TABLE XXXI.

(180) ANALYSIS AND WEAVING PARTICULARS FOR HEAVY BOX AND MELTON CLOTHS.

I. BOX CLOTH (30 oz. per yard).

Warp: 10½ to 11 skeins drab woollen.
Weft: 12 to 13 ,, ,, ,,
14's reed 2's, 90 in. wide in the loom, 36 or 37 picks per inch.
Finished width: 56 in. with 45 threads and 44 picks per inch.
Weight per yard: 30 to 31 oz.
Weave: 2/2 twill cutting two's in the threads.

II. BOX CLOTH (39 to 40 oz. per yard).

Warp: 14 to 15 skeins drab woollen.
Weft: 17 to 18 ,, ,, ,,
8's reed 4's, 99 or 100 in. wide in the loom, 76 to 78 picks per inch.
Weave: 3-ply in the weft, arranged, 1 pick *weft* swansdown for face, 1 pick plain (centre) and 1 pick warp swansdown for back.

III. MELTON (22 oz. per yard).

Warp: 15 skeins woollen.
Weft: 14 or 14½ skeins woollen.
13's reed 2's, 90 or 92 in. in the loom, 34 picks per inch.
Finished width: 56 in. with 43 threads and 42 picks per inch.
Weave: 2/2 twill cutting two's in the picks.

IV. MELTON (24 oz. per yard).

Warp: 10½ or 11 skeins woollen.
Weft: same as warp, but looser spun.
12½'s reed 2's, 90 in. in the loom, 22 to 24 picks per inch.
Finished width: 56 in. with 40 threads and 34 picks per inch.

Pilots are usually twill woven and made of moderately heavy counts of yarns. The cloths have a beaver finish. The following setting data give a 35 to 36 oz. cloth:—

V. PILOT.

Warp: 10 skeins left-hand twine firmly spun.
Weft: 6½ or 7 skeins right-hand twine loosely spun.
7½'s reed 4's, 90 or 92 in. wide in the loom, 24 picks per inch.
Finished width: 56 in. with 48 threads and 30 picks per inch.

Beavers and doeskins are cloths of a similar characteristic, but the doeskin of the finer construction. Table XXXII contains particulars of several grades of manufacture applicable to these fabrics.

TABLE XXXII.

(181) Constructive Particulars for Doeskin and Beaver Cloths.

I. Prunelle Doeskin (12 oz. cloth (narrow width)).

Warp: 24 skeins fine woollen.

Weft: 13½ or 14 skeins ,,

16's reed 4's, 35 in. in the loom for each narrow piece, with 40 to 42 picks per inch.

Finished width: 28 in. narrow with 80 threads and 48 picks per inch.

Weave: 5-end sateen.

II. Doeskin (14 to 14½ oz. cloth, 28 in. wide).

Warp: 22 to 23 skeins Saxony left-hand twine.

Weft: 10½ to 11½ skeins Saxony right-hand twine loose spun.

12½'s reed 4's, 38 to 40 in. in the loom, 36 to 38 picks per inch.

Weave: 5-end sateen.

Routine of finishing: Knot and mend. Scour with solution at 8°. Twaddle. Mill to 28 in. Wash off. Tenter. Raise damp, 5 sides. Allow to dry. Beat on the raising gig. Cut. Warm press. Boil 3 to 4 hours 160° F. Allow to cool. Re-wind from opposite end of piece and reboil. Cool. Re-boil, reversing order of winding. Cool. Dye. Raise in a saturated condition to straighten and comb out and spread the surface fibre. Dry beat and steam on the gig. Brush. Cut or crop. Hot press with high temperature and pressure. Steam and brush lightly in the direction of the fibrous pile.

III. Beaver (24 oz. cloth).

Warp and Weft: 10½ to 11 skeins Saxony left-hand twine 8·4 turns per inch.

6½'s reed 4's, 90 to 92 in. wide in the loom, 26 picks per inch.

Weave: 2/2 twill cutting 2's in the warp.

IV. Beaver (24 to 25 oz. cloth).

Warp: 14 skeins, right-hand twine.

Weft: 16 skeins, left-hand twine.

16's reed 2's, 90 in. wide in the loom, 40 picks per inch.

Finished: 51 threads and 47 picks.

Weave: 5-end sateen.

V. Beaver (34 oz. cloth).

Warp: 26 skeins Saxony, right-hand twine.

Weft: 14 ,, ,, left-hand twine.

12½'s reed 4's, 82 to 84 in. wide in the loom, 64 to 68 picks per inch.

Weave: Weft-backed 5-end sateen, Fig. H, Plate III.

VI. Warp-backed Beaver (24 oz. cloth).

Warp: 18 skeins, left-hand twine for face and right-hand twine for backing yarns.
Weft: 22 skeins, right-hand twine.
16's reed 4's, 70 in. wide in the loom, 54 picks per inch.
Finished: 80 threads and 62 picks.
Weave: Fig. B, Plate IV.

VII. Devon Pilot (35 to 36 oz. cloth).

Warp: 12 skeins, left-hand twine, firmly spun.
Weft: $6\frac{1}{2}$ skeins, right-hand twine, loosely spun.
$7\frac{1}{2}$'s reed 4's, 90 in. wide in the loom, 24 picks per inch.
Finished: 49 threads and 30 picks.
Weave: 2-and-2 twill to the left.

(N.B.—In the foregoing Examples, the percentage of waste varies with the quality of material used. The length shrinkage or milling in each case is, in practice, adjusted to agree with the required weight per yard.)

Various classes of doeskin and beaver cloths are constructed in compound weaves as indicated in Examples V and VI. The reversible weft principle (Figs. D and H, Plate III) is also applied to union cloths in which the warp is cotton and the weft spun from reclaimed or re-manufactured materials. The 2-fold warp structure (Fig. G, Plate IV) admits of the use of a lower quality of weft than warp yarn, without any perceptible detriment to the quality of the face or back of the texture; and the double-make construction (Fig. N, Plate IV) is utilized in the manufacture of heavy cloths of 40 or more oz. per yard.

Beaver, doeskin, pilot, and other face-finished cloths, exemplify the diversified and extensive field of manufacture available in this branch of the woollen industry. In attaining, approximately, the same weight per yard, the counts of yarns, setting, weave structure, and all other technicalities may be dissimilar. Technological data, formulated on the results of experimental research, and established by practical observation and experience, are, in the application of such manufacturing methods, the factors which determine and ensure success.

CHAPTER XI.

FELT MANUFACTURES.

(182) Historical Data; (183) Mechanical Practices; (184) Distinctive Felt Types; (185) Preliminary Processes—Raw Materials; (186) Fibre and Colour Blending; (187) Colour Standards and Mixture Shades for Felts; (188) Carding and Batt Formation; (189) Batt Hardening: Bywater's System; (190) Hardening Machines: Roller Principle; (191) Table-Hardening Machines; (192) Fulling for Carded Felts; (193) Woven Felts; (194) Felting for Specific Textile Effects; (195) Heavy Woven Felts; (196) Tubular Felts—Manufacturing Features; (197) Tubular or Circular Cloths—Weave Construction.

