STANDARD CLOTHS

STRUCTURE AND MANUFACTURE

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(GENERAL, MILITARY, AND NAVAL)

BY

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WITH NUMEROUS ILLUSTRATIONS IN THE TEXT AND SIXTEEN PLATES IN MONOCHROME AND COLOUR

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PREFACE

COMMERCIAL and technical standards have obtained recognition in several branches of the textile industries. Systems of yarn counting or measuring, and of fabric construction of a prescribed weight per yard or *mètre*, are standardized factors in worsted, woollen, cotton, and other woven and knitted productions. Specialized standards have also been established relative to fabric breaking-strain, elasticity, colour, and finish for Government and official contracts.

Standardized practice facilitates commercial dealing and is favourable to manufacturing proficiency. Textural fineness and quality are, apparently, subtle and anomalous technicalities to standardize, but the problem does not offer insuperable difficulties. The two controlling elements involved are the nature of the fibrous materials utilized, and the organized individual and collective groups of processes and operations of manufacture.

With a view of elucidating the technical scope and diversity of the subject, collections of trade, general and original specimens have been consulted, and the data ascertained and collated verified by experimental research. Analyses and illustrations of numerous typical and other varieties of fabrics—supplemented by expositions of the principles and schemes of manufacture they represent—will be found to form an essential part of the book.

For the Government cloths treated of, I desire to express my indebtedness to the officials of the Royal Army Clothing Department and the Admiralty, who have placed at my disposal the standard samples of woven materials requisitioned for military and naval purposes.

Mr. Frank Beaumont, of the Convoy Woollen Company, Ltd., Co. Donegal, has supplied the wool and colour-blend specimens of the Khaki and French Grey Army Cloths on Plates XIII and XIV.

I have further to acknowledge the interesting and suggestive form in which the publishers have printed and illustrated the volume.

R. B.

LEEDS,
October, 1915.

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(1) Woven Fabrics—Methods of Construction.

Fabrics or textures are manufactured of fibrous materials by felting, plaiting, knitting, and weaving. Each system of work is representative of several groups of textures having specific properties, structural characteristics, and different uses and applications. They are divisible into two main classes:—

1. Cloths made direct from fibrous materials by a process of felting and in the manufacture of which there is no spinning or equivalent operation for twisting the prepared fibres into a thread-like form.

2. Fabrics constructed of spun yarns or threads, composed of fibrous substances, by plaiting, knitting, or interlacing such yarns into a texture.

The former are compacted, solidified filaments; and the latter thread-contrived textile structures. In one instance, a cloth is acquired by utilizing the natural disposition of wool or hair to felt under prescribed conditions; and, in the other, a fabric is produced by passing lengths of thread over, under, and round each other.

(2) Felted Cloths.

Felting is the most primitive method of making a cloth. It was understood and practised by Eastern craftsmen at a very early period, and in later times by the Romans and the ancient Gauls. Rough, coarse blankets, coverlets, mats, and carpets were thus manufactured before the invention of the art of spinning.

Felt manufacture is now a standard method of cloth production and comprises *unwoven* and *woven* materials. Unwoven felts are the original type, and result from felting prepared strands, or layers of fibres, into pieces of cloth, the quality and substance of which are determined by the fineness of the wool or hair, and the number of layers of "cardings," or lengths of scribbled and carded fibrous materials, felted together.

Modern felts—in the production of which camel, goat, and other varieties of hair, wool substitutes, and coarse, medium, and fine-grown wools are employed—range from inferior classes of carpets and rugs to fine cloths made for decorative and clothing purposes, and vary in thickness from a hat-band material, soft and flexible, to a cloth of one or more inches, and of characteristic firmness and solidity.

(3) Yarn-made Structures—Lace, Knitted and Woven Textures.

Yarn-made textures—obtained by the plaiting of threads as in lace-making, the looping of threads as in knitting, and the interlacing of threads as in weaving—differ from each other in three important essentials:—

(*a*) *Composition*, or the standard group or set of threads of which the texture is made; (*b*) *Structure*, or the method of binding or securing the standard threads to each other; and (*c*) *Surface characteristics*, e.g., compactness, density, evenness, and diversity of yarn intersections or crossings.

(*a*) *Composition.*—In lace (Fig. 1) a development of the art of plaiting, the textural "effect" is the net or mesh. The connecting strands, in the specimen illustrated, consist of two threads loosely twined together, but separated and recombined by interlacing in alternate order at the extremities of each mesh.

The "effect" in a knitted material is derived from the scheme of looping. The ordinary principle is shown in Figs. 2 and 3. The loops on the face extend lengthways of the texture, but on the reverse side they move transversely. Loop succeeds

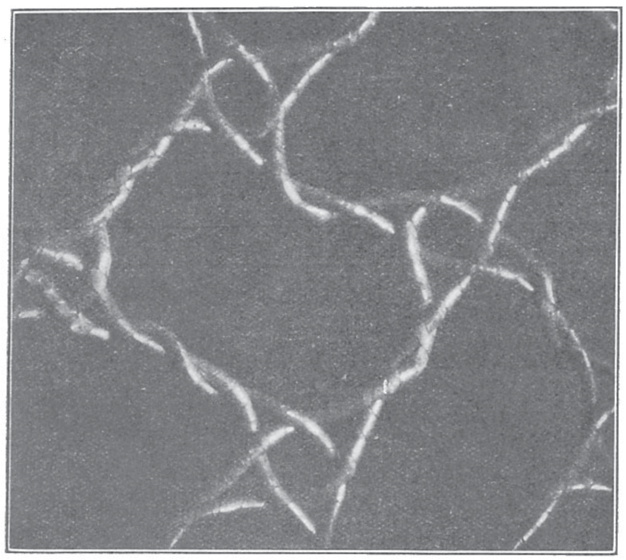

FIG. 1.—Venetian lace: Fourteenth century.

loop in regular sequence in the making of the fabric. The omission of a single stitch drops a loop and leaves an unformed place in the texture.

Woven cloths are distinct in composition from both lace and knitted materials. In all instances they are produced by the alternate crossing of two series of yarns at right angles to each other. To make the simplest "effect," four threads—two *warp* A and B, and two *weft* C and D (Fig. 4)—are necessary.

(*b*) *Structure*.—Textural structure, or the methods of securing the threads to each other, is most diversified in weaving.

In both lace and knitted work it is restricted by the plaiting or looping of the threads *individually* and not in *series*. The number of threads in a strand of the mesh, or in the sequence of loops, does not change the singleness of yarn movements in either lace or knitted structures. This is a fundamental element of their construction. No such restrictions apply to loomwork. Here the yarns may work in groups consisting of

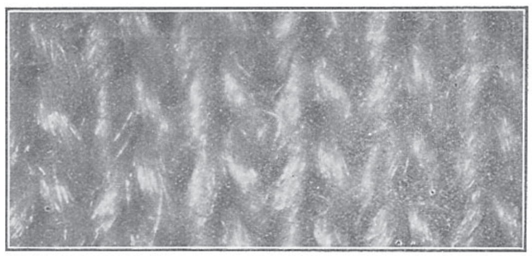

FIG. 2.—Knitted texture. Face surface.

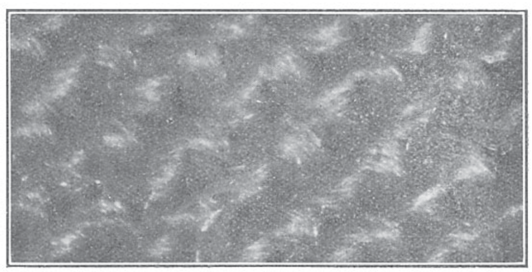

FIG. 3.—Knitted texture. Reverse surface.

the same or different numbers of threads and in any prescribed order.

(*c*) *Surface Characteristics.*—The surface qualities and features of lace are chiefly varied by the nature of the fibrous materials and the fineness of the yarns. Several threads may be formed into one strand, but little variation is observed in the net or mesh. In knitting, there is facility for modification of the surface of the fabric in the form of the stitch, and in the drawing together and arrangement of the loops, producing plain, ribbed, and other effects. Knitted textures are more flexible, elastic, and porous than the ordinary classes of fabrics, but are deficient in tensility and firmness. Uniformity of surface is a characteristic of each of these distinctive textures; but whereas in lace it mainly implies regularity of construction, in knitted and woven fabrics it may also signify a degree of smoothness.

As each method of crossing warp and weft yields a different type of fabric, the surface effects developed by weaving may be plain, twilled, matted, ribbed, diagonalled, striped, checked, honey-combed, diapered, etc. Moreover, in the most elementary woven structure (Figs. 4 and 4a) many varieties of manufactures are obtainable. This is not possible to the same extent in knitted schemes. For example, by changing the qualities and counts of the yarns, the setting, and other data of construction, it is feasible to produce in the plain interlacing the thin, light flannel, the heavy melton, the fine cambric, the coarse calico, the jute carpet, and the hemp sacking. Other standard weaves—twill, mat, and sateen—have a fuller range of applications, and combined with the schemes of design which may be developed in the loom, afford the widest scope for the construction of fabrics rich in surface characteristics.

(4) Materials and Fabrics Microscopically Considered.

Microscopic research has contributed to the knowledge of the physical structure of fibrous materials and to the accurate determination of the qualities they produce in the woven fabric; of technicalities in yarn construction; and of the influence and value of the nature of the fibre, and of yarn and fabric structure on the felting, raising, and lustring in finishing routine. The theory and technicalities of these processes have been verified and elaborated by experimental and microscopic investigations.

The microscope reveals and distinguishes the minutest details and elements in the composition of woven fabrics made of materials of different manufacturing properties. Microscopic views of flax, cotton, ramie or rhea, silk, artificial silk, asbestos, and wool, indicate the specific qualities of each material, which are as strongly pronounced and distinctive in the manufactured

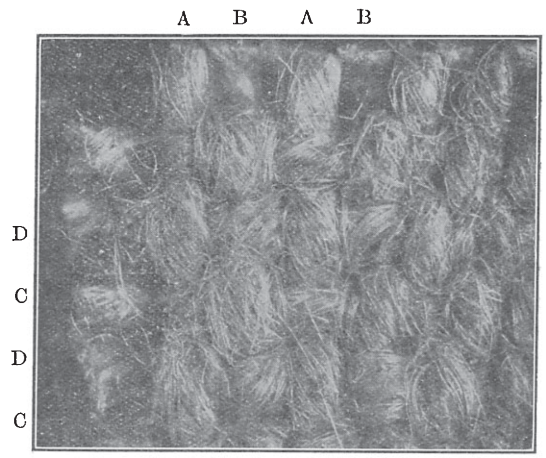

Fig. 4.—Coptic fabric.

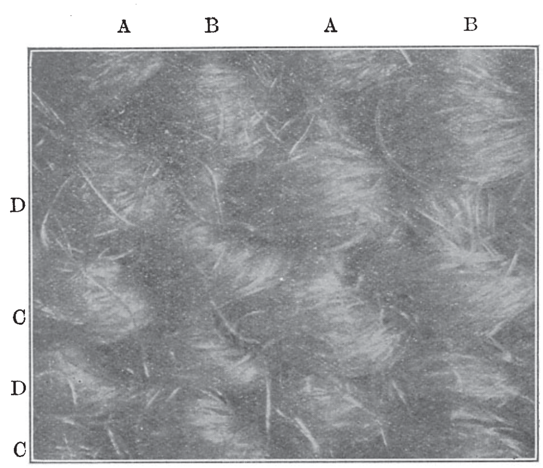

Fig. 4a.—Coptic fabric. Weft rib effect in the Plain Weave.

as in the unmanufactured state. Comparison emphasizes the excessive quantity of active or assertive fibres in woollen as contrasted with cotton and linen fabrics. This is suggestive of the specific clothing properties of woollen textures, and also of the exceptional tensile strength and elasticity which they are known to possess.

Fibrous compactness and consistency are characteristic of the yarns in both the flax and cotton specimens (Figs. 5 and 6),

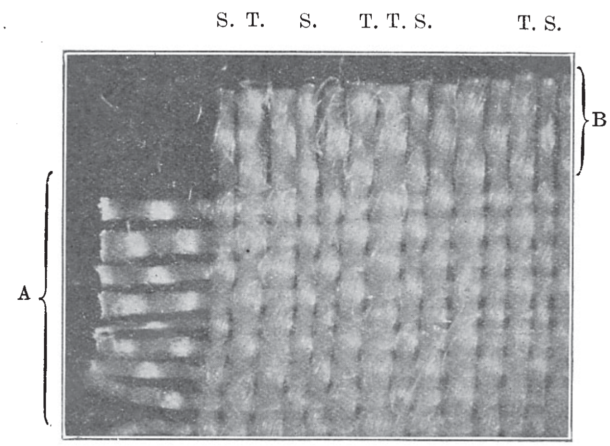

Fig. 5.—Linen Cambric.

but obviously there is an absence of extraneous and surface filaments which form such a decided feature of the woollen examples (Figs. 4 and 4a). The cause of the level, smooth, and bright surface of the linen texture is distinctly traceable to the uniform separatedness, and even condition, of the flax fibres of which it is composed. The crushed, flattened, and partially collapsed form which the threads possess, is due to the pressure applied to the fabric in the calendering and finishing work, and adds to the permanent lustrous quality of the texture. Straightness, evenness, and brightness, which are so prominently brought out as the distinguishing characteristics of linen in Fig. 5 (a fine cambric) are more clearly understood when

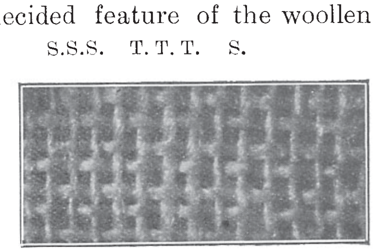

Fig. 6.—Cotton texture.

contrasted with cotton both in the yarn and fabric. Fig. 7 is a view of a fine muslin made of Egyptian cotton of superior spinning property. The yarns are smaller in diameter than those forming the cambric texture, but retain the round, concave surface of an ordinary spun thread. If the fabrics were calendered, the yarns would not be flattened or assume the same characteristics as the linen.

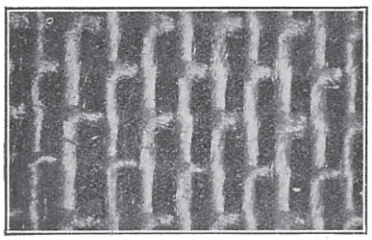

FIG. 7.—Muslin.

Fig. 8 is a union linen—cotton warp and flax weft. The flax in such an inferior quality of fabric is not of the best, but still the

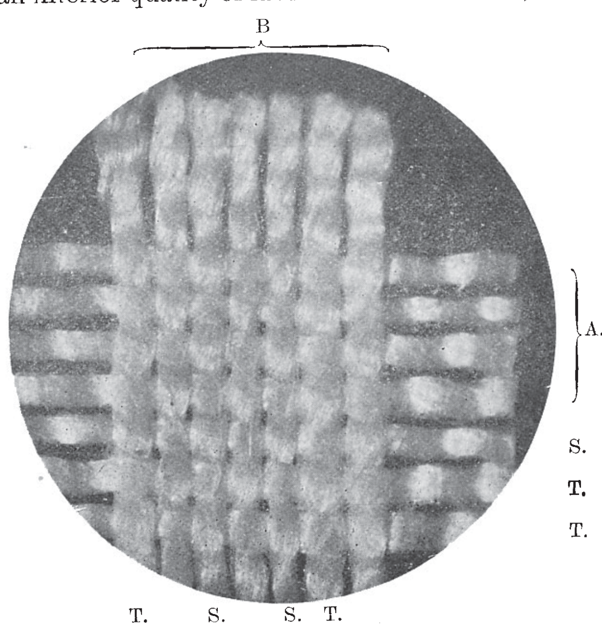

FIG. 8.—Union linen. Cotton warp and linen weft.

straight and somewhat collapsed features of the linen are noticeable in contrast with the rounded surfaces of the cotton yarns. Particularly is the straightness of the fibres in the linen threads observed in section A or the unravelled portion of the fabric.

Compare these in fibrous compactness and smoothness with the ends of cotton warp in section B of the illustration.

Close examination of Fig. 5 shows that the flattening of the threads has developed waviness of disposition in the fibres, and that this is in exact coincidence with the frequency of the interlacings of the warp and weft. The lustrous quality is apparently better accentuated in the loose ends A and B than in the woven texture, and slightly more in A than B, but this is caused by the warp yarns being spun from a finer flax than

FIG. 9.—Ramie texture: warp and weft threads disarranged.

the weft yarns, and therefore fuller of fibre and more flexible in structure.

The lustrous quality of ramie (Fig. 9) or China grass has another source, namely, the high degree of smoothness of the filament, with the absence of surface abrasions, and regular physical structure and formation. Ramie yarns differ from flax in possessing some fine extraneous fibres which fill up the interstices between the interlacings of the warp and weft in the fabric, but unlike flax the threads, in the dressing of the texture, retain their oval or round consistency.

In silks (Fig. 10) the fibres lie in straightened series or in parallel line, so that the magnified threads have the appearance of smooth bands or ribbons intersecting each other, with the minimum amount of twisting or crossing of the filaments. Artificial silk as regards lustre is a satisfactory substitute for natural silk,

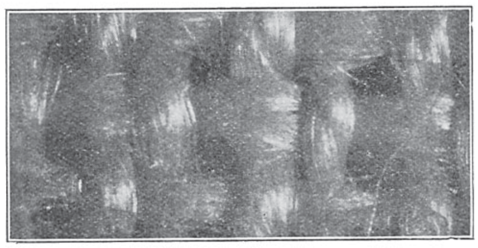

FIG. 10.—Silk texture.

having in the fabric, under the microscope, the same ribbon-like quality and form of threads (A. Fig. 11), but the analogy ceases

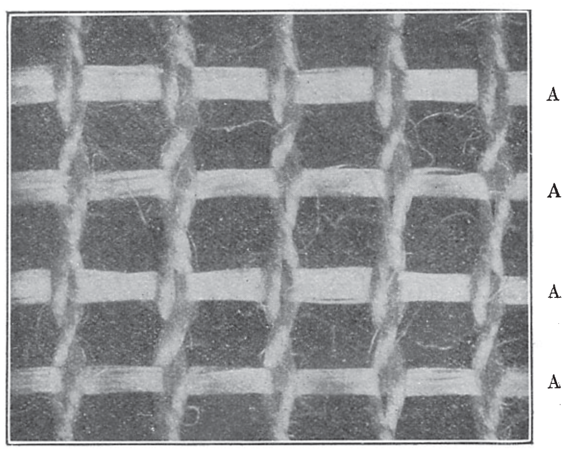

FIG. 11.—Gauze fabric. Cotton warp. Artificial silk weft.

here, the pure silk being washable, durable, pliant, and elastic, and the artificial silk being brittle and comparatively deficient in elasticity and suppleness.

Jute has specific features—brightness and clearness of thread distinction, with the individual fibres well lined with each other, but without the firmness and compactness characteristic of cotton, the qualities of fibrous straightness, stiffness, and smoothness not being favourable to the production of closeness of contact by the processes of yarn manufacture.

The intersections in an asbestos fabric, when magnified, appear indefinite and indistinct, and the whole surface has a cloudy appearance. The yarns are ill-defined, and resemble cotton floss rolled into threads fairly even in circumference, but in which the fibres have been crushed together rather than spun round and over each other.

(5) Various Types of Wool Textures Under the Microscope.

Fabrics resulting from the manufacture of wool comprise a larger diversity of types than those produced from other fibrous materials, but for microscope analysis they may be grouped into two main classes :—

1. Fabrics having distinctive characteristics derived from the nature and properties of the wools used in their production, as, for example, wools fine or coarse in fibre, and short, medium, or long in staple, and also from such fibres as Mohair, Alpaca, and Vicuna.

2. Fabrics differing in structure, surface features, and technical properties, on account of being made from yarns manufactured on distinct systems though from the same or similar qualities of wool.

From these two fundamental groups of "wool" fabrics three classes of microscopic investigations may be made :—

(*a*) In woollen fabrics, typical Saxony and Cheviot.

(*b*) In worsted fabrics, typical Botany and Crossbred.

(*c*) In Mohair, Alpaca, and dress materials.

Experiment and practice in the manufacture of Saxony and Cheviot cloths have rendered their respective qualities and textural features definable. The superior fibrous fineness and density of the Saxony (Fig. 12) and the rougher, stronger quality of the Cheviot (Fig. 13) are clearly brought out in microscopic examination. Such a mass of crossed and mingled filaments as forms the surface of the Saxony—considering that it is but the external or outer layer of a similar but more compacted series of layers of fibres—implies the composition of a fabric supple and elastic, and warmth-yielding in the wear. The nature

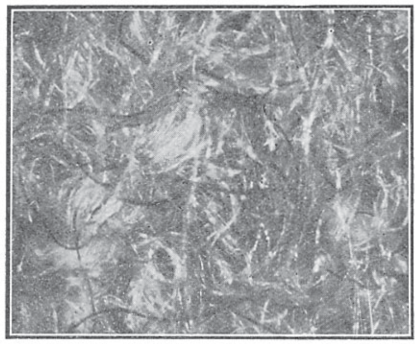

FIG. 12.—Saxony Angola (Merino wool and cotton).

of the surface of the Cheviot suggests crispness, brightness, and more distinctiveness of filament with a possibility of greater

FIG. 13.—Cheviot costume cloth (Welsh wool).

freshness of tone of colour than in the Saxony, but a fabric slightly more porous in structure; from which it will be understood that the true principle of manufacturing adapted to the classes of wools used in making these fabrics, is to develop and emphasize the features microscopically delineated in Figs. 12 and 13, or, in other words, the natural properties of the wools utilized.

The two types of worsted fabrics, Botany (Fig. 14) and fine Crossbred (Fig. 15), are equally distinct in character as the two woollen textures considered, with this important difference—the

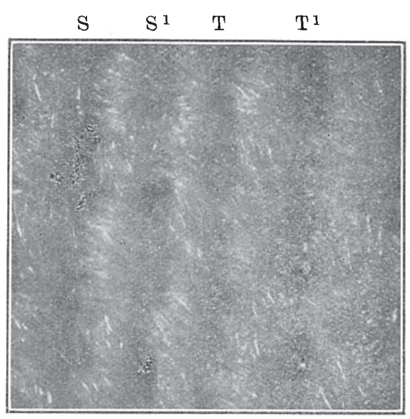

FIG. 14.—Botany Worsted Flannel.

structure of the yarns and the interlacings of the warp and weft are better defined. But few traces of the threads are discern-

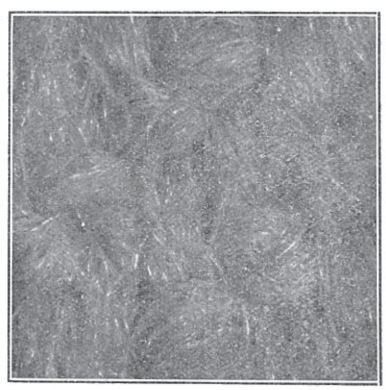

FIG. 15.—Fine Crossbred Worsted.

ible in either the Saxony or Cheviot, the yarns being covered with extraneous filaments,—a characteristic feature of the surface of the cloths. Worsted textures are quite different.

Whether fine or medium in quality, that is, made of wools similar to those used for the styles of fabrics in Fig. 14 or Fig. 15, or of different degrees of fineness, the threads of warp and weft are distinct, and the scheme of intertexture traceable under the microscope. The thread structure is also more or less discernible, for in Figs. 14 and 15 both the progressive movement of the interlacing of the threads, and of the actual structure and arrangement of the fibres in the yarns, are revealed. Clearly, the fibres of the wool in producing these yarns have been, in the scheme of yarn manufacture, straightened or combed as well as twisted round each other, the straightening process

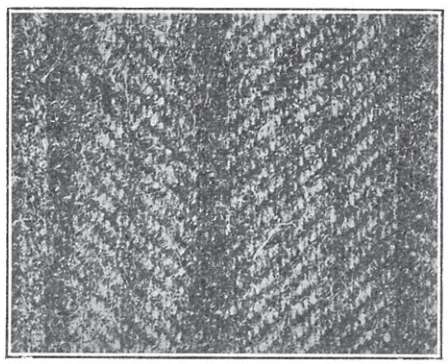

FIG. 16.—Medium Cheviot fabric.

being performed to such a degree as to impart that level smoothness of circumference which is discernible in the threads of both the Botany and Crossbred specimens.

