

DESIGN  
IN  
TEXTILE FABRICS



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MANUALS OF TECHNOLOGY.

EDITED BY

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DESIGN  
IN  
TEXTILE FABRICS.

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WITH 10 COLOURED PLATES AND 106 DIAGRAMS.

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## P R E F A C E.

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IN this manual an attempt has been made to place before the reader, as briefly and completely as possible, the principles of design in textile fabrics in its broadest sense, and to deal with the subject in such a manner as to combine with the question of decoration that of the proper structure of the cloth.

The practice of paying little or no attention to the proper structure of the fabric, and its suitability for the purposes to which it is to be applied in the arrangement of designs, is unfortunately far too common, and is the cause of a considerable waste of labour and expense in our manufacturing concerns. This may, perhaps, be to some extent due to the method of training those who are to be the designers, and also, to an even greater extent, to the fact that there has hitherto been no systematic treatment of the question. Most men engaged in the manufacture of textile fabrics have confined their attention to one branch, or to one class of goods, and have become proficient from practice only in that class. Their success has been entirely dependent upon the amount of attention they have paid to the particular class of fabrics they were engaged in manufacturing, or to the accuracy of their observations, and not to any—or, at the most, only to a slight—degree upon any systematic method or basis for their work. In the textile trades, as in every other, the

“rule of thumb,” or guess-work, must rapidly disappear, and be replaced by system. Fabrics must be made, as other articles are, with a proper regard to ornament, utility, and economy; the designer must consider both the end and the means, and nothing but this will secure success to him.

The rapid disappearance of the old apprentice system, the growth of large establishments, and the consequent subdivision of labour, accompanied by the ever-increasing demand for fabrics of a more artistic character to be applied to useful purposes, make it imperative upon the would-be designer or manufacturer to understand more fully than he has done in the past the principles upon which fabrics should be constructed, so as to fulfil all the necessary conditions. He must work on sound principles and leave nothing to chance.

The reader must not expect to go through this work in a hurried manner, or to thoroughly grasp all the details of the subject without further effort. Within the compass of this volume it is, of course, impossible to enter into all the particulars which would make the student at once perfectly conversant with the whole; but an effort has been made to lay down the leading principles clearly and completely, and to guide the student generally, rather than to enter too closely into minor details, which can only be sufficiently mastered by actual practice in the mill or workshop.

T. R. A.

*Bradford.*

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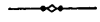
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# DESIGN IN TEXTILE FABRICS.



## CHAPTER I.

### TEXTILE FABRICS AND THEIR USES.

**1. The Objects to be kept in View in designing Textile Fabrics.**—The first objects we must set before us in designing textile fabrics are the uses to which they are to be applied, and the purposes they are intended to serve. Exactly in the same manner, if we are designing a bridge, a house, a mill, or a machine, our first concern must be to secure all the conditions of strength, convenience of arrangement, and other requisites, which will make it most suitable for the purposes to which it will be put. This having been done, we may then proceed to ornament the structure as we please, always taking care that the ornamentation does not in any way detract from the conditions of strength and general utility which have been our first and foremost aim. It thus follows that, in speaking of designing textile fabrics, we do not necessarily mean the application of art principles to their decoration, but we use the phrase in a more comprehensive sense, not only in reference to the decoration or ornamentation of the fabric, but also to its structure. If that is so, we must have what is commonly termed a theoretical basis upon which to build our fabric, and it may be as well to inquire, before going further—What is this theoretical basis? or

**2. What is the theory of the structure of fabrics?**  
—A theory may be described as a supposition with



regard to cause and effect—or the connection and sequence of phenomena—which embraces all the circumstances known to attend their occurrence. A theory is tested by trial and observation. It must be founded upon actual knowledge of things—of the end to be attained, and the means which have been employed, not only by ourselves but by others, to attain the object at which we are aiming, or a similar object.

Upon this basis, then, we may at once proceed to examine into the theory of the manufacture of cloth, or “Design in Textile Fabrics.” Before we can enter into the question of the structure of fabrics, or deal with the materials from which they are made, we must determine what are the purposes they are intended to serve, and the qualities or properties they must possess to ensure those purposes being served in the best possible manner. It may, in the first place, be said that one of the chief uses of textile fabrics is as a covering for the body, to keep it warm, or to protect it from the inclemency of the weather; or it may be that the covering is merely ornamental, and need not be of such close texture as that which the needs just referred to demand. Again, whether the covering be of the purely useful or of the purely ornamental character, yet, in all probability, in each case it will have to fulfil one condition of usefulness—namely, wear. This means that its structure must be such as will enable it to bear some strain, and in many cases also to resist a considerable amount of friction without damage.

In addition to the fabrics of a purely useful or purely ornamental character, we may in many cases be called upon to produce fabrics where both qualities are requisite. As the artistic taste of the people improves, they are not contented with the purely useful; articles of utility must also be made more or less beautiful. We must ornament wherever we can, but in introducing the ornament we must be careful that we do not do it at the cost of utility.

We may, then, say that in these considerations of

utility or ornament we have the groundwork or basis of our theory. We have the knowledge of what we require, but that is only the first step. Before our theory can be complete we must consider how these fabrics are to be constructed, the materials from which they are to be made, and also, to some extent, the mechanical operations involved in their formation; and, being guided by a knowledge of what others have done before us, we must, as far as we can, determine the best and most economical methods of obtaining given results.

Textile fabrics may be generally described as a combination of filaments or threads, interlaced with each other in such a manner as to form a texture; and it is for us to ascertain what is the best method of interlacing those threads, so as to produce the fabric most adapted to our requirements.

In all cases where utility is to be the first consideration, the warp and weft threads which form the fabric must be so interlaced as to produce all the firmness possible, not only so as to be able to bear the greatest amount of strain, but also to be able to resist friction. In many instances we must also combine with these qualities bulk, or thickness of fabric; consequently, our fabric must be constructed so as to allow of the requisite amount of material being introduced into it.

Before going any further into the subject, we will see how fabrics are constructed, and what is the meaning of "warp and weft." In Fig. 1 we have a plan of what is known as a plain cloth. It

will be seen that there are two sets of threads, which cross each other at right angles, and interweave alternately. The threads marked *a*, or the longitudinal threads—or those running in the direction of the length

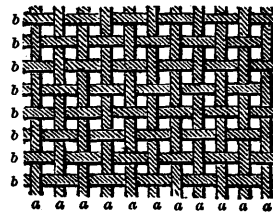


Fig. 1.

of the piece, and which are usually shown on paper in a vertical position, are what are termed the warp threads, and the transverse threads, *b*, are termed the weft threads. In all woven fabrics we have these two sets of threads to deal with, and the relation which one bears to the other, as well as the order of interweaving for the purpose of forming patterns, *constitute the design of the fabric.*

In the plain cloth plan in Fig. 1, it will be seen that, although we produce a very firm texture by the manner in which the two sets of threads interweave, yet we cannot possibly produce a very close texture. Certainly the fabric will be strong, each thread supporting the other to the utmost, yet it cannot be made sufficiently compact, either to produce a heavy fabric or a fabric which will retain heat, or keep the body warm to the fullest extent. By the very manner in which the threads intersect each other, they are prevented from lying perfectly close together; consequently, the fabric must be, in a greater or less degree, perforated.

**3. The Effect of the Yarn upon the Fabric.**—The perforations in a plain cloth will vary greatly under certain conditions: for instance, the thicker the threads from which the fabrics are made, the larger will be the perforations, and the thinner the threads, the smaller the perforations. Of course, in such cases the perforations will bear exactly the same ratio to the diameter of the thread if the relation of warp to weft be the same, but cloth made from fine yarns will possess the useful properties in a much greater degree in proportion to its weight than that made from thick threads. Other considerations will also affect the usefulness of the fabric. If we desire to produce a fabric of close texture—one which will have the perforations reduced to the smallest possible dimensions and retain the warmth of the body in the highest extent—we must use a yarn in which the fibres of which it is composed are laid as loosely together as possible. We can then, in the mechanical operations of weaving,

bring those threads closely together, and the looseness of the fibres will permit of their spreading out, and so of reducing the interstices to the lowest point.

On the other hand, if the threads are twisted very hard—that is, if the threads are made solid and compact—they will resist compression in the operation of weaving, and, the fibres being held firmly together in the thread, there is nothing left to spread out and cover the interstices; consequently, we shall have an open fabric, but the fibres being firmly interlocked in the thread, we shall have a fabric which will bear more strain, and will offer also more resistance to friction, than in the other case. We must, therefore, obtain one quality in this fabric at the cost of some other.

4.—The Effect of the Twist of the Yarn.—Another matter which materially affects the closeness of texture in a plain cloth is the direction of the twist of the weft in relation to that of the warp. On reference to Fig. 1 it will be seen that the two sets of threads when placed together in the fabric have the twist running in the same direction; that being so, the fibres—or, if we may so term them, the strands—of the two sets of threads will become embedded into each other, and so make a close and compact fabric. If, on the other hand, the twist of the weft be contrary to that of the warp when the two are placed together, as shown in Fig. 2, the threads cannot become so intimately connected, and, consequently, the fabric cannot be so close and free from perforations.

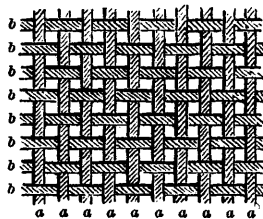


Fig. 2.

To give an illustration on a large scale. If we take two thick cords or ropes, and lay them together at right angles to each other, with the twist of both in the same direction, we shall find that the thick strands of one

rope will fall into the hollows between the strands of the other, and so the two will occupy the smallest possible space; but if the strands are in opposite directions, instead of their falling between each other, and one strand filling the hollow in the other, their ridges will come together, and there will be an opening equal to the hollows between the strands of *both* ropes. We have, therefore, increased openness in the structure of the fabric without a corresponding gain in any direction.

**5. Relations of Warp and Weft, and their Effect upon the Fabric.**—Up to this point we have been dealing only with what may be called a *true* plain fabric, or a fabric in which the weft and warp are equal, or nearly so, in their diameters and in the number of ends per inch each way; but we may produce fabrics in which the relations of weft to warp are quite altered, and we may do this for two purposes—either for obtaining increased strength, warmth, and weight, or for ornamentation.

Suppose we take the class of fabrics commonly known as poplins, and which present a corded or ribbed appearance, the ribs running across the fabric in the direction of the weft; in such fabrics there is a great preponderance of warp over weft, more especially as regards the number of threads per inch. But for the production of fabrics of the best type the warp threads are much thinner than those of the weft. In fact, although the interweaving of weft with warp is precisely the same as in the plain cloths with which we have been dealing, the alteration in the relative quantities and thickness of weft and warp completely changes the texture and appearance of the fabric. A plain cloth, in which warp and weft are equal, will present an appearance of waviness in both warp and weft on the fabric being dissected; but a fabric in which the warp threads predominate largely over the weft, so far as ends per inch go, and in which, consequently, the warp threads are proportionately thinner, would present the weft as a straight line, and

the warp bending round it. A plan of this fabric is shown in Fig. 3, and a section in Fig. 4.

In the plan it will be seen that the weft threads are much thicker than the warp threads, and also that the latter are placed closely together.

In some fabrics of this type these are placed so closely that they are actually compressed, and made to occupy a space less than their true diameter. It will also be seen that the weft threads are some distance apart. It only



requires a careful examination of the structure of the fabric to ascertain the cause of this, as also its effect upon the appearance, as well as upon the usefulness of the cloth.

The warp threads are placed close together, and cross between each weft thread, or *pick*, as it is technically termed. The warp is also much thinner

than the weft; as a consequence, no matter how much tension may be put upon the warp, either in the process of weaving or after the fabric is formed, it cannot bend the weft out of its straight line, simply because the intervals of space between the warp threads are so small, as compared with the thickness of the weft, that the weft cannot be bent into them either from above or below; or, in other words, the closeness of the warp threads forms a continuous bed upon which the weft is laid. Then, with regard to the distance apart of the weft threads, or picks, the warp crossing between them prevents them from coming close together; each pick being separated from the other in this manner produces the ribbed-like effect peculiar to this class of fabric. It will be evident from the structure of the fabric, the closeness

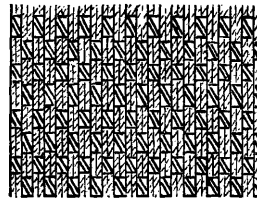


Fig. 3.

of the warp threads, and the strength of the weft that this class of cloth is well calculated both to resist wear and retain warmth, and there is, probably, no kind of fabric which, for the weight of material employed, can compare with it in these respects.

Another class of fabric of a very similar character is largely employed for decorative purposes, and to some extent also for articles of dress—namely, the cloth commonly known as “repp.” Its structure is different from that of either of the two plain cloths of which we have been speaking, though possessing one of the chief characteristics of the poplin, or gros-grain, type, inasmuch as the warp is made to bend round the weft, and the weft is laid in perfectly straight lines. In Fig. 5 we have a section of what is considered the best type of this class.



Fig. 5.

Here it will be seen that in both the warp and the weft there is a thick and a thin thread alternately, and in the operation of weaving the thin thread in the warp is held very tightly, while the thick thread is held very loosely. Again, the thin weft is always between the warp threads on *the same side* of the thin thread, and the thick weft passes always on the *contrary side* of the same thread; the result is that the thick warp—which usually consists of several threads put together—in consequence of the slight tension upon it, is made to bend round the weft threads, and the thin warp is held quite or nearly straight, thus producing the clearly-defined-rib, very prominent on that side of the fabric where the thick weft is, and less so on the other side.

Again, another class of plain fabric is obtained by a reversal of the conditions which produce the poplin—that is, the warp threads are thick and the weft thin. The warp is held in straight lines, and the weft made to bend round it. The plan shown in Fig. 3 may be taken

as a plan of this class of cloth, as well as the plan of a poplin cloth, only that the thick straight threads must be taken as warp, and the thin bent threads as weft. The section Fig. 4 would also be a section of this cloth, but would be a transverse section, the circles showing the end of the warp threads and the bent threads being the weft. This class, commonly known as cords, is usually made with two or more warp threads run together to produce the requisite bulk, instead of using one thick thread.

In the production of the four classes of plain fabrics mentioned, great care should be exercised in proportioning the warp to the weft, but more especially with reference to the poplin and cord. In what we have spoken of as the true plain cloth we have assumed that warp and weft are equal in quantity, and in that case both warp and weft would be slightly bent out of the straight line; each would exert an equal power over the other. That being so, if friction be applied to the cloth, each set of threads would hold the other firmly in its place, and no matter whether the friction be applied in the direction of the warp or weft, the result would be the same—each would possess the same power of resistance. In the other classes it would not be so. If we take the poplin type, where we have the weft laid straight and the warp bent round it, any friction in the direction of the warp threads could have little or no effect; but friction in the direction of the weft would have the effect of displacing the warp, because there is nothing to keep them in place except their pressure one against another; they are bent round a straight body more or less smooth, and have no support except their own pressure. Thus, unless they are sufficiently close together to give each other sufficient support, the cloth cannot be serviceable as an article of dress, or for any other purpose where it will have to resist friction. The same remark will apply also to the “repp” and “cord” classes, but in the latter the dis-



placement will be in the weft threads by friction in the direction of the warp.

In all four classes of plain cloth we could only vary the weight of cloth by altering the size of thread; and our means of ornamentation are also limited. We can only alter the size of cord or rib by the use of different sizes of threads; but we can ornament the fabric by the introduction of colour, and that colour we may use in the warp only, in the weft alone, or in both warp and weft. So far as the use of colour goes in ornamenting plain cloths, we have a wide field; but that is a subject we must consider in another chapter. We must first deal with the structure of fabrics, and their ornamentation by the variation in the interweaving of the threads which compose the fabric.

**6. Twilled Fabrics.**—We must now discuss the structure of other than plain fabrics, and ascertain what is the use or value of other methods or systems of constructing cloths.

The class of fabrics which comes nearest to plain cloth is that known as twills or twilled fabrics; and in their production we may have two objects in view—first, increase of bulk or thickness of fabric; and second, ornamentation. The first and chief difference between the structure of this class of cloth and plain cloth is that in the latter the warp and weft interweave alternately, whereas in twilled fabrics they interweave at such intervals as may be required for the formation of the pattern. Again, what is termed the complete pattern in plain cloth is represented by two ends of warp and two picks of weft, while in twilled cloth a greater number of ends and picks are required to complete the pattern; or, in other words, in all plain cloths, every alternate end is a repetition; the same holds of the picks, but in twilled cloths the repetition will occur at longer intervals. Fig. 6 is the plan of a twill of a very common order, and one regularly in use in fabrics made from all kinds of materials.

In this it will be seen that each warp thread passes alternately over and under two weft threads or picks, and in like manner each weft thread passes alternately under and over two warp threads. But each end does not pass under and over the same two picks, nor does each pick pass under or over the same two ends, nor are they alternate in their action, as are the ends and picks of plain cloth; but they change in regular consecutive order; that is, if the first end passes over

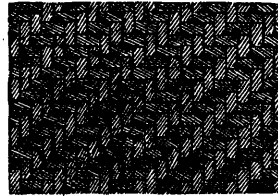


Fig. 6.

numbers one and two picks, the second end passes over numbers two and three picks, and so on, each end advancing one pick before it rises to the surface, or passes to the back, and each pick advancing one end in the same manner. This order of changing of the ends and picks will have the effect of producing a distinct pattern upon the fabric, a species of cord running in a diagonal direction across it. But another matter of much more importance than the mere pattern is the fact that this order of working permits us to introduce more material into the fabric, and so make it more bulky and closer in its structure. The reason for this is to be found in the simple fact that the weft and warp interweaving only at intervals of two ends or picks permit the two threads both of warp and weft to lie closely together, and consequently to allow of a greater number per inch to be introduced into the fabric than can be done in plain cloths.

True, as we have shown, we may make plain cloths in which the warp threads lie perfectly close together, and others in which the weft threads lie perfectly close together; but in the one case the weft threads are a considerable distance apart, and in the other the warp threads

are a considerable distance apart, whereas in the twill cloth the weft and warp both lie equally close together, so that we obtain the requisite closeness of texture in both directions, and a corresponding increase in the bulk of the fabric. Along with this closeness of texture, and increased weight or bulk, we also obtain another advantage over the plain cloth, namely, that by the order of interweaving the warp bends round the weft, and the weft round the warp in an equal degree, exactly as in the first order of plain cloth. So that if the number of threads per inch each way is properly proportioned to their diameters, and to the order of interweaving, the fabric will possess the power to resist friction, not merely in the same degree as the plain cloth of the first order, but in a greater degree proportionate to the increased quantity of material it contains.

7.—Alteration of Twill to increase Bulk.—We also possess the power of increasing the bulk in a great degree by altering the twill so as to interweave the two sets of threads at greater intervals, and just as we increase the intervals we increase the number of threads which may be contained in a given space. Of course along with this a limit of increased usefulness will be reached. We say that we increase the powers of resisting friction by the increased material employed in the construction of the fabric, but if our intervals of interweaving are too great, the two sets of threads will to some extent lose their power of supporting each other; we shall have too great a length of loose yarn presented on the surface. This yarn being composed of fibres, each individual fibre is presented for a considerable portion of its length to the wearing surface; and if friction be applied, it may be too readily drawn away from its fellows, and so by degrees the thread, and ultimately the fabric, becomes weakened. Again, no doubt the looseness of the interweaving will reduce the power of the fabric to bear a strain; although a loosely interwoven cloth—if the quantity of yarn be properly

proportioned to the order of interweaving—will still be the stronger so far as tensile strength is concerned, than one more closely interwoven, yet it will not be so strong in proportion to the quantity of material of which it is composed; and if the number of threads in a given space, or the diameter of the threads, be not properly proportioned to the pattern, the fabric will be positively weaker.

**8. Alteration of Twills to increase Strength.—**  
**Satins.**—Quite apart from the question of ornamentation, there are certain orders of arrangement in twills which may be specially resorted to for the production of fabrics which are designed to bear an increased amount of friction or strain in one direction or another; and when we are arranging our patterns for the purpose of ornamentation, we must not forget the peculiar properties which attach themselves to patterns of given classes.

If we take one class as typical, in order to point out the peculiar arrangement and its effect upon the fabric, it may serve as a guide to us when dealing with patterns for ornamenting. This class is commonly known as satins or broken twills. The peculiarity of this sort of twills is that the order of interweaving the two sets of threads does not follow consecutively, but at intervals, especial care being taken that at no point do they follow consecutively. An example of the simplest kind, and one most commonly employed, is shown in Fig. 7.

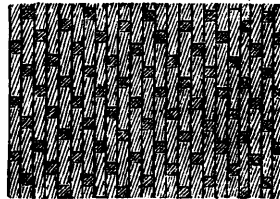


Fig. 7.

In this plan it will be observed that the order of interweaving is at every fifth end or pick, and that the two succeeding picks do not interweave with adjoining ends, but at intervals of two; that is, if number one pick pass over the first end of warp, number two will

pass over the third end, and so on. Now suppose that we wish the fabric to be able to bear a great strain in the direction of the warp, it will be made with what is termed a warp surface. The warp threads will be placed as closely together as possible; certainly they should be placed as close to each other as their diameters will permit; and as the weft is inserted, one end will be withdrawn from the surface of the fabric, and will bend round the weft at the back. As the next pick is inserted another end will be withdrawn, the first one returning to its original place, but as the ends are not withdrawn in consecutive order, the weft is not made to bend round the warp in any degree, but remains perfectly straight, the warp only being drawn out of its course. That being so, the weft threads cannot be laid close together, but will always be separated from each other by at least the diameter of the warp thread; therefore we shall always have a greater number of warp threads per inch than of weft threads. Again, if it be desired to produce on the fabric a smooth, unbroken surface, with no pattern visible, the warp threads may be placed so closely together that as one is withdrawn to bend round the weft, those on each side of it will close over the vacancy and completely hide the point where it has interwoven with the weft. In that case the number of warp threads would be increased in proportion to the number of weft, and consequently the fabric will be capable of bearing an increased strain upon the warp, or in the direction of the length of the piece, but a decreased strain in the direction of its width, or of the weft.

Exactly the same principle will apply to fabrics where a weft surface is produced. The warp threads are set such a distance apart as will permit of the weft threads passing readily between them, and bending round them. The weft threads are inserted as closely as their diameters will allow, and in some cases so as to pass over and hide the point where weft has bent around warp; and again, in many cases so closely that the weft is compressed, and

loses its true cylindrical form. In such fabrics the greatest strength is in the direction of the weft, just in the proportion to the quantity of material employed.

**9. Satins used for Ornamental Purposes.**—This principle of interweaving is sometimes employed where the object is purely ornamental, as in the satins used so largely for trimmings and for ladies' dress goods. In such cases the first object is to produce a highly lustrous surface, perfectly smooth, showing no pattern. Then if the fabric is intended to serve an useful purpose, as well as to bear strain, we must take care that the material which is present in least quantity, whether it be weft or warp, shall be of sufficient strength to compensate for the absence of quantity; otherwise the fabric will be able to bear strain in one direction only, whereas by proper attention to the strength of the material employed we may make it able to bear the requisite strain in both directions.

Although this class of satins is a large one in itself, yet we are only considering it here as representing a type of structure which may be, and is, used very commonly in conjunction with patterns for ornamentation. These we shall have to consider more fully in a subsequent chapter.

