the pattern. In Fig. 27A the metallic threads are applied in both the warp and the weft. Those inserted into the

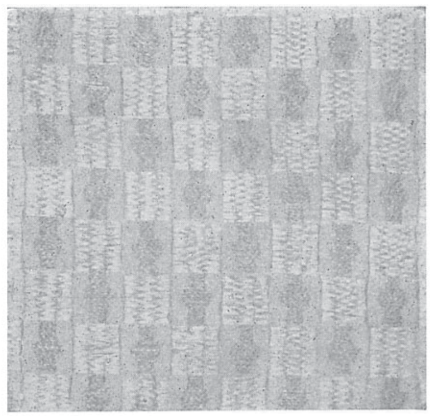


FIG. 27.—COTTON-YARN AND METALLIC-THREAD TEXTURE.

warp (stripings A) appear bright and distinct, but those used in the shuttling and making the central portion of

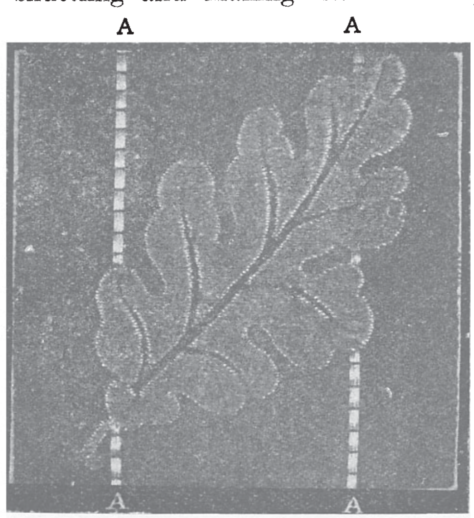


FIG. 27A.—SILK AND METALLIC-THREAD SPECIMEN.

the leaf come out in a subdued or grey tone. The specimen is, therefore, instructive in illustrating the nature of the phenomena of the direction of the rays of light in viewing textures composed of these yarns. With the power of illumination in coincidence with the lateral surfaces of the threads the "lustre" is accentuated, which partially explains the scintillated colouring and textural qualities produced in this class of woven combination.

When strands of a metal category are employed, they may be folded, as in Fig. 27. with cotton and linen threads for the purpose of enhancing their weavable structures; but in the case of mineral fibre, e.g. asbestos, being used, it is prepared and spun into an individual yarn of a like formation to the yarns made of other sorts of textile material.

57. *The Twine Factor in Spun Yarns.*—Yarn structure, in any quality or description of material, is variable with the degree of twine, or turns per inch, imparted into the thread in the spinning operation. The terms "hard" and "soft" twist, applied in the trade, have a relative meaning, inasmuch as the length of staple of which the yarn is composed, and the yarn counts, regulate the twine factor in producing a specified class of yarn. "Twist" concerns, in the first place, the elasticity and breaking strain of the thread, and, in the second place, the application to which the yarn is put in commercial manufacture. Thus, weaving range and work are affected, as well as the make and style of the finished cloth, by the amount of twine in the warp and weft threads employed. Some cloths necessitate the use of yarns loosely spun, as in acquiring textures of a soft handle or with a fibrous surface; and others, as in voiles, crêpes, and fine, clear twilled goods, necessitate the use of yarns of a maximum twist. Between these two extremes in "twine" there are the ordinary types of yarn in which the twist is adjusted to produce a yarn of sufficient elasticity to sustain satisfactorily the tension applied in rapid weaving, and, at the same time, give the required quality of fabric.

The technical terms of "right-hand" or "crossband," and "left-hand" or "openband," signify the direction in which the twist is developed in the thread during spinning. In regard to the two descriptions of yarn which are in this way obtained, it is a general method, in cloth construction, to apply one "twist" of yarn in the warp and the reverse "twist" of yarn in the weft. But the rule is not hard and fixed, and is subject to modification with the weave effect and textural result to be acquired. It is the practice to follow in the manufacture of fabrics in which smartness and clearness of surface is essential, but may be advantageously departed from in making cloths in which the warp and weft intersections are not intended to be visible in the finished goods.

Twills, venetians, sateens, and other similar weave structures are, as will be shown, developed by having due regard to the direction and degree of "twine" in the yarns selected. They impose the combination of firm-spun warp and medium-spun weft yarns; whereas soft-handling dress serges, wool cashmeres, velveteens, flannel textures and habit cloths may be correctly made by combining loose-spun yarns. On the other hand lustre dress goods, cotton poplins, and many crêpe cloths are composed of hard-twisted yarn one way and soft-twisted yarn the other. In the instance of repps, gauzes, lenos, and voiles the emphasis of the distinctive characteristics seen in the textures, is dependent upon the selection of yarns of the requisite hardness of twist.

58. *Folded Yarns and Twine Insertion.*—"Twine" has so far been considered as a factor irrespective of whether the yarn specified be single or folded in character. It has other and important relations as it bears on the twisting together of two or several threads into a compound yarn unit. For example, in producing two-ply or multi-ply yarns the separate threads combined, and also the resultant folded yarns, may be modified in the process of doubling or folding. First, in combining two threads, say, A and B, both of the same kind of twine, and folding them by twisting in conformity with the original twine

in each thread, the hardness of the two threads is augmented; whereas by twisting them in the reverse direction of the original twine has the contrary effect, and would cause both threads to be looser and softer in structure. Second, in combining a thread C, right-hand twist, with a thread D, left-hand twist, and making them into a folded yarn by (1) twisting to the right, and (2) twisting to the left would change the respective threads thus—

(1) C would be rendered firmer and D a softer yarn.
(2) D ,, ,, softer ,, C a harder yarn.

In each form of doubling the quality, tensility, and features of the folded yarn developed would be also affected. Increasing the multiple of the single threads employed, and using threads of different materials or of a different system of construction, adds to the technical interest and value of the compound yarns obtained, more especially when it is taken into account that each type of folded yarn has a distinctive utility in fabric building and as a quality producer in cloth manufacture.

59. *Compound Yarns and the Dress Trade.*—The problem, as it concerns the dress industry, is exemplified in the folded-yarn specimens illustrated in Fig. 28. The thread units applied in the formation of each yarn type, and the practice adopted in the folding operation, are specified in the Table shown on page 70.

60. *Types of Folded Yarns.* SERIES A (Fig. 28).—These examples are illustrative of the kind of yarn resulting from folding two yarns of the same counts by varying the degree of twine inserted in the process of doubling, thread No. 1 being soft twine, thread No. 2 medium, and thread No. 3 hard twisted. Examining the yarns under magnification—as should be done in all the specimens—reveals the slacker structure of No. 1 as compared with No. 2, and No. 2 as compared with No. 3, and also the evener, fuller thread obtained as the turns per inch increase in the doubling; for this factor, as it augments, reduces the twist ingredient in the single threads.

TABLE V

FOLDED-YARN CONSTRUCTION—Fig. 28

M = Medium Twine. ′ = Right-hand Twist. ‵ = Left-hand Twist.
S = Soft ,,

Speci-men Nos.		Yarn Units.	Twine in Folding Operation.
A	1	1/40's Botany M′ twisted with 1/20's M′	S‵
	2	1/40's ,, M′ ,, ,, 1/20's M′	M‵
	3	1/40's ,, M′ ,, ,, 1/20's M′	H‵
B	4	1/40's ,, M′ with 1/20's Crossbred M′	M‵
	5	1/20's ,, M′ ,, 1/40's ,, M′	M‵
	6	1/40's ,, M′ ,, 1/40's Botany M′	M‵
	7	1/40's Crossbred M′ ,, 1/40's Crossbred M′	M‵
C	8	1/40's Botany M′ with 1/40's Botany M′ and 1/40's Botany M′	M‵
	9	1/40's ,, M′ ,, 1/40's ,, M′ ,, 1/40's ,, M′	M′
	10	1/40's ,, M‵ ,, 1/40's ,, M′ ,, 1/40's ,, M′	M′
	11	1/40's ,, M‵ ,, 1/40's ,, M′ ,, 1/40's ,, M′	M′
	12	1/40's ,, M‵ ,, 1/40's ,, M‵ ,, 1/40's ,, M′	M‵
	13	1 40's ,, M‵ ,, 1/40's ,, M‵ ,, 140's , M′	M′
	14	1/40's ,, M‵ ,, 1/40's ,, M‵ ,, 1/40's ,, M	M‵
D	15	30 skeins Saxony M′ with 60's/2-fold silk	M′
	16	,, ,, M‵ ,, ,, ,,	M′
	17	,, ,, M′ ,, ,, ,,	M‵
	18	,, ,, M‵ ,, ,, ,,	M‵
E	19	2/40's Botany M‵ twisted with 1/40's Botany M′	M′
	20	2/40's ,, M‵ ,, ,, 1/40's ,, M‵	M′
	21	2/40's ,, M‵ ,, ,, 1/40's Crossbred M′	M′
	22	2/40's ,, M‵ ,, ,, 1/40's ,, M‵	M′
	23	2/40's ,, M‵ ,, ,, 1/40's Botany M′	M‵
	24	2/40's , M‵ ,, ,, 1/40's ,, M‵	M‵
	25	1/40's Crossbred M′ with 1/40's Botany M′=M‵, and 1/20's Crossbred M′	M′
	26	1/40's ,, M′ ,, 1 40's ,, M′=M‵ ,, 1/20's ,, M‵	M′
	27	1/40's ,, M′ , 1/40's ,, M′=M‵ ,, 1/20's ,, M′	M‵
	28	1/40's ,, M′ ,, 1/40's ,, M′=M‵ ,, 1/20's Botany M‵	M‵
	29	1/40's ,, M′ ,, 1/40's ,, M′=M‵ ,, 1/20's ,, M′	M‵
	30	1/40's ,, M′ , 1/40's ,, M′=M′ ,, 1/20's Crossbred M‵	M‵
F	31	30 sks. Saxony M′ with 60's/2 silk M′ and 2/60's Botany M′	M‵
	32	,, ,, M‵ ,, 60's/2 ,, M′ ,, 2/60's ,, M′	M‵
	33	,, ,, M′ ,, 60's/2 ,, M‵ ,, 2/60's ,, M′	M′
	34	,, ,, M‵ ,, 60's/2 ,, M‵ ,, 2/60's ,, M′	M′
G	35	2/30's Botany M′ with 30 skeins Saxony M′	M′
	36	2/30's ,, M‵ ,, 30 ,, ,, M′	M′
	37	2/30's ,, M‵ ,, 30 ,, ,, M	M′

SERIES B.—Here yarns of different counts and qualities are combined. No. 4 is a compound of 1/40's Botany and 1/20's crossbred, both medium spun, and crossband or left-hand twisted in the folding. The yarn unit of the thicker diameter forms a distinguishing feature of the two-fold structure. This is emphasized in No. 5 where the Botany is 20's and the crossbred 40's counts, and hence the greater contracting value of the

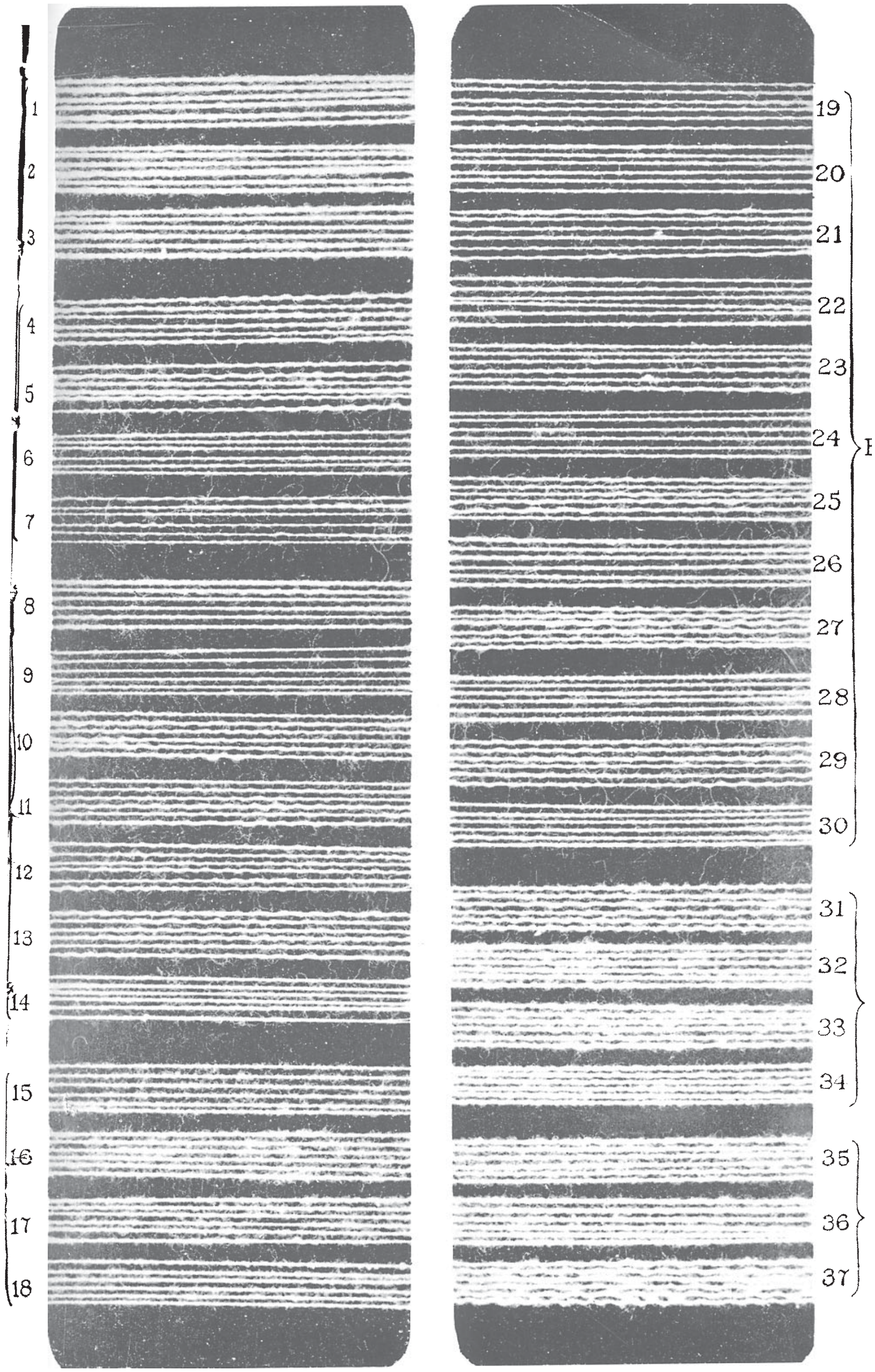


Fig. 28.—Folded Yarn Specimens—Natural Size.

Botany causes the latter to wave the surface of the folded yarn. Combining threads of the same counts (single 40's Botany, No. 6) and both flyer spun, yields a yarn of special evenness as to elasticity test and surface features; while changing one of the units to 40's crossbred (No. 7) makes a more "wiry" yarn and one less smooth and equalized in formation.

SERIES C.—Three-fold yarns are also typified in this series of specimens. First, three threads, in No. 8, of single 40's Botany, each openband twine and medium spun, are twisted together crossland twine, which gives a yarn of apparently a fuller diameter than yarn No. 9, consisting of like thread units but with the twine reversed in the twisting. The cause of this differentiation is a reduction in the turns per inch of the original threads in No. 8 in the folding operation, and the addition of twine in such threads in the folding operation in specimen No. 9. In yarn No. 10 a further element is introduced, one of the three threads is the reverse twine of the other two, and this thread receives a supplementary degree of twist in the folding work, whereas the spun twist of the two threads is diminished, hence the irregular or somewhat corrugated surface of the 3-ply yarn. Reversing the twist in folding—(No. 11) enables the single threads of a corresponding twine to control the formation of the compound yarn, so that, though the gimped disposition is still traceable, it becomes less accentuated. In specimen 12 two of the single threads are crossband and one thread openband twine, with the folding twist agreeing with the former and opposing the latter. On the other hand in No. 13 the folding twist coincides with that of the third thread, reducing the turns per inch in two of the threads, making a softer but still a slightly waved-surface yarn. For levelness of structure No. 14 is suggestive, resembling No. 9 in the "folded" and "spun" twist being the reverse of each other, with, however, this distinction, the folded unit No. 9 is medium right-hand twine, and that of No. 14 medium left-hand twine.

Series D.—The selection of yarns made of different materials provides for the acquirement of the other qualities and types of compound threads. The four specimens (Nos. 15 to 18) consist of two yarn units, namely, 30 skeins woollen and 60's /2-fold silk. Nos. 15 and 16 are both right-hand twine in the folding, which has increased the turns per inch in the 30 skeins thread in No. 15 and developed the effect due to the silk, but subtracted from the twine ingredient in the 30 skeins thread in No. 16, and so far softened in structure as to partially conceal the 60's/2 silk thread. Imparting the twine in folding in the opposite way, and also leaving that of the "spun" twist unmodified in the woollen, produces similar compound yarns as seen in specimens Nos. 17 and 18.

Series E.—These yarns are all of the 3-fold category, but Nos. 19 to 24 are formed of 2-fold 40's with single 40's; and Nos. 25 to 30 of two threads of single 40's with one thread of single 20's. Further, in the first group, the yarn units are all of the Botany quality, but in the second group they include both Botany and Crossbred threads. Each specimen exemplifies a principle and practice in folding. Nos. 19 to 22 are right-hand twisted in the doubling, with the 2-fold 40's threads left-hand twine, and the single threads modified thus: Nos. 19 and 21 right-hand twisted and Nos. 20 and 22 left-hand twisted, with the threads Botany and Crossbred respectively. The difference, therefore, between 19 and 21 or 20 and 22 is caused by changing the quality of the single yarn. This modification of the appearance of the folded yarn is the more noticeable in specimens 20 and 22, the former being the leveller and smoother thread. Specimens 23 and 24 are interesting as showing the alterations in the folded yarn caused by the single 40's being untwisted by doubling in the first, and supplemented in twist in the second instance, with the resultant diameter of the 3-fold yarn perceptibly diminished in No. 24, and rendered more even in construction in No. 23.

With the interchange of thread units from Crossbred to Botany and also in the counts, yarns of a still more varied character are obtained. Analyzing specimens 25 to 30 will make this clear. Taking No. 25, a single 40's Crossbred (M′) is doubled with a single 40's Botany (M′) in the reverse twine or M′; then this 2-fold thread is twisted with a 20's (M′) in the same direction as the 20's yarn. There are here two processes of compound thread production, the 2-fold yarn consisting of threads of equal counts and corresponding twine, and of Crossbred and Botany quality respectively. With this yarn a third thread (Crossbred) is folded, and of the same thickness as the two single threads (40's) combined. This system of multi-ply thread making is also practised in specimens 26 to 30 inclusive. What originates the dissimilarity in the surface elements and in the evenness of the several compound structures, is the relation of twine in the single threads to the twine direction in the folded yarns. It will be observed that Nos. 28 and 30 are the more regular and even in construction. Their dissection shows that specimen 28 agrees with specimen 30 in the twist inserted in folding, with the single thread in No. 28 Botany, and in No. 30 Crossbred. Examples 27 and 29 also differ in the single thread units; both are rippled but 29 is the softer in character.

Series F.—These yarns consist of five threads folded into one, namely, of one thread of 30 skeins Saxony, one thread (= two single threads) of 60's/2-fold silk, and one thread of 2-fold 60's (= two single threads) Botany worsted. The silk unit is emphasized in specimen 31, subdued in specimen 32, and has an intermediate effect in specimens 33 and 34. In each of these multi-fold yarns, the 2-fold 60's worsted is right-hand twine, hence, in the folding, the turns per inch in this thread are decreased in Nos. 31 and 32, and increased in Nos. 33 and 34. The worsted is not, however, so assertive in shaping the characteristic of the folded yarn as the carded or woollen thread. The latter, as a consequence of being softened in structure in the folding process in 31 and 34, and hardened in structure in 32 and 33, is responsible for the modifications in the type of the resultant yarn.

SERIES G.—The examples in this series are compounds of 2-fold 30's Botany and 30 skeins Saxony, or of worsted and carded yarns of a similar wool quality, and of, approximately, the same counts. They are typical of having, in folding, (1) the " spun " and " doubling " twist in coincidence, specimen 35; (2) the turns per inch augmented in the woollen and diminished in the worsted; and (3) the twine reduced in both the worsted and the woollen thread. The first practice yields a firm, the second a worsted, and the third practice a fibrous quality of folded yarn.

