knives and forks at the time. For long periods these and other standard fabrics have been and probably will continue to be made, but the time has gone when the demand runs on one particular make or type of cloth to the exclusion of every other, which necessarily involves that the manufacturer who would succeed must learn to adapt himself to modern ideas and ever-changing fashions. No linen or other manufacturer can afford to stand still; to do so would be to drop out. In conclusion, every manufacturing industry which is to obtain and maintain a position in the commercial world worthy of the name must seek to educate its workpeople by giving them a progressive course of instruction in the scientific and technical principles underlying their trade; for success now depends on scientific knowledge, research, and an intimate acquaintance with the inventions, the experiments, the successes and the failures of others; and whether our nation does or does not provide every facility in this direction, we may rest assured that textile production will continue its progressive course, and will be led by those who have made themselves capable of leading by adapted thought and knowledge, combined with enlightened energy, which directs its force to meet the vast and varied requirements of the world.

CHAPTER XVIII

RECENT DEVELOPMENTS AND THE FUTURE OF THE TEXTILE INDUSTRIES

Although nearly all the principles employed in textile machinery were in use, say, by 1850, still with what may be termed the refined organization of the twentieth century there have been, and apparently will always be, opportunities for the improvement in so-called "details," which details are nevertheless so important that the status of the whole industry may depend upon them.

With reference to the treatment of raw materials perhaps the most noticeable development has been in the handling and in the carrying forward of the material by conveyors from one machine or room to the next machine or room.

Within the last twenty years wool scouring with the volatile agents has become a practical fact, but, curious to relate, has only become established where it has been necessary to scour large quantities of wool in a rough-and-ready manner, noticeably in the United States.

In the preparatory processes the chief advance has been in the accuracy in workmanship put into most machines, noticeably into cotton combs and wool combs. Heilmann's comb, after being suppressed in the wool trade for fifty years, is again making its appearance, and is likely to prove a marked success for certain styles of work.

Noble's comb, which for the last forty years has been placed on the market with two inner circles, is now being made with three and four, and these additional circles, with a new pressing-in motion taking the place of the old dabbing-brush, are resulting in double the work being done. More positive machines—particularly cone drawing and roving—appear to be taking the place of the go-as-you-please machines; while in the Bradford district white yarns on the French mule-spun system are now being produced in quantity, and it seems more than probable that in the near future coloured yarns will also be similarly produced, so that Bradford designers will be able to compete in the soft-coloured French styles.

In spinning, the only marked advance made—notwithstanding the trial of many hybrid machines—appears to be in the direction of a frame to take the place of the woollen mule. Messrs. Platt Bros., of Oldham, now make a frame of this type which will apparently do the work, so that it is now simply a question of the initial expense and cost of up-keep and running. A development of which more is likely to be heard in the future, is in the direction of self-doffing motions for spinning frames. With the suppression of the "half-timer" and the scarcity of "full-timers" the difficulties of running spindles in both Yorkshire and Lancashire are daily increasing. To take the place of "doffers" several mechanisms have been patented for application to both flyer, cap, and ring frames. The only two successful inventions up to the present, however, are those of Messrs. Clough, of Keighley, and H. Arnold-Forster, of Burley-in-Wharfedale, both being applied to the flyer frame. The former is said to yield 15 per cent.

more turn-off, and so may be regarded as an advantage, irrespective of labour scarcity; while the latter, although still on trial, is giving evidence of a similar saving being effected. Of course, such frames take more following from the overlooking point of view, so that the advantages and disadvantages should be very carefully considered.[1]

In warping, sizing, dressing, etc., one or two developments are to be noted. The old upright warping mill, owing to its tendency to produce a repeating defect in certain goods, is being rapidly displaced by the Scotch or horizontal warping mill in the coating trade and by the warper's beam system for the dress-goods trade. A marked development of sizing single botany warps directly on to the loom beam is to be noted, such fine counts as 1-50's and 1-60's botany being so dressed and successfully woven. The Barber warp knotter may be specially noted as a wonderful machine. It is employed with perfect success in tying-in plain warps into gears, working at the rate of 250 knots per minute. Unfortunately, it is not sufficiently reliable for fancy coloured styles, where an odd thread wrongly tied would throw the whole pattern out.