**10. Double Cloths.**—We next come to the consideration of a different class of fabric, not necessarily different in the principle upon which the fabric is constructed, but in regard to its use and ornamentation.

It frequently happens that in producing fabrics intended to serve special purposes, we cannot obtain the requisite weight and bulk of fabric without producing at the same time coarseness and openness of structure. If we wish to produce a heavy fabric, we have only two possible means of doing it—either the use of thick bulky threads, or an increased number of fine ones. If we use thick bulky threads, our fabric must present an appearance of coarseness, no matter what may be the order of interweaving; and we have no possible means of

reducing the coarseness. If we use fine threads, it is more than likely that the order of interweaving will prevent the introduction of as many threads as will produce the weight of fabric we desire. Then we have no alternative but to resort to *double cloth*; that is, instead of trying to crowd into a given space of a single fabric a number of threads, which will necessitate an undue compression of each individual thread, and require an immense amount of power to do so, and at the same time injure, in a greater or less degree, the threads of either warp or weft, or both, we must make two fabrics, and bind them together in the process of weaving so as to make them really one. There are among double cloths, or what are commonly known as double cloths, certain classes which are not really double cloths, but, more correctly speaking, double-faced cloths, that is, there may be one warp and two wefts, or one weft and two warps. A true double cloth must be really two separate fabrics, each having its own warp and weft. The two fabrics are woven at the same time, certainly; they are more or less intermixed with each other, but they never lose their individuality, whether they are combined for the mere purpose of producing a fabric of a given weight, or for ornamentation, or for both combined. So as to obtain readily a clear conception of what is really meant by double cloths, we will first examine the double-faced cloths. If we turn to Fig. 7, we find in that a closely-set warp, interwoven with weft in such a manner that the weft is practically invisible on the surface of the fabric. Suppose we introduce another warp, and so interweave it with the same weft that the weft is contained between the two warps; we shall then have a fabric both sides of which present warp only, the weft which binds the two warps together being contained between them. This we can easily do by taking care to select the point of interweaving the weft with each warp in such a manner that the one warp does not interfere with the other, as shown in the section, Fig. 8.

We have here, then, a ready means of producing a fabric which will give increased weight and bulk, increased strength to bear strain in the direction of the

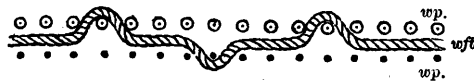


Fig. 8.\*

warp, and a cloth which may be used as a reversible article. One side may be of one colour, and the other side of a different colour; or we may use it for the purpose of producing an article of dress, one side being a fine fabric and the other side a coarser one, to serve merely as a lining.

Then, exactly in the same manner as we may make the satin referred to in Fig. 7 to have either the warp or the weft predominating, we may have our double-faced cloth so as to present weft on both sides instead of warp on both sides. In that case we should simply reverse the conditions—the warp would be contained between the two wefts; the greatest strength will be in the direction of the weft. And in the same way we may make one side fine and another coarse; one side in either cloth may be highly ornamented, either with colour or in the order of interweaving the threads together, and the other



Fig. 9.\*

side may be quite plain as regards colour, and nearly so as regards pattern. Fig. 9 would show a section of a fabric having two weft surfaces.

In the case of a double cloth, as has been said, we must employ two separate warps, and also two separate wefts, each weft interweaving with its own warp, and

\* In this and other figures, the letters "wp." stand for "warp," and "wft." "weft."



consequently each fabric made quite separate and apart from the other. Not only may the fabrics be separate, but each may be of a different degree of fineness, made from a different material, and of a different pattern; then the two may be bound together so as to form one fabric.

In cases where we desire to produce a fabric of a given weight and degree of fineness, and the pattern or order of interweaving we desire to apply to the fabric will not enable us to introduce as much material as will produce the required weight, we may then resort to double cloths, because here we can combine any two fabrics, and so obtain a greater weight, along with fineness, than we can with a single cloth. Again, we may make one of the fabrics fine and the other coarse, and so produce the required weight at a less cost than in a single fabric of the same weight; and at the same time we may secure all the advantages of strength, power to resist friction, and to retain warmth as an article of clothing, in an even greater degree than in a single fabric of the same weight. In many cases cloths are made not only double, but three and even fourfold. Whenever double cloths are resorted to there is a distinct object in view—to produce weight alone, or at a small cost, to make a fine surface on a fabric of a given weight, to secure additional strength, warmth, and wearing powers, or sometimes for the purpose of ornamentation solely, by causing the cloths to exchange places and so form figures.

**11. Gauze Cloths.**—Another class of fabrics, and one which differs very materially from each of the others, is gauze. This belongs to the purely ornamental fabrics. Because of the manner in which it is constructed, it will not permit of a close or thick fabric being formed; in fact, it may be said to be of the lace type of fabrics. The threads do not merely interweave with each other, but they twist round each other in such a manner as to form an open perforated fabric. One

peculiarity of the structure is to give great strength for the quantity of material it contains; but from the fact of the threads twisting round each other, the quantity of material must be very limited. Although we cannot produce in this class of fabrics articles of use, so far as their power of retaining warmth is concerned, we have probably the widest field for ornamentation, because we can combine it with the other orders of working or interweaving, and so have at our command all the means of ornamentation which structure of cloth can give.

Thus far, we have dealt with the structure of cloth only, so that we might see upon what basis we must work for ornamentation. No matter to what purposes fabrics are to be applied, we must not in ornamenting them detract from their utility; and as the chief mode of ornamenting them is in the variations of the order of interweaving the threads of which they are composed, the structure of the fabric must be the first question to consider in applying our ornamentation to it.

**12. Plush or Pile Fabrics.**—We have not yet referred to ornamenting by the introduction of additional threads, these threads being arranged in such a manner as to form figures or patterns, or it may be to form what is termed pile or plush. By the use of such threads we have an unlimited field for ornamentation, without in any way detracting from the usefulness of the fabric, but in the great majority of cases really adding materially to its strength, and making it more useful.

We have now so far developed our theory as to have determined the common principle of structure of fabrics, and in a general way the qualities or properties each variety of structure must possess, so as to suit it for the purposes to which it is to be applied.

## CHAPTER II.

## THE STRUCTURE OF THREADS.

13. **Relation between Thread and Cloth.**—Immediately connected with the structure of the cloth, and really exerting considerable influence upon it, is the structure of the threads of which it is composed. Not only will this affect it so far as its usefulness goes, but it will also largely affect the power of ornamenting.

It may appear out of place in a work on Design in Textile Fabrics to enter into the question of the structure of threads and the fibres from which they are made; but as they affect in such a degree the structure of the cloth, we must deal with it before we can have a thorough comprehension of our power of varying that structure and ornamenting it.

14.—We may begin by asking, "*What is a thread?*" A thread is said to be "a filament composed of fibres twisted together or otherwise." Thus, before we enter into a detailed examination of the structure of the thread itself, we will examine very briefly the chief characteristics of the fibres from which it is made. The fibres most largely used in the manufacture of textile fabrics are wool, cotton, silk, and flax, and each possesses peculiar properties which give it a special and particular value.

15.—If we examine a lock of wool as it comes from the back of the sheep, the first thing which will attract our attention is a peculiar waviness or crimpiness in the lock. If we separate a single fibre from the rest, we shall find that it is waved in the same manner, and also that the waves are very regular throughout. If we carry our examination further, and place the fibre under

a microscope, we shall find the whole surface covered with scales, the scales forming a series of rings round the fibre, and all pointing from root to tip. We shall also find that the fibre is a hollow tube filled with a granulated liquid. It is the wave and scale of the wool which give it its peculiar value. In the preparation for spinning, the fibres are intermixed in such a manner that the directions of the scales are as much opposed to each other as possible; that is, the fibres are placed root to tip and tip to root. As they are spun, the scales of the opposing fibres engage with each other, and become interlocked, and the more the thread is spun the more firmly do they hold each other, and so make a strong thread; but the spinning property, or the readiness to form a thread, is not the only value of these scales. After the fabric is formed most woollen goods undergo a process of milling or felting; that is, the fibres are made to interlock with each other more firmly, and consequently the fabric becomes more close and compact. In this operation the waves or crimps of the fibre are valuable as well as the scales. To cause the felting to take place, the cloth is moistened with a strong solution, consisting largely of soap, and pressure is applied. The result is the fibres are straightened out; the scales of opposing fibres engage with each other. As the pressure is removed, the natural spring of the fibre asserts itself; it tries to return to its original wavy condition; in doing so the fibres are drawn more closely together. The pressure is again applied, and the operation repeated. By degrees the fibres become so closely intermixed that the threads lose their individuality, and the cloth becomes one compact solid mass. To assist this operation of felting, where it is required in a great degree, the thread must be specially constructed; and it will be very evident that when the cloth is operated upon in this manner, whatever pattern existed must be, in a great measure, lost.

Different classes and qualities of wool differ very

much in the degree in which they possess those waves and scales, and consequently in their value for the production of fabrics of given characters.

16.—Cotton, which is a vegetable fibre, presents a very different appearance from wool; it is really a thin, collapsed tube, and under the microscope appears like a ribbon more or less twisted. These twists in the fibre—which is of a very soft, pliable nature—are valuable as giving strength to the thread by their friction upon each other.

17.—Silk is a straight, smooth fibre, very highly polished, and when magnified, presents somewhat the appearance of a glass rod. It is very soft and pliable, and lends itself readily to the formation of a thread.

18.—Flax is a vegetable fibre and has an appearance something like long grass; it is cylindrical in form, and with knots at intervals, exactly as we often see it in canes or long grass.

Although we have here four classes of fibre, each is capable of being made into two distinct kinds of thread, and it is the formation of this thread which so materially affects the formation, or at least the ornamentation, of the fabric.

**19. Preparing and Spinning the Fibres into Yarn.**  
**Woollen Yarn.**—If we deal first with the preparation and spinning of wool, it will enable us to have a clearer conception of the preparation and spinning of the other fibres.

The first process after the wool has been washed to free it from its impurities, is the separation and straightening of the fibres, and this is equally necessary for the production of both classes of yarn made from wool, although the mode of dealing with long wool in the first operation is very different from that of dealing with short wools. In the separation and straightening of the fibres of the latter, a carding machine is employed. This machine consists of a series of cylinders covered with cards, or finely set teeth; these cylinders revolve in

different directions, and at different speeds. They are placed so near each other that as the wool is carried forward by one upon its teeth, it is caught by the teeth of the other, and so, by degrees, each fibre is separated from the other, but there is little or no attempt to secure the parallelism of the fibres; they are simply separated.

If the wool is intended for the production of what is termed a woollen thread, it is passed through two or three of these carding machines, according to the quality of yarn to be produced, and as it comes off the last machine it is condensed or reduced to thick rope-like threads, and from there it passes to the mule to be spun. It must be remembered that in passing through the carding machines, the chief object has been the separation of the fibres, without much regard to their parallelism. When the thread formed by the condenser is placed upon the mule it is passed through a pair of rollers, and thence to the spindle. This spindle is carried upon a carriage which alternately recedes from and advances towards the rollers through which the thread has been passed. Having attached the thread to the spindle with the carriage brought close up to the rollers, the carriage is made to recede, at the same time the spindles commence to revolve, and so twist the thread; the rollers also revolve and give off yarn. After the carriage has travelled a given distance the rollers stop, and consequently cease the delivery of yarn. The carriage still continues to recede, and consequently draws out, or attenuates, the thread. At the same time the spindles are continuing to revolve and twist the yarn, so that the process of attenuating or drawing out the thread and twisting go on at the same time. The result of this is that the longest fibres composing the thread, and those most nearly approaching parallelism form the core or centre of the thread, and the short fibres, and those which have not been laid parallel, become partly embedded in the thread, and partly project from it, so that the thread presents a rough appearance with fibres projecting from

it all round its circumference, and throughout its entire length.

**20. Inequality of Woollen Thread.**—Another feature of woollen threads is the inequality of thickness. In the preparation of the wool for spinning no means are provided, except in the feeding of the wool to the carding machines, to insure equality. And, again, in the actual process of spinning on the mule there is a tendency rather to increase than diminish the inequalities. As the twist is being put in the thread by the revolutions of the spindles, it will exercise more power over the thin than the thick portions of the thread, and so make it firmer, and consequently of less diameter than the portions over which it exercises less power.

If we take a thread and make a section of it at points representing the various thicknesses or diameters, the area of these sections will vary as the squares of their diameters, therefore the power of the twist over these portions will be in the direct ratio of the area of their sections. True, a certain amount of equalisation will take place as a result of this varying power of the twist, and of the operations of drawing and twisting occurring simultaneously. As the thin portions become firmly twisted they will naturally resist the drawing process, so that from the moment these thin places have become sufficiently firm to resist the drawing action, the attenuation will be confined to the thick portions, but the latter will not be reduced to the proportions of the thin parts, which all the time are receiving more and more twist, and as a consequence, although they retain all the fibres, or have none drawn from them, are still becoming thinner owing to the compression of the fibres by being more firmly twisted.

**21. Advantage of Structure of Woollen Threads.**—We may now see what advantages or disadvantages this type of thread possesses in the production of fabrics of given character. From its very unevenness, and what we may term roughness, from the projecting fibres upon

its surface, it is unfitted for the production of fabrics where pattern is to be formed by the interweaving of the threads, because the loose, fibrous character of the thread will tend to hide any pattern so produced, and, added to that, the inequalities in its diameter will tend to make the pattern appear very irregular. On the other hand, where the fabrics have to undergo the process of milling or felting, the loose, fibrous character of the thread is a great advantage, because the fibres of one thread can become readily interlocked with those of another and so assist to the utmost the process of felting. Again, there is a further tendency, in consequence of the threads losing their individuality, to lose or hide any pattern in the fabric ; so that we may say that the loose, fibrous woollen thread is specially suitable for the manufacture of close, felted cloths, which will give fine texture, firm compactness of structure, great power of retaining warmth and of resisting strain or friction, but not the power of producing patterns by the interweaving of the threads.

22. *Worsted Yarn.*—We will now glance briefly at the structure of the second class of thread made from wool, or what is commonly known as worsted. It is usually supposed that the chief difference between woollen and worsted is that the former is made from short wool exclusively and the latter from long wool. In reality, large quantities of worsted are made from wool of exactly the same class and quality as woollen yarns. Certainly, much shorter wool can be spun into woollen than can be spun into worsted, but the difference in the length of wool does not constitute the difference in the two threads.

In preparing the wool for spinning into worsted yarns, the first process, as in that of woollen yarn, is the separation of the fibres, and, indeed, where short wools are employed, upon practically the same machine, but accompanying or immediately following the process of separation, the fibres are drawn parallel to each other.



The wool passes through several machines for the sole purpose of obtaining this parallelism; when that has been accomplished as far as possible the wool is "combed"—that is, the wool is passed to a machine which draws it through fine steel combs, which further ensures the parallelism of the fibres, and at the same time takes away all the short fibres which, owing to their shortness, are incapable of being straightened out, so that we have all our fibres laid straight and parallel, and at the same time all the very short fibres removed, and we retain for the yarn we are about to spin only the longest and straightest fibres. After the process of combing commences a process of equalisation and attenuation. The wool is drawn from the comb in a thick rope, or "sliver." A number of these slivers are put together, passed through a series of combs for the purpose of preserving, and, if necessary, increasing, the parallelism of the fibres, and drawn out to the thickness of one or less than one of the original slivers. This process of equalisation goes on until in many cases the last thread has been drawn out some millions of times, so that any inequalities in one of the original slivers has been neutralised by inequalities in other slivers. After the process of equalisation is complete, it undergoes a process of attenuation, or further drawing out, and is then passed to the spinning frame. Worsted yarns are usually spun upon the "throstle" frame. This machine is provided with a series of drawing rollers, which by their varying speed further reduce, or draw out, the thread before the operation of twisting commences; it is then twisted and wound upon the bobbin at the same time. But in this the spinning and drawing out do not take place simultaneously as in woollen, but successively; consequently, in whatever position the fibres have been laid in the drawing they will not be disturbed in the spinning, and as we have taken every precaution in the preparation of the yarn for spinning to ensure the parallelism of the fibres, they will still retain that

position. Further, the thread has been equalised as far as possible; therefore, when spun, we may expect great regularity in its diameter.

### 23. Advantages of Structure of Worsted Threads.

—We have here, then, a thread of great regularity in its diameter, with all its fibres laid parallel and nearly of the same length. It will, therefore, possess great and tolerably uniform strength, and be specially suited for the formation of patterns in the fabric. It will not be suitable for milling or felting, because the fibres of one thread cannot combine with those of another thread, and thus they cannot lose their individuality; consequently, although the fabric is strong in the individual threads which compose it, these threads cannot intermingle so freely as in woollen cloth. It cannot possess the power to resist strain and friction in the same degree and in the same way, because the threads retain their individuality, and the fabric not being so compact as a woollen cloth, it will not have the same power of retaining warmth. On the other hand, any pattern woven upon it will not be lost or hid in the process of finishing, so that each class of thread has its own peculiar properties and advantages.

24. **Preparing and Spinning Cotton.**—Cotton is prepared like woollen on the carding machines, but undergoes a process of equalisation like worsted; sometimes, for the production of high-class yarns, it is combed. The spinning is done sometimes on the mule and sometimes on the throstle frame, so that the majority of cotton yarns may be said to partake of the character of both woollen and worsted so far as their structure is concerned. A combed yarn spun on a throstle frame would exactly answer in structure to the worsted thread. Of course, in yarns made from wool there are many which partake of the compound character.

25. **Preparing and Spinning Flax.**—Flax also gives us two classes of yarn—namely, linen or line yarn, and tow yarn. The processes of preparing linen yarn are very similar to

those of preparing worsted ; of course, the machines are different in their construction, because of the difference in the length and character of the fibre. Flax is "hackled" —beat or crushed—to make it flexible ; it is then "scutched," an operation equivalent to combing. In some cases the fibres are too long to work ; they are then broken by a "saw." After the scutching the short fibres are carded for "tow" yarn in the same manner as the "noil," or short fibres of wool after combing, are carded for woollen yarn.

**26. Preparing Silk Yarns.**—Silk is very different from any of the other fibres. Raw silk is drawn from the cocoon of the silk-worm in one long continuous filament ; several of these are put together, and produce what is known as "tram," or weft silk, and "organzine," or warp silk. The one is put together loosely, with little or no twist, and the other is twisted firmly together to make a solid, compact thread. Both have the same feature of being formed of long filaments, consequently they are suited for the production of patterns upon the fabric, and also possess great strength.

In some cases the cocoons are damaged, and incapable of being wound or drawn out in one continuous filament. Such cocoons are taken and torn up into lengths. They are then combed, the fibres laid parallel, and spun in the same manner as cotton or worsted. This yarn, of course, does not possess the freedom from fibres upon its surface which "raw" silk does ; yet, the fibres being combed out, and being of considerable length, it is a very strong thread, and well suited for the production of patterns upon the fabric.

We have now a tolerably clear conception of the first principles which must guide us in our application of ornament to fabrics. First, we have examined into the theory of the structure of cloth, and the suitability of the various kinds of structure for useful and ornamental purposes. We have then had a brief examination of the structure of threads, and the fibres from which they are

made, and the suitability of each for the different purposes to which it may be applied. Our next object must be to examine into the principle of ornamenting fabrics, either by the order of interweaving the threads together, the introduction of colour, or both. And throughout we must keep closely in view the purposes to which the fabrics are to be applied, the considerations of strength and general utility, and in no case must we impair the utility of the fabric by ornamentation, but rather combine the two to the utmost, and direct our attention always to the production of an article which shall not only be pleasing to the eye as a work of art, but also serve to the utmost all the objects for which it is designed.

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### CHAPTER III.

#### ORNAMENTATION OF FABRICS IN THEIR STRUCTURE.

27. *Relation of Ornament to Structure.*—Our next duty is to consider the ornamentation of the fabric, and in doing so we must take care that we do nothing which will detract from its usefulness. We may, of course, ornament with colour to any extent without in any way adding to or detracting from the utility of the fabric so far as its wearing properties, strength, &c., are concerned. But the question of the use of colour we may deal with separately; our present concern must be to ornament by the varying order of interweaving of the threads or constructing the fabric. In the first chapter we have shown that plain cloths may be ornamented to a certain extent by the alteration of the relative quantities of warp or weft, so as to cause the formation of cords or ribs; these cords would at all times run parallel to each other, either longitudinally

through the piece or transversely. That is the simplest form of ornamentation ; and, if proper regard be paid to the proportions of warp and weft, although simple, it is very neat and effective.

**28. Twilling.**—The next kind of ornament is what is commonly known as twills. These, in their simplest form, are merely ribs or cords running diagonally across the fabric. It would seem at first sight as if this form of decorating fabrics would not permit of much variation, but, in reality, it offers a wide field, and is probably more used than any other. The first and simplest sort of twill is represented by the plan, Fig. 10.



Fig. 10.

In this it will be found that each weft thread passes over two and under one warp thread, and that the order of interweaving is consecutive, that is, each pick of weft passes under a different end of warp, following in the order 1, 2, 3. The result of this is that every third pick and every third end are repetitions, or, in other words, the whole pattern is complete upon three ends and three picks, and that the whole fabric consists of any number of repetitions of these three ends and picks. All these repetitions join to each other in such a manner that the line of twill or pattern is continuous. Although this is the simplest form of pattern-making next to plain cloth, yet, like plain cloth, it is capable of being ornamented by the alteration of the relative quantities and thickness of warp and weft. The twill may be made more or less bold, and the angle at which it runs across the fabric may be altered, and it may be made to present a fine or coarse surface. If the threads per inch of warp and weft be equal, the angle at which the twill will run across the piece will be forty-five degrees, because of its moving from end to end in consecutive order. In this particular pattern either warp or weft must preponderate on the surface of the fabric. As it is presented here, the weft preponderates in the proportion of two to one. If

the pattern were worked in the reverse order—that is, the weft to pass under two threads and over one—the warp would preponderate on the surface in the same degree that weft does now. It is a generally accepted rule—and, as will be shown with other patterns, very properly, too—that whichever set of threads, warp or weft, preponderates on the surface in the order of interweaving, the same threads must also preponderate in the actual number per inch, though not necessarily using threads of the same diameter.

In this case, then, we say weft preponderates on the surface. Then we should have a greater number per inch of weft than warp; and if we do so, the angle at which the twill runs will be less than forty-five degrees. We have here, even in a greater degree than in plain cloth, the power of producing a fine compact fabric, and at the same time ornamenting. But the question will naturally arise, Of what does the ornamentation consist? because the mere alteration of the angle of the twill can scarcely of itself be called an increased ornamentation. Certainly it cannot; but accompanying this altered angle will always be an alteration in the fineness of the surface, and this of itself is an improvement. At the same time, along with this fineness we have more compactness, and consequently increased usefulness. As we increase the number of threads per inch we must decrease their diameters in the proper proportion, otherwise the proper balance will not be maintained between warp and weft, and in all fabrics this must be carefully attended to. Then if we have a greater number of threads per inch, and these threads are proportionately thinner, we must have increased fineness, and consequently a better appearance, a closer and more compact fabric, stronger in proportion to the weight of material it contains.

