TEXTILE DESIGN

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TEXTILE DESIGN

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PREFACE

Of the 515 pages of this work about two-thirds appeared originally in serial form in the *Textile Manufacturer*, under the title of "Jute and Linen Weaving, Part III. Designing, etc." It was at first our intention to restrict the subject-matter to design as applied to jute and linen textures, but as the work progressed it became more and more apparent that most of the text and practically all the illustrations were of general interest and application. We therefore decided to extend the work so as to cover practically the whole field of textile design as applied to the various branches of the industry. Many pages of text and illustrations have, therefore, been added in order that the book might be a comprehensive treatise on the subject of textile technical design.

Almost every important type of textile fabric is illustrated and described in more or less detail; and some idea of the scope of the work may be gathered from the fact that there are altogether 307 illustrations, embodying over 1400 different designs, plans, intersections, and photographical reproductions of many textile fabrics.

T. WOODHOUSE.
T. MILNE.

January 1912.

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CHAPTER I

INTRODUCTION

In its widest sense the term Textile Design embraces the pattern development, the weave structure, and the colouring of all textile fabrics, but the particular meaning conveyed by the term will vary, naturally, with the different branches of the weaving industry. It may, for example, be considered chiefly from the point of view of art, of colour, of weave structure, or from a restricted combination of these sections. Many types of elaborately figured fabrics, both white and coloured, are limited in their structure to a few standard weaves: one type depending almost entirely upon artistic beauty of form and the closely-set fine yarns in which the design is developed, as in silk, linen, and other damasks; another type depending almost wholly upon the joint effect of the forms, yarns, and colouring, as in Brussels, Wilton, Scotch or Kidderminster, Axminster, etc. carpets, rugs, certain quilts, and many kinds of upholstery cloths. Very little actual knowledge of cloth structure is required by the designers of the above fabrics, for, in most cases, the structure, which does not appear on the design, is imparted automatically by specially constructed machinery. The designs are, therefore, more or less elaborate treatments of flat ornament arranged to conform with certain restrictions of reproduction and of harness-mounting—where a harness is required. Even in the case of full harness damask designs, the few weaves used are of an elementary and stereotyped nature. In this and similar cases, however, the designer requires a little more knowledge of cloth structure, and of the processes of production; but in nearly all the above cases the build of the fabric is only of secondary importance to the designer, being developed, as stated, by automatic means.

On the other hand, many cloths are produced in which the weave structure or build of the fabric is of vital importance: in which the whole effect depends upon the method of interlacing the warp and the weft in the process of weaving. Such cloths are made from yarns of every well-known kind of textile fibre. Designers of these fabrics must have an intimate knowledge of cloth structure, and should thoroughly understand how to make due allowance for the various restrictions imposed upon them by the particular type of loom in which the designs are to be developed. For such men a purely art training is not an absolute necessity, unless, indeed, when they are engaged in the preparation of the more elaborately figured kinds.

Where coloured yarns are extensively used, as in the woollen, worsted, and silk industries, a sound knowledge of the principles of colouring and their application to the blending of the fibres, and to the arrangement of the coloured yarns, is essential; while, for certain kinds of cloth, *e.g.*, tapestries, brocades, etc., the designer is expected to be conversant with all branches—art, colour, weave structure, and processes of production.

Of the various sides of this subject enumerated above there is, perhaps, from a purely textile point of view, none

more important than that of weave structure. It is, in many respects, almost the very essence of the art of weaving, and, when considered from an applied standpoint, includes, as a subsidiary side, the processes of production.

Apart altogether from the requirements which are demanded of a designer in any particular branch of the textile industry, it is, in his own and his employer's interest, very desirable that he should study widely the different types of cloth structure. Ideas spring from many sources, and no opportunity should be neglected of becoming conversant with the various sides of one's occupation.

The classification of fabrics is not in itself an important branch of textile study, nevertheless, it is an interesting and instructive proceeding to classify the various textiles under one or other of a few comprehensive groups. From the nature of the case it is evident that such groups must be arbitrarily chosen, since they may be considered as depending upon weave or structure, fibre, colour, sett, or upon a combination of the many different elements which may influence the characteristics of any textile fabric. For the majority of purposes those divisions which are based upon the broad lines of weave or structure are found to be most useful, since they are founded upon features which apply equally to all fibres, and are independent of sett or colour considerations.

The following divisions are therefore suggested:—

Group I. Single or simple fabrics which contain only one warp and one weft interwoven at right angles to each other.

Group II. Compound fabrics having two or more warps or wefts interwoven at right angles.

Group III. Leno or gauze fabrics in which part of the warp threads, in singles or groups, interweaves alternately to right and to left of the remaining portion.

Group IV. Pile fabrics of all classes.

Group I. includes all single or simple cloths of whatsoever weave, fibre, or sett. Group II. embraces all backed cloths; extra warp or extra weft fabrics; two, three, or more ply cloths; padded fabrics; tapestries, etc. Group III. covers all those fabrics into which the characteristic movement, continuous or intermittent, of gauze or leno work enters. Group IV. includes Brussels, Wilton, Axminster, and similar carpets, upholstery velvets, velveteens, plushes, cords, and pile fabrics of all kinds.

In several cases it may be found that the above divisions overlap, and that the structure of a certain fabric belongs partly to two or more groups, but at the best such a method of grouping must be of a somewhat indefinite character. Many cloths are so peculiar in structure that each would require to be classed alone.

Whatever be the nature of the fabric, it is essential that the interweaving of the threads and picks of which it is formed should be capable of being represented distinctly on paper, or on some other suitable medium. The most convenient, and at the same time the most effective way, is, undoubtedly, the graphic method; indeed, except in the simplest cases, it is the only possible way.

All students of weaving are more or less familiar with squared paper, or what is generally known as point or design paper. It consists, as shown in Fig. 1, of paper ruled with two sets of parallel lines perpendicular to each other. To facilitate the counting of the vertical and the horizontal rows of squares thus formed, to suit the class of

jacquard, and the relative numbers of warp and weft threads, it is found necessary to introduce, at certain intervals, in both directions, thicker or more prominent lines. These are shown in Fig. 2 at X in the vertical set, and at Y in the horizontal set. As a general rule, it may be taken that the distance between any two adjacent heavy lines is the same in both directions. The heavy lines, therefore, divide the paper into a series of true squares technically termed "blocks." The number of small squares contained in one of these blocks may vary both horizontally and vertically according to requirements, but there is,

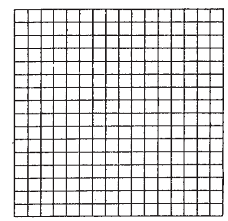


Fig. 1.

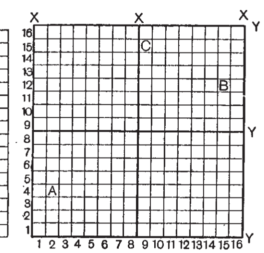


Fig. 2.

naturally, the same number of small squares in each block of any one sheet.

If the only consideration were the counting of the squares, it is clear that the most rational method of ruling would be that in which the heavy lines would occur at intervals of ten. For the textile trade, however, the most common rulings, so far as the vertical lines are concerned, are those in which the thick lines occur at intervals of eight or twelve.

It will in all cases be supposed that the vertical rows of small squares represent the warp threads; the horizontal rows of small squares will consequently represent the weft threads or picks. It will also be supposed that if any unmarked square represents a thread in a certain position, either over weft or under weft, the designer may, by introducing a mark in the same square, indicate that that particular thread now occupies the opposite position. It is quite arbitrary as to which method is adopted—*i.e.*, as to whether a mark indicates that a thread has been raised or depressed. Both methods are in common use, that which is adopted being generally preferred from motives of convenience and expediency.

In accordance with the above description, Fig. 2 represents 16 warp threads and 16 weft threads—more commonly designated 16 threads and 16 picks. If the unmarked squares are taken to indicate warp threads under weft threads, then marked squares will indicate warp threads over weft threads. In three different squares in Fig. 2 are letters A, B, and C, which have the following signification :—

A	indicates the	2nd	thread lifted	over the	4th	pick.
B	,,	15th	,,	,,	12th	,,
C	,,	9th	,,	,,	15th	,,

Instead of using letters, it is the common practice to represent these movements by means of simple isolated marks of any convenient nature, or, if a number of contiguous squares require to be marked, by painting these over solid with some transparent colour. Dots, crosses, lines at different angles, and full squares are very largely employed —sometimes all of them appearing in the same design.

One kind of mark is in general sufficient for the simple weaves or structures, but distinctive marks are valuable, and are often used, to point out any particular character in the plan, and in some cases to show more clearly the synthesis of the fabric or of the design.

CHAPTER II

PLAIN, TWILL, AND SATEEN WEAVES

REARRANGEMENTS

THE fundamental plan, that for plain cloth, is shown in Fig. 3. It will be seen that the first thread rises and falls on alternate picks throughout, while the second thread falls and rises alternately; consequently the two threads always occupy opposite positions. Since repetition of the pattern may occur for any desired number of units, it follows that, on the first pick, all odd threads would be lifted to the highest position, while all the even threads would remain in, or be taken down to, the lowest position. The two sets of threads (odd ones above, even ones below) would thus form two layers of warp, between which the shuttle containing the weft would pass. For the second pick all the even threads would be lifted, and the odd ones depressed, and between these two layers in their new positions the weft would be passed for the second time. These operations might be continued with 8 threads for 8 picks, and, if it is assumed that the warp is black and the weft white, then the figure would indicate, more or less correctly, the effect which would be produced in the cloth by the above disposition of yarns. If white warp and black weft were used, then the same movements would simply cause the colours to change places.

An examination of the figure shows that each pair of vertical rows is similar in every respect to the first and second rows. In exactly the same way the first and second picks are repeated on each succeeding pair of picks. Hence, the whole plan is a repetition of the first four squares—two horizontal and two vertical. These four squares may be said to contain the "unit" weave, and this unit is in itself sufficient to indicate the make of the cloth from a structural point of view.

Fig. 3 is reproduced in Fig. 4, but with a slight alteration in the marks. The space occupied by this unit weave is enclosed in the four squares bracketed A, and the lifted threads are indicated by solid marks. The remaining

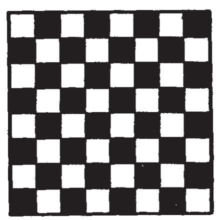


Fig. 3.

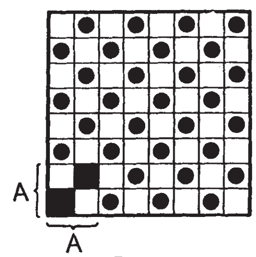


Fig. 4.

circular marks simply show the repetition of the weave in both directions. Now, since all the odd threads in Figs. 3 and 4 rise and fall together throughout the weave, they may be drawn in and controlled by one shaft or leaf of the camb; similarly, all the even threads may be drawn through the heddles of, and controlled by, a second leaf. From this example the following simple and yet comprehensive rule for drafting or determining the minimum number of shafts necessary for the weaving of any pattern may be deduced.

Rule for Drafting

All threads of the warp which rise and fall together throughout one repeat of the weave may be drawn through

the heddles of one shaft of the camb, or be controlled by one hook of the jacquard. In drafting, it is important to notice that the threads must follow each other in their proper order, no matter on which leaf or shaft they happen to be drawn. It is also necessary to point out that the minimum draft is not always the most desirable from a practical point of view.

In Figs. 5, 6, and 7 are shown a few different methods of indicating the leaves or shafts on which the different threads are drawn. Fig. 5 indicates a plain cloth draft on two shafts—a suitable method for coarse fabrics such

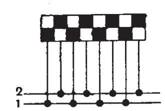


Fig. 5.

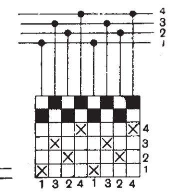


Fig. 6.

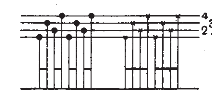


Fig. 7.

as jute, and generally adopted in that industry. Where warp is closely set, however, as in the cotton, linen, silk, and worsted industries, it becomes practically impossible to accommodate all the warp on two shafts; four shafts are therefore employed as indicated in Fig. 6. When working in the loom, shafts Nos. 1 and 2 are tied together, so also are shafts Nos. 3 and 4. They are then controlled and worked together exactly like two single shafts. In both the above figures the shafts are indicated by horizontal lines, and the warp threads by vertical lines; the circular mark, where the lines cross, indicates the shaft on which that particular warp thread is drawn. The order of drafting in Fig. 6 makes the same leaves suitable for both plain and twill weaves.

Fig. 6 shows that the design paper may be used to indicate the draft. The horizontal rows of squares, below the design, represent the shafts themselves, the bottom row being No. 1 or that nearest the weaver; the vertical rows of squares indicate the threads, and, by placing any convenient mark, usually a X, in a square representing any particular thread and shaft, the order of drafting may be clearly shown. A further method, probably the most convenient to the initiated, is also indicated in this figure. Immediately under the threads—*i.e.*, along the bottom of the design—is a series of numbers, *e.g.*, 1, 3, 2, 4, 1, 3, 2, 4. These numbers indicate the shafts on which the different threads are drawn. In this manner a draft may be represented by a series of numbers alone, provided the threads are understood to be in consecutive order.

It is a common practice to show the draft apart from the weave, and two styles in which this may be done are shown in Fig. 7. The particular order of reeding—*i.e.*, the number of threads per split in the reed—may be indicated by short horizontal lines connecting the vertical ones. Thus, in the first part of the figure the reeding is shown to be in twos—the ordinary method for plain fabrics,—while in the second part of the same figure four threads are indicated for each split of the reed.

The most natural and the simplest extensions of the plain weave are those in which two or more succeeding threads or picks are identical. In Figs. 8, 9, and 10 are shown three weaves with 2, 3, and 4 picks respectively in a shed. These weaves may be considered as derivatives of the plain weave, but they are usually classed under warp ribs or warp reps. Weaves of this type produce, as their name implies, well-defined ribs or bars extending from selvage to selvage of the cloth, provided a sufficient number

of warp threads per inch be inserted. The width of the bars depends upon the weave, and also upon the number of picks per inch and the thickness of the yarn employed. When the picks per inch are constant, the three weaves produce bars whose widths are in the ratio of 2 : 3 : 4 ; but where the picks per inch vary, the width of the bars may be anything desired, within reasonable limits. For example, if 10, 15, and 20 picks per inch be introduced respectively into cloths woven by the aid of the weaves in Figs. 8, 9, and 10, the width of the bars in each piece would be the

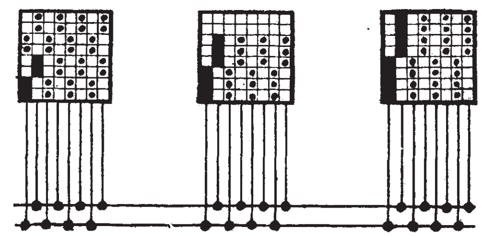


FIG. 8. FIG. 9. FIG. 10.

same, for in each case there would be 5 bars per inch. It is assumed that the same count of weft would be used in each case, but, whatever the count may be, the same result would be obtained, provided the number of picks per inch were inserted.

If two kinds of weft, with an excessive difference in count, be used, the character of the rib may be materially altered. Indeed, the thickness of the weft is an important factor in the production of this type of fabric, for, if desired, it is possible to obtain a decided rib effect with the simple plain weave and a proper choice of wefts. This is illustrated in Fig. 11, where at A is shown the intersection of 1 thread with 8 picks of weft, all the latter being of the same diameter; but at B, which shows 2 threads and 4 picks, an entirely different effect is produced, this being obtained by alternate picks of thick and thin weft. This method produces a broad, round, and prominent rib, although for certain classes of fabrics the appearance would be unsatisfactory. If broad and narrow bars are required alternately, with a more or less flat effect on the surface of the fabric, a different number of picks may be

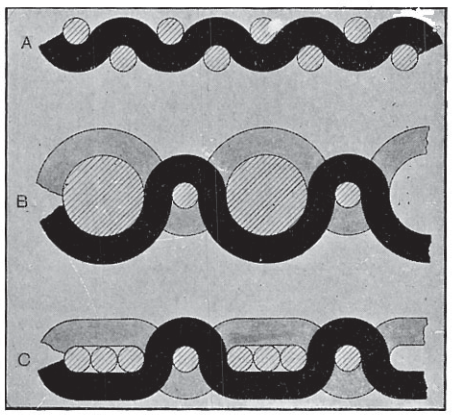


FIG. 11.

inserted in the two bars. Thus, the effect at C, Fig. 11, shows the same width of bars as that at B, while the thickness of the cloth would be more uniform than in the latter case. Three picks are woven in the same shed for the broad bar, while one pick forms the narrow one. The weave plan is shown in Fig. 12, and this, along with its companion weave, Fig. 13, is largely used in the manufacture of heavy carpeting. The two weaves are in reality the same, beginning only on different picks. It will be

seen that the weight of the heavy yarn used in B, Fig. 11, is considerably in excess of that required for the effect at C, since the weight of one pick of the heavy yarn is three times the weight of the three picks which form the corresponding part in C. In addition to the increased weight of weft, it would be necessary to have a pick-and-pick box loom, running at a reduced speed, to obtain the effect at B.

The weaves shown in Figs. 8, 9, 10, 12, and 13 do not by any means exhaust the possibilities of warp rib effects. For finer work the number of picks per shed may be con-

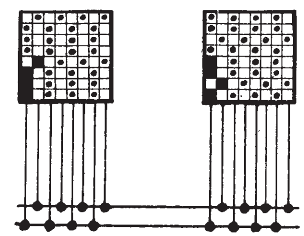


FIG. 12. FIG. 13.

siderably greater than shown. In addition, there may be more than two distinct widths of ribs; indeed, there is, theoretically, no limit to the number of different ways of arranging this type of weave, but those given are quite sufficient to illustrate the principle involved.

For ribs in the opposite direction—*i.e.*, parallel to the threads of the warp—it is only necessary to arrange the weaves as in Figs. 14, 15, and 16, while Figs. 17 and 18 may be used for the same purpose, or to obtain a weft effect somewhat similar to the warp effect obtained by the combination of weaves 12 and 13. Any of the above patterns of warp and weft ribs may be woven with two shafts or leaves. This is shown clearly by the drafts which accompany the designs.

At first sight it would appear that some elegant checks might be produced by a combination of these two methods of producing ribs; but it must be remembered that the relative numbers of threads and picks per inch in the two

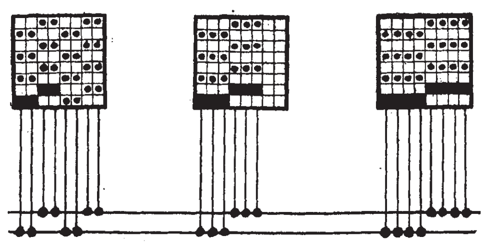


Fig. 14. Fig. 15. Fig. 16.

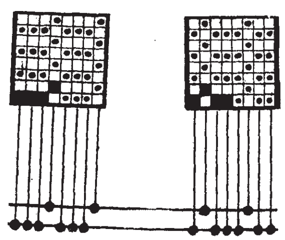


Fig. 17. Fig. 18.

systems are directly opposed to each other. Thus, in warp ribs the threads should predominate to form transverse bars, while in the weft ribs the picks per inch must considerably exceed the threads per inch to obtain a satisfactory result. Now it is obvious that both conditions cannot obtain in the same cloth.

In Figs. 19, 20, and 21 are three designs developed from

these unit weaves. They appear quite satisfactory on paper, but none of the designs would give the same satisfaction in the cloth. For instance, in Fig. 19 the draft indicates that it could be woven with two shafts. In one

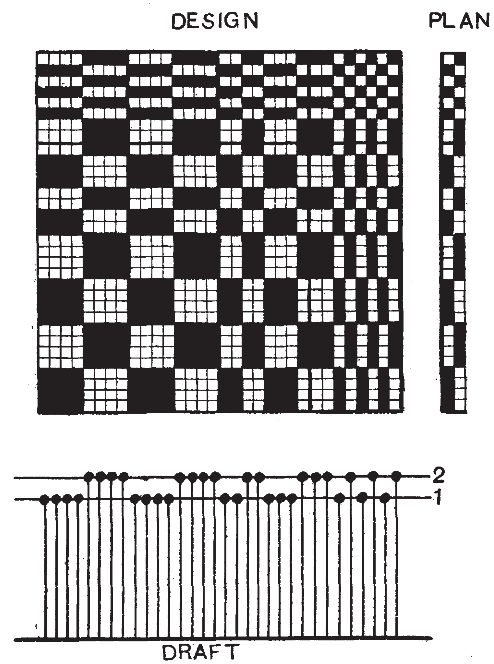


Fig. 19.

part of the design, where the last 6 threads interweave with the last 6 picks, the result produced is plain weave. But these same 6 picks and the first 26 threads have to form a weft rib, a type of weave which demands a maximum number of picks per inch; while the last 6 threads and the first 26 picks are supposed to form warp rib effects which demand a maximum number of threads per inch. But the maximum number of threads and picks cannot be inserted in the same piece of cloth. The plain part referred to would be the main factor in regulating the number of threads and picks.

In Fig. 20, which may be drafted on to six shafts, similar objections may be adduced, since the plain effect obtains at four different parts of the design. Besides these difficulties, special arrangements would have to be provided for at least two warp beams, since the threads in the various parts of the design have different intersecting powers, and would therefore contract or take up differently.

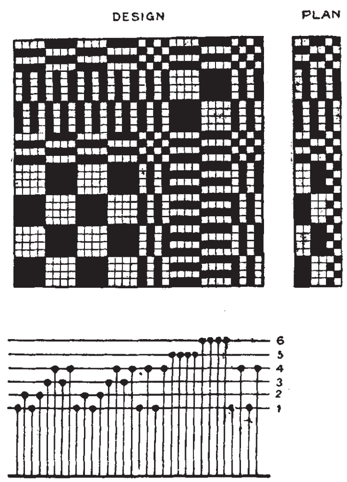


Fig. 20.

Fig. 21 is formed on a dice basis from the warp and weft rib weaves, and requires eight shafts. If this were put into work, it is quite probable that the necessities of the one weave structure would neutralise the effect of the other, with a result unsatisfactory to both. Although these three designs may give unsatisfactory results when made under the conditions described, it does not follow that checks or designs of this type are useless. It will be seen later that such plans as these may be used, with advantage, as motives in several classes of design.

The primitive weaves shown up to and including Fig.

18 are all capable of being woven with two shafts. It may be noted that in each case up to Fig. 13 the unit represented in solid black indicates the weaving plan, or the order of rising and falling of which these shafts must partake to reproduce the particular designs with the given drafts. The weaving plan for Figs. 14 to 18 is simply the unit bracketed A in Fig. 4. A different condition obtains, however, with Figs. 19, 20, and 21. The weaving plans for these are shown immediately to the right of the designs. In Fig. 19 the weaving plan consists of two vertical rows of small squares, one for each shaft of the draft; but it contains as many picks as the design itself. The first vertical line indicates the rising and the falling of shaft No. 1, and corresponds exactly with the movements of any thread which is drawn on that shaft. Similarly the second vertical row of squares corresponds with the rising and the falling of any thread drawn on shaft No. 2. The number of picks in the weaving plan of Fig. 20 is again coincident with those of the design (this must always be the case), while there are six vertical rows of squares, one for each shaft of the draft. The first row corresponds with any thread on shaft No. 1, the second row with any thread on shaft No. 2, and so on in consecutive order. Similarly with Fig. 21, each vertical row of the weaving

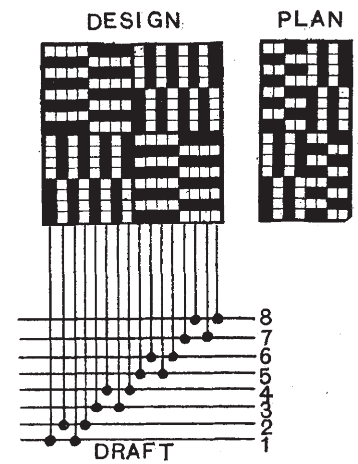


Fig. 21.

plan, taken in consecutive order, would correspond with the movements of the threads drawn on the 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, and 8th shafts respectively.

