OPINIONS OF THE PRESS

ON

"WOOLLEN AND WORSTED CLOTH MANUFACTURE."

"Mr. Beaumont's book is, for a work dealing with a subject of some intricacy, singularly clear. He evidently understands how to bring out the essential points of any difficulty, and to make the way plain for a learner. The volume is, in fine, likely to be of great value to all interested in the manipulation of textile fabrics. Its clear arrangement and useful index will much simplify reference, and the illustrations materially enhance the value of the book."—*The Yorkshire Post.*

"Mr. Beaumont has furnished to every beginner in the manufacture of woollen and worsted fabrics what may be called a complete handbook to his industry. The opening chapter on materials forms a very good and assuring specimen of the skill and knowledge with which Mr. Beaumont has known how to achieve at once comprehensiveness and conciseness in his work. . . . The construction of yarns and fancy twist threads, both for woollen and worsted cloths, having been very carefully treated of in three chapters, Mr. Beaumont goes on to devote the bulk of his work to a very careful and masterly handling of the subject of cloth construction, from the stage of loom-mounting, or preparation of the yarn for the loom, onwards until the cloth is "finished" and prepared for market. . . . . We are very glad to see such a book from the pen of a lecturer and demonstrator at the Yorkshire College, and are confident it will be very largely serviceable in the cause of technical education."—*The Leeds Mercury.*

"It stands out among works of its kind as dealing fully, and yet concisely, with the whole routine of the production of the fabric of which it treats. The exposition is always lucid, and made more clear by a great number of illustrative plates and diagrams. Workmen engaged in the making of woollen cloth, and students preparing for examination in the industrial arts alike, will find the work worthy of their attention."—*The Scotsman.*

"Every page bears the indication of the conscientious work of a workman thoroughly master of his subject. . . . . It is not a commonplace expression to say that it should be studied and inwardly digested by every student of the textile arts."—*The Textile Recorder.*

"The work is also illustrated with over two hundred figures, large and small, which obviously considerably enhances its value as a manual to the textile student. . . . . It is written in a clear and easy style, with the subject paragraphs numbered for easy reference. . . . . We have great pleasure in recommending the book."—*The Textile Manufacturer.*

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"Designing, as regards pattern, colouring, and the use of fancy yarns, is thoroughly put before the reader, and in such a manner that the work cannot fail to be of the greatest utility to either workman or employer. . . . . We predict for this work a standard place amongst the too few books of practical value now before those interested in the various branches of the textile trades."—*Journal of Fabrics.*

"Le plan général en est assez bien compris, comme nos lecteurs pourront en juger par l'intitule des chapitres: 1° Matières premières; 2° Filature du cardé; 3° Filature du peigné; 4° Retordge simple et de fantaisie; 5° Preparation des chaines; 6° Principes du tissage. Tissus fondamentaux; 7° Métiers à la main; 8° Métiers mécanique; 9° Empoutage et rentrage figurés; 10° Echantillonnage; 11° La Science de la coleur appliquée aux tissus nouveautés; 12° Tissus renforcés et tissus double toile; 13° Analyse des tissus et calculs divers; 14° Apprets. M. Beaumont résume toutes ces operations d'une manière fort intelligente. Les explications en general sont tres claires . . . . Nous en recommandens à ceux de nos lecteurs aux quels la langue anglaise est familière, l'ouvrage de M. Beaumont."—*Le Jacquard.*

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"As a practical manual, or text-book, it will be found invaluable in our technical schools. . . ."—*The Irish Textile Journal.*

"An exceedingly valuable book."—EDITOR, *Boston Journal of Commerce.*

"I have looked carefully through it, and think it admirably done, and in every way a book which will be of much use to the trade."—W. S. B. MCLAREN, ESQ., M.P., Author of *Woollen and Worsted Spinning.*

TECHNOLOGICAL HANDBOOKS.

EDITED BY H. TRUEMAN WOOD,

Secretary of the Society of Arts.

WOOLLEN AND WORSTED CLOTH MANUFACTURE.

TECHNOLOGICAL HANDBOOKS.

WOOLLEN AND WORSTED CLOTH MANUFACTURE:

BEING A PRACTICAL TREATISE FOR THE USE OF ALL PERSONS EMPLOYED IN THE MANIPULATION OF TEXTILE FABRICS.

BY

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AND AUTHOR OF ARTICLES ON DESIGNING AND MANUFACTURING
IN THE "TEXTILE RECORDER."

WITH OVER TWO HUNDRED ILLUSTRATIONS.

(INCLUDING SKETCHES OF MACHINERY, DESIGNS, CLOTHS, ETC.)

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PREFACE.

PRACTICAL and intelligible Manuals of Technology are greatly needed by those whose employments are associated with the industrial arts. Especially are such works wanting on textile subjects. There is reason to anticipate, however, that the establishment of technical schools—which have received such munificent support from the Clothworkers' Company—combined with the technological examinations appointed by the City and Guilds of London Institute, and the publication of interesting trade journals—which bring to the notice of those interested in the advancement of British industries the improvements effected from time to time in machinery, as well as the most economic methods of manufacture—will, by operating in a beneficial manner on the intelligent and skilled artizan, ultimately result in producing men capable of supplying this want of the times. In a word, technical training having created the "want" for this class of literature, will discover the means of supplying it. Already there are evidences of its power to do this; for, during recent years, several useful books have been published on woollen, worsted, and cotton yarn manufactures, and also on weaving. But it is remarkable that no treatise has appeared dealing with the whole routine of any class of textile production, such as cotton, wool, or silk. At least in this particular this Manual may claim to be unique and distinct in character.

Thus the object of the book is to place within the reach of the reader, in as concise a form, and yet in as comprehensive a manner as possible, information on the following subjects :—The physical structure and clothing properties of the raw materials or fibres used in the production of woollen and worsted fabrics ; the processes of yarn construction ; the preparation of the yarns for weaving ; the manipulation of the loom ; designing and colouring the texture, and the operations to which the cloth is submitted subsequent to weaving.

Separate chapters have been devoted to the manufacture of the woollen and worsted threads respectively, and also to fancy yarns, including two and three-ply twists, and knopped, curled, and cloud threads. The special uses of these yarns in pattern formation have also been carefully noted.

As the loom forms a very important department of a cloth factory, a considerable portion of the book is utilized in describing the various classes of both hand and power-looms now employed in the production of textiles. In order to simplify, as much as possible, the difficult question of loom mechanism, many original sketches of the principal motions of the loom are introduced into the text. By consulting these illustrations, probably the reader will more readily arrive at the principles of loom construction than if elaborate and detailed descriptions had been furnished without such drawings.

With regard to Designing, it has received attention so far as it relates to woollen and worsted cloths ; while the general principles of textile design underlying the ornamentation of all classes of woven fabrics have also been explained. Special attention has been given to the production of pattern by the employment of fancy yarns. Colour, it is needless to observe, is the *prima materia* of many classes of woven ornament, and yet in the works previously published on Weaving, pattern or design resulting from the amalgamation of coloured threads has obtained but brief consideration. An attempt has been made in the following pages to treat this branch of textile design in a practical manner. The effect of weave on various systems of colouring, and the principle of applying colour to designs of a single make and of a combination character, are the points which directly concern the textile designer, and which should, before all others, receive detailed explanation in a work of this class. A portion of the illustrations, and also of the text relating to Design, was embodied in a series of articles written by the author for the "Textile Manufacturer." The inquiries the editor of that journal received from correspondents respecting their republication in book form, is one of the reasons why they have been used in this Manual.

Under the heading of "Cloth Analysis," the system of dissecting woven fabrics, whether composed of wool, worsted, cotton, or silk yarns, has been described; including explanatory notes on the method of calculating the weight of warp and weft used in the production of goods of a prescribed length and width. Respecting calculations, it may be observed that the most important occurring in cloth manipulation have been dealt with in a simple manner. There is no calculation in the whole routine of cloth manufacture which cannot be worked by anyone possessing the rudiments of arithmetical knowledge.

One further remark need only be added, and that in reference to Cloth Finishing. It has not been possible to allude to the construction of finishing machinery, but information is furnished on the various processes through which the cloth passes after weaving, and also on the characteristics of the different kinds of "finish," giving the reader a succinct idea of the modifications the fabric undergoes after it leaves the loom.

The thanks of the publishers and of the author are heartily rendered to the proprietors of the "Textile Manufacturer" for loan of blocks of designs and patterns; to the editor of the "Textile Recorder," for illustrations

of textile fibres and textile threads; to Messrs. Taylor, Wordsworth, and Co., Leeds; and to Messrs. Rhodes and Sons, Morley, for the use of blocks of machines of which they are manufacturers.

Should the book have a satisfactory sale, other works dealing with specific branches of manufacture may subsequently be prepared.

R. B.

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CHAPTER I.

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1. *Four Methods of Diversifying a Woven Product.*—Apart from actual weaving, in the manufacture of textiles, there are four distinct and important methods of modifying the character of a woven pattern, and also the texture of cloths produced in the loom. These methods, when classified in the order of sequence, are as follows:

I. By the employment of a diversity of materials.

II. By blending materials of various properties or colours together.

III. By the use of different classes of yarns.

IV. By varying the "finish" applied to the woven fabric.

2. *Textile Materials.*—The materials used in textile productions include fibres of an animal, of a vegetable, and of a mineral origin. Each fibre, of whatever species, possesses its specific properties, which, of a necessity, characterize the woven fabric in which it appears. The quality,

softness, elasticity, strength, and lustre of a texture depend, in a primary sense, on the nature of the material or materials used in its manufacture. Skilful carding, spinning, weaving, and finishing cannot possibly produce a soft, fine piece of goods from a coarse, hard material. In fact, the art of manufacturing does not consist in changing, but in retaining, the natural properties of the fibre employed; or, in other words, it consists in reducing the material into a thread-like form, and of weaving it into a wearable fabric at a minimum detriment to its original characteristics. In the processes of manufacture, all fibres necessarily undergo modification. Firstly, in the application of colour, or in dyeing; and, secondly, during the after processes of spinning, weaving, milling, and finishing, where the filaments of the material are re-adjusted to suit the ends of cloth production. Yet in all cases the principal qualities of the fibre characterize the appearance of the finished goods. In a word, the same features which distinguish the materials from one another in the raw state are also the distinguishing features of the finished cloths in which they are separately used. Allowing this, it follows that fabrics made of wool, silk, cotton, hair, jute, mungo, and other substances, not merely differ from each other on account of having passed through processes of manufacture slightly dissimilar to each other in character, but also, and in a more important sense, a difference arises in the texture and properties of these several fabrics from the individual characteristics of the materials of which they have been separately made. Thus a woollen cloth, providing it has been made of a fair quality of wool, is soft and full in the hand, and possesses in a large degree the natural characteristics of the wool, namely, firmness, elasticity, strength, and durability; a cotton fabric, on the other hand, although it may handle firm, yet it is comparatively hard and lean, lacking elasticity and suppleness. Fabrics made of silk possess a character of richness, brilliancy, and fineness unapproachable by any other material. Cloths produced partially, or wholly, from such secondary materials as mungo, shoddy, and extract possess to a certain extent the characteristics and general appearance of goods composed of pure wool, but are greatly wanting in suppleness, brightness of tone and durability.

It is scarcely necessary to give further illustrations of the variety of textile goods resulting solely from the manufacture of different classes of fibrous substances; for, in addition to the fibres just referred to, cashmere, camel-hair, alpaca, jute, China grass, and flax are also made into other styles of woven goods. Not only is it possible, however, to produce a variety of cloths from totally different types of fibres, such as silk, cotton, and flax, but also when limited to the use of one material, like, for example, that of wool. Some wools, such as those of Silesia, Saxony, and Port Philip, are specially suitable for the finest woollens, and dressed or boiled-faced goods; others possessing a fine hair and long staple for worsted fabrics; and a third class, small in the fibre, but only of inferior milling or felting property, for flannels; while the coarser wools with a strong and thick hair are used in the production of blankets and goods of a similar character,—showing that if wool were the only textile fibre known to manufacturers, it would be possible, by its use, to produce a considerable variety of effects in the cloth without any material change in the operations of the loom.

3. *Materials used in Woollen Manufacture.*—The fibres used in woollen and worsted manufacture are divisible into three great classes—first, the animal class, of which wool, silk, alpaca, and mohair are standard representatives; second, the vegetable class, in which cotton is the principal fibre, jute and China grass having only been applied to the woollen industries to a very limited degree, while flax and hemp, as yet, have found no place in wool fabrics, being used mainly in the production of carpets and bagging; and, third, the artificial or re-manufactured

class, which includes noils, mungo, shoddy, extract, and flocks. The latter class of materials, as will afterwards be shown, forms a prominent factor in the manufacture of so-called woollen and worsted fabrics.

Animal fibres, which, in woollen cloth production, are the most valuable, may readily be distinguished from vegetable fibres as follows: when a flame is applied they curl up, carbonize, and emit a disagreeable smell, whereas the latter burn with a flash. A chemical test consists in applying strong nitric acid to the respective fibres; thus, if this acid is applied to wool it turns it a bright yellow, but effects no material change in the colour appearance of cotton. Again, cotton may also be detected from wool by subjecting the fibres to a bath of bleaching liquor, which whitens the former, and gives a light brownish shade to the wool. As for shoddies, mungoes, extracts, &c., the want of fulness, softness, and length of fibre make it almost impossible to take them, in the raw state, for pure wool.

4. *Wool.*—Wool, the natural product of the sheep alone, is, undoubtedly, the most important fibre used in the manufacture of goods for clothing purposes. From the earliest times it has been employed in the production of textile fabrics. For ages before the invention of spinning and weaving the skin of the sheep, with the wool on, may have been worn as a garment, as in the case of Elijah's mantle. By what means it was originally converted into thread it is impossible to say, but it may be assumed that its soft, warm, lustrous, and elastic character would recommend it to the pre-historic producer of woven fabrics.

Wool has been defined as a very fine hair. This definition may be said to be theoretically correct. Practically, however, hair and wool are two very different fibres. Thus while hair (that of the rabbit and beaver, for example, or cow's hair, which is sometimes used in the making of low imitation sealskins) is stiff and straight, wool is curly, flexible, and wavy. When camel's hair, the fibre of the Angora goat, or mohair, are considered, then the resemblance which these filaments bear to wool is more pronounced; but even here the same disposition of straightness is apparent. Microscopically, these fibres also possess a very different formation. Hair is one smooth, level, stem-like structure, while wool is a combination of serrations or notches of irregular sizes overlapping each other, and tapering from the root to the tip of the fibre. These scales, or thin plates, are sometimes funnel-shaped, and completely surround the fibre.[1] (See B, fig. 1.)

5. *Felting Property.*—When a lock of wool (*i.e.*, a number of fibres) is drawn between the forefinger and thumb in a reverse direction to the order of growth, or from tip to root, these serrations are more or less evident to a sensitive touch, according to the class of wool examined. This peculiarity in the mechanical structure of the fibre comprises the essential difference between wool and all other materials employed in textile manufacture. It is, in short, the factor to which the milling or fulling power is primarily due, or the quality which causes a woollen fabric, when submitted to heat, moisture, and pressure, to mat, felt, or, in other words, to decrease in length and breadth and increase in thickness or bulk. For instance, Saxony wool—possibly, the finest, softest, silkiest, and, in many particulars, one of the best wools grown, and, moreover, a wool of acknowledged superior milling power—contains no less than from 2,700 to 2,800 serrations in an inch. Australian, another excellent clothing wool of good milling property, contains 2,400,

[1] The wool fibre is quite solid, not being tubular in form like cotton or flax. When a transverse section of wool is examined microscopically it is seen to consist of three classes of cells:—(1) of the marginal cells or external scaly protrusions; (2) of the inner bark or cortical substance, which is composed of spindle-shaped cells; and (3) of the medullary cells, which are not always visible. The lustrous and fulling properties of the wool are due to the uniformity and compactness of the outer scaly sheath, while the elasticity and soundness of the fibre depend on the density of the inner cells.

while Leicester wool of comparatively inferior felting quality only contains 1,800 serrations in an inch of fibre. From such particulars as these it would appear as though the degree of milling power extant in wool might be ascertained from its structure as revealed by the microscope. Generally, it will be found that the felting property is the highest in wools containing the largest number of imbrications, but there are exceptional fibres. Cape wool, for example, although fine in the hair, and full of serrations, is not a good milling wool. According to the microscope, its fibres possess all the characteristics of a wool of excellent felting powers, whereas, practically, it is regarded as only a secondary wool in this respect. Port Philip and Buenos Ayres wools might be instanced as two other fibres which would, if the milling characteristic depended entirely on the multiplicity of serrations in a given length of fibre, be similar to each other in this particular. But instead of this being the case they are almost as different in felting power as it is possible for the produce of the same genus of animals to be. Port Philip is almost without a parallel in point of fulling property, while the defectiveness of Buenos Ayres in this essential may be said to be proverbial.

That the milling quality is determined by the serrations in the fibre is indisputable; the lack of such serrations would imply a fibre of little or no fulling power, but there are other features in wool which act as auxiliaries to its scaly, undulated surface, for unless it also possesses elasticity and strength, and a wavy and crimpled form, it is not likely to felt well. There are two causes, therefore, to which the felting property of wool is attributable: first, the mechanical formation of the fibre; second, the strength and elasticity of its staple, combined with the resisting power of the individual imbrications of which the fibre is composed.

6. *Wool a good Absorbent of Colour.*—Possibly there is no fibre used in textile manufacturing easier to dye than

wool. Aniline colours may be fixed on this material by simply bringing the fibres into contact with the liquid containing the colouring matter. Silk has a strong affinity for dye substances, but permanency of colour is not so readily procured on this as the wool fibre. Both these filaments have been known to absorb the dyeware out of the solution and leave the liquid quite clear.

When cotton is used along with wool, great care has to be exercised in fixing the colour, otherwise it is liable to run or "bleed" in the finishing processes. Goods have been made in which a cotton thread has formed a part of the warp, the vegetable fibre in which, when submitted to scouring, has parted with a considerable proportion of the colouring matter applied in dyeing, damaging the texture. The tubular structure of the cotton fibre does not admit of that free absorption of the dye-solution which is necessary to effect permanent colouring. The infinitesimal indentations or undulations in the wool fibre caused by the serrations overlapping each other are at the foundation of its colour-absorbing capacity.

The application of dye substances in some cases impoverishes the wool, the agents used destroying in some degree the natural clothing properties of the fibre. A wool dyed scarlet, brown, or russet, for instance, invariably handles harsher and dryer in the dyed than in the raw state, while a blue or green colouring agent often feeds the wool, even going to the extent, in the case of indigo, of increasing its weight.

7. *The Properties of Clothing Wools.*—Fineness of fibre, strength and elasticity of staple, softness of handle, a disposition to felt, and a clear white colour, are the properties which a good clothing wool ought to possess.

Fineness of Fibre. The fibre of some wools is extremely fine, varying in the superfine qualities from a fifteen hundredth to an eighteen hundredth part of an inch in diameter. The finest wool grown by any breed of sheep, both in respect to smallness of fibre and quality of staple, is called "lambs," so termed on account of its being clipped when the animal is about six months old. The second clip, which is somewhat thicker in fibre, and both longer and stronger in staple, is styled "yearlings," while all the subsequent growths are indiscriminately designated "fleece," which is generally rather coarser in the hair than the two first yields. Nevertheless there are some very fine fibre wools in this class. In spinning small yarns it is necessary to use wools possessing a fine fibre. A wool thick in the hair is not capable of being spun to the same length as a fine wool. When it is required to spin a woollen thread to the extent of 15,360 yards to the pound, or, in the case of worsted, a thread to twice this number of yards to the pound, a small, fine fibre is of primary importance. Wools capable of being spun into threads of such fineness (amongst which may be classed Silesian, Saxony, Port Philip, Sydney, and, when blended with other fibres of a stronger growth, Western Cape) are invaluable in the production of yarns for twisting purposes, or for yarns composed of two or more single threads, and technically designated twists. In the manufacture of Cheviot cloths and fabrics of a medium fineness, in which the yarns may vary from 2,560 to 5,120, or, in a few instances, 7,680 yards to the pound, this characteristic of smallness of hair is not so essential in the wool used. It is of more importance in making cloths of this type to procure a wool with a sound, healthy staple, such, for instance, as a half-bred New Zealand, which possesses a strong and moderately thick fibre, and a good general character. This wool, in the fabrication of tweeds, is sometimes blended with Cheviot or skin wool (obtained from animals slaughtered for food, hence sometimes called "dead" wool), or if a cheap piece is required, probably Cheviot wool with mungo.

Strength and Elasticity of Staple form two of the most important qualities of wool. The resisting capability of the fabric is dependent upon these properties of the raw material. Whether the cloth is fine or coarse, if made of wool, it should be elastic and strong, supple and firm in the hand.

The term elasticity as applied to wool signifies the power it possesses to assume its former condition after being subjected to pressure. The extent to which this property is present in wool may be illustrated by comparing it with cotton and mungo. If a sample, say, of good Egyptian cotton is taken in one hand, and a sample of fair Australian or New Zealand wool in the other, it may be roughly estimated how superior the latter is to the former in point of elasticity. As the materials are pressed in the hands the cotton almost yields without resistance, and handles comparatively "unkind;" the wool, however, resists the force applied, and possesses a soft, full, lofty handle.

Compare, in the second place, a "union" fabric made of cotton warp and mungo weft with a Scotch Cheviot made of pure wool. The superior fulness, elasticity, and substance of the Cheviot texture is at once apparent, the original or natural strength of the wool imparting to it a thickness and body that are remarkable by their absence from the cotton and mungo production.

LENGTH OF STAPLE is a quality of more importance in worsted than woollen yarn manufacture. By "staple" is meant a group or lock of fibres. The "staple" varies from what may be termed scarcely any definable length to from fifteen to twenty inches. The finest wools are generally short in staple, yet by no means invariably so. Long, strong, healthy wools, though costly, usually prove the most economical in the manufacture of worsted yarns. The necessary sequence to the use of wools defective in these features is an unsatisfactory thread and an increase of waste fibre. On the other hand, a short stapled wool, providing it possesses the other clothing essentials enumerated, is, all things considered, the most suitable for woollen yarn spinning.

SOFTNESS OF HANDLE is a property that, strictly speaking, varies according to the quality of the wool. It is very much sought after in the woven article. A cloth defective in this primary essential very seldom obtains an extensive sale, whatever its other features may be—hence the importance of the raw material from which goods are made possessing a soft, warm touch.

That the wool should possess a DISPOSITION TO FELT is absolutely necessary to produce such fabrics as doeskins,

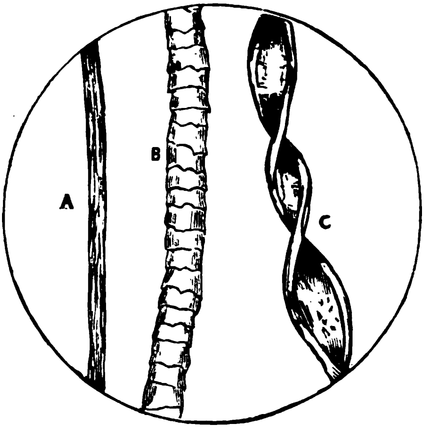


Fig. 1.[1]

plain broads, beavers, pilots, and Moscows, or goods where the texture of the cloth is completely hid by milling the threads of which it is composed firmly together, presenting the appearance of one felted mass of fibres. The short wools of England, such as Norfolk and Southdown, could not be made up into cloths of this description. Possessing but little felting property, and being moderately fine

[1] This diagram is printed here by permission of the late Professor John Beaumont, having been taken from his lecture on the "Twine in Woollen Yarn," published in the "Textile Recorder," October and November, 1885.

in the hair, they are more suitable for fabrics of a flannel class in which milling is not an absolute requisite; consequently they are sought after by the producers of these goods.

PURITY OF COLOUR is a fifth essential. A snow-white appearance is an important auxiliary in dyeing fancy colours. In piece-dyed fabrics, or in dyeing dark shades, a pure white foundation is not of such vital consequence, but brilliant colours cannot be so readily nor so satisfactorily obtained from a dingy yellow as a pearly white material. Some classes of wool, Port Philip for example, after scouring, are of a pure white character, and hence, with careful and skilful manipulation, may be dyed any shade. A good white is also essential in wools for yarns intended for use in the undyed or scoured state. It should be observed that certain wools, amongst which may be mentioned some classes of East Indian, Egyptian, and Spanish, are not white, but of a fawn, gray, or brown colour, and are often spun into yarn and made into cloth in their natural shades.

8. *Wools of different Countries.*—Soil, climate, food, and skilful farming all affect the character of the wool produced by any particular breed of sheep. English sheep imported into Australia in course of time yield a much finer quality of wool than in this country, the staple gradually becoming more uniform in length, and the fleece evener in fineness throughout. The Downs' wools of England are said to be softer and cleaner in staple when the sheep graze on the rich pasture land of Kent and Sussex than if fed on the herbage grown on the sandy soil of Norfolk or the chalk hills of Wiltshire, where they have been found to assume a somewhat harsh and dry appearance. That careful attention to the animals is also a cause to which the growth of fine wool is more or less due is attested from the excellent wool now obtained from Germany. Formerly, Spanish wool was esteemed as the finest grown; however, since the importation of the merino sheep into Germany from Spain, in consequence of unre-

mitting care having been exercised in breeding, &c., a better wool both as regards regularity of staple and smallness of fibre is now produced in Germany than in the latter country.

Wools may be said to differ from each other in quality according to the country from which they are obtained. For this reason a few of the typical wools coming from the most important wool-growing countries will be briefly described.

As *German wools* are unsurpassed in quality and general characteristics, they may be treated of first. Saxony and Silesian are the two most important. They are both wools of excellent clothing properties. The fibre is fine and full of imbrications, staple short, strong, and elastic, felting power excellent, and colour good. These wools are invariably selected for the finest woollen fabrics where much milling is required, as in doeskins, dressed or boiled-faced fabrics, and felt cloths for piano hammers.

Next, as to Colonial Wools. Large as the quantity of Australian wool shipped into this country is, its value and importance can only be understood when its quality and fineness are taken into consideration. Such are the superior clothing properties of this wool that only the best clips of the Continent could supply its place. British wools are almost invariably unsuitable for the purposes to which colonial wools are applied. The high repute in which the produce of the merino sheep in Australia is now held arises from the peculiar softness and fullness of the cloths in which these wools appear.

Port Philip, *Sydney*, and *Adelaide* are three of the best Australian wools imported into this country. The former is one of the most useful wools grown. Practically, it is suitable for the best qualities of yarns, whether woollen or worsted. Though its fibre is not so fine as Saxony, yet it is a wool that spins well, and generally makes a true thread. It possesses a sound staple of a fair length, while its colour is invariably good. Being an excellent milling wool, it may be employed in the manufacture of fabrics requiring excessive felting.

Sydney Wool, which is shipped from Port Jackson, New South Wales, usually possesses a fine fibre and a medium length of staple, but is occasionally wanting in strength. Sometimes it is defective in colour, containing yellow locks, which prevent it from being dyed into light shades. As the felting property is high, it is a wool that may be employed to advantage in making goods of a doeskin type.

Adelaide does not compare favourably either with Port Philip or Sydney in general character. While only moderately fine in the hair, the staple is not of a uniform length, nor can the colour be said to be exceptionally good. However, it mills moderately well, and is a fairly useful wool in the manufacture of both woollen and worsted goods.

Van Wool, grown on the island of Tasmania, possesses many excellent clothing properties, for it is small in the hair, long and strong in staple, of a bright, snow-white appearance, and mills remarkably well. It is suitable for both combing and carding purposes.

The fibre of *New Zealand Wool* is moderately fine, the staple sound and of a medium length, while its colour and milling property are all that can be desired. As it generally imparts a full, substantial handle to the woven fabric, it is a wool highly esteemed for blending with mungo. It is also largely used in both woollen and worsted yarn production.

Cape Wool, from the Cape of Good Hope, South Africa, has a fine small hair, but is generally short in staple, and rather deficient in strength, while that known as Eastern Cape, although very much improved of recent years, still contains many bright, dead fibres, termed "kemps." These, if not carefully picked out, as they do not dye along with the healthy wool, produce faulty places in the woven fabric. It is an indifferent milling wool, but possesses a fair colour. Generally it is used in the manufacture of yarns for shawls and other fabrics where felting is not essential. Sometimes this wool is also blended with others possessing strength and elesticity of staple in the production of small yarns for twisting purposes.

The wool coming from *Buenos Ayres*, South America, is usually fine in the hair, but dirty and burry—that is, full of seeds, motes, and twigs. It also lacks strength and elasticity of staple, and is deficient in milling property. After destroying, by a chemical process, the burrs, &c., this wool contains, continental manufacturers use it largely in worsted yarn spinning.

Odessa is a very important Russian wool, with a strong, vigorous staple, fibre of medium thickness, and colour milky white. The latter characteristic occasionally causes it to be used in making yarns to be employed in the white state. Australian and Odessa wools, when blended together, produce very satisfactory goods. Odessa wool is suitable for a large diversity of fancy woollen fabrics.

British Wools.—These are divided into two classes—the long or lustre wools, and the short-stapled wools. In the former class are included Lincoln, Leicester, Romney Marsh, and the Black-faced breed; while South Down, Hampshire, Oxford, and Norfolk Downs, as well as Cheviot, Welsh, Shetland, and Irish, all belong to the short-stapled class. Lincoln and Leicester are the most important of the lustre wools. Possessing a long, bright, silky, and strong staple, and also being fairly fine in the hair and of a good colour, they are suitable for a large variety of combed or worsted yarns. Leicester is somewhat smaller in fibre than Lincoln, but its staple is not so soft and lustrous; it is, nevertheless, a valuable wool for combing purposes. Romney Marsh resembles Leicester in general properties, and is also used for similar goods. The Black-faced, or Highland Breed is, strictly speaking, a medium wool, its staple being of a middle length; it is, however, technically classed as "long." This wool possesses a coarse fibre and varies very much in quality, and is consequently almost entirely confined to the manufacture of rugs, Scotch carpets, and blankets.

Short Wools.—*South Down* is one of the most valuable short-stapled wools. Though somewhat harsh and brittle, it possesses what may be defined as a fine hair, about one-eleven-hundredth part of an inch in diameter. Its milling property is only moderate. The shorter varieties of this wool are carded and made into flannels and other light woollen fabrics, while the longer qualities are combed.

Hampshire only differs from the preceding in being somewhat longer and coarser in staple, while *Oxford Downs* is of a more open growth still. *Norfolk Downs* is comparatively a fine, soft wool, but slightly deficient in strength and elasticity. *Cheviot* is a fair average wool. The staple is of a medium length, handle soft, fibre sound and strong, milling property good, and colour bright. It enters into a large variety of both fancy woollen and worsted cloths.

Welsh Wool, which lacks waviness of character and fineness of hair, is used largely in the manufacture of the flannels of this name. *Shetland* is not unlike Welsh wool in general character, but, if anything, slightly finer in fibre and softer in handle. It is principally employed in the fabrication of knit goods of a shawl and handkerchief class.

Irish Wool possesses a strong, thick hair, is moderately long in the lock and is of a fair colour. Manufacturers of low and medium class tweeds, that is of fancy woollen cloths not requiring small yarns, find it a useful wool.

9. *Mohair, Alpaca, and Cashmere.*—These are three materials more largely used in the manufacture of fabrics for ladies' than gentlemen's wear. *Mohair* is obtained from the Angora goat. Its staple is lustrous and silky in appearance, about five or six inches in length, and hangs in wavy ringlets. The colour is of a milky white. Along with woollen yarns, it is used in the manufacture of Astrakans, or fabrics covered with short curls. Another style of goods in which it figures largely is plushes, or velvets, where its lustre imparts a desirable richness to the pile, which may vary from one-eighth to half an inch in height.

Alpaca wool is derived from the Peruvian sheep, or

Llama. Like mohair, it possesses a soft, lengthy staple, but the fibre is not so silky. It is principally employed in the production of dress fabrics. Naturally, it is either white, brown, fawn, or black in colour.

Cashmere is another fibre commercially classed as wool. It is the product of the goats of Thibet, which are covered with felted tufts of hair of a black or dark-brown colour, underneath which grows a brownish-gray down that can be readily separated with care. This down is the Cashmere of commerce. The soft, fine, silky texture of this material has caused it to be appropriated to the manufacture of those beautiful productions of the loom known as Cashmere shawls.

10. *Wool Substitutes.*—In the manufacture of so-called woollen and worsted goods, various materials are used as substitutes for wool proper. The employment of such fibres has tended to cheapen, to a very considerable extent, the productions of the loom, and made it feasible to weave an attractive article at a surprisingly low price. The trade generally has also been largely extended by the entrance of re-manufactured fibres into textile productions, The following are the most important and valuable wool substitutes now in use: noils, mungo, shoddy, extract, and flocks.

11. *Noils.*—Noil is the short, curly fibre cast out as waste in combing wool for worsted yarns. Strictly speaking, it is the pure produce of the sheep. It does not, however, possess the same degree of elasticity and wavy fulness as the original fleece from which it is extracted. This arises from the preliminary processes of worsted yarn production to which the material is subjected previous to the noil being formed, tending to comb the curl out of the wool, or to straighten the fibres.

Noils are of four classes—Botany, English, Mohair, and Alpaca. The first class is the outcome of combing Australian and other fine wools. The second class is obtained from English wools of a Lincoln and Leicester type ; while

Mohair and Alpaca noils result from combing the produce of the Angora and Alpaca goats.

Botany Noils are the most valuable. The uses to which they are put are almost too numerous to mention. However, it may be stated that such noils occupy an important place in the materials used in the production of fancy woollen fabrics. They are blended with wool in making yarns for shawls, and are also suitable for mixing with cotton in spinning small twist threads.

English Noils are of a coarser and broader quality, but are, nevertheless, used for similar purposes as Botany, only in lower classes of goods. Cheviot fabrics consume a large proportion of English noils, many cloths thus designated being made entirely of noil. Sometimes these noils, when used in the black, are mixed with black shoddy, or with shoddy and cotton, the latter fibre assisting the materials to spin to a greater length.

Mohair and Alpaca Noils are much brighter in appearance, as well as softer and more silky in the hand, than the two preceding kinds. They possess but little milling property, and are, therefore, not selected for cloths where felting is essential. In combination with shoddy and cotton they are occasionally spun into weft yarns for low goods; but the principal trade which absorbs these noils is that of the Scotch, or Kidder carpet manufacture. As the chief essentials in yarns intended for this class of goods are strength, brightness, and thickness, Alpaca and Mohair noils are highly adapted to their production.

12. *Mungo and Shoddy.*—Although these materials are obtained from different sources, yet, as the mechanical operations to which the rags are subjected from which they are derived are practically the same, they may be treated of together. Both fibres are wool products, being obtained solely from wool garments. Mungo is the result of grinding into a soft, fibrous form rags of a hard character, such as milled cloths, whereas shoddy originates from soft rags of a blanket or comforter class, and also from

knit goods. There are two descriptions of mungo—*new* and *old*. The former is produced from new rags, *i.e.*, tailors' clippings, pattern clippings, &c., while old mungo is got from fragments of cloth that have, at one time, appeared in a made-up garment. The smallness of the cost of these materials, as well as the diversity of shades in which they can be obtained—for mungoes and shoddies can be purchased in the black, brown, blue, or almost any colour or mixture desired—cause them to be employed in almost all classes of woollen goods. The method of applying mungo or shoddy to the better qualities of fabrics with a warp face consists in blending them with wool in the formation of the weft thread. In other cloths, mungo forms the bulk of the material used in the construction of the backing yarn, or the thread used in producing the underneath surface of the texture. The method of introducing this fibre into low goods is somewhat different to the preceding. Here it is the principal and the most expensive material used in the composition of the fabric, the weft thread generally being mungo simply, and the warp cotton. Both warp and weft yarns used in medium-priced fabrics are usually a combination of wool and mungo, the proportions varying according to the quality of the texture produced.

13. *Difference between Wool and Mungo.*—The properties of a good wool are necessarily of a very superior character to those of mungo. Under the microscope there is not always a marked dissimilarity between the fibres, the filaments of some mungoes being in a far more perfect state of preservation than others. Sometimes the fibres are partially stripped of serrations, but probably others might be examined from the same handful of material possessing, when microscopically examined, the complete mechanical development of the wool fibre. Evidently the difference between mungo and wool does not arise in the main from any necessary dissimilarity in the structure of the fibres. Practically, mungo possesses no definite length of fibre—staple, as compared with wool, it has none—while in

elasticity and strength it is also deficient. Doubtless some of these deficiencies are due to the mutilation of fibre occasioned in the grinding process to which the rags are submitted, and in which filament is forcibly torn from filament, causing, as a natural consequence, the material to be short, brittle, and wanting in elasticity.

Of course the milling power of mungo depends entirely on the nature of the wool used in making the cloth from which the fibre has been obtained. If the rags ground up were originally made from an excellent fulling wool, then the mungo will undoubtedly possess a certain degree

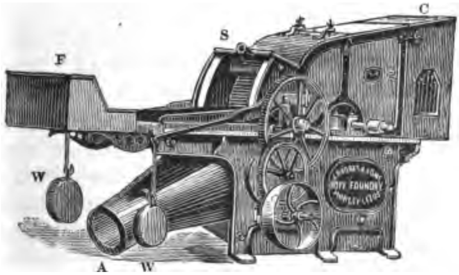


Fig. 2.

of felting property. Shoddies, though longer in the fibre than mungoes, do not usually felt so well—the wools employed in the production of the rags from which they are recovered being principally of an inferior fulling power.

14. *Mungo Production.*—Rags intended for conversion into mungo pass through various processes before they assume the fibrous appearance of wool. *Dusting* is the first operation. It consists in shaking the dust and dirt out of the rags before they are transferred to the hands of the sorter, who classifies them according to quality and colour. Considerable care and judgment have to be exercised in this preliminary work in order to ensure the production of a regular and uniform stapled material. Both old and new rags are submitted to this process. As many

as from twenty to thirty varieties have been collected from one bale.

Seaming follows sorting. It applies solely to rags obtained from cast-off garments, and consists in removing all the cotton threads used in stitching. The rags are now oiled to soften the material and facilitate grinding. The machine in which this, the principal work in mungo production, is effected is shown in fig. 2. It consists of feed-sheet, fluted rollers, main cylinder, or swift, and funnel for conducting the mungo out of the machine. The swift S, which may be said to be the leading feature of the machine, is enclosed in the framework; it is about 18 inches long, 42 inches in diameter, has a surface space of 1,638 square inches, and contains from 12,000 to 14,000 strong iron teeth. The speed at which it runs varies from 640 to 800 revolutions per minute. The rags, having been spread on the feed-sheet F, are conveyed to the fluted rollers, on emerging from which they are seized by the teeth of the cylinder, which not only separates thread from thread, but literally tears fibre from fibre, and thus reduces the whole to a flossy, wool-like state. As the rags are ground up, the material is forced down the funnel A, and thus finds an exit from the machine. Any hard fragments of cloth only partially torn to pieces fall into the cage C, from whence they are replaced on the feed-sheet. The weights, W, allow the upper fluted roller to rise should the machine be overcharged, and by this means admit of the rags being conveyed without retention direct off the feed-table on to the cylinder, which continues to throw them into the cage until the machine gets properly cleared.

15. *Extract Wool.*—This material is obtained from rags of which the threads are composed of cotton and wool respectively, as in stuff goods with a cotton warp and mohair or lustre worsted weft, or in low union fabrics which have a similar warp thread, but thick woollen weft. As the object in extracting is to recover the animal fibre, the vegetable thread is destroyed by a process of car-

bonizing. To effect this, the tissue is steeped in a solution of sulphuric acid and water, and then heated in an enclosed chamber. This drying process causes the water to evaporate, leaving the sulphuric acid in a very concentrated form upon the fabrics, in which state it has a very powerful action on the vegetable matter they contain, entirely transforming it, and reducing it to such a condition that it powders when friction is applied. Washing-off now takes place, to remove the acid from the reclaimed woollen thread. This effected, the material is run through a coarse, open carder, which gives it the required woolly appearance of a textile fibre.

As to the properties of extract—it is not a good milling wool-substitute, and is wanting in fullness, elasticity, and substantial feel. It can be obtained in a large variety of colours, and is used in the manufacture of low tweeds, and also, when blended with wool, in the production of medium-class fancies.

16. *Flocks.*—These are soft, fluffy fibres cast out of the different machines used in the various processes of cloth production. They are of three kinds, "milling," "cropping," and "raising." The first class, which is formed in the milling or fulling machine, is of more value to the textile producer than either cropping or raising flocks. White fulling flocks always command a high price, and are suitable for blending with wool in the production of a large variety of goods of a Cheviot class. As fulling flocks sometimes possess a bright colour and generally diffusiveness of character, they are largely used by sale yarn spinners.

Cutting or *cropping* flocks are the fibres removed from the cloth in what is termed the cutting operation. Such flocks are not frequently selected by manufacturers as a fit material for yarn making, only for goods of a very low quality, being principally used in the production of what are called flock-papers for decorative purposes.[1]

[1] In silk winding, and gassing, a species of "flocks" is obtained which, like the cutting "flocks" here described, are so short in fibre as

Raising flocks are derived from the teazles of the "gig," which retain a certain quantity of the short fibre, drawn from the surface of the cloth in the raising process. Such fibres, when removed from the teazles, are designated raising flocks, and are similar in character to those formed in the fulling process, hence they are employed for like purposes in textile productions.

17. *Cotton.*—Wool and cotton fibres do not only differ from each other in mechanical structure, but also in those special properties which they both possess, making them highly suitable for clothing purposes. The cotton fibre (c, fig. 1) is short, fine, and brittle, possessing the appearance of a flattened and somewhat twisted tube, or resembling a wrinkled, twisted, irregular ribbon. Commercially, cotton wool is divided into long and short stapled, the former being used for warp and the latter for weft yarns; but these distinctions are by no means always adhered to, the two qualities being blended in such proportions as will result in making a cheap and satisfactory thread.

The length to which cotton may be spun is very remarkable, as many as 252,000 yards of yarn having been spun from one pound of material. Its spinning quality causes it sometimes to be mixed with wool to facilitate the production of cheap and finely-spun yarns. The fineness and strength of the cotton fibre, and its downy nature, are at the basis of its spinning capabilities. The large variety of fabrics in which it is used is proof of its adaptibility to textile threads, thus it is employed in the production of fine lace, muslins, stout calicoes and sheetings, velveteens, cords, and fustians. In addition to being blended with wool and other materials in woollen cloth production, it forms the warp thread in union cloths; and it is also used, on account of its fineness, in making various styles of backed goods, where its function is to bind the yarns employed in the formation of the face to those constructing the back of the texture.

to be unfit for textile work, hence they are utilized in the manufacture of high class wall paperings.

18. *Silk.*—This fibre is also utilized to some extent in the production of woollen and worsted goods. Of all fibres, it possesses the least diversity of physical construction, resembling, when magnified, a transparent glass rod, and possessing but few surface creases. (See A, fig. 1.) In reality it is a longitudinal body of flexible gum, chemically termed *Sericin*, and is totally void of cellular structure. When the fibre is heated to 110° C. it loses its natural moisture, while at 170° C. it decomposes.

Silk threads, in the better qualities of fancy wool fabrics, are twisted with worsted and woollen yarns, while in other cases they are introduced into the fabric in the single state to give tone and richness to the pattern. These are the two principal methods of applying this fibre to textiles made of wool. Of course in more elaborate fabrics, such as mantles, vestings, figured plushes, and some classes of dress goods, it forms the most important yarn employed in the production of the texture.

The silk imported into this country is of two classes, that which arrives in the hank form, and is wound direct from the cocoon, and receives the name of *neat* silk; and, second, *spun* silk, or the thread which results from combining and spinning the cocoons which are too entangled to be wound, and the waste made in the winding process. Before silk is capable of being used as a warp or weft thread it is converted into one of the following forms: *singles*, *tram*, and *organzine*.

Singles is simply a reeled thread to which twist has been added to give it strength and firmness. *Tram*, which is generally used as weft, consists of two or more reeled threads twisted firmly together. *Organzine*, or *thrown* silk, is formed of several singles twisted together in a contrary direction to that in which the twine is introduced into the individual threads of which it is composed.

Strength and lustre are the distinguishing characteristics of silk yarns. There is, in fact, no weavable thread in proportion to its fineness comparable in elasticity with that obtained from this material. For this reason an ordinary silk ribbon will sustain as much tension and friction as a woollen fabric which has been felted for several hours and is many times its thickness. The lustrous quality of silk is, however, the one most esteemed in textile manufacturing. Mohair is the only animal fibre which possesses anything approaching its bright, shiny appearance. China grass and jute, both vegetable fibres, are more or less lustrous, but they are incapable of being spun to the same degree of fineness as silk. As both alpaca and mohair possess a lustrous staple, they are sometimes employed in the stuff trade as substitutes for this rich and costly fibre.

CHAPTER II.

WOOLLEN THREAD MANUFACTURE.

19. Sorting—20. Wool Washing—21. Detergents used in Scouring—22. Wool Steeping—23. Methods of Scouring—24. Scouring Machines—25. Utilization of Waste Scour Liquor—26. Drying—27. Teazing—28. Burr-Extraction—29. Oiling—30. Blending—31. Preparing the Blend—32. Fearnought—33. Carding—34. Systems of Carding—35. Actual Operation of Scribbling—36. Parts of a Scribbler—37. Speeds of the Cylinders—38. Modes of Conveying the Scribbled Wool from one Engine to another—39. Condensing—40.—Spinning—41. Mule or Spinning Frame.

19. *Sorting.*—The initial process in wool manufacturing is that of sorting or classifying the fibres of the fleece, as clipped from the sheep's body, according to length, fineness, elasticity, and soundness of staple. The necessity for this operation arises frόm the wool varying in quality in different sections of the fleece. Coarse, fine, strong, and tender locks being present in the wool in its natural condition, it is, until sorted, unfit for textile purposes. An attempt to utilize it in the fleece state would result in the spinning of uneven, faulty, and unsatisfactory yarns. About thirteen or fourteen sorts may be obtained from one fleece, but very frequently not more than five or seven are made. The following table shows the relative qualities of the wools grown on the various parts of the body of a merino sheep :—

1. The shoulders. 2. The sides.	The wools grown on these parts are remarkable for length and strength of staple, softness of feel, and uniformity of character. They are usually the choicest wools found in the fleece.

3. Lower part of the back.	This is also a wool of good, sound quality, resembling in staple that obtained from the shoulders and sides, but not so soft and fine in fibre.
4. Loin and back.	The staple here is comparatively shorter, hair not so fine, but the wool on the whole of a true character. In some cases, however, it is rather tender.
5. Upper parts of the legs.	Wool from these parts is of a moderate length, but coarse in fibre, and possesses a disposition to hang in loose, open locks. It is generally sound, but liable to contain vegetable matter.
6. Upper portion of the neck.	The staple of the wool clipped from this part of the neck is only of an inferior quality, being frequently faulty and irregular in growth, as well as full of thorns, twigs, &c.
7. Central part of back.	This wool is nearly like that obtained from the loins and back, being rather tender in staple.
8. The belly.	This is the wool which runs quite under the sheep, between the fore and hind legs. It is short, dirty, and poor in quality, and frequently very tender.
9. Root of tail.	Fibre coarse, short, and glossy, and the wool often run with kemps or bright hairs.
10. Lower parts of legs.	Principally a dirty and greasy wool, in which the staple lacks curliness and the fibre fineness. Usually it is burry, and contains much vegetable matter.

11. The head. 12. The throat. 13. The chest.	The wools from these parts are in some places classed together, all having the same characteristics. The fibre is stiff, straight, coarse, and covered with fodder, the wool also being kempy.
14. The shins.	This is another short, thick, straight, and shinny-fibred wool, commonly called shanks.

Such terms as picklock, prime, choice, super, head, seconds, abb, and breech are applied to the several varieties into which the fleece is divided. *Picklock* comprises the very choicest qualities of the wool, both as regards fineness of fibre, elasticity, and strength of staple; *prime* is a similar wool to the preceding, only of a slightly inferior character; the staple of *choice* is true, but the fibre is not so fine as prime; *super* is similar in general properties to *choice*, but not, as a rule, so valuable; *head* includes the inferior sorts and the wool grown on this part of the sheep; *downrights* is derived from the lower parts of the ribs or sides; *seconds* consists of the best wool clipped off the throat and breast; *abb* contains the skirtings and edgings of the fleece; while *breech* consists of short, coarse fibres obtained from this part of the animal's body. "In the worsted trade these names are not used, the following being those generally adopted: blue, from the neck; fine, from the shoulders; neat, from the middle of the sides and back; brown-drawing, from the haunches; breech, or britch, from the tail and hind legs; cow-tail, when the breech is very strong; and brokes, from the belly and lower part of the front legs, which are classed as super, middle, and common, according to their quality. For finer sorts of wool there are no special names, and Botany and similar fleeces are sorted according to their numbers or the counts of yarn they will spin to, such as 50's, 70's, 80's, and so on."

The sorter prepares for the work of classification by spreading the fleece on a table with a wire cage surface, through which a portion of the dust, sand, and other hard particles of matter in the wool falls into a drawer beneath, during sorting. The centre of the back of the sheep forms an indefinite line down the middle of the fleece, which the sorter follows in dividing it into two portions before commencing the actual work of analysis. His work may be said to consist, firstly, in removing a portion of the loose vegetable substances the fleece contains, such as seeds, twigs, and bits of bark; and, secondly, in cutting off the hard tufts of fibres which have by some means or other got fastly adhered together. These preliminaries having been attended to, he proceeds to analyze the fleece carefully, casting the locks according to quality into different skeps with which he is provided. He judges of the wool mainly by its soft, silky handle, and by thickness or density of growth—weakness of staple, harsh, or unkind handle, and want of rankness of hair, are all indications of an inferior wool.

20. *Wool Washing.*—Wool is naturally impregnated with a greasy substance termed yolk or *suint*, an unctuous varnish caused by the perspiration of the skin, and partly by the animal secretion which lies at the root of each hair finding its way to the tip of the fibre. Yolk is a compound of potash and animal fat. It also contains small quantities of acetate of potash, lime, and chloride of potash. Such is the amount of foreign substances present in some wools that they lose as much as seventy per cent. of their weight in scouring. Certain merino wools contain, in addition to yolk, a considerable proportion of earthy and greasy matters, for according to Chevreul's analysis they decrease, on an average, nearly two-thirds in weight during the washing process. He states the composition of this class of wool in its natural state to be as follows:

Earthy substances	26·06
Suint, or yolk	32·74
Fatty matter	8·57
Earthy matter fixed by grease .	1·40
Clean wool	31·23
	100·00[1]

Several of these substances are recovered by chemical agents from the refuse scouring solution, previously conducted into large tanks, and pass into commerce under different forms and under new names. The yolk, for example, after having been separated from the other ingredients of the waste lye, has recently been utilized in the production of a soap said to be specially valuable, on account of the animal fat it contains, for medical purposes. Crude carbonate of potash is obtained in considerable quantities from the residuum of the used scour liquor. Another substance which results from a method (which will afterwards be described) largely practised in chemically decomposing this otherwise worthless solution is a class of oil used to some extent in lubricating rags for shoddies and mungoes.

Now the object in scouring is not simply to remove the greasy product from the material, but also the dirt and other extraneous matter with which the wool may be covered. This should be effected without injury either to the physical structure or chemical composition of the fibre. A wool thoroughly cleansed should be of a pure colour, should handle soft and elastic, dye readily, produce a true thread, and ultimately form a texture full and velvet-like to the touch. On the other hand, wool only partially

[1] Chemically wool is a very complicated molecule, being composed of no less than 234 elementary atoms, whereas silk—C_{24} H_{38} N_8 O_8—only contains 78, and cotton—C_6 H_{10} O_5—but 21 atoms. *Keratine*—C_{42} H_{157} N_5 SO_{15}—is the name that has been applied to the specific compound forming wool. The basis of all animal fibres is *gelatine*, while that of all vegetable fibre is *cellulose*.

scoured resists the action of mordants, and takes a streaky colour, the dyes not penetrating the fibre, but remaining on the surface. Indifferent scouring endangers good scribbling and spinning, and also causes the woven fabric to be hard, stiff, and unkind in feel. A generally accepted opinion amongst manufacturers is, that if the raw material is impartially cleansed, every one of the subsequent processes will to some extent suffer therefrom ; the imperfection arising from this cause becoming, in some cases, the most perceptible in the finished cloth. For these reasons too much intelligence and skill cannot be exercised on this preliminary process of cloth manufacture.

21. *Detergents used in Scouring.*—Potash, carbonate of soda, silicate of soda, ammonia, and soap are all more or less used in wool washing. Soda is sometimes employed alone in scouring wools of a coarse, open growth, but as this alkali is well known to have a corrosive and energetic action on animal fibres, it should seldom, if ever, be used for this purpose. As a detergent, it destroys the natural mellowness of the hair, and, instead of acting as a bleaching agent, imparts a yellow tinge to the wool. Potash, on the contrary, being present in the fibres of the raw material, is, so to speak, the alkali naturally most suitable for whitening and purifying wool, to which it gives a diffusive character and soft feel. Silicate of soda is said to be used largely on the Continent, with good results. However, if this detergent should be employed, precautions should always be taken to thoroughly squeeze the scouring liquor out of the material before rinsing with cold water—if this is done it is held the wool will be white, clean, open, and soft, and also dye freely. Ammonia is milder in its action than either soda or potash. Formerly it was extensively used for wool-scouring purposes, for which it is well adapted, removing the dirty, greasy matter from the wool without injuring the staple. Soaps are now generally the scouring agents selected. Those in which potash enters should invariably be chosen, soda

soaps being more energetic, and having a tendency, for reasons stated above, to dissolve the wool. For wool-washing a soap containing an excess of alkali is perhaps the best, there being a certain percentage of grease on the fibres.

The quantity of water in soaps may be ascertained by reducing a sample to parings and placing in a hot oven, in which it should be allowed to remain until it ceases to become lighter, when the difference between its original and dried weight will indicate the percentage of water evaporated. Other adulterations may be detected by immersing the soap in a strong solution of alcohol and applying heat, which dissolves the soap, but leaves the impurities insoluble.

Wool may be injuriously acted upon by being subjected to too hot a scouring solution, or from being brought in contact with powerful alkalies. No rigid rule as to temperature can be furnished, this being a feature of scouring which varies according to the nature of the wool in hand. However, the liquor should never be at a higher temperature than is absolutely necessary to cleanse the material. For wools open, broad, and free in staple, from 32° C. to 54° C. is a good average, but for fine wools the temperature may range from 48° C. to 60° C. To avoid unsatisfactory consequences, the temperature and alkalinity of the liquor should always be tested before a batch of wool is submitted to the scour bath. This might readily be done by dissolving the detergents to be employed and diluting until a milky solution is obtained which feels soft and smooth to the hands. A few samples of wool might now be dipped, and the alkalinity of the solution varied, until the material readily parts with the dirt and grease it contains, and possesses a soft, silky handle. The hardness and softness of the water used is a question of importance. Soft water dissolves the soap the best, and is, in consequence, the most preferable for cleansing wool. Water varies in hardness according to the proportion of salts, lime, chalk, and other mineral substances it may contain. To use such water for wool washing, without previously softening it, is a very uneconomical course, as a considerable proportion of the soap is thereby taken up by the lime, &c., before any of it can be available in purifying the wool. When water is not softened the lime forms with the detergents what is called an insoluble lime soap—a compound perfectly useless as a scouring agent. It is also very difficult to remove when fixed on wool. A general mode

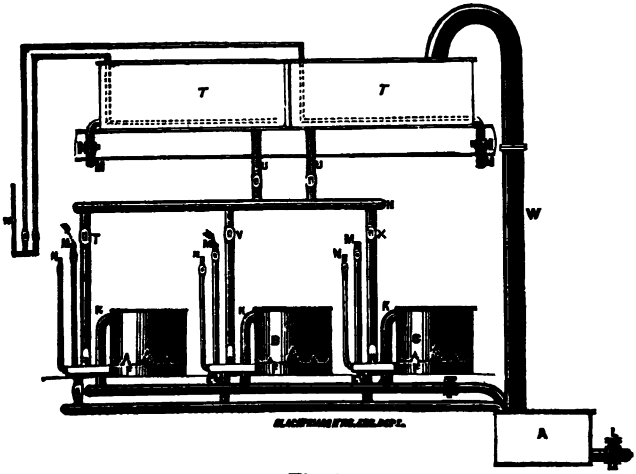


Fig. 3.

of softening water for wool scouring consists in collecting it in tanks, when from two to six pounds of refined carbonate of potash per 1,000 gallons is added, which in a short time precipitates the lime and leaves the water ready for use. Sometimes the potash or soda is added in the scouring machine previous to introducing the soap into the solution, but the former seems to be the more preferable plan.

22. *Wool Steeping.*—Of recent years an apparatus has

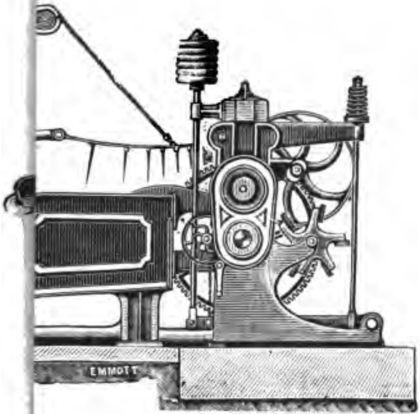
been invented for preparing greasy wools for scouring by subjecting them to a process of steeping, the object being to drive off the acid which the fibres contain and dissolve the hard, dirty substances, without removing any of the yolk in the wool. The apparatus shown in fig. 3 consists of three steepers, A, B, and C, similar to each other both in size and construction. Each steeper has two bottoms, the upper one being perforated as indicated by the dotted lines. The water is kept in tanks, T and T, the pipe connections with which are so arranged as to admit of the steepers being worked separately or together. The steam enters the vessel containing the material at the bottom, and is forced upwards, passing through the hard, clotted, and entangled masses of wool; thus the whole is opened and softened, and a large amount of extraneous matter removed. As there are no chemical agents used in the process the natural pliability, lustre, and colour of the fibre are perfectly preserved.

The main advantage arising from steeping greasy wools, previous to washing, is the considerable saving thereby effected in soap. The cost of steeping, when once the apparatus has been obtained, is not to be compared with the difference in the quantity of detergents used when the wools are submitted to the scouring process without having the hard limy matter with which they are coated softened or dissolved, as is the case with those that have passed through this operation. After steeping, the material readily parts with the dirty substances it contains, the fibres being in a more expanded state and the impurities more readily acted upon, so that the time required in scouring, and the quantity of soap used, are considerably decreased, while cleansing is accomplished with less injury to the properties of the wool.

23. *Methods of Scouring.*—Wool is scoured both by hand and by machinery, but the former method is almost entirely out of date, having been superseded by machine washing, and hence need only be briefly described. The wool, in

such a case, is placed in a large vat or tub which possess a false perforated bottom that rests on small supports about 6 inches from the bottom proper; it is freely agitated for some time in the solution contained in this vat, when it is lifted on to a large scray to allow some of the liquid it contains to drain off. Rinsing follows, and is performed in the "rinse" box, a long, narrow trough also having a perforated bottom to admit of any hard, dirty particles, that may have not been removed in the scouring bath, to escape. Here the material is subjected to a stream of clean fresh water, which thoroughly cleanses it of the "scour" it contains on being removed off the scray. One workman on this system of scouring will cleanse from five hundred to a thousand pounds of greasy wool per day.

24. *Scouring Machines.*—There are various kinds of machines now used for wool-washing purposes, but the one generally regarded as constructed on the best principle is that shown in fig. 4. Usually two tanks or bowls are employed (one of which is given in the engraving), so that if necessary a stronger scouring solution may be used in one than in the other. Another obvious advantage in this arrangement is, that a certain percentage of the dirt having been cleansed from the wool before it leaves the first tank, the second tank may be employed more for rinsing than scouring purposes. In some classes of scouring machines the wool is considerably disturbed by swing rakes during its passage through the scour liquor. This treatment has a tendency to cause the fibres to felt or mill, which, in washing, should, if possible, always be obviated. Scouring being more a chemical than a mechanical operation, it is important to bring the suds into contact with the fibres, for the required length of time, at a minimum mechanical disturbance, and thus cleanse the wool, not so much by tossing and beating it about as by dissolving the dirt and grease that cover the staple. To attain this result the system of propelling the wool when in the scour bath by reciprocating swing rakes has



To face page **34.**

been substituted in this machine by a series of iron prongs set at uniform distances apart. The wool is carried into the tank by the feed sheet, A. The frame, C, in which the prongs are fixed, has both a lateral and vertical movement. At the feeding end of the machine it carries what is called a perforated immerser plate, B, some few inches deep and the entire width of the inside of the tank. As the wool is conveyed into the machine by the feeder, A, it is immediately immersed, and held for some time in the liquor by the plate, B, by which means it is thoroughly saturated, and the fibres prevented from floating on the surface of the scour. The wool is not now forked along the trough, as is the case in some machines, but gently propelled forward by the prongs of the frame, C, which ultimately deliver it to the squeezing rollers, D, where the liquid it contains is pressed out and conducted into what is termed the receiver, when the revolving buckets, E, replace the scour in the tank. On this system the wool is scoured in a fully expanded or open condition, which allows the suds to act with greater freedom on the fibres, and thereby effects a material saving in soap. Even before the wool passes into the second bowl, where the same process is repeated, it is comparatively clean, soft, open, and free in the hand.

25. *Utilization of Waste Scour Liquor.*—The waste suds, resulting from scouring both wool and cloth, are, in all well-conducted factories, run into a series of tanks in the open air, with the object of reclaiming the fatty ingredients which they contain. In order to separate the grease from the other substances in the solution, sulphuric acid is introduced into the tanks. The fatty matter is thus liberated, and rises to the surface, whilst the soda and ammonia compounds remain in solution. The greasy substance thus formed is, after the water has been drained off, pumped into a shallow filter. It remains here until partially solid, when it is cut into blocks about 18 inches square. By applying pressure and heat a quantity of oil is reclaimed,

which is used in lubricating rags before grinding, while the residuum, after pressing, is bought up by soap manufacturers.

26. *Drying.*—Now the wool has been cleansed of impurities it only remains to remove the moisture it contains on leaving the scouring solution. A very common mode of drying consists in spreading the wool on a table possessing a wire cage surface, the apertures in which admit of hot air being forced through the wool. The stand on which these cages are fixed is built in a semicircular form, and contains a number of steam-pipes and huge revolving fans for driving the heat rapidly through the material. It is important when using the drying table that the wool should be spread as evenly as possible, and turned over at regular intervals, to prevent scorching some of the fibres and partially drying others. If these points are carefully attended to, the material will be well and uniformly dried.

Another machine used in wool-drying is constructed on the continuous feed and delivery system. This is, without doubt, the safest method of drying, as the material is always on the move. A representation of such an apparatus is given in fig. 5. It consists of an enclosed chamber (containing a series of five shelves, or tables, one over the other, and some 18 inches apart), about 20 feet long, 4 feet 6 inches wide, and 11 feet high. Hot air is forced through the machine by a rapidly revolving fan, which makes about one thousand turns per minute, and is situate underneath the chamber. The current of air it creates passes through the tubular heater, and from thence into the chamber, as indicated by the arrows. The heat of the air can be regulated as required. The tables consist of two classes of bars, stationary and movable; the latter convey the wool through the machine. As the material reaches the end of the respective tables it is deposited on the one below, and so on till it reaches the bottom table, where it is passed on to the delivery lattice.

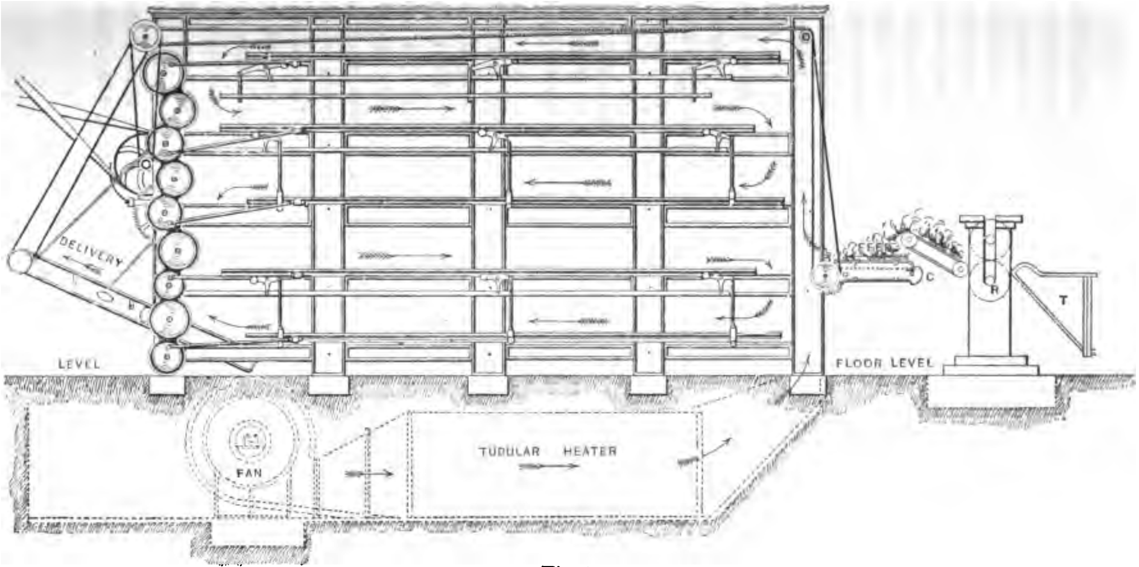


Fig. 5.

Drying being on this system accomplished in an enclosed chamber, the washing machine may be in the same room as this apparatus, thus admitting of the wool being conveyed by the delivering table of the scouring machine on to the feed table of the "dryer." This mode of transferring the material from one machine to the other is shown in fig. 5. Here the parts T, R, and C are the delivering end of the "scourer," being the tank, pressure rollers, and delivery lattice respectively. Necessarily this arrangement economizes both space and labour. The usual method, however, is to place the wool on the feed-table by hand, when it is at once carried into the chamber and forced by a strong blast of hot air on to the upper table. It now travels over the separate shelves in succession, being dried and opened to some extent during its entire passage through the machine by the current of hot air which moves in the same direction as the wool. There being no beating, tossing, or teazing of the fibres in this drying apparatus, it is suitable for all varieties of wools. As many as from three to five thousand pounds of material can be dried in this chamber in one day.

A third contrivance, that may be briefly described, differs from the two preceding arrangements in the heat applied being somewhat differently diffused. Here there is no blast of hot air, but the wool is conveyed by a series of small revolving rollers fixed across the machine and close together, over a number of steam pipes. Thus the interior of this chamber consists, firstly, of two levels of pipes charged with steam; secondly, of two series of small rollers, the lower series carrying the wool from the feeding to the delivering end of the machine, and the upper series *vice versâ;* and thirdly, of a large spiked drum, which throws the fibres off the lower on to the top row of rollers. About one hundred pounds of material are fed into the machine at one time, and allowed to remain until perfectly dry, when a door is opened, and the cylinder rapidly casts the wool on to the floor.

27. *Teazing.*—The condition of the material after drying is such as to necessitate its being subjected to some operation that will, in a measure, open and disentangle its fibres before being passed on to the scribbling machine. The technical name for this operation is teazing, or willowing. Fig. 6 is a representation of the machine in which the work is carried on. Its principal parts are a large skeleton cylinder, or drum, C, (shown in the sectional drawing, fig. 7), with ten arms, each mounted with two rows of teeth tapering from the base to the point; and three small

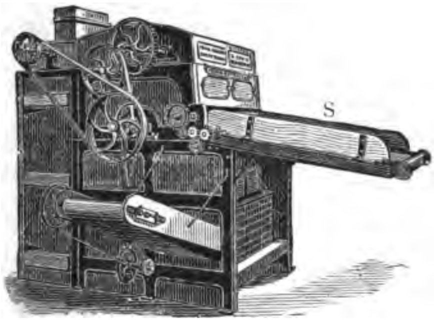


Fig. 6.

rollers, W, termed workers, fixed above the cylinder, and studded with teeth, which work between those of the latter when the machine is in motion. These parts are all enclosed in a strong case, and are driven by wheel-gearing on the outside of the framework. The wool is weighed out in regular quantities and spread on the feed-sheet, S, which carries it into the interior of the machine, where it is received by the teeth of the main cylinder.

The principle of the machine is this: a large and centre drum, making from 400 to 500 revolutions per minute, charged with wool, working against, or turning in a contrary direction to, a series of three smaller rollers, making from 30 to 40 revolutions per minute; so that no sooner is the material forced round by the main cylinder than the teeth of the workers come in contact with the felted and entangled locks, effecting a thorough separation amongst the fibres. In addition to thus opening the wool and imparting to it a pliable and diffusive character, preparing it for the reception of the oil and for the action of the wire of the scribbler, teazing also removes any particles of dirt or other impurities which the fibres retain after the scouring process.

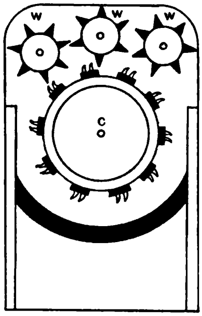


Fig. 7.

28. *Burr Extraction.*—At this stage in the manipulation of the fibres some classes of wools, Buenos Ayres, for instance, have to be submitted to a special process, arising from a troublesome sort of seed, known as burrs, being frequently entangled in the fleece. In size and form these seeds, which possess a coating of minute prickles, causing them to cling tenaciously to the fibres of the wool, resemble very closely an ordinary bean. Of course the purpose of the *burring* process is as far as possible to remove the burrs from the staple with little or no waste of fibre, and without injury to the strength and other properties of the wool. Should the wool be allowed to pass on to the carding operation previous to the burrs having been thoroughly

extracted, they will occasion serious waste both in that and the subsequent processes. When not properly removed before reaching the scribbler, they are liable to enter in small portions into the condensed sliver, and thus prove injurious to the spun thread.

Burrs may either be chemically or mechanically extracted. The former process consists in steeping the wool in a solution of vitriol and water (standing at about 9° Twaddle) for about half-an-hour, when it is taken out, allowed to drain, and then removed to the drying-room and submitted to a temperature of about 200° F. When the moisture has been absorbed out of the material the acid attacks the burrs and other small seeds, reducing them to carbon, after which the wool is rinsed in soda and water to remove the acid, and then again dried, when it is ready for oiling. It will be observed that in this process the vegetable substance is dissolved by the sulphuric acid, while the wool remains sound; but in the mechanical mode of removing the burrs they are not destroyed, but actually beaten or shaken out of the material.

The burring machine in general use consists of the following parts: feed-sheet and rollers, revolving fan, lattice-sheet, revolving brush *for passing the wool on to the swift, or cylinder;* main cylinder, burr rollers, grid, and a large roller for beating the burrs on to the same; and, lastly, revolving brush *for removing the wool off the cylinder.* These parts are all enclosed in a strongly-built frame, somewhat similar in construction to that of the teazer, or willey. The wool, after having been placed on the feed-sheet, is conveyed by the feed-rollers into the interior of the machine, when the fan forces it on to the lattice-sheet. This sheet immediately conveys it to the revolving brush, which yields it up to the teeth of the cylinder. Now, as the latter revolves, the burr roller, which turns in the opposite direction, beats, lashes, and opens the wool, the result being that in a short time the larger burrs commence to hang somewhat loosely on the surface of the cylinder, in which condition they are readily knocked on to the grid by a roller mounted with spiked arms for that purpose. The distance at which the burr roller is set from the cylinder varies according to the length of the staple of the wool operated upon. As the material gets free from burrs it is removed out of the machine by the delivering brush.

For wools containing a large quantity of broken and small burrs, motes, and seeds, the chemical mode of "extracting" is generally held to be the most preferable; but for fine wools full of large burrs the burring machine is usually employed, which possesses one material advantage over the chemical process: it preserves the natural strength and colour of the fibres.

29. *Oiling.*—Having deprived the wool, by scouring, of its natural lubricant, the yolk, its condition is such that if passed on to the scribbler without being oiled, much waste of fibre would ensue. After washing and drying, the fibres lack adhesiveness, and hence a large quantity of them would, if not lubricated, be cast off the different cylinders of the carding machines in the scribbling processes, and go to form what are called flyings or droppings. Oil is applied to the wool to minimize the production of such flyings, and also to soften and impart smoothness to the fibres. By affording these qualities to the material, it causes the individual filaments to glide past each other with as little friction as possible, and facilitates separation and re-adjustment of the same, preserving, by so doing, to some extent, the natural length of the staple.

There are various compositions used in oiling wool, but one of the best lubricants is olive or Gallipoli oil. Being unctuous to the feel, and almost colourless, it is very suitable for this purpose. About two gallons of this oil are applied to 120 pounds of wool.

Oleines, which are also largely used as wool-lubricants, are obtained by pressure from animal fats, and are known in the trade as tallow oleines, lard oleines, and neat's-foot oil. That, however, applied to wool is mainly derived from oleic acid, previously separated from stearine, a mixture of which occurs as a result of one of the processes in the manufacture of candles. By distillation, oleine or elaine is obtained from the oleic acid, while the stearine is used in candle production. If due care has not been observed the oleine thus obtained is liable to be contaminated with the sulphuric acid employed in some stages of its manufacture, which injuriously affects the wire teeth, or card clothing, covering the cylinders of the scribbling engines. This necessitates frequent grinding and cleaning of the cards. The wool is also impoverished by the action of the acid, its colour being injured, which implies the production of a less valuable cloth and consequent loss. Good oils are therefore recommended, as the wool is by far the most expensive article, and should, as far as practicable, be preserved sound throughout all the processes of manufacture.

A common method still practised in oiling wool is that of using an ordinary can with a large T-shaped nozzle. A layer or "lighter" of material is spread on the floor, then the oil distributed over it as evenly as possible, the operation being repeated till a large sheet or bed of wool has been piled up.

Fig. 8, shows a contrivance for oiling the wool as it enters the fearnought. The tank, A, underneath the feed-sheet, F, contains the oil, which is pumped into the cistern, B, to be conveyed by the arm, C, on to a ridged plate, from whence it trickles on to a revolving brush, which distributes it in a fine spray on the fibres. The supply of oil is quite uniform, and can be regulated as required. It should be observed that whatever method of lubrication is adopted, the object should always be to impart the same quantity of oily substance to every portion of the wool.