FELTS have already been defined (Chapter I) as cloths made direct, that is without the routine of yarn construction and the aid of the loom, from animal fibres by a process of fulling. Neither spinning nor weaving, and the subsidiary operations they involve, are essential in their production. They form, as a consequence, the most elementary grade of textile manufacture.

(182) HISTORICAL DATA.

Historically, felts are likely to have been the earliest variety of hand-made covering, or material, obtained from wool and hair. Prior to the discovery of the manual arts of carding, spinning, and weaving, the fibrous skins of domesticated and wild animals were used as clothing. This application, in the course of time, suggested the feasibility of manipulating the fibre, hair, or fur into a matted or felted texture of some degree of uniformity of substance, shape, and thickness. The continued use of these fibrous materials, in the natural or unprepared state, would result in the filaments, locks, or staples, assuming, at first, an entangled but irregular consistency of composition. Whatever the exact order of occurrence, the inventive faculty of the wearer would be arrested by the adhesive clustering of the filaments into a felted stuff of some degree of firmness, to be imperceptibly exercised in devising means, and crude appliances, for the systematic separation and opening of the fleece of wool. The step to re-blending the fibres thus manipulated, and of felting, was easy of attainment. It would be the immediate precursor of converting the material into layers of matted fibres of regulated evenness and density.

Felts were originally an Eastern manufacture. They have been produced from early times in various parts of Asia, but more especially in Persia, Turkey, Russia, and India. Several grades of felts were utilized by the Romans, who are stated to have "embroidered one style of cloth in a different manner from the Parthians and the Ancient Gauls". Pliny records in detail that "wool is compressed for making felt, which, if saturated in vinegar, is capable of resisting iron; and, what is still more, after having gone through the last process, will even resist fire; the refuse, too, when taken out of the vat of the scourer, is used for making mattresses". Proceeding, he refers to the *gausapa* or *gausapum*—a thick texture made of fine wool and dyed purple, and "used particularly for covering tables, beds, and for thick coats to keep out the wet," and which were "brought into use in his father's memory". He also alludes to the *amphimalla*—a cloth napped on both sides—and to the shaggy apron of the artisan.

(183) Mechanical Practices.

Until the invention of machinery, felted stuffs had only a limited application. The scheme of production was restricted in scope, and inadequate in principle, and did not facilitate or provide for industrial development. The substitution of mechanical systems of carding, invented in the latter part of the eighteenth century, led to the practical formation of sheets of prepared fibres continuous in length, uniform in breadth, and of like equality and compactness throughout. Basing experiments on the results of the manual methods, it was early discovered that layer upon layer of carded material could be densified and hardened, and treated in the fulling stocks, in such a way as to give a cloth of a known length, width, and substance. These discoveries, and improvements in routine of work resulted in felt production developing into a considerable branch of textile manufacture; so that felts are now made in thin, medium, and heavy materials applicable to blankets, mats, carpets, saddle padding, table covers, and a large variety of cloths suitable for clothing and decorative purposes.

(184) Distinctive Felt Types.

There are two distinctive types of these manufactures, namely, those acquired by felting laps or sheets of carded wools and other animal fibres, and felts produced by the ordinary operations of spinning and weaving, and following with excessive fulling. The two types differ structurally, in tensility, and in behaviour under stretch and friction. The woven felts, in the common varieties, register the higher breaking strain. Providing identical materials are employed, and the cloths are of corresponding weight per yard, the woven structure also possesses the superior wearing property. A loom-constructed felt does not fray nor tear in the same way as carded felt, each strand of yarn offering a measure of resistance. The scheme of interlacing, or binding of the threads with each other, further adds to the elasticity and firmness of the cloth. *Unwoven* felted structures possess excellent warmth-yielding properties. On this account, they are selected as the most effective material as foot-wear for durability, and for resisting icy coldness, by the natives of Siberia. As blankets, mattresses, and wrappings for use in sleeping in the open, they are unequalled, being more supple, closer in texture, and denser in fibrous composition, than similar materials spun into yarns, and knitted or woven to make a fabric.

Strength, hardness, and solidity are developed, in the heavier styles of carded felts, by prolonged fulling or milling. By this process, and by blending fine-fibred wools of uniform growth and soundness of staple, and of superior felting characteristics, cloths are produced of the toughness of newly-cut wood. Such solidified felts are applied to piano-hammers, and to mechanical tools and instruments for deadening sound due to heavy and frequent concussions.

Summarizing these comparisons, it is clear that *unwoven* felts acquire strength and cohesiveness by compressing, under conditions favourable to fulling, the filament units, forming the carded lap, into close and unific contact; whereas *woven* felts derive similar qualities by compelling, into the closest affinity with each other, the interlaced threads or yarns of which they consist. Fibril units are finer and therefore more multitudinous than yarn units, and, as such, give a cloth of the higher homogeneity and density. On the other hand, the extraneous or circumferential fibres of the yarns have specific linking and binding or interlocking functions. Under the repeated compressions and raised temperature, produced in the mechanical work of milling, and whilst the cloth is in a saturated alkaline state, in which the yarns have a tendency to expand or swell, the wool filaments, or hair of the raw material, are compacted into one common solidified piece. By chemical and mechanical action a clothy material is thus made in which all traces are obliterated of single or distinctive threads—whether intercrossed by knitting or weaving—as separate and spun strands of fibres.

(185) Preliminary Processes—Raw Materials.

The preliminary work of manufacture, in making any species of cloth from fibrous materials, comprises three phases or schemes of treatment. First, it consists in cleansing the raw product; second, in opening the staple and separating filament from filament, disintegrating the order of growth; and, third, in re-mingling and re-grouping the fibres with systematic definiteness, forming thereby a fleece or "lap" of material of uniform consistency and fibrous arrangement. Cotton preparation is done by ginning, opening, and carding, or by carding and combing; flax, by heckling and straightening; jute, by carding for "tow" spinning and heckling for "line" spinning; silk "waste," by dressing (corresponding in method and technical results to the operation of heckling); and wool, first, for *felt* cloths, by "teazing" and carding, making a "batt" or piece of fleecy material; second, for *woollen woven* cloths, by teazing, carding, and condensing, producing soft, thick "slivers" of a thread-like character but unspun; third, for *worsted* fabrics, by (*a*) carding, back-washing, and drawing, making a "roving" from which a spun thread may be formed; (*b*) by carding, back-washing, and combing, giving a "top" or ribbon of levelled, straightened fibres; and (*c*) by gilling—straightening and levelling—and combing. A common mechanical principle obtains in each of these systems of preparation, which may be defined as a compound procedure, involving the opening, separating, and re-combination of the filaments in the raw material, bringing them into such relations as to give a fleece, lap, ribbon, or thread grouping of straightened or combed filaments uniformly commingled. This agreement, in principle, of the several methods of work, facilitates the admixture of two or more varieties of materials in the production of the cloth whether a derivative of felting or of spinning, weaving, and fulling.