These microscopic dissections demonstrate the technical reasons for worsted yarns being better adapted for the development of weave and design details than yarns made on the woollen principle; they afford a precise definition to the interlacings of warp and weft, or to the weave scheme, which is not so feasible in woollen cloths composed of yarns with a rough, fibrous surface. Differences in wearing property and characteristics are also distinguished. The features are evident which develop glossiness in the wear of a worsted, and thread-bareness in the wear of a woollen fabric. Friction, such as that developed in wear, is chiefly on the lateral sides of the fibres and on the yarns in the former; but in the latter, it is both on the points and sides of the intermingled filaments distributed on the face of the fabric. Clearly, it is the thread structure which sustains the friction in

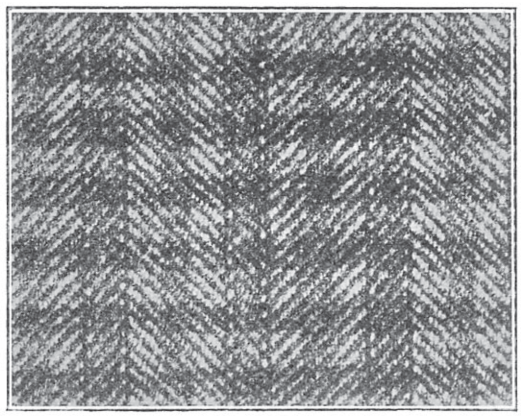

FIG. 17.—Medium Saxony fabric.

the wear of a worsted cloth, this being distinctly exposed (Fig. 14). In woollens, the extraneous fibres may conceal and cover the threads (Figs. 12 and 13), or the details of the patterns

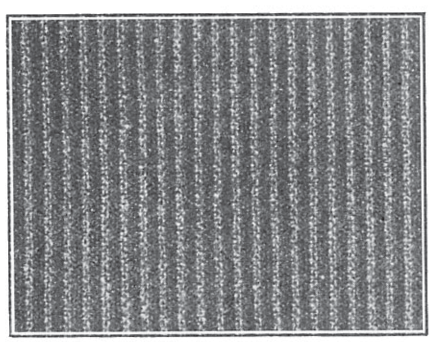

FIG. 18.—Striped Saxony trousering (clear finish).

may be made distinguishable, in consequence of the surface filaments having been removed in the finishing routine, as in Figs. 17 and 18, but the modifications effected by wear are the same in each of these classes of fabrics.

(6) Magnification of Mohair and Alpaca Fabrics.

Mohair and Alpaca have a similar physical structure to wool, with the fibres less serrated, and the outer scales larger

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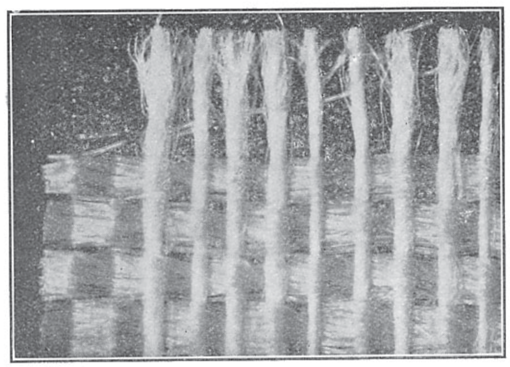


Fig. 19.—Mohair weft and Cotton warp.

and flatter than in the medium and short-stapled wools. These materials are exceptionally smooth, soft, and lustrous. The nature of the yarns and class of fabric they yield are dis-

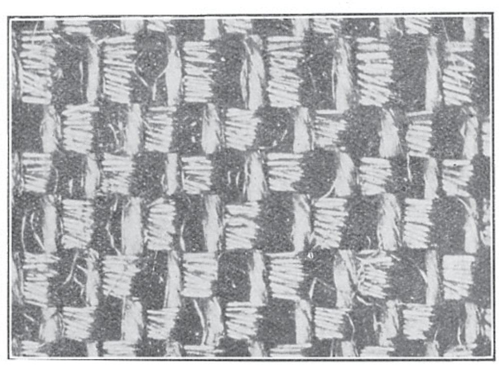


Fig. 20.—Alpaca weft and Cotton warp.

tinctly brought out in Figs. 19 and 20, sections of union dress stuffs, composed of Mohair and Alpaca wefts and cotton warp. The functions of the several threads in the two structures are rendered distinct—the cotton imparting firmness and strength of fabric, and the Mohair or Alpaca fibrousness and glossiness. The difference in the relation and compactness of the fibres in the threads is also marked—the cotton solid, round, and wire-like; the Mohair loose in formation, flat, and plain, with the filaments spread in a manner to occupy the spaces between the interlacings of the yarns. The impracticability of obtaining from either Mohair or Alpaca a texture of a woolly quality, will be understood from these microscopic illus-

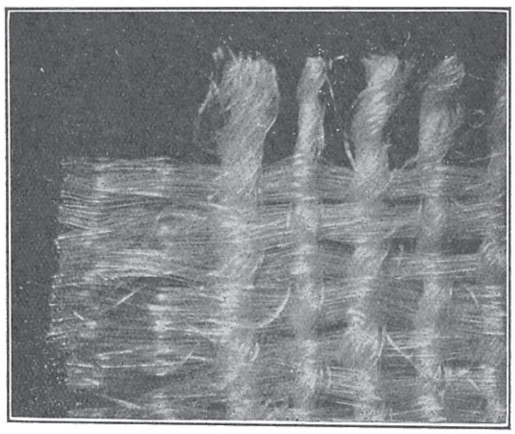


FIG. 21.—Mohair warp and weft.

trations. Such materials are specially suitable for the manufacture of fabrics having a smooth, bright surface and of silky softness, hence their application to dress textures or "lustres". When both the warp and weft yarns are Mohair (Fig. 21) the fabric is denser in structure and fuller of fibre. The twofold construction of the warp threads, to give tensile strength and wearing property, is well defined. Folding and twisting soften, but do not destroy the characteristic straightness and line arrangement of fibres, forming the marked features of all classes of Alpaca and Mohair yarns.

(7) Fabrics Composed of Yarns of Different Fibrous Properties.

Fabrics acquired by using two or more kinds of yarn of dissimilar fibrous composition present interesting qualities.

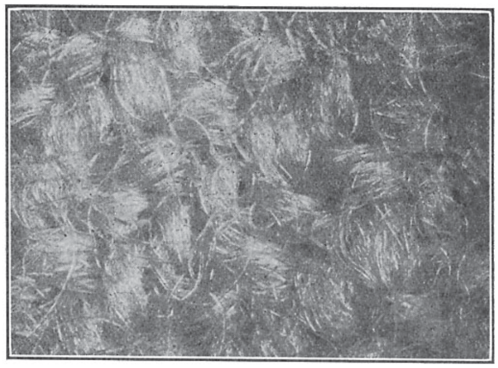


Fig. 22.—Botany worsted warp and weft fabric.

The typical combinations include fabrics made of yarns of cotton and wool, cotton and worsted, cotton and linen, cotton and

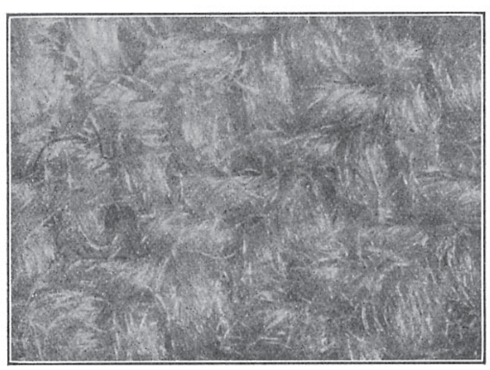


Fig. 23.—Botany warp and Saxony weft fabric.

Mohair, Alpaca, Camel's hair, artificial silk, and other lustrous materials. In the manufacture of union flannel and costume cloths, firmness and clearness of structure, as in Mohair unions, are due mainly to the cotton warp threads, and fibrous quality to the worsted or woollen weft. The effect in the fabric is generally noticeable in the straightness and uniformity of disposition of the cotton warp yarns, which, though regularly interlacing with the worsted weft yarns, are but slightly deflected, whereas the worsted are bent and curved at the points of intersection. Though in this specimen (Fig. 19) the diameters of the two yarns nearly correspond, affording the least facility for accentuation of these technicalities, yet the relative qualities of the materials are clearly distinguishable, and each class of thread retains its individuality of character and structure.

FIG. 24.—Botany warp and Cheviot weft fabric.

Union cloths in which the warp is cotton and the weft woollen may consist of yarns of very different thicknesses, such for example as cotton threads $\frac{1}{88}$th of an inch in diameter crossed with woollen threads $\frac{1}{33}$rd of an inch in diameter. This results in a cloth in which the cotton yarns are quite concealed by the fibres composing the woollen yarns. The solidity and evenness of the cotton threads as compared with the soft and bulky fibrous condition of the woollen, are strongly accentuated. Such a warp and weft compound, when microscopically examined, exhibits the distinguishing features of the two kinds of threads and their relation to each other in the build of fabric.

(8) Microscopic Examination of Fabrics in which Cotton is Used.

Cotton and silk union textures present two contrasts: first, in lustre; and, second, in the methods of grouping the fibres in the formation of the respective threads. The silk filaments are lined and spread as in Alpaca yarns. The strong, hard cotton warp yarns deflect the softer and more flossy silk weft, emphasizing the brightness of the latter.

Allusion has already been made to the characteristics of linen, Mohair, and Alpaca unions in Paragraph 6.

In each instance cotton is primarily employed to reduce the cost of the fabric. It also affects quality and wearing characteristics. The union linen specimen (Fig. 8) has a spongy murkiness of tone, the short, straggling fibres on the edges of the cotton threads detracting from clearness of textural definition, which forms an essential feature of the finest-made linen fabrics. Cotton with lustrous materials—Alpaca, Mohair, etc.—gives a type of texture wanting in the qualities of brightness and softness when compared with similar productions in which the warp and weft yarns are prepared from the same class of fibre.

In many varieties of fabrics, admixtures of cotton and wool, and cotton and wool substitutes, are made in the processes of yarn preparation, and not in weaving, by combining yarns of different materials. This is fibrous blending in the place of yarn mixing. It yields a perfect intermingling of the two or more classes of fibres utilized. Union fabrics manufactured by this method are microscopically examined for fibrous diversity and detection, and chemically analysed for quantitative composition.

Fig. 12 is a microscopic view of a Saxony fabric in which a percentage of cotton has been used. It consists of 85 per cent of wool and 15 per cent of cotton fibres. With the exception of dullness of colour tone, and deficiency in suppleness and softness, it might pass for a woollen texture. Microscopic examination exhibits the characteristics in the fabric due to each kind of fibre—the straight and comparatively stiff fibres of cotton, and the curly, wavy, diffusive fibres of wool. It is a ready and accurate method of detecting admixtures of vegetable, animal and other fibres, but it may not be as successfully applied in determining the use of wool substitutes—noils, flocks, mungo,

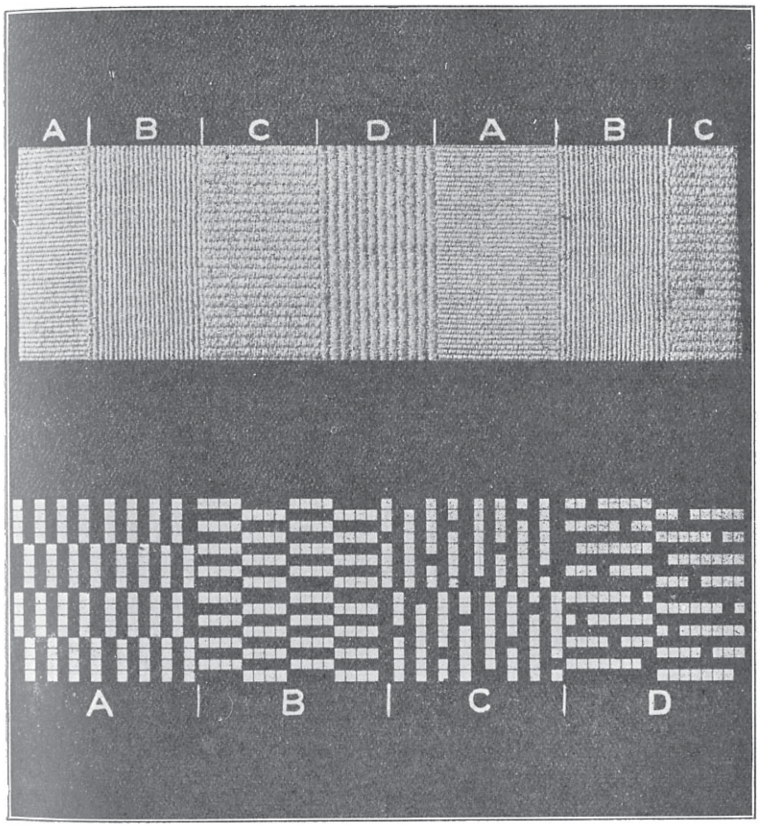


Fig. 26.

Fig. 25.

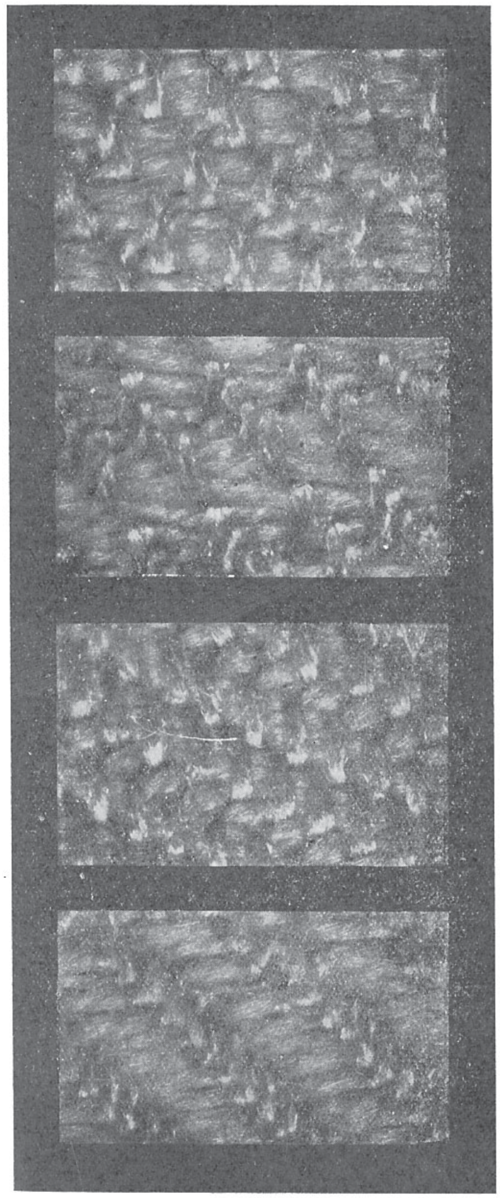
Fig. 25.—Striped design composed of warp and weft cords.
Fig. 26.—Sample of woven texture for Fig. 25.

shoddy, and extract—or the presence in the same fabric of lustre wools, Mohair, Alpaca, and Camel's hair, or fibres of a like genus but of dissimilar textile attributes.

(9) Experiments in Fabrics made of "Wool" Yarns of dissimilar Structures (Figs. 22, 23, and 24).

As shown, the minutest differences in fibre and in yarn structure have some influence on the style and character of the fabric. Other minutiæ influence clearness of weave delineation. There are, apparently, inappreciable technicalities in practical manufacturing, defined by microscopic analysis, which result in more accurate fabric construction, or in the utilization of manufacturing data and routine scientifically adapted for attaining the type of texture or style of effect required. To demonstrate these points, experiments have been made in three groups of fabrics, the warp in each being 2-fold 30's and the wefts like the warp (Fig. 22), and Saxony and Cheviot single yarns but of a similar count (Figs. 23 and 24). Practice has determined some of the differences in quality and weave distinctiveness in the three descriptions of cloth resultant. Microscopic investigation goes further, and reveals the fibrous relation of the warp and weft yarns, and also the effects of fine and strong-fibred wools on the surface of the texture and on the nature of the weave. The pure Botany specimen (Fig. 22) has the most level, even, and smooth surface with the neatest twilled appearance. From this it is conclusive that the more regular the structure and fibrous equality of the yarns, the better the development of these technicalities. Contrasting Fig. 22 with Fig. 24, the coarser wool composition of the Cheviot weft produces a more open twill and a rougher fabric, the degree in which the two textures differ in these features being definitely noticeable. It is obvious that the admixture of yarns in Fig. 24 is not adapted for giving evenness of warp and weft twill distinction. The Saxony weft crossing the Botany warp (Fig. 23) yields a third variety of fabric. The twills are more suppressed with the warp effects clearer than the weft effects, forming a combination of yarns of practical value in the manufacture of cloths in which one order of twills—warp or weft—is required to be brighter than another. In addition, this specimen shows the correct relation of yarn structures to obtain softness of weave tone, the fibrous density and compactness of the woollen weft, with its extraneous filament, affecting this characteristic and also the supple quality of the cloth.

These microscopic analyses emphasize the following technical points:—



A B C D

Fig. 27.—Derivatives of the 4/4 twill (photomicrographs of the textures.)

1. The highest degree of neatness of texture combined with clearness of weave interlacings, is the most satisfactorily developed in 2-fold Botany yarns of a fine quality.

2. A difference in the definition of the warp and weft twills is obtainable by interweaving a Botany worsted warp yarn with a Saxony woollen weft yarn.

3. Comparative openness of weave effect, with fibrous roughness of fabric, results from crossing a Botany worsted warp with a Cheviot weft yarn, or a yarn made on the woollen principle and of a Crossbred quality of wool.

4. Degrees in these contrasts are variable as required in actual manufacture, by changes in the quality of the fibre and the structure of the yarn.

(10) Microscopic Research and Schemes of Intertexture.

An important section of textile microscopic research concerns technical elements in fabric structure, as produced and modified by different schemes of interlacing warp and weft. The relative compactness of the intersections and their composite effects, and also the angular direction of the groups of interlacings—i.e. the "move" constant in the twill or design, are technicalities for investigation. Research should be based upon experiments in fabric construction and planning, originated and carried out to determine specific data in textile structures and in weaving.

Typical series of woven examples experimentally produced for this purpose will be analysed. The first series is a compound of two sets of warp and weft cords, one set being finer than the other; or the floats limited to four interlacings in the first example and eight interlacings of either warp or weft in the second example. The characteristics of a correctly-constructed cord are indicated in Fig. 26, A, Design 25, A. It consists of an adequate cohesion of warp yarns to cover the series of weft yarns, and yet to develop a clean rib or rep across the fabric.

In Fig. 26, C and D, the detail contrasts between a group of comparatively long floats of weft in association with shorter floats of warp are observed, and also the effects of the latter on the compactness and closeness of structure of the section adjoining the warp cord. The picks in this part of the texture are drawn together in fours and not regularly spaced as in the adjoining weft cord. Fig. 26, B, is the reverse in principle to

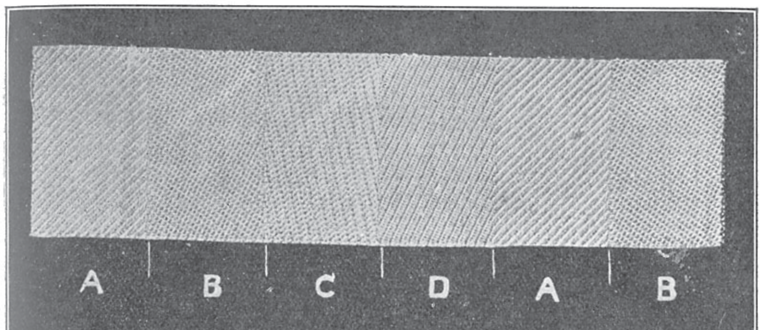


FIG. 28.

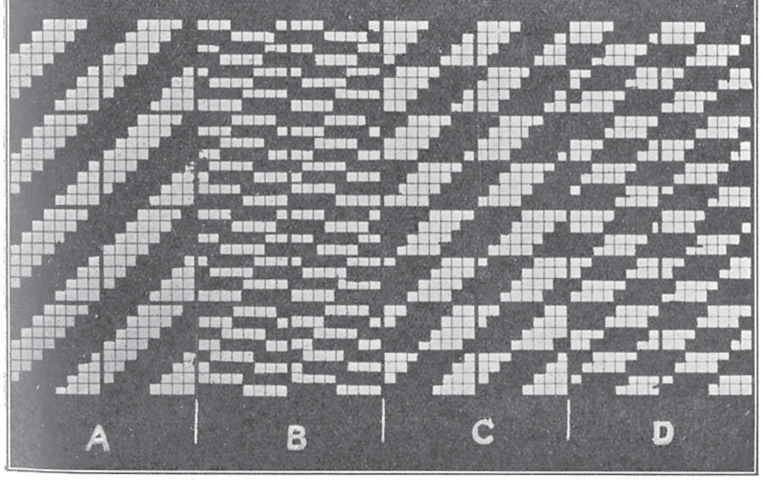


FIG. 29.

FIG. 28.—Striped pattern composed of 4/4 twill derivatives.
FIG. 29.—Design for Figs. 27 and 28.

Fig. 26, C, the finer weft cords being adjacent to the more open or loose-woven warp cords, and also more perfectly formed. The zig-zag or irregularity seen down the edges of the cord stripes is caused by the stitching or binding points of the respective weaves.

The effect of binding the floats of warp or weft in sections C and D (Fig. 25), and how it influences the level character of the cords, is traceable in the corresponding sections of Fig. 26. An interruption in the yarn floats produced by the stitchings produces in this specimen a degree of unevenness of surface, but improved firmness of fabric structure.

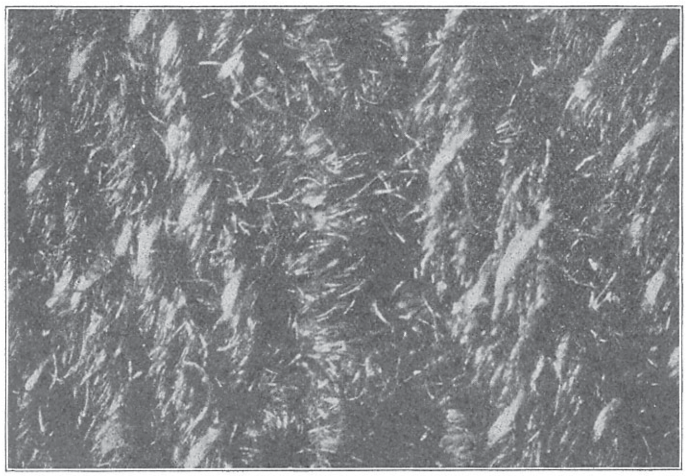


FIG. 30.—Stripe effect (worsted) composed of fine warp twill, weft cord, and bold warp twill. Photomicrograph of a section of the fabric in Fig. 38.

(11) SURFACE AND STRUCTURAL CHARACTERISTICS OF FABRICS DETERMINED BY WEAVE.