Perhaps reference should here be made to the development in warp mercerizing in preference to hank mercerizing to ensure evenness in result. Weft yarns are thus warped, mercerized in warp form, and re-wound end by end, the superior result in evenness in subsequent dyeing amply compensating for the additional expense.

[1] Between writing and publishing the above, Cap Doffing has become an accomplished fact, Messrs. Hall and Still, of Keighley, having made a number of these frames for mills both at home and abroad. As in the case of the Flyer Doffer, there are secondary advantages of almost prime importance.

In weaving machinery two developments are taking place, the one contending against the other. In the first case, the automatic or self-shuttling or spooling loom—invented in this country, but developed in the United States—is making rapid headway in the plain cotton trade, and is being seriously tried in the stuff trade. Against this certain Yorkshire and Lancashire loom-makers (especially Mr. Robert Pickles, of Burnley) are ranging specially-built and speeded-up looms of the ordinary type. In the cotton trade, in which broken picks matters little, the automatic loom is already a success, but the extent to which it can supersede the ordinary well designed and timed loom where perfect weaving is required is still undefined. In this case, as with the automatic doffer, it is possibly already demonstrated that, irrespective of the shortage of labour, there is an advantage under certain conditions. With the labour shortage it is more than probable that automatic looms will come more and more into use, as it is claimed that a weaver and one or two tenters can keep twenty-four of these looms going on standard cotton goods. For stuffs and worsteds the looms are necessarily broader and the number to a weaver is much smaller. Broken picks are inadmissible, and until recently no feeling action to bring into play the bobbin-changing mechanism to obviate broken picks has been satisfactory, the best resulting in a waste of about 5 to 10 per cent. The Arlington mills, U.S.A., however, are now employing a split bobbin indicator, in which the weft holds the bobbin together until the last two or three layers, on reaching which the pressure from the inside opens the bobbin slightly, and this in turn brings into play the bobbin-changing mechanism. With this mechanism the waste has been reduced to 2 per cent.

Automatic looms are usually provided with a warp-stop motion in addition to a weft-stop motion and shuttle-box swell and stop-rod mechanisms. Several types of these motions, chiefly electrical, seem satisfactory for long warps, but probably none pay for short warps, as the initial cost is considerable and the cost of resetting on a new warp not inconsiderable.

In designing and cloth construction the chief advance made has been in designing single-yarn soft-goods styles such as Amazons, nuns' veiling, etc., and in producing soft lightly-twisted mohair goods by twisting the mohair with cotton for weaving purposes, and then extracting the cotton in the finishing operation, leaving the mohair everything that can be desired as to lustre, softness, lightness, etc. Within the past ten years some remarkable endeavours have been made to simplify and accelerate designing methods, notably in the "Designograph" of Mr. Mackintosh, "Photographic Designing" of M. Szczepanik and "Electric Card-cutting" by Messrs. Szczepanik and Zerkowitz. Unfortunately, in no single instance has any lasting impression been produced on the methods in vogue for the production of textile designs. Again, so far as jacquards are concerned, the medium pitch and the Verdol, or fine pitch machines, are undoubtedly making headway, especially on the Continent. These, however, involve no change in principle. The Carver electric jacquard, however, is very different from the ordinary jacquard, and for pure reversibles may prove a success. It is being tried in Ireland at the present moment for the production of standard linen fabrics of elaborate floral design.

So far as finishing is concerned the greatest advances have been made in finishing mercerized and soft French goods, chiefly on the initiative of the Bradford Dyers' Association. Fabrics have been built up from mercerized cotton, specially to stand and show to advantage the Schreinering process with truly remarkable results, certain black goods being almost undistinguishable from fine satin goods made of the best organzine silk. So far as the French goods are concerned, the better grades are now being woven and finished in Bradford in bulk, but in the lower grades the French manufacturers and finishers still lead.

