TEXTILE DESIGN

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TEXTILE DESIGN

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PREFACE

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

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

T. WOODHOUSE.
T. MILNE.

January 1912.

CONTENTS

CHAPTER I

INTRODUCTION

CHAPTER II

PLAIN, TWILL, AND SATEEN WEAVES

CHAPTER III

MOCK LENOS, HUCKABACKS, HONEYCOMBS, ETC.

CHAPTER IV

CRÊPES AND OTHER GROUND WEAVES

CHAPTER V

SPIDERS

CHAPTER VI

HERRING-BONES, DIAMONDS, AND DIAPERS

CHAPTER VII

DICES

CHAPTER VIII

SPOTS

CHAPTER IX

DAMASKS

CHAPTER X

CHECKS AND SMALL EFFECTS

CHAPTER XI

COMPOUND FABRICS

CHAPTER XII

DOUBLE WEFT-FACED FABRICS

CHAPTER XIII

BACKED CLOTHS

CHAPTER XIV

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

CHAPTER XV

EFFECTS PRODUCED WITH EXTRA WARP AND EXTRA WEFT

CHAPTER XVI

DOUBLE CLOTHS

CHAPTER XVII

THREE AND MORE PLY FABRICS

CHAPTER XVIII

VELVETS, PLUSHES, AND SIMILAR WARP-PILE FABRICS

CHAPTER XIX

BRUSSELS, WILTON, TAPESTRY, ROYAL AXMINSTER, AND PATENT AXMINSTER CARPETS

CHAPTER XX

TURKISH TOWELLING, OR TERRY FABRICS

CHAPTER XXI

WEFT PILE FABRICS

CHAPTER XXII

BEDFORD CORDS, PIQUÉS, TOILET COVERS, ETC.

CHAPTER XXIII

GAUZE AND LENO FABRICS

CHAPTER XXIV

LAPPET AND SWIVEL FABRICS

CHAPTER XXV

SILK PICTURE DESIGNS AND FABRICS

CHAPTER I

INTRODUCTION

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

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

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

Of the various sides of this subject enumerated above there is, perhaps, from a purely textile point of view, none more important than that of weave structure. It is, in many respects, almost the very essence of the art of weaving, and, when considered from an applied standpoint, includes, as a subsidiary side, the processes of production.

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

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

The following divisions are therefore suggested :—

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

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

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

Group IV. Pile fabrics of all classes.

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

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

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

All students of weaving are more or less familiar with squared paper, or what is generally known as point or design paper. It consists, as shown in Fig. 1, of paper ruled with two sets of parallel lines perpendicular to each other. To facilitate the counting of the vertical and the horizontal rows of squares thus formed, to suit the class of jacquard, and the relative numbers of warp and weft threads, it is found necessary to introduce, at certain intervals, in both directions, thicker or more prominent lines. These are shown in Fig. 2 at X in the vertical set, and at Y in the horizontal set. As a general rule, it may be taken that the distance between any two adjacent heavy lines is the same in both directions. The heavy lines, therefore, divide the paper into a series of true squares technically termed "blocks." The number of small squares contained in one of these blocks may vary both horizontally and vertically according to requirements, but there is,

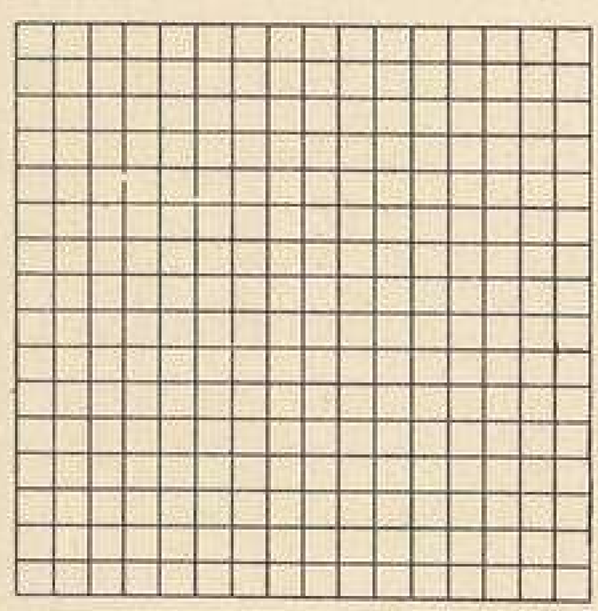


Fig. 1.

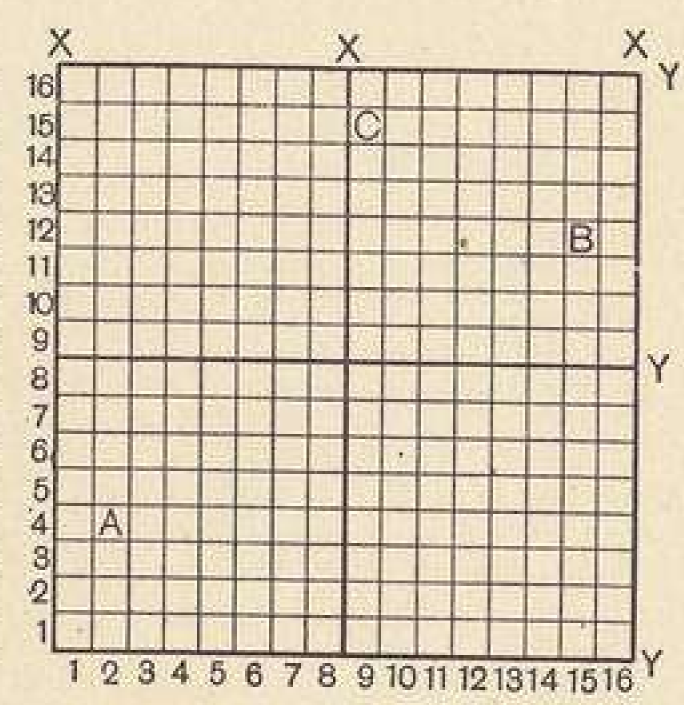


Fig. 2.

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

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

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

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

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

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

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

CHAPTER II

PLAIN, TWILL, AND SATEEN WEAVES

REARRANGEMENTS

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

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

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

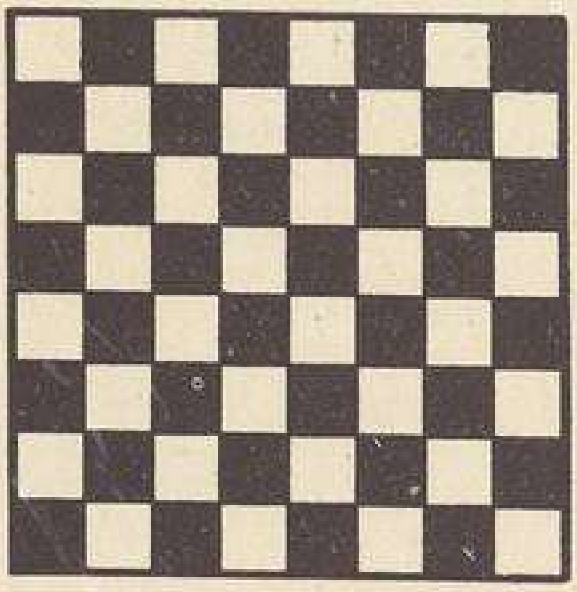


Fig. 3.

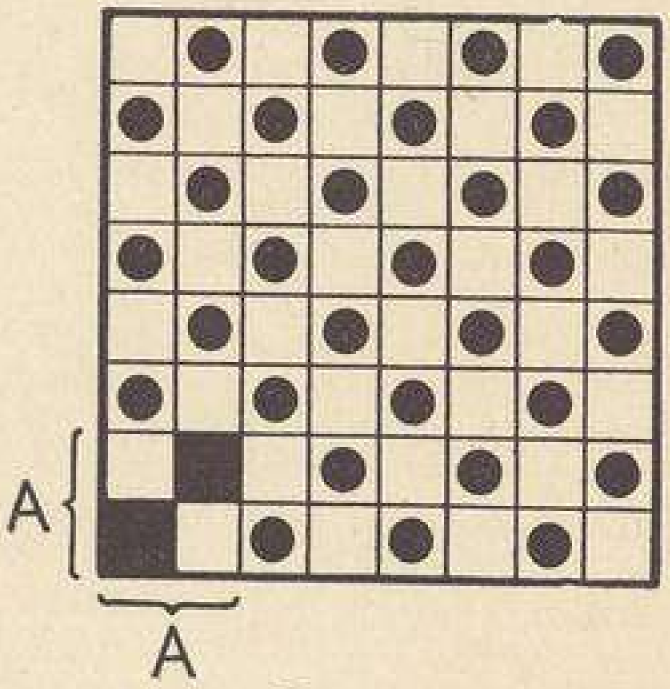


Fig. 4.

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

Rule for Drafting

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

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

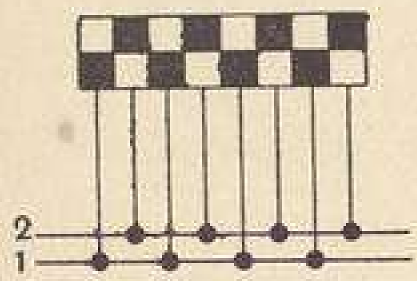


Fig. 5.

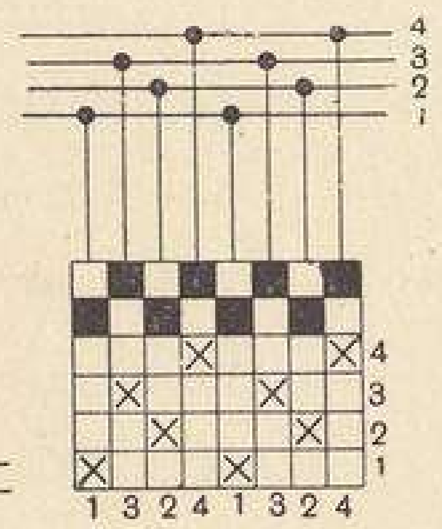


Fig. 6.

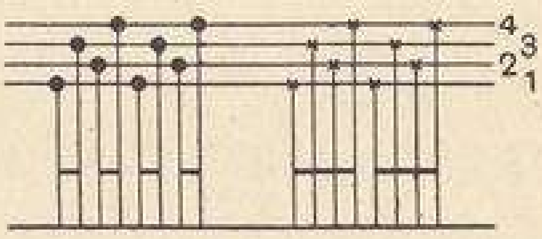


Fig. 7.

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

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

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

The most natural and the simplest extensions of the plain weave are those in which two or more succeeding threads or picks are identical. In Figs. 8, 9, and 10 are shown three weaves with 2, 3, and 4 picks respectively in a shed. These weaves may be considered as derivatives of the plain weave, but they are usually classed under warp ribs or warp reps. Weaves of this type produce, as their name implies, well-defined ribs or bars extending from selvage to selvage of the cloth, provided a sufficient number of warp threads per inch be inserted. The width of the bars depends upon the weave, and also upon the number of picks per inch and the thickness of the yarn employed. When the picks per inch are constant, the three weaves produce bars whose widths are in the ratio of 2 : 3 : 4 ; but where the picks per inch vary, the width of the bars may be anything desired, within reasonable limits. For example, if 10, 15, and 20 picks per inch be introduced respectively into cloths woven by the aid of the weaves in Figs. 8, 9, and 10, the width of the bars in each piece would be the

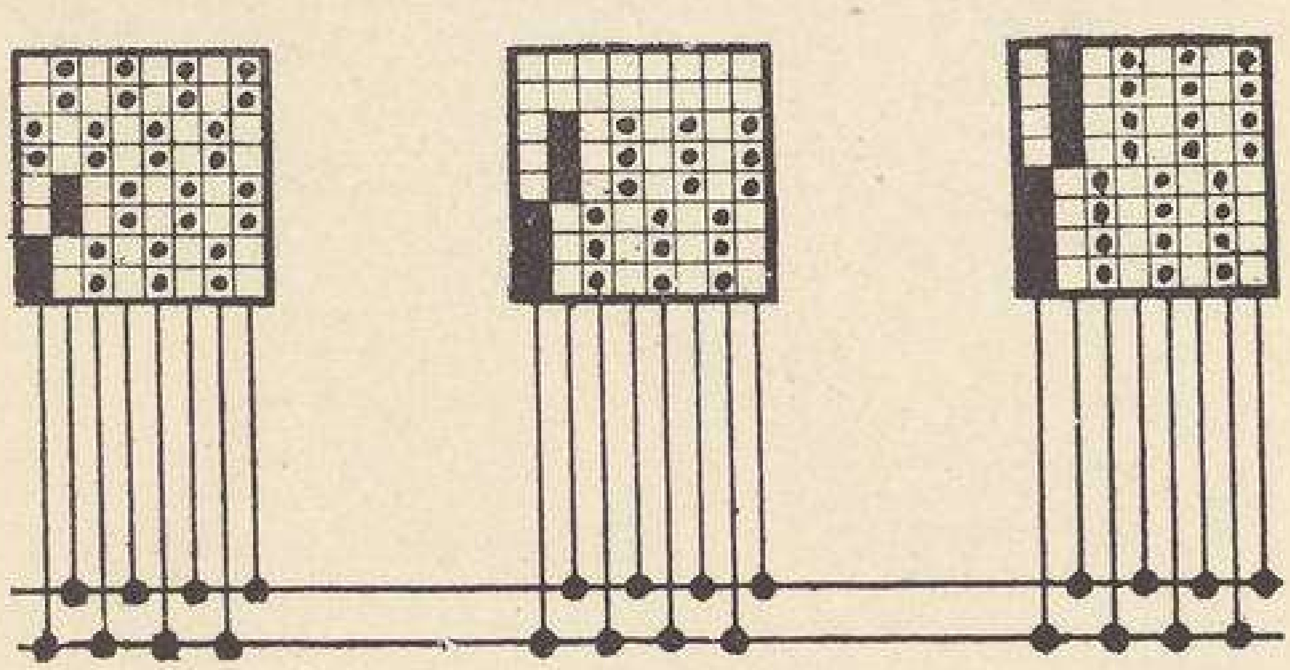


FIG. 8. FIG. 9. FIG. 10.

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

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

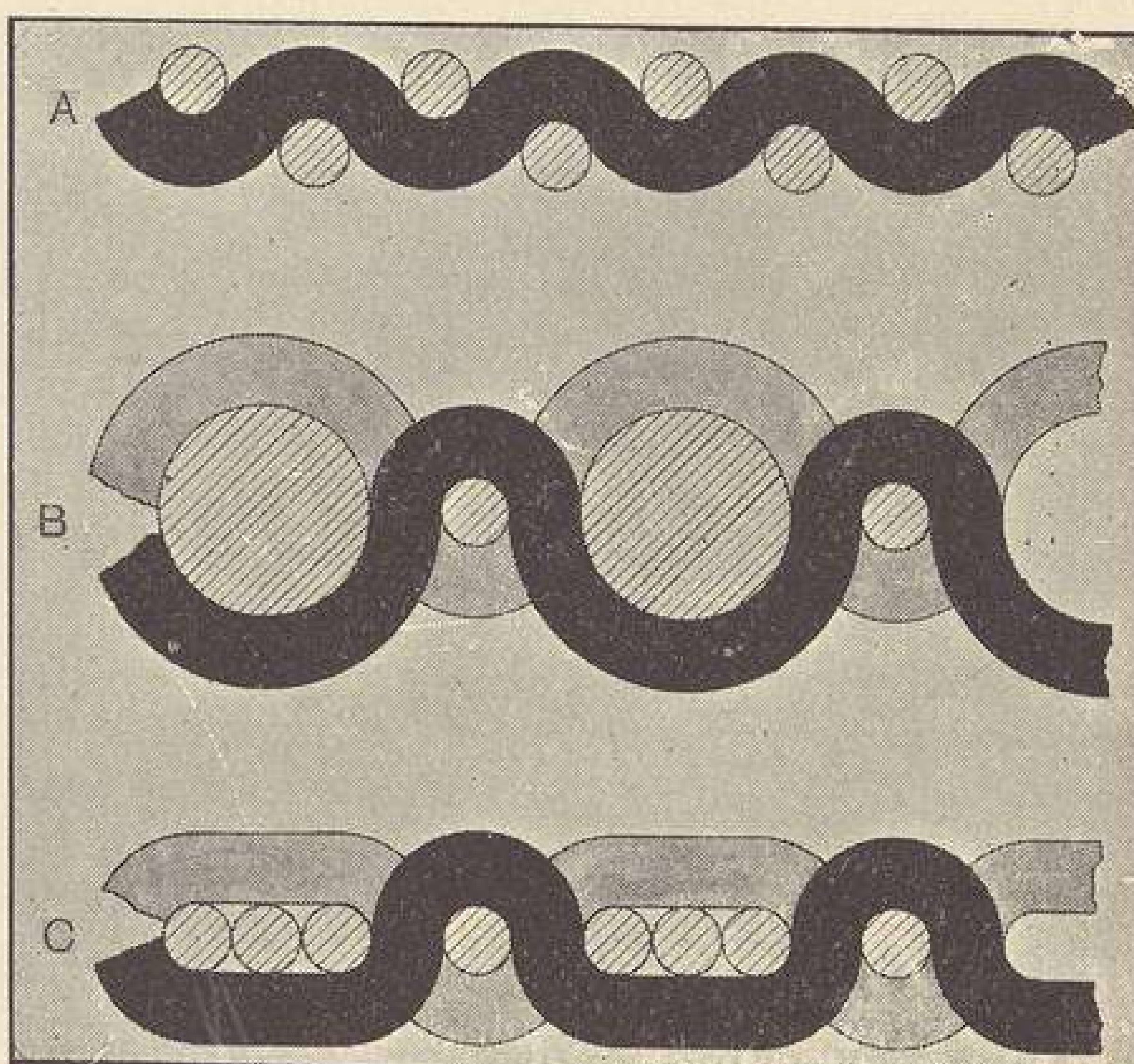


Fig. 11.

inserted in the two bars. Thus, the effect at C, Fig. 11, shows the same width of bars as that at B, while the thickness of the cloth would be more uniform than in the latter case. Three picks are woven in the same shed for the broad bar, while one pick forms the narrow one. The weave plan is shown in Fig. 12, and this, along with its companion weave, Fig. 13, is largely used in the manufacture of heavy carpeting. The two weaves are in reality the same, beginning only on different picks. It will be seen that the weight of the heavy yarn used in B, Fig. 11, is considerably in excess of that required for the effect at C, since the weight of one pick of the heavy yarn is three times the weight of the three picks which form the corresponding part in C. In addition to the increased weight of weft, it would be necessary to have a pick-and-pick box loom, running at a reduced speed, to obtain the effect at B.

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

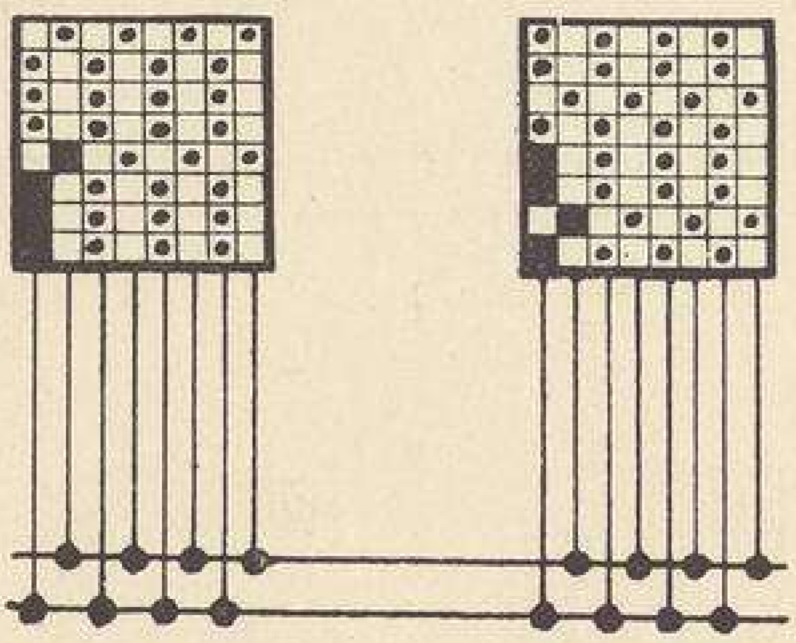


Fig. 12. Fig. 13.

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

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

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

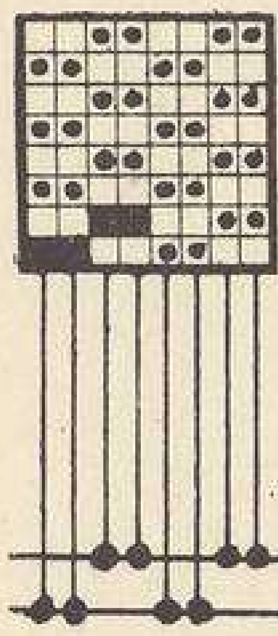


FIG. 14.

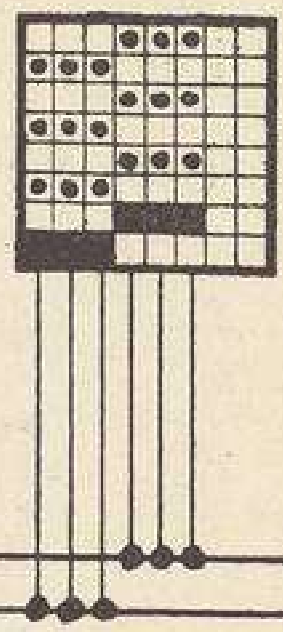


FIG. 15.

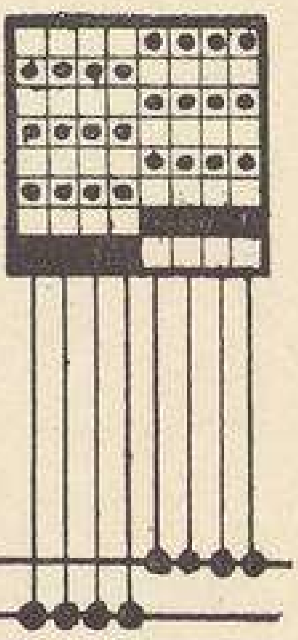


FIG. 16.

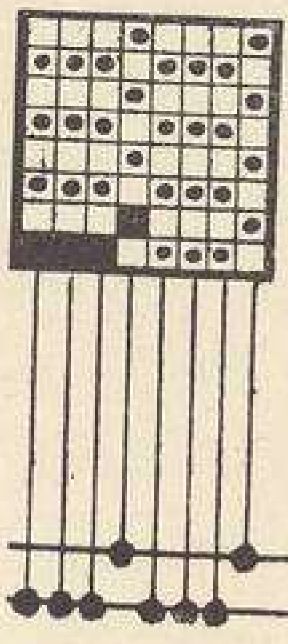


FIG. 17.

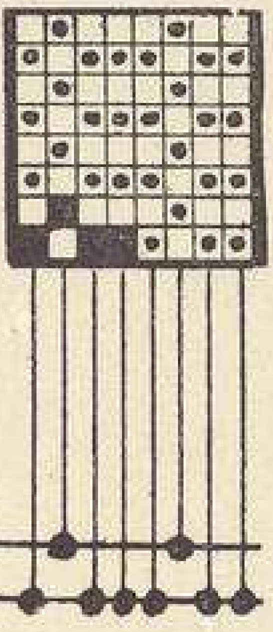


FIG. 18.

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

In Figs. 19, 20, and 21 are three designs developed from these unit weaves. They appear quite satisfactory on paper, but none of the designs would give the same satisfaction in the cloth. For instance, in Fig. 19 the draft indicates that it could be woven with two shafts. In one

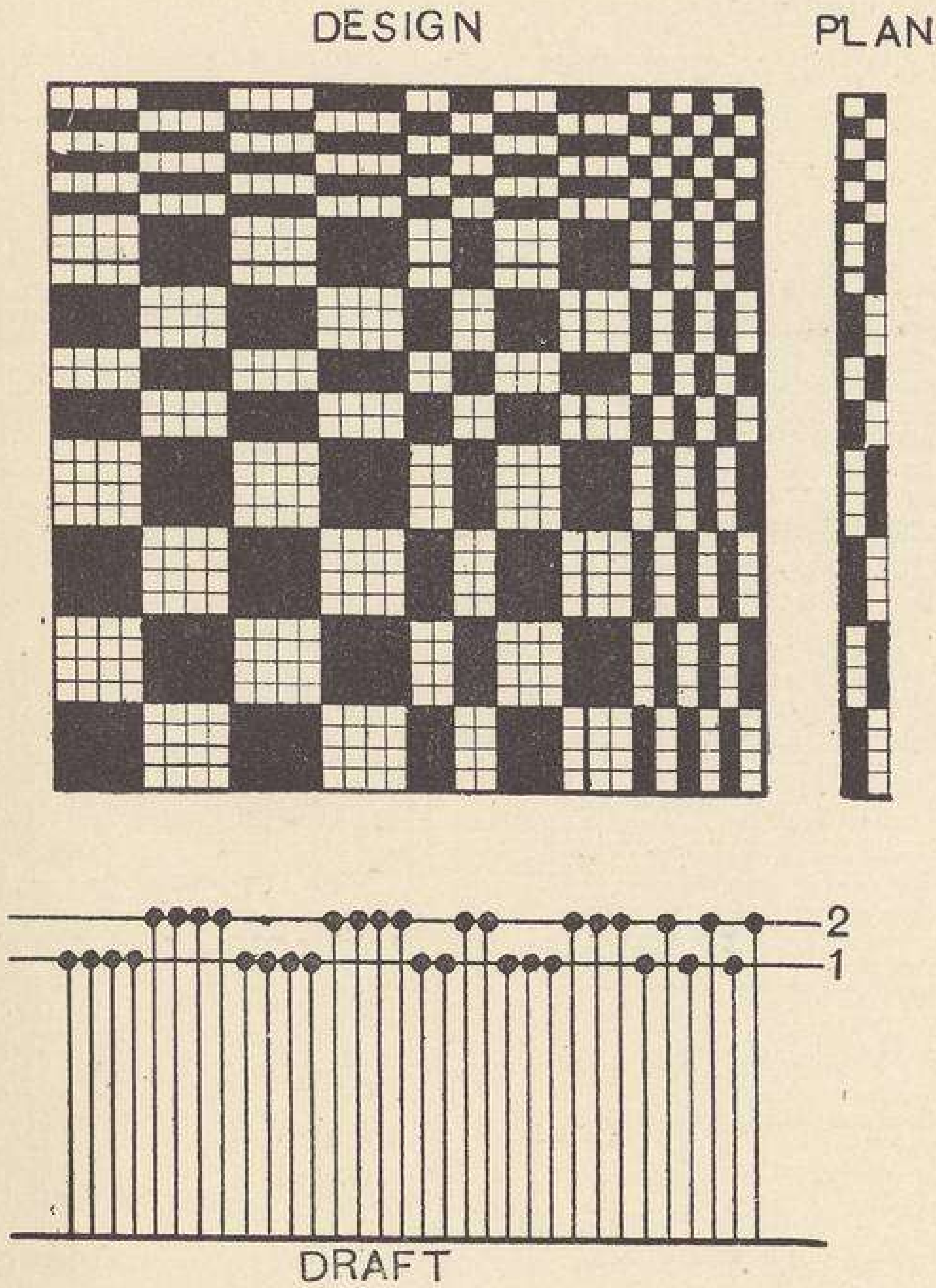


FIG. 19.

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

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

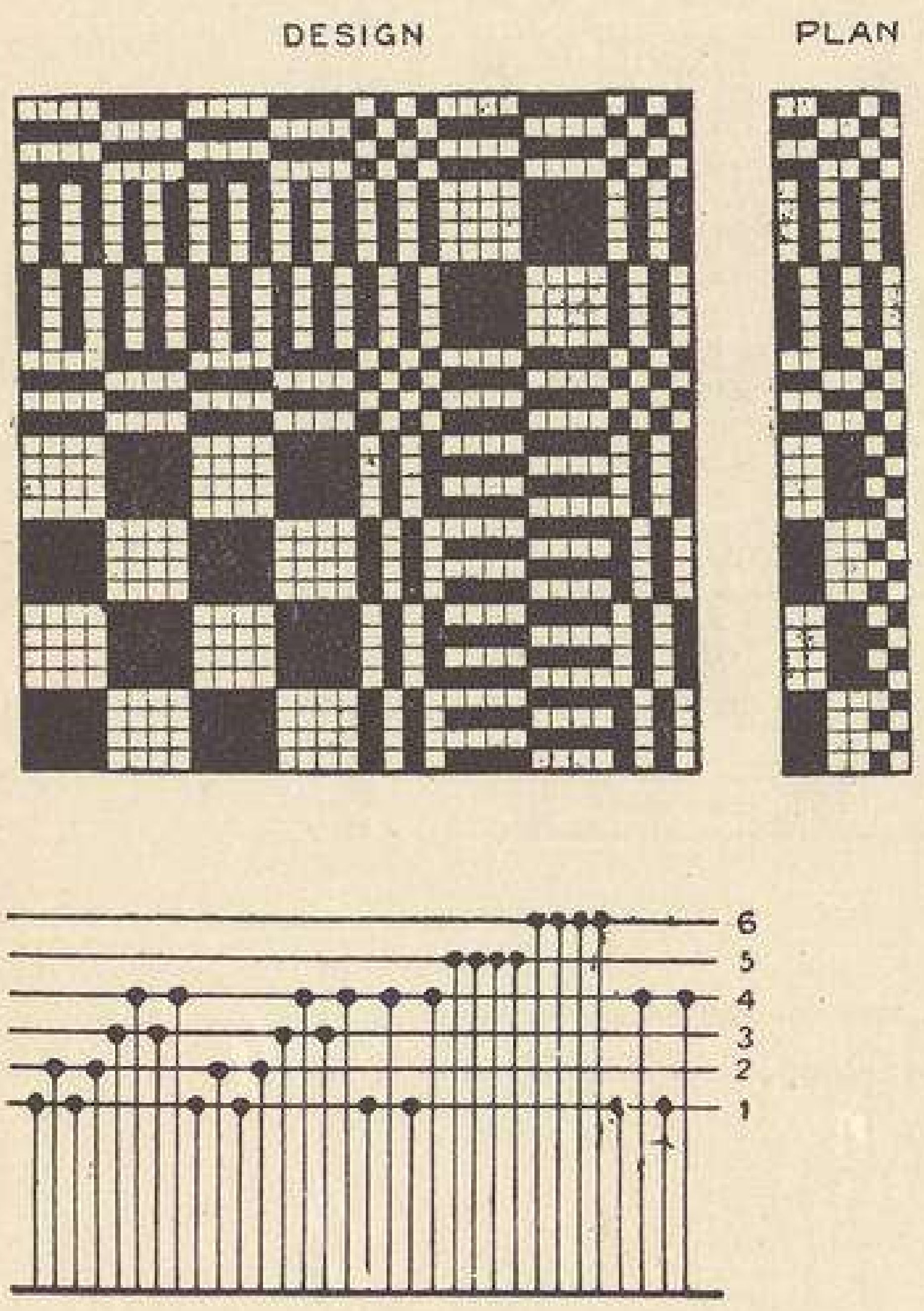


Fig. 20.

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

The primitive weaves shown up to and including Fig.

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

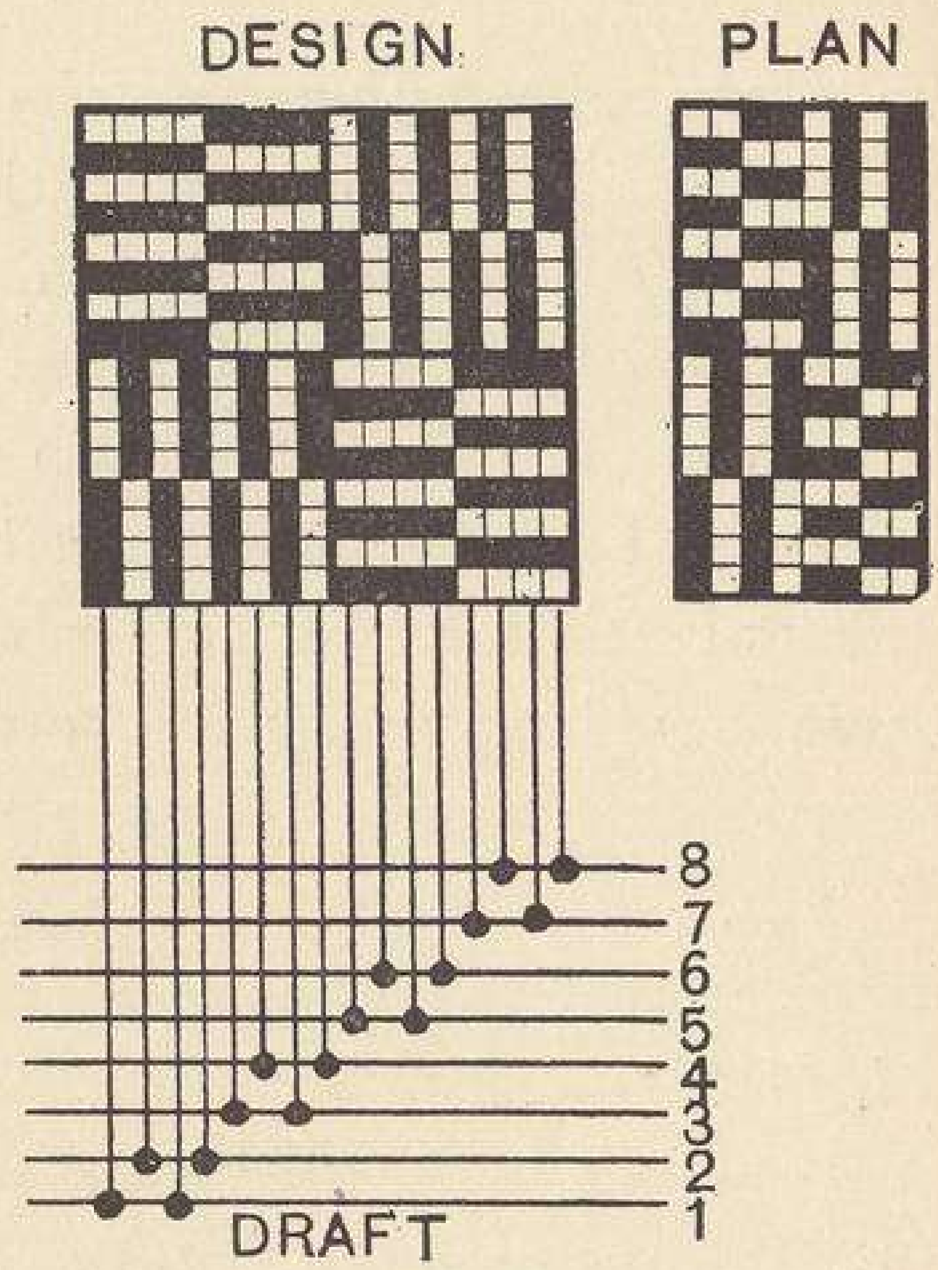


Fig. 21.

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

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

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

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

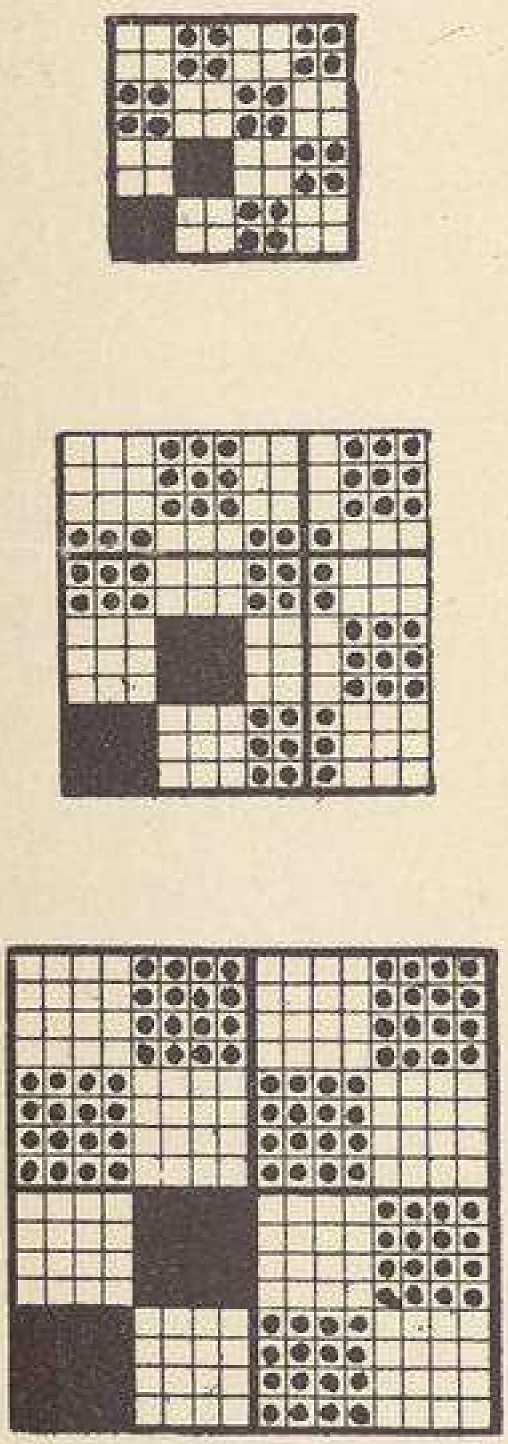


FIG. 22.

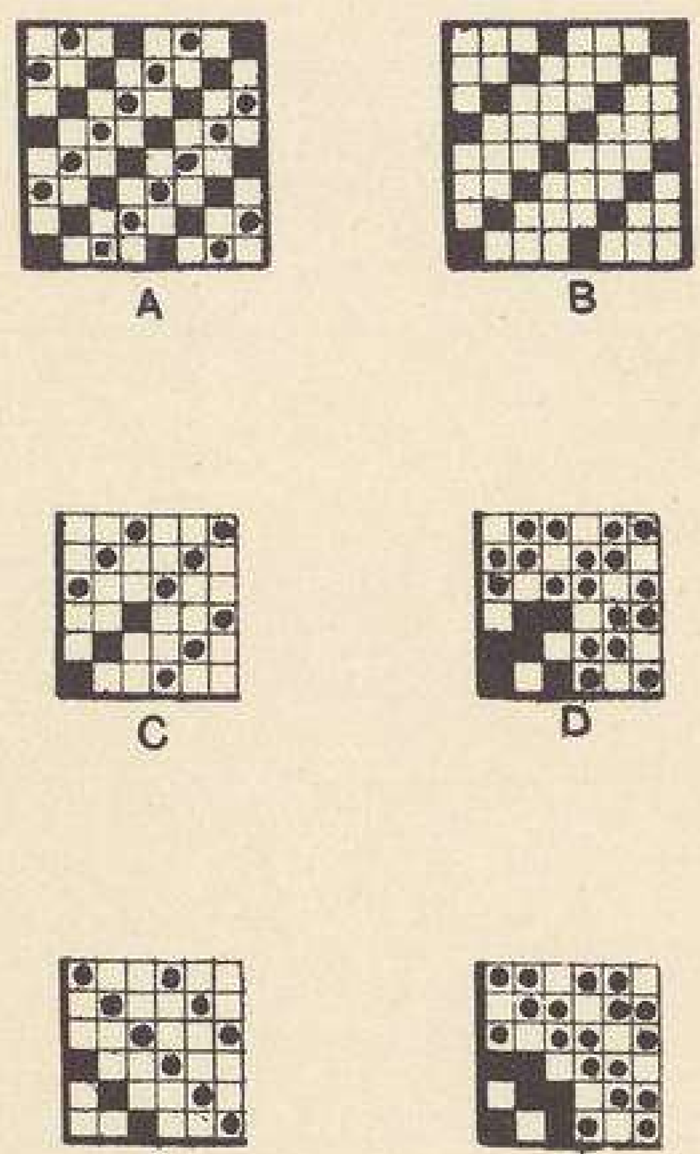


FIG. 23.

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

(*a*) Ornamentation of the fabric.

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

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

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

The simplest twills, or what might be termed the fundamental twill weaves, are those in which there is one, and only one, mark on each thread and pick, and in which the arrangement of such marks is a succession of steps of one pick forward and one thread to the right. The result in every case is the formation of a diagonal line forming, on paper at least, an angle of 45° with the horizontal. This angle is maintained in the cloth, provided the number of threads per inch of warp and weft is the same, but only when such a condition obtains. From the nature of the above arrangement of .marks, it is quite clear that there can be only one such weave for each fixed number of threads and picks, although by moving one step upwards and one step to the left, an apparently different result is obtained; the difference, however, is simply one of direction, and not of structure.

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

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

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

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

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

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

The 4-thread rolling twills G, J, K, and M are sometimes, but not extensively, used in the jute and linen industries, but the $\frac{2}{\quad}\overline{\ \ }_{2}$ twills H and L are, next to the plain weave, probably the most extensively used of all weaves. They are popularly known in different districts as the serge, common, cassimere, shalloon, blanket, or two-and-two twill, are widely used in jute carpet manufacture, for sheetings and other linen goods, for many types of silk and cotton fabrics, but perhaps most extensively for woollen and worsted clothing and dress material.

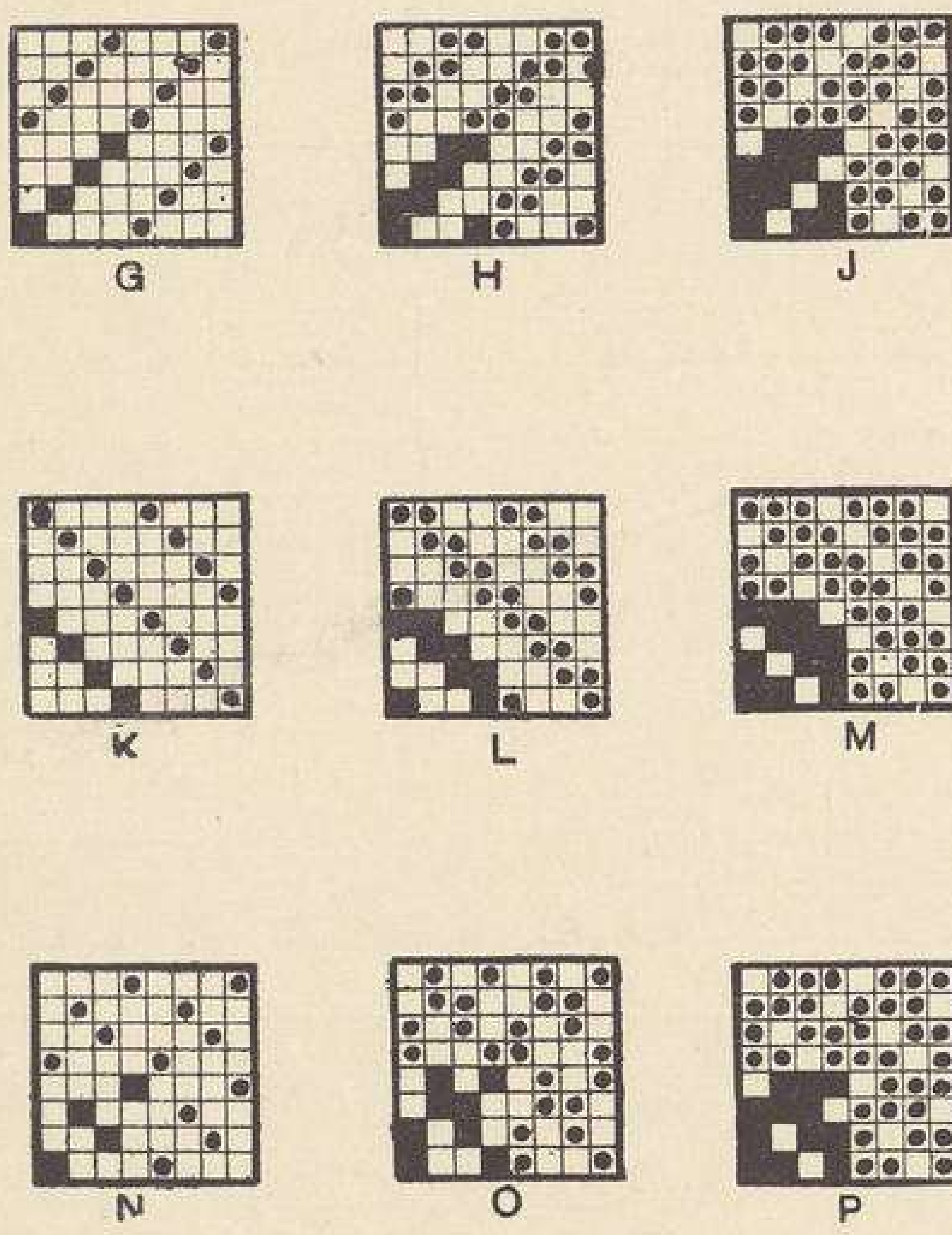


FIG. 24.

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

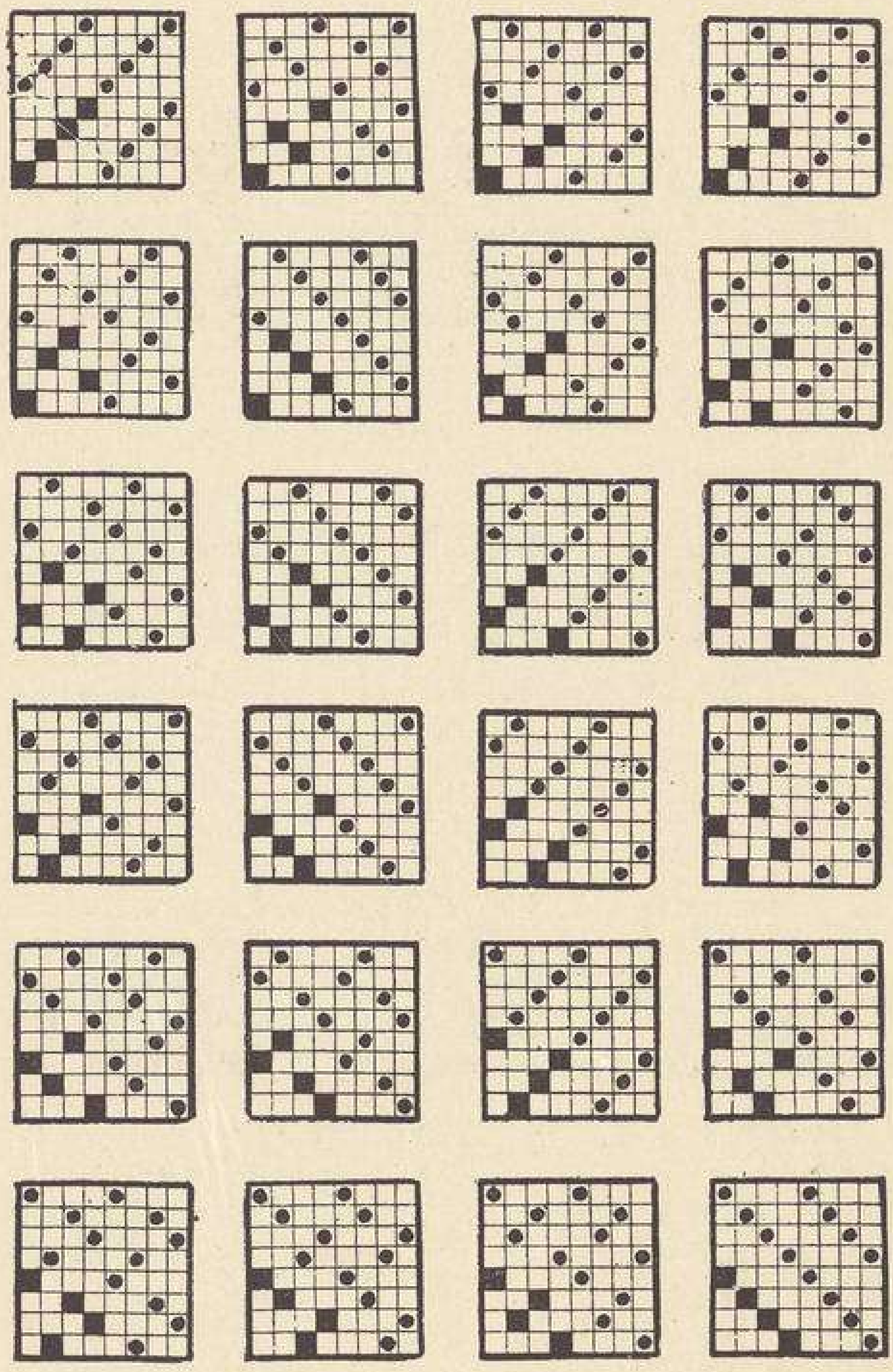


Fig. 25.

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

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

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

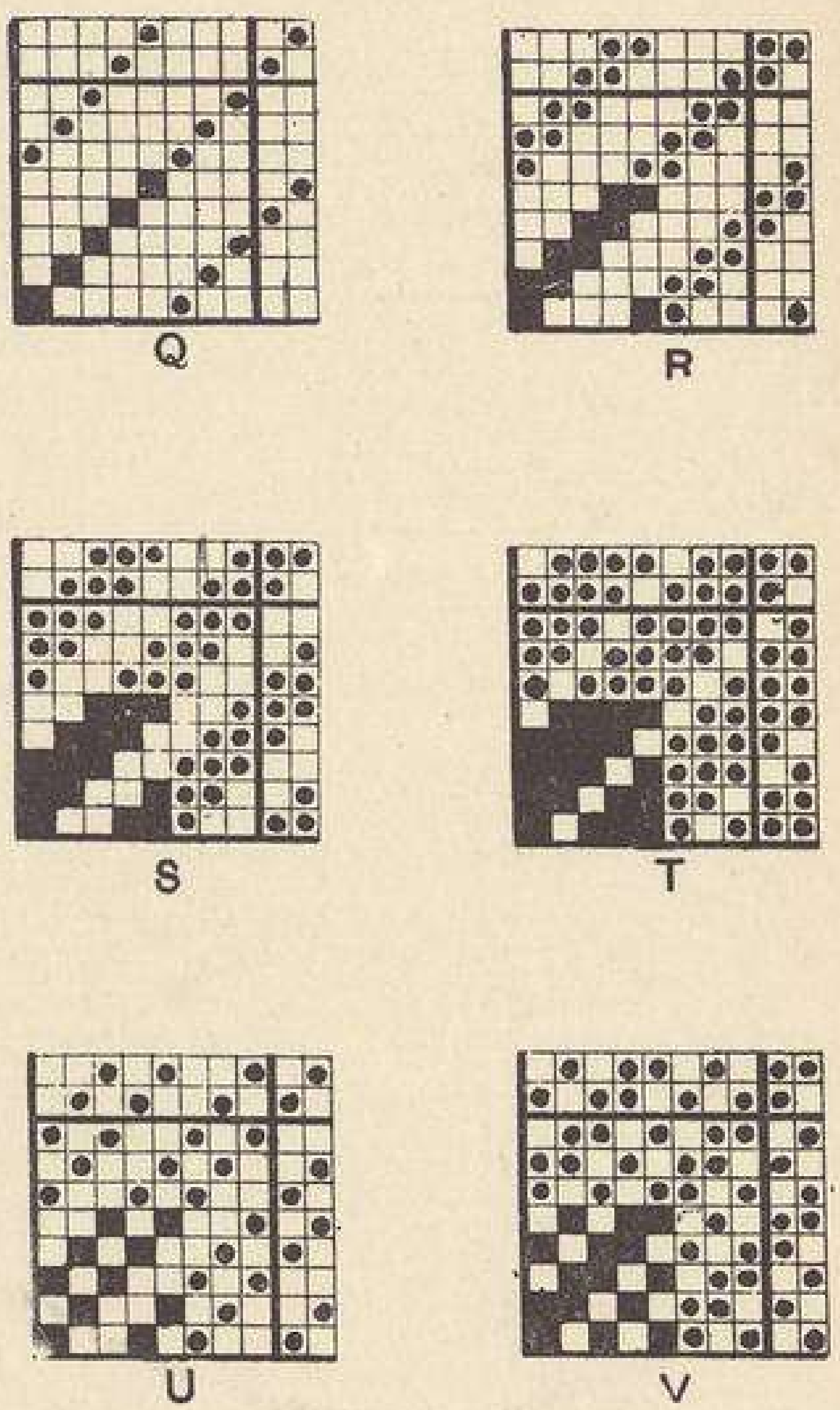


Fig. 26.

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

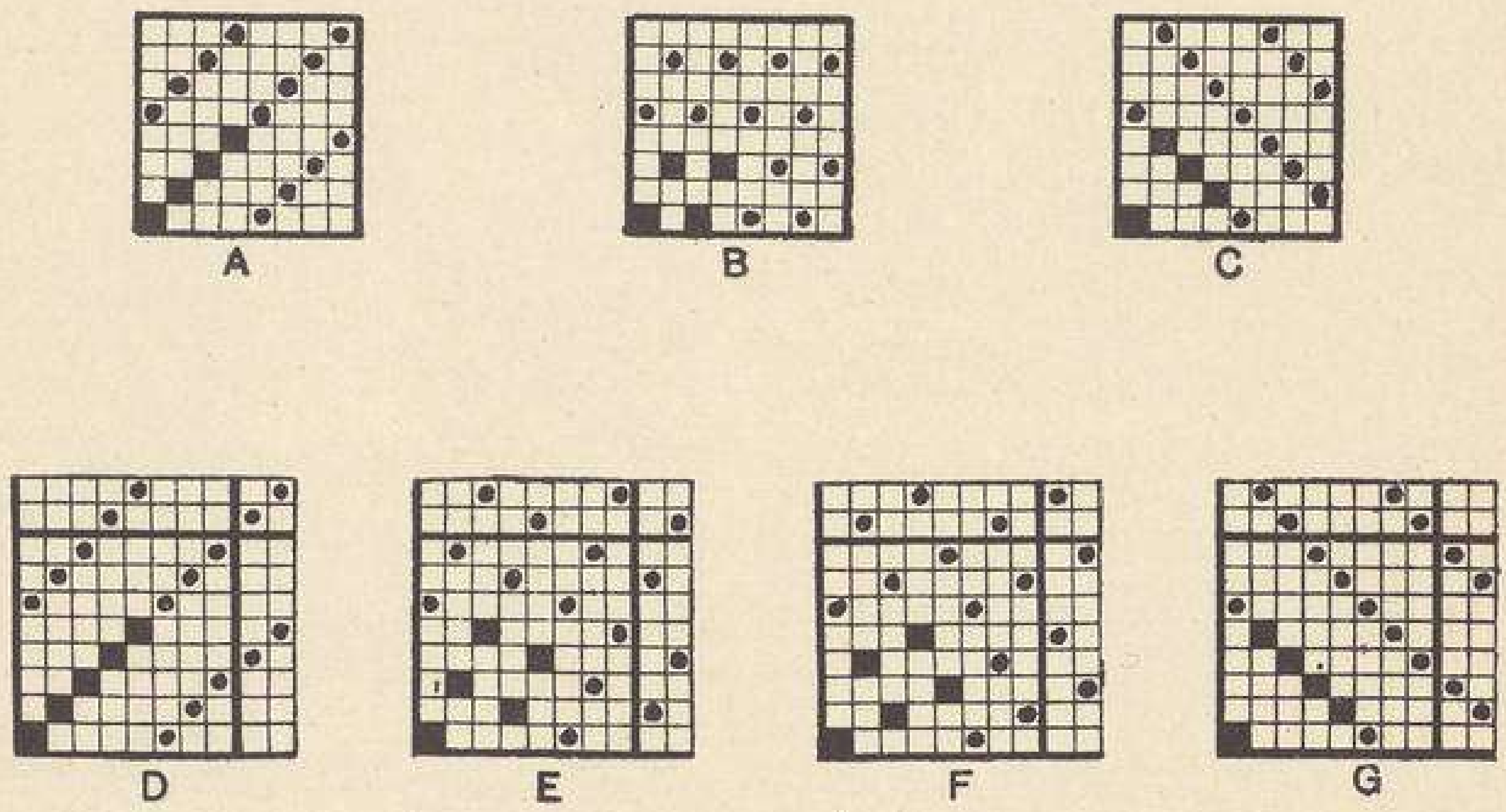


FIG. 27.

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

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

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

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

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

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

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

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

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

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

All the above movements are shown in Fig. 28, for six, seven, and eight threads. It is interesting to note that there is no regular sateen on six threads; with seven threads there are four, the last two, however, being the images of the first two; while with eight threads there are two regular sateens of oppositely directed twills. When

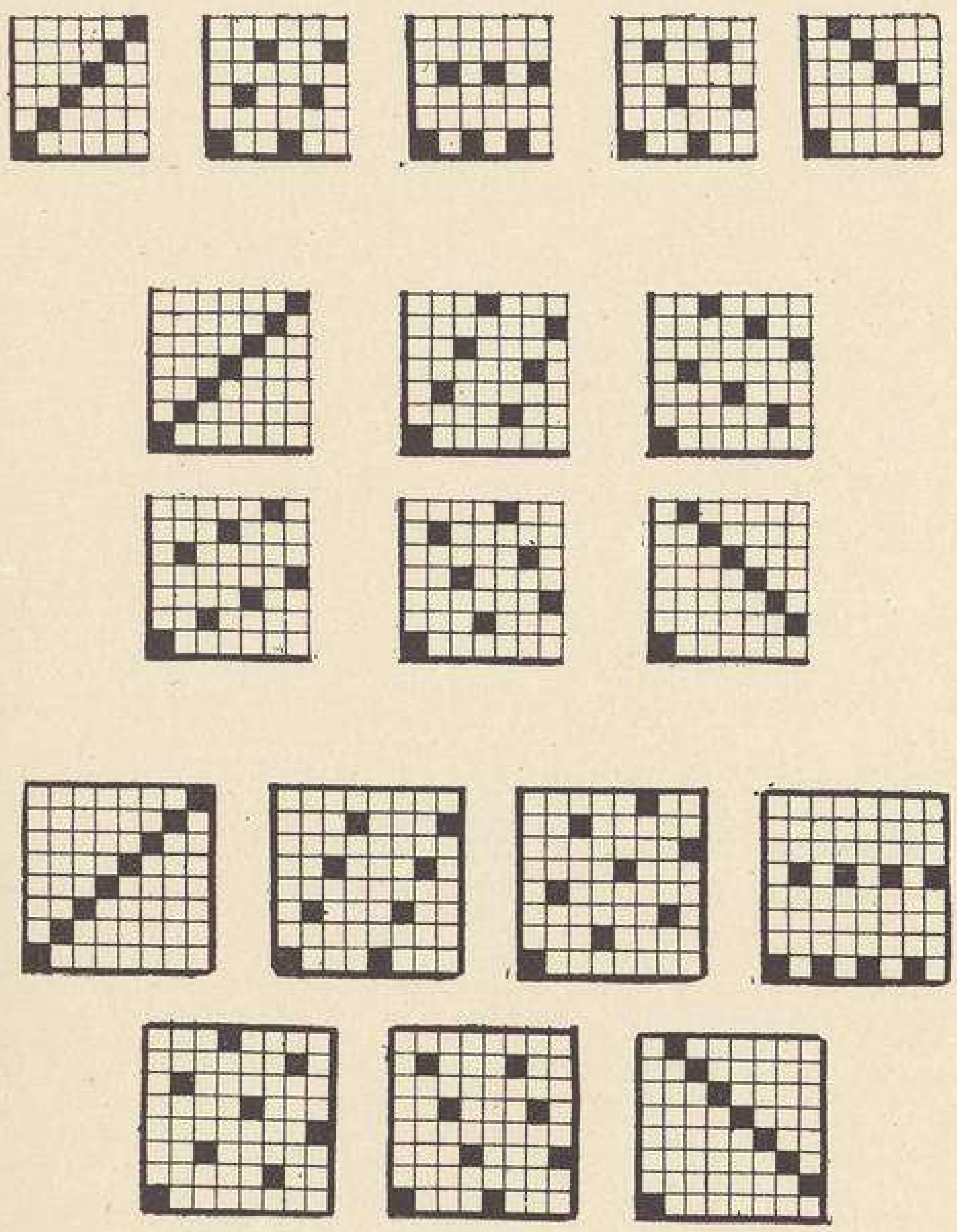


Fig. 28.

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

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

No. of Threads in Weave.	Magnitude of Step.	Magnitude of Step.
5	2.	3.
6	none	none
7	2.3.	4.5.
8	3.	5.
9	2.4.	5.7.
10	3.	7.
11	2.3.4.5.	6.7.8 9.
12	5.	7.
13	2.3.4.5.6.	7.8.9.10.11.
14	3.5.	9.11.
15	2.4.7.	8.11.13.
16	3.5.7.	9.11.13.
17	2.3.4.5.6.7.8.	9.10.11.12.13.14.15.
18	5.7.	11.13.
19	2.3.4.5.6.7.8.9.	10.11.12.13.14.15.16.17.
20	3.7.9.	11.13.17.
21	2.4.5.8.10.	11.13.16.17.19.
22	3.5.7.9.	13.15.17.19.
23	2.3.4.5.6.7.8.9.10.11.	12.13.14.15.16.17.18.19.20.21.
24	5.7.11.	13.17.19.

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

We have given the number of different sateens up to 24 threads, but the choice of any particular one would naturally depend upon the effect desired, some of the sateens having their points or marks more regularly distributed than the others. It is seldom that a 24-thread sateen is used except in fine silks, but in this material the 48-thread sateen is occasionally used.

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

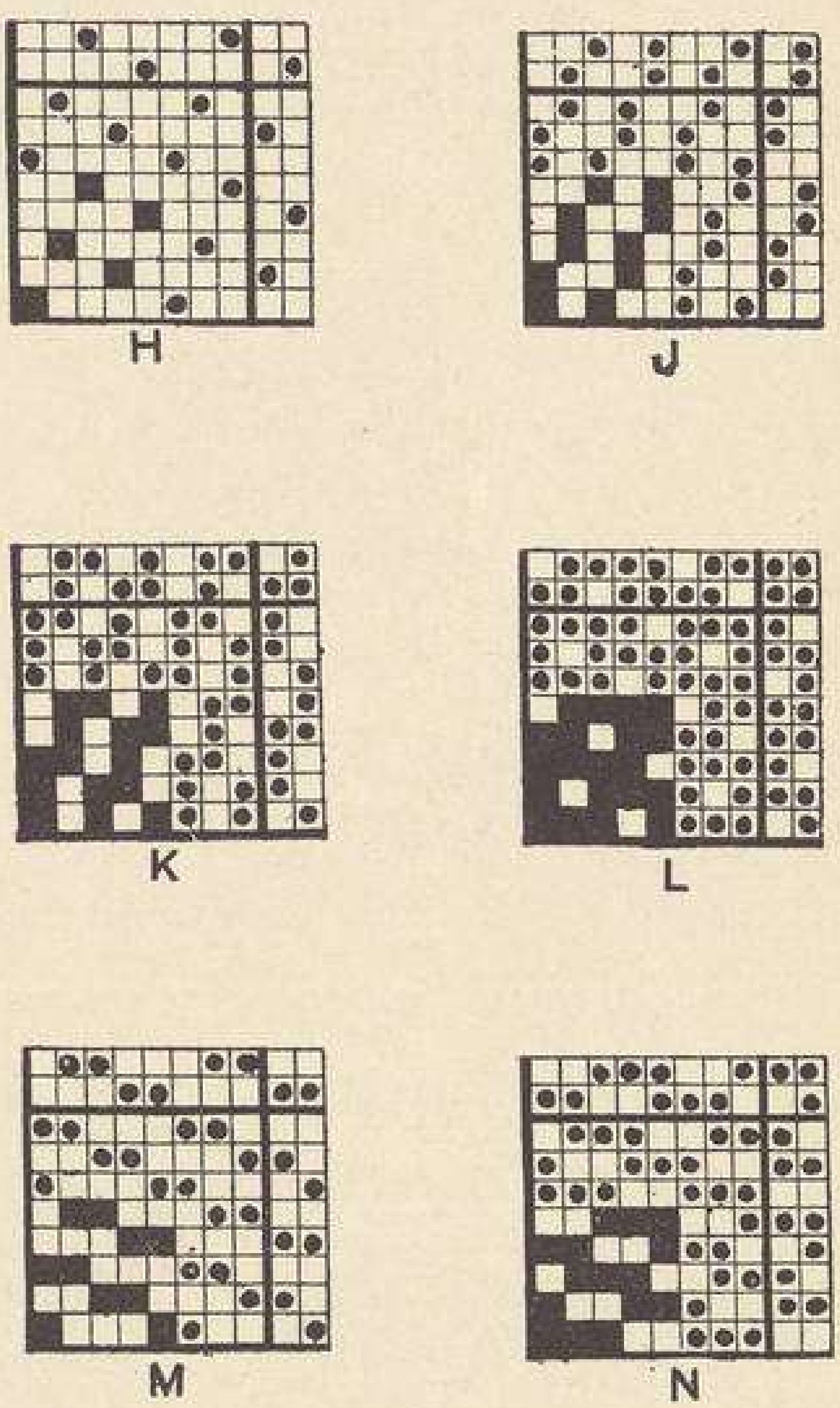


Fig. 29.

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

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

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

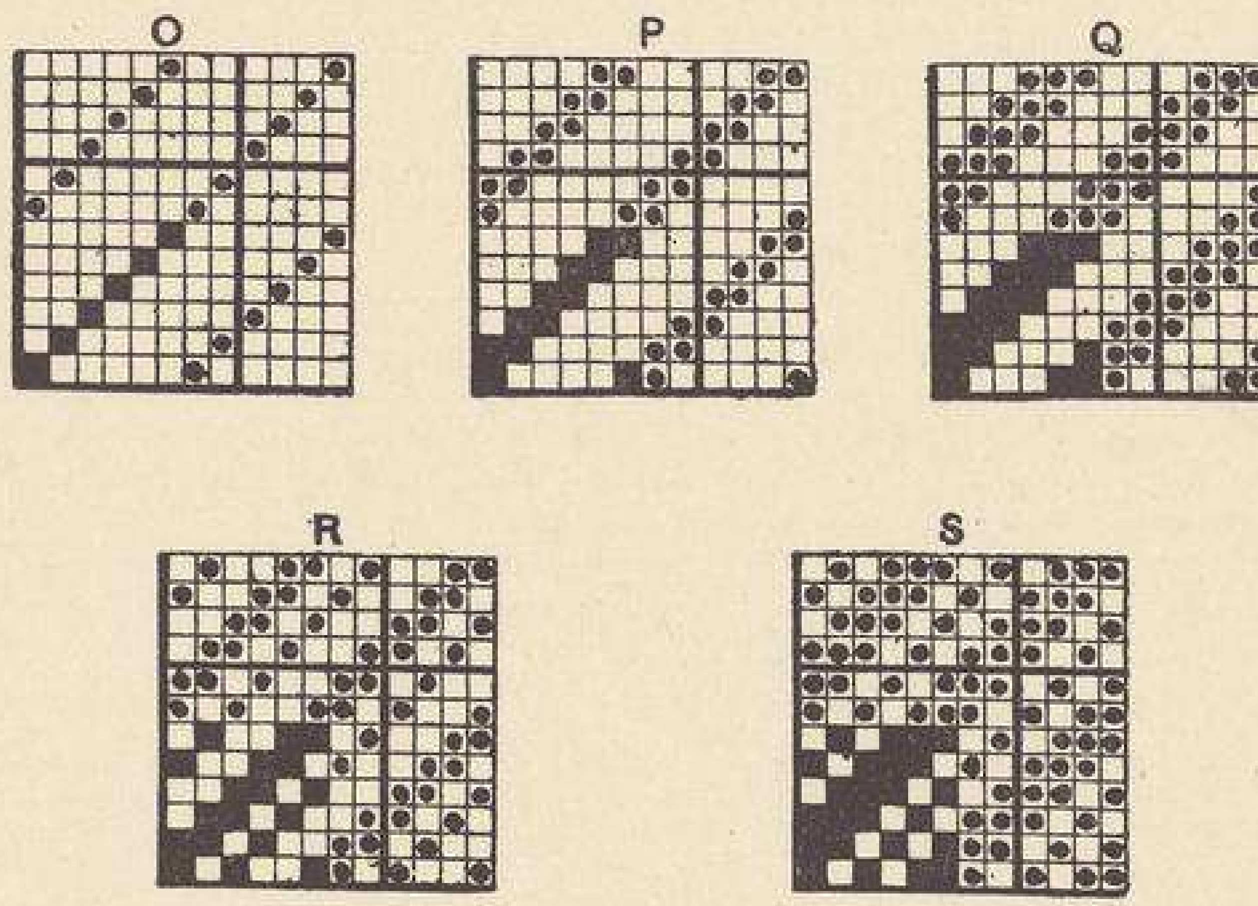


Fig. 30.

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

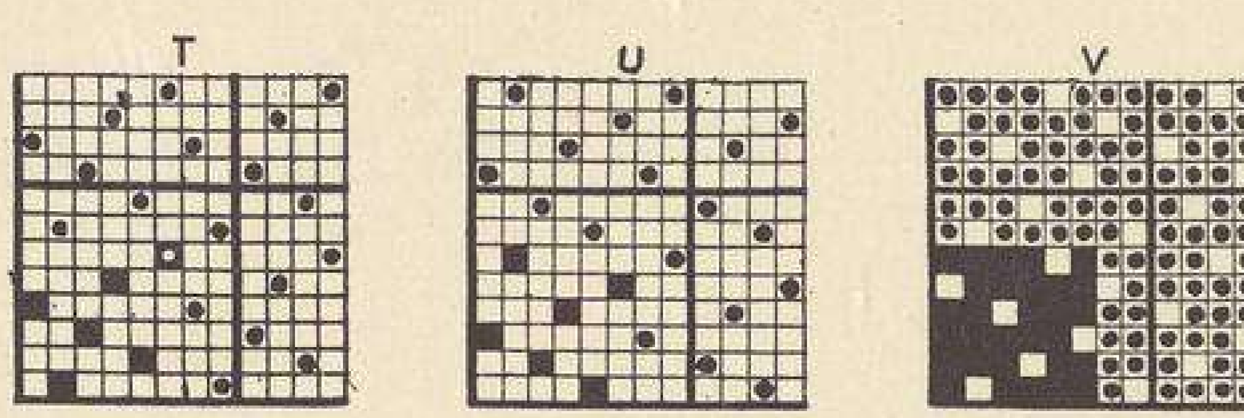


Fig. 31.

pick. For example, if we arrange the picks of a 5-thread sateen in the order 3, 4, 5, 1, 2, or the picks of the 5-thread fundamental twill in the order 2, 5, 3, 1, 4, and then add the extra sixth mark as already indicated, we obtain the 6-thread irregular sateen as shown at T in Fig. 31. The extra mark is shown by a white circle in the centre of the square. This weave, if arranged as at U in the same figure, may, along with the corresponding warp flush at V, be used for dices and damasks. They are seldom so employed, however, probably because they are more difficult to spot out on paper than the 5 and 8-thread weaves. The peculiar and irregular arrangement of the spots gives also a unique and valuable effect when it is used as a base for small figures, for the more or less twilled effect which results from the employment of the regular sateens for this purpose is almost entirely eliminated when this 6-thread base is adopted.

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

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

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

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

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

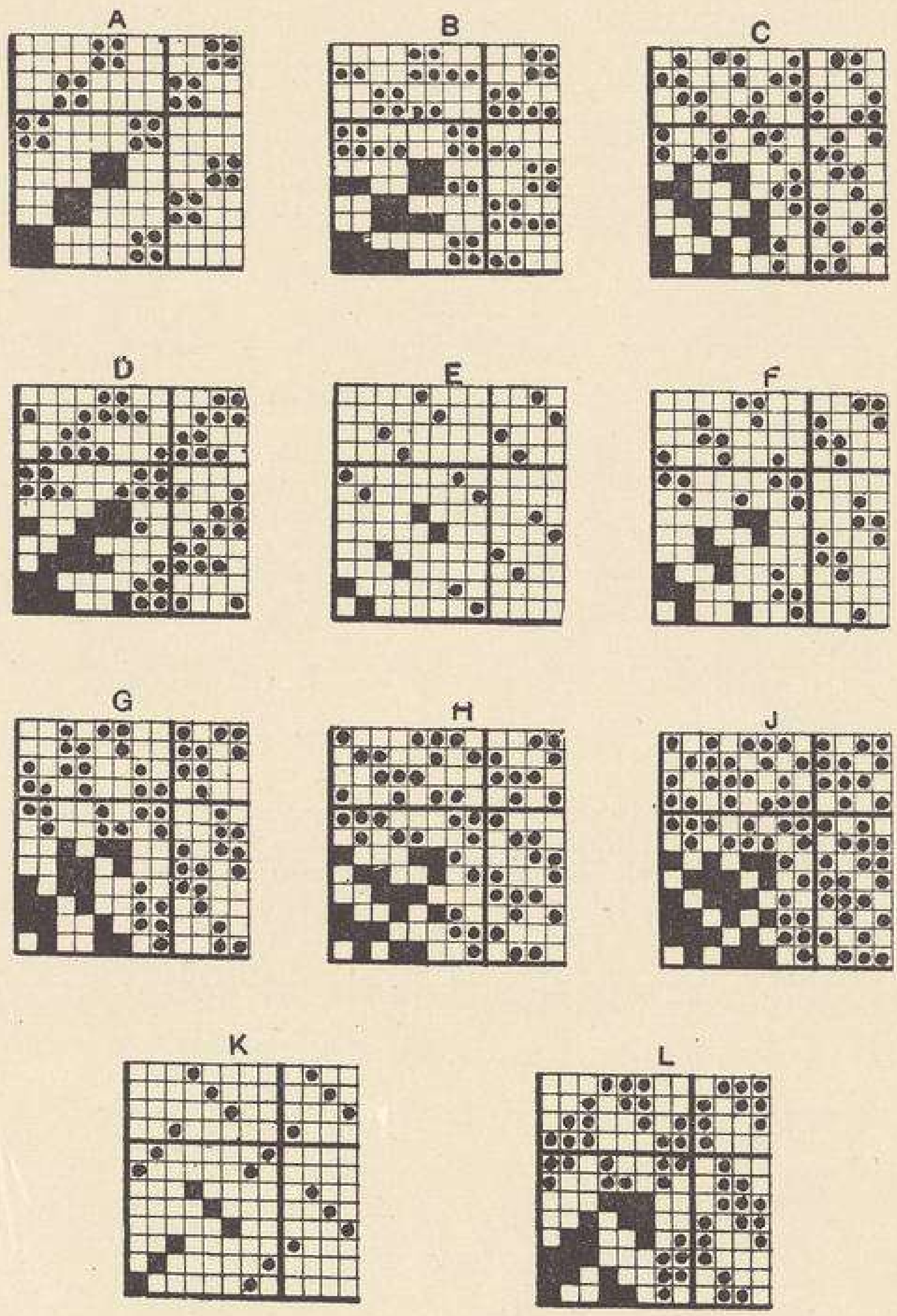


Fig. 32.

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

The student may obtain the number in any particular case by arranging them on design paper, or by writing down the full range graphically and then crossing out any which repeat within themselves or otherwise. Thus, the range in one direction for 7 by 7 is: $\frac{1}{6}$, $\frac{2}{5}$, $\frac{3}{4}$, and

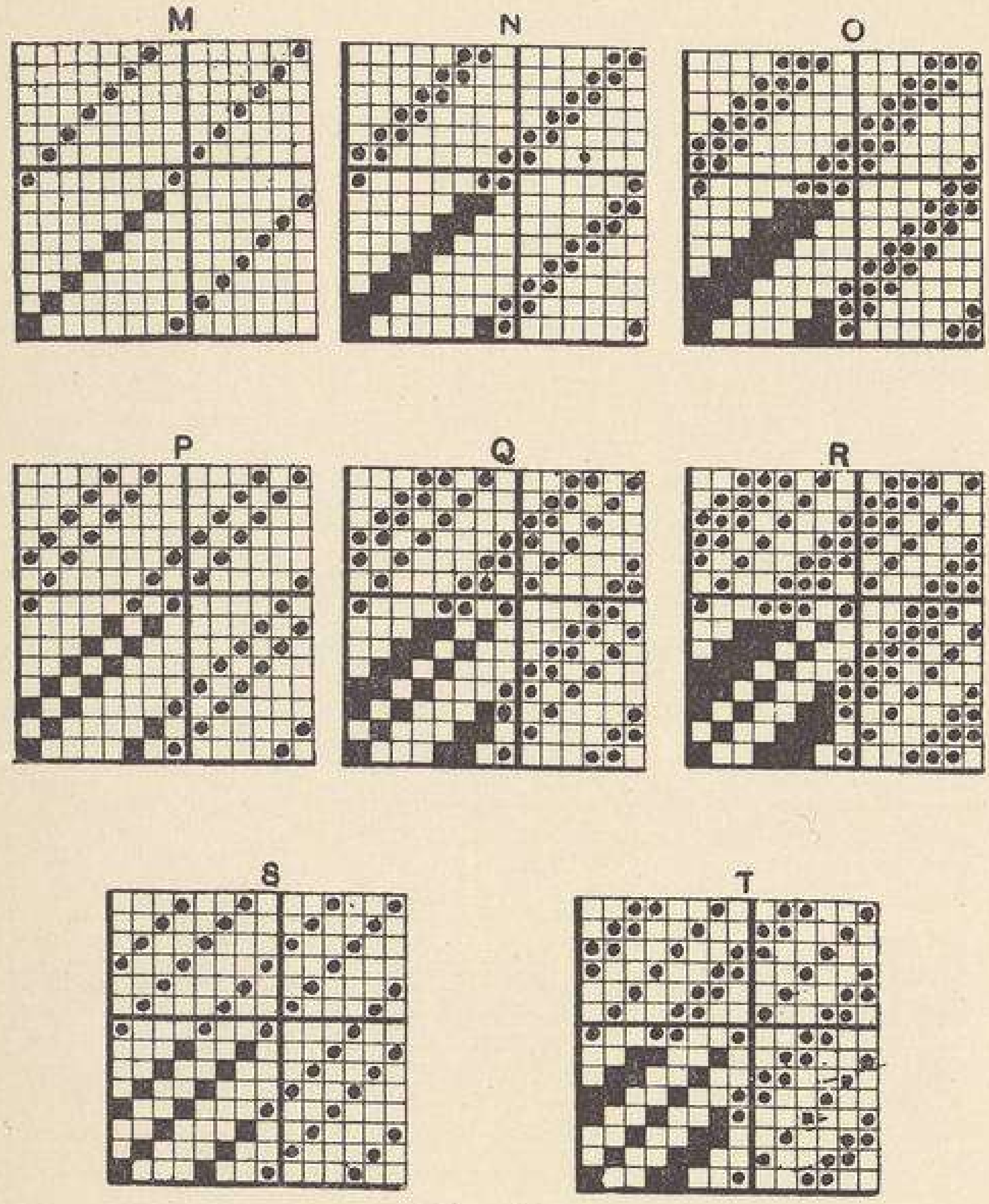


FIG. 33.

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

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

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

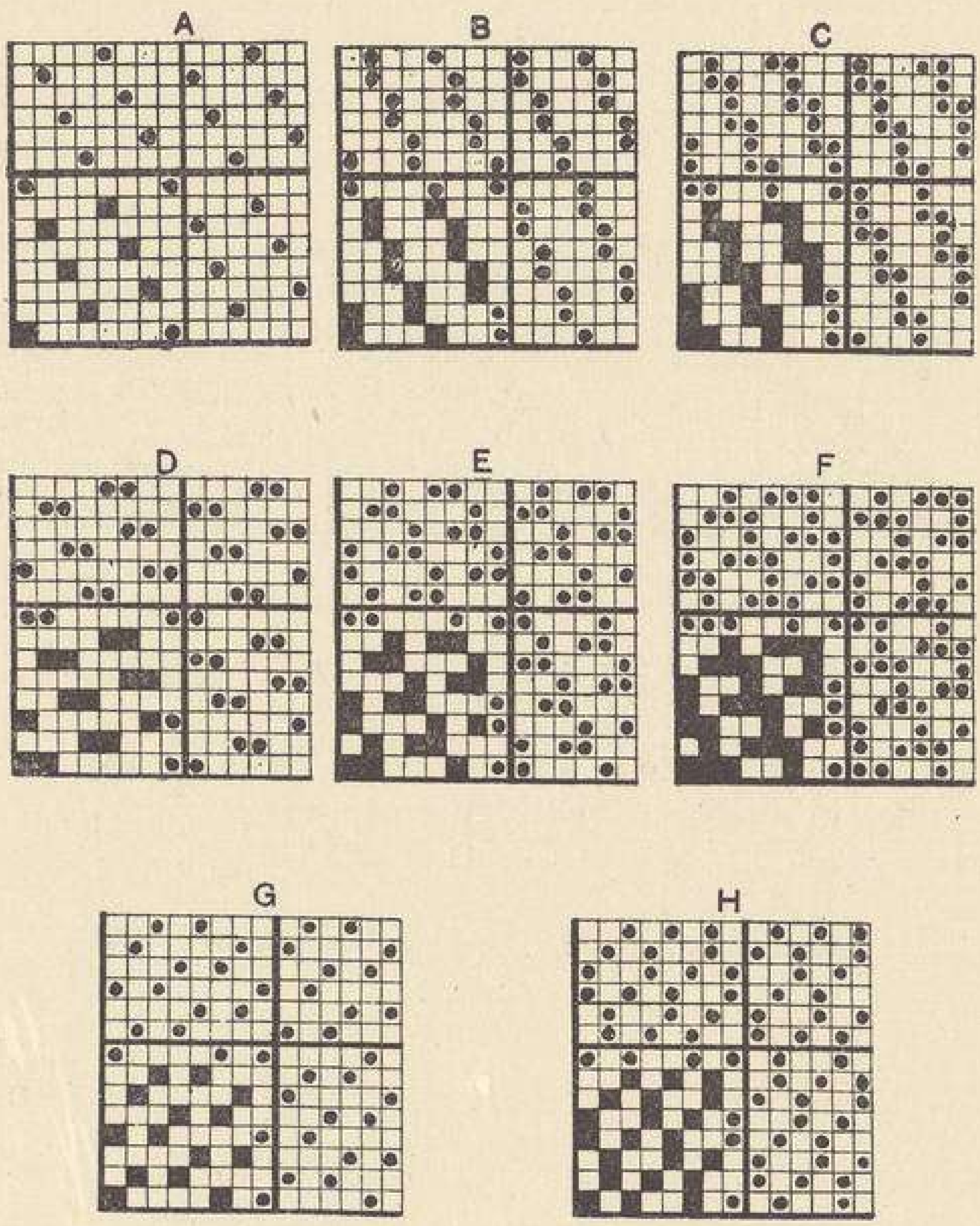


Fig. 34.

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

If the 7-thread weaves be taken, and the designs be limited to 7 threads and 7 picks, there are four sateen methods of arranging new weaves—viz., on the steps of 2, 3, 4, and 5. In each case, however, the distribution of the spots is the same, although the angle and the direction of twill may vary. A to H in Fig. 34 show respectively the sateen arrangement of M to T, Fig. 33, constructed with a step of 5—*i.e.*, in the order 1, 6, 4, 2, 7, 5, 3.

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

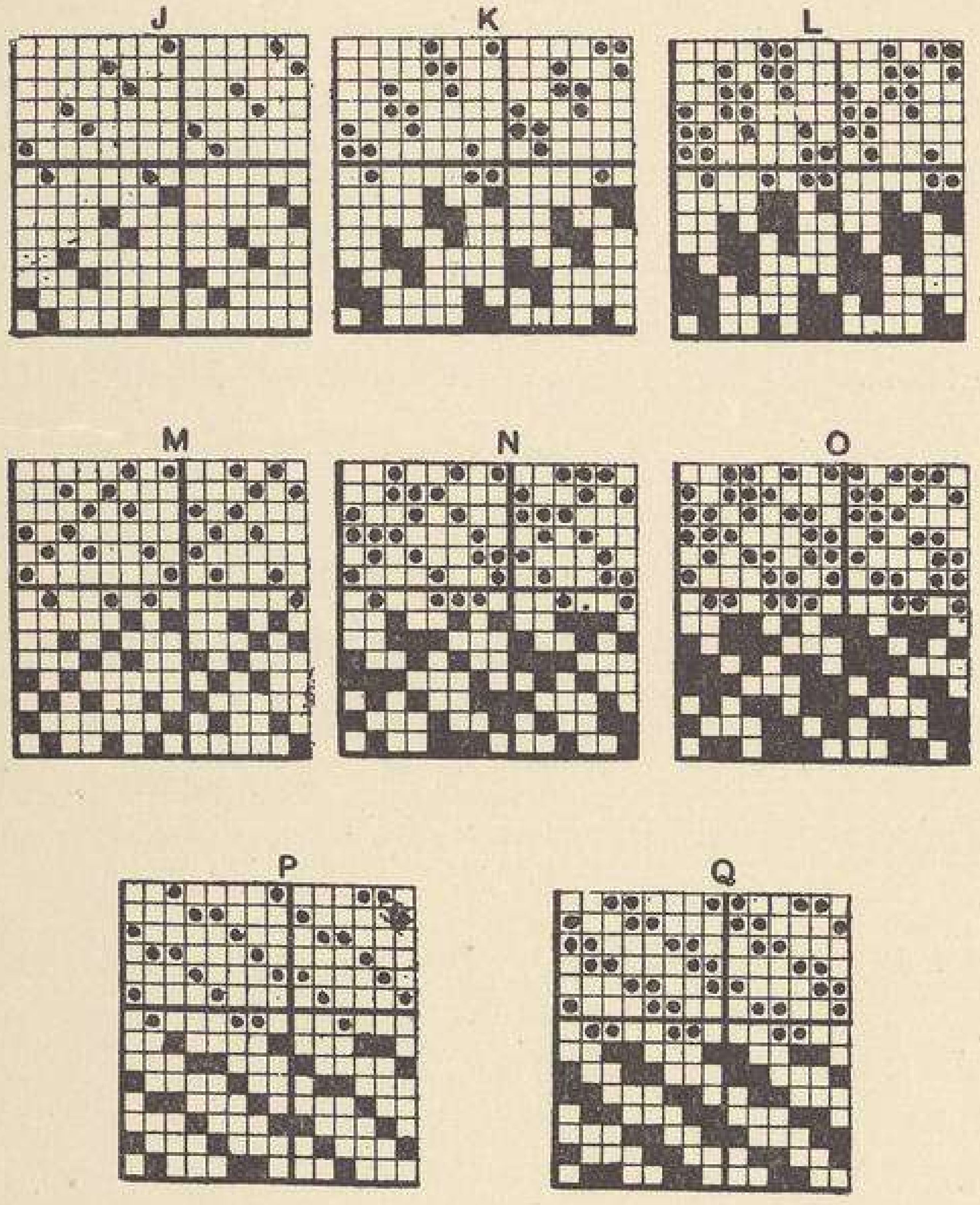


Fig. 35.

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

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

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

While Nos. 4 and 29 have no reverses.

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

With 8 threads and 8 picks the marks upon each thread may be arranged in one, two, or three sections

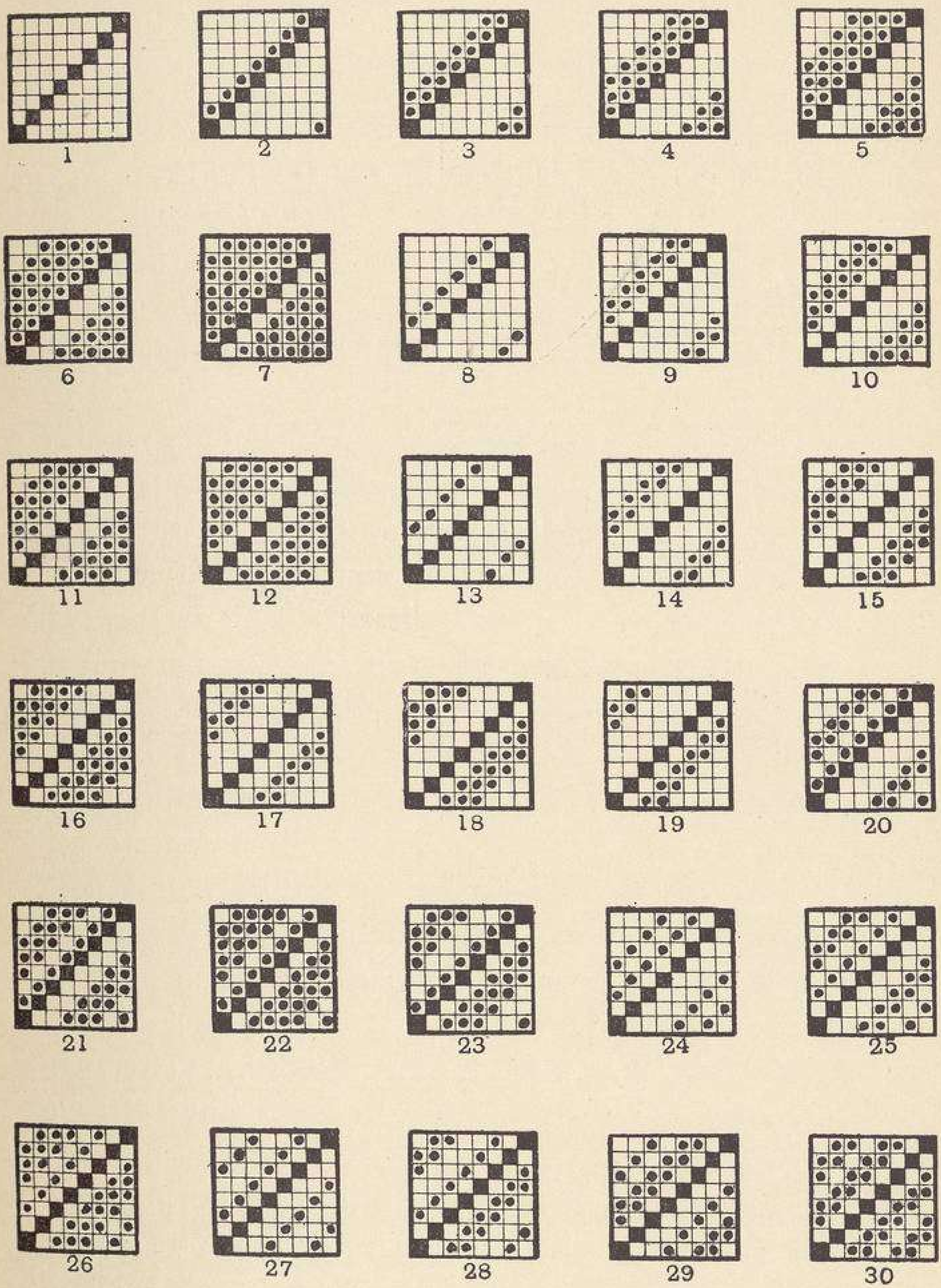


Fig. 36.

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

A weave of 2 parts is of the form $\frac{1}{\;\;7}\ldots\ldots\frac{7}{\;\;1}$

" 4 " " $\frac{1}{\;\;1}\frac{1}{\;\;5}\cdots\frac{2}{\;\;2}\frac{3}{\;\;1}$

" 6 " " $\frac{1}{\;\;1}\frac{1}{\;\;1}\frac{1}{\;\;3}\cdot\frac{1}{\;\;1}\frac{2}{\;\;1}\frac{2}{\;\;1}$

In Fig. 36, Nos. 1 to 7 inclusive contain 2 parts.

" 8 " 23 " " 4 "

" 24 " 30 " " 6 "

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

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

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

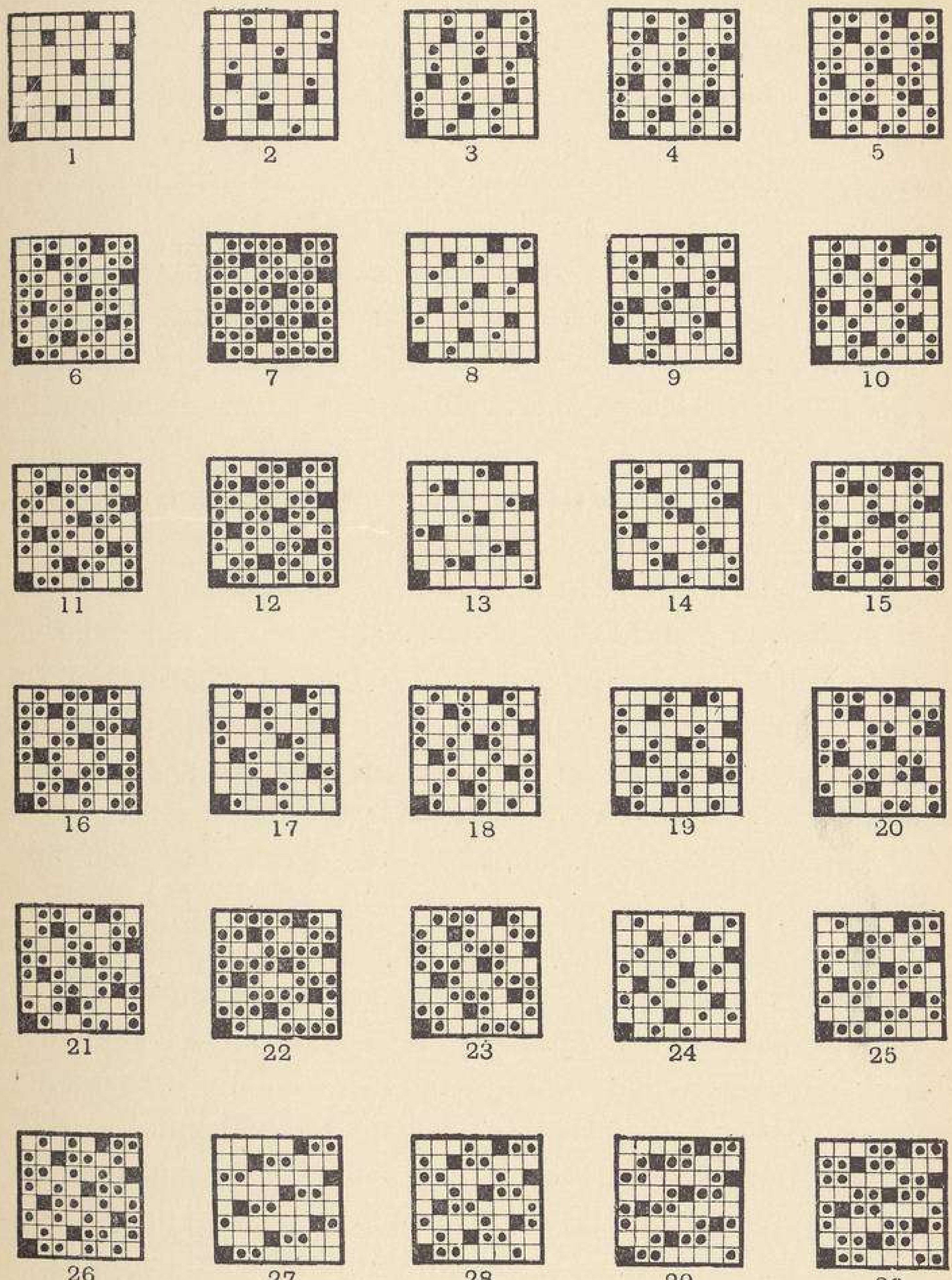


Fig. 37.

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

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

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

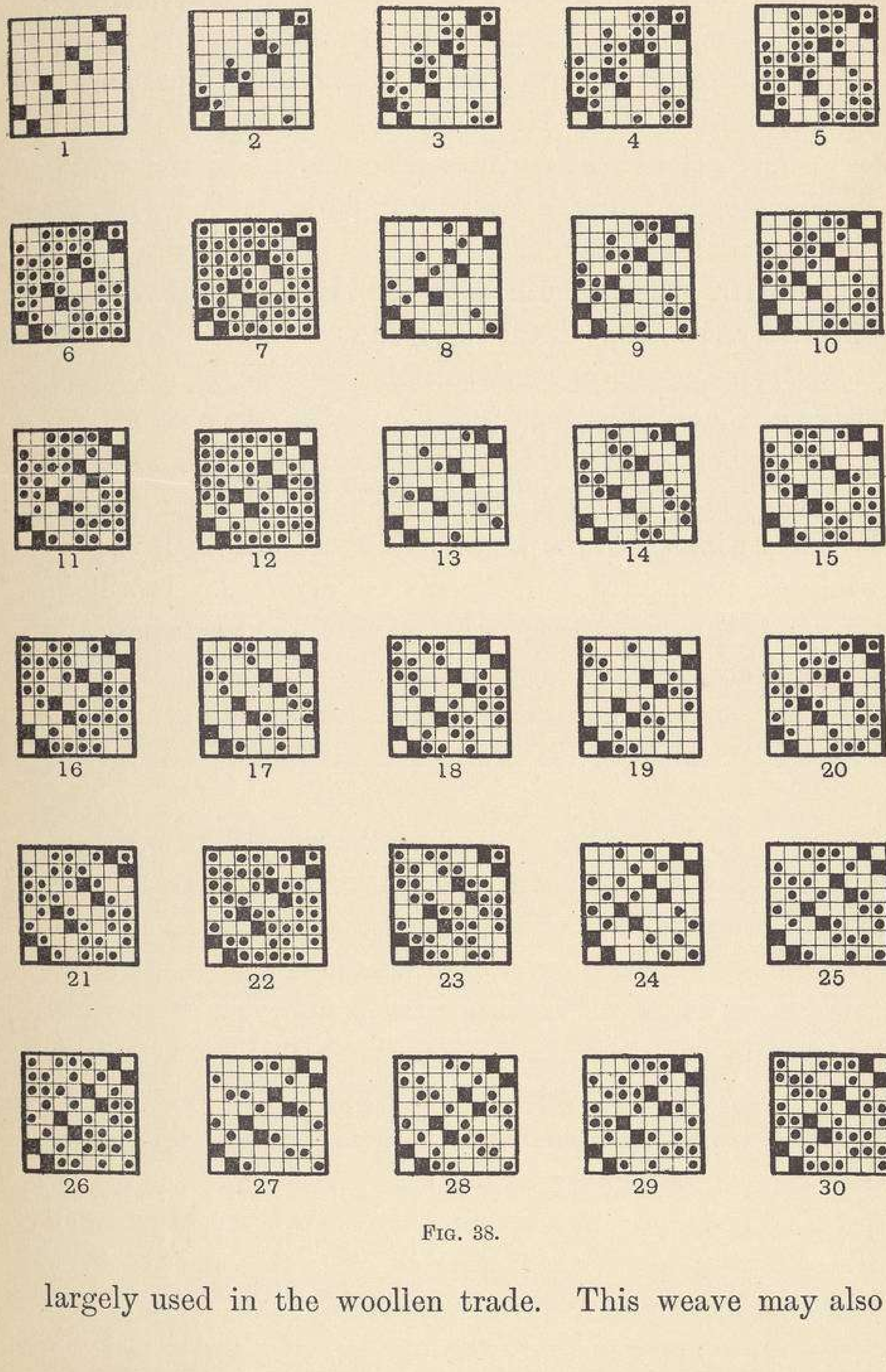


Fig. 38.

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

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

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

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

In addition to the various systems of rearrangement already indicated for the formation of new weaves, there are several methods of combination by which other new designs may be formed from simple twills. Thus, any

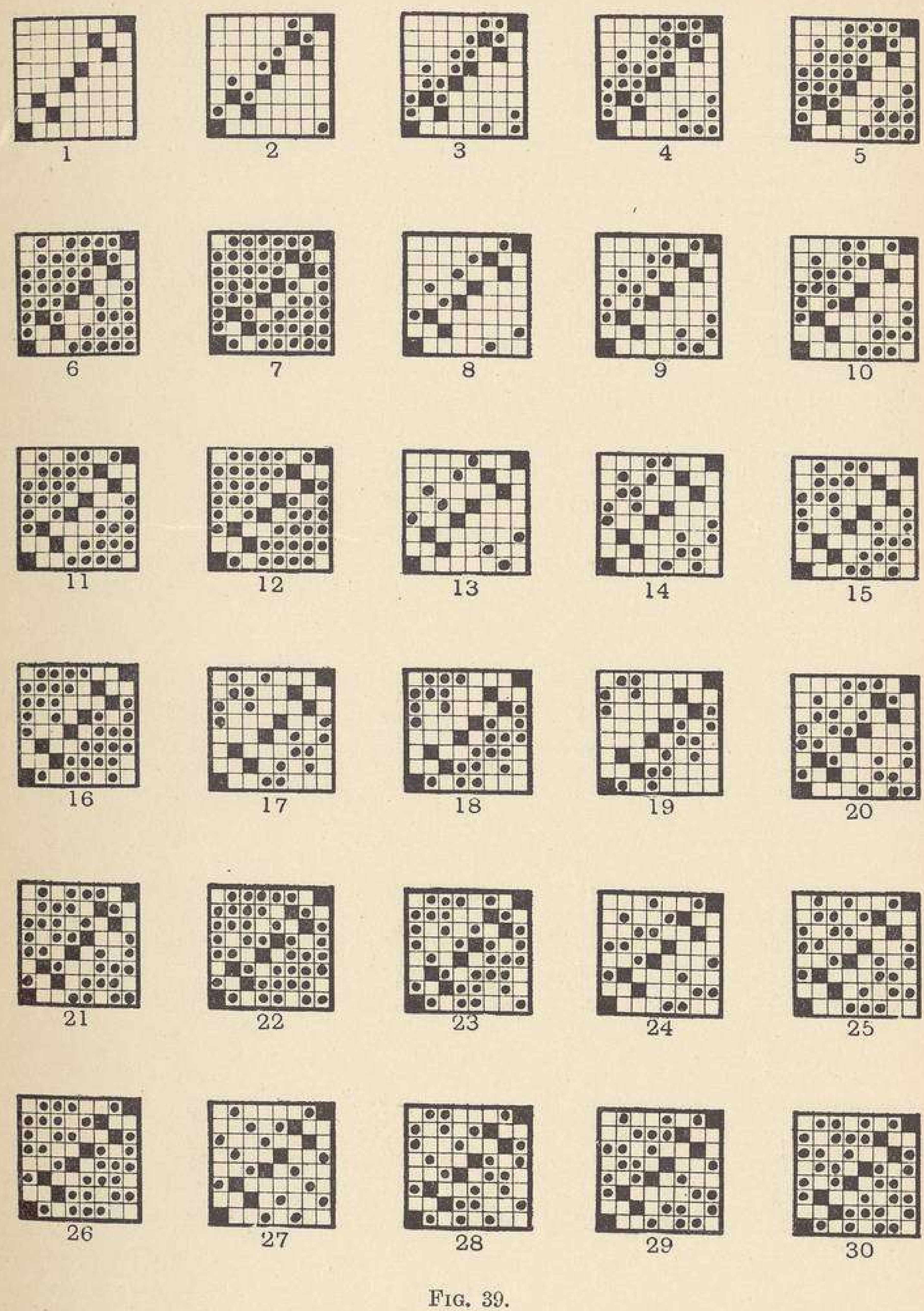


FIG. 39.

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

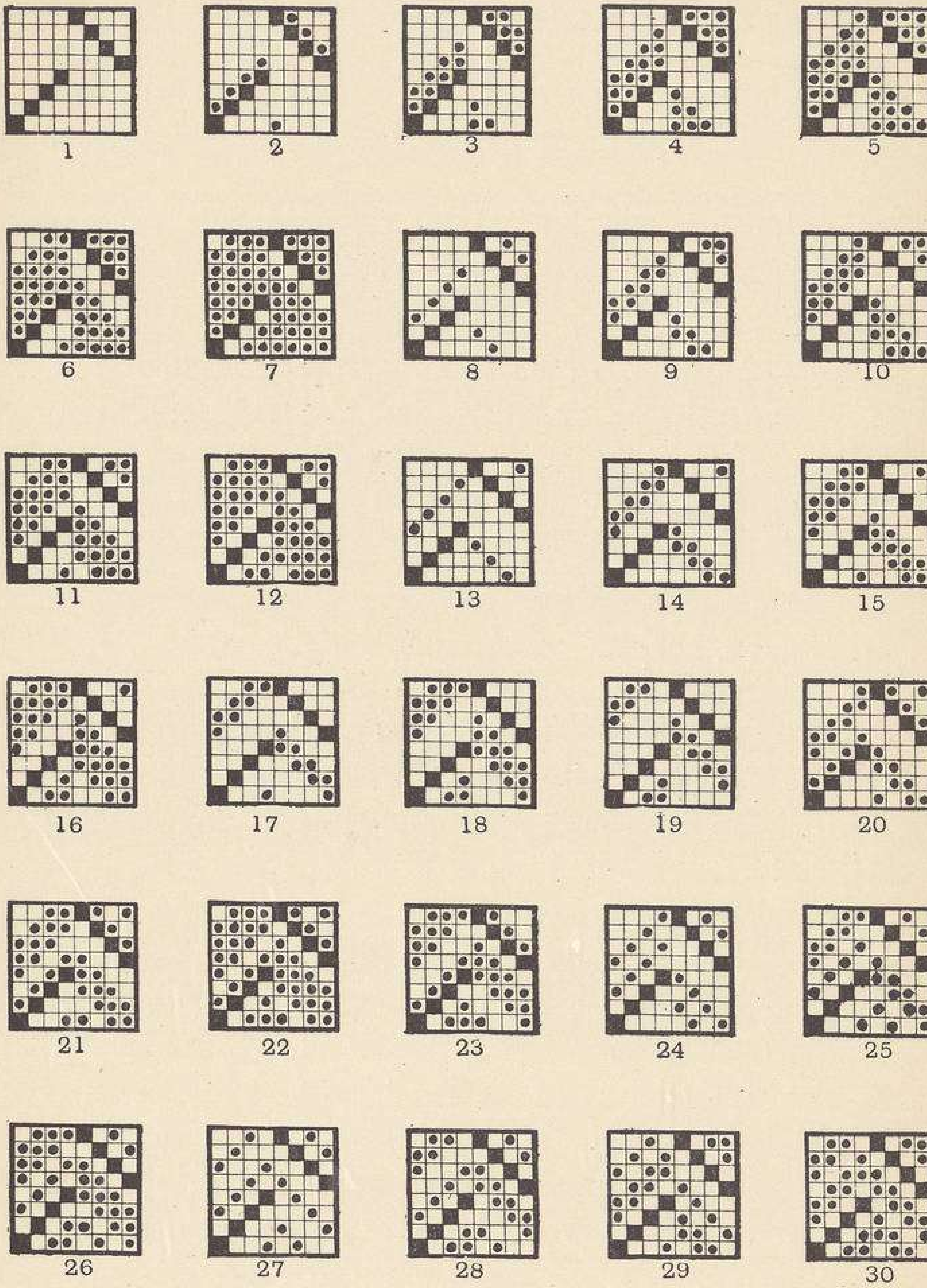


Fig. 40.

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

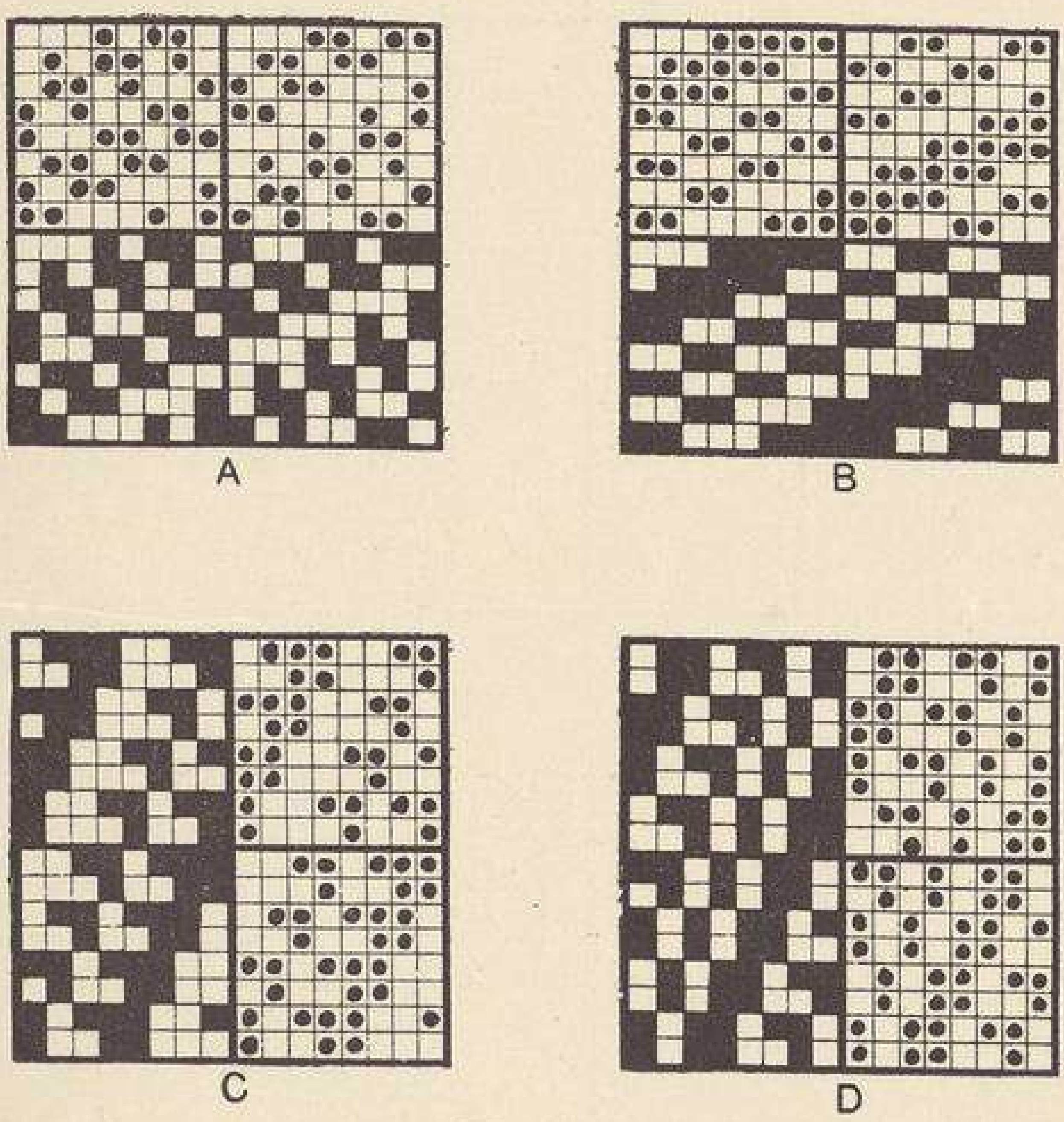


Fig. 41.

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

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

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

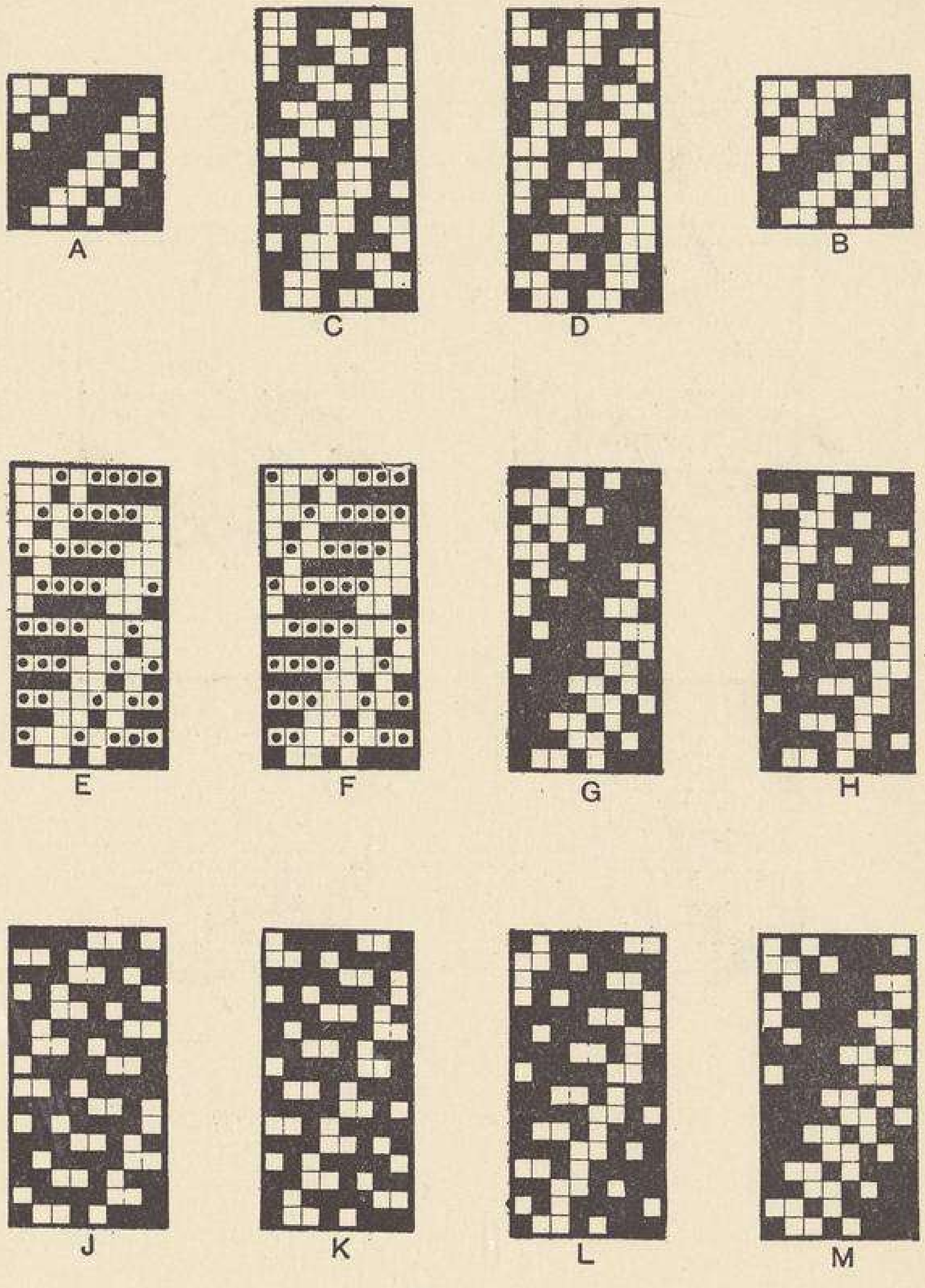


FIG. 42.

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

Figs. 42 and 43 show more complete methods of forming such weaves; the designs in the former figure being arranged pick and pick. The unit weave A appears on odd picks in precisely the same order in designs E to M inclusive, while the even picks are taken from the same

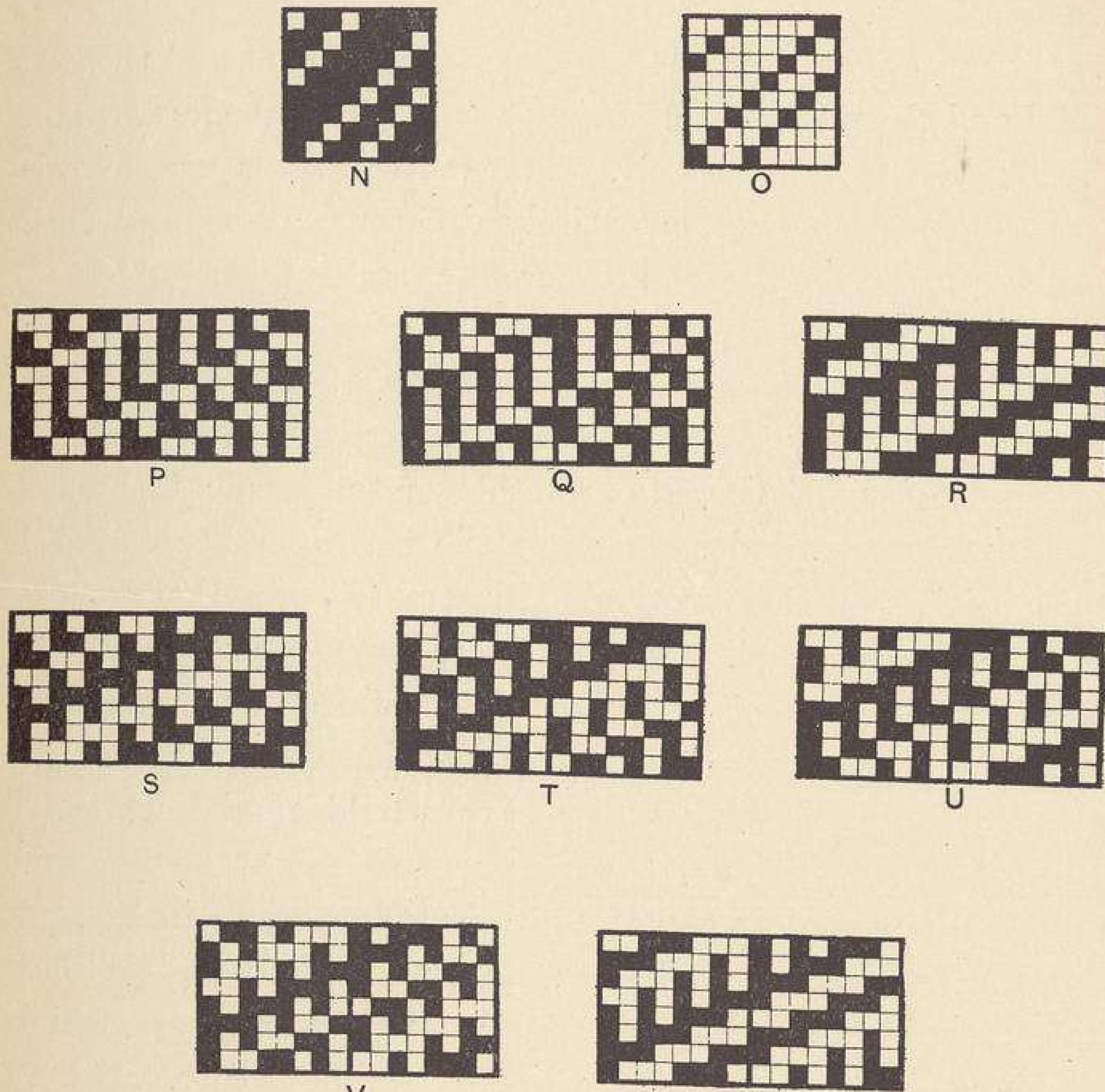


Fig. 43.

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

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

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

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

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

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

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

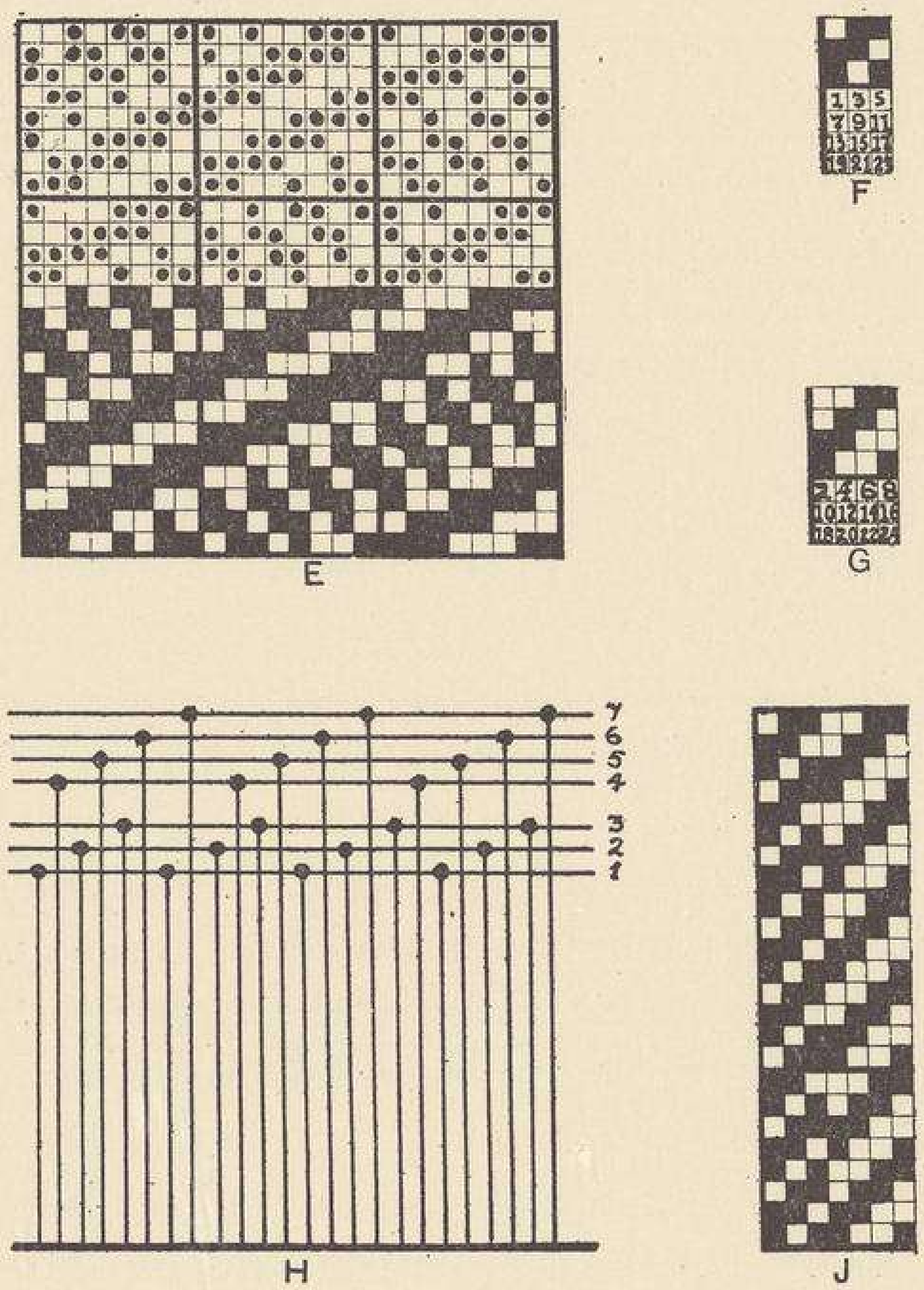


Fig. 44.

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

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

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

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

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

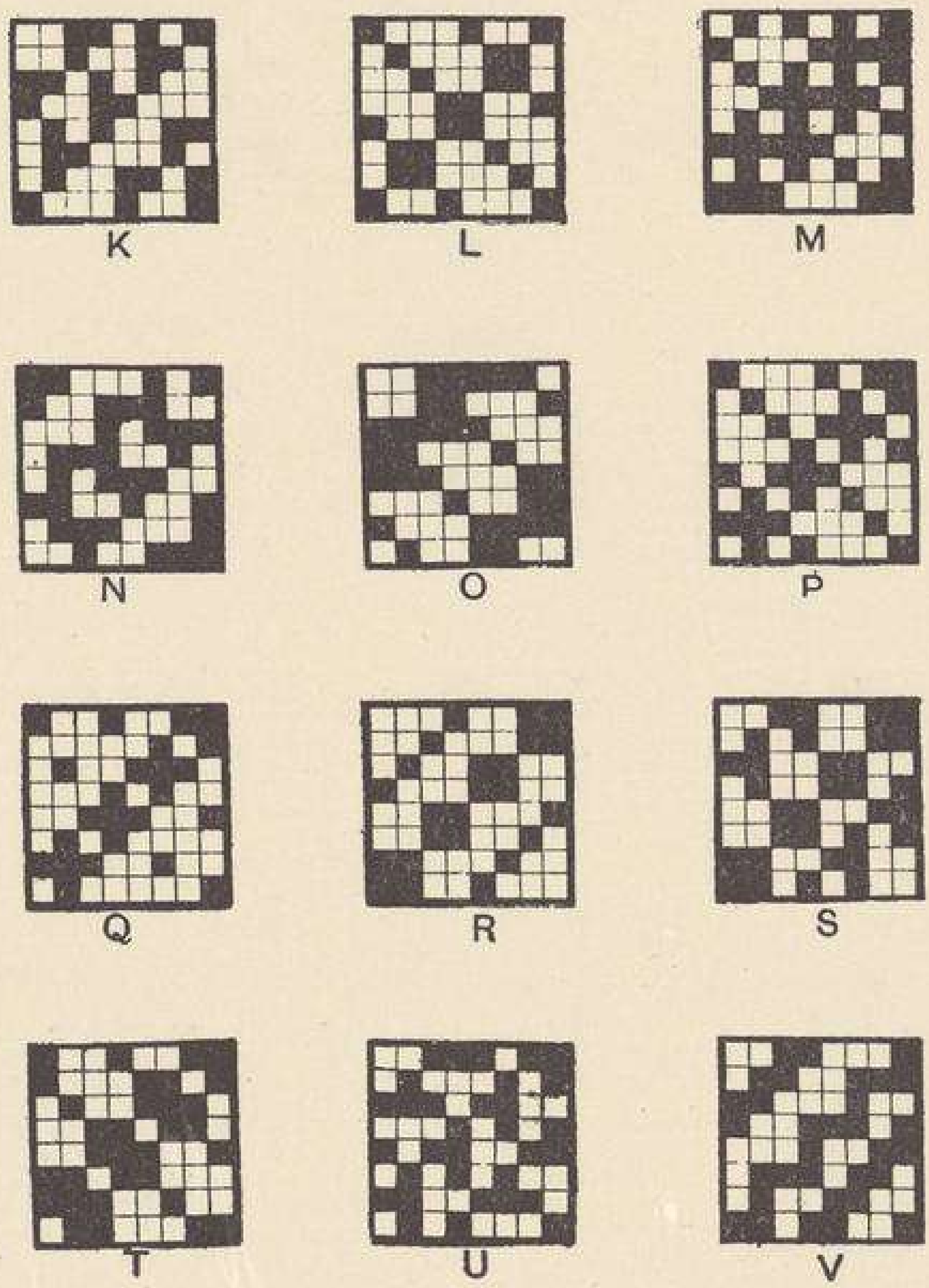


Fig. 45.

seventh of the second, and the eighth of the first). The third stage C shows the complete effect on four threads, the two threads added here being exactly the reverse, according to the above definition, of the two threads shown at B. Two repeats of the complete weave on 4 threads and 8 picks are shown at D. E, in the same figure, is a similar effect developed from a 3 by 3 unit, and therefore complete on 6 by 6, while the small designs F to N show 8 effects on 8 by 8 developed in a similar manner, each one from a 4 by 4 unit.

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

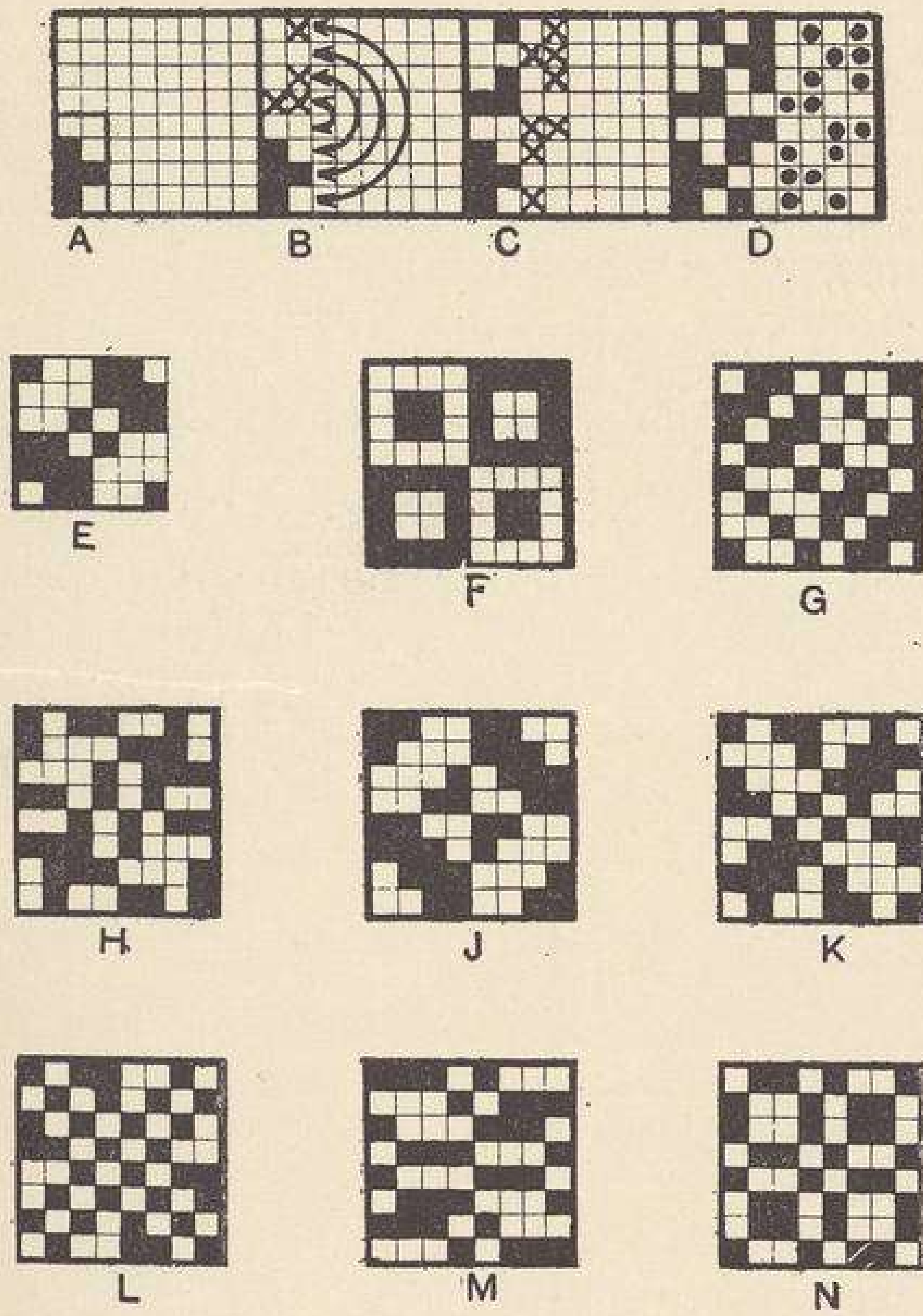


Fig. 46.

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

CHAPTER III

MOCK LENOS, HUCKABACKS, HONEYCOMBS, ETC.

Several designs developed by the above method produce such highly characteristic results in the cloth that they are classed apart under the term of mock leno or imitation gauze effects. They are so called because the cloth produced imitates, to a considerable degree, the openwork appearance of a true gauze fabric. This result is due, in about equal proportions, to the character of the weave itself, and to the method of reeding adopted. The latter should be in threes, fours, fives, etc., according to the number of threads occupied by the initial small effect adopted. When this is so, the dents of the reed gather the warp threads together into natural groups or divisions, a proceeding which is materially aided by the character of the design. Thus the first three threads of O, Fig. 47, must be in one split of the reed, and the second three threads in the next split, in order that the reed may assist the tendency of threads 3 and 4, which weave plain, and of threads 6 and 1, which do likewise, to force themselves apart; or, what amounts to the same thing, to allow threads 1 and 3, and also threads 4 and 6, to approach each other closely. This inclination to gather together in threes is also influenced by the binding nature of the second and fifth picks, which float alternately, over the threads in one split and under the threads in the next. A similar, but modified, result is obtained in the way of the weft, only in this direction no assistance is received from the reed. Increased openings among the warp may naturally be obtained by omitting one or more splits every three threads, but the character of the cloth would be slightly altered, as a corresponding alteration could not conveniently be made in the spacing of the weft.

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

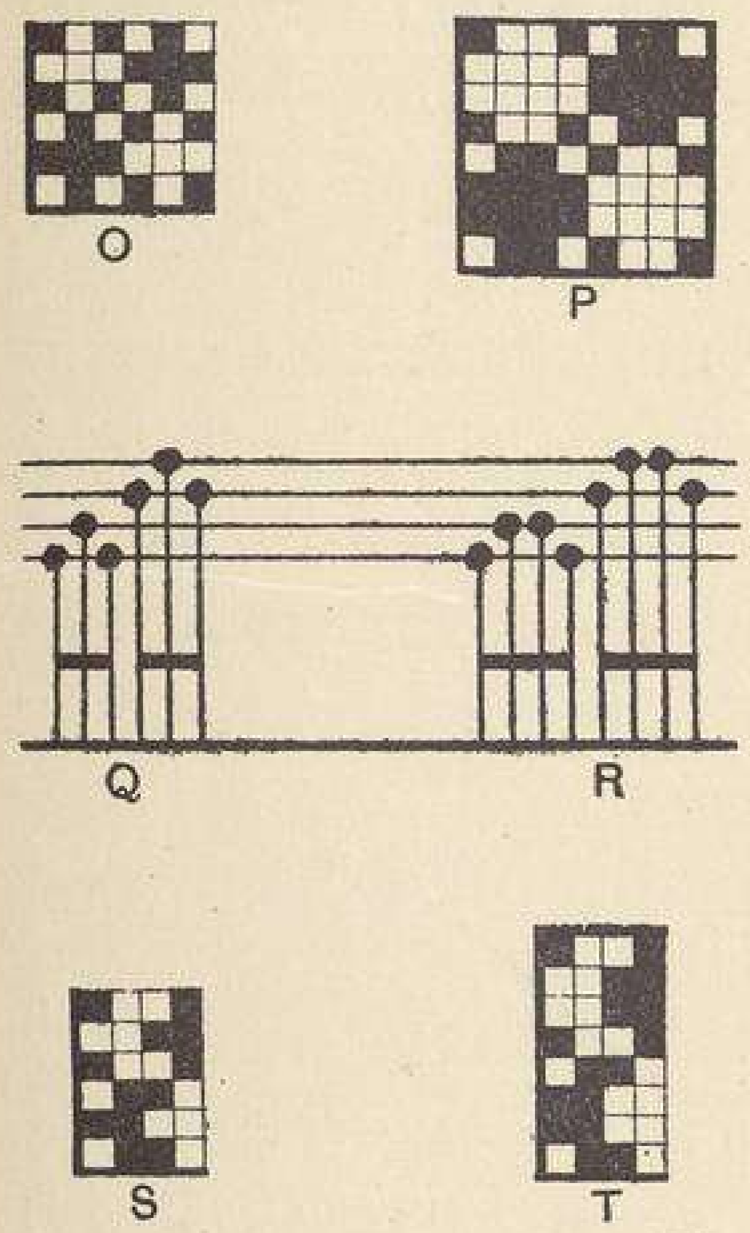


Fig. 47.

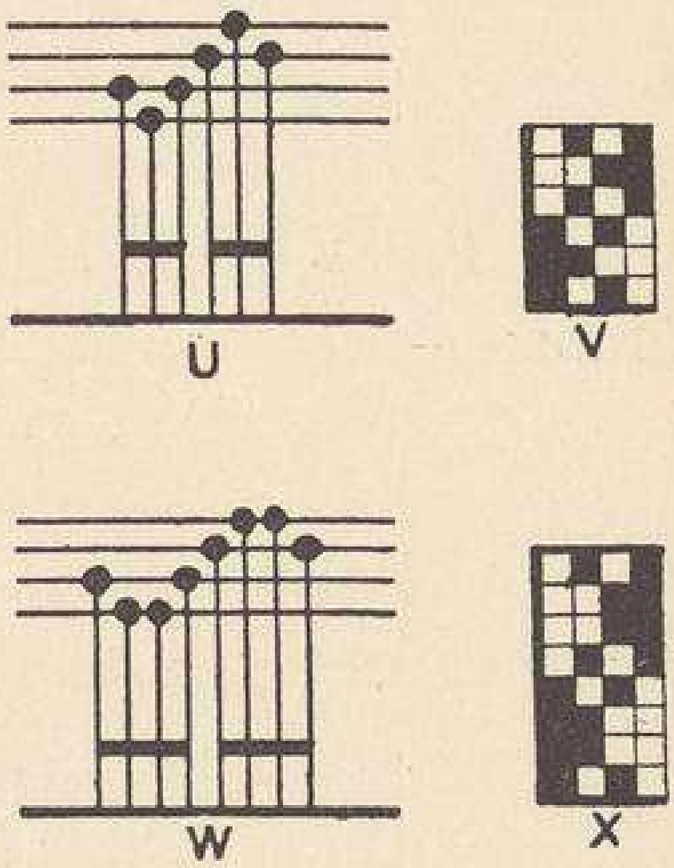


Fig. 48.

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

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

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

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

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

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

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

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

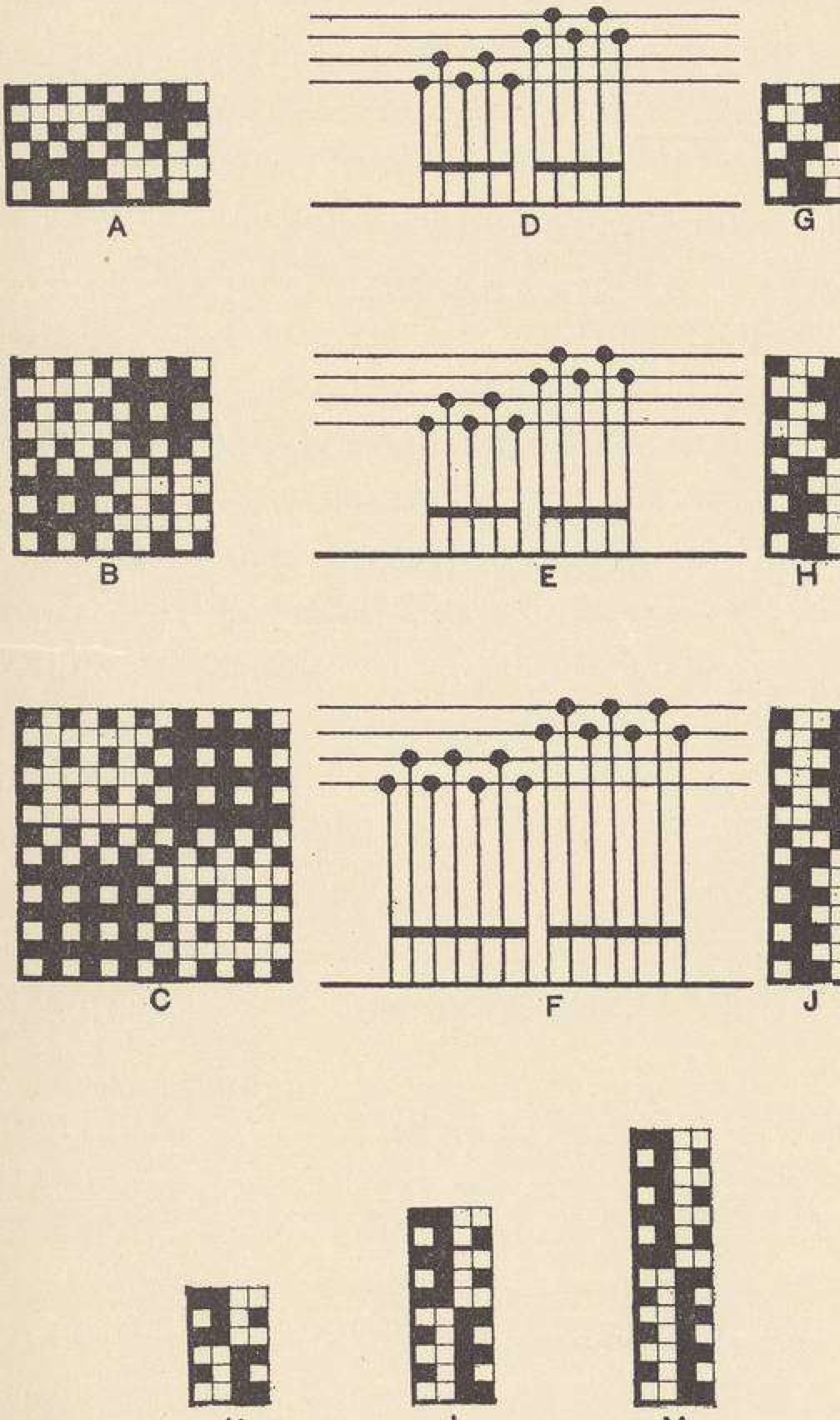


Fig. 49.

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

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

When the threads are drawn through the camb in the manner indicated, it is possible to use the same camb and warp for plain cloth as well as for huckaback. The draft shows clearly that all the odd threads of the warp are on the front two shafts, while all the even threads are on the two back shafts. To weave plain cloth it is only necessary to couple the shafts as indicated at P and Q, and to actuate them by an ordinary plain wyper, or by the two plain blades (Nos. 1 and 4) of the huckaback tappet. The weft for the "Devon" huck is almost invariably double or two-fold. It is sometimes prepared on the doubling or twisting frame with a minimum amount of twist, but is more fre-

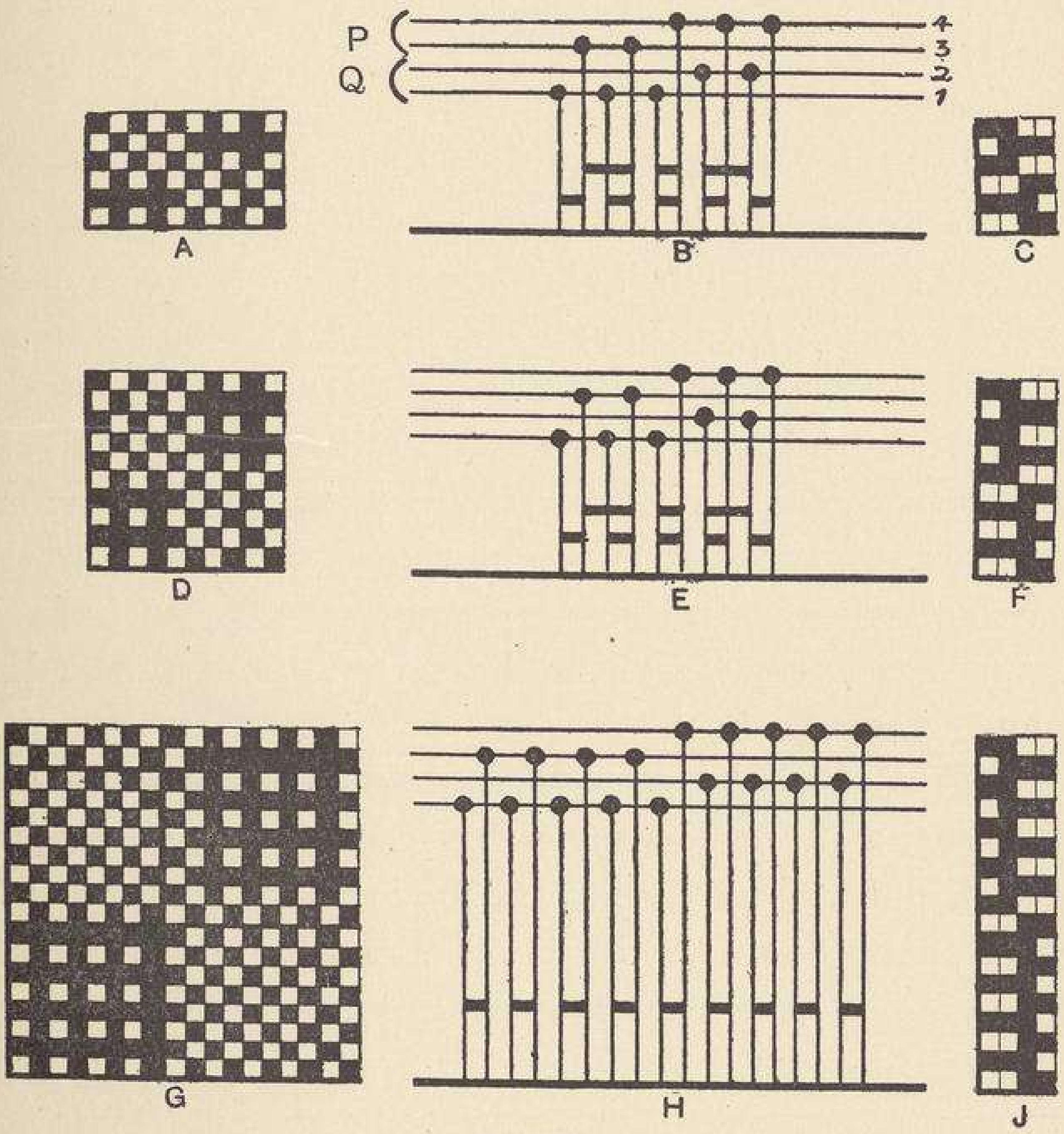


FIG. 50.