From the above explanation it is seen that the weaving plan, sometimes termed the pegging or treading plan, from which the cards for the dobby should be cut, or the tappet arranged, must contain a vertical row of squares for each shaft of the camb. These rows must be arranged in consecutive order, and the marks on each row must coincide with those showing the rising and the falling of any thread on such shaft; while the total number of picks in the weaving plan and in the design must be the same.

The extensions of the plain weave in both directions, as shown in Figs. 19 and 20, produce, in addition to the two kinds of ribs, solid rectangles of various forms. Many of these are irregular, while others are quite regular and form perfect squares. The latter are known by the names of mat, hopsack, or basket weaves, and are exceedingly useful when used either alone or in conjunction with others of a different nature. Fig. 22 shows respectively the 4-thread, 6-thread, and 8-thread hopsack weaves. In each case the weave consists of two distinct orders of movement, and consequently the warp may be drawn on two shafts; the picks in one repeat of the weaving plans being 4, 6, and 8 respectively. Each figure shows four complete repeats of the weave, the solid marks representing, as usual, the complete unit or weave. Except in very fine fabrics, it is rare to find basket weaves on more than 8 threads and picks. Such weaves are, however, of so simple a nature that, if further extensions are necessary, the student should find no difficulty in making them, whether they be of a regular or of an irregular kind.

With little imagination we might consider the plan of

the plain weave as being composed, not of alternate black and white squares horizontally or vertically arranged, but of diagonal bands of black squares or dots as shown at A in Fig. 23, each band forming with the horizontal an angle of 45°. If alternate diagonal bands—the dots, for example —be removed from this figure, the remaining bands will

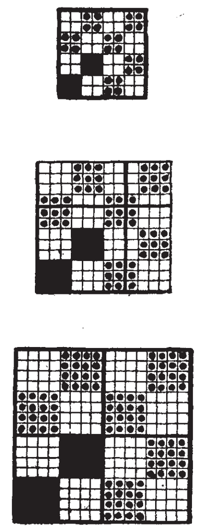


Fig. 22.

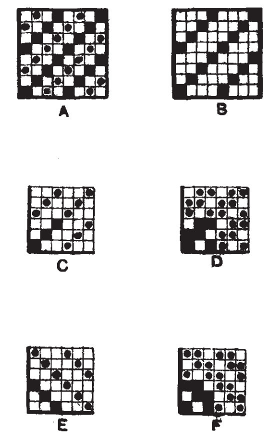


Fig. 23.

appear much more pronounced; indeed, they will form a very decided effect, as will be seen at B, which shows the result of this change. Weaves of this nature—that is, those in which the warp is retained in one position for two or more successive picks, and where the step is such that it produces an oblique effect—are termed twills or diagonals; they form a very extensive and useful class. Such weaves are resorted to chiefly for two reasons:—

(*a*) Ornamentation of the fabric.

(*b*) To permit of a cloth of considerable weight and firmness being made from comparatively light yarns.

The regular twills may be conveniently distinguished from each other by stating the number of threads upon which the different unit weaves are complete, and by graphic representation. Thus B in Fig. 23, which shows four repeats of a twill weave, is completely defined by the following :—

Four-leaf twill to right $\frac{1}{3}$; because the marks appear diagonally in a direction from left to right, and each thread is up for one pick and down for three. It is manifestly impossible to make a twilled fabric with the plain weave or with two shafts, although a considerable difference in the counts of the warp and weft, as well as in the number of threads and picks per inch, may, in some cases, impart a twilled appearance to a fabric woven in the plain weave. Twills may, however, be formed on any number of threads above two.

The simplest twills, or what might be termed the fundamental twill weaves, are those in which there is one, and only one, mark on each thread and pick, and in which the arrangement of such marks is a succession of steps of one pick forward and one thread to the right. The result in every case is the formation of a diagonal line forming, on paper at least, an angle of 45° with the horizontal. This angle is maintained in the cloth, provided the number of threads per inch of warp and weft is the same, but only when such a condition obtains. From the nature of the above arrangement of marks, it is quite clear that there can be only one such weave for each fixed number of

threads and picks, although by moving one step upwards and one step to the left, an apparently different result is obtained; the difference, however, is simply one of direction, and not of structure.

The particular direction in which the fibres of the yarn are twisted, as well as the desired effect in the cloth, determines, in many cases, the direction of the twill. In order to add a little variety to the appearance of a fabric, it is a common practice to combine both directions of movement in the same cloth. These movements are technically termed right and left-hand twills. This slight ornamentation does not increase the weaving apparatus; the only further condition being the proper arrangement of the draft of the warp in the camb leaves. The twist of the yarn is, however, an important factor, for in a cloth made as above, the two oppositely directed twills will not be developed to an equally prominent degree.

C and E in Fig. 23 show the two fundamental weaves on three leaves, the solid marks showing the complete units. In addition to the weaves thus obtained, it is possible to obtain apparently different weaves by marking each thread for two picks, as shown at D and F. We might, however, point out that in all single cloths the two sides twill in opposite directions, and that if on one side the warp predominates, the opposite side will have an excess of weft. Such being the case, it is easy to see that a cloth woven with the design shown at C on the surface, will have F on the reverse side. Similarly, E is the reverse of D.

We have mentioned that the combination of C and E in the same cloth does not involve any additional weaving apparatus, but simply a forward and backward draft in the camb shafts. The reversing of the draft merely alters C to E, consequently we may obtain the latter weave by reversing the former. Any twill weave may, of course, be made to move in the opposite direction by this method, the effect, moreover, being quite independent of the particular thread upon which the reverse twill is started, or the particular shaft of the camb on which the draft is reversed. By this remark we wish to impress upon the reader the fact that in order to make a satisfactory turning point, he may commence with any suitable thread of the weave. This will be more apparent later; one of our objects in mentioning this condition at this early stage being to show that the simple weaves we have just illustrated, and those which follow, may not be combined without due regard to the effect at the point of junction.

C to F show the full range of twills on 3 threads and 3 picks, but it is easy to see that all are derived from C by the above methods. It is impossible to obtain any other effect on this number of threads and picks, a statement which the reader may easily prove by trials. These 3-leaf twill weaves are extensively employed in the jute industry in the manufacture of sacking, and in the linen trade for the production of drills, ticking, lining, etc.

With 4 threads and 4 picks, each thread may be marked on 1, 2, or 3 successive picks, as indicated in Fig. 24 at G, H, and J respectively; while similar but left-handed twills are shown at K, L, and M.

The reverse side of G is M
,, ,, H ,, L
,, ,, J ,, K

The 4-thread rolling twills G, J, K, and M are sometimes, but not extensively, used in the jute and linen industries, but the $^{2}\!-_{2}$ twills H and L are, next to the plain weave, probably the most extensively used of all

weaves. They are popularly known in different districts as the serge, common, cassimere, shalloon, blanket, or two-and-two twill, are widely used in jute carpet manufacture, for sheetings and other linen goods, for many types of silk and cotton fabrics, but perhaps most extensively for woollen and worsted clothing and dress material.

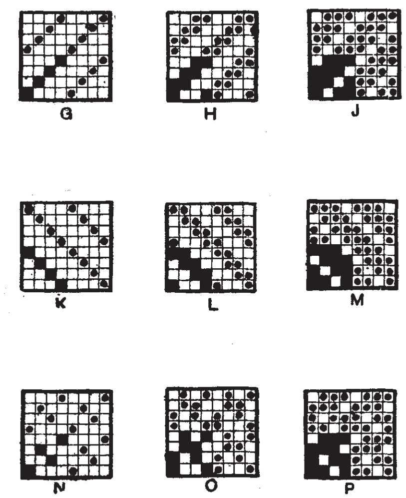


Fig. 24.

In addition to the ordinary or straight twill arrangement, the weaves on 4 threads and 4 picks may be arranged in a broken or irregular order; thus, N, O, and P have been made by rearranging the threads of G, H, and J in the order 1, 3, 2, 4, instead of 1, 2, 3, 4. G to P, inclusive, represent the total number of regular variations on 4 threads and 4 picks. By the word regular in this case we mean where each thread of any one weave possesses the same number of marks. Perhaps the most conclusive proof of this statement is to take the fundamental weave G and arrange this in every possible way. Fig. 25 shows the weave so treated, and it will be observed that although the unit weaves show

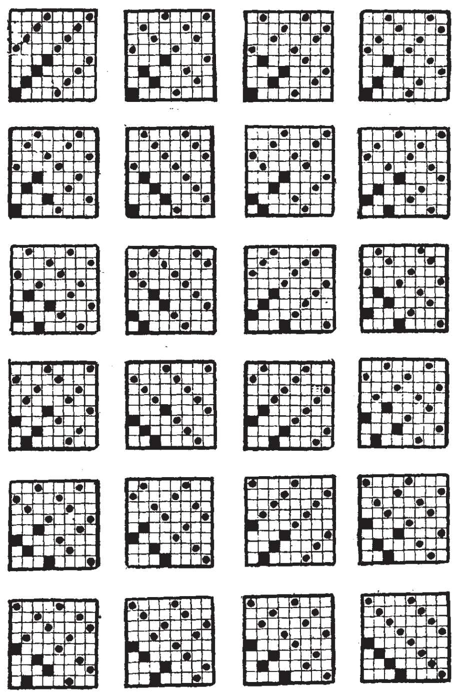


Fig. 25.

apparently 24 different forms, there are in reality only three, namely, weaves shown at G, K, and N in Fig. 24. Now, as the remaining weaves H to P have been derived by adding one or two points to each thread, it is clear that the total number of regular weaves is as stated.

The 4-thread broken twills, N and P, are extensively used in coarse and medium linen dices, in woollens, in double-faced cloths of different classes, and as ground weaves for some compound fabrics. The straight twills G and J are also sometimes used for these purposes; while O, which is one of the most useful of crêpe weaves, is occasionally used for jute carpeting. N is very useful as a base for fancy weaves, and also as a base for the arrangement of spots or small figures in many different types of fabric.

The regular straight twills obtainable on 5 threads and 5 picks are shown in Fig. 26, but it will be observed that S, T, and V are respectively the reverses of R, Q, and U. The six examples are, therefore, reducible to three elemental or initial twills, from which the others may be easily constructed. Each weave may, of course, be arranged to twill to left as well as to right. In U and V the marks upon each thread are in two sections or groups, a peculiarity which is first possible with five picks, and which shows that in each repeat of the weave any thread so marked will twice occupy the highest and lowest positions of the shed. Five is also the minimum number on which a weave of a true sateen character may be obtained.

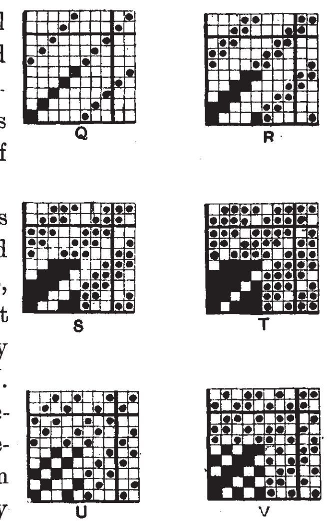


Fig. 26.

The distance between a mark on any thread and the corresponding mark on the previous thread is what we have called a step or a movement, and the order of stepping has, hitherto, been a regular one of one thread and one pick. With any number of threads and picks less than five, it is impossible to obtain a new weave by regularly stepping more than one; but from this number upwards, with the exception of six, new weaves may be produced by regular steps of greater magnitude. The simplest method of obtaining the different variations is to mark one set, say

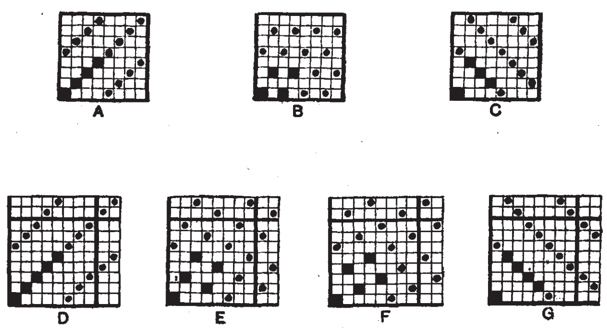


Fig. 27.

the threads, successively, and to make the steps of 1, 2, 3, etc., on the picks. Thus, suppose we mark each thread in succession and each pick in succession for 4 threads and 4 picks, we obtain A in Fig. 27, which is the same as G in Fig. 24. If in the second instance we place the first mark on the first thread and first pick, then miss a pick and place the second mark on the third pick—that is, a step of two picks instead of one,—and proceed similarly, we obtain B, which is not a weave at all, since no mark whatever falls on the second or the fourth pick. A step of three will give us C, which is the same as K in Fig. 24.

A step of four cannot be taken, since it goes beyond the limit and marks the first pick of the next repeat. Consequently, with 4 threads and 4 picks we can get only two fundamental weaves.

If, however, we take 5 threads and 5 picks, and proceed in precisely the same way, we get:—

D	by stepping	one pick at a	time.
E	,,	two picks	,,
F	,,	three ,,	,,
G	,,	four ,,	,,

D is, of course, identical with Q in Fig. 26, while G is the same weave but twilled in the opposite direction. Similarly, E and F have the same structure, but opposite directions of twill. These two latter show the well-known sateen weaves, the only possible weft sateens on 5 threads and picks. It will be noticed that the marks in D and G are equally inclined to the horizontal, but oppositely directed; similarly, E and F are identical in inclination but of opposite directions. In a word, F and G are, when correctly set, the images of E and D. It is similar with every arrangement on an odd number of threads, for if there be $2n+1$ threads, there will be $2n$ figures produced by moving or stepping successively for 1, 2, 3, 4 . . . $2n$ picks; the last n of these figures will be the images of the first n figures, while the first and last (1st and $2n$th) will always be the fundamental right and left-hand twill weaves.

In the weaves on any even number, say $2n$ threads, where $2n-1$ figures will result, we shall find that the first $n-1$ figures are the images of the last $n-1$ figures, while the middle one—*i.e.*, the nth figure—has no image. Again, the first and last figures will be the right and left-hand fundamental twills.

In addition, it is found that although the above numbers result, no weave will be obtained unless the step, and the threads minus the step, are prime to each other. When making trials for these weaves, or when completing any weave, the student must remember that if a point or mark falls outside the initial unit—that is, falls in the next unit, —such a mark must be placed in the corresponding square of the initial unit.

It is now easy to find out, as first pointed out by Gan in 1867, what particular numbers are capable of giving regular sateens, and also how many of such weaves can be produced. Thus, if we adopt his particular method for six, seven, and eight threads respectively, we have :—

Six Threads.		Seven Threads.		Eight Threads.	
Step.	Threads—Step.	Step.	Threads—Step.	Step.	Threads—Step.
* 1	* 5	* 1	* 6	* 1	* 7
* 2	* 4	2	5	* 2	* 6
* 3	* 3	3	4	3	5
* 4	* 2	4	3	* 4	* 4
* 5	* 1	5	2	5	3
...	...	* 6	* 1	* 6	* 2
...	...	...	...	* 7	* 1

If we now place a star to indicate the cancelling of all numbers (including unity) which are measures of the number of threads employed, or which are multiples of any such measure with the exception of unity, we are left with the steps which will produce sateen weaves. The first and last numbers in the steps—that is, the first and $(n-1)$th (if n is the number of threads)—give us the fundamental straight twills.

All the above movements are shown in Fig. 28, for six, seven, and eight threads. It is interesting to note that

there is no regular sateen on six threads; with seven threads there are four, the last two, however, being the images of the first two; while with eight threads there are two regular sateens of oppositely directed twills. When

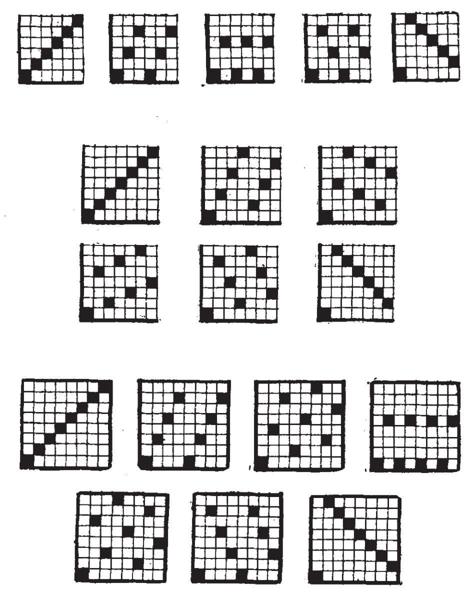


Fig. 28.

testing for the number of sateens and their steps, it is only necessary to go half-way down the column.

We append the number of regular sateens with their steps up to 24 threads, it being understood that those in the right-hand column are oppositely directed twills to those in the left. Indeed, the numbers in the third column, if read backwards, are the complementary numbers to those in the second column with respect to the number of threads. They might with advantage be termed "complementary steps."

No. of Threads in Weave.	Magnitude of Step.	Magnitude of Step.
5	2.	3.
6	none	none
7	2.3.	4.5.
8	3.	5.
9	2.4.	5.7.
10	3.	7.
11	2.3.4.5.	6.7.8.9.
12	5.	7.
13	2.3.4.5.6.	7.8.9.10.11.
14	3.5.	9.11.
15	2.4.7.	8.11.13.
16	3.5.7.	9.11.13.
17	2.3.4.5.6.7.8.	9.10.11.12.13.14.15.
18	5.7.	11.13.
19	2.3.4.5.6.7.8.9.	10.11.12.13.14.15.16.17.
20	3.7.9.	11.13.17.
21	2.4.5.8.10.	11.13.16.17.19.
22	3.5.7.9.	13.15.17.19.
23	2.3.4.5.6.7.8.9.10.11.	12.13.14.15.16.17.18.19.20.21.
24	5.7.11.	13.17.19.

The reader will perhaps have observed that the number of possible regular sateens which may be obtained by the above method depends upon the number of measures which any given number possesses; in the prime numbers, 5, 7, 11, 13, 17, 19, and 23, we get the maximum variations, these in every case, counting the images, being equal to $n-3$, where n is the number of threads. When the two fundamental twills are included, the total number obtainable from prime numbers is $n-1$.

We have given the number of different sateens up to 24 threads, but the choice of any particular one would naturally depend upon the effect desired, some of the sateens having their points or marks more regularly distributed than the others.

It is seldom that a 24-thread sateen is used except in fine silks, but in this material the 48-thread sateen is occasionally used.

Although the above number—that is, 24—will rarely, if ever, be reached except in certain silk fabrics, the study of this method is valuable, for the weaves so produced serve as bases for the production of many fancy weaves, while the simpler ones are used as bases for the distribution of small figures. All sateens are more or less valuable in that they afford a means of obtaining a practically solid warp or solid weft effect, the degree of solidity increasing with the number of threads used.

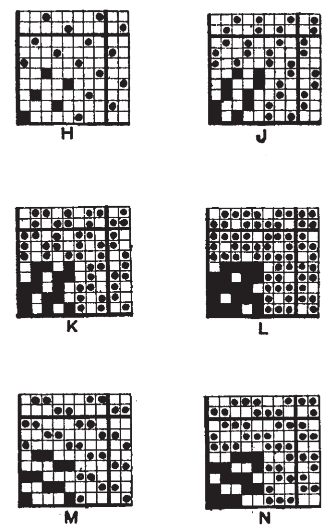


Fig. 29.

Let us now return to Fig. 26. If we take the threads of Q in regular succession and rearrange them in the order 1, 4, 2, 5, 3 to form a new design, we shall obtain H in Fig. 29, which is identical with E in Fig. 27, while R to V in Fig. 26 produce, when treated similarly, J to N in Fig. 29. J (Fig. 29) is the well-known venetian twill, and is extensively used in the woollen and worsted trade for coatings, dress goods, etc.; it also forms, along with the other figures in the same group, the shading weaves for single damasks.

There are five regular elemental twills which may be obtained on 6 threads and 6 picks (see O to S, Fig. 30).

Each of these may have its reverse in the same direction (with the exception of Q, the reverse of which is exactly the same), and then all may be arranged to twill to the left, making altogether 18 regular twills. It has already

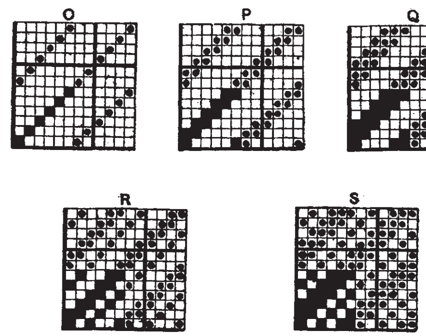


FIG. 30.

been shown that no regular sateen can be made on 6 threads, but an irregular sateen is possible by arranging the 5-thread sateen in a certain order, and then adding a mark at the intersection of the sixth thread with the sixth

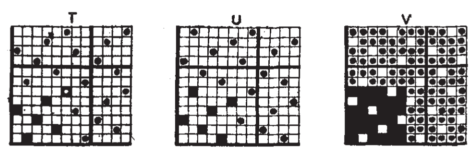


FIG. 31.

pick. For example, if we arrange the picks of a 5-thread sateen in the order 3, 4, 5, 1, 2, or the picks of the 5-thread fundamental twill in the order 2, 5, 3, 1, 4, and then add the extra sixth mark as already indicated, we obtain the 6-thread irregular sateen as shown at T in Fig. 31. The

extra mark is shown by a white circle in the centre of the square. This weave, if arranged as at U in the same figure, may, along with the corresponding warp flush at V, be used for dices and damasks. They are seldom so employed, however, probably because they are more difficult to spot out on paper than the 5 and 8-thread weaves. The peculiar and irregular arrangement of the spots gives also a unique and valuable effect when it is used as a base for small figures, for the more or less twilled effect which results from the employment of the regular sateens for this purpose is almost entirely eliminated when this 6-thread base is adopted.

Four systematic methods are shown below for developing other effects on 6 threads and 6 picks, methods which are also applicable to all even numbers above 6.

(*a*) By doubling alternate threads of a certain unit.
(*b*) By taking alternate threads from two separate units.
(*c*) By rearranging the threads in the order 2, 1, 4, 3, 6, 5, etc.
(*d*) By rearranging the threads in the order: 1, 2, 3, . . . n, then $2n$, $2n-1$, $2n-2$ . . . $n+1$; in this particular case, 1, 2, 3, 6, 5, 4.

In addition to these four systematic methods, there are special methods which will be explained later.

A and B, Fig. 32, show two effects produced respectively from the elemental weaves P and R, Fig. 30, by the method (*a*). C and D, Fig. 32, are both obtained by method (*b*) from Q and R, Fig. 30, with a slight difference in the arrangement. E to J, Fig. 32, are respectively the rearrangements of O to S, Fig. 30, according to method (*c*). K and L, Fig. 32, are typical rearrangements by method (*d*).

The regular elemental twills obtainable on 7 threads and 7 picks are, strictly speaking, eight in number (see M to T, Fig. 33), although it will be seen that the reverse of Q, if read downwards, is the same as R read upwards.

