# THE FINISHING OF TEXTILE FABRICS

(WOOLLEN, WORSTED, UNION & OTHER CLOTHS)

BY

ROBERTS BEAUMONT, M.Sc., M.I.Mech. E.

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*WITH 151 ILLUSTRATIONS OF FIBRES, YARNS, AND FABRICS, ALSO SECTIONAL AND OTHER DRAWINGS OF FINISHING MACHINERY*

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# CONTENTS.

## CHAPTER V.

### THEORY OF FELTING: FABRIC STRUCTURE.



## CHAPTER VI.

### THEORY OF FELTING: COMPOUND FABRICS.



## CHAPTER VII.

### FULLING AND MILLING MACHINERY.



## CHAPTER VIII.

### THE THEORY OF RAISING.



## CHAPTER IX.

### RAISING MACHINERY AND THE RAISING PROCESS.

## CHAPTER X.

### Cutting, Cropping or Shearing.



## CHAPTER XI.

### Lustring Processes and Machinery.



## CHAPTER XII.

### Methods of Finishing.

# LIST OF ILLUSTRATIONS.

# TABLES.

# CHAPTER I.

## WOOLLEN, WORSTED AND UNION FABRICS.

(1) Woollen Cloths: Saxonies and Cheviots. (2) Worsted Fabrics: Botany and Crossbred. (3) Fancy and Piece-dye Woollens. (4) Fancy and Piece-dye Worsteds. (5) Union Fabrics: Piece dyes and Fancies. (6) Whipcords, Buckskins, Venetians, Cords and Twist-warp Fancies. (7) Heavy Woollens: Box Cloths, Meltons, Pilots. (8) Friezes, Shetlands and Naps. (9) Special Types of Overcoatings. (10) Golf Cloakings. (11) Vestings.

### (1) *Woollen Cloths: Saxonies and Cheviots.*

WOVEN manufactures in which wool and wool substitutes are used, are divided into the woollen, the worsted and the union-fabric industries. In the woollen industry, the chief divisions are "Saxony" and "Cheviot". The terms have originated in the difference in the grades of wool used in each branch of the trade. Formerly, fine woollen cloths, such as those of which the staple trade of the west of England consisted, were made, largely, of Saxony and Silesian wools. The development of the Colonial merino-wool industry has resulted in the fine cloths made in this country being composed mainly of Colonial wools; but the term "Saxony" has been retained as defining the nature of the fabrics. The "Cheviot" designation has arisen from Cheviot wools being used in the production of these fabrics in the early history of the tweed trade. But here again the varieties of wool have much increased in recent years, both in Great Britain and Ireland, and also in the wool-growing countries of Australia, New Zealand, the Cape, Natal and South America.

Saxony and Cheviot cloths differ in (*a*) fineness; (*b*) quality of handle; (*c*) textural surface; and (*d*) wearing property. Saxonies are characterised by fineness and density of fabric, soft quality of handle and smooth surface; Cheviots are rougher in appearance, more porous in nature or open in structure, and have a comparatively strong-fibred surface, as in the Irish frieze. Industrial requirements, are, however, tending to destroy this distinctiveness of cloth—the qualities of Saxonies and Cheviots approaching each other in an increasing degree. This is more apparent in Cheviots, where the use of finer wools in the better-class fabrics has imparted some of the distinguishing qualities and features of the Saxony.

(2) *Worsted Fabrics: Botany and Crossbred.*

Worsted, like woollen manufacturing, consists of two main divisions, namely, "Botany" and "Crossbred". The former term is applied to the finer grade of textures, and was given, originally, to indicate merino wools shipped from Botany Bay, New South Wales, but now also denotes all similar qualities of wool wherever grown. "Crossbred" defines the more serge-like or rougher types of worsted fabrics. It will be observed that the two terms have synonymous meanings to "Saxony" and "Cheviot" in the woollen industry, for they describe the fine and coarse classes of fabrics respectively.

There are many intermediate grades of worsteds between the pure Botany and the pure Crossbred. The peculiar characteristics of the Botany are fineness of texture, clearness of surface and "quality"; and those of the Crossbred, comparative roughness, and crispness of handle. Similar qualities of wool may be used in Saxony (woollen) and Botany (worsted): and also in Cheviot (woollen) and Crossbred (worsted): so that clearly any difference in these woven manufactures is not, necessarily, in the raw material or fibre, but in the routine of yarn manufacture. The two distinct systems of yarn-making, woollen and worsted, are the cause of fabrics so different from each other in appearance and quality; and of the varied treatment to which they are subjected in the finishing processes subsequent to weaving.

### (3) *Fancy and Piece-dye Woollens.*

Each class of the woollen, the worsted and the union-fabric industries is subdivided into "fancies" and "piece-dyes". The term "fancies" is applied to cloths in which the pattern is developed in weaving, and not in dyeing, printing or any other process; the latter to fabrics dyed in the piece, or made of yarns in the natural colour of the wool, as distinct from wool or yarn-dyed cloths. The terms are occasionally somewhat misleading, because piece-dyes may be striped, checked or spotted with colour, when the effects or patterns correspond to those produced in the loom. Such effects are due to the dyeing properties of animal and vegetable fibres, which in the same dyeing operation take different tones of colour.

Woollen "fancies" comprise a wide range of textures, including flannels, flannel suitings, costume cloths, trouserings, suitings, overcoatings, golf cloaking, mantles, rugs and shawls. Each of these may require special treatment in the processes of finishing. Flannels and costume cloths are classed together as regards weight and style of texture. In Saxonies, trouserings may be a distinct type of fabric from suitings or coatings, but this, as a rule, is not the case in Cheviots made for the same purpose. Much variety of colouring and design, thickness and construction of fabric, and style of finish, obtain in the heavier fabrics for rugs, mantles, etc. Between the two extreme weights, namely, the lightest texture from about 7 to 10 oz. to the yard, and the heavier cloths, 32 oz. to the yard (these are not the limits, as special cloths are made over 48 oz. per yard), there are many grades of fabrics both in materials and qualities. Where such differences exist in woven productions, or, in the amount of fibre in the cloth, as indicated by these weights, there is corresponding scope for diversity of finishing.

More complete standardisation is possible in "piece-dye" than in "fancy" fabrics. Included in the more important types of piece-dye woollens—which are generally well felted and raised—are the following: "soft-finish" costume cloths, "plain supers," "doeskins," "beavers," "billiards," "Sataras," "box," and other cloths. It should be observed that wool-dyeing is also practised in making such fabrics. One of the leading characteristics of each of these cloths is the fibrous or dress-face surface. This quality is a distinct effect of the processes of finishing, for it does not exist in the cloths in the loom. In the first place, by the process of milling, density of texture is acquired, that is, individual threads of warp and weft are felted into one composite mass of fibres; and secondly, by the process of raising, fibres are straightened and combed in one direction over the face of the fabric, concealing traces of separate warp and weft yarns. The methods of manufacture followed, produce a woven surface suitable to such treatment in finishing.

Considering the types of fabrics in the order named above the "costume" cloth and the "plain super" are the simplest in construction, varying in shrinkage from 15 to 25 per cent., but the "super" is more highly finished, possessing a denser pile and a more lustrous surface. "Doeskins," "beavers," and "billiards" are stronger and firmer made, but otherwise have similar qualities, with the surface fibre short, dense and bright. The "Satara" is one of the oldest of woollen cloths, ribbed or striped in the weave, weft ways. There is no branch of the woollen industry in which a greater degree of skill and experience is exercised than in the production of the finer qualities of these fabrics. Finishing effects changes in the condition and appearance of the cloth, but at the same time is liable to accentuate any fault formed in the preceding processes of yarn and fabric structure. This applies to all classes of fabrics dyed one colour, and which are well milled and lustred by boiling or crabbing, and pressing.

### (4) *Fancy and Piece-dye Worsteds.*

Fancy and piece-dye worsteds are more diversified in structure and weave than woollens. As observed, variety of yarn construction and systems of finishing are the two principal sources of the several classes of woollen fabrics, but in worsteds of all kinds, there is a large diversity of woven fabrics resulting from weave, and build or make of texture. If the scope for distinct fabrics were restricted to weave elements alone, unlimited possibilities would be afforded for variety of texture. Weave includes such typical effects as fancy twills, mats, ribs, cords, sateens, corkscrews, diagonals and honeycombs. Many of these are capable of re-arrangement and of combination with each other, forming groups (which are also subdivided into other classes) of textile patterns. Such patterns may be either fancy or piece-dye, the colours being applied in weaving, or the fabrics may be woven in the grey and dyed afterwards.

Fancy worsteds are grouped into three classes:—

(*a*) Dress and costume textures.

(*b*) Suitings, trouserings and coatings.

(*c*) Heavy cloths, such as overcoatings, mantle and decorative textures.

Class (*a*), in addition to the ordinary types of woven fabrics, comprises lenos, gauzes, lappets, and many other styles which bear special trade names, such as zibelline, crêpeline, voile, crêpe de chîne, and canvas cloths. They are commonly single in structure, but double weaves may be used in figured fabrics. Classes (*b*) and (*c*) comprise single, backed and compound structures, and are subdivided into (1) colour fancies, in which the patterns are simple in weave and due to colour, consisting of stripes and checks; (2) weave fancies, invariably piece-dyes; and (3) fancy patterns, composed of two or more weaves and colours, and of various forms of design. Type (1) is also common to woollens, but types (2) and (3) are distinctly characteristic of worsteds, though in elementary styles they may be made in woollen yarns.

A special feature of worsted manufacturing—which has not the same recognition in woollen manufacturing—is "quality". This enters into every branch of the trade. Two fabrics may be identical in counts of yarn, setting, finish and all other data, but one finer in quality, to a recognised or standard degree, than the other. It is in the latter point that the difference between two similar woollen and two similar worsted fabrics is distinguishable. In the case of the woollen, quality is not fixed or standardised, whereas in worsted manufacturing it is approximately defined. Top making is the basis on which this fineness is fixed. For example, a 60's top may be spun to a 60's yarn (usually the extreme limit) or it may be spun to a 40's, in which instance it should yield a better thread than if spun to the higher counts. This applies to the several kinds of worsted, mohair and other yarns, in which the material is prepared in the top form. If a worsted fabric is made from yarn lower in counts than the quoted top, it should be correspondingly finer than a similar fabric made of the same counts of yarn, but in which the highest possible counts has been spun from the quality of top used. This difference in quality is more perceptible in piece-dyes than in fancies, where the design and colour may conceal the inferior character of the material, but in the handle and wear of the fabric the absence of quality would be apparent.

Fabric structure is very diversified in worsted manufacturing. In piece-dyes there are such standard makes of texture as the weft-backed cloths, warp-backed cloths; double cloths, with the same counts of yarn on the face and back; and double cloths, with thicker counts of yarn on the back than on the face; and other compound weaves. The warp yarns are, as a rule, twofold, but the weft may be either twofold or single. When softness of handle is required, single woollen weft may be used, and still the cloth styled a worsted.

One quality that should, generally, be paramount in worsted fabrics is smartness and brightness of weave and colour.

### (5) *Union Fabrics: Piece-dyes and Fancies.*

Several classes of union cloths are of modern construction and manufacture. Until a few years ago the term "union" was mainly descriptive of fabrics composed of cotton warp and thick mungo or shoddy weft, or cloths which still largely constitute the low branch of the woollen industry. Now the word has a broader meaning, union fabrics being variously constructed. For example, the *warp* may be worsted, and the *wefts* fine cotton and woollen, in making a cloth in imitation of a solid worsted; or in the better quality of union, the *warp* worsted, and the *weft* woollen. One of the principal objects to be attained in the manufacture of unions, is the production of a type of fabric of similar qualities to cloths made in the higher branches of the trade, as cheaply and economically as possible. There is a like diversity in weight and style of cloth as in the woollen trade. The finish is equally diversified.

Piece-dye unions are distinctly imitations, in appearance and other qualities, of woollens of the milled and raised type. Meltons, presidents and pilots are the more important varieties. The routine of finish has, therefore, to be similar to that of all-wool fabrics. But in structure, scheme of weaving and other technicalities, unions are distinct from woollen cloths, of which they are imitations at a reduced cost. Union costume fabrics are similar in colour and finish to light-weight dress-face woollens. Presidents and pilots resemble, in surface characteristics, the woollen beaver cloth. The degree of lustre developed in these fabrics, considering the materials used, shows the skilful manufacture practised in their production. Invariably the warp is cotton and the weft thick mungo or shoddy, and hence the woven structure has to be such as to conceal the cotton yarn and make it feasible, by felting and raising, to cover the face of the cloth with fibre, which can only be obtained from the weft yarn. If a beaver and a president are compared, the superiority is obvious in the fulness and fineness of fibre in the pile of the woollen production. This is not remarkable when it is considered that both the warp and weft yarns have contributed to this fibrous condition, and the larger proportion of threads to the inch than in the union.

Worsted piece-dye unions are fabrics in which the worsted warp alone shows on the face, with a binding cotton weft thread and mungo yarn for the back. To improve the handle and appearance of the cloth, the under side is raised, the face being treated as in the finishing of a worsted.

"Union fancies" are chiefly utilised in the ready-made clothing industry. Whatever quality of texture, nature of colouring or design are originated in fancy worsteds and woollens, are reproduced in these lower grades of woven manufactures. The designations applied to the genuine woollen or worsted are also used for the low-class fabric.

The chief methods of union cloth manufacture comprise:—

| | WARP. | WEFT. |
|---|---|---|
| 1. Union prints . . . | Cotton. | Mungo. |
| 2. Low-class fancies . . | Soft spun cotton twist. | Mungo or shoddy. |
| 3. Low Cheviots . . . | Shoddy. | Shoddy. |
| 4. Low woollens . . . | Mungo. | Mungo. |
| 5. Union worsteds: Costumes | Part cotton twist and part worsted. | Same as warp. |
| 6. Union worsteds: Coatings | Worsted. | Cotton and mungo. |
| 7. Union blankets and rugs . | Cotton. | Shoddy or lustre worsted noils. |
| 8. Dress fabrics . . . | Cotton. | Lustre worsted or mohair. |
| 9. Flannels . . . . | Single cotton. | Single cotton. |

The first type closely resembles a woven pattern, but the texture of the cloth is naturally harsh and wanting in tone. Classes 2 and 3 also approach the woollen fabric in effect, the best qualities of the fibre being developed in finishing. Some union fabrics, *e.g.* Group 5, are as satisfactory in the finished cloth as a worsted for wearing in a warm season, on account of the cool quality of the cotton. Rugs, dress fabrics and flannels also form important branches of the union trade.

Unions of all grades have a useful place in the woollen industry, constituting the chief source of utilisation of otherwise textile waste products.

### (6) *Whipcords, Buckskins, Venetians, Cords and Twist-warp Fancies.*

These are woollen fabrics in which the weave effect may be almost as clear and decided in tone as in a worsted fabric. The reason for this is that the warp yarns are folded, or two threads twisted together, varying in degree of twine according to the character of the cloth required. This process of doubling or twisting yields a level thread, one adapted for giving a more precise effect to the weave structure than the ordinary single woollen yarn. In order to prevent undue hardness in the texture which twist yarns sometimes produce, the weft is usually soft spun, and may be slightly thicker in counts than the warp.

One of the simplest and oldest kinds of these fabrics is the "whipcord," of which the weave is an ordinary $\frac{3}{1}$ warp twill. The cloths are well felted to give the sound wearing quality which is requisite. The "buckskin" is another standard woollen, of a finer twilled effect, than the "whipcord". It is the reverse in character to a "doeskin". Both cloths are excessively milled, yet one is a soft fibrous texture and the other a pronounced, but fine twill, due to the twist warp. The "Venetian" is similar in construction to the "buckskin," but finer in the weave. It is the standard covert coating cloth, and may be produced in three qualities: (1) With the fine twilled weave clear and distinct, when the warp yarn is twofold, either worsted or woollen, and the weft single woollen; (2) single yarns in warp and weft, and the fabric slightly raised in finishing, subduing the twill effect; and (3) the piece-dye Venetian, with the twill either clearly developed or softened by raising the fibre, and in which the warp yarn may be either single or twofold.

Woollen ribs or cords, *e.g.*, Bedford cords, are frequently twist, or folded yarns in the warp. The pattern consists of ribs or reps, the fulness of each stripe due to the weave structure being increased by inserting thick wadding threads between the face warp and the weft. The weft is arranged to stitch the warp in twill or plain order and float on the back of the cords alternately; that is, if the odd picks form the face effect in one cord, they appear on the under side of the adjacent cord and the even picks *vice versa*. Finishing should develop this structural feature of the fabric by milling moderately to produce cover on the back, and by cutting close to remove, from the face, extraneous fibre.

Whipcords, buckskins, Venetians and Bedford cords, even when striped and checked with fancy colours, are woven in standard weaves, to which the same designations are applied.

Twist-warp fancies obtain in light, medium and heavy fabrics. In the extreme fancy manufactures for costume and similar cloths a rich variety of twists is used. Such folded yarns may be composed of woollen, worsted, mohair, cotton and other fibres. In no type of texture and pattern are more pronounced changes developed in finishing than in those consisting of knop or flake twists. Prior to milling and raising, the projecting parts of the folded yarns may be of solid knops of fibres. By raising, each compact mesh of fibres forming such spots or knops are spread or combed over the face of the fabric.

(7) *Heavy Woollens: Box Cloths, Beavers, Pilots, Meltons.*

These are typical of the substantial heavy woollen cloths made of wool and wool substitutes, ranging from 28 to 36 oz. to the yard. Such cloths are necessarily hard felted, being set from 80 to 90 inches in the reed, if made of wool of good fulling property. . It is only possible to obtain cloths of this weight by two other methods than milling. First, the use of thick yarns; second, of compound weaves. Neither method would produce the sound, firm and compact texture which characterises box cloths and meltons. If the weight resulted from thick yarns, the texture would suffer in fineness, and if from using a compound weave, in firmness of construction. Excessive milling is, therefore, an essential in the finishing of this heavy kind of cloth.

"Box cloths" are made in several shades of drab. Wool dyeing is usual to secure a perfectly even colour in the finished cloth. Fabrics so well milled are not so porous as an ordinary woven or milled texture, and as a consequence the dye would penetrate less freely, hence the advantage of wool dyeing. Carriage cloths, with either a lustrous or semi-lustrous face, should be classed with box cloths, being of a similar structure and felted character. One of the common weaves for both box and carriage cloths is the $\frac{2}{2}$ twill cutting 2's, the alternate picks interlacing plain giving the necessary sound build of texture.

The "pilot" cloth is not so hard and firm when finished as the box cloth. Neither has it the fineness and quality of the "beaver," which should be as lustrous and as soft in the handle as the single-make doeskin, with additional firmness and weight.

While the pilot is a single-weave fabric, the beaver is frequently backed or double. If single, the weave is a sateen or a make that brings more warp than weft on to the face, and the warp should be a better quality than the weft and have a higher raising property. There is, therefore, a difference in the methods of weaving. In the pilot, the warp and weft consist of medium counts of yarn and are equally on the face of the fabric, but in the beaver a finer and better quality of yarn may be on the face than on the back. As a result, it is feasible to obtain a smart, fibrous finish which forms the principal characteristic of the beaver cloth.