It is clear from these examples that the surface features of the cloth, and the textural qualities are determined by the scheme of warp and weft intersections, that is, by the weave plan. Further, several microscopic illustrations may be analysed. Fig. 27, sections A, B, C, and D are derivatives of the 4/4 twill (Design, Fig. 29). In one respect they are regular in construction, for there is no variation in the length of the interlacings in the weft with the warp, but the arrangement or grouping of the interlacings as seen from the plans (Fig. 29); and section B, Figs. 27 and 28, results in a variation in the length of the warp floats. The four textures A, B, C, and D (correspondingly lettered in the illustrations) are, however, quite uniformly planned. They show

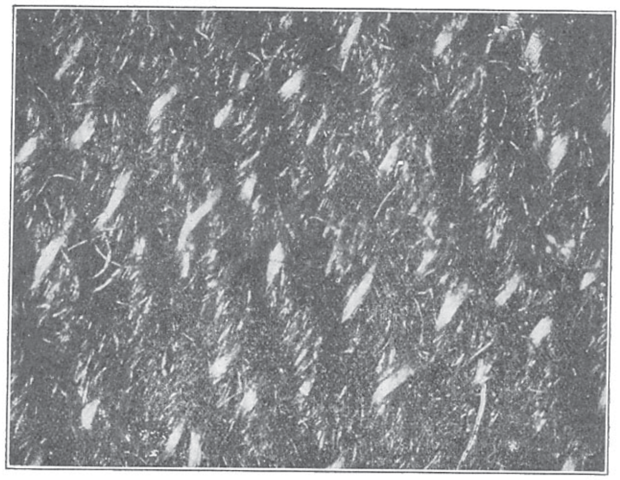


FIG. 30a.

FIG. 30b.

the influence of the scheme of grouping the interlacings in (1) making an evenly balanced woven texture, fast or firm in structure; (2) the acquirement of diversity of textural effects; (3) the production of strength.

Compactness and regularity are observed in each fabric, A, B, C, and D (Figs. 27 and 28) denoting the use of a correct weave base, but this regularity, though a common factor, does not impart the same degree of firmness of structure in each example. There is in section B a more frequent binding or interlacing of the warp and weft than in A, C, or D. Section D is, however, fastly woven, having more bindings or intersections than either A or C. The latter yield fabrics of diminished soundness of construction.

Comparing A and C, in this respect, brings out the value of progressive movement in twilled weaves in distributing the warp and weft intersections in the construction of the fabric. All the four specimens possess characteristic surface features, but pattern C is the most interesting, the scheme of interlacings forming a texture of diversified effects.

(12) Whip-cord and Fine-twilled Textures.

In the manufacture of standard woollen and worsted fabrics of the whip-cord or fine-twilled variety, the twilled characteristic is chiefly due to the warp yarns, and from microscopic investigation it may be shown what is the true relation of the "twine" in such yarns to the movement of the twill, and also to the structure of the weft yarn. Figs. 30, 30a, and 30b are sections of a stripe pattern in which two types of warp twill—fine and open (Figs. 30a and 30b) in the make—are combined with a line of weft cord (Fig. 30). The contrast between the bolder and the closer twill, or the effects produced by weaves of different structures, are illustrated, the warp and weft yarns in each section being the same. The law of "twine" or direction of the fibres in yarn spinning, as it controls or modifies twill development, is here exemplified. The twine in the warp twill in sections A and B (Fig. 30), and also the fold of the yarn, are at the correct angle with the furrows formed by the twills, so that the edges of the threads are clearly defined, and give a pronounced whip-cord effect with the edges of the twills smartly accentuated.

Taking the finer effect, traversing the fabric to the left, the twill forms an angle of approximately 70°, and the twine of the fibres, moving to the right, an angle of 60 to 65°. The folding or "doubling" traverse of the threads, as indicated by the white lines (silk), have an angle of some 40 or 45°. In the broader effects the angle of the twill is changed to 60°, but that of the twine of the fibres, and also of the fold in the yarns, remain the same. The effect of the single yarn used in the weft is noticeable in the clean definition of the edges of the series of warp twills, the

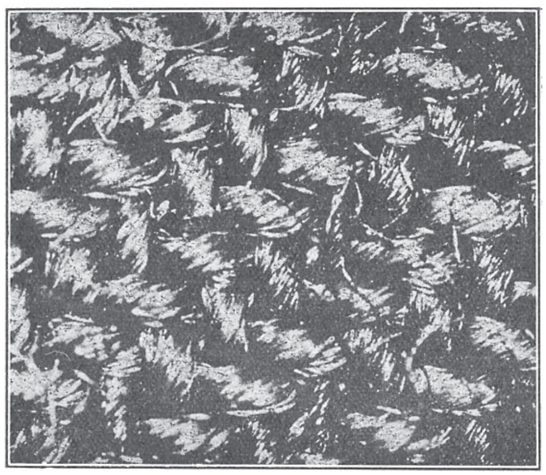


FIG. 31.—Crossbred Worsted, firm-spun yarns.

fibres of this yarn being embedded in the furrows between the ridges or twilled cords. That, however, the weft yarns may, if required, be useful in imparting twilled emphasis in which both warp and weft effects are equally pronounced, is illustrated in Fig. 31. Here the twill angle is 40°, that of the warp twine about 60°, and of the weft, as it lies in the texture, from 15 to 20°. The direction of the weft twine cuts the direction of the warp twine, a combination which accounts for the precision of both sets of twills. Moreover the weft twine, though corresponding in direction with the twill, is of a different angle. When the direction and angle of the twills and twine of the fibres of the yarns coincide, clearness of effect is wanting. Further, when the twine of the warp and weft yarns correspond in relation to each other in the texture, the filaments in the two sets of threads mingle with each other, and develop an indefinite weave effect.

(13) Microscopic Studies and Clearness of "Weave" Definition.

These microscopic studies teach that twilled and other schemes of intersection are affected in clearness of definition by the following technical data:—

First, in warp-face twills and other weaves.

(1) The direction and angle of the twine of the fibres and fold in the *warp* yarn in relation to the direction and angle of the twill.

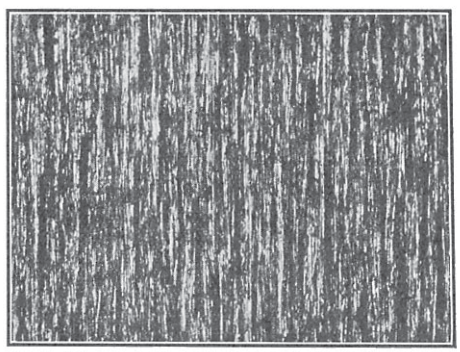


Fig. 32.—Photomicrograph of silk Satin.

(2) The structure of the *weft* yarn—single or folded, "soft" or "firm" spun.

Second, in ordinary twill and other weaves in which the warp and weft appear equally on the face of the texture.

(1) The direction and angle of the twine of the fibres and fold in the *warp* and *weft* yarns in relation to the direction and angle of the twill, or distinctive features of the weave.

(2) The direction and angular movement of the twine of the fibres in the *warp* yarn in relation to the direction and angular movement of the twine of the fibres in the *weft* yarns.

(3) The relative angular movements of the twine of the fibres in the weft to the angular movements of the twill in the weave.

(14) Analysis of the Causes of Defects in Fabrics as Revealed by the Microscope.

The nature and causes of defects in manufacturing are subject to microscopic investigation for discovering (*a*) the qualities

Fig. 33.—Sateen lining reverse side. A = Fast woven. B = Looser woven.

of the materials used in yarn construction as to fineness of fibre; (*b*) irregularities in thread structure; and (*c*) irregularities in weaving. Variations in finishing and other routine may be determined, in some instances, by microscopic analysis. The limitation to this process of deduction is the minute area in which the defects are examinable. Several tests should be made for comparison. These if carefully carried out are especially valuable, as shown, in determining the fibrous composition of the yarns in the woven texture, and also evenness or faultiness of thread structure. In the finest as in the medium and the low-grade fabrics examined, a degree of imperfection in yarn construction occurs in cotton, linen, woollen, and worsted fabrics. This irregularity is less pronounced in worsted than in woollens, and in twofold than in single yarns, proving (1) that the more searching the processes in yarn manufacture, the more level the type of thread resultant; and (2) that the twisting or folding of two or more threads into one, distributes the inequalities of each, and produces a compound yarn of more even formation than either of the single or simple threads employed.

Fabrics which appear to be composed of yarns correct and uniform in counts, when naturally examined, present irregularities under the microscope. This is quite noticeable in the linen texture (Fig. 5). Compare, for example, threads S and T, yarns of variable diameter or counts. There is a corresponding dissimilarity in threads S and T (Fig. 8) combined with the additional defect of lack of uniformity in diameter in each sort of yarn, caused by imperfect preparation of the fibres for spinning, or by irregularity in the spinning operation. The fine muslin (Fig. 7) is the most correct in thread structure of these specimens. The difference in the diameters of the yarns here is so minute as to be inappreciable in the woven fabric. Accuracy of construction is also observed in the several warp yarns in Fig. 19. Each considered separately is perfectly even, the faultiness is in the difference in thickness when the threads are compared with each other. Presumably spun to the same counts, they vary in diameter. Crossed, as in this specimen, with a loose fibrous weft yarn, this defect in spinning might not be discovered in the texture—the weft threads covering and concealing the cotton warp threads; but, obviously, if several threads similar to T and others similar to S were indiscriminately grouped together, and the warp and weft yarns were of the same size or counts, stripeness would develop in the fabric. In the Mohair illustration (Fig. 21), as in the examples in other classes of materials, there is both in the twofold warp and single weft unevenness in yarn counts. In the *warp* the two extremes of thickness are noticeable in threads S′ and T′; and in the *weft* in picks S″ and T″; the fuller fibrous density of the texture due to the yarns T″ as compared with that due to yarns S″, being distinctly marked. The fabric is more porous in the sections formed of the finer threads than in the sections formed of the thicker threads; in the first, the interstices between the warp and weft yarns are quite evident; but in the second, scarcely visible. This feature is magnified by the nature of the material used in the manufacture of the fabric, but it is one which characterizes all types of cloths of corresponding inequality, as this specimen, in the counts of the warp and weft yarns. As showing this, a fine worsted flannel (Fig. 14) may be analysed. It is

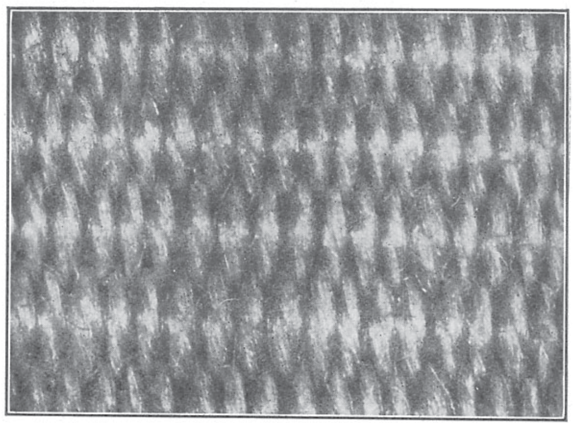


FIG. 34.—Photomicrograph of the Poplin texture.

made of twofold 70's warp and 56's weft yarns, and contains 76 threads and 70 picks per inch. As in Fig. 5, the thicker threads T T^1 form, with the weft interlacings, a close structure, but the smaller threads, S S^1, crossed with the same weft, yield a structure containing clear interstices. Increasing the diameter of the yarns, and employing a material of coarser and stronger fibre, accentuates defects of this nature.

Faults in the fabric, caused by defective yarn structure, are not readily determined by ordinary spinning tests which may verify accuracy in counts but not detect this kind of irregularity. They may result in imperfect development of the weave details. Such defects show the more distinctly when microscopically examined in irregular and fancy weaves. The "constant" interlacings of the warp and weft appear to be discontinued, but this is not the case. Microscopic dissection points to the weft yarn, in these faulty places in the fabric, being smaller in diameter than the normal, though the "counts" are uniform. This may indicate a variation in degree of twine as the cause of incorrectness of "weave" definition in the cloth.

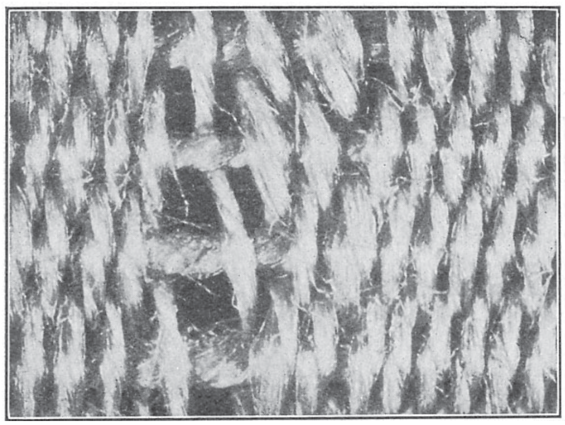


FIG. 35.—Photomicrograph of Poplin, defective structure.

(15) DEFECTS CAUSED BY INACCURACIES IN SLEYING AND HEALDING.

Defects arising from irregular "sleying" or "reeding," and inaccuracies in healding and weaving, are traceable under the microscope. An illustrative example is given in Fig. 10. The minute but irregular spaces (marked by the arrows) between the pairs of threads, are "reed" or "sley" marks, a species of defect which forms in the texture if the warp threads are not correctly grouped in the reed. In mat, cord, and other types of weaves, the yarns which interlace together—e.g. in sets of twos, threes, fours, etc.—should be as frequently divided by the splits in the sley as possible. The smaller the number of threads in each reed, providing the yarns are not chafed in weaving by the sley, the more correctly spaced they appear in the fabric. But it will be understood that, in the manufacture of many classes of cloths, a number of ends have to be entered into one split. However technically accurate sleying may be done in regard to the construction of the weave, and the nature of the yarns, "reediness" may be caused by bent dents, etc., in the sley. The finer the gauge of the reed, the more liable the smallest inequality is to cause streakiness in the fabric. This is observed in the silk-warp sateen specimen, containing over 400 threads per inch, and illustrated in Fig. 32. The streaky lines, which in this instance are only perceived under the microscope, are caused by the "rolling" of the threads in the reeds in weaving. "Streakiness" in such fine-set fabrics cannot be entirely obviated. In worsteds crowded in the warp two sleys may be used, one fixed behind the other, with the spaces and reeds alternating, to remove defects of this character. By using, for example, two sleys, 20 reeds per inch, and entering 6 threads in a reed of each sley, but each 6-thread group in the front sley being taken from 2 reeds in the back sley, an actual result is attained equivalent to sleying in 3's.

(16) Irregular Weaving Defects.

Fig. 33 is illustrative of defects caused by irregular weaving. Though the irregularity is sufficient to manifest some shadiness in the fabric, yet it is not so marked as to be clearly traceable by ordinary methods of analysis. Microscopic examination at once indicates that the operations of the loom in the insertion of the picks per inch have not been uniform. Inaccuracy of construction is also definable by this system of investigation. The rep or cord specimen (Fig. 34) is even in yarn counts and in weaving, but unsatisfactory in wear. Friction causes the warp threads to separate or slip apart, as seen in Fig. 35. The structure is defective in two particulars: (1) in the incorrect proportion of picks of weft to threads of warp; and (2) in the relative counts and qualities of the two sets of yarns. The warp threads are closely set, but the weft picks are loosely woven, or the bindings of the warp and weft yarns are too infrequent to secure firmness of structure. With a thicker and more fibrous weft, a greater degree of cohesion of the threads would have resulted from the scheme of interlacing practised. Ordinary principles of dissection would prove these defects in the manufacture of this fabric; microscopic examination reveals them without any unravelling of the texture.

CHAPTER II.

FABRIC QUALITY.

(17) Application and Meaning of the term "Quality"; (18) Influence of Fibrous Materials on Quality; (19) Yarn and Fabric Characteristics and Fineness of Fibre; (20) The Value of Yarn Counts; (21) Tensile Strength —A Yarn Derivative; (22) Elements in Yarn Structure controlling the Breaking Strain of the Fabric; (23) Causes of Uniformity of Strength in Woven Fabrics; (24) Modifying Effect of the Degree of Twine in the Yarn on the Texture; (25) Influence of "Folding" or "Doubling" on the Tensile Strength of Cloths; (26) Textural Qualities and Weave Structure; (27) Fabric Structure—Hardness, Roughness, Softness; (28) Bedford Cord Characteristics; (29) Formation of Honeycomb Textures; (30) Fabric Setting and Quality; (31) Finishing processes and Textural Features; (32) Felting—Durability and Compactness; (33) Raising—Softness, Smoothness; (34) Clearness of Surface—Brightness of Texture.

(17) Application and Meaning of the term Quality.

Quality in textile fabrics is determined by the nature and fineness of the materials, method and correctness of yarn construction, and adaptability and accuracy of manufacturing routine. It comprises softness, lustre, smoothness, fibrous density, tensile strength, and wearing property. Each of these characteristics may give the distinctive quality of the cloth. Softness and suppleness make the "quality" of Cashmere and Vicuna fabrics; strength, density, and firmness the "quality" of a heavily-milled cloth; clearness and evenness of surface, combined with flexibility of structure and wearing strength, the "quality" of "solid" Botany worsteds, and silky brightness and smoothness the "quality" of lustre dress materials.

(18) Influence of Fibrous Materials on Quality.

The nature and fineness of the fibres employed in manufacturing are the principal factors which fix the quality of a woven fabric. Manufacturing efficiency and routine may accentuate the inherent physical characteristics of the raw material; but in the case of wool, hair, and silk, it is not the object of the processes of fabric production to develop artificial textile properties. Cotton yarn, by mercerizing, is made to assume a degree of the brightness of silk, but mercerizing is not a manufacturing process, being distinct from the method of yarn construction, and the lustre it produces is purely an artificial or applied quality. In worsted and some classes of woollen textures, there is apparently a higher degree of lustre present than characterizes the raw materials used in their manufacture: this is in consequence of the cleansing, arranging, straightening and dressing the fibres undergo in making the yarn and in the finishing of the fabric. Manufacturing work is competent of giving additional effect and value to the natural physical features of the fibres, but it is not competent or designed to change these features or to supply new and supplementary properties.

(19) Yarn and Fabric Characteristics and Fineness of Fibre.

The influence of the qualities of fineness, elasticity, and softness of fibre on the type of yarn and fabric produced is a subject of technical analysis.

Fineness of fibre is responsible for the approximate diameter or counts of the yarn spun from a definite class of material. This is practically recognized, hence worsted yarns are made from combed tops of standard qualities, such as 40's, 60's, etc., implying that these combed materials may be spun, by ordinary drafting in the drawing operations, to yarns of 40's or 60's counts, that is yarns of 22,400 and 33,600 yards per lb. That there should be no corresponding standards admitted in woollen spinning does not depreciate their meaning and utility, for fineness of filament is also here answerable for the spinning limit; but it is found to be more convenient in practice to allow of a greater latitude in the use of materials, as to yarn counts, in the woollen than in the worsted industry.

Fineness of fibre in well-grown wools is also characteristic of elasticity and suppleness. Wools, however, vary as to the degree in which these qualities are combined. Some varieties of Welsh and Downs wools are sufficiently fine in the hair to be spun into yarn small in diameter, yet they are deficient in soundness as compared with Merino wools, and are chiefly suitable for fabrics of inferior elasticity and fibrous softness. A measure of flexibility and suppleness may be acquired in the manufacturing processes, as, for example, in a good grade of mungo cloth, which possesses, to some degree, both these qualities, derived, firstly, from their presence in the original mungo or shoddy fibres, and, secondly, from the scheme of operations practised in the manufacture of the fabric.

(20) Value of Yarn Counts.

Yarn counts do not prescribe the qualities of the cloth so far as softness and flexibility are concerned. A 60's yarn may be spun from a 50's combed top; but as compared with a true 60's yarn obtained from a 60's top, it would yield a texture slender and thin to the feel and unsatisfactory in the wear. The result is similar in woollen manufacturing if a quality of fabric is attempted which the material is not adapted for producing. This may be shown by a commercial practice which trade exigencies at periods demand, namely, Cheviot qualities in fine cloths. Now, to make a fabric of this description necessitates the employment of yarns of a higher counts than can be satisfactorily made of Cheviot and similar grades of wool. If a yarn from such wools exceeds some 24 yards per dram., the result is a "wiry" cloth of inferior wearing property. The technical cause is apparent. The wools available are not of an average fineness to spin to this counts, and when this spinning limit is attained a "lean" thread is formed or a yarn impoverished in density of filament. By blending Cheviot with wools of a finer growth the spinning results are raised, giving yarns of an appropriate counts for the manufacture of the required cloths as to fineness, but it reduces the value and influence of the Cheviot characteristics.

Taking an illustration in the reverse of this practice—blankets and rugs are made of thick counts of yarn, but differ in suppleness and softness according to the variety of wool utilized. There is here no question of spinning qualification, either coarse or fine wool being equally applicable for the thickness of yarn needed, so that the natural quality of the wool, with a minimum amount of change due to manufacturing causes, determines the quality of the blanket. Strong-haired wools, with an open, wiry staple, are restricted to the production of cloths thick in structure and rough in character; but fine-haired wools, dense, wavy, and elastic in staple, may be manufactured into thick or fine fabrics of a soft, flexible quality. The range of fabric qualities, between the extreme fine and the extreme coarse, is not limited by the varieties of wool grown,—from the finest Merino lambs, from which a yarn may be spun to approximately 70,000 yards per lb., to the coarse Shetland or East India not spinnable to more than 400 to 500 yards per lb.—for the blending of two or more varieties, in proportions adapted to commercial requirements, largely extends the formation of grades in qualities in the manufactured cloth.

The departure, in actual practice, from an approved standard of fabric, is often to be traced to a lowering of the average quality of the material in the process of blending, or to a variation in the natural properties of the wool or fibre of which the stock is principally composed.

(21) Tensile Strength—A Yarn Derivative.

Tensile strength in the fabric has its source in the soundness of the staple of the raw material, and this is affected by uniformity in diameter, length, elasticity, and breaking strain of individual fibres. It is a quality of the cloth also dependent upon the system of yarn construction, fabric setting, and structure, and finishing routine. Primarily, it will be understood, from the considerations stated, that the highest measure of tensile strength obtainable from a certain variety of wool, will be found in cloths produced from yarn which have been spun to a counts within the limit determined by the average diameter of the fibres.

The problem needs further explanation. To spin to the extreme limit of the quality of the wool involves the manufacture of a yarn irregular in fibrous composition or homogeneousness. If, as in woollen spinning, more particularly, this is done, the yarn constructed varies in soundness and trueness. Now, in the ordinary fabric single in structure, each thread is assigned a similar place and function. Individual threads have identical work in bearing strain in weaving, and in resisting and sustaining friction in the wear of the cloth. It is not a matter of certain yarns, or groups of yarns, having a different utility from other yarns in the fabric. It follows that, if they vary in fibrous compactness and consistency, the texture will be unsound.

(22) Elements in Yarn Structure Controlling the Breaking Strain of the Fabric.

The important element in yarn making, as it influences the breaking strain of the fabric, is accuracy of construction, and this, in all systems of manufacture, comprises the following technicalities: (1) A sufficient amount of uniform separation of the fibres in the raw material employed so that a sheet of filaments ("carding" in "woollen," and "top" in "worsted") of uniform fibrous composition is produced; (2) the dividing of this prepared material into threads ("condensed sliver" in "woollen" and "roving" in "worsted") of the same weight and diversity of fibres in any transverse or lineal section measured; and (3) the imparting of a corresponding degree of twist or twine to the fibres, from end to end of the yarn, in the spinning operation. The divergence from this principle of work produces yarns irregular in strength and elasticity, that is, yarns defective in manufacturing properties.[1]

(23) Causes of Uniformity of Strength in Woven Fabrics.

