

the cloth by alternate threads of the two colours of the warp. By turning the draft in the opposite direction, regular or irregular herring-bone twills may be made; and, finally, diamond patterns might be produced by turning both draft and design.

Fig. 150 illustrates a kind of wave and diamond pattern, arranged to give each pair of threads full liberty of appearing in the same straight line. Although both sides of the fabric are similar and show a warp face, the

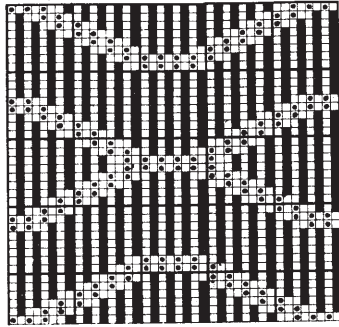


FIG. 150.

underside would be the better if marks on the design indicate, as usual, threads to rise. This is because the weft never passes under two successive threads, but it passes over two threads on the face all round the figures. For this reason, blanks to rise would probably be used for this design. The design has been made in this manner in order to show up the above slight defects on one side of the cloth.

The construction of these double warp-faced fabrics is, in general, very simple. They may, of course, be of any pattern, but those in diamond form are the most common for shaft work. The first step is to construct a diamond on any of the principles illustrated under diamond design. Thus design A in Fig. 151 is a simple diamond made from the  $\frac{3}{2}\frac{1}{2}$  twill, while design B is the exact opposite—i.e.,  $\frac{2}{3}\frac{2}{1}$  twill. Each design contains 14 threads and 14 picks, and, as they have to be combined thread-and-thread,

the complete design will occupy 28 threads and 14 picks. Weave A is placed on the odd threads, and weave B on the even threads; consequently, the threads forming each pair

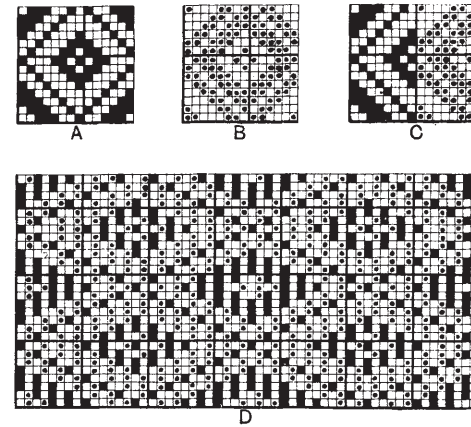


FIG. 151.

in the complete design are cutting threads. Four repeats of the design appear at D, while C is the weaving plan if the draft be arranged as at E, Fig. 152. It is usual, however,

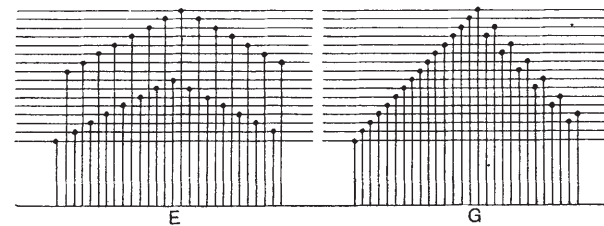
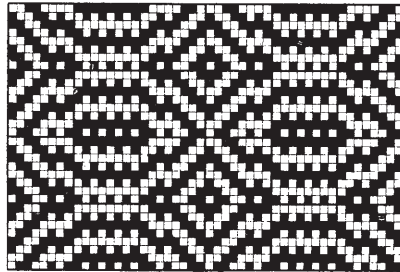


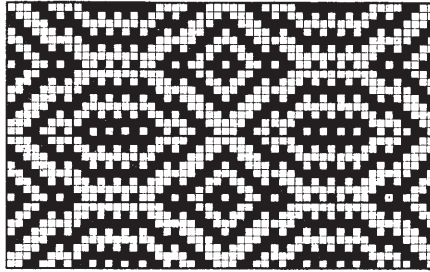
FIG. 152.

to place the cutting threads on the adjoining shaft, so that the draft would be arranged as at G. The weaving plan for draft G, Fig. 152, would be made up by arranging the

first 8 threads of weaves A and B, Fig. 151, in alternate order. Although Fig. 151 illustrates clearly the principle on which such designs are constructed, the resulting pattern is very elementary when we consider that 16 shafts are required for its production.



H



J

FIG. 153.

Two other motives for the same class of fabrics are illustrated at H and J, in Fig. 153. The only difference between these two patterns is that the central diamond parts in J are moved one thread to the right and one to the left of the lozenge figures. Four repeats of each are illustrated, the unit of H occupying 24 threads and 16 picks, while J is complete on 26 threads and 16 picks. If

the motive H be arranged on the odd threads of a design on 48 threads and 16 picks, and cutting threads arranged on the even threads, it will be found that the complete design requires only four shafts. The draft for design H, as it stands, is: 1, 2, 3, 4, 1, 2, 1, 2, 3, 4, 3, 4, 3, 4, 3, 4, 3, 2, 1, 2, 1, 4, 3, 2. But the threads marked 1 are exactly opposite to those marked 3; similarly, those marked 2 are the opposite of 4. Consequently, the weave of the cutting thread for all those marked 1 is simply the same as 3, while the weave for the cutting thread of those marked 2 is number 4. Such being the case, the draft for the complete design may be as follows: 1, 3, 2, 4, 3, 1, 4, 2, 1, 3, 2, 4, 1, 3, 2, 4, 3, 1, 4, 2, 3, 1, 4, 2, 3, 1, 4, 2, 3, 1, 2, 4, 1, 3, 2, 4, 1, 3, 4, 2, 3, 1, 2, 4. Or, better still: 1, 2, 3, 4, 2, 1, 4, 3, 1, 2, 3, 4, 1, 2, 3, 4, 2, 1, 4, 3, 2, 1, 4, 3, 2, 1, 4, 3, 2, 1, 4, 3, 2, 1, 3, 4, 1, 2, 3, 4, 1, 2, 4, 3, 2, 1, 3, 4. For the first draft the weaving plan is the first 4 threads and 16 picks of design H, Fig. 153, while for the second weaving plan threads 2 and 3 would change places.

Although there is so little difference between the motives H and J, there is a great difference between the number of shafts which they require. Design J drafted as it stands is as follows: 1, 2, 3, 4, 5, 6, 7, 6, 8, 9, 10, 11, 10, 11, 10, 11, 10, 9, 8, 6, 7, 6, 5, 4, 3, 2; but it will be seen that although threads 1 and 12 are cutting threads, numbers 2, 3, 4, 5, 6, 7, 9, 10, and 11 have no cutting threads. Therefore the thread-and-thread design made from this pattern would require no fewer than 20 shafts. It will thus be seen that, from a practical point of view, the simpler design would, in almost all cases, be preferred.

A photographic reproduction of a cloth woven with H as a base appears in Fig. 154. The base for the cloth shown in Fig. 155 is illustrated in the upper part of Fig.

156, while immediately underneath is the full design with the draft. The weaving plan consists of the first four threads of the complete design. The base in Fig. 156

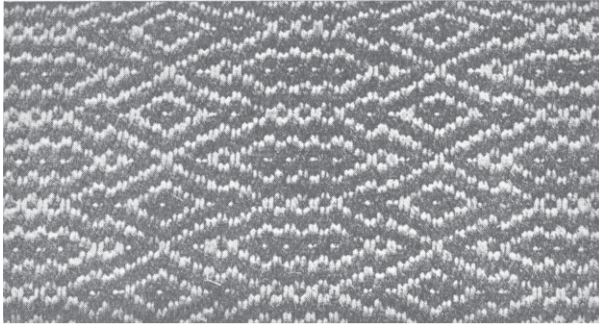


FIG. 154.

appears out of proportion when compared with the photographic reproduction of the cloth, and so also does H,

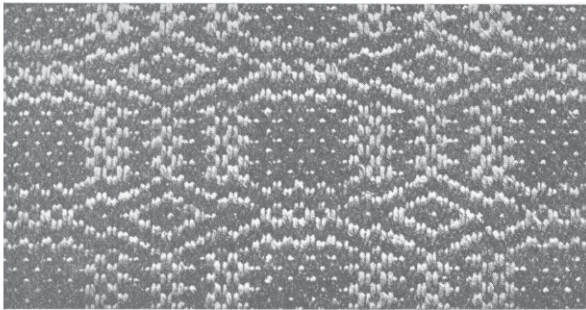


FIG. 155.

Fig. 153, with Fig. 154; but this is simply because the design paper is not of the proper dimensions. In each of the above cases one thread in the base represents four

threads in the cloth. These cloths usually contain from 16 to 20 warp threads per inch, and 8 or 9 shots per inch; the yarn in both cases being about 36 to 48 lbs. per spyndle in 3 to 4-fold twist.

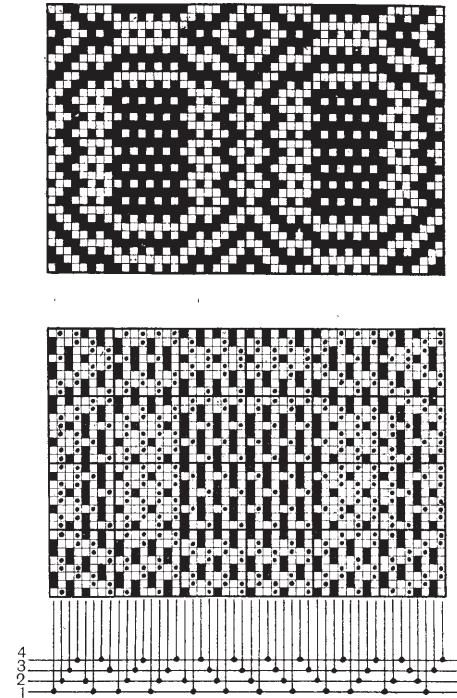


FIG. 156.

The employment of cutting threads as described above plays a very important part in the production of jute carpets, as well as in many other branches of the textile trade. Examples of other methods of arrangement are shown in Fig. 157. Design K is very useful as a ground

weave, and results in a non-continuous rib. The ribs may be of any desired length, and they may be all of the same length or of different lengths, but short ribs produce the firmest fabric. Design L is arranged for two threads of face to one thread of back; the face threads changing positions every pair. A similar proportion of face and

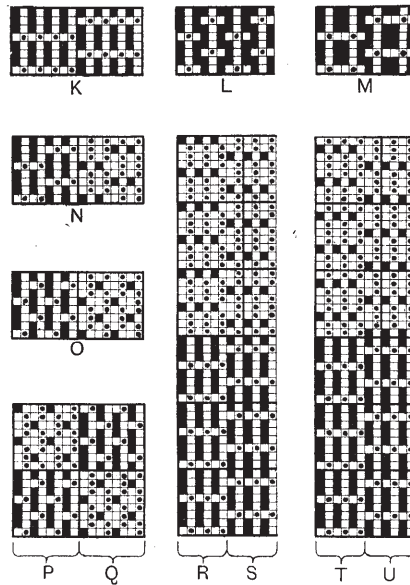


FIG. 157.

back threads appears in design M, but here the face threads change every four. K may produce a perfectly reversible fabric, but L and M are not properly reversible, and for the two latter designs the weft should be the same colour as the back threads.

Designs N, O, P, and Q are intended for 1 thread dark and 1 thread light throughout. With this order of warping

N and O would give stripe effects, the dark threads appearing on the face in the first half of each design, and the light threads in the other half. Design O appears again in the lower half of P and Q, the top half of the design being reversed as explained under Dices. This combination naturally gives a dice or check pattern, although the figure, which is intended to show the principle, is too small for practical purposes. The design marked R and S is for a larger pattern, one in which each of the parts R and S is repeated, say, four times. When very heavy yarns are used, the method of joining up the two portions of the weave in R and S, as illustrated in picks 24 and 25, and picks 48 and 1, is not satisfactory: it causes these picks to lie too far apart at the junctions. A better plan of joining for these heavy fabrics is illustrated at T and U in the same figure. The face threads in this, as well as in R and S, are grouped in threes, and the warping arrangement for each part is:—

$$\left. \begin{array}{l} 1 \text{ thread dark} \\ 1 \text{ ,, light} \end{array} \right\} \text{for 48 threads.}$$

The dark and light threads need not necessarily be always of the same shades; indeed, much better results are obtained when four shades are employed. Fig. 158 illustrates a pattern which has been made in this way, the warping arrangement being as follows:—

$$\left. \begin{array}{l} 1 \text{ thread maroon} \\ 1 \text{ ,, red} \\ 1 \text{ ,, green} \\ 1 \text{ ,, éceru} \end{array} \right\} \text{for 48 threads.}$$

The draft throughout is: 1, 2, 1, 2, 1, 2, 3, 4, 3, 4, 3, 4; and the weaving plan is the first two threads of T combined with the first two threads of U.

As a final example of this type of weaving we submit

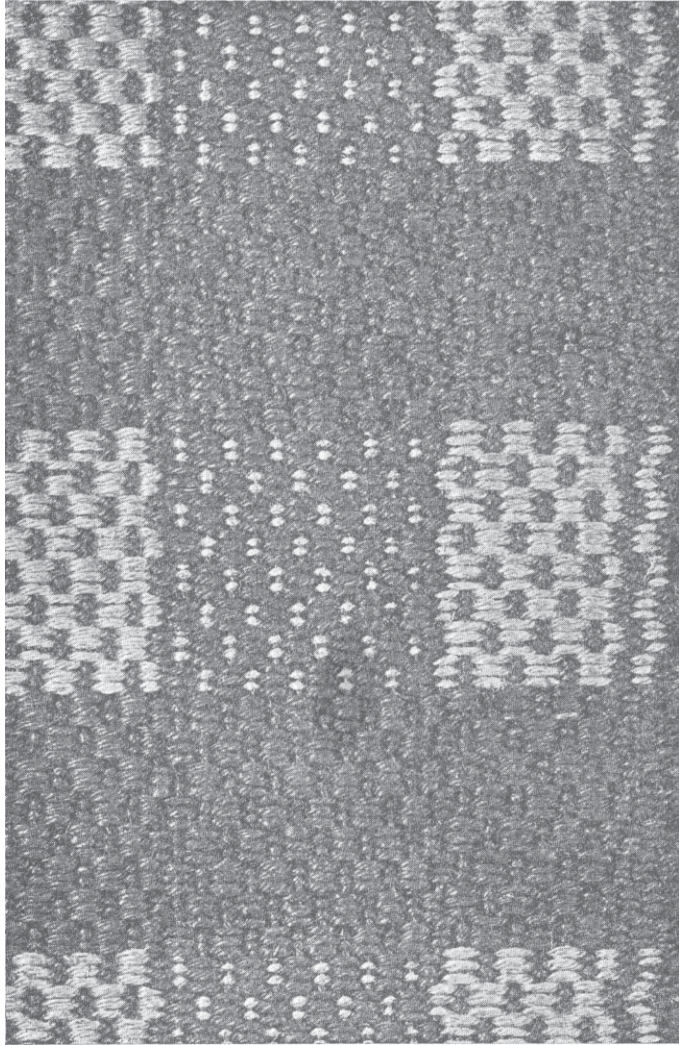


FIG. 158.

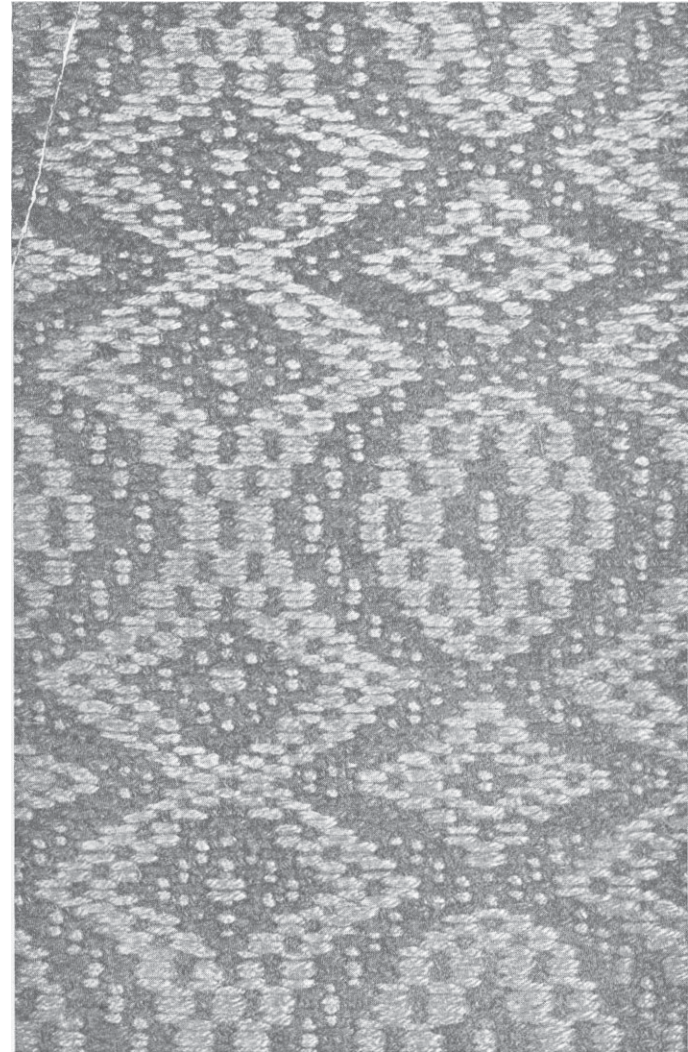


FIG. 159.

Fig. 159, which at first sight would suggest a large number of shafts. But by a careful arrangement of the original or base weaving plan, so that one-half of the shafts will work

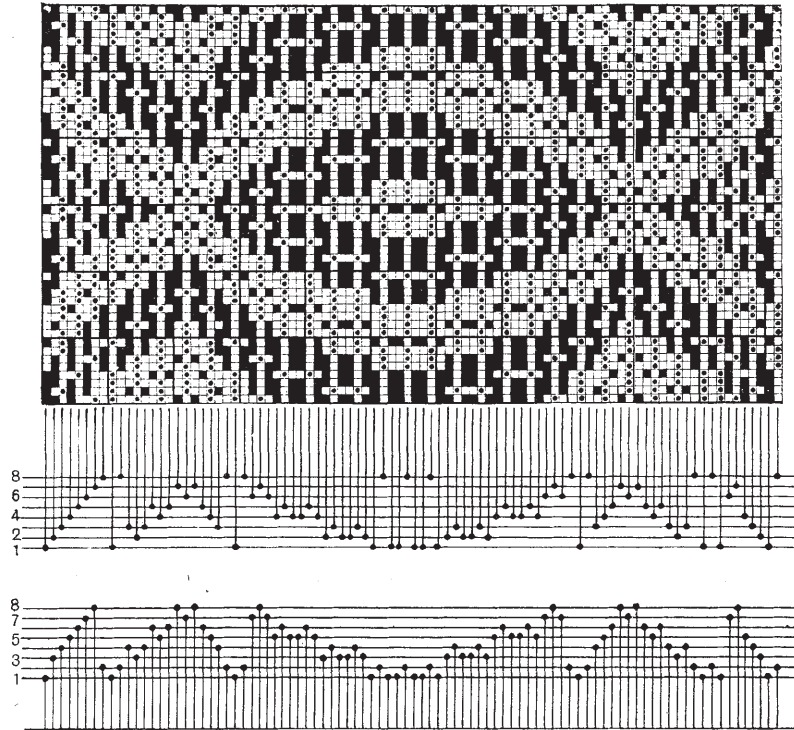


FIG 160.

in opposition to the other half, and thus control cutting threads for each other, the cloth may be woven with 8 shafts and 48 picks. The design for this particular cloth is fully worked out in Fig. 160, with two orders of drafting. The weaving plan for the first draft is the first 8 threads

of the design, while for the second draft, which would be used in practice, it would be necessary to use threads 1, 8, 2, 3, 4, 5, 6, 7. All these patterns are heavy as well as decorative fabrics, and are arranged for the warp to predominate on both sides.

Many decorative fabrics, constructed on the same general principle of double warp-face, are much lighter in weight than the foregoing, and are intended for hangings, table covers, etc. A higher order of decoration is essential for such fabrics, and they are generally produced by the aid of a jacquard machine. Either a full harness or a special harness jacquard may be used, but for economical reasons, chiefly with regard to cost of designing and cards, a special jacquard should be employed. With a full harness machine every thread of the warp requires individual treatment on design paper, either alternately as indicated at D, Fig. 151, or in sections as at A and B in the same figure, according as the harness is arranged; whereas with a special machine, where each needle controls two hooks with heads turned in opposite directions, so that if one is pressed off the rising knife the other is pushed on, only the face warp requires to be considered in designing. This effects a saving of about 50 per cent in the cost of design and cards for any particular pattern. Due, however, to the harder twist, and therefore usually stiffer character of warp yarns, fabrics so figured are not so widely found in light and medium weights; in these grades a considerable proportion of the figuring is developed by weft yarns. Still, on account of more rapid and economic production, it is often possible to produce warp-figured textures more cheaply than similar weft-figured fabrics, notwithstanding the higher cost of warp yarns.

## CHAPTER XII

## DOUBLE WEFT-FACED FABRICS

WHEN considered from a structural point of view, fabrics showing a surface of solid weft on both sides are very similar to those showing a surface of solid warp on both sides, or what we have termed double warp-faced cloths. In both cases the weaves employed, and the disposition of the yarns, are such that practically only one series of threads is visible on the surface of the cloth—the other series is hidden in the centre, and serves only as a binder for the face or figuring yarns, and for weight-giving purposes. In addition, that series of threads or picks which forms the surfaces will, for obvious reasons, be closely set, while the other series will be set comparatively open. In connection with double warp-faced fabrics it is mentioned that arrangements are usually made whereby the lifting of one thread to the face of the cloth will automatically cause its neighbouring or cutting thread to fall to the back. It is impossible to obtain similar results in the way of the weft by one simple operation; but, since such a disposition of weft yarns greatly simplifies designing and card-cutting, it forms a structure which is often adopted. For figured fabrics the general method is to prepare the design as in full harness damask weaving—*i.e.*, the figure is painted solid upon design paper with any suitable transparent colour, the twills in ground and figure are reversed in direction, and the edges of the figure are “bound” in the usual manner to secure a distinct outline. The design is then ready for the card-cutter, who cuts two cards for each weft line of

the design paper. On the first reading he cuts the twill in the ground portion, and the same colour in the figure all through the design, but on the second reading he cuts the unpainted portion of the ground as well as the twill part in the figure. Briefly, the cutting is tantamount to the following:—

1. Cut all red for odd-numbered cards.
2. „ blank, or other than red, for even-numbered cards.

The two sets of cards are thus the exact opposites of each other, and when laced in their proper order complete the chain for the loom. The one-and-one order of lacing is certainly the most desirable, and will give the best results. If, however, the loom has boxes at one end only, it is necessary to lace the cards two from each set alternately. In some cases this system is exceedingly undesirable.

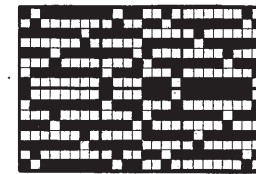
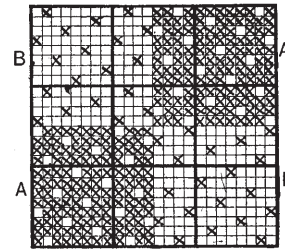


FIG. 161.

Fig. 161 illustrates a simple block or dice design developed on the above principle. The blocks marked A would be painted solid, and the twill in parts B would be of the same colour. Then a black or an opaque white paint would be used to indicate the twill in parts A. Each line of the design would then be cut twice, as explained, so that 48 cards in all would be prepared. The central picks of the design are shown developed pick by pick in the lower figure; this shows clearly how 16 cards

would be cut from the 8 picks—numbers 9 to 16 inclusive of the upper design.