61. *Basic Principles in Folded-Yarn Construction—Fancy Twists.*—The specimens examined exemplify the basic principles in folding two or more threads together as they are comprised (1) in the selection of yarns of the same counts, with each

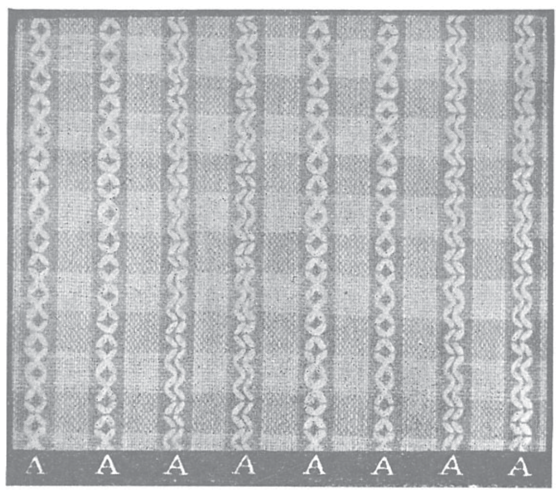


FIG. 29.—COTTON STYLE WITH THICK FOLDED WARP ENDS.

thread twisted in a corresponding or in a different direction, and also in relation to the nature of the twine generated in the folding process; (2) in the combination, under similar twisting conditions, of threads of dissimilar thicknesses; and (3) in the use of threads varying in structure and in the

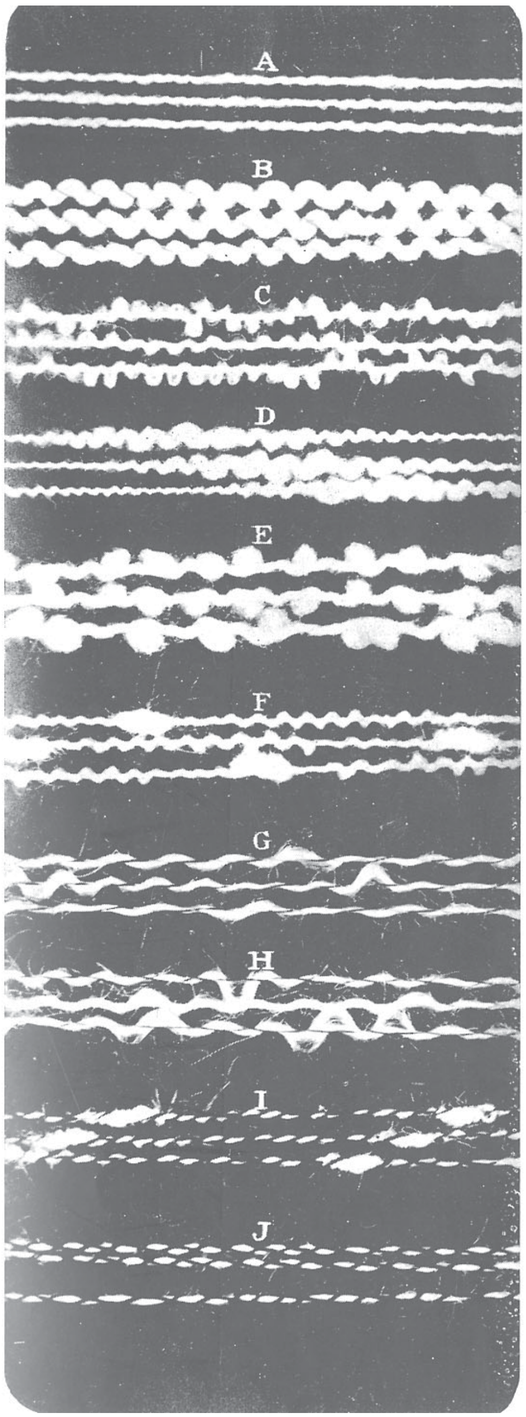


FIG. 30.
FANCY TWIST OR EFFECT YARNS.

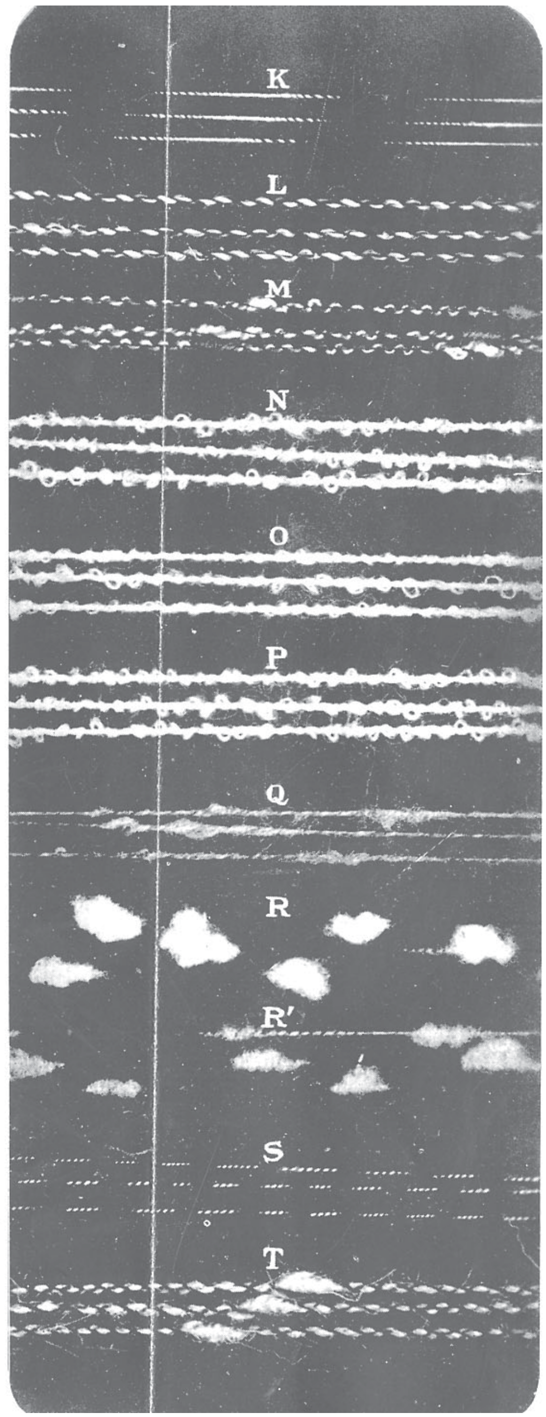


FIG. 30A.
FANCY TWIST OR EFFECT YARNS.

5264—(*bet. pp.* 74 *and* 75)

materials of which they are spun. Multi-fold yarns in which three, four, five, or a larger number of threads of one diameter are formed into a thick thread for giving a fuller quality of effect in the cloth than that characteristic of a single spun yarn of the required thickness, are also produced. Threads A in the striped and checked blouse texture in Fig. 29 are of this construction, being composed of five single threads of 40's cotton. Being more diversified in composition and in formation than thick single threads of equivalent counts, they impart clearness of tone to the pattern details to which they are applied. Such multi-fold yarns are, however, distinct in structure from "fancy" twists, which are strictly "effect" yarns (Figs. 30 and 30A) or yarns which develop definite features in the woven fabric. The systems of production are set forth in the dissected particulars, supplied in Table VI, of the "effect" and fancy folded yarns illustrated in Figs. 30 and 30A.

TABLE VI

PARTICULARS OF DISSECTED FANCY-TWIST YARNS

(Figs. 30 and 30A)

Specimen A.—Crimped or small Gimped Yarn consisting of a fine worsted roving and cotton thread twisted together, and afterwards retwisted in a contrary direction with a second cotton or binding end.

Specimen B.—Accentuated Gimped Yarn formed of two roving threads slackly twisted one with the other, and subsequently refolded with a small cotton thread, the latter being delivered under tension and the former delivered loosely.

Specimen C.—Looped Fancy Yarn obtained by running a mohair thread under easy tension and twisting it with a cotton yarn, followed by binding the two into one by folding with a further cotton thread.

Specimen D.—Flaked and Gimped Yarn made of a mohair roving and of a worsted or cotton thread with the mohair delivered intermittently, and to which a binding thread is subsequently added in refolding.

Specimen E.—Curl Yarn produced by using a mohair or lustre worsted roving twisted with a worsted thread, with the mohair so delivered that it may be drawn into curls by the "up-and-down" movement of the looping motion. For binding the two-fold thread thus acquired, it is retwisted, in the opposite direction to the initial twist, with a single cotton, worsted, or other yarn.

Specimen F.—Knopped and Gimped Yarn also three-fold in structure.

The knops are formed by twisting a mohair roving with a cotton thread, in which operation the mohair is intermittently delivered. The resultant two-fold yarn is then retwisted with a binder thread.

Specimen G.—Slackly-twisted Waved Yarn—formed of a mohair or lustre worsted and of a Botany worsted or cotton thread, the mohair being in the process slackly tensioned. A degree of the twist imparted is reversed in applying the binding end in the refolding operation.

Specimen H.—Similar to *G* but with still less tension applied to the mohair yarn in the process of twisting.

Specimen I.—Knopped Yarn made, in the first place, by twisting a mohair thread with a cotton thread, which, in the second place, is wrapped by reverse twisting with a cotton end.

Specimen J.—Similar to *I* without the use of the knopping motion in the first operation of twisting.

Specimen K.—Flaked Cotton Twist. This is a two-fold yarn in which black and white threads are alternately delivered at varying speeds.

Specimen L.—In this Fancy Yarn two worsted threads are first folded and then retwisted with two small ends of a different colour, when the four-fold yarn is reverse-twisted with a single yarn.

Specimen M.—Diamond or Chain Twist slightly knopped and consisting of one lustre thread and two fine cotton threads. In the first operation, a mohair and a cotton thread are combined, twisting from left to right, and in the second operation a second cotton thread is applied, twisting from right to left.

Specimen N.—Irregular small Curl or Loop Yarn formed of three threads, namely, lustre worsted and two cotton ends, and in a similar manner to specimen *C.*

Specimen O and P.—Variations of Yarn *N.*

Specimen Q.—Fancy Yarn acquired by allowing slubs of various colours to be run intermittently with the threads used in twisting.

Specimens R and R^1.—Slub Yarns usually made of two fine cotton threads in which condenser slivers are combined at regular intervals in the twisting operation on the same principle as in yarn *Q*, but the slivers or slubbings less continuously delivered.

Specimen S.—Knopped Diamond Twist made in the same way as specimen *J*, but with the worsted roving knopped and the chain or diamond characteristic better developed.

62. *Folded and Multi-ply Twist Threads.*—(*See* Figs. 30 and 30A.)

Gimp Yarns.—The ordinary types of these yarns are composed of two single-spun threads. Two- and three-fold specimens (Series A to G, Figs. 28) have already been referred to.

The gimped feature is developed in 2-ply yarns when the component threads are of like or dissimilar counts but of opposite twine, as the twisting of the two into one yarn deducts from the turns per inch in one thread, and adds to the turns per inch in the other thread. As the disparity in the counts of the respective thread units increases, the gimped characteristic becomes accentuated, as will be observed in samples A and B. Thick and thin places are formable in the resultant yarn (specimen D) by delivering the single threads at different speeds during twisting, and allowing the degree of twine to remain constant.

Curled and Gimp Yarns are similarly constructed, with one of the threads—mohair or lustre worsted—released at intervals by the rollers of the twisting frame, enabling the thread so treated to be drawn into loops or curls as seen in C; or such intermittently delivered thread may be shaped into beads or knops, as in F.

Corkscrew and Waved Yarns (G and H) may be slack or intermediate twisted and made of three separate threads, two being fine in counts and frequently cotton, and the third thread comparatively thick in counts and loosely spun from a lustrous class of material. The thicker thread is irregularly delivered, and in lengths corresponding to the dimensions of the "waved" or "looped" effect desired.

Buckled or Looped Yarns (E) are a species of curl twist, with, however, the buckled details compactly developed in the length of the compound thread.

Chain and Diamond Twists.—In these yarns (I, J and L) three threads are ordinarily employed, one forming a centre or core thread, with the two other yarns wrapped round it in reverse directions. Thread units of the same quality and diameter are combinable; but, as shown in the specimens, they may differ in these respects and also in colour. The surface of the twist may, in addition, be knopped or curled by the thread made of a bright description of fibre.

Flake Yarns.—Specimen K is a fine cotton twist of this formation. Two threads are used, and these are freely delivered and checked in the delivery in succession, causing tight and slack-twisted lengths of twist yarn to be alternately produced.

Three-colour Yarns.—As three threads are usable in these twists, they may be *beaded*, *knopped* (M), *gimped* (N, O, P), or *curled* in construction.

Slub Twist Yarns.—By selecting, as one component of the folded yarn, a condensed sliver or slubbing, and by delivering this intermittently in the twisting operation, compound threads of the character illustrated at Q are obtainable. More diversified yarns result from combining two or three shades or tints of slubbing and distributing these in the length of the twist in consecutive order.

Irregular Twists.—From the principles of fancy yarn construction defined it will be understood that, with their modification or elaboration, a varied assortment of irregular and unclassified multi-ply twists are producible. Two examples (R and S) are supplied, one of which consists of a 2-fold yarn wrapped with a third thread, and the second of a 3-fold yarn in which one thread is utilized in forming a special group of effects.

63. *Fancy Yarns in Dress and Costume Textures.*—These several descriptions and types of fancy twist yarns are adaptable to the different branches of dress, costume, and blouse cloth manufacture. They serve a useful purpose in the warping or wefting schemes of goods and builds of fabric in which the staple yarn employed is spun from cotton, flax, wool, or silk, and also in admixed yarn textures. Two specimens have been described in Paragraph 19. In the fine worsted and cashmere fabric illustrated in Fig. 13 twists of the mohair knop structure are effectively applied in the warp; and, as explained, yield the essential pattern details, or the compacted strands of white fibre which, in the raising of the piece, streak the surface of the cloth with long, hairy filament. In the second example quoted (Fig. 14) gimp yarn of the

character shown at A and B, Fig. 30, stripe the texture transversely. Other methods of applying such yarns are typified in Figs. 31, 32, 33, and 34. The first of these (Fig. 31) is a plain woven silk in which the gimped thread structure has been inserted in the weft for forming interesting lines across fabric. The use of an ordinary folded yarn of the same quality and thickness in this way would leave the lines severe, and produce a monotonous textural style. Variegated knopped yarns, formed of cotton, linen, and of cotton and silk, are applied to cotton blouse cloths on some such practice as indicated in Fig. 32, a fabric warped and woven thus—

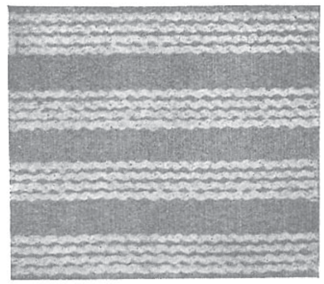


FIG. 31.—PLAIN SILK TEXTURE LINED WITH GIMP YARN.

Tint A—	Threads or	Picks	8	8	8	8	–	–
„ B—	„	„	8	–	8	20	38	20
Fancy Yarn —	„	„	–	′	–	′	′	–

Here, and in all similar styles, the overchecking lines, in fancy

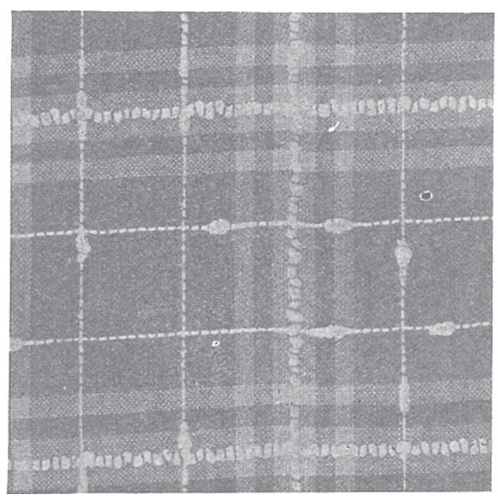


FIG. 32.—CHECKED BLOUSE TEXTURE WITH EFFECTS IN KNOP TWIST YARN.

yarn, form the special and novel feature of the design. Worsted and tweed costume cloths present a fibrous surface on which to display the yarn structure and composition. This surface

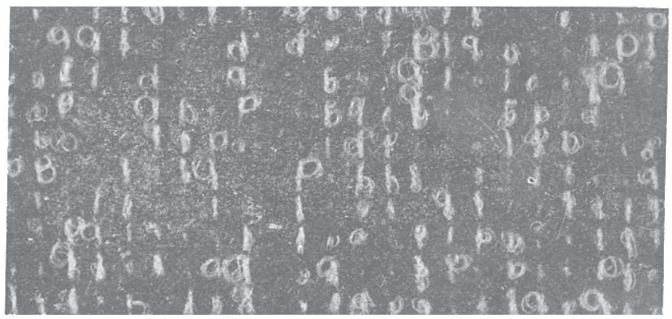


FIG. 33.—CROSSBRED WORSTED COSTUME CLOTH WITH CURL-TWIST YARN EFFECTS.

contrasts with the clear, bare surface in cotton and linen fabrics, and results in the twist threads being less distinctive in tone, inasmuch as they blend more satisfactorily with the plain or ordinary yarns with which they are combined. The examples in Figs. 33 and 34 are suggestive of the application

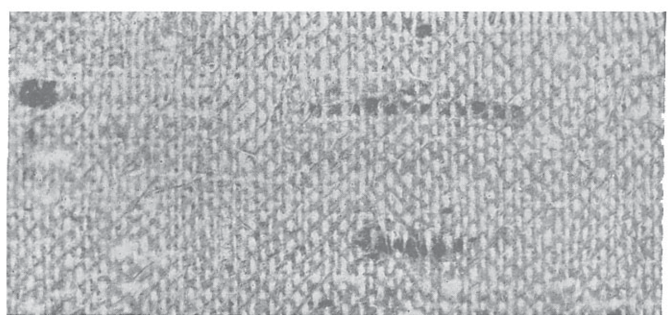


FIG. 34.—DONEGAL TWEED COSTUME CLOTH WITH CARDED KNOP YARN FEATURES.

of curl and knop yarns to two qualities of woven manufacture—one a Crossbred texture and the other a Donegal tweed. In the first, small curl yarns are used, and, in the second, knopped threads in which the knop is developed in the carding and not in the twisting operation.

CHAPTER III

SILK: THROWN, SPUN, AND ARTIFICIAL

64.—Thread-like Structure of the Silk Filament. 65.—Superior Qualities of the Fibre, contrasted with Cotton. 66.—Silk and Linen Textures compared. 67.—Silky Lustre. 68.—Early Origin of Silk—Historic Data. 69.—Organization of the Silk Industry. 70.—Technical Terms applied to Silk Textures. 71.—Watered Moiré Silks. 72.—Sources of Silk and Silk Waste Supplies. 73.—Seri-culture. 74.—Filament Fineness. 75.—Classification of Cocoons. 76.—Silk Reeling. 77.—Winding, Doubling, and Throwing. 78.—" Waste " Silk. 79.—Varieties of " Net " and " Waste " Silk Yarns. 80.—Different Qualities of Silk Waste. 81.—Gum Discharging—" Boiling-off." 82.—" Schappe " or " Steeping Practice." 83.—Routine of Spun-Thread Production. 84.—Softening and Conditioning. 85.—Filling Operation. 86.—Dressing and Combing. 87.—Short Fibre and Noil. 88.—Spreading and Lap Making. 89.—Drawing Operations. 90.—Roving. 91.—Spinning. 92.—Gassing, Cleaning, and Lustring. 93.—Silk Yarn Specimens. 94.—The Nature of Artificial Silk. 95.—Early History and Present Production. 96.—The Basis Material. 97.—The Chardonnet Process. 98.—The Cuprammonium Process. 99.—The Viscose Process. 100.—The Acetate Process. 101.—Qualities. 102.—Distinctive Tests. 103.—Relative Properties, Tenacity, etc. 104.—Relative Textile Values. 105.—The Treatment of Artificial Silk. 106.—Dyeing. 107.—Sizing, Soft Finishes, etc. 108.—Storage and Effect of Moisture, etc. 109.—Winding. 110.—Spooling. 111.—Twisting. 112.—Warping. 113.—Weaving. 114.—Artificial Silk in Woven Fabrics. 115.—" Fibro." 116.—Defects in Fabrics. 117.—The Trend of Development.

64. *Thread-like Structure of the Silk Filament.*—Silk, unlike other varieties of material employed in textile fabrication, already possesses, in the natural state, the form and continuity of length of a fine thread or yarn. While other descriptions of fibre require to be subjected to mechanical treatment in order to convert them into a thread-like structure, silk is emitted by the silk worm (*Bombyx mori*) as a continuous filament and wound into an egg-shaped cocoon. Hence the silken thread or filament from such cocoons may be reeled from end to end, that is, from the beginning to the termination of the process of production by the worm, and in a similar manner as spun yarn is reeled for hanking purposes. The twin filament from a single cocoon is too fine and delicate for ordinary use in manufacture, but by the combination in reeling, of the filaments from several cocoons, warp (*organzine*) and weft (*tram* or *trame*), silk yarns are acquired.

65. *Superior Qualities of the Fibre contrasted with Cotton.*—As a textile filament, silk is superior in lustre, tensility, and in wearing efficiency, to either plant or animal fibre, and also in the fineness (counts) of the threads in which it is weavable. Its unique and superlative qualities are at once evident when textures made of cotton, linen, and silk are compared of a corresponding structure, thread diameter, and loom setting (ends and shots per square inch). The silk satin and damask, and the plain or twilled silk fabric, differ from cotton and linen fabrics of a like designation and construction. With the selection of mercerized yarns, the cotton sateen—warp or weft face, appears to approach the silk-woven tissue in lustre or sheen and in other technical characteristics; but when the two textures are examined side by side for brightness and smoothness of surface, purity of colour, and kindness and quality of feel, the enhanced value of the silk manufacture is apparent. These differentiations in the features and properties of the silk satin and the cotton sateen, are to be equally discerned in plain, twilled, and the common sorts of texture. One manufacture, the silk, has an unsurpassed softness, flexibility, evenness of surface, and brightness of tone, and the other, the cotton, though highly suggestive of these technical elements, only exhibits them in a comparative or lesser degree.

66. *Silk and Linen Textures Compared.*—Extending the analysis to linens and silks, the contrasts between the woven products are likewise fully accentuated. Taking, for example, a typical damask, made, respectively, in silk and linen warp and weft yarns identical in counts, with the number of threads and picks in agreement in each, and both textures consisting

of one design scheme—the silk is firm and lustrous in structure, with the pattern details clearly visible, as a consequence of the distinction between the warp-face sateen in the ground and the weft-face sateen in the figure; the linen is firmer and harder and fine in the make, but less lustrous, with the pattern details more subdued, as a consequence of the closeness of the relation, in effect, of the warp and weft weave units in the cloth. These obvious variations betwixt the fabrics have resulted in the use of silk weft in the finest classes of linen goods for the purpose of developing a superior richness of cloth, and of improved clearness of design delineation than is feasible in goods made of pure flax yarns.

67. *Silky Lustre.*—The lustre in silk runs through the thread, being present in the larva of the *Bombycid* moth or silk worm, of which the filament is composed. Its lustre is, in this sense, distinct from that of cotton, flax, and wool. In the two former, lustre may be acquired by pressure applied to the yarn or fabric, chemically prepared, as in mercerizing and in calendering for assisting the mechanical action, and rendering the "gloss" produced more permanent in nature. In wool, lustre is mainly a derivative of the outer scales of the fibre, and is, therefore, a superficial but natural quality of the filament, and one which varies in degree with the class of wool selected. The lustre in cotton or linen is definable as a "glossy sheen" artificially induced. It is not inherent in the fibre as understood in the case of silk, which, after degumming, presents what is termed "silky," as distinguished from "metallic," lustre.