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

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

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

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

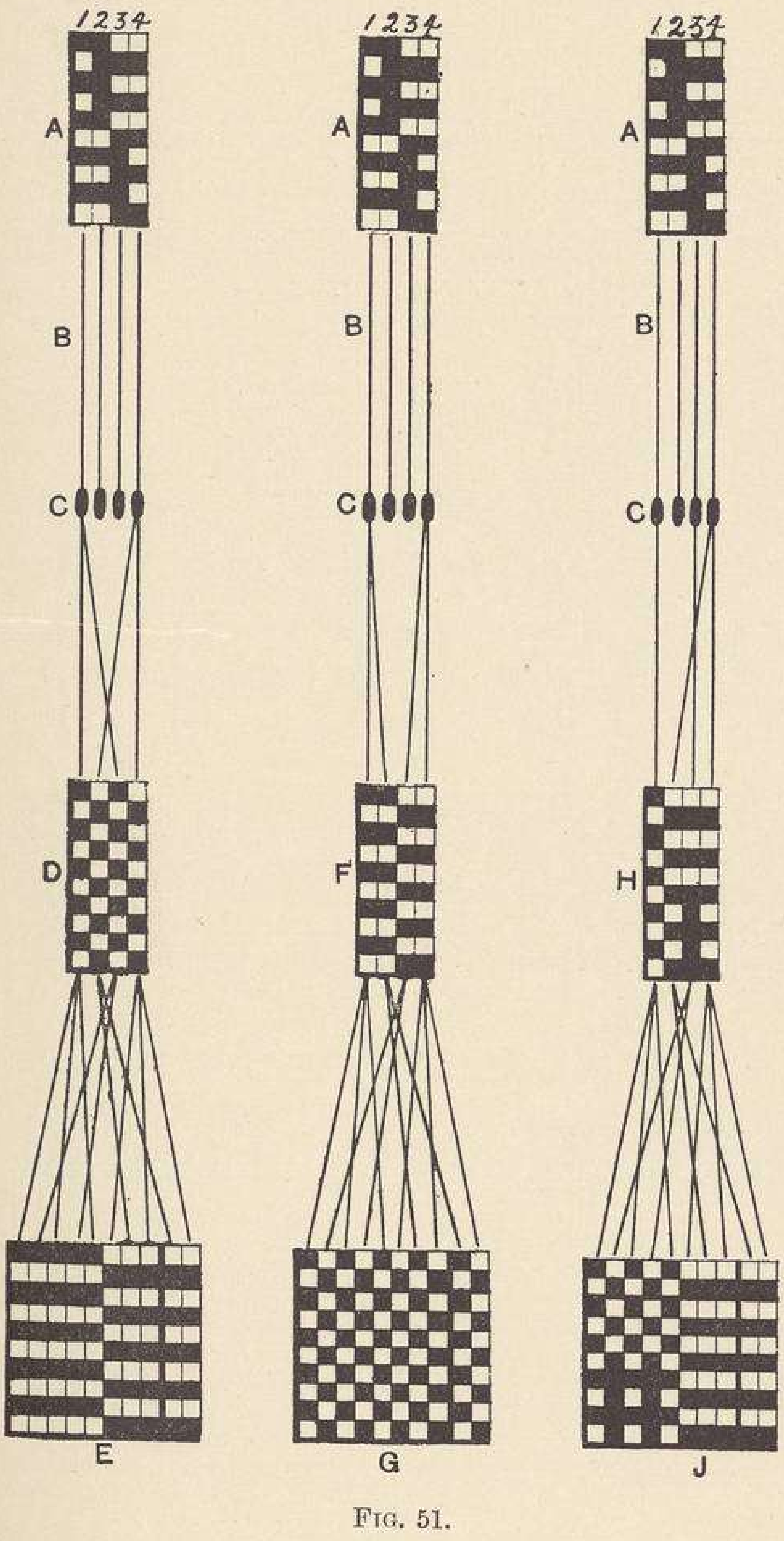


FIG. 51.

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

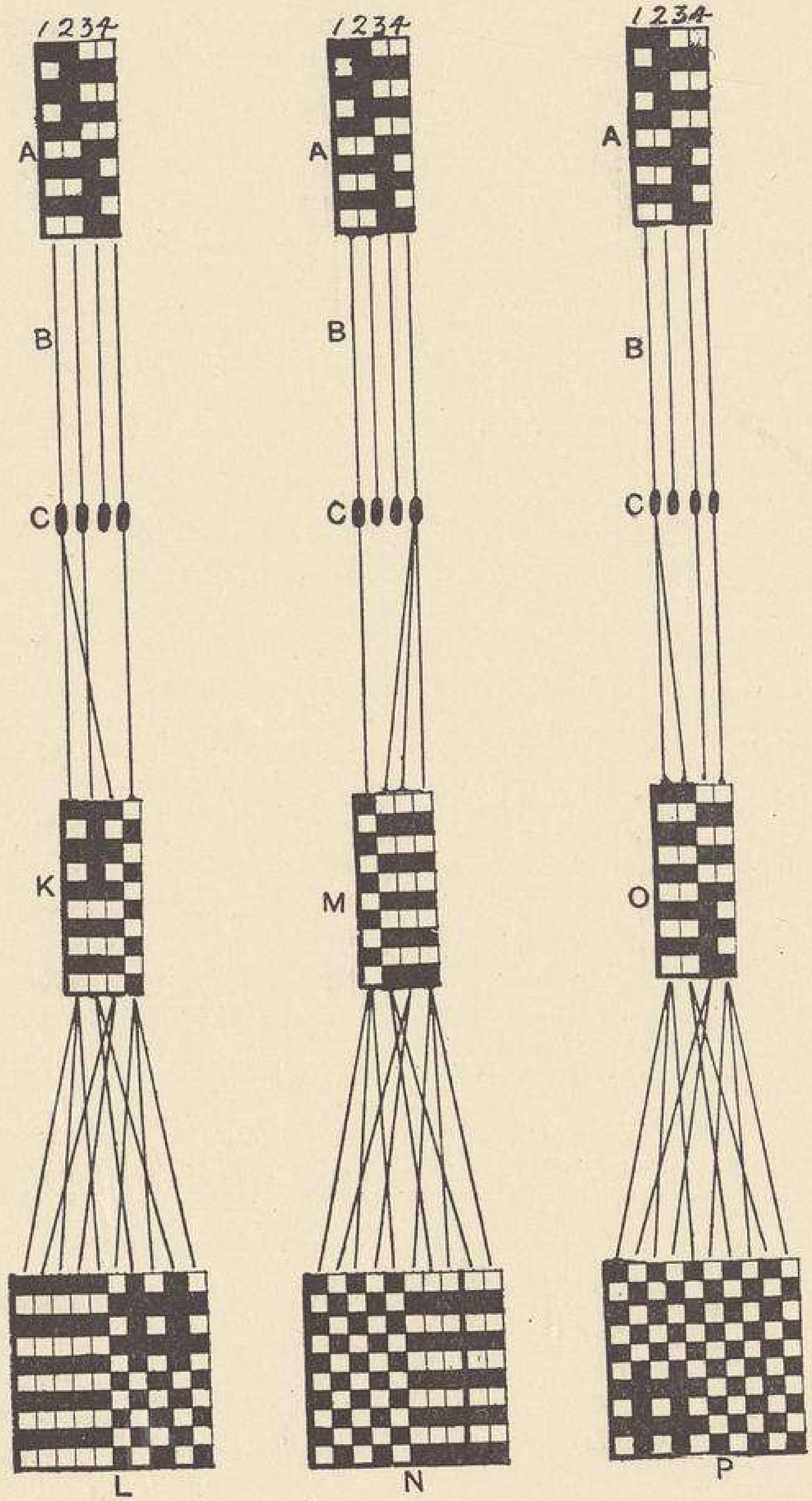


Fig. 52.

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

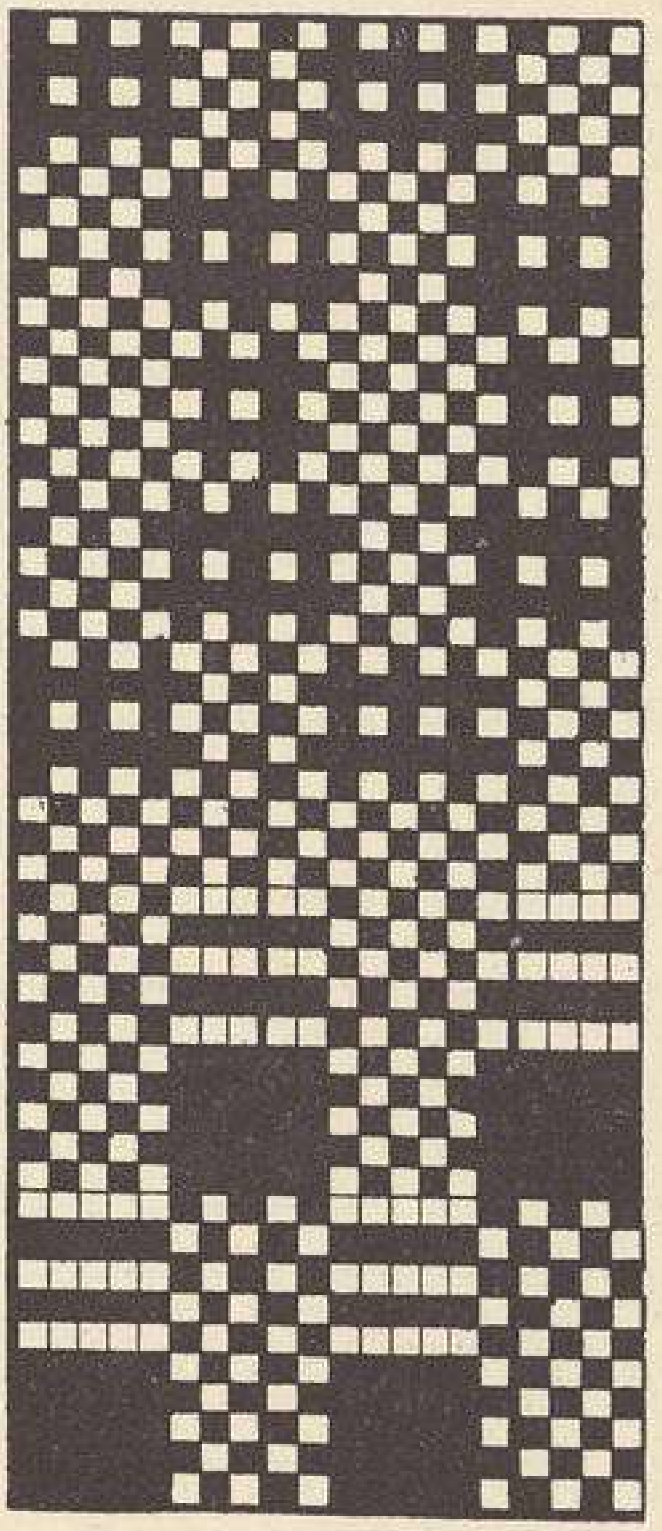


Fig. 53.

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

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

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

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

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

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

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

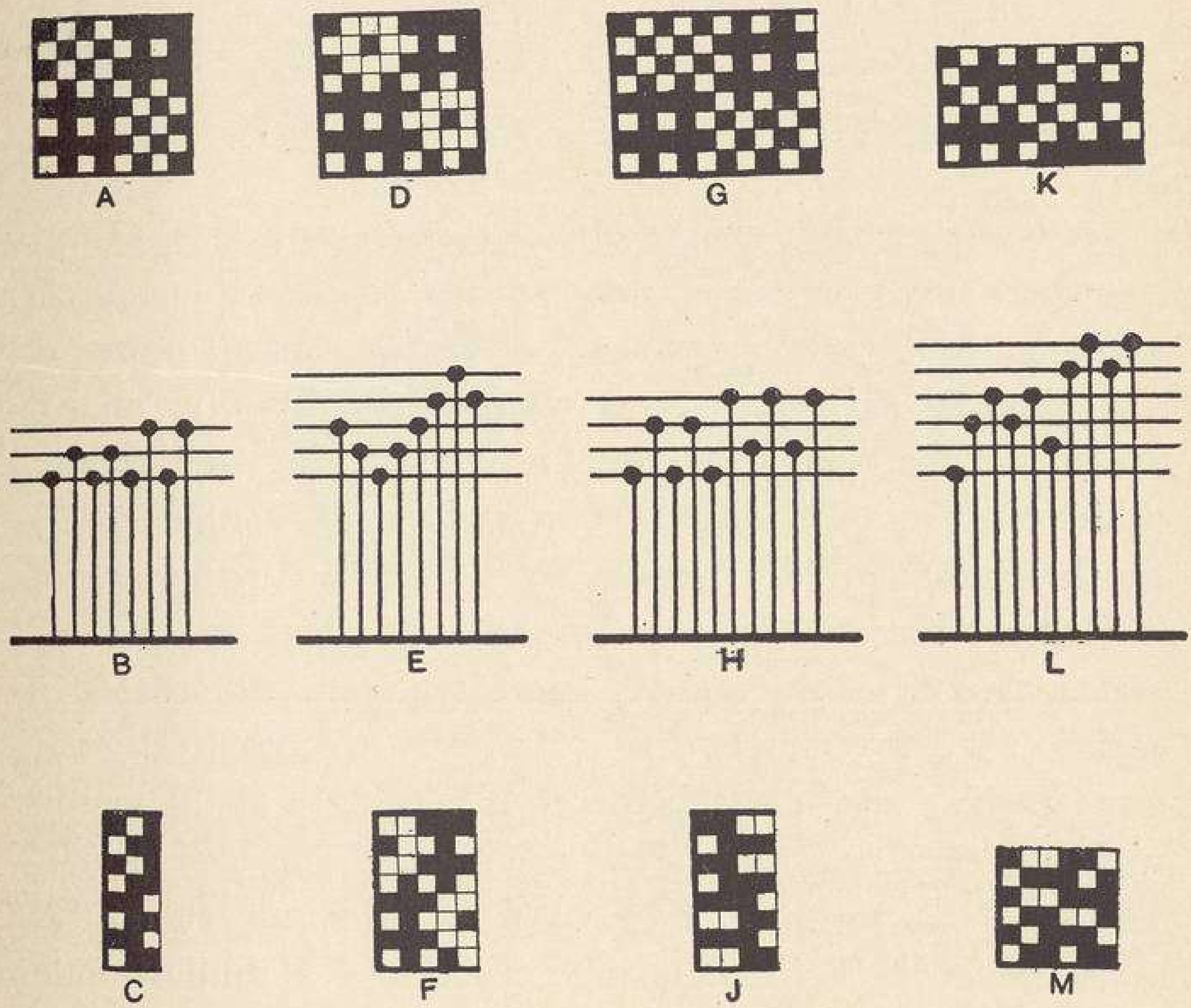


FIG. 54.

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

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

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

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

The cell-like appearance referred to above is the result of the difference in weave structure of the main portions of the design. For example, at the intersection of the 8th, 9th, and 10th threads with the same picks of design A, the weave is virtually plain, whereas the 9th thread and the 9th pick float over 7 picks and 5 threads respectively, before joining to form part of the plain cloth.

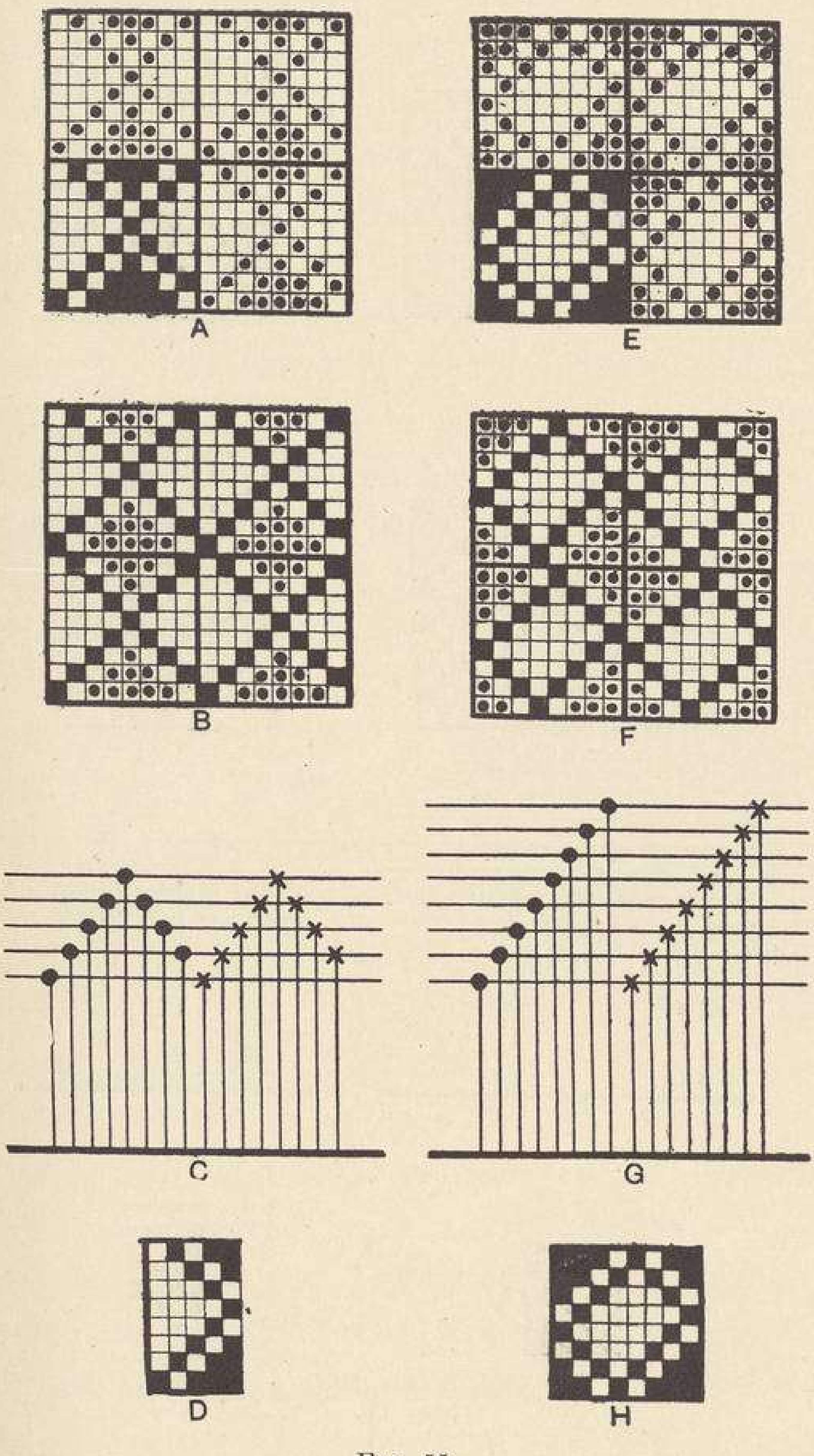


Fig. 55.

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

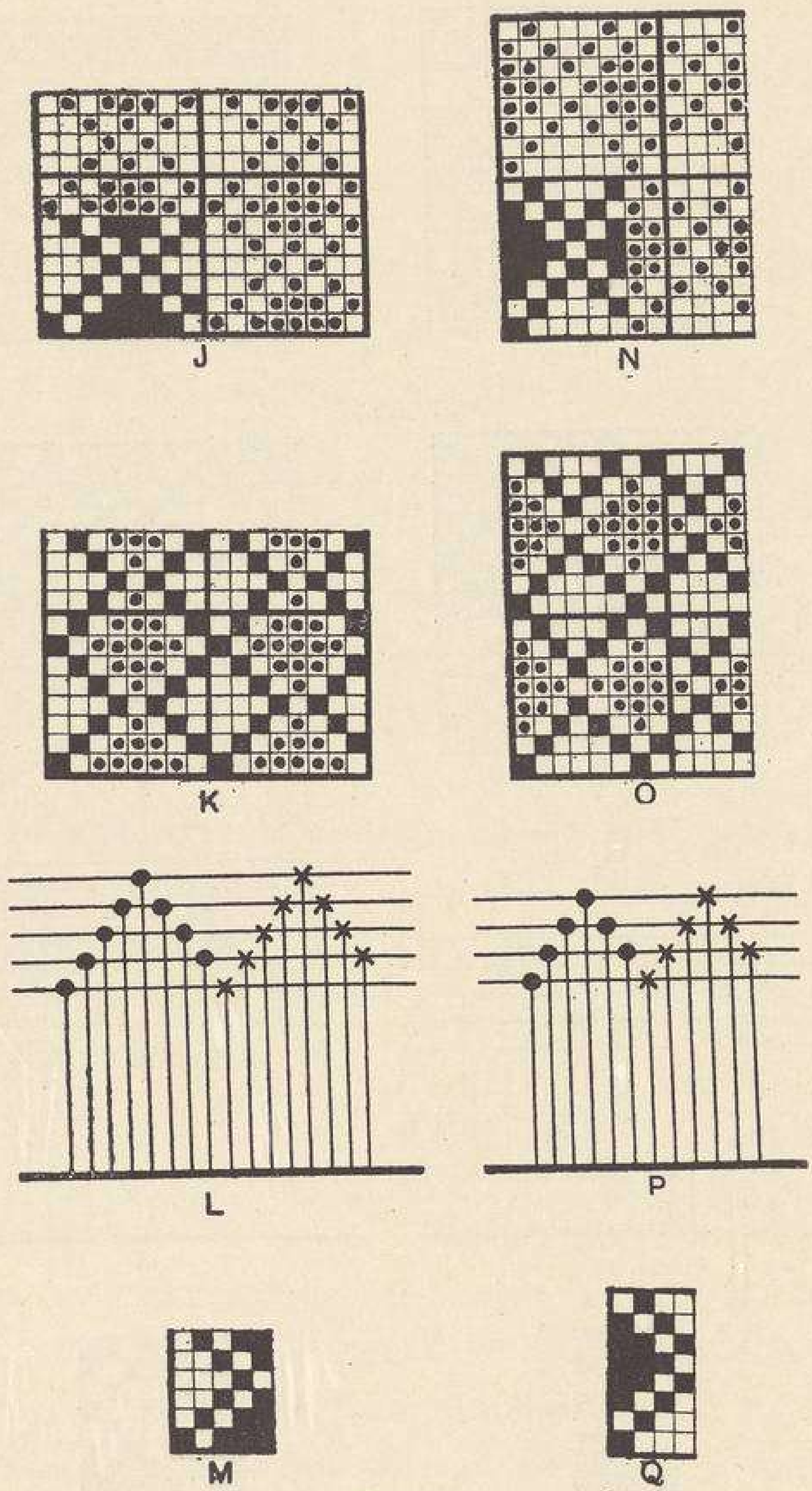


Fig. 56.

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

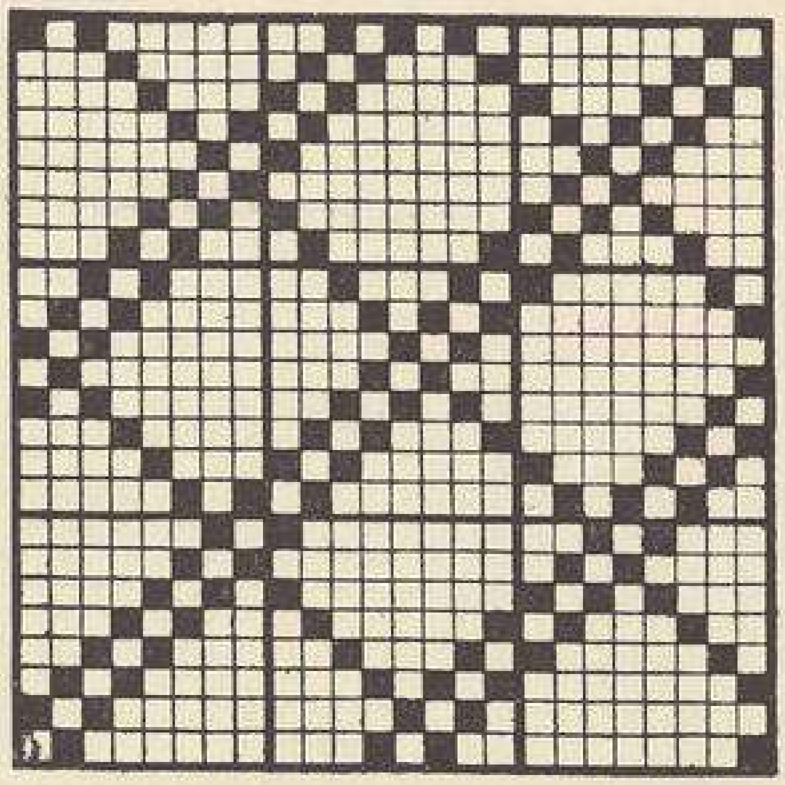


Fig. 57.

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

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

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

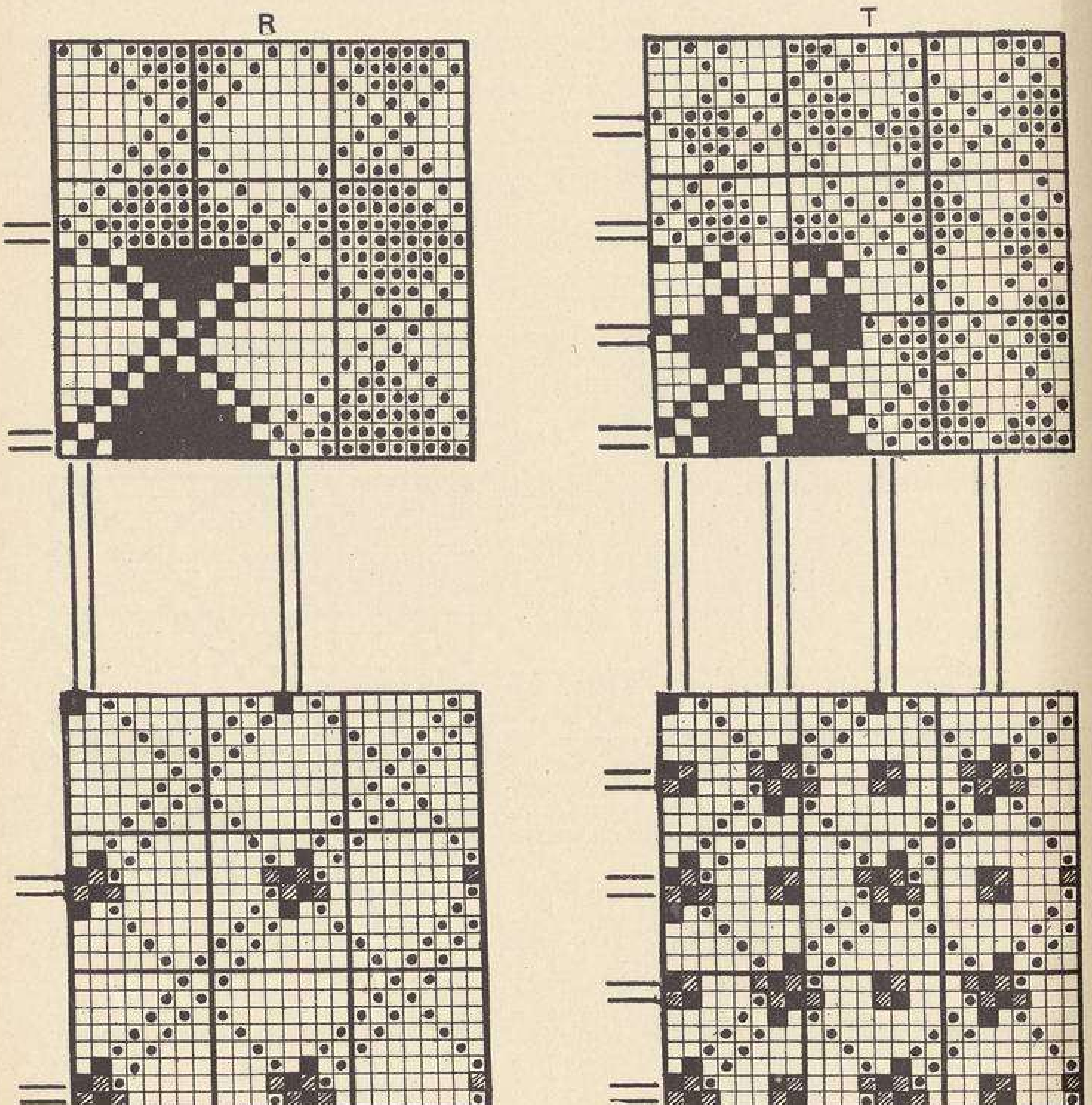


FIG. 58.

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

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

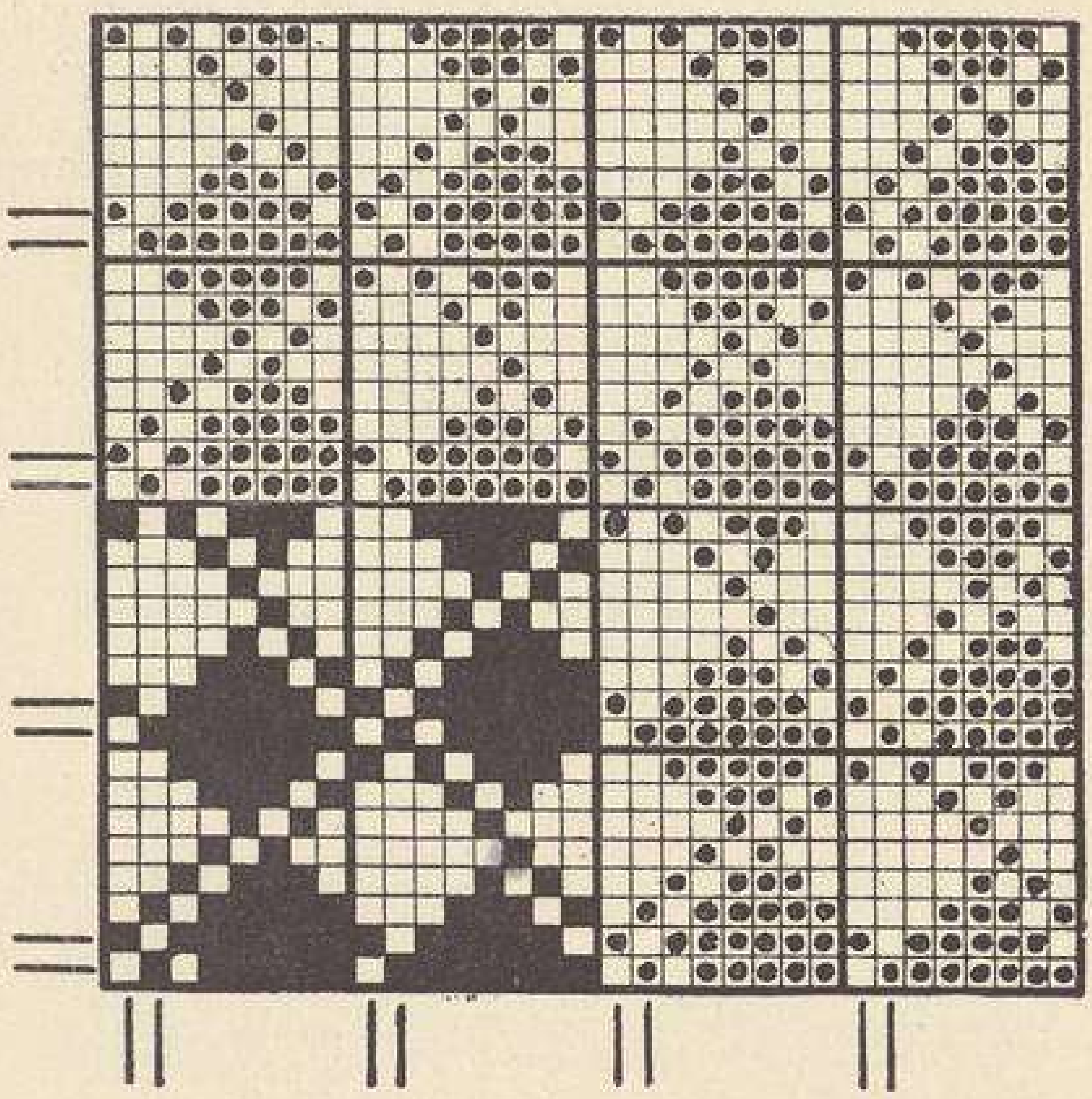


Fig. 59.

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

CHAPTER IV

CRÊPES AND OTHER GROUND WEAVES

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

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

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

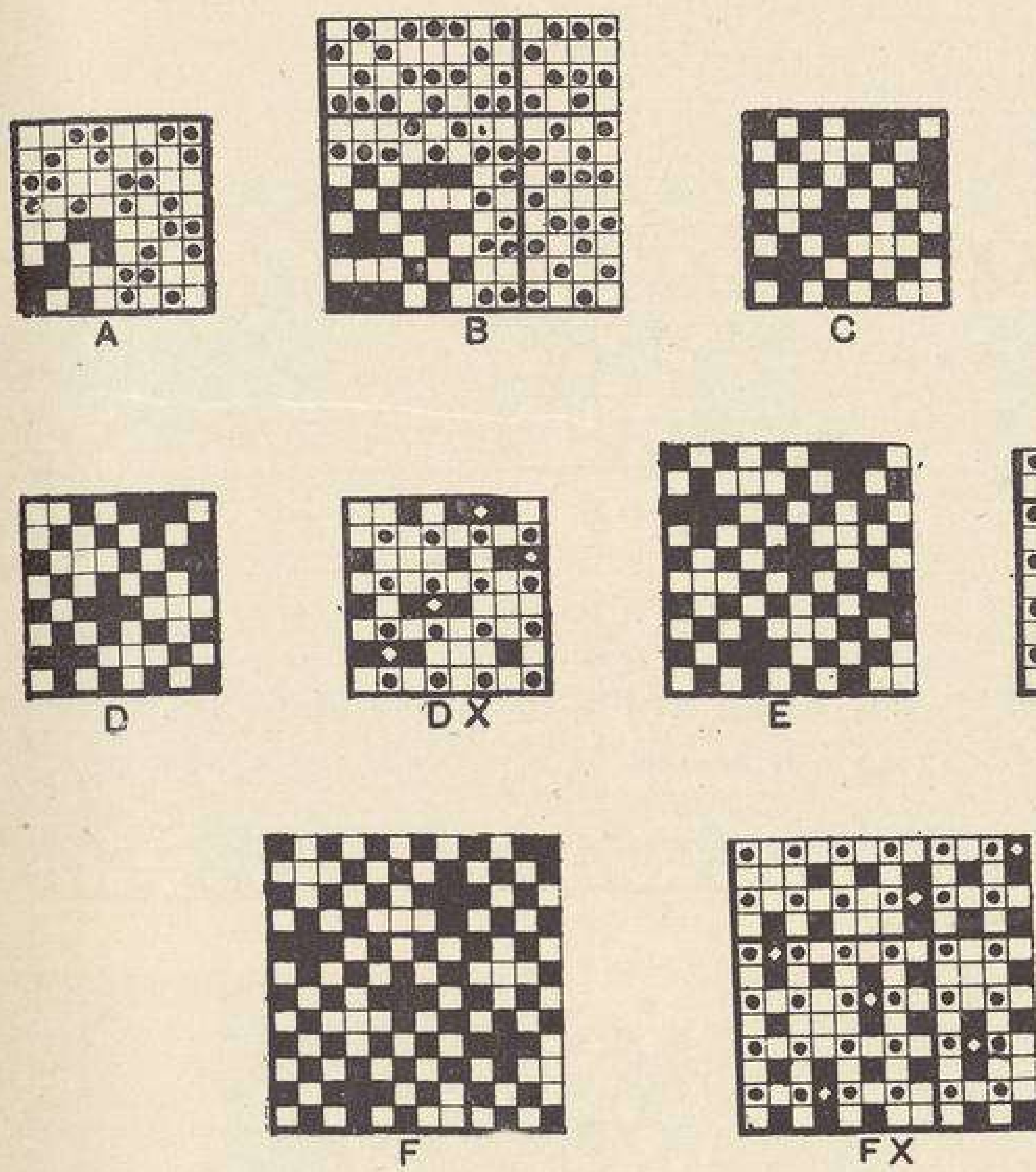


FIG. 60.

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

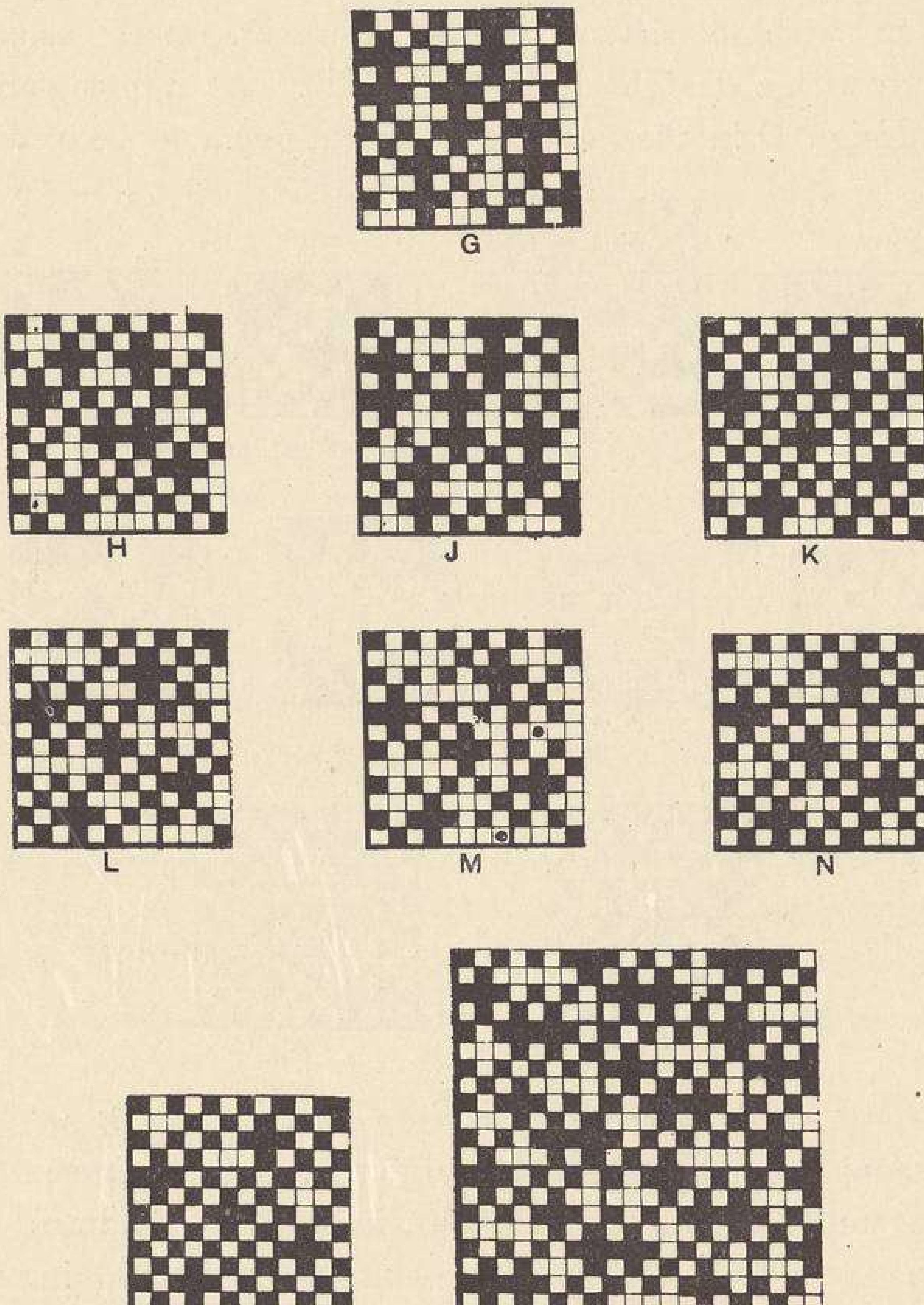


Fig. 61.

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

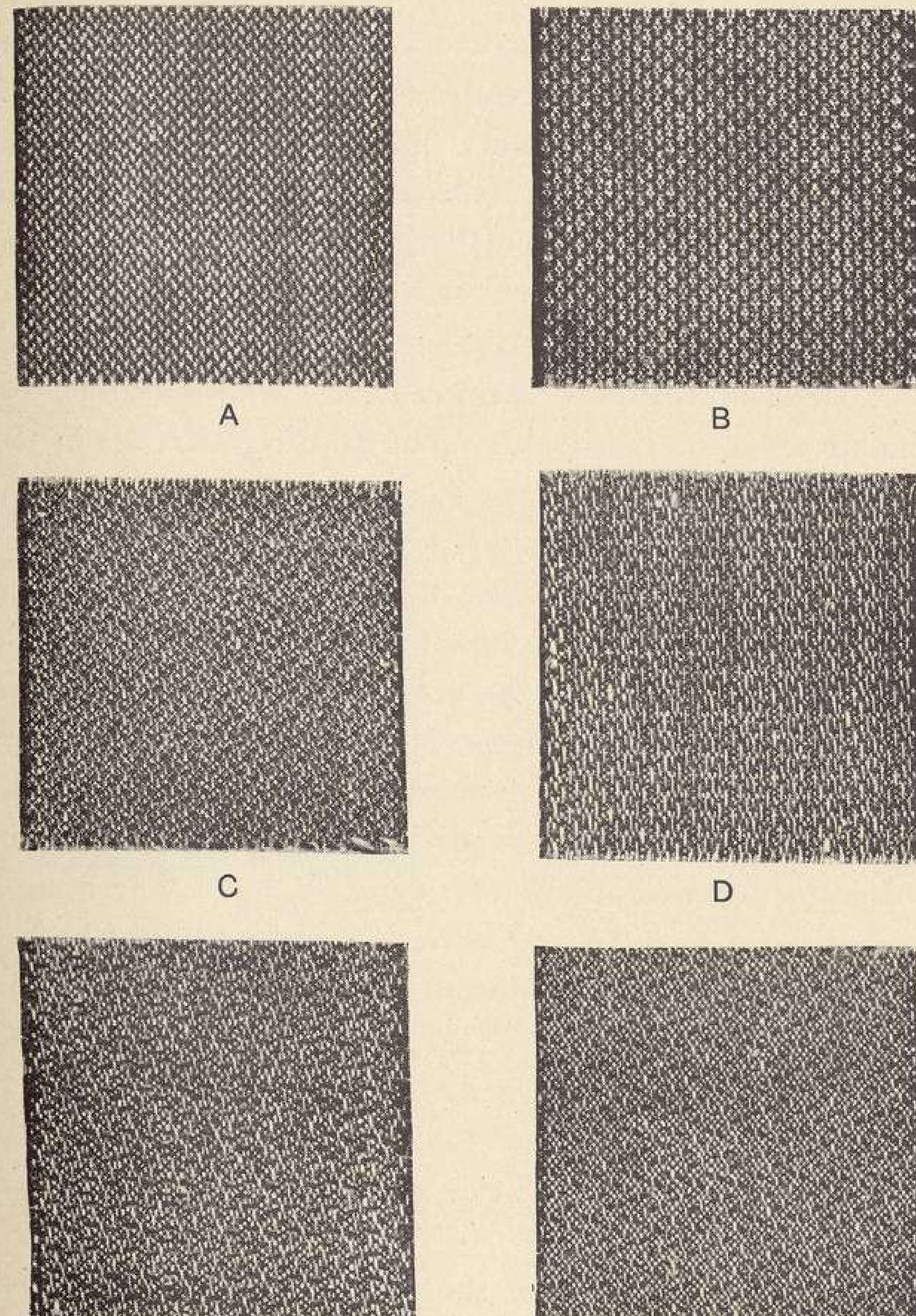


Fig. 62.

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

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

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

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

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

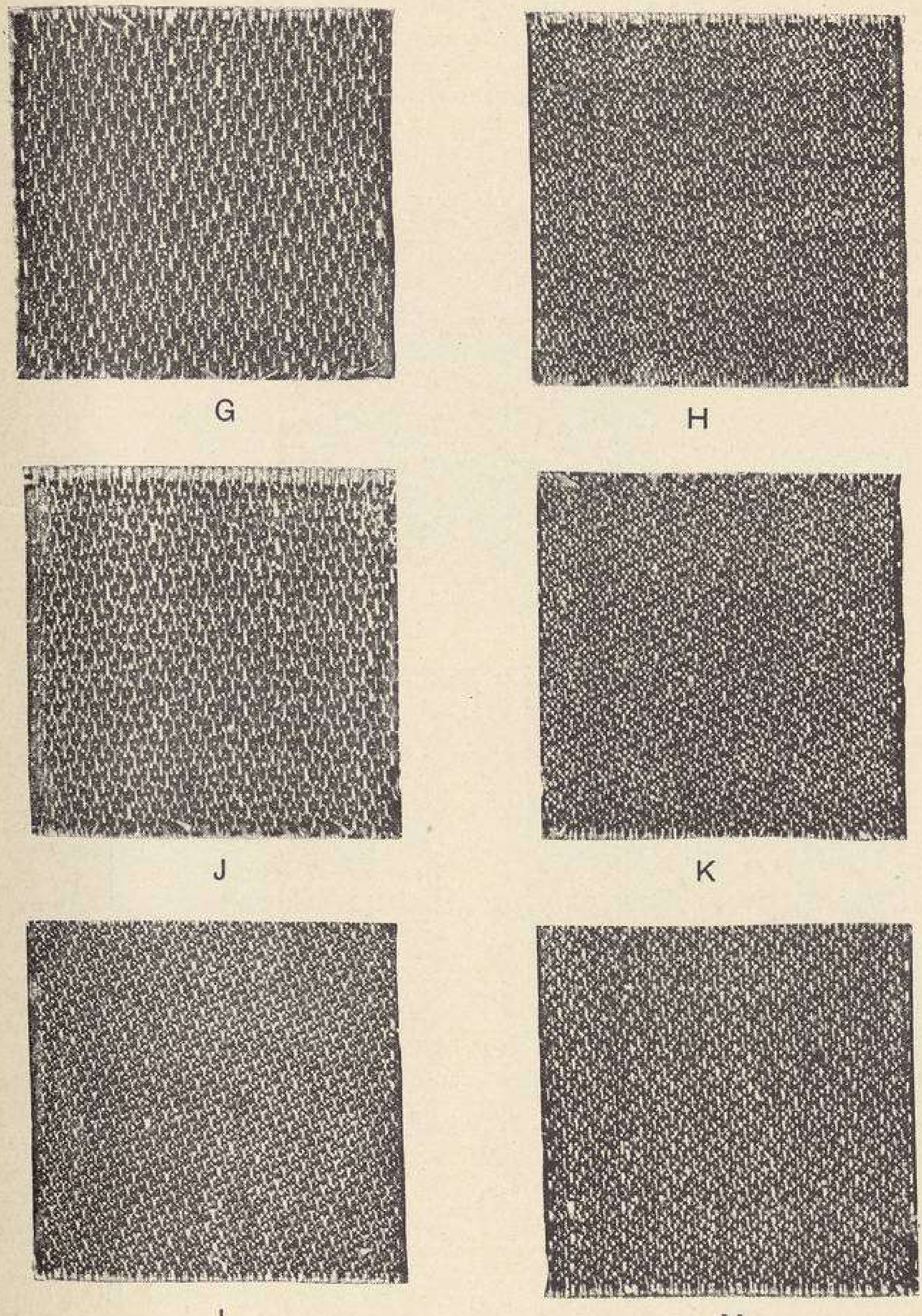
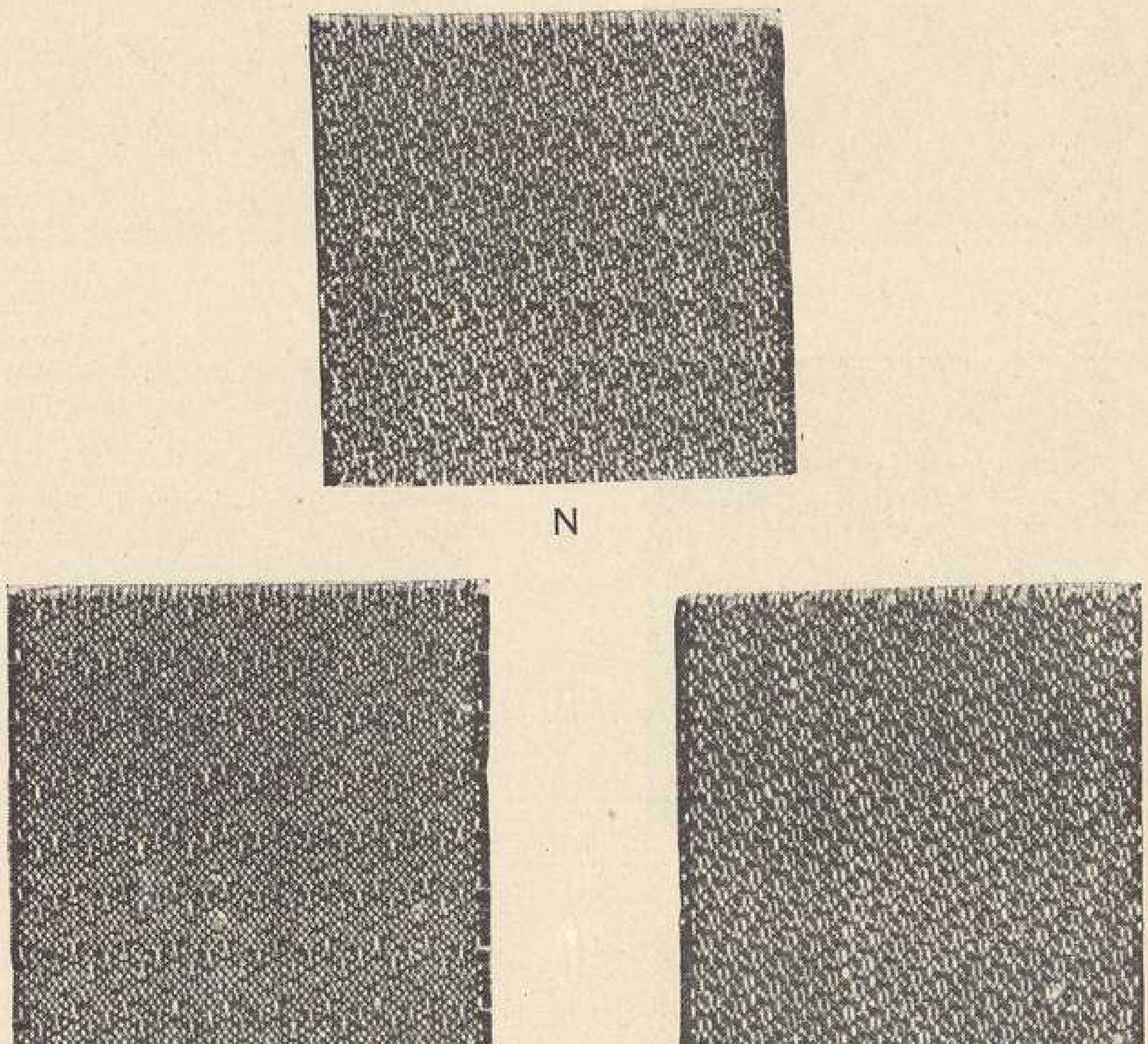


Fig. 63.

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



N

O P

Fig. 63*a*

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

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

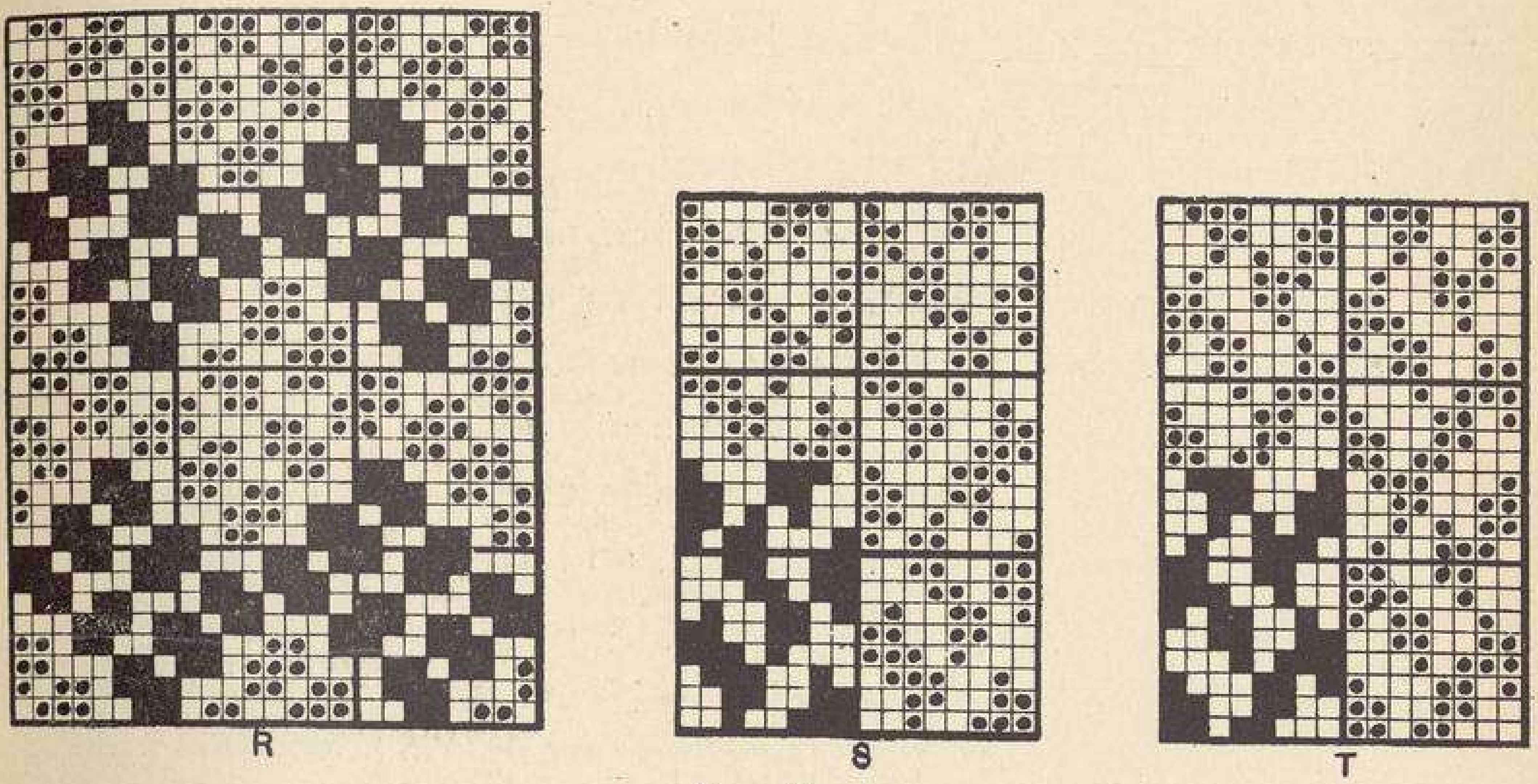


FIG. 64.

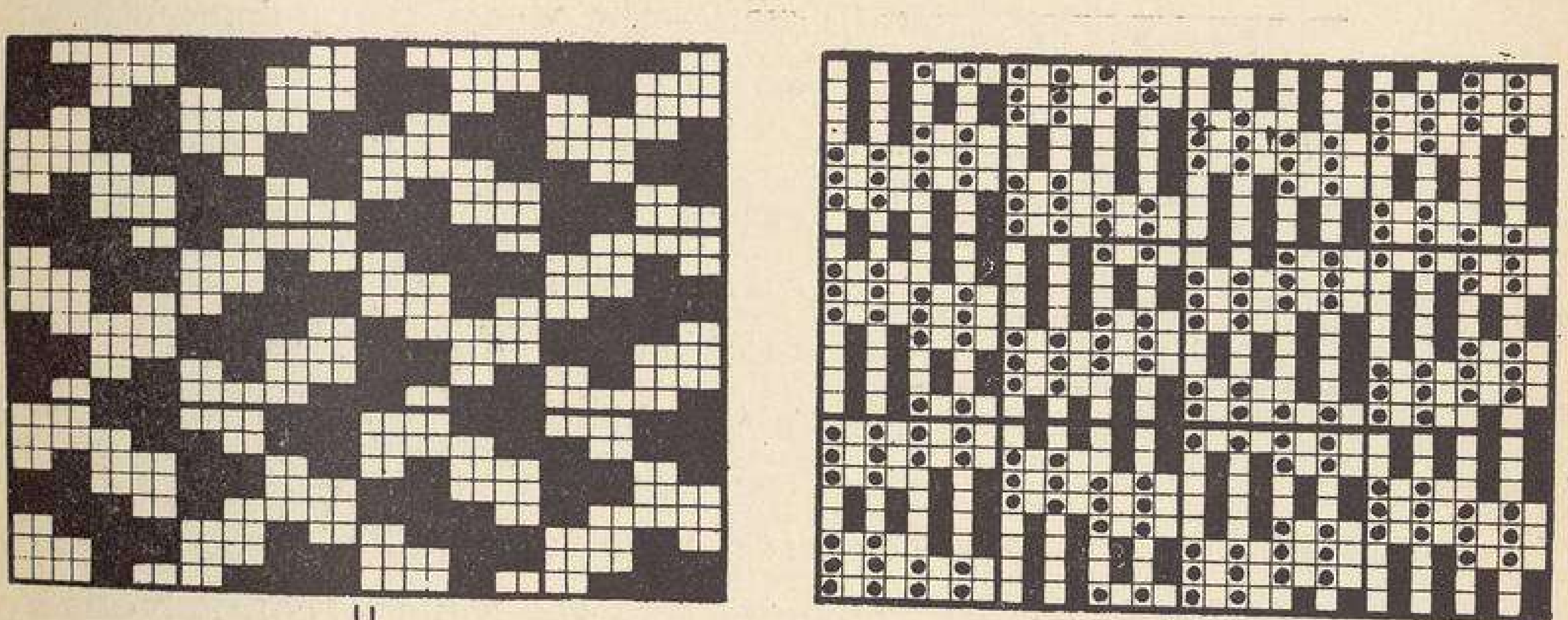


FIG. 65.

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

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

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

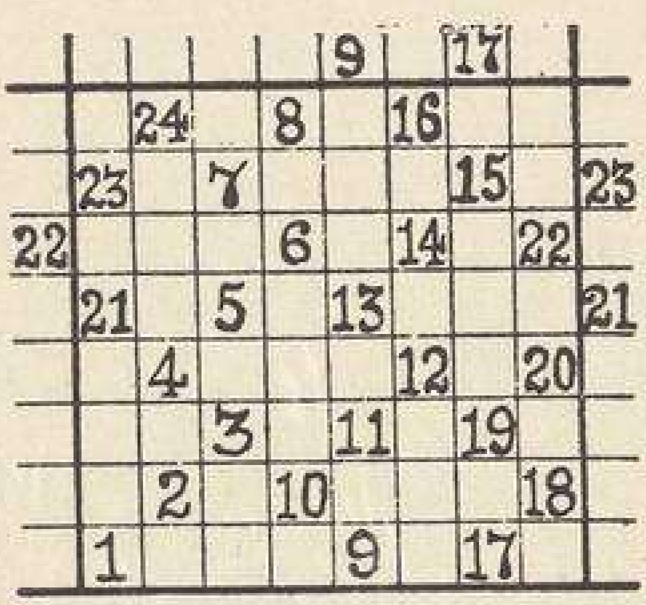


Fig. 66.

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

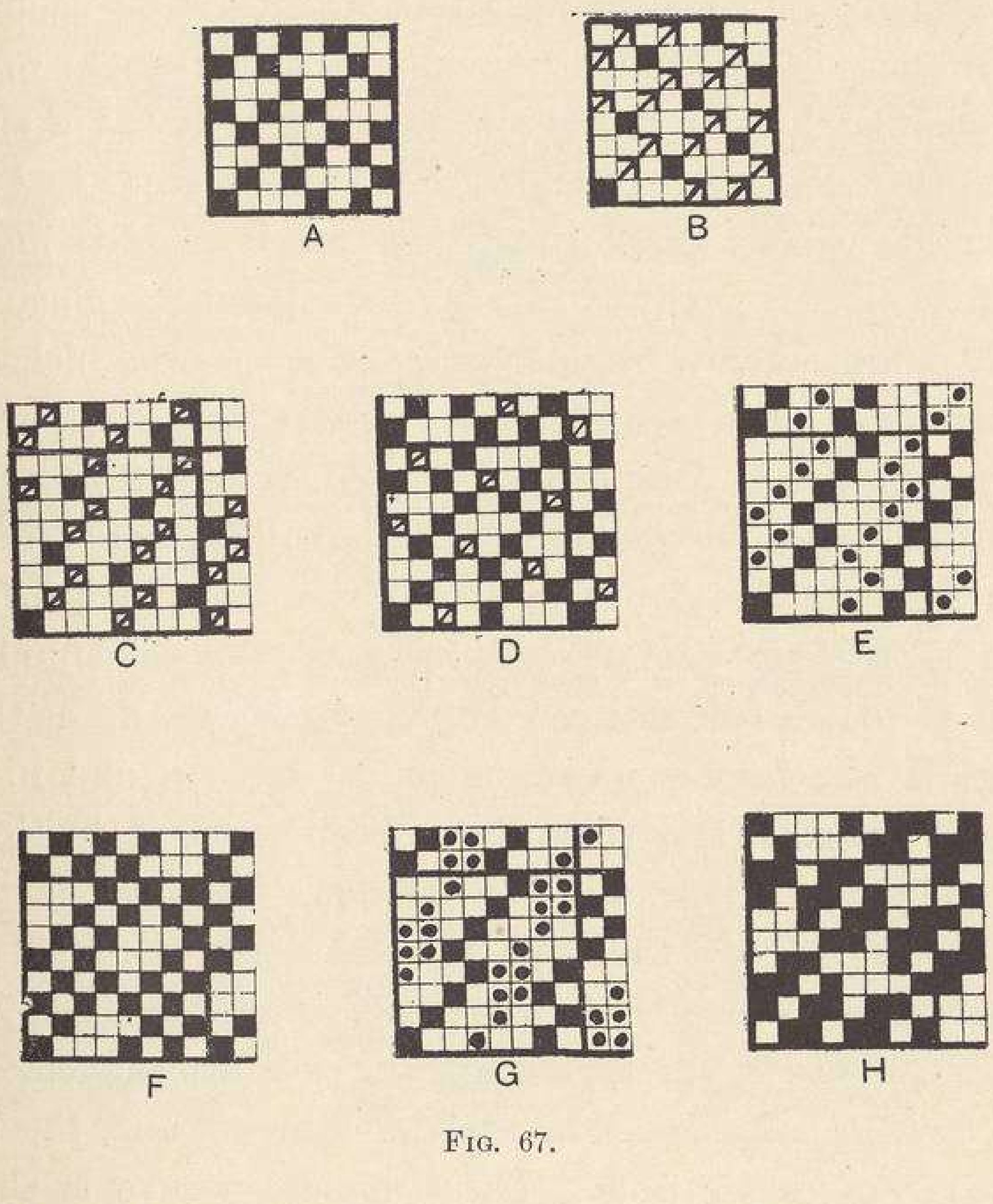


FIG. 67.

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

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

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

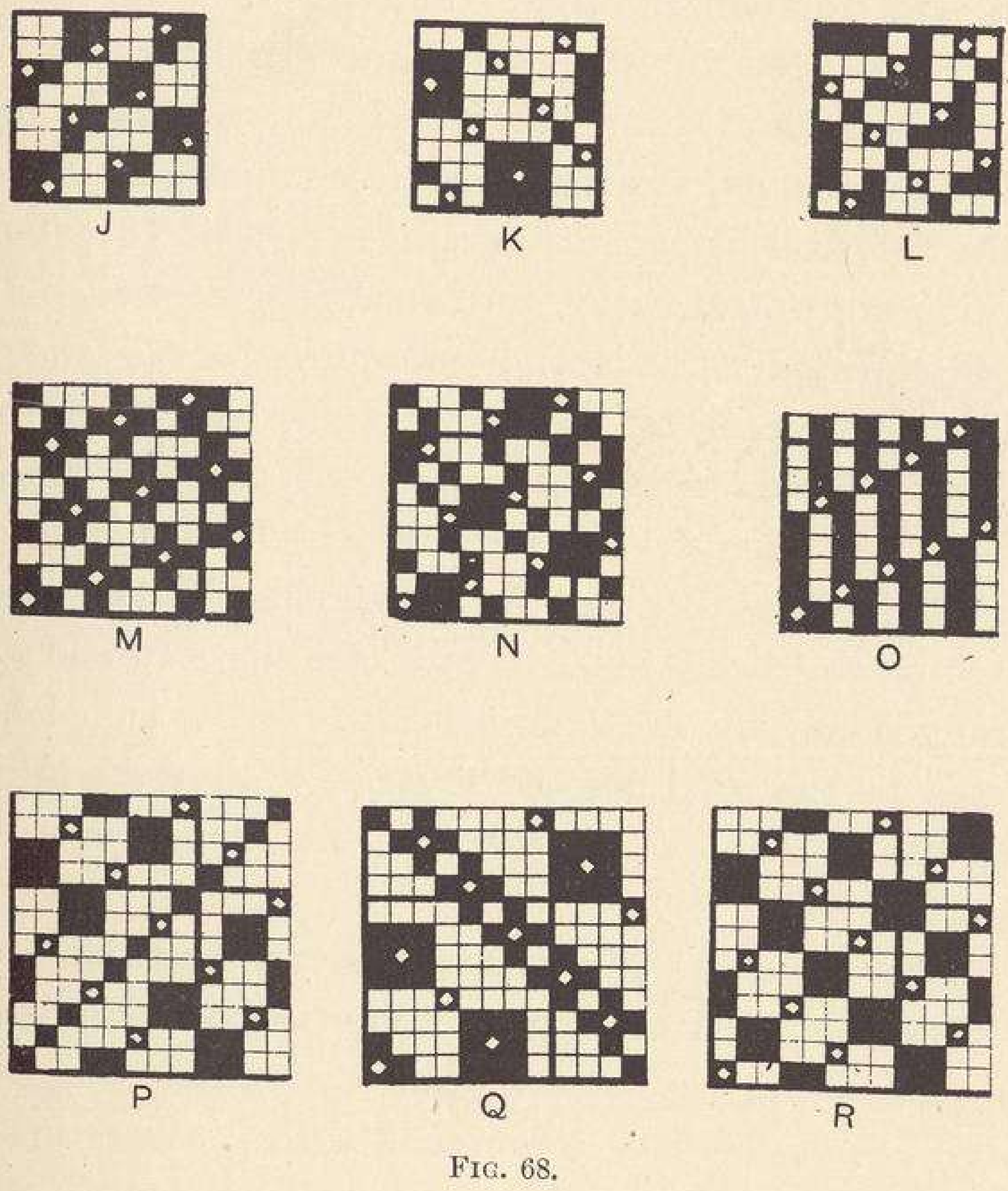


FIG. 68.

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

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

A rather unique method of obtaining irregular weaves is by means of superposition. Any two or more weaves may be placed on the same threads and picks, and, should suitable weaves be so combined, some interesting and satisfactory effects may be obtained. The principle will be understood by referring to Fig. 70, which results from placing the 8-thread sateen weave on a plain ground. It will be noticed that the resulting design is identical with No. 26, Fig. 37 (p. 41); and, indeed, this is probably the simplest method of constructing this particular design. One peculiarity of the above combination is that all the marks of the sateen weave fall on unoccupied squares, whereas if the weave were moved one thread to the left or one thread to the right, every mark would fall on a square already occupied by the plain weave. It is only in exceptional cases that the two weaves do not clash at some point or points, and even in the simple combination of plain and sateens the same result does not always obtain.

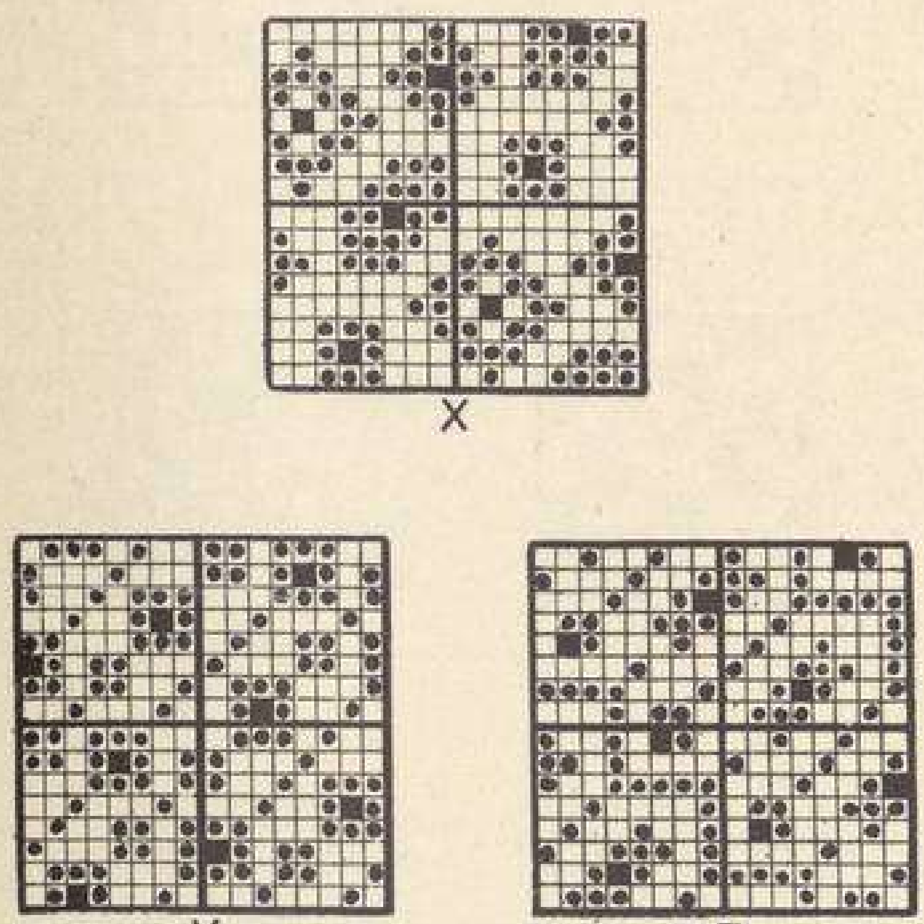


FIG. 69.

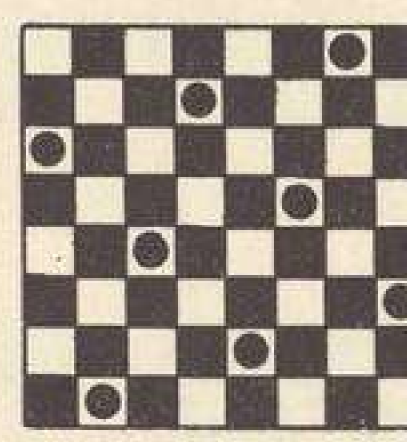


FIG. 70.

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

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

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

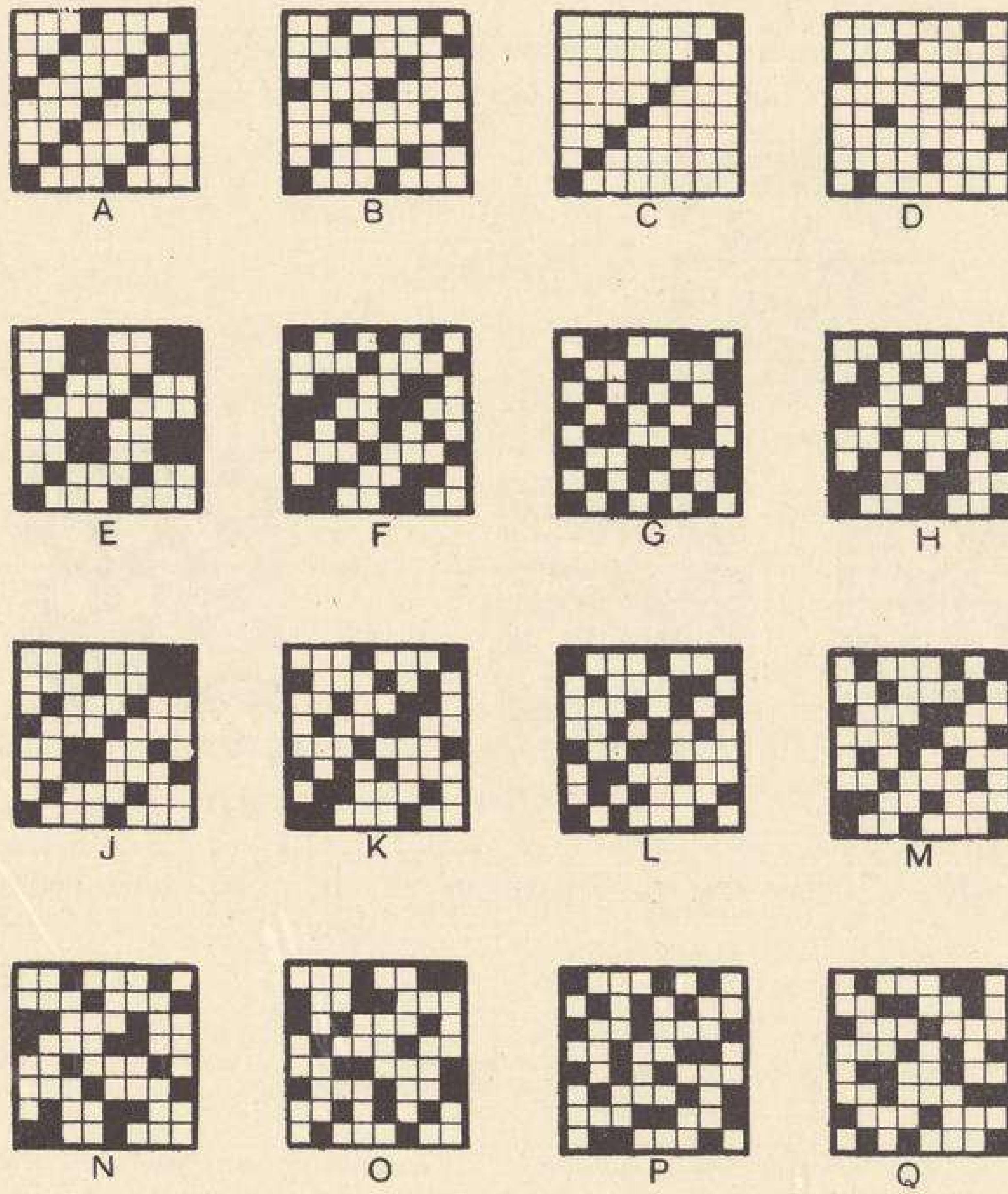


FIG. 71.

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

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

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

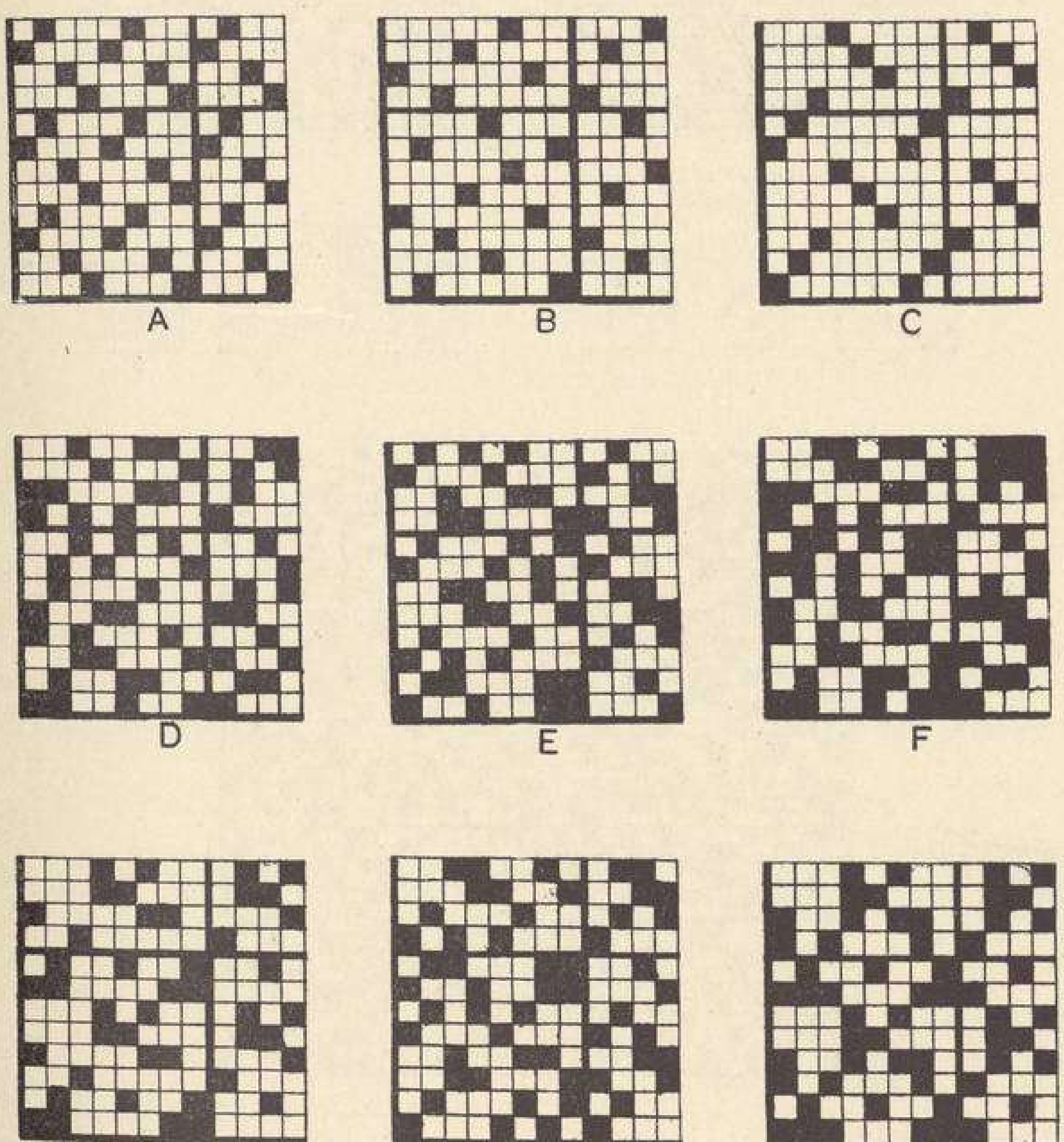


Fig. 72.

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

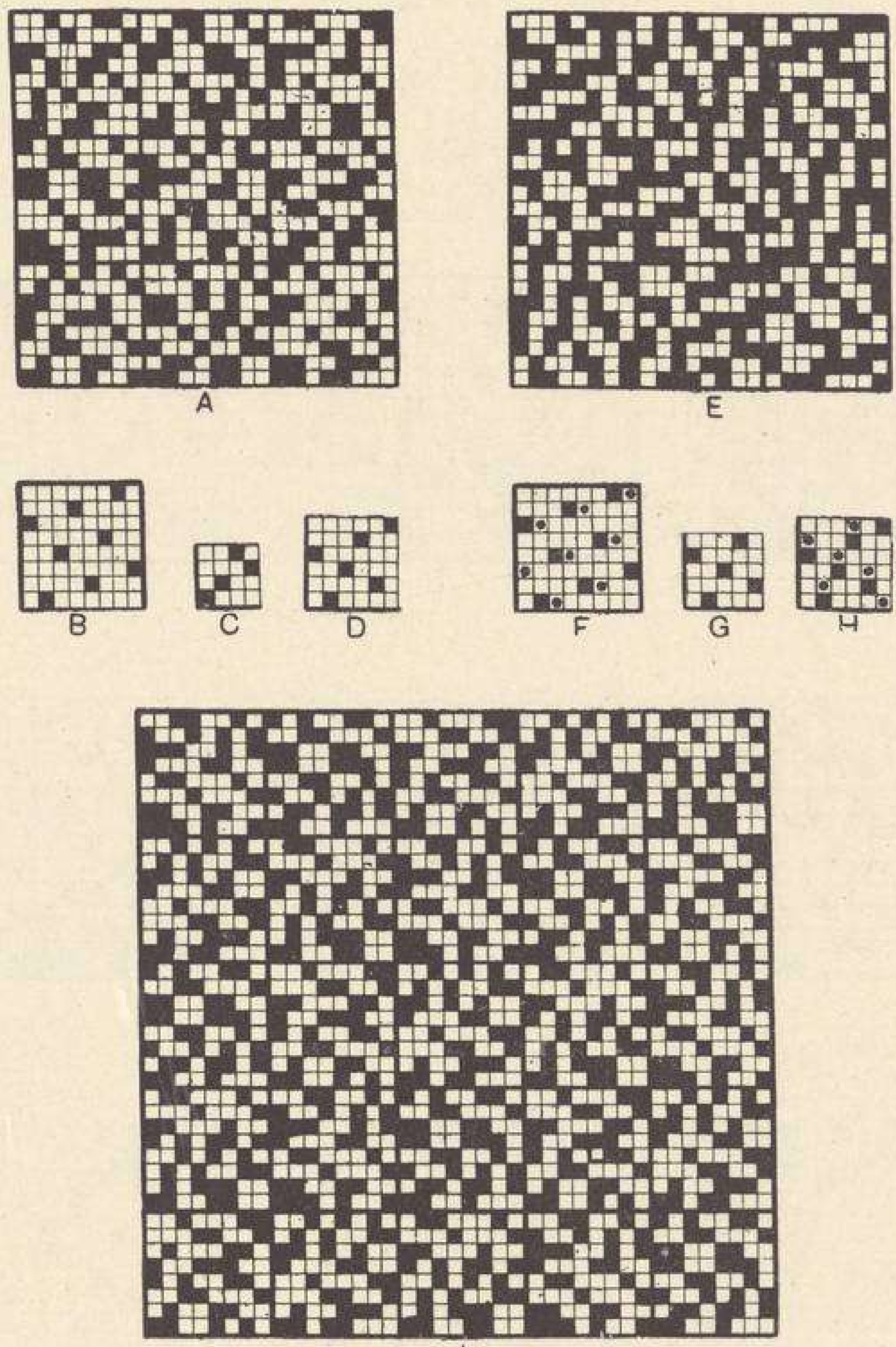


Fig. 73.

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

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

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

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

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

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

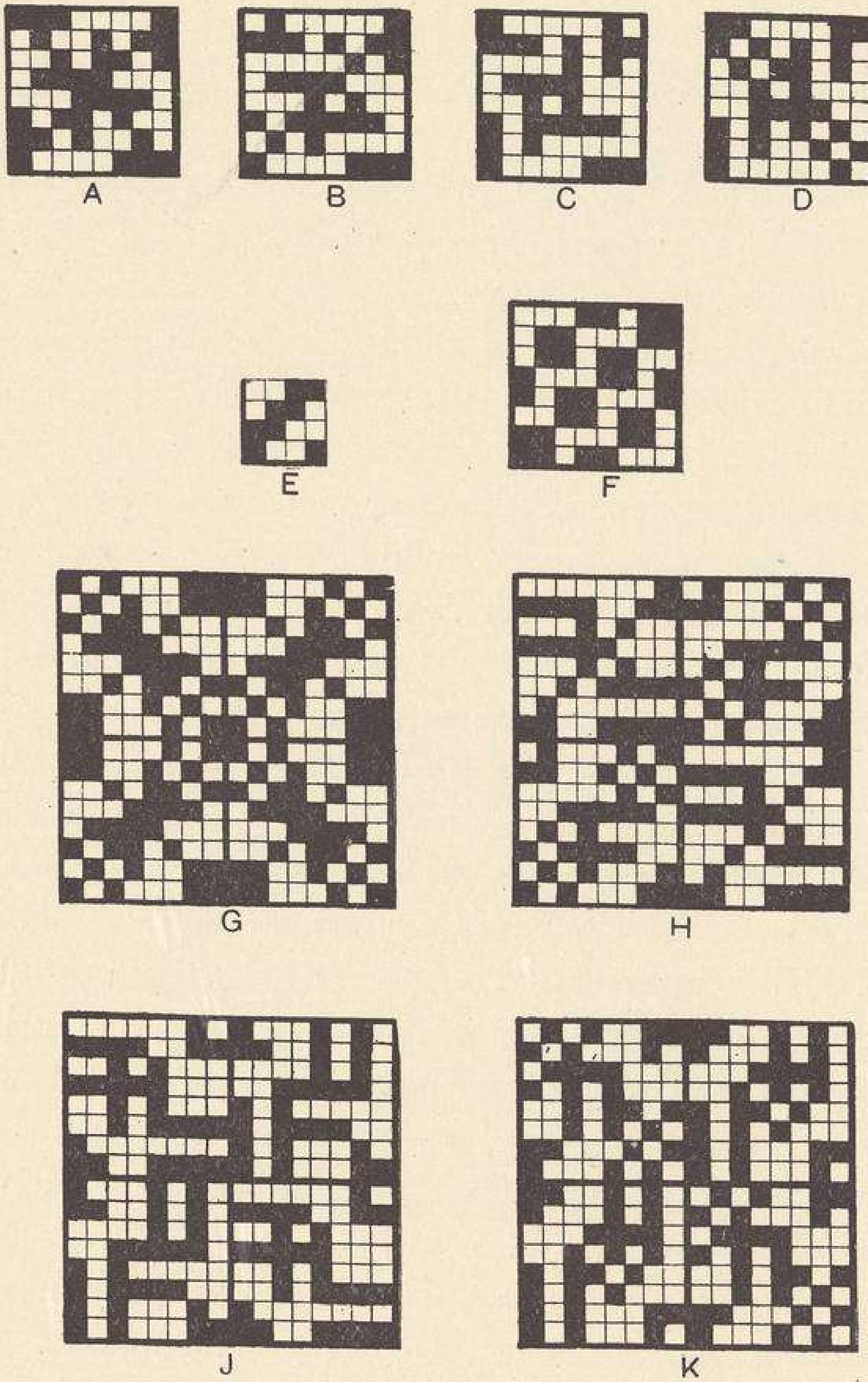


Fig. 74.

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

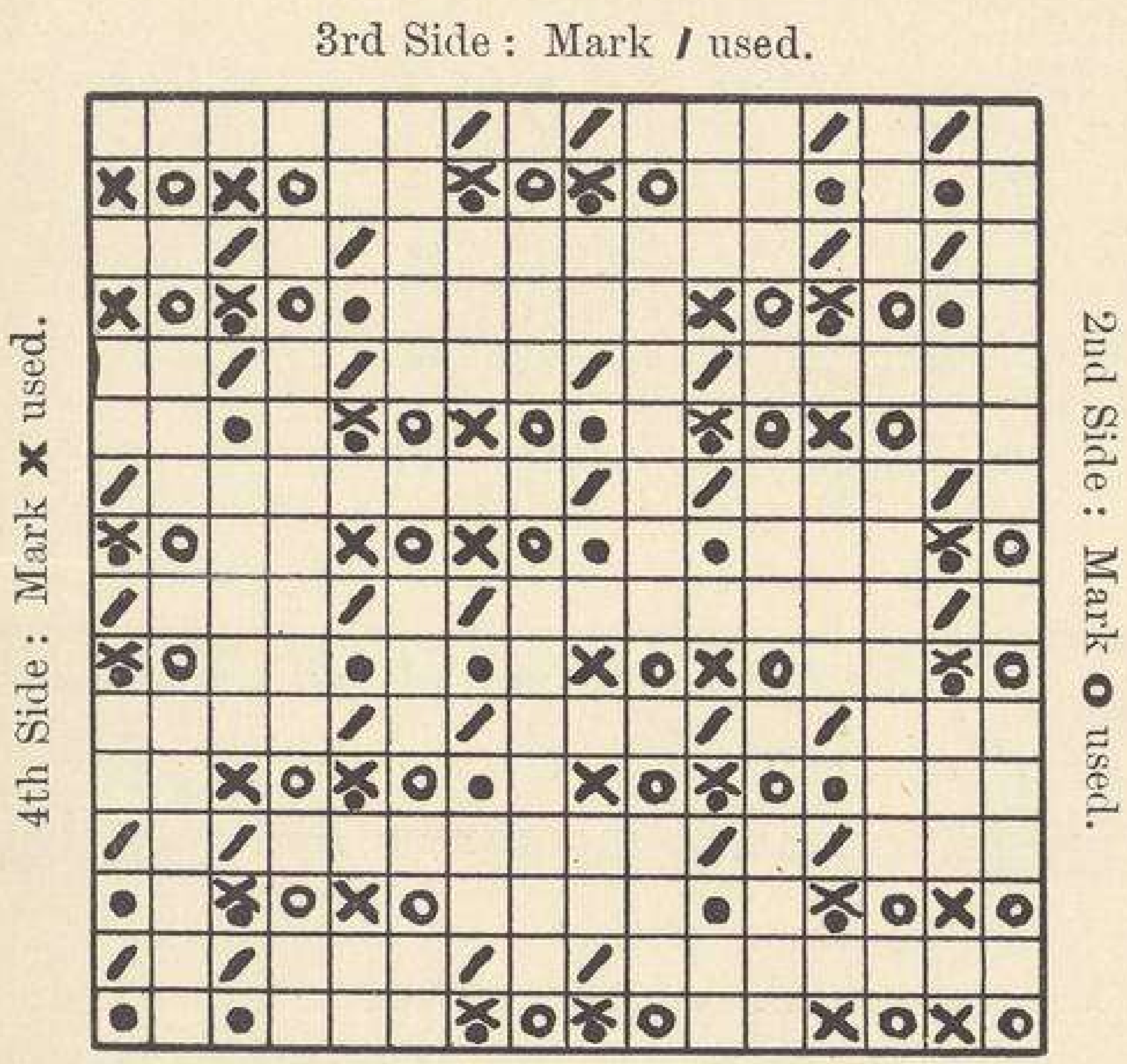


FIG. 75.

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

[TABLE

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

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

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

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

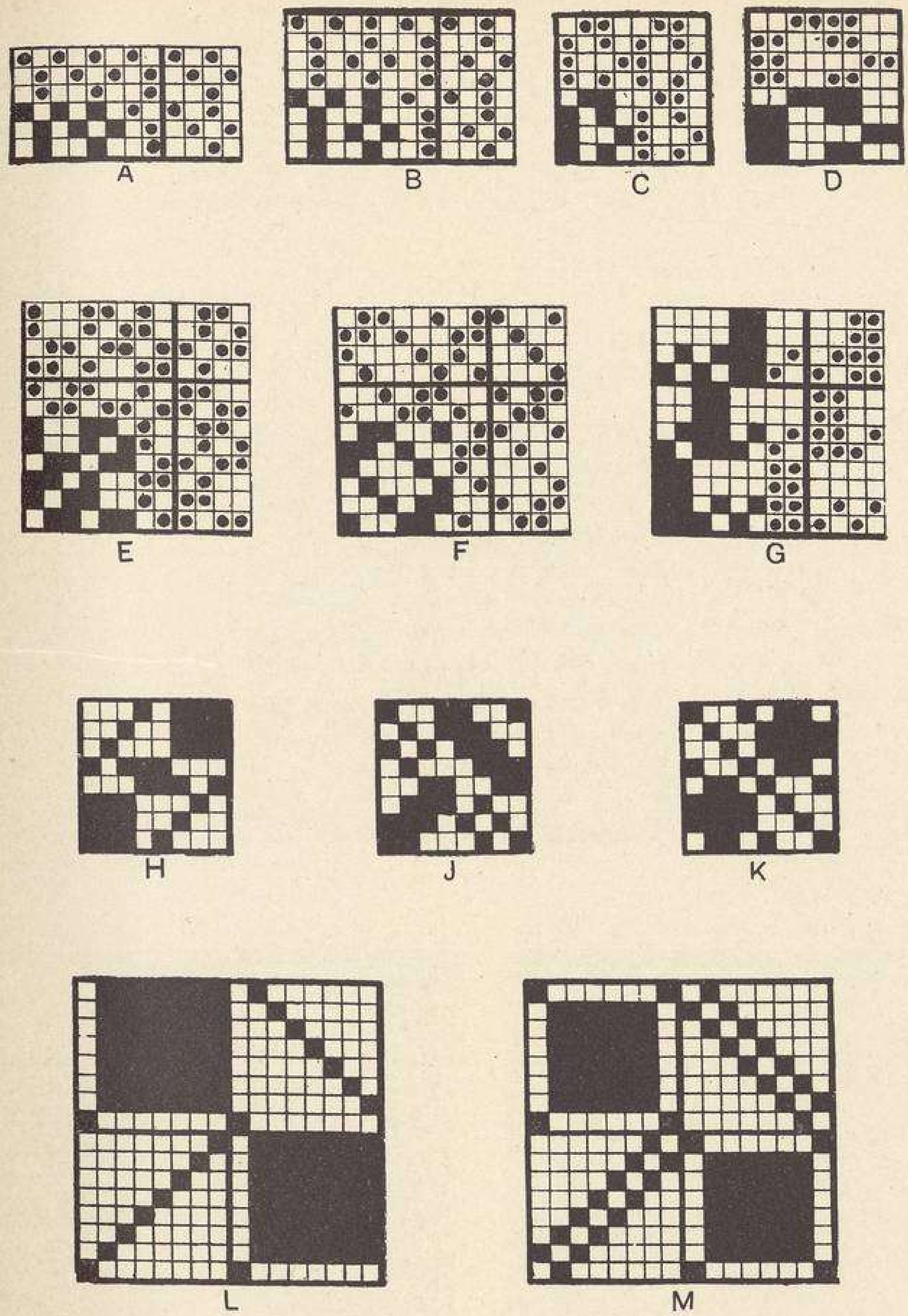


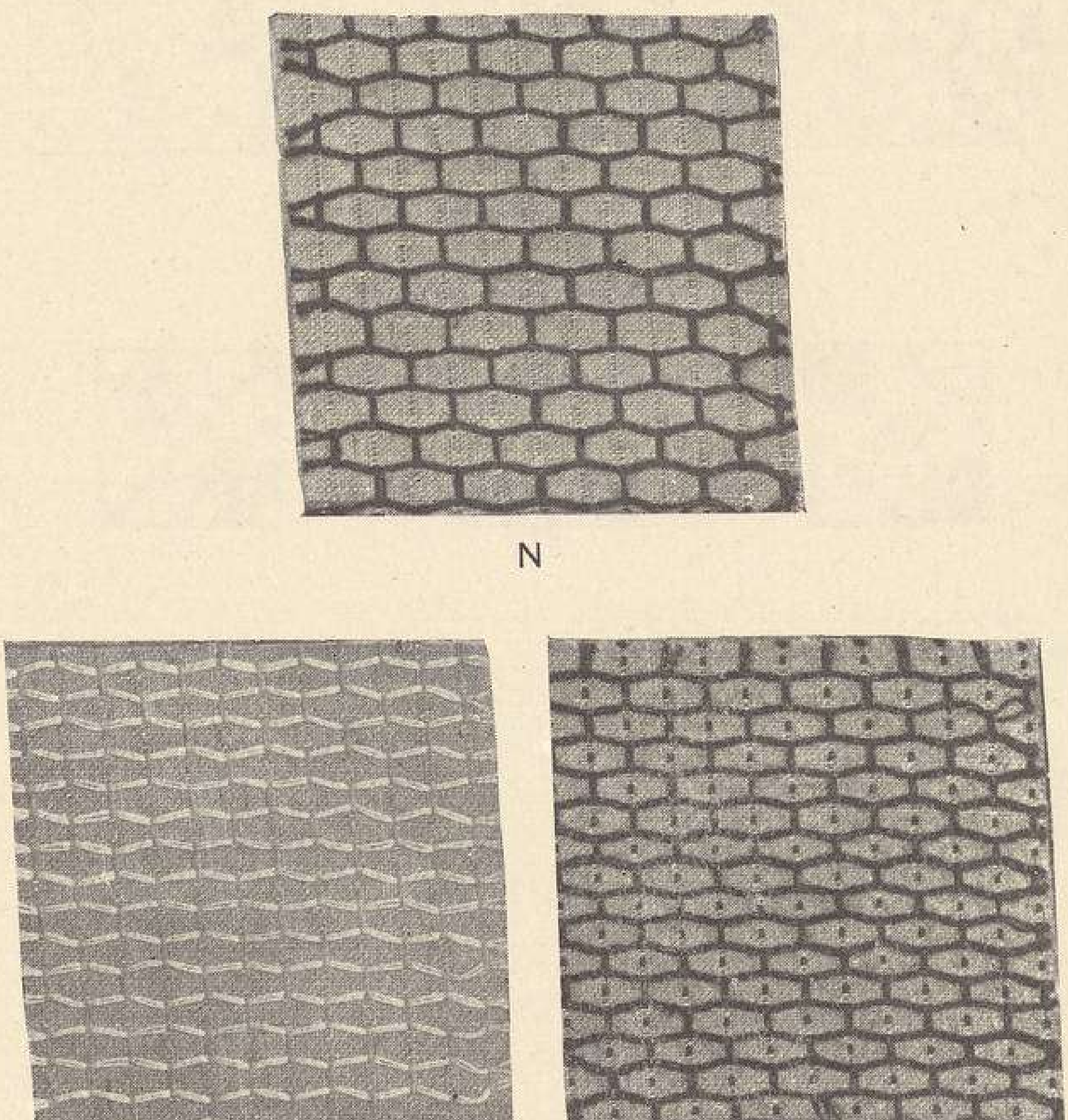
Fig. 76.

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

CHAPTER V

SPIDERS

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



N

O

Ox

FIG. 77.

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

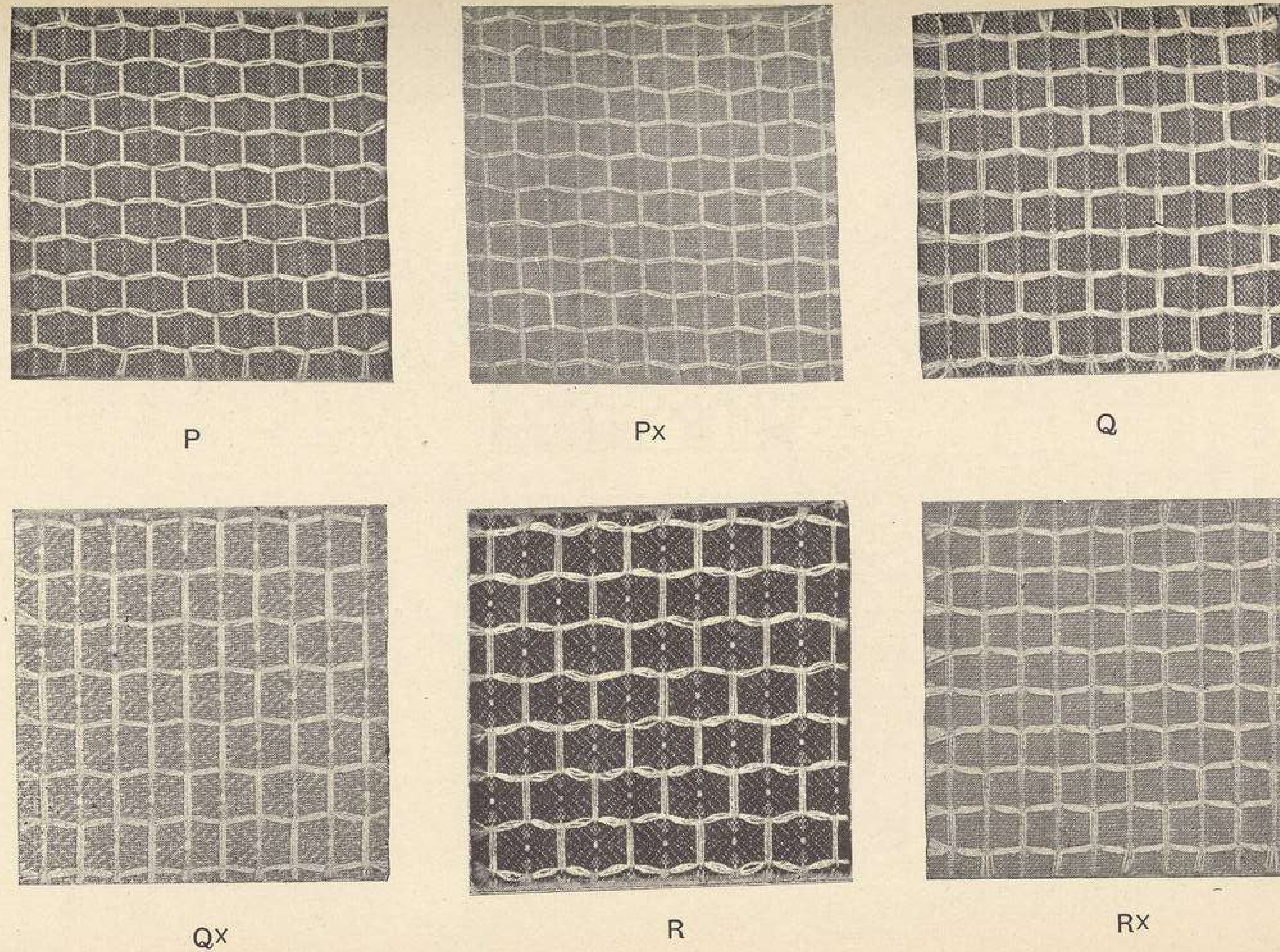
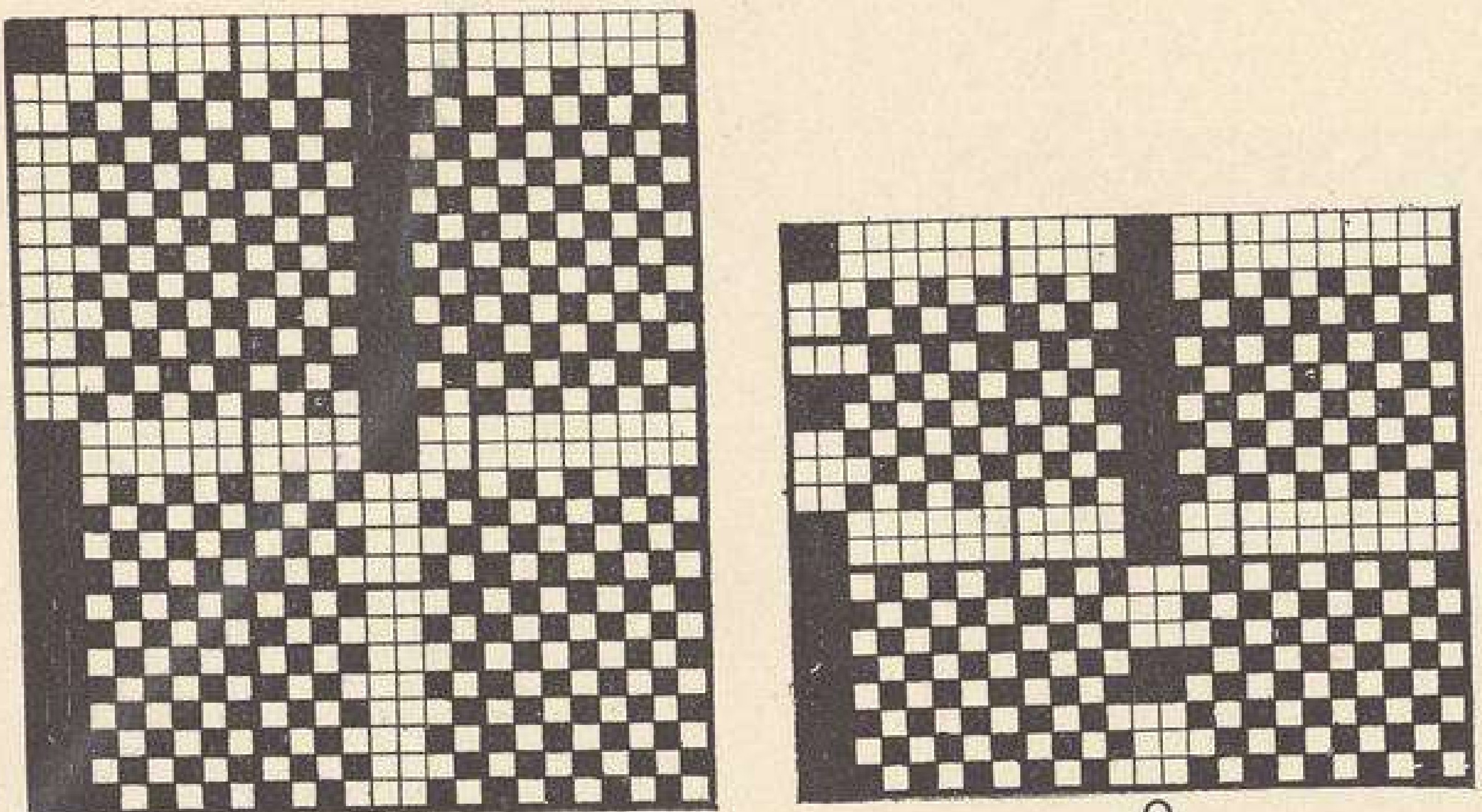


Fig. 78.

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



N O

Fig. 79.

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

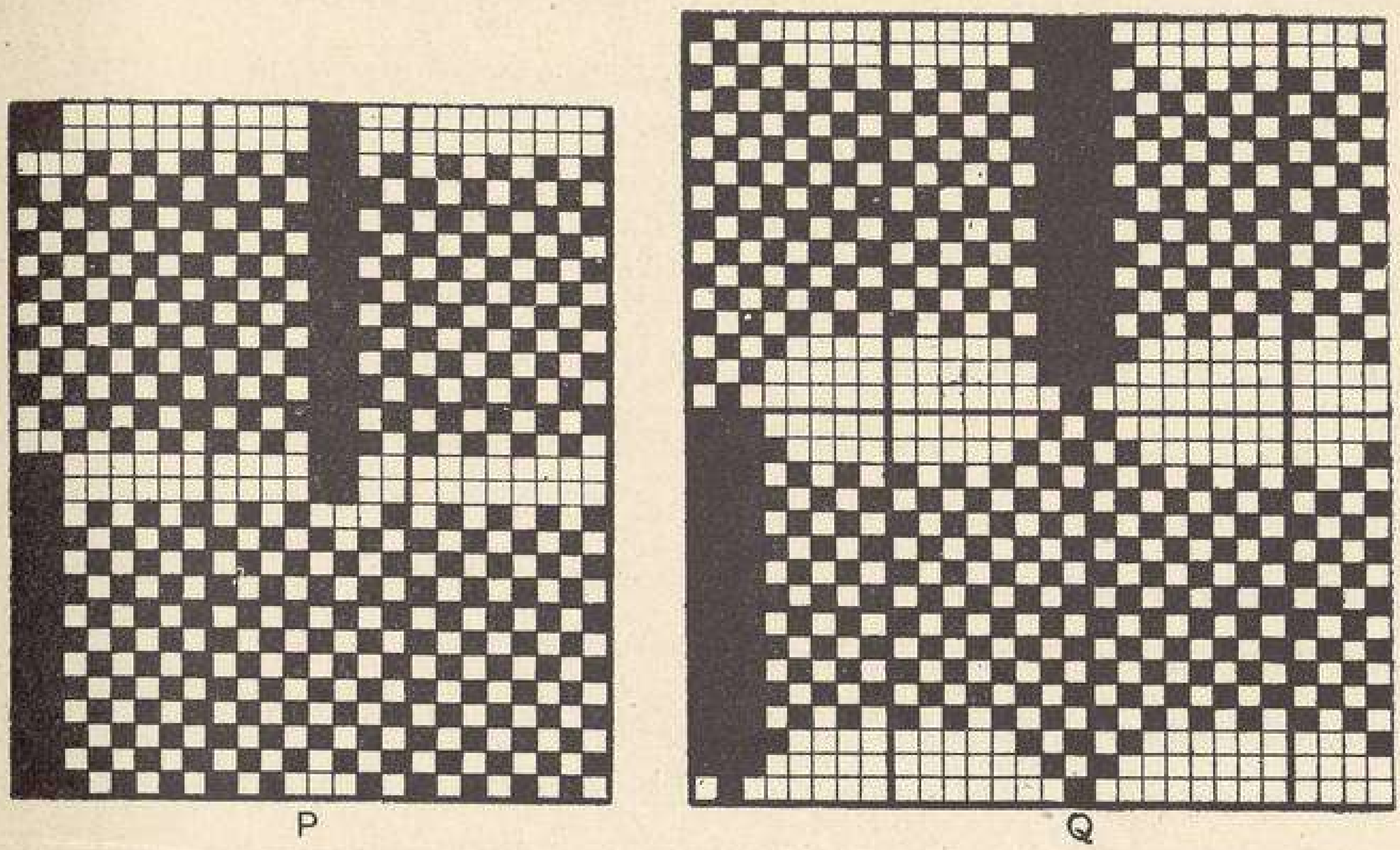


FIG. 80.

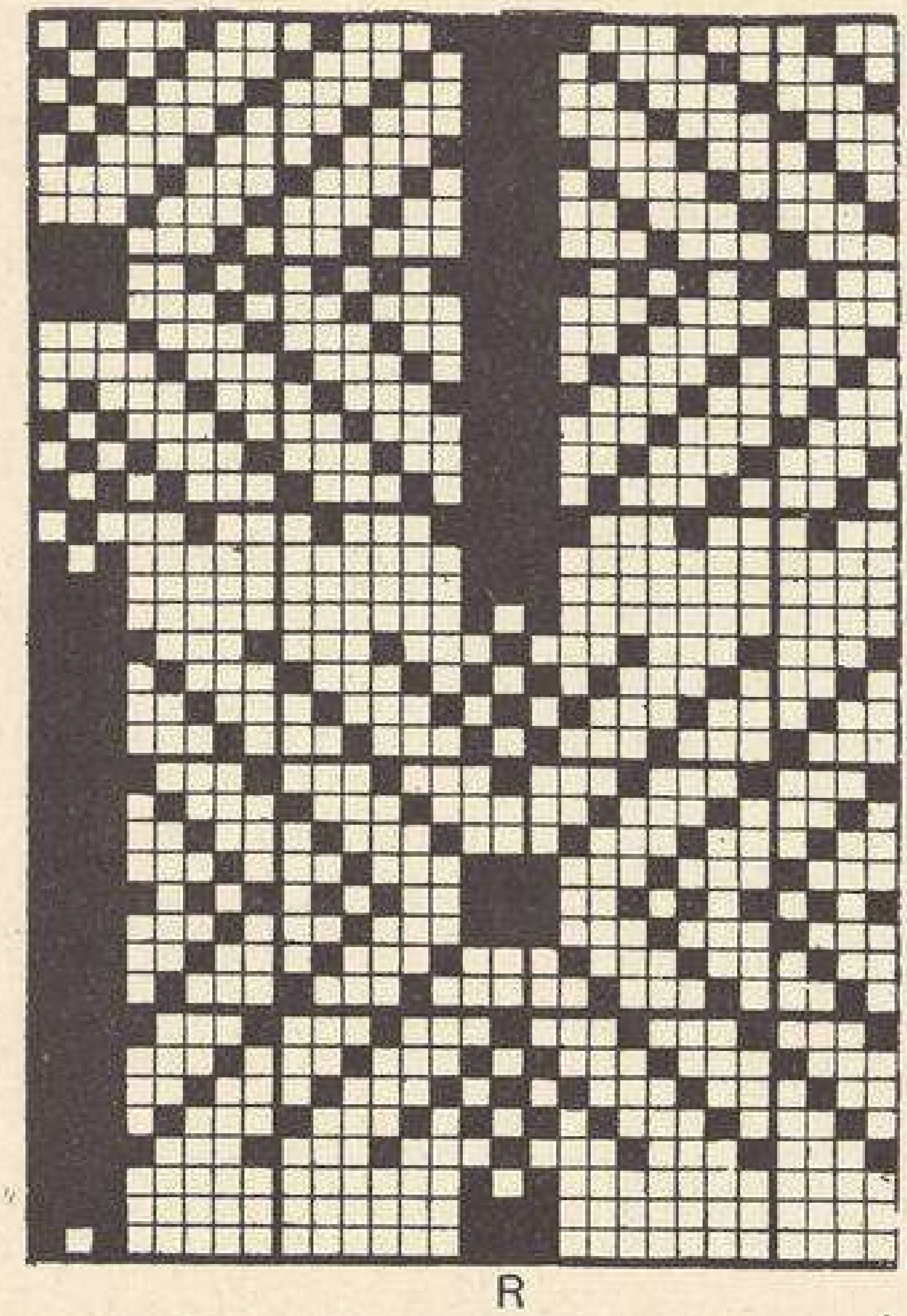


FIG. 81.

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

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

[TABLE

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

CHAPTER VI

HERRING-BONES, DIAMONDS, AND DIAPERS

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

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

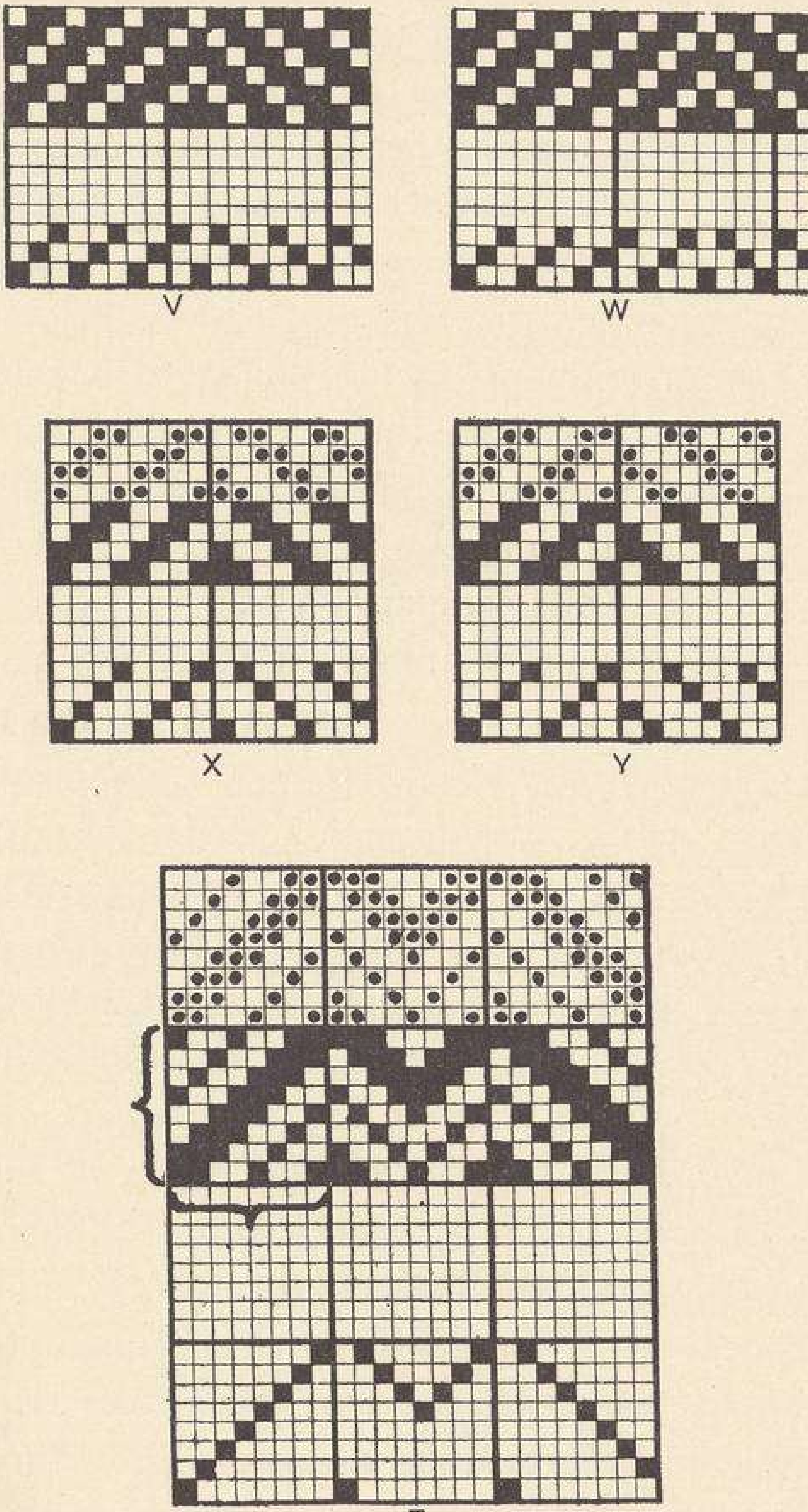


Fig. 82.

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

Two further examples are given at X and Y, Fig. 82, on 16 threads and 4 shafts. These two designs resemble each other very closely, but there is an interesting difference between them at the point where the differently directed twills meet, that is, between the 8th and 9th, and 16th and 1st threads in both designs. It will be observed that design X is perfectly symmetrical about its turning points—the 1st and 9th threads. This results in a weft float of three on each side of the cloth (see the 1st and 3rd picks), an effect which, in many cases, is considered objectionable. In the jute, and also in the tweed and other industries, the method of turning or joining the twills as indicated in design Y is regularly adopted; this arrangement is free from the long floats, but it is clear that the method acts only in special cases. Thread 9 in this design is arranged to "cut" with or work directly opposite to thread 8 by drawing it upon the proper shaft and continuing the draft from that point. When this is done, and the draft continued to a multiple of the number of shafts employed, the last thread of the draft (*e.g.*, No. 16, Y, Fig. 82) will "cut" with the first thread in a similar manner. This method has a tendency to create a split or opening in the cloth at the cutting points, but it is generally considered that it produces a firmer fabric than the other method, particularly if the cloth be somewhat open in sett. With both methods each shaft is again made to carry an equal portion of the total warp, provided that the number of threads drawn in both directions is a multiple of the number of shafts employed. It is, of course, understood that it is not absolutely essential for the stripes to occupy a multiple of the threads of the unit weave, but it is better for the camb when this condition obtains. There are numerous cases where the arrangement of the draft will not permit of the same number of threads on each shaft.

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

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

Shafts 1 and 5 each take $\frac{3}{24}$ of the total number.
,, 2, 3, and 4 ,, $\frac{2}{24}$,, ,,
,, 6, 7, and 8 ,, $\frac{4}{24}$,, ,,

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

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

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

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

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

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

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

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

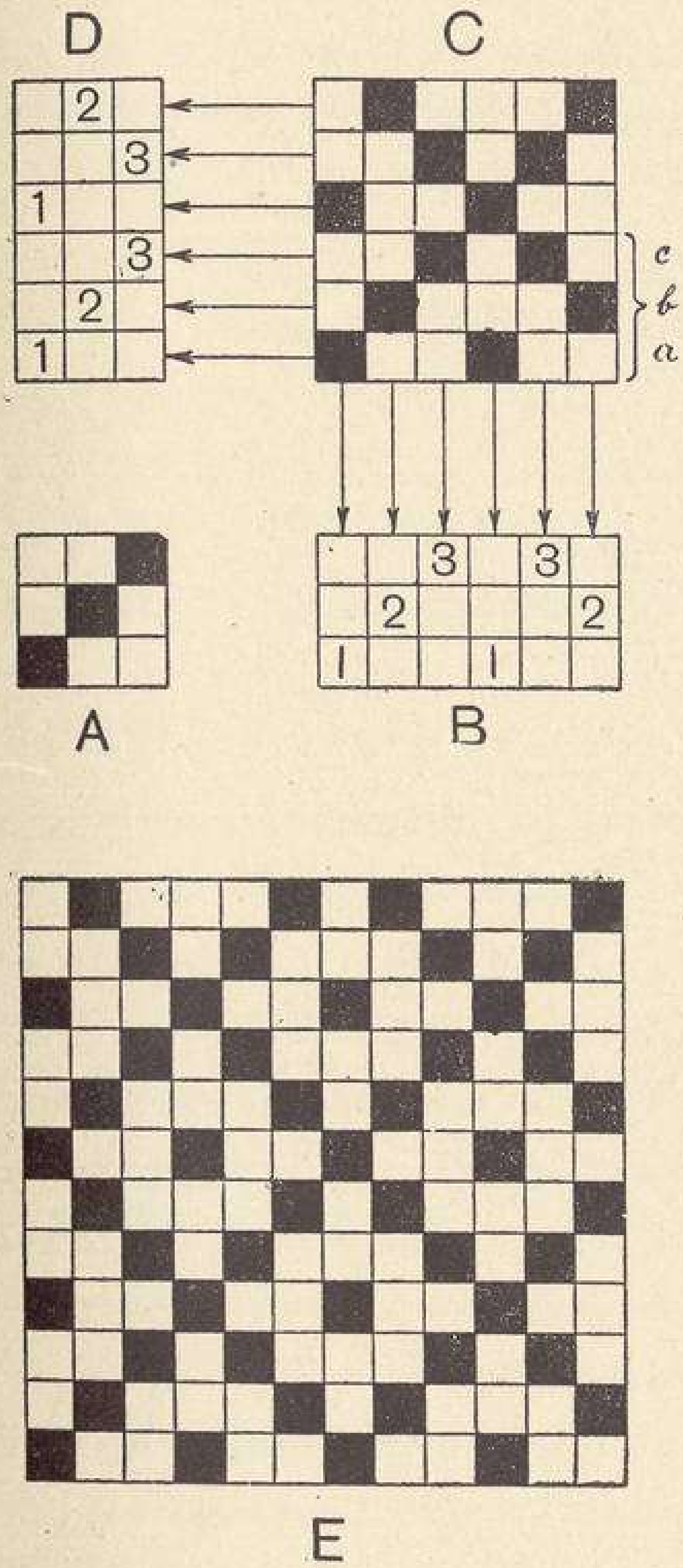


Fig. 83.

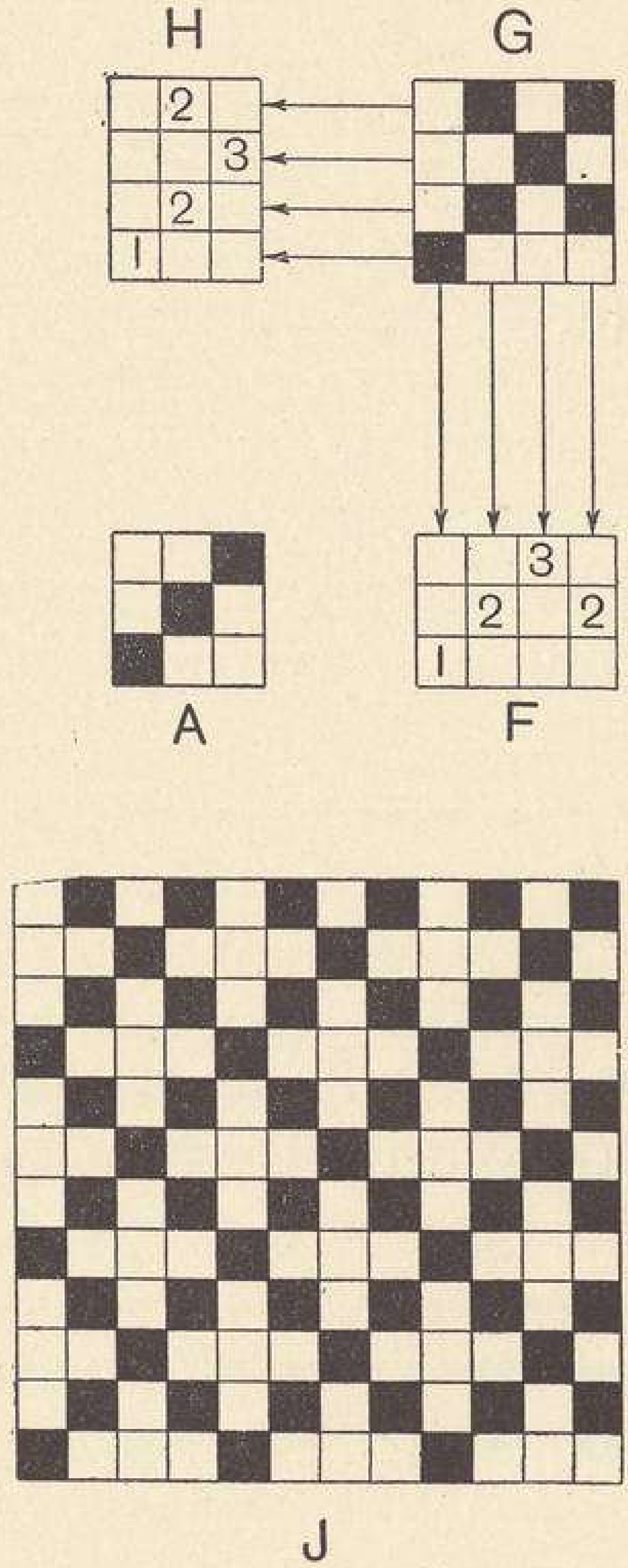


Fig. 84.

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

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

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

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

$$1, 2, 3, 4, \ldots (n-3), (n-2), (n-1), n;$$
$$\text{then } (n-1), (n-2), (n-3), (n-4) \ldots 5, 4, 3, 2.$$

The arrangement of the picks is again identical with that of the threads, the total number in either the warp or the weft direction being equal to $2n-2$, where n is the number of threads in the base weave. It will be observed that each leaf of the camb in the first system (B, Fig. 83) controls the same number of threads, while in the second system (F, Fig. 84) the first and the last shafts have each only half the number of threads controlled by each of the remaining shafts (in the figure there is one shaft only with double the threads). E, Fig. 83, and J, Fig. 84, show 4 and 9 repeats respectively of the units C and G, and although the figure J appears of the nature of a diamond, it is too small to give such an effect in the cloth. It will be seen that one half of the threads is of the same plain order, while the remaining half consists of two threads of the $\frac{1}{3}$ twill. In most diamond designs it is essential that the order of reeding should be considered in order that the single spot at the side of the diamond may not be covered by the adjoining longer float. In another part of this work it is stated that the shorter the float the nearer the horizontal centre of the cloth will the thread or pick appear, and the prominence of the threads or picks on either side of the cloth will increase with the length of the float. By carefully studying this tendency of one thread to overlap another, it is possible, in some cases, to reed the warp so that the short floating threads will not be covered by the adjacent long floats. Thus the effect obtained by design E depends somewhat upon the order of reeding. The object to be attained is to have a split of the reed between the first two threads and between the last two threads of each enclosed diamond, *i.e.*, between threads 2 and 3, 5 and 6, 8 and 9, and 11 and 12. This can always be done by reeding one thread per split, but in most cases such a reed would be much too fine. It is impossible to make the division in design E by reeding two threads per split. If reeded three threads per split, commencing with a three, the result will be faulty; but if reeded three threads per split, commencing with the third thread, the result will be more satisfactory. In many cases it is impossible to split satisfactorily each pair of threads forming the corners of the diamond. There is nothing to prevent the similar weft threads from overlapping, but, except in very heavily wefted fabrics, the long floats of weft have not the same tendency to cover the shorter ones.

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

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

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

$$\underbrace{1 . 2 . 3 . 4 . 1 . 2 . 3 . 4}_{\text{Twice straight or twill to right.}} ; \text{ then } \underbrace{1 . 4 . 3 . 2 . 1 . 4 . 3 . 2.}_{\text{Twice reverse or twill to left.}}$$

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

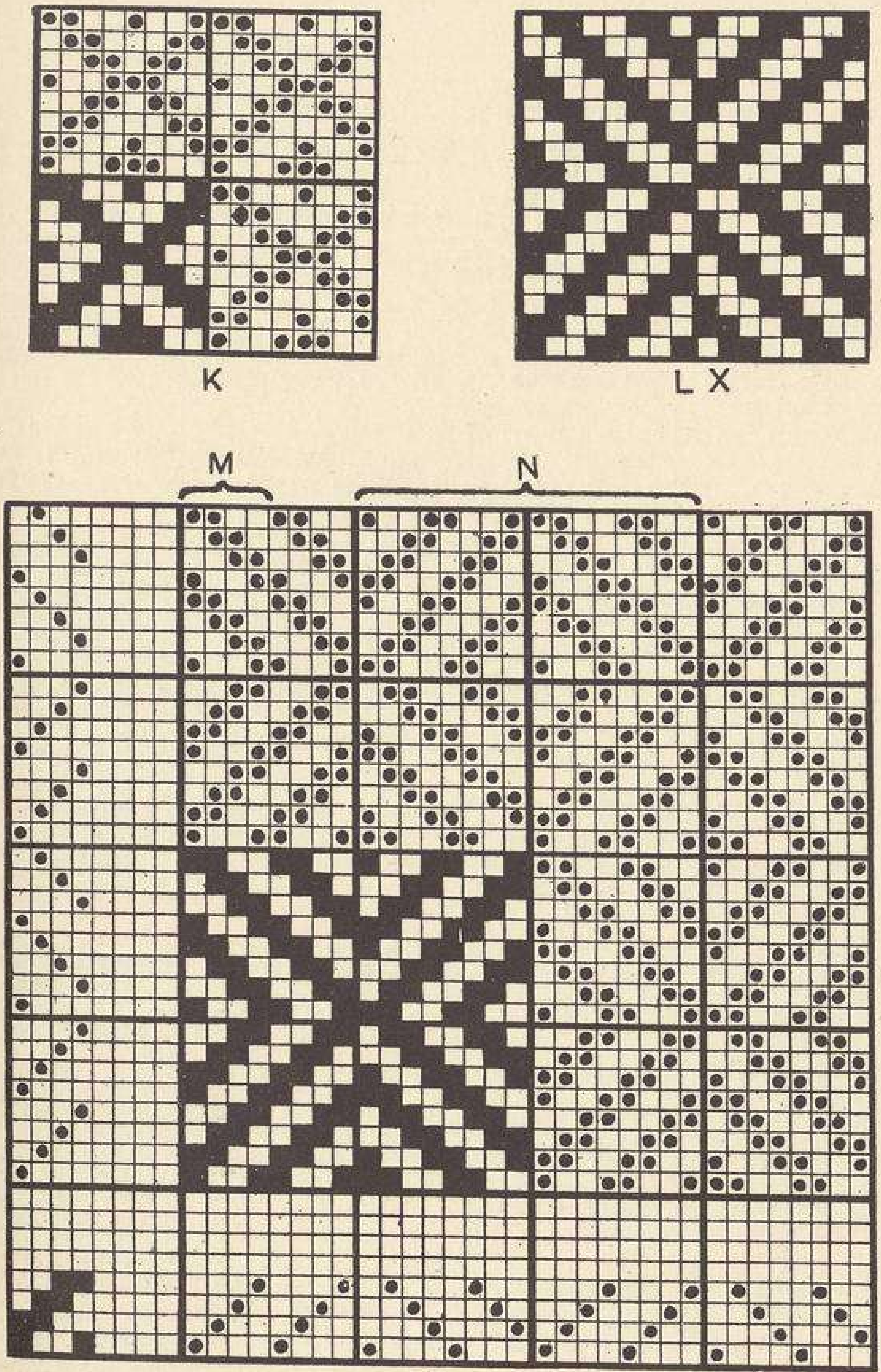


FIG. 85.

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

In the jute and other industries, where comparatively thick yarns and open or coarse setts are used, the floats of three in design L are in many cases considered objectionable, and a method of drafting is therefore adopted which limits the floats to two threads or two picks. This is illustrated in design LX, which has been developed on 16 threads and 16 picks from the $\frac{2}{2}$ serge twill. The two pairs of threads and picks which form the junction of the oppositely directed twills are arranged to "cut," or, in other words, to work in opposition to each other: the whole design is, indeed, an example of reversing, as illustrated in Fig. 46. Designs O and P, in Fig. 86, show two ways of forming a diamond pattern on the principle illustrated in K and L, Fig. 85. The weave used is the $\frac{3}{2}\frac{1}{2}$ twill, and the designs are identical when repeated; the apparent difference is due to the different way of inserting the initial weave.

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

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

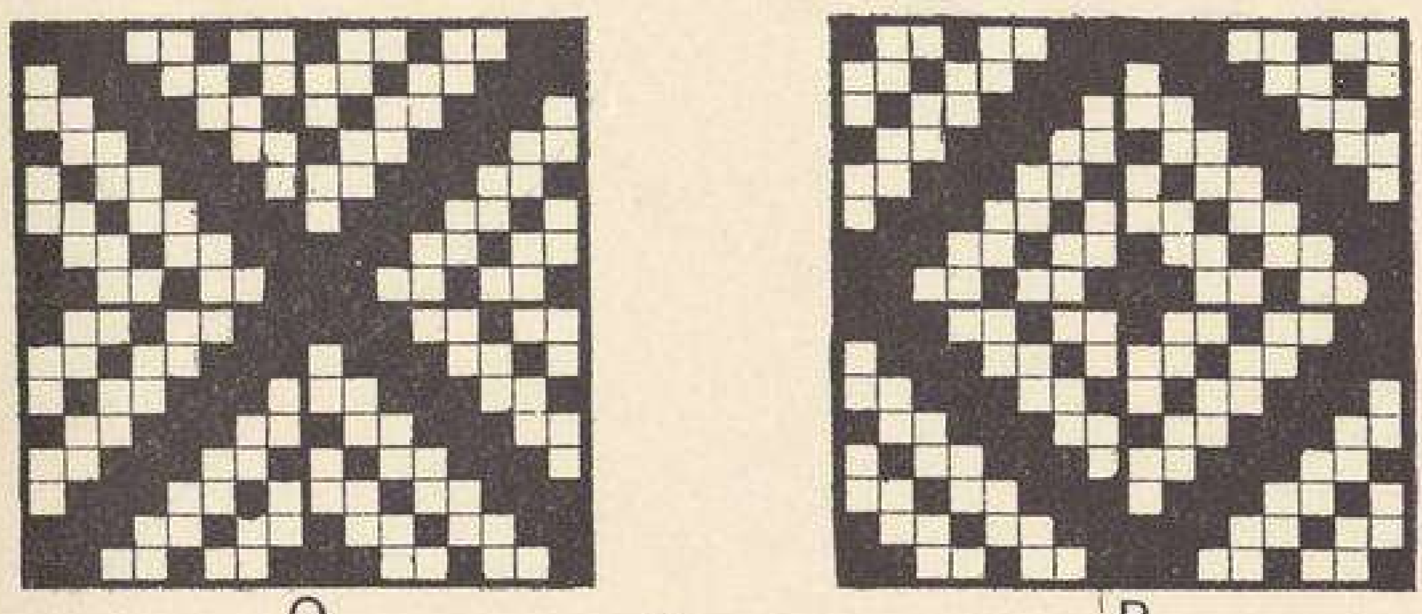


FIG. 86.

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

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

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

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

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

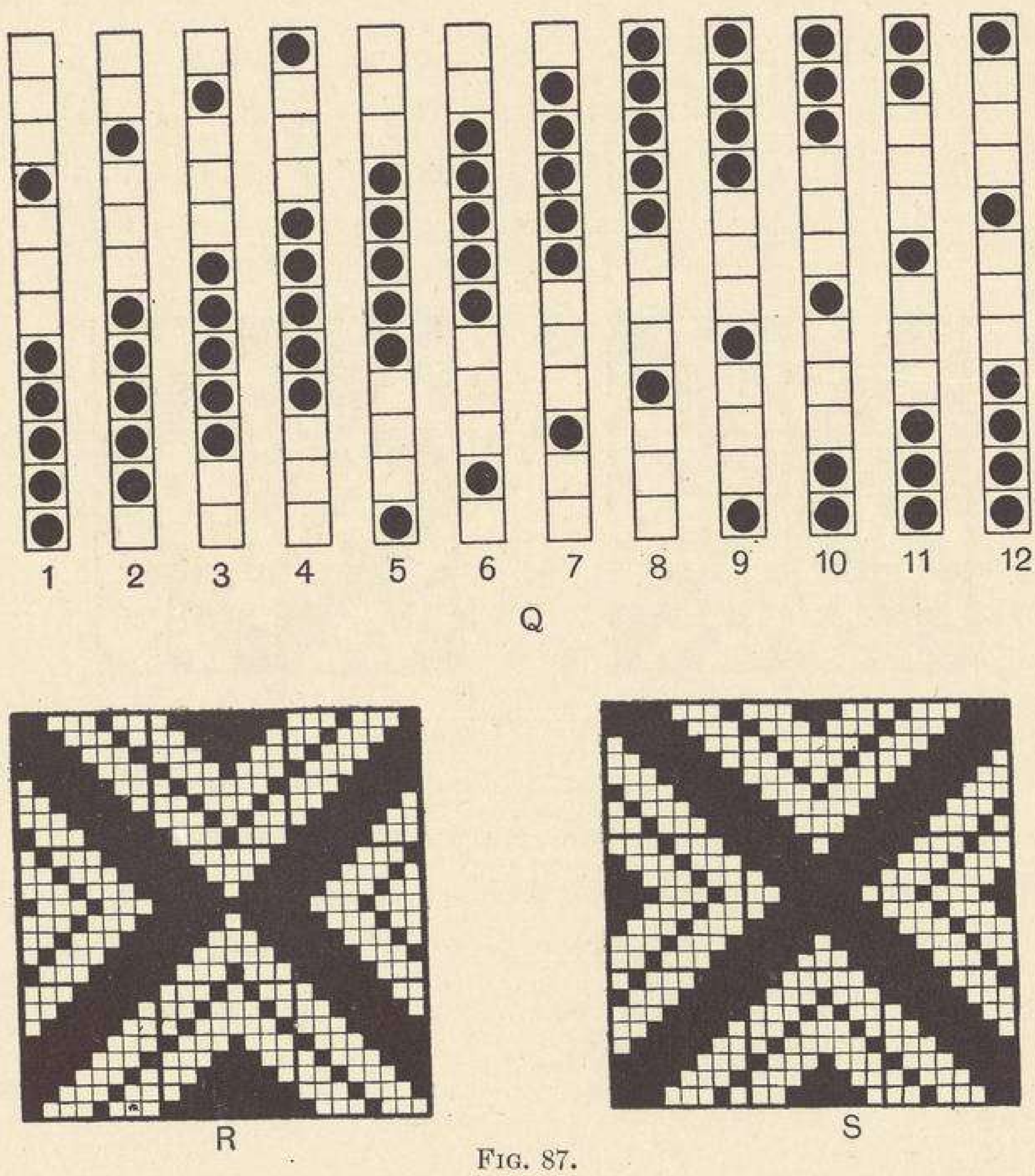


Fig. 87.

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

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

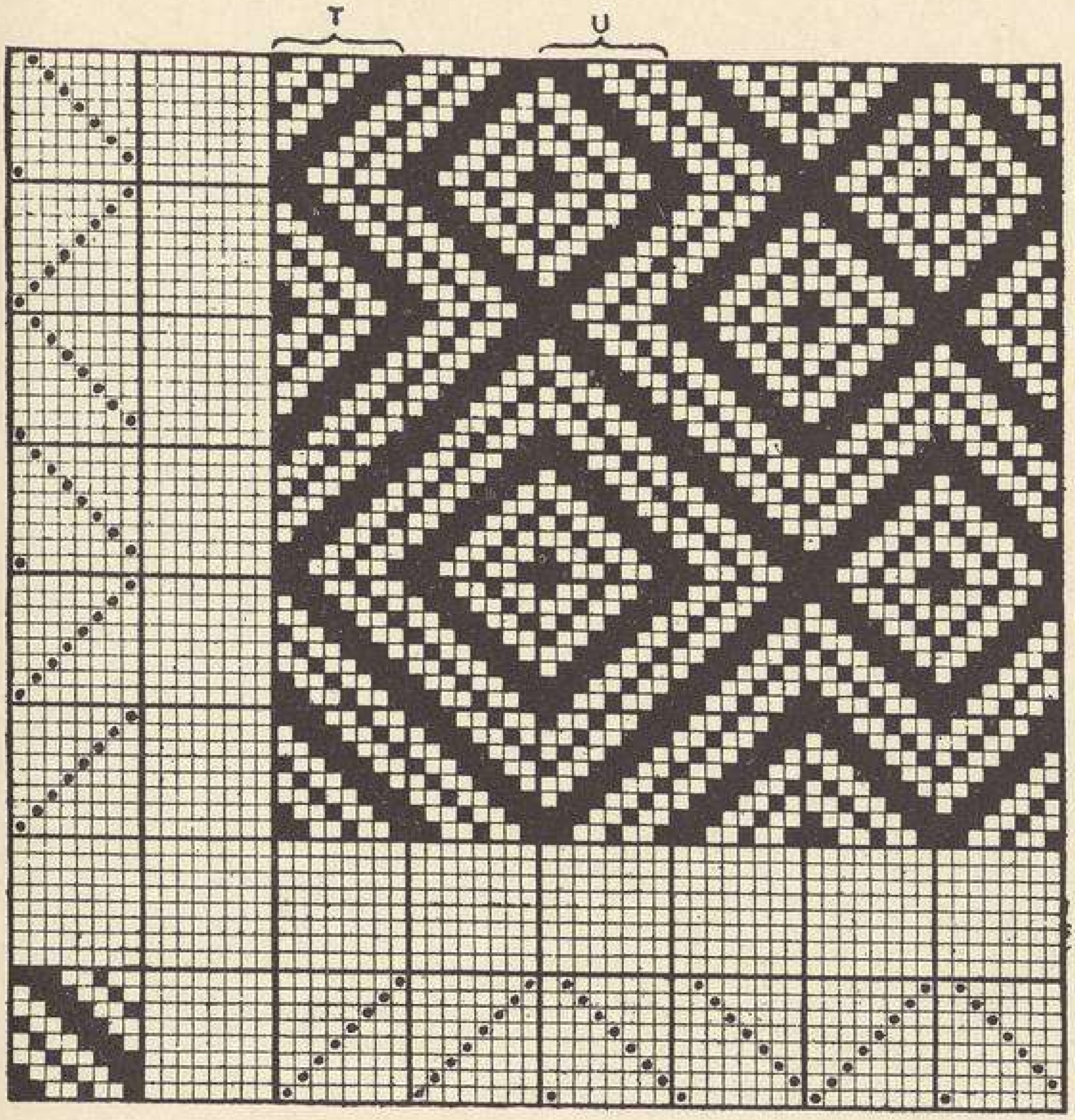


FIG. 88.

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

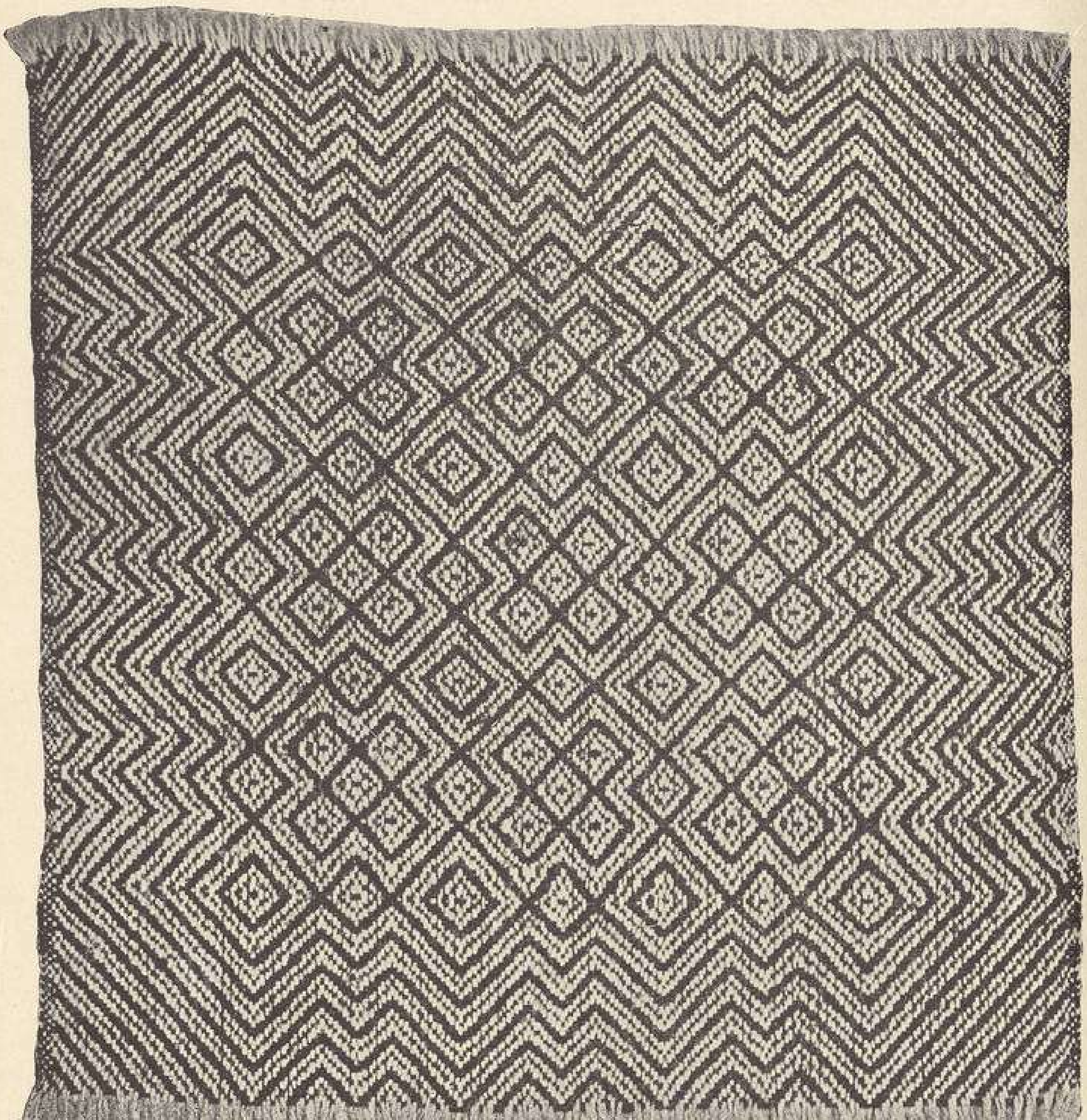


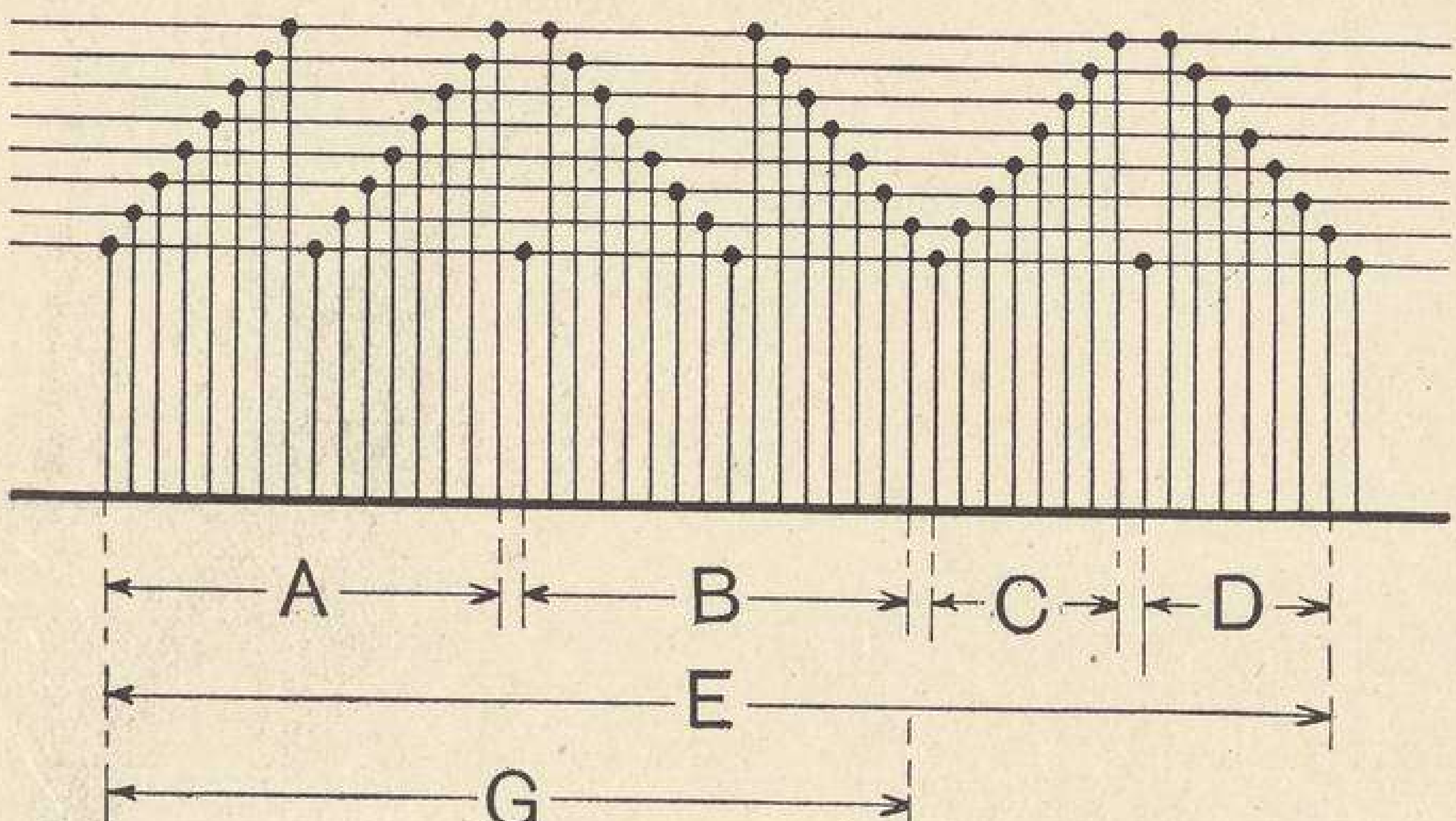
Fig. 89.