As already mentioned, this method simplifies both designing and card-cutting, but it is faulty in that the stitching points in each pair of picks are on the same warp thread. One of the chief points for consideration in the designing of double weft-faced structures is the arrangement of the stitching points of the wefts. A few of these fabrics are woven with the plain weave, in which case it is impossible to give consideration to stitching points. In general, however, a float of some length is desirable in order to give a more or less solid appearance to the fabric, and the majority of these textures are developed in weft twills, sateens, etc. With all such weaves it is possible to arrange the weaves so that the stitching points of the back weft will not be visible on the face of the cloth, nor those of the face weft on the back. The essential conditions for obtaining this result will be explained and illustrated shortly; but, stated briefly, the principle involved is that no warp thread should stitch or bind both back and face wefts on two successive picks. We are, of course, at present dealing with two figuring wefts, but the binding points are made on precisely the same principle when simply backing with weft.

In order to illustrate the preparation of a design in which the binding points are satisfactorily placed, we introduce Fig. 162. This is practically the same design and twills as in Fig. 161. Parts A, which are invariably termed the figure portions, are again painted, say in red; the ground parts B remain unpainted except where the twill marks are introduced. Any style of colouring may be adopted, provided the binding points are quite distinct. Some such order as the following would be quite suitable for green design paper :—

1. Paint all the figure in red, represented by marks  $\times$  in parts A, Fig. 162.
2. Paint ordinary twill in figure in white, represented by marks  $\bullet$  in parts A, Fig. 162.
3. Paint ordinary twill in ground in black, represented by marks / in parts B, Fig. 162.
4. Paint binding twill in ground in white, represented by marks  $\circ$  in parts B, Fig. 162.
5. Paint binding twill in figure in brown, represented by marks  $\blacksquare$  in parts A, Fig. 162.

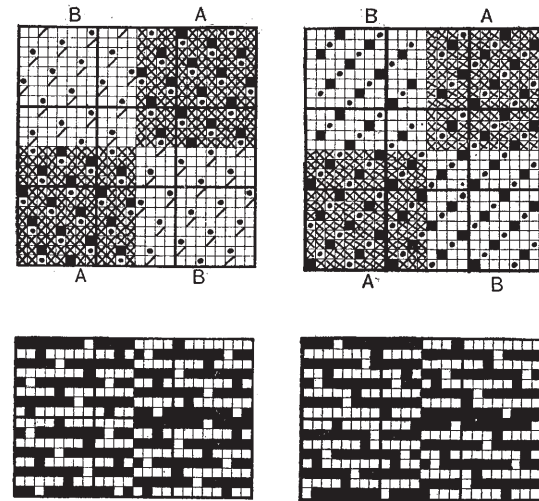


FIG. 162.

FIG. 163.

It will thus be seen that the essential difference between this and the full harness damask method is the addition of a mark immediately above each twill mark in both ground and figure. The card-cutter again cuts two cards for each weft line of the design paper, and in the following manner :—



1st reading: Cut all  $\times$  and  $\blacksquare$  in figure and / in ground.  
 2nd reading: ,,  $\bullet$  in figure, and all blanks and / in ground.

When figuring with two 8-thread sateens, as in the above example, there are always two equally good places where stitching or binding may be performed. The arrangement in this design illustrates what is perhaps the simpler plan as regards the insertion of the twill, but the binding would do just as well if the marks  $\bullet$  in the ground were moved one point to the right—those in the figuring remaining where they are. Similarly, an equally perfect binding would result if the solids in the figure were moved one point to the left. The actual cutting for the middle eight picks appears immediately under the design.

There is nothing very difficult in the painting of the twills in the above design, but an even simpler method is illustrated in Fig. 163. Here, the preparation, so far as painting is concerned, is the same, but the twills are painted in 4-thread twill order as shown—the two sets of marks appearing alternately. The binding is not so perfect by this method, but it is satisfactory, and the method has the great advantage of being exceedingly simple to prepare. It is often used in practice with the following order of cutting:—

1. Cut all  $\times$  and  $\bullet$  in figure, and  $\bullet$  in ground.
2. ,,  $\bullet$  in figure, and all blanks and  $\bullet$  in ground.

The lower figure again shows the central eight picks of the design fully developed according to the above cutting instructions to give 16 cards. For the first pick of weft it is clear that the solid squares act as the binding twill on the figure, while the dots perform a similar function on the ground. The exact opposite holds good for the second pick.

It is always a distinct advantage to have the edges of the figure sharply defined. The actual cutting plan in Fig. 162 shows that it would result in perfect definition of the figure edges, but all designs prepared in this way do not turn out so fortunately. A perfect cutting edge may, however, be obtained by omitting the twilling marks at the junction of the ground and figure. This has been done in Fig. 163 at the joining parts of the two upper blocks—that is, on threads 1, 12, 13, and 24, where no

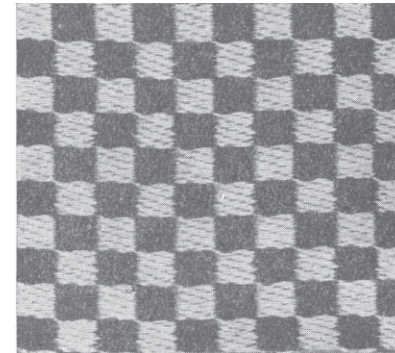


FIG. 164.

twilling marks appear. Fig. 164 is a photographic reproduction of a cloth woven from design 163; the practical results of the two styles of treatment are clearly illustrated in this figure. The dark squares in the even horizontal rows are much more perfect than are the corresponding squares in the odd rows. This method is in some respects an extension of that adopted in full-harness work, where the twill marks in both ground and figure are omitted if there is any tendency to injure the outline. Long vertical floats in the full-harness designs

cannot, however, be left, but in this method such a proceeding makes no difference, for the two wefts make the binding secure, and no long floats appear on the cloth.

Such is, in general, the method of preparing designs for double weft-faced fabrics, and it may be remarked that what has been said concerning the development of pattern in double warp-faced fabrics may be considered applicable to double weft-faced goods if the design for the former be turned through an angle of  $90^\circ$ . In each case both colours of the figuring series appear alternately on the surface, and, in addition to developing the pattern in this manner, they naturally add considerably to the weight, and in some cases to the durability, of the texture. When, however, the end in view is merely the addition of weight, an entirely different procedure is practised. The extra weight, whether of warp or of weft, is arranged so that no part of it is allowed to appear on the surface. When this extra layer is formed by the weft, the process is usually termed "backing with weft," while for similar reasons those fabrics with an extra layer of warp are designated as "backed with warp." Both, therefore, are of the nature of backed cloths.

## CHAPTER XIII

### BACKED CLOTHS

#### 1. FABRICS BACKED WITH WEFT

THE relative number of face and back picks, or face and back threads, in multiple fabrics is determined

principally by the sizes of the respective yarns, for it is clear that if both sets are to lie closely together, the diameters must be considered. We simply mention this in passing, but the necessity of taking this into account will become apparent as we proceed. The varieties of order in the backed cloths are, however, very few, consisting principally of 1 pick face to 1 pick back, 1 thread face to 1 thread back; or 2 picks face to 1 pick back, 2 threads face to 1 thread back. But whatever proportions are adopted, provision must be made for the free movement of one set of picks or threads independently of the other set. For facilitating the construction of these weaves it is customary to mark the back picks or threads in some transparent colour, although after a little practice this operation may be omitted.

In Fig. 165 there are four designs, the odd picks in all the designs being identical, and representing the ordinary 8-thread sateen with weft on the surface. The intersection of the first pick for two repeats of each weave is shown by the solid black lines in the four corresponding sections immediately under the designs. If, as we have stated, the only object is that of adding an extra layer at the back for weight, the yarns which form this extra layer should not only be firmly bound into the cloth, but should be completely covered by the face yarns. These conditions are most satisfactorily fulfilled when one set of picks can easily slide along the threads over the other set of picks. To make this more clear, let us revert to Fig. 165. The odd picks, which are the same in each case, are for the face of the cloth; the even picks form the back layer in each case on the same 8-thread sateen weave, but this back weave starts in each design at a different place. The intersections consist of the first

two picks and two repeats in the way of the warp, or 16 threads, and each is marked by a letter corresponding to that of the design. If we imagine the 16 threads in section *a* to represent the sections of 16 rods, it is

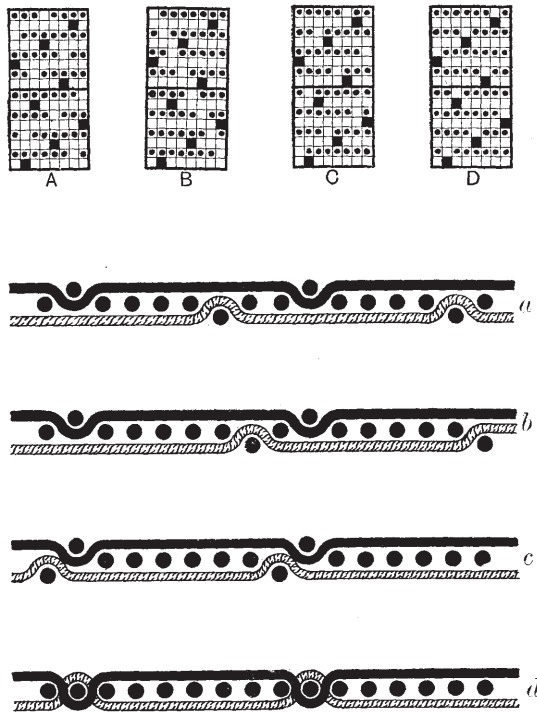


FIG. 165.

easy to see that, whether pick 1 or pick 2 be in a stationary position, the other could easily slide along the rods or threads with which it interweaves. Now, whichever pick happened to lead in weaving, that pick would remain in its position while the other one was being pushed

forward by the reed; and, although the movement of the pick on the threads cannot be compared with the ease which it would move along the supposed rods, still the fact of choosing the stitching point of the back weft as far removed as possible from the stitching point of the face-weft facilitates this movement. The point chosen in A or B would be quite satisfactory as shown by the intersections *a* and *b*. Intersection *c*, however, shows that some slight resistance would probably be offered to the free movement of pick 2, while intersection *d* illustrates clearly when it is absolutely impossible for the whole length of one pick to slide completely under the other. This intersection also shows that with this method of stitching, each pick appears on the opposite side of the cloth—a state which we are supposed and attempting to prevent. It is evident from the sections that for satisfactory work the binding weft should pass over a face thread which is near the middle of a group of threads covered by the floating of the previous and the succeeding face picks. In other words, the particular face thread chosen for stitching should fall for three successive picks, the middle one being the back pick.

The principle of backing with weft is further illustrated in Fig. 166, where the solid marks again represent the face picks. The  $\frac{2}{2}$  twill to right at E is repeated four times on the face picks in design F, while the back weave is the 8-thread sateen. All marks in design F represent threads lifted, and it will be seen that each of the blank squares on the even picks chosen for the stitching point is between two blanks on the same thread. The effect in the cloth obtained by the use of design F would be precisely the same as that resulting from design G, provided marks represent falling threads in the latter;

indeed, each thread in design G is the reverse of the corresponding thread in design F. The number of separate marks on design F is 88, as compared with 40 marks on design G, and in all cases, except where the

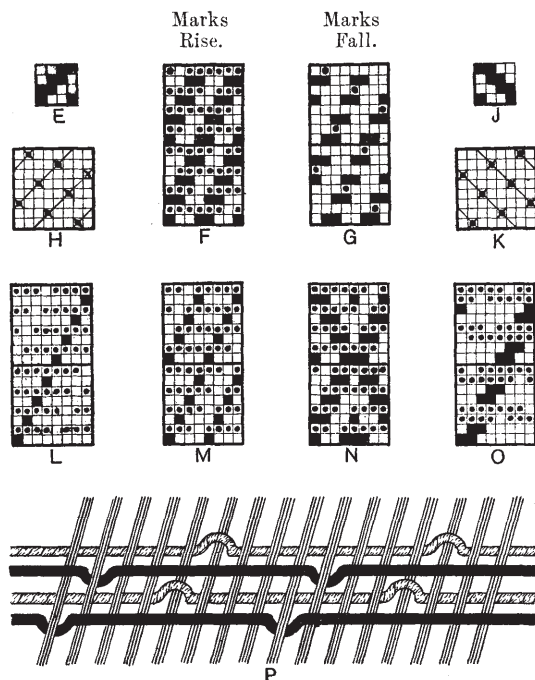


FIG. 106.

face picks float over the maximum number of threads, a saving of labour in designing is effected by the convention that "marks fall." But a greater advantage attending the use of "marks to fall" is the comparative ease with which the stitching points may be located. It is always easier to mark a square between two other

marked squares on the same thread, than to leave a blank square between two other blanks.

With the pick-and-pick arrangement the right-hand twill should be backed by the sateen weave H, while for left-hand twills the sateen weave K must be used. The diagonal lines in H and K are inclined in the same direction and at the same angle as the twills in E and J. Some straight twill face weaves cannot be perfectly backed with either sateen weave—*e.g.*, no weave with less than four threads in eight dropped on each pick is suitable, nor any with four threads dropped except the two shown, while several with five down out of eight are unsuitable. In some cases a straight twill backing arrangement is more suitable; this method of backing is illustrated in design L, although the face weave in this example could be easily and satisfactorily backed with a sateen weave. This design L illustrates clearly that the same number of marks would be required if the design were made for marks to indicate threads down—64 marks would appear in each method.

The  $\frac{1}{3}$  straight twill, backed with the  $\frac{7}{1}$  straight twill, appears at M. Any 8-thread or 4-thread straight face twill, with two or more successive threads down on each pick, can naturally be backed with the  $\frac{7}{1}$  straight twill, but irregular weaves require special treatment. Thus, the face picks in design N constitute the simple 8-thread diamond made from the unit weave E. It is impossible to use a perfectly straight twill for the back of this weave, because, as is pointed out in the chapter on diamond designs, the outline or base of the diamond is not continuous. A weave with irregularly distributed marks must therefore be used; the stitching points on the weave employed will be found on threads 3, 4, 1, 2,

8, 5, 6, and 7. The student should remake this design with marks to fall, and notice the advantage of so doing.

Design O is arranged as follows :—

2 picks of the  $\frac{2}{6}$  straight twill for face.  
2 ,, an irregular twill for back.

The 8-thread sateen H can be arranged for the back of this, but the one illustrated is sometimes used because it places the stitching points nearer the centre of the floats. A 2-and-2 pick arrangement would hardly ever be adopted, unless where the loom had a single box at one end, or was not fitted with a pick-at-will motion. The figure at P, which shows the first four picks of design L, is a further proof of the advisability of choosing the stitching point near the middle of the float in order to facilitate the desired movement.

All the designs in Fig. 167 are arranged with two picks of face to one pick of back. The marks in designs Q and S indicate threads lifted, while the same designs are illustrated in R and T with marks to fall. It will be seen from Q and R that it is impossible to back the  $\frac{2}{2}$  twill in a perfect manner with these proportions of face and back picks. No proper point is available on any of the even threads, so that if such a cloth were required, it would be necessary to place all the stitching points on the odd threads, as shown, or to introduce part of them on the even threads and risk the back weft showing through on the surface.

The blocks of the 4-thread basket or hopsack should be split up as indicated in designs S and T, otherwise no point is satisfactory. Even as it is, the back weave must be an irregular one if the stitching point is to appear on every thread, and this is desirable. All designs with these

proportions of face and back picks require a more or less irregular back weave. The back weaves for designs U, V, and W appear immediately under each design, and may be considered as irregular sateen weaves.

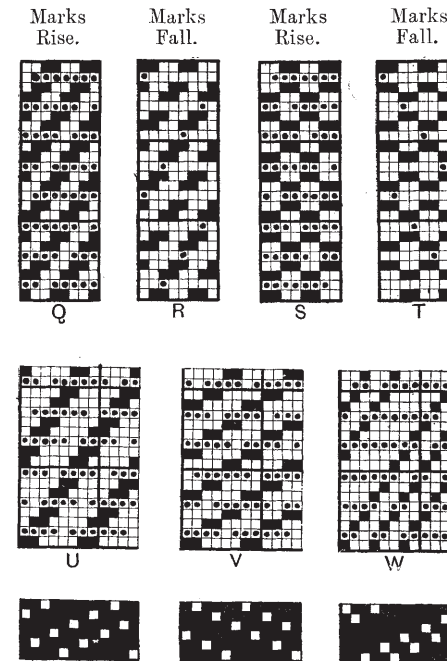


FIG. 167.

By this time the reader will probably be convinced that the method of indicating the designs of weft-backed fabrics by marks to fall is the simpler; indeed, if designs U, V, and W, in Fig. 167, had been made in this manner, it would have been unnecessary to introduce the back weaves separately. Being of this opinion, we adopt marks

to fall in the next figure. When the proper kind of loom is not available, the 2 face 1 back cloths are sometimes woven by the equivalent but less desirable numbers 4 face 2 back; it is, however, often impossible to adopt the latter scheme. Thus, in Fig. 168 (marks fall) we show the  $\frac{4}{4}$  twill

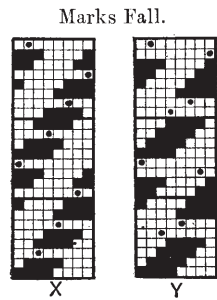


FIG. 168.

backed in two ways. The 2 face 1 back design at X would be quite satisfactory, but it is clear that the same order of weaving for the back picks would be unsuitable for the 4 face 2 back method shown at Y. In short, when any mark on a back pick is immediately above or below a blank on a face pick, the binding is imperfect, and the tendency for these points to appear on the surface increases as the number of successive picks of the same kind increases.

## 2. FABRICS BACKED WITH WARP

If the principle of backing with weft be thoroughly understood, little need be said about the construction of fabrics backed with warp. The chief difference between the two types is that face picks slide over back picks in weft-backed fabrics, whereas it is the face threads which hide the back threads in fabrics backed with warp. In order, therefore, to arrange the marks so that the face threads will conceal the stitching points of the back threads, it is necessary and sufficient to lift a back thread between two lifted face threads. Thus, there should be three successive threads lifted on the same pick—the middle one being the backing thread.

Designs A and B, Fig. 169, are typical examples of the method of backing with warp. The former is a combined twill and basket pattern backed with the 8-thread straight twill. Design B is the  $\frac{2}{2}$  twill to left with a sateen back. It will be seen that the latter design is precisely the same as G, Fig. 166, but turned through  $90^\circ$ . Any design, therefore, on the weft backed principle with marks to fall can be utilised for a warp backed fabric, provided the design is turned quarter round, and marks taken to indicate rising threads. The only difference which results from such an operation is that the twill is reversed in direction and developed by warp instead of weft.

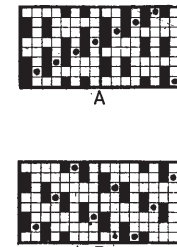


FIG. 169.

While the foregoing notes embody the main principles involved in the methods of utilising yarns in the structure of the ordinary three-layer cloths, special systems are sometimes introduced; but these are, as a rule, unable to supplant the above general processes. For example, a system intended to replace the previously mentioned method of backing with warp is illustrated in Fig. 170. Design A shows four repeats of the  $\frac{2}{2}$  twill. By increasing the number of warp threads per inch, decreasing the number of picks per inch, and retaining this weave, it is possible to make the warp predominate on the surface. But this can be done only to a limited extent. If, however, alternate twills of design A, shown in solids, be arranged on the odd threads of a new design, and the remaining twills, shown in crosses, be placed on the even threads of the same design, we shall obtain design B. This is a much opener weave than A, hence more threads per inch may be

introduced; indeed, we may use almost the same number of threads per inch as in the ordinary warp-backed fabrics. When arranged in this way the floats of each pair of threads take up a position which is almost in the same straight line, and the effect on the surface of the cloth is somewhat similar to that obtained by the ordinary  $\frac{2}{2}$  twill. The floats of warp are precisely the same, but the weft shows alternate narrow and wide twills, approximating to floats of 2 and 3 respectively. By a similar thread-and-thread

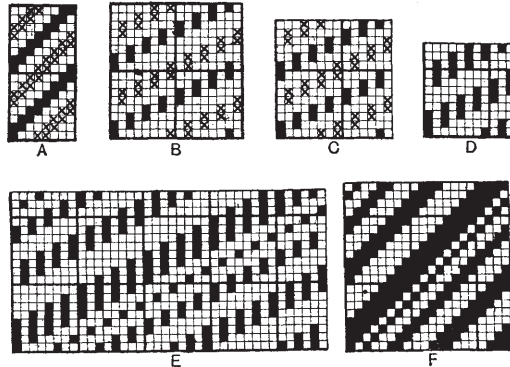


FIG. 170.

arrangement of weave A, and a slight reduction in the number of threads and picks per inch of the complete design, the floats of weft in each twill can be made of a constant length. Thus design C contains the same four twills marked in solids and crosses, and if each pair of threads moves into the same straight line, the floats of weft will be the same length as those in design A—assuming, of course, that the latter contains only half the number of threads per inch used for design C. It is evident, however, that the threads of each pair must cross each other; they

cannot, therefore, give precisely the same effect as the face threads of an ordinary warp-backed fabric. Moreover, since each thread plays a part in the formation of both sides of the fabric, it is clear that all the warp threads must be of the same quality—a very obvious financial objection. Design D is a similar arrangement for the  $\frac{3}{3}$  twill.

Design E is probably the best way of reproducing the single  $\frac{4}{4}\frac{3}{3}\frac{2}{2}\frac{1}{1}$  twill shown at F by the above thread-and-thread arrangement. Each pair would again fall into the same straight line if the number of warp threads per inch were approximately double that required for design F. The system is in reality a modification of the corkscrew weaves. By turning these designs through an angle of  $90^\circ$  similar fabrics on the double weft principle can be obtained.

The ordinary principles of backing which have just been described are very extensively applied in all branches of the textile industry.

It has been shown that the two layers of weft, or the two layers of warp, may be displayed continuously on opposite sides of the cloth without any change of position, or both may be used conjointly on each side—one to form the figure, and the other to form the ground of any kind of ornamental fabric. When each yarn binds uniformly in ground and figure, the preparation of the design may, in many instances, be simplified; but where the binding is irregular, as in many tapestries, it is often desirable, although perhaps not absolutely necessary, that each thread should occupy a line of its own on the design paper. The order of lifting may thus be clearly defined, not only for the designer, but also for the card cutter and all others concerned.