68. *Early Origin of Silk—Historic Data.*—That a raw material of such adaptable and special properties for loomwork should have been used from early times is in keeping with inventive progress in the manufacturing arts. For some 4,000 years silk-worm culture has been known and practised in China. The *Book of Odes,* compiled by Confucius about 550 B.C., contains poems of a much greater antiquity, in which references are made to cotton, serge and other fabrics, but particularly descriptive of textures for silken wear. From

China the knowledge of seri-culture and of silk-reeling and throwing, and possibly also of decorative (harness) silk weaving, was transmitted through India to Persia, and from the latter country by Alexander the Great to Egypt and Greece, and thence to the Roman world. In the fourteenth to the seventeenth centuries, the art of silk fabrication, from the natural fibre to the woven texture, flourished in Florence, Venice, and Genoa, and in the South of France, and was subsequently stimulated in England by the settlement of the Huguenot weavers in Spitalfields, London.

69. *Organization of the Silk Industry.*—The silk industry, as now organized, comprises in manufactured goods: (*a*) plain and decorative fabrics; (*b*) lace, hand and frame produced; (*c*) hosiery and knitted goods; (*d*) embroidered, embossed, and printed textiles; and (*e*) small-ware and passementerie textures. In class (*a*) are found the different styles of dress and blouse cloths, first, in plain, twill, and other elementary weaves; second, in coloured cloths; third in spotted and figured fabrics, simple and compound in structure; and fourth, in decorative robe textures of the brocade and pile-woven varieties.

70. *Technical Terms applied to Silk Textures.*—Amongst the trade terms applied to silk manufactures, elementary in weave structure, the following may be mentioned—

1. Plain-Woven Fabrics: Taffeta mousseline, taffeta chiffon, crêpe de chine, glacé, diaphanes, e.g. ninon, tulle, voile, marquisette; moiré or watered silks, e.g. moiré ondé, tabissé, semé de flammes, moiré français, moiré antique and moirés faconné.

2. Cord or Repp Structures: Gros de Tours, gros de Naples and gros royale.

3. Twilled Woven: Sarcenet (also taffeta make), surah, serge, and linings.

4. Sateen Woven: Satins—yarn and piece-dyed—satin mousseline, peau de soie, satin lumière, charmeuse, de Lyon; soie radium, soie meteor, soliels, etc.

5. Cross or Gauze Woven : Chiffon gauze, mousseline, gauze, leno and striped and fancy gauzes.

6. Velvet or Pile Woven : Velvets, plain, terry, frisé, Utrecht, velours de nord, velours chiffon, velours sabre, and different kinds of plushes.

7. Coloured Silks or Fancies : Striped, checked, chiné or warp printed, foulard, chiffon, etc.

Mousselines, chiffons, and crêpes include the light, soft, delicate types of texture ; and diaphanes those of a semi-transparent character. Gros de Tours and all silk cord stuffs are repped or ribbed across. Sarcenet and twilled fabrics are firmer in the build than the mousseline, and are applicable to linings. Irish poplins are a species of repp in which the warp is made of silk and the weft of wool fibre. Other silk unions comprise crêpons, lustres, Sicilians, matelassés, and various sorts of velvets.

The peculiarity—irregular crimpled appearance of silk crêpes—arises from the practice in dyeing and dressing. A glutinous composition is, in the work, applied to the pieces, and this, in stiffening the threads, neutralizes a degree of the twine inserted in their formation, and thus yields the textural property distinguishing this class of fabric.

71. *Watered or Moiré Silks.*—Watered silks are a further variety of plain goods. Their waved and indefinite figured character is obtained by passing two pieces, face to face, between a pair of pressure rollers, one of which is steam-charged and heated. However smooth and level the surface of a plain texture may seem, as it is formed by the interlacing of threads of warp and weft in alternate order with each other, it is, in reality, a grained surface, the fineness or coarseness of the grain coinciding with the diameter of the two series of yarns intersected. With the grain of one texture impelled into the grain of a second texture, while both are under tension, the minute unevenness in their surfaces is perfectly equalized. It follows that, in so bringing two woven surfaces into absolute conformity, such areas of the surface of each

texture as are subjected to the severer pressure, receive and retain the brighter lustre, and, conversely, such parts of the two pieces as are lesser affected in the operation, necessarily assume a duller lustre. These contrasts in lustrous tone, being irregularly distributed in waved lines, and in nondescript forms, on the face of the fabrics, produce the so-called "watered" feature from which the goods derive their commercial designation.

72. *Sources of Silk and Silk Waste Supplies.*—Silk-worm culture is industrially pursued in China, Japan, India, Persia, Turkey, Italy, France, and America. Japanese and Chinese silks have, in recent years, greatly improved in standard under the technical and scientific methods which have been introduced. The School of Seri-Culture in Tokio, is admirably equipped and organized, and the instruction imparted has raised the annual silk product of the country, and improved the efficiency with which Japanese silks are prepared for commerce. Chinese silks, known for their purity of colour and brilliant whiteness, are undergoing the same process of betterment. They, as those of Japan, are used in native textile manufactures, but are also extensively exported in the raw state to this country. Bengal silks are another important variety, the "country reeled" being, however, an inferior quality to the "filature" spun. The latter, in the better grades, enters into competition with European silk. Persia and Turkey are both silk producing countries, and, in this relation, are capable of considerable development by the fuller adoption of European practices as applied to silk-worm rearing and silk reeling. The silks of France, Italy and Switzerland rank amongst the finest produced. Scientific investigation and technical training have secured for France the premier position in the production of the silk filament, in silk thread preparation, and in the manufacture of silk goods.

The world's supplies of silk and "silk waste" are, however, mainly derived from China, Japan, and Italy, France not exporting the raw fibre, but manufactured goods; and the silk product of other countries—Turkey, Persia, Switzerland, etc.—is more in the nature of a supplementary than of a substantial asset. As regards the United Kingdom, it acquires some 60 per cent. of its silk from China, with a growing supply from Japan. This restriction in the sources from which silk for British textile production is drawn, points to the desirability of Government measures being taken to encourage seri-culture in India and other parts of the Empire where the conditions are favourable.

73. *Seri-culture.*—The eggs deposited by the silk moth are no larger than mustard seed. At first they are of a yellowish colour, but in a few days assume a blackish tint. Incubators are now customarily employed, in which hatching is effected in about thirteen or fourteen days. While in the caterpillar stage the skin is changed four times. The worm (which feeds chiefly on mulberry leaves) increases rapidly in size while the skin is soft, measuring at full growth from 3 to $3\frac{1}{2}$ ins. in length, and weighing some 75 grains. Hummel states that "the silk substance is secreted by two glands symmetrically situated on each side of the body of the caterpillar, below the intestinal canal. Each gland consists of three parts—a narrow tube with numerous convolutions, the veritable secreting portion; a central part somewhat expanded and constituting the reservoir of the silk substance, a capillary tube connecting the reservoir with a similar capillary canal common to both glands, and situated in the head of the worm, whence issues the silk."

When the spinning period is reached, the silkworm develops signs of restlessness and proceeds to construct a sort of rough scaffolding, fashioned of flossy material, by intertwining filament with filament attached to adjacent points (twigs, etc.) for support. On this structure the labour of cocoon making is performed. The cocoon is approximately the size of a pigeon egg, the dimensions of the cultivated varieties being $1\frac{1}{2}$ in. by $\frac{1}{2}$ in., of Tussur $1\frac{1}{2}$ in. by $\frac{7}{8}$ in. and of certain wild varieties, 3 in. by $1\frac{1}{2}$ in. Frequently the length of the *bave* (= the *brin* or two-filament silk thread) from one cocoon exceeds 1,100 ft. On gathering the cocoons, the chrysalis is destroyed by placing the cocoons in a heated oven (*étouffoir* or *séchoir*), raising the temperature sufficiently to destroy the worm without injuring the silk fibre. Should this not be done, the worm would gradually pierce through the silk coil and disrupt the length of the filament.

74. *Filament Fineness.*—Under the microscope the fibre shows a great uniformity of diameter measurement, with, however, slight variations in the layers of filament on the inside and the outside of the cocoon. Chinese, Italian, Japanese, and Bengal filaments, when thus examined, presented the following comparative diameters—

	Diameter of fibre from outer part of cocoon.	Diameter of fibre from inner part of cocoon.
Chinese	$\frac{1}{2150}$ fractional part of an inch.	$\frac{1}{2150}$ fractional part of an inch.
Italian	$\frac{1}{2150}$,, ,, ,,	$\frac{1}{2100}$,, ,, ,,
Japanese	$\frac{1}{1800}$,, ,, ,,	$\frac{1}{1650}$,, ,, ,,
Bengalese	$\frac{1}{2000}$,, ,, ,,	$\frac{1}{2200}$,, ,, ,,

Considering that each filament from sound cocoons is a reelable thread, if the silk fibre could be woven into a texture without further doubling, plain woven fabrics would be producible, constructed on the intersection basis of setting, with more than 1,000 threads and shots per inch.

It has been estimated that for making 16 ozs. of reeled thread, 12 lbs. of cocoons are required, and that these represent the total yield of from 2,800 to 3,000 silk worms, to supply which with food, during the caterpillar state, 150 lbs. of mulberry leaves are consumed. The weight of silk quoted might be converted into 16 yards of silk texture (*gros de Naples*) of an ordinary grade, and some 14 yards of a superior quality.

75. *Classification of Cocoons.*—All species of cocoons, when gathered, include a number of more or less imperfectly-formed structures, hence cocoons for commercial purposes are classified into the following categories: (*a*) *Sound* or *good* cocoons, which are not necessarily the largest, but which are even, compact, and free from external defects, so that they are normally windable without breakage; (*b*) *Pointed* or *irregularly-shaped* cocoons, which reel satisfactorily until the point of the cocoon is reached when the filament, being unduly weak and attenuated, gives out. (*c*) *Cocalons*, which are usually of a larger size than the average cocoon, but softer and looser in texture. They have a disposition to "furze" more readily than sound cocoons, and for this reason are reeled separately. (*d*) *Doupions* or *double-shaped* cocoons, the fibre of which is liable to be meshed, making correct reeling impracticable. (*e*) *Soufflons*, partially transparent cocoons of an open structure, or spongy in composition, and unfit for winding. (*f*) *Pierced* or *perforated* cocoons, and (*g*) *Choquettes*, or cocoons in which the worm has died in the work of thread production. These are classed as sound and faulty, the former being windable, though the filament lacks the brilliance of that from good cocoons, while the latter are unusable for reeling. Still further varieties are formed and designated *Calcined* and *Royal* cocoons. In the first, from the worm having been attacked by disease after the completion of its labour, the chrysalis becomes petrified, or, in some instances, reduced to a powdered dust. The second, on account of the cocoons having been pierced by the breeding moths, are not reeled, but prepared with the *soufflons* and *perforated* cocoons.

76. *Silk-Reeling.*—As described, the two-unit filament, obtained from each cocoon, is too fine and delicate in structure to be fit for manufacturing application. On these grounds several filaments, or the products of several cocoons, are reeled together.

The reeling frame is simple in construction, ordinarily consisting of a trough or bowl in which the cocoons are immersed in soft warm water; of suitable guide and tensioning rails; and of the reel for hanking the threads. The object of the water bath is to release the gummy matter, and facilitate the unwinding of the cocoon, the gelatinous substance retained causing the filaments to adhere to each other in the formation of the compound thread required. At the beginning of the operation the reeler presses the cocoons with a *battage* brush—made of fine twigs and even at the ends—into the tepid water, gently stirring them meanwhile. The loose fibres of the cocoons thus become attached to the points of the brush, from which they may be drawn through the fingers and cleared of floss and other impurities. Taking four or more ends—the number varying with the sort of thread being prepared—they are passed together through the eyelet in the guide rail fixed above the cocoon bowl. Two such compound threads are then twisted with each other, to produce a cylindrical form of yarn as differing from a similar silk yarn in which the fibres lay flat or in a ribbon-like relation. Following this routine, the silk is wound into a skein or hank on the reel. Reeling is carried out to give any description of silk thread, such as that formed of the composite filament from one cocoon, and that made of the filaments from several to as many as 100 cocoons; but, in ordinary practice, it is rare to exceed the amalgamation of more than thirty filaments in producing one thread unit. The balls of silk are not in the process run off to the extreme end, for the simple reason that the husk would be liable to foul the yarn. On nearing the completion of the silk, the chrysalis drops off the fibre, leaving the ball so much the lighter, which causes it to rise out of the water and come in contact with the guide rail of the machine.

An even thread, one absolutely uniform in size, is an essential object to be attained in reeling. This necessitates care and skill in the work of production, inasmuch as the filaments of the different cocoons are not of equal diameters, or degrees of tenuity. The art of reeling consists in uniting such fibres as coincide with the fineness and quality of the yarn required, which is not strictly definable by the multiple of ends it contains as a thread formed of three, four, five, or six filaments, but as a silk thread consisting of 2–3, 3–4, 4–5, etc., fibres.

77. *Winding, Doubling, and Throwing.*—Raw silk is, before weaving, converted into one of three forms, namely: (*a*) Singles; (*b*) trame; and (*c*) organzine. The first may be reeled silk to which twist has been added for imparting tensile property; the second and the third are made by combining several reeled threads, with the *trame* quality loosely twisted, and the *organzine* quality firmer twisted and in the reverse direction to the single threads of which it consists.

The operations of silk-throwing and spinning include: (1) Winding from the reeled skeins or hanks on to bobbins; (2) sorting for quality after winding; (3) twisting or spinning, and (4) folding and twisting the requisite number of threads into one of a suitable size and structure. In winding, the skeins of silk are run off the reels or "swifts" and wound on to bobbins laterally fixed in the winding machine. It is followed by twisting for giving "singles," the twist being inserted on the flyer principle of spinning. Should the silk be intended for dyeing in the hank, the amount of twist is moderated. *Singles*, for *organzine*, are in the first operation twisted to the left, and then retwisted in the opposite sense. The doubling of two, three, or other number of silk threads is next effected; after which, bobbins of the two or multi-ply threads so prepared are mounted in the throwster frame. Here the threads, from two or more bobbins, are combined and spun into yarn which is delivered in hanks. The twist, generated in the construction of the yarn, develops a disposition to crinkle in the silk. This crimpiness is eliminated by steaming the silk thread while extended on the swifts.

The thread thus obtained is known as "hard" silk. It still contains the natural gum, which is useful in the operations described on account of the adhesive qualities it gives to the fibre. The discharge of this gummy matter from the material is now done by boiling the skeins of thrown silk in a solution of soap and water, leaving the yarn soft and lustrous.

78. *Waste Silk.*—The term is descriptive of pure or raw silk fibre. The material is not a by-product but a resultant of a certain filament obtained in the making of the cocoon by the silkworm, or in the preparation of the silk thread. What is termed "floss" silk is derived from the network of fibre covering the cocoon proper. It is therefore a material acquired in the cultivation of the silkworm for "net" or "thrown" silks, and also in the production of the "wild" varieties of silk of which the Tussur is suggestive.

It has been shown that there is quite a number of sorts of damaged cocoons, the fibre of which is unreelable, and these constitute a second and important source of "waste" silk adapted for mechanical thread construction. Moreover, it will be understood that in reeling, winding, doubling, throwing, and spinning, some considerable amount of waste fibre is made; and that, by reason of the practices by which it accumulates, it will contain good and indifferent qualities, but largely the former. The sorts in which hard twisted ends and pieces of thread occur, necessitate great care in combing, unless the ends, etc., are picked out by hand.

To the descriptions of fibre got from defective cocoons have to be added what are technically termed "Knubbs," or cocoons which have been entangled and formed into attenuated meshes of fibre, as well as the rough, coarse-looking hanks of silk, styled "Punjam Books," and which consist of silken yarn which has been spoiled in the winding. The wild varieties of silk, in consequence of the cocoons being imperfectly developed and irregular in formation, are classed as unwindable, and hence yield an important "waste" staple, though not one of a high quality.

79. *Varieties of "Net" and "Waste" Silk Yarns.*—The

different varieties of silk yarns and the systems by which they are obtained are stated below—

TABLE VII

VARIETIES OF "NET," "WASTE," AND "WILD" SILK YARNS

A. Net and Thrown Silk Yarns—from
 (1) Degummed or boiled-off silks.
 (2) "Souple" or partially boiled-off silks.

B. "Waste" or Spun Yarns—from
 (1) "Floss" gathered from all descriptions of cocoons.
 (2) Fibre from damaged cocoons.
 (3) Fibre from the manufacturing processes in the preparation of Net or Thrown silk yarns.

C. "Wild" Silk Yarns—produced by
 (1) Boiling-off or English system.
 (2) Steeping (Schappe silks) or Continental system.

N.B.—In the making of the yarns in (B) and (C) there is a percentage of fibre or "noil" extracted in the combing process, which is valuable for admixture with other textile materials in union-yarn manufacture.

80. *Different Qualities of Waste Silk.*—Waste silks, being derived from such a diversity of sources, are necessarily of different qualities. Referring, for instance, to the waste products from China and Japan, and to those from European centres, the former are generally in a harder and more meshed condition than the latter, arising from the custom in the Far East of pressing the materials, somewhat promiscuously, in bales. Chinese "wastes" range in colour from pure white to a clear yellow in the better sorts, and from a full yellow to a brownish fawn in the inferior sorts. European wastes are fairly free from foreign matter, and of a tinted grey or yellowish colour. The class known as filature waste, resulting from the processes of throwing and spinning, occasionally contain a portion of hard ends and bits of yarn.

81. *Gum Discharging, "Boiling-off."*—After sorting, for classification as to fineness and quality, the first work is to discharge the viscid gum, which is done by two practices, that

of "boiling off" and that of "steeping" or "soaking." The former is the older and the English method. It is carried out in large wooden vats or iron pans, circular in shape, like a dye vat, perforated at the bottom and steam heated. Having run into the vessel a sufficient quantity of water, 10 to 15 lbs. of sliced white curd soap are introduced, and the temperature raised till the soap is in solution. Some 100 to 120 lbs. of silk are now placed in the vat, either in the loose state, or in prepared canvas cotton cloth bags. The whole is then brought to a boil. The finer varieties of Chinese waste only require a small percentage of soap, and to be in the vat for a short time, but other kinds, such as the dark coloured wastes, require protracted treatment, or the boiling and cleansing to be repeated two or three times. Bluing or tinting of silk, if done, is performed in the final stage of boiling, by adding to the bath the diluted colouring ingredient. For removing the liquid from the silk, the boiled silk material is passed between squeezing rollers, hydro-extracted and dried.

82. "*Schappe*" *or Steeping Practice.*—The "Schappe" or "steeping practice" consists in placing the supply of waste silk in jacketed pans, and pressing it firmly down, in which state it is retained by applying flatboards. Fermentation is induced by heating up the vessel periodically. After fermentation has continued long enough, the material is removed from the vessels, pounded, rinsed in clean water, and exposed in a suitable temperature for drying purposes. The idea in the system is to soften the silk without discharging the gum, whereas the idea in the English system, is a complete expulsion of all adhesive and gelatinous matter. In the case of the waste silks selected on the Continent, the practice is satisfactory. The softened gum left in the fibrils acts as filament "size" in the operations of dressing, combing, and thread preparation, reducing its diffusiveness, and rendering the "waste" less liable to work into "nibs" and hard "neps" of fibre.

83. *Routine of Spun-thread Production.*—The routine of silk

waste or spun-thread manufacture comprises (*a*) softening; (*b*) conditioning; (*c*) dressing; (*d*) spreading and lap making; (*e*) drawing; (*f*) roving; (*g*) spinning and (*h*) cleaning, gassing and lustring.

84. *Softening and Conditioning.*—To prepare the "waste" for combing and dressing, it is, after discharging and drying, passed through the softening machine, containing six pairs of fluted rollers which successively rotate forward and backward, but with an accelerated forward movement. This has the effect of loosening, opening, and smoothing out the staple. The batch of material, having been thus treated, is "piled" in the conditioning chamber, where it is mechanically dewed or sprayed, or manually sprinkled with water. In this humid state the fibres acquire "condition" or an increased suppleness, flexibility, and working fitness.

85. "*Filling*" *Operation.*—Prior to being transferred to the dressing frame, the "waste" is dealt with in the filling engine, consisting of a feed sheet—on which it is evenly distributed in lots of 3 to 5 lbs.—of feed rollers; of a series of porcupine rollers or leather bands covered with porcupine (pinned) clothing; and of a large cylinder mounted with twelve to eighteen combs. It is the function of the combs in the cylinder to gather up the staple as delivered by the feed rollers. When this has been done, the motion of the machine is interrupted while the attendant severs the draft of fibres on the respective combs; turning their free ends backward. This makes it feasible for hinged boards to be so operated as to grip the fringe of fibres. Then, by effecting a downward action of the boards, the "strippings" are taken in serial order off the combs, and the "fill"—i.e. drawn and straightened staple from each comb in the cylinder—is completed, which, in an eighteen-comb cylinder, would be equal to the formation of this number of boards or "books" of fibre required in charging the dressing frame.