We have in this one pattern one of the best illustrations in its simplest form of the ornamentation of fabrics where colour is not employed; and it must be

borne in mind that a very large proportion of textile fabrics made for articles of dress are of one colour only, and not a combination of colours, and are dependent upon structural ornamentation for the production of an article which will be pleasing to the eye.

We may now proceed further in the examination of twill patterns.

If we refer again to Fig. 6 we shall find that precisely the same principle of arrangement, so far as the consecutive order of working is concerned, has been adopted as in the pattern of which we have just been speaking, but instead of either warp or weft preponderating on the surface, they are exactly equal. The generally accepted theory of the true structure of a fabric of such a pattern as this is, that warp and weft should be equal not only in quantity but in thickness. That is quite true, though we may produce a perfect piece of cloth without this being actually the case, but the proper proportion or balance must be maintained; we may increase the quantity of weft or warp, but we must reduce the diameters in a proper degree. Although the actual number of threads per inch is not the same in warp as in weft, the true proportion of one to another must be retained. If we do so, we shall alter the angle of the twill, we shall alter the fineness of the fabric, and the increased fineness will add a value to it, render it more pleasing to the eye, and at the same time a more serviceable article.

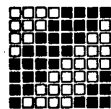


Fig. 11.

Proceeding from this form of simple twill, we may commence to make designs of a larger and more ornamental character. In patterns of the class of which we have just been speaking, whether the repetition occurs every three, four, or any number of ends, we should simply have a series of diagonal bars or ribs, all of equal size, and running parallel to each other. We may add very much to the beauty of the pattern by

varying the size of these lines or ribs, and in doing so would probably add very much to the firmness of the structure.

If we take, for example, the two patterns in Figs. 11 and 12, we have the same quantities of weft and warp on the surface, but one would present a series of parallel lines all equal in size, and the other would present a bold and a faint line alternately. The one showing the variety of lines would be the finer structure, because the warp and weft inter-

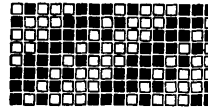


Fig. 12.

change more frequently, are more firmly interwoven together, and so secure firmness of texture. There is, however, one thing which must not be overlooked. If we are desiring to produce a heavy, bulky fabric, the pattern Fig. 11 will better enable us to do it, by allowing a greater number of threads to be introduced into a given space. We have, however, still a means left open of producing variety of lines, and yet of securing the requisite weight, and also the requisite firmness and closeness of texture. We have simply to enlarge our design and employ a greater number of threads in the formation of the pattern, and we may vary the lines at will.

**29. Arrangement of Designs on Paper.**—Before going further, it will perhaps be better to explain to the student who may be just commencing his studies of Textile Fabrics the meaning of the arrangement of patterns in Figs. 11 and 12. The series of vertical spaces represent the warp threads, the horizontal ones the weft, and the black points of intersection indicate that weft, and the open spaces that warp, is coming to the surface. Thus by the use of paper ruled in this manner we have a ready means of conveying to the eye the appearance the pattern will present in the fabric, and of judging of its effect by the order of interweaving.



**30. Patterns having a Twilled Basis.**—Having now determined the mode of ornamenting by the use of simple twills, and their effect upon the structure of the fabric, as affecting not only the appearance of fineness, but its usefulness, we may proceed further, and see what effects we can produce by varying the order and di-

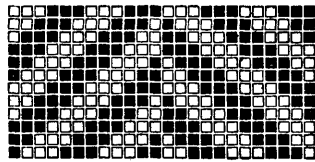


Fig. 13.

rection of the twills. Here we have an immense field. We may take any simple twill and by altering its direction at intervals, regular or irregular, we may produce patterns of the most elaborate character, and add beauty to the fabric without in any degree affecting its structure or usefulness. Generally, this mode of decorating will assume one of three forms: first, stripes; second, check effects; and, third, figures partaking more or less

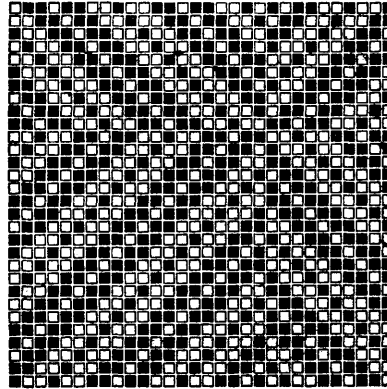


Fig. 14.

of a diagonal character. The patterns in Figs. 13, 14, and 15, are examples of the three orders or classes, each based upon a different twill. They may, of course, all have been based upon the same twill; but by using a different one for each we can more readily demonstrate the use of variety of twills in producing patterns.

In ornamenting fabrics by the use of twills in this

manner, we have a very great advantage over the use of twills running continually in one direction. We can obtain all the variety of lines which the continuous twill would give. We can also obtain variety of form to any extent we please, and we retain the same texture and the same degree of usefulness.

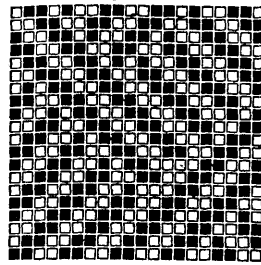


Fig. 15.

Extensive and valuable as this form of ornamentation is, it is really only the first introduction to our work.

Certainly, a very large proportion of the fabrics made are decorated from a basis of simple twills only, probably in many cases because of structural advantages; yet the use of twills in other forms may readily be resorted to, and with all the advantages of the simple twill, and greater scope for producing variety of pattern.

Another form in which twills may be, and, indeed are, very largely used, is shown in Fig. 16, where a very bold diagonal line is run, and a smaller twill running

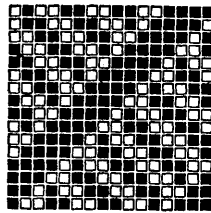


Fig. 16

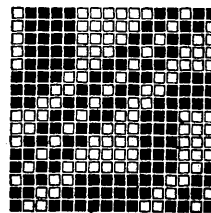


Fig. 17

between and in the opposite direction, and again in Fig. 17, where the same diagonal line is employed, and a small spot introduced between. In either of these orders of working we have an immense field for the production

of variety of pattern. When dealing with the system of combination shown in Fig. 17, it requires great care and judgment to prevent the fabric from becoming too loose in its structure. If we attempt to make the figure too large, or the diagonal line too bold, we are running great danger of interweaving the warp and weft at such long intervals that the fabric will lose its value as an article of utility.

Again, we may produce patterns in twill, forms which are nothing more or less than a series of small figures arranged in diagonal lines, without producing actually one continuous unbroken line, as in Fig. 18, and also in many cases—and these are a very large class indeed—where we have a diagonal line running upon a ground-work of plain cloth. In the case of a pattern upon a ground of plain cloth, we produce a fabric of very firm texture, but not one

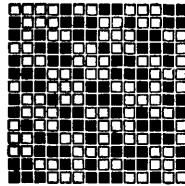


Fig. 18.

into which we can introduce a very large quantity of material. In fact, whenever we combine plain with any order of working, we reduce our power of making either heavy or bulky fabrics, so that whenever our object is to produce heavy goods we must bear this carefully in mind.

**31. Twills Arranged in Satin Order.**—We must now turn our attention to another class of twill, and one which is of much importance, not only from a decorative point of view, but also from considerations of utility. In the first chapter (Sect. 8) reference was made to satins as being arrangements suitable for the production of fabrics requiring strength in one direction only; but satins are also valuable for the production of fancy patterns; or, rather, perhaps we should say for the present, the principle upon which satins are arranged is valuable when applied to other patterns, as twills.

In that portion of the first chapter to which we have just referred, it is pointed out that the peculiar feature of satins is, that no two succeeding picks of weft interweave with adjoining ends, but that the points of interweaving are distributed regularly, and in such manner that no two can come together. This is dependent upon the principle of arrangement, or perhaps it would be as well to say rearrangement, of the threads, or the points of interweaving. On examining any satin it will be found that those points of interweaving are such distances apart as will be represented by such a number of threads as is not a measure of the total employed in the pattern. Thus, in what is termed a five-thread satin, the points of interweaving are two threads apart; in an eight-thread satin they are three threads apart, and so on. This



Fig. 19.

may be taken as representing the rearrangement of the threads of a regular twill. Suppose we take Fig. 19 as representative of a simple twill upon five ends, and we number the ends 1, 2, 3, 4, 5; we then take these five ends and rearrange them in such manner that the points of interweaving are always at intervals of two from each other, as shown in Fig. 20. By following the numbers in Fig. 20, it will be seen that the threads are simply rearranged.



Fig. 20.

It has already been pointed out that in any pattern where either warp or weft preponderates on the surface of the fabric in the order of interweaving, it must also preponderate in the actual quantity of yarn employed, and that this applies more especially to satins. In the case before us, where we have a twill and satin side by side in Figs. 19 and 20, and we show that the satin is simply the rearrangement of the twill, it would appear that the rule should apply equally to both; but it cannot quite do so, because of one interweaving warp

with weft in consecutive order, and the other at intervals. Now, if that be the case in this kind of simple twills, it is even more so in that of other twills. Let us examine the two patterns Figs. 21 and 22.

Here we have the separate warp threads numbered in exactly the same manner as Figs. 19 and 20, the only difference being that a greater number of threads are occupied, and therefore the order of rearrangement is different, though it is based upon precisely the same principle—namely, that the interval in the order of interweaving is equal to the first number which is not a measure of the total.

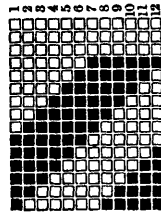


Fig. 21.

To make a perfect fabric with the pattern in Fig. 21, warp and weft should be equal in every respect. There is the same quantity of each on the surface, the order of interweaving is consecutive, and the angle of the twill would be one of forty-five degrees, but in the rearrangement, as in Fig. 22, the conditions are altered. True, there is still the same quantity of warp and weft on the surface; the angle of the twill is also one of forty-five degrees, but the order of interweaving is completely changed. In the pattern, when worked as a regular twill, each end as it comes to the surface is supported for five-sixths of its length by the end adjoining it on each side, consequently the cloth will look fine and compact if the threads are just set so close as to touch each other, or if they occupy a space each equal to their diameters.

The same remark will apply exactly to the weft, but in the pattern as shown in Fig. 22 alternate ends are brought to the surface, as in the formation of plain cloth, but they remain on the surface for a longer period than in plain cloth. If we weave this pattern with the warp

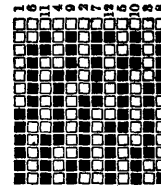


Fig. 22.

set the same distances apart as for the regular twill, each warp thread will stand separate and distinct, and the cloth would not be nearly so firm as in the common twill. We must compare patterns of this class with plain cloths constructed so as to form a rib across the piece; we must have the warp threads fine, and so closely set that all those on the surface will be in actual contact with each other, or so near



Fig. 23.

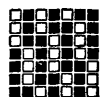


Fig. 24.

as not to show any division. The weft is contained between the warp, it will therefore be laid straight, and the warp will bend round it. Another example is shown in Figs. 23 and 24; and, further, in Figs. 25 and 26.

In both the instances of regular twill patterns, Figs. 23 and 25, the quantities of warp and weft are nearly equal, and the order of interweaving would produce a very firm fabric. In the rearranged patterns, in Figs. 24 and 26, each pick is as nearly as possible a plain pick—that is, under and over alternate threads—and for at least one half the pattern two picks together are under and over the same threads. Again, they differ from the pattern in Fig. 22 in the angle at which the twill runs across the fabric. In Fig. 22 two

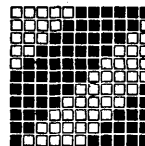


Fig. 25.

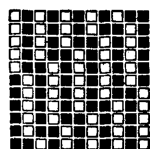


Fig. 26.

threads come to the surface together at regular intervals, in Figs. 24 and 26 they do not, taking in both cases the black dots as indicating weft. In Figs. 24 and 26 the number of ends employed is an odd number, while in Fig. 22 it is even. Although all the three patterns in Figs. 22, 24, and 26 are arranged upon the same basis—they are all simple rearrangements of a regular twill—they will produce different effects in the fabric, first, as to the angle,

and second, as to the regularity of the twill. However, they all possess one feature in common, namely, that they are akin to the corded or ribbed class of plain cloth, but the rib will not be in the direct line of the weft, and at right angles to the warp, but will be more or less of the nature of a diagonal line. They all require that the warp shall be closely set, and the angle of the twill varies in each case as the relative quantity of warp and weft varies.

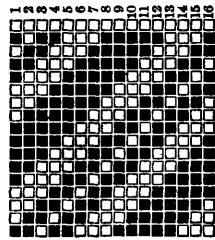


Fig. 27.

We have in this principle of rearrangement in satin order a very easy and simple method of producing patterns for ornamentation, and if proper relations be maintained between warp and weft according to the order of interweaving, our fabrics will be of a most useful character. In fact, in many cases the rearranged pattern will give a more useful fabric than the simple twill, just in the same manner as the corded plain cloth is a more useful and stronger cloth than the plain cloth of the pure type.

The rearrangement of twills in satin order will, in a great many cases, produce patterns of a very ornamental character, and presenting an appearance greatly different from that of the original twill from which it comes. This is well illustrated in Figs. 27 and 28.

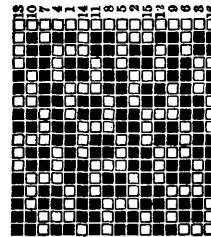


Fig. 28.

In the former we have a twill of ordinary type, but in the latter we have one of a very different character. Not only is it a distinctly ornamental twill, but the angle at which it runs is altogether different; the order of interweaving is different so far as the successive order of each end is concerned, though the ends

taken individually are precisely the same. In fact, if we examine the ends and their numbering, we shall see that Fig. 28 is Fig. 27 rearranged. It would be a very easy matter to give a very large number of illustrations, but the limited space will not permit it, and the number of patterns capable of being produced has already been fully illustrated in my "Album of Textile Designs."

It was pointed out on page 38 that in many cases the rearrangement of a twill in satin order very frequently altered the angle of the twill, and by the alteration of angle, as well as the order of interweaving, would necessitate the alteration of the relative quantities of warp and weft. This is true in the great majority of cases; if the rearrangement takes place in the warp threads, the angle of the twill generally runs in the direction of the weft, and so approaches a ribbed fabric, as shown in Figs. 24 and 26, but in some cases the angle of the twill will remain the same as in the original, though these cases are not very numerous. In some few the angle will be more in the direction of the warp. The alteration of the angle is mostly dependent upon the order of rearrangement, but in a few instances it is affected by the order of interweaving of each individual thread. In any case it is a matter of the greatest importance that the relation of warp to weft should be carefully adjusted to the pattern, so as to secure a proper balance of structure, and so make the fabric serve all useful purposes to the utmost.

There is one point here which may be observed: if the fabric is to be fine in the warp, or to be able to bear great strain in the direction of the warp, it is generally most readily obtained by rearrangement of the warp threads, as already shown; but if it must be fine in the weft, or be able to bear lateral strain, then it may be readily obtained by the rearrangement of the picks or weft threads. The ornamentation of patterns of this character need not be dependent only upon the particular



class of pattern shown in Fig. 28, but as in ordinary twills it may consist of a variety of lines, or, in other words, by variation in the thickness or width of the ribs.

From what has been said the formation, and more especially the rearrangement, of twills is intended to serve the joint purpose of ornamentation and increased usefulness; but rearrangement of twills may be made for the sole purpose of ornamentation, and we have in this mode of working an immense field. It may be said that by the rearrangement of twills we have a means of producing a large variety of fancy patterns by a purely mechanical process, and that for their application to the fabric only judgment in selecting is required so as to apply that class of pattern which is most suitable for the class of fabric to be produced.

**32. The Production of Pattern by Rearrangement in Different Orders.**—The system of rearrangement of which we have been speaking is one of the most perfect, but, as has been shown, it will produce generally but one class of pattern. We must now look for systems which will give us greater variety. We might look to what is commonly known as permutation to supply us with this, but we must be careful not to be led away by false ideas of the number of patterns we can produce, or the modes of producing them.

According to the system of permutation, two objects can be placed in two positions in relation to each other, three objects can be placed in six positions, four objects in twenty-four positions, and so on. At first sight it would appear that we may produce so many patterns upon any number of ends as permutation will give us positions, and that simply by the rearrangement of those positions. Further, we might say that as each end of warp must interweave with a given number of picks of weft, the number of patterns capable of being produced upon a given number of ends and picks would be repre-

sented by the permutation of ends and picks together ; thus, if we take four ends and four picks, as represented here,  $\begin{array}{cccc} \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \end{array}$  there are sixteen points of intersection of warp  $\begin{array}{cccc} \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \end{array}$  with weft. Now, the permutation of sixteen gives us a number represented by fourteen places of figures, or 20,867,685,888,000, so that it would appear that that would be the number of patterns we can produce. We must see what is the real state of the case. Patterns must have some definite order in their arrangement, and they must also be so arranged as to be continuous. Any pattern must be so that it will join to itself on all sides, and be perfectly continuous if extended or repeated in any direction. Let us take, for example, a plain cloth.  $\begin{array}{cc} \square & \square \\ \square & \square \end{array}$  Here we have a complete plan of a plain cloth.  $\begin{array}{cc} \square & \square \\ \square & \square \end{array}$  Two ends and two picks are used ; there are four points of intersection. Those two ends and picks would be repeated any number of times so as to produce the width and length of fabric required. Suppose we exchange the places of the two ends, thus,  $\begin{array}{cc} \square & \square \\ \square & \square \end{array}$  and repeat this rearrangement any number of  $\begin{array}{cc} \square & \square \\ \square & \square \end{array}$  times, we should not produce a new pattern ; when extended they would both be exactly the same thing. Again, in exchanging the ends we have also exchanged the picks, so that it is quite incapable of further alteration in this respect, and all further efforts to produce patterns in this direction will be in vain. We will go one step further, and alter the order of interweaving, thus,  $\begin{array}{cc} \square & \square \\ \square & \square \end{array}$  Here we make three of the four spaces black, or  $\begin{array}{cc} \blacksquare & \blacksquare \\ \blacksquare & \square \end{array}$  make weft come to the surface at three of the four points. If we were to exchange the places of either ends or picks the result would be the same as in the previous case—that is, the pattern being repeated, the threads would be made to bear the same relation to each other as they did originally, so that we can go no farther in that direction. There is another point also which reduces this proposition to an absurdity. It will be seen that one pick of weft passes *over both* the *ends* employed, and also

that one end passes *under both picks*; therefore, no interweaving can take place, and cloth will not be formed.

It must always be borne in mind that whatever number of ends or picks are employed in the formation of a pattern, we are confined to that number, and the whole fabric is a series of repetitions. That being the case, plain cloth is incapable of any variation in the order of interweaving, although, as previously shown, it may be made the *basis* of a system of ornamentation. If we take three ends and three picks we have apparently some room left for ornamentation, but in reality we are again limited to two positions, thus,  $\begin{array}{cc} \square\square & \\ \square\square & \\ \square\square & \end{array}$  or  $\begin{array}{cc} \square & \square \\ \square & \square \\ \square & \square \end{array}$  We may place our three ends in any order we please, but they will always produce exactly the same thing—a regular twill running from left to right or from right to left; and any alteration in the order of the ends will produce an exactly corresponding alteration in the picks. In fact, it is as if we take three straight lines; we can produce but one figure from them—namely, a triangle. We may obtain an apparent alteration in the twill by bringing weft over two warp threads instead of one, thus,  $\begin{array}{cc} \square & \square \\ \square & \square \\ \square & \square \end{array}$  but it is the same pattern. We are merely substituting weft for warp on the surface, and the back of one fabric will be exactly like the face of the other. If we take four ends we have a little more scope for the production of patterns, but it is still very limited. We may run our twill in one direction or the other, or we may break the pattern into two portions, and reverse the order of position of one of the pairs, thus,  $\begin{array}{cccc} \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \end{array}$  and so produce a quite distinct effect, but so far as rearrangement goes, that is all we can do, every other rearrangement producing precisely the same result. We have, however, one advantage, which increases as the number of ends employed increases—that is, we can vary the order of interweaving more—though with four ends we are limited to two—the one given above and

that in which we allow weft to pass over and under two warp threads, thus,  $\begin{matrix} \blacksquare & \square & \square \\ \square & \blacksquare & \square \\ \square & \square & \blacksquare \end{matrix}$  each being equally capable, of the same variation.

If we were to proceed in detail through each number of ends in succession, we should find at each step that we have not only the advantage which has just been pointed out—the power of varying the order of interweaving—but greater variety of rearrangements. We have not only the satin arrangement already spoken of, but a great number of other orders. For example, we might transpose the ends in twos, threes, fours, or any number—thus, 2, 1, 4, 3, 6, 5, or 3, 2, 1, 6, 5, 4, &c. Each of these transposed orders may be further rearranged. After we have transposed, say, in twos, take the resulting pattern and rearrange it in satin order, the pattern resulting from that in some other order, and so on, until we eventually return to the original starting point. There is but the one thing to bear in mind—that all our rearrangements must be regular; there can be no pattern without regularity and order. If we do not carefully attend to that, we shall have simply a jumble of threads together and no pattern.

### 33. Patterns Produced by Combination of Twills.—

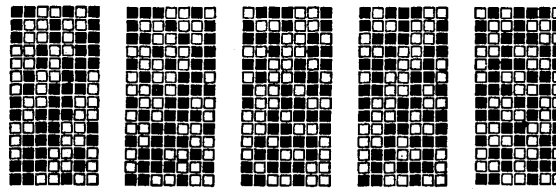
This method of producing patterns by rearrangement is but the first step in the production of new designs for fabrics in a systematic manner. Great as is the number of designs which may be obtained by this mode of working, it is small compared with what may be obtained by other and equally systematic methods. We may turn our attention next to what is known as the doctrine of combinations, and from that we shall be able to obtain an infinite variety. We will first examine into the system of combinations, and then see how far we can apply it to the work in hand. Although, as has been shown, permutation gives nominally great power of producing patterns, yet, in reality, when applied in regular order, as is necessary for designs, it is limited. It might

almost be said that combinations give an unlimited power. The combination of two square pieces, each divided diagonally in two colours, is said to be capable of being made in sixty-four different ways. According to Prestet's calculation, the combinations possible of the twenty-four letters of the alphabet taken by twos, then by threes, and so on, amount to a number represented by thirty-three places of figures, or thirteen billions of billions, or 139 quintillions, or so many different words may be produced. There is this difference between the combination of such things as the letters of the alphabet and the ends of a pattern—whereas the letters of the alphabet are all different, the order of working of the ends of a pattern should be similar. Still, although the working of the ends should be similar, the order of interweaving of the picks need not necessarily be similar; and again, any two letters will admit of but one combination, but two patterns will admit of a number of combinations, and at each one produce a new pattern.

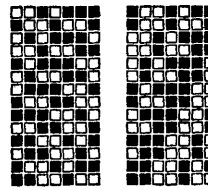
Combinations are generally taken as denoting the placing together of objects, quantities, &c., and their alteration or variation in all possible ways. Thus, one object will admit of no combination; two objects will admit of one combination only, provided they are simple objects, but if they are not simple ones—if they present different appearances on their different sides, as in the case of the coloured squares—then they will permit of a great number of combinations; and further, as we increase either the variety or the number of objects, we increase at the same time the number of fresh combinations possible. We will proceed first with the combination of simple objects in twos. Two objects will admit of one combination only—viz., AB; three objects will admit of three combinations—AB, AC, and BC; four objects will admit of six combinations—AB, AC, AD, BC, BD, CD; five objects will admit of ten combinations; and so on. The combination of any number of objects will proceed ac-

according to the triangular numbers 1, 3, 6, 10, 15, 21, &c., or a general formula will be  $\frac{N \times (N-1)}{1 \times 2} = \text{combinations}$ ; that is, let N represent the number of objects—suppose 6—then  $\frac{6 \times (6-1)}{1 \times 2} = 15$ ; or fifteen will be the number of combinations which may be produced from six objects.