In the design and construction of spinning, weaving, and finishing mills and sheds steady advance has been made. New mills and sheds are so designed that, as a rule, they are admirably adapted for the particular purpose in view. Two advances, however, claim more than passing comment. These are "electric driving" and "lighting." The mechanical drive is so fully understood and developed that to say the least, the electrical drive advocates have "a hard nut to crack." At the present, taking everything into account, electric driving seems to cost at least half as much again as mechanical driving; but the electrical men are so strenuously endeavouring to bring down the price of electricity that the situation, to say the least, is interesting. Of course, there are many cases where an electric drive is obviously the best drive, and even if electricity does not supersede the steam engine in large works, it will obviously be more and more employed in the small concerns which day by day are springing up. In lighting, again, electricity is held by gas-lighting in various forms,[1] expense and deterioration of light being the difficulties. Two special electric lights are, however, making marked headway, viz., two forms of colour-correct light and the inverted arc light. The first weaving shed has just been lighted by the colour-correct light, while the value of the inverted arc light in suppressing shadows makes it specially useful in sheds and rooms sufficiently high, and in which specially high machinery is not installed. Incandescent gas-lighting has proved so successful in the past that it is not likely to recede in usefulness in the future. Gas-lighting under pressure, however, is the latest development which appears to be making headway. This section would not be complete without reference to the attempts made to control the atmosphere in our spinning and weaving sheds. Our climate is so equitable that it is still questionable whether marked advantages accrue from the adopting of humidifying, ventilating and heating systems; but in other countries less fortunately situated the extremes of heat and cold, in summer and winter respectively, must be corrected. Upon the whole, for reasons which cannot be elaborated here, it is probable that even our favourable natural condition may be controlled and modified to considerable advantage.

In all branches of the industry, from the raw materials room to the counting-house, labour-saving contrivances are continually being introduced, principally from the United States. Day by day the industry becomes more complex and more difficult to grasp. In the past men might keep their accounts in their heads and leave their million of money, but in the future very different methods must prevail. Scientific method—deliberate intent, not casual

[1] The Keith Pressure System is one of the best of these.

acquaintance and drift—will be absolutely necessary in the near future in both acquiring the knowledge of and directing a business. Unless we are prepared to admit this and live up to it we must be prepared to see our strenuous present-day friends of the East, the Japanese (and probably the Chinese), with their freshness and directness, reap the benefit of our experience, simply because we shall be unable to reap it ourselves. The great question for us at the present time is not "Do we believe in technical education?" but "Do we feel and realize the complexities of modern conditions and the consequent necessity for scientific method?" If we once feel this technical education will be accepted without question, and instituted not in a half-hearted way on necessarily inefficient lines, but rather on a generous scale to enable the rising generation to grasp the helm, not to be tossed about at the mercy of wind and tide.

THE FLAX SUPPLY.

	Irish Production.	Imports.	Exports.	Net Supply.
	Tons.			
1896	10,844	36,650	4,565	42,929
1897	6,818	37,715	4,446	40,087
1898	6,281	34,440	3,634	37,087
1899	6,743	40,145	3,438	43,450
1900	9,479	31,563	3,789	37,253
1901	12,797	28,785	3,839	37,743
1902	10,975	29,727	4,129	36,573
1903	8,064	38,168	3,487	42,745
1904	8,069	33,024	3,446	37,647
1905	10,073	40,063	2,771	47,365
1906	11,812	37,332	3,276	45,868
1907	11,571	46,201	3,845	53,927
1908	8,421	32,511	4,242	36,690
1909	7,565	42,828	4,587	45,806

World's Production of Cotton.

	Bales.	Per cent. of Total Production.
United States	10,882,385	65·9
British India	2,444,800	14·8
Egypt	1,296,000	7·8
Russia	620,000	3·8
China	428,000	2·6
Brazil	370,000	2·2
Mexico	85,000	0·5
Peru	55,000	0·3
Turkey	80,000	0·5
Persia	51,000	0·3
Other Countries	200,000	1·3

The world's commercial production of the last five years has been:—

	Bales.
1904	18,803,000
1905	15,747,000
1906	19,942,000
1907	16,512,185
1908	19,120,420

New Sources of Cotton Supply.

Estimated Cotton Production in Other Countries.

(In thousands of bales.)