86. *Dressing and Combing.*—The flat dressing type of machine has, in the first place, a frame A movable on its

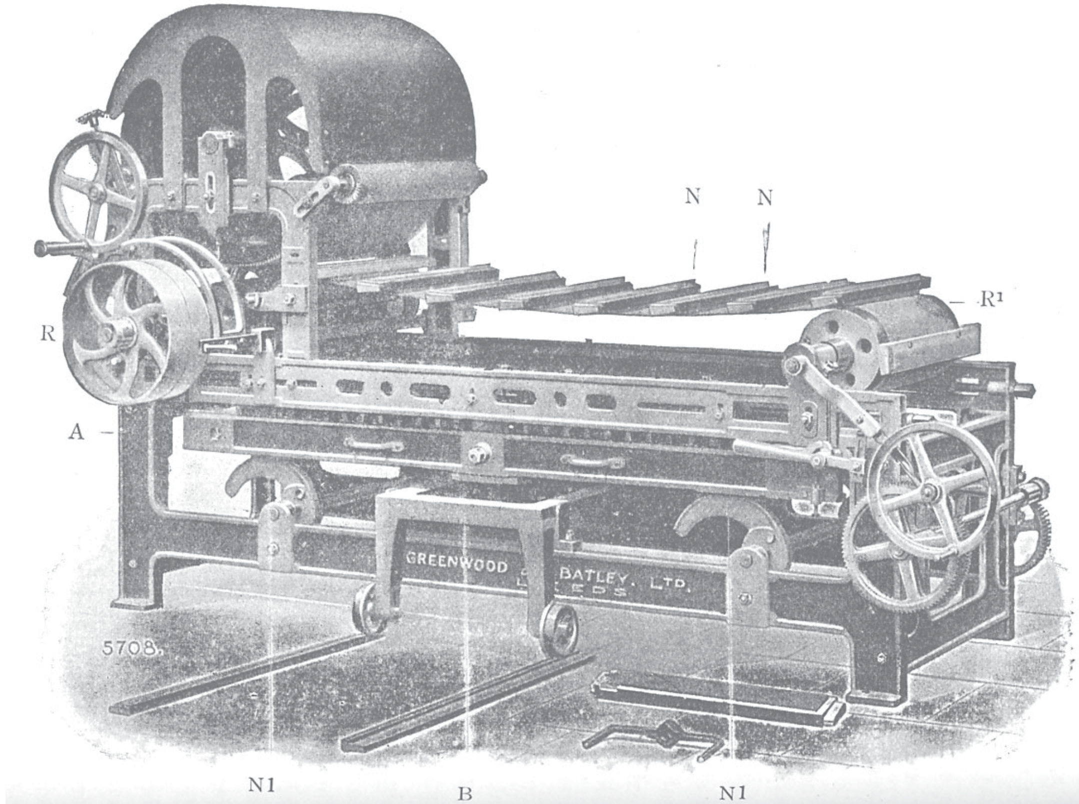


FIG. 35.—FLAT DRESSING FRAME, WITH SELF-ACTING STRIPPING DRUM.

centre (Figs. 35 and 35A), divided as shown into two sections, and which may be made to traverse inwards and outwards on the carriage B. Each section is arranged to take a "fill" of books from the preparing engine. These are fixed vertically in the frame with the fringe of fibres projecting above the extremities of the boards. Second, the machine consists of an endless belt or web to which are secured the sectional combs N. The belt passes tautly round the surface rollers R, R^1, immediately over the frames, carrying the "books" of filament. The latter are, by the press cams, M, gradually raised, during the rotation of the web and its combs, until the whole length of the fibre has been treated or combed through, or the edges of the boards are nearly in contact with the pins of the combs N. At this stage in the work the press is automatically lowered, the frame turned on its centre, the carriage run out, and the process re-performed, with the object of the combing action being effected on the respective sides of the fibres successively. The combing pins in the first routine, move through the fringe of the material from left to right, and in the second, from right to left, and, in each instance, as the action continues, proceed from the ends of the fibres to the point where they are firmly held by the boards.

Obviously only one portion of the lengths of silk fibre has so far been combed; the dresser therefore removes the boards, a pair at a time, from the frame, taking one of the boards in the right hand on which the fibres are laid, and the other in the left hand, and neatly changes their position, presenting the uncombed section beyond the ends of the boards. Having thus reversed the strippings of material, and refilled frame A, the operation described is repeated.

87. *Short Fibre and Noil.*—As in the combing of wool or cotton, one of the features is the effective opening of the clusters of short fibre, so in the practice of "waste" silk combing and dressing. In the second combing there are commonly attached to the web sheet, narrow widths of card clothing S, Fig. 35A, intermediate between the combs, which

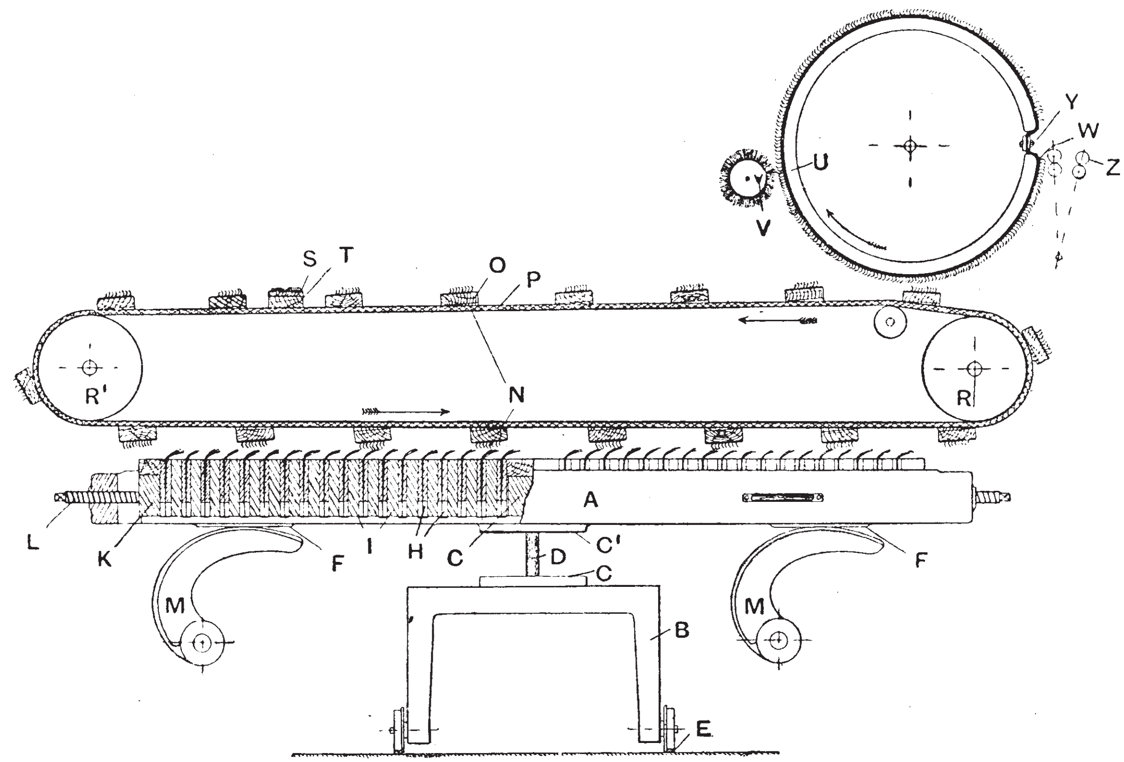


FIG. 35A.—SECTION OF WASTE SILK DRESSING FRAME.

have the effect of opening and levelling the more neppy fractions of filament.

The dressed product obtained is described as the dressers' "strick," corresponding to a "strick" of flax in linen yarn making, or to the lengths of cleared and equalized fibre ready for the preparing operations. There is a small percentage of fibre, which does not form part of the "stricks," such as that remaining in the pins of the combs. This becomes, when extracted, the silk "noil." A modern method of clearing the combs of this fibre is by means of a card-clothed cylinder U, Fig. 35A, a revolving brush V, and a pair of drawing-off rollers, W, which, as shown, have two positions, that in which they are operative and close to the drum, and that in which they are inoperative and indicated at Z. The unclothed division, Y, in the cylinder U, is the point where the thin layer of fibre is disrupted, and removed by the delivering rollers. Another method, in which this mechanism is not employed, consists in passing the "boards" across the web of the frame by hand, and behind the comb to be cleared, with the free ends of the fibres well gripped between their surfaces. This strips the comb, or transfers the fibre from the pins of the comb to the boards.

The first dressing, in this system of work, yields a "first-draft," the second dressing a "second-draft," and so on. Silk waste, furnishing successive drafts in which the fibre serially diminishes in length and weight of "strick," may be satisfactorily and advantageously treated to the lowest draft. Chinese "wastes" are of this class, while other sorts of "waste" drop off more suddenly in both fibre measurement and in quantity of result, and only consequently give a small number of "drafts."

As each "draft" consists of an equalized length of fibre, it was at one time the practice to treat the several "drafts" down the drawing, in the production of different qualities of silk yarn, such as from the first, second, and other consecutive "drafts." This is not now strictly done, admixtures of two or more drafts being carried out. There is not that degree of correspondence in filament length in the respective "drafts" to establish this as a fixed economic basis of manufacture. Chinese silks, for example, will present fibre in the first "draft" of from $2\frac{1}{2}$ to 6 or more inches in length, with fibre of from 1 to 3 ins. in the final "draft" made; while ordinary descriptions of "waste" result in "drafts" I, II, III, and IV, varying respectively from 2 to 6, 2 to 4, $1\frac{1}{2}$ to $3\frac{1}{2}$, $1\frac{1}{2}$ to 3, and from $\frac{1}{2}$ to 3 ins.

The flat dressing-machine described is also made in a continuous form for increasing the productive output, when it compares, in this particular, more favourably with the circular construction of dressing frame employed on the Continent. The latter, which is suitable for "Schappe" treated waste silk, comprises (1) a large drum, whose circumference is divided into three or five sections, in each of which the rods of silk are inserted and turned by the dresser and his assistant; (2) comb rollers, one on each side of the drum, and fixed in a lower position; (3) comb brushes, and (4) drawing-off rollers for clearing the circular comb. The principle of action is similar but severer on the fibre than that of the flat dressing frame, but it is found, as stated, adapted for the treatment of only partially degummed or steeped waste silk.

The dressed silk is stripped from the rods in the cylinder by placing a cloth over the surface of the rods, with the prepared fibre projecting, and affixing it to a small roller. By turning this roller, the film of silk is wound thereon, one film of combed silk linking with another from adjacent rods, and giving what is designated a "nappe" of dressed silk.

For the shorter varieties of silk fibre the Heilman combing machine may also be utilized. In principle of mechanism, and in method of adjustment and working, it is applicable to the straightening and alignment of the shortest classes of filament, and is for this reason used, to a limited extent, in the dressing of short silk wastes.

The subsequent operations may be grouped into those for long-fibre thread making, including spreading and gilling, drawing, roving, and spinning-flyer, cap or ring practice ; and for short-fibre thread making, namely, scutching, drawing, slubbing and spinning on the ring frame. The first system of operations will be examined.

Spreading machinery is of three forms of construction known as the Open Screw Gill, the Intersecting Screw Gill, and the Rotary or Porcupine Roller Gill Spreader. The first is the older and commoner type, but is being superseded by the Intersecting Gill Box. Both the first and second types of machine agree in principle of levelling the sliver, but in the latter a second and upper set of fallers are introduced, whose pins work through the ribbon of fibres in a downward direction. The advantage derived is twofold ; the additional fallers prevent the fibres from riding on the surface of the pins, by penetrating them from above, and reduce the amount of filament leakage in the operation. The Rotary Spreader is built on the French or Continental plan, porcupine rollers taking the place of the fallers, studded with pins, and traversing on screws between the front and the back rollers of the machine.

88. *Spreading and Lap Making.*—The process will be described by referring to the illustrations (Figs. 36 and 36A) of the Intersecting Screw Gill Spreader. On the feed sheet A the dressed fibre is laid lengthways, with each spreading joining up with the preceding one, supplying a continuous and even layer of fibres to feed rollers B. These, and rollers D, have different circumferential speeds, causing the sliver of fibre to be drafted or attenuated between them. The fallers C move forward on the upper screw and travel backward on the lower screw, and the fibres, in sliver form, are, therefore, drawn through their pins by the increased speed of rollers D as compared with rollers B. There passes over the lower roller D, and a second roller adjacent to the drum of cylinder E, an endless leather belt by which the treated sliver is collected into a lap of the required thickness, when it is removed by the machine minder. Such laps are further equalized in length

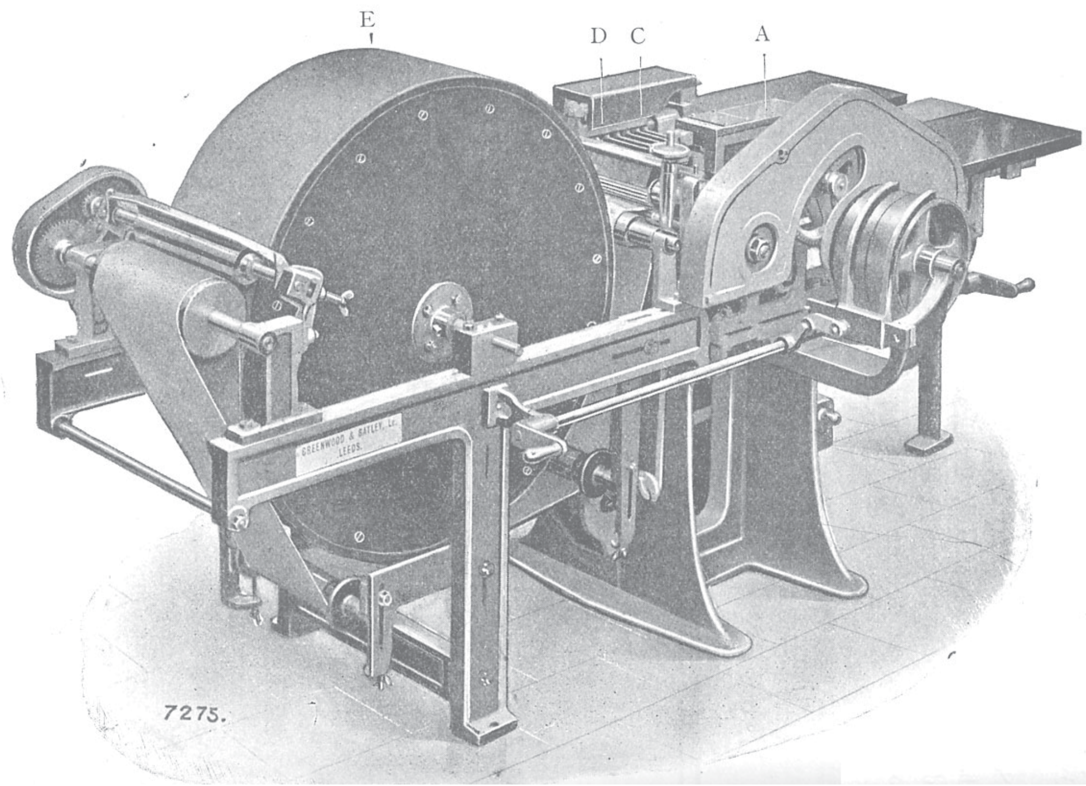


FIG. 36.—INTERSECTING SCREW GILL SPREADER.

and weight on the re-lapper, during which the blending of filament qualities, for the construction of a definite class of yarn, may be done.

The prepared lap of fibre is converted into a sliver in the Sett Frame, which is similar in arrangement to the Gill Spreader, having two pairs of rollers—back and front revolving at dissimilar speeds—and faller gills, with the addition, however, of winding-off rollers for conveying the sliver into a can.

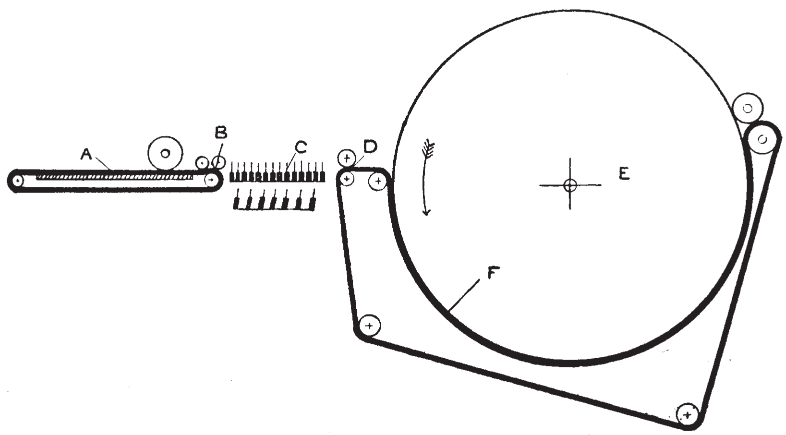


FIG. 36A.—SECTION OF SCREW GILL SPREADER.

89. *Drawing Operations.*—The silk filament is now in a suitable condition for the drawing operations. Ten or twelve cans of slivers are put behind the first head (four in number) of the Single Screw Drawing Frame (Fig. 37) and drawn out between the rollers A and B to a sliver slightly greater in length and somewhat smaller in thickness than the sliver in the series employed. Intermediate between the two sets of rollers are the usual faller gills. In the complete box, with ten or twelve slivers fed into each of the four heads, there would be respectively obtained 10,000 and 21,736 doublings of the slivers in forming one final sliver product. With this amount of amalgamation of sliver units, as well as the measure of levelling and straightening action of the fallers of each head, and also that

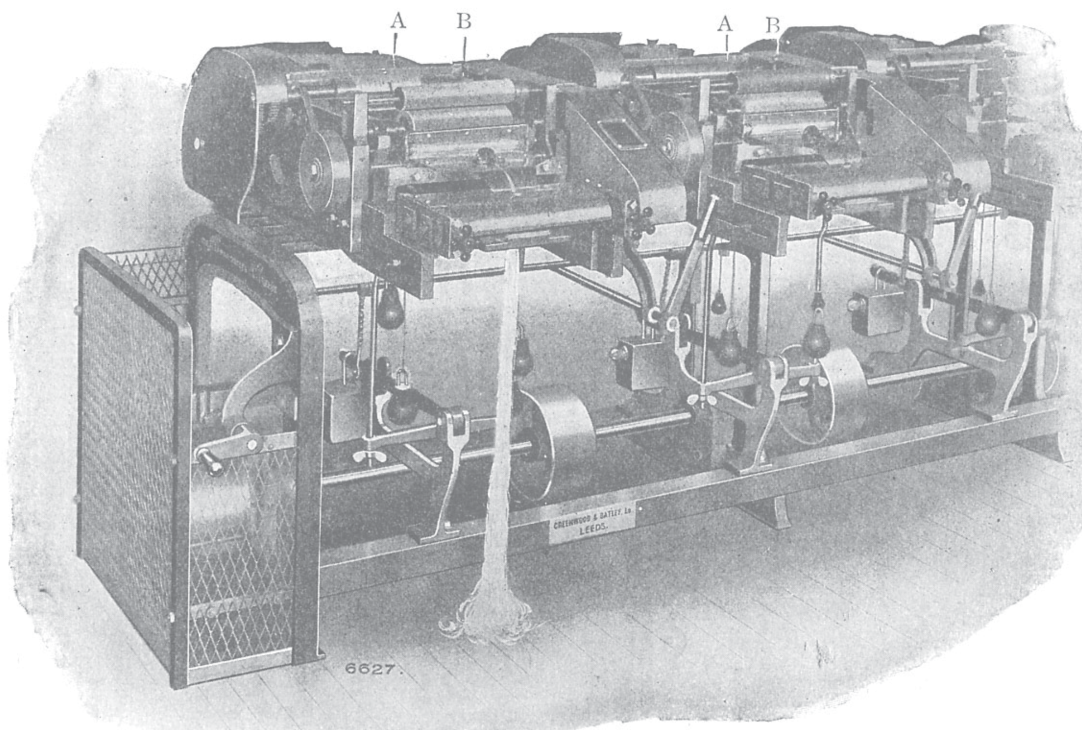


Fig. 37.—Open, or Single Screw Gill Drawing Frame, of Four Heads, all on one Stand and Each Driven Separately.

of the degree of attenuation to which the slivers are subjected in passing from one pair of rollers to another, an even drawn sliver is ensured of the calculated fineness for giving the desired counts of yarn in the spinning process.

90. *Roving.*—The slivers from the last drawing box are transferred to the Gill Screw Rover for further drafting by the same complement of parts, and for winding on to a bobbin by passing the " slubbing " round a flyer and on to the bobbin. This slubbing has a definite relation in counts (weight as regards length) to the counts of the yarn to be produced, that is, the smaller the slubbing and the finer the spun thread, and *vice versa.* Some degree of twist is inserted, just sufficient to form a thread structure adapted to dandy roving and spinning. In this roving frame (Fig. 38) the gill fallers are dispensed with, but the drafting takes place as in Fig. 37, between the front and back rollers A and B, the lower roller, A^1, being positively driven, and the smaller rollers *c* being carriers. Two or three bobbins, varying with the thickness of the roving, and the counts of the roved thread to be obtained, are placed in the creel D for supplying a roving to each spindle in the frame.

91. *Spinning.*—Silk waste spinning is practicable on the self-acter (little used on account of its compound action), and on the ring, cap, and flyer frames. Flyer-frame spinning is largely practised, and is similar in principle to this form of spinning in cotton and worsted yarn manufacture.* It yields an even, a smooth, and a true thread. The cap has a higher productive capacity, the spindles being, in some classes of work, speeded up to 9,000 revolutions per minute. Ring spinning is specially suitable for yarns consisting of medium and short fibre. The method of regulating the winding and twisting, by means of " travellers " of different sizes is in its favour. The type of machine employed is illustrated in Fig. 39. The spindles are mounted in the lower frame F^1, and the " travellers " revolve on the rims of the ring frame F.