"Meltons" are another special type of milled cloth. The yarn and method of weaving may be identical with a box cloth, yet the surface of the finished fabric is different. There is no laying of the fibre in the process of raising. It is allowed to project vertically, offering the same slight resistance in whichever direction the hand traverses the face of the cloth. This is an essential quality, combined with firmness and strength of construction. Such a fibrous surface has better wearing properties than that of the doeskin or beaver, the entire mass of the ends or tips of the fibres sustaining a degree of the friction in the wear; whereas the lateral surfaces of the fibres mainly resist the friction in the beaver-finished cloth.

Another element which should be noted in contrasting lustrous pile-finished cloths with those of the melton class is, that the latter—providing all details of construction are the same—is likely to possess a greater tensile strength. The lustre applied in producing the fine pile of the doeskin does not tend to add to the elasticity and strength, but rather the reverse. The repeated processes of boiling and raising, necessary to develop and fix the brightness of pile, reduce to a greater degree the strength of the cloth than the mere raising, to produce a dense, vertical, non-lustrous pile, as in a melton.

### (8) *Friezes, Shetlands and Naps.*

"Friezes" and "Shetlands" are rough-surfaced tweeds made of coarse-fibred wool, and also of wool substitutes and mixtures of wool, shoddy and mungo. The "frieze" was originally an Irish production. It is used for heavy overcoatings. The apparent roughness of texture may be increased by raising and "napping". Friezes are made in mixtures, such as greys, browns, olives and blues. Thick yarns are used—some 8 to 10 yards to the dram—and the pieces are set loose in the loom to provide a degree of shrinkage that will partially cover the weave and develop and fix the fibrous nature of the surface of the cloth.

The "Shetland" also possesses a fibrous quality. Similar materials, counts of yarn and setting are common to both fabrics. The chief difference is in surface characteristics, the Shetland being somewhat softer in handle and more closely approaching an ordinary heavy tweed.

"Naps" form another standard type of thick overcoatings. The face of the fabric is covered with "naps" or small curls of fibres. Though possessing fulness of handle, these cloths are comparatively light. This is a feature in which they differ from both friezes and Shetlands. The nap is a development of the process of raising and "napping" or rubbing of the pile of fibres into minute beads or curls. This effect may be partially obtained by other methods. For example, when in Crossbred serges loose weave structures are employed, rapid felting occurs, and the yarns buckle or loop, causing the fabric to have a "napped" appearance on the face.

The varying shrinkage properties of fine and coarse wools, and of wool and mohair, also make it feasible to produce this curly condition of fibres in woven fabrics. Should a lustre yarn float loosely on the face of the texture, and a Saxony interweave with the warp to make a fast foundation fabric, then in milling, the Saxony, having greater felting property, causes the mohair or lustre worsted to buckle or loop. Imitation astrakhans and other curl fabrics are woven in this way. Such effects cannot be strictly defined, even when sufficiently minute, as naps, for the fibres are looped on the yarn and not raised out of the warp and weft by friction in the operation known as "napping".

### (9) *Special Types of Overcoatings.*

In addition to the standard types of thick fabrics to which reference has been made, there are special makes of heavy cloths constructed for mantles, cloakings and overcoatings. Compound fabrics with woven linings are an important variety. Here the two sides of the cloth may be different in weave, materials and colouring. Indeed, in these details, the distinction may be as marked as between a fabric and the lining used in making the garment.

When the materials for the face and back are dissimilar, *e.g.*, worsted and woollen, Saxony and Cheviot, the finishing routine for each has to be modified. As for instance, in an overcoating with fine worsted yarns composing the face texture, and Saxony yarns the under side, then the former would be a clear, smart finish, and the latter slightly raised or a "fibrous" finish, acquiring in one cloth both the characteristics of the worsted and the Saxony, yet each distinct from the other.

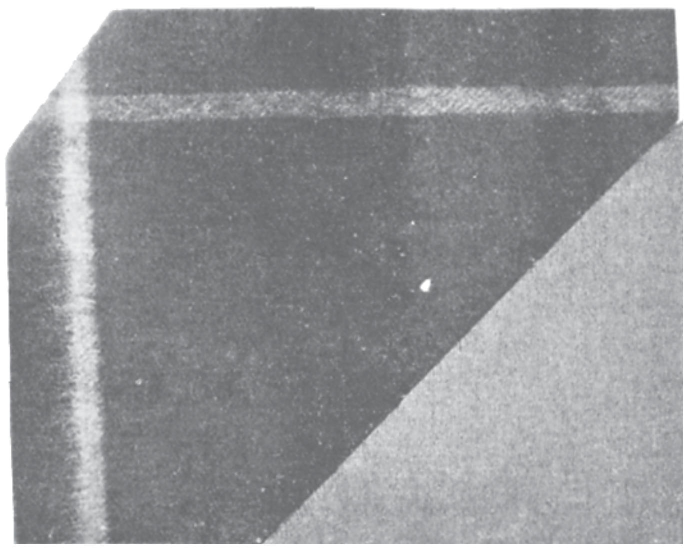
There is also a diversified class of overcoatings in mixtures and solid colours raised on one or both sides, but different in length of pile, or some other feature, from the standard cloths described. These are chiefly special in weave, being double and treble in structure. The manufacture of such cloths also involves something new, or different in yarn construction, or the utilising in the same fabric yarns of several fibres or qualities, such, for example, as Saxony and mohair, Botany and Crossbred worsted. The kind of yarn to be used is determined by the lustre and softness of texture required, and also by the length of pile to be developed on the surface of the cloth.

In reversible heavy cloths, both surfaces may be composed of the same yarn, or with a lustre yarn for the face and a non-lustre for the under side, with a fast spun yarn for the centre, giving a structure that may be heavily raised on both sides.

Generally, the fibrous-faced cloths described range in weight from 30 to 34 oz. per yard, and are set loose in the reed, 72 to 90 inches wide, for the standard width finished, according to the firmness of fabric and character of surface required for finishing.

### (10) *Golf Cloakings.*

Golf cloakings come in the same category as heavy fabrics with woven linings. They are made in a large diversity of materials and counts of yarn, and usually with quite a distinct quality of finish on the under side from the face side. In the coarser fabrics, Cheviot yarns, or yarns of a lustrous nature, are used for the face, and Saxony yarns for the lining. In the finer qualities, worsted yarns for the face and fine Saxony for the under side, as in Fig. 1. This cloth illustrates, in a typical



Back of Fabric. Face of Fabric.

Fig. 1.

way, the difference in finish, as well as in texture, possible in such cloakings. One side of it is composed of fine worsted yarns in a clear, smart twill, and finished on the worsted principle; the lining, on the other hand, is covered with fibre, being made of yarn which yields a woolly surface in the milling machine. The contrast as to texture, handle and surface, is as marked in this cloaking as between a pure Botany worsted and a pure Saxony. Strictly, there are two textures independently constructed, though regularly stitched together in weaving. This principle of fabric structure and finish applies to the many kinds of mantle, wrap and rug cloths.

(11) *Vestings.*

Perhaps no type of woven fabric is produced in so many schemes of manufacturing as fancy vestings. They are knitted as well as woven, in simple and complex designs. An almost unlimited range of yarns is utilised in their construction. It follows that the finishing routine is alike diversified.

Technically, the typical methods of weaving are as follows :—

(*a*) Solid worsted vesting, in weave compounds, weighing approximately 10 oz. per yard, narrow width.

(*b*) Saxony warp and weft vestings, for heavier cloths, 13 to 15 oz. per yard, narrow width.

(*c*) Woollen Cheviot vestings.

(*d*) Union vestings :—

(1) Cotton warp, worsted weft.

(2) Cotton warp, woollen weft.

(3) Fine worsted warp, closely set with cotton binding weft and woollen weft for backing.

These methods of manufacture may be modified according to the kind of fabric to be woven. Silk, or mercerised cotton, form the extra yarn in the finer fabrics, but worsted, in bright shades, is preferable for Saxony and Cheviot vestings. The Saxony cloths are frequently double in structure, and the spottings or other effects on the face are due to reversing the weaves and yarns.

## CHAPTER II.

### PROCESSES OF FINISHING AND THEIR EFFECTS.

(12) Qualities of Unfinished Woollens. (13) Worsted Fabrics and Finishing. (14) Preliminary Work. (15) Finishing Processes. (16) Scouring and the Detergents Used. (17) Hydro-extracting. (18) Tentering and Drying. (19) Felting and its Effects. (20) Condition of the Piece in Milling. (21) Potash and Soda Soaps. (22) Effects of Raising. (23) Influence of Textural Conditions on Raising. (24) Theory of Raising and the Twine in the Yarn. (25) Fabric structure and Raising Surface. (26) Several Kinds of Raising—Dewing. (27) Lustring Processes. (28) Pressing.

### (12) *Qualities of Unfinished Woollens.*

ALL woollen fabrics in the unfinished or "balk" condition, or when removed from the loom, have a loose, thready structure, and may be easily unravelled, or the warp and weft yarns separated. The interlacings of the weave are also clear, and there is an absence of cohesiveness of fibres in the individual threads. In this condition, the strength and elasticity of the fabric are chiefly determined by the frequency with which the warp and weft are interlaced in weaving. The quality and soundness of the yarns primarily affect the tensile strength of the cloth; but, prior to finishing, the fabric, in any quality of yarn, owes its firmness of structure solely to the operation of weaving. Density and fastness of texture also vary with the degree of mechanical compression applied to the yarns in the loom; hence the terms "hard" and "loose" woven. With yarns of the same counts or diameter, using a similar weave structure, two cloths may differ in compactness from each other, one being open and the other firm in "make" or build. But this is a difference which only modifies, in degree, that distinctness of threads characterising the loom-felled fabric, which the processes of finishing may entirely obliterate.

Softness and elasticity of texture, freshness of colouring, clearness of weave, and smoothness of surface are wanting in the greasy woollen piece. Finishing changes the cloth in all these qualities. Comparative harshness of handle is due (*a*) to the threadiness described; and (*b*) to the grease and dirt with which the yarns are impregnated. The processes of scouring and shrinking eradicate these textural conditions. Finishing thus, in a general sense, improves woollen fabrics in softness, density, soundness of structure, brightness of texture and design. In specific cloths, such as those milled and raised, finishing produces new qualities, *e.g.*, a fibrous surface, a lustrous smooth pile of fibres, or a dense, velvety pile; and these in fabrics which, when examined in the loom, have an ordinary woven structure and character.

### (13) *Worsted Fabrics and Finishing.*

There is an important difference between fabrics made of woollen and worsted yarns, when contrasted unfinished. The worsted more closely resembles the finished fabric, both in structure and appearance, than the ordinary woollen. As shown, the latter is invariably modified in several essential features. This does not necessarily follow in worsteds of the Botany class. Here finish should develop the qualities of texture produced in the loom. A worsted is strictly a loom-felled fabric as distinct from a texture changed in density and other technical features after weaving. The main causes of the closeness of comparison between a worsted unfinished and finished are (1) the relatively clean condition of worsted yarns; and (2) the even, smooth, bright surface they possess, and which the finishing of the fabric should enhance.

Yarn structure is a controlling element in the routine of finish applied to the fabric. Botany and Crossbred worsteds are examples of this, as are also Cheviot and Saxony woollens. In the case of the Botany, the first end to be attained is preservation of the qualities of the yarn; and this at once limits the possibilities of "finish". But if this were not the object, the true worsted, when considered in relation to finishing routine, is not comparable with the typical woollen in fibrous density. Length, quality and fineness of fibre may obtain to a much fuller degree than in the woollen; but the lack of density detracts from the value of the thread for giving a fabric capable of like varied treatment in finishing. Fibrous bulk is essential in the cloth when it has to undergo the processes of milling and raising. The improvement of textural characteristics, rather than the alteration of them, is therefore in finishing worsteds a necessary sequence, and one over which the finisher has only measured control. The ideal "worsted" finish adds to the softness and brightness of texture, and clearness of weave and colouring. It gives a permanent evenness of surface, one in which the qualities of the threads are better "set," and if slightly milled, additional elasticity and fulness of fabric.

In Crossbred worsteds, there is not the same variety of finish as in Saxonies, but it is possible to felt to a considerable degree, and this results in marked changes in the fabric due to finishing. Crossbred worsteds are fabrics in which either a bright or rough surface may be developed after weaving. A Crossbred is distinguishable from a Botany by (1) its crispness of feel and (2) its lack of softness of surface. Rough Crossbred serges are *milled* and not merely *shrunk*. According to the weave structure and the roughness and serge-like effect wanted, they are set from sixty-eight to seventy-five and more inches in the loom for fifty-seven finished. Felting here is obviously comparable to that applied to Saxony woollens, and the results as to weave indistinctness and want of clearness of surface in the texture are similar. But one distinctive feature remains, namely, brightness due to the worsted yarn. In the finer Crossbred cloths, made of fine yarns, and simple in weave, the staple of the wool used is somewhat of a Botany nature, so that the finished qualities, as to smartness and weave precision, approach those of the Botany worsted. The unmilled or slightly shrunk fabrics, comprise costumes and suitings, and are similarly modified in finishing as Botanys. When milling forms a substantial part of finishing, the textural conditions are quite changed, as in heavy Crossbred overcoatings, which are covered with pile similar to a woollen, bright or semi-lustrous in tone. This type of Crossbred is varied in density, elasticity, weight and surface features by finishing.

### (14) *Preliminary Work.*

Finishing relates to all the processes to which the fabric is subjected after being woven. Each process does not necessarily effect a change in the fabric. The preliminary operations of perching, knotting, mending and burling are corrective work concerned with the eradication of defects occurring at some stage of manufacture.

The first handling of the piece, after weaving, is done by the percher, preferably in a north light, with the object of detecting faults due to the yarn, imperfect weaving, or irregular action of the loom. The work is comparatively simple, but requires judgment, quickness of sight, and some knowledge of fabric structure. All faults are marked and, as far as possible, repaired before scouring.

Knotting consists in first examining the piece on the under side, the knots being detected by touch as well as by the eye, and drawn by burling irons on to the back of the cloth and carefully removed: subsequently the face is similarly examined. When uneven parts in the yarns have to be taken out, it is done by the mender, new yarns being inserted.

Mending, like knotting, may be done both before and after scouring. Defects are liable to occur even in satisfactorily woven fabrics which require the attention of the mender. Common causes of faults in the piece are broken picks, and want of care on the part of the weaver in picking up broken threads. The finer the fabric, and the more intricate the weave, the more difficult this work. The correct interlacing of the weave structure has to be followed in inserting new threads, whether of warp or weft.

Burling is also a preliminary work. In the union trade, burl dyeing, that is, dyeing the cotton yarn in the piece, is practised, but in the woollen trade, burling is the operation of removing specks of vegetable matter, such as broken burrs, which have remained in the wool through the processes of carding and spinning. In pieces composed of cotton and wool, in which the yarn, either warp or weft, may be Angola, the cotton may be stained by applying to the surface of the cloth a diluted solution of ink. This is done in the inking machine, Fig. 2, where the piece passes round guide rollers and over roller C. The lower roller A revolves in the trough containing the solution, so that

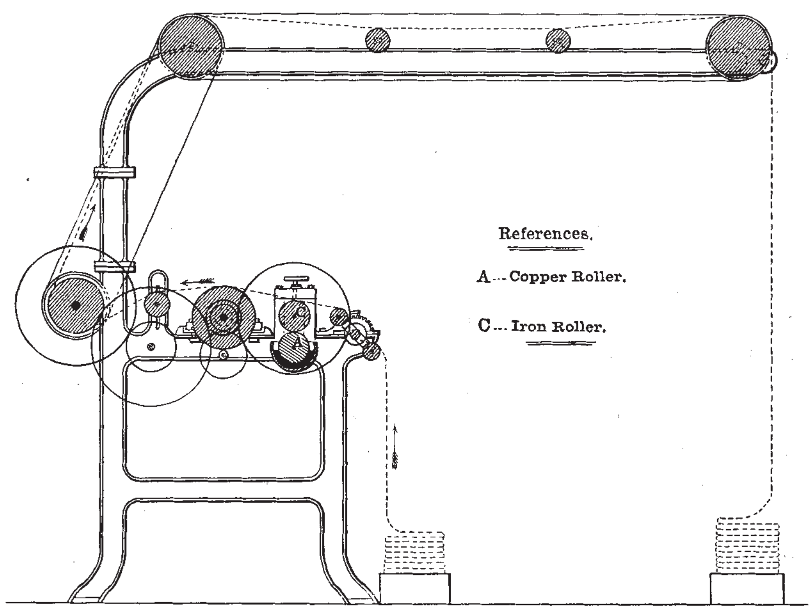



FIG. 2.

the upper roller carries some of the solution from A on to the fabric. The piece now passes over a revolving brush and round suitable guide rollers overhead, as shown. This process is repeated until a sufficient quantity of ink has been applied to colour the cotton. The stain more effectively penetrates the yarn if the pieces after inking are taken to the brushing machine or mill, and brushed on both sides in succession, first without and finally with steam. Woollen fabrics, in which there is a quantity of vegetable matter, broken burrs, etc., are carbonised, that is, placed in a bath of diluted sulphuric acid, and then dried at a high temperature.

### (15) *Finishing Processes.*

Finishing processes (after the preliminary work described) comprise scouring, hydro-extracting, tentering, milling or felting, raising, cutting, napping, blowing, crabbing, boiling, dewing, brushing, steaming and pressing. The routine is divided into three departments, namely, the scouring and milling or *wet* processes; raising and boiling for woollens, crabbing and brushing for worsteds; and the cutting, pressing and steaming, or *dry* processes. In the factory these are natural divisions, there being a foreman for each section. For another reason they are kept separate; the nature of the work is so different and can be more accurately controlled when in the departments named.

In these sections no mention is made of tentering, which again is separate and in a convenient part of the mill for obtaining steam for drying purposes.

### (16) *Scouring and the Detergents Used.*

The pieces having been perched, knotted and mended, are ready for scouring, the object of which is to thoroughly cleanse the cloth from grease and other impurities. Loom qualities possessed by the fabrics, namely, harshness of handle and threadiness, should be removed, and softness and loftiness of touch imparted, leaving the colours clear and bright, and with the surface of the fabric free from creases. During scouring, the fibres and threads are compressed into closer contact with each other. The pieces, when impregnated with soapy lather, are in a condition favourable to felting; but felting should not form an essential part of scouring, though some allowance is made for shrinkage of woollen pieces in this process when determining for the finished width.

Piece scouring, like that of yarn and wool, is a chemical and mechanical process. A German system, in which experiments are being made, consists in extracting the grease and dirty matter by means of electricity. The pieces run in a continuous length and full width from end to end of the machine. In the first place, the pieces enter the tank containing the liquor charged with electricity, then pass between squeezing rollers and into a second tank containing water for washing off. Here, the pieces pass to the bottom of the tank, round guide rollers, then between pairs of squeezing rollers, the process being repeated several times.