Country.	1907–8.	1906–7.	1905–6.
Japan	15	35	20
Korea	70	50	70
China	1,000	800	750
Indo-China	15	15	20
Dutch East Indies	12	13	15
Philippines	6	6	6
Asiatic Russia, Turkestan	750	675	612
Persia	80	60	50

NEW SOURCES OF COTTON SUPPLY—*continued.*

ESTIMATED COTTON PRODUCTION IN OTHER COUNTRIES—*continued.*

(In thousands of bales.)

Country.	1907—8.	1906—7.	1905—6.
Asia Minor	125	85	100
Turkey	5	8	8
Cyprus	1	2	1
Greece	15	10	10
Italy	5	3	10
Africa, French	2	1	·5
,, East and Central	7	6	6
,, West	50	12	12
,, Sudan	6	19	15
Australia and New Zealand	1	—	·2
Pacific Islands	—	—	·2
Peru	110	70	90
Chili	—	1	5
Argentina	2	1	1
Colombia and Venezuela	10	5	1
British West Indies	15	11	6
Hayti	10	7	10
Mexico	90	180	250
TOTAL (estimated)	2,402	2,075	2,069

Below are the figures of the cotton crops for the countries named for the two seasons particularized:—

Country.	1907—1908.	1906—1907.
American (United States)	11,572,000	13,511,000
Brazilian	2,867,000	
Egyptian	964,622	926,636
	1907.	1906.
East Indian	4,880,000	4,435,000

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BRADBURY, AGNEW, & CO. LD., PRINTERS, LONDON AND TONBRIDGE.

THE "WESTMINSTER" SERIES

Coal. By JAMES TONGE, M.I.M.E., F.G.S., etc. (Lecturer on Mining at Victoria University, Manchester). With 46 Illustrations, many of them showing the Fossils found in the Coal Measures.

LIST OF CONTENTS: History. Occurrence. Mode of Formation of Coal Seams. Fossils of the Coal Measures. Botany of the Coal-Measure Plants. Coalfields of the British Isles. Foreign Coalfields. The Classification of Coals. The Valuation of Coal. Foreign Coals and their Values. Uses of Coal. The Production of Heat from Coal. Waste of Coal. The Preparation of Coal for the Market. Coaling Stations of the World. Index.

This book on a momentous subject is provided for the general reader who wishes accurate knowledge of Coal, its origin, position and extent, and its economical utilization and application.

Iron and Steel. By J. H. STANSBIE, B.Sc. (Lond.), F.I.C. With 86 Illustrations.

LIST OF CONTENTS: Introductory. Iron Ores. Combustible and other materials used in Iron and Steel Manufacture. Primitive Methods of Iron and Steel Production. Pig Iron and its Manufacture. The Refining of Pig Iron in Small Charges. Crucible and Weld Steel. The Bessemer Process. The Open Hearth Process. Mechanical Treatment of Iron and Steel. Physical and Mechanical Properties of Iron and Steel. Iron and Steel under the Microscope. Heat Treatment of Iron and Steel. Electric Smelting. Special Steels. Index.

The aim of this book is to give a comprehensive view of the modern aspects of iron and steel, together with a sufficient account of its history to enable the reader to follow its march of progress. The methods of producing varieties of the metal suitable to the requirements of the engineer, foundryman and mechanician are described so that the worker may learn the history of the material he is handling.

Natural Sources of Power. By ROBERT S. BALL, B.Sc., A.M.Inst.C.E. With 104 Diagrams and Illustrations.

CONTENTS: Preface. Units with Metric Equivalents and Abbreviations. Length and Distance. Surface and Area. Volumes. Weights or Measures. Pressures. Linear Velocities, Angular Velocities. Acceleration. Energy. Power. Introductory Water Power and Methods of Measuring. Application of Water Power to the Propulsion of Machinery. The Hydraulic Turbine. Various Types of Turbine. Construction of Water Power Plants. Water Power Installations. The Regulation of Turbines. Wind Pressure, Velocity, and Methods of Measuring. The Application of Wind Power to Industry. The Modern Windmill. Constructional Details. Power of Modern Windmills. Appendices A, B, C Index.