* See Chapter V in *Woollen and Worsted.*

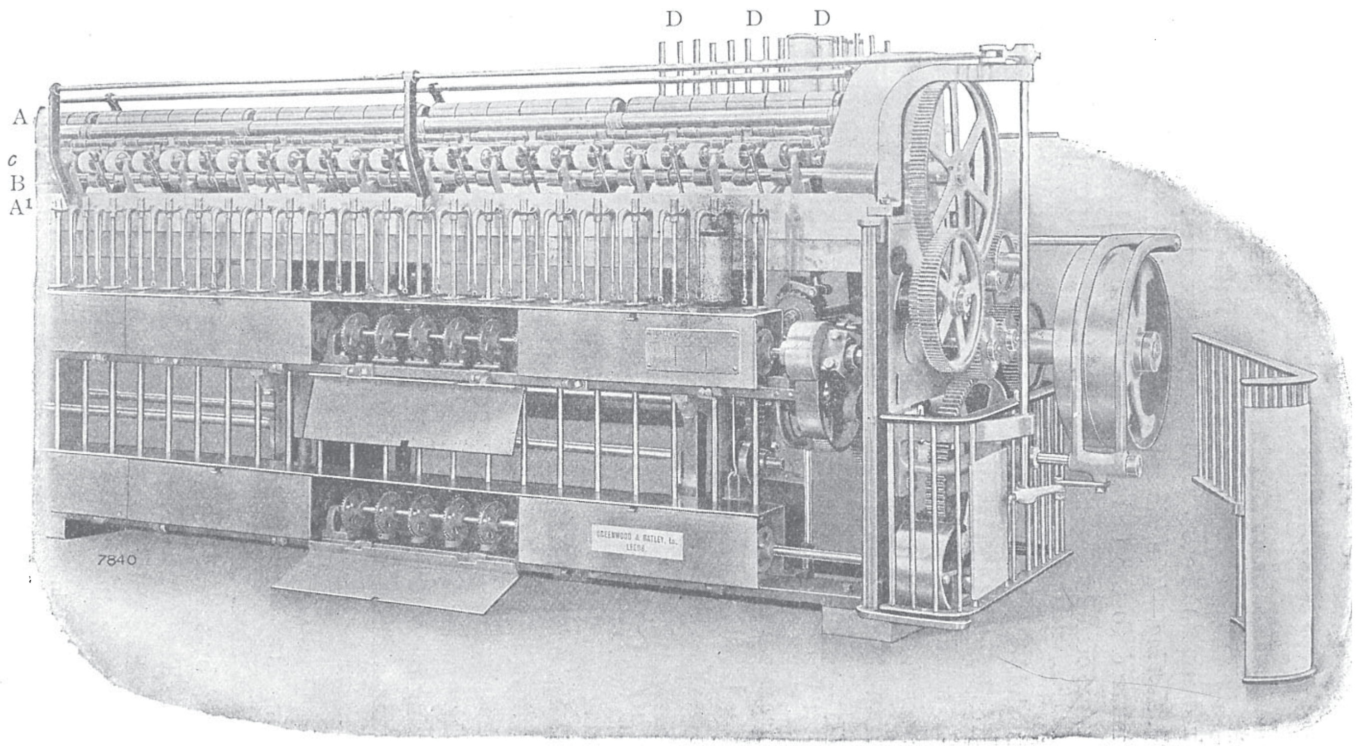


FIG. 38.—DOUBLE ROVING FRAME.

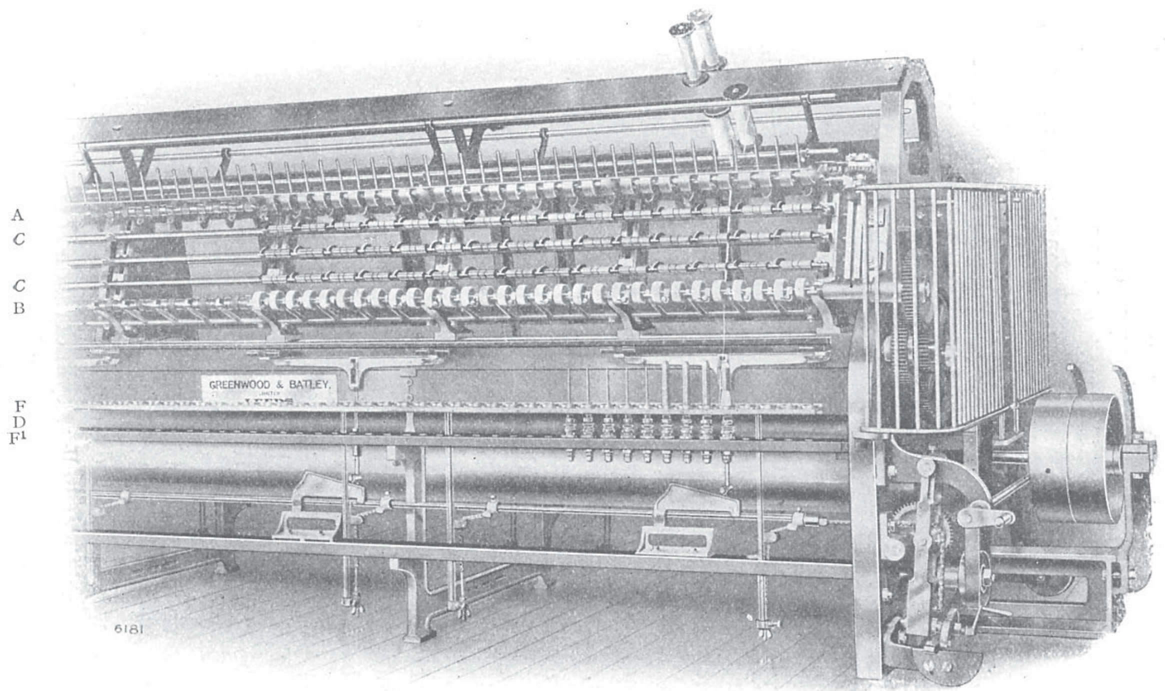


FIG. 39.—RING SPINNING FRAME.

This frame has an up-and-down traverse for distributing the yarn on to the bobbin. The driving of the spindles is done by tape or leather bands passing round the drum *c*, and the whorls of the spindles. The roving bobbins are grouped on iron pegs in the creel, the threads from which are passed separately between rollers A, the carriers C, and the front rollers B, and thence under the "travellers" on to the bobbins. The turns per inch imparted to the yarn are determined by the ratio of the yarn delivered by rollers B, and the ratio of the yarn wound on to the bobbin or spool.

92. *Gassing, Cleaning, and Lustring*.—The excellence, quality, and value of silk yarns depending on their smoothness and brightness, it is essential that all surface nibs, hairiness, and inequalities should be removed. For this purpose the spun thread is cleaned, gassed, and lustred. Gassing is the principal operation to which the yarns are, in this work, submitted. A view of the gassing machine, and also a section showing the arrangement for tensioning and gassing the threads are given in Figs. 40 and 41. The thread is taken from the bobbin D, and wrapped, as required, round the vertical cones E (see section at T), or as shown at R and S. Between the two series of cones is a bunsen gas jet F, and the path of the yarn to the winding spool is through the bunsen flame. The traverse-wound bobbin H, is driven by frictional contact with the drum K. On the breakage or discontinuance of the thread, the burner, F, is automatically moved on one side. If the yarn should be "nibby" and "hairy," and should need severer gassing, each thread is double-wrapped by being conveyed round one or more cones in both series.

Brightness of thread is further developed by treating the hanks of washed and dyed yarn in the lustring machine, consisting of a pair of hollow cylinders, one of which is heated and belt-driven. The second cylinder is constructed and fitted in the framework so that it may be carried away from the first cylinder. As the hanks of yarn are stretched between

E E H K

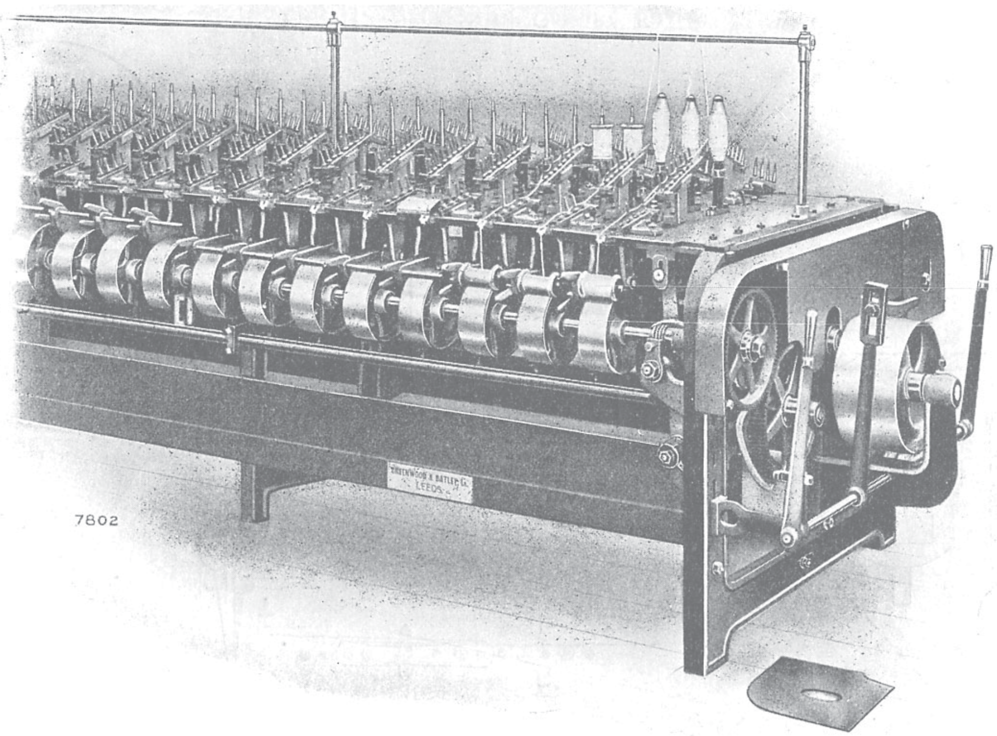


Fig. 40.—Cleaning and Gassing Frame.

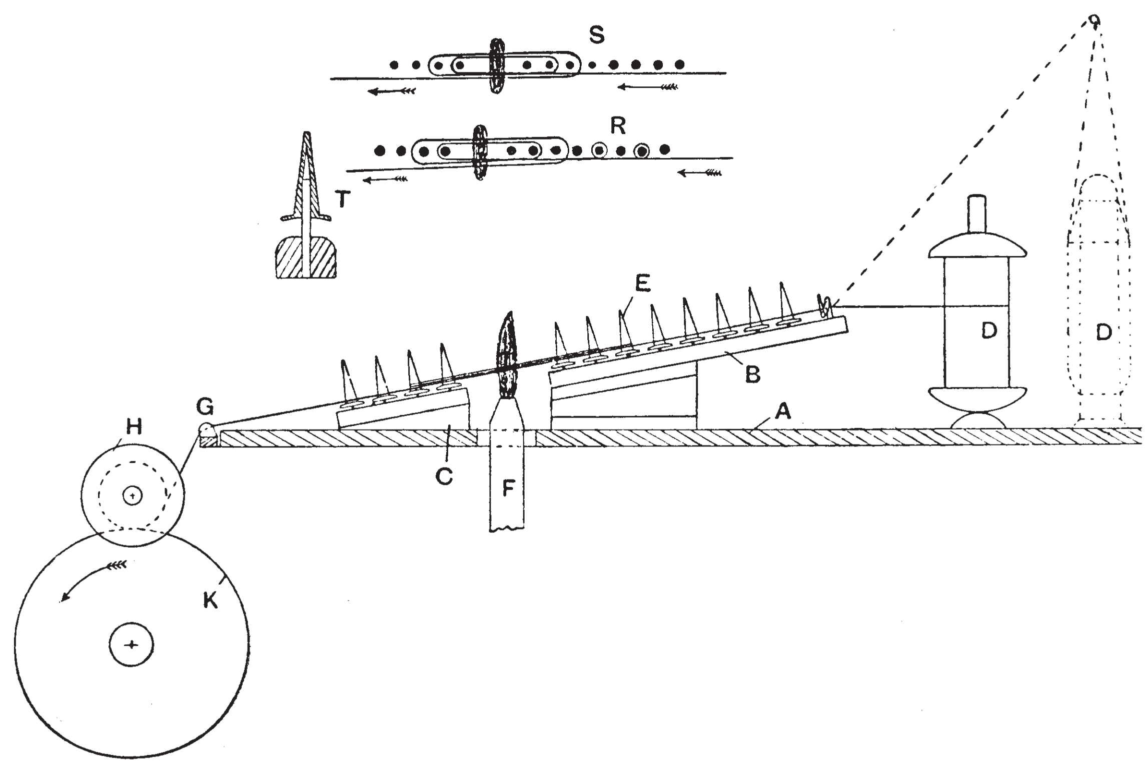


Fig. 41.—Section of Gassing Frame.

the two, the silk thread acquires increased straightness and smoothness, and improves in lustrous nature and quality.

93. *Silk Yarn Specimens.*—These include specimens of "raw" or thrown silk (Fig. 42) of "waste" or spun silk (Fig. 42A) and of artificial silk threads (Fig. 42B). The first Fig. 42, are illustrated in *organzine* (Nos. 1 to 5) and in *trame* (Nos. 1A to 5A), both in 29, 66, 132, 264, and 528 denier; the second, Fig. 42A, in folded or warp twist (Nos. 1 to 7 in 80's/2, 60's/2, 53's/2, 40's/2, 30's/2, 20's/2, and 15's/2), and in single or weft twist (Nos. 1A to 5A in 86's, 72's, 50's, 43's, and 27's counts); and the third, Fig. 42B, in warp twist (Nos. 1 to 4 in 75, 150, 250, and 500 denier), and in weft twist (Nos. 1A to 4A in the same counts); with "sized" yarns at 1B to 5B.

As the samples are reproduced to scale, they represent the actual and relative fineness and structure of the yarns in the counts quoted. The hanked samples of each yarn specimen give some idea of the lustre and diffusive properties of these three varieties of commercial silk. The artificial product possesses the higher degree of surface brilliancy; the raw silk the higher degree of textile lustre value; and the spun silk the higher degree of filament density. The lustre of the natural silk differs in quality from that of the artificial fibre. The brightness of one is rich and full, and of the other metallic, in tone. The spun yarn yields a soft species of texture, but one less distinctive in character than that producible in natural silk yarns.

Each variety of thread is employed in combination with yarns made of other classes of fibre. The super-freshness and richness of the colour of the artificial silk, render it specially valuable in the manufacture of union dress, blouse, and lining fabrics. On the other hand, for the admixture with worsted and woollen yarns, the spun silk is well adapted. The mechanical practices by which it is constructed, as well as the variable lengths and grades of filament of which it is formed, cause the yarn to present a similar structural composition as yarns made of wool, cotton, or flax. In these essentials it differs from either natural or artificial silk yarns (with the exception of "Fibro" silk, see Par. 115), which consist of filaments running through the length of the thread, so that the latter thread structure varies with the number of filament strands—of an indefinite length measurement—combined in the processes of doubling, twisting, and winding.

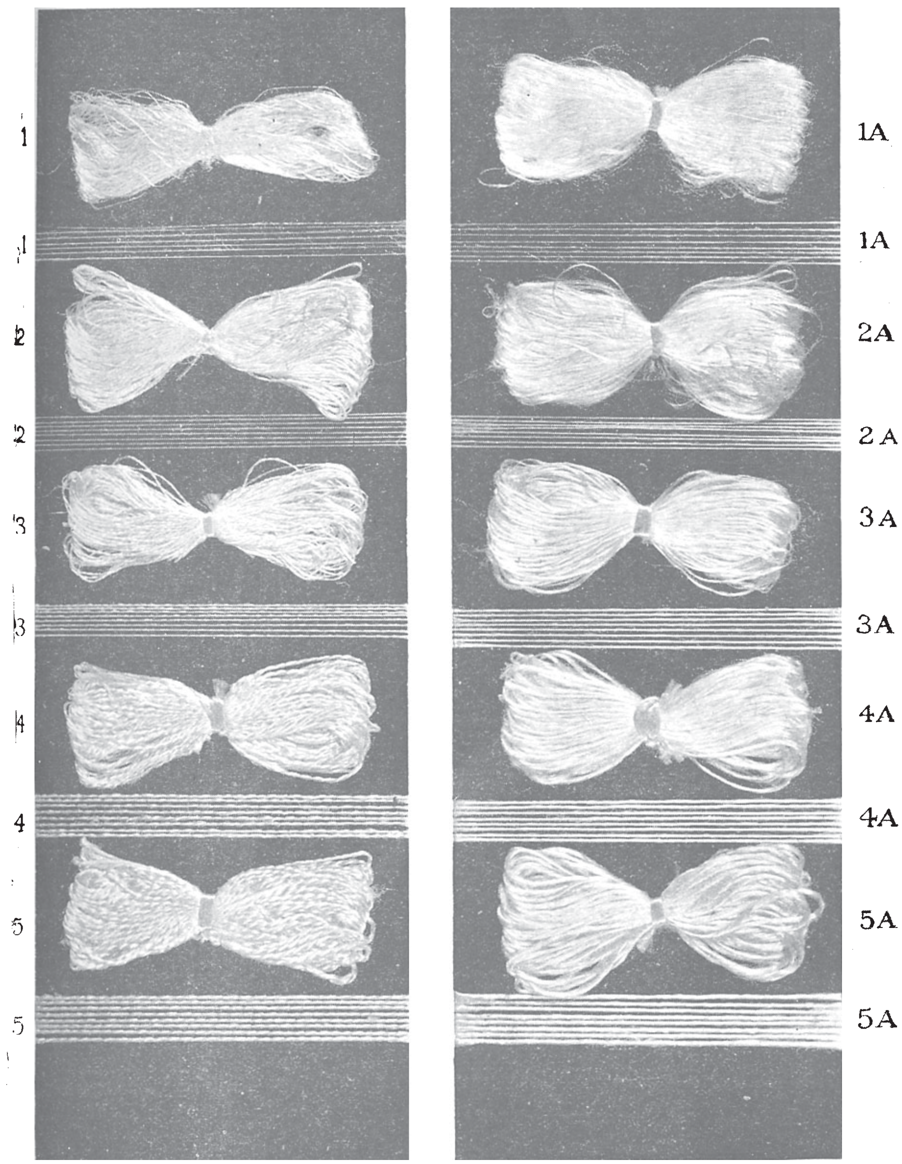
Thrown and artificial silk yarns are simple in structure, each filament used—of whatever fineness or tenuity—being of a thread-like length and formation ; whereas the spun silk yarn is compound in structure, being composed of fibres of different lengths, aligned with each other, and twisted together into a continuous thread of a prescribed diameter.

The peculiar brightness of tone which natural silk imparts to the surface of a woven fabric is apparent in the decorative styles in Figs. 6, 7, and 8, and also in textures made partially of silk and partially of other yarns, in the specimens shown in Figs. 5, 19, and 21. The diffusive lustre value of artificial silk is particularly noticeable in the gauze specimen (Fig. 42C), in which shots A have a ribbon-like character, and the cotton threads, D, an evenly-rounded formation. Where, in this example, picks A bend *over* threads D they possess softness and smoothness combined with surface shimmer, and where such picks bend *under* threads D the individual fibres in the silk yarns scintillate and glitter. These qualitative textural tones obtain in all varieties of fabric in which artificial silk shots are successively floated over and under the warp yarns in the weaving process. Artificial silk yarns obviously yield textile characteristics allied with those developed in natural silk, with, however, a lesser refraction of light, and hence the brilliancy of the textures in which they occur.

Artificial Silk.*

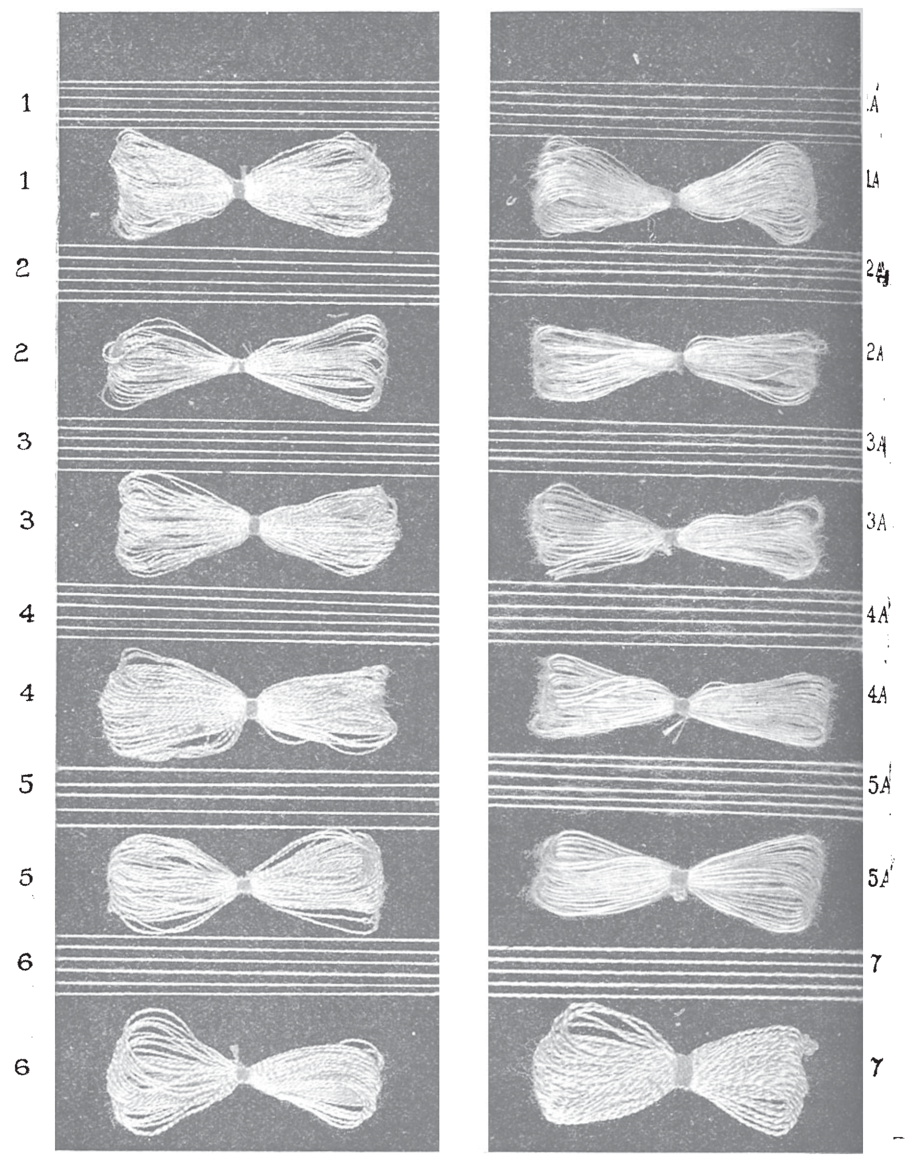
94. *The Nature of Artificial Silk.*—Artificial silk is a fibre which, in its general properties, is unique, for while like natural

* Paragraphs 94 to 117 on Artificial Silk, with Figs. 43, 44, 44A, 44B, 44C, 44D, 44E, 45, 46, and 46A, are contributed by the late Leonard Wilson, F.C.G.I., F.I.C. *See* prefatory reference.