The simplification in the preparation of designs has already been illustrated in Figs. 161, 162, and 163, and further systems of contracted methods of designing are

exemplified in Fig. 171. A and B are respectively the  $\frac{1}{3}$  and the  $\frac{3}{1}$  twills, and these weaves have been joined together in C to form two repeats in the way of the warp. The same two weaves or units are employed in design D, which is identical with C, except that the last pick in C is the first pick in D. Both designs would produce fabrics of the type termed "double weft-faced." If the two designs C and D be joined together as shown at E and F, the marking of the squares remains the same, although the two

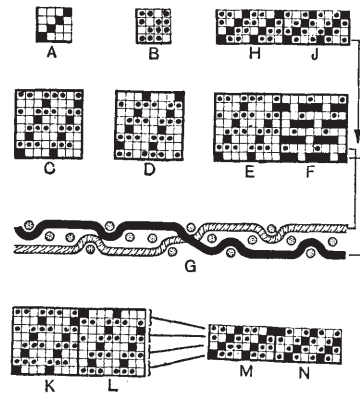


FIG. 171.

kinds of marks have been changed in F so that each line in the direction of the weft may indicate a certain colour throughout. Thus, the solid marks on the odd picks may represent dark weft, and the dots on the even picks may indicate light weft. A cloth woven from this design would be similar in construction to the intersection G, which shows approximately the positions that the first two picks would occupy. When cotton warp is used in conjunction with two colours of heavy woollen weft, and the piece is milled or fulled and then raised during finishing, as is done

for some classes of carriage rugs, etc., the warp threads are completely covered, and the ground and figure of the fabric are thereby developed in solid colours. The same degree of solidity of colour cannot be obtained with jute weft, but the principle of designing is exactly the same. In these fabrics the number of picks per inch is usually about double that of the threads, so that for figured work 8 by 16 or 12 by 24 design paper would, under ordinary conditions, be necessary if, say, weave E were used for the ground and weave F for the figure. In order, however, to dispense with this fine ruling of the paper in the way of the weft, and to be able to use paper ruled on the "square"—*e.g.*, 8 by 8 or 12 by 12,—the designs are sometimes prepared as at H and J for ground and figure respectively. Two cards would, of course, be cut for each line of the design paper. Thus:—

- 1st card : Cut solids in H and all marks in J ;
- 2nd card : Cut all marks in H and solids in J.

and so on for each line of the design. The arrow from the first weft line in J shows that the intersection would be the same as that from the first two picks in E and F. The figure is painted on design paper in the usual manner, and the 4-leaf  $\frac{3}{1}$  twill inserted as at J with a distinctive mark on the middle spot, while the distinctive mark for the ground weave is placed on the first square of each float as at H. An even simpler method is illustrated at K, L, M, and N, in the two latter of which it will be seen that the same twill is inserted all over ground and figure, but the distinctive marks are on the first square of each float for the ground, and on the second square of each float in the figure. If this style is adopted the  $\frac{3}{1}$  twill may be printed on the design paper.



## CHAPTER XIV

## SPOT AND SIMILAR ISOLATED EFFECTS PRODUCED WITH EXTRA WEFT OR EXTRA WARP

FABRICS produced as indicated in Fig. 171 are essentially "reversible"; both sides may, in consequence, be utilised, although as regards the colour effect one side is usually superior to the other. A reversible fabric possesses one obvious advantage, but there are many fabrics which are not reversible; indeed, there are many types of compound fabrics which cannot be so constructed, while in several other cases it is unnecessary that they should be reversible. The extra weft or warp in these fabrics appears on the surface to form more or less elaborate figures, and when not so engaged it is either floated loosely on the back of the fabric or bound to the back at regular or irregular intervals. When so bound the structure of the cloth at these places is identical with the weft-backed or warp-backed fabrics. Although labour-saving devices may be practised to some extent in these designs, we prefer to illustrate each shot or pick by a separate line on the design paper.

Design A, Fig. 172, is of a diamond nature, the foundation lines being composed of the 6-thread imitation gauze weave shown at B, while the rest of the weave is  $\perp$  plain. If this design were reproduced in cloth, the outlines of the diamond would have the open appearance which is characteristic of all imitation gauze weaves, whereas the centres of the diamonds would be perfectly plain. Design C illustrates the method of forming weft spots, the ground-work being formed by design A, which is shown developed

in solid marks. The 3rd, 4th, 14th, 15th, 19th, 20th, 30th, and 31st picks are the extra figuring weft, and since marks indicate warp to rise, it is clear that each of these picks will form long floats at the back. As a matter of fact they float over only three threads when on the surface, and then pass to the back of the fabric, where they float, untied or unbound, between adjacent figures. This is demonstrated by the intersection E formed by the two picks in section D, and which are the same as picks 2 and 3 in design C.

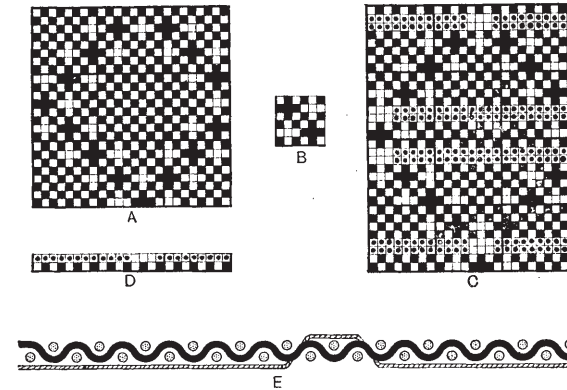


FIG. 172.

One of the great objections to these fabrics with spot effects, especially if they are dark spots formed on a white or light-coloured ground, is the tendency which the figuring yarn has of showing through, and thus casting a kind of shadow or dark band across the fabric. The defect is minimised when warp and weft combine to form a heavy texture, but otherwise the fault is almost sure to appear, with disastrous results. There are two ways of dealing with a fabric so as to eliminate this defect:—

- (a) By cutting off the long floats at the back; a process which involves an extra operation and machine, leaves the yarns forming the spot insecurely held by the ground picks, and reduces the weight of the fabric. The material thus removed may be sold, and thereby partly compensate for the loss in weight and the cost of removal. In spite of these drawbacks the above method is largely practised for fabrics similar to Madras muslins, the use of which—*e.g.*, for curtains—naturally requires the removal of the floats in order to develop the pattern distinctly.
- (b) By introducing the spots by swivel or lappet weaving—costly processes as a rule, but possessing the distinct advantage of displaying the figuring yarn practically only where it is required, and thereby preventing any undue waste of what is usually costly material, and also of securely binding the extra weft yarn.

The figure under notice illustrates, sufficiently well, the ordinary method of applying extra weft, although in many cases it is found necessary to introduce a little plain weave on both sides of each figuring spot: this secures the picks more firmly, but it usually makes the pattern less distinct. In a design such as that illustrated in Fig. 172, the figuring or spot picks should appear on the surface only in the gauze part; if they appeared on the plain part, and floated under the imitation gauze part, it is evident that a barred effect would result, since it would be impossible to hide the picks immediately under the imitation gauze or openly woven parts of the cloth.

Two diamond designs are illustrated in Fig. 173, and if they are carefully compared it will be found that design

F is exactly the reverse of design G—*i.e.*, if the paper were doubled over along the line HJ, the marks in one design would fall on the blanks in the other. Many fancy vestings are made with similar weaves developed in linen, cotton, woollen, or worsted grounds, and with extra wefts of silk or similar lustrous material for spotting. Since the figuring yarn is usually much finer than the ground yarns, it is essential that the figuring floats should be comparatively long, unless special precautions are observed in the

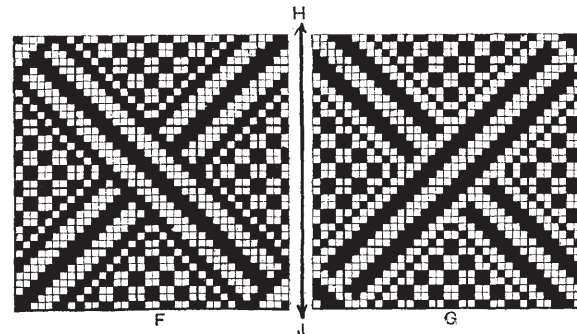


FIG. 173.

preparation of the design. To illustrate our meaning we introduce Fig. 174, which is a weft spot pattern arranged on 36 threads and 48 picks. The ground weave of this design is identical with F in Fig. 173, and the spot is simply composed of six picks, four of which float over six threads, and two which float over four threads. The spots are placed exactly in the centres of the two diamond parts, both of which are developed in the 4-thread basket or hopsack weave. Since marks lift in this figure, the blanks on the figuring picks indicate where these weft threads are on the surface. Although this design is similar in general

principle to that in Fig. 172, it is more complete, since in addition to illustrating the introduction of a spot, it demonstrates the method of checking the long floats between laterally adjacent spots. On the figuring picks, which are represented by dots, the blank floats of four and six indicate the spot, while the isolated blank squares on the same picks indicate the stitching points. It will be

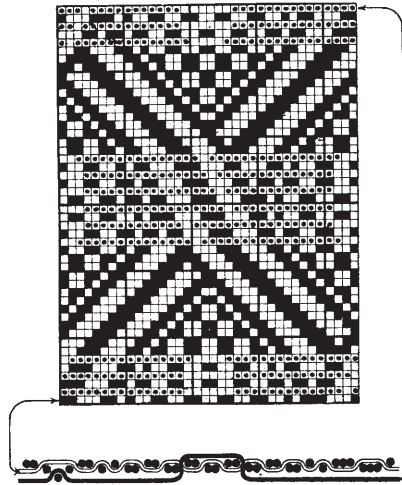


Fig. 174.

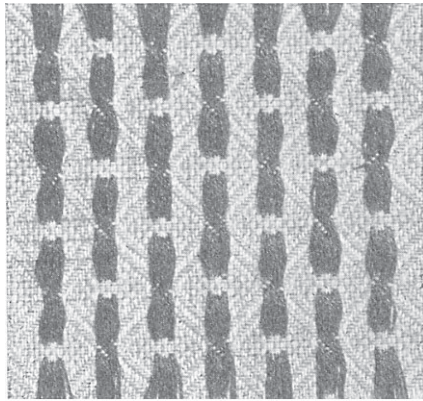
seen that wherever a single blank square appears in the horizontal direction on a figuring pick, it is the central one of three successive blanks in the vertical direction on that thread. This method of stitching is precisely in keeping with the method described in reference to designs A and B in Fig. 165. Clearly, then, while each figuring pick illustrates the method of figuring with weft, it may also illustrate the method of backing with weft—the stitching and backing being performed in exactly the same way,

although for different purposes. The intersection at the bottom of the figure shows the interweaving of the threads with the ground weft, as well as the method of floating and of stitching. All the threads in the design are represented in the intersection, but only those picks which are indicated by the lines and arrows. The stitching point is over the fourth thread, and the figuring float is over the six middle threads.

Fig. 175 is a photographic reproduction of both sides of a cloth which has been woven from the design in Fig. 174. K is, of course, the face of the cloth, and the spots show up prominently in their respective positions. L is the back of the cloth, the dark patches being the dark figuring weft. It will be easily seen where the dark weft passes to the surface to form the spot, and it will also be noticed that the floats are checked by the stitching points. There are six stitching points in every group, but some show clearer than others.

Each of the spot floats in Fig. 174 and in the woven examples in Fig. 175 is longer than the longest weft float of the ground weave, and when this is the case the figuring picks are certain to appear distinctly on the surface. If, however, some of the spot floats were short, and the ground weave were introduced in its entirety as in the figure, there would be some danger of the fine figuring picks being covered by the comparatively heavy ground picks. It is in such cases that special provision must be made to ensure the proper development of the spot or spots. Little fault can be found with the appearance of the spots in Fig. 175, but it is possible to obtain an even sharper outline by modifying that part of the ground weave which is immediately under the spot. Although recourse to this treatment has been found unnecessary in the above example,

some modification becomes absolutely essential in certain

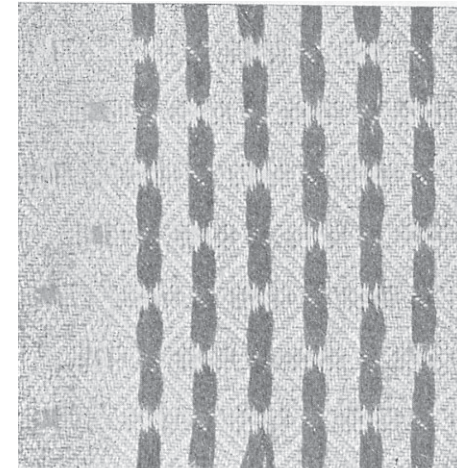


L



K

FIG. 175.



N



M

FIG. 176.

particular cases. Take, for example, the patterns of cloth illustrated at M and N in Fig. 176. Three-fourths of

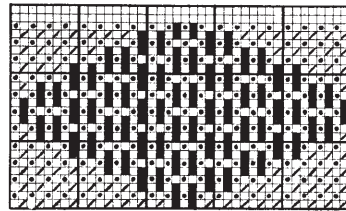
pattern M from the bottom upwards shows the weave effect which would be produced in the fabric by using design G, Fig. 173, as base. The diamond parts in the figure are developed entirely in the 4-thread basket weave as indicated in the design, but it will be noticed that five small blocks in each diamond are dark, while the others are light. These five blocks (which are of the same size as all the other blocks in the diamond part, and which would appear in white if the pattern were woven as a single cloth from design G, Fig. 173) are developed in M, Fig. 176, by extra weft: hence the floats of the figure weft in this example are no longer than, but just the same length as, those immediately surrounding the spots, and yet they are quite well defined. If an attempt had been made to produce this small spot effect upon ground weave G, Fig. 173, without any alteration of the ground weave, the result would have been a distinct failure. The ground weave must be modified in order to secure the desired effect; and the top part of M, Fig. 176, shows the woven result of the modified ground weave with the figuring picks removed. This upper part of the pattern shows that some threads are floating for a considerable distance: indeed, four of them in each diamond float over ten picks, while the remaining two float over six picks. The scheme is simply the following: All threads within the area of the spot, which would have been dropped in an ordinary single or simple cloth weave, are here raised for the ground picks, but are dropped on the following extra weft or figuring picks. In short, the dark figuring picks supplant white picks at each of the five small blocks in each diamond—that is, in the above-mentioned area. Pattern N, Fig. 176, is the opposite side of pattern M, and the large spaces between the groups of dark weft show that the ground

as in most other things, is the price, and when, for competitive reasons, the amount of pile yarn is reduced greatly, and, in addition, an inferior yarn is used, the most important feature of the fabric is the colour scheme. Since this work does not embrace the application of colour to woven fabrics—a phase of the subject which is very extensive, and very difficult to illustrate satisfactorily even by the best known processes of printing—we shall consider these fabrics almost solely from the structural point of view. It is, however, chiefly due to the fact that colour plays such an important part in all the above mentioned fabrics that special makes of machines are used for the production of each type of fabric. By this means the preparation of the designs is materially simplified; as a matter of fact the designs are made without regard to the methods of interweaving, simply because nearly all examples of any particular type are of the same structure, and the latter need not, therefore, be considered by the designer. In some cases the same design without any alteration may be used for different structures.

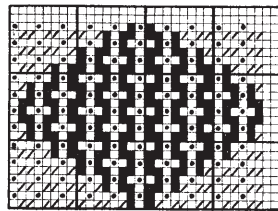
Perhaps the simplest and cheapest of all pile carpets is that known as Tapestry—a term which, unfortunately, is also applied to distinguish other well known, but more complex fabrics. But since this type of carpet is really a cheap imitation of Brussels carpet, we prefer to leave its brief description until the Brussels and Wilton carpets have been discussed.

Brussels carpet, unlike many other carpets, both inferior and superior, requires a jacquard for its production. The carpeting consists essentially of two kinds of warp yarns, pile and ground, and one kind of weft. Often three kinds of warp are used—pile, ground, and stuffer—and in all

by the warp threads appears in Fig. 178. It is complete on 48 threads and 36 picks. The ground weave G, Fig. 173, is introduced just as it stands, but it is in reality the same as that used for the last example. Each spot is formed by the floating of six threads, and the latter are



O



P

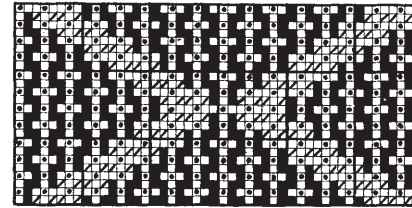
FIG. 179.

left the middle figuring thread is shown raised for stitching purposes.

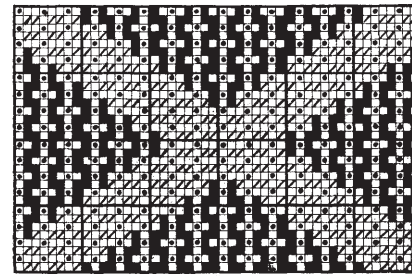
Spot patterns may, of course, be formed without either extra warp or extra weft, and in Figs. 114 to 118 inclusive (pp. 159-164), we have illustrated and described one method of developing such fabrics. We now illustrate in Fig. 179 another method which is extensively used in many branches of the textile industry. The structure of this type is exceedingly simple, and depends, as shown, upon one ground warp and one combined ground and figuring warp.

stitched as explained in the part which deals with warp-backed fabrics. The intersection immediately under the design shows how the first pick interweaves with all the 48 threads. The solid dots indicate the ground threads, while the circles represent the figuring threads. Some of the latter appear on the surface near the middle of the intersection, some on the right hand are at the back of the fabric, while near the extreme

In both designs the ground warp is represented by dots, while the figuring warp is shown in solids when forming the figure, and in diagonals when forming the ground. The threads in design O are arranged 1 and 1, and those



Q



R

FIG. 180.

in design P are arranged 2 and 1. In both cases the floats are limited in length to three picks: this limit, combined with the plain structure of the ground, makes a firm fabric. The same principle is observed in designs Q and R, Fig. 180, the diamond forms in the former figure being joined together, whereas in the latter they are detached.

## CHAPTER XV

EFFECTS PRODUCED WITH EXTRA WARP AND  
EXTRA WEFT

FIGURING by means of either extra warp or extra weft affords immense scope for the development of pattern. Greater facilities naturally obtain when both systems are combined, but on the other hand such a combination involves many practical difficulties. Some of these difficulties will suggest themselves if we compare the two systems :—

Fabrics with Extra Weft.	Fabrics with Extra Warp.
Usually one warp beam only.	Often two or more warp beams.
Usually a minimum number of shafts required.	Usually a maximum number of shafts required.
Great variation in the number of shafts lifted.	Number of shafts lifted on each pick is more constant.
Comparative simplicity in the draft.	More complicated drafts ; but since the extra warp threads are drawn on separate shafts the system offers facilities for introducing different spots without disturbing the ground draft.
Box motion, and pick-at-will motion necessary, therefore slow speed of loom.	One shuttle loom, therefore high speed of loom.
Danger of weft trailing in, involving waste of material, and extra labour in removing it.	No such danger.
Minimum production of cloth on account of the maximum number of picks per inch.	Maximum production of cloth on account of the minimum number of picks per inch.
Number of picks per inch varies in different parts of the same cloth, hence special control of uptake motion is desirable, and in many cases necessary.	Number of picks per inch is constant, hence the uptake motion is under ordinary control.

Fabrics with Extra Weft.	Fabrics with Extra Warp.
Slightly inferior yarn may be used for the figure.	Good yarn required for figure.
Loops formed on selvages.	Perfect selvages.
Maximum number of broken patterns.	Minimum number of broken patterns.
Minimum amount of trouble with cloth roller.	Maximum amount of trouble on account of thick and thin places in the length of the piece.

On the whole, extra warp is perhaps more used in lighter dress goods and in decorative fabrics, and extra weft in the heavier cloths, such as winter vestings. The chief recommendation of extra warp is the possibility of increased production.

Neglecting the mechanical and commercial difficulties which might arise from the combination of the two systems, and considering the subject purely from the point of view of displaying a pattern to the best advantage, we introduce Fig. 181. In this example we shall suppose that sketch S, which shows two repeats, illustrates the parts which are to be developed by the extra figuring yarns. It would be almost impossible to reproduce this pattern satisfactorily by one system alone, and even if a satisfactory pattern resulted from the employment of either system, it is easy to see that an enormous amount of figuring yarn would be wasted. This yarn, whether of warp or weft, would, in either system, run continuously with the corresponding ground yarn. But if the combined system be adopted, the vertical lines in sketch S would be developed in the cloth by extra warp yarns, and the horizontal lines by extra weft yarns. There would, therefore, be a great saving of material even in a cloth woven from the example given, and if the pattern were enlarged the saving would be propor-

tionately greater. In addition to this great advantage, the various lines would be developed much more clearly.

The complete design in Fig. 181 contains 64 threads and

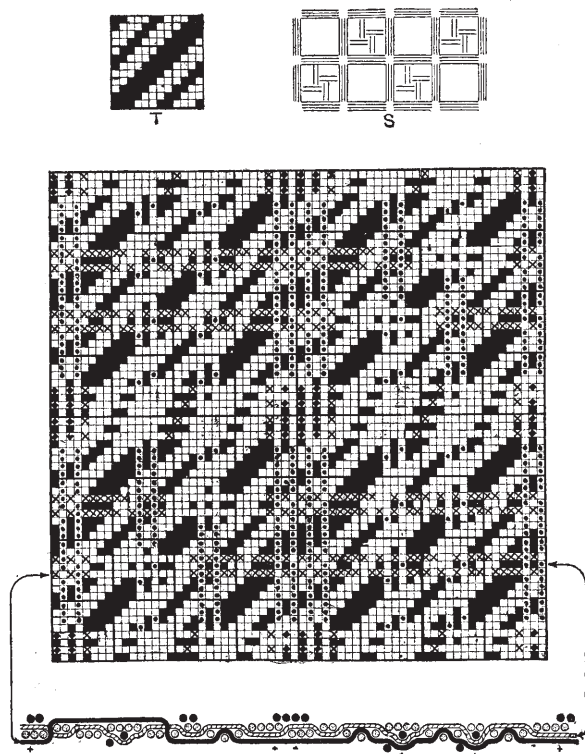


FIG. 181

64 picks, and of this number 48 are ground threads and picks—the ground being developed in the 12-thread twill  $\frac{4}{3} \frac{2}{3}$  shown at T, of which there are four repeats in each direction of the design. The ground weave appears in

solid marks, the extra warp in dots, and the extra weft in crosses. Some little care is necessary in order to keep the extra weft or extra warp from appearing on the surface where it is not required. Take, for instance, the small white squares in sketch S, where both the four horizontal and the four vertical figuring yarns leave the surface. The point-paper development of one of these squares is in the very middle of the design. Since marks lift it is easy to see that the four extra warp threads leave the surface of the cloth between the 28th and 29th picks, and reappear on the face between the 37th and 38th picks. The corresponding extra weft lines or threads are represented by picks 30, 32, 34, and 36. On these picks the long groups of blank squares indicate the weft on the surface, so that to take the weft to the back for any distance it is only necessary to mark the squares for that distance. If, however, we adopted this principle, say, where picks 30, 32, 34, and 36 leave the surface between the 28th and 29th threads, and marked, say, the 29th to the 37th threads inclusive, we should lift nine successive threads, and the extra weft would certainly pass under these nine threads. Such a procedure would cause the four extra warp threads to be above the extra weft threads, and, although they would clearly be under the body of the fabric, there might be a tendency for them to show, or perhaps to drag up the ground weft. Instead, therefore, of adopting this method, we have dropped each figuring thread for nine successive picks, thereby reducing the number of movements of the threads, and making sure of the threads being removed from the face by causing them to be under the figuring weft. Each figuring weft passes over every figuring warp thread, but under every ground thread within the same area; the extra weft picks would, consequently, lie between the extra warp threads



and the ground cloth. The diamond-shaped marks indicate where ground threads are raised to allow the extra weft to pass under.

The lengths of the floats in the extra warp threads are limited by dropping them for one pick under the extra weft, and not under the ground weft, so that if both extra warp and extra weft were the same colour, the long floats of coloured warp would be checked by the same colour of weft, an arrangement which would preserve a practically unbroken colour effect. When the extra yarns are at the back of the fabric they are stitched, as explained under the system of "weft-backed" and "warp-backed" fabrics, but when they are tied on the surface the arrangement is such as to display them to the best advantage. For example, picks 30, 32, 34, and 36 are tied on threads 16, 17, 18, and 19, as well as on threads 48, 49, 50, and 51, as shown by the crosses—they are bound at points where they cross threads at right angles, and therefore have every facility provided for appearing prominently on the surface.