(186) Fibre and Colour Blending.

For *unwoven* felts the operations which prepare the substance or foundation of the piece are "carding" and "batting". Prior to this treatment, as explained, the fibrous materials are opened on the teazer, or, in the case of strong, matted wools on the fearnought.

Blending.—Blending or mixing of wools and hair, etc., of different qualities, or natural and dyed colours, is effected at this stage. It is accomplished for two principal functions: (1) the combination of materials of dissimilar characteristics and values to acquire a definite quality of carded lap, i.e. fine, rough, or coarse in fibrous composition; and (2) to obtain fancy or mixture shades diversified in tone, tint, and colour hue.

(1) It will be understood that the latitude in the first scheme of blending is only measured by the diversity and cost of the materials available. Their respective properties have, however, to be considered. Materials differentiating too widely in lengths of staple will not card satisfactorily together or yield a level,

regular fleece or "batt"; and, similarly, wools too distinctive in felting property, though of corresponding carding features, cannot be blended with favourable practical results. In illustration of these points—fine "clothing" wools vary from a fraction of an inch to two or three inches in length, whereas wools of a coarser growth vary from five to twelve inches. Now closeness and fibrous density of staple are the highest in the shorter- and the finer-fibred wools, and these elements denote felting power. Merino lamb's wool, as regards fulling duration, exceeds that of coarse "black-face" wool by some 50 per cent. Wools, differing in felting degree, are utilized for the production of special technical effects in the manufacture of *woven* felts, but, in *carded* felts, it is the ordinary practice to restrict the scope, in blending, to the use of wools of approximately the same fulling strength, or which, at any rate, in the work of milling will give an even cloth. That this is essential to successful felt production is apparent on considering the differences in felting quality and behaviour of the two varieties of wool forming respectively the surfaces of the compound overcoating fabric, Specimens A and B, Fig. 146. Composing one and the same cloth, they have been treated identically in the fulling machine. Surface A, however, is made of Lincoln lustre wool, and surface B of Sydney clothing wool. In the process of milling, both wools, in the first or preliminary period, felt uniformly; but, as the operation proceeds, the Merino wools gain the ascendancy and finally control the activity and acceleration of the shrinkage. As seen in the cloths, the augmented fulling facility of the finer, as compared with the coarser wool, causes the yarns of the latter to loop or bend and form the irregular, wavy surface A. By the same routine, a smooth, compact, level texture is produced in B.

Whereas such wools may, by allocating them to different functions in a compound woven cloth, be effectively combined, yielding results of technical and commercial value, yet it is not feasible to induce like combinations in pure or carded felts in which each class of fibres constitutes a part of a composite whole. Distinctiveness of position is not practicable in the latter instance. Carding, the fundamental and productive process of this species of felt manufacture, blends the fibrous

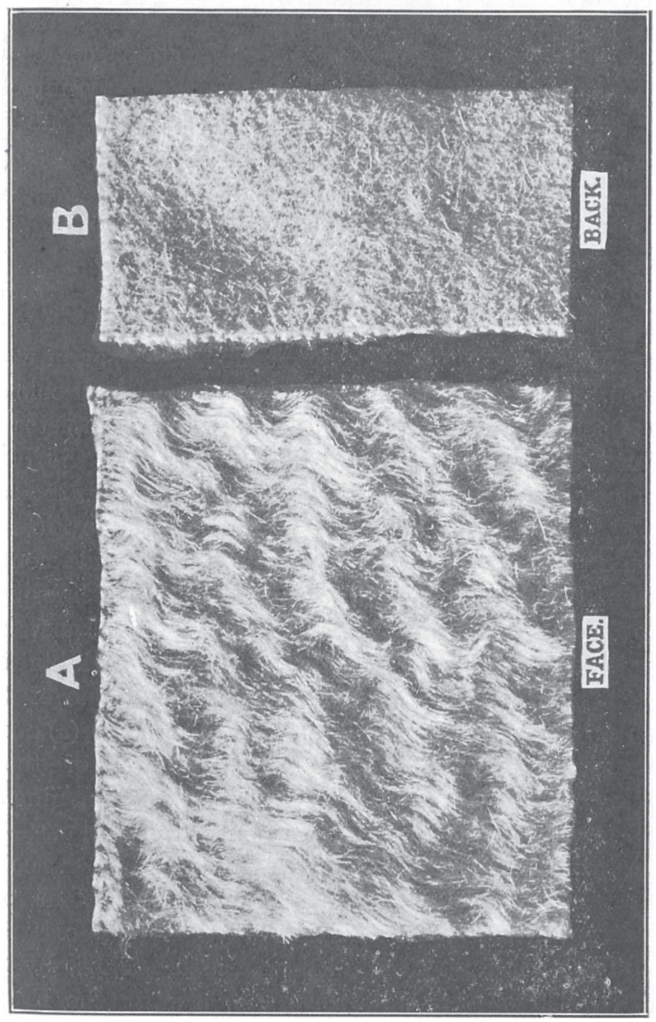

Fig. 146.—Waved surfaced texture due to felting. A = Lustre-wool yarn; B = Sydney-wool yarn.

materials promiscuously. It is not a mechanical routine designed to select and appropriate groups of fibres, applying them to specific sections of the cloth, but a compound work in which all lengths and sorts of fibres are systematically and uniformly intermingled and conglomerated. For the better classes of felts, short-stapled and fine-fibred wools are combined; for medium varieties, Crossbreds, Cheviots, and wool substitutes; and for thick, heavy felts, such as carpets and saddle cloths, coarse wool —East India, Shetland, etc.—and hair. In hat manufacture the fur of the rabbit and hare are mainly employed, the finer felts being made of Vicuna and Camel's hair, and the fur of the beaver and musk-rat. Different classes of wools are also employed, especially in the production of "soft felts" in which many tones of mixture shades obtain.

(2) Blending for the production of fancy shades is a branch of the science and technology of textile colouring. It is the same, in theory and principle of application, in felt as in woven manufactures, being accomplished by the admixture of coloured wools and other fibres previous to carding which completes the process of colour assimilation and the formation of the blend. Two systems of treatment may be followed, namely, the composition of "mixtures," graduating, in mathematical ratio, from a light tint to a dark tone; and, second, the acquirement of mixture shades of a corresponding depth of tone but differing in quality of hue. Specimens *a*, *b*, and *c*, Fig. 147, are examples in a simple scheme of greys obtained by blending dark blue and white in the proportions of (*a*) three of white and one of dark blue; (*b*) two of white and two of dark blue; and (*c*) one of white and three of dark blue. The gradation of toning and tinting may, in practice, be extended to six, nine, or twelve degrees. Moreover, any two contrasting colours—e.g. light and dark—or a dark colour with white, and a light colour with black, may be combined. A third or tinting colour, of a bright hue, may also be introduced into this group of "mixtures," to impart tone to the shades formed. Thus, by this method, if green or warm brown were added to the French grey compound on Plate XIV, the resultant shade would be a greenish or brownish blue grey.