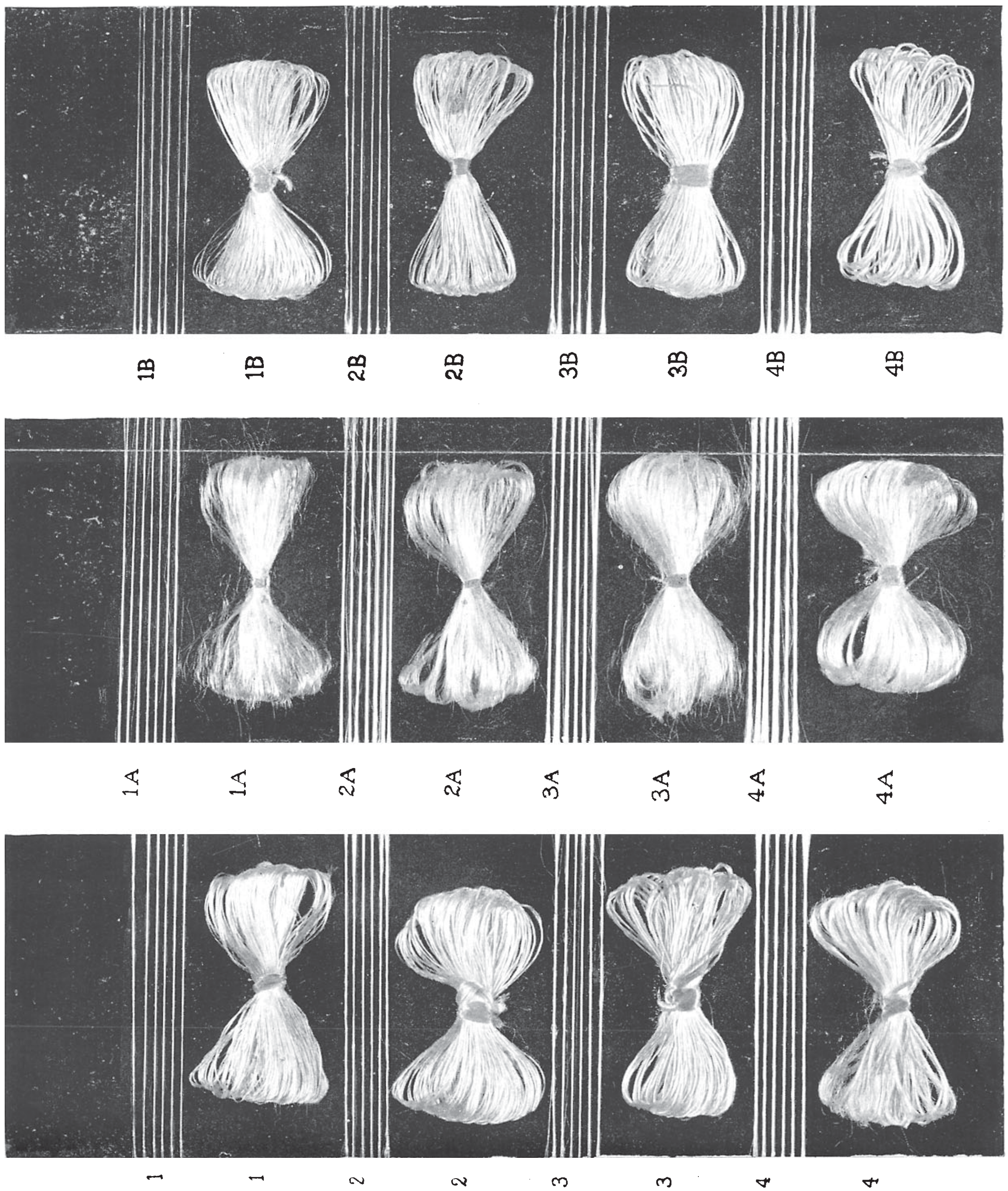
Organzine. *Trame.*

FIG. 42.—SPECIMENS OF THROWN SILK.



Nos. 1 to 7 = Warp Twist   Nos. 1A to 5A = Weft Twist.

FIG. 42A.—SPECIMENS OF SPUN SILK.



SIZED SPECIMENS.

WEFT-TWIST SPECIMENS.

WARP-TWIST SPECIMENS.

FIG. 42B.—ARTIFICIAL SILKS.

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Fold-out rotated 90° to fit on page.

silk—which is of animal origin—it consists of fine filaments of indefinite length, it has none of the characteristics of an animal fibre, but instead, with the one exception of length, it has those of vegetable fibres in general, being, as at present produced, either cellulose itself or a cellulose hydrate.

In consequence, artificial silk can be used in the same manner as natural silk and treated like cotton; it produces

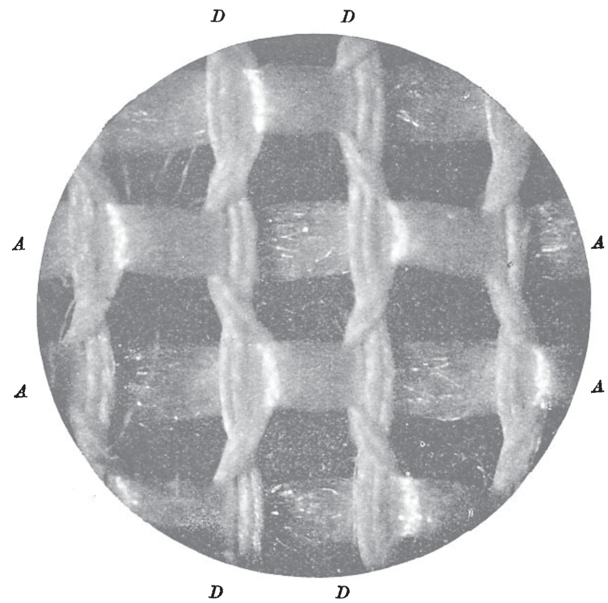


FIG. 42C.—COTTON-WARP AND ARTIFICIAL-SILK GAUZE STRUCTURE.

beautiful smooth lustrous fabrics which may be of almost any texture or weight, and when used either alone or in admixture with other fibres it may be dyed with the ease of cotton by means of either direct or vat colours.

95. *Early History and Present Production.*—The history of artificial silk dates back to the suggestion of Réaumur, made in 1734, that, just as a silkworm produces fibres from its liquid secretion, so a similar product might be made artificially from solutions of resins or gums.

This idea, however, did not materialize until about 1885 when Audemars applied for a patent for the production of silk-like threads from a solution of cellulose nitrate. During the next six years, a great deal of work on these lines was done both in this country and abroad, and, in 1891, Compte Hilaire de Chardonnet began to manufacture at Besançon about 100 lbs. a day of cellulose nitrate silk, the output from this time increasing rapidly.

The investigation which preceded and accompanied the production of silk from nitro-cellulose led, in 1890, to Despaissis taking out a patent for the use of a solution of cellulose in ammoniacal copper oxide; nothing, however, resulted from this until Pauly, in Germany, took out his first patent in 1897. Many modifications of the Cuprammonium process were proposed and employed, and it formed the basis of the commercial enterprise carried on by the Vereinigte Glanzstoff Fab. Akt. Ges. of Elberfeld.

These two processes, Nitro and Cuprammonium, each had a period of great prosperity; the Chardonnet company, for instance, paid its maximum dividend, 60 per cent., in 1905, which fell to 0 per cent. in 1909, largely due, no doubt, to the competition of the Cuprammonium process, which was then meeting with increased success and this continued up to the year before the war, when the Vereinigte Glanzstoff Fab. Akt. Ges. paid a dividend of 34 per cent.

But before this time another competing process was in the field, and just as the first was almost wholly French and the second German in inception and development, so this last—one may state with satisfaction—was British from the discovery of Cross, Bevan and Beadle that cellulose would yield a soluble xanthate, to the production of Viscose silk in Britain on the present impressive scale.

At the present time, the production of nitro-silk is very small and almost confined to Belgium; cuprammonium has a very much decreased production, while viscose has increased to such an extent that nowadays viscose silk and artificial silk are practically synonymous. The total output of the world is probably now about 40 tons a day, Great Britain, America, France and Germany being the largest producers, while lesser amounts are manufactured in Switzerland, Austria, Belgium, Holland, Italy, Russia, Japan and Sweden.

Processes employing substances other than cellulose have been proposed, and also several for the use of cellulose compounds; none of these, however, has attained the position of a commercial fibre, although cellulose acetate silk is being experimented with on a considerable scale.

96. *The Basis Material.*—The three processes which have in turn reached the stage of being commercial successes have at least one feature in common, namely, that they consist of and have for their starting material, cellulose, the substance which forms the main portion of all vegetable fibres, and which, in other fibres, has stood the test of centuries.

In the case of both the nitro and cuprammonium processes, cotton is the form of cellulose employed, but in the viscose process—although cotton may be used—the more abundant and cheaper form of cellulose, that obtained from wood, is almost invariably used with complete success.

A short description of the manufacturing processes will bring out other points of difference.

97. *The Chardonnet Process.*—The Chardonnet process consists first of the formation of nitro-cellulose by treating cotton with a mixture of nitric and sulphuric acids, followed, after purification, by solution of the nitro-cellulose in a mixture of alcohol and ether.

This solution is formed into threads by squirting through glass jets into warm air, when the solvents rapidly evaporate leaving a solid thread which is wound on to bobbins.

The threads from a number of jets are gathered on to one roller, the whole machine being covered with a hood through which the warm air is drawn to remove the solvent from the thread. The air is subsequently cooled to recover the solvents, but this is not by any means completely achieved, and the loss of solvent constitutes one of the chief items of expense in this process of manufacture.

In some modifications of the process, the nitro-cellulose solution is forced through jets into water which removes the solvent and forms filaments which are wound on to bobbins.

The groups of filaments from which the solvent has been removed are next twisted to form a thread ; this, however, still consists of cellulose nitrate, and is extremely inflammable, subject to slow spontaneous decomposition with complete loss of strength and, further, is not readily dyed in a satisfactory manner. These defects are removed by heating in a solution of alkaline sulphide, which almost entirely denitrates the fibre leaving it in the form of cellulose, in which state it is employed for textile purposes.

This denitration considerably reduces the weight of the product and is, therefore, for two reasons, another source of considerable expense.

The nitro process is now practically obsolete except for the Chardonnet factory at Tubize in Belgium ; in this country it was tried about twenty years ago at Wolston, near Rugby, but without success.

98. *The Cuprammonium Process.*—This, as has been mentioned, is almost entirely a German process, but it has been worked on a commercial scale by the British Glanzstoff Co., a company subsidiary to the Vereinigte Glanzstoff Fabriken, of Elberfeld, at Flint, North Wales, and in the Thiele modification on an experimental scale at Great Yarmouth.

It is not now carried on at either of these places, however, operations having been suspended at the latter place, and in the former transferred to the viscose process.

As in the nitro cellulose process cotton is the raw material employed for the production of Cuprammonium Silk, and is prepared by boiling under pressure with caustic soda followed by bleaching. It is then dissolved by stirring in a solution obtained by dissolving copper oxide in ammonia.

This solution is of a dark-blue colour, and, when the cotton is dissolved in it, is of great viscosity. Threads are formed from it by forcing it through fine jets generally of glass into solutions either of acid or of strong caustic alkali, the groups of filaments being wound on to glass bobbins.

The chemicals are removed by washing, and the thread is subsequently wound and twisted in the method described for nitro-cellulose. By the Thiele modification of this process, filaments of extreme fineness are obtained by drawing out during the coagulating stage.

Owing to high prices of both copper and ammonia, of which the recovery is by no means complete, this process is relatively expensive compared with the later viscose process which has very largely supplanted it.

99. *The Viscose Process.*—The Viscose process is, as we have said, the British contribution to artificial silk development and one of its important differences from other processes is that it starts with wood pulp as a raw material.

This wood pulp is specially prepared from spruce by the sulphite process and is then converted by means of caustic soda into alkali cellulose. Then follows a treatment with carbon bisulphide which converts it into cellulose xanthate; this is dissolved in water forming a thick solution, which, after careful filtration to remove any undissolved portions, is forced through platinum jets into acid solutions.

Each of these jets is perforated by a number of holes corresponding to the number of filaments which are to form the ultimate thread.

On meeting the acid solution, the xanthate is decomposed and filaments of cellulose are produced. The method employed for dealing with groups of filaments at this stage is peculiar to the Viscose process and merits notice.

The filaments, after being drawn from the bath, pass over a roller and from this drop into a rapidly rotating centrifugal box, the filaments are thus simultaneously twisted together and flung against the sides of the box where they pack into a ring or cake (Fig. 43), from which the thread is afterwards wound into skeins.

The skeins, after this, are washed free from chemicals and bleached.

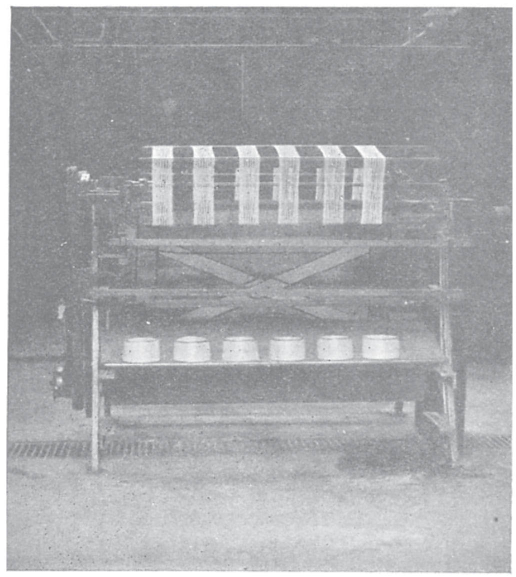


FIG. 43.—REELING FROM CAKES OF ARTIFICIAL SILK SPUN IN A TOPHAM CENTRIFUGAL BOX.

100. *The Acetate Process.*—Besides the three principal processes which have been described, there are several which have, up to the present, attained little or no commercial importance.

In some cases, an attempt has been made to use animal material and so to copy, to some extent, the composition of natural silk by means of gelatin, fibroin, and similar substances.

In others, cellulose, but in different solvents from those described, has been used, e.g. cellulose in zinc chloride or sulphuric acid, and compounds such as cellulose formate and ethyl cellulose have also been proposed, but none of these has met with any success.

Cellulose acetate silk, however, has progressed farther than any of those mentioned, and although at present it is not obtainable in commercial quantities, preparations are being made to produce it on the large scale.

The acetate itself is formed by the action of acetic anhydride on cellulose—generally cotton—and has been largely employed for the manufacture of aeroplane dope and non-inflammable photographic films.

For the production of artificial silk it is dissolved in an organic solvent in the manner employed for nitro silk and the spinning and subsequent operations resemble this process also, except that there is nothing comparable with denitration since the acetate silk is not inflammable and the finished thread is not cellulose but a compound of this with acetic acid.

101. *Qualities.*—The qualities which have commended artificial silk—particularly viscose—to the public are, its lustre, which exceeds that of all other fibres ; its price, which is very considerably less than that of natural silk ; its excellent washing and wearing properties and the fact that it can be readily dyed in all shades and with fast colours. These characteristics have united to raise it to a unique position among textile fibres.

Artificial silk is generally classified for commercial purposes according to the thickness of the thread into deniers, which, contrary to cotton counts, rise with increased thickness of thread, the number of deniers indicating the weight in grammes of 9,000 metres of thread.

The appearance, as regards lustre and degree of whiteness, depends generally on the process employed or the factory of origin, but there is a further usually accepted standard of quality of which the highest grade is described in England as "A" quality, which indicates practically complete freedom from broken filaments, lower grades being called " B " and " C."

102. *Distinctive Tests.*—The tests which are used to identify the products of the different processes of manufacture are mainly chemical.

The most easily distinguished is nitro silk, since the process of denitration which is used to reduce the inflammability of the Chardonnet product is never complete. The residue of nitrate which remains serves to identify the silk, which turns to a dark-blue colour when wetted with a solution of diphenylamine in strong sulphuric acid.

Viscose and cuprammonium are not so readily distinguished for both are relatively pure forms of carbohydrate, but they can be recognized by pouring a small quantity of strong sulphuric acid upon the silk to be tested. Cuprammonium threads become yellow giving in a few minutes a straw-coloured solution which afterwards becomes brown, while viscose silk turns immediately reddish-brown.

Acetate silk in strong acetic acid dissolves to a colourless solution which, on the addition of water, becomes turbid owing to the precipitation of cellulose acetate.

The differences in cross section which are mentioned in a subsequent paragraph, also assist in the identification of the various threads.

103. *Relative Properties, Tenacity, etc.*—The most important properties of artificial silk are strength, both when wet and dry, extensibility, affinity for dyestuffs, and capability of resistance to the various wet processes, such as washing, to which textiles are subjected.

The strength is measured by the weight required to break a thread of definite size, and is expressed as grammes per denier, while the extensibility is the percentage elongation which takes place before the thread breaks under the maximum load which it will carry.

The following figures represent the approximate values obtained from both the poorer and the better commercial qualities of each of the varieties, except that, in the case of acetate, the limited number of samples available does not warrant a range of figures—

	Ten. Dry.	Ten. Wet.	Extensibility.
Nitro. Silk . . .	0·75 – 1·4	0·25 – 0·6	7·5 – 16
Cuprammonium .	1·0 – 1·35	0·35 – 0·55	14 – 18
Acetate . . .	1·1	0·7	18
Viscose	1·2 – 1·6	0·45 – 0·7	11 – 22

In order to obtain a correct figure for the tenacity when dry, the measurements must be made under standard conditions of atmospheric moisture or a correction must be made to compensate for the variation from normal conditions.

The resistance to wet treatment is measured both by the wet tenacity, i.e. the strength of the thread when thoroughly wetted with water, and by the weight of the thread which is soluble in weak caustic soda solution. With 8 per cent. caustic soda, the figures range between a solubility of 10 per cent. for a good viscose and 80 per cent. for some makes of cuprammonium.

From what has been said above it will be seen that viscose silk is in all respects at least equal to, and in most surpasses, the silk produced by other processes.

104. *Relative Textile Values.*—The textile value of artificial silk depends, in addition to those properties which have been described, on its affinity for dyestuffs and its covering power.

The affinity of silks of different makes for dyestuffs varies over a wide range, acetate silk, for instance, will not take up direct colours under normal conditions of dyeing, but absorbs basic dyes for which nitro silk also has a great affinity.

The latter, however, is a form of cellulose, of which cuprammonium and viscose silks are still more typical, and therefore these three in their general behaviour towards dyestuffs resemble cotton.

This, however, is by no means a complete statement with regard to the matter, for there is often a great difference in the amounts of dye taken up by two varieties of silk if they are dyed together and direct colours generally are more readily dyed upon viscose than upon cuprammonium or nitro silk.

The covering power of artificial silk is dependent chiefly upon the surface possessed by a given weight of thread, and this again upon the relation between the length of the periphery and the area of the cross section of the individual filaments of the thread.

As regards the size of the filaments the cover increases as the size decreases in proportion to the diameter of the filaments, so that of two threads of the same denier, one with eighteen filaments and the other with thirty, the latter would have about 29 per cent. more cover than the former, i.e. $\sqrt{\frac{30}{18}} = 1{\cdot}29$.

The weight of the filaments, however, is not the only factor nor does the specific gravity of the various silks vary enough to be taken into account, but the shape of the cross section of the filaments is of great importance in this connection for since a circle is the form which has the minimum periphery for unit area, a filament with a circular section has less cover than a filament of any other shape, and the greater the departure from a round section the more effective is the covering power of the thread; also with increased surface for the reflection of light, other things being equal, there is a correspondingly increased lustre.

The bearing of these statements may be seen from the photographs (Figs. 44, 44A, 44B, 44C, 44D, and 44E) of cross sections of various types of artificial silk.

It will be observed that nitro, cuprammonium, and acetate are all of smooth outline, and that cuprammonium particularly is approximately round, while viscose is generally irregular and deeply serrated.

This is the explanation of the superior covering power of the last-mentioned silk, and also of its greater lustre in comparison with other artificial fibres.

The cross section of viscose silk, however, is variable over a wide range, the controlling factors being the constitution of the cellulose xanthate and the composition of the coagulating

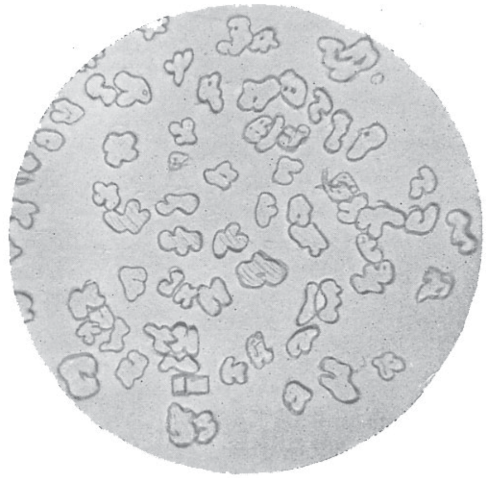


FIG. 44.—ARTIFICIAL SILK—NITRO SPECIMEN.