The intersection immediately under the design shows all the 64 threads interweaving with the 12th and 13th picks. Ten of these figuring threads are on the surface for the 13th pick, but for the 12th pick four of these ten, as well as two others, are indicated by a small cross as being down. It is naturally impossible to show these particular threads in two places on the same drawing. The first three crosses and the last one represent the threads dropped for limiting the length of the float, while the 4th and 5th crosses indicate the position of the threads immediately before being raised over the 13th pick for stitching purposes—these threads are shown in solid under the 13th pick, and they would be concealed, as shown, by the threads on each side.

Such an example as the above illustrates the different

points which arise in connection with figuring with both extra warp and extra weft. There are many other methods which might be discussed, but we propose to illustrate only one, which is a simple type of figuring with both warp and weft. In the last example special threads and special picks were employed to develop the figure; but in this example, Fig. 182, the bulk of the warp and the whole of the weft are utilised to form the structure of the fabric in addition to developing the pattern. The structure of this pattern is on the cutting-thread principle, but the cutting threads, which are of small black cotton, serve merely as binders. The warp is arranged two threads of twofold jute, which conceals the weft, and one thread black cotton binder, which allows the weft to be seen. It will thus be apparent that when the jute warp is up and the cotton warp is down, the figure is developed by the jute warp; but where the cotton warp is up and the jute warp is down, the figure is developed by the jute weft. A pick-at-will loom is required, as the weft is 1 pick dark to 1 pick light. The two colours of weft will thus appear alternately on the surface, while any number of differently coloured warp threads may be used. Six colours are employed in this example.

Fig. 183 shows the movements of the face threads for one complete repeat, as well as of 10 threads of the second repeat—the latter 10 threads being marked U. No cutting threads are shown, but the draft for the first 24 face threads, as well as for the cutting threads, appears immediately under the design. Dots represent the binder threads, and the figure threads are double, so that one thread in the actual design represents three threads in the cloth. Four shafts only and 88 picks are required, as will be seen from the weaving plan V. The last eight picks in the design, being the commencement of the second repeat, are not shown in

the weaving plan. More elaborately figured patterns are

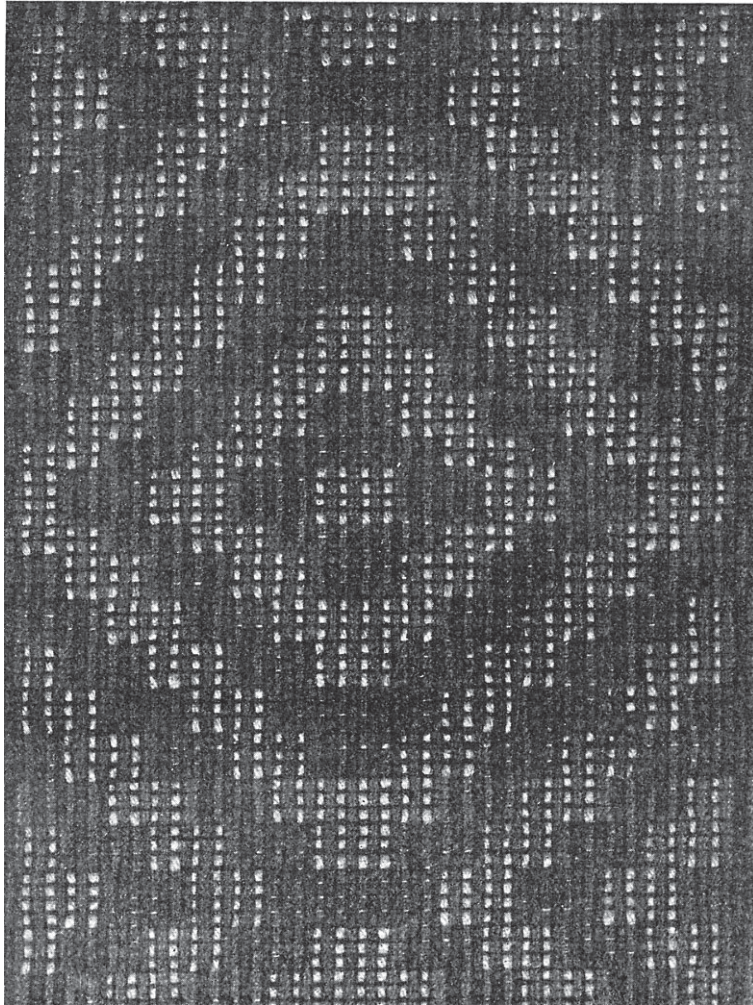


FIG. 182.

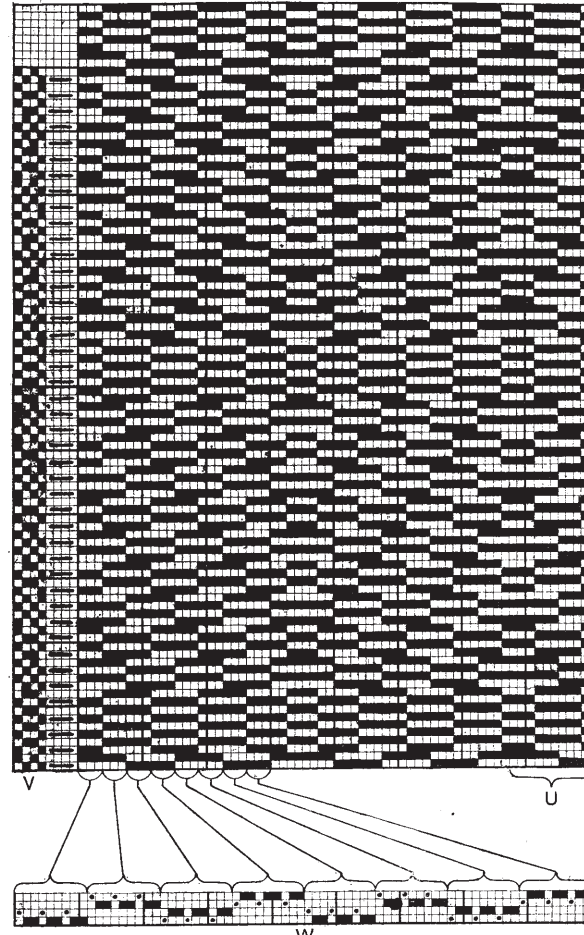


FIG. 183.

made on the same lines, with the exception that instead of

X

having two figuring wefts there is one only—a second and smaller weft being used as a kind of binder. In these cases the jute warp is usually all of the same colour, with a different colour of jute weft—one colour, say, the warp, forming the ground, while the other colour, in weft, forms the figure, or *vice versa*. The same type of weaving may be adopted with any fibre provided the figuring warp and figuring weft are much thicker than the binding warp.

We shall close this section on extra warp and weft figuring by considering an example of a rather more complicated nature. The ground-work of the fabric is developed in the 4-thread basket weave (see Fig. 184).

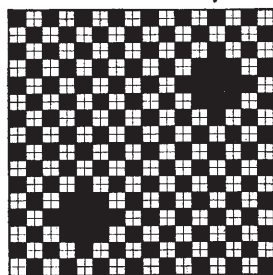


FIG. 184.

of the cloth in Fig. 185. When this black weft goes to the back of the fabric it is bound to the face in the ordinary way. In addition, there are other backing picks which, naturally, never appear on the surface of the cloth, while every third warp thread is a backing thread. The upper illustration in Fig. 185 shows the face of the cloth, while the lower one illustrates the back of the cloth. Although the back of the cloth is comparatively dark, the face is white except at the angles of the figures. A better idea of the general structure of the cloth will be gleaned from Fig. 186, which illustrates the complete design, and an intersection of all the warp threads with picks Nos. 38 and

39. The face weave is in solids (■), the backing warp in crosses (×), and the extra figuring and backing weft in

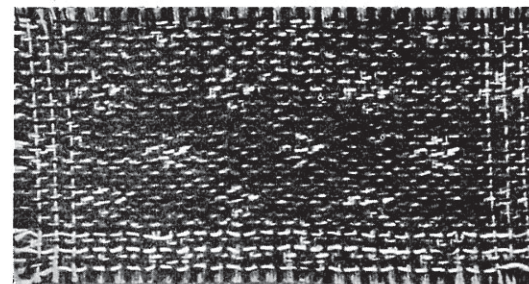
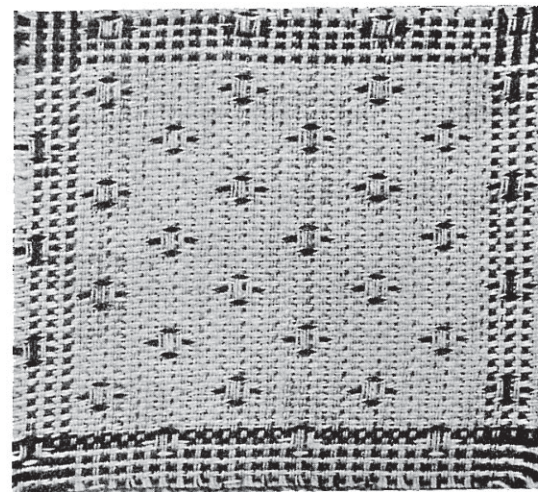


FIG. 185.

dots (●). These extra wefts appear every third pick, the figuring picks being marked B to indicate that they

are black. On these black picks the long groups of blank squares indicate where this weft appears on the surface near the angles of the diamond figures; the other extra picks, in dots, represent the red backing weft. Throughout all the ground part each backing thread rises for two successive picks and then drops

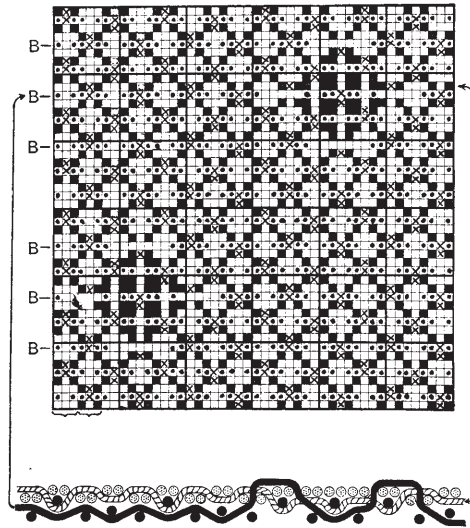


FIG. 186.

for four; it thus interweaves plain with the extra or backing weft, and, in addition, is regularly bound to the face weft. The intersection shows the positions of the backing threads when they are raised for binding, and it also illustrates the plain structure at the back, and two points where the extra or backing weft rises to the surface for figuring purposes.

## CHAPTER XVI

## DOUBLE CLOTHS

HAVING illustrated and described at length the structural characteristics of the differently backed cloths, or what we have termed cloths of three layers, it is a natural step to take up the discussion of fabrics in which there are four layers of yarn in the thickness. Such fabrics are invariably termed "double cloths" on account of there being two distinct warps and two distinct wefts employed in their construction. Although the warps, which are termed face and back warps respectively, are quite distinct, it does not follow that they must be on separate beams—in some cases such a separation is necessary, in others it is not. The relative numbers of face and back threads, and of face and back picks, depend mainly upon the relative diameters of the two kinds of threads and picks, and upon the desired closeness or openness of the texture of the fabric. The simplest proportion or order, and that in which we shall initiate the description, is where the warp is arranged: 1 thread face to 1 thread back, and the weft with 1 pick face to 1 pick back. As in the case of backed cloths it is a very convenient proceeding to indicate the back threads and picks on the design paper in some transparent colour, and thus provide a guide for the insertion of the different face and back weaves.

The simplest form of double cloth is that in which both sides of the fabric are woven perfectly plain with yarns of the same colour and count, and with the same number of

threads and picks per inch. But instead of describing this type of cloth at present, we prefer to introduce it later, and to take up meantime a more general and extended case which will elucidate the principle more fully. We shall adopt an arrangement of 1 thread face to 1 thread back, and 1 pick face to 1 pick back, but shall take the

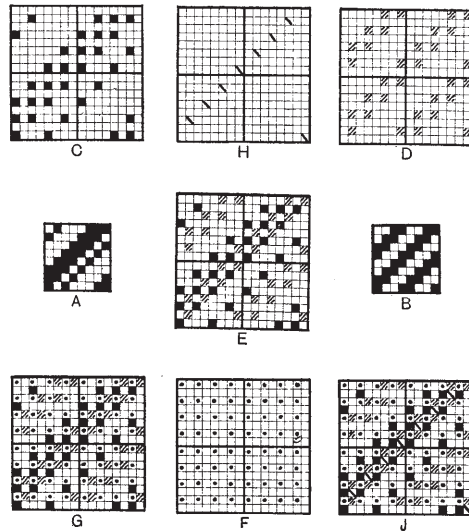


FIG. 187.

$\frac{3}{3}-1$  twill for the face cloth (see A, Fig. 187), and under this cloth we shall add a back cloth composed of the  $\frac{2}{2}$  twill shown at B. Since there are 8 threads and 8 picks in the repeat of the face weave, it is clear that, with the one-and-one arrangement of yarns, we must also employ 8 threads and 8 picks for the back; therefore the full design will occupy 16 threads and 16 picks. It is a matter of indifference as to whether the face threads shall occupy

the odd or the even positions; but it is usual to assume that the face threads are the more important, and consequently the odd threads, as well as the odd picks, are generally reserved for the face weave, and the even threads and picks for the back weave, when these appear alternately as in this example.

After having marked the design paper to differentiate face threads and picks from back threads and picks, the first step is to mark the face weave on the threads and picks which are reserved for it: thus on the odd threads and picks of C reproduce the face weave A. We could, naturally, without making any difference to the design, commence by first inserting the back weave B on the even threads and picks as shown at D. They are both required on the same design, and are here represented separately merely for the sake of illustrating the principle. If plan E be now carefully examined, it will be found to be composed of weaves A and B compounded in the order in which they appear at C and D. By this method it is clearly impossible for one weave to interfere with the insertion of the other. Design E as it stands thus shows the face and back weaves in their proper positions; but before a double cloth can be made it is essential that the face warp shall interweave only with the face weft, and the back warp only with the back weft. Thus, the first pick in design E must interweave only with the odd threads of the design, and consequently no back thread must be lifted on this pick. But no back thread or even thread is lifted on this pick, hence the 1st pick is quite correct as it is; indeed, all the face or odd picks are correct. The face picks are perfect without any addition, simply because marks indicate threads lifted. Had marks indicated threads down it would have been necessary to indicate the

dropping of the back threads on face picks by some kind of mark; but since blanks in this figure indicate threads down, no other mark is required. The separation of the two sets of threads is, however, just as necessary when the back weft is being inserted on the even picks, but in this case it is clearly essential that the face threads should be lifted, otherwise the back weft would pass over the face threads and show on the face of the fabric. Plan F shows all odd threads lifted on even picks, that is, all face threads are lifted on back picks. In order, therefore, to separate the two sets of yarns, and so produce a cloth having the face formed by weave A and a separate cloth at the back formed by weave B, we need only add plan F to plan E; this is illustrated at G, which, it will be readily seen, comprises the three plans C, D, and F.

From the foregoing remarks it should be gathered that if weave G were used in conjunction with the following order of yarns:—

Warp: 1 thread black	Weft: 1 pick black
1 „ white	1 „ white

—the resulting fabric, or rather fabrics, would be a perfectly black cloth  $\frac{3}{3} \frac{1}{1}$  twill on face, with a pure white  $\frac{2}{2}$  twill cloth immediately under—the two cloths, if perfectly woven, being quite separate even at the selvages. Two such cloths would never be made on this principle, but we simply mention what would result if the above conditions were observed, in order to demonstrate that some further procedure is necessary before a perfect double cloth can be formed from the two single ones. In short, the two single cloths must be bound together, either by special binding threads (which would interweave with the weft of both cloths) or by the yarns of one cloth

interweaving with those of the other cloth; it is the latter way which we now purpose describing.

There are two methods of binding, which, stated briefly, are as follows:—

- (a) By lifting a back thread over a face pick.
- (b) By dropping a face thread under a back pick.

The choice of one or the other depends, amongst other things, upon the thickness of the yarns and their sett in the fabric; but as a general rule method (a) is adopted. The lifting of any back thread over any face pick at any point will bind the two fabrics together, but something more than this is necessary to preserve the appearance of the cloth. The point of binding must be carefully selected; indeed, it must be chosen so that the back thread, although lifted over the face pick, will not show on the surface. This can be done by lifting the back thread between two floating face threads in precisely the same way as is indicated in fabrics backed with warp. By referring to plan C, Fig. 187, it will be seen that there are two such points available between each pair of face threads—the one chosen for our example is the lower point as illustrated by the diagonal marks at H. The positions of the binding points can therefore be easily located in the face weave. When these points from plan H are added to weave G, the final operation is performed, and the complete design will appear as at J.

We have described at some length the various steps used in the production of a design for a pure double cloth, but even yet the demonstration is incomplete. The design at J, Fig. 187, is quite correct, but this is because the relative positions of the two weaves A and B on the design have been purposely chosen to achieve this end. It is

quite possible to construct a design from the elements used in Fig. 187, conforming with all the rules exemplified therein, and still obtain a result which is unsatisfactory. In order to illustrate this point fully we introduce Fig. 188. The different marks in this figure fulfil the same functions as those used in Fig. 187. Thus :—

- Solid (■) = face weave on face threads and face picks ;  
 Shaded (//) = back weave on back threads and back picks ;  
 Dots (●) = face threads lifted on back picks ;  
 Marks (∖) = binding points (back threads lifted on face picks).

Design J in this figure is a facsimile of J in Fig. 187, while design K differs only from these two in the starting point of the  $\frac{2}{2}$  back weave. But this slight alteration has an adverse effect upon the structure of the lower cloth. Since one group of warp floats of the back weave in design J runs concurrently within the diagonal limits formed by the long warp floats of the face weave, it is obvious that the extreme upper portion of this particular diagonal will be formed by the face warp threads, while the extreme lower surface will be developed by the back weft. The lower surface of the corresponding part in design K is, on the other hand, developed by the back warp. Since face weft would thus meet back weft in the centre of the fabric, this latter arrangement would result in somewhat imperfect binding, and the intersections L to Q inclusive are introduced to demonstrate and to qualify this statement. The lines joining the intersections to the designs show that the 7th and 8th threads and all the picks have been chosen for the longitudinal sections, while the transverse sections are formed by the 9th and 10th picks and all the threads. In weft section L the 8th thread is shown as being lifted over the 9th pick ; but clearly this section is

faulty, because no warp thread would make such a sharp turn, and rise for such a distance, as is here illustrated. The exact position which such a thread would occupy depends much upon the relative diameters of the yarns, to some extent upon the fibres from which they are made, and to a considerable degree upon the tension to which they are subjected during the process of weaving. But

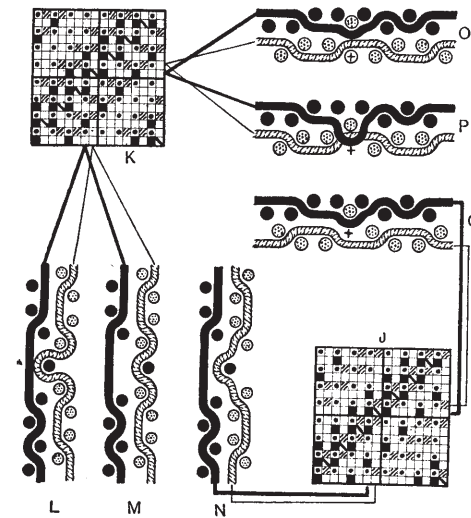


FIG. 188.

where there is not a great difference between the diameters of the threads, as is assumed in this case, the tension on the warp thread No. 8, and the positions it occupies under the 8th and 10th picks, would unitedly cause pick No. 9 to assume a position more nearly that shown in intersection M. The corresponding section from design J appears at N. This view shows clearly that the tension on the 8th warp thread would be distributed over picks Nos. 8, 9,

and 10, that the two outside ones would be pressed towards each other, and that pick No. 9 (face pick) would be covered by back picks Nos. 8 and 10 in precisely the same manner as explained in connection with fabrics backed with weft. In choosing a binding position between two floating warp threads we evidently transfer the face weft to the back, and this weft must itself be covered by two back picks which are floating behind. This can only be accomplished when the warp floats of both face and back weaves run concurrently in the same diagonal as shown in design J. Similar reasoning in connection with the transverse or warp sections O, P, and Q will tend to confirm the above statements. Thus, the 8th thread, which is shown lifted over the 9th pick from the position indicated by a small mark +, is, in design K, down for two picks before and two picks after the 9th; the thread will, consequently, tend to draw the 9th pick into the position shown in section P. No such tendency obtains in section Q, which illustrates the corresponding threads and picks from design J. In this case, as will be seen on reference to design J, the 8th thread is up for three successive picks—the middle one appearing in the intersection Q; the floats of the 8th and 10th backing picks are therefore in the best possible positions for covering effectively the face pick No. 9 when it passes under the 8th thread. It will thus be seen that the best facilities for successful binding are obtained when the warp floats of both face and back weaves run alongside of each other as in design J, and that this arrangement usually entails less movement upon the camb or heald shaft controlling the backing thread than if the weaves were arranged as indicated in design K. It must be remembered that the actual threads and picks would be much closer together than they are represented

in the intersections—a condition which is absolutely essential if the binding points are to be hidden from view.

When the proportions of the yarns for both warp and weft are two threads of face to one of back, this arrange-

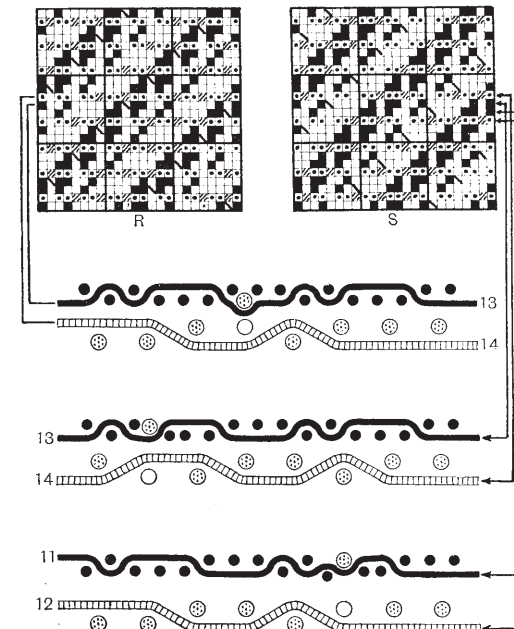


FIG. 189.

ment usually appears in the design paper in the equivalent order:—

- 1 thread face, 1 thread back, 1 thread face ;
- 1 pick face, 1 pick back, 1 pick face ;

as illustrated in designs R and S, Fig. 189. These designs are based on the  $\frac{3}{3} \frac{1}{1}$  face twill and the  $\frac{2}{2} \frac{3}{1}$  back twill, but neither of them is perfect. The binding points in



design R are correct, but the back weave is not in the best place, while the reverse obtains in design S. In both cases the binding points have been distributed over all the face picks and the back threads. The two lower warp intersections taken from design S are obviously imperfect, since the binding thread appears on the surface of the fabric. On the other hand, however, the binding point in the upper intersection, which represents the 13th and 14th picks of design R, appears to fulfil the necessary

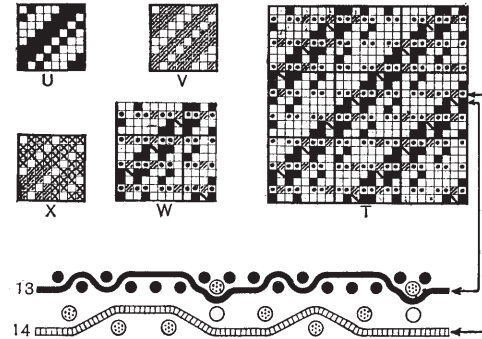


FIG. 190.

conditions for successful binding. A close examination will show, however, that it is defective—the weft of the 13th pick, when it passes under the 11th thread, would be partly covered by the 14th pick, but would be left exposed to view by the 12th pick. If the present binding points in design S were removed to the positions shown in design R, the former design would be correct. Design T in Fig. 190 is composed of the same weaves as those used in the last figure; these weaves appear at U and V, and are placed in this order in the design. In this case there is also a binding point on every back thread, but

these binding points are placed on alternate face picks. An intersection of the 13th and 14th picks with all the threads appears at the bottom of the figure.