Now let us see how this will apply to patterns, and how far we may extend it by placing the patterns in a



different position in relation to each other. In Fig. 29 we have a combination of two seven-end twills, pick and pick alternately; that is, the first, third, fifth, &c., picks would form one complete seven-end twill of themselves, and the second, fourth, sixth, &c., picks would form one pattern. The two patterns are placed together alternately, one pick of one and one pick of the other, and so form a new pattern. Now, as we have just pointed out, two simple objects permit of one combination only; but two patterns can scarcely be called simple objects. In the first place, each pattern occupies seven ends, consequently they can be placed in relation to each other in at least seven different positions, as shown in patterns 29 to 35.



Then, after we have found by the formula given

how many combinations we can produce from a given number of patterns, we may multiply that by the number of ends in the pattern, because we can combine them in as many positions as there are ends employed.



Fig. 36.



Fig. 37.

Upon seven ends suppose we make, say, sixteen simple twills—not a very difficult thing to do.

We can combine these sixteen twills in  $\frac{16 \times 15}{1 \times 2} = 120$  times in one position in relation to each other, and as there are seven ends, we may produce  $120 \times 7 = 840$  patterns

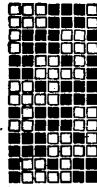


Fig. 38.

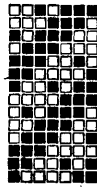


Fig. 39.

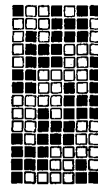


Fig. 40.

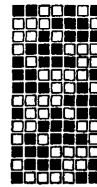


Fig. 41.

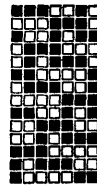


Fig. 42.

by combinations. But we have not done even yet, for each of these simple twills is capable of rearrangement, and they can then be combined in their rearranged form. Thus, Figs. 36 and 37 are rearrangements in satin order of the two patterns of which Fig. 29 is composed, and the patterns 38 to 44 are combinations of those rearrangements. The appearance presented by these patterns is very different from that of those composed of straight twills, so that we have here again 840 more patterns possible. But this is only one rearrangement. Many others may be made; each again may be dealt with as before, and so give us

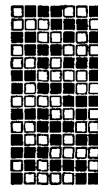


Fig. 43.

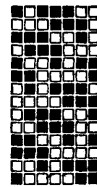


Fig. 44.

an unlimited field for the production of new designs. Perhaps, in producing this great number of patterns, we should find in many cases that we have repetition, though the repetition would not take exactly the same form, but probably the pattern would appear in reverse order; still, it would be none the less the same pattern, and again, many of the patterns would come so nearly alike that they would amount practically to the same thing in the fabric. However, the principle is valuable as enabling us to produce a large number and variety of designs with the least possible amount of labour, and giving us a power of producing patterns of even a more elaborate character than the combinations previously alluded to produce.

So far we have been speaking of combining our twills in regular order in twos only, but we may vary the order as much as we like, provided only it is on a systematic basis; and we may combine in threes, fours, or any number we please. We will see how far the combinations in threes or any number will enable us to go. If we combine in threes, three objects will admit of but one order, four objects will admit of four orders, ABC, ABD, ACD, and BCD, and five objects will admit of ten combinations. Thus for combinations in threes a general formula will be  $\frac{N}{1} \times \frac{N-1}{2} \times \frac{N-2}{3}$ , and so on; and the same formula may be extended to the combination of any number of objects, and by any number at one time; and the formula for determining the number of combinations will be as above, continued to  $m$ , the number of factors. In these series, as in the series of twos, each pattern is capable of being placed in relation to each of the others in as many positions as there are ends used. So that we have surely a sufficiently wide field for the production of designs of this class without having in any way to draw upon imagination, but we have to exercise a proper discretion in applying them to the fabric.



## CHAPTER IV.

STRIPES, CHECKS, AND FIGURES FROM COMBINATION OF  
DIFFERENT TWILLS.

**34. The Effects of Combination of different Twills in Stripe form.**--We may now proceed to deal with the production of designs from the combination of twills or other patterns, and in doing so we must not only take into account the pleasing effects we may obtain from such combinations, but also the relations of the structure of fabric of one pattern to the structure of another pattern; and thirdly, the economic use of patterns in the process of weaving. We have already pointed out in reference to Figs. 13, 14, and 15 that patterns may be readily produced from simple bases, by combining them so as to form stripes, checks, and figures. In all those cases the pattern is produced by combining the twill with itself; that is, it is allowed to run for a given number of ends or picks in one direction, and then for a given number in another direction, so forming the pattern by the twill lines running in various directions. This is probably the easiest mode of producing patterns of a large size, and also of an elaborate character, though it must of course be borne in mind that there will always be a certain stiffness about them. One chief value of patterns arranged upon this basis is their economical production in the loom. The stripes or checks may be varied to any extent; the pattern may be as large or elaborate as we please; but if proper care is taken in their arrangement there are only a limited number of different orders of working; that is to say, the whole pattern consists of a twill, which is represented by a limited number of ends. These ends are simply repeated over and over again, perhaps not exactly in the same order, but the

order is varied according to the working of the pattern. Still a few ends are representative of the whole, and consequently a few "healds" will suffice in the loom for weaving the pattern. It only requires that proper care be taken to arrange the order of succession of the ends, and the order in which they are drawn through the healds, to ensure the proper pattern being produced in the most economical manner.

In the principle of rearrangement with which we dealt in Chap. III. we have a power of producing patterns of much greater variety than we can obtain by the mere combination of a simple twill with itself, at the same time that we preserve the economical mode of working. But in its application very great care becomes necessary to ensure the fabric being perfect; and not only for that reason, but also because although we may combine patterns which have the same common base, and so produce a pattern which can be worked with a small number of healds, yet we may so combine the two that they cannot be worked with a small number. And again, we must bear in mind the similarity of the two patterns, or their bases, must not be imaginary but real.

We will examine first into the question of the combination of patterns coming from the same base, but producing different effects in the fabric, and requiring a rearrangement of the proportions of warp and weft. If we refer to Figs. 21 and 22, we shall find an illustration of the fact that the rearrangement of the threads of a pattern will require an alteration of the relative quantities of warp and weft. Now, these two patterns come from the same base. Every separate end in one pattern is raised and depressed exactly in the same order as the ends in the other pattern, only they do not bear precisely the same relation to each other in their order of succession, as is indicated by their numbers. But one can be woven upon the same healds as the other; that is, the heald which carries

thread No. 1 in one pattern might also carry thread No. 1 in the other, and so with thread No. 2. This is usually the first point looked to in the arrangement of patterns, because if we can produce an elaborate design upon a small number of healds, we can do our work in the most economical manner; and so far as the two patterns to which we have referred are concerned, this can be done readily, but we must look carefully to the effect in the cloth. We have already seen that in the two patterns to which we are now alluding the one will require considerably more warp threads per inch than the other, or if we were to weave them both from the same warp, with the same size of yarn and the same number per inch, there would be a great difference in the two cloths. Then it must be very evident that if we combine these two patterns in the same cloth in stripe form, there will be a difficulty in the formation of the fabric in consequence of one portion interweaving more loosely than the other. The effect will be that the warp forming one portion will gradually become slack, and an effect commonly termed "cockling" will be produced. If we make very small patterns, or patterns occupying only a very small number of ends, this would not perhaps be so apparent; but if the pattern be large, then it would become a serious objection, and in fact it would be almost, if not quite, impossible to produce a perfect piece of cloth, unless the two patterns were made from different warps, and came from different warp beams in the loom.

**35. Combination of Different Twills in Check Form.**—If we take the same two patterns, and combine them in a different order, say so as to form a kind of chequered pattern, as in Fig. 45, we shall obviate the difficulty to some extent. Here it will be seen that each set of threads works first to one pattern and then the other alternately. That being the case, one will neutralise the other, and so prevent the "cockling" which will occur in the case of a stripe pure and

simple. We have in this case obviated one difficulty, but care must be taken that in doing so we don't fall into another. If we are working in this stripe form, by a simple combination of the two patterns Figs. 21 and 22 side by side regularly, there would be no difficulty about weaving the pattern with the smallest number of healds possible—namely, twelve—because one portion is simply the other rearranged, so that it is really a continual repetition of the same twill, but not with the ends always in the same consecutive order. The same may be said also of the design Fig. 45, but as the two orders of working exchange places at intervals, unless those exchanges are properly arranged, the two sets of warp threads will not be exact facsimiles of each other; and unless they are so, they could not possibly be woven with the same healds.

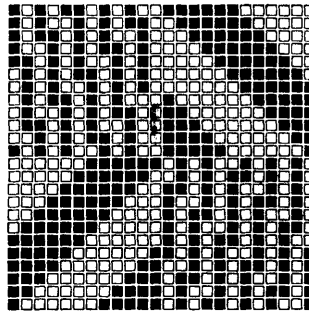


Fig. 45.

It is not intended here to enter closely into the question of "drafting," as that subject is fully treated in my "Treatise on Weaving and Designing Textile Fabrics;" but it is necessary to refer to it so as to enable the student to more fully understand the application of design to the fabric from a practical point of view. For the purpose of explaining this more clearly we will refer to Fig. 46. This is, in all appearance, exactly the same pattern as Fig. 45. It is, in fact, the same combination, and made in apparently the same manner; but if the threads be carefully examined all through the pattern it will be seen that there are no two exactly alike, so that although we are making the same pattern, exactly the same combination, we have

made it more difficult and more costly to produce, by requiring a greater number of healds to weave it with.

**36. The Method of Joining Patterns in Combination.**—In arranging patterns of this kind, the manner in which the two patterns join together requires much care. The point of junction should be such as to show no imperfection; that is, the weft or warp should not pass

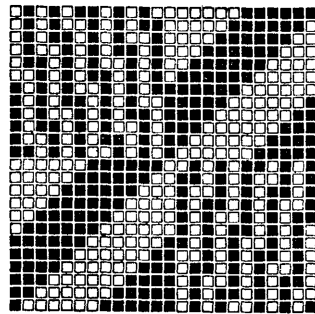
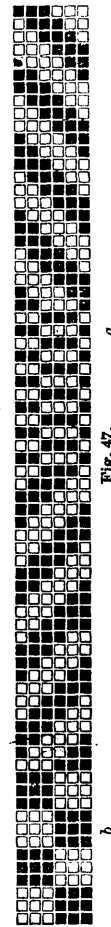


Fig. 46.

under or over a greater or less number of threads at that point than they do anywhere else. There are instances where some little imperfections must occur at the junction, but all care must be exercised to reduce them to a minimum, and present the fabric to the eye perfect or nearly so. In this system of producing patterns we have the basis of most of the designs for fabrics for men's wear, and we certainly obtain a very great variety; and they are used both for heavy fabrics, such as coatings and trowserings, and for many other cloths.

**37. Effects upon the Fabric.**—In the illustration in Figs. 45 and 46 of the difficulty of combining two patterns one of which is a rearrangement of the other, we have not by any means shown all the difficulties, nor in the simplest form. In dealing with patterns which appear easy and simple, and in which the principle of rearrangement is carried out in its simplest form, we may find that the effect of the two portions in the fabric is very different; and we cannot be too careful how we place them in juxtaposition. Suppose we take a pattern based upon a simple six-end twill, as in Fig. 47. We may have no doubt or difficulty about

its working. The twill occupies the largest portion of the fabric; the stripe, *a*, occupies but a small portion, as does also *b*. In the order of interweaving of these three portions it would seem that there could be little difference, and there certainly is not so much difference as there may be in some patterns, but just enough to require caution and proper arrangement. It will be evident that in the twill portion the weft and warp will bend round each other in an equal degree, and consequently that the same quantities of warp and weft will be required to form a perfect cloth. The same may be said of the stripe *b*, although it is not the same kind of structure; but there is this difference between this portion and the twill: whereas in the twill every succeeding end and pick interweave differently—that is, not under and over the same threads—in the portion *b* there are three warp ends, and three weft picks together exactly alike, and therefore a greater number of threads per inch of the same size of thread could be introduced into a fabric of the structure *b* than of the twill cloth. In the portion *a* of the pattern each weft pick passes between alternate warp threads, and three succeeding picks are exactly alike, so that the warp in this case cannot exercise power over the weft, and make weft bend round warp in any degree, but the warp must bend round the weft. That being so, to make a perfect structure of the fabric there should be a greater number of warp than weft threads per inch. It must be clear that if we were to combine three orders of working such as these in large patches or stripes, say of one inch each, there must be some



difficulty in obtaining a perfect cloth. As has already been said, the difference in this case is not so great as in

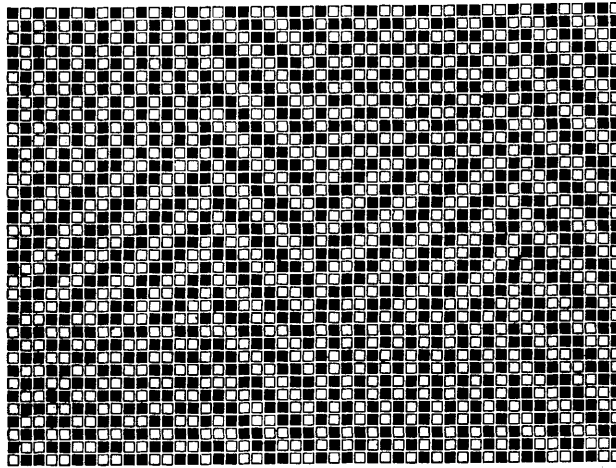


Fig. 48.

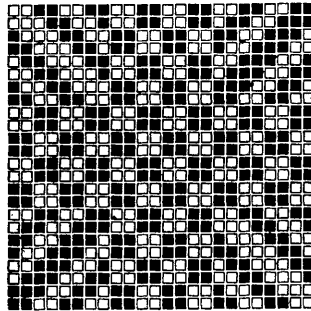


Fig. 48a.

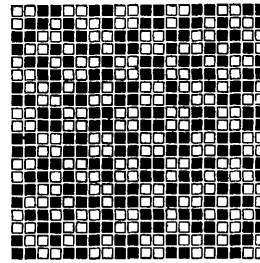


Fig. 48b.

many patterns which are combined ; still, it is sufficient to cause trouble if used in large patches. Then there are

only two alternatives: we must use the stripes in small quantities, so that the difference in the order of working cannot assert itself as it would in large stripes; or we must have the relations of warp and weft in our cloth such as to produce as nearly as possible a perfect cloth in *all the three* orders of working at the same time. Of course, each one will be something short of the true structure of a cloth of the class to which it belongs, but will not be so far removed from perfection as to be positively faulty or imperfect to the eye. We have next to show that from this system of combination, patterns of a very elaborate character may be produced, either all coming from the same simple base, or a combination of patterns of a different character. For this purpose we have prepared a few designs shown in Figs. 48, 48A, and 48B.

**38. Combination of Twills occupying Different Numbers of Ends.**—Although we have a wide field in the class of patterns and combinations we have been dealing with, yet it is only the first step, and our power of obtaining varied patterns increases enormously as we depart from this simple system of combinations. At the same time, many of the patterns with which we are now about to deal are built upon the same basis—that is, the same principle of combination is employed.

We have already pointed out how patterns may be readily produced by the combination of two twills.

In the examples given in Figs. 29 to 35 we have simply the combination of two twills, each occupying the same number of ends; but in many cases the combination of twills

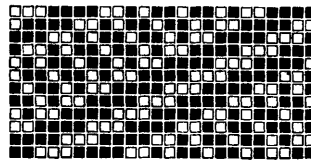


Fig. 49.

occupying different numbers of ends or picks may be very desirable, and we shall produce large patterns, and in many cases very elaborate ones. Take, for ex-



ample, the pattern Fig. 49 ; we have the combination of a simple four-end twill with a three-end twill, an end of each alternately. It will be seen of this pattern that it differs from the combination of two twills, each occupying the same number of ends, inasmuch as the two twills in this case fall in relation to each other in all the positions possible ; consequently, we have all the variety in this one pattern which is obtainable, and, what is quite as important, the pattern can be produced in the most economical manner. As it consists of two simple twills, one occupying four and the other three ends, the whole pattern will require but seven healds for its production in the loom. We must, however, examine patterns of this description from every point of view. It is very easy and pleasant to see the advantages we may obtain by working in a certain manner, but we must also, at all times, look for whatever disadvantages may accompany it. It has been pointed out already that every end in a pattern should work as nearly as possible alike, so as to prevent variation in the tension during the process of weaving, or that some other safeguard must be resorted to to counteract any varying tension. In the pattern before us—Fig. 49—we have a combination of two twills which interweave differently, one passing over and under the weft at intervals of two threads, above and below, the other over two and under one weft thread, or *vice versa*. That being the case, the pattern which interweaves most frequently, which has to bend round the weft more than the other, will of necessity “take up” more, or, in other words, require a greater length of yarn to produce a given length of fabric ; therefore, if the two threads are being given off side by side an equal length of each, one must of necessity gradually become tighter than the other. In this particular pattern the difference would be very slight, perhaps not so much as to cause any trouble to the weaver. That would depend to some extent on the class of material employed. If the thread be of an elastic nature—one

which would stretch some length without breaking—it would be quite easy to produce this pattern; but if the thread be of a stiff, brittle character, it would probably be a little difficult. Of course, there is always this to be said of patterns combined alternately, or, as it is technically termed, “end and end.” Although there may be considerable difference in the order of working of the two patterns combined, the fact of their being alternate will tend, in a great measure, to neutralise the difference in the working, because that which interweaves most loosely will exert very little power over the weft, and so when the thread which is interweaving more intimately begins to have a greater tension than its neighbours, it will cause the weft to bend a little out of its course, and so decrease the tension upon the warp thread.

In applying patterns of this character to the fabric, all these considerations must be carefully taken into account; as also must one or two other matters which will have a material effect upon it. We have already shown how the elasticity or rigidity of the warp threads may affect it; in the same manner, if the weft be of a very stiff material—one upon which the warp threads cannot exert much force—the warp has no opportunity of recovering itself by bending the weft. Again, if the warp threads be set very closely together, it is very difficult for the warp to act upon the weft, but the warp will always bend round the weft. In this case, care must be taken that the difference in the order of working is as little as possible; in fact, it ought to be accepted as a general rule, unless there be some specific object in view—a desire to produce some special effect—that the working of each thread in the pattern be nearly alike. It very frequently happens that this is the case. For example, one half or any portion of the warp may be desired to form the ground-work of the fabric, and the other half may simply be used for the purpose of ornamentation. In such cases it may be a great advantage for the threads which form the ground-work to be as

tight as possible, so as to throw up the ornamenting threads prominently. But even if such is not the case, and it is desired to keep each thread nearly equal in tension, any inequalities in the order of working which would affect the tension may be perfectly neutralised in the process of weaving, by allowing the two sets of threads to come from two separate warp beams, and regulating the amount to be given off exactly according to the length required by the increased or decreased intervals of interweaving. It requires some little skill on the part of the weaver to accomplish this satisfactorily, but it is not one of the most difficult tasks, and it certainly is one which, as we shall have to show in reference to other fabrics, must be frequently resorted to.

In the case of fabrics where difficulties might arise in consequence of the variation in the tension of the warp threads, we are still at liberty to apply this class of pattern by simply inverting it, making warp become weft and *vice versa*, or, in other words, combining the patterns pick by pick, instead of end and end alternately. If we do this, the pattern cannot be woven on so small a number of healds in the loom as in the other case, and of course the relative quantities of warp and weft must be reversed to produce a perfect fabric, but the ornamentation will be equally effective.

**39.—When Patterns produced by Combinations are Complete.**—One question

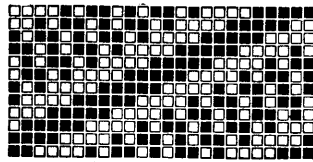


Fig. 50.

might probably arise in the mind of the student as to the extent of the pattern produced by the combination of such simple twills as those occupying three and four ends respectively. In all

cases of the combination of two patterns the design must be carried out to such a point as will give both patterns employed complete at the same moment. In the case

before us, when the four-end twill is once completed the three-end twill is once and one-third complete; when the four-end twill is twice complete the three-end twill will be twice and two-thirds complete; and when the four-end twill has been three times repeated, the three-end twill will have been four times repeated; they will, therefore, both be complete at the same time. Then, as the patterns are combined end and end, twelve ends will be required of each pattern to complete the design, or twenty-four ends in all; but only twelve picks will be required, because in the warp the patterns are alternate with each other, but in the weft they are running simultaneously; or if the patterns are combined pick and pick instead of end and end, twenty-four picks and twelve ends would be needed.

A very great variety of patterns may be produced by this method of combinations, and, like those with which we have previously been dealing, they are made in a systematic manner. It will generally be found that the best patterns, and those showing the greatest variety of workings, are produced by the combinations of patterns, each occupying such a number of ends that they have no common measure. If we combine, for instance, two occupying six and four ends respectively, we shall have the pattern complete upon twenty-four ends—twelve of each—and twelve picks; or one of the twills will have been repeated twice over, and the other three times. In that case, the two patterns would be placed in three positions in relation to each other only, as shown in Fig. 50. This certainly makes a fairly effective pattern, but it does not show such great variety of working. If we alter one of those twills which form the base—make the six-end into seven, or the four into five—we shall alter the whole effect. In the one case we should require twenty-eight ends of each pattern, or fifty-six in all, and twenty-eight picks; in the other we should require thirty ends of each twill, or sixty in all, and thirty picks, and in each case

the two twills will be placed in all the positions in relation to each other which are possible, as shown in Fig. 51.