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

It is not absolutely essential that the designs should be made with drafts as regular as those we have just described. There are certainly some exceptions, but, as a general rule, there is very little restriction to the order of drafting which one might select. Fig. 88 shows a design on 48 threads and 48 picks, made from the same weave as O and P

FIG. 90.

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



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

FIG. 91.

In connection with designs O and P in Fig. 86, we stated that the choice of inserting the initial weave was optional—that in both cases the same cloth would result. Different conditions, however, obtain when we deal with complicated drafts. This remark is reflected in Fig. 92, where the same draft is used as in Fig. 88, and also the same base weave $\frac{3}{2}\frac{1}{2}$. The weave, however, twills to right in Fig. 92, and it is easy to see that a totally different effect is obtained by this method.

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

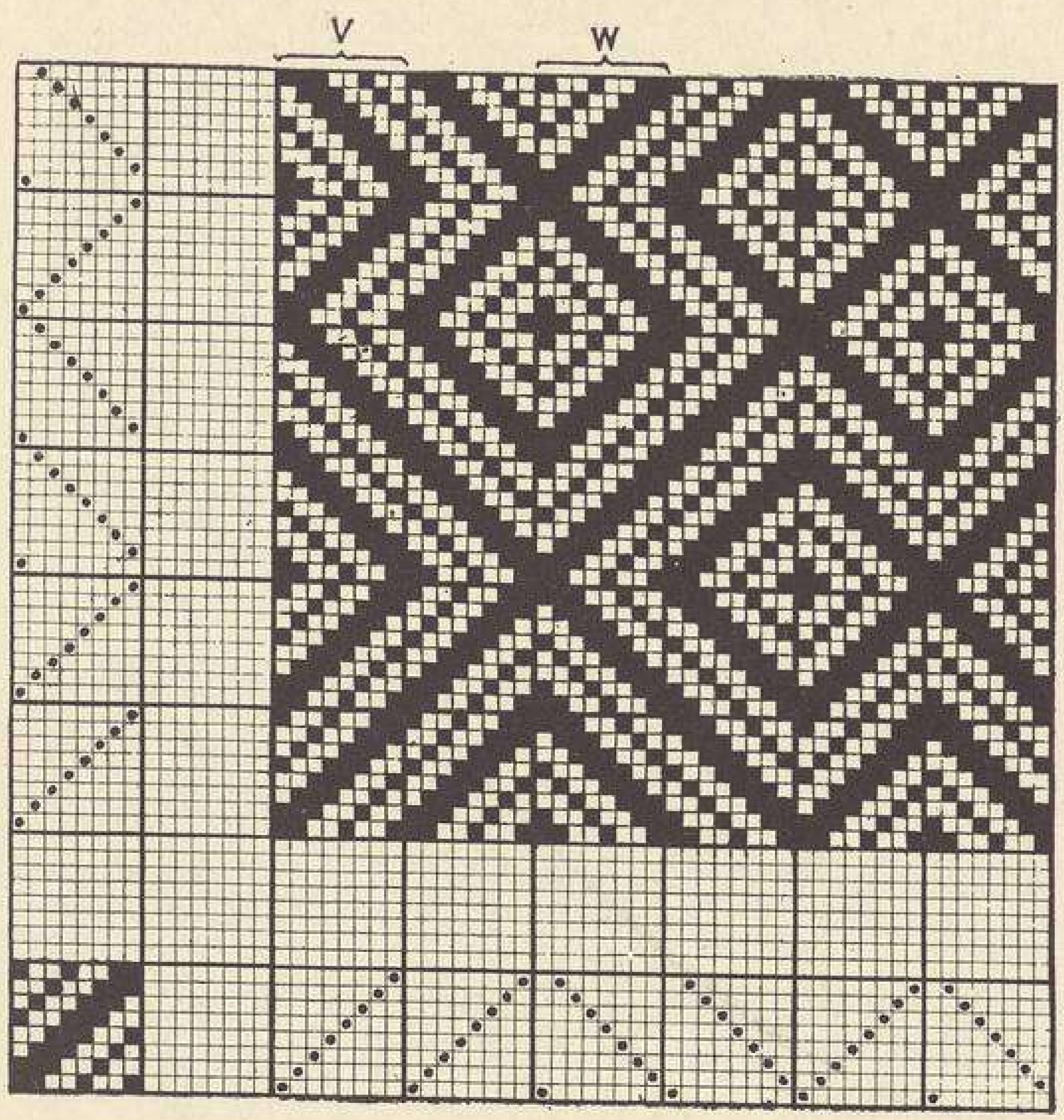


FIG. 92.

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

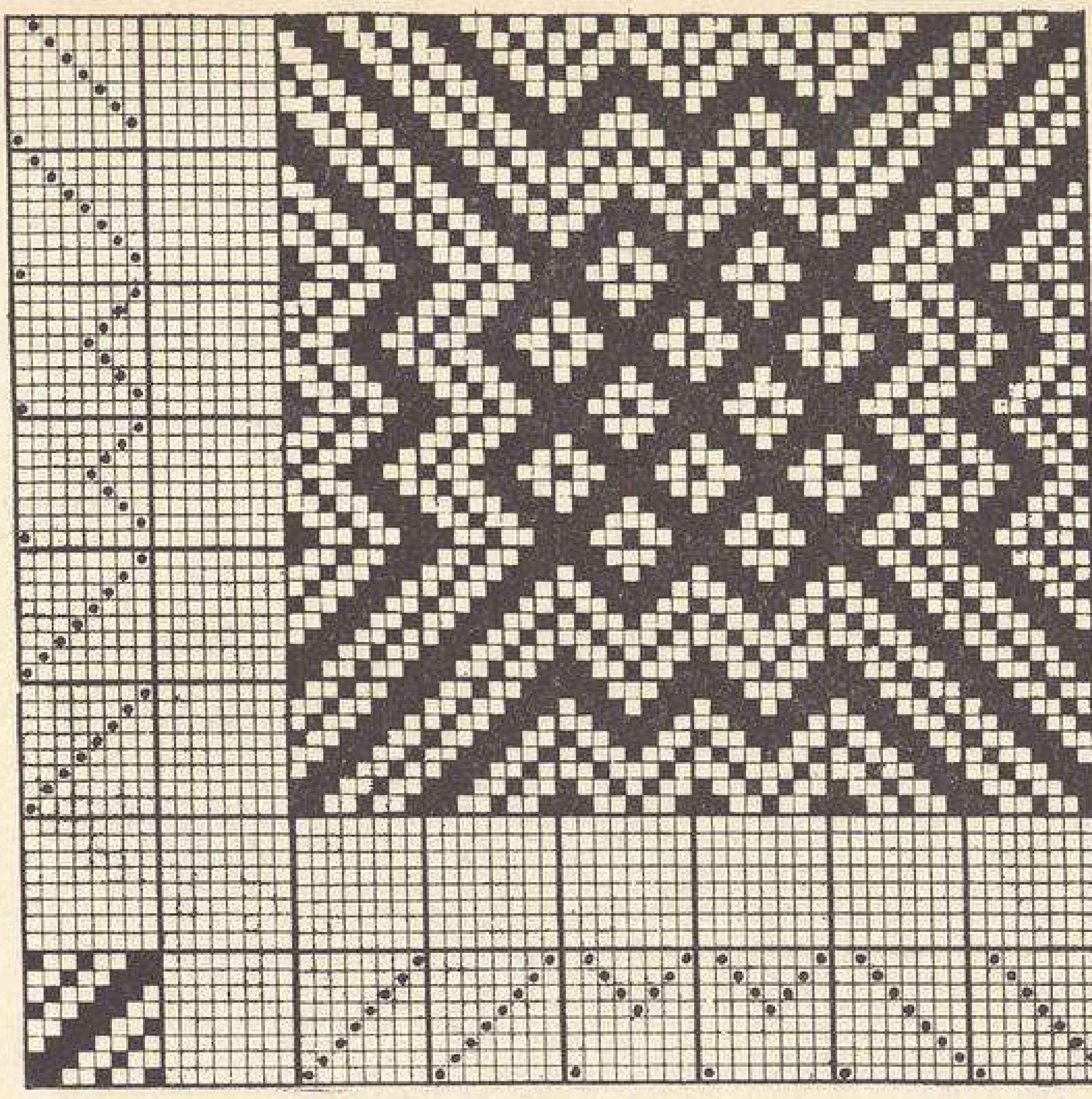


Fig. 93.

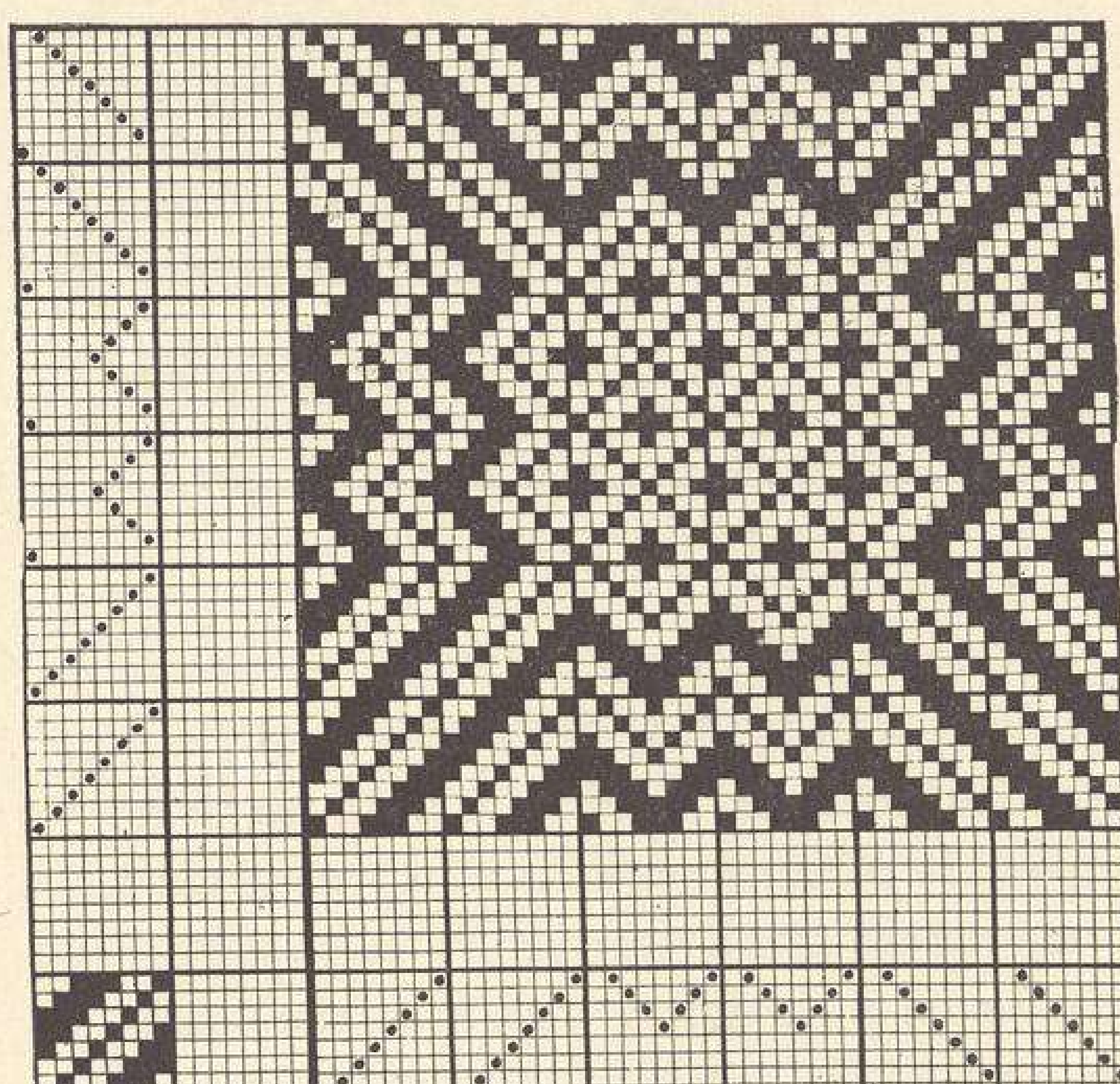


Fig. 94.

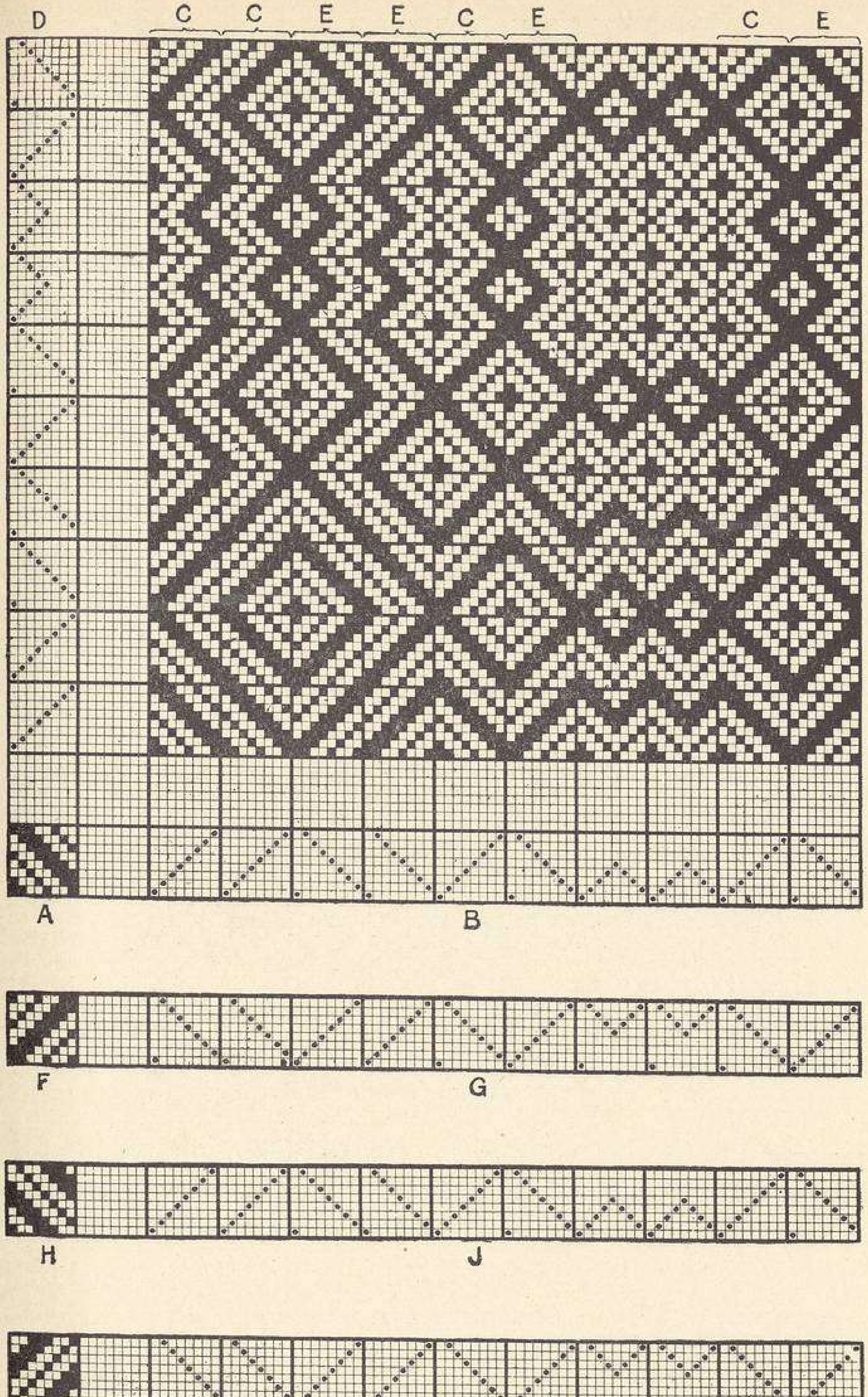


Fig. 95.

requirements are the draft and the weaving plan, the latter being arranged from the draft. The first eight threads marked T from the 1st to the 48th pick constitute the weaving plan for Fig. 88, but with the same draft and part U as weaving plan, it is possible to produce the design in Fig. 92. Similarly part V is the weaving plan for Fig. 92, but part W may serve to produce Fig. 88.

The number of diamond designs is greatly increased if both methods of production—*i.e.*, with drafts as at B and F in Figs. 83 and 84—are combined. Thus, still adhering to the same 8-thread weave, we have, by the joint method of drafting, made the diamond shown in Fig. 93, and a different design would result if the initial weave twilled in the opposite direction. An alternative method of obtaining a similar design is illustrated in Fig. 94, produced as shown by commencing the initial weave with the thread $\frac{1}{2}\frac{3}{2}$. Again, the same weave, but twilled to the left, may be used if another effect is desired.

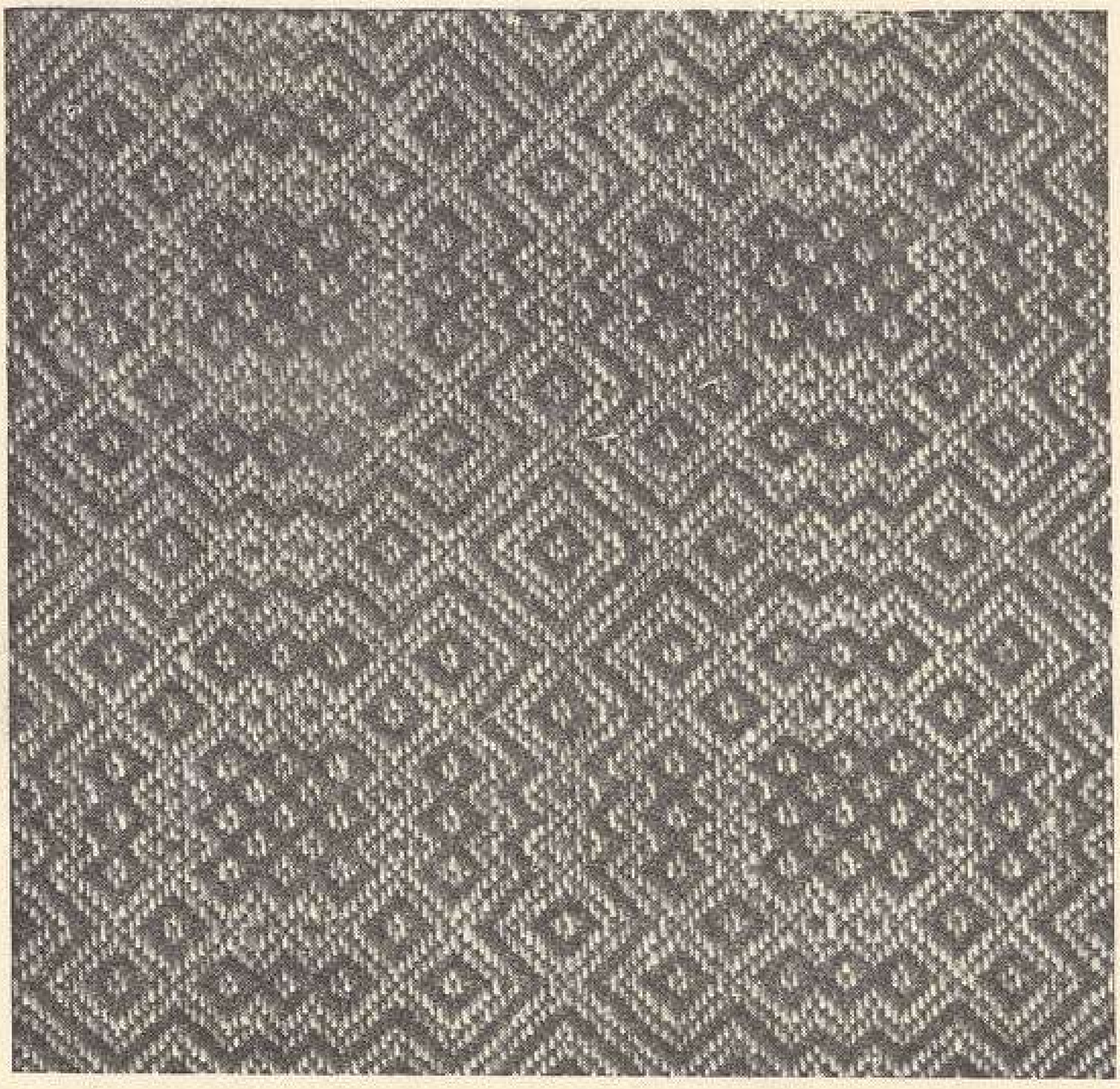
The foregoing demonstrates clearly that it would be extremely difficult, if not altogether impossible, to define the possible limits of this joint method, even if we were confined to one weave unit. It has been shown that any desired size of diamond may be obtained even with a small weave; the same principle may be employed when using a more elaborate weave, the diversity of effect increasing with the varied character of the weave. It is impossible to show this except by large designs, and these when reduced to the proportions necessary for reproduction would lose all their effect. We, however, conclude this unique method by a design of a rather larger size, as shown in Fig. 95. Here we show three distinct sizes of diamonds formed by the heavy lines; in addition to these, there are diamonds of a different character, and also semi-lozenge figures. The

M

N

Fig. 96.

O



P

Fig. 97.

means by which the effect has been obtained are clearly shown in the figure :—

A is the base or unit weave.
B „ draft of the cambs.
C „ weaving plan.
D „ picks arranged in order of draft.

We think that this figure is sufficient to prove that, with suitable arrangements of drafts, it is possible, theoretically, to obtain diamonds graduated from as large as we wish to the smallest effect obtainable by the particular weave adopted.

Figs. 96 and 97 are photographical reproductions of cloths made from designs of the above nature. Pattern M is made from the design in Fig. 95, while pattern N is the reverse side of the same cloth. Pattern O, Fig. 97, is the right side of the cloth, and pattern P is the reverse side of the same cloth made from a design composed of the unit weave H and draft J, Fig. 95. A different design would result if plan K were taken for the unit base; but if, in conjunction with this base, the draft L were employed, and the picks arranged to correspond, the same design would be obtained. Similar remarks are applicable to the weave units and drafts A, B, F, and G. The reader is advised to work out designs from drafts B and G, using part E as the weaving plan.

Having explained at some length the possibilities of the straight or rolling twill in the production of diamond patterns, we must now consider the methods to be followed when basket weaves are utilised for similar purposes. It has been shown that there is practically no restriction with the former kind of weave—a base or unit weave on any number of threads and picks may be chosen, and the turning point in the draft fixed at will. In patterns where the basket weave is present, however, certain limitations are presented. In breaking up a three or other odd float, as explained in reference to S, Fig. 87, the warp threads only were considered; but it is quite clear that if the required condition obtains with respect to the initial thread in the twill weave, it will apply likewise to the initial pick. This is clearly shown at S in Fig. 87, for the first thread and the first pick begin and end in exactly the same manner. These remarks, however, do not apply without modification when splitting up a 3 or a 5 float in a basket weave. Where such a weave occurs, it is obvious that so far as the warp threads are concerned this splitting up may be done on any one of the three or five threads respectively, according as the basket effect appears in solid blocks of 9 or 25 squares. With a basket or block of 9 squares, the only possible way of breaking up the group, provided that the foundation lines of the diamond are required to appear in basket, is shown at P in Fig. 98. The solid marks represent the unit weave as it should be commenced, and it will be observed that the beginning and the finish of the first thread are identical with the corresponding parts of the first pick. Should the basket effect be required to form the inside portion of the diamond, then the arrangement should be as at Q in the same figure. Here the choice of the initial thread and the initial pick must be such that both the twill part and the basket part—the latter both in the way of the warp and of the weft—will be split so as to fulfil the necessary condition of having one square more of the total float at the beginning of the base weave than at the end. In both designs, the first turn of the weave, *i.e.*, in the way of the warp, is shown in crosses; while the turn in the weft is illustrated by dots. The observance of these little yet important details enables one to produce the basket parts in their proper sizes, although every case of the

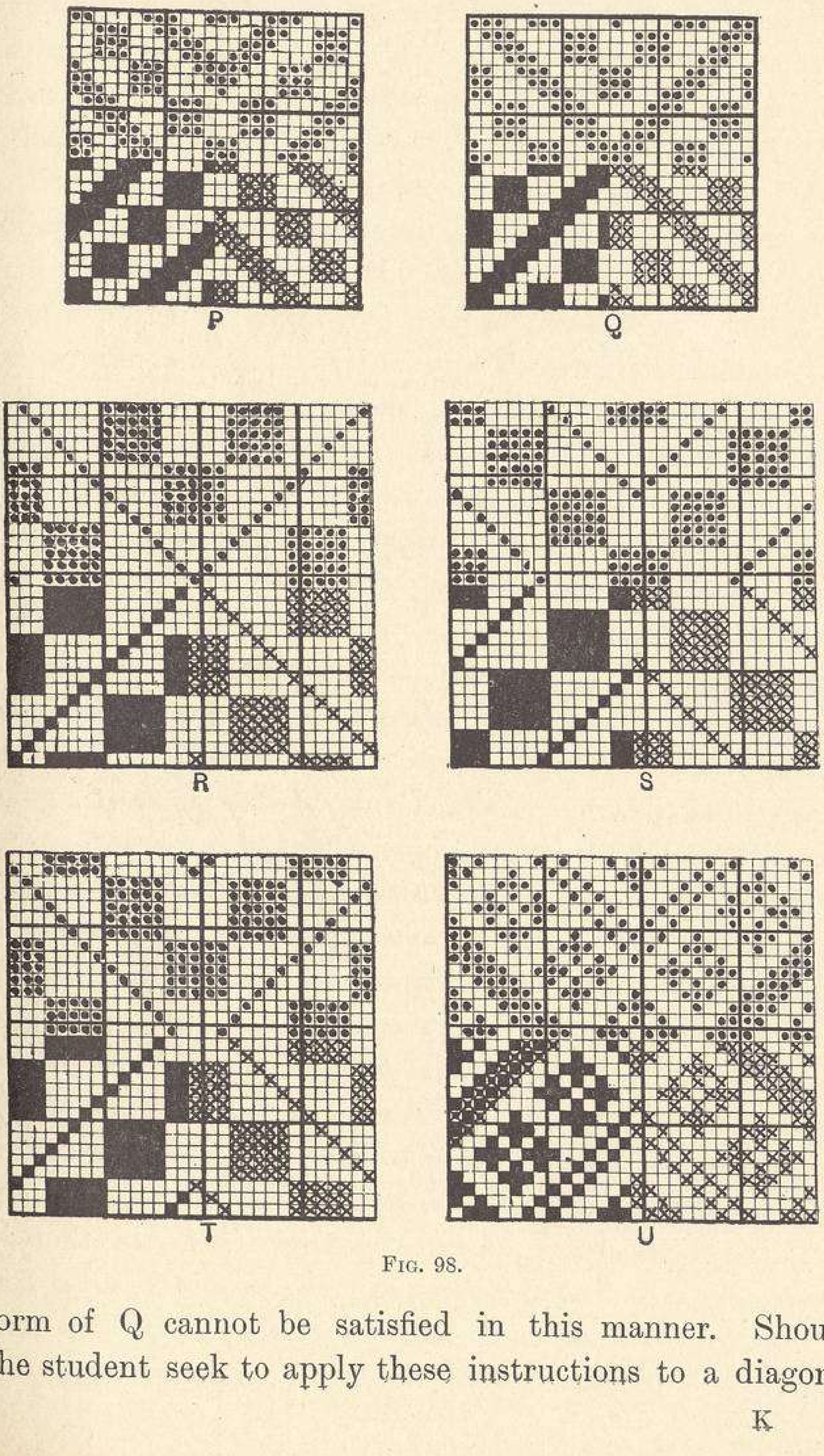


FIG. 98.

form of Q cannot be satisfied in this manner. Should the student seek to apply these instructions to a diagonal weave on 9, 15, etc., threads and picks, where three or five groups of basket appear in the weave, and where the straight twill float is over an odd number of picks, he will find that it is impossible to get an effect similar to Q in the above figure. In other words, with such a weave on an odd number of threads and picks, it is impossible to get the diagonal parts in continuous straight lines, and at the same time have perfect squares in the basket parts of the design. To obtain a perfect result, the number of threads and of picks in the unit weave adopted must be equal to $2mn$, where m = any number greater than 1, and n = the number of threads or picks in the basket group. It is easy to see that the number $2mn$ is even. If the number of threads in the unit weave were odd, and the float of the straight twill part also odd, it is evident that their difference would be an even number. Now, when from this even number we deduct the float of the basket—an odd number—we are left with an odd remainder which cannot be split so as to give equal spacing on each side of the main diagonal lines. Designs R and S, constructed from the 15-thread twills given, demonstrate this clearly, although perhaps not exhaustively. The weaves might be commenced at other points, but similar imperfect results would ensue. R is a very imperfect design, and would never be used in practice; S is a feasible design, for here the basket parts are perfect, but the spacing on each side of the basket is unequal. This could be remedied by adding another row of marks to the twill parts on the right and left-hand sides of the design, but the unit could then be used only as it stands—the twill part would have a float of two, and consequently could not be utilised to form continuous diagonal lines. Similar remarks apply to design T, which differs slightly from the last examples. These designs are given with little ornamentation, in order that the method of construction may be clearly seen, but all three might be modified, and probably improved, by judiciously adding some and taking away other spots. Design S has been so treated to form design U in the same figure. The space on each side of the diagonals is equal, but in order to obtain this result it has been necessary to add the marks ✖ to the solid unit, and to make the corresponding alterations on both sides of the design. Such alterations show clearly that the design may be considered as being formed from an irregular unit, and not from a regular weave.

The method just described leads us naturally to the third method of forming diamonds, as illustrated at A, Fig. 99. It consists of first forming the foundation or base lines as indicated by the solid marks — that is, commencing on the first thread and first pick, and running out one diagonal on the desired number of threads and picks; then commencing on the second thread and last pick, and twilling in the opposite direction. The four half diamonds thus formed may be filled in as fancy dictates, but generally in symmetrical form, while keeping in mind the cloth for which the design is intended. If they require filling in with straight twills it is only necessary to observe that the marks added within the diamond shall be situated at regular distances from the base lines. The top and bottom parts of A show this method of filling. If, however, any basket weaves or other small spot effects are to be introduced, some little consideration will require to be given before the marks are added, in order that the space at disposal may be properly utilised, and that a symmetrical arrangement

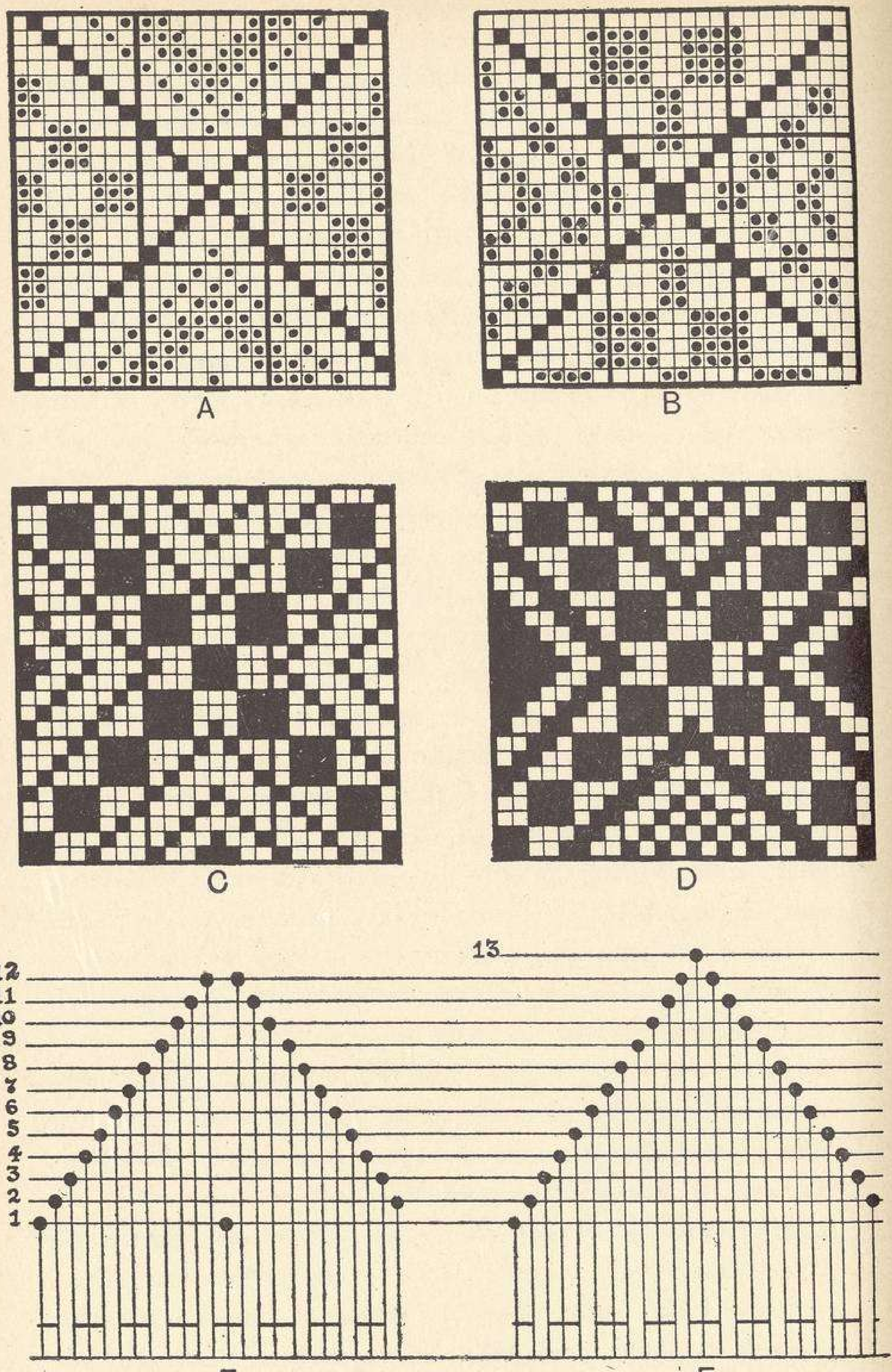
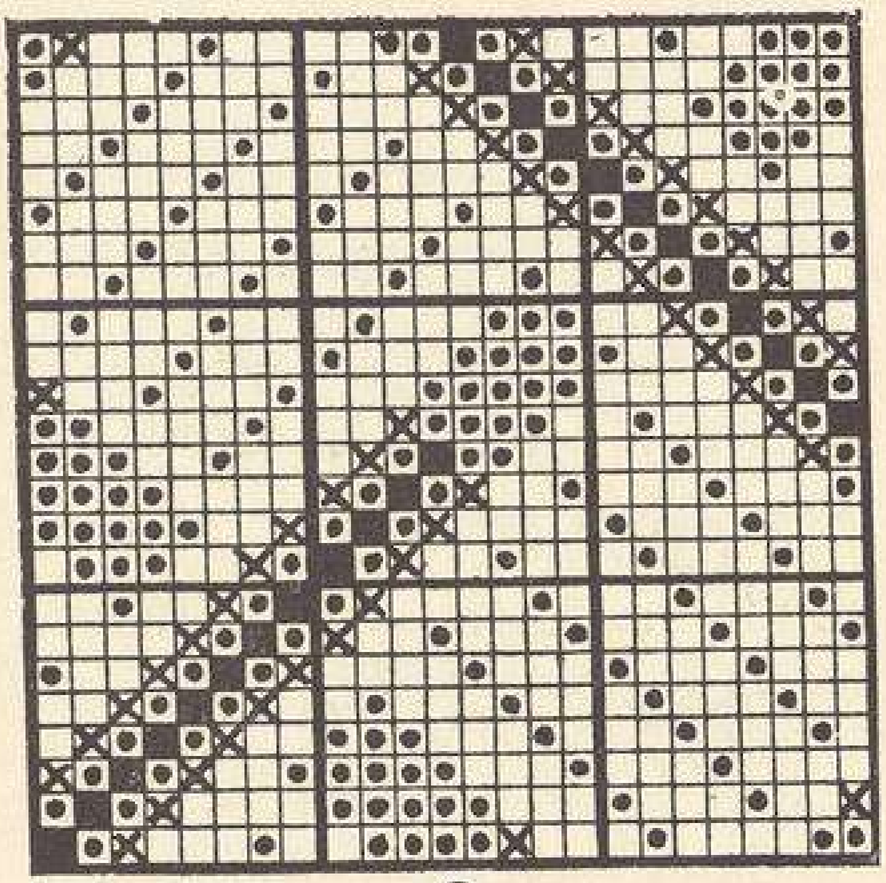


FIG. 99.

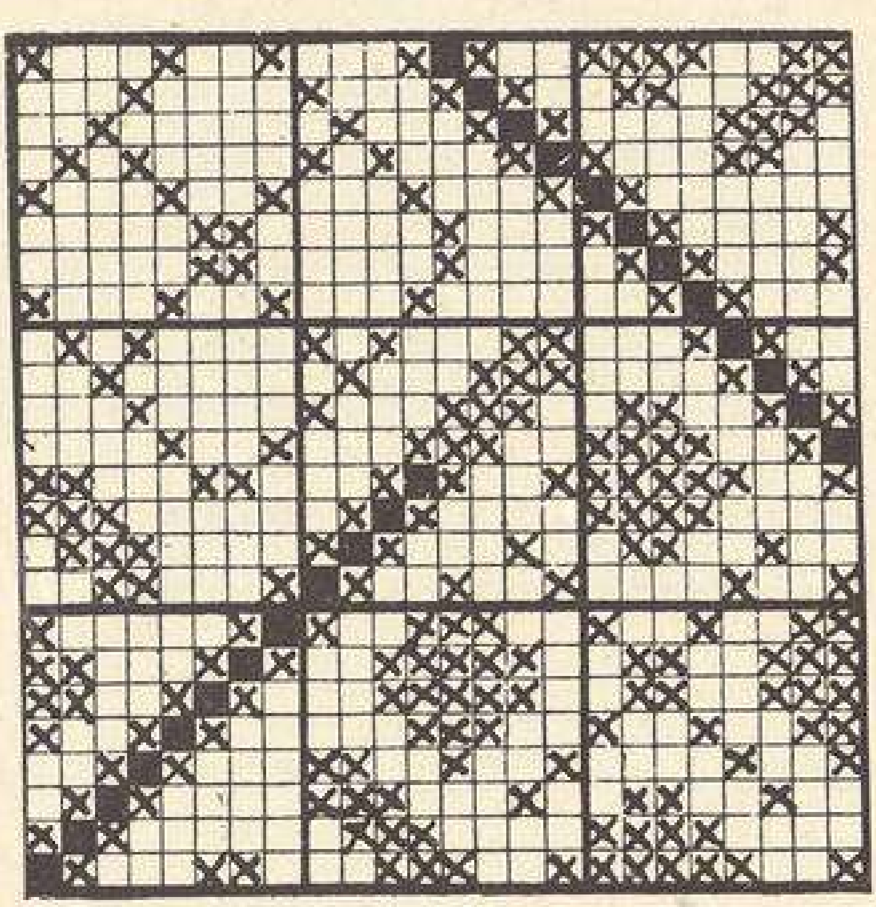
may be obtained. Methods of calculation might be formulated to give assistance in this respect, but the simpler way is to find out by trial what is most suitable. This may be done by beginning at the centre of the diamond and then working outwards and around it. The right and left-hand portions of A have been treated in this manner. Design B, Fig. 99, is developed on the same principle, but on an odd number (23) of threads and picks. The design shows that if an odd number be selected, a double thread—technically termed a "flat" —will result. Except on special occasions, two threads working as one is a distinct fault, and should be avoided. It will be seen that the base at A, Fig. 99, is made on exactly the same principle as that for the honeycomb design already given in A and B, Fig. 55 (p. 69).

Designs C and D in Fig. 99 have been introduced to show that the system of drafting at F may be derived from that at E by altering, if it is thought desirable, the centre of either diamond or the centres of both. Consequently, after the design has been prepared according to the method of drafting illustrated at E, any symmetrical alterations may be made on the pattern with an increase of only one shaft in the draft. Such alterations affect the draft only so far as the similarity of the turning threads is concerned; when these differ a shaft is required for each, but when they are alike they may be drawn on one shaft. A comparison of the drafts E and F shows that in the latter the thirteenth thread has been transferred to an extra or thirteenth shaft, due to the change effected in design D, as compared with the original design C. The reeding is indicated by the short horizontal lines as being in threes. This order prevents the breaking up of the basket portions.

The fourth method of forming figures of a diamond nature, or what might be termed diamonds with interlacing foundation lines, consists in arranging the foundation or base lines on the principle illustrated by the solid marked squares of G, Fig. 100, and then adding to or taking from these marks, as seems most desirable. In G, which is arranged on 24 threads and 24 picks, the solid marks were first twilled straight for 12 threads and picks; then beginning on the thirteenth thread and the twenty-fourth pick, the twill was reversed to the twenty-fourth thread and thirteenth pick. The crosses were added next, and finally the dots to complete the design. H, in the same figure, is a slightly different development on the same base lines.



G



H

Fig. 100.

Double interlacing effects may be obtained by similar methods, as indicated at J, Fig. 101. This result might be classed under the third system of forming diamonds, since, if two parallel bars of marks form the base line of the design, the consequent line of blanks between them might be taken as the guide. The solid bars in such cases must be the same distance apart from the corner square or true diagonal of the design. Having determined such distance, and the extent of the float for the solid bars, the latter are twilled or run out in the ordinary way, sufficient squares being left blank where the twills intersect to break the continuity of the line. Design K, Fig. 101, shows the same base lines, but separated by a wider gap. The foundation lines in this design are almost completely over-

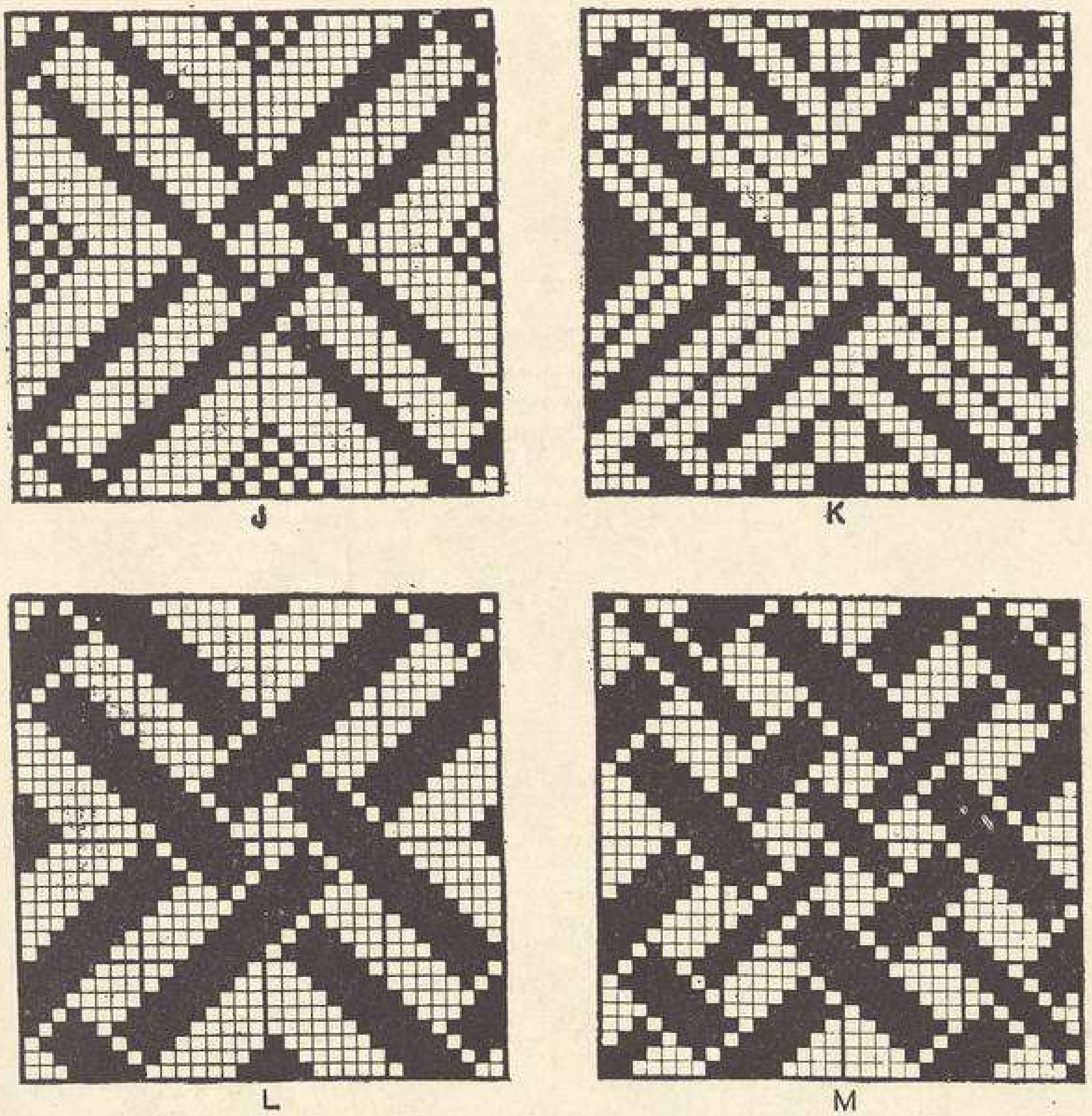


Fig. 101.

shadowed by the amount of detail added. The effect desired is all a matter of taste, but examples of this kind point out the desirability, if not the necessity, of studying closely the various methods of development. If the base lines are required to be very prominent, then broader lines and less detail should appear; this is emphasised at L in the same figure. Design M shows a further example, but composed of three bars in both directions. The diamond effect, or base, is almost completely lost because of the relatively small size of the design. In Fig. 102 the same base lines have been applied in a modified form, and, although some detail has been added, the constructional lines are much more distinct.

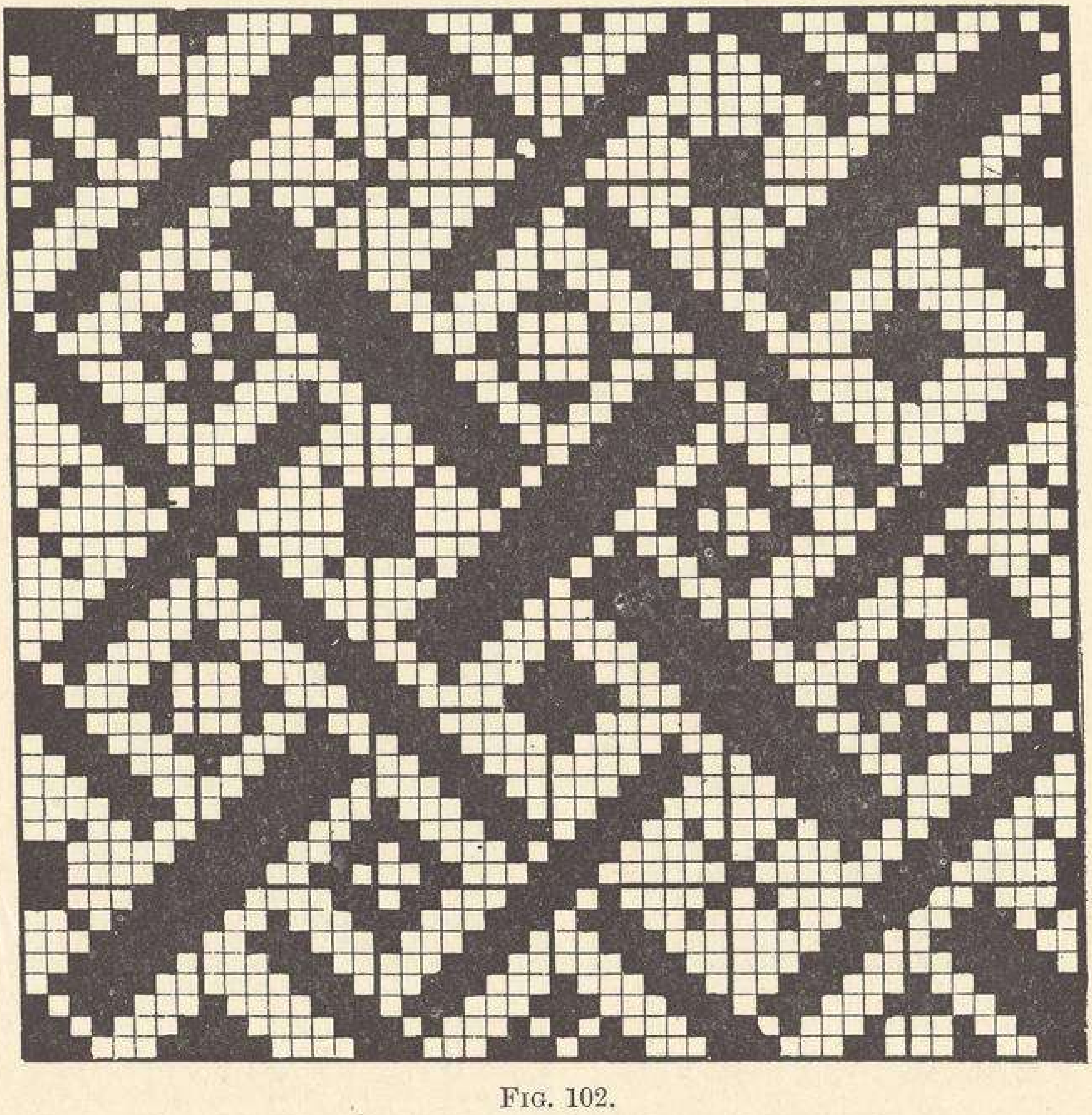


Fig. 102.

Designs of the above character, although approximately symmetrical, are yet sufficiently removed from the strict fulfilment of that condition to require a straight draft; they are, therefore, generally beyond the range of a dobby machine of ordinary compass. For the production of these designs, a harness or jacquard machine is desirable. It should, moreover, be mounted, say, for 192 or 384 hooks or threads—numbers which contain many sets of factors.

CHAPTER VII

DICES

Dice Patterns.—All patterns of a counterchange character, of which there is a large variety, and for the production of which there is practically an unlimited field, may be classed under the above head. The 2-shaft plain weave, in its elemental form, is a perfect example of this condition of counterchange, although from a structural point of view it is unsuited for designs of a dice character. This weave, however, and its derivatives (see Figs. 8 to 22, pp. 11-19), provide us with an almost endless variety of suggestions or motives for the development of dice patterns. In all such patterns, produced from warp and weft of one shade or colour, the effect depends primarily upon the predominance of the warp and of the weft in contiguous rectangles, and to ensure that the yarns will predominate on the surface of the fabric, and in equal proportions over the different parts of the design, the two weaves which are chosen for the structure of the cloth are almost invariably the counterpart or complement of each other. All fundamental straight twills, satin weaves, and a few of their derivatives, are available for this purpose, although some are more suitable than others, and are therefore more often used. For linen goods the weaves most usually employed are the two 4-shaft broken twills and the two 5-thread sateen weaves, while occasionally sateens on a greater number of threads are used. Straight twills are also employed for these goods, and usually with satisfactory results. The best effects are naturally obtained from weaves which permit the warp and the weft to predominate to the greatest possible extent in their respective rectangles; nevertheless, in the choice of any particular pair of weaves it is necessary to take into

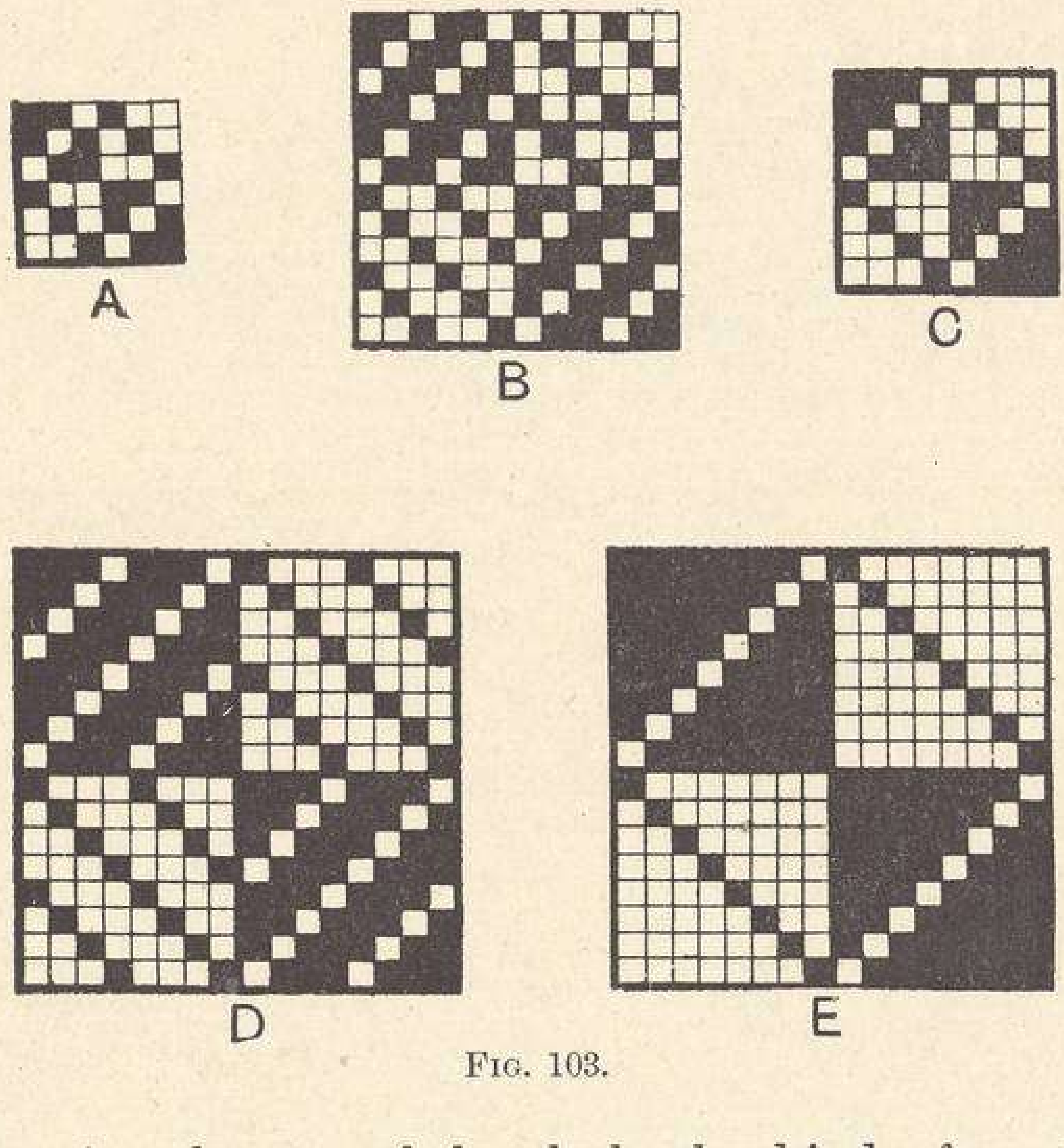


Fig. 103.

consideration the sett of the cloth, the kind of machine at command, the use to which the fabric is to be put, and finally its price.

Five dices of a simple character, which have been produced from straight twills, are shown in Fig. 103. Design A requires six shafts, and so does design B, but the same draft will not do for both. Similarly, eight shafts are required for designs C and D, but again the drafts will be different. Although designs A and C are distinctly dices in principle, they are much too small to produce such effects in the cloth. Designs B and D may be considered as the smallest sizes of dices, and even these are suitable only for moderately coarse textures. Nevertheless, they illustrate the two chief principles which are essential to the proper construction of such patterns. In each case it will be observed that the twills run in opposite directions in the adjacent portions of the design, and that where the warp float portions meet the weft float portions, the contiguous threads, as well as the contiguous picks, are the exact opposite of each other. In other words, the threads "cut" and thus firmly bind the edges of the pattern. This very desirable condition in dice patterns is more fully illustrated in Fig. 104, which shows at F and G respectively the incorrect and correct methods of treating the 4-thread broken twill. In G, which shows four repeats of the twill in each section, the first and last threads and the eighth and ninth threads form two pairs of cutting threads. A similar cutting effect obtains between the first and last and between the eighth and ninth picks. This, however, is not the case with the incorrect design F, where, although the twills have been reversed, and the first and last threads, as well as the eighth and ninth threads, cut correctly, the corresponding picks do not cut. In this instance the fault is due to the order adopted in developing the weave. In the correct method the order of marking is 1, 3, 2, 4, while the order of marking in the incorrect dice is 1, 2, 4, 3. The order of marking makes no difference in the cloth, provided that an all-over weave be used; it is only when two weaves of a warp and weft float respectively are combined, as in dices, that any attention to order of marking is necessary.

A defect sometimes urged against the correct method, as illustrated at G, occurs at the junction of the eighth and ninth threads and picks, where the four adjacent squares form plain weave. This defect is repeated at the junction of the sixteenth and first threads and picks, and it produces a somewhat open or pinhole effect. To obviate this result, the weave is sometimes started on the second

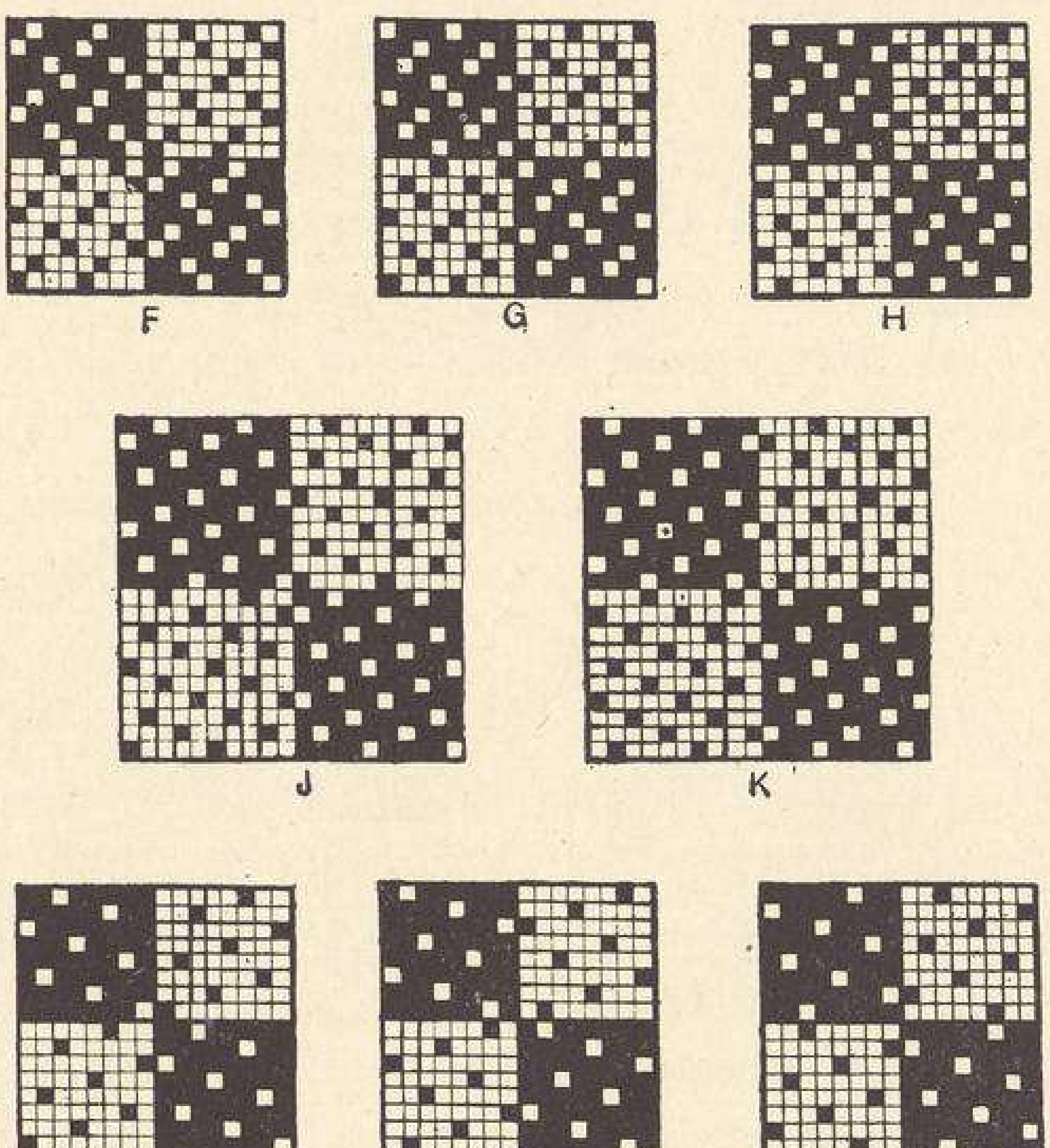


FIG. 104.

thread, as shown at H. The order is still 1, 3, 2, 4, commencing on 2; the arrangement is therefore 2, 4, 1, 3. This is probably the better way in which to arrange this weave for the production of dices, since, in addition to obviating the above defect, it is in keeping with the regular method of beginning the 5-thread and the 8-thread sateen weaves—viz., on the second thread. The incorrect and correct methods of arranging dices from the 5-thread sateens are shown respectively at J and K. The incorrect dice from the 8-thread sateens appears at L, while two correct arrangements are illustrated at M and N. In designs H, K, and M, the first point is placed on the second thread—a fact which can easily be remembered. Although this thread is in general as satisfactory as any other, still it is not the only satisfactory thread, as design N testifies; moreover, in special cases it is unsuitable. The incorrect dices, F, J, and L could, obviously, have been made to cut if the top half of each design had been made the reverse of the lower half—and designs can be so treated —but, if this were done, more difficulties would be introduced in designs of a more complicated character, as for example, Fig. 107.

Having explained the conditions which are essential for the production of perfect dices, and emphasised them by illustrations, we shall now endeavour to show how to determine the correct starting point or points. In Fig. 28 (p. 29) we have shown how it is possible to obtain all the sateen weaves from the fundamental units; and at A, Fig. 105, we reproduce one of the 8-thread sateens. If we examine this weave for two successive picks, which read from opposite sides of the design in precisely the same order, we shall find that the third and fourth picks, as well as the seventh and eighth picks, fulfil this condition. Any weave which contains two such picks may be split up between them, and then used for the formation of correct dices. The first and last picks of the ground weave will then be, as it were, the images of each other. This is clearly shown in weaves B and C in the same figure, and the dices formed from these units have already appeared at M and N in Fig. 104. The 10-thread sateen weave D, in Fig. 105, has been split up in the same manner, and the designs E and F show the two correct ways of starting the weave, while G and H illustrate their respective dices. A dice pattern from an irregular sateen appears

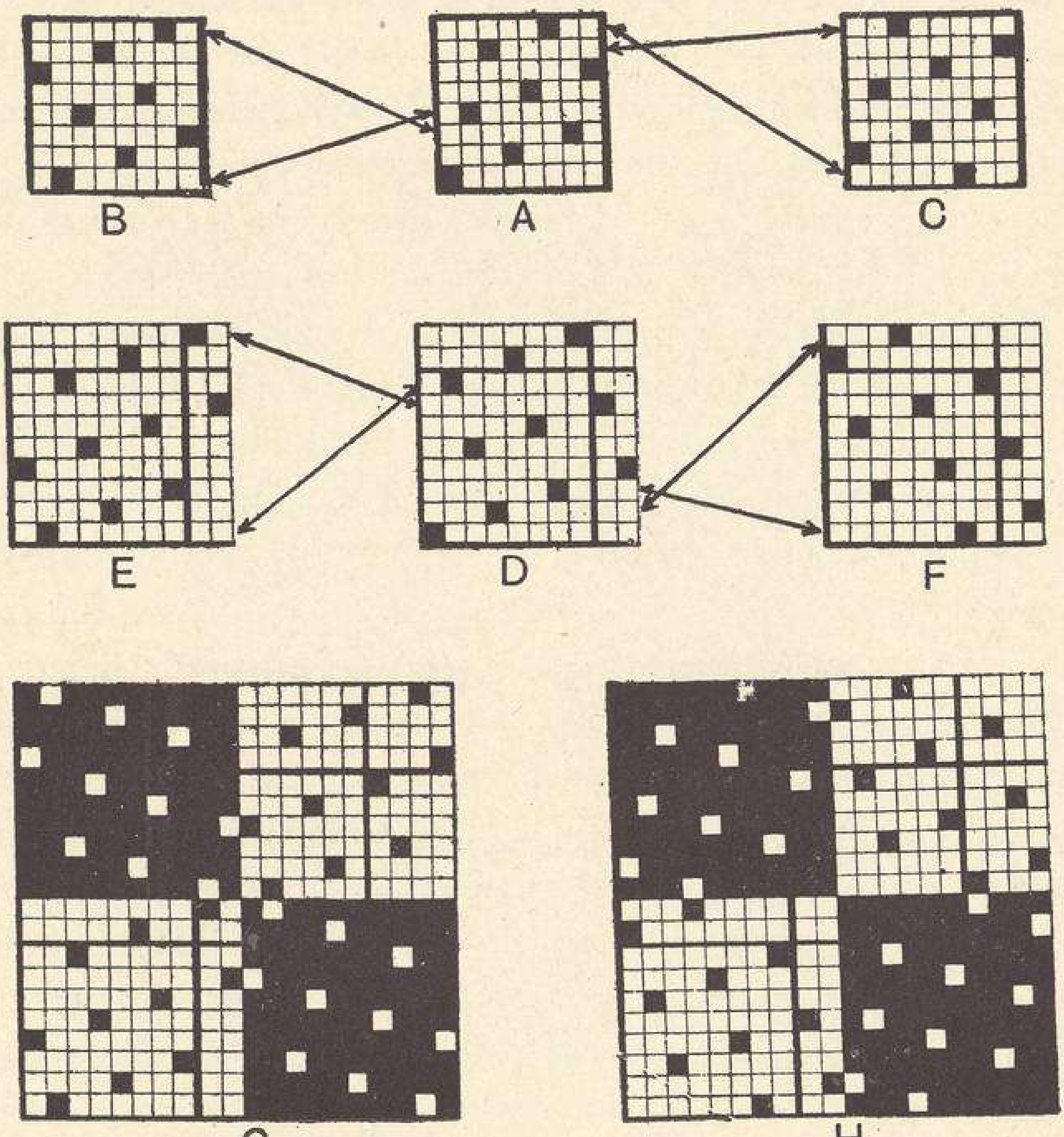


Fig. 105.

at J, Fig. 106, while K, which is of an entirely different character, is made from the same base weave, but starting on the fifth pick. Weave L shows the regular method of arranging the 6-thread sateen twill, weave M shows the arrangement after splitting up the weave between the first and second picks, while design N illustrates the smallest dice which can be made from weave M and its complement. It is easy to see from weave O that all fundamental straight twills may be used for dices, and weave P demonstrates that all the above weaves on an even number of threads may be split up in the middle and then used for

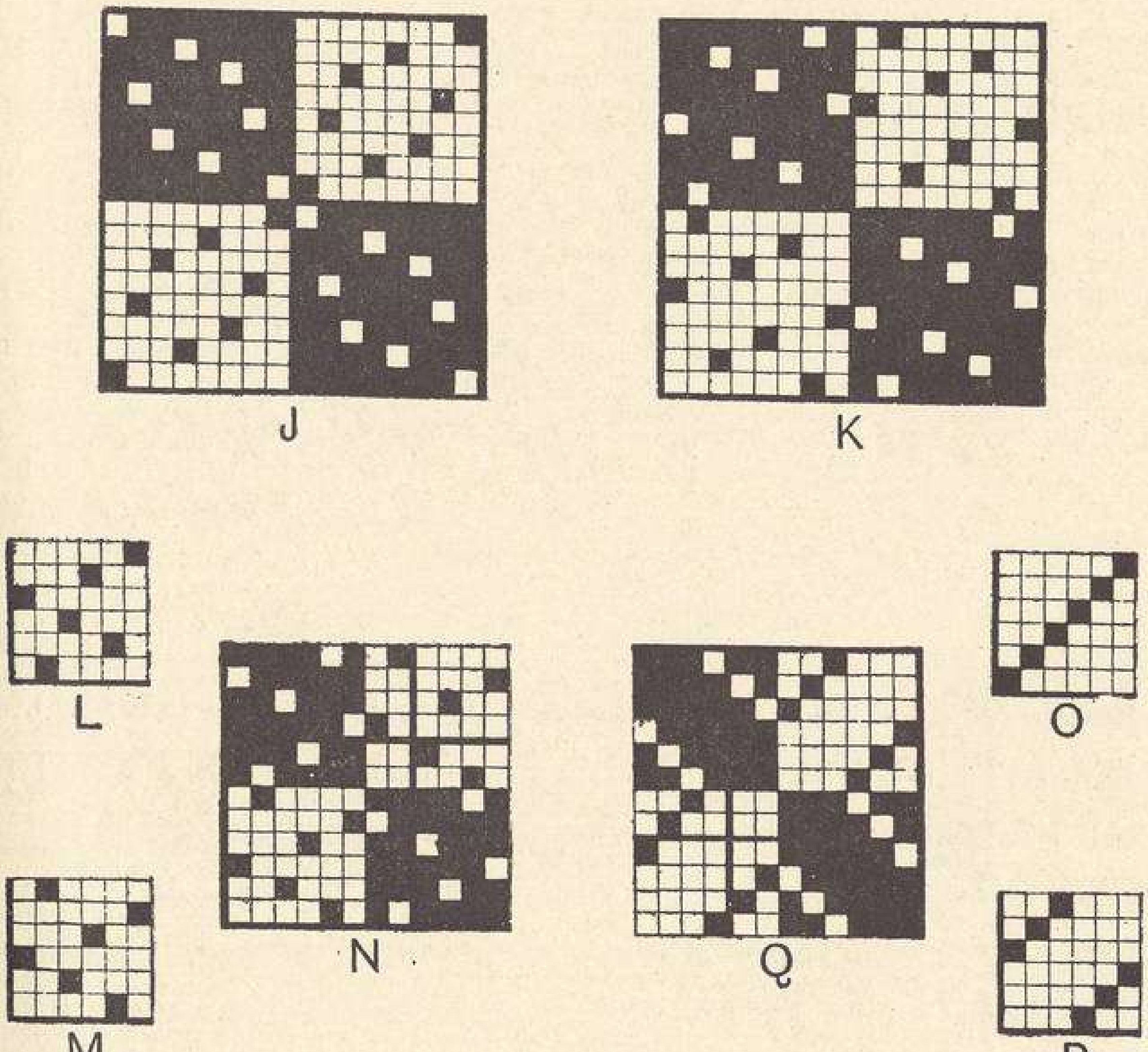


Fig. 106.

similar purposes. Design Q is a typical example of a dice made in this manner, the base weave being P.

In every case the unit weave, or any multiple of it, is first arranged in the proper manner as illustrated; the first thread of the opposite or right-hand part is then carefully arranged to cut with the last thread of the unit twill, while each succeeding thread (reading to the right) in the dark portion or warp figure is made the complement of each succeeding thread (reading to the left) of the light portion or weft figure. The two complete weaves or parts change places for the second half of the design. By attention to these details it is possible to construct any dice pattern in which the different portions will be perfectly bound. This statement naturally assumes that the number of threads and picks in each rectangle is a multiple of the twill or sateen weave used; if otherwise, special precautions are necessary. It must be remembered that all these figures have been made on the smallest possible scale: the characteristic feature of dice patterns can be obtained only when each weave is repeated two or more times in both directions.

As has already been mentioned, there is no limit to the number of ways of combining these weaves for dice and similar patterns, and in Fig. 107 we introduce a simple design on the same lines. The pattern is complete on 40 threads and 40 picks, and is composed of the same two 4-thread broken weaves that form design H, Fig. 104. The draft immediately under the design in Fig. 107 shows that eight shafts are required. The weaving plan is indicated by the first eight threads of the design, and 40 cards would be necessary if no automatic machine were used.

All the above dices are technically known as "two-division" designs—a method of distinguishing them which is due to the fact that, if all like vertical groups were placed together, there would be but two divisions. Each division requires the same number of shafts as the unit weave contains threads; thus, a 2-division design made from the 5-thread sateens requires 10 shafts (the example in Fig. 107 is a 2-division design requiring only 8 shafts).

When this class of 2-division work is made a speciality, the dobby machines are sometimes so arranged that only

4, 5, or 8 cards are necessary, according as the dice is made from the 4, 5, or 8-shaft weaves. Each card has two rows of holes, the cutting of the top row being opposed to the cutting of the bottom row. Either of the

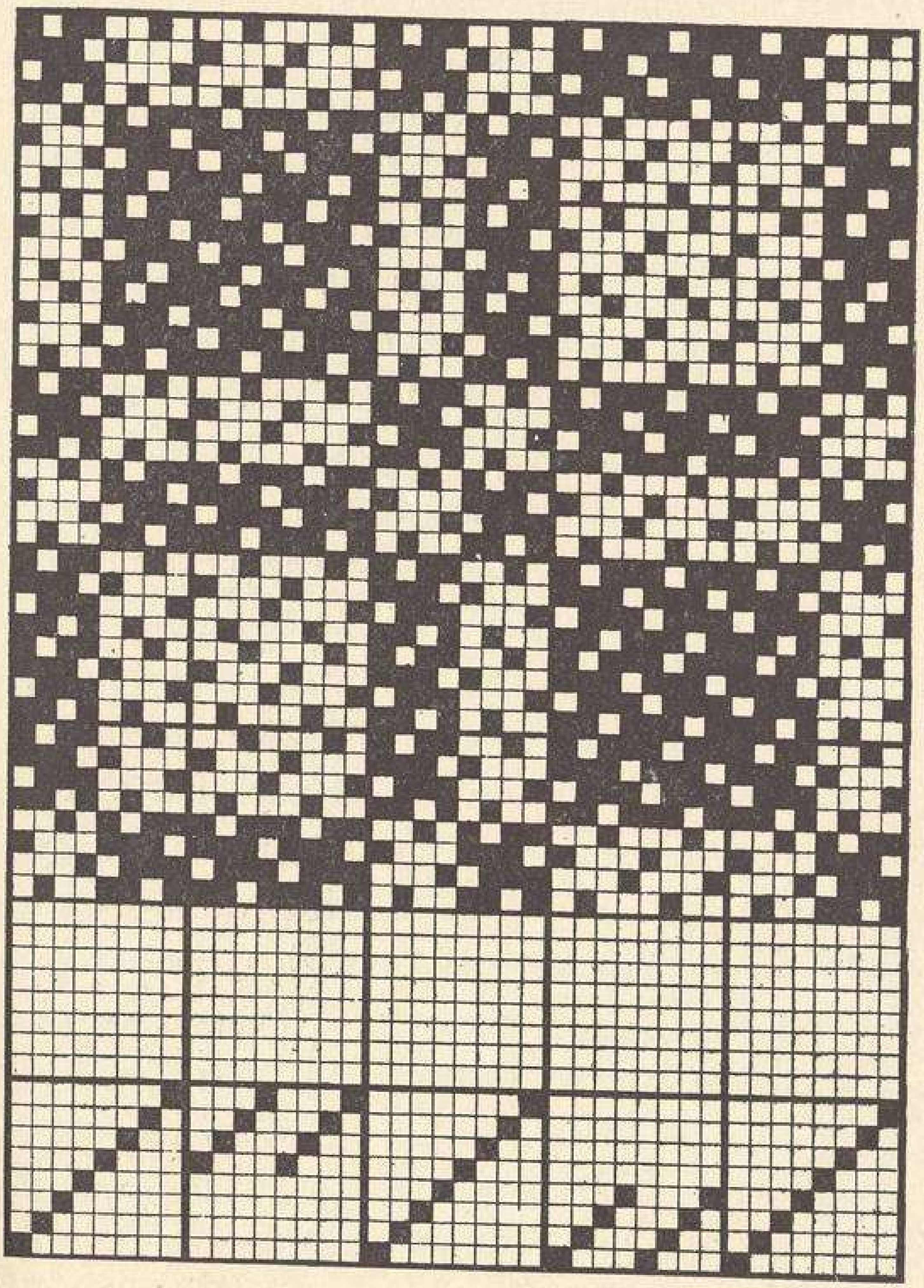


FIG. 107.

two rows may be brought to act against the needles of the dobby, and thus change the various sections from warp flush to weft flush, or *vice versa.* The controlling chain, which determines whether the upper or the lower row of holes on the card shall be in action, may be built to suit any 2-division pattern.

When a dice pattern consists of three, four or more different parts, it is termed a 3-division, 4-division, etc., design, and such patterns may be woven by a dobby machine fitted with the necessary number of needles, by a jacquard, or by the special automatic cardless dobby made by Messrs. Robert Hall and Sons, Bury. Fig. 108 shows ten designs of this type of dice, but a careful examination will show that all the ten are of the 4-division class, and, moreover, that all are composed of different arrangements of the same four divisions. The draft on 20 shafts at the bottom of the figure will do for all the designs, and, if an ordinary dobby be employed, the weaving plan shown to the right would be necessary for the production of the first design. All the other designs could be made with the same cards, provided that the draft be suitably altered in each case. If the draft remains as shown, then a fresh set of cards would have to be cut for each pattern.

The cards or lags which are used in the ordinary dobby are replaced in the automatic cardless dobby by a series of chains. Each chain controls (in this case) five shafts, and it is only necessary to move it every five picks; so that for a design on 20 shafts and 155 picks, only four chains, each composed of thirty-one links, are necessary. The parts marked 1, 2, 3, 4 in the weaving plan are obtained by the four chains shown immediately under the designs. Each large link represents five threads or shafts and five picks of the $\frac{4}{1}$ sateen, while each small link represents the same number of the $\frac{1}{4}$ sateen. The four chains and the four parts of the weaving plan may be compared in the figure by commencing at the left hand of the chains and at the top of the weaving plan. One great advantage of the cardless dobby is the fact that no alteration of

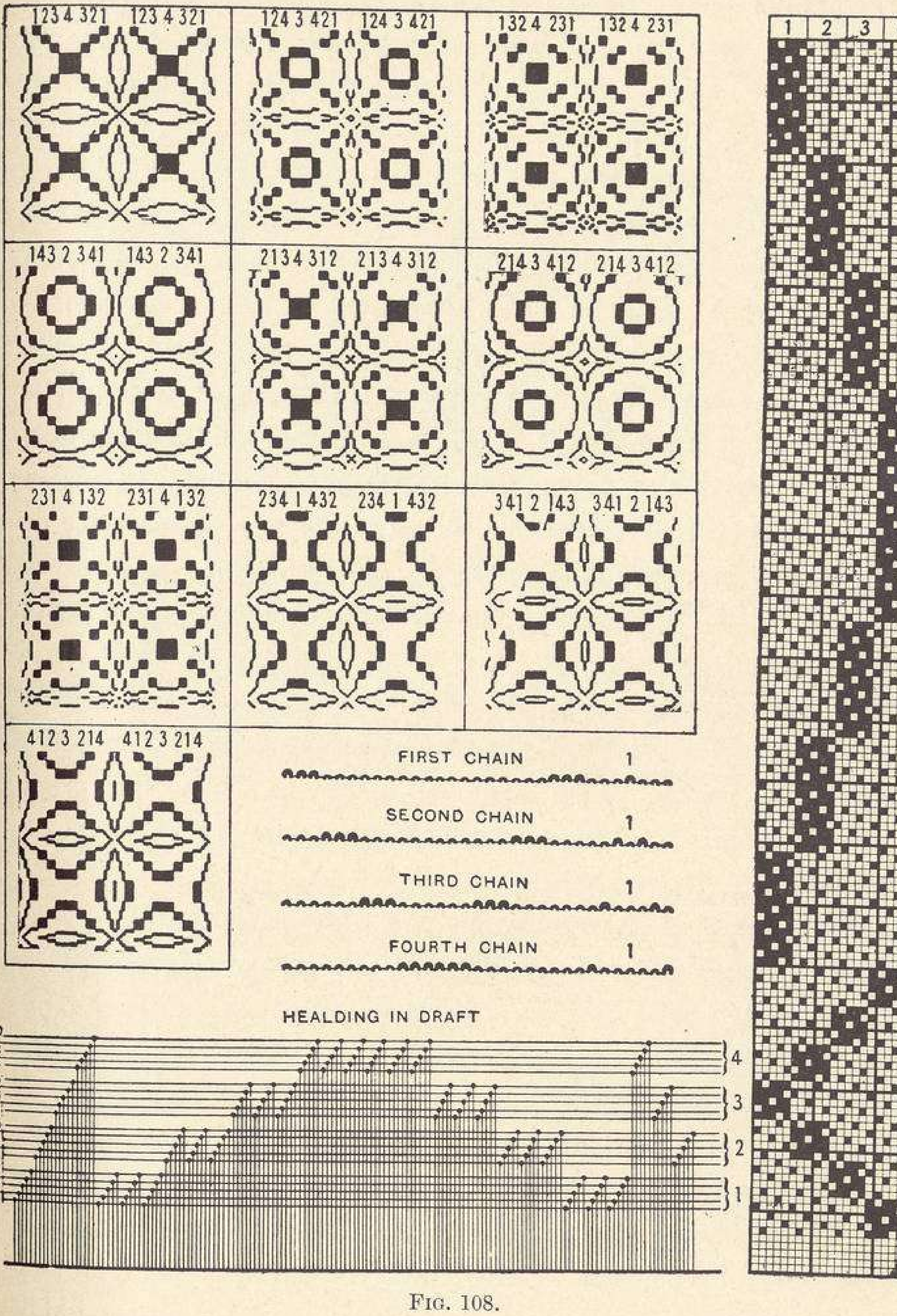


FIG. 108.

the draft is required for the production of the ten designs shown; all that is necessary is to change the positions of the chains according as the pattern alters—a method which, although easy in the case of separate chains, is clearly impossible when the full weaving plan is on one set of cards or lags.

All the designs in Fig. 108 are continuous, or all-over effects, and the draft given would, consequently, be repeated until the desired width of cloth was obtained. If side borders were required, then any part of the draft which would give a satisfactory effect could be repeated for a convenient number of times at both sides of the fabric. This arrangement would be quite sufficient for piece-goods, and still leave the design and cards continuous. In many cases, however, it is desired to complete the appearance of the towel or the tablecloth by the addition of a cross border, and this border is usually the same pattern as the side border. Whenever this desire is put into effect, it is essential to use a special set of cards in the ordinary dobby, or a special set of chains in the cardless dobby. In some cases the centre chain may be made to form the cross border, while in many cases part of the chain may be utilised.

Two such bordered designs are illustrated in Fig. 109. The top part of either design would do quite well for a cloth with a side border, and both could be produced by the four chains illustrated in Fig. 108. The draft for the centre part of design No. 1 is the same as the draft in Fig. 108, with the exception that it has been commenced in the last group of five shafts instead of in the first group of five shafts. This arrangement simply means that the positions of the four chains must be altered, and it has been adopted simply for a variation, and for educational purposes. The side border is merely a repetition of the first 20 threads and of the last 20 threads until the desired width of border is obtained.

The cross-border part in design No. 1 is the same as

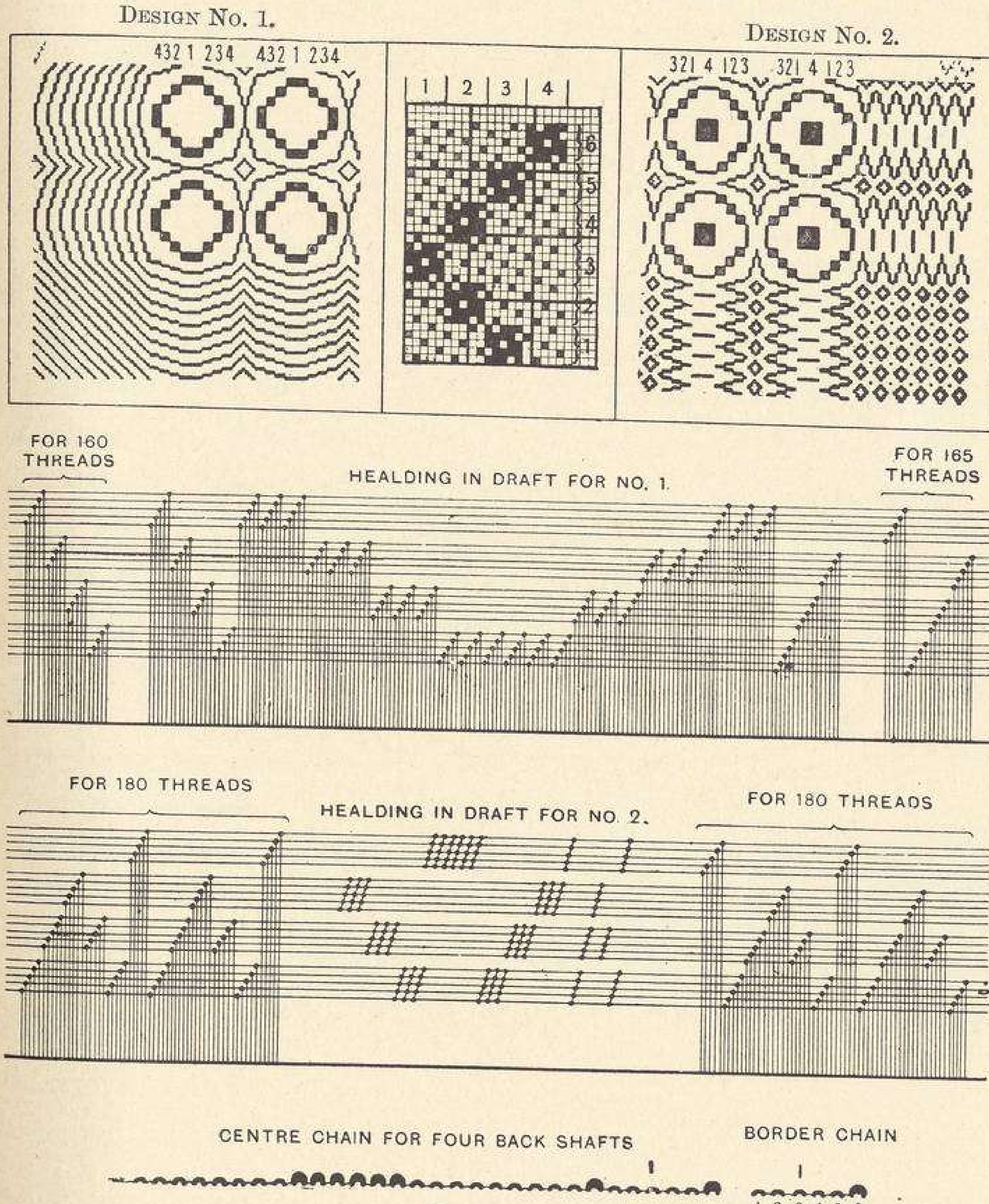


FIG. 109.

the side-border, while the corner part is a straight twill. The different parts of this border are obtained in a similar manner to those in Figs. 89 and 90. We cannot enter here into a discussion of the merits of the machine, nor into a description of it, but we may say that if any continuous part of the centre design appears in the cross border, the chains may be made to continue in one direction, or to reverse at will. These desirable movements are obtained by the introduction of an auxiliary controlling chain.

Design No. 2 in the same figure is specially interesting, for either the heavy part of the design or the small effect may be used for the centre of the cloth, and the other for the corner piece. The same long chains are still applicable, and one of them, as well as the draft, appears at the bottom of the drawing. Six repeats of the draft, or three times the amount shown, are required for each side border. The centre part should consist, if possible, of a certain number of repeats, minus the last 35 threads in the last repeat; this arrangement would make the pattern perfectly symmetrical. Weaving plan No. 2 shows only the arrangement of the shedding for the cross-border part; the short chain at the bottom of the figure is for group No. 4. Four links would give the same effect if the chain reversed on the third and sixth; a reduction here, however, would necessitate a greater number of links in the controlling chain, in addition to an excessive amount of reversing. If the reversing were done in this way, the last four links of the large chain would be utilised for the border. A better way would be to use the last four links and the first three links—seven in all,—thus reducing the reversals by one-half. The choice of any particular method of reversing naturally depends upon the character of the design, and upon the length of the chain.

Fig. 110 shows all the possible ways of arranging four groups or divisions, but it will be seen that numbers

1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, and 15 are respectively identical with, but start at different points from

24, 18, 22, 12, 16, 10 23, 17, 20, 14, 21, and 19.

A method of adapting the first design for a simple

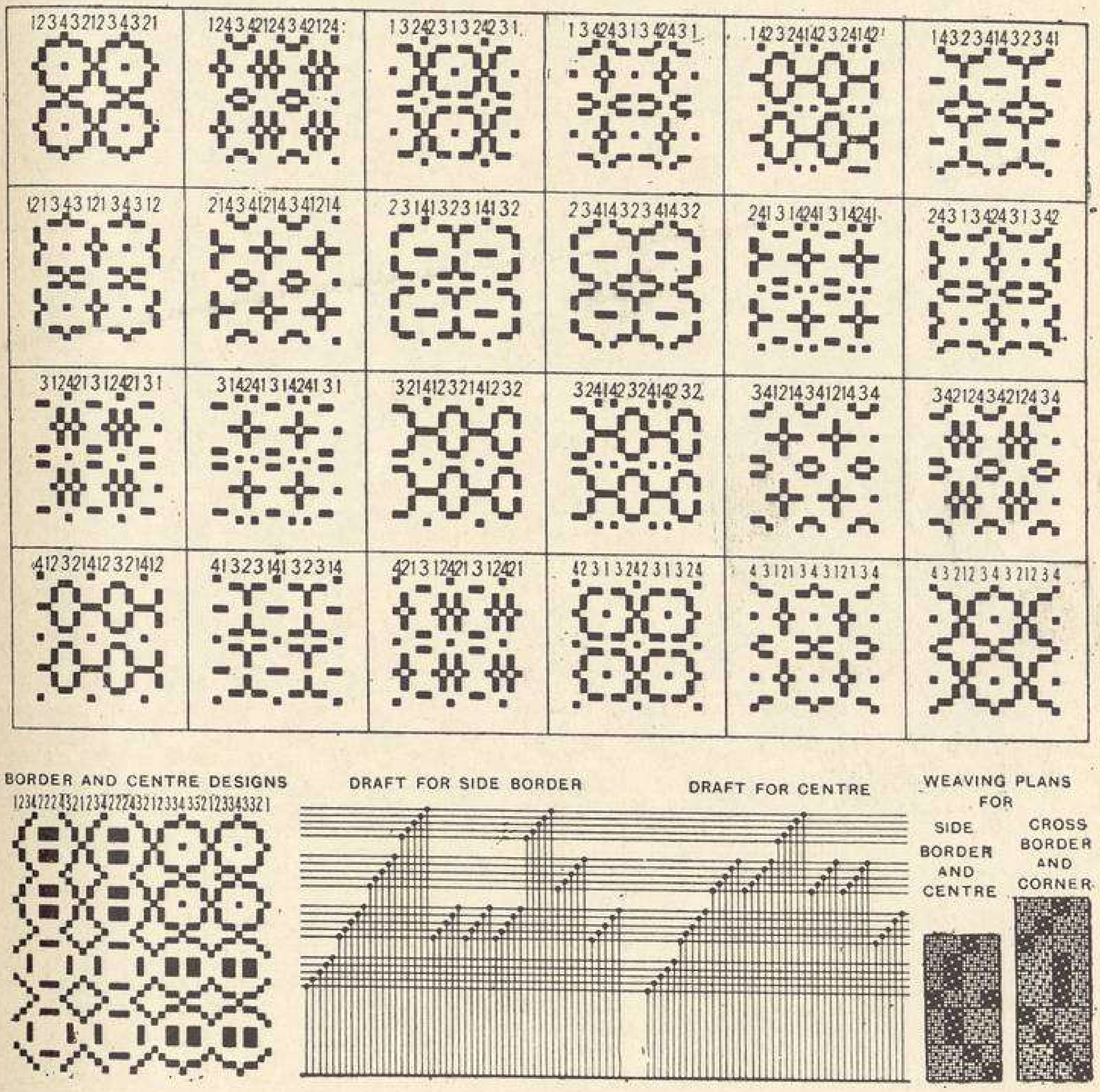


FIG. 110.

bordered cloth is illustrated at the bottom left-hand corner of the figure, while alongside to the right appears the drafting and the ordinary weaving plans. The latter would be replaced by four chains and a controlling chain if arranged for the cardless dobby.

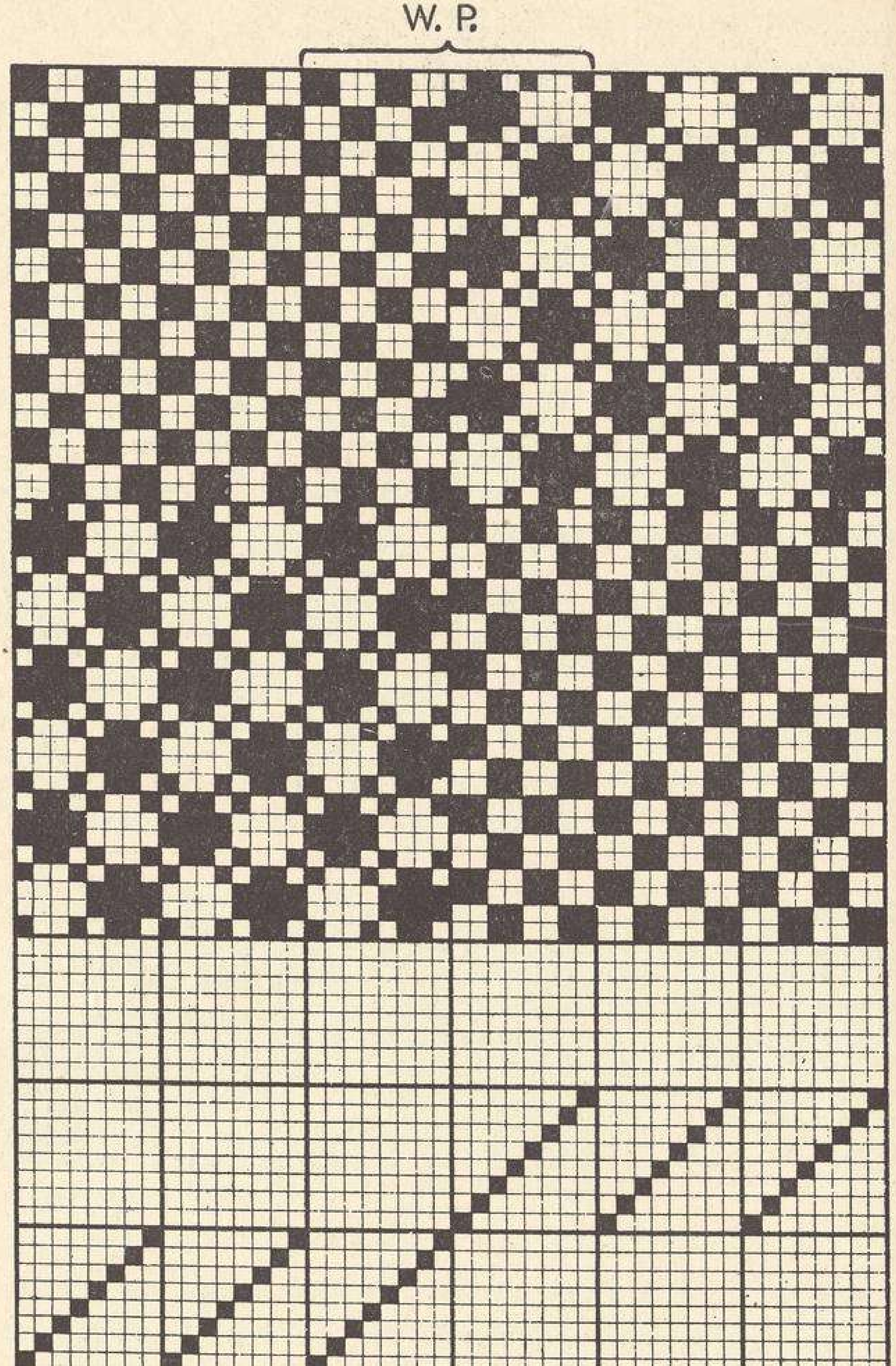


Fig. 111.

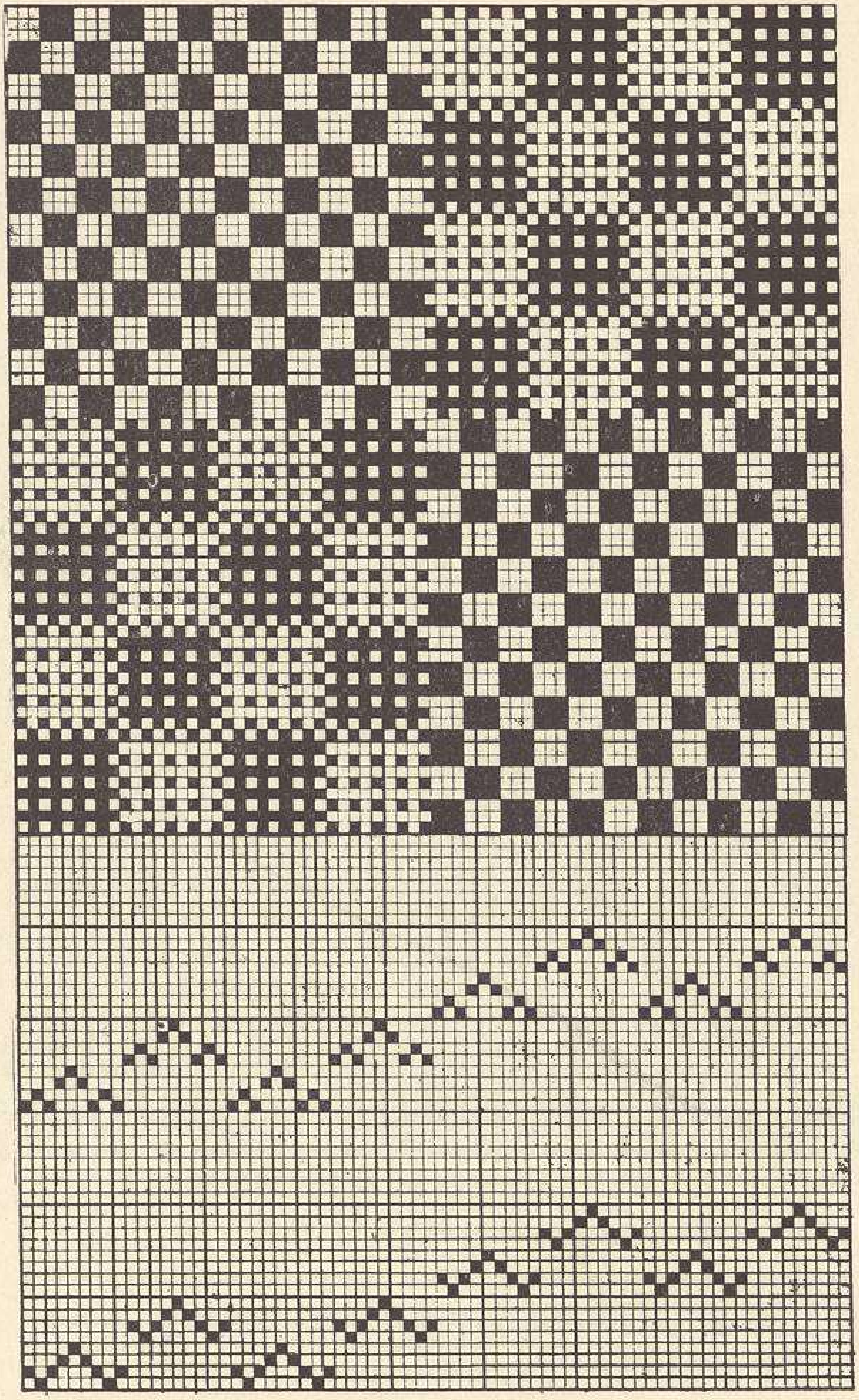


Fig. 112.

All the aforementioned dices are formed from weaves which result in fabrics possessing flat surfaces. These fabrics are intended for the most part for table decoration or other domestic use, and they serve admirably for such

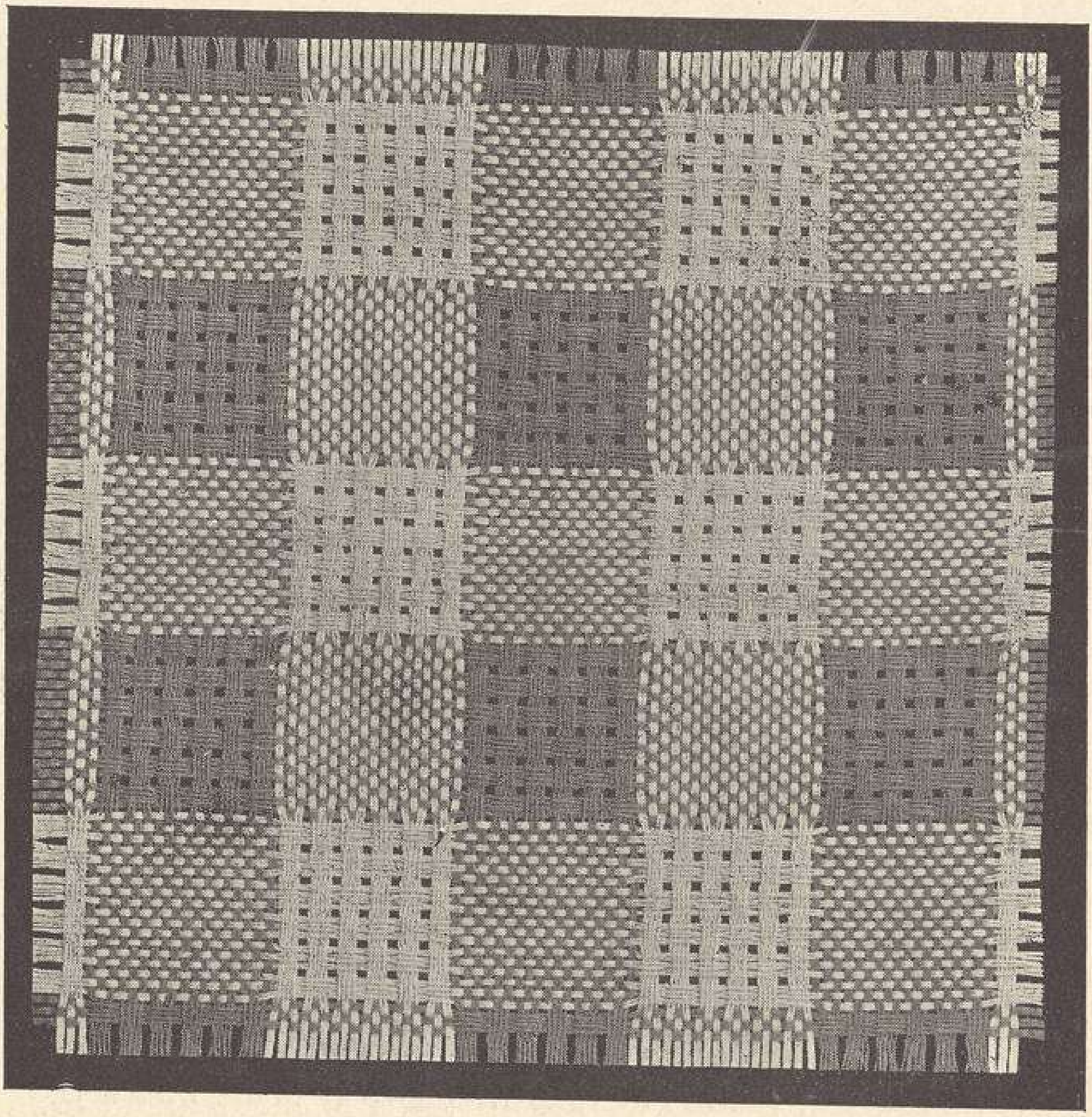


Fig. 113.

purposes. The development of dice patterns, however, is not confined to cloths of this character, but is also largely applied in the ornamentation of fabrics directly intended for decorative purposes. Such fabrics may be made up as piano covers, sideboard covers, duchesse covers, stand covers, table centres, tea-cosy covers, cushion sacks, bedspreads, various kinds of mats, and all varieties of fancy articles. The cloth may be used just as it comes from the factory, or, if the nature of the cloth is suitable, it may be further decorated by embroidery. Fig. 111 illustrates a small dice of this character. It is made from the 8-thread imitation gauze and the 4-thread basket weaves. The draft appears at the bottom of the figure, while the weaving plan consists of all the 48 picks and the 16 threads bracketed and marked W.P. A more elaborate example is shown in Fig. 112, made from the 18-thread imitation gauze and the 6-thread basket weaves. Two different drafts are given for this pattern, and the weaving plans would consist of the proper 16 threads selected from the design. Thus:—

Weaving plan for the top draft consists of threads

1, 2, 4, 5, 10, 11, 13, 14, 37, 38, 40, 41, 46, 47, 49, 50,

while for the bottom draft the weaving plan would consist of the following threads:—

2, 3, 4, 5, 11, 12, 13, 14, 38, 39, 40, 41, 47, 48, 49, 50.

The cloth made from the design in Fig. 112 lends itself admirably to further decoration, but it may be utilised with good effects without further treatment. Fig. 113 is a photographic reproduction (half-size) of such a cloth, woven with two colours of warp and two colours of weft. The structure of the cloth is identical with Fig. 112; it differs only in the number of repeats of each unit for each dice portion. If the design in Fig. 112 were woven in the same sett of the reed as Fig. 113, it would produce a cloth two-thirds the size.

CHAPTER VIII

SPOTS

Spot Patterns.—Of the various methods of technical design employed for the embellishment of textiles, it may be safely asserted that the system of developing simple spot patterns on the surface of the fabric, in some well-defined repeating order, is, by reason of its simplicity, more widely applied than any other single system of ornamentation. The term "spot" is here used in its narrowest interpretation, although it is regularly applied in a much wider sense to many sizes and forms of ornament; the term is also understood to include the many different orders of arranging small figures.

In almost all ornamented textiles it is considered desirable, and in most cases necessary, to arrange the ornament in some definite and regular order, and spot patterns form no exception to this rule. Except in the simplest cases, the object of the designer should be to obliterate, as far as possible, the simple base upon which the design has been built. Spot patterns, in the strictest sense of the word, are, perhaps, more suited to adorn dress materials than any other type of fabric, for the simple reason that the cloth is cut up into pieces of comparatively small proportions, which are, however, still large enough to admit of a few repeats of the figure. As a consequence this type and setting of ornament are extensively employed in the production of silk, cotton, woollen, worsted and linen goods for the various articles of dress. This wide range of cloths, however, does not by any means exhaust the applications of this valuable method of ornamentation, for it is used largely in table damask and other domestic and household fabrics, as well as in many cloths used for upholstery, floor covering, and other decorative purposes.

All ornament may be considered as being dependent upon some form of contrast, otherwise the figure could not be distinguished from the ground. The essential requirements of most spot patterns are that they should be comparatively small; hence, when the warp is the same colour as the weft, the floats in the figure, although generally longer than those of the ground weave, are still comparatively short. Consequently, if the whole is to be effective, the ground of the fabric should be developed in plain, basket, rib, simple twill, sateen, or some such non-conspicuous weave. When coloured yarns are used in conjunction with weaves of a two or more ply nature, the contrast may be, and often is, obtained with the same simple weave in both ground and figure—a difference in the lengths of the floats being no longer necessary. Although this is the case, it very often happens that different weaves are used in the two parts of the cloth; indeed, in several instances, the figure is formed, not only by distinct colours, but also by distinct weaves from those employed in the ground. There is really little restriction as to the number of colours which may be introduced either in the figure or in the ground, but for the ground part it is customary to use only one kind, the shade or tint of which is usually of a quiet monochromatic nature.

From what has been said it is very apparent that spot patterns may be produced in many ways, but in the meantime we shall confine our remarks to those of the simplest character, reserving the description of the more elaborate systems for the proper time and place.

The only method of adding ornament to single mono-coloured cloths, neglecting the effects obtainable by yarns of different counts, by fancy yarns, or by yarns with different directions of twist, is to change the order of the interweaving of the warp with the weft at certain well-defined places of the cloth. The development of the pattern at these places is therefore restricted to the floating of the warp, of the weft, or of both in some different order to the floats or weave in the ground. While it is essential that a regularly repeating weave should be used for the ground, no such restriction is placed upon the part allotted to the spots—in the case of large figures some modification must naturally be made, but the figure in these cases can hardly be said to come within the limits of spot patterns. The production of these simple spot patterns resolves itself, therefore, into a system of floating of warp or weft threads according to the size of the different parts of the spot, but the limitation thus imposed still affords plenty of scope for the inventive mind to evolve quite a number of distinct effects. Variety in form, difference in size, and change in order of arrangement, as well as in the position of the figures, may all be employed in order to produce something novel. Circles, stars, triangles, diamonds, lozenges, rectangles, and irregular geometrical figures, as well as small floral effects, may be used either separately or in conjunction with each other in the same cloth. The spots may also vary in size from, say, one-quarter of an inch to one inch in diameter, or all may be of the same size. Any practicable order of arrangement of the figures may be used—*e.g.*, the base may be on the diamond, or what may be also called the plain weave base, or it may be on the straight twill, broken twill, or sateen principle. There is really no restriction, nor is there any fixed rule; but, in general, it will be found that the most satisfactory results are obtained when the base is planned on the plain weave, 4-thread broken twill, or the 6-thread imperfect sateen.

In Fig. 114 we show four repeats of a design, with a spot of diamond form, arranged in the plain weave or diamond order, and surrounded by a ground weave which is also plain. The complete design occupies 24 threads and 24 picks. The design is capable of being drafted

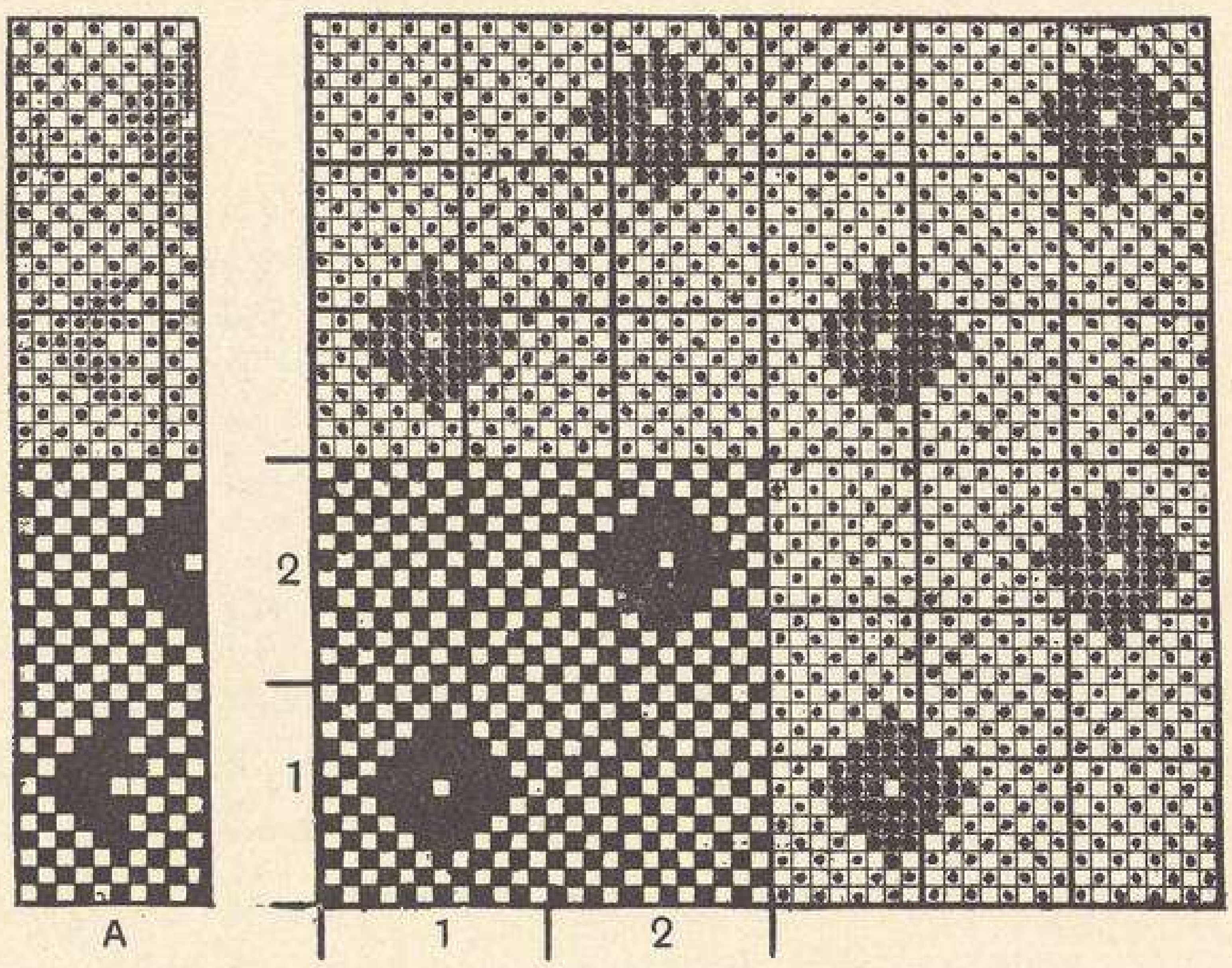


FIG. 114.

on to ten leaves which would rise and fall according to the weaving plan A, shown in solid to the left of the design. It is not always the best policy to reduce the designs to the least possible number of shafts. Much depends upon the extent of the orders likely to be received, upon the weaving rate for the number of shafts, and upon the variety of patterns in the range. Thus, if a large quantity of cloth were required of the same setting, and with similar arrangements of symmetrical figures on a plain ground, the best method would be, not to reduce to ten shafts as shown, but to employ a dobby fitted with sixteen shafts, and to arrange the draft as follows :—

$$\left.\begin{array}{l} \quad\ 1, 2, 3, 4, 5, 6, 7, 6, 5, 4, 3, 2 \\ \text{Then } 8, 9, 10, 11, 12, 13, 14, 13, 12, 11, 10, 9 \end{array}\right\} = \begin{array}{c}\text{24 threads in} \\ \text{pattern.}\end{array}$$

Many similar patterns could then be produced without taking the warp out of the loom, or, at the most, with tying-in a warp of a different count or colour. In general, however, it is much more desirable to employ a jacquard with a capacity of 200, 300, or 400 hooks. With the smallest of these, and a repeating tie of 192 hooks, a cloth with 60 threads per inch may still have a finished pattern nearly three inches in width.

Designs such as Fig. 114 may be constructed in the following ways :—

(*a*) On what we have termed the plain weave base.

(*b*) On the diamond base.

Both systems, which are illustrated in Figs. 115 and 116, have their advantages, but we may say that the cloth produced by both methods would be identical except near the selvages. In the plain weave base, Fig. 115, the design paper is divided into four large blocks of 12 threads and 12 picks each by the triple lines A B and C D, thus representing on a larger scale the four small squares of the plain weave. In two of the large blocks we have introduced the figures in precisely the same way as the marks appear in the plain weave. The centre of the figures must lie on the diagonal line E F, or on a similar one drawn from the other two corners, and as near as possible midway between the two corners of the squares C E B and A F D. Care must be taken that the figures occupy similar positions in the two quarters of the design.

There are twelve squares in the first block crossed by the diagonal line, and the pattern occupies, in the diagonal direction, five squares; therefore, it is impossible for the middle spot to be exactly in the middle of the line. It is placed on the seventh; but it would have done equally well on the sixth, except for convenience in card-cutting.

In the diamond base, Fig. 116, we have drawn a diamond G H J K, which occupies just one-half of the design, while the other half is equal to the diamond, but is represented by the four equal triangles at the corners; we have also drawn a diagonal line L M. If the centre of

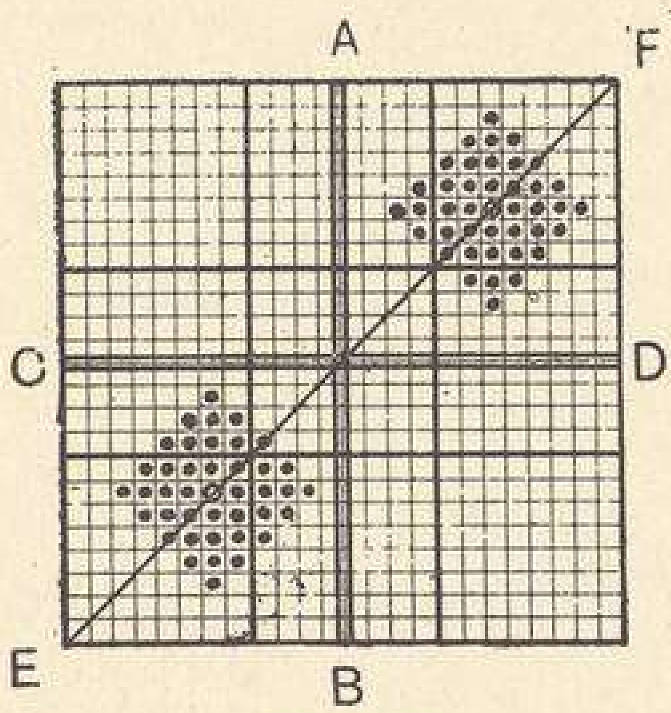


FIG. 115.

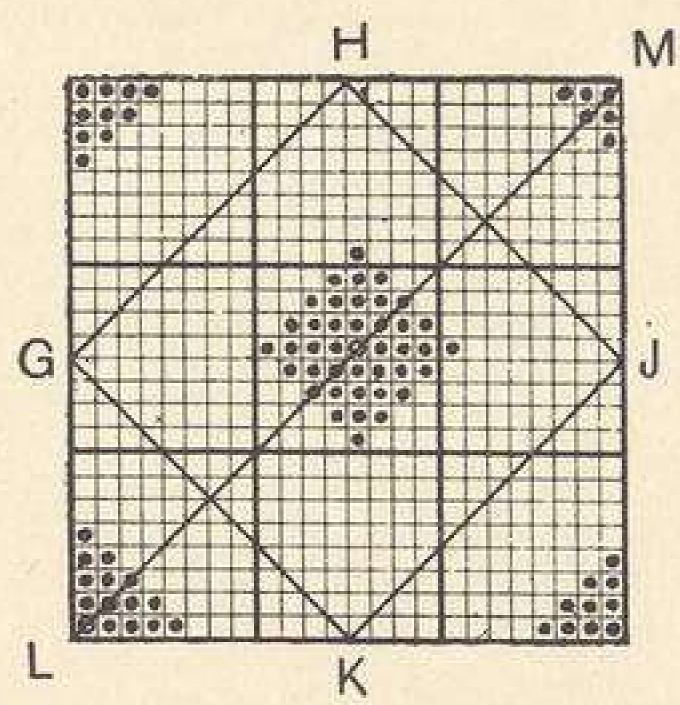


FIG. 116.

the figure contains an odd number of points diagonally, the central point may be placed on the first square as shown, and the remainder of the figure worked round it. The centre of the other figure would be on the same line L M, but twelve squares higher up, since twelve is half the total number employed. It is easy to see that in both methods the only guide required is the diagonal line.

When the ground of a design is plain weave, it is desirable that the floats of the figure or spot should all be odd, so that the figure and the ground may fit correctly without altering the shape of the former. It is also an advantage when painting in such figures to observe that the outline fills squares where odd threads intersect odd picks, and where even threads intersect even picks. If this be done it will be found unnecessary in practice to fill in the ground weave, since the card-cutter may be instructed to cut odd punches on odd picks, and even punches on even picks for the ground. A further important principle essential to the proper designing of detached figures, and also of all damask designs, is well illustrated in the above design. We refer to the arrangement of the ground weave so that no part of it will touch the figure to the detriment of the outline of the latter. Where the ground weave is $\frac{1}{1}$ plain, as in Fig. 114, this principle may be easily observed by arranging the figure as already indicated; but with other ground weaves it may be, and very often is, necessary to break the continuity of the twill or weave to avoid spoiling the outline of the figure. This will be fully illustrated as we proceed.

Fig. 117 shows a design on 48 threads and 48 picks, with a rectangular figure arranged in the 4-thread broken twill order. This order 2, 4, 1, 3, which has also been used as the ground weave, is shown in solid squares on the first 4 threads and 4 picks, and is marked A. Variety is obtained by inclining the rectangles and their diagonal twills at different angles. Spots such as these may, of course, be woven without any break of the float, but this depends entirely upon the character of the design, the sett of the cloth, and upon the yarn. The boldness or prominence of the spot increases with the length of float, but if the sett be open and the yarns fine, it may be necessary to limit the length of the float to a few squares in order to make the cloth sufficiently firm in texture.

In setting out the design on point paper, the 48 threads and 48 picks are divided into the same number of compartments as there are small squares in the base weave. Thus—

$$\left\{\begin{array}{l}\dfrac{\text{Threads in design}}{\text{Threads in base}} = \text{number of threads for each spot; and} \\[2ex] \dfrac{\text{Picks in design}}{\text{Picks in base}} = \quad \text{,,} \qquad \text{picks} \qquad \text{,,} \qquad \text{,,}\end{array}\right.$$

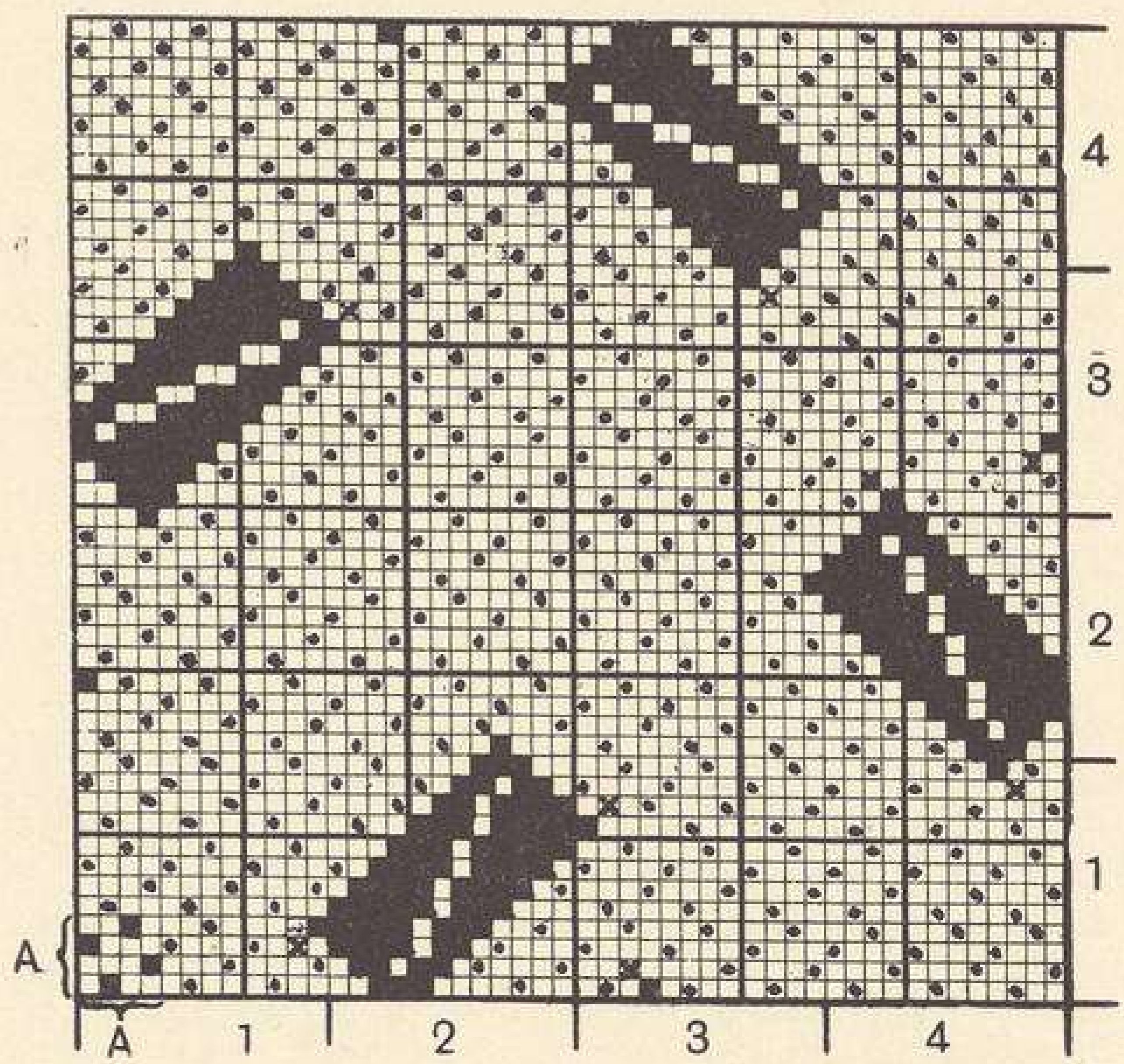


Fig. 117.

The threads equal the picks in the unit or base weave shown in solid at A, and the threads also equal the picks in the design.

$$\therefore \frac{\text{48 threads and picks}}{\text{4 threads in base}} = \left\{\begin{array}{r}\text{12 threads and also 12 picks for} \\ \text{each spot.}\end{array}\right.$$

This division is simply an enlargement of the base weave A, and the spot patterns are placed in precisely the same order on the design as the solid squares are in the base—viz., 2, 4, 1, 3. Each spot should occupy the central, or else the same relative position in its respective portion of the design, no matter how it is inclined. This rule may be departed from to the extent of a single small square up or down, or to the right or left in some special cases, particularly where such departure will be more suitable for the continuity of the ground weave, but it is not desirable to deviate any further, since doing so would upset the general distribution of the figures. It

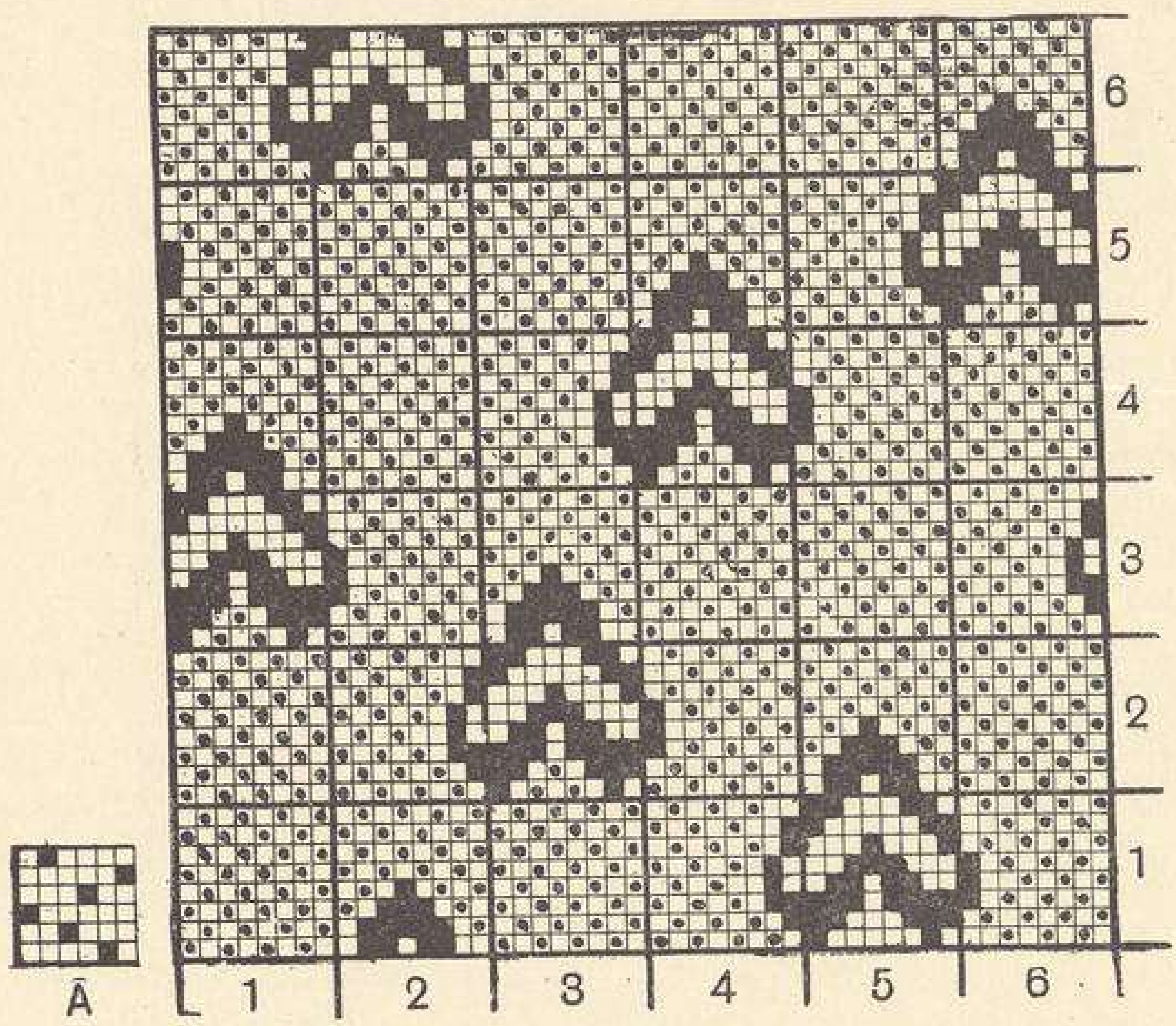


Fig. 118.

will be observed that no part of the ground weave has been allowed to interfere with the outline of the figure, but a close examination will show that in eight distinct places, two for each figure, the continuity of the ground weave has been broken purposely to obtain this desirable result. The eight places referred to in the ground weave are indicated by a cross (×) instead of by the customary dot.

Fig. 118 illustrates a warp and weft spot, arranged in the 6-thread broken sateen order, on 48 threads and picks, the ground weave being $\frac{1}{1}$ plain. The 6-thread sateen, or basis of arrangement, is shown in the detached figure A on the left.

$$\frac{\text{48 threads and picks in design}}{\text{6 threads and picks in base}} = \left\{ \begin{array}{c} \text{8 threads and picks for} \\ \text{each spot.} \end{array} \right.$$

The six large spots have been arranged in these thirty-six large divisions in precisely the same order as the small spots are distributed in the small detached base A. In the design, however, the centres of the spots do not appear exactly in the centres of the divisions, but each part of the spot appears in one division in just the same position as it does in any other. The particular place of starting the figure in all-over effects is generally of no account, and any starting point may be chosen if it facilitates the operations of drawing, painting, or card-cutting, and does not interfere with the general distribution of the figures.

When the figures are detached, as in the above three designs, it is important to notice that the ground weave must repeat on the total number of threads and picks in the design, and we would again remind the student that, while the ground weave may be anything which will fulfil this condition, the best results will generally be obtained with weaves of a simple character, since they contrast much better with the comparatively short floats of the spots than do weaves of a more ornate nature. It is, of course, not essential that the spots should be confined within the limits of their respective divisions; each one may be extended as much as is wished, provided it does not interfere with the others.

CHAPTER IX

DAMASKS

Damask Designs.—There is probably no pattern development in textiles of more ancient origin than that practised in damask weaving. According to popular belief, this particular branch of the weaving industry was introduced into Eastern Europe from Damascus in the early Christian era, but it probably originated farther East still in that ancient and most interesting land, China. It has, naturally, undergone many modifications since its introduction — modifications which have combined to place it among the highest developments of the weaving art as applied to textiles of single or simple structure.

Damask weaving is more or less extensively applied in all the textile industries, but more particularly in those connected with cotton, linen, and silk—in the two former for the production of tablecloths and covers generally, in cotton, as well as in worsted, for dress goods, and in the silk industry for upholstery and decorative fabrics in general, and for the better class of dress goods. In addition to those fabrics which are made of only one material, there are many which contain two or more different kinds of fibrous yarns. In some of these fabrics the individual yarns are all of one colour, while in others there is a variety of colouring. It is hardly necessary to point out that dyeing may give valuable aid in improving the appearance of a cloth. The best results are, naturally, obtained where colour is employed in conjunction with yarns of the finest fibre —results which cannot be approached with white or grey yarns of a considerably coarser character, or of an uneven nature.

In what is now known as a true damask, the pattern is developed by permitting the warp, in some parts, and the weft in others, to float on the surface of the fabric in practically solid masses. The two sets of floating yarns are at right angles to each other, and each set in turn, as has already been stated, reflects the light more effectively than the other, and so renders the pattern visible. Each series of threads is, of course, stitched to the other at regular intervals for the purpose of forming a firm texture, but such stitching points are carefully chosen with the view of preserving a practically solid surface of warp, or of weft, as the case may be. In the relatively coarser cotton and linen textures the 5-thread and the 8-thread weaves are generally employed for stitching purposes, although in the finer grades of table damask the 10-thread and the 12-thread sateens are sometimes used. In silk goods, *e.g.* silk pictures, it is not unusual to find the 16-thread sateen employed. In some of the finer table damasks the ground of the cloth is developed in the 5-thread sateen, and the figure in the 8-thread sateen. This is done with the object of making the figure appear bolder, and, consequently, richer. Difference in texture should, however, be indulged in only sparingly, unless it can be arranged equally over the whole width of the fabric. It often results in an appreciable difference in the take-up of the warp yarn, and causes considerable trouble to the weaver through part of the warp hanging slack.

Since the introduction of the jacquard machine many cloths have been woven under the general name of damask —cloths in which other weaves, of a more ornamental nature than the true sateens, have been introduced. These new weaves change slightly the structure of the cloth, but they introduce novelties and variety. They are resorted to, and rightly so, only to a very limited extent in table linens, although the practice is much more widely adopted in cotton and silk, and in articles of linen manufacture not intended for table decoration of an ordinary type. Such fabrics have, however, in virtue of this departure, lost their true damask characteristic, and on this account are, in some centres, referred to as brocades. The designer of these fabrics, besides sketching and arranging the general outline of the figure, must give consideration to the different weaves in which the various portions of figure and ground of the fabric are to be developed. It is, in general, desirable that a balance of texture — *i.e.*, the interweaving of the warp with the weft — should be preserved in the various portions of the design; but, on the other hand, many excellent results are obtained by a decided contrast in the texture of the different parts.

The weave structure of a proper damask fabric is very simple, and is, in many instances, beyond the control of the designer. Designs for cloth to be woven on this principle are therefore more or less art productions arranged to meet the necessities and restrictions of harness mounting and reproduction generally. It is not our intention to discuss the wide and much-debated question as to what the nature of the ornament selected for damask designs should be, but, since the surface of the fabric is perfectly flat, we are of the opinion that the treatment of the ornament should also be flat. Designers should reflect that their duty is to ornament the fabric, and not to consider the latter as a medium through which they may develop flights of the imagination. In table damasks, with which we now desire more particularly to associate our remarks, suggestions for ornament are taken from all forms of life, but chiefly from floral subjects. Suggestions are taken from other sources, and many excellent designs are woven in which the ornament, which has no counterpart in nature, consists entirely of graceful curves, lines, and forms, but which, nevertheless, appeals to the cultivated taste. Still, it is true that the great majority of designs are based upon some well-known flower or plant, since such designs appeal most successfully to the general buying public. The flower or plant selected for treatment should be used more for the purpose of suggesting lines of growth and beauty of form than as an object for mere reproduction on the cloth.

In the production of true damasks there are two well-defined systems of weaving:—

1. The full harness system, in which each needle and hook of the jacquard employed controls only one thread in any one repeat of the design, and for which all stitching points of the sateen binding weaves used must be indicated on the design paper, and also cut on the cards for the jacquard machine.
2. That system in which the binding twill of both ground and figure is automatically inserted by the shedding mechanism. For this system no twill requires to be inserted on the design paper, nor cut on the pattern cards.

The latter system is generally adopted for the finer fabrics because of its economical application to the production of very large patterns.

Two distinct methods of weaving are employed in which the twills are automatically inserted :—

(*a*) The pressure harness method, in which an ordinary one-hook to one-needle jacquard is used, but each hook of which may control two or more successive threads in one repeat of the design. In this method the figure only is controlled by the jacquard, and the twill is automatically woven by a set of five or of eight shafts situated between the figuring harness and the reed.

(*b*) The self-twilling jacquard method, in which each needle controls two or more successive hooks, and therefore two or more contiguous threads of the warp in each repeat of the design. The cards control pattern only, but the twill is automatically introduced in both ground and figure portions of the cloth by mechanism which suitably controls the lifting blades of the machine griffe or brander.

In both methods (*a*) and (*b*) each card may be presented to the needles of the jacquard for two or more successive picks. (For a more detailed description of both methods see *Jute and Linen Weaving*, Part I., "Mechanism," pages 174 to 198.)

From a consideration of the automatically twilled system, which is the more complex of the two, but which is still the more direct descendant of the ancient methods, it is clear that the outline of the pattern so produced will be inferior to that developed by the full harness system of weaving. In the latter, each thread of the warp in any repeat of the design is under independent control, and therefore the outline of the figure may move in any direction in steps of single threads of warp, and also of single picks of weft, since only one shot is inserted for each card. In the so-called common harness method, however, the outline of the pattern, except in very exceptional cases, must change in steps of two or more threads of warp or picks of weft, according to the number of contiguous warp threads controlled by one needle, and the number of picks inserted for one pattern card.

Notwithstanding the indifferent outline—a defect which becomes less apparent as the fineness of the sett of the fabric is increased—and other defects of a minor character also incident to the system, it is yet very widely applied. This is because the system effects enormous savings in the production of those cloths with very large figures—

1. In the cost of designing.
2. In the number of cards required.

Assuming that each needle controls two warp threads, and that two picks of weft are given to each card, then a direct saving of 75 per cent is effected in the cost of designing, cards, and cutting alone, as compared with the same design produced in the same quality by the full-harness system. Moreover, the reading of the design by the card-cutter is reduced to its simplest form.

The common harness system is also economical in respect that one set of cards may be and often is utilised, within limits, for the production of the same design in various widths of any one quality; it is also theoretically applicable to the production of the same design in similar widths of different qualities, although it is seldom taken advantage of in this respect. How it may be so adapted will be explained in detail at the proper time.

A designer for table damasks may commence his sketch designs under one or other of two conditions. Firstly, he may have no knowledge of the quality of the cloth, or of the exact nature of the harness mounting to which the design may ultimately be applied. Should this be so, he will probably arrange the sketch to suit some average quality and widely adopted harness arrangement. Still, should his sketch be accepted, there will in all probability be considerable alterations or adaptations to be effected. Secondly, and preferably, he may know exactly the quality of the cloth, and the harness arrangement for which the design is intended. We shall, necessarily, assume these latter conditions.

Table damasks vary very considerably in sett or quality from about 30 threads per inch of warp and weft in the case of low cotton warp unions, to about 140 threads per inch of warp and 200 picks per inch of weft in the finest linen goods, while considerably higher quantities are used in silk damasks. These figures refer to the threads and picks per inch in the finished condition of the fabric—a condition which we shall assume in all our calculations in this section, since we regard it as the safest course to pursue to make sure of the correct proportions of the figure. We are well aware that in certain districts it has been customary to calculate the dimensions of a sketch from the sett of the cloth in the loom condition; but, since cloth made from vegetable fibres contracts in width and increases in length in the process of finishing, it is not surprising to find many finished fabrics with distorted figures, due to the almost unavoidably wrong proportion of picks of weft to threads of warp.

The general style of the ornament depends greatly upon the sett of the fabric, hence only bold, simple designs should be chosen for low and medium qualities up to about

60 threads per inch. Finer lines and more detail may be introduced when the cloth contains 65 to 70 threads per inch, while practically anything of the designer's creation may be developed when 90 threads per inch and over are used.

Besides controlling the general style of the pattern and its fineness of detail, the sett of the cloth also determines the particular design or point paper which must be used. Most qualities of table damask are shotted either "square" or "over square"—that is, they have either as many weft threads as warp threads per inch, or the weft threads predominate over the warp. Some few cloths are undershotted, but they are the exception. In any case, however, the same rules apply. Where the cloth is to finish "square," the ruling of the design paper used must also be square, thus:—8 by 8, 10 by 10, 12 by 12, 16 by 16, etc., according as the jacquard machine to be used has 8, 10, 12, or 16 needles in one short row of the needle board. 8 by 8 paper is regularly used for 16-to-the-row jacquards; it is the correct proportion, and the heavy line occurring every eighth cord acts as an additional and intermediate guide to the card-cutter.

Where the cloth is not "square," the ruling of the design paper per block is determined—

1st. By the number of needles in one short row of the jacquard for the warp. (The vertical ruling for all kinds is fixed by the number of needles in a short row.)

2nd. By the ratio of the weft threads to warp threads per inch or other unit in the finished fabric for the weft.

In all ordinary design paper the heavy lines of the ruling divide the sheet into perfectly square blocks of a convenient size. These are further subdivided vertically to represent warp threads, and horizontally to indicate weft threads, the number of divisions in each direction being determined as indicated above, and by the numerical example below.

Example.—Find the ruling of the design paper for a cloth to count 60 warp threads and 65 weft threads per inch finished. A 600's or 12-row jacquard to be used.

Obviously, the design paper must have 12 vertical divisions per block to correspond with the 12 needles in the short row; while the horizontal divisions for the weft will be found as follows:—

$$\text{Number of vertical divisions} \times \frac{\text{picks per inch}}{\text{threads per inch}} = \text{horizontal ruling.}$$

$$\therefore\ 12 \text{ vertical divisions} \times \frac{65 \text{ picks}}{60 \text{ threads}} = 13 \text{ horizontal divisions.}$$

In other words, 12 by 13 paper must be used.