The principal detergents used in the ordinary methods of scouring are fuller's earth, soap and alkalies (soda and potash), and special compounds such as soap ash. Fuller's earth is suitable for washing after dyeing, as it removes any particles of dyeware.

If vegetable oils, olive or Gallipoli, have been used preparatory to carding, as these oils do not readily saponify, they have to be removed from the piece by emulsion, and soap and an alkali are used for this purpose. When olein has been the wool lubricant, it is possible to scour the cloth by means of an alkali only; about 20 lb. of soda ash or 30 lb. of pearl ash will saponify 100 lb. of olein or fatty acid. Standardisation is desirable in scouring solutions. This is done by combining a fixed percentage of soap and alkali with given volumes of water; as, for example, 5 lb. of curd soap with 3 gallons of water, and 2 lb. of potash with the same volume of water. The degree of alkalinity should be higher in heavy greasy cloths, and lower in comparatively clean fabrics and in pieces in which bright colours occur.

Soaps as near neutral as possible are the most useful for both scouring and milling. A soap containing more than 0·75 of free alkali should not be used. The following are analyses of hard and soft soaps of good scouring properties:—

| | Tallow Soap. | Curd Soap. |
|---|---|---|
| | Per cent. | Per cent. |
| Free Alkali, NaOH | 0·16 | 0·40 |
| Combined Alkali, Na | 5·75 | 5·75 |
| Fat | 69·19 | 64·85 |
| Moisture | 24·90 | 29·00 |
| | 100·00 | 100·00 |

POTASH SOAP.

| | Per cent. |
|---|---|
| Free Alkali, KOH | 0·156 |
| Combined Alkali, K | 8·307 |
| Fat | 44·400 |
| Potassium carbon | 3·657 |
| Moisture | 43·480 |
| | 100·000 |

Soap-ash compounds, which are used for scouring goods in which olein has been applied to the materials prior to carding, are composed of sodium carbonate and water, in the form of soda crystals, with soap, as seen from the analyses below :—

I.

| | Per cent. |
|---|---|
| Sodium carbonate | 26·818 |
| Water | 70·300 |
| Soap | 2·882 |
| | 100·000 |

II.

| | Per cent. |
|---|---|
| Sodium carbonate | 36·464 |
| Water | 58·800 |
| Soap | 4·736 |
| | 100·000 |

In washing fancy fabrics strong alkalies should not be used, as they have an injurious effect on bright colours, causing them to run or bleed. Excessive alkalinity of the scouring solution also tenders the fibres and lessens the elasticity of the fabric. Dulness or want of tone in the colours and of the fabric may be produced (1) by imperfect washing off; and (2) by the "scour" not having neutralised the greasy matter in the cloth.

(17) *Hydro-extracting.*

After washing off, if the hydro-extractor is not used, the pieces are passed through the wringer before tentering. The wringer is made in two forms, with one or two pairs of rollers. In the latter machine, the lower roller of the front pair is flanged, and the back pair without flanges are covered with indiarubber composition. The speed of the rollers varies from 90 to 100 revolutions per minute.

The hydro-extractor is another method of expelling the moisture from the piece. It consists (1) of the outer case work, and (2) of the metal basket or cage, which may be either on fixed or elastic bearings, and speeded to make from 1,200 to 1,500 revolutions per minute. When the machine has been loaded, by evenly distributing the piece in the twisted condition round the cage, the centrifugal velocity expels the water through the perforations of the cage, and leaves the piece in an open, free condition. On this system there is little possibility of the fabric being creased, as might be the case with the use of the wringer in pieces made of Crossbred worsted, mohair and lustre worsted yarns.

### (18) *Tentering and Drying.*

At this stage the pieces should be measured in width and length, so that the shrinkage may be fixed for milling. Tentering may at once follow; it straightens the piece for subsequent work. This may be done on the hand tenter bars or by machinery. Tentering in the open air on tenter bars, or natural drying, imparts a better condition to the cloth, the fibres being softer and the texture fuller in the handle, hence the preference in the blanket trade, wherever possible, for open-air tentering.

The usual form of automatic tentering for woollen and worsted cloths is shown in Fig. 3. The piece enters the machine from a raised table, A, being hooked on to the tenter chains at each list, and passes from the upper to the lower tier of steam pipes in succession, being delivered by an ordinary folding mechanism, D. The machine possesses a superheater for utilising the hot air, instead of an ordinary exhaust fan which is employed in other machines. The number of tiers may vary.

Another method of hot-air drying is adopted in treating certain classes of rugs, imitation sealskins, astrakhans and other pile fabrics, vertical tenter bars or frames being used for this purpose. An installation of this kind is shown in Fig. 4, and consists of an air heater and two fans. These distribute the hot air, at a temperature of 120° F., through pipes which extend the length of the room, and have frequent outlets so that the air penetrates the pieces. The tentering room can be cooled in a short time by closing the hot-air outlets and admitting cold air, to allow the workers — if pile fabrics are being treated — to beat the pieces on the underside to force the fibre out of the foundation of the fabric.

In a second system of this character, adapted to the drying of woollen and worsted cloths, the pipes are fixed in the floor or a little above it, the fan drawing the heated air through the pieces which are hung on rails. If needed, valves are provided so that the warm air, when sufficiently dry, can be circulated back through the fan and re-heated, obtaining a high tem-

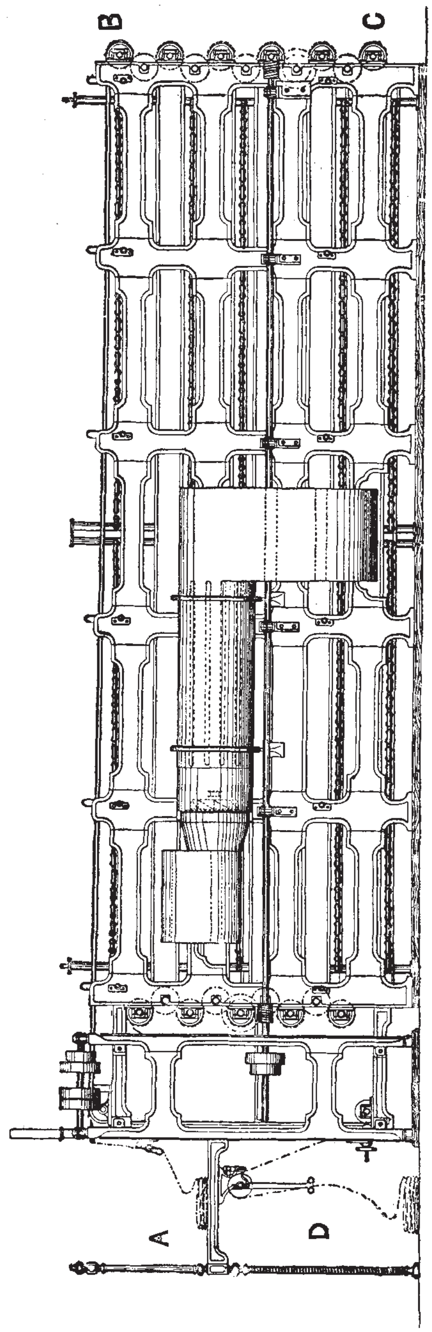


Fig. 3.

perature by an economic use of steam. With either installation, by having separate connections to each section of the heater, the temperature of the air can be readily regulated.

After the process of tentering, if the piece is a woollen, it is covered with loose or balk fibre which has developed on the surface. This fibre is a valuable quantity in milling. What-

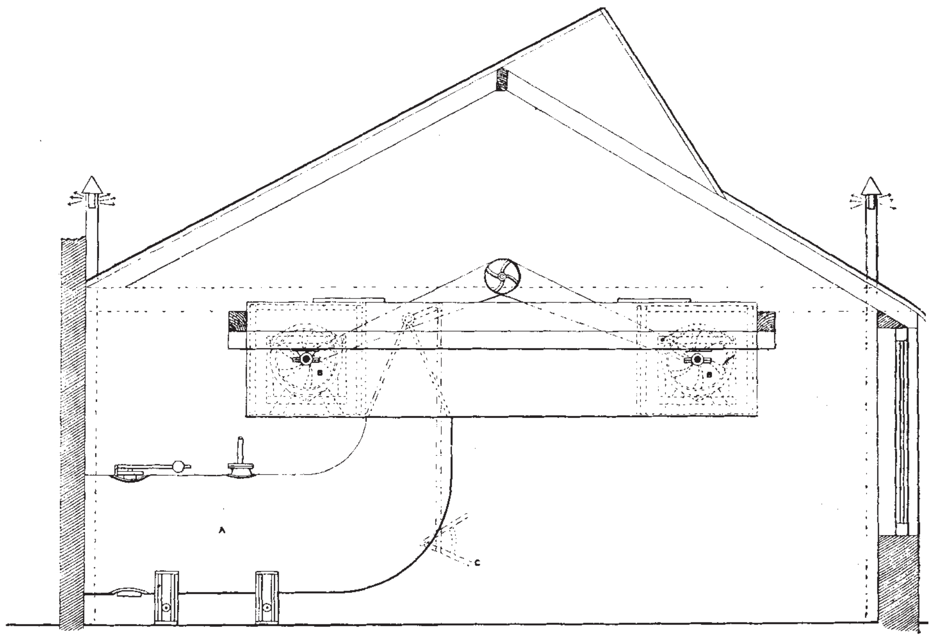



FIG. 4.—Section of a tentering room with air heater and revolving fans.

A = *Super heater*. B = *Revolving fans*. C = *Regulating valve*.

ever the yarns or materials used, tentering imparts a dry and somewhat unnatural handle, but this is removed by subsequent processes.

Pieces lose weight in tentering, not only by the evaporation of the moisture they contain after hydro-extracting, but by drying to such a degree as to take off a percentage of the humidity which the material naturally absorbs. This weight the fabric regains in normal atmospheric conditions.

### (19) *Felting and its Effects.*

The power of contraction of a woven fabric is primarily due to the fulling property of the wool, which is the source of more radical change in finishing than any other quality in the material. It modifies the fulness, elasticity and wearing strength or durability of a woven fabric, and also produces certain textural characteristics which render diversity of finish feasible in woollen and other fabrics.

Density of texture due to felting or fulling differs in degree and nature from the compact union of threads, the result of weaving. Porousness and looseness of structure are substituted by fibrous homogeneity, in the process of felting. Literally, to full or felt is to add to the thickness or substance, but to reduce the length and width of the piece. Even if the fibres in a woollen fabric had a smooth surface, they would, in the routine of yarn manufacture, entwine and form entangled meshes. Fulling is more than this. It is the compression into a dense mass, of threads separately interlaced, and of the fibres of which they consist. Contact is succeeded by cohesion of fibres. The fibrous change is of a physical and chemical nature, the chemical action of the soap or fuller's earth applied to the piece originating conditions which are necessary to fulling. The threads are rendered more pliable and the fibres softened by reason of their hygroscopic properties. Contraction in the piece is progressive throughout milling, the individual fibres gradually filling up the interstices which are such a feature of the scoured cloth.

### (20) *Condition of the Piece in Milling.*

The piece may be milled before or after scouring. The former is termed "raw-thread" milling, the piece being in the greasy state, and is practised when softness as distinct from firmness of fabric is desired.

When milling follows scouring, the pieces, after hydro-extracting, may be cuttled up and allowed to rest for a period, or, in light felting, immediately placed in the milling machine. Evenness of soaping is most important. Should some parts of the fabric be more freely treated than others, irregular felting will ensue, and possibly develop flakes or patches. There are two methods of preparing the pieces for milling: (1) by applying the soap and placing the pieces for a short time in the stocks; (2) by running the pieces through the lecker or soaping machine. This machine consists of a trough containing a standard fulling solution, entering which the cloth passes under guide rollers immersed in the soap, and then through a neck to a pair of squeezing rollers. The quantity of solution carried off by the fabric is regulated by the pressure applied as it passes between the rollers. An excess of soap induces the pieces to slip too freely between the compressing parts of the milling machine, and gives sponginess of handle, whilst if the quantity of soap is insufficient, a waste of fibre ensues, and the period of felting is unduly prolonged. The proper condition is one of uniform soapiness without the formation of a lather. There should be indications of the soap on the surface without a tendency to scour. The action of the fatty matter in the soap imparts pliability to the fibres and smoothness to the surface of the fabric, diminishing the quantity of flocks produced by the constant friction in fulling.

### (21) *Potash and Soda Soaps.*

The shrinkage of wool, in whatever period of manufacturing,—*i.e.*, in layers of carded fibres, the spun thread, or the woven fabric,—is caused by applying to the material a solution of soap or fuller's earth. A portion of the soapy compound is held in the interstices of the threads, and a portion absorbed by the fibres. As, however, this process of absorption commences and continues when the pieces are under compression, the area in which the fibres are lodged being diminished, impels them into closer contact with each other.

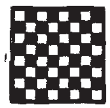
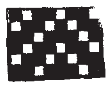
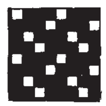
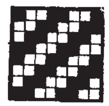
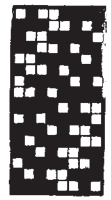
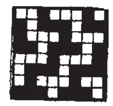
The nature and chemical composition of the soap applied to the piece affects the process of shrinkage. The relative value of potash and soda soaps on Cheviot and Saxony yarns in several weaves and settings is stated in Table I. By using a cotton warp in the fabric, the contraction in length is almost *nil*, so that the comparison is distinctly upon the woollen yarns and in the direction of the weft. The conditions as to pressure in fulling, temperature and periods of milling, are identical in each case.

Table I.

MILLING PROPERTIES OF SAXONY AND CHEVIOT FABRICS WHEN TREATED WITH POTASH AND SODA SOAPS.

Potash Soap. A.

Warp—2/20's cotton. Sett—12's reed 2's. 31 inches wide in loom.

| Plan Nos. | I. | II. | III. | IV. | V. | VI. | I. | II. | III. | IV. | V. | VI. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| |  |  |  |  |  |  | | | | | | |
| Class of Wool. | Saxony. | | | | | | Cheviot. | | | | | |
| Counts of Weft | 20 skns. | 20 skns. | 20 skns. | 20 skns. | 20 skns. | 20 skns. | 22 skns. | 22 skns. | 22 skns. | 22 skns. | 22 skns. | 22 skns. |
| Picks per inch | 40 | 50 | 55 | 57 | 64 | 80 | 40 | 50 | 55 | 57 | 64 | 80 |
| Width in loom | 31″ | 31″ | 31″ | 31″ | 31″ | 31″ | 31″ | 31″ | 31″ | 31″ | 31″ | 31″ |
| Width out of loom | 27½″ | 27½″ | 27½″ | 27½″ | 27½″ | 27½″ | 28½″ | 28½″ | 28¾″ | 28¼″ | 28¼″ | 28¾″ |
| Width after Scouring | 26″ | 25″ | 24¾″ | 24″ | 23½″ | 24″ | 26½″ | 26″ | 26″ | 26″ | 25½″ | 25½″ |
| Width after Milling, First Period | 20½″ | 20½″ | 20½″ | 20″ | 20″ | 20″ | 25″ | 22½″ | 22½″ | 22½″ | 20½″ | 22″ |
| Do., Second Period | 20¼″ | 18″ | 16¾″ | 17″ | 18″ | 16¾″ | 21½″ | 18″ | 17½″ | 17″ | 18½″ | 17½″ |
| Do., Third Period | 19″ | 17″ | 16¼″ | 16″ | 17″ | 16″ | 20″ | 17″ | 17″ | 16½″ | 17½″ | 16¾″ |
| Do., Fourth Period | 18″ | 16¾″ | 15½″ | 15½″ | 15¾″ | 15½″ | 19½″ | 16″ | 16¼″ | 16″ | 14½″ | 15¼″ |

Soda Soap. B.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Width after Milling, First Period | 21½″ | 19½″ | 19½″ | 19½″ | 19″ | 19″ | 24″ | 21½″ | 20½″ | 21¼″ | 19½″ | 21″ |
| Do., Second Period | 20½″ | 19″ | 18½″ | 19″ | 18½″ | 18¼″ | 23½″ | 21″ | 19¼″ | 20¼″ | 18½″ | 19″ |
| Do., Third Period | 20½″ | 18½″ | 17½″ | 18″ | 17″ | 17¼″ | 22″ | 19½″ | 18½″ | 19″ | 16¾″ | 17″ |
| Do., Fourth Period | 19¼″ | 17½″ | 16¼″ | 17″ | 16½″ | 16″ | 20½″ | 18¼″ | 17″ | 17¾″ | 15¼″ | 16¾″ |

Quantity of Soda Soap = 9 °/ₒ of the weight of the piece. Quantity of Potash Soap = 7 °/ₒ of the weight of the piece.

*Foldout rotated 90° to fit on page.*

The analyses of the two soaps in which these comparisons are made are as follows:—

| POTASH SOAP. | Per cent. |
|---|---|
| Combined alkali, K . . | 8·97 |
| Free alkali, KOH . . | traces |
| Fatty acids . . . . . | 43·50 |
| Water . . . . . . | 47·53 |
| | 100·00 |

Actual percentage of soap, 52·47 per cent.

| SODA SOAP. | Per cent. |
|---|---|
| Combined alkali, Na . . | 5·30 |
| Free alkali, NaOH . . | 0·50 |
| Fatty acids . . . . | 59·72 |
| Water . . . . . | 34·48 |
| | 100·00 |

Actual percentage of soap, 65·02 per cent.

The milling results are stated in four periods, after the pieces have been in the machine 30, 60, 90 and 120 minutes.

The fulling period not only alters the measure of shrinkage, but when two or more wools are combined of different felting properties, it produces other effects in the piece. Table I., however, indicates mainly the difference in the behaviour of the two wools, Saxony and Cheviot, in the periods named. In the first period, the highest felting in each weave is with the hard soap; in the second period with the potash soap, and the increase in felting is maintained with the potash throughout the third and fourth periods, showing that if rapid and light shrinkage is needed, the soda soap is preferable; but if heavy shrinkage, continuing for some time, then the potash is the more satisfactory.

Taking the plain weave and the $\frac{2}{2}$ twill, the following are the felted results from a piece 31 inches wide in the loom:—

TABLE II.

POTASH SOAP.

| Milling Periods. | Plain Weave. | | $\frac{2}{2}$ Twill. | |
|---|---|---|---|---|
| | Saxony. | Cheviot. | Saxony. | Cheviot. |
| I. Period . | 20½″ | 25″ | 20″ | 22½″ |
| II. ,, . | 20¼″ | 21½″ | 17″ | 17″ |
| III. ,, . | 19″ | 20″ | 16″ | 16½″ |
| IV. ,, . | 18″ | 19½″ | 15½″ | 16″ |
| SODA SOAP. | | | | |
| I. Period . | 21½″ | 24″ | 19½″ | 21¼″ |
| II. ,, . | 20½″ | 23½″ | 19″ | 20¼″ |
| III. ,, . | 20½″ | 22″ | 18″ | 19″ |
| IV. ,, . | 19¼″ | 20½″ | 17″ | 17¾″ |

In both counts of yarns and weaves the results correspond in the two soaps, that is to say, more shrinkage in the potash than in the soda after the first period. Compare, for example, the shrinkage in the $\frac{2}{2}$ twill, Period IV., the piece having shrunk to 15½ inches with the potash soap, against 17 inches with the soda in the Saxony; and in the Cheviot, to 16 inches (potash) against 17¾ inches (soda).