**40. The Combination of Rearranged or Irregular Twills.**—In the combination of twills which occupy

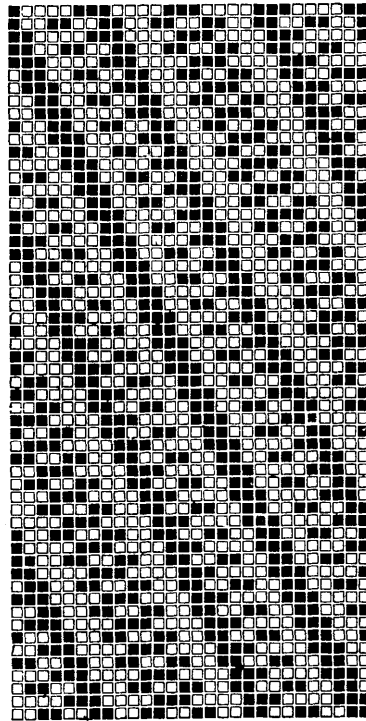


FIG. 51.

different numbers of ends we may deal with them in the same manner as with those which occupy the same number, that is, combine them as simple regular twills, or one twill regular and the other rearranged, or both rearranged. Of course we cannot place them in as many positions in relation to each other as we can when they occupy the same number of ends, and so produce a great number of different patterns, because in one combination we have the two patterns in all the positions possible. Of one thing we must be careful—

in combining regular with broken or rearranged twills the result will be irregular. In fact, we may be guided by the well-known axiom that equals added to equals produce equals, &c., and put it into language which will suit the

case, and say regular twills combined will produce regular patterns, regular combined with irregular will produce irregular patterns, and irregular combined with irregular will produce regular patterns. These axioms must be carefully borne in mind, because a very great proportion of the patterns produced by the combination of regular with irregular twills are such that they could not properly be called patterns, but some few may be sufficiently regular to be worth while using and calling patterns. Take, for example, the patterns in Figs. 52 and 53; in each case

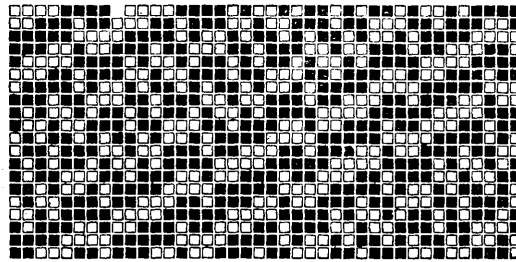
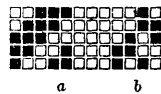


Fig. 52.



we have a combination of regular with irregular, the basis of the combination being shown at *a* and *b* in each. In the one it will be seen that the four-end twill is rearranged, or in broken order, and in the other the five-end twill is in the rearranged order. Now, in both patterns, more especially in Fig. 52, there is some show of reason for the result being regular. Although the twill is rearranged, and the pattern resulting is not what is commonly known as a regular twill, yet there is a great amount of regularity about it. It runs continuously in the same direction, although the angle is not one of forty-five degrees, as in the four-end twill which accompanies it; yet the fact of the rearrangement being a regular

one and giving a continuous twill, will cause it, when combined with another regular twill, to produce a regular effect. But although the effect has the appearance of regularity, it is not the character of regularity which is to be found in the patterns resulting from the combination of regular twills, but rather what might, perhaps, be termed regularly irregular; yet the pattern is a pleasing one, and is of a style which might with advantage be employed in a great many fabrics. This illustration will serve as a guide as to what will

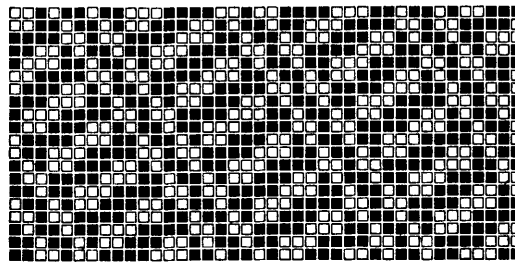
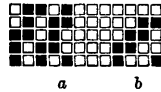


Fig. 53.



produce good patterns. Although we say that the combination of regular with irregular will produce irregular patterns, yet, when the irregularity of the pattern which is to form one of the bases is of the character shown here, the resulting pattern will, in all probability, be a satisfactory one; but it is not generally desirable to resort to such combinations, unless the intention is to produce some special effect resembling a figure, as these combinations usually do

**41. Elongated Twills.**—We have not yet done with the arrangement of patterns which assume a twill form, or which have a twill for their base. We may vary them still further than we have done in an infinite degree, but there are one or two special modes

of arranging them which it will be necessary to deal with here. It was pointed out in an earlier chapter that twills often run across the fabric at an angle of more or less than forty-five degrees—that is, they may be nearly vertical, or nearly horizontal; and in many cases such twills may be most readily produced by the combination of two or more twills “end and end,” or “pick and pick,” as the circumstances of the case may require. Although that is a ready mode of producing such patterns, yet very frequently when we desire to procure some special effect we may more readily obtain it by the simple process of elongation. We may take any ordinary twill for the base of our pattern, and draw it out or elongate it to any extent by simply making any number of ends or picks alike, as in Fig. 54; then we may alter the pattern so as to prevent a number of picks being alike, as it is in this pattern, by introducing some order of working twill or otherwise between the main twill, as in Fig. 55, when a small twill is run between the main twills, and in the contrary direction.

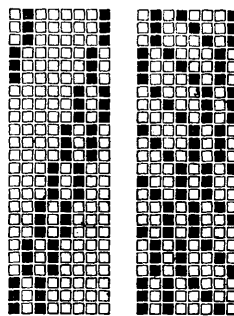


Fig. 54.

Fig. 55.

This not only prevents more than one pick being exactly alike, but gives variety also to the pattern. The small twill may, of course, be varied, as well as the main twill, and it may be made to actually join, or finish quite clear of, the main twill; though it is generally best not to let the two come in actual contact. Thus the pattern will be more decided and clear. In many cases figures or spots may be substituted for the small twill, or even introduced along with it, and so give again greater variety and character.

Twills or patterns of this description are, after all,



only combinations of simple twills. If the picks in succession be examined, they will be found to consist of a series which, if separated from each other, and if all those which work in the same order be put together, would form a twill of themselves, so that the whole would be the result of the combination of two, three, four, or more simple twills. The same result might, of course, have been obtained by the simple process of combination. But what would be the advantage or disadvantage of either mode of working? In the first place, when we proceed upon the system of combinations, if we desire to produce some special effect, we must use great care and judgment, and be thoroughly familiar with every possible form of twill, and their effects when combined with each other, or we could never be certain what would follow from a combination of any two or more patterns together; in fact, our patterns would be more the result of chance than design. By the system of elongation we aim at once at a given effect; we take the surest means of attaining the object we have in view, and consequently lose little time in experiments, and leave nothing to chance. It is certainly desirable to have easy methods of working to obtain a variety of patterns, but it is quite as desirable to be able to obtain whatever result we want at once by design, and leave nothing to accident. We must study all the short methods of economising time and labour, but we must, as far as we can, be sure that the results are those for which we are seeking, otherwise it will be better for us to study the doctrine of chances instead of the principles of design.

**42. Figured Twills.**—In many cases we may desire to produce patterns having a figure running between the twill without having the pattern elongated, or without having recourse to the system of combinations. A definite result is aimed at at once; it is desired to produce a given effect without leaving anything to chance; we desire, say, to produce a pattern of the character of that shown

in Fig. 56. In this we have a decided figure running between the twill, and the angle of the twill is one of forty-five degrees. If we were to analyse this to find of what it consists, it may be said to be the result of the combination of *portions* of four distinct twills, but to attempt to produce the pattern by the system of combinations would probably be an absurdity; that is, to produce it as an original design. We might obtain what we are seeking, but again we are trusting to chance. If we wish to produce figured twills, we must proceed in a manner which will ensure what we are trying to produce. We must determine beforehand the character and proportions of the twill. We must determine also the character of the figure, and combine the two as the combination of twill and figure, not as a number of twills. Our readiest mode of working is, first to put down the twill upon paper, after we have determined its size and character, then to introduce the figure between, and continue or repeat the figure until complete. Of course the production of patterns of this class is dependent entirely upon the inventive faculties of the designer, and his ingenuity in combining two different orders of working so as to produce a harmonious whole, but there are certain rules which may assist him, and in some instances guide him. It is generally understood that variety in a design, if properly treated, may conduce to beauty. In designs for textile fabrics it is desirable in many cases not only to make the pattern continuous, but such that any repetitions of it shall not be too apparent to the eye. For instance, in making such patterns as figured twills, we should not arrange the figures in such a manner that they appear to run in straight lines, either longitudinally or transversely, in the fabric, or, to use the technical phrase, "their repeti-

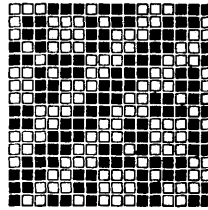


Fig. 56.

range the figures in such a manner that they appear to run in straight lines, either longitudinally or transversely, in the fabric, or, to use the technical phrase, "their repeti-

tion either in the warp or weft must not be in lines or rows." There must appear an equal and regular distribution; there must be nothing which will be too striking or attract too much attention to itself to the cost of the rest of the composition. In the pattern before us—Fig. 56—there is not much to fear on this score; it is so small, and repeated at so short intervals, that no such difficulty could arise, but in the case of large patterns it might, and even sometimes in the case of comparatively small patterns also. In such case we may resort to the plan shown in Fig. 57, where the figure is a series of steps. Now, if these steps all formed in the same horizontal or vertical line, the appearance of the pattern would certainly be unpleasant; it would simply present a series of lines straight across, or running the length of the piece, broken at regular intervals by the diagonal line; but as it is, the lines are broken by the relation of the steps to each other, and we have consequently a more

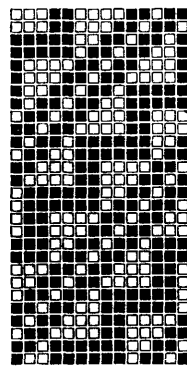


Fig. 57.

harmonious diagonal. The steps in the figure do not fall either immediately under or alongside each other, consequently there is nothing to break the diagonal line. We have only given variety to it by the introduction of the waved line. The diagonal is the principal feature of the design, the figure is merely an accessory, and each plays its own proper part.

Then we must arrange such figures so that they cannot form lines, and as we have said, this is more especially necessary when dealing with large figures, because they stand out more prominently, and strike the eye more readily, and therefore any little defect or want of harmony is more apparent. But the question naturally arises, how can we ensure this? We

must, as we have said before, leave nothing to chance. The most simple and ready manner of doing this is to make the figure occupy a number of ends or picks which will not be a measure of the number occupied by the diagonal. In Fig. 57 the number occupied by the diagonal is fourteen, the number occupied by the figure is four; therefore at each repetition of the twill we do not have a repetition of the figure, but only at every alternate repetition. The variety would even be greater if the figure occupied a number which has no common measure with that of the diagonal, as, for example, the diagonal occupying fourteen, and the figure five ends. The repetition would not be so frequent; that is, the point where the twill and figure meet at the same moment would not occur so often, and consequently there would be less risk of the figure detracting from the diagonal, or breaking the line.

**43. When Figured Twills are Complete.**—We have only one matter now to look at in connection with this system of combining twill or diagonal patterns and figures—namely, the determining the point where the pattern is complete; and the principle which we applied to the combination of twills occupying different numbers of ends will also apply here—that is, carrying them forward to a number of which that occupied by the diagonal and the figure shall be a measure. Thus, in Fig. 57 the twill occupies fourteen ends and the figure, counted diagonally, occupies four; then the number of which fourteen and four are both a measure is twenty-eight, so that the pattern will require fourteen ends and twenty-eight picks, or *vice versa*, to complete it; had the figure occupied five ends and the diagonal still remained upon fourteen, then the number of picks required to complete the pattern would have been seventy, because that is the first number of which each is a measure.

**44. Combination of Different Orders of Working in Stripe Form.**—We have now one other system of

combining twills or other working for the purpose of producing patterns to consider, and in this, although the mere placing of the patterns together upon paper is much the same as some of those we have already considered, yet the conditions or characters of the combinations may be such as to completely alter the structure of the fabric and to require special consideration of the relative quantities of warp and weft in each portion of the cloth. We will, in the first place, deal with the subject in the most simple manner, by combining two patterns of the plainest character. It often happens that we desire to produce a striped effect upon a fabric having a plain ground, and we desire to make this stripe stand out as plainly and prominently as possible, whether the stripe be of the same colour as the ground or of a different colour. Or it may even be that the *material* composing the stripe is different from that of the ground, and the order of working also different. We will take, for example, Fig. 58, and suppose in the first place that we are using one colour only, and one material only, so that we may see more directly the effect upon the fabric of the different orders of interweaving. In the first place, we have a number of ends weaving quite plain, or interlacing with each other alternately. We have then a number of ends weaving in the order of a twill, or interlacing with each other at intervals of four. Now, it must be obvious that if all the warp threads of which the cloth is to be composed are of the same thickness, are set equally close together, and come from the same warp beam, so that the same length of each be given off as the fabric is formed, the portion which is weaving plain cloth, being more intimately woven with the weft, will "take up," or become much tighter than the portion which is forming twill. In addition to that, the texture of the fabric in the plain portion will be much firmer than that of the twill portion. It is a generally accepted rule that all portions of a piece of fabric should be as nearly as possible equal in firm-

ness of texture, and also that the portion which forms the ornamental part should certainly not be inferior to the ground or body of the fabric. Then we must resort to one of two expedients—either we must use thicker warp, or there must be a greater number of ends in the twill portion than in the other. If we use thicker warp simply, we increase the bulk of the fabric very much, and greatly increased bulk is objectionable. On the other hand, if we increase the number of ends simply, employing the same thickness of warp as for the ground, we again obtain increased bulk, though certainly not in the same degree as in the previous case; that is, if we bring the threads of the same weight as the ground warp sufficiently close together to make the twill portion as firm in texture as the plain, we shall not have so much weight as if we keep the number of threads in a given space, as in the ground, and increase the thickness of the threads to a sufficient extent to obtain the requisite firmness of texture, because the weight of threads does not vary in the direct ratio of their diameters, but as the squares of their diameters. This being the case, it is clearly better not to increase the weight of the threads employed in forming the stripe, but to increase the number of threads in a given space; because we not only keep nearer the weight of the ground fabric, but we increase the firmness of the stripe, and so improve the appearance. Indeed, we may go a step further, and instead of using the same thickness of thread for the stripe as for the ground of the fabric, use a much thinner thread, and increase the number again proportionately, and we shall not only be bringing the relative weight of stripe and ground nearer together, but we shall be bringing the relative firmness of structure nearer the same level, and at the same time improving the appearance of the fabric in a great degree; for in many cases, especially where only one colour is employed, the fine appearance of the stripe is the chief thing relied upon for the ornamentation. Well, suppose we don't resort

to these expedients, we must see what will be the general effect of the fabric. In the first place, as we have already pointed out, the stripe portion will be less firmly interwoven than the ground; it will consequently have a ragged, thin, and meagre appearance, and from this very thinness and looseness it will be liable to "fray," or the threads will slip upon each other, instead of being held firmly in their places. Again, it will probably present an unsatisfactory appearance from what is termed "cockling," or, in other words, one portion of the fabric will appear nice and straight, while another, the stripe portion, will be uneven and appear as a series of ridges and hollows.

Such a state of affairs could not of course be satisfactory, therefore in all such cases we must take care that the ground and stripe are properly proportioned to each other, and the relative quantities of warp and the thickness of the warp in such portion properly proportioned to the order of interweaving.

In the example (Fig. 58) we have taken the stripe as a simple twill, but very frequently the stripe is a

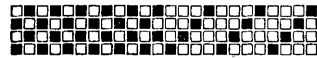


Fig. 58.

satin, or it may be any order of working which will separate it sufficiently from the ground, and show it up with enough

prominence. It may also be not only of a different colour, but also of a different material. It is no uncommon occurrence to see the ground of the fabric formed with cotton warp and the stripe portion silk. In any case the true relations must be maintained between the stripe and the ground, and either the difference in the thickness, or the number of ends in a given space, or both, must be properly regulated to the order of interweaving, so as to secure the most perfectly balanced fabric.

In many fabrics the ground will show a predominance of weft on the surface, while the stripe shows

a predominance of warp. Here the relative quantities will require even more careful attention, though perhaps in some few instances the predominance of weft in one case will, to some extent, neutralise the predominance of warp in the other. But we have already pointed out that, in general, when the weft or the warp predominates on the surface in the order of interweaving, it should also do so in the actual number of threads employed in a given distance. In any case it is necessary that great care should be taken to make the fabric as perfect as possible.

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## CHAPTER V.

### DOUBLE CLOTHS.

**45. The Value of a Knowledge of Double Cloths.**—Whilst considering the structure of fabrics, combined with their ornamentation, and before entering upon the question of ornament purely, there is one class with which we must deal—namely, double cloths. This comprises a great many of the most useful fabrics made, and enables us to produce not only an useful article, but gives us great powers of ornamentation. Another feature of much importance in double cloth is that a thorough knowledge of fabrics of this structure is perhaps the best guide to the production of fabrics of a purely ornamental character. In fact, any one who has a complete mastery of the principles of the weaving of double cloths, and the methods of ornamenting with them, need not despair for a moment of being able readily to deal with fabrics of any description. For he must not only be able to ornament his fabric, but he must be able to follow in detail every separate thread, or set of threads, and deal with each, and apply it to the purpose for which it is intended, with



a due regard to both the structure of the fabric of which this set of threads is composed and also to the order of working of the fabric and threads which may accompany it.

46. We may inquire, in the first place, *What is the object of making double cloths?* Generally speaking, we may be said to have one of two objects in view, or perhaps the two may sometimes be combined. First, we may make double cloths for the purpose of producing a fabric of great bulk and strength, and with great power of retaining warmth as an article of clothing; second, we may make double cloth for the sole purpose of producing an ornamental fabric; or we may combine the two by producing an article both useful and ornamental. In discussing this portion of the subject we must be careful to omit no detail which is likely to have a bearing upon future work; and the student must be equally careful to be thoroughly master of it before he leaves it, otherwise he may find that some of the fabrics with which he may have to deal appear quite foreign to him, based upon a principle of which he has no knowledge, whereas they may have their first basis or ground-work in double cloths, perhaps of the most simple kind. It will not be necessary here to enter too fully into the mere arrangement of the design upon paper, as that has already been done in the "Practical Treatise on Weaving and Designing," already referred to; but we must deal more especially with the structure of the cloth, and the methods of ornamenting it.

47. **Cloths with two Wefts and one Warp.**—In the first place let us consider what are commonly known as double cloths, which are made for the purpose solely of producing a heavy fabric, chiefly with a view to making a warm, useful article of clothing, and then show the application of the same mode of working for producing an ornamental as well as an useful article.

This class of what are called double cloths, is double

only in one sense—namely, there are two separate wefts, one for the formation of the wearing surface, and the other for forming the back, or, as it is sometimes and very properly called, the “lining” of the cloth, and there is only one warp. Generally speaking, the pattern on the face of the fabric is a fancy one, and that on the back of as plain a character as the structure of the cloth will permit; but sometimes, more especially when the article is intended to be reversible, both patterns are alike. In the latter case the most general practice is to make both patterns of a plain character, a simple twill or plain satin, the chief object being to cover the warp as effectively as possible, and at the same time to prevent the weft of the opposite side, which is frequently of a different colour, from showing through. We will first deal with the class where the back cloth or back weft is used merely to add to the weight, strength, or wearing qualities of the fabric, regardless of pattern. In such cases we should deal with the face fabric as regards pattern, proportion of weft to warp, and other conditions, just as if we were dealing with a single cloth. In fact, the conditions of structure must be just as if there were no probability of a back being put upon it. We must consider the back as a “lining” only. We must prevent it interfering with the face, either as regards the formation of the pattern or as affecting the relative quantities of warp and weft. The back must be merely an addition, introduced independently of the face, with a view to make the fabric serve the purpose for which it is intended more thoroughly, and must be interwoven with the warp so as substantially to form a part of the fabric, but must not, unless for some special reason such as we may have to point out, in any way interfere with the working of the face pattern.

We will take for our first illustration one of the plainest patterns possible, so as to show clearly what is meant by this system of making double cloths or

lining them. Fig. 59 is the working design for a plain twill cloth face and a back of weft upon it, such as is commonly used for cloths for gentlemen's coatings. The separate designs for face and back respectively are shown at *a* and *b*. In designing fabrics of

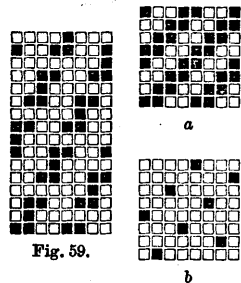


Fig. 59.

this kind these are the two chief objects—namely, the proper relation of the back to the face pattern, and the proper relation of the warp and weft which forms the face. Let us examine this pattern for the purpose of showing how we may best deal with these considerations. First, with regard to the relation of the two patterns to either. An examination of the pattern in Fig. 59 shows that it is simply a combination of the two patterns *a* and *b*, but that combination is made in a particular manner; in fact, the two patterns are specially arranged to suit each other. We are not proceeding upon the same lines of combination as we did when we were combining merely to produce new patterns for ornamentation, but we are proceeding to combine with a specific object in view. It will be observed in the design that at the point where the back weft passes over a warp thread the same thread is also passed over by the face pick of weft which goes before as well as by that which follows the back pick; or, in other words, we have first arranged our face pattern, then introduced the weft which is to form the back or "lining," and interwoven that back weft into the warp at a point where it is on the under side of the fabric. By this means the weft forming the back is effectively prevented from coming to the surface of the fabric; the face picks will close over it, and continue to form their own pattern as if the back had no existence. Thus we have here the first principle

of making designs for double cloths; and, although we are speaking of one class of double cloth only, that one feature belongs to all classes. We have now to consider more in detail the arrangement of the design. It may be said that, so long as the face pattern is perfect—a regular continuous twill, or a complete pattern of any description—it matters little as to the order of binding the back weft provided it does not interfere with the face; but in this, as in the arrangement of all designs, we must have regularity and definite order, and the order of binding the back must be arranged to suit the face pattern, so that it will always fall in the proper place. Sometimes it may be that the pattern on the back is a twill, or it may be a satin or other broken order. In the case before us we have the back pattern arranged in satin order simply as a matter of necessity, so that it shall fall always in the same position in relation to the face twill, and also so that the binding falls equally in each twill and upon every end of the pattern. It will be noticed that there is one pick of the face weft to one of the back weft; the face pattern is a four-end twill, the weft passing over two and under two ends alternately; the back pattern passes over one and under seven ends. The twill of the face advances one end to the right at each pick, and the back pattern advances three ends to the left or five to the right at each pick. The face twill having advanced one to the right, and being twice repeated in the whole pattern, may be said to have brought the point in the face twill corresponding to that when the first backing pick is bound, to a position three ends to the left or five ends to the right from that binding point; consequently, if we advance three in one direction or five in the other with our binding of the back, we shall place each backing pick in the same position in relation to the face, and, as three is not a measure of eight, the result will be a perfect distribution of the binding points; each end will be occupied. We have, therefore, a perfect pattern on the

back. Each of the face twills has an equal number of binding points, and those points always fall in the same relation to the face twills, and we have as perfect an arrangement of double cloth as it is possible to obtain. We will examine another arrangement of the same face twill with a back upon it, and then we shall be able to see more readily the defects which may occur. Take the pattern in Fig. 60. Here we have the same face pattern, but we have two picks of the face to one of the back. The pattern has, therefore, advanced two ends from the position of the first binding of the back before we come at the proper place for the binding of the next back pick, and, as two is a number which is a measure of eight, we cannot resort to the satin arrangement of the back pattern. We must, of course, keep

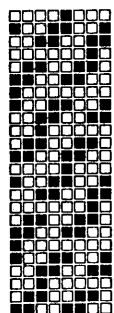


Fig. 60.

the binding in the proper position in relation to the face pattern; we must also distribute the binding equally over all the twills; therefore the arrangement shown at Fig. 60 is the only possible one. On the paper this has all the appearance of being perfect, and, perhaps, in some qualities of cloth would be so, but it is not all that could be desired, and in other fabrics may be very imperfect. It will be noticed that, in consequence of the order of arrangement of the back pattern, only every alternate end of the warp is occupied by it; and again, there is a decided twill formed by the back weft running in a direction contrary to the face twill.