Mixtures diversified in hue, but of a like depth of tone, include a varied assortment of colour compositions. The khaki specimen — Plate XIII—has been analysed. Though given in relation to the woven fabric, it is equally suggestive as an example in "mixtures" for felts, the shade resultant being identical in tone and tinting in both the carded "batt" and the finished cloth. Theoretically, and practically, the colour elements, and method of technical work, are of the same character in each of these manufactures. What is involved is, the admixture, by mechanical treatment, of two or more dyed wools to produce a definite compound mixture shade. The whole gamut of natural as well as artificial tints, tones, and hues of colour are in the process available to the colourist.

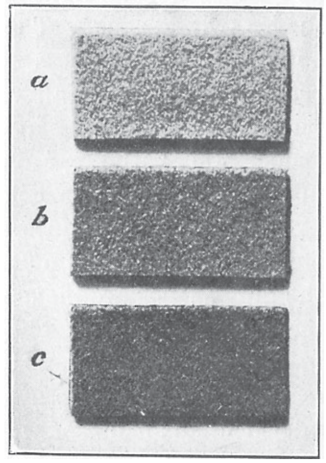

FIG. 147.—Woven felts, graduated in shade.

(187) COLOUR STANDARDS AND MIXTURE SHADES FOR FELTS.

Accuracy and proficiency of manufacture in the production of fancy mixture shades in felt cloths, render it desirable, both in experimental research and in commercial practice, to follow a scheme of colour standardization. Such a scheme is formulated by the selection of series of initial or standard colour units, to which should be added the primary and secondary hues and their derivative tones and tints. The "standards" must be of correlative qualities, that is to say, adjacent colours, in the series or scale compiled, must have one hue in common. This colour "link" obviates a break or interruption of hue in the chromatic circle. On this principle—in a scheme based on experimental research—commencing with grey the colour tones comprise blue, blue-green, green-blue, green, yellow-green, yellow-brown, brown, red-brown, purple, and warm blue assimilating with the initial shade, neutral grey. These hues form a practical scheme of standardization as regards specific colour units. Each hue is toned and tinted, in uniform ratio, to ten degrees, by the admixture in the light shades with white, and in the dark shades with black. The net result is 110 "standards," all obtainable by "process" dyeing. To complete the scale and render, when essential, the influence of fibrous mixing practically imperceptible in the carded lap in producing new shades, and without resorting to additional dyeings, the chromatic relation of the colour hues is more closely established by the formation of intermediate groups of shades obtained by blending equal parts of two adjacent colours. For example, the grey shades are blended with the blue shades, forming intermediate shades of blue-grey; the blue shades with those of blue-green, for intermediate blue shades tinged with green; the red-brown with pure brown or with purple, forming respectively intermediate shades of warm and purple-brown.

Provision is made in the application of this system of colour standardization for two technical essentialities, namely, (1) latitude for variation in the quality of the standards utilized, as to degree of sombreness and mellowness or brightness and pungency of hue; and (2) facility for reducing or increasing the series of the standards: factors which enable the colourist to select the tone and number of shades in agreement with the colour phenomena obtaining in any specific branch of manufacturing.

These fundamental features, so vital to the utility of the scheme, need further explanation. First as to colour quality, tone, and hue—it is imperative that these should accord with the nature and diversity of the composite colouring practised in each section of the industry to which they relate. Thus it will be at once apparent that the colour standards in coincidence with the "colour scheme" applicable to clothing felts, are not of the most useful in character to agree with the "colour scheme" developed in felt carpets. For the former more sombre shades are appropriate and requisite than for the latter. Decorative felts command, in addition, a full range of bright, clear, and distinctive hues and tones possessing depth, mellowness, and bloom. Overlapping necessarily exists, but it is not so inclusive as to obviate the desirability of an independent group of standards for each style of manufacture, if colour excellence and freshness are to be available. But no deviation in degree from the chromatic base—already described—is permissible in the compilation of such standards. This element is not variable with a modification of the brilliancy or otherwise of the standards selected. The principle of hue gradation or toning is a fixed factor determined by the colour scale of the colorific circle. As demonstrated, if the "linking" hue in the formation of the circle is weakened or interrupted, the combination of the standards in the processes of manufacture, instead of resulting in solid colours, would produce shades presenting the "hue" ingredients of their blended composition. On the other hand, the prevalence of the "linking" hue, throughout the series of shades standardized, effectively neutralizes the formation of these characteristics and secures solidity of shade resultant.

Second, as to the number and diversity of the standards: Industrial and technical facilities for colour practice and application are the controlling conditions here. In some branches of felt production each standard need not, as in this scheme, be toned to eleven degrees. Six, for practical purposes, would probably be found ample, and the intermediate shades due to the admixture of two adjacent shades in the scale, might, moreover, be dispensed with, which would have the effect of reducing the number of "stock" shades from 110 to 66. In other sections of the industry, as for instance the decorative branches, in order to facilitate colour range and novelty, the complete number of standards indicated and described would be desirable.

The leading objects ensured by this system in the manufacture of coloured felts are: "(1) Economy of colour production, a limited set of colours yielding an unlimited set of distinct shades; (2) the substitution of uncertainty of colour or shade formation due to independent dyeings by certainty of result due to mixing; and (3) the manufacture of yarns by blending from a series of fixed colours which may be stocked, producing new shades as varied and solid in appearance as those obtainable in dyeing. In the ordinary method of acquiring new shades by blending, there is an absence of a scale of fixed or standard colours; neither in the blending is there a base of proportions, nor in the colours combined a standard scheme of colour gradation." Thus it will be seen that, in addition to degrees and grades of colour toning, with positive matching, being afforded in the production of solid shades, the prolific and useful art of colour blending, in fibrous materials, for ordinary varieties of mixture shades is established on a scientific and technical base.

(188) Carding and Batt Formation.

Following the preparatory routine of cleansing and blending, the materials are carded, hardened, and fulled. These are the principal processes in carded felt manufacture, which is a limited scheme of textile work as compared with the simple and compound operations, practised in the construction of ordinary fabrics in the loom.

Carding, the process which yields the basis of the felt, resembles, in nature and object, the mechanical treatment of the wool in scribbling and carding in yarn production, but "batt" formation takes the place of condensing. One or two machines —single- or double-cylinder in arrangement—are employed. Loose and open wools, and materials, may be prepared on the single type of machine, but for the closer-grown and matted-staple wools, or materials necessitating considerable opening and blending, it is advantageous to combine a double-swift scribbler with a single- or two-swift carder. The scribbled lap, in this instance, is conveyed from the first to the second machine by Blamire's Lap Former, or by the Scotch Overhead Feed. In either case, a fleece of scribbled wool is laid, in the reverse direction, on the lattice sheet of the carder, to that in which it is delivered by the doffing cylinder of the scribbler.