30. *Blending.*—A large variety of fabrics results from

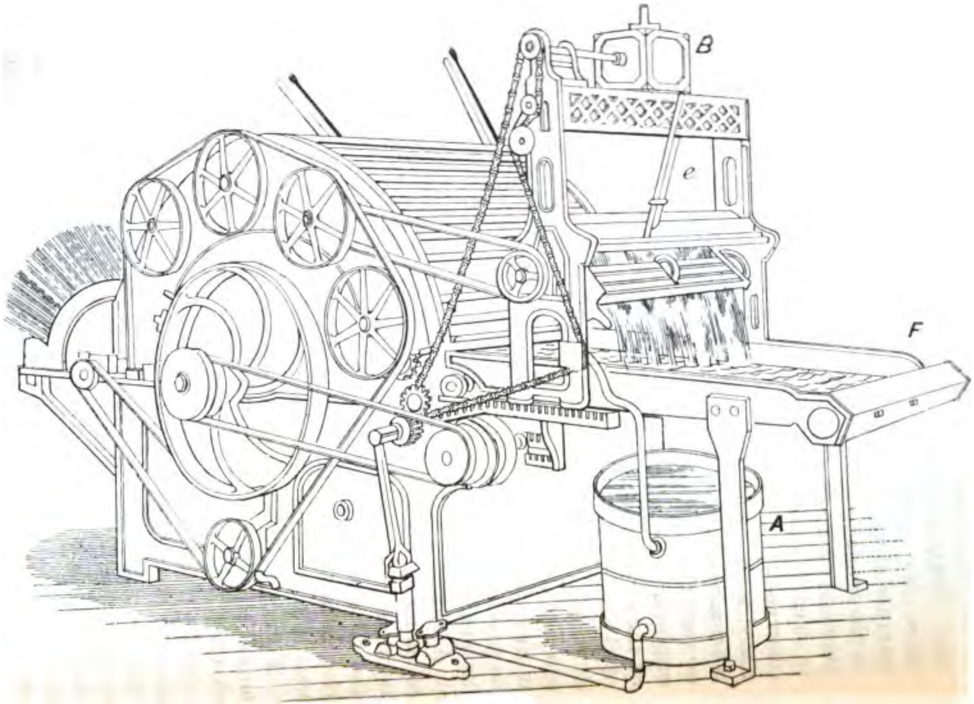


Fig. 8.

mixing two or more materials together, such as cotton and wool; mungo, cotton and wool; flocks and wool, &c. Of course, the principal object to be attained in mixing such materials with the more costly fibre of wool is that of reducing the cost of the yarn, and also of the manufactured article. Perhaps in no single instance will the cloth be improved in texture, or enhanced in value, from the entrance of these fibres into the blend, parcel, or stock previous to the scribbling process; on the contrary, the fabrics, generally speaking, are low in quality in consequence of the yarns employed being a composition of pure wool, and of a re-manufactured material only possessing inferior clothing properties. However, the decrease in the value of the woven product that takes place in proportion to the quantity and quality of the adulterating material used in the blend does not alter the fact that scribbling and spinning two or more distinct classes of fibres into the same thread is the source of an extensive range of textile goods, necessarily approaching in their general characteristics those of woollen and worsted fabrics, but sufficiently different as to be distinguished in the market as inferior articles. There are cases, as in the mixture of silk with wool, where the object is to obtain a smarter, and in every sense of the word a more stylish, thread, which ultimately adds to the beauty of the woven fabric in which it is employed; but in such instances the manufacturer does not seek to reduce the cost, but to improve the appearance of the goods produced.

Blending, in addition to allowing of various fibres being introduced into the same thread, also comprises a combination of several colours, or shades of the same or different materials. It thus affords ample scope for the origination of novelties in the shape of mixture yarns for cheviots and other classes of goods of a similar character. Such fabrics derive their leading features from the nature of the yarns used in their production, which have their characteristics formed, so far as colouring goes, in the blending operation, for the quantities of the various colours combined all contribute, according to their intensity and richness of hue, to give tone and bloom to the spun thread. Hence in this preliminary process of cloth fabrication there is considerable scope not only for making a cheap yarn, but, at the same time, a thread that will be valuable to the designer in the production of new styles.

One or two illustrations will clearly show how the process of blending can thus change the character of the yarn. Supposing, for example, that it is required to make three neutral gray mixture yarns, namely, dark, mid, and

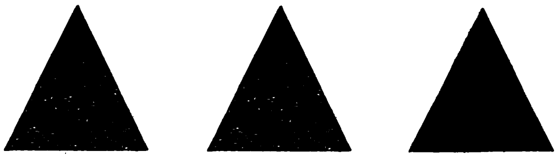


Fig. 9 *b*. Fig. 9 *a*. Fig. 9.

light gray respectively. Now, as black and white when mixed with each other produce *gray*, it will only be necessary to blend, card, and spin certain quantities of black and white wool together, varying in proportion, one to the other, according to the tone of the mixture yarn required. Thus, three pounds of black wool blended with one pound of white wool would give the dark gray shown in fig. 9; two pounds of black wool blended with two pounds of white would give a similar shade to that represented in fig. 9 *a*; while the light gray (fig. 9 *b*) would be formed by blending three pounds of white wool with one pound of black wool. For practical purposes other colours would probably be added in small quantities to give bloom and warmth to the blends; but these illustrations are sufficient to show the effect of combining black and white in the formation of gray shades.

Take another example of a slightly different character, namely, an olive mixture. Such a shade could be obtained by blending black and yellow-olive in equal quantities, whether in wool, mungo, extract, or any combination of fibres. Other illustrations are unnecessary, as the most elementary colourist will understand that as there is no limit to the variety of tints and shades that are obtained by combining several colours in different proportions, so in like manner there is practically no end to the variety of mixture yarns made for manufacturing purposes, in browns, bronzes, olives, greens, grays, &c., resulting from diversifying the combination of the shades used in the blend: a valuable proof that blending should be regarded as a useful auxiliary to the weaving process in imparting a new feature to the finished cloth.

31. *Preparing the Blend.*—As the object in blending is to mix the several fibres together as they will form a thread in which they cannot be distinguished from each other, much care is taken in preparing them for the machines in which yarn construction is performed. Blending does not alter the individual characteristics of the fibres combined. each retaining its own nature and properties, and yet the amalgamation is so complete that a perfectly uniform mixture is the result. The materials about to be combined, after having been teazed, are *bedded* or arranged in layers one above the other, in regular succession. Thus, if the blend consists of different classes of wools of the same shade, a foundation layer, some few inches in thickness, of one wool is distributed evenly over a prescribed place on the floor. This "spreading," having been oiled, a layer of a different class of wool is added and oiled, the processes of spreading and oiling being repeated to the completion of the "bed." In order to preserve the condition of the blend, when passing the material on to the teazer with the object of forming a more promiscuous mixture, the sheet is cut into vertically, and not transversely, with a strong, stout stick. When two or more

colours—say, for instance, black, tan, and green—are introduced into the blend, the routine is as follows: A layer of black is uniformly spread; then comes a layer or "lighter" of tan, and lastly a layer of green, the order being repeated to the top of the pile. The thicknesses of the individual layers vary according to the quantity of each colour required to form the proper mixture. Each lighter also receives its proportionate share of lubrication. A blend of this character, in order to ensure the production of an even thread, may be passed through the teazer two or three times.

If the mixture thus obtained is intended to be used with other stock, that is, for combining with cotton, silk waste, &c., it is sheeted up till required, in which condition it is designated "mellowing," or "melling."

In cases where cotton forms a portion of the bed the main point to be observed is to prevent, as much as possible, oil from getting on to this fibre. A layer of teazed cotton is, in such blends, first spread for a foundation, then lighters of wool and cotton alternately, the oil being distributed on the wool alone. Should mellowing be used, no oil is required. When wool, mungo, and cotton are blended together the order is to deal with the two former first, by making a bed of teazed wool and cotton in alternate stratas—this is now run through the teazer and forms an "angola" mellowing, *i.e.*, a mixture of wool and cotton. A new bed is next composed of this angola blend, and mungo of one or several shades, each being taken in succession in spreading the layers, however many colours are employed. If necessary, a little oil is imparted to the mungo. This bed complete, the whole is submitted to the action of the cylinders of the teazer, when it is ready for the scribbler.

32. *Fearnought.*—To better disentangle the fibres, and more perfectly mix the materials before carding proper, they are generally passed through the fearnought, or tenter-hook willey (fig. 10). Probably the latter name

has been applied to this machine on account of the peculiar shape of the teeth inserted in the swift or main cylinder. The back part of these teeth is slightly bent in the form of a bow, while the other side gradually tapers from the base to the point. The main cylinder is about 45 inches in diameter, and makes from 150 to 200 revolutions per minute. The smaller cylinders, W, are called workers, and those lettered S, strippers. There are three pairs of these rollers over the swift. The material, after having been spread on the feed lattice, is passed forward to the main cylinder by a couple of feed

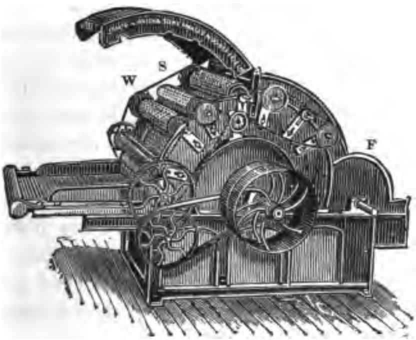


Fig. 10.

rollers, when the workers and strippers engage the tufted and matted locks, and cross and intermix the fibres together. The fan, F, draws the wool from the cylinder and casts it out of the machine. In order to prevent waste arising from loose fibres flying off the cylinders, the rollers are covered with a casing of sheet-iron when in operation. The machine is similarly enclosed underneath, but here there are perforations in the casement to allow any hard, dirty substances to escape, while the loose fibres remain on the grating.

33. *Carding.*—This process is, in one sense of the word, a continuation, on a more systematic principle, of the

separation and mixing of the fibres of the wool commenced in the teazer and fearnought. In fact, carding perfects the work of these two machines and prepares the wool for spinning. On the scribbling, or carding engines, the felted locks are not simply opened and disentangled, but actually divided into their component parts, the fibres being literally separated from each other, and afterwards so effectively crossed and blended together as to produce one promiscuous mixture of uniform density throughout. The operation consists, in the first place, in destroying the natural condition or order of the fibres; and, secondly, in re-adjusting them with such mechanical nicety as to cause them to amalgamate, in subsequent processes, in a thread-like form. In scribbling there is no attempt made to lay the fibres in parallel lines—the very opposite of this effect being designed, namely, to mix and intermingle them on one common but uniform system. After carding, the individual filaments of the wool, to a large extent, bear the same relation to each other as to closeness of contact, for they hang loosely together in one endless film or gauze-like combination; but, in other respects, they are as dissimilar from each other in arrangement as possible, for they point in all conceivable directions. Every species of fibre takes its place in the carded sliver—curly, straight, short, long, fine and coarse. From these facts it is evident that the condition of the material undergoes an entire change in the scribbling operation, for the felted locks are here reduced to detached filaments, and the wool is made pliable, diffusive, and expansible. These, in short, are the elements of the carded material which distinguish it from the wool in the raw state.

The scribbling machine (fig. 11), in which this work is accomplished, consists, briefly speaking, of a number of cylinders of various dimensions, revolving in opposite directions and at different speeds. These are all covered with fine, pliant, wire teeth, called *card clothing*. The wool is reduced to an open, fibrous condition by the con

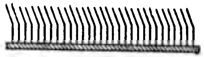


Fig. 11 A. Card Clothing.

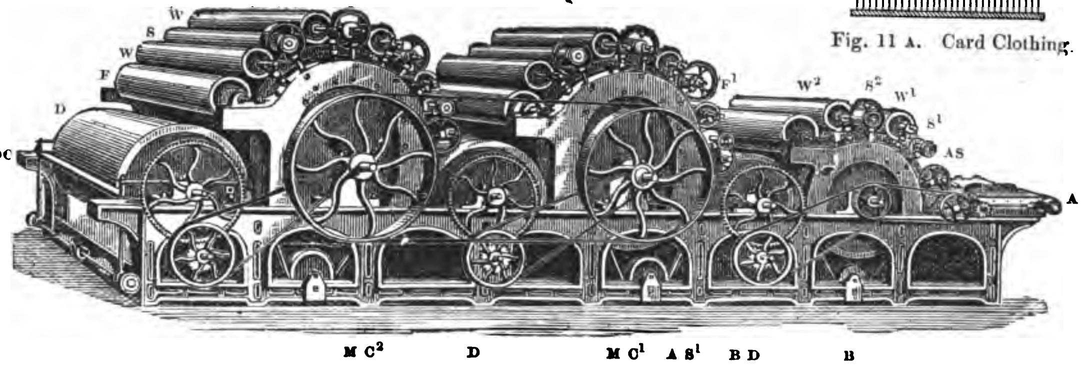


Fig. 11.

A = Feed Sheet.
A S = Breast Angle Stripper.
W = Workers.
S = Strippers.
F = Fancy.
A S¹ = First Angle Stripper.
B = Breast Cylinder.
B D = Breast Doffer.
M C = Main Cylinder.
D = Doffer.
D C = Doffing Comb.

tention, so to speak, which takes place between the wires of adjacent cylinders for possession of the fibres. The principle of the operation is this: the teeth of one cylinder work against those of an adjoining cylinder in recovering and drawing out the material which they both possess, while a third cylinder, with a large surface velocity, is constantly propelling the fibres from one couple of rollers to another. Supposing, for illustration, the wire of any particular cylinder is charged with wool, and that it comes in contact with the teeth of an adjacent roller, revolving either at a different speed or in a contrary direction, then the material will necessarily be expanded, straightened, crossed, and, in a measure, combed between their movements—a condition which is no sooner acquired than the propelling roller (*i.e.*, the main cylinder) takes the fibres in charge and conveys them a stage nearer the exit end of the machine. This is an epitome of what is repeatedly transpiring in the scribbling and carding operations.

An idea of the amount of dislocation and blending of fibres which such teeth subject the wool to may be gathered from their multiplicity. For example, it has been estimated that there are upwards of fifty-six millions of points in a machine similar to that shown in fig. 11; fifty millions of which engage the wool, carry it forward, and resist the action of the wires of other cylinders when they come in contact with the material. Six million points, on the other hand, play the part of extractors and springers, drawing or lashing the fibres from between the teeth of other rollers. According to this data it is further calculated that in an ordinary scribbling engine the wool is continually submitted to the disturbing and intermixing action of 25,000 points. When it is considered that in carding three separate machines are sometimes employed, containing an increasing number of points, it will be obvious that nothing less than a perfect separation and readjustment of the fibres can fail to ensue from passing the wool through this operation.

34. *Systems of Carding.*—There are two systems of carding. In the one most generally adopted in the woollen textile centres of Great Britain a complete set of carding machines consists of *scribbler* (containing breast cylinder and two swifts), *intermediate* (containing two swifts), and carder (containing two swifts and condenser). The *intermediate* is not always employed. In the second system, which is almost universally adopted in America, and in recent years used to a limited extent by English manufacturers, there is the same set of three machines—scribbler or breaker, intermediate, and carder or finisher, with condenser attached—but in this case each engine has only one swift or large cylinder (see fig. 12, which is a drawing of the carder and condenser of this build of machines), and hence does not occupy so much floor space as the former set. There are usually five pairs of rollers over the swifts in both the breaker and intermediate in the machines of this class, but only four pairs over the carder. Both these methods of wool-carding are practised with satisfactory results. It may be said of the two-swifted-system that it is applicable to all classes of materials, both for fine and coarse work, whereas the one-cylinder principle has, thus far, in this country, been mainly confined to wools intended for medium and fine counts of yarns.

In the limited space that can be devoted to this subject here the first-named system of carding will alone be described in detail. However, as the principle of scribbling is identically the same in both sets of engines, the explanations given will also be more or less applicable to the latter system of carding.

35. *The Actual Operation of Scribbling.*—The passage of the material through the scribbler will now be described. (The reader is referred to fig. 11, which is a correct representation of the scribbling engine, and will assist him to understand the principle of this important operation in woollen yarn manufacture.) The wool is, in the first place, laid on the feed-sheet, A, which is divided transversely

into equal sections, to facilitate even spreading. Uneven distributing of the wool on the feed-table causes irregular and faulty scribbling. Mechanical feeds are now largely employed for laying the wool on the travelling lattice, and, if anything, equalize the supply more efficiently than by weighing, as adopted when feeding by hand. Before the fibres are conveyed to the breast-cylinder, B, the wool is subjected to a preliminary mixing, which has a tendency to regulate the quantity of material passed on to the breast-cylinder, as well as to prepare the fibres for the more minute dislocation they undergo in other parts of the machine. The blending referred to is accomplished by five rollers, three of which are termed feed rollers, one the "licker-in," and the other the "angle-stripper." The relative positions of these rollers are as follows:—the three-feed rollers are fixed one above the other; directly behind them is placed the licker-in, and over it the angle-stripper. As the wool is carried into the machine by the feed-sheet it is taken possession of by the bottom "feed" and then transferred to the licker-in. The middle roller also gathers up a portion of the wool, which, in conjunction with the top "feed," it opens and delivers to the licker-in, which, in turn, yields it up to the angle-stripper, from whence it is received by the wire of the breast cylinder.

Now it is at this juncture that the real process of scribbling begins. The wire of the breast cylinder propels the material forward until it comes in contact with the first pair of small rollers, W^1 and S^1, called workers and strippers. The worker, which is placed behind the stripper, is the larger roller, and removes the material off the cylinder, while the stripper takes it off the worker and delivers it over, after it has been worked, to the rapidly revolving cylinder. This process is repeated by each pair of workers and strippers in the machine.

It is not the object of the scribbler to effect at a single operation a perfect separation and blending of the fibres, for, in so doing, it would be liable to break the staple of the wool; hence the several small cylinders employed in disentangling and re-mixing the fibres. The first pair of rollers are only intended to operate upon the largest entanglements, being set the furthest off the cylinder, and also the coarsest in the wire, or containing the smallest number of teeth. The material which escapes their points is dealt with by the second couple of rollers, while the smaller tufts of fibres still are engaged by the third set of workers and strippers, and so on throughout the operation. By this repeated transfer from one cylinder card to another a continuous opening and blending of the material is carried on from the time when it enters the machine at the feed-sheet to leaving the same at the doffer.

It will be more clearly understood how the wool is transferred from cylinder to worker, from worker to stripper, and from stripper back again to cylinder, if the character or bend of the wire in the card clothing of the different cylinders is taken into consideration. A representation of this wire is given in fig. 11 A. There are three ways in which the wires meet each other: first, point to point; second, point to smooth side; third, smooth side to smooth side. The wool is most effectively "worked" when it passes between two rollers in which the points of the wires of their respective surfaces oppose each other. Such is the case with the wire of the swift and that of the workers, the points of the latter leaning in a contrary way to those of the main cylinder. The points of the card clothing of the stripper come in contact with the smooth side of those of the worker, enabling it to remove the wool off this cylinder; for a similar reason the wire of the swift can readily recover the material off the strippers. The high speed at which the main cylinder revolves, in addition to its using the points of its card clothing, gives it the power to force the wool forward, and ultimately to deliver it to the doffer.

To return to the wool at the point where it is reclaimed by the breast cylinder from the first stripper, s^1—from thence it is conveyed to the second pair of rollers to be submitted to further blending, and then to the third set, the amount of crossing and separation the fibres undergo increasing as the wool progresses from point to point on the surface of the breast. Having escaped from the second stripper, s^2, it is again engaged by the active cylinder and carried forward to the fancy, F^1. The function of this roller is not to "work" the wool, but merely to lift, or lash it on to the surface of the wire of the breast and main cylinders. As the material is being subjected to the action of the different workers and strippers, and in consequence of its repeated transfer from these rollers on to the cylinder, it becomes embedded in the card clothing of the latter, the fibres sinking below the points of the teeth. The wire of the fancy is long and elastic while it revolves at a high velocity, hence it brushes up the wool, raises it on to the points of the clothing of the cylinder, and facilitates its removal by the doffer. The points of the wires of the "breast" and the swifts work against those of the doffers, but, as the material is well brushed up by the fancy, the action of the two cards is considerably modified, and the latter may be said to receive rather than take the wool off the cylinders. After leaving doffer, B D, the angle-stripper of the first swift, A s^1, places it on the wire of that cylinder, where the passage from card to card already described is repeated.

To take the scribbled wool off the last doffer, a steel comb or doffing knife, D C, is employed. It is the entire width of the machine, and moves rapidly up and down, imparting as it descends a shaving stroke to the surface of the card, and thus removes off the wire of the doffer a continuous fleecy web of fibre.

36. *Parts of a Scribbler.*—Having described the order in which the fibres pass over the wires of the various cylinders, explanations may now be given on the special functions of the different parts of the scribbler. It should be

observed before doing so that the arrangement of the rollers is precisely the same in the scribbler as in the intermediate and carder, only the two latter engines do not possess a breast cylinder and its accessories.

Passing by the feed sheet and rollers, licker-in and angle-strippers, attention will first be directed to the *breast cylinder*, This roller is about 36 or 38 inches in diameter and is generally mounted with two sets of workers and strippers. It is the first large cylinder in the machine, and is, in reality, a miniature swift performing the same functions as the latter.

Workers.—These operate upon the wool at different points on the surface of the breast and main cylinders. They are about 8 inches in diameter. The points of their wire should be sharp and fine to lay hold of the wool, and yet smooth in order to release it with as little friction as possible. Both workers and strippers are set closer to the swift, and increase in fineness of wire progressively, or according to the positions they occupy in the machine.

Strippers.—Sometimes these rollers, which are from 3 to 5 inches in diameter, are termed cleaners. After opening the wool, in conjunction with the workers, they yield it up to the wire of the swift.

Main Cylinders or Swifts.—These are generally about 48 inches in diameter, and make from fifty or sixty to one hundred revolutions per minute. Strictly speaking, they are more the conveyers than the carders of the wool, forcing it from worker to worker, and finally delivering it up to the doffer.

Fancy or Fly.—This roller is covered with long elastic wires, and somewhat resembles a strong metallic brush. It is some 12 inches in diameter, and has a surface velocity exceeding that of the swift by about one-fifth. Generally it is set moderately deep in order to extract the imbedded fibres from between the wires of the main cylinder; but it should not work so deeply as to throw the wool off the cylinder, its function being merely to raise the material on to the points of the wires.

The *doffer* removes the fibres brought on to the surface of the swift by the fly. In fine work it is about 24 inches, and in coarse work 36 inches in diameter. It should be set as close as possible to the swift, while its points should be both sharp and keen, to secure a clean removal of the fibres from the main cylinders.

The *doffing comb* is fixed slightly above the axle of the doffer. When carding short wools it requires a high up-stroke, but for long wools, with a greater speed of doffer, a low down-stroke. The comb should not touch the doffer, but be set quite close. Its action should also be as slow as convenient with a satisfactory delivery of material.

37. *Speeds of the Cylinders*.—This is another matter that in practical work requires careful adjustment. One series of speeds is not suitable for all classes of blends and wools. The main cylinders, for example, vary from sixty to one hundred revolutions per minute, and the doffers from five or six to over twenty. For all wool blends intended to be spun into fine yarns, ninety is a good average for the swifts; for coarse, strong wools, or blends of mungo and wool, seventy to eighty is the standard velocity. If the cylinders revolve too quickly when carding coarse blends, the quantity of fibres which fall underneath the machine in the form of "droppings" is largely increased. The fancies, for a like cause, have in such cases to be run slowly, otherwise they cast off a lot of loose fibres as "flyings." The motion of the workers and strippers, on the other hand, should in this class of work be accelerated, the speed of these rollers generally being the highest when the materials are coarsest in quality; but in wools requiring well "working," or much carding, the speed of these cylinders is at the lowest, because the longer the material remains on the main cylinder the more effectively is it opened. In fine work the doffer should make from five to six revo-

lutions per minute; in coarse work the first doffer might make as many as twenty; but the other doffers should be speeded somewhat more slowly. As this roller "doffs" the wool off the swifts, the lower its velocity the better are the fibres carded, opened, and blended.

38. *Modes of conveying the Scribbled Wool from one Engine to another.*—The object aimed at in transferring the material from one carding machine to another is, as much as feasible, to prevent the production of an unevenly scribbled material, by presenting the fibres in a new form to the cylinders of the *intermediate* or *carder*, as the case may be. There are no less than three distinct modes of doing this. First, there is the *lap* system, in which the material as it leaves the scribbler is conveyed in successive layers by a travelling apron, set at right angles to the doffer, on to a huge drum; hence the fibres are distributed on to the carder in the opposite direction to what they come off this machine. Second, there is the *Scotch feed*, a contrivance which reduces the scribbled material into a flat ribbon or band some 5 inches broad, and from a quarter to half an inch thick. This "sliver" is laid on the feed of the carder by what is called the carriage, in a slightly diagonal sense, each layer being arranged to overlap its predecessor to such an extent as to ensure a level and uniform distribution of the material. Third, the *balling* or *side-drawing* system, so called on account of the fibres being delivered in the form of a rope to which a little twist is imparted as it passes through what is known as the funnel, on its way to the balling machine, where it is conducted between guide-pins on to bobbins 3 inches broad. These bobbins, when full, are placed in the creel, and the separate ends passed between another series of guides on to the feed rollers of the carder. A remarkable feature about this system consists in the fibres being spread in the same direction on the carding engine as they leave the doffer of the preceding machine; whereas, in both the lap and Scotch systems the fibres are delivered, say, lengthways, and fed on to the

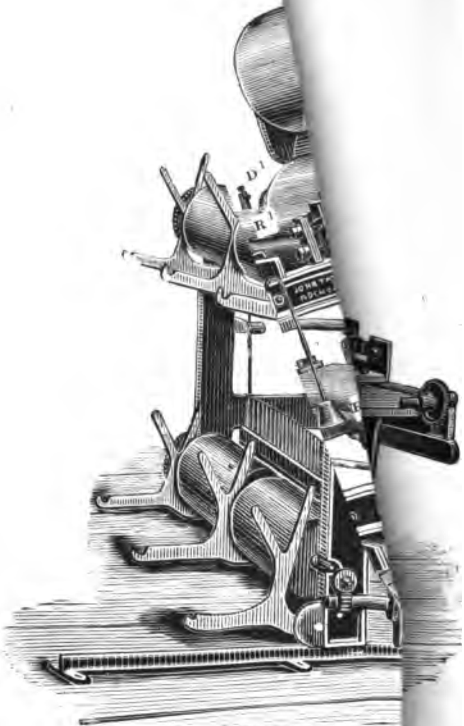
carder transversely. Another characteristic of the balling feed is that the fibres are twisted into a rope condition (which implies that a certain degree of twist or twine has been introduced amongst the filaments), and that in this state the material goes on to the cylinder of the carder, where the primary object is to reduce the wool into one thin, level film of fibres.

39. *Condensing.*—The condensing machine is attached to the carder, the wool being stripped off the last swift of this engine by the ring doffer or doffers of the condenser. The object of this operation is, as its name implies, to condense or reduce into compact slivers, the sheet of fibres delivered by the last main cylinder of the carding engine. By pressure and friction it divides the material into a series of soft, round, flabby threads, technically designated slivers, supplying to them a sufficient degree of uniformity, solidity, and adhesiveness as to make them capable of bearing the tension brought to bear upon them in the twisting process.

There are three descriptions of condensers:—

I. Single-doffer and single-stripper machine.
II. Single-doffer and double-stripper machine.
III. Double-doffer and double-stripper machine.

The construction of the single-stripper machine will first be considered. The doffer in such a condenser is covered with rings of card clothing about 13-16ths of an inch in width, allowing a space of 3-16ths between each sliver stripped off the cylinder of the carder. So that if the cylinder were 72 inches wide there would be about 13½ inches of its surface that the wire of the doffer would never operate upon. To prevent the accumulation of fibres on the uncleaned parts a twofold action is supplied to the workers on the second swift of the carding machine, for they have both a rotatory and transverse motion, so that any fibres escaping the action of the ringed clothing of the doffer are re-distributed on the surface of



G1.

the cylinder. This arrangement, in time, places the fibres in such positions as they cannot fail to be laid hold of by the wire of the condenser. The narrow bands of fibres are taken off the doffer by the stripper and passed by it on to a pair of rubbers which deliver them up to the bobbins in the creel. "The characteristic feature of roundness the slivers attain in this process is due to the action of the rubbers, which not only revolve on separate rollers, but oscillate from side to side. The slivers, which are in an extremely soft and pliable condition when leaving the doffer, gradually become rounder and rounder, firmer and firmer, under the continued transverse motion of the rubbers, until they ultimately assume the appearance of loose, untwisted threads."

The construction of the single-doffer and double-stripper machine is similar to the one described, only there are two pairs of rubbers, and the slivers are rounded and solidified by both at one time, the yield of each being wound on to separate bobbins.

In the double-doffer and double-stripper condenser (fig. 12) there is a slight difference in the method of removing the wool from the swift of the carder from that adopted in the two preceding machines.

Both of the doffers, D^1 and D^2, are clothed on the "ring" principle, but the stripes of card clothing in D^1 are opposite to the spaces in D^2, and *vice versâ*, so that the fibres which escape the teeth of one are engaged by those of the other doffer. There is a stripper and a pair of rubbers, R^1, and R^2, to each doffer, which increase the working power of the machine very materially. This class of condenser is now very largely employed, as it not only turns out more work, but more perfectly cleans the swift of the carder than the single-doffer machine.

There is another method of condensing to which allusion should be made. It is a Belgian arrangement, and is regarded by some scribbling engineers as the best principle of condenser yet invented. In the English machines described it will have been observed that the continuous width of fibre formed on the swifts of the carder is divided into longitudinal bands by the ring clothing of the doffer of the condenser. It is found that although two such doffers are employed, yet the removal of the fibre from the wire of the carder is not satisfactorily effected. The Belgian condenser has no cylinder ringed with card clothing, the doffer in this case being completely covered with wire, and has the wool taken off its surface by the action of an ordinary doffing knife. The sheet of fibres pass from this doffer between a pair of iron cylinders divided into as many parts as there are slivers condensed. The rollers of a 60-inch cylinder machine may contain as many as 120 divisions. Each alternate section is grooved, the smooth parts of one roller opposing the grooved parts of the other. Leather bands of the same width as these divisions pass the material between the grooved cylinders. The slivers on the narrow straps of each roller are next wiped off, entering different rubbers, where they are rounded and condensed in the usual manner. The principal advantages, of this system of condensing, over some others, consist in the use of a doffer the entire surface of which, being mounted with wire, plays against the card of the swift, securing, by this means, a more perfect removal of the wool; and also in admitting of a larger number of slivers being formed from a given width of material.

40. *Spinning.*—" There is but one process, after that of condensing, the wool has to pass through, namely, spinning, before a weavable thread or yarn is obtained. The condensed sliver is nothing less than the basis of the spun yarn, for all that is requisite to make it suitable for weaving purposes is the addition of twist. This, of course, is necessary to impart strength, firmness, and solidity—three essentials which are not present in the soft thread yielded by the condenser. A sliver is the result of rubbing a limited number of fibres together, but the yarn produced on the mule or spinning frame is ob-

tained by two distinct motions—firstly, that of twisting, compressing, and twining the individual fibres of which the sliver is composed firmly round one another, affording thereby strength, compactness, and tenacity to the thread; and, secondly, that of extenuating the sliver, which increases its length in the same ratio as it decreases its thickness or circumference."

Professor John Beaumont, in his lecture on a "Lock or Fibre of Wool from the Bale to the Finished Cloth," thus describes the nature of the condensed thread and the purpose of the spinning process. This much will be gathered from the above description, that the sliver of the condenser possesses little or no adhesiveness. It has the form of a thread, but lacks weaving capabilities. When tension is applied it readily breaks. This arises from the relation which the fibres sustain to each other. They are simply balled or rolled one over the other into a continuous circular longitudinal form, without any motion being applied to secure them permanently in this condition. To impart strength and elasticity to the sliver thus formed, and, in a word, to transform it into a thread or yarn capable of bearing the friction and strain of the weaving process, a binding affinity or cohesion of the fibres must be brought about. The method of effecting this, as already noted, consists in imparting into the sliver twist, or twine, a factor which forces the individual fibres into closer contact with each other, reducing as a natural sequence the thickness of the thread, and substituting solidity, resisting power, and tenacity, for softness, lack of firmness, and lack of elasticity.

41. *Mule, or Spinning Frame.*—The mule, or spinning-frame (fig. 13), in which this work is done consists of the headstock, A (which like the crank shaft in a power loom either directly or indirectly communicates motion to all the parts of the machine), the carriage, B, and the stationary frame C. The carriage travels backwards and forwards, and contains the spindles on which the bobbins,

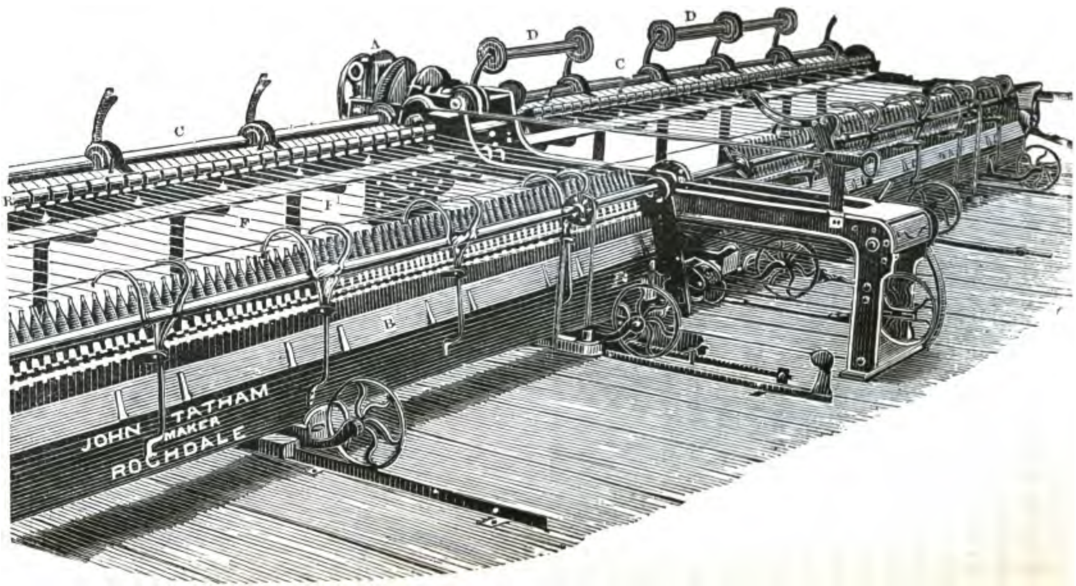


Fig. 13.

or tubes, for the formation of the cops of yarn are placed. In the frame the condenser bobbins, D, are fixed. The principle of the machine is this—to give out from the small rollers, E, fixed in the frame, a certain length of sliver simultaneously with imparting a degree of twist, when the rollers cease to revolve, but the carriage continues to recede, elongating the sliver by so doing; meanwhile the spindles are speeding round at an increased velocity, furnishing what may be called the finishing twine.

The rollers supply the length of sliver to be operated upon, the carriage extenuates, and the motion of the spindle generates the twist. The method of introducing twine into the sliver deserves detailed notice. Running from one end of the carriage to the other is a metallic cylinder, or drum (see G, fig. 14), which, by means of a central shaft, receives motion by wheel and other gearing from the headstock. Round this drum and each spindle is wrapped a cord, H, called the spindle band, which causes the spindle to revolve when the cylinder is in motion. A contrivance has been recently invented and patented for driving the spindles by bevel wheel gearing. Each spindle is driven off the same shaft, which extends from end to end of the carriage like the cylinder, but is mounted with as many wheels as there are spindles, giving a regularity of movement scarcely attainable by the use of cords. In fact, the band system has several drawbacks. Should the cords, for example, not be of one uniform tightness an uneven spin is sure to be the result; and, as the bands are always liable to give after being on the stretch for a short time, and vary according to the temperature of the room, it will readily be understood there are important defects in this principle of spindle-driving.

Now, as the threads are being twisted, they are held slightly above the tops of the spindles by what is called the faller (F, fig. 13), to prevent the yarn being wound up. When a sufficient degree of twist has been added, the spindles make a few turns backward to undo the extra twine imparted to the yarn nearest the point of the spindle ; this done, the faller, F, guides the yarn on to the cop in formation. The counter-faller, F[1], keeps the threads at an even tension during the winding operation.

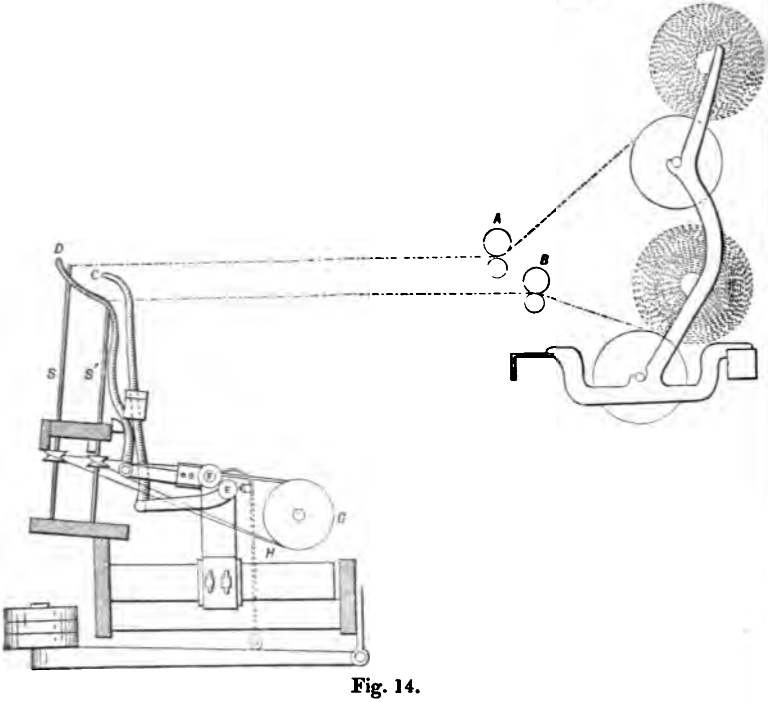


Fig. 14.

42. *Duplex Spindle Arrangement.*—Usually the carriage only contains one row of spindles, but a contrivance is shown in fig. 14 by which the cylinder is made to give motion to two series, thus increasing the working capacity of the mule. The back spindles, S, are somewhat longer than the front row, to keep the two yarns as distinct as

possible. Without this difference in the heights of the respective series of spindles the yarns, in twisting, would get entangled and foul, or break each other down. Each row of spindles has its own delivering rollers, the points of the front spindles being exactly the same distance from, and on the same level with, rollers B as spindles S are with A. Both S and S^1 are driven off the same drum, so that they have precisely the same velocity. The ordinary fallers, carrying the guide and building wires, are replaced by light arms, C and D, worked by the shafts, E and F. These arms operating on the yarns of each row of spindles in the same manner, the cops are built exactly alike in every respect. Of course, the principal advantage claimed by this arrangement is increased turn out. A secondary advantage is said to be that the mule requires less attention in proportion to the number of spindles, while the "piecers" having their worker in a smaller compass can do it more efficiently. The smallness of the space between the individual spindles, when a mule is mounted on this system, is possibly the main objection to this duplex-motion. But this difficulty has in a measure been surmounted by the separate rows of spindles being kept distinct from each other. In open pitch machines (say spindles 3½ inches apart) this arrangement has been known to give every satisfaction.

CHAPTER III.

WORSTED THREAD CONSTRUCTION.

43. The Worsted Thread—44. Principle of Construction—45. Preliminary Processes—46. Backwashing—47. Gilling—48. Combing—49. Nip and Square Motion Combs—50. Scribbled and Combed Wools—51. Drawing—52. Drawing Machines—53. Roving—54. Worsted Spinning.

43. *The Worsted Thread.*—The unique structure of worsted yarn makes it invaluable in the production of textile fabrics. Lustre and uniformity of surface are its distinguishing characteristics. The method on which it is formed causes it to be capable of sustaining more tension, in proportion to size or thickness, than the pure woollen. This characteristic, combined with its lustrous quality, gives it a pre-eminent position in the manufacture of fine coatings: in fact, it is questionable whether any other textile thread is so highly adapted as the "worsted" to this important branch of the weaving industry. A finer cloth, possessing a brighter and clearer surface, is certainly producible with worsted than with woollen yarns. The mechanical system of adjusting the fibres in the formation of the latter is such as to result in the manufacture of a thread possessing a somewhat indefinite and fibrous surface, which neutralizes the character of the weave, or destroys, in some degree, the effect in the woven goods due to crossing warp and weft threads at right angles with each other. As the fibres are prepared on a different system in worsted yarn construction, a class of weave ornamentation of a decided or marked type may be obtained by employing this kind of thread. There is, in a word, more scope for pattern production of a weave description in the use of

worsted than carded or woollen yarns; for the level and regular structure of the former imparts a distinctness to every section of a pattern resulting from a combination of different weaves, and hence the variety of effects which obtain in worsted trouserings and coatings, both in highly-coloured patterns and in piece-dyed goods or fabrics of one shade throughout. The advantages which the worsted possesses over the woollen thread for some classes of goods are twofold: (*a*) a smarter texture, *i.e.*, a clearer surface; and (*b*) a more definitely pronounced weave effect. As to the carded thread, it is more suitable than the "worsted" for cloths in which the colourings of the pattern require to be well blended together, the texture fibrous, or the fabric well milled; *e.g.*, fancy tweeds (both Saxonies and Cheviots), and thick, heavy cloths, comprising doeskins, meltons, pilots, naps, and beavers, and also fine twilled goods of a buckskin and Venetian class.

44. *Principle of Construction.*—Worsted yarns may be said to be of three distinct kinds. An important class to the clothing manufacturer is that obtained from short and medium stapled wools, which are made into yarn by carding, gilling, and combing. Secondly, there is a valuable variety of thread produced from long wools, possessing a fibre, on an average, of not less than four or five inches in length. Such wools are not carded, but simply gilled and combed after the fibres have been regularly straightened and adjusted by hand. To card long wools would be very injurious to the material, for it would result in breaking the fibres, and so produce a large quantity of noil—a point which cannot be too closely guarded against in making worsted yarns. When a soft, open thread, with plenty of fullness and fibre, is required, as in carpet and some classes of knitting or fingering yarns, then the wool is neither gilled nor combed, being first carded and afterwards drawn and spun.

Whichever system of thread production is adopted, the principle of manufacture is the same, for in all worsted yarns the fibres are more or less straightened and arranged in one order. The more combing and gilling the wool passes through the higher the degree of parallelism attained.

This should be particularly noted, that in worsted yarn making it is not so much a blending and frequent re-mixing as a systematic separation, drawing out, and arranging of the fibres in one common line that is sought after. Of course a perfect combination of the fibres used is necessary; but, although the distinctive feature of woollen thread manufacture is that of mixing the fibres thoroughly together, so as to produce a level sliver, yet there is no regular system of amalgamation adopted, for fibres may, in the condensed material, lay either across or lengthways of the thread: on the other hand, in worsted yarn construction, in addition to forming a continuous ribbon of fibres, uniform in thickness throughout its length and breadth, the several filaments must be arranged side by side on one distinct system—in a word, they must be parallel to each other.

The actual condition of fibres now to be attained may be illustrated by taking a strand or lock of raw wool and drawing out the fibres between the forefinger and thumb of each hand—a process which first straightens, and then brings the fibres into one common line. This is the principle on which a worsted thread is produced. Carding in worsted yarn making, when adopted, is only a secondary operation. The adjustment of fibres it secures is not intended to be permanent, but is simply to facilitate the formation of an even ribbon. By separating the fibres it *prepares* them for the drawing out and extending in the same direction to which they are subsequently subjected to in the gill box and combing machine. The various changes the wool undergoes in being transformed into a worsted thread, when the first method of construction is adopted, may be briefly defined as follows:—(1) Opened and separated, but crossed and intermingled on the wire of the carder; (2) Straightened, extenuated, and levelled in gilling; (3) The short and curly fibres extracted, and the straight and long laid parallel one to the other in combing; (4) An even ribbon formed on the drawing frame; (5) The thick, rope-like thread produced in roving twisted into a weavable yarn on the spinning machine.

45. *Preliminary Processes.*—The preliminary processes of scouring, oiling, blending, and carding are much the same in both woollen and worsted yarn production; in fact, they only differ from each other in a few minor details, hence it is unnecessary to describe them lengthily here, seeing they were fully discussed in the previous chapter. Some brief allusion may, however, be appropriately made to the worsted carder, as it is somewhat dissimilar in build to the woollen machine. Sometimes it contains as many as four lickers-in, or openers, as they are called, garnished with very strong steel teeth, increasing in fineness from one roller to the other. The speed of these cylinders also varies in a similar manner, that of the last roller being the highest. Fixed in close proximity with the two front lickers-in are what are termed the burring rollers. These are not covered with card clothing, but with steel blades, which knock the burrs out of the wool on to a tin tray. In some machines a triple burr-roller arrangement is applied. In such a case each burr-roller has a separate guard-roller for lashing the burrs, seeds, &c., out of the material. The burr-rollers are all covered with fine steel teeth, inserted into the surface of the cylinders, that on the first roller being of the coarsest pitch, that on the second of an intermediate pitch, and that on the third of the finest pitch. On this system the large burrs are removed by the first guard-roller off the front burring cylinder, the medium-sized burrs by the second, and the broken burrs and seeds by the last guard-roller.

When the material reaches the swifts, it passes through the same process of opening as in carding for woollen yarn. The wool is, however, delivered in the ball or ribbon form, the sheet of fibres being focussed in the centre of the machine, as stripped by the doffing-comb off the last cylinder, and passed through a kind of a tunnel on to a large bobbin which, having both a lateral and rotary motion, winds the lap of fibres regularly on to its surface. After carding, the material is ready for those processes which belong, strictly speaking, to worsted yarn manufacture, namely, backwashing, gilling, combing, drawing, roving, and spinning on the throstle frame.

46. *Backwashing.*—On the material leaving the carder, it is somewhat discoloured in consequence of the oil added to facilitate its passage through the carding-machine, and it also contains a certain percentage of dirty substances. It is very desirable, before gilling, to remove such impurities

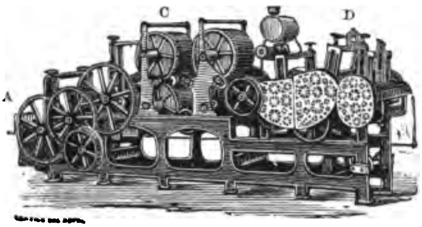


Fig. 15.

and thoroughly cleanse the "cardings" of all greasy and foreign matter. This is done in the backwashing machine, to which is frequently attached a screw gill-box, as shown in fig. 15 [kindly lent by the makers, Messrs. Taylor, Wordsworth, and Co., Leeds]. The machine consists of a couple of sud bowls, each of which possesses a pair of immersing and a pair of squeezing-rollers, of drying cylinders C, and gilling apparatus D. The sliver or slivers, in the first place, pass between the guide-pins A, and from thence into the front bowl and between the "immersers" on to the squeezing-rollers, leaving which the fibres enter the second bowl, where the process of immersing is repeated, and then the scour completely pressed out of the material by passing it through the second pair of squeezing-rollers. From here the wool travels over a number of drying cylinders C, charged with steam, where it is perfectly dried, and delivered up to the rollers of the gill-box part of the machine, the principle of which will be described under the head of gilling.

Another system of backwashing consists in squeezing the material at four separate times, thus—first, in the suds, called a wet nip; second, out of the suds; third, when in the scour; and fourth, when out of the scour. It is held by the users of this class of machine that when the wool is only squeezed out of the liquid, the oil applied previous to carding is not perfectly removed, which is said to cause the yarns, after being made into cloth, to be susceptible to suddenly presenting a shiny appearance.

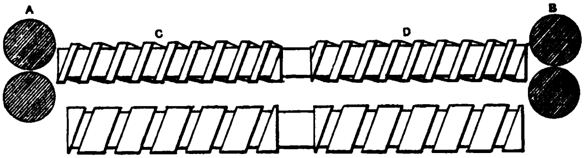


Fig. 16.

Whether this theory holds good or not, there seems to be one feature in favour of this system of backwashing—the cardings necessarily part more readily with the greasy matter they contain when squeezed alternately in the suds and out of the suds than if only squeezed when in the latter condition.

47. *Gilling.*—The object of this process is to straighten the fibres, draw out and level the carding, and prepare the material for the combing-machine. The main parts of the gill-box in which the operation is carried on are the receiving and delivering rollers, the fallers containing the gill-pins, and the screws on which the fallers travel from one end of the machine to the other alternately. The arrangement of these parts in the machine is shown in the sectional drawing given in fig. 16. Here rollers A first

receive the wool, which is forcibly drawn between the pins of the fallers by rollers B, the latter revolving more quickly than the "receivers" A. The fallers move forward on the upper screw, C, at a somewhat quicker rate than the fibres are delivered by rollers A. When they reach the end of the traverse they are knocked down on to the lower screw by an eccentric, travelling to the end of which they are replaced by a lever on the upper screws. The lower screws are coarser in pitch than the top set, thus admitting of a large number of fallers being up than down at one time. The principle of the gill-box is that of a number of fallers

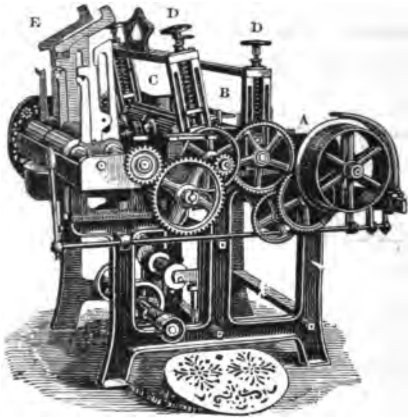


Fig. 17.

or bars of iron, studded with steel pins, travelling on two sets of screws. While the fallers are on the upper set, the fibres of the wool are straightened and elongated between the gill-pins; but the action of the gills on the material is suspended when the fallers are moving on the lower screws. Fig. 17 [kindly lent by the makers, Messrs. Taylor, Wordsworth, and Co., Leeds] is a perspective drawing of the gilling-machine. At A the slivers from the backwasher are fed into the box and pass between the fluted rollers, B, and the gill-pins of the fallers on to the drawing, or delivering, fluted rollers, C, from whence the ribbon is balled by the appliance E, called the balling head. By means of screws D, or in some cases weights and levers, pressure is put on to the rollers, causing them to firmly grip or nip the lap of fibres.

It will be observed that in fig. 16 the screws are divided into two sections. The object of this is to admit of two sets of fallers being used, those on the first screws, C, travelling slowly, or making a draft of about two from the rollers A, while the fallers on the second set of screws travel three times as fast as those on screws C. Unless this arrangement is adopted in the first gill-box, the staple of the wool is likely to be very seriously mutilated, and the fibres shortened and broken by being forcibly drawn from the nip of the receiving rollers by the gill-pins of the fallers, and again by the delivering rollers through the gills. The first set of fallers in a gill-box constructed on this principle prepares the lap of wool for the second fallers where drafting proper is effected. Drawing out and straightening of the fibres, or drafting, is thus effected with as little injury to the length of the wool as possible.

A complete set of preparing-boxes contains five or six machines, all similar to each other in construction. For the first and second boxes a double set of fallers is recommended, but it is not so important in the third and subsequent machines, as the fibres are well straightened and uniformly arranged after leaving the first box. The lap of fibres resulting from first gilling is taken and passed through the second box, to be again balled and delivered in the lap condition—of course, the material being more minutely straightened, and the fibres more uniformly arranged. In the third box a change is made in the method of delivering the fibres. Here they are, after leaving the delivering-rollers, passed through a brass oval hole, and then between a pair of perfectly smooth pressing-rollers, which causes them to be delivered in the ribbon form, not on bobbins, as in the previous boxes, but in long, deep cans. To further level and equalize the ribbon, some six of such cans are placed behind the fourth box and drawn out to the thickness of any of the single ribbons combined. A similar number of extenuated ribbons are taken and re-drafted, or reduced to the size of one of the six in the fifth box, the process being repeated in the sixth machine, if such a box is employed. It will at once be evident that this amount of combining and extenuating of the ribbons will necessarily result in the production of a level and uniform band of straightened fibres.

The effect of gilling on the wool will now be readily understood. The laps of material are kept at full tension during the time they are being drawn between the pins of the fallers, a process which not only separates and adjusts the fibres, but draws out the curl, elongating the ribbon, and bringing the filaments into one uniform line.

A gilling machine of a somewhat different construction to that described has recently been invented. Instead of drafting in this case by two pairs of rollers revolving at different speeds, it is done entirely by the fallers, the speed of which gradually increases as they approach the terminus of the top traverse. This is accomplished by employing screws graduating in pitch or fineness. The machine is in two sections, each of which has its upper and lower pair of screws. Between these are a pair of rollers which simply keep the lap of wool between the pins of the fallers. Drafting is due to the variable speed of the gills, for as the screws increase in fineness of pitch the gills move quicker, each faller gaining speed on its successor, and so drawing out the fibres between them. The speed at which each faller travels is constantly accelerating, from the moment it rises until it falls; and exactly as the speed of the traverse augments, the distance between one faller and another increases. In the two screws of a gill-box of this description, which have a combined length of 42 inches, the gain in speed is as

$12\frac{1}{2}$ is to 1. The advantage claimed for this method of gilling is less breakage of fibre, in consequence of the material not being dragged through the pins of the fallers by the delivering rollers.

48. *Combing.*—There is a twofold object to be attained in combing—first, to thoroughly adjust the fibres in parallel form; and, second, to remove the short, curly fibres present in the wool. Gilling, as has already been explained, produces a fairly level ribbon, but if it is closely examined it will be found to be a combination of short and long, crimpy and straight, fibres. All "neppy" and wavy filaments, until straightened, are unfit for utilization in worsted yarn construction. For this reason the wool, in the combing operation, is divided into two distinct classes —that is to say, the long fibres of the gilled ribbon are combed, and go to form what is called the top, while the short and wavy fibres are cast out as noil. A worsted thread is distinctly the result of utilizing the straightest and longest filaments contained in the stock, whatever that may be, and hence the importance of the combing operation. By frequent gilling a level ribbon may be obtained, but to form the basis of a lustrous thread, with a smooth uniform surface, something more is essential; the fibres which retain their crimpy character, and resist the action of the gill-pins, must be extracted, and, if possible, totally removed out of the ribbon; consequently, one of the main functions of the combing machine may be defined as that of separating the short and curly from the long and straight fibres.

There are several classes of combing machines, but the principal makes used by English top producers are the circular, nip, and square motion. As the circular comb is the most extensively employed in preparing yarns made of medium and short-stapled wools, it will be treated of first. A drawing of this comb is furnished in fig. 18 [kindly lent by the makers, Messrs. Taylor, Wordsworth, and Co., Leeds]. It will be noticed that the machine is built in a circular form—hence its name. In the trade it is also designated the Noble's comb, after the inventor of this principle of combing.

When this machine is used the ribbons of prepared wool from the last gill-box are wound on bobbins in fours on a balling machine specially constructed for this purpose. These bobbins rest on the rollers A and B, fig. 18. The outside roller is made to impart motion to the bobbin, and give off the same length of ribbon to each revolution of the frame, or creel, in which they are fixed. Each of the four slivers on the bobbin is passed through a separate feed-box. All the boxes are of the same dimensions, and are so constructed that they are open on the outside of the machine, as seen in the engraving. Having the hinge at the back, they allow the lids to compress or nip the ribbons, thus preventing them from falling backwards. The part D is the dabbing brush. There are two in the machine, one on each side of the comb, and they rise and fall alternately, working at an immense speed. The circumference of the wheel, C, which is called the stroker, or divider, is covered with pointed teeth, which can be adjusted altogether as to length, with the greatest nicety. The machine is driven off the pulley P, keyed on to the centre of the horizontal shaft S. By means of bevel wheels motion is imparted to the two upright shafts inside the castings M, M^1. These shafts, in turn, by other wheel gearing, communicate motion to the various parts of the comb.

The interior of the machine, where the actual process of combing is effected, consists of three circular combs and a number of vertical drawing-off rollers. The large or main circle is from 48 to 60 inches diameter, and the small circles only from 16 to 20 inches in diameter. The three combs, which rest on a steam chest to heat the wool during combing, along with the creel, boxes, and bobbins, all revolve together, and in the same direction. The wool is combed by being stretched between the pins of the main and small combs. The latter only touch the large circle at one point, and that on opposite extremities

To face page 77.

f the comb. Each circle is studded with several sets of ne teeth, which increase in fineness of pitch from the uter to the inner set. The material is drawn into the nachine from the feeding boxes at the point where the arge and small combs come in contact with each other, nd is immediately pressed between the pins of each circle y the dabbing brush D. Both combs carry off a propor-ion of the wool received. As the angle between them ncreases, the fibres are gradually drawn out between the eeth of the respective circles. In the case of the main omb the wool forms a continuous fringe on the inner

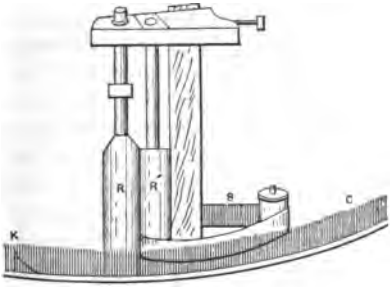


Fig. 18 A.

edge, but in the small comb it hangs on the outside edge. The divider, C, operates on the fibres at the juncture where they are drawn out between the pins of the two combs.

This part equalizes the lengths of the filaments by always dividing the wool stretched between the circles at the same point, and, also, by stroking the ends downwards, instead of allowing them to project straight out, facilitates the action of the drawing-off rollers. The material hanging on the inside of the large comb, along with the fibres on the outside of the small comb, go to form the top, while the short filaments remaining in the small circles are removed by steel blades or knives, and constitute the noil.

The order of the process will be described by referring to fig. 18 A. In this sketch a section of the large circle, with its accompanying pair of vertical drawing-off rollers R R′, are shown. The opposite side of the comb possesses a similar pair of rollers; but each of the small combs possess two pairs, one for removing the top and the other the noil. The action of rollers R R′ will first be considered. They are set in close contact with the comb, and draw off the fringe of fibres as it is formed between the teeth of the two circles. For instance, supposing the fibres have been pressed by the dabbing brush between the pins of both combs, then, as the circles revolve, they draw the fibres out of each other, stretching and straightening them at the same time. At this juncture the strap S guides the fibres between the rollers. Up to this point the wool projects from the comb, having been drawn out by the small circle, but after it has passed R R′, it is, on the inside, quite clean. The fibres which still remain between the teeth are lifted out by a number of knives, to be again fed on to the teeth of both circles. Thus, between each row of teeth the comb contains, there is a knife, K, which gradually tapers down to a point. As the circle C revolves, the knives lift the wool entirely out of the comb, when it is conveyed over a steel-plate on to the dabbing-brush, to be re-placed on the combs of the respective circles. By this arrangement the large circle is not only twice cleaned (once immediately before it reaches each dabbing-brush) every time it revolves, but a fresh supply of wool is fed into the machine. This is effected by the boxes travelling on an inclined plane, which causes them to be on a level with the top of the pins in the comb when passing the dabbing-brushes. The plate, on which the wool glides after being lifted out of the comb by the knives, is also fixed just before the dabbing-brush, so that the wool gliding over it is immediately pressed between the teeth of the circles, the respective movements of which draw the ribbons off the bobbins in the creel into the interior of the machine. The feeding-boxes, on passing the point of contact between the two circles, fall with the delivering end below the top of the comb, causing the fibres to be well embedded in the teeth during the removing of the combings by the drawing-off rollers.

On the combed material leaving the rollers R R′, it is conveyed to the brass tube S, which guides it between the rollers C C′, fig. 19. These are called the centre-vertical pressing rollers, and are situate in the centre of the large circle. The four combings, two from the large circle and one from each of the small circles, are passed between

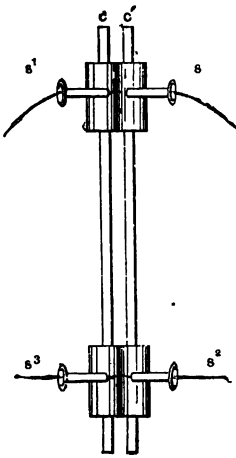


Fig. 19.

them. The part S is simply a brass tube or funnel, which, being made to revolve quickly, imparts sufficient twist into the combing to keep up a continuous supply of top, or combed wool, from the drawing-off rollers, R R′, fig. 18 A, and also from rollers C, fig. 20, of the small circles. The combings produced by the latter circles pass through S^2 and S^3 of fig. 19, and from thence between the centre-pressing rollers. The four combings are then, by these rollers, delivered as two, those from the smaller circles forming one, and those from the large circle a second. The ribbons thus obtained travel separately up to the brass oval hole seen in sketch 21, where they are combined and passed between a pair of smooth horizontal pressing rollers into the funnel, from which the ribbon drops into deep cans provided for the purpose. Should the can-coiler (see F, fig. 18) be employed, the centre pressing rollers are dispensed with, the separate combings passing through what is called the trumpet, simply a metal tube, in which they are collected together in the centre of the machine. The top from here is conducted to the can-coiler, an arrangement for giving a little false twist to the ribbon, and for coiling it into the can.

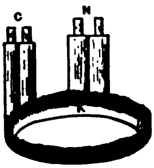


Fig. 20.

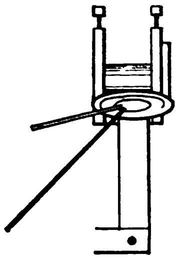


Fig. 21.

Having followed the process of top production, attention must now be given to the noil. This, as has been previously stated, is formed solely by the small circles. It is nothing but the fibre which the rollers C, fig. 20, fail to draw out of the teeth of the comb. Each time the circle passes these rollers all the short fibre it contains is lifted out by steel knives set between the rows of pins, and at once removed by the rollers N. Escaping from between these, the noil is conveyed by a spout out of the machine.

49. *Nip and Square Motion Combs.*—These are two very important machines. The "nip" is considered the best

comb extant for long lustre wools of a Lincoln, Leicester, or Romney Marsh character, while the square-motion machine is largely employed in combing fine Australian wools. Each machine will be briefly described. Commencing with the nip comb, it may be observed that it is built on an entirely different principle to the Noble. It is so called on account of the employment of two plates which close together or nip the material when drawing it out from the fallers of the machine. Strictly speaking, it consists of two distinct motions; for, in the first place, there is an ordinary screw gill-box, attached to which is the nip contrivance, and, in the second place, the circular comb. The former part of the machine resembles in its main features the gill-box previously described. In this case, however, the wool is pressed between the teeth of the fallers by the action of a dabbing brush. On the material being released by the last faller it is immediately taken in charge by the nip, which forcibly draws it through the gill-pins, stretching and combing the fibres all the while. The wool is now delivered to what is called the carrier comb, which simply conveys it, in conjunction with a second dabbing brush, on to the circular comb. The drawing-off rollers next operate upon the fibres by gathering the material off the revolving comb. Ultimately, the combing or top is transferred to the funnel, by which it is delivered from the machine. The short fibres, retained by the pins of the comb, are lifted out by knives set for that purpose, and deposited into a can or box. It will, perhaps, have been observed that in this machine the wool is subject to four separate combings. First, between the fallers and the nip; second, between the nip and the carrier comb; third, between the carrier and the circular comb; and fourth, between the latter comb and the drawing-off rollers. At the end of this route the fibres can scarcely fail to be arranged on one uniform system.

The *Holden or Square Motion Comb* ought also to be briefly sketched, as it is considered by some worsted yarn spinners as a very suitable machine for combing certain classes of wool. Here the material is carried to the main comb, which is constructed on the circular principle, in the shape of two thick ribbons, by a pair of feeding-rollers. These rollers have a peculiar come-and-go motion, swinging backwards and forwards, like the going-part of a loom. They almost touch the teeth of the comb, on which they distribute a portion of wool and then recede, drawing or combing the fibres out in the meantime. That which remains on the inner side of the comb constitutes the noil. As the feeding-rollers keep up a constant supply of material to the comb, a considerable proportion of the fibres hang loosely from the pins over its side or edge. In this condition they are carried round until they come in contact with the square motion, which simply consists of a set of some seven fallers constructed in an arc form to work within the convex of the comb. They have a very rapid motion, and are, consequently, very frequently introduced into the wool. Each one of them, on rising, carries off a portion of the fibrous fringe formed on the edge of the comb. Any noil they may contain is removed by a small comb, which is inserted between the pins as they are descending. A series of drawing-off rollers finally take charge of the combings, and conveys them from the machine.

There is still another machine that is deserving of notice, because it may be said to be a combination, to some extent, of both the circular and nip principles. It is a comb said to be well adapted for combing short wools; and will also comb wools with a staple of six or seven inches in length. Briefly speaking, it consists (*a*) of the circular comb about 3 feet 6 inches in diameter, and mounted with two rows of pins; (*b*) of the feeding head, situate inside the comb, and comprising screw-gill contrivance arranged for eight fallers up at one time, and nip cylinder, which contains six pairs of jaws; (*c*) of drawing-off rollers for circle, and stripper for noil; and (*d*) of coiling motion for delivering combed top in cans. The action of the machine is as follows: The gilled or prepared wool, in the form of three laps, is fed on to the fallers by a pair of rollers having an intermittent-motion. It is drawn by the jaws of the nip cylinder through the pins of the fallers, and deposited by it on the teeth of the circle. Such is the action of this cylinder that it places the wool on the comb with the *uncombed* ends behind the pins, while the *combed* wool hangs on the outer edge of the circle. The drawing-off rollers now come into action, and, by drawing the fibres through the pins, straighten the ends not combed between the nip cylinder and the fallers. The short fibre or noil remaining in the comb is removed by stripping-knives. On this system of combing the circle receives the wool with one end already combed (that hanging over its outer edge), so that there is less friction occasioned in drawing the wool out of the comb than if all the fibres were combed between its pins. Length of fibre is also by this means preserved, while the quantity of noil resulting from the process is reduced to a minimum.

50. *Scribbled and Combed Wools.*—The combed top, which forms the basis of the worsted thread, consists of a very different arrangement of fibres from the sheet or flat ribbon of scribbled wool. Fibres in the top are comparatively straight, curliness having been combed out of the wool, and the short crimpy filaments removed. In the scribbled condition the fibres retain their curly character, and occupy the very opposite to uniform or parallel relationship to each other. The top is, moreover, composed of the longest and straightest fibres contained in the wool, whereas the carded sliver is a combination of every species of filaments the stock possesses, whether curly or straight, short or long. In one particular, however, there is some resemblance between combed and carded wool, for in both conditions the fibres are so arranged as to be capable of readily being transformed into a weavable yarn.

51. *Drawing.*—The principle of drawing is simply this:

that of combining several ribbons, and extenuating them to such an extent as to produce a thick soft thread which, when twisted, will form a yarn capable of bearing the tension and friction of weaving. If a single ribbon of fibres from the combing machine were taken and drawn out without doubling, it would be liable to tear across, or at least form a defective thread irregular in thickness.

To prevent such an unsatisfactory result, several ribbons are drawn out together to a length equal to the sum of their combined lengths; that is to say, if six ribbons were drawn into one, a yard of such would be attenuated to six, and of course reduced to the same size as one. This system of equalizing and levelling the top also further adjusts the fibres, while the amount of doubling that takes place is alone sufficient to regulate any defects in individual slivers. Some six or nine machines are employed in this process, all built on a similar principle. Each machine possesses two pairs of rollers, travelling at different speeds, one pair receiving the ribbons and the other delivering them. Drafting or attenuation is in every machine effected on this system. The "ratch" or distance between the pairs of rollers is regulated according to the average length of the fibres in the wool, a slight reduction being made as the top progresses from one frame to another. It will be readily understood that if both sets of rollers revolved at the same speed, the ribbon would undergo but little modification in this operation; but if the "deliverers" turned twice as fast as the "receivers," the ribbons would, in traversing from one to the other, be doubled in length, the increase in the length or the amount of draft put into the ribbons being in the same ratio as the speeds of the respective rollers to each other. When six drawing machines are employed, the tops are doubled about 5,760 times; the order of doubling being as follows: six ribbons at the first and second frames, five at the third, four at the fourth and fifth, and two at the roving machine. Should, however, nine machines be used, as is generally the case in fine short wools of a Botany quality, then the roving produced results from combining, in the drawing operation alone, the enormous number of 288,000 tops. The order of doubling in a series of machines of this class is eight at the first frame; six at the second; five at the third, fourth, and fifth frames; four at the sixth; three at the seventh; two at the eighth; and two again at the roving frame.

While referring to doubling and drafting, it should be remarked that the tops or ribbons of fibres should never be attenuated twice the same way in succession. The reason for this is obvious—to prevent the formation of an uneven ribbon, and to equalize or distribute the tension put on the fibres in drawing as much as possible. It is easy to understand that a band of filaments will be more level and uniform throughout if attenuated from each end alternately than if drawn out from one end time after time. By adopting the former system of lengthening out, the opposite ends of the fibres have alternately to bear the strain of drawing, but on the latter principle the same ends have the tension mainly to sustain.

52. *Drawing Machines.*—There are two distinct classes of drawing-frames, English and French. The former may be subdivided into open and cone drawing machines. In English frames the arrangement of the rollers for drawing, as stated in the previous paragraph, is always the same, similar to what it is in the gill-box; but for wools that have only been carded, and neither combed nor gilled, fallers are not used. As the short fibre remains in ribbons prepared on this system, to pass the wool between a number of gill pins in drawing would impair the regularity of the ribbon, for as each faller dropped out of the material it would leave a series of short filaments extending across the sliver. Although all drawing-frames are alike so far as the arrangement of taking in and delivering rollers is concerned, yet they differ from each other in important details. For instance, the wool is delivered

from the first machine in the flat ribbon form and in cans, but in all the subsequent frames it is twisted into a soft slubbing and wound on to bobbins, the size of the latter, as well as that of the slubbing, decreasing as the material passes from frame to frame. Again, the first two machines are mounted with fallers, gills, and screws like the gill-box, but the remainder of the frames only possess two sets of rollers between which the slubbing is drafted. The only difference between open and cone drawing con-

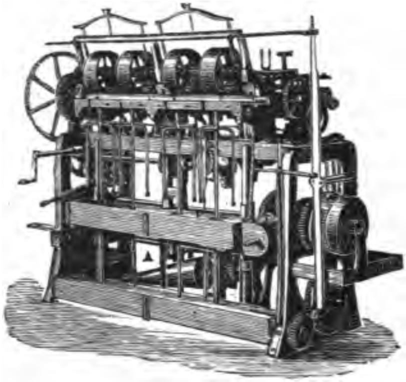


Fig. 22.

sists in the method of varying the speed of the bobbin as it gets larger in circumference by coil upon coil of soft thick thread being wound upon it. To explain the principle on which this is effected in open drawing, reference will be made to fig. 22 [kindly lent by the manufacturers, Messrs. Taylor, Wordsworth, and Co., Leeds]. This is a *cone* drawing machine, but as the flyer and spindle are the same in open frames, it will serve to illustrate the method of winding the drawn or elongated thread on to the bobbin in both systems. In all drawing machines the bobbins are loose on the spindle while the flyer is fixed on it. Round one arm of the flyer the thread is twisted, and then passed through a guide or twizzle on to the bobbin. The flyer, as it revolves with the spindle, drags the bobbin round; the more resistance the latter offers the motion of the flyer, the greater its speed. It follows, therefore, that the heavier the bobbin becomes (*i.e.*, the fuller of yarn), the less will be the difference between its speed and that of the flyer; thus the gradual increase in the weight of the bobbin as it fills with yarn, by increasing the *drag* between it and the flyer, causes its speed to accelerate as the slubbing is wound upon it. By this means the same length of slubbing is wrapped on the bobbin whether full or empty. Now it will be observed that on the variation of the *drag* on the slubbing depends, in open drawing, the speed of the bobbin. In cone drawing it is sought by mechanical arrangement to so vary the speed of the bobbin that the tension on the slubbing will always be uniform. The bobbin again runs loose on the spindle, but receives motion from the plate on which it rests, the latter being driven by wheel-gearing off two conical drums. One of these drums, A, is shown in the drawing. The base of the top cone is opposite the apex of the lower cone. By means of a strap the upper cylinder, which always revolves at the same speed, drives cone A. This strap travels from the base to the apex of the top drum during the filling of the bobbin. When the bobbin is empty, there is a 5-inch cylinder driving a 2-inch, but when full a 2-inch driving a 5-inch; so that the speed of the plate on which the bobbin is fixed gradually increases as the latter is filled with slubbing.

The principle of the French drawing frame is, in one particular, similar to the English, namely, there are two pairs of rollers for drawing out the ribbons. Thus the combined slivers in this machine pass between a pair of taking-in rollers, then over the porcupine roller (*i.e.*, a cylinder studded with fine pins), leaving which they pass on to the front rollers. These revolve somewhat quicker than the porcupine cylinder, so that the fibres are straightened and lengthened by being drawn between its teeth.

After leaving the front rollers the ribbon passes between a pair of rubbers, which, like those of the condenser in woollen carding, transform it, without adding twist, into a thick slubbing, or roving, when it is wound on to bobbins. The essential difference between English and French drawing is that while in the former twist is imparted into the slubbing, there is no twine added to the material in the latter till it reaches the spinning process.

53. *Roving.*—This is the last operation through which the slubbing passes before spinning. It may be defined as a combination of drawing and twisting, with an excess of *drawing*, while spinning is a combination of the same processes with an excess of *twisting*. In the roving box two of the thick slubbings from the preceding machine are combined and reduced in size, but increased in length, as in the drawing machines, the operation being the same with the exception of imparting more twine to the soft thread formed.

Before passing on to spinning, a word or two may be said on the respective nuclei of worsted and woollen yarns. The roving on the French principle of drawing resembles very closely the sliver of the woollen condenser, only the fibres are more parallel; but being minus twist it may be said to be a very similar thread. Between the roving resulting from the English drawing frames and the condensed sliver there is not this marked similarity. The roving having been twisted, may be again attenuated on the spinning frame before additional twine is imparted; the sliver, on the other hand, being devoid of twist, is so soft as to be incapable of sustaining drawing out until twine is added—the fibres in the condensed thread being simply balled or rubbed together. There is yet another important dissimilarity between them, namely, the fibres in the sliver in many instances lie transversely, while in the roving they are arranged longitudinally, or in the direction of the thread.