### (22) *Effects of Raising.*

Raising has various effects on the condition and appearance of the fabric. A vertical or a laid pile of fibres may be produced; if the former, it is termed a "velvet" pile, and if the latter, a "dress-face" pile. A third kind of surface consists of a short, full, fibrous pile, such as obtains in a typical melton.

The nature of the pile producible and the degree in which it alters the characteristics of the cloth is seen in Figs. 7 and 8. Fig. 5 is the fabric as it leaves the loom; Fig. 6 after scouring and milling; Fig. 7 after raising the cloth damp. The difference in the conditions of these three fabrics is very marked. The prominent features in Fig. 5 are the clear twills, whether in white or colour, and the distinctiveness of the threads, warp or weft; in Fig. 6 the twills are subdued, and the warp threads concealed, the surface of the cloth having become more fibrous, and the individuality of the threads less distinct.

Raising causes the effects seen in the fabric, varying in degree and in the manner in which the fibres are spread. That is to say, the fibre which develops in felting is drawn or laid on the surface of the cloth. This should result without the individual threads—which resist the action of the raising points, whether teazles or card clothing—being disturbed.

In Fig. 7A is shown a number of the weft yarns which have been removed from the fabric. These retain their adhesiveness and have a similar appearance as the fabric proper, showing that milling and raising have caused the weft yarns to adhere to each other. If withdrawn from the loom-felled fabric, Fig. 5A, they have no such affinity. From Fig. 6A it is clear that the picks hang together prior to raising, without the warp; the drawing of the fibres from one pick to another in Fig. 7A causes

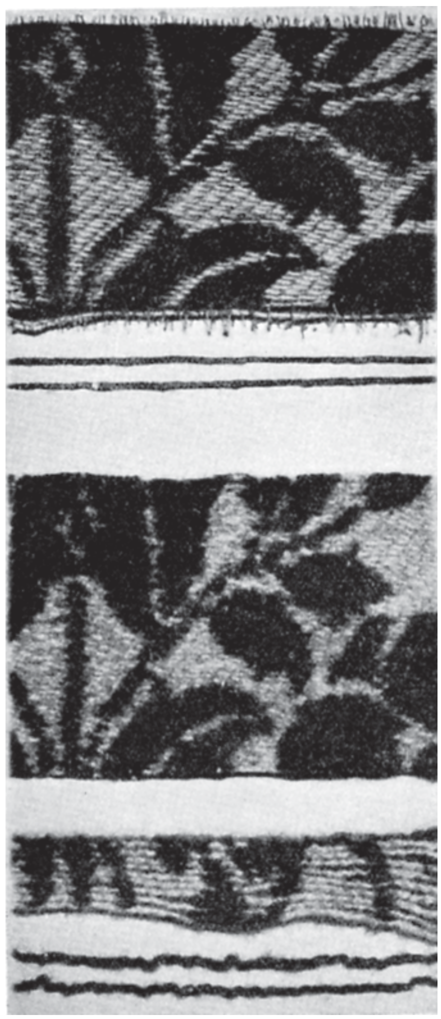


Fig. 5.

Fig. 5A.

Fig. 6.

Fig. 6A.

the materials in the successive picks to overlap each other, forming a continuous fibrous pile.

The distinctive features given to the cloth by raising are (1) fibrous surface; (2) increased softness and fulness of handle;

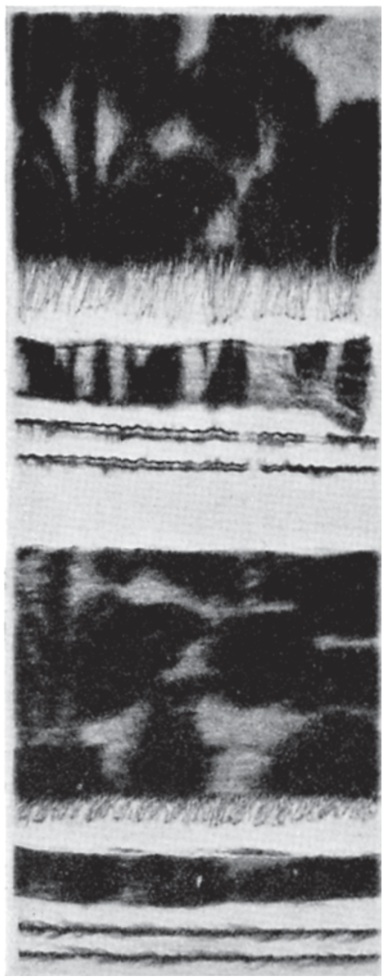


FIG. 7.

FIG. 7A.

FIG. 7B.

FIG. 8.

FIG. 8A.

FIG. 8B.

(3) concealment of the threads and weave effect; and (4) subduing of the colours and softening of the outlines of the pattern. As to the strength and elasticity of the cloth, these suffer if

raising is excessive, and if done when the cloth is in too dry a condition. The process should not, however, impoverish the cloth of fibre, nor so disturb the fibres of the threads, of either warp or weft, that the elasticity and strength of texture are diminished.

### (23) *Influence of Textural Conditions on Raising.*

First, in regard to the surface of the fabric. This should be firm and close when more than light raising is essential. The greater the degree in which the work has to be done, the sounder and closer the structure of the fabric, whether due to weaving, felting or both. If a full pile of fibres has to be obtained, there must, in addition to the closeness of threads resulting from weaving, be a "balk" or fibrous quality developed in felting. It is this difference in the surface of fabrics which is the primary cause of the variation in the raised conditions. Comparing, for example, the surface of a worsted texture with that of a hard-felted woollen, the latter is exactly of the kind to be suitable for raising and the former the reverse. To treat an unmilled worsted with the raising points of the teazles, would immediately disturb the fibres of the threads which it is the object of finishing to preserve, and this follows, because of the absence of loose, extraneous filament in a smooth thread of uniform structure. In the woollen yarn there is a fuller quantity of fibre, diameter for diameter, as compared with the worsted, and there is also more balk fibre on the surface of the yarns, which felting secures to the fabric, so that straightening and combing out of the pile is rendered possible without detaching the filament.

There are three technicalities which modify the surface of a woven fabric in relation to the process of raising, whether made of woollen or worsted yarns, namely: (1) fineness or quality of the materials; (2) structure of the yarns as to degree of twine; and (3) the structure or build of the fabric.

Obviously, the nature and quality of the wool influence the possibilities in raising. To obtain a short dense pile a finefibred wool, possessing a full, short staple, must be used; but if the pile should be of a blankety character, longer, coarser and less dense, then wools of a strong, more open staple, such as East Indian or Shetland, would give these qualities by raising. What applies to pure wool fabrics is also applicable to union textures made of mungo or shoddy; mungo, being the shorter and finer staple, is suitable for fabrics on which a pile may be raised similar in character to that of a beaver cloth; but shoddy, for fabrics in which a longer pile is required, or for the under side of union worsteds raised to give the cloth a fuller handle.

It will be readily understood, the harder a woven surface the greater the difficulty of raising. Hardness of texture is produced by firmness in weaving, by the measure of felting, and by the number of turns per inch in the yarn. Yarn doubling also minimises raising facility in the fabric, two or more threads folded together offering increased resistance to the raising points. On whatever principle the yarn is constructed, twine, greater or lesser in amount, changes the raising surface of the texture. An example of this is found in a union fabric with a mungo weft, which makes a surface that raises well and quickly to a certain degree of fulness, beyond which the resultant pile is soon impoverished owing to the short and inferior nature of the material. The weft yarn here being extremely soft in twine—only possessing a sufficient number of turns to form a weavable thread—is the primary cause of the raising quality. Fabrics of the whipcord class, in which raising only produces a surface pile, are examples of the effect of hardness of twine on raising. In these, though the material may be of a much finer character than in the mungo cloth, yet on account of the firmness with which the fibres are twisted together there is a want of raising essentials.

### (24) *Theory of Raising and the Twine in the Yarn.*

There is another important definite relation between the raising quality in the woven fabric, as affected by the twine in the yarn, and the number of turns in a given length, namely, the direction in which the threads in the cloth are acted upon by the teazles. This may be either transversely or longitudinally, the character of the pile being modified by the nature of the action. If the face of the fabric consists of the weft yarn, and raising is done in the direction of the warp, the teazles, coming in contact with the sides of the threads, more rapidly produce a pile, but it is rougher in the foundation of the texture than if

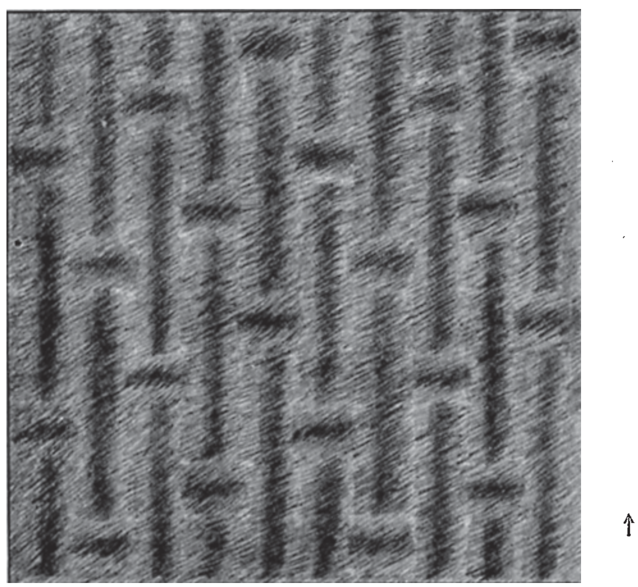


FIG. 9.

the surface of the cloth were warp and the raising points travelling in the line of the length of the thread. To obtain equal raising action, transverse and longitudinal, on the yarns, the build of the fabric has to be such as to give alternate and equal interlacings of warp and weft on the surface.

### (25) *Fabric Structure and Raising Surface.*

In raising from end to end of the piece, there are three distinct types of woven surface in regard to the direction of contact of the raising points with the yarns, namely: (1) Fabrics with a weft surface; (2) fabrics with a warp surface; and (3) fabrics with a warp and weft surface.

These three textural surfaces are shown in Figs. 9, 10 and 11. The direction of the raising point in traversing the cloth is indicated by the arrows. In Fig. 9, raising is across the thread forming a rough shag of fibres on the sides of resistance (see Fig. 7B). Naturally such action freely disturbs the normal relation of the fibres if the raising contact is severe. It is not an economical method of producing a full, close pile, in which the fibres have actually to be "raised" out of the threads. It is less detrimental in cloths made of yarns possessing a raising quality of extraneous filament.

The action on the yarns is kinder in Fig. 10, being lengthways of the thread, so that the raising points move in a line with a larger average of the fibres, and gradually comb them in the same direction. The condition of the yarns from Fig. 7 and Fig. 8 (Figs. 7B and 8B) after treatment by the two methods, shows that cross-thread raising may even destroy the continuity of the thread or reduce its fibrous compactness to breaking point, whereas raising in the direction of the yarn leaves it sound and straight. This is remarkable when the relative fulness and quality of the pile in Figs. 7 and 8 are compared. That in Fig. 7 is a degree fuller in the foundation, but there is a want of evenness of length of fibre so essential in a good pile. "Cross-thread" raising acts immediately on all fibres, long and short, on the surface of the yarn, producing a pile in a brief period, but one characterised by inequality of length. On the other hand, raising lengthways of the yarn first lays and straightens the long fibres, and more gradually acts upon the shorter ones, hence a more level fibrous surface. Obviously, if a full handling cloth is the chief characteristic wanted, cross-thread raising is satisfactory; but if this quality is required, combined with evenness and brightness of pile, then raising in the sense of the length of the thread is preferable. It should, however, be observed that the difference between these two distinctive principles of raising may be lessened by the nature of the yarns used and the amount of felting. The finer the yarn, and the larger the number of threads and picks per inch, the more felting and the greater quantity of "balk" fibre produced. In other words, if felting be continued until the yarns are "burst," the fibre resultant is more closely the same in character for raising purposes, whether due to the weft or the warp yarns. For instance, assuming the surface of the cloth to be as in Fig. 10 (warp-face sateen),

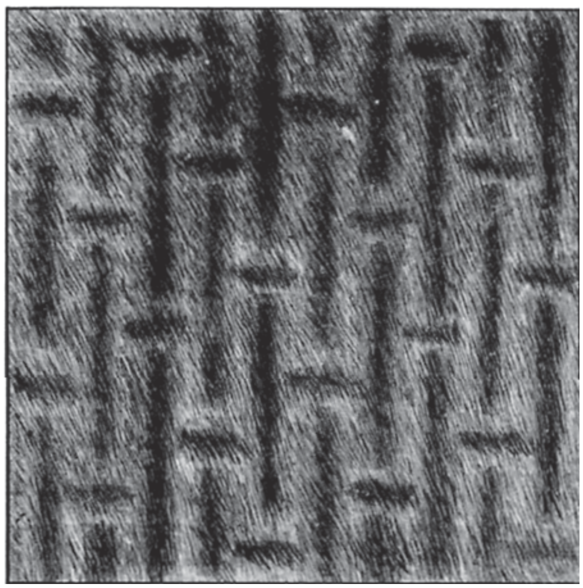


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Fig. 10.

and made of the same yarns as Fig. 9 (weft-face sateen), then, by heavy felting, the threads are so matted together as to form in each texture a surface of similar qualities for raising; that is, a layer of filament which may be treated before any new fibre is raised out of the yarns. But if the process of getting up the pile continues until the actual surface of the yarns is affected, the conditions defined in relation to the raising of fabrics, Figs. 7 and 8, are developed.

The third type of woven surface, Fig. 11, allows of an equal degree of transverse and longitudinal raising on the threads, cross-thread raising on the weft and the reverse on the warp, or *vice versâ*, according to the character of the operation. This is the woven surface which gives quality to the pile of the plain "super" and the highly-finished billiard cloth, namely, the combined effects of raising on the length and across the yarns, warp and weft. There is obtained in this way the closest and fullest pile possible.

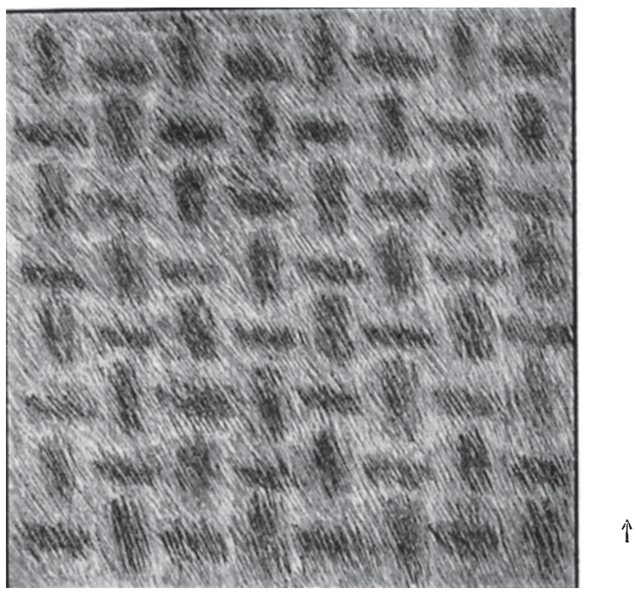


Fig. 11.

An element affecting this compound raising is the direction of the twine in the warp and weft. In Fig. 11, it appears the same in both yarns in the cloth, due to the weft being at right angles to the warp; but in Fig. 12, the weft appears the reverse of the warp, and is so in relation to raising contact. Clearly, in Fig. 11, the points of the teazles would act upon the fibres of both yarns as nearly as possible at the same angle. The only difference would be side action on the weft and the lengthway action on the warp. The direction of the fibres, whether of warp or weft, in relation to the movement of the teazles through the surface filament of the cloth, would be the same providing the turns per inch were identical in each yarn. On the contrary, in Fig. 12, the resistance of the twine of the fibres would alternate from warp to weft, producing another technical feature capable of modifying the nature of the pile obtained.

In contrast, a woven surface with the twine in the yarn, as

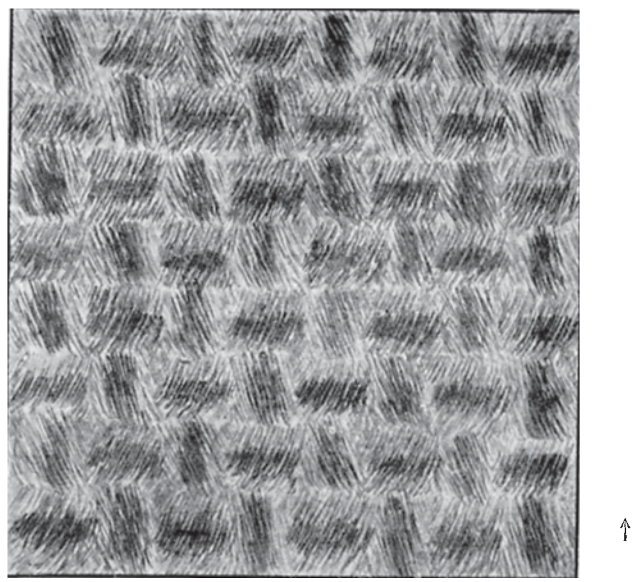


Fig. 12.

in Fig. 11, raises straighter and more level: but a greater degree of fulness of fibre in the foundation of the fabric results when the warp and weft are reversed in twine, as in Fig. 12.

(26) *Several Kinds of Raising: Dewing.*

Ordinarily, raising takes place after milling, but if it immediately follows scouring—"raw-thread" raising—it produces a pile of peculiar softness. When felting thus succeeds the raising process, it covers the weave with fibre and eradicates threadiness without rendering the fabric too firm and stiff in the handle.

"Cross" raising consists in treating the piece from list to list. By raising the cloth from end to end and then across, the density of the pile is improved, both warp and weft being operated upon transversely, and in the direction of their length.

To add to the raising properties of the wool, water is applied to the pieces, and this is known as the "wet" process. Cloths are raised in a normal state of dryness with the object of getting up the surface filament. Clear-finished fabrics are generally raised dry, the work being mild in character.

Raising moist or wet both preserves the fibre and renders the wool more flexible, making it feasible to raise a full nap with a minimum loss of "flock" or filament. All fabrics in which the fibrous pile is a distinguishing feature of the finished condition, undergo the wet process of raising. The degree of dampness depends upon the quality of the materials of which the fabrics are made, and the density of nap producible. In the harder, stiffer materials, *e.g.*, unions, the pieces are quite wet in certain stages of raising; this is also the case in woollen doeskins in the early part of the routine, improving the action of the raising points on the threads. Velvet pile cloths and "soft-finish" fabrics—with a slight draw of fibre on the surface—are, on the other hand, raised in the damp or moist state.