It is all-important to the making of an even lap, free from neppiness and irregularities, that the number of carding surfaces in the machines employed should be adequate to the work of complete separation, re-blending, and re-arrangement of the fibres of the raw material. The carded sheet or batt—see

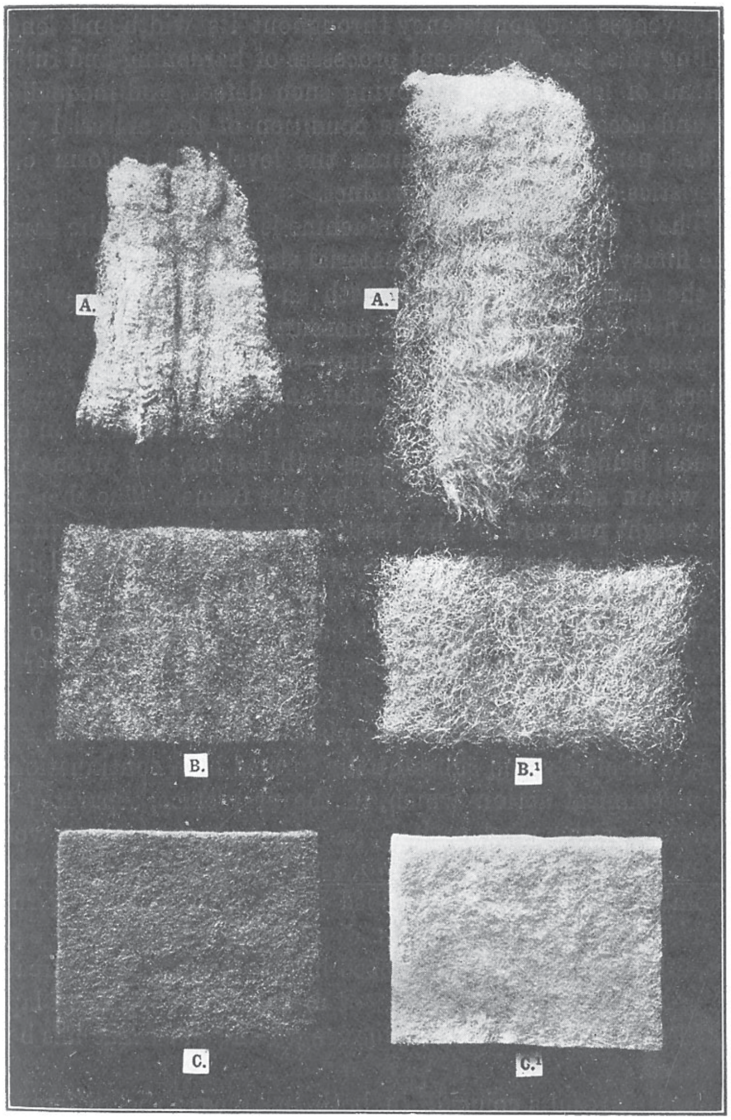

PLATE XVI.—Specimens illustrative of felt-cloth manufacture. A, A^1 = Merino and Crossbred wools; B, B^1 = Carded batts from A, A^1; C, C^1 = Hardened compound batts from B, B^1.

specimens B, B[1], Plate XVI—requires to be of one fibrous cohesiveness and consistency throughout its width and length. Failing this, the subsequent processes of hardening and fulling, instead of lessening or removing such defects and inequalities, fix and accentuate them: the condition of the material when carded permanently determines the level and uniform characteristics of the hardened product.

The "batting" frame or machine is attached to the carder. The flimsy, fibrous sheet of material stripped from the "doffer," by the doffing comb, travels with an endless linen texture—some fifty yards in length or a measure equivalent to the length of piece prepared for hardening—over a series of pairs of rollers, placed one above the other and in an enclosed frame or chamber. This linen piece or carrier is maintained at an even tension, being bound at the edges with leather, and arranged to run within suitable grooves of the batt frame. The thickness and weight per yard of the hardened felt are regulated, in this operation, by the number of layers of carded material laid in succession one over the other on this endless sheet. When the required number has been combined, and conveyed into the batt frame, the lap is broken off and run on to a smooth surface roller, and forms a "batt" ready for hardening.

It should be observed that a piece of felt cloth, like a spun yarn, is primarily and substantially formed by a continuation of the mechanical action which, in the first place, separates the filaments of the wool or hair, and, in the second place, works the material into a condition to be adaptive and conducive to re-combination after a prescribed method. If a spun yarn is required, the carded fleece is divided into lengths of equal ribbon-like dimensions and rubbed into fluffy untwisted threads; if a piece of felt is the object of manufacture, lap upon lap is united until a "batt" of suitable length and substance has been produced.

Carding results coincide in both instances: the differences exist in the method of preparation for subsequent processes and technical routine.

(189) Batt Hardening: Bywater's System.

Specimens of batt material are shown at B and B[1] on Plate XVI. They result from the Sydney and Crossbred wools illustrated at A and A[1]. Wools of this quality and fineness are applicable to felts for clothing purposes.

Fibrous adhesiveness is observed in each of the "batt" samples, but firmness of texture is lacking. Still, the filaments are so effectively crossed, and promiscuously grouped, as to give a fleece or lap of regular thickness and density. These features render the product suitable for yielding, in the hardening operation, a cohesive and solidified though somewhat spongy piece.

The object of hardening is to convert the "batt" into a piece of sufficient substance, and tensile strength, as to be capable of undergoing, without breakage or mutilation, the mechanical work applied in the fulling stocks or the milling machine. It is effected by damping and steaming followed by friction and pressure. Moisture and heat produce cohesiveness of fibrous condition. The outer scales of the fibres, combined with waviness of staple and method of fibrous grouping, augment the binding contact of filament with filament. Permanence of result is secured by compression.

(190) Hardening Machines: Roller Principle.

Two types of machines are constructed—"roller" and "flat" or "table" hardener—some 90 inches in width and adapted to the treatment of batts of carded material from 50 yards in length and upwards. One to six batts may be hardened together and delivered separately, or in two or several batts forming one piece. Fig. C is a four-batt and Fig. C[1], Plate XVI, a six-batt product.

The roller machine contains twenty lower metal rollers, six of which are made of copper and steam heated. These alternate at intervals with the unheated iron rollers. Over this series of bottom cylinders are placed nineteen smooth wooden rollers, each operating on the sheet of material as it passes from the surface of one bottom roller to another. They have both a rotary and lateral action. Revolving in the direction of the passage of the piece, they carry it forward in conjunction with