With regard to the combination of weaves for this purpose it need hardly be mentioned that each weave must be repeated until both finish correctly—thus in design T the face weave appears twice in each direction, so that the complete back weave may be inserted. If an 8-thread weave, say V, be backed with a 4-thread weave, say X, with the 2-and-1 arrangement of yarns, then the complete weave requires only 12 threads and 12 picks (see design W).

It is, of course, possible to arrive ultimately at the proper number of threads and picks by repeating each weave until all the four elements begin to repeat in their original relative positions. The total number of threads and picks may, however, be calculated directly if desired, and the necessary space allotted for the complete design, thus:—

$$\begin{aligned} \text{Let } F &= \text{the number of threads in the face weave;} \\ B &= \text{,, ,, ,, ,, back weave;} \\ m &= \text{,, ,, successive face threads in one unit of} \\ &\quad \text{arrangement;} \\ n &= \text{,, ,, successive back threads in one unit of} \\ &\quad \text{arrangement.} \end{aligned}$$

$$\left( \text{L.C.M. of } \frac{F}{m} \text{ and } \frac{B}{n} \right) \times m = \left\{ \begin{array}{l} \text{total number of face threads or} \\ \text{picks;} \end{array} \right.$$

$$\left( \text{L.C.M. of } \frac{F}{m} \text{ and } \frac{B}{n} \right) \times n = \left\{ \begin{array}{l} \text{total number of back threads or} \\ \text{picks;} \end{array} \right.$$

$$\therefore \left( \text{L.C.M. of } \frac{F}{m} \text{ and } \frac{B}{n} \right) \times (m + n) = \left\{ \begin{array}{l} \text{total number of threads} \\ \text{or picks in the design.} \end{array} \right.$$

This system may be applied to all kinds of multiple weaves.

Neglecting the arrangement of the drafts, there is just one other feature to consider in the designing of these

fabrics, and designs Y and Z, Fig. 191, are introduced to demonstrate this final consideration. Both designs have the  $\frac{3}{3}-\frac{1}{1}$  twill for the face, and the plain weave for the back. Clearly, the binding points may be placed in either of the positions shown, and with equally satisfactory results as regards concealment. But from a practical point of view design Y should have the preference, because the movements of each thread or leaf of the camb for the back weave are only four in each repeat of the design, whereas with design Z there would be six—that is, leaves Nos. 2, 5, 8, and 11 would require, with design Z, to make 50 per cent more movements than the same threads in design Y.

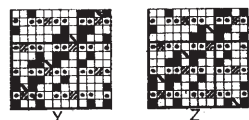


FIG. 191.

The foregoing illustrations of double cloth are typical examples of those in which each weave remains on one side of the fabric throughout, but only a little extension of the principle is necessary in order to make the two weaves change simultaneously from one side of the fabric to the other. Such an arrangement would clearly be essential for the construction of a figured double cloth in which the figure depended for its development entirely upon a difference in the character of the weave, or in which the same weaves, but different colours of yarns, were used for the figure and ground respectively. The construction is carried out on the same lines whichever scheme is adopted. In Fig. 192 we reproduce part of a figured double cloth in which the figure is composed of white warp and white weft, and the ground of yellow warp and yellow weft. The weave in both parts is, however, the same, and is, in fact, the 8-thread imitation gauze, which we illustrate again at A in Fig. 193. The outline or motive of the

figure, when considered apart from the ground threads and picks, moves in blocks of 4 threads and 4 picks, and since the design is arranged 1 of ground (yellow) to 1 of figure (white) in both warp and weft, we may represent each change, which actually embraces 8 threads and 8 picks, by a single small square on the design paper. Thus, each small square in B represents 8 threads and 8 picks

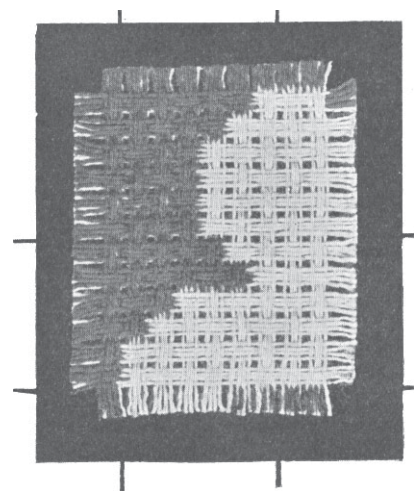


FIG. 192.

in the complete design C, and both represent the lower part of the pattern in Fig. 192—that is, the part enclosed by the intersections of lines drawn from the eight indicated points. The construction of design C is as follows: On all ground threads and picks introduce weave A; this is done in completely filled squares. Then mark in the same weave on all figure threads and picks as indicated by the three diagonal marks  $\diagup$ . If now all figure threads were lifted on ground picks, an untied double cloth would result, the upper

part of which would be white, and the lower part yellow. But if we raise only a portion of these white figure threads on yellow ground picks, and in the remainder of the design raise the yellow ground threads on white figure picks, we shall obtain alternate patches or areas of white

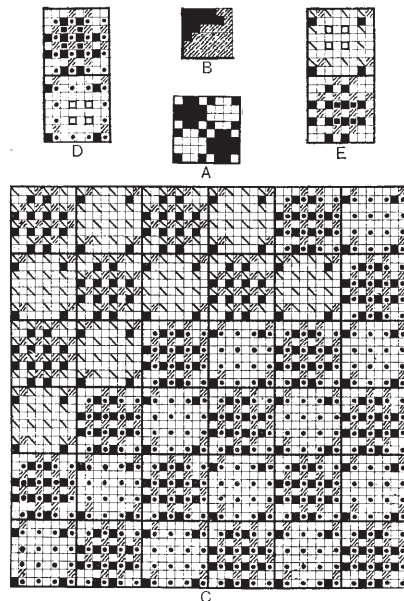


FIG. 193.

and yellow, and of such shapes as are represented by the differently marked portions. This is evidently what is necessary in order to develop the small pattern B, or any other desired pattern. Each block of 8 by 8 in design C represents the corresponding small square in motive B, and it will be seen that in 24 of the large blocks the even threads (white figure threads) have been lifted over

the odd or yellow ground picks, as shown by the dots ●, while in the remainder of the large blocks the diagonal marks \ show that the odd threads (yellow ground threads) have been lifted on the even or white figure picks. In this way each warp and weft may be made to change places as desired. The design at C represents the complete treatment of motive B without binding or stitching points; these have been purposely omitted for the sake of avoiding unnecessary confusion. If the loose parts require binding, they may be bound as illustrated in detached plans D and E. Plan D shows the binding in the figure portion: the small solid squares (■) indicate yellow ground threads raised on white figure picks, and the outlined squares (□) indicate white figure threads dropped on yellow ground picks—both systems of binding being illustrated. Similarly plan E is the binding scheme for the ground portions, and here the small solid squares (■) denote white figure threads raised on yellow ground picks, and the outlined squares (□) denote the dropping of yellow ground threads on white figure picks. Both plans D and E show a binding arrangement in each block, but in some cases the binding may be at less frequent intervals, and in the small areas it may be omitted entirely.

The main principles involved in the construction of double fabrics in general having been thus explained and illustrated, we shall now proceed to consider one or two particular cases, but chiefly the simplest type of double cloth, or that in which both sides are perfectly plain. Still adhering to the same distinctive marks:—

- Solid marks (■) for face threads and picks;
- Diagonal marks (//) „ back „ „
- Dots (●) „ separating the face and back cloths,

it will be easy to follow design A, Fig. 194. The above-

mentioned distinctive marks, which appear in the two designs A and B, represent the double plain weave, sometimes termed the hose-pipe or seamless bag weave, while

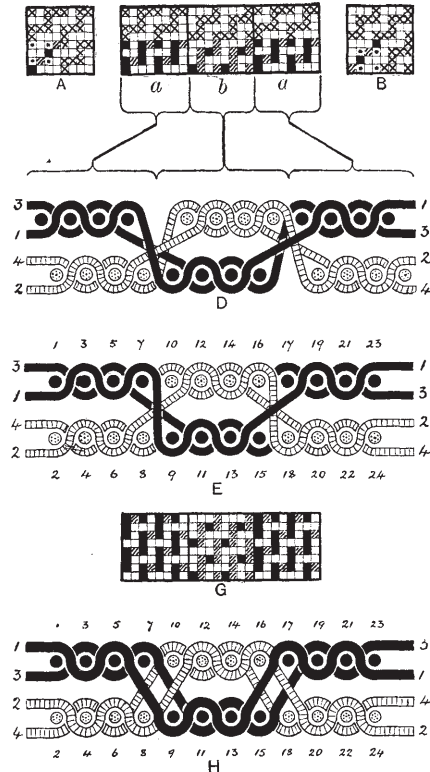


FIG. 194.

the crosses in the remaining part of the designs are simply repetitions of the unit designs. It is not difficult to see that design B is precisely the same weave as A, but commencing on the 2nd thread and the 2nd pick. Either

design would give the double plain structure, but a comparison will show that—

The 1st thread and the 1st pick in A are for the face or upper cloth; and  
 " " " B " back, or lower cloth.

If the two designs be combined as exemplified at "a, b, a," the two cloths formed by the parts *a* would interchange for the middle section with the two cloths formed by part *b*. This double change would produce a structure similar to the intersection D, which illustrates all the 24 threads and the first four picks of the design. This intersection appears a little defective at the points where the two cloths change positions, but this is because the back threads are placed midway between the face threads. If they are arranged as shown at E, where each thread and pick is numbered, the defect disappears. In this latter intersection each pick at some point seems to drop or rise perpendicularly from one side of the cloth to the other; but if this movement is considered faulty—and it cannot be said to be so in practice,—the weave may be arranged as at G, which will result in the corresponding intersection H. In this case each pick appears to form the same angle with the horizontal plane when passing from one side of the cloth to the other.

Provided the order of the warp as well as that of the weft be 1 of black to 1 of white, it is clear that the resulting fabric would be a double plain stripe; it is also evident that the stripes may be the same in width all across the cloth, or they may be made of any desired width in any part simply by drawing the required number of threads on the first four shafts for parts A, and on the back four shafts for parts B; further, a simple change of the positions of the two plans A and B would enable dice patterns to be

woven. Finally, any geometrical or floral design may be developed by using one of the two weaves for the ground, and the other for the figure. Thus, with a warp arranged 1 thread black and 1 thread white, and 1 pick black and 1 pick white for weft, with weave A on the figured portion and weave B on ground, the resulting fabric would be a black figure on a white ground on the face of the cloth, and a white figure on a black ground on the back. This particular structure is, in reality, the same as that which obtains in the simpler makes of Scotch, Ingrain, or Kidderminster carpets. The looms for these fabrics are, however, so arranged that no weave is required on the design paper, and, moreover, the design paper is only one-quarter the size of that required for the full-harness type of designing and working as illustrated above. The machine generally used is one of those specially built jacquards suitable for one particular type of structure only, but which entails only the minimum amount of labour in the designing, and in this case actually does the work with half the number of cards, and these only half the size of those required for the same design in a full-harness jacquard.

Although we are not at present dealing with colour and colour effects, it is yet advisable—indeed, almost imperative—to introduce this branch casually in reference to particular examples. Thus, with regard to the double plain weaves, variety of effect may be increased by modifying the weaves, while still retaining the one-and-one order of colouring and the double plain structure. By systematically rearranging the double plain weave in every available way, we should, naturally, obtain every possible effect; but several of these effects would be duplicated. After eliminating all duplicates we should find that there are nine different effects available. Thus:—

Dark warp crossed by dark weft.  
 " " " light "  
 " " " alternate picks of light and dark weft.  
 Light " " light weft.  
 " " " dark "  
 " " " alternate picks of light and dark weft.  
 Alternate threads of light and dark warp crossed by dark weft.  
 " " " " " light "  
 " " " " " alternate picks  
 of light and  
 dark weft.

Fig. 195 illustrates this; all the nine designs are rearrangements, either of threads or of picks, or of both threads and picks, of an ordinary 4-thread double plain weave; the illustrations immediately above these designs are photographic reproductions of the woven samples. The complete particulars are as in the table.

Design Number.	Bottom Row of Patterns. Warp: 1 thread light. 1 " dark. Weft: 1 pick light. 1 " dark.	Top Row of Patterns. Warp: 1 thread light. 1 " dark. Weft: 1 pick dark. 1 " light.
	Effect on Face of Cloth.	Effect on Face of Cloth.
1.	Dark warp crossed by dark weft.	Dark warp crossed by light weft.
2.	Light " " light "	Light " " dark "
3.	Dark " " light "	Dark " " dark "
4.	Light " " dark "	Light " " light "
5.	Alternate threads of light and dark warp } " light "	Alternate threads of dark and light warp } " dark "
6.	" " dark " }	" " light " }
7.	Light warp " { alternate picks of light and dark weft.	Light warp " { alternate picks of light and dark weft.
8.	Dark warp " " }	Dark warp " " }
9.	Alternate threads of dark and light warp } { alternate picks of dark and light weft.	Alternate threads of dark and light warp } { alternate picks of dark and light weft.

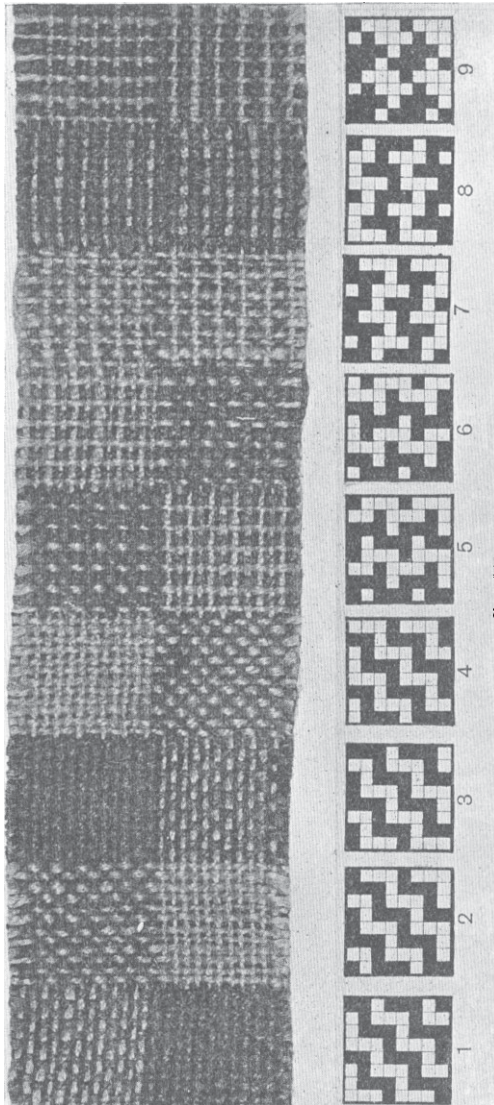


FIG. 195.

The double plain weave is extensively used in the manufacture of many types of narrow goods, and Fig. 196 illustrates a listing fabric in which the whole of the double plain structure is formed with small cotton threads, while in two of the openings or tubes are woven seven thick jute cords, each cord being composed of about ten individual threads.

If weaves A and B, Fig. 194, were used for the production of a similar fabric—and it is quite possible to do so,—it would be found that nine shafts would be required. In the case under notice, however, six shafts only are necessary.

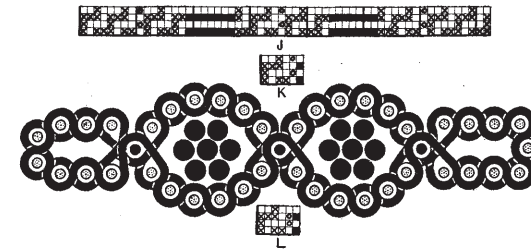


FIG. 196.

Design J, Fig. 196, represents all the 58 threads used in the intersection, as well as the 4 picks. The crosses (×) show the double plain structure, the rings (o) the binding threads, and the solids (■) the cord yarns or stuffer warp. The weaving plan appears at K, but probably a better method is that shown at L, where the binder is working 2 up and 2 down. The reader will probably notice that the extreme ends of the intersection differ slightly. We shall explain the reason for this in connection with Fig. 197, in which 16 threads of a double plain weave design appear at M, and an intersection made from this design is illustrated at N. From this latter figure it is seen that two

threads at the extreme left are in the same shed, thus forming a "flat." This defect occurs as demonstrated if the shuttle starts from the left-hand box for the first pick; if it starts from the right-hand box the double thread will be on the right. Now, it is quite clear that it is only necessary to remove one of these two threads in order that the intersection may be like P, and this has been done in

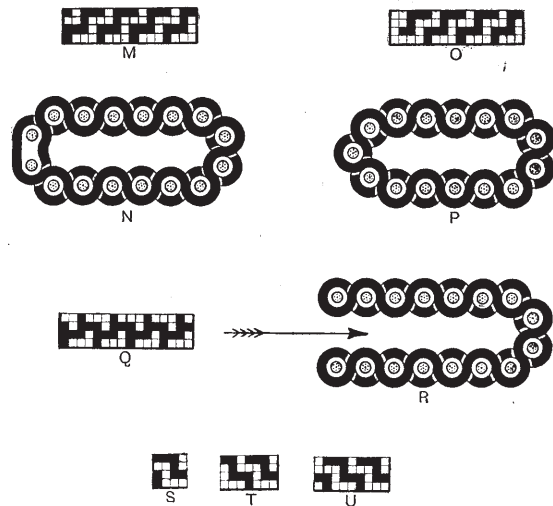


FIG. 197.

design O, where the first thread is omitted. A perfect circular plain cloth may therefore be made if the warp contains a multiple of 4 threads minus the first one. A similar perfect fabric would result if an extra thread were added to the beginning of design M—that is, if the warp contained a number of threads which was one more than some multiple of four. To obtain effect P from design O, however, the shuttle must start from the left-hand box on

picks 1 and 3, or from the right-hand box on picks 2 and 4. Otherwise a double thread will appear at each selvage. The reader might ascertain what the effect would be if an extra thread were added to M instead of removing a thread from the beginning. This circular or tubular weaving is practised to some extent for pillow-cases, ties, listings, lamp-wicks, various kinds of bags, etc., and always for the manufacture of hose-pipes. The latter are, of course, tubular throughout, but many bags are woven in which the bottoms are closed up by a different weave (say  $\frac{3}{1}$  twill or 4-thread basket) which compounds both upper and lower sections of the cloth. Sometimes it is desirable to make the bags so that the mouth is formed by the selvages; when this is required it is naturally essential to arrange the design so that the cloth will be woven with two perfect selvages at one side of the loom. This may be done by rearranging the picks of design M in the order 1, 2, 4, 3, as shown at Q, when the resulting fabric would be as illustrated at R; the sides of the bag would then be formed by compounding the upper and lower sections at regular intervals, depending upon the width of the bag. The intersections at N, P, and R in this figure are not truly representative of the relative positions of the warp and weft yarns. The weft is shown as it would appear in weft rib structures, with the warp threads practically straight. Where the warp and weft bend equally, as in many circular bags and pillow-cases, it is impossible to show the intersection in one view, and the above method has been adopted for the sake of clearness. On the other hand, when the number of warp threads per inch greatly exceeds the number of picks per inch, the conditions illustrated in the above intersections are reversed, and this is what happens in a hose-pipe fabric. Such a cloth is really one of three

layers, two of warp and one of weft, and it appears something like the illustration in Fig. 198. The threads in the actual fabric are much more closely set than is represented here, but these are about as close as it is possible to place them, and still show each thread distinct and separated from its neighbours.

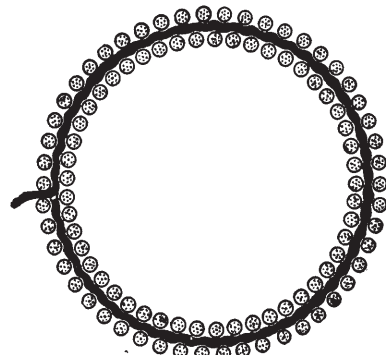


FIG. 198.

The figure represents 99 threads of warp ( $4 \times 25 - 1$ ) and two picks of weft, although the latter naturally appear as one continuous line. The figure is admittedly more difficult to follow than intersection P, Fig. 197, but it resembles the real article more closely; both are made from weave O, Fig. 197.

Circular weaving is not restricted to the double plain weaves; any kind of weave may be introduced, but the simple ones are naturally applied the most. Up to a certain stage the principle of constructing circular weaves is identical with

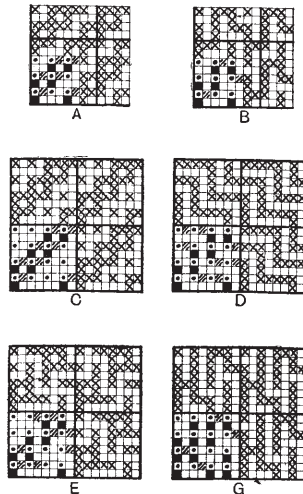


FIG. 199.

that for any double cloth in which no binding points are added. Binding points are obviously not desired in circular fabrics. In Fig. 199 we illustrate six different designs, each without binding points. The various marks have the same signification as those in the other double cloth designs. Taking the direction of the twills as they appear on the design, we have the following arrangement:—

Design A :  $\frac{2}{1}$  twill to right, face weave ;  $\frac{2}{1}$  twill to right, back weave.  
 „ B :  $\frac{2}{1}$  „ „ ;  $\frac{1}{2}$  „ left, „  
 „ C :  $\frac{2}{2}$  „ „ ;  $\frac{2}{2}$  „ right, „  
 „ D :  $\frac{2}{2}$  „ „ ;  $\frac{2}{2}$  „ „ „ „  
 „ E :  $\frac{2}{2}$  „ „ ;  $\frac{2}{2}$  „ left, „  
 „ G :  $\frac{1}{1}$  „ „ ;  $\frac{1}{1}$  „ „ „ „

In an earlier part of this work it is mentioned that the direction of the twill on the face is reversed on the back. Consequently, if a circular fabric were made with design A, one-half, or one side, of the tube would be  $\frac{2}{1}$  twill to right, but the other side of the tube, although formed by a similar  $\frac{2}{1}$  twill to right, would, when viewed from the other side, be equivalent to a  $\frac{2}{1}$  twill to left. Now, the first consideration in the manufacture of a circular fabric is that the two sides should show the same amount of the same kind of yarn; the second consideration is that the twill should be perfectly continuous, not only on the two outer sides of the tube, but also wherever it changes from one side to the other—that is, when it is forming what would be in ordinary cloth the selvages of the fabric. For a circular fabric with warp flushes on each side, the first consideration would clearly be satisfied by design B, and not by design A. The second consideration is partly fulfilled by design B, seeing that the upper side of the face weave is  $\frac{2}{1}$  twill to right, and that the back weave, which shows  $\frac{1}{2}$  twill to left, would naturally appear on the underside also as a  $\frac{2}{1}$  twill to right. Designs C, D, and E



are all composed of the  $\frac{2}{2}$  twill both back and face, but it is evident that design E is the only one which satisfies even the first consideration. Design G would show  $\frac{3}{1}$  twill to right on both sides of the fabric or tube.