If the weft used for the back happened to be very thick, more especially if at the same time that of the face was fine, not only would this counter twill be distinctly visible, but the ends passed over by the back weft would tend to work much more tightly than the others, and so produce a fabric of a most imperfect kind; in fact, it would be a quite unsaleable article, and the nature of the defect is such that it could not be remedied.

Again, in Fig. 61 we have the same face pattern, but the back is different. In this case we have the same defect of the binding only occupying every alternate end, and the twill of the back running counter to the face, or rather the appearance of a twill—it is not in reality a twill; but as the binding and this apparent twill are so much more frequent, there would probably be less of the defect visible on the face. There is, however, another matter to consider here—namely, that the binding of the back into the warp occurring at every fourth end, instead of at every eighth, as in Fig. 60, it might in some degree prevent the face weft going in so closely, and thus prevent the face from being made quite so fine in texture. In the fabrics with which we are now dealing the general practice is to make the back weft of very much coarser and heavier material than the face, the chief object being to increase weight,

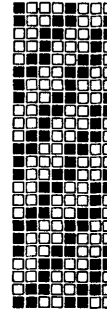


Fig. 61.

and to make the fabric more useful as a warm article of clothing, and at the same time to make it as cheaply as possible. It is therefore evident that great care must be taken to prevent the undue interference of the back with the face cloth, because we must make the face extremely fine, and free from faults or blemishes.

**48. Pattern formed by Binding.**—In some few instances the back weft is purposely brought through into the face to assist in the formation of patterns, or perhaps it would be more correct to say to form a pattern in addition to that made by the face weft. For instance, by bringing the back weft through to the face at regular intervals, and constantly upon the same end or ends, a stripe would be produced, and if to this were added one of the picks coming through in like manner all across the piece a check design would be obtained. Any pattern may be formed by bringing the back weft

through at such points as may be required for its formation.

**49. Reversible Cloths.**—Another most valuable use to which this class of double cloths is largely applied is the production of reversible fabrics, which may be worn on either side at will—such as shawls, rugs, a great many mantle and other cloths. Usually in fabrics of this description, the pattern upon both sides is the same, but the colours are different. Fig. 62 shows a plan of a fabric of this kind which is simply a combination of two satins, one showing a greater proportion of weft than of warp to the surface, and the other the same quantity to the back. In this it must be observed that the same principle of arrangement is carried out as in Fig. 60—namely the point where the back pick interweaves with the warp is covered on the face both by the preceding and the succeeding picks, so that there is no possible chance of its showing through to the face; and, in the same manner, the point where the face weft interweaves is hid at the back by



Fig. 62.

the back weft, so that both sides shall be equally perfect. In this class of pattern we have to consider both sides of the cloth, unlike that in which the back is simply a "lining," and the two also differ in this respect—that whereas reversible fabrics must have both sides equal in quality or degree of fineness, and generally in texture or pattern also, those which are simply backed to give weight may have the back any degree of fineness or coarseness, and the pattern may be anything which will not interfere with the face.

The colours of the weft used may be different for each side, or one side may be all of one colour and the other side any fancy stripe pattern. Generally the chief object in fabrics of this description is to make each side as different as possible from the other, whether they be both solid colours, or one side solid and the other striped, or both striped, and to ensure this distinction there must

be absolute certainty that the weft of one side cannot possibly show through to the other, and that the warp—which may be of an indifferent colour—cannot be seen on either side. If the pattern be a twill, we may prevent the wefts from showing through to the opposite sides, but we cannot prevent the warp from showing, because, the order of interweaving being consecutive, each succeeding warp thread is, as it were, laid bare, and must be visible on the surface of the fabric.

Then to cover this the usual practice is to make the pattern a satin, so that by the order of interweaving being arranged at intervals, each succeeding pick has an opportunity of covering the binding of the preceding pick, and so securing a perfectly solid surface, and avoiding the possibility of the warp showing through. Of course in such cases there can be no pattern visible, except that formed by the varying colours of weft; there is no pattern in the fabric formed by the interweaving of the warp and weft threads.

**50. Figured Reversible Cloths.**—Although so far we have dealt only with reversible cloths in which we are dependent entirely upon the use of colour for ornamenting, we have other means still at our disposal for producing ornamentation upon them. It has been shown that we may have a fancy pattern on one side of the cloth, and a plain or simple twill on the other, and also that in fabrics where the working or order of interweaving the warp and weft is the same on both sides, it may be reversible for wear, and each side may be of a different colour or colours. We have now to deal with the ornamentation of this latter class by figuring. This mode of figuring differs somewhat from all other systems, though to a certain extent it resembles in style one or two methods with which we shall have to deal. We have already pointed out that in making reversible cloths we use two distinct wefts, one for each side of the fabric. In making figured reversible cloths exactly the same principles are involved, only



instead of letting each weft remain always on the same side they are made to exchange places. Fig. 63 shows a section. The dots represent the warp threads just as we



Fig. 63.

should see them if we were to cut the cloth and look at it as it has been cut, and the wavy lines represent the weft, and show the order of interweaving with the warp. This section shows each weft forming a four-end twill pattern with the warp, but at the points *a* and *b* respectively the weft which has been on the face of the fabric passes to the back, and that which has been on the back comes to the face. This would be repeated at each succeeding pick, and the points where the two wefts exchange places would alter according to the pattern to

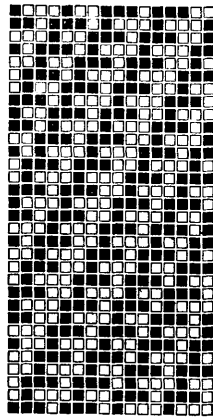


Fig. 64.

be formed. So that, assuming the two wefts to be black and white, we should have on one side of the cloth a white ground with black figures, and upon the other side a black ground with white figures. Of course the size, form, and order of distribution of the figures would be the same upon each side, being formed as they are simply by the two wefts exchanging places. In Fig. 64 we have a plan of a pattern showing this order of working, and forming a diagonal of black and white alternately. If each pick of weft be examined, it will be seen that for a given distance each comes to the surface of the fabric and then passes to the back, and the next succeeding pick works exactly the reverse,

the point of exchanging places altering at each succeeding face pick in such a manner as to form the desired pattern.

This system of figuring may be carried to any length. There is practically no limit to the variety of patterns we may produce. They may be large or small, simple or elaborate, at will, and the fabric will always be such as can be worn on either side. It may, perhaps, be as well

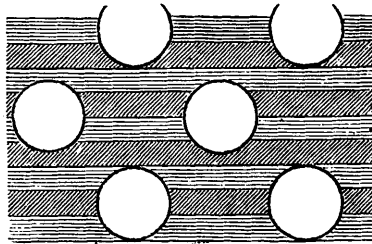


Fig. 65.

to guard the student against one possible misconception of the words we have just used as to the variety of the patterns we may produce by this mode of working. What is meant is, that patterns, or, as they are usually termed in the trade, "figures," of the most varied forms may be produced,

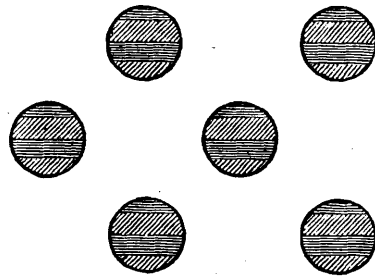


Fig. 66.

but not that variety of colours may be introduced into the design. We have one colour of weft for one side, and another colour for the other side, and, as we have shown, the figure or pattern is formed by these exchanging places and occupying

alternate sides of the fabric; therefore we have one colour of ground, and a different coloured figure upon it on one side of the cloth, and exactly the reverse on the other side, so that the ground is one

solid colour, and the figure is another solid colour in each case. Sometimes a variation is made, and one side of the cloth is striped in the ground ; in that case the figure of the reverse side is striped in exactly the same manner, as shown in Figs. 65 and 66 ; but that stripe in the figure will be more likely to spoil the effect than to add to its beauty, because in all probability, if the stripe be a small one, the figure will present a quite broken-up appearance, without any order, and if the stripe be a large one, it may be divided into two portions, one of one colour and the other of the other. Those portions may be equal or unequal, and unless considerable care and skill be employed, the divisions of the colours in the various figures will be very irregular. In any case the use of varied colours in fabrics of this class must be of a more or less stiff character, partaking of the stripe form ; and where the fabric is not figured—each weft remaining on its own side—they may be used with advantage ; but when figured, the greatest care must be taken that the figures are not too much or too irregularly broken up, otherwise the effect will be very unpleasant. If the patterns be of a regular character, as a diagonal, then the use of more than one colour may be decidedly advantageous, because the pattern being continuous, the striping will occur regularly, and will be no drawback, but may rather add to the beauty and variety of the design.

Generally, any variety of colour in stripe form is confined to one side of the cloth, at any rate in figured goods, so that we have on one side a solid coloured figure on a striped ground, and on the other side a striped figure on a solid coloured ground. If both ground and figure were striped, the effect would probably be too much of a mixture, especially if the sizes of stripe in each case were similar. However, we must be guided at all times by the particular effect desired, and also by the due consideration of the purposes to which the fabric is to be applied, and suit our pattern to the requirements of the case as best we can.

51. Cloths with two Warps and one Weft.—The second class of double cloths, or what is known as double warp faced cloths, consists, as before said, of two warps and one weft, and is really the class with which we have just been dealing inverted, warp becoming weft, and weft becoming warp. The uses to which this class of fabric is put are probably much fewer than the double weft face, but still sufficient to make it well worth while for the intending designer becoming thoroughly master of the principles upon which it is based. This principle of structure is most generally applied to fabrics in which both sides are intended to be alike in pattern and quality, though they may be different in colour. The arrangement of the plan upon paper is precisely the same as for double weft face, taking weft for warp, and *vice versa*; for example: Fig. 62, if read warp for weft, would be a plan of a double warp

face, as shown in Fig. 67. We need not, therefore, dwell at length upon the arrangements of the design or plan of this class of fabric, seeing that all we have

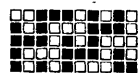


Fig. 67.

said of the double weft face applies also to the double warp face, so far as it is used in practice. We must, then, apply ourselves to the consideration of the uses of double warp face to the production of useful fabrics, and see how far what we have said of double weft face is applied in practice to double warp.

It has already been pointed out that this principle of structure is most generally applied to fabrics where both sides are alike in quality and structure, as, for example, to ribbons used by ladies for trimming, when one side is of a totally different colour from the other, but both present the same fine satin appearance. In fact, it is to this class of goods more than any other that the double warp face is applied. For this reason such goods are usually made with fine silk on the surface, and in the process of weaving an immense number of threads of such fine material may be used per inch as warp. Their

very fineness, and the smooth nature of the silk thread, will not create any difficulty in the process of weaving; and the small number of threads per inch in the opposite direction or weft enables the weaver to produce a much greater length of fabric per day than if the cloth were made on the double weft principle, where the conditions would be reversed; but in the case of woollen-faced goods these considerations would not hold, because of the thickness and roughness of the thread, which would render it quite impossible to weave with the number per inch which would be required to produce the necessary fineness of fabric. In some few instances the use of two warps is applied to fabrics made from wool for the same purpose as the use of two wefts—namely, to obtain increased weight. In such cases the face, or fine warp, forms the fabric proper with any pattern that may be desired, and the back warp forms merely a lining of any loose pattern which will not interfere with the face. Such fabrics are not so easy to weave as if they were made with two wefts instead of two warps, because of the thickness and roughness of the threads; but the necessity for employing two warps may often arise from the fact that our looms are not adapted to the production of double weft cloths. For instance, if our looms are constructed to weave with one shuttle only, we are only able to use one weft; and if the material we are using for the face cloth be very fine, we cannot afford to use that for the lining also, because the cost of the cloth would be so much increased without a corresponding advantage. Then we must resort to the use of an extra warp for the back, and although we may increase the difficulties of the weaver, we shall, by the use of coarser material for the back, be enabled to produce the fabric at a cheaper rate. We may say, generally, that the use of the double warp cloth is confined chiefly to the two classes of goods we have named, being rarely used for producing figures, though perhaps in some few instances it may be so employed,

but those will, in most cases, be where the warp is silk, or very fine yarns in other materials; but the loose fibre upon yarns made from other materials than silk renders it somewhat difficult to weave with the number of threads per inch required to make the fabric sufficiently fine, even if the yarns are spun to very fine counts.

**52. Two separate Cloths.**—We now come to the third and most generally useful class of double cloth—namely, where there are two separate and distinct fabrics, each formed with its own weft and warp—and the consideration of the various purposes which it may serve; and we must urge the student to pay the closest attention to this class of fabric, and make himself thoroughly master of it. A complete knowledge of the two preceding classes will help him very much in understanding this class; but he must not be content with this. If he wishes to be a competent designer for fancy cloths he must study this branch until he has entirely mastered it.

To begin, let us examine the manner in which double cloths of this class are produced. In the first

place, we have a separate warp and weft for each cloth; and in making our working plan



Fig. 68.

each must be dealt with by itself, so far as pattern goes, as though the other had no existence. We have in Fig. 68 a section showing two cloths, both of which are twilled; or, rather, we show two picks (one of each cloth) which may each be taken as being the first pick of a twill, in which weft passes over and under two threads alternately. Each weft interweaves with its own warp only, and the two cloths are consequently quite independent. They are both woven at once, but the material forming each cloth is confined to that cloth alone, and takes no part in

nor combines with that forming the other cloth in any degree. The plan of this cloth is shown in Fig. 69. In it the first, third, fifth, and seventh ends and picks are those which are to form the face, or upper cloth, and the second, fourth, sixth, and eighth ends and picks are those which are to make the back or lower cloth. Now, if the dots upon those ends

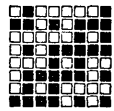


Fig. 69.

and picks which are to form the face cloth be examined, it will be seen that they make a regular twill, and those dots which are upon the back ends and picks *only* also form a regular twill; but upon those picks of weft which are to form the face cloth dots are placed at the point where they intersect the *warp threads of the back cloth*. In all cases we are assuming that those dots represent weft as passing over warp. That being so, it will at once be seen that the face weft passes clear over *every* end of the back cloth; and in like manner the weft of the back cloth passes under *every* end of the face cloth, so that each weft interweaves with its own warp only, each warp being kept out of the way—lifted up or left down, as the case may require—while the weft of the other cloth is being inserted. Then, in arranging the plans for two separate cloths, this is the principle upon which we must proceed: first put the face-cloth pattern upon those ends and picks which are to form that cloth, then do the same with the back cloth, and next arrange that as each pick of weft is inserted they interweave with the warp of the cloth to which they belong *only*.

**53. Relation of the two Cloths to each Other.**—So far as the arrangement of the plan of the fabric is concerned, the foregoing is perhaps sufficient to indicate the general mode of procedure, but we have now to consider the relation of the two cloths to each other. Double cloths of this class are capable of a great variety of arrangements, but they may be classed generally under four distinct heads: first, when the two cloths are

equal in quality and pattern ; second, when they differ in pattern only ; third, when they differ in quality only ; and fourth, when they differ in both quality and pattern. Of those in use, it may be said that the first and fourth of the above are by far the most general, and, as we shall proceed to show, for quite sufficient reasons.

In considering each of these four types of double cloths one question must be kept constantly before us—namely, the relations of the warp to the weft and to the pattern. It must be evident if the two cloths are equal in quality and pattern, the “take up,” or shrinkage of both will be equal, both in the warp and weft, but if they are equal in quality and different in pattern, should one pattern interweave more loosely than the other, the “take up” of one will be greater than of the other, and if they are bound together in the process of weaving, that which works most loosely will be liable to “cockle” on the surface. Perhaps it may be done for a purpose ; if so, well and good, but generally it is desired to obviate such an effect and make the surface of the cloth as smooth as possible ; in fact, to give it all the appearance of a single cloth. In that case the greatest care must be taken to make the cloths equal, and if they *must* for any reason differ either in quality or pattern, every precaution must be observed to ensure the “take up” being equal in both. Or, if the two cloths be made from materials which possess in a different degree shrinking properties, and which may be differently affected in the process of finishing the goods, then they must be made to neutralise each other, or some influence must be brought to bear which will neutralise them in the fullest extent.

We will first deal with cloths which are equal both in quality and pattern. Such cloths are usually made for the same reason as some of the double weft face cloths, namely, to produce greater weight, or to make the fabric reversible—more generally the latter ; and in



such cases the two fabrics, though equal in all other respects, will be different in colour, or one may be a solid colour, and the other a stripe or check. In any case the same principle of making the plan is carried out as has been already indicated in Fig. 69, the warp and weft of each cloth being arranged alternately, end and end or pick and pick, and each weft interweaving only with its own warp.

**54. Binding Double Cloths.**—Cloths of this description have usually to be bound together, so as to make them appear as one cloth, and in fact to become one cloth. In such cases the warp of one has to interweave in a greater or less degree with the weft of the other; but this must be done so as not to interfere with the pattern of either, and if the two are of different colours, they must not show through each other at the point of binding. This being so we must select a point where the weft of one cloth and the warp of the other meet, if possible at a point where one or both are interweaving very loosely, so that there will be no probability of the two being so intimately interwoven as to show one cloth through the surface of the other.

Again, we must consider whether we desire to produce in the cloth a feeling of firmness of texture or otherwise. If we want the cloth to be of a firm texture, we must bind the two separate parts very frequently and intimately; if we want softness and looseness, we must bind them only as often as will hold the two together, and no more. This knowledge of the frequency or firmness of the binding can of course only be gained by actual practice, combined with a knowledge of what is wanted in respect to looseness or firmness of texture; but no matter whether the binding be frequent or otherwise, the same principle will hold good as to the selection of the point where the binding shall take place.

**55. Relation of the Pattern of each Cloth to Facilitate Binding.**—In making the selection of the

point of binding, it is often necessary to consider the relations of the patterns of the two cloths to each other, so that the weft of one and the warp of the other may be brought into such a position that they can be interwoven in the readiest and the most perfect manner. The surest method of working is to make a section first of the two patterns, and place the two sections together so that the weft of one cloth at some point where it is interweaving loosely will be immediately above or below the warp of the other at a point where it also is interweaving loosely, and by that means the designer can see at a glance the best relation of the two patterns so as to secure the best binding place.

**56. Figuring with two Cloths.**—The most useful purpose to which double cloths of this class can be applied is in the production of figured goods, the figuring being obtained by the two cloths exchanging places, in a similar manner to the weft exchanging places in double weft face goods. And there is this decided advantage in figuring with two separate cloths which are equal in structure—that each may be either perfectly plain or of any texture which may be desired; and if the weft of each be of the same colour as the warp with which it is interwoven, we shall have a perfectly solid coloured figure upon an equally solid ground.

Figuring with two separate cloths of this description is practised in the production of a very large variety of fabrics, and in all cases the results are most satisfactory; for we have not only a strong fabric, but a very warm one, and one also capable of resisting both strain and friction. These advantages, coupled with that of great facilities for ornamentation, make it a most useful class, and one which may be resorted to for a variety of purposes.

**57. Cloths of the same Quality but different Patterns.**—We must now turn our attention to the

second of the four classes—namely, those in which the fabrics differ in pattern but remain of the same quality. In the use of the term “same quality” it must be distinctly understood that we simply refer to the number of threads per inch of both weft and warp, the thickness of the yarn being exactly the same in both cloths, and not to the quality of the fabric as it will be affected by the structure or order of weaving. It must



Fig. 70.

be our object to show that where two cloths which are woven together are made from the same material, it

requires the greatest possible care to insure the quality of the two being the same in texture as well as in the material from which they are made. The pattern of each cloth must be so arranged as to secure this, otherwise the fabrics will not be perfect.

We will begin, for example, with an illustration of the simplest kind, and combine two patterns which are probably more known and used than any other—that is, a four-end twill and a plain cloth, as in Figs. 70 and 71. Suppose we are weaving two cloths together, one of which is plain and the other the twill given here, and that the threads per inch both in warp and weft, and the thickness of these threads, are the same in both. The two could not be equal in texture. One would be much firmer than the other; they could not both be equally perfect in structure. If the quantity or thickness of the material be arranged to

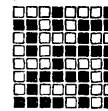


Fig. 71.

suit one of the patterns and to make it a perfect fabric, it could not make the other equally perfect. Perhaps a medium might be found—the plain cloth made heavier and firmer than it should be, and the twill lighter and looser, so that neither should be so far removed from a true and perfect structure as to be so imperfect as to be objection-

able ; and, at the same time, the two might be so intimately bound together that the plain or stronger fabric would support, and to some extent improve, the strength and quality of the twill cloth. Still, with all these precautions, there would be danger of the fabric being imperfect. In the process of weaving the plain cloth would work very tight and firm, and would require a greater length of warp to make a given length of cloth. Again, not only will there be more shrinkage in the warp (which may be overcome by letting the two warps come from different warp-beams), but there will be more shrinkage in the weft, because of its having to bend more round the warp threads in a plain cloth than in a twill. In some cases, perhaps, this may be advantageous, because if the two cloths are sufficiently bound together it will in its shrinkage carry the twill cloth with it, and so give greater roundness to the twill. On the other hand, if the fabric has to undergo a process of finishing, which will cause shrinkage, the twill cloth, because of the very looseness of the threads, will be liable to shrink more in the finishing than the plain one, and so counteract its influence. But in fabrics of this description the two must be bound together very closely. It is difficult to estimate the exact amount of shrinkage which is likely to take place relatively in the two cloths, and more especially if the process of finishing be a severe one, or if the material be of a nature which will assist the shrinkage, as, for instance, in woollen cloths which are milled. If, in such cases, the two cloths are too loosely bound together, or the points of binding are too far apart, that which shrinks most, even if it be only in a slight degree, will cause the other one to form bubbles, or "cockle," and so give a most unsatisfactory appearance to the whole.

It is even more difficult to deal with fabrics of this class if we attempt to figure with them in the same manner as when the two cloths are equal in quality and texture, because usually in figured double cloths there

is no binding introduced, except where the two cloths intersect each other. Consequently, if one should shrink more than the other, the "cockles" or bubbles would exactly correspond with the figure. There are double cloths where an effect similar to this is aimed at, but in such we must adopt means which will ensure the evenness and regularity of the embossed character which it will present; we must not trust to chance, or the possibility of the effect being produced by one shrinking more than another. It may be all very well to rely upon it to some extent, but we must not do so too much, otherwise we shall probably be often disappointed.

It will readily be seen that the combination of two cloths of the same quality, so far as the number of threads per inch and thickness of these threads is concerned, but of different patterns, is not a desirable thing to practise, unless for some specific purpose; and even when resorted to great care and skill must be exercised to secure the proper result. Sometimes, perhaps, it may be necessary, but it is well to avoid it as far as possible, and where it must be employed, let the conditions be examined with the greatest care, otherwise disappointment will be sure to follow.

**58. Cloths of the same Pattern, but different in Quality.**—What has been said of cloths which are of the same quality but differ in pattern will apply practically to cloths which are of the same pattern but differ in quality. For instance: if we make two cloths together in the same loom, both of the same pattern, and both having the same number of threads per inch, but the threads of one cloth of a different thickness from those of the other, the two cannot possibly work well together, or assimilate; and it is an imperative condition in nearly all double cloths that the two must assimilate and combine to form the same fabric; but if one be very fine, and the other be very coarse, this is scarcely possible.