Equality or uniformity of tensile strength in a woven fabric is derived from evenness of yarn structure. On this ground, worsted fabrics have a higher breaking strain than woollen fabrics made of the same counts and qualities of yarns, and identical in setting or weaving data. A woollen yarn is not so

[1] See the Chapter on "Yarn Structure" in "Woollen and Worsted" by the same author.

exact and equalized in diameter and compactness of filaments as a worsted yarn manufactured from a similar class of wool. The process of fibrous selection and elimination in combing is a

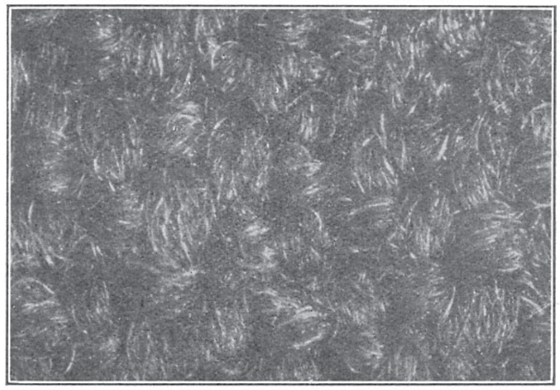


Fig. 36.

contributory, but not the main cause of this difference. The repeated drawing operations in worsted yarn spinning—attenuation and union of slivers of like weights and filament composition—is, of all systems of preparatory treatment in yarn making, the best calculated to give accuracy and uniformity of adjustment and combination of fibres, or to result in a thread of the greatest regularity and balance of structure. Carding and condensing may as far as practicable be correctly performed in woollen-thread preparation, but the method of drawing out and spinning of the slivers at one compound operation—immediately following condensing, the reduction of the sheet of carded fibres into a number of soft, fluffy threads—is not adapted to produce a type of thread of the same regularity of structure as that obtained from the

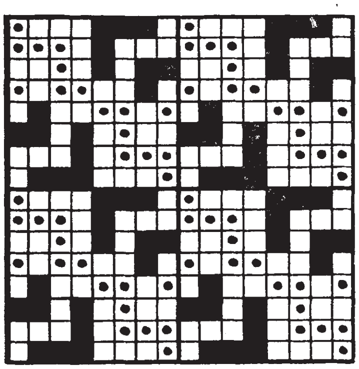


Fig. 36a.

thousands of compound "draftings" and "doublings," necessary to make a yarn on the worsted principle. The more systematically and completely the carding is done on the woollen system, the better the distribution of all classes of fibres combined throughout the length of yarn, and, therefore, the more even the thread construction; but this operation does not supply the service of the "levelling" work in worsted-yarn making, which renders *worsted* superior to *woollen* yarn for giving cloths of higher tensility of construction.

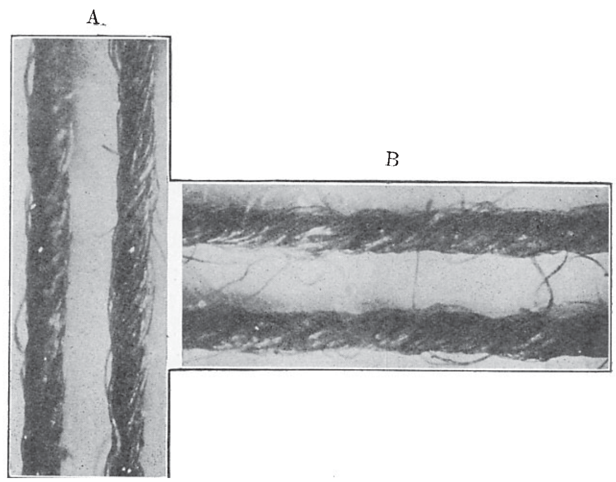


FIG. 37.—Crossbred yarns (hard spun).

(24) MODIFYING EFFECT OF THE DEGREE OF TWINE IN THE YARN ON THE TEXTURE.

The degree of twine in the yarn—that is, the number of turns per inch—is sufficient to modify the elasticity and wearing characteristics of the fabric. Firmness and clearness of cloth structure are changed by the amount of twine in the yarns utilized in its manufacture. A medium-spun yarn has, normally, a higher breaking strain than a soft-spun yarn, and a more uniform breaking strain than a hard-spun yarn, i.e. a thread excessive in degree of twine. The more frequent the twining of the fibres round each other in the final operation of yarn making, the more compact the thread structure, or closer and faster the affinity of the filaments of which it is composed. Should, however, the degree of twine exceed the maximum to produce an even arrangement and grouping of the fibres in the transverse

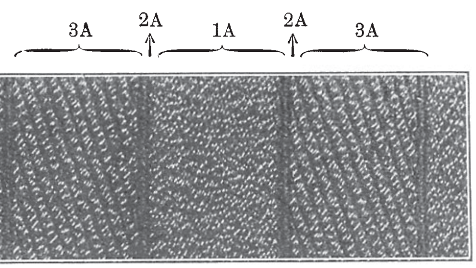


Fig. 38.—Fine rib trousering.

and lineal sections of the yarn, the result is a yarn variable in elasticity and strength. Tensile tests of the fabric in the weaving of which such yarn has been used, indicate dissimilar standards. Soft-spun yarns impart suppleness, but not tenacity of

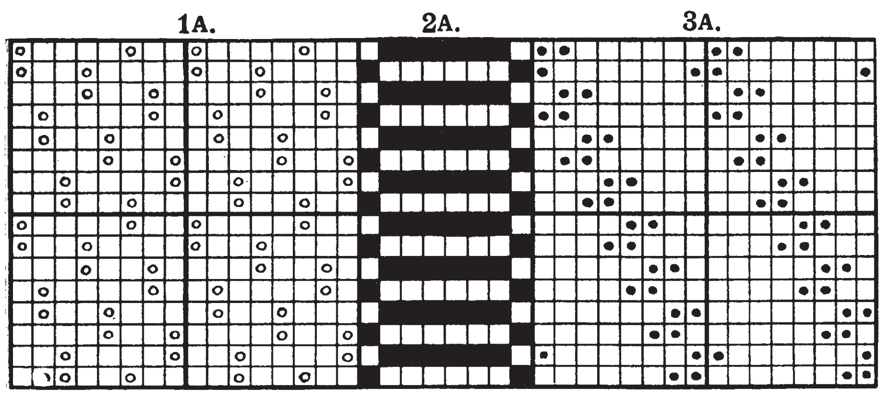


Fig. 39.

texture, the properties developed in finishing routine not being taken into account. Medium-spun yarns, or yarns in which the ratio of twine is in agreement with the average thickness of the fibres and the diameter of thread formed, are of a suitable construction for producing cloths of the greatest uniformity of quality. Extremes in degrees of twine in yarn spinning limit the uses of the yarns. Firm, hard threads are chiefly employed in the manufacture of cord, rep, gauze, and leno fabrics, and are also suitable for lace and some varieties of knitted materials. Loose or soft spinning yields a yarn of such slender tensility as to be only suitable for weft in the weaving operation, and which is specially adapted for the making of fabrics of high milling and raising qualities.

(25) Influence of "Folding" or "Doubling" on the Tensile Strength of Cloths.

Folding or doubling also develops yarns of distinctive properties. A multi-ply yarn—a thread of two or more fold—has a higher breaking strain than a single yarn of corresponding counts or diameter, so that such yarns are employed, in manufacturing, rather for supplying strength than flexibility of fabric. They have also another function; in correct setting in the loom, they secure a definition and clearness of fabric structure not possible in single-yarn textures. These points are illustrated in Figs. 31 and 36.

The influence of the hard-spun yarn (Fig. 37) is noticeable in the first example by the singleness of detail and the distinctness of the interlacing of warp and weft. Fig. 36 (weave 36a) is also a worsted fabric—twofold 28's counts—but how fibrous and, comparatively, mingled and subdued in character the intersections of the yarns! A difference in degree of twine in the respective threads is the principal cause of the difference in the qualities of the two fabrics, the weaves applied not affecting the features defined. The amount of twine in the yarns in Fig. 36 is normal, hence the qualities of fibrous softness combined with, in worsted yarns, a fair definition of weave structure. In Fig. 31 the amount of twine in the yarns (Fig. 37) is abnormal, hence the hard clearness of the individual threads, and the pronounced precision of the weave details.

Another typical example may be considered, a fine warp twill or whip-cord pattern (Fig. 38). The utility of the folded-warp yarn is here seen in the clearness of the twill, and the utility of the soft-spun weft yarn in the suppleness of the texture. The desiderata of some types of fabrics are firmness and crispness of handle as in Fig. 31, in which case both the twofold warp and single-weft yarn are hard spun; in others, the standard scheme of manufacture, suppleness of texture must be allied with definiteness of weave effect and soundness of wearing structure as instanced in Fig. 36; and in a third principal variety, the weave characteristic is a warp development as in whip-cord cloths (Fig. 38, sections 1A and 3A), the loosely-spun weft yarns giving softness of fabric and fibrous quality. The methods of yarn manufacture and construction adapted to the production of these characteristics are elucidated by the analyses made.

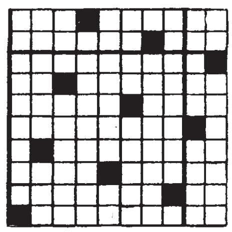


Fig. 40.

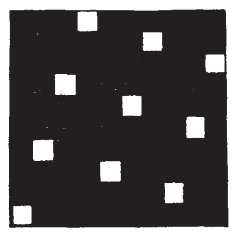


Fig. 41.

Sections 1A, 2A, and 3A (Fig. 39) are the weave plans for sections the same in Fig. 38.

(26) Textural Qualities and Weave Structures.

Weave structure modifies the tensile strength of the fabric, softness of texture, and wearing efficiency. The weave element in a number of standard cloths is simple, and for this reason might be regarded of secondary importance. Its utility and value in the senses named is, however, of direct consequence in manufacturing. Obviously, the more regular the formation of the weave or the method of warp and weft interlacing, the more level and correctly balanced the structure of the fabric. Provided accuracy of yarn manufacture, loom setting, and weaving, the qualities of the resultant cloth are determined by the weave, which, in sateens, will produce a smooth woven surface; in regular twills, a level surface with warp and weft yarns equally distinct, and in irregular mats and "honeycombs" and corresponding "makes," a rough surface; each description of fabric, in like materials and setting, differing in breaking strain and wearing characteristics.

The effect of weave structure on tensile strength may be primarily considered. Maximum breaking strain is a result of maximum warp and weft interlacing; for all technicalities of manufacture being the same, the breaking strain of woven fabrics is proportionate to the number of warp and weft intersections. This affords a fixed base of calculation. Identical fabric structures as to grouping and diversity of interlacing, are of like tensile strength and flexibility. Thus the four woven specimens, A, B, C, and D (Figs. 27 and 28; weaves A, B, C, and D, Fig. 29) have, as stated in Chapter I, the same intersections when transversely examined and would, if these were identically planned, indicate corresponding breaking strain; but actually B is slightly higher than D, and D than C, while C and A practically show no difference. The scheme of intertexture, as to binding power of warp and weft (compare the photomicro illustrations of the weaves, A, B, C, and D, Fig. 27), is the origin of the variation in strength in favour of B; but this cause of variation is not such a constant and calculable factor of fabric tensility as the number or frequency of intersections. This will be better understood by analysing longitudinal sections of 32 picks (see the repeats of weaves A, B, C, and D, Fig. 29) in each of these textures. Assuming 100 to represent the breaking strain, then that of each of these fabrics would be based on the ratio of intersections compared with this standard. Thirty-two intersections would on 32 picks be the maximum, so that 8 in A, 28 in B, 14 in C, and 20 in D, would give breaking strains of 25, 87·5, 43·75 and 62·57. For the effective demonstration of this principle of fabric structure, as it modifies tensile property, a setting has been practised in which the same number of picks per inch are feasible in a like counts of warp yarns and reed, and yet in each plan, as seen in Fig. 28, a regular and technically perfect fabric is weavable. Obviously, if the picks per inch were changed, that of the ratio of intersections would be affected. To

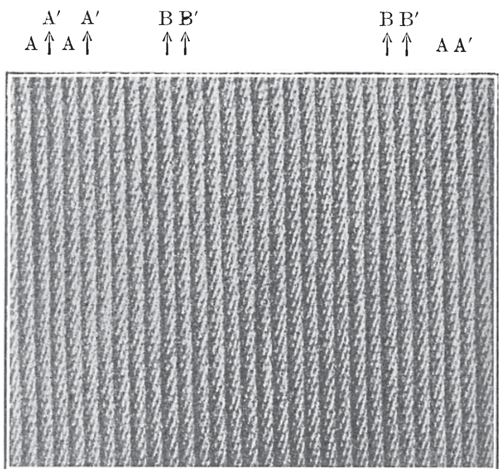


Fig. 42.—Bedford cord.

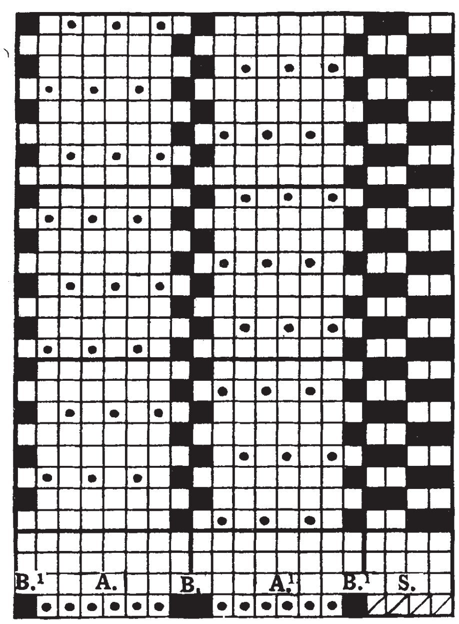


Fig. 43.—Bedford cord Plan. S = Selvedge threads.

take an example, if the number of picks per inch in B were 48 and in C 96, the two weaves would be in agreement as to frequency of intersections, a condition which would render the dissimilarity in weave structure inefficient in varying the tensility of the fabric.

(27) FABRIC STRUCTURE—HARDNESS, ROUGHNESS, SOFTNESS.

That the scheme of intertexture may give prominence to certain groups of threads and picks in the fabric is suggestive of the influence it may exercise on the hardness, roughness, and firmness of the cloth. All ordinary twills and mats, and regular weaves in which the warp and weft have corresponding and alternate interlacings, yield woven fabrics of a level surface. When deviations from this principle are made (1) by varying the proportion of warp yarns to weft yarns on the face or reverse side of the cloth; (2) by the system of grouping the warp and weft intersections; and (3) by the combination of two or several schemes of interlacing in one "weave" principle; diversity of fabric conditions as to suppleness and smoothness, or firmness and hardness, are obtained. Consider, for instance, the first principle, that of either a maximum warp or maximum weft surface as in doeskin and sateen-woven fabrics. This type of weave produces a smooth, soft texture for two reasons: (*a*) the weft interlacings give a minimum interruption of the parallel arrangement of the warp yarns (Fig. 40) in a warp-face, and of the weft yarns, (Fig. 41), in a weft-face weave; and (*b*) the interlacings are not consecutive as in an ordinary twill, so that little definite or distinguishable weave effect is formed. As to the first of these two characteristics it is also present, but in a lesser degree, in warp- or weft-surface fabrics of the cord or "corkscrew" twill type. The absence of effects, due to the crossing of the warp and weft with each other, in which both are distinct and productive of specific woven features, allows of one of these sets of yarns to form the surface of the fabric, yielding as smooth and level a texture as it is feasible to construct by laying the threads of warp or weft in a line with each other, and by binding them together in mathematical but not consecutive sequence.

4

The second characteristic is chiefly of relative importance. The order of intersections in a sateen weave, if changed to a twill, mat, or other simple but progressive weave order, would detract from the quality of textural smoothness. It is this possible variation, in the method of grouping the warp and weft interlacings, which accounts for the differences in fabric, as to clearness and smartness of surface, and as to qualities of roughness and smoothness. Sections A to D in Fig. 27 are illustrative of this principle. As already indicated, transversely, the interlacings in each are 4-and-4, yet in grouping the picks four types of fabric are formed. In section A a regular and even surface is developed; in B one varied and more knitted in character; in D a texture of intermingled broken composition; and in C a texture of similar quality to A but of a distinct weave pattern. These magnified specimens emphasize the differences in surface structures and the nature of the qualities they possess. Only one weave element—4/4 twill—has been utilized, yet the rearrangement of the picks has produced textural results variable as to handle, flexibility, and surface evenness. Providing two or more elements are combined as in Figs. 30, 30a, and 30b the scope for diversity of firmness or suppleness of fabric is increased. Again, it is purely the weave factor which is under analysis, the qualities of cloth affected by yarns and setting being constant, Fig. 30 (Fabric, Fig. 38) is a compound of three weave elements forming a stripe pattern in the same cloth. The smoothest part of the fabric is due to the weft cord (Section 2A, Fig. 39), the finest to the small twill, Section 1A, and the ribbed or furrowed part, to twill 3A. It is an example in which degrees of hardness, smoothness, and durability of texture are determined by weave formation.

(28) Bedford Cord Characteristics.

The Bedford cord (Fig. 42) receives its furrowed surface and striped character from the type of weave (Fig. 43) necessary in its construction. It is a fast-woven texture in which prominence is given to the threads forming lines A and A′ as a result, first, of picks 1 and 4 (Fig. 43) interlacing plain in A′ and passing under

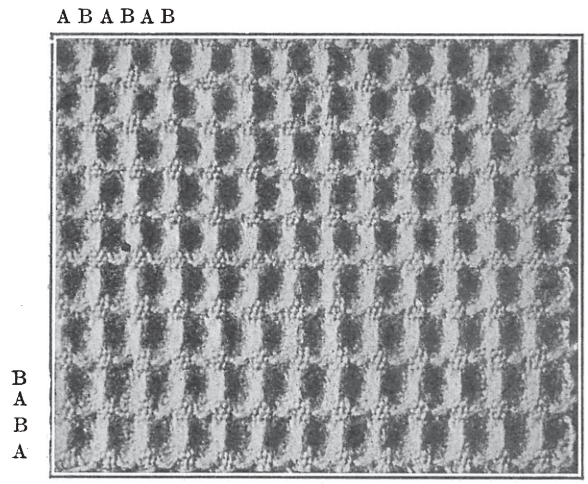


FIG. 44.—Honeycomb texture.

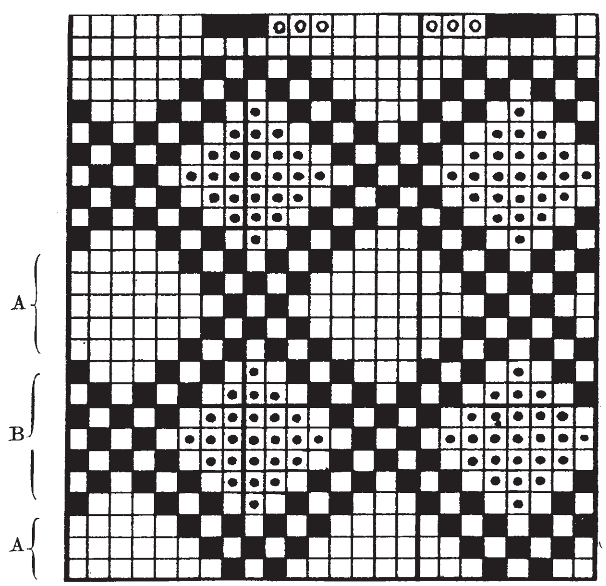


FIG. 45.—Honeycomb weave.

the threads in A, and picks 3 and 6 interlacing plain in stripe A and passing under the threads in A′; and, second, to threads B, B′, weaving plain with all the picks in the plan, and picks 2 and 5 passing under the threads in both sections A and A′. The details of manufacture, and technicalities they comprise, are treated of in Chapter VII. The chief features for attention here are the prominent and indented lines developed in the cloth, and its firm, compact surface, caused by the two contrasting schemes of intertexture obtaining in sections A, A′ and B, B′ of the fabric, and also indicated in the design, Fig. 43.

(29) Formation of Honeycomb Textures.

The third example is of the honeycomb type and consists of loose and fast-woven structures as seen in A and B (Figs. 44 and 45). Such weave contrasts give roughness of surface but flexibility of texture. They are used for specific styles of pattern, and for a variety of vesting fabrics in which certain threads and picks are rendered so prominent as to protrude on the surface of the cloth producing yarn ridges.

(30) Fabric Setting and Quality.

The relative proportion of warp to weft threads, and their number in a prescribed counts and make of cloth, are also effective factors in the production of distinctive textile qualities. Flexibility and wearing strength are modified by these elements classed as "setting". The law of diameters and intersections —fixing a possible ratio of threads and picks in certain counts of yarns and weaves—is secondary to the principles of setting in cloth manufacture, which give the qualities of fabric required. These are based upon experiment, investigation, and experience, in manufacturing. Materials, yarn characteristics, and weave structures, and their influence on the nature of the finished cloth, have to be taken into account. Setting is a practical branch of the art of designing and manufacturing not conformable, in various classes of woollen, worsted, and union cloths, to mathematical formulas, but determinable by experimental knowledge of weaving and fabric structure. Yarns made of fine wools are on the average suitable for firmer setting than yarns made of coarse-fibred materials, worsted threads than woollen threads, hard-twisted and twofold yarns than soft-spun and single yarns. But to these general features must be added the relative properties of the warp and weft threads, their specific functions in the cloth in regard to development of weave or pattern details, clearness of surface, density, compactness, and durability of texure. Some of these elements are exemplified in the setting of the whip-cord pattern (Fig. 38, section 1A). Strength and soundness of fabric are combined with smartness of twill details. The technical practice is to set "closely" in the warp and to weft comparatively "loosely". This is based on the leading textural characteristics developed; first, definiteness of twill or weave, with satisfactory tensile strength of fabric in a lineal section, due to using well-twisted warp yarns; and, second, softness and flexibility of handle produced by the weft yarn, which is single in structure and not too firmly spun. This explains the manufacturing causes, in fabrics of this order, for more compact warp than weft setting. Such setting is adapted to the nature and qualities of the yarns, and their functions in producing precision of weave character, and tensile soundness, with satisfactory fibrous density of texture.

As a general rule "close" setting yields comparative hardness of fabric, and is practised in the manufacture of cloths with a clear surface; and "loose" or "open" setting yields suppleness and flexibility of fabric, and is practised in the manufacture of cloths with a smooth or fibrous surface.

(31) FINISHING PROCESSES AND TEXTURAL FEATURES.

Several varieties of fabrics undergo treatment in finishing which modifies their characteristics. Flannels, serges, and ordinary Cheviots are the least affected. These very largely retain the textural features and qualities which distinguish them on leaving the loom. But other varieties of woollens, unions, and also milled worsteds, are changed in density, durability, and quality of handle by the scheme of finishing practised.

The three principal sources of alteration in the character of the fabric, after cleansing, are shrinkage or felting, developing compactness of structure; raising, producing fibrousness of surface; and cutting and pressing, imparting clearness and brightness of texture.

(32) Felting—Durability and Compactness.

Wearing durability in a woven fabric may be produced or augmented by felting or milling. Examined in the "balk" or woven condition, the cloth may be loose, thready, and flexible; but after shrinkage it is firm and compact, the fibres and yarns being securely felted together. In the process of change the fabric deteriorates in softness and elasticity, but improves in firmness, strength, and durableness. Felting work varies, in its results on the cloth, with the degree of efficiency with which it is continued. Soundness of fabric, and augmented wearing property, are acquired in the felting applied to the ordinary classes of woollens and milled worsteds—the fibrous density and fullness of the textures also being increased—but in friezes, Shetlands, meltons, pilots, and other thick overcoating cloths, felting is practised to such a degree that the fabrics, while developing a high-breaking strain, become somewhat hard if not lacking in flexibility of handle.

(33) Raising—Softness, Smoothness.

Fineness of material, and suitable methods of yarn construction, have been shown to be essential in the manufacture of cloths characterized by softness and smoothness. These qualities are not developable in the fabric apart from their existence in the raw material. Raising, which forms a "cover" of fibres on the surface of the cloth, gives suppleness and warmth of feel; and, if the fibres are combed and straightened in the process, a parallel distribution being effected (Fig. 50), additional brightness is also obtained. This is the result in "face" costume cloths and cloths of the doeskin class, but not in rough serges, blankets, and rugs, in which the function of raising is to impart increased suppleness of handle and warmth-yielding quality.

(34) Clearness of Surface—Brightness of Texture.