We must now consider the continuity of the twill at the two turning points where the weft passes from front to back, or *vice versa*. This will, perhaps, be better explained by reference to Fig. 200. In this figure design H is the same as design B, Fig. 199, except that it commences

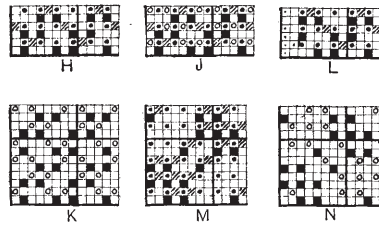


FIG. 200.

on the last thread of the latter, and then shows two repeats, plus one thread, or 13 threads in all. In illustration J, Fig. 200, the additional marks O indicate, not rising threads, but where the back threads float on the back or underside of the tube—these rings therefore show the position of the back threads when the weft is passing over them in the formation of the lower half of the tube, while the solid marks indicate the face threads over the weft when the upper half of the tube is being formed. These two sets of marks (solids and rings) have been separated from the other marks in J, and are introduced for two repeats in the diagrammatic figure K, and it will be easily understood that the first two threads on the left are in juxtaposition, although one is a face thread and the other a back thread. Similarly, the two threads on the extreme right are neighbours. The floats of the 13th thread join up perfectly with those of the 12th thread, and in the same way the floats of the 2nd thread join properly with

those of the 1st thread. The rings, of course, appear to twill, and actually do twill in the opposite direction to the solids; but if the reader keeps in mind the fact that these rings indicate the floating threads on the back, and if he holds the design up to the light and looks through from the back, or holds it to a mirror, he will see that the outer surfaces of the cloth or tube are both developed in the  $\frac{2}{1}$  twill to right.

If design L be examined, and the first two threads (shown faintly in dots) be considered as being absent, it will be found that a precisely similar effect, so far as continuity of twill is concerned, will result; the 12th thread joins correctly with the 11th thread; and the 3rd thread, which is in the upper cloth, joins perfectly with its neighbour, the 4th thread, which is the extreme thread on the left of the lower part.

We therefore see that, with the 3-leaf twills, a perfectly circular fabric would be obtained either—

- (a) By adding one thread at the beginning of the warp to any number of repeats of the weave; or
- (b) By leaving out two threads at the beginning of the warp from any number of repeats of the weave.

And in any kind of twill we may arrive at similar results by leaving off  $n - 1$  threads at the beginning, where  $n$  equals the number of threads occupied by the single weave; or by adding one thread at the beginning. The only other consideration is that the shuttle should start from the right-hand box on the odd picks. Now, we have already stated in connection with Fig. 197 that in order to avoid double threads at the selvage it is necessary, when using design O, to commence from the left. This is simply because in the construction of the original double plain

weave the first two threads and not the last two threads in the design are continuous, whereas in the construction of the above twills we have made the last two threads continuous. The double plain weave may be brought in line with the twill weaves so that condition (a) or (b) may apply. All that is required for this is that the camb leaves be operated as indicated at S, Fig. 197. Designs T and U show respectively the joinings when one thread is removed from the beginning, and when one thread is added to the beginning.

The method of construction, and the order of lifting the shafts for the double plain, and for the 3 and 4-leaf

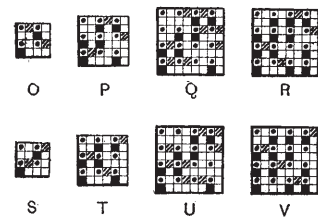


FIG. 201.

double twills, are shown in Fig. 201; and the following tabulated arrangements are necessary for the various weaves, if straight drafts are used, in order that the picking may commence on the right-hand side.

Design.	Circular Weave.	Commence Draft on Shaft No.	Finish Draft on Shaft No.	Commence Picking from
O	$1_{-I}$ plain . . .	4 or 2	4	Right hand.
P	$2_{-I}$ twill to right	6 ,, 3	6	"
Q	$2_{-II}$ ,, ,,	8 ,, 4	8	"
R	$3_{-I}$ ,, ,,	8 ,, 4	8	"
S	$1_{-I}$ plain . . .	1	1 or 3	"
T	$2_{-I}$ twill to right	1	1 ,, 4	"
U	$2_{-II}$ ,, ,,	1	1 ,, 5	"
V	$3_{-I}$ ,, ,,	1	1 ,, 5	"

The above method is general for all kinds of twills, but if small figures are used and arranged as dices the principle

shown in M and N, Fig. 200, may be adopted. The weave in solid marks ■ in M is the same as that developed by the three diagonal marks /|. In design N the circles show the back threads floating on the under surface, and the warp may evidently be complete on any number of full repeats, or it may finish at a half repeat, and still the pattern will be continuous.

In the manufacture of certain kinds of double cloth it is sometimes impossible to select satisfactory places for the stitching together of the two fabrics. At other times, while a satisfactory stitching point could be found, a subsequent finishing process, such as the milling operation in the woollen industry, may have a tendency to cause such stitching points to appear on the surface of the fabric, if the ordinary warp threads were utilised for this purpose. Whenever difficulties such as these obtain, a distinct advantage results from the employment of special binding or stitching threads, the sole purpose of which, as their name implies, is to bind the two fabrics together without taking any part in the formation of the actual fabric. When such special threads are used, they are invariably very fine—much finer than the threads and picks which constitute the fabric proper; and since these threads are so fine it is naturally a comparatively easy matter to conceal them. Fig. 202 shows one method of this particular type of binding. The arrangement of the yarns is as follows:—

<i>Warp.</i>	<i>Weft.</i>
2 threads back.	2 picks back.
1 thread binder.	1 pick face.
1 ,, face.	

The face warp and weft are much thicker than those for the back, and although the face yarns make plain cloth, the binding threads are easily concealed. When the

warp and weft are forming stripes in two or more colours, or checks, it is usual to choose a coloured binding thread to match the colour of the adjoining face thread.

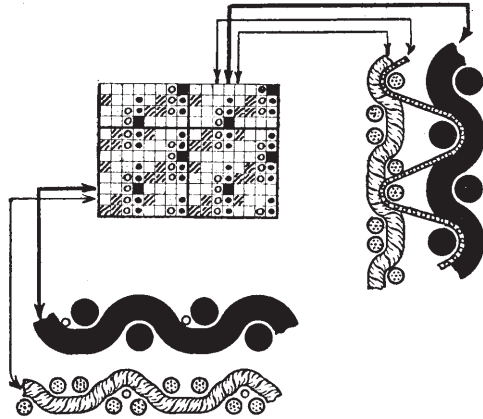


FIG. 202.

In the figure it will be seen that the binder changes positions frequently; this stitches the two cloths firmly together, but if fewer changes in the binder are desired, the arrangement may be made accordingly. The intersection on the right of the figure shows the 11th, 12th, and 13th threads interweaving with all the picks; the binder being covered on the underside in the ordinary way, and almost as effectively covered on the surface by the much thicker face warp threads. The intersection immediately under the design shows the 3rd and 4th picks with 17 warp threads (the 1st thread in the design appears at both ends of the intersection).

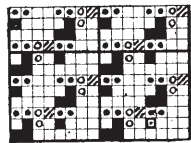


FIG. 203.

Fig. 203 shows a similar design, but arranged for the

fine threads to be on the surface, and the coarse ones on back. It is really Fig. 202 reversed.

## CHAPTER XVII

### THREE AND MORE PLY FABRICS

IN order to obtain a greater diversity of colour effect, or to obtain a thicker fabric and at the same time to retain the fineness of the set, the number of layers of yarn may be further increased, and Fig. 204 illustrates the various stages in the construction of a three-ply plain fabric. Fig. A shows one method of marking threads and picks for the guidance of the designer. In this case the marking is as follows:—

Threads and picks (1 and 4) of top cloth in white;  
 " " (2 " 5) " middle cloth in etching;  
 " " (3 " 6) " bottom cloth in dark grey.

The same style of marking is adopted in all the figures; but, except for purposes of reproduction, the different threads and picks should be marked, when necessary, in distinctive colours. The development of the design is illustrated in the successive figures, thus:—

- A shows the marking only of the three sets of threads and picks.
- B shows the plain weave on the threads and picks of the upper cloth.
- C shows the plain weave on the threads and picks of the top and middle cloths.
- D shows the plain weave on the threads and picks of the top, middle, and bottom cloths.

E shows all the weaves, and also shows face threads lifted on centre picks.

F shows all the weaves in position, as well as face threads lifted on centre and back picks, and centre threads lifted on back picks.

The complete design F is reproduced at G in Fig. 205,

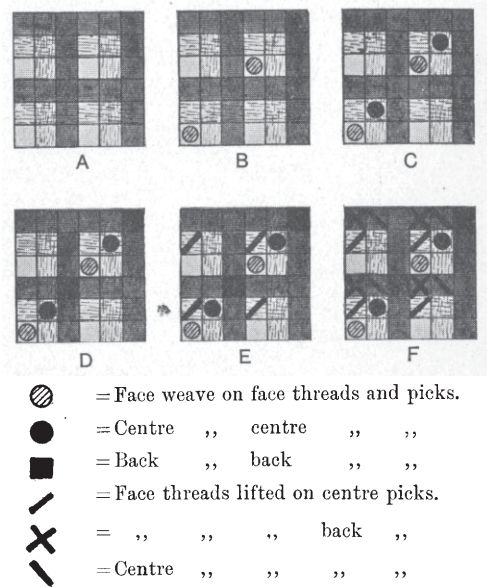


FIG. 204.

but in the latter figure the weft of any particular cloth is represented by the same type of marking. The intersection on the right shows 24 threads and 6 picks, and it is clearly seen that the three fabrics are quite distinct. Design H is composed of the same six picks as design G, but the last three picks have been reversed as indicated by the numbers 1, 2, 3, 6, 5, 4.

If design G were woven with one shuttle, the three fabrics would still be distinct except at the selvages, where the weft would form connecting loops between the upper and lower cloths. Design H, on the other hand, would produce a structure similar to the intersection opposite,

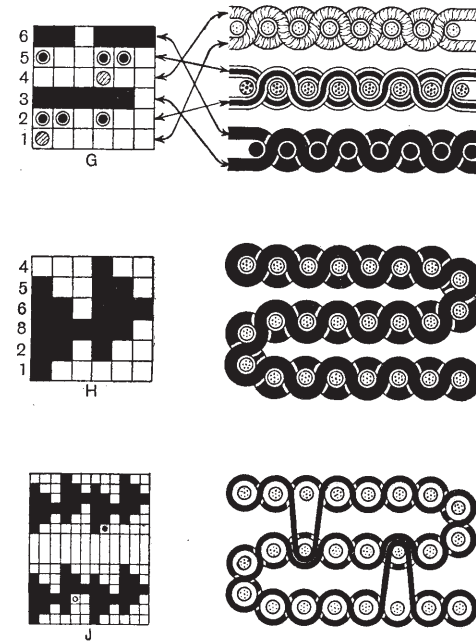


FIG. 205.

but the cloths would still be untied ; indeed, it is easy to see that in this case the resulting fabric, when opened out, would be a perfectly plain cloth, three times the width of the illustration. This is the preferable method of forming a three-ply fabric, because when woven this way the selvages are much neater than those formed by G, which

results, as stated, in the formation of loops in consequence of the weft passing from the bottom fabric to the top one, or *vice versa*. The three cloths in either design may be stitched together to form a compact three-ply texture.

Design J shows 24 threads (12 in the upper part and 12 in the lower part) of the three-ply fabric shown at H, but arranged to stitch the three fabrics together. The solid dot ● indicates where the 8th thread from the centre cloth is lifted to allow the 1st pick of the upper cloth to pass under; whereas the small circle on the 17th thread (5th thread in the lower part of the design J) is meant to indicate the dropping of this particular centre thread (the 17th) on the 3rd pick, which belongs to the bottom cloth. If, however, any difficulty is experienced with this type of stitching, special binding threads may be introduced in a similar manner to that shown in Fig. 202.

The chief advantages of three-ply or six-layer cloths lie, perhaps, not so much in the above type of cloths as in those where a great diversity of colour obtains, such as the better makes of Scotch carpets, closely woven tapestries, and similar goods. In these varieties each cloth is brought to the surface or top position at the necessary interval to form its own particular portion of the pattern. To produce such a fabric it is evident that some modifications of the three-ply cloth illustrated at G, Fig. 205, are necessary at certain places. Consider, for instance, Figs. 206 and 207, which are photographic reproductions of both sides of a three-ply fabric. Each part of this cloth consists of six layers of yarn, and, although it is not essential that the two middle layers should actually interweave with each other, they must nevertheless be present in the fabric. For our present purpose, however, we shall consider that perfect interlacing does take place wherever the various



FIG. 206.



FIG. 207.

groups of warp and weft yarn are situated ; afterwards we shall indicate the special construction which obtains when the two middle layers of yarn, which for the moment occupy the central position, do not interweave together.

A casual glance at the Fig. 206, which shows the more important side of the fabric, indicates clearly that there are three distinct grades of colouring yarns, which, for purposes of enabling us to discriminate, may be considered as light, medium, and dark ; only the medium and dark shades appear on the back of the cloth shown in Fig. 207. In practice, any one of these three shades may appear either on the surface or at the back of the fabric, or be concealed in the centre, just as fancy dictates. The surface of the fabric is, naturally, the chief consideration, but the remaining two sets of yarns must be dealt with at the same time. In order to make the description of the simplest possible nature, we shall suppose that in all cases the light, medium, and dark warps interweave each only with its own colour of weft ; hence, there being a combination of three groups, we shall have six different orders of distribution. We must, therefore, arrange the three groups or three sets of warps and wefts in six different ways, each way to form a three-ply plain fabric.

Fig. 208 shows the disposition of the yarns for these six effects, the light yarns in each design being represented by the 1st and 4th threads and picks, while the plain weave is indicated by the numerals 1, 1, 1. Similarly, the plain weave for the medium and dark yarns is shown respectively by the numerals 2 and 3. Each weave is represented by two repeats in the intersection, where the warp threads for the light, medium, and dark cloths are distinguished by the numerals 1, 2, and 3. The path of

each separate cloth is easily followed, but in order to enable the reader to see quickly and clearly the relation between the designs and the intersections, lines have been drawn from the two lower corners of each design to indicate the limits of each intersection. In addition, we show the positions by the annexed table.

Design.	Top Fabric.	Middle Fabric.	Bottom Fabric.
M	Light warp : light weft.	Medium warp : medium weft.	Dark warp : dark weft.
N	„ „ „ „	Dark „ „ dark „	Medium „ „ medium „
O	Medium „ „ medium „	Light „ „ light „	Dark „ „ dark „
P	„ „ „ „	Dark „ „ dark „	Light „ „ light „
Q	Dark „ „ dark „	Light „ „ light „	Medium „ „ medium „
R	„ „ „ „	Medium „ „ medium „	Light „ „ light „

It will be seen that design M, the first of the above series, is the same as design F in Fig. 204, and design G in Fig. 205.

As already mentioned, it is not always necessary to interweave those threads and picks which, for the time being, happen to be entirely enclosed between the upper and lower surfaces of multiple fabrics: as a matter of fact, the threads and picks immediately under the light parts of Fig. 206, do not interweave. Nor is it essential that the other parts of the texture should be plain in structure. Each separate cloth may be of a different weave; moreover, each cloth may be made with different weaves at different parts of the fabric. It is impossible to give examples of all the modifications, but a general idea of the possibilities will be gleaned from the examples illustrated in Fig. 209. In designs S and T the upper and lower fabrics are again perfectly plain, but the threads and picks (2nd and 5th in each) of the third group, which, in these instances, are inside the fabric, do not interweave,

but simply lie straight between the two plain cloths. In

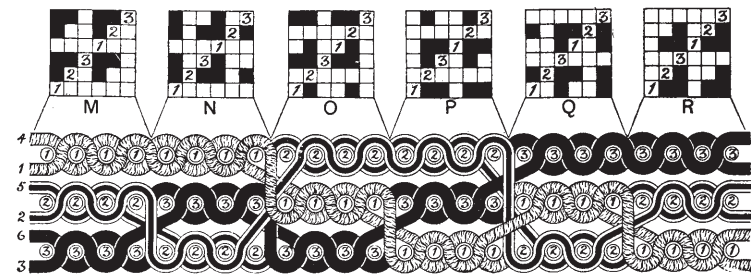


FIG. 208.

design S the centre threads are always down on the centre picks, whereas in design T the centre threads are all raised

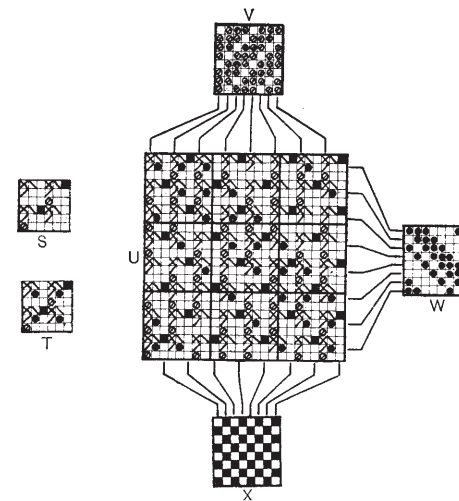


FIG. 209.

on centre picks. In the former case the weft lies as a sheet on the warp threads, while in the latter case, which

is identical with the light parts of Fig. 206, the warp threads lie on the weft. Similar arrangements could be adopted for the central yarns in any part of a three-ply figured fabric, no matter what weaves are used in its construction.

Design U, Fig. 209, complete on 24 threads and 24 picks, is made up of three different weaves. Any three weaves could, naturally, be employed; but, in order to keep the design within reasonable limits and still exhibit variations, we have introduced weaves which are complete on 2, 4, and 8 threads respectively. If, for example, we had chosen weaves on, say, 3, 4, and 5 threads, the design would require to be extended to 180 threads and picks. Thus:—

$$\left(\text{L.C.M. of } \frac{3}{1}, \frac{4}{1} \text{ and } \frac{5}{1}\right)(1 + 1 + 1) = 60 \times 3 = 180.$$

With weaves on 2, 4, and 8 threads the number is reduced to—

$$\left(\text{L.C.M. of } \frac{2}{1}, \frac{4}{1} \text{ and } \frac{8}{1}\right)(1 + 1 + 1) = 8 \times 3 = 24.$$

In design U, Fig. 209, the  $\frac{3}{1}$  twill to right is on the face; the  $\frac{3}{3}\frac{1}{1}$  twill to the left is in the centre; and the  $\frac{1}{1}$  plain weave is on the back. These three weaves appear detached at V, W, and X respectively, and the lines from the threads or picks show the position which each one occupies in the complete design U. The remainder of the design is composed of crosses and the two kinds of diagonal marks; these three signs having the same signification as those in Fig. 204.

Since design U is supposed to illustrate some part of a figured fabric, it contains no stitching points; these cloths are often sufficiently well bound by the constant changing

of positions of their various components (see Figs. 206 and 207). In order, however, to secure a firm structure in those parts where large areas of the same order appear, it is advisable to stitch the fabrics together, and thus avoid the formation of "pockets" or loose parts. This stitching may be done in a similar manner to that already described, or special systems may be adopted. Thus, in many parts of the fabric which is illustrated in Figs. 206 and 207, the three fabrics are stitched as illustrated in Fig. 210. The warping and wefting arrangements for this fabric are as follows:—

*Warp.*

- 1 thread light shade silk.
- 1 " dark " cotton.
- 1 " light " silk.
- 1 " medium shade cotton.

*Weft.*

- 2 picks light shade silk.
- 1 pick dark " fancy twist.
- 2 picks light " silk.
- 1 pick medium shade fancy twist

The intersection in Fig. 210 shows 6 threads and 18 picks, the dark and medium yarns being on the face and back respectively, while the light yarns, which are much smaller than the dark and medium wefts, appear in the centre. The structure is perfectly plain, but it will be seen that each dark and medium cotton thread passes over or under a shot of thick dark or thick medium shade

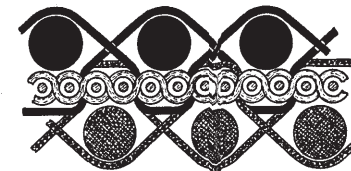


FIG. 210.



weft, then passes completely through the plain light silk fabric, remains there for two silk picks, and finally returns through the silk fabric to bind alternate picks of the same colour of weft. Sometimes pleasing effects may be obtained when double or multiple fabrics are structurally bound, and Fig. 211 shows a double plain fabric with stitching points shown by solid marks, and arranged in 8-thread sateen order. Wherever those stitches occur the cloth is drawn down slightly, and the effect obtained is somewhat

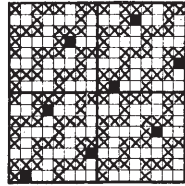


FIG. 211.

similar to that which results from the sewing of buttons in upholstery.

Any kind and any ply of multiple make fabric may be constructed by following the general principles laid down in the designing of the above three-ply textures. In some cases it may be necessary to introduce special types of binding, but whether a thread from the bottom fabric or one from the top fabric is stitched to the next fabric, or to any one farther removed, the principle is the same—it is only a question of lifting a thread, say, from the bottom fabric over a pick of the particular ply selected, or of dropping a thread of the top fabric under a pick of the selected layer.

In the foregoing illustrations we have restricted the examples to those in which each colour of warp interweaves with its respective colour of weft; but it will be obvious that a much greater variety of colour effect will be obtained if each colour of warp be combined at different times with the various shades of weft employed.

When unbound multiple plain fabrics of various plies are constructed as indicated by design H and accompanying intersection in Fig. 205, a curious resemblance obtains

throughout. Thus in Fig. 212 we introduce eight designs, all of which are different plies of plain cloth.

- A is the ordinary plain weave.
- B is a double cloth weave.
- C „ three-ply „
- D „ four-ply „
- E „ five-ply „
- F „ six-ply „
- G „ seven-ply „
- H is an eight-ply „

The number of threads and picks in multiple plain weaves is, of course, the product of the threads in the

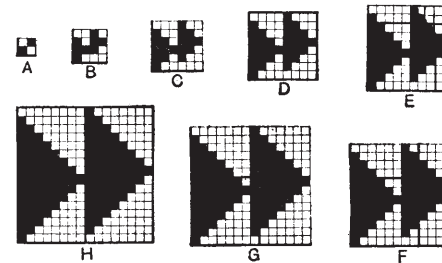


FIG. 212.

weave and the ply of the fabric. In each of the examples B to H it will be observed that the design consists of two similar, and indeed identical, triangular forms; the triangle on the right being one small block or step higher than its neighbour on the left. It is therefore easy to construct immediately the design for any number of unbound plies of plain cloth, and thus obtain a structure similar to the above-mentioned intersection opposite design H in Fig. 205, and differing from it only in the number of layers or folds.