Two departments of Engineering and their applications to industry form the subject of this volume: the "natural" sources of water and wind power which supply mechanical energy without any intermediate stage of transformation. Most people will be surprised at the extent to which these natural power producers are used. The widespread application of water power is generally known, but it is interesting to learn that the demand for windmills was never so great as it is to-day, and there are signs of abnormal expansion in the direction of their useful application in the great agricultural countries of the world. Though primarily of importance to the engineer, this work will be of great interest to every manufacturer who in economizing his means of power production can take the natural forces that lie to his hand and harness them in his service. The author is the son of Sir Robert Ball, the eminent mathematician and astronomer.

Liquid and Gaseous Fuels, and the Part they play in Modern Power Production. By Professor VIVIAN B. LEWES, F.I.C., F.C.S., Prof. of Chemistry, Royal Naval College, Greenwich. With 54 Illustrations.

LIST OF CONTENTS: Lavoisier's Discovery of the Nature of Combustion, etc. The Cycle of Animal and Vegetable Life. Method of determining Calorific Value. The Discovery of Petroleum in America. Oil Lamps, etc. The History of Coal Gas. Calorific Value of Coal Gas and its Constituents. The History of Water Gas. Incomplete Combustion. Comparison of the Thermal Values of our Fuels, etc. Appendix. Bibliography. Index.

The subject of this book has, during the last decade, assumed such importance that it is hoped this account of the history and development of the use of various forms of combustible liquids and gases for the generation of energy may do some service in its advancement.

Electric Power and Traction. By F. H. DAVIES, A.M.I.E.E. With 66 Illustrations.

LIST OF CONTENTS: Introduction. The Generation and Distribution of Power. The Electric Motor. The Application of Electric Power. Electric Power in Collieries. Electric Power in Engineering Workshops. Electric Power in Textile Factories. Electric Power in the Printing Trade. Electric Power at Sea. Electric Power on Canals. Electric Traction. The Overhead System and Track Work. The Conduit System. The Surface Contact System. Car Building and Equipment. Electric Railways. Glossary. Index.

The majority of the allied trades that cluster round the business of electrical engineering are connected in some way or other with its power and traction branches. To members of such trades and callings, to whom some knowledge of applied electrical engineering is desirable if not strictly essential, the book is particularly intended to appeal. It deals almost entirely with practical matters, and enters to some extent into those commercial considerations which in the long run must overrule all others.

Town Gas and its Uses for the Production of Light, Heat, and Motive Power. By W. H. Y. WEBBER, C.E. With 71 Illustrations.

LIST OF CONTENTS: The Nature and Properties of Town Gas. The History and Manufacture of Town Gas. The Bye-Products of Coal Gas Manufacture. Gas Lights and Lighting. Practical Gas Lighting. The Cost of Gas Lighting. Heating and Warming by Gas. Cooking by Gas. The Healthfulness and Safety of Gas in all its uses. Town Gas for Power Generation, including Private Electricity Supply. The Legal Relations of Gas Suppliers, Consumers, and the Public. Index.

The "country," as opposed to the "town," has been defined as "the parts beyond the gas lamps." This book provides accurate knowledge regarding the manufacture and supply of town gas and its uses for domestic and industrial purposes. Few people realize the extent to which this great industry can be utilized. The author has produced a volume which will instruct and interest the generally well informed but not technically instructed reader.

Electro-Metallurgy. By J. B. C. KERSHAW, F.I.C. With 61 Illustrations.

CONTENTS: Introduction and Historical Survey. Aluminium. Production. Details of Processes and Works. Costs. Utilization. Future of the Metal. Bullion and Gold. Silver Refining Process. Gold Refining Processes. Gold Extraction Processes. Calcium Carbide and Acetylene Gas. The Carbide Furnace and Process. Production. Utilization. Carborundum. Details of Manufacture. Properties and Uses. Copper. Copper Refining. Descriptions of Refineries. Costs. Properties and Utilization. The Elmore and similar Processes. Electrolytic Extraction Processes. Electro-Metallurgical Concentration Processes. Ferro-alloys. Descriptions of Works. Utilization. Glass and Quartz Glass. Graphite. Details of Process. Utilization. Iron and Steel. Descriptions of Furnaces and Processes. Yields and Costs. Comparative Costs. Lead. The Salom Process. The Betts Refining Process. The Betts Reduction Process. White Lead Processes. Miscellaneous Products. Calcium. Carbon Bisulphide. Carbon Tetra-Chloride. Diamantine. Magnesium. Phosphorus. Silicon and its Compounds. Nickel. Wet Processes. Dry Processes. Sodium. Descriptions of Cells and Processes. Tin. Alkaline Processes for Tin Stripping. Acid Processes for Tin Stripping. Salt Processes for Tin Stripping. Zinc. Wet Processes. Dry Processes. Electro-Thermal Processes. Electro-Galvanizing. Glossary. Name Index.