The former of these characteristics is acquired by clearing the extraneous fibre from the surface of the fabric. This is chiefly done in the operation of cutting or cropping. In fine Saxony cloths, Bedford cords, warp twills, and certain qualities of worsteds, smartness and distinctiveness of textural details, whether due to weave or colour, are attained by raising or brushing the extraneous filament on the yarns on to the face of the fabric, and removing it in the cutting operation. Other technicalities of manufacture also produce clearness of surface as explained in the references to yarns and setting, but it is in the work of cutting that this characteristic is principally developed. Enhanced brightness and improved evenness of texture are obtained by applying steam at a high pressure, that is, by "blowing" or "boiling" the pieces when tightly wrapped on a perforated roller for the former, and on a smooth wooden roller for the latter process. This brightness of texture is further emphasized and rendered more permanent in the final operation of pressing.

CHAPTER III.

SYNOPSIS OF CLOTHS.

(35) Identical Principles of Intertexture applicable to all classes of Woven Fabrics ; (36) Cloth Varieties ; (37) Coptic, Cheviot, and Saxony Fabrics ; (38) Cheviots and Saxonies Analytically Considered ; (39) Examples in Cheviot and Saxony Standards in Different Grades of Manufacture ; (40) Fibrous Contrasts : Cheviot and Saxony Cloths. CHEVIOT AND SAXONY CONTRASTS ; (41) Yarn Composition ; (42) Fabric Structure ; (43) Wearing Efficiency ; (44) Suppleness, Elasticity, and Tensile Strength ; (45) Weave Distinctiveness and Colour Tone ; (46) Quality and Tone of Cheviot Colouring ; (47) Specimen in Overcoatings with Woven Lining, Cheviot Face, and Saxony Back ; (48) Variety of Finish applicable to Cheviot and Saxony Fabrics ; (49) Botany and Crossbred Fabric Contrasts ; (50) Weave Definition and Colour Tone in the two Standard Worsteds ; (51) Examples and Contrasts in Manufacturing Data and Results—Crossbred and Botany Textures ; (52) Schemes of Finishing applied to Botany and Crossbred Fabrics.

(35) IDENTICAL PRINCIPLES OF MANUFACTURE APPLICABLE TO ALL CLASSES OF WOVEN FABRICS.

IT must be evident that all woven fabrics are acquired by the same principles of warp and weft interlacing. Pile textures would on a primary consideration appear to be an exception. That these should possess a pile of cut filaments, or of looped threads, would suggest some other method of production. But this is not so in the main features of intertexture. Taking the cut pile for example, as it obtains in the common velvet, the Axminster carpet, and the decorative plush, it results, in the foundation and in the pile, from the intersection or crossing of warp and weft yarns. The fact that one series of yarns—either warp or weft—should be cut or severed, causing the ends of the filaments to project on the surface of the texture, does not impose a distinct system of weaving from that common to the ordinary classes of fabrics. It does, however, necessitate the employment of special sets of yarns regularly bound into the foundation cloth, or systematically woven with the picks or shots of weft. The loop pile is a similar woven composition with the pile yarn left looped as in terry velvet (*velours frisé*) and the Brussels carpet. The principle was known and practised in ancient Egypt. In weaving in the vertical loom or frame, the crossing or weft threads, in the operation of interlacing with the warp yarns, were drawn, at suitable intervals in the width of the fabric, into loops of various lengths. These drawn threads were severed or left in the looped form. The hand-tufted carpet of Eastern origin, and also woven in the vertical loom, does not come within the same category of pile-fabric construction, the pile tufts being separate and distinct in method of insertion, or application, to the texture, from a pile of fibres due to cutting threads of warp or weft interlaced together by the ordinary mechanical changes of the loom. The tufts, or small bunches of yarn, vary in length and density of filament with the quality and style of the carpet. They are tied or knotted to the threads of warp extending vertically, being relatively secured to the foundation of the carpet by ground picks of weft yarn fastly interlacing with the warp yarns, and inserted into the warp following each line or series of pile tufts.

Considering the many varieties of textiles produced for wearing and decorative use, it is significant that the fundamental principles of intertexture are in all instances invariably followed. It suggests the latitudinal nature and diverse functions of the process of weaving. This is as uncircumscribed as the number of threads and picks in the fabric afford for diversity of crossing. Pictorial or decorative subjects are producible in the loom with the same simple elements of intertexture as the commonest twilled weave. The difference is not in the manner of fabric construction, but in the weave units utilized. The range of textural possibilities is also extended by the use of several series of warp and weft yarns, which may interchange in position, or be located in the fabric, as required in the development of complex design details.

(36) Cloth Varieties.

The cloths to be dealt with in this treatise are chiefly varied in character by manufacturing routine, and not by design and colour elements. They comprise four main categories divisible into the groups of textures indicated in the following Table :—

TABLE I

Varieties of Cloths.

Class.	*Group.*
A. Woollen Fabrics.	(1) *Cheviots*—Simple and compound in structure — including flannels, costumes, suitings, serges, rugs, blankets, and heavy overcoatings. (2) *Saxony Cloths*—Also simple and compound in structure and including in addition to the textures in Group (1) the following varieties (*a*) Simple-weave fabrics more or less heavily milled with a clear surface; (*b*)Face-finished fabrics or cloths covered with fibre or pile developed in the operation of raising; and (*c*) Fabrics with a rough fibrous pile of the melton type or with a curly fibrous surface, such as napped cloths for cloakings and overcoatings.
B. Worsted Fabrics.	(1) *Crossbreds* — Simple and compound in structure — including serges in great variety of make and applicable to flannels, dress, and costume materials, suitings, and medium and heavy overcoatings. Different degrees of milling are practised in acquiring the qualities of cloth necessary. (2) *Botany Fabrics*—In many types of weave, design construction, and builds of cloth — single, double, treble and irregular in structure. The group includes (*a*) milled and (*b*) unmilled varieties in medium and the finest qualities of wools, and in light and other textures—costumes, blouse materials, tennis flannels, fine trouserings, vestings, suitings, and overcoatings.

C.

Woollen Unions.

(Composed of cotton warp and woollen weft, or of cotton warp and a weft yarn made of a wool substitute, e.g. mungo, shoddy, extract, and flocks.)

(1) *Union Fabrics* of a Cheviot class in which the weft yarn is made of Crossbred wool or of fibre obtained from the coarser classes of blankets, rugs, also Cheviots, serges, etc.

(2) *Union Fabrics* of a Saxony class in which the weft yarn is made of Merino or fine-fibred wools, or of material obtained from the better qualities of blankets, rugs, and cloths of the Saxony and Botany varieties. N.B. "Woollen unions" are (*a*) single, and (*b*) compound in structure in the weft. In both types the weave is constructed to cover the cotton warp yarns with the weft yarns. The cloths comprise thin materials for costumes, flannels, and inferior qualities of suitings, overcoatings, rugs, and blankets.

D.

Worsted Unions.

(Composed of worsted warp and woollen weft.)

(1) *Worsted Unions* in which a Saxony quality of woollen weft is used, and comprising costumes, suiting, and coating cloths — mixtures and piece-dyes.

(2) *Worsted Unions* in which a Cheviot or Crossbred quality of woollen weft is used, and which only comprise a limited range of fabrics.

It will be seen that woollen, worsted, and union cloths are each divisible into two main groups suggestive of the qualities of the materials employed in their manufacture.

(37) Coptic, Cheviot, and Saxony Fabrics.

The earliest variety of woollen cloth would be made of coarse-grown or strong-haired wool. The Coptic specimens, in Figs. 4 and 4a, form typical examples of the nature of the fibres applied in the production of these early styles of woollen textures. They are not unlike certain qualities of Cheviot fabrics, of modern manufacture, in fibrous composition and crispness and flexibility of handle. Wools of a similar diameter of fibre, and strength and openness of lock, to those employed in the making of "homespuns," and the coarser types of Cheviots, are more readily worked into a weavable yarn than those of the Merino variety, which are essential in

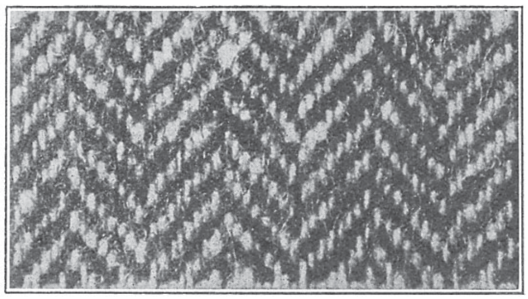


FIG. 46.—Donegal tweed.

the preparation of yarn for all classes of Saxony cloths, and also for the finer groups of Cheviots. Their natural adaptability for manual treatment would cause them to be selected for carding and spinning, prior to the fine-haired wools. Practice, and advance in the arts of hand-carding, spinning, and weaving, led to the use of wools of a finer grade. With the era of machinery, the modern classification of woollen fabrics into Cheviots and Saxonies was brought about. The distinction between woollens and worsteds was recognized at an early period in this country and during the *régime* of manual practice in manufacturing. It was, in the first instance, purely originated by the two principal varieties of English wools, namely, "long" and "short" stapled. *Combing* was a necessary operation in preparing the former for thread construction, and *carding* was adopted for the treatment of the latter. These original distinctions have been largely eliminated by the employment of improved mechanical systems of worsted and woollen yarn manufacture.

(38) CHEVIOTS AND SAXONIES ANALYTICALLY CONSIDERED.

Cheviot and Saxony fabrics have already been defined and their technicalities microscopically compared. They may now be analytically considered in respect to the following features :—

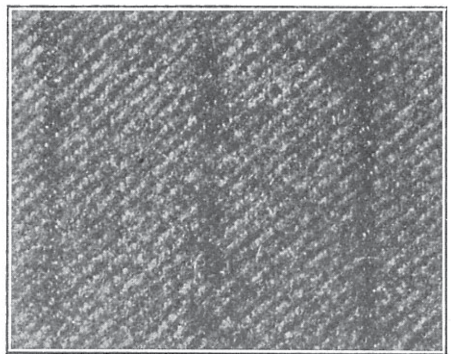


Fig. 47.—Tweed : Saxony warp and Cheviot weft.

(*a*) Quality and nature of the fibrous materials.
(*b*) Fibrous composition and characteristics of the yarns.
(*c*) Fabric structure.
(*d*) Suppleness, elasticity, and tensile strength.
(*e*) Wearing efficiency.
(*f*) Weave distinctiveness and colour tone.
(*g*) Variety of finish applicable.

For this purpose standard grades of fabrics will be taken, e.g. suitings, trouserings, twilled travelling rugs, and union blankets. The general routine of manufacture is similar, and need not therefore at this stage enter into consideration. On an average the wools are 40 to 60 per cent finer in the fibre in the Saxony than in the Cheviot cloths. The counts of yarns, plan of weave, and methods of finishing practised in the production of these textures are given in Table II.

(39) Examples in Cheviot and Saxony Standards in Different Grades of Manufacture.

TABLE II.

Data for the Manufacture of Typical Cheviot and Saxony Cloths and Union Rug Fabrics.

Cheviots.

Ex. 1.—Rough Donegal tweed (Fig. 46).

Warp yarns: 8 yd. per dram, 20 threads per inch in the loom.
Weft yarns: 8 yd. per dram, 18 picks per inch in the loom.

Width in reed: 68 in.

Weave: 2/2 twill angled.

Finishing routine: Scoured, tentered, levelled in cutting, weighted or cold pressed.

Weight per yard: 20 to 21 oz.

Ex. 2.—Tweed suiting: Saxony warp (medium quality) and Cheviot weft (Fig. 47).

Warp yarns: 20 skeins Saxony, 32 threads per inch in the reed.

Weft yarns: 24 skeins Cheviot, 36 picks per inch in the loom.

Width in reed: 70 in.

Weave: 2/2 twill.

Finishing routine: Scoured, milled 18 to 20 per cent in width and 10 per cent in length, washed off, tentered and dried, brushed, cut moderately clear to develop weave, warm pressed, brushed, and steamed.

Weight per yard: 12½ to 13 oz., modified by the percentage of loss in finishing.

Ex. 3.—Cheviot travelling rug, Irish wool (Fig. 48).

Warp yarns: 2/15 skeins white and 10 skeins light and medium shades, 24 threads per in.

Weft yarns: same as warp, 24 picks per in.

Width in reed: 81 in.

Weave: 4/4 twill.

Finishing routine: After scouring, mill to 68 in., wash off, tenter, raise three times on the face and twice on the reverse side on the card wire or mover machine.

Weight per rug: 64 × 64 in. = 40 to 41 oz.

Ex. 4.—Union Rug blanket, Cheviot quality (Fig. 49).

Warp: 2-fold 20's cotton, 12's reed 2's.

Weft: 1 pick of 7 to 10 skeins medium shade (soft spun 6 turns per inch).
1 ,, ,, 7 to 10 skeins white ,, ,, ,, ,, ,,
44 to 48 picks per inch.

Width in reed: 90 in. for 64 in. finished and 102 in. for 72 in. finished.

Weight per rug: 72 × 72 in. = 60 to 64 oz.

Finishing routine: After preliminary routine and scouring, mill to 68 in. for 64 in., and 75 in. for 72 in. finished, wash off, tenter, but not too dry, raise four times from reverse ends of the piece, re-tenter and dry, "top" in cutting if necessary, brush, and steam. If a rougher pile is required than in the specimen, raise four times on the Moser and twice on the gig.

Ex. 5.—Union Rug blanket, lustre quality (Fig. 50).

Similar weaving data and finishing routine as Fig. 49, but raising done entirely on the teazle gig, and the weft yarns 6 to 7 skeins with 32 to 36 picks per inch. The long shag of the lustre fibres is the feature to develop in finishing.

Saxonies.

Ex. 6.—Checked suiting (Fig. 51).

Warp yarns: 22 skeins (fine quality) 48 threads per inch in the reed.

Weft yarns: same as warp, 46 picks per inch in the loom.

Warp and Weft: yarns arranged 5 threads black and 5 threads grey.

Width in reed: 67 in.

Weave: 2/2 twill to the right with the yarns right hand twine.

Length of piece woven: 56 yd.

Length of piece finished: 50 to 52 yd.

Finishing routine: Following knotting, scour, mend, mill to 56½ in., wash off, tenter, raise damp (for soft or fibrous surface), cut to trim fibre, hot press, brush and steam, cold press if necessary.

Weight per yard: 56 × 36 in. = 17 to 18 oz.

Ex. 7.—Fine Saxony trousering (Fig. 52).

Face and backing yarns: 25 skeins face (fine quality, firm spun) and 22 skeins backing.

56 threads per inch in the loom.

Weft yarn: 22 skeins moderately soft spun.

60 picks per in. in the loom.

Width in reed: 68 in.

Weave: warp-backed swansdown, arranged 1 thread face yarn, 1 thread backing, and 1 thread face.

Length of piece woven: 56 yd.

Length of piece finished: 52-53 yd.

Finishing routine: Knotted, scoured, mended, milled, washed off, tentered, raised dry to get up the surface filament, cut clear to develop pattern and twill, hot press, and follow as in Fig. 51.

Approximate weight per yard: 19 to 19½ oz.

Ex. 8.—Lined overcoating, Saxony yarns for check lining, and Cheviot yarns for fibrous face (Fig. 53).

Face warp yarns: 12 skeins Cheviot.

Backing warp yarns: (lining) 32 skeins Saxony.

Centre warp yarns: (stitching) 2/40's worsted.

72 threads per in. in the reed.

Face and backing weft yarns: same as warp, but backing weft softer spun than the backing warp.

60 picks per in. in the loom.

Width in reed: 75 in.

Weave: 2/2 twill face and back, arranged 1 back, 1 face, 2 back, 1 face, 1 centre, woven lining side or back up.

Finishing routine: Preliminary processes as in Fig. 48, milling to 58 in., tenter, cut clear on the back, raise several times on the face with piece in damp condition, brush and steam, hot press, steam after pressing on face side brushing to lay the pile of fibres.

Weight per yard: 56 × 36 in. = approximately 28 to 29 oz.

Ex. 9.—Union Rug blanket, Saxony quality (Fig. 54).

Counts of yarns and setting similar to Fig. 49, but Saxony instead of Cheviot yarns for weft.

Raising is done on the teazle gig and in two operations—twice before and four times in succession after milling, and from reverse ends of the pieces alternately.

The counts of the weft yarns in such blanket rugs range from 4½ to 10 skeins in two-ply weft structures of the type illustrated. The picks per inch are varied proportionately with the reduction in the counts or diameter of the weft yarn.

(40) Fibrous Contrasts: Cheviot and Saxony Cloths.

The nature of the physical properties of the wools used in the manufacture of these cloths is observed in their distinctive characteristics. Effects due to weave are discernible in five of the fabrics (Figs. 46, 47, and 48, and 52 and 53), but the effects are clearer defined in the Saxony than in the Cheviot samples, with the exception of Fig. 46, where the contrast between the white warp and the dark weft, the thickness of the yarns, and the looseness of the structure, afford distinctiveness to the interlacings.

Contrasting the Cheviot samples (Figs. 46, 47 and 48) their textural qualities may be defined. In Donegal and Harris tweeds, it is the aim of manufacture to emphasize the colour elements and contrasts, produce a clear weave result, and yet leave the rough fibrousness of the wool a paramount feature of the fabric. Fig. 46 is typical and illustrative of these characteristics. Other points in Cheviot manufactures are exemplified in the checked travelling rug specimen in Fig. 48. It is made from North-country Crossbred wools of medium quality, composed of standard yarn counts, and woven in the 4/4 twill. The lines or furrows of the weave are well developed in the white and grey shades forming sections A and B, but such is the amount of extraneous fibre of the warp and weft threads that it effectively conceals all traces of the twilled pattern in section C.

By changing the quality of the wool for either warp or weft (Fig. 47), a fabric is produced smoother and closer in texture,

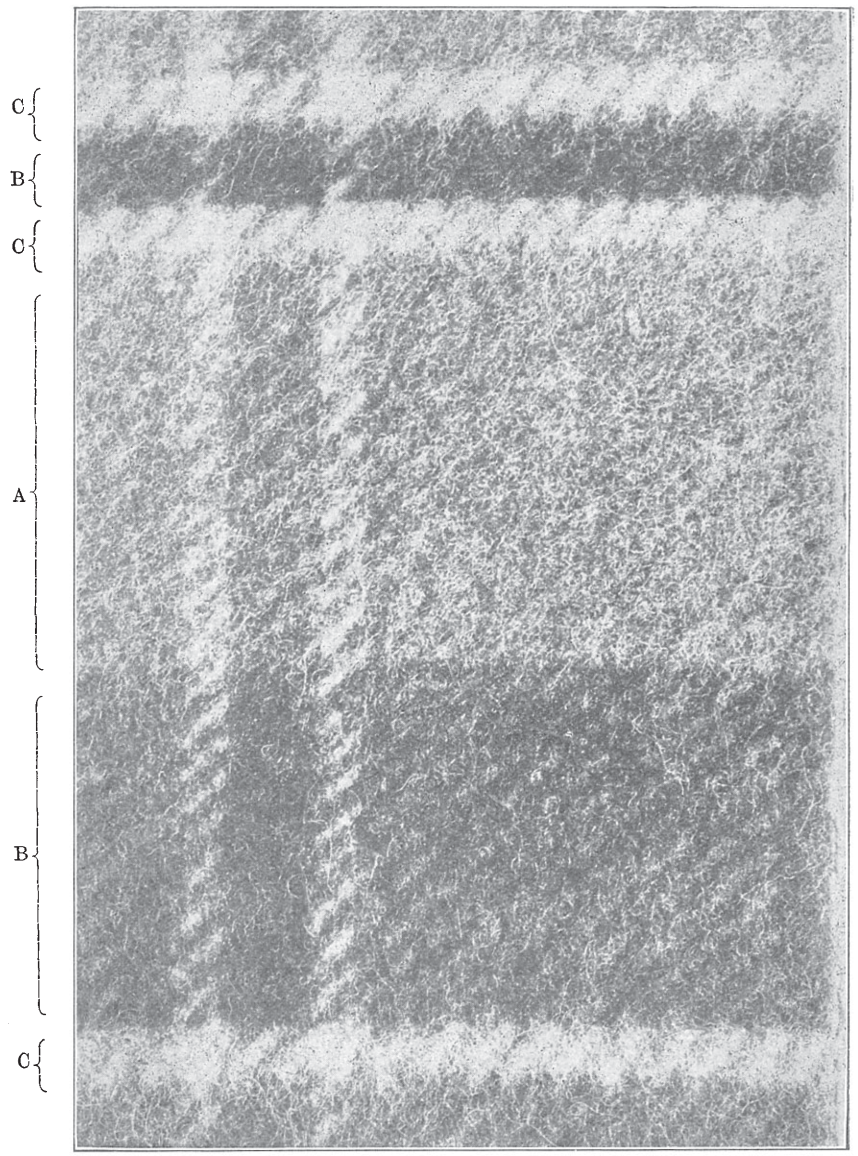


PLATE I, FIG. 48.—Cheviot rug.

and with the twill effect neater and better developed than obtainable in the ordinary class of Cheviot. Saxony yarns, as illustrated in Figs. 51 and 52, also improve the compactness and density of the texture. Fig. 51 is a fabric with a fibrous surface, but how different in quality from the Cheviot rug on Plate I! The fibres in both cloths conceal the weave, but this is the only common factor. The face of the Saxony consists of a soft, even and dense pile of filaments, but that of the Cheviot of entangled masses of hairy fibres.

The utility of Saxony yarns, in fine counts or of small diameter, for getting clearness of weave and pattern details, is typified in the trousering texture in Fig. 52. Cloths of this group, in finishing, are well milled and raised and cut clear—processes which produce firmness of fabric structure in combination with smartness of surface.

Union rug blankets (Figs. 49, 50, and 54) form an important class of standard fabrics in the heavy woollen trade. Three typical qualities are illustrated. Similar counts of yarns, setting, and finishing routine have been adopted in their manufacture. The differences in handle, appearance, and textural features, are caused by the grades of wools used in their production. The Cheviot sample (Fig. 49) is made of Crossbred wools of a strong staple; the lustre rug of lustre-wool and mohair noils; and the Saxony rug of Merino wools.

An application of yarns, consisting of wools differing in quality, obtains in double-cloth lined overcoatings of which Fig. 53 is an example. The face texture (Section A) of this compound fabric is made of Cheviot yarns — possessing some of the qualities of the "frieze" or "Shetland"—and the back texture (Section B) of Saxony yarns, utilized in producing the checked pattern. As a result of the dissimilarity in the fibrous nature of the two surfaces, two routines of finish have in the specimen been practised, one to develop a clear, effective pattern, and the other to develop a dense and fibrous nap.

(41) Cheviot and Saxony Contrasts: Yarn Composition.

Technical points have been illustrated and analysed which determine the quality of the yarns. Now it is a question of how the fibrous composition of the yarn is capable of modifying the characteristics of the finished fabric. It is understood that finer or smaller yarns may be spun from Merino than Crossbred wools, and employed in the manufacture of Saxony than Cheviot cloths. The range in the former is from 5 up to 44 yards per dram and in the latter from 5 up to 24 yards per dram. The two extremes may be slightly extended, but not with practical results of much value. The comparisons to be drawn, however, are not in relation to fineness of yarn counts, but in relation to yarn structure and characteristics, the wools being of Cheviot

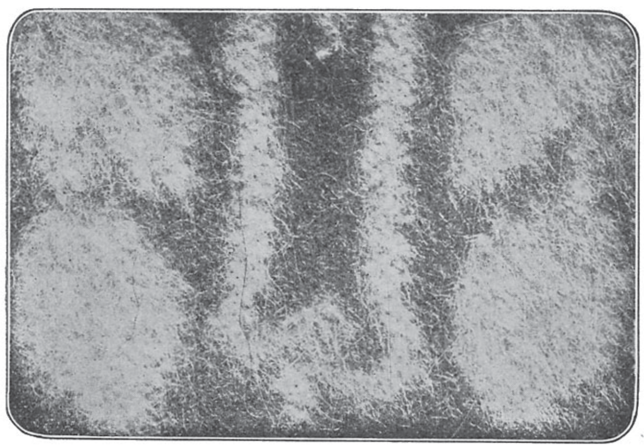


FIG. 49.—Union rug blanket Structure (Cheviot quality).

and Saxony (Merino) varieties. The mechanical methods of preparing the wools in the production of both yarns being identical, any points of disagreement in their qualities and structural features arise from the nature and physical properties of the classes of wools employed. Crossbred wools of the Cheviot variety, especially the qualities commonly used in woollen yarn manufacture, are not so evenly grown as Merino wools—that is to say, there is on the average, bulk for bulk, more diversity in diameter and length of filament, and also in length of staple, in wools of the Cheviot than of the Merino class. This accounts for the greater irregularity in fibrous composition in the Cheviot as compared with the Saxony yarn. Dissection proves this.