54. *Worsted Spinning.*—The spinning frame used in

worsted yarn manufacture differs very materially in construction from the mule. There is an important reason for this: It is not required to impart twist into the roving

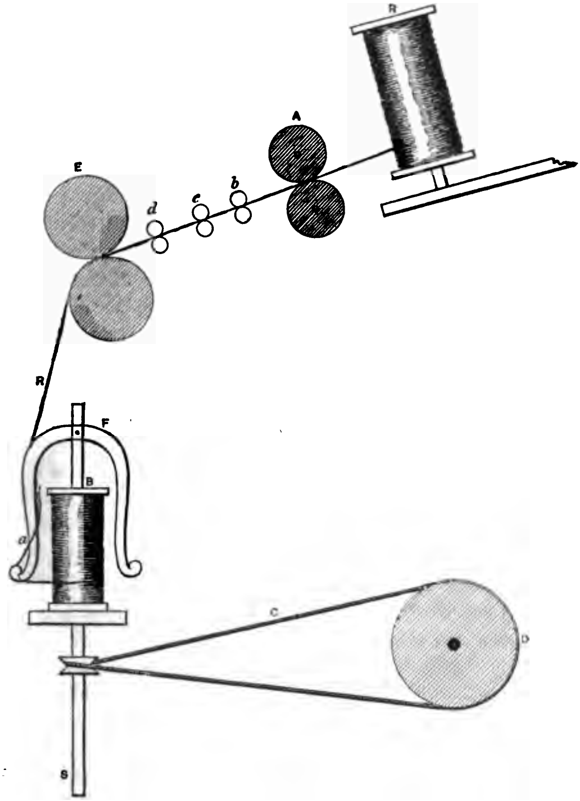


Fig. 23.

in the same manner as into the condensed sliver. As already pointed out, the roving contains a degree of twist, and may correctly be called a spun thread. In the worsted spinning frame, or throstle, the rollers are so arranged as to draw out the roving before any twist is furnished.

Worsted spinning machines are of three classes, flyer, cap, and ring. When the roving has been formed on the French principle it is spun on an ordinary mule, giving really four methods of spinning worsted yarns. Whether the flyer, cap, or ring principle of twisting the roving and winding the yarn on to the bobbin is adopted, the method of drawing out the roving is the same. Thus the roving bobbins having been fixed in the frame on pegs provided for that purpose, the ends are passed between rollers A, *b*, *c*, *d*, and E, fig. 23, and then conducted on to the bobbin. The drafting takes place between A and E, the distance between which, as in the roving frame, is called the "ratch," and varies according to the average length of the fibres in the sliver. The small rollers *b*, *c*, *d* are termed "carriers," and merely convey the roving to the front rollers E, the top one of which is styled the pressing roller, and is covered with leather, while the bottom roller is furrowed. The rovings no sooner escape these rollers than twist is quickly imparted to them as they pass on to the bobbin in the form of finely spun yarns. To drive the spindles (or tubes in cap spinning), a large cylinder, or drum D, similar to that in the carriage of the mule, runs from end to end of the machine. As the frames are generally constructed double, this cylinder gives motion to the spindles on both sides. Each spindle, or wharl, has its separate cord. In some machines a strap travels round two spindles on each side of the frame, and thus one belt drives four spindles. Where this system of driving is applied the cylinder slightly rises and falls with the bobbin, to keep the straps at one uniform tension throughout the ascending and descending traverse of the bobbin on the spindle.

When the flyer principle of spinning is adopted, which is the most suitable for low counts of yarns, the bobbin runs loosely on the spindle. The flyer, as shown in the drawing, gives motion to the bobbin. The amount of twist put into the yarn depends on the respective speeds of the bobbin and the flyer. If, for example, the latter makes sixty turns per minute, and the bobbin fifty, there will be ten wraps of yarn on the bobbin for sixty turns of the flyer, or six turns in each wrap of yarn on the bobbin. The flyer in reality serves a threefold purpose: first, it keeps the thread at one regular tension; second, it inserts the twist; and third, winds the yarn on to the bobbin. In fig. 23 the arrangement of the twisting and winding parts of the "fly" frame are given. Here D is the driving drum, C the spindle cord, S the spindle, B the bobbin, F the flyer, and R the roving. The spindle receives motion from the cylinder D, and imparts movement to the flyer which is screwed on to it. The bobbin is moved up and down on the spindle on what is called the lifter plate. By twisting the thread round the arm *a* of the flyer it is tensioned as it is wound on to the bobbin.

The principle of cap spinning is very different from that of the flyer. Here the spindle has no rotatory motion. A tube, or shell, which receives the bobbin is placed on it. The shell is mounted with a wharl, and receives motion off the driving-drum on the same principle as the spindle in the "fly" frame. Sketch 24 will give an idea of what this arrangement for spinning is like. The spindle, S, and cap, C, are the stationary parts. The latter is a hollow cup shaped like the bobbin. Its lower rim is perfectly smooth and polished, to occasion as little friction as possible on the thread as it rapidly whirls against it. Around the wharl, W, the driving cord or strap travels—this wharl gives motion to the tube and the latter to the bobbin. By an up-and-down motion being given to the bobbin by the spindle the yarn is regularly distributed on its circumference. For fine yarns cap spinning is better adapted than the "fly" principle, as there is scarcely any limit to the speed at which the bobbins may be made to run; but for lower qualities, there being nothing to protect the thread as it whirls through the air on the rim of the cap, it is not so suitable as the flyer, the yarns in this case being reduced in value by the friction they have to sustain. Low counts of yarns, made of coarse long wools, when produced on this system are liable to possess a wild, fibrous surface.

Next as to ring spinning. A drawing of the parts of the ring frame which effect the twisting and uniform

Fig. 24.

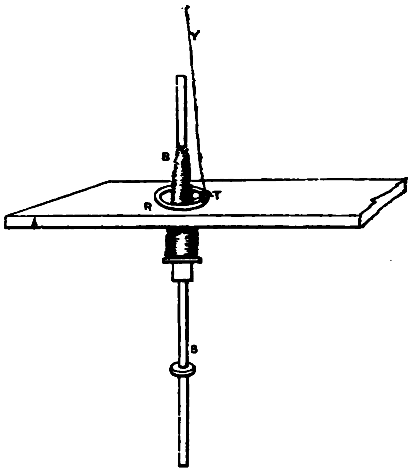


Fig. 25.

distribution of the yarn on the bobbin is given in fig. 25. Here B is the bobbin, R the ring, T the traveller, A the ring rail, S the spindle, and Y the yarn. The bobbin is fastened on to the spindle, and hence revolves along with it. The rail, A, constantly moves up and down during the winding of the yarn on to the bobbin. Winding and twisting are effected by B and the traveller, T. The latter, under which the yarn is passed on to the bobbin, revolves on the rim of the ring, R. In this case the bobbin gives motion to the traveller, which is just the opposite to the "fly" principle, where the flyer actuates the bobbin. The bobbin here twists the yarn while the traveller winds it on its circumference. As to the shape of the bobbin of spun yarn, it is regulated by the up-and-down motion of the rail, A. The ring frame, in worsted yarn production, is more largely used for doubling—that is, making twofold yarns—than for spinning. For this purpose it is admirably adapted—in fact, the same principle, so far as the ring and traveller are concerned, is adopted in twisting two or more woollen threads together. Cotton yarns are very largely spun on this system.

CHAPTER IV.

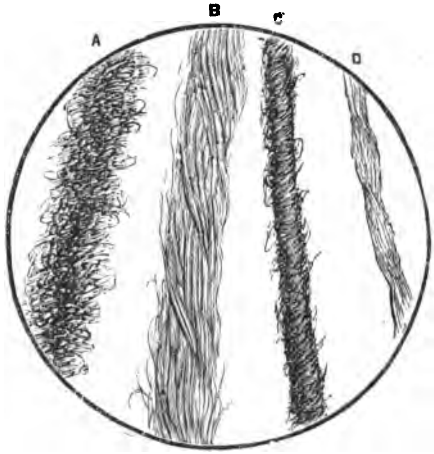
YARNS AND FANCY TWIST THREADS.

55. *Woollen, Worsted, and Cotton Yarns.*—The character and general appearance of a woven texture are formed, to a certain extent, by the mechanical structure of the thread used in its production. A good illustration of the effect different systems of making yarns have on the nature of woven fabrics is to be found in worsted and woollen goods; where, although both cloths may be manufactured from a similar class of wool, and dyed to the same shade, yet they are almost as distinct from one another in the finished state as if they had been produced from materials totally distinct from each other in physical properties. This difference in effect is entirely due, in some cases, to the structure of the yarns used in weaving. Woollen and worsted threads may be said to be as dissimilar from each other as possible in formation. Perhaps, all things considered, the former is the most characteristic and remarkable in construction; yet both, on account of their individual weaving characteristics, deserve close examination. An entangled arrangement of filaments forms the very basis of the woollen yarn, whereas in forming a worsted thread the aim is to lay, as far as practicable, the fibres in a uniform line with each other in the direction of the thread. As has been shown, teazing, scribbling, and

carding all tend to effect a complete separation and re-blending of the fibres in one common but confused order. Condensing simply consolidates the mixture produced in the previous operations, and transforms it into a series of threadlike slivers; while in the compound operation of spinning the meshlike condition of the fibres is not only increased, but, during the rapid convolutions of the slivers occasioned in twisting, more permanently and firmly secured. In producing worsted thread there is, as in woollen yarn manufacture, one simple object in view; but, while in the case of the so-called *woollen* or *carded* thread a perfect separation and re-adjustment of the fibres is required, irrespective of any particular order, or of the length and disposition of the individual filaments, in the *worsted*, from the entrance of the wool into the gill-boxes to the spun yarn, the fibres are not only arranged in one parallel form, but those that are too curly, too short, or otherwise unfit for the thread being produced, are cast out in the combing machine as noil. From this it is evident that these yarns differ very materially from each other in the principle of construction or build. The system on which a woollen thread is formed may be defined as that of separating and of re-crossing the fibres of the material, and finally of twisting the individual filaments firmly round one another when in a doubled or entangled state. Undoubtedly it will have been observed that the opposite principle of construction obtains in worsted yarn making; for, throughout the processes of its manufacture, the fibres of which it is composed are mechanically arranged according to one regular order of parallelism, producing by this method a more symmetrical thread than the pure woollen, where the fibres project from the main body, or central core, of the yarn on all points of its circumference.

Another remarkable feature in these yarns is the solid and compact centre or foundation of the woollen thread, and the large number of fibres of which it is composed as compared with the even and regularly formed, but somewhat open structure of the worsted thread. (See A and B, fig. 26.) No doubt this important difference in the character of these two representative types of all-wool yarns arises from the short or curly fibres being removed in the combing process when preparing wool for worsted; while, on the other hand, if the material is intended for woollen yarns every class of fibres contained in the stock is scribbled, condensed, and spun into one and the same

Fig. 26.



A = 30 skeins woollen yarn. C = 40's cotton.
B = 2-fold 30's worsted. D = 2-fold 60's silk.

This diagram is printed here by permission of the late Prof. John Beaumont, having been taken from his lecture on a "Lock or Fibre of Wool," which was published in the "Textile Recorder," Manchester.

thread. Microscopically, these yarns also differ very materially from each other in structure. When thus examined the woollen thread "resembles one continuous mesh of entangled fibres, tightly clustered together, especially in the heart of the thread, where they form one solid mass, which gradually decreases in density towards the edges. The worsted yarn appears comparatively more regular in construction, the multiplicity of the fibres not being so large, nor yet so compactly twined round each other; the object of the processes of manufacture in this instance being to use the strongest, straightest, and longest of the fibres, and also to arrange them, as far as possible, in parallel lines. As to cotton, it resembles in general appearance, when examined under the microscope, a solid cane; it possesses, however, a slightly undulated surface, while a few straggling filaments are distinguishable here and there on its circumference. In the silk yarn the individual fibres are so firmly grouped together that it scarcely seems to have been produced from a material of a fibrous character." [1]

56. *Lustre of the Worsted Thread.*—The superior lustre which the "worsted" is acknowledged to possess, when compared with a carded yarn, is probably due to two causes: in the first place, a parallel arrangement of fibres admits of a more powerful reflection of light than if crossed at every imaginable angle with one another as in the construction of a woollen thread; in the second place, the large variety of fibres that are scribbled together, in making woollen yarns, causes a high degree of twist to be necessary in order to reduce the size of the sliver and impart the required strength and elasticity to the spun yarn, which twist or twine, by forcing the fibres into the centre of the thread, naturally gives solidity and compactness, but at the same time detracts from the reflecting power of the individual fibres which help to form the yarn. Threads possessing such totally different characteristics as these two standard wool yarns cannot possibly be made into the same classes of goods, the structure of each asserting itself in the weaving process, and leaving its mark indelibly on the woven fabric. In order to thoroughly understand this subject, and also to point out the special woven effects for which each thread is suitable, the character

[1] Lecture on a "Lock or Fibre of Wool from the Bale to the Finished Cloth," by the late Professor John Beaumont.

and properties of a superfine doeskin may be contrasted with those of a fine worsted coating of a corkscrew pattern. The qualities of lustre, softness of handle, and fineness of texture are common to both these fabrics; but, however carefully the doeskin may be examined, if the pile or nap raised on the face is not removed, either by friction or singeing, the crossing of the threads will be found to be completely hidden from view, causing the cloth to appear more like the result of felting wool than of interlacing individual threads of warp and weft with each other.

On taking up the worsted cloth, although the crossing of the threads may not be followed without the aid of an analyzing glass, and perhaps not even then, yet it is clear to the casual examiner of the cloth that its leading feature is obtained by the mode of interlacing the threads. This leads to an important conclusion—namely, that the soft, pliable, and mellow condition, or rather structure, of a woollen thread make it capable of admitting of a different finish to that of the worsted, while the latter is most suitable for fabrics where the weave is intended to be a prominent feature of the pattern. The well-defined surface of such a thread fully develops the effect of the make or design in the woven goods, and hence the large variety of weave effects seen in worsted fabrics for both ladies' and gentlemen's wear.

57. *Two Methods of imparting Twine.*—All yarns used for weaving purposes, whether made on the woollen, worsted, or cotton systems, providing the material employed in their manufacture is of a fibrous character, and has to be submitted to the process of spinning before it assumes the form of a weavable thread, may be divided into two great classes—namely, *openband* and *crossband* twists. The origin of this classification obtains in the twisting process. Here, as a simple experiment will show, there are two distinct methods of imparting twist to the attenuated sliver of the condenser or roving of the roving machine. Suppose, for example, a number of wool fibres,

which had previously been reduced into a compact thread-like condition, were about to be twisted together by hand; in order to accomplish this, one end of the thick fibrous thread should be held in a fixed position between the fore-finger and thumb of the left hand, while the right hand would be engaged in imparting twist amongst the fibres, causing them to twine round each other from left to right, and forming, in so doing, what would be termed an open-band thread. A sketch of such a yarn is given in B, fig. 27, in which the direction of the twine is clearly indicated.

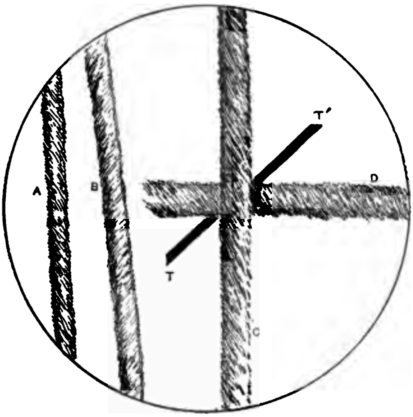


Fig. 27.

To produce the opposite kind of twine, that shown in A, called crossband, it would only be necessary to reverse the motions of the right hand, and thus cause the fibres during the imparting of twist into the sliver to revolve from right to left. In making this, or a similar experiment, the left hand corresponds to the wooden frame, which was, in Hargreave's machines, substituted for the hands of the spinner, or to the giving-off rollers of the spinning frame in present use; for these grip the thick thread while the spindles give the necessary twine, the direction in which the latter revolve, like the motions of the right hand, determining the character of the twist of the spun thread.

58. *Openband and Crossband Twists.*—As to the terms applied to these twists, "openband" and "crossband," they probably originated in the earlier days of cloth production, when the one-spindle spinning wheel was the most improved apparatus in use for preparing yarns for the loom. If the cord, which was wound round the wheel and wharl of the spindle in such a wheel, were crossed, it produced a *crossband* yarn, or, in other words, the fibres of the thread were twisted from right to left; but, if the cord were open, or merely wrapped round the wheel and the spindle without being crossed, the thread formed would be twisted from left to right, and received the name of *openband.*

59. *The Effect of Twine on Twills.*—Now the method adopted in furnishing twist to the thread materially alters its effect on the design in the woven fabric. This would scarcely appear possible on a casual examination of this subject, and but little importance might consequently be attached to the two varieties of twisting just described. It is remarkable, however, that if two fabrics were made of the same blend of materials, size, and colour of yarns, and also of the same make or plan of weave, this difference in the structure of the threads would be sufficient to produce two distinct classes of cloth, the strong individuality of the yarns, whether twisted to the right or to the left, giving character to the respective fabrics in the manufacture of which they have been employed. A difference of this kind in woven goods is possibly more perceptible in woollen and worsted fabrics than in any other kind of textiles, and, if anything, more distinctly marked in the use of woollen than in the use of worsted threads. This is probably due to the large number of fibres that compose a given length of a pure woollen thread, as compared with a similar length of worsted equivalent in size and thickness. The fibres of the material in woollen yarn, as previously indicated, are

forcibly twisted by the rapid revolutions of the spindles into certain permanent relationships with each other, and as unity in combination with numbers gives strength, the unique charactor of the twine in such a thread may be specially attributed to the multitude of fibres that are, to a very large extent, twisted together in the same sense or direction in the process of its construction. But yarns made on the worsted principle must not be regarded as lacking the characteristics of twine possessed by openband and crossband woollen threads. The mention of a worsted fabric, produced for dress goods, in which the pattern was solely obtained by the use of two kinds of twists in both warp and weft yarns, is a practical indication that here, as in woollen goods, effects may be got by a combination of threads twisted to the right and left respectively. The pattern referred to was a piece dyed brown, made entirely of a simple four-thread twill, hence the check figure distinctly seen on its surface in certain lights was due to causes outside the provinces of colour or weave. To the uninitiated it would certainly seem as though two shades of brown, one of a lustrous and the other of a non-lustrous character, had been used in its manufacture; but on analyzing the cloth and comparing the threads forming the respective parts of the check it was evident that they were exactly of the same size, material, and shade or colour. Now, when the weave and colours of the yarns are not the figuring agents of a woven fabric, there is but one other method of producing the pattern that can be consulted—viz., that of using two kinds of threads, the fibres in some of which are twisted to the right, and in others to the left hand. Such, in fact, was the method of producing the neat and stylish check of the fabric under consideration, the pattern being obtained by weaving twenty-four threads crossband, and eight threads openband, in both warp and weft. This is but one example of the nature of the so-called woven effects resulting from using yarns of opposite twists. Perhaps the special character of the effect each yarn has in the woven state will be better understood by referring to an illustration of a different stamp to that just considered, namely, what is known as an angled stripe.

In fig. 28 a sketch of a style of this class, or of a simple double-sided twill pattern, is furnished. It might be supposed that as the weave in both sections of this stripe is precisely the same, only moving in opposite directions, that it would be equally effective whether twilling to the right or to the left, in the woven product. Such, however, is not the case, for, on examining the separate stripes in the cloth, there is a marked difference between them, apparently arising from a variation in the crossing of the threads. In one stripe the twill of the weave is bold and clearly developed, but in the other it is indistinct, undecided in character, and wanting in fullness. Knowing, for a fact, that the respective stripes are composed of the same four-thread make (*i.e.*, of the same crossing or plan of intertexture), the cause of this difference in the character of the effect of the twill in sections A and B of this pattern will be readily understood. Of course it is not now the difference in effect of twilling to the right and left that has to be considered, but what is the cause of the weave in one part of the pattern possessing, in the woven fabric, a more perfectly defined character than in the other part, although the same classes of yarn are used in the formation of each stripe. Now it would be found that if the warp yarn used in weaving this design were crossband twist, the twill when moving to the right, as in section A, would be more fully developed than when moving to the left hand, as in B. This implies that if the twine in the yarn (which in this case, being crossband, is twisted from right to left) opposes the direction of the twill in the weave, the effect of the latter in the cloth will be well and clearly defined; while, on the contrary, if the twine in the yarn and the twill on the design move in one and the same direction, the character of the weave will be dull and undecided.

Accepting this conclusion, the cause of the difference seen in the effect of the weave in the two divisions of an angled stripe is quite apparent; for in one section of the pattern, as in A, fig. 28, the twill opposes the twine in the yarn, while in the other section, as in B of the same design, the direction in which the twill crosses the piece corresponds with the direction in which twine is imparted to the thread, and hence, in the cloth, one side of the pattern appears more prominently brought out than the other.

60. *Methods of applying Twine to Twilled Weaves.*—The following are the three methods of altering the effect of a twilled weave by a suitable application of open and cross-band twists:—

(1) If the twine of the fibres in the yarns opposes the

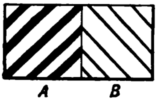


Fig. 28.

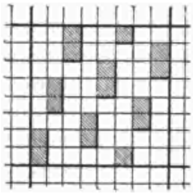


Fig. 29.

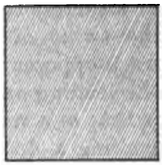


Fig. 29 A.

twill of the weave, the latter will be well defined in the woven texture.

(2) If the twine of the fibres in the yarns runs in the same direction as the twill in the cloth, the weave will possess a dulled, indefinite appearance.

(3) If the warp contains both classes of twists, arranged thread and thread alternately, the twine in the respective yarns will neither assist to develop, nor yet to detract from, the effect of the weave or design employed.

61. *Twine in Relation to Buckskins and Doeskins.*—Reasons have already been adduced in support of the two first inferences, but they may now be followed up with one or two practical illustrations. In making a buckskin cloth, for example, in which a clear decided twill is

essential, care should always be taken to cause the twisting of the fibres in the warp threads to cut the direction of the twill in the weave. The warp, and not the weft, is specified, because in such goods the warp contains those threads that appear by far in the largest proportion on the face of the cloth; the buckskin weave, fig. 29, giving what is termed a *warp* twill, or an effect similar to that seen in fig. 29*a*. The relation of the twine in the warp and weft threads to the twill in the weave in making such a fabric is shown in fig. 27. Here C is the warp thread twisted from right to left, D the weft thread twisted in the opposite direction, and $T T^1$ the twill running from left to right, or cutting the twine in the warp. This is what gives the definite and pronounced weave effect in buckskin cloths; for it necessarily follows that the deepest furrow or smartest twill will be obtained across the piece where the twine of the fibres in the individual threads of the warp opposes the crossing of the weave, and consequently the leading and characteristic feature of a buckskin cloth is that of a small, but bold and smartly defined twill. In making a doeskin fabric, however, where the object is to obtain a soft, smooth face, the fibres of the warp yarns are twined round each other in the same direction as the twill runs in the production of the cloth, thus preventing a clear, smart development of the structure of the weave.

62. *Arrangement of Yarns for Herring-bone Styles.*—The crossing in both parts of an angled design, or herring-bone, may be made equally decided in appearance in two ways: first, by arranging the yarns one thread crossband and one thread openband alternately; and, second, by arranging for the twine in the yarn to oppose the twill in both sections of the pattern. The former method would not develop the make, and hence is very seldom adopted. According to the latter method the warp yarns for a pattern similar to that shown in fig. 28 would be ordered as follows:—

8 threads of crossband yarn for section A.
8 „ openband „ „ B.

Such an arrangement of threads would cause the weave to be well pronounced in character in the respective stripes.

63. *Twisting.*—One important feature that should not be overlooked in connection with the subject of preparing yarns for weaving purposes is that of twisting two or more threads of different colours together; thus, an ordinary or plain twist thread simply implies that two yarns, such as black and scarlet, black and blue, black and olive, or black and white, have been twisted into one and the same thread. Yarns of this description play a prominent part in the formation of patterns applied to woven fabrics. They may be considered, in fact, as more or less applicable to every class of textile production, and are specially adapted to the broken, blended, all-over effects generally sought after in woollen goods. However, as the leading characteristics, in many of the designs in worsted coatings and trouserings, are smartness, clearness, and, withal, uniformity of effect, this class of yarns is not so largely applied to these goods as all-wool fabrics; self-coloured threads in several cases being considered more suitable; firstly, because they admit of more definite or decided development of the pattern, and, secondly, because they are of a less expensive character. What, apparently, has caused them, to some extent, to be discarded in worsteds has given them preference and preeminence in woollens. Here fancy twists are, without doubt, invaluable, as their extensive use in all classes of woollen fabrics plainly indicates. It should, however, be remarked that quite recently twist yarns have been largely used with very good results in making the better classes of worsted goods, some fabrics being composed entirely of "twists."

64. "*Selfs*" *and Twist Threads.*—Highly-coloured yarns,

such as scarlet, green, blue, and orange, would invariably be regarded as too loud in tone to be applied to the general run of fancy woollen coatings, trouserings, and suitings, unless previously twisted with other colours to assist in breaking the continuity, so to speak, of the coloured effect single yarns have on the woven cloth. No matter how sparingly such threads were interspersed in the warp and weft of the pattern, they would fail to amalgamate with other shades of a more sombre character. Instead, therefore, of imparting bloom and freshness to the whole blend, as intended, they would stand out prominently, and appear separate and distinct from the rest of the colourings, attracting the eye of the beholder, and preventing him from noticing the beauty or excellence of the general colouring of the pattern. From this it would appear that yellows, blues, and reds, or other colours equally as loud in tone, unless employed as twist threads, are comparatively useless in making patterns for woollen goods; for a good blend of colourings is one in which each shade appears to have its individual part to play in giving tone to the whole, and is not a combination in which some colours are so strong and effective in tone and hue as to prevent others from being noticed. The importance and advantage of employing twists in place of self-coloured yarns in such goods can be readily illustrated. Let it be required for instance, to make a small check pattern in which scarlet and blue are to be the fancy colours, the arrangement of threads in both warp and weft being as follows:—

1	thread of	Scarlet.
2	,,	Black.
3	,,	Olive-green.
1	,,	Blue.
2	,,	Black.
3	,,	Olive-green.

Single fancy yarns in such a combination in ordinary woollen goods would not produce a satisfactory check. The scarlet and blue threads would prove by far too powerful to give a soft, mellow, although lively contrast, which would naturally be looked for in such a style. Yet it is not the shades themselves that are out of harmony with one another; for when these highly-coloured threads, which are now destroying the harmony of the pattern, are twisted with black they impart a desirable tinge of freshness to the otherwise dull and heavy black-and-olive check which forms the ground of the design.

The cause of this difference in the effect of these two kinds of yarns (single and twisted) should next be considered. A twist thread, as it has been stated, is composed of two or more colours, such as russet and green, each shade alternating throughout the entire length of the thread. This is the feature in twist yarns which, by breaking the separate colours in the thread into fragmentary patches, as it were, detracts from the power it possesses to alter the tone of the pattern. Note, the original intensity of the colour does not suffer by changing the thread from a self to a twist, but that its purity is retained, only undergoing those modifications which are due to contrast, and placing two or several colours in juxtaposition. A feature of great moment, because it is frequently found in pattern making that it is not the colours themselves which are too strong in character to produce harmony of colouring, but that the flushes in the weave do not sufficiently break up the continuity of the effect of the fancy yarns. In other words, highly-coloured threads, if used in the single state, produce in the woven fabric lines of unbroken colours, excepting in those places where they are crossed by the weft yarns in weaving. This can be successfully obviated by using twist threads, for if in the style to which attention has just been called the blue and scarlet had been previously twisted separately with black threads, they would have had an intermittent instead of a continuous effect in the pattern; thus the blue thread would have been alternately black and blue and the scarlet thread alternately black and scarlet from the beginning to the end of the piece. This is one of the qualities which these yarns possess that may be said to make them of inestimable value in the production of woollen patterns. If limited to dark or sombre shades, as would necessarily be the case, in a large measure, in woollen fabrics, without the use of twist yarns, the styles seen in all wool goods would soon lack brightness and freshness of colouring. It is frequently necessary, in order to impart tone and smartness to the combination of shades forming a given pattern, to resort to such colours as scarlets, greens, &c., which, it has been pointed out would not enhance, but rather detract from the harmony of the colourings if employed in the shape of self-coloured threads; from which it may be concluded that twists are primarily of importance, on account of admitting with good results of the introduction into woollen and worsted goods, more especially the former, bright and highly-coloured fancy yarns. In some cloths both warp and weft, or at least those yarns which form the face of the fabric, are composed entirely of twist yarns, the effect produced resembling small patches of colour interspersed irregularly over the surface of the cloth: a type of pattern which cannot be so effectively produced with single threads. There are also certain classes of worsted goods in which twists may be advantageously employed. When fancy-coloured worsted coatings were first introduced into the market about the year 1870, the neat, but simple, check patterns then in vogue were obtained by employing fine worsted twists in both warp and weft. Some of the best styles seen in these goods since that date have been figured on a similar principle, the yarns in modern productions being fancy twists composed of worsted and silk threads, thus proving that twists, when judiciously applied, give good results in both worsted and woollen textures.

65. *Difference in Effect of Twists and Selfs.*—To further illustrate the special characteristics of patterns formed of twist yarns, attention may be called to two fabrics: one made, say, entirely of black and white twists (such as A, fig. 30), and the other of similar shades, but of single threads. In order to produce as striking a contrast between the effect of these two descriptions of threads as possible, in making the latter cloth two ends of warp—

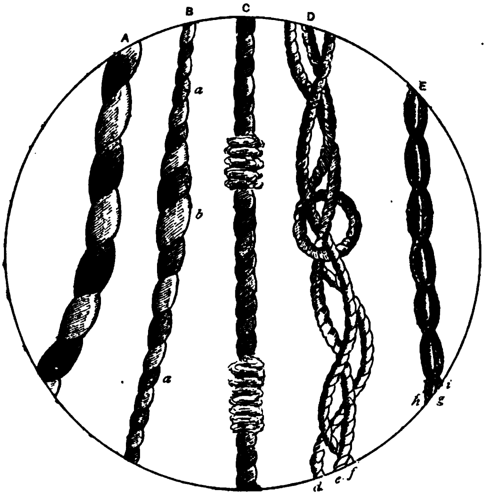


Fig. 30.

black and white respectively—should be drawn through the same heald, or, in other words, be elevated and depressed together as though they formed one simple thread, thus making the movements of the two yarns equivalent to that of one compound or twist thread, which they should, when thus combined, also equal in size or thickness.

A black thread and a white thread should be wound together on to the weft bobbin, and then woven as one simple yarn, which, in combination with the arrangement of yarns to be adopted in the warp, would afford every facility for making the pattern resemble that produced by twist yarns. But what is the result? The mixture or blend of black and white is proportionately balanced, and equally effective in both cloths; but this is the only particular in which they can be said to approach each other either in style or general appearance. In other respects they are as different from each other as goods made of totally opposite shades. For, while the effect in the pattern made of self threads may be described as consisting of lines of black and white, of irregular lengths, running longitudinally and transversely in the cloth, the surface of the twist fabric is completely covered with a beautiful blend of indefinite patches of black and white, the broad or small effect of which varies according to the amount of twine imparted to the yarns in the twisting operation. A second advantage which these threads possess over those designated as selfs may therefore be defined as that of producing a more complete intermingling of colours.

66. *Threefold Twists.*—Thus far, twist yarns made of two colours have only been considered. Threefold fancy twists may now be briefly described. These are simply composed of three separate shades, and sometimes of different materials, as a black (worsted), russet (worsted), and green (silk) twist, or a black (worsted), blue (worsted), and gold (silk) twist. Woollen twists are sometimes threefold. Some very stylish threads are producible by such combinations, but, on account of their cost, are only sparingly used, more, in fact, for imparting character to the general appearance of the pattern than anything else.

67. *Cloud, Knopped, Curled, and Diamond Twists.*—Cloud yarns are generally made of wool, or of a combination of wool and silk, but they have also been produced in limited quantities in cotton. The construction of this thread may

be better described by referring the reader to B, fig. 30. A remarkable feature that will at once be noticed is the unevenness in its thickness or circumference. This irregularity in size is probably the main cause why yarns of this description are not so generally and permanently fashionable in woollen and worsted fabrics as ordinary or simple twists. The alternate variations in thickness is obtained by an intermittent motion being applied to one pair of the delivering rollers of the twisting frame, the thick thread, or in some cases the condensed sliver, being given off in this manner, while the small thread is delivered quite uniformly, and hence the irregularity seen in the turns per inch in these yarns. In the smallest part of a medium-sized cloud yarn, corresponding to *a*, fig. 30, there may be from fifteen to twenty turns in the inch, but in the thickest part, corresponding to *b*, only about three to five turns on the inch. Some very good intermingled colourings have appeared in cloths made of these yarns. Thus, if a warp were made of cloud twists and woven in a simple twill with one colour of weft, the pattern would consist of elongated patches or spangles of colour running lengthways of the cloth ; but if the same warp were afterwards woven with cloud twists, similar patches of colour would be produced by the weft yarn across the piece, forming an irregular check pattern.

The knopped twist, C, fig. 30, is in one sense more irregular in structure than the cloud. In such a yarn complete knops, or buttons, are formed at uniform distances apart on the circumference of the thread. It is used in the production of fancy woollens, shawls, and other goods. The pattern, in the making of which threads of this character are employed, is figured with small knops of colour, giving, in some cases, a novel appearance to the design.

The curled or looped yarn, D, fig. 30, may be a twist of either two or three colours, for it is composed of three separate threads, *d*, *e*, and *f*. The curl, from which characteristic the yarn receives its name, is the result of twisting thread *e* round threads *d* and *f*. There is a mechanical contrivance in the twisting frame which at regular intervals forms the curl as the twist is being introduced into the combined thread. Recently this class of yarn has been used to a considerable extent in fancy woollen coatings and suitings; the cloth, however, made of curled twists has not a desirable handle, although it possesses a certain freshness of character due to the loops of colour which form the leading features of the pattern.

The diamond or chain twist, E, fig. 30, is also a combination of three distinct threads, namely, of the centre or ground thread *g*, and of those which form the chain or diamond, *h* and *i*, which may either be of the same or of different colours, while sometimes a silk thread is employed, resulting in the formation of a good useful yarn.

CHAPTER V.

LOOM-MOUNTING, OR PREPARATION OF THE YARNS FOR THE LOOM.

68. Meaning of the Term "Loom-mounting"—69. Warping—70. Woof and Creel—71. Leasing—72. How to Reckon the Number of Threads Warped—73. Warping on the Mill—74. Sectional Warping Machines—75. Warping, Sizing, and Drying Machines—76. Fancy Warping on the Sectional System—77. Sizing—78. Beaming—79. Raddling—80. Healding or Drawing-in—81. Irregular Healding Drafts—82. Sleying or Reeding—83. Reeds.

68. *Meaning of the Term "Loom-mounting."*—The general term of "loom-mounting" includes all operations through which the yarn passes from the spinning frame to the loom. Such operations are practically the same in the manufacture of all classes of textile fabrics. They may be enumerated as follows:—Warping, sizing, beaming, healding, and sleying. A thorough knowledge of these processes is both useful and necessary to the textile designer. Not that it is absolutely essential that he should be a competent warper, sizer, beamer, or healder, no more than a practical loom-turner, but that he should so thoroughly understand this preliminary work as to be in a position to say *what can and what can not be done.* Then, again, this subject of loom-mounting forms, on account of these processes preceding in actual work the operation of weaving, not only a suitable, but a necessary introduction to a theoretical analysis of the art of cloth fabrication. In a word, to give an explicit explanation on the principles of weaving it is important that something should be said relative to the operations intervening spinning and weaving, and hence they will be fully described in this chapter.

69. *Warping.*—This is the first operation through which

the yarn passes *en route* to the loom. It consists in collecting into one body, and of reducing to one uniform length, those threads which are intended to be stretched longitudinally in the cloth. If the pattern about to be produced is composed of various colours and sizes of yarns, warping then also implies arranging the fancy threads after a given order, and in such a manner that this order

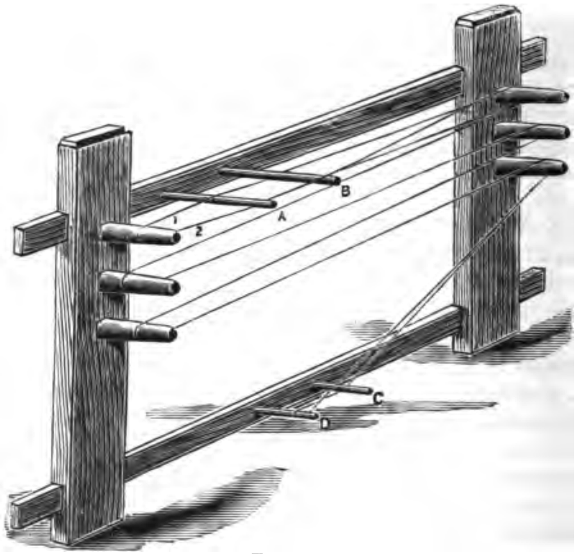


Fig. 31.

will be preserved to a thread throughout all the subsequent operations of manufacture. This important work may be accomplished either on the warping-woof or on the warping-mill—two machines which differ very widely from each other in construction. The mill may be used either automatically or otherwise, but the woof is confined to hand manipulation. In making warps for pattern ranges, the latter is, perhaps, the most preferable machine, because of the convenient manner in which changes may be effected on it, while sometimes the woof is also employed in preparing fancy woollen and worsted warps for piece lengths. Warping on the woof will be treated of first on account of its being the oldest and simplest method of preparing yarns for the loom. As, strictly speaking, warping, on this system, is a manual operation, the principles of forming the chain may be more clearly described as performed on the woof than either on the mill, or on any of the patent sectional warping machines so largely employed in the manufacture of some classes of goods.

70. *Woof and Creel.*—The woof, fig. 31, is made either of wood or iron, and stands on two upright posts, each of which is mounted with a series of pegs or pins over which the threads are passed during the production of the warp. These upright posts are connected at the top and bottom by two rails, from which project the *healding lease* pins, A and B, and the *footing lease* pins, C and D. Before the threads intended to constitute the warp can be transferred in a regular order on to the woof, they are previously arranged in the creel (fig. 32), a frame specially built to contain the cops or bobbins of yarn, and a necessary apparatus in any system of warping. Creels vary in size and construction, but those in general use in hand warping are similar to the one shown in the drawing.

In the part lettered A the cops or bobbins are arranged according to the plan indicated in the *pattern of warp*. If, for example, it were required to make a warp in which the yarns were arranged in the following order:—

4 ends of black
2 „ mid grey
2 „ black
2 „ white

then the first thread of black would be placed in the first hole of the back row B, the second thread in the first hole of the front row C, the third thread in the second hole of the back row B, the fourth thread in the second hole of the front row C, and so on to the end of the pattern. This arrangement of threads is clearly shown in fig. 32.

71. *Leasing.*—Having mounted the creel with cops or

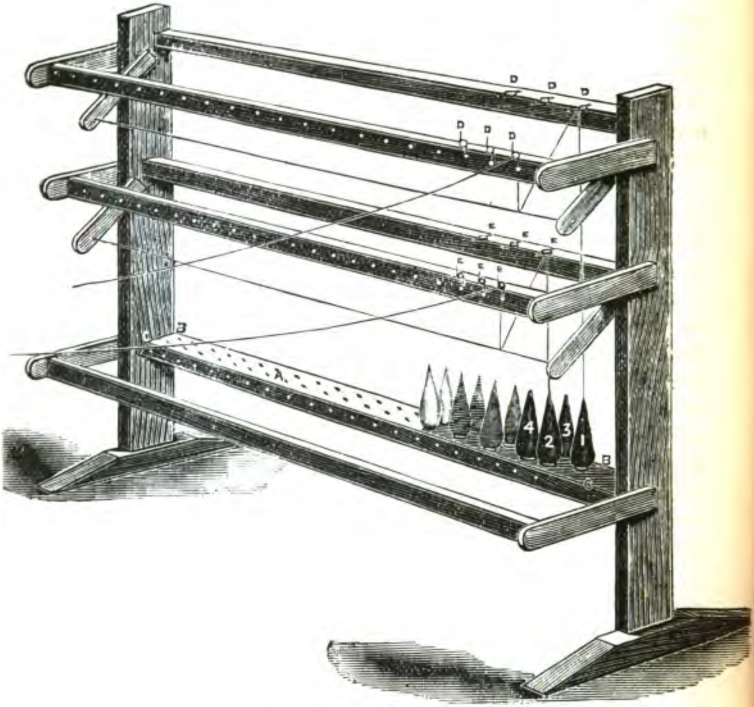


Fig. 32.

bobbins of yarn, the warper proceeds to enter the threads from the back series of cops through the eyelets lettered D, and the threads from the front series of cops through the eyelets lettered E, thus forming an important distinction between the two series of threads. In commencing to transfer the yarns on to the woof, it is necessary to form what is termed the "lease" by crossing the alternate threads with each other between the lease pins of the woof, A and B, fig. 31. This crossing is of the utmost importance, because the immutability of position each thread is supposed to possess in the warp depends on this work being perfectly carried out; when any of the threads pass over the lease pins in pairs they produce what are technically called "flats" or "sisters," and make it impossible to ascertain by an examination of the warp, which thread ought to be first in order in the woven cloth.

The manner in which the lease is obtained may be explained by referring the reader to fig. 31. Here it will be observed that while thread No. 1 is carried over pin A and under pin B, the route taken by thread No. 2 is just the reverse; that is to say, it moves under A and over B, and thus a perfect crossing is produced between the even and odd threads, which cannot fail, so long as the lease is kept secure, to prevent each thread from leaving the place assigned to it in the pattern of warp. Of course the length of the chain or warp may be varied according to the number of times the yarns cross the woof. When the required length has been obtained the "footing" is formed on pins C and D, at the base of the woof. This is simply a lease on an enlarged scale, the threads forming crossings in groups of 4's, 6's, 8's, 12's, or 16's, and not in singles, as in the lease proper.

72. *How to Reckon the Number of Threads Warped.*—By counting the crossings or "rounds" at the footing end of the chain the warper can readily ascertain when a sufficient number of threads has been warped; a "round" including both a downward and upward movement of the yarns on the woof, and hence twice as many ends as there are bobbins in the creel. Before a warp can be completed, however, it is necessary to calculate the number of threads it will be required to contain. This may be accomplished by taking the number of threads per inch in the fabric

intended to be woven and multiplying by its width in inches in the loom. It has just been stated that in order to ascertain the number of threads passed on to the woof the warper examines the footing and not the least end of the warp. He does this for obvious reasons—firstly, because it is, comparatively, an easy task to count the rounds; and, secondly, because the number of rounds, and not the number of threads or ends, are generally given on the warper's ticket. Suppose, for example, a warp or chain is about to be made for a cloth containing 64 threads on the inch, and set 66 inches wide in the loom, and that the creel is suplied with 48 cops or bobbins, then

$$\frac{\text{64 threads per inch} \times \text{66 inch width of cloth in loom}}{\text{96 twice the number of cops in creel.}}$$

$= 44$, the number of rounds in the warp.

The warp or chain being now completed, it is only necessary to secure the healding and the footing leases by interlacing cords through the openings between the yarns on the pins A and B, and C and D respectively; when this has been safely effected the warp is removed off the bar-trees and is ready for the sizing bath.

73. *Warping on the Mill.*—Warping, as performed on the woof, having been described in detail, possibly it will only be needful to give a brief sketch of the mill machine, which, as has already been stated, resembles a huge vertical reel, varying in height and diameter. The bobbin creel attached to this machine differs very considerably in construction from that employed when warping on the woof; thus the bobbins are arranged in horizontal tiers so that the creel admits of a large number of bobbins being set in at one time, which may be considered an advantage, as the larger the number of threads used in warping the more expeditiously can the warp be completed. About five or six feet from the creel stands an upright frame mounted with an apparatus for forming the lease. This apparatus bears the name of "*heck-box,*" and consists of a

series of well-polished and hard-tempered vertical pins, fixed in a wooden frame in such a way that half of the pins, taking every other, may be raised alternately. Now each pin possesses a small eyelet through which the threads pass from the bobbins in the creel on to the mill, hence if half of the wires were elevated, taking every other, 1, 3, 5, etc., the odd threads would be lifted, which forms an alternate crossing of the yarns or one division of the lease; the opposite crossing is obtained by raising the wires 2, 4, 6, etc., which elevates the even threads, and thus completes the formation of the lease. The yarns are now transferred on to the lease pins fixed in the lower part of the machine, and the mill set in motion. As it revolves from right to left the leasing appliance or heck-box gradually rises, distributing the warp on the arms of the machine until it arrives at full height, when the mill is stopped and the threads divided into groups of what are called porties, that is, into 19's or 20's, and carried in this form on to the footing pins. After this has been done the machine is again set in motion, this time revolving, however, from left to right, and the heck-box gradually descending to its normal position, where another healding lease is taken, and the operation of winding the warp yarns on to the mill repeated to the end of the chain. The warps are invariably calculated by the porty, which contains in some districts 38 and in others 40 threads. The latter number is the most suitable, and ought, in order to simplify the working of subsequent calculations, to be invariably adopted. The mill, which was formerly used in the production of warps in the fancy vesting trade, is now the principal machine employed in making worsted, silk, and cotton warps.

74. *Sectional Warping Machines.*—These machines are so called on account of the warps being made in sections or cheeses of about 4½ inches in width. The principal difference between this and the two previous systems of warping consists in the warp being run through a coarse

sley on to a miniature beam during its production. By this means the threads are maintained at an uniform tension throughout the making of the warp. On the mill and the woof slack or loose ends are almost unavoidable, but, in sectional warping machines, by passing the yarns through a sley or reed as they are wound on to the cheese, such defects are largely prevented. A sketch of a warping machine constructed on this principle is given in fig. 33. The principal parts are C, the creel; H, the heck-box; S, the sley; and B, the sectional beam or cheese. To arrange the yarns in the creel the warper commences by placing the first thread of the pattern in the top row, and takes the rows or tiers in succession until he reaches the base of the frame. No sooner are the threads mounted in the creel than they are passed separately through the holes in the pins of the heck-box and between the reeds of the sley. (See sketch.) Here, by sleying or running four or six ends in one split or dent, the warp is brought within a compass corresponding with the width of the cheese. The lease is formed in the heck-box at the commencement of each section. This done, all the attendant has to do is to keep the creel well supplied with bobbins, the yarns after leasing being drawn through the sley in regular order, and wound on to the sectional beam by the automatic movements of the machine. A number of cheeses are now combined on what is called the block or shaft, to form the entire warp.

75. *Warping, Sizing, and Drying Machines*—This class of machine is also constructed on what is called the sectional principle. For the production of plain woollen and worsted warps it is admirably adapted, and has completely superseded the hand woof or bar-trees. In such machines, as in the old system of warping, the yarns have, in the first place, to be arranged, according to pattern, in the creel. Each thread is then passed through a coarse sley; this keeps the threads at equi-distances apart, and also brings them into a smaller compass, preparing the yarns

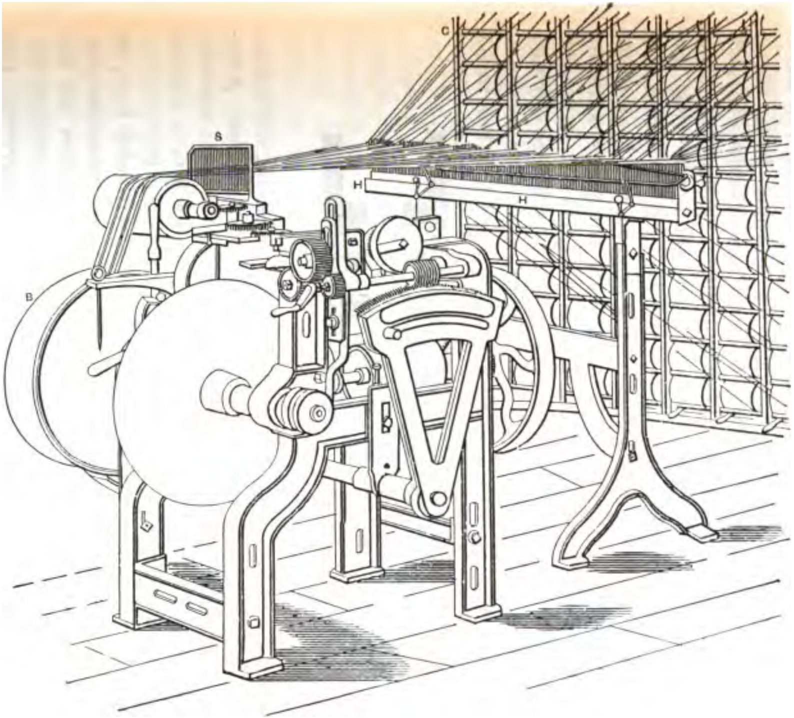


Fig. 33.

for entering the sizing bath, which is placed immediately behind the sley. Passing from thence between a pair of brass pressing rollers, the sizing solution is pressed out of the thread and returns into the trough. When the warp is composed of woollen yarns, on escaping from these rollers it is passed directly over a large cylinder charged with steam, and also a smaller cylinder (called the angle roller, on account of it being set at an angle with the cylinder containing the steam); whilst in this position the warp is subject to a rapid drying process, the heat from the cylinder absorbing the dampness the yarns contain. But if the warp is made of worsted thread it is passed over an additional series of small rollers before drying. The reason for this is the size requires more time to penetrate worsted than woollen yarn, and hence this has to be

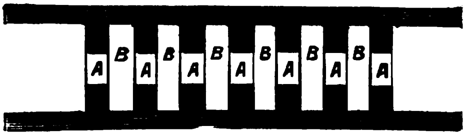


Fig. 34.

arranged for in the mechanism of the machine, otherwise the process would not be satisfactorily accomplished. After drying, every string or 10 feet of the warp is automatically marked, when the yarns are carried forward to a second sley in which the lease is formed. One peculiarity about this sley is that every other split is partly solid both at the top and the bottom, as shown in fig. 34, consequently, when the attendant by means of a rod presses all the threads down, those in the spaces lettered A remain up, while those in the spaces lettered B are depressed; this gives the first crossing of the lease. The second crossing is secured by lifting the threads, which gives the opposite result—viz., the threads in spaces A below and those in spaces B above. The lease having been completed, the section of the warp now made is wound evenly, as it passes through the sley, on to the cheese or miniature beam. The cheeses are collected together when the proper number has been warped and placed on a strong iron shaft, from whence they are run on to the loom beam. The advantages of this system of preparing the yarns for the loom over that of warping on the mill or woof, sizing in a trough or bowl, and drying on the balloon, are very evident. Three processes are here enacted at one time, while, if anything, sizing and drying are better and more regularly effected than on the old system of treating the processes separately.

76. *Fancy Warping on the Sectional System.*—Sectional warping machines are not, all points considered, as well adapted to the making of extreme fancy as simple or plain warps. When the number of threads in each repeat or pattern is not a multiple of the number of threads the cheese is, according to the "set" or number of ends in the warp on the inch, calculated to contain, some complication is liable to ensue. The standard width of the cheese in machines for medium goods is, as already stated, $4\frac{1}{2}$ inches, but in those constructed for coarser yarns, as in the blanket trade, the width is 9 inches. Each sectional or miniature beam must contain the same number of threads, and, if possible, a complete and not a fractional number of patterns. Warps in which a whole number of patterns cannot practically be applied to each cheese occasionally incur a loss of time in resetting the creel. An uneven beam, and ultimately, an irregular texture, results from some cheeses receiving more threads than others. Possibly, in heavy woollen goods, a few extra threads on some sections to give the required total in the warp may not make any perceptible difference to the regularity of the fabric; but in fine cloths, as in worsted coatings, the utmost uniformity in the beam should be aimed at, so that two points are evident: (*a*) that each cheese ought, if practicable, to receive a complete number of patterns, and (*b*) that the same number of patterns ought to be warped on each section.

Bearing these points in mind, the method of dealing with complicated patterns on these machines may now be considered. Let it be supposed that a given pattern of warp contains 104 ends, and that the fabric is intended to have 96 threads on the inch, and is to be set 66 inches wide in the loom. The warp would thus contain 6336 ends. The first work would consist in ascertaining the number of patterns in the entire warp; thus 6336, divided by 104, the number of threads in a pattern, equals 60 patterns or repeats, and 96 threads over. To find the requisite number of cheeses, divide the width of the warp in the loom (66 inches) by the width of the cheese ($4\frac{1}{2}$ inches). In this case 14 would be the number. Next ascertain the number of patterns to be warped on each section by dividing the total repeats in the warp by the number of cheeses, as 60 repeats divided by 14 cheeses, equals 4 patterns to each cheese and 4 patterns remaining; showing, that if this number of cheeses were employed, the warp would be 4 patterns, or 416 ends (not including the 96 threads, or fraction of a pattern) to narrow in the loom. This would imply that the warp would be 63 inches wide in the beam, but only 61 in the sley instead of 66. The question is, how may such a reduction in the breadth of the warp be avoided? or how may the missing ends be added to the warp? Fourteen cheeses, each containing 4 patterns, give (that is, $14 \times 4\frac{1}{2}$) 63 inches of warp on the loom beam, so that if an additional cheese were employed it would only cause the warp to occupy 67 instead of 66 inches on the beam, and yet provide space for the 416 threads required. Fifteen cheeses would contain 60 patterns, or all the threads of the warp, with the exception of 96 ends. These, unless absolutely necessary, would not be warped, as they would necessitate either the employment of another cheese, or overcrowding some cheeses with yarns. Take a second example. In this case the pattern contains 23 threads; there are 48 ends on the inch, and the fabric is calculated to be set 36 inches wide in the loom. First find the number of patterns in the warp; thus, 48 threads on the inch, multiplied by 36 inches, width of the cloth in the reed, would give 1,728 ends in the warp. Divide this number by 23, the number of threads in the pattern given, and the result is 75 patterns. The requisite number of cheeses is obtained by dividing 36 by $4\frac{1}{2}$, giving 8. Next divide the total number of patterns, 75, by the number of cheeses, which gives the number of repeats to be warped on each cheese, namely, 9. Nine cheeses, would, however only contain 72 patterns (9 patterns $\times$ 8 cheeses $=$ 72 patterns) or $34\frac{1}{2}$ inches of cloth. By making use of seven cheeses, and mounting each with eleven patterns, the warp, although containing two repeats too many, would be $4\frac{1}{2}$ inches narrower on the cheeses than required to be in the healds; so that it would, in fine goods, probably be necessary to raddle it out to the full width in running it on to the loom beam, and, at the same time, remove the excess of threads.

From these examples it will be evident that the method of calculating the number of cheeses and patterns for each cheese on sectional warping machines is as follows:—First, ascertain how many patterns are required to give the proper width of warp; second, divide the total number of patterns by the number of cheeses nearest the required width on the beam. If such a number, when complete patterns are applied to each section, will not admit of the whole warp, then fewer or more cheeses, and a larger or smaller number of patterns are adopted as required. In the first example given the cheeses were increased, but in the latter they were reduced, and an extra pattern placed on each. It will generally be found that by a little contriving of this description that the warping of the most irregular patterns on these machines is feasible.

77. *Sizing.*—The mechanical structure of worsted, woollen, or cotton yarns necessitates the application of some glutinous substance to their surfaces before subjecting

them to the weaving process, the object being to cause the individual fibres which compose the threads to cling more tenaciously together. Although a high degree of evenness and regularity of structure may be attained in worsted yarn manufacture, yet, when microscopically examined, a large proportion of the fibres appear to hang loosely on the outside of the thread. An illustration of this is given in thread A, fig. 35, which is a two-fold hundred's worsted

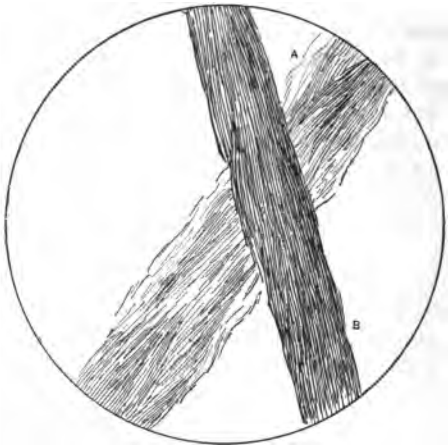


Fig. 35.

yarn previous to sizing, while thread B is taken from the same hank, but has been passed through the sizing bath. There is a very noticeable difference in the appearance of these yarns. In A the fibres seem to be but loosely attached to each other, and hence if tension were applied to the thread those fibres that form the body or centre of the yarn would have it principally to sustain, but in B, in consequence of the fibres having been more firmly united to one another, the strain when applied is more equally received, from which it may be inferred that a sized yarn will weave better, and is capable of sustaining more friction and tension, than one that has not been sized. A good size is of considerable importance in the manufacture of worsted and woollen fabrics whenever the warps are made of small, tender, or long-fibred threads. For, as has just been shown, sizing tends to give solidity, smoothness, and compactness to the individual yarns, and by fastening the somewhat loose and straggling fibres that cover the surface of the thread together, or rather by binding them to the body of the yarn, it increases the weaving properties of the warp, more or less preparing it for the tension, friction, and wear and tear it must necessarily undergo on its way to the woven fabric, and especially when passing through the healds and sley during the process of weaving.

One of the simplest, and, at the same time, most primitive methods of hand-sizing consists in immersing the warp in a large trough or tub containing the sizing solution, care being exercised in distributing the size as equally as possible over every portion of the warp; in fact, it is advisable that it should be thoroughly saturated in order to give the solution time to act on each thread of the warp. The size is afterwards squeezed out by wringing the warp or chain in the hand, which is finally exposed to the atmosphere in some convenient place where it can be well stretched and frequently opened by running the raddle from one end to the other to prevent the threads from fastening or becoming matted through the action of the size. If the sizing solution is too strong or not well pressed out, the threads are almost certain to glue to each other, and when this happens serious trouble is sure to ensue after the warp has been mounted in the loom. In weaving each thread has to pass through a separate mail in the healds, and it will be obvious that if half-a-dozen or more are stuck fast together, before this single passage can be effected some breaking and repairing of threads must necessarily occur, showing the importance, whether sizing by hand or by machinery, of guarding against over or irregular sizing.

The sizing trough in common use is very simple in construction. The warp enters at one end and passes through the size on to the pressure rollers, which free it of the solution it may have absorbed in the trough. It is now raddled and wound on to the arms of the balloon, a huge cylindrical frame revolving on its axis, and generally partitioned off from other machinery and surrounded with steam pipes, the heat arising from which speedily dries the warp. Sometimes the warps are beamed direct from the balloon, but at others they are rolled up into a large ball, to be passed on to the beaming frame. Very fine worsted and cotton warps are frequently sized or dressed in a very different manner from the methods already described. The warps in this case are first beamed and sleyed, and then wound off the beam of the beaming frame on to the beam of the loom. The beamer, having stretched a portion of the warp across the frame, takes the size, which in this instance consists of fine flour paste, and spreads it as evenly as possible over the warp yarns with a pair of hand-brushes. A fan is then employed to accelerate drying, which has no sooner been accomplished than the length of warp thus sized is wound on to the loom beam, so that in reality sizing, drying, and beaming are carried on at the same time.

78. *Beaming.*—There are but few indications of any specific object having been in view in the warping process, with the exception of obtaining a certain number of threads of a uniform length, when the warp reaches the beaming frame. The order of the various colours of yarns, as obtained on the warping machine, seems to have been entirely destroyed in sizing and drying, the warp being one confused multitude of threads, to all appearances bundled together without any definite object. On examining it a little more minutely, however, with a view of

preparing it for the loom, it will be discovered that every thread has retained its original position, or that place assigned to it in the operation of warping. Now, the object of beaming is to spread the warp ends evenly and regularly on the beam of the loom. If this work is not properly done the cloth will suffer both in texture and appearance. To obtain an even surface in the woven fabric it is necessary to have the threads of warp uniform in tension, which cannot be effected with an irregular beam, and hence one of the first matters that should be carefully attended to—especially in the manufacture of fine goods—when preparing the warp for weaving, is that of good, even beaming. Such is the importance of having the warp yarns under proper control during the operations of the loom, that, in some classes of fabrics, two, and even three beams are employed. These are adopted when certain threads rise and fall more frequently than others, and, as a result, "take-up" more quickly in weaving; hence, if beamed with the rest of the warp, they would ultimately become so tight, as the piece was being woven, as to seriously damage its texture. To prevent such being the case, those threads which are so frequently intersected with weft are placed on a separate beam, and tension applied accordingly.

The beaming frame is generally of the simplest construction. It consists of four upright posts, connected together at the bottom by wooden rails; fixed to each of these posts, at one end of the frame, are the two supports for the loom beam, while the other end of the frame is mounted with an additional rail for the warp to pass over as it proceeds to the beam. The operation of beaming is commenced by drawing the warp footing end first over the rail, and carrying it forward to the loom beam. It is here that the lease taken on the footing pins of the warping machine first proves to be of practical service. Through the last division of this lease a wooden or iron rod is passed, enabling the beamer to hold the warp tight while he performs the preparatory work of "raddling," which always precedes beaming proper.

79. *Raddling.*—The raddle, fig. 36, is employed to maintain the warp at one required width, and also to open the warp threads as they are being wound on to the beam. It is simply a wooden bar mounted with a series of upright pegs set at equal distances apart, and varying in number according to fineness; thus a 5's raddle is equivalent to five pegs to the inch, a 6's to six pegs to the inch, and so on. The raddle cap, C, is removed during the time the warp is being raddled. Each space between the pegs receives one section of the footing lease—that is to say, whatever number of threads is grouped in one

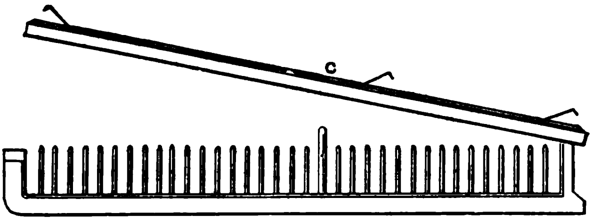


Fig. 36.

crossing over the footing pins of the woof or mill, the same occupies one division in the raddle. After the warp has been equally distributed between the pegs, the rod previously inserted in the footing lease is fixed in the groove of the beam, and the warp wound once round, merely to prevent the rod from springing out, while the flanges, which keep the warp straight and even at the edges, are being adjusted on the beam, the distance between them corresponding with the required width of the warp in the healds and sley. In beaming warps for hand-looms, flanges are very seldom used, the weaver building the side supports for the warp with narrow slips of cloth or listings; this he does by wrapping layer upon layer tightly round the beam. The loom beam is turned either by hand or power, and the warp held at a regular tightness by being passed round a large cylindrical drum, the revolutions of which are controlled by a twitch rope or tension brake. As the warp passes on to the beam the workman slightly alters, ever and anon, the position of the separator to distribute the threads as evenly as possible over the circumference of the beam. When beaming has thus been completed, the healding lease of the warp is preserved by inserting a pair of lease rods in the positions of the lease bands; these are fastened together at both ends to prevent them from slipping out, and also to retain the alternate crossing of the threads characterizing the lease. The raddle cap is next

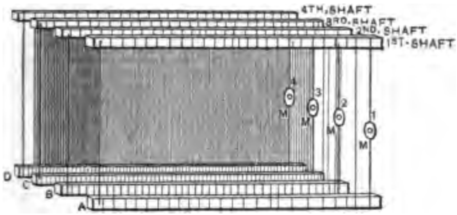


Fig. 37.

removed, which permits the raddle to be easily taken out of the warp, when the latter is ready for the succeeding operation, namely, healding.

80. *Healding, or Drawing-in.*—Attention has just been called to what is termed the "footing" when raddling; but it is the lease proper that will not only be found a useful adjunct in healding, but an absolute essential. If the warp about to be drawn-in is intended for the handloom, the work will, in all probability, be performed in the loom; but if it has been prepared for the power-loom, the shafts and the beam, around which the warp has been wound, will be suspended at a convenient height for the weaver and his assistant, or for the drawer and the reacher-in. The simplest plan of healding is generally

termed "straight draft" or "straight gate" (a draft indicating the methodical order observed by the workman in passing the threads through the healds of the shafts), and simply implies that the warp ends are entered in regular succession through the mails or loops of the healds, beginning with the first heald to the right of the first shaft, and taking the corresponding healds on the following heddles—no matter how many there may be—until the first heald of the last shaft is charged with a thread, when the second heald of the first, second, third, and other shafts are similarly dealt with, this order being repeated to the last thread of the warp. This will be somewhat simplified by consulting fig. 37. Here are four heddles, A, B, C, and D; A representing the front and D

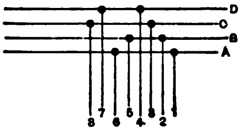


Fig. 38.

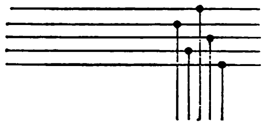


Fig. 39.

the back shaft. The beam having been hung behind the shafts, the reacher-in takes the first end in the warp from between the lease rods, and places it on the hook passed through the first mail m^1 of the first shaft, A, by the drawer-in; the second thread is then drawn through the first mail m^2 of the second shaft, B; the third thread through the first mail m^3 of the third shaft, C; and the fourth thread through the first mail m^4 of the fourth shaft, D. This completes one course or what is technically termed a "gate," and has to be repeated to the very last end in the warp. If the passage of the threads through the healds in a straight draft on four shafts is analyzed, it will be found that the first, fifth, ninth, and thirteenth threads are drawn on the first shaft; the second, sixth, tenth, and fourteenth, &c., on the second shaft; the third, seventh, eleventh, fifteenth, &c., on the third shaft; and the fourth, eighth, twelfth, sixteenth, &c., on the fourth shaft, showing that in all straight drafts a course just includes as many threads as there are different shafts, which is seldom, if ever, the case in irregular drawing.

In fig. 38 a backward and forward or angled healding draft is given; the horizontal lines A, B, C, and D, represent the shafts, and the lines 1 to 8 inclusive the threads of the warp. A "gate" in this draft occupies eight threads, the first thread being drawn through the first heald of the front shaft; the second, through the first heald of the second shaft; the third, through the first heald of the third shaft; and the fourth, through the first heald of the fourth shaft, but instead of the fifth thread falling on the second heald of the first shaft, as in straight drawing, it takes the second heald of the second shaft, while the sixth thread takes the first heald of the first shaft; the seventh thread the second heald of the fourth shaft, and the eighth thread the second heald of the third shaft. This method of drawing has a two-fold effect on the weave in the cloth; for it twills it to the left and right alternately, and produces, by so doing, an angled stripe or herring-bone, and hence the term "angled" draft. Another well-known plan of healding that should be briefly noticed is that furnished in fig. 39. It is generally called the sateen draft or "skip-shaft," because the threads always miss one heddle for each draw; thus the second thread falls on the third shaft, the third on the fourth, the fourth on the second, and so on. This mode of healding is occasionally adopted in making fine goods, when the warp contains a large number of threads to the inch, or is drawn on a large body of shafts. Of course the weave has, in such cases, to be made to work with the draft.

81. *Irregular Healding Drafts.*—Two methods of healding or drafting are sometimes employed on one series of shafts. This is generally the case in double-make cloths, and goods backed with warp. In such instances the shafts used in forming the back or under side are kept

distinct from those which form the face of the fabric. Fig. 40, for example, illustrates this system of healding. Thus shafts A and B in this draft are simply mounted with the backing chain, while shafts from C to J inclusive, contain the face warp, or those threads which appear on the upper side of the cloth. Two beams would probably be employed in weaving a backed fabric of this character, one containing the face and the other the backing warp. Let it be supposed that these have been fixed or suspended behind the shafts, and that the threads require to be healded according to the draft given under this figure. The operation would be commenced by the reacher-in taking the first thread from the lease of the backing warp, which

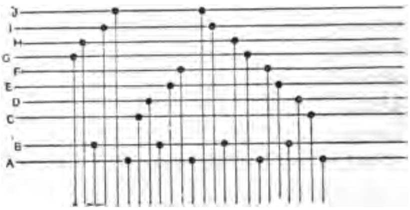


Fig. 40.

would be drawn through the first heald of shaft A. The first thread of the face warp would next be passed through the first heald of shaft C, and the second face thread through the first heald of shaft D. The second thread of the backing warp would now be dealt with by passing it through the first heald of shaft B, after which the third face-thread would be entered into the first heald of shaft E, and the fourth face-thread entered into the first heald of shaft F: in this manner healding would be proceeded with, the exact order or arrangement of threads indicated in the draft being strictly followed out to the last thread in the respective warps.

The number of healds on each shaft, in a given space, in drafts where all the heddles contain an equal number of threads, varies according to the required number of threads per inch in the warp, and also according to the number of shafts mounted in the loom. Thus, supposing a piece of cloth is intended to contain 60 threads in the inch, and that 12 shafts are employed in its manufacture, then take the threads per inch, 60, and divide by 12, the total number of shafts, and the quotient 5 will be the required number of healds on each shaft. If 20 instead of 12 shafts had been used there would only have been three healds per inch on the separate shafts; while, on the other hand, if the fabric had contained 96 in the place of 60 threads on the inch, and 12 shafts had been employed, each shaft would have contained eight healds per inch. It is plain, therefore, that to ascertain the *set* or healds per inch for any given number of shafts, providing they all contain the same number of threads in the draft, it is only necessary to divide the total number of shafts given into the threads required per inch in the warp. Sometimes, however, every shaft does not receive the same number of threads, and, when such is the case, it is needful to examine the draft and calculate for each shaft separately. In fig. 40, which has already been alluded to, a draft of this kind is given. It is for a backed fabric set 72 threads on the inch, and warped two threads face and one thread back, or, in other words, 48 threads of warp to the inch are proportioned to shafts C, D, E, F, &c., and 24 threads to shafts A and B. So the question is reduced to the following: A face cloth on eight shafts, containing 48 threads per inch, and a backing cloth containing 24 threads per inch, on two shafts. Adopting the rule laid down above $48 \div 8 = 6$ healds per inch on each of the face shafts; $24 \div 2 = 12$ healds per inch on each of the backing shafts. These results are not so easy to obtain when the draft is of a broken or of an irregular character. This will be obvious by consulting fig. 41. Here is furnished a draft for a single cloth containing 64 threads on the inch, in which some shafts receive a larger number of threads than others.

Hence it is not possible to divide it into two sections as in fig. 40. Some other method of calculation must therefore be adopted. It will be found on examining this draft that it contains 32 threads. This number should be divided into the number of threads in the set, thus, 64 ÷ 32 = 2 repeats of the draft in one inch of the warp. Now ascertain the number of threads on the separate shafts in the healding plan; four threads on shafts 1 and 2; three threads on shafts 3, 4, 9 and 10; two threads on shafts 5, 6, 7, 8, 11 and 12. If the number of the repeats of the

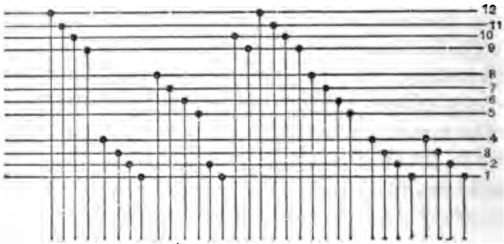


Fig. 41.

draft in the set is now multiplied by these threads separately it will give the results required as follows :—

2 × 4 = 8 healds per inch on the 1st and 2nd shafts	16
2 × 3 = 6 healds per inch on the 3rd, 4th, 9th and 10th shafts	24
2 × 2 = 4 healds per inch on the 5th, 6th, 7th, 8th, 11th and 12th shafts. . . .	24
	64

Of course there are various methods of counting healds, the system of "healds per inch," although applicable to all classes of goods, is only adopted in some manufacturing districts. In Batley and Leeds, for instance, one speaks of a 90's, a 120's, and a 140's set or *gear*, implying that in one quarter (nine inches) there are 9, 12, or 14 porties of 38 threads each. In ordering a gear, therefore, in either of these places it would be necessary to state not only the *set*, but also the number of shafts required; thus, an 80's set on six shafts, a 40's set on four shafts, &c. To ascertain the equivalent to any gear of this class in the "healds per inch" system, which is practised in Huddersfield and several other important textile districts, take the set given and multiply by the threads in a porty, and divide by the number of inches in a quarter multiplied by the number of shafts the set occupies. *Example:* Required the healds per inch in a 90's set, on two shafts. A 90's set equals 9 porties to the $\frac{1}{4}$, therefore,

$$\frac{9 \text{ porties} \times 38 \text{ threads in a porty}}{9 \text{ in. in a } \frac{1}{4} \times 2 \text{ shafts.}} = 19, \text{ the number of healds per inch on each shaft.}$$

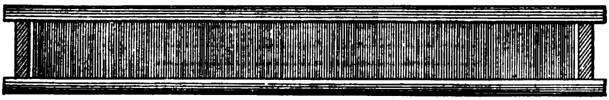


Fig. 42.

82. *Sleying or Reeding.*—After healding the work of loom-mounting is comparatively simple, the only operation requiring attention being that of sleying. The primary object of this process is to keep the threads of warp at equal distances apart, and also in the same relative positions throughout the whole operation of weaving. The sley, fig. 42, is divided into splits or dents, the number of which in a standard width regulates its fineness. The threads of warp are drawn through the splits, in the order in which they succeed each other in the healds, in 2's, 3's, 4's, &c., according to the character of the fabric being produced. As the sley is fixed vertically in the going-part of the loom it carries or drives the weft picks against each other at they cross the warp in regular succession, in fact it is used as much for this secondary object as for that of

separating the threads in a systematic manner. Perhaps no satisfactory rules can be given for ascertaining, by mathematical calculations, the proper method of sleying any particular warp or specific make of cloth; this is a matter subject to such a multitude of exigencies, such as the nature and sizes of the warp yarns, or any speciality in the structure of the fabric, that experience and general knowledge of textile productions are probably the only safe guides to accuracy in this particular. For whatever rules were framed they would require to have a fixed basis, or, in other words, a certain size of yarn and count of

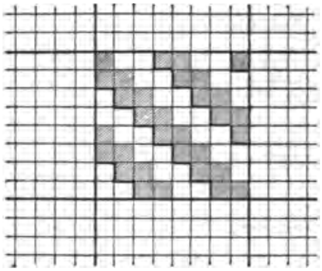


Fig. 43.

reed would have to be regarded as a standard to work upon, and, unfortunately, the results obtained from such arithmetical calculations would be comparatively valueless if a special thickness and weight of cloth had to be produced from a given grist of yarn and twill or design. In such an emergency rules would have to be laid on one side, and experience and practical knowledge brought to bear on the subject. Further, what one textile producer would regard as a suitable reed or sley for a given size of yarn, another would, in all probability, discard either as too fine or too coarse, for some manufacturers believe in *making* the cloth in the loom, while others would weave similar goods in more open sets, and impart the required strength or solidity in the process of milling. For these reasons any rules bearing on sleying or setting can only have a limited application, and possibly are only of practical value so far as furnishing to the inexperienced *weavable* sets for stated grists of yarns and simple makes of cloth. Diversity of weave, yarn, and structure of fabric, all tend to prevent the formulating of one regular proportional system of reeding established on such a basis as to make it applicable to every branch of textile industry. However, it may be stated that, generally speaking, the

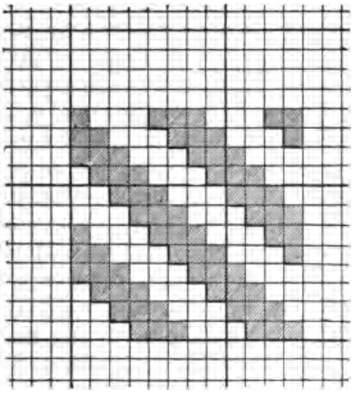


Fig. 44.

two main factors to be taken into consideration are the structure of the weave or design, and the circumference, or thickness, of the yarns employed. It may be useful to point out how these two conditions regulate the fineness of the counts of the reed or sley. To begin with the weave, figs. 43 and 44 are two very simple and common twills running at the same angle in the piece, but, nevertheless, somewhat different from each other in appearance. This difference in effect is traceable to the breadth of their respective furrows, or to the fact that while weave 44 flushes three threads and three picks in succession, weave 43 only flushes two threads and two picks. A slight difference of this kind in the flush of the make is sufficient to necessitate the counts of the reed being altered. Thus let both of these twills be woven in a warp composed of 20 skeins yarns—(*i.e.*, a yarn 20 yards of which will weigh one dram) and what is the practical result providing the set is the same in each case? If the reed or sley employed produces a good firm cloth in fig. 43, it will be correspondingly poor and lean in fig. 44; while if the cloth is all that can be desired in the latter weave, it will be hard, stiff, and unsaleable in the former, the threads of warp in this instance being too rankly sleyed for a make of such limited flushes. Fig. 43 would yield a satisfactory piece of goods if it were made of 20 skeins yarns, and woven in a 10's reed, 4 threads in a split (that is a sley containing 10 dents or splits in one inch, and 4 threads in each split, or 40 threads on the inch); but to produce a cloth equally full and firm in the hand in fig. 44, it would be necessary to use a 12's reed, and sley 4 threads in a dent. Hence one general principle that should be observed in reeding is, the faster the make of the weave, or the smaller the floats or flushes of warp and weft, the opener the set to be employed. Again, as to the thickness of the yarn. The set for a 10 skeins thread, or a yarn twice as thick as the 20 skeins already alluded to, would have to be reduced from a 10's to an 8's reed, 4 threads in a split, or from 40 to 32 threads to the inch. Unless this was done there would be considerable difficulty in introducing the same number of threads to the inch in the weft as there are in the warp, and weaving would be a difficult task to accomplish. The reduction of the set, on increasing the size of the warp yarns, is a practical necessity if the weave or make is to remain unchanged. To increase the size of the yarns without any regard to the set would imply overcrowding the splits or reeds in the sley, the movements of which would, as a necessary sequence, chafe the warp, and produce an uneven texture hard and boardlike in the hand. On the other hand, to decrease the thickness of the yarns and not to increase the fineness of the set would produce a cloth as materially defective in other respects—it would in this case be thin and open in texture and lack body and firmness. A second principle that deserves notifying in connection with the question is, therefore, that when the weave remains the same and the sizes of the yarns are increased the fineness of the set should be *decreased*, but if the warp threads are decreased in thickness, the set should be proportionately *increased*.