It is sometimes impossible to get the exact proportions required—as, for example, when a cloth to be woven in a 600's jacquard should contain, when finished, 64 threads per inch and 72 picks per inch.

$$12 \text{ vertical divisions} \times \frac{72}{64} = 13\tfrac{1}{2} \text{ horizontal divisions.}$$

But

$$\frac{12 \text{ vertical divisions}}{13\frac{1}{2} \text{ horizontal divisions}} = \frac{8 \text{ vertical or warp divisions}}{9 \text{ horizontal or weft divisions.}}$$

Therefore, for a cloth containing 64 threads and 72 picks, one or other of the following three courses may be adopted:—

1st. Use 8 by 9 paper, as found above, and paint the figure, without distortion, upon the proper number of threads and picks; then re-rule the paper vertically in 12's by hand for the card-cutter's guidance.

2nd. Use 12 by 13 paper, and distort the design in painting by elongation to occupy the proper number of picks in the proportion of $13\frac{1}{2}$ weft to 12 warp.

3rd. Use 12 by 14 paper, and distort the design by compression to occupy the proper number of picks.

One of the two latter methods would probably be adopted, although the first method would be most likely to give the best result. Any ruling of design paper may be had in whole numbers; but some rulings are, naturally, in much more constant demand than others.

The foregoing remarks and calculations apply only to those cloths which are woven on the full harness system. Other methods which will be duly indicated are applicable to common harness designs. To sum up, the quality or sett of the cloth acts as a guide to the designer with regard to the general style of design which should be adopted; it also limits or restricts him as to the fineness of detail. At the same time, it determines the ruling of the design paper, or point paper, upon which the sketch must be transferred and the weaves introduced before the cards can be cut. The harness mounting and the quality of the cloth, on the other hand, regulate the dimensions of the actual size sketch and the positions and order in which the various units of the design will be repeated across the width of the cloth. Briefly, the design and the harness mounting are interdependent—the one cannot well be considered without the other. Designs may, of course, be originated to suit any particular arrangement of the harness, and a harness may be mounted to suit any design, but it is better if both be considered together. When originating a sketch, a designer will naturally try to make the most of the machine at his command; but it is not desirable to sacrifice simplicity in the harness mounting in order to secure what may seem to be an elaborate pattern.

Harness mounts or ties are of three kinds:—

1. Straight through or repeating ties; sometimes, but inadvisably, we think, termed "lay-over" ties.
2. Centred, pointed, or gathered ties.
3. Combinations, in different ways, of 1 and 2.

Except in very special cases, the number of threads in the weave employed, and the number of hooks in one short row of the jacquard, should each be a measure of each section of the tie or mount. Thus a 5-thread sateen weave on a 400's or 8-row jacquard should have the various sections of the mount in multiples of 40 threads.

5-thread sateen and a 600's or 12-row jacquard in multiples of 60 threads.
8-thread sateen and a 400's or 8-row jacquard in multiples of 8 threads.
8-thread sateen and a 600's or 12-row jacquard in multiples of 24 threads.

If this rule be observed, the various sections, besides being multiples of the twill, will be complete on full rows of the machine, and thus tend to simplicity and to the minimum of trouble and error on the part of all concerned.

Since the dimensions of tablecloths are usually in multiples of $\frac{1}{4}$ or $\frac{1}{2}$ yard, it is desirable that the repeating portion of the design should be 9 or 18 inches in length and width, so that the various sizes of cloths may be obtained by increasing or decreasing the number of repeats. When the style of design will permit, it is also desirable to arrange the ornament so that it may be broken at a half repeat without such a break being unduly evident. In this way intermediate sizes of cloths may be readily arranged for. Similar remarks apply, although perhaps in a modified degree, to napkin designs.

Where the complete effect of the pattern—as in the case of a large border produced by the aid of a small number of hooks—is dependent upon the repetition or the reversing of any part or of different parts of the harness, the art of the designer should be exerted to conceal effectively such repetition as far as possible. The general effect of a pattern will be much less pleasing to the eye should the plan of mounting be prominent than if the same be concealed or subdued by the designer's skill.

Before entering into the details of harness arrangements, it may be advantageous first to consider a few particulars concerning the various full harness jacquards in use at the present time. Jacquards may be made of any convenient size, but it is natural to find that certain well-defined sizes have been adopted by each branch of the textile industry. These sizes will naturally vary according to the extent of the figuring required. When very large patterns are desired, it is often thought advisable to adopt a medium or a fine pitch jacquard in place of two or more machines of a coarser pitch. Fig. 119 illustrates a few cards of different sizes and different pitches; all are used in connection with damask weaving, and since all are reduced to the same scale, the relative pitches and sizes remain correct.

The standard British pitch is represented by card A, which is for a 600's machine. In this pitch—

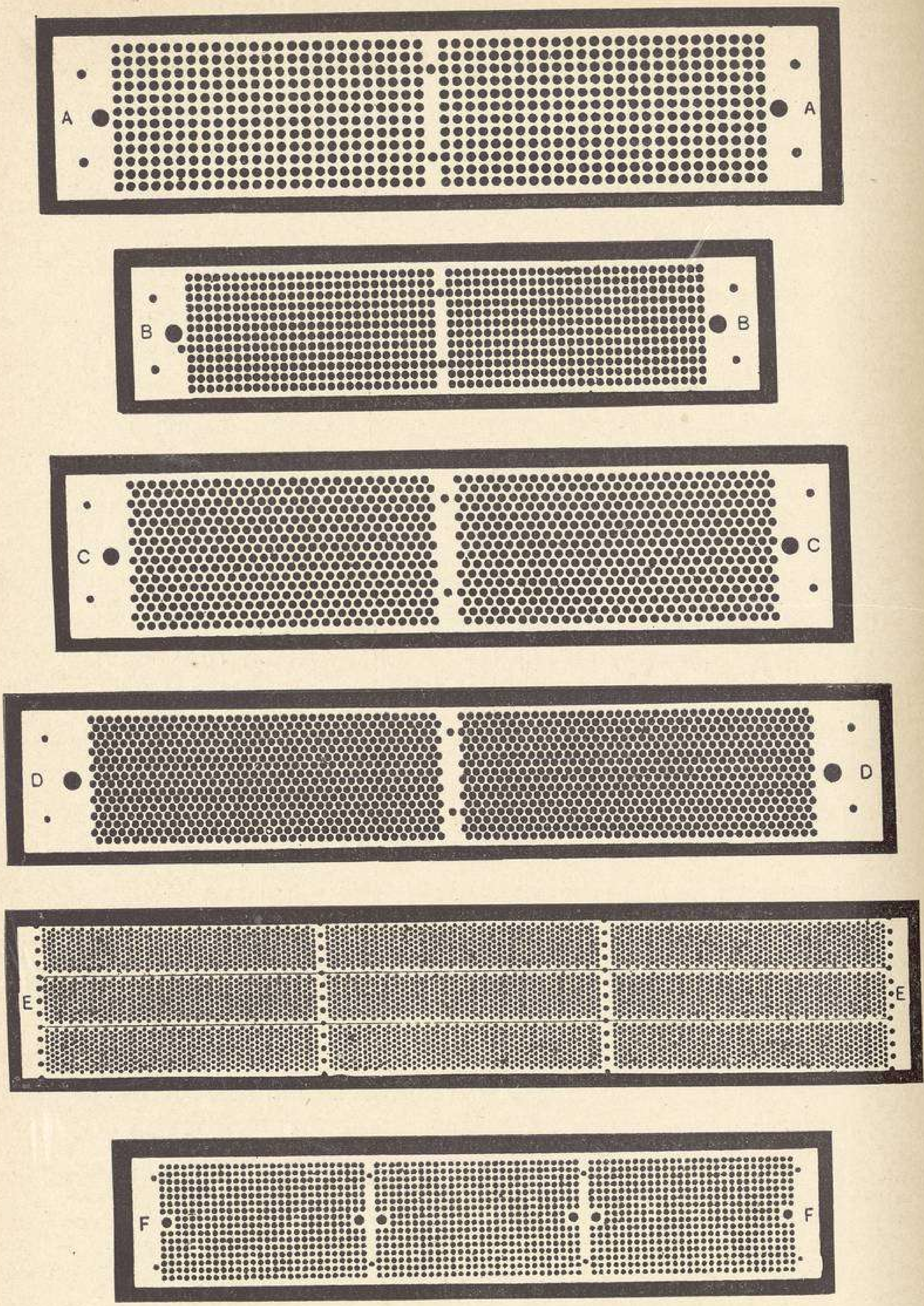


Fig. 119.

The 400's jacquard has	51 rows of	8 hooks each	= 408	hooks.
„ 500's	„	„	10	„	= 510	„
„ 600's	„	„	12	„	= 612	„

The 600's jacquard has occasionally 76 rows of 8 hooks each, while a 900's has 75 or 76 rows of 12 hooks each. Nearly all smaller sizes are the same pitch, but these are seldom used except for lettered goods in linen, for narrow fabrics, and for small effects in dress goods and similar material.

Card B is for a	660's	machine with	55	rows of	12	hooks.
„ C „	912's	„	57	„	16	„
			or 114	„	8	„
„ D „	1216's	„ with	76	„	16	„
			or 152	„	8	„

Several Continental machines are made in multiples of 28 rows of 16 hooks each, thus giving 448, 896, 1344, and 1792 hooks per machine. The cards for these machines, which are of the Verdol type, are represented by card E. Other machines, on account of several incomplete rows, have only 440, 880, 1320, and 1760 hooks; this type, which is also Continental, as well as British, is illustrated by card F.

The above cards illustrate several of the different pitches in daily use, and they indicate that many efforts have been made to obtain machines of a large figuring capacity which will also be economical in the use of cards. They also show that a designer may have many machines at his command, although it is unlikely that any manufacturer will have more than two different pitches in his factory—the standard pitch and another,—since each pitch requires its own card-cutting and repeating machines, and card lacing or stitching apparatus. Multiplicity of systems, or of types of machinery, does not assist in the direction of economy in production, nor is it desirable from the employés' point of view.

Machines of 400's or 40 design capacity are extensively used in the manufacture of doilies of all qualities, lettered and damask bordered towelling, figured glass cloths, diaper and damask towels, stair coverings, table napkins in low and medium qualities, tray cloths, and low-quality tablecloths. They are also occasionally used in conjunction with larger machines to supplement the figuring capacity of the latter. Of all the different kinds the 600's or 60 design machines are probably the most extensively used in the fine and medium linen trade. One machine is usually sufficient for a doily or a napkin, but two or three machines are used for the majority of medium-quality tablecloths. Two or three of such machines are now, however, often displaced by one or two of the finer-pitch and larger-capacity machines already referred to.

As doilies are amongst the smallest articles woven with the jacquard machine, we will consider one of these cloths as the first example in damask designing and mounting. Doilies may be divided into two common classes—those which are ornamented by needlework after weaving, and those which receive all their ornamentation in the loom. A very popular style of the former class consists of a circular piece of cloth, from 3 to 6 inches diameter, on which a specially prepared circular pattern has been woven. After the cloth is woven, the complete circular patterns are cut out, and the edges whipped by a special machine, in order to prevent fraying. This whipping also strengthens the edges and makes them suitable for the application of crochet work. When no crochet work is intended, the doily is usually provided with a fringe. Although these cloths are made more for the decoration of circular articles than for those of other shapes, it is a common practice to arrange the design so that the finished fabric may be equally suitable for square and circular cloths. When a fringe is required it is usual to weave two cloths in the width; the fringe all round may be 1 to $1\frac{1}{2}$ in. in length, so that a 12-in. doily may have, say, 10 in. of solid cloth. If from this 10 in. we deduct $\frac{1}{2}$ in. on every side for the plain satin cloth, we have 9 in. for the actual pattern. Assuming 70 threads per inch finished, we have :—

$$9 \text{ in.} \times 70 \text{ threads per inch} = 630 \text{ figuring threads.}$$

Designs for doilies are usually symmetrical or semi-symmetrical in style—generally the latter, since the strictly symmetrical design is somewhat stiff in character. In the above case of 630 threads a purely symmetrical design could be arranged on a 400's jacquard, but such an arrangement would not utilise the machine to its fullest capacity, nor would the resulting design be as effective as that which may be obtained by mounting a portion of the jacquard "single"—that is, by having in this portion only one harness cord attached to each hook. Naturally the designer has increased scope, and better designs are likely to result when the number of hooks in the single part of the mounting is increased, but there is a limit to the number of hooks which may be used for the single mount. Suppose this doily of 630 threads had to be woven in a 400's jacquard. It is clear that the difference between the total number of threads and the total number of hooks indicates the number of hooks for the double portion :—

$$630 \text{ threads} - 400 \text{ hooks} = 230 \text{ double portion}$$

—that is, 230 hooks must each control two harness cords—

one on each side of the single portion. It is also clear that the total number of hooks minus the double portion must be the single portion :—

400 hooks – 230 for double = 170 hooks for single.

Therefore :—

230	hooks double	× 2 =	460	threads
170	,, single	× 1 =	170	,,
400	hooks controlling		630	threads.

But, as already shown, it is desirable, whenever possible, to have the various sections of the mount in multiples of the twill and short rows of the jacquard; assuming that the 5-thread sateen is to be used, multiples of 40 would be necessary to suit this requirement. By inspection we see that the nearest numbers to satisfy these conditions, and to be approximately the same as those already found, are 240 and 160. Giving effect to this condition, the complete harness arrangement would be :—

Needles Nos. 1 to 3 =	3 idle					
,, 4 ,, 8 =	5	for 5-thd. sateen	=	60 thds.	=	$\frac{6}{7}$ in.
,, 9 ,, 248 =	240	,, double . .	=	480 ,,	=	$6\frac{6}{7}$,,
,, 249 ,, 408 =	160	,, single . . .	=	160 ,,	=	$2\frac{2}{7}$,,
	408 needles.			700 thds.		10 in.

It will be observed that in the above arrangement no provision is made for the working of a plain or other selvage; but such provision is unnecessary, since the machines employed are always provided with 4 or 6 extra hooks for working such selvages or edgings independently of the needles actuated by the pattern cards. Fig. 120 shows a design of this character, and a plan of the harness reed or comberboard arranged to suit. In numbering the latter, the leading hook, or No. 1, is at the left-hand side and at the back of the board or harness reed, as the case may be. This is in accordance with one of the two methods of numbering in general use.

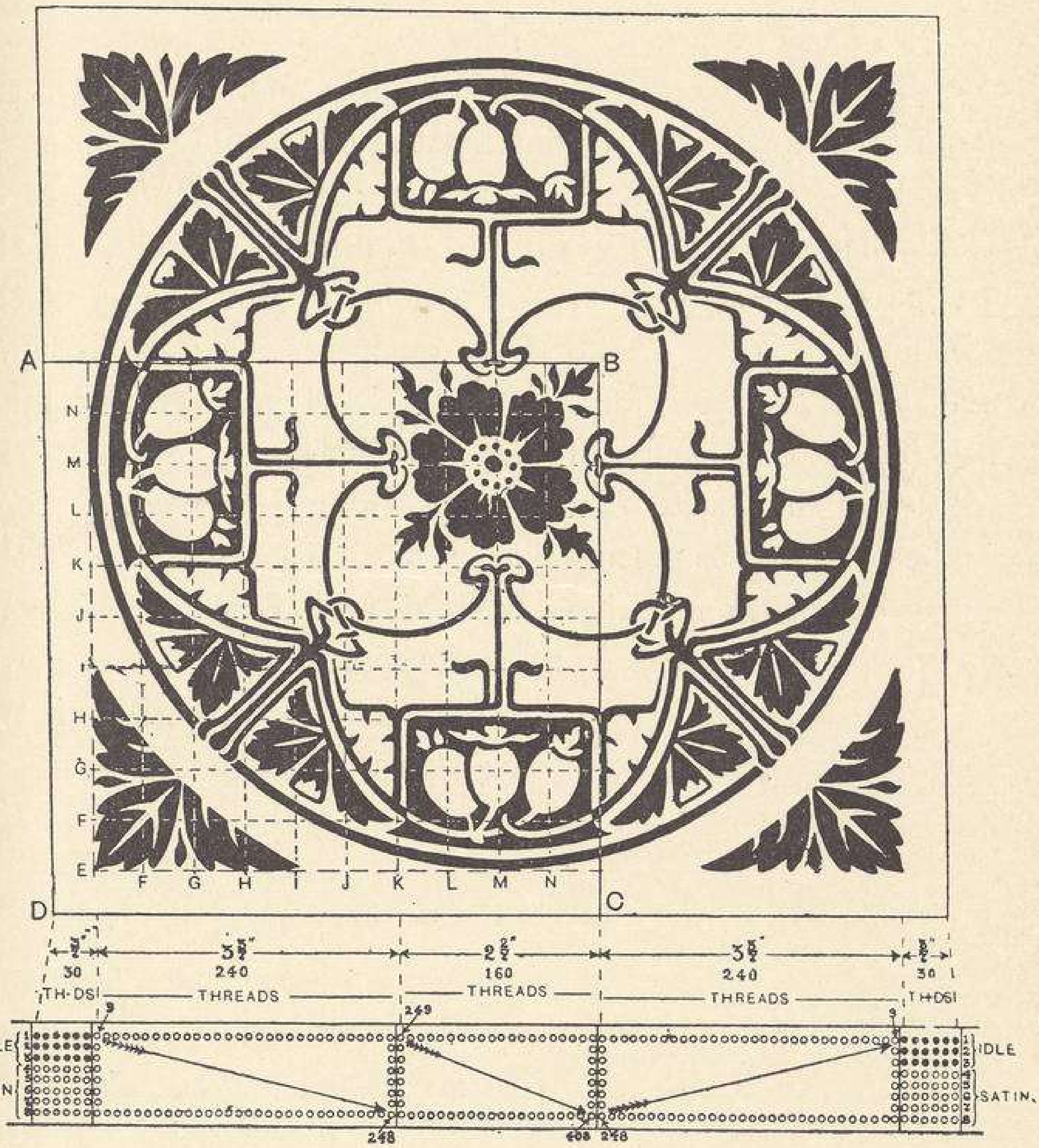


FIG. 120.

When facing the needle board of an ordinary jacquard machine we find it divided into two sections, one of 26 rows of 8 or 12 needles on the right of the division, and the other of 25 rows on the left; in all, 51 rows of needles. The division is caused by the omission of one row of hooks to allow room for the centre lacing of the cards. It is customary to select the first needle, and therefore the first hook from the first row on the right hand of the 26-row section; in some districts the top needle is selected as No. 1, while in other districts the bottom needle is the leading one. Both methods are practised to about the same extent (in actual working the one has no advantage over the other), but care must be taken to cut the cards to correspond to the system of mounting chosen. If the top needle is chosen, then the hook in that row next the needleboard is No. 1, and if the cards fall over the warp—that is, at the back of the loom—No. 1 harness cord must also be at the back of the comberboard or reed. If, however, the bottom needle is taken, then the hook farthest from the needle board—that is, the one next the spring box of the machine—is No. 1, and No. 1 harness cord must pass through the front of the comberboard if the cards fall over the warp. Cards cut for either method will suit the other by turning them over; still it is much better to see that the systems of harness mounting and card cutting are arranged to correspond to each other.

Where cards fall over the weaver's head the positions just described are moved through an angle of 180°, so that No. 1 hook and cord, instead of being at the left and back of the board, are now at the right hand and the front in one case, and at the right hand and back in the other. Whether the harness is mounted with the leading hook or thread at the left hand or at the right is immaterial in the case of damask, since it is seldom desired to show a twill or a diagonal of any kind in any particular direction—the twill has often to incline the same as some part of the ornament, but if the twill is turned in the opposite direction the ornament is likewise turned. Nor is it generally material even in the case of lettered or other similar goods, because a proper manipulation of the lacing or of the working of the cards is usually sufficient to cause the lettering to read in the proper way. It is usual, however, to adhere to one method in any continued explanation, and the one we have adopted is that indicated in Fig. 120. This method requires the design to be turned upside down, and read from right to left in card-cutting, but this proves to be no obstacle in the way of production, or of accuracy of work. When the first hook or cord is at the left and at the front, the design does not require turning, and the reading is, consequently, from left to right.

When No. 1 is at the back, as in Fig. 120, Nos. 2, 3, 4, etc. follow in succession towards the front until one short row (eight in this case) is reached. In the example under consideration, however, the first three hooks are idle; hence no harness cords are passed through the corresponding openings in the first six rows of the harness reed. Hooks 4 to 8 control the first thirty and the last thirty threads of the warp—that is, six repeats at each side of the 5-thread sateen weave. The thirty-first thread of the warp is the first thread of the actual pattern, and is controlled by hook No. 9. The succeeding hooks are then taken in consecutive order till No. 408 is reached. Up to this point—that is, for 430 threads—the draft or drawing-in of the warp is from back to front of the harness reed, and, of course, from left to right; but, from the 431st thread onwards, while continuing from left to right, the draft is arranged from front to back. In other words, the 431st thread is controlled by hook No. 248, the cords from which go to the front of the harness reed, since all cords from one long row of the jacquard pass through the corresponding row of the harness reed. Succeeding threads of the warp are then drawn in from front to back until the extreme right hand is reached. The general direction of the draft in each part is indicated in the diagram by arrows.

We have stated that two such cloths are generally woven in the width of a narrow loom; when this is done it is evident that a second section of the harness reed or comberboard must be filled in exactly the same way as the one indicated. Sufficient space would be left between the two sections to permit of the inside fringes being formed, while "catch threads" would be arranged about 1½ in. from the outsides to retain the weft for the outside fringes. A few plain threads or simple gauze threads might also be introduced close to the cloth of the doily to prevent the outside threads of the cloth from moving laterally from their proper position.

A distinct advantage results when every hook of the jacquard is occupied by a mount of the above type, for strictly symmetrical patterns, as well as semi-symmetrical ones, may be woven without any alteration in the tie-up. To illustrate this, let us consider a cloth of the same size and sett as the one just given on 640 threads. Such a cloth, with a strictly symmetrical design, would require only 320 hooks, and if a 400's jacquard were used, 80 hooks would be left idle. But the mounting illustrated in Fig. 120 may be used without alteration for this pattern if the designer paints or drafts half of the complete design on the first 320 figuring hooks, Nos. 9 to 328, and completes the total number of 400 cords or threads on the design paper by re-drafting, in reverse order, 79 out of the last 80 cords in the design—that is, Nos. 327 to 249 inclusive. This arrangement would be tantamount to a centre tie of the single part, turning on the 328th hook. A harness cord would be empty in the middle of the cloth, and, if necessary, the warp could be re-reeded from this point to close up the fault caused by this omission. Any long float at the centre could be checked by a proper placing of the twilling dot on every fifth pick. This method saves the trouble and expense of mounting another loom and machine, and is applicable to cloths and designs of all dimensions, as well as to doilies.

When transferring the sketch in Fig. 120 to design paper, the designer confines his attention to that part enclosed by the rectangle A, B, C, D. All to the right of this boundary is produced in the cloth by the doubling of the harness, and the upper part of the pattern by the combined action of the doubling of the harness and a set of cards similar to the first set, but laced backwards. To begin with, he divides up the sketch by parallel lines into a series of squares, the number of which is arbitrarily chosen to suit the total number of small squares in the design paper. In the case under consideration there are 400 each way, if we neglect the first or odd row of the jacquard (part of which is idle and part working the satin) and assume that the cloth, and therefore the design paper, is square. Ten divisions would, therefore, be a suitable number in which to divide this sketch, since it would give 5 blocks of 8 cords each, or 40 cords of the design paper per division each way. If a finer division is necessary, the part A, B, C, D may be divided into the same number of divisions as there are large blocks in the design paper. The former method is usually adopted for large designs. The design paper is then divided to correspond to the sketch; the lines on the design paper being usually marked in chalk, and those on the sketch in pencil. The latter are represented on the design in Fig. 120 by the dotted lines E to N. When both sketch and design paper are squared off, the designer proceeds to transfer the sketch to the design paper by freehand, being guided in the process of enlargement by the corresponding squares on the respective sheets. In some cases the enlargement may first be roughly indicated in chalk, then a finer and more accurate outline may be pencilled in, after which the figure portion is painted in solid colour with scarlet, vermilion, or crimson lake. The outline of the painted design should always be firm and decided, to enable the card-cutter to decide immediately when changing from ground to figure; the colour should also be as transparent as possible, so as to show up the divisional lines of the design paper, and the twilling dots of black or of white which it is necessary to insert afterwards.

The above method of enlargement is that which is in general use, although repeated attempts have been made to devise means for automatically enlarging the sketch. A mechanical method sometimes adopted is that in which the pantograph is used. This instrument consists of four light rods joined together to form a parallelogram, the sides of which are extended to convenient distances beyond their joints. Fig. 121 is an illustration of such an instrument. Point A is fixed to some convenient part of the board, B provided with a tracing point for the outline of the sketch, and C with a pencil to reproduce the enlargement on the design paper. Although B and C are movable, A, B, and C are always in a straight line; therefore, since D E and B F are always parallel,

$$\frac{A\,B}{A\,C}=\frac{E\,F}{E\,C}=\frac{D\,B}{E\,C};$$

hence, any movement of B will impart a similar but larger movement to C—the enlargement being in the ratio of D B to E C. This ratio is increased or decreased by decreasing or increasing the perpendicular distance between the parallel rods D E and B F. The rods are kept parallel by means of screws or clamps at D and F. On account, however, of the inaccuracies in the dimensions and proportions of the original sketch, and the difficulty of adjusting the different sides of the instrument to the proper ratio, the pantograph has not been found to be of much practical value for this particular work.

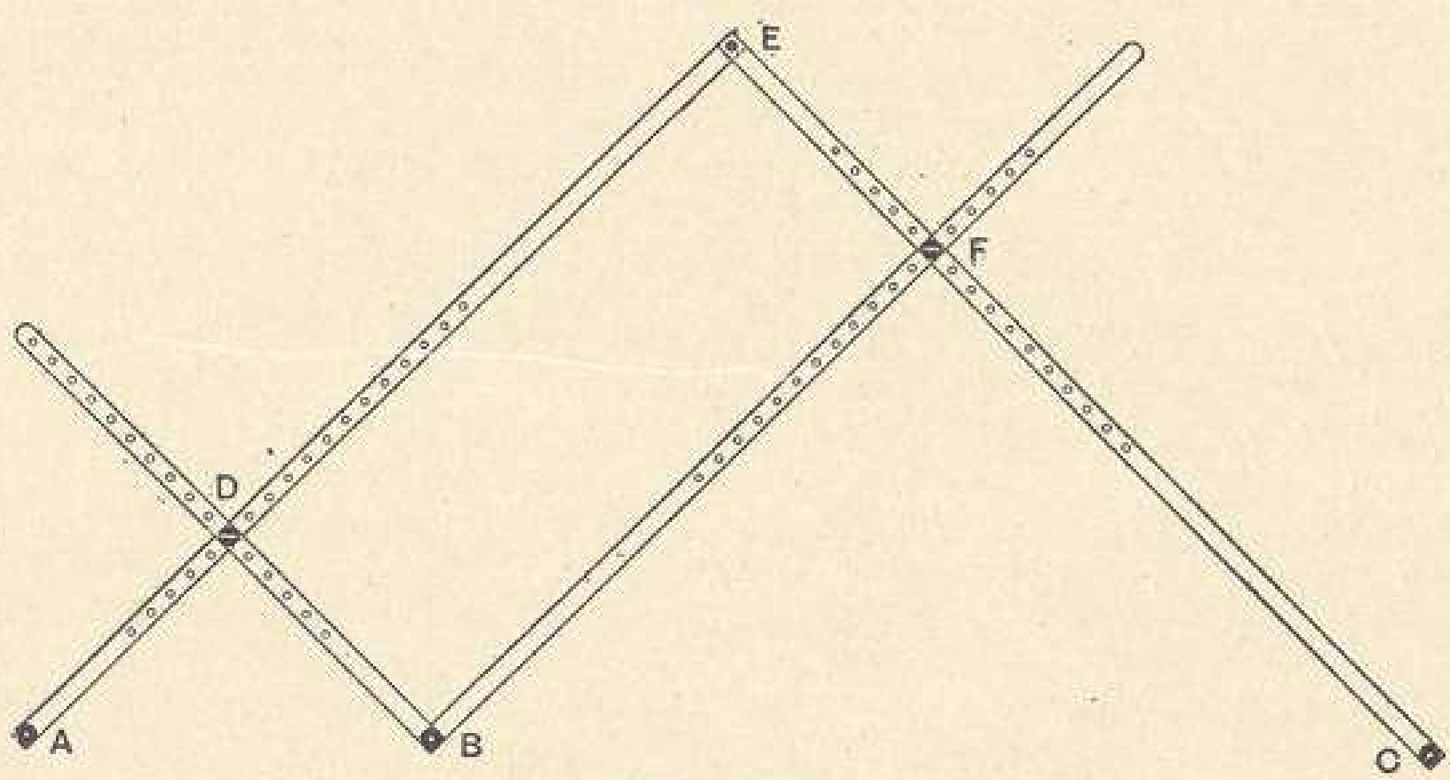


FIG. 121.

Photography has also been employed for enlargement purposes alone, a negative of the sketch being used for the purpose of throwing an enlarged view on to design paper. A pencil tracing is then made by hand round the outline of the figure, which is afterwards painted in the usual way. More recently, in the Szczepanik system, negatives and positives of the sketch were made (the former for the figure and the latter for the ground), and, by the aid of suitable screens, the designs were enlarged to the required degree on sensitised paper. At the same time the binding weaves were inserted, and the paper ruled or squared off into small divisions with the necessary horizontal and vertical guiding lines for the card-cutter. Ingenious as this was, however, difficulty was experienced in the placing of the weave points round the edges of the figure—a difficulty which we are afraid cannot be overcome by any mechanical or automatic means.

In Fig. 122 we show a section of the sketch given in Fig. 120 enlarged to design paper. Part of the enlargement has been left in freehand outline, another part has been outlined in keeping with the squares of the design paper, a further part has been painted solid, while the balance has been painted and twilled in both ground and figure. The first three cords of the design paper have been ignored, since the hooks corresponding to these are idle. The 4th to 8th cords have been twilled with the 5-thread sateen weave, because the hooks corresponding to these cords actuate the satin part of the design. The same 5-thread sateen weave, but twilling in the opposite direction, is used in the figure. Twilling in the opposite direction is adopted with the intention of giving the weaves every opportunity of "cutting" or binding automatically where ground and figure meet. Should the weaves bind naturally it is generally by accident, except in cases where the number of threads of figure intervening between the two ground portions is a multiple of the weave employed. The method of beginning the weave as shown at E (marking the second thread on the first pick instead of the first thread) is one of the two correct methods. Beginning with the second thread and first pick, or with the second pick and the first thread, generally ensures that the various portions of the border, corner, and repeating part of the design will join up properly. In many cases this result cannot be obtained if the weave begins on the first thread and first pick (see J and K, Fig. 104, p. 140). How the twill of isolated portions

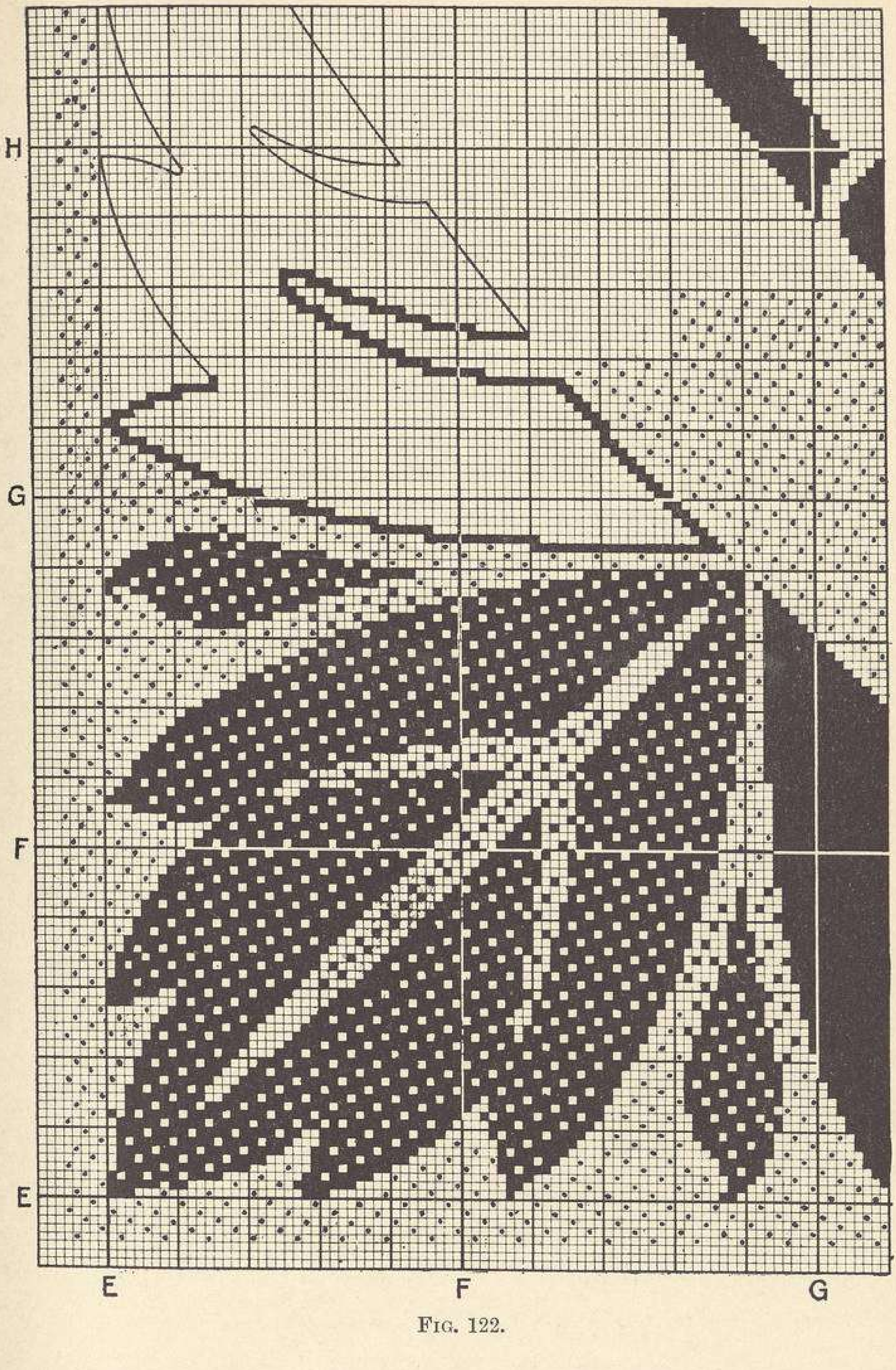


Fig. 122.

of the figure begins does not really matter. In the case of rectangular figures parallel to the threads, and all similar straight line edges, it is always arranged to cut with the ground twill; but for figures with curved edges it may begin at any convenient spot—*i.e.*, where a dot of the ground twill weave comes hard against the outline of the figure. In many parts of Fig. 122 it will be seen that the dots of the twill have been misplaced to prevent their marring the outline of the figure, and in several portions the floating threads have been bound without regard to the perfect continuity of the twill. Where the regular order of the ground twill has been departed from to meet either of the above cases, full squares have been substituted for the customary dot.

When approaching the edge of the figure with the ground twill, it is not essential that every spot of the twill should be inserted; nor should every spot of the figure twill be inserted when nearing the ground. If it were so, the photographical method would probably be a success. With the 5-thread twill the normal float is four in both warp and weft, but in practice this may be extended to six in either direction, on and around the edge of the figure. Where the 8-thread twill is used, a float of ten may be permitted in similar circumstances. In other words, floats of seven and eleven must be checked in the 5-thread and 8-thread twills respectively. This practice of permitting the ground and figure threads at the edges to float slightly in excess of the normal at the edges generally results in an enhanced appearance of the figure. Particularly is this the case in the finer qualities; care must be exercised, however, when the practice is introduced into designs for low quality fabrics.

An important feature in the twilling of the design given in Fig. 120, and of any design of similar character, is the treatment necessary for the single portion of 160 threads. This part being in the centre of the design, or rather between these portions of the warp which are actuated by the double portion of the harness, must be twilled at both sides to meet with, or coincide with, the continuity of the twill of the double portion. Since the double portions end and begin on the same or a similar thread—No. 248,—the ground twill of the first thread of the single, No. 249, and of the last thread, No. 408, must be alike, and must be continued to right and left respectively in the same manner until they reach the edges of the figure portion intervening. Should no figure intervene, and the twills from both sides meet—an unlikely occurrence, except at isolated parts,—the twill must be broken in the centre to avoid the appearance of a pointed draft. Portions of the figure which do not extend into the double part may all be twilled in one direction in precisely the same way as the figure of the double portion, but those portions of the figure on the right edge of the single must be twilled to join up properly with their corresponding doubled-over continuations.

The second example of mounting is a napkin or serviette. Full harness designs for these fabrics are very varied in character, but, in general, the plan or scheme of each may be placed under one or other of the following :—

1. Designs of a perfectly symmetrical character: these are few in number.
2. Designs of a semi-symmetrical nature, in which a considerable portion of the centre of the cloth is mounted single to permit of any ornament of the monogram nature being woven.
3. Designs consisting of a simple straight-tie border and a straight-tie repeat. This is a very widely-adopted

and serviceable type. Approximately half the machine is mounted for the two borders, and the other half utilised for four or five repeats, as may be found necessary to give the desired width.

Examples:—

$$\left.\begin{array}{l}200\text{ border}\\200\text{ repeat}\end{array}\right\}\text{ or }\left\{\begin{array}{l}320\text{ border}\\280\text{ repeat}\end{array}\right\}\text{ or }\left\{\begin{array}{l}300\text{ border}\\300\text{ repeat}\end{array}\right\}\text{ etc.}$$

4. Designs in which larger borders of the symmetrical or semi-symmetrical types may be obtained by mounting a number of the hooks double and single, as illustrated in Fig. 120, while the remaining hooks are reserved for a simple repeating centre.
5. Designs in which an outer border and an inner border—that is, main and subsidiary borders—are formed on about three-fifths of the total number of hooks, while the other two-fifths are utilised for the necessary repeats. Both borders are separated slightly by an intervening portion of plain satin cloth.

The quality of the cloth and the style of design required are the factors which decide the number of hooks. This number varies from 400 to 1200, but a single jacquard of 600 hooks is generally employed.

Designs of types 1 and 3 are so simple that no further detail is necessary. Type 2 has already been referred to in detail under doily designs, although there are many modifications of this style. Type 4 will be treated fully under the tablecloth example to follow, while type 5 is fully illustrated and described as under. We shall assume a 24 in. finished napkin with 80 warp threads per inch, that is, with 24 in. × 80 = 1920 threads, and that a 600's jacquard is to be used, arranged as follows:—

240 hooks for outer border	}	$= \frac{3}{5}$ of 600.
120 ,, inner ,,	}	
240 ,, repeat . . .		$= \frac{2}{5}$ of 600.

The various sections of the mounting are in multiples of 8 and 12; this is because the 8-thread sateen twills would be used in conjunction with the 12-row machine.

2 borders each of 360 threads =	720 threads.
1920 threads − 720 border threads =	1200 threads for the repeats, serge twill, and satin parts.
4 repeats of 240 threads each =	960 threads.
1200 threads − 960 threads . . . =	240 threads, or 120 on each side for extras.

These 120 threads would probably be allotted as 40 for the inner satin, 64 for the outer satin, and 16 for serge or other firm twill weave between the plain selvage threads and the outer satin. The full mounting would therefore be as shown in the table given below.

4 threads plain . .	×2 = 8	threads actuated by needles and hooks independently of the design.		
16 ,, serge twill .	×2 = 32	,, ,, ,,		
		Hooks Nos.	1 to 4 idle	= 4
64 ,, outside satin .	×2 = 128	,, on ,,	5 ,, 12	= 8
240 ,, ,, border	×2 = 480	,, ,, ,,	13 ,, 252	= 240
40 ,, inside satin .	×2 = 80	,, ,, ,,	5 ,, 12	= . . .
120 ,, ,, border .	×2 = 240	,, ,, ,,	253 ,, 372	= 120
240 ,, repeat . .	×4 = 960	,, ,, ,,	373 ,, 612	= 240
	1928 threads.			612 hooks.

Fig. 123 shows a sketch plan of a simple geometrical design arranged to illustrate the foregoing harness mount; it also illustrates the planning out of the comberboard or harness reed to correspond. The actual sett or pitch of the latter does not at present concern us, but it must be such that the total width of the harness will coincide with the width of the warp in the reed. Now in those sections of the harness marked A and B there are only 8 cords per row, while in all others, with the exception of the extreme outside or serge portions, there are 12 cords per row. But

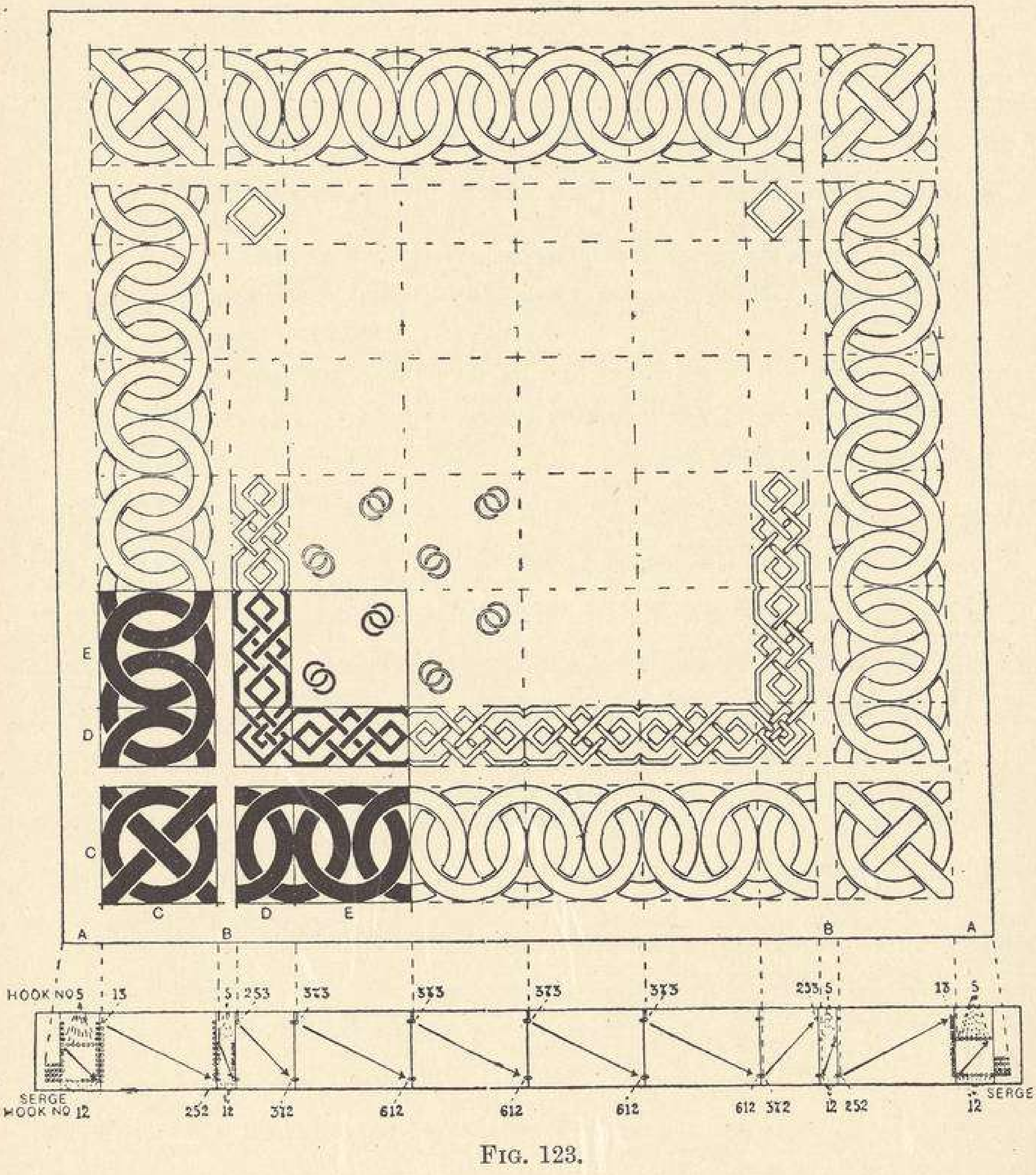


Fig. 123.

since the sett of the loom reed is constant all over, it is evident that in order to have the loom reed width the same as that of the harness reed, the sett of the latter at the portions A and B must be considerably closer than at the main border and repeat parts. The pitch or rows per inch of the various portions must be inversely proportional to the number of cords per row, and, in the present case, since these are 8 and 12, the pitch of the sections A and B must be 50 per cent closer than the other parts of the harness reed or comberboard. With a comberboard built on the sectional principle, the sections of the requisite pitch could be placed where required, but with a harness reed the common practice is to "crowd" or "cram" the harness to the necessary extent. A constant sett throughout could, of course, be arranged if the satin part were actuated by two rows of the jacquard, but this would reduce slightly the figuring capacity. The first and the last cord of each section of the pattern are indicated by their corresponding numbers, while the arrow heads indicate the general direction of the draft in each section.

The complete unit of the design is shown in solid black, and the various repeats are either continued in outline or indicated by means of dotted lines, which show the extent of each repeat. When transferring a design of this type to design paper, the plain satin portion at B is, of course, omitted, since it is actuated by those needles or hooks which control the portions marked A. Sections C, D, and E are therefore brought close together to form a continuous painting on 600 warp cords, and, should the threads and picks per inch in the finished state be the same, the painting would also occupy 600 weft cords. Mathematical instruments would prove of great assistance in enlarging a design such as this to design paper. The twilling of all damask designs is so much alike that no further illustration is necessary.

In Fig. 123 it will be seen that, besides circular figures, there are horizontal, vertical, and inclined bars or bands. These are in general the same width, but it must be remembered that for the same width the inclined bars require a longer float than the horizontal or vertical bars. When, as is usual, the inclination is 45°, the number of squares or the float of warp and weft for the inclined bar is $\sqrt{2}$ times that occupied by the horizontal or vertical bars; the nearest whole number being, of course, taken. Thus, in Fig. 124, which is intended only for illustrating this fact, the horizontal and vertical bars float over five squares; therefore the float in the inclined part is $\sqrt{2} \times 5$—*i.e.*, $1{\cdot}41 \times 5 = 7$ squares.

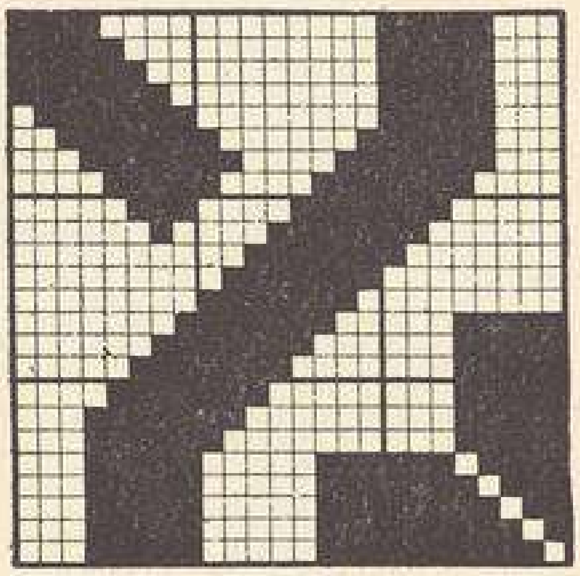


FIG. 124.

Designs for tablecloths are very similar to, although usually a little more elaborate than, those for table napkins; and the five types of mounting indicated under the latter head may be taken, in a general way, as illustrating the more extensive schemes of mounting employed for the larger fabrics. Special mountings may require to be arranged to meet special cases, but these exceptions are, in most cases, simply modifications of one or more of the five types referred to. Recently there has been an increasing demand for extensive borders of the single character illustrated in type No. 3, two 600's machines or 1200 hooks being often used for the border tie alone, with a third 600's machine for the repeat or filling portion. A 900's machine is occasionally used with the two 600's, and when this does not afford sufficient scope, two machines of 1320 hooks each may be employed for one design. The general plan of the mounting is, however, very simple, and we shall illustrate a mounting of the type indicated in No. 4, using two 600's machines. Designs of this type are also very widely adopted, since they give comparatively wide borders on a relatively small number of hooks. In some cases the single portion of the border of a design of No. 4 type is so arranged that, in addition to forming part of the main border, it may also appear alone between the main border and the filling or centre of the cloth; it thus forms a supplementary border, and is technically known as a "lift-in" border. This type is clearly a combination of the styles indicated in Nos. 4 and 5. The dimensions of the ornament on the cloth are so chosen that the commencement of the supplementary or "lift-in" border coincides with the edge of the table top, while the main border hangs over the edge of the table.

When the width of a border is considerably increased, it is generally desirable, from an artistic point of view as well as for the sake of proportion, that it should also be increased in length. In many cases, therefore, the length of the border repeat is made 16 to 18 in., while the centre repeat is only 8 to 9 in. long. Two repeats of the centre pattern must, therefore, be woven for one repeat of the side border; and, should an odd number of centre repeats be necessary to give the requisite length of cloth, it is obvious that the border pattern must be broken half-way. Sometimes the border pattern is three times the length of the centre pattern. All border patterns of the above nature must be so designed that the breaks will not occur at points which will seriously affect the appearance of the completed design. Since the number of hooks which control the filling or centre is usually much less than the number of picks in such a side border, it follows that the side-border design or painting cannot be used in its entirety for the end border as well, although, under certain circumstances, and with careful designing, half of the side-border design may be, and often is, utilised for the repeat of the end or cross border portion. In order that the side-border pattern may be used as well for the end or cross border, the following essential conditions must be observed :—

1. The number of picks in the repeat of the side border must be the same as the number of threads in the width of the repeating portion of the cloth.
2. The design paper (and, therefore, the sett of the cloth) must be square : 8 by 8, 12 by 12, etc.—since the vertical ruling in one case becomes the horizontal ruling in the other, and *vice versa.*

Specimen mounting, type No. 4, for a tablecloth 72 in. wide, 75 threads per inch finished. Two 600's jacquards to be used—one for a border pattern about 10 in. wide, and the other for a straight tie repeat. The 5-thread sateen weave to be used for both ground and figure. With this weave and a 12-row jacquard the various sections of the mount should preferably be in multiples of 60.

10-in. border pattern × 75 threads per inch = 750 threads.
750 − 600 hooks = 150 hooks to be mounted double.

To retain the mounting in multiples of 60 there must be either 120 or 180 hooks mounted double. Either number might be adopted—120 double would make the border slightly narrower than 10 in., while 180 double would make it a little wider. We shall take 180 hooks for the double portion, and therefore 600 − 180 = 420, for the single, as indicated in table below.

[TABLE.

180 + 420 + 180 = 780 threads for each border.
= 1560 ,, both borders.

75 threads per inch × 72 in. wide = 5400 threads in all.

5400 threads − 1560 border threads = 3840 threads for centre and satin parts.

Say 6 repeats × 600 = 3600 threads for the filling; then 3840 − 3600 = 240 threads for side serge and satin.
= 120 ,, each side serge and satin.

20 of these may be serge and 100 satin. The full mounting would therefore be as follows:—

First Machine.	4 threads plain × 2	= 8 threads actuated by special needles and hooks.			
	20 threads serge × 2	= 40 ,, ,, ,, ,,			
			Hooks Nos. 1 and 2 idle	=	2 hooks.
	100 threads satin × 2	= 200 ,, ,, ...	,, 3 to 12	=	10 ,,
	180 ,, double border	= 780 × 2 = 1560 ,, ,, ...	,, 13 to 192	=	180 ,,
	420 ,, single border		193 to 612	=	420 ,,
					612 ,,
			Hooks Nos. 1 to 12 idle	=	12 ,,
Second Machine:	600 threads repeat × 6	= 3600 threads actuated by	,, 13 to 612	=	600 ,,
		5408 threads.			612 ,,

Fig. 125 is a sketch of a design arranged according to the particulars given above, with a plan of a portion of the comberboard arranged to correspond. Two repeats are given in the length of the design, and one repeat and a half in the breadth of the repeating part or filling.

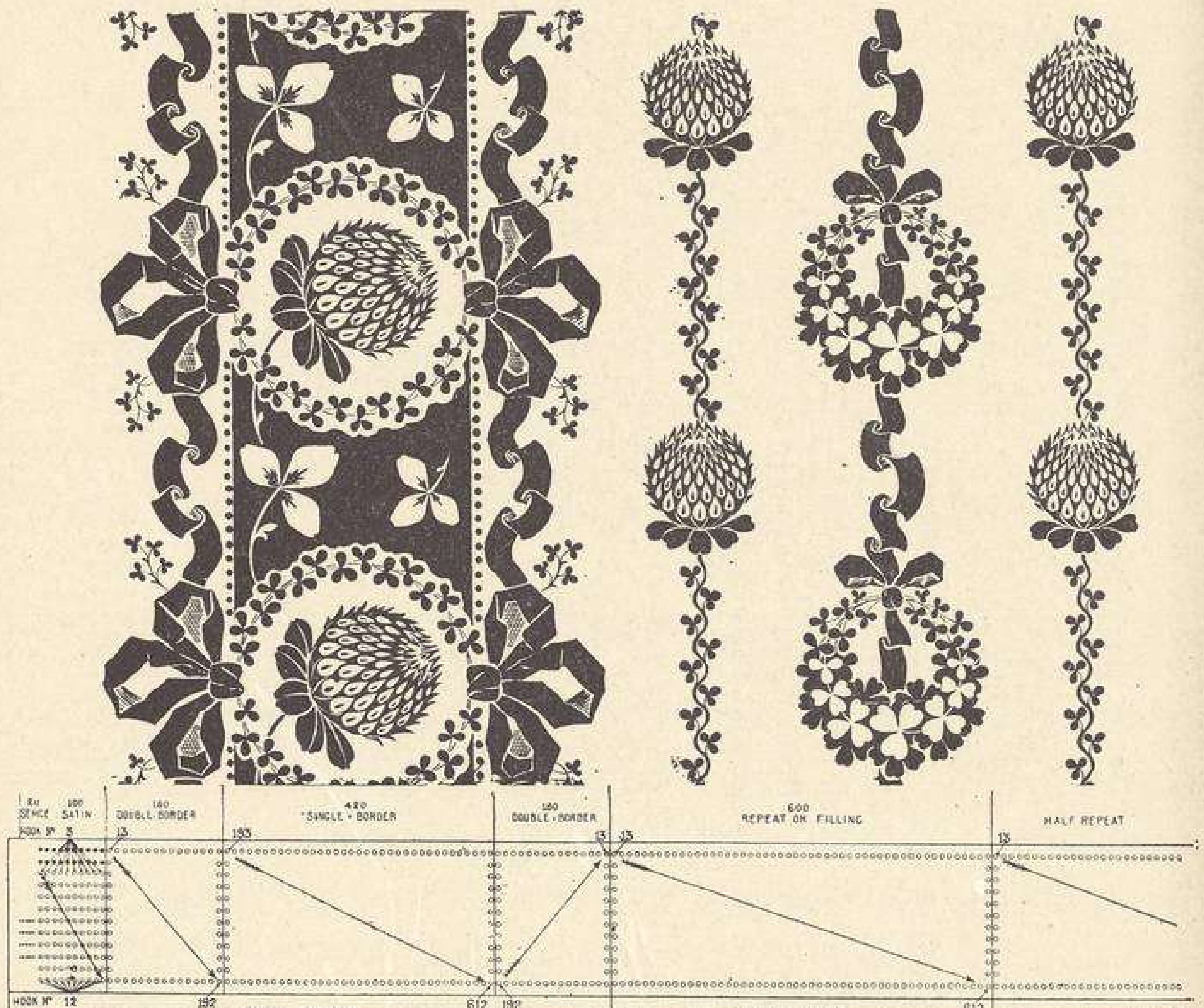


FIG. 125.

This figure illustrates clearly that the design is capable of being broken at a half repeat if necessary, in order to meet the requirements of certain widths. A close examination will also show that it may be broken at half the length as well—immediately above and below the wreath portion of the centre—without unduly breaking the centre pattern. Breaking of the border pattern cannot always be avoided, but this is of much less importance than breaking the repeating part.

If we assume that the above cloth is to be woven square —that is, to contain 75 threads and 75 picks per inch when finished,—then it is only necessary to paint three sheets of design paper for the card-cutter. If we neglect the ten hooks for outside satins, each sheet would be 600 by 600 square. Sheet No. 1 would contain the corner piece: this is not shown on the sketch, nor is it usually shown by designers in practice, but it must be designed to be in keeping with the border. The side border would be painted on sheet No. 2, while the repeating part of the design would be on No. 3 sheet. This is more fully illustrated by the sketch plan of a complete cloth in Fig. 126, where heavy rectangles have been drawn indicating the various parts of the design taken by each sheet of design paper. Sheet No. 2 is also utilised for the end or cross border portion by turning it through an angle of 90°, as indicated in the figure. Section A of the side border and corner is the image or turn-over of the first 180 threads of sheets 1 and 2, and is obtained by the backward draft of harness cords from hooks 192 to 13; while section B of the cross border and corner is produced by re-cutting the first 180 cards of the corner and border designs, and then lacing them backwards. Should the cloth be shotted "over square" or "under square" it would be necessary to paint a fourth sheet for the cross-border part, since the ruling of the side-border sheet would be unsuitable.

Since the clearest reproductions are those in black and white, no attempt has been made to shade off any part of the design in Fig. 125, although different methods of treating the underside of the ribbon have been suggested. In actual practice, however, the various folds of the ribbon would be shaded, and not represented, as in the figure, by a flat treatment in painting. With the 5-thread sateen twill it is impossible to obtain a very fine gradation in the shading of any portion of a design, although in the example given in Fig. 127 a sufficiently fine gradation has perhaps been

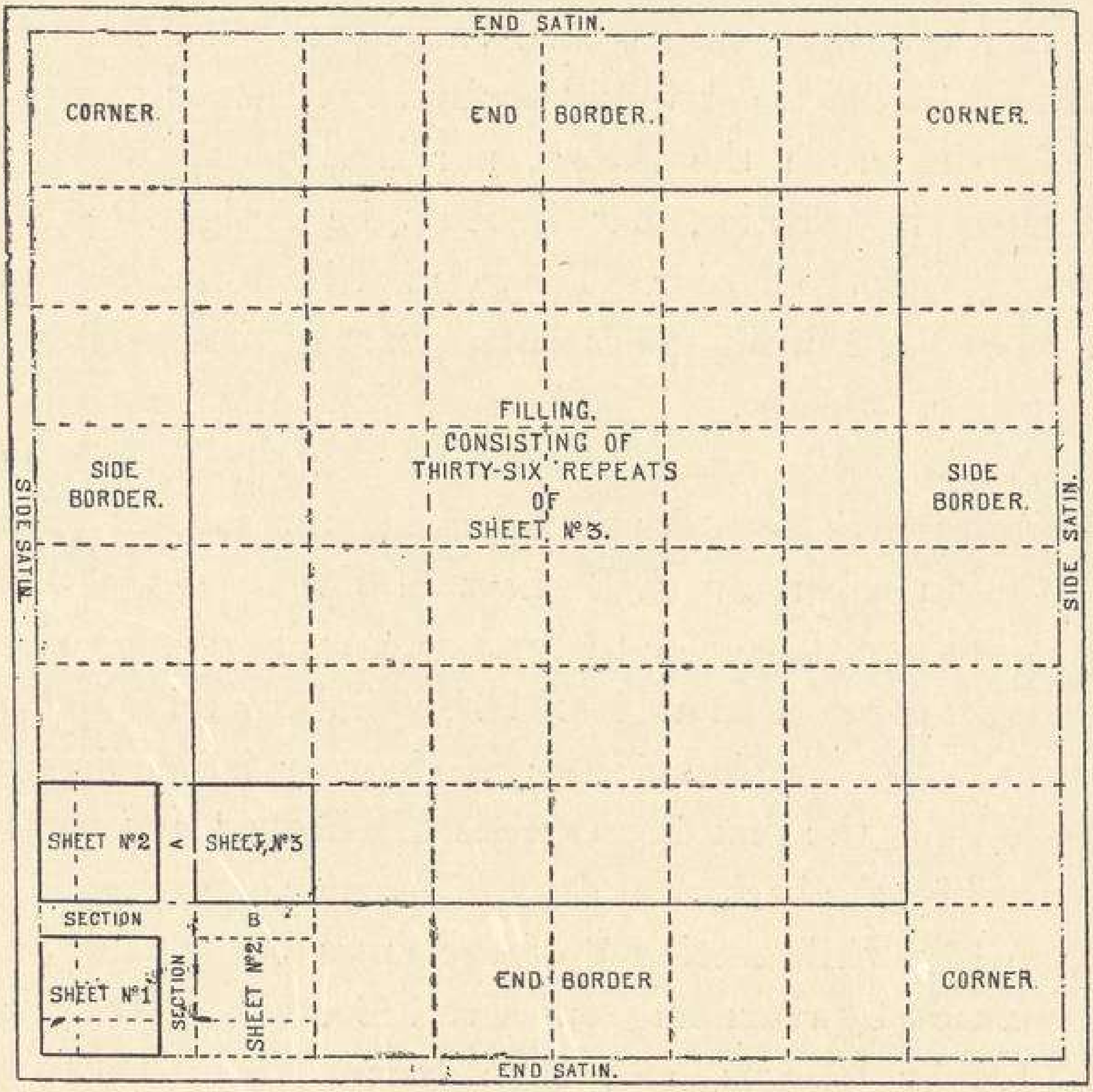


FIG. 126.

obtained to convey the desired impression. In order that the figure may blend or shade off gradually and naturally into the ground portion of the design, the method of shading generally employed is that of running out or continuing the ground twill as far as may be necessary, and then of gradually adding extra dots in the way of the warp to those already marked; or, in other words, increasing the length of the warp float step by step from a minimum of one pick or mark to a maximum of four or seven, according to the weave employed. One feature of this method, illustrated

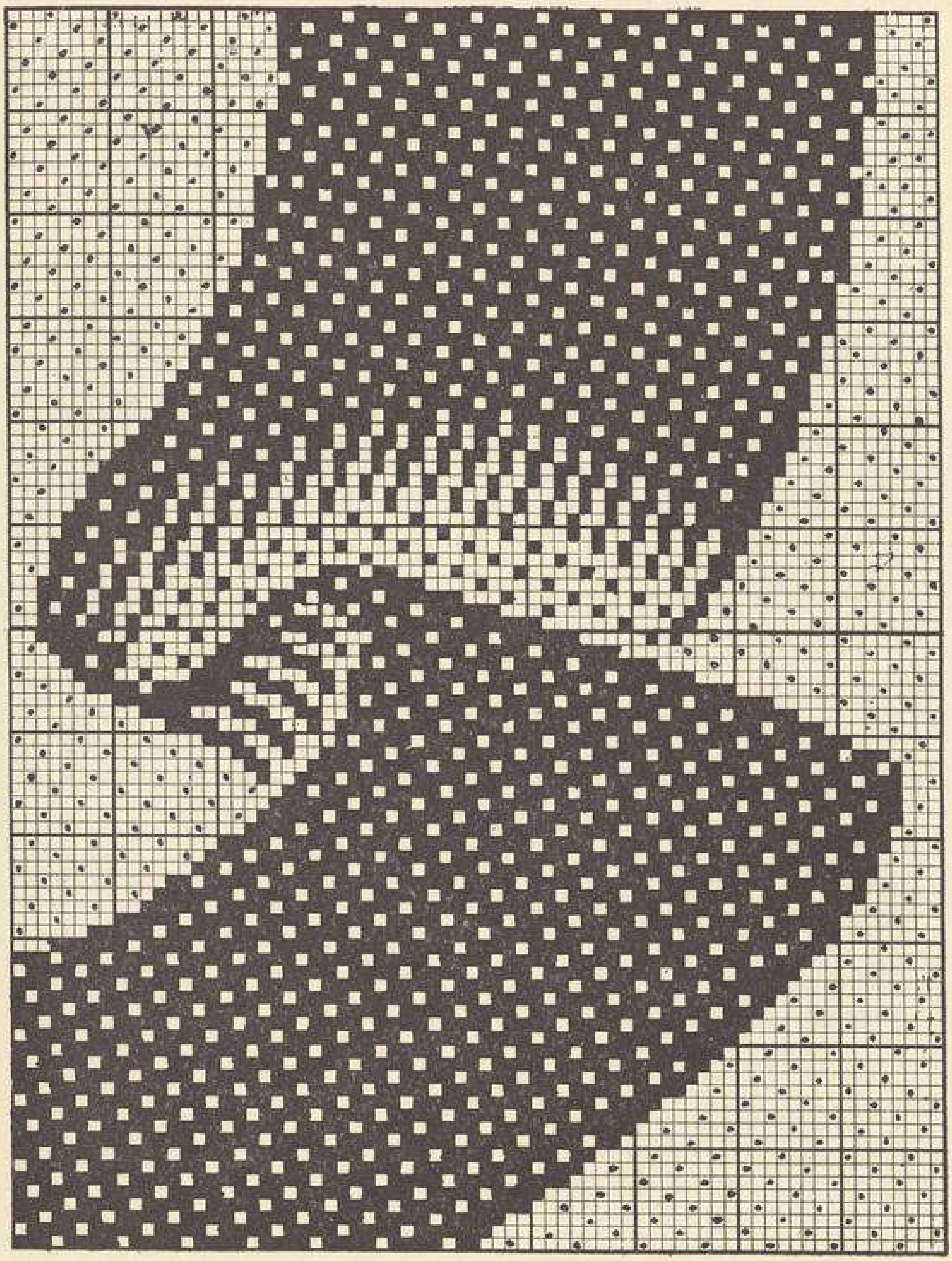


FIG. 127.

in the upper part of Fig. 127, is that the binding twills in both ground and figure run in the same direction. This may or may not be an objection, according to the conditions under which the shading is practised. Should it be likely to prove objectionable, the opposite ground twill may be used for the beginning of the shaded parts. At A in Fig. 128 the twills have been reversed just where the shading commences—that is, between the thirteenth and the fourteenth picks. For the first thirteen picks the step is five picks upwards and one thread to the right; but from the fourteenth pick onwards the step is only three picks upwards. This is clearly shown by the first pick of each float in any diagonal of the shading twill.

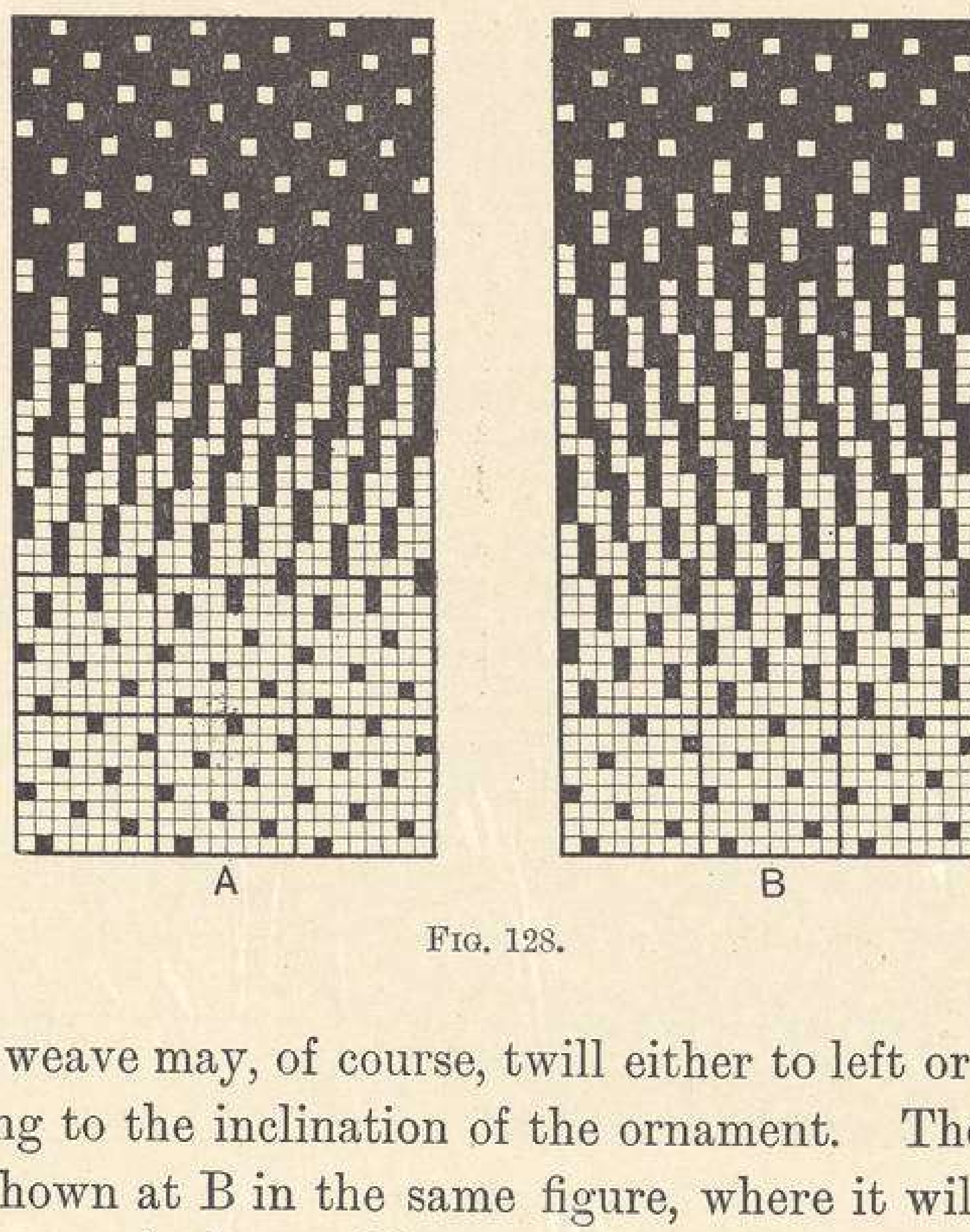


Fig. 128.

The weave may, of course, twill either to left or to right, according to the inclination of the ornament. The twill to left is shown at B in the same figure, where it will be seen that the step is three picks upwards and one thread to the left. The change from ground to figure is more gradual in B than in A, and, when the fundamental sateen twill commences, as shown at B, it has the decided advantage of a perfect gradation to the ordinary warp float weave illustrated at M, Fig. 104 (p. 140). The change from weft float to warp float is occasionally made by increasing the floats of the picks instead of the floats of the threads. This method is, however, more suitable for cloths where the threads per inch of warp exceed the picks per inch of weft. The particular method of shading adopted must always rest with the designer, who will choose the gradation which happens to be the most suitable for his purpose.

A type of shading which gives a rapid change from ground to figure, and which is well adapted for combination with the 8-thread sateen twill, is illustrated in the upper portion of the leaf in Fig. 129. It is really a 4-thread straight twill rapidly enlarged from a float of one to a float of three. The ground twill of the 8-thread sateen may be readily changed to the $\frac{1}{\;\;3}$ straight twill by the addition of alternate marks; then one or two extra marks may be added at will to increase the float to three picks, although a little care must be exercised where the twill again reverts to the sateen order in the figure portion. The gradual development of the change is illustrated in the detached parts of the figure.

Fig. 129 also illustrates the method of applying a straight twill in order to give the effect of relief or of prominence to any part of the figure. The turned-up portion of the leaf in the same figure is scarcely large enough to permit of properly graded 8-leaf shading, but this has been already illustrated in Fig. 128.

The so-called common harness system of damask weaving, whether it be performed by the older and more intricate method of pressure harness, or by the more modern and more desirable self-twilling jacquard, is employed for essentially economic reasons. As we have indicated elsewhere, this system, compared with the full harness system, effects enormous savings, particularly in designing and cards, and indirectly gives the designer wider scope for the production of large and flowing designs. The treatment of the design is almost invariably flat, since the automatic insertion of the

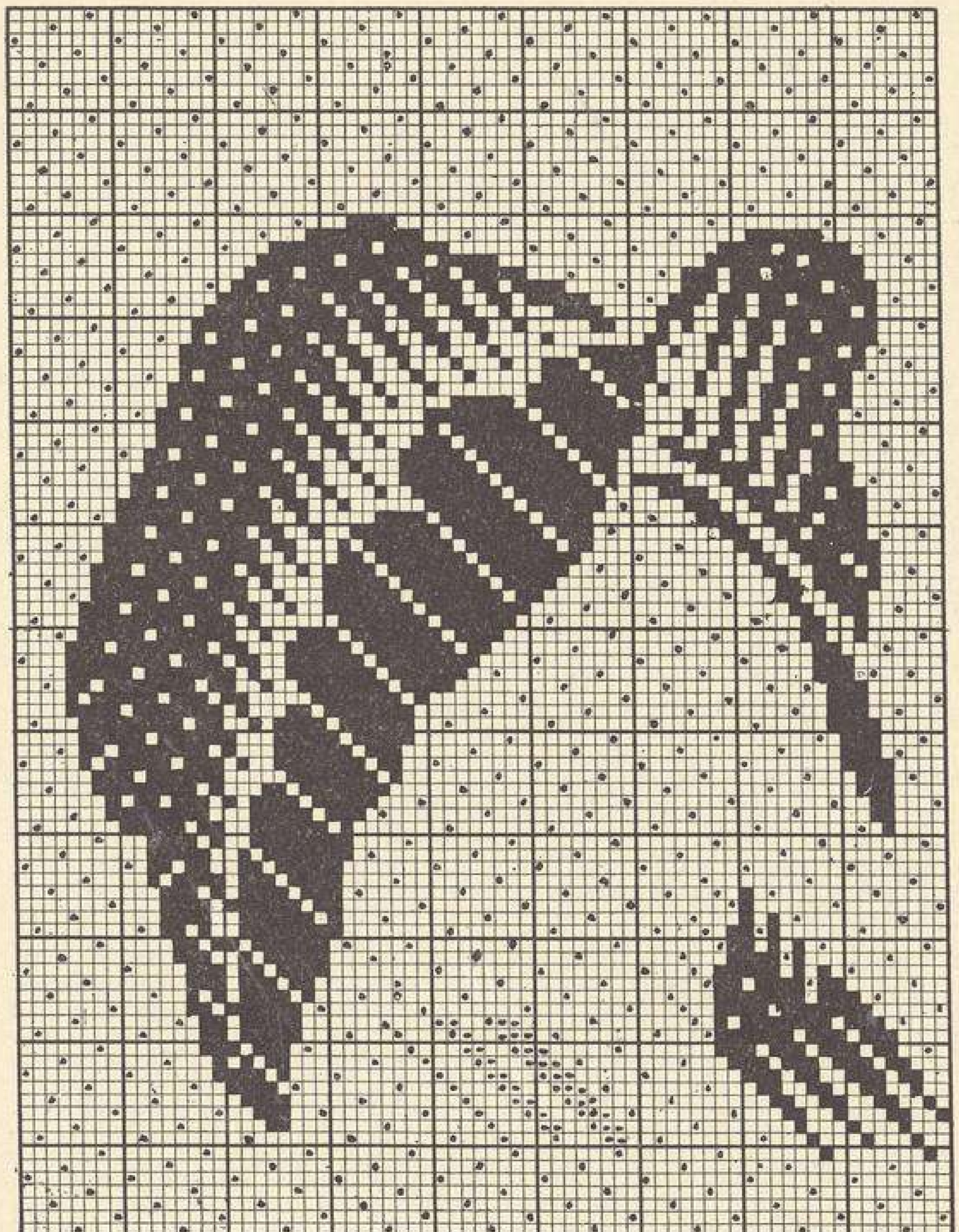


FIG. 129.

twill by the shafts of the pressure harness, or by the twilling knives of the jacquard, makes it impossible to introduce ordinary shading into the cloth. Nevertheless, effects approaching shading are often obtained by a process which will be explained later. Although in special cases under this system each needle and each card may control respectively only one thread or one pick in each repeat of the pattern, it is more general to find two or more contiguous threads operated by one needle, and each card presented to the needles for two or more successive picks, while in silk fabrics these numbers are often exceeded. Such being the case, it is evident that each vertical and horizontal cord or row of the design will represent two or more adjacent threads or picks in the cloth. Consequently, the designer may introduce much finer detail than it would be wise to attempt in the case of full harness designs; indeed, he may paint single cords in both directions.

Many of the linen and other cloths woven on this system, perhaps the great majority of them, are overshotted to the extent of 50 per cent, or, in other words, they contain 50 per cent more weft picks than warp threads per inch. With the full harness system of weaving it would be necessary in such cases to have the design paper ruled to correspond—*i.e.*, ruled 12 by 18 for 600's machines, and so on; but with the common harness system it is not essential that the ruling of the paper should correspond with the sett of the cloth, since each card may be presented to the needles for any practicable number of successive picks. It must be remembered, however, that the outline of the design will suffer in clearness and sharpness in proportion as the picks per card are increased. In order, therefore, to obtain the best results, paper should be used in which the vertical and horizontal ruling are approximately in the same ratio as the threads and picks per inch of the cloth. Thus, 8 by 12, 10 by 15, or 12 by 18 paper, according to the jacquard to be used, would suit for cloth shotted 50 per cent over square. By using paper ruled in keeping with the sett of the cloth, the number of picks per card is kept at the minimum, and the graceful curves and general fineness of the outline of the design are improved accordingly. This procedure, although often adopted, is admittedly more expensive in cards, as well as in the painting of the design; it is, therefore, very common to find square design paper used, and the proportion of weft to warp made up by increasing the number of picks per card at the expense of the distinctness of the outline of the figure.

In some very fine linen damask, made on the common harness system, and counting about 140 to 150 threads per inch each way, the practice of overshotting is departed from with distinctly beneficial results as regards the general effect of the design, and we think that a more general adoption of this principle, with a maximum of two hooks per needle and two picks per card, would result in a most desirable improvement in many of the designs which at present are woven with three and four hooks per needle, and sometimes with more than four picks per card. Besides, the reduction of the shotting would enable the cloth to be produced more rapidly, and therefore more cheaply. Heavier weft would, of course, require to be used to maintain the original weight, but since heavy yarns are relatively cheaper than the finer counts, a further economy would be effected.

Harness mountings for cloths and napkins worked on the common harness principle are usually very simple in character. For a table napkin the harness may, in extreme cases, consist of a straight through tie from selvage to selvage. Jacquard machines of large capacity are required to weave patterns of this class; but, on the other hand, the designer has unrestricted scope. He should, however, remember that it is desirable to have both borders practically, if not strictly, alike. Variety in the detail of the borders may be permitted, but the general arrangement of the heavy masses should be the same in both borders. To develop a pattern of the foregoing character on a 27-in. table napkin with 90 threads per inch finished would require a scheme somewhat as under :—

27 in. $\times$ 90 threads per inch $=$ 2430 threads in the warp.

3-in. plain satin, or other simple weave ($1\frac{1}{2}$ in. at each selvage) $\times$ 90 threads $=$ 270 threads.

2430 threads $-$ 270 threads for satins and selvages $=$ 2160 threads for pattern.

$$\frac{2160 \text{ threads}}{2 \text{ hooks per needle}} = 1080 \text{ needles.}$$

$$\frac{1080 \text{ needles}}{12 \text{ needles per row}} = 90 \text{ rows of needles required.}$$

Since such jacquards are made with either 51 rows or 75 rows of needles, it follows that two machines of 51 rows each, or 102 rows in all, would be adopted. Ninety rows would be occupied by the pattern, part would be used for side satins and selvages, and the remainder would remain idle.

In this example we have assumed two machines of 24 hooks per row, with a total capacity of 2448 hooks or 1224 in each. It is therefore evident that the pattern portion of the napkin might be increased beyond 2160 threads, should it be thought necessary, since there are plenty of hooks to spare. To do so, however, to any great extent, would reduce the satins too much, and thus impair very considerably the appearance of the complete napkin.

Other methods of mounting for the same design might be arranged. Thus, a 900's machine (75 rows of 12 needles) with 32 hooks per row might be used. Setting apart one row of 32 hooks for side satins, the remaining 74 rows might be "fileyed" in two ways. Thus :—

$$\text{(A)}\quad \left.\begin{array}{l}2 \text{ rows} \times 32 \text{ hooks per row}\\ 2 \text{ rows} \times 28 \text{ hooks per row}\end{array}\right\} \text{for 72 rows} = 2160$$
$$\text{Then 2 rows of 32 hooks per row} \;.\;.\; = \quad 64$$
$$\text{Pattern threads } 2224$$

Leaving 2430 threads − 2224 threads = 206 threads for satin, etc.

$$\text{(B)}\quad \left.\begin{array}{l}2 \text{ rows} \times 28 \text{ hooks per row}\\ 2 \text{ rows} \times 32 \text{ hooks per row}\end{array}\right\} \text{for 72 rows} = 2160$$
$$\text{Then 2 rows of 28 hooks per row} \;.\;.\; = \quad 56$$
$$\text{Pattern threads } 2216$$

Leaving 2430 − 2216 = 214 threads for satin, etc.

In both cases the average is approximately 74 rows of 30 hooks per row.

Now this number—thirty hooks per row—could be obtained exactly with the same machine, provided the 5-leaf twill were to be used; and 32-row machines are often specially filled 3, 2, 3 hooks per needle, four times repeated, so that they may be quickly and economically changed to 30-row machines for the 5-thread twill by removing the first and last hook of each row. This arrangement causes four twos to come in succession, but it is found to be, on the whole, satisfactory. The 5-thread sateen weave is, however, seldom used for linen fabrics containing over 80 threads per inch, particularly where the cloth is shotted half over square. It is used in square sett linen cloths up to about 80 threads per inch, and in lower sett union, as well as in cotton damasks of both square and over square sett.

Again, a 500's machine (51 rows of 10 needles) with 40 hooks per row—4 hooks to each needle—might be used. If one row be left aside for satins there would be 50 rows of 40, or 2000 hooks available for pattern. This would leave $2430 - 2000 = 430$ threads for satins, *i.e.* nearly 5 or $2\frac{1}{2}$ in. at each selvage. Such a width of plain cloth by no means improves the appearance of the napkin, but the method of having a good breadth of plain satin at the selvage is sometimes adopted because it affords a simple and ready means of making small alterations in the width—by reducing the satins alone—without requiring to touch the mounting of the pattern proper.

Of the above three methods the first is the most expensive, but it would produce the most satisfactory result, since no needle controls more than two successive threads of warp. The second method is cheaper than No. 1 in respect of the first cost of machines, and also in designing and card-cutting, but it would result in a distinctly inferior outline in the pattern, since half of the needles of the machine would each control three successive warp threads. Method No. 3 would be the cheapest of all, but since each needle in such a machine controls four hooks, and therefore four successive warp threads, the outline of the pattern would be very ragged and most unsatisfactory.

A further method which might be employed, and one which would utilise to the full the available needles of the two machines referred to in the first method, besides giving the most satisfactory results, would be to reduce these machines by the process of "fileying" or casting-out of superfluous hooks to an average of 22 hooks per row instead of 24 hooks. It is impossible to fill the machines with 22 hooks per row and still preserve the sequence of the ground and figure twills, but they may be filled with two rows of 20 hooks each, alternating with two rows of 24 hooks each, and so give an average of 22 hooks per row over all. Since it is an essential feature of the principle that every needle must be employed, it is evident that where 12 needles control 20 hooks, 8 needles of the row will have 2 hooks each, and 4 needles only 1 hook each; the arrangement generally adopted being 2, 2, 1, four times repeated. In this way 50 rows of each machine, or 100 rows in all, equalling 2000 hooks, would be utilised for the pattern, while two full rows of 24 hooks each would be available for the 230 satin threads. The filling of the machines in this special manner might be a little troublesome on account of the necessity of making special needles for the "fileyed" rows, but the result would be most certainly worth the trouble, since no needle would control more than two threads of the warp, while only one each would be controlled by a certain number of needles.

Other and less expensive harness mountings than the above are, however, generally adopted, the most usual being that in which about one-third to two-fifths of the pattern nearest each selvage is doubled or turned over, while the remaining portion in the centre is single. In other cases a perfect centre tie is adopted. With the latter mounting it is clear that the total number of hooks necessary will be equal to half the number of the pattern threads, and that the designs resulting from such a mounting will be perfectly symmetrical. With the former mounting the portion of single in the centre permits of designs of a perfectly symmetrical nature being woven, but it is more directly intended for those of a semi-symmetrical character, and for others where it is necessary to introduce words, initials, monograms, or other distinctive features which demand a single mount. If the napkin referred to were produced with a purely centred tie, one 600's needle jacquard with an average of 22 hooks per row, or $50 \times 22 = 1100$ pattern hooks, would be sufficient; but if the part single tie were introduced for the same size and sett of napkin a machine of larger capacity would be necessary. Suppose the total number of threads equals 2200, then

$$\frac{2200}{3} = 733 \text{ threads in the doubled portion, but}$$

$$2200 - 733 = 1467 \text{ single threads or hooks necessary.}$$

$$\text{But } \frac{1467 \text{ hooks}}{50 \text{ rows}} = 29\tfrac{17}{50} \text{ hooks per row.}$$

Now, by the process of casting-out or "fileying" already referred to, it is possible to fill the jacquard so that practically any average number of hooks per row may be obtained. It is not desirable, however, to complicate the machine by filling it in such an unusual manner, unless very special circumstances arise to demand it. In the case under consideration it would be much simpler and more satisfactory to fill the machine for an average of 30 hooks per row, and modify the mounting to correspond. A 32-row machine could be used with advantage, provided it were filled with two rows of 32 hooks alternating with two rows of 28 hooks for 48 rows—then one row with 32 hooks and one with 28, thus giving an all-over average of 30 hooks per row. The last or fifty-first row would have the full 32 hooks for side satins. The full mount might be arranged thus :—

$$\begin{array}{lllll}
\text{24 rows double : border} & \left\{\begin{matrix}12 \times 32 \text{ hooks} \\ 12 \times 28 \quad ,,\end{matrix}\right\} = 720 \text{ hooks} & \times 2 = & 1440 & \text{threads.} \\
\text{26 rows single : centre} & \left\{\begin{matrix}13 \times 32 \quad ,, \\ 13 \times 28 \quad ,,\end{matrix}\right\} = 780 \quad ,, & \times 1 = & 780 & ,, \\
\text{1 row side satins (1st row of machine)} & \} = 32 \quad ,, & = & 210 & ,, \\
 & \overline{1532} \quad ,, & & \overline{2430} & ,,
\end{array}$$

210 threads would give little more than an inch of satin at each selvage, but, should this be considered too small, it could easily be increased when painting the design. The

figure portion can be kept in a little from the extreme edge of the double portion of the harness.

It is, in general, an essential feature in the use of self-twilling jacquards that the complete number of hooks per row in the machine, or in a repeat of the sequence of the "fileying" arrangement, must be a multiple of the binding twill employed—in this case the 8-thread twill; and in the above mounting this condition is strictly observed until the last row of the single portion of the machine is reached. Since this row is an odd one of 28 hooks, it is clear that it will contain $3\frac{1}{2}$ repeats of the weave, and that in consequence of this ending the last thread of the single portion will be the fourth thread of the weave. If the last row of the single portion formed a multiple of the weave, there would be a maximum float of fourteen where this part of the cloth joins the doubled-over portion; on the other hand, when the arrangement is as described—that is, with the single part finishing on the fourth thread of the weave,—the maximum float at the junction of the two parts of the harness will be ten instead of seven as under normal conditions. But since the cloth is fairly fine in quality, this float of ten will not detrimentally affect the appearance of the cloth. In all cases of a similar kind, no matter what twill is used, the best results are obtained by ending the single portion on half, or approximately half, a repeat of the twill.

Harness mounts for common harness cloths are arranged on the same general lines as those for napkins of the same class. In some few instances the harness may be centre-tied, as has already been pointed out, but in the majority of cases a portion of the pattern in the centre of the cloth is single—usually about one-fifth of the total pattern in eight-quarter wide cloths, or one-third of the needle capacity employed. The pure centre mounting is suitable only for perfectly symmetrical designs, whereas the other type of mounting is adaptable for designs both symmetrical and semi-symmetrical in character.

Two machines of 900 needles each, or their equivalent, three 600-needle machines, are employed for the finer qualities: in either case there are approximately 150 rows of hooks. If three 60-design machines were employed for the work, and two of them, or 100 rows of hooks, were mounted with double cords, and the other machine, or 50 rows of hooks, with single cords, the figuring capacity of the whole mount would, with 32 hooks per row, be sufficient for 8000 threads. Thus:—

$$\left.\begin{array}{l}100 \text{ rows double} = 200\\ \ \ 50 \ \ \text{,,} \ \ \text{single} = \ \ 50\end{array}\right\} = 250 \times 32 = 8000 \text{ threads.}$$

With 40 hooks per row the capacity would be proportionately greater, but in extreme cases, and for certain patterns of the finer qualities—as, *e.g.*, in 90 in. and 108 in. widths,—four 600-needle machines of 48 hooks per row may be employed.

In the napkin examples already referred to we have indicated that one full row of the machine would be set aside for satins, but in practice a full row is seldom used for this purpose. Sometimes 16 hooks only are utilised for satins, at other times only 8, while in many cases the full 51 rows of needles and hooks are employed for the pattern alone, the side satins being worked from eight or sixteen special hooks (five or ten in the case of the 5-thread twill) attached underneath to the twilling bars of the machine. Where two or more "fileyed" or broken row jacquards are employed on one mount, it is of course imperative that the twills of the different machines should be continuous—in other words, that the twill of No. 2 machine should begin where the twill of No. 1 leaves off, and so on. This arrangement is obtained automatically with full-row machines, but with fileyed machines, and particularly where the full 51 rows have been utilised for pattern, great care must be taken when filling the machines to arrange the hooks so as to secure this essentially important feature in the cloth. Even under such circumstances it is quite possible that the double portion of the harness may not end on a complete twill; but this is immaterial provided the single portion begins on the succeeding thread and ends with a thread of the twill which will form a satisfactory juncture with the first thread of the doubled portion of the pattern.

To determine the actual number of hooks per row necessary for any particular case, let us assume that an eight-quarter cloth is required to count 105 threads per inch finished, with approximately 68 in. of pattern and 4 in. of satin (2 in. at each selvage) in the width: in all $105 \times 72 = 7560$ threads. If three machines be used—two mounted double and one single, as previously indicated—then

$$105 \text{ threads} \times 68 \text{ in.} = 7140 \text{ threads, and}$$

$$\frac{7140 \text{ threads}}{250 \text{ rows}} = 28\tfrac{14}{25} \text{ hooks per row.}$$

Now, while this number could be easily approximated to by filling the machine with a few rows of 32 hooks among the rows of 28 hooks—as, *e.g.*,

$$8 \times 32 + 42 \times 28 = 1432 \text{ hooks,}$$

$$\text{and } \frac{1432 \text{ hooks}}{50 \text{ rows}} = 28\tfrac{16}{25} \text{ hooks per row,}$$

—the filling of the machine would be unnecessarily complicated, and a much better and more practicable proceeding would be to fill the machines with 28 hooks per row all over, and to use every row in each machine for pattern purposes. Two machines at 51 rows each double and one machine with 51 rows single are equivalent to 255 rows, and 255 rows × 28 hooks per row = 7140 threads exactly.

The number of hooks in two rows of 28 is a multiple of the 8-thread twill, so that with the above arrangement the double portion of the design would end on the last thread of the twill and the single portion on the fourth thread, while the satins would be worked by special hooks as indicated. In a mount of this character, No. 1 machine, or that one taking the outer portion of the border, would be placed, not at the outside, but between machines Nos. 2 and 3, in order to avoid undesirable angles in any portion of the harness. The exact order in which the machines are placed is of little importance provided the cords are arranged in their proper order and with due regard to the proper slope, and, of course, that each machine is provided with the right cards.

If a pattern containing the above number of threads (7560) were to be treated for a centre tie or pattern, it is probable that, for economical reasons, only two 600-needle machines, with 102 rows of hooks in all, would be used. But in this case half the pattern, or approximately 105 threads × 34 in. = 3570 threads, must be controlled by, say, 100 rows. Evidently, then, a 40-row machine would be required, but filled with 36 hooks per row:—

100 rows × 36 hooks per row = 3600,
and 3600 × 2 = 7200 pattern threads.

This would still leave 7560 − 7200 = 360 threads for side satins, or a little more than $1\frac{1}{2}$ in. at each selvage. It is true that if desired three machines could be mounted for the centre tie, but such a proceeding, besides limiting the mount to strictly symmetrical patterns, would cost as much in designing and in cards as the mount containing the single tie. Three machines would, therefore, be seldom or never adopted in practice.

All mounts of a similar character may be treated in a similar manner, and mounts for different widths of the same quality may be treated either directly as fresh cases or by proportion. It regularly happens that a certain pattern is required in different widths of the same sett, and if it is intended to weave the cloth from the same cards, or a repeat of them, it is, of course, imperative that the same number of needles and rows of hooks be employed. Thus, if a ten-quarter or 90-in. cloth were required to match the above eight-quarter, then we should have

$$\frac{28 \text{ hooks} \times 10}{8} = 35 \text{ hooks per row for the new width.}$$

This number could be obtained on the average by filling a 40-row machine with 4 rows of 36 hooks alternating with 4 rows of 34 hooks, and so obtaining $255 \times 35 = 8925$ pattern threads. But the total number of threads must equal 105×90 in. $= 9450$; $\therefore 9450 - 8925 = 525$ threads for satins, or $2\frac{1}{2}$ in. at each selvage. Or the machine might be filled all over with 36 hooks per row, in which case it is clear that 255 fewer threads, or only 270 threads in all, would be available for side satins. This would give only $1\frac{1}{4}$ in. at each selvage: rather little perhaps for a 90-in. cloth, but still sometimes found in practice.

In making alterations such as these it is clear that when the pattern is increased in width it must also be equally increased in length, in order that the true proportions of the ornament may be maintained. This is simply done. For example, we shall suppose that in both widths of above pattern the cloth is shotted to finish half over square, and that a correspondingly ruled paper (12 by 18) has been used for the design. In the case of the eight-quarter cloth, since there are $28 \div 12 = 2\frac{1}{3}$ hooks per needle, the same average number of picks must be given to each card, or 7 picks to 3 cards; and for the ten-quarter cloth, with $36 \div 12 = 3$ hooks per needle, three picks per card should be given. In the latter case fewer satin cards might require to be used at the end of the cloth, since the side satins have not been increased in proportion to those of the eight-quarter cloth; or the same number of cards could be retained and the shots per card reduced slightly under three to compensate. The former method would be the simpler. The correct proportions would, of course, be maintained if the machines were used giving an average of 35 hooks per row, and the shotting motion arranged to give $35 \div 12 = 2\frac{11}{12}$ picks per card, or 35 picks on 12 cards. Since this number might involve a rather large shotting disc, a smaller one might be used, say one giving 20 picks on 7 cards, or about $2\frac{1}{2}$ per cent fewer picks per card than with 35 on 12. But since the proper length of the cloth must be obtained, a few extra cards might be added to the end satins, and the picks per inch slightly reduced to give the required length.

Where it is necessary to make alterations in the dimensions of the cloth in one direction only, as, for instance, when making an eight-quarter cloth in three different lengths—8/4, 10/4, and 12/4,—it is necessary to introduce extra cards in proportion to the extra length required. These cards are cut for each machine, and for some symmetrical designs from an 18-in. extension-piece specially designed to fit into the centre of the 8/4 cloth. At other times this piece is designed in keeping with the character of the original design, and intended to join on, as a repeat, to the end of the single portion. In other cases the single portion of the design, or that part of it which, in practically symmetrical designs, is treated as single, is utilised for the above purpose with a small extra piece specially designed to bring it up to the requisite dimensions.

While designs prepared for the common harness system are, in general, used only for different widths of the same quality, they are to some extent also available for other qualities provided the harness mount is the same in both cases; but for business reasons the same pattern is seldom woven on two or more qualities of linen damask. Should one pattern be desired, however, in another quality, and the width of the cloth be alike in both cases, then it is only necessary to reduce or increase the number of hooks per row in proportion to the different warp setts. Thus, given that a 28-row machine is suitable for 105 threads per inch, and that a change is desired to 80 threads per inch, then

$$\frac{28 \text{ hooks} \times 80 \text{ threads}}{105 \text{ threads}} = 21\tfrac{1}{3} \text{ hooks per row.}$$

A 24-row machine might be used filled 2 rows of 24 hooks alternately with 2 rows of 20 hooks (average 22 hooks per row), but should this leave too few threads for side satins the machine could be filled as follows: 1 row with 24 hooks, and 2 rows of 20 hooks alternately, giving $(1 \times 24) + (2 \times 20) = 64$; and $64 \div 3 = 21\frac{1}{3}$ hooks per row (average). Should width and sett both be different, the change is still one of proportion, and may be calculated on the approximate number of pattern threads available in each case.

When making such changes it is, of course, a practical question whether the detail of the design suitable for one quality would be equally suitable for the other, but that is a question which can only be decided at the time. The effects of such changes are always apparent, although perhaps in a modified degree, even when the quality or sett of the cloth is retained and a reduction of width only is made. In cases where one needle controls less than two hooks—and it frequently happens that 12 needles control only 16 hooks, and sometimes less,—it is evident that at many points of the design one needle will control only one warp thread. When this occurs, or is likely to occur, the designer should be careful not to paint single cords to any great extent on the design paper, because, should these cords coincide with needles which control only single threads in the warp, the effect in the cloth will likely prove most unsatisfactory. To be safe, painting on single cords should only be practised in the finer qualities where each needle is certain to operate two or more hooks.

Designs prepared for eight-quarter cloths are usually utilised for all widths from 6/4 to 12/4, but where napkins are required to match, another but similar painting is made on a much smaller number of needles—usually about half that occupied by the design for the cloth.

Designs for these fine damasks are usually of a floral nature with free and flowing stems, tendrils, and leaves, although those of a stiffer and more strictly ornamental character are sometimes chosen. These latter, an excellent specimen of which, entitled "Autumn," we reproduce in Fig. 130, do not, however, always specially lend themselves for reproduction by the common harness system of weaving. The perfectly horizontal and vertical lines which often form features in such designs cannot, with this type of weaving, be properly bound at both sides of each line. When straight lines are introduced in designs intended for this type of weaving, their direction should be more or less diagonal; indeed, the same remark applies to the general direction of most of the ornament.

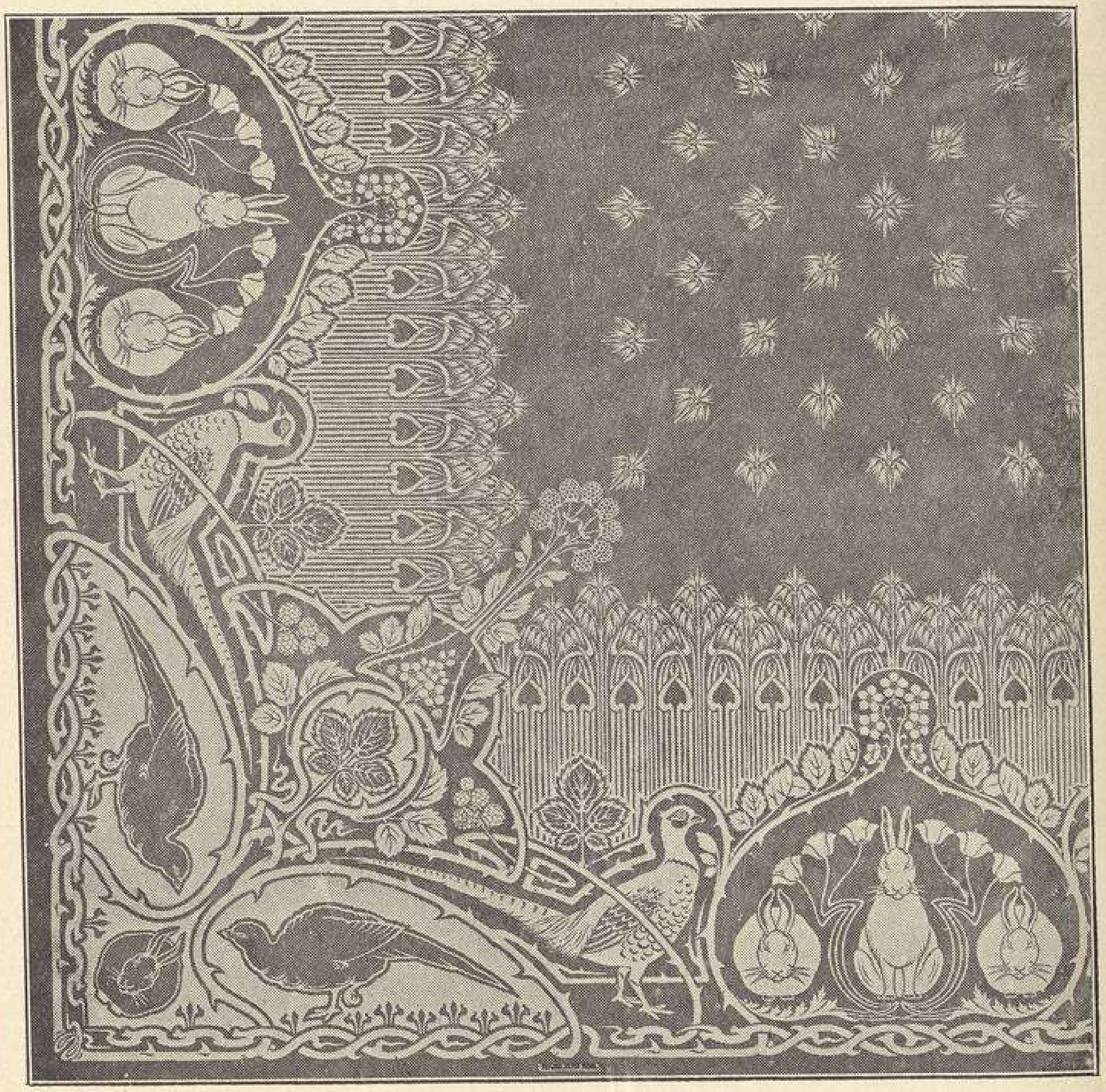


Fig. 130.

The above design, by Mr. Henry Drummond, Dunfermline, was awarded a silver medal by the South Kensington authorities in 1903; but, while recognising the artistic qualities of the design, and the ability with which the subject has been treated generally, we are afraid that the above-mentioned practical difficulties in regard to sharp and distinct reproduction would prevent its adoption in practice. It is true that the design could, at considerable expense, be perfectly woven by the full harness system, but it is somewhat defective in the respect alluded to when intended for the common harness method of weaving—the method which is almost invariably employed for large designs. Otherwise, although not strictly symmetrical at all points, the design is an excellent example of the symmetrical type, and might easily be adapted to a centre-tied harness. A part single tie would, however, be preferable, and would most probably be adopted; nevertheless, several economies could be effected by treating it as strictly symmetrical, more especially if it were to be painted on 12 by 12 paper. Under such conditions much painting of the design might be saved, since part of the side border cards could be cut from part of the end border painting; and, besides, it would only be necessary to cut cards for half the cloth, the other half being produced by working the cards backwards. Where a single portion is introduced into the cards, it is necessary, after this single part in the way of the weft has been woven, to reel or turn back the cards, with the loom standing, until the last card of the double portion is brought round; the loom is then restarted, but the cards now work backwards. If non-square paper were used—as, *e.g.*, 12 by 18—it would be necessary to paint the design full out, since with such paper the side border cards cannot be cut from the end border painting of the design. Assuming, however, that the design is to be treated as strictly symmetrical, and is yet to be woven with a mounting in which part of it is single, we shall endeavour to show the painting of the design necessary if square paper were used. We must first determine the extent of the single mounting in the harness, and, while the design could be adapted to any usual amount, we shall assume that the single part is to be one-third of the total needles employed, or one out of the three machines already supposed to be mounted. Now it is clear that the centre of the single portion of the mount must coincide with the centre of the cloth, or, with reference to the design in Fig. 130, with the centre of the heart-shaped space in the end or cross-border. But since the whole of the single mount occupies exactly half as many needles as the double mount, it follows that half of the single part of the design will be equal to one-fourth of the double part of the design at one side of the cloth; consequently, if we divide the design for half the complete width into five equal portions, four of these will represent one side of the double, and the fifth portion will represent half the single, while a precisely similar portion on the other side of the cloth centre will give the remaining part of the single. This is shown clearly in Fig. 131, in which the leading lines of the design have been reproduced. From this figure it is evident that the design in Fig. 130 shows slightly more of the ornament than it would be necessary to paint for the card-cutter. Fig. 131 also shows diagrammatically that nine sheets of design paper, A to J, each 50 or 51 blocks square, would be necessary for the complete design if 12 by 18 or any other non-square paper were used, and if that part of the design contained by sheets A, B, and C were all single. But since the design is to be treated as strictly symmetrical it would be necessary to design and cut cards only as far as the centre of the cloth indicated by the line K L. The second half of the cloth in the way of the length would be produced by reversing the working of the cards from this point. By symmetrical treatment alone, therefore, three half sheets of designing would be saved. A much greater saving results if 12 by 12 paper be used, for it would be

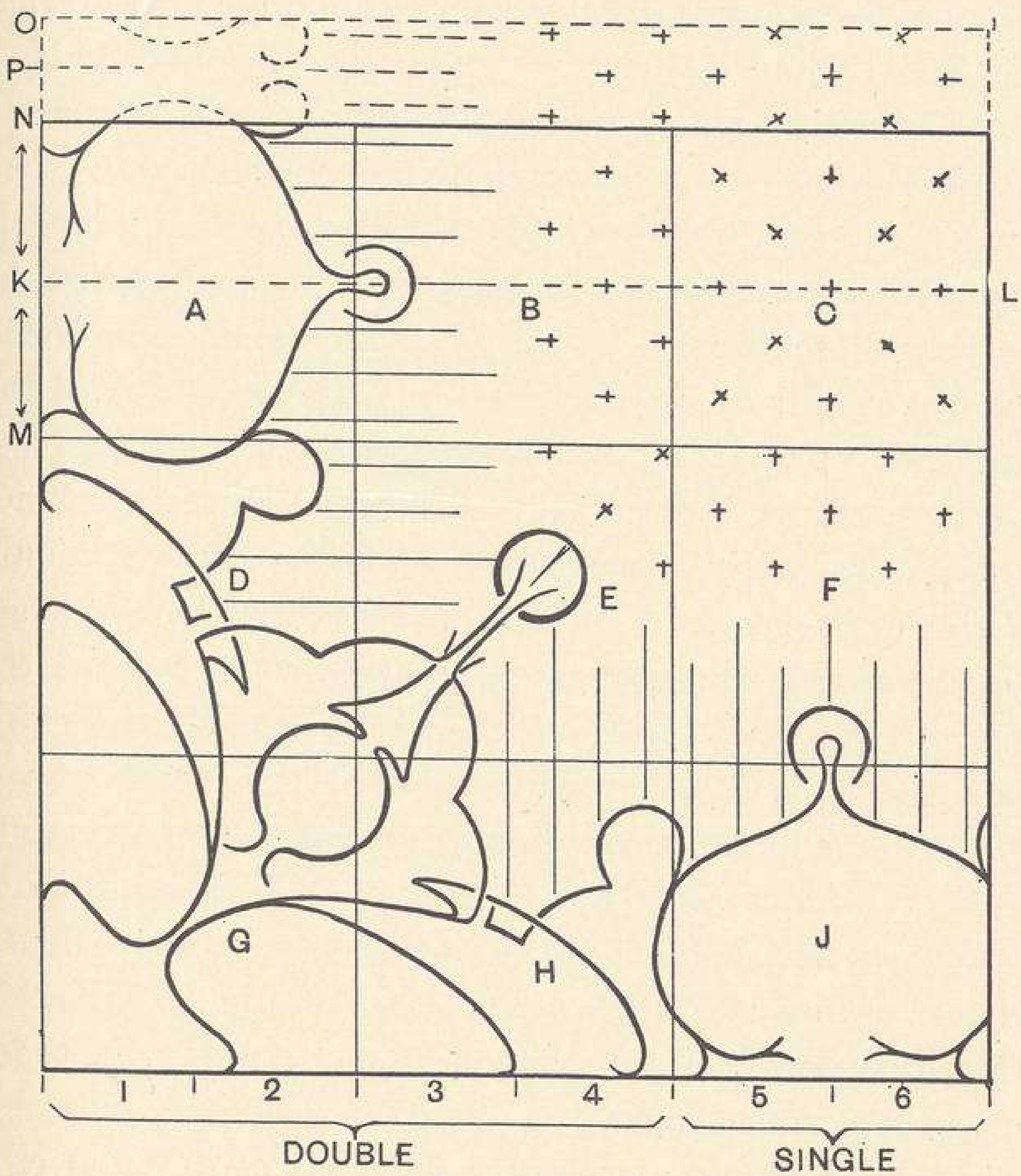


FIG. 131.

possible to utilise sheet H for sheet D by turning the former through 90 degrees, and either lacing or cutting the cards backwards, while half of sheets J and F, by similar treatment, would fulfil similar functions for A and B. With symmetrical treatment, therefore, and the use of 12 by 12 paper, only $5\frac{1}{2}$ sheets of design paper (G, H, J, E, F, and $\frac{1}{2}$ C) would be required as compared with 9 sheets for 12 by 18 paper and full single treatment. At a very modest estimate this represents a saving of about £15 in the cost of designing alone.

Extension pieces of designs which contain animate forms, as in Fig. 130, are often more difficult to manipulate than are those which are intended as complements to purely floral sketches. If the design under consideration were required to be adapted for a cloth ten quarters in length, part of the extra cards required would be obtained by repeating those already in use for section K M, and lacing them backwards to produce section K N (see Fig. 131). In addition, it would be necessary to design a special piece for each machine to form half of the section N O. Since the design is being treated symmetrically, cards for only half this extra section would be required. The whole set of cards would work forwards to the new centre of the cloth at P and then reverse. To be correct, all the cards thus added from K to P should increase the length of the cloth by 9 in., and this, when duplicated by reversing, increase the length by 18 in. Now M to N is one-fifth of the pattern length of the 8/4 cloth, 68 in.$\div 5 = 13{\cdot}6$ in.; K N is therefore $13{\cdot}6 \div 2 = 6{\cdot}8$ in. K P = 9 in., and K N = $6{\cdot}8$ in., therefore N P must equal $9 - 6{\cdot}8 = 2{\cdot}2$ in. in order to give the correct length.

If M N or $13{\cdot}6$ in. is produced by 600 cards, then N P or $2{\cdot}2$ in. will require

$$\frac{600 \text{ cards} \times 2{\cdot}2}{13{\cdot}6} = 97 \text{ cards.}$$

96 cards would probably be cut from a painted design of the same number of lines. For a further extension to twelve quarters long it would only be necessary to repeat

the cards from K to P and to lace them backwards. In designs where the treatment is not symmetrical the extra piece N O would be fully painted, and extra cards would be cut for the full 18 in. from M to O.

Figs. 132 and 133 illustrate the types of design which are usually submitted for the common harness method of weaving. Part A, Fig. 132, shows one quarter of the sketch as it would be prepared (except perhaps that the figure would be black on a white ground) ready for transference to the design paper, while part B is the complete design as it would appear on the cloth. This particular example is perfectly symmetrical about the centre. The complete design, D, Fig. 133, is, however, very similar in its proportions to Fig. 130—about one-fifth in the centre being single tie. A little more than one-quarter of the sketch is shown at C. Both figures illustrate the free and flowing nature of such designs, the general trend of the ornament towards the centre, and the entire absence of stiff horizontal or vertical lines—a very desirable feature. Design D, Fig. 133, is, perhaps, a little too heavy or full of figure, but it must be remembered that in the illustration it has been reduced to a very small scale. The quarter design at C in the same figure appears more open, and the woven article would appear even more so. Assuming that the single part is one-half of the double part in sketch C, the design might be mounted on two medium pitch machines, each having 57 rows of 16 needles by 2 hooks per needle, or 32 hooks per row if the warp sett were, say, 90 threads per inch finished.

$$57 \text{ rows} \times 2 \text{ machines} = 114 \text{ rows.}$$

$\dfrac{114 \text{ rows}}{3 \text{ parts}} = 38$ rows per part—*i.e.*, 76 rows for the double portion and 38 rows for the single.

A

B

Fig. 132.

C

D

Fig. 133.

$$\left.\begin{array}{l}76 \text{ rows double} = 152 \\ 38 \quad ,, \quad \text{single} = 38\end{array}\right\} = 190 \text{ rows} \times 32 \text{ hooks each} = 6080 \text{ pattern threads.}$$

$$\frac{6080 \text{ threads}}{90 \text{ threads per inch}} = 67\tfrac{5}{9} \text{ in. of pattern.}$$

This would leave 72 in. $-$ $67\frac{5}{9}$ in. $= 4\frac{4}{9}$ in. of satin, or $2\frac{2}{9}$ in. at each selvage in an 8/4 cloth.

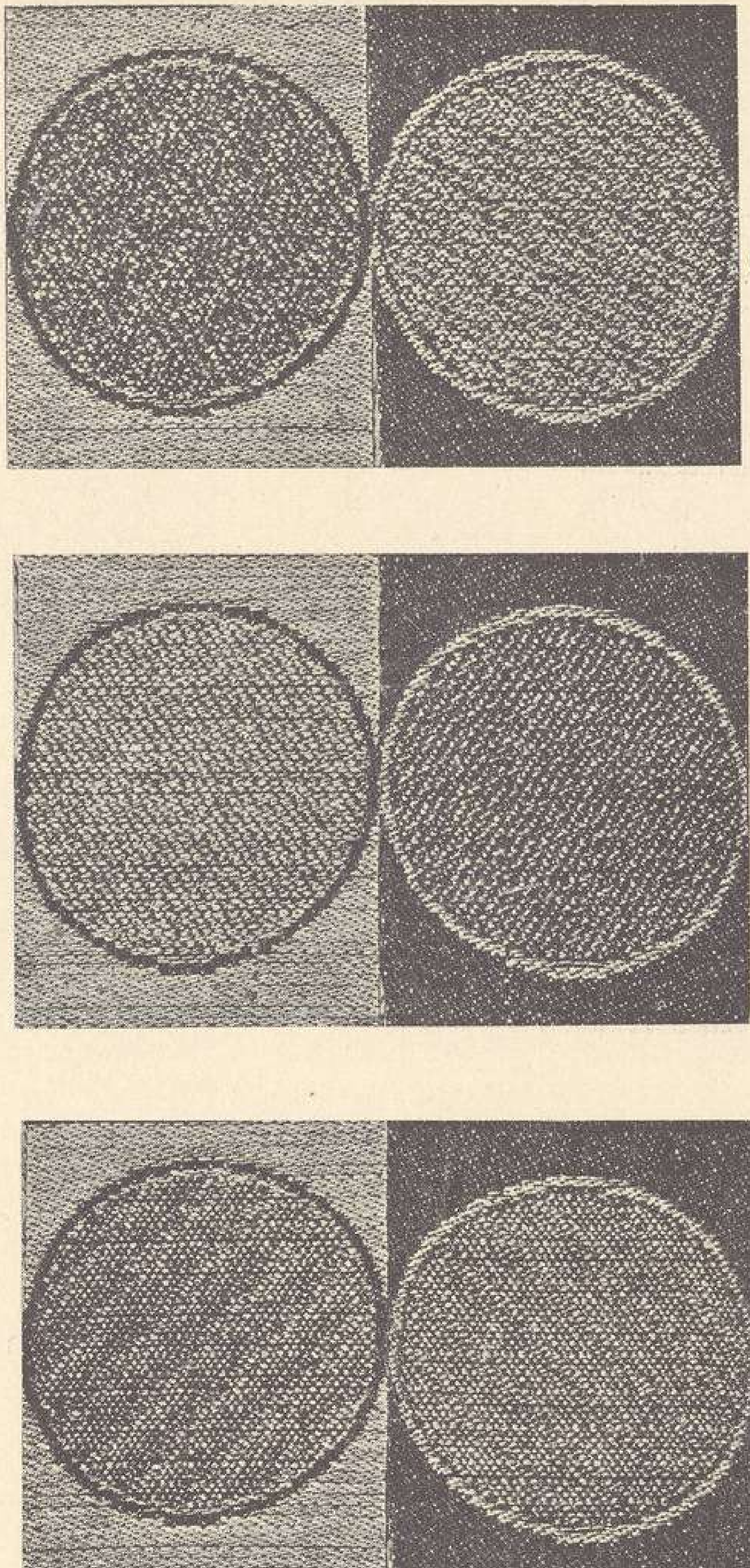
The benefits derived from mounting on two such machines instead of on three 600-needle ordinary machines would be :—

1st. The saving of 33 per cent of cards.

2nd. The outline of the figure would still be kept very fine, since no needle would control more than two hooks or more than two contiguous warp threads.

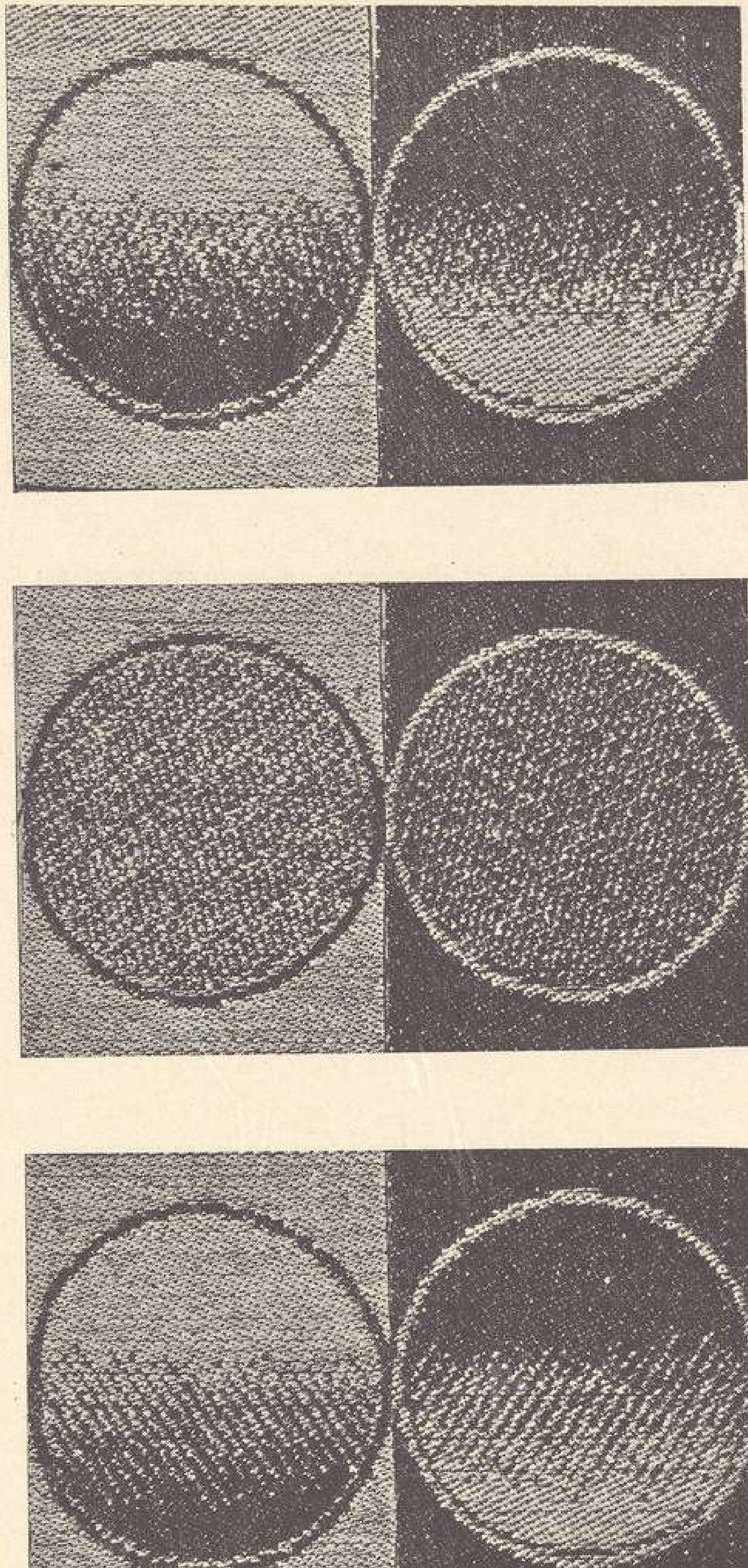
The enlargement of a common harness design from the sketch to design paper proceeds on exactly the same principle as in the case of a full harness design, but when using 12 by 18, or similarly proportioned paper, it must always be remembered that vertical and horizontal lines of the same breadth, while covering equal linear spaces on the design paper, will cover an unequal number of cords in proportion to the ruling of the paper. Thus a float of two warp cords must be equalled by three weft cords, and so on. Although as a general rule detail may be painted to a much finer degree than in full harness, still, it is always essential that great care should be taken to round off the curves very gradually, since a step of two warp or weft cords on the design paper may mean a step of anything between four and eight threads or picks in the cloth.

Under ordinary circumstances it is not desirable to introduce into the design any shading effect, or other variation from the perfectly flat sateen treatment, since the automatic insertion of the twills makes it impossible to



A B C

Fig. 134.



D E F

Fig. 135.

reproduce such shading accurately in the cloth. Modified effects of light and shade between those obtained by the sateen extremes are sometimes produced by the introduction of several simple weaves—as, *e.g.*, $\frac{1}{1}$ plain; $\frac{1}{2}$ and $\frac{2}{1}$ twills, separately or combined; the 4-thread straight twills graduated from $\frac{3}{1}$ to $\frac{1}{3}$; the $\frac{2}{2}$ twill arranged in broken order—1, 2, 4, 3; the 5-thread

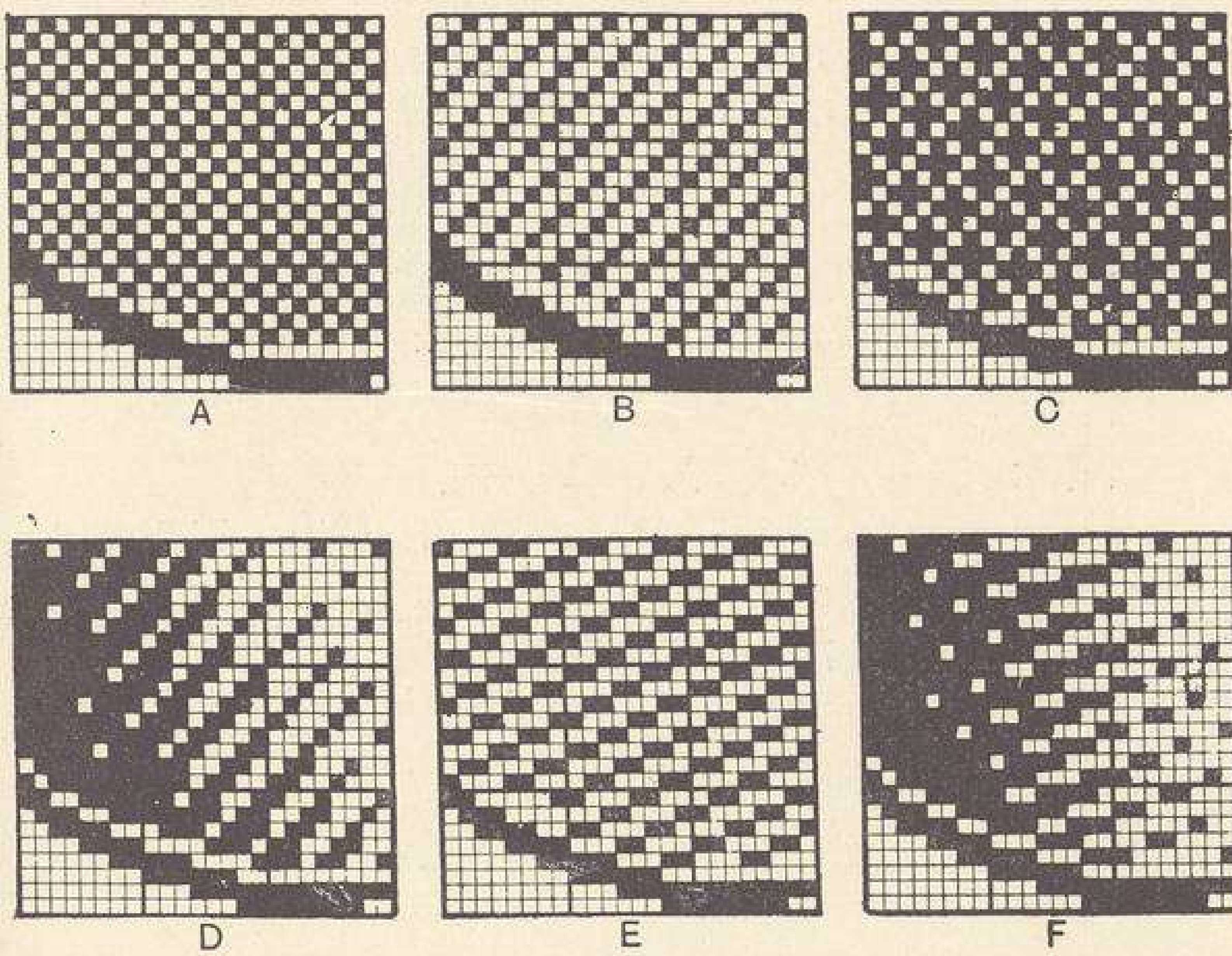


Fig. 136.

sateen $\frac{2}{3}$ arranged warp way or weft way; some 8-thread twills arranged in sateen order, and the 8-thread sateen regular shading. Six of these effects showing both sides of the cloth in each example are illustrated in Figs. 134 and 135, while the corresponding weaves are given in the sectional designs in Fig. 136. In four of these examples, A, B, C, and E, the circles are filled with all-over effects, while in D and F shading is attempted with the 4-thread graduated twills and the 8-thread sateen shading respectively. The cloth contains about 85 threads by 125 picks per inch, and was woven on a 28-hooks per row jacquard—arranged 2, 2, 3 hooks per needle, and with 2, 2, 2, 3 = 9 picks on 4 cards, or $\frac{9}{4} = 2\frac{1}{4}$ picks per card. 12 by 18 design paper was used, and the machine was necessarily arranged for the 8-thread twill. Where the plain weave is used for shading, as in A, care must be taken not to extend it over a large surface of the cloth, since on account of its high interlacing value it is inclined to make the cloth too firm and hard.

Fig. 137 is introduced chiefly to illustrate the application of several different methods of obtaining shaded or half-tone effects in common harness designs. The following varieties may be traced in the design :—

1. $\frac{1}{1}$ plain.
2. $\frac{1}{2}$ twill, graded into the $\frac{2}{1}$ twill.
3. The smallest possible diamond effect in which alternate threads are plain. (This effect is exactly the reverse of Fig. 84, p. 109.)
4. A 7-thread sateen arrangement of the order $\frac{2}{2}\frac{2}{1}$ moving two picks at a time. A similar weave in the way of the weft is also used.
5. A novel effect which is obtained by painting all odd picks solid, and even picks in $\frac{2}{1}$ twill order.

The design, which was evidently painted for a 10-row machine to be used in conjunction with a pressure harness hand-loom, also illustrates a somewhat conventional, but perhaps on this account a more truly artistic treatment of buds and foliage. The pattern was made about seventy years ago, and it is interesting to know that the designer of this example was the father of the celebrated artist—the late Sir Noel Paton.

In fine fabrics of the foregoing character both ground and figure portions of the design are usually developed in the 8-thread sateen weaves; the 5-thread weaves are,

Fig. 137.

however, sometimes used in medium and lower grade qualities of damask. In connection with full harness designing it is stated that the figure in some designs is developed in the 8-thread weave, and the 5-thread weave used for the ground. This decrease of binding points or of structural value in the figure portion results generally in a greater prominence of that part of the pattern. It is impossible, however, to give effect to this combination of weaves with the ordinary twilling jacquard, but on different occasions during the past few years mechanical parts have been added and electrical additions made to the machine whereby this combination becomes possible. These arrangements are generally very ingenious, and while some place restrictions upon the type of machine and are therefore of limited application, others are of general application. All are clever attempts to deal with a difficult problem, but, apart altogether from the question as to whether such a combination of weaves is generally desirable in damasks, the extra mechanism essential involves additional expense and adds further complications to an already sufficiently complex machine.

Where the combination is applied in full harness weaving, the edging of the figure is defective, since the sudden change from a 5 to an 8-thread weave permits the weft to close together to a greater degree at that point than at places where no change takes place. A similar, but opposite effect results where the change is made from figure to ground. Twilling jacquards have also been introduced in which the twills of ground and figure are arranged to run in opposite directions with the object of producing automatic binding at the edges of the figure, but this innovation complicates the mechanism and restricts the work of the designer. Other attempts have been made, and are still being made, to produce automatic binding by means of additional parts in the machine without changing the direction of the twill, but so far without commercial success. Such binding is undoubtedly desirable in all damasks, but if the method by which it is obtained is to be of any commercial value, little or no restriction must be placed upon the designer or upon the type of machine. In addition, the extra mechanism required should be simple and inexpensive, while, to be effective, it should bind transverse as well as longitudinal lines.

When a longitudinal line is continuous throughout the piece or pattern it can easily be effectively bound. The automatic action of the twilling jacquard binds one side or edge, while the other side is bound by redrawing the first thread of the ground portion through a mail which is controlled by any hook working in opposition to the last thread of the stripe or figure portion. Transverse straight lines cannot, however, be so treated, and isolated portions of lines in the longitudinal direction of the piece should not be, since there is the risk of marring the appearance of the design at some other part.

The method indicated above may also be used with advantage in full harness designs at those points where a straight portion of the harness meets a turned-over portion —as, *e.g.*, where the first or inside thread of the turned-over side border meets the last thread of the last repeat of the filling or centre portion of the design. In cases such as the above—and they are numerous—it will often be found that both the threads indicated normally rise and fall alike, particularly when weaving the ground. This gives rise to what is technically termed a "flat," and is, usually, unsightly. It can be avoided in practically every case by suitably redrawing either of the threads; and, in general, it will be found that by actuating, say, the last thread of the repeat from the hook controlling the first thread of the repeat, a much more satisfactory result will be obtained. Similar faults in the way of the weft cannot be treated except by introducing a special card, but they may be made less apparent by beginning to work the border cards backwards from the second last card instead of from the last.

CHAPTER X

CHECKS AND SMALL EFFECTS

On more than one occasion we have emphasised the fact that the appearance of many fabrics is distinctly enhanced by carefully joining up the various parts of the design or weave. In many cases the method adopted is that of employing weaves which work in opposition to each other in the different portions of the fabric, and so join up perfectly by cutting where they meet. In other cases, where weaves are used which gradually merge into each other, this feature is undesirable; but again, in others, where a sharp distinction between the various portions of the design may be desired, the weaves employed may be of such a nature as to render it impossible to obtain a clear and distinct joining without the introduction of specially arranged cutting threads. To unite satisfactorily the various weaves forming a design is a work which often calls for very careful and judicious treatment, since, in many instances, it is a matter of very great difficulty to keep the floats at the points of junction within reasonable limits without impairing the appearance of some part of the design. No satisfactory rules can be given for this work, since each design of this kind requires special treatment. The particular way of checking the long floats is largely influenced by the relative lengths of float, and by the relative numbers of threads and picks per inch. For rectangular figures the value of special cutting threads, in whole or in part, is considerable.

No cutting by special threads or otherwise appears in Figs. 82 to 102, but in these designs the necessity for cutting does not arise; nevertheless, the long floats caused by the mode of construction often injure the general effect of the design. From Figs. 103 to 110 the cutting effect is essential; indeed, the smartness of the fabric depends largely on this feature. A similar effect, not necessarily continuous, is desirable in many designs formed by two or more distinct weaves.

If the line of movement of all parts of a design could be made to coincide with that of the twill or outline of the weave used, the operation of joining the several parts would be considerably simplified; but, unfortunately, or fortunately, this seldom happens. Fig. 138 will explain, to some extent, the meaning of the first part of this statement. Here the direction of the weave, although it is plain, may be considered as moving diagonally to left and to right at an angle of 45°, and the figures, which are placed on it, also move diagonally and at the same inclination. Any straight, zigzag, or diamond figure, with perfect contours, may be thus introduced on a plain ground, provided the floats cover odd numbers of threads or picks; indeed, a great variety of continuous as well as detached figures may be arranged on this principle, and, with skilful treatment, very few shafts need be used. The longest float in the figure is five, but it is easy to see from the outline of the central part of the figure that a design may be made where no float exceeds three. The design is complete on 48 threads and 48 picks, the heavy bands and the central figure forming jointly a kind of diamond pattern, while the narrower bands form a check of smaller diamonds, the whole appearing on a plain ground.

Some very pretty effects may be obtained by using

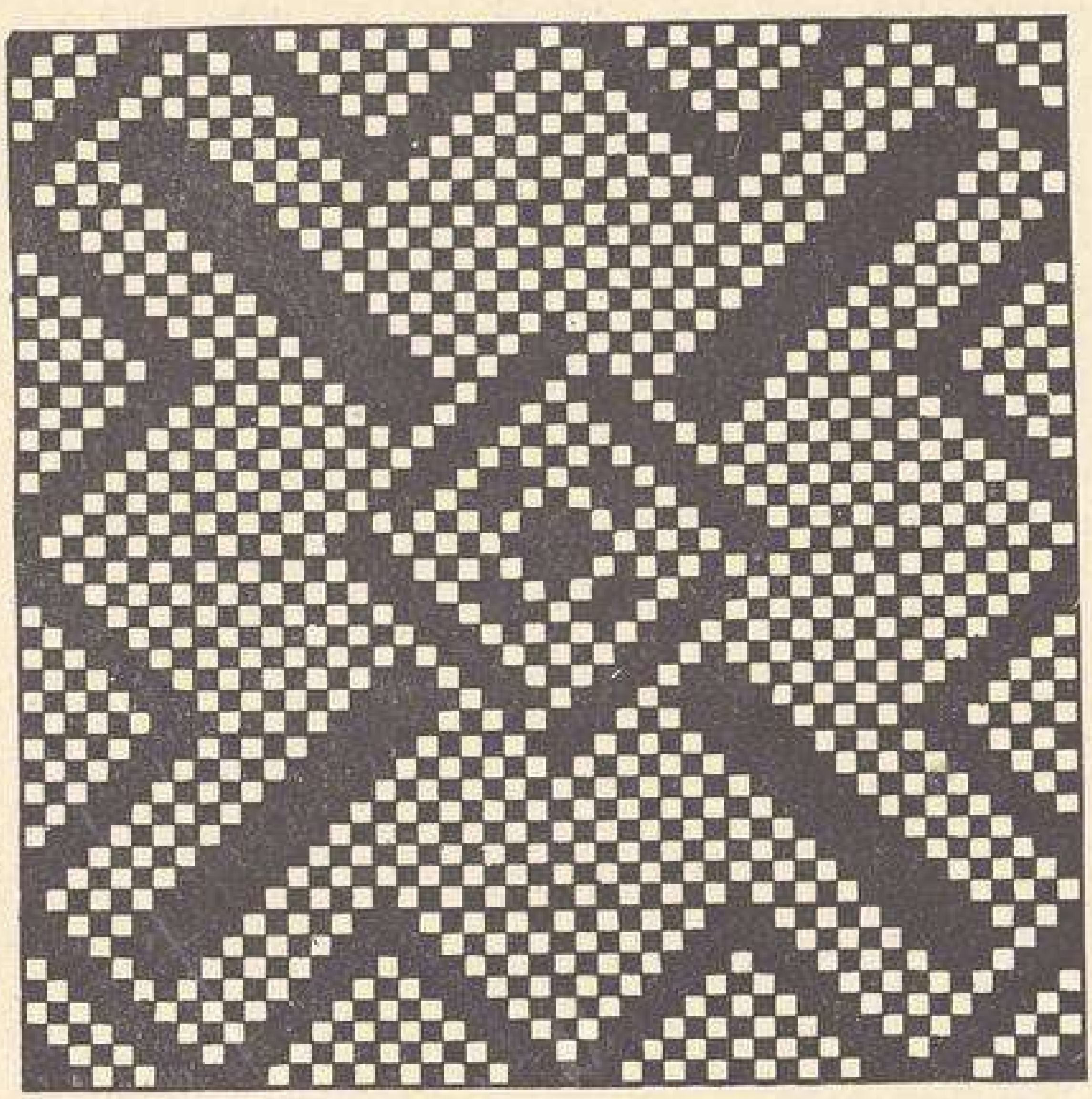


FIG. 138.

the plain weave in conjunction with warp and weft floats, and Fig. 139, which shows two repeats in the way of the warp, is a typical example. Here, again, the floats of both warp and weft conform with the direction of the marks of the plain weave, and no difficulty is experienced in joining the parts. It is, of course, only in special cases where such a satisfactory joining can be obtained by these three units. The general appearance of the design is unique, and the woven fabric is equally effective—the long floats resembling interlacing ribbons.

Fig. 140 is a stripe design, the first part of which is made on the same principle as Fig. 139, but with shorter floats, while the second part consists of straight twills. Fig. 141

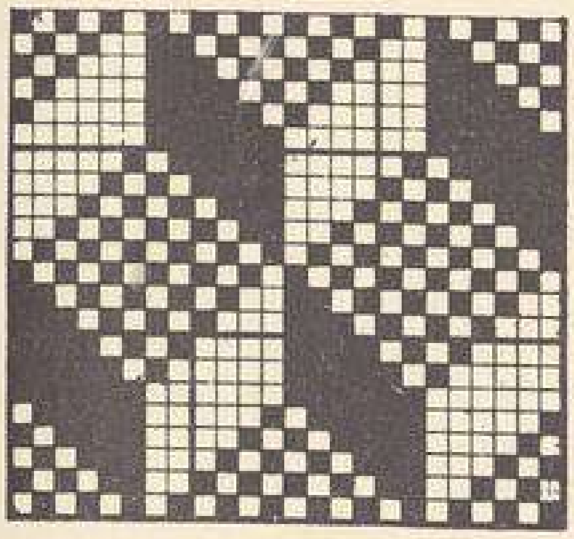


Fig. 139.

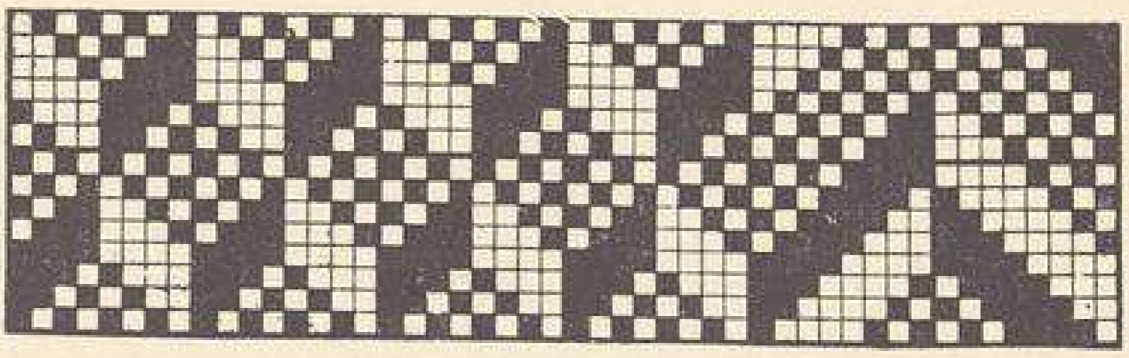
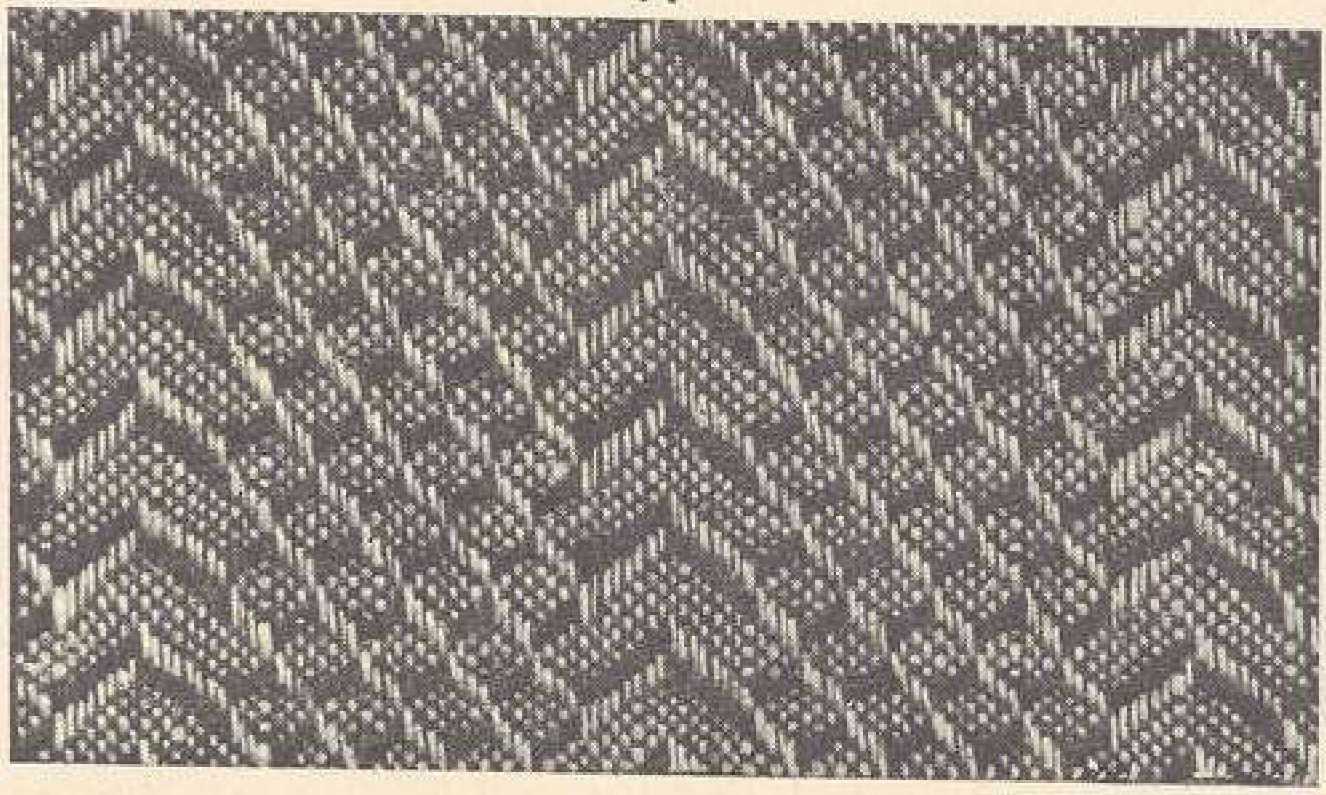
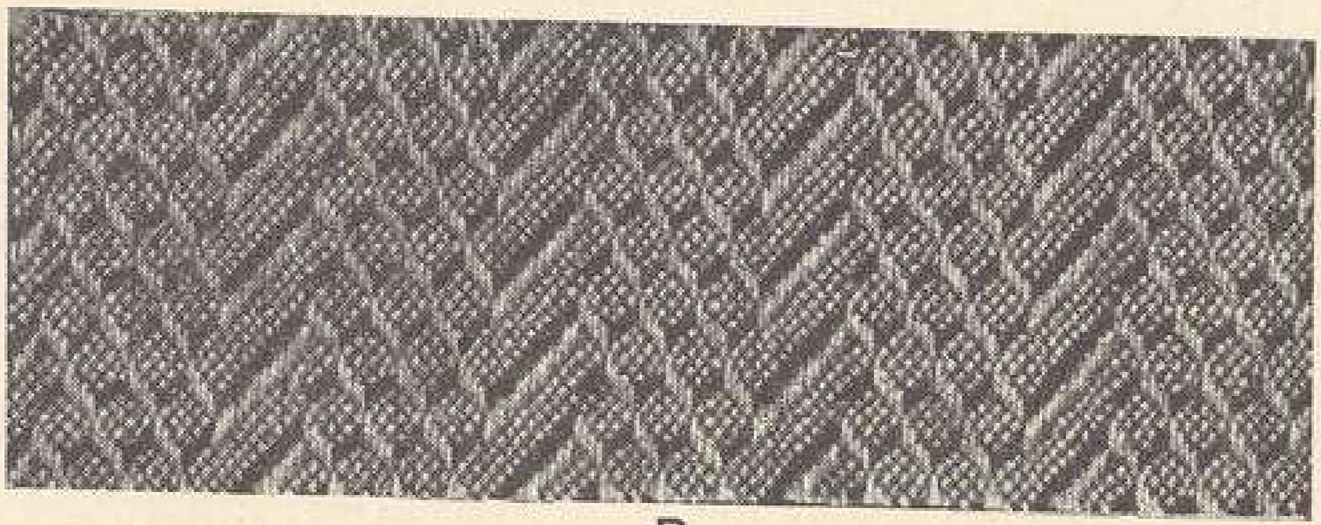


Fig. 140.

A





B

Fig. 141.

A is a photographic reproduction of the woven fabric, while 141 B is of a similar type. The sett and counts of the latter are more suitable for this weave than are those used in A.