Whatever the condition of dampness, it should be uniform throughout the piece, or streakiness develops. The dewing machine may be used for this purpose, or the water may be sprinkled on the pieces during raising. One useful form of machine consists of a trough or tank containing the water, and a circular brush, which revolves in the same, sprays the water on to the piece. This is a simple and effective method. Another form, really a damping machine, consists of a trough, with a large rubber covered roller, and two upper rollers placed above the main roller. The former revolves in the water in the trough, the height of the water being fixed according to the degree of dampness required on the piece. The upper part of this roller is not immersed in the water, but the piece passes over it, being pressed in contact with it by the two smaller rollers. Dewing is also done to restore condition in the cloth after excessive dryness, and improves its handle.

### (27) *Lustring Processes.*

Brightness of surface in a woven fabric may be due (*a*) to the natural qualities of the wool; and (*b*) to the methods of finishing. In Sicilians and glacés—dress fabrics with a cotton warp and mohair weft—lustre is a pre-eminent quality of the fibre, enhanced by the treatment the fabric undergoes in such processes as cleansing, cutting, singeing and pressing. But in a union beaver or a similar cloth, with a cotton warp and mungo weft, brightness is artificial, not being a perceptible quantity in the raw material. In dress-face woollens and fine piece-dye worsteds, the lustre of the finished fabric is higher than in the wool in the natural state.

Lustre is developed in textile fabrics by (1) the mechanical adjustment of the fibres in (*a*) yarn construction, and in (*b*) raising; and (2) by subjecting the pieces to high temperature and pressure. Lustring processes include raising, boiling, crabbing, blowing and pressing.

The lustre due to yarn construction—the result of combing the wool prior to drawing and spinning, and so distinct from that developed in the woven fabric by finishing—suggests the principle underlying all surface brightness in a fabric made of wool, namely, parallelism of fibres. The more this can be secured, whether in yarn manufacture or in raising, the higher the lustre of the texture. Still, neither the combing of the wool, nor the straightening action in raising, so much impart lustre as produce fibrous conditions favourable to the display of such natural brightness as the wool possesses. Both combing and raising straighten the separate fibres and draw them in a line with each other. But the processes of boiling, blowing, crabbing and pressing, both develop and fix the fibrous lustre. Boiling is practised in woollen finishing. Crabbing is a compound process of boiling for a short time, and steaming, and has a similar effect on worsted fabrics to that obtained on dress-face woollens by boiling.

The pieces, being tightly stretched when subjected to these processes, are straightened and levelled on the surface, all creases and similar inequalities being totally eradicated. The work secures a thoroughly even, straight fabric before dyeing. It is also done before scouring in Crossbred pieces, which so readily "rig," or develop creases in this operation and milling.

Whatever conditions remain in the pieces after blowing or crabbing are all but permanent. Steaming the pieces under this high tension adds lustre to the fibre, smoothness to the yarns, and smartness to the texture; but at the same time, if the pieces are not perfectly clean, if they are specked or stained, or if not under a uniform tension from end to end and list to list in winding on, defects will arise that it is almost impossible to remedy.

### (28) *Pressing.*

Pressing is the final process in finishing, and has a twofold object, namely, to give permanent evenness to the fabric, and to enhance its lustre. Cloths which have been crabbed and boiled may be wanting in firmness and brightness; while those which have not are comparatively loose and spongy, and readily show signs of wear. Straightness of surface and clearness of texture are only partially developed in the preceding routine of finishing; but they are rendered permanent in the pressing operation.

The pieces are treated at an ordinary temperature or with heat—"hot" and "cold" pressing respectively. The cold process is applied when little "press" is required or to fabrics where weight alone is sufficient to produce evenness of texture.

The heat generated in hot pressing, and time occupied, varies with the nature of the cloth and the kind of finish to be obtained. In pressing rough Cheviots—where the natural qualities of the wool should be retained—neither much heat nor pressure are needed; but in Saxonies, worsteds and unions, a temperature of 104° to 112° F. is common, with 3,360 lb. to the square inch.

Cold and hot pressing differ in the conditions they produce in the fabric. Wool is rendered more flexible and more susceptible to mechanical treatment under (1) a high temperature, *e.g.*, in combing in worsted yarn manufacture; and (2) by humidification, *e.g.*, in raising. It follows that pressure applied to the cloth in normal conditions as to moisture and heat, has little effect beyond saddening the surface. The extraneous filament remains prominent on the face of the fabric, not being laid or forced into the threads of the cloth. In each of the four typical all-wool textures—Cheviots, Saxonies, Crossbreds and Botanys—the difference in the firmness or soundness between fabrics "hot" and "cold" pressed is distinctly marked. A Cheviot hot pressed improves in brightness; the fibres protrude in a much less degree from the face of the fabric; there is closer cohesion of the yarns, and the spaces between the threads are reduced by the loose fibre being pressed into the surface of the cloth. On the other hand, the same weight applied without heat leaves the threads with less adhesiveness to each other; the fibres loosely projecting on the yarns; the textural threadiness more marked and the handle rougher, but the natural quality of the wool in this respect better preserved. On this ground, cold pressing, not imparting artificial qualities, is preferred in the finishing of "homespuns" and rough tweeds.

Similar points of difference, but more pronounced, obtain between a Saxony pressed with, or without, heat. The characteristics of the cold-pressed cloth are deficiency in firmness and smoothness of handle; the texture too spongy and elastic, possessing an undesirable fibrous roughness. The same cloth under similar pressure, but a higher temperature, becomes bright and firm.

An ordinary Crossbred of a clear weave structure, after cold pressing, is only slightly changed, the thready ridges of the twills being clearly visible, the surface loose and open, with an absence of compactness of structure; but if heat is applied, a smooth surface results, and a fabric in which the rigidness of the twills is obliterated without over-subduing the weave effects, and one in which the yarns have, to a much higher degree, the property of cohesion.

Fine Botany worsteds, before pressing, are bright and clear on the surface, and hence cold-pressing would effect no perceptible improvement. It is only by the addition of heat, and the humidity in the piece, that the lustre, smoothness and soundness of fabric are enhanced and made more permanent in nature.

Neither heat nor pressure, applied separately, have the effects on the fabric which are known to develop in the press. The moisture or humidity which arises at the commencement of hot pressing, assists in softening the threads and fibres, so that they are increasingly susceptive to the conditions induced by pressure. But the essential distinction in pressing with and without heat, is the expansion and contraction of the wool fibres, occurring during heating and cooling in the former, and which are not present in cold pressing. These are changes affecting the fibres rather than the yarns. In other words, the threads are partially collapsible under continued pressure, but this is not, to the same degree, characteristic of the fibres. At the same time, as the yarns yield to compression, the cells constituting the principal part of the fibre expand, induced by the humid conditions obtaining. Such dilation of the spindle-shaped cells, with the cloth under high pressure, flattens the outer scales, causing the fibre to more closely resemble, in external structure, mohair. Yarn compression adds to the compactness and firmness of the texture; fibrous expansion, with compression of the external scales, produces brightness of surface. These qualities are fairly permanent. If the cloth is "glazed," steaming softens the threads without removing the brightness developed, or affecting the smoothness and straightness of the textural surface.

# CHAPTER III.

## THE PROCESS OF SCOURING: SCOURING MACHINES.



### (29) *Impurities in Greasy Pieces.*

WOOL is impregnated with from 20 to 60 per cent. of impurities chiefly consisting of fatty matter or suint. These are removed in the processes of washing. Yet in this non-greasy condition wool could not, without injury to the staple and wasteful results, be carded into a fleecy web of uniform consistency. A lubricant is necessary to preserve the natural length of the fibres, and also to facilitate the opening, blending and combing operations on the various cylinders of the carder. As a result of this application of oil to wool, some 15 to 20 per cent. is added to its clean or net weight, accounting in woollen manufacturing for a corresponding loss of weight in the scouring of the spun yarn or woven piece. The ordinary processes of manufacture do not add, to any considerable degree, to the percentage of impurities in the cloth. The passing of the material through the operations of carding, combing, spinning, winding and weaving, and other work in which it is handled, must affect its clean condition; but it is the oil applied to the wool prior to carding that renders the difference so appreciable, in some classes of woven manufactures, between the weight of the loom-felled and scoured pieces. Worsted fabrics, for example, in the yarn production for which little or no lubricant may be used, do not, on the average, lose in scouring more than 5 to 7½ per cent. On the other hand, in mungo and shoddy manufactures, the loss may attain 35 per cent., due to the oil applied to the rags for grinding and carding, and to the impurities the rags may contain.

The decrease in weight of pieces in washing or scouring is generally proportionate to the following:—

(1) The character of the yarns, such as worsted or woollen.

(2) The materials used—wool, mungo, shoddy, extract, cotton, etc.

(3) In union fabrics, the nature and quality of the several

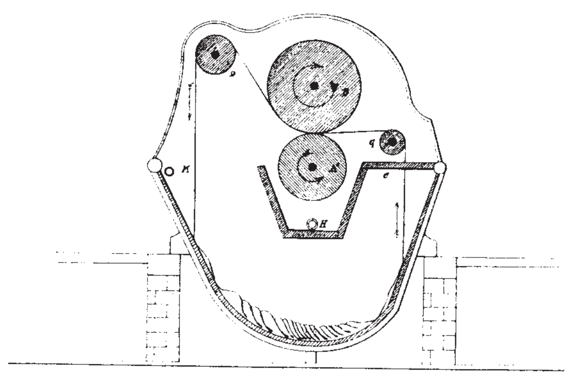


Fig. 13.

yarns, such as woollen and worsted, cotton and woollen, worsted, cotton and woollen.

Assuming, for example, that a piece is made of three materials, cotton, worsted and woollen, then in calculating the weight, the approximate estimated loss which would result in scouring, on each material, would be taken separately, about 2 to 3 per cent. for the cotton, 7½ per cent. for the worsted, and 20 to 25 per cent. for the woollen. Or, if a cloth were composed of worsted warp weighing 20 lb. and woollen weft 30 lb., a total in the grease of 50 lb., in estimating the clean weight, if 20 per cent. were deducted from the woollen and 7½ per cent. from the worsted, the approximate total would be 43½ lb.

### (30) *Scouring Machines.*

These machines are of four distinct types :—

(1) The ordinary rope scourer.

(2) The open or full-width machine.

(3) The scourer in which the lower roller is flanged.

(4) The combined scouring and milling machine.

Each of these machines is used for special purposes. The first type is adapted for the scouring of woollen and heavy greasy pieces; the second, for worsteds and fabrics in which it is necessary to keep the cloth straight; the third, for heavy low woollen fabrics, where the percentage of grease and other impurities is high, and in which as much pressure as possible has to be applied to the squeezing rollers, to expel such matter; and the fourth type for fabrics in which only light milling is required.

### (31) *The Rope Machine: Scouring Operation.*

In all scouring machines, the process consists in running the pieces in succession through the alkali or soap solution, and between a pair or pairs of squeezing rollers. The pieces collect in cuttles or folds (see Figs. 13 and 18), or in a form inducing thorough saturation, in the trough containing the scour or lye; they then pass in a continuous length to the squeezing rollers. The process is similar to soaping a length of material and placing it in the scour by hand, holding it there for a time, then withdrawing it and expelling by pressure the solution which it has absorbed. To simply run the pieces into and through the scour is insufficient, there must be immersion followed by such mechanical pressure as will expel the lye from the fabric. Immersion softens the materials or yarns in the cloth and assists the soapy solution to liberate the dirt and grease, whilst compression forces such matter from the interstices of the threads, so that at each successive immersion and squeezing, impurities are removed.

A general view of a scouring plant is given in Fig. 14, showing the arrangement of the machines, water and steam connections, also a lecker or soaping machine, conveniently fixed for treating the pieces prior to running them through the scourer.

Fig. 15 is a front view of the rope scourer. The upper part of the framework is removed to show the pieces as they pass

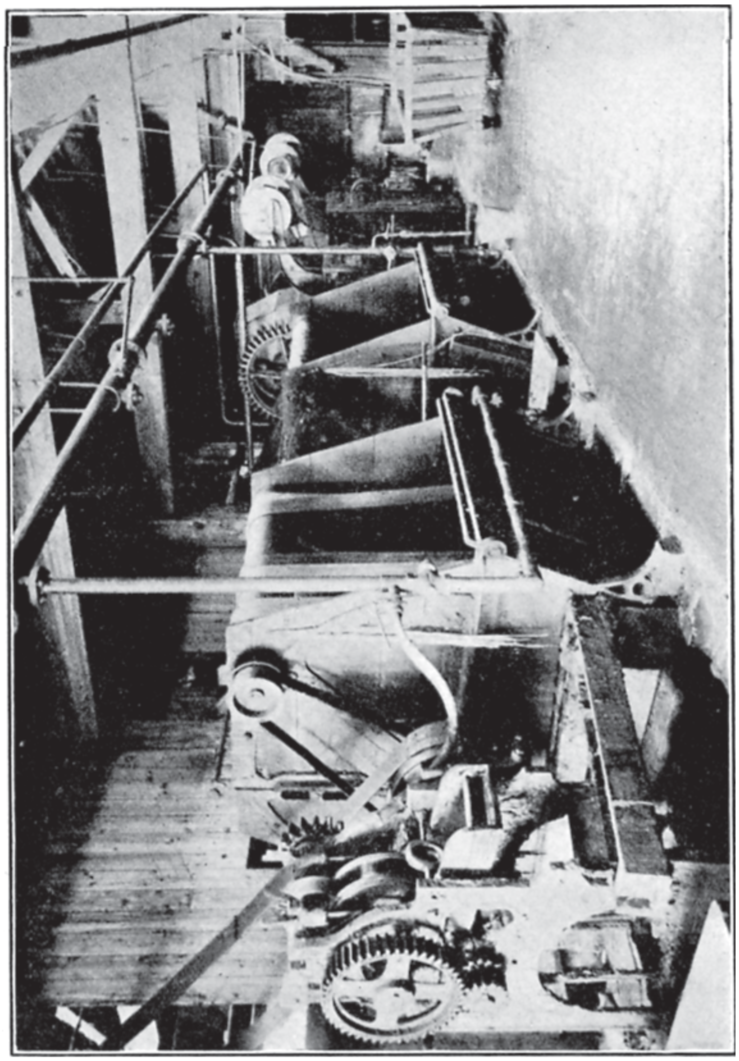


FIG. 14.—View of Scouring Plant.

from the squeezing rollers over the guide roller in front, into the main trough. The driving is also distinctly seen. In some machines, the setting-on motion consists of wheel and screw gearing, as in Fig. 16.

Fig. 13 is an end section of the rope scourer, usually made 5 feet, or 5 feet 6 inches in width. A¹ and B are the squeezing

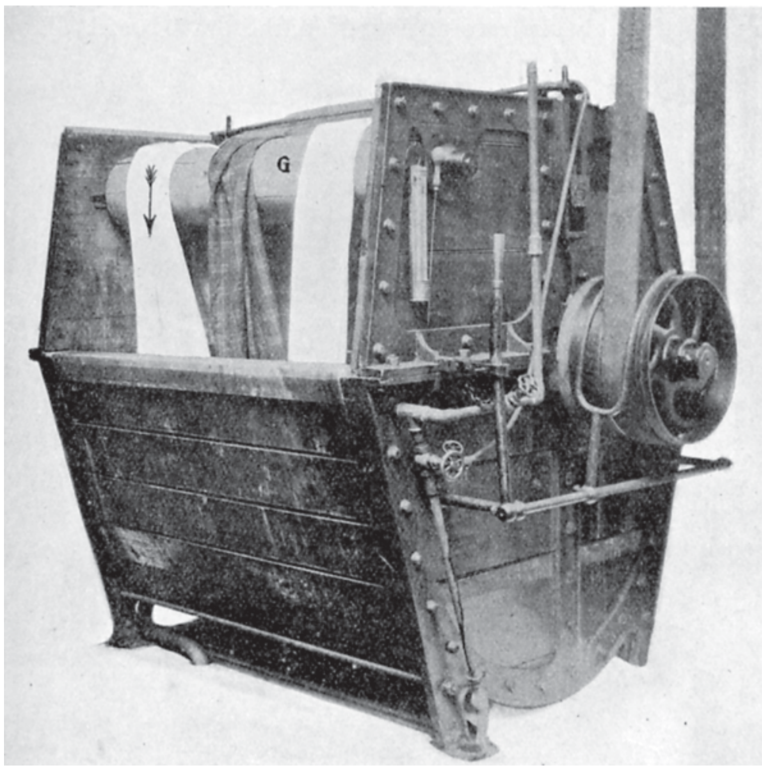



Fig. 15.—Front View of Rope Scourer.

rollers, G and D guide and draw rollers. When rollers A¹ and B are made of wood, they may be 20 inches and 28 inches in diameter respectively. Should either of the main rollers be of metal, the diameters vary, as in Fig. 16. In order to obtain as even a crush as possible upon the pieces, the rollers are sometimes covered with rubber composition; but for ordinary purposes wooden rollers are used of the diameters given. The lower portion of the machine is built into the flooring, making the working parts more accessible, and providing convenient means for running off the waste scour.

Fixed behind $A^1$ and B is the draft board C, Fig. 13, divided into three sections. Six pieces may be treated at one time, running in pairs through separate apertures in the draft board. Each

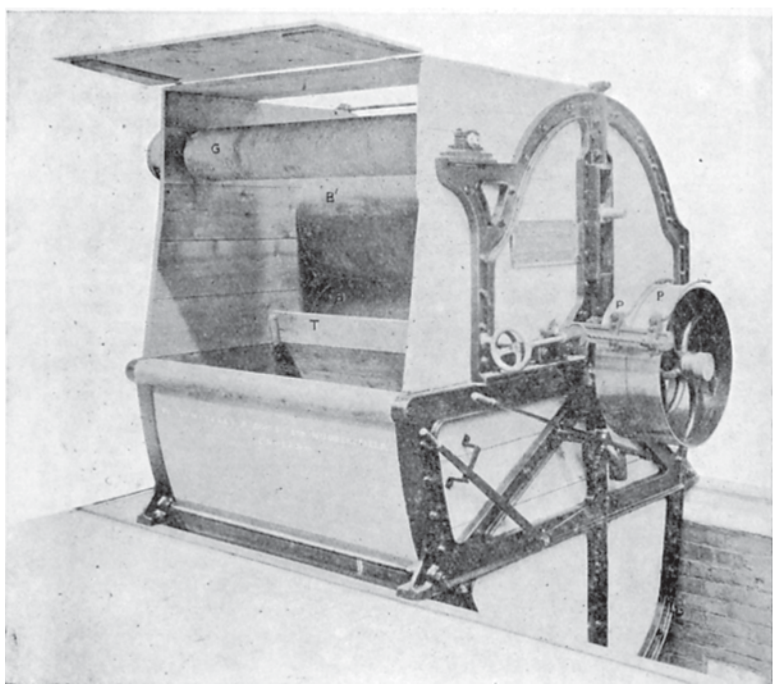



FIG. 16.—Rope Scouring Machine.

draft of pieces is placed in the main trough and drawn through board C, over guide G, between rollers $A^1$ and $B^1$, and over the front draw roller D, and the beginning and finishing ends sewn together. The scouring solution is in the trough. During the operation, the slide in the upper trough H is open, so that any lye squeezed out of the pieces runs back into the lower trough. The work continues until there are no indications, when the cloth is tested by rubbing the face and under side, of the presence of grease. The clean condition is also determined by the bright appearance of the fabric.