83. *Reeds.*—Reeds are counted in a variety of ways, almost every manufacturing locality having its own peculiar system. In some districts the calculations are based on the number of sets, of 40 threads each, in a stated width of the sley, as in Bradford, where 36 in. forms the basis of calculations. A 40's set, therefore, in this place would be equal to

$$\frac{40 \times 40 \text{ threads to the set}}{36 \text{ inches}}$$

or nearly $44\frac{1}{2}$ threads to the inch. In Glasgow the reeds are counted by the hundred, thus a 1,300's set is equivalent to thirteen hundred reeds in 37 inches of the sley. In some of the woollen districts of Scotland a system is practised based on the number of splits in $1\frac{7}{8}$ in., and the number of threads in each split or dent. For example, a 20's reed sleyed 2's would be equivalent to 40 threads in $1\frac{7}{8}$ in.

It will be noticed that this system resembles in principle that of so many reeds to the inch, and sleyed in 2's, 3's, &c., according to the structure of the fabric, which is undoubtedly the most rational system that has yet been adopted, and the one which is gaining supremacy in the trade. It is a mode of sleying that reduces reeding into the simplest practicable form, and that can be applied to every class of weaving, whether silk, cotton, linen or wool, and hence there is reason to believe that ultimately it will become the acknowledged standard system throughout the whole textile industry.

CHAPTER VI.

THE PRINCIPLES OF CLOTH CONSTRUCTION. FUNDAMENTAL WEAVES.

84. Woven and Knitted Fabrics—85. Warp and Weft—86. The Heald Shafts—87. Plain or Tabby Weaving—88. Design or Point Paper—89. Twilling—90. Cassimere Twill—91. Sateens—92. Derivatives of the Sateen—93. Corkscrews or Round Twills—94. Construction of Twills—95. Hopsacks or Mats.

84. *Woven and Knitted Fabrics.*—Every variety of woven fabric, whether plain or figured, results from crossing, or rather from interlacing two distinct series of threads together. Thus, when a woven cloth is submitted to analysis, it is found to be composed of two classes of yarns; first, those which extend longitudinally in the piece and which are termed collectively *warp*, *chain*, or *web*; and, second, those which extend transversely in the piece, and which are designated *weft*, *woof*, *abb*, or *filling*, according to the district in which the goods are manufactured.

Warp and weft may be considered as the two essential factors of every type of loom production. They are of paramount importance both in weaving the plain cloth and the artistic tapestry hanging. There is, however, a class of goods made on the stockinette frame, which, although only containing one body of threads, is often regarded as a woven texture. But, strictly speaking, such a cloth is not *woven* but *knitted*. By a process of knitting, and not by weaving, the individual threads of which a stockinette fabric is composed are interlaced into one regular texture. The work is performed in a kind of a frame or loom, in which the yarns are arranged in parallel order, at uniform distances apart, as in ordinary weaving. Of course the machine is automatic in its movements, and capable of producing a greath length of cloth in a very short time. The fabric thus formed is ornamented with a fine ribbed pattern similar in character to that seen in common knit goods. This article generally handles soft, full, and elastic, but lacks those valuable characteristics of strength and firmness of texture, or make, which obtain in a woven cloth proper. The difference between the structure of this fabric and that resulting from weaving warp and weft yarns together may be illustrated as follows: Take a sample of stockinette cloth and try to extract a thread, and what is the result? The whole construction is unravelled. Next submit a loom product to a similar examination, and it will be found that if a longitudinal or warp thread is removed, the transverse or weft threads will remain; while, on the other hand, if the latter are withdrawn, the warp threads will, although the texture may be partly destroyed, still remain, to a certain extent, undisturbed. Again, the manner in which a knitted fabric is constructed limits the designer to one class of weave effects—these being of a stockinette character—whereas the principles of weaving are of such a description as to admit of unlimited change or variation in design.

85. *Warp and Weft.*—The two series of yarns, warp and weft, already alluded to, are not only the principal agents in forming the texture but also the figure or design which embellishes the face of the cloth, and hence the inference that all kinds of woven goods, whether ornamented with the most elaborate figures, or completely void of ornament or design, have the same principia of construction; from which it will possibly be evident that, in order to explain the structure of a woven fabric, it will be necessary to carefully examine the evolutions made by the warp and weft threads used in its formation. The warp may be considered first. It is always understood to contain those threads that are arranged, as described in

Chapter V., in the healds and sley of the loom previous to the commencement of the operation of weaving. When the warp is mounted in the loom, the various threads run parallel to each other at equal distances apart, and are as perfect in arrangement and as complete in number at the beginning as at the end of the piece. The *picks*, *shoots*, or threads of weft are, on the contrary, introduced one by one in regular succession into the interior of the warp, and, consequently, they increase in multiplicity as the cloth is woven and wrapped round the piece-beam of the loom. The weft is woven or interlaced into the warp, and not the warp into the weft. The warp forms the foundation of the cloth, or comprises those threads which are intersected by the picks of weft during the production of the fabric. Weaving may, therefore, be defined as the art of interlacing weft threads between warp threads; but not a simple crossing of the weft over the warp, for such an arrangement, instead of producing a firm texture would merely result in the formation of two layers of threads one above the other.

86. *The Heald Shafts.*—Now, in order to accomplish this object, the warp is subjected to certain mechanical operations, which prepare it for the introduction or crossing of the weft yarns. The elevation and depression of the healds, which contain the warp threads, regulate the construction of the fabric. In order to prepare the warp for the picks of the filling yarn, certain shafts are elevated and others depressed, lifting and sinking those threads with which they are individually charged. This motion causes a division, or *shed*, as it is technically termed, in the warp, through which a pick of weft is passed and the shafts brought simultaneously into their normal position. Another order of shafts is next raised and depressed respectively, forming a second *shed* for the reception of an additional pick of weft, which is conducted across the warp by the shuttle, and in this manner the amalgamation of the warp and weft yarns is proceeded with. This leads to

an important conclusion—namely, both warp and weft threads appear alternately on the face and under sides of the cloth, for whenever a warp thread is *depressed*, a weft pick will flush or pass *over* it, but whenever a warp thread is *elevated*, a weft pick will flush or pass *under* it. In short it is this interlacing passage of the weft threads which binds the warp threads—previously hanging loose—together, forming, by securing each thread to its neighbour, one continuous breadth of cloth.

87. *Plain or Tabby Weaving.*—The order in which the yarns cross each other in woven productions may be

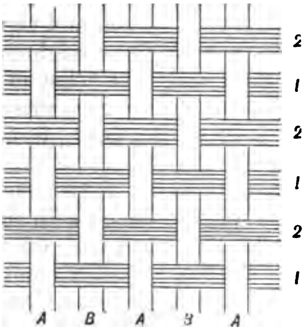


Fig. 45.

readily described by the aid of fig. 45. This is nothing more than an enlarged sample of plain or tabby cloth. A very brief study of the arrangement of the threads here shown will indicate that there are only four different movements of the yarns in the whole construction. The warp is represented by the lines A and B, and the weft by the lines figured 1 and 2. The weaver, to secure this result in the cloth, elevates the front shaft which contains the odd threads, and depresses the back or second shaft which contains the even threads; by this means he divides the warp into two equal parts, and into the opening thus formed introduces a shoot of weft. The second *shed*, which receives another pick, is obtained by reversing the movements of the heddles, or by elevating the second and depressing the first shaft. The object in furnishing fig. 46 is to point out the special functions of the shafts in the formation of the sheds in the warp. In this figure the healds are almost shown in front view, while the warp threads are sketched, as much as possible, from a side view, so that the principle on which the former lift and depress the threads can be clearly illustrated. To simplify the subject, the shafts only contain four healds each, and the warp eight threads. The first shaft, H^1, carries the first, third, fifth, and seventh threads, and the second shaft, H^2, the second, fourth, sixth, and eighth threads, the healding plan for the warp being straightgate. The elevation of the front shaft and depression of the back shaft will cause, therefore, half of the warp threads to be raised and half of them to be drawn down, forming the shed S for the reception of the shuttle.

Two heald shafts only admit of two methods of interlacing the warp and weft threads, for in such a mounting the weaver would be limited to the production of woven effects with either the even threads up and the odd threads down, or *vice versâ*. The texture could, however, be varied in appearance by entering two or three picks of weft into one shed, which would produce a kind of rep, or warp cord, varying in size or breadth according to the number of shoots inserted into one division of the warp. And this may be regarded as a summary of the movements of the shafts, and also of the threads and picks in plain weaving, showing that when pick 1 of fig. 45 enters the warp, it passes *under* the threads lettered A, and *over* the threads lettered B, but when the second pick enters the warp, it flushes *over* the threads A and *under* the threads B, resulting in the production of the fastest, firmest, but simplest cloth that can possibly be woven.

88. *Design or Point Paper.*—It will probably have been already inferred from the explanations given on the struc-

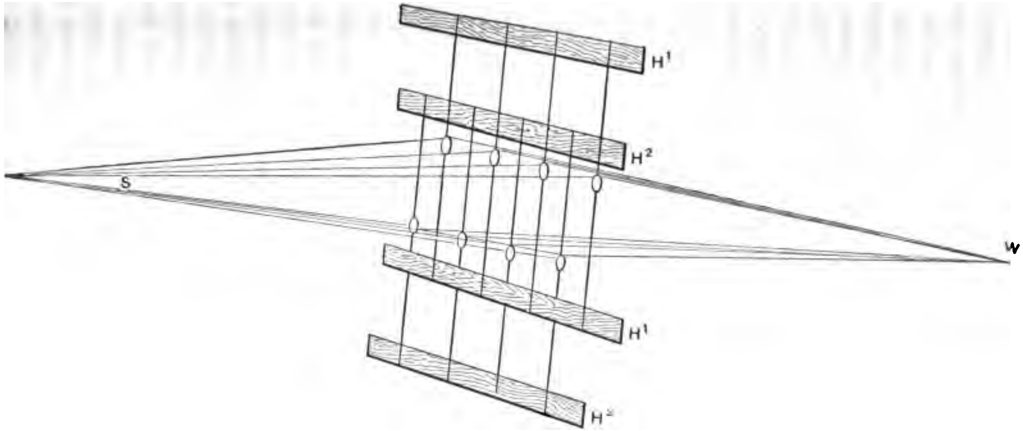


Fig. 46.

H = Heald shafts. W = position of warp, or yarn beam. S = Shed.

Diagram showing the position of the healds when the shed is open or the warp threads divided for the reception of the shuttle containing the weft yarn.

ture of a woven cloth, that the whole art of textile designing, so far as weave effect is concerned, consists in the origination of new plans or methods of inserting the weft yarns into those of the warp. Accepting this as an accurate inference, the uses of what is termed design or point paper will soon be evident. This paper is supposed to be a representation of at least one series of the threads employed in the production of a woven fabric. Thus the blank spaces from *a* to a^1 correspond to the warp threads hanging loose, or in an unwoven state, in the loom. These spaces or squares are dotted precisely in that order in

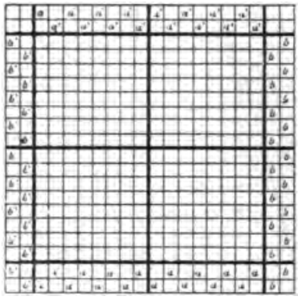


Fig. 47.

which the threads cross over, or under, each other in weaving. The dots, or marked spaces, fig. 48, indicate where the weft passes over the warp, while the blanks indicate where the warp passes over the weft. It might be said that previous to any dots being arranged on the paper, all the warp threads are in an elevated condition, while the weft yarns, without a single exception, are under the warp. Hence the dots or marks represent the effect of the weft in the cloth, and the blanks the effect of the warp. This, however, is not invariably the case; in fact, in some mills the practice is to dot the warp and leave the weft blank, but possibly the more rational system is that of marking the effect of the latter, because during the operations of the loom the filling is added to the warp, and not the warp to the filling.

The manner of representing a weave on design paper may be pointed out by referring to fig. 45. This small sample of cloth only contains five threads and six picks, or, on the point paper, fig. 48, the five spaces lettered A and B in a longitudinal sense, and the six spaces figured 1 and 2 in a transverse sense. Let it be understood that one thread of warp is represented by one series of blank squares from a to a^1, fig. 47, and one shoot of weft by one series of blank squares from b to b^1. Now the first pick of fig. 45 is represented on point paper as follows: One square blank and one square dotted for five threads; the second pick, one square dotted and one square blank for five threads; the third and fifth picks are like the first, and the fourth and sixth like the second, as shown in the plan given in fig. 48. This is the general method of arranging weaves or designs on point paper for practical purposes, and the form in which the plans are given to the weaver when intended to be tried in the loom.

In addition to each longitudinal series of squares being synonymous to a thread in the warp, it also corresponds to one shaft in the witch or dobbie, and one needle in the jacquard machine, while each transverse series from b to b^1 represents one lag in the witch or one card in the jacquard loom. If a number of lags were applied to the dobbie machine without being pegged, all the shafts mounted in the loom would be depressed, or if a blank card were applied to the jacquard cylinder, all the threads would remain unlifted. The lags must be pegged, and the cards must be stamped, before the former can supply any motion to the heald shafts, and before the latter can be made to elevate indirectly the threads in the warp. Again, if a sample of point paper were completely void of dots it would simply be understood to represent a number of loose warp threads, but add the dots or marks, and the pegging plan or design is produced, or, in other words, a weave indicating to the weaver where in the lags he will require to insert pegs to form the desired pattern in the cloth.

The "counts" of the paper is regulated by the number of small squares contained in a large division. Fig. 47 is what is called 8 by 8 paper. The larger squares are also of importance when preparing elaborate designs for the loom. They aid the card cutter very materially in his work, enabling him at a glance to ascertain exactly what thread or pick of the design he last worked upon. For this purpose each large square contains as many smaller divisions as there are holes in the card-cutting plate. There are other kinds of paper in addition to that shown, such as 10 by 10, 12 by 12, 8 by 12, 12 by 8, and 8 by 16. These various

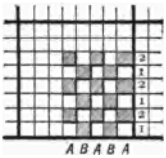


Fig. 48.

types are all necessary to the manufacture of the different classes of textile goods. The 10 by 10 is principally employed in the production of designs for jacquards of 100 harness or a multiple of ten, and is extensively used in the preparation of figured patterns for tapestry cloths, where two five-shaft sateen weaves are combined, warp and weft flush respectively. The 12 by 12 paper is advantageously used for 600 jacquards, where each of the transverse rows of the card-stamping machine plate contain twelve holes. The other classes of point-paper mentioned are essential in designing for fabrics in which the warp and weft do not contain an equal number of threads per inch—that is to say, in cloths where there is either an excess of warp or an excess of weft. An 8 by 12 paper would be employed in cloths containing 12 picks of weft to 8 threads of warp, while a 12 by 8 type would be used in designing for goods where the proportion of warp threads to weft threads was as 12 is to 8.

89. *Twilling.*—In a twilled fabric parallel diagonal lines, or ribs, extend from side to side of the cloth. When the twill is of a simple kind (see fig. 49a) the spaces between the lines are blank, but when the weave is termed a broken or irregular twill (see fig. 49b) the equal distances between the furrows are interspersed with small figures or cross diagonals. A few simple but useful twills of the first class are furnished in figs. 50 to 54. These makes form the basis from which a large variety of other twills of a more complicated character originate. The plain weave as given in fig. 48 possesses no appearance

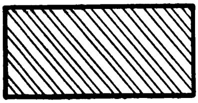


Fig. 49 A.

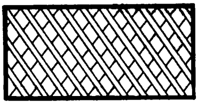


Fig. 49 B.

whatever of a twilled pattern, but, on the contrary, seems to form a small check effect. In fig. 50, which is the next change in the interlacing of warp and weft to the plain make, there is every indication of a twilled weave; in short this plan is the simplest twill or diagonal that can possibly be obtained. It is known in the trade as the three-shaft or three-end prunelle twill, warp flushed. In reality it only occupies three threads and three picks, but it has been repeated on the point paper in order to furnish a better idea of the twill effect it produces in the cloth. Whatever number of threads and picks form a crow or swansdown (fig. 52) twill, the principle of intertexture is always regular, the weft passing pick after pick from one thread to another in the warp until an oblique furrow extends from side to side of the piece. The size of the warp flush depends on the number of threads the weave occupies. Thus a 4-end swandown would give a three flush, a 5-end a four flush, and a 6-end a five flush in the warp.

90. *Cassimere Twill.*—The shalloon or cassimere twill is given in fig. 51. This weave occupies four threads and four picks, and would, consequently, require a similar number of shafts and lags in weaving. As it is one of the most useful weaves employed in the manufacture of both woollen and worsted goods, a sketch is furnished in fig. 55 of the order in which the warp and weft threads cross

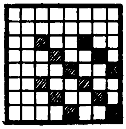


Fig. 50.

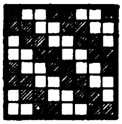


Fig. 51.

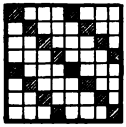


Fig. 52.

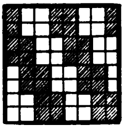


Fig. 53.

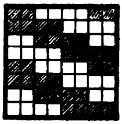


Fig. 54.

each other in the production of the woven fabric. The following is an analysis of the method of intertexture shown in this figure:—

Pick	No. 1	floats over	A and B	and under	C and D.
„	No. 2	„	B and C	„	A and D.
„	No. 3	„	C and D	„	A and B.
„	No. 4	„	A and D	„	B and C.

This weave may be said to resemble the plain or tabby make in one or two particulars in its construction, for, in both crossings, half of the warp threads are raised and depressed respectively in the formation of the separate sheds for the reception of the individual picks of weft. The warp and weft furrows in this twill, unlike those in the serge, are equal in flush, forming a very different effect to the latter in the woven fabric. It was observed that in a swandown weave no single thread remained depressed for more than the intersection of one pick, the flush of the warp to that of the weft in fig. 52 being in the proportion of 3 to 1; now, however, in the cassimere make, each warp thread, whether elevated or de-

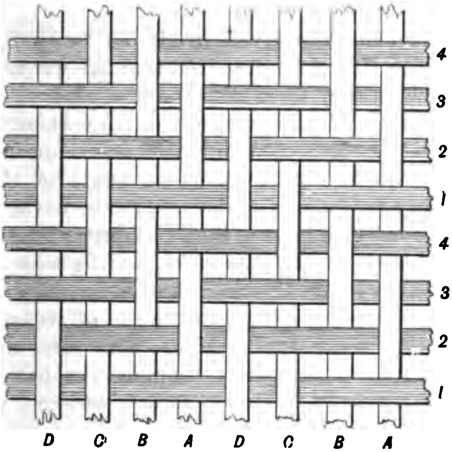


Fig. 55.

pressed, flushes two picks, while each weft shoot, whether on the face or under side of the fabric, flushes over two threads of warp. On a further examination of the structure of this useful make it will be noticed, on a reference to fig. 55, that two adjoining threads are always up and down during the insertion of the weft yarns. Thus, as pick 1 crosses the warp, the thread lettered C, which rises with D, is elevated for the last time, while D is elevated for the first time; on the other hand thread

A is depressed for the last time, and B for the first time, the threads of the warp rising in pairs in the following order:—C and D, D and A, A and B, and B and C. The flush of each warp thread takes hold of the flushes of the adjacent threads on both sides, and continues the direction of the furrow or twill until perfect and uniform connections in the flushes are formed on every side of the weave, both by the threads of warp and the picks of weft, so that the two and two flush in the twill, is continued from side to side of the cloth, and from one end of the piece to the other.

In the few examples given in simple twills in figs. 50 to 54 inclusive it will be observed that the weaves vary in the angle which they form with the first pick. The furrow of the twill in fig. 54, for example, runs at an angle of about 30° in the cloth, that in fig. 51 at an angle of about 45°, while that in fig. 53 forms an angle of about 60°. By combining twills of a similar character to the above, it will subsequently be shown, that a variety of designs may be produced both in stripes, checks, and figures.

91. *Sateens.*—In considering the fundamental methods of intertexture, such an important class of weaves as the *sateen* deserves some explanation. The term applied to this type of crossing partly implies the nature of its effect in the woven texture, sateen weaves generally imparting a soft, full appearance to the fabric. Now, although this kind of make is not so largely applicable to the manufacture of worsted and woollen goods as the cassimere, prunelle, or even the plain or tabby weave, yet it is more or less employed in the production of both fancy and piece dyed fabrics, such as doeskins, and other classes of fine twilled cloths for overcoatings. The structure of the weave, however, limits its use in so-called fancies, for it is of such character that the cloth produced always possesses either a *weft* or a *warp* face. The principle of constructing a sateen is that of depressing or elevating one thread in the weave on each pick or shoot:

thus, in fig. 56, which is the 5-heald sateen or doeskin, the following is the order of intertexture :—

Pick A, 1st thread depressed, and 2nd, 3rd, 4th, and 5th threads elevated.

Pick B, 4th thread depressed, and 1st, 2nd, 3rd, and 5th threads elevated.

Pick C, 2nd thread depressed, and 1st, 3rd, 4th, and 5th threads elevated.

Pick D, 5th thread depressed, and 1st, 2nd, 3rd, and 4th threads elevated.

Pick E, 3rd thread depressed, and 1st, 2nd, 4th, and 5th threads elevated.

This analysis shows that each pick of the weave not only takes down a separate thread, but only flushes over one thread out of the total number the make occupies—a principle that obtains in all types of sateens. The 4-heald broken swansdown, fig. 59, is sometimes described as the simplest sateen that can possibly be produced ; but, strictly speaking, this weave is simply an irregular serge or broken crow twill, the two picks A and B twilling to the left, and the two picks C and D twilling to the right in weaving.

It should be remarked that all crossings of a sateen character, with the exception of that formed on six healds, give an upright twill in the cloth when the warp is flushed, and an oblique twill when the weft is flushed. The six-shaft make is what may be termed an irregular sateen, forming a broken twill in the fabric, while, unless arranged on the principle given in fig. 57, two threads of warp are depressed, *a*, *a*, fig. 58, in succession, a feature which should never prevail in weaves of this description.

92. *Derivatives of the Sateen.*—Sateens possess one characteristic which makes them useful for other purposes than simply that of forming a suitable method of interlacing warp and weft yarns—they form a broad basis for the origination of new weaves, while in figured designing they

are frequently worked to as the plan of arranging the various parts of the design. Their derivatives are not only more diversified in character, but also more perfect in structure than those obtained from other simple modes of crossing. In fact, a weave made on a sateen basis, if systematically constructed, cannot fail to produce a regular or uniform texture. There is, however, considerable skill required in this class of elementary designing. The origination of *new* weaves is always a difficult task. It implies

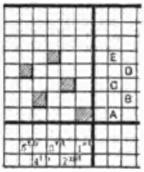


Fig. 56.

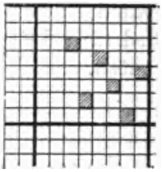


Fig. 57.

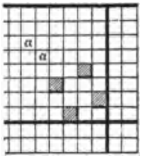


Fig. 58.

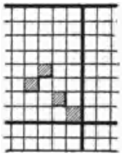


Fig. 59.

both the exercise of ingenuity and of a knowledge of cloth production.

Such valuable makes as the corkscrew, twilled hopsack, and Mayo or Campbell may all be formed on the sateen principle. As examples of the diversity of crossings resulting from employing these weaves as a basis the designs given in figs. 60 to 71 inclusive, may be considered. In each of these cases the full square dots, ■, represent the sateen weaves proper and the spaces marked in diagonal lines, ▨, the additions made to produce a new effect. What are designated the 8-shaft and 12-shaft twilled hopsacks are shown in figs. 62 and 66. The former is one of

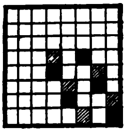


Fig. 60.

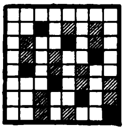


Fig. 61.

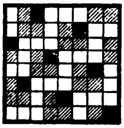


Fig. 62.

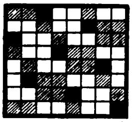


Fig. 63.

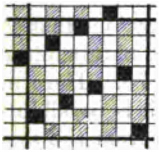


Fig. 64.

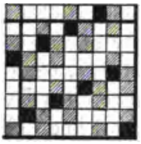


Fig. 65.

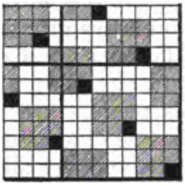


Fig. 66.

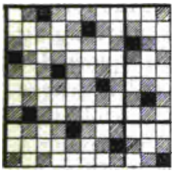


Fig. 67.

Fig. 68.

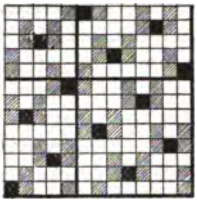


Fig. 69.

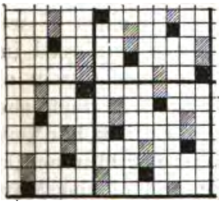


Fig. 70.

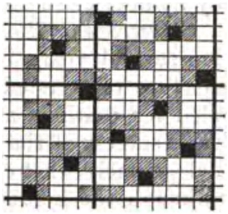


Fig. 71.

Examples of Weaves on a Sateen Base.

the most useful weaves employed in the manufacture of worsted coatings. The characteristic feature of these weaves is that the small squares of which they are formed are always arranged in such a manner as to produce *en bloc*, not only a mat or hopsack, but also a twilled effect. The manner in which these makes have been constructed, and also that of the Mayo, fig. 63, is made evident by the two classes of marks used in the figures.

Perhaps a few of the most striking illustrations that can be furnished of the variety of weave effects obtainable on this method are given in figs. 68, 69, and 70. Here are three as differently constructed weaves as it is possible to make, and yet they have all been obtained from the same fundamental weave, which may be traced in the respective designs. In the first of these crossings, fig. 68, the addition of the small squares marked in diagonal lines produces a weave of a basket character suitable for fine worsted cloths. The same base is made to do duty in the formation of an irregular twilled pattern in fig. 69, by arranging a pair of diagonal-marks on both sides of each square dot in the weave. When the latter dot is removed it leaves (fig. 70) a weave of the corkscrew class, while the addition of the marks as indicated in fig. 71, results in forming a good useful weave of a twilled mat character. Figs. 65 and 67 are simply further illustrations of the readiness with which this plan of constructing weaves can be adopted on any number of shafts.

93. *Corkscrews or Round Twills.*—This class of weaves has for several years been extensively employed in the manufacture of worsted goods, more especially in cloths intended for coatings and trouserings. In fact, the remarkable success of the corkscrew fabric has had but one parallel—namely, that of the cassimere or four-end twill; for, although the hopsack or celtic, and of the Mayo or Campbell, are both very noted and useful weaves, yet the quantity of cloth made of these crossings, in a given period, will not bear comparison with that made of the corkscrew

or round twill. Possibly it might be supposed, from the style of the designation applied to this kind of make or weave, that the effect in the woven fabric would be of a corkscrew or wavy character, or, at least, possess the feature of roundness; but it should be noted that none of these characteristics are sufficiently pronounced to lead to the origin of these technical names. The latter designation—that of round twill—is certainly the more applicable of the two, because there is a fulness and general softness, which may be said to approach roundness, about the effect of such makes in the woven fabric that might probably have given rise to this term, for it is a feature that is more or less wanting in other classes of twills. But any person familiar with goods produced from this type of weave would experience considerable difficulty in explaining either how or why the terms *corkscrew* and *round twill* came into use; unless the object was to deceive the uninitiated, and, by giving the cloth a novel and at the same time fantastical name, cause it to be regarded as a new article. This, along with the fact that the weave has only been in vogue for a comparatively limited period in worsted cloths, has led to the assumption that the corkscrew is a make of modern invention. It is only necessary to refer to certain woven specimens, still in existence, made of the weave shown in fig. 64 or of the nine heald corkscrew, as long ago as 1860, to prove that this generally accepted opinion is erroneous. These cloths were then made in woollen and not in worsted yarns, the following being a sample of the weaving particulars adopted in the manufacture of the corkscrew goods produced about the year 1860:—*Warp*, 40 skeins woollen, 17's reed, 4 threads in a split; *Weft*, 30 skeins woollen, 54 picks on the inch. The same weave may now be made of twofold 48's worsted for warp, in a 24's reed, 4 threads in a split, and 24's worsted for weft, 96 picks on the inch. So that the modern cloth not only excels its predecessor in fineness of texture, but, on account of being made of worsted, it also possesses a more lustrous surface.

The structure of what may be termed the ordinary class of corkscrews is based on the sateen or doeskin principle, for, whether the 7, 9, or 11-heald make is examined, it will be found that the common doeskin forms the basis of the weave. Now the principle of a sateen make, as already explained, is one thread down on each pick or shoot, no matter how many threads it may occupy. Thus in figs. 61 and 64, the squares, ■, in each case, form the sateen basis, which may be readily changed into the corkscrew proper by adding two, three, or four marks, according to the size of the twill, and one above the other in succession, as indicated in the respective figures. The ordinary buckskin and five-shaft venetian are constructed on a very similar principle. Here again the squares give the doeskin weaves, one mark only being required to be added on each thread, and that above the squares, in order to produce in the former what is termed the fine twill or venetian, and, in the latter figure, the buckskin twill.

94. *Construction of Twills.*—Small twills and diagonals are by far the easiest types of weaves to originate; for it will be obvious that to construct a new twill of a simple character it will only be necessary to vary the base or first pick of the weave. This arises from the fact that every pick of a regular twill is simply a model of the first, moved either one thread to the left or to the right of its predecessor, according to the direction in which the twill runs.

Thus, on examining fig. 72, it will be found that the second pick is marked or figured exactly like the first, but started on the second thread, B, and finished on thread A. Further, if the respective picks were similarly considered, they would each correspond, in arrangement, with the base line of the weave. Take, for example, the last pick in this design, No. 8, which commences, as indicated by the numeral 1, on the 8th thread, H, and reads as follows:—3 threads down, 1 thread up, 1 thread down, and 3 threads up, ending on the 7th thread; now this is precisely the order in which the threads are elevated and depressed in the 1st pick, only the latter begins on the 1st thread, A, and ends on the 8th thread, H. It is apparent, therefore, that the difference between any two picks of a simple twilled weave only arises from their relative positions in the make which they help to form. This will probably so far explain the structure of a common twill as to enable the reader to understand that when the base line or first shoot of such a twill is given, in order to complete it each succeeding pick will require to be a repetition of this base, but advanced one thread beyond its predecessor either to the left or to the right; the same order

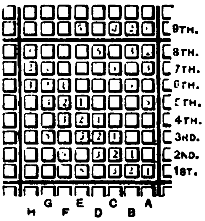


Fig. 72.

of depressing the threads being repeated till the arrangement of marks on the 1st pick recurs. This, it will be noticed, takes place on the 9th pick in fig. 72. Of course, in working out a weave from such data, each pick must be confined to the number of threads the base pick occupies. For this reason the numeral 5, on the 5th pick in the figure just explained, is brought on to the 1st thread, and not carried on to the 9th, which is not included in the number of threads occupied by the first shoot. In some classes of twills where there are two picks of weft in one shed of the warp, or where in one portion of the twill the depression of the threads is the same during two or more succeeding shoots of weft, it is necessary, to enable the designer to continue or complete the weave, to furnish such a number of picks as will indicate the character of the make.

95. *Hopsacks or Mats.*—A word or two of explanation may be given here on what are termed *hopsack*, *celtic*, *basket*, or *mat* weaves. Next to the cassimere twill the 4-heald make of this class is one of the most useful weaves employed in making woollen and worsted goods. Correctly speaking, it is nothing but the plain weave on an enlarged

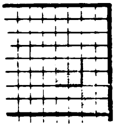


Fig. 73.

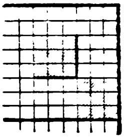


Fig. 73 *a*.

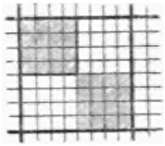


Fig. 73 *b*.

scale; the principle of its structure coinciding with the latter weave, as may be seen by consulting these makes as mapped out in figs. 73, 73 A, and 73 B. Here it will be observed that the largest of these weaves only contains, like the plain weave, two classes of sheds, four threads and four picks always working together, and performing the same office as one thread in tabby weaving. These weaves are made on a considerable variety of healds, such as 4, 6, 8, 12, and 16, but the numbers in most general use are the three former.

CHAPTER VII.

HAND LOOMS.

96. *Motions of the Loom.*—There are five principal motions in weaving common to both hand and power looms, namely, *shedding*, *picking*, *wefting*, *setting-up* of the cloth, and *letting-off* of the warp or chain. The *shedding* motion, which is by far the most important, divides the warp threads into two sections, elevating some ends and depressing others; the *picking* motion impels the shuttle from side to side of the warp; the *setting-up* arrangement winds the woven cloth on to the piece-beam, while the *letting-off* appliance unwinds the threads from the chain-beam. The shuttle-box motion should also be mentioned, as it is invariably applied to looms used in the production of fancy cloths. In practical weaving the shedding motion first effects a division in the warp, when the shuttle containing the weft-thread is propelled by the picking motion through the opening, or "shed," formed in the chain between the elevated and depressed threads; the movement of the going-part, or the wefting motion, then beats the weft yarn thus extended across the warp, before the shed closes, or the warp yarns are brought on to one common level, into close contact with its predecessor; at

this juncture the letting-off motion gives in the chain, the setting-up appliance at the same time imparting movement to the piece or cloth beam.

97. *Uses of the Hand Loom.*—Although the hand-loom has during recent years been largely superseded by the power-loom, yet it still holds an important place in the weaving of some classes of textiles. As it is simple in construction, it can be readily altered to suit the requirements of any particular branch of woven fabrics. For this reason it is preferable to the automatic loom for pattern or experimental weaving. Modifications in the motions of the power-loom are comparatively difficult to make. If, for example, a change had to be made in the order of picking, or in the method of introducing the several shades of weft yarns into the cloth, it would necessitate either the construction of a new chain, the use of a fresh set of lags, or of a different series of cards for the shuttle-boxes, according to the class of power-loom employed. But if a similar change in picking had to be effected in the hand-loom, the weaver, having the shuttling arrangement under complete control, could, without any alteration in the mechanism of the loom whatever, introduce the threads of weft into the cloth as required. Other advantages in making pattern ranges on this loom consist in the facility with which the cloth can be wefted, the warp changed, and, in a word, the expeditious manner in which a new fabric or pattern can be produced.

For figured goods, where an irregular and complicated order of weft threads of several colours is used, the hand-loom is again the best adapted, simply because the weaver can readily control its motions so as to make them accord with the required method of colouring the design. Plush fabrics and various classes of tapestry cloths, carpets, and figured shawls are also, to a limited extent, woven on the hand-loom, but its special *rôle*, as stated above, is certainly in pattern production. Hence in fancy woollen and worsted mills of any note, a number of hand-loom weavers are engaged solely in the weaving of new pattern ranges.

To the student of textile design this loom is specially useful, for he can more feasibly put his ideas into practical shape by its employment than by using the power-loom. Experiments are as necessary in a study of weaving as in chemistry or any other practical science; and as it is, to say the least, inconvenient for the student to have a power-loom in his laboratory or workshop, he cannot do better than procure a hand-loom. Small hand-looms, as simple and complete in construction as possible, are the most suitable for this purpose. There is no advantage in having a miniature power-loom which may be worked by the foot alone, like a sewing-machine, as there is far too much mechanism and gearing required in looms of this description. The less mounting a loom takes, the better for the student. He ought to be able to vary the number of weft threads to the inch in the fabric, alter the shuttling, and change the design without re-adjusting the various parts of the loom. This is necessarily impracticable in looms that are workable by the foot alone. Possibly the best hand-loom constructed for students' use is that invented by the late Professor John Beaumont, and of which there are some eighty in use (in addition to full-sized hand-looms, jacquards, and power-looms of various descriptions) in the textile classes of the Yorkshire College. This loom, while a combination of neatness and simplicity, possesses a weaving capacity equivalent to that of the largest power-loom mounted with shafts or heddles, and also every necessary contrivance for making pattern ranges.

98. *Parts of the Loom.*—The following are the principal parts of the hand-loom: The frame, the warp-beam, the piece-beam, the breast-beam, the going-part or batten, the rock-tree, or rail, on which the going-part swings, the shuttle-box lever, and the setting-up lever and wheels.

The frame is very similarly constructed, whether intended for the treadle, witch, or jacquard shedding motions.

It consists of four upright posts joined at each side in the direction of the warp and also at the back by a lower and an upper rail. In the front the low rail is dispensed with, the breast beam, against which the weaver leans during weaving, and over which the cloth passes to the piece-beam, taking its place. The breast-beam, like the rail over which the warp passes from the chain-beam to the healds, is fixed a little higher than the mails of the healds or harness.

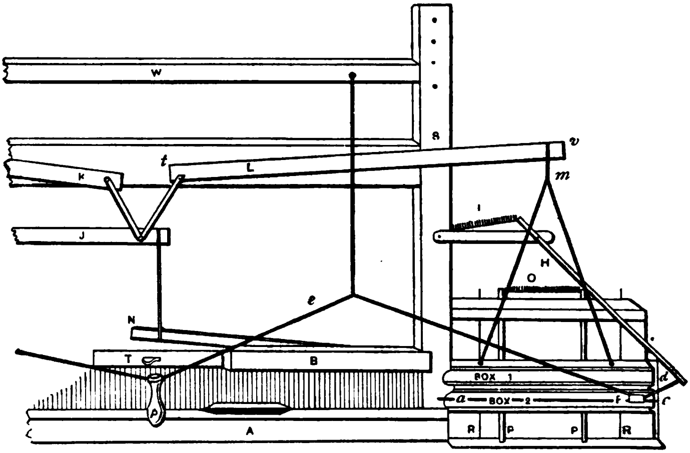


Fig. 74.

One of the most important parts of both hand and power-looms is the going-part or "batten." In fig. 74 one end of the going-part used in ordinary hand-looms is represented. The bottom part of this piece, A, is called the race, the shuttle running upon it during weaving. The sley or reed is fixed between the hand-tree, B, and the race. Both ends of the going-part are mounted with a similar series of boxes to that shown in the figure. In this sketch only two boxes, C and D, are given, but as many as from four to six may be employed.

The sword, S, or the upright arms on which the going-part oscillates, have several holes near the top by which it can be lowered or elevated at the option of the weaver. For this purpose cords are passed through the holes and fastened round the "rock-tree," a stout wooden beam, mounted with two iron pins, which move in grooves screwed on to each of the upper side rails of the frame.

When the weaver desires to insert a pick of weft into the warp, he presses the batten from him, which should bring the race on a level with the depressed yarns, and thus form the base on which these threads rest; by the aid of the picking-stick he forces the shuttle across the warp, after which he draws the going-part forcibly against the cloth already woven, pressing the pick or shoot of weft into close contact with the one previously inserted. The picking motion may also be fully explained by referring to fig. 74. Here *p* is the picking-stick, which the weaver holds in his right hand, F the picker travelling on the spindle S, H the picking-arm, I the picking-arm spring, and *e* the cord connecting the picking-stick to the picker. The action of the parts is as follows: If *p* is drawn from the boxes it causes the picker F to slide on S, driving the shuttle out of the box. This is no sooner done than the picking-arm to which F is also attached is drawn back by the spring I, and again brought into striking position. In order that the picker may be quickly drawn out of the boxes, the weaver lets the cord *e* slack immediately after imparting motion through F to the shuttle.

As the shuttle-box motion is connected with the going part, it may now be described. The box lever, which is not shown in the figure, is generally fixed on the left side of the loom, and is in direct communication with lever K. The box lever does not control the motion of the boxes, but is simply employed to lighten the work of elevating them to the weaver, being weighted at one end. The parts which have directly to do with the elevation and depression of them are shown in the sketch. The boxes rise and fall on the two spindles R, R, and are kept in position by sliding on to steps projecting from the rods P, P. These rods are joined together at the top by the spring O, which allows them to move backward in the slot in which they are placed in the top of the framework of the boxes, as the iron snecks on the back of the latter press against the projections; but immediately after the snecks have passed above them the rods are drawn forward, and the boxes rest on the steps of P, P. To lift the boxes, the rod N is depressed, drawing down lever J and L to which it is attached at *t*, which causes it to rise at *v*, at which point it is in direct communication by cord *m* with the tops of the boxes. To depress them, it is necessary to press the trigger T, in the centre of the hand-tree, inwards, which being connected with P P by a small cord, draws them backward, and thus removes the supports from underneath the snecks on the boxes, causing them at once to drop. The parts N and T, on which the weaver keeps the thumb and finger of his left hand, are thus made to control in a simple and effective manner the boxes containing the several shuttles employed.

99. *Setting-up Motion.*—The setting up of the cloth is, in hand-looms, and also in many classes of power-looms, primarily effected by the movements of the going-part. Projecting from the top rail of the batten is a thick wooden rod, round which a cord is fastened and attached to a lever fixed in front of the loom. This lever at the opposite end by cord *e*, fig. 75, is made to lift the setting-up lever, A. It will be noticed that A carries the setting-up catch B, which imparts motion to the piece-beam wheel, P, through the train of wheels shown in sketch. Here E is the ratchet-wheel, and carries small pinion F, which gives motion to the intermediates, H and D, and they in turn to P. The holding-up catch, C, prevents the ratchet from running back when the lever A is descending. The cloth is only set up when the going-part moves backward. Thus if pressed from the cloth the rod projecting from the

rail w, of fig. 74, depresses the top lever at the end to which it is attached, and raises it at the other, lifting A of fig. 75, and giving motion to the piece beam as described.

100. *Letting-off Motion.*—The usual method of maintaining the warp threads at one uniform tenison in hand-looms is by what is called the friction-brake. This is a thick rope wound on the head of the yarn-beam in a contrary direction to that in which the warp is delivered from the beam. Some classes of power-looms are mounted with a similar letting-off arrangement. The various parts

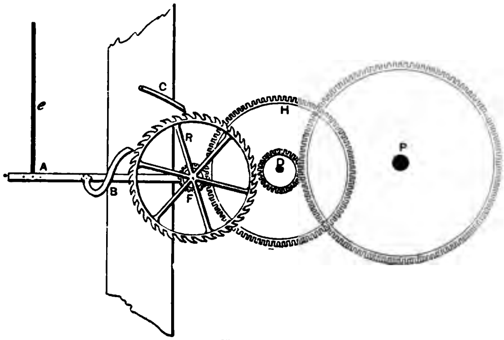


Fig. 75.

of this method of tensioning the warp are shown in fig. 76. In this sketch B is the warp beam, C the twitch rope, L the weight lever, R the low rail of the loom, and D the weight. The rope C having been fastened to rail R, is passed round the beam, and thus supports the lever L, which is fastened by cord E to the floor, while the weight is supported by the opposite end of the lever. Of course the heavier the weight, or the further the weight from the fulcrum, the more tension put on the warp. When this letting-off contrivance is applied to the power-loom, two levers and two twitch-ropes are used, one for each end of the loom. The levers in this case are fastened to castings bolted on to the framework of the loom.

101. *Shedding Motions.*—In hand-loom weaving there are three methods of elevating and depressing the warp threads, or of forming a shed in the warp; first, the treadle system; second, by the witch or dobbie; and, third, by the jacquard machine. The treadle system is the oldest and rudest in construction. It is still employed in some parts of Scotland in pattern weaving, and possibly its simplicity and cheapness will retain it in use for some time to come for this purpose. The witch machine is one of the

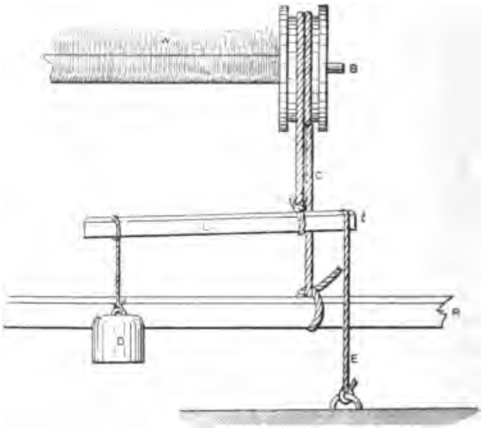


Fig. 76.

best principles of shedding extant. It is said to have been first constructed in its present form in the West Riding of Yorkshire, and has, ever since its invention, been regarded as well adapted to the requirements of the woollen and worsted trades. Up to the year 1830, or thereabouts, the dobbie, as now built, was unknown, a machine styled the drum witch or engine, which resembled it in many particulars in construction, being then employed in the weaving of fancy woollens. The principle of the dobbie forms the basis of construction of many of the power-loom shedding motions of the present day, in fact, there is scarcely one system of automatic shedding, excepting the tappet, which does not resemble the witch in some particulars. As to the third method of shedding, that of the jacquard machine, it is the system *par excellence* for figured weaving. Practically there is no limit to the capacity of this loom. Elaborately figured fabrics are always woven on the jacquard. The great feature in which it differs from other shedding mechanisms is in the use of harness instead of shaft mounting, and cards instead of lags and pegs, bowls and bushes, or tappets and treadles. It was invented, about 1801, by Joseph Marie Jacquard, and although the machine has undergone many modifications since this date, it is still the same in principle as when it first left the hands of the inventor.

102. *Treadle Systems.*—This shedding motion comprises four series of levers, namely, treadles, long lambs, short lambs, and jacks. The treadles are worked by the weaver's feet, and both depress and elevate the heddles. The long lambs are connected first to the treadles and then to the jacks by what are termed the streamer cords. The jacks are attached to the top of the heddles and the short lambs to the bottom. The latter are also in communication with the treadles. The elevation and depression of the heald shafts depends entirely on two classes of cords, *long* and *short*, used in connecting the treadles to the long and short lambs respectively. The long cords being attached to the short lambs depress, while the short cords being attached to the long lambs lift the shafts. The positions of these cords and of the several sets of levers are shown in fig. 77. In this sketch, a a^1 are the short cords, b b^1 the long cords, T T^1 the treadles, L L^1 the long lambs, C C^1 the streamer cords, J J^1 the jacks, and H H^1 the heddles or shafts. Now it will be obvious that if T were depressed it would draw down long lamb L^1, being attached to it by short cord a. Lever L^1, by means of cords C^1, would then depress J^1 at g, and lift it at i. As J^1 at this point is in communication with

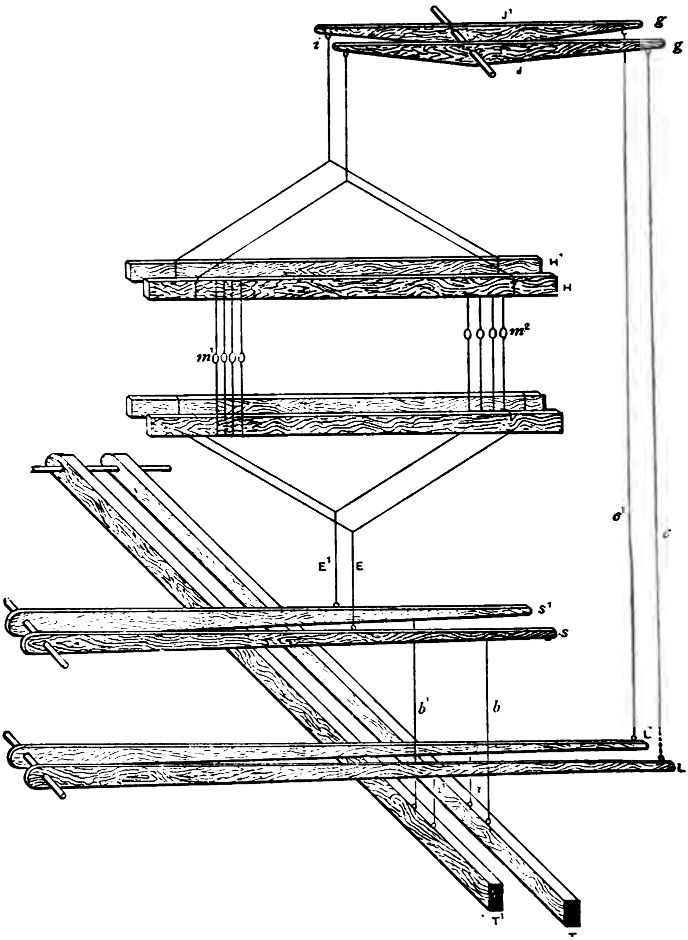


Fig. 77.

Diagram of Shedding Mechanism of Treadle Loom.

the upper shaft of heald H[1], it would, when depressed at *g*, rise at *i* and lift this heddle. This is not the only result of depressing treadle T, for as it is connected by a long cord *b* to short lamb S, and as the latter by cord E is connected to the lower shaft of heald H, when this treadle is elevating heddle H[1] it is depressing H. It follows that the threads drawn through the mails, m^2, of H[1] will, when treadle T is depressed, be lifted, while those drawn through m^1 of H will be sunken. Next suppose the weaver depresses the second treadle, or T[1]; this would just reverse the positions of the threads, for this treadle would, by

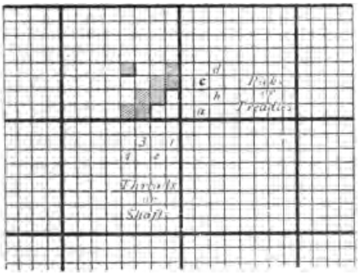


Fig. 78.

means of a^1, drawn down L, lifting through the streamer cord *c*, and jack, J, the first or front heddle, H. In the second place T[1] would depress H[1], for it is connected to the bottom shaft of this heddle by b^1, S[1], and E[1]. Possibly it will now be clear how the lifting and depressing of the heald shafts depends entirely on the method of attaching the cords *a* and *b* to the treadles.

103. *Tie-up or Cording Plans.*—As the effect in the woven fabric, in treadle weaving, is due to the principle on which the healds are actuated by the long and short lambs, the cords *a* and *b* are tied up according to the weave or plan of fabric required. In the diagram referred to, they are arranged to weave a plain cloth. To illustrate the principle of cording, a "tie-up" for the cassimere twill, given

in fig. 78, will be arranged. In making a cording plan, the first thing to do is to draw as many horizontal lines parallel to each other as there are shafts or threads in the weave. Across these rule four perpendiculars corresponding to the picks *a*, *b*, *c*, and *d* in fig. 78 and to the treadles in the loom, as represented in sketch 79. This done, the point to determine is which class of cords shall be marked *long* or *short*. It is customary to mark the latter, or those which lift. Thus on pick *a* of weave 78, the 1st and 2nd shafts are elevated, hence they are marked in the cording plan where treadle A cuts them. On the second pick, *b*, the 1st and 4th shafts are up, and the 2nd and 3rd down, which is indicated in the cording plan by crosses being placed on treadle B where it intercepts the 1st and 4th shafts. The picks *c* and *d* are then dealt with in a similar manner, producing the cording plan sketched in fig. 79. The marks made on this sketch indicate that short cords are to be attached to the treadles and long

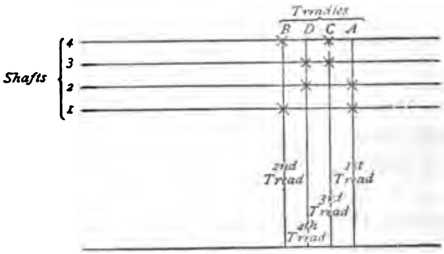


Fig. 79.

lambs, while the absence of marks, from those positions where the two series of lines cross each other, shows that long cords are to be attached to the treadles and short lambs. Thus, according to the above cording plan, the following would be the method of attaching the cords to the treadles and long and short lambs in mounting the loom: I. Treadle A, for pick *a*, short cords to long lambs 1 and 2, and long cords to short lambs 3 and 4. II.

Treadle B, for pick *b*, short cords to long lambs 1 and 4, and long cords to short lambs 2 and 3. III. Treadle C, for pick *c*, short cords to long lambs 3 and 4, and long cords to short lambs 1 and 2. IV. Treadle D, for pick *d*, short cords to long lambs 2 and 3, and long cords to short lambs 1 and 4. It should be observed that, as the lambs run parallel to the shafts, and are fixed underneath them, the first or front shaft takes the 1st lamb in each set, the second shaft the 2nd, the third shaft the 3rd lamb, and so on throughout the entire series of shafts. Another feature about the cording plan that must be noted is the method of arranging the treadles. It will be noticed that although pick *b* of weave 78 is the second on the plan, yet it is actuated by the 4th treadle. The reason for this will soon be obvious. The weaver, in treading making use of both feet, must, in order to avoid crossing them, either tread from the outside or the centre of the complete set of treadles. In the plan given he would start on the 1st treadle with the right foot, then take the 4th treadle with the left foot, the 2nd treadle with the right, and the 3rd treadle with the left.

104. *The Witch or Dobbie.*—The various parts of this shedding motion are given in fig. 80. The part B, called the block, slides up and down between the two ends of the frame. It contains the knives or lifting bars, K. Elevation and depression of the healds are effected by the upright wires *b* and *c*. These wires are bent in the form of a hook at the top, so that if over the knives when the block rises they are immediately lifted. Uprights *b* and b^1 are attached to the tops of the heald shafts, while uprights *c* and c^1 are, by the means of the streamer cords e e^1, connected to the jacks J^1 J^2, two sets of levers fixed underneath the healds in what is called the jack frame. These levers, as will soon be pointed out, perform the same functions as the short lambs in treadle weaving, for they depress the shafts. There is one spring wire, a a^1, to each pair of uprights, *b* and *c*, and b^1 and c^1 respectively. The

object of the spring wire is to actuate the uprights, thus *a*, by means of the cross wire *g*, may be made to impart motion to uprights *b* and *c*, for it is twirled round both of them. When there are no lags on the cylinder, or when the machine is out of action, the front row of uprights are all off knife 1, whereas the second series are all on lifting-bar 2. If, therefore, the spring wire *a* were pressed forward it would force the upright *b* on to knife 1, and upright *c* off knife 2; on the other hand, if spring wire a^1 were not to be actuated, upright b^1 would remain off knife 1, while c^1 would be lifted by knife 2. This arrangement of wires is sketched in fig. 80, and the effect it has on the healds will next be traced. Let the result of lifting wire *b* and depressing wire *c* be first considered. The shaft H^1 to which *b* is attached by cord *d* is represented as up, because this wire has been raised by the front lifting-bar. In order to allow it to rise, the jack levers are elevated at the ends, where they are attached to the shafts by cords *f*. They could not be thus actuated if the upright *c*, to which they are attached, were not depressed. This, however, is the case, for when the front row of uprights rise, the back row fall, and hence, in the drawing, *b* is shown to be elevated and *c* to be down. Now turn to the method of depressing the healds. This is always done by lifting the back row of uprights and sinking the front row. Thus in fig. 80 upright c^1 is on knife 2, while b^1 is off knife 1. The effect is this, c^1 being elevated by the block, by means of cord e^1 lifts the jack levers J^2 at *i*, and depresses them at *m*, thus drawing down, through cords f^1, heddle H^2. In order to level the shafts after they have been lifted and sunken, the block is allowed to fall, which admits, first, of the heddles which have been elevated being depressed; and, second, of the heddles which have been sunken being lifted. The lifting or levelling of the healds is accomplished by the spring S and eccentric E. A strap passes from the spring over E, and is attached to the wooden support on which the base

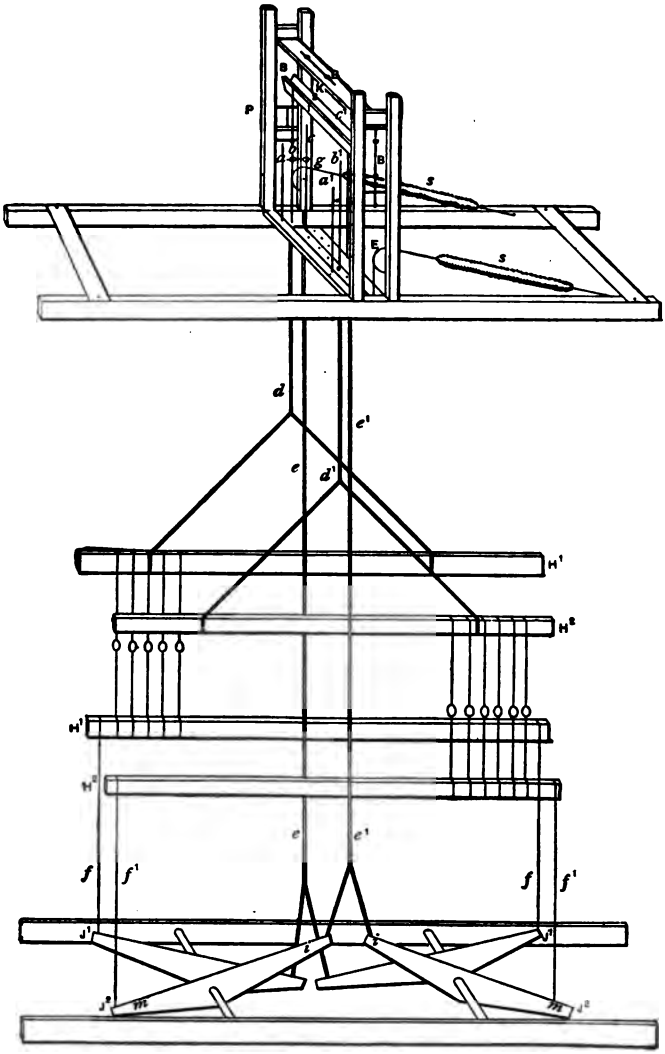


Fig. 80.
Diagram of the Witch or Dobbie Shedding arrangements.

of the uprights rest. Both sides of the machine possess this arrangement, so that when the block B falls not only do the lifted shafts sink, but those which have been depressed by the jack levers are drawn up by the spring, strap, and eccentric on to one common level.

The various parts of the machine operate as follows: The weaver first depresses the treadle drawing down the lever to which it is attached, and lifting the block. As the latter contains the knives, it elevates the upright wires, which, in turn, actuate the healds, those in series *b* lifting, and those in series *c*, in consequence of being in communication with the jacks and the lower parts of the heddles, depressing the shafts. The pick of weft having

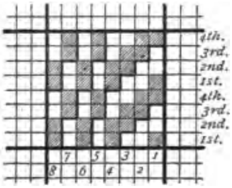


Fig. 81.

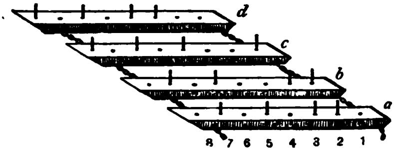


Fig. 82.

been inserted into the shed, which such an arrangement of healds would produce in the warp, the treadle is allowed to rise, when the block descends, and the shafts are brought into their normal position.

105. *The Lags.*—There is one important feature about this machine which has not been referred to in the previous paragraph, namely, the manner in which motion is given to the upright wires. Both series of uprights being connected to one spring wire, it is only necessary to actuate the latter in order to impart movement to both *b* and *c*. This is done by the lags (fig. 82) into which pegs are inserted according to the pattern it is required to produce. These lags pass round the cylinder, which usually contains eight grooves and makes one-eighth of a revolution each time the treadle is depressed. It is fixed with its long

sides to the spring wires in the supports, *p*, fig. 80, of the upright posts of the witch frame. To show how the lags are prepared for the loom, let it be supposed that it is required to weave plan 81; then, as this weave occupies eight threads and four picks, the lag would contain eight holes, each hole representing a thread. The lag may either be pegged from the right or left side, but it is usual to commence with the first hole on the right; that is to say, the numerals 1 to 8 represent the same threads in the weave. When the blank spaces on the design denote threads up, the holes in the lags representing such spaces are pegged. Each lag corresponds to one pick; thus lag *a* is the 1st, *b* the 2nd, *c* the third, and *d* the 4th pick of the weave. On this design the 1st pick reads thus: 1 thread dotted, 2 threads blank, 1 thread dotted, 1 thread blank, 1 thread dotted, 1 thread blank, and 1 thread dotted. The lag for this pick is pegged as follows: 1 hole empty, 2 holes pegged, 1 hole empty, 1 hole pegged, 1 hole empty, 1 hole pegged, and 1 hole empty. So that in preparing the lags, pegs are only inserted into the holes corresponding to the blank spaces in the several picks. The principle of pegging the succeeding lags, *b*, *c*, and *d*, is precisely the same as that observed in inserting pegs into lag *a*.

106. *Relative Advantages of the Treadle Loom and Witch Machines.*—In one particular, at least, the witch machine has a very considerable advantage over the treadle loom. Twelve or sixteen shafts in the latter necessitates the use of as many treadles as it is possible for the weaver feasibly to control. Moreover such a number of heddles is not sufficient for the requirements of the fancy woollen and worsted trades. The witch has, however, a weaving capacity of no less than forty-eight shafts, and these are all workable by the same treadle. In the direction of the weft there is no limit whatever in this machine to the size of the pattern. While in the treadle-loom, as has already been pointed out, each distinct pick requires a separate

treadle to form it; in the dobbie a weave or design may contain almost an unlimited number of picks, and yet be as workable as if it only occupied four or eight. If the treadle system can be said to possess any advantages over the dobbie, it is in the variety of weave effects which may sometimes be obtained with one "tie-up," whereas every

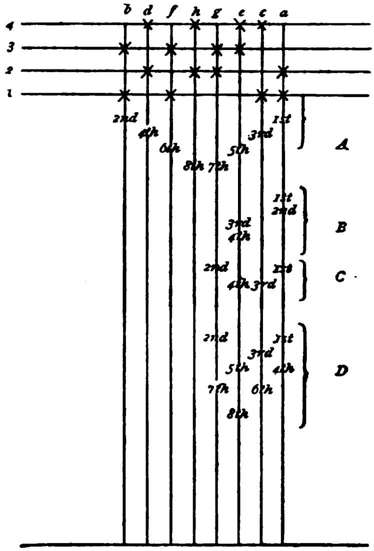


Fig. 83.

fresh effect in the dobbie necessitates the production of a new set of lags.

A few illustrations will show how such changes are possible in the treadle-loom. In fig. 83, part A, the tie-up or cording plan is given for weave 84. Now it will be obvious that all crossings composed of the same picks as those which form this weave, but differently arranged, will be producible in the same tie-up. For example, in plan 85, there are only two classes of picks—*a* and *b* being like *a*, and *c* and *d* like *e* of weave 84. It follows, therefore, that fig. 85 could, if the treadles were depressed, as indicated at B, in fig. 83, be produced in the same tie-up as the latter plan. Plans 78 and 86 could also be worked on the same set of treadles and cording arrangement. Consider plan 78 first. Pick *a* here is like *a* in weave 86, pick *b* like *c*, pick *c* like *e*, and pick *d* like *g*; hence if the treadles are depressed, as shown at C, fig. 83, allowing the last four treadles to rest, they would give the common twill required. Lastly, as to weave 86. Picks *a* and *d* of this plan correspond to *a* of weave 84, picks *b* and *g* to *g*, picks *c* and *f* to *c*, and picks *e* and *h* to *e* of the same figure. By treading as indicated at D, in fig. 83, this

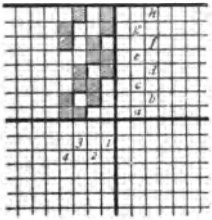


Fig. 84.

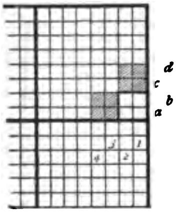


Fig. 85.

arrangement of picks may be obtained. If the last four treadles of the cording plan were worked independently of the first four, they could be made to form the plain cloth, and also a large variety of warp cords, with two, four, or six picks in a shed.

107. *The Jacquard Machine.*—This shedding motion is in reality divisible into two parts—the mechanism for producing one repeat of the pattern as stamped on the cards, and represented on the design paper, or the *jacquard* machine proper; and the harness which repeats the effect produced by the cylinder and the cross and upright wires from one side of the fabric to the other.

A harness instead of a shaft mounting, perforated cards in place of wooden legs and pegs, are not the only features which characterize this machine. In fact there are some power looms in which the cylinder and card apparatus is employed in a modified form. Much of the dissimilarity between the jacquard and the dobbie arises from the arrangement of the upright and cross wires in the respective machines. In the dobbie there are but two rows of uprights, one row of which is off the front lifting-bar, and the other row on the back lifting-bar. The uprights in both rows are actuated by the same spring and cross wires. A very different arrangement of wires obtains in the jacquard. Here the uprights are arranged in four, eight, or twelve rows, each row containing twenty-five or fifty wires,

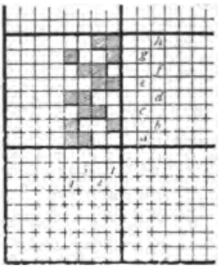


Fig. 86.

according to the capacity of the machine. The cross wires are arranged on a similar system. There are no spring wires, the cross wires or needles giving motion to the uprights.

108. *Block and Cylinder.*—An engraving of a 100 jacquard is given in fig. 87. It shows the principal parts of the machine for actuating the harness. The block A, as in the dobbie, contains the knives or lifting-bars. Here, however, these bars vary in number according to the size of the machine. Thus, in a 100 machine, there are only four knives, in a 200, or 400, eight, and in a 600 machine twelve. Each row of uprights requires a separate lifting-bar. The knives are fixed obliquely in the block to pre-

vent them from falling on the tops of the hooks of the uprights, and from thus destroying them when the latter drops.

The cylinder, C, has four sides, each of which contains as many holes as there are cross wires in the machine. Each series of holes corresponds to one row of cross or upright wires. In a 400 jacquard there are eight, and in a 600 twelve series of holes. When the block is lifted, the cylinder is pressed some slight distance from the front of the machine, which brings the knoggers, D, into action, for they are fixed to the frame, and the top catch rests on the

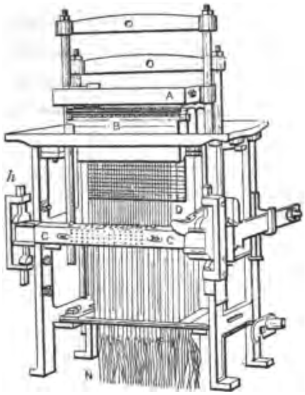


Fig. 87.

drumhead of cylinder, consequently as the latter is being pressed back it makes one-fourth of a revolution. As the cards pass over the cylinder, they are by this arrangement brought one by one in regular succession against the ends of the needles. To pick back the weaver simply raises the catches, which brings the lower knogger into action, causing the cylinder to turn in the opposite direction.

109. *Upright and Cross Wires.*—The upright wires, W, fig. 88, are bent in the form of a hook at both ends. The upper hooks rest over the knives, *k*, of the block, while the neck-bands of the harness, N, fig. 88, are attached to

the lower hooks. Each upright, as previously stated, must have its corresponding cross wire, the front end of which plays against the card when the cylinder is brought in contact with the needle-board of the machine. It is

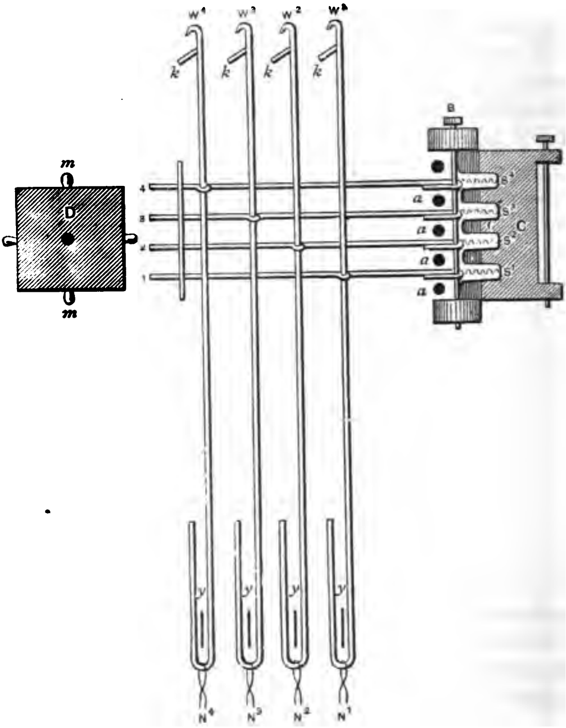


Fig. 88.

completely twirled round the "upright," so that whether pressed forward or backward it imparts movement to the latter. The back of each cross wire is bent in the form of a hook, *a*, fig. 88, admitting of the wire working between the pins in the grate of the spring-box, C. To keep the wires steady when in action, and also perfectly straight, a pin, B, is passed through the grate and the bends *a*. Each needle or cross wire works against a small spring, s^1 s^2 s^3 s^4, which gives it a forward motion on the card being withdrawn, by the cylinder D, from the front of the needles. In order to prevent the uprights from turning round, the grate *y*, which contains as many bars as there are series of uprights in the jacquard, is fixed between the lower bends of the wires, rising and falling with them.

The number of upright wires in a jacquard, as in a witch machine, defines its weaving capacity. On these wires and the needles depends the transference of the pattern, as impressed on the cards, on to the warp in the loom ; for the cross wires communicate the motion received from the card to the uprights, while the latter actuate the neck-bands of the harness, N, fig. 89, which lift their respective harness cords, and these in their turns the threads of warp.

110. *The Harness.*—Thus far the construction of the machine proper has only been considered. It is necessary now to ascertain how the various parts already described, when set in motion, reproduce the pattern, as stamped on the cards, in the woven fabric. It is already understood that in all cases the jacquard is a harness loom, and it is the mounting of the harness and the functions it performs in the weaving process that next comes under consideration.

The first work to be done in connection with such a mounting is, I. to decide on the capacity of the machine ; II. the set or number of threads per inch required in the woven fabric ; and, III. the width of the harness in the comber-board. Let it be supposed these points are settled as follows : I. a 100 machine ; II. 32 threads per inch ; and, III. 36 inches wide. There are only three distinct parts in connection with the harness of the loom, so they will be described separately. They are the neckbands, comber-board, and harness cords.

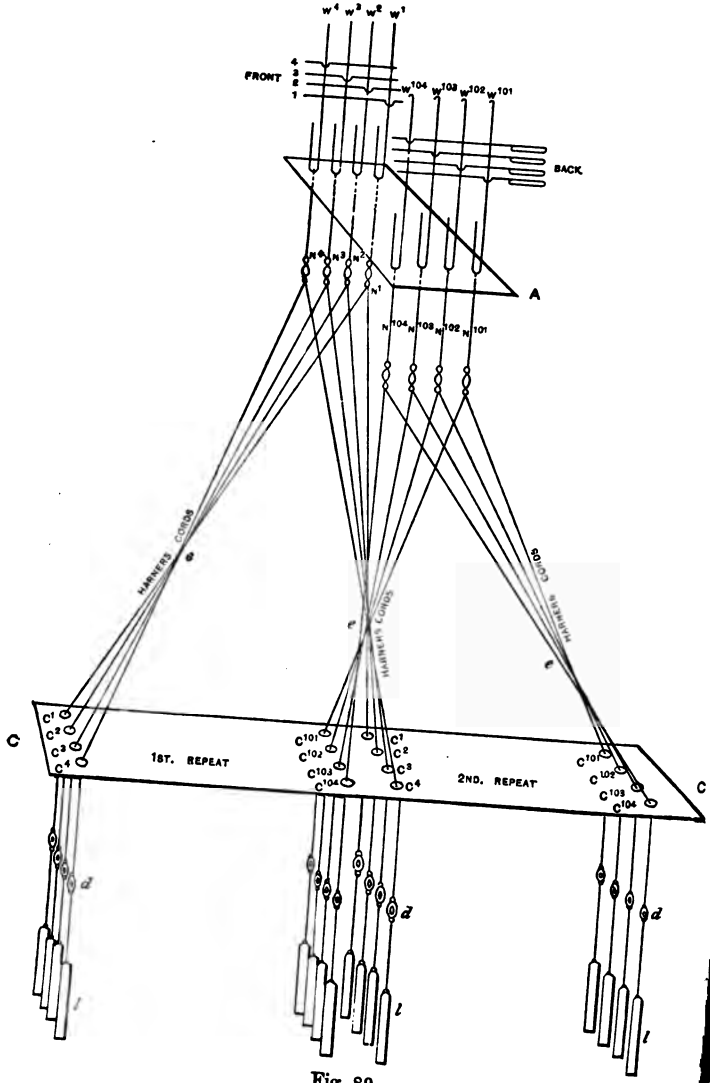

W⁴ W³ W² W¹
FRONT
W104 W103 W102 W101
BACK
A
N104 N103 N102 N101
HARNESS CORDS
C
1ST. REPEAT
2ND. REPEAT
d
l

Fig. 89.