Untwisting a Cheviot yarn and drafting or drawing out the fibres in breaking the thread, and comparing them with the fibres obtained in the untwisting and breaking of a Saxony yarn of a similar diameter and twine, shows their want of uniformity in length and fineness: features which affect the structure of the thread, consisting, at various points, of two or more lengths of fibres. A Cheviot thread in this experiment may be actually broken and yet the longer fibres may remain in twined contact; but a Saxony yarn indicates no corresponding characteristics, the fibres being shorter and of a more even fineness and quality. Other features for comparison are the relative

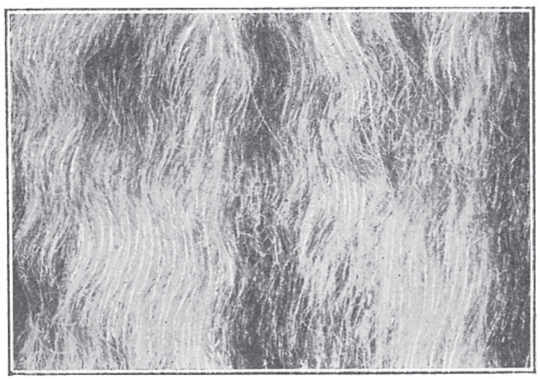


FIG. 50.—Union rug Structure (lustre quality).

degrees of cohesiveness of fibres in the two yarns, and their relative properties due to the nature of the extraneous or circumferential fibres. The Saxony is the more compact, the fine fibres clustering closer together and falling in the line of thread in the spinning process. This produces evenness of surface in the texture. The Cheviot yarn is of a looser or more open structure. Both threads possess a quantity of extraneous fibres roughly arranged and entangled. It is this fibre which imparts the hairy characteristic to fabrics of the Cheviot description.

(42) CHEVIOT AND SAXONY CONTRASTS: FABRIC STRUCTURE.

Fabric structure is prescribed by yarn construction and qualities; setting or number of threads and picks per inch; and by the weave or plan of warp and weft intersections. The fibrous nature of the yarns is a modifying factor as regards setting. Woollen cloths are invariably set or gauged in the loom to provide for a definite percentage of contraction or shrinkage in the operations of scouring and milling. Cotton and linen fabrics are set to allow for the contraction from the reed, or maximum width, to the normal or unstretched width, which is proportionate to the counts of the yarns and the frequency of the warp and weft interlacings—a plain woven fabric correctly set, as determined by the law of diameters and intersections, offers the minimum degree of contraction. In woollen and worsted cloths, there is a wide range of shrinkages varying in the former from 10 to 40 per cent, and in the latter from 5 to 15 or 20 per cent. Such shrinkage producing a difference in the closeness of the yarns, the woven and finished fabrics are more or less distinct from each other. A twilled or other style of cloth having 40 threads per inch in the loom and 60 per inch after milling, has changed in structure and textural elements. Now the nature of the yarns, and classes of the wools used, account for the range of possibilities in setting and shrinkage. There is not, for example, the same latitude in these technicalities in the use of Cheviot as in the use of Saxony yarns. Crowded or even close setting is not to be recommended in Cheviots, and to set loosely, and exceed a moderate amount of felting, tends to remove surface brightness and clear openness of fabric structure, or the distinguishing features of correctly manufactured Cheviot cloths.

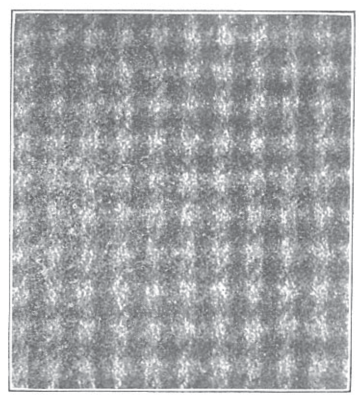


Fig. 51.—Checked Saxony (fibrous finish).

Saxony textures have different properties—the yarns admit of loose or firm setting; and also of moderate or full felting. Yarns regular in circumference, and of equal fibrous density, may be set more compactly in the reed than yarns of a more irregular formation and fibrous composition, and they have also freer felting propensities. Two cloths may be identical in weight, counts of yarns, and number of threads per inch in a definite area, but, in the Cheviot quality, the loom and finished product will correspond, whereas, in the Saxony quality, they possess distinctive characteristics. As a general rule, Cheviot yarns prescribe that the fabric should be set to yield approximately a similar cloth, but cleaner and brighter and somewhat firmer in structure in the finished than in the woven condition. Figs. 16 and 46, for example, are fabrics which, in the loom and after finishing, have strictly the same structure; but Figs. 51

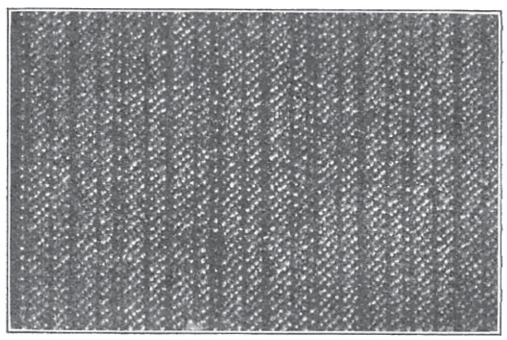


FIG. 52.—Fine Saxony trousering (clear finish).

and 52 are cloths which have acquired smartness, neatness, and flexibility in finishing and become distinct textures in these essentials from the loom productions. These features may be extensively varied in the manufacture of cloths made of Saxony yarns. Should sound milling and strong raising be practised, as in blankets and rugs (Figs. 49 and 54), to obtain a raised pile of filaments, then both types of yarns—Cheviot and Saxony—are utilized in weaving cloths which finishing routine completely changes in character and quality.

(43) SAXONY AND CHEVIOT CONTRASTS: WEARING EFFICIENCY.

Each type of texture is of high-wearing efficiency. It is not so much a question of standard of wear as in the effects of wear in which points of disagreement develop. The two cloths do not behave similarly in this respect. The suppleness of the Saxony—if not too hard milled—will result in the Saxony "bagging" or "stretching" under strain and friction, but in the Cheviot manifesting threadiness of surface. Quality for quality the Cheviot would be the more satisfactory, or it would stand harder and rougher wear than the Saxony. This is equally true of serge as of fine-wool flannels, and of Cheviot costume, suitings, and overcoatings, as of similar cloths of a Saxony quality. Strong-grown, coarse-fibred wools possess a fuller wearing efficiency in the manufactured state than fine-fibred, close-grown wools short and soft in the staple. Quantity and quality of fibre are in favour of the Saxony, but strength and length of fibre are in favour of the Cheviot. It follows that Saxonies are the softer and smoother, and the cloths of the smarter finish, and that Cheviots are the fabrics more suitable for garments of a utilitarian character.

When a Cheviot fabric once yields in the wear its life is short and it becomes quite unsatisfactory. Lacking the elasticity and flexibility of the Saxony, which by skilful treatment—damping and pressing—will regain some of its original qualities, it cannot be well restored. The source of this difference is in the relative quantity of fibre in the respective fabrics, that of the Saxony, taking cloths made of yarns of 20 yards per dram, being 25 to 35 per cent higher than the Cheviot. Wear on the Cheviot first removes the surface fibres, exposing the yarns, and as these are not so full of fibre as Saxony yarns, they become thin and the fabric yields. Particularly does this occur if the normal spinning quality of the wool has been exceeded in the attempt to acquire a small thread and a fine fabric. Wear on the Saxony has different results. In the ordinary finished cloths, it is primarily on the short fibres, forming the outer circumference of the yarns. These filaments are very numerous, and are partially embedded in the texture and protect or shield the actual surface of the threads. Once wear affects the latter, the texture suffers in a similar way to the Cheviot, but again the mass of filaments, short and clustered in the warp and weft threads and intermatted together, preserve the texture intact.

(44) Cheviot and Saxony Contrasts: Suppleness, Elasticity, and Tensile Strength.

In these qualities the two types of fabrics distinctly differ. The suppleness of the Saxony is higher than the Cheviot. Taking the finest quality of Cheviot—made of yarns of approximately $\frac{1}{65}$th of an inch in diameter—it does not agree in this property with a medium but all-wool Saxony. The true Cheviot is intended to possess a degree of crispness or sharpness. It must not be too supple. Firmness and fullness are the desirable characteristics. Flexibility and softness must, however, be present in the Saxony, but sponginess of cloth is detrimental and is the result of defective manufacture or the use of low materials. The absence of a full degree of suppleness and elasticity is also an indication of wool substitutes having been employed. A disposition to hardness and crispness of feel in Saxonies, may be taken as suggestive of the wools having been too open in staple or too coarse in the fibre, as dullness of surface and want of trueness of handle are indicative of the presence of shoddy in Cheviots.

Quality of fabric, in either Cheviots or Saxonies, is determined by textural firmness, elasticity, and fibrous fullness. A pure Saxony, made of fine wool, possesses a high degree of softness and flexibility, but an inferior quality of cloth is comparatively hard and non-elastic. Similarly, a pure Cheviot, made of sound wool, is crisp, elastic, and strong, but a Cheviot produced from wool substitutes is hard and harsh, and defective in tensile strength. Comparing the two cloths further, they may correspond in breaking strain when the schemes of manufacture are alike; but in elasticity or stretch they may be dissimilar, the Saxony slightly exceeding the Cheviot. This will be understood from the fibrous nature and structural formation of the two classes of yarns described. Strength of filament, and the measure of overlapping of the fibres in the spinning operation, are mainly responsible for the tensile strength of Cheviot fabrics. The base of the elasticity of the Saxony cloth is, however, the dense mass of fibres in the circumference of the yarns, producing continuous interfeltings of the texture in certain processes of finishing.

(45) Cheviot and Saxony Contrasts: Weave Distinctiveness and Colour Tone.

Distinctiveness of weave elements may be better emphasized in Saxony than in Cheviot cloths. The amount of extraneous fibre on the surface of the Cheviot yarns has the effect of subduing the intersections in the weave. The more uniform and level the yarn structure, the clearer the development of the interlacings in the cloth.

Comparing plain woven linen, cotton, worsted, and woollen fabrics (Figs. 5, 6, 14, and 4), the intersections are the most clearly defined in the linen, that is, the specimen in which the yarns are the smoothest in construction and have the fewest marginal filaments. The straggling fibres, in the circumference of the cotton thread, modify the clearness of the warp and weft crossings. The worsted yarns are less compact in formation, and the wool fibres have greater elastic and diffusive properties than either flax or cotton, so that the weave definition is still further softened, while in some woollen fabrics of the Cheviot type sections (A and B, Fig. 48) the mass of entangled fibres on the surface of the threads partially obliterates the crossings of the yarns.

These points relative to weave expression apply in a special way to the contrasts in cloths of Saxony and Cheviot qualities. The loose structure of the Cheviot yarn and the thicker and longer fibres of which it is composed, and its rough circumference, obviously render weave patterns indistinct. Saxony threads, as shown, being more compact and composed of short fibres small in diameter, have not a corresponding value in lessening weave delineation. This is noticeable in the various examples in standard cloths, e.g. whip-cords (Saxony) and serges (Cheviot), and ordinary Saxony trouserings and Cheviot suitings. In whip-cord fabrics (Section 1A, Fig. 38) the fine twills are clearly developed, but in serges they are dimmed or blurred. In fine Saxony trouserings (Fig. 52), closely set and clearly cut in finishing and consisting of yarns small in diameter, the weave details strongly contrast with the indefinite character they possess in the Cheviot suiting (Fig. 16). In both these compari-

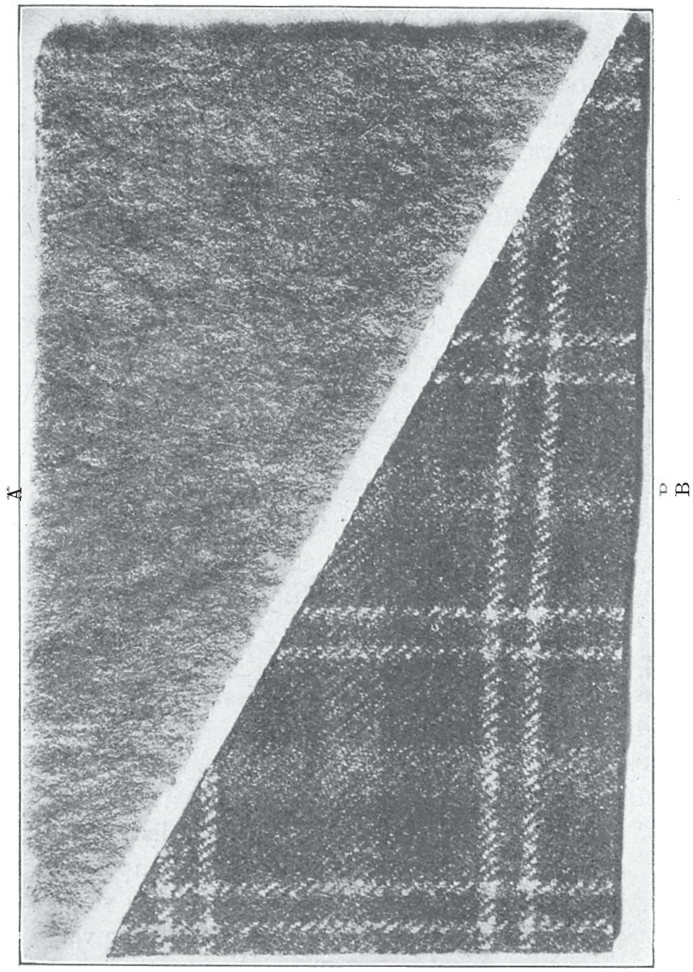


FIG. 53.—Raised overcoating cloth with woven lining. A = Face, Cheviot yarn. B = Lining, Saxony yarn, clear finish.

sons, the Saxony yarns are higher in counts than can be spun from Crossbred wools, a feature which accentuates their adaptability for imparting emphasis to elements of the pattern due to warp and weft intersections. This must not, however, be taken to imply that Cheviot yarns are inapplicable to fabrics in which weave contrasts are developed. With a suitable degree of difference in the shades of the warp and weft, and correct setting and finishing routine, twilled, mat, and other simple weaves may be made a feature of Cheviot styles. Thus the rug specimen (Fig. 48), though consisting of rough fibrous yarns, has a pronounced weave characteristic; and in the Donegal suiting example (Fig. 46) the effects of the weave intersections are also well defined. The fibrous nature of the cloth remains a distinguishing feature, hence the weaves are not so smartly defined as in the more even and less fibrous surface of the Saxony cloths, but they are none the less a marked element in the patterns.

(46) Quality and Tone of Cheviot Colouring.

Colour tone or brightness forms a principal characteristic of all classes of Cheviot fabrics. Wools of a Crossbred quality are specifically adapted for diversity of colouring acquired in the operation of blending. Finer wools are not so suitable for yielding distinctive richness of colour result. Blending for "mixture" shades is largely practised in the production of both woollen and worsted yarns—Cheviot and Saxony, and Crossbred and Botany; but the colour tone lacks freshness—in mixture shades composed of similar colour ingredients—in fine-fibred wool as compared with the colour tone acquired in coarse-fibred wool. This is particularly apparent in Cheviot and Saxony blends. The loss of brightness, consequent to the fineness of the wool, will be better understood by contrasting Lovat and heather mixtures as produced in Crossbred and Merino wools. Illustrations may be taken in typical blends composed as follows:—

Lovat Mixture.	*Heather Mixture.*
8 parts of blue	8 parts of black.
4 ,, ,, orange	1 part of scarlet.
1 part of white	1 ,, ,, buff
	1 ,, ,, medium green.

Assuming both classes of wools to be dyed, as near as practicable, identical colours as to depth and brilliancy of hue, and blended as indicated, the colour quality and positiveness of the Cheviot would be quite distinguishable in the carded material, the spun yarn, and the woven fabric. Each colour ingredient—the blue, orange, and white in the Lovat, and the black, scarlet, buff, and medium green in the heather compound—forms a distinctive element in these Cheviot blends. Shades of uniform colour tone result, but no single colour loses its specific hue. Each coloured fibre tinges the mixture. Uniformity of shade, equally diversified in tinting, is also obtainable in Saxonies, but individual colours suffer in distinctiveness of hue, and in the finer cloths are scarcely traceable as separate colour units. Cheviot wools, yarns, and fabric structures are peculiarly suitable for the production of styles of pattern rich and varied in colour com-

FIG. 54.—Union rug Structure (Saxony quality).

position; and Botany wools, in Saxony yarns, give clear decisive effects in solid shades, but soft and mellow colourings in mixture shades either bright or sombre in tone.

(47) OVERCOATING SPECIMEN WITH WOVEN LINING—CHEVIOT FACE AND SAXONY BACK.

The characteristic effects due to each class of yarn and also the specific qualities of the textures resultant are illustrated in Fig. 53 (see method of manufacture, page 63). The face of this two-ply or compound cloth (Section A) is made of *Cheviot* warp and weft, and the underside (Section B) of *Saxony* warp and weft. Both textures are produced from wools of a medium quality—the grey shade in each is composed of similar proportions of black and white which links the two surfaces together in colour tone. Each surface or fabric has been treated differently in the finishing routine—the Saxony being a "clear" finish and the Cheviot a "raised" or "rough" finish. Had the method of finishing been the same in both specimens, there would still have been an appreciable difference in their fibrous nature and other characteristics.

This specimen illustrates and emphasizes the clearness of weave and pattern detail producible in Saxony yarns, in contrast with the quality and fullness of fibrous surface possible in fabrics made of Cheviot yarns.

(48) Variety of Finish Applicable to Cheviot and Saxony Fabrics.

Finishing routine as shown in Paragraph 31 modifies the character and quality of the fabric. In all classes of Saxony cloths it is more varied than in Cheviot cloths. It is essential in Cheviot manufacturing that the natural properties of the wool should be observed in the finished fabric. Cheviots, moreover, are cloths made of yarns of an open, fibrous staple, and this is not favourable to diversity of finishing treatment. The Cheviot finish is of the simplest routine, ordinarily including scouring, milling, slight raising or brushing, cutting to shorten but not to remove the surface fibre, and pressing to level and solidify the fabric; or in Donegal and Harris tweeds it may be as elementary as that applied to the sample given in Fig. 46, and stated on page 62. But there are exceptions. The routine is diversified and extended in finishing the finer qualities and classes of Cheviots, in many varieties of which the surface filament is removed in cutting to better develop the texture and the colour style; but in friezes and thick overcoatings and suiting cloths, milling is practised to such a degree as to conceal the warp and weft yarns, and to form a rough pile of fibres on the face of the fabric; and in blankets milling and raising yield a vertical nap of fibres on both sides of the texture.

Finishing is a skilful branch of manufacture in the production of Saxony cloths. Several varieties of fabrics obtain their distinctive characteristics in the finishing processes. Saxony cloths of every description undergo important changes in texture, suppleness, evenness, brightness of surface, and fibrous characteristics in the several operations comprised in the finishing routine. Three specific grades of textural variation are in this work developed relating to, (1) cloths with a clear surface and in which the pattern due to colour or weave is distinctly brought out; (2) cloths with a short, rough pile of fibres, and in which the weave and textural effects

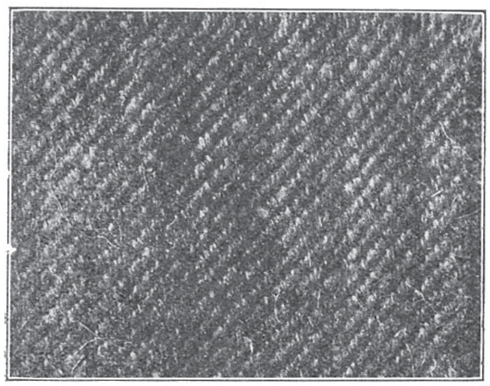


FIG. 55.—Crossbred worsted suiting.

seen in the loom are obliterated in the operations of milling and raising; and (3) cloths with a dense, bright pile of fibres and in which the weave effect is also concealed. Intermediate styles are obtained in each grade, e.g. (*a*) the "natural" finish consisting of slight milling and raising to get up the fibre and prepare for cutting, leaving some short fibres on the texture; (*b*) the "soft" or "fibrous" finish which is obtained by milling and raising the cloth damp, producing a "draw" or layer of short filaments evenly spread on the face of the fabric; and (c) the "velvet" finish which gives a vertical pile of short fibres subduing colour contrasts, and imparting fullness of handle to the cloth. The compact fibrous density of Saxony yarns—threads with a sound central core encircled with myriads of short, curly, filaments—is favourable to different systems and degrees of treatment in the several groups of finishing processes. As the quality and fineness of the wool approach the Cheviot or Crossbred variety, the scope for distinctions in the finish of the cloth is restricted, because this involves a corresponding diminution in the quantity of fibre composing the yarn.

(49) Botany and Crossbred Worsted Contrasts (Figs. 55 and 56).

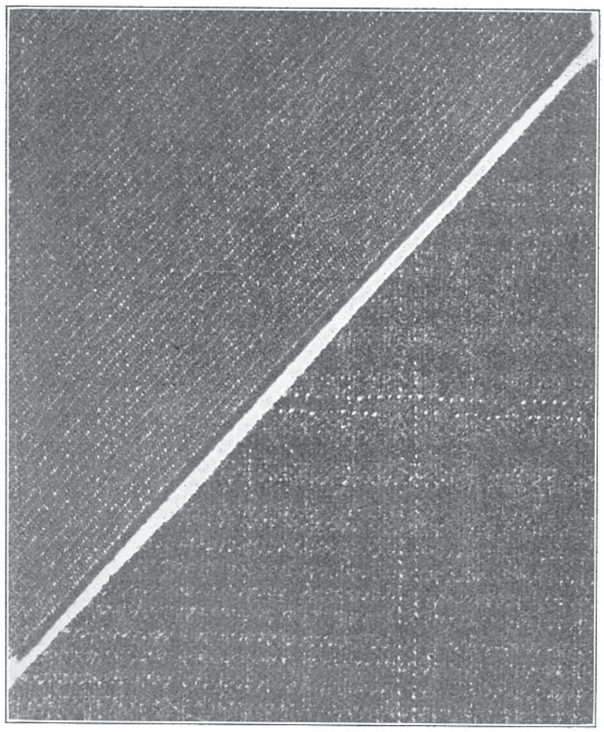
The difference between these two classes of worsted fabrics are not so varied in character as those obtaining between Cheviot and Saxony cloths. The comparisons, made as to fibrous qualities, have a similar significance in both the woollen and worsted varieties of textures; but wools of a longer and more even length of staple are usually selected for worsted than for woollen spinning. Distinctions in thread structure have relatively the same applications. Serges and Botany yarns, like Cheviot and Saxony yarns, differ from each other chiefly in fibrous composition, the Botany being made of the finer and shorter wools, and the Crossbred of the longer and coarser-grown wools; with the result that the spun counts in Botany range from 10's to 120's, and in Crossbred from 5's to 44's.

As to the comparisons made relative to fabric structure, suppleness, elasticity, tensile strength, and wearing efficiency of cloths made of woollen yarns, they are also applicable to serge and Botany worsteds, but the contrasts in these textures are not so distinctive or pronounced in character as in Cheviot and Saxony cloths. The scheme of worsted yarn manufacture, prescribes this. A worsted thread, whether made of Crossbred or Merino wools, is level and even in structure. A variation in the quality of the wool does not have the same effect on the technicalities of the fabric as in woollen manufacturing. The woollen-thread structure accentuates, to a greater degree than the worsted-thread structure, the differences between yarns spun from coarse and fine wools and also the fabrics in which they are utilized.