The foregoing descriptions and illustrations which we

have submitted embody the main varieties of multiple cloth structure; but, before leaving this branch, we purpose illustrating a decorative fabric which in several respects



Fig. 213.

may be considered a four-ply structure. It differs from the majority of those which have been illustrated, in that the whole of the ornament is developed by the weft yarns, which, when either at the face or back of the cloth, inter-

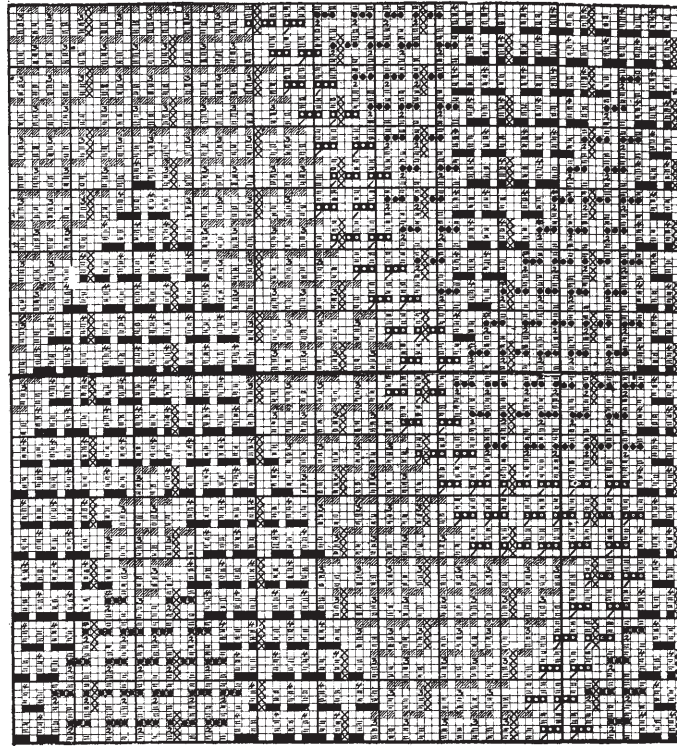
weave in perfect plain order with the small black cotton face and back warps respectively. Fig. 213 is a photographic reproduction of the fabric, the pattern of which is approximately 24 in. wide, and about 30 in. long; a complete repeat appears only in the direction of the width. The fabric is, in reality, a two-warp and four-weft modification of the true four-ply cloth, because the wefts, which for the moment are in the centre of the cloth, do not interweave with any warp, but simply lie in a sheet or layer somewhat similar to those mentioned in connection with designs S and T, Fig. 209. At all parts of the fabric there are four colours of weft, three of them being continuous, but the fourth is changed at irregular but pre-determined intervals in order to obtain a diversified colour effect. Red, white, and blue wefts appear throughout, while the 4th box carries the planted colours—greens, yellows, etc.

A small part of the pattern is worked out in detail in Fig. 214; the warping and wefting arrangements, reading from left to right, and from bottom to top, are as follows:—

*Warp.*

1 thread black cotton for face	}	for 10
1 " " " back		threads.
1 " " " binder.		
38 threads per inch.		

Or, neglecting the binder threads, which would be operated by two shafts working oppositely  $\frac{4}{4}$ , 34 threads per inch for the figure. Since the figure is nearly 24 in. wide, the capacity of the jacquard would be  $34 \times 24$  in. = 816 needles—say two machines having a capacity of 408 needles each.



■ Blue weft on surface.	⊠ Blue weft on back.
● Red „ „	⊡ Red „ „
▣ Green „ „	⊢ Green „ „
▤ White „ „	⊣ White „ „
● Yellow „ „	⊤ Yellow „ „
≡ Back threads dropped for two wefts to lie in centre.	⊞ Binding threads down.

FIG. 214.

*Weft.*

- 1 pick blue.  
 1 „ red.  
 1 „ green, yellow, or etc.  
 1 „ white.  
 92 picks per inch.

The differently coloured wefts appear throughout in the following positions:—

When blue is on the face, white is at the back, and the remaining two are in the centre.

When red is on the face, blue is at the back, and the remaining two are in the centre.

When white is on the face, green or yellow is at the back, and the remaining two are in the centre.

When green or yellow is on the face, red is at the back, and the remaining two are in the centre.

The distinctive marks for these colours, as well as the marks for the other particulars, appear immediately under sectional design Fig. 214.

The introduction of the binding threads in the design shown in Fig. 214 interferes somewhat with the continuity of the floats; consequently picks 9 to 16 inclusive have been repeated in Fig. 215, along with all the threads except those used for binding purposes. Floats of three squares indicate where the respective wefts appear on the surface, whereas floats of three blanks on the same weft lines indicate the wefts on the back of the fabric. At all other points marks (=) appear alternately with blanks to indicate back threads down and face threads up where the wefts lie in the centre of the fabric (marks fall throughout this design). Although the outer positions of the wefts are represented by floats of three marks or three blanks, the structure of the cloth on both sides is perfectly plain, for

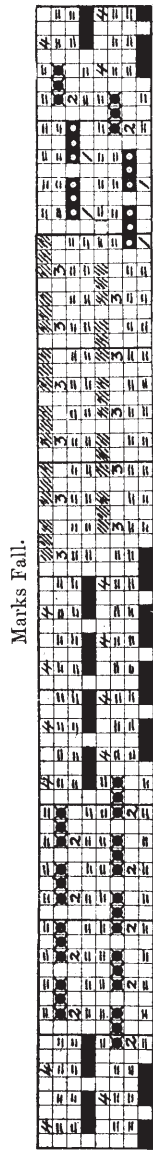


Fig. 215.



Fig. 216.

the outside marks in each float of three indicate the back threads dropped when the weft is on the surface, and the outside blanks in each float of three represent the lifting of face threads when the weft is at the back.

A much clearer idea of the structure of the fabric will be obtained from Fig. 216, which is an intersection of all the threads and picks shown in Fig. 215, and consequently of picks 9 to 16, and all threads except binding threads in Fig. 214. The picks are numbered and have the same distinctive marks as the corresponding picks in Figs. 214 and 215. In order to make the intersection as clear as possible, slight deviations from the natural paths followed by the picks have been resorted to in one or two places, but these slight alterations make no difference to the general character of the illustration; on the other hand, they have the distinct advantage of enabling the reader to compare more easily each pick with the corresponding parts of the design in Figs. 214 and 215.

It will perhaps not be out of place to consider briefly one mechanical method of forming this fabric. Fig. 214 represents, as we have said, a small portion of Fig. 213. This small portion, which is near the bottom of the latter figure, is reproduced, without weaves of any kind, in Fig. 217, the marks representing the same colours of weft as the similar marks in Fig. 214. The face of the cloth only is represented in Fig. 217, and the part illustrated embraces 40 face threads and 24 lines of weft—each line representing four picks of different colours. The two weft lines indicated by arrows in Fig. 217 therefore represent all the eight picks in Fig. 215, and it would be well to refer to these two parts jointly, as well as to Fig. 216, when considering the harness arrangements and the card-cutting particulars, which are as follows:—

All face or odd threads in Fig. 215 are operated by a 400's jacquard; all back or even threads controlled by a second 400's jacquard; or the whole may be controlled by the first and second sections of an 896 Continental pitch jacquard, with a suitable mounting. The binding threads, which are not shown in Fig. 215, would, naturally, be worked by two shafts immediately in front of the harness.

Card-cutting particulars: Consider 3rd weft line of

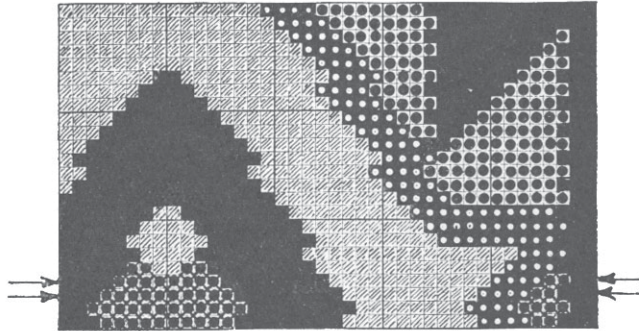


FIG. 217.

design in Fig. 217 (line opposite lower arrow), or first four lines of design in Fig. 215.

1st Card: Blue weft, marked solid on the face, and strokes on the back :—

1st jacquard { Cut plain weave  $\frac{1}{1}$  on face needles in the parts or 1st section \ marked solid. Cut all others on face needles.

2nd jacquard { Cut plain weave  $\frac{1}{1}$  on back needles in parts or 2nd section \ marked with white dot.

2nd Card: Red weft, marked white dot on face, and No. 2 on back :—

1st jacquard { Cut plain weave  $\frac{1}{1}$  on face needles in parts or 1st section \ marked with white dots. Cut all others on face needles.

2nd jacquard { Cut plain weave  $\frac{1}{1}$  on back needles in parts or 2nd section \ marked with cross and dot in centre.

3rd Card: Green weft marked with cross and dot in centre on face, and No. 3 on back.

1st jacquard { Cut plain weave  $\frac{1}{1}$  on face needles in parts or 1st section \ marked with cross and dot in centre. Cut all others on face needles.

2nd jacquard { Cut plain weave  $\frac{1}{1}$  on back needles in parts or 2nd section \ marked in shaded squares.

4th Card: White weft marked in shaded squares on face, and No. 4 on back :—

1st jacquard { Cut plain weave  $\frac{1}{1}$  on face needles in parts or 1st section \ marked in shaded squares. Cut all others on face needles.

2nd jacquard { Cut plain weave  $\frac{1}{1}$  on back needles in parts or 2nd section \ marked solid.

The next four cards for weft line 4 in Fig. 217 (line opposite upper arrow), and picks 5 to 8 inclusive in Fig. 215, are the same as the first four cards except as follows :—

Cut plain weave  $\frac{1}{1}$  on face needles, and  
Cut plain weave  $\frac{1}{1}$  on back needles.

For the double mount the two sets of cards would operate simultaneously, and produce the structure which is shown in Fig. 216. Other methods may be adopted with the same object in view—viz., the preparation of designs in colours only, no weave being necessary.

## CHAPTER XVIII

## VELVETS, PLUSHES, AND SIMILAR WARP-PILE FABRICS

THERE is, perhaps, no class of fabric which possesses the same amount of durability, and which, at the same time, is so useful for articles of dress and for decorative purposes as that of pile or plush. Even in self-colours these fabrics are extremely rich and effective, and, if closely woven, they will stand an enormous amount of rough usage. The very nature of the structure of these textures, however, shows that a great amount of material is necessary for their production; but their increased cost is, in some measure, counterbalanced by their rich and beautiful appearance, and by their wear-resisting qualities. Such fabrics may be divided roughly into two great classes—warp pile and weft pile; and each class may then be divided into a much greater number depending upon the desired degree of gradation. Since warp plushes and velvets are usually the more valuable, we purpose dealing with these first. We might mention in passing that when the pile is short, the cloth is generally termed “velvet,” as distinct from “plush,” which indicates a more valuable fabric with a longer pile. When the pile is very long it is invariably an imitation of long-haired animal skins. All these terms imply that the upper surface of the texture is formed by the erect position of the yarns, the extreme surface of each being the ends of the fibres of which the yarn is composed. All fabrics with warp surfaces like those described are technically termed “cut pile” fabrics, and the pile or velvety

surface may be formed with or without wires, except those with long pile, which are invariably made with the aid of some type of wire or rod. In addition to the fabrics with velvety surfaces, termed “cut pile,” in which each thread appears to stand erect from the foundation of the structure, there is another large class of pile fabrics, termed “uncut pile,” in which the threads which form the surface appear in small loops or curls. The terms “cut pile” and “uncut pile” serve to distinguish between those fabrics in which the extreme upper surfaces are formed by the ends of the fibres, and those in which the extreme upper surfaces are formed by the longitudinal parts of the fibres in the shape of curls or loops.

In all pile fabrics the warp length of the pile yarn greatly exceeds that of the binding yarns; hence the threads which form the pile or plush must come from a separate beam or beams, and, in many cases, from indi-

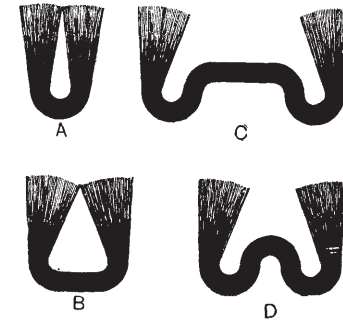


FIG. 218.

vidual bobbins. It is naturally essential that the pile should be sufficiently well bound to the body of the cloth to prevent it from becoming displaced, and, in the case of “cut pile,” it must be securely held in position. Many different methods of binding the yarns are employed, but when the yarn is cut the most general forms assumed by the individual lengths of pile are those illustrated in Fig. 218. These show the tufts as they would appear when withdrawn separately from the fabric: A is the simplest form, and the least securely held, since it simply passes under one shot

of weft; B, on the other hand, passes under two shots; C is in close touch with four shots, being under the first and last shots, and over the two middle ones; while D differs from C only in that it passes over one middle shot instead of two. These, as we have said, constitute the chief forms of the self-coloured "cut-pile" fabrics. In figured plushes both ends of one length of pile may be near to each other at many points, as are those in any of these examples; but, on the other hand, the two ends of one pile may be very far apart. Still, the type of binding in all cases will be very similar to one or other of those illustrated in Fig. 218.

In order to fix our ideas as to what is meant by "cut pile" and "uncut pile," consider Fig. 219, which will enable us to demonstrate this point, and also to illustrate two kinds of binding. In both cases the ground weave of the fabric is plain, as shown at E, and by the intersections of the ground yarns at F. Examine the lower design, G, first. The 1st, 3rd, 4th, and 6th threads are for the ground, and so are all the odd picks. These ground threads, indicated by crosses,  $\times$ , when considered apart from the remaining portions of the design, show that they are weaving in plain order. The 2nd and 5th threads of the design are for forming the pile, and both these threads are lifted every even pick as indicated by the solid marks. When these pile threads are raised, all the ground threads are dropped, and between these two layers is introduced what is termed a wire, which is afterwards removed at a convenient time. The removal of the successive wires leaves the surface of the cloth composed either of small loops, or of projecting ends of fibres,—in other words, as an "uncut pile" or a "cut pile." The difference in result or appearance is

due to the shape of the end of the wire, and to its withdrawal from the fabric.

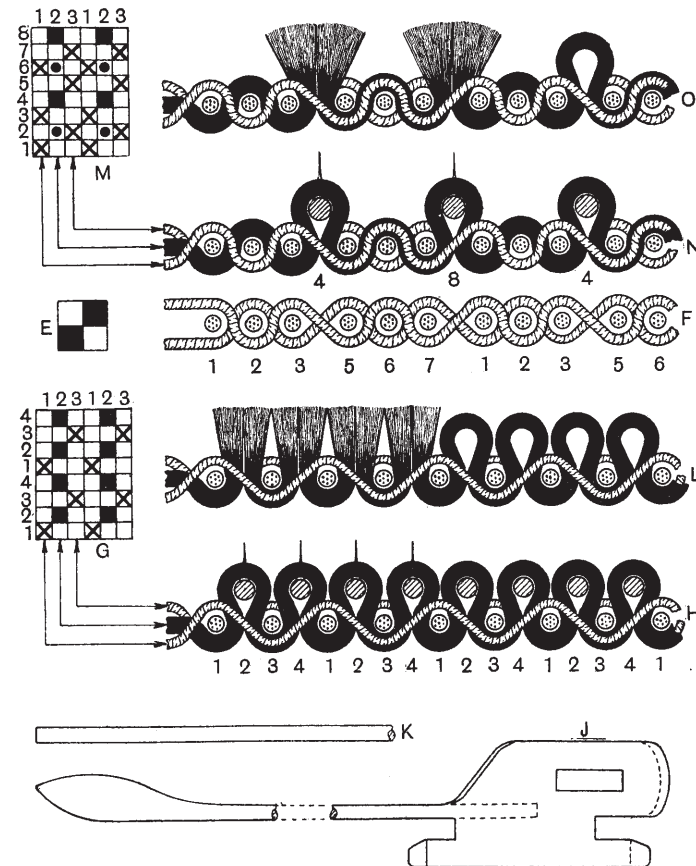


FIG. 219.

For power-loom work two types of wire are in general use—those shown at J with a sharp edge on the extreme

left for cutting the loops as the wire is withdrawn; and similar wires, but without the sharp edge, as shown at K, for the "uncut" pile. In section, the shape of the wire may be perfectly round, or it may be flattened somewhat similar to the wires of a reed. The particular sectional shape of the wire depends upon the number of picks per inch and upon the length of the pile required. Flat wires are essential when long pile is required. For coarse work in hand looms a deep wooden rod is often used, the rod being grooved if for "cut pile"; while for fine "cut pile" in hand looms it is usual to use two flattened wires, soldered at both ends to keep the two wires in position, and so arranged that a gap is left between them for guiding the cutting knife. These wires for broad hand looms are very flexible; this enables the boy (wirer) to pull them out easily, and also to introduce them quickly in a minimum amount of room at the loom end. The entering end of the wire for such hand looms is curved, which allows it to glide smoothly over the bottom layer of warp when it is entering in the shed. Each wire for power-loom work is provided with a head somewhat similar to that shown at J, with slots to facilitate the entrance and withdrawal of the wire by the wiring motion, and for keeping the heads vertical. Modified types of wire heads are often used for hand-loom work.

Intersection H shows the first three threads of the design G for two repeats. In the first repeat four cutting wires are shown in position under the loops, while in the second repeat the pile threads are over four looping wires. Intersection L shows what will happen to these pile threads when the eight wires are withdrawn—the first four will form a surface of "cut pile," where each tuft is similar to that shown at A, Fig. 218; and the second

four will remain in the looped condition, thus producing a surface of "uncut pile." It is, of course, understood that in all cases sufficient wires must be inserted before one is withdrawn, to prevent the tension of the warp from pulling the loop towards the body of the cloth after the wire is withdrawn. When once the proper number of wires is inserted into the cloth, the operation of wiring consists of withdrawing, successively, the wire nearest the weaver, and then introducing it into the next shed for producing pile. The picks, including the ones for the wire, are numbered on the design G, and corresponding numbers appear under the picks in intersection H. These may easily be located also in intersection L, in which it will be observed that each pick supports its own row of tufts or loops, and consequently the fabric produced will be close in the pile, or full-bodied.

The arrangement of the warp threads for the top design M, in the same Fig., is exactly the same as that for design G, but the 4th and 8th picks or lines only are for the wires. These are again shown in solids, all the remainder on the same lines being blank. On the 2nd pick, however, both pile threads are raised with the 3rd and 6th ground threads, while on the 6th pick both pile threads are raised with the 1st and 4th ground threads; but on neither of these picks is a wire inserted—the pile threads are raised simply to ensure a more firmly-bound pile. The interweaving of the first three threads with eleven ground picks and the proper number of wires is illustrated at N, while drawing O shows the result of withdrawing the two cutting wires and the single looping wire. The tufts formed by this method will be similar to that shown at D, Fig. 218, but it is evident from the illustrations that the pile formed by method O will not be so close as the pile formed by method L.



Fig. 219 demonstrates, in a general way, the principles of warp-pile weaving, but it is defective in the sense that the wires must be inserted independently of the picks. It will soon be demonstrated by designs and drawings how the two operations of picking and wiring may occur simultaneously, but it is clearly impossible to perform these two functions at the same time for fabrics identical with those exemplified in Fig. 219, or, indeed, for any

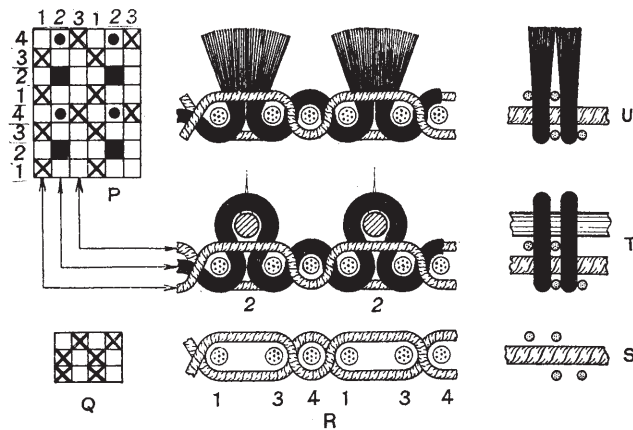


FIG. 220.

pile fabric where the pile thread is down on the pick before, and also on the pick after the wire is inserted, unless it be designed so that a line of pile shall coincide with a weft shot of the ground fabric. If this latter method were adopted with a plain ground the pile would appear on alternate picks instead of on every pick, as at L in the figure; and in addition to the defect of a comparatively bare appearance, the tufts would be less securely held in position.

Design P, Fig. 220, is for a fast-pile fabric, the pile of

which is the same as D, Fig. 218. The ground weave is shown at Q with intersection at R, while immediately above R is the section showing the first three threads and one repeat of the picks, and above this the effect which would be obtained by withdrawing the two cutting wires. Side sections S, T, and U give some idea of the positions of the ground threads, the picks, the round part of the wire, and the pile. Drawings T and U demonstrate that

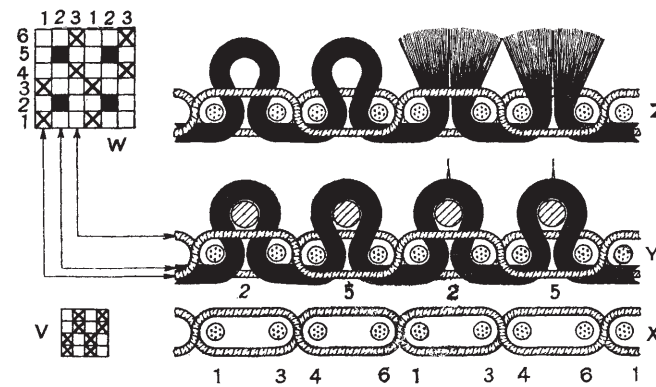


FIG. 221.

a fairly close setting of the warp is essential in order to hold the tufts or piles firmly in position.

The two ground weaves illustrated in Figs. 219 and 220 are not in such general use as the ground weave V in Fig. 221 and its intersection X. Another class of pile design is exemplified at W, the picks for the wire being on the 2nd and 5th horizontal lines. Drawing Y shows the first three threads and nine ground picks with two looping wires and two cutting wires in position. Drawing Z illustrates the "uncut pile" and the "cut pile," the latter of which is clearly of the type illustrated at B, Fig. 218.

All the designs in Figs. 219, 220, and 221 require the wires to be inserted independently of the picks. It is easily seen that such a procedure is a great hindrance to rapid production; consequently it is usually contrived so to arrange the weaves for power-loom work that a ground pick can be sent across simultaneously with the insertion of the wire. When this is performed it is necessary to make a double shed, *i.e.* an ordinary shed is lifted for the shuttle to pass through; but, in addition, the pile threads are raised sufficiently high above the top layer of the ordinary shed to leave room for the free insertion of the wire. This method requires greater lifts on some of the wipers, and a deeper and stronger reed, but these drawbacks are more than compensated for by an increased production of the woven article.

Design A in Fig. 222 represents one type of design which permits of the above mentioned double movement. The pile yarns are again on the 2nd and 5th threads, and the lifting of the pile threads for the wires to pass under appear as usual in solid marks and on separate pick lines. The common type of ground weave, and the intersection without the pile threads are displayed at B and C respectively. In planning the design on point paper it is unnecessary to introduce picks marked 2 and 5; it is sufficient to indicate, as is done on picks 3 and 6, that the pile warp is raised for the wire at the same time that part of the ground warp is raised for the shuttle. By following the lines from the 1st and 3rd threads of the design to the corresponding threads in the intersection D, the reader will readily understand how the different parts interlace, and will also recognise the necessity for the double shed when such fabrics are made by the aid of wires. Thus, it is clear that the first wire on the left hand is under the

pile thread but over the raised ground thread No. 1, consequently, the threads as they appear at this point represent, roughly, their positions when the shot of weft and the wire are passing through the shed at the same instant. The withdrawal of the wires leaves the loops and tufts as indicated in sectional drawing E—the tufts partly encircling only one pick and consequently being of the form shown at A, Fig. 218. Although the tufts are of that type which suggests an imperfectly bound pile, still

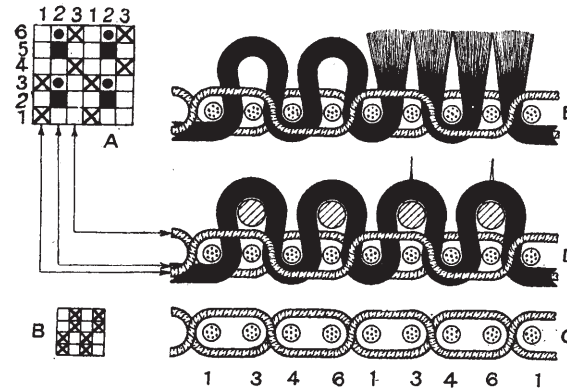


FIG. 222.

an examination of the structure will prove that each tuft is gripped well on one side by the crossing of the two ground threads, and on the other side by the two picks in the same shed, provided, of course, that the threads and picks are closely set.