When the direction of the main twill or figure does not run in line with the groundwork it is not always an easy matter to join the several portions. Thus, Fig. 142 is also composed of warp and weft floats upon a plain ground, but here the joinings appear very irregular. The effect in the cloth, however, is not irregular, but rather attractive. The long floats of warp and weft are the main features; they form a heavy corded effect, and enclose two areas, one large and one small, developed in plain weave. When woven in a medium to fine sett with suitable yarns the cord is so prominent that it closely resembles some type of embroidery.

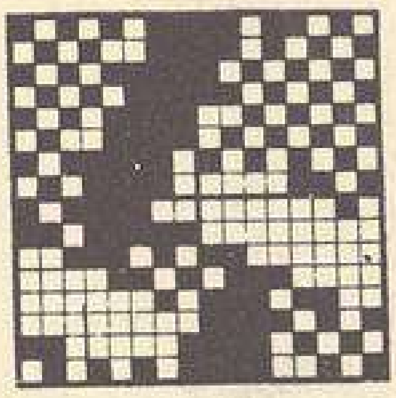


Fig. 142.

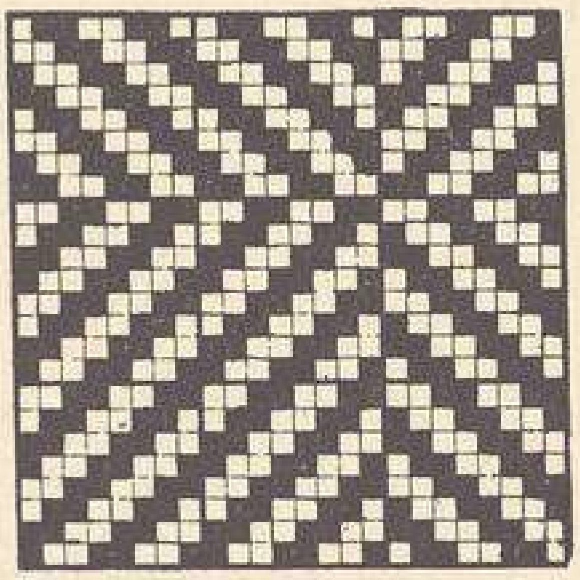


Fig. 143.

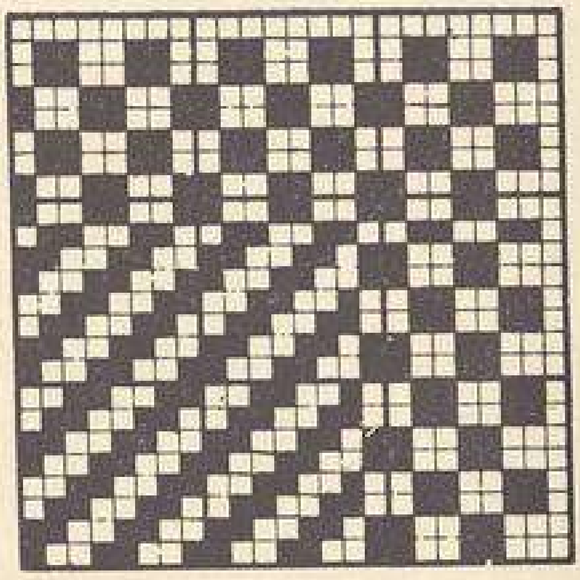


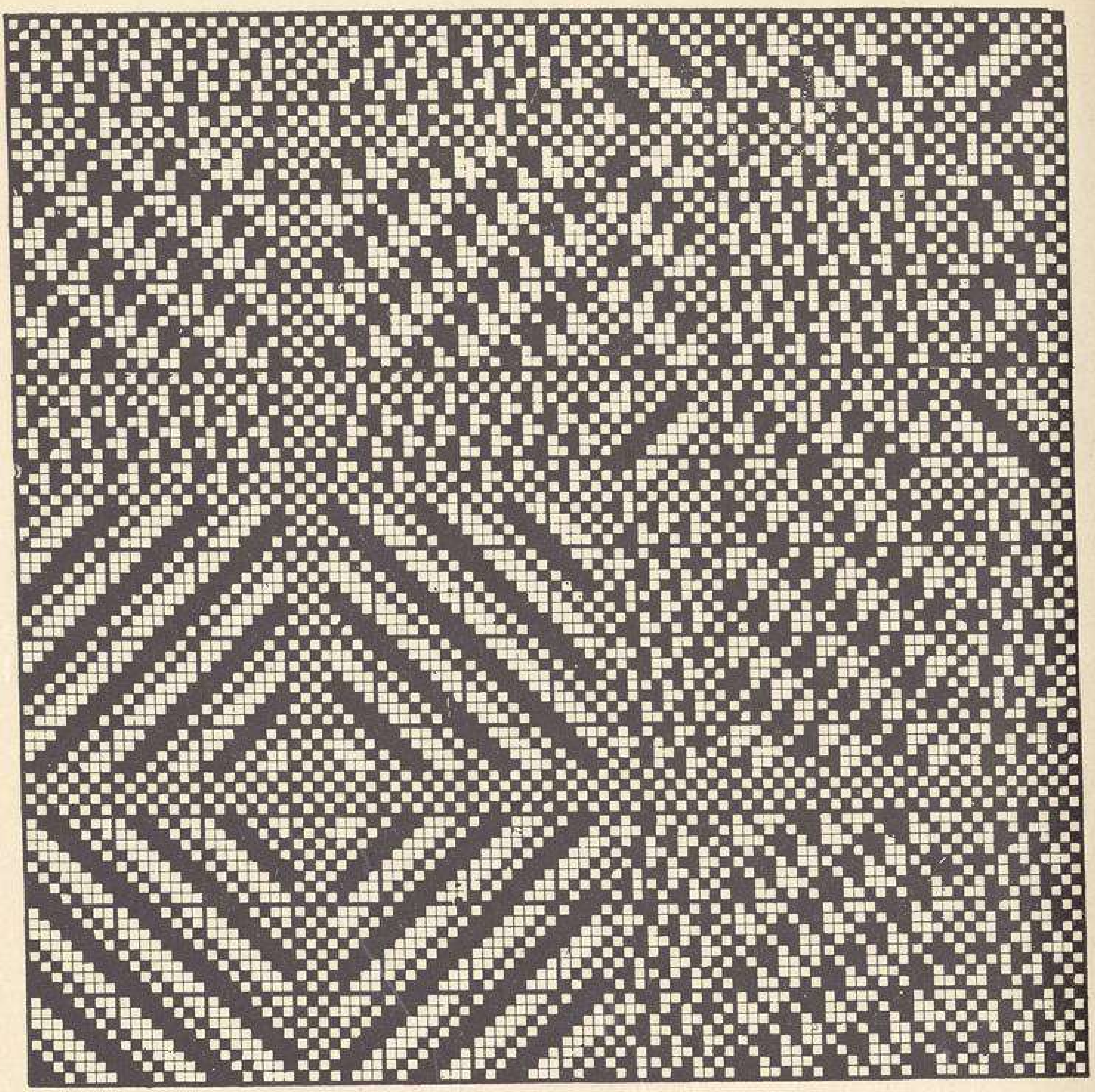
Fig. 144.

It is often impossible to arrange the weaves in perfect order, but slight imperfections in the design are occasionally imperceptible in the cloth; while, on the other hand, an elegant design on paper may be quite worthless when reproduced as a texture. This is particularly the case where there is a great diversity in the lengths of the float in small areas.

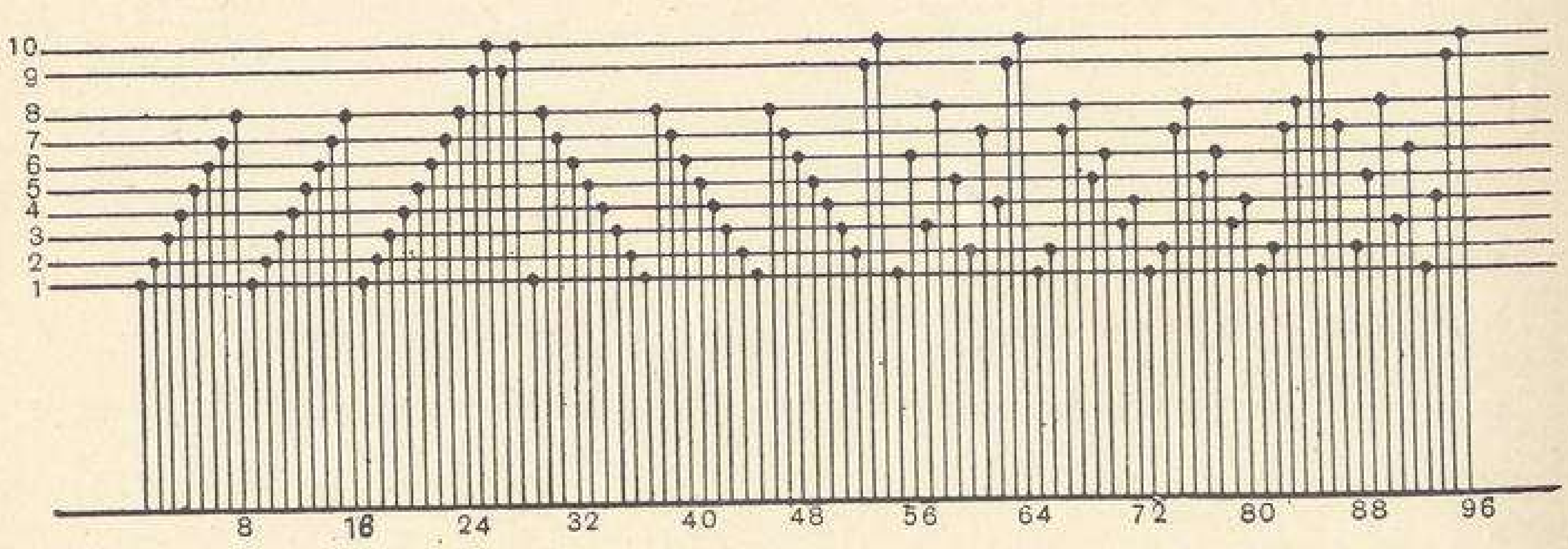
One is always quite safe to predict the effect which would be obtained by such designs as Figs. 143 and 144. Both are made in the form of checks (they are made on a small scale simply to illustrate a principle), and in both cases the checking part cuts at all junctions with the ground part. It is quite an easy matter to give effect to this cutting in Fig. 143, and in all such designs where each separate part occupies a multiple of the unit weave, for it is only necessary to reverse the parts, or a certain portion of each, as illustrated in the figure. It is different, however, with Fig. 144. The basket weave contains only two different kinds of threads and picks, consequently it can cut with only two threads or two picks of the $\frac{2}{\ }\frac{\ }{2}$ twill. The central part of the check must, therefore, finish on an odd number of threads and picks, and even then it is impossible to arrange the parts as perfectly as those in Fig. 143.

A check design of a larger size is illustrated in Fig. 145. It is introduced chiefly as an example of what may be done by the rearrangement of a simple twill, although it must be remembered that the variations shown do not by any means represent the total number possible. As a matter of fact there are only six arrangements of the $\frac{3}{\ }\frac{\ }{1}\frac{1}{\ }\frac{\ }{3}$ twill used in conjunction with the plain weave; these six appear at 1, 2, 3, 4, 5, and 6, in Fig. 146. From what has been already shown, the reader will easily follow the draft in Fig. 145 and the corresponding weaving plan in Fig. 146; but, in this respect, we may add that the shafts which operate the plain weave would be better at the front than at the back. Although there are many fabrics in which certain threads weave plain throughout, as in this example, still there may be some difficulty in the work unless these threads are on a separate beam. In the design under notice one-twelfth of the threads weave plain, and it will be seen that the introduction of these special cutting threads and picks limits the floats to three.

The rearrangements of one weave or a number of



Design.

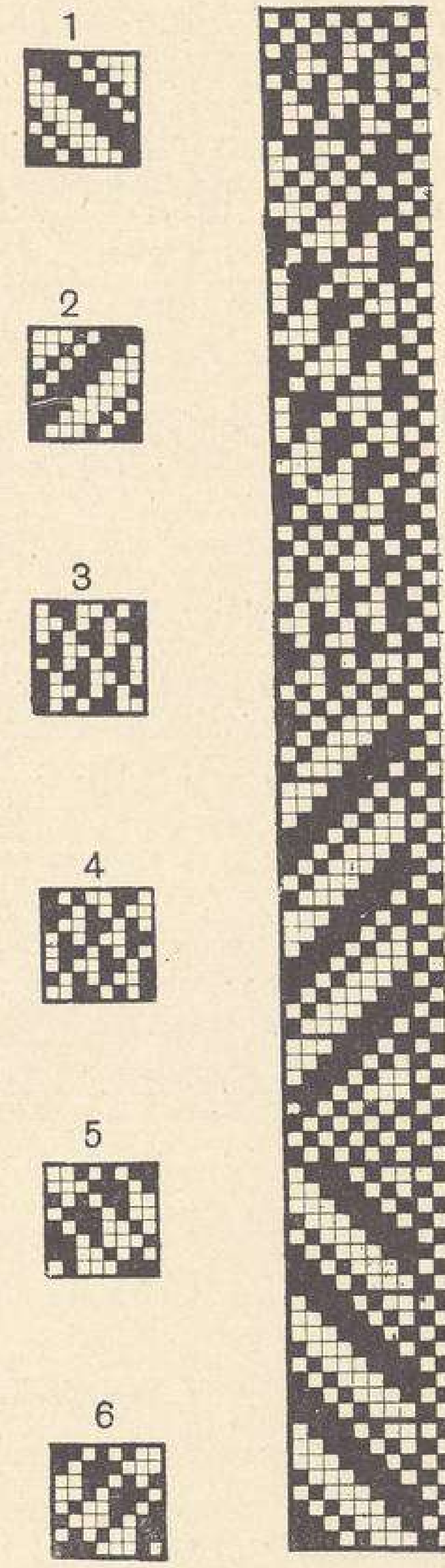


Healding in Draft.

Fig. 145.

different weaves may be employed in developing any kind of floral or geometrical figure. These weaves usually consist of the plain, simple twills, sateens, oatmeals, crêpes, etc., and one of the chief considerations for a designer, after the primary one of the figure itself, is to choose such weaves for the several parts of the design as will develop each part to the best advantage. The various parts must then be joined up so as to prevent any unsatisfactory or lengthy float.

When a single cloth is developed in a variety of weaves or textures as indicated above, the fabric often receives the name of "brocade," although a true brocade is essentially different. Such designs are usually prepared for, and woven by means of, an ordinary jacquard, in which each hook works independently of any mechanism other than the ordinary card, needle, and knife. It will thus be seen that a so-called "brocade harness" is the same as what we have invariably termed a "full harness."



Weaving Plan.
FIG. 146.

CHAPTER XI

COMPOUND FABRICS

DOUBLE WARP-FACED FABRICS

In the manufacture of practically all textile fabrics the utilitarian point of view is of prime importance. Design and ornament, when applied to textiles, must generally be subsidiary to the purpose for which the fabric is intended; more especially is this true when considering design from the technical side—or, in other words, from the point of view of fabric build or structure. In the consideration of such cases the means by which the weight of the fabric may be materially increased forms an important, if it be not the controlling, element. Elsewhere we have shown (see *Jute and Linen Weaving*, Part II., "Calculations") that for given sizes of yarns there is a limit to the number of threads and picks per inch which may be introduced into what is termed a perfectly balanced cloth; this maximum number per inch is, for the said type of cloth, coincident with the maximum weight for any particular size or count of yarns. It is easy to see that, in a range of such cloths, the weight will increase or decrease as the cloth becomes coarser or finer respectively, because while the width remains constant, the thickness of the cloth is a varying quantity, and is approximately equal to the combined diameters of one warp thread and one weft thread. Such being the case, an increase of weight in a simple or single make of the above type of cloth can be obtained only by the use of heavier yarns in a coarser sett. If the same yarns be used in a finer sett, the result will be an alteration in the structure of the fabric.

Fig. 147 has been prepared to show what would happen

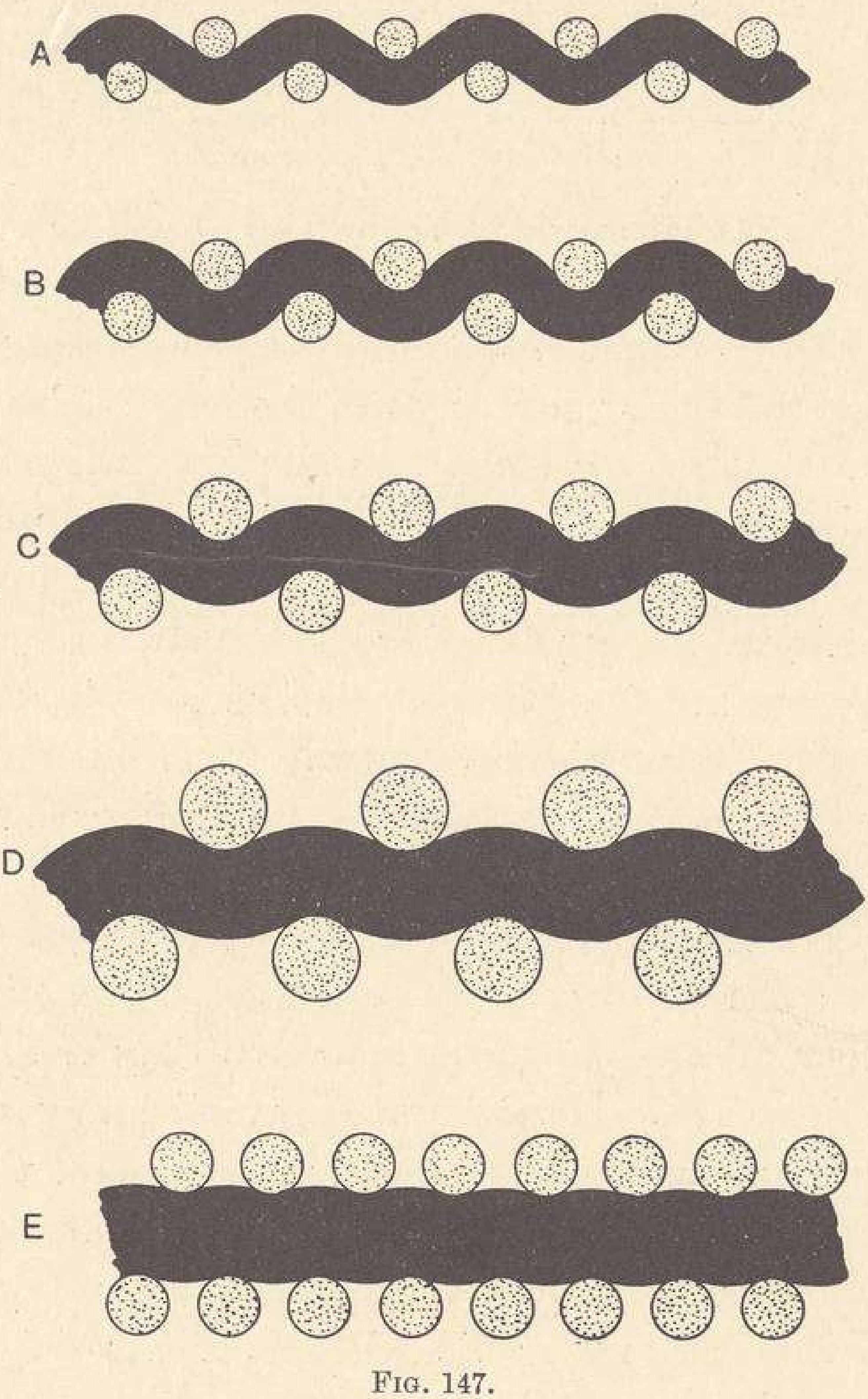


FIG. 147.

if an attempt were made to retain the sett, and at the same time to increase the weight by employing thicker yarns; the weft in each diagram is shown in solid black. Intersection A represents a good make of plain cloth, but not a maximum one; so that if this particular cloth were required heavier, an increase of weight, within limits, could easily be obtained without sensibly altering the structure. This is illustrated at B, in which the maximum is attained. It will be seen that if horizontal lines were drawn above and below each of these figures, each line would touch warp and weft, since they both rise and fall to the same horizontal planes.

Although the threads and picks in C and D are much thicker than those in A and B, the number per inch is the same. Fabrics C and D are, however, considerably heavier than the first two; but it will be observed that the structure is entirely changed. Indeed, as the yarns are increased in diameter, the disposition of the weft yarn approaches more and more closely to a straight line. The fabric is, in reality, approaching the structure shown at E, which, for want of a better definition, may be termed a 3-layer cloth (two layers of warp and one of weft), as distinct from A and B, which are 2-layer cloths (one of warp and one of weft). Some difficulty is experienced in finding correct definitions for these two types, but we think that the words "simple" and "compound" are fairly satisfactory ones to denote makes of two layers and three or more layers respectively. We are well aware that the ordinary warp and weft ribs may be woven with two shafts: still, these fabrics have all the characteristics of a compound structure. On the other hand, many fabrics which would fall under the class termed "simple," are made from elaborate designs.

It is possible, however, to increase the weight and at the same time to retain apparently the structure of any fabric; but this can be done only by the addition of an extra layer of warp, or of weft, or of one or more of each. We now purpose describing and illustrating the different ways of adding such extra layers to the various kinds of fabrics.

Briefly stated, there are two chief reasons for modifying the structure of a fabric :—

1. To increase the weight of the cloth, and so impart desirable properties—*e.g.*, heat retention and durability.
2. To beautify the fabric.

Perhaps the simplest and most natural way of increasing the thickness, and therefore the weight, of an ordinary cloth, is by increasing the number of threads of warp per inch, since economic production results when the number of picks per inch is less than the number of threads. There are many fabrics of this type, generally termed double warp-faced fabrics—*e.g.*, repps, double-warp tapestries, etc. Flax and cotton sailcloth or canvas is a particular example of this type, and the structure of this fabric resembles closely that at E, Fig. 147, except that the warp threads usually run in pairs. These sailcloth and other similar fabrics probably represent the extreme limit of plain cloth weave; but they can hardly be considered as of single or simple structure, since their thickness consists of three layers of yarns.

Besides increasing the weight of the fabric, we secure, under certain conditions, other important results when the threads of the warp are closely set; we refer to the effects produced by the use of coloured threads in the warp. Diagram E in Fig. 147 shows clearly that when the maximum number of warp threads is employed, the weft is almost completely covered. It is also clear that if the warp threads were alternately

1 thread dark,
1 „ light,

the present disposition of the yarns would result in a practically solid dark line from selvage to selvage on the underside of the fabric; while a similar but light coloured line would appear on the surface. Any change in the shedding would reverse these effects, and, when repeated, would produce alternate light and dark ribs across the fabric, even with the plain weave.

Design A, Fig. 148, shows the 8-pick rib weave. Such weaves always require a large number of threads per inch, because similar floats of any pair of consecutive threads are capable of appearing almost in the same longitudinal line in the cloth; the only resistance to this lateral movement being the point where the threads change positions. The greatest facility for this action of closing together is, therefore, in such weaves; but any weave which tends to this style requires, for the same reason, a much greater number of threads per unit space than do the ordinary twills. Consider designs B and C in the same figure: each thread in B keeps the neighbouring threads in their relative positions, as shown on the paper; but in C a lateral movement is possible, and necessary to the proper effect in the fabric. It is in virtue of the natural tendency of threads, as well as of other bodies, to move in the line of least resistance, that such movement takes place; and, although the above two weaves are composed of the same seven threads, it is clear that, while the common intersection theory of cloth structure

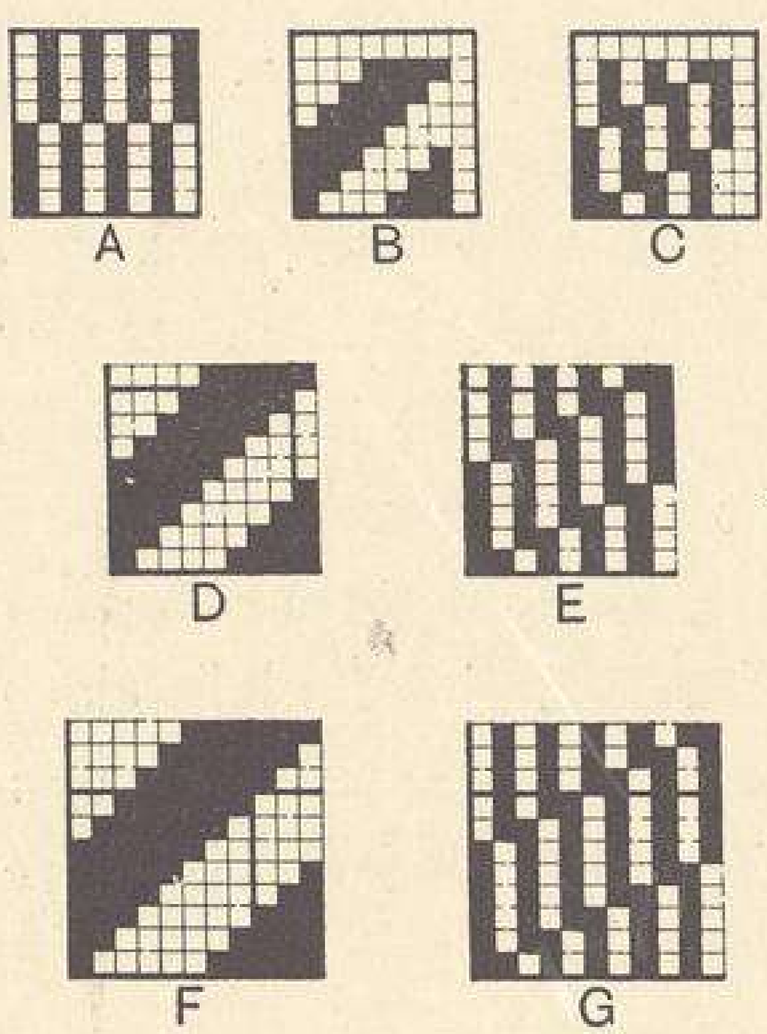


FIG. 148.

may hold good in regard to B, it is absolutely valueless for design C.

Designs B, D, and F, Fig. 148, are respectively the $\frac{4}{3}$, $\frac{5}{4}$, and the $\frac{6}{5}$ straight twills, while plans C, E, and G are the well-known corkscrews made from these weaves. The method of construction for any of these ordinary corkscrews, which were used extensively a few years ago in the manufacture of worsted coatings, is the same. It will be seen that the threads of the straight twill are taken in regular succession, and introduced on alternate threads for the formation of the corkscrew. They may also be made from certain sateen bases, but perhaps the simplest mode of construction is to make the design on $2n+1$ threads and picks, with a float and also a step of $n+1$ on successive threads.

Since the warp threads in these corkscrew weaves practically conceal the weft, it is evident that a thread-and-thread arrangement of colouring will result in two parallel and adjacent twills of distinct colours. This principle of colouring, and the elaboration of the weaves, are extensively adopted in the fancy carpet trade, and in other branches of weaving.

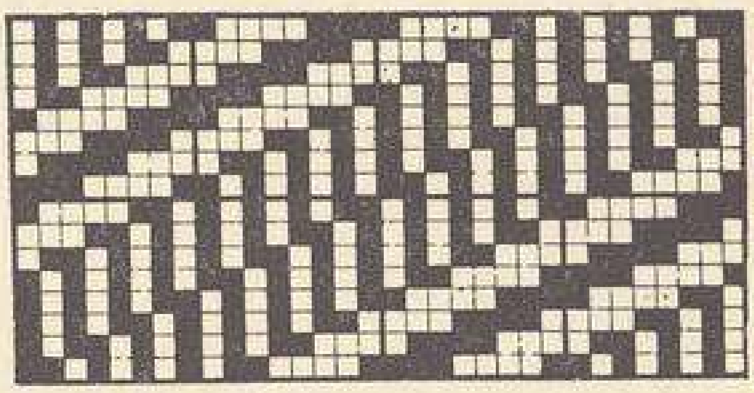


FIG. 149.

Fig. 149 illustrates a method of obtaining differently-coloured diagonals. The main or central part of the weave is identical with design E, Fig. 148, and would, consequently, form two bands representing the colours of the warp. Each band of coloured warp is bounded by a weft diagonal, which, to be effective, would naturally be of a different colour from either of the warp threads; while the solid black band in the design would be represented in 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 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.

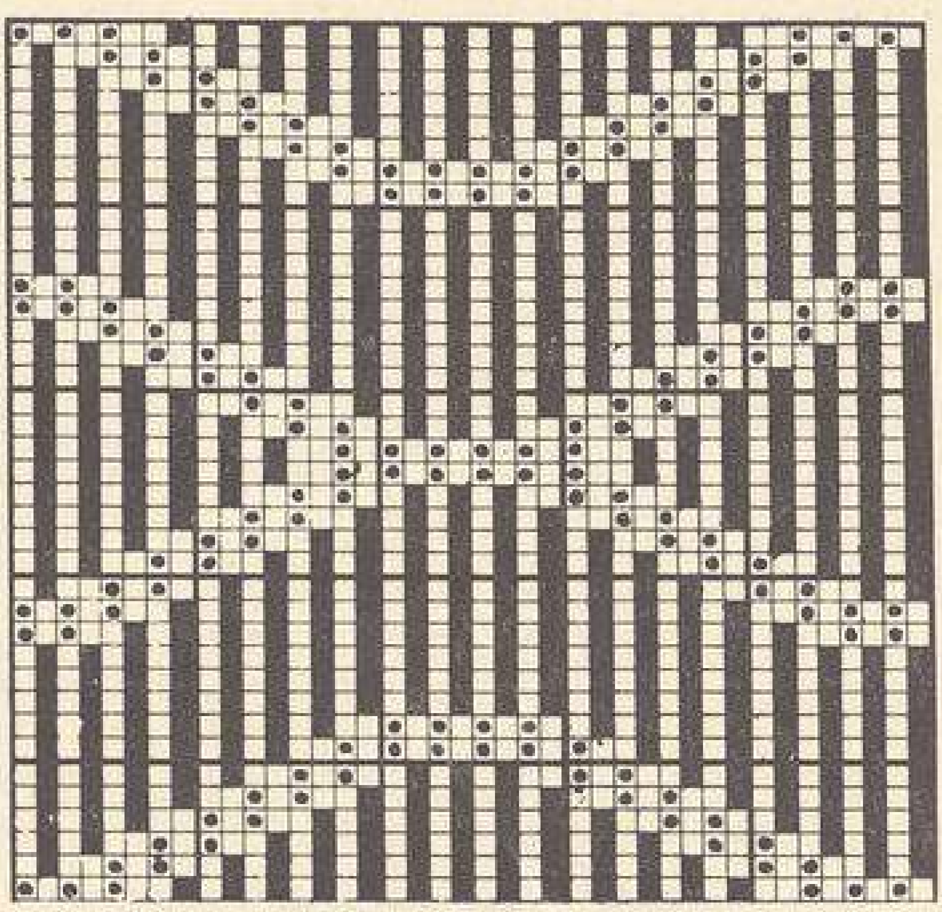


Fig. 150.

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

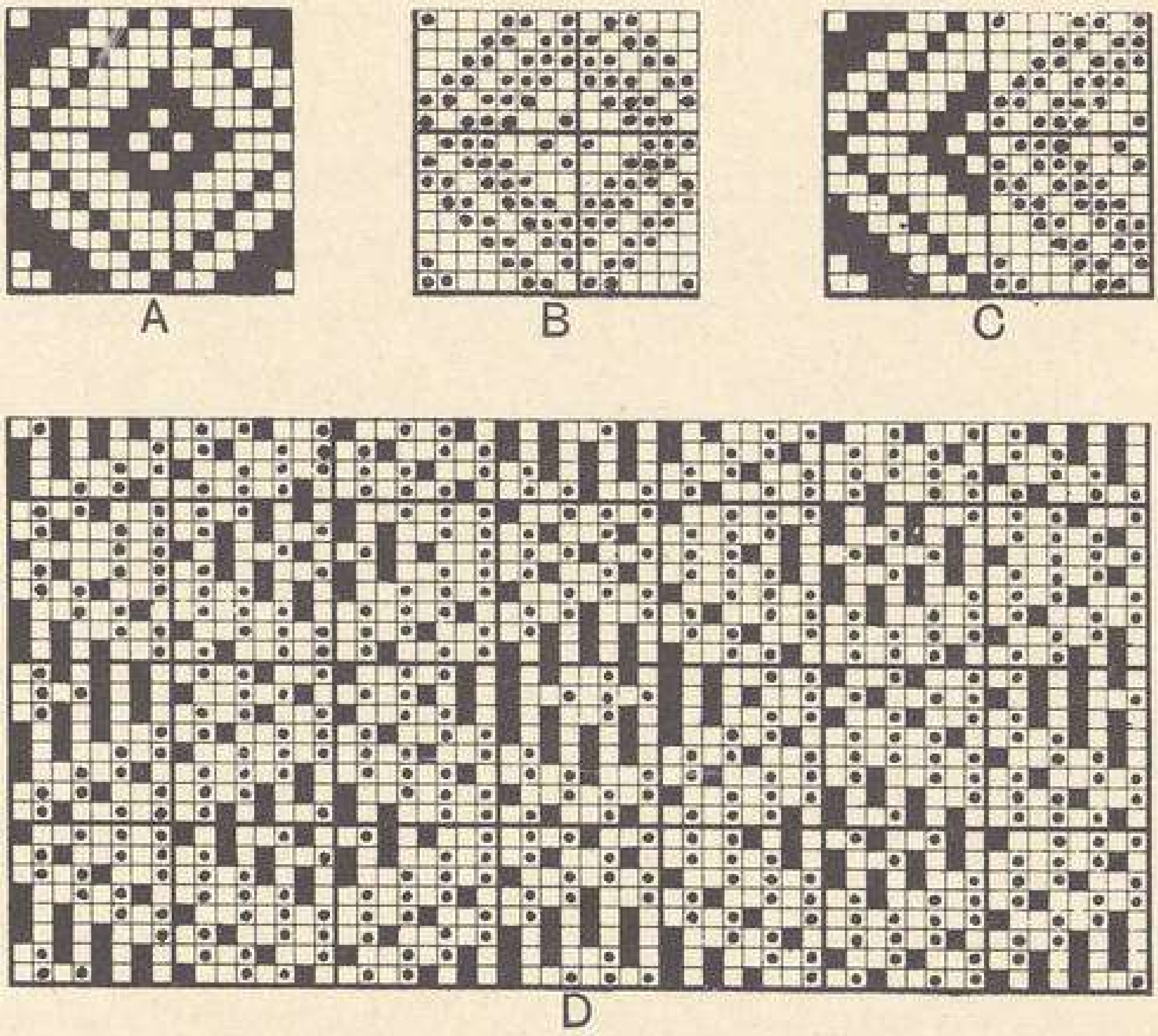


FIG. 151.

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,

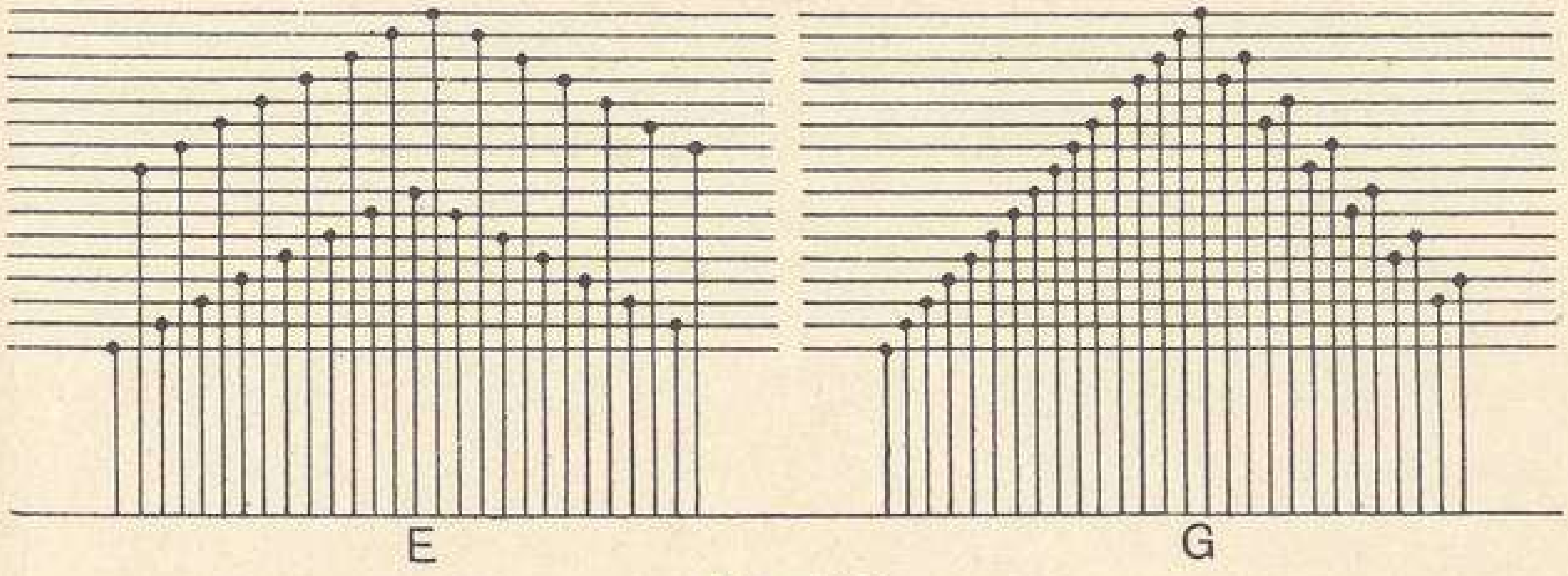
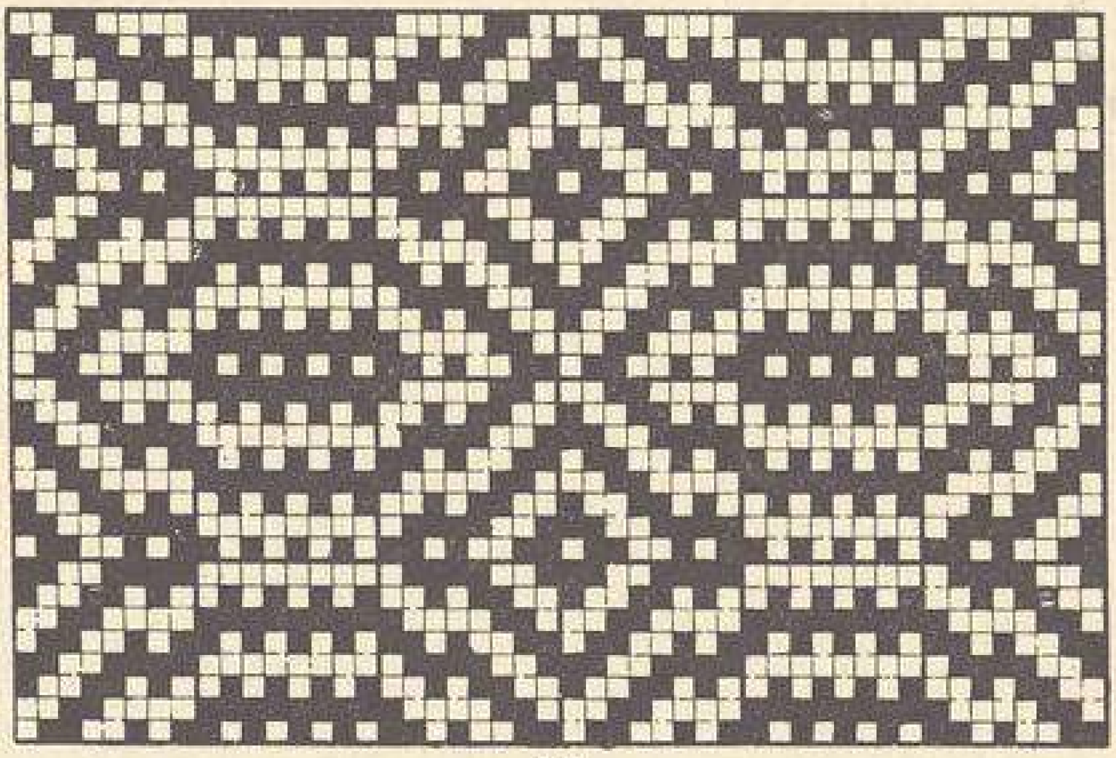


FIG. 152.

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.



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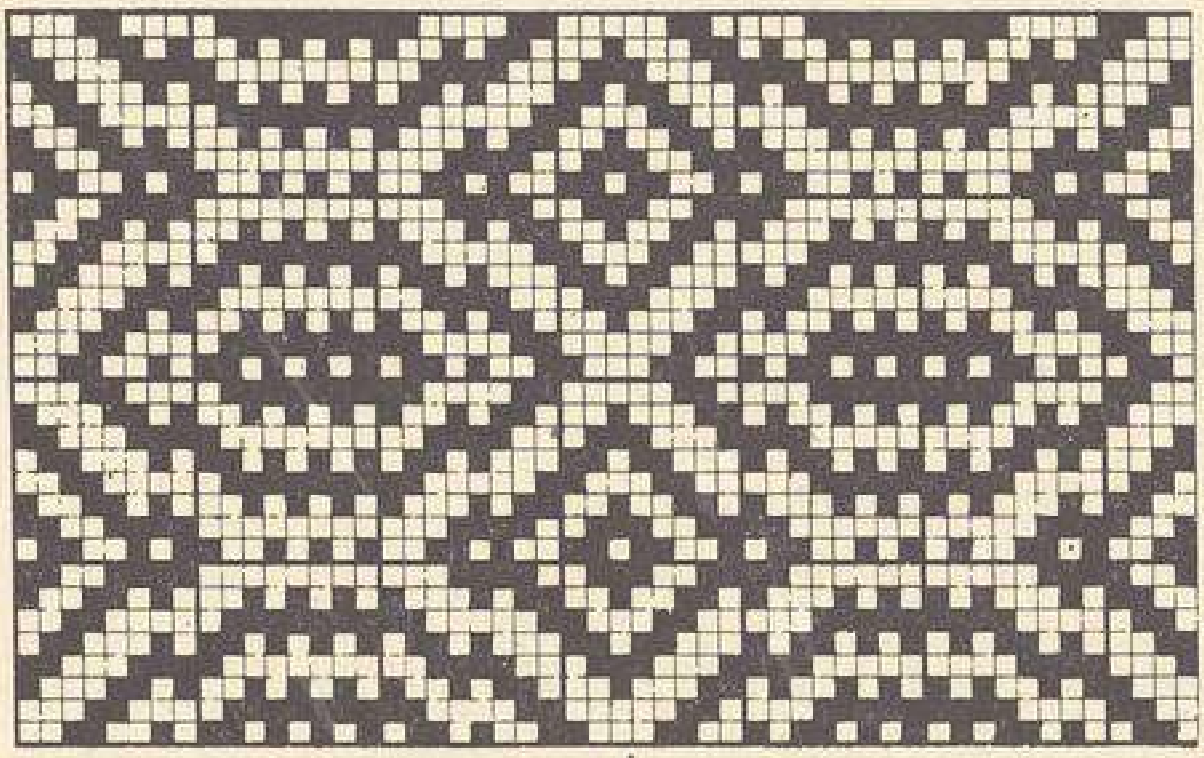


J

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, 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 photographical 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 photographical reproduction of the cloth, and so also does H,

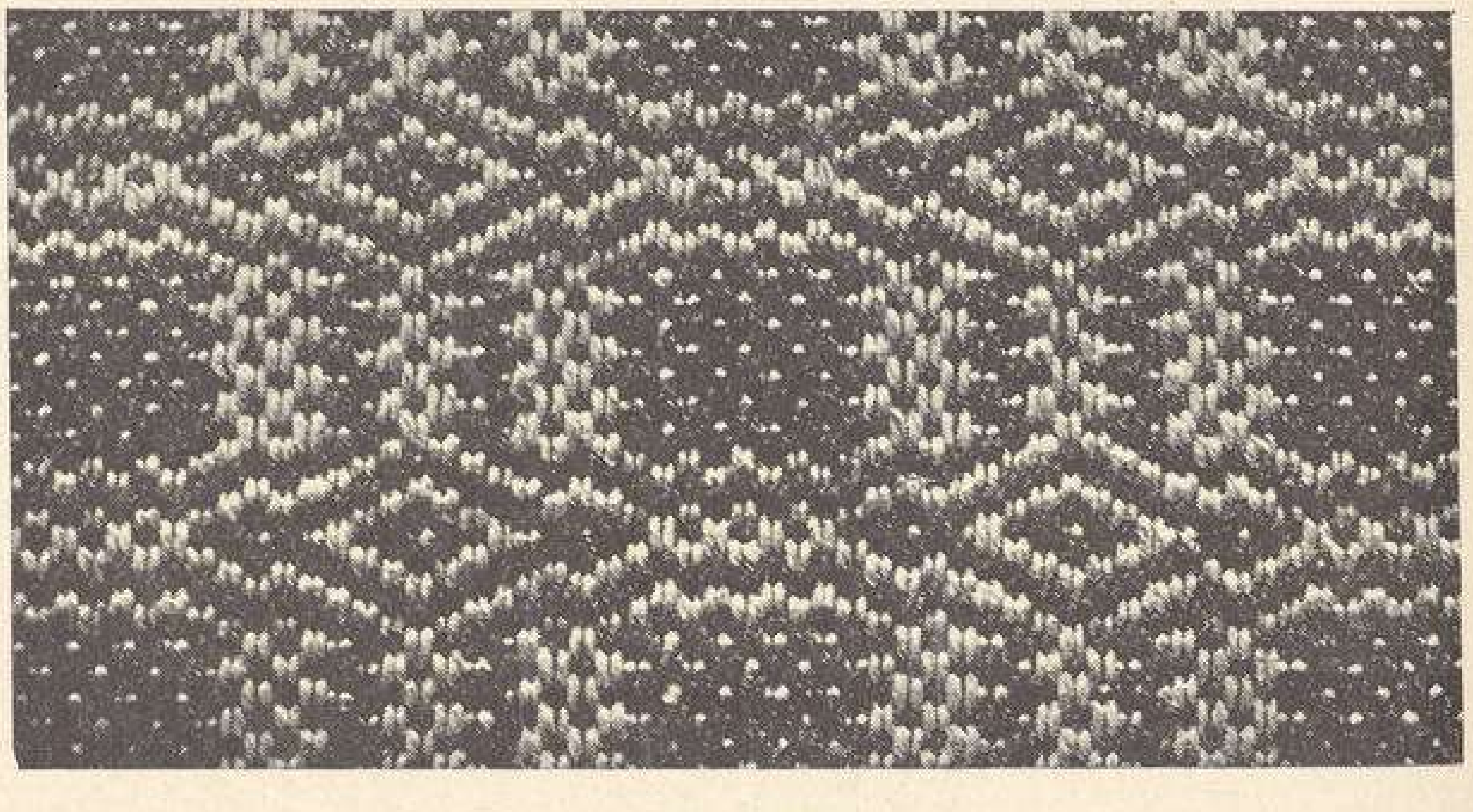


Fig. 155.

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.

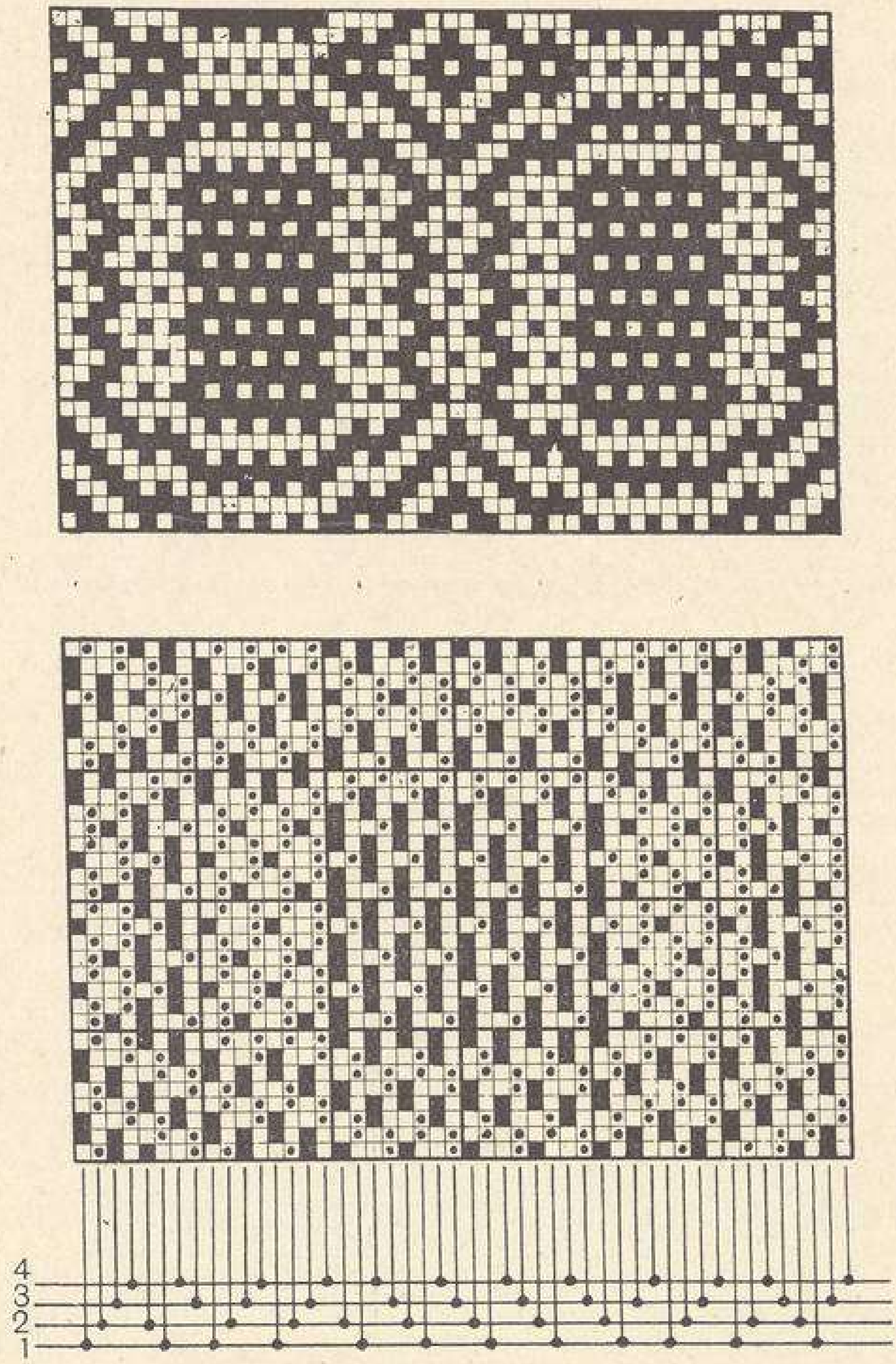


FIG. 156.

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

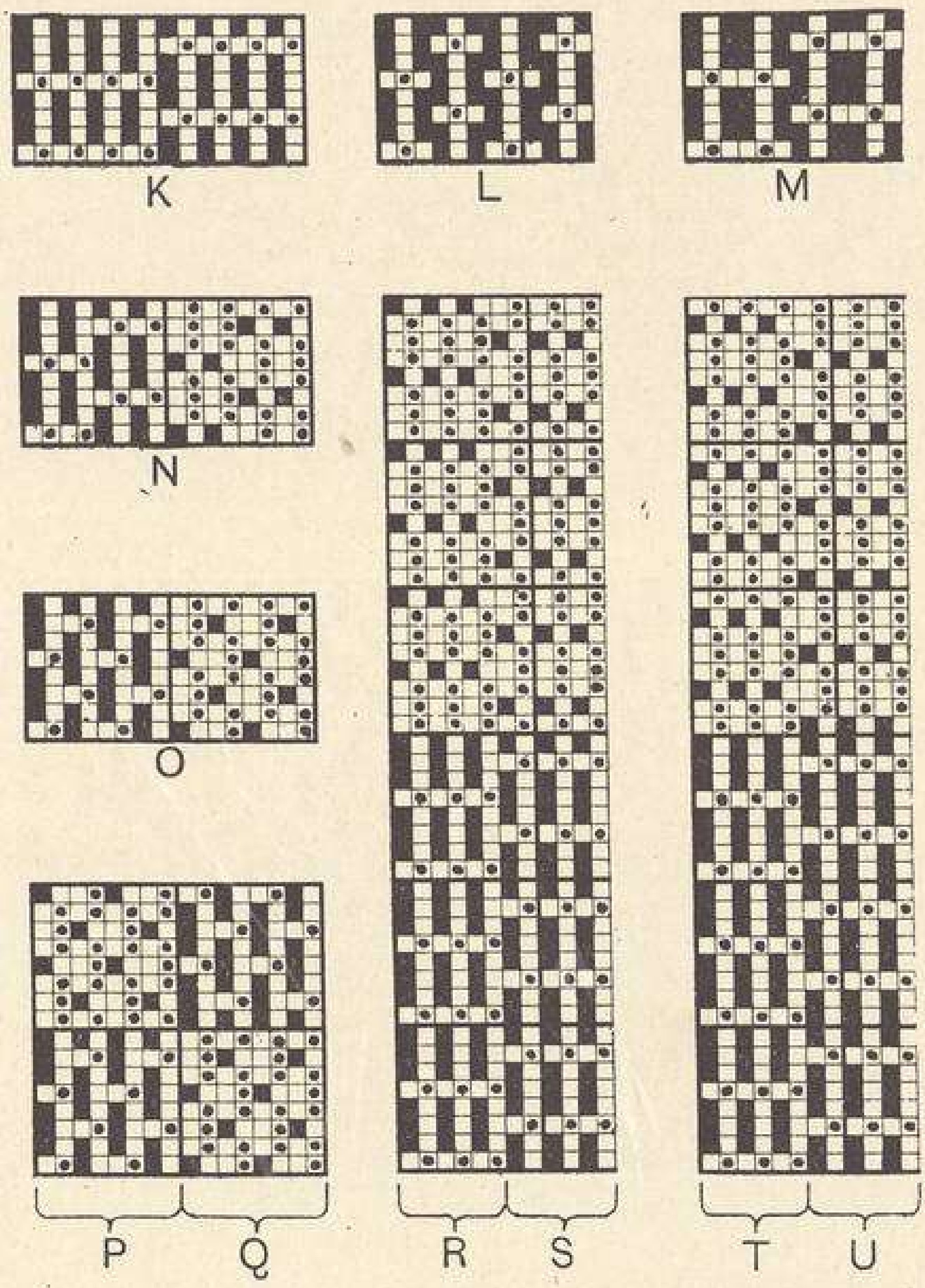


FIG. 157.

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:—

1 thread dark } for 48 threads.
1 „ light }

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:—

1 thread maroon } for 48 threads.
1 „ red }
1 „ green } „ „
1 „ écru }

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

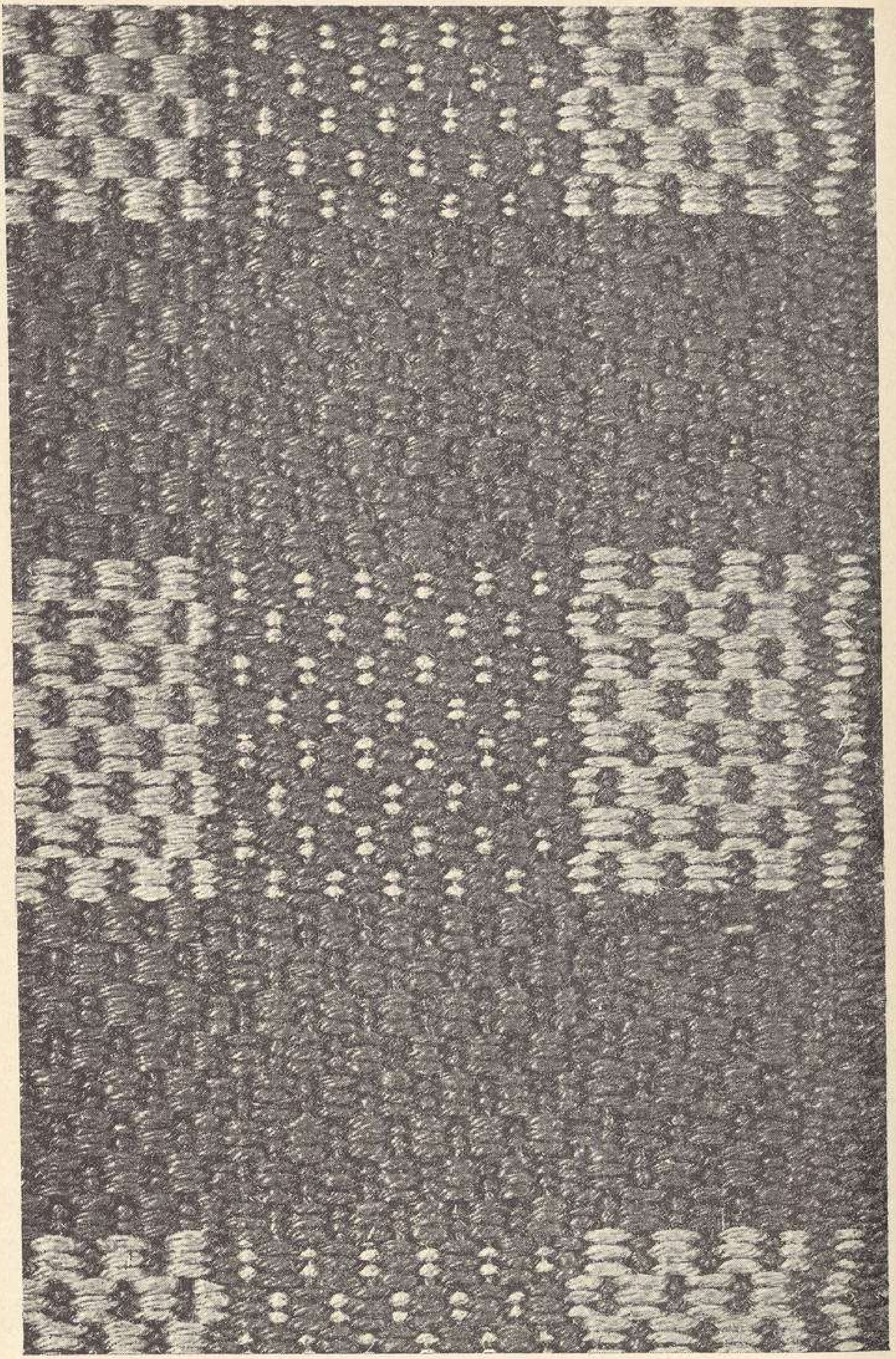


Fig. 158.

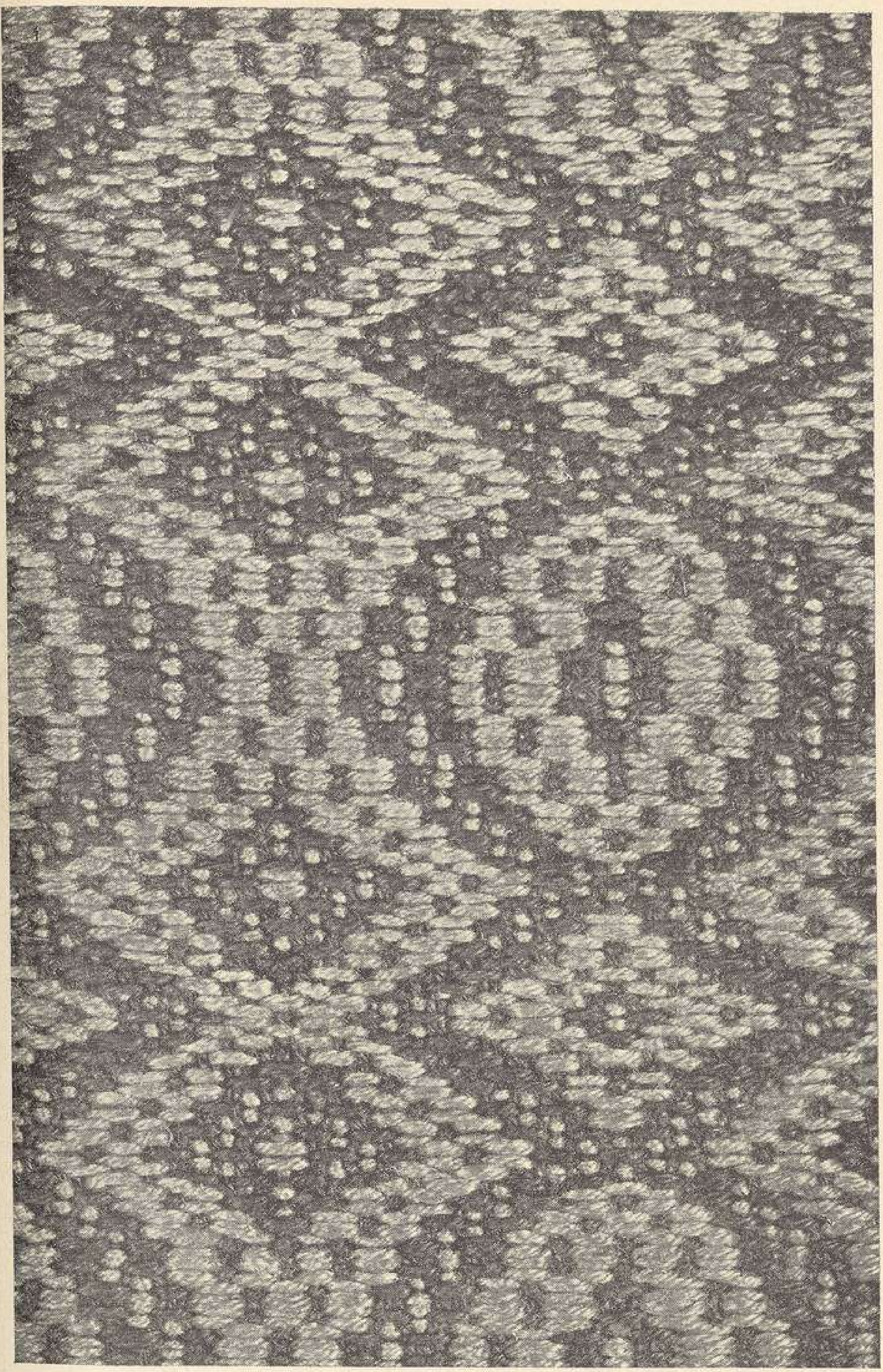


Fig. 159.

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

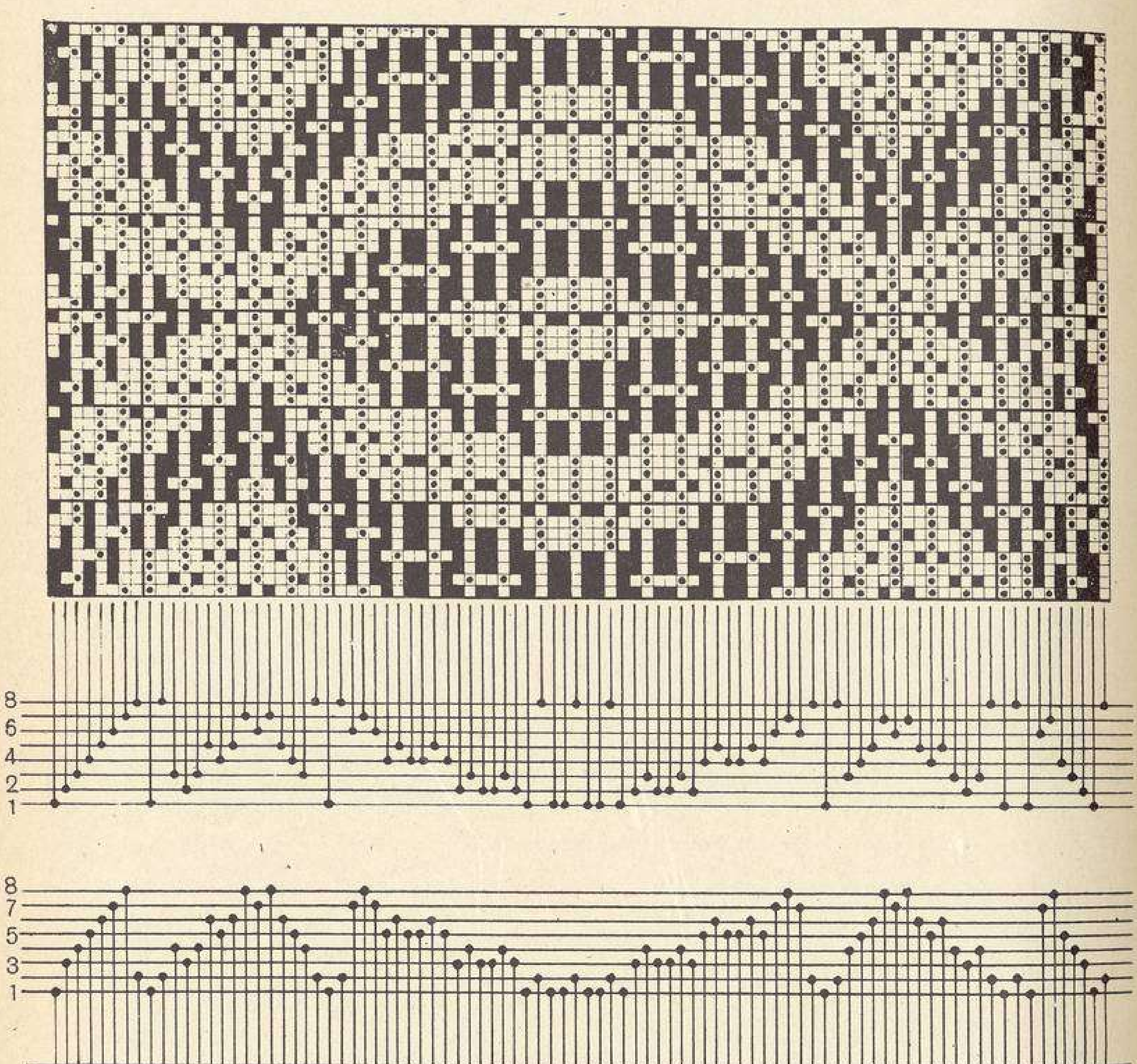


FIG 160.

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 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

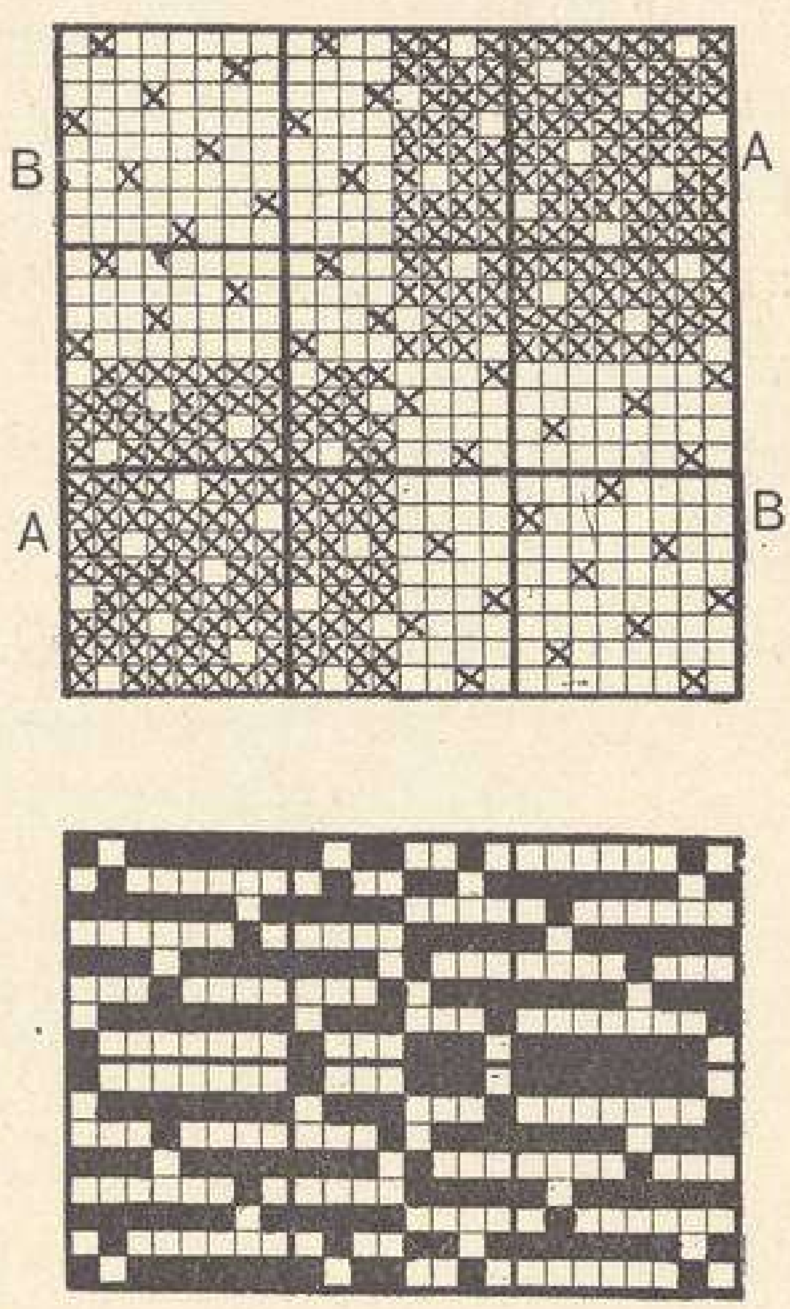


Fig. 161.

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 × in parts A, Fig. 162.
2. Paint ordinary twill in figure in white, represented by marks ● 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 ● in parts B, Fig. 162.
5. Paint binding twill in figure in brown, represented by marks ■ in parts A, Fig. 162.

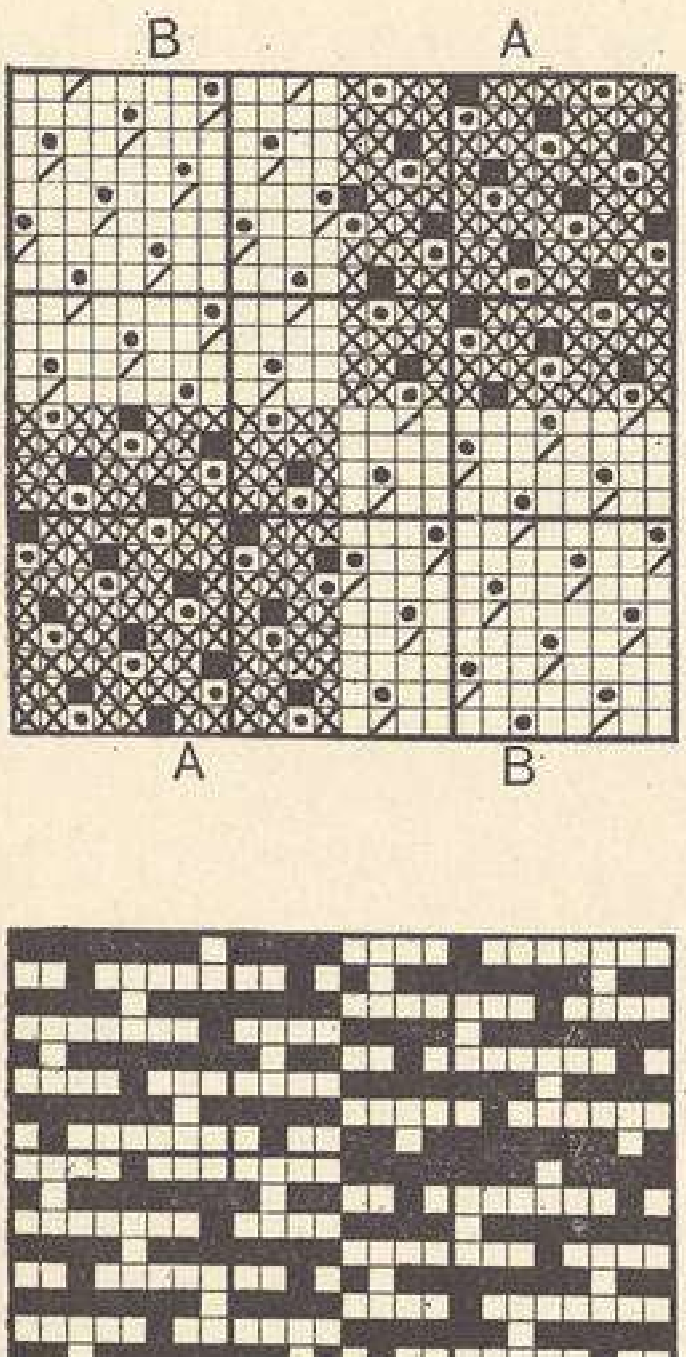


Fig. 162.

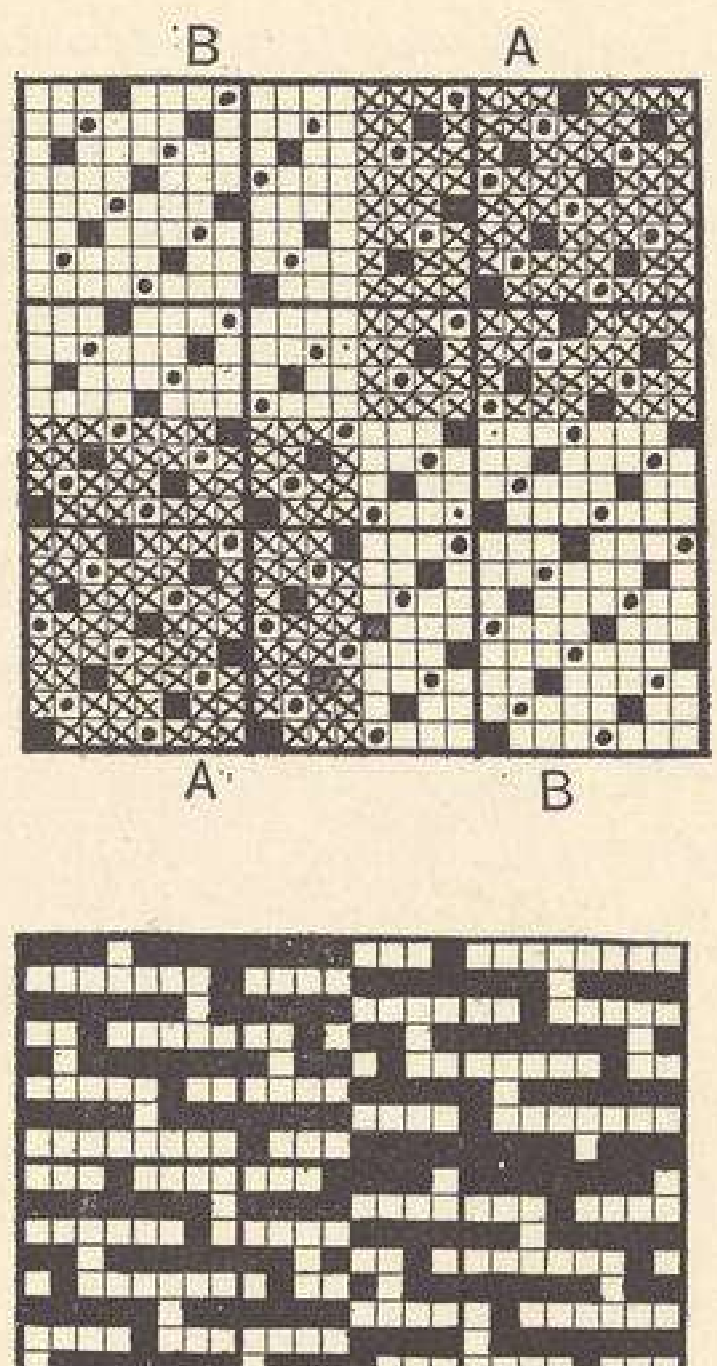


Fig. 163.

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 × and ■ in figure and / in ground.
2nd reading: „ ■ 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 ● 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 × and ● in figure, and ● in ground.
2. „ ● in figure, and all blanks and ● 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

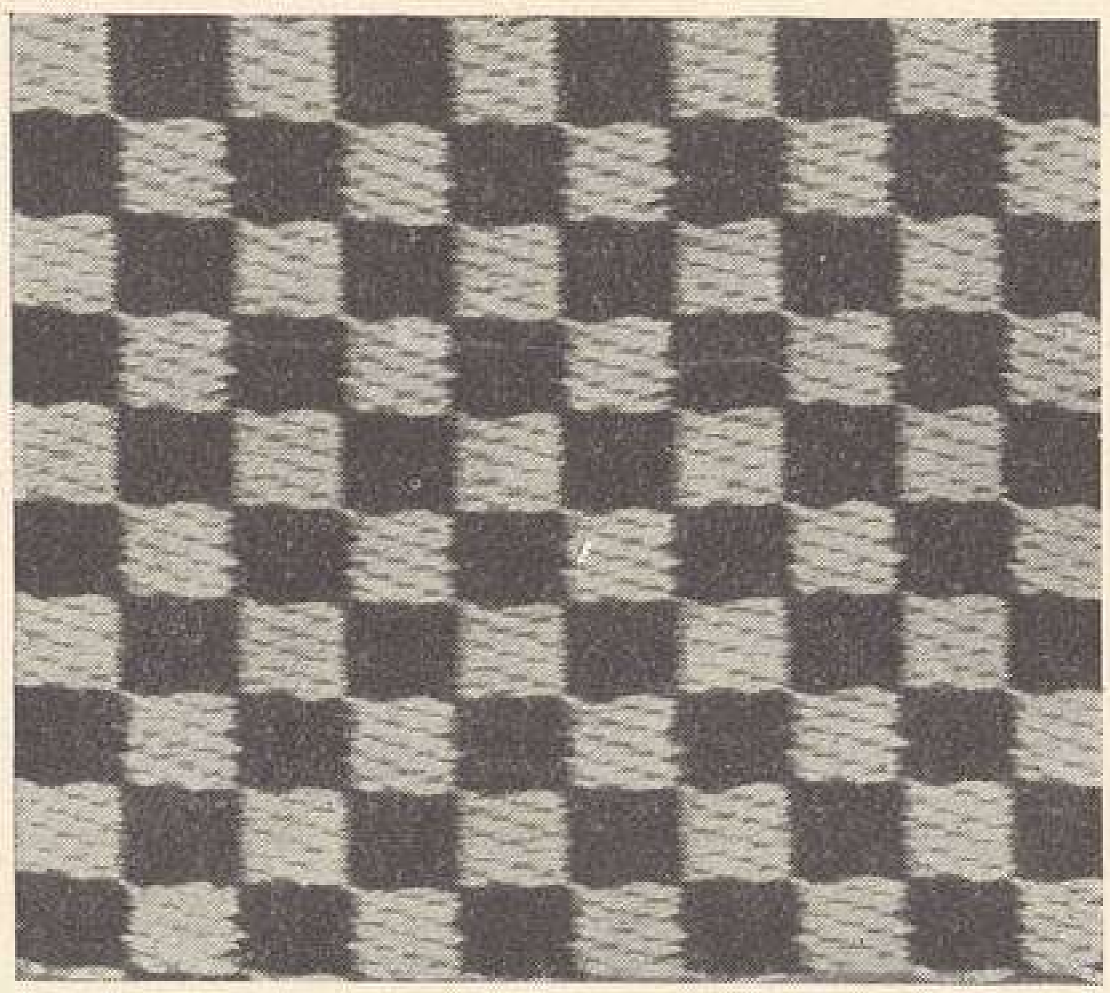


FIG. 164.

twilling marks appear. Fig. 164 is a photographical 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°. 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

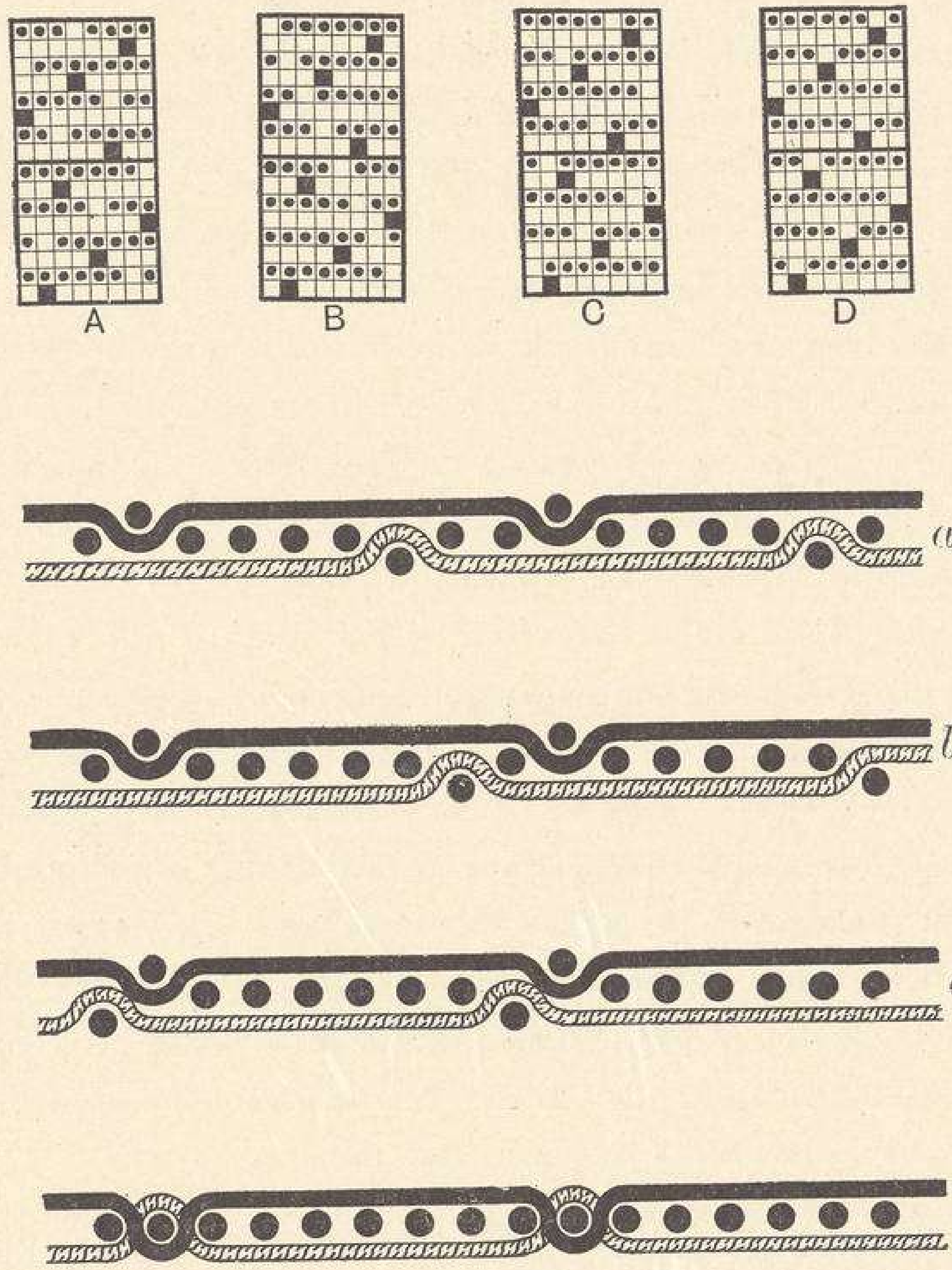


Fig. 165.

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

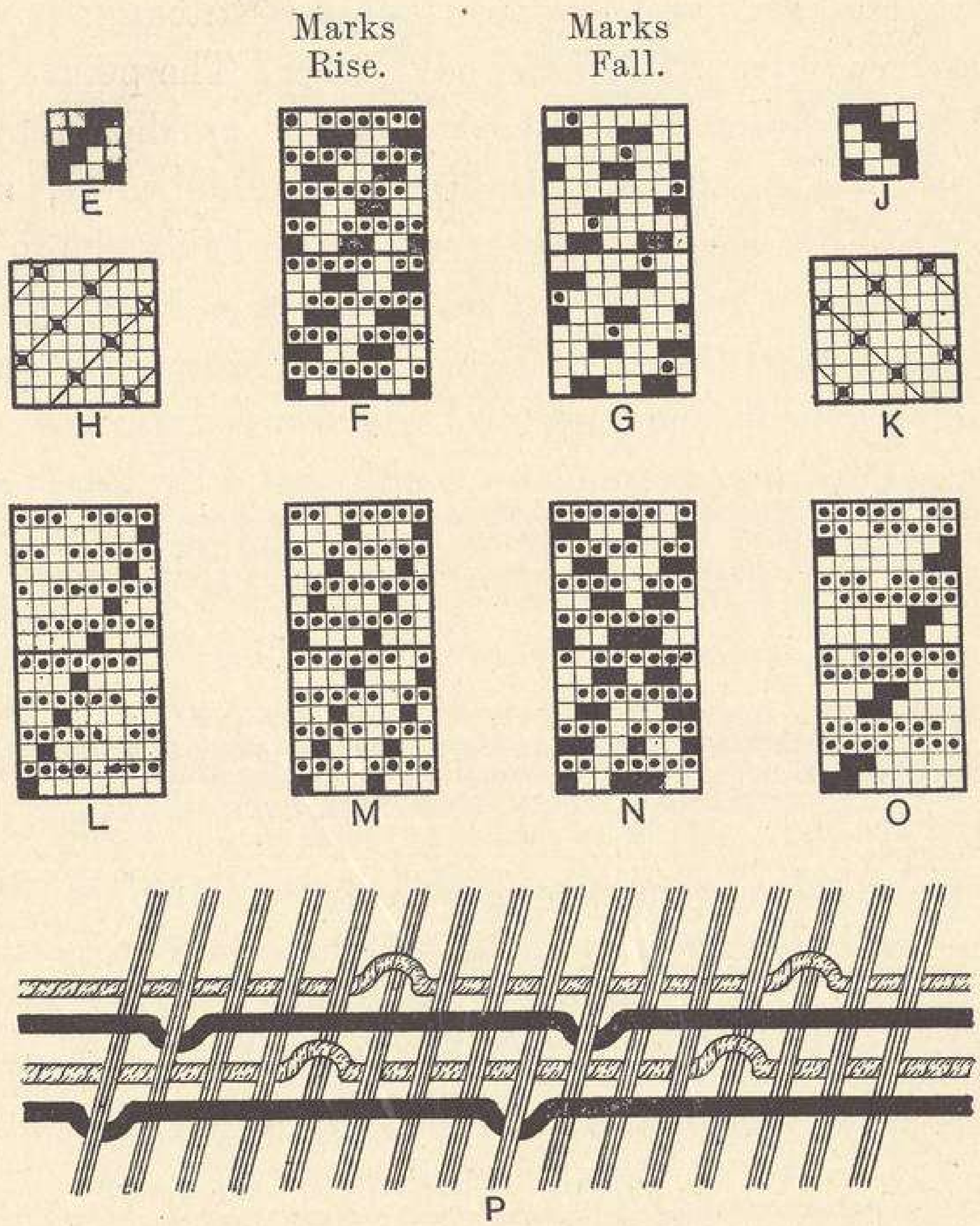


Fig. 166.

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.

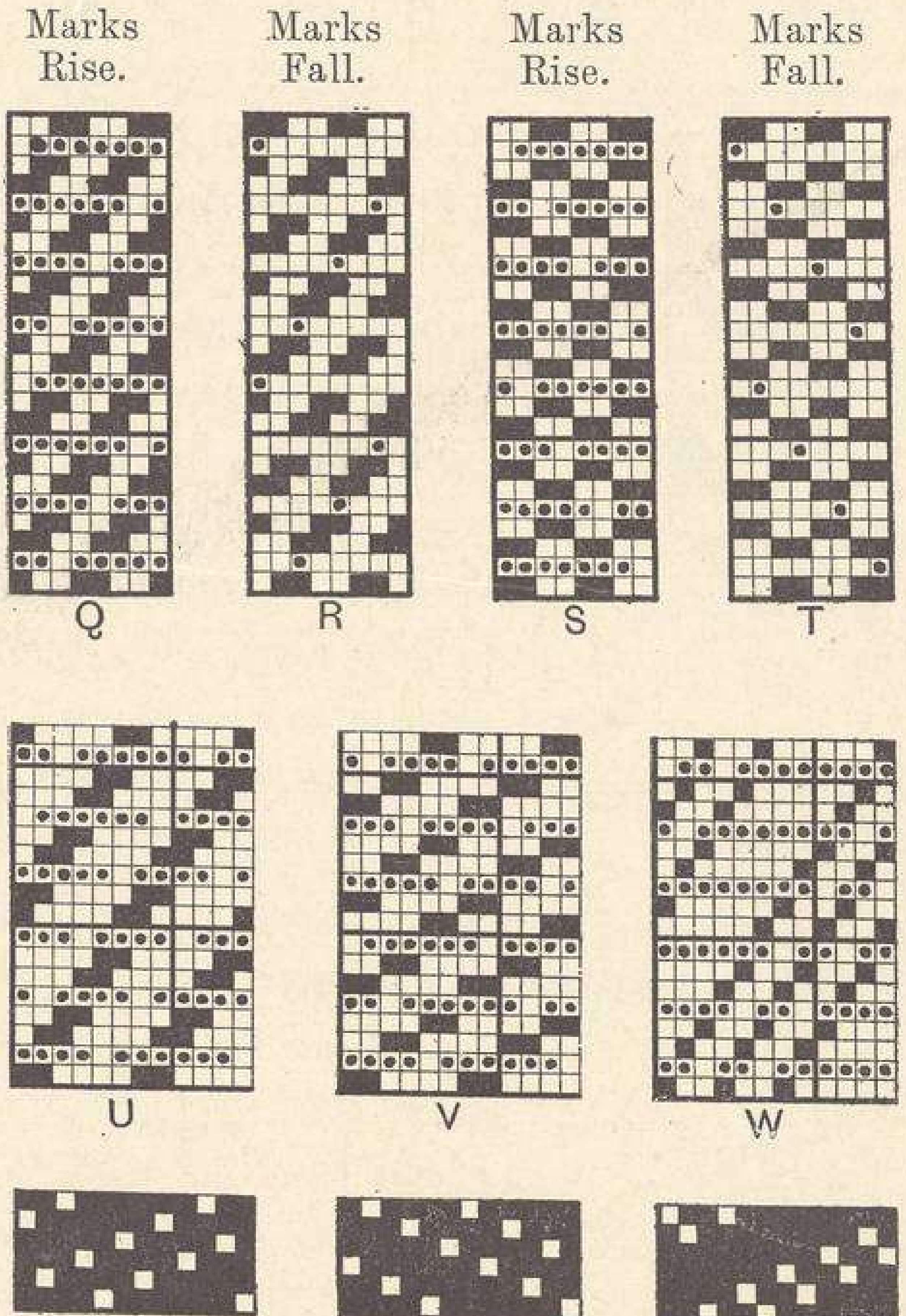


Fig. 167.

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 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.

Marks Fall.

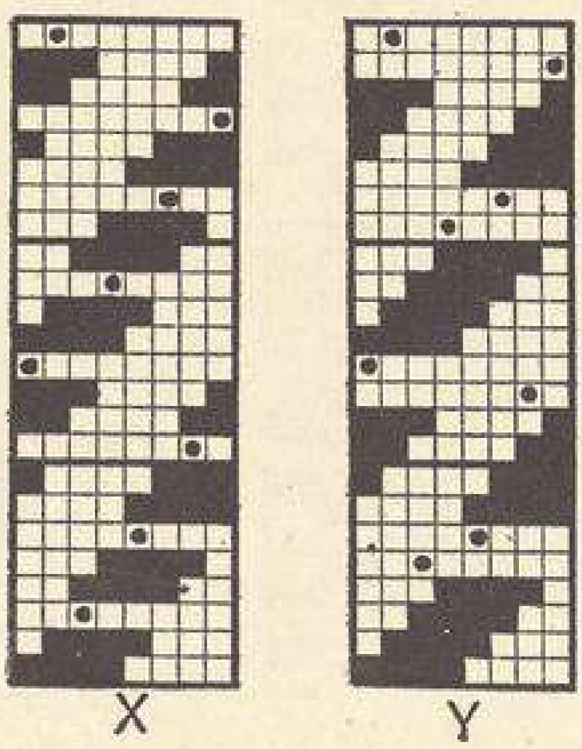
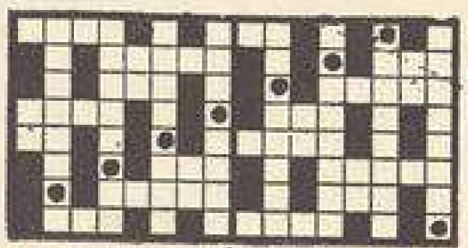


FIG. 168.

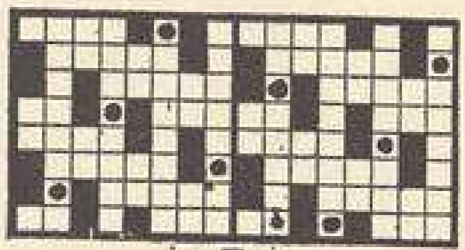
2. FABRICS BACKED WITH WARP

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°. 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.



A



B

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

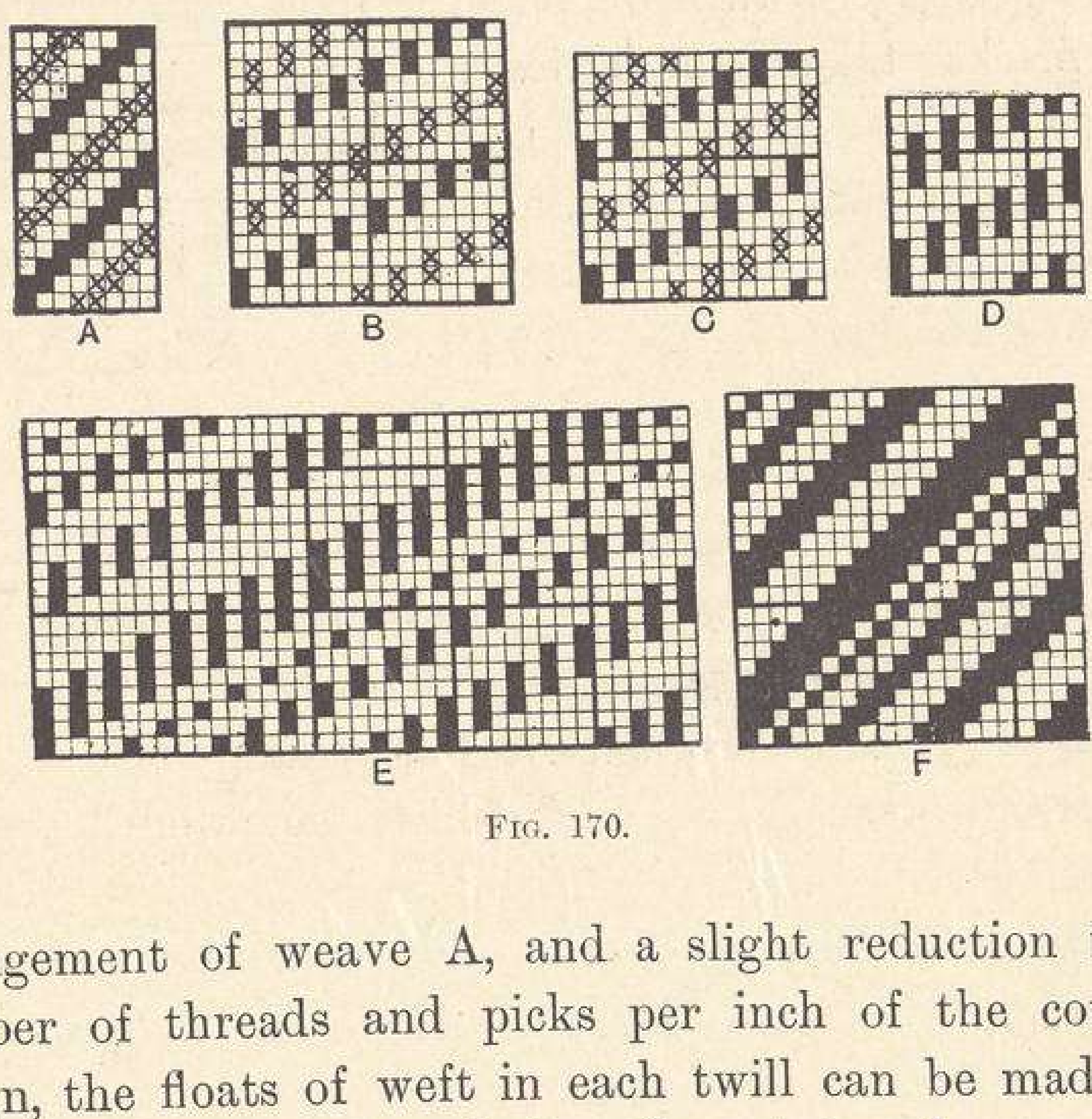


FIG. 170.

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° 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

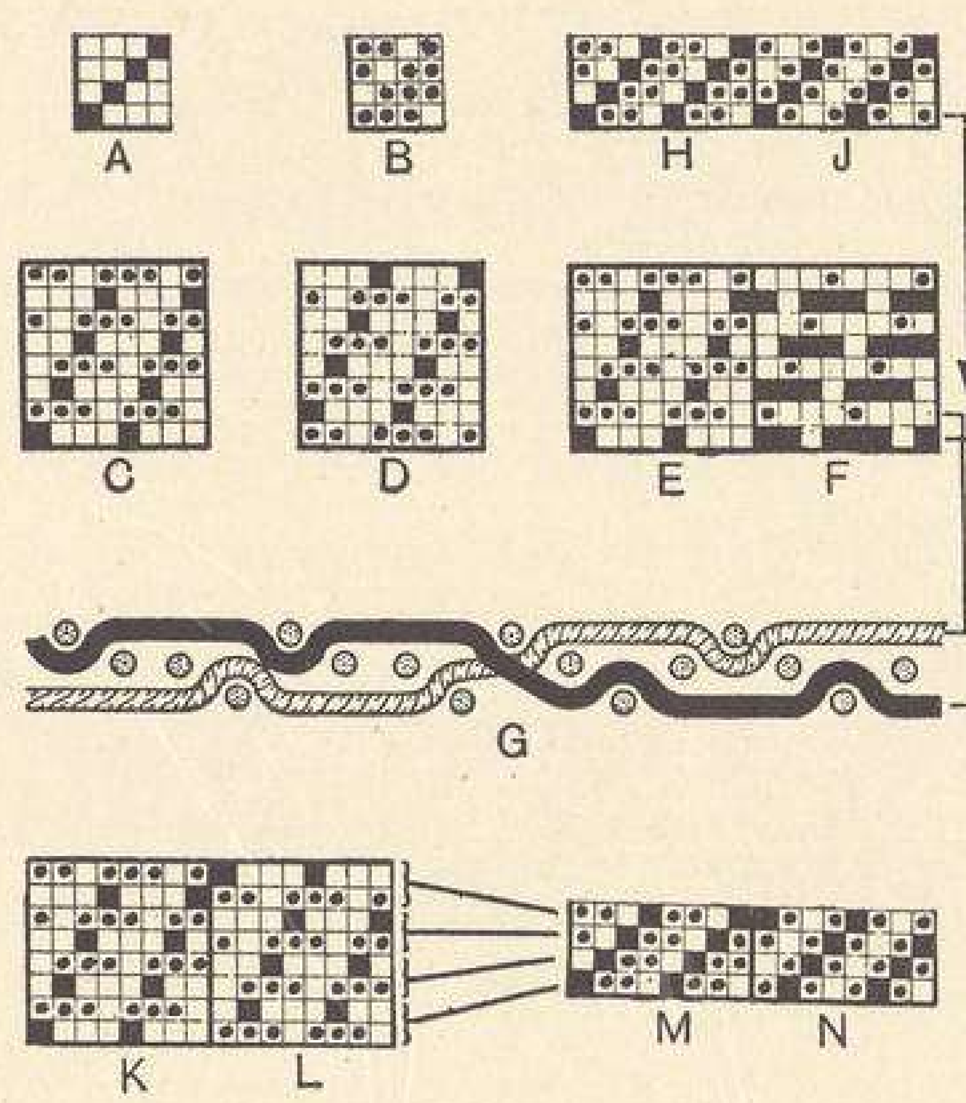


FIG. 171.

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 $\frac{1}{1}$ 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 groundwork 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.

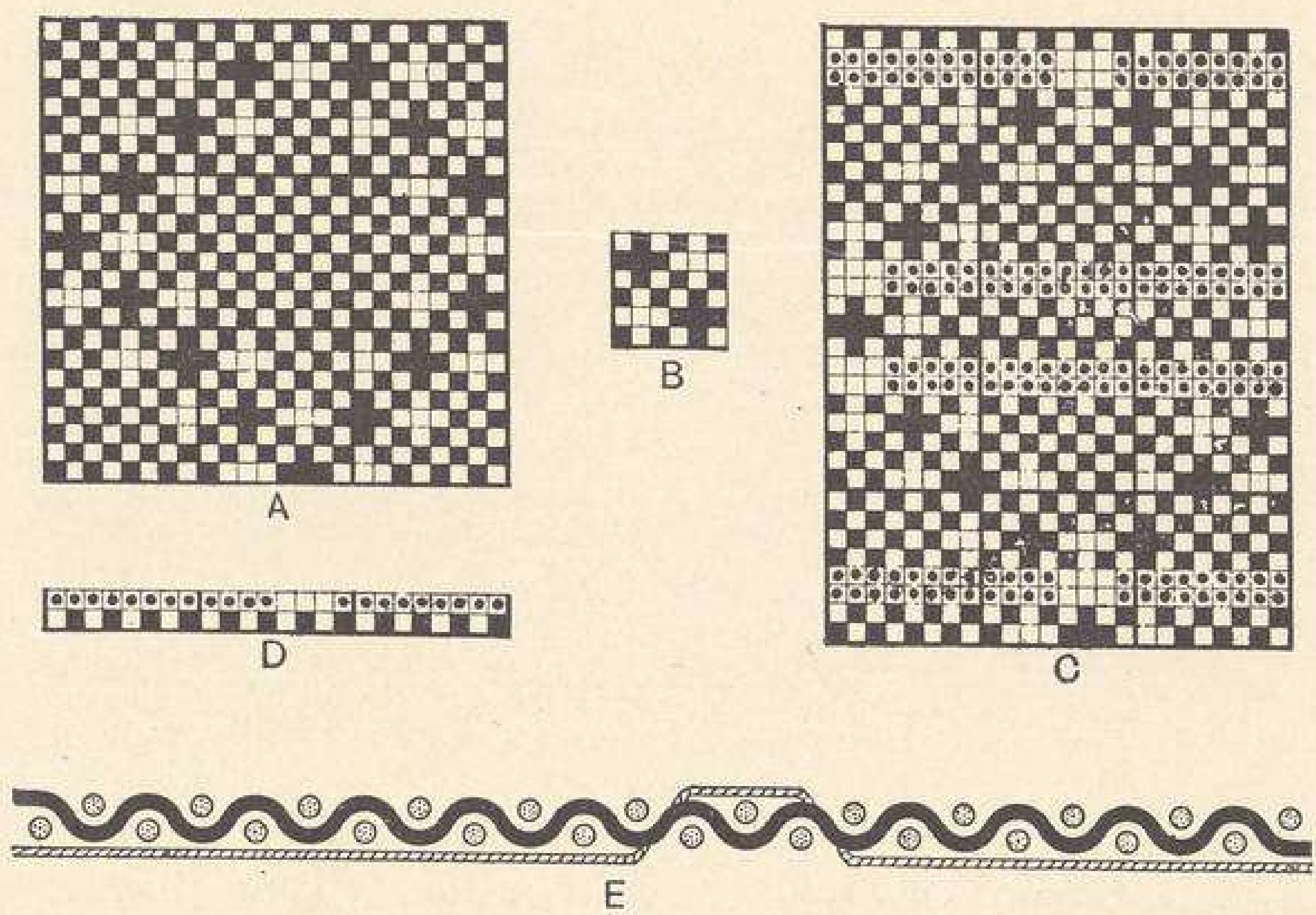


FIG. 172.

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

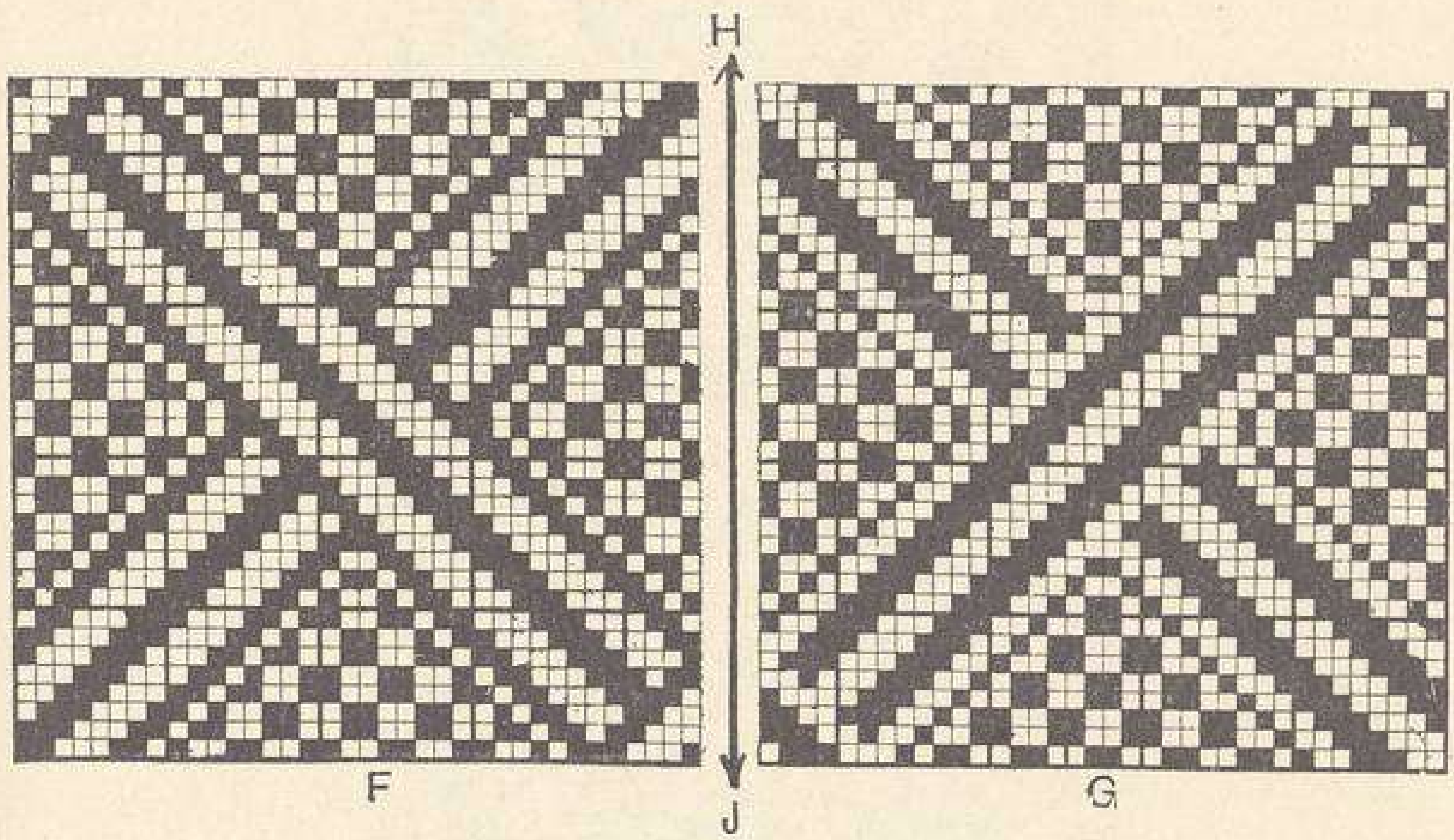


FIG. 173.

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

U

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

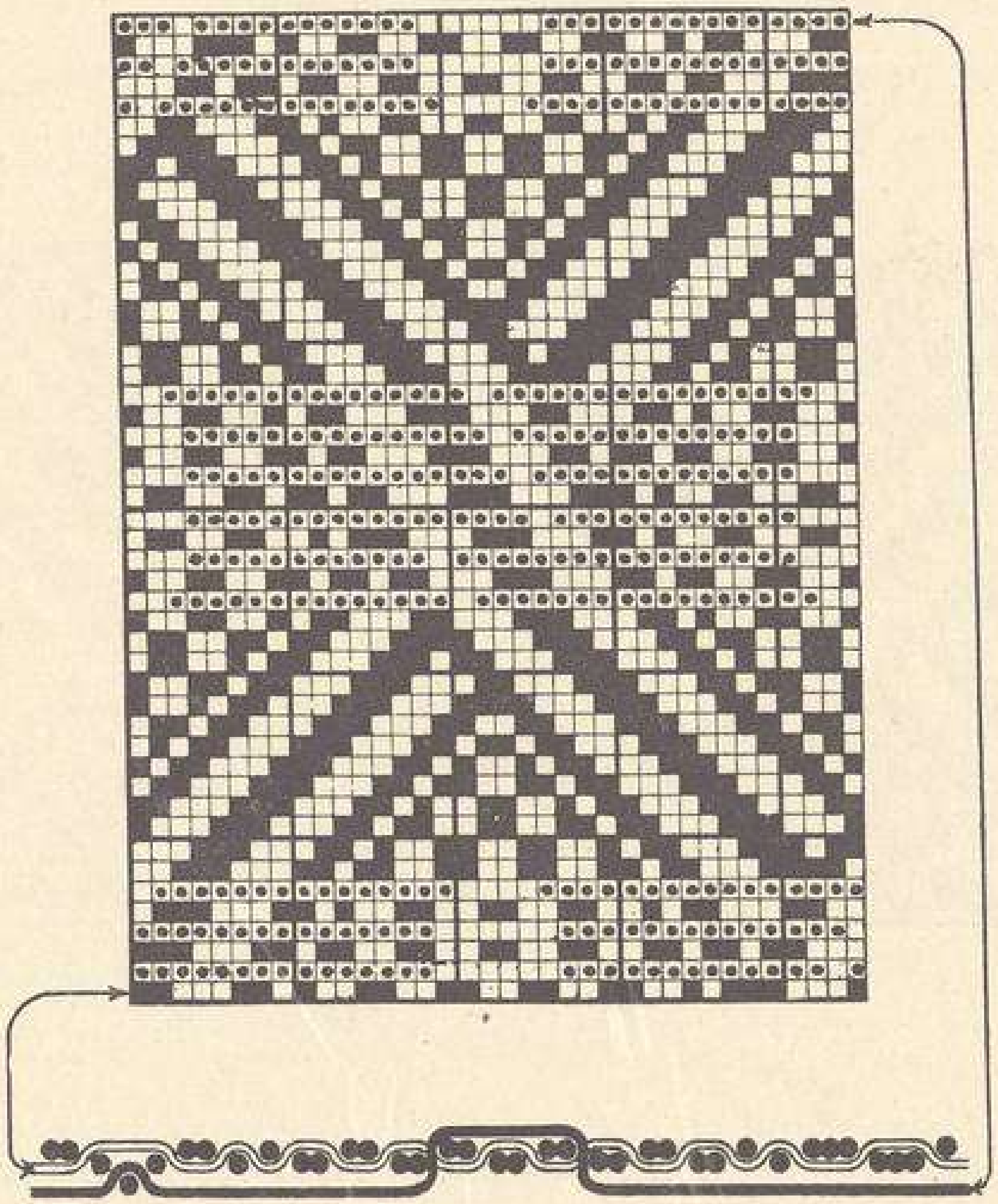
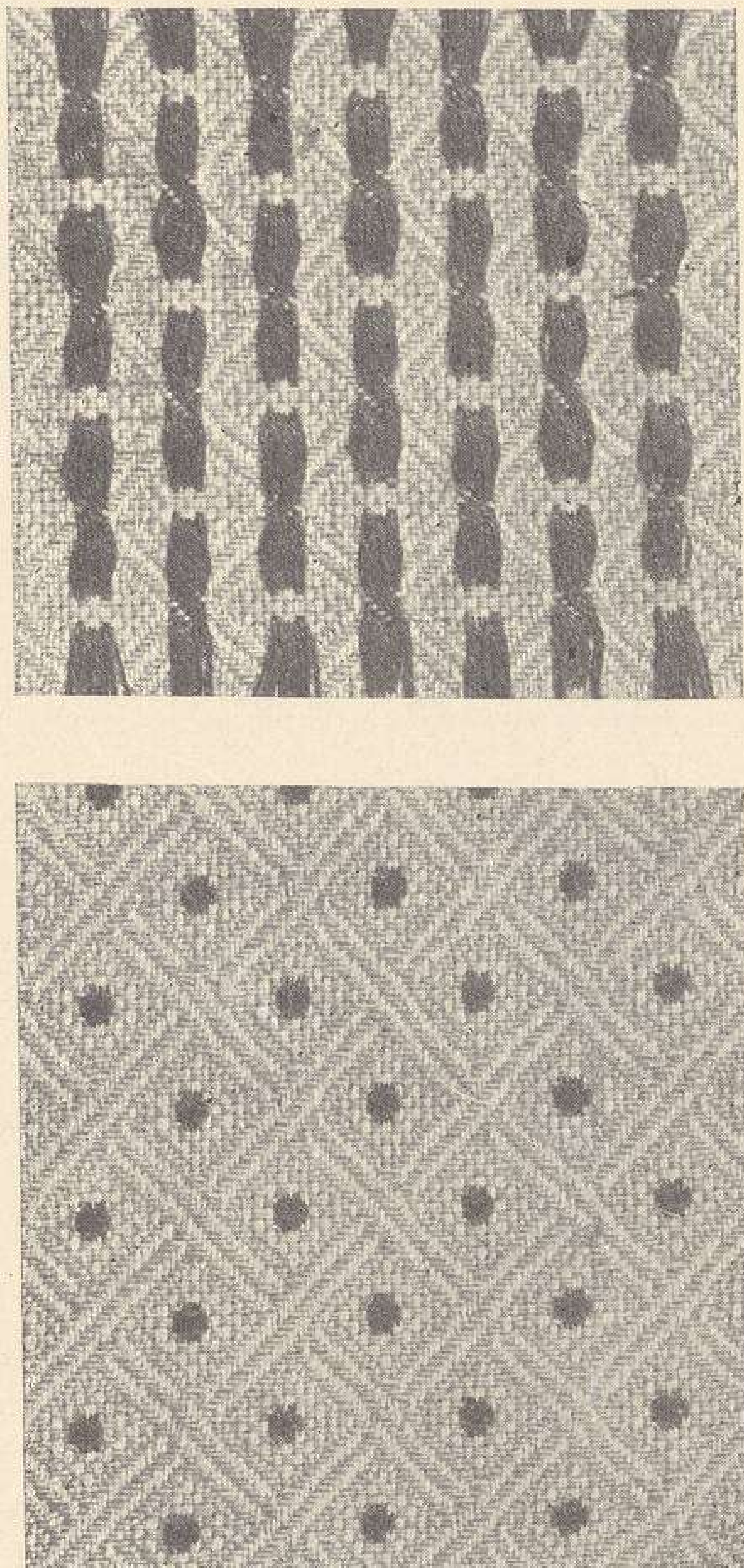


FIG. 174.

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 photographical 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

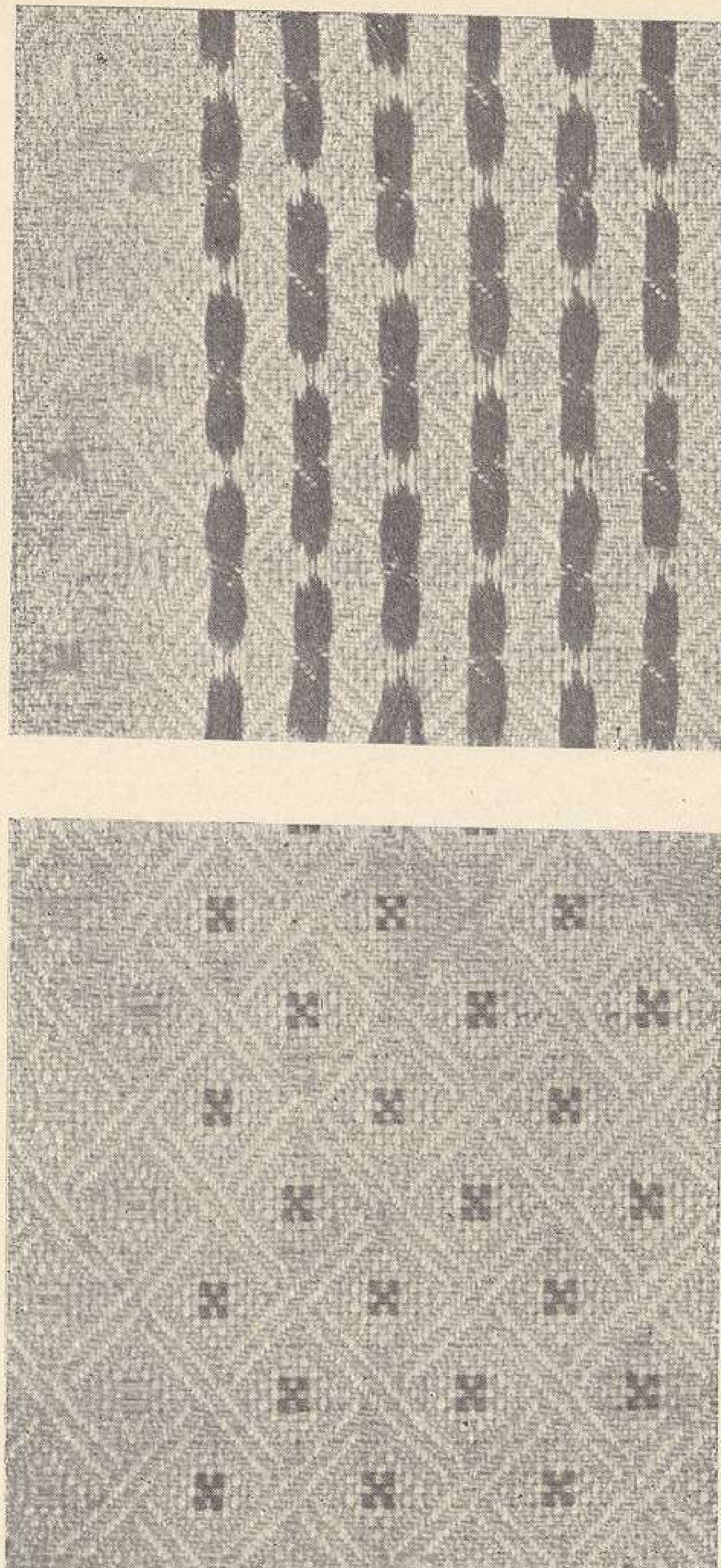


L

K

Fig. 175.

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



N

M

Fig. 176.

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 weft does not interweave with the ground threads, but simply floats on the back. The order of stitching is the same as in L, Fig. 175. The complete design for the cloth reproduced at M, Fig. 176, is illustrated in Fig. 177, in which all marks indicate threads down. The ground weave in this example is that shown at G, Fig. 173, but arranged to commence on the 19th thread of G in order to show up a complete diamond in Fig. 177.

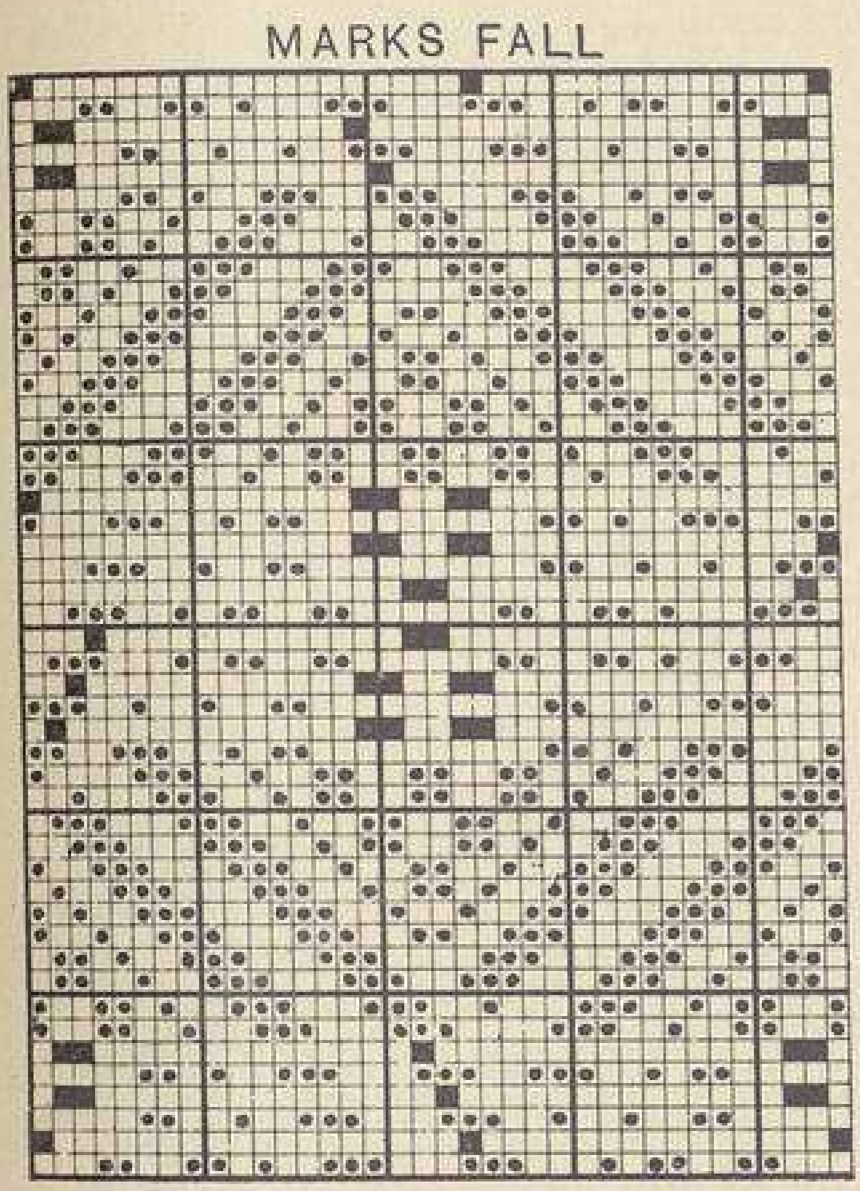


Fig. 177.

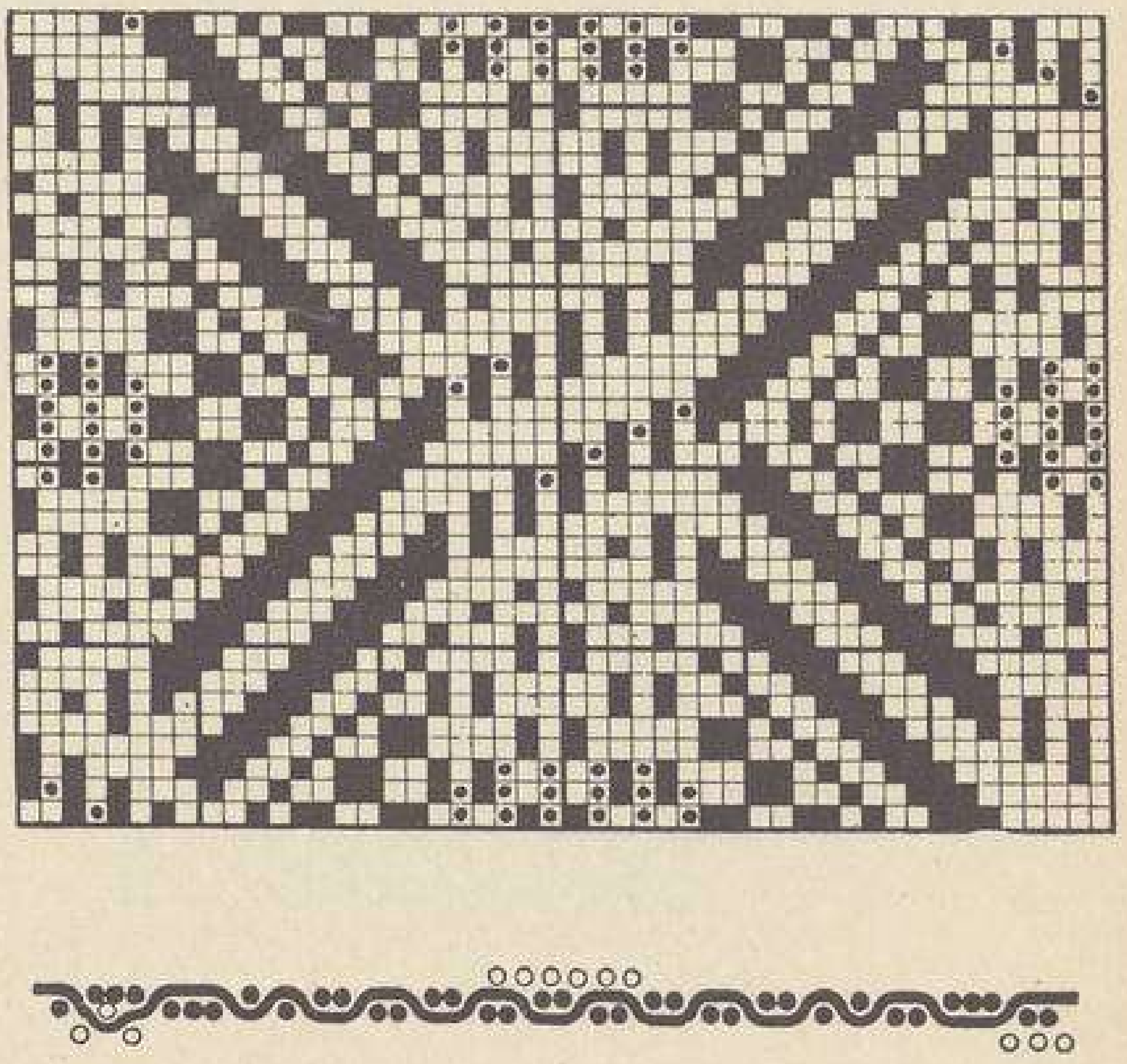
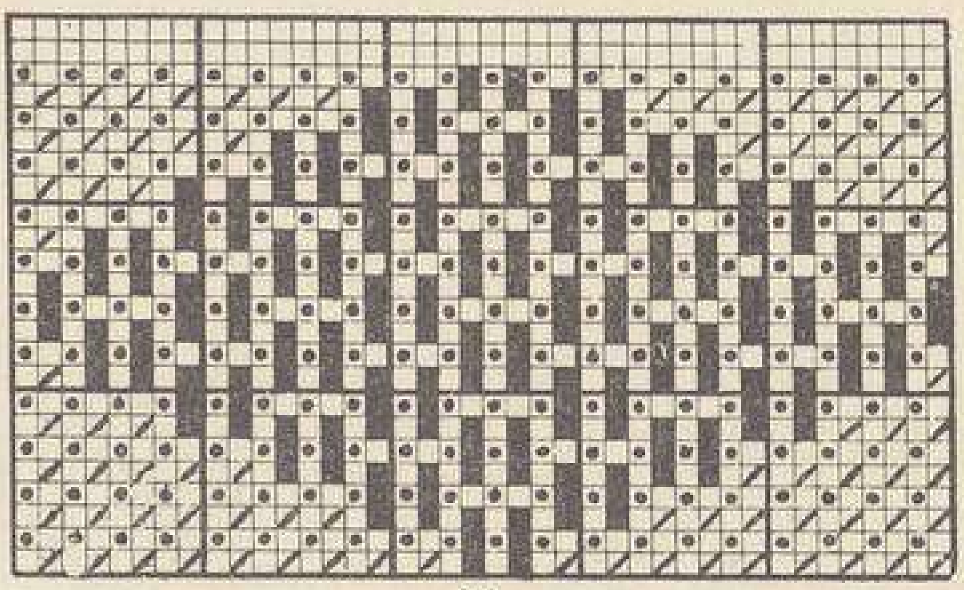
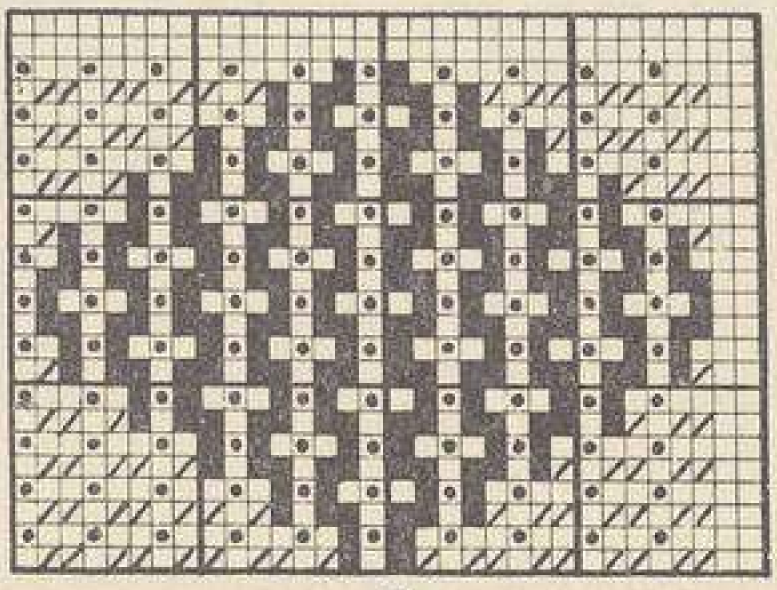


Fig. 178.

All ordinary weft spots, where the spots depend upon extra weft, are made more or less on the principle which we have just demonstrated. We need hardly point out, however, that any kind of weave—plain, twill, or fancy—may be used for these fabrics; that the floats of the figuring weft may be of any length provided that special precautions are taken to display them satisfactorily; and that the stitching points need not be in regular order. A typical example of a design in which the spot is developed 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 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 left the middle figuring thread is shown raised for stitching purposes.



O

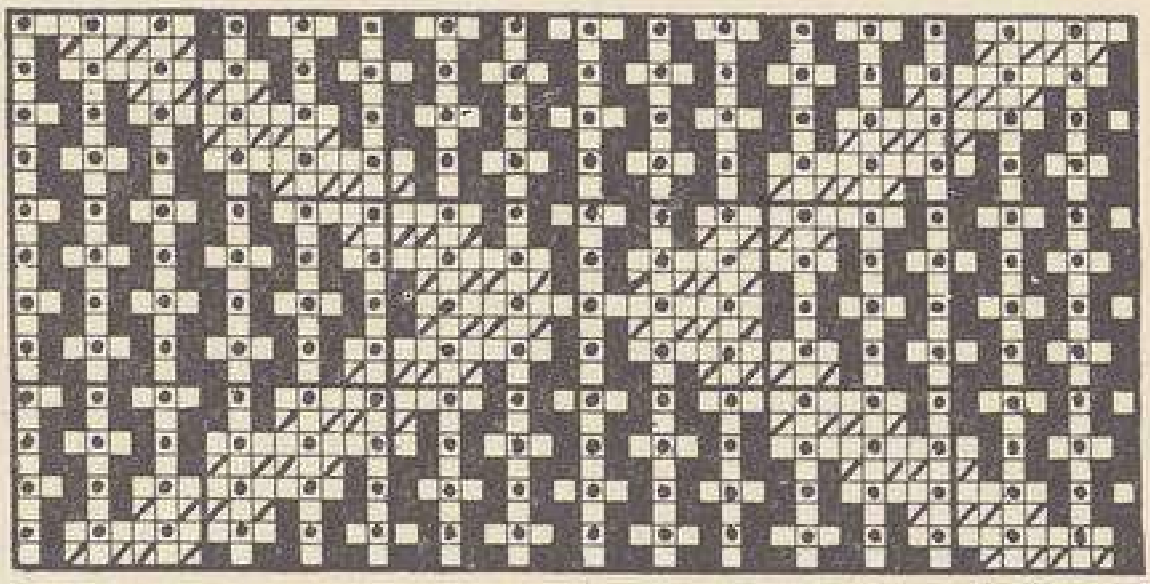


P

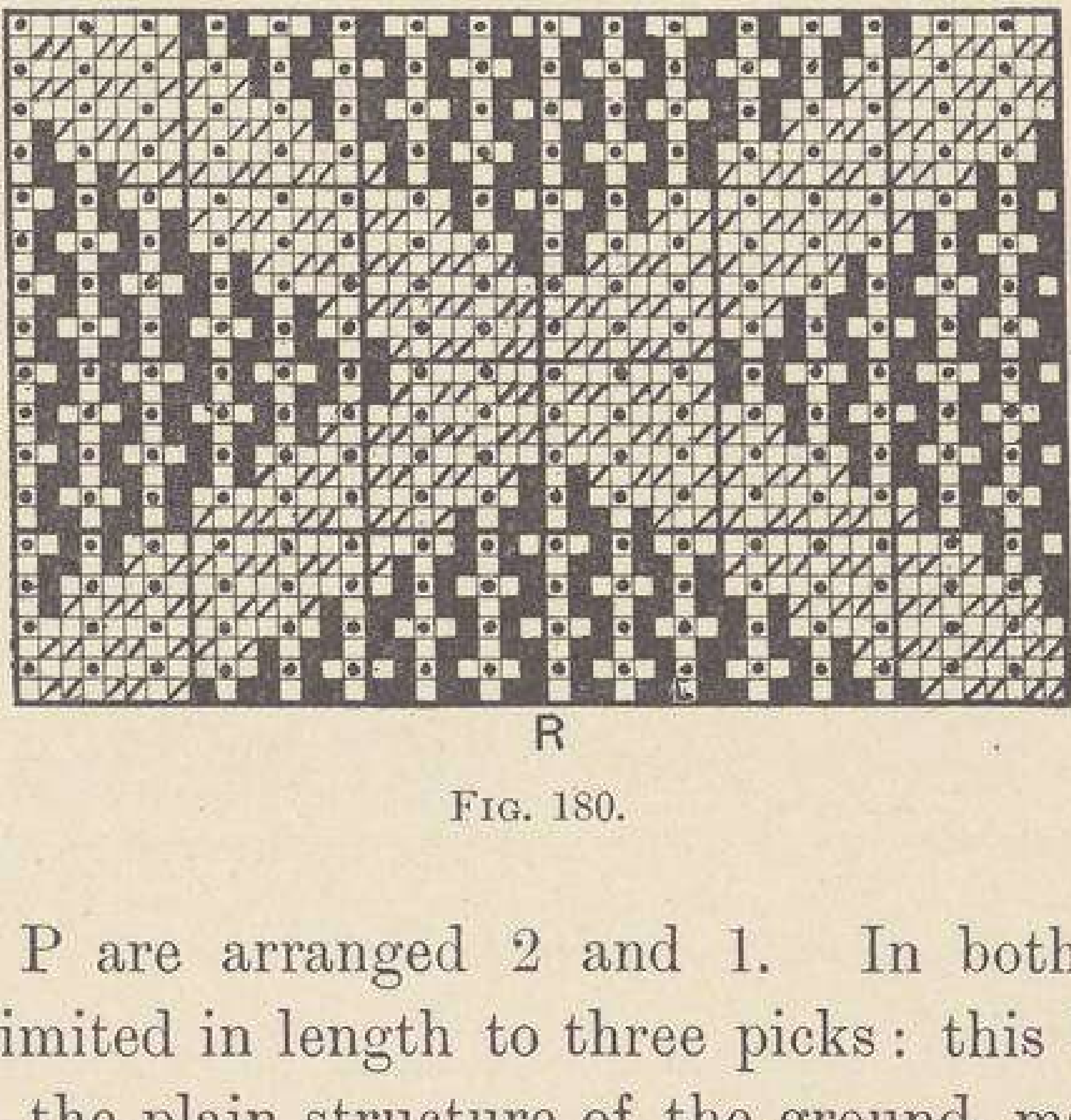
Fig. 179.

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.

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 proportionately 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

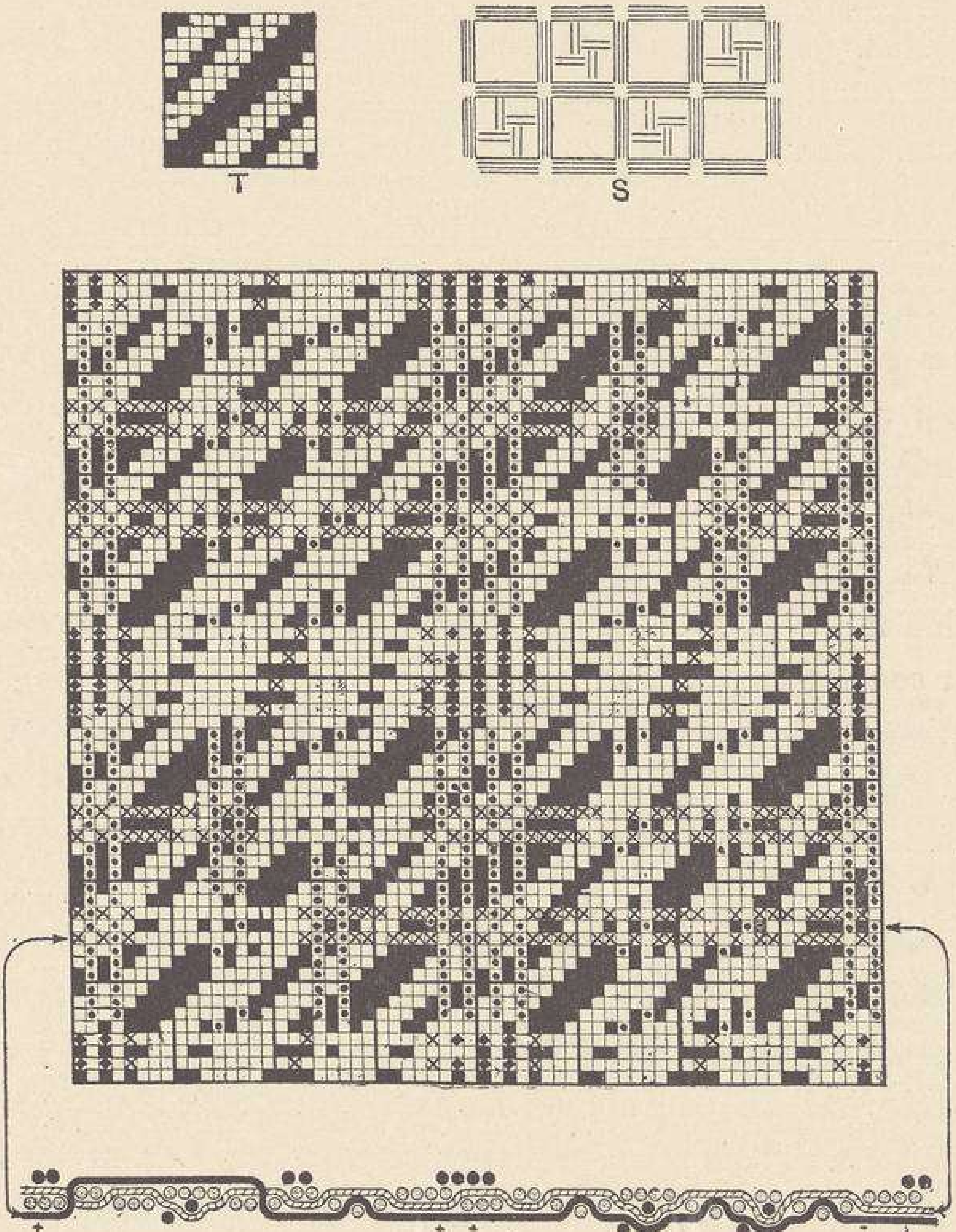


Fig. 181

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

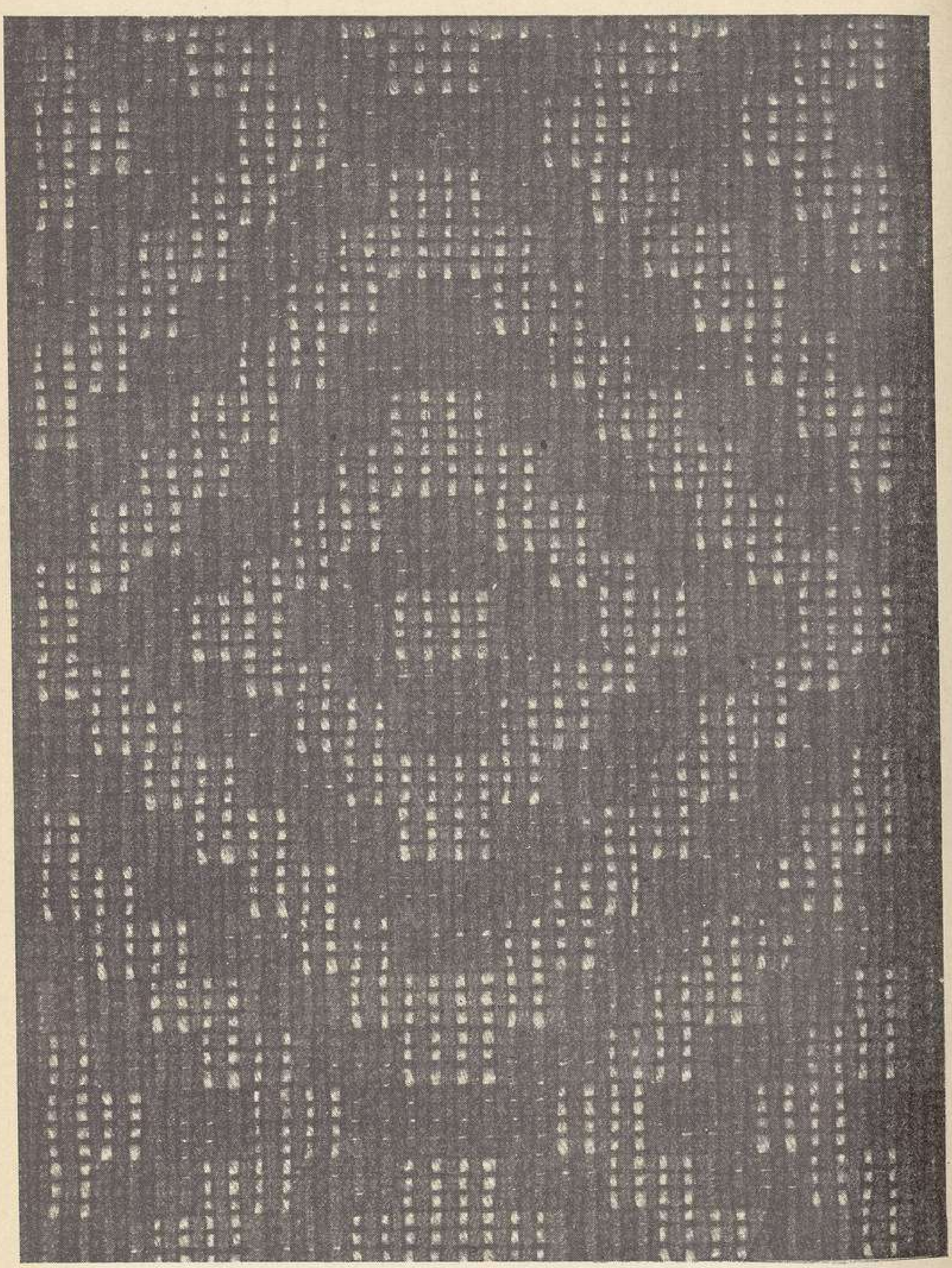


Fig. 182.

the weaving plan. More elaborately figured patterns are

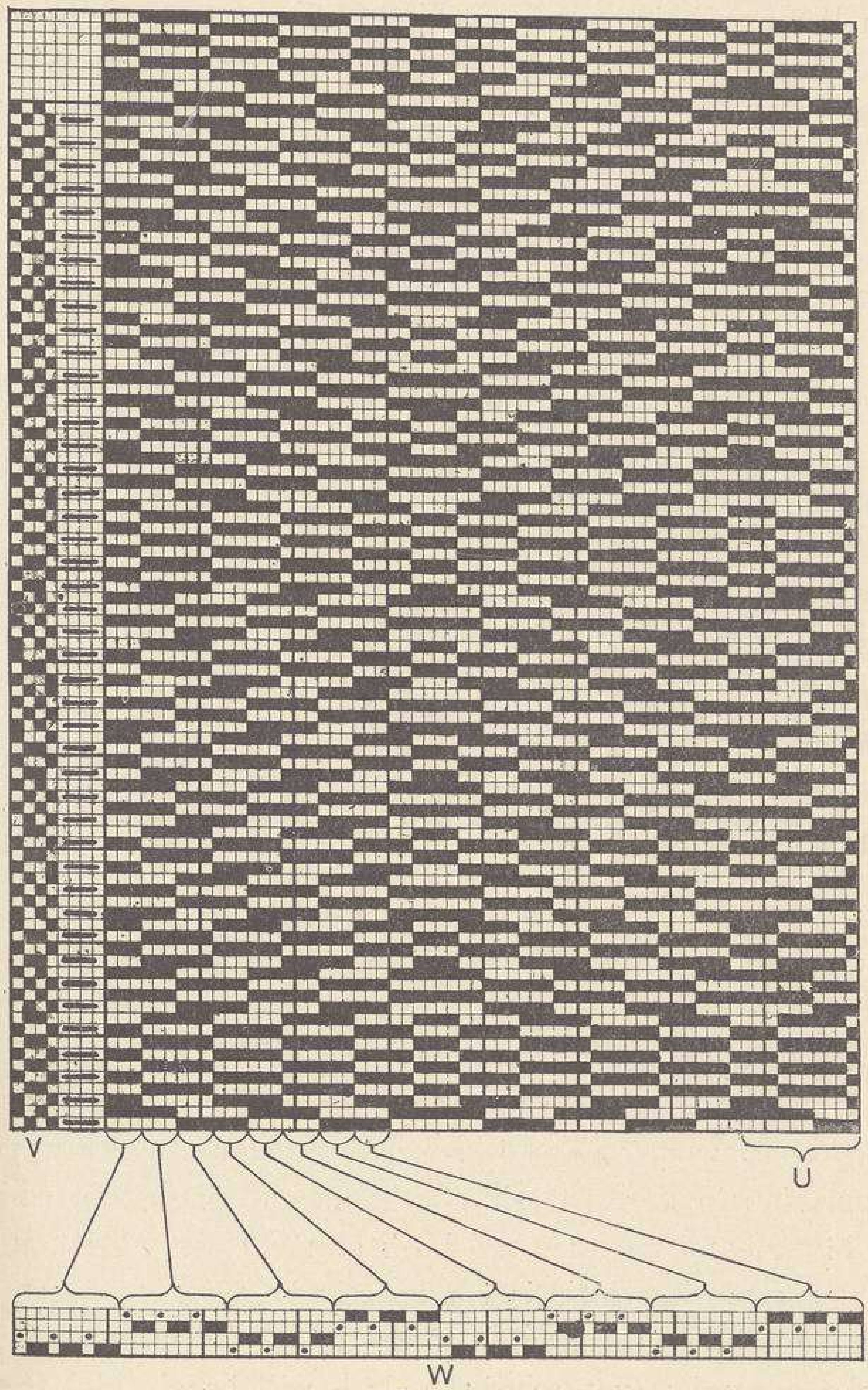


FIG. 183.

made on the same lines, with the exception that instead of 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 groundwork of the fabric is developed in the 4-thread basket weave (see Fig. 184). Six of the threads in each half repeat float for a number of picks as shown by the diamond figures, while at each corner of these diamonds a short float of extra weft appears as shown in the top pattern of the photographical reproduction 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

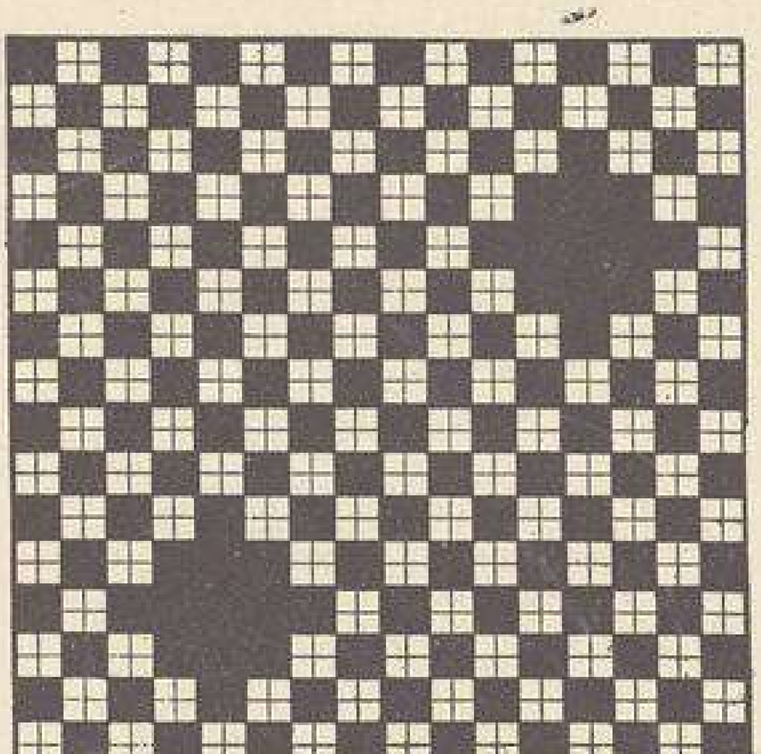


FIG. 184.