(50) Weave Definition and Colour Tone in the Two Standard Worsteds.

Fine and Crossbred worsteds are as dissimilar in these technicalities as Saxony and Cheviot cloths. Many of the points de-

A



B

Fig. 56.—Botany worsted overcoating. A = Face of fabric. B = Reverse surface or lining.

fined in Paragraph 36, particularly those concerning the styles of effects for which each class of fabric is adapted, may be fitly applied here. But there are fuller facilities for weave design, and precise or definite colour toning, in both Serges and Botanies than in Cheviots and Saxonies.

In the manufacture of fabrics of the fine Botany class there is scope for extreme fineness of texture, clearness of weave expression, and distinctiveness of pattern details due to colouring. The relative characteristics of the Crossbred and Botany varieties of worsted cloths are illustrated in Figs. 54 and 55, the former a Crossbred suiting, and the latter a lined overcoating manufactured as indicated in the subsequent paragraph.

(51) Examples and Contrasts in the Manufacturing Data and Results—Crossbred and Botany Textures.

Crossbred Worsted, Milled Finish (Fig. 55).

Warp and weft: 2/28's worsted 44's quality.
12's reed 4's.

Width in the reed: 68 to 70 in.

Picks per inch: 48.

Weave: 2/2 twill.

Finishing routine: Knot, mend, scour, mill to 57 in., wash off, tenter cut level, brush and steam, blow with steam, hot press, steam.

Weight per yard: 56 × 36 in. = 13½ to 14 oz.

Botany Worsted, Lined Overcoating (Fig. 56).

Face warp yarns: 2/40's, medium grey.

Backing warp yarns: 2/40's, arranged.

Grey mixture .	2	For	4	4	4	—	4	4	84 threads.
Black . .	2	44	4	4	—	2	4	4	
Twist . . .	—		—	—	1	1	—	—	

Face weft yarns: 2/40's black.
90 threads per in. in the reed.

Backing weft yarns: 2/40's, arranged.

Grey mixture .	2	For	4	4	4	—	4	4	92 picks.
Black . .	2	52	4	4	—	2	4	4	
Twist . .	—		—	—	1	1	—	—	

Width in reed: 64 to 66 in.
88 to 90 picks per in. in the loom.

Weave: 2/2 twill face and plain back, arranged in both warp and weft, 1 thread face, 1 back and 1 face.

Finishing routine: Following careful knotting and mending, scour for 15 minutes with the solution at 4° Twaddle, washing off in clean water at a temperature of 90° F., next scour with soap for 10 to 15 minutes and re-wash off, tenter to 56 in., brush and steam, cut four times on the face and twice on the back, brush, blow with steam for 3 minutes, allow to cool, re-wind from the opposite end and re-blow, shrink, by being well steamed, rolled up, and allowed to cool, hot press, steam and cold press.

Weight per yard: 56 × 36 = 18 to 18½ oz.

There are in the Crossbred strong textural and weave effects, but not smartness of definition in the warp and weft intersections. It is a type of fabric intermediate between the Saxony and the Cheviot, having the effective qualities of the latter with less fibrousness of surface, or combined with a degree of the clearness of the Saxony. Serge yarns are better adapted for the development of weave effects than either of the two classes of woollen yarns, a fact which accounts for the applications to worsted serge fabrics of several varieties of regular crossings arranged on sateen and twill bases. Neither the yarns nor the cloths are, however, well suited for coloured patterns composed of fancy yarns, but in mixtures, formed of similar colour units as Cheviots, they possess a special brightness of tone with attractive textural qualities.

Fig. 56 has been selected to typify the Botany technicalities and characteristics for two reasons: first, clearness of weave as seen in Section A; and, second, distinctiveness of pattern obtained by the grouping of the coloured yarns in the plain weave, Section B. Any type of regular weave design, if the fabric is correctly set and finished, may be developed in Botany yarns with the precision here illustrated. Yarn quality, evenness, smoothness, and brightness, as determined by the use of sound wools, and accuracy in combing and drawing, to attain perfect parallelism of fibres, modifies the lustre of the textural surface acquired, and, as a consequence, weave and pattern definiteness. Similarly the treatment in finishing—thorough cleansing in scouring; the production of evenness of texture in "crabbing" or forcing of steam through the piece; brushing of the extraneous fibres of the yarns on to the surface of the fabric; correct setting or adjustment of the cutting parts of the machine in the cutting operation; and the requisite degree of heated and cool pressing—includes technicalities which have an important influence on the specific qualities of Botany worsteds.

(52) Schemes of Finishing Applied to Botany and Crossbred Fabrics.

Finishing routine is less diversified in worsteds than woollens as to textural classifications, but not as to smartness of textural effects. Vicuna and "milled" worsteds possess some of the quality of suppleness and of fibrous density of fine Saxonies, but they have not the weave clearness of "unmilled" worsteds. Felting is applied to impart certain woollen characteristics, but should not be practised to such an extent as to be destructive of the true worsted characteristics, namely, brightness of texture and precise development of weave details. Shrinkage may be effected in the scouring by employing the Bailey apparatus, in the milling machine, or in the stocks. On the former principle, the pieces may be felted from 10 to 15 per cent, and on the two latter systems from 15 to 20 per cent, but rarely more. The cloths are set proportionately wide in the loom, and should not be as firmly woven as fabrics not intended for this style of finish. As felting, in all classes of cloths, lessens the value of weave design and colour pattern, it follows that worsted fabrics thus treated, whilst improving in suppleness and elasticity, suffer in textural smartness and tone. Increased wearing efficiency is also attained in this work, the fabric being rendered less porous, its density being augmented with the degree of felting applied.

CHAPTER IV.

STANDARD GRADES OF MANUFACTURE.

(53) Standard Tests for Government, Railway, Corporation, and other Cloths; (54) Margin allowed in Standard Tests; (55) Component Elements of Textile Analysis; (56) Quantitative Factors determinable by Calculation; (57) Diversity of Manufactured results in Producing to a Standard Sample; (58) Dissection for Fibrous Quality of a Fnished Standard; (59) Government Cloths; (60) Navy Flannel—Specification and Analysis; (61) Blue Cloth—Specification and Analysis; (62) Causes of Difference in the Breaking Strain of Cloths; (63) Scarlet Serges; (64) Elements in Setting: Shrinkage and Tensile Strength; (65) Clear and Fibrous-surfaced Scarlet Serges Compared; (66) Fearnought and Kersey Standards; (67) Analyses of Fearnought and Kersey Standards; (68) Loss in Finishing: Percentage of Shrinkage; (69) Khaki Tartan-Drab Mixture; (70) Analysis of Khaki Standard; *A, Tartan Drab Mixture*, and *B, Cloth Drab Mixture;* (71) Mixture Shade Dissection; (72) Variation in Yarn Construction.

(53) Standard Tests for Government, Railway, and Corporation Cloths.

All cloths for Government, corporation, railway, and official contracts are manufactured to specification. Sample or standard patterns are submitted, and these must be equalled in all points of manufacture—materials, quality, colour, and finish. Standard tests are specified relative to breaking strain, weight of a prescribed area of the cloth, and colour or dye. Accuracy in manufacture is required in regard to :—

I. Quality as compared with the sample cloth.
   - (*a*) Purity, fineness, and character of the materials.
   - (*b*) Colour—match as to shade or blend if a mixture fabric, also as to fastness to milling and light: or fastness to both milling and light.
   - (*c*) Finish—surface characteristics, firmness of fabric structure, nature or suppleness of cloth.

II. Structure and quality of the yarns—woollen, worsted, or unions, single or folded.

III. Width within the selvedges.

IV. Length of the piece in yards.

V. Breaking strain or tensile strength in the direction of the warp or length of the piece.

VI. Breaking strain or tensile strength in the direction of the weft or width of the piece.

(For measuring these the dead-weight test is applied. In the Government Army and Navy Clothing Departments the type of machine made by Goodbrand and Holland is employed.)

VII. Weight per yard for width of cloth specified.

(54) Margin Allowed in Standard Tests.

Some margin may be allowed on the standards indicated, but only such as may arise from natural causes in the manufacture of identical cloths in different factories and under varying conditions. Obviously, some latitude must be permissible, but necessarily it is of a grade which knowledge and practice in manufacturing is competent of not exceeding. The exact materials, yarns, setting, and routine of manufacture are not prescribed. For these the manufacturer must rely upon his own initiative and capacity. It follows that manufacturing on these lines, for a specific make and quality of cloth, differentiates in method and principle from manufacturing to produce to sample already made in the factory and of which all the data of construction are known.

Success can only be attained in proportion to an exact analysis being made of the standard sample, and to the practice of systems of work which will coincide with those adopted in the production of the original cloth.

(55) Component Elements of Textile Analysis.

The analytical data of any class of woven fabric comprises the following: Plan of weave or scheme of intertexture: Quality of the materials or the variety of fibres employed in its manufacture: Counts or diameters of the yarns in the actual specimen and, as estimated, when spun, including the turns per inch, and if a compound or folded thread, the structure or counts of each yarn of which it is composed; also the breaking strain and elasticity: In the case of mixture yarns, the shades or colour units and the quantitative value of each colour used: Actual weight per yard finished: Threads and picks per inch in the standard sample: Degree of shrinkage or felting in width and length: Working particulars for weaving: and The routine of finishing.

These component elements of textile analysis may be tabulated as below:—

TABLE III.

ANALYTICAL DATA OF WOVEN FABRICS.

I. Plan of weave.

II. Quality and properties of the fibre, wool, or material used.
(*a*) Fineness and length of fibre; (*b*) Softness and elasticity; (*c*) Average evenness of the staple; and (*d*) Felting and lustrous characteristics.

III. Yarn structure.
(*a*) Counts: (*b*) Character of twine, right or left-hand twist; (*c*) Single or folded; (*d*) Turns per inch in the simple or single, and also turns per inch in the compound or folded yarn.

IV. Mixture yarns.
(*a*) Colour units or composition; and (*b*) Proportionate quantities of the several colours in the blend.

V. Weight per yard of a specified width of the finished cloth as calculated on the standard sample.

VI. Threads and shots or picks per inch in the standard sample.

VII. Percentage of shrinkage.
(*a*) In length; (*b*) In width, indicating how effected in scouring, milling, or both these processes.

VIII. Set or gauge of the fabric in the loom.
(*a*) Width in reed and method of sleying (i.e. number of dents per inch and threads in each split); and (*b*) threads and picks per inch.

IX. Style of finish.
(*a*) Milled or Unmilled; (*b*) Clear or fibrous finish; (*c*) Rough or smooth pile, i.e. melton, doeskin, beaver, nap, or velvet pile, stating the possible routine of processes.

(56) Quantitative Factors Determinable by Calculation.

Quantitative factors in these analyses may be accurately determined by calculation, but the qualitative factors may only be arrived at by deduction and comparison. The gauge of the cloth in the loom, the threads per inch, the counts of the yarns, and the degree of twine are obtained by mathematical rule and mechanical tests. Degree of shrinkage is estimated by the difference in the length of the yarns in the sample and when drawn out to their normal or spun length. The frequency of the warp and weft interlacings and the diameters of the threads, or the number of intersections—curves or bends in the yarn—plus the shrinkage in scouring and milling, control the length of thread used in weaving a definite length of fabric. If, for example, the yarns in a $2\frac{1}{2}$ inch square sample, when abstracted and naturally stretched, measure $3\frac{1}{8}$ in. (warp) and $3\frac{1}{3}$ in. (weft), the shrinkages would be 20 per cent on the warp and 25 per cent on the weft; from which (*a*) the loom width and length of the piece, and (*b*) the ends and picks per inch of the fabric in weaving may be derived by simple equation:—

(*a*) Shrinkage in width is calculated to be 25 per cent, therefore the loom width would be greater by this amount than the width of the finished piece.

$\therefore$ 75 : 100 : : 56 in. (finished width of piece) = 74 to 75 in. in the reed.

(*b*) Assuming the standard sample analysed to contain 60 threads and 56 picks per inch, the numbers in the loom would be less by the percentages of contraction thus:—

25 per cent shrinkage in width = 100 : 75 : : 60 threads per inch in the fabric = 45 threads per inch in the loom.

20 per cent shrinkage in length = 100 : 80 : : 56 picks per inch in the fabric = 44 to 45 picks per inch in the loom.

(57) Diversity of Manufactured Results in Producing to a Standard Sample (S.S.).

It is remarkable with what uncertainty factors relating to loom setting and counts of yarn, and therefore resultant weights, are estimated in some instances. An example may be given. The S.S. for a tramway clothing contract was made to show the following finished particulars :—

Counts of Warp Yarn.	Thread per inch.	Counts of Weft Yarn.	Picks per inch.	Weight per Yard 56 in. × 36 in.
2/48's	112	2/40's	100	$24\frac{1}{3}$ oz.

Thirteen manufacturers tendered, and with the exceptions of A, I, and K, were, as seen from the data appended, remarkable for want of exactitude in calculation.

Sample.	Counts of Warp Yarn.	Threads per inch.	Counts of Weft Yarn.	Picks per inch.	Weight per Yard 56 × 36 in.
A	2/48's	104	2/40's	108	$24\frac{1}{3}$
B	2/32's	73	2/32's	65	23
C	2/48's	104	2/44's	100	$22\frac{1}{2}$
D	2/24's	54	2/24's	51	22
E	2/48's	104	2/44's	104	23
F	2/48's	102	2/44's	100	$22\frac{1}{4}$
G	2/24's	56	2/42's	49	$21\frac{3}{4}$
H	2/48's	102	2/44's	104	23
I	2/48's	110	2/40's	98	25
J	2/32's	74	2/32's	65	22
K	2/48's	96	2/40's	108	24
L	2/48's	120	2/52's	96	$21\frac{1}{2}$
M	2/32	68	2/32's	64	$20\frac{1}{2}$

The disparity in results may not have been caused by inaccurate dissection but by the practice of schemes of manufacture independent of the inferences to be drawn from analysis. Whatever the nature of the cause, the divergence from the original cloth in yarn counts, setting, and weight, is unsatisfactory, and shows a want of technical knowledge and skill. The production of cloths to a standard sample containing 112 threads per inch and 100 picks, with 2-fold 48's warp yarns and 2-fold 40's weft yarns, indicates a deficiency in technical training and practical experience in manufacturing when such data are employed, as, in one instance (tender B) 2-fold

32's (warp and weft) and 73 threads and 65 picks per inch; and, in a second instance (tender D) as 2-fold 24's (warp and weft) with 54 threads and 51 picks per inch. Other contractors' analyses show the practice of methods of production equally inaccurate, viz. G, J, and M.

The deductions concerning quality are correspondingly imperfect. In specimen L a higher quality of yarn had been used than necessary, but in specimens B, D, G, J, and M, 40's instead of 60's quality had been selected for warp, resulting in discrepancies in the suppleness of the respective textures and also in the fineness and appearance of the finished fabrics.

(58) Dissection for Fibrous Quality in a Finished Standard.

To determine accurately qualitative characteristics (Factors II and IV, Table III) is a more subtle problem than to estimate the quantitative components of the cloth or Factors III, V, VI and VII. It involves the selection of wools which, with suitable routine of manufacture, will yield cloths of similar properties to those of the original sample, of a correct dissection of the fibrous composition of the yarns, and technical judgment. Unnecessary errors arise from incorrectly determining, by yarn analysis, the actual materials composing the original cloth. For instance, a contract was accepted for the manufacture of a considerable quantity of pieces of mohair dress fabrics. The pieces produced were identical in weight per yard, counts of yarns, setting, shade, and finishing routine with the standard sample. There was, however, a manifest difference in the quality of the manufactured pieces as compared with the specified pattern. Now a discrepancy of this nature may be proved by fibrous analysis. In this example microscopic examination and comparison of the threads of the respective textures, and also their dissection for fibrous composition, verified each other, and proved that the yarns in the sample, though of a similar diameter to those used in weaving the pieces, contained on an average 10 to 15 per cent more fibre. That is to say, they were denser by this difference in percentage of fibre than the yarns in the pieces. This implied that the fibres of the material of the sample were finer or smaller in diameter than the fibres of the material composing the contract fabrics. Fineness of fibre in such textures is an indication of quality and lustre or the features in which these manufactures were demonstrated to be deficient.

In mohair and lustre yarns, differences in fineness and length of fibre are more readily detected than in Saxony and Botany yarns, but in these threads accurate dissection on the lines defined will also approximately gauge the quality and grade of the materials used in the manufacture of the finished cloth.

(59) Government Cloths.

To further illustrate the technical methods of work in manufacturing to a standard grade of fabric, a few examples in Army and Navy (Government) cloths will be analysed, namely, "Flannel," "Blue Serge," "Scarlet Serge," "Fearnought," "Kersey" and "Tartan Mixture" or "Khaki," quoting the specification for each texture.

(60) Navy Flannel Specification and Analysis.

Flannel.—Used principally for seamen's vests and cholera belts.

SPECIFICATION.

1. *Quality and Specification.*—The flannel to be supplied under this contract shall be answerable in every respect to the following specification, and in point of quality, fineness, make, strength, finish, colour, manufacture, and freedom from dark hairs, in every respect equal to the pattern exhibited at the time of tendering.

The flannel shall be self-white, 30 in. wide within the selvedges, and shall be delivered in pieces each of which shall measure with the list or fag ends 42 yd. of 36 in., but a margin of half a yard per piece over or under will be allowed. Each piece shall be marked with the actual length contained. The flannel shall be stoved with sulphur, and any chemical agent used in the process of manufacture or bleaching shall be completely removed; to be warranted pure finish, not filled or weighted.

The flannel (ordinary) shall weigh, when properly dried, 16 lb. per piece of 42 yd. In proving the weight a margin of $2\frac{1}{2}$ per cent either way will be allowed on each piece.

Proceeding by technical analysis of the flannel, the following data of manufacture are determined according to Table III :—

I. Plain weave.
II. Fine Crossbred wool, Southdown quality.
III. *Warp* yarns = 20 yd. per dram, woollen. Turns per inch, 11·65 ; left-hand twine.
Weft yarns = 30 yd. per dram, woollen. Turns per inch, 9·45 ; left-hand twine.
V. 6 oz., 30¼ in. wide.
VI. 32 threads and 42 picks per inch in the standard sample.
VII. Shrinkage (*a*) 20 per cent.
,, (*b*) 15 per cent.
VIII. (*a*) 38 in. to 40 in. ; 12's reed 2's or 12½'s reed 2's.
(*b*) 24 threads and 36 picks per inch in the loom.
IX. Natural finish. Routine : scoured, milled to 32 in., washed off, tentered, slightly cut and pressed.
X. Loss of weight in finishing 10 to 15 per cent.

This is an elementary fabric to manufacture. A wool must, in the first place, be selected which will give the requisite clearness of colour without stoving, and the soft crispness yet firmness of texture which the degree of shrinkage analysis allows. In the second place the relative turns per inch in the warp and weft yarns and their relative counts are important. The finer weft and softer twine, with a larger number of picks per inch than threads, imparts fibrous cover and suppleness of handle or the distinctive quality of the flannel. An identical fabric to the original as to weight per yard, colour, and surface appearance could be obtained by using weft yarns of the same counts as the warp yarns and reducing the picks in the ratio of the increase in the diameter of the weft thread, but the texture would not be the same either in wearing property or in quality. It is only in the simpler as in the more complex manufactures that exact reproduction is feasible by strict adherence to the evidence of analysis.

(61) Blue Cloth—Specification and Analysis.

Blue Cloth.—Two samples are included in the following specification differing in quality, weight, tensile strength, and also in methods of manufacture.

Cloth No. 1 is used principally for making seamen's caps and clothing for chief petty officers and men not dressed as seamen; and cloth No. 2 for making seamen's overcoats and watch coats.

SPECIFICATION.

1. *Quality and Specification.*—The cloth to be supplied under this contract shall be made of all new pure wool, without any admixture of waste or shoddy; shall be answerable in respect of quality and fineness of material and manufacture to the patterns exhibited at the time of tendering; and shall be of such strength that pieces cut from deliveries, measuring $6\frac{5}{8}$ in. square between the points of security, shall bear the following strain by dead-weight machine, viz.:—

The No. 1 cloth, warp 225 lb., weft 190 lb.
The No. 2 ,, ,, 376 ,, ,, 345 ,,

A margin not exceeding 5 per cent either way will be allowed in testing for strength.

The cloth shall be dyed in the wool with natural vat indigo and shall stand equally and in every way the same test as the respective patterns; shall be identical in shade of colour therewith, and shall be properly cleansed so that the colour does not shed or rub off. None of the cloths shall be burl-dyed or chromed, and the acid used in the extracting process shall be thoroughly removed.

The cloths shall be thoroughly shrunk and properly dried, and shall be delivered carefully steamed off face and back and cold pressed.

The No. 1 cloth shall be 58 in. wide within the list, and shall be delivered in pieces, each of which shall measure, within the list or fag ends, 37 yd. of 36 in. A margin of half a yard per piece over or under will be allowed, but the total delivery must average 37 yd. to the piece. To be cuttled in 16-in. folds, and each piece to have a ticket affixed at the head end with the name of the manufacturer and length. Each piece shall weigh, when properly dried, 52 lb. and 10 oz. per 37 yd. In proving the weight a margin of $2\frac{1}{2}$ per cent either way will be allowed on each piece.

The No. 2 cloth shall be 58 in. wide within the list, and shall be delivered in pieces, each of which shall measure, within the list or fag ends, 37 yd. of 36 in. A margin of half a yard per piece over or under will be allowed, but the total delivery must average 37 yd. to the piece. To be cuttled in 20-in. folds, and each piece to have a ticket affixed at the head end with the name of the manufacturer and length. Each piece shall weigh, when properly dried, 79 lb. and 12 oz. per 37 yd. In proving the weight a margin of $2\frac{1}{2}$ per cent either way will be allowed on each piece.

The analytical results prove the methods of construction to be :—

CLOTH No. I.

I. Plain weave.
II. Fine quality of Cape wool (clothing).
III. *Warp* yarns = 18 skeins or yards per dram.
Turns per inch 18·9 ; left-hand twine.
Weft yarns = 20 skeins or yards per dram.
Turns per inch 11·85 ; right-hand twine.
V. 20 to 21¼ oz. per yard, 58 in. wide.
VI. 48 threads and 48 picks per inch finished.
VII. Shrinkage (*a*) 33 per cent to 35 per cent.
,, (*b*) 25 per cent to 30 per cent.
VIII. (*a*) 90 in. ; 8's reed 4's.
(*b*) 32 threads and 34 to 36 picks per inch in the loom.
IX. Beaver or face finish.[1]
X. Estimated loss in finishing, 15 to 20 per cent.

CLOTH No. II.

I. Prunelle twill (weft face) moving to the right.
II. Fine merino Crossbred (Australian).
III. *Warp* yarns = 10 to 11 skeins or yards per dram.
Turns per inch 13·6 ; left-hand twine.
Weft yarns = 10 to 11 skeins or yards per dram.
Turns per inch 8·3 ; right-hand twine.
V. 34½ oz. per yard 58 in. wide.
VI. 38 threads and 36 picks per inch finished.
VII. Shrinkage (*a*) 33 per cent to 35 per cent.
,, (*b*) 30 per cent to 33 per cent.
(*a*) 90 in. ; 10's reed 3's.
(*b*) 30 threads and 26 to 27 picks per inch in the loom.
IX. Melton finish.[1]
X. Loss of weight in finishing, 20 per cent.

(62) MANUFACTURING CAUSES OF DIFFERENCES IN THE BREAKING STRAIN OF CLOTHS.

In considering the two cloths together some of the special points in their manufacture may be contrasted and emphasized. The same specification applies to both, but the cloths are distinct as to character of finish, breaking strain, and weight per yard.

[1] See "Finishing of Textile Fabrics" by the same Author, published by Scott, Greenwood & Son, London.