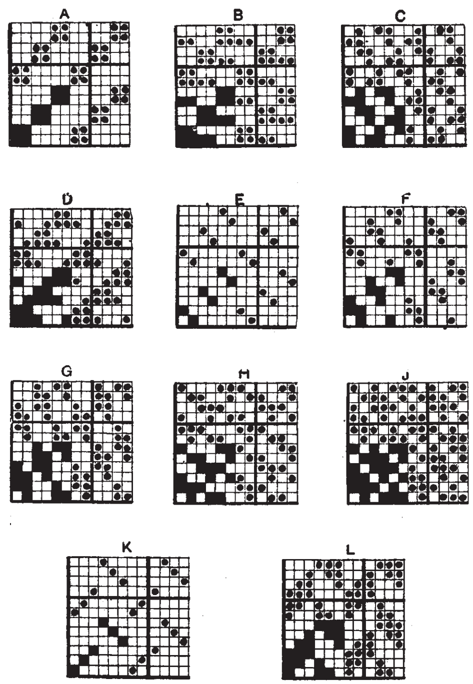


Fig. 32.

Each of the above may have its reverse in the same direction, and, again, all may twill to the left; consequently there might be 32 weaves in all.

The student may obtain the number in any particular case by arranging them on design paper, or by writing down the full range graphically and then crossing out

any which repeat within themselves or otherwise. Thus, the range in one direction for 7 by 7 is: $\frac{1}{6}$, $\frac{2}{5}$, $\frac{3}{4}$, and

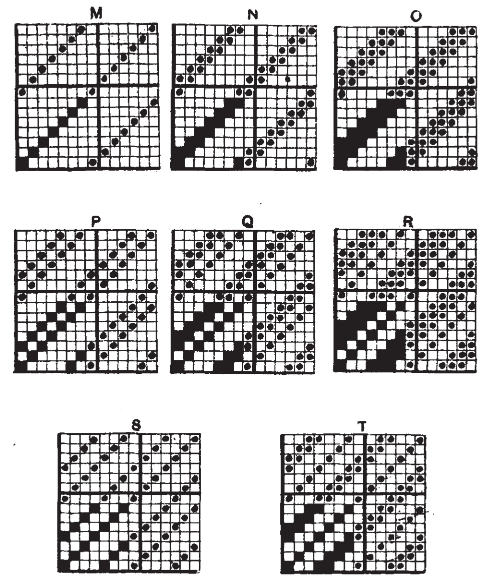


Fig. 33.

so on for 16 twills. Half of the above 16 are the reverses of the other half, as shown by the following table:—

Elemental Weaves shown in Fig. 33.		Reverses of Ditto not shown in Fig. 33.
M . .	$\frac{1}{6}$	$\frac{6}{1}$
N . .	$\frac{2}{5}$	$\frac{5}{2}$
O . .	$\frac{3}{4}$	$\frac{4}{3}$
P . .	$\frac{1}{1}\frac{1}{4}$	$\frac{1}{1}\frac{4}{1}$
Q . .	$\frac{1}{1}\frac{2}{3}$	$\frac{1}{2}\frac{3}{1}$
R . .	$\frac{1}{1}\frac{3}{2}$	$\frac{1}{3}\frac{2}{1}$
S . .	$\frac{1}{2}\frac{1}{3}$	$\frac{2}{1}\frac{3}{1}$
T . .	$\frac{1}{2}\frac{2}{2}$	$\frac{2}{2}\frac{2}{1}$

Weaves on 7 by 7, and on other odd numbers, do not lend themselves so well as those on even numbers to systematic methods of rearrangement. If, however, we place no restriction on the relative numbers of threads and picks, there is plenty of scope for pattern develop-

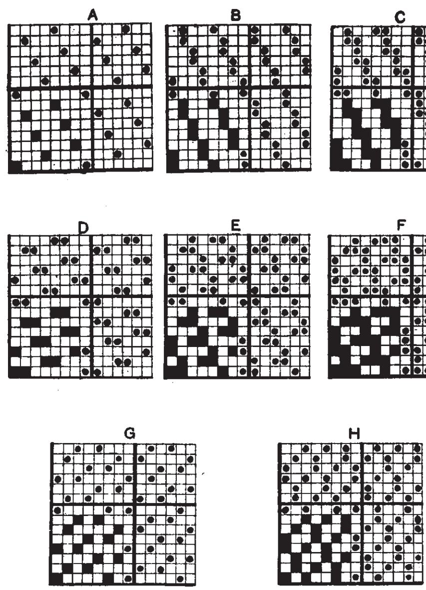


Fig. 34.

ment. In addition, the well-known corkscrew weaves are all produced on an odd number of threads and picks.

If the 7-thread weaves be taken, and the designs be limited to 7 threads and 7 picks, there are four sateen methods of arranging new weaves—viz., on the steps of 2, 3, 4, and 5. In each case, however, the distribution of the spots is the same, although the angle and the direction

of twill may vary. A to H in Fig. 34 show respectively the sateen arrangement of M to T, Fig. 33, constructed with a step of 5 —*i.e.*, in the order 1, 6, 4, 2, 7, 5, 3.

If no restriction be placed on the number of threads for rearrangement, the orders 2, 1 ; 4, 3 ; 6, 5, etc. ; 3, 2, 1 ; 6, 5, 4, etc., may be used. Rearranged according to the

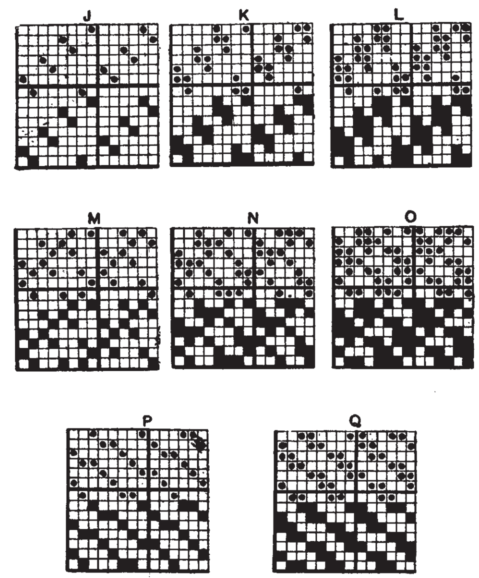


Fig. 35.

first of these orders, we obtain J to Q, Fig. 35, from the 7-thread weaves in Fig. 33. (The weaves in Fig. 35 are repeated only in the way of the weft.) It will be seen that when successive threads are reversed in twos, the number of threads per repeat is double that of the original weave. If reversed in threes, fours, fives, etc., the number of threads will be 3, 4, 5, etc., times the original, provided the number per group of reversed threads is prime to the original number of threads. If otherwise, the design will, naturally, repeat sooner, while, if the group is half the number of threads, the twill is reversed. Similar weaves may be obtained by rearranging the picks instead of the threads; this method would increase the number of picks with a constant number of threads, the reverse of the above method.

In connection with the fundamental weaves up to 7 threads and 7 picks, it has been shown how other weaves on the same number of threads and picks might be systematically obtained, but, before leaving this part of the subject, it is proposed to illustrate it in a more complete manner by showing the variations obtainable on 8 threads and 8 picks by similar rearrangements. Starting with the fundamental 8-thread weave, No. 1, Fig. 36, and proceeding systematically, there are 30 straight weaves which twill to the right, and 30 similar weaves, not shown, which twill to the left.

No.	1	is the reverse of	No.	7	No.	13	is the reverse of	No.	22
,,	2	,,	,,	6	,,	14	,,	,,	23
,,	3	,,	,,	5	,,	15	,,	,,	20
,,	8	,,	,,	12	,,	17	,,	,,	21
,,	9	,,	,,	16	,,	24	,,	,,	26
,,	10	,,	,,	18	,,	25	,,	,,	28
,,	11	,,	,,	19	,,	27	,,	,,	30

While Nos. 4 and 29 have no reverses.

In 14 cases, as noted above, the weaves are the reverses of others shown, but it is desirable to include both the so-called elemental and the reverse twills in this instance in order that the principle may be fully illustrated.

With 8 threads and 8 picks the marks upon each

thread may be arranged in one, two, or three sections

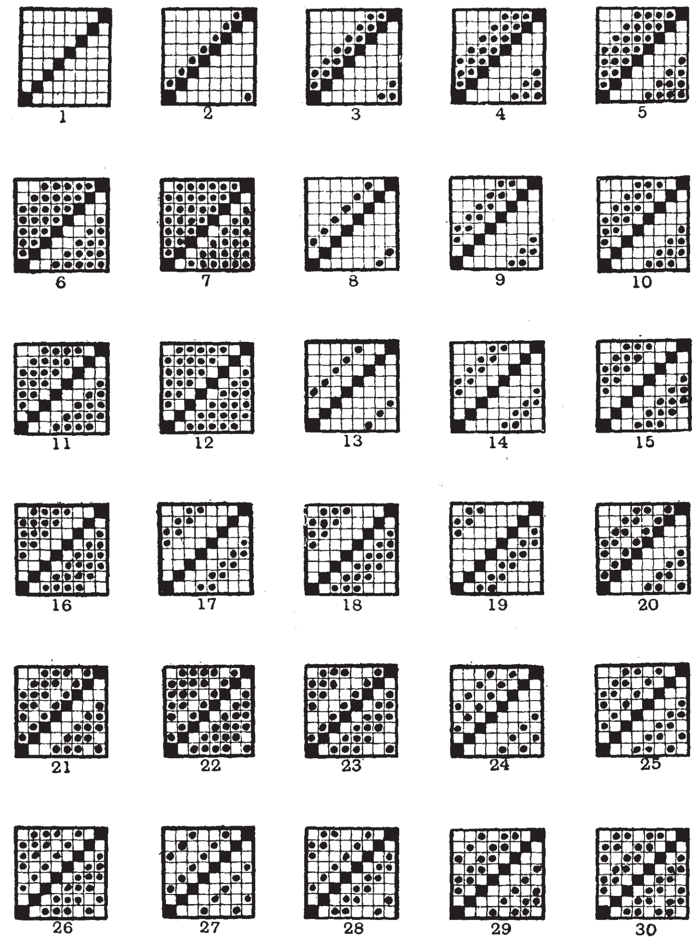


Fig. 36.

or groups, thus breaking up the weave into two, four or six parts. This is clearly shown by the designs themselves, or by the following graphical method. Thus :—

A weave of 2 parts is of the form $\frac{1}{7}\ldots\ldots\frac{7}{1}$
" 4 " " $\frac{1\ \ 1}{1\ \ 5}\ldots\frac{2\ \ 3}{2\ \ 1}$
" 6 " " $\frac{1\ \ 1\ \ 1}{1\ \ 1\ \ 3}\cdot\frac{1\ \ 2\ \ 2}{1\ \ 1\ \ 1}$

In Fig. 36, Nos. 1 to 7 inclusive contain 2 parts.
" 8 " 23 " " 4 "
" 24 " 30 " " 6 "

The evolution of the various designs in the above figure from the fundamental or base weave is clearly indicated in each case.

Nos. 1 to 30, Fig. 37, show the corresponding numbers of Fig. 36 arranged in the 8-thread sateen order, 1, 4, 7, 2, 5, 8, 3, 6. The first seven weaves in this figure are the weaves used for shading purposes in the figures of linen damask, where the 8-thread sateen is the twill adopted. They are also used for similar purposes in cotton, worsted, and silk fabrics. Shading may also be produced by weaves similar to the above, but with the extra marks added horizontally instead of vertically to the same base, No. 1. This method is not so satisfactory in cloths where the weft threads exceed the warp threads to any appreciable extent. Other directions of shading are possible, but those given are, at least for linen damasks, the ones usually employed. No. 4 is sometimes termed the French-grey effect, and, in linen damask, is often used in solid masses to impart a neutral shade to any particular portion of the cloth. It gives a very pleasing effect between the two extremes of weft flush and warp flush, as represented by Nos. 1 and 7 respectively. No. 6 is also an extensively-used weave, and in the woollen trade is known as the buckskin weave, while Nos. 15 and 20 are twilled hopsacks.

Weaves such as No. 18 (that is, those in which the

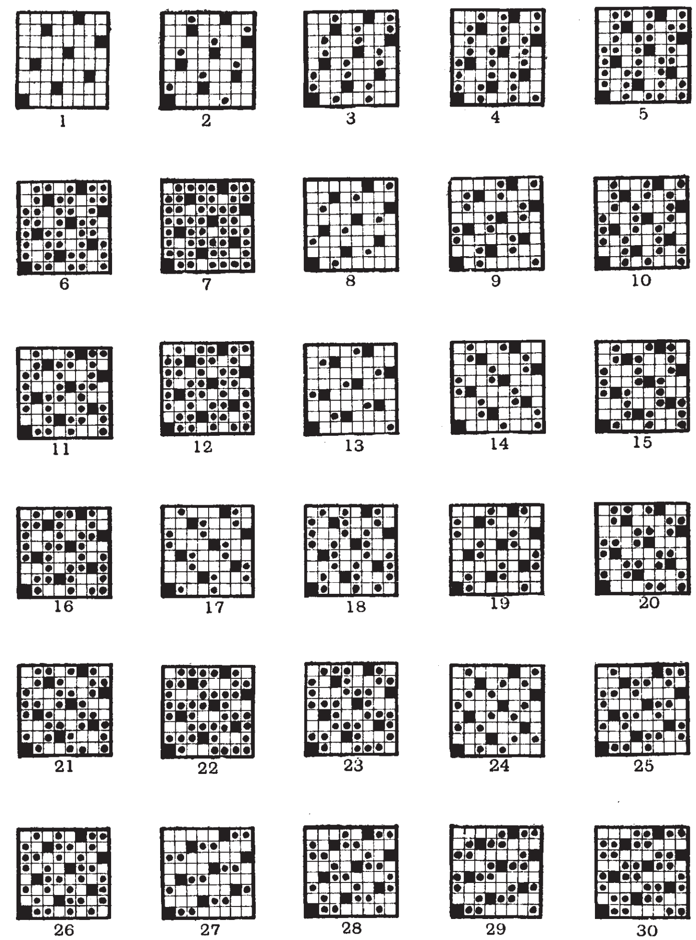


FIG. 37.

warp and weft are equally disposed on each side of the cloth, and where the successive floats are a little removed from each other) form a very valuable series for the production of towels. They produce reversible cloths, and since the floats of warp on each side are not contiguous, a considerable surface of comparatively loose yarn is exposed, and the absorbing power or value of the fabric is consequently increased. A close examination of such weaves shows that the floats in the direction of the warp are greater than those in the direction of the weft. This is the chief reason why the cloth produced has a preponderance of warp floats on both sides. It is naturally assumed that the threads per inch of warp either equal or exceed the picks per inch of the weft, for the actual lengths of the floats of warp and weft in the cloth may be made anything desired by the alteration of the relative numbers of threads and picks. The best results are obtained both in the cloth and in economical production when there is a preponderance of warp threads. A reversal of these conditions and the employment of No. 25 weave, Fig. 37, would give a weft effect on both sides.

Nos. 1 to 30, Fig. 38, show the weaves of Fig. 36 arranged in the order 2, 1, 4, 3, 6, 5, 8, 7. The results obtained by this arrangement are, in some cases, very effective, any tendency to the straight twill effect being generally entirely removed. This method is sometimes resorted to for fancy linings, and for ground weaves in figured fabrics. As a general rule, the fundamental weave is easily traced in the cloth, but occasionally some little difficulty is experienced in tracing the origin. For example, Nos. 24 and 26 would give a combination of straight twill and small warp or weft spots, while several of the others may have a tendency to lead the eye from the original source.

No. 15 is the well-known Mayo or Campbell twill,

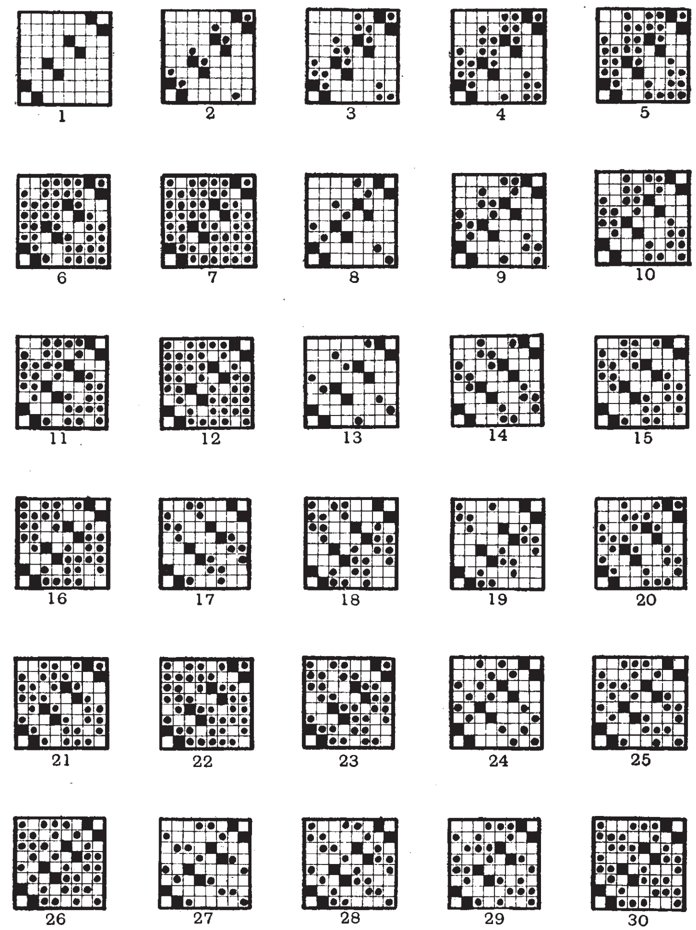


Fig. 38.

largely used in the woollen trade. This weave may also be produced by a sateen base, but the above method is the simpler. In examining any design for the principle of construction, it is advisable first to scrutinise the threads in order to ascertain if all rise and fall in the same order. If they do, the base is clearly a twill.

A more or less irregular rearrangement of the weaves in Fig. 36 is shown in Fig. 39. The base may be considered as the 4-thread imperfect sateen arranged in twill order. This method breaks up the weave more effectively than any of the foregoing methods. Several of these weaves used in combination with straight and other twills give good results in some classes of goods.

A further method of rearrangement of the same 30 weaves is shown in Fig. 40. Here the first four threads remain twilling to the right as in the original weaves, while the remaining four threads are reversed. It will be observed that all these weaves are also systematically obtained from No. 1, Fig. 36.

Other orders of forming weaves by rearrangement on 8 threads and 8 picks may be resorted to—*e.g.*, 1, 2, 4, 3, 6, 5, 8, 7; 1, 2, 3, 4, 6, 5, 8, 7; 1, 2, 3, 4, 5, 6, 8, 7; 1, 3, 5, 7, 2, 4, 6, 8; but the methods illustrated are probably the most valuable. It is possible to increase greatly the number of weaves on eight threads if no restriction be placed on the number of picks, and *vice versa*, if no limit be imposed on the number of threads. For instance, by the rearrangement 2, 1, 3, 2, 4, 3, 5, 4, 6, 5, 7, 6, 8, 7, 1, 8, a weave is obtained on 16 threads and 8 picks, but this method has been sufficiently illustrated in connection with 7-thread weaves.

In addition to the various systems of rearrangement already indicated for the formation of new weaves, there are several methods of combination by which other new

designs may be formed from simple twills. Thus, any

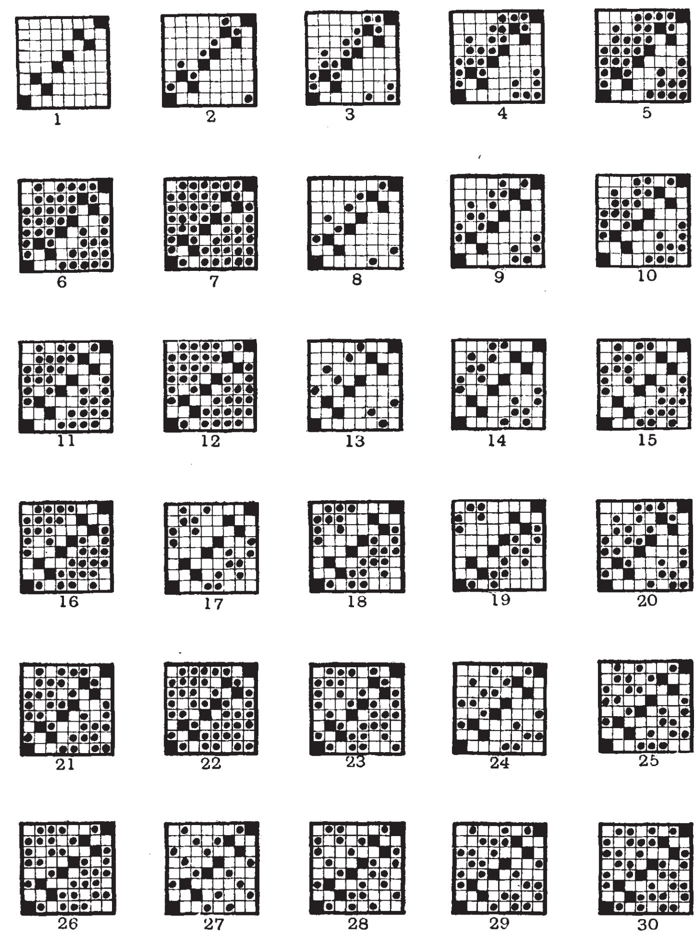


Fig. 39.

two 8-thread weaves may be selected, and combined thread by thread alternately to produce a new design on 16

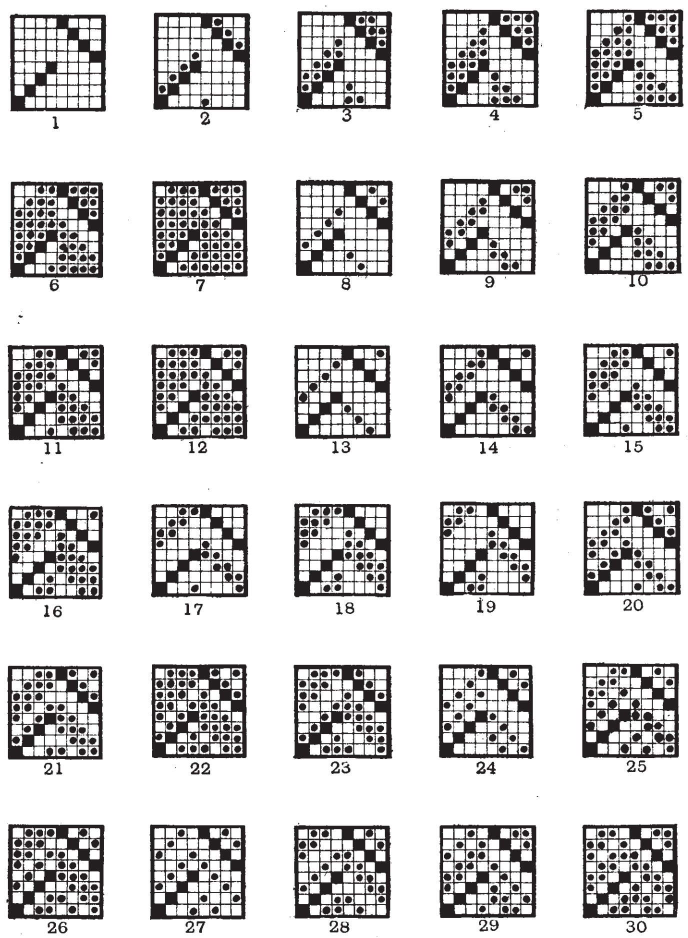


FIG. 40.

threads and 8 picks; or the same two weaves may be

combined pick by pick alternately, the result being a new pattern on 8 threads and 16 picks. In each case the general principle is the same. Two illustrations of each method are given in Fig. 41, the solid marks, in all the plans, representing the complete design. A and B are examples of the former type of combination, and C and D

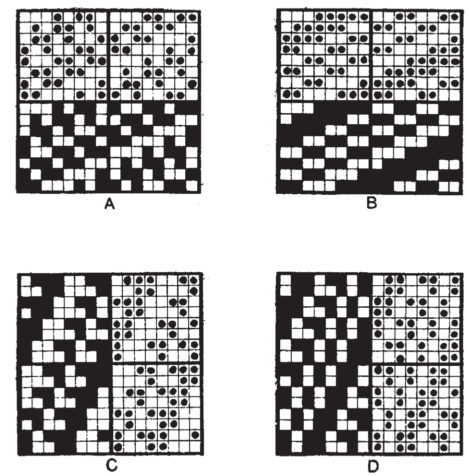


FIG. 41.

of the latter. It will be seen, on referring to Fig. 36, that

Design	A	is obtained	from Nos.	20	and	28
,,	B	,,	,,	25	,,	26
,,	C	,,	,,	17	,,	23
,,	D	,,	,,	28	,,	30

The solid marks indicate clearly that the method employed for designs A and B doubles the number of shafts necessary for their production when the threads in each design are different, whereas no increase of shafts is required for designs C and D. The principle is, of course, applicable to weave units on any number of threads and picks; it being understood that for this particular method

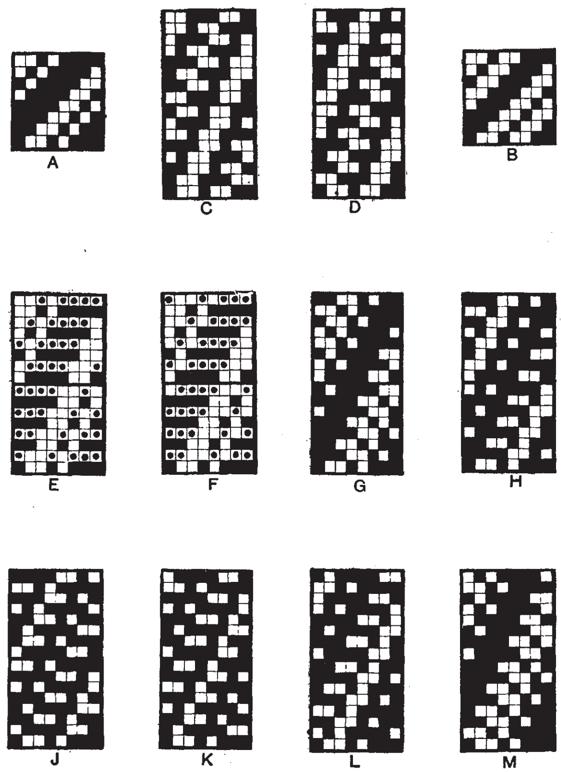


Fig. 42.

the two units selected shall be complete on the same number in each direction.