All the pile or plush designs illustrated to this point are what might be called "single warp plushes," a definition which implies that all the warp threads for the pile interweave in exactly the same order and at the same times, and may therefore be placed on one warp beam. This is

possible simply because all the pile threads make the same kind of movement simultaneously with each other. In Fig. 223, however, a variation occurs. By studying design F it will be seen that the first pile thread (3rd thread in the design) is raised for the first wire (2nd horizontal row), and that the second pile thread (6th thread in the design) is down when this 1st wire crosses. The conditions are reversed on the 5th horizontal row, when the 2nd wire is introduced; *i.e.* the 1st pile thread is under the wire

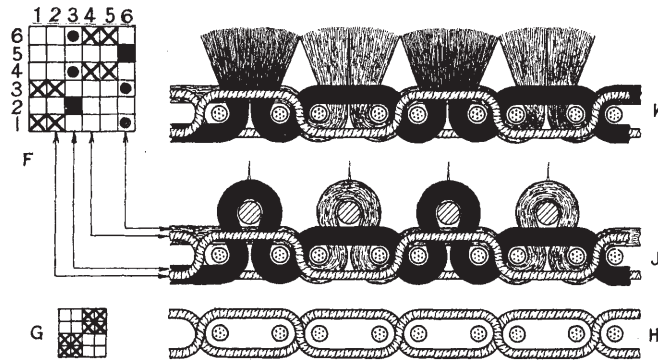


FIG. 223.

and the 2nd pile thread is over the wire. Since this arrangement is continued from side to side of the cloth, it follows that all the odd pile threads work together, but at a different time from all the even threads, which, however, also work in unison. Now since at different times in the operation one half of the pile warp is raised over the wire, and the other half passes only over the ground picks, it is evident that a greater length of warp will be required temporarily for the movement of that group which is raised for wiring than for that group which passes over the

ground picks only. This is the reason why each group of threads should be placed on a separate beam. The temporary demand for an increased length will occur alternately on the two beams, but the ultimate length required for the cloth will be the same on both pile beams, if the length of the pile or the size of the wire is constant. For some of the lighter fabrics of this nature the pile warp is placed on one beam, and each group of pile threads is then passed over a separate vibrator or easing-rod which yields at the proper moment to supply the extra length of pile warp required for the "wire" shed. Indeed in every case there must be provision made for letting off a greater quantity of pile at one moment than at another. It will also be noticed that two shafts are required for the pile yarn of these fabrics, whereas one shaft only is necessary for the simpler ones. Of course, it must be remembered, that if the pile yarn for the latter is very close, it may be, and often is, necessary to employ two shafts for the sake of distributing the heddle cords. The basket or hopsack weave G is used for the ground weave in Fig. 223, but only two opposing threads are represented in the ground intersection H. Four threads (two ground and two pile) from the design are displayed in intersection J, and, as no pick is introduced immediately under the wire, it follows that the wire must be introduced while the shuttle is stationary. Each tuft from the finished state K is of the type illustrated at C, Fig. 218.

Fig. 224 is another example where half the pile warp is lifted at a time. It differs from Fig. 223, however, in that the wire is introduced at the same time as every second shot of weft. Although design L shows six picks to the round, the 3rd and 6th may be omitted from the working design since these are for the wires which are operated

respectively at the same time as ground picks 2 and 5. There are, therefore, only four picks to the round, the only reason for illustrating six in the Fig. is for the sake of showing each part or operation separately. The 4-pick rib ground weave is here utilised, producing, without pile yarns, the intersection N. The numbers under the intersection correspond to the numbered picks in the design, the wire picks being, of course, omitted; the wires in the

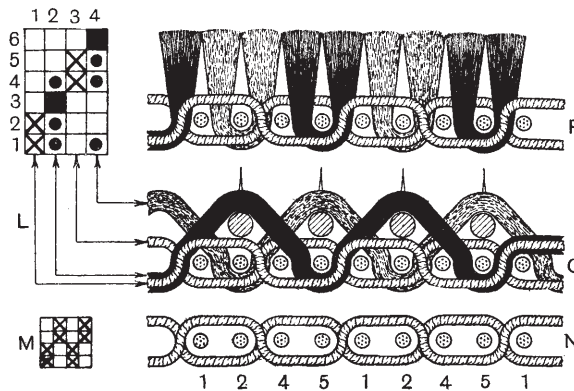


FIG. 224.

intersection O are clearly equivalent to two repeats of the 3rd and 6th picks of the design. It is again easy to see from the positions of the picks and wires in section O that a double shed is essential every second pick for this fabric, the appearance of which, when complete, is somewhat similar to illustration P. The loops resemble those at A in Fig. 218.

Most of these examples are for self-coloured plushes, but it is clearly possible to make longitudinal striped designs with any of them, while with Figs. 223 and 224, the addition of transverse stripes at desired intervals in the

width may be obtained by 1-and-1 warping; mottled or intermingled effects, with perhaps a tendency to fine hair lines, by arranging the pile yarns 2-and-2 alternately of different colours; or a combination of both these orders of warping. Thus, the effect or rather pattern illustrated in Fig. 225, or any similar combination of four effects, may be obtained by the use of two distinct colours of pile yarn. The solid black and the solid white vertical stripes are due to solid black and solid white warping respectively for the width required; the barred pattern in the middle of each of the border stripes is made by 1 black 1 white alternately; while the medium shade is to represent an

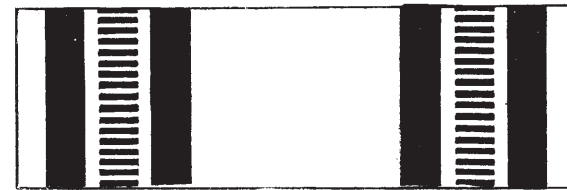


FIG. 225.

effect which is composed of equal quantities of black and white pile yarn, 2-and-2 warping, an effect which is not so definite in character as the 1-and-1 warping. It is clear, however, that hair-line stripes may be obtained by a slight addition to the number of each colour. The white transverse bars may run without break into the vertical white stripes as shown in the Fig., or they may be closed up by introducing one or two extra black threads at each side, and thus producing a kind of chain pattern.

The above gives a general description of the process of pile or plush weaving by means of wires. A close examination of the examples given will show that the tufts appear to be most securely held in those cases where the

wire is inserted while the shuttle is at rest. It is possible, however, to obtain the same degree of binding by another system of production, and this without any loss of time in the weaving. A firmly bound pile is certainly much to be desired, but the introduction of the process by which these fast bound and other plushes are made is due, not so much to the desire to obtain a particular type of binding as to the desire to dispense altogether with the wiring motion. It is not such a difficult matter to arrange and control a wiring motion when the wires themselves are comparatively thick, such as are used for many types of rugs, Brussels and Tapestry carpets, etc., but, when closely looped or cut fabrics are required as in silks, it is not so easy to control a very small or thin wire, and the guiding of such a weak instrument and the keeping of it in an approximately horizontal position while it is passing through the shed, call for very accurate adjustment and careful supervision.

The manufacture of these plush fabrics in what is known as the double plush loom dispenses altogether with the wires. Other difficulties naturally appear, but, on the whole, the double plush method of weaving is preferable for the finer fabrics.

The ground work of all double plush fabrics is essentially some double cloth structure, the particular type depending upon various considerations. The structure of double cloths has already been dealt with, so little need be said here about it. We might, nevertheless, compare the double plain structure illustrated at Fig. 194, p. 324, with the ground work of the double plush design illustrated in Fig. 226. In the latter design the unit, so far as the groundwork is concerned, is indicated by crosses, while the complete design for the double plush fabric contains only one thread extra, and therefore consists of the first five

threads or the last five threads,—the last two threads shown in dots are the same as the first two threads, while the pile thread is indicated by solid marks. Something more than the mere operation of the five shafts is, naturally, required to obtain a structure similar to the left-hand half of the intersection in Fig. 226. Some such remark is considered necessary here because we have already stated that a somewhat similar design is sometimes employed to produce a compact double cloth (see design K, Fig. 196, p. 329).

When long pile is being formed the two shafts which

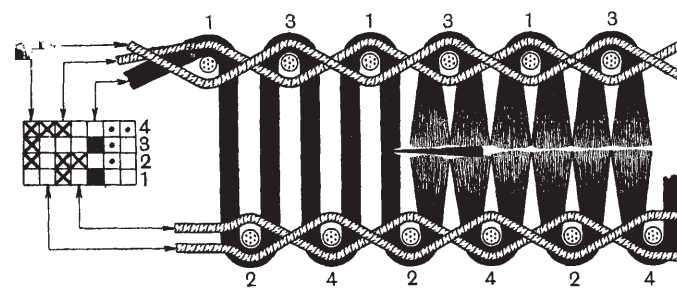


FIG. 226.

operate the upper cloth of the double plush are sometimes mounted a little higher than those two which control the threads for the lower cloth; for such cases it is usual to have V-shaped grooves in the race of the lay, or else to insert wires in the lay to answer the same purpose, viz. that of allowing the threads of the bottom cloth to sink lower than those of the top. In any case the mechanism must be so arranged as to keep the two sets of yarns sufficiently far apart to produce the desired length of pile. A temple, round which the weft passes, is used to help to keep the cloths apart, and also to hold the cloths in tension during the process of weaving.

By following the threads as indicated by the arrows in Fig. 226 it will be seen that the complete round is four picks—see numbers above and under the picks—and that the path of the pile threads is as illustrated. As the double cloth so made approaches the breast beam of the loom, the pile threads are severed by a sharp knife which moves to and fro in unison with, but at right angles to, the movement of the lay. In the figure the knife is shown as having cut through a little more than half of the part illustrated. The compound structure is thus split or rather cut up into two fabrics, each of which is passed round a separate beam. When thus separated, the structure of each cloth is identical with the single fabric illustrated at L in Fig. 219. Some kinds of double plush fabrics are cut open after they are removed from the loom.

The pile or plush in Fig. 226 is produced by what is sometimes termed a single pile arrangement. In Fig. 227 we illustrate two distinct pile threads which work opposite to each other. The ground of both fabrics, as exemplified by the crosses, is the same as that in the last example. The two pile threads are shown in solid marks, and the path of all may be easily traced by noticing the connecting links between the design and the intersection. After being cut the tufts are of the single binding type.

Fig. 228 illustrates a double pile fabric with two pile threads, and with the 2-and-2 ground plan. This is a very common type, and it will be noticed that the resulting fabric and the type of tuft are identical with those illustrated in Fig. 222. The design Q for this fabric is arranged as follows:—

2 picks in	top	cloth	}	equivalent to 4 successive picks	
4	„	bottom			„
2	„	top			„
	„	„			„

in each cloth.

In such an arrangement the weft passes from top to bottom, and *vice versa*, once only in four picks; conse-

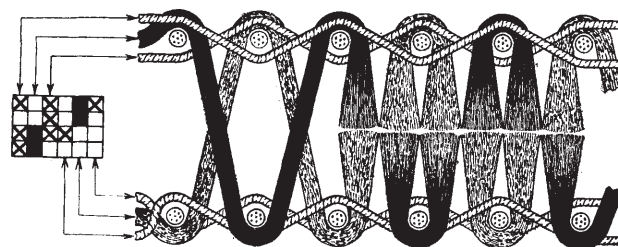


FIG. 227.

quently a more perfect selvage is formed, and a smaller quantity of weft requires cutting at the edges. On the

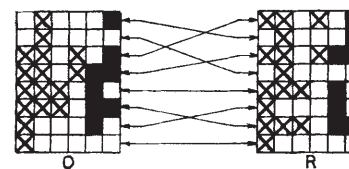
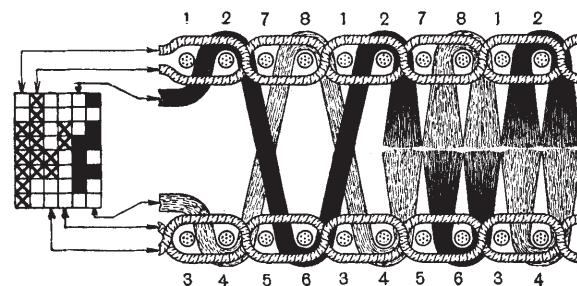


FIG. 228.

other hand the weft passes round the temple at one side only. In such cases special arrangements are usually made

for the opposite side. If the pattern were woven with one pick in top and bottom alternately, then the weaving plan would be that shown to the right at R.

It will be noticed that the double plush fabrics illustrated in Figs. 226, 227, and 228 result in what is termed the loose pile similar to A, Fig. 218. It is possible, however, to employ the same kind of weaving, and obtain any of the fast-pile types shown at B, C, or D in Fig. 218. Thus, the tufts in the cut part of illustration S in Fig. 229 are similar to type D, but in this particular instance the pile is securely held by picks 2, 5, 8, and 11, which lie between the pile and ground threads 5, 6, 2, and 3. In addition to this, extra binding threads are introduced. In order to make the illustration as intelligible as possible, we have drawn it in two parts, S and T, but it must be remembered that in the actual fabric all the ten threads and twelve picks are required to make one unit. The left-hand part of the upper illustration S shows the ordinary binding threads 1, 2, 3, and 4, shown in crosses in the weaving design, as well as the two pile threads, 5 and 6, which appear in the weaving design in solid marks and etched lines respectively. The right-hand side of the upper illustration S shows that the tufts would be of type C, Fig. 218, after the two cloths have been cut. In addition to the above mentioned threads there are extra binding threads 7, 8, 9, and 10, not introduced in illustration S, but shown in position in the lower illustration T, and indicated by dots ● in the design. The group U in the design represents the four ordinary binders and the two pile threads, while group V embraces the same two pile threads and the four extra binders. It will thus be seen that the pile is very securely held—a necessary condition in many pile fabrics, and a desirable one in all.

The picking arrangement is numbered, three successive shots being introduced first into the top cloth and then into the bottom cloth; a good selvage is thus obtained, the weft passing round the temple at each side every third shot.

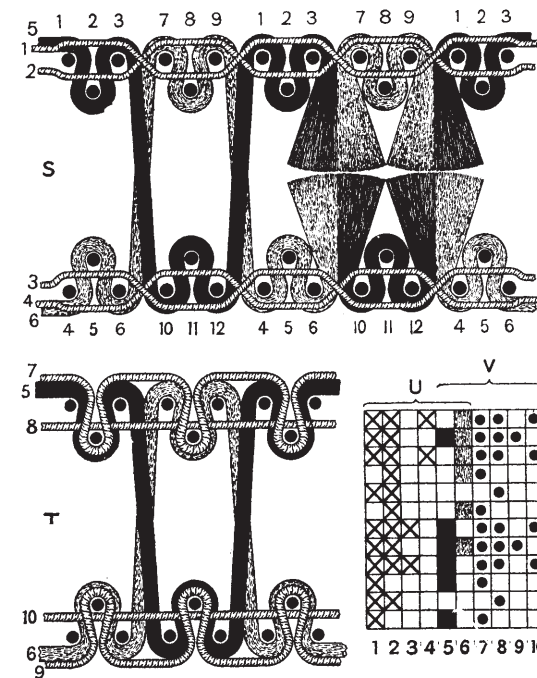


FIG. 229.

Fig. 230 is a little more elaborate in construction, four distinct pile threads being used in order to secure a firmly bound tuft, each tuft being identical with C, Fig. 218. In this particular example there are sixteen picks to the round, and the order of picking is shown to be alternately in the

upper and lower fabrics. This has been done for the sake of simplicity, although in actual practice it is usual to depart from this simple order, and to arrange the picks accordingly. Twelve threads form a repeat in the warp as indicated by design W; eight only appear in the intersection

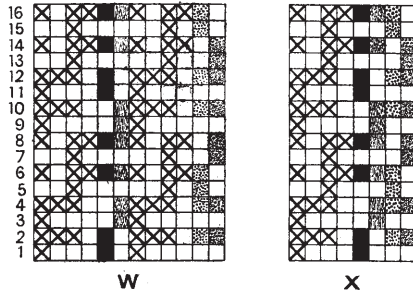
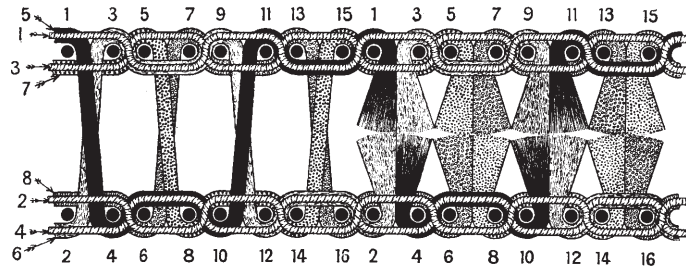
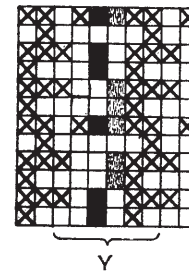
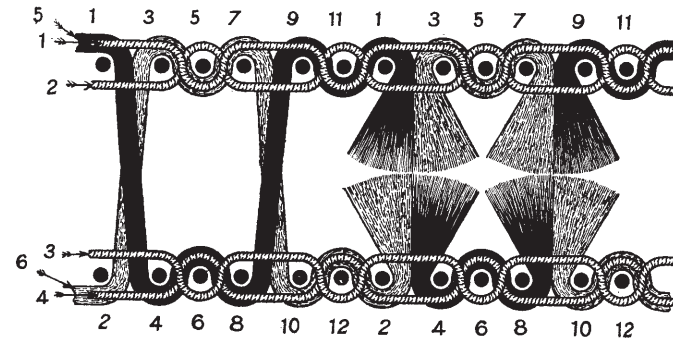


FIG. 230.

because threads 7, 8, 9, and 10 in design W are duplicates of the first four. The eight threads in the intersection are numbered and correspond to those in design X. The four pile threads are shown in distinctive marks for the sake of enabling the reader to follow the movements from the design. In actual work, however, all the pile threads may or may not be the same colour.

Another firmly bound pile with tufts as at D, Fig. 218, is introduced in Fig. 231. Six threads and twelve picks complete the design as is shown by the bracketed portion in design Y. Ten threads, however, appear altogether in



2 Picks crossing  
at the same time  
ditto.  
ditto.  
ditto.  
ditto.  
ditto.

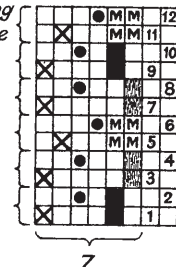


FIG. 231.

this design, and it is the first six which constitute the intersection. Modifications in the order of picking for the purpose of selvaging may and do obtain, but we have shown most of the designs as if the weft passed alternately into the top and the bottom cloths.

A great number of the finer plush fabrics are made on



the double plush loom; a further effort to increase production was the attempt, with partial success, to weave these fabrics by sending two shuttles across at the same time. We believe the principle is being revived, not only for double plush fabrics, but also for weaving two simple fabrics at the same time. In the ordinary method of double plush weaving each warp thread, during the passing of the single shuttle, may occupy, at different times, a high and a low position. When two shuttles are sent across at the same time the ground threads are similarly operated, but, since the pile threads are common to both structures it is essential that these yarns should be capable of assuming three different positions, viz., highest, lowest, and a position about midway between the two extremes. To make this more clear let us examine design Z, Fig. 231, which represents the movements of the six threads shown in the illustration. There are six double picks bracketed at the left-hand side of the design, while the single numbers on the right indicate separately the twelve picks which form one complete round. All odd-numbered picks belong to the upper fabric, and all even-numbered ones to the lower one. No difficulty will be experienced in following the movements of the ground threads shown in crosses and dots, so we will pass on to describe the movements of the 1st pile thread marked in solid squares. Since this thread is over both the 1st and 2nd picks, and under the 3rd and 4th picks, it is represented by two solid marks and two blanks; but on the 5th and 6th picks (see intersection as well as design), which pass through at the same time, the thread must be under the 5th pick and over the 6th; now it can be there only by remaining in the centre while both shuttles cross. This middle position is marked by the letter M on

the 5th and 6th picks, and similarly on the 11th and 12th picks, where the same positions must be assumed. The 6th thread, shown in etching, must be operated in precisely the same manner on the 5th, 6th, 11th, and 12th picks; they are, consequently, marked with the letter M—a letter which means in each case that the thread is raised or lowered to the middle position so that one shuttle may pass above it, and another shuttle under it at the same moment. The shedding tappets will thus have dwells or pauses corresponding to the three different levels.

Cut and uncut pile are occasionally woven in the same fabric on the double plush principle; when this is done, a thread or a thin wire has to be inserted between the two cloths in order to form the loops, and this thread or wire must, obviously, be withdrawn before any cutting takes place, otherwise the loops would be cut as well as those threads which pass directly between the two grounds.

By expanding this principle of double plush weaving so as to obtain three distinct fabrics, it is clear that the top and bottom fabrics would be identical with one or other of those illustrated, while the central fabric would possess a pile on each side. Although this method of producing a double-faced pile fabric might be adopted, we think it scarcely likely that any such fabric required would be made on this principle in preference to that of the wire system of forming the pile. We shall, therefore, confine our remarks to the latter method.

Fig. 232 is a photographic reproduction of a jute double-faced plush fabric,—not one which requires cutting to form two distinct cloths, but a fabric both sides of which are developed by pile warp threads. The cloth was woven all one colour, and then both sides printed so as to imitate a figured plush. We have no record of the exact way

in which this cloth was woven, but from the structure it appears certain that if a wire had been used, the whole of the plush would have been woven on one side of the cloth, and then half of the plush drawn through the cloth to the



FIG. 232.

opposite side. Thus the lines from design C, Fig. 233, show that the resulting structure would be somewhat similar to intersection D, which demonstrates that:—

1st. The ground threads interweave in plain order with

- the 3rd and 7th picks (these picks pass through at the same time as the wire as indicated in design C).  
 2nd. That the 1st and 5th picks are entirely above the ground warp, but under the pile warp.  
 3rd. That the 2nd, 4th, 6th, and 8th picks are entirely under the ground warp, but over the pile warp. The 2nd and 6th picks marked ■ in design

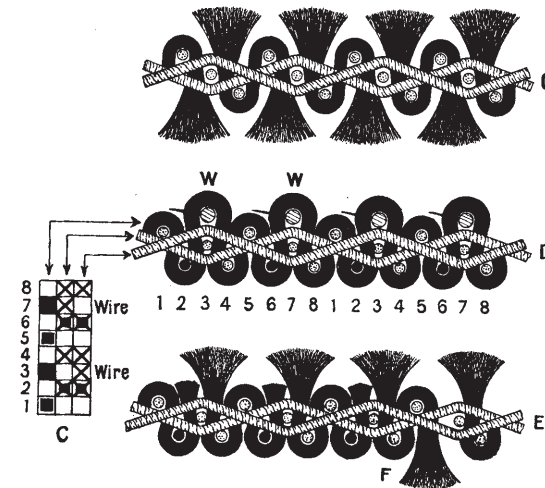


FIG. 233.

indicate that these picks will be withdrawn afterwards.

- 4th. That the cutting end of the wire is not vertical but a little to one side. This will result in the loop being cut into two unequal portions in order that the pile may be approximately equal in length on both sides of the cloth.

After the cutting wires are removed the fabric will