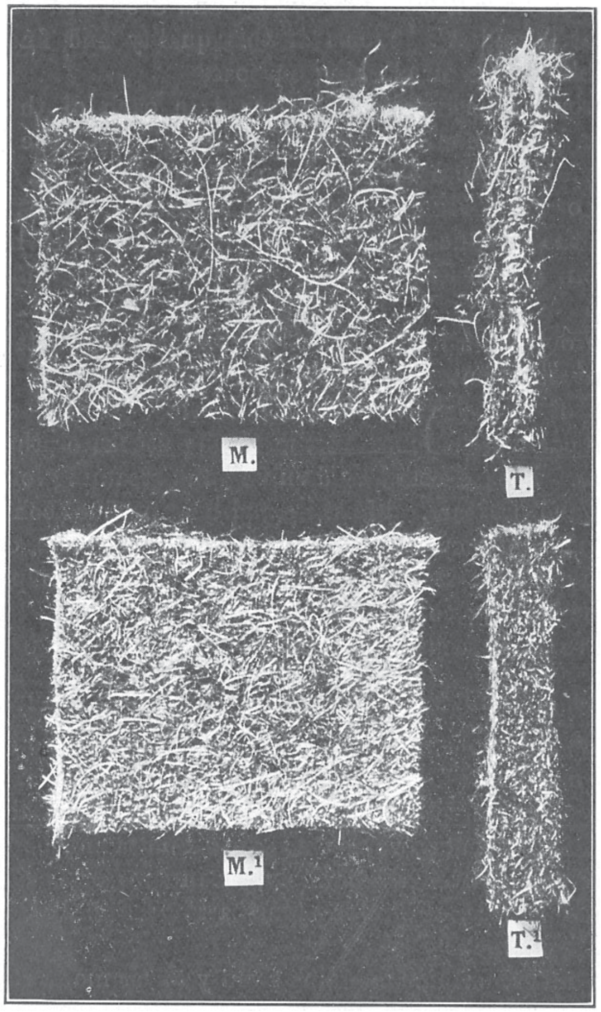

FIG. 148.—Fulled or milled carded felts. M = Four-batt needled cloth; M^1 = Six-batt cloth; T, T^1 = End section showing the thickness of M, M^1.

the metal rollers. At the same time the lateral traverse apply an amount of friction, rubbing the batt of wool and thereby accelerating felting or hardening. As only a minimum amount of reduction occurs in the operation in the width and length of the batt, it will be understood that the work is of a solidifying rather than of a fulling nature.

The routine consists in conveying the carded batt or batts on a linen piece running in contact with the lower rollers. This piece is kept in a damp state by being immersed in a water bowl, extending the full breadth of the machine, for each passage between the complete set of rollers. As the moistened material is carried over the heated copper cylinders, a steaming effect is generated, under which the fulling disposition of the wool is stimulated and rendered active, the batt or piece being, as a result, cohered and stiffened under the friction and pressure of the wooden rollers. The processes of conveying, surface-rubbing, and heating and steaming are continuous, but the time fixed for the treatment of each length of batt may be mechanically adjusted to agree with the quality of the materials. On the hardened pieces leaving the last pair of rollers, they are wound on to separate cloth beams, in which condition they are allowed to cool naturally, when they are ready for the next operation, that of fulling.

(191) Table Hardening Machine.

Bywater's table hardener is of a different construction from the roller machine. Being intermittent and not continuous in action, the work is done in sections of about 1½ yards in length. The system of damping, frictioning, and heating corresponds, in order of sequence and in principle, to that practised in the roller hardener. The batts are again run through the machine on a linen carrier which passes through a water tank, and then, with the material, over a heated surface saturating the piece with steam. The batt is now conveyed to the hardening table which has an upper and lower surface, the latter being fixed, but to the former a lowering and raising and also an oscillating movement is applied. During the traverse of the batt, the top section of this table is raised. For hardening, it is lowered to lie in contact with the material; then, for a short period—which is varied to suit the stuff operated upon—the upper and pressure section of the table is reciprocated by eccentric gearing, having practically the same effect as the lateral traverse of the rollers in the first type of machine. The hardened batts are finally run on to piece beams.

Though this machine, as indicated, is intermittent in action, it is entirely automatic, the compound motions being mechanically controlled by the driving pulley. All the motions are, in addition, convenient of adjustment, facilitating the felting and hardening of any class or blend of fibres, and also of pieces of different thicknesses, composed of single or multiple batts.

(192) Fulling for Carded Felts.

Several of the standard woven manufactures analysed in previous Chapters are of a felted character, but, being yarn-spun and loom-made products, the qualities developed by fulling are supplementary and additional to those giving the fabric structure proper. Correctly speaking, in these examples, the operation is not constructive in principle. It is practised to supply distinct and new characteristics to a fabric already accurately and firmly constructed as, for instance, in the manufacture of Meltons, Beaver, Friezes, and other cloths. Felts, on the other hand, are a sole product of carding, hardening, and fulling. On the felting work depends the tensility of the texture, the wearing strength, and, for general use, the untearableness of the cloth. It is in the production of these essential cloth-like elements, that fulling work and results differ from the effects of fulling on a fabric formed in the loom or stockingette frame.

Four systems of fulling treatment are in common practice. The hardened piece may, first, be operated upon in the ordinary milling machine; second, in the "fuller" stocks; third, in the compound machine consisting of both the mechanical parts of the "mill" and of the "stocks"; and, fourth, by running the pieces for a period in the mill for preliminary felting, and subsequently in the fuller stocks for the final fulling, which is a sound practice for attaining evenness and permanence of felted qualities.

In each system fulling is effected by a continued series of

FIG. 149.—Woven-fur effects.

FIG. 150.—Fabric with undulated or crepon surface due to shrinkage in steaming.

crushings, or, in the case of the fuller or mechanically-driven stocks, of poundings or concussions of the pieces of cohered and hardened materials. The cloth, in the operation, augments in substance and firmness, shrinking in area. When examined, it is found to be a compact layer of filaments only separable from each other with difficulty. Carding and batt formation, as described, provide an even, extensible structure of cohesive fibres of a definite thickness and dimension; fulling, succeeding hardening, transforms this sheet of flexible stuff into a piece of cloth of leathery, buckram consistency and toughness (Figs. 148, M and M^1). The sponginess characteristic of the hardened material—specimens C and C^1, Plate XVI—is substituted by fibrous solidity and textural firmness. Yet, as a cloth, the structure is more flexible and yielding than a well-felted woven fabric made of the same quality and weight of material. Flexibility and wadding-like nature render it, however, specially adapted for floor-covering, wraps, saddle cloths, and for the general purposes to which it is applied.

Cheapness and simplicity of manufacture are also in its favour, hence the applications of felts to certain classes of low-priced productions for under garments, table-covers, and decorative hangings in which pattern or design and colour novelty are acquired by the art of block or machine printing.

(193) Woven Felts.

These offer more latitude in construction than carded felts. They form ordinary textile structures single or multi-ply in weaving, submitted to such excessive fulling as to possess a similar appearance combined with some of the features of felted carded cloths. Usually they are made of fine materials or at least of fibres of sound milling and raising properties. The single-make fabrics, produced in the plain, 2-and-2 twill and swansdown weaves, and thin but firm in construction, range from 16 oz. to 24 oz. per yard, 54 inches in width. Manufactured in fine merino wools, dyed in fresh and bright colours, they are used for the decoration of military cloths and also for trimmings. To provide for the requisite amount of shrinkage the pieces are set wide in the reed, 104 to 110 or more inches for 54 or 56 inches finished.

(194) Felting for Specific Textile Effects.