It may be said, if we combine two cloths of the same pattern, each composed of threads of different

thicknesses, we may vary the number of threads so as to compensate for the difference in thickness. That is perfectly true; but there must be some harmony between the relative number of threads in each cloth. Suppose, for example, one had, say, sixty threads per inch, whilst the other had eighty-five, there would be a difficulty in weaving. In the first place, they could not be arranged satisfactorily in the reed, nor could the weaver arrange the succession of the picks in any definite order without an immense amount of labour. The points of binding the two together would be ever varying in relation to the pattern, and altogether there would be endless confusion in the work. To weave double cloths satisfactorily it is imperative that there must be regular order of succession of the threads of both warp and weft; that is, they must be alternate, or two of one cloth to one of the other, or some such order. Then it follows that if the patterns be equal, and the threads are alternate, the diameters of the threads must be equal. If the patterns be equal, and the order of succession or proportion of threads in one cloth be two to one, then the diameter of the threads must bear the same relation to each other; and whatever the proportion of threads in one cloth be to the threads of the other, their diameters must bear the same relation. Fabrics of this description are often made, but unfortunately the true ratio of the threads per inch and their diameter are not always considered, and even if they are, they are in many cases considered upon a false basis, the designer proceeding upon the assumption that the diameters of threads vary in the direct ratio of their weights, instead of the ratio of the square root of their weights. This false assumption is probably a greater source of trouble to the makers of double cloths of all descriptions than anything else. No matter what may be the character of the fabric, the true ratio of the diameter should never be lost sight of from first to last.

Cloths of this class are frequently used, more especially where it is desired to have a heavy, strong fabric with a very fine surface. The face may be made as fine and the back as coarse and heavy as we please, so long as we preserve the proper proportion between the two; in fact, the back becomes simply a "lining," something to give weight and strength. Fabrics of the most beautiful texture on the face, and yet of a very heavy, useful character, may be made upon this principle, and it is capable of application in a great many ways. At the same time, although the texture may be varied, the patterns are not much varied in cloths of this class, but are confined chiefly to plain or simple twills, for the reason that it would be absurd to make the back pattern a fancy one, when it is intended only as a lining.

**59. Cloths where both Quality and Pattern are Different.**—If we wish to produce a fabric with a fancy face, and gain weight and strength by putting in a lining, we must resort to the fourth class of double cloths, where pattern and quality are both different. Here we have at command all the capacity of ornamentation which single cloths give, combined with the means of obtaining weight and strength, by the use of double cloths. Double cloths of this type are perhaps more used than any other. Throughout the woollen trade, in making cloths for men's wear, they are almost universal, and in many other branches they are also largely used. Generally such cloths are made with some fancy pattern on the face fabric—fancy, not only in the order of interweaving, but also by the use of colour—while the back cloth is either a perfectly plain one or a simple twill. The face cloth is usually very fine, made from fine material, while the back is coarse and heavy. Of course the face cloth may be made as elaborate as possible, and the back as plain as possible; in fact, the plainer the back, provided it will admit of a sufficient quantity of material being put in, the better, because

the plainness adds to the strength by the warp and weft being so intimately interwoven.

The arrangement of the pattern on paper for this class of fabric is, of course, precisely the same as for cloths which are equal in both quality and pattern, only instead of the threads of warp and weft being alternate, they will generally be two of face to one of back, or in such proportion as is required to give the proper weight or thickness of cloth, or to produce any desired effect.

In making double cloths of this class the cultivation of the habit of dealing with each independently of the other is of the greatest value, so that the designer may know exactly what is the structure of each, and be able to see what is the pattern upon it at a glance; he can then compare their relative orders of working, and select his binding places with certainty. Of course the same principle of binding must be followed in this class of cloth as in the preceding, but in many cases there is much greater difficulty of binding than in the others. In the first place, the difference in the quality and thickness of the yarns makes it necessary to select binding places where there can be no risk of their showing through to the face; and it is most advisable, to assist perfect binding, to select the two thinnest materials; for example: if the back cloth be a very coarse, heavy one, in most cases the weft will be thicker than the warp, and the back weft will certainly be thicker than the face weft; so that it would be very desirable, in such a case, to bind the two together by lifting a back warp thread, and allowing a face weft thread to pass under it. Of course this must be done in accordance with the rule mentioned for binding two equal cloths together—namely, that the back warp must be on the upper side of the back cloth, or next the face cloth, and the face weft must be on the under side of its cloth, so that neither is drawn out of its regular course more than the mere thickness of the thread.



Then the second, and in many instances the greatest, difficulty arises from the relation of the two twills to each other. If the two patterns, for example, occupy such a number of ends each that they are not both complete at the same time, or, in other words, that the number of ends occupied by the back pattern is not a measure of the number occupied by the face, then at every repetition of the face pattern the back will fall in a different position in relation to it, and a binding place selected at one point which might be perfect would be entirely wrong at the next repetition of the pattern. We will take, for example, a ten-end pattern for the face and a four-end pattern for the back, and make a section as shown in Fig. 72.

This pattern cannot be complete until twenty ends of each are gone over, because that is the first number of which ten and four are both a measure. Had the relative quanti-

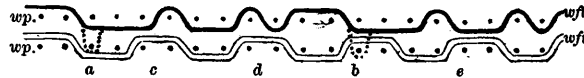


Fig. 72.

ties of face and back cloth threads been two to one, then it would have required forty threads of face and twenty of back to complete it, and consequently the difficulty of binding would have been greater. However, we will examine the binding of this pattern. We have selected our first binding point at *a*; the next repetition of the face pattern is at *b*, but if we bind at *b* we are not taking an end from the back twill corresponding to that we have taken at *a*, and if the binding at *a* is perfect that at *b* cannot be.

Again, if we take every corresponding end of the back twill, they will fall at *c*, *d*, and *e*. Now, every one of these points occupies different positions in relation to the face twill, and if the weft be brought from the face under the back at these points, some of them would be

very imperfect. Take, for instance, the point *d*, where we should have to bring the face weft through its own warp to bind under the back end. Instead of weft of one cloth and warp of the other being together, we have the warp of both cloths together, the weft of one cloth above and that of the other cloth below them, so that it would be quite impossible to bind them perfectly at such a point. It will be obvious that nothing but great care in selecting the points at which the binding is to take place, and in arranging the relation of the two patterns to each other so as to facilitate this selection, can ensure perfect fabrics, more especially when the two patterns occupy different numbers of ends, and fall in different positions in relation to each other in consequence. Of course, having found one or two places where binding can take place if the two patterns run concurrently, as they very frequently do, there would be no further trouble. We can bind as often as we please simply by following up the line of pattern, and always binding at corresponding points. Sometimes, though, we are debarred from this, and we have another kind of difficulty presented to us. Suppose we have on the face a fancy twill running, say, in a vertical direction up the fabric, one which may be the result of the combination of two or more twills, or simply produced by the process of elongation, as, for instance, in Fig. 49 or Fig. 55, and we are putting a back cloth of an ordinary twill along with it. The two patterns running at different angles, we should have to find fresh binding places at every point where we wish to bind. Because of the different angles, the two patterns could not occupy the same position in relation to each other at any two points, except at such distances apart, determined by the repetitions of the back pattern bringing it into concurrence with the face, as would probably be too great for binding purposes. At any rate we can never deal with the binding of such patterns in the same easy manner as we can where the two twills run concurrently. When we are using such patterns as this

for the face it is generally better, if we can, to use a plain back, not only because of the binding, but quite as much because the different angle of the two twills may make one cloth draw the other a little out of its proper place, and so cause "cockling." We cannot always use a plain cloth, perhaps, because of the weight of fabric we wish to obtain, but we should do so wherever we can, and avoid whenever possible—and it is possible in most cases—the combination of two twills which do not run at the same angle.

**60. Forming Patterns on Double Cloths by Binding.**—The binding of double cloths may be used for the purpose of producing patterns; and in certain classes of goods with which we shall presently have to deal the whole of the figuring is produced by binding, but in considering the subject generally we may point out how the figure may be most effectively produced. Of course such patterns are obtained by binding the two cloths together as firmly as possible all round the outline of the figure; for instance, if we wish to make a check pattern upon a cloth by binding, as is frequently done in worsted coatings, and also in many woollen goods. Along the line of the check, both warp and weft way, we make the two cloths become one, not at intervals, as in ordinary binding, but throughout the length of the piece upon the warp threads, and across the piece upon the weft threads, which mark the line of the check. These patterns may be made as fanciful as we please, but generally in the cloths we have named they are confined to stripe or check form.

**61. Relations of Face to Back Cloth in both Quality and Pattern.**—Before we enter into the question of the application of double cloth to particular fabrics, we must consider the relation of the back to the face cloth in all its aspects. We have already examined the relation of the two cloths to each other when they differ in pattern only, and when they are the same in pattern but differ in quality. We must now proceed

to the examination of those which differ both in quality and pattern. As has been already pointed out, the fabrics which differ in both quality and pattern are far more numerous than the other classes; and we may say that it almost necessarily is the case, for if we are making a fancy fabric, and putting a back cloth upon it which is intended merely for a lining, we usually make the lining as simple a pattern and as cheap a fabric as possible. As a matter of course, the face cloth—that which is to be seen, and which is to be the wearing surface—must receive the first attention. We must make that not only a fancy fabric in the great majority of cases, but we must make it as unexceptionable as we can. It must be what is termed a well-balanced cloth, perfect in structure. The relative quantities of warp and weft must be properly apportioned according to the pattern, and, in fact, every care taken that it is treated properly, as if it were a single cloth. We must then consider the back. Usually, as we have seen, the back cloth may be made as plain as possible, and if not actually a plain cloth, it must be a twill of the simplest character, and only just sufficiently loose in its order of working to permit of the quantity of material being put in to give the required weight. It too often happens that the pattern of the back or the thickness of the threads are determined by arbitrary rules, or perhaps more frequently by guess-work, or “rule of thumb.” Now, if the two fabrics are to be perfect, and neither cloth to interfere with the other, as we have shown they may do, they must both be constructed equally firm. Not that the back cloth must be as fine as the face, or that the pattern must be in the same order of interweaving, but that the thickness of the yarn and the ends per inch must be suited to the pattern in one cloth as perfectly as it is in the other. The quantity of material in one must not be such as to make a firm, stiff fabric with the pattern in which it is being woven, while that in the other is making a loose,

flabby article; they must be as nearly equal as possible. If the face cloth has two threads of warp and weft to one of the back, it does not necessarily follow that the weight of the back threads is double the weight of those forming the face; but we must take first their relative diameters into account, and then the relative order of interweaving. Suppose, for instance, we determine that the back shall be a plain cloth, and the face a twill, say a four-end twill, two weft and two warp on the surface, and that we have two threads of face cloth to one of back, both in weft and warp,—the question will be, what should be the relative thickness of the face and back threads to produce a perfect cloth, and one in which the two are alike perfect. Now, although in both patterns weft and warp on the surface of their respective cloths are equal, yet the order of interweaving is not equal; the twill will be a much looser fabric than the plain. Therefore, although the number of threads is as two to one, the diameters of the threads must not be in the same ratio, but we must take into account the order of interweaving, which in the twill to the plain will be as six is to eight, the number of ends of face to back, which is as two to one, and the diameter of the threads, which are to each other as the square root of their counts. We shall then make each cloth equally perfect; the "take up" of one will be equal to that of the other, and there will be no fear of one acting upon the other, and so affecting its appearance. Well, it may be said, "in practice we cannot take all these things into account; we are working upon certain counts of yarn, and we cannot alter exactly to suit any fancy system of calculation of this kind." The only answer is, "Then your fabrics cannot be perfect." Very frequently fabrics are made without any previous calculation of the relative thickness of the two sets of threads, and they come up so nearly perfect that they pass as such; but in these cases the maker is guided entirely by previous knowledge of fabrics which have been

made, and which are approximately perfect, and using this previous knowledge he may again arrive at something sufficiently near perfection; but that is not quite enough, for he may have to make a number of experiments, waste time, labour, and material, and in the end his results are only *approximately* true, whereas a proper consideration of the condition will give him with certainty the proper counts of the material for one cloth to make it perfect in its relations to the other.

So far we have been speaking on the assumption that the weft in each cloth is equal to its own warp, but frequently the warp and weft may be very different. In the face cloth this may be governed by the pattern, as was pointed out in dealing with single cloths, and in the back cloth it may be governed by questions of economy. Perhaps, in some cases, although the warp threads are as two to one in the two cloths respectively, the character of the patterns may render it necessary that the wefts may be in different proportions. Again, it may be that our back warp must be of cotton and the weft of woollen, then the weft would be much thicker than the warp; yet we must not lose sight of the proper relation of that weft to the face weft, and to the order of interweaving, and so keep our two cloths as perfect as possible in their relations to each other. If any difference does exist between the two cloths, generally the back one should be the looser and softer. Serving as it does the purpose of a lining, we can afford to have a greater degree of looseness and softness in it than we can usually in the face, because the face has to be subjected to wear, to friction, and in a great measure to strain, which does not fall upon the back, and any liability to "cockling" is far less objectionable in the back cloth, which is never seen in wearing, than in the face cloth. However, this difference must not be too great; it must not be such as to be very perceptible either to the eye or the touch, and more especially in cloth such as woollen—a material in which this class of fabric is more

made than in any other—where a process of milling or felting has to be undergone. In some cases this increased softness of one cloth may be an advantage: it will give more elasticity to the cloth as a whole, and make the face cloth assert itself more, and consequently show to better advantage; but it must not be carried too far, whatever degree of softness be given to it: it must not be much looser than the face, else the advantage gained by increased elasticity will be more than counteracted by excessive looseness and loss of wearing power.

**62. Three and Four "Ply" Cloths.**—In addition to double cloths pure and simple, there are many others known as "three ply," "four ply," &c., implying that the cloth is not merely a double but a three or four-fold cloth. It does not always follow though that a three or four ply cloth means that there are three or four distinct fabrics woven together, though that may be so; there may be two perfect and complete cloths, and a filling between them which is not in itself, strictly speaking, a complete cloth. Or it may be that we combine two double-faced cloths, as, for instance, is the case with some very thick bulky cloths which are used for covering rollers and other purposes. A section of a cloth of this kind is shown in Fig. 73, where we have two double weft face cloths combined to

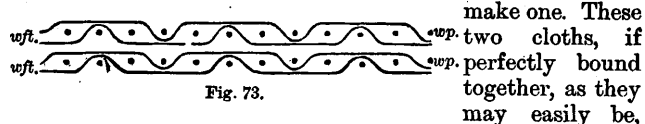


Fig. 73.

make one. These two cloths, if perfectly bound together, as they may easily be, make an immense thick bulky fabric; in fact, when milled, if the proper thickness of threads be employed in their manufacture, they will present a section fully a quarter of an inch in thickness. This in common speech would be styled a four ply cloth, and may be so called with a certain amount of propriety, because each of the cloths of which it is composed is a

double-faced cloth; there are only two warps, but there are four wefts, and the manner in which these weft threads are interwoven with their respective warps allows the whole four to go into the space of one in an ordinary single cloth. This is one of the most simple applications of the three or four ply cloths, but it will help us to understand how the multiplication of cloths will enable us to produce fabrics of any bulk. Of course the principle of structure is exactly the same as in a pure double cloth. We have only to consider how many warps and wefts we have, and deal with each independently, as a weft or warp; but in combining we must consider its relation to the other wefts or warps, or the other cloths, so that they can be bound together in the most perfect manner, and so that each cloth, although bound to another, is still a cloth in itself.

It would be an easy matter to multiply illustrations, and perhaps by doing so we might add force to the one object we have in view—namely, urging the student to practise the consideration of all the individual threads which go to form a fabric, and to classify them, and consider them, in the first place at any rate, as being there for one specific purpose, and that they form part of a whole for that purpose only.

So that we may be able to do this more completely, and to prepare for the consideration of other fabrics in a more thorough manner, we will examine some of the applications of double cloths as they are generally used and applied to fabrics which come under the almost daily notice of every one, whether engaged in the textile trades or not. If we can direct the attention of the student to objects which are daily before his eyes, but of which, perhaps, he takes little or no notice, we shall probably do more to educate him than by any amount of rules or definitions. He will examine and think for himself, he will begin to inquire the reason, and in many cases he will familiarise himself with the principle of the structure of fabrics, which in after-



life he may apply to goods of a totally different character. It is not sufficient for the designer or manufacturer of textile fabrics to know merely the structure of some particular class in which he is immediately engaged; he should have a general, and, as far as possible, a particular knowledge of the structure of other classes of fabrics, so that he may import new ideas into his own branch of industry; and it is for this reason that we lay so much stress upon a complete knowledge of double cloths, because it will be found to be the keystone of a vast variety of fabrics to which, at first sight, perhaps, it has no relationship.

**63. Scottish or Kidderminster Carpets.**—One of the most largely manufactured class of fabrics to which double cloth is applied, is what are known as Scottish or Kidderminster carpets, which consist of simply two separate cloths of the same texture but of different colours. These cloths exchange places so as to form figures or patterns. In many of these carpets great variety of colours is employed, and patterns of the most elaborate description produced, but a careful examination of them will show the student that each cloth remains to itself throughout. They exchange places to form patterns, but each weft weaves into its own warp. This is one of the simplest forms of application of double cloth to figuring. The fabrics may sometimes be made three or four ply, and the figures be of the most elaborate character, yet the application of the principle of double cloth is extremely simple.

**64. Quilts.**—Another large class of fabrics made as double cloths, and one in which the most elaborate patterns are produced, although no colour is employed, the articles being white only, is what are generally known by the name "quilts," which includes coverlets for beds, and also toilet covers and other such articles. These goods are usually of that class of double cloths which are equal in pattern but different in quality.

Usually both cloths are quite plain, but the face is very much finer than the back, and in some of the commoner qualities, which are known as "mock," or imitation quilts, there is no back warp but only weft. The system or mode of producing figures in this class of fabrics is very different from that of other double cloths of which we have spoken, though it is in effect the same as that mentioned in connection with coating cloths in section 60.

So as to deal in the most complete manner with this important class of fabrics, it will perhaps be as well to begin with an examination of the best qualities, and show the mode of producing patterns, then the other and inferior qualities will be more readily understood, and a more comprehensive knowledge obtained of the whole system.

Quilts of the best quality may in one sense be called three ply cloths, though there are not three distinct and perfect cloths, but two cloths and a "wadding." That is, there are two distinct and perfect plain cloths, and a loose weft inserted between them, which not only gives bulk to the fabric but assists in producing that embossed effect which is peculiar to this class of fabric. The section (Fig.

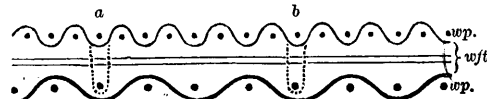


Fig. 74.

74) will explain most readily how the cloth is constructed and the figure produced. There is a fine face cloth, represented by the thin lines and dots; a back cloth, represented by the thick lines and dots; and the wadding, represented by the double straight lines. It will be seen that the face and back cloths are both perfectly plain, and the wadding pick passes clear between them. The manner in which the figure is produced is by binding the two cloths together, as shown at the points *a* and *b*, all round the outline of the figure. By binding the

cloths together in this manner, with the wadding weft between them, the figure is raised, and so produces the embossed effect. This is easily accounted for, because at the point of binding the two cloths become one, and so compress the wadding weft between them, while in the body of the figure the two are quite loose from each other, and the wadding loose between them; so that the latter pushes the cloths apart, and of course the larger and more loose the figures, the more this will take place. Fabrics produced upon this principle not only give wide scope for producing very elaborate designs, but they also give a very substantial useful fabric. From the fact of the cloths both being plain, the strength is all that could be desired, and the wadding gives warmth. In this case the back cloth, of course, is a lining only; in fact, the whole structure is as if we had taken two separate cloths, laid one upon the other with a thick wadding material between them, and then with a needle stitched through the whole mass all round the outline of the pattern, so as to bind them firmly together. It is very obvious that the drawing of the two cloths together with the stitching, leaving the body of the figure without any stitching, will produce an embossed effect, and the thicker the wadding and the larger the figure, the more roundness we give to it. The structure of this cloth is just as if we had done so, the only difference being that instead of using the needle, the cloths are bound together in the process of weaving, and by the threads of which the cloth is composed.

In many of the lighter fabrics of this class no wadding weft at all is used, but simply the two cloths, and more effect is given to the figure by the two cloths becoming one where no figure is being formed.

By this means pretty much the same effect is produced as if wadding were used; though of course the figures do not stand out quite so prominently as if wadded, nor is the cloth so stout and bulky; yet the very flatness of the ground where the two cloths form

one gives more prominence to the figure than would be expected. A section of a cloth figured in this manner is given in Fig. 75. Even more prominence will be given to it by the weft of the back cloth being thick like wadding, and by allowing, at the back of the figure which is to be most raised, the back material to be quite loose; the weft, which may be called wadding, lying loosely between the plain face cloth and the loose back warp, the latter having no weft interwoven with it at this point. In fact, the great majority of common toilet articles seem to be made after this latter method. Again, a similar effect may be produced by using backing weft only, and



Fig. 75.

letting it interweave into the ground, so as to form a thick cloth, and then pass loosely behind the figure in the same manner as the foregoing, only that there is no back warp. By this method the figures are not quite so clearly defined, and the embossed effect is not quite so good. However, by any of the three methods we have a ready means of producing most elaborate patterns without the use of colour, and the patterns may partake of any character; they need not be of the stiff type, as stripes, checks, diamonds, &c., but they may be floral, or in fact of any style which the requirements of the cloth for the purpose to which it is to be applied, or the fancy of the designers may call forth.

**65. Matelasses.**—Another class of fabric which has been largely used within the last few years may be said to belong to the same family as quilts, though the material of which it is made is different, and there is also more ornamentation on the face cloth. These fabrics are chiefly used for ladies' jacket or mantle cloths, and are known as "matelasses." The face cloth is

generally silk or fine worsted ; the back cloth woollen and cotton, or all cotton, according to the quality of the goods. The principle of structure is precisely the same as in the best quality of quilts. The face and back are two separate cloths, and there is a wadding weft. The figure is produced by the binding of the two cloths together in exactly the same manner as in quilts, but in addition to the figuring by binding, greater effect is given to it by varying the working of the face cloth by twilling and otherwise, so that the cloth is ornamented to the utmost, and also gives a thick useful fabric. In this, of course, the pattern may be of any character, and more effect be given to floral designs, especially by the twilling, &c., on the face than can be given in quilts when the cloth is quite plain. This system of figuring is, of course, applicable to many other fabrics ; we have merely selected these two for illustration, because more complete and perfect representatives of their class than any of the others.

**66. Woven "Tucks," &c.**—To enumerate all the applications of double cloths would be a difficult task. We might point to the weaving of hose, which is made as a double cloth, and many others, but we should be occupying space needlessly. However, we may refer to one or two other forms of application of a more or less novel kind ; for instance, the weaving of "tucks" for children's dress skirts, a section of which is shown in Fig. 76. To make these tucks, all the warp forms one solid fabric for the ground, then



Fig. 76.

when the tuck is to be formed, every alternate warp end only is used until a sufficient length has been woven. The warp is brought off two

beams, and as soon as the tuck has been woven the warp of which it is formed is let forward, and the tuck pressed forward by the reed, or, what is equivalent, the ground cloth is let back up to the reed, until the

edge of the tuck and the point where it commenced being formed are brought together, then the whole warp again begins to form one solid fabric, leaving the tuck as a protuberance on its surface. This operation is repeated at intervals, greater or less according to the size of tuck or their distances apart.