### (32) *Washing Off.*

This is a rinsing process and takes place in the scouring machine, either after scouring or milling. Warm water flows freely and constantly on to the pieces, as they pass from the draw roller D, into the lower part of the machine, removing all traces of the scour lye. The greasy suds squeezed out of the cloth

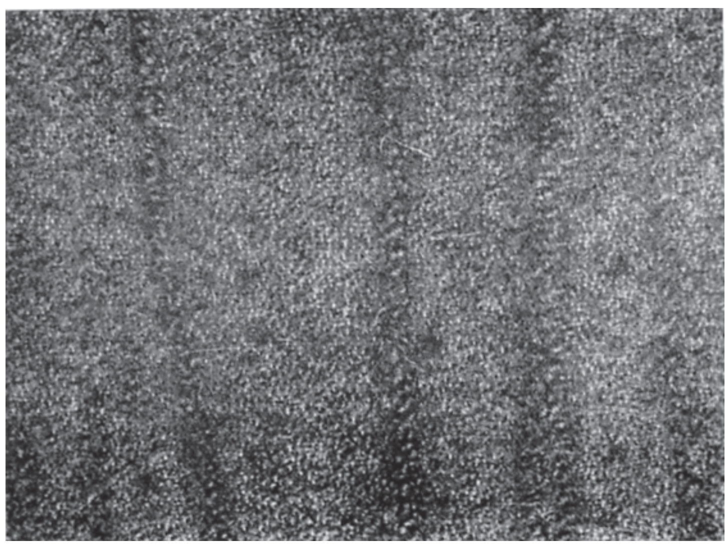


FIG. 17.

pass into the upper trough and from thence into the waste pipe. This is effected by closing the valve in trough H and opening the valve in the main trough. A clean-water bath is thus gradually obtained by diluting the suds and removing a quantity of them as the piece passes between the rollers. If the suds were run out of the lower tank and water turned on to the piece, the soapy and dirty sediment in the cloth would not be perfectly washed out. By allowing the pieces to absorb such solution during the process of changing it to clean water, all the scouring efficiency is retained for extracting the greasy matter. Commencing with the water at 85 ° F., the temperature is reduced until cold. Should this be effected too quickly, and the time allowed too short, the soap in solution in the piece will not be fully carried off, leaving the cloth comparatively hard. After all traces of the lather have been removed, the final rinsing takes place.

Thorough washing-off is a necessary sequence of good scouring. If imperfectly done it may be the cause of serious defects in the finished fabric. Piece dyes, in which the washing-off and rinsing have not been satisfactory, develop, in dyeing, flaky or blotchy patches due to certain parts being free from the scouring suds and others only partially so, in which case the former take a brighter tone of colour than the latter. Fancy fabrics would suffer in brightness of colour, and possess a blurred dull quality, if any traces of the soap suds remained in the pieces. In heavily milled goods another kind of defect results, namely, inequality of felting property in different parts of the pieces, producing rig marks and streakiness.

### (33) *Points in the Use of the Rope Scourer.*

This system of scouring is common in treating heavy greasy fabrics, and the ordinary classes of woollens. In pieces made of low materials it would be impossible, in the open width, to have the repeated squeezings effective enough to expel the dirt and greasy matter from every part of the fabric. Pieces must be scoured through and through, and not merely surface cleansed, and as the greasy compounds impregnate every fibre in the texture, it is only by this mechanical action that some types of fabrics can be perfectly washed. A freer and more efficient scouring of such pieces is possible by treating in the folded state than in the open width.

One difficulty, however, in the use of the rope scourer is the prevention, in certain makes of fabrics, of defects due to the pieces running for a period in the same series of folds. The limited space in which they are held, 8 or 12 inches, in which condition they pass between the squeezing rollers, though 70 or

80 inches wide, is a cause of crease marks. Cuttling in the lower trough does not sufficiently change the relative positions of the layers lengthways of the fabric. The machine minder endeavours to rectify this by opening out the pieces during

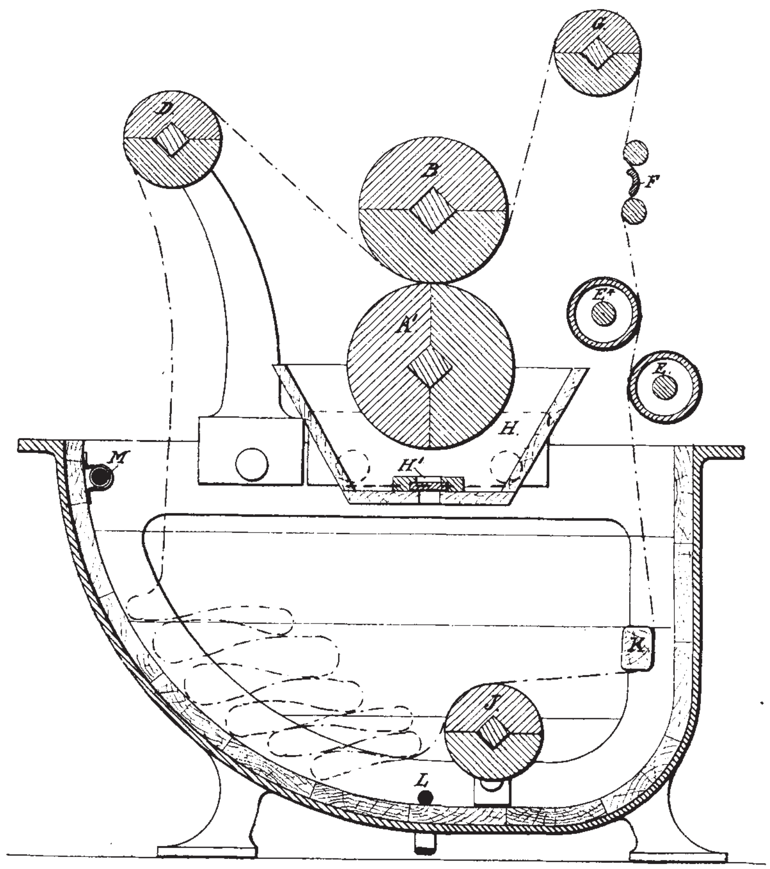



Fig. 18.—Open-width Scourer (section).

scouring, but, at the best, this is an imperfect method of distributing the foldings. Mechanical contrivances have been applied to remedy this defective treatment, such as the use of pairs of smooth rollers inserted in the draft board, or of corrugated rollers, adjustable as to space from each other. The action of either class of roller may minimise this mechanical cause of defects, but a degree of friction which is undesirable necessarily results on the cloth.

Cross drafting is also practised to lessen the effect of operating on the pieces in the folded state. It consists in placing the

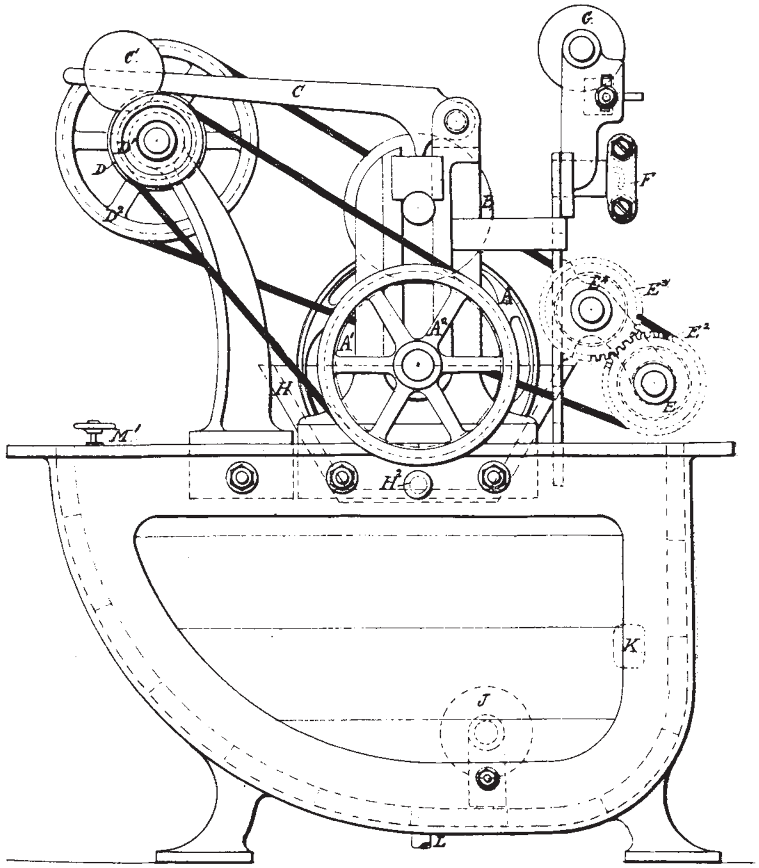


FIG. 19.—Open-width Scourer (side elevation).

pieces in the machine in such a way that one series or "draft" will interlace with a second draft in the lower trough, for each passage between the squeezing rollers. This is done by fastening the two drafts of pieces into an endless length, so that they change from side to side of the draft board and the rollers of the machine. Possibly, this is as effective a method of securing frequent and regular changing of the folds in the pieces as can be adopted in this type of scourer.

Rope scouring is, more or less, unsuitable for fabrics composed of materials and yarns in which unevenness of crush tends to develop flakiness, crease marks, and other faults in the woven piece. For example, fabrics made of Crossbred yarns, owing to their wiry, hard and unyielding nature, when scoured by this system rapidly and permanently crease in places, or some threads may, to a slight degree, curl or loop. The stronger the fibre or staple of the wool, the firmer the yarn and more pronounced the faults. Union fabrics, with a cotton warp and mohair or lustre weft, are still less suitable for this system of scouring. Under the squeezing action, the yarns in the folded places in the fabric burst and form loops, so that the pieces are not perfectly level prior to milling, but rather in a condition to rig or crease in the felting process. A specimen of such a fabric is given in Fig. 17. The lines of loops traversing the surface irregularly, are where the piece was folded in scouring. In the milling operation, these formed prematurely or before curliness resulted in other parts of the texture. More increased felting would produce curliness in every part of the fabric, but these sections would be correspondingly pronounced, and the piece still defective.

When the fabrics have a smooth, level, fine surface, as in vicunas and worsteds, it is obviously an essential object in each process of finishing to retain and develop these qualities. If, however, the pieces should be washed and run in folds, the surface is liable to be creased and marked, and any fault produced in textures of this fineness is likely to be accentuated in the subsequent finishing processes.

### (34) *The Open Scourer: Construction.*

Figs. 18, 19 and 20 are section and side and back elevations of the open scourer. The method of driving, adjustment and relation of the rollers to each other are the same as in Figs. 15 and 16. In this scourer the scroll opener is applied, consisting of rollers E and $E^1$, (Fig. 20), for retaining the piece full width during scouring, and in a central position on the roller G, by the action

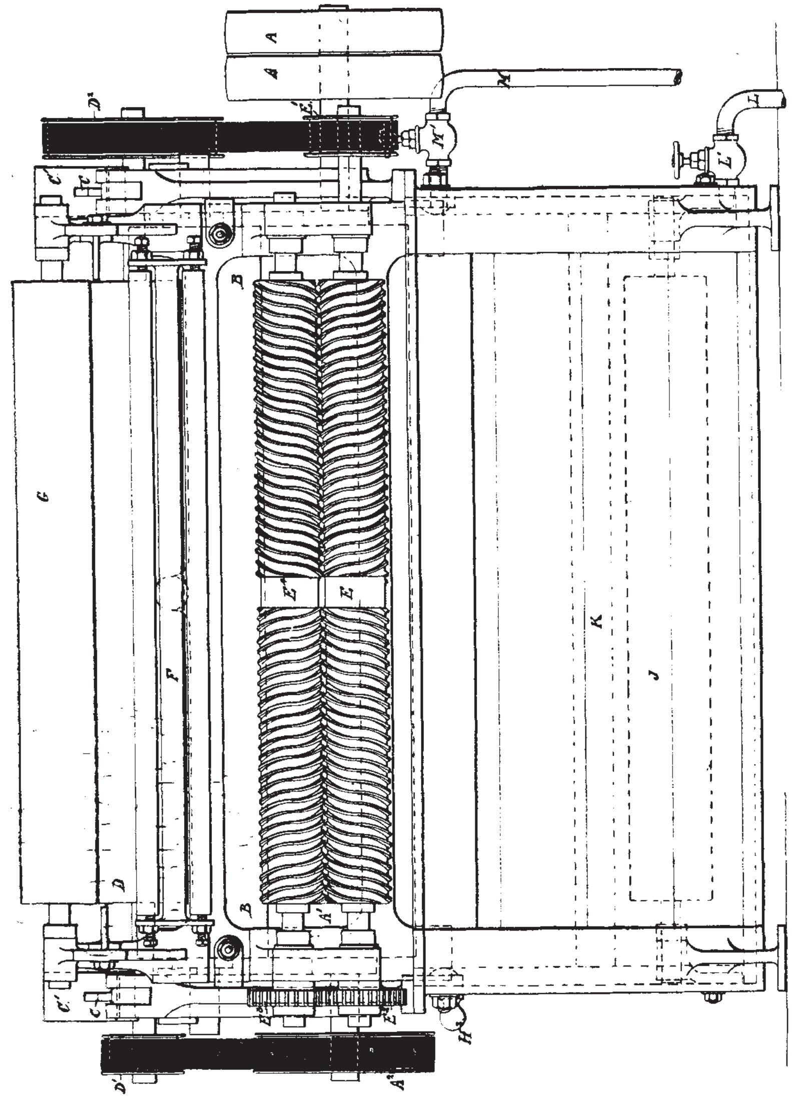



Fig. 20.—Open-width Scourer (back elevation).

of the frame F oscillating on a pivot. The operation of the parts is as follows: A, Fig. 20, is the strap pulley on the main shaft of roller $A^1$, Fig. 19, which by friction turns B, the amount of pressure of which is regulated by weight $C^1$ on lever C. On the opposite end of the main shaft is the pulley $A^2$, which imparts motion to the front draw roller D (with a surface speed similar to the main roller), the shaft of which at the other side carries strap pulley turning the lower scroll roller E. $E^2$ gears into $E^3$ on the upper scroll.

The pieces pass between rollers $A^1$ and B, Fig. 18, and then over roller D and into the trough, over guide J, and round the tension bar K, between the scroll rollers E and $E^4$, interlacing with the bars of the oscillating frame F, over guide G, and return to the squeezing rollers. The action of the scroll opener is similar to pressing on the cloth from the centre to the outer edges, so that it is constantly maintained straight and level without any actual tension being applied. As the frame F operates on a central pivot, if the cloth tends to move to either end of the roller, this frame rises at the same end and at once causes the piece to assume the normal position on the roller.

(35) *Advantages of the Open Scourer.*

The chief advantage of this machine consists in the pieces being washed full width, and therefore are perfectly even when they pass between the squeezing rollers $A^1$ and B, Fig. 18, giving a uniform pressure on every portion of the surface of the cloth. There is not the inequality of crush or compression as when the pieces run in folds, and there is an absence of conditions which develop and make permanent creases. In many classes of goods, especially those made of worsted yarns, the pieces are comparatively clean, so that scouring by this method may be practically as well done as by the older method, with the great advantage that if the pieces are run for a sufficient period, and with proper treatment as to scouring solution, they will be perfectly clean throughout. Every portion of the fabric, whether in scouring or washing-off, is subjected to like treatment; it absorbs the same quantity of scouring solution, undergoes the same pressure at each passage between rollers $A^1$ and B, and, in washing-off, the water is equally distributed on the cloth. The whole routine tends to secure perfect evenness of result, so essential to uniform dyeing.

The open scourer should be used when cleansing textures made of Crossbred and Botany yarns, and generally those fabrics in which a fine clear surface is required. It may also be used in washing-off heavy felted woollen goods possessing firmness and stiffness of structure, the surface of which is liable to be cracked or damaged in the folds when the process is done in the rope machine.

(36) *Scouring Machine with Flanged Roller.*

The construction of this machine, Fig. 21, in regard to the rollers is similar to an ordinary milling machine, that is to say, the lower squeezing roller is flanged, and the upper roller fits between the flanges and is heavily weighted. The pieces are thus in a more compressed state during the crushing or squeezing than in the rope machine. The other parts of the machine are similar to the rope scourer. T is the upper trough, G the guide roller, B and C additional parts for delivering the piece, after scouring, into the trolley or barrow, and K is the knocking-off board. In addition to the cleansing process between the rollers, there is a spout at the back of the machine which holds about 25 yards of cloth, and gives additional crushing, instead of all the cloth remaining at the bottom of the machine. This method of scouring is chiefly suitable for pieces of a low quality, containing a large percentage of greasy substances, in the manufacture of which mungo and shoddy have been used, and a lubricant of inferior quality. In order to expunge these from the cloth and produce a clean condition, this heavy crushing is essential. By this system, such pieces can be better and more rapidly scoured than in the ordinary rope scourer.

The upper roller is 3 feet in diameter and has a possible pressure of 10 to 12 cwt. on the cloth, producing a thorough crush and a greater degree of softness, which forms a better preparation for milling than is possible by the ordinary machine. The rollers are cog driven, and mounted on springs to secure steadiness of action on the top squeezer.

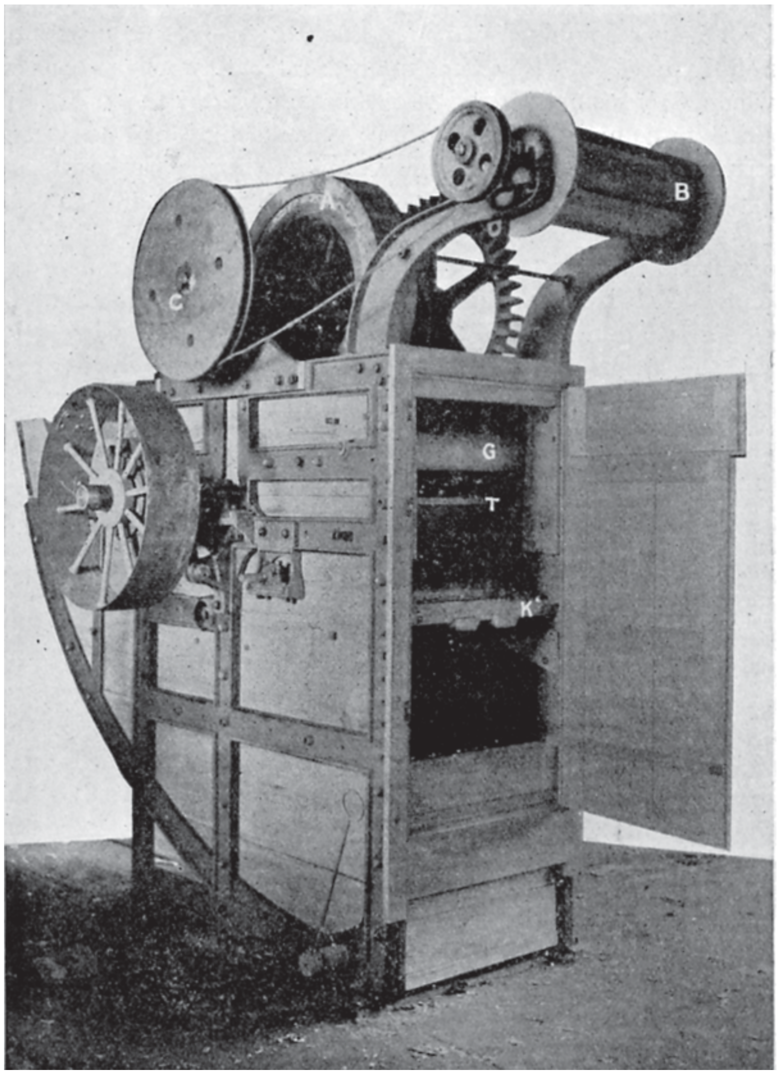



Fig. 21.—Kilburn's Scouring Machine for Heavy Pieces.