THE NECKBAND, HARNESS, AND COMBER-BOARD.—In a witch machine 24 upright wires, or jacks in the power-loom, imply a weaving capacity of 24 shafts. Now each of these shafts contains a definite number of healds to the inch, and if the warp is straight drawn there will be as many repeats of the design in one inch as there are healds per inch on each shaft. Take an illustration: In a loom mounted with 16 shafts and 48 healds per inch there are 3 healds on the inch of each shaft, which gives this number of "repeats" of the design in each inch of the fabric, providing it occupies the complete set or series of shafts. A witch machine with 16 shafts can only be made to produce by straight healding a 16-thread design. In the 100 jacquard under consideration, there being 104 upright wires, but probably only 96 wires for figuring purposes, and 8 wires for weaving the lists, a design may occupy 96 ends; but as there are no shafts to repeat the pattern from side to side of the fabric, some other arrangement has to be adopted. The neckbands are employed for this purpose. They perform the same functions in the jacquard shedding motion as the shafts in the witch or dobbie; for, like the shafts, they carry the cords which repeat the design in the fabric. Each neckband, after having been attached to the lower hooks of the upright wires, is connected to as many harness cords (equal healds in the dobbie) as there are intended to be repeats of the pattern in the cloth.

The comber-board, C, fig. 89, is the wooden frame through which the lower ends of the harness cords pass. Each cord passes through a separate hole. Generally the number of holes across this frame corresponds with the number of upright wires across the neck or upper comber-board, A. This comber-board determines the width of the harness.

The harness consists, first, of the harness cords, *e*; second, of the mails, *d*; through which the warp ends are drawn; and, third, of the weights, or lingoes, *l*. As each harness cord is mounted with a mail and a lingo, each thread in the warp is depressed by a separate weight.

The number of harness cords actuated by each neckband depends entirely on the number of upright wires in the machine, set, and width of the harness. Thus in a 104 machine, when 8 wires have been deducted from the lists, it leaves 96 wires for the figure; now, if this number is divided into the threads per inch, multiplied by the width of the harness in inches, it will give the number of repeats of the pattern in the fabric, or the harness cords to be tied to each neckband. Thus:

$$\frac{32 \text{ ends per inch} \times 36 \text{ inches wide}}{96 \text{ wires}} = 12 \text{ harness cords to each neckband.}$$

One method of tying up the harness very commonly adopted is shown in sketch, fig. 89. In this case the short sides or ends of the machine are parallel with the long sides of the comber-board. Only two "repeats" are given in the drawing, and simply the first and last series of uprights. The plan adopted in tying up the harness-cords will be evident from the numerals on the upper and lower comber-boards. For example, the harness-cords of the neckbands of the uprights w^1, w^2, w^3, w^4, always take the first series of holes of each repeat in the comber-board c; while the second series of neckbands, not shown in the figure, would support the cords for the second rank of holes in the comber-board, and so on to the last or 26th set of neckbands, the harness-cords of which occupy the row of holes in the comber-board lettered c^{101}, c^{102}, c^{103}, and c^{104}. It will be quite evident from the few cords sketched in the figure, that the harness when completed will be very much crossed on this system of mounting, causing considerable wear and friction of the cords.

In the second method of hanging the harness such an unnecessary crossing of the harness cords is avoided. It consists in fixing the jacquard with the long sides of the neck-board, B, fig. 90, parallel with the long sides of the comber-board, C, or with the cylinder of the machine, either in the front or behind the loom. On this system, as shown in this sketch, the back row of uprights takes the back row of holes in the comber-board; the 2nd row,

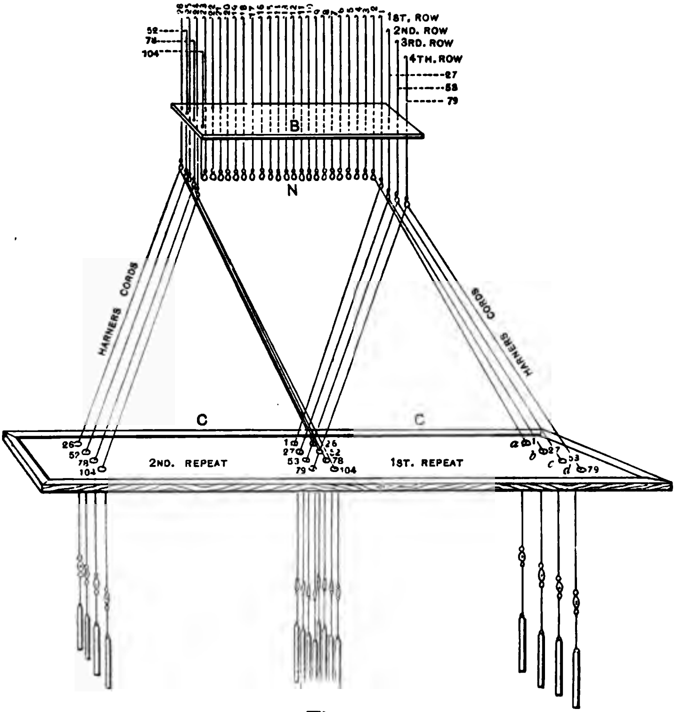


Fig. 90.

the series *b*; the 3rd row, the series C; and so on throughout the machine.

111. *The Pattern Cards.*—As previously explained, the upright wires are, when the machine is not in motion, all on the lifting bars, so that before any shed can be formed in the warp it is necessary to press some of the wires off

the knives before the block is lifted by the lever and treadle. To effect this a series of cards, stamped according to the design intended to be woven, are employed. These cards perform exactly the same functions as the lags in the witch machine, for they actuate the upright wires. They are prepared on the card-stamping machine, the plate of which bears an exact resemblance to one face of the cylinder. If the whole of the card were cut, it would have precisely the same effect as the cylinder without a card. A hole in the card is always understood to signify a thread of warp lifted, and a blank in the card a thread of warp depressed. The cards when stamped and laced are a perfect representation of the design on point paper in another form. Each card represents one pick and the complete series of

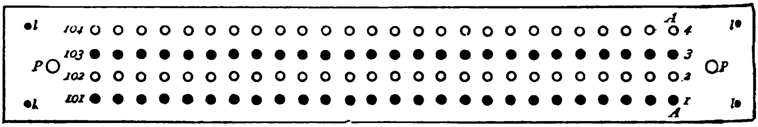


Fig. 91.

threads in the design, and hence the cards *en bloc* produce the pattern in the woven fabric through the agency of the upright and cross wires and the harness cords.

A card stamped plain for a 104 machine is given in fig. 91. The black spaces, or rows 1 and 3, represent holes *cut*, and the rows 2 and 4 spaces *uncut*. The former would lift and the latter depress threads. The effect of the first four spaces of this card, A, A, if applied to a machine mounted in a similar manner to that sketched in fig. 89, may be carefully traced. Take holes 1 and 3 first. These would be opposite cross wires 1 and 3, and as all the cross wires fit into the perforations in the cylinder before any card is applied, if the card is stamped with holes the wires will still remain stationary, so that the uprights, W^1 and W^3, to which they are attached would be lifted, raising neckbands, N^1 and N^3, and harness cords, C^1 and C^3, in both the first and second repeats in the comber-board. The blanks 2 and 4 would have a different effect, covering the holes in the cylinder opposite wires 2 and 4 they would press them back along with the uprights, W^2 and W^4, admitting of the block being lifted without elevating them, hence neck-bands, N^2 and N^4, with their accompanying harness cords, would remain depressed. It will be observed that the spaces in the card are numbered in the same relative order as the upright and cross wires, the first space on the card corresponding to the first needle in the jacquard. This space also represents the first thread in the design. The holes, P, fit on to the pivots, M, fig. 88, while the small holes, *l*, are for threading the lacing cord through when stringing the cards together.

112. *Double-lift Machine.*—In the ordinary jacquard machine, when forming the shed, those threads which are not lifted remain in a stationary position. To produce a division in the warp yarns in the dobbie or treadle looms the threads are both elevated and depressed. This is certainly the most satisfactory method of dividing the yarns, and is termed double shedding. There are certain arrangements for attaining this result in the jacquard. One of the simplest and most effective motions consists in employing two blocks, the lower one of which rises when the upper one is descending and *vice versâ*. Instead of the bottom hooks resting on the neckboard as at A, fig. 89, they rest on the lower block, which, when the shed is being formed, falls, allowing those wires which have not been engaged by the knives of the top block to be drawn down by the lingoes attached to their harness cords. By this simple contrivance the shed opens from the centre as in treadle or dobbie weaving. To level the warp the upper block or griffe lowers the uprights on its lifting bars, while the lower griffe lifts the uprights resting on its sinking bars.

113. *Harness and Shaft Mounting.*—For some classes of figured fabrics it is necessary to have recourse to both

harness and shaft mountings. The usual method of arranging such a mounting is for the shafts to be placed in the front of the harness just behind the lay or batten. They are lifted by special upright wires and depressed by weights. When weaving fine silk plushes the healds contain the ground warp and the harness the figuring yarns. By this combination of mountings a very fine, rich texture can be produced. In other cases the heddles are employed for weaving or inserting the ground into the figure or design formed by the harness. Thus some five ends might be drawn through each mail in the harness and then separated in the healds—the latter possessing mails of such a length as to admit of a shed being formed in the warp by the harness when they are all on one level. The process consists in the jacquard or harness elevating the threads in groups of fives to produce the required figure, when it remains stationary until the necessary number of sheds has been formed by the heddles to weave the ground of the texture. This class of mounting is largely employed in weaving figured damasks, and other fabrics elaborately ornamented with design.

114. *Uses and Advantages of the Jacquard Shedding Motion.*—The jacquard is a principle of shedding entirely distinct from the witch or treadle motions. The machine is so constructed that practically it affords unlimited scope for pattern production. A design of 48 threads in size is the limit to what may be feasily obtained in the dobbie; but in the jacquard, patterns may be woven containing from 100 to 1,200 ends, or, in certain classes of damasks for curtains and tablecloths, some 56 inches in size. It is no uncommon thing to employ a 600 machine (that is, a jacquard which admits of the production of figured designs containing this large number of individual threads, each of which performs a distinct part in the construction of the design) in the weaving silk fabrics and other elaborately figured goods. By tying up the harness on the pointed draft principle such a machine may be made

to form a pattern of a diamond or lozenge shape, which will contain 1,198 threads before there is a repetition of the pattern. Moreover, it admits of these large facilities for the production of woven figured effects, without any special complication of parts. In this respect it has proved a great boon to the textile designer. The manufacture of figured patterns on the draw-loom previous to its invention was a very laborious task. However, it is not simply in the production of figured goods in which this machine is pre-eminently useful, but also in experimental weaving. It is a principle of shedding that is adapted to all descriptions of fabrics, whether plain or elaborately figured, as the following extract from Professor Beaumont's lecture on the "Jacquard Machine" will show:—

"The witch or dobbie, tappet, and treadle looms are very useful contrivances for weaving some classes of goods, and are, without doubt, better adapted to the work on which they are generally engaged than the jacquard machine; but while the weaving capacity of these looms is limited to 36 shafts, or in some instances probably to 48 shafts, the jacquard may have a figuring capacity of from 200 to 1,200 threads, which makes it suitable for the production of almost any class of goods, whether made of coarse or fine materials, or whether the patterns consist of small figures or of large and complex designs.

"To clearly demonstrate the advantage of having access to a jacquard loom in making trial patterns or "randoms," it will be supposed that a designer has at command three looms constructed on the witch principle, and mounted with 24, 32, and 36 shafts respectively. In these mountings, which may be said to afford the largest possible scope for variety of weave and pattern, it is only practicable to obtain eleven variations in the number of shafts a design may occupy unless the looms are re-mounted, which would imply the labour of re-drawing the warp, and cause a considerable loss of time. Of course, the weaving capacity of these machines opens out a fair field for the production of a diversity of figure and pattern, and would, perhaps, be regarded by some manufacturers as affording ample scope for designing the ordinary run of styles in worsted and woollen fabrics. All this may be true, but the point it is desirable to show with greater force is this, that while eight variations necessitate the employment of three looms, on the witch system—such as those just mentioned,—fourteen variations may be obtained in a 384 jacquard machine, including those weaves that may be produced in the 24, 32, and 36 shaft dobbie looms, with two exceptions. But in addition to these fourteen variations in the number of threads occupied by any weave, and which, when woven, run out in the jacquard, and make a perfect piece of cloth, it is possible to produce, without redrawing the warp, or any other alteration in the mounting of the loom, weaves ranging from three to any reasonable number of shafts used in the construction of a single make cloth, although such weaves may not properly or evenly divide into the total number of threads in the jacquard. For instance, a 384 machine would give in a set of forty-eight threads per inch a pattern of eight inches, in a set of sixty-four threads per inch a pattern of six inches, in a set of seventy-two threads per inch a pattern of five and a third inches, and in a set of ninety-six threads per inch a pattern of four inches in size. So that although the total number of threads which forms the capacity of the jacquard may not be a multiple of the number of threads in the weave, yet such a design may be tried, and a perfect sample of cloth produced, without any time or labour being spent in preparing the loom, further than that of cutting a few cards. Supposing, for the purpose of illustration, a 9 shaft weave is taken (and 384 is not a multiple of this number), there would be in the woven fabric forty-two repetitions of the weave before any brake would occur in the pattern, which would form, if woven in the finest set named—ninety-six threads per inch—a four inch sample of cloth sufficiently large to show the effect of the design.

"This peculiar advantage makes the jacquard loom highly suitable for the pattern weaving room, and gives it an extraordinary pre-eminence over the dobbie or witch; for in the latter machine no weave can be woven to form even the smallest perfect sample of a pattern in the piece, unless the number of threads the weave occupies will divide, without leaving any remainder, into the number of shafts mounted in the loom. Moreover, any design that can possibly be produced by drafting in a sixteen, twenty-four, or a thirty-six shaft witch machine, providing the number of threads it occupies does not exceed the capacity of the jacquard at command, may, without labour being spent in making either draft or pegging plan, be woven in this machine."

CHAPTER VIII.

POWER LOOMS.

115. The Power Loom—116. Development of the Loom—117. Fast and Slow Running Looms—118. Methods of Driving—119. Timing of the Motions—120. Open and Closed Shedding—121. Various Shedding Arrangements—122. Principle of the Tappet Motion—123. Methods of Depressing the Healds in Tappet Looms—124. Variation of the Speed of the Tappet Shaft—125. Construction of Tappets—126. Stroke of the Tappet—127. Dobbie Shedding in Heavy Power Looms—128. Principle of Actuating the Upright Dobbie—129. Lagging and Picking-back Motion—130. The American Shedding Motion—131. Various parts of the American Dobbie—132. Formation of the Shed in the American Loom—133. Special Points in the American Shedding Motion—134. Picking Motions—135. Cam and Cone Pick—136. Over-pick Arrangement—137. Under-pick Motion—138. Positive Letting-off Motion—139. Winding of the Cloth on to the Piece Beam—140. Change Wheel Setting-up—141. Lever and Catch Motion—142. Shuttle-box Mechanisms—143. Link and Chain Box Motion—144. Effects of the Links of the Box Chain—145. Lag and Peg Motion—146. Bowl and Rod System—147. Circular Box Motion—148. Weft Forks—149. Shuttle Box Swell.

115. *The Power Loom.*—Weaving, whether considered from an artistic or a mechanical standpoint, is, unquestionably, one of the most important processes of cloth manufacture. Other operations are only of secondary importance, having for their object the preparation of the raw material for the loom, or the improvement of the appearance, handle, and surface of the woven product. On the process of weaving depends, to a very considerable extent, the success of manufacture in general. The employment of good, sound, even yarn cannot possibly result in the production of satisfactory goods providing

the motions of the loom are in anywise defective. Undoubtedly, this matter has weighed with both inventors and loom makers, and induced them to endeavour to produce a perfect loom. Whether they have yet succeeded can only be ascertained by an examination of the weaving machinery in present use, which certainly ranks amongst the finest and most improved of the factory. Even a casual analysis of the mechanism of the power loom is sufficient to evince the completeness, symmetry and uniformity of its various parts. As a mechanical invention it may justly be classed with the foremost productions of the human mind.

When considering its mechanism it should be remarked that it is not merely a machine of one simple motion, but of a considerable number, all of which work in conformity with each other to attain one result, that of the weaving of a perfect piece of cloth. The power loom is so constructed that it forms the shed in the warp according to the required pattern or design, propels the shuttles in consecutive order across the piece, beats the picks of weft into close contact with each other; in short produces a woven fabric and figures it with design and colour, and finally winds the woven cloth on to the piece beam. All this, and much more, is accomplished by the modern automatic loom; for it is replete with many other minor motions for facilitating quick weaving, such as, for example, the arrangement by which the loom is brought to a standstill without interference on the part of the weaver should the weft yarn be broken or run off the bobbin; and the motion for stopping the loom if the shuttles do not reach their proper destination.

116. *Development of the Loom.*—Of course the loom has gradually developed to its present improved construction. When first invented it was simply sought to produce a woven fabric without manual labour. Shuttle-box and other important motions have all been subsequent inventions—the natural outgrowth of the practical possibility

of cloth weaving by power. Automatic weaving, barely a century ago, was in itself a wonder. The process was slow and imperfect,—the loom, when completed by Dr. Cartwright in 1787, being heavy and ponderous, if not clumsy in construction. Soon, however, the weaving or figuring capacity of the shedding contrivance was enlarged, shuttle-box, positive letting off, positive setting up, and weft fork motions added; so that by stages the loom was equipped with its present accessories. Such is the progress that has been made in power loom construction that now the most elaborate ribbons, carpet and damask fabrics, as well as the simplest textiles, are producible with astonishing rapidity and correctness. Pile or plush, and gauze or leno goods are also woven by power, the wires employed in the production of the former class of textures, which in handloom weaving are inserted by a lad engaged for this purpose, are, in power looms, specially constructed for pile weaving, introduced into their proper sheds and afterwards withdrawn automatically.

The range of textiles which has hitherto only been made on the hand loom is becoming, in consequence of the constant development of the power loom, more limited every year. It is only in the production of fabrics in the weaving of which continual and elaborate changes have to be made in the order of the weft colourings, and in which the utmost care and intelligent skill are necessary to produce a perfect texture, that the former is still employed —excluding, of course, its pre-eminent uses as a pattern loom.

117. *Fast and Slow Running Looms.*—When the mechanism of the loom had been so far improved as to be right in principle, attempts were made, with considerable success, to increase the speed of its motive parts, or to produce a fast or quick-running loom. The result is, that now there are looms of every description—quick and slow running, heavy and light in build, varying in speed from 54 to 300 picks per minute. The most improved loom for

weaving fancy woollen and worsted cloths of a medium thickness, although the shuttle travels for every pick about 90 inches, runs at the rate, on an average, of 84 to 90 shoots per minute.

That a loom can be made suitable for producing all classes of goods, such as light stuff fabrics and heavy overcoatings, is totally impracticable. Experience has taught both the loom maker and the cloth manufacturer, that the weight and construction of the loom must correspond with the strength and thickness of the texture it is required to weave. For fine worsted fabrics or good woollens made of sound, true, elastic yarns a quick running loom is a considerable advantage; but in cloths re-

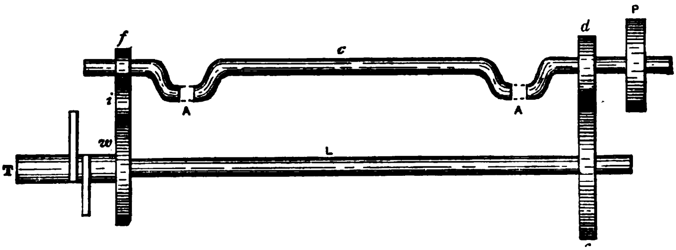


Fig. 91.

quiring heavy wefting, or in which the warp is tender, a slow speeded loom of a heavier build would be preferable. It does not necessarily follow that the most satisfactory weaving is the quickest. A heavy loom for producing oxford shirtings and light stuff cloths is no more a mistake than running at an excessive speed when the yarns are of an indifferent weaving quality. Cases have been known where a more profitable turn-out has resulted from running at the rate of 60 picks per minute than at from 84 to 90; the cause of this anomaly being, the goods from the slow loom were comparatively perfect while those from the quick loom required extra mending and repairing in the finishing operations, necessitating considerable expense to make them marketable. Obviously there can be no advantage in using a fast running loom with, perhaps, one-third as much more turn-out as a slow running loom, if the cloths produced are imperfect or damaged. As, however, fast running is frequently desirable, looms should be employed, the speed of which may be varied to meet, with the greatest facility, the requirements of the change in the strength and elasticity of the warp yarns. There is a plan of employing change wheels, varying in size according to the speed required, each cog making a difference of five picks per minute, by which the loom can be varied in speed. It is applied to the American or Knowles open shed loom, and affords facilities for altering, in a moment's time, the speed of the loom from 70 to 90 or 100 picks per minute.

118. *Methods of Driving.*—Now every class of motion in the power loom is actuated, either directly or indirectly, by the crank or main shaft, which extends from side to side of the loom. In the ordinary top swing loom, such as that shown in fig. 99, on one end of the main shaft the driving pulley, round which the strap passes, is fixed: in low and underpick looms the arrangement is very frequently that represented in sketch 91. The pulley, P, drives the main shaft, *c*, which by means of wheels, *d* and *e*, imparts motion to the low shaft, L. The latter shaft carries the picking cams, and, in tappet looms, the loose tappet wheel, *w*. In both these instances, as the crank shaft is mounted with the strap pulley, the loom is driven directly. There is, however, a mode of driving the crank or main shaft off the low shaft known as indirect driving. Motion in such looms is produced by a short, stout shaft placed at right angles to the crank, connection with the latter being obtained by a pair of bevel wheels, the smaller one of which is the change wheel. This driving gear is shown in fig. 92. Here A is the driving pulley fixed on the short shaft, *g*, which, by means of the change wheel, *h*, and the bevel wheel, B, gives motion to the low shaft, F. Wheel C then

imparts movement to D, which drives the main shaft, E. The advantages of this method of driving are twofold: first, steadier and more uniform movement in the various parts of the loom; and, second, the increased facility with

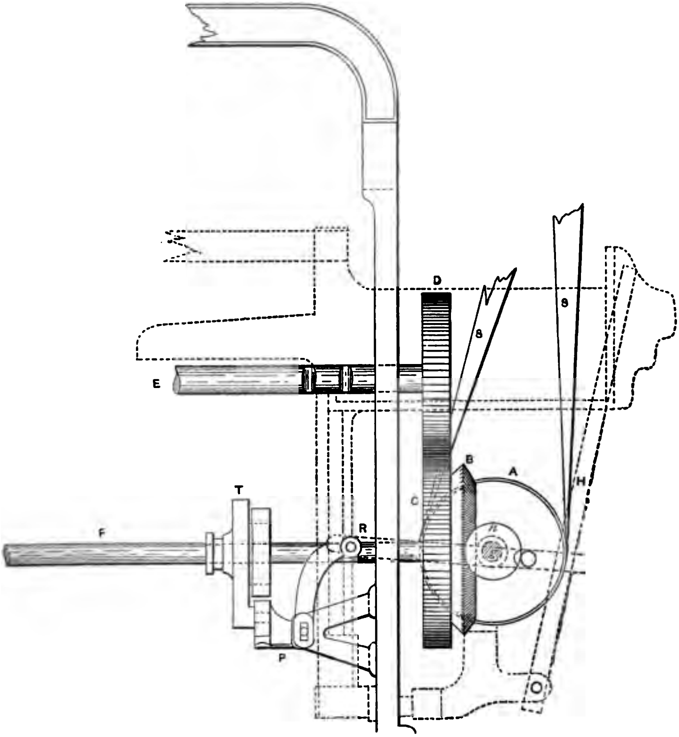


Fig. 92.

which the speed of the loom may be varied by altering the size of the change wheel, *h*.

Assuming that the crank shaft has been set in operation, the routine in which it transmits motion to the various parts of the loom, such, for example, as the shedding apparatus, the shuttle-box motion, letting-off, setting-up, and picking gearings, may be traced. These are the principal motions in every variety of loom, and, when understood, furnish a fair idea of the complete mechanism of the machine, whatever the merits of its weaving capacity, or of its mechanical construction.

119. *Timing of the Motions.*—The order in which the various motions of the power loom operate in relation to each other is as follows:—I. the shedding apparatus begins to raise and depress the warp threads when the going part or lay touches the cloth; II. the picking motion begins to drive the shuttle across the web when the going part is half its complete traverse from the cloth, or when the crank is at the bottom; III. the weft is driven home by the forward movement of the reed as the shed closes; IV. the piece is set up and the warp let off simultaneously with the beating up of the weft; and, V. in drop box looms, the shuttle boxes rise and fall with the shed.

As the timing of the motions is controlled entirely by the movement of the crank shaft, the question may be more clearly explained by referring to fig. 93. On the position of the crank, C, depends the action of the various motions. Thus, as the crank, by arm A, is connected to the race of the going part, B, it moves the latter forward and backward alternately as the shaft S revolves. When C is at the top, as shown in the sketch, and travelling towards the cloth the shed has just been closed, and continues so until the crank is straight out or parallel with the warp threads, when the lay presses against the fabric: at this juncture the shed begins to open and is not fully formed until C is at the bottom (see A, fig. 91) when the shuttle is propelled across the piece, the shed remaining open until the crank points from the cloth, it then begins to close, being quite shut on the crank attaining the top position shown in the drawing. In the open shed loom the timing is the same, with this exception, the shed remains open during the traverse of the crank from the bottom to the top positions, the heald shafts changing if necessary as C travels towards the piece. The order of the motions in the hand loom is thus:—the shed formed by the weaver depressing the treadle, the going-part pressed from the cloth, the pick of weft inserted into the warp, and lastly the going-part brought against the cloth and held in contact with it till the treadle has been again depressed. If this routine is observed, and an expert handloom weaver always adheres to it, the timing

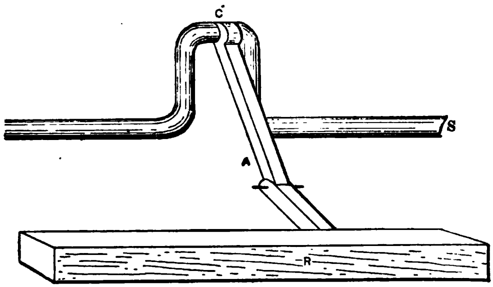


Fig. 93.

of the motions is synonymous in both hand and power looms.

120. *Open and Closed Shedding.*—There are two distinct systems of shedding, open and closed. Generally, fast running looms are constructed on the former, and slow running looms on the latter principle. On the closed shed system the healds are levelled after the intersection of each pick, and the shed is formed from the centre; that is, if a shaft for the preceding shed had been depressed and afterwards required lifting, it would, in the first place, be brought to the centre, and then lifted, the motion, in reality, being of a twofold character. In other words, in all closed shedding looms the shafts are brought on to

one level after the insertion of each pick of weft into the warp. This process is gone through whether the succeeding shed is precisely the same in the design or not. In open shedding the operation is very different. Here if a shaft is down it can be elevated, and if up can be depressed at one movement; so that, in this particular, open shedding has an advantage over closed shedding, inasmuch as it saves time in the formation of the sheds. Moreover the shafts in open shedding remain stationary, or elevated or depressed for any number of picks as required. Other advantages resulting from the use of this class of motion are less strain and friction on the warp, thus affording improved facilities for weaving tender or twitty yarns.

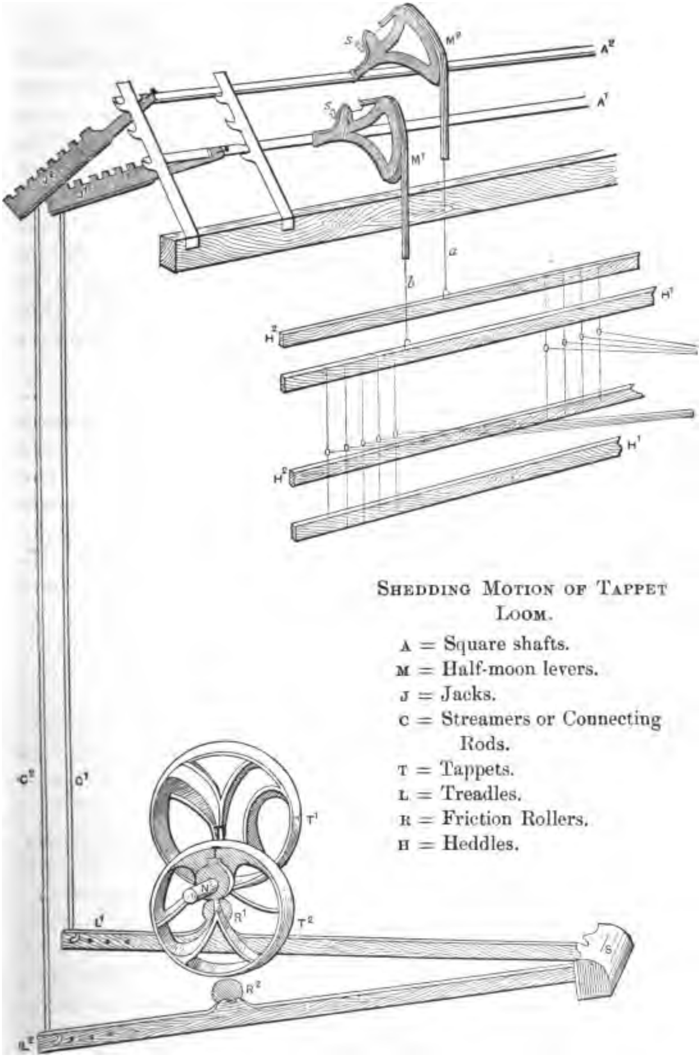
121. *Various Shedding Arrangements.*—The variety of shedding motions in power looms is very large. Practically, however, there are only three principal systems, namely:—

I. The tappet arrangement.

II. The close shedding mechanism as applied to the heavy woollen loom.

III. The open shed motion, such as that applied to the Knowles or American loom.

122. *Principle of the Tappet Motion.*—The tappet is of all power loom shedding motions the simplest in construction. It consists of treadles, tappets, jack levers, square shafts, and half-moon levers. These parts are all shown in fig. 94. The treadles, L^1 L^2, perform the same functions as similar levers in the hand treadle loom, while the tappets or wipers, T^1 T^2, correspond to the weaver's feet, depressing the treadles when the loom is in operation. By means of the streamer rods, C^1 C^2, the treadles are connected to the jacks, J^1 J^2, fixed on the ends of the square shafts, A^1 A^2, which are also mounted with the half-moon levers, M^1 M^2. The cords and straps, *b* and *a*, are attached to the latter by the screw, *s*, and then to the upper shafts of the healds. In the drawing the tappets are shown fixed on the end of the low shaft and not in the centre as in



SHEDDING MOTION OF TAPPET LOOM.

A = Square shafts.
M = Half-moon levers.
J = Jacks.
C = Streamers or Connecting Rods.
T = Tappets.
L = Treadles.
R = Friction Rollers.
H = Heddles.

Fig. 94.

broad looms. Two sets of half-moon levers are necessary for lifting the healds, one for each end of the shafts, but only one set and a portion of the heald shafts are shown in the sketch. It will be noticed that each heddle requires treadle, tappet, jack lever, half moon lever, and square shaft to elevate it, the mechanism for depressing the healds not being represented in this figure. The method of driving the tappets is given in fig. 91. The change wheel, *f*, is fixed on to the crank shaft, and by means of the intermediate, *i*, drives the tappet wheel, *w*. This wheel is cast with the tappet shaft and revolves loosely on the low shaft, L.

The result of bringing the tappets into action, as indicated in fig. 94, is the depression of the front and elevation of the back heddle. Tappet T^2 is here shown in contact with treadle L^2, while T^1 is completely out of action. The effect of this position of the tappets on the heald shafts will be clearly traced, because it demonstrates the principle of this shedding motion. Thus the parts operate as follows: T^2 depressing L^2 draws down J^2, and so imparts movement to the square shaft A^2, which raises the half-moon lever M^2, and the shaft to which it is attached. Should the positions of the tappets be reversed, T^1 instead of T^2 would be brought into action, which would result in elevating H^1 and depressing H^2. Such are the successive changes wrought by this mounting as the tappets revolve on shaft N, producing, in practical work, a plain woven fabric.

The tappet motion is a system of shedding extremely well adapted for weaving simple make fabrics, comprising doeskins, Venetians, single worsteds, oxford and cotton shirtings, towellings, and plain and twilled dress fabrics. It is constructed on the open shed principle, and it is generally applied to quick-running looms. There are many drawbacks to the employment of tappets in fancy weaving, the principal being the very narrow compass they afford for pattern production of a weave character, ten or twelve healds forming a considerable number to be workable by this motion.

123. *Methods of Depressing the Healds in Tappet Looms.*—The parts of the tappet motion considered only lift the healds; it now remains to explain the mechanism for depressing them. Strong, stout springs, or weights, are sometimes employed for this purpose, but the most general and effective method consists of an arrangement of stocks and bowls. This system of drawing down the shafts is based on a simple lever, which is multiplied in power by adding bowls or pulleys, round which straps are passed and attached to the bottoms of the healds. In fig. 95 the "draw" for working four heddles is shown. It consists of

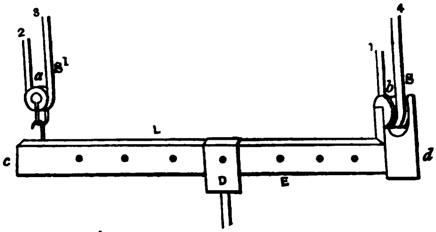


Fig. 95.

the lever, L, of the pulleys, *a* and *b*, and of the straps, s and s'. The ends of the strap s, after having been passed round the pulley *b*, are attached to the 1st and 4th shafts respectively; while the ends of strap s', which passes round pulley *a*, are fastened to shafts 2 and 3. There are two levers (similar to L) employed, one for each end of the shafts. They are fastened to the framework of the loom, and, of course, are fixed underneath the heddles.

To show that this "draw" would admit of any three of the four shafts being up at one time, its effect will be carefully analyzed. Suppose, firstly, that shafts 1, 2, and 3, are required up, and 4 down, then the lever would rise at *c*, and fall at *d*, the strap s lowering at 4 and rising at 1.

Secondly, suppose shafts 2, 3, and 4, are up, and 1 down, then the lever would again rise at *c*, and fall at *d*, allowing shafts 2 and 3 to be lifted together, while strap s would be up at 4 and down at 1: suppose, thirdly, shafts 1, 3, and 4, are up, and 2 down, then the lever would rise at *d* and fall at *c*, the strap s^1 being drawn up at 3 and down at 2: lastly, suppose 1, 2, and 4 are up, and 3 down, then the lever would be lifted at *d*, but depressed at *c*, strap s^1 rising at 2 and falling at 3.

This analysis plainly proves that any arrangement of heddles could be obtained, providing one shaft were depressed in the series. If two additional pulleys were worked by one end of each of the straps, and then two other straps passed round the pulleys added, the lever could be made to work six instead of four shafts. Where there are more shafts depressed by one end of the lever than the other, it is necessary to change the position of the fulcrum, D. For this purpose the lever is divided into equal parts, and the fulcrum pin altered to balance the lighter against the heavier draw in irregular mountings. In a seven-shaft weave, for example, where four shafts are depressed by one end of the lever, and three by the other, the fulcrum pin would be moved to hole E, thus proportionating the lever according to the draw, or as 3 is to 4. The end of the lever lettered *d* would, if the fulcrum were moved to E, for a seven-shaft draw, actuate four of the heddles, and *c* end three of them.

124. *Variation of the Speed of the Tappet Shaft.*—The tappets are keyed on to the tappet shaft, T, fig. 91, which, as already stated, runs loose on the low shaft of the loom. One revolution of this shaft represents one repeat of the weave or design, that is to say, if there are six picks in the plan it would revolve once to the loom picking six times.

To each pick of weft inserted into the warp the crank shaft in all classes of power looms revolves once. In the tappet loom, therefore, as the tappet wheel is driven off the main shaft, it follows that the latter will require to make as many turns to one revolution of the former as there are picks or sheds in the weave. By referring to fig. 91 this can be clearly explained. Wheel *f* here drives the tappet wheel *w*, turning the tappet shaft, T. As every revolution of T implies one repeat of the weave (in other words, if mounted with nine distinct tappets, the insertion of nine separate picks into the warp), its speed has to be varied according to the plan of weave being produced. To ac-

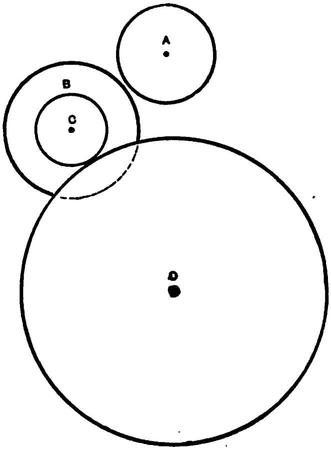


Fig. 96.

complish this the size of the driver, *f*, is changed: this wheel is frequently called the change wheel. The method of ascertaining how many cogs it must contain for any given weave up to six shafts, is extremely simple—thus the tappet wheel, *w*, always contains 120 teeth, which number, if divided by the number of threads the weave occupies, will give the number of teeth in the change wheel, namely, 40 cogs for 3 shafts, 30 cogs for 4 shafts, 25 cogs for 5 shafts, and 20 cogs for 6 shafts. Beyond this it is not possible to go, as there is not sufficient metal, after boring, for the formation of the teeth for a wheel smaller than 20 cogs. In weaves occupying more than six threads, and also in weaves which do not occupy a number of threads that is a multiple of 120, another train of wheels is employed, such as that outlined in fig. 96. Here A is the change wheel, keyed on to the crank shaft, B the intermediate, C the driver, and D the tappet wheel. Now, as the object is to run wheel A several times quicker than D, according to the number of shafts occupied by the weave, the formula for ascertaining the number of teeth in the change wheel is as follows:

$$\frac{B \times D}{A \times C} = \text{difference between the speeds of A and D.}$$

Thus, supposing it is required to weave a nine shaft make, then A would have to revolve nine times to D once, therefore, $\frac{B \times D}{A \times C} = \frac{1}{9}$. Now, assuming, for illustration simply, that B contains 45 cogs, C 15, and D 120, then $\frac{120 \times 45}{9 \times 15} = 40$, number of teeth in the change wheel required. This result can readily be proved by multiplying the two driven wheels, B and D, into each other, and dividing by the drivers, A and C, which should give the number of picks in the weave, thus:— $\frac{120 \times 45}{40 \times 15} = 9$.

125. *Construction of Tappets.*—Each revolution made by any particular tappet, as it turns on the tappet shaft, represents one complete series of the changes of the heddle it actuates. Consequently, if a heald shaft is actuated six separate times in the production of one round or repeat of the weave, the circumference in which the tappet travels is divisible into this number of parts, each section thus obtained representing one pick, or one movement of the particular shaft the tappet is mounted to work. Supposing, for example, it were required to construct the tappet for weave 97, then, as this make occupies eight shafts and

eight picks, a circle would be divided into this number of sections, as indicated in fig. 97A, which is a sketch of the tappet required. The projections represent shafts elevated. If the changes of the first thread in the weave are analyzed, and compared with this tappet, it will be found that the lifts of the former correspond exactly with the projections on the latter. Thus, it is up on the first pick, hence there is a projection on section 1; down on the second pick, equalling no projection on section 2; up on the third, fourth, and fifth picks, corresponding to the projections on these parts of the tappet; and lastly down for three picks, represented by sections 6, 7, and 8. Of course, as every thread in this weave is like the first, only commencing on different picks, the same tappet

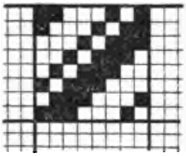


Fig. 97.

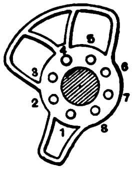


Fig. 97 A.

would be used for all of them, the twilled effect being obtained, when keying the tappets on to the tappet shaft, by placing each tappet one tread or section in advance of the other, or in the same order as the threads in the weave.

126. *Stroke of the Tappet.*—On the stroke of the tappet depends very largely the depth of the shed formed. It does not follow, however, that if the shed is 4 inches deep in the healds the tappet has a 4-inch stroke. There are other parts of the loom that also affect the size of the shed obtained, such as the length of the jacks, of the half-moon levers, and of the treadles. An example will serve to show how the size of the tappet required for producing a given shed may be readily ascertained. Suppose, there-

fore, a tappet loom is mounted with 9-inch jacks, 6-inch half-moon levers, and 30-inch treadle, the friction roller of which is 20 inches from the treadle pin, and that it is required to ascertain the stroke or size of the tappet to produce a shed 4 inches deep in the healds. Now, if the jacks were the same length as the half-moon levers, it would only be necessary to obtain a displacement of the treadles equal to the size of the shed required, which could be done by stating as the length of the treadle—30 inches—is to the distance of the friction pulley from the treadle-pin—20 inches,—so is the latter to the size of the shed given—4 inches. Thus, $30 : 20 :: 4 = 2\frac{2}{3}$ inches stroke of tappet. The length of the jacks and half-moon levers has, however, to be taken into consideration, for if the stroke of the tappet is $2\frac{2}{3}$ inches when these levers are equal in length, it will be larger to produce the same size of shed when the jacks are 9 and the half-moons 6 inches long, the result being obtained as follows:—

Multiply the length of the jacks, 9 inches, by the stroke of the tappet ($2\frac{2}{3}$ inches) to give the required shed when the jacks and half-moon levers are equal in length, and divide by the length of the half-moon levers, 6 inches, thus:

$$\frac{9 \times 2\frac{2}{3}}{6} = 4\text{-inch tappet.}$$

The method of finding the size of the tappet to produce the requisite shed for a shuttle of given dimensions to pass through, when the distance of the healds from the cloth is known, is similar, after the size of the shed in the healds has been ascertained, to that of working the problem just considered. The latter particular can readily be arrived at. Assuming, for example, a going-part makes a stroke of 6 inches, that the healds are 12 inches from the piece, and that the shuttle is $1\frac{1}{2}$ inches deep, what will be the size of the shed in the shafts? All power looms commence to pick when the crank is in the bottom position, or half its traverse from the cloth, or, in this case, when the going-part is 3 inches from the fabric, so that the shed at this juncture must be equal to the size of the shuttle, or $1\frac{1}{2}$ inches deep. Now, it follows that if the shed at 3 inches from the piece is $1\frac{1}{2}$ inches wide, it will be larger at 12 inches, the exact size in the healds being obtained by stating as the distance of the going-part from the cloth when the loom picks, is to the distance of the healds from the cloth, so is the latter to the size of the shed when the shuttle enters the warp, equalling a 6-inch shed in the shafts. The stroke of the tappet for giving this result would then be calculated in the same manner as the preceding example.

127. *Dobbie Shedding in Heavy Power Looms.*—In this system of shedding, which is extensively used in weaving heavy woollens and backed worsteds, the shafts are elevated by a series of jack levers fixed on the top of the loom. Each lever of this kind is supplied with jack blade, needle, and spring. Further, there are in machines of this character two knives or rocking bars, one for elevating, and the other for depressing the healds. All the jack blades are on the lifting-bar before any lags are placed on the cylinder, hence a peg is employed in this machine to press the blades off the upper knife, and thus cause them to be depressed by the falling-bar, K, fig. 98. The actuation of the healds is entirely controlled by the jack blades; if these are elevated by the dobbie, the shafts are lifted, but, if depressed, the shafts are sunken. This arises, in the first place, from the levers having their fulcrums in the centre; and, in the second place, from the upper heald shafts being attached to the blade ends of the jacks, while the lower heald shafts, by means of streamer wires, are in connection with the opposite ends. The effect of these levers on the movements of the heddles may be more clearly pointed out by a reference to fig. 98, which is a sketch of the position of the levers and jacks in the formation of a plain shed. In this drawing, B^1 and B^2 are the jack blades; L^1 and L^2, the top levers for lifting the heddles; J^1 and J^2, the bottom levers for depressing them;

W, the streamer wires; *c*, the connectors; and S [1] and S [2], the shafts or heddles. The principle of the motion is as follows: the blade, B [1] of the top lever, L [1], having been depressed, in consequence of a peg forcing it off the lifting-knife, it sinks at *a*, and rises at *b*. Now, as the long

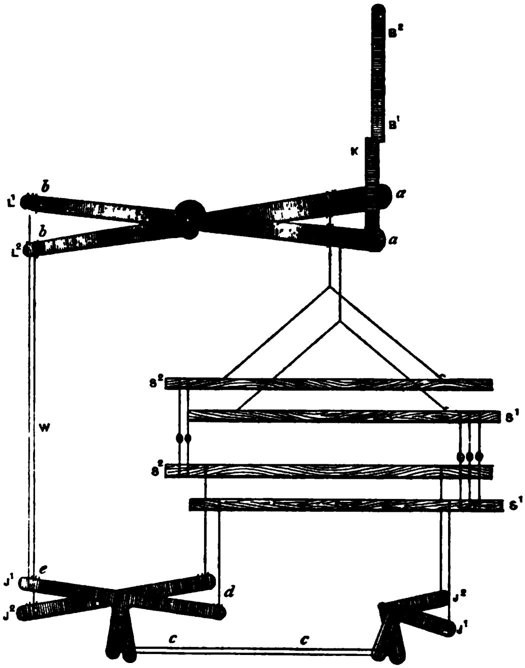


Fig. 98.

streamer wires, W, are connected both to the top levers and the jacks underneath the shafts, and as the latter are also attached to the bottom of the heddles, if lever, L [1], is elevated at *a*, it will depress shaft S [1]. This is clearly indicated in the drawing—J [1] having been lifted at *c*, and sunken at *d*, depressing the heald shaft to which it is connected. At to heddle s², it is elevated by L², the blade of which has been raised by the upper lifting-bar of the dobbie. It will be seen from this illustration that when a shaft is raised, the jacks to which it is attached rise at the opposite ends to what they do when the same shaft is depressed.

128. *Principle of Actuating the Upright Dobbie.*—On one end of the crank shaft is fixed the balance wheel, B, fig. 99, the inside of which contains the shell, fig. 99a. Within the eccentric part of the latter works the stud of the upright connecting rod for giving motion to the lever, L, fig.

Fig. 99 A.

99, which actuates the racks for elevating and depressing the knives or lifting bars. The stud, S, fig. 99a, which is fixed on to the upright connecting rod, C, fig. 99, runs in the groove, A A¹. When in the position shewn in the sketch the heddles are all on the same level, but, as the main shaft, C, revolves, S is made to travel a distance from the centre from which it started equal to the space between A and C. It must be understood that S does not revolve in the groove A A¹ but that it is quite stationary, the shell turning on the shaft C. The upright connector is lifted, therefore, by stud S, and maintained, by the eccentric formation of the shell, elevated until the point A¹ is passed, when it suddenly but steadily falls.

The manner in which the upright in turn gives motion to the lever L, will be evident from consulting fig. 99, which is a drawing of the loom in which this motion is employed. There is just one more point about the shell that should be noted, it is in reference to the "dwell," or

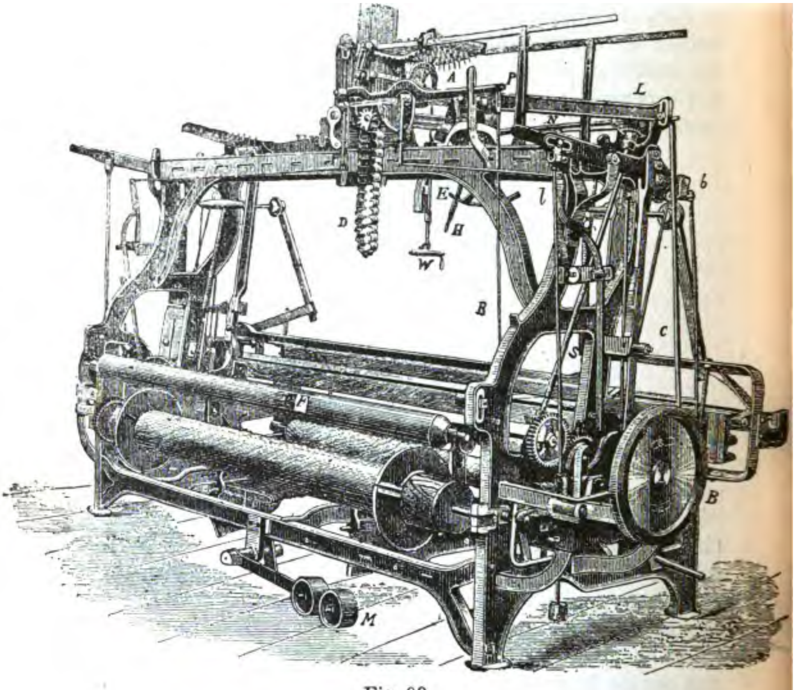


Fig. 99.

the time the shed remains open for the shuttle to pass across the warp. This is determined by the groove A A^1, which is of such a character that when the shell is bolted on to the balance wheel, the shed is closed when the crank has just passed the top position, opening as soon as point

A reaches the stud, and continuing fully open till A^1 passes S, or the crank has made one complete revolution; hence the "dwell" determines the time the shed is retained open for the shuttle to pass through.

The lifting bars or knives are worked on the cog wheel and rack principle, that is to say they are fixed in a pair of racks, so that when one rises the other falls. The jack blades are primarily actuated by the pegs in the lags, A, fig. 99. Each peg works against a separate needle and spring, and presses the blade, to which it imparts motion, off the lifting on to the falling bar. Pegs generally depress the healds. The lags revolve over the cylinder, which makes one fourth of a revolution to each turn of the crank shaft. The cylinder is brought into action by the rods S and N, and bevel wheel gearing. As in the hand-loom dobbie, the number of holes in the lag corresponds to the number of shafts the machine is capable of working.

This class of shedding motion is as positive in action as the tappet loom, for those shafts which are not lifted are in this dobbie depressed, the shed being formed from the centre. For some classes of woollen fabrics it is questionable whether a more suitable motion can be obtained, as all classes of fancy woollen and worsted goods for coatings, suitings and trouserings may be woven by it.

129. *Lagging and Picking-back Motions.*—In power looms mounted with dobbies or engines a simple and effective reversing motion is very important and advantageous to the weaver. It frequently happens that a broken pick has to be turned back to, or the cloth unravelled for one or two inches to undo some imperfection, and without the loom were equipped with mechanism for turning back the sheds, &c., this work would incur considerable loss of time. The reversing motion for the heavy woollen shedding contrivance just considered is of a twofold character. It is controlled by the handle H, and the wheel W, fig. 99. As long as the handle remains in the position shewn in the

engraving the loom weaves straight forward, but should it be necessary to find a broken pick the weaver by removing it to the centre of the frame, E, throws the picking gear out of action. By wheel W he then turns the lags back as far as he considers requisite to enable him to find the wrong or broken shoot of weft. If several picks have to be unwoven the handle H is removed to the point *l*, when, in addition to the picking gear being put out of action, the lag and box cylinders are reversed in motion causing the loom to form shed for shed in the opposite order to that in which they succeeded each other in weaving. The motion, on the whole, is simple, effective and reliable, and is well adapted to the upright dobbie machine to which it is applied.

130. *The American Shedding Motion.*—The object in the ordinary dobbie and tappet shedding motions is to lift and depress the heald shafts by a series of levers, but in the American invention the object is to attain the same result by a system of pulleys. Instead of *lifting* and *sinking* the heddles by jack levers they are, in this motion, *drawn* up or down by a number of pulleys. To each heald there are no fewer than three pulleys, two for elevating and one for depressing purposes. The principle of this shedding mechanism and the manner in which it lifts the leaves or shafts may be forcibly illustrated by passing a cord over a pulley rigidly fixed at any convenient height. Let one end of this cord he held in the hand some distance from and slightly above the pulley and a weight attached to the opposite end. The hand may now be supposed to represent the jack lever, and the weight the shaft. Now, if the former were drawn backward or away from the pulley, it would necessarily lift or rather draw up the weight, and this is exactly the kind of mechanical arrangement adopted in this machine in raising the healds. For example, a strap, in mounting the loom, having been attached to the upper portion of the jack lever, *b*, fig. 102, it is then passed over the pulleys P^1 or P^2, and fastened to the top of its

proper heald shaft; so that if the jack is pulled backward it will elevate the heddle to which it is attached.

131. *Various parts of the American Dobbie.*—Before proceeding to give a detailed description of the manner in which the various parts of this motion are brought into communication with the shaft mounting, it will be necessary to describe each piece separately. The advantage of adopting this course will be obvious to the reader when it is stated that all the parts are dissimilar from those employed in the tappet and dobbie motions previously alluded to. For instance, there is neither spring, needle, lifting bar or knife, top lever, or jack blade in this loom, the following

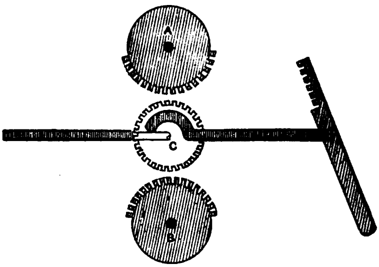


Fig. 100.

parts performing their functions: cylinder gears, vibrator levers, vibrator gears, connectors, and harness jacks. Steel rods take the place of the lags, while bowls, small pullies, or rolls, act as substitutes for pegs.

The Cylinder Gears.—(See A and B, fig. 100.) These correspond, in their relation to the other parts of the machine, with the knives in the ordinary dobbie; the upper cylinder elevating, and the lower cylinder depressing the healds. One-half of the circumference of these gears, as will be evident from referring to the sectional drawing furnished in fig. 100, is in the form of a cog wheel, and hence they have been called toothed cylinders. They are arranged so as to regulate the heald, shuttle-box, and picking motions, and are made in such a manner that the section which works the shafts is adjustable, admitting of the healds and boxes starting at different times; or the former a little in advance of the latter, in order that the shed may be changed previous to the picks or shoots of weft being driven home. This is a considerable improvement to a loom constructed on the open shed principle; because, in such a machine, the lay or batten leaving the piece before the shed has been altered by the engine, the pick or thread of weft last inserted is very liable to spring or fall back; this constituting one of the main causes why looms shedding on this principle do not generally admit of such heavy wefting as the closed shedding motion. The difficulty, however, is satisfactorily overcome in this loom by simply

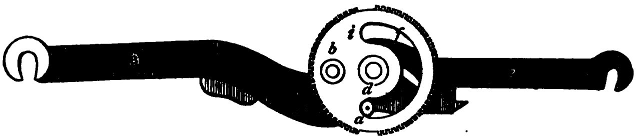


Fig. 101.

adjusting the heddle and box gearings on the cylinder to start operating on the vibrators at different times. Of course, it will be understood that, whenever the toothed section of one cylinder is changed, it is necessary to make a similar alteration in the other.

Either the upper cylinder, A, fig. 100, or the lower cylinder, B, must engage the vibrator gears, C; if the former, the shafts are elevated, if the latter, they are lowered.

THE VIBRATOR LEVERS, VIBRATOR GEARS, AND CONNECTORS.—These, in reality, being connected together, form one piece, B, C, E, fig. 101. The vibrator lever performs the same functions as the needle in the dobbie, receiving the bowl (which is equivalent to the peg in the lag system), of the pattern chain, and the vibrator gears to the jack blade, while the connectors communicate motion to the harness jacks. One very important and notable feature about the vibrator gears is the mode in which they, in combination with the cylinders, operate upon the shafts. No doubt it would be observed, when transmitting motion to the healds by a series of levers on the upright dobbie principle, that strain and tension were applied very suddenly to the warp, and also as suddenly withdrawn; but the special characteristic of this motion is, that the strain on the warp is slight and easy when the shafts commence to move, augmenting until the shed is fully formed, or until the vibrator gears have reached the centre, when the strain gradually decreases to the other extreme of the motion. As these gears are constructed on the crank principle, the greatest speed is in the middle of the throw, the commencement and terminus of the motion being gradual. Thus, supposing the lower cylinder engages the vibrator gear, it carries it forward, tooth by tooth, until it has made one-half of a complete revolution, and lowered, by so doing, its heald jack and shaft. The vibrator gear, C, fig. 101, is rivetted on to the connector, E, at the point lettered *b*, and revolves on a small pivot, or pin, fixed in the lever B at *d*; the slot, *f*, and projection, *a*, determining the extent of its movements. If the lower cylinder engages the vibrator, C, it carries it round to the other extremity of its slot, or until point *i* comes in contact with the iron pivot, *a*, of the lever. This results in E being propelled forward, and in lowering the heald of the jack lever, to which it is secured. Providing the upper toothed cylinder next engaged, C, it would reverse the motion, causing the vibrator to assume its former position, or that represented in the sketch, drawing back, at the same time, the connector and jack, and thus raising the shaft, to which the latter is attached.

THE HARNESS JACKS.—These are somewhat similar in shape to those used in the ordinary loom, but are made all in one piece with their fulcrum at the elbow. (See D^1 and

D², fig. 102.) They transmit the motion of the vibrators to the harness. When drawn backward, they elevate the healds, but when propelled forward, they depress them.

THE PATTERN CHAIN.—This chain, as in other looms, regulates and controls the movements of the heald shafts.

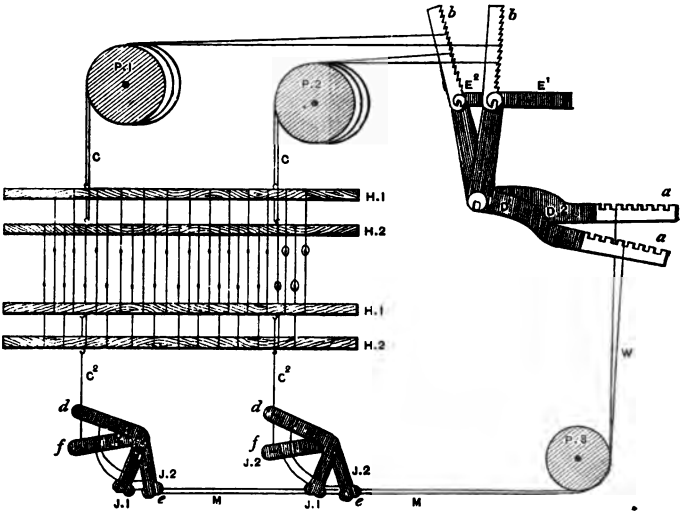
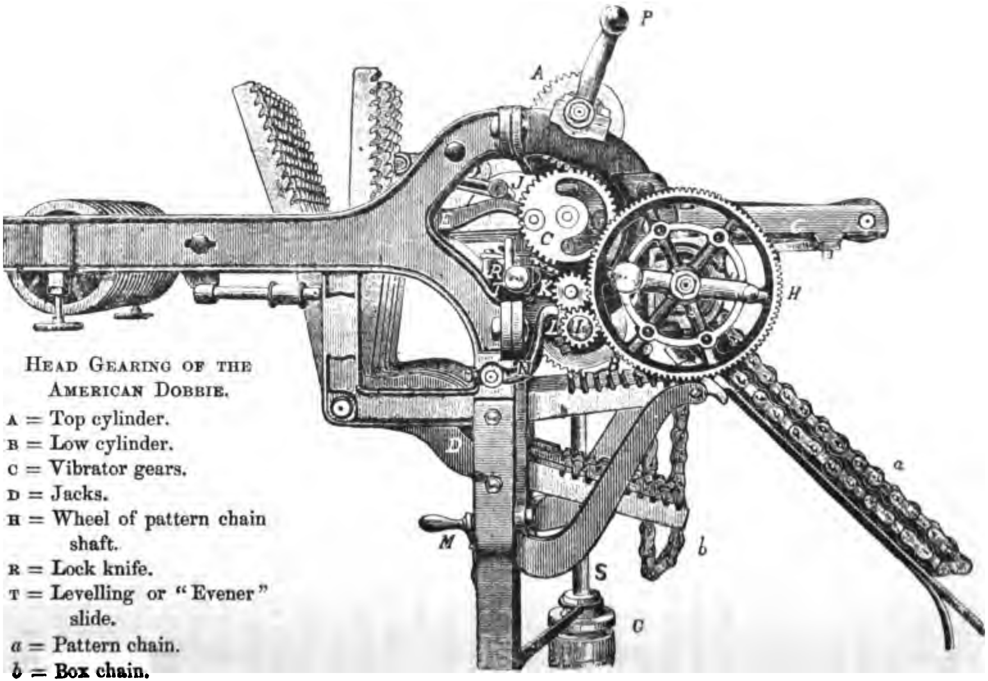


Fig. 102.

It has already been intimated that it is very differently constructed from that employed in other descriptions of dobbies or engines, for it does not consist of a succession of lags, in which pegs are inserted, but of steel rods on which bowls, or small pulleys and bushes are arranged according to the plan or design intended to be produced. Perhaps this method of imparting the pattern to the mechanism of the engine is simpler and steadier than that of the older plan of using lags. At any rate, it possesses this considerable advantage over the latter, the bowls are not liable to accidents by breakages as pegs are, while they possess a smoother action, lifting the vibrator gears gradually; whereas the pegs are no sooner brought into contact with the needles of the jack blades than they force the latter off the lifting bar. Again, a competent workman would, perhaps, prepare a design for the loom as expeditiously on this as on the former principle. He has only to slip the bowls on to the ends of the rods, the distance between each being fixed by the insertion of thin bushes or tubes, varying in size according to the flushes in the pattern. The bushes serve two important and practical purposes:—they keep the bowls in position, and they define the floats of warp and weft in the cloth, or control the skipping of the shafts like the empty holes in the lags.

132. *Formation of the Shed in the American Loom.*—The method of actuating the healds by this shedding motion will be described by referring to figs. 102 and 103. In the latter diagram the mechanism for imparting movement to the jack levers is given, while in the former sketch the positions of the jacks, when the heddles are lifted and depressed respectively, is clearly represented.

The machine is driven by the upright connecting shaft, S, fig. 103, which receives motion through a pair of bevel wheels, from the main or crank shaft of the loom. Upright S carries two cog-wheels for driving the toothed cylinders A and B. The pattern chain shaft, that is, the piece round which chains *a* and *b* travel, is driven off the lower cylinder gear, B. Thus the shaft of this cylinder is mounted with pinion L, working within the teeth of wheel H, fixed on the pattern and box chain shaft I. It will be evident that the connections with upright S are such that, if it is set in motion by the crank shaft, it not only turns the cylinders A and B, but also the pattern chain shaft I. Once in motion the cylinder gears come in contact with the vibrator plates, C, imparting either a forward or a backward movement to the connectors, and the latter actuating the jacks which they individually operate. Should the lever of C be lifted by a bowl on the pattern chain, the



HEAD GEARING OF THE AMERICAN DOBBIE.

A = Top cylinder.
B = Low cylinder.
C = Vibrator gears.
D = Jacks.
H = Wheel of pattern chain shaft.
R = Lock knife.
T = Levelling or "Evener" slide.
a = Pattern chain.
b = Box chain.

Fig. 103.

vibrator is engaged by gear A, and the connector drawn back; but if it is engaged by B, in consequence of a bush or tube having been placed underneath it on the rod of chain *a*, it is carried forward, propelling the jack lever, to which it gives motion, towards the heald shafts. Cylinder A revolves from right to left, and cylinder B from left to right.

Now turn to fig. 102. The vibrator gear of E^1 has been lifted by a bowl, and hence engaged by the top gear A: the lever of E^2, however, has rested on a bush of the pattern chain, causing the vibrator to be carried round by the lower cylinder, B. The effect of bowls and bushes, and also of the respective cylinder gears, will now be apparent. First consider the result of lifting E^1. This connector, having been drawn backward by the cylinder A coming in contact with its vibrator plate, has given a corresponding motion to D^1, lifting, as a necessary sequence, by means of the harness cord C, the front shaft H^1. As the jacks have their fulcrums at the elbow, when drawn backward at *b* they sink at *a*; but, when propelled forward at *b*, as in the case of D^2, they rise at *a*. Unless the jacks thus operated, the cords for drawing down the heddles, C^2, would draw against those for lifting them. According to the arrangement shown, jack D^1 having been pulled away from the healds by connector E^1, has lifted H^1; the lower shaft of this heddle has elevated levers J^1 at *d*, thus maintaining the connecting wires, M, and streamers, W, when the jacks are lowered at *a*, at one tension. Next refer to connector E^2, which has been engaged by the bottom cylinder gear, hence it has imparted a forward movement to D^2 and lowered heald shaft H^2. It will be noticed that the jacks at point *a* are connected by streamer gearing to the levers underneath the healds, which are employed mainly for depressing the shafts. Thus the streamer wire of D^2, having been passed under the heald pulleys, P^3, is attached to J^2 at *e*, while the same jack is in communication with the bottom of the heddles. So that the final issue of D², being raised at *a*, is, that it draws J² towards the pulleys P² at *e*, which depresses it at *f*, and so sinks the heald shaft to which it is attached, namely, H².

133. *Special Points in the American Shedding Motion.*—There are other specialities about this loom to those already enumerated, such as the open shed arrangement, and the contrivances for reversing the head gearing, and for leveling the healds, which merit a passing word.

THE OPEN SHED ARRANGEMENT.—The principal appliance to be considered in connection with the "open shed" is the holding-up bar or lock knife shown at R, fig. 103. This part, by means of an eccentric fixed on the shaft of the bottom cylinder, B, presses the lever N backward, which imparts a corresponding movement to R removing it from the grate. The lock knife is only operated upon by the eccentric when the shed is being formed; this done it is brought against the grate, and kept in position, to retain the exact arrangement of the shafts of the shed produced until the bowls and tubes of the succeeding rod of the pattern chain occupy the places of their predecessors on the chain shaft. In the diagram, R is shown when in contact with the grate, or, in position when maintaining the order of the heddles in the shed last formed.

CONTRIVANCE FOR REVERSING THE SHEDDING APPARATUS OR HEAD GEARING OF THE LOOM.—Some reference has already been made to the importance of a motion of this character. Without an arrangement for reversing the movements of the machine, if a broken pick had to be removed from the fabric woven, the weaver would be under the necessity of turning the pattern chain round and round until he found the shed required, whereas in looms supplied with this mechanism he has simply to reverse the shedding and other motions and lag back to where the damaged or broken pick was inserted. The facility with which this work can be effected in this loom ought not to be overlooked. As the shed, pick, and shuttle-box movements are all controlled by one shaft, it is accomplished by reversing its motions. Thus, the mechanical contrivances are such that when the coupling, G, of the upright shaft, S, has been disconnected by drawing the lever M towards the front of the loom the knob I of cylinder B can be drawn out. The disconnection of coupling G′ makes it possible by handle P to turn the box and pattern chains, and elevate and depress the shuttle boxes without actuating any other parts of the loom. When the knob I is pressed into the cylinder B, it causes a small pinion fixed behind L to work wheel H, and turn the pattern shaft from right to left. On the other hand should the knob be drawn out, L turns pinion K, and the latter turns wheel H from left to right; so that by drawing out this knob, after disconnecting shaft S, the pattern chain can be made to travel backwards by turning the handle P forwards.

ARRANGEMENT FOR LEVELLING THE SHED.—A very considerable drawback to open-shed looms has been the difficulty attending the piecing of broken ends in the warp, with a formed or *open* shed. Some loom makers saw this difficulty several years ago, and supplied motions to their looms for bringing all the healds on one common level, when required. The apparatus for accomplishing this in the American shedding motion consists of the flat piece, T, fig. 103, which is fixed under the front end of the vibrator levers, on to the grate, and is termed the "evener" slide. When this slide is drawn out it raises the gears, O, above the teeth of the bottom cylinder, so that by turning over the upper cylinder gear, A, all the shafts are elevated or brought on to one level, admitting of broken warp threads being repaired with as much facility as in a closed shedding loom. Another very valuable feature about this invention is the system on which all the parts are positively connected together, so that when turning back for a broken pick the shuttle boxes, the shed, and the picking motions always exactly correspond with each other at every point, allowing the loom to be started right off on the fault being repaired. This is not the case with the ordinary dobbie, for after the pick has been found in this machine the shuttle boxes are still out of accord with the run of the pattern, necessitating the shuttles being changed into different positions before the loom can be started. There can be no doubt but that this shedding motion is one of the best extant. In point of weaving capacity, running speed and facility with which its various motions may be adjusted, it is, for the production of fancy tweeds, worsted coatings, &c., superior to any other description of mechanism for actuating the healds, whether applied to slow or quick running looms.

134. *Picking Motions.*—There are three distinct kinds of picking mechanisms: first, the cam and cone motion; second, the over-pick motion; and third, the under-pick motion.

The first class of "pick" is applied to the tappet and to other fast running looms of a light build. It is a simple, steady and sure motion. The "over-pick" arrangement is mainly employed in heavy looms where the shuttle is large and requires considerable power to drive it. The woollen loom mounted with the upright or Dobcross dobbie picks on this principle. An "under-pick" motion is one in which the picking arms operate underneath the shuttle boxes, and not over them as in the two preceding contrivances. Fast running looms, mounted with the open shedding motion, and in which the swords of the going part swing from the bottom of the framework, are usually supplied with the under-pick arrangement.

135. *Cam and Cone Motion.*—Diagrams of this motion are given in figs. 104 and 105. The letters in both drawings refer to the same parts. Thus, A is the picking arm and carries the strap B, which is mounted with the picker for driving the shuttle; P is the upright shaft on which the picking arm is fixed; C is the cone, and is bolted on to shaft P; E is the cam; and M is the low shaft of the loom. It should be noted that only those parts are given in the sketches which actuate the picking arm on one end of the

loom; those on the other side are, however, precisely the same, only the cams of the respective ends are so arranged as to engage the cones at different times.

In fig. 104, the picking arm, A^1, is shown out of action, or before striking. To impart a forward movement to it the upright shaft, P^1, is made to oscillate. This is done by

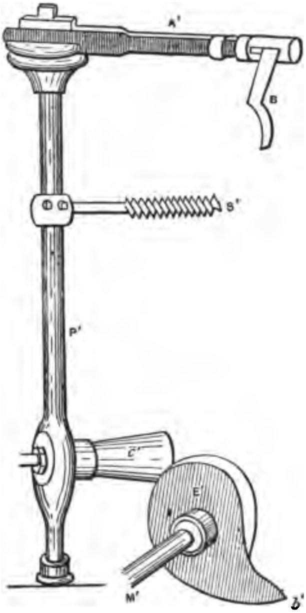


Fig. 104.

the cam and cone arrangement. As the low shaft, M^1, revolves it carries round with it cam E^1, the point, *b*, of which, coming in contact with the cone (see fig. 105) presses it backward and so propels the picking arm towards the centre of the loom. In order to secure a rapid and definite movement of A the cam is curved inward just before the point *b*. After striking, the circular part of the cam allows the picking arm to be gradually brought back to its normal position by the spring, S.

136. *Over-pick Arrangement.*—A much stronger "pick" is required in heavy looms than that of the cam motion. When a shuttle, weighing from 3 to 4 lbs., has to be driven

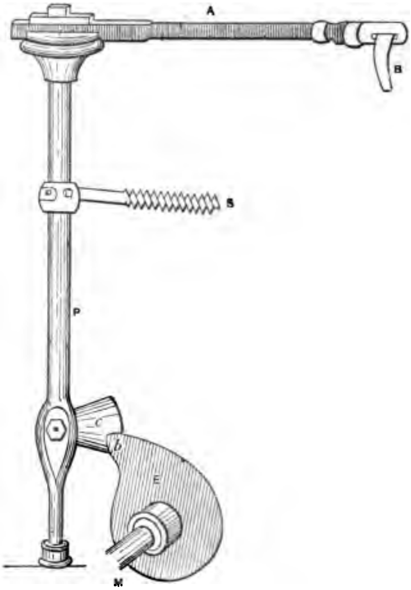


Fig. 105.

across a loom 100 inches wide, and make from 64 to 72 traverses per minute, it is necessary to have a very effective driving or propelling arrangement.

A sketch of the general type of "over-pick" is given in fig. 106, where C is the crank shaft; N, the picking neb or eccentric; T, the picking lever or treadle; R, the connecting rod; L, the lever for actuating shaft E; A, the picking stick; B, the picking arm for carrying the picker; E, the oscillating shaft for giving motion to the picking arm; and S, the spring for bringing A into position after striking. The principle of the motion is this: as the crank shaft revolves it brings the eccentric, N, in contact with the pulley, W, of the lever, T, which depressing L at *d* causes E to oscillate, and impart motion to A, which brings the picker carried by B against the shuttle and so propels it across the piece. The rapidity of the motion depends on the form of the picking neb, which it will be noticed is almost tapered to a point so that it depresses the lever, T, very quickly, and allows it to rise with equal velocity, giving the spring, S, power to draw B out of the shuttle-box as soon as the shuttle has been forced across the warp.

The motion is controlled by the links in the box chain, D, fig. 99. A projection on the links of the chain coming in contact with lever P, causes it by means of rod R and other mechanism to draw pulley W, fig. 106, which works on a pin in the lever T, from underneath the picking neb, so that the latter revolves on the crank without engaging the pulley. Although the lever P, fig. 99, when lifted, throws the picking motion out of action on the right side of the loom, yet it brings the pulley of the lever T on the left side in such a position as it is engaged by the picking neb. In the cam and cone motion the loom picks from each end alternately, but on this system it may be made to pick several times in succession from one side—the order of picking being controlled by the movements of the finger or lever P.

137. *Under-pick Motion.*—This arrangement of picking, like that of the cone motion, is driven off the low shaft. In sketch 92 the parts of the under-pick motion applied to the American loom are shown. The tappet T is caused, by the head gearing of the loom, to engage, as required, the part P, which by means of strap R draws the picking stick, H, forward, and thus gives motion to the shuttle. The picking arms are brought into striking

position by a powerful steel spring fastened to their lower ends.

As in the over-pick motion the loom can, on this principle, be made to pick from either end several times in

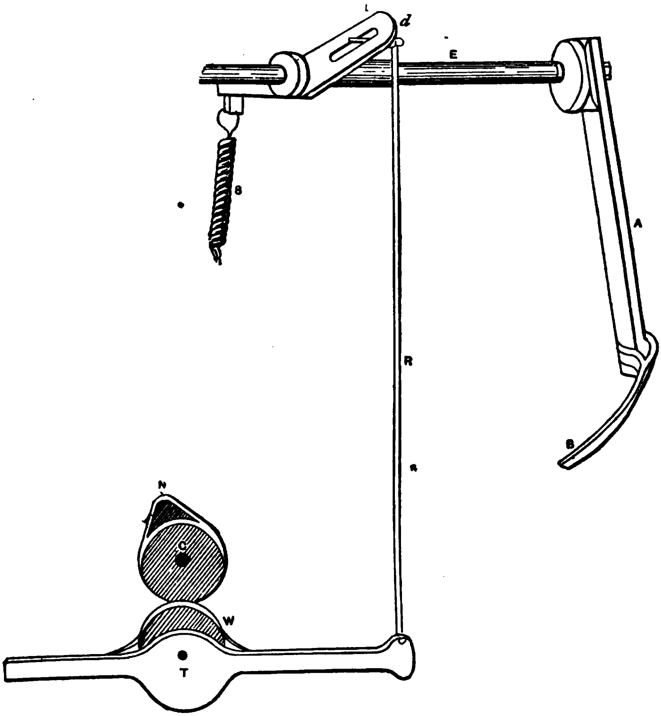


Fig. 106.

succession. A bowl or pulley is used in this case to lift what is called the pick jack; which, when thus raised, gives motion to the picking gearing on the right side of the loom, while the absence of a bowl causes the loom to pick from the left side.