Felting is practised in the production of special textural qualities and design characteristics. Fabrics of this description are not strictly " felt " manufactures, but they are so extensive in variety as to need some explanation. Yarns differentiating in fulling or contracting power are combined in their formation, such as cotton and woollen, silk waste and woollen, worsted and silk, and cotton, fine woollen and mohair or lustre worsted. Wool fibre is in each combination the felting unit, and controls the development of the characteristic effect seen in the finished fabric. Three examples may be dissected and compared as exhibiting the elements of manufacture and textural principles involved. Fig. 146, a compound of cotton warp yarns, and of fine wool for the backing weft and lustre wool for the face weft, is illustrative of the materials and yarns utilized in the manufacture of certain groups of curl and imitation astrakhan fabrics in which the crimpled effect, as explained in Paragraph 186, is a product of felting.

In the second example—Fig. 149—a non-shrinkable yarn (commonly cotton) is used for warp, and a carded yarn composed of approximately 70 per cent of fine-fibred wool, 20 per cent of Vicuna wool or Camel's hair and 10 per cent of silk waste, for weft. Both surfaces of the cloth are formed of this blended yarn, and cotton at the same time concealed, by using a reversible five-shaft weft sateen—Plan H or I, Plate III. A variety of fur characteristics is producible in this build of fabric, as in the illustration, by felting and raising. Length and lustre of shag are determined by the fibrous composition of the yarns, and fur-like colouring and effects by the scheme of the design.

Worsted and silk structures—the third example Fig. 150,—derive their crepon pattern or undulated surface from the distinction in the shrinkage property of the two materials. Both yarns—worsted and silk—interweave plain, forming one compound fabric, knitted together in the loom, to produce either an irregular or a definite style of pattern, which is more or less invisible before contraction of the worsted-yarn texture is induced by the routine of damping and steaming.

The three specimens are typical and illustrative of degrees of felting as a productive quantity and quality, when applied to compound woven structures, in developing and forming specific effects, and design elements, in what would otherwise appear plain-surfaced fabrics.

(195) Heavy Woven Felts.

Two-, three-, and several-ply weave structures are employed in the manufacture of these cloths, which are woven in thick counts of yarns, and the pieces fulled from 30 to 50 per cent in both breadth and length. Felt productions of uncommon warmth of substance and supple fullness of handle are the result. An example in a 60 to 64 oz. per yard cloth is composed of 6 skeins warp and weft yarns with 48 to 54 threads and 44 to 48 picks per inch and woven 80 to 84 inches wide in the loom. The plan is the three-fold 2-and-2 twill, R, Plate IV. Differing in firmness, wearing strength, and tensile property from a carded felt of similar thickness and weight, this style of cloth is producible in three layers of yarns of distinct shades such as light-grey, white, and medium-grey, or any three colours suitable, grouped to coincide with the plan of the weave in both warp and weft. On cutting a three-ply cloth thus felted, three strata of colours, cleanly separate from each other, are distinguishable. Other compound weaves are also applied including three plain makes; weft swansdown for face, 2-and-2 cassimere for centre, and warp swansdown for back; and also such plans as those illustrated in Figs. 66, 68, and 69. The selection of the type of weave is determined by the quality and raised surface—short or shaggy pile—of the cloth required.

(196) Tubular Felts—Manufacturing Features.

Tubular woven felts are applied to roller covering in the printing and paper industries.

The chief technicalities to be observed in this branch of skilful woollen manufacture comprise :—

(1) The acquirement of a fabric having a perfectly smooth surface free from all species of defects or flaws likely to mark the paper, such as neps, burrs, and vegetable matter in the carded material, and twitty places, snarls, faulty "piecings," and knots in the spun yarn.

(2) The development of a close fibrous cover well pronounced on the upper side of the felt.

(3) Elasticity and flexibility of texture, that is a felt possessing a full degree of compressing, "cushion," and squeezing property.

(4) The correct formation of the weave in the cloth at the points which, in ordinary piece weaving, make the selvedges or listings. Any break or interruption in the plan of the warp and weft interlacings, however small, would cause irregularities in the circular web of the piece, blemishing the surface of the paper when the felt is in use on the printing rollers of the machine.

The whole minutiæ and routine of manufacture involve the exercise of technical proficiency, and skilful practice and execution. In the first place, trained judgment and proved experience are of paramount value and utility in the choice of suitable wools. These require exact classification or sorting as to carding and spinning qualities. In the second place, it is of primary importance that the sets of carding machines employed, should provide a sufficient amount of card clothing surface and roller action as to secure (*a*) the complete or thorough opening and blending of the material ; (*b*) a carded lap of similar cohesiveness and agreement in all portions of its formation ; and (*c*) uniform "sliver" result as to filament composition, tenuity, and "counts". Trueness of yarn structure is affected by the relative length measurements of the condensed and the spun threads. If the former too closely approximate the latter the spun yarn is liable to be uneven in diameter ; and, on the other hand if the discrepancy between the two threads is too pronounced, the spinning operation produces a twitty yarn of irregular structural formation.

Experiment and practice, with definite blends of wools, and systems of carding, are the reliable factors, and may be rendered increasingly productive of success by accurate and systematic technical research. A fundamental rule to follow is, that the attenuation or drafting in spinning should straighten and elongate the fibres, but not be carried to such an extent as to develop "thin groupings" of filaments, which tend to form "small" places in the yarns. To produce sound and satisfactory threads, small in diameter, from a given counts of condensed sliver, double drawing and spinning are practised—the first operation yielding approximately two-thirds of the counts of the spun yarn required; e.g. condense to 16 skeins, first spinning to give 24 skeins, and second spinning to yield 32 to 36 skeins. Compound spinning, in the manufacture of yarns of this smallness, produces a more level thread, therefore one better adapted for fine felt cloths, than condensing to a higher counts with the object of attaining the size of thread necessary at one spinning operation.

As in carding and spinning, so in all other technicalities of fabric production—skilful performance and exactitude are desiderata. In the preparation of the yarns for the loom, in the actual weaving of the pieces, and in the scouring, milling, and finishing routine, it is imperative to combine scientific method with practical work, to ensure accuracy of manufactured result.

(197) Tubular or Circular Cloths—Weave Construction.

Circular or tubular fabrics are compound woven structures. The ordinary types are double in arrangement, but thick, heavy, smooth cloths are made three, four, and several ply. Two-fold fabrics (single-cloth felts) are produced in unstitched simple double weaves. In multi-fold plans, stitching in each group of fabrics constituting the layer of felt is necessary. This point will be better understood by taking examples. Fig. N and R, Plate IV, are respectively two-fold or double-make sateen, and three-fold or treble-make cassimere twill. To convert them into plans for producing tubular cloths, four series of warp and weft yarns would be necessary in the former, and six series of yarns in the latter structure, grouped together thus :—

Double-Sateen Fabric.

	A
1 thread of face yarn }	Upper cloth
1 ,, ,, back ,, }	in weaving
	B
1 thread of back yarn }	Lower cloth
1 ,, ,, face ,, }	in weaving

Three-fold Twill Fabric.