### (37) *Combined Scouring and Milling Machine.*

This is a combined machine consisting of both scouring and milling parts. As there are many classes of woollen goods in which only a small degree of felting is necessary to impart the requisite compactness of texture, this machine has been constructed with a view of having more economic work without loss of efficiency. It differs from the ordinary scourer in that the squeezing rollers are only 8 inches wide, and that the lower one is flanged, with the two upper rollers fitting between the same. The lower or chief roller is 2 feet and the top rollers 18 inches in diameter, the total width of the machine being 28 inches. It is capable of treating pieces varying in weight from 10 to 180 lb.

The machine consists of lower and upper troughs, and of guide rollers as in Figs. 13 and 18, of the two upper rollers under the control of springs and of the elongated trough or spout in which the pieces are felted warp ways by the spout lid, and weft ways by the spout sides. The latter are connected to levers which are weighted according to the degree of weft shrinkage required. When scouring, only that amount of compression is applied to the rollers to get an effective nip or crush, and there is no weight on either the lid or the sides of the spout, which are hinged. The felting is done by applying weights to the parts mentioned, and running the pieces through soapy solution about 18 inches in depth in the lower trough. Then follows washing-off in the usual way, with the machine adjusted as in scouring.

## CHAPTER IV.

### THEORY OF FELTING.

(38) Qualities of Wool in Relation to Felting. (39) Shrinkage Properties of Merino and Cheviot Wools. (40) Felting Contrasts. Merino and Southdown Wools. (41) Utility in Woven Manufactures of Wools of Different Shrinking Qualities. (42) Yarn Structure. (43) Felting affected by Yarn Composition. (44) Methods of Yarn Construction and Felting. (45) Shrinkage of Fabrics made of Re-manufactured Fibres. (46) Degree of Twine in the Yarn. (47) Folded Yarns and Shrinkage.

#### (38) *Qualities of Wool in Relation to Felting.*

THE felting or shrinkage property of a woven fabric is determined by the nature of the wool fibre; the structure of the yarns; and the construction or make of the cloth. Each of these characteristics has an important influence upon the degree of felting possible in woven productions; and also exercises a modifying effect upon the actual process of felting or milling.

In regard to wool, its felting power is controlled by:—

(1) The physical structure of the fibre.

(2) The elasticity, waviness and density of the staple.

(3) Uniformity of length of fibres in the locks of wool, and the strength of the staple.

To make this clear, Merino (Tasmanian) and British (Cheviot) wools may be contrasted in these qualities, Figs. 22 and 23.

Comparing, first, the physical structure or the external formation of the fibres of the two wools, it will be observed that the Merino is much finer and truer in growth than the Cheviot, with a larger number of serrations in a given length of fibre; and these, as is well understood, are active elements in the milling of the cloth.

Second, the Merino (Fig. 22) is elastic, wavy and dense in staple; but the Cheviot (Fig. 23) comparatively open, and consisting, on the average, of a less number of fibres. In waviness, the difference is also marked, Merino lambs' wool—possessing excellent felting property—being distinguishable for this quality; whereas English wools, even of the short staple class, such as the Downs (Fig. 24), are wanting in waviness, and also felting power.

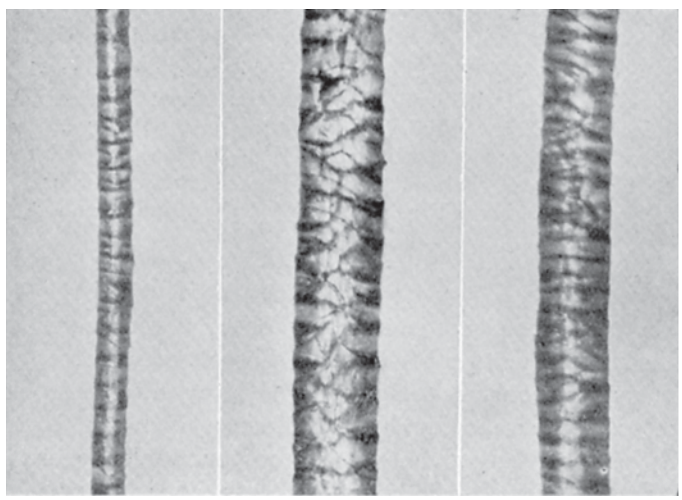


Fig. 22. Fine Merino (Sydney). Fig. 23. Border Cheviot. Fig. 24. Southdown.

Third, strength and soundness of staple and uniformity of length of fibre induce and maintain felting; a wool tender in staple may felt, but not for a like period, or to the same degree, as one possessing these qualities. The high breaking strain of individual filaments, which is found in the better grown qualities of medium and coarse stapled wools (Figs. 23 and 26), also affects the duration to which shrinkage may be continued. This is contingent upon the average fibres in the lock being of a similar quality, length and diameter. In some of the finer Cheviots, the felting power has been proved to be more active in the third and fourth hours in the milling machine than during the first 120 minutes. Want of waviness and density of serrated surface were here neutralised by the soundness and strength of the fibres in the wool staple.

(39) *Shrinkage Properties of Merino and Cheviot Wools.*

The results of two series of experiments may be useful. The first series contrasts the relative shrinkage of Merino and Cheviot wools under like conditions when used as weft in a union texture; and the second series contrasts the felting qualities of

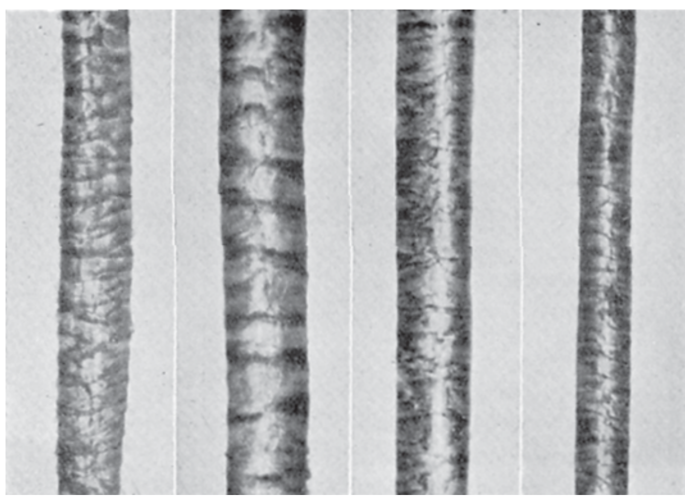


FIG. 25. Welsh. FIG. 26. Lincoln. FIG. 27. Mohair. FIG. 28. Alpaca.

Tasmanian Merino and Southdown wools in the following relations:—

(*a*) Merino warp and Merino weft. (Yarn of the Saxony type.)

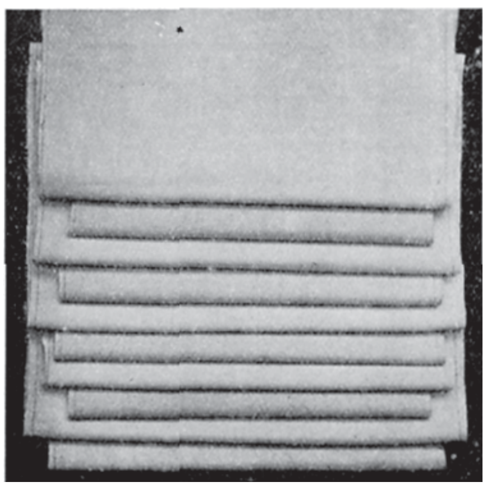
(*b*) Merino warp and Southdown weft.

(*c*) Southdown warp and Southdown weft. (Yarn of the Cheviot type.)

(*d*) Southdown warp and Merino weft.

Considering the first series, the counts of the weft yarn, both Merino (Fig. 22) and Cheviot wools (Fig. 23) were 20 skeins, with approximately twelve turns per inch, the warp being cotton, set 31 inches in the loom, and in 12's reed 2's. The yarn structure was, as near as practicable, the same in each quality of wool, thus eliminating any cause of difference in the felting other than the physical properties of the raw material.

Fig. 29 shows the relative widths of the fabric from the Plain weave, Prunelle twill, $\frac{1}{3}$, and $\frac{2}{2}$ twills, and backed $\frac{1}{3}$ Swansdown, after scouring, milling, and finishing, in the order



Backed $\frac{1}{3}$ twill.
$\frac{2}{2}$ Twill.
$\frac{1}{3}$ Twill.
Prunelle twill.
Plain weave.

Fig. 29.

in which they were woven, Cheviot and Merino weft alternately. The picks per inch were in the Plain weave, 40; in the Prunelle, 50; in the $\frac{1}{3}$ twill, 55; in the $\frac{2}{2}$ twill, 57; and in the backed $\frac{1}{3}$ Swansdown, 80. The different shrinkages of the two yarns is clearly defined in these fabrics.

Fig. 30 is a diagram of the contraction or shrinkage curves of the two wools, under corresponding periods of time and treatment, in the scouring and milling processes. That the structure of the fibre is the chief modifying element in the changes effected, is apparent when the curves 1 to 5 are compared. There is a similar ratio of alteration in the textures made of

Merino and Cheviot yarns in each pair of curves. Relatively, the two fabrics undergo the same shrinkage in the plain, twill and other weaves. Neither the yarn nor the fabric structure are, therefore, recognisable factors in any difference in the measure of contraction here indicated, when each set of curves is considered, and the effect of the Merino weft is compared with that of the Cheviot. The influence of the weave is traceable in the variations in shrinkage in Plans 1 to 5 in both materials.

The investigation is thus restricted to the comparative milling properties of the wools of which the yarns are composed. It is interesting to note, in the first place, that the nature of each material has a different power of contraction prior to, and during scouring. Taking the shrinkages on the reed and scouring lines A and B, they are as follows :—

TABLE III.

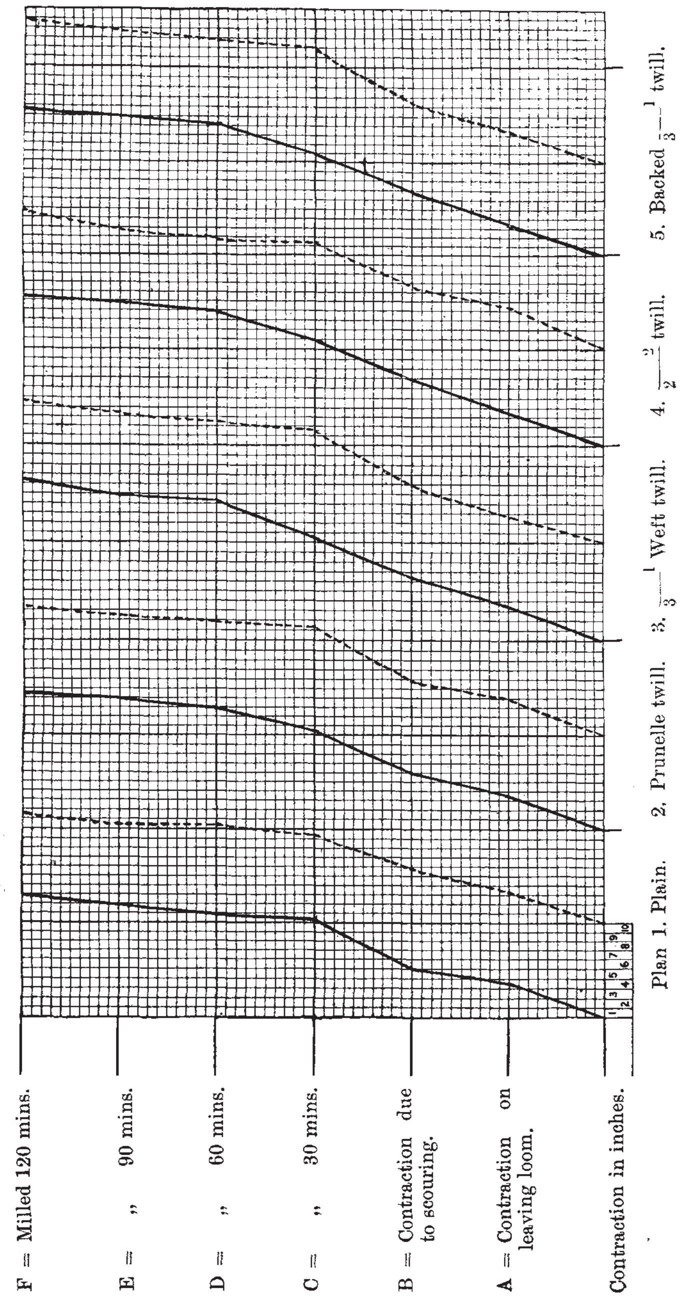
SHRINKAGE OF MERINO AND CHEVIOT FABRICS.

| Plans. | Plain Weave. | | Angled Prunelle. | | Swansdown. | | $\frac{2}{2}$ Twill. | | Backed Swansdown. | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wool. | Merino. | Cheviot. | Merino. | Cheviot. | Merino. | Cheviot. | Merino. | Cheviot. | Merino. | Cheviot. |
| Contraction in Inches :— | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. |
| Line A . . | 3½ | 2½ | 3½ | 2½ | 3½ | 2 | 3½ | 3 | 3½ | 2¼ |
| Line B . . | 5 | 4¼ | 6 | 5 | 6¼ | 5 | 7 | 5 | 7 | 5 |

The Merino weft shows, at this stage, higher shrinkage than the Cheviot. On the scouring line B, the superior felting property of the Merino is also apparent.

The behaviour of these wools in this process coincides with what occurs in the several periods of milling. The fine Merino felts more rapidly, and to a greater degree than the Cheviot, as is observable by following the variations in the curves on lines C and D. They more closely approximate each other in the two latter periods E and F.

Cotton Warp and Merino (Saxony) Weft.



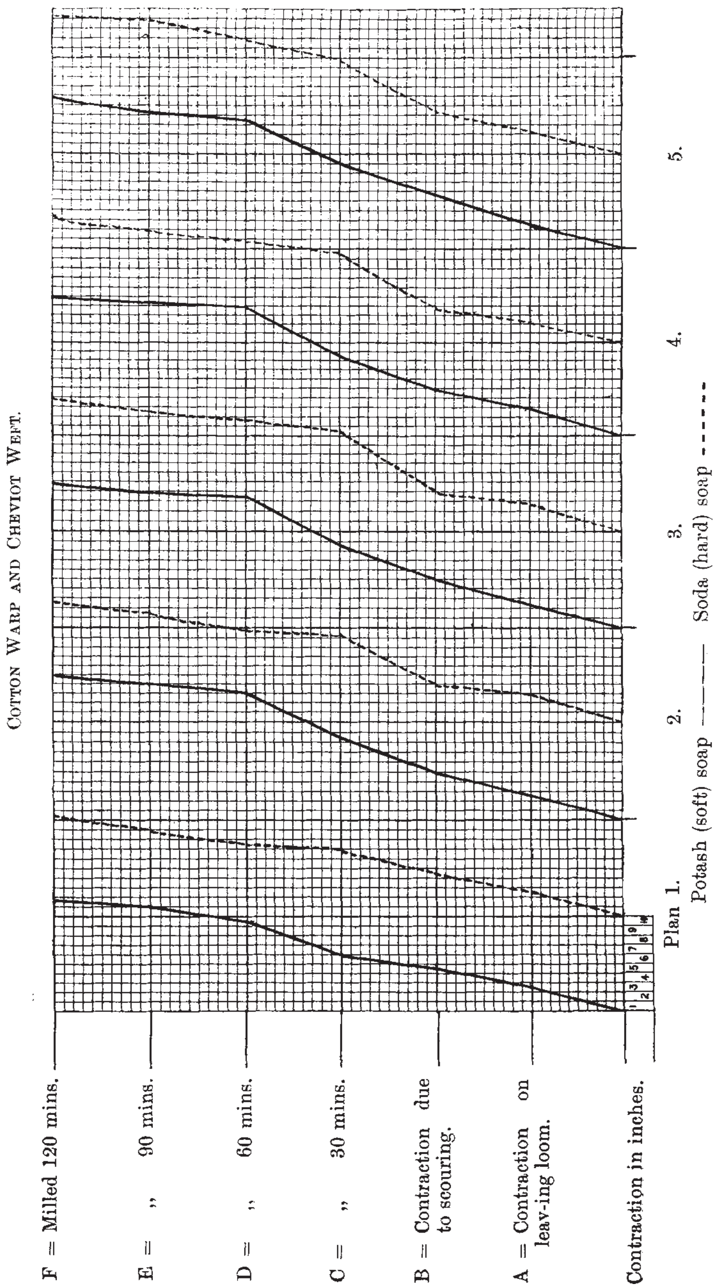



Fig. 30.—Milling comparisons in Saxony and Cheviot fabrics and potash and soda soaps.

Milling research has confirmed this theory, but the ratio of shrinkage under various conditions as to time, pressure and temperature still leaves many problems unsolved.

The shrinkage curves on lines C to F prove (1) that when the felting quality of these wools is measured, it is variable in definite periods of time; and (2) that the excessive felting of the Merino appears in the first, and is maintained to the last period. That such wools are relatively of dissimilar felting property, trade practices and general observation have determined, but their characteristic behaviour in the several periods of milling—which form so valuable a feature in manufacturing—are only definitely determinable by experimental research.