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

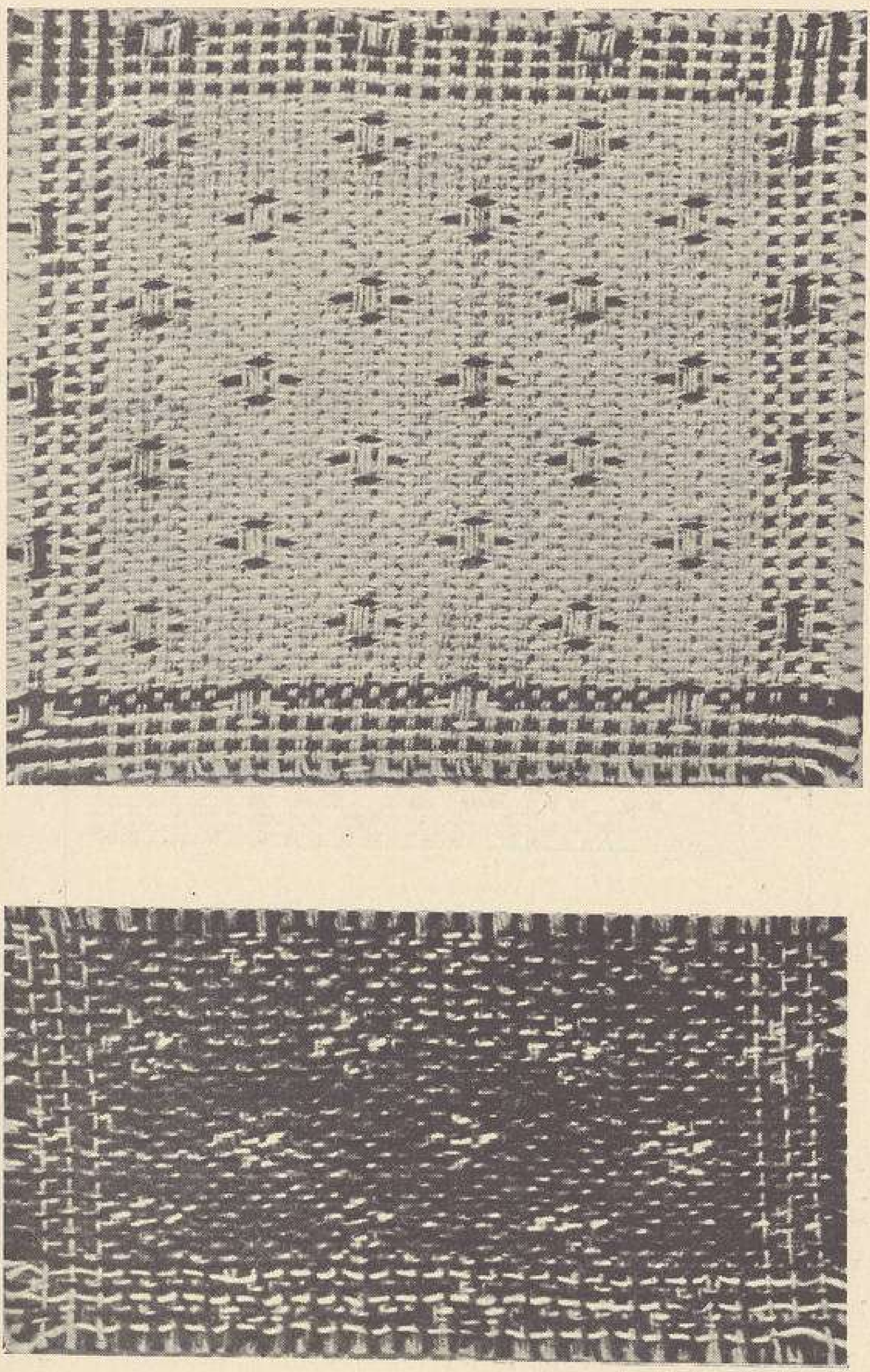


FIG. 185.

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

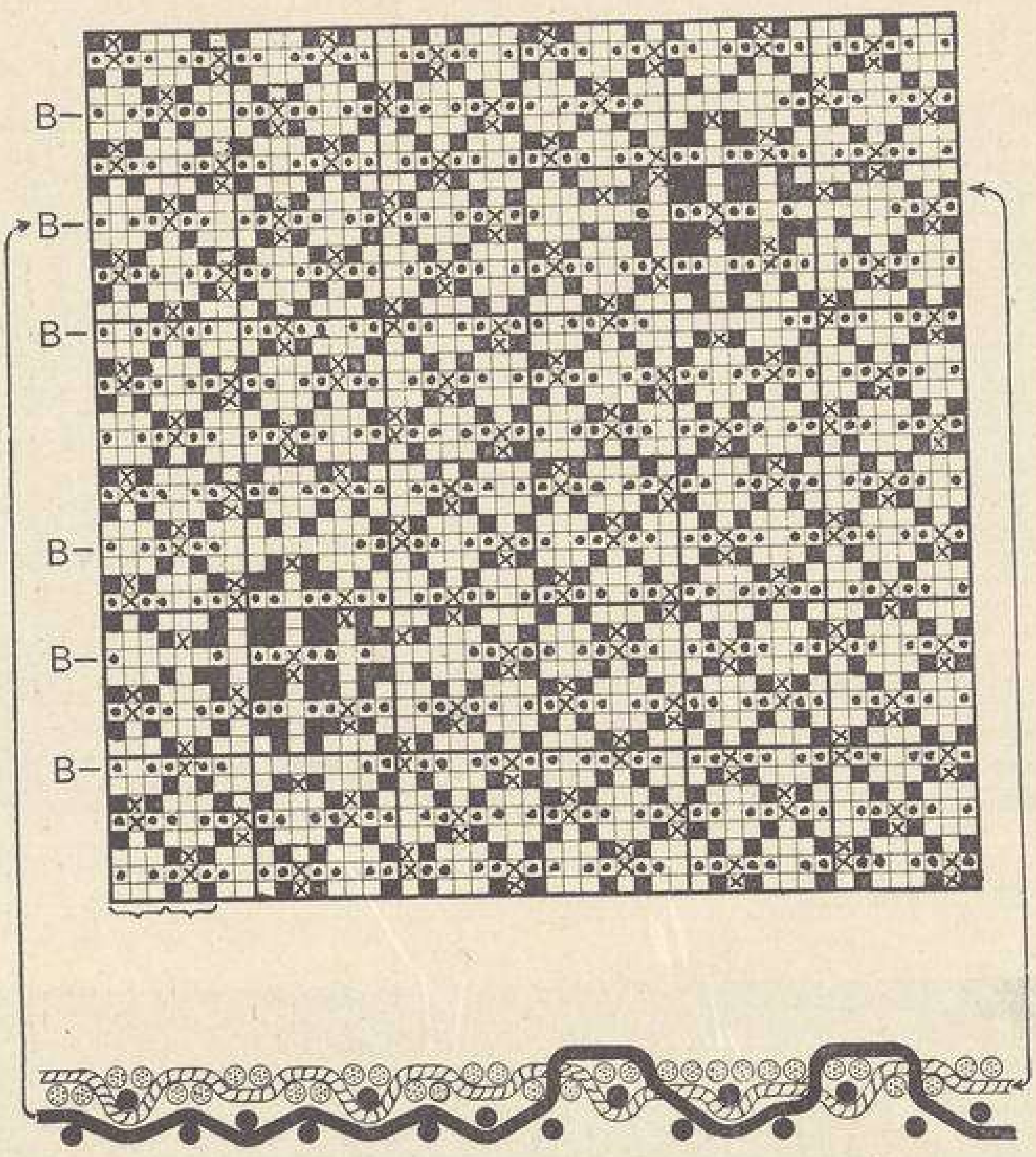


FIG. 186.

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

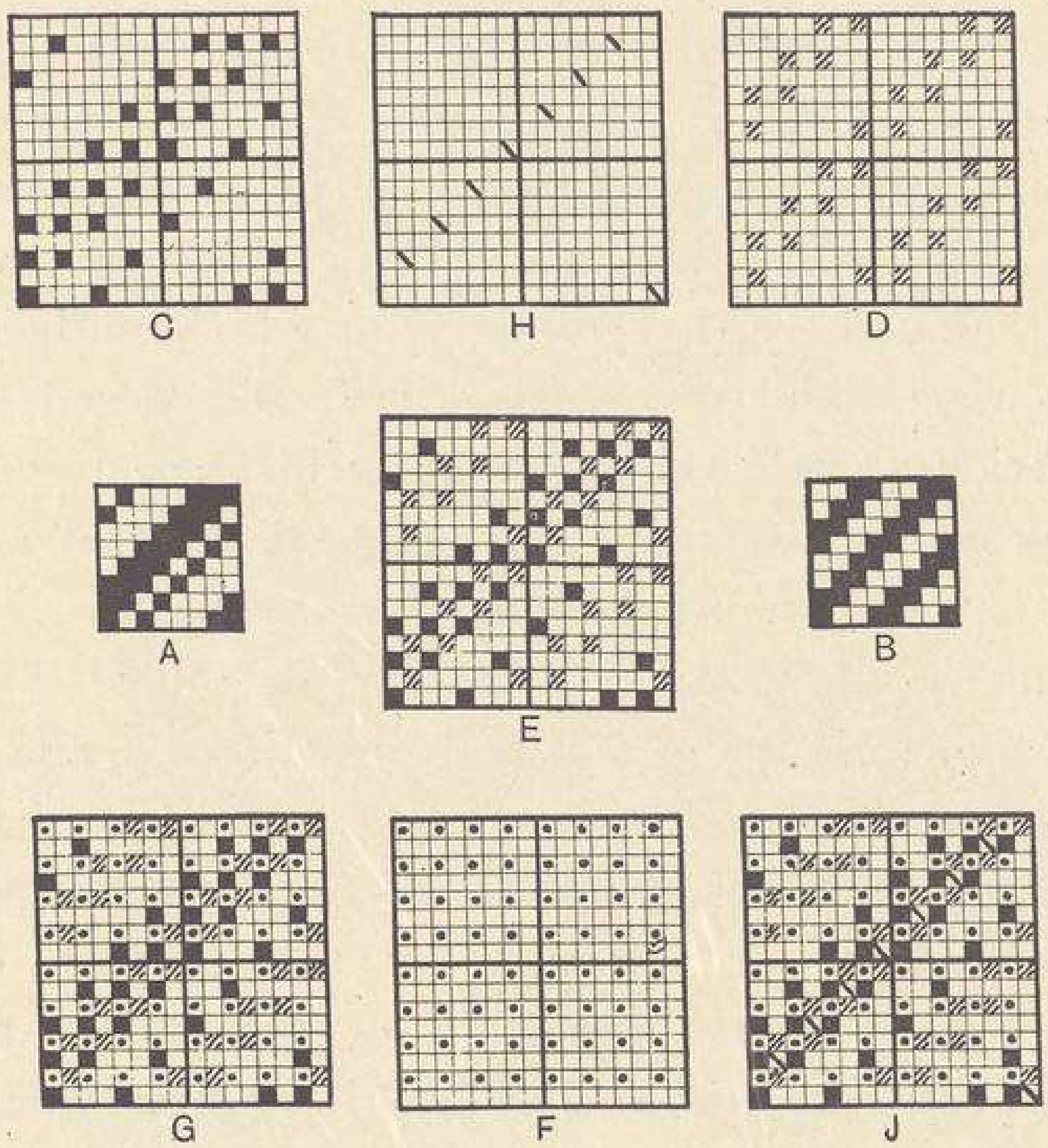


Fig. 187.

$\frac{3}{3}\frac{1}{1}$ 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

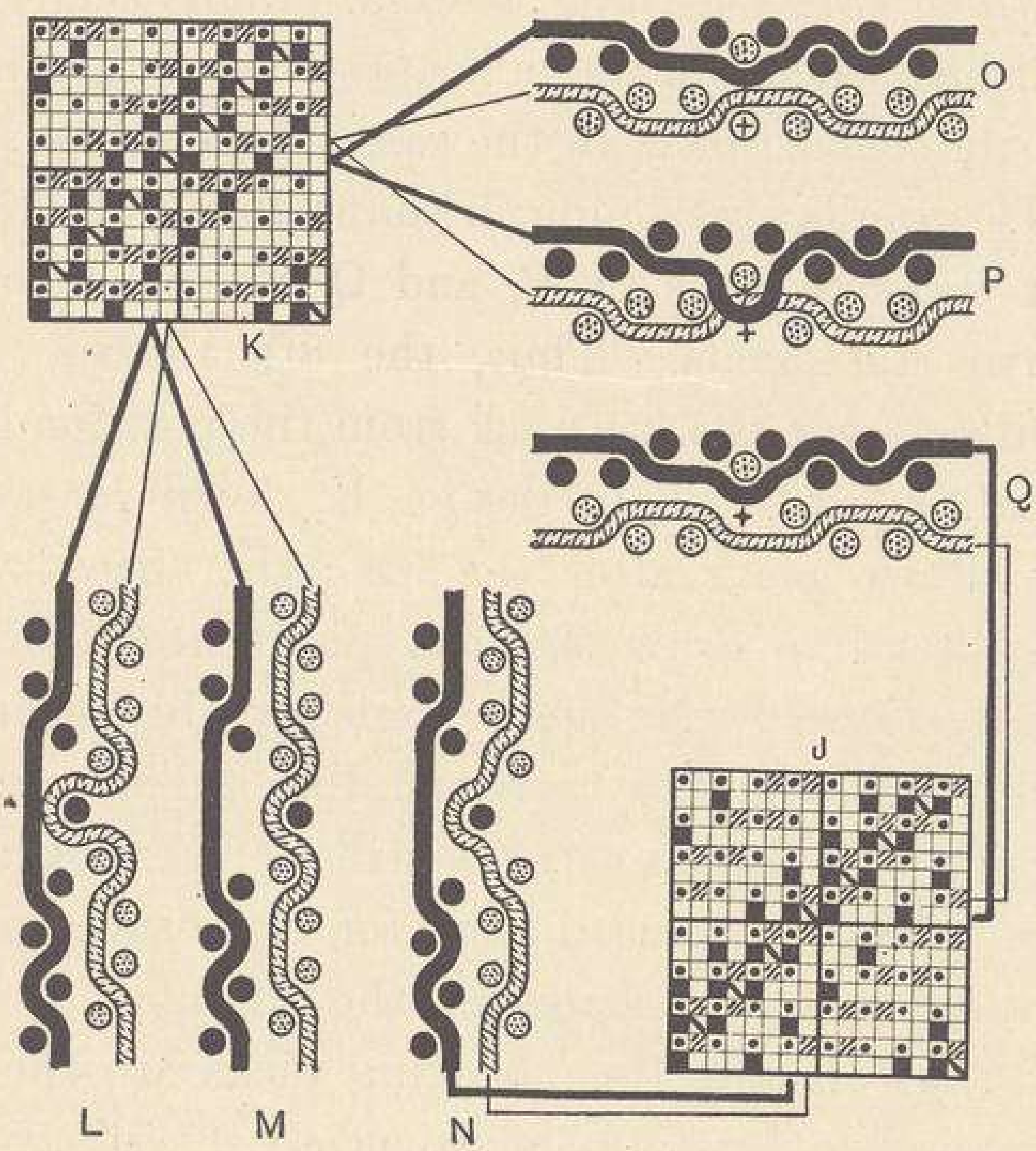


Fig. 188.

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-

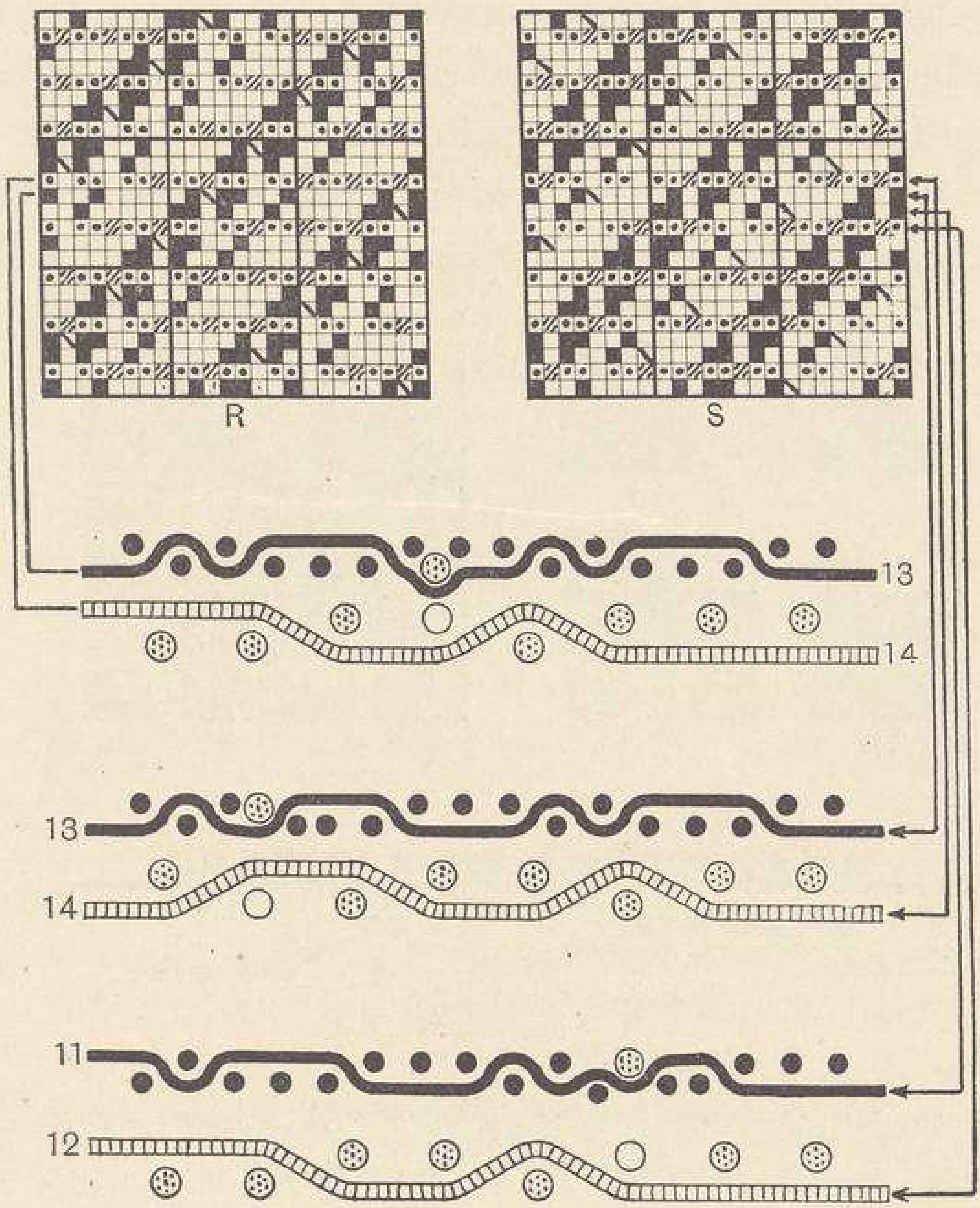


Fig. 189.

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

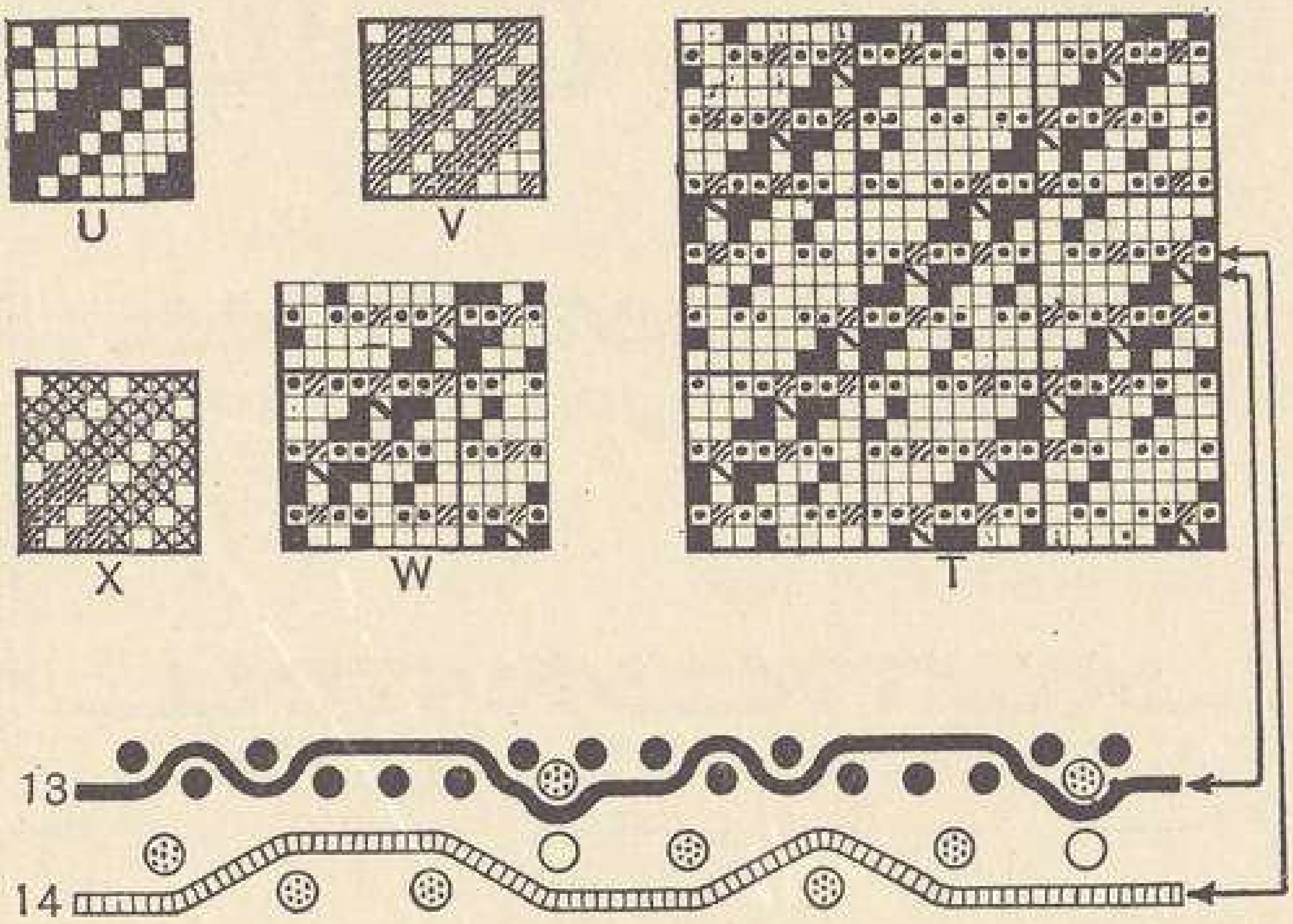


FIG. 190.

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:—

Let F = the number of threads in the face weave;
B = " " " " back weave;
m = " " successive face threads in one unit of arrangement;
n = " " successive back threads in one unit of arrangement.

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

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

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

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 that the same threads in design Y.

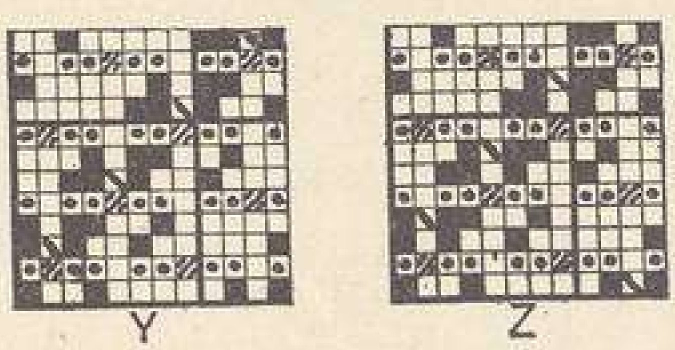


FIG. 191.

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

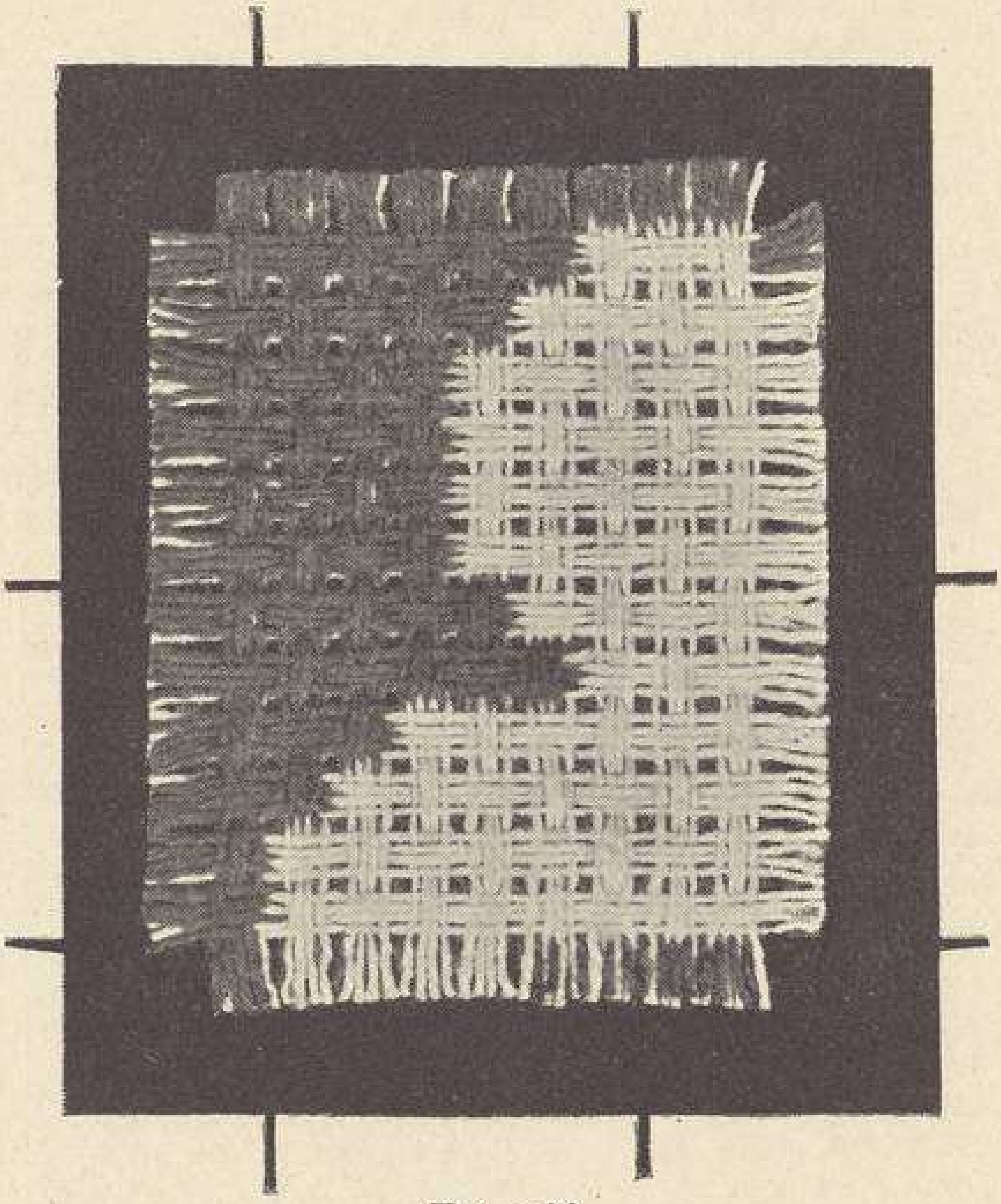


FIG. 192.

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 ///. If now all figure threads were lifted on ground picks, an untied double cloth would result, the upper

Y

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

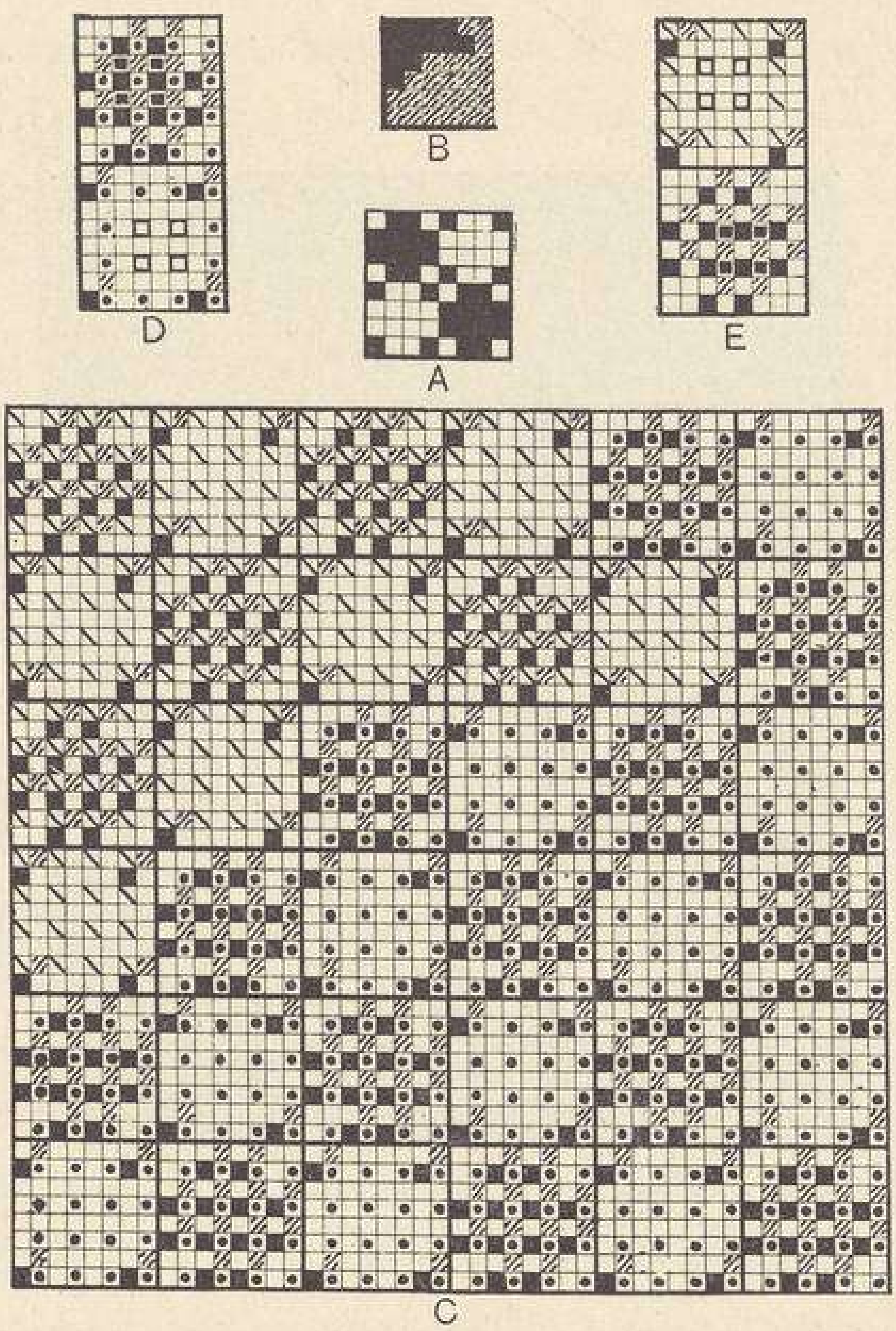


FIG. 193.

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

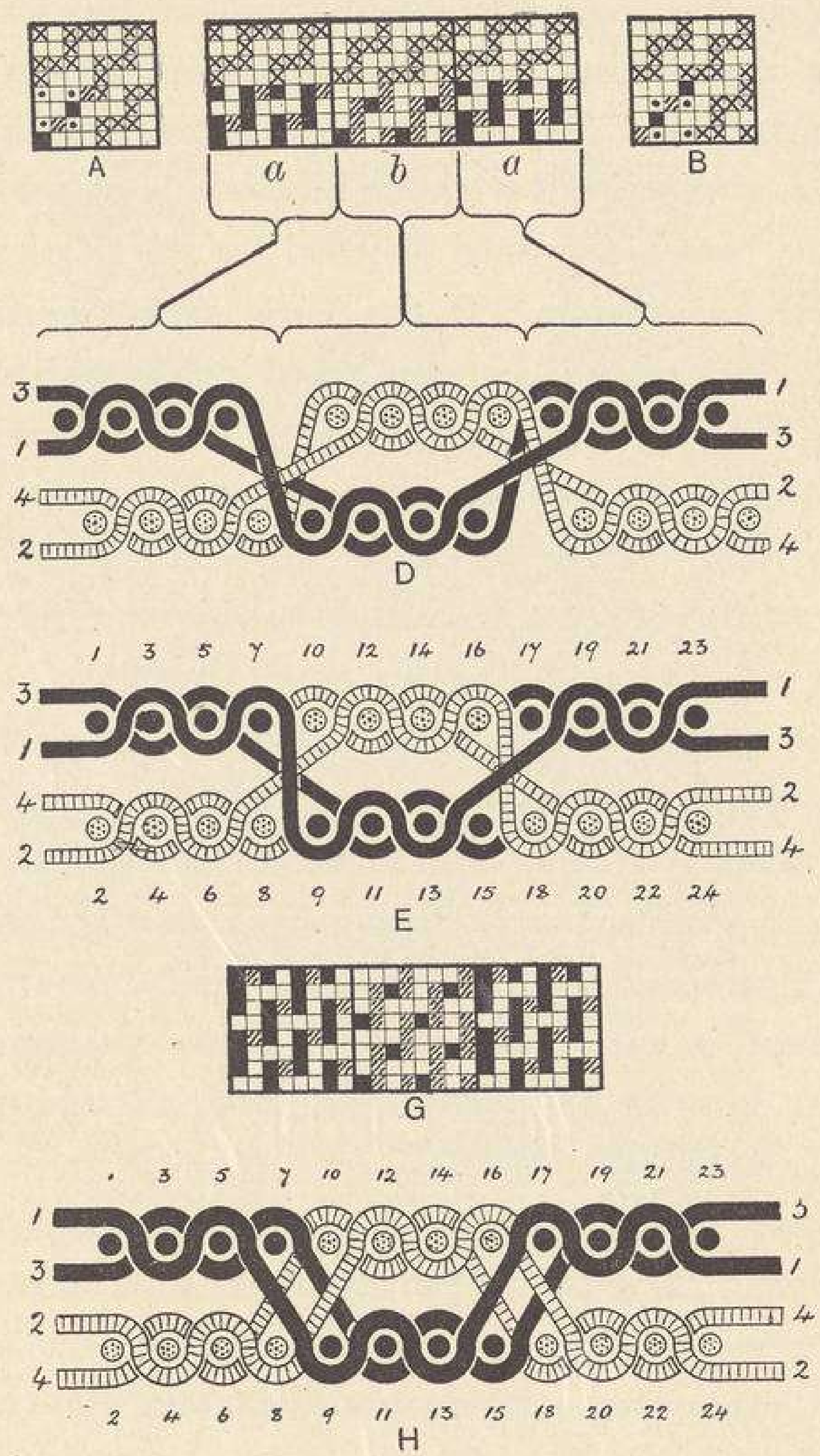


FIG. 194.

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 photographical 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. Effect on Face of Cloth.	Top Row of Patterns. Warp: 1 thread light. 1 „ dark. Weft: 1 pick dark. 1 „ light. 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.

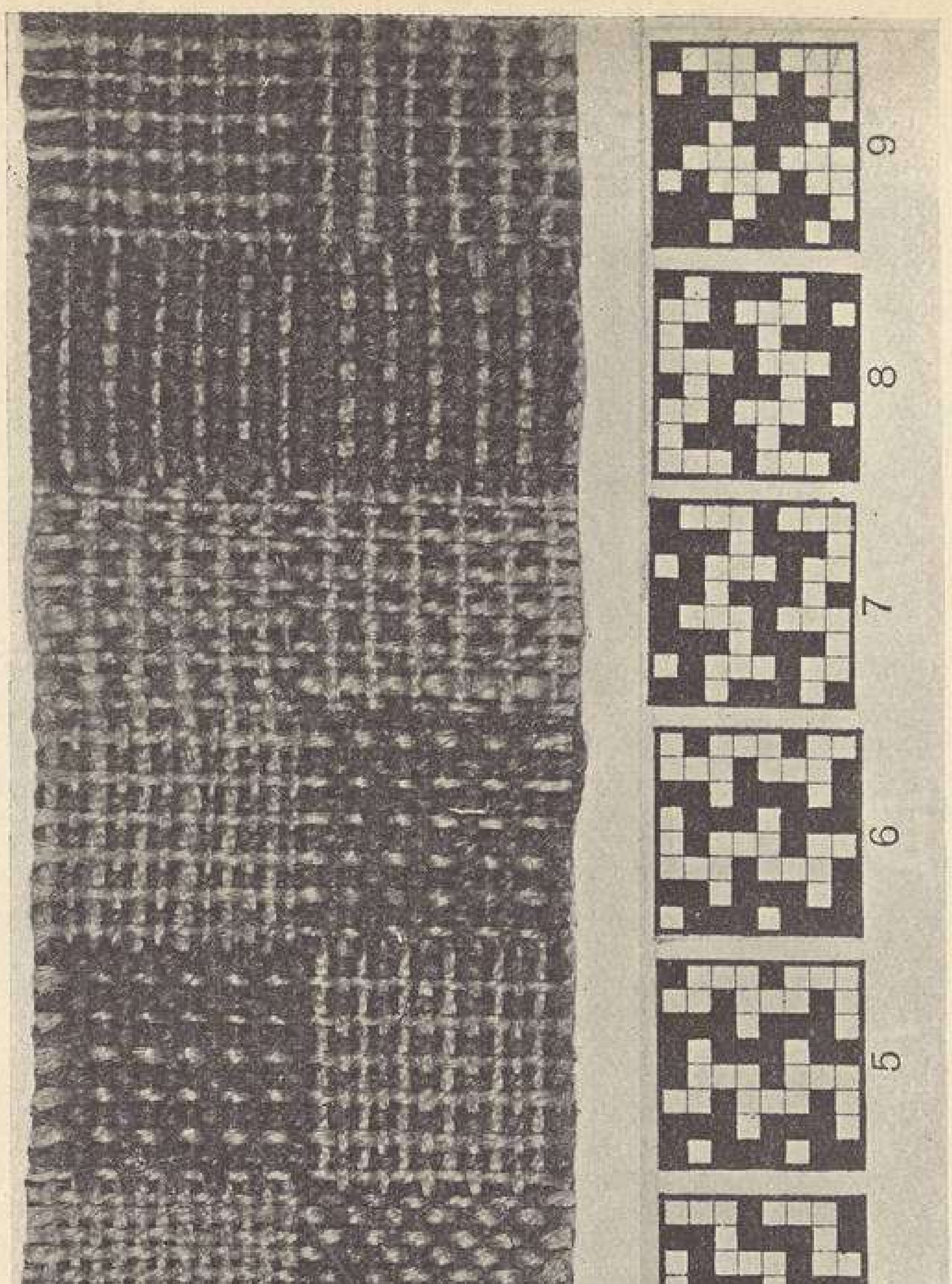


Fig. 195.

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.

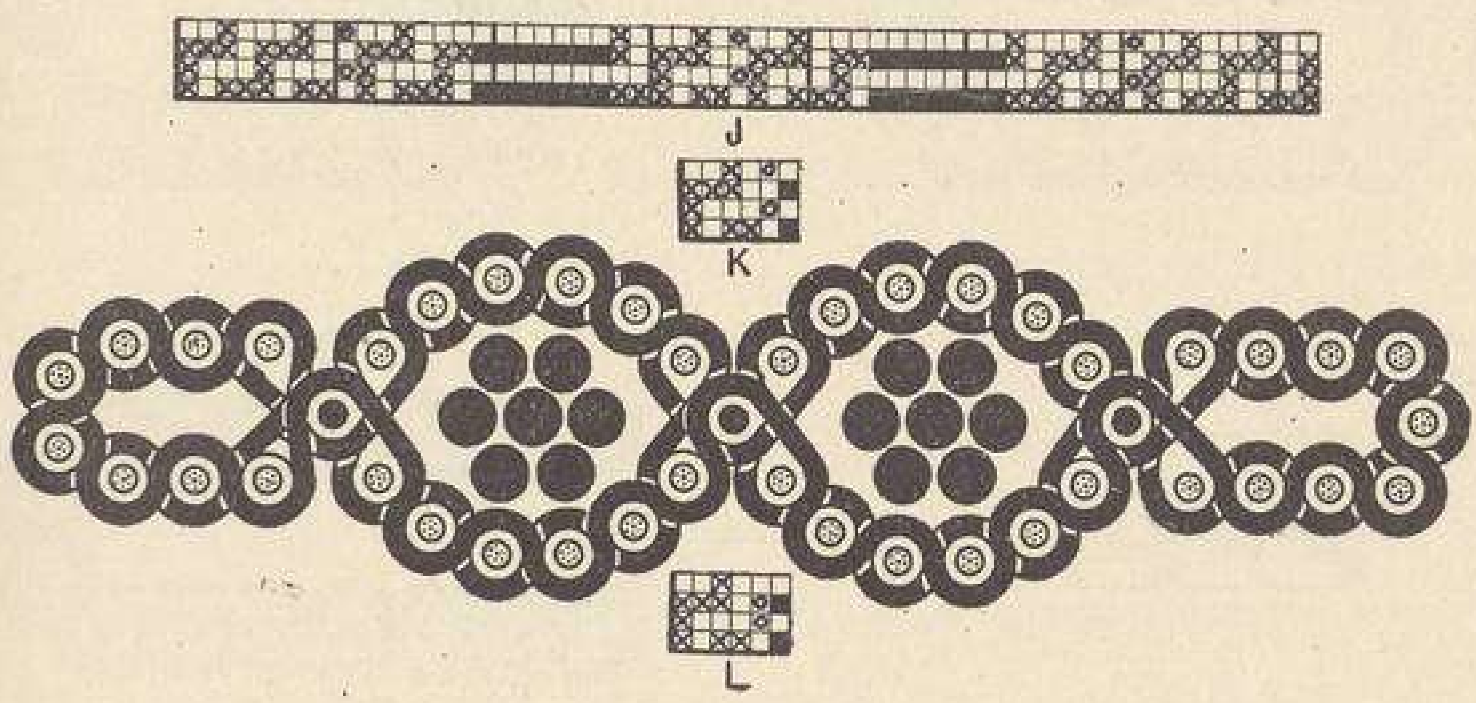


FIG. 196.

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

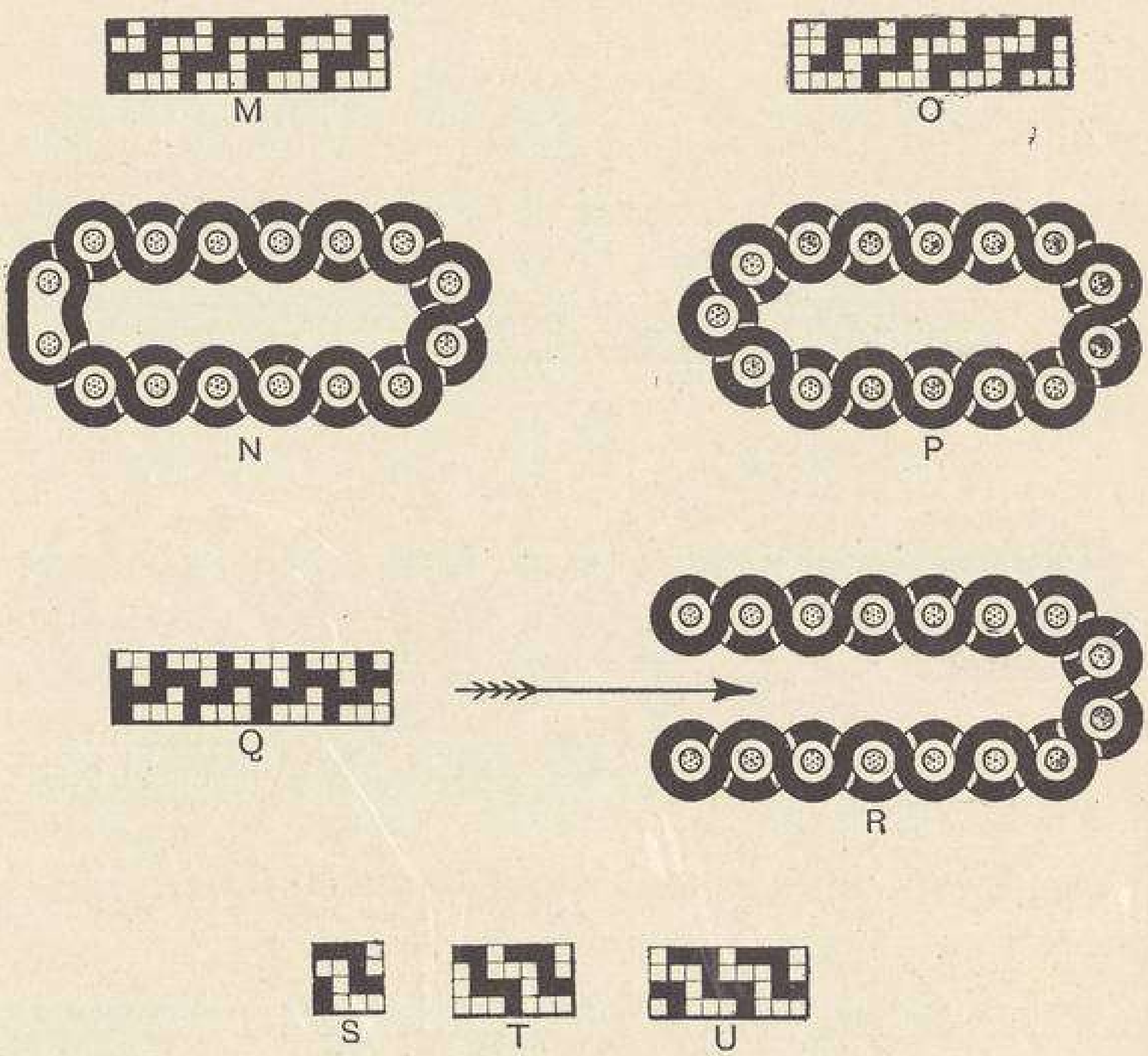


FIG. 197.

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. 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.

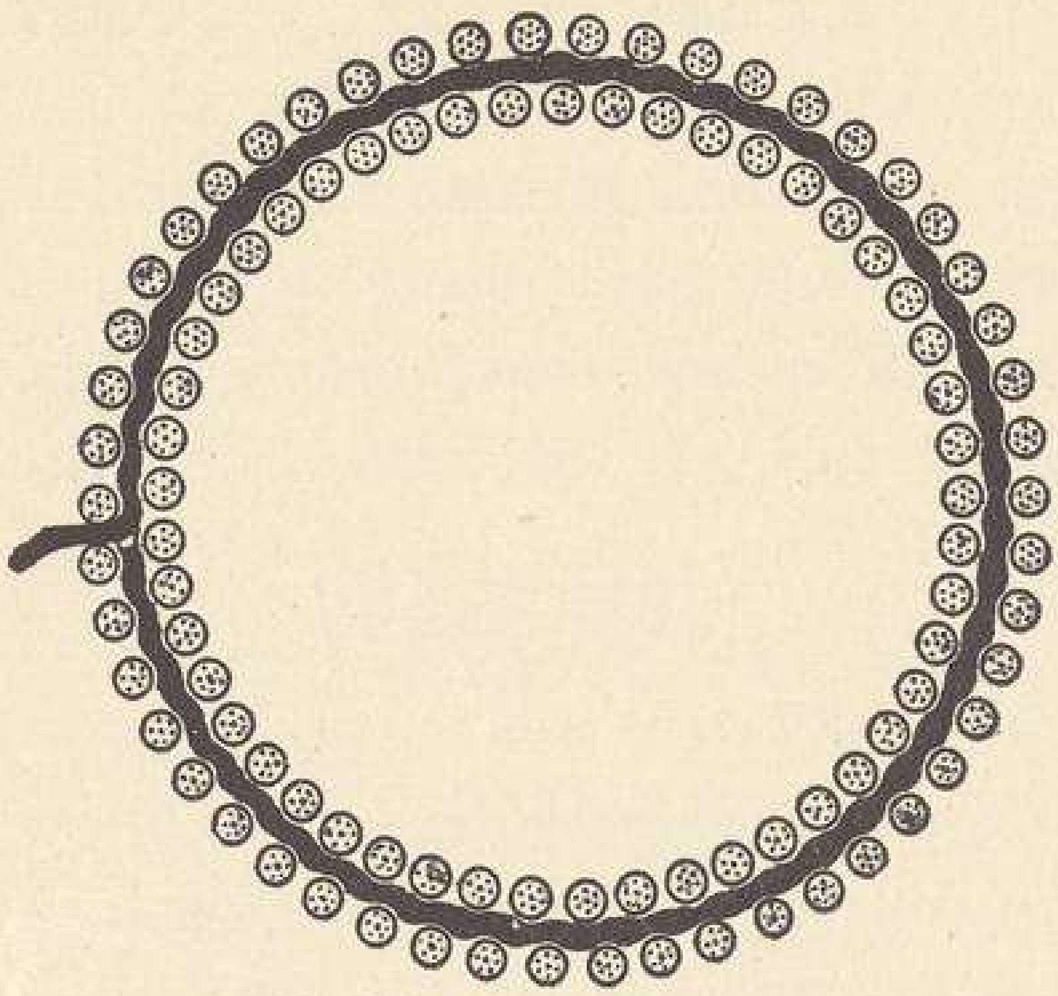


Fig. 198.

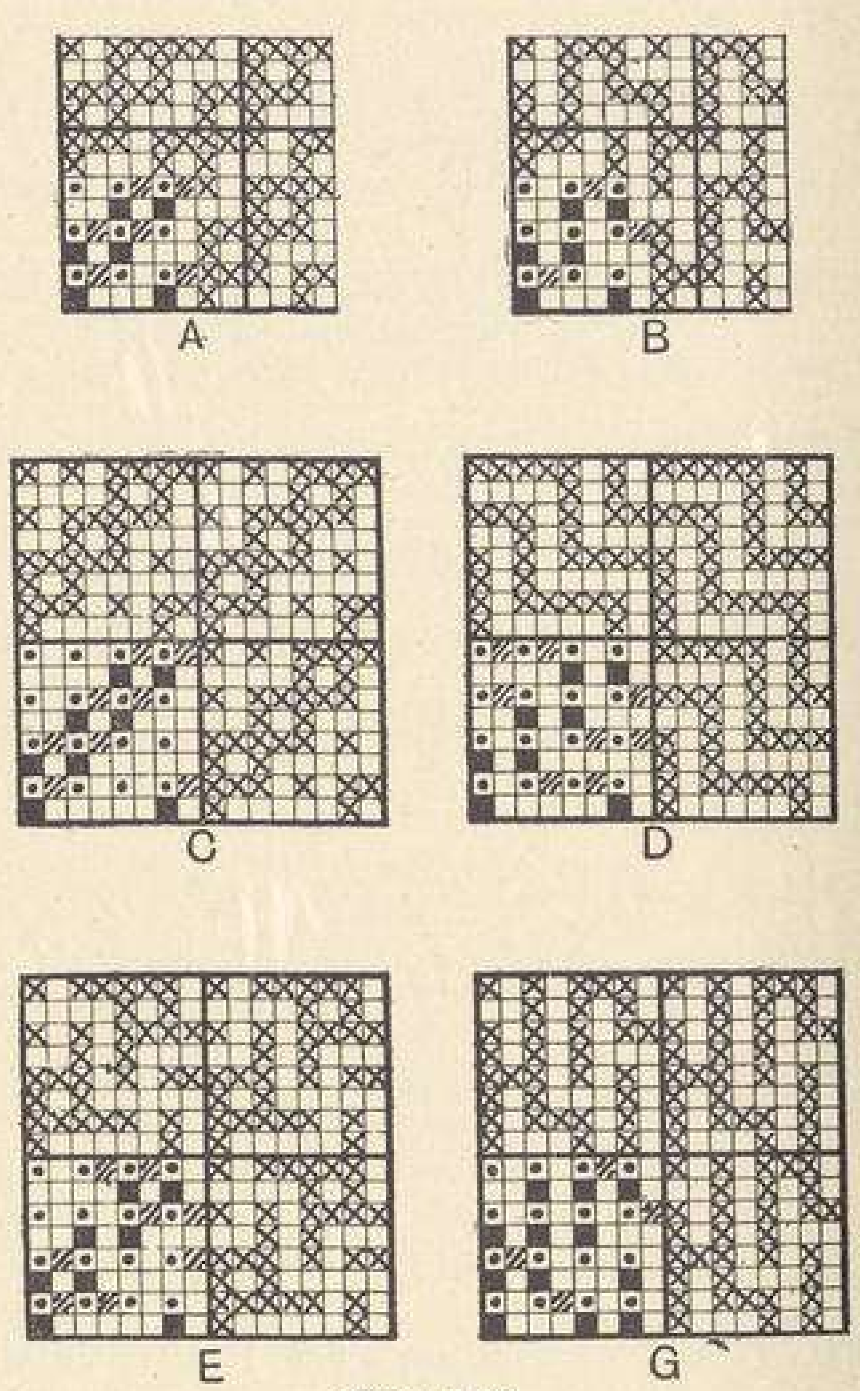


Fig. 199.

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 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 :	$\frac{3}{1}$	,,	,, ;	$\frac{1}{3}$	,,	,,	,,

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 $\frac{1}{2}$ 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 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

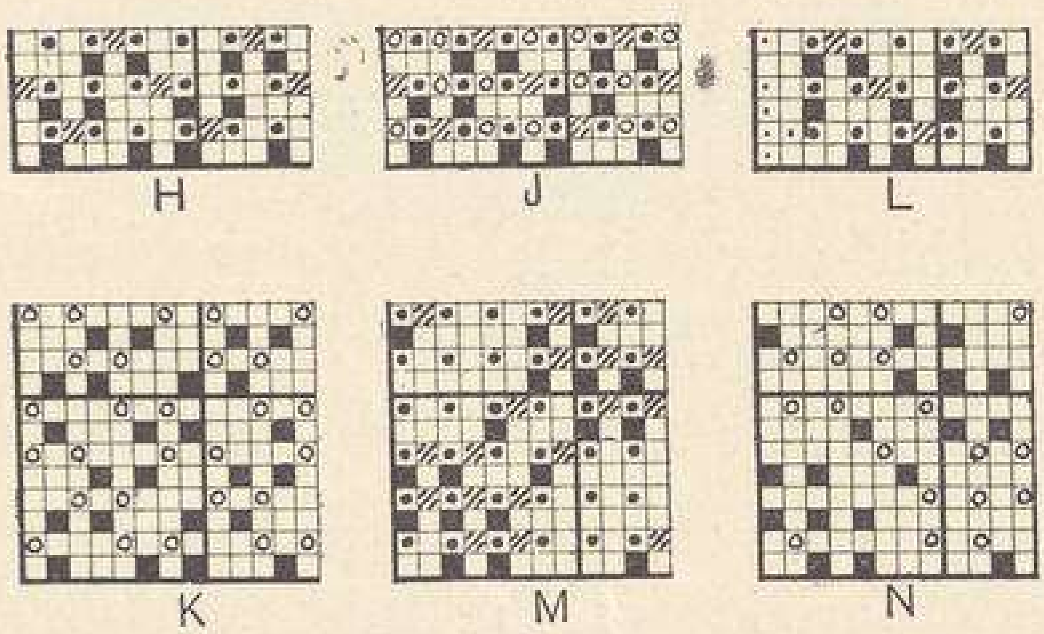


Fig. 200.

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 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.

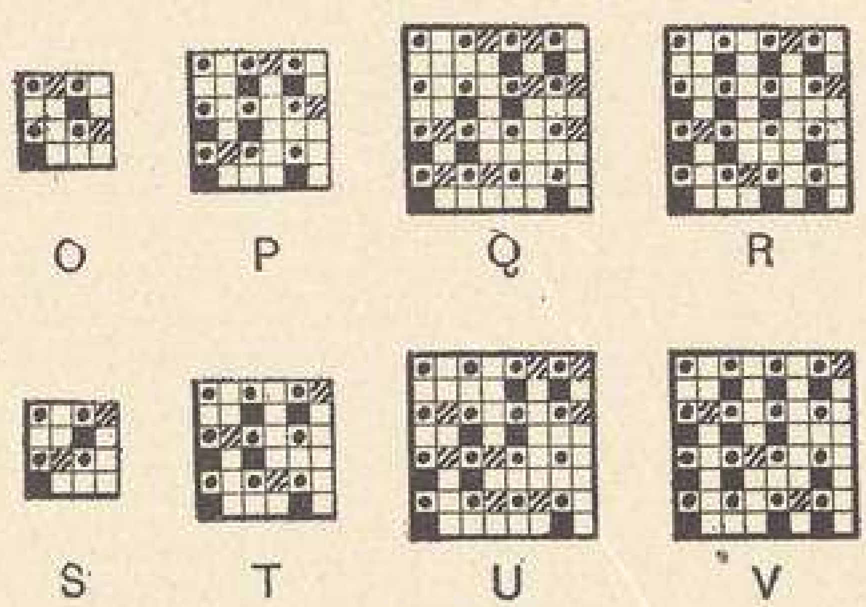


Fig. 201.

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

Warp.	*Weft.*
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.

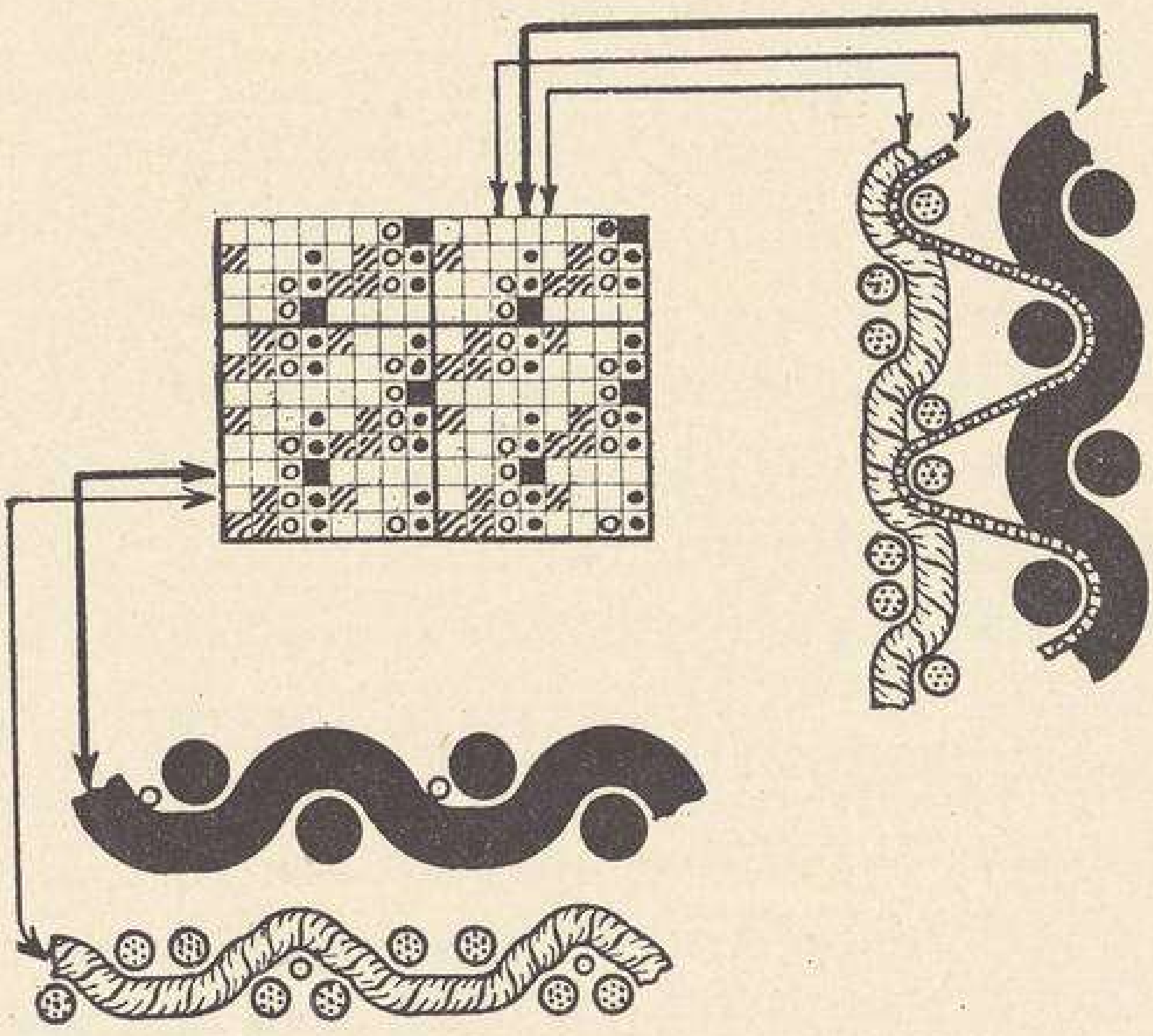


FIG. 202.

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).

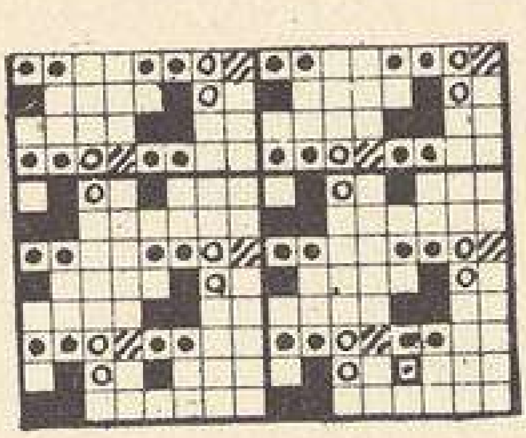


FIG. 203.

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,

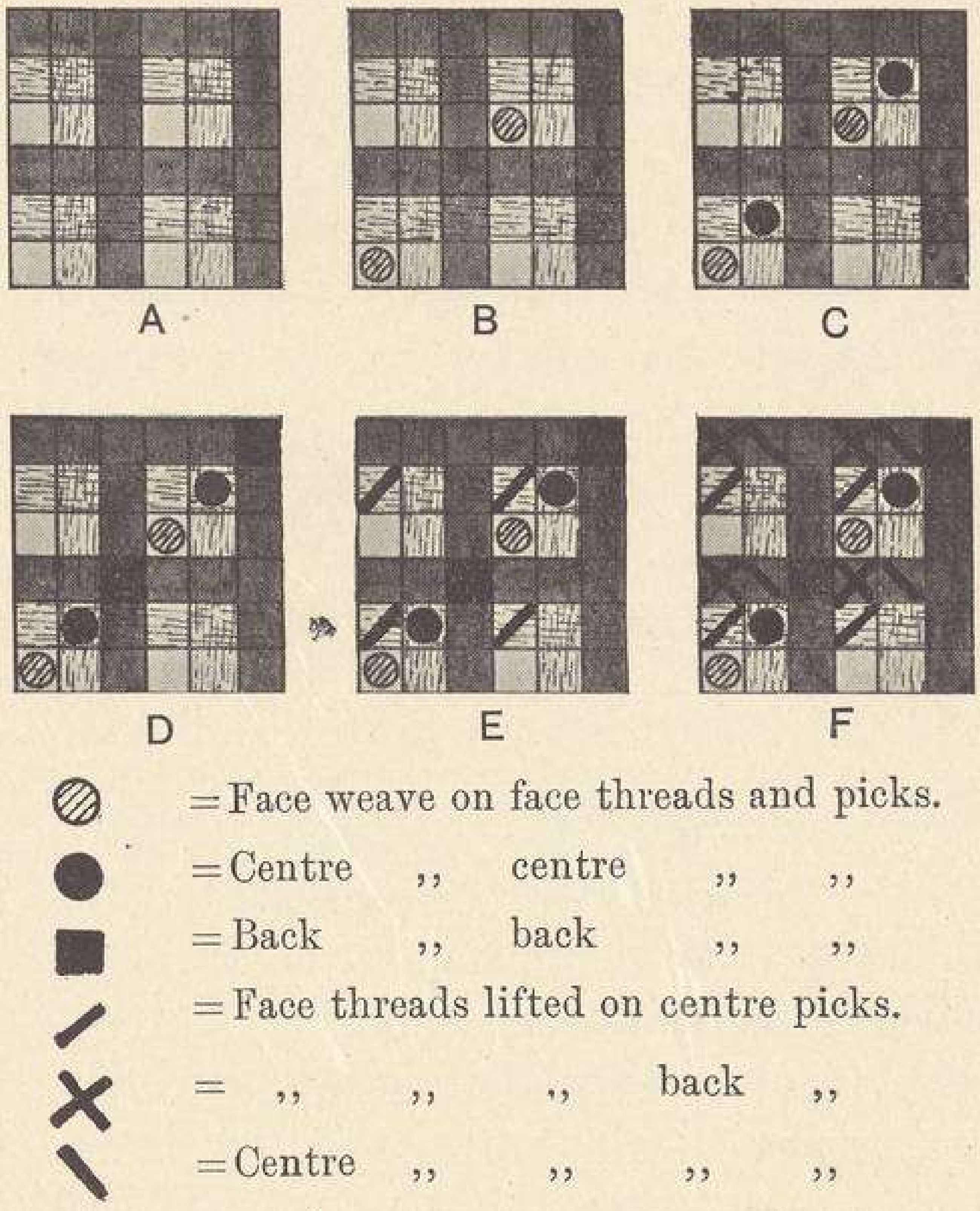


FIG. 204.

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,

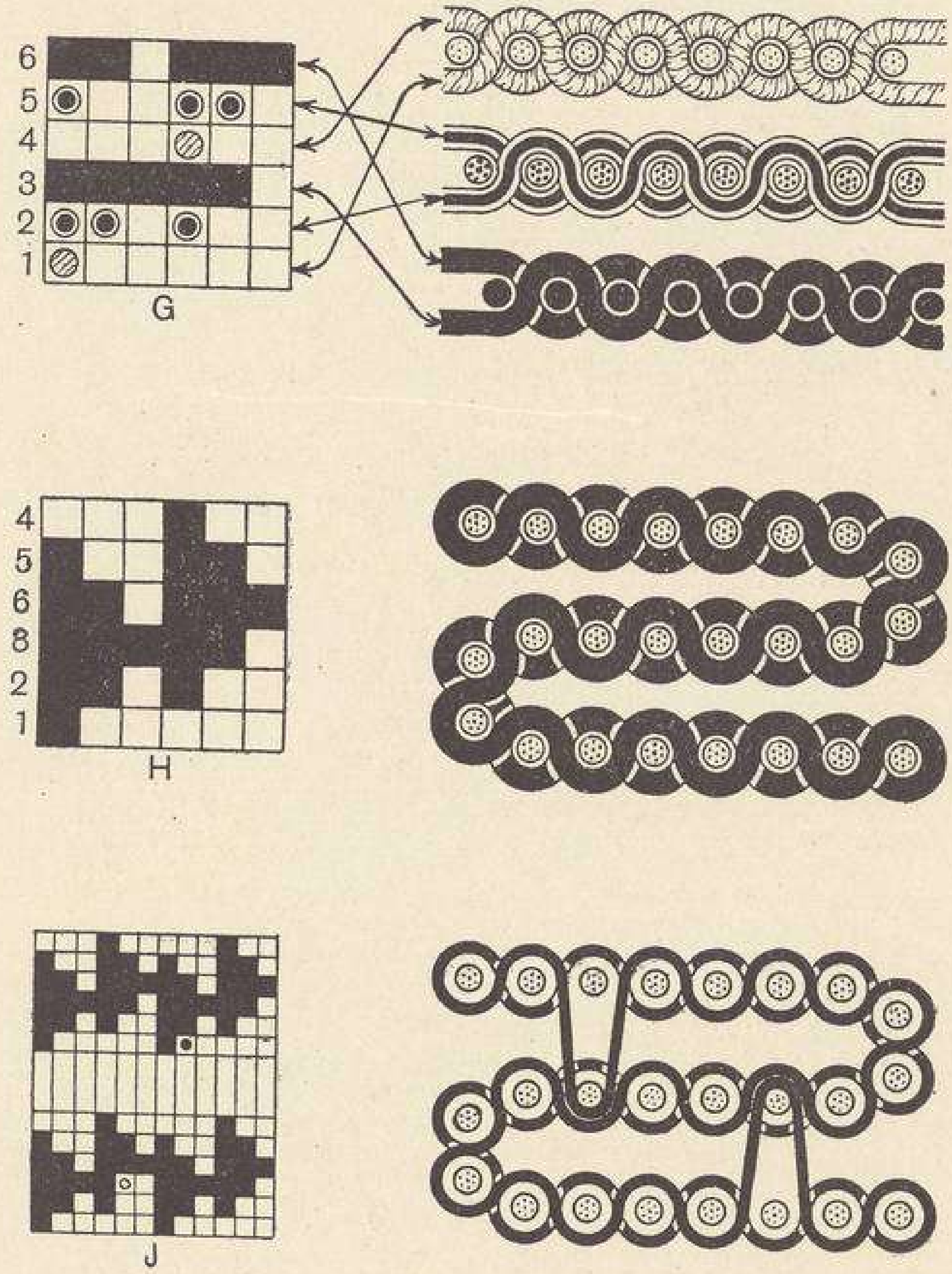


FIG. 205.

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 photographical 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

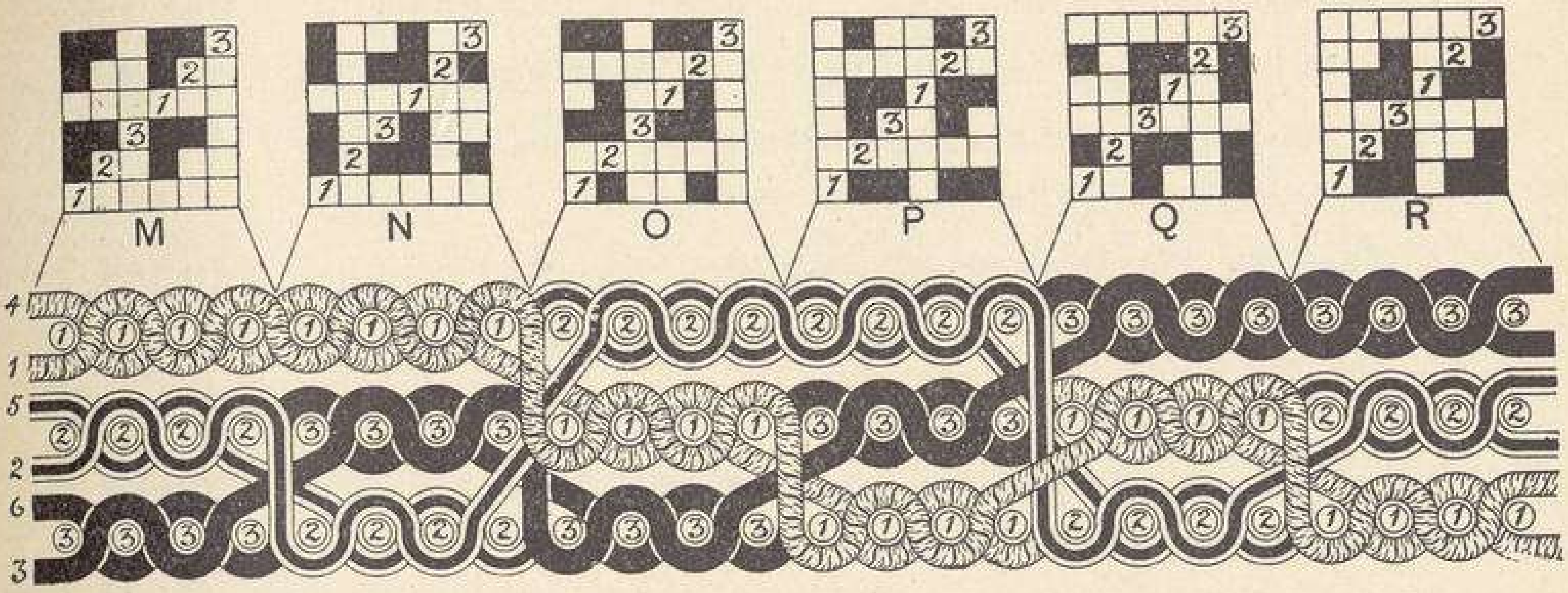


FIG. 208.

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

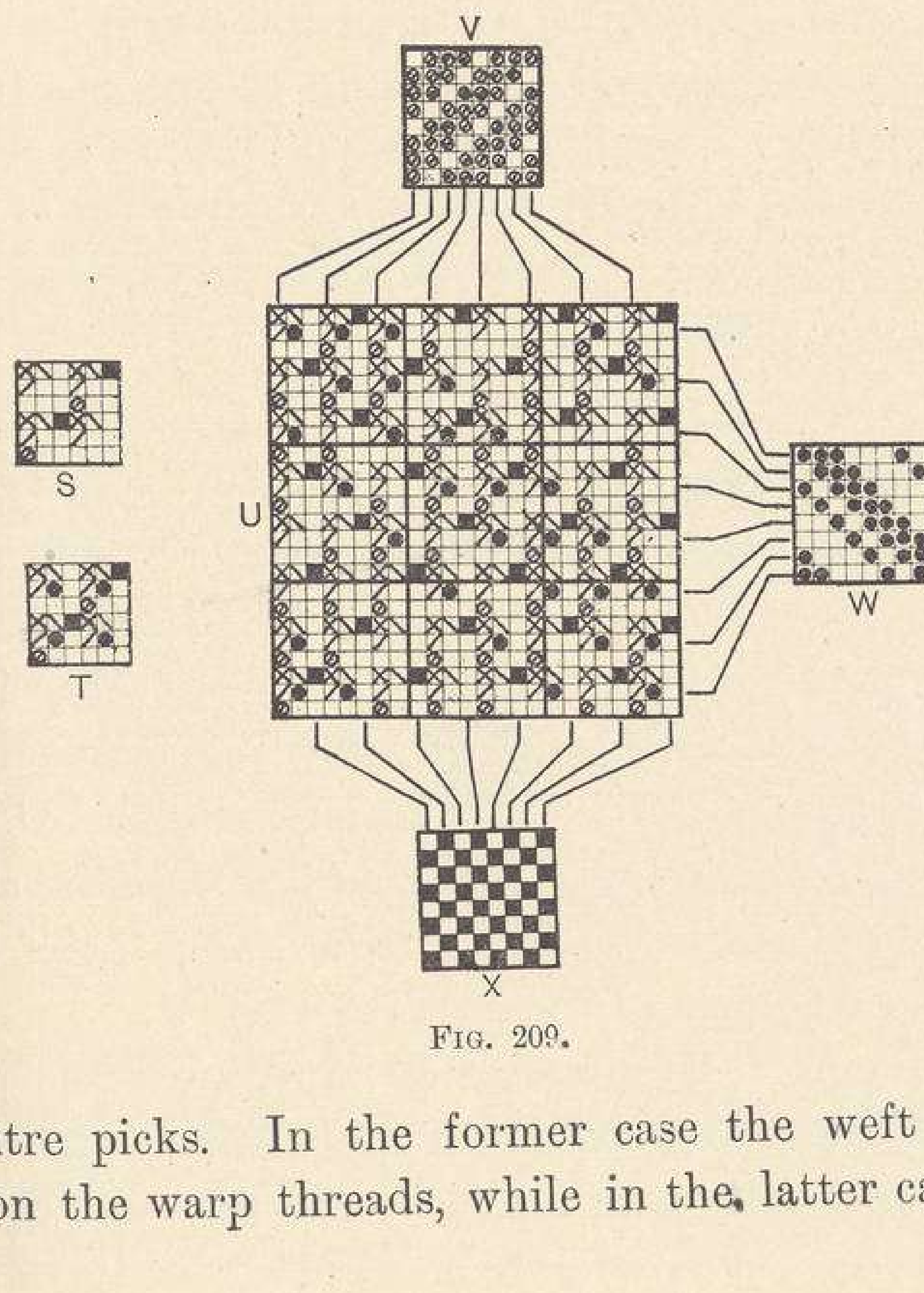


FIG. 209.

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 we had chosen weaves on, say, 3, 4, and 5 threads, the design would require to be extended to 180 threads and picks. Thus:—

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

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

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

In design U, Fig. 209, the $^{3}{}_{1}$ twill to right is on the face; the $^{3}{}_{3}{}^{1}{}_{1}$ twill to the left is in the centre; and the $^{1}{}_{1}$ 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

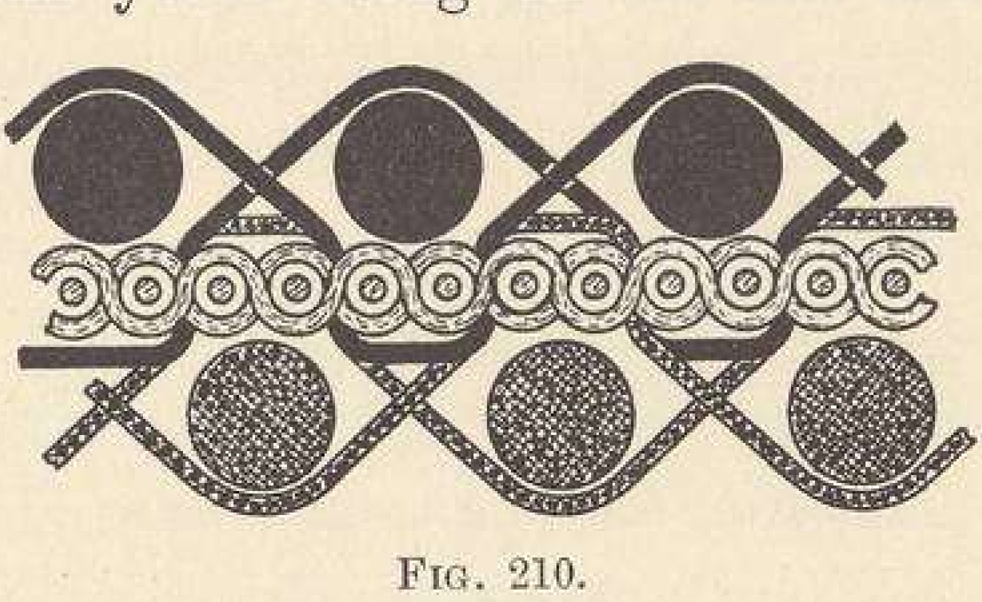


FIG. 210.

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

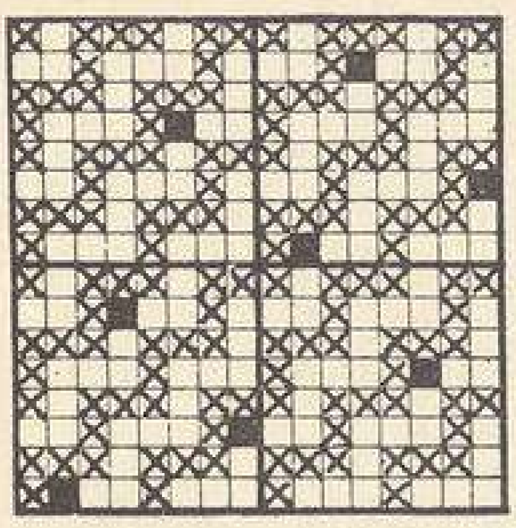


Fig. 211.

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

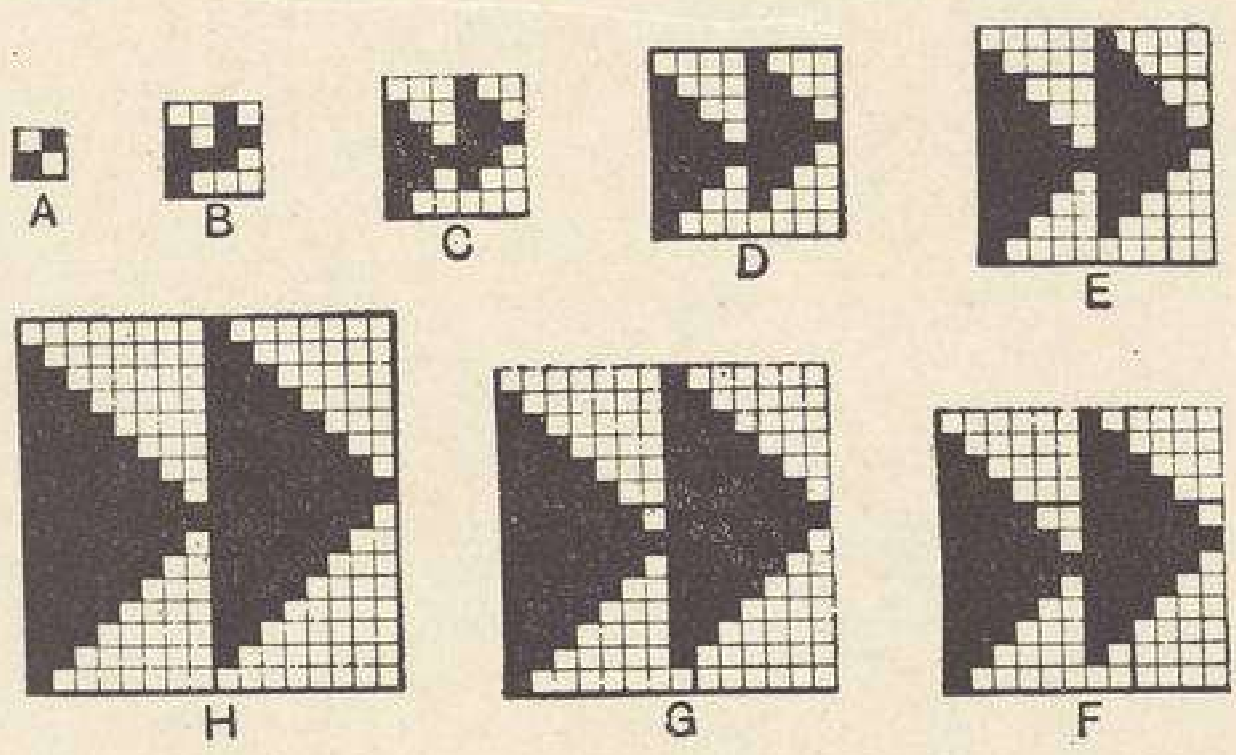


FIG. 212.

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.

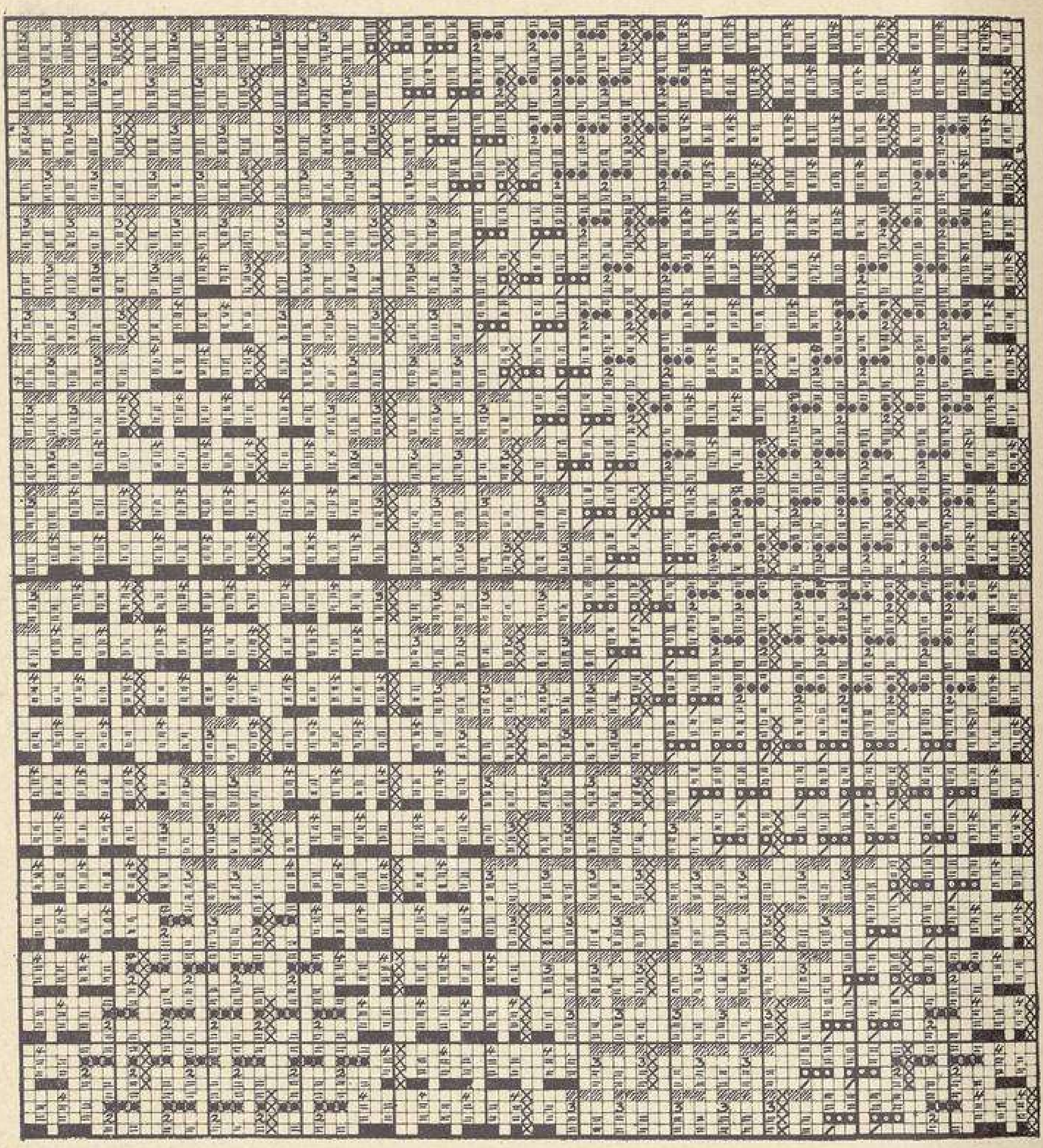
may be considered a four-ply structure. It differs from the majority of those which have been illustrated, in that the whole of the ornament is developed by the weft yarns, which, when either at the face or back of the cloth, interweave in perfect plain order with the small black cotton face and back warps respectively. Fig. 213 is a photographical 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 predetermined 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 × 24 in. = 816 needles —say two machines having a capacity of 408 needles each.



■	Blue weft on surface.	◪	Blue weft on back.
◘	Red ,, ,,	2	Red ,, ,,
▣	Green ,, ,,	3	Green ,, ,,
▨	White ,, ,,	4	White ,, ,,
◙	Yellow ,, ,,	3	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

Marks Fall.

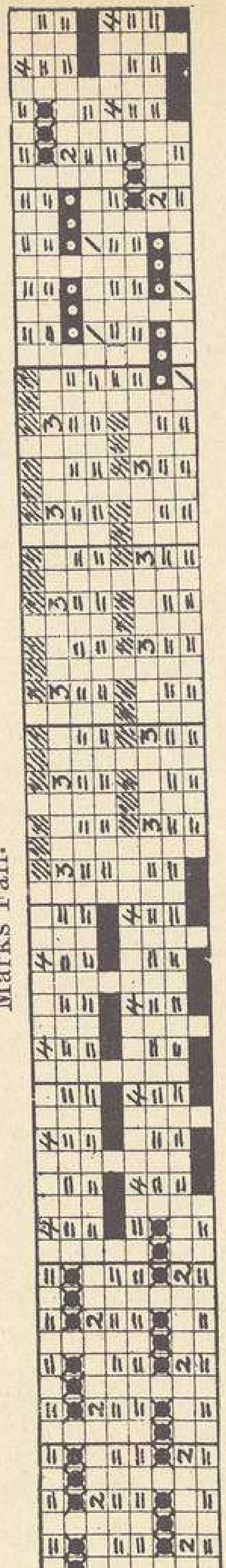


Fig. 215.

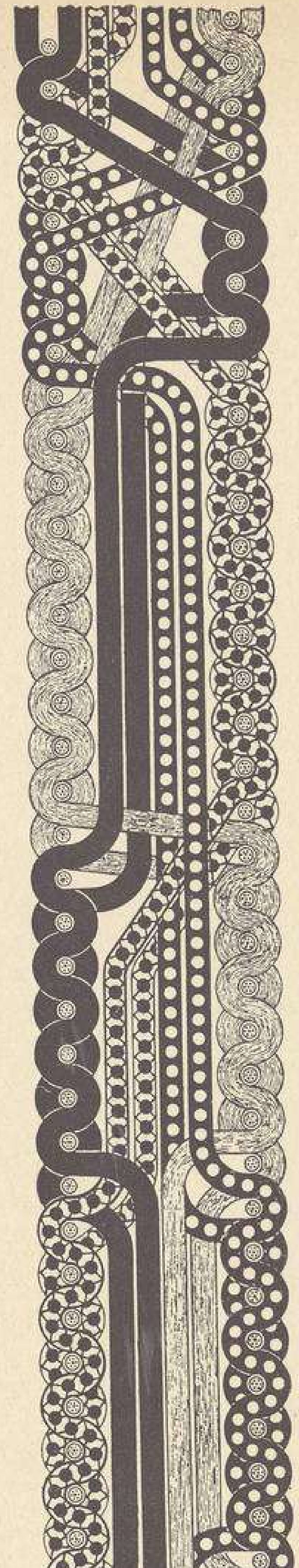


Fig. 216.

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

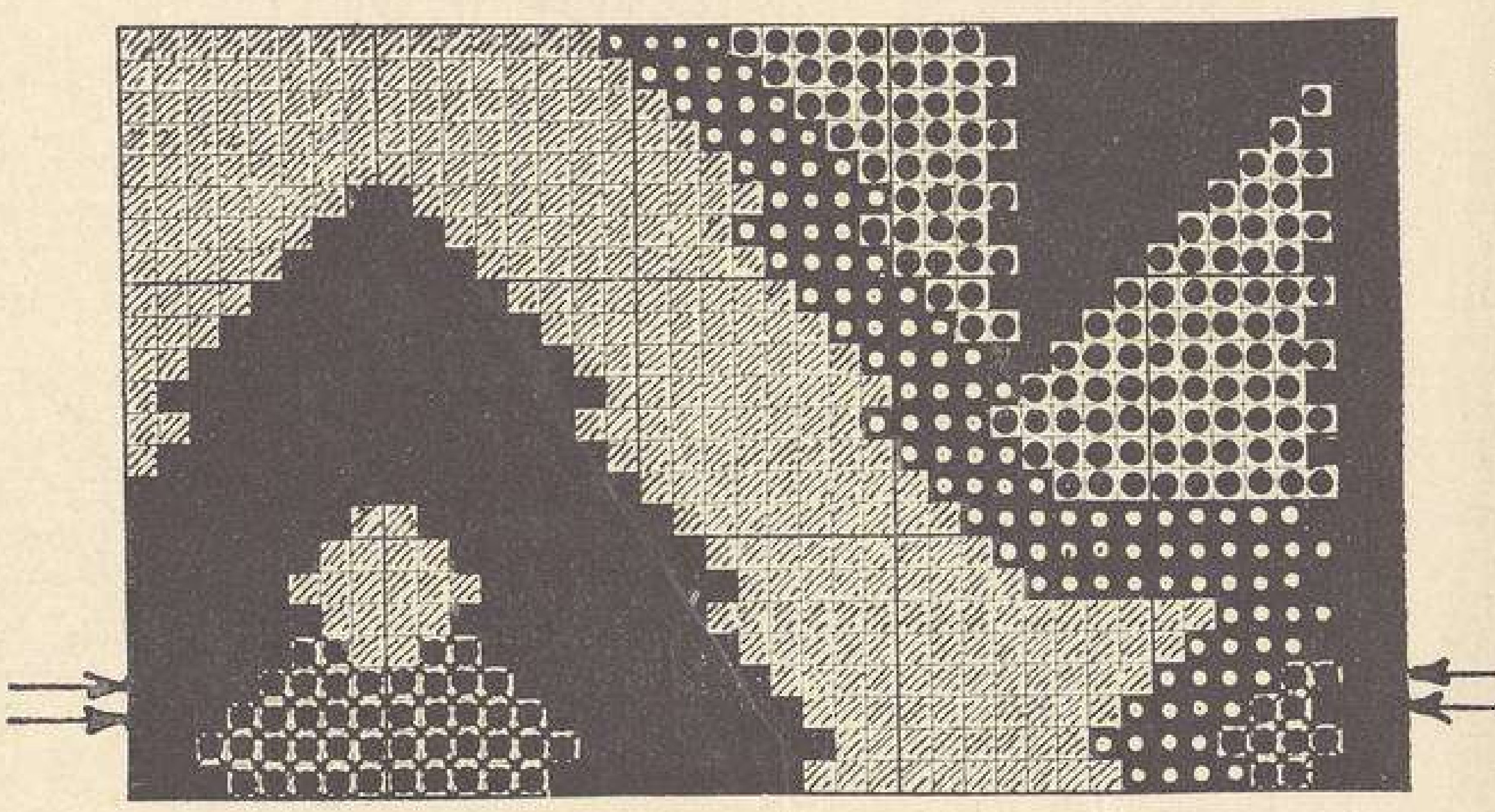


FIG. 217.

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

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

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

1st jacquard or 1st section	Cut plain weave $\frac{1}{1}$ on face needles in parts marked with white dots. Cut all others on face needles.
2nd jacquard or 2nd section	Cut plain weave $\frac{1}{1}$ on back needles in parts 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 or 1st section	Cut plain weave $\frac{1}{1}$ on face needles in parts marked with cross and dot in centre. Cut all others on face needles.
2nd jacquard or 2nd section	Cut plain weave $\frac{1}{1}$ on back needles in parts marked in shaded squares.

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

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

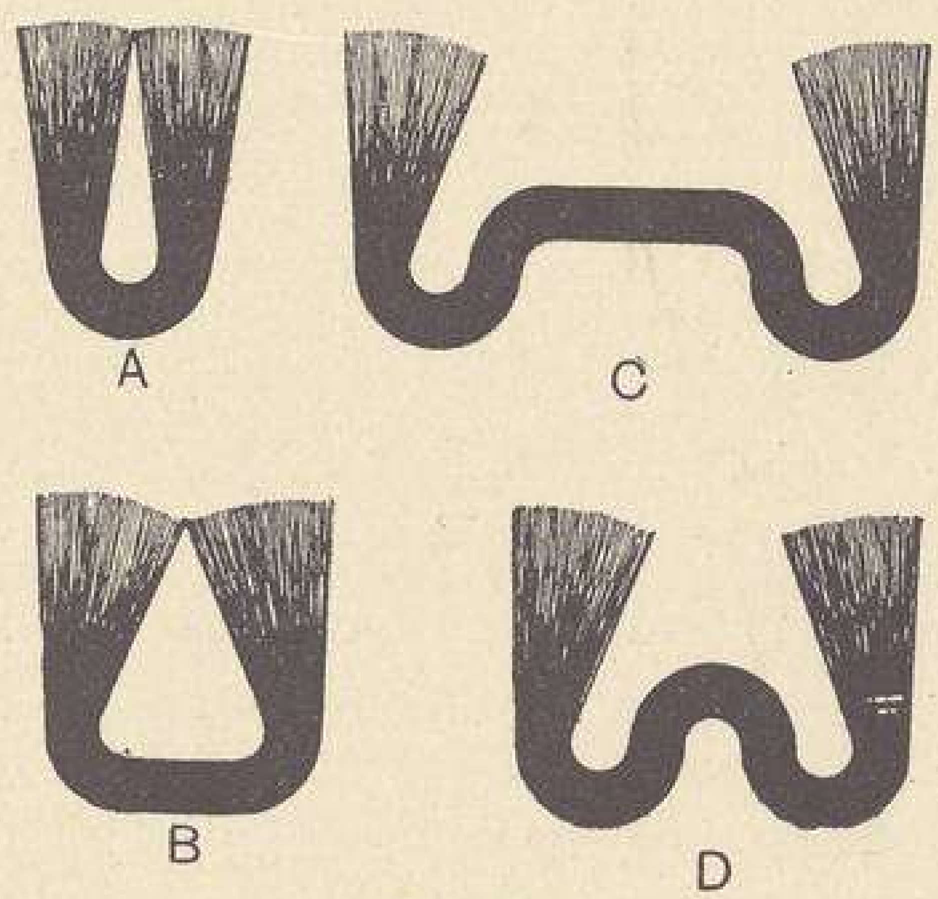


FIG. 218.

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 individual 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, ×, 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.

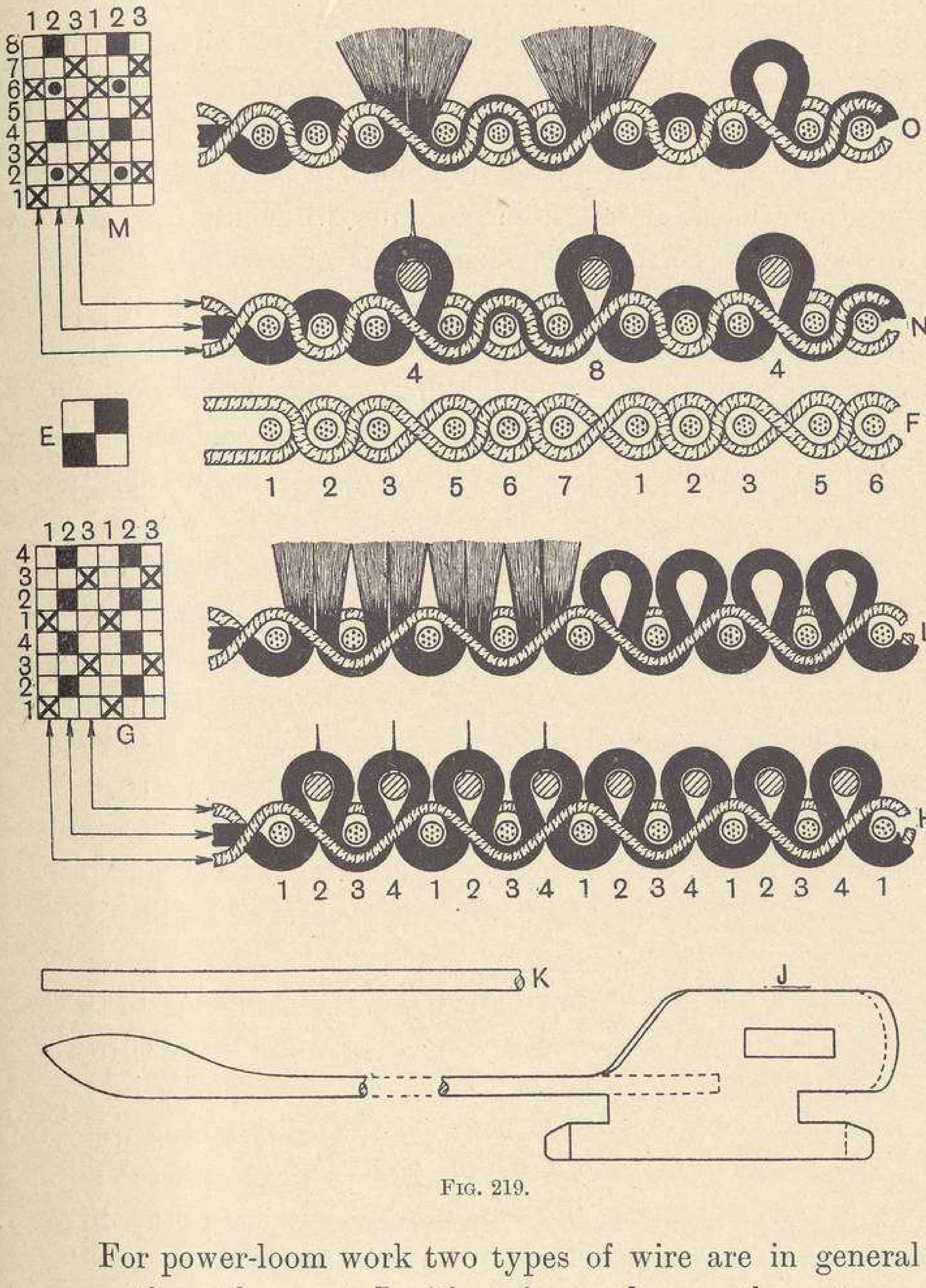


FIG. 219.

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

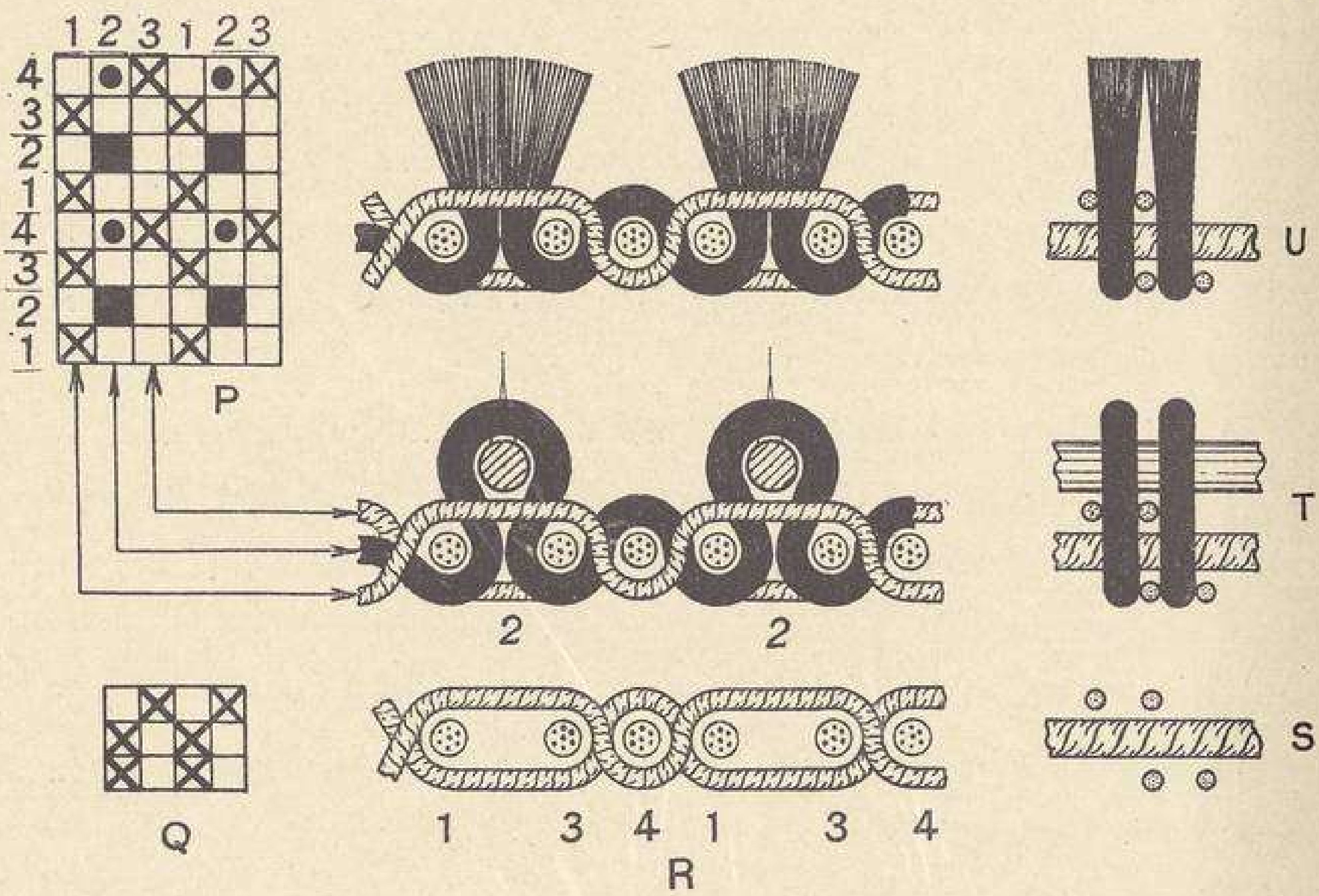


FIG. 220.

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

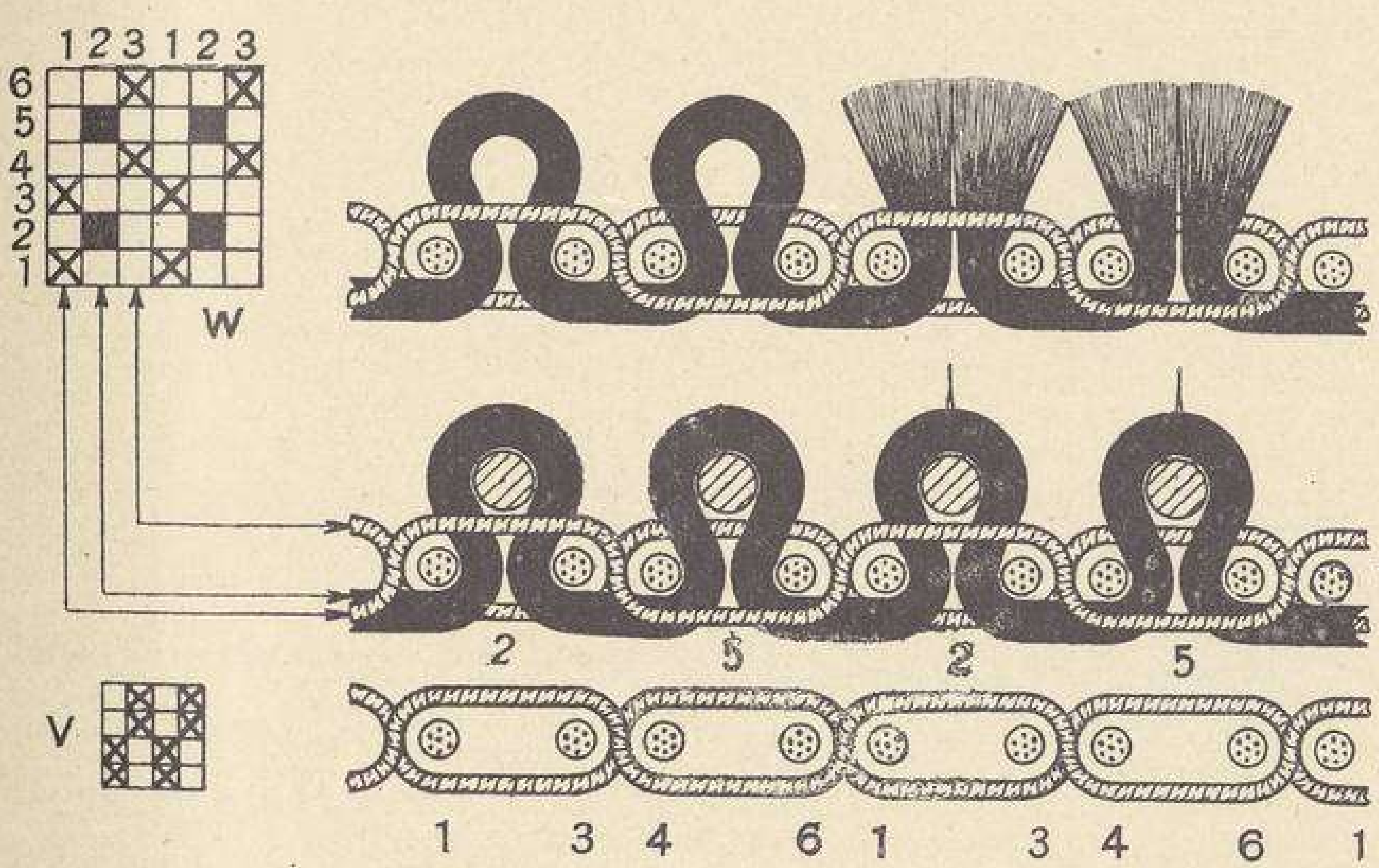


FIG. 221.

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 wypers, 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

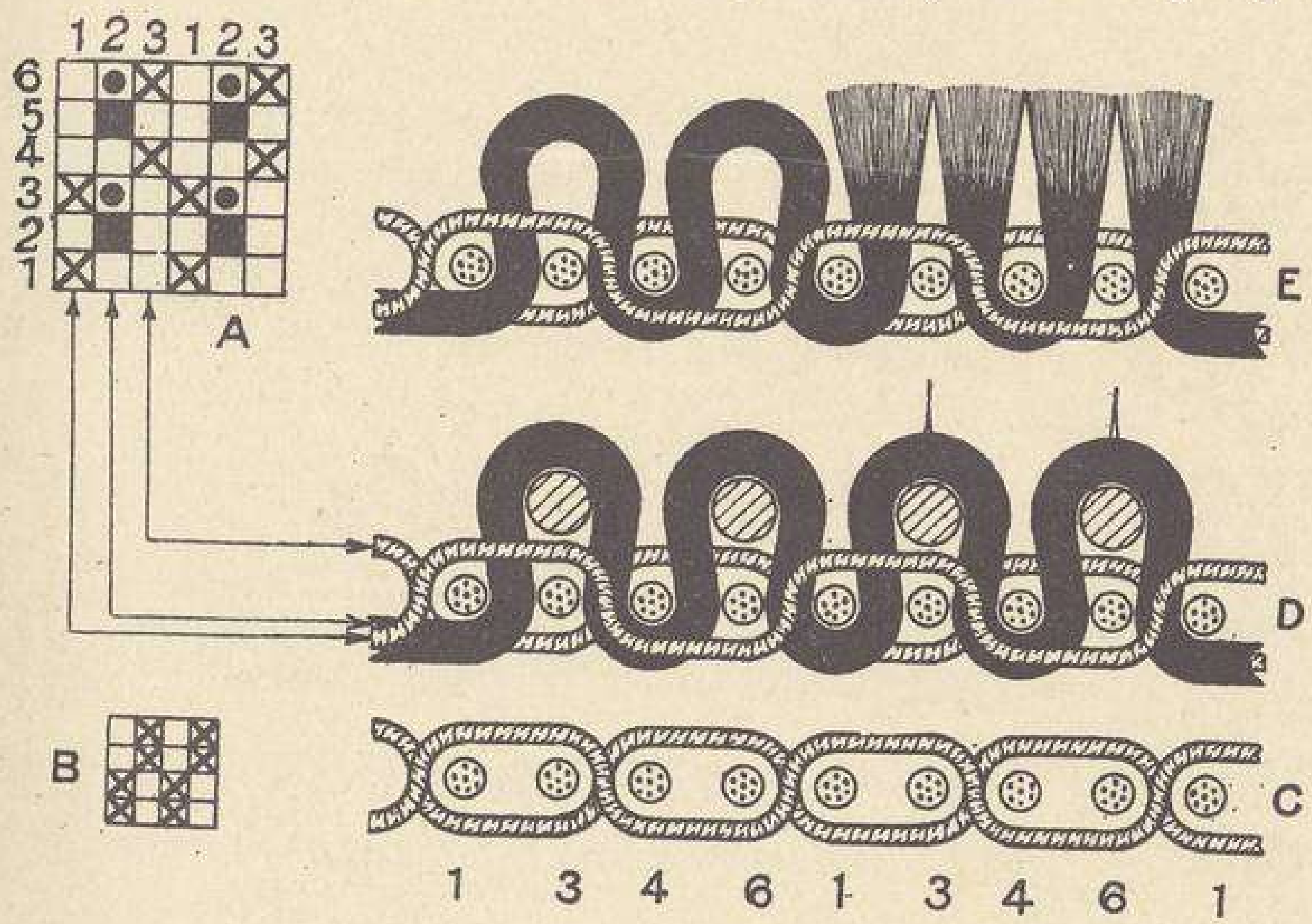


FIG. 222.

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

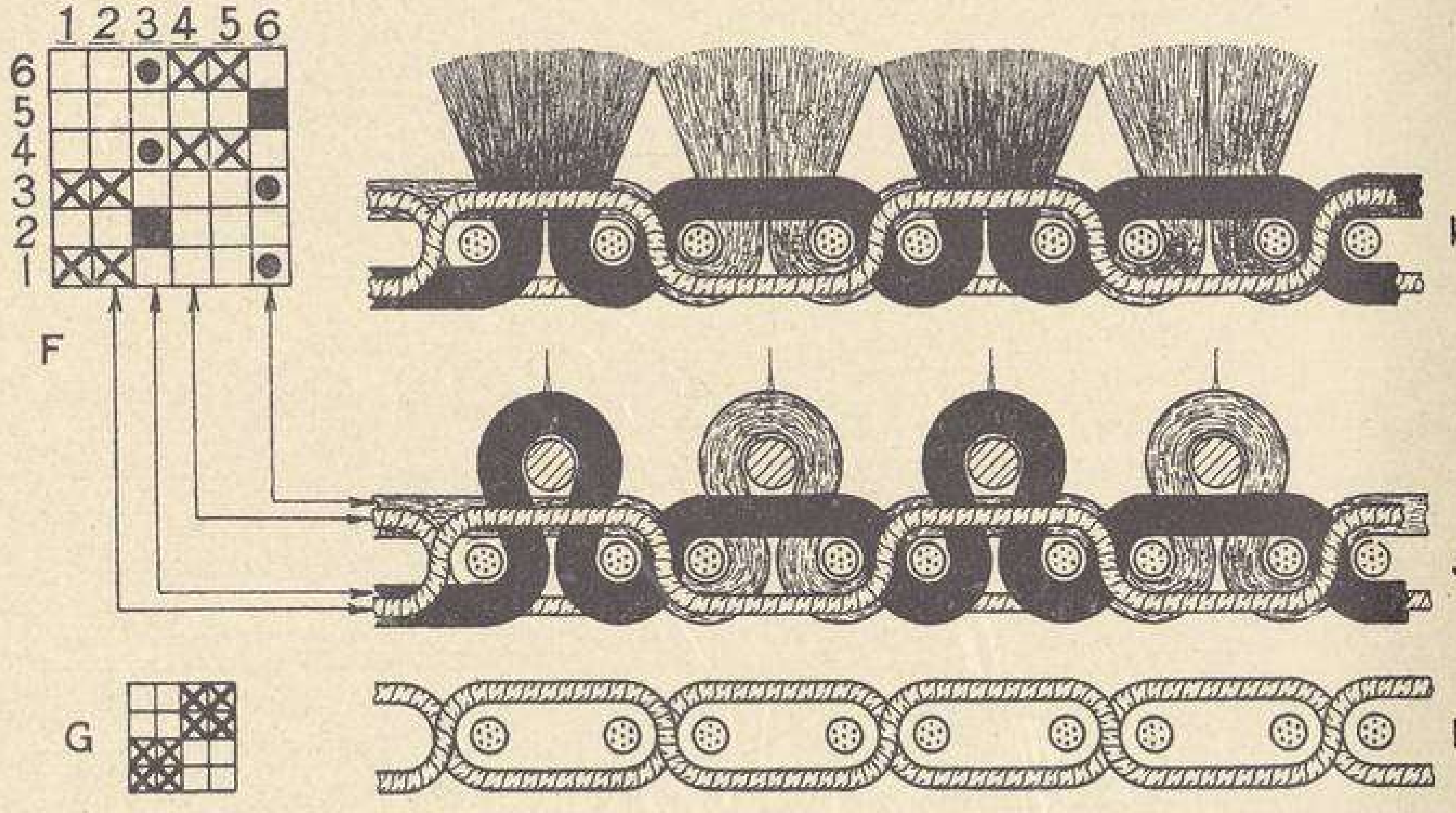


Fig. 223.

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

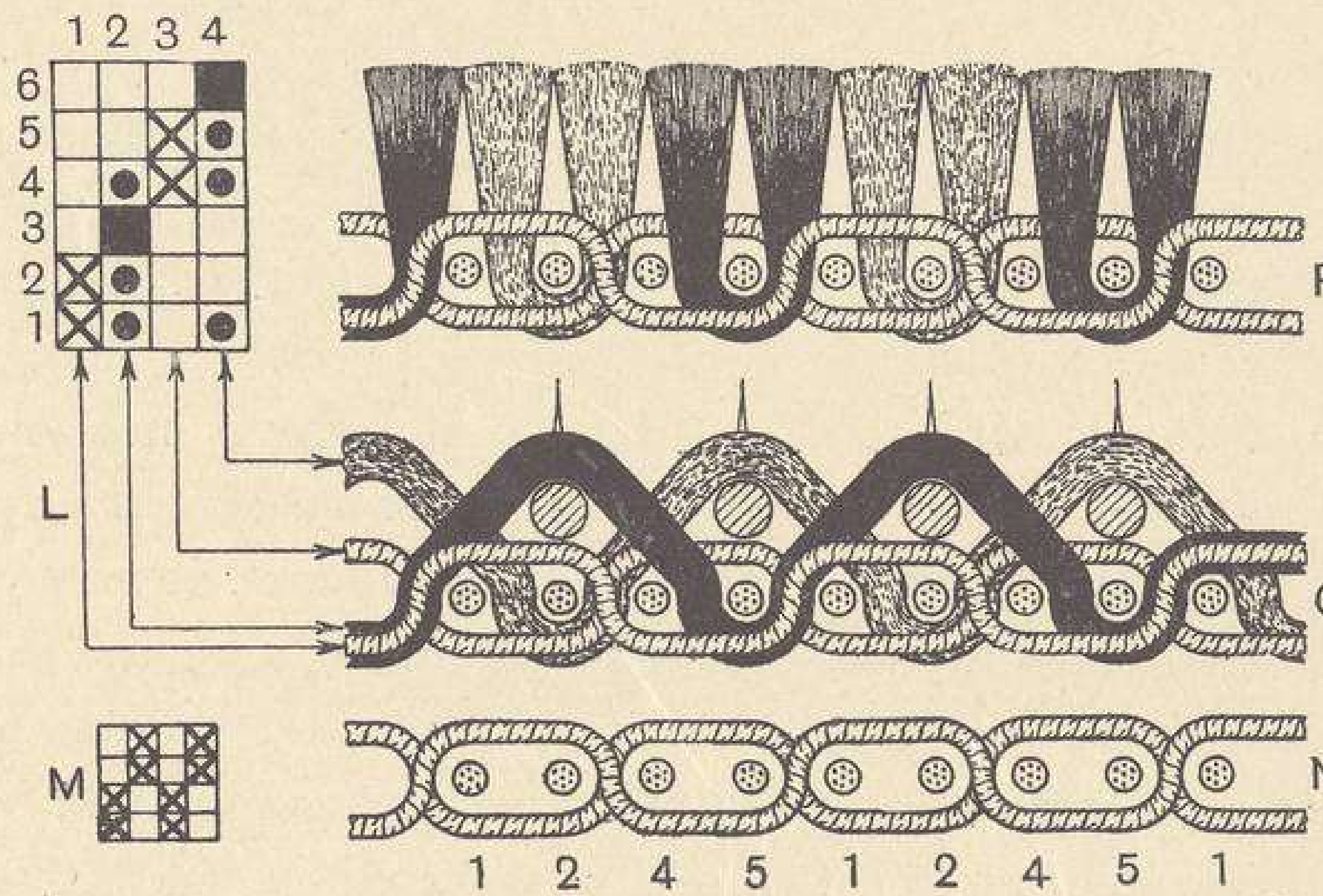


FIG. 224.

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

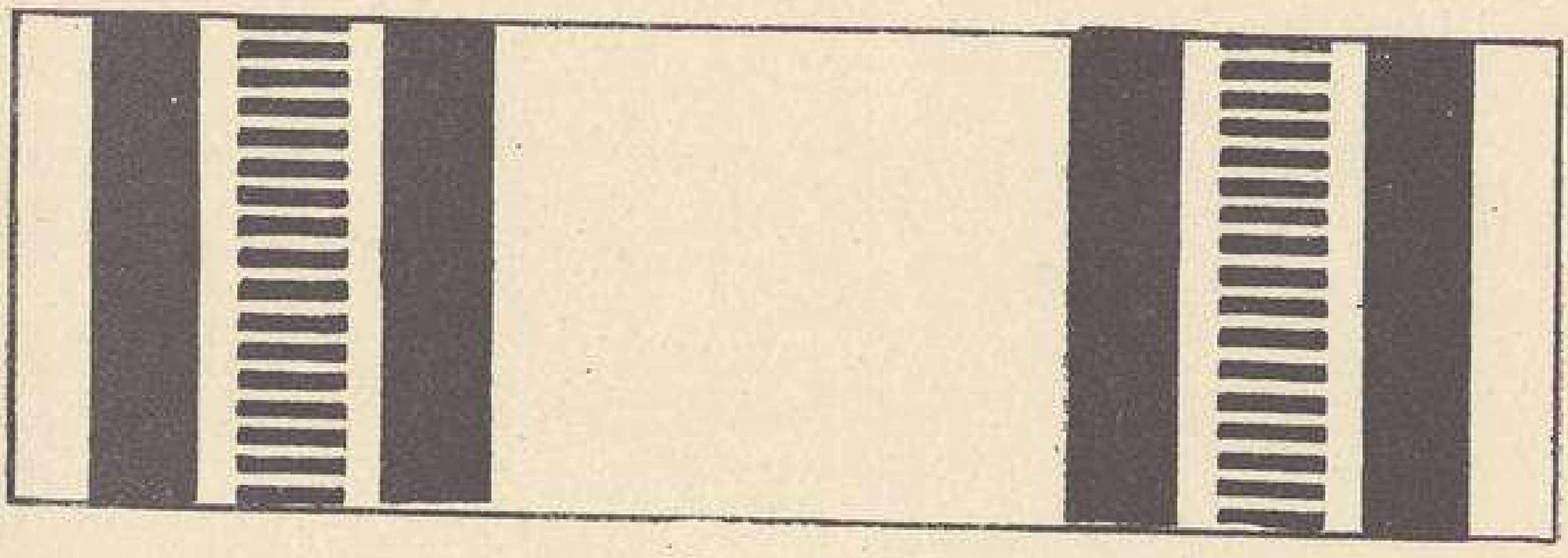


Fig. 225.

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

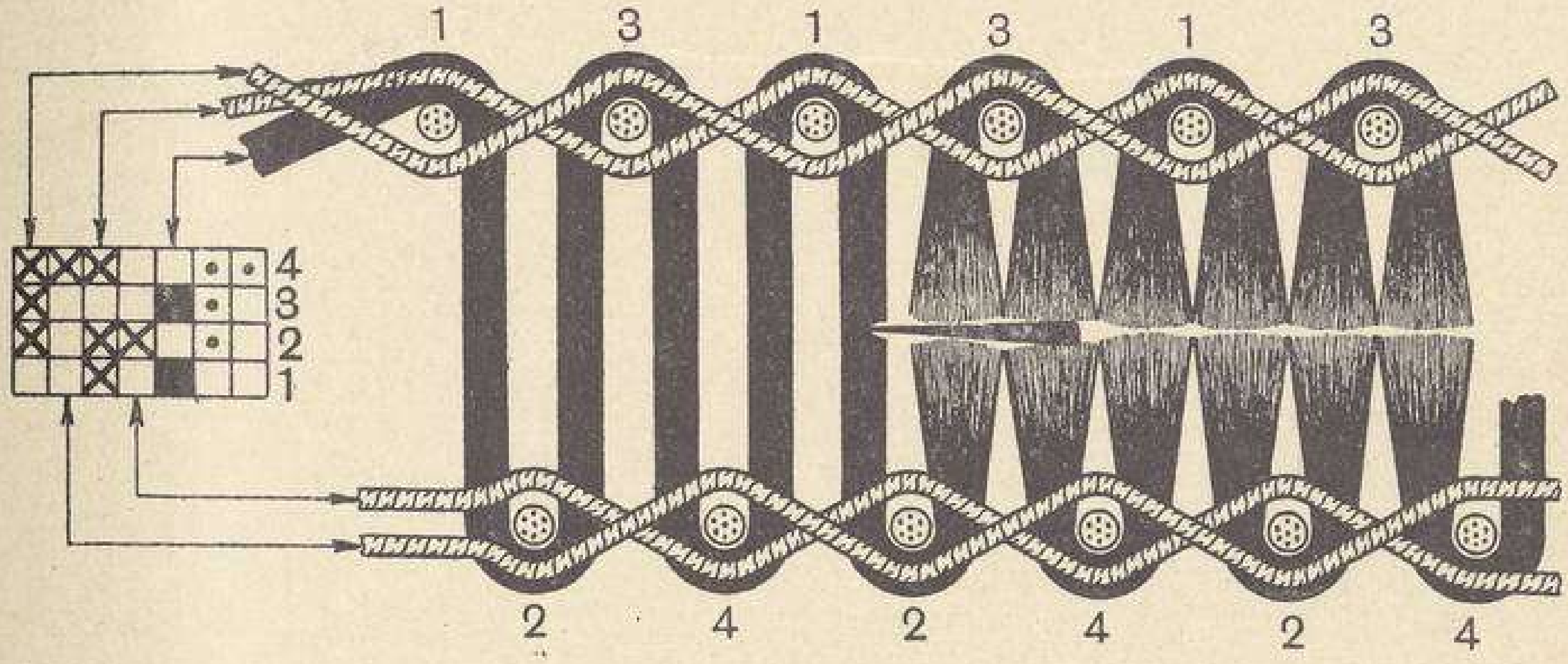


FIG. 226.

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 in each cloth.
4 ,,	,,	bottom ,,		
2 ,,	,,	top ,,		

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

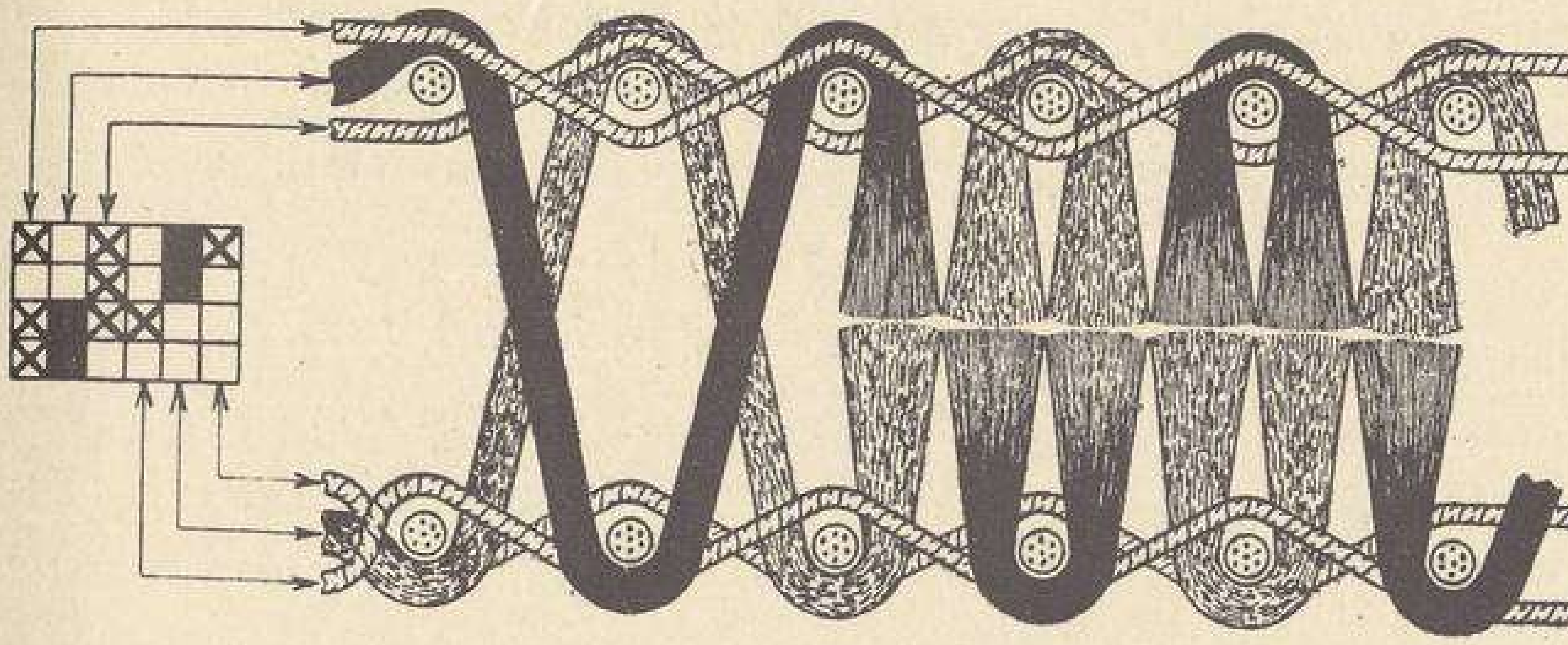


FIG. 227.

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

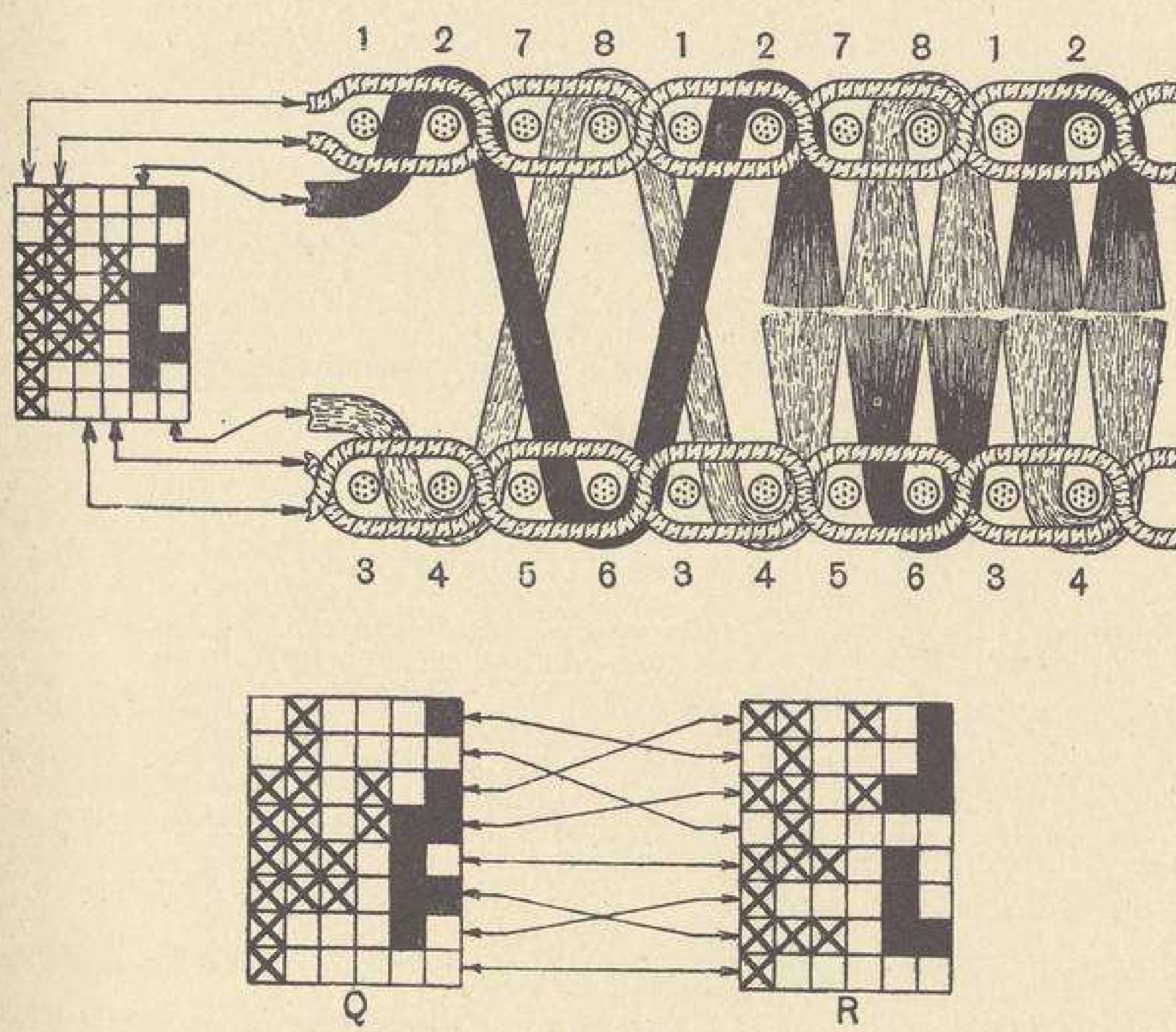


FIG. 228.

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.

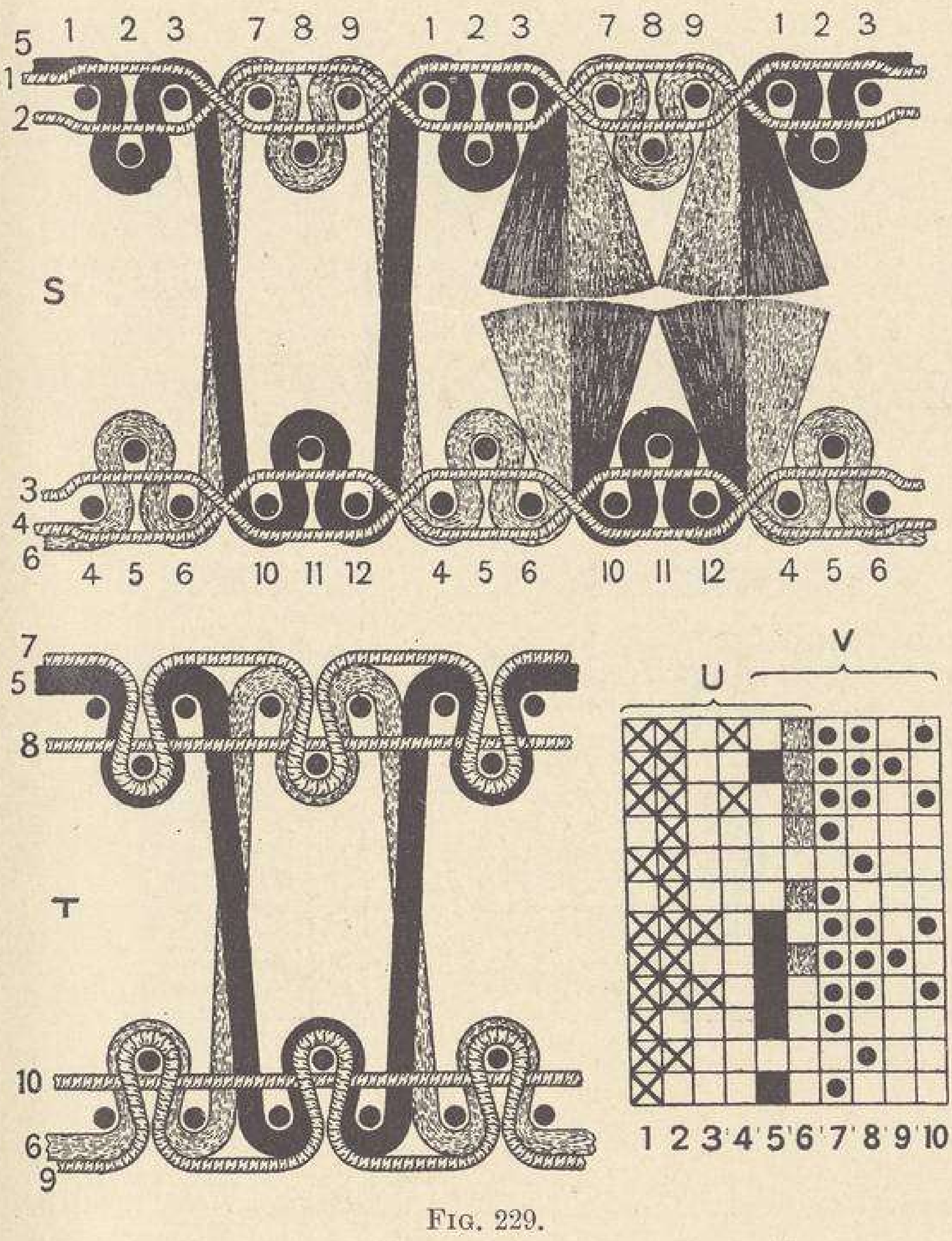


Fig. 229.

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

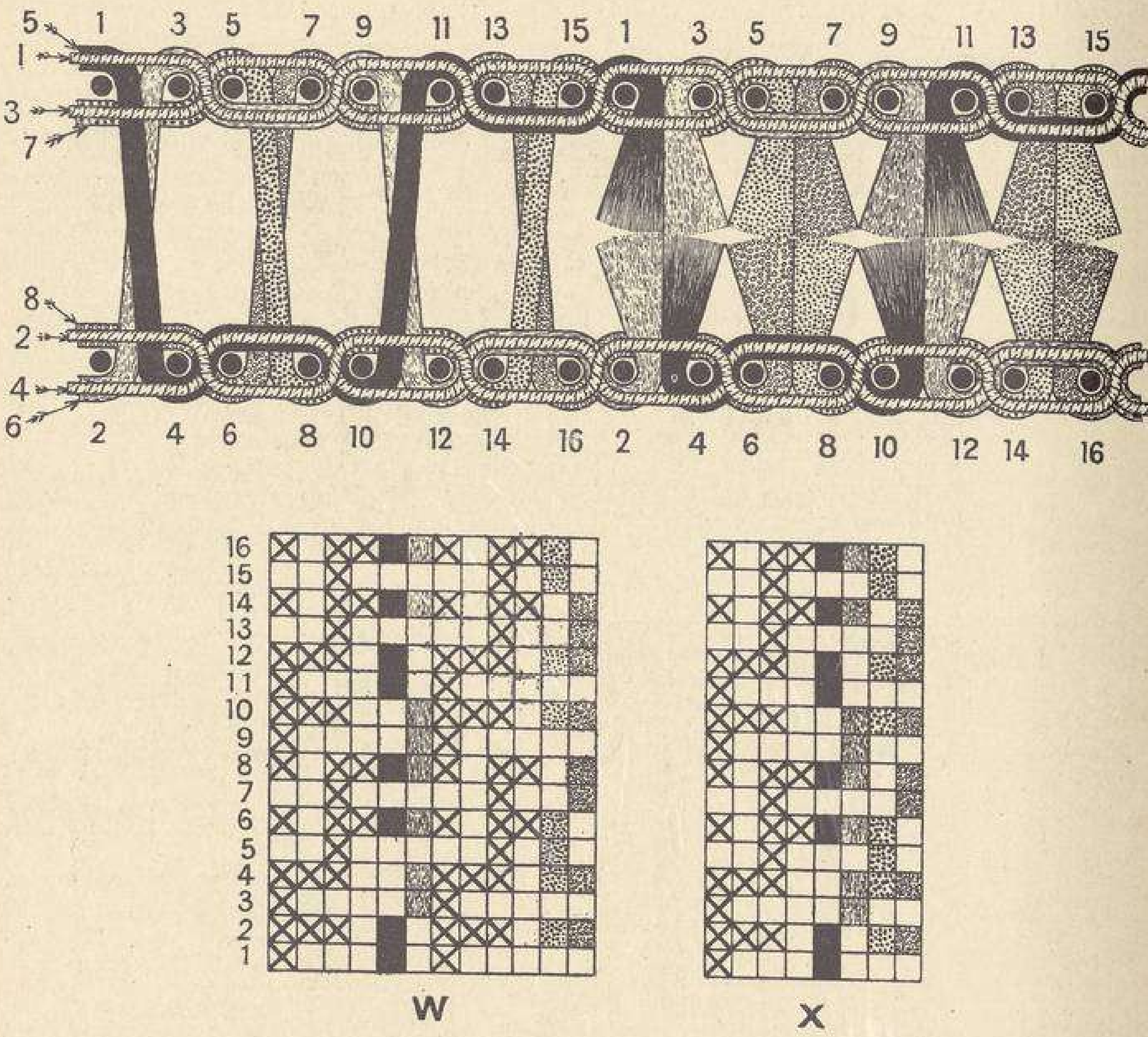


FIG. 230.