138. *Positive Letting-off Motions.*—The letting-off motion in dandy looms is generally on the twitch rope or friction brake principle. This method of delivering the warp off the chain beam has been described in the chapter on hand looms. It is the positive letting-off arrangement to which attention will now be given. In power loom weaving it is very important that the warp should be delivered as regularly as possible. As a definite length of cloth is "set-up" every time the loom picks, a corresponding length of warp ought to be given off the warp beam. The object of the positive motion is to effect this, hence it is actuated by the same parts of the loom as the setting-up arrangement, namely, either the crank shaft, or the sword of the going-part.

The various parts of this motion, as it is usually constructed, are given in fig. 107. In this drawing B is the warp beam head; W, the perpetual screw or worm wheel; S, the letting-off shaft; D, the brake wheel; C, the catch wheel; H, the connecting rod; E, the letting-off lever; M, the eccentric on the crank shaft; and G, the support for the rest roller over which the warp passes to the healds.

Of course, the object is to impart motion to the wheel, B. To accomplish this, the letting-off rod, S, carries the perpetual screw, W, which works within the cogs of the yarn beam-wheel, so that if this rod is set in motion, it will turn B. Three catch-wheels, C—fine, medium, and coarse in pitch respectively—are fixed on shaft S. The catch *d* is lifted by rod H, the latter rising and falling as the eccentric, M, actuates the lever, E. In some looms the rod, H, is attached to the sword of the going-part. The length of warp let off the beam depends on the screw, F, and support, G, and also on the weight-lever, M, fig. 99. The longer the screw, F, and the lower does the catch, *d*, drop, imparting, when lifted by lever E, a corresponding length of movement to shaft S, and wheel W. Support G, working on pin *e*, relieves the strain on the warp as the going-part presses against the cloth. It does this by allowing the back roller, F, fig. 99, over which the yarns pass from the beam to the shafts, to be drawn slightly inwards. To prevent the roller from yielding too much, G is connected by rod *n*, to the lever, M, (fig. 99), which is weighted according to the tension it is required to put on the threads. Of course, the more G moves inward at *i*, the greater the length of warp let

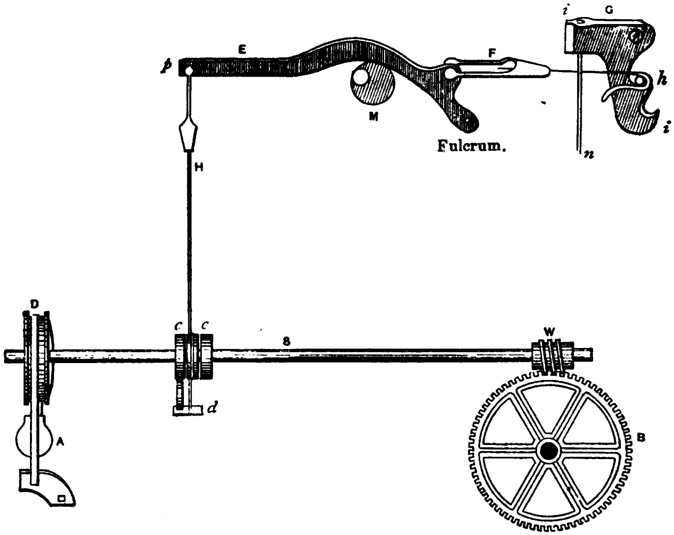


Fig. 107.

off the beam. Thus a thick thread of weft causes the warp to be unwound more than a small thread; for to drive such a pick into close affinity with the preceding shoot, the going-part presses heavily against the cloth, causing G to be drawn towards the bealds to such an extent as to allow the lever, E, to fall considerably at *p*; so that, when lifted by M, as the going-part travels from the piece, it causes catch *d* to actuate one of the wheels C one or more cogs. Providing the weft yarn is small, it can be forced to its destination with less pressure on the cloth, only imparting slight movement to support G, hence the stroke of the lever, E, is correspondingly diminished, probably not turning the worm shaft a single cog. To further describe the principle on which this motion operates, let it be supposed that the going-part is in contact with the piece, or is pressing the last pick of weft inserted into the warp into its proper position in the fabric, at this juncture, the support, G, would be drawn inward at *i*. So long as it remains in the position shown in the drawing, the screw, F, prevents the lever, E, from falling at *p*; but, as soon as its pressure on hook *h*, is withdrawn, the catch, *d*, descends. It must be noted that E is always lifted to the same height by the eccentric, M; but, nevertheless, it has a variable stroke, for it does not always drop to the same extent at *p*. The motion of the support, G, determines the sweep of the letting-off lever. Thus, the less G is drawn inward, the more diminished is the drop of the catch, and hence a corresponding small length of warp is unwound from the yarn-beam. Now, as the going-part moves from the cloth, the eccentric, M, lifts lever E, and catch *d*, unwinding, by so doing, the warp off the beam through the motion thus imparted to wheel B, by shaft S, and worm, W. Lever, M, (fig. 99), as screw W turns wheel B, (fig. 107) draws the support, G, back into the position in which it is sketched in the drawing. As to the strap passed round wheel D, and the weight A suspended to it, they are simply to check the action of catch *d*. But for this weight shaft S would always be actuated proportionate to the stroke of lever E.

139. *Winding of the Cloth on to the Piece-Beam.*—Setting-up motions are of two kinds—that applied to looms of a tappet class, and which invariably works in conjunction with the friction brake letting-off arrangement, and that applied to power looms in which the positive motion, described in the previous paragraph, for unwinding the

yarn off the warp-beam, is employed. The former may be termed the "change wheel," and the latter the "lever and catch" setting-up motion. The change wheel system is applicable to fast-running looms, made for weaving light but fine fabrics, such as cotton goods and dress stuffs; it is not, however, a very useful motion for setting-up heavy cloths, composed of medium or stout yarns, and requiring "hard" wefting, or for fabrics having a large number of picks on the inch. The "lever" arrangement, on the other hand, is best adapted for looms in which heavy goods are produced; in fact, in such cases, it is by far the most preferable motion.

140. *Change Wheel Setting-up.*—This motion (fig. 108) comprises setting-up lever, L; catch, C; ratchet wheel, R; change wheel, W; friction or feed roller wheel, A; intermediate, B; pinion, P; and holding-up catch, H. The piece-beam is turned solely by friction, the sand or friction roller of wheel A, being in close contact with it, so that the movement of A is equivalent to that of the cloth beam. The motion is driven off the sword. Thus, when S moves towards the fabric, it presses the catch, by means of lever L, to which it is attached by pin *g*, forward, imparting movement to the ratchet wheel. Now, as the ratchet works on the same stud as the change wheel, it follows that, if it is set in motion, it will cause W to turn intermediate B, which, through the pinion P, gives movement to A. The holding-up catch is merely to prevent the ratchet from running back when C is carried backward by the receding motion of the sword of the going-part.

The distinguishing feature of the motion is the change wheel, W. By altering the size of this wheel, the number of picks woven to the inch in the fabric can be varied according to the weight of texture required. To find the size of the change wheel, first multiply the picks given by the circumference of the friction-beam in inches, and divide by the number of teeth in the ratchet wheel; second, multiply the teeth in the friction roller wheel by the teeth in the intermediate, and divide by the quotient of Rule I. multiplied by the teeth in the pinion. Example :

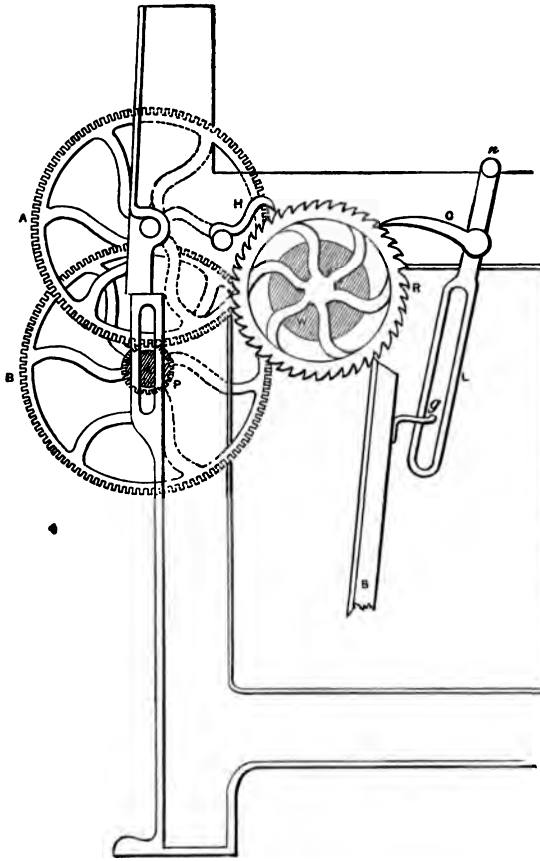


Fig. 108.

Required the number of teeth in the change wheel for weaving 56 picks on the inch, when the circumference of the friction beam is 13 inches, the ratchet wheel containing 60 teeth, friction beam wheel 120, intermediate 120, and the pinion 20.

$$\text{I.}\quad \frac{56\ (\text{picks}) \times 13\ (\text{inches in the circumference of the friction-beam})}{60\ (\text{teeth in ratchet wheel})}$$

$= 12\frac{2}{15}$ revolutions of the ratchet wheel to weave 13 inches of cloth, or to 1 revolution of the friction or feed beam. That is, supposing R = the ratchet wheel, W = the change wheel, A = the friction beam wheel, B = the intermediate, and P = the pinion then, $\frac{A \times B}{W \times P} = \frac{1}{12\frac{2}{15}}$ in another form W must make $12\frac{2}{15}$ revolutions to A making 1. Therefore, the formula, according to Rule II., for completing the problem, will be as follows:—

$$\frac{120\ (\text{teeth in friction beam wheel}) \times 120\ (\text{teeth in intermediate})}{12\frac{2}{15}\ (\text{revolutions of ratchet wheel to weave 13 inches of cloth}) \times 20\ (\text{teeth in pinion})}$$

= practically 59 teeth in change pinion.

141. *Lever and Catch Motion.*—Here there is no change wheel, any alteration in the setting-up of the cloth being effected by the variable movement of the lever, S, fig. 109. Suspended on the rod, *n*, of this lever are a number of weights, W. The larger the number of weights applied, the more is the lever depressed, and the quicker is the cloth wound on to the beam. The various parts of the motion operate as follows: as the sword of the going-part, D, lifts the connecting rod, A, and lever, S, it raises the catch, C, thus giving motion to the catch wheel, R, and also to the pinion, P, the latter driving the piece-beam wheel, B. Holding-up catch, H, is of a two-fold character, possessing two tongues, arranged in such a way that half a cog of wheel R may be set up at one time. In the sketch furnished of this motion, the method of driving off the crank shaft adopted in some makes of looms is shown. It

Setting-up Motion for Heavy Looms.

D = Sword of going part.
A = Connecting rod.
S = Setting-up lever.
C = Setting-up catch.
H = Holding-up catch.
B = Cloth beam wheel.
L = Setting-up lever for driving-off the crank shaft.
E = End of crank shaft and eccentric.

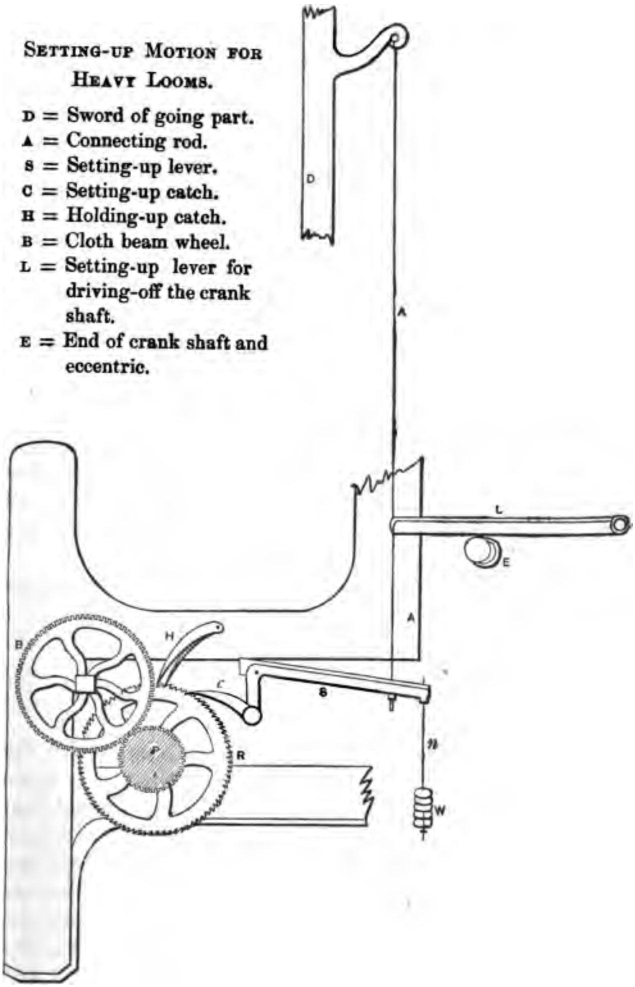


Fig. 109.

B

simply differs from the above in the use of the lever, L, and eccentric, E, in place of the sword of the batten. Thus, as the crank revolves, E raises the lever L, which lifts the setting-up lever, S, to which it is connected by rod A.

142. *Shuttle Box Mechanisms.*—For some reasons it would have been advantageous to have considered the various systems of shuttling in conjunction with the picking motions; but as there are looms in which only one shuttle can be employed, and hence in which a box contrivance is not a necessary adjunct; and as there are other looms in which the shuttling and picking arrangement are quite distinct from each other, there is ample cause for treating the subject separately.

A good shuttle-box motion is a very important accessory to a loom intended for weaving fancy fabrics. The boxes, however controlled, should move at one uniform speed, whether rising or descending, whether revolving forward or backward; and they should, moreover, all work in perfect accord with the other motions of the loom.

There are four distinct systems of actuating the shuttle boxes in power looms, namely:—

I. The link or chain motion.
II. The lag or peg motion.
III. The bowl or pulley and rod motion.
IV. The circular box motion.

143. *Link and Chain Box Motion.*—In this motion the shuttle boxes are lifted by a number of eccentrics, or cams of different sizes. These eccentrics are so combined that they may all be controlled by one lever. They are fixed on the end of the main shaft, and have both a rotatory and a lateral movement. In a 3-box loom the eccentrics are of two sizes only, but in a 4-box they are of three sizes, the largest lifting the fourth, the medium the third, and the smallest eccentric the second box. Two levers, F and F^1, fig. 99, are employed to bring these cams into action. The motions of F are determined by the links of the box

chain, D, revolving over the box cylinder E. This cylinder is driven by rod and wheel gearing off shaft S, which receives motion through wheels J and K from the crank or main shaft of the loom. In reality the motion is divisible into two parts, first, the gearing for actuating the eccentrics; and, second, the gearing for lifting and depressing the boxes. The former gearing comprises the parts sketched in fig. 110. The object here is to cause the disc,

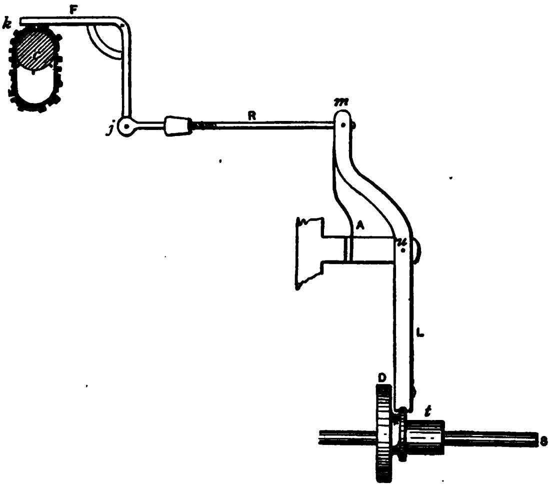


Fig. 110.

D, which carries the eccentrics or cams for lifting the boxes, to travel backward and forward on part *t* of the crank shaft, S. The extent to which it travels determines the box lifted, or the size of cam which engages the box lever. It will be evident, from the arrangement of the parts shown in the drawing, that to impart motion to D it will only be necessary to lift the lever F at point *k*. It should be observed that there is a lever like F and its accompanying parts for each series of boxes. Between them is placed the pick lever P, fig. 99, to which allusion has already been made.

When the loom is in motion the box chain D, composed of iron links of different sizes, passes over the box cylinder C (fig. 110), and necessarily lifts F at *k*, drawing it back at point *j*, and finally, through the lever connections shown, presses D on to the slide *t*. The steel spring A, when F is liberated by the links of the chain pressing against upright L, draws the disc back into its former position.

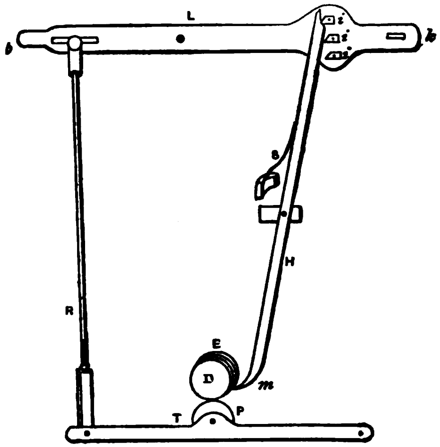


Fig. 111.

Next as to the parts for lifting the boxes represented in fig. 111. Here D is the disc mounted with the eccentrics E. The effect of lifting lever F in the previous drawing was to bring the eccentrics into such a position on part *t* as they would engage pulley P of lever T of this sketch. This done, the connecting rod R sinks lever L at *b* and lifts it at *k*, at which point it is connected to the top of the boxes, as shown at *b*, fig. 99. Upright H then holds the boxes up as long as required, the projections *i* resting on the top of this lever. To depress them the eccentrics are made to engage H at *m*, thus forcing it from underneath the parts *i*, and lowering lever L at *k*.

144. *Effect of the Links in the Box Chain.*—As there are three levers over the box cylinder, two for controlling the motions of the boxes, and a third for controlling the picking gearing, each link of the box chain may be said to be divided into three sections. Thus, part A of the link shown in fig. 112, actuates lever F^1, part B the pick jack P, and part C the lever F, fig. 99. Rod R is simply employed to connect the links together. The effect of the projections is as follows:—

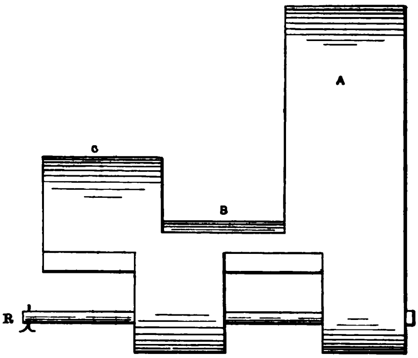


Fig. 112.

(1.) A projection on the right, as at A, lifts the boxes on the right side of the loom.

(2.) A projection in the centre picks from the right.

(3.) A projection on the left lifts the boxes on the left side of the loom.

(4.) The absence of a projection from the centre, as at B, picks from the left.

The projections on parts A and C are of three heights. The lowest projection, C, lifts the second box, the medium projection the third box, while the highest projection, A, lifts the fourth box.

145. *Lag and Peg Motion.*—In large, or top swing looms, such as that shown in fig. 99, the shuttle boxes may be governed in two ways: by the engine or dobbie, or by a chain composed of various kinds of links revolving over a barrel or cylinder fixed behind the loom, that is the method which has just been described in detail. In the lag and peg motion the former is the system adopted in conveying movement to the boxes. For this purpose two principal levers, S, fig. 113, are employed, one for each series of

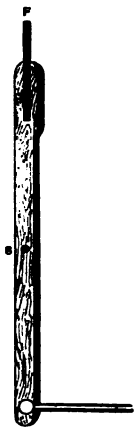


Fig. 113.

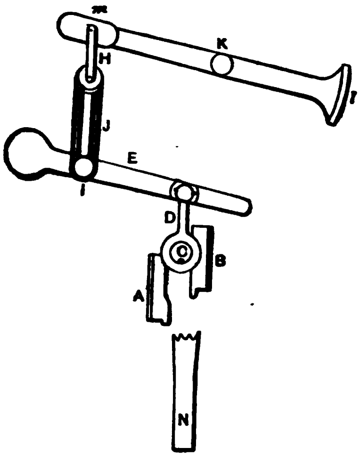


Fig. 114.

boxes; these, in a four-box loom, carry two smaller, or swing levers, F, which are so arranged as to operate indirectly, or through the agency of the levers proper. Thus, if a peg were to strike the outside swing lever it would give one-third of a complete movement to S, and also to the part N, fig. 114, to which it is connected by rod and lever gearing, elevating the second box; the centre swing lever, F, would, however, impart two-thirds of a complete movement to S, raising the third box; while, if the peg came in contact with the principal lever proper, the fourth, or bottom box, would be lifted. From this it is evident that a peg elevates a box, so that, having, when four boxes are employed, three lifts at each end of the going-part, the lag contains six holes for the shuttle boxes and one for the pick jack.

In some looms on the end of the lever L, fig. 111, a large weight is fixed, called the balance weight, which steadies the descent of the boxes; but still the drop is neither smooth nor regular. It will be clear that in such a case the movement of the boxes cannot be so rapid at the commencement as at the termination of the fall; in fact, they necessarily move comparatively slowly at first, but gain speed as they proceed downwards, concluding the drop with considerable vibration. There is the same

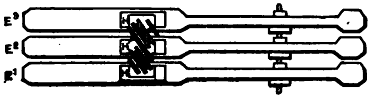


Fig. 115.

defect when a balance weight is not employed, only the vibration caused is more lasting, and even more injurious to the loom, because in such machines, when the stay, or support, H, fig. 111, which maintains the boxes in an upright position, is withdrawn, as there is no checking or balancing power to control the drop, the boxes descend with increased weight on to the low framework of the going-part. Now, in the peg system of actuating the boxes under consideration, if the mechanism employed is that given in figs. 113 and 114, the speed of the boxes is, whether travelling up or down, perfectly uniform. Fig. 114 shows the arrangement of the various parts of the motion for lifting and depressing the boxes. Thus, lever K, at point *l*, is in direct communication with them, while at *m* it is connected to balance weight levers by means of the chain J, and pullies H and I. Fig. 115 is a plan of these levers, showing the method in which the pullies are arranged in the block swinging on lever K at point m; although there is a separate balance weight lever, E, for each lift, yet it will be noticed, there is only one lever proper in direct connection with the boxes. The pullies, H, fig. 115, of the block, are set at an angle with the levers E, to allow the same chain to connect them to the lifting lever. If the outside balance lever, E^1, is raised, it elevates the second box, but in combination with the centre lever, E^2, the third box, while, if the three levers operate together, they lift the fourth box. The connecting chain, J, can never run slack, for when any particular lever is raised the weight of the boxes keeps it at one uniform tension. Again, lever E, fig. 114, is attached to part D, which carries a cam, or eccentric, C, mounted with a pinion working between the two racks A and B. The racks are the parts primarily acted upon by motion of lever N, and convey movement through levers E and K to the boxes. Part N has a twofold motion, receiving a come and go movement from the box lever S, fig. 113, and an up and down movement from a cam on the crank shaft. The function of this lever is to engage the respective racks according to extent of the motion imparted to it by the peg levers. Box lever K is lifted by eccentric gearing on the crank shaft.

A peg on the outside of the lag causes N to engage E^1, a peg in the second hole causes it to engage E^2, and a peg in the third hole causes it to engage E^3. (See fig. 115.) In this system of shuttling there need not, therefore, any complication arise in preparing the box lags, or in changing the picking plan.

146. *Bowl and Rod System.*—This is the motion applied to the American loom. The boxes, which are four in number, are under the control of separate levers, similar in construction to those used for raising the healds. One material advantage this motion possesses over the link system consists in its being worked by the same gearing

as that for actuating the picking and shedding contrivances. As the box, shed and pick motions are driven off the same shaft and by the same cylinder gears there is always perfect accord between them. The levers are of two classes—simple and compound—and one of each kind is required for the complete set of boxes at both ends of the loom. If the simple levers are raised by the bowls in the rods they lift the second boxes, the compound levers the third boxes, and both levers, in combination, the fourth boxes. Still more clearly will this motion be understood by consulting fig. 116. Only the gearing which controls

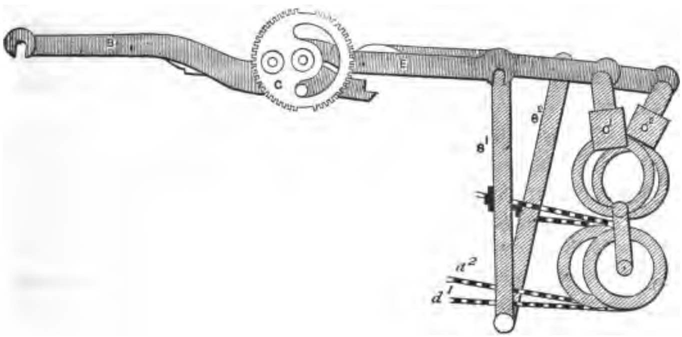


Fig. 116.

the motion, and not that in direct communication with boxes is shown. It will at once be evident that it is similar to the gearing employed for actuating the shafts so far as the vibrator levers, gears and connectors are concerned, but necessarily different in the simple and compound levers. Simple lever S^1, and compound lever C^1, have been operated upon by the top cylinder gear A, fig. 103, which would practically result in lifting the fourth box on the left side of the loom. By passing the chain, d^1, which communicates motion to the boxes, from the simple lever over the pulley of the compound lever, both S^1 and C^1 can be worked together. Lever S^1 is sufficient to effect the elevation of the second box, C^1 the elevation of the third box, while, if acting in combination, they, as just stated above, raise the fourth box. The boxes on the right side of the loom are controlled by levers S^2 and C^2.

The principle of the motion may be defined as that of two levers with arms of different lengths to produce three lifts, the short-armed lever effecting the first lift, the long armed lever the second lift, and the two, when combined, the third lift. The advantages of this system of shuttling are both numerous and important. Firstly, the chain is simple to construct, for there is only one height and shape of bowl and not several as in the use of links; secondly, the boxes like the healds are elevated gradually; thirdly, rising on a spring they may be pressed down by hand, and yet, when released, they will return to their proper positions.

147. *Circular Box Motion.*—Cards in this motion (fig. 117) are the agents for actuating the boxes. They revolve over the cylinder C, which makes $\frac{1}{6}$ of a revolution each time the loom picks. The boxes revolve on shaft E, which carries a circular plate from which project as many pins as there are shuttle boxes. The uprights B and B^1 engage these pins and so impart motion to the boxes on the shaft. A hole in the left side of the card brings B into action, while a hole on the right side of the card sets B^1 in operation. Of course these levers never engage the boxes together.

Over the cylinder C are placed two levers similar to F. Each lever actuates a series of parts like those shown in the drawing. The parts sketched are simply for actuating B, those for imparting motion to B^1 not being represented. Lever F, having its fulcrum at *m*, when lifted at *d* presses back the jack J, the hook of which is thus brought over the grate *g*. On the low shaft S an eccentric or cam is fixed which, by lifting lever P, elevates J, and through it the treadle T. Now as T has its fulcrum pin at *i*, if lifted at *n* it falls at *r*, and so draws down the upright B, the hook of which engages the projection on the circular plate of the shaft E, on which the boxes revolve.

This class of box motion is principally applied to quick running looms, and is well adapted to the production of light fabrics of a check description, such as dress stuffs, shirtings, &c.

148. *Weft Forks.*—The weft fork motion is employed to stop the loom, when the weft yarn breaks, without the in-

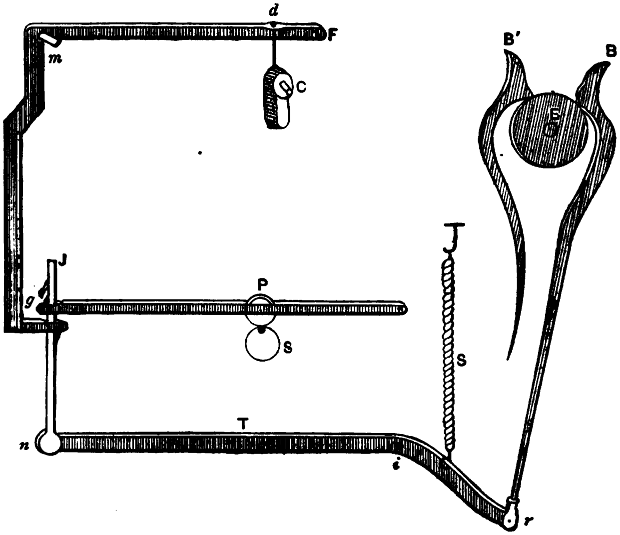


Fig. 117.

terference of the weaver. One very excellent arrangement for this purpose may be explained by referring to fig. 118. Here E is the low shaft carrying the tumbler, D. The object is to throw handle B out of position. Every time the weft is successfully carried across the piece the prongs of the fork F are pressed backward lifting it at *a*, and thus causing it to clear the projection on lever C. Should, however, the weft break, the prongs of F pass between the splits of the reed and hence it fastens on to the top of C. As the tumbler D lifts C at *f*, each time the low shaft revolves, it presses it back at *g*; hence if F fastens on to C it will be drawn backward by this lever, and A will force the handle B off the catch which throws the strap off the fast or driving pulley of the loom.

There are several other kinds of weft fork motions, but the one described (which is applied to the tappet and dandy looms) illustrates the principle on which they are constructed. It may be remarked, however, that in broad looms the fork is fixed in the centre of the race of the going

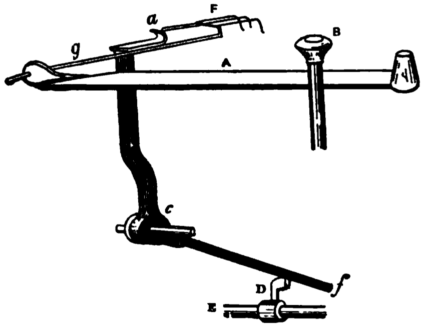


Fig. 118.

part, and is kept above the warp yarns as long as the weft thread continues intact, but drops into a groove in the race on the weft breaking, and so brings the contrivance for knocking the setting-on handle out of gear into action.

149. *Shuttle Box Swell.*—It is only necessary to allude very briefly to this motion, which is employed to stop the loom when the shuttle fails to reach its proper destination, or when it fails to "box." Unless the loom were quickly brought to a standstill under such a contingency very considerable damage would necessarily ensue. In the illustration, fig. 119, S is the swell and consists generally

of a strong steel spring, E the stop-rod finger, and B the shuttle box. Now when the shuttle properly enters the box the swell by pressing E back raises it at *d*, and so

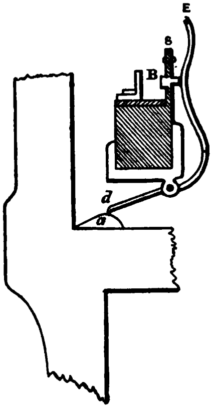


Fig. 119.

causes it to clear the iron projection *a* fixed on to the loom frame. On the other hand, should the shuttle only partially enter the box the swell not being pressed out to the full extent the finger comes against *a* and stops the loom.

CHAPTER IX.

WEAVE-COMBINATIONS. DRAFTING.

150. Four Methods of Producing Textile Design—151. Weave-Combinations—152. Points for Consideration in Combining Weaves—153. Some Weaves applicable to Worsted and other Weaves to Woollen Fabrics—154. The Fineness of the Texture a Factor for Consideration—155. The Weaves Combined should be equal in Wefting Capacity—156. Combination Patterns divisible into Three Classes—157. Uses of Drafting—158. Principle of Drafting—159. Method of Constructing the Draft—160. Drafting large Designs—161. Figured Patterns Drafted—162. Principle of Producing New Designs in a given Draft.

150. *Four Methods of Producing Textile Design.*—In the ordinary classes of woollen and worsted fabrics there are four distinct methods of forming pattern or design in the loom. The first method—that of the employment of single makes in warp and weft yarns of the same colour—has been alluded to at length in Chapter VI. The second method consists in employing two or more different weaves, but only one colour of threads. As to the third principle of design, it comprises a combination of various colours or sizes of yarns in both warp and weft of the fabric, but only admits of the use of one weave. The fourth method is the most comprehensive, including both a combination of weaves and a combination of fancy coloured yarns.

151. *Weave-Combinations.*—The effects resulting from a combination of weaves alone—*i.e.*, the second method of producing pattern in the loom—forms the next step in textile designing to the acquirement of a knowledge of the structure of the various fundamental crossings. Designs formed on this principle cover a very considerable range of the productions of the loom. In all cases where a neatly

figured effect is required—in cloths made of the same shade of yarns, in both warp and weft,—this method of constructing the design is invariably adopted; and hence *combinations*, or patterns composed of several types of intertexture, are applied very largely to worsted trouserings, mantle cloths, dress goods, and other classes of fabrics.

As every plan of crossing, whether twill, mat, diamond, or small figure, produces a different style of pattern in the woven texture, a considerable field for the production of new effects is accessible by combining several distinct types of weaves.

152. *Points for Consideration in Combining Weaves.*—There are certain characteristics which weaves intended for amalgamation with each other must possess in common. Any variety or co-mixture of makes will not produce a regular fabric. Some judgment has, therefore, to be exercised in selecting weaves for combination purposes. The constant modifications obtained in the structure of single weaves makes it impracticable to catalogue those crossings which are suitable for combining with each other in the composition of the same pattern; but it may be remarked, that on no account should weaves be combined without due regard being paid to their structure or plan of formation. In fact, there are two important particulars which should be examined before a combination of small crossings is decided upon—first, the class of fabric intended to be produced, whether wool, worsted, silk, or cotton, and whether fine or coarse in texture; second, the weaving capabilities of the separate makes about to be combined.

153. *Some Weaves applicable to Worsted and other Weaves to Woollen Fabrics.*—The former particular should be carefully considered, because there are some weaves specially applicable to woollen and other weaves to worsted effects. The reason why the same makes are not always suitable for both fabrics will be evident from the sequel. Probably the character of a simple crossing, or any weave effect, is, as a rule, more fully pronounced or developed in

worsted than woollen goods. This arises from the differences in the mechanical construction of the two classes of yarns employed in the manufacture of the respective cloths. Complicated designs, resulting from a novel arrangement of weaves, cannot be so advantageously applied to all-wool suitings and trouserings as to fabrics of a worsted character. When selecting weaves, therefore, for designs intended for woollen cloths, those of a very regular or uniform structure, even if approaching each other in effect, are generally considered the most preferable. As the opposite characteristics obtain in worsted goods, weaves of a very different description are sought after. Here the design formed by the interlacing of the warp and weft yarns is of paramount importance. So much so, in fact, that the principal feature of a piece dyed solid worsted, whether coating, trousering, or mantle, may be termed a decided and clearly-defined make. Consequently the weaves employed in *combinations* for these fabrics may be as different from each other as possible in the effect they produce in the cloth, providing they are similar to each other in one particular, namely, in their weaving or wefting capabilities.

154. *The Fineness of the Texture a Factor for Consideration.*—The fineness of the texture should also be considered when constructing a design formed of various weaves. Generally speaking, the smaller the yarns the larger the flushes admitted in the makes employed. A cloth made of 10-skeins yarn, and containing 24 threads on the inch would be very coarse and open in appearance, if formed of the 8-heald twill, four threads up and four threads down alternately; but if formed of the plain or tabby weave, it would be firm and regular in construction. This clearly shows, that as certain weaves are only useful for some sizes of yarns, it is important to have the fineness of the fabric in view when selecting weaves for combination purposes. The following table has been framed to give the reader some idea of the class of makes suitable for certain yarns

and sets or counts of reeds. What may be termed the standard flush, both in the direction of the warp and weft in the different weaves, has been given. Of course, these flushes cannot always be adhered to, but they will afford the student material assistance and prevent him from falling into gross mistakes, as well as from combining fantastical weaves, which, although they possess a "pretty" appearance on design paper, yet, when practically applied, are perfectly valueless. The table is only applicable to single-cloth combinations. The flushes refer more particularly to weaves of a simple twill and hop-sack character.

	Sizes or Grists of Yarns.	Counts of Reeds.	Average warp flush in weave.	Maximum warp flush in weave.	Average weft flush in weave.	Maximum weft flush in weave.
Woollen.	10 skeins	8's Reed 4's	2	3	2	3
	20 "	10's " 4's	2	4	2	3
	20 "	12's " 4's	3	5	3	4
	30 "	14's " 4's	4	6	4	6
Worsted.	2-fold 30's	12's Reed 4's	2	3	2	3
	2-fold 30's	14's " 4's	3	4	3	4
	2-fold 40's	18's " 4's	3	6	3	4
	2-fold 50's	20's " 4's	4	6	4	6
	2-fold 100's	20's " 6's	6	8	6	8

155. *The Weaves Combined should be Equal in Wefting Capacity.*—Now as to the wefting character of weaves suitable for designs of a combination class. They should in this respect be as nearly alike as possible; if not, the cloth is sure to be uneven in texture, and more or less defective in appearance. However widely simple crossings may differ from each other in structure, if intended to be combined, they ought to possess a similar capacity for the admission of weft, otherwise they cannot be made to weave nicely together. The importance of this may be better understood by referring to fig. 120. Here is given a representation of a sample of cloth of a striped descrip-

tion. The threads in the section lettered A are intersected on the six-shaft hopsack principle, while those in section B are working plain. Now, as the threads of warp and weft interweave each other exactly twice as frequently in B as in A, it will be readily understood that the alternate crossing of the yarns will have a tendency to prevent the weft threads from being as closely pressed against each other in the former as in the latter stripe. The rule is, the more frequently the warp and weft yarns cross each other, the greater the difficulty in driving each pick of weft closely

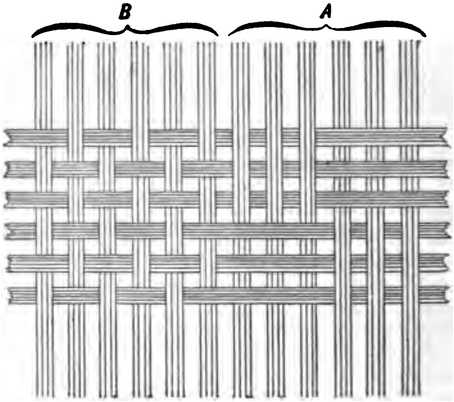


Fig. 120.

against its predecessor. On the other hand, the more open the weave, the better will it take weft. Hence, as three threads of warp are depressed and elevated in succession in part A, this portion of the cloth admits of the weft much more freely than part B. Of course, the larger the stripes the more apparent does this defect become, resulting in section B being *cockled*, and forming an uneven surfaced fabric. Fast and open flush weaves should rarely, if ever, be combined, as they can only be manipulated with difficulty. Certainly, there are some instances where the flushes may be varied without detriment to the regularity of the fabric, but very few. For example, in figured designs, where the various parts are not continuous from one end of the piece to the other, but where a weave is simply introduced for a number of threads and picks to give character to the figure, the diversity of flush in the weaves employed is sometimes very large. In certain classes of dress fabrics the figure or design is formed of large flushes of warp and weft, although such a fast make as the plain or tabby is used for the ground of the fabric; but in such cases the incontinuity of the figured portion of the cloth prevents faulty results occurring like those pointed out in reference to fig. 120.

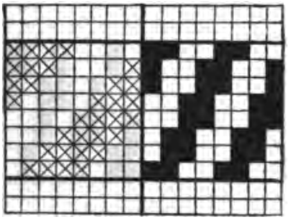


Fig. 121.

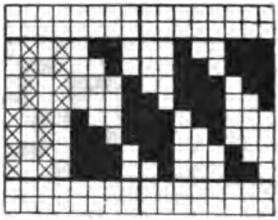


Fig. 122.

For general combinations, the weaves, although they may be decidedly different from each other in the effect they produce in the woven fabric, should, if possible, be similarly constructed so far as the admission of weft goes.

156. *Combination Patterns Divisible into Three Classes.*—The effects obtained from a combination of weaves may be classified as follows:—(1) stripes, (2) checks, (3) spotted or figured patterns. One or two illustrations will be furnished in each class. The striped patterns are, perhaps, the simplest to construct. They are obtained by combining a certain number of threads, varying according to the size of the design, of two or more weaves. Thus, in fig. 121, which is a simple combination of this character,

suitable either for fine woollen or worsted trouserings, only two weaves have been employed. Fig. 122 is another stripe also composed of two varieties of crossings. The section marked in crosses is termed a warp cord, and contrasts very strongly with the double-twilled effect of the adjoining weave. Three types of weave effect are shown in fig. 123. The first part, A, is composed of twilled hopsack; the second part, B, of cassimere twill running to the left; and the third part, C, of the same weave twilling to the right. It should be observed that the makes in each of these designs have been combined in such a manner as to prevent any increases in the flushes of the respective weaves in those positions where they oppose each other.

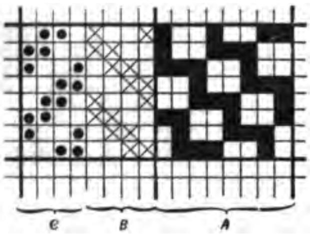


Fig. 123.

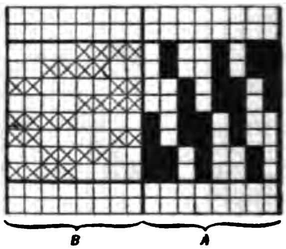


Fig. 124.

In other words, the makes, in each stripe, form what are technically called correct junctions. The matter of fitting the weaves together in such a way as the joinings cannot be distinguished in the woven fabric is of great importance. The makes have frequently to be started on various threads and picks before a satisfactory joining position can be discovered. As an example of weaves of this class examine fig. 124, which, although but a stripe of two varieties of crossings, yet to move either part A or B one shoot up or down, or one thread to the left or to the right, would produce a number of irregular flushes or floats in the design, such as would make a very defective pattern. In all combinations, if practicable, avoid increasing the flushes in the weaves where they are brought in contact with each other in the design.

Check patterns are more difficult to arrange than stripes. In making simple striped designs, the weaves only cut each other on either side, but in checks every side of the

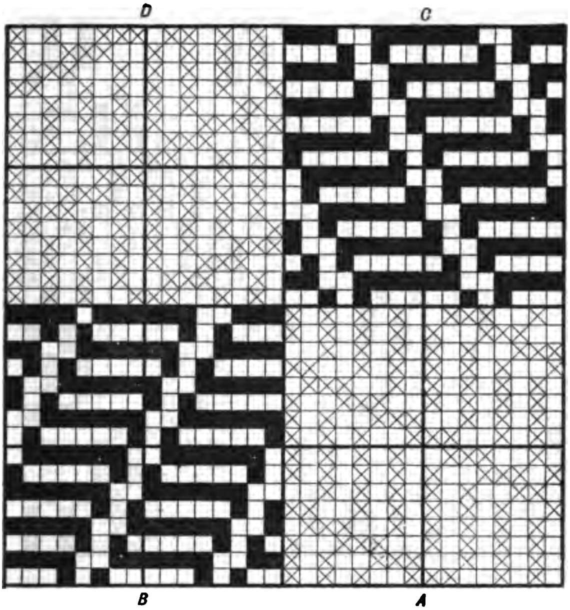


Fig. 125.

weave has to be made fit neatly and perfectly on to the sides of its adjoining weaves. Thus, in fig. 125, which is almost as good a specimen of the effective patterns that may be produced by reversing two weaves as can be furnished, the various parts have been so arranged as to meet each other without any extra flush whatever. This design makes an excellent mantle cloth, producing four varieties of effect in the fabric; for it will be noticed that although parts A and D are formed of the same weave, yet they are opposed to each other in twill, giving, therefore, two distinct effects. The same remark applies to sections B and C. Other examples might be furnished in check patterns, but they occupy so

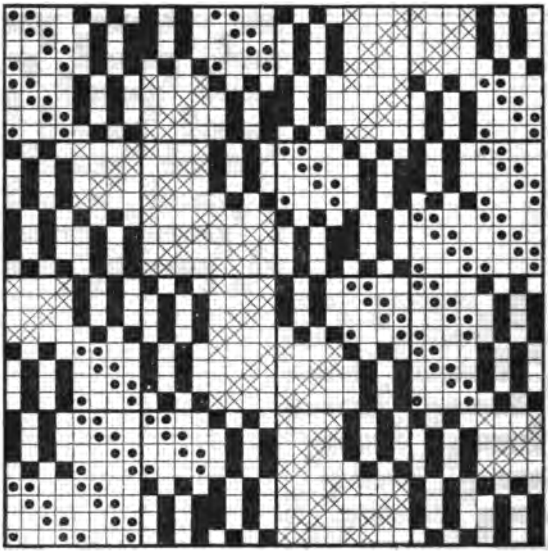


Fig. 126.

much space. A small figured combination is given in fig. 126. It is suitable for a worsted mantlet. The figured effect in the design is obtained by using a weave of a cord or rep class, while the ground is cassimere twill, the weave in one section, that marked in crosses, twilling to the right; while in the section marked in small round dots it twills to the left. This arrangement of twilling and combination of weaves gives a very pleasing result in the cloth.

157. *Uses of Drafting.*—It has been pointed out how designs of a somewhat complex description may be formed by combining simple plans of intertexture, and now it is necessary to explain the manner in which these designs, after having been arranged on point paper, are reducible, in many cases, to such an extent as to render it possible to weave them in the ordinary dobbie machines used in both hand and power-loom weaving. The capacity of such shedding motions ranges from 12 to 36 or 48 shafts, so that any design occupying more than this number of threads could not be produced in looms of this class unless submitted to a reducing process; for it has already been explained that each thread in any weave or design represents a heald shaft in the loom. On this principle, therefore, a 64-thread design would, in a dobbie machine, necessitate the employment of 64 heddles. Perhaps it is unnecessary to say that not only would considerable difficulty be experienced in manipulating the loom when mounted with such an unusual number of shafts, but the expenses of cloth production would also be largely increased. So that here are two important reasons for trying to bring large designs into as small a weavable compass, in respect to the number of heald shafts absolutely essential to their production, as possible. When jacquard or harness looms are not at command, an assay has necessarily to be made to reduce the number of healds the design occupies on point paper. Of course it will be understood that the reducing process to which a pattern may be submitted does not in any way destroy its original character, but rather re-arranges it on such a principle as to make it weavable on a practicable number of healds. The technical name of this process is *drafting*. It may be defined as the method of reducing a design to its minimum number of heddles. In some kinds of figured patterns, more especially those obtained from combining a variety

of small weaves, it not unfrequently happens that the same design contains several threads which have precisely the same movements during the making of the cloth ; in other words, certain integrant parts of the pattern have a similar formation. Now drafting makes it possible to dispense with all the repeats of any particular section or sections, and hence if a design occupies 192 threads, but only contains eight different or individual threads, it could, according to this system, be woven on eight shafts; for, after having been drafted, the latter threads would only be required for what is called the weaving or pegging plan.

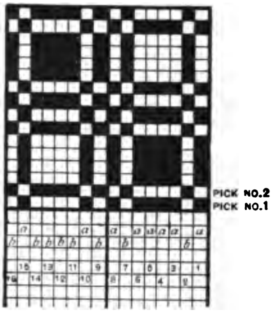


Fig. 127.

158. *Principle of Drafting.*—This subject will possibly be better understood if allusion is made to fig. 127. This weave, although standing on 16 threads, may, if drafted, be woven on two shafts.

That this should be practicable will almost appear contradictory to the principles of design previously explained, for does not each thread in this figure correspond to a shaft in the loom ? How, then, is it possible to weave it on two heddles ? This may be partly shown by considering one or two elementary questions. For example, how is it that while two shafts are only necessary to produce a plain cloth, four shafts are requisite in the production of the cassimere twill? Does it not arise from the fact that there are only two methods of intersecting the warp threads in the plain make, but no less than four methods of intersecting them in the latter weave? This shows that only those threads in a design which *work differently* from each other require separate heddles. Hence, no matter how many threads a weave may occupy on point paper, it may be produced on that number of shafts which corresponds to the number of individual changes it contains in the warp. Here will be found the reason why it is possible to weave the 16-thread design given in fig. 127 on two shafts. Thus, on analysis, it will be apparent that in reality this weave is simply a combination of the two threads lettered *a* and *b*, the remaining threads in the design being simply repeats of these; thus threads 1, 3, 4, 5, 6, 8, 10, and 15, are all similar in arrangement to thread *a*, while 2, 7, 9, 11, 12, 13, 14, and 16, are all exactly like thread *b*. It must not be supposed, however, that if the two threads shown in fig. 129 were taken and applied to the loom that they would, without any special mode of healding being previously adopted, produce the design in the cloth which they have, in fig. 127, been made to form. The weave under consideration occupies 16 threads on the point paper, and hence, to reproduce it in the woven fabric, this number of threads, in the precise order in which they are here mapped out, must be allotted to it in the loom. Such conditions are, for obvious reasons, absolutely essential to the production of any woven effect. From which it is evident that if the reduced plan, fig. 129, is to be of any practical service it must be accompanied by some adjunct or other which will increase it to the required dimensions during the weaving process.

159. *Method of Constructing the Draft.*—The arrangement for the proper completion of a design, when such a reduced plan is employed, is generally termed the healding draft. What has now to be discovered, then, is that

method of entering the warp threads into the heald shafts, which will so modify fig. 129 during the operations of the loom, as to transform it into the design given in fig. 127, in the woven texture. The draft required can be obtained as follows :—First carefully examine the design with the object of ascertaining which threads correspond to each other in arrangement; these should be lettered alike (see fig. 127). Here, as thread 3 is a repetition of thread No. 1, it is lettered *a*, while thread 7, which is dotted in the same manner as thread 2, is lettered *b*, and so on throughout the design. This process gives the number of individual threads the design contains, or the

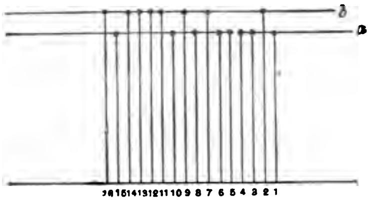


Fig. 128.

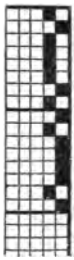


Fig. 129.

number of shafts required to weave it, which, in this case, is only two.

The healding draft proper may be constructed from the letters arranged on the threads of the design. The horizontal lines, *a* and *b*, fig. 128, represent the heddles required, or the two distinct classes of threads in fig. 127, while the perpendicular lines correspond to the sixteen threads in the design. The first thread being lettered *a* it is placed on shaft *a*, while the second thread, for a similar reason, is placed on shaft *b*; so that the letters on the threads in the design indicate the shafts on which they have to be individually drawn in preparing the draft.

One important feature about the healding plan thus formed is that the threads have been dealt with exactly in that order in which they succeed each other in the design. Providing this order were not adhered to the draft could not perform the functions for which it is employed. Now, when the heddles have been charged with the warp threads on the system indicated in fig. 128, they would, if elevated and depressed according to the reduced weave or pegging plan, fig. 129, produce the original pattern. In order that this may be clearly understood let an analysis be made of the effect of draft 128 on this reduced crossing. Shaft *a*, it will be noticed, carries the following threads 1, 3, 4, 5, 6, 8, 10 and 15, while the second shaft is mounted with threads 2, 7, 9, 11, 12, 13, 14 and 16; so that if the former

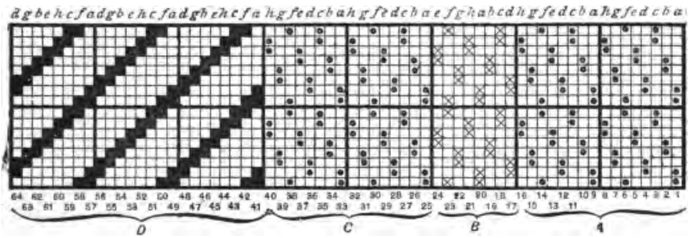


Fig. 130.

heddle were depressed, and the latter heddle raised according to the first pick of the pegging plan, the shed formed would be exactly the same as that of pick No. 1 of fig. 127, for in such a case the first series of threads given above would be down and the latter series elevated. The second pick in the design simply being the opposite of the first it can readily be obtained by reversing the shed. As the remaining shoots are but repeats in a different order of the first and second, the reader will be able to trace for himself the manner in which the peg plan and draft combined, actually reproduce the design, from which they have been deduced.

160. *Drafting Large Designs.*—The extent to which some

classes of patterns are reducible may be illustrated by a consideration of fig. 130. This design is one of the examples given by Prof. Beaumont some years ago at the Yorkshire College, and is published here by his kind permission. It will be seen that it occupies 64 threads, and is composed of four separate stripes, A, B, C, and D. Each of these sections produces a distinct effect in the woven fabric. The character of the pattern may be briefly described as follows:—

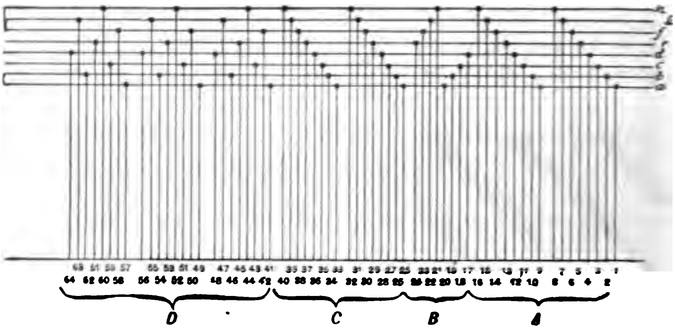


Fig. 131.

A, a stripe of 16 threads of buckskin twill running to the left.

B, a stripe of 8 threads of buckskin twill running to the right.

C, a stripe of 16 threads of buckskin twill running to the left.

D, a stripe of 24 threads of ordinary twill running to the right.

The special feature for analysis here, however, is the method of reducing the design. On examining the pattern carefully and lettering the different threads as they follow each other in the figure, it is found that the whole results from eight individual changes. In other words, sections B and D are composed of exactly the same threads as sections A and C, only they are arranged on different systems. Now, as the latter sections are simply obtained from the first eight threads in the example, only this

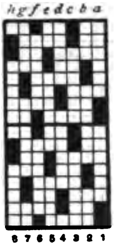


Fig. 132.

number of shafts will be requisite in weaving the design. These have been represented in the draft, fig. 131, by the lines from *a* to *h* inclusive. The method on which the threads are entered into the healds of the shafts can be easily traced by comparing the numerals on the threads in the

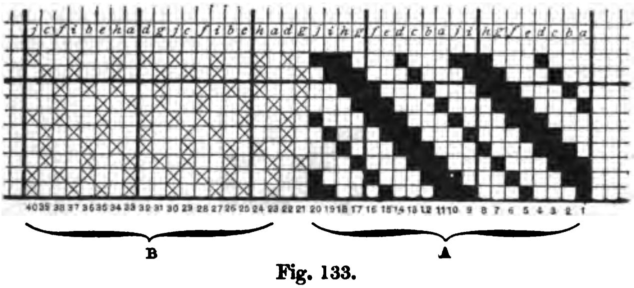


Fig. 133.

draft with those in the design. As the pegging plan to any drafted pattern always consists of one of each sort of threads it contains, arranged in consecutive order, in this example it will be represented by the eight threads given in fig. 132. The design given under fig. 133, is drafted on a somewhat similar principle to that just considered. But as it stands on 40 threads, and is formed of a very different type of crossings, it may be briefly referred to. Section A is composed of a simple twilled weave, while the plan of intertexture in B is more of a fancy

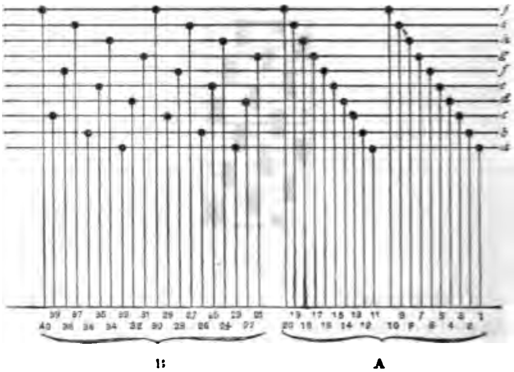


Fig. 134.

diagonal character. Although these makes appear so very differently formed from each other, yet the reader will find, if he compares the threads of the respective stripes, that the design only contains ten varieties, all of which are in-

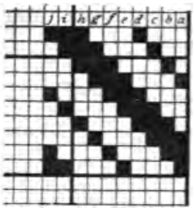


Fig. 135.

cluded in the first ten threads of part A. The draft and peg plan, figs. 134 and 135, being obtained in the same manner as those of the previous illustrations, it is not necessary to explain them in detail.

161. *Figured Pattern Drafted.*—The two last examples are both of a striped description, but a design of a figured character will now be considered; it is given in fig. 136, and is weavable on 16 heddles. It illustrates the variety

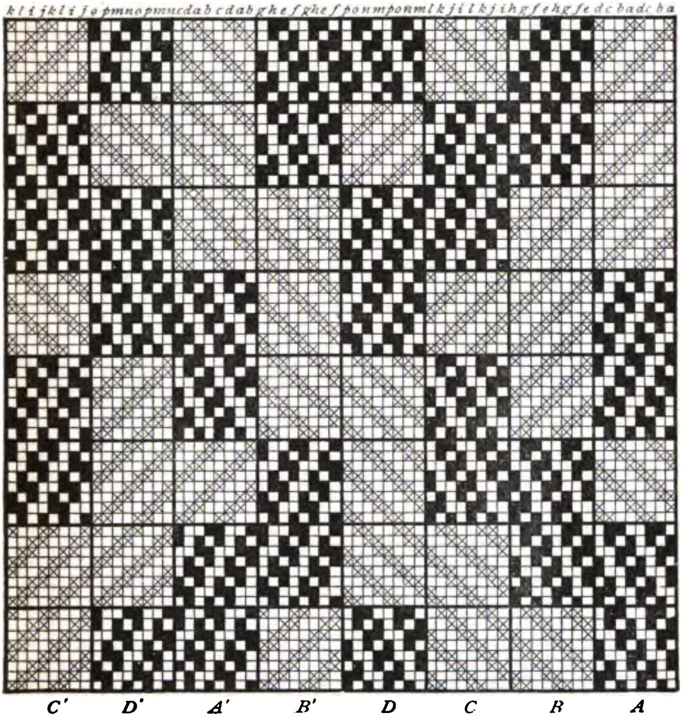


Fig. 136.

of changes which, by drafting, may be produced on a limited number of healds. The pattern may be said to be composed of four parts, A, B, C, and D, each of which is workable on four healds. The only difference between these parts and A^1, B^1, C^1, and D^1 is in the twill of the weaves. Not only is it an excellent design on account of

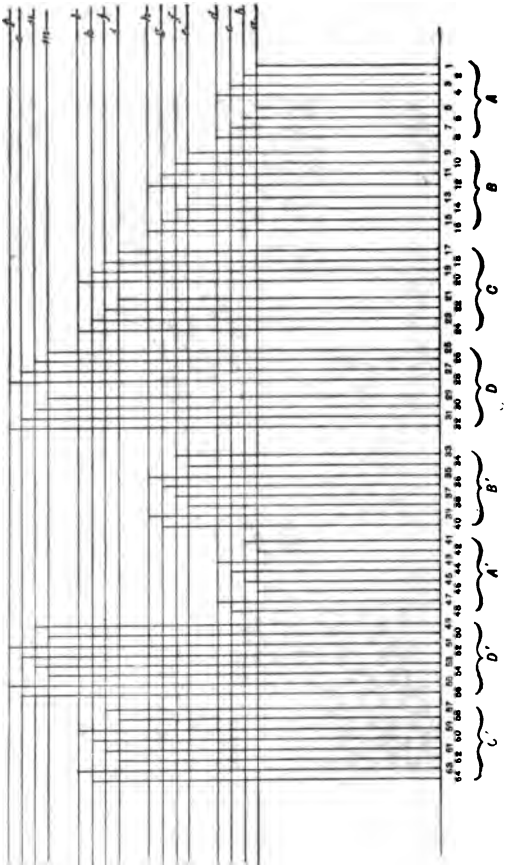


Fig. 137.

the amount of figure obtained on such a small number of shafts; but, also, on account of the ingenious manner in which the weaves have been combined, four varieties of weave effect being produced in the woven fabric by twilling each of the makes employed in two directions. The principle on which the draft and weaving plan, figs. 137 and 138, have been constructed is evident from the letters placed on the threads of both design, draft, and pegging weave, for these relate to the same threads in each case.

162. *Principle of Producing New Designs in a Given Draft.*—There is still another branch of this subject which requires attention. It is this: the principle of varying the weave effect without necessitating a re-drawing of the warp when a complicated draft has been adopted in healding. That there is some difficulty in accomplishing this will be evident from the fact that a considerable proportion of the threads in a drafted pattern have their positions assigned to them in the woven fabric by the healding plan. Thus three parts of fig. 136 are formed in the cloth, when the reduced plan is employed, by the draft. It will be clear, therefore, that unless the healding plan in such cases is taken into consideration, the woven results will be unsatisfactory. A primary point that should be consulted in connection with a draft of this class

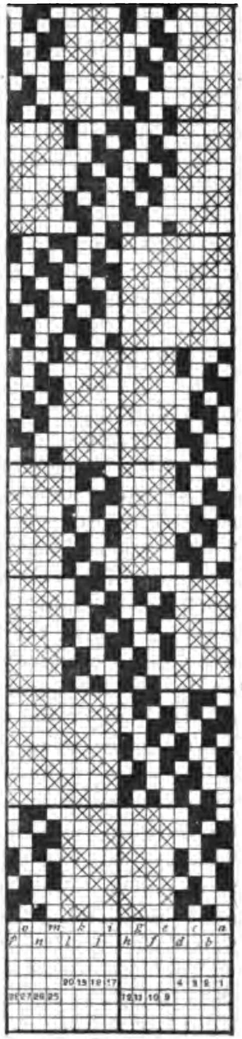


Fig. 138.

is the order in which the threads are arranged, whether in 3's, 4's, or 6's. In the draft furnished to fig. 136 they will be found to move in 4's, hence any weave occupying this number of heddles might be employed without danger of producing an irregular fabric; the effect of six shaft weaves, on the contrary, would be completely destroyed. A 4-shaft make in this draft could only be subject to one modification, and this would arise from the order of healding in the latter four sections being the reverse of the order adopted in portions A, B, C, and D. If, for example, the cassimere twill were applied to the loom after it had been mounted with 16 heddles and healded as indicated in fig. 137, it would be transformed into an angle stripe 32 threads twilling to the left and 32 threads twilling to the right alternately.

The method of obtaining a check effect in a draft of this kind will next be alluded to. A sketch of the pattern it is intended to produce is shown in fig. 139, which has been repeated in order to better illustrate its effect in the woven fabric. Each thread in the sketch represents eight threads in the draft. Parts A, or the thread here marked in solid black lines should, in the design, be formed of the 4-heald hop-sack or mat, the blank squares of cassimere twill and the squares marked in diagonal lines of the same weave twilled in the opposite direction. To proceed with the construction of the design, fill in eight threads and 64 picks on the point paper with hopsack, corresponding to section A of this figure. Now, according to the draft, the same section, in a slightly altered form, is repeated on the threads represented by A^1. By following out this arrangement, two stripes, with 32 threads between them on one side and 16 threads between them on the other side, would be produced. In order to obtain the required check effect it is only necessary to cross them at right angles with corresponding stripes, that is, by filling in the sections represented by d and d^1. The outline of the pattern having thus been completed, the next work consists in adding the detail. The sections should be dealt with in the order in which they occur in the draft. Parts B, C, and D might all be differently formed if it were thought fit, as they are drawn on separate sets of heddles in the draft. The remainder of the pattern would require to be completed thread for thread from the healding plan.

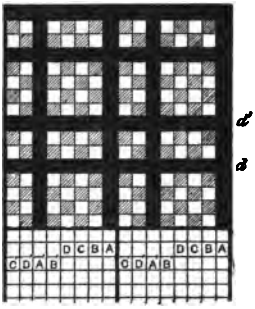


Fig. 139.

When this design is worked out in hopsack and twill, as described above, it produces a very neat style for worsted coatings. A variety of both striped and figured patterns may also be formed in the same draft, but probably the illustration given is sufficient to show the principles on which this class of pattern is obtained.

CHAPTER X.

PATTERN DESIGN.

163. The Function of Weave in Coloured Patterns—164. Effect of Fancy Warping and Wefting on the Plain Weave—165. Hairline Stripes in the Plain Weave—166. Hairline Stripes of Three Colours—167. Figured Hairlines—168. Hairline Stripes of Four Colours—169. Solid Stripes in Mat and other Weaves—170. Examples in Colourings for Simple Striped Cloths—171. Figured Patterns in the Plain Weave—172. Over-check in the Plain Weave—173. Fancy Check—174. Diagonal and Fancy Coloured Patterns—175. Mixtures in the Plain Cloth.

163. *The Function of Weave in Coloured Patterns.*—Thus far the principles of textile design considered have related solely to effects obtained by interlacing, after different plans of intertexture, threads of warp and weft of the same shade together. The method of constructing pattern by employing a variety of fancy yarns in one weave, that is, the second method of producing design in the loom, will therefore be next examined. A considerable assortment of styles in wool, worsted, silk, and cotton fabrics is obtained on this principle. Weave in such cloths is, in one sense of the word, a factor of secondary importance, the design, whether check, stripe, or broken figure, resulting principally from blending several colours or kinds of yarns together in producing the texture. Scotch tweeds are purely illustrative of this type of textile ornament. Strictly speaking, the weave in such fabrics is only useful so far as it constitutes a firm substantial cloth, and enhances the effect resulting from a judicious commixture of colours. Designs of a weave description are sparingly applied to patterns of this character. Thus the weaves used in the manufacture of fancy tweeds are of the simplest construction, comprising such makes as the plain or tabby,

the cassimere, the swansdown or crow, and the six-leaf twills; also, in a few instances, the mayo, eight-heald twilled hopsack, and other regular crossings. There is, therefore, considerable ground for the assertion that Scotch woollen goods may be manipulated, in a weave relation, with as little difficulty as any class of cloth produced; the success they have attained in the trade being due to two causes, purity of materials, and bright and attractive colouring. In the fancy worsted trade it is somewhat different; weave in this case is an important feature of the pattern produced as well as colour, necessitating the use of a large assortment of crossings, occupying from 2 to 36 shafts. From this it is evident that the effect of weave, and of its applicability to pattern mainly due to a combination of fancy yarns, are subjects for study in designing for worsted coatings and trouserings. In woollen fabrics, however, the art of producing saleable patterns consists primarily in a proper selection and blending of shades.

One of the distinguishing characteristics of patterns formed of blends of colours is neatness combined with simplicity. This arises from employing uniform crossings in the production of the cloths, for such weaves not only materially assist in the formation of a neat effect but also construct a good foundation for the application of colour. To suitably develop the shades combined in the warp and weft of the cloth respectively, an even surface on the texture is of the highest importance, and this can be most readily secured by employing a simple weave. Intricate weave combinations are generally more difficult to treat satisfactorily with fancy yarns than an ordinary twill or hopsack make. Then, as a rule, the simpler the crossing the firmer and more durable the woven fabric; so that there are many causes why pattern development, more especially in woollen tweeds, is mainly confined to very simple weaves.

The changes producible in the appearance of plain, twilled, and mat fabrics, by introducing fancy shades into the warp and weft yarns, are varied, interesting and numerous. Of course some styles of coloured patterns can be more effectively produced in one class of weave than another; thus a large variety of stripes, checks and mixtures may be woven in both the four and six-shaft twills, but to produce a hairline stripe, either the plain weave, the prunelle twill, or the broken swansdown make is essential. As a rule the ordinary styles of checked and striped effects are formed in weaves of a twill or hopsack class, where the flushes of warp and weft are about equal, but other types of coloured patterns are only obtainable by using special weaves.

164. *Effect of Fancy Warping and Wefting on the Plain*

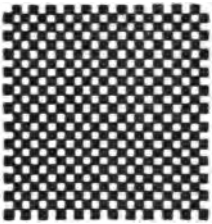


Fig. 140.

Weave.—A few patterns of a striped order, resulting from employing a simple arrangement of coloured threads in the warp and weft of a plain cloth, may now be considered. The simplest pattern obtainable in this weave is that represented in fig. 140. Its method of production is so simple that a passing allusion to it is all that is necessary. Thus it will at once be evident that a series of black and white checks, such as those sketched in this illustration, would result from using a white warp and black weft in weaving a plain fabric—the alternate crossing of these two opposite shades giving the diapered or checked effect represented. To further illustrate the principle of colouring this weave reference will be made to fig. 141. Let it be supposed that the warp for the three sections of this figure is arranged one thread black and one thread white alternately, the order of wefting being, however, different in each stripe. Thus in the first section, *a*, it is exactly the same as the warp, producing two distinct lines of black and white; in the second section, *b*, it is all black, while in the third section, *c*, the weft is all white. The effect of the black weft is to form a solid black line adjoining a broken white line, while the white weft in section *c* gives a solid white line adjoining a broken black line; showing that a variety of patterns may sometimes be originated from interlacing one arrangement of warp yarns with several distinct systems of wefting.

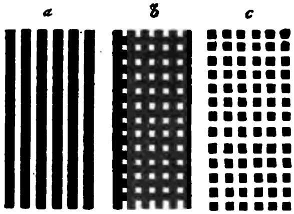


Fig. 141.

The same illustration may also be employed to demonstrate the effect of different methods of warping on one order of weft threads. Supposing, for example, this sketch represents a fabric in which part *a* is warped as above, one thread black and one thread white; part *b*, warped all black; and part *c* composed entirely of white warp yarns; the weft for each stripe to be one pick black and one pick white alternately; then precisely the same results would be obtained as just described; from which it is evident that the appearance of the cloth may be modified by applying fancy colours in two ways, (1) by varing the order of warp yarns; (2) by varying the arrangement of weft yarns. To produce check, mixture, and other patterns, coloured threads are introduced into both these series of yarns.

165. *Hairline Stripes in the Plain Weaves.*—The causes to which the patterns sketched in fig. 141 are attributable deserve some explanation. It may, therefore, be useful to consider how, from a plain weave warped and woven one thread black and one thread white, the solid lines of these colours sketched in section *a* have been formed. Such a pattern is called a "hairline" on account of the smartness and smallness of the respective stripes in the woven fabric. The separate lines of colour, in a finished cloth of this character, are as solid and continuous as if they were painted on the surface of the texture with a fine brush. An effect of this class can only be obtained by covering the black warp with the black weft, and

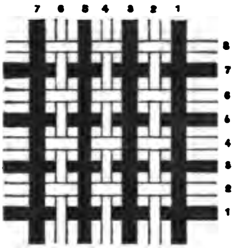


Fig. 142.

the white warp with the white weft; and unless the weave used is constructed on such a principle as to admit of this arrangement of yarns during weaving, the formation of the separate lines is impracticable. That the structure of the plain make allows of the production of this pattern, however, is evident from the order in which the two classes of yarns intersect each other in the construction of the fabric. It follows that as this crossing only contains two threads and two picks, the odd picks will always cover the odd threads, and the even picks the even threads. A reference to fig. 142 will show that this is the characteristic which makes it feasible to produce a stripe of two solid colours in the plain make. Here, it will be noticed, the black picks, 1, 3, 5, and 7, enter the warp when the black threads are depressed and the white threads elevated; hence, while the solidity of the black stripes is thus preserved, that of the white stripes is not interrupted. The same conditions are observed during the introduction of the white picks—namely, the black threads are lifted and the white threads are depressed, preventing the former from being covered with an opposing shade, and also preserving the continuity of the respective stripes.

166. *Hairline Stripe of Three Colours.*—It will be clear from the analysis furnished of a thread-and-thread hairline stripe, that each line of colour in any pattern, providing it is solid from one end of the piece to the other, must,

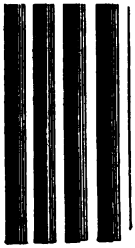


Fig. 143.

in weaving, be crossed with a corresponding colour of weft. This may be said to form the principle on which all hairlines are produced. Hence, in order to form three or four lines of different shades of yarn, weaves containing these numbers of shoots, and in which each pick intersects a separate warp thread, must necessarily be employed. To make this clearer, the plan of constructing a stripe of three distinct colours similar to fig. 143 will be described. Not only is it essential to use a 3-shaft weave to procure this pattern, but the weave must also contain at least three picks in order to admit of each of the single thread stripes being covered with such weft yarns as matches them in colour or shade. The prunelle twill, fig. 143*a*, will be found to be the weave exactly adapted to these requirements. The pattern of both warp and weft of this striped effect is arranged as follows:—One thread black, one thread grey, one thread white. The first thread and first pick of the weave according to this order of colouring will be black; the second thread and second pick grey; and the third thread and third pick white. On comparing the plan of crossing the threads with the methods of warping and wefting, it will be ascertained how the weave, and arrangement of yarns alluded to, combined, produce the pattern required. The following analysis of the interweaving of the threads on the prunelle principle will explain the system on which the individual stripes of colour are formed:—

The first pick (black), depressing the first thread (fig. 143*a*), and elevating the second and third threads, floats under the grey and white, but over the black yarns in the warp, thus forming a solid black line.

The second pick (grey), depressing the second thread and elevating the first and third threads, floats under the black and white, but over the grey yarns in the warp, thus forming a solid grey line.

The third pick (white), depressing the third thread and elevating the first and second threads, floats under the black and grey, but over the white yarns in the warp, thus forming a solid white line.

167. *Figured Hairlines.*—The effect of the same order of yarns in weave 143*b*, which is just the reverse of weave 143*a*, will next be pointed out. The first pick of this crossing, depressing the second and third threads, floats under the black thread, and over the grey and white threads, producing a black line across the piece; the second pick, depressing the first and third threads, conceals the black and white warp, and, in conjunction with the grey threads, gives a grey line across the piece; while the third pick produces a white transverse line, because the black and grey threads are down during its introduction into the

warp. Instead, therefore, of giving stripes lengthways of the fabric, this make forms them in a transverse direction. This being so, by combining weaves 143*a* and 143*b*, a considerable assortment of patterns in checks and figures may be produced. Take the design given under fig. 145 as an illustration. This small checked weave when warped and woven in the same order as the preceding styles gives the basket check effect, sketched in fig. 144. The parts lettered A of the design form the longitudinal, and the parts B the transverse stripes. As there are two repeats of the weave in each section of the design, there is the same number of black, grey, and white lines in every part

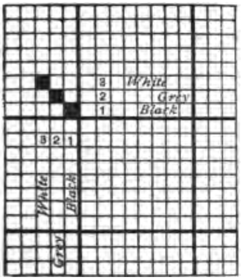


Fig. 143 A.