**67. Grooves in Cloth.**—Fabrics are sometimes woven with grooves in them for various purposes, the grooves being formed by weaving two separate cloths for a given distance, then combining them so as to form one cloth only. The section would be similar to that shown in Fig. 75, except that the grooves would be straight across the piece. Then the woven "ladder-tapes" for Venetian window-blinds are made upon the same principle, the narrow cross-pieces entering the body of each separate tape alternately.

**68. The Ornamentation and Uses of Double Cloth.**—We have now gone pretty fully over the principles of double cloth making, and examined the advantages to be gained in increased weight of fabric—strength, and warmth—as well as the various methods of ornamentation which it places within our reach. We may ornament one of the cloths only, and use the second only as a lining; we may bind the lining into the face cloth in such manner as to produce additional patterns; or we may cause the two cloths to exchange places for the production of figures, and have by that means a solid coloured figure upon a ground of another colour. These are the chief features of double cloth, but in their application there is no limit to the varieties.

A thorough knowledge, however, of the manufacture of double cloths in all the varieties of form or combination, is not only valuable as giving the power of producing a great variety of fabrics more or less heavy, but we can constantly apply it to fabrics which do not come strictly under the head of double cloths, but which are rather more for the purpose of ornamenting single cloths by the introduction of material which is used for figuring only,

and which form more or less of a double cloth only at the point where the figuring comes in.

Before leaving this subject we might briefly point out generally the classes of fabric to which the various classes of double cloth weaving are most applied. In the first place, there are those which consist of one warp and two wefts, used chiefly for woollen goods, such as union shawls, mantle cloths, rugs, coating cloths, and other heavy fabrics. Secondly, there are those which consist of two warps and one weft: applied to silks, ribbons, a few coating cloths, but mostly to fine material where a great many threads per inch in the warp can be used without difficulty. And thirdly, there are those which are two separate cloths: applied to heavy shawls, carpets, quilts, heavy coating cloths, and heavy goods generally, whether of an extreme fancy character or where plain texture is required.

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## CHAPTER VI.

### FIGURED CLOTHS.

**69. Forming Patterns upon the Fabric.**—We have in the previous chapters dealt chiefly with the structure of the fabrics and the consideration of ornamenting in the structure, with the view of rather adding to than detracting from its usefulness. Of course, as we pointed out in the first chapter, we must at all times have the application of the fabric before us; yet we may determine the general structure first, and then the question of ornamentation separately. As we have dealt with the question up to this point, we have kept the two strictly together. We may now begin to consider the question of ornamentation from a somewhat different standpoint. We have to deal with pattern of a more elaborate character and its application to fabric, and make

structure of cloth subservient to design rather than design subservient to structure, at least so far as the question of usefulness goes. Of course, we can never afford to ignore the latter, but, as we have considered it so very fully, we may now make it, perhaps, more of a secondary question.

So far we have only discussed the question of figuring on fabrics in a general way, without entering into the question of arrangement of figured patterns. The designs with which we have dealt, except in double cloths, have been figures of a simple description, commonly designated twills, the one chief characteristic being that they are continuous and unbroken all over the fabric. The number of threads occupied by one complete pattern is very small, and although, as we have shown, there may be a great number of patterns produced, either of twills or having twills for their base, yet there is little room left for the play of imagination, at any rate as compared with what may be exercised when dealing with designs of a floral character or patterns occupying a larger area. Again, the patterns with which we have dealt in detail—except the references made in the last chapter to figuring with double cloths—being such as occupy only a small number of threads, are capable of being woven in the loom with healds; but as the area of patterns so woven is necessarily limited, we must resort to the Jacquard machine to enable us to produce larger and more complicated patterns, or, in other words, to give us command over a greater number of threads, so that we may vary their order of working in a greater degree, and not have the repetition of the pattern occurring so frequently.

In all the patterns which we have discussed up to now, where we have formed a pattern by interweaving the warp and weft threads in varied order, it has been formed by both sets of threads in a similar degree. We have had no fixed or definite ground fabric with



a figure upon it. The figure has covered the whole ; in fact, we may be said to have been designing fabrics. There has been only ornamentation on a small scale in the structure. We must now determine the structure of the fabric first, or what is technically termed the ground pattern, and then work our design upon it. For forming the figure upon the surface of the cloth, we may use either the material which composes the body of the fabric or we may introduce extra material. Suppose we are weaving an ordinary plain cloth, and we wish to ornament it by the introduction of a figure, we may either introduce additional warp or weft to make the figure, without in any way interfering with the plain fabric, or we may let the ground warp and weft, as that which forms the fabric is termed, cease to interweave with each other, and simply lie loosely one above the other at intervals regular or irregular according to the arrangement of the figure we desire to produce. Sometimes we may have the weft thrown to the surface, sometimes the warp, according to the material of which each is made ; or we may bring up portions of each for the purpose of producing some special effect, as, for instance, if warp and weft are of different colours. In many cases also we not only make figures with the material of which the ground or body of the fabric is composed, but we also introduce along with it some extra material either in the warp or weft, or both.

We must examine into this subject very closely, so that we may see clearly not only how the figure is made, but the arrangement of designs, and the probable effect upon the fabric of designs of different characters when the pattern is formed by the ground material.

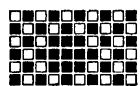


Fig. 77.

**70. Figures Formed by the Ground Material.**—Let us take Fig. 77 as a plan of a small figure, formed by the ground weft upon a plain cloth, and Fig. 78 as a section of the same. The general body of the cloth is per-

fectly plain, the warp and weft passing over and under each other alternately, but the figure is formed simply by their ceasing to interweave, each set of threads being quite free from the other. When figures are so made the quality of the cloth must be in some degree affected; but this will vary according to the amount of figuring introduced, the size of the separate figures, and their distances apart. We say that plain cloth is the most firm in texture of all ordinary fabrics, but if we intermix with the plain a quantity of figuring where the warp and weft are both quite loose, we make the fabric loose in texture exactly in the degree in which we figure it. Generally speaking, the amount of figure introduced is not so much as to affect the fabric detri-

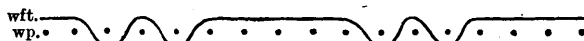


Fig. 78.

mentally, but this, of course, must be carefully watched by the designer of the pattern; and if his cloth would be deteriorated by the introduction of a certain amount of figure, then he must alter it by the use either of a greater number of threads per inch, or of a thicker yarn. The consideration of the structure of the fabric, as affected in this way, is not the only or even the most important one in designing figured goods, but the arrangement and distribution of the figure also require a proper amount of attention. If the design be floral it will be necessary to distribute the weight of figuring equally, not alone for the purpose of pleasing the eye, but so that the fabric shall not be more loose at one part than another. It must always be borne in mind by the designer of fabrics of this type that large figures or figures set closely together will give looseness and extreme softness to the cloth. And by having a large quantity of loose weft or warp thrown to the surface the wearing qualities of the fabric are very much affected; in

fact, where the figure is formed there is no cloth—cloth has ceased to be formed, it is simply loose warp and weft, and it does not require an expert to know that this must not be carried too far. In a great portion of the fabrics figured upon this principle the designs are not strictly floral. Perhaps floral objects may form the basis of the design, but they are set at regular intervals over the surface, not arranged as a continuous pattern, not a design, perhaps, in the general acceptation of the word, but simply an object or number of objects scattered at regular intervals and in definite order over the surface.

Take Fig. 79 as an example. We have here the same object as we used in Fig. 77, but a number of them are distributed. So as to arrive at a definite understanding

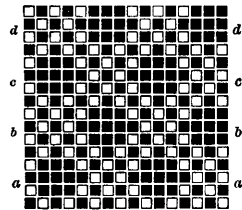


Fig. 79.

of the order of arrangement we must examine each spot or object and its relation to each weft pick and warp end of the pattern. It will be noticed that the spots *aa* each commence on the same pick, and so do *bb* and *cc*, &c., and further, that *a* and *c* are upon the same warp ends, and so are *b* and *d*, so that *a* is a repetition of *a* in the direction of the weft, and *c* is a repetition of *a* in the direction of the warp; and in like manner *b* and *d* are repetitions of *b*. Consequently *a* and *b* constitute the complete pattern, the rest being simply repetitions of these two. This mode of arranging the spots is usually spoken of as being "two spots set alternately," which simply means that there are only two spots in the complete pattern, which are arranged so that they occur alternately in the order of weaving. This is the simplest and easiest mode of arranging the distribution of spot figures over the surface of the fabric, and may be applied to figures of any size or form, but it possesses what is generally considered a disadvantage in

of the order of arrangement we must examine each spot or object and its relation to each weft pick and warp end of the pattern. It will be noticed that the spots *aa* each commence on the same pick, and so do *bb* and *cc*, &c., and further, that *a* and *c* are upon the same warp ends, and so are *b* and *d*, so that *a* is a repetition of *a* in the direction of the weft,

woven fabrics, as far as appearances go, but which is much greater so far as the structure of the cloth is concerned. In the pattern before us, if we glance along the centre of the figure we see the weft passing clear over five warp threads, and interweaving only with three. Exactly the same occurs with the warp threads through the centre. Again, if we look along the line where one figure is just ending and the next beginning, we shall see that the weft passes under and over every alternate warp thread. The same also occurs with the warp thread interweaving with the weft at the corresponding position. Such a variation in the order of weaving of the various threads of which the fabric is composed must produce irregularities in its texture, which are objectionable, for they not only detract very much from its appearance but also from its usefulness, because of the different degrees of tension thrown upon the threads. In a figure so small as this it might not be serious, but in a large one it certainly would, and the small pattern is used here only for the purpose of illustration.

Then, if the arrangement of spots alternately in this manner is objectionable, as it evidently must be in some cases at least, we must adopt some other mode which will obviate the difficulty. Now, it is very clear that whatever system of arrangement we use, there must be regularity: the spots must be regular distances apart, and equally distributed. Fig. 80 is one of the most perfect arrangements of its kind. Here we have the same spots; they are equal distances apart, equally distributed, and the order of interweaving of each respective end and pick is also equal. The appearance of the fabric, so far as size and distance apart of the spots are concerned, would be exactly the same as that of Fig. 79, but the cloth will be more perfectly

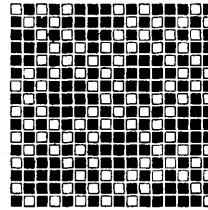


Fig. 80.

constructed, more pleasing to the eye—inasmuch as the figures do not run in the same straight lines—and more serviceable, because of the equality in the tension of the threads by reason of their interweaving regularly and equally throughout. This arrangement is extremely simple, being upon the basis of what is commonly known as an eight-end satin. In some cases other orders of satin may be adopted, doubtless for a good and sufficient reason. We must, of course, calculate the area we propose to give to the figure, and find the number of ends and picks it will require to occupy, and if that number happens to be one which is not a measure of the number of hooks contained in our Jacquard machine, which simply means the total number of threads at our disposal for figuring purposes, then we must alter it and adopt five, six, eight, or ten, as the case may require. Again, perhaps the form of the figure is such that an arrangement of eight spots in satin order would give them the appearance of irregularity; if so, we must adopt some other system which is better suited to it. For instance, an elongated figure may frequently be better arranged with five or ten spots than eight, because the order of distribution is not quite so regular to the eye; and this apparent irregularity may be neutralised by the placing of the elongated figures, and thus present a much more regular appearance. On the other hand, as a matter of course, if the spot is regular in shape, no method of arrangement can be better than an eight-end satin. Although the example we have taken for our illustration is a figure of a very stiff character, and one which perhaps exaggerates the difficulty, yet the rule is more or less applicable to figures of every description, whether they be stiff or free in their outline. No doubt the difficulty is greatest in figures which vary so much in the length of “float”—that is, in the number of ends over which the weft passes without interweaving. If they are pretty equal in this respect, then the only reason for abandoning the alter-

nate order of arrangement is to prevent the figures from running in straight lines across or the length of the piece.

So far we have confined ourselves to figures upon a plain cloth, and formed with the material of which the fabric is composed; but we are not necessarily confined to plain cloth; we may figure with equal facility upon twilled or satin cloth. In fact, we determine the fabric first, and then figure upon it; and the figure must be made subservient to the structure of the cloth, not the cloth to the figure. What we mean is, that we determine the weight, quality, and texture of our cloth, according to the purposes to which it is to be applied, and then proceed to ornament it.

In ornamenting twilled or satin fabrics, there is less risk of affecting the general character of the cloth than in plain cloth, because the looseness of the figure more nearly accords with the nature of it, the looseness of the interweaving of the ground of the fabric approximating more closely to the figure; and as there is necessarily more material employed, a slightly increased looseness is not so detrimental. Further, in cloths which have not a plain ground we employ figures with more freedom of outline. In plain cloths we are bound to consider the order of interweaving, and as this happens at every alternate end, our outline must necessarily be more or less stiff; whereas in a satin, for instance, the interweaving would be only at every fifth end, and we can, therefore, change from weft to warp, or *vice versa*, with more freedom, and consequently relieve the outline from stiffness. This is also assisted by the increased quantity of material employed.

One feature of the arrangement of spot figures must not be overlooked, whether we arrange them alternately, or in satin, or any given order. If the form of the figure is such that more threads are used in one direction than the other, whether in the warp or weft, by one spot, whatever number of spots are employed, the whole must occupy a space proportionate

to that occupied by one. Suppose, for instance, that one spot occupies thirty ends, and only sixteen picks, and we are employing five, eight, or ten spots, the number of ends and picks which the whole number of figures occupies must be proportionate to those occupied by one spot. It would be absurd to put eight, say, of such spots upon a square space; at some points, if they were not actually touching each other, they would come very near, while at others they would be very wide apart.

In many instances, when we figure with the ground weft or warp, or even with both, upon a plain cloth, the figure is not allowed to be quite loose, but is twilled, or the warp and weft are bound together in satin order; and even upon other than plain fabrics this may be done. The first object in doing this is to give firmness to the cloth, and sometimes also effect to the pattern. If the spots be large ones, the introduction of twilling will give more effect, more light and shade, as it were, to the pattern, and at the same time the cloth will be more useful for wearing purposes, and there will be less loose material on the surface.

Spot figures of the type of which we have been speaking are amongst the simplest and easiest patterns to produce. They require simple, methodical treatment only. We take any small object, either from nature or fancy, and distribute it in regular order and with mathematical precision over the surface, so that the designer's skill—from an art point of view—is called forth chiefly in the selection of his object. He will have no difficulty in finding plenty to select from. If he wishes to have large figures he has a great variety of flowers, leaves, &c., from which to select, which readily admit of variation, and which he may conventionalise to an unlimited extent. If only small objects are required, the number to choose from is even greater. The petals of flowers, grains of corn, portions of leaves, and other objects in nature, afford him unlimited scope.

In many cases small objects which are stiff in outline

are arranged in such order as to form a continuous pattern, like that shown in Fig. 81, which may be compared to a series of intersecting diagonals, made by objects each of the same size and shape. In patterns of this type effect is frequently given by variety of twilling, and at the same time the balance of pattern or looseness of weaving is regulated by it. In this design, for instance, the thick bars where the weft is laid loosely on the top of the fabric are coincident with the plain cloth, whilst at the point where there is little or no plain the figure is twilled, thus giving a balance or equality of texture.

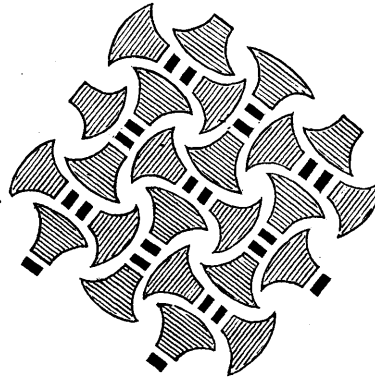


Fig. 81.

In the arrangement of these patterns too much attention cannot be paid to such little matters, for the same reason that in the small set spots we distribute them in satin or some other order which will equalise the interweaving. If our pattern will not admit of such orders of distribution, we must take other means of equalising the texture.

#### 71. Floral Designs formed by the Ground Weft.

—In making floral designs, all the same conditions must be observed as in the patterns of which we have just been speaking. We must take care that our pattern does not run in too straight lines either with the weft or warp. It may be permitted to run diagonally, because that would not affect the relative tension of the threads. Any inequalities may be neutralised by varying the twilling, and by the same means variety given



to the pattern, and to some extent the absence of variety of colour supplied.

In some cases, where the floral design is of a scroll character trailing over the surface, after the fashion of climbing plants, with leading or prominent objects occurring at intervals, it is well to arrange these first, so as to ensure their equal distribution. They may be placed in satin, or some other more or less regular order, and the general body filled up afterwards, and in such a manner as to relieve the stiff monotony of the regular order of arrangement. If this is done judiciously, not only will it assist beginners in their first arrangement of original designs, but it keeps before their eyes constantly the necessity of this regular order of distribution; and a thorough conviction of the necessity of this, so as to keep the fabric regular, is one of the surest guarantees of success to the designer of textile fabrics.

**72. Figured Stripes.**—In many cases figures are made to run in regular stripes the whole length of the cloth; that is, a stripe is produced upon the fabric by figuring alone. It may be that the stripe is a floral pattern, and the ground is either plain or twilled, or has small spot figures distributed over it. In such patterns care must be taken as to the relative tension of the warp threads of the stripe and ground fabric, or, if there be a great difference, the warps for each respectively must come from different warp beams, because it would require so much more length of warp to make a given length of cloth in one case than the other; and if they both come off the same beam, the same length of each being given off, one would of necessity be much tighter and straighter than the other. Of course the necessity for two beams would only arise when the difference in the orders of working made a very perceptible difference in the tension of the warp. Sometimes the figure of the stripe may be of the same character as the ground, but differing from it either in some of the forms employed, or in the arrangement or distribution of the objects, and

the difference in the orders of working might be so slight that there would be no real difference in the tension, and consequently no need for the employment of two warp beams.

**73. Stripes which differ in Texture and Quality from the Ground.**—We have already referred to making stripes finer than the ground, or what is called “crammed stripes,” but we spoke of them merely as plain stripes, or simply twilled. The same class of stripe is also largely used for figured goods. The ground of the fabric may be either plain or twilled, or may have spot figures over it—the last two are the most common—and the stripe may be twilled or satin, and the figure running upon it.

This is by far the most effective method of making stripes, because not only does the figure give character to it, but its very closeness and compactness distinctly mark it, and separate it from the ground. Again, stripes of this description are frequently a different material from the ground, as well as a different colour or shade of the same colour. When we say that these stripes are usually finer than the ground, we say so in a very broad sense, or perhaps it will be better to qualify it, and say that it is either much finer or there is a greater quantity of material in a given space. For instance, if the stripe be twilled, we may either have more threads per inch than in the ground, or an equal number of a thicker thread. The latter possesses the advantage of being cheaper, but the former that of superior appearance. If the stripe be a satin, we cannot so readily resort to the thicker material only, as the nature of the pattern requires a greater number of threads to make it “cover” properly. In either case there must be an increased quantity of material, whether there be actually increased weight or not. If we simply use thicker threads there will be increased weight, but if we use more threads of a finer count the increase of weight accompanying the number of threads is neutralised by their fineness in a greater or less degree.

In making figured stripes; the same rule must be observed as in the combination of any two patterns in any form—namely, that either the number of picks occupied by the ground pattern, or whichever is smaller, must be a measure of that occupied by the stripe or larger pattern, or they must be continued to a point where the two meet at the same time. In the majority of instances, the stripe will occupy the greater number of picks, because that is usually the fancy portion of the fabric, the ornamental part put on as a decoration to it. But this is not the universal rule; sometimes the ground may be figured, and the stripe a plain twill or satin introduced to give relief to the ground. This may be determined variously by the caprices of fashion, or the uses to which the article is to be applied. An example of each kind is given in the coloured plate I.

When the figuring occurs on the stripe, the best effect is generally obtained by having the ground darker than the stripe and solid in colour; that is, the weft and the warp of the ground both alike in colour, whether they are in the material or not, and the warp of the stripe either a lighter colour, or a somewhat lighter shade or tint of the same colour. By this means the figure on the stripe will be darker than the stripe itself, and will therefore give more effect to it. Where it is a plain stripe upon a figured ground the same rule will apply to some extent, but more liberty may be taken. A light figure upon a dark stripe will give a rather “seedy” appearance, it will be wanting in force or character, but a dark solid stripe upon a light figured ground will not be deficient in the same degree. Or even if the plain stripe be of the same colour as the ground, it will be more pleasing than a figured stripe upon a plain ground of the same colour. In the first case the stripe will break, and give relief to the figure, but the plain ground cannot give relief to the figured stripe to the same extent. Of course this will somewhat depend upon the relative quantities of stripe and figure; if they are equal, or nearly equal, the

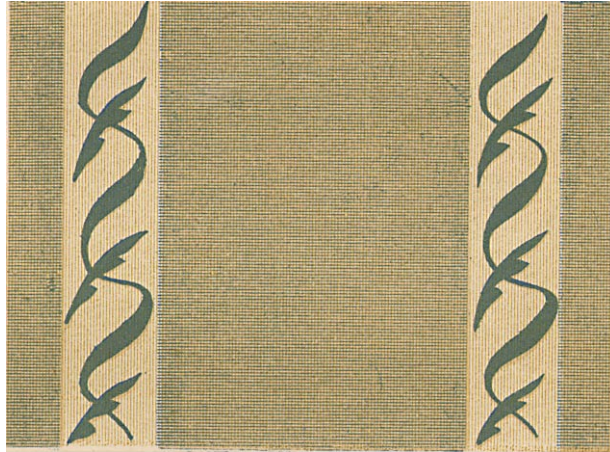


PLATE I.

condition will not be exactly the same as if the ground be three or four times as broad as the stripe. The designer must be guided by this in his use or non-use of different depths of colour, as well as by other circumstances accompanying it.

**74. Figures running over both Stripe and Ground.**

—Although we have been speaking of figuring the ground and stripe separately, we are not, necessarily, bound to confine ourselves strictly to that. Very excellent effects are produced by letting the figure run over both stripe and ground; in fact, arranging the pattern as though the stripe had no existence. This may be done whether the stripe be finer than the ground or not, though in most cases it has most effect when stripe and ground are equal in all respects except colour; as, for instance, if the fabric is a fine satin throughout. Again, very pleasing effects may be produced by letting the figure run over the ground in sprays, and have the termination of its branches in the stripe; and this may be done either when ground and stripe are equal or otherwise. Probably in such cases the best effect is produced when the stripe is finer than the ground, as it will give a more striking contrast to the terminals of the sprays. If the object of running the figure over ground and stripe alike is to break up the stripe a little, and make it lose some of the harsh straight outline which usually distinguishes stripes, it will be better to let the stripe and the figure occupy different numbers of ends, or, in other words, occupy different spaces. Suppose, for instance, that the stripe is repeated every three inches and the figure every four inches, then the stripe will not be broken by the corresponding part of the figure until it has been repeated four times and the figure three times, so that it is relieved considerably of the monotonous repetition which would present itself if the stripe were broken all across the piece at the same point. This, of course, may or may not be an advantage, but in most cases it is a most decided one, because the harsh outline



PLATE II.