Figs. 42 and 43 show more complete methods of forming such weaves; the designs in the former figure being arranged pick and pick. The unit weave A appears

on odd picks in precisely the same order in designs E to M inclusive, while the even picks are taken from the same

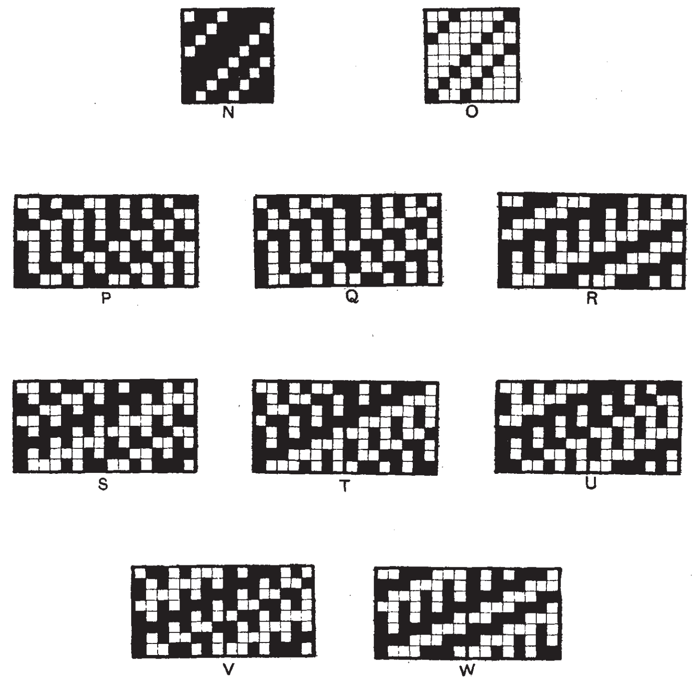


Fig. 43.

unit A, but in each design the unit commences with a different pick. Thus:—

In Design	E	the even picks	commence with pick	1	of unit A
"	F	"	"	2	"
"	G	"	"	3	"
"	H	"	"	4	"
"	J	"	"	5	"
"	K	"	"	6	"
"	L	"	"	7	"
"	M	"	"	8	"

C and D are made in a similar manner from weave unit B, the even picks commencing with the 6th and 5th respectively.

The designs in Fig. 43 are arranged thread and thread; the odd threads in each design are in the same order, and are taken from weave N. The even threads are, in this case, taken from O, an entirely different weave, and each design commences with a different thread of weave O.

Combinations of similar units may be effected in many other regular or irregular orders—*e.g.*, 2 threads of one unit followed by 1 thread of another or the same unit; 3 threads of one, 1 thread of another or the same; 2 threads and 2 threads, and so on; but the thread-and-thread and the pick-and-pick methods illustrated are those most commonly adopted. Care and judgment must, however, be exercised in the selection of the units, otherwise the result may be very different from what is expected. In some cases no satisfactory weave would result, while in others, weaves of a compound nature might be formed. We have purposely chosen units for the designs in Fig. 43 to illustrate this possibility; designs R and W fulfilling the requirements for certain compound weaves, while designs C and D in Fig. 42 are of a similar nature.

In the above instances the units chosen for combination are each complete on the same number of threads and picks (8 by 8), but similar combinations may also be effected between units which are not complete on equal numbers. For example, a 3-thread by 3-pick weave may be combined with a 4-thread by 4-pick weave, or a 4 by 4 with a 5 by 5, and so on. In such cases it is desirable to know what dimensions the completed combination will possess. In the simple cases already illustrated, it is easy to see that two 8 by 8 weaves, if combined thread by thread, must result in a 16-thread weave; similarly, if combined pick by pick, they would give a design on 16 picks. In other words, if combined thread by thread, the new weave would be complete on twice the number of threads in the unit, and, if combined pick by pick, on twice the number of picks in the unit. A slight difference obtains, however, where the units are complete on different numbers. If the combination is thread by thread, the new design, when complete, would contain threads equal to twice the least common multiple of the two units, and picks equal to their L.C.M. If combined pick by pick, the number of picks in the new design would be twice the L.C.M., and the threads equal to the L.C.M. of the units. Thus, a combination of two units, one on 3 by 3 and the other on 4 by 4, would result in a new design on 24 threads and 12 picks, since 12 is the L.C.M. of 3 and 4. Similarly, two units, on 5 by 5 and 6 by 6 respectively, would give a thread-by-thread combination on 60 threads and 30 picks. One example of this method of combination is illustrated at E in Fig. 44; the units from which it has been formed appear at F and G. Since the design E is composed wholly of threads from the units F and G, it follows that the number of shafts required must be 7, for no two threads in the two units are the same. The draft of the design E is shown at H, while two repeats of the weaving plan appear at J in the same figure.

Such combinations may not be of great interest to textile students in the jute and linen industries, but the principle involved is an important one, and therefore worthy of attention. One obvious result of the procedure is the alteration of the angle of the twill; the diagonal produced by the thread-and-thread method forms, with the horizontal, an angle of between 26° and 27°, while the pick-and-pick method gives an angle of about 64°. These figures refer, of course, to the effect upon "square" design paper, the actual angle upon the cloth being chiefly

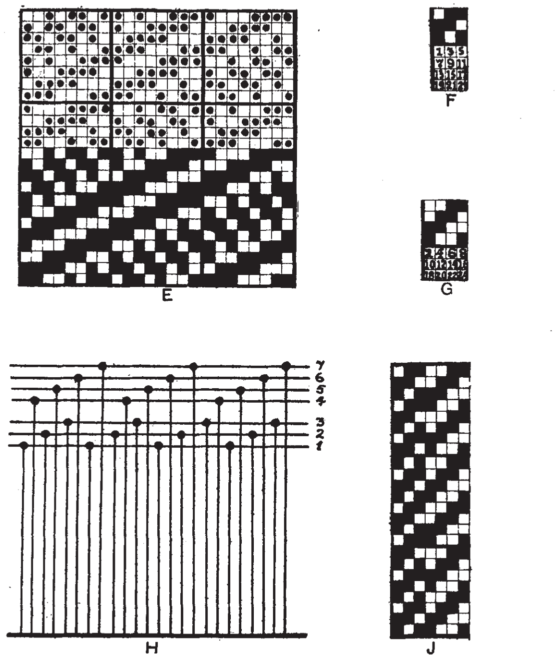


FIG. 44.

dependent upon the relative number of warp and weft threads per inch.

A further method of combination is also available whereby a new 8-thread by 8-pick design may be formed by combining alternate threads, or alternate picks of any two 8 by 8 twills. Thus, K to V, Fig. 45, have been formed in this manner from the units indicated in Fig. 36.

			Nos.		
K	has been obtained by combining	alternate thds. of	17	and	18
L	"	"	17	"	14
M	"	"	24	"	12
N	"	"	17	"	11
O	"	"	10	"	15
P	"	"	24	"	10
Q	"	"	8	"	15
R	"	"	17	"	15
S	"	"	14	"	23
T	"	"	20	"	15
U	"	"	24	"	21
V	"	"	17	"	21

This method results in some very characteristic and pleasing effects, but, as a general rule, care should be taken to select for combination those units which have approximately the same "take-up" or structural value. This condition is, however, not absolutely essential, for it frequently happens that elegant effects are obtained by the combination of threads the interlacing powers of which are very different. The units Nos. 24 and 12 (Fig. 36), from which M (Fig. 45) is composed, are different in this respect, since No. 24 is a weave of 6 parts and No. 12 a weave of 4 parts; for this reason it is just possible that alternate threads might have a tendency to hang slack. Otherwise the design suggests an effect of the huck nature, but which would probably be considerably modified in the cloth.

Another prolific method for the systematical production of small or ground weave effects is the process known as reversing. Any small weave or effect, say on 2 threads and 3 picks, 2 by 4, 3 by 3, 4 by 4, 5 by 5, etc., may be taken and reversed, first in the direction of the warp, and then in the direction of the weft; this double reverse gives a design which is complete on twice the number of threads and picks contained in the original effect selected. The first stage of this process is seen at A in Fig. 46, where a small effect on 2 threads and 4 picks is shown. At B, the second stage, another 4 picks have been added, these being exactly the reverse of the first four (that is, the fifth pick is the reverse of the fourth, the sixth of the third, the

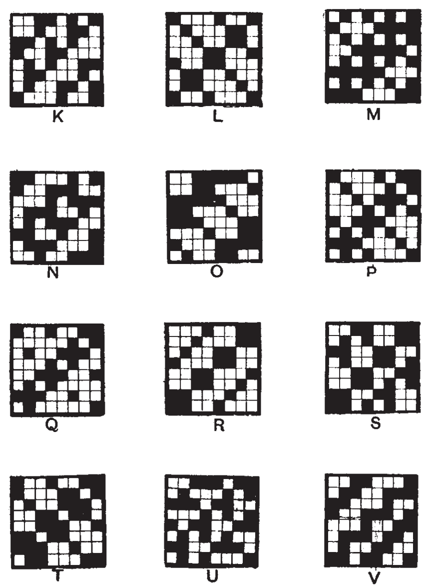


Fig. 45.

seventh of the second, and the eighth of the first). The third stage C shows the complete effect on four threads, the two threads added here being exactly the reverse, according to the above definition, of the two threads shown at B. Two repeats of the complete weave on 4 threads and 8 picks are shown at D. E, in the same figure, is a similar effect developed from a 3 by 3 unit, and

therefore complete on 6 by 6, while the small designs F to N show 8 effects on 8 by 8 developed in a similar manner, each one from a 4 by 4 unit.

Some of the results of this process of reversing are, as already indicated, valuable in themselves as ground weaves,

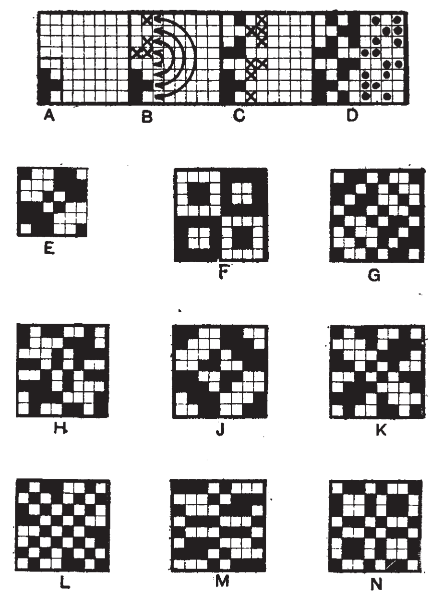


Fig. 46.

while others, such as E, F, H, and N, might serve as motives or bases for larger designs. Others, again, such as D and M, result in weaves which approach the crêpe type. That extensive class of design, too, generally known as dice patterns, is really of this character. They will, however, be treated as a class by themselves.

CHAPTER III

MOCK LENOS, HUCKABACKS, HONEYCOMBS, ETC.

Several designs developed by the above method produce such highly characteristic results in the cloth that they are classed apart under the term of mock leno or imitation gauze effects. They are so called because the cloth produced imitates, to a considerable degree, the openwork appearance of a true gauze fabric. This result is due, in about equal proportions, to the character of the weave itself, and to the method of reeding adopted. The latter should be in threes, fours, fives, etc., according to the number of threads occupied by the initial small effect adopted. When this is so, the dents of the reed gather the warp threads together into natural groups or divisions, a proceeding which is materially aided by the character of the design. Thus the first three threads of O, Fig. 47, must be in one split of the reed, and the second three threads in the next split, in order that the reed may assist the tendency of threads 3 and 4, which weave plain, and of threads 6 and 1, which do likewise, to force themselves apart; or, what amounts to the same thing, to allow threads 1 and 3, and also threads 4 and 6, to approach each other closely. This inclination to gather together in threes is also influenced by the binding nature of the second and fifth picks, which float alternately, over the threads in one split and under the threads in the next. A similar, but modified, result is obtained in the way of the weft, only in this direction no assistance is received from the reed. Increased openings among the warp may naturally be obtained by omitting one or more splits every three

threads, but the character of the cloth would be slightly altered, as a corresponding alteration could not conveniently be made in the spacing of the weft.

The 8 by 8 imitation gauze is shown at P in Fig. 47, while the drafts and weaving plans for both designs are given at Q, R, S, and T. It will be seen that each design requires four shafts, while the correct method of reeding is shown by the heavy horizontal lines in Q and R; the

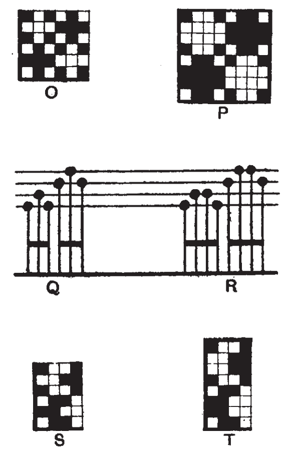


FIG. 47.

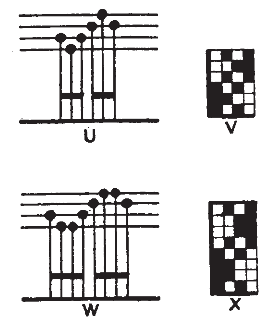


FIG. 48.

threads of the former draft are grouped in threes, whereas those of the latter appear in fours.

At this point we might just mention the fact that there are usually several ways of arranging the draft of any design, but each change of draft necessitates a corresponding change in the weaving plan. In general it is desirable to arrange the draft in the simplest possible manner, unless other factors demand consideration, and at U and W in Fig. 48 we illustrate the most desirable drafts for the two designs O and P in Fig. 47. There is certainly little difference in the two methods, but those at U and W are better, from the weaver's point of view, than the corresponding ones at Q and R. The new weaving plans are shown at V and X respectively in Fig. 48.

When the warp threads are closely set, it is a common practice to place nearest the reed those shafts which rise and fall the most times in a repeat of the weave. When, however, the number of shafts in use is very small, as in the above instances, it matters little what position any particular shaft may occupy; consequently, we may draft the design to suit the weaver's convenience.

A, B, and C, Fig. 49, are designs of the same nature as those in the previous figure, but they occupy 10 by 6, 10 by 10, and 14 by 14 respectively. The best results are obtained when the warp threads for these designs are reeded as follows:—

A with 5 threads per split.
B ,, 5 ,,
C ,, 7 ,,

Consequently the designs are most suitable for fine setts. Workable drafts and weaving plans accompany the designs at D to J in the same figure, but it might be preferable to use the huckaback draft (to be shown immediately) and the weaving plans K, L, and M. Both are included in the following table:—

Design.	Draft.	Weaving Plan.
A	D	G
A	Huckaback	K
B	E	H
B	Huckaback	L
C	F	J
C	Huckaback	M

Such weaves on 6 by 6 and on 8 by 8 are extensively used in linens and jutes for embroidery cloths, and in

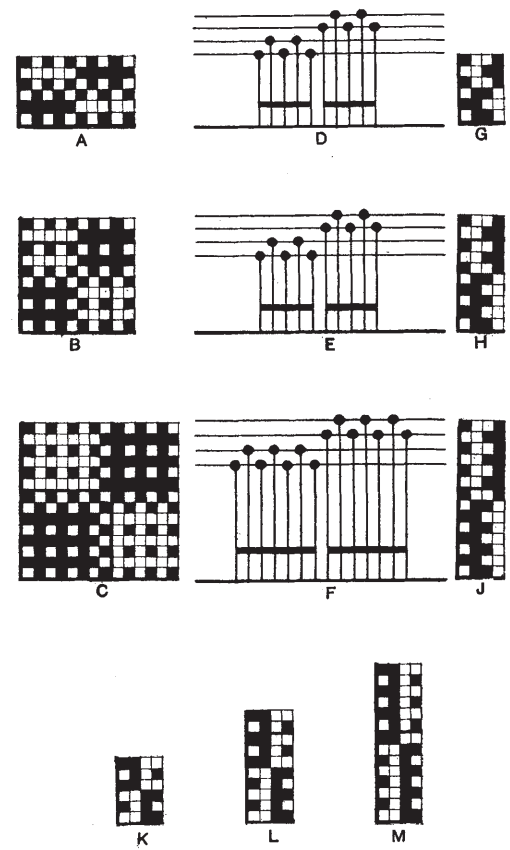


Fig. 49.

cottons and worsteds for fancy household articles, as ground weaves in figured fabrics, or as embellishments of plainer types of weaving.

Huckabacks.—These weaves produce a style of cloth which continues to maintain a wide and deserved popularity, both in piece-goods and in towels. It might appear at first sight as if they were natural developments of the foregoing imitation gauze weaves, but the evolution, if there is any connection of this character, is probably in the opposite direction. The simplest form of huckaback is that on 10 threads and 6 picks, as shown at A in Fig. 50. It is commonly known as the "Devon" huck, but is sometimes termed a "Medical" huck. The order of drafting is given at B (this is termed the huckaback draft), and is a more convenient form than that shown at D, Fig. 49. It is usual to reed the warp for these weaves in a special manner—3 threads and 2 threads per split alternately,—to avoid or prevent the tendency of the warp threads to split up into sections. Thus threads 2, 3, and 4 are drawn in one split, threads 5 and 6 in the second; 7, 8, and 9 in the third, 10 and 1 in the fourth, and so on. Sometimes the warp is reeded throughout 2 threads per split. Both methods are indicated in the usual manner at B, Fig. 50. In the alternate 3 and 2 method of reeding, the two floating threads are in the same split of the reed. A similar arrangement of reeding is occasionally employed in order to separate the floating threads; thus, | 3.4 | 5.6.7 | 8.9 | 10.1.2 |. In any case the method of reeding has no effect upon the weaving plan, which is shown at C in the same figure.

When the threads are drawn through the camb in the manner indicated, it is possible to use the same camb and warp for plain cloth as well as for huckaback. The draft shows clearly that all the odd threads of the warp are on the front two shafts, while all the even threads are on the two back shafts. To weave plain cloth it is only necessary to couple the shafts as indicated at P and Q, and to actuate

them by an ordinary plain wyper, or by the two plain blades (Nos. 1 and 4) of the huckaback tappet. The weft for the "Devon" huck is almost invariably double or two-fold. It is sometimes prepared on the doubling or twisting frame with a minimum amount of twist, but is more fre-

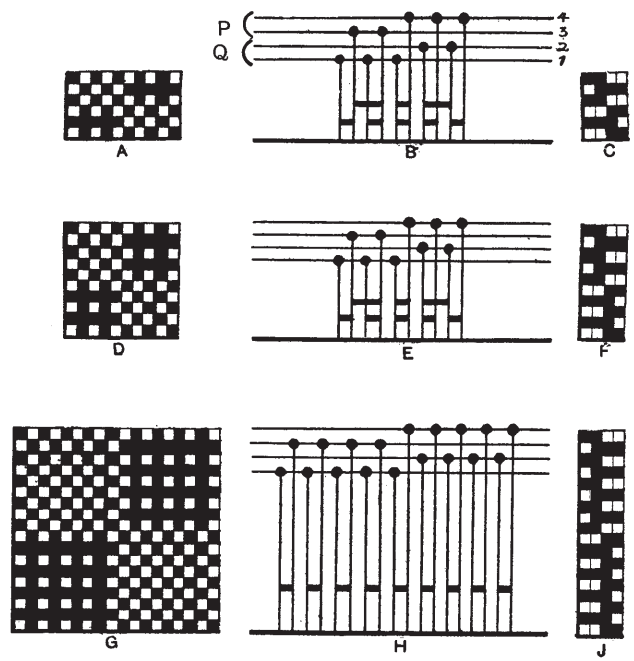


Fig. 50.

quently wound direct to the pirn from two separate hanks. Occasionally the double weft is obtained by inserting two cops in the same shuttle. With this weave and the double weft it is possible to approach the effect obtained by the ordinary huckaback in about three-fifths of the time taken to make the latter.

The ordinary, or 10 by 10, huckaback is shown at D, Fig. 50, while the draft and the weaving plan appear at E and F. The two patterns A and D are so similar that further comment is unnecessary. A further development of this type of weave is illustrated at G with the necessary draft H and weaving plan J. This weave is usually termed the basket or honeycomb huck, and, as a rule, the threads are reeded two per split as shown.

When the Woodcroft tappet is the mechanism employed for the weaving of these cloths, some rather elegant cross-border effects may be obtained by a slight alteration of the cords J (see Figs. 57 and 58, pp. 89 and 90, *Jute and Linen Weaving*, Part I.) with respect to the treadles C. The cords which connect the treadles C to levers G, and thence to the shafts F, may be so arranged that any one may be easily removed from one treadle C to another; this may be conveniently done by employing metal links or leather attachments, which the weaver can slip off and on the treadles at will.