The subject of this volume, the branch of metallurgy which deals with the extraction and refining of metals by aid of electricity, is becoming of great importance. The author gives a brief and clear account of the industrial developments of electro-metallurgy, in language that can be understood by those whose acquaintance with either chemical or electrical science may be but slight. It is a thoroughly practical work descriptive of apparatus and processes, and commends itself to all practical men engaged in metallurgical operations, as well as to business men, financiers, and investors.

Radio-Telegraphy. By C. C. F. Monckton, M.I.E.E. With 173 Diagrams and Illustrations.

Contents: Preface. Electric Phenomena. Electric Vibrations. Electro-Magnetic Waves. Modified Hertz Waves used in Radio-Telegraphy. Apparatus used for Charging the Oscillator. The Electric Oscillator: Methods of Arrangement, Practical Details. The Receiver: Methods of Arrangement, The Detecting Apparatus, and other details. Measurements in Radio-Telegraphy. The Experimental Station at Elmers End: Lodge-Muirhead System. Radio-Telegraph Station at Nauen: Telefunken System. Station at Lyngby: Poulsen System. The Lodge-Muirhead System, the Marconi System, Telefunken System, and Poulsen System. Portable Stations. Radio-Telephony. Appendices: The Morse Alphabet. Electrical Units used in this Book. International Control of Radio-Telegraphy. Index.

The startling discovery twelve years ago of what is popularly known as Wireless Telegraphy has received many no less startling additions since then. The official name now given to this branch of electrical practice is Radio-Telegraphy. The subject has now reached a thoroughly practicable stage, and this book presents it in clear, concise form. The various services for which Radio-Telegraphy is or may be used are indicated by the author. Every stage of the subject is illustrated by diagrams or photographs of apparatus, so that, while an elementary knowledge of electricity is presupposed, the bearings of the subject can be grasped by every reader. No subject is fraught with so many possibilities of development for the future relationships of the peoples of the world.

India-Rubber and its Manufacture, with Chapters on Gutta-Percha and Balata. By H. L. Terry, F.I.C., Assoc.Inst.M.M. With Illustrations.

List of Contents: Preface. Introduction: Historical and General. Raw Rubber. Botanical Origin. Tapping the Trees. Coagulation. Principal Raw Rubbers of Commerce. Pseudo-Rubbers. Congo Rubber. General Considerations. Chemical and Physical Properties. Vulcanization. India-rubber Plantations. India-rubber Substitutes. Reclaimed Rubber. Washing and Drying of Raw Rubber. Compounding of Rubber. Rubber Solvents and their Recovery. Rubber Solution. Fine Cut Sheet and Articles made therefrom. Elastic Thread. Mechanical Rubber Goods. Sundry Rubber Articles. India-rubber Proofed Textures. Tyres. India-rubber Boots and Shoes. Rubber for Insulated Wires. Vulcanite Contracts for India-rubber Goods.

The Testing of Rubber Goods. Gutta-Percha. Balata. Bibliography. Index.

Tells all about a material which has grown immensely in commercial importance in recent years. It has been expressly written for the general reader and for the technologist in other branches of industry.

Glass Manufacture. By WALTER ROSENHAIN, Superintendent of the Department of Metallurgy in the National Physical Laboratory, late Scientific Adviser in the Glass Works of Messrs. Chance Bros. and Co. With Illustrations.