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

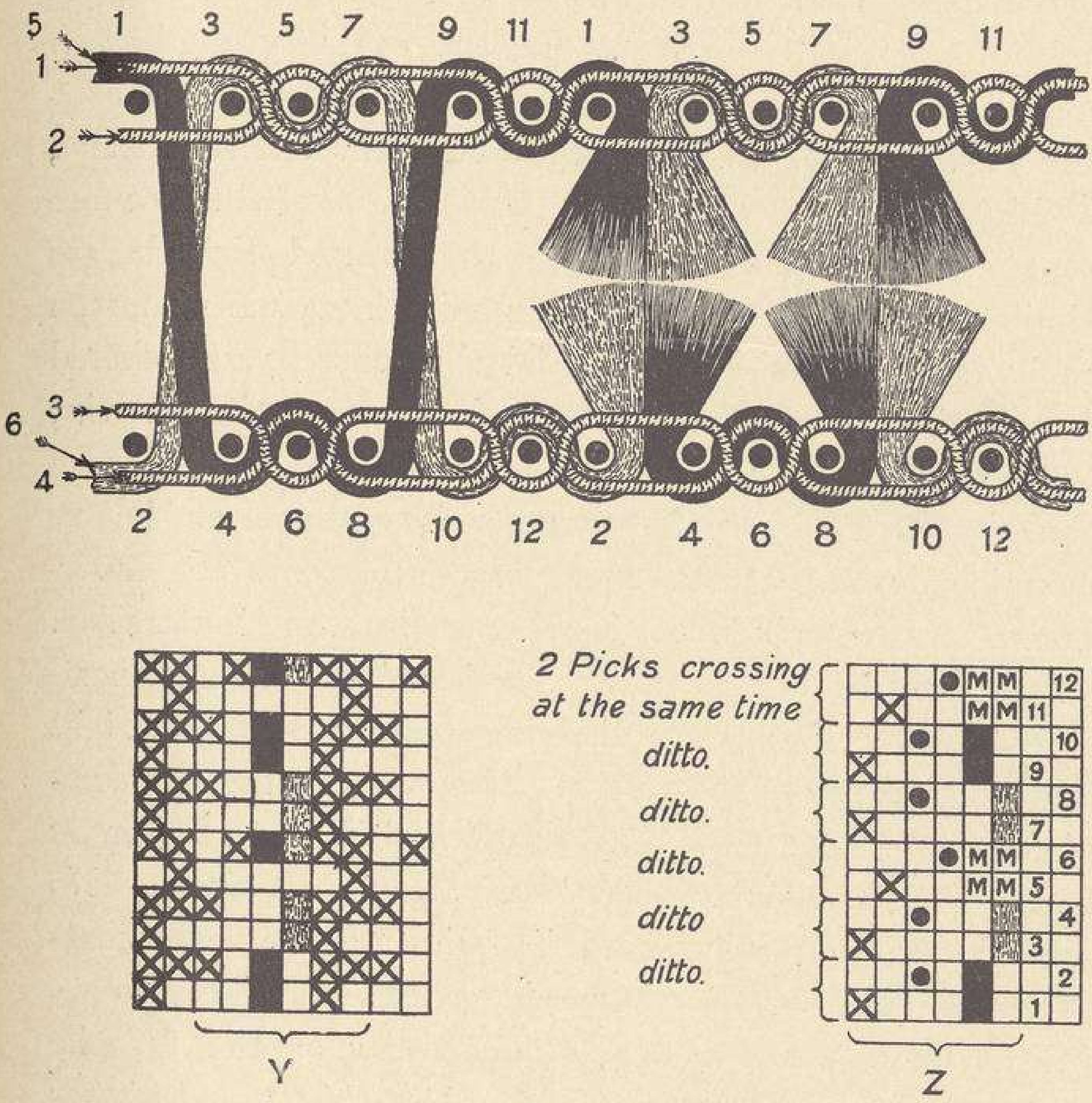


Fig. 231.

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 photographical 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

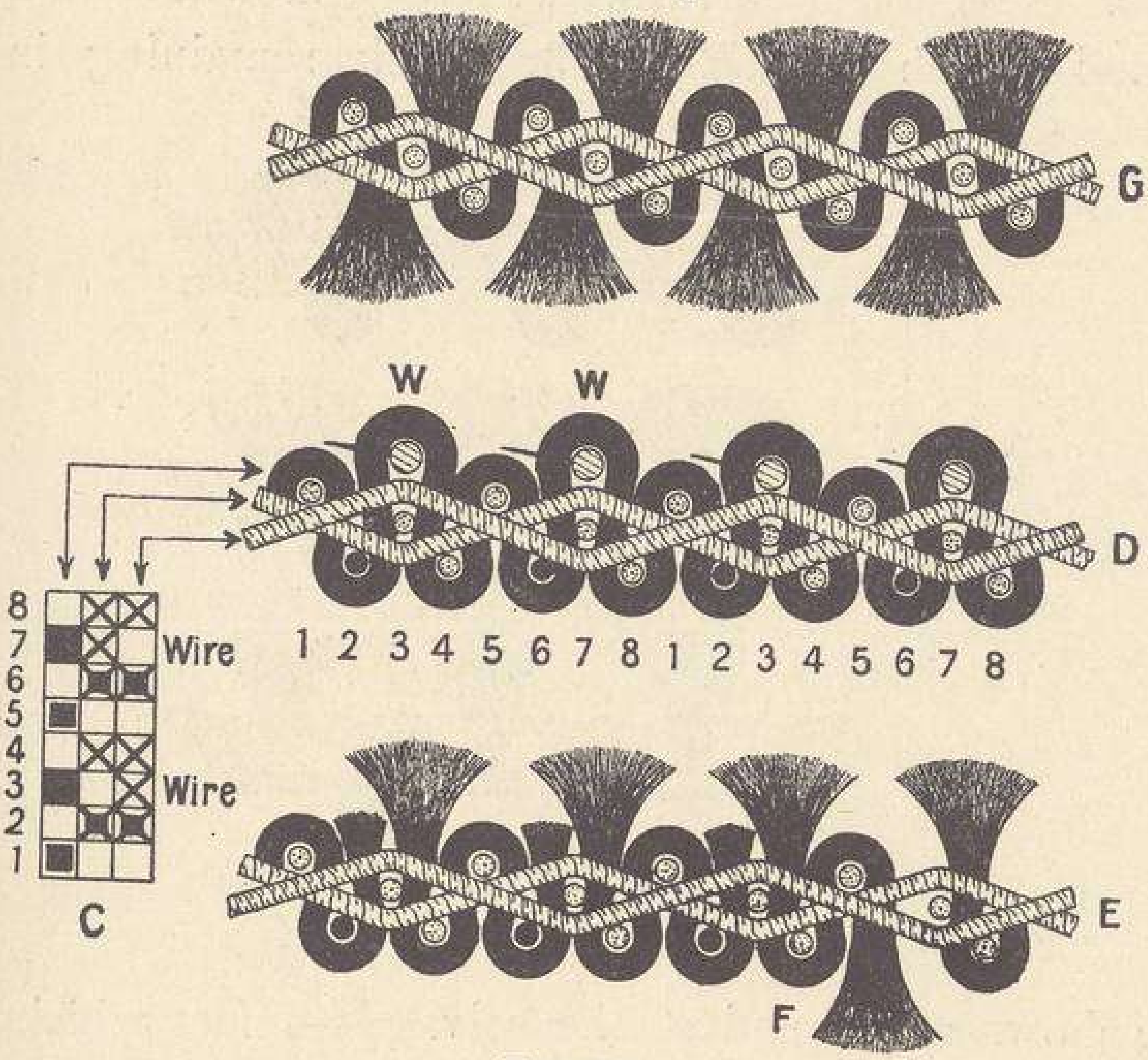


FIG. 233.

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 appear as at the left hand of E, and finally by cutting the 2nd and 6th picks in each repeat at one selvage only, and pulling in the proper direction, the left-hand part of each cut loop will be pulled through to the opposite side of the cloth as indicated in one instance at F. As this operation is carried out the plain or ground picks will, naturally, assume equidistant positions between the tufts of pile. The ultimate result will be somewhat similar to sectional sketch G. Every 3rd pick remaining in the

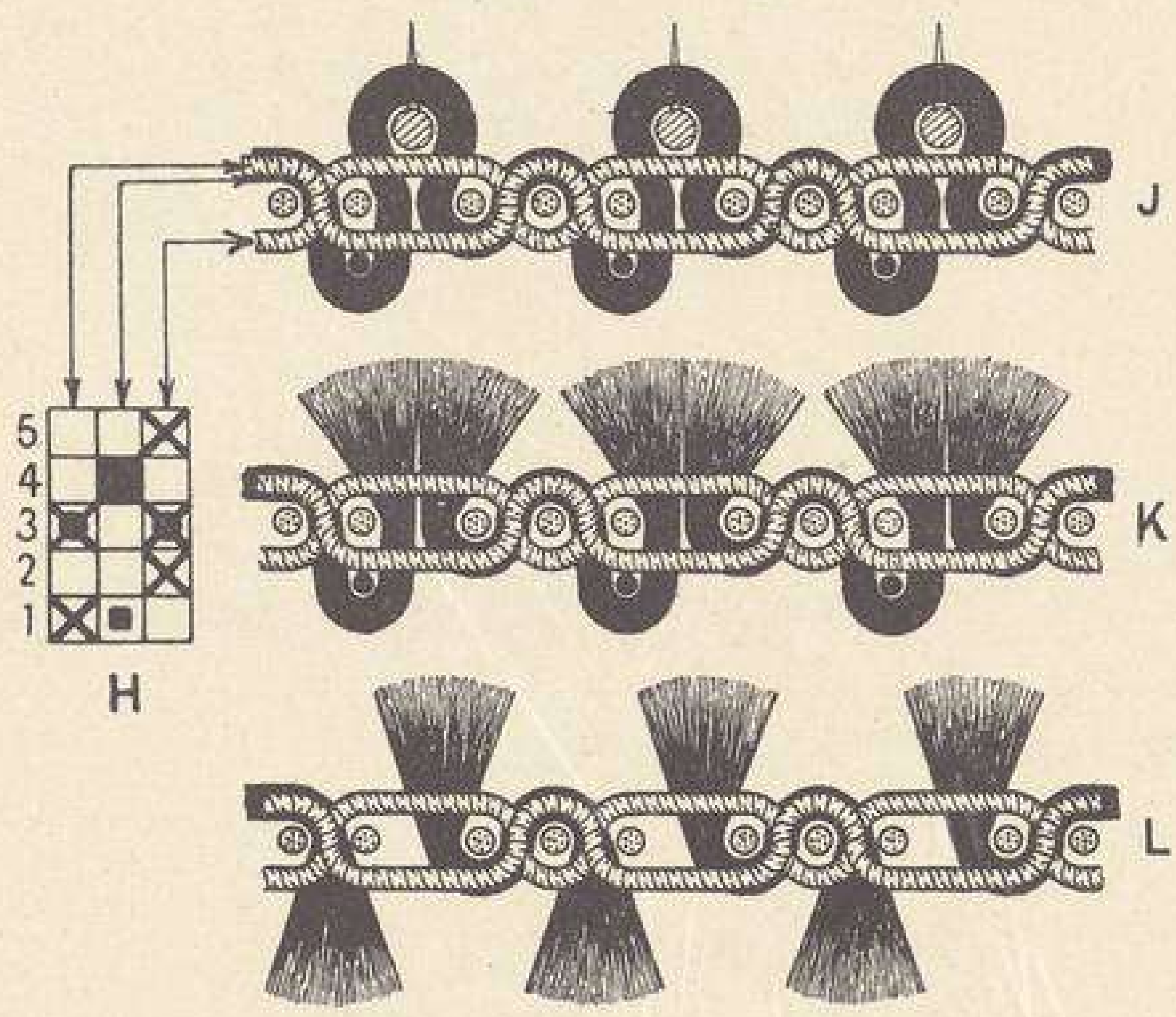


FIG. 234.

fabric shows a cut end at the selvage—a fact which in a measure indicates that the method of production was as described.

It is probably only in extra thick fabrics such as the one illustrated in Figs. 232 and 233 that it would be necessary to cut with a slanting knife edge. It is easily seen, however, from Fig. 234 that a defect would occur in such fabrics if a vertical knife were used. This figure shows another method with the 2-and-1 ground weave, the resulting fabric from design H being illustrated at J. When the pile is cut as at K, the lengths of the pile are equal, but when the right-hand part of each tuft is drawn through by means of pick No. 3, it is evident that the pile on one side will be longer than that at the other. To be correct the two sides should be as shown in intersection L.

Two such fabrics could be obtained by weaving them on the double plush principle, in which case one of the picks for pulling through the pile warp would be under all ground threads for the bottom cloth, and the other would be above all ground threads for the top cloth. We are not aware, however, that these methods of plush or pile fabric production are extensively practised.

The foregoing detailed description indicates the chief methods by which the ordinary all-over self-coloured and nearly self-coloured plushes are formed. Tappets are invariably used for these types because of the certainty of action of shedding apparatus so controlled. When, however, figured plushes are desired, a dobby or a jacquard must be brought into use. The introduction of these more complicated machines, however, does not alter the general principles of plush weaving; but, on the other hand, they entail an extraordinary increase of work in the designing. Moreover, since each thread may be called upon at any time to make plush, or to interlace in the ordinary manner in either the bottom or the top cloth, it is evident that each pile thread must be operated independently of every other, and represented individually on design paper. Each pile thread must also be wound separately on to a small bobbin, since the take up of the different threads may vary enormously.

Fig. 235 will give some idea of what can be done in figured plush weaving. This pattern is developed in six differently coloured pile threads, the whole appearing on a pale-green ground formed by a simple weave. It is actually a plush fabric on a simple rib ground. There are about 40 tufts per inch, so that it would be extremely difficult to construct wires for this pattern. The cloth has been made on the double plush principle.

Fig. 235.

There is one obvious objection to the employment of several colours of pile warp for patterns similar to that illustrated in Fig. 235. In spite of the ingenuity of the designer, which is often remarkable, it is almost impossible to avoid a more or less defined stripe in the fabric. If coloured yarns are not used, then the figuring with cut pile depends upon solid patches of pile woven upon a ground of plain or ornamental structure, or with part of the figure developed in pile, and the remainder of the figure in ordinary jacquard weaves upon a more or less simple ground structure. The pile could be varied a little by using wires of different sizes, if the pattern were woven with wires; but, since the bulk is woven on the double plush principle, this type of ornamentation may be neglected, as may also all effects obtained by embossing, etc. in the finishing.

A very common and at the same time exceedingly effective method of ornamenting these fabrics is the combined loop and cut pile—often termed uncut and cut pile. Fig. 236 has been prepared to illustrate one method of making a design for the small dice pattern shown at M. In this pattern the marks ⌘ represent the cut pile, while the solid marks indicate the loops. The detailed designs N and O show an arrangement where the cutting and looping wires are indicated on successive lines, and we would urge the reader to make sections from the designs. Two points in connection with them are quite evident:—

1st. When the cutting wire is being inserted, only those threads represented by the marks ⌘ must be lifted.

2nd. When the looping wire is being inserted, only those threads represented by solids ■ must be lifted.

The ground weave P is the same in both designs N and O, while plan Q shows the ground weave in relation to the wiring. The blank picks are for the wires, while the middle pick in each group of three plain ones is marked by an arrow to indicate that all pile threads are raised over this pick. In design O the same pile thread is used for both cut and uncut pile, which is the usual way when all

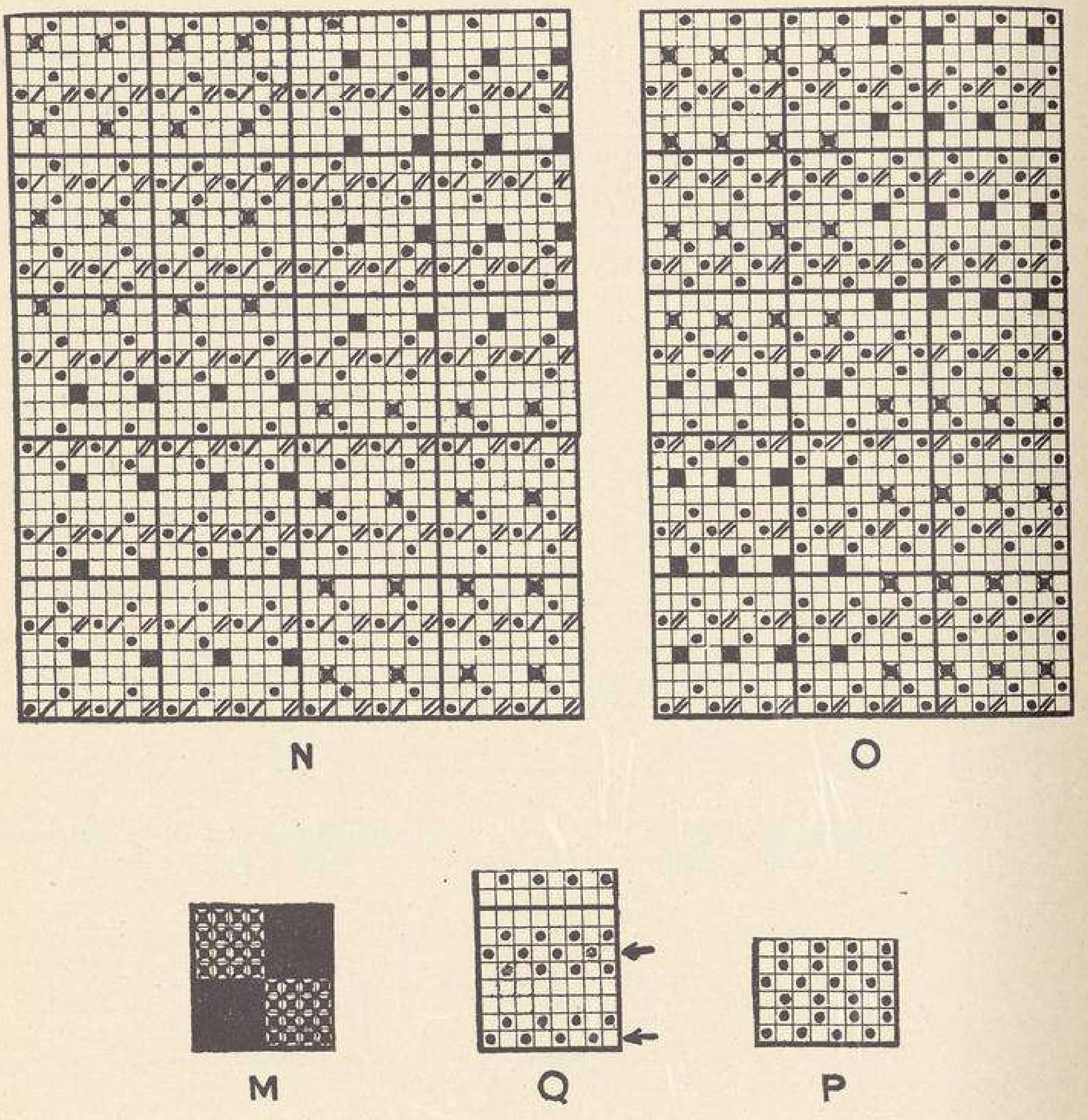


FIG. 236.

the pile warp is the same colour. But although the piles are developed in one colour of yarn, the different effects in the two parts are very striking; the loops reflecting a great proportion of light appear lustrous and bright, whereas the cut pile, which reflects very little light and absorbs nearly all which falls on this area, has a soft subdued effect. The contrast is really charming, and such fabrics have a very rich appearance.

In design N, separate threads are used for each line of pile; such a method would, however, only be adopted when cut and uncut pile of two colours were used, in which case four distinct shades would be displayed in the four squares of the dice pattern, that is, cut and uncut pile of both colours. Now if four effects can be obtained in dice patterns, the same number of effects can be got in figured fabrics; and, seeing that the ground threads work throughout in precisely the same order, all ground threads may be operated by shafts, and need not appear on the design paper. It is sufficient, therefore, to represent a figured pattern in four distinct colours; two colours of yarn, and two effects (cut and uncut) of each. Thus a small part of a figured design on point paper is introduced at R, Fig. 237, where the marks have the following meanings:—

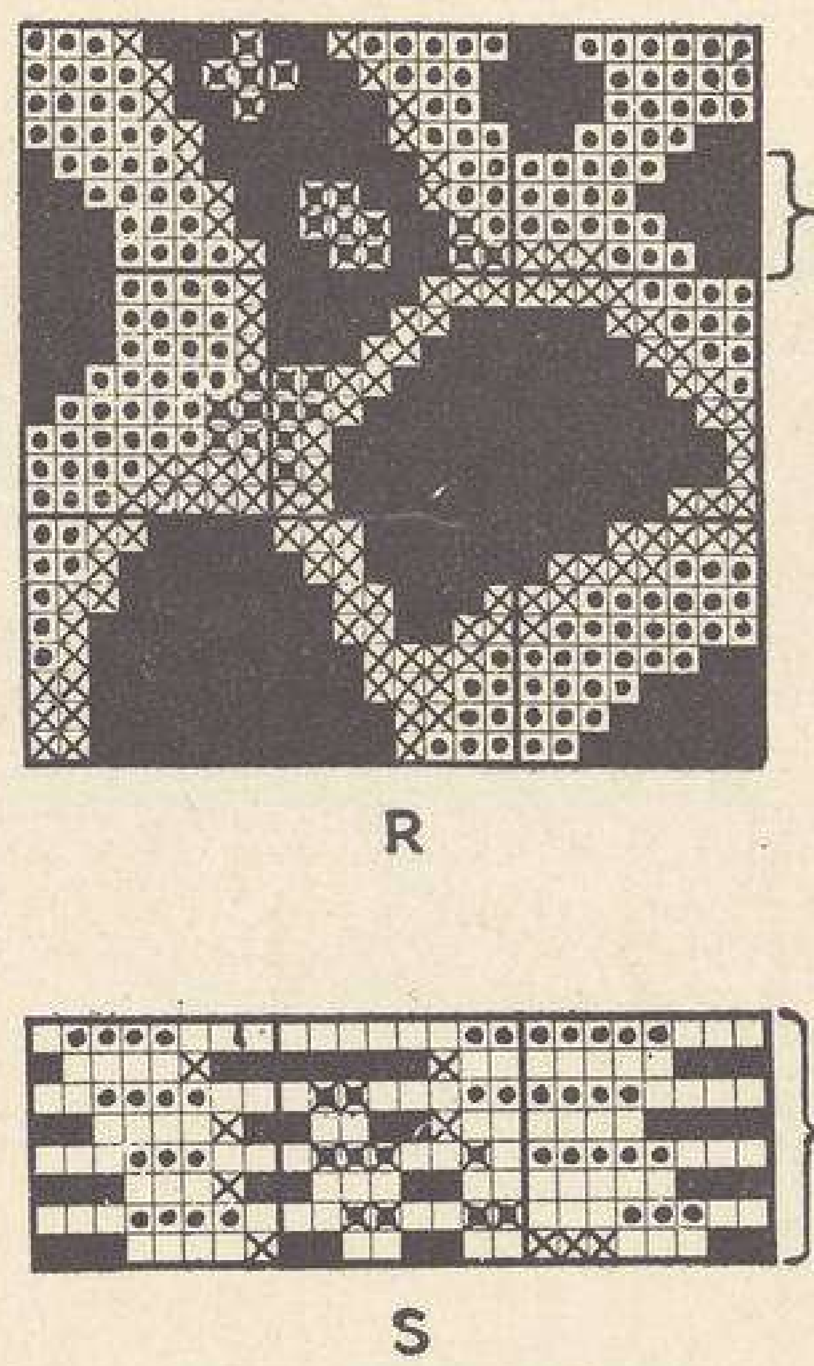


FIG. 237.

Solid marks ■	indicate parts	developed in	cut dark	plush;
Marks ⌘	,,	,,	uncut ,,	,,
Crosses ×	,,	,,	cut light	,,
Dots ●	,,	,,	uncut ,,	,,

Each line of design R represents two wires or four effects, although in some parts of the illustrated portion only three shades appear. Picks 17, 18, 19, and 20 from design R are separated and shown at S, where the marks on odd weft lines indicate the lifted light and dark threads for the cutting wire, and the marks on even weft lines represent lifted light and dark threads for the looping wire.

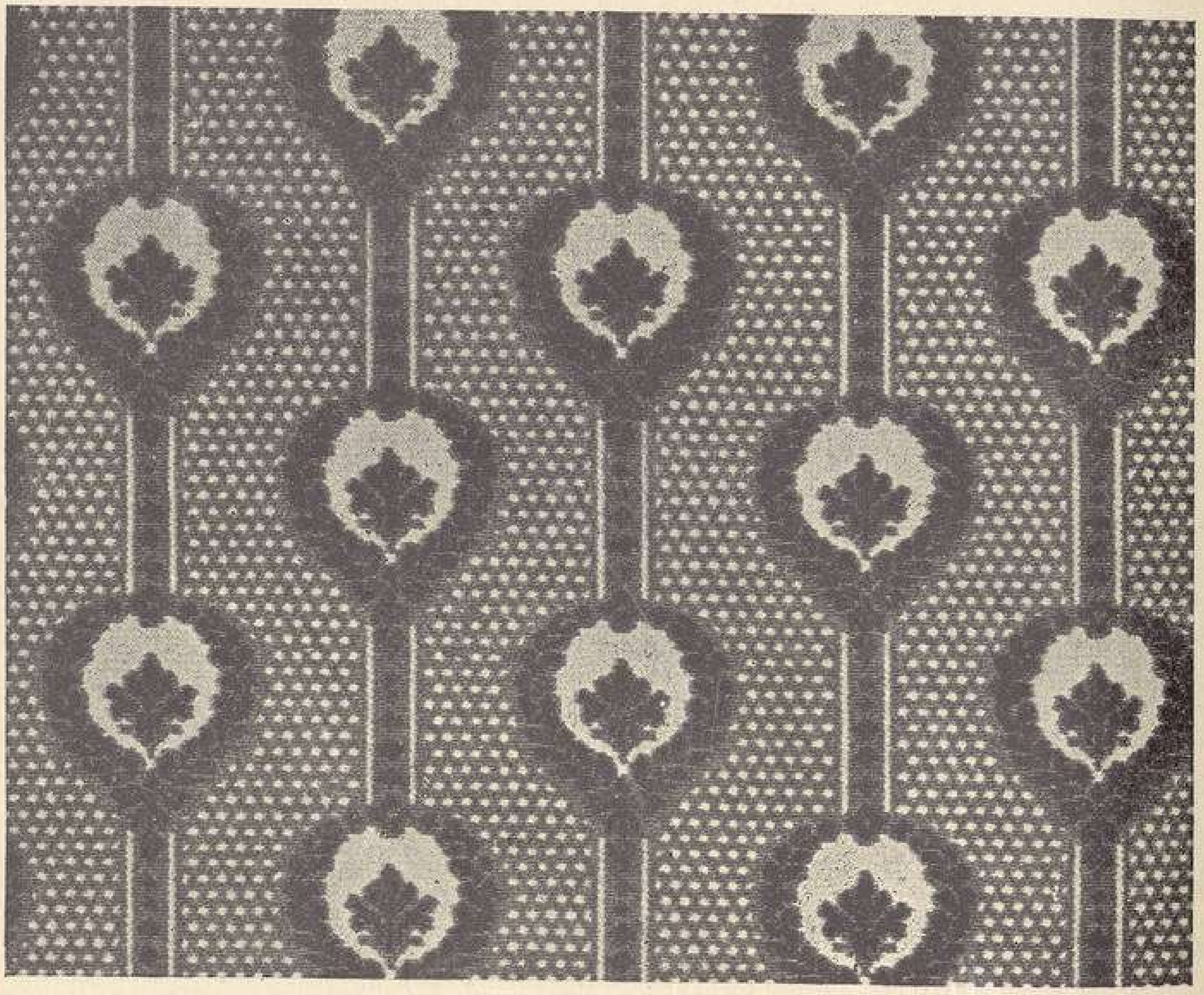


Fig. 238.

For a final example of this particular type of weaving we introduce Fig. 238, which is a photographical reproduction of a beautiful fabric. The warp is arranged :—

6 threads of gold for ground and binder ;
2 ,, green for pile.

The following three distinct effects appear :—

1st. The dark patches forming the chief parts of the main figures and connections are developed in cut pile.

2nd. The outlines of the more or less honeycomb shaped patterns and some of the stripes are developed in loops or uncut pile.

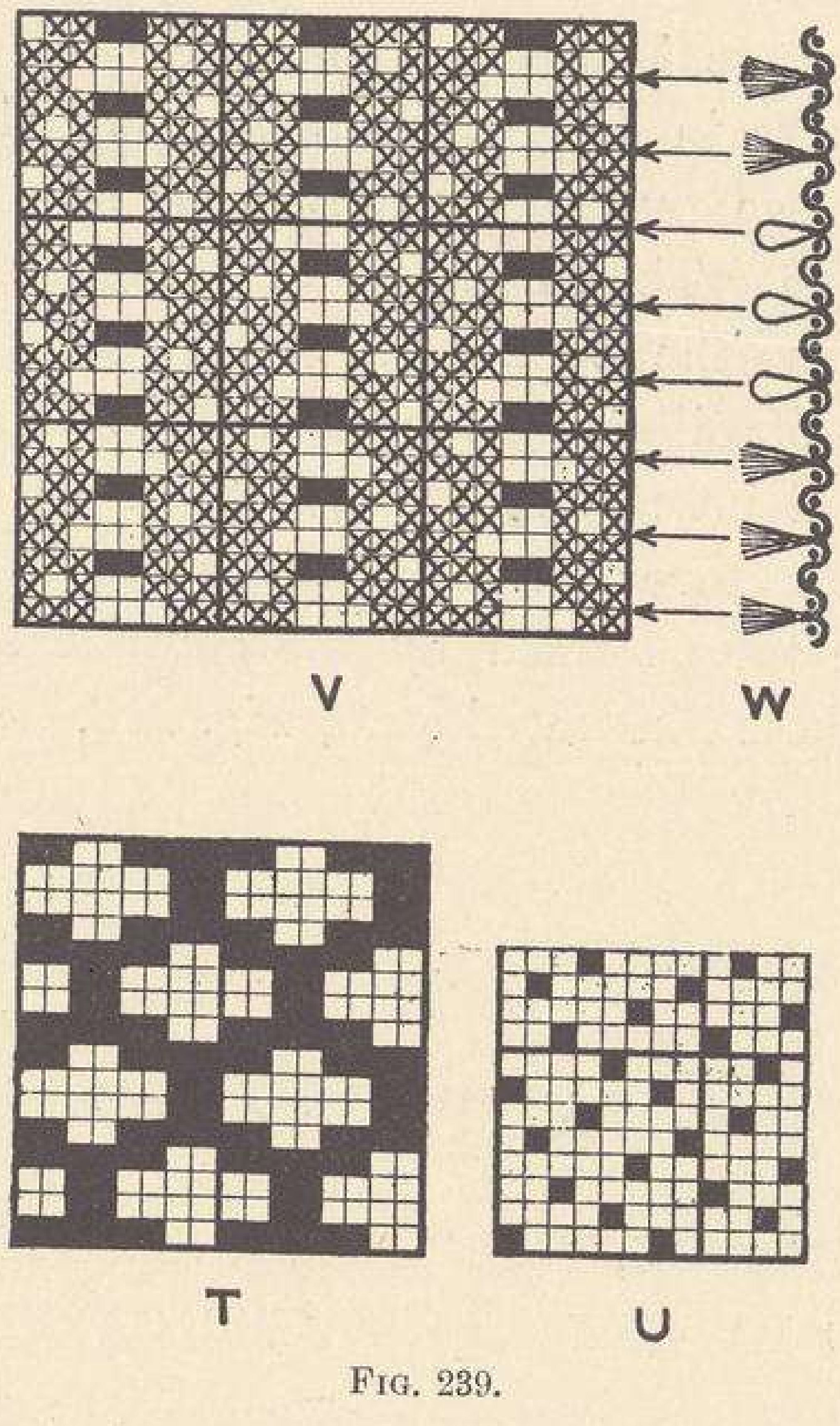


FIG. 239.

3rd. The light parts, that is the centres of the honeycomb pattern, some of the stripes, and a large part of the centre of each main figure, are developed by the gold threads in 6-thread sateen twill warp flush.

Fig. 239 illustrates sufficiently well the chief parts.

Plan T shows the order of interlacing or of lifting the pile threads on the looping wires when making the outlines of the honeycomb type of ornament. Plan U is the 6-thread sateen, weft flush, and is practically the same as that illustrated at M, Fig. 106, p. 143. The crosses in design V represent the ground threads which weave in a similar 6-thread sateen, but with warp flush instead of weft. This weave is used for the whole of the ground. The solid marks in design V simply show that the pile threads are raised over every third weft shot in order to make a fast pile. The small arrows to the right of design V indicate where the looping and cutting wires are inserted —both types of pile appear in every line of the fabric— while the small intersection W is introduced to show the path of the pile threads for both types. It will be easily seen that the tufts formed by the cut pile are precisely the same as those illustrated at D, Fig. 218.

CHAPTER XIX

BRUSSELS, WILTON, TAPESTRY, ROYAL AXMINSTER, AND PATENT AXMINSTER CARPETS

THE richness of a carpet depends partly upon the length and density of the pile, partly upon the fibre of which the pile is formed, and partly upon the colour effect. It is difficult to say which factor is the most important, but when all three are judiciously combined, the resulting fabric has a charm which few types of textiles can approach. The chief factor, however, in most carpets, 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 cases a system of wiring is necessary for the formation of the well-known loops.

To facilitate the description we may immediately call the reader's attention to Fig. 240, in which are different views illustrative of what is termed a 5-Frame Brussels Carpet. The term, 5-frame, in its strictest, or most exact sense, means that each point or loop of the pile of the carpet may be formed from one of five distinct pile threads which are drawn through one split of the reed, and any one of which may be lifted at will to form the successive piles along the warp. Each pile thread in each group of five is of a distinct colour, and comes from a separate frame; the latter must therefore contain as many bobbins as there are loops of pile in the width of the carpet. The number of frames indicates the number of pile threads per split in the reed, and, in a sense, indicates the relative quality of the carpet. Should each frame be filled with bobbins all of one colour there will clearly be the same number of threads of each colour in the fabric, although the same quantity of each may not and invariably does not appear on the surface. Each frame in the best class of 3/4 wide 6-frame Brussels contains 256 to 260 bobbins, and if more than six colours are required in any pattern, one or more of these frames must contain two or more colours. The frame is then said to be "planted." It will thus be seen that a 5-frame Brussels, which is the one generally used, may, by a system of planting, easily be made to contain six or even more colours. There are, as already mentioned, 256 loops in each row from selvage to selvage, or approximately $9\frac{1}{2}$ loops per inch; but since the total number of pile threads is, in general, the product of the number of frames and the number of loops in a row, there are far more threads in the fabric than are required on its surface at any time. The bulk of the material is therefore made to occupy a place between the two sets of picks; it thus acts as a padding to the fabric, and also assists in imparting to it the properties of elasticity and softness to the tread. A 6-frame Brussels may contain 6×256 pile threads for the best quality, but a 3-frame Brussels may contain 3×256 threads, or three times a smaller number, with or without a few extra threads for planting colours. It will thus be seen that the quality of a Brussels carpet is influenced, not only by the number of loops, say 7 to $9\frac{1}{2}$ per inch, but also by the number of frames of solid colours which are used; indeed the prefixes 3-frame, 4-frame, 5-frame, and 6-frame indicate, irrespective of material or number of bobbins in a row, ascending qualities of carpets.

In practice the figure and the ground of Brussels carpet designs are painted in colours similar to those intended for the actual fabric, although it is clearly possible to substitute subsequently other colours in the various frames for the purpose of obtaining different colour effects in different carpets of the same design. The ground and the various parts of the figure are therefore painted in their respective colours—such colours indicating lifted threads both for figure and ground.

In the small design D, Fig. 240, we illustrate at A, B, and C three threads and thirteen picks by a scheme of marking which would, in practice, be replaced by five distinct colours. A complete 3/4 wide design of the best quality would contain 256 such threads, and a number of picks which would depend upon the length of the pattern or design. It will be evident that, since five different colours are represented in each line, five threads, one of each distinct colour, will be required to develop each line,

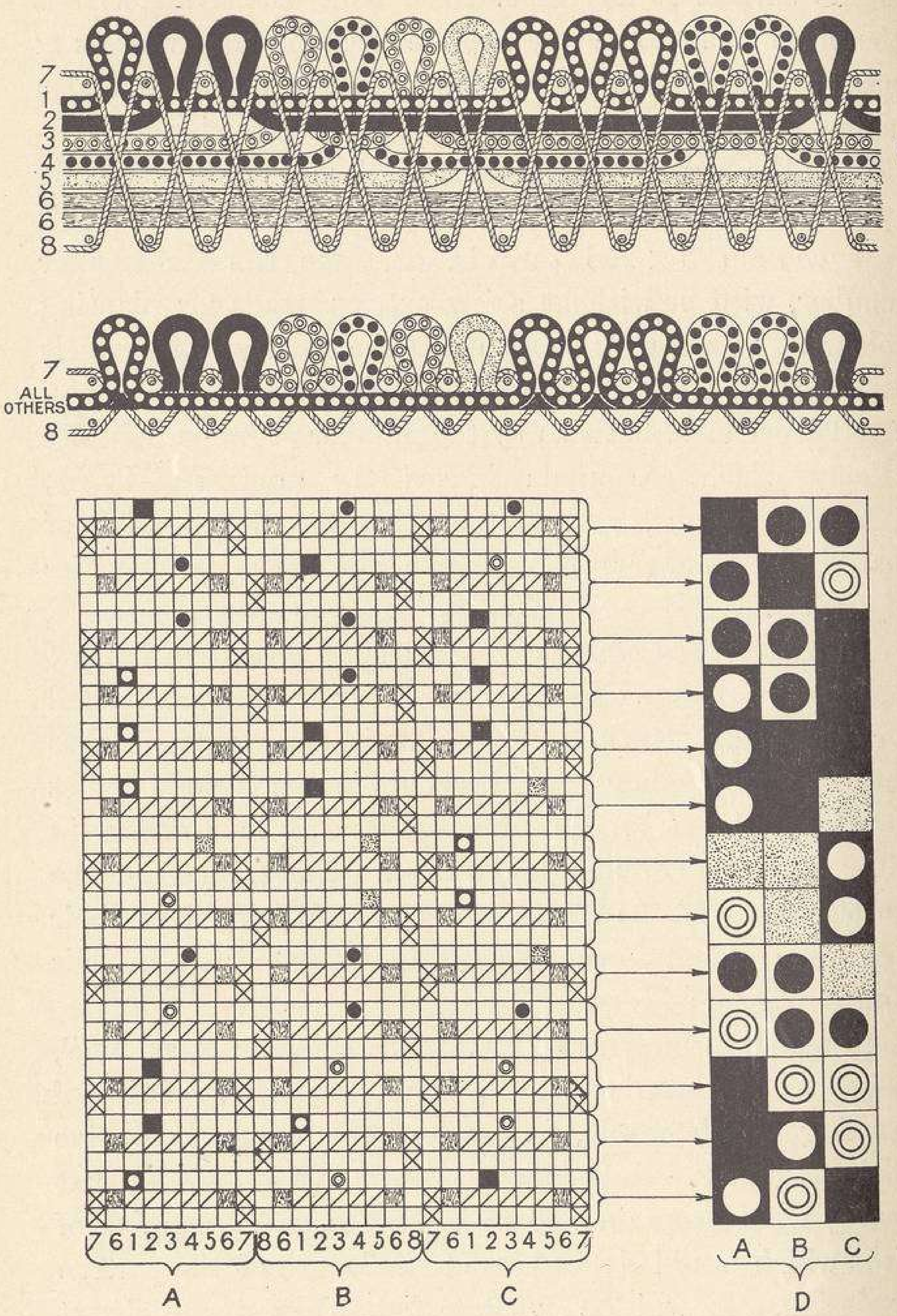

7
1
2
3
4
5
6
6
8
E
7
ALL OTHERS
8
F
7 6 1 2 3 4 5 6 7
8 6 1 2 3 4 5 6 8
7 6 1 2 3 4 5 6 7
A
B
C
A B C
D

FIG. 240.

or altogether $5 \times 256 = 1280$ coloured pile threads. In addition, two picks and one wire are necessary for each line of weft. The actual structure for threads A, B, and C, and for the corresponding ground and stuffer threads is shown to the left, no fewer than nine distinct threads of warp being used for each warp line of the design D. The numerals 1, 2, 3, 4, and 5 indicate the five different colours of pile warp; 6 and 6 the two threads of stuffer warp; 7 and 7, or 8 and 8, the two threads of binder warp. Altogether nine threads pass through each split of the reed, but one only appears on the surface to form the loop. The weft lines are bracketed in groups of three, the last one in each group indicating the wire which passes, as indicated under one and only one thread of each group A, B, or C. The wire is inserted simultaneously with the pick represented by the middle line—a double shed being formed for these two lines. Twenty-six picks, instead of 39 as shown, are therefore required for the 13 lines of the design. If now we imagine the wire lines to be superposed on the lines immediately preceding, we shall see that the binding warp threads 7 and 8, shown in crosses (×), interweave in 4-thread basket or hopsack order. The complete order of lifting for the first three lines is as follows:—

1st pick. All pile threads (1 to 5 inclusive), all stuffer threads 6, and half the binder warp threads down, the remaining half of the binder threads being lifted.

2nd pick. All pile warp threads, all stuffer threads, as well as the same half of the binder threads lifted for the shuttle to pass under, and the particular thread in each group of the pile warp, as indicated by the first line in design D, lifted by the jacquard to a higher plane to permit of the wire being inserted. For this pick the whole of the pile warp is lifted to the medium position by the comber board—knots on each harness cord permitting of this operation.

From this it is evident that:—

1. All figuring threads work plain as indicated by the diagonal marks (/), but selected ones from the design (one thread in each group) are lifted higher by the jacquard itself.
2. All stuffer threads work plain throughout, as shown by marks ⁝⁝.
3. All binder threads work $\frac{2}{\ \ 2}$ in 4-thread basket order.

An intersection through the weft is illustrated at E. This shows the course followed by all the threads in group A, in addition to a binding thread similar to 8, but placed in front of all the other threads. The markings of all the pile threads and the stuffer threads are similar to the marks in both designs, while the numbers immediately to the left of the threads correspond to the similar numbers in the detailed design. All threads, 1 to 6 inclusive, are under the top row of picks (1st pick in each group in detailed design), but are over the bottom row of picks (2nd pick in each group in detailed design). The intersection is much deeper than the actual fabric, which appears more or less like the intersection F, where all pile and stuffer threads are evidently in the same plane. Intersection E, however, enables one to follow the path of each thread clearly, and thus to see the structure in a favourable light.

It will be seen from the detailed design, and from the intersection, that the bulk of the pile yarn lies in the body of the fabric; in general, two-thirds, three-fourths, fourfifths, and five-sixths of this yarn occupy such a position in 3, 4, 5, and 6-frame Brussels respectively. This gradually increasing quantity of dormant yarn in the ascending qualities naturally increases the cost of the fabric, but at the same time it provides a kind of cushion which does not obtain in those fabrics which are not so provided with padding of elastic material.

The loops in Brussels carpets are made by the use of wires very similar to that illustrated at K, Fig. 219. If the wires had cutting ends as shown at J in Fig. 219, it is evident that cut pile would be produced, and a less lustrous, but deeper colour effect obtained. In some of the cheaper makes of carpet a cutting wire is used, and the fabric is then termed "Wilton Carpet." Such a method is, however, resorted to only for convenience and for cheap production. For the sake of variety a number of plain wires are sometimes introduced alternately with the same number of cutting wires, say three or four of each, to produce alternate horizontal bands of uncut and cut pile. The surface of a real Wilton carpet is certainly composed of cut pile but the binding warp threads interlace differently from those in Brussels. This will be seen by reference to illustration H, Fig. 241, which is a section through 30 weft shots of such a fabric. The binding threads are in the front in illustration G, and are therefore clearly seen to pass alternately over three picks and under three picks. The ten loops in illustration G are taken from thread B in Brussels design D, Fig. 240, but it is evident that if this method of weaving were adopted for Brussels it would be much more expensive. Twenty picks of weft would suffice for the ten loops in Brussels weaving, whereas thirty picks are necessary by the method shown at G, Fig. 241. Since all pile loops in Brussels are uncut there is no danger of withdrawal, but when the pile is cut there is such a danger, and the tufts should therefore be securely bound. On this account it is advisable to

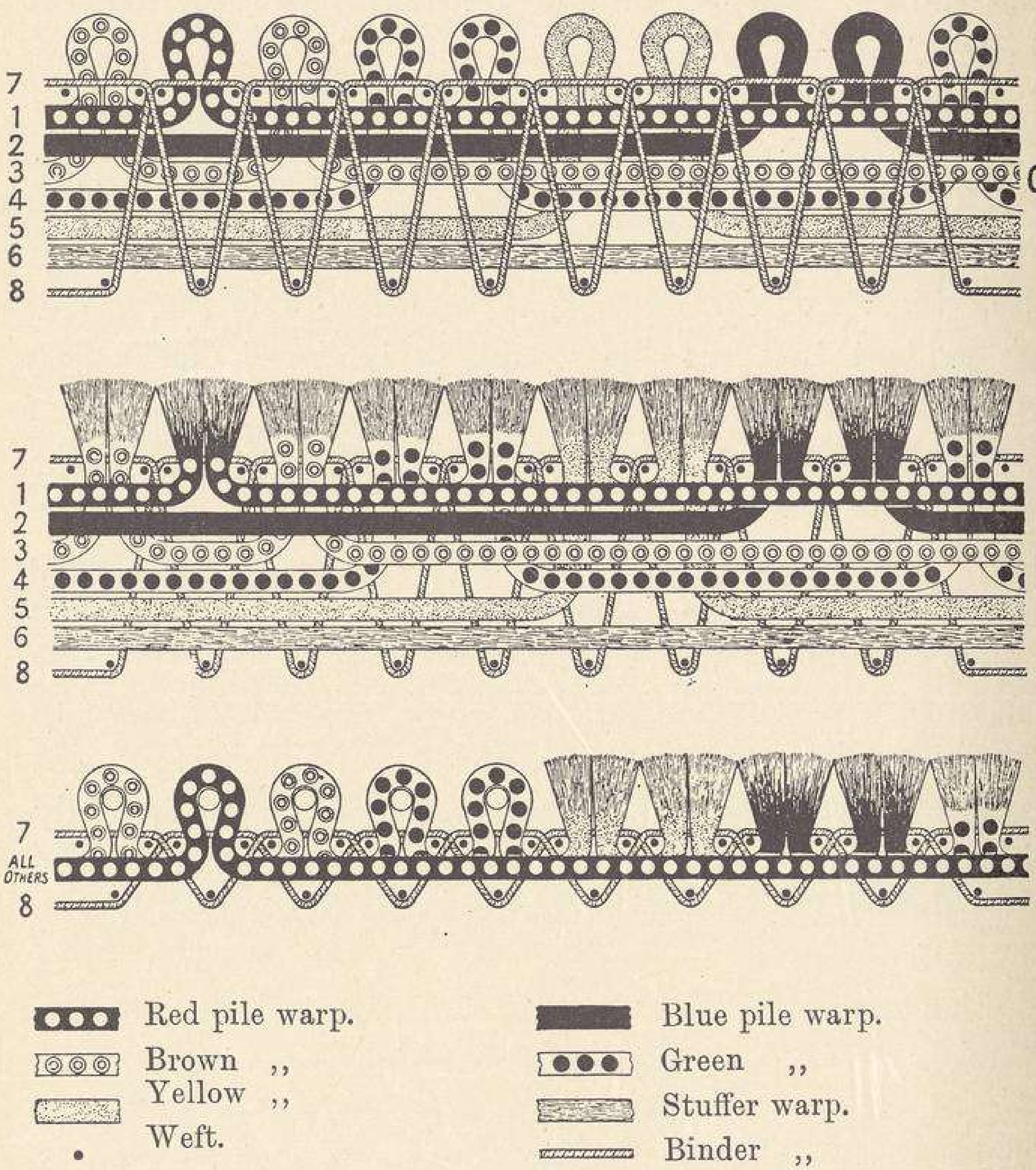


Fig. 241.

adopt the particular method of binding shown at G and H, Fig. 241, in the manufacture of Wilton carpet.

The method of reeding, and also of operating the pile threads for the wire, are the same as for Brussels ; the pile and stuffer threads require to be down for two picks and up for one, and the cutting wire is inserted on this latter pick, that is, when all the pile picks are above the shuttle. This arrangement of binding threads lessens the production, but the pile threads are more securely held. The left-hand part of illustration J shows the general appearance of the actual section with the five wires under the loops, while the right-hand side shows a part where five cutting wires have been withdrawn. The differently marked pile

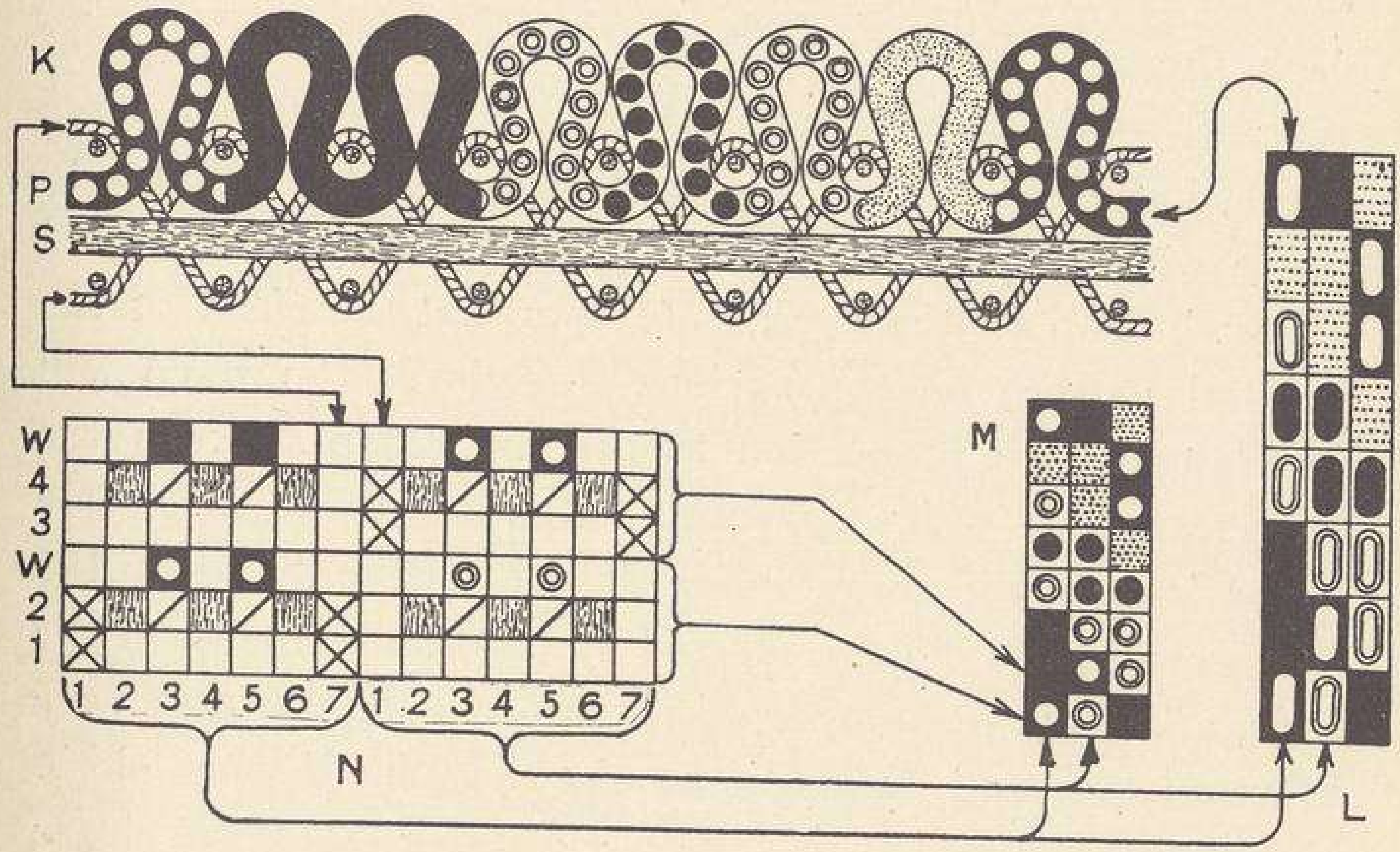


FIG. 242.

threads may be considered as representing the colours mentioned at the bottom of the figure.

Tapestry Carpets.—Fig. 242 illustrates the chief parts of a tapestry carpet which, as we have already stated, is a cheap imitation of Brussels carpet. No jacquard is required for tapestry carpets, but a wiring motion is a necessity. The preparation of the warp threads for the loom is an elaborate process, but the actual weaving is not very complicated; indeed, with the exception of the mechanism for the wiring, the process is comparatively simple. Each pile thread in a Brussels or Wilton carpet is a particular colour throughout its entire length (if two differently coloured threads are twisted together the yarn would still be considered as an unvarying colour) and rarely more than six colours are used unless in very elaborate planting. On the other hand, each pile thread of a tapestry carpet is printed, at different parts of its length according to pattern, with all the colours which appear in one length or one thread of the design. The printing is done on each thread separately, and for a considerable number of repeats, while the yarn is wound tightly round a large drum, but since the length of yarn which is required to make each loop is much longer than the space occupied by such loop in the cloth, it follows that the effect of the printed pattern on the various threads of the warp will be elongated in proportion to the difference between the measurements. The difference between the two clearly depends upon the more or less sinuous course taken by the pile yarn ; it is chiefly affected by the size or depth of the wire, and by the number of wires per inch, and may vary between two and three times the length of the cloth. Illustrations M and L, Fig. 242, will make this point clear ; the former is part of a design painted on design paper to the actual size of the cloth, while the latter shows the same pattern as it would appear in elongated form on the pile threads before weaving. In this example the lengths of pile yarn and cloth are as 7 to 4. 6½ to 8 threads per inch multiplied by the width of the fabric represents the total number of pile threads in a cloth, and as all these threads are over every wire, it follows that the resulting fabric will lack the weight of a Brussels carpet unless a large number of stuffer threads are used. Design N shows that three stuffer threads are inserted for each looping or pile thread, so that each split of the reed will contain one pile thread, three stuffer threads, and two binder threads. For the better grades of Brussels, Wilton, and Tapestry Carpets the pile warp is usually threefold twofold worsted; the binding warp threefold hard twisted cotton; and the weft flax. Stuffer warps may be either flax or jute.

Axminster Carpets.—The preparation of the pile warp in all types of Axminster carpets, as in tapestry carpets, involves elaborate and lengthy processes; the weaving mechanism for the production of Axminster carpets is much more elaborate than that employed for tapestry carpets, although it is similar to it in that no jacquard is required.

There are two distinct types of Axminster carpets—Moquette or Royal Axminster, and Chenille or Patent Axminster—each type involving its own distinct preparatory and weaving processes. In the former or "Royal" type of fabric each tuft of pile is securely bound into the body of the fabric by one or other of many different interlacings, whereas in the "Patent" type the pile is laid as it were on the surface of a substantial foundation and is secured to it by means of special binding threads. When completed, both kinds are very similar in appearance. Theoretically there is no limit to the number of colours which may be employed in either type of Axminster, and in this respect each has a decided advantage over the Brussels or Wilton types. This statement must not be regarded as implying that the beauty and effect of carpet designs depends mainly upon the number of colours used, for exceedingly rich effects may be obtained with a number of colours which is quite within the compass of a Brussels machine. On the other hand, the liberty of a choice of any number of different colours is certainly an advantage, as no restriction is then placed upon the designer with regard to the production of designs having elaborate colour schemes.

One structure, which is common to many Royal

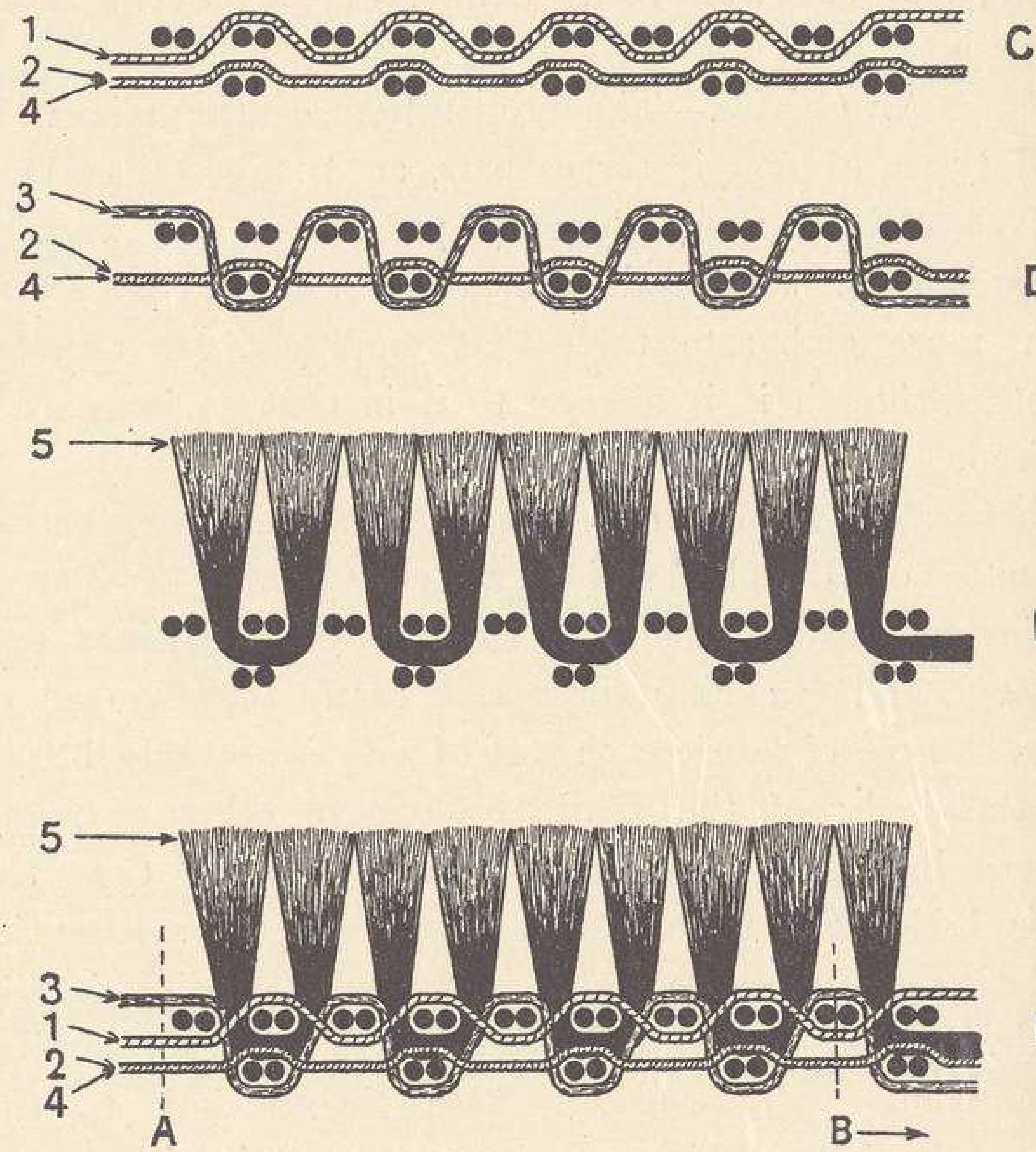


Fig. 243.

Axminster carpets is illustrated in Figs. 243 and 244, which represent respectively sections through the weft and the warp. In the particular type illustrated there are five warp threads and three double picks in each repeat. The picks are double because the weft is carried through the shed by means of an eye in the end of a long steel wire or needle; the needle eye, in its return stroke, simply slides along the second half of each double shot, the latter being held secure by a catch thread inserted at the selvage opposite to that from which the needle acts. This catch thread is contained in a very small shuttle which moves in a crescent-shaped guide and passes through the loop of the weft thread formed by the needle eye as it projects through the open shed of the fabric. The sequence of

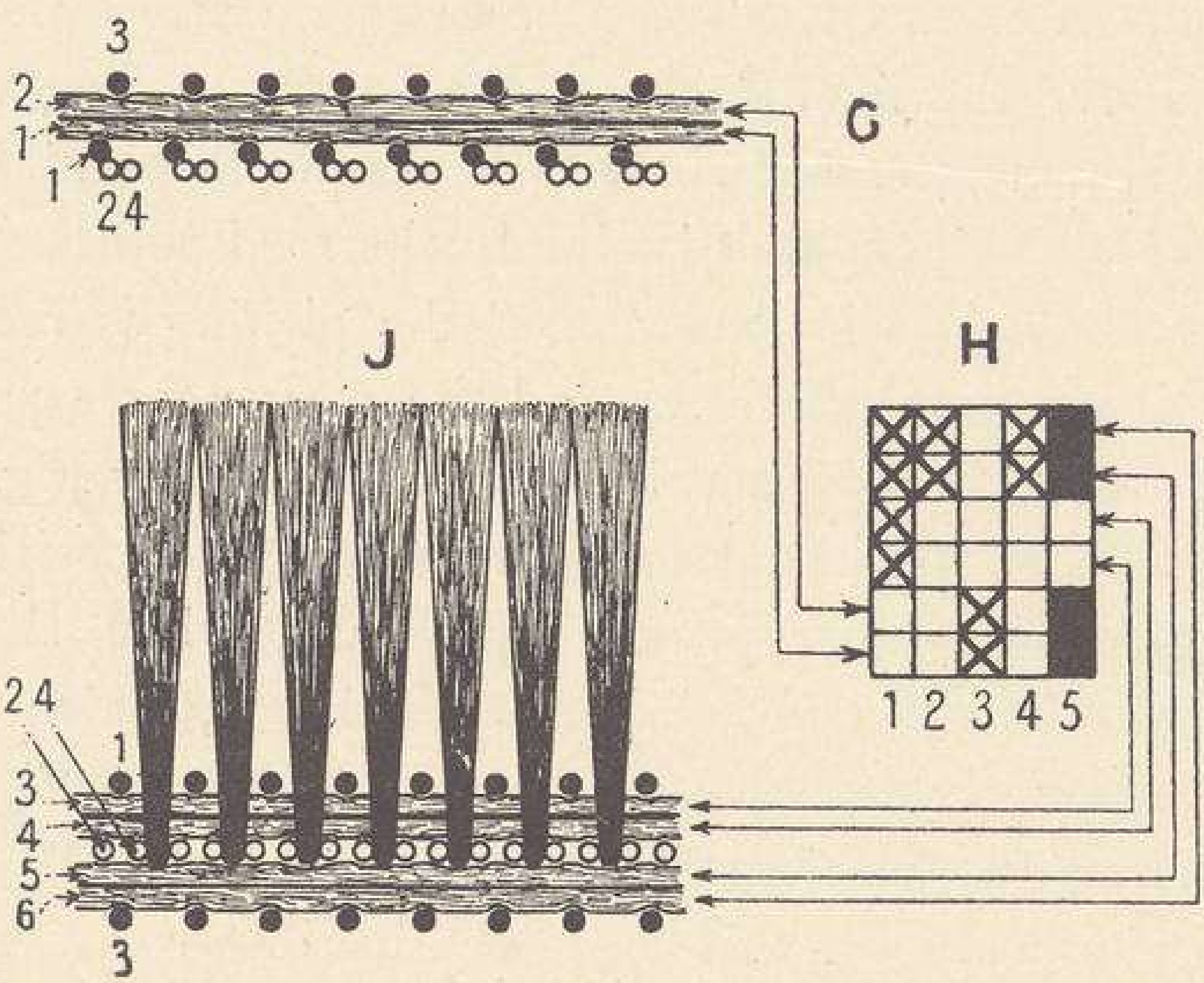


FIG. 244

the double shotting is clearly seen in each sectional view of Fig. 243, where :—

C shows	threads 1, 2 and 4 as well as 5	repeats of weave H, Fig. 244.		
D	,,	2, 3 and 4	,,	,,
E	,,	thread 5 or tufting thread	,,	,,
F	,,	all 5 threads	,,	,,

Threads 2 and 4, being identical in movements, are represented by one thread only in each view, although the 4th thread would naturally appear behind threads 1, 2, and 3, and not in front of all as illustrated.

For 20 units of length of cloth there are required approximately:—

22 units of length of	thread	1,	4/14^s white cotton;
21 „	threads	2 and 4,	4/12^s brown cotton;
42 „	thread	3,	7^s brown flax;
88 „	„	5,	6 skeins wool.

The length of the pile yarn varies in different fabrics according to the length of pile wanted, but it is seldom less than that stated which provides for a pile which rises $\frac{1}{4}$ inch above the foundation of the texture. The weft is 2/7 lbs. brown jute, and since it is practically straight, the length of each single shot is simply the reed width.

In the complete intersection F the picking is reckoned from the left (dotted line A), and the weave corresponding to this order of picking is illustrated at H, Fig. 244. Intersection G in the latter figure shows the positions of all warp threads, except the pile yarn, when the first double pick is inserted, while intersection J, which shows all threads, is taken along the dotted line B, Fig. 243, when viewed in the direction of the arrow.

The pile warp for this type of Axminster is arranged and run on to small beams or wide bobbins with small flanges; each beam is the exact width of the fabric, and the number of beams employed is identical with the number of horizontal rows of tufts in one repeat of the pattern. Each beam contains the same number of individual pile threads, and the colour arrangement of the threads on the different beams corresponds with the order of colouring required in the respective rows of pile from selvage to selvage of the carpet. In extreme cases no two beams will have exactly the same order of colouring, and in most cases a considerable number of beams must, naturally, differ from each other. All the beams are supported at both ends in an endless chain, which is led forward over the loom to a position directly over and parallel to the fell of the cloth, so that the several beams may be presented in succession for the selection of the successive rows on the tufting picks. The movement is somewhat similar to the action of the endless lag chain of an ordinary dobby, but the analogy differs in that, whereas the set of lags remains intact throughout the whole process, the small beams must, in succession, be detached bodily from the chain, and placed, with the pile threads which they contain, near the cloth or shed when their time of selection arrives.. This movement is accomplished automatically by special mechanism, which also replaces the beam in its respective position in the chain. It will thus be seen that the number of patterns which can be woven from these small beams is obtained by dividing the total length of each warp thread on the beam by the length of warp required for each pattern, while the length required for each pattern is the product of the number of pile rows per pattern and the length of each tuft.

Patent Axminster Carpet.—Quite a different method is used for the patent or Chenille Axminster, although it is equally essential to adopt a system which will admit of a free choice of the number and position of coloured yarns in order to reproduce all possible colour arrangements. The preparation and introduction of the pile yarn in Royal Axminster constitute the most difficult operations in the process, and in like manner the corresponding operations in the manufacture of patent Axminster involve the maximum amount of trouble.

Fig. 245 is introduced to demonstrate the chief features of the structure of a patent Axminster.

The binding warps may interweave in various ways in different fabrics of this type, but the preparation of the pile yarn is practically common to all. Although this pile yarn is ultimately introduced into the fabric as weft, it must first be woven in a loom before it can be used as such. Chenille or Patent Axminster is therefore the

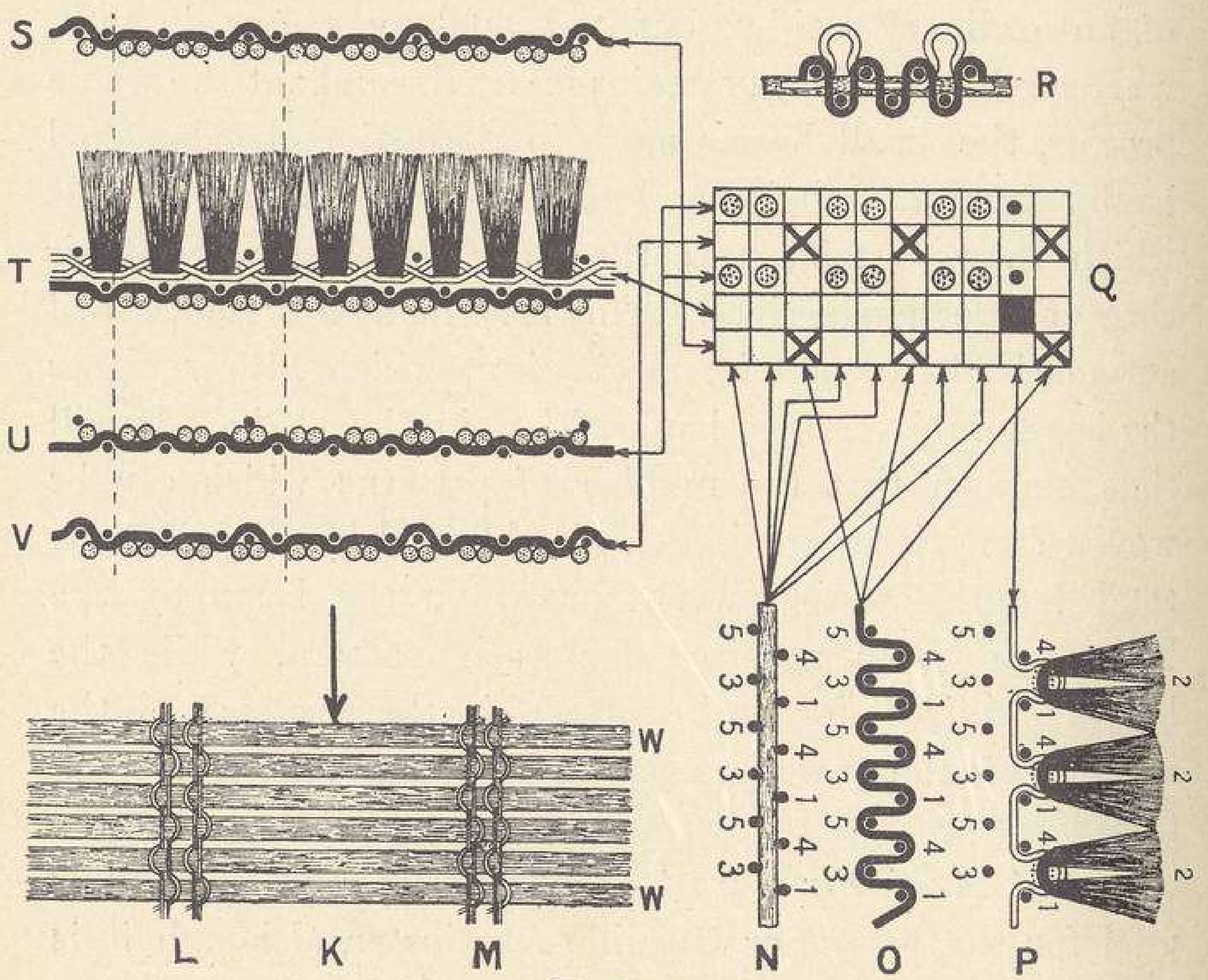


FIG. 245.

result of two perfectly distinct weaving operations. The *modus operandi* for the development of the pile thread, or rather the pile pick, is illustrated at K, Fig. 245. Two groups of six threads each are shown at L and M. In each group four threads weave perfectly plain, and these four threads are locked together by two crossing threads, which are manipulated on the principle known as gauze weaving (see pp. 453 to 476), and therefore take the circuitous path shown. The six threads in group L pass through one split of the reed, and those in group M pass through another split. The two groups, however, are not in adjoining splits, but are separated from each other by a number of splits which occupy a space equal to the total length required to form one complete tuft, which will ultimately appear as shown at 2 in illustration P.

By introducing into an ordinary loom a warp beam containing a series of groups similar to L or M, and by separating adjoining groups in the reed by the desired length, we may clearly insert the weft W, which for simplicity is shown in one colour only. Any length may, therefore, be woven, and when completed the groups may be separated by clipping each weft thread along a line indicated by the arrow in illustration K. When so separated each group of six threads holds, and is in the middle of, a quantity of short weft shots, each about $1\frac{1}{4}$ inches long, which form a kind of double fringe. The projecting fringes are then bent upwards by grooved rollers until they assume the form shown in the three groups in illustration P. Here the six threads in each group appear at the bend—in illustration K, four threads out of the six appear at the top, but in illustration P they are at the bottom; they may clearly be either way in practice, but they have been arranged as illustrated for convenience. The number of threads in each group may be fewer than six, and it may or may not include crossing threads.

Now if all the weft used were of the same colour, the tufts would, naturally, be of one shade, and the process of weaving them would be of the simplest possible nature. Such extreme cases are, however, seldom attempted unless for self-coloured curtains and similar chenille fabrics; the more usual plan is to introduce five, six or more colours, in which case it is necessary to change shuttles repeatedly, at predetermined intervals according to pattern, in order to introduce the proper colours of weft. The order of colouring along every group L, M, . . . etc., would be the same, and each group would be identical with the colouring in the carpet as obtained by following the picks of weft of the design from left to right, then right to left, and so on until every pick of the design had been passed over. The effect of this to-and-fro movement along the picks has its counterpart in the pile thread or pick as it follows the shuttle from selvage to selvage and back again until the full pattern is woven. One complete colour arrangement therefore extends for a considerable length; indeed the length must be, in every case, the product of the reed width and the number of pile picks per pattern. With four tufts per inch, the length of woven pile required for each square yard of carpet would be :—

$$\frac{4 \times 36 \times 36}{36} = 144 \text{ yards.}$$

Three to six tufts per inch are common numbers, and these determine the outline of the pattern along the piece. More liberty is given in the outline from selvage to selvage, and when comparatively fine divisions are required, each weft line W, in illustration K, Fig. 245, may consist of two or more separate shots. Sharper contours may therefore be obtained. Perfect rectilinear lines may be produced in the way of weft, but it is difficult, indeed almost impossible to produce similar perfect lines in the way of the warp.

The chenille is obviously a cumbersome form of thread to be manipulated as weft, but ingenious contrivances are now in vogue for inserting this weft mechanically. The operation is, however, often performed manually, the weaver inserting by hand the weft, which has been previously wound on pegs, laths, or cops. As already mentioned, this pile yarn is laid on a strong foundation, the structure of one kind of which will be gathered from the intersection R, Fig. 245. This shows one of each kind of the warp threads in position, as well as seven picks; the two pile picks are, however, omitted. The three threads shown in this view are the last three threads of design Q viewed from the right-hand side. In all ten threads are required, six of which are of one kind forming the body of the structure, three of another kind for the foundation binders, and one for binding the chenille. The lines from the weft intersections N, O and P to the design Q show the respective positions of these threads. Intersections S, T, U, and V, which represent all five picks (3rd and 5th are identical) and 31 threads, indicate the positions when viewed on the successive picks; while the part enclosed by the dotted vertical lines embraces the ten threads which appear in the design Q. Intersection T is the most important since it shows how the chenille pick is placed on the foundation structure; it also shows the position of the chenille binder when it is over the chenille pick. In the chenille pick itself the gauze or crossing threads are omitted, but the remaining four plain threads are shown gripping the tufts.

Suitable particulars for the above-mentioned fabric are as follows:—

Warp: Referring to design Q.	The Order in Loom.
2 threads 3/5 lbs. brown jute.	1 thread 3/5 lbs. brown jute.
1 thread 10^s flax.	1 „ 10^s flax.

Warp: Referring to design Q.	The Order in Loom.
2 threads 3/5 lbs. brown jute.	2 threads 3/5 lbs. brown jute.
1 thread 10^s flax.	1 thread $5/12^s$ brown cotton.
2 threads 3/5 lbs. brown jute.	1 ,, 10^s flax.
1 thread $5/12^s$ brown cotton.	2 threads 3/5 lbs. brown jute.
1 ,, 10^s flax.	1 thread 10^s flax.
	1 ,, 3/5 lbs. brown jute.

Cloth length	= 20 units.
Length of jute stuffer thread (3/5 lbs.)	= 20 ,,
,, flax binder ,, (10^s)	= 40 ,,
,, cotton chenille binder ($5/12^s$)	= 25 ,,
,, weft	= 20 ,,

16 picks per inch in ground ;
4 chenille picks per inch ;
9 binding threads per inch ;
18 stuffer threads per inch.

CHAPTER XX

TURKISH TOWELLING, OR TERRY FABRICS

ALTHOUGH the term "terry" may be used to designate any fabric on the surface of which a pile of uncut loops has been formed, it is usual, on account of the great diversity of looped fabrics, to apply the term solely to those in which the loop is formed in the loom without the aid of wires. Such fabrics almost invariably go by the name of Turkish towelling or terry cloths.

The production of a terry pile fabric depends partly upon the weave structure, as do all other fabrics, but chiefly upon a variable movement given to the reed every few picks, and upon a difference in the tension of the ground and pile warps. The two distinct warps, which are essential for the manufacture of terry pile fabrics, interweave with the same weft in many different ways, and the usual sequence of weaving operations, which is general for most types of terry cloths, will be explained

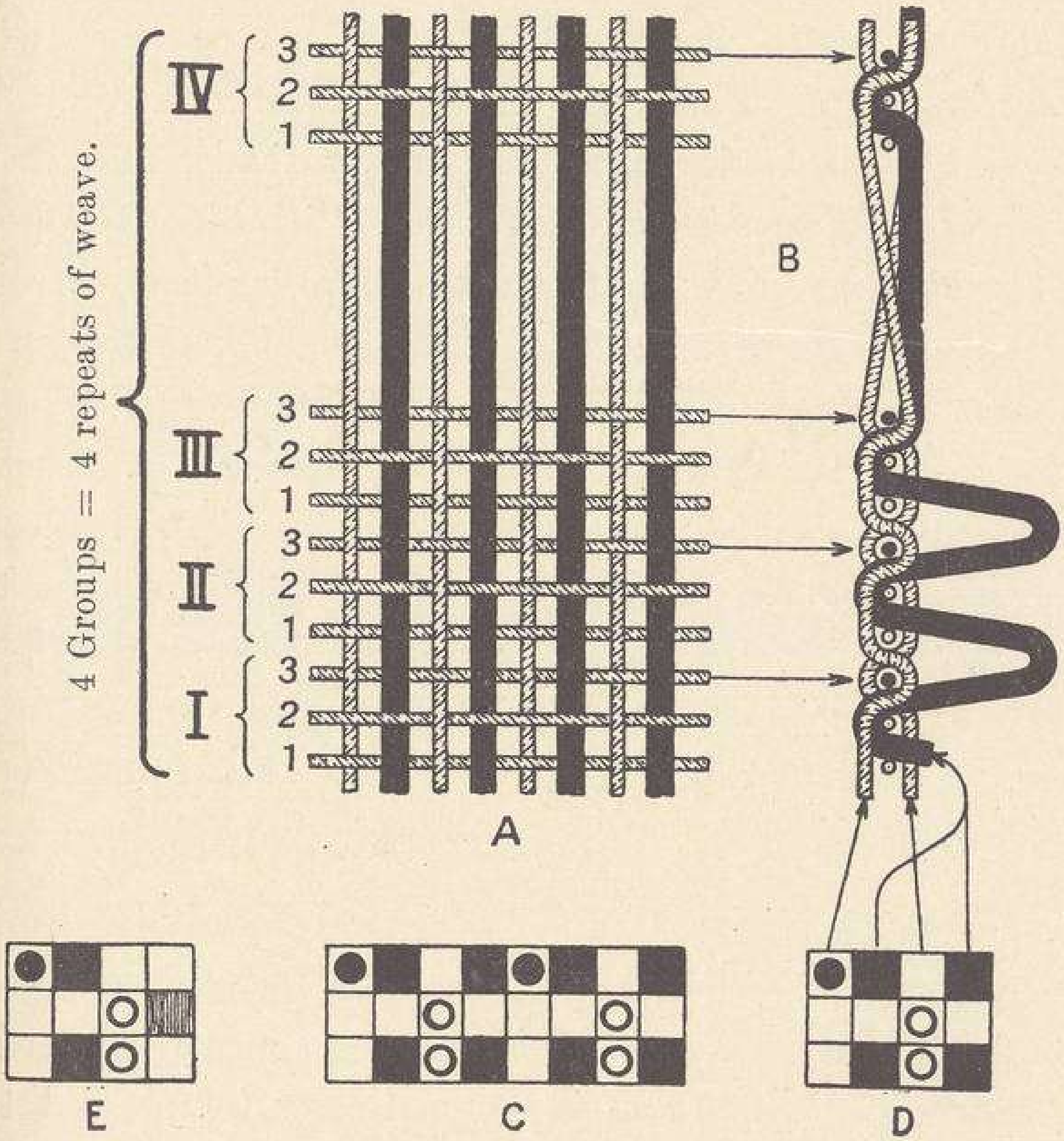


FIG. 246.

briefly in conjunction with the description of Fig. 246. This figure illustrates a 3-pick terry, in which all the pile appears on one side of the cloth. Few fabrics are made exclusively in this manner, but the figure illustrates the principle of terry weaving with fewer parts than are necessary for the description of a fabric in which the pile appears on both sides.

Illustration A is a plan of a fabric in which there are nine equidistant picks interweaving with eight threads, and forming three repeats of the weave in groups I., II., III.; a similar group of three picks is shown at IV., but these picks are separated from the other groups by a long gap B. Plan C shows two repeats of the weave in the way of the threads, while plan D is the unit weave from which the arrows point to the threads in the intersection. The solid black marks indicate the pile threads, and it will be seen that these threads are formed into loops opposite nine equidistant picks, but that they are perfectly straight between the last of these and the first pick of group IV. The last pick shown in group III. represents the fell of the cloth, and the three picks in group IV. must be beaten up together to join the other groups already in position. It is during this beating up process that the straight pile threads, extending over gap B, are caused to double up and to form loops similar to the others. Clearly then the reed has two functions to perform:—

1. To move picks 1 and 2 forward only a limited distance in order to leave the gap B; and
2. After pick 3 has been inserted to move forward its normal distance, as in an ordinary loom, and thus beat up all three picks to the fell of the cloth.

When the reed makes its minimum journey and leaves the pick a short distance from the fell, the loom makes what is termed a "loose pick"; but when the reed moves its maximum distance and reaches the fell of the cloth the pick is termed a "fast pick." (In all these intersections on terry weaving the fast picks are indicated by solid marks.) In Fig. 246 the first two picks of each group are "loose picks," but the third pick is a "fast pick"—indicated as above, and also by arrows from the plan—when the reed, held rigidly, moves forward the full distance of its travel, and pushes in front of it the three picks last inserted to meet the cloth already formed. As these three picks are being carried forward by the reed, they slide along the highly tensioned and dressed ground threads, and carry forward with them the lightly tensioned pile threads which double up, as shown, to form loops.

As previously stated, this illustration has been

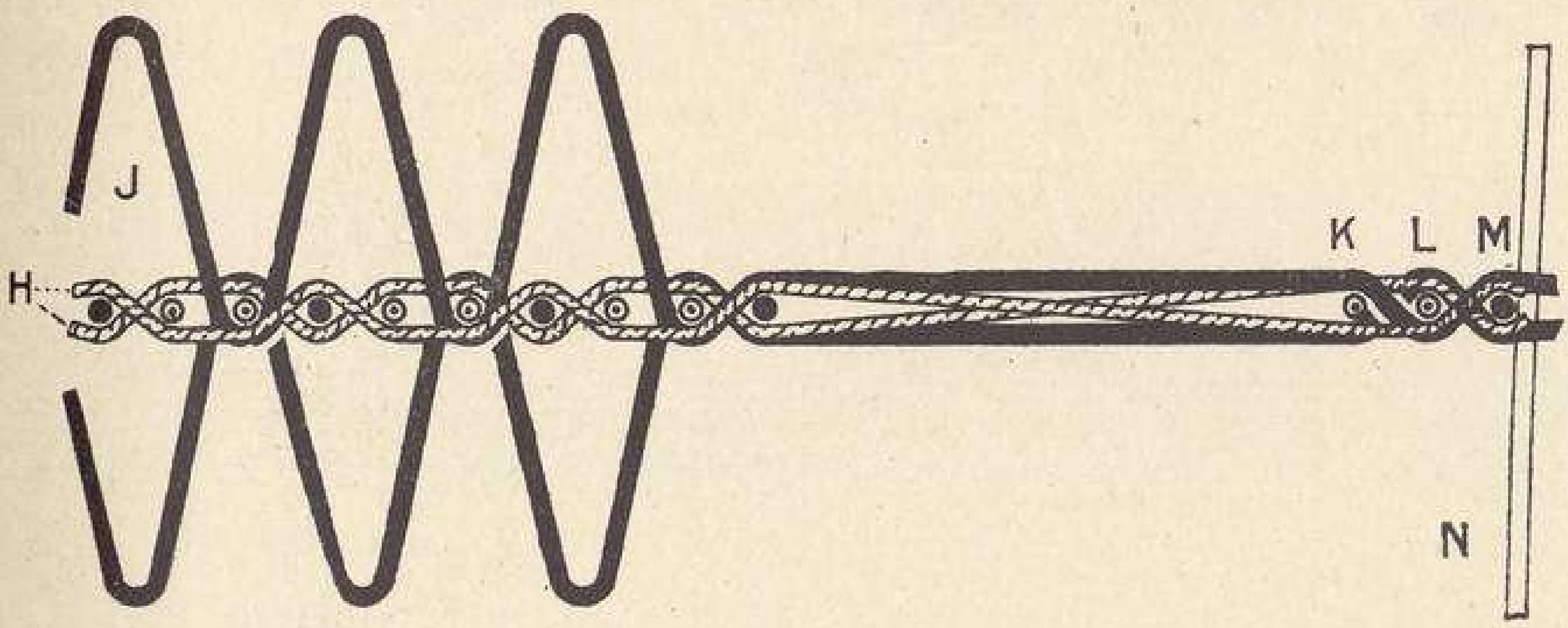
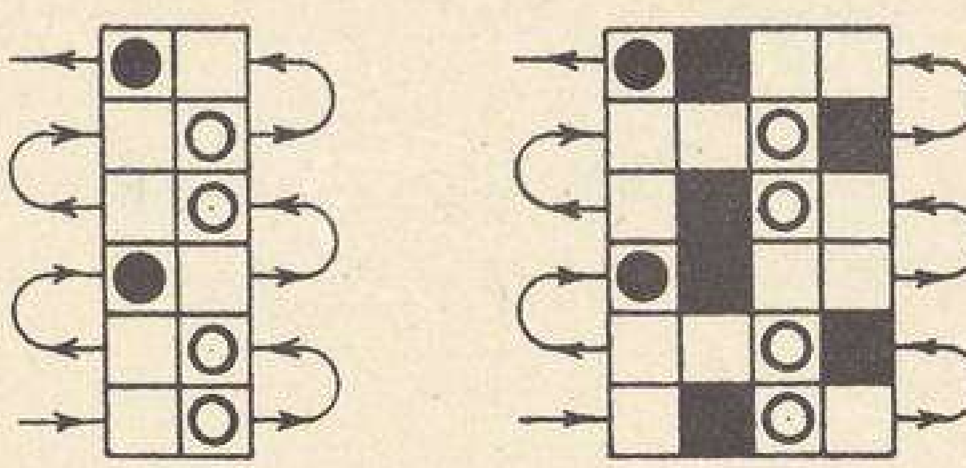


FIG. 247.

introduced mainly to show the principle involved; if, however, we arrange the weave so that the pile threads cut with each other, as do the ground threads, we shall obtain design E. The first three threads would be identical with those in intersection D, but the 4th thread would form loops on the under side of the fabric, and the structure would then be similar to the section illustrated in Fig. 247. This is the structure which obtains in the simplest type of terry fabrics, and it is evident that four leaves and three picks only are required for its manufacture. It is obvious, however, from design F, Fig. 248, that satisfactory selvages cannot be made with the ground shafts alone, because the weft would return in the same shed twice in every six picks, or once from each selvage. A suitable though slightly imperfect selvage may be made if a few threads from the extreme edge of the ground warp be drawn through the four shafts; this will be apparent from design G. It will be understood that continuous terry weaving would produce cloth suitable for roller towelling, but if hand towels are required with headings or cross borders, extra tension must be placed on the pile threads at these parts, and the reed made to travel its full distance every pick. Coloured picks of various yarns and counts may also be introduced, and ordinary weaving may alternate with pile weaving to give variety to the border; coloured threads may also be used to form stripes, but no choice of weave or structure is permissible in these simple cases beyond that of the alternate use of pile and ordinary weaving.



F G

Fig. 248.

It will be observed that the ground warp threads H in Fig. 247 work $\frac{2}{1}$ and $\frac{1}{2}$, but at different times to the similar movements of the pile threads J; the latter cross between the two "loose picks" K and L, but the former do not cross at this time. This arrangement enables picks K and L to grip the pile yarns firmly, and thus facilitate the formation of the loops when the three picks are beaten up by the reed N on fast pick M.

In Fig. 249 the design, draft and weaving plan are given for the usual 3-pick terry arranged to form equal pile on both sides of the cloth, and for a one-thread pile to one thread ground order of drafting. Nine shafts are necessary for the draft given, four of the nine being extra or skeleton shafts for selvage work only; but for the

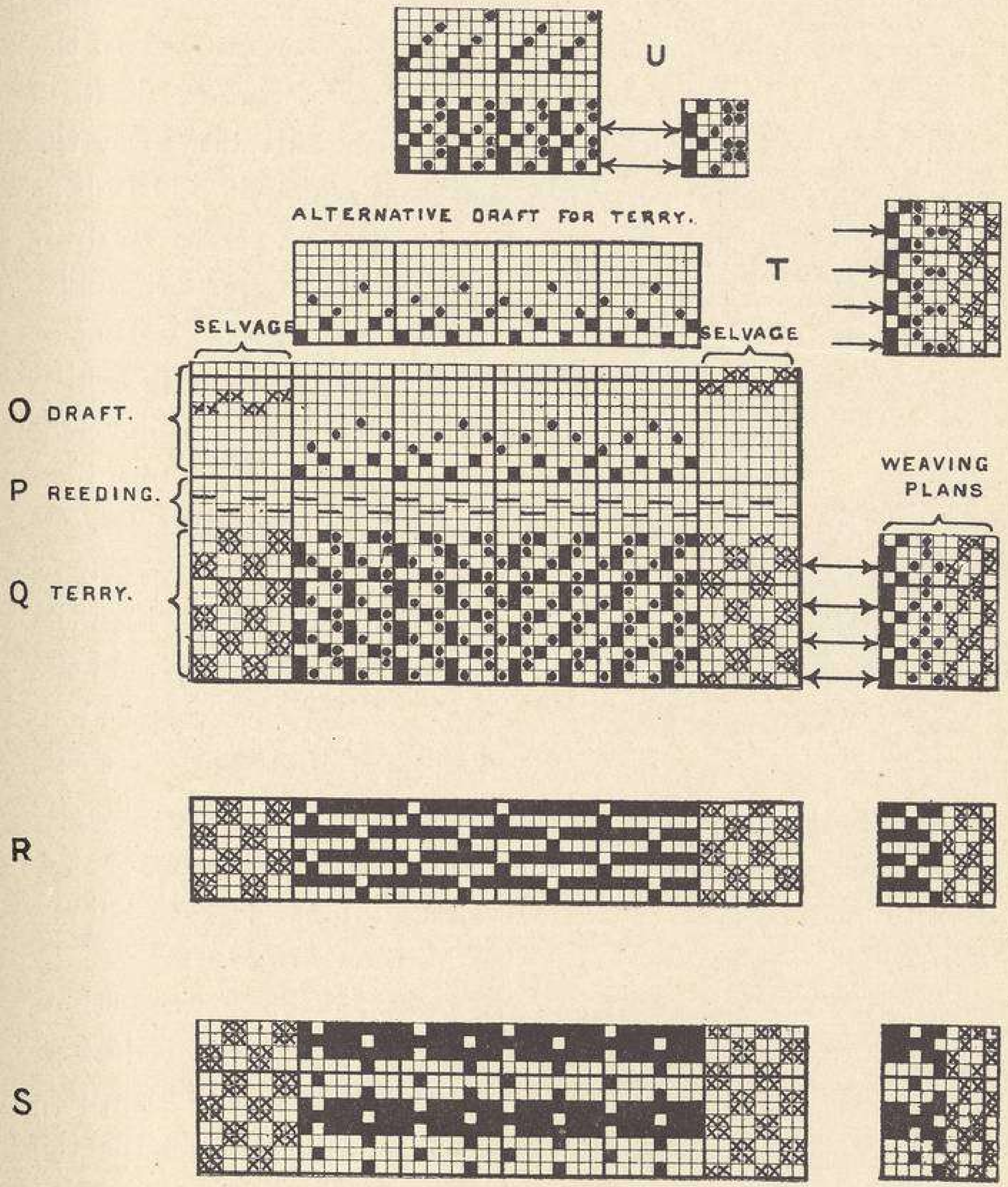


Fig. 249.

simple terry design illustrated at E, Fig. 246, four shafts only are required—two for the pile warp and two for the ground warp. When this type of terry is woven in a dobby loom, it is customary to employ five leaves for the body of the cloth, and to draw the threads as shown by draft O, Fig. 249, so that a further variety of shedding may be obtained when it is necessary to insert the headings or cross borders of individual towels. With regard to the draft given it will be observed that, as arranged, shafts 3 and 5 carry only half the number of threads taken by the other three shafts; they are therefore knitted only half as fine as shafts 1, 2 and 4. By adopting the alternative draft and weaving plan T, these two coarsely knitted shafts become Nos. 4 and 5, and are therefore placed together at the back of the camb. In practice the three shafts which operate the ground threads are invariably in this position, the pile warp being drawn on the shafts nearest the reed so that the best shedding results may be obtained. Eight threads only are shown at each selvage, but twelve or sixteen may be used according to requirements. Since the weave of the selvage portion repeats on four picks, and the terry weave repeats on three, both must be extended to twelve picks at least if the shedding operations are to be controlled by a dobby. Suitable weaves for cross-border purposes are shown at R and S arranged to suit the draft O. The picks which are beaten up by a rigid reed are indicated in design Q by double-headed arrows.

Terry warps are usually arranged in equal proportions of pile and ground threads, although they may be drafted either 1-thread pile, 1-thread ground as shown, or 2-threads pile, 2-threads ground. The former order is perhaps the more widely adopted, although the latter gives equally satisfactory distribution of the pile in the finer setts, and has certain practical weaving advantages to commend it. In the 1-and-1 arrangement, one pile thread and one ground thread are drawn together in one split of the reed, but in the other method two pile threads are in one split and two ground threads in the next, and so on. Now terry weaves are so arranged that the two pile threads forming a pair work in opposition, a method of working which also applies to each pair of ground threads. But a pile thread and a ground thread, forming a splitful, sometimes shed in the same direction, and sometimes in opposition, with the result that the highly tensioned ground thread has a tendency to prevent the free movement of the lightly tensioned pile thread in the same split. By the 2-and-2 method of drafting, pile and ground threads are separated by the reed wires, while each pair of pile threads, as well as each pair of ground threads, is in turn separated by the shedding apparatus, thus enabling a fairly open shed to be presented for the passage of the shuttle. The actual draft of the warp is also materially simplified for both drawer and weaver, as will be evident on reference to U, Fig. 249, where this alternative method is shown.

When the 1-and-1 order of drafting is adopted it is usual to arrange the warps as follows:—

> 1-thread pile, 1-thread ground to the centre of cloth; then
> 1-thread ground, 1-thread pile to the other selvage.

Design Q, Fig. 249, is so arranged—the pile threads being first for half the width, then the ground threads are first. This is done also to avoid a further tendency which the tight ground threads have of controlling the loose pile threads. It is well known that warp threads under tension, and particularly those near the selvages, have a distinct tendency to pull towards the centre of the cloth, and thus to bear against the inner reed wire of the split through which they pass. If the pile threads are drawn to occupy the outer position in each split on both sides of the centre of the reed, they will, in all probability, have greater freedom of movement, and be less liable to be influenced by the highly-tensioned ground threads than if they are drawn in the same order throughout.

Cross borders may be of different types, but the following arrangement with reference to Fig. 249 gives a fairly good effect.

18 picks (weave S) single Turkey-red cotton weft;
About $1\frac{1}{4}''$ (terry weave Q) usual weft, with reed rigid and pile warp beam under tension giving ordinary cloth;
30 picks (weave S) heavy twist cotton weft;
18 „ („ S) single Turkey-red weft;
24 „ („ S) heavy twist cotton weft;
18 „ („ S) single Turkey-red weft;
30 „ („ S) heavy twist cotton weft;
About $1\frac{1}{4}''$ (terry weave Q), usual weft, reed rigid and pile beam under tension.

Total length of border about 5 inches. A good average sett is about 55 threads per inch in the reed; 25^s lea linen for both pile and ground warps; ordinary weft 12^s to 16^s cotton; about 35 shots per inch in terry portion, and 50 to 60 shots per inch in plain portion of borders. In some cases the number of picks per inch is practically the same throughout, but these proportions may be varied, between limits, by the proper control of the uptake motion. If desired, weave R, Fig. 249, may be substituted for weave S in the Turkey-red portions of the border. In the cheaper grades it is customary to use single waste cotton weft in place of the heavy twist cotton in the cross borders. Terry pile is also introduced into the borders for the sake of variety.

Most pile fabrics of this character are developed entirely in cotton yarns, although a considerable number of all linen towels and of union towels in cotton and linen are made. When developed as unions these so-called Turkish towels may have the ground warp and the weft cotton, and the pile only linen; or both warps may be linen and the weft only cotton; or again, ground warp only may be cotton and the pile warp and the weft linen. Cloths produced on this principle are very full, and, on account of the looped and comparatively loose nature of their surface, are eminently suitable for bath and other towels, where the power of absorbing moisture is essential, and where a semi-rough surface is desired.

In terry weaving it is, in general, only necessary to put in two "loose picks" in succession, viz. the last pick of the float which is to form the loop, and the succeeding pick or that which binds the pile warp with the weft (see K and L, Fig. 247). Any further picks in the repeat of the weave are usually for the formation of the ground cloth, and for further binding purposes; these "fast picks" must be beaten up with a rigid reed. Terry weaves are few in number, and are designated 3, 4, 5, or 6-pick terrys, according to the number of picks contained in each horizontal row of loops. By far the greater portion of these fabrics is made in the above described 3-pick terry, the other weaves being used only when it is desired to make heavier and firmer fabrics with the pile in some cases exceptionally well bound into the body of the cloth. It is necessary to observe, however, that while a firmer fabric may be made by increasing the number of picks per row of loops, the density of the pile or the rows of loops per inch will be correspondingly reduced unless the number of picks per inch be increased in proportion.

4, 5 and 6-pick terrys differ only slightly from those on three picks. In the 4-pick variety the pile warps work in opposition to each other in $\frac{3\ \ }{\ \ 1}$ and $\frac{\ \ 1}{3\ \ }$ order, while the ground warp may be either $\frac{2\ \ }{\ \ 2}$ and $\frac{\ \ 2}{2\ \ }$, or $\frac{3\ \ }{\ \ 1}$ and $\frac{\ \ 1}{3\ \ }$ in opposition. Fig. 250 illustrates the design, weaving plan, and intersection of the 4-pick terry with the 2-and-2 ground weave. The weaving plan, which shows two repeats like the design, is arranged for the draft given in

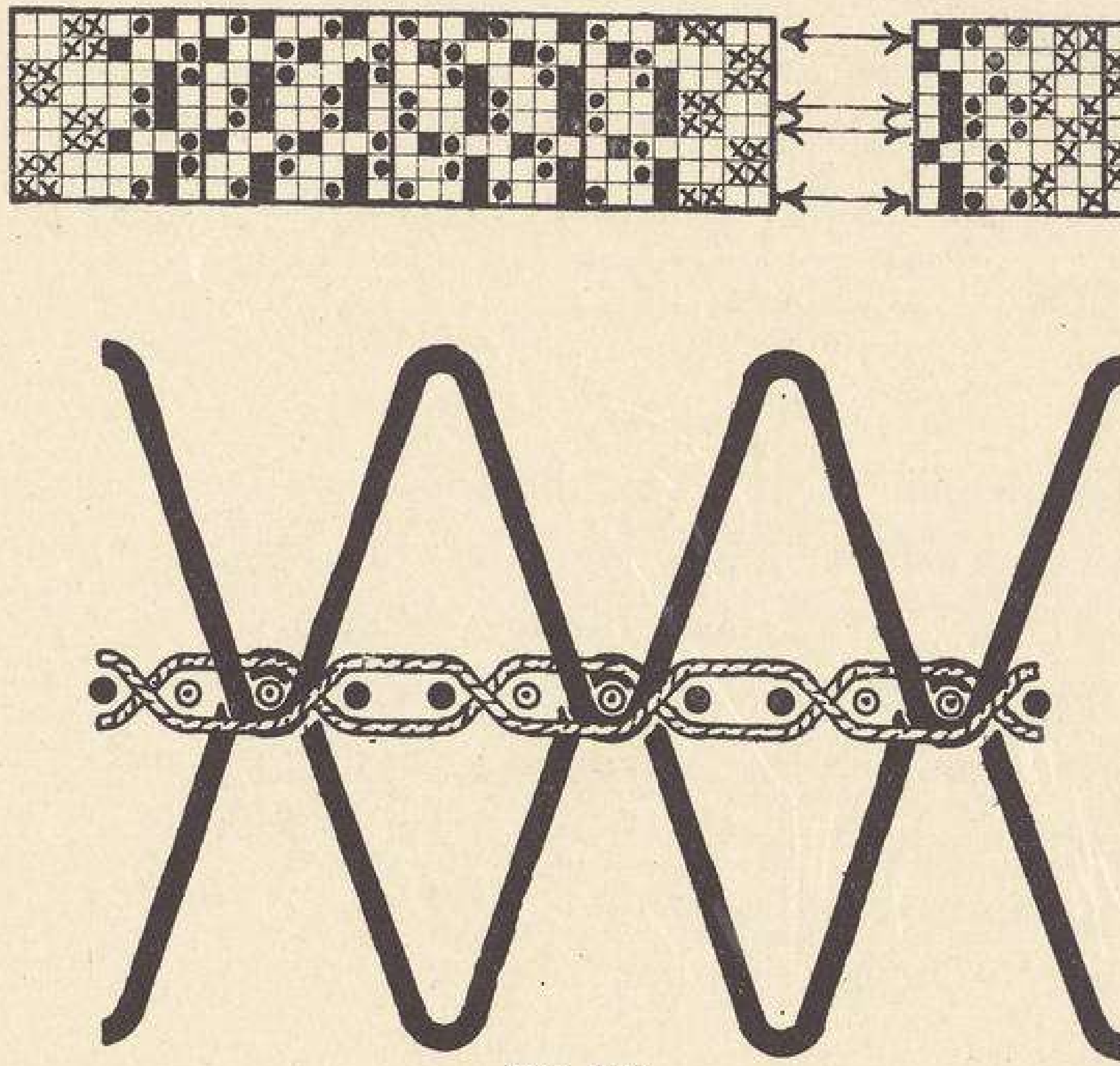


Fig. 250.

Fig. 249. When the 2-and-2 order is adopted for the ground warp it is possible to dispense with two of the selvage skeleton shafts suggested in that draft, since the selvage threads at one side could be drawn upon, and controlled by the shafts which operate the ground warp. Double-headed arrows again show the picks which are beaten up by the rigid reed, and solid black circles in the intersection show that two fast picks alternate with two loose picks.

The 4-pick terry with the 3-and-1 order of ground and pile weaving is illustrated in Fig. 251 in exactly the same manner as Fig. 250 illustrates the 2-and-2 order. With the 3-and-1 order, however, all four selvage shafts are necessary if the 2-and-2 basket or matt order is desired for selvage weave. From the weaves illustrated in Figs. 250 and 251 it will be seen that special

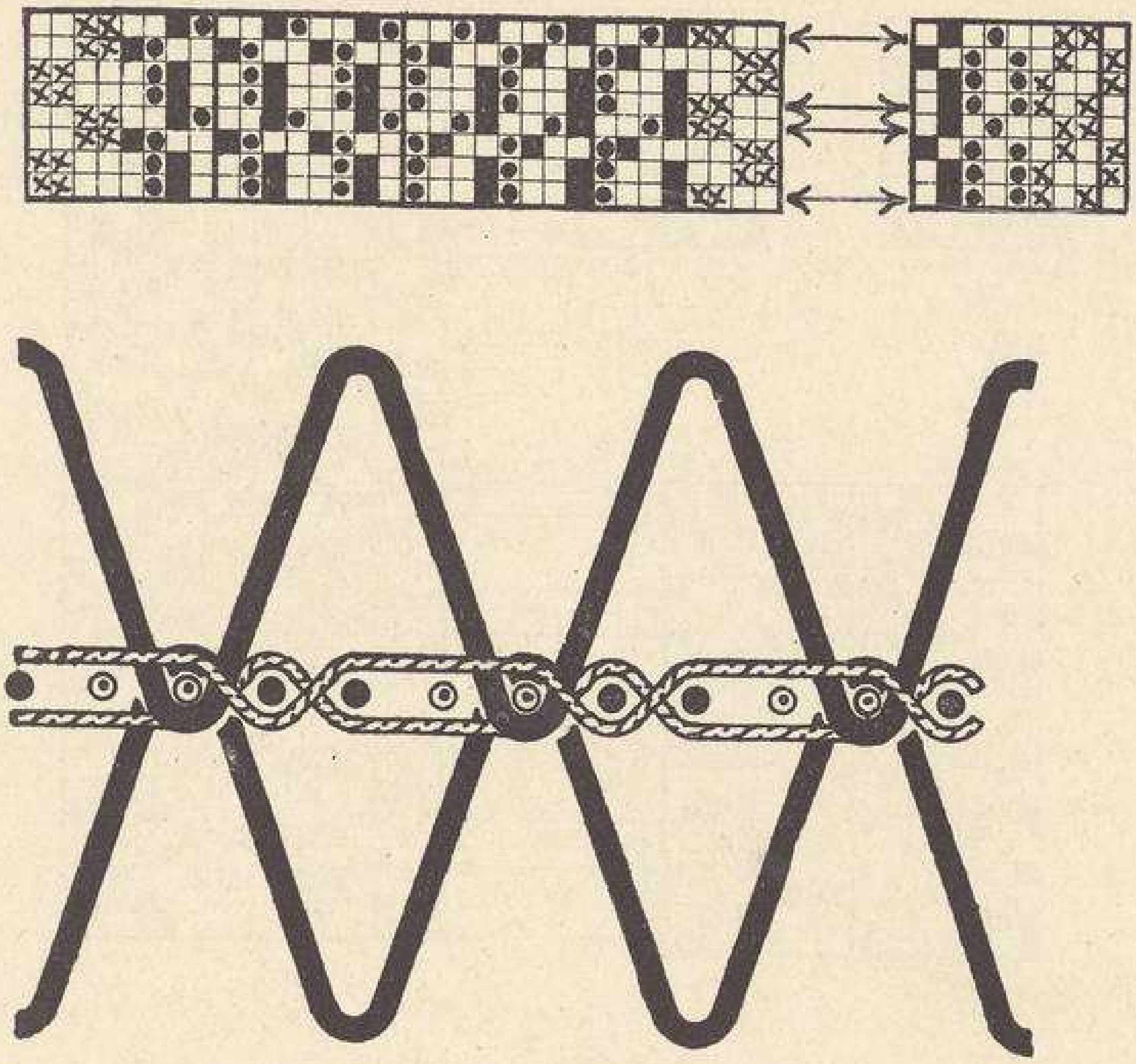


FIG. 251.

provision must be made for the selvages, seeing that in the former the 1st and last, or the 4th and 5th picks of the terry portion are alike in every respect, and in the latter the 1st and 2nd picks are identical. Catch bands might, of course, be used, but it is preferable to use the basket weave as illustrated and to arrange the picking to suit the shedding. As the designs are arranged the first pick in each case should travel from left to right.

Five-pick terrys are usually woven, both ground and pile warps, in the $\frac{2}{1}\frac{1}{1}$ order, arranged as usual in opposition as indicated in the design base V, Fig. 252. Two repeats of the weave are given, and the "fast picks" are again indicated by arrows. Although this weave may be used for ordinary piece goods and towellings, its most important application is in the manufacture of bed covers,

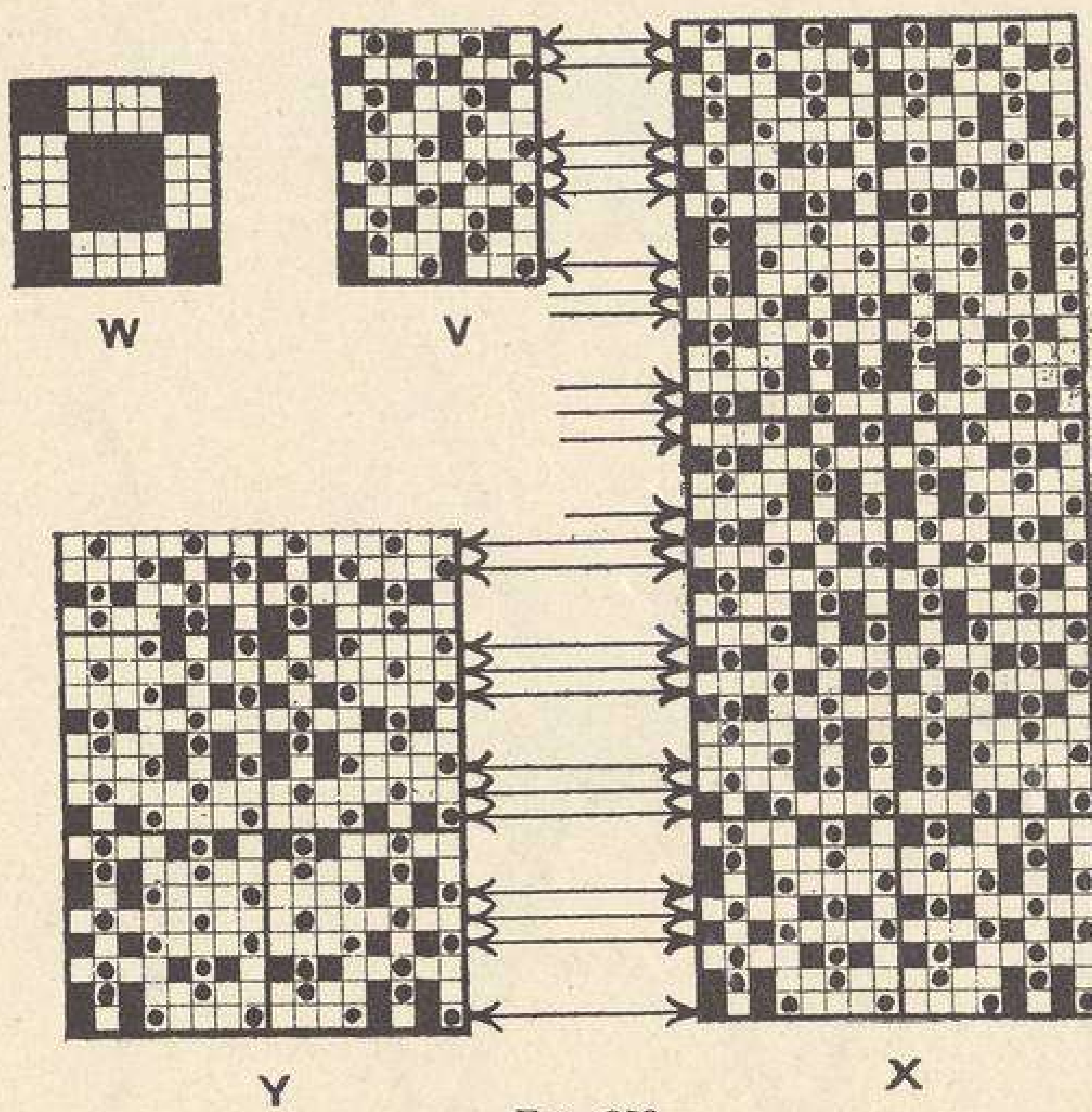


Fig. 252.

furniture cloths, and other fabrics which are figured on both sides by means of a terry pile on a plain or bare ground. For this purpose only 1-pile warp is necessary, since all pile threads loop simultaneously, but the side of the fabric on which the loops will be formed is determined by the jacquard which controls the pile warp. Ground warp threads work throughout in the same order, and may therefore be controlled by two or three shafts in the usual way. This feature sets the jacquard free to control pile threads only, and reduces the preparation of designs to form or outline alone. Card-cutting is, in consequence, materially simplified, since all pile threads, which are to loop on the top side of the cloth, work exactly alike; in a similar manner all those which are to loop on the under side also work alike, although in opposition to those looping on the top side. The cards will therefore be cut solid in some parts and missed entirely in other parts, according to the design. Five cards will be required for each horizontal row of the design paper for an ordinary full harness jacquard. At W, Fig. 252, a small motive or design is given as it would appear for jacquard work, while its full thread by thread and pick by pick working is shown at X.

In some cases the terry structure shown at X is modified in that the pile threads when looping at the back of the fabric interweave with the weft in $\frac{1}{4}$ order instead of in the order given at X. If the $\frac{1}{4}$ order be desired, no modification of the design as prepared for card-cutting is necessary, but the card-cutter will require to be instructed to the effect that threads forming pile on the under side are to be lifted only on the second loose pick of each repeat of the terry motion. This result is indicated in detail at Y, Fig. 252, which shows the lower half of the motive W developed in the modified form.

There are several 6-pick terrys, but practically only one of note, viz. that shown in design form and in section in Fig. 253, and generally known as the "Osman." As far as design, draft and weaving of the shafts are concerned, it is practically identical with the 3-pick terry illustrated in Fig. 249. The reed control, however, is different, in that there are four fast picks and two loose picks, as shown by double arrows. This arrangement causes the pile warp threads to be much more intimately woven into the ground fabric as shown in the sectional view, and is the chief reason for this modification of the ordinary 3-pick terry.

Without entering into a description of the different methods of controlling the backward swing of the reed when in the so-called "loose" position, for the purpose of

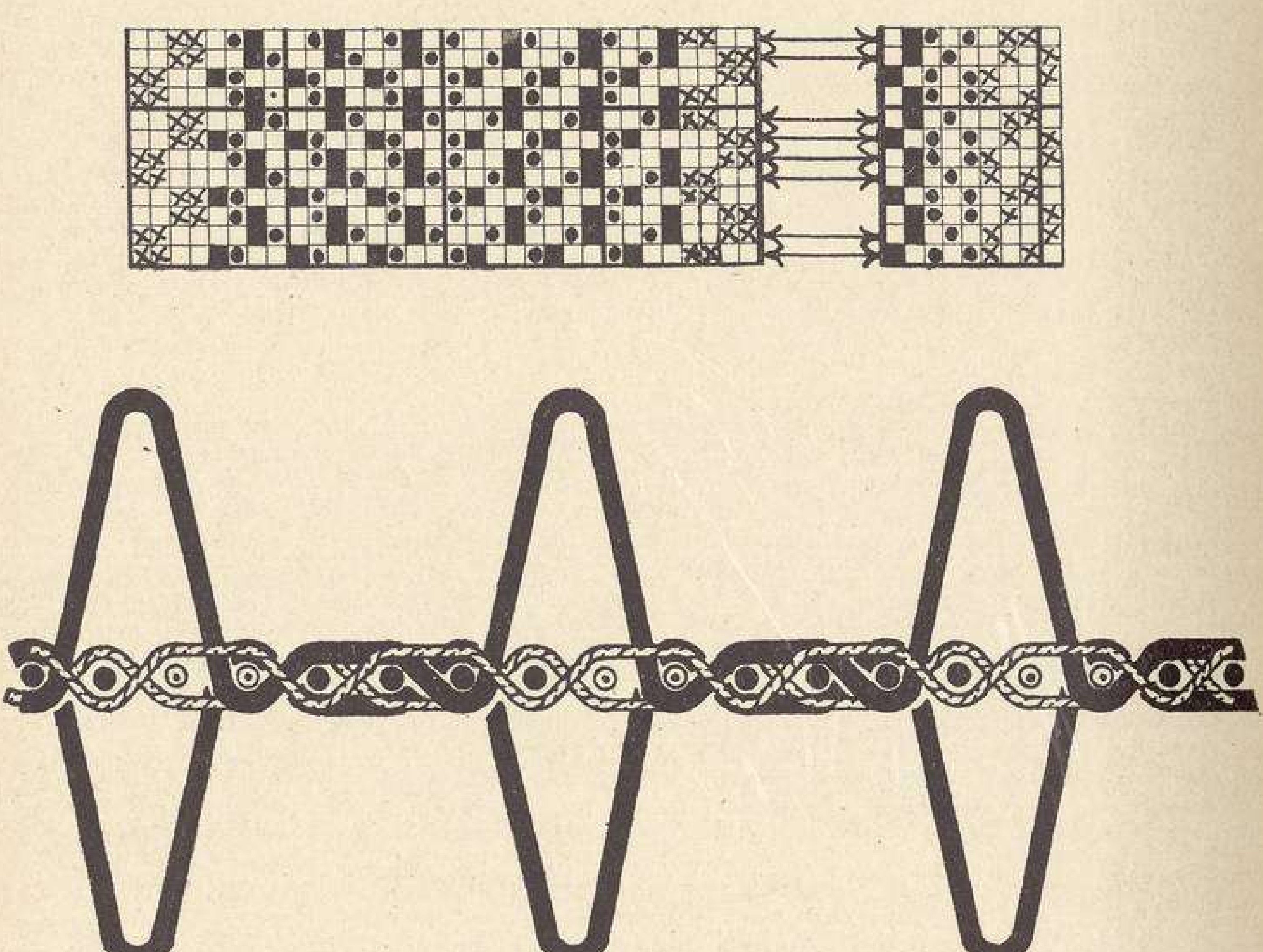


Fig. 253.

determining the length of the pile to be formed, it is sufficient to say that in most terry looms this may be regulated at will, so that the pile warp required may be varied in length from about four times to eight or nine times the length of the ground warp. In practice, however, it is not unusual to determine whether the pile is a satisfactory length by the weight of the first piece or of the first dozen towels woven, as the case may be.

CHAPTER XXI

WEFT PILE FABRICS

A CASUAL glance reveals very little difference between certain kinds of warp pile and weft pile fabrics, although the two methods of weaving and of pile development are quite distinct. In general the weft pile textures are made of comparatively cheap materials, and the pile itself is as a rule shorter than that of the better class warp pile and plush fabrics. When the pile is formed of cotton weft—which is invariably the case with the short weft piles—the fabric is termed a "velveteen." These weft pile cloths are woven in the loom in the ordinary way with a single weft, certain picks being intimately bound with the warp to form a ground fabric, while others are less securely stitched at longer intervals. Afterwards the long weft floats are cut, either by hand or by machine, to form a projecting pile. When cut by machinery, one or more rows or races may be cut at the same time—usually one for the sake of accuracy—and the cutting is more rapidly done than by hand. Hand-cutting is, however, extensively practised, and probably always is employed for the very long weft pile such as obtains in imitation lambskins and similar fabrics.

The method employed in the manufacture of velveteens will probably be more clearly understood by a reference to Fig. 254, which shows parts of a very simple structure. This example is introduced specially to demonstrate the principle, the usual velveteens being somewhat different. Two repeats of the complete weave for this fabric appear at D in Fig. 255, the first three picks of which are shown

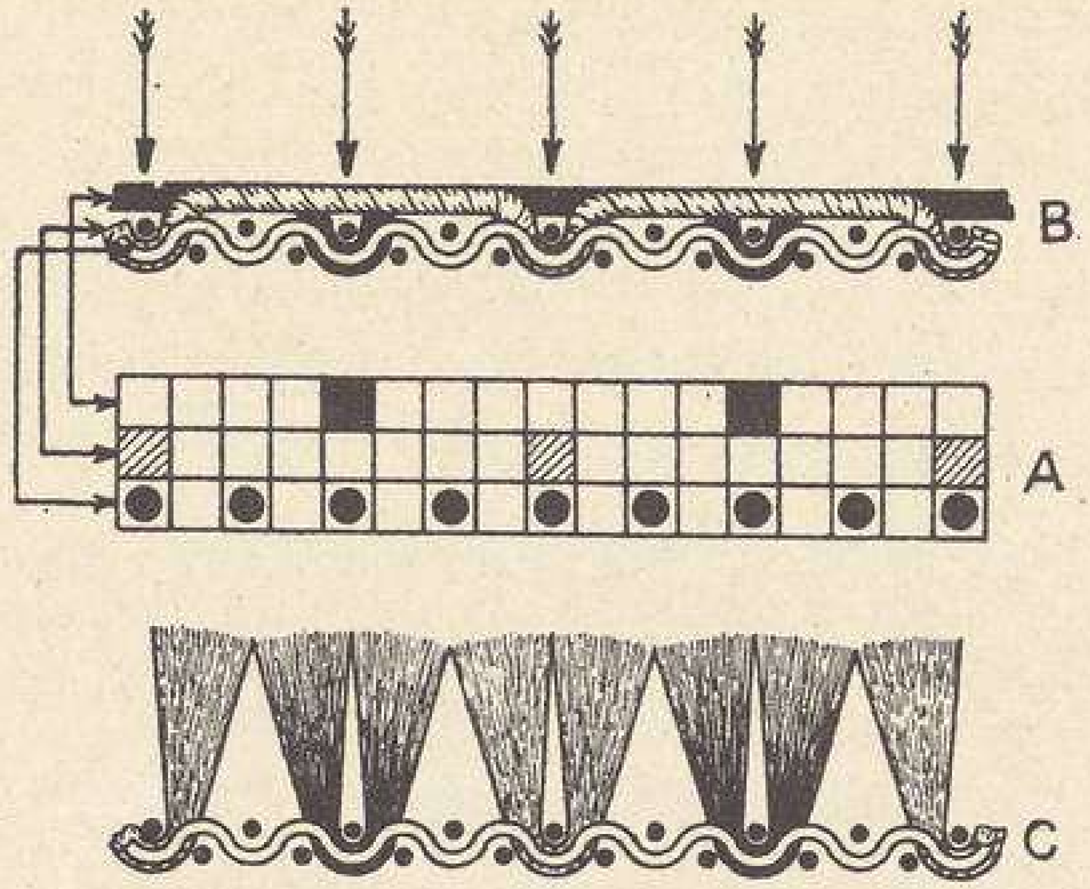


FIG. 254.

at A in Fig. 254. These three picks, before they are cut, are shown at B; the long floats, indicated in distinctive

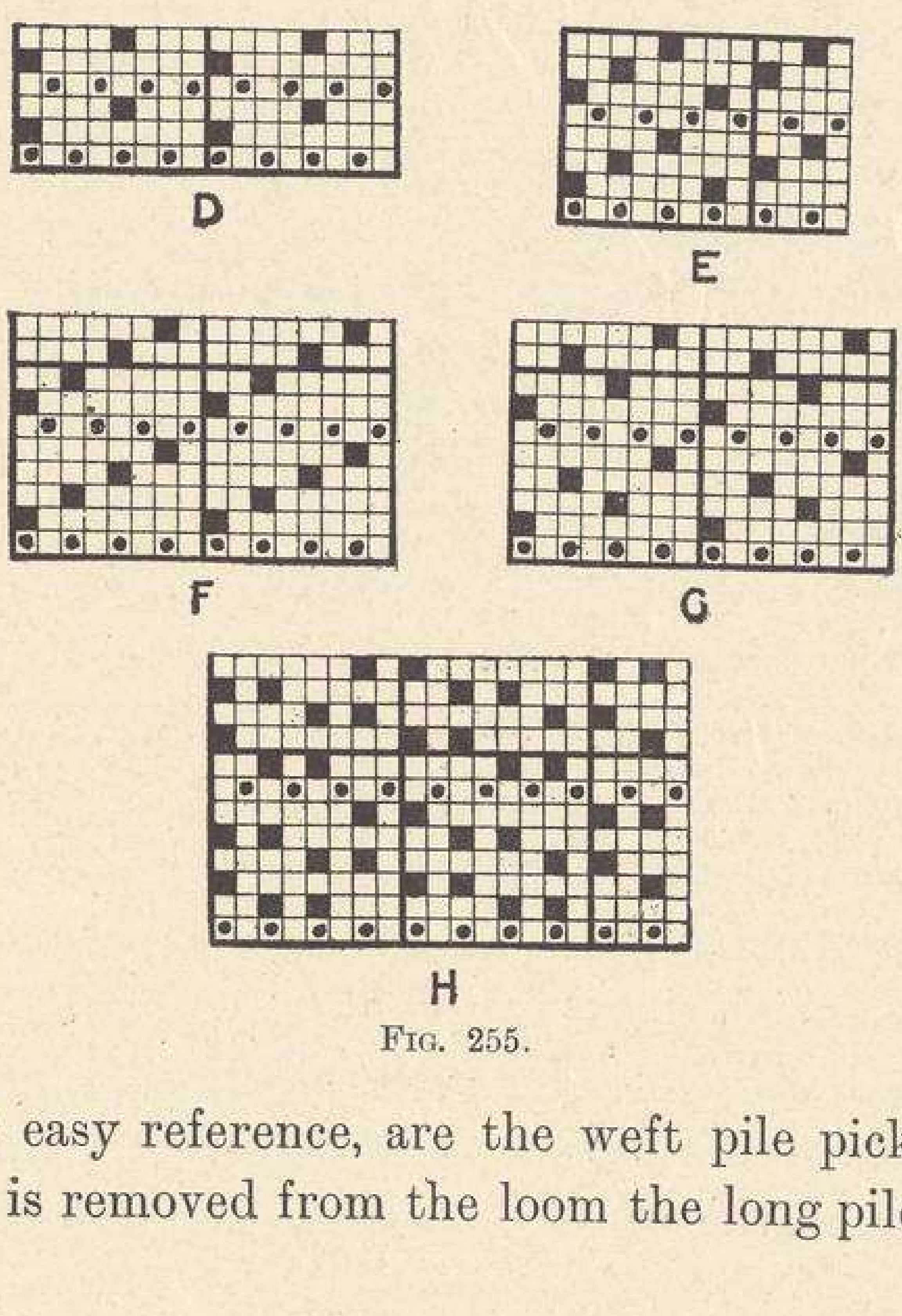


FIG. 255.

marks for easy reference, are the weft pile picks. When the fabric is removed from the loom the long pile picks are cut through the middle by a special knife at the points indicated by the arrows. All the warp threads and the ground picks, being undisturbed, form the foundation of the fabric, from the body of which the cut-pile picks stand erect as indicated in illustration C.

Design E, Fig. 255, is extensively used for velveteens; it is an 8-pick plain back, capable of being drafted to four leaves, but usually woven on six, so that the heddles will not be crowded, and that the 3-leaf twill back may also be used with the same draft. The weave is reproduced at J in Fig. 256 in the order often woven, two repeats again being shown as is the case with all these velveteens. The plan of the fabric, showing two plain picks and three pile picks, is illustrated at K, each pile pick appearing in a distinctive mark.

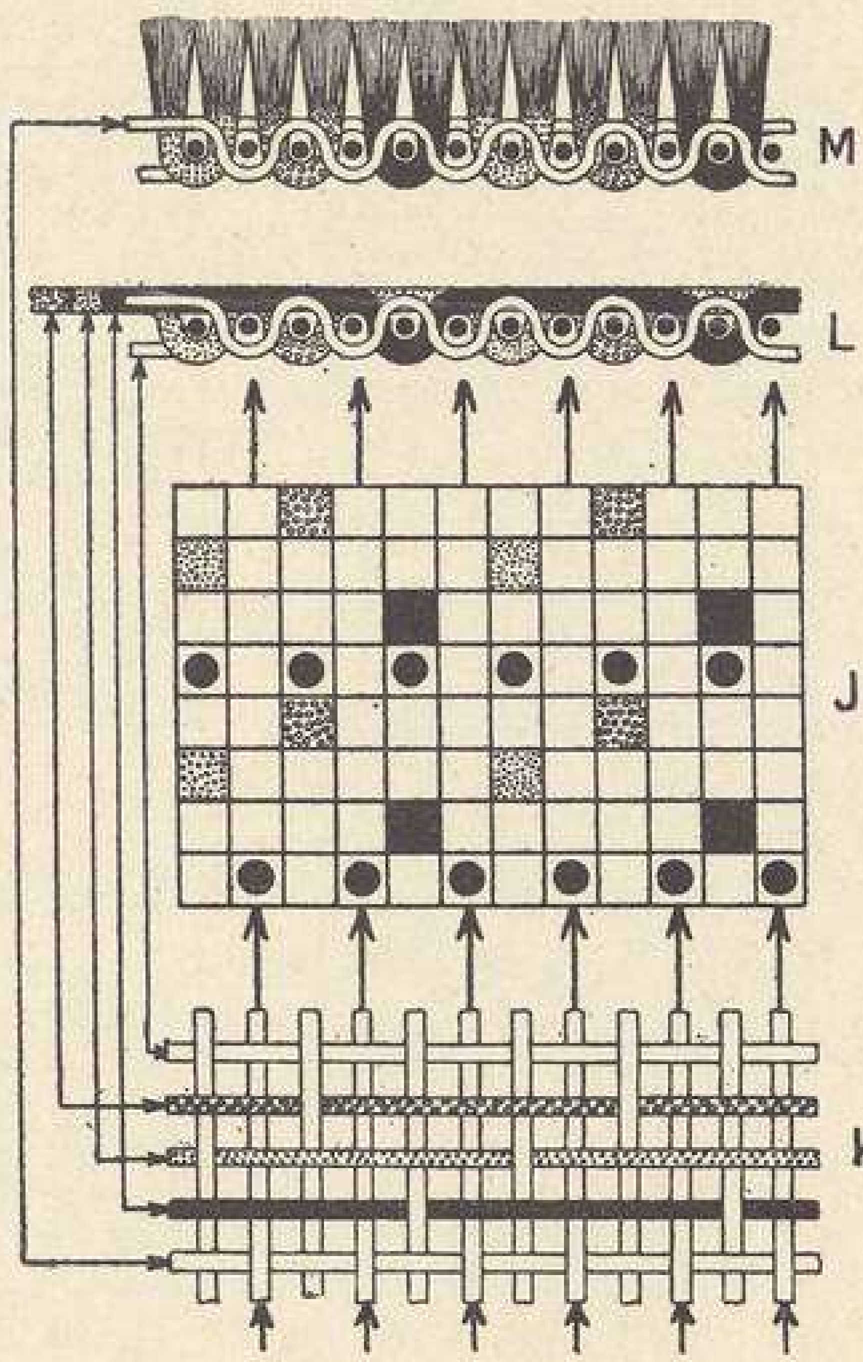


Fig. 256.

From what has been said with respect to cloths backed with warp, it will be easily seen that these three-pile picks will overlap each other more or less and form a compact body. The appearance of the yarns when the cloth leaves the loom is shown by intersection L. The cutting knife runs along three races in each repeat as indicated by the arrows, and after the floats of weft have been cut, the pile picks in each group appear in a straight line between two ground picks as shown by the cut intersection M. These tufts, although made of weft yarns, are precisely the same shape as the warp yarn tufts illustrated at A, Fig. 218. Two 10-pick velveteens are introduced at F and G, Fig. 255, each with four-pile picks between each pair of ground picks; while design H is a 12-pick fast pile velveteen, each pick being

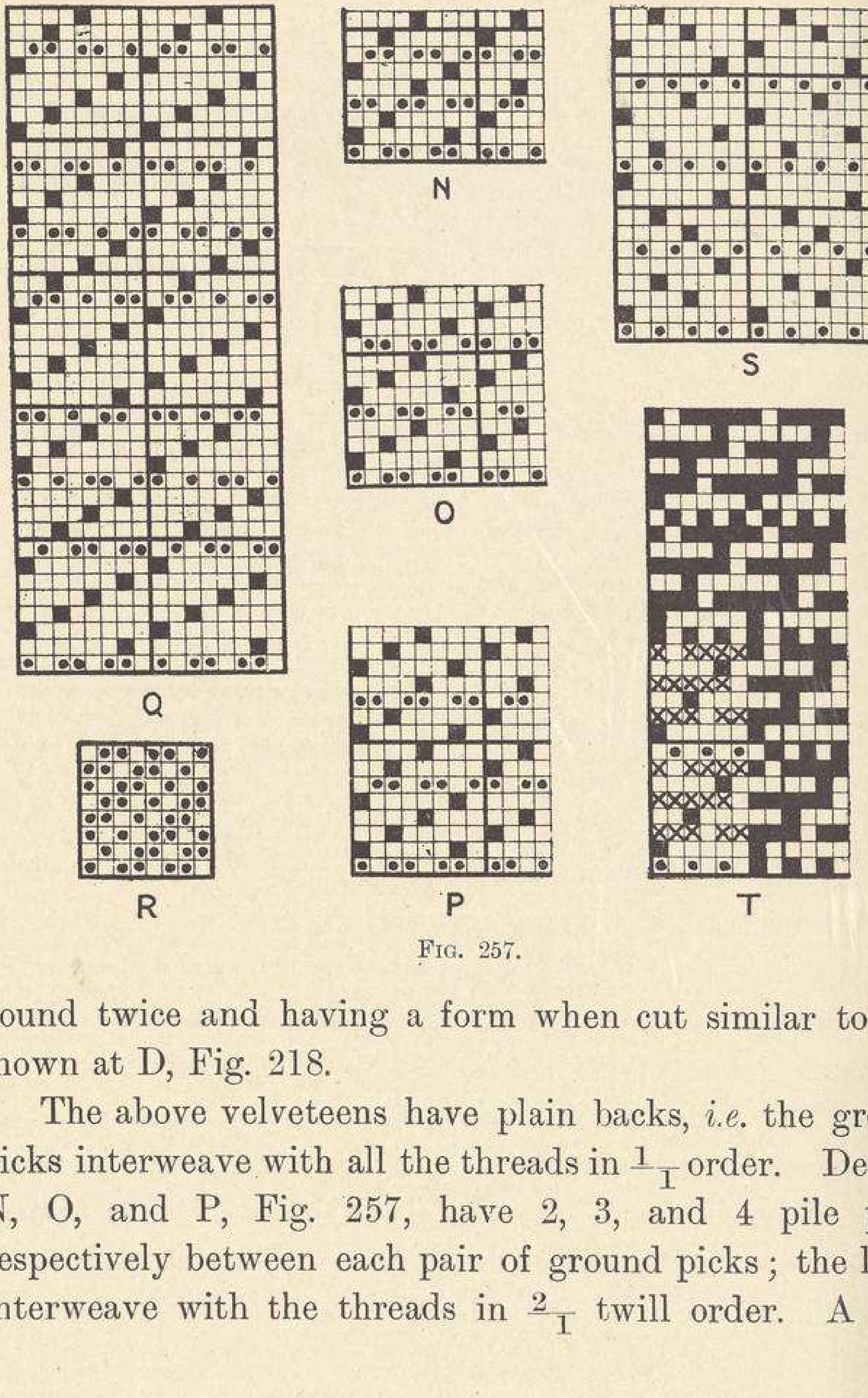


Fig. 257.

bound twice and having a form when cut similar to that shown at D, Fig. 218.

The above velveteens have plain backs, *i.e.* the ground picks interweave with all the threads in $\frac{1}{1}$ order. Designs N, O, and P, Fig. 257, have 2, 3, and 4 pile picks respectively between each pair of ground picks; the latter interweave with the threads in $\frac{2}{1}$ twill order. A twill back of this kind places the weft floats at the back of the fabric; hence there is less danger of cutting the ground picks during the operation of cutting the pile than would be the case if the weft floated above the threads. Design Q is a somewhat similar fabric, the ground weave being shown at R. Since there are 40 picks, of which 8 are ground, the fabric is equivalent to one with 4-pile picks between each pair of ground picks. Design S is another 4-pile to 1-ground velveteen with a plain back; the pile picks, however, are arranged to start at different points in the four sections. The particulars for common makes of the above are from 80 to 88 threads per inch of 28^s to 32^s cotton or equivalents in 2-fold yarns, and from 300 to 400 picks per inch of 40^s to 60^s cotton. Design T shows four repeats of a reversible velveteen, but we are not aware that there is a large trade in this type. Fig. 258 shows a design for a weft pile imitation lambskin fabric, the weft of which is usually woollen or worsted, and is, naturally, much thicker than the corresponding yarns employed for the ordinary velveteens.

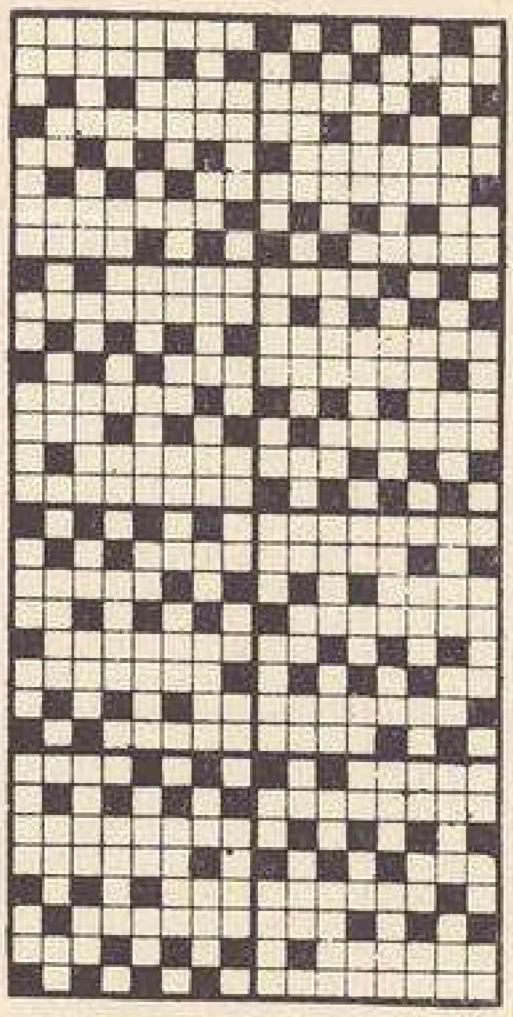


Fig. 258.

The ordinary velveteens, termed plain velveteens, have practically a flat surface, *i.e.* all the tufts are approximately the same length. It is possible, however, to obtain the "Patent Velvet" or velvet cord from some of the designs which are used for the plain velveteens. Thus, designs F and G, Fig. 255, or design Q, Fig. 257, may be used for this purpose. In Fig. 259 we reproduce the first four pile picks of designs F or G crossing 33 warp threads; the latter are shown only in very thin lines. Immediately under these picks is a series of arrows, each one of which is numbered. The numbers indicate the place and order of cutting. One complete round is bracketed U, and the effect which results from cutting one round in this order is shown at the top of the illustration. The numerals immediately under each line of uncut weft show which

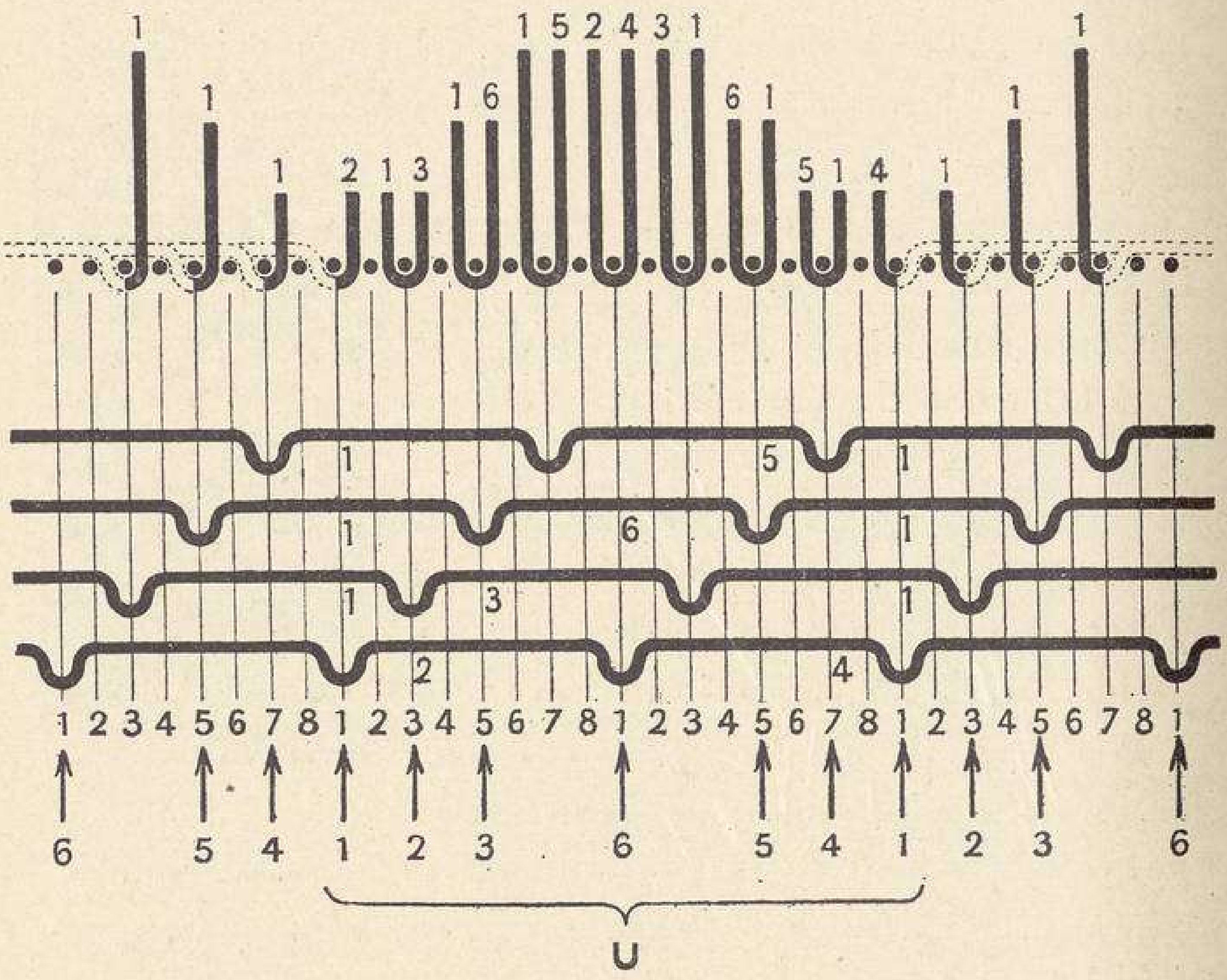


FIG. 259.

floats would be cut in the successive races, while the corresponding numbers above the tufts indicate where the two ends of each cut float would appear in the fabric. Although the design is complete on 8 threads, it requires 16 threads to the round for cutting, the finished fabric having a rounded or corded appearance, as shown in the top part of the figure. The above principle of weft pile weaving is applied to figured fabrics, although not to the same extent as warp pile; the cutting of the pile for the former is a difficult operation.

Closely associated in appearance with patent velvets, but more extensively manufactured than they, are the corduroys, fustians, cotton or Genoa cords. They are usually of

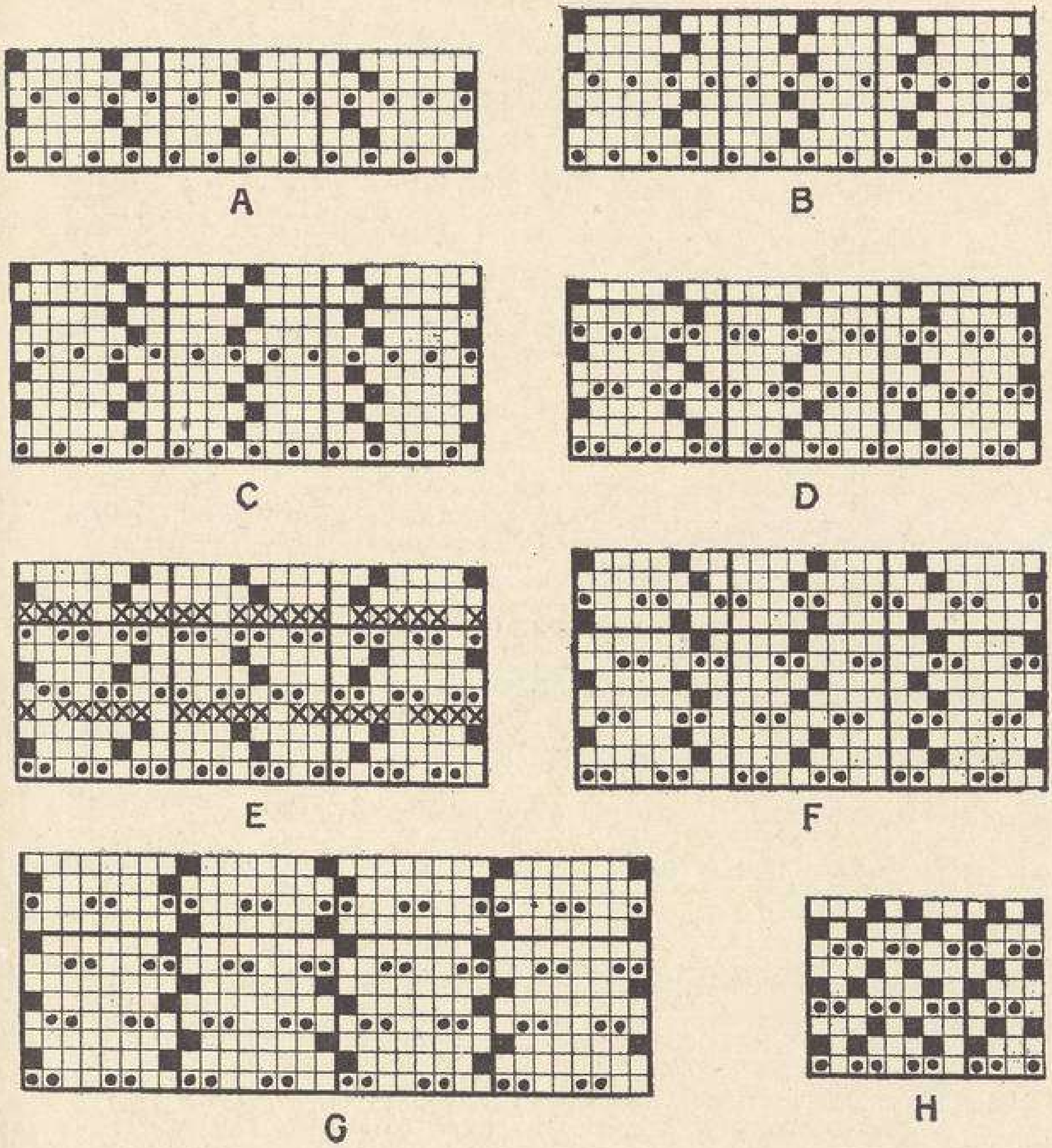


Fig. 260.

heavier makes than the velveteens and patent velvets, and are used mostly for men's clothing. In general, they are made with two picks of pile to one pick of ground, but occasionally three or more pile picks are used for each ground pick. Every second thread in velveteens takes part in the binding of the pile picks, whereas corduroys are bound on 2, 3, or more successive threads, and hence the cutting process is much more easily done. Fig. 260 illustrates different kinds of corduroys, each design showing two repeats.