In Figs. 51 and 52 we show six huckaback weaving plans at A, each one identical with F, Fig. 50. From each plan A depend four lines connecting the ends of the treadles C. When the cords are in this order, and the draft is as given at E, Fig. 50, the ordinary huckaback is produced. But if we take the link from the third treadle and place it on the first, and also remove the link from the second treadle and place it on the fourth, the first and fourth treadles would be carrying two links each, and, in virtue of the further connections, would actuate two shafts each, according to lines 1 and 4 of the weaving plan A. Blades 2 and 3 of the tappet would, of course, continue to revolve and to impart their motion to the second and third treadles, but, these being disconnected from the shafts, would have no effect

upon the movements of the latter. The movements of the

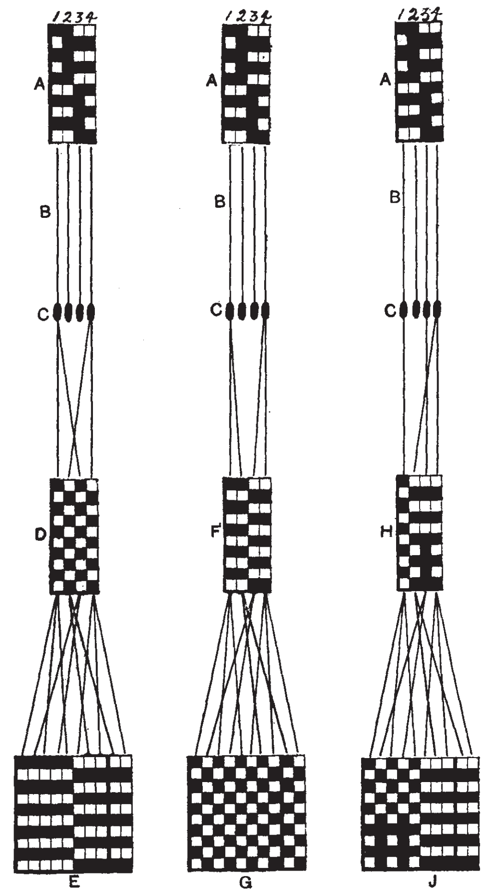


Fig. 51.

shafts, under the altered condition, are shown by the plan D, which indicates distinctly that Nos. 1 and 3 have now the same movements, as also have Nos. 2 and 4. The lines

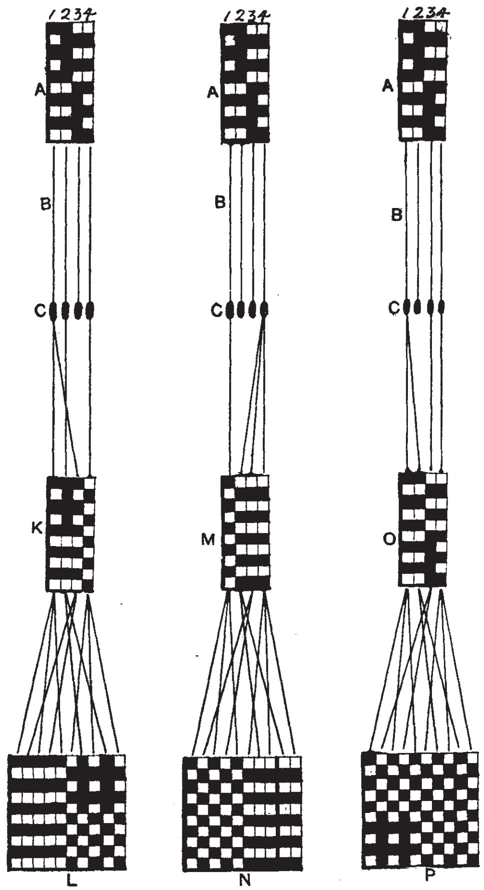


FIG. 52.

connecting the treadles C and the plan D are intended to show, in a graphic method, the change just described—viz.,

that Nos. 1 and 3 of the new plan D are controlled from No. 1 of the old plan A, and, similarly, that Nos. 2 and 4 of D are now both actuated from No. 4 of A. The effect of this change in the action of the shafts, with the huckaback draft, is given at E, a weft rib weave. The lines between plan D and design E simply indicate the draft. If No. 1 treadle carries the first and second links, and No. 4 treadle carries the third and fourth links, the resulting plan would be as at F, while the weave produced would be plain, as at G. Similarly, the plans H, K, M, and O are rearrangements of the original plans A, and they produce respectively weaves J, L, N, and P, for the draft is the same in each case.

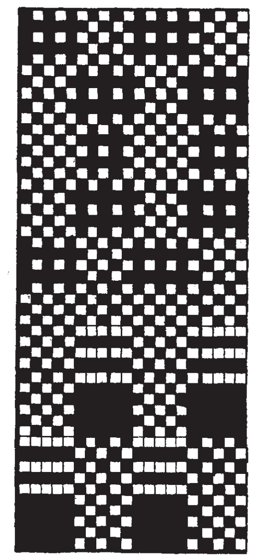


FIG. 53.

The weave E is of the same character as those illustrated in Figs. 14 and 16, p. 14. Such weaves take up a large quantity of weft, and unless special provision is made for the selvages, the latter would resist the insertion of a great number of picks per inch for any great distance. Fortunately this is seldom required, as the most effective results are obtained by a moderately narrow rib, where special provision for selvages is unnecessary.

The three effects E, G, and N, Figs. 51 and 52, have the advantage that the weaver may change at any point without fear of making an imperfect joining in the cloth; and little, if any, consideration is needed in the case of J, L, and P, when, as is invariably the case, they are preceded and followed immediately by either E or G. Other slightly more elaborate results might be obtained, but they would scarcely justify the extra care and attention involved on the part of the weaver. These effects are, however, of great educational value, and the reader is advised to study Fig. 53 from the same standpoint.

There is certainly some friction caused by the working of the cross bands, but this disadvantage is, in many cases, more than counterbalanced by the results. It is scarcely necessary to state that designs A and G, Fig. 50, may be treated in a manner analogous to that described with regard to D, nor is it necessary to enlarge upon the fact that all these results may be obtained in the dobby by means of double or treble decked barrels. Five or six different effects have been produced by dobbies fitted up on this principle.

Other varieties of the huckaback type of weave, with suitable drafts and weaving plans, are given in Fig. 54.

Design.	Draft.	Weaving Plan.
A on 8 × 8	B	C
D on 8 × 8	E	F
G on 10 × 8	H	J
K on 10 × 6	L	M

It is not absolutely necessary that the drafts should be as above; other arrangements may obtain, in which case the weaving plans would require corresponding alterations. Weaves of the above type have a two-fold feature; the bulk of the weave being plain, a moderately firm cloth can be made even in a coarse set, while the long floats of warp

and weft impart a maximum absorptive surface to the fabric.

Honeycombs.—Another type of weave, the cloths from which possess a large surface area for absorption, is that known as the "honeycomb." The different forms and

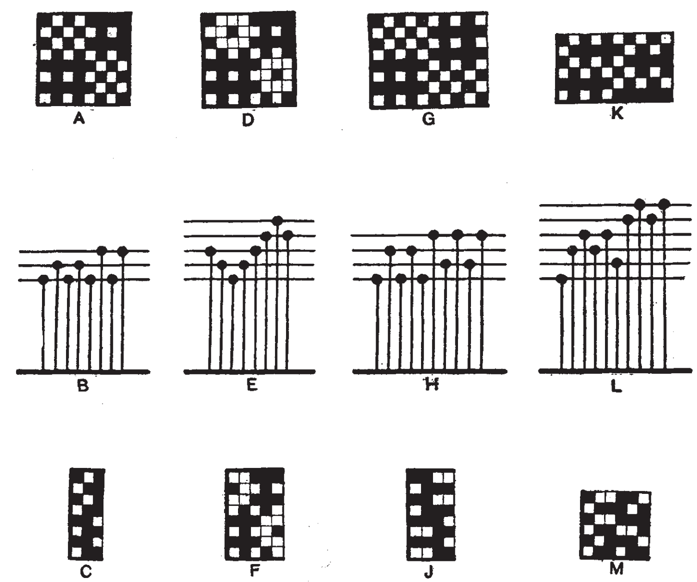


Fig. 54.

sizes of this weave are used extensively in towels, bed quilts, and covers, and in many other ways for the decoration of fabrics. The name "honeycomb," as applied in this case, is derived from the cell-like appearance which the weaves impart to both sides of the fabric.

In Figs. 55 and 56 we illustrate a few of the smallest, but most important of this useful series, with their drafts, weaving plans, and structural bases. The arrangement is given below :—

Design (4 repeats).	Structural Base.	Draft (2 repeats).	Complete Weaving Plan.
A	B	C	D
E	F	G	H
J	K	L	M
N	O	P	Q

A is the common weave of this section, and this, as well as others produced from a base similar to B, are sometimes termed "perfect honeycombs." The interlacing power of the threads in such weaves varies considerably, and it frequently happens that the first thread in each repeat, which rises and falls only once in each repeat, hangs loosely on the cloth. In this respect the design E is superior, for here the threads are more uniform in their movements and a firmer cloth results; moreover, the difference in design is scarcely perceptible. J and N are practically the same design; the latter, however, is capable of being woven with one shaft less than what is required for the former. The solid marks in B, F, K, and O show the structural bases, while the solid dots in C, G, L and P indicate one complete repeat of each draft. Although we have reduced the draft to the least number of shafts, it is a common rule to find all these designs woven with straight drafts; A, E, and J on eight shafts, and N on six shafts.

The cell-like appearance referred to above is the result of the difference in weave structure of the main portions of the design. For example, at the intersection of the 8th, 9th, and 10th threads with the same picks of design A, the weave is virtually plain, whereas the 9th thread

and the 9th pick float over 7 picks and 5 threads respectively, before joining to form part of the plain cloth.

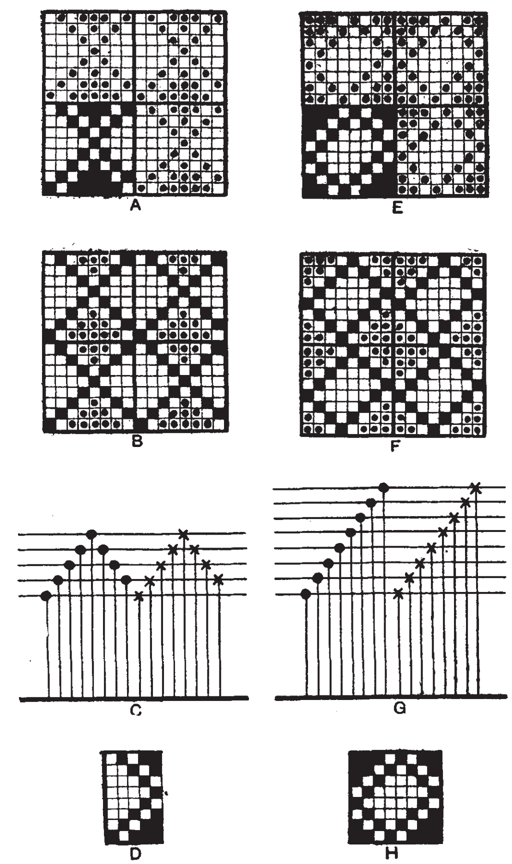


FIG. 55.

The 1st thread and 1st pick are identical with the 9th, while at the intersection of the 4th, 5th, and 6th threads and picks the plain portion again occurs. We have thus a plain portion in the centre of a square formed by floats of

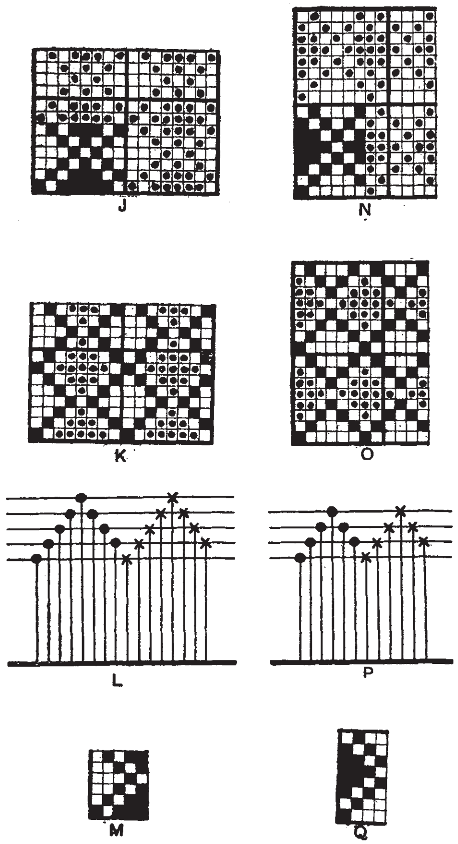


Fig. 56.

varying length of warp and weft. The change from one extreme to the other is perfectly gradual, and the threads and picks therefore form a tier of squares around the

central portions, such tiers being raised in proportion as the length of float is increased. In weaving generally it may be taken almost as an axiom that the longer the float the more prominent will the yarn appear on the surface of the fabric. This simple fact is of considerable value in the synthesis of fabrics, and does not usually receive the attention which its importance deserves. In the fabric under consideration the tightening effect of the plain weave draws the cloth down at that portion to form the bottom of the cell, the top being formed by floating the 1st and 9th threads and picks. A similar result is produced on the opposite side of the cloth by the plain portion at the intersection of the 8th, 9th, and 10th threads and picks, the floating threads and picks in this instance being the 5th and 13th.

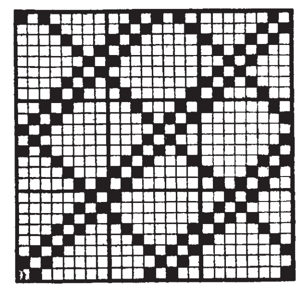


Fig. 57.

The base at F in Figs. 55 and 56 is very simple, but in order to show the analogy between design E in the same figure and the so-called Brighton weaves, we illustrate in Fig. 57 another base for the same class of weaves. This figure shows four repeats, the unit being on 12 by 12.

R and T, Fig. 58, are two designs constructed with the base shown in Fig. 57. R will be recognised as of type E, Fig. 55, but since it contains floats of nine, it is suitable only for fine sets. Our object in introducing this weave is not so much to supply a larger design as to illustrate the adaptation of coloured threads and picks to weaves of this character.

If the order of warping and wefting for R, Fig. 58, be 2 threads dark, 10 threads light, the dark threads and picks would appear on the surface only at the centres of the cells

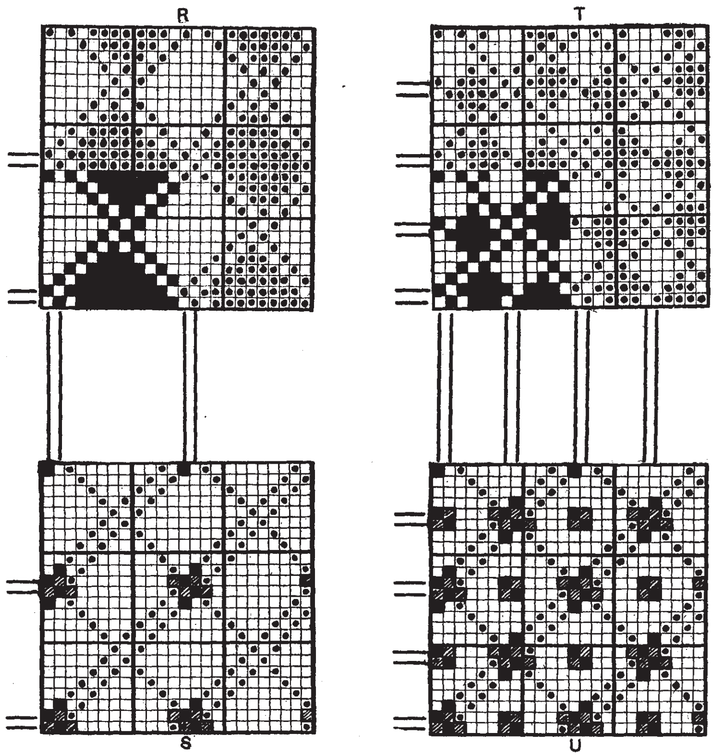


Fig. 58.

—*i.e.*, where the plain weaving occurs,—and the result in the cloth would in consequence be somewhat similar to the effect shown at S. Here the solid squares represent the dark warp, and the shaded squares represent the dark weft.

At all other parts the dark threads float on the back, where they would form the highest part of the cells. On the face side, the small figures would be distributed in the form of a square as shown; the dots simply show the base of the design. At T in the same figure we give the 12 by 12 Brighton plan; if the warp and weft for this be arranged 2 dark 4 light, a similar effect will be obtained. In this case, according to the figure U, the spots are of two

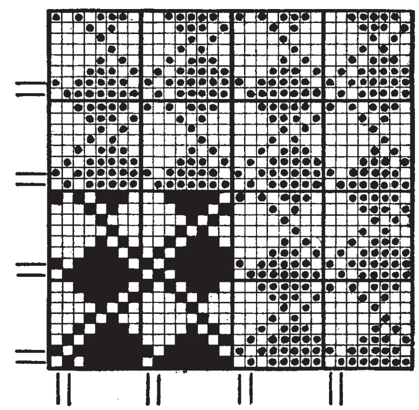


Fig. 59.

sizes. In the cloth, however, the smaller ones are scarcely visible, while the larger ones appear in diamond form. The dots again show the structural base, while in both the designs and in the effects the vertical and horizontal lines show the positions of the dark threads and picks respectively. The 12 by 12 Brighton, T, Fig. 58, which is sometimes employed with flax warp and soft cotton weft for towels, is on the whole on the small side for the colour effect. A more elegant effect is obtained by one on 16 by 16, four repeats of which we show in Fig. 59. The order of colouring in both warp and weft for this cloth, which is not reversible, is 2 dark, 6 light, as indicated by the short lines at the bottom and on the left-hand side of the design.

CHAPTER IV

CRÊPES AND OTHER GROUND WEAVES

Crêpes.—Another very important and interesting class of ground weaves are those termed crêpes. They are used in the construction of a large variety of fabrics, particularly in cotton, linen, and union towelling, linen and other dress goods, in silk ties, mufflers, damasks, and tapestries, while in a lesser degree they appear in certain linen damasks for the purpose of imparting a neutral shade to some portions of the design. The chief object of these weaves is to impart a rough surface to the cloth, and at the same time to avoid all tendency to a twilled or other prominent effect. In order to fulfil these conditions, the repeat or unit of the weave should not be clearly defined, nor should either warp or weft float predominate unduly on one side of the cloth.

The simplest, and probably the most useful example of this type, is the $\frac{2}{2}$ serge twill arranged in the broken twill order 1, 2, 4, 3, see A, Fig. 60. Another example on 6 threads and 6 picks, but capable of being woven with 3 shafts, is given at B, while a very widely adopted weave of a similar character, often termed the oatmeal weave, appears at C. This design consists of four alternate threads of the 8-shaft twill, $\frac{3}{3}\frac{1}{1}$, arranged in the 4-thread broken twill order, on the even threads of an 8 by 8 block;

while the odd threads of this block are filled in plain. The method of construction is shown at CX, from which it is apparent that the weave could be drafted on, and woven with 5 shafts; it is, however, more usually woven with a straight draft on 8 shafts. At a first glance, the design D in the same figure might seem to be exactly

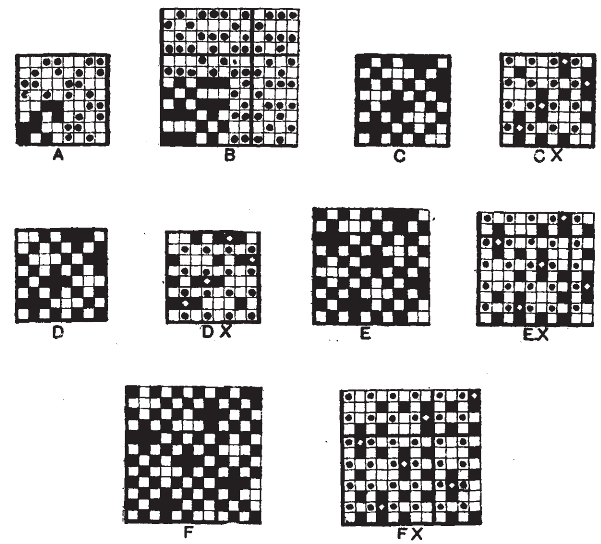


Fig. 60.

the same weave as C, but it is different in respect that it is developed by way of the weft, instead of the warp, as in the case of C. It is at present being utilised in the manufacture of ladies' summer hats; the yarns used are either single or 2-ply jute. As shown by the constructional plan DX, the even picks are arranged $\frac{3}{3}\frac{1}{1}$ in the 4-thread broken twill order, while the odd picks are filled in plain. The results in the cloth are somewhat different, as may be seen on referring to Fig. 62, which is a photographic reproduction of samples of cloth made in

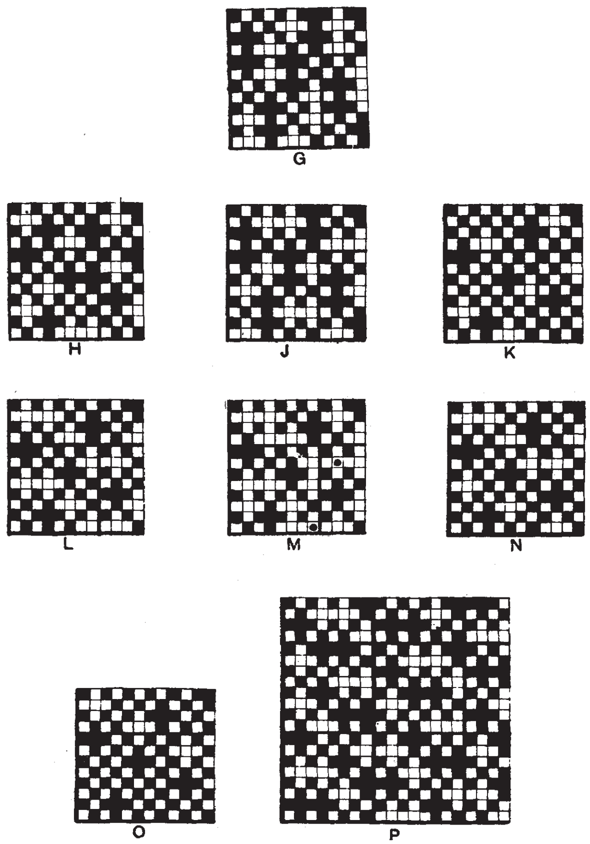


FIG. 61.

the weaves given in Fig. 60. The cloths in Fig. 62 bear the corresponding letters of the designs in Fig. 60. In the two cases under notice—*i.e.*, C and D—the weft gives the

more characteristic effect in the former, while in the

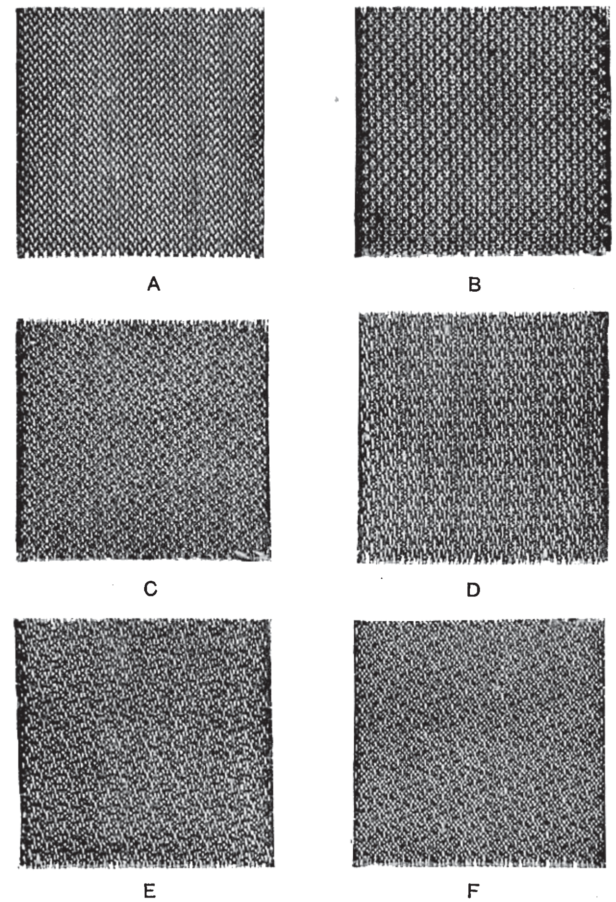


FIG. 62.

latter the floats of the warp threads have the greater deflection.