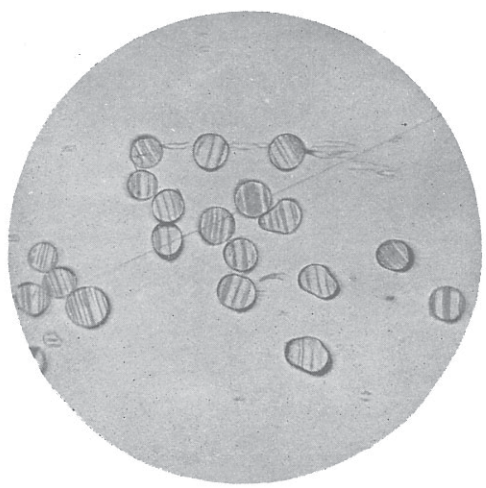


FIG. 44A.—ARTIFICIAL SILK—CUPRAMMONIUM SPECIMEN.

bath in which the threads are formed. This enables the manufacturer to choose such conditions that the thread produced is the most suitable for the purpose for which it is intended; how widely the cross sections of viscose silk and,

FIG. 44B.—ARTIFICIAL SILK—ACETATE SPECIMEN.

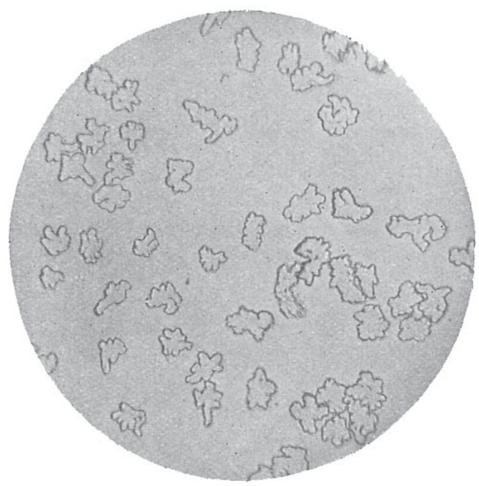


FIG. 44C.—ARTIFICIAL SILK—VISCOSE SPECIMEN.

therefore, its covering power and lustre may vary, are shown in the accompanying photographs, Figs. 44C, 44D and 44E.

105. *The Treatment of Artificial Silk.*—Artificial silk, when sold, is usually sufficiently bleached for all ordinary purposes,

and it is, therefore, a mistake to combine it in a fabric with unbleached fibres and then to bleach in the piece, thus

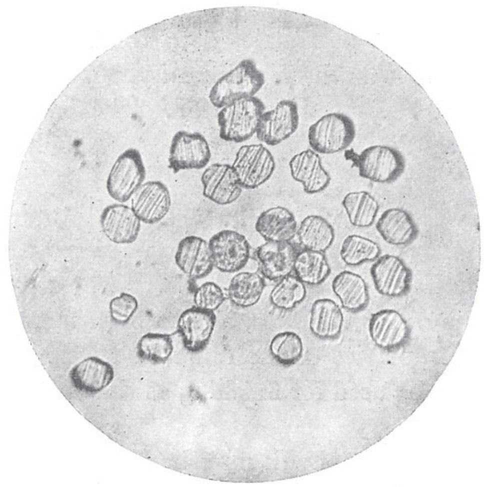


Fig. 44d.—Artificial Silk—Viscose Specimen.

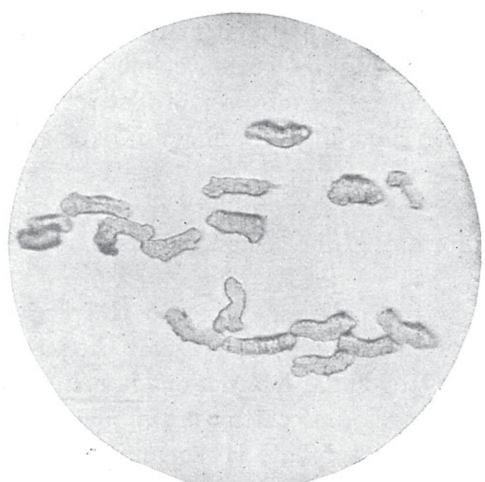


Fig. 44e.—Artificial Silk—Viscose Specimen.

subjecting the silk to a second and excessive treatment. Oxidation and partial destruction of the thread frequently result and, in some cases where this method has been employed, as much as 30 per cent. of the silk has been lost and the remainder very much weakened.

In the exceptional circumstances where a second bleaching is essential, it should be restricted to the minimum amount and carried out in a bath of sodium hypochlorite containing not more than 0·1 per cent. chlorine. The bath should not have an acid reaction and its temperature should not exceed 20° C.

Artificial silk should never be subjected to hot alkaline treatment as this causes the partial solution of the fibres; viscose silk, however, resists such a treatment to a greater extent than the other varieties, as has been mentioned when discussing the properties of the different types. An alkaline water should not be used for finishing as this results in thread of inferior colour.

106. *Dyeing.*—Artificial silk may be said, on the whole, to dye like cotton, but this statement is too wide to be true in all respects. Nitro silk, for instance, has a considerable affinity for basic dyestuffs without mordanting, in addition to its normal affinity for direct cotton colours; cuprammonium and viscose, like cotton, require a mordant for the fixation of basic colours, but have a good affinity for direct colours and for the vat colours commonly used for cotton; untreated cellulose acetate has, under ordinary dyeing conditions, very slight affinity for any of the cotton colours, but takes up basic colours readily.

The direct cotton colours, owing to their wide range of shade, ease of application and fastness, are the most commonly employed, and the general instructions issued by dye manufacturers for the dyeing of cotton are applicable to artificial silk also, but sodium sulphate is recommended in preference to other assistants, and the temperature of 65° C., which has been regarded as the highest permissible for artificial silk may, where necessary, be exceeded and even 90° C. may be used with advantage as, with some dyes, more even results are thus obtained.

For an even shade throughout a batch or piece of artificial silk in such cases the dyebath should be heated up to the temperature at which dyeing is to take place before immersing the material, and not heated up after the material has been entered as is the common practice.

When fastness greater than that of the direct cotton colours is required, sulphur dyestuffs may be used with advantage; these dyes are not quite so simple in application, nor can the brightest shades be obtained from them, but their resistance to both light and washing entitles them to a more extended use than they have at present.

For fabrics which have to withstand laundry treatment there is no class of colours equal to the indanthrenes, in which may be obtained brighter shades than in the sulphur dyes and superior fastness which will, in the majority of cases, even resist a chlorine bleach.

107 *Sizing, Soft Finishes, etc.*—Sizing is, in many instances, essential to the successful weaving of artificial silk, in order that the filaments may be held together when in the loom.

Sizing takes place either in the hank or in the warp; in the latter case, a special machine is employed which will size, dry, and beam in one operation. Whether sizing is carried out in the hank or in the warp, the results depend both on the method of application and the material employed, the latter being generally either gelatine or a form of starch.

Whatever the adhesive employed it should be carefully ascertained that it gives a neutral solution, as the drying of thread containing either acid or alkali is very detrimental to its quality and particularly to its strength. Soluble starches which are sold under numerous fancy names are the worst offenders in this respect, since they are frequently produced by heating starch with acid which, owing to indifferent after-treatment, is allowed to remain in the finished product.

The temperature of the sizing solution affects its viscosity to a considerable extent, and the amount of size which a thread holds is dependent therefore on the temperature of the bath as well as its strength; when machine sizing a warp, a thinner solution is necessary than when sizing in the hank, in order that the threads may be separate on the beam.

Sometimes a soft finish is required for artificial silk, and for obtaining this, an emulsion of pure soap and oleic acid is most satisfactory. This can be made by adding 21 lbs. of caustic soda solution of 3 per cent. strength to 10 lbs. of oleic acid, and stirring vigorously until a perfectly smooth cream is obtained; a mechanical mixer is almost essential for this operation, which should be continued for at least three hours, and which results in a mixture of equal parts of soap and free oleic acid.

For use, 16 to 20 lbs. of the emulsion are dissolved in 100 gallons of water at a temperature of 35° C., the water employed for the solution being previously softened, as otherwise the lustre of the silk will be reduced.

108. *Storage and Effect of Moisture.*—In common with all other fibres, artificial silk absorbs moisture from the atmosphere, and this, under normal conditions, amounts to about 11 per cent. of the weight of the thread.

If, however, the silk is stored in a damp place, this amount of moisture will be considerably increased and the strength of the thread temporarily reduced, while its extensibility will become greater. Thread used in this damp state will probably behave in an irregular manner and cause faults in the cloth owing to variations in the amount of contraction on drying.

In the case of sized silk there is an additional reason for considering storage conditions, for it should be remembered that starch and gelatine rapidly deteriorate if not kept dry, and on this account, sized materials which have to be stored—for example, warps on the beam—should be kept in a dry ventilated store-room. It has not infrequently happened that complaints have been made of sized materials which on investigation have shown that damp storage has been the only source of trouble, with the result, perhaps, that the outside of the beam has become unsized while the inner portion is in perfect condition.

Artificial silk which has been properly finished retains its quality unchanged for a number of years, but should it contain impurities which are either alkaline or acid, a deteriorating effect is produced, and the silk becomes both tender and discoloured; this has sometimes in the past been a serious defect in the case of nitro silk, of which some specimens have developed acid and eventually crumbled to powder.

Variations in the amount of atmospheric moisture must be guarded against not only during storage, but also during the subsequent working of the thread. The cooling of the atmosphere during the night and the consequent approach to saturation, will cause a warp left in the loom to absorb more moisture and to become slack, with subsequent unevenness in the cloth when woven.

109. *Winding.*—Although for most manufacturing purposes artificial silk is used in some other form than skeins, it commonly comes on to the market as skeins or hanks. The reasons for this are, first, that in the chief method of manufacture where viscose is spun into a Topham box, the thread is reeled direct into skeins from the cakes formed in the box; second, for any after-treatment, such as dyeing, softening or sizing, the skein is usually the most convenient form to handle and lastly, for packing or carriage it is the form which occupies the least space.

As a first step towards using thread which is in the skein form, it is almost invariably wound on to small wooden bobbins on machines similar to those used for winding silk. The skein is placed on a swift which is supported in such a way that it is free to run on its axle and above it the bobbin is fixed on a spindle by means of either a screw or spring, the spindle being driven by friction from the face of a wheel carried by a horizontal shaft.

If the thread sticks, a frequent occurrence when winding dyed yarn from the swift, the pull of the thread is sufficient to prevent the rotation of the bobbin until the winder is able to release the skein, this arrangement reducing to a minimum the number of breakages and consequent knots.

The thread is led on to the bobbin by guides, which should be of smooth stone ware or glass to prevent breakage of the filaments, and they should be so arranged that the thread winds on to the bobbin without running up the sides.

In the cuprammonium, nitro-cellulose, and acetate processes, the thread is wound from the glass bobbin, on to which it is drawn when first formed on to smaller wooden ones without being twisted; these are then mounted on vertical spindles driven at a high speed, and from them the thread is drawn on to other bobbins so that it is simultaneously twisted and wound.

110. *Spooling.*—It is essential that thread, when put on spools, should be wound with regular tension, and, for this reason, it cannot be done direct from the skein as the pull of the swifts is variable; the thread therefore, must be wound on the spool from bobbins.

In order to obtain regular tension the spindle on which the bobbin is carried runs against a weighted friction brake and the thread passes to the spool over a tension spring and through a guide eye. All obstructions, such as knots, which would prevent the thread leaving the spool freely in the loom, must be avoided, as anything which prevents free running will cause tight picks and bright lines in the weaving.

111. *Twisting.*—Like those of all other textile fibres, the filaments of artificial silk require to be twisted together into thread units before they can be used for weaving purposes, and it was formerly the practice to give the warp an additional twist, i.e. several more turns to the inch than weft thread.

As, however, increased twist has the effect of reducing lustre this practice has almost ceased, and the twist of two and a half to three turns per inch given in the viscose process to the thread as it enters the Topham box, is employed both for warp and weft. Instead of the filaments of the warp thread being held together by extra twist they are sized so that they adhere sufficiently for weaving, and, when the size is removed, their soft twist gives them increased lustre.

For special purposes, there are very numerous varieties of warp twist according to the type of fabric desired, and a compound thread may be composed of two or more smaller threads twisted together to various extents. In some cases where the twist is to be dyed, it is wound directly on to reels from the throwing or twisting bobbins, so forming skeins, a method, however, which does not ensure such even twist as does twisting on to bobbins. To prevent the natural tendency of artificial silk to untwist if left dry, it is steamed before removal from the reel or bobbin.

The dyeing of twisted thread is, as a rule, not entirely satisfactory owing to incomplete penetration of the dye, with resulting lighter coloured portions in the inside of the twist; for this reason the thread is commonly dyed before twisting, although owing to the handling to which the skeins have been subjected during dyeing, they are generally more difficult to wind and so produce more waste.

112. *Warping.*—The bobbins from which a warp is to be wound should be of equal weight and size, and free from rough edges. They should be so arranged on the creel that the thread runs from all of them with equal tension and to obtain this result they must be placed so that the angle at which the thread runs is approximately the same for all the bobbins, and is such that it does not run against the bobbin flange, which would both increase the tension and tend to cause broken filaments.

Where a sized warp is required with more than 1,400 or 1,500 ends, it is, owing to the difficulty of machine sizing more than this number at once, made in several portions which are sized separately and dressed together, and the beam should be made quite hard, light beaming, however, being preferable for unsized warp.

113. *Weaving.*—The value of a fabric composed wholly or in part of artificial silk depends very greatly on the extent to which the special properties of the silk thread, namely, its lustre and freedom from broken filaments, are exhibited, and, therefore, it is of the utmost importance that these should be diminished as little as possible.

To achieve this, care is, of course, necessary in all operations but especially in weaving where the thread is subjected to greater strain and more frequent friction. To obtain the best effects, the healds should be perfectly smooth and free from obstructions; the reed and the warp on the beam should be of the same width and the reed should be fine, flexible, and smooth; similarly, the shuttle and the shuttle race should be quite free from defects wherever the thread comes in contact with them.

Great care must be taken to ensure an even tension upon the weft, since either slack or tight picks are serious defects with artificial silk, appearing as lines of different lustre from that of the rest of the material. To obtain a regular drag, and by this means the even tension desired, fur is commonly placed inside the shuttle.

114. *Artificial Silk in Woven Fabrics.*—Artificial silk is comparatively rarely used alone in the manufacture of materials such as are described in this book, although for tapestries, ribbons, knitted goods, and other fabrics it is employed without admixture with other fibres, giving very beautiful results; for light dress and blouse materials, it is used both as warp and weft in conjunction with cotton, wool, and, occasionally, natural silk.

To produce woven pattern stripes in fancy voiles, it may be put in the warp with cotton, and since in this material a cotton weft is used, the percentage of artificial silk required to produce an effective pattern is often very small; dyeing is carried out in the piece. In these and in similar cheap fabrics made with a weft stripe, it is common to find that economy in artificial silk has been carried too far, the threads, whether warp or weft, being drawn too tight and a great deal of possible effect thus being lost.

In another class of cloth, of which "Luvisca" may be cited as an example, the warp is entirely cotton and the weft all artificial silk, striped effects being produced by coloured threads in the cotton warp, and the weaving pattern commonly adopted is arranged to keep the artificial silk chiefly on the face and the cotton on the back of the fabric. Materials of this type are eminently suitable for blouses and shirtings as, owing to their smooth surface, they resist soiling, and if made from viscose yarn they will be unharmed by frequent laundering.

These, and the crêpes, poplins, and numerous other fabrics into which artificial silk enters, together with other fibres, will be described in detail in another chapter.

115. "*Fibro.*"—Artificial silk has recently come on to the market in a new form which, although unaltered in its chemical characteristics, enlarges the field of its usefulness. Fibro, as the new product is called, is a viscose fibre, but instead of being a twisted thread composed of filaments of indefinite length, it consists of short fibres a few inches long which are spun into yarn by the various methods employed for the natural short textile fibres, particularly wool.

The filaments are considerably finer than is usual with artificial silk, but are of equal lustre and resemble it in all its other properties, and, therefore, the new fibre affords a means of obtaining, in types of cloth which have hitherto been composed chiefly of wool, new effects with increased brilliance and lustre by using it either alone or in admixture.

116. *Defects in Fabrics* (Figs 45, 46 and 46A).—The defects which occur in woven artificial silk materials may be divided into two classes: those caused by the silk, and those due to the methods by which it has been treated.

It is not always, however, a simple matter to determine to what cause a defect is due: for instance, a fabric may contain many broken filaments and have a fluffy appearance, and this result be due either to subjecting a yarn of good quality to excessive tension, or to the use of a yarn the individual filaments of which varied greatly in size, a defect not uncommon

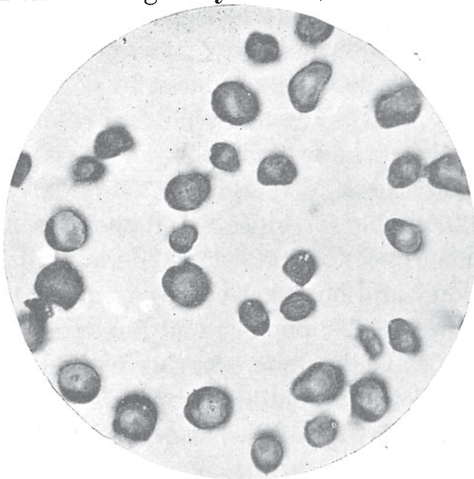


Fig. 45.—Dyed Viscose Silk.

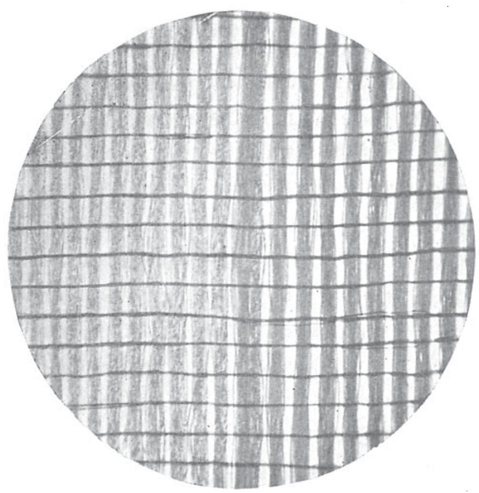


Fig. 46.—Fabric Showing Variation in Nitro Silk Weft.

in some Continental makes of artificial silk, with the result that reasonably moderate tension caused the breakage of the finer filaments while those of proper size remained undamaged.

Again, the production of bars of varying shades following the artificial silk weft of a cloth may be due to the thread having been dyed in batches which, owing to imperfect matching, are unequal in shade, or to the uneven affinity of the artificial silk for the dyestuff, or to the use by the weaver of artificial silk from different sources which would almost certainly have different rates of absorption of dye.

Other defects may be due to excessive tension, isolated

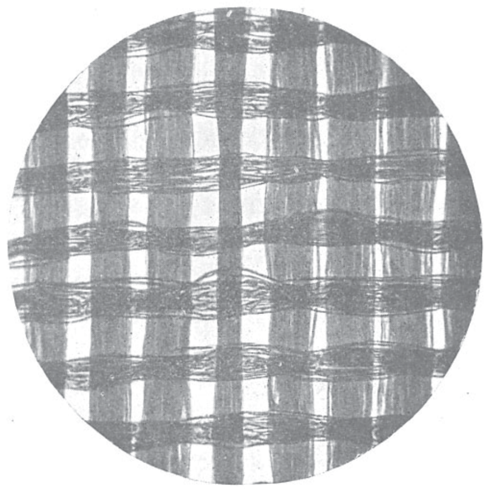


FIG. 46A.—TEXTURE SHOWING EFFECT PRODUCED BY THREADS, THE FILAMENTS OF WHICH ARE STUCK TOGETHER.

bright threads running through a fabric are often caused by irregularities during winding or spooling, as has been mentioned; but where a fabric contains stripes of artificial silk woven to form a design, excessive tension on all the threads of the stripe reduces to a great extent the relief of the pattern, so losing much of the possible effect. Where the artificial silk is in the weft, a similar poor result is produced by excessive stretching in the stenter, in fact it has sometimes happened that the endeavour to obtain an inch or two more in the width of the material by stretching during finishing has resulted not only in the loss of effect but also in the extensive breakage of the weft.

117. *The Trend of Development.*—The lines of progress which are being followed in the manufacture of artificial silk are chiefly those which lead to improved qualities in the product, rather than to novelties either of form or appearance, and although a considerable amount of yarn is now manufactured with finer filament than formerly, the greatest change is to be seen in the improved properties of the product, so that particularly as regards viscose, it now has an increased tenacity both in the wet and the dry condition, an improved resistance to treatment in the wet state, and a more regular rate of absorption of dyestuffs. The result of these improvements is to be seen in the extension of the uses to which artificial silk, especially viscose, is put. Ten years ago it was chiefly employed for braids, small knitted goods, fringes, and the like, a little only being used for weaving ; now, very great quantities, limited for the moment only by the output of yarn, are used both as warp and weft, alone or mixed with other fibres, white or dyed, for all classes of cloth, from very light dress goods to heavy tapestries for upholstery, and it would hardly now be safe to say that there is any class of fabric in which, in one form or another, artificial silk could not be used with advantage.

CHAPTER IV

THE YARN UNIT APPLIED

118.—Scheme of Yarn Manufacture and Fabric Character. 119.—Yarn Type and Textural Effects. 120.—Silk Threads relative to Fabric Features. 121.—Fineness of Silk Yarns and Weave Definition. 122.—Development of Detail in Woven Silks. 123.—Linen Yarns and Weave Definition. 124.—Application of Smooth and Fibrous Yarns. 125.—Examples in Patterns obtained in " Foody " Yarns. 126.—Frame and Self-Actor Spun Yarns. 127.—Value and Utility of the Yarn Unit in Fabric Construction. 128.—Yarn Diameter and Fabric Types. 129.—Basic Principles of Loom Setting. 130.—Elements in Practical Setting. 131.—Thread Counts and Fabric Thickness. 132.—Textural Weight per Yard. 133.—Technical Practice and Yarn Counts. 134.—Variations in " Warp " and " Weft " Settings. 135.—Coloured Effects and Yarn Diameters. 136.—Pattern Contrasts. 137.—Comparison of Standard Cotton Yarns.