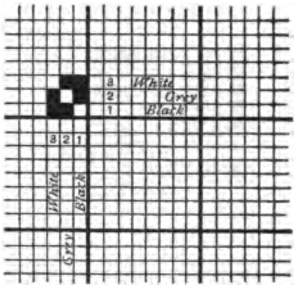


Fig. 143 B.

of the pattern. This style of effect is very frequently seen in all wool goods of a suiting, dress, and shirting class.

The plan most frequently used, however, is that given in fig. 146, which is usually warped and wefted two threads of a dark shade, and one thread of a medium or light shade.

Of course, this arrangement only gives two lines of colour, but as the weaves can, in producing this pattern, be more correctly combined than in the design for fig 144, they form a better and evener texture.

168. *Hairline Stripe of Four Colours.*—Fig. 147 is a hairline stripe composed of four colours. It may be ob-

tained by employing weave 147*a*, and arranging the warp and weft yarns as follows :—

Warp.	Weft.
1 thread of black . .	1 pick of black.
1 „ dark grey .	1 „ dark grey.
1 „ mid grey .	1 „ white.
1 „ white . .	1 „ mid grey.

The reason for changing the positions of the white and mid grey yarns in wefting will be apparent from an examination of the structure of the plan of make used.

Thus the first and second picks of weave 147*a*, depressing the first and second, or the black and dark grey threads of the warp, form continuous lines of these respec-

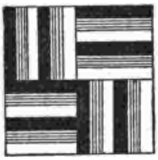


Fig. 144.

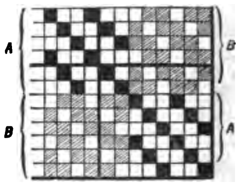


Fig. 145.

tive shades; but it will possibly be noticed that the third pick takes down the 4th thread, which, according to the pattern of warp is white, and hence to make the line of this colour solid in the piece, this pick must also be white; while the 4th shoot, for a similar reason, namely, because it covers the light grey warp thread, it must also be of this colour, and not white as the fourth thread in the warp. The pattern produced by this arrangement is very largely applied to woollen goods, being neat and quiet in appearance, more especially if judiciously coloured.

169. *Solid Stripes in Mat and other Weaves.*—To produce stripes of two threads in width, instead of one, the weaves have to be differently constructed. An illustration of one type of makes used for this purpose is given in fig. 148. This crossing is sometimes employed in making worsted

trouserings. If the threads in the warp were arranged 2 black, 2 olive, 2 light drab, and 2 olive again, and the weft 2 black, 2 olive, and 2 light drab, the pattern produced would be of the following description :—

1st, a continuous stripe of two threads of black.				
2nd,	,,	,,	,,	olive.
3rd,	,,	,,	,,	light drab.
4th,	,,	,,	,,	olive.

The reason why the 7th and 8th threads of the pattern are exactly like the 3rd and 4th, is on account of the structure of the weave, for it admits of both these pairs of threads being covered with the olive weft during weaving. By this means another style of effect from those already described is secured.

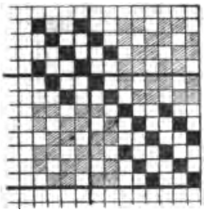


Fig. 146.

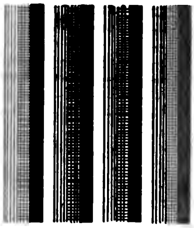


Fig. 147.

A simple two-and-two thread stripe is generally woven in the 4-shaft hopsack. Fig. 149 shows the system on which the warp and weft yarns intersect each other in gaining an effect of this kind. The pattern obtained strikingly illustrates how the character of a weave may be changed in the woven fabric by the addition of colour. This make, unless the threads are arranged on the principle here indicated, invariably gives a mat or check effect in the cloth, but in this example it has here been used in such a manner as to be the agent in forming two solid lines of black and grey respectively.

170. *Examples in Colourings for Simple Striped Cloths.*— No allusion has been made, as yet, to the diversity of

colouring that may be applied to the various styles described. But it will, without doubt, be obvious that an almost endless variety of changes may be obtained, by a simple modification of colours, in these weaves with the precise orders of threads already given. Here are a few examples of colourings to be woven in the same order as those previously furnished to fig. 141.

I.			II.		
1 thread of black.			1 thread of black.		
1	„	black and blue twist.	1	„	black and olive twist.

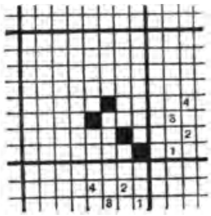


Fig. 147 A.

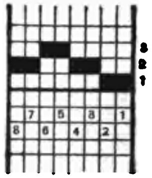


Fig. 148.

III.

1 thread of olive.		
1	„	white.
1	„	olive.
1	„	black.

If the weft for the latter pattern were 1 pick olive and 1 pick white, it would, in the plain weave, in which it is intended to be woven, give continuous stripes of these colours only, for the black thread in such a case would be crossed with white.

The following colourings are given as a sample of the class of shades which may be combined, with good results, in fig. 143.

I.			II.		
1 thread of white.			1 thread of black.		
1	„	drab.	1	„	mid green.
1	„	olive-brown.	1	„	black and blue twist.

III.

1 thread of dark brown.
1 „ light brown.
1 „ blue-lavender.

These examples have simply been furnished to show that when once the principle of producing any one of the effects described is understood, ingenuity and taste may be exercised on a variety of colourings almost *ad infinitum.*

171. *Figured Patterns in the Plain Weave.*—In the plain weave, particularly in woollen cloths, a considerable variety of patterns obtains of a check, mixture, and spotted or small

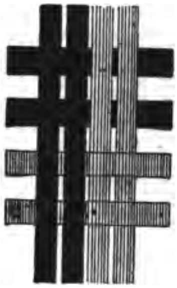


Fig. 149.

figured character. As the effect of this weave in the woven fabrics is *nil*, such designs are developed entirely by the systems of combining the fancy yarns in the manufacture of the cloth. Consequently, the subject for analysis is that of textile design, in a *plain* fabric, as it results from modifying the arrangement of warp and weft yarns employed in weaving the texture. In each of the illustrations which will subsequently be given of fancy styles applied to this crossing, the first pick is always understood to enter the warp when the odd threads are depressed, but the second pick when such threads are elevated. It would materially assist the student in mastering the principle of pattern construction in the plain make, if he mapped out on point paper the same number of threads and picks of this weave as the patterns of warp and weft, or one repetition of the design contains.

As the hairline stripe, in the plain crossing, was obtained by thread-and-thread warping and weaving, it may next be pointed out what style of effect results from arranging the yarns, in both warp and weft of the fabric, two ends black and one end white. This simple modification in the order of the yarns produces a distinct difference in the style of effect obtained, for it forms a pattern consisting of a number of small figures or lines of colour running lengthways of the piece, each of which is crossed at right angles with

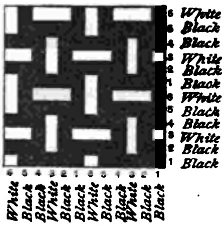


Fig. 150.

a figure of corresponding dimensions. The character of this effect will be better understood on referring to fig. 150. Here, it will be observed, the black threads and picks meet each other and form a solid black ground, while the white threads form the short lines or figures. If the warp had been arranged, two threads of white and one thread of black, the pattern produced would have been exactly the reverse of that sketched in the illustration, namely, a series of short, disconnected black lines arranged on a white ground.

In order to make it clear that these two classes of yarns —black and white respectively, and warped and woven two ends of the former to one end of the latter—cross each other in the plain weave on such a principle as to form this pattern, the plan of construction will require to be carefully examined. Suppose, therefore, that the first two threads of the weave are black, the third thread white, the fourth and fifth threads black, and the sixth thread white; and, further, that the warp yarns are drawn on two shafts, and that the first heddle has been depressed and the second heddle elevated for the reception of the first black pick, then the black threads, 2 and 4, and the white thread, 6, would be raised, but threads 1, 3, and 5 would at the same time be covered with the weft yarn; hence pick 1 allows the sixth thread, that is, the second white thread in the design, to appear on the face of the fabric. The elevation of the second and depression of the first shaft allows the third thread in the warp, which is the first white end in the pattern, to float over the second black pick. The third pick, which is white, next enters the warp, and not only continues the white line commenced on the third thread by the previous pick, but also forms a cross figure by floating over threads 5 and 7, and by floating under thread 6; causing the line formed across these ends—5, 6, and 7—to be of the same length as if the pick had flushed over three threads in succession. As the fourth pick is exactly like the second both in the weave and in colour, the white figure on the third thread is again continued. The fifth pick is a repetition of the first. The sixth pick, or second white weft thread in the illustration, falls on the opposite shed of the weave to its predecessor of the same shade, and, as a result, forms a white cross line on threads 2, 3, and 4. This it does in the following manner: The first thread, being black and elevated, covers the weft introduced; the second thread, however, being down, allows the white filling yarn to flush over it; the third thread of the pattern appears on the face of the texture, but, as it is white and not black, it continues the formation of the white cross line begun on the previous thread; the weft next crosses over the fourth thread, where it completes one transverse figure, then under the fifth, and lastly over the sixth thread.

A very common mode of making this pattern consists in arranging the threads thus: two ends of self-coloured yarn, and one end of fancy twist yarn, as, for example, two threads of black and one thread of black and olive twist; or two threads of dark brown and one thread of black and lavender twist. In each case the weft would, of course, be made to match the warp.

172. *Over-Check in the Plain Weave.*—The principle of

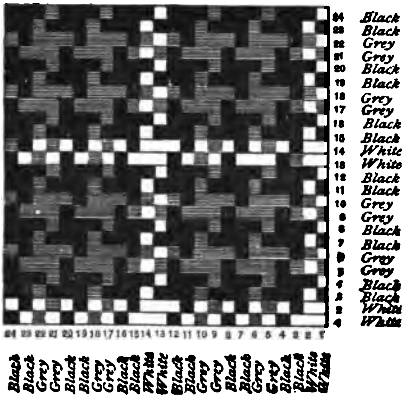


Fig. 151.

constructing a simple check pattern in this weave will next be considered. A sketch of an example in this style of effect is furnished in fig. 151. This design is very frequently seen in woollen suitings, and it is both neat and effective in appearance. It may be produced in either the plain or hopsack. Should the checks be about the same size in the cloth as represented in the illustration the hopsack weave has been used in the production of the fabric. The following is the order of the warp and weft yarns for constructing this effect in the plain weave:—

2 threads of white.
2 „ „ black.
2 „ „ grey.
2 „ „ black.
2 „ „ grey.
2 „ „ black.

The white threads and white picks form in conjunction with each other what is technically called an *over-check;* that is, in this case, a large check of white, containing a number of smaller squares of black and grey. The object of introducing these threads into the pattern is to impart a freshness to the appearance of the cloth. The design might be made more attractive and saleable by the following combination of threads:—

1 thread of black.
1 „ „ black and blue twist.
2 threads of black.
2 „ „ black and white twist.
2 „ „ black.
2 „ „ black and white twist.
2 „ „ black.

The over-check in this set of colours would be formed of black and blue twist yarns, and the small figures of black, and black and white twists respectively.

An analysis of the process of producing this pattern will no doubt be useful. On consulting the arrangement given above of the warp and weft yarns, it will be noticed that the first two threads are white. The first pick would, therefore, in consequence of covering the odd threads, form a three-flush of white with the 1st, 2nd, and 3rd threads, and a similar flush with the 13th, 14th, and 15th threads, because, on this pick the even threads, 2 and 14, which are white, are elevated, while the black threads, 3 and 15, are depressed. Pick 2, which is also white, entering the warp when the even threads are down, forms flushes of three threads each on the 24th, 1st and 2nd threads, and the 12th, 13th, and 14th threads respectively.

According to the arrangement of the threads already mapped out for this pattern, the 3rd and 4th threads are black, and hence the two succeeding picks of weft will also require to be yarns of this colour. The part these shoots play in the formation of the design is very distinctly marked in the black figures covering the surface of the texture. For instance, the first pick of black forms a series of black flushes, each of which is equal to a float of three threads in length, across the piece; these are separated from each other by the elevation of single threads of grey or white, according to the positions they individually occupy in the pattern of warp. Pick 4, it will be seen, allows the 1st, 5th, and every 4th odd end, counting from the latter thread, to show on the face of the cloth, which causes each line of black to be moved one thread to the right of its predecessor. By carefully going through the design in this manner the reader will possibly be able to arrive at the principle on which this effect has been constructed.

173. *Fancy Check.*—A check of a much more intricate description than the one just described appears in fig. 152. The order of colouring this style in both warp and weft is as follows:—

2 threads of black.	2 threads of black.
1 thread of white.	1 thread of white.
1 " " black.	1 " " black.
1 " " white.	1 " " white.
1 " " black.	1 " " black.
1 " " white.	1 " " white.
2 threads of black.	2 threads of black.
2 " " white.	2 " " white.

The somewhat lengthy order of threads seems to indicate, when the nature of the pattern is considered, that the more varied the effect obtained, the more intricate the method of combining the yarns in both warp and weft. In thin materials this style forms a very suitable design for dress fabrics, and generally finds a sale in the market. It is given here, however, as a practical illustration of the variety of effect obtainable in the plain weave by two colours. The method on which it is formed deserves careful study.

No doubt it will be observed that parts A and A¹ are simply isolated portions of the hairline effect got by thread and thread warping and picking; while sections B

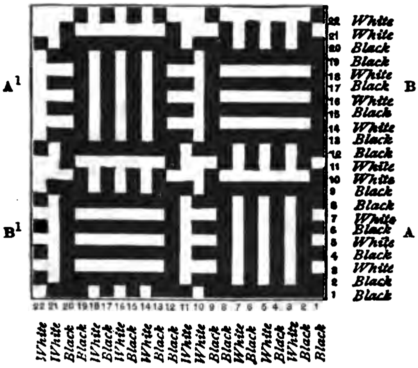


Fig. 152.

and B¹ are the same stripes placed in a transverse instead of a longitudinal direction. It is not necessary to go over the ground of the principle on which parts A are formed, so attention will be directed to section B. Now a brief examination of this pattern will show that both B and B¹, although totally different parts of the design, occupy, relatively, exactly the same positions in the weave. Thus section B commences to be formed on the thirteenth pick, while B¹ begins to be formed on the twelfth thread. If the arrangement of the coloured threads employed is consulted, it will be found that the thirteenth pick of section B is black; the weave, it must be remembered, depresses the odd threads during the intersection of the odd picks, hence the thirteenth thread will be down when the thirteenth pick is entering the warp. Again the second pick, on which the parallel horizontal lines of B^1 commence to be formed, is also black, and enters the warp when the twelfth and the remainder of the even threads are depressed; showing clearly that the threads of the respective sections intersect each other in precisely the same order, although forming different portions of the pattern. This being so, the matter is somewhat simplified, for the remarks made on section B will also be applicable to B^1. An analysis of this part of the figure, from the 2nd to the

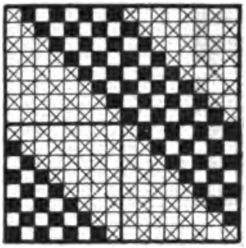


Fig. 153.

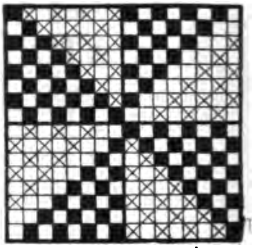


Fig. 154.

8th pick, shows that the black picks enter the warp when the white threads are down and the black threads are elevated; whereas the white picks are introduced into the warp when the black threads are down and the white threads up. In A, however, the black picks float over the black threads and the white picks over the white threads, hence in the former case the lines are formed across, and in the latter case lengthways of the fabric.

174. *Diagonal and Fancy Coloured Patterns.*—This principle holds good in all instances where the plain weave is used—namely, colour over colour gives longitudinal stripes, and colour under colour horizontal stripes in the woven

cloth. As this is an invariable rule, some curious effects can be got by a slight alteration of the weave. Take, as examples of what is here alluded to, weaves 153 and 154. If these designs were woven in self colours they would almost present a plain faced texture; in fact they are merely the plain weave, in some parts of which the make commences on the opposite threads to what it does in others. Thus the odd threads of fig. 153, in the portions formed in full square dots, are always depressed when the odd picks interweave with the warp, but in the portions marked in crosses the same picks cover the even threads. This has a very pronounced effect on the simplest mode of warping.

Supposing the plan of the warp and weft threads was,

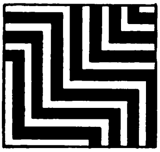


Fig. 155.

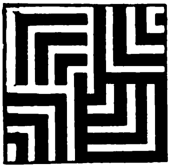


Fig. 156.

for example, one thread black and one thread white, then, in those sections of these designs where the plain is formed in full black dots, upright lines would be produced, but in the adjoining sections, marked in crosses, transverse lines would be formed. The character of the effect given by the former weave in the cloth resembles in appearance the pattern shown in fig. 155. The curiously arranged design seen in fig. 156 is obtained from the same order of warping as pattern 155, but by using weave 154. Here the lines formed in the direction of the warp result from colour floating over colour in the sections dotted in square characters; in the portions of the design marked in crossed dots, however, the plain starting on the opposite thread to what it does in other sections, the relative positions of the warp threads to the warp picks are changed, which causes shade to float under shade and thus produce black and white lines of various lengths, running in the direction of the filling yarn.

175. *Mixtures in the Plain Cloth.*—Another very neat plain cloth effect is sketched in fig. 157. It is designated a *bird's eye* pattern. The method of production is of the simplest character. The warp in such styles is generally all one colour—say, in this example, all white woven one pick black and one pick grey. Now, although the black and grey yarns produce spots of these colours on the face of the fabric, yet neither shade forms a continuous stripe. One portion of the warp crosses over the black, and a

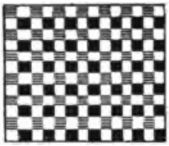


Fig. 157.

second portion over the white weft, causing the dots of colour to be arranged on the check principle.

A few useful colourings in this style of pattern are appended:—

I.

Warp: All black and white twist.
Weft: 1 pick black and white twist; 1 pick olive.

II.

Warp: All olive.
Weft: 1 pick indigo blue; 1 pick lavender.

III.

Warp: All black and lavender twist.
Weft: 1 pick black; 1 pick black and olive twist.

CHAPTER XI.

COLOUR APPLIED TO TWILLED AND FANCY WEAVES.

176. *Uses of the Cassimere Twill in Coloured Patterns.*—The practical worth of the cassimere twill as a weave suitable for developing effects of a coloured character cannot be over-estimated. Its neat and simple structure make it adapted to all kinds of fabrics, and hence it is employed in the production of fancy woollen, worsted, cotton, and silk cloths.

There are some weaves which, on account of their irregular construction, can only be used, with satisfactory results, in one class of yarns and one kind of set or reed, and even when these conditions are complied with they are only suitable for a very limited range of effects. Corkscrew makes are of this class. Hence, although precisely the same shades and order of threads may be employed in both warp and weft of such twills, yet the colourings in the woven pattern appear more pronounced in tone in the direction of the warp than in the direction of the weft. This is due to the principle on which corkscrews are constructed, for they are essentially what may be defined warp-faced weaves. Obviously, then, crossings of this character are totally unsuitable for real check patterns. A kind of a broken or an irregularly-formed check may, of course, be woven in them, but the perfect rectangular formation, characteristic of check effects, is never so clearly developed in both warp and weft of the pattern if the weave used allows either of these two classes of threads to appear more on the surface of the fabric than the other. It should be observed that there are cases where a decided check is not required, but simply a pattern in which the colourings of the weft are somewhat more subdued than those of the warp, or an effect possessing the features of both stripe and check. Weaves in which the warp flushes predominate are frequently employed in such styles; but when a true check has to be produced, a make of an ordinary twilled stamp is the most likely to yield the best

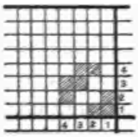


Fig. 158.

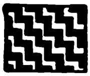


Fig. 159.

results. As the cassimere twill is of this construction, it affords unlimited facilities for a variety of arrangements as to colourings.

177. *Difference between the Effects obtained in the Cassimere and Plain Weaves.*—The effects produced in this twill are decidedly different from those obtained in the plain weave, even when the method of colouring is precisely the same in both cases. All patterns formed in the latter crossing are completely void of ornament of a weave character; in effects obtained in the "cassimere," however, a twill or small diagonal, in addition to the shades or colours combined, ornaments the surface of the texture. Thread-and-thread warping, as pointed out in the previous Chapter, gives, in the plain weave, a hairline stripe, but in this twill it forms a diagonal of a step character as shown in fig. 159.

This indicates that when the arrangement or classification of threads remains unaltered, if the weave is changed, a complete modification of pattern results. A more striking example of how the style of the design, under such conditions, is entirely remodelled could not be furnished than that represented in this illustration. By merely varying the weave from plain to twill a striped pattern has been transformed into a well-defined diagonal. The principles of weaving which underlie this result deserve careful analysis. The cassimere twill, fig. 158, contains four threads and four picks, while the plain weave only contains two; that is to say, the former make repeats itself on every fifth, but the latter on every third thread. This alone, it will soon be apparent, is sufficient to impart a new character to the woven effect although the same colourings may be employed in both weaves. For, if the patterns of warp and weft are arranged one end black and one end white, one repeat of the weave in the plain crossing would imply one complete repeat of the design, whereas the arrangement of yarns would be twice repeated in one formation of the twilled make. Let the plan and colourings be now examined. Pick 1, weave 158, covers the first and second threads and forms in combination with the third thread (which is black and elevated during its intersection) a black float of three threads, as indicated in the pattern, fig. 159. When pick 2 enters the warp the second and third threads are up and the fourth thread down, so that it forms by joining on to the second thread a transverse line of white. If this analysis were continued it would show that the odd picks always form three-end flushes of black and a one-thread flush of white; while the even picks form three-end flushes of white and a one-thread flush of black.

It will be noticed that although the twill of the weave runs to the right hand, that of the pattern moves to the left. To reverse the direction of the diagonal in the woven pattern, the weave employed would require to go to the left hand in weaving.

178. *Broken Diamond in the Cassimere.*—Fig. 160 is another pattern which has been produced in the same order of threads by using the check weave given in fig. 160*a*.

It is unnecessary to explain in detail how this broken diamond, or, perhaps, more strictly speaking, irregular check pattern has been constructed. The weave used, it will be quite clear from the remarks made on the previous pattern, is arranged on such a principle as to give this result. Both the pattern and the weave may be divided into four separate parts. The twill of the design in sections A and A[1], forms those parts of the pattern in which

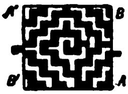


Fig. 160.

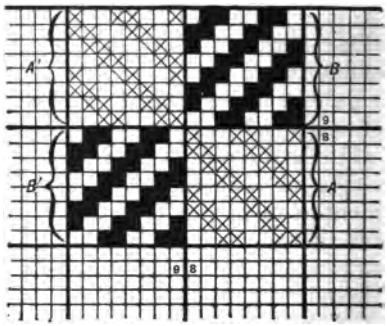


Fig. 160 A.

the diagonal moves to the left, while sections B and B[1] produce the parts in which the diagonal runs to the right.

When this pattern is enlarged (say about four or six times its present size), it becomes a very effective style. In these dimensions it often finds a place in both woollen and worsted goods. The appearance of the design is sometimes improved by forming an over-check on those threads of the weave which oppose each other, thus in this figure it would be constructed on the 8th and 9th threads and picks. Not unfrequently this design appears in dress fabrics in exactly these colours, when its neat and plain characteristics obtain for it a considerable sale.

179. *Stripes in the Four-end Twill.*—There are three patterns of striped designs given in figs. 161, 162, and 163, which are extensively woven in this weave (see fig. 158). The first of these is warped two threads black and two threads white alternately, and crossed with black weft. Its appearance may be varied by introducing two fancy yarns on the 15th and 16th threads and picks respectively. Fig. 162 may be called a four-and-four-end stripe; it is made as follows: *warp*, four threads of grey and four threads of white; *weft*, all grey. The last of these stripes is warped exactly in the same manner as fig. 161, only picked with grey. Each of these three samples when properly managed in colouring give useful and serviceable

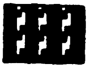


Fig. 161.

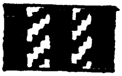


Fig. 162.

Fig. 163.

patterns. By appropriate modifications in colours and method of wefting, they may be varied to an almost unlimited extent. In fact, the changes in style in woollen goods, particularly of a simple striped class, originate, generally, from the employment of new shades, and not from varying either the order of warping, picking, or plan of weave.

180. *Shepherd Plaid.*—The universally known black-and-white shepherd plaid, such a favourite of former days, and not yet completely discarded by fashion, is another effect that is frequently produced in this weave. A sketch of a sample of woven fabric thus ornamented is given in fig. 164. If the arrangement of the threads for warping and weaving is furnished, no doubt the reader, by a little study, will be able to trace its formation to the twilled make given in fig. 158. Both warp and weft are composed of four threads

of black and four threads of white alternately. Possibly it is scarcely necessary to suggest that this order of yarns may be put to very extensive service by combining such shades as browns, olives, drabs, blues, greys and slates, or any other neat, but sombre colours.

181. *Fancy Check.*—Only one more pattern in the cassimere twill need be described, that furnished in fig. 165. The arrangement of threads in this illustration is four ends of black, four ends of grey, four ends of white and four ends of grey. The check thus formed is of a shaded class. Three colours of brown—dark, mid, and light—or black, dark blue and olive, if similarly arranged also give satisfactory patterns.

The style thus produced is bold and effective in character,

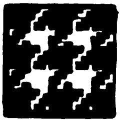


Fig. 164.

Fig. 165.

and is one that generally finds an extensive sale. It is, in reality, a threefold check, the black ends forming one series of squares, the white ends a corresponding series, while the grey ends form checks adjoining both the black and white squares. Perhaps this method of colouring is more prominently developed in the cassimere twill than any other weave to which it can be applied. The effect of the crossing is very distinctly represented in the sketch. This species of pattern is not confined to woollen and worsted cloths for gentlemen's wear, but is extensively used in the production of mantle and dress fabrics.

182. *Colour Applied to Five-End Makes.*—Five-shaft weaves are not very largely used in the production of

fancy woollen and worsted fabrics. The reason for this is, that on four shafts, which is a far more convenient number of heddles as well as a less expensive number to work, a larger variety of patterns can be produced. However, there are some styles which are only obtainable in five-heald makes. Amongst these may be mentioned the striped fabric sketched in fig. 166. The weave in this case is doeskin (see fig. 56), while the pattern of warp is as follows: 3 ends of grey, and 2 ends of white; and the weft 1 pick grey, 1 pick white, 1 pick grey, 1 pick white, and 1 pick grey. Although one of these stripes contains three and the other two threads, yet they are both solid colours throughout, for the grey shoots, in weaving, cover the grey threads and the white shoots the white threads; an arrangement of yarns which cannot fail to produce stripes of grey and white respectively. This is the special characteristic of this striped pattern that is due to the structure of the weave, for the five-heald doeskin is the only crossing that can be made to develop a stripe thus arranged. A four-heald sateen make would, of course, give a similar effect, or a stripe 2 threads of grey and 2 threads of white alternately; while the six-heald sateen can be made to produce a stripe of the same class, 3 threads of grey and 3 threads of white alternately, but neither of these weaves will give precisely the same effect as that seen in fig. 166.

Fig. 166.

A very pleasing variation in the character of this style may be obtained by employing twist yarns in the warp, thus: 3 threads of brown and white twist, and two threads of brown. The weft for such a pattern would be arranged

1 pick of brown and white, 1 pick of brown, 2 picks of brown and white, and 1 pick of brown. Another method of wefting this weave consists in employing the same colour of yarn in the filling as that forming the principal shade in the warp: that is, the weft for the previous example would be all brown; but for a pattern of warp composed of 2 threads of drab and white twist, and 1 thread of drab, it would be all drab. The latter order of warping and wefting gives a smaller effect than the preceding method, but it is, nevertheless, a popular mode of combining colours in this crossing.

When the doeskin make is employed—as in these examples—in the production of fancy cloths, the patterns are invariably of a striped character. Being a warp-flushed, or warp-faced weave, there is comparatively little opportunity afforded for imparting any special effect to the cloth by a diversity of weft yarns. It would be impossible to form a check in a weave of this type, simply because the colourings in the warp would overpower those of the weft. Four portions of warp to one of weft appear on the surface of the texture, so that, strictly speaking, the face of the fabric—so far as appearances go—is all warp, while the underneath surface is all weft. But if the pattern or design cannot be materially varied in effect by the weft yarns, the smooth, uniform surface, formed by the warp threads, somewhat compensates for this drawback. The face of the cloth is as soft, fine, and regular in texture as possible, the individual threads of warp and weft being scarcely discernible. Now the flushing of the warp in this manner admits of a lower quality of yarn being employed for weft than warp, which in some cases reduces the cost of the cloth considerably. An arrangement of this kind in such a weave as the cassimere twill would prove detrimental to the face of the pattern, but in the doeskin make, as the filling thread is principally on the back of the cloth, if it is not too thick and coarse, it will not affect the character of the face to any perceptible degree.

The "Venetian" (see fig. 60), another five-heald make, is employed chiefly in the production of fine twist-warp fabrics for light overcoats. The weft in such cases is generally a single thread, as an olive and white twist-warp crossed with an olive weft, or a drab and white twist-warp woven with a drab weft. Effects of a striped character are very seldom seen in this weave, in fact, its use is almost limited to the production just named.

The five-end twill admits of a much larger range of patterns being produced by its crossings than can be formed in the two preceding makes. It differs somewhat in construction from the cassimere or four-end twill, for it runs three threads up and two threads down on each pick. The pattern shown in fig. 167, which it has been made to

Fig. 167.

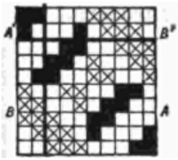


Fig. 167 B.

produce, is of a simple striped description. The yarns are ordered as follows:—

Warp.	Weft.
2 ends of black.	All grey.
1 end of grey.	
2 ends of white.	

The black and the white threads both form broken stripes, the former producing black lines, and the latter white lines, crossed with grey; while every fifth thread in the pattern forms a continuous or solid stripe of grey in the piece. When this pattern is woven, with the same colourings in the weft as in the warp, it forms a neat, stylish check. If worsted yarns are used, the single thread (*i.e.*, the grey thread in fig. 167) might be either a silk yarn or a silk twist; as, for example, 2 ends of black, 1 end of black worsted and crimson silk twist, and 2 ends of olive green; or 2 ends of drab, 1 end of olive worsted and blue silk twist, and 2 ends of white. Weft in both examples to be same as warp. By reversing the weaves, as shown in design 167*b*, and warping and wefting five ends of black and five ends of brown, or any other two contrasting shades, a good, useful check pattern may be obtained. The structure of this design causes the colourings in section A to be more pronounced in tone in the direction of the warp than in the direction of the weft, but in sections B more pronounced in the weft than in the warp. If the lower part of the design were used, or a stripe combination made 48 threads of A and 48 threads of B, and then coloured *five-and-five* in both warp and weft, it would give a good trousering pattern.

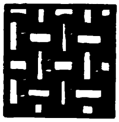


Fig. 168.

183. *Effects in the Six-end Twill.*—In the six-shaft twill (see fig. 44) there is endless scope for variety. It is almost, in fact, as useful a crossing as the cassimere. Its structure being of a very uniform type, and flushing both warp and weft yarns to the same extent on both sides of the cloth, it produces evenly-balanced effects. To commence with a very simple arrangement of warp and weft threads, namely, 1 end of black, 1 end of grey, and 1 end of white, it will be evident from fig. 168 that by the use of this twill a pattern of some importance in the trade is producible. One matter that should be attended to in making patterns for this or any other small weave is, that the colours in the aggregate should generally meet or tally with the weave. Thus the total number of threads in either pattern of warp or weft for this weave should be a number that is either a multiple

of six, or divisible, without a remainder, by six. For example such numbers as 3, 6, 12, 18, and 24, &c., are all right for this weave, as are also 9 and 15, although these cannot be divided with six without a remainder of three. As a remainder of three threads, however, divides the weave exactly into two parts it is not so liable to produce an unsatisfactory result as a remainder of 1, 2, 4, or 5. In a word, some of the best broken effects produced in this weave are obtained in patterns of 9 and 15 ends. But to return to the 3-thread pattern drawn in fig. 168. In the cloth the grey and black yarns form two distinct diagonals of a step character, while the white threads meet each other, and produce a series of small figures arranged at right angles one to the other. The order of warping and picking forming this style is frequently applied to both

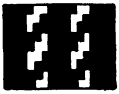


Fig. 169.

worsted and woollen goods, when it makes a saleable fabric: the success of the pattern depending, in most instances, on the colourings combined in its formation.

A well-patronized stripe, prominent amongst six-heald twill patterns, is shown in the next sketch, fig. 169. This effect is got by warping three ends of black and three ends of white alternately, and crossing with black weft alone. It is an order of threads that may be used in a large variety of shades, such as black and blue, brown and green, blue and olive, dark grey and white, &c. Not unfrequently it is checked with corresponding colours in the weft, when it makes either a suiting or a coating style. Another method of producing a small stripe in this weave is furnished in fig. 170. Here again the threads being arranged two ends of black, two ends of white, and two ends of grey, the pattern only contains a total of six threads. Although the effect produced in the woven fabric is comparatively small, yet it possesses a neat and decided appearance in both woollen and worsted goods. Amongst other colourings which come up well in this style, the following may be enumerated:—

I.	II.
2 ends of black	2 ends of dark blue.
2 „ olive green.	2 „ slate.
1 end of black and tan twist.	1 end of black and scarlet twist.
1 end of black and lavender twist.	1 end of black and light olive twist.

III.

2 ends of dark brown.
2 „ olive brown.
1 end of black and blue twist.
1 „ black and green olive twist.

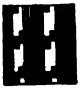


Fig. 170.

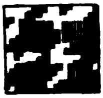


Fig. 170 *a*.

The wefts for the respective patterns are black, dark blue, and dark brown.

184. *Checks in the Six-end Twill.*—Now a check effect will be described. This pattern in the woven fabric is, perhaps, as neat a style as can be produced in the six-shaft twill. The threads in both warp and weft of this illustration (fig. 170*a*) are arranged as follows:—

3 ends of black.
3 „ grey.
3 „ white.

As there are 9 threads in the colourings, the weave has to be repeated three times and the pattern of warp and weft twice before any repeat of the design is effected. One repeat has been sketched in the illustration. The success of this style is, no doubt, due in some measure to its not being of a stiff, formal character. The colourings are not only congruous in tone, but are uniformly distributed over the surface of the fabric, each shade forming a kind of an irregular check. By introducing a fancy twist yarn into the design on every 18th thread, the character of the pattern undergoes a suitable modification. While treating on the subject of checks in this weave, what is known in the trade as a basket check may be alluded to. This is simply an ordinary check of large dimensions. For instance, such a pattern is sometimes obtained in the six-end twill by warping and wefting in the following order:—

For 24 or 36 ends, according to the size of check required.	3 ends of black. 3 „ grey.

and then—

For 24 or 36 ends.	6 ends of black. 6 „ grey.

Fig. 171.

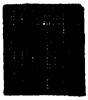


Fig. 172.

The six-and-six combination of this pattern forms a large check (composed of a series of solid squares of black and grey) which completely surrounds a number of irregular and smaller checks formed by the three-and-three thread arrangement. Ulsterings and some classes of mantle cloths are figured on this principle.

185. *Patterns in the Mayo.*—Passing by the patterns obtained in seven-shaft weaves, which, barring those got in the corkscrew, are very limited in variety, allusion will be made to a few characteristic styles appertaining to eight-

heald makes. One or two effects obtained in the "Mayo" (see fig. 63) will first be considered. Patterns 171 and 172 both result from the employment of this weave. The former is warped and woven 2 threads of black and 2 threads of grey; and the latter 4 threads of black and 4 threads of grey. In fig. 171 the weave produces a small figured effect, but in fig. 172 a broken check pattern. Of course in the woven fabric the designs would not be so distinct or pronounced in effect as in these sketches; they would be on a more minute scale, and the parts somewhat better blended together. These effects strikingly illustrate what a diversity of pattern is due to a simple alteration in the method of applying colour to any given crossing. While the four-and-four effect in this instance belongs, strictly speaking, to the family of checks, the two-and-two effect belongs distinctly to figured diagonals. Both patterns may be improved by the addition of a few fancy threads here and there, according to the effect required. Fig. 171 is suitable for either coating or suiting fabrics, but fig. 172 is more adapted for trouserings.

186. *Colour in Relation to the Eight Shaft Diagonal.*—The eight-shaft diagonal (See fig. 62), is another weave specially useful for colourings. It not only clearly developes the arrangement of threads, but its plan of intertexture beautifies the fabric. Only one example of colouring this weave will be referred to—that given in fig. 173, which is warped thus:—

2	ends of	black.
2	„	white.
2	„	black.
2	„	grey.

Order of picking to be same as warp. The result is an irregular check pattern, neat in combination and attractive in appearance. There is nothing vulgar or stiff about its formation; on the contrary, although of a clearly-defined character, yet it is neat, smart, and stylish. The character of the weave prevents the production of anything resembling a formal, set, printed article, for it breaks up the colours into small patches of divers shapes, and intermingles them with one another in a very pleasing and taking manner. Stripes and checks of all sizes and classes, in a large diversity of colours, are made in this weave in woollen, worsted, cotton, and silk goods.

187. *Arrangement of Colourings for Twilled Hopsack.*—There is still one more important eight-heald weave that may be briefly dealt with, namely, the twilled hopsack (see fig. 62). This weave occupies a very exceptional place in this class of textile designing. Particularly is it valuable in the manufacture of worsted goods, where it both ornaments the cloth with the character of its crossings and the colourings applied in the warp and weft.

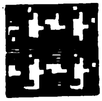


Fig. 173.

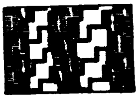


Fig. 174.

Some specially neat effects can be developed in it by combining shades of a similar colour but slightly different from each other in depth of tone, as two shades of brown, two shades of grey, and two shades of olive. The pattern sketched in fig. 174 develops both the weave and colourings. It is a striped fabric, warped four threads of grey and four threads of white, and is woven with black weft. These colourings are too loud for practical application, but they serve to illustrate the style of effects obtainable in this crossing.

188. *Colour applied to Weave Combinations.*—Quite a different class of effects, to those resulting from the employment of colours in single weaves, are obtained in woven goods by the application of a variety of shades to designs formed of several crossings. Of a necessity this

type of design is more difficult to manipulate than that resulting from the interlacing of warp and weft threads on various principles of crossing, or from colour as applied to one simple weave. It requires a knowledge both of design construction, and of the art of colouring. The patterns produced on this system are in reality due to two distinct arrangements, acting independently of each other, that of a mixture of weaves, and that of a mixture of colours. In such styles the combination of makes should of itself form a figured effect in the cloth, while the plan on which the colourings are blended together should, if applied to a simple weave, produce a definite pattern.

Woven design based on a combination of weaves is of a very different character to that based on a combination of colours. Hence it is possible to be expert in one of these classes of design, and yet deficient in the other. One may be a good colourist, and still incapable of making a saleable fabric; or proficient in cloth construction, and yet the blender of the most incongruous shades. A thorough knowledge of the structure of woven goods, and an inventive faculty, are the requisites to the attainment of success in weave-design. But in the case of colour, in addition to being capable of constructing a good, firm texture, an acquaintance with the effect of colour on weave, as well as a natural and cultured taste for colouring, are indispensable.

Now, in cloths ornamented with both a blend of shades and a combination of crossings, the effects due to each should be clearly discernible in the woven product. To employ an intricate arrangement of weaves when a simple make would give a similar pattern, implies increasing the difficulties of weaving, and the expenses of cloth production, to no purpose. The matter of developing with smartness and precision the effects due to weave as well as colour is too frequently overlooked in designs of this class. French patterns in both woollens and worsteds are occasionally faulty in this particular. Fabrics are sometimes manufactured in which the designs are of a very complicated description, but the effects which they ought to impart to the cloths are completely destroyed by the system practised in colouring them. When adding fancy yarns to figured designs it should be recognized that the latter have some part to play in the formation of the pattern; the effect of the various weaves they contain should if possible be distinctly manifest, and not be made next to *nil* by the application of loud colouring. Colour, when introduced into such designs, should allow the weaves to impart some special or novel appearance to the cloth. If this object is not attainable by using an intricate combination of small makes, a simple weave, which can be manipulated in the loom with much more facility, had better be employed.

189. *How to Colour Intricate Weave Designs.*—Before applying colour to a large design, the character of the various weaves of which it is composed should be taken into consideration. It has been previously shown that the effect of any particular method of colouring on the woven fabric may be completely changed by an alteration in the weave, indicating that different crossings require special treatment as to colour. Now if a modification in the plan of a simple weave materially varies the style of the pattern, an elaborate combination of makes, such as that furnished in fig. 126, Chapter IX., would necessarily alter the effect of the colourings on the woven production still more. Precisely the same arrangement of fancy yarns as would form a neat, regular check, in an ordinary twill, would give a very broken, undecided pattern if applied to some classes of weave combinations. There are, therefore, various causes for considering the structure of the several weaves in adding colour to a figured design.

The course that should be adopted in this kind of designing is, when the weave-pattern has been constructed, to examine its various parts and calculate as near as possible

[illegible]

be found in fig. 136, Chapter IX. A four-and-four thread order of yarns would form a decided check in those sections of this design marked in crosses. The checks formed in the sections in which the twill runs to the left would be slightly different from those produced in the sections in which the same weave is twilled to the right. But in the upright twill introduced into this design, and marked in full square dots, these colourings would present quite a different aspect. The checks of black and white in these parts would be both indefinite in appearance and irregular in formation.

190. *Cloths Figured by Weave and Colour.*—All-wool mantles and ulsterings are sometimes figured on this principle, but the bulk of the ordinary classes of woollen

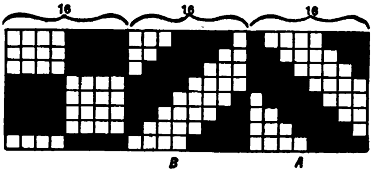


Fig. 175 *a*.

fabrics is chiefly ornamented with colour, the weave usually being a simple twill or mat. As a rule woollen cloths, unless skilfully managed, possess a vulgar character when the designs are mainly of a weave-description. Of course there are exceptional patterns, and cases where novelties in woollens, as well as in worsteds, are due as largely to a combination of weaves as colours. Neither of these modes of procuring woven effect should be discarded. The drawback to the use of figured designs in the manufacture of woollen goods is the difficulty there is in constructing them in such a manner as to produce a uniform texture. If there is one thing more than another which has a tendency to depreciate the value of weave ornament, in woollen fabrics, in the eyes of consumers, it is the irregular fabric weave designs are liable to produce. In the

the effect they would each produce if a specified order of threads were employed. Thus, supposing a check design composed of two four-heald makes—cassimere twill and hopsack—were warped and woven two threads black and two threads white, the appearance of the colourings in the respective weaves would be as different from each other as possible. While they would produce in the twill a series of small black and white checks, in the hopsack or mat portions of the design they would form a series of solid but narrow stripes of these colours. The mat weave, it will be remembered, when thus woven produces a striped pattern of the hairline class (see reference to fig. 149, Chapter X). The application, therefore, of this two-and-two order of colours to fig. 126, Chapter IX., would give a totally different style of effect from that obtained in the check design just alluded to. Certainly in the twilled sections of fig. 126, these colourings would form precisely the same class of pattern as the cassimere produces in the check example just considered. But as the twill is here (fig. 126) arranged in the form of a figure instead of a check, the small square effects resulting from the combination of black and white threads would be grouped together on a figured principle. As to the ribbed weave in fig. 126 (marked in solid squares), its effect in these colourings would be anything but pleasing. A diversity of weft yarns is unsuitable for a warp rib crossing, while the two black and two white system of warping would have a tendency to destroy the characteristic effect of the weave. By warping, fig. 122, Chapter IX., which contains four threads of a ribbed weave (see the section marked in crosses), four black, four brown, four black, four black-and-white twist, and weaving with black weft, not only would the rib crossing be preserved distinct from the other portions of the design in point of colour, but also in weave effect. Another example of how the various effects produced by the several weaves in a large design may be changed by the application of coloured threads will be found in fig. 136, Chapter IX. A four-and-four thread order of yarns would form a decided check in those sections of this design marked in crosses. The checks formed in the sections in which the twill runs to the left would be slightly different from those produced in the sections in which the same weave is twilled to the right. But in the upright twill introduced into this design, and marked in full square dots, these colourings would present quite a different aspect. The checks of black and white in these parts would be both indefinite in appearance and irregular in formation.

190. *Cloths Figured by Weave and Colour.*—All-wool mantles and ulsterings are sometimes figured on this principle, but the bulk of the ordinary classes of woollen

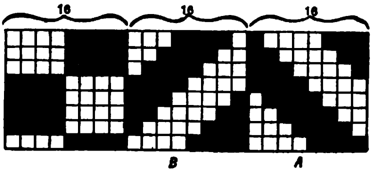


Fig. 175 *a.*

fabrics is chiefly ornamented with colour, the weave usually being a simple twill or mat. As a rule woollen cloths, unless skilfully managed, possess a vulgar character when the designs are mainly of a weave-description. Of course there are exceptional patterns, and cases where novelties in woollens, as well as in worsteds, are due as largely to a combination of weaves as colours. Neither of these modes of procuring woven effect should be discarded. The drawback to the use of figured designs in the manufacture of woollen goods is the difficulty there is in constructing them in such a manner as to produce a uniform texture. If there is one thing more than another which has a tendency to depreciate the value of weave ornament, in woollen fabrics, in the eyes of consumers, it is the irregular fabric weave designs are liable to produce. In the plain weave, cassimere, six-end twill, and mat or hopsack, a good regular fabric is ensured, but, when several makes of different flushes are combined, the smoothness of the cloth is not so much to be relied upon. A judicious selection and combination of makes materially prevents unsatisfactory results arising from these causes; but, in too many instances crossings are combined that have no weaving affinity for each other, and hence the production of an uneven cloth which is rejected by the buyer as handling hard and "unkind." There is, however, a probability of woollen goods becoming more largely figured by a combination of weaves.

Worsted fabrics are extensively ornamented on this principle. A few illustrations in these goods will, there-

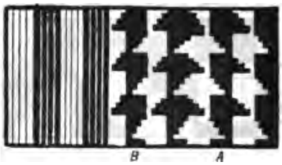


Fig. 175.

fore, be considered. The weaves combined in the first example, to which attention will be given, are simply eight-shaft twill and eight-shaft hopsack, fig. 175*a*. The twilled make running both to the right and left hand in the design forms an angled stripe, adjoining which is a stripe of sixteen threads of the mat or hopsack crossing. This arrangement of weaves, when warped and woven four threads black and four threads white, produces a very effective pattern. Sections A and B show how reversing the direction of a twilled make alters the appearance of the pattern resulting from a mixture of colours. For instance, the broken checks in part A, fig. 175, are of a different formation to those seen in part B. In fact, there are three separate effects produced by design 175*a* on this four-and-four order of shades, although only two weaves have been combined in its construction : first, a series of checks in which the patches of colours twill or lean to the left ; second, a series of checks in which the colours move to the right ; and third, a series of solid black and white stripes. Had only one weave been employed, and that twilled simply to the right hand, this order of yarns would merely have given one style of pattern : but it is clear from the results obtained in this illustration that any system of warping and wefting may be made to produce, by the application of designs containing a variety of crossings, several distinct effects in the woven goods.

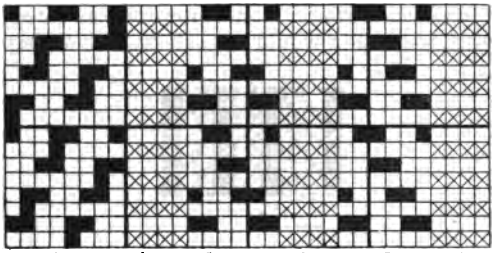


Fig. 176 *a*.

191. *Ribbed Patterns.*—The next example in this class of designing is what is known as a *rib* style. No doubt the term *rib* has been applied on account of the furrowed or ribbed effect this kind of weave combination produces in the fabric. There is but one principle of constructing a design of this class—the figuring or face picks of one weave must oppose the backing picks of the adjoining weave. On consulting fig. 176*a*, it will be better understood what is here referred to. It will be noticed that in this figure the cassimere twill in sections B always takes the even picks while the rib weave, sections A, falls on the odd picks. It is this cutting of the face picks of one weave with the backing picks of the other that results in the for-

mation of the so-called ribbed appearance. The rib proper, however, is produced by the four threads of the weft-cord weave forming those parts of the design lettered A. In such positions in the cloth as where this make is introduced, the weft picks, having been beat closely together, completely conceal the warp threads and form, by so doing, solid lines or ribs slightly elevated above the rest of the surface of the texture. Fabrics figured on this principle, when well managed in the weaving and finishing departments of manufacture, always possess a smart appearance. Colours cannot be applied with such facility to these designs as they are to goods made from simple crossings: for there are only some parts of a ribbed design which admit of weft colouring. Thus fancy threads inserted in the warp in sections A would be useless so far as improving

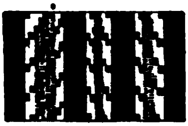


Fig. 176.

the face of the texture goes, for in these parts the weft covers the warp threads. However, if these yarns are of no use in the warp, in weft-rib weaves, they can be advantageously employed in the filling, for by a judicious combination and application of fancy weft shades a style of pattern can be obtained that is not producible in any other description of make. The ribbed or furrowed sections, for instance, are often woven of two or more colours, which only show in the rib weave. For example, whatever colour or colours of yarns were used in weaving the rib portion of fig. 176*a*, they need not appear in the cassimere twill sections of the design—this make falling on the even picks could be woven of an entirely different shade.

An excellent effect is got in this class of combination by employing two dark colours of weft and weaving, about

12 or 16 picks of each alternately. Another method of wefting consists in introducing into the rib, at from half to three-fourths of an inch apart, a few picks of silk of a bright colour, such as crimson or blue, the other weft being a dark shade. Pattern 176 is coloured in the following manner in the warp, while the weft is black:—

For 20 threads.	4	ends of	black.
	2	"	white.
	2	"	grey.
	2	"	white.
	4	"	black.
	2	"	white.
	4	"	grey.
	2	"	white.

Fancy coloured yarns would give a more stylish pattern, but these clearly show the character of the effect obtained by this order of warping in weave 176*a*. Various patterns might be produced in this arrangement of makes by employing a diversity of colours both in the warp and weft, while the design might be altered in several ways to give a different effect. Thus 4 threads of rib and 12 threads of twill running to the right, and 4 threads of rib and 12 threads of twill running to the left would make a suitable variation. Other methods of varying the colourings and weave combination will no doubt suggest themselves.

CHAPTER XII.

BACKED AND DOUBLE CLOTHS.

192. *Definition and Uses of Backed Cloths.*—Single weave cloths differ very materially in structure from backed cloths. In the former there can only be one warp and one weft—the threads of which appear on both surfaces; in the latter there may be either two warps or two wefts—the additional warp or weft, as the case may be, forming the back of the fabric. A backed cloth is a single texture, on to the underside of which is woven a *back* or a layer of threads distinct from, and independent of, those yarns which form the face or upper side. Backed fabrics are not necessarily double. Technically a marked distinction is made between a backed and double-make texture. In the finished goods there are some features in which these cloths resemble each other, and hence backed fabrics are sometimes very erroneously designated double. But, practically, there is as decided a difference between the construction of *backed* and *double* as between *backed* and

single weaves, for while a double cloth is twofold in both warp and weft, a backed cloth if twofold in the warp is single in the weft, and if twofold in the weft is single in the warp.

Without the backed principle of intertexture it would be impossible to increase the weight or substance of the fabric, and at the same time retain its fine, smart face. To secure the fine face indispensable to some styles of worsted coatings, and the better class woollens, small yarns have necessarily to be employed. These, of course, produce a comparatively thin and flimsy texture. Fine or small threads do not possess sufficient thickness or body to impart substance and fulness to a single weave cloth, even when the largest practicable number of threads on the inch in both warp and weft is adopted. Moreover, to vary the thickness of a single fabric, the yarns used in its production have either to be increased in size or more rankly set in the loom. Such alterations, as a few examples will show, always change the appearance of the cloth. Thus, supposing, in the first instance, to gain weight thicker yarns are employed. Then more open setting would be an absolute necessity, which would cause the weave in the piece to possess a broader or coarser grain. In a second experiment suppose finer yarns are used, and the number of threads on the inch proportionately increased to the difference between the thickness of the yarns in the original and the new woven sample; in such a case the crossing would be of a more minute character. Providing that in a third example the same sizes of yarns are used as in the original fabric, but more rankly sleyed or set, this would cause the make in the cloth to appear cramped or compressed, while the texture itself would be unsatisfactory; showing, that if weight or thickness is to be added to a cloth already accurate in structure or build, it will not have to be effected either by varying the thickness of the yarns or the system of setting, but by applying to it what is technically designated a *back*, or attaching another fabric on to its under surface.

193. *Two Methods of Backing.*—There are two methods of constructing backed weaves: first, by employing two series of weft and one series of warp threads; second, by employing two series of warp and one series of weft threads. The former is, perhaps, the simpler of the two principles, but is not applicable to all the requirements of backed goods. For medium and lower qualities of cloths it is excellently adapted, as it admits of a very inferior yarn being used for backing purposes; a thread of such coarseness, in fact, that it would almost be impossible to weave it in the warp. On the other hand, there are certain advantages in backing with the warp yarns, such as one shuttle only being required, and also the practicability on this principle of figuring the back of the cloth with a striped design of various colours. It is very important in some styles of backed goods that both sides should resemble each other as much as possible. Fancy colours cannot be applied with any degree of success to the under surface of goods backed with weft only. This method of backing simply produces bars or stripes of colour across the back of the piece. This is one of the reasons why the warp back is preferable in the manufacture of the better classes of fabrics. Some of the finest worsted styles backed on this system are almost as neatly coloured and figured on the back as on the face of the texture. As backed cloths are in somewhat bad repute amongst buyers, in consequence of the low materials used in some localities in the making of yarns for the underside, more especially when backing with weft, a good backed fabric, if a fancy, is now invariably coloured on both surfaces, and hence backed with warp, while, if a piece dye, the same quality of thread is used for both face and backing warps.

194. *Cloths Backed with Weft.*—These cloths may be divided into two classes—(*a*), those woven one pick face and one pick back alternately; and (*b*), those woven two

picks face and one pick back. Both these methods of backing are extensively practised. When the one-and-one principle is adopted, the backing should not be much thicker than the face yarn. Unless this rule is strictly adhered to, the face threads will fail to completely cover those yarns used in the formation of the back. In order to secure an even face in goods backed with weft, it is essential that the same number of picks should be woven

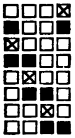


Fig. 177.

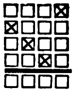


Fig. 177*b*.
Backing weave for Fig. 177.

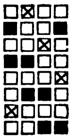


Fig. 177*c*.

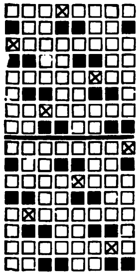


Fig. 178.

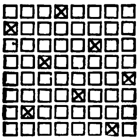


Fig. 178*b*.
Backing weave for Fig. 178.

in the inch on the upper surface as would be inserted if the cloth were made minus the backing weft—that is to say, if a piece of cloth contains 40 picks on the inch in the single weave, it should, to preserve the exact proportions of the structure when backed on the thread-and-thread system, contain about 80 picks. If such a texture were backed on the two-and-one principle, 60 picks would only be introduced, or 20 for back and 40 for face. To compensate for the reduction in the number of picks on the back in this latter instance, the backing yarn would be about half as thick again as that used for the face.

145. *Principle of Backing Simple Twills.*—Figs. 177 to 180 illustrate four different methods of backing the ordinary four-heald twill with weft. The crosses in each example represent the backing and the solid squares the face weaves. Figs. 177 and 179 are principally used in the manufacture of medium and coarse set goods, the backing picks never floating under more than three threads, whereas in figs. 178 and 180 they float under seven threads; so that to produce a neat back in the latter weaves a comparatively finer set is requisite. It will be noticed that there is one principle observed in the structure of each weave—namely, the threads on which the backing "ties" are placed are invariably down both previous to and after the insertion of the backing picks. Thus the first backing pick of weave 177 takes down the second thread, which is not only depressed by the first but also by the second face pick, causing the face yarn to be flushed on both sides of the backing weft. The object of fastening the backing weft on to the cloth in such positions of the design as here indicated, is to admit of it being entirely concealed by the face yarns. If the backing weave were arranged on the system shown in fig. 177*c*, the warp threads being elevated on both sides of the ties, the face weft could not possibly cover them; which would result in the production of a faulty texture, for the backing yarns would destroy the regularity and evenness of the face of the fabric. Let it, therefore, be regarded as a primary principle of backing designs with weft, that the ties should always (providing the structure of the design admits of such an arrangement) immediately be preceded and followed by flushes of face weft.

Fig. 178 forms one of the most satisfactory methods of backing the cassimere twill, or any regular make occupying four or eight shafts. The back here, as seen from weave 178*b*, is a sateen or doeskin, and produces a soft, full texture.

The backing weave for fig. 177 (which is a very useful method of backing the cassimere twill when only a limited number of shafts is at command), is swansdown or crow twill.

The two-and-one principle of backing is illustrated in figs. 179 and 180. The only difference between this and the one-and-one system consists in having two face picks between each backing shoot instead of one, the principle of constructing the *back* being the same in both systems. One drawback to the use of these weaves is, each warp thread does not receive the same proportion of stitching or crossing by the backing yarns. On examining the makes it will be found that the backing picks only interweave with the odd threads in the design—in other words, they

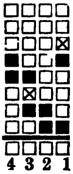


Fig. 179.

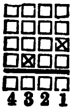


Fig. 179*b*.

Backing weave for Fig. 179.

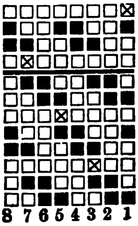


Fig. 180.

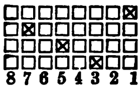


Fig. 180*b*.

Backing weave for Fig. 180.

always float under the second, fourth, sixth, and eighth threads. Now, every thread in backed fabrics should, as far as practicable, be stitched alike. Take fig. 178 as an example of a design backed on this principle. Here each thread in the pattern is stitched down once by the backing weft in 16 picks; in fig. 177 each thread is depressed once in eight picks by the backing shoots. Both these designs are constructed on the basis of one tie on each thread in one "round" or repeat of the weave.

196. *Effect of Irregular Tieing.*—An important principle obtaining in cloth construction is that those threads of the warp which are crossed or interlaced the most frequently by the weft yarns take up the fastest. This point can be explained by referring to sketches A and B, fig. 181. Let

it be supposed that A and B represent two warp threads taken from the same cloth. Thread A is interlaced or covered by the weft four times in 16 picks, while B is only crossed once. The frequent semi-revolutions which A makes in passing under the weft threads necessarily cause it to take up more quickly than B. In order to weave the same number of yards of cloth with A as B, the former would require to be of a greater length, a matter which could only be regulated by the use of two beams. Admitting this it will be at once evident that weaves 179 and 180 are not backed on the best possible system. True they are often used as here given, but where the backing yarn is much thicker than the face (as in low goods), after a length of cloth has been woven, those threads on which the backing ties fall work tight, and ultimately produce

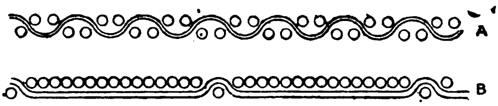


Fig. 181.

"streaky" places in the piece. The thicker the backing thread, the more pronounced in character, as well as the sooner, will defects arising from such stitching be apparent. Where, however, the backing weft is only slightly thicker than the face, a considerable length of cloth may be woven of these designs without its appearance suffering to any noticeable degree.

197. *Systems of Backing Check Designs with Weft.*—In figs. 183*a* and 183*b* two methods of backing a check pattern are given. The face weave in both designs is twilled hopsack, checked, or the design given in fig. 182. There is, however, a considerable difference in the systems adopted in the respective weaves of fitting on the backing picks. In fig. 182*a* the first backing shoot is inserted between the second and third picks of the face weave, and the second backing

pick between the fourth and fifth. This arrangement causes the "ties" on the fourth backing shoot, which falls between the eighth and ninth face picks, only to be partially covered with the weft flushes of these picks; for it will be noticed that the ninth thread in the design, on which one of the ties in the fourth backing pick is placed, is elevated on the preceding shoot, while the second thread in the pattern rises immediately after the "tie" on the eighth or last backing pick, so that in both these cases the backing "ties" would only have flushes of face weft yarn on one

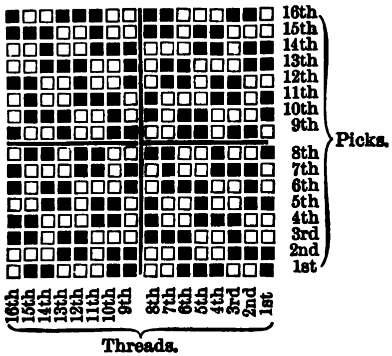


Fig. 182.

Face weaves for Figs. 182*a* and 182*b*.

side of them. In fact, by the method adopted in pairing the picks of the face weave in this design, it is impossible to avoid defective tieing, for picks 1 and 16, and 8 and 9 (see weave 182) cut or oppose each other, *i.e.*, the white or blank spaces of one pick meet the solid black squares of the other, showing the impracticability of arranging for a flush of face weft yarn to both precede and follow the "ties" on those backing picks inserted between either of these pairs of shoots. A different arrangement obtains in fig. 183*b*. Here the picks of the face weave are paired as follows: 2nd and 3rd, 4th and 5th, 6th and 7th, 8th and 9th, 10th and 11th, 12th and 13th, 14th and 15th, 16th and 1st; providing proper positions, as may be seen by consulting weave 182*b*, for the insertion of the backing ties. Each tie in this design is placed between weft flushes of the face weave, while there are two ties on every pick, and one tie on each thread. From these examples in backed check designs it is apparent that those picks of the face crossing which cut each other should be coupled together. Generally, it will be found that the more com-

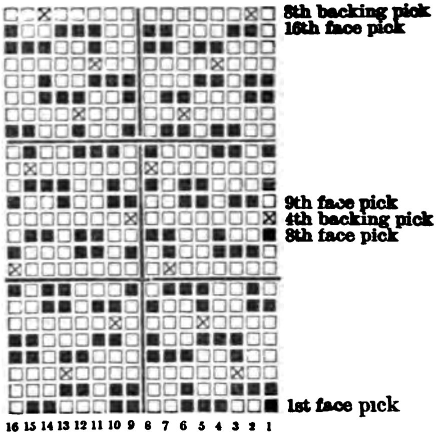


Fig. 182*a*.

plicated the combination of weaves, the greater the difficulty experienced in backing the design in such a way as to obtain an even surface on both sides of the texture; but, as a rule, by varying the plan of pairing the shoots a passable back may be applied to almost any class of weave pattern.

198. *Figured Weave Backed with Weft.*—A figured weave (design 183) backed with weft will next be described. It is a 16-shaft design, and is woven two picks face and one pick back. To back a plan of this character, first

arrange the face weave on point paper, omitting the spaces on every third pick on the paper. Now decide on the number of "ties" to be placed on each backing pick and each thread of warp—say in this instance two "ties" on the former and one on the latter. Next take the blank shoots in the order in which they occur in the design, and insert the "ties" in such places as they will be properly hid in the woven fabric. Thus, in treating fig. 184, begin with the backing pick A, and carefully run the eye across

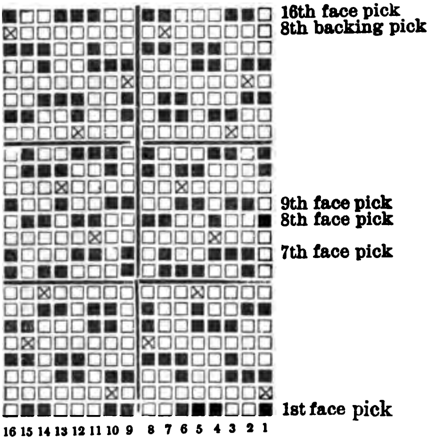


Fig. 182*b*.

it to ascertain where the stitches or "ties" may be best introduced. The 8th and 15th threads are those on which this backing pick should be tied. Suitable positions for stitching pick B occur on the 1st and 10th threads, and on the 3rd and 12th threads for pick C. In this manner the backing picks should be dealt with separately, care being taken not to tie on the same warp thread twice.

199. *Principle of Backing Union Fabrics.*—Two other classes of weaves backed with weft will also be alluded to. The first is for a piece of cotton warp goods, the weft being

worsted for face and woollen for back. The weave or figured effect obtained in these fabrics is solely due to flushes of worsted weft, the woollen yarn forming the back of the texture, while the cotton is the thread employed to knit the two wefts together, and, by limiting the sizes of the floats of the respective yarns, to form the pattern designed. Some good patterns for low-priced coatings are produced on this principle of intertexture. The weave given as an example (fig. 184) is an excellent style. The

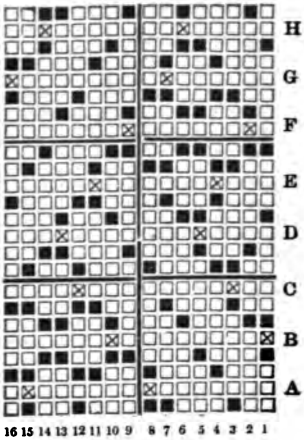


Fig. 183.

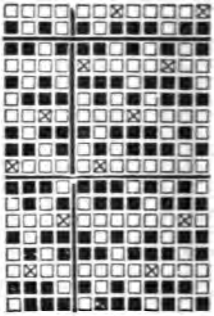


Fig. 184.

solid black square represents the effect of the worsted yarn, and the crosses the backing picks. When making designs of this class the main point to be observed is to so arrange the structure of the face weave as the cotton warp will be completely hid from view. In fact it is very desirable that this yarn should not be discernible on either the right or under side of the fabric. It is not a difficult matter to back weaves of this type, as the long flushes of face weft readily admit of a proper adjustment of the backing picks.

Another class of backed goods in which cotton is used is made of worsted yarn for warp, and woven with cotton and woollen weft. Here the weave effect is due to the system of flushing the worsted warp. The cotton weft acts as the regulator of the dimensions of the warp flushes, and causes them to be arranged in the precise order in the woven cloth as in the design. Tieing on the backing weft is effected by depressing the warp threads. These goods are more difficult to manage, both in the loom and in

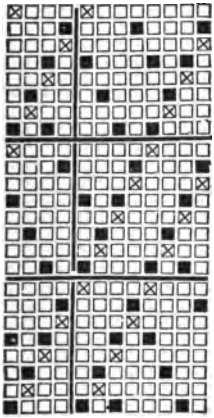


Fig. 185.

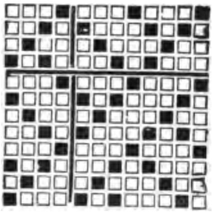


Fig. 185*a*.

Face weave of Fig. 185.

backing, than the preceding class. In order to cover the cotton and woollen yarns, the worsted warp has to be very rankly set in the healds and sley. Fig. 185 is a design constructed for these fabrics. The crosses represent the stitches on the backing picks, and the solid black squares the plan on which the cotton weft intersects the warp threads. The blank spaces in fig. 185*a* show the effect of the worsted yarn on the face of the texture. In weaving, the first pick of design would be cotton, and the second pick woollen.

200. *Cloths Backed with Warp.*—When *backing with weft* one body of warp threads interweaves with two series of weft or filling threads; but when *backing with warp*, one body of weft threads interweaves with two series of warp threads. Further, a weft back is stitched to the face of the texture by bringing the backing weft yarns over the warp threads, but the tieing in goods backed with warp is effected by bringing the yarns of the backing web over the picks or shoots. In all warp-backed fabrics the chain for the back works independent of that forming the face—the

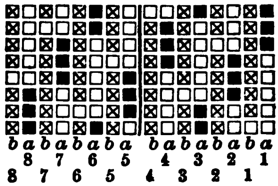


Fig. 186.

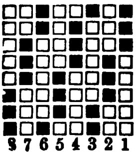


Fig. 186*a*.

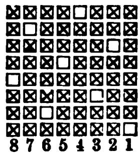


Fig. 186*b*.

warps are, in fact, drawn on separate shafts, and can in consequence be made to produce different weaves. There is not, however, much variety of crossing applied to the under-surface of these cloths, the weave generally being of a doeskin or buckskin character. The face weaves are not so limited in variety; here every diversity of crossing is employed. Fine worsted fabrics are very frequently backed on this system. The yarn used in the backing warp is, as a rule, about the same size or thickness as that used for the face, the cloths containing a large number of threads on the inch.

201. *How to Back Cloths with Warp.*—The order of the threads in the warp in making this style of backed fabrics is invariably one thread face and one thread back. To arrange the threads two of face to one of back would necessitate the use of a coarser yarn for backing, and even then would only produce a raw, open texture on the under side of the cloth. The method of procedure when backing any particular weave with warp is as follows:—Mark the threads on the point paper intended to be occupied with the face and backing weaves respectively, then run the face weave on to the face threads and the backing weave on to the backing threads. Suppose, for example, it is required to back design 186*a* with weave 186*b*. As each of these crossings occupies eight threads, when combined they will occupy sixteen, or those lettered *a* and *b* in 186. The first thread of weave 186*a* is transferred on to the first thread lettered *a* of 186, the second thread on to the second thread *a*, the third thread on to the third thread *a*, and so on throughout the weave. After the face crossing has been dealt with the backing weave is added, taking the threads in the order in which they are arranged in fig. 186*b*. There is still one other point that requires noting: the "ties" (*i.e.*, those pieces in the design where the backing warps threads are elevated) should, if possible, be planned to fall in such positions of the pattern as there will be face warp threads elevated on both sides of them. Just as flushes of face weft on each side of the stitches are necessary to effect successful tieing when backing with weft, flushes of face warp are necessary to cover the ties when backing with warp. There should always be the same number of ties on each pick.

Goods backed on this principle generally require twice as many shafts as there are threads in the face design. This feature of double-chain goods will, to some extent, prevent packing with warp from becoming extensively practised in the manufacture of low goods. Thus while the cassimere twill may be satisfactorily backed with weft on four shafts, it requires no less than twelve shafts when backed with warp—four for the face and eight for the backing weave. (See fig. 187.)

202. *Patterns on the Under Surface of Backed Goods.*—The eleven-shaft corkscrew backed with warp is given in the next design, fig. 188. It will be seen that the system of constructing this weave is exactly the same as that already demonstrated in referring to design 186; hence it is unnecessary to give any explanations on its structure. The principle on which a striped pattern of various colours is obtained on the back of these cloths may, however, by its

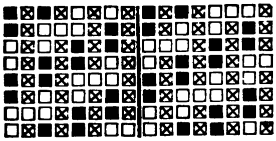


Fig. 187.

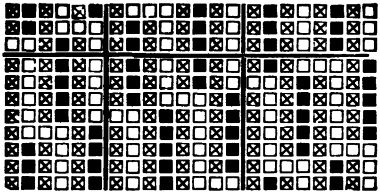


Fig. 188.

use, be illustrated. In reality, as there are two warps in this class of backed designs, there are, when the face is figured with one arrangement of colours and the back with another, two distinct patterns of warp. Thus, supposing the order of shades for the face were as follows—

11 { 1 end of black worsted.
     { 1 „ brown „
1 „ black worsted and blue silk twist.
1 „ black „ „ white „
1 „ black „ „ blue „
19 ends of black „

—then the backing warp might be a simple striped pattern of two colours, say 11 threads of black and 11 threads of brown alternately. As two beams are generally employed in weaving these cloths, the warps would be made separately, although the sizes and quality of the yarns might be the same in both cases.

203. *Features of Double Cloths.*—When backing with warp or weft simply, although a different weave is producible on the back from what obtains on the face of the texture, yet the weave on the under surface, particularly in weft backed goods, has invariably to be arranged to meet the construction of the face design. On the other hand, when backing with warp, the yarns are usually warped one thread face and one thread back alternately.

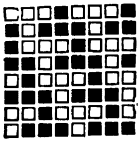


Fig. 189.

If not thus arranged a satisfactory back is not obtainable, for reasons named in a previous paragraph. Further, a warp back in order to cover well and possess a full and soft appearance, must necessarily be constructed on the floating principle, that is to say, the weaves must be of a sateen or buckskin type, which implies that but few crossings are suitable for backing this class of fabric. An attempt to back such cloths with makes of a common twill or mat description would result in destroying the uniformity of the face of the fabric. Hence it is apparent there is little scope for varying the weave effect on the under surface of cloths backed with warp. The same holds good in backing with weft. In this case the backing weave frequently flushes or floats a great deal, the dimensions and plan of the flushes being determined, as stated above, by the structure of the design employed in the formation of the face of the fabric. On both these principles of backing, satisfactory cloths may be produced, but the weaves only being partly double cannot be made to form that diversity of texture which obtains in double-weave goods proper. For example, reversibles or cloths figured and wearable on both sides, can only be produced in double weaves. Of course, as already explained, when backing with warp one order of colourings may be applied to the face and a second order to the back, but the pattern on the under side being formed entirely by the warp yarns is necessarily of a striped character. Again, there is a class of carriage rugs made of the backed weave, given in illustration 189, figured on both surfaces, but that such a fabric is not reversible, strictly speaking, is evident from the colourings in these goods always being applied in the weft and forming stripes across the piece. Warp colourings in this type of design would not in the least change the appearance of the pattern, for the weft yarns on both sides of the cloth completely hide the warp threads, so that, as in union goods the warp threads in this weave simply act as the agents for binding the two wefts together. Evidently if these two systems of backing were combined they would form a class of weave in which the same effect could be woven on both sides of the fabric. What one system lacks, the other possesses. Thus, while backing with two chains affords facility for gaining pattern on the under surface of the cloth, backing with weft admits of colouring across the piece. A double-weave is nothing less than a cloth backed with both warp and weft, or one in which the two principles of backing, already described, enter. Literally such a weave forms a twofold texture. In a double make each weave regulates the elevation and depression of a separate series of warp and weft threads, thus making it feasible to apply the same style of pattern to both surfaces of the fabric. The advantages of using double-weaves in backing woven goods over the system of backing with warp or weft only may be said to be as follows: 1st, the same design and colourings may be employed on both sides of the cloth; 2nd, a more regular back may be constructed; and 3rd, a larger variety of patterns is obtainable coupled with a more perfect texture.

204. *Various Types of Double Cloths.*—There are three distinct classes of double-weaves.