Other weaves of a similar nature may be systematically produced on any even number of threads and picks, by adopting the sateen or broken twill basis of distribution for the floating threads or picks, and arranging the intervening ones to work plain. Design E, Fig. 60, is a weave on 10 by 10, constructed on this principle. Alternate threads of the 10-thread twill $\frac{3}{1}\frac{1}{1}\frac{1}{3}$ are arranged in 5-thread sateen order on the even threads of design EX; the odd threads are then marked in plain weave. F and FX show the weave and structural base of a similar effect on 12 by 12. The floating threads in this case are taken from the $\frac{3}{3}\frac{1}{1}\frac{1}{1}\frac{1}{1}$ twill, and are then arranged in the 6-thread broken twill order—2, 5, 3, 1, 4, 6. In the determination of the order of weaving of these floating threads it is desirable to remember that the best results will probably be obtained when the warp and the weft are floated equally on both sides of the cloth.

The condition of equal warp and weft floats on both sides of the cloth is observed in plan G, Fig. 61, where the floating threads are of the type, $\frac{5}{5}\frac{1}{1}$. The basis of distribution of the floating threads indicated in FX, Fig. 60, is also employed in design H, but here the floating threads weave differently. Thus, threads 4, 8, and 12 are taken from the $\frac{3}{3}\frac{1}{1}\frac{3}{1}$ twill, while threads 2, 6, and 10 form part of the $\frac{3}{3}\frac{1}{3}\frac{1}{1}$ twill; thus, the combination preserves the equal distribution of warp and weft on both sides of the cloth.

Design J is arranged on the FX basis, with the floating threads weaving $\frac{5}{3}\frac{1}{3}$; K with similar threads weaving $\frac{3}{1}\frac{1}{1}\frac{1}{3}\frac{1}{1}$; and L with the threads weaving $\frac{3}{3}\frac{1}{1}\frac{1}{3}$; this latter arrangement gives unequal distribution of warp and weft. Plan M is constructed in a similar manner with the floating threads weaving $\frac{3}{3}\frac{1}{5}$, but at two points (the

8th thread and the 1st pick, and the 10th thread and the

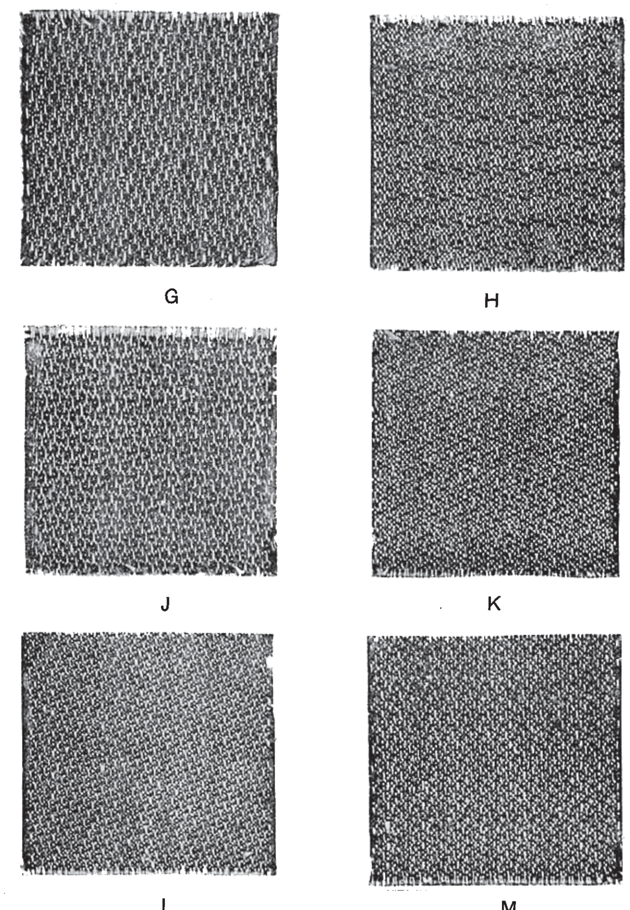
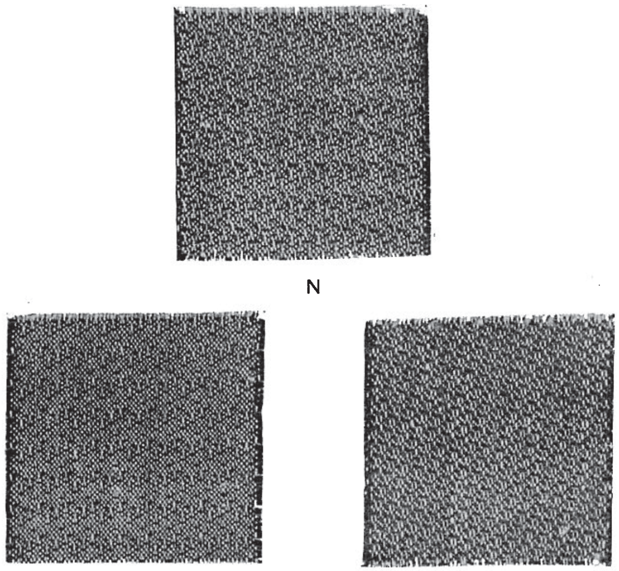


Fig. 63.

7th pick) two extra marks have been introduced in order to break a float of seven in the weft. This little addition, almost essential from a structural point of view, is sufficient to give the cloth an undesirable stripey character, the effect of which may be detected in M, Fig. 63. Design N is arranged on the same basis, but with alternate floating threads working $\frac{3\;1\;1\;1}{1\;1\;1\;3}$ and $\frac{3\;1\;1}{3\;1\;3}$, while the



N

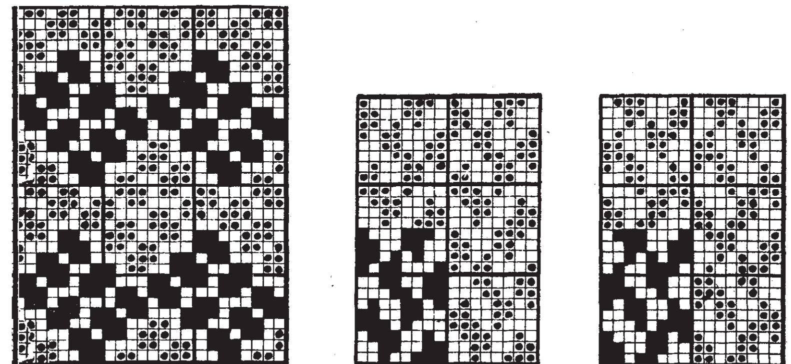
O P

Fig. 63*a*.

floating threads in design O weave in the orders $\frac{3\;1\;1\;1\;1}{1\;1\;1\;1\;1}$ and $\frac{3\;1\;1\;1}{3\;1\;1\;1}$.

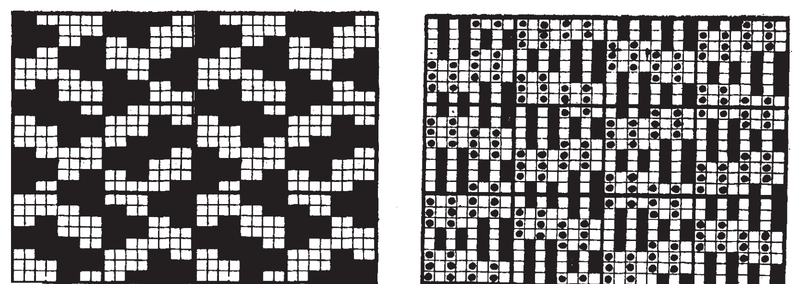
A somewhat more extensive weave of the same nature is given at P; it is complete on 20 threads and 20 picks. Alternate or floating threads are, of course, distributed on a 10-thread sateen base—2, 5, 8, 1, 4, 7, 10, 3, 6, 9,—and the order of the interweaving of these is arranged so that each thread moves for 10 picks in the order $\frac{3\;1}{3\;3}$, while the

remaining 10 picks of each thread are arranged $\frac{3\;3}{1\;3}$. This arrangement again ensures an equal distribution of



R S T

Fig. 64.



U V

Fig. 65.

warp and weft on both sides of the fabric. K is probably one of the most characteristic effects in the illustrations; B, E, and P are too regular and suggest twills; M, as already mentioned, is stripey, while O seems to have too much plain weave in the construction.

An extensively used crêpe for linen and cotton damasks, where a neutral effect is desired, is shown at R, Fig. 64. Two repeats of both warp and weft are given, the weave being complete on 12 threads and 16 picks; sometimes the weave is turned through 90° and woven with 16 threads and 12 picks.

A more elaborate weave of this character, which forms a splendid ground for most fabrics, but more particularly where the warp exceeds the weft in the proportion of two to one, is shown in various stages at S, T, U, and V in Figs. 64 and 65. S and T indicate two methods of arranging the base structure, T being the opposite of S. In each case the weave is given in single threads, and from T particularly it is clear that the base is simply a development of the 4-thread broken twill arrangement, 1, 2, 4, 3. U gives four repeats of the general effect, while V shows the full weave with two repeats of the weft—the weave being complete on 12 picks.

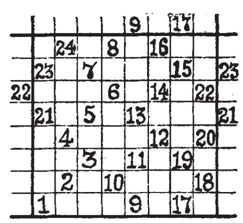


Fig. 66.

Many other neat ground effects may be obtained by carefully selected orders of movement. Fig. 66, which repeats on 8 threads and 8 picks, has been constructed for an explanation of one of these methods. The numerical order given in the figure shows that the scheme consists of eight groups of short, straight twills of three marks each. The picks are marked consecutively, but after the completion of each group, the starting-point of the next group drops back a thread. Thus the first, second, and third marks are on the corresponding threads and picks, but the fourth mark, although placed on the fourth pick, appears on the second thread. Stepping to the right is again continued, so that the marks 5 and 6 fall on picks of the same numbers, but on the third and fourth threads. The three marks 7, 8, and 9 bear the same relation to marks 4, 5, and 6 that these latter do to marks 1, 2, and 3. This procedure is continued until mark 24 is reached, when it is apparent

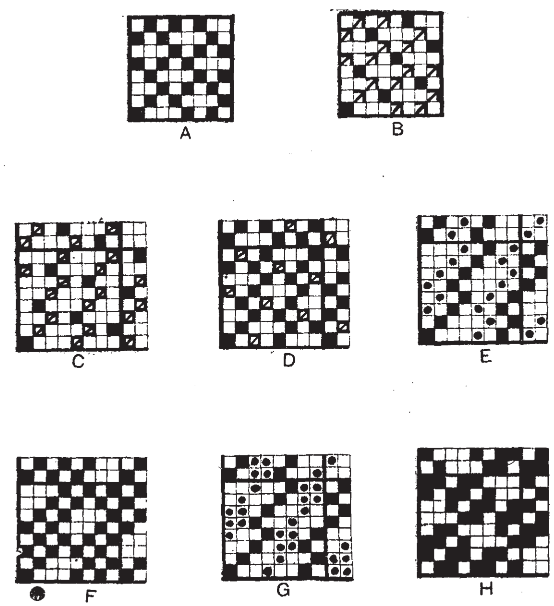


Fig. 67.

that the order would begin to repeat. The numbers outside the main block in Fig. 66 are given for the purpose of showing the connection between the first and the last picks, and the first and the last threads of the 8 by 8 portion.

Fig. 67 illustrates a few ground or all-over crêpe effects obtained by the above and by similar orders of movement. Design A shows the ordinary method of placing the weave on paper, but it will be seen that this plan is identical with that given in Fig. 66. The basis of structure would not be so evident from an examination of the unit as given at A, but its relation to the sateen method of structure is clearly illustrated at B in the same figure. Here the solid squares are arranged in the 8-thread sateen order, and to each such square have been added two marks at an angle of 45°. The complete design might also be considered as a simple sateen rearrangement of the 8-thread twill weave $\frac{1}{3}\frac{1}{1}\frac{1}{1}$. One might almost predict that the result of this method would coincide with a sateen arrangement, since the numbers are taken in regular order on successive picks, and are arranged in a sequence of threes—the step of the 8-thread sateen. Design C in Fig. 67 is developed on 10 by 10 in exactly the same manner, the solid marked squares again showing the sateen base. Design D, which forms a much better weave of the crêpe class, consists simply of design C with a fourth mark added to each group of three. Design E is a further example on 10 by 10, and in this weave 4 threads and picks have been marked in succession, and the step then made to the left. This arrangement alone—indicated by the solid marked squares—results in rather a loose weave, consequently it is thought advisable to add a second series of marks with similar movements; these, which commence on the first thread and the fifth pick, are shown by dots. The complete weave is shown solid at F—very nearly plain cloth—actually, however, a small weft spot arranged in the 5-thread sateen order on a plain ground. Design G is of a similar nature, but developed arbitrarily on the solid groundwork given at E. Design H is the reverse of G, and probably shows the 5-thread sateen arrangement of the little spot more distinctly than the latter figure.

It is evident from what precedes that the sateen orders may be used as bases around which marks may be added in some regular order for the production of other ground weaves; Fig. 68 shows nine such weaves. Designs J, K, and L have all been constructed from the 8-thread sateen

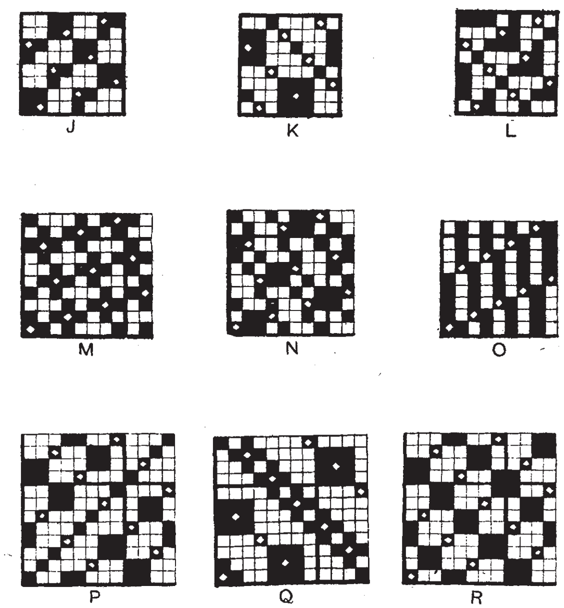


FIG. 68.

base; in each case this base is indicated by partly filled squares, and to these the solid squares have been added for the formation of the new weave. Designs M and N have been developed in a similar manner by the aid of the 10-thread sateen base. Every base mark in M has received the same additions, whereas in the others a variety of treatment has been adopted. Design O is a similar weave on 9 threads and picks, and is a representative of the corkscrew weaves. It is not much used in linens, but with warp threads closely set and the weft suitably proportioned, it produces a very serviceable type of double-warp-faced woollen or worsted cloth; these weaves are obtainable only on an odd number of threads and picks. Designs P, Q, and R have been similarly developed on 12 by 12. The various plans adopted for filling in should be readily understood from a careful examination of each design.

This principle is capable of almost indefinite extension by taking any sateen weave and arranging it in such a way that all the odd threads and odd picks, or all the even threads and even picks, are missed. The new base would, therefore, be four times the size of the original weave—*i.e.*, twice the number of threads and twice the number of picks. The three designs, X, Y, and Z, Fig. 69, are constructed on this principle. In each case the 8-thread sateen is arranged on the even threads and the even picks, as indicated by the solid marked squares, while the additional marks have been added round them in a systematic manner.

A rather unique method of obtaining irregular weaves is by means of superposition. Any two or more weaves may be placed on the same threads and picks, and, should suitable weaves be so combined, some interesting and satisfactory effects may be obtained. The principle will be understood by referring to Fig. 70, which results from placing the 8-thread sateen weave on a plain ground. It will be noticed that the resulting design is identical with No. 26, Fig. 37 (p. 41); and, indeed, this is probably the simplest method of constructing this particular design. One peculiarity of the above combination is that all the marks of the sateen weave fall on unoccupied squares,

whereas if the weave were moved one thread to the left or one thread to the right, every mark would fall on a square already occupied by the plain weave. It is only in exceptional cases that the two weaves do not clash at some point or points, and even in the simple combination of plain and sateens the same result does not always obtain.

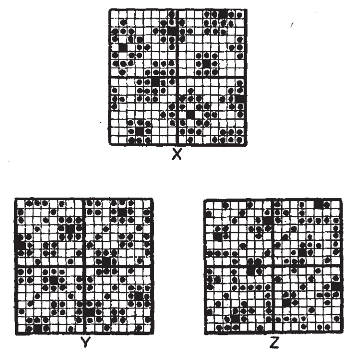


Fig. 69.

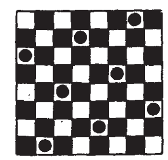


Fig. 70.

In Fig. 71 we show 12 designs made from the units A, B, C, and D, and according to the following table:—

Design.	Constituents.
E	Weave B + weave A commencing on the 1st thread
F	,, B + ,, A ,, ,, 2nd ,,
G	,, B + ,, A ,, ,, 3rd ,,
H	,, B + ,, A ,, ,, 4th ,,
J	,, C + ,, B ,, ,, 1st ,,
K	,, C + ,, B ,, ,, 2nd ,,
L	,, C + ,, B ,, ,, 3rd ,,
M	,, C + ,, B ,, ,, 4th ,,
N	,, D + ,, B ,, ,, 1st ,,
O	,, D + ,, B ,, ,, 2nd ,,
P	,, D + ,, B ,, ,, 3rd ,,
Q	,, D + ,, B ,, ,, 4th ,,

It will be seen that in designs G, L, and P the combining weaves do not interfere with each other, whereas in all the others some of the marks of one weave fall on squares already occupied by the marks of the other weave. There

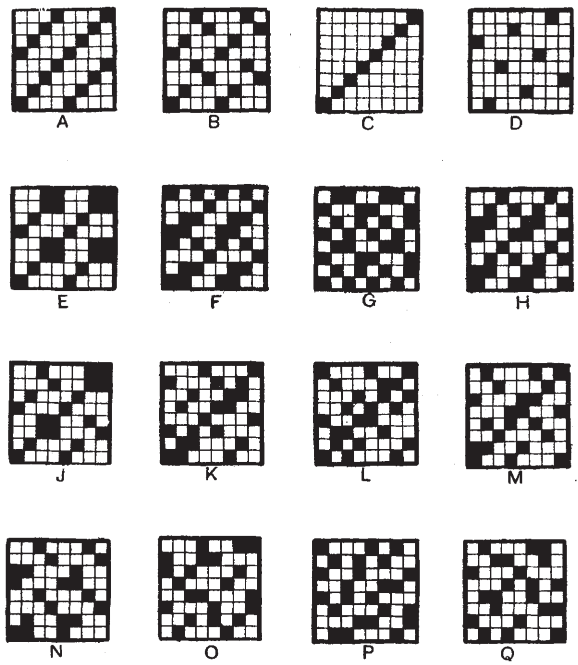


Fig. 71.

is very little difference between designs F and H and between K and M.

Fig. 72 is a further illustration of the same scheme; A, B, and C being the bases from which the six designs D to J have been formed, the particulars being as under:—

Design.	Constituents.
D	Weave B + weave A commencing on the 3rd pick
E	,, C + ,, A ,, ,, 1st ,,
F	,, B + C + A ,, ,, 3rd ,,
G	,, B + weave C ,, ,, 1st ,,
H	,, C + ,, A ,, ,, 3rd ,,
J	,, B + ,, C + weave C commencing on the 4th thread and the 4th pick.

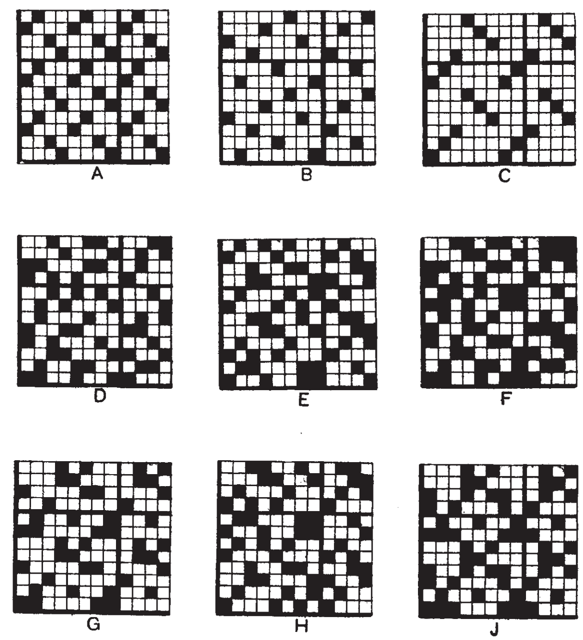


Fig. 72.

The best effects are likely to result from the superposition of irregular weaves, and in Fig. 73 we illustrate two designs on 24 threads and 24 picks, which should serve to demonstrate the extent to which this principle may be applied. Design A is made by repeating the three units B, C, and D in their present order for 24 threads and

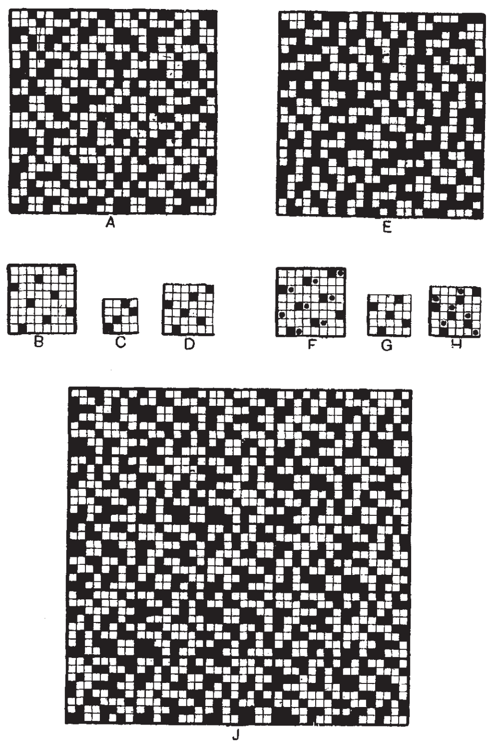


FIG. 73.

24 picks, while design E is made in a similar manner from units F and H. The two latter are simply the B and D units with the addition of the dots. It is quite evident that the designs may be made as large as we wish by

adopting suitable units. The number of threads and picks in the full design, in every case, is the L.C.M. of the units employed, so that if, in addition to the units B, C, and D, we used a 5-thread unit, the complete design would occupy 120 threads and 120 picks.

A great variety of results, more or less similar, may be obtained from the same units by altering their relative positions at the start; this is illustrated in Fig. 71 and the table referring to this figure. In addition, any one or more of the weaves may twill in the opposite direction, and may have additional marks, as shown at F and H in Fig. 73. As each additional weave invariably adds to the number of marks on the design, it is clear that those units with a small number of marks are most useful.

The chief difficulty with designs of this nature is their transference on to paper, for it would clearly be a difficult and tedious operation to repeat, say, either A or E over a large surface, unless special facilities, such as a photographical apparatus, were employed. For hand-work the simplest method is to complete each weave in turn, and to use a different mark for each for the purpose of detecting errors. This principle of construction might, with advantage, be adopted as groundwork for the production of figured linen or union dress goods. A rather more elaborate specimen, produced by this method and embracing 40 threads and 40 picks, is shown at J, the constituent weaves being the units B, C, and G.