The differences in breaking strain are an important feature, and suggests elements in manufacturing requiring analysis. Cloth No. 1 has a variation in tensile strength in the warp and the weft of 35 lb. and Cloth No. 2 of 31 lb. The causes of this variation, in the respective fabrics, are not identical. In Cloth No. 1 it is produced, first, by the weft yarn being finer to counts than the warp yarn; and, second, by the turns per inch being lower in the weft than the warp. Both these factors reduce the strength of the yarn, and of that direction of the fabric to which it is applied. With a corresponding degree of shrinkage in the piece warp way as weft way, and with, practically, the same ratio of threads and picks per inch finished, the cloth necessarily shows a higher breaking strain on the warp (the thicker and harder spun yarn) than on the weft—the smaller and softer spun yarn. In Cloth No. 2, the counts of the warp and of the weft are the same, with, however, a difference of 5 turns per inch in the two classes of yarns, that of the warp yarn having 13·6 and that of the weft yarn 8·3 turns per inch. The utility of the firmer spun yarns is found in the strength and elasticity of the cloth, and of the looser spun yarns in the development of suppleness of handle and fibrousness of surface

In the manufacture of well-milled cloths, attention should always be given to the relative counts and turns per inch of the warp and weft yarns, and also to the direction of the twine in the threads. A dense pile or nap is characteristic of each of these fabrics. To produce the best quality of raising surface in a plain woven cloth, the twine of the fibres of the warp yarns should be the reverse in direction to the twine of the weft yarns. In twilled fabrics, e.g. Cloth No. 2, another technical element has to be taken into account, namely, the movement of the twill and whether *warp* or *weft* face. If *warp*, with the twill to the right, the twine in the yarn should also be to the right, with the twine of the *weft* to the left. This relation of the filaments in the yarns, results in the production of the fibrous quality of surface favourable to raising. On the other hand, if the twill is *weft* face and moves to the right, the twine in the yarns should be the reverse of that indicated, or to the left in the warp and to the right in the weft as in Cloth No. 2. When the twill develops the warp and weft equally on each side of the fabric, the twine in the warp yarn should correspond with the traverse of the twill in the cloth, but if the twine of the weft yarn be opposite to the twill, that is, should the twill run to the right hand, the twine in the two yarns should be as stated in the analysed particulars for Cloth No. 1.

Want of correctness in the technical minutiæ described, develops cloths dissimilar from the original samples. A fuller degree of transverse felting would render the cloths better balanced in tensile strength, or the use of a thicker and stronger weft yarn would have the same influence; but the fabrics as a result would be modified in character, in one instance the firmness of handle would be affected, and in the other the quality of textural fineness.

(63) Scarlet Serges.

The abbreviated specifications for these two serges—Nos. 3 and 4—are as follows:—

Specification.

Quality and specification.—The cloths to be supplied under this contract shall be made of pure wool and answerable in respect of quality and material to the standard sample; and shall be of such strength that pieces cut from deliveries, measuring $6\frac{3}{8}$ in. square between the points of security, shall bear the following strain by dead-weight machine tests:—

No. 3 scarlet serge, warp 250 lb., weft 430 lb.
No. 4 scarlet serge, warp 385 lb., weft 310 lb.

The cloths shall be cochineal dyed and equal to pattern in dye and shade of colour, also in finish, and be London shrunk.

The standard samples test:—

No. 3 sample: Warp 22 threads and weft 34 threads per $\frac{1}{2}$ in.
No. 4 sample: Warp 27 threads and weft 20 threads per $\frac{1}{2}$ in.
No. 3 sample: Weight per yard, 36 in. × 56 in., $14\frac{1}{2}$ to 15 oz.
No. 4 sample: Weight per yard, 36 in. × 56 in., 20 to $20\frac{1}{2}$ oz.

The analyses of the respective samples give the following data of manufacture:—

No. 3 Scarlet Serge (Worsted).

I. Cassimere or 2/2 twill.
II. 40's top Crossbred.

III. *Warp* yarns = 2-fold 32's worsted.
Turns per inch 2-fold yarn = 10; left-hand twine;
single yarn = 9·45; right-hand twine.
Weft yarn = single 14's worsted.
Turns per inch 5·65; right-hand twine.
V. 14 oz. per yard, 56 in. wide.
VI. 44 threads and 68 picks per inch finished.
VII. Shrinkage (*a*) 10 per cent to 12 per cent.
(*b*) 5 per cent to 7½ per cent.
VIII. (*a*) 63 in., 13½'s reed 3's.
(*b*) 40 to 41 threads and 64 picks.
IX. Clear worsted finish. Routine: scour, wash off, tenter, brush and cut, blow with steam, dye, wash off, tentered, re-blow with steam, brush and cut clear, hot and cold press.

No. 4 SCARLET SERGE (WOOLLEN AND WORSTED UNION).

I. Cassimere or 2/2 twill.
II. Material for warp — 40's top Crossbred.
Material for weft — medium quality of merino clothing.
III. *Warp* yarn = 2-fold 24's worsted.
Turns per inch 2-fold yarn = 10.6; left-hand twine.
Turns per inch single yarn = 7.5; right-hand twine.
Weft yarn = 13 skeins or yards per dram., woollen. Turns per inch 11·6; left-hand twine.
V. 19 oz. per yard, 56 in. wide.
VI. 54 threads and 40 picks per inch finished.
VII. Shrinkage (*a*) 15 per cent.
(*b*) 7½ per cent.
VIII. (*a*) 66 in. to 68 in.; 11's reed 4's.
(*b*) 44 threads and 38 to 40 picks per inch.
IX. Semi-rough finish with twill showing faintly. Routine: similar to No. 3 Cloth, but the pieces only to be topped in cutting and re-blowing after dyeing not essential.

(The Hospital Blue Serge is of a similar quality and weight but nearly balanced in threads and picks per inch, testing 250 lb. and 270 lb. on the warp and weft respectively.)

(64) ELEMENTS IN SETTING: SHRINKAGE AND TENSILE STRENGTH.

These serges differ from Cloths 1 and 2 in the character of the yarns used, methods of setting, and in the degree of shrinkage, the contraction in the serge pieces in finishing being produced solely in scouring, and not by felting as a separate process. The tensile strength in such textures is dependent upon the normal breaking strain of the yarns and upon the threads and picks per inch.

According to the specification, serge No. 3 shows on the *warp* a test of 250 lb. and on the *weft* of 430 lb., while that on the *warp* of serge No. 4 shows 385 lb., and on the *weft* 310 lb. The two serges thus differ in transverse and length tests. The technical points for consideration are how these results have been acquired. At the outset of manufacturing they must be determined. The causes of the differences in the tests of the two cloths are evident on examining the yarn structures. Taking the warp threads, they are worsted and twofold in both samples, but that in serge No. 3 is eight counts finer than in serge No. 4 with 41 against 44 threads per inch. When individual threads are tested those from the latter are 10 per cent higher in breaking strain and elasticity than those from the former; but the small disparity between the turns per inch in the single yarns of the twofold 24's and the twofold 32's does not appreciably modify the nature and strength of the two fabrics. The high weft test of serge No. 3 is obtained by having one-third more picks to the inch than threads, and using a weft yarn three counts thicker than the warp yarn. For a corresponding technical reason the satisfactory weft test in sample No. 4 has been developed, the weft being six counts lower than the warp (13 skeins equals actually $5\frac{2}{3}$'s worsted), with only four picks less to the inch than threads.

(65) Clear and Fibrous Surfaced Scarlet Serge Samples Compared.

The two fabrics are distinct in character, No. 3 being smart and clear in weave and finish, with the twill moving at an angle of 35°, and No. 4 fibrous and indistinct in surface, with the twill moving at an angle of 40°. The weft yarns are responsible for these dissimilar results. It will be observed in the data of analysis that the twine in the weft thread of sample 3 is the reverse of the twine of the weft thread of sample 4; and it is in such cloths that the weft characterizes the twilled development, giving clearness in one instance and indefiniteness in the other. The relative structures and qualities of the two yarns are also important factors. Thus the 14's worsted is a smooth, even thread, but the 13 skeins woollen is a thread of rougher fibrous formation—one adapted for producing a distinct definition of weave and a bright texture, and the other for improving the fibrous density of the fabric, and developing a rough quality of texture with the surface fibre concealing the diagonal lines of the twill.

In manufacturing to standard sample, the distinctive features of the cloth having been determined, and the scheme of construction having been accurately dissected, it is absolutely essential that the technical elements ascertained and the inferences drawn therefrom should be strictly, and not generally, interpreted and applied. For example, in the two cloths under consideration the yarn structures and loom settings are at the base of the manufactured issues, and hence the scheme of reproduction mapped out.

(66) Fearnought and Kersey Cloths.

Both are thick, well-milled fabrics made of strong-fibre Crossbred wools; the Fearnought being used principally for special clothing in stokeholds, torpedo and submarine boats, and the Kersey—made in green and red—for man "ropes," laying down on decks, notice boards, and covering screens. In neither of these well-milled textures are there traces of the twilled weave, and both possess some of the fibrous features of felted carded material.

SPECIFICATION.

1. *Quality, Specification, etc.*—The Fearnought to be supplied under this contract shall be answerable in every respect to the following specification and to the description given in the schedule, and in point of quality of material, make, and finish in every respect equal to the patterns exhibited at the time of tendering.

To be made of all pure wool, without any admixture of waste, shoddy, or cotton of any description, in bolts of 50 yd. in length and 27 in. in width, and to be entirely free from dressing, and not to be stoved with sulphur. Each bolt to weigh not less than at the rate of 1 lb. per yard of length, and not to exceed 1 in. beyond the prescribed width. Pieces cut from the fabric, 9 in. long in the direction of the weft and 6⅝ in. wide, to bear a tensile test of 220 lb. in the direction of their length, and similar pieces of 9 in. long in the direction of the warp and 6⅝ in. wide, to bear a tensile test of 270 lb. in the direction of their length.

The Kersey shall be answerable in every respect to the following specification, and to the description given in the schedule, and in point of quality of material, make, shade of colour, and finish, in every respect equal to the patterns exhibited at the time of tendering.

To be made of all pure wool, without any admixture of waste, shoddy, or cotton of any description, in bolts of 45 yd. in length and 50 in. in width, and to be entirely free from dressing. A latitude of not more than ½ in. over or under the prescribed width will be allowed. Each bolt to weigh not less than at the rate of 20 oz. per yard of length.

The colours to be bright and permanent, produced with the following dyes :—

Red Kersey	Madder and cochineal.
Green Kersey	Indigo extract and picric acid.

Pieces cut from the fabric, 9 in. long in the direction of the weft and 6⅝ in. wide, to bear a tensile test of 125 lb. in the direction of their length, and similar pieces of 9 in. long in the direction of the warp and 6⅝ in. wide, to bear a tensile test of 235 lb. in the direction of their length.

One bolt in every 10, or less number delivered, to be tested.

Two samples shall be tested from each selected bolt (one for weft and one for warp) ; half the samples shall be taken from the ends, and half from the centre of the bolt.

The results shall be averaged and if the mean does not reach the present standard test numbers, the whole shall be rejected (subject to the conditions of Paragraph 5).

2. *Inspection and Tests.*—An inspecting officer and such other person or persons as the commissioners for executing the office of Lord High Admiral of the United Kingdom of Great Britain and Ireland, hereinafter called the Admiralty, may appoint, shall be permitted to enter into and inspect the manufactory or works belonging to the contractors when the material to be supplied, in pursuance of the contract, shall be in course of manufacture, in order to see that the said material is made in a proper manner, and is conformable in every respect with the terms and conditions of the contract. The contractors shall keep proper testing apparatus at the works, and shall provide at their own expense the material and labour necessary to carry out such tests as the said officer may deem necessary. The inspecting officer will also arrange for the Kersey to be subjected to a chemical test by the Admiralty chemist. Material that has passed such inspection and tests shall be marked by the contractors as the inspecting officer may desire, and being so marked shall not be subject to rejection by the officers of the respective dockyards. If, however, any damage occurring in transit be discovered by the examining officers at the dockyards, the same shall be made good at the cost of the contractors. The name and address of the inspecting officer will be communicated

to the firms accepted, and he should be notified by the contractors when a consignment is ready for survey.

3. *Marking.*—All Fearnought shall have a distinguishing mark consisting of a blue line running through its entire length; such marking, however, shall only be carried out after the material has been certified for by the inspectors.

The component parts of the solution for marking shall be :—

Indigo	1 lb.
Turpentine	4 gals.

(67) Analyses of "Fearnought" and "Kersey" Standards.

The sample cloths supplied under these specifications yielded the following analyses :—

"Fearnought" Sample.

I. Plain weave.
II. A medium quality of strong-fibred Cheviot wool.
III. *Warp* yarns : 5 to 6 yards per dram.
Turns per inch, 9·8 ; right-hand twine.
Weft yarns : 5 to 6 yards per dram.
Turns per inch, 6·2 ; left-hand twine.
V. 15 to 16 oz. per yard, 27 in. wide (fabric under weight).
VI. 24 threads and 24 picks per inch finished.
VII. Shrinkage (*a*) 30 per cent.
,, (*b*) 25 per cent + 5 per cent for take-up of warp in weaving.
VIII. (*a*) 40 to 41 in. 8's reed 2's.
(*b*) 16 threads and 16 picks.
(*c*) Length of piece woven = 66 yd.
(*d*) Length of warp for 66 yd. of cloth = 72 yd.
IX. Natural Cheviot finish.
X. Estimated loss in weight in finishing, 15 to 20 per cent.

"Kersey" Sample (Green).

I. Cassimere or 2/2 twill weave to the right.
II. Medium quality of strong-fibred Cheviot wool.
III. *Warp* yarns : 8 to 10 skeins.
Turns per inch (10 skeins), 8·1 ; left-hand twine.
Weft yarns : 8 to 10 skeins.
Turns per inch (10 skeins), 6·15 ; left-hand twine.
V. 23 to 24 oz. per yard, 50 in. wide (weight required 20 oz. per yard).
VI. 32 threads and 30 picks.

$$Warp = \frac{B\ 16 \times D\ 40 \times E\ 70}{A\ 5\frac{1}{2} \times 16 \times 16} = 31\tfrac{9}{11}\text{ lb.}$$

$$Weft = \frac{C\ 16 \times D\ 40 \times F\ 66}{A\ 5\frac{1}{2} \times 16 \times 16} = 30\text{ lb.}$$

$$\overline{G\ 61\tfrac{9}{11}\text{ to }62\text{ lb.}}$$

G = Piece 40 in. × 66 yd. less 30 per cent weft and 25 per cent warp shrinkage = 27 to 28 in. × 49½ to 50 yd.

∴ 62 lb. less 20 per cent loss in finishing = H, approximately 50 lb. ÷ 50 yd. = 16 oz. per yard.

GREEN KERSEY.

$$Warp = \frac{B\ 25 \times D\ 64 \times E\ 56}{A\ 10 \times 16 \times 16} = 35\text{ lb.}$$

$$Weft = \frac{C\ 25 \times D\ 64 \times F\ 52}{A\ 8 \times 16 \times 16} = 40\tfrac{1}{2}\text{ lb.}$$

$$\overline{G\ 75\tfrac{1}{2}\text{ lb.}}$$

G = Piece 64 in. × 52 yd. less 20 per cent weft and 15 per cent warp shrinkage = 50 to 51 in. × 44⅕ to 45 yd.

∴ 75 lb. less 20 per cent loss in finishing = H, approximately 60 lb. ÷ 45 yd. = 21⅓ oz. per yard.

RED KERSEY.

$$Warp = \frac{B\ 24 \times D\ 66 \times E\ 60}{A\ 10 \times 16 \times 16} = 37\tfrac{1}{8}\text{ lb.}$$

$$Weft = \frac{C\ 26 \times D\ 66 \times F\ 56}{A\ 10 \times 16 \times 16} = 37\tfrac{1}{2}\text{ lb.}$$

$$\overline{G = \text{Practically } 75\text{ lb.}}$$

G = Piece 66 in. × 56 yd. less 25 per cent weft and 20 per cent warp shrinkage = 49½ to 50 in. × 44⅘ to 45 yd.

∴ 75 lb. less 20 per cent loss in finishing = H, approximately 60 lb. ÷ 45 yd. = 21⅓ oz. per yard.

(68) LOSS IN FINISHING: PERCENTAGE OF SHRINKAGE.

The loss in finishing should not be arbitrarily fixed. The approximate known loss in the manufacture of these cloths has been denoted in each case, but the correct method to adopt is to determine by experiment the exact amount of this loss, using the materials and yarns from which the pieces are to be produced.

Shrinkage is conformable to some adjustment as to length, but the exact finished width of the cloth must be attained. It is desirable, however, not to rely upon variations in shrinkage from the percentages upon which the calculations are based.

with accuracy in condensing and spinning, producing the specified counts of yarns, and possessing, as a result of actual tests, the percentage of loss in weight in the scouring, milling, and finishing work, it should be feasible to adhere closely to the scheme of manufacture prepared. This is the correct plan to practise. It is chiefly where inaccuracies occur in carding and spinning, excessive contraction in dyeing—if dyed in the piece—and not estimating correctly the loss from the greasy to the clean condition, that adjustment in shrinkage or milling is relied upon for giving the exact weight per yard of the piece.

(69) "Khaki" Tartan-Drab Mixture.

A summary of the specification for this contract is as follows:—

Quality.—The tartan to be supplied under this specification is to be answerable in point of quality of material, make, and finish to the pattern exhibited at the time of tendering. It must also be of the same dye and shade of colour. The pieces must be 56 in. in width and weigh 1 lb. 7 oz. to 1 lb. 8 oz. per yard of 36 × 56 in. and be London shrunk.

Pieces cut from the fabric 9 in. long in the direction of the weft and $6\frac{5}{8}$ in. wide to bear a tensile test of 350 lb. in the direction of their length; and similar pieces 9 in. long in the direction of the warp and $6\frac{5}{8}$ in. wide, to bear a tensile test of 350 lb. in the direction of their length.

(70) Analysis of Khaki Standard.

A. Tartan Drab Mixture.

The sample cloth submitted showed an estimated contraction from the loom to the finished width of approximately 15 per cent, and from the greasy to the finished length of $12\frac{1}{2}$ per cent. As the breaking strain on the length and the width of the fabric is identical, the counts of the warp and weft yarns should be uniform, and the ratio of threads and picks should correspond.

I. Cassimere or 2/2 twill to the right.

II. Fine Crossbred.

III. Warp yarns: 2-fold 14's.
Turns per inch 2-fold yarn, 13·8; left-hand twine.
,, ,, single yarn 10·2; right-hand twine.
Weft yarns: 2-fold 15's.
Turns per inch 2 fold yarn, 9·8; left-hand twine.
,, ,, ,, single yarn, 6·5; right-hand twine.

IV. *Warp* yarns (*a*) fawn, white, brown, blue, and red; (*b*) 44·5 per cent, 33 per cent, 14 per cent, 6 per cent, 2 per cent.
Weft yarns (*a*) fawn, white, and blue; (*b*) 60·5 per cent, 31·5 per cent, 8 per cent.

V. 23 oz. per yard, 56 in. wide.

VII. (*a*) 12½ to 15 per cent; (*b*) 12½ per cent.

VIII. (*a*) 66 in. to 68 in., 12's reed 3's; (*b*) 36 threads and 40 picks per inch.

IX. Worsted serge milled finish, surface fibrous and concealing weave effect. Mill to 57 in., scour, and wash off, tenter, blow with steam on Whiteley's or Bailey's machine, allow to set and cool, brush and cut to trim surface, press, and steam.

X. Estimated loss in finishing, 5 per cent.

(*A similar fabric is also manufactured of 2-fold 24's Crossbred warp yarn and single 12's Crossbred weft yarn; set 69 in. in the reed and in 11's reed 4's, and woven with 44 picks per inch.*)

B. Cloth Drab Melton (Thin).

Summary of Specification.—Width of pieces within lists, 56 in. Weight per yard, 36 in. × 56 in. – 15 to 15½ oz. Finish as per pattern which tests as follows:—

Warp: 21 threads per ½ inch.
Weft: 21 threads per ½ inch.

Tensile strength.	*Elasticity.*
Warp: 180 lb.	2 in.
Weft: 180 lb.	2½ in.

The results of analysis and method of manufacture are given below:—

I. Plain weave.

II. Fine merino.

III. Warp yarns: 22 skeins, left-hand twine, 14 turns per inch.
Weft yarns: 23 skeins, left-hand twine, 12·25 turns per inch.

IV. Colour analysis of mixture for both warp and weft (*a*) white, brown, fawn, and lavender-blue; (*b*) 40 per cent, 30 per cent, 20 per cent, and 10 per cent.

V. 15 to 15½ oz., 56 in. wide.

VII. (*a*) 20 per cent ; (*b*) 15 per cent.
VIII. (*a*) 70 in., $8\frac{1}{2}$'s reed 4's ; (*b*) 34 threads and 41 to 42 picks per inch.
IX. Melton finish.[1]
X. Estimated loss in finishing, 12 to 15 per cent.
(*N.B.—For Cloth and Drab Mixture heavy cloth, see Chapter X.*)

(71) Mixture-shade Dissection.

The colour analysis for "shade" is arrived at by taking a definite weight of yarn, say one dram, from the sample cloth, untwisting the threads and selecting each colour of fibres. These are weighed separately for ascertaining the proportionate quantities in the blend. All mixture yarns are treated in this way in determining their shade components. Before proceeding to fix up piece quantities, experiments should be made with small lots, mixing and carding and following by felting the material into a "batch" sample which should be scoured and compared with the original. If found correct, instructions for dyeing and blending in quantities may be given.

(72) Variations in Yarn Construction.

This example (A) differs from the preceding cloths in being made entirely of worsted yarns. A similar strength and shade of fabric could be manufactured by using woollen weft (Cross-bred quality) either single 15 skeins or 2-fold 30 skeins. The latter would give a cloth of almost identical quality to the original and be more economical in manufacture. The single yarn would not be so satisfactory. Unless hard or firm twisted, which would change the handle of the texture, it would not yield a cloth of the strength specified, and to augment the felting in the width of the piece, though augmenting the breaking strain, would develop a cloth wanting in suppleness of structure. In producing contract fabrics, the first method of yarn modification from a two-fold worsted to a two-fold woollen yarn of corresponding counts and quality is permissible and also practicable if the pieces, as in this instance, are milled finish, but it should not be attempted in other classes of fabrics, e.g. ordinary un-

[1] See "Finishing of Textile Fabrics".

milled serges and worsted cloths with a clear finish. But, as indicated, variations in yarn structure, counts, degree and direction of twine, should only in rare instances be made in producing pieces to be answerable in every respect—quality, finish, weight, and tensile strength—to a given standard pattern.

CHAPTER V.

WEAVES TYPES.

(73) Weave Limitations ; (74) Weave Nomenclature and Classification ; (75) Single-Weave Structures ; (76) Weft-backed Structures ; (77) Warp-backed and Compound Structures ; (78) Soundness of Fabric Structure ; (79) Change in Weave Structure to Improve the Tensile Strength of the Fabric ; (80) Warp and Weft-face Weaves ; (81) Angled and Checked Twills ; (82) Double Plains ; (83) Reps or Cords and Cord Twills ; (84) Compound Structures ; (85) Ratio of Face and Backing Yarns in Two-fold Structures, and of Face, Centre, and Backing Yarns in Three-fold Structures ; (86) Yarn Groupings for Irregular Three-fold Fabrics ; (87) Yarn Counts in Compound Weaves ; (88) Value of Intersections in Compound Weaves.

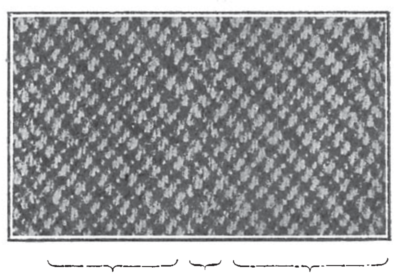


FIG. 57.

(73) WEAVE LIMITATIONS.

THE compass for "weave" variation, as regards effect or design, is very restricted in standard cloths. Three of the principal causes of this restriction may be defined as :—

1. Diversity of weave structure produces design characteristics, and fabric features, so varied in composition as to give cloths which, though coming within the range of general classification, are unsuitable for the purposes of standardization. This