	A
1 thread of face yarn }	Upper cloth
1 ,, ,, centre,, }	in
1 ,, ,, back ,, }	weaving
	B
1 thread of back yarn }	Lower cloth
1 ,, ,, centre ,, }	in
1 ,, ,, face ,, }	weaving

Sections A and B form separate compound cloths stitched together on the ordinary system, but no binding or stitching places are inserted between the upper and lower cloths in the loom. This rule is practised in all builds of these fabrics, and secures the production of a tubular piece whatever the compound structure of cloth, A or B.

The grouping of the yarns, in the upper and lower layers of the piece in the loom, make it clear that the scheme of warp and weft intersections in B (the lower structure) would be the reverse of those in A (the upper structure). But this is only in the operation of weaving, and done with the object of acquiring a regular continuation of the weave and fabric structure. Shuttling should correspond with the arrangement of the plan, that is, the insertion of the picks must coincide with the order of the yarns in the compound weave. Deviation from this rule destroys the accuracy of construction.

The principal groups of weaves applied comprise plain, twill, swansdown and sateen, with numerous distinctions in the relative settings and counts of yarns for each texture of which the compound cloth is formed. These afford technical latitude in schemes of manufacture and in principles of fabric structure.

APPENDIX.

THE Belgian khaki is a very similar mixture shade to the English, but the Russian is warmer in colour tone. The fabrics are also similar in principles and schemes of manufacture to the English cloths, only differing in constructive details. The particulars given in the table below are taken from the official specifications of the varieties of khaki requisitioned for the clothing equipment of the Russian army.

ABSTRACT FROM RUSSIAN KHAKI SPECIFICATIONS. SEE FOOTNOTE ON PAGE 279.

Cloth.	Weight of specified piece with selvedge 28″ long × 52½″ wide.	Threads per square inch.		Strength of piece of cloth 7″ × 3″.		Shrinkage on specified piece 28″ long × 52½″ wide.
		Warp.	Weft.	Warp.	Weft.	
Tunic	19·62 to 21·42 oz.	40	40	88 lb.	88 lb.	Not more than 79·63 square inch.
Trousers	20·28 to 22·68 oz.	35	32	121 lb.	93 lb.	
Overcoat Freeze	27·90 to 28·98 oz.	36	25	154 lb.	99 lb.	Not more than 67·38 square inch.

INDEX.

(See also the Sectional Headings of the Chapters.

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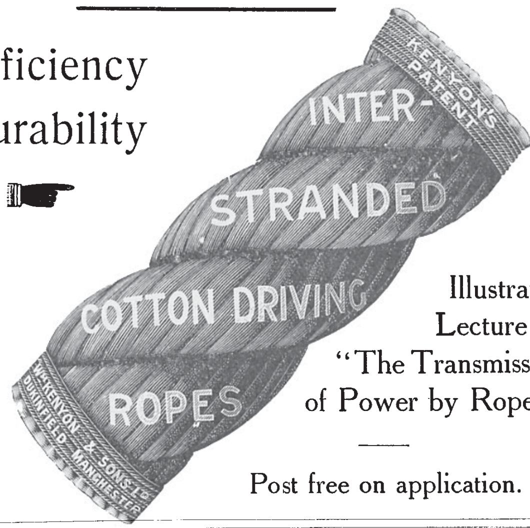

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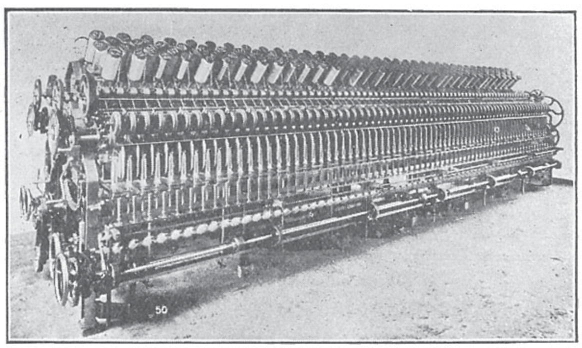

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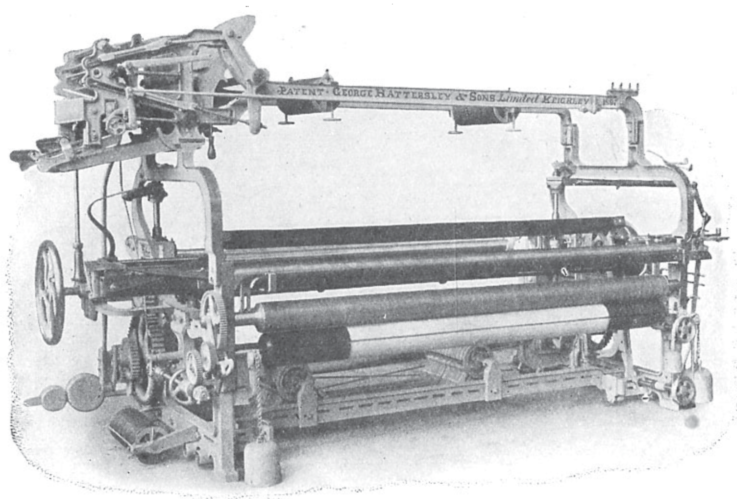

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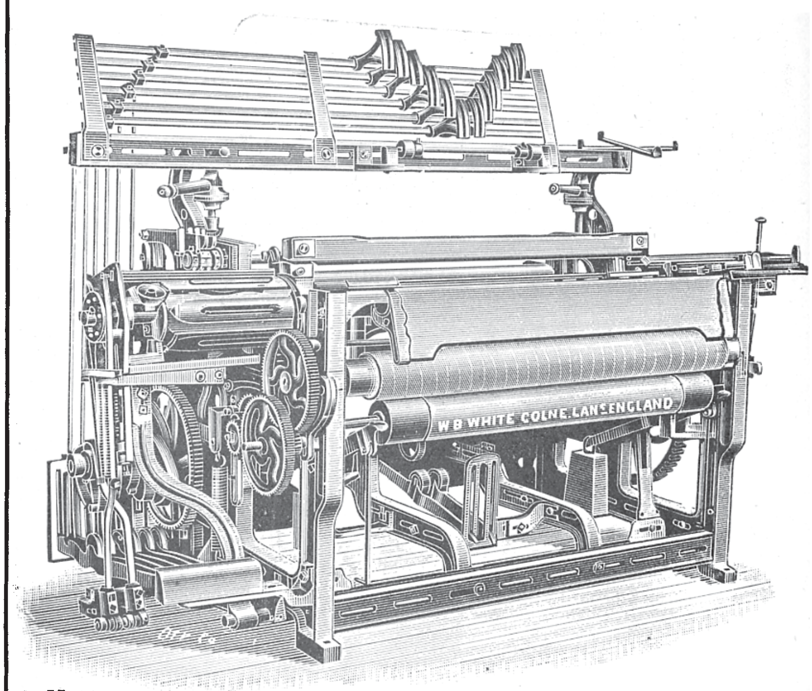
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