CONTENTS: Preface. Definitions. Physical and Chemical Qualities. Mechanical, Thermal, and Electrical Properties. Transparency and Colour. Raw materials of manufacture. Crucibles and Furnaces for Fusion. Process of Fusion. Processes used in Working of Glass. Bottle. Blown and Pressed. Rolled or Plate. Sheet and Crown. Coloured. Optical Glass: Nature and Properties, Manufacture. Miscellaneous Products. Appendix. Bibliography of Glass Manufacture. Index.

This volume is for users of glass, and makes no claim to be an adequate guide or help to those engaged in glass manufacture itself. For this reason the account of manufacturing processes has been kept as non-technical as possible. In describing each process the object in view has been to give an insight into the rationale of each step, so far as it is known or understood, from the point of view of principles and methods rather than as mere rule of thumb description of manufacturing manipulations. The processes described are, with the exception of those described as obsolete, to the author's definite knowledge, in commercial use at the present time.

Precious Stones. By W. GOODCHILD, M.B., B.Ch. With 42 Illustrations. **With a Chapter on Artificial Stones.** By ROBERT DYKES.

LIST OF CONTENTS: Introductory and Historical. Genesis of Precious Stones. Physical Properties. The Cutting and Polishing of Gems. Imitation Gems and the Artificial Production of Precious Stones. The Diamond. Fluor Spar and the Forms of Silica. Corundum, including Ruby and Sapphire. Spinel and Chrysoberyl. The Carbonates and the Felspars. The Pyroxene and Amphibole Groups. Beryl, Cordierite, Lapis Lazuli and the Garnets. Olivine, Topaz, Tourmaline and other Silicates. Phosphates, Sulphates, and Carbon Compounds.

An admirable guide to a fascinating subject.

Patents, Designs and Trade Marks: The Law and Commercial Usage. By KENNETH R. SWAN, B.A. (Oxon.), of the Inner Temple, Barrister-at-Law.

CONTENTS: Table of Cases Cited—*Part I.—Letters Patent.* Introduction. General. Historical. I., II., III. Invention, Novelty, Subject Matter, and Utility the Essentials of Patentable Invention. IV. Specification. V. Construction of Specification. VI. Who May Apply for a Patent. VII. Application and Grant. VIII. Opposition. IX. Patent Rights. Legal Value. Commercial Value. X. Amendment. XI. Infringement of Patent. XII. Action for Infringement. XIII. Action to Restrain Threats. XIV. Negotiation of Patents by Sale and Licence. XV. Limitations on Patent Right. XVI. Revocation. XVII. Prolongation. XVIII. Miscellaneous. XIX. Foreign Patents. XX. Foreign Patent Laws: United States of America. Germany. France. Table of Cost, etc., of Foreign Patents. APPENDIX A.—1. Table of Forms and Fees. 2. Cost of Obtaining a British Patent. 3. Convention Countries. *Part II.—Copyright in Design.* Introduction. I. Registrable Designs. II. Registration. III. Marking. IV. Infringement. APPENDIX B.—1. Table of Forms and Fees. 2. Classification of Goods. *Part III.—Trade Marks.* Introduction. I. Meaning of Trade Mark. II. Qualification for Registration. III. Restrictions on Registration. IV. Registration. V. Effect of Registration. VI. Miscellaneous. APPENDIX C.—Table of Forms and Fees. INDICES. 1. Patents. 2. Designs. 3. Trade Marks.

This is the first book on the subject since the New Patents Act. Its aim is not only to present the existing law accurately and as fully as possible, but also to cast it in a form readily comprehensible to the layman unfamiliar with legal phraseology. It will be of value to those engaged in trades and industries where a knowledge of the patenting of inventions and the registration of trade marks is important. Full information is given regarding patents in foreign countries.

The Book; Its History and Development. By CYRIL DAVENPORT, V.D., F.S.A. With 7 Plates and 126 Figures in the text.

LIST OF CONTENTS: Early Records. Rolls, Books and Book bindings. Paper. Printing. Illustrations. Miscellanea. Leathers. The Ornamentation of Leather Bookbindings without Gold. The Ornamentation of Leather Bookbindings with Gold. Bibliography. Index.

The romance of the Book and its development from the rude inscriptions on stone to the magnificent de Luxe tomes of to-day have never been so excellently discoursed upon as in this volume. The history of the Book is the history of the preservation of human thought. This work should be in the possession of every book lover.