Figs. 74 and 75 illustrate another of the many methods of obtaining fancy crêpe or irregular ground weaves. The principle consists of rearranging any selected small weave or small figure on four times its original area, and in the following manner:—The unit weave or figure is first placed on alternate threads and picks—let us say the odd ones—

of the extended area; the design paper is then rotated clockwise through 90°, and the same unit is again inserted

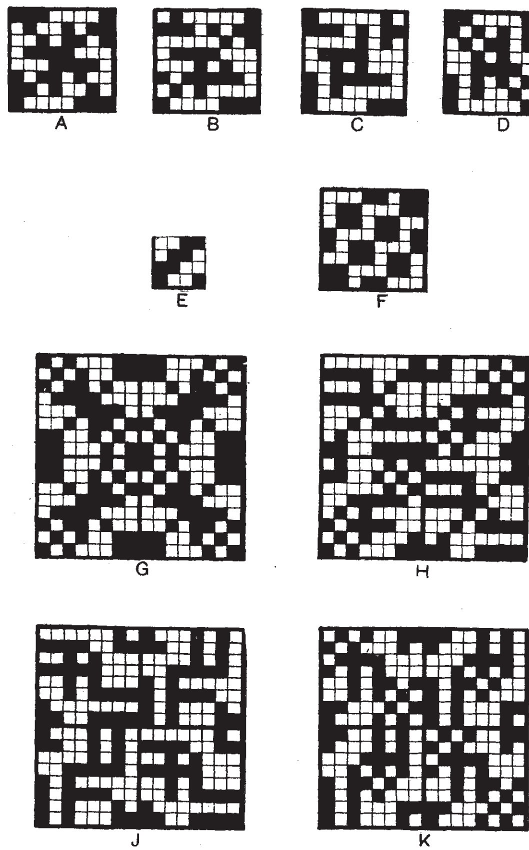


Fig. 74.

on alternate threads and picks; this procedure is repeated until the design appears in its original position. In other

words, the weave is placed on alternate threads and picks four times, each side of the square of design paper acting in turn as the bottom side. The result of this process, with the $\frac{2}{2}$ twill, E, Fig. 74, is given at A in the same figure. Design B was produced exactly like A for the first three sides, but when the fourth side appeared at the

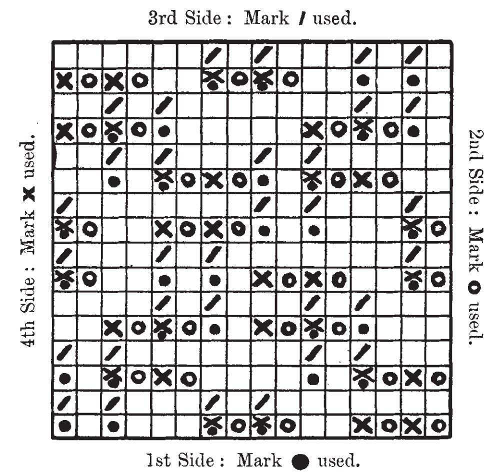


Fig. 75.

bottom, the weave was placed on the even threads and odd picks. Designs C and D were produced from the same unit E, while designs G, H, J, and K were evolved in a similar manner from the 8-thread twilled hopsack F. The details of the order of marking, for the different sides of each, are given in the following table:—

[Table

Designs A and G.	1st side	Odd threads and odd picks.
	2nd ,,	,, ,, ,,
	3rd ,,	,, ,, ,,
	4th ,,	,, ,, ,,
Designs B and H.	1st side	Odd threads and odd picks.
	2nd ,,	,, ,, ,,
	3rd ,,	,, ,, ,,
	4th ,,	Even ,, ,,
Designs C and J.	1st side	Odd threads and odd picks.
	2nd ,,	,, ,, ,,
	3rd ,,	Even ,, ,,
	4th ,,	,, ,, ,,
Designs D and K.	1st side	Odd threads and odd picks.
	2nd ,,	Even ,, ,,
	3rd ,,	,, ,, ,,
	4th ,,	,, ,, ,,

It might be noted that the use of odd threads and even picks, instead of even threads and odd picks, would give slightly different results in some cases, and entirely different effects in others.

Fig. 75 shows in detail the construction of J, Fig. 74. It will be seen that in several cases the marks from different sides occupy the same square.

Designs A to M, Fig. 76, illustrate a few independent ground weaves of various dimensions. They are all used, more or less, for towelling, while some of them—*e.g.*, F and J—are suitable for dress goods. Design K is a modification of the 8 by 8 imitation gauze shown in Fig. 47 (p. 57). The addition of the four marks to the latter weave alters the character of the cloth considerably—it reduces the openwork nature, and consequently makes a firmer cloth. Design L is termed the Barley-corn, while design M is of a similar structure. Both may be used as ground effects in figured goods, but since both weaves possess long floats,

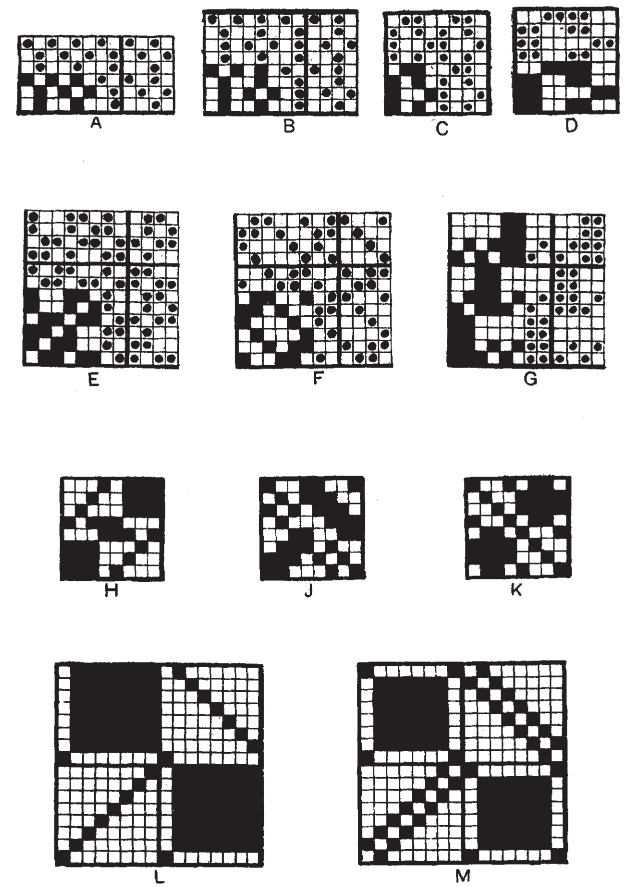


FIG. 76.

they are best suited for medium and fine setts; for coarser setts, similar but smaller patterns should be made.

CHAPTER V

SPIDERS

Figs. 77 and 78 are photographic reproductions of several cloths of an ornamental dress character made on what is

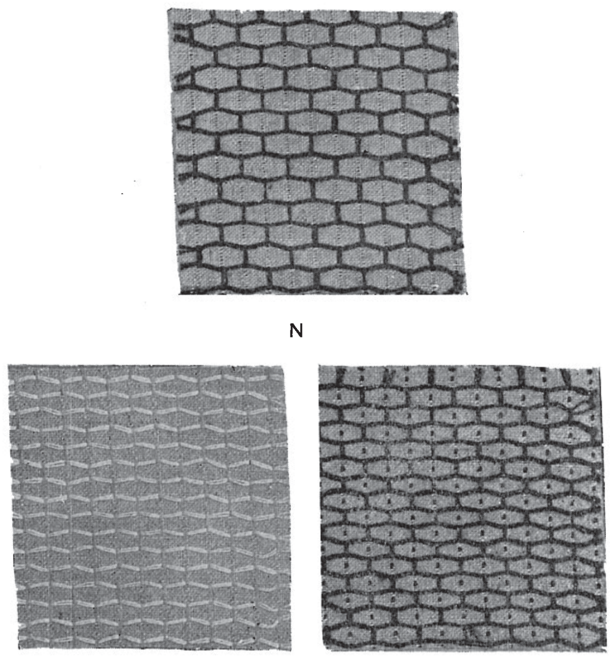


Fig. 77.

sometimes termed the "spider" principle. The working designs are given in Figs. 79, 80, and 81—cloths and

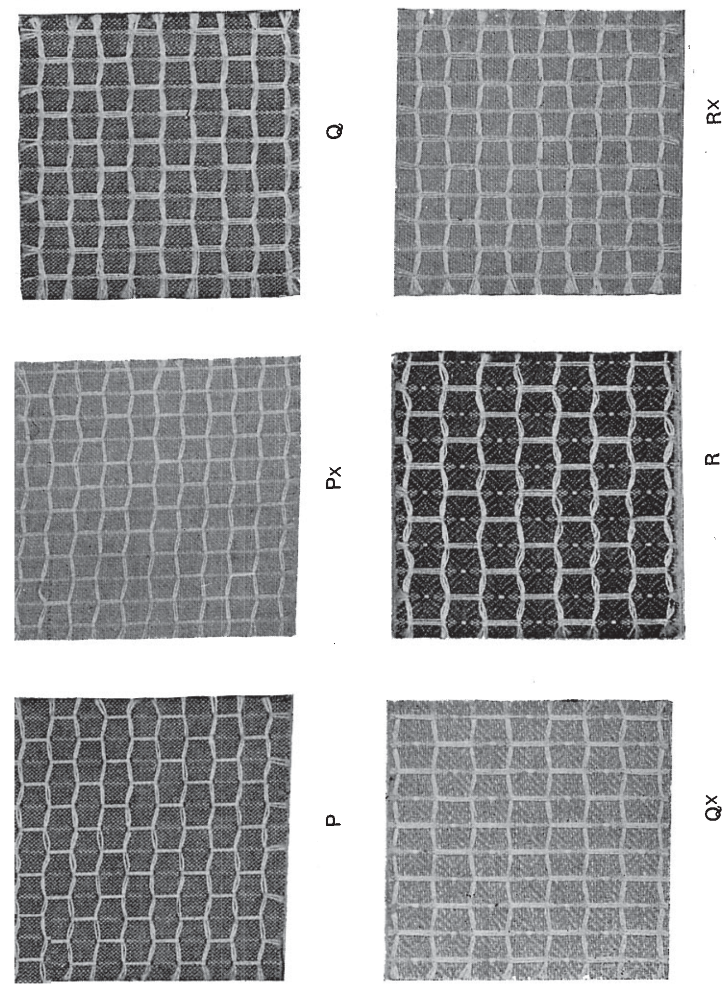


Fig. 78.

designs are lettered alike. The general principles involved are somewhat as follows:—At stated intervals two or more warp threads (1st and 2nd, and 13th and 14th in N, Fig. 79) are permitted to float alternately on the surface of the fabric for two or more picks more than half the repeat of the design. These floating threads are arranged to overlap, as it were, at each end, or on the 13th and 14th, and on the 27th and 28th picks. At these overlapping points the weft yarns or picks, two or more

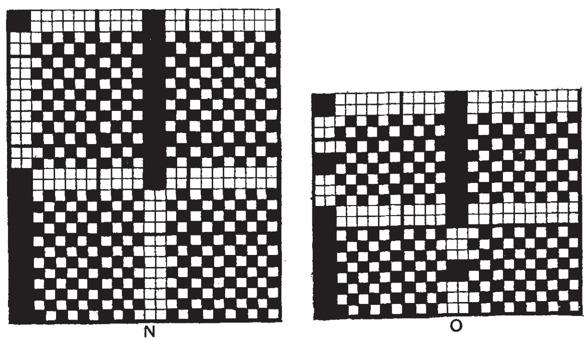


FIG. 79.

as the case may be, are also permitted to float on the surface, except where they are bound down by the floating warp; the remainder of the design is filled in with the plain weave. Thus in N, Fig. 79, the whole design is plain weave with the exception of four threads which float over 16 picks and under 12 picks, and four picks which float over 10 threads and under 2. The deflection of the weft threads from the straight line is due to the fact that picks 12 and 15 close together in the cloth, as do also picks 26 and 1; picks 13 and 14, also picks 27 and 28, rest upon the surface of the cloth. They, however, do not

appear in a straight line with the plain picks, for they are

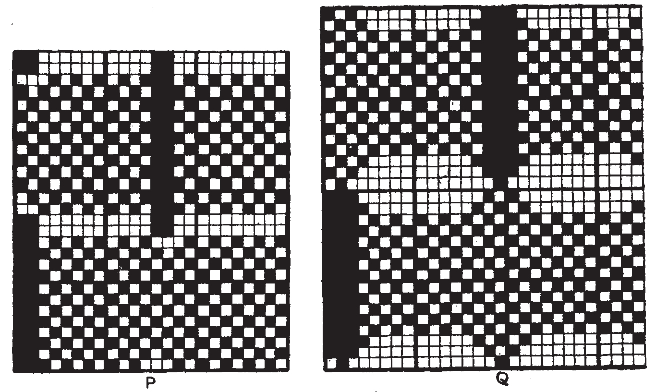


FIG. 80.

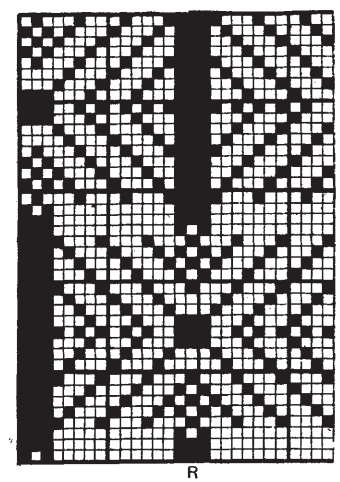


FIG. 81.

drawn in opposite directions by the two sets of floating warp threads which intersect with the cloth at this point, but on opposite sides of the figuring weft. This result does not seem to be affected, nor do we think it should be affected, by the character of the weave filling up the body of the design, or by the fact that the floating warp threads do not interweave at any other point. (The floating threads in the huckabacks draw the weft in a somewhat similar manner.) In piece-work, however, such threads might begin to hang slack and prove troublesome unless they were taken from a separate beam. The design, however, may be modified to overcome this to a certain extent, and in design O the floating warp threads have been arranged to come to the surface in the centre of the plain portion; in P, Fig. 80, they have been arranged to work plain all the way. This necessitates due consideration of the colour arrangement of the threads. In Q, three floating threads, drawn through one split of the reed, have been taken, while the floating weft yarns have been increased to five. A slight change has also been made in the method of overlapping the floats. In design R, Fig. 81, the body of the design has been filled in with the $\frac{1}{3}$ twill arranged in diamond form, with the floating warp threads brought to the surface in a 3-square float. Extra warp threads, as well as extra weft threads, might well be used, with probably more successful results.

The following table gives a few particulars of the yarns employed for the cloths illustrated in Figs. 77 and 78.

[TABLE

Design.	Ground Warp.	Figuring Warp.	Ground Weft.	Figuring Weft.
N	Cream linen	2-fold black worsted	Bleached linen .	2-fold black worsted
O	,,	Cream linen . .	Cream linen . .	2-fold white mercerised cotton
OX	,,	2-fold black worsted	,,	2-fold black worsted
P	,,	2-fold white mercerised cotton .	2-fold black worsted	2-fold white mercerised cotton
PX	,,	,,	Cream linen . .	,,
Q	,,	,,	2-fold black worsted	,,
QX	,,	,,	Cream linen . .	,,
R	,,	,,	2-fold black worsted	,,
RX	,,	,,	Cream linen . .	,,

CHAPTER VI

HERRING-BONES, DIAMONDS, AND DIAPERS

In all ornamental cloths of single make where warp and weft are alike in colour, and approximately the same in diameter, the development of the pattern, or, rather, the effect produced, depends almost entirely upon the degree to which the light is reflected by the different portions of the surface of the fabric. Warp and weft are interwoven at right angles to each other, and, according to the intensity of the light, the angle of incidence of the rays, and to the position of the observer's eye, either the one or the other series of threads will, for the time being, act as the higher reflective medium. In order, however, to obtain the best results, it is necessary that either the warp or the weft should preponderate upon the surface of the cloth, and that it should appear in comparatively solid masses, so that the reflection may be obtained from a relatively unbroken surface of warp or of weft. The ordinary plain weave, $\frac{1}{1}$, when woven in a so-called "square" cloth, is the antithesis of this condition, and it is well known that patterns cannot be developed upon cloth in the above manner with this weave, since the surface continuity of every warp and of every weft thread is perfectly broken up. Small ground weaves of the crêpe class may also be included in this category, since one of their chief aims is to break up the ground of the fabric into a neutral and almost totally non-reflective surface. Where, however, there is systematical floating of the warp (or of the weft) for two or more successive picks (or threads), and where such floats overlap each other in the slightest degree, as, for example, in the simplest of twills, then it is possible to have pattern development with yarns of one shade or colour.

The most elementary method of ornamenting cloths by such means is the simple one of altering the direction of the twill, or, in other words, of producing designs that are technically termed "arrow-head," "feather," "pointed," or "herring-bone" twills. This ornamentation involves no increase in the weaving mechanism required for the simple or straight twills, provided that one weave or unit only is used at a time. At V, Fig. 82, such a twill on 18 threads and 3 picks is shown repeated twice in the way of the weft. The order of drafting on three shafts is given underneath the design, and it will be seen that each shaft bears an equal number or proportion of the total threads in one repeat. This condition is, in the majority of such cases, a most desirable feature, as it permits of the use of a camb and a reed of the same sett without any fear of the width of warp in the camb differing from the width necessary in the reed. Any number of threads desired

may be drawn in one direction, and the same or a different

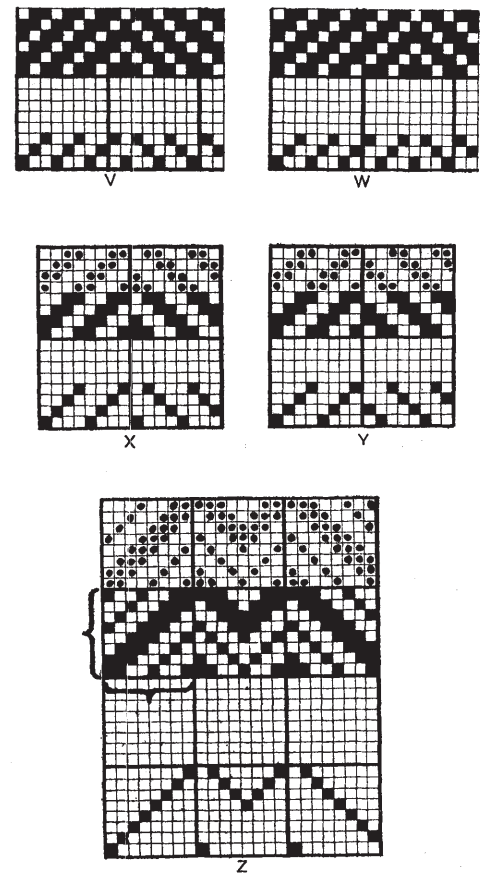


Fig. 82.

number may be drawn in the opposite direction, provided, generally, that in each case the total number drawn in any one direction is a multiple of the number of shafts employed. Thus W, also Fig. 82, where the draft is straight for 12 threads, and reversed for 6 threads, would be quite suitable for such a case. This reversal of the twill is largely employed where the goods are of a striped character, such as tickings, where one colour of warp may be twilled in one direction, and the other colour in the opposite direction, or the turning of the twill may commence in the middle of each colour. In many cases, especially in mattress ticks, the change takes place two or three times in the same stripe; this is admissible in this type of fabric, for the ground stripes are, in general, much wider than those in the ordinary ticks.

Two further examples are given at X and Y, Fig. 82, on 16 threads and 4 shafts. These two designs resemble each other very closely, but there is an interesting difference between them at the point where the differently directed twills meet, that is, between the 8th and 9th, and 16th and 1st threads in both designs. It will be observed that design X is perfectly symmetrical about its turning points—the 1st and 9th threads. This results in a weft float of three on each side of the cloth (see the 1st and 3rd picks), an effect which, in many cases, is considered objectionable. In the jute, and also in the tweed and other industries, the method of turning or joining the twills as indicated in design Y is regularly adopted; this arrangement is free from the long floats, but it is clear that the method acts only in special cases. Thread 9 in this design is arranged to "cut" with or work directly opposite to thread 8 by drawing it upon the proper shaft and continuing the draft from that point. When this is done, and the draft continued to a multiple of the number of shafts employed, the last thread of the draft

(*e.g.*, No. 16, Y, Fig. 82) will "cut" with the first thread in a similar manner. This method has a tendency to create a split or opening in the cloth at the cutting points, but it is generally considered that it produces a firmer fabric than the other method, particularly if the cloth be somewhat open in sett. With both methods each shaft is again made to carry an equal portion of the total warp, provided that the number of threads drawn in both directions is a multiple of the number of shafts employed. It is, of course, understood that it is not absolutely essential for the stripes to occupy a multiple of the threads of the unit weave, but it is better for the camb when this condition obtains. There are numerous cases where the arrangement of the draft will not permit of the same number of threads on each shaft.

The principle of straight and return twilling may be extended indefinitely to any number of threads, and any practicable number of shafts, and a further example on 8 shafts and 24 threads is given at Z, Fig. 82; two repeats of the weave are given in the direction of the weft. The 8 by 8 unit weave chosen is indicated by the brackets {,
while the draft appears immediately under the design. We have already stated that such drafts may be indicated in different ways; *e.g.*, on design paper, as in the figure, by a series of dots or other suitable marks on a number of parallel horizontal lines representing the shafts, or simply by a series of figures which indicates the number of the shaft on which consecutive threads are drawn. Thus the draft of design Z, Fig. 82, should be equally well understood by the initiated by the following order of numerals:—1, 2, 3, 4, 5, 6, 7, 8, 1, 8, 7, 6, 5, 6, 7, 8, 1, 8, 7, 6, 5, 4, 3, 2, as by either of the graphic methods referred to.

From the inspection of the draft of design Z it is clear that each shaft does not carry an equal proportion of the total number of threads. Thus—

Shafts 1 and 5 each take $\frac{3}{24}$ of the total number.

" 2, 3, and 4 " $\frac{2}{24}$ " "

" 6, 7, and 8 " $\frac{4}{24}$ " "

In such a case three courses are open with regard to the camb which may be employed.

1st. A camb with each leaf built equal to the sett of the finest shaft required could be used, in which case a large quantity of spare heddles would require to be missed on 1st, 2nd, 3rd, 4th and 5th shafts. This method tends to produce faulty drafts, and a wrong width in the camb.

2nd. Shafts might be built specially to each sett required; thus, if the cloth required 72 threads per inch in the reed:—

			Heddles.
Shafts 1 and 5	would require	$72 \times \frac{3}{24} = 9$ per in.	$\times$ 2 shafts = 18
" 2, 3, and 4	"	$72 \times \frac{2}{24} = 6$ "	$\times$ 3 " = 18
" 6, 7, and 8	"	$72 \times \frac{4}{24} = 12$ "	$\times$ 3 " = 36
			72

But even this method would scarcely be satisfactory if the heddles were equally spaced upon the shafts, because the threads are not equally spaced in their positions in the draft.

3rd. Shafts may be used on which the heddles are mounted loosely, so that they may be increased or decreased in quantity at pleasure, or moved along the shaft to any position desired. This is similar to the wire heddles, and is probably the best method in such cases.

Designs which produce wave-like or zigzag effects across the cloth—*i.e.*, from selvage to selvage—may be turned through 90°, so that what were originally weft threads may now represent warp threads, and *vice versa*. If the design in its altered form were applied in the production of cloth, the zigzag pattern thus produced would naturally be in the direction of the warp. No good purpose would be served by giving examples of this kind of zigzag or pointed design, for those produced in the direction of the weft, as illustrated in Fig. 82, may be considered as warp zigzags if the paper be turned one-quarter round. The production of these designs in the direction of the warp would entail an increase in the weaving mechanism, since the tappet which produced the weft zigzag with a simple change of draft is incapable of adapting itself to the lengthened weaving plan of the warp zigzag. Moreover, in most cases the change necessitates the employment of a dobby machine, consequently it is unusual to weave them in this manner if the other direction will suit the purpose for which the cloth is intended. The combination of the two methods is, however, a very interesting study, since by such combinations are produced practically all those weaves of the diamond or diaper class. This side of the subject forms a very important part in the designing and manufacturing of jute and linen goods, as well as in many fabrics made from the other fibres.