### (40) *Felting Contrasts: Merino and Southdown Wools.*

The effect of Merino wool in fabrics composed of Southdown warp (Crossbred or Cheviot quality) and Merino (Tasmanian) weft, or *vice versa*, in the process of felting, and also the contrasts between the felting property of these wools in other technical conditions than those already described, are indicated in the analyses of the milling results of fabrics made as follows, and woven together:—

| Warp 1. | Warp 2. |
|---|---|
| 20 skns. (Tasmanian wool.) 13·2 turns per inch. | 20 skns. (Southdown wool.) 13·4 turns per inch. |

*Wefts:* Same as warps.

| *Weaves:* | |
|---|---|
| Plain, | 24 picks per inch. |
| $\frac{2}{2}$ twill, | 36 ,, ,, ,, |
| Swansdown, | 36 ,, ,, ,, |
| Mat, | 32 ,, ,, ,, |
| $\frac{3}{2}$ twill, | 38 ,, ,, ,, |

In order that the felting should be dependent upon the physical properties and qualities of the two wools, and not upon technicalities in manufacturing, the yarns used were, as

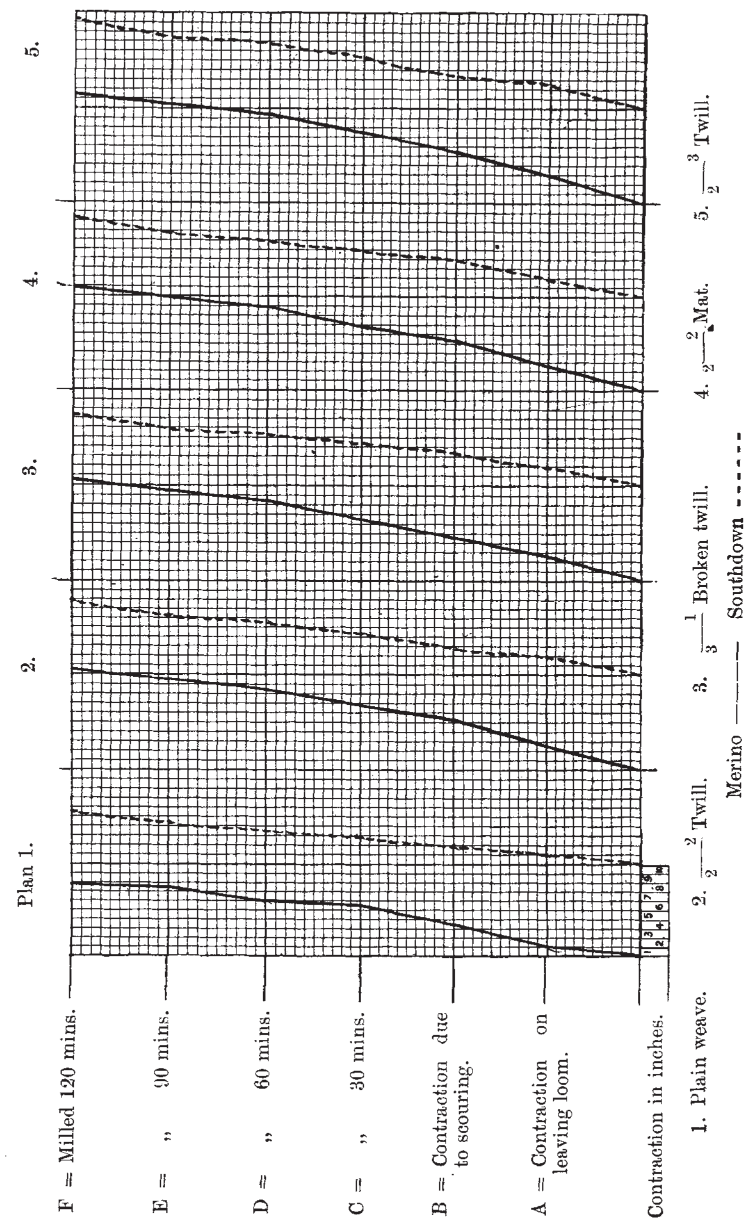



FIG. 31.—MILLING COMPARISONS IN MERINO AND SOUTHDOWN FABRICS.

in the first series of experiments (Par. 39), of similar counts and turns per inch.

The shrinkage curves of the pure Merino and Southdown are given in Fig. 31. In each instance, it will be noticed that the Southdown is more uniform than the Merino. Taking the curve on the plain weave, it traverses the same unit for each period up to ninety minutes after scouring, and only makes a variation of half a unit in the last period, or between lines E and F. Between lines B and C, C and D, and D and E, it is the same. That of the Merino, between lines A and C, moves $5\frac{1}{2}$ units, and the Southdown $2\frac{1}{2}$, but between C and D, the two wools have a similar shrinkage and also between E and F, but the Merino curves comprise two units between D and E, against one in the Southdown. In the twill, the curves have a corresponding relation, from A to D, namely, six in the Merino and four in the Southdown, then in an almost parallel relationship to line F. The curves for the weaves, swansdown, mat and $\frac{3}{2}$ twill, have, relatively, similar units of difference to those of the plain and $\frac{2}{2}$ twill.

The cause of the increase in shrinkage, due to a change in the weave, will be fully treated of later, but here it is a question of the ratio being maintained in the fabrics made of both Merino and Southdown wools. As the shrinkage of the former increases, so proportionately does the latter. If this did not follow, it might be assumed that there was some auxiliary factor in operation, but the change being constant in each wool clearly determines that the quality and structure of the fibres of the respective materials are alone responsible for the different results, in each weave, which arise in scouring and milling.

It has yet to be explained how the behaviour of these wools in regard to shrinkage is affected when the Merino warp is woven with the Southdown weft, and the Southdown warp with the Merino weft; that is (1) to what degree one wool may modify the properties of the other when thus used; (2) to what degree the Merino controls the felting; and (3) to what degree the finer and softer wool, with the fibres of a lesser breaking strain, exercises a greater felting quality than the wool with the thicker and stronger fibres. The following contraction results bear upon these problems:—

TABLE IV.

SHRINKAGE IN SCOURING AND MILLING OF MERINO AND SOUTHDOWN WOOL FABRICS.

| Weave. | Weft. | Percentage of Contraction in Scouring. Merino Warp. | Percentage of Contraction in Scouring. Southdown. Warp. | Percentage of Contraction in Milling. Period: 2 hours. Merino Warp.* | Percentage of Contraction in Milling. Period: 2 hours. Southdown Warp.** |
|---|---|---|---|---|---|
| Plain, A . | Merino | 10·25 | 11·75 | 23·50 | 25·75 |
| $\frac{2}{2}$ twill, B . | ,, | 16·75 | 17·50 | 31·00 | 32·25 |
| Swansdown, C | ,, | 13·25 | 16·75 | 31·00 | 32·25 |
| Mat, D . . | ,, | 16 00 | 16·00 | 32·25 | 34·50 |
| $\frac{3}{2}$ twill, E . | ,, | 16·00 | 18·75 | 33·75 | 36·75 |
| Plain, A′. . | Southdown | 5·75 | 5·75 | 18·00 | 16·75 |
| $\frac{2}{2}$ twill, B′ . | ,, | 8·75 | 8·75 | 26·50 | 23·50 |
| Swansdown, C′ | ,, | 8·75 | 10·25 | 23·50 | 22·00 |
| Mat, D′ . . | ,, | 10·25 | 11·75 | 25·00 | 25·00 |
| $\frac{3}{2}$ twill, E′ . | ,, | 10·25 | 10·25 | 26·50 | 29·25 |

*A to E. *Effect of two hours' milling on fabrics made of Merino warp and weft.*
**A to E. ,, ,, ,, *Southdown warp and Merino weft.*
*A′ to E′. ,, ,, ,, *Merino warp and Southdown weft.*
**A′ to E′. ,, ,, ,, *Southdown warp and weft.*

An analysis of this Table shows that, first, the Merino weft increases the felting property of the Southdown warp, giving in the plain weave A, a plus shrinkage of 9 per cent. over A′; in the twill B, of 8·75 per cent. over B′; and in the swansdown C, of 10·25 per cent. over C′. Second, that in these experiments, the Merino weft, in the period named, also produces a plus shrinkage on the Southdown warp as compared with the Merino warp. The explanation of this is found in the shrinkage curves, Fig. 31, where from line E to line F the Southdown has a higher shrinkage quality than the Merino. This is distinctly seen in Weaves 3, 4 and 5. In the swansdown and mat weaves, the Southdown moves 1½ units to the Merino 1 unit; but in the

$\frac{3}{2}$ twill, 2½ units in the former to 1 in the latter, so that here the Southdown accelerates the shrinkage of the Merino. Third, the Southdown weft diminishes the shrinkage of the Merino warp in both the scouring and milling processes. Compare again the plain weave A, Merino warp and weft, shrinking 10·25 per cent. with the same weave A′, in Merino warp and Southdown weft, shrinking 5·75, or in milling 23·5 in the former and 18·0 in the latter; and similarly with other weaves.

These comparisons are confined to contraction in the width of the fabric, and show both in scouring and felting that whereas the Merino weft increases the felting on the Southdown warp, the Southdown weft lessens the shrinkage on the Merino warp.

### (41) *Utility in Woven Manufactures of Wools of Different Shrinking Qualities.*

The fact that Crossbred and Merino wools behave differently in the milling process, both as regards periods and degrees of felting, has led to the manufacture of special fabrics in which this property produces the characteristic effect required. It follows that, when separate yarns are made from these two wools, and woven alternately either in warp or weft, during the period when the Merino or Saxony yarn has the higher felting power, the Southdown must contract. Felting is the gradual interlocking of fibres, as distinct from yarn contraction, without fibrous homogeneity being produced. In illustration of the compound process referred to, take the felting of the rug specimen (Fig. 32) woven one pick Saxony and one pick of Crossbred yarn. As described, in the early stages of felting the Merino wool has the power to cause the yarn of the Cheviot, or similar wool, to be drawn into loops or buckles. The foundation of the texture becomes a mass of intermatted filaments, on the surface of which are distributed loops or buckles of the yarn of less shrinking power, and the continued milling of other fibres in the fabric does not eradicate this characteristic.

Other applications of the distinctive felting effect of Merino and Crossbred wools and Mohair obtain in dress and mantle textures and trimmings. Imitation astrakhans (Fig. 33), in which the curl is due to milling, are examples, on account of the method of construction and the use of cotton for warp, and fine Saxony

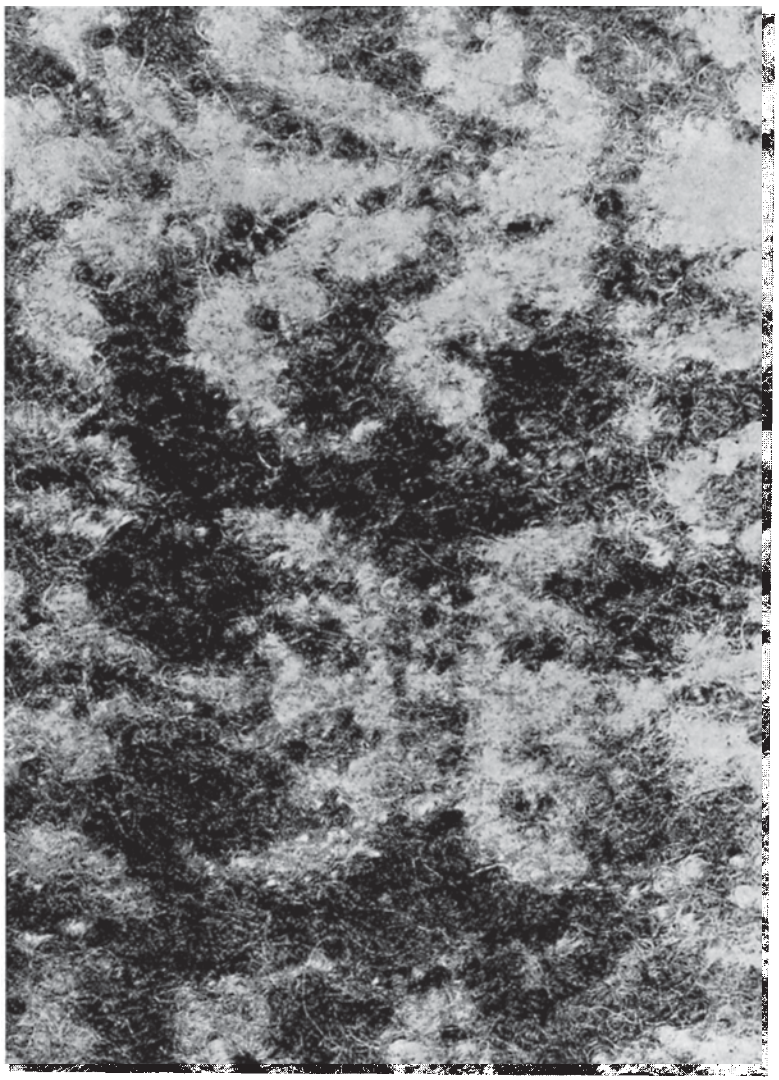


Fig. 32.—Union Fabric, showing the effect of milling on Merino and Crossbred yarns, woven pick and pick.

and semi-lustrous, or lustrous yarns for weft. There is, in the Saxony, a material of sound felting property; in the cotton, a fibre unshrinkable by the methods applied; and on the face, a lustrous yarn of totally distinct fulling power to the Saxony. The fabric is built to have a plain cotton centre with a sateen woollen underside, and floats of lustre yarn on the face. The structure is thus arranged to emphasise the varying milling properties of the yarns. From the deductions made it is evident, as the

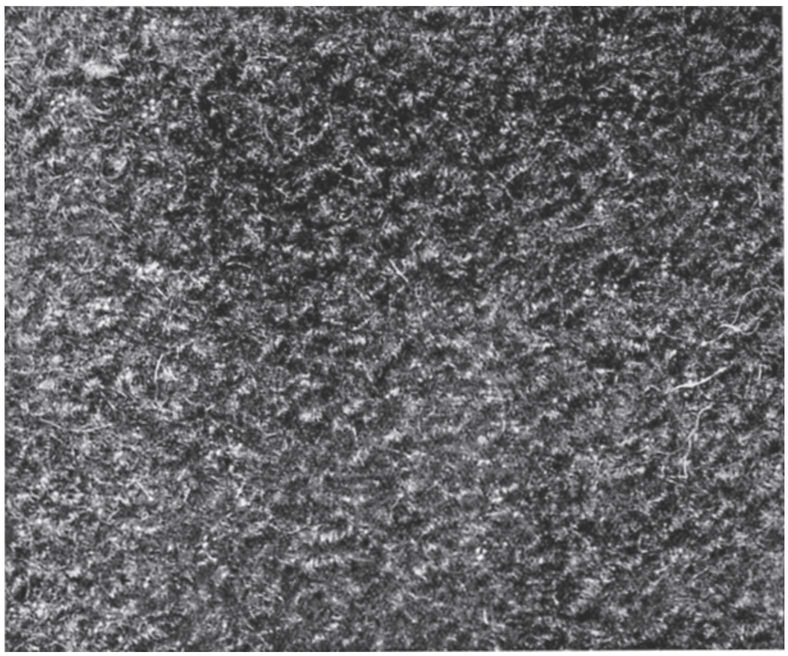


FIG. 33.—Curl Fabric: Effect of milling.

ratio of felting is diminished in the face yarn and increased in the Saxony, by reason of the weave construction there ensues, in the preliminary period of milling, a fabric with the underside consisting of felted yarn and the upper surface of curls. These loops or curls may be diversified in character and dimensions by the structure of the weave and the nature of the yarn, that is, its lustrous quality and counts. Thus, in the same fabric, by appropriating a wool of the fine Merino class to the underside, and one of a Crossbred nature to the face, the former is made to yield a smooth surface, but the latter is covered with small curls of a similar character to those obtained by using wires. Yet in the loom both sides of the fabric are level and even, and there are no traces of this distinctive characteristic which develops in felting.

### (42) *Yarn Structure.*

Considering the different methods of converting wool into yarn, sufficient regard, in explaining the theory of felting, has not yet been given to this subject. Next to the structure of the wool fibre is the yarn structure as a modifying element in the felting of woollen, worsted and union fabrics. It may induce and accelerate, or diminish and retard the natural felting of the material.

Yarns vary in felting property according to (1) quality and nature of the material; (2) method of construction, woollen or worsted; (3) degree of twine inserted in spinning or twisting; and (4) whether single or folded, that is, consisting of one or several threads folded or twisted together.

### (43) *Felting affected by Yarn Composition.*

As the nature of the yarn is so definitely related to the milling property of the fabric, the materials of which it is composed—modifying its strength, evenness, elasticity and density—form an initial cause of the felting property possessed by the woven fabric in which such yarn is used. Wools may have a similar serrated structure, but differ in quality, staple, and the average diameter and length of the fibre. The character of the yarn is determined more by these features of the wool than by its structural formation. All physical peculiarities of the fibres are noticeable in the quality of the yarn. For example, considerable variation in length of fibre results in a yarn wanting in uniform breaking strain, or variation in the diameter of the fibres results in a yarn irregular in density and thickness. These characteristics in wool closely affect the structure of the yarn and in consequence the felting process.

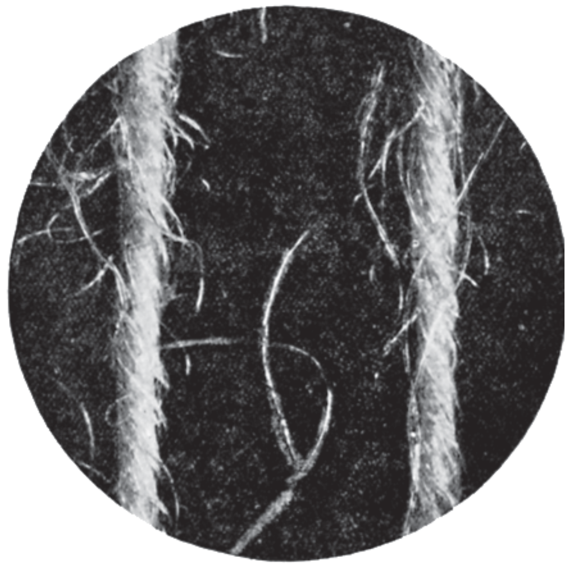


FIG. 34.—Cheviot yarns. 12 skeins (13·8 turns per inch).

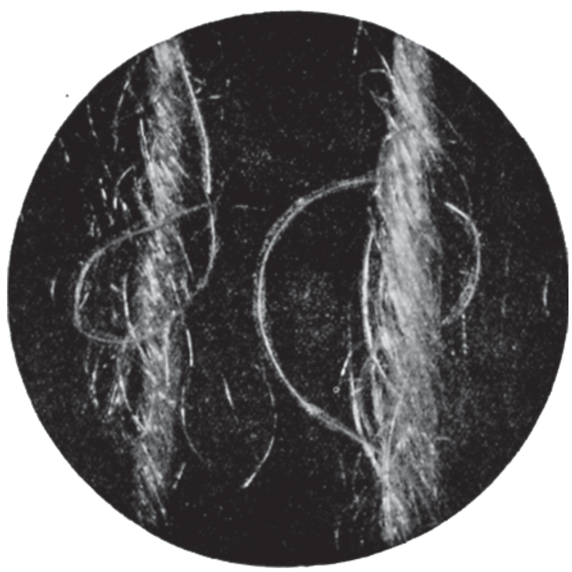


FIG. 34A.—Cheviot yarns. 12 skeins (8·3 turns per inch).