I. Those in which there is an equal number of threads on the back as on the face of the fabric, or cloths warped and woven one thread face and one thread back.

II. Those in which two-thirds of the warp and weft yarns appear on the face and one-third on the back of texture, or cloths warped and woven two threads face and one thread back.

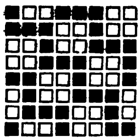


Fig. 190.

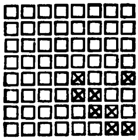


Fig. 191.

III. Double-makes in which three-fourths of the warp and weft yarns appear on the face and one-fourth on the back of the cloth, or fabrics warped and woven three threads face and one thread back.

The first two classes of weaves are in very frequent use in the manufacture of woollen and worsted goods, but the third class is almost limited in application to the finest fabrics for worsted coatings.

205. *Method of Constructing Double-Makes.*—In making a double cloth design it is always necessary to determine at the outset to which of the three classes just enumerated it is intended to belong. Having decided this point, the question arises as to what weaves are to be employed for

the respective surfaces of the cloth; because, although the face of the fabric may simply consist of a small twill, yet either the same, or another weave of a different construction, will require to be used for the underneath of the texture, and until the weaves have been selected the construction of the design cannot be proceeded with. Suppose now it is required to make a double cloth, in which the yarns are to be arranged one thread face and one thread back alternately, and the face weave to be twilled hopsack or fig. 190, and the backing weave cassimere twill or fig. 191; then mark out on point paper the threads intended

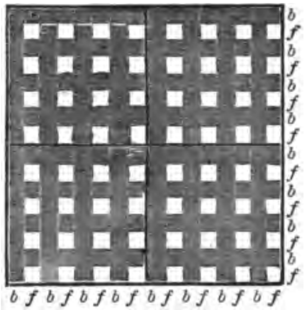


Fig. 192.

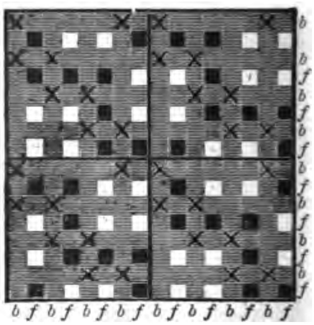


Fig. 192*a*.

to represent the backing yarns. These are represented in fig. 192 by the threads and picks marked in parallel lines. This done, run the face weave on to the unmarked threads or those lettered *f*, fig. 192*a*. Next transfer the backing weave on to the threads and picks lettered *b*. Although the weaves have thus been placed on separate threads and picks, yet the construction of the design is not complete. A consideration of the positions of the yarns will show that when the face picks are entering the warp all the backing threads are elevated. One primary object in making backed weaves is that of effectively hiding the backing yarns, or, in other words, of preventing the threads used in the formation of the under side of the cloth from damaging the face of the texture. It is not enough, therefore, to have placed one crossing on the threads and picks of the design representing the face fabric, and a second crossing on the threads and picks representing the backing fabric. Something more must be done, in a word the threads of the backing warp must be depressed *en masse* during the introduction of the face picks into the face warp. In fact the invariable rule is, that all the backing threads (with the exception of those which tie or tack the two cloths together) should be down on the face picks; while, on the other hand, the face threads should all be up on the backing picks. In order, therefore, to complete the design under consideration it will be necessary to depress the backing threads on each of the face picks. This can be done by dotting the threads as indicated in fig. 192*b* by the diagonal lines thus ▨. The second condition, that all the face warp should be up on the shoots of the backing weft, is already complied with; so that the design should now form if put into the loom, two cloths, the upper one figured with twilled hopsack and the lower one with the cassimere crossing. The question is, will the weave in fig. 192*b* give these results? Let the construction of the design be briefly re-examined. In the first place the weave furnished in fig. 190 was transferred on to the threads lettered *f*, then weave 191 on to the threads *b*, so that thus far the two makes were kept to their own threads and picks. It was then found that the backing warp yarns being unmarked (see fig. 192*a*) were elevated on the face picks, *f*. This, of course, would prevent the formation of a proper face texture, for the backing yarns would be floating on the upper surface of the cloth. These threads were, therefore, dotted, which depressed them, and admitted of the face weft being woven into the face warp, and the backing weft into the backing warp; and, by this means, allowed of two distinct cloths being produced according to the structure of the weaves given. From which it may be concluded that the diagonal marks, ◩, in reality do not in any way alter the weave effect produced—they simply prevent the yarns of the backing warp from rising during the formation of the upper cloth.

206. *Tieing, or Stitching.*—The design, as now arranged, would, if woven, make two fabrics separate from each other. For some classes of goods, as in sacking, probably the weave, as here formed, would do all that is required, with the exception of tieing the two cloths together at the

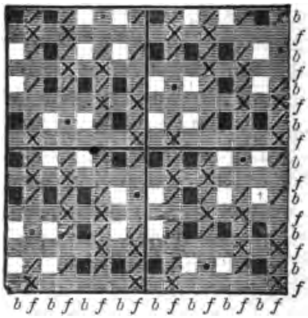


Fig. 192*b*.

sides to save the labour of sewing. In goods for garments this is not sufficient. The distinct fabrics must be fastly stitched together, in order that they may be made to handle and pass as a single cloth. If the cloths are only indifferently tied, the wearing qualities of the twofold texture will suffer very materially. There have been goods made in which the face has parted from the back fabric after a brief period of wear, in consequence of indifferent tieing.

There are only two modes of stitching—first, by bringing a backing warp thread over a face pick; and second, by bringing a backing weft thread over a face warp thread. As to which is the best method, it may be said that the former gives the most satisfactory results for at least two reasons—firstly, the yarns used for the backing warp are invariably smaller in size and of a better quality than those used for the backing weft, and hence are not so liable to be seen when brought on to the face of the fabric; secondly, warp ties are better concealed in scouring and milling than weft ties, in consequence of the cloths shrinking somewhat more freely in direction of the weft than in the direction of the warp yarns. When stitching with the warp, there should always be, if possible, a face thread elevated on each side of the tie. Thus in fig. 192*b* the ties, ■ (which would be lifted in weaving) are inserted in such positions in the design as face threads are elevated on both sides of them. Take, for instance, the tie on the first backing thread, which, it will be noticed, has a face thread elevated on the same pick on both sides of it. The elevation of such threads has a tendency to hide the tie. Again, the stitches should always be arranged on a sateen principle if the weave admits of it. This type of crossing forms the best possible plan on which to arrange the ties in backing simple makes. If the stitches run in a diagonal line across the design, they are apt to form a contrary twill in the woven fabric to that of the weave employed in the production of the face. Hence to back the four-shaft twill on the principle given in fig. 193, and tie as there shown, produces a cross twill; while to arrange the ties as seen in fig. 194 causes one furrow or rib of the face weave to appear somewhat fuller than its neighbour. Tieing should, therefore, always be done on a well-defined principle. Stitches should not be introduced where there happens to be face threads elevated without due consideration being given to arrangement. A systematic basis should always be adopted where possible, and for this purpose the sateen is recommended, because it distributes the ties evenly and yet is the least liable, on account of its indefinite character, to alter the condition of the face design of any class of crossing that could possibly be used.

207. *Weft Tieing.*—Next as to tieing with the weft thread. If the principle of backing cloths with weft simply is thoroughly understood, this mode of stitching will not afford any difficulty to the reader. On this system of tieing the backing picks have to be made to depress the face threads. They should, however, only do this in such positions in the design, as they will be covered with face weft, so that the rule in tieing double fabrics with the backing weft is the same as in backing cloths with weft only—namely, there should be flushes of face weft on each side of the tie. This method of tieing is very useful in some double weaves. Fig. 195, for example, is a design in which it may be advantageously employed. The good, solid flushes of face weft in weaves of this class completely

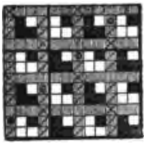


Fig. 193.

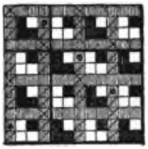


Fig. 194.

conceal the ties. Sometimes weaves are stitched on both systems, but this is generally unnecessary and should not be attempted, as it is liable to injure the face of the goods. It should be observed that the ties, ■, in weft stitching represent threads depressed.

208. *Structure of the Double Plain Crossing.*—This is one of the most useful weaves employed in the woollen trade. West of England goods are very extensively woven on this method of intertexture. The double plain weave is, strictly speaking, a combination of two plain makes, which, in the loom, under certain conditions, produces two distinct cloths, one above the other. In fig. 196 the threads lettered *a* represent the face, and those lettered *b* the backing weave. An analysis of the structure of the crossing shows that picks *a* enter the warp when threads *b* are

depressed; while threads *a* are all elevated on picks *b*. Consequently, if the threads and picks lettered *a* were white, and those lettered *b* black, this weave would form a plain white cloth over a plain black cloth. This point may be better explained by referring to fig. 197. From this sketch it is clear what the effect of weave 196 is, in the

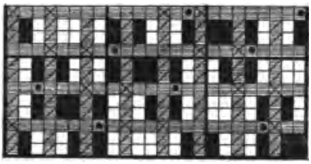


Fig. 195.

woven fabric, when the yarns are arranged as above. The respective threads are, by this crossing, kept as distinct from each other as if woven in separate looms—the black warp weaving with the black weft, and the white warp weaving with the white weft. On comparing the crossing of the threads in this sketch with the plan of interlacing

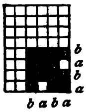


Fig. 196.

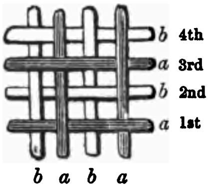


Fig. 197.

the threads indicated in the weave, it will be seen that they are precisely the same in both cases. Thus the first pick in both the weave and the sketch flushes over threads 1, 2, and 4, and under 3; the second pick under threads 1, 3, and 4, and over 2; the third pick under thread 1 and over threads 2, 3, and 4; the fourth pick under threads 1, 2, and 3, and over 4.

209. *Stitching Double-Plain Cloths.*—Now, as the weave furnished in fig. 196 gives two distinct cloths, it will require to be altered before it can be used in the production of fabrics for ordinary wear. In a word, the weave requires tieing. This is effected in the double-plain crossing in making striped and figured patterns in a different manner from what it is in the general run of two-ply cloths. For instance, in double plain goods, stitching is accomplished by reversing the positions of the weaves, or by bringing that weave which in one part of the texture forms the back on to the face, and by causing that weave to do duty on the back previously employed in the construction of the upper surface. Reversing the positions of the weaves also reverses that of the colourings of which

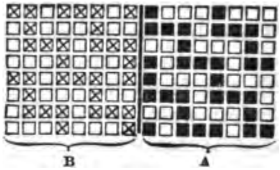


Fig. 198.

they are separately composed. Thus, if weave 198 were warped and woven one thread black and one thread white, it would form a stripe of four threads black and four threads white in the piece. This arises from the fact that in section A the black picks interweave with the black threads and form a black over a white fabric, while in B the position of the weave having been changed, the white picks interweave with the white threads and produce the opposite result—namely, a white over a black fabric. An examination of the design will show how this effect is obtained. It will be noticed that in section A the black threads appear on the face, while the white threads form the back of the texture. Again, the 2nd and 4th picks in this part being black, flush over the white threads, but produce a plain fabric in combination with the black threads. In B, however, the white yarns form the face while the black yarns form the lower texture, as will be seen by carefully following the construction of this portion of the weave.

210. *Double-Plain Stripes.*—As double-plain weaves always give a plain-surfaced texture, any pattern which they are made to produce is solely due to the method of arranging the colours. The structure of the weave has, however, to be altered to make it tally with the order of colouring. The invariable rule in constructing a double-plain weave for a striped pattern is this—it must be so arranged as to admit of the various shades of yarns used in the weft covering corresponding shades in the warp, and

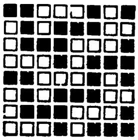


Fig. 199.

these alone. For example, suppose it is required to make a double-plain stripe, one thread black and one thread white on the face. Then the weave must be arranged in such a manner as to allow the black picks to float over the black and under the white threads, and the white picks over the white and under the black threads. A crossing for producing this effect is furnished in fig. 199, the order of warping and wefting being 2 picks of black and 2 picks of white.

To show what a variety of patterns may be woven in a thread-and-thread arrangement of warping by suitable alterations in the structure of a double-plain design, reference will be made to figs. 198 to 201 inclusive. Above it was shown that this order of warping in fig. 198 produced a four-and-four stripe, while in fig. 199 it produced a single thread stripe. Now, if the same order of threads were applied to designs 200 and 201, it would give in the former a two-and-two, and in the latter a four-and-two stripe. Other examples might be furnished, but the principle on which one arrangement of threads may be made to produce four as different stripes as it is possible to produce, and yet each cloth possesses a plain surface, is the feature of importance that requires explanation. Take the last pattern—the 4-thread black and 2-thread white stripe—as suitable for illustrating the principle on which this variety of effects is obtained from one simple combination of colours. The weave for this style, fig. 201, occupies 12 threads, the first 8 lettered C, working the 4-thread

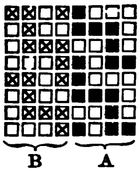


Fig. 200.

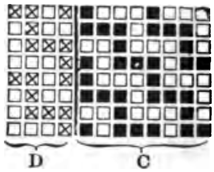


Fig. 201.

stripe of black, and the latter part, lettered D, the 2-thread stripe of white. The relation of the weft picks to the warp threads in section C is as follows: First, all the white threads are down on the black picks and half of the black threads; second, all the black threads are up on the white picks and half of the white threads; hence, in this part of the design, a stripe of 4 threads of black covers a stripe of 4 threads of white. In D, the position of the weaves being changed, and that of the threads remaining the same, as the black picks are introduced, all the white threads are up, and half of the black; while, on the white picks, all the black threads are down and half of the white, forming a stripe of 2 threads of white over a stripe of 2 threads of black.

211. *Three and Four Single-Thread Stripes.*—Two other examples need only be referred to. The first is for a stripe of three, and second for a stripe of four, distinct colours, each colour, in both examples, being formed by a single thread. The weave for the former is given in fig. 202. The warp might be arranged on such a system as the back would be formed of one colour of yarns; thus, 3 ends of black, 1 end of grey, 1 end of black, and 1 end of white. In this case the backing yarn is black. The order of picking would be as follows: 1 pick black (covering the black face thread), 1 pick grey (covering the grey face thread), 1 pick black (covering the black face thread), and 1 pick white (floating under all the face threads). The double-plain weave is more broken up in the production of this pattern than any other simple stripe.

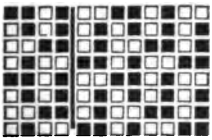


Fig. 202.

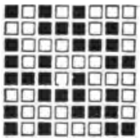


Fig. 203.

By employing weave 203, four stripes may be obtained. It should be remarked that as there are only four changes in the double-plain weave, this is the largest number of solid lines of colour producible in this make. The following arrangement of threads gives stripes of black, olive, brown, slate, blue, and lavender on the face, while the backing yarn in the warp is all slate, and about half as thick again as the face threads:—

Warp.

1 end of black (small yarn).
1 „ slate (thick yarn).
1 „ olive brown (small yarn).
1 „ slate (thick yarn).
1 „ slate (small yarn).

1 end of slate (thick yarn).
1 „ blue lavender (small yarn).
1 „ slate (thick yarn).

Weft.

1 pick black (small yarn).
1 „ olive brown (small yarn).
1 „ slate (small yarn).
1 „ blue lavender (small yarn).

212. *Figured Double Plains or Reversibles.*—This is another branch of double-plain designing. To produce a pattern of this description two weaves are always used—

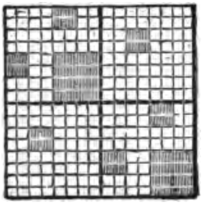


Fig. 204.

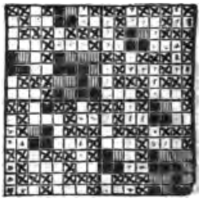


Fig. 204*a*.

say, A and B, of fig. 198. It will be noticed that in A the odd threads and picks flush on the face, while in B the even threads and picks form the upper surface. Hence, if the two weaves were combined, as in fig. 204*a*, and warped 1 thread black, and 1 thread brown, the face side of A would be black while the face side of B would be brown. This may partly explain the principle on which figured double-plain effects are produced. In designing the figure is first marked out in solid-colour on the paper, and then the weave run on afterwards. For example, the parts represented in vertical lines in fig. 204 form the design proper; on these parts, weave A would be transferred (see fig. 204*a*), while weave B would form the ground. If this design were warped and woven 1 thread black and 1 thread twist, the parts on which the weave has been placed would be twist yarn, while the ground weave would be self colour. Some very elaborate patterns for shawls and various kinds of mantle cloths are designed on this principle, the fabrics in some cases can be made in such a way as they are wearable on both sides.

213. *Characteristics of Cut Double Cloths.*—Another class of double make effects that requires a word of explanation is that known as *cut* patterns. These are designs in which the figured sections are separated from each other by fine, smart, decided furrows. In those portions of the cloth where such lines are introduced, the fabric possesses a cut appearance; in other words, the outline or skeleton of the

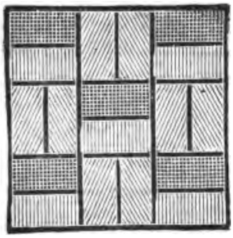


Fig. 205.

patterns figuring these goods seems to have been indented on the surface of the texture by the application of some sharp instrument, so decisive and clear is the cut produced. Sketch 205 will furnish an idea of the woven effect of this type of design. The thick black lines in this drawing represent the "cut" effect, or the outline of the pattern, the spaces between which are, in practice, filled in with different weaves, such as hopsacks, twills, and other small crossings. This variety of pattern is successfully applied to worsted coatings, trouserings, and mantle cloths, and also, when suitably modified, to a certain extent, to fancy vestings.

214. *Principle of Constructing Cut Double-Make Patterns.*

The method of constructing cut patterns will be described by referring to fig. 206. Here is given a simple striped pattern, the cut or sharp indented lines of which are formed in the woven cloth by the 2nd and 3rd and the 14th and 15th threads respectively. The cross marks represent the plain backing, and the round dots the face weaves. A *cut* may always be formed with two threads, the movements of which are arranged in such a manner that one thread is always up when the other is down, and *vice versâ*. For example, in design 206, the second thread, which forms a cut with the third, floats under the three picks

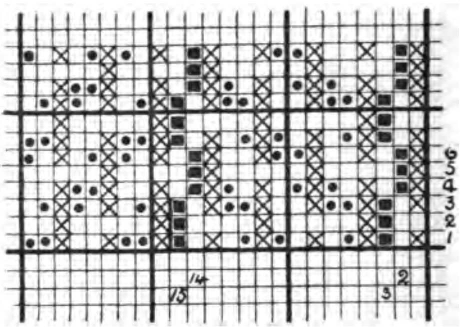


Fig. 206.

numbered 1, 2, and 3, and then covers picks 4, 5, and 6, this order of elevation and depression of threads being repeated throughout the pattern. By this arrangement, the backing picks always float over one of the cutting threads, fastening, by so doing, the two fabrics together. In cloths where the cuts are, say, not more than eight or twelve threads apart, the stitching thus effected is regarded as sufficient to secure a permanent adhesion of one cloth to the other.

In fig. 207 a cut check pattern is shown, the arrangement of the threads in which for forming the indentions lengthways of the design are the same as in the previous illustration, so attention need only be directed to the cutting picks. These, it will be noticed, are similarly arranged to the threads forming the warp cuts; in fact, if the design were turned round, and warp taken for weft and weft for warp, it would be found that the cutting picks—12 and 13, and 1 and 24—are exactly the same in arrangement as the threads figured 2 and 3 and 14 and 15. Examina-

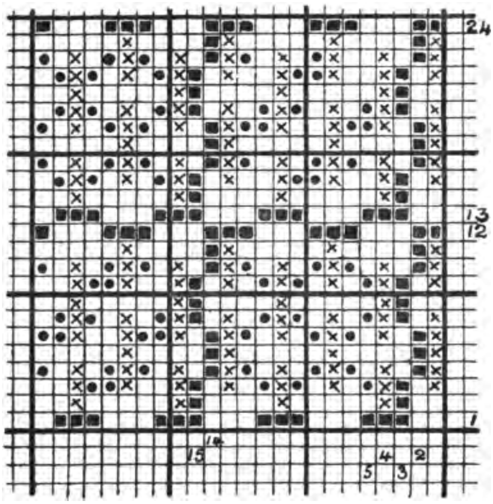


Fig. 207.

tion will show that they each flush under and over three threads in succession, one pick being *over* the threads, while the other is *beneath* them. Take, for instance, the 12th and 13th picks; while the former is flushing under the first and second threads, the latter is flushing over them. In the case of the third, fourth, and fifth threads, the process is reversed—namely, the 12th pick is on the surface, and the 13th pick underneath. In short, the rule in making double cloth "cuts," whether backing two threads face and one thread back, or one thread face and one thread back, is always the same, for it is imperative that the flushes in the cutting threads and picks oppose each other.

Sometimes the threads used in making the furrows are arranged on both sides of the backing ends, but although this method gives a broader or wider cut, it is not so definite and distinct in character. The system of cutting illustrated in the examples alluded to is the best in practice. A good plan of colouring styles of this class consists in introducing the fancy yarns into the cutting threads and picks; thus, the following arrangement of threads for the check pattern furnished illustrates this principle of colouring:—

For 9 threads	1 end of black wool (backing),
	1 ,, black and orange worsted twist,
	1 ,, black and blue worsted twist,
	1 ,, black wool (backing),
	2 ends of black worsted.

Pattern of weft to be same as warp. Another method of applying fancy shades to such patterns consists in introducing the colours into the body, so to speak, of the design, or in the threads and picks between the cuts. Both systems may be practised with satisfactory results.

215. *Drafting and Setting of Double Cloths.*—Double fabrics should, wherever possible, be woven on two beams. This is almost an absolute necessity if an even fabric is to be produced where the yarns used for the respective surfaces are of different thicknesses. Cut double-make fabrics occasionally require three beams—one for the face weaves, a second for the cutting threads, and a third for the backing yarns. In addition to two or three beams being used in some classes of double cloths, in many cases the face design is drafted on to one series of shafts, and the backing weave on to a second series. In fig. 208, for example,

which is the draft for design 207, shafts A are for the backing yarns, shafts B for the cutting threads, and shafts C for the face designs. As the principle of drafting and healding has been fully explained in previous articles, it is only necessary to add that the threads would be drawn through the healds in the order indicated in the draft. The pegging or weaving plan is given in fig. 209.

As to the setting of double cloths, this is a factor that is dependent both upon the character of the face texture re-

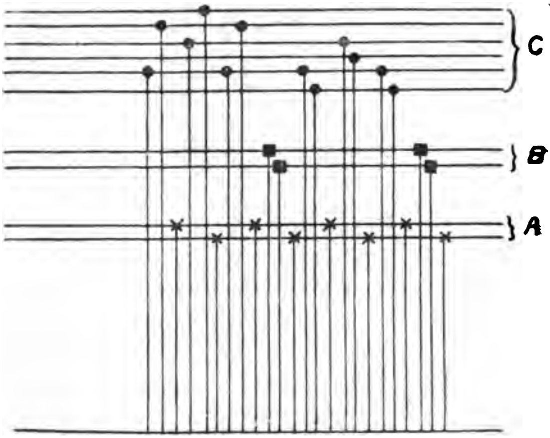


Fig. 208.

quired and the principle of backing adopted. If, for instance, a fabric contains forty threads on the inch, and is formed of a single weave, and it were required to back such a cloth on the thread-and-thread principle, and at the same time retain its exact condition of fineness of texture, it would, when double, contain 80 threads per inch. If, however, it were backed two threads face and one thread back, then 60 threads on the inch would be sufficient, for the requisite fineness could in this case be obtained by adding 20 threads for the backing to the number of face ends given. To compensate for the reduction of ends in this latter example as compared with the thread-and-thread arrangement, the backing yarns would require to be proportionately increased in thickness. There are no more important points in constructing double fabrics than those of setting, and the use of proper sizes of yarns. Now, in general, when a single cloth has been correctly built, the particulars for the backing texture to be added

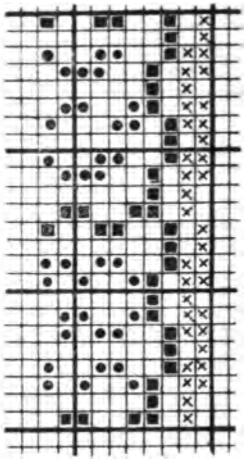


Fig. 209.

should be worked from the sizes of yarns and set employed in its construction. Take an illustration: Supposing a cloth is made of 2-fold 40's worsted and the weave is six-end twill, and it contains 64 threads on the inch, then what size of woollen yarn would require to be used for backing purposes, and how many threads and picks should be introduced to the inch, if the 2-and-1 system of double cloth structure is adopted? The latter particular can readily be got, for the backing texture would contain half the number of threads as the face, giving a total of 96 threads in the inch when added to the 64 employed in formation of the upper surface; while if the 1-and-1 principle of construction were adopted 128 threads would be necessary to preserve the character of the single texture now requiring backing. Before the thickness of the yarn can be calculated it will be necessary to find the equivalent to a 2-fold 40's worsted in woollen counts. This can be done as follows: 2-fold 40's worsted equals 20 hanks of 560 yards each, or 11,200 yards to the pound. Divide this sum by 256, the number of drms. in a lb., the basis on which woollen yarn is estimated, and the size required will be the result; thus, $\frac{11,200}{256}$ = nearly 44 skeins. This would be about the thickness of yarn necessary for backing if the cloth were woven one thread face and one thread back, and providing the same weight and structure were essential on both sides; but, as in practical work, the backing thread is generally somewhat thicker than the face to give increased substance, a 28 or 30 skeins yarn would probably be employed. The fabric under consideration is, however, for a 2-and-1 double make, which would necessitate the backing thread being somewhat thicker than half the size of the face thread—say 20 skeins. In ordinary goods this method of arriving at the size of the backing thread and set from the particulars of a given single cloth may be invariably practised with satisfactory results, but there are cases—when a new cloth has to be constructed, for instance—where experience and knowledge of weaving can alone be relied upon.

CHAPTER XIII.

ANALYSIS OF CLOTHS AND CALCULATIONS.

216. *Textile Analysis.*—The decomposition of fabrics is a very important part of textile manufacturing. New cloths are frequently submitted to designers and manufacturers, which, before they can be correctly imitated, have to be dissected; in other words, the particulars of production have to be deduced by a process of unravelling the texture.

The key to successful analysis of woven stuffs is a complete knowledge of cloth structure. If the principles of making the various classes of single, backed and double-weave fabrics have been mastered, the method of analyzing any description of woven texture will be readily understood.

Cloth analysis may be divided into three sections:—

I. Unravelling the fabric to obtain the weave or design used in its production.

II. Ascertaining the set in which the cloth has been woven, and the sizes of the yarns of which it is composed.

III. Calculation of the weight of the different sorts of yarns employed in the manufacture of the fabric.

The first section, in addition to relating to the weave or design used in weaving the given texture, also comprises the method of arranging the fancy yarns in both warp and weft of the fabric, and, if the design is a drafted one, the healding arrangement and the reduced weave or pegging plan.

The *set* of the cloth refers to the counts of the reed, threads in a dent, width of the warp in the sley, and picks on the inch. The sizes, or grists of the yarns employed

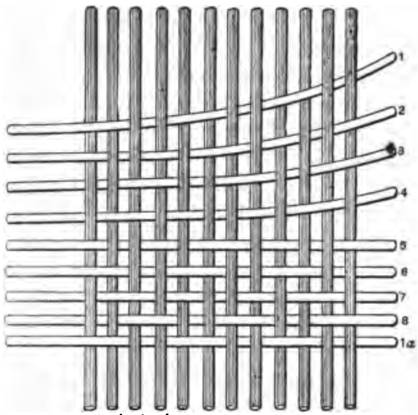


Fig. 210.

in weaving the fabric, also comes under the second head of analysis.

As to the weight of the cloth this is estimated from data obtained in dissecting the texture according to principles that will afterwards be explained.

Taking these particulars as embracing all the requisite items of manufacture, cloth dissection will be described in detail.

217. *How to find the Weave of a given Texture.*—In dissecting a woven fabric the weave should be first ascer-

tained, as its structure will test the accuracy of other particulars. Before commencing to map out the weave on paper it is necessary to prepare the fabric for the unravelling process by extracting a few threads of warp and weft, as in the sample of cloth sketched in fig. 210. When such threads have been removed, an analyzing glass and a pointed instrument, such as a needle mounted in a penholder, should be employed to trace minutely the construction of the cloth. By the aid of the former the analyst can decipher the crossing of the threads, while the latter is used to draw the last pick or shoot a slight distance from its adjacent pick. In fig. 210, pick 1 has thus been removed from pick 2, so that its interweaving with the warp threads can be more readily determined. The passage this shoot makes with the threads A to H would, after it had been partly withdrawn, as indicated in the diagram, be sketched on point paper, the threads floating *over* the picks in all cases being represented by blank spaces, and the threads floating *under* the picks by marks. Thus the first pick in fig. 210, floating under threads A and B, and over C and D, is indicated on pick 1 of weave 211 by marks on the two former, and blanks on the two latter threads. The unravelling of the texture in this manner, proceeding pick by pick, must be continued till the weave repeats itself both in the direction of the warp and in the direction of the weft. In the illustration the weave repeats on thread A^1 and pick 1 *a*.

Of course, when the cloths are very fine and contain a large number of threads to the inch, analyzing proves a very difficult process. It then requires extraordinary care and patience. Should the cloths have been well fulled or milled and raised, that is, should the threads be fastly felted together, and the surface of the texture covered with fibre or nap, as in doeskin, moscow beavers, and similar fabrics, it is necessary, previous to the unravelling process, to remove such fibre by singeing and scraping; and even then it may be impossible to distinguish the crossing of the threads, or to remove a single shoot of weft without breaking it into fragments. In such cases experience in cloth structure is the only resource, the build of the fabric having to be more assumed than dissected in detail. Fabrics have been submitted to analysis which were so excessively milled that to extract either a warp or a weft thread without destroying it was simply impracticable. However, in the ordinary run of woollen, worsted, cotton, silk, and union fabrics, the weave or plan of intertexture is obtainable by care and concentrated attention. The design having been ascertained, the next work consists in reducing it to its lowest number of healds. On examining design 211, which corresponds in every parti-

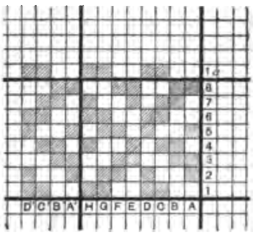


Fig. 211.

cular to the interlacing of threads given in the enlarged woven sample of cloth sketched in fig. 210, it will be evident that it is feasible to weave it on four shafts. As, however, drafting has been previously explained, it is only necessary to say that the healding arrangement and the reduced or weaving plan for the design are given in figs. 212 and 213.

218. *Ascertaining the Sizes of the Yarns.*—After having ascertained the precise order in which the cloth is woven, the sizes of yarns and the patterns of warp and weft require consideration. The latter may be readily obtained as follows: Take the threads out of the cloth separately and in regular succession, noting the colours of the yarns in

the exact order as they are withdrawn from the texture. The warp is usually treated first. If the cloth is backed and coloured on both sides, dissect the colourings for each side separately.

The sizes or thicknesses of the threads are not so easy to arrive at as the warp and weft patterns. The general method practised is to compare them with yarns of a known size or counts. For this purpose a series of yarns, of as many different sizes as obtainable, in wool, worsted, cotton, and silk, should be at hand. A yarn balance has recently been invented for indicating the counts of all classes of yarns, from small lengths such as those resulting from dissecting cloths, while another method consists in

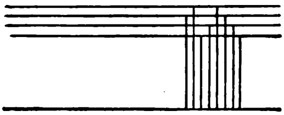


Fig. 212.

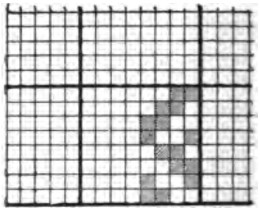


Fig. 213.

weighing a small sample of the fabric and calculating from its weight the counts of the yarn. The latter system is only applicable to fabrics made of a very limited variety of yarns, say one class of threads for the warp and a second class for the weft. In dissecting small samples of fancy cloths not more than two or three inches square, and often not so large, and composed of several sorts of yarns, the textile analyzer will find the first method, that of comparison, the readiest, and withal the most reliable.

219. *Calculations on Setting.*—The set, as already stated, relates to the number of ends per inch in both warp and weft of the fabric. This, in worsted and cotton fabrics, which have not been shrunk to any material extent in finishing, is not difficult to ascertain. In woollen textures

it is somewhat different. Thus the number of ends in such cloths, in the finished state, is considerably in excess of what it is in the loom, arising from the reduced length and width of the piece after fulling, or the smaller space into which the threads are in this process compressed. For example, some cloths, such as army goods, contain in the loom about 32 ends on the inch, but when finished over 50, the increase of ends being due to fulling, in which operation the cloth is reduced some 36°/₀ in width.

The question is, how is the original set of a woollen fabric that has thus been fulled to be calculated from a small pattern. Of course the first point is to reckon the number of threads on the inch in the finished fabric, say 54. Then, as the standard width of a narrow piece is 28 inches and of a broad piece 56 inches, not including lists, the total number of threads in the entire width of the piece (that is, in the warp,) can be obtained by multiplying the ends per inch by the width, thus: $54 \times 28 = 1{,}512$. The allowance made for felting in the ordinary classes of woollen textures varies from 10 to 20°/₀ according to the style of fabric analyzed. Assuming, for illustration simply, the piece has shrunk in fulling 15°/₀, and that it is 28 inches wide in the finished state, it would be about 32 inches wide in the loom. If the width of the cloth in the sley is divided into the total number of threads in the warp it will give the end per inch in the reed, as $1{,}512 \div 32 =$ nearly 48 threads on the inch.

Having found, in this manner, the threads per inch in the warp in the loom, the next question is that of sleying, which is regulated according to the weave of the cloth. For a *set* of 48 threads on the inch a 12's, 16's, or 24's reed, sleyed 4's, 3's, or 2's respectively, might be employed. In weaves of a mat character the threads have a tendency to "roll" or twirl round each other if those ends which are coupled together in the weave are not split in the sley, necessitating the use of as fine a reed as practicable. As, however, the coarser the reed the less friction on the threads, it is generally advisable to employ a medium counts of sley.

Single-make cloths are invariably woven on the square, so that the number of the picks per inch is the same as the threads in the warp. In backed and double-weave fabrics, the picks to the inch on the face is first obtained, from which basis the number on the back can be readily ascertained by discovering the order of wefting, that is, whether woven one, two, or three picks of face to each pick of backing weft.

220. *Method of Calculating the Weight of the Warp Yarns.*—When the warp yarns are all of the same shade and size the weight can be found as follows: Multiply the total number of threads in the warp by the length of the chain in the loom, and divide by the number of yards in a pound of the yarn of which it is composed. *Example:* A warp 60 yards long contains 1,512 ends, and is made of 20 skeins yarn (that is, 20 yards of such thread weighs one drachm) find its weight.

$$\frac{1{,}512 \times 60 = \text{number of yds. of yarn in the whole warp}}{20 \times 16 \times 16 = \text{number of yds. of 20sks. yarn in a lb.}} = 17\tfrac{23}{32} \text{ lbs.}$$

Should the warp be composed of fancy colours and of various sizes of yarns, the weight of each sort of threads has to be ascertained separately. Suppose, for instance, the pattern of warp for the fabric sketched in fig. 210 is as follows, and that it is required to find the weight of each kind of yarn in the warp, which, it may be again assumed, contains 1,512 ends, and is 60 yards long.

3 threads of 20 skeins black.
1 thread of 60 skeins black, 60 skeins light brown, and 60 skeins white twist.
2 threads of 20 skeins lavender.
1 thread of 40 skeins black and tan.
1 „ „ 40 skeins black and scarlet.
—
8
═

221. *Estimating the Size of Twist Yarns.*—Before proceed-

ing with the calculation, the size of the 40 skeins and 60 skeins twist yarns must be ascertained. To find the size of a 2-fold twist yarn, multiply the counts of the respective threads into each other, and divide by their numbers added together. Thus, the formula for ascertaining the size of the 40 skeins black and 40 skeins tan twist is as follows: $\frac{40 \times 40}{40 + 40} = 20$ skeins.

When three separate threads are twisted together, first calculate the size of two of them, and then the counts of this compound thread when twisted with the third yarn. For example, what is the actual size of the 60 skeins black, 60 skeins light brown, and 60 skeins white twist?

$$\text{That is, } \frac{60 \times 60}{60 + 60} = 30, \text{ then } \frac{30 \times 60}{30 + 60} = 20.$$

So that both the 40 skeins and 60 skeins twist would be reckoned as 20 skeins. If two yarns of different material are combined—as, for instance, a 2-fold 80's worsted with a 2-fold 60's silk—then they have both, in the first place, to be reduced to the same counts. A 2-fold 50's worsted is equal to 25 hanks of 560 yards each in a pound, whereas a 2-fold 60's silk is equal to 60 hanks of 840 yards each to the pound; so that it is essential to find the equivalent either of a 2-fold 60's silk in the worsted counts, or of a 2-fold 50's worsted in the silk counts. The silk will be brought to its equivalent in worsted hanks.

In order to reduce any two counts to the same basis, bring one of them to yards, and divide by the standard length of the other.

Example.—2-fold 60's silk equals 60 hanks, or, in other words, a pound of such silk contains $840 \times 60 = 50{,}400$ yards. Now, if this number is divided by the yards in the worsted hank, 560, it will give the equivalent required, thus: $50{,}400 \div 560 = 90$'s worsted.

So that the question is reduced to the following: A 2-fold 60's silk, equal to 90's worsted yarn, twisted with a 2-fold 50's worsted (*i.e.*, 25's worsted) required the size of the compound yarn,

$$\text{that is, } \frac{25 \times 90}{25 + 90} = 19\tfrac{13}{23}.$$

Should the 2-fold 60's silk be twisted with a woollen yarn—as, for example, a 30 skeins thread—its equivalent in woollen counts would be obtained by dividing the number of yards in a pound of this yarn by the basis of the woollen counts. According to the skein system of reckoning woollen yarns, a 1 skein yarn is equal to 1 yard to the drachm, 16 yards to the ounce, and 256 yards to the pound; hence the size of a 2-fold 60's silk in this system of counts would be procured as follows: $\frac{840 \times 60}{256}$ $= 196\frac{7}{8}$ skeins.

222. *Finding the Weight of each Sort of Yarn in the Warp.*—Attention may now be turned to the fancy pattern of warp given in paragraph 220. The first work in calculating the weight of each sort of yarn in such a pattern consists in finding the number of each sort of ends in the chain. To do this, divide the total number of threads in the warp, which has been taken as 1,512, by the number of threads in a pattern; thus, 1,512 ÷ 8 = 189 patterns, or repeats, in the entire warp. Now multiply the number of patterns by each class of yarns separately, as indicated below:—

189 patterns, multiplied by 3 ends of black, equals 567 ends of black yarn in the warp.

189 patterns, multiplied by 2 ends of lavender, equals 378 ends of lavender yarn in the warp.

As there is only 1 end of 60 skeins black, light brown, and white twist, 1 end of 40 skeins black and tan twist, and 1 end of 40 skeins black and scarlet twist in the pattern of warp, there would only be 189 ends of these respective compound threads in the whole chain.

The total number of each kind of threads having thus been obtained, the calculation is completed in the following manner:

$$\frac{567 \text{ (ends of black)} \times 60 \text{ (length of the warp in yards)}}{20 \text{ (skeins or size of thread calculated)} \times 16 \times 16}$$

$= \frac{567 \times 60}{20 \times 16 \times 16}$ —that is, the number of yards of black yarn—34,020—divided by the yards in a pound of 20 skeins yarn, namely 5,120, gives the weight of this thread in the warp, namely, $6\frac{165}{256}$ lbs.

Each colour of yarn in the warp is dealt with on this principle, the rule in all cases being to divide the number of yards of the particular yarn calculated by the number of yards one pound of it contains. To proceed, then, with the 60 skeins black, light brown, and white twist:

$$\frac{189 \text{ (ends of 60 skeins twist)} \times 60}{60 \text{ skeins twist 3-fold yarn reckoned as 20 skeins} \times 16 \times 16}$$

$$= \frac{189 \times 60}{20 \times 16 \times 16} = 2\tfrac{55}{256} \text{ lbs.}$$

$$\frac{378 \text{ (ends of lavender)} \times 60}{20 \times 16 \times 16} = 4\tfrac{55}{128} \text{ lbs.}$$

$$\frac{189 \text{ (ends of black and tan twist)} \times 60}{40 \text{ skeins twist 2-fold yarn reckoned as 20 skeins} \times 16 \times 16}$$

$$= \frac{189 \times 60}{20 \times 16 \times 16} = 2\tfrac{55}{256} \text{ lbs.}$$

$$\frac{189 \text{ (ends of black and scarlet twist)} \times 60}{40 \text{ skeins twist 2-fold yarn reckoned as 20 skeins} \times 16 \times 16}$$

$$= \frac{189 \times 60}{20 \times 16 \times 16} = 2\tfrac{55}{256} \text{ lbs.}$$

Summary.

		lbs.
20 skeins black yarn	=	$6\frac{165}{256}$
60 skeins twist yarn	=	$2\frac{55}{256}$
20 skeins lavender yarn	=	$4\frac{55}{128}$
40 skeins black and tan twist yarn	=	$2\frac{55}{256}$
40 skeins black and scarlet twist yarn	=	$2\frac{55}{256}$
Total weight of warp		$17\frac{184}{256}$

220. *Estimating the Weight of Weft Yarns of one Size and Colour only.*—The rule for finding the weight of weft yarn in a piece of cloth woven of one colour and size of yarn is as follows: Multiply the picks per inch in the fabric by the width of the cloth in the loom, and then multiply the product thus obtained by the length of the warp in yards, and afterwards divide the result by the yards per pound of the yarn used in weaving the texture.

Example.—A piece of cloth, made from 60 yards of warp, contains 48 picks on the inch, is 32 inches wide in the loom, and is woven of 20 skeins woollen yarn, required the weight of the weft.

$$\frac{48 \text{ picks} \times 32 \text{ inches wide in the loom} \times 60 \text{ length of warp}}{20 \text{ skeins or size of yarn} \times 16 \times 16}$$

$$= \frac{48 \times 32 \times 60}{20 \times 16 \times 16} = 18 \text{ lbs. of weft yarn.}$$

224. *Calculating the Weight of Weft composed of Various Kinds of Yarns.*—Let it be supposed that it is required to find the weight of each sort of weft yarn in a piece of cloth 36 inches wide in the loom, made of 60 yards of warp, containing 40 picks on the inch, and woven as below:—

4 picks of 20 skeins black.
4 „ 20 skeins brown.
2 „ 40 skeins black and lavender twist, to be reckoned as 20 skeins.
2 „ 40 skeins black and tan twist, to be reckoned as 20 skeins.

By the aid of two rules the method of obtaining the weight of any combination of weft threads in a woven fabric may be made clear to the reader. They are as follows: 1. Multiply the picks on the inch by width of the cloth in the loom, and divide by the number of picks in the pattern. 2. Multiply the result of the foregoing rule by each sort of picks in the pattern separately, and then the product of each by the length of the warp in yards, which divide by the yards in a pound of the thread calculated. Thus, in the cloth to which the weaving particulars are given above, the piece is 36 inches wide in the loom, and contains 40 picks on the inch, while the pattern of weft is composed of 12 picks; therefore, the formula, according to Rule I. will be $\frac{36 \times 40}{12} = 120$ repeats of the pattern in a length of cloth equal to the width of the warp in the loom.

Now this number, according to Rule II., should be multiplied by each sort of shoots in the pattern, then by the length of the warp, and the total divided by the number of yards in a pound of the thread, so that the calculation would be completed thus:—

$$\frac{120 \times 4 \text{ (picks of black)} \times 60}{20 \times 16 \times 16} = 5\tfrac{5}{8} \text{ lbs. of 20 skeins black.}$$

$$\frac{124 \times 4 \text{ (picks of brown)} \times 60}{20 \times 16 \times 16} = 5\tfrac{5}{8} \text{ lbs. of 20 sks. brown.}$$

$$\frac{120 \times 2 \text{ (picks of black and lavender twist)} \times 60}{20 \times 16 \times 16} = 2\tfrac{13}{16} \text{ lbs.}$$

of 40 skeins black and lavender twist, reckoned as 20 skeins.

$$\frac{120 \times 4 \text{ (picks of black and tan twist)} \times 60}{20 \times 16 \times 16} = 2\tfrac{13}{16} \text{ lbs. of}$$

40 skeins black and tan twist, reckoned as 20 skeins.

225. *Ascertaining the Weight of a Worsted Fabric.*—The quantitive analysis of a worsted, cotton, union, or any other cloth is obtained on exactly the same principle as the woollen fabric considered. As there is, however, some slight dissimilarity in the method of working the calculations, arising from the different methods of gristing or reckoning the size of the threads in these respective cloths, an example in a worsted texture will be given. Suppose, then, the weaving particulars for a worsted trousering style made of the 13-shaft corkscrew are as given below, and that the weights of the various sorts of yarns in both warp and weft are required for making the piece.

Warp.

26 ends of 2-fold 60's black, reckoned as 30's.

13 ends. { 1 end of 2-fold 120's black and tan twist, reckoned as 30's.
1 „ „ 2-fold 60's black, reckoned as 30's. }

13 ends of 2-fold 60's black, reckoned as 30's.

13 ends. { 1 end of 2-fold 120's black and green olive twist, reckoned as 30's.
1 „ „ 2-fold 60's black, reckoned as 30's. }

Weft.

26 picks of 30's black.
26 „ „ 30's brown.

To be woven in a 20's reed, 6 ends in a split, and to have 120 picks on the inch. The width of the piece in the loom to be 64 inches including lists, and the warp to be 120 yards long.

First find the total number of ends in the warp thus: $64 \times 120 = 7{,}680$ threads. Next divide 7,680 by 65, the number of ends in the pattern of warp, giving 118 repeats and 10 ends over. The latter threads will require to be calculated with the black. The rule is, when there is a remainder, after dividing by the ends in the pattern, to proportion such threads to the different sets of colours in the order in which they succeed each other. For example, if there had been a remainder of 27 threads, 26 ends would have been added to the black, and 1 to the black and tan twist.

Having obtained the number of patterns in the warp, proceed by ascertaining the number of each sort of threads in the arrangement of colours, which it will be found, on consulting the pattern of warp, are as follows :—51 ends of black, 7 ends of black and tan twist, and 7 ends of black and green olive twist.

Now complete the calculation thus :—

$$\frac{(118 \text{ patterns} \times 51 \text{ ends of black}) + 10 \text{ ends over} \times 120 \text{ length of warp}}{30, \text{ No. of hanks in a lb. of 2 fold 60's or 30's worsted} \times 560 \text{ yards in the worsted hank}}$$

$$= \frac{(118 \times 51) + 10 \times 120}{30 \times 560} = 43\tfrac{2}{35} \text{ lbs. of 2-fold 60's black.}$$

$$\frac{118 \times 7 \text{ ends of black and tan} \times 120}{30 \times 560} = 5\tfrac{9}{10} \text{ lbs. of 2-fold 120's black and tan twist.}$$

$$\frac{118 \times 7 \text{ ends of black and green olive} \times 120}{30 \times 560} = 5\tfrac{9}{10} \text{ lbs.}$$

of 2-fold 120's black and green olive twist.

The weight of the weft yarns may be procured on the lines indicated in the rules given in the previous paragraph.

The working out of the calculation would be accomplished as follows:—

$$\frac{64 \text{ inches wide in loom} \times 120 \text{ picks on the inch}}{52 \text{ picks in the pattern of weft}} = 147 \text{ repeats and 19 ends over.}$$

Then,

$$\frac{(147 \times 26 \text{ picks of black}) + 19 \text{ ends over} \times 120 \text{ length of warp,}}{30, \text{ No. hanks in a pound of 30's worsted} \times 560 \text{ yards in a hank}}$$

$$= \frac{(147 \times 26) + 19 \times 120}{30 \times 560} = 27\tfrac{61}{140} \text{ lbs. of 30's black.}$$

$$\frac{147 \times 26 \text{ picks of brown} \times 120}{30 \times 560} = 27\tfrac{3}{10} \text{ lbs. of 30's brown.}$$

226. *Method of finding the Size of the Weft Yarn for Weaving a Piece of Cloth of a Given Weight.*—A problem of the following class sometimes arises in making woven goods. Required the size of the weft yarn for weaving a piece of cloth, say 60 yards long, 36 inches wide in the loom, with 40 picks on the inch, the weight of the weft being 20 lbs. In the first place ascertain the number of yards of weft yarn in the whole piece, and then divide by

the number of drachms in the weight of the weft. That is to say, supposing A = the length of the piece, 60 yards; B = the width of the piece, 36 inches; C = the picks on the inch, 40; and D = the weight of the weft, 20 lbs.; then $\frac{A \times B \times C}{D} = \frac{60 \times 36 \times 40}{20 \times 16 \times 16} = 16\frac{7}{8}$ skeins.

Take a second example,—a piece of worsted cloth 120 yards long, 66 inches wide in the loom, and 48 picks on the inch, weighs 106 lbs., find the size of the weft yarn, when the warp is made of 2-fold 30's worsted and set in a 14's reed, 4 threads in a split. First find the weight of the warp thus:—

$$\frac{56 \text{ threads on the inch} \times 66 \text{ inches width of cloth in loom} \times 120 \text{ length of warp}}{560 \text{ yards in worsted hank} \times 15 \text{ size of warp yarn}}$$

$= 52\frac{4}{5}$ lbs. Then 106 lbs. weight of piece — $52\frac{4}{5}$ lbs. weight of warp = $53\frac{1}{5}$ lbs. of weft yarn. Now proceed as in the previous example, thus:—

$$\frac{120 \times 66 \times 48}{53\frac{1}{5} \times 560} = \text{practically, 12's worsted.}$$

227. *Calculating the Picks per Inch for Weaving a Specified Weight of Cloth.*—In this case the size of the yarns, length and width of the cloth, and weight of the weft are given, and it is required to find the picks on the inch. For example: Ascertain the picks per inch in a piece of cloth 30 inches wide in the loom, 60 yards long, the size of the weft yarn being 8 skeins, and the weight of the weft 30 lbs. The first thing to do in solving this problem is to ascertain the number of yards of 8 skeins yarn in 30 lbs., and then divide by the width of the piece multiplied by its length. In another form, supposing A = the weight of the weft yarn, 30 lbs.; B = the size of the weft, 8 skeins; C = the width of the piece, 30 inches; and D = the length of the piece 60 yards; then $\frac{A \times B}{C \times D} = \frac{30 \times 16 \times 16 \times 8}{30 \times 60}$ $= 34\frac{2}{15}$ picks on the inch.

Here is a more complex question of this kind: Find the picks per inch in a piece of cloth weighing 120 lbs., and made in the following manner: warp, 2-fold 40's cotton, 102 beers (38 threads to the beer); weft, 2 picks of 24's worsted and 1 pick of 5 skeins low woollen. Width of the cloth in the loom, 66 inches; length of the warp, 72 yards.

It will be necessary to first obtain the weight of the warp, and by deducting it from the total weight of the piece, find the number of pounds of weft yarn in the whole fabric.

$$\frac{102 \text{ beers} \times 38 \text{ ends in beer} \times 72 \text{ yards length of warp}}{\text{2-fold 40's} = 20 \times 840 \text{ yards in cotton hank}}$$

= nearly 17 lbs.

Then, 120 lbs. weight of piece—17 lbs. weight of warp = 103 lbs. of weft yarn.

Now divide the number of yards in an ounce of 5 skeins woollen into the number of yards in an ounce of 24's worsted, this will give the number of ounces of woollen yarn, equivalent in length to one ounce of worsted; thus, 840 yards in one ounce of 24's worsted ÷ 80 yards in one ounce of 5 skeins wool = $10\frac{1}{2}$. But as there are two picks of worsted to one pick of wool, one ounce of worsted in weaving this cloth would be equal to $5\frac{1}{4}$ ozs. of wool. Having found these particulars, add the proportionate lengths together, and then, as the result is to either the woollen or the worsted yarn, so is that to the weight of the piece—that is to say, 1 oz. worsted + $5\frac{1}{4}$ ozs. woollen = $6\frac{1}{4}$; then, as $6\frac{1}{4} : 5\frac{1}{4} :: 103 = 86\frac{13}{25}$ lbs. of woollen weft. The weight of worsted is obtained by subtracting $86\frac{13}{25}$ from 103 = $16\frac{12}{25}$ lbs.

Now, having got the width of the cloth in the loom, 66 inches, the length of the warp, 72 yards, and found the weight of the worsted weft $16\frac{12}{25}$ lbs., and also the weight of the 5 skeins woollen $86\frac{13}{25}$ lbs., the problem may be completed on the same lines as the foregoing example:

Thus, taking the woollen weft first, $\frac{86\frac{13}{25} \times 16 \times 16 \times 5}{72 \times 66} =$ practically, 24 picks on the inch. As there are two picks of worsted to one pick of woollen, there would be a total of 72 picks on the inch in the woven fabric.

CHAPTER XIV.

CLOTH FINISHING.

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228. *Effect of Finishing.*—Generally speaking, all classes of fabrics alter in appearance, handle, and firmness of texture in the finishing processes. If, however, there is any particular style of goods liable to lose the character it possesses in the loom more than another, through the application of finish, it is an all-wool fabric. Thus the fineness, soft and substantial touch, compact texture, and lustrous surface of a fine doeskin are principally due to the mechanical treatment this class of cloth is subjected to in finishing. In all dressed-faced cloths the warp and weft threads, so easy to distinguish before finishing, are completely covered with pile or nap, or, in other words, with the fibre drawn out of the body of the texture, and spread on the surface of the fabric by the teazles of the raising gig. As a woollen cloth is milled or fulled, previous to raising, the thready surface which characterizes it on leaving the loom totally disappears in the fulling process, causing the fabric to resemble a felted rather than a woven production. A piece of doeskin goods, therefore, in the finished or marketable condition, possesses but few features common with a similar fabric in the raw woven state, for finishing produces marked changes in its appearance and

general character. In the finishing operations to which such a cloth is submitted, a degree of softness and lustre is imparted. Then, again, the bare surface and thready handle the fabric possesses in the loom are, after finishing, no longer distinguishable, the former being substituted by a soft, velvety pile, and the latter by a clothy and elastic touch.

229. *Finish in Relation to Worsted Cloths.*—The processes of finishing do not, however, produce such distinctive changes in the condition of a worsted cloth, for here the character of the weave or effect of crossing the threads, is not only carefully preserved, but smartly and boldly developed. A worsted cloth in the loom, if well woven, is the same, to a very considerable degree, in appearance and handle as when in the finished or saleable condition. The only noticeable alterations that the application of finish effects in this case is a desirable improvement in the qualities of softness and lustre. An ordinary buyer would, however, experience little difficulty in tracing the resemblance between an unfinished and a finished piece of worsted goods; possibly he would notice that the effect of the weave or make is more pronounced in the latter than in the former, which arises, no doubt from the finished cloth having been submitted to the process of cropping or cutting, which removes the loose or straggling fibres that generally appear on the surface of a woven fabric. The point that should be specially noted here is that while a worsted fabric neither increases, to any material degree, in thickness nor strength during the finishing operations, a woollen fabric, more especially when milled for a considerable period, increases both in density and fulness of handle, these qualities being obtained more or less in the milling machine. Of course it is not to be inferred from these remarks that a tender cloth can be made firm and elastic by subjecting it to this process; but, that by reducing the piece in length and breadth, which takes place in proportion to the period of time it is operated upon in the

fulling mill, the fabric naturally increases in compactness, solidity, and strength.

230. *Variety of Finish in Woollens.*—There is considerably more scope for producing a variety of effects by finishing in woollen than in worsted goods; for there are two features which invariably obtain in a worsted cloth whether single or backed, namely, a well pronounced weave effect and a clear, bright face, implying the application, to a very large extent, of one style of finish. It is very different in the case of woollen goods. Here the cloth finisher is not limited to one or two methods of improving the surface of the goods, as the classes of fabrics named in the sequel, which are all differently treated in the finishing operations, clearly shows.

The most important and skilful class of finish is technically termed "dress face." It is applied to plain broads, moscows, beavers, pilots, and all descriptions of doeskins. These are fabrics, as will already have been gathered from the reference made to the doeskin, where the face of the cloth is entirely covered with short fibres, which are raised or drawn in one direction over the surface of the piece, and afterwards evened or reduced to one uniform length throughout by cropping or cutting. The fibre thus obtained is designated the pile or nap of the cloth. Lustre is added to the face of these goods by subjecting the piece to a process of boiling. As the primary object in finishing such fabrics is to cover the threadlike character of the texture, the weave is necessarily concealed by the mass of fibrous pile raised on its surface in accomplishing this result. From a consideration of this style of finish, attention may be called to cheviot goods, and the ordinary classes of woollen coatings and suitings, where weave is of more importance in the finished cloths than in fabrics of a doeskin and pilot class; and hence, the finish applied, leaves the effect of the crossing of the warp and weft yarns moderately clear, but not so decided and smartly defined as in worsteds. In buckskins and Venetians the very opposite effect is obtained by the finishing processes, to what exists in a dressed face cloth, for here the effect of the weave is so definite and clear that it will compare favourably, in this particular, with a piece of worsted goods. Further reference might be made to nap cloths for overcoatings and velvet-finished fabrics. In the former, small naps or curls are formed on the upper side of the cloth in the finishing operations, while a piece of goods finished on the velvet principle is covered with an erect pile of fibres. The various kinds of finish that have now been alluded to show that the weave or make used in the formation of the fabric may be completely hid from view in the finishing processes, or left sufficiently prominent as to give character to the pattern, or in a third instance it may be clearly brought out and form the leading feature of the style as in a common buckskin or Venetian. But as these results are only obtainable in woollen fabrics, the allusions that may now be made to the effect any particular process has on the condition of the woven goods, will be specially applicable to all wool textiles.

231. *Nature of Fulling.*—Milling or fulling will be treated of first, because, after scouring, it is the primary process in finishing which produces a decided change in the nature of the woven fabric. The object of this operation is apparent from the name it bears, the literal meaning of fulling implying an increasing in bulk or substance. This is what actually takes place as the cloth is being passed through the fulling mill where it increases in thickness, density, and body. There is possibly no finishing operation of more importance than this in the manufacture of some classes of woven goods, while the various kinds of woollen suitings, coatings, trouserings, ulsterings, &c., handle loftier and fuller, possessing, in a word, more substance, for having been subjected for a short time to the action of the fulling machine or stocks. The question that suggests itself for consideration in connection with this subject is, what are the main causes of an open woven

texture being changed into a close, compact piece of goods in the milling machine? For this is what actually occurs in the fulling operation, the fabric being thready in the bottom, loose in structure, and lacking softness and fulness on leaving the loom. The subject certainly merits a careful investigation. It is remarkable that this change is characteristic of woollen and worsted goods alone, but more especially to the former, for reasons which will shortly be alluded to. The wool fibre appears to be the only textile material that possesses this peculiar felting or fulling property. So far as modern investigation teaches it arises from the saw-like serrations which form the structure of the fibre; these in the fulling operations cause the individual fibres of the threads in the warp and weft of the cloth to be closely and permanently bound together. In a primary sense, therefore, the cause of the shrinking which takes place in a woven cloth, while in the fulling mill, arises from the natural structure of the wool fibre, the number and strength of the serrations in a given length of which may be said to define the milling power of the wool. But, in a secondary sense, this shrinking feature is due to the mechanical arrangement of the fibres in the construction of a woollen thread. The mixing and blending of the material, in scribbling and spinning, producing exactly that kind of yarn which not only facilitates but accelerates the fulling of a piece of woven goods; the worsted thread, on the contrary, is constructed on that principle which may be said to be most likely to even diminish the natural felting property in the wool. Hence a woollen cloth mills better than a worsted.

232. *Process of Milling.*—The order of the milling process as performed in the fulling machine is as follows:—The cloth is in the first place well saturated with soap and water, and then passed between two vertical rollers in a twisted condition, the pressure here applied causing it to shrink in the direction of the weft. On emerging from

between these rollers the progress of the piece is interrupted, being cuttled up in the meantime in a kind of a box, where it is retained for a certain length of time, and then liberated to admit of a second quantity, and so on till the whole piece has been submitted to this process. While cuttled in the box or case the fabric shrinks in the direction of the warp. The true character of the change produced in the condition of the cloth in this operation may be forcibly illustrated. A piece of all-wool goods, made of small yarns, and set 36 inches wide in the loom, when milled for nearly two whole days, was found to be no more than 18 inches in width, and somewhere about half its original length. The surface of this cloth, after fulling, had no resemblance to that of a woven texture, the effect of the weave having entirely disappeared, and the fabric being like a thin layer of felted wool. So firmly had the warp and weft thread been milled together that it was impossible, with the greatest care, to separate them from each other without a large number of breakages. Admitted that this is an unusually severe change to make in the cloth by milling, yet it serves to illustrate that, according to the amount of fulling a fabric is subjected to, the more compact and substantial will be the texture, while the more it is reduced in length and breadth the more perceptibly will it be increased in thickness. These, along with the quality of a soft, firm handle, are the main changes in the condition of a woollen cloth due to the fulling process.

233. *Milling Reduces the Size of the Pattern.*—When the cloth has passed through the fulling mill, and been tentered and dried, it is generally more or less covered with loose straggling fibres. These, in some classes of woollen goods, help to form what has been called the nap or pile of the finished cloth, but in other classes of fabrics they have to be entirely removed, in order to admit of a full development of the colours and weave of the pattern. The effect of the weave or make, and of the arrangement of

the colours in both warp and weft yarns, suffers somewhat in brightness and clearness during the passage of the piece through the fulling machine; for, in addition to the cloth decreasing both in length and width, which implies a proportionate reduction in the size of the pattern, the fibres that appear on the surfaces of the piece in this operation also help to subdue the effect of the design. That is to say, if a cloth should be set seventy-two inches wide in the loom, and milled down to fifty-six inches, the pattern or design would, at least in the direction of the weft, be $\frac{2}{9}$th's smaller in the milled than in the unmilled fabric. Such a considerable reduction in the size of a medium or small pattern necessarily softens the effect of the design; and hence, in fancy fabrics, where weave and colour are essential to the sale of the goods, the fibres on the face of the cloth have to be removed in the subsequent operations, which may be said to more than compensate for the loss of effect by the reduction in the size of the pattern, because such a removal of loose fibres necessarily gives a smart and definite character to the weave and colours employed in the formation of the style.

234. *Raising and its Effects.*—Now, whether it may be necessary to clear the surface of the cloth of fibre or pile in order to attain the required finish or not, the piece is submitted, after milling, to a very important finishing process, technically called *raising*, which possesses a two-fold character. Thus the change which this work effects in the nature or appearance of the cloth depends on the *wet* or *dry* condition of the piece during the process—dry raising rooting up the fibres on the surface of the cloth, and leaving them in upright positions; while wet raising, by disturbing the face of the texture, obtains enough fibre to form the pile or nap, which is spread evenly on the surface of the fabric. The raising gig, or the machine on which this work is done, consists of a large skeleton cylinder containing a number of iron rods closely set with teazles. This cylinder, which is the principal part of the machine,

revolves at a very quick-rate, and in the opposite direction to the way in which the piece is going. The latter travels very slowly, and is brought into contact with the sharp and pliant teazles, which raise the fibres, by a series of rollers, capable of adjustment as to distance from the cylinder of the gig. The primary object of this process is to disentangle and open the fibres which completely cover the surface of the piece after milling and tentering. But, as there are two distinct classes of gig raising, which are applied with very different results, it will be useful to consider them separately. Wet raising will therefore be treated of first. Dressed face goods, such as doeskins, plain broads, moscows, pilots, beavers, and presidents, are all passed over the raising gig in a wet or damped condition. Again, this principle of raising is frequently adopted in finishing goods made of a low quality of backing yarn which it is desirable to hide as much as possible, and hence the underside of the fabric is raised wet. That the fibre is not removed in the subsequent process of cutting, when the cloth has been raised according to this system, may be ascertained by passing the hand over a piece of fine doeskin, or any other style of fabric that has been similarly treated; so long as it moves in the direction in which the fibre has been raised on the gig, it will glide smoothly along, but, on reversing the movement, the hand at once opposes the entire mass of fibres.

Now, as this pile or nap is not characteristic of the cloth in the loom, it is an indication that raising has produced a remarkable change in the condition of the fabric. Such, in fact, is the nature of the raising process that the bare and thready appearance the woven fabric originally possessed is, by the stirring action of the teazles, completely covered with a layer of fibres, which so perfectly conceals the woven character of the cloth that neither the threads of warp or weft used in its manufacture are visible on its surface. In short, the fibrous face which characterizes cloths raised on this principle arises mainly from this process; wet raising not only disturbing the face of the cloth in such a manner as to cover it with fibre, but, by distributing the same over the surfaces of the fabric, preserving the length of the pile during the cutting or cropping operation. It will shortly be observed that dry raising has almost an opposite effect on the condition of the cloth, for, although this class of raising alters the woven character of the fabric, yet, instead of preserving the fibre, it prepares it for being removed by the knife of the cutting machine. Worsted coatings and trouserings, and the ordinary classes of fancy woollen goods, are usually raised in the dry state. In worsted goods, however, more especially when finishing the finer fabrics, this operation partakes more of a brushing than of a raising character: the action of the teazles, as applied in raising all-wool goods, would be too severe in effect, and probably damage the even appearance of the face of this kind of cloth. The principal reason why dry raising is more suitable than wet raising in finishing these fabrics, is because in such goods a smart, clean face is generally required. Then, again, the effect of the weave is also of paramount importance, and, in order to give prominence to this feature of the fabric, it is necessary to remove the fibre which, it has been shown, covers both sides of the piece after milling, and also hides the interlacing of the yarns employed in the production of the cloth. Hence, raising is resorted to, in this instance, to facilitate a complete removal of the fibre in the cutting process. However, in order to obtain a fair idea of the bareness and general character of cloths raised dry, let a fabric of this description be put to a similar examination as the doeskin mentioned above. This experiment will, at least, contrast the difference in the handle of goods raised wet and dry respectively. In this case the hand may be moved in every possible direction over the surface of the cloth, and yet it will not be discovered that the fibre leans in any particular manner; on the contrary, it offers equal resistance to the motion of the hand whichever way it may be directed, showing that the fibres have not only been raised into upright positions, but so effectually removed in the subsequent operation of cutting as not to possess sufficient length to be perceptibly laid either in one direction or another; in a word, what remains of the pile projects perpendicularly from the surface of the piece as raised on the gig.

235. *Differences between Wet and Dry Raising.*—This naturally leads to a consideration of the differences in the effect of these two distinct methods of raising woven goods. No doubt it will have been observed that wet raising prevents to some extent the removal of the pile by spreading it evenly over the surface of the cloth; this preservation of the length of the fibre causes these goods to admit of a more lustrous finish, and kinder handle than if the piece had been raised dry. The dry class of raising, on the other hand, raises the fibre into that condition in which it is most likely to be entirely removed by cutting or cropping. These two standard methods of raising give, therefore, opposite effects, one method almost perfectly concealing the crossing of the threads, and the other, by facilitating a clear cut, imparting smartness and precision to both weave and colour. The difference is more distinctly apparent, however, when the two cloths have been submitted to the cutting process; for, while the only perceptible change effected in the condition of the wet raised fabric, is the production of a more even pile, all straggling fibres being removed, the dry raised cloth undergoes a complete change. This arises from the knife of the cutting machine taking off every species of fibre and leaving the surfaces of the cloth clean and smart, so that both the effect of the make, and also of the combination of the colours, are now more pronounced than in the loom, while the beauty of the pattern is enhanced on account of the bare thready texture having undergone a material change in the fulling operation.

236. *Boiling and Crabbing.*—Boiling is another very

important finishing process, especially when a high or dressed finish is required. It is effected by winding the piece tightly on a large roller, and then boiling it for two or three hours, after which time it is taken off and re-wound on the cylinder, commencing with the opposite end of the piece, in order that the cloth may be evenly boiled throughout. This process is said to impart a permanent lustre. Piece dyed worsted goods are subjected to a similar operation, and a process equivalent in effect so far as imparting lustre is concerned; it consists in wrapping the piece on a perforated cylinder through which steam is forced; this occupies some five or eight minutes, when the cylinder is allowed to cool, and the cloth removed and treated in a like manner for a second time, as in boiling a woollen fabric.

237. *Pressing*.—The object of the next process in finishing, namely, that of pressing, is to sadden and impart solidity to the cloth, and perhaps, in a secondary sense, to give lustre. But this should be said of the lustre a fabric obtains in the press, it is more or less of a fugitive character, pertaining more to the nature of a glaze than a permanent brightness. That the object of pressing, however, is not so much to afford lustre as solidity to the fabric, is evident from the steaming process to which goods are submitted, after being taken out of the press, to remove the excessive glaze due to pressing, which has a tendency to give the cloth a stiff, unkind handle.

The various changes that a woven fabric undergoes in the finishing processes have now been succinctly considered, and they have shown that the productions of the loom are considerably improved in these after operations of cloth manufacture. The following are the principal features in the marketable cloth specially due to the application of finish: a soft, full handle: a compact texture; a fibrous face; a permanent lustre; an increased resisting power, and firmness combined with solidity.

It only remains to describe the various classes of "finish" applied to both woollen and worsted goods. These may be treated of in the following order:—doeskin, or dress-face finish; velvet, or erect pile finish; dry, or bare finish; Melton or Scotch finish; and the worsted finish.

238. *Doeskin Finish.*—This finish requires the most skilful workmanship, occupies the most time, and comprises the largest diversity of processes. The cloth intended to be finished on this principle having been submitted to the preliminary operations of washing, milling, and tentering to remove the creases in the piece, it is taken to the gig for *first raising*. Here the real work of finishing commences. To assist the teazles in straightening and drawing out the fibres covering the face of the cloth, the piece is evenly damped as it passes on to the gig. Raising should disentangle the fibres but not remove them, comb out the curliness, and arrange them in parallel order. First raising should be done with old or weak teazles so as not to destroy the texture. Too harsh treatment in this operation should be carefully guarded against, as the fabric is liable to be damaged if severely operated upon. Second tentering is the next process, after which comes dry beating to prepare the cloth for cutting or cropping. In this operation the fibre should be cut low, but not too close, otherwise the cloth, when finished, will appear grey and bare in the bottom. Uniformity in the length of the pile is the primary object to be attained in cutting. The piece is now damped or moistened and then cross raised, in which process the fibres are drawn from list to list, or in the direction of the weft. Raising on the gig for a second time follows, the cloth being treated head end first, and then tail end first, to procure an even distribution of the fibres. Tentering to prepare the piece for middle cutting next takes place. Both previous to and after this cropping the fabric is well brushed on the brushing machine. After pressing the piece for the first time, it is wrapped round a huge wooden

roller head end first, and boiled from 4 to 6 hours, then raised and re-wound tail end first on the roller to be again boiled. This process may be repeated for ten or twelve times in succession. After last boiling the cloth is again raised and then washed in clean water, when it is tentered and dried and taken to the gig for dry raising to facilitate cutting. Every care is needed in final cutting, as it is extremely important that the pile on the face of the fabric should be perfectly uniform in length and yet sufficiently shortened. The cloth might probably at this stage be examined by the fine drawer and finishing burler, after which it is pressed and steamed. Having been subjected to the latter process the piece is sometimes cold platted, in other words, put into cold press papers and weighted as much as necessary to give the requisite lustre and solidity of texture.

239. *Velvet Finish.*—The object of this class of finish is to procure, as its name implies, an erect pile on the fabric. To obtain a good permanent pile, the cloths require to be made of wool possessing excellent milling and elastic properties. Woollen yarns are highly adapted for this class of finish, possessing plenty of fibre. Fabrics intended for velvet finish should be well milled, not made too firm in the loom, but allowing both length and width for excessive fulling; and thus admitting of the production of a cloth with plenty of fibre and substance to work on.

The piece, having been scoured, milled, dried, and tentered, is evenly damped, raised, or, in some cases, first removed to the dubbing board to be raised across before being passed on to the gig. This is called "breaking-in." In raising the piece it is treated from both ends in succession, in order to secure an erect pile. Beating follows. It is effected on the "batting" or beating frame, which consists of a stout beam, round which the piece is wrapped face downwards, and of a second roller, through the slot of which the cloth is passed; between these rollers the fabric is stretched, while it is beaten with long rods working either automatically or otherwise. This operation causes the fibre to project straight out from the surface of the cloth. Tentering and drying follow, when the piece is re-beaten in a dry condition, and then cut, which prepares it for the market.

240. *Dry Finish.*—This is sometimes termed the West of England finish, on account of the fine woollen trouserings and coatings made in the West being extensively finished on this principle. The object is to remove the fibre and obtain a clean, smart, even face. Cloths finished in this manner require to be well woven, and should not be milled any more than absolutely necessary to impart firmness and compactness to the texture.

The order of the processes in dry finishing is as follows: Washing or scouring, mending, milling, tentering after washing-off, dry raising, cutting several times in succession, and, if too hard milled, re-raised after cutting, cropping again, inking and drawing, pressing, steaming, and cold platting.

241. *Scotch and Melton Finish.*—This is the most simple and easily managed finish in connection with the woollen trade. It consists in removing the goods from the tenter when dry, and taking them to the cutting machine and giving them two or three cuts, and if for Scotch finish, pressing them between warm plates. They remain in the press till perfectly cold, this sometimes requiring two nights and a day, after which they are measured, cuttled, and sent to the merchant. English meltons are finished in a similar manner, except in the better class fabrics, where a little raising takes place, then cutting, pressing, steaming, and often cold platting, to smooth the face of the cloth, and also to impart a little more firmness to the piece.

242. *Worsted Finish.*—In order to get a "dress" or "face" on worsted goods, they are submitted to a large variety of processes. These need not be described in detail. Of course it will be understood that all classes of

fabrics after leaving the loom are perched, the object being to examine them on both sides to note the defects in their manufacture, and, if possible, to remedy them in the subsequent operations. Providing, then, the piece has been perched, it is submitted to the hands of the knotters and burlers, who remove the knots, small lumps, and repair any defective places produced in weaving. Mending succeeds burling—it implies the repairing of broken picks, and removing of imperfections in the texture of the cloth, such as those resulting from ends not having been properly picked up, &c. Tentering, mending after scouring or scour thread mending, brushing on the gig, cutting and pressing follow. Then comes a very important process called crabbing, the nature of which has already been described. By this means a lustre or face is got on the cloth before dyeing. After the latter process comes washing-off, hydro-extracting, brushing, cutting, pressing, and steaming. Fancy worsteds are similarly treated up to scouring, but are only brushed, cut, and pressed after this process.

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