There are four systematic methods by which such weaves may be formed, two of which we shall refer to immediately. In the production of almost every class of design it is usual first to conceive the idea and to materialise it by making a rough sketch, then to transfer such sketch on to design or point paper, and finally, in the case of tappet or dobby weaving, to reduce it, if possible, to a smaller number of threads or shafts in order to facilitate weaving. The application of this method of designing is almost universal; still, we shall find that in many cases excellent results may be obtained by forming the design by an inverse procedure. Consider for a moment the examples illustrated in Fig. 83. A is the 3-leaf twill, $\frac{1}{2}$, and this we take as a base for building up a design or diamond pattern. The same weave is introduced at the bottom left-hand corner of C, then other three threads of the weave, in the order 1, 3, 2, are added, thus making a small design on 6 threads and 3 picks; the three picks are indicated by the small letters *a*, *b*, and *c*, at the right-hand side of the figure. Clearly, from the method of construction, the draft for this design is B, while the weaving plan is A. Consequently there are three shafts required for this design on 6 threads and 3 picks. Now, although we cannot reduce the number of picks in a design, we may, if it serves our purpose, indicate similar picks in precisely the same manner as we indicate similar threads. The first three picks of design C are thus indicated by the numerals 1, 2, 3, reading from the bottom of D. To complete the procedure we repeat at D the draft already given at B; then, since similar numbers in part D represent similar picks, we have merely to introduce at C, on the 4th, 5th, and 6th picks respectively, the original picks *a*, *c*, and *b*, or 1, 3, 2. We then obtain what is really the smallest diaper or diamond weave. This is what we term the first method of producing diamonds in a systematic manner. Any

straight twill, on any number of threads, odd or even, may be treated similarly. In its simplest form the process consists, first, of putting down the desired weave

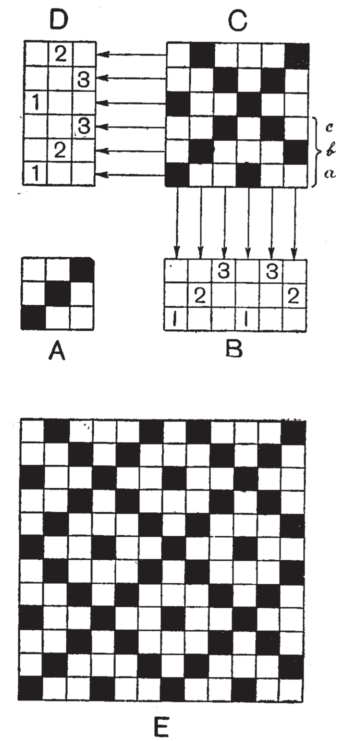


Fig. 83.

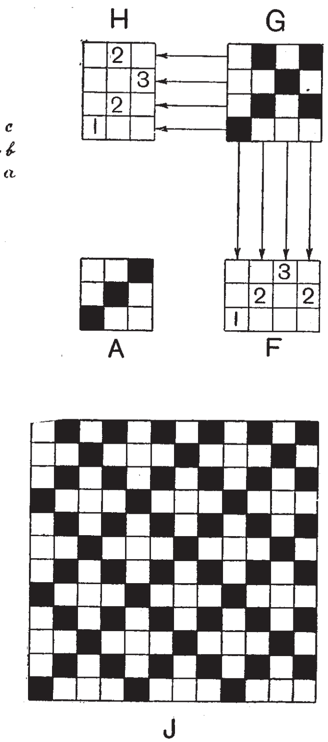


Fig. 84.

unit on design paper, then twilling the same to left, commencing on the first thread and reading backwards, and, finally, of arranging the picks in the same order as the threads. It will be observed that when arranged in this way the number of threads, as well as the number of picks, is exactly double that in the base weave, and that the order of drafting in both is as follows:

1, 2, 3, 4 . . . $(n-3)$, $(n-2)$, $(n-1)$, n for 1st half of design;
then 1, n, $(n-1)$, $(n-2)$ . . . 5, 4, 3, 2 „ 2nd „

where n is the number of threads in the base weave. The above is simply a straight draft once over the total number of leaves, then a reverse draft commencing with the first shaft and finishing on the second.

The second method of producing diamond patterns is illustrated in Fig. 84, where A is the same base weave, but the design G is obtained by the common pointed or herring-bone draft F, the general form of which is:—

1, 2, 3, 4, . . . $(n-3)$, $(n-2)$, $(n-1)$, n;
then $(n-1)$, $(n-2)$, $(n-3)$, $(n-4)$ . . . 5, 4, 3, 2.

The arrangement of the picks is again identical with that of the threads, the total number in either the warp or the weft direction being equal to $2n-2$, where n is the number of threads in the base weave. It will be observed that each leaf of the camb in the first system (B, Fig. 83) controls the same number of threads, while in the second system (F, Fig. 84) the first and the last shafts have each only half the number of threads controlled by each of the remaining shafts (in the figure there is one shaft only with double the threads). E, Fig. 83, and J, Fig. 84, show 4 and 9 repeats respectively of the units C and G, and although the figure J appears of the nature of a diamond, it is too small to give such an effect in the cloth. It will be seen that one half of the threads is of the same plain order, while the remaining half consists of two threads of the $\frac{1}{3}$ twill. In most diamond designs it is essential that the order of reeding should be considered in order that the single spot at

the side of the diamond may not be covered by the adjoining longer float. In another part of this work it is stated that the shorter the float the nearer the horizontal centre of the cloth will the thread or pick appear, and the prominence of the threads or picks on either side of the cloth will increase with the length of the float. By carefully studying this tendency of one thread to overlap another, it is possible, in some cases, to reed the warp so that the short floating threads will not be covered by the adjacent long floats. Thus the effect obtained by design E depends somewhat upon the order of reeding. The object to be attained is to have a split of the reed between the first two threads and between the last two threads of each enclosed diamond, *i.e.*, between threads 2 and 3, 5 and 6, 8 and 9, and 11 and 12. This can always be done by reeding one thread per split, but in most cases such a reed would be much too fine. It is impossible to make the division in design E by reeding two threads per split. If reeded three threads per split, commencing with a three, the result will be faulty; but if reeded three threads per split, commencing with the third thread, the result will be more satisfactory. In many cases it is impossible to split satisfactorily each pair of threads forming the corners of the diamond. There is nothing to prevent the similar weft threads from overlapping, but, except in very heavily wefted fabrics, the long floats of weft have not the same tendency to cover the shorter ones.

Before referring to the other two methods of producing diamonds, we desire to illustrate more fully the different phases of the first two methods. At K, in Fig. 85, we have treated the 4-thread, $\frac{2}{2}$ twill, in precisely the same way as the $\frac{1}{2}$ twill in Fig. 83. The complete design is indicated by the solid marks, while the remaining marks merely show repetitions of the pattern. This design, which is extensively applied to many types of fabrics, sometimes receives the name of "bird's-eye diaper." Design C in Fig. 83 is, however, often known under the same name, while the larger diamonds are occasionally termed "pheasant's-eye diaper." It will be observed that the central parts of successive diamonds in design K, Fig. 85, are identical in any particular horizontal or vertical line—*i.e.*, the central parts are composed either of four marks or of single marks; but obliquely, the two kinds of centres alternate. Further, the lines which form the groundwork of the diamonds are not perfectly continuous, but deviate a little to left and to right in both diagonal directions. (We shall refer to these points again.) It will also be noticed that the design is formed by one repeat only in each direction of the draft; that is:—

1 . 2 . 3 . 4 ; then 1 . 4 . 3 . 2.

Now this is the smallest number of threads and picks on four leaves with which a design on this principle can be constructed. But the extension of the principle is, theoretically, unlimited, and that even without increasing the number of shafts. Any extension, however, increases the number of picks in the weaving plan, and hence increases the number of cards, lags, or bowls necessary for the dobby or other shedding mechanism. Design L, Fig. 85, illustrates an extension, where it will be seen that each part of the draft appears twice in every unit. Thus the solid black marks illustrate the complete design, while the draft immediately under shows that the order is:

$$\underbrace{1.2.3.4.1.2.3.4}_{\text{Twice straight or twill to right.}};\ \text{then}\ \underbrace{1.4.3.2.1.4.3.2.}_{\text{Twice reverse or twill to left.}}$$

In completing the design it is, of course, necessary to indicate the sequence of picks in precisely the same order.

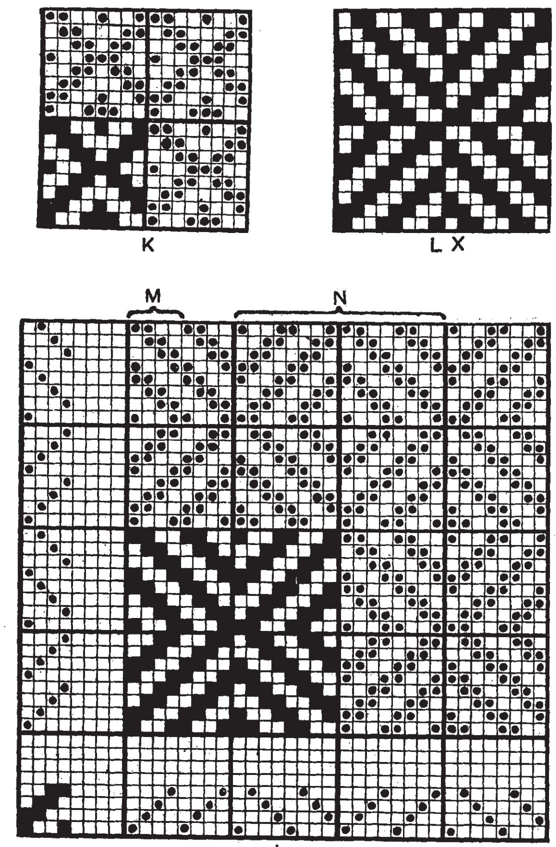


Fig. 85.

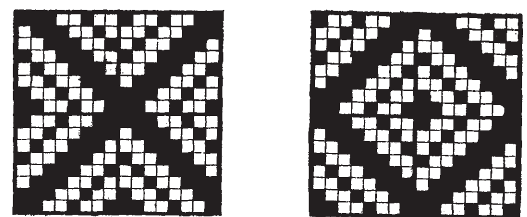
The weaving plan is the first four threads and any 16 picks—1 to 16 or 17 to 32, as shown at M. The same characteristics appear in this design as in design K—that is, the inner parts of the diamonds are unlike, and the bounding lines are not in the same diagonal line. Each centre of design L is surrounded by a perfect diamond, while every additional repeat of the initial unit adds an additional diamond to the pattern. Consequently a square design, with sides equal to the width of the cloth, might be obtained by repeating the straight draft to the centre of the cloth, then reversing to the opposite selvage, and extending the picks similarly. If this were carried out to the letter, the appearance of the cloth would be similar to the part in solid marks in design L, with this difference—that a great number of pairs of lines would meet in the central horizontal and vertical lines. If, however, a weaving plan corresponding to the first four threads of part N in the same design were used, and the proper number of picks used, the central part of the figure would be a single spot, and arranged round this would be diamonds of increasing magnitude. A close analogy to this is the effect caused by the dropping of a stone into the centre of a sheet of water.

In the jute and other industries, where comparatively thick yarns and open or coarse setts are used, the floats of three in design L are in many cases considered objectionable, and a method of drafting is therefore adopted which limits the floats to two threads or two picks. This is illustrated in design LX, which has been developed on 16 threads and 16 picks from the $\frac{2}{2}$ serge twill. The two pairs of threads and picks which form the junction of the oppositely directed twills are arranged to "cut," or, in other words, to work in opposition to each other: the whole design is, indeed, an example of reversing, as illustrated in Fig. 46. Designs O and P, in Fig. 86, show two ways of forming a diamond pattern on the principle

illustrated in K and L, Fig. 85. The weave used is the $\frac{3}{2}\frac{1}{2}$ twill, and the designs are identical when repeated; the apparent difference is due to the different way of inserting the initial weave.

In O the first part is made to twill to the right.
,, P ,, ,, ,, ,, left.

The complete figure in the former is made up of four half diamonds, while the latter figure is composed of one full diamond and four quarters. It is easy to see that O is the same as P if we commence the former on the 9th pick, or the 9th thread; consequently, when woven, the cloth



O P
Fig. 86.

produced is the same in both cases. This remark is only true for the simple cases such as we have described.

There are two interesting features connected with O and P—shown most clearly in O—which we desire to point out.

1st. The boundary or foundation lines (the heavy ones in the figure) are perfectly straight.

2nd. The centres of each diamond in both designs are identical.

These conditions may be obtained from any straight rolling twill, provided each thread floats under or over an odd number of picks, and that this float be so split up that the beginning of the first thread of the design contains one more square of this float than does the end. In addition, the whole of the design inside the boundary line will be the same in each diamond, provided the initial weave is symmetrical about the diagonal line. It will be seen that these conditions are fulfilled in designs O and P. To illustrate further these peculiarities we have prepared designs Q, R, and S in Fig. 87. Q shows the 12 detached threads of

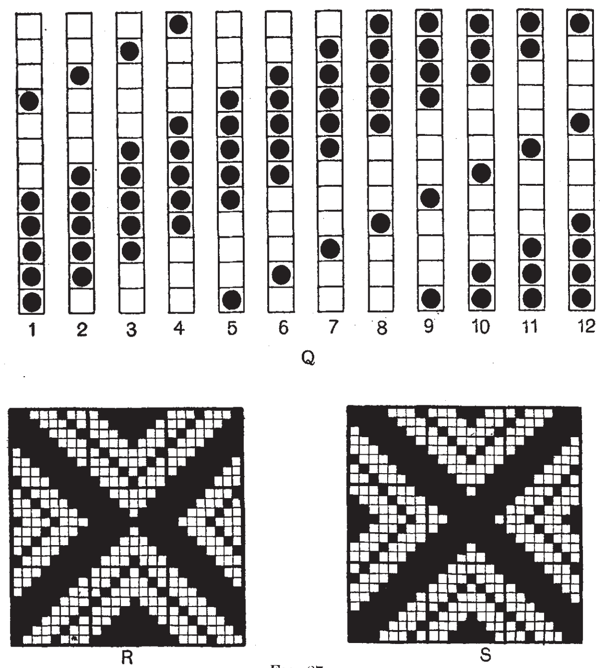


Fig. 87.

the $\frac{5}{3}\frac{1}{3}$ twill. By the method described, and with this weave, it is possible to produce four distinct diamond weaves in which the foundation lines (black or white) appear in straight unbroken lines. To obtain these four it is necessary to commence the initial weaves with the

3rd, 5th, 7th, and 11th threads of figure Q; a diamond pattern produced by commencing on any other thread will result in a broken foundation line. Design R has been constructed with the leading thread similar to No. 1 in Q, while design S commences with thread No. 11; the difference in the effect produced by the heavy bands is

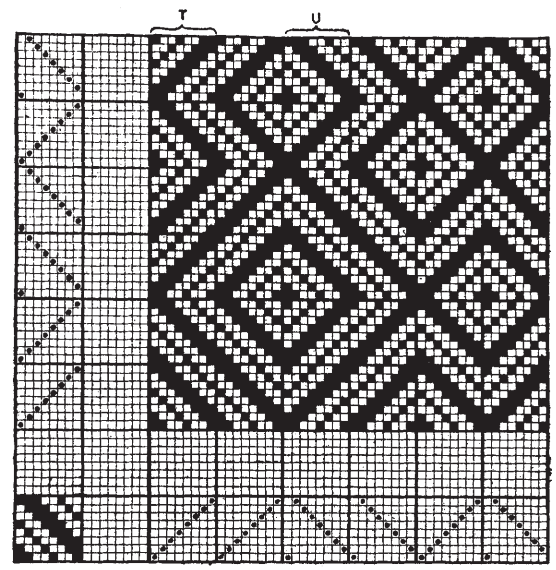


Fig. 88.

quite apparent. There is also a considerable difference of character in the centres of the two designs; in S, both centres are the same as stated, but in R the centres are widely different. If the design were commenced with the 12th thread of Q, the difference between the two centres would not be so great. As a highly educational and instructive exercise each student is advised to make the 12 possible simple diamonds from weave Q on this principle, beginning with each thread in succession and noting the differences both in the centres and in the foundation lines.

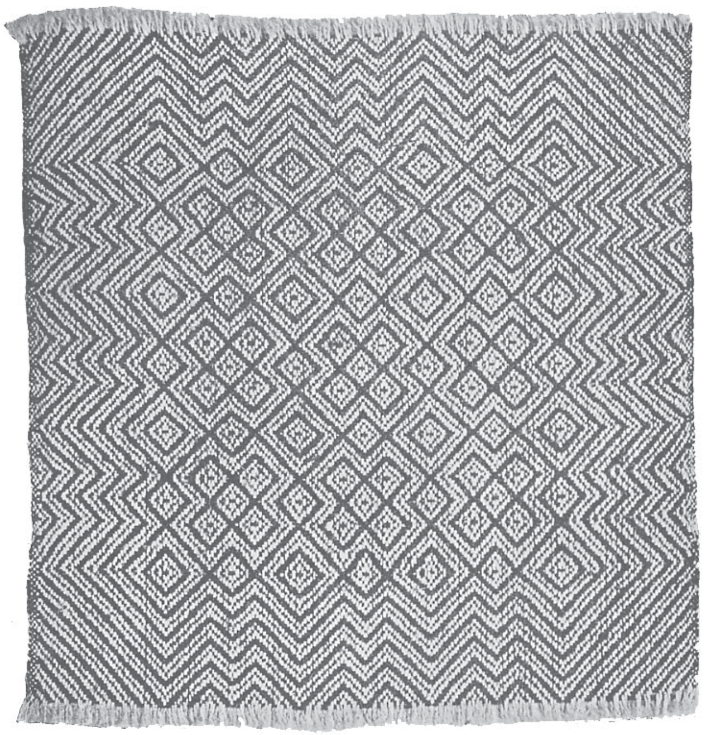


Fig. 89.

This would be excellent practice, and would yield valuable and convincing results.

It is not absolutely essential that the designs should be made with drafts as regular as those we have just described. There are certainly some exceptions, but, as a general rule,

there is very little restriction to the order of drafting which one might select. Fig. 88 shows a design on 48 threads and 48 picks, made from the same weave as O and P

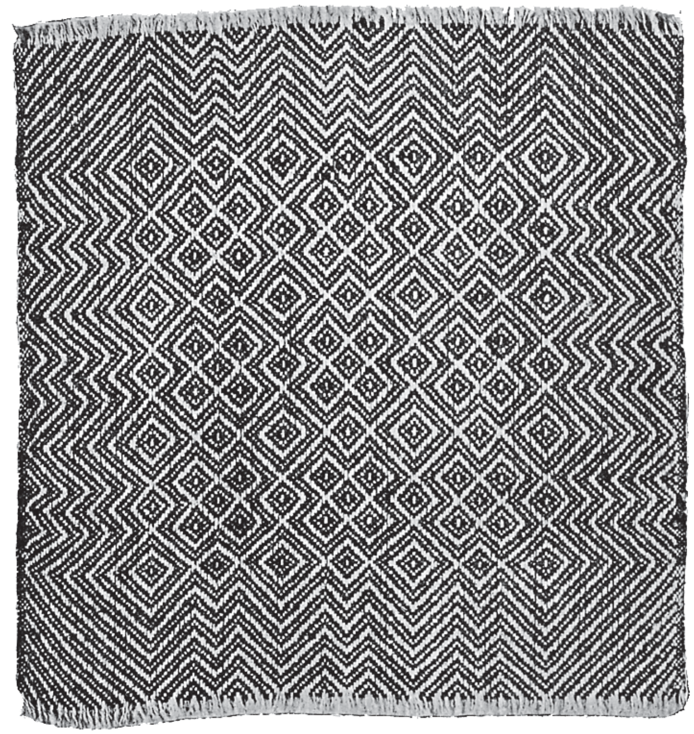
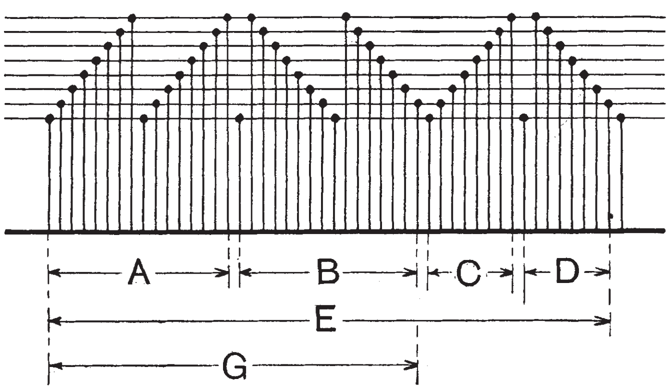


Fig. 90.

in Fig. 86. As indicated by the draft immediately under the design, it will be seen that the threads are drawn twice over the shafts in a straight draft, twice backwards, once forward, and, finally, once backward. The cloth would show five diamonds within a kind of check formed by alternate large and small diamonds. A practical application of the principle is shown in Figs. 89 and 90, which are photographical reproductions of two jute fabrics made specially to illustrate the method, and so arranged as to form complete squares. The figures also serve to illustrate further, the making of zigzag patterns and their application as borders to diamond centres. The weave used is the same as in Fig. 88, and the particulars of the draft appear in Fig. 91.



2 repeats of A = 2 × 16	= 32	threads.
3 ,, E = 3 × 48	= 144	,,
Part G	= 32	,,
2 repeats of B = 2 × 16	= 32	,,
The last thread in draft	= 1	,,
	241	threads.

Fig. 91.

In connection with designs O and P in Fig. 86, we stated that the choice of inserting the initial weave was optional—that in both cases the same cloth would result. Different conditions, however, obtain when we deal with complicated drafts. This remark is reflected in Fig. 92, where the same draft is used as in Fig. 88, and also the same

base weave $\frac{3}{2}\frac{1}{2}$. The weave, however, twills to right in Fig. 92, and it is easy to see that a totally different effect is obtained by this method.

If the student has already carried out the suggestions made with reference to Q in Fig. 87, he will be convinced that Figs. 88 and 92 do not by any means exhaust the

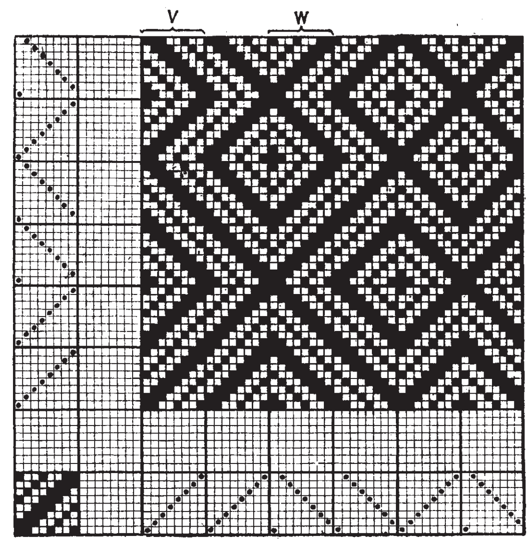


Fig. 92.

possible productions from the 8-thread weave used. He will also have noticed that the number of weaves with straight foundation lines, obtainable from any base weave, depends upon the number of floats of an odd number, up or down, in one repeat of the thread or unit weave. By employing the same 8-thread weave with the initial thread $\frac{1}{2}\frac{3}{2}$, we obtain two totally different effects. In actual practice it is unnecessary to fill in all the figure; the only