118. *Scheme of Yarn Manufacture and Fabric Character.*—The " Yarn Unit," by reason of the nature of the fibrous or other material of which it is composed, determines the quality and style of the fabric woven. This accounts for the differentiation between cotton and silk textures when produced in the same size or diameter of yarns and with a similar number of threads and picks per inch ; or between linen, worsted or any other varieties of fabric of similar thread density, and consisting of warp and weft yarns of a corresponding thickness.

In the case of wool, the character, handle, and appearance of the fabric are also modified by the system of yarn construction adopted, such as woollen or worsted ; and, in the worsted system, by preparing and spinning the yarn on the English or on the Continental principle. The effects of the scheme of yarn construction are not so evident in the woven results in the use of other descriptions of fibre, though there are distinctions betwixt the cloths obtainable in frame and mule-spun yarns, and with cotton as the staple material. Thus two cotton textures, one made of the former type of yarn, and the other of the latter type, though the counts of warp and weft should be the same, and also the loom setting, would differ in quality and smoothness of surface. The texture made of the frame-spun yarn would be the more even, and that of the mule-spun yarn the rougher, owing to the differences in the two varieties of thread structures. In so far as the system of yarn manufacture aims at the parallelization of the fibres in the processes of yarn preparation, the thread resultant gives the highest degree of fabric evenness which the raw material selected is capable of yielding. Similarly, in so far as the system practised intermingles all sorts of fibres in the material employed, crossing the fibres promiscuously as in carding, and forming them in a "slubbing" and yarn in this mixed relation, a thread is produced which imparts a distinctive fibrous quality to the fabric surface.

119. *Yarn Type and Textural Effects.*—It follows, if the idea in fabric construction is clearness of textural detail, whether the result of "weave" or of "colour assortment," the type of yarn to be applied is that in which the fibres are both levelled and straightened in the routine of thread-making. Should, however, the idea be a cloth soft and fibrous in character, with the fibres not only visible on the face of the texture, but with the fibres imparting fulness of handle, then the thread structure to use, of whatever material formed, is that in which the filaments are variously but homogeneously intercrossed and intersected with each other, as for example, in the carded and mule-spun cotton or woollen yarn.

120. *Silk Threads Relative to Fabric Features.* These points in yarn structure are fundamental in manufacturing work applicable to cotton, linen, worsted, woollen, and silk goods. Examining, for instance, silks (in which the effects of these distinctions in the yarns on the fabric may be said to be the least marked) it has been explained that if "waste" silk threads should not be satisfactorily cleaned and gassed, they suffer in brilliancy and smartness. A percentage of "flossy" filament adheres to the thread, and this, while in a degree rendering the texture soft and supple in the feel, detracts from the definition of the pattern details. It is not here a question of any difference in the principle of yarn making, but simply one of leaving certain fibres, which have not been

coherently formed into the yarn, on the outside of the thread. This extraneous filament proves detrimental to the smart delineation of the textural style, and affects the wearing quality of the fabric.

121. *Fineness of Silk Yarns and Weave Definition.*—The ideal silk-thread structure is one perfectly clear of external fibre, or it is one composed—as in the reeled and thrown "net" silk yarn—of fibres compactly twined together. It is,

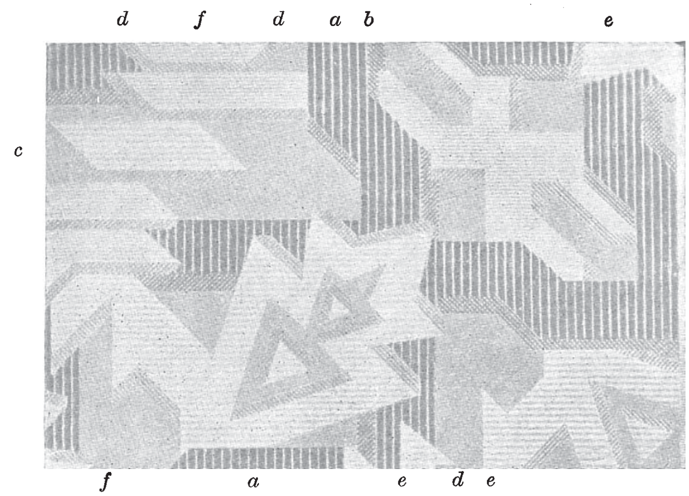


FIG. 47.—SILK SPECIMEN ILLUSTRATION OF WEAVE STRUCTURE.* ¼-SCALE.

therefore, a yarn which closely approximates, in the effects it gives in the fabric, one made of metallic substances. Other classes of woven fabric are not comparable (Paragraph 55) in clearness of detail with those made of silk yarns. This is the more remarkable when it is considered that silk threads are the finest or smallest in diameter usable in the loom. In some fabrics the woven features are clearly pronounced as a result of the comparative thickness of the threads employed; but in silks, these qualities are solely due to the absolute evenness of the yarns. Fig. 47, a silk specimen, is illustrative of the

* See lecture on "Textile Colour Theories" in the *Textile Institute's Journal*, and given by Professor Roberts Beaumont at the Ghent Congress in 1913.

technicalities referred to. It contains 200 threads per inch, 52 denier, or equivalent to 2-fold 200's cotton, the weft being 70 denier, or equivalent to single 75's cotton. Each weave effect—weft cord in section *a*; step twill in section *b*; fine weft rib in section *c*; step twill reversed in section *d*; and warp cord in sections *e* and *f*—is clearly defined. The photographic reproduction (Fig. 47) does not adequately show the degree of weave development, but the photo-micrographic specimens (Figs. 48, 49, 50, and 51) show that the various schemes of weaving combined are all effective units in the fabric. Moreover, these microscopic analyses make it evident that it is the quality of thread formable of silk fibre which renders the diversified woven surface here acquired so distinctive in composition.

122. *Development of Detail in Woven Silks* (Figs. 48 to 51).—Examining these photo-micrographic sections (Plans *a′*, *b′*, *c′*, *d′*, *e′*, and *f′*, Fig. 47A) more closely, in the plain-rib *a* each thread is clearly traceable, and the interlacings of the threads in the formation of the fabric are also visible. When the weft, as in parts *b* and *d*, intersect with the warp threads in a varied order, the twilled characteristic, due to each shot of weft and thread of warp, is as well delineated as if produced by the crossing of metallic threads. The superior value of silk here, however, as a thread, when compared with one made of metal filaments, is particularly observed in the cord (portions *a*) where a compact weft surface is developed, with the shots of weft in such close contact with each other as to give an apparently unbroken filament surface. Metallic yarn would yield the twilled distinctions in *b* and *d*, or the thread intersections visible in *c*, but its hardness and inflexible formation would not yield the surface features seen in this and similar specimens.

The striped twill fabric in Fig. 52 (Plan 52A), on account of its comparative simplicity of construction, emphasizes, in another form, the unique adaptability of silk yarns in expressing weave features. Produced in 66 denier warp and weft, with 160 ends and 140 shots per inch, the design is a diagonal make, angled, the formula for each pick of the diagonal being $\frac{6}{6}\frac{1}{1}\frac{1}{1}$, with the twill and plain sections formed two shots

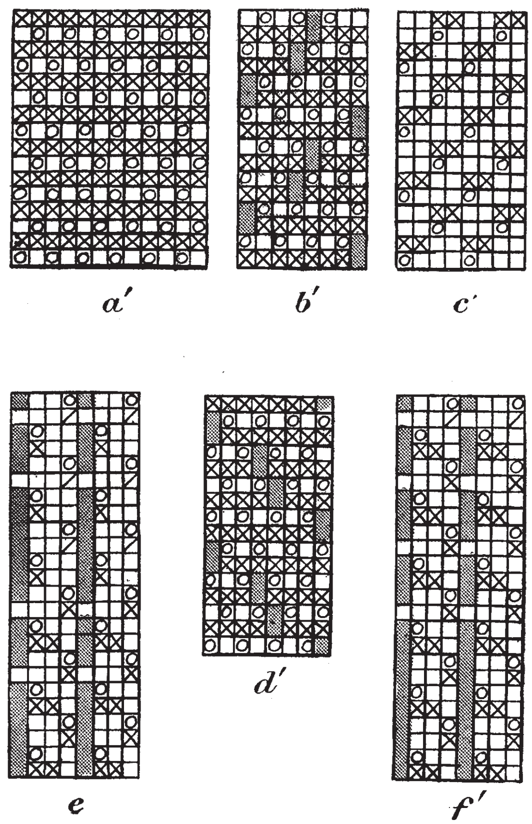
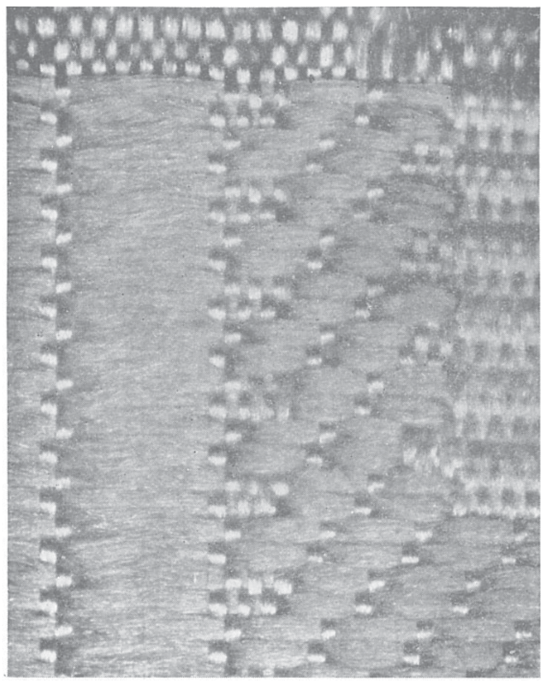


FIG. 47A.—WEAVE PLANS FOR FIG. 47.

in a shed. All the weft elements are as precisely delineated in the specimen as if pen drawn. There is strictly, in this quality of Italian silk thread, no surface fibre, so that each species of interlacing in the texture is equally accentuated and rendered distinctive in character.

123. *Linen Yarns and Weave Definition.*—The technicalities

explained make it obvious that, in applying the "Yarn Unit" for the purpose of acquiring the clearest degree of textural tone and pattern development, silk is the ideal thread structure. Linen yarns, in the finer counts, give the nearest approach to silk yarns in defining weave details, as will be



a *b*

FIG. 48.

understood from examining the three linen cloths seen in Figs. 53, 54, and 55. These bleached white textures, like the silk specimen in Fig. 52, derive their pattern or structural effects purely from the plan of crossing the warp and weft yarns in the process of weaving. No contrast in colour, or variation in tint between the two sets of threads, assists in bringing out the mat or hopsack (Fig. 53), the small diagonal,

(Fig. 55), or the ribbed stripe (Fig. 54). The straightness, lack of diffusiveness, and length of the flax as compared with the cotton fibre, is the cause of the smoothness, compactness, and evenness of the linen thread; and these special features of the yarn result in the more elementary, as in the more complex,

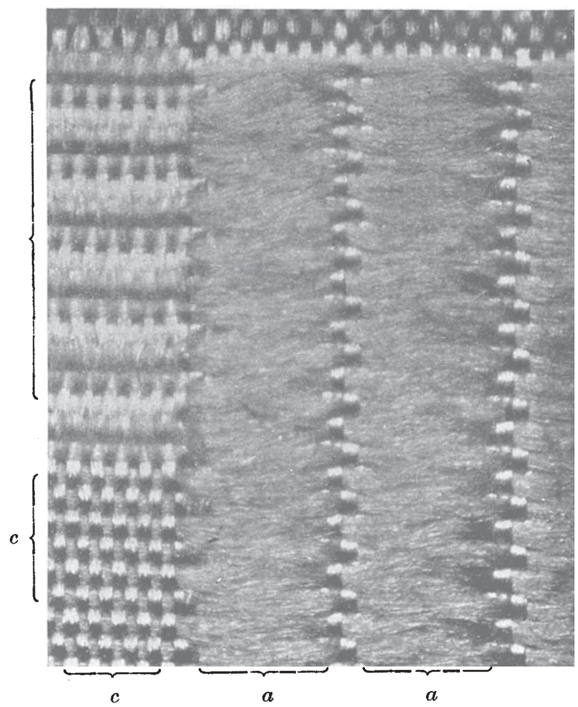
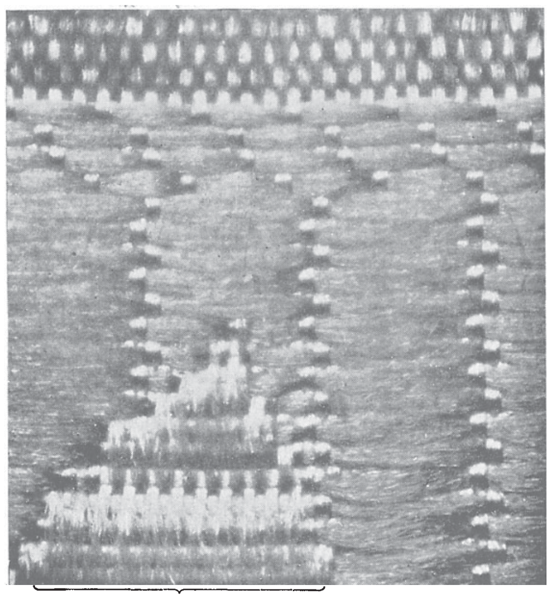


Fig. 49.

schemes of intertexture, being effectively brought out in the better varieties of linen cloths. The sheen which the fabrics acquire in the finishing and dressing, particularly in bleaching and calendering, contributes to the purity and freshness of the textural tone, but the weave definition and accentuation are in a principal degree originated by the formation of the spun yarn, for this enables structural details to be clearly defined in unbleached or naturally dressed as in highly-finished goods.

124. *Application of Smooth and Fibrous Yarns.*—Another feature which enters into consideration is yarns made of either wool or cotton may be required to give—(*a*) clearness of fabric tone, and (*b*) a fabric possessing a fibrous face. Cloths with a soft finish—cotton or wool, flannelette in the former,



e

Fig. 50.

and costume fabric in the latter—are preferably obtained in yarns made on the carded principle. On the other hand, cloths, cotton or wool, with the face details clearly defined, necessitate the use of yarns in which the fibres, in the processes of thread-spinning, are combed, drawn, and frame-spun. Two types of thread, one with a clear, and the other with a more or less rough structure, are obviously producible. When selecting either one or the other for woven purposes, the nature of the fabric required has to be taken into account. The subject may be explained by alluding to the specimens in Figs. 56 and 57, both made of worsted yarns, but French-spun in the first texture, and English-spun in the second. It will be noticed that in Fig. 56 the weave elements are subdued, while in Fig. 57 each twilled line is observed. Some degree of the fibrous character of the French-yarn cloth is due to the piece having been contracted in milling or felting from 70 ins.

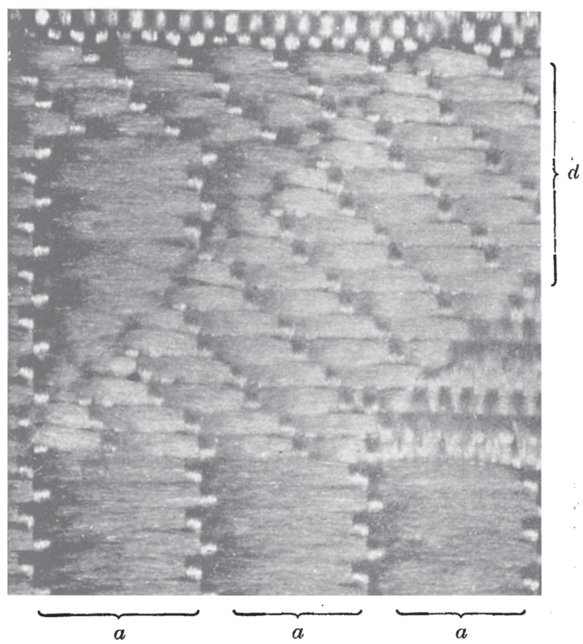


FIG. 51.

in the reed to 54 ins. finished; whereas the cloth made of English yarns has been set 63 ins. in the reed, and only shrunk in scouring. The finishing treatment, to which the two cloths were subjected after shrinkage, was, therefore, of a different character. In the English-yarn fabric, the object of the processes, especially those of brushing and cutting, was to remove all surface fibre, but in the French-spun yarn texture the fibre was brushed up, and the face of the fabric only slightly cropped. The full filament structure of the French yarn (paragraph 48) is suitable for giving the quality of cloth here illustrated, while the smoother and more even English-spun yarn is adapted for the clear definition of the twill or pattern details, and also for making a cloth with a bright, smart face.

125. *Examples in Patterns obtained in "Foody" Yarns.*—It should be pointed out that, even in fibrous-surfaced yarns, it

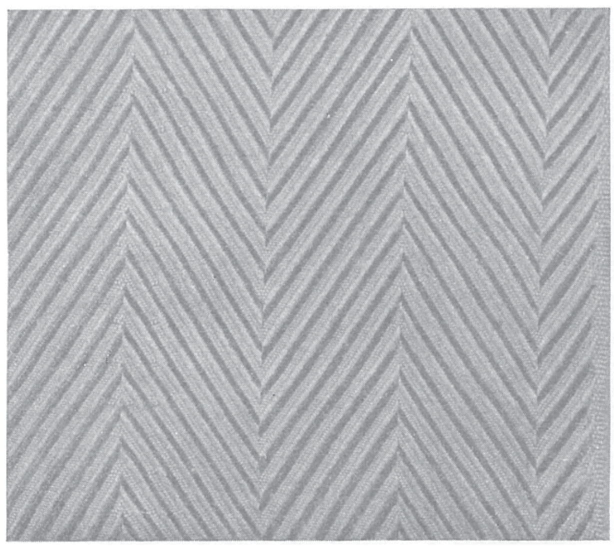


FIG. 52.—ANGLED DIAGONAL—SILK TEXTURE.

is possible, by the system of cloth finishing practised, to get clearness of pattern type as seen in Figs. 58A and B. In these examples, woven in French-spun worsted and Saxony woollen yarns, distinctness of style has been acquired by raising the fibre on the face of the fabric, and following with clear cutting. The use of a "foody" quality of thread in such manufactures is valuable in producing suppleness of handle and wearing durability in the cloth. Yarns of this structure are not adapted for the type of pattern of which Fig. 68 is illustrative. The weave requires to be of a simple description—plain, twill, or mat, and compound or double in construction. For Fig. 58A, double-plain makes have been combined, and for Fig. 58B, double-cassimere twills. One of the two plans used brings the odd threads and picks on to the face of the texture, and the other takes these threads and picks on to the back, and forms the face side of the texture in the even threads and picks. By arranging the warp and weft yarns 1-and-1 in light and

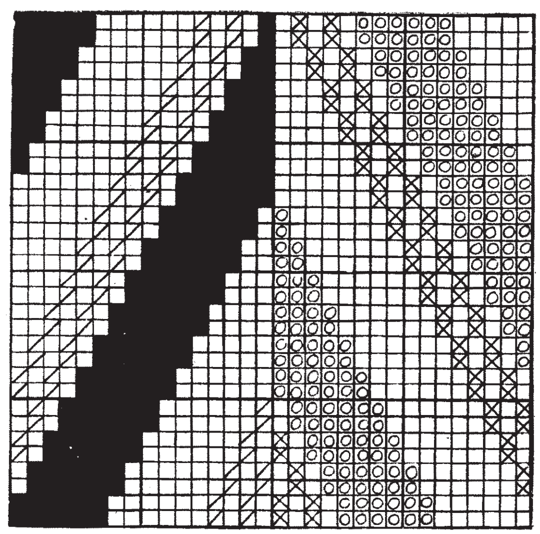


FIG. 52A.—SECTIONAL PLAN FOR FIG. 52.

dark shades, in such positions as the first of the two double-weaves is used, the pattern is developed in the light colour, and in such positions as the second double-weave is used, the effects are woven in the dark shade. It follows that by grouping two such compound or 2-ply weaves in a prescribed order they may be employed in developing any class of design—striped, checked, spotted, or figured—required ; but the effects, in all instances, are due to transposing the positions of the two shades of yarn in the warp and weft, and not to any variations in the textural plans. Both the face and the underside of the fabric in Fig. 58A are plain woven, and in Fig. 58B twill woven—the first resembling an ordinary plain, and the second an ordinary $\frac{2}{2}$ twill texture.*

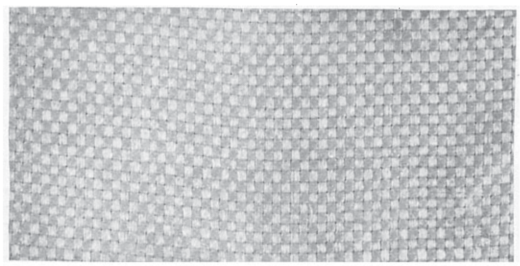
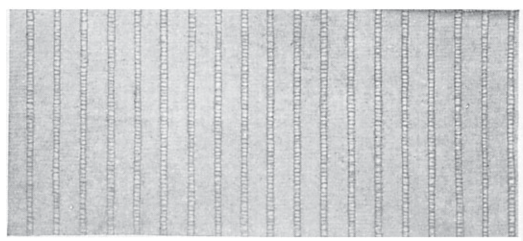


Fig. 53.



d d d d d Fig. 54. *d d d d*

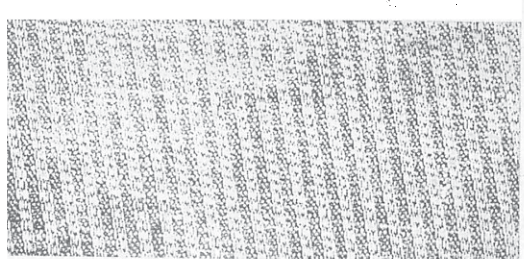


Fig. 55.
Types of Linen Fabrics.

While, therefore, yarns of a fine woollen quality may be thus utilized in the manufacture of costume fabrics, to which the schemes of patternwork observed in Fig. 58B are applicable,

* See Chapter XIII. *Colour in Woven Design.*