A, B and C are 2, 3 and 4 pile pick corduroys with plain backs, each weave requiring six leaves;
D is an 8 leaf, 9 pick corduroy or Genoa cord, $\frac{2}{1}$ back;
E is the same weave as D, but with backing picks which are shown in crosses;
F is an 8 leaf, 12 pick corduroy or Genoa cord, $\frac{2}{2}$ back;
G is an 8 leaf, 12 pick corduroy or Genoa cord, $\frac{2}{2}$ back, with longer floats for more prominent cord.
H is a 6 leaf, 9 pick "thickset" cord, $\frac{2}{1}$ back.

The general structure of these fabrics will be understood by the various illustrations in Fig. 261. J and M show the first three picks from A and G respectively, Fig. 260. K and N show the positions of the warp and weft yarns before cutting, while L and O illustrate the appearance of the finished fabric. The arrows show the points where the pile picks are cut by the knife, and it will be seen that each odd tuft has a short and a long side, whereas each even tuft has a long and a short side. When in conjunction in the fabric, the successive pairs form a rounded or corded effect similar to that illustrated. All the designs in Fig. 260 produce cloths of the same character. Designs P, Q, and R, Fig. 262, show corduroys of a slightly different construction; they are termed "constitution cords," and it will be seen that every alternate pile pick is more securely bound than are those illustrated in Fig. 260.

The foregoing examples illustrate the chief makes of warp and weft pile fabrics produced as follows:—

1. By wires during weaving;
2. By double plush weaving;
3. By cutting the floats after the piece leaves the loom.

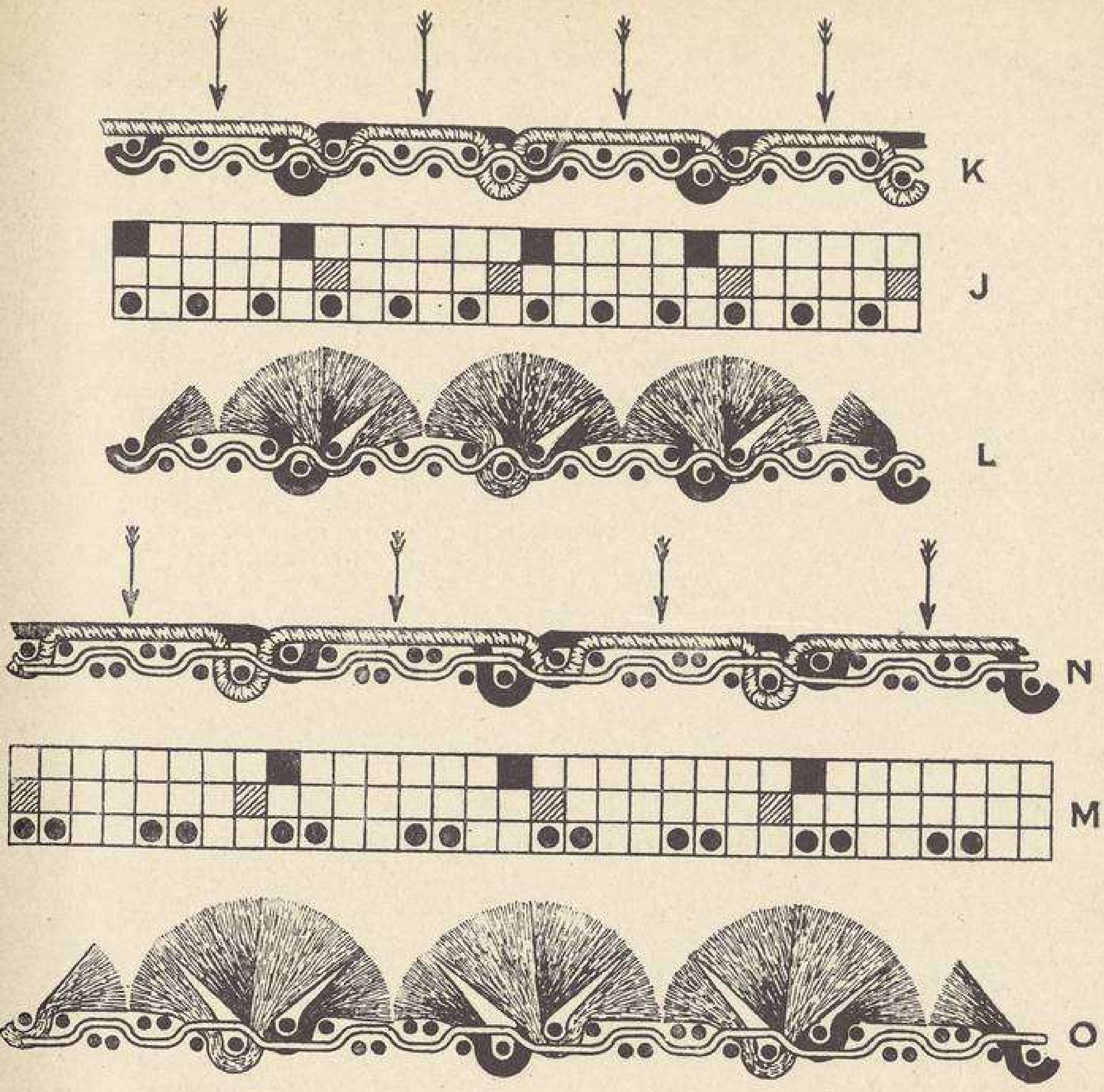


Fig. 261.

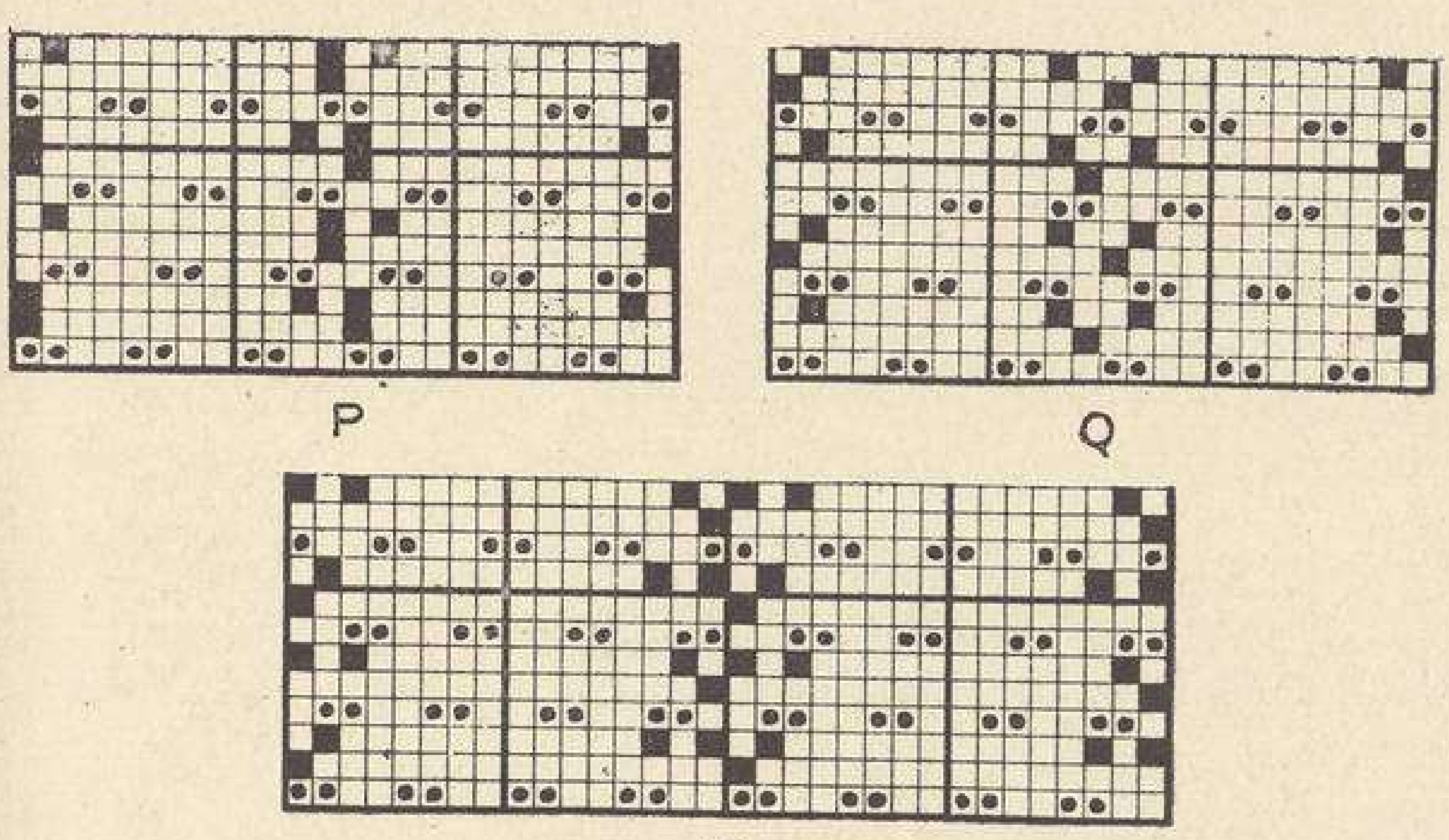


Fig. 262.

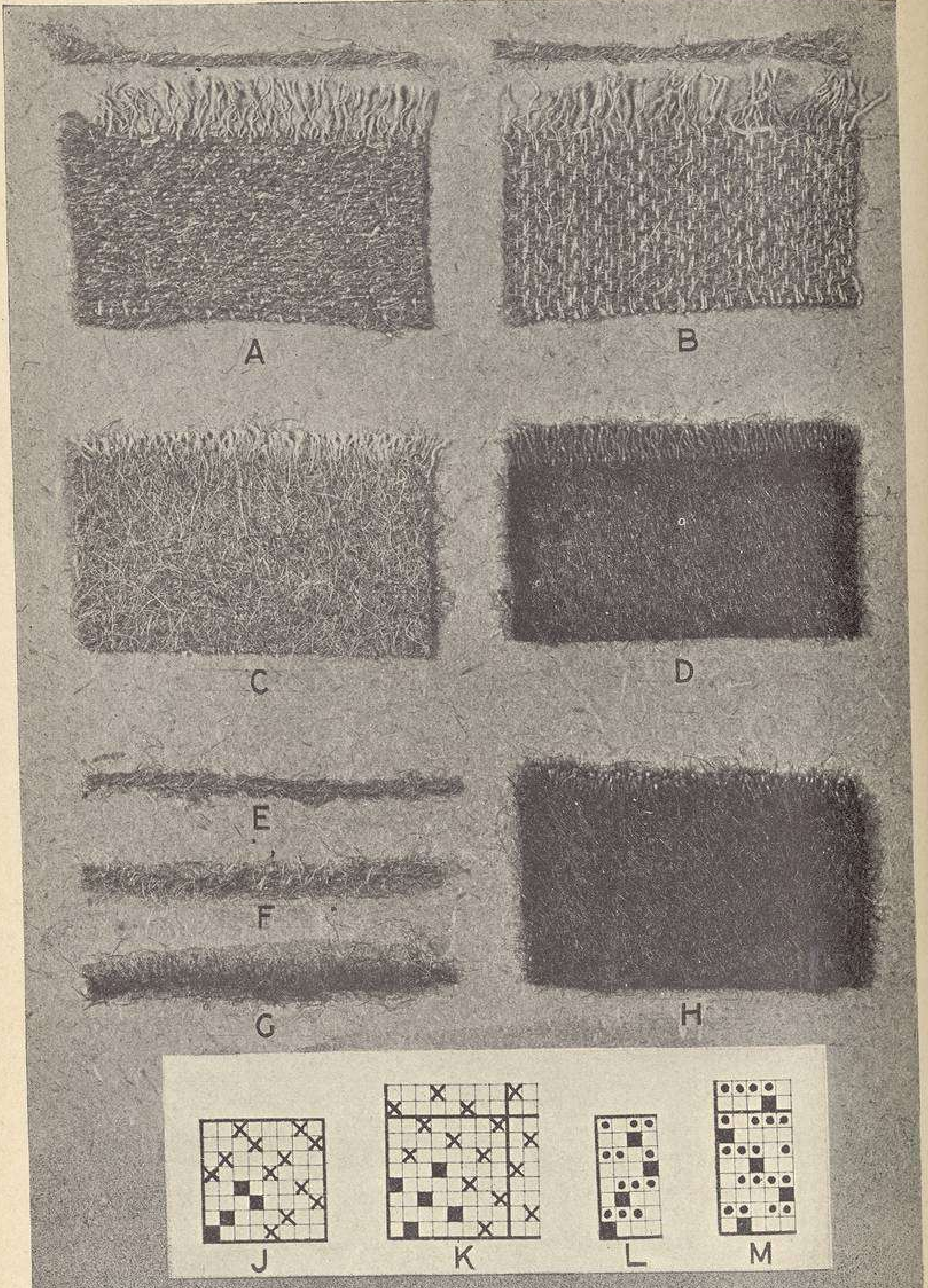


Fig. 263.

We shall close the chapter on pile fabrics by a short description of the processes involved in the manufacture of the cheaper imitation sealskins and plushette fabrics—fabrics which are produced without the aid of any of the above methods. Photographical reproductions of the cloth in various stages appear in Fig. 263, where A and B show the face and back of the cloth as it leaves the loom. The cloth contains about 30 threads per inch $2/20^s$ white cotton, and 28 picks per inch of $6\frac{1}{2}$ skeins (104 yards per ounce) weft composed of cow or calf hair and a small quantity of dark wool; the weft appears above each pattern. C shows the face of the cloth in the milled state,

FIG. 264.

while D is the same fabric after having been raised and dyed. The exhaustive processes of raising and beating raise the pile which, when dyed to the proper colour, is a good imitation of skin. Threads E, F and G show the weft in the three stages—loom, milled and washed, dyed and finished; while pattern H is a cloth with a pile on both sides. Pattern D is made with weave J, the 4-thread broken twill or swansdown, while pattern H is made on the principle of backing with weft; the design for this pattern is L, which is simply the 4-thread broken twill, weft flush, backed with weave J. Plan K is often used for similar fabrics of a better quality, while M is the 5-thread sateen backed with weave K, and intended for a better class double-faced plush. These fabrics are extensively used for curtains, portières and similar articles. They may be finished off in self colours as shown at D or H, or afterwards ornamented by a process of printing. Fig. 264 illustrates part of a pattern of this nature; the cloth, which was originally exactly like pattern D, Fig. 263, has a red ground upon which the figure is printed in green and yellow. The same type of cloth is often printed in imitation of leopard and other animal skins, and is then used for carriage rugs; it is also frequently used in the printed and unprinted conditions as a cheap fabric for the upholstering of furniture.

CHAPTER XXII

BEDFORD CORDS, PIQUÉS, TOILET COVERS, ETC.

BEDFORD cords and simple piqués are very similar in appearance to corduroys; they differ from them, however, in that the corded effect is developed in plain cloth instead of in different lengths of cut pile. The ribs in Bedford cords are in the direction of the warp threads, whereas those in piqués run from selvage to selvage. Bedford cords were originally used mostly for equestrian purposes, but they are now made of many different materials for dresses, trimmings, etc., and are sometimes termed "new corduroys. The piqués, on the other hand, are made mostly of cotton, and are used for blouse and light dress materials. Fig. 265 illustrates two typical Bedford cord designs, and the method of making them. A, B, and D show the same design, and the reader will readily remember the construction by studying these plans. The first pair of picks in each design floats over seven out of eight threads, and then weaves plain for the next eight threads, whereas the second pair of picks does the reverse. Two repeats in the way of the weft are given at A, B, and D, as well as in the weaving plan C, which requires six leaves. This weave forms, perhaps, the

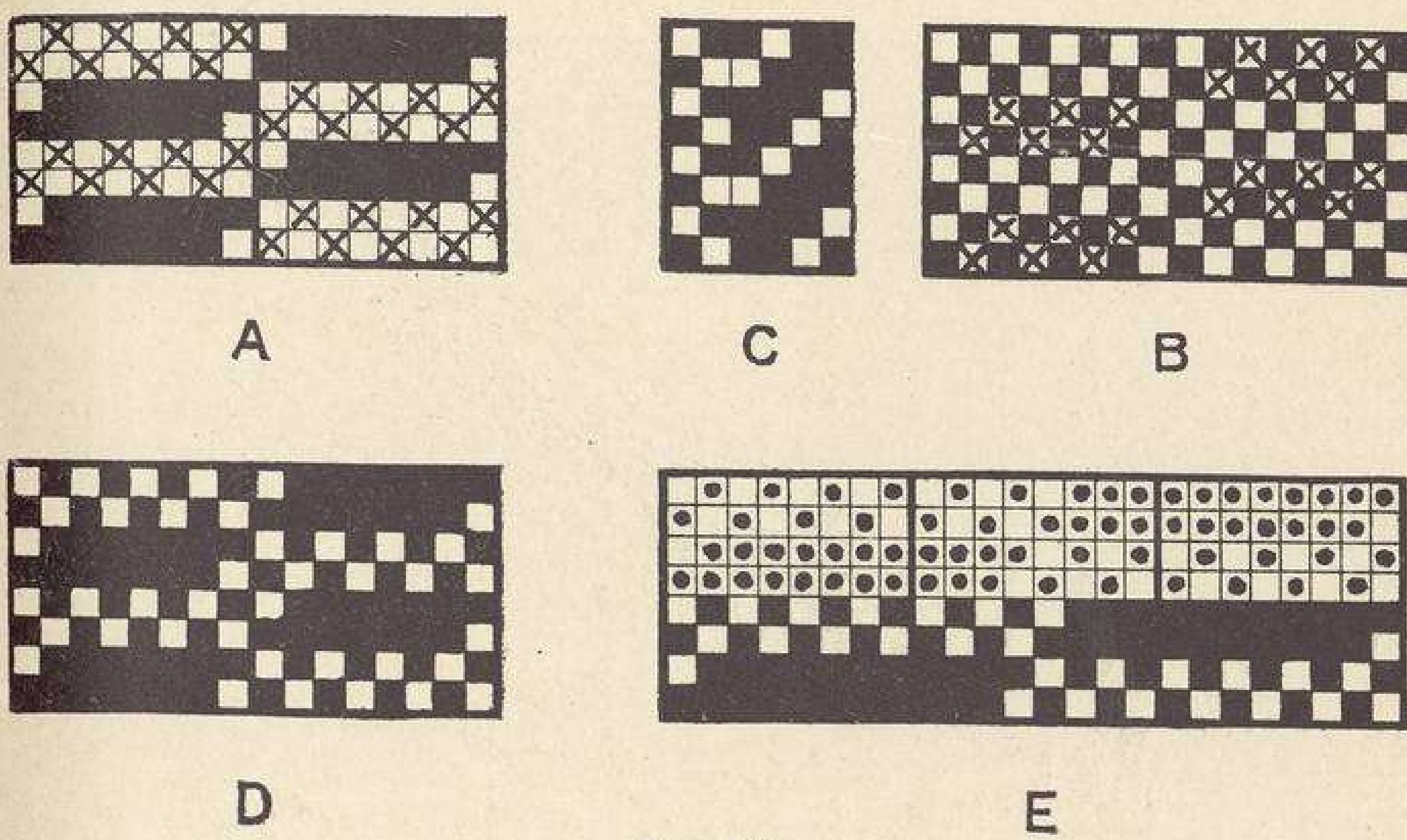


Fig. 265.

simplest effective cords, *i.e.*, cords without stuffer threads. By extending the floats, as shown in design E, a more prominent rib or cord is obtained without increasing the number of leaves, but necessitating a slightly different draft.

Fig. 266 illustrates the general appearance of these fabrics; it is a half-tone reproduction of the same cord in seven different colours—red, pale green, Oxford blue, pink, Cambridge blue, white, and heliotrope, represented by H, J, K, L, M, N, and O respectively. The particulars for the warp and weft are as follows:—

Face warp:	96 threads per inch of	30^s cotton;
Stuffer warp:	8 ,, ,, ,,	6^s cotton;
Weft:	68 picks ,, ,,	24^s cotton.

The design for these fabrics appears at P, Fig. 267; it is the same as design E, Fig. 265, except for the threads marked with arrows, which represent stuffers. One or more stuffers may be used as desired in each cord, but stuffer threads must be warped on a separate beam. A

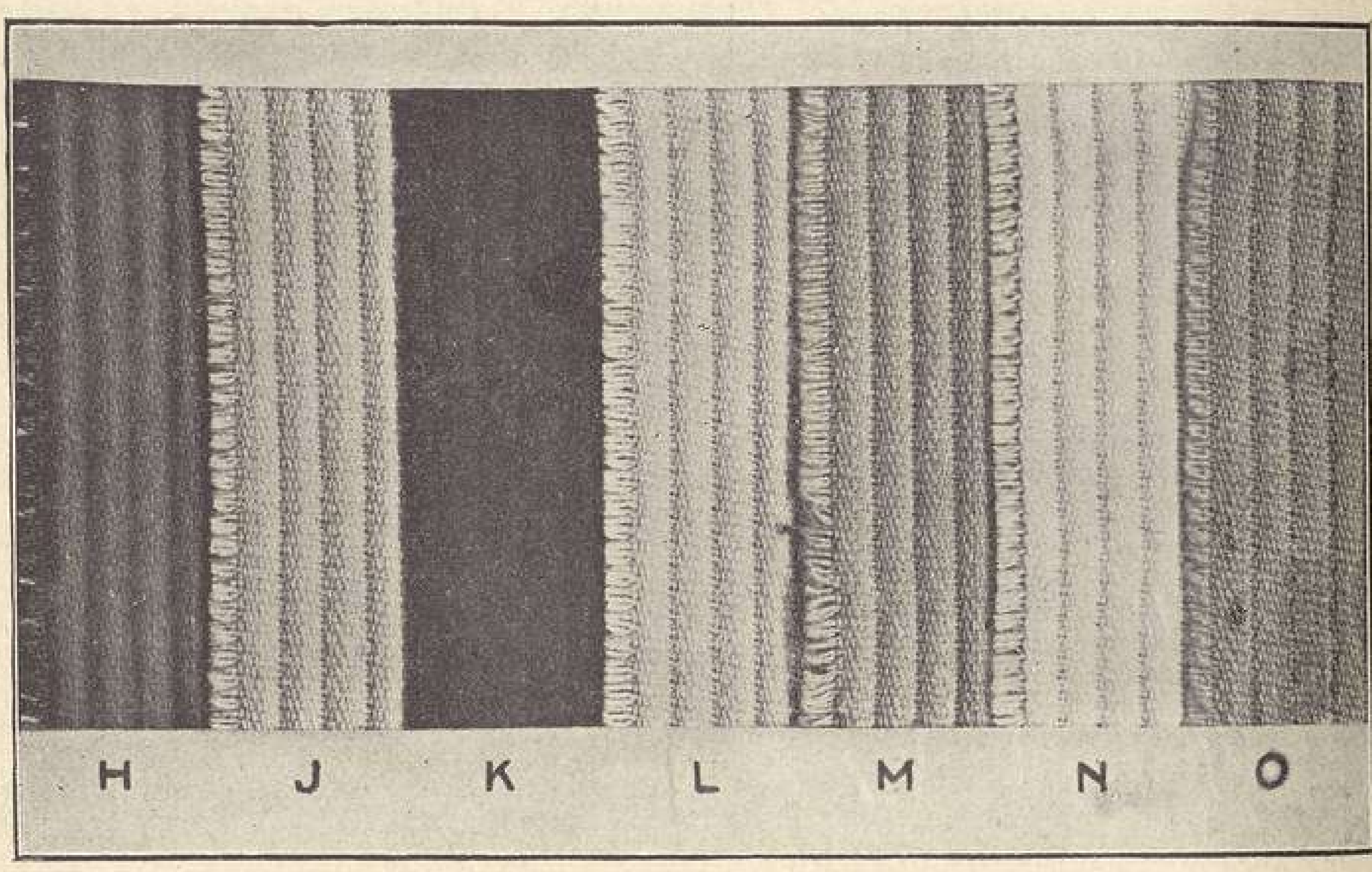


FIG. 266.

design showing a slight modification of the ordinary cord is illustrated at Q, in which two stuffer threads appear in each face cord. The intersections for P and Q, Fig. 267, are shown at R and S respectively in Fig. 268, a complete repeat in each case appearing between the dotted vertical lines. The numbers refer to the picks of weft, but in S only four are shown, because the remaining four would be immediately behind. The stuffer threads appear in the gaps between the plain cloth and the floating picks, and they lie approximately straight. If the stuffer thread be removed from intersection R, the figure would represent design E, Fig. 265.

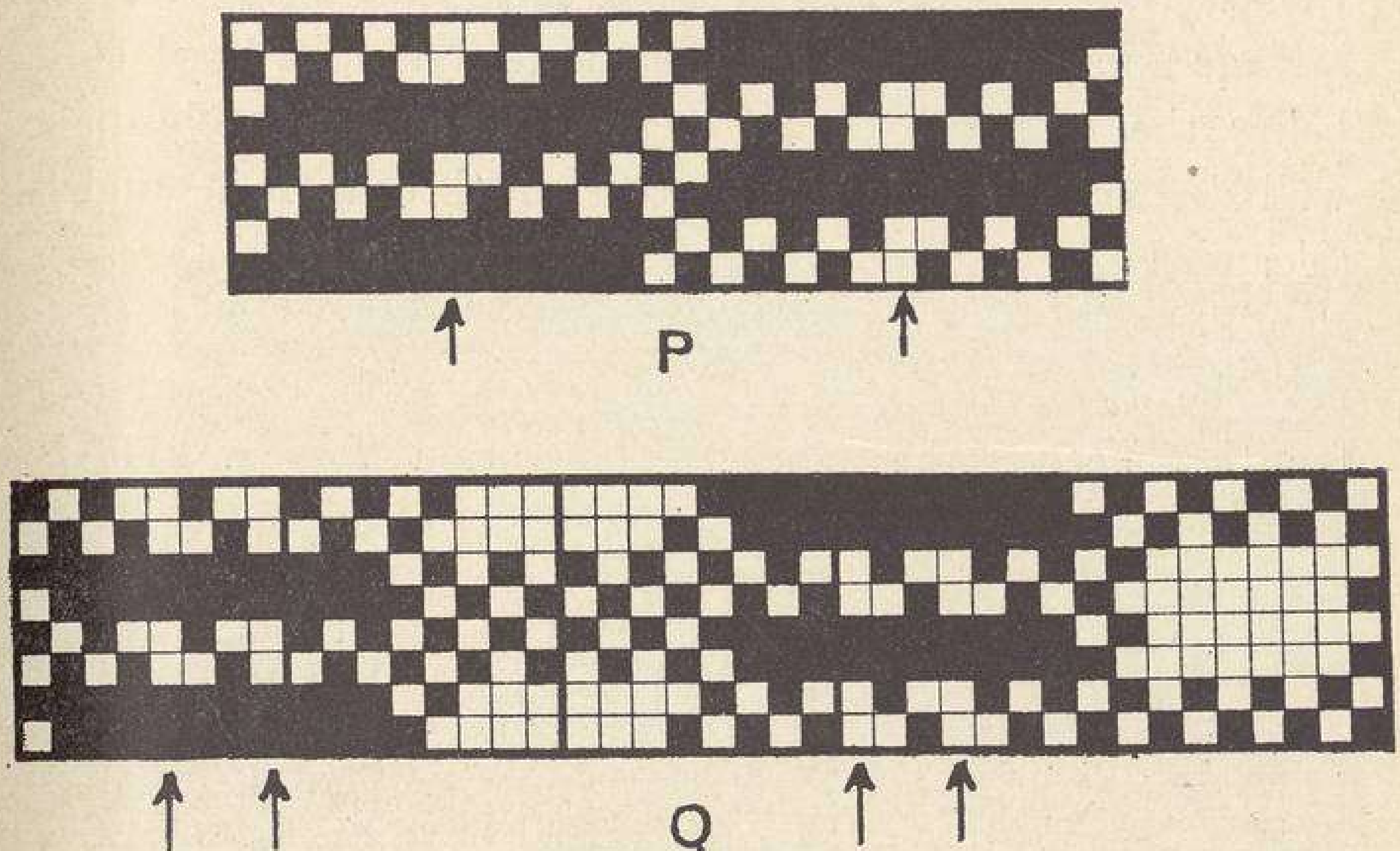


Fig. 267.

Similar types of cords may be obtained in the way of the weft, and the cloths are then termed piqués, as

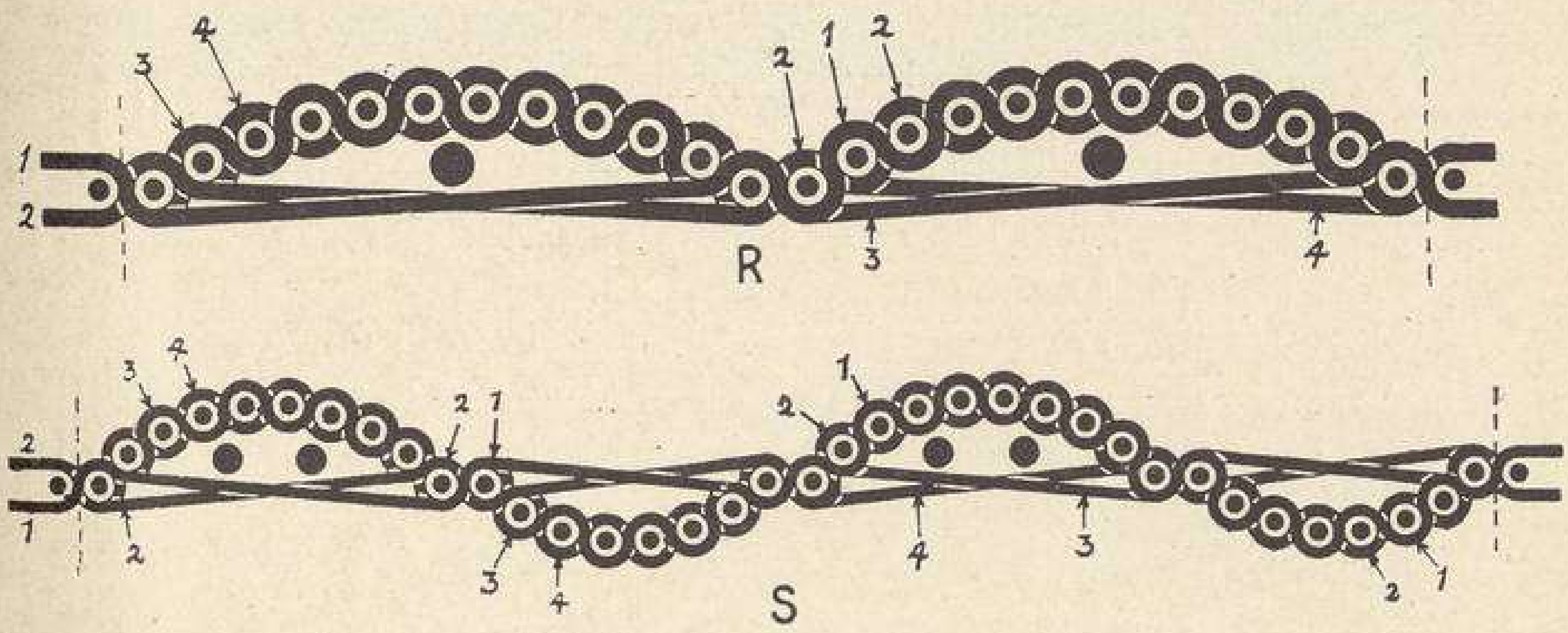


Fig. 268.

already stated. Designs T and U, Fig. 269, are two of these weaves, differing only on the first three picks ; each design shows three repeats in the way of the warp. The cloth from which the design U is taken is shown at X, Fig. 270, where the cords are horizontal, as opposed to the vertical ribs of the Bedford cord shown at W. A selvage appears in both patterns, that of the Bedford cord being the 4-thread basket weave. In order to obtain a well-defined rib it is necessary that threads 2, 5, and 8 (T and U, Fig. 269), along with the other back threads, should be placed on a separate warp beam, so that they may be heavily paced in comparison with the threads for the face of the fabric. Illustration Y, Fig. 270, is

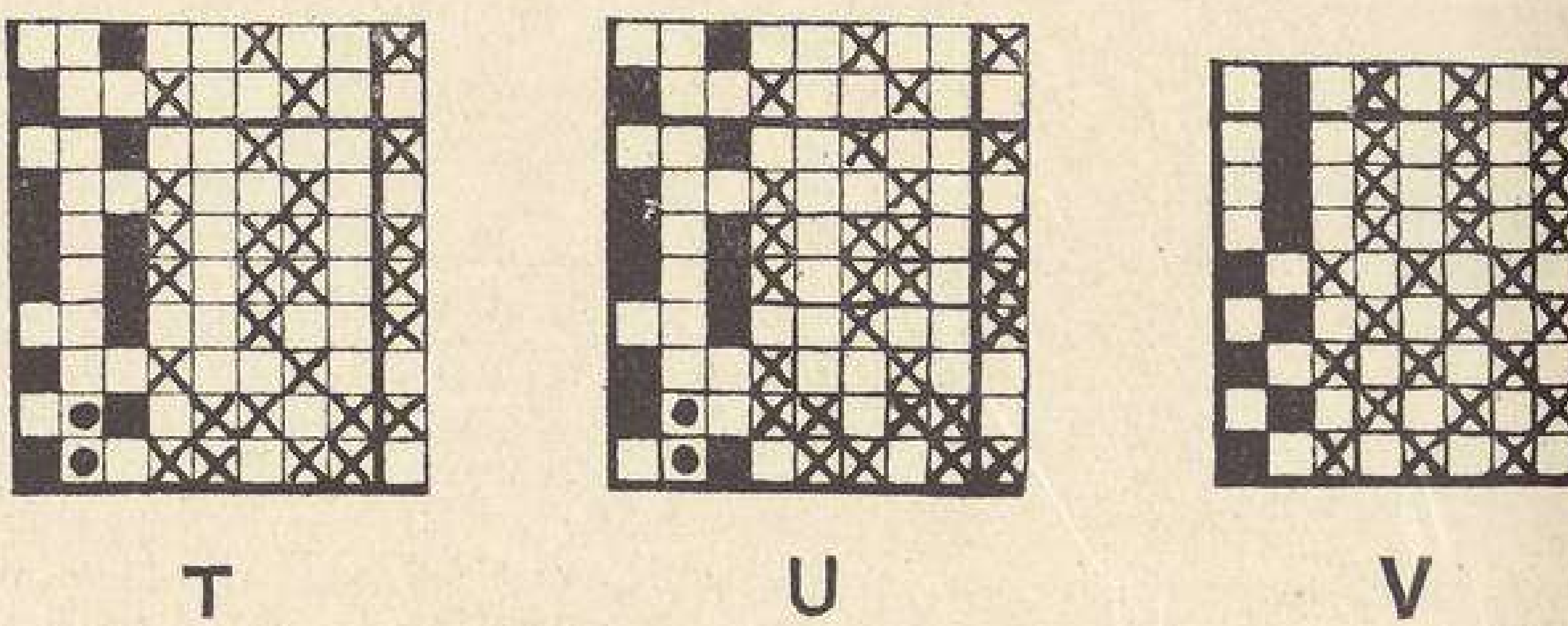


Fig. 269.

also a corded fabric, but this is obtained by thick and thin weft, as explained in connection with Fig. 11 (p. 12). The design, which shows four repeats, is given at V, Fig. 269, but since the last four picks are introduced at the same time, the weave is equivalent to $\frac{1}{1}$ plain. There are 320 threads per inch of silk (2-fold 24,000 yards per ounce) in the warp, and the weft is :—

5 picks of 12,000 yards per ounce silk.
4 picks of 2/60^s worsted inserted as one pick.
36 picks (6 repeats) per inch.

The photographical illustration of this cloth at Y, Fig.

270, demonstrates clearly the difficulty of forming a perfect selvage with comparatively thick weft.

Figured toiletings and toilets are constructed on much the same principle as piqués, from which fabrics they differ chiefly in pattern. Both structures require two warp beams; one for the ground, moderately paced, and the second for the stitching, binding, or figuring threads,

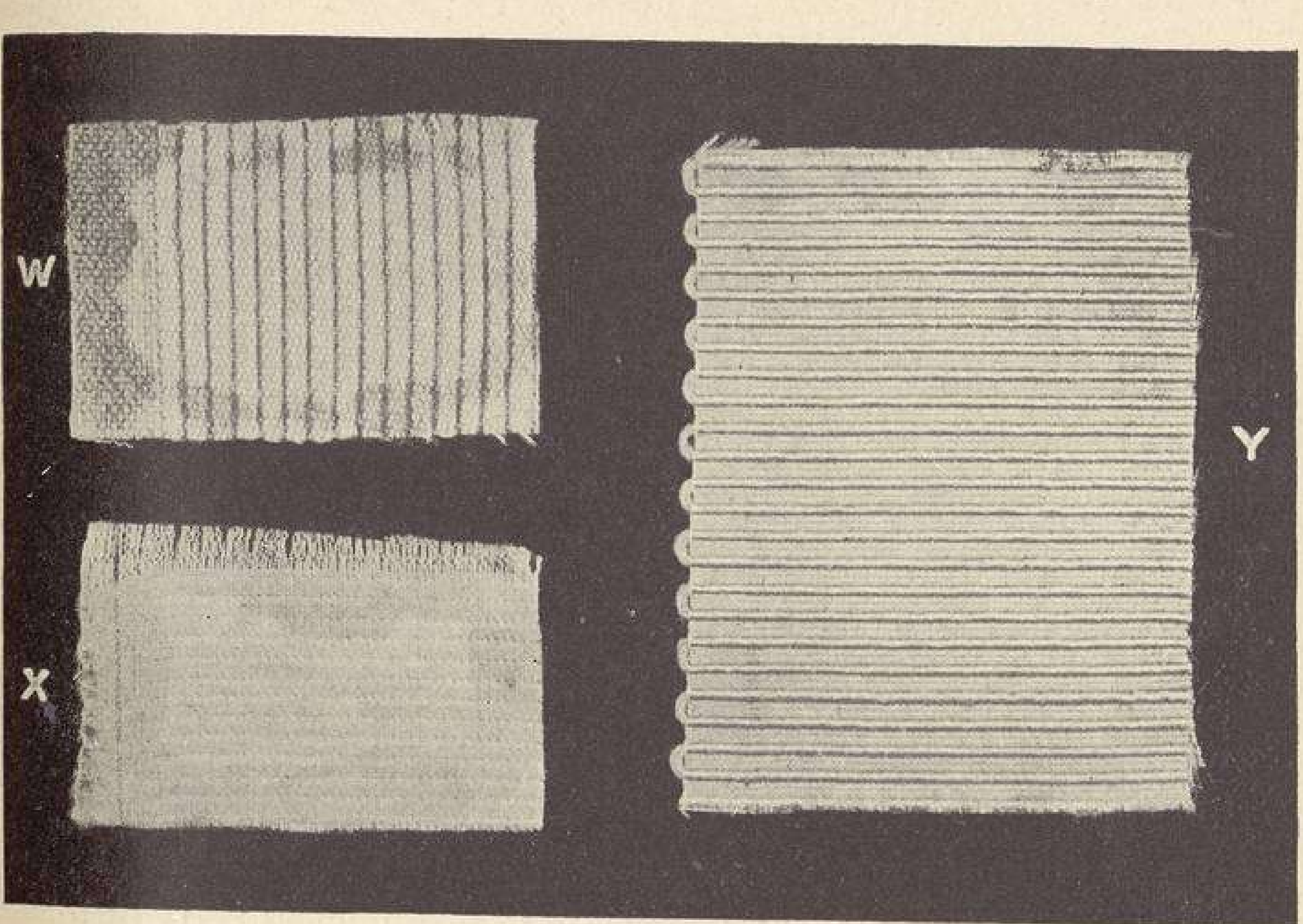


FIG. 270.

which must be tightly paced. In piqués the stitching threads all lift over the same two picks to form a groove or hollow across the fabric, but in toilets or toiletings the stitching threads are operated by the jacquard, and, according to the type of toilet, are lifted for 2, 3, 4, 5, or 6 successive picks, according to the pattern, in order to stitch the face cloth. In accordance with the number of picks over which a stitching thread is lifted to form the figure the cloth is termed a 2, 3, 4, 5, or 6-pick toilet. The face cloth is almost invariably plain, although twills may be used, and the face warp, which is controlled by shafts, is arranged in the proportion of two threads face to one thread back or stitching. When the face weave is plain, two of the picks over which the figuring threads float are for the face cloth; the remainder of the picks (1, 2, 3, or 4, as the case may be) over which the figuring threads float are utilised for padding or backing purposes.

Toiletings may be divided into three types—loose back; semi-fast back, sometimes termed "stocking" back; and fast back. In the first type the stitching warp always floats loosely at the back of the cloth when not lifted over the weft for stitching purposes. This is necessarily the case with all two-pick toiletings, because there is no extra pick available for interweaving at the back of the cloth with the floating back threads. Three-pick toilets may, however, be either loose back or semi-fast back, since there is one pick in each float available either for filling only, or for filling and interweaving with the floating back threads. This pick is, in general, used as a padding pick only, and in the lower grades the same medium count of weft is used all through in order that a single shuttle loom may be employed. In finer grades two wefts are used, and, where a pick-at-will loom is available, the wefts may be inserted 2 picks face, 1 pick back; but in many, and perhaps most cases, the arrangement is 4 picks face, 2 picks back, in order that boxes may be required at one end of the lay only. When a three-pick toileting is desired with a semi-fast back, it is usual to lift the stitching warp over the padding weft in plain cloth order once in every 18 picks, and in this manner to bind the threads at the back and thus reduce the length of the floats. With a single shuttle or a pick-at-will weave all odd figuring threads would lift on the 9th pick, and all even threads on the 18th pick, but a slightly different order is necessary when the order of wefting is 4 picks face, 2 picks padding. This plain cloth binding is usually accomplished by dividing the comber-board, which controls the figuring harness, into two equal sections, one section having all odd backing or figuring threads, and the other section all even ones; all the harness cords are knotted immediately above the boards, and the boards are worked as two shafts. In all cases special combinations of shafts and harnesses are employed for the production of these fabrics, and, as a general rule, it is only necessary to cut the figure on the cards.

In fast back or full toilet, the harness and shafts are so controlled that two perfect cloths—a fine one and a coarse one—are always formed independently of the figuring, or of the padding picks. When making the design, the figure only, or rather the outline, is painted, and no two adjacent threads should be lifted on the same pick; nor should any thread be lifted for two picks in succession, since such marking would cause the stitching thread to float over four face picks and thus nullify the effect desired. Further, it is best to adhere to one method of painting, and always to mark odd threads on odd picks, and even threads on even picks, so that were the design paper completely filled in, a perfect plain weave would result. This method of marking is indicated at A, Fig. 271, which shows the smallest diamond possible, and which is complete on 4 threads and 4 picks. This little motive is developed in each of the designs B, C, D, and E, but in each successive design the floats of

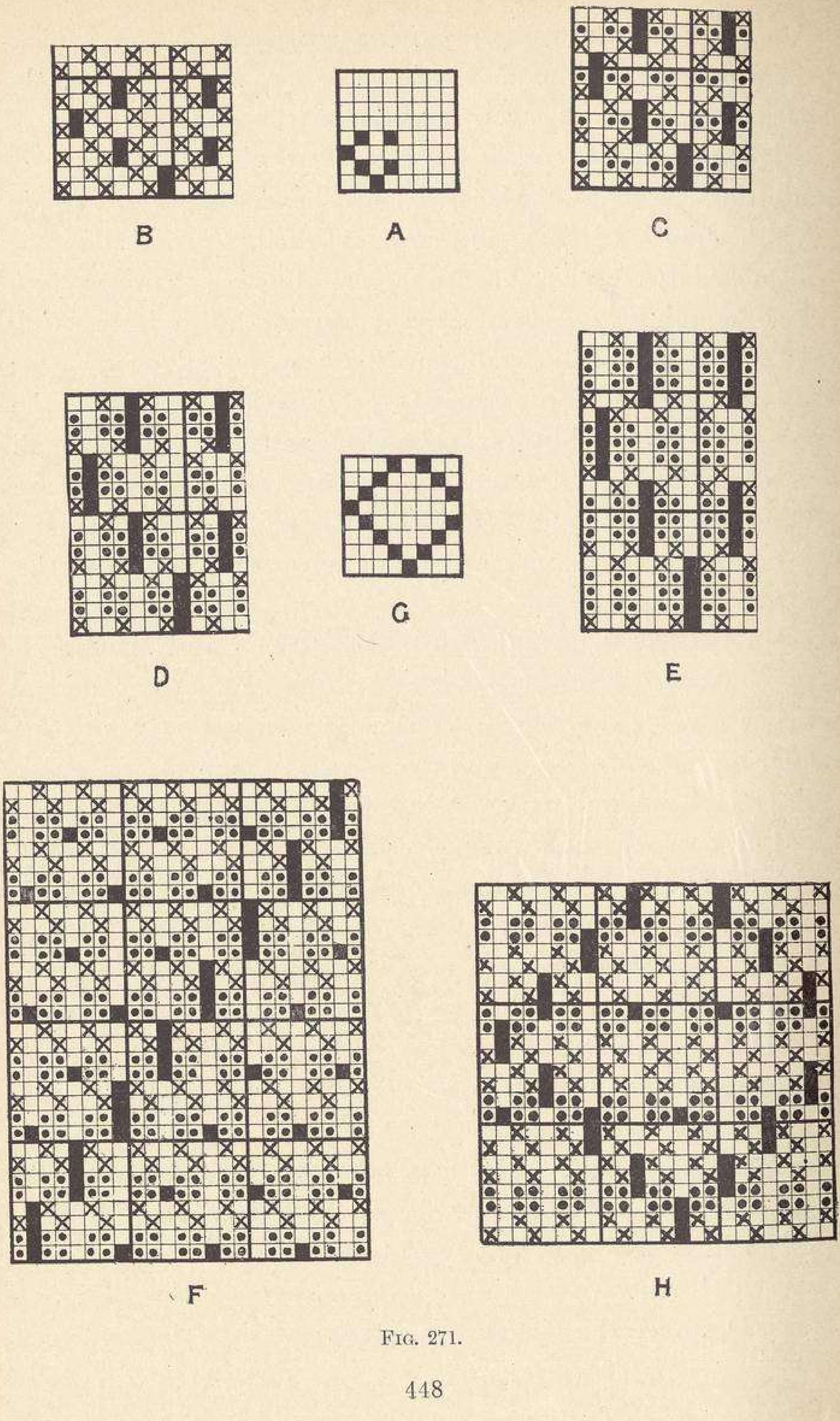


Fig. 271.

the figuring or stitching threads are increased by one pick. In all the designs the face weave (plain) is developed in crosses, while the dots in designs C, D, and E indicate the lifting of the face threads for one, two, and three picks of padding or backing weft respectively. If cards were cut according to the motive A, they would be equally suitable in most cases for 2, 3, 4, or 5-pick toilets, provided all other arrangements as to shedding, picking, and box motions were properly made. Weaving is materially simplified when wefting can be arranged in multiples of two picks of the same kind of weft, and for this reason design C is, as already indicated, generally woven with one shuttle, and the same weft used for both face and padding. When a different weft is desired for padding purposes the order of wefting is usually 4 picks face, 2 picks padding, so that multiple boxes are required only at one end of the lay. Design D is arranged as a four-pick loose back, although a four-pick semi-fast back, in which the padding picks interlace every twelfth pick with the back warp, is common. The five-pick toilet is the best generally made, and is used for most high grade fabrics. It is usually fast back, and where a pick-at-will loom is available, the wefting order shown at E, 2 picks face, 3 picks padding, will be suitable; but, in order to employ looms with boxes at one end only, it is not unusual to bind the backing threads with face weft, and to use a secondary or coarser weft solely for padding purposes. In such a case the order of wefting may be as indicated in Fig. 272.

The wefting is therefore equivalent to—

4 picks	fine weft :	picks	9, 10, 1, 2	in	Fig. 272
2 ,,	coarse ,,	,,	3, 4	,,	,,
2 ,,	fine ,,	,,	5, 6	,,	,,
2 ,,	coarse ,,	,,	7, 8	,,	,,

The full thread-by-thread working of a four-pick fast back toilet is illustrated in design F, Fig. 271, where the isolated marks indicate stitching threads lifted by the sectional comber-board for binding purposes on one of the padding picks. Designs G and H show respectively a small motive on 8 threads and 8 picks and its thread-by-thread development as a three-pick semi-fast back toileting, with the wefting order, 4 picks face, 2 picks padding. Four isolated solid marks on the 9th and 16th picks indicate where the stitching threads are lifted above the padding weft by the sectional comber-boards for binding purposes. The repeat of the ground texture in this case is on 18 picks.

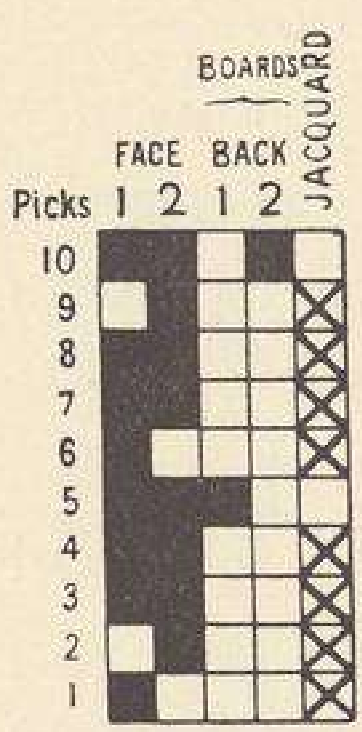


Fig. 272.

Fig. 273 illustrates the construction of the "patent satin" quilt. The name satin in this case has no reference whatever to the weave of that name, since the fabric is an intimately stitched double plain cloth in the proportion of 2 threads face to 1 thread back. For symmetry the yarns for design J are arranged as follows :—

Warp : 1 thread medium white cotton for ground ;
1 ,, fine ,, ,, figure ;
1 ,, medium ,, ,, ground.
66 to 84 threads per inch.

Weft : 1 pick medium white cotton for ground ;
1 ,, thick blue ,, ,, figure.
88 to 112 picks per inch.

The thick blue weft covers the fine white warp and gives a comparatively solid blue figure.

Alternative arrangement :—

Warp : 1 thread medium blue cotton for ground ;
1 ,, fine white ,, ,, figure ;
1 ,, medium blue ,, ,, ground.

Weft : 1 pick medium blue cotton for ground ;
1 ,, thick white ,, ,, figure.

In design J the figuring threads have only two movements, $\frac{2}{2}$ in both ground and figure; they may, therefore, be drawn on two shafts. The ground threads are drawn alternately through the two sections of the movable comber-board which controls them for plain cloth weaving,

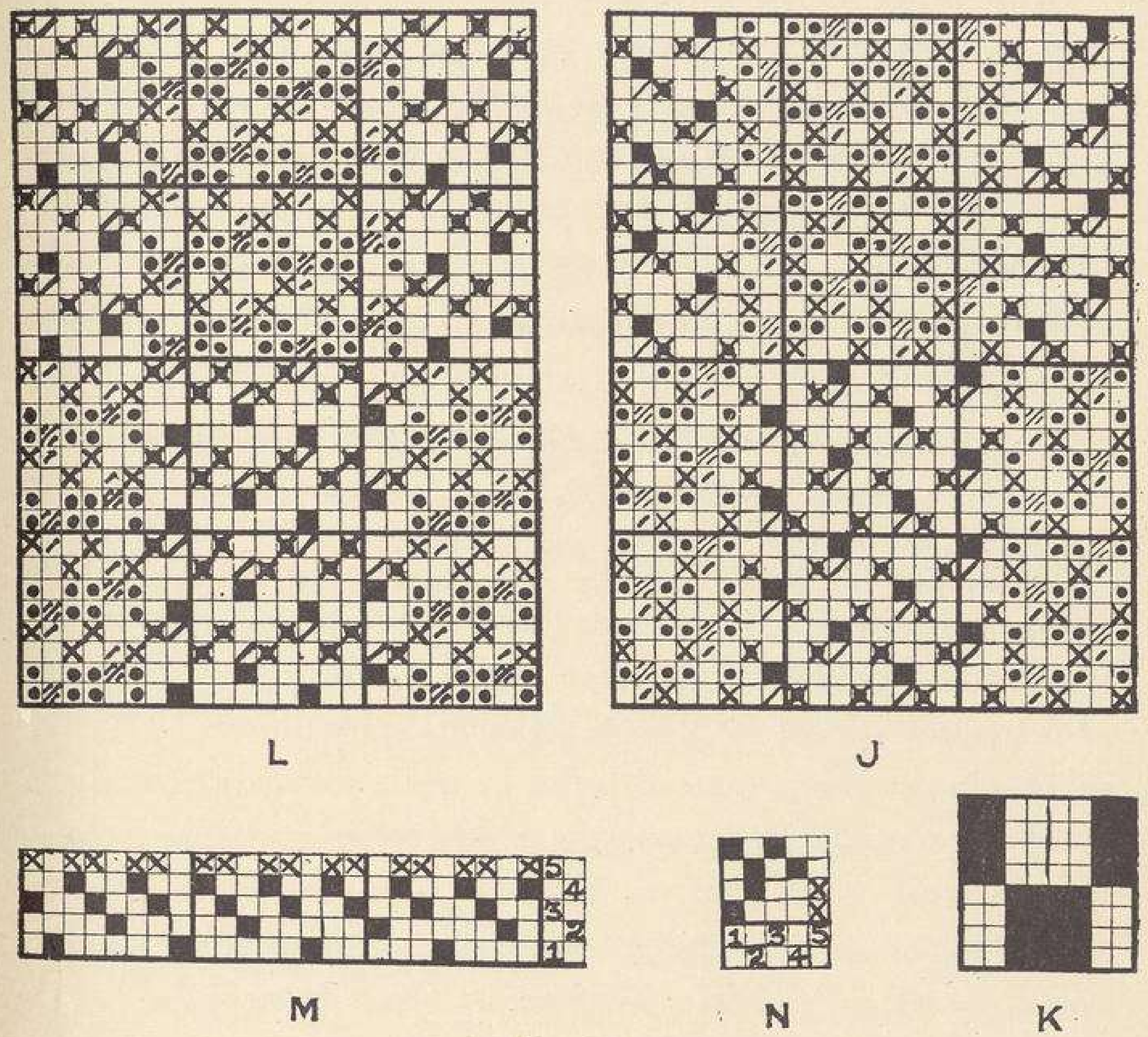


Fig. 273.

while the jacquard controls them for pattern. The different marks in the design have the following significance:—

■ = white figuring threads weaving plain with thick white weft on surface;
'/, = ,, ,, ,, ,, ,, back;
× = blue ground ,, ,, ,, medium blue weft on surface;
✖ = ,, ,, ,, ,, ,, back;
/ = lifting of figure threads over ground picks in figure;
⁄ = ,, ,, ,, ,, ground;
● = ground threads lifted for thick weft to pass to back.

Each needle of the jacquard controls two adjacent ground threads (Nos. 1 and 3, 4 and 6 in the design, although they are usually arranged 3 and 4, 6 and 7, etc.), since they work together on even picks, while the two sections of the comber-board control them individually on odd picks to produce the plain weave indicated by × and ж. In order to obtain weave J it is only necessary to paint the design paper as shown at K. Each vertical cord on the design paper represents three threads in the cloth, and each pick on the paper is equal to four picks in the cloth. With 66 threads and 88 picks per inch the ratio of the vertical ruling to the horizontal ruling would be :—

$\frac{66}{3} : \frac{88}{4} = 22 : 22$, or 8 by 8 paper for 400^s machine, and
12 by 12 ,, 600^s ,,

Similar square paper would clearly be required if the cloth contained 84 threads and 112 picks per inch. Consequently the simple dice pattern, fully worked out at J, would appear on design paper as shown at K.

In almost every case of toilet or quilt weaving, arrangements are made to weave the cloth with multiple boxes at one end only, and to do this with the cloth under consideration the wefting must be arranged, 2 picks heavy weft, 2 picks medium. The development of motive K by this method is indicated at L, where the various marks have the same significance as at J. The draft for both J and L would be the same, and is given at M, but the weaving plan would be different—that for design L appears at N.

Line No. 1 of the draft is shaft No. 1 taking odd figuring threads ;
,, 2 ,, ,, 2 ,, even ,, ,,
,, 3 ,, the front section of comber-board taking odd ground threads ;

Line No. 4 of the draft is the back section of comber-board taking even ground threads ;
,, 5 ,, ,, jacquard harness taking all ground threads.

From weaving plan N it will be seen that shafts 1 and 2 work in opposition in $\frac{2}{2}$ order, and that shaft 2, which is up on the second heavy pick (pick No. 2), remains up for the first fine pick (pick No. 3). Similarly shaft 1, which is up on the second fine pick (pick No. 4), also remains up for the first heavy pick (pick No. 1). In this way the cloths are intimately bound together, and a firm and durable fabric results. The jacquard works also in $\frac{2}{2}$ order, being up on the two heavy picks, and therefore lifting ground warp over figuring weft (it should be remembered that ground and not figure is cut on the cards), while it remains down on the two fine picks while the sectional boards work the plain ground cloth.

CHAPTER XXIII

GAUZE AND LENO FABRICS

ALTHOUGH gauze and leno fabrics depend upon the interlacing of at least two sets of threads, as do all woven fabrics, their construction is quite distinct and characteristic with respect to the path followed by some of the warp threads. In all the foregoing types of fabrics the warp and weft, although following a sinuous path according to the structure, move in more or less horizontal and vertical planes. Certain threads may diverge slightly, as in the case of oatmeal and spider fabrics (see Figs. 64, 65, 77, and 78), but on the whole the principle is that of rectilinear interlacing, and all threads retain their relative lateral positions throughout the process of weaving. With gauze and leno fabrics, however, an entirely different principle is introduced. The weft and part of the warp interweave in the ordinary manner, but certain warp threads are made to change their relative positions, to cross, in fact, from side to side of one or more other warp threads, and thus produce a fabric which resembles, in some degree, that of a net or lace texture. Such being the case, it is evident that gauze and leno fabrics will be of a comparatively open nature, and, consequently, are useful only for decorative and for light clothing purposes, or for embellishing other heavier materials. It is, perhaps, natural to find that the production of any really characteristic effect involves some kind of difficulty in the manufacturing process. This is certainly the case in the weaving of gauze and leno cloths, the difficulties being found in the operation of the various parts involved in the successful working of the crossing threads. The simplest type of this cross weaving is probably that which is employed for the production of centre or patent selvages (see *Jute and Linen Weaving*, Part I, Figs. 217 to 221, pp. 361 to 364), in which the very simplest apparatus is utilised. When this system of cross weaving is required to extend continuously or intermittently from side to side of the fabric, the best results are obtained by the use of other and proper apparatus. It is not essential that the gauze or crossing thread should cross from side to side every pick, but, whenever it does cross, it must be lifted over the weft to ensure its remaining in that position. In pure gauze or "simple gauze" weaving, however, the crossing thread does pass from side to side every pick, and this is the type which will be described first.

In the formation of the cloth by the two picks which constitute a repeat in the way of the weft, there are two types of shed, known respectively as the "open shed" and the "crossed shed." The nature of these two sheds, and the means adopted for procuring them, will be understood by reference to Figs. 274 and 275, in which the former figure shows the "open shed," and the latter figure indicates the "crossed shed." The threads run in

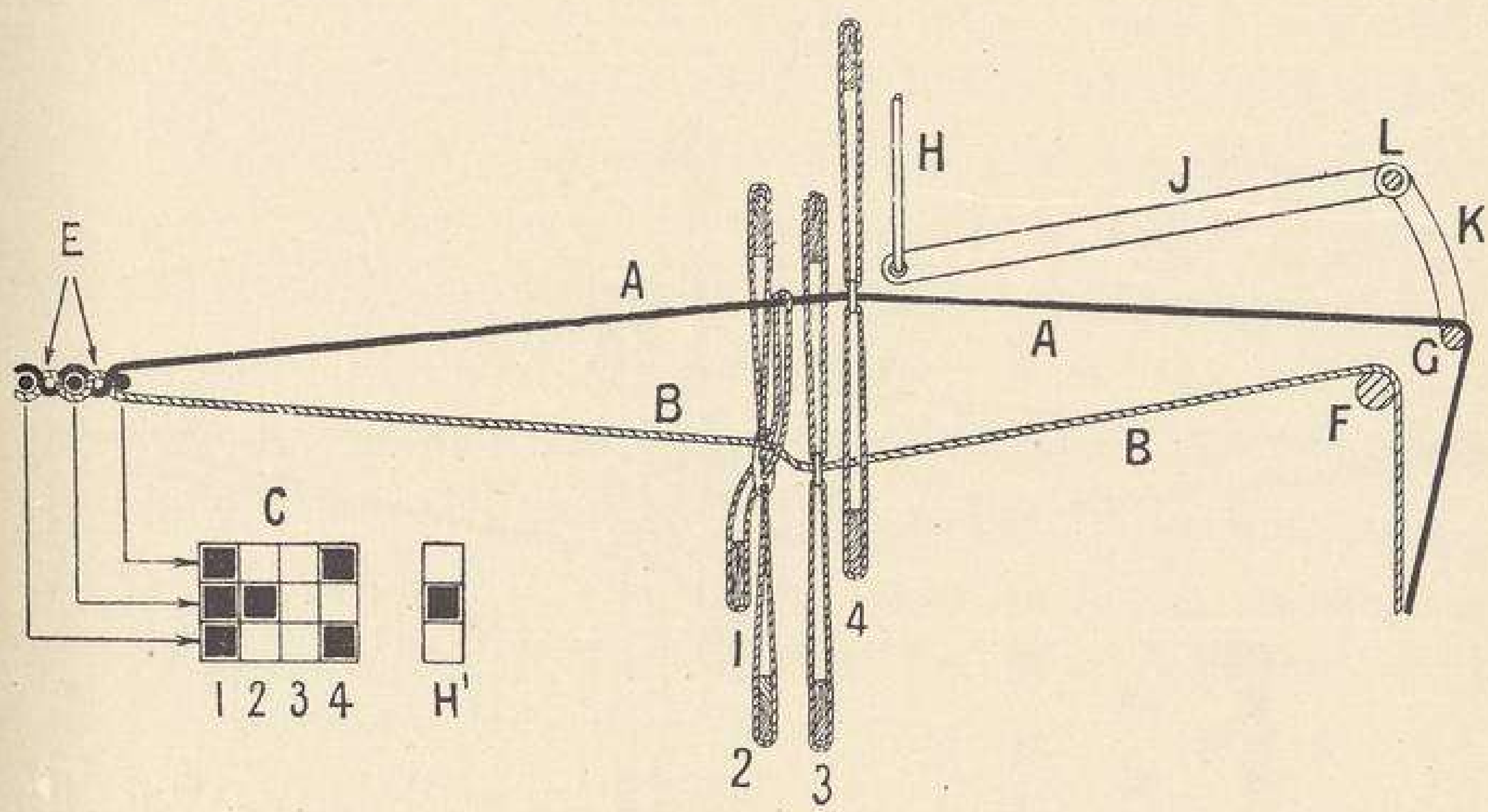


Fig. 274.

pairs, which are identical, but two threads only are shown in each figure.

1st. The dark thread A, or crossing thread, which is over every shot as indicated by thread No. 1 in plans C and D, and also by the picks at the fell of the cloth. Three picks are shown in Fig. 274, and four picks in Fig. 275.

2nd. The light thread B, or crossed thread, which is under every shot of weft, as indicated by the 3rd thread in weaves C and D, and by the picks at the fell of the cloth.

Now, since all dark threads A are over every shot, and all light threads B are under every shot, it is evident that some method of locking the yarns together, other than that practised in the ordinary methods of weaving, must be employed to make a coherent texture. The warp yarns are bound together between each pair of picks by the apparent crossings of both threads of each pair (see parts E between the picks). In reality, the mechanical operation

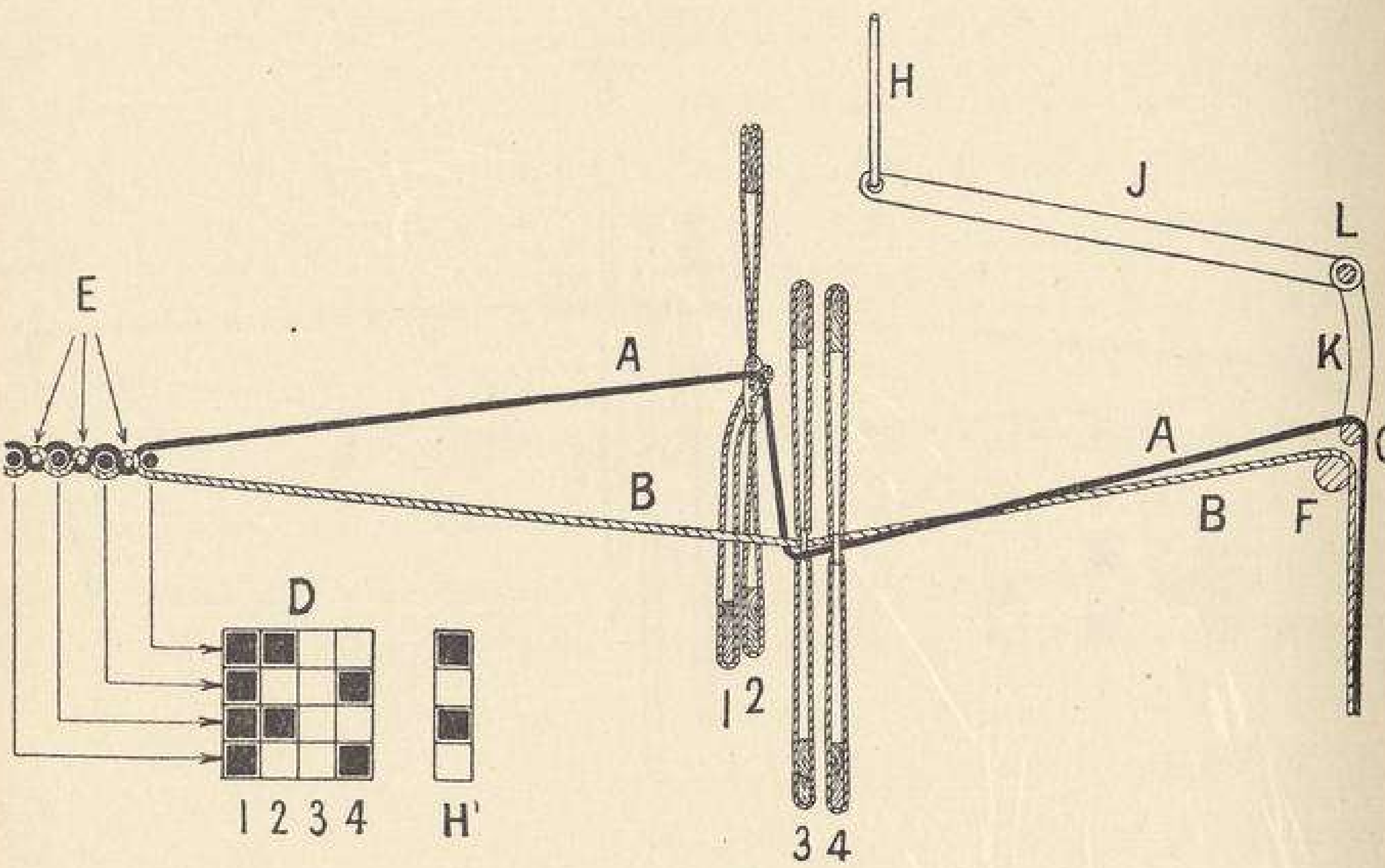


FIG. 275.

of crossing is performed only by the black thread, although each thread ultimately bends about equally. It therefore follows that one warp beam only is necessary for this particular example. As the two sets of threads leave the warp beam, however, they are separated into two layers, so that the crossed threads B pass over the stationary back rest F, and the gauze or crossing threads A pass over the movable back rest G. This latter is usually termed the "slackener" or "easer," being so named because it is capable of being moved towards the back rest G when the crossed shed is being formed. At this time it is obvious that a greater length of yarn A is required between the yarn beam and the cloth than is sufficient for the same thread when forming the open shed, as in Fig. 274. The provision for this regular alteration in the lengths of the dark threads for the two sheds is obtained by lifting rod H from the position shown in Fig. 274 to that shown in Fig. 275, when the levers J and K, turning about stud L, place the rest G in the position shown in Fig. 275. They thus place the thread A in practically the same path as thread B as far as the cambs; beyond this, the extra length required to form the crossed shed is equivalent to the amount of yarn yielded by the inward movement of rail G.

Three picks are shown in design C and four picks, or two repeats of the weave, in design D; while the lifting of the rod H, when the crossed shed is being formed, is indicated by the detached plan H′. To complete this brief description of the working of gauze, it will perhaps be as well to consider Fig. 276 along with Figs. 274 and 275. In all figures the lettering and numbering refer to similar parts. The threads from the back rails F and G in Fig. 276 are shown as being drawn through four leaves, and the characteristic effect of gauze is due partly to the peculiar method of drawing the threads through the leaves, and partly to the unique method of operating, jointly or separately, the combined leaves numbered 1 and 2.

No. 1 is termed the loose slip or doup; the heddle twine which forms this doup passes through two eyes of the mail of No. 2 leaf. Many ways obtain of threading the doup, but the one shown will illustrate the principle quite clearly.

No. 2 is the doup carrier.

Nos. 3 and 4 are two plain leaves through which the whole of the warp is drawn, as illustrated in Fig. 276.

After the warp has been drawn through leaves 3 and

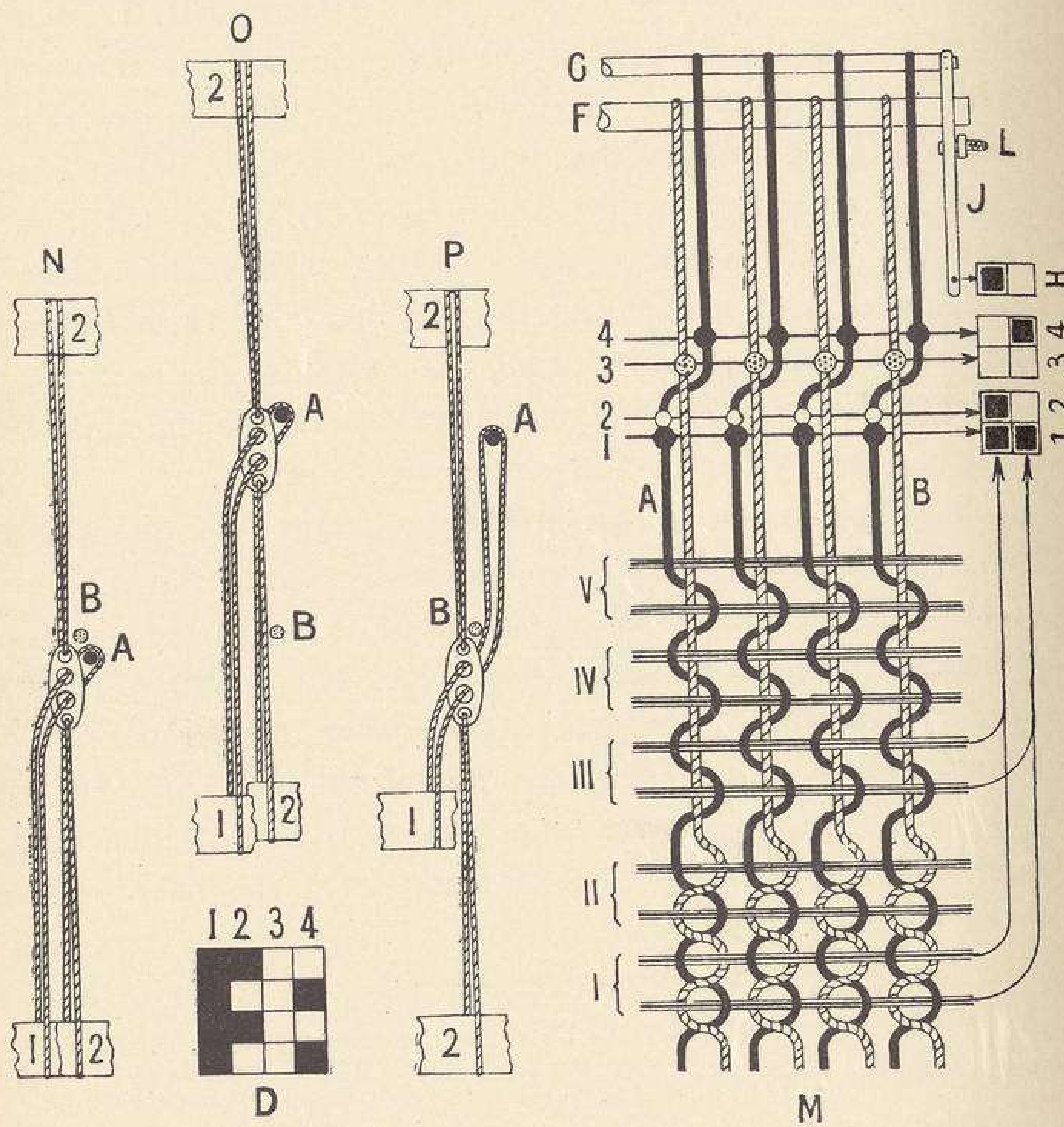


FIG. 276.

4 alternately as shown, each thread from leaf 4 is crossed under its neighbouring thread on leaf 3, and is finally drawn through the eye of the slip or doup, but not through the mail of the doup carrier. The solid black circles in the draft show that the black threads are drawn

through leaves 4 and 1, being crossed between these points under the light threads which are drawn on leaf 3. Five repeats of the weave are illustrated in groups I to V in diagram M, the first two groups representing the cloth approximately as it appears, with both threads equally bent, and the last three groups showing, for facilitating the description, the bending of the black threads only. Consider the first pick in group V, where the black threads are on the right-hand side of the light threads. This is the "open shed," in which the doup and shaft No. 4 are lifted—the shaft of the heald is lifted by the wyper, but the doups themselves are drawn upwards through the mails of the doup carrier by the threads which are lifted by shaft 4, see diagram P, Fig. 276. After the shuttle has passed through the open shed, the two leaves descend and their lowest position is shown by diagram N. Now it is evident that if the doup carrier 2, and the doup 1, be lifted as indicated on the second pick, thread A will be lifted on the left of thread B as shown in diagram O, which is the same position as that illustrated in Fig. 275. When these two shafts are lifted the "slackener" must also yield to supply the increased length of yarn required for the crossed shed. The repetition of these two picks is represented by groups III, IV, and V, Fig. 276, but the actual appearance of the cloth more closely resembles that shown in groups I and II.

When the cloth is formed by the crossing of half the number of threads in the warp on every pick, first to the left, and then to the right, the resulting fabric is usually termed "pure gauze," or simple gauze, but the same type of weaving may be employed in conjunction with ordinary rectilinear weaving of any kind. In addition, the gauze threads may be made to move symmetrically, so as to form a type of ogee pattern, and this without any addition to the number of doups and slackeners. Each alternate slip or doup must, however, face in the opposite direction to the remainder, and the threads must be drawn in to suit. Thus in Fig. 277 we have the same combination of 1 doup, 1 doup carrier, and 2 leaves as in the last example. Each pair of threads marked Q is identical with each pair in M,

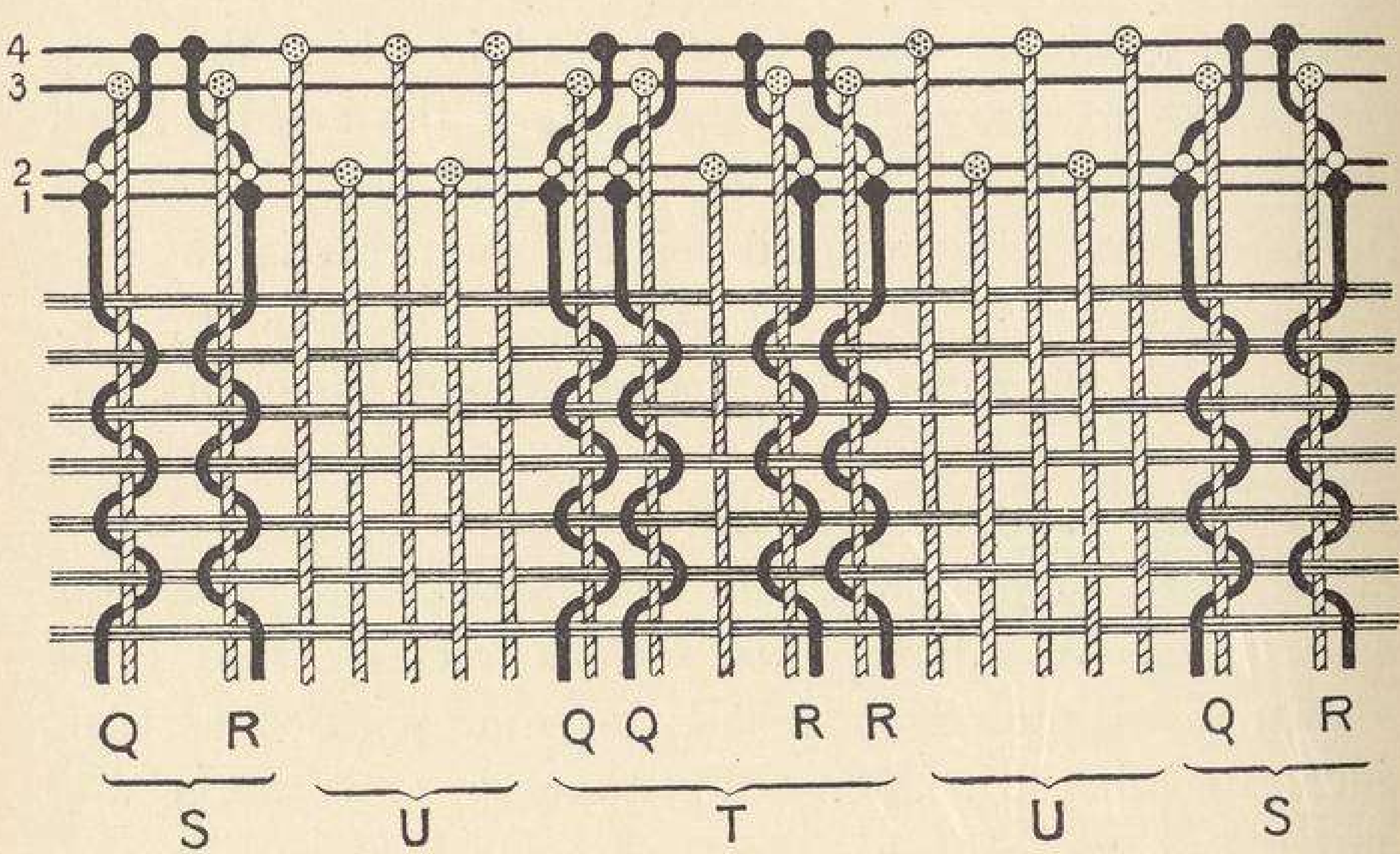


Fig. 277.

Fig. 276, but the gauze threads in parts R cross under the light threads in the opposite direction. Consequently, when doup 1 and doup carrier 2 are raised, each dark thread in parts Q will appear on the left of the light crossed threads, whereas each dark thread in parts R will appear on the right of its neighbour. On the other hand, when doup 1 and leaf 4 are lifted to form the open shed, both dark threads in groups S will appear between the two light threads. A similar arrangement obtains in group T, but here the threads move in pairs, instead of singly. It is quite clear that since the threads embraced by parts U are drawn alternately on leaves 2 and 4, without passing through the doups, they will weave plain with the weft (see plans D, Figs. 275 and 276), and thus add variety to the structure. A choice selection of coloured threads adds beauty to the fabric, and it will also be quite evident that any twill or fancy weave may be obtained by employing the necessary number of shafts behind those shown in the figure, and operating them according to the pattern required. This will probably be sufficiently well illustrated in Fig. 278. The same four shafts which are shown in Fig. 277 would suffice to produce pattern W, Fig. 278, provided that they move as indicated by design X. In this pattern the central thread is drawn through a mail on the doup carrier; both will therefore rise and fall together. We have already seen (see design D, Figs. 275 and 276) that the doup carrier rises and falls alternately when making simple gauze, so that if a thread be drawn through a mail of this shaft, and not through the loose slip or doup, it will weave plain as indicated in the plan of the cloth and in design X, while gauze is being formed, and also in those parts where the gauze or crossing thread is in the crossed position. The crossing thread can also be made to weave plain when leaf 4 is prevented from rising—see picks 12 to 16, W and X. When, however, the crossing threads are on the "open shed" side, *i.e.* the inner position of W, the doup carrier must remain down, hence the middle thread, which is drawn on this leaf, must also remain down, although the crossing thread may at the same time be weaving plain, see picks 7 to 11. If, therefore, plain weaving be desired in conjunction with the system of cross weaving illustrated in Fig. 278, the threads which are to form the plain cloth must be drawn through two separate leaves as at Y, and the two leaves operated as shown at Z. From this it is evident that if any other weave were required at Y, it could be introduced by using the proper number of shafts in place of

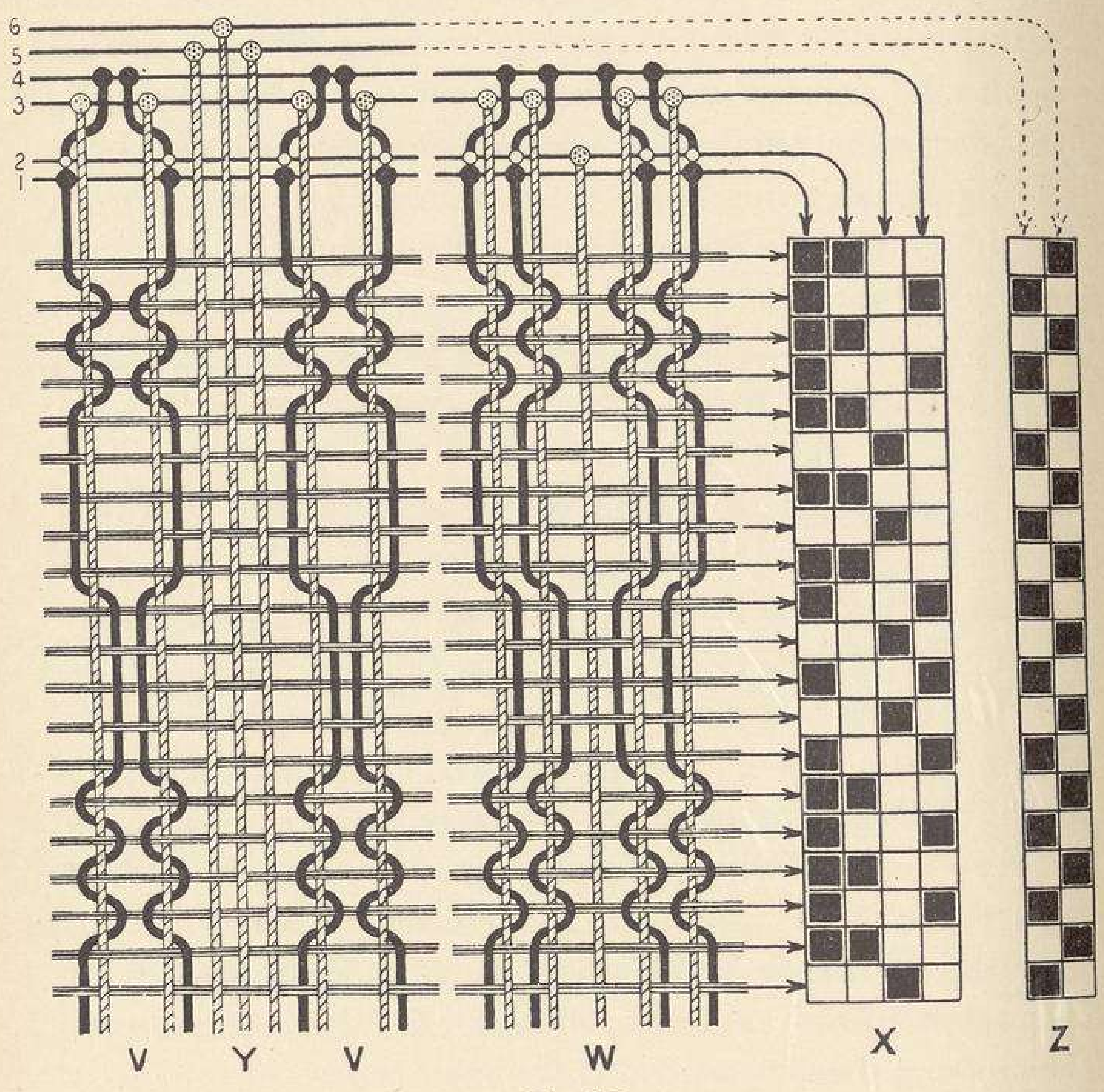


FIG. 278.

the two plain shafts, and substituting a new weaving plan for Z.

When the crossing thread is operated by the healds in this manner behind the reed, it is obvious that it must be in the same split of the reed as the thread or threads round which it partly travels. In the illustration given the threads should be two in a split in the gauze parts, and three per split in the plain part.

The above designs are made for use with what are termed "bottom doups," that is to say, with a set of leaves in which the doup or loose slip is situated as shown in Figs. 274 and 275. When operated in this manner the cloth is woven face downwards. As a result weaving faults are not easily detected, and the doups, which break frequently, are difficult to repair. The cloth may be woven face upwards if "top doups" are employed; irregularities in the weaving are then more easily detected, and broken doups are quickly seen and more readily replaced. It will be understood, however, that the use of "top doups" will require the gauze threads to cross over the crossed threads instead of under, and that the weft passes over the crossing thread instead of under—indeed, all movements are reversed.

Fig. 279 is a photographical reproduction of a fancy gauze or leno fabric in which bands of plain cloth A alternate with the gauze portions B, C, B. Fig. 280 illustrates part of the design for this fabric, and is arranged for top doups. Two doups are required, the threads for each doup being drawn to right and left alternately so as to develop the more or less ogee or diamond forms. In the weaving plan E, 8 leaves are shown, and these are attached by dotted lines to the 8 horizontal lines which represent the leaves.

No. 1 is the loose slip or doup for the large gauze figure;
„ 2 „ doup carrier „ „ „ „
„ 3 „ loose slip or doup „ small „ „
„ 4 „ doup carrier „ „ „ „
„ 5 } are for the plain cloth in parts A, and for the plain weave double
„ 6 } warp in parts D—the centres of the large gauze figure;
„ 7 is the leaf working in conjunction with doup and doup carrier 1 and 2;
„ 8 „ „ „ „ „ „ „ „ 3 and 4.

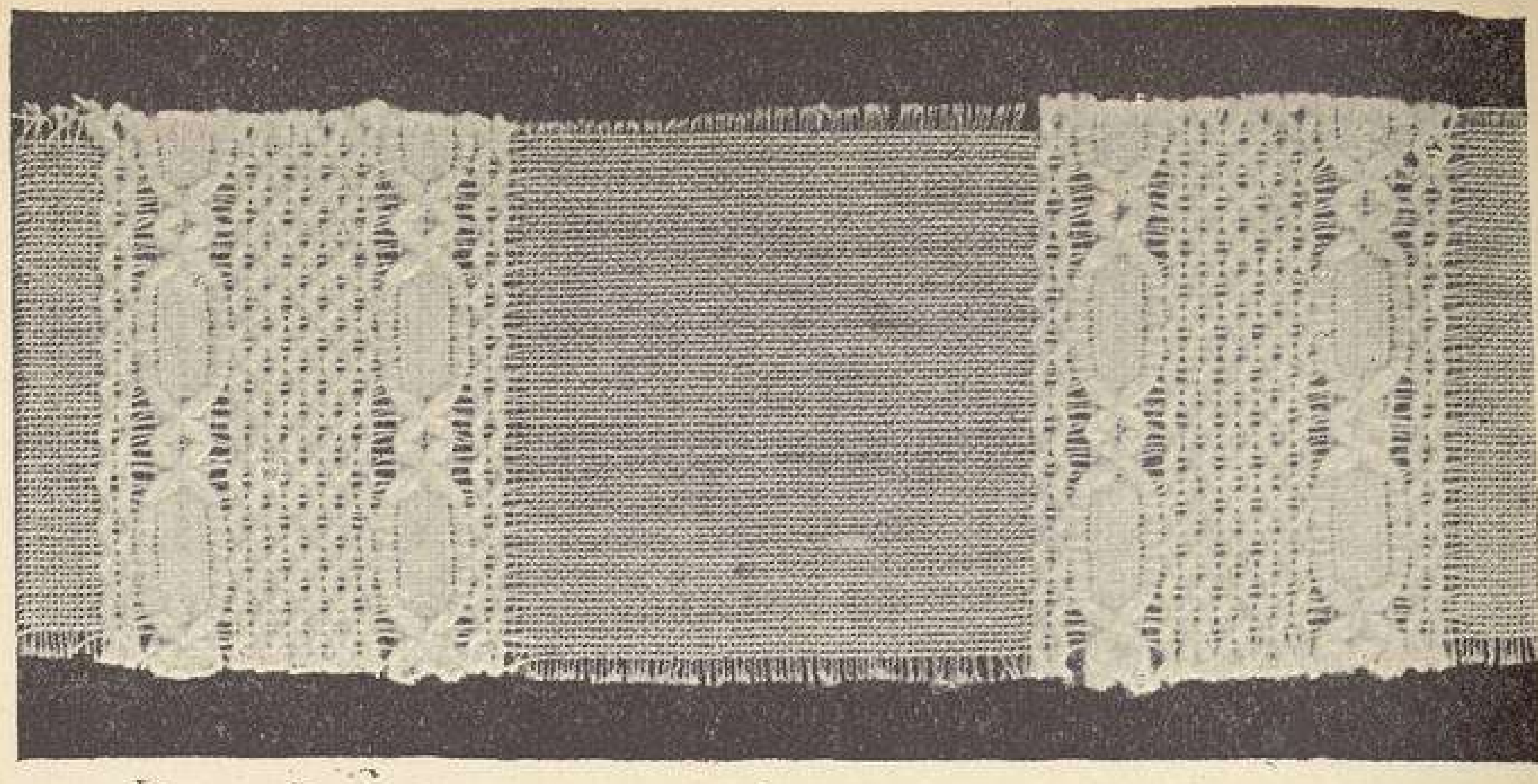


Fig. 279.

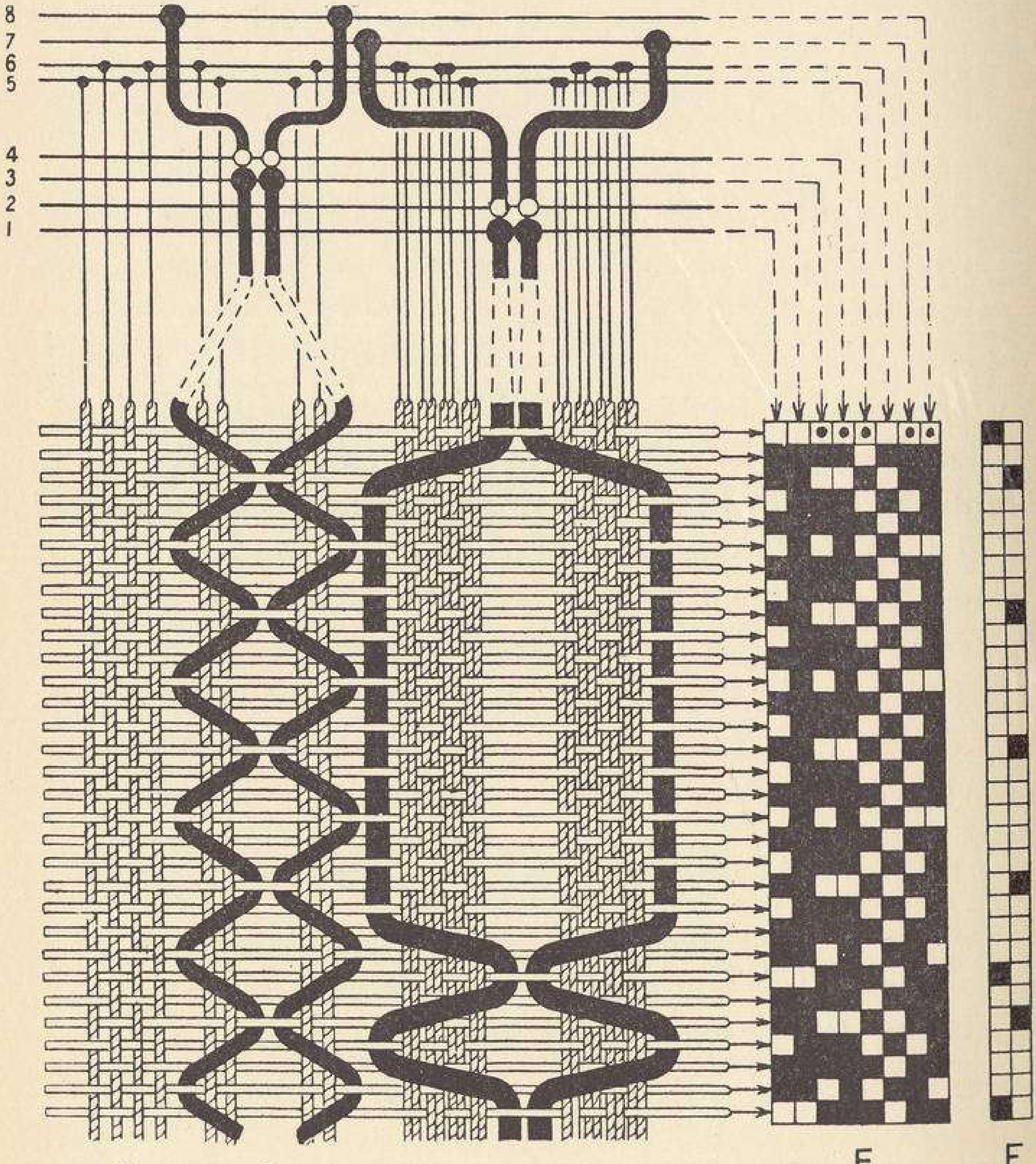


Fig. 280

An ordinary reed with regularly spaced wires could be used for this pattern, but a special reed would probably be more suitable. The reed may be built specially, or reed wires may be withdrawn at certain parts to suit the gauze portions. We have stated that the crossing thread and all the threads which it crosses should be in the same split if the crossing thread is operated behind the reed. If the reed for this cloth were built specially as in Fig.

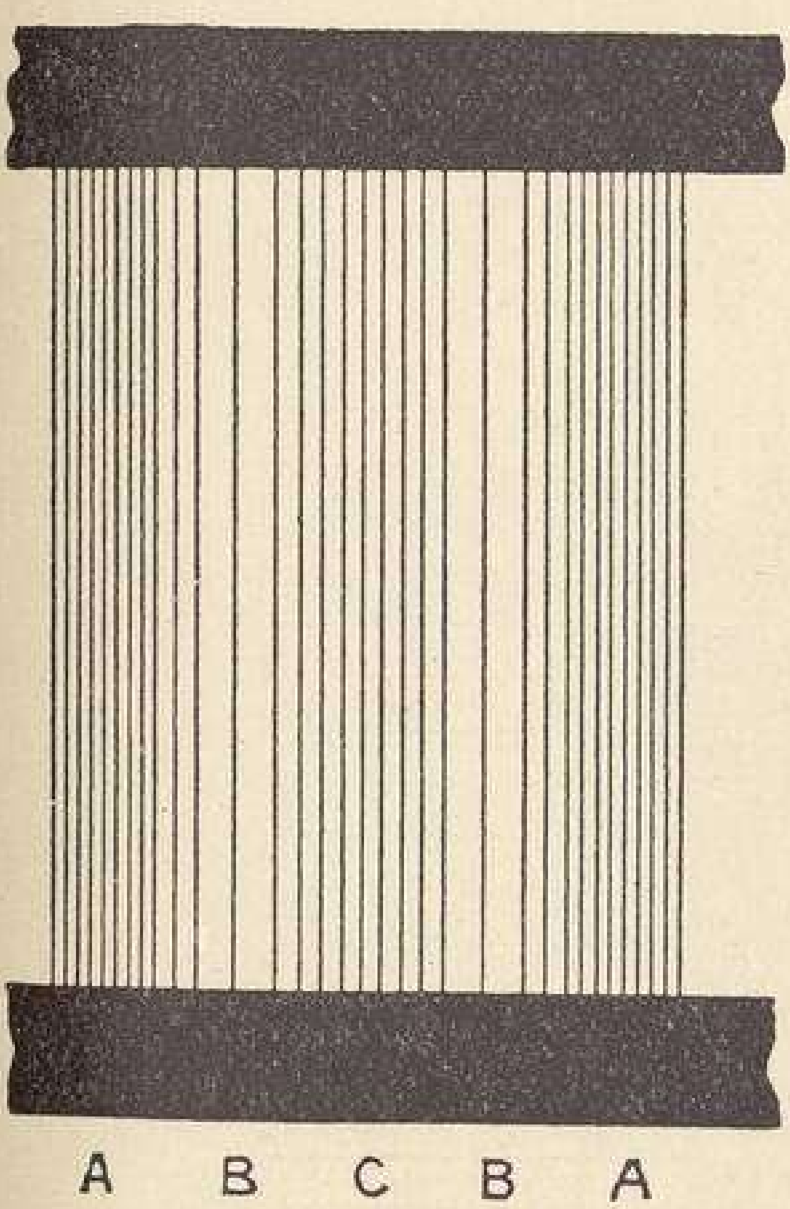


Fig. 281.

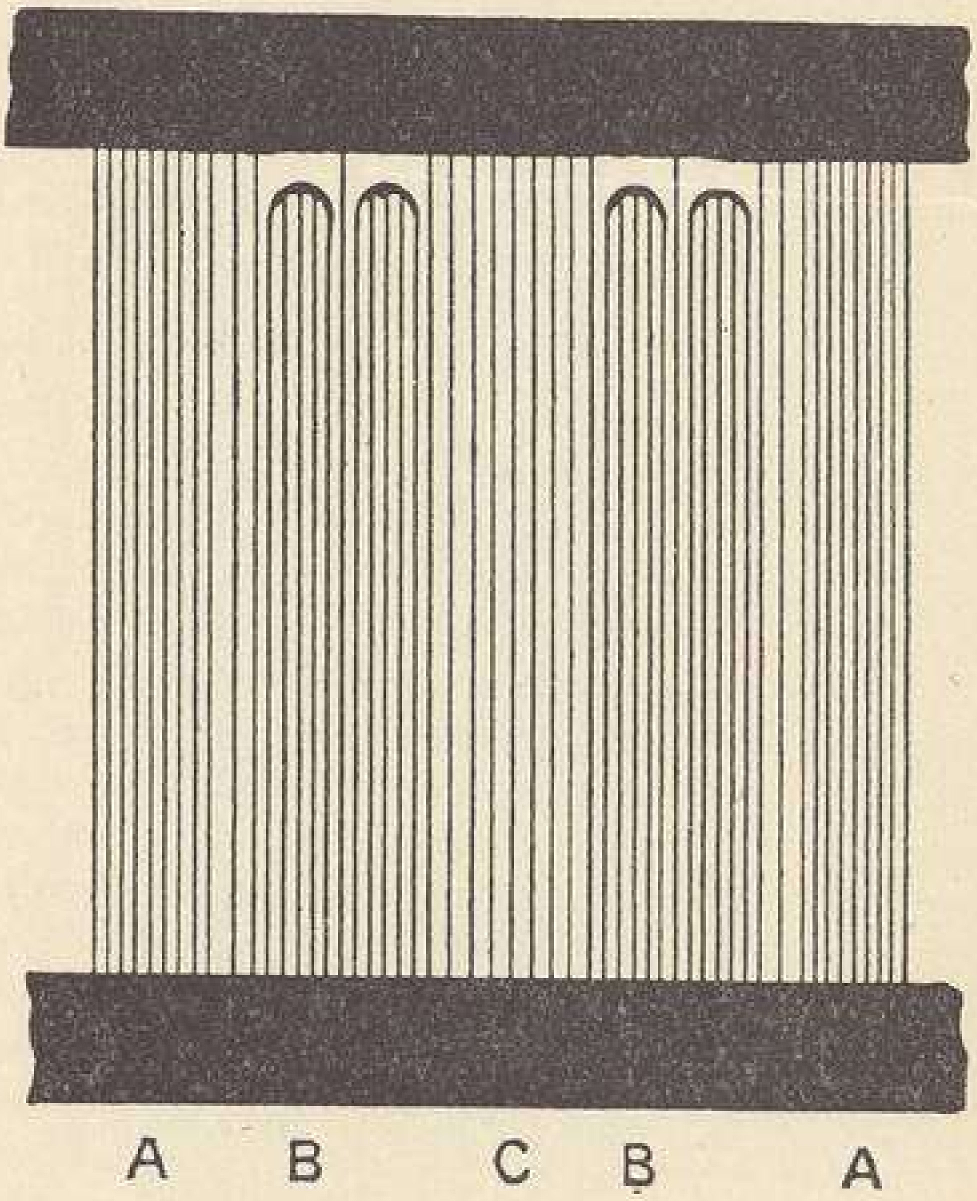


Fig. 282.

281, the parts A would contain two threads per split, and the parts C three threads per split. At B, however, nine threads constitute one group, and an extra wide split, about three times as wide as the ordinary ones, would be used for this group. In some fabrics the gauze threads have to cross over more threads than that shown, and in such cases the crossing thread is operated in front of the reed, or else the reed is made specially as indicated in Fig. 282. In this illustration the reed is intended for four splitfuls,

2 H

say of plain cloth, and in these parts B the reed wires are secured only by the bottom ribs of the reed; the crossing threads move from side to side of these four splits, being permitted to do so by the large gaps at the top of the reed.

When the crossing threads have absolutely distinct

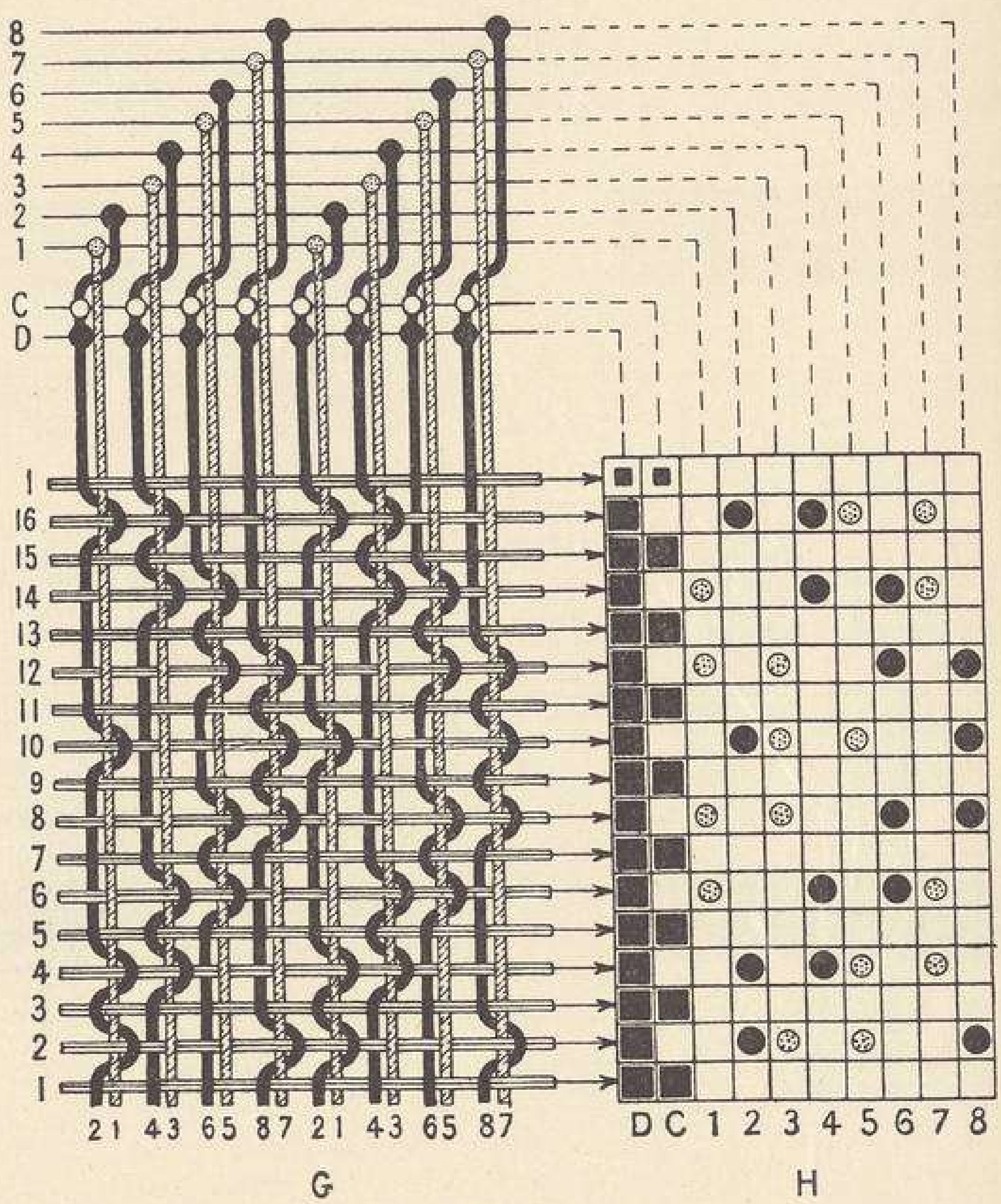


FIG. 283.

movements, a separate doup and a separate slackener are required for each. It is, however, almost impossible practically to increase the number of these beyond two or three, but this restriction does not prevent the formation of patterns which have the appearance of requiring such a number, or even a larger number, of doups and slackeners. Thus, consider plan G, Fig. 283, which shows two repeats of the pattern in the way of the warp. Here the threads 2, 4, 6 and 8 are crossing at different times; hence, on the principle just described, it would appear that four doups are necessary. As a matter of fact the pattern may be woven with one doup and one slackener, but before showing how this may be done, we illustrate,

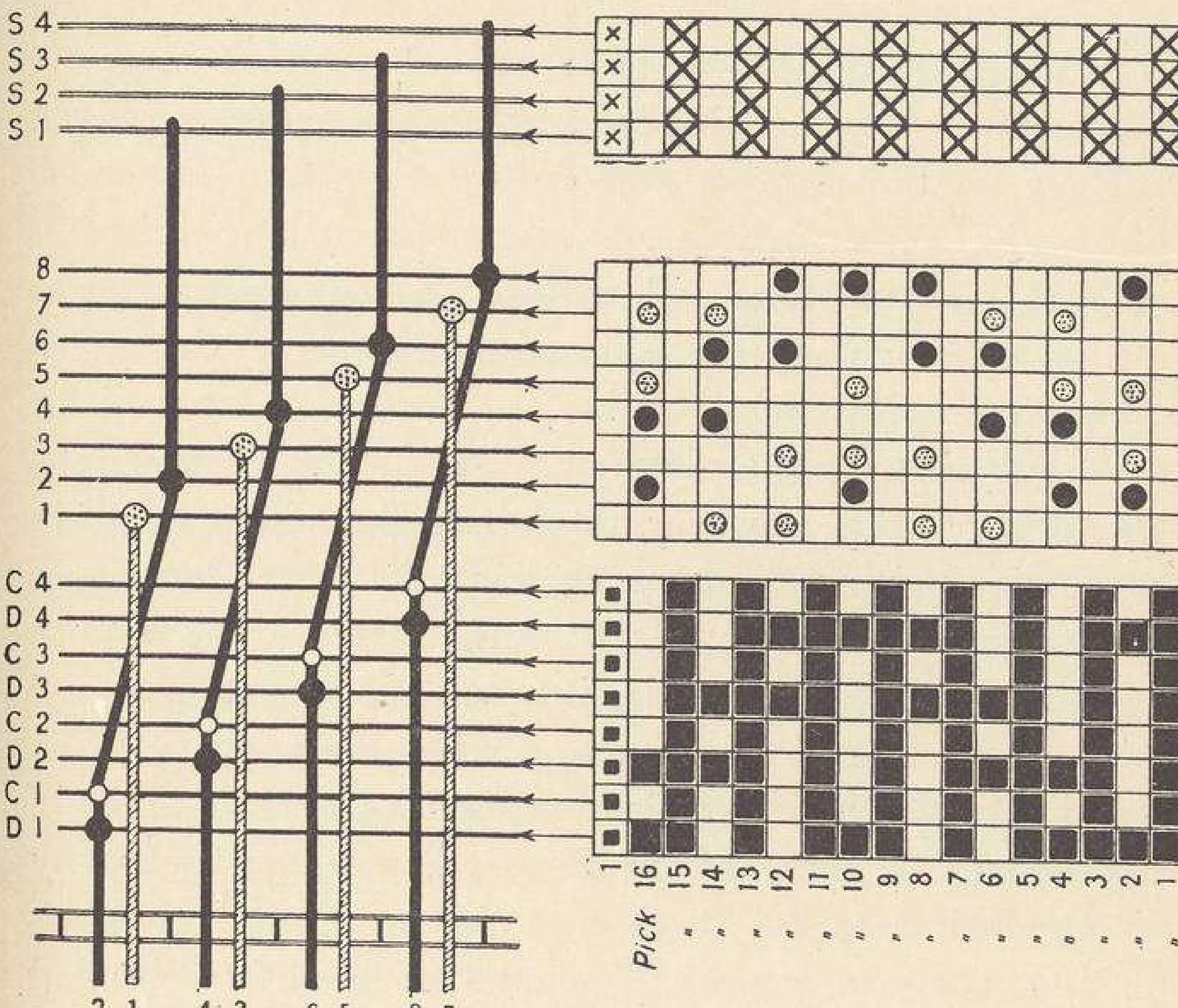


FIG. 284.

in Fig. 284, the apparently necessary four doups. We also show four slackeners, although one is sufficient even when four doups are used. In Fig. 284 :—

D1, D2, D3, D4 are the four loose slips or doups ;
C1, C2, C3, C4 are the four corresponding doup carriers ;
S1, S2, S3, S4 are the four slackeners ;
1, 2, 3, 4, 5, 6, 7, 8 are the eight ordinary shafts, the even numbers of which work in conjunction with the doups.

Whenever the doup and doup carrier rise together, the slackener must also come into play, and it will be seen that these movements take place on all odd picks, *i.e.* when the crossing thread is on the left hand side of the crossed thread with the draft as shown. If the draft be reversed, then the conditions are reversed. Now, since the slackeners yield only when the doup and doup carrier rise together, it follows from the above that they are inoperative on even picks, *i.e.* when the crossing thread appears on the right of the crossed thread. Thus, each of the slackeners yield on odd picks, but remain motionless on even picks, therefore all crossing threads might just as well be over one and the same slackener. And since each doup carrier rises on odd picks, and is down on even picks, it is clear that one doup carrier is sufficient. It would be almost impossible, however, to operate four doup shafts in connection with one doup carrier, and four doups are necessary according to Fig. 284. If, therefore, the pattern be woven on this principle, it would be essential to use four doups, four doup carriers, and one slackener. The weaving plans (or lifting plans as we have termed them in this figure) for each set are detached, and represented by distinguishing marks.

Now whatever principle is employed for the production of the pattern illustrated in Fig. 283, it is evident that there must be four distinct movements either on the part of the doups themselves, or of the doups and doup carriers combined, simply because there are four distinct orders of crossing the gauze threads. If, therefore, it is decided to allow the four distinct movements to be made by the loose slips or doups and four ordinary leaves, one doup carrier only will be required. Thus, in Fig. 283, the crossing threads are drawn through leaves 2, 4, 6 and 8, crossed under threads 1, 3, 5 and 7 respectively, and then all the even threads are drawn through the loose slips D of the same doup carrier C. On odd picks all even or crossing threads appear on the left of the odd threads, and they are placed in this position by the lifting of the doup carrier and the doup. On even picks two crossing threads appear on the right, this position being determined by the lifting of the doup D and the two leaves which control the crossing thread (shown by solid black circles in plan H). Two other threads are also lifted on even picks, shown in plan H by marks ⦾. It is easy to see that plain cloth may be made at any part by lifting doup D and doup carrier C on odd picks, and by lifting leaves 1, 3, 5 and 7 on even picks, or *vice versa*. The chief drawback in the one doup arrangement for this class of work is that, when the doup rises to form the open shed, only part of the loose slips are required to form gauze—the remainder, although lifted by the doup shaft, should really be down. As a result the loose slips double up and sometimes cause yarn breakages or faulty weaving.

The single doup method is, however, extensively applied in jacquard gauze weaving, and it may, and almost invariably does work in conjunction with the mails of the harness from one or two long rows of hooks. With 10 rows of needles it is usual to operate 12 rows of hooks, in addition to the doup, and to cross the threads as desired by the particular type of fabric. Thus, in Fig. 285, where we show 13 horizontal lines and a small part of the comber-board, the front line represents the doups or loose slips which may be operated by special heavy hooks in the jacquard, or by ordinary hooks in the spare row at each side of the jacquard. The cords from the 1st and 2nd rows of the machine pass through part A of the comberboard; these cords are for the doup carriers, which must work in unison with the hooks for easing the warp. The 11th and 12th, or two back rows or cords in part C, are for easing the threads on the crossed shed, *i.e.* when the

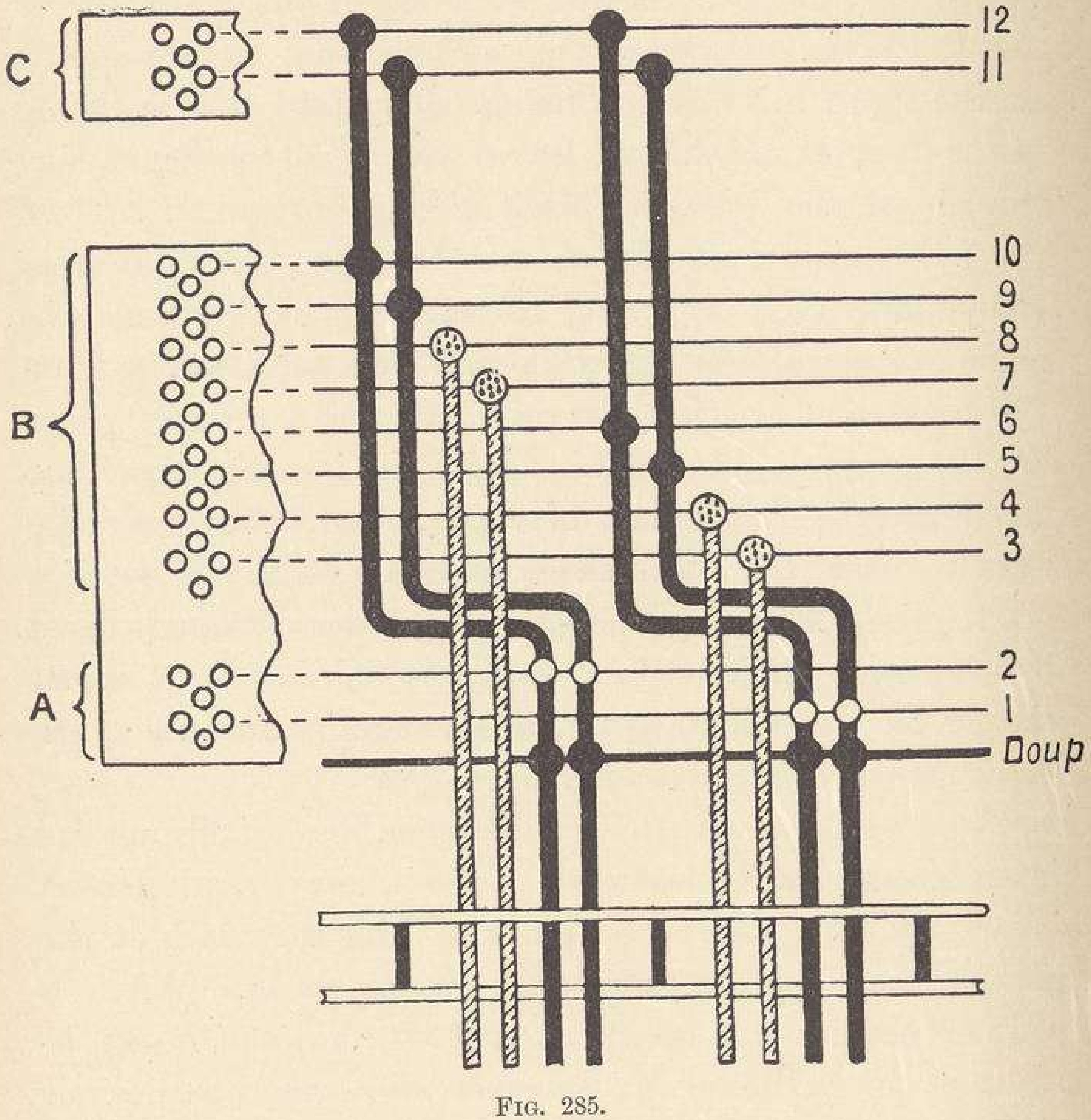


FIG. 285.

doup carriers rise; hence, each needle in the 1st row controls a hook in the 1st row and another hook in the 11th row. Similarly, each needle in the 2nd row controls two hooks — one in the 2nd row and another in the 12th. Since the easing hooks in the two back rows are not required to rise as high as the ordinary hooks (half the distance is usually sufficient) they are operated by a separate griffe. Both griffes are lifted by the same lever, but the point of connection of the lever with the hooks of the easing griffe is nearer the fulcrum than is that for the ordinary hooks, hence a shorter movement is obtained. Rows 3 to 10 inclusive, or cords in part B, are for forming the figure. The harness is shown drawn from back to front, and two threads from separate rows cross two ordinary threads; they are then drawn separately through the two slips of the doup carriers. It will be seen that rows 3 to 10, along with the doups, are used for figuring purposes with an open shed, and that rows 1 and 2, part A, with their corresponding easer rows 11 and 12, part C, are used only when forming the gauze portions or crossed sheds.

Since there are 10 needles to be operated, it would appear at first sight that 10-row paper would be the most suitable, but if we refer to Fig. 285, we shall see that, although there are 10 rows of needles, there are only 8 individual threads actuated by each short row. Conse quently, if the cloth be square, which is often the case, it will be very convenient to use 8 by 8 paper, and to use proportionate paper if the number of picks per inch differ from the number of threads per inch. If 10-row paper were used, it is clear that, since there are only 8 threads for the 10 rows, it would be necessary to use 10 by 8 paper for fabrics in which the number of threads per inch equals the number of picks per inch, and to use proportionately ruled paper for under and over shotted fabrics.

Before showing how the 8-row paper may be used for these 10-row machines, we will consider the designing of gauze fabrics without regard to the number of hooks in a

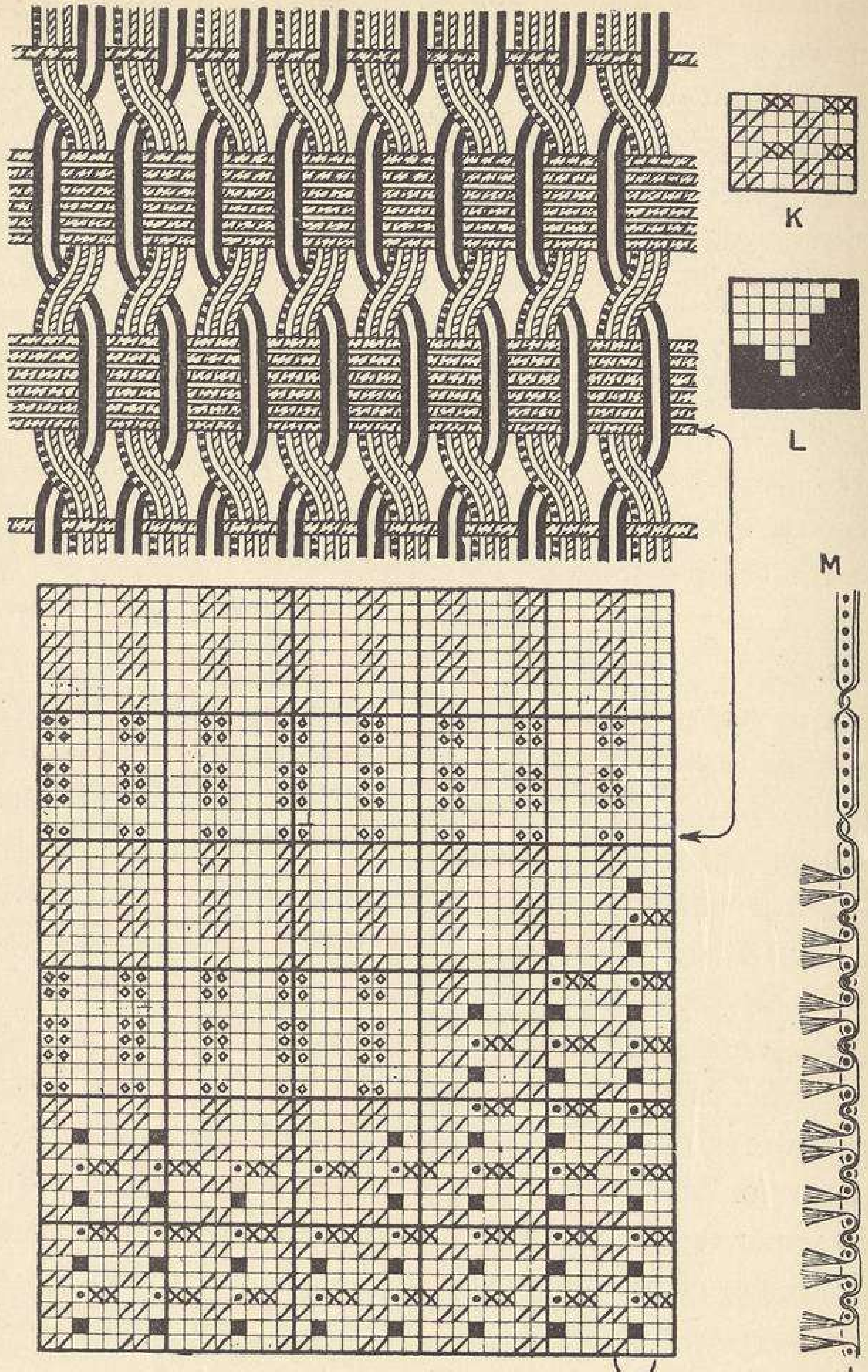


Fig. 286.

row. Fig. 286 is the design for part of a fabric in which a plush figure is developed upon a gauze ground; in the gauze portion there are six picks in each open shed, and six in each crossed shed. Design J shows 40 threads of the pattern, each individual thread being shown separately. The drawing or plan of the fabric immediately above the design shows the same 40 threads as they appear in the fabric when forming the gauze ground with the weft. The warp throughout is as follows: 2 crossing threads, 1 pile thread, 2 ground threads. The two crossing threads pass over the weft on the left, and remain above the weft on that side for six picks; they then cross to the right, and appear at that side over six successive picks. Plan K is the ground plan; L is a small part of the plush figure represented in design J by the solid marks; while M is an intersection of the last five threads, the three middle ones only being in view. Although two threads cross three, it will be seen that the ground threads work together in pairs, and may, therefore, be drawn double through the mails; indeed, the practical mounting would be so in order that the warping arrangement may repeat in the short rows of the jacquard.

Fig. 287 shows the same part of the design arranged on 8 by 8 design paper for the card-cutter, and for the 10-row machine with draft as illustrated in Fig. 285. The crossing threads in Fig. 287 are on the 1st and 2nd, and the 5th and 6th vertical lines or cords; when the design is turned through 180°, or upside down, for cutting, these cords will correspond with the 10th, 9th, 6th, and 5th rows of holes, part B, Fig. 285. The diagonal marks (/) in the design Fig. 287 indicate the crossing threads on the left in the open shed, *i.e.* when lifted by the loose slips through the action of the cords in rows 10, 9, 6 and 5, Fig. 285.

The small diamonds (◇), on the same cords as the diagonals in Fig. 287, show that the crossing threads must be on the right to form the crossed shed; therefore rows 1 and 2, part A, Fig. 285, with easer rows 11 and 12, part C, must be cut for lifting. The card-cutter therefore cuts as follows:—

1st and 2nd rows on card, or rows 10 and 9 (Fig. 285) for open shed when represented by diagonals /

9th row on card, or row 2 (Fig. 285) for crossed shed when represented by diamonds ◇

5th and 6th rows on card, or rows 6 and 5 (Fig. 285) for open shed when represented by diagonals /

10th row on card, or row 1 (Fig. 285) for crossed shed when represented by diamonds ◇

3rd, 4th, 7th and 8th rows on card, or rows 8, 7, 4 and 3 (Fig. 285) for ordinary and plush weaving.

This fabric contains about 144 threads per inch, that is about 28 pile threads per inch.

The groundwork of the better class Madras muslins is formed by gauze, but in this case the crossing is done by means of what is termed a "gauze reed," which performs the same function as the doups, etc. In this particular fabric, however, all the crossing threads move from side to side at the same time, and cross one thread only. The gauze reed consists of ordinary reed wires extending between the two usual ribs of the reed, and between each pair of ordinary reed wires is a second wire which reaches to the middle of the reed. These half length reed wires have smooth pointed tops, and each contains a hole near its point for carrying one of the odd or crossing threads which do not pass through the harness mails. The even or harness threads are taken straight from the harness and passed loosely between the wires of the gauze reed. These threads, however, pass singly through splits of a plain or "tug reed" situated midway between the harness and the gauze reed. The latter rises and falls every gauze pick in order to raise the crossing thread above the weft, but previous to rising, on odd gauze picks say, the tug reed is positively moved to the left by the action of a cam so

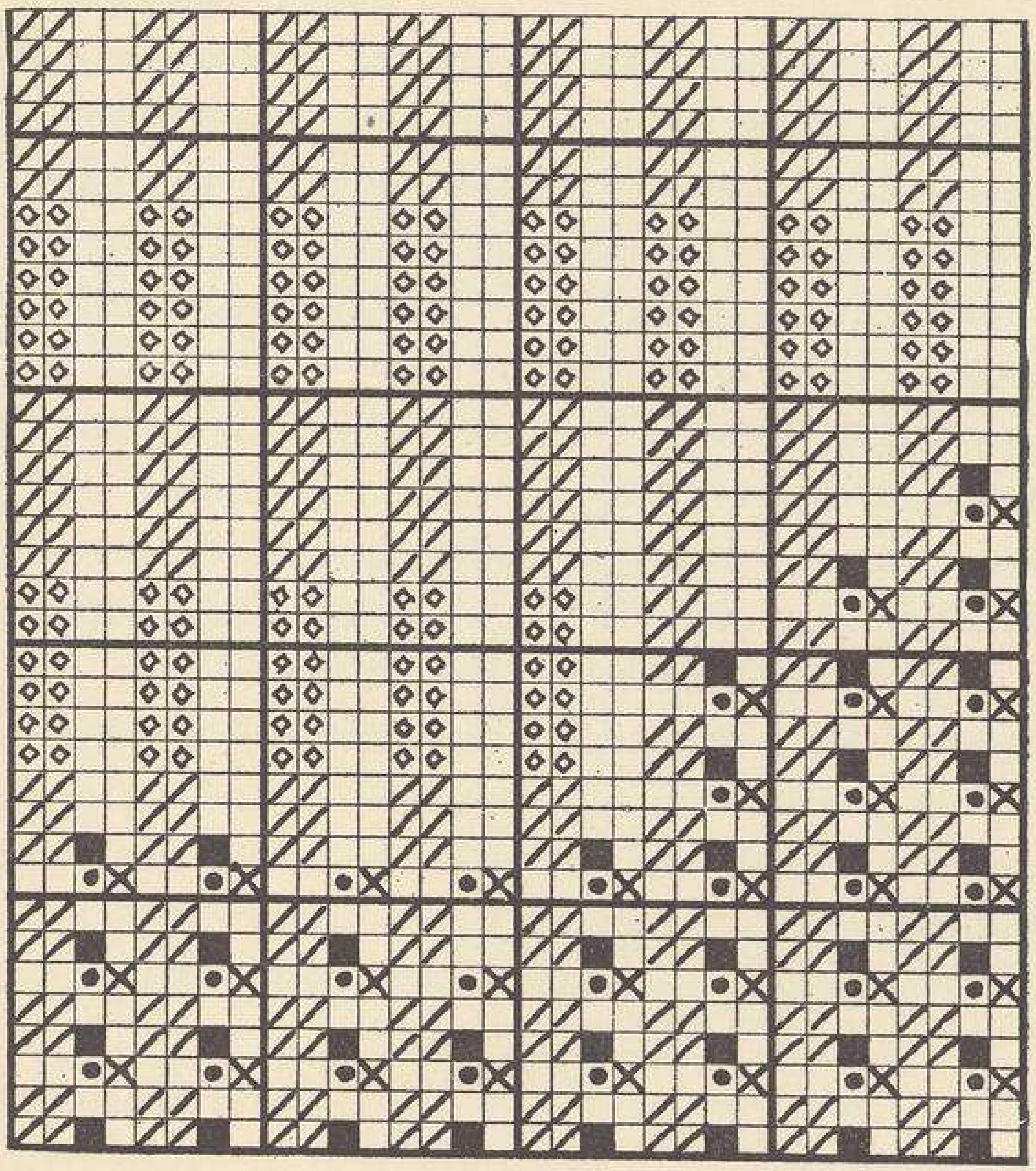


FIG. 287.

that all crossing threads rise on the right of all harness threads; then previous to even gauze picks the tug reed is returned to the right by the action of a spring, thus carrying all harness threads in that direction, hence when the gauze reed rises it lifts all crossing threads to the left of the harness threads. In older forms the tug reed was omitted, and the comber-board containing the harness was moved bodily to right and to left, but this method has been almost entirely superseded by the above-mentioned tug reed.

The designs for these fabrics are made on the same principle as those for common harness damask designs; no weaves appear on the paper, and when two or more colours of weft are introduced, the newer form of loom is arranged to perform all these functions automatically. A card is laced for each pick—blank for the gauze pick, but cut according to pattern for the one, two, or more coloured figuring picks intervening. Each card controls the box motion for its own particular weft, and the loom picks at will from either end. The figuring weft passes over all odd or crossing threads, and under all harness threads where pattern is being developed, but at other places it passes over all warp threads and floats entirely unbound on the surface of the fabric. After the piece leaves the loom these floating portions are cut off by machinery. For such a fabric, and with these methods of production, little knowledge of the actual cloth structure is required by the designer.

CHAPTER XXIV

LAPPET AND SWIVEL FABRICS

Lappet weaving, or the ornamentation of woven fabrics by means of lappet frames, is executed in the loom simultaneously with the weaving of the foundation texture itself, and produces a type of textile ornament akin to embroidery.

This type of figure development may and does produce some striking and varied effects, but it cannot be relied upon for absolute accuracy or for neatness in the development of the figure. While lappet ornament may be applied to many types of woven texture, its application is almost entirely restricted to plain woven muslin textures, or to fabrics of a gauze nature. The ornament itself may be either continuous or intermittent in character; if of the latter type, the loose or floating threads, which connect succeeding spots or small figures, are shorn off in a subsequent finishing process.

Although mechanical processes are not within the scope of this work, it will be necessary to refer briefly to the chief features of a lappet loom in order that our further remarks concerning lappet designs may be rendered intelligible. In addition to the ordinary parts which are essential for the production of the foundation texture—say a plain cloth—a lappet loom is provided, among other items, with the following accessories :—

1. A pin frame, situated immediately behind the race of the lay; this frame rises as the lay recedes, and presents its pins close against the race board so as to form the back support of the shuttle as the latter passes from box to box; the frame falls again, as the lay advances, until the tops of the pins are beneath the warp and the cloth in order that the reed proper may beat up the weft, and that the needle frame, as well as the whip or ornamenting threads, may be traversed laterally by the lappet wheel through the distance required to form the ornament.

2. One or more needle frames—four being the usual limit—placed between the pin frame and the reed; the latter is supported about three inches behind the race of the lay to provide room for the frames. (The traverse

of the lay of a lappet loom is usually about three inches more than that of a similar loom for plain fabrics.) Each needle frame consists of a wooden bar which is provided with a series of brass or steel needles, each of which is from 3 to $3\frac{1}{4}$ inches long, pointed at the top for easy entrance between the threads of the warp, and provided with an eye for the passage of the whip or lappet threads. The spacing of the needles in each frame, as well as the number of needles, depends upon the distribution of the pattern and the cloth to be ornamented, but the spacing of the needles, and the traverse of the needle bars, must both be arranged as accurately as possible in multiples of splits or dents of the reed used for the ground texture. Each needle frame may, at will, partake of a rising and falling movement in unison with the pin frame, and also of a short lateral or side to side movement; or if desired any frame may remain inoperative both vertically and laterally as determined by the pattern wheel.

3. Extra warp beams or rolls for the whip or lappet threads, one whip roll being usually required for each needle frame. These rolls are supported either under or over the warp beam proper, and the threads from each roll are passed in a zigzag manner through a special tensioning device, one tensioning arrangement being necessary for each roll. Each whip thread is then led loosely between the heddles of the camb shafts, under the reed, up to and through an eye of the needle frame by which it is controlled. In some special cases the whip threads for the front needle frames pass under the intervening back frames, but in most instances they pass directly from the under side of the groove supporting the reed to the needle eye. As the needle frames rise, they lift their whip threads to or near the top of the shed, *i.e.* above the

weft: after the passage of the shuttle, the frames fall below the warp line to permit the reed to beat up the weft, and to enable them to be moved laterally to their proper position for forming the pattern. On the succeeding pick the whip threads are lifted above the weft in a different part of the cloth. It is thus evident that, when the needle frames are mounted below the warp, the lappet figure will be developed on the under side of the fabric, and invisible, unless by mirror reflection, from the weaver's position. Further, it is also evident that a lappet thread is always stitched or bound round a weft thread, and that there can be no intermediate stitching between the extreme points on the same horizontal whip line.

4. A pattern wheel, unless the lag and peg motion is used, mounted upon and oscillating with the lay, and employed to control the lateral position of the needle frames, or the extent of their movement, and to determine whether they shall operate vertically or remain inoperative. The usual form of pattern wheel, termed the "Scotch" lappet wheel, is made from a solid piece of well seasoned, close grained, wood—plane tree or sycamore. A number of ratchet teeth—a measure or a multiple of the picks in a repeat of the pattern—are cut on its periphery: thus, if the wheel is advanced one tooth every two picks, the number of teeth may be half that of the picks; it may be the same number; or it may be a multiple of half the picks. When the wheel is moved one tooth per pick, it is clear that the number of teeth must be equal to, or some multiple of, the number of picks. One concentric groove for each needle frame is then formed in the face of the wheel in accordance with the pattern to be developed. A projection or peck, attached to a lateral extension of the corresponding needle frame, enters into this groove,

and by it is laterally controlled. On the opposite face of the wheel parts may be fixed to determine when the frame or frames shall be inoperative as regards vertical movement. Accurate cutting and forming of the grooves in the pattern wheel are essential to secure accuracy in the development of the pattern.

Pattern wheels are of two general kinds, termed "common wheels" and "presser wheels"; they are distinguished as follows: In a common wheel each ratchet tooth, and therefore each corresponding radial division of the wheel, serves for two picks; and, since the needle frames for this type of wheel are automatically, but negatively, moved from left to right, and from right to left, on alternate picks, in regular succession, both sides of the groove must be carefully formed. Each side of the groove limits the movement of the frame, and is therefore employed for forming the pattern. In this case the groove in the pattern wheel does not move the needle frame, but simply limits its movement; other parts move the frames negatively to left and to right continuously.

Wheels of this type are necessarily somewhat limited in their application, since they cannot advance a lappet thread in the same direction on successive picks. Notwithstanding this limitation, however, they are used for a wide range of patterns, and are more generally utilised than the presser wheels. In presser wheels, each ratchet tooth and each radial division serves for a single pick only. These wheels press or pull a needle frame positively in one direction by the form of the groove, while a spiral spring returns the frame when permitted to do so by the contour of the groove. Both in advancing and returning the frame, the same side of the groove is in action. One side only, therefore—the outside—requires to be carefully cut; the other side is just arranged to follow the general contour of the pattern while leaving room for the free movement of the peck. It will be obvious, however, that with the presser wheel there is no restriction as to the direction of movement of the frames, other than that of the pattern wheel and the working limits of movement—say about $3\frac{1}{2}$ inches—of the frames themselves. In both systems the outer pattern grooves control the needle frames nearest the pin frame, and the inner grooves control the frames further back. When the pattern is suitable, it is possible to combine the leading features of both systems in one wheel.

Each order of interlacing requires a separate needle frame and groove in the pattern wheel, and, in general, each pattern requires its own pattern wheel. It is possible, however, by altering the spacing of the needles in the various frames, to obtain different combinations of the individual orders of working on the cloth, and so produce varied effects from one wheel. Coloured yarns may also be used, with considerable effect, for developing the patterns. The dimensions of the pattern wheels vary between 8 or 10 inches as a minimum to 24 inches maximum outside diameter, and are determined, among other considerations, by the following: The number of picks in a repeat of the lappet figure must be accommodated; the pitch of the ratchet teeth must not be too fine, otherwise the action will not be reliable; the arc, or rather the circular space between two adjacent radial lines near the centre of the wheel must not be too small for the diameter —say $\frac{1}{4}''$ to $\frac{3}{8}''$—of a feeler or peck; space must also be provided for a groove for each frame to be employed. A wheel 12 inches diameter over the points of the teeth would give a circumferential space for practically 38 teeth

($12'' \times 3{\cdot}1416 = 37{\cdot}7$ teeth) of one inch pitch, and at a radius of $2\frac{1}{4}''$ we should have

$$\frac{2{\cdot}25'' \times 2 \times 3{\cdot}1416}{38 \text{ teeth}} = \frac{7}{19}''$$

or practically $\frac{3}{8}''$ space between each pair of radial lines at this distance. 38 teeth $\times$ 2 picks per tooth $= 76$ picks in a repeat of the pattern for a common wheel. This number could be doubled by increasing the diameter of the wheel to 24 inches; and it could then be further increased by reducing the pitch of the teeth, say, to $\frac{3}{4}$ inch. Thus:—

$$\frac{24'' \times 3{\cdot}1416}{0{\cdot}75'' \text{ pitch}} \times 2 \text{ picks per tooth} = 201, \text{ say } 200 \text{ picks.}$$

If the pitch of the teeth be further reduced to $\frac{1}{2}$ inch, giving approximately 150 teeth or 300 picks in a revolution, the arc between two radial lines, at 6 inches from the centre of the wheel, would measure only a quarter of an inch. This would require a peck of not more than $\frac{1}{4}''$ diameter.

Wheels are marked off or scored concentrically by means of a comb of the same pitch as the loom reed in the case of coarse setts, and of half the pitch in fine setts. In the former case, the actual spacing of the splits of the reed is marked directly upon the wheel; in the fine setts every second split only is marked, and a single split is judged by the eye. As a concrete example of lappet wheel dimensions and construction let us consider the "common wheel" specimen illustrated in Fig. 288. It is a 3-frame example—two frames produce the key stripe by working continuously, while the third frame produces the intermittent spot effect.

The pattern repeats on 33 splits and 26 picks, and there are 28 splits per inch in the reed. Since it is a common wheel type there would be only 13 teeth in a repeat, but this would be doubled to 26 teeth in order to get a wheel of workable size; there would be, therefore, two repeats of the pattern cut round the wheel. If we assume a peck of $\frac{1}{4}''$ diameter, the arc between two adjacent radial lines must not be less than $\frac{1}{4}''$ in length (a shade longer), at a

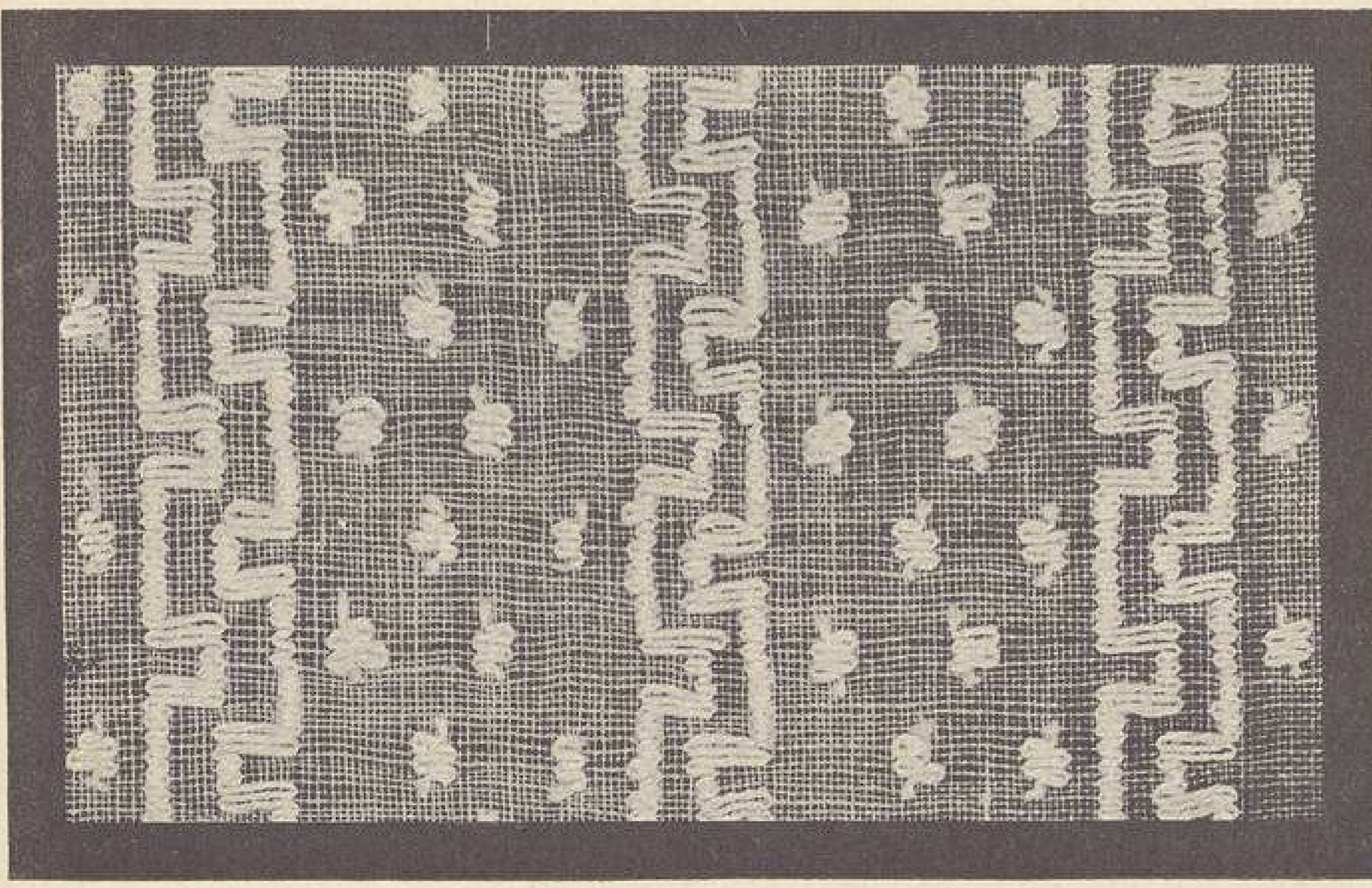


FIG. 288.

distance equal to the radius of the peck from the innermost circle of the groove—

$$\text{radius} = \frac{\text{circumference}}{2\pi} = \frac{26 \text{ teeth} \times 0{\cdot}25'' \text{ pitch}}{2 \times 3{\cdot}1416} = 1{\cdot}035'',$$

and $1{\cdot}035'' - 0{\cdot}125''$, radius of peck $= 0{\cdot}91''$ as the distance of the innermost circle of the first groove from the centre of the wheel.

To this distance must be added the space occupied by 6 splits, or $\frac{6}{28}''$ for the extreme movements of each of the frames 1 and 2; and 9 splits, or $\frac{9}{28}''$ for the movement of the third frame—in all, $\frac{6}{28}+\frac{6}{28}+\frac{9}{28}=\frac{21}{28}$, or $\frac{3}{4}$ inch. Further, to each distance of movement should be added the diameter of the peck, and about half an inch of wood should separate the grooves. The total distance from the centre of the wheel to the outer circle of the last groove will therefore be :—

$$0{\cdot}91'' + (\tfrac{6}{28}'' + \tfrac{6}{28}'' + \tfrac{6}{28}'') + (3 \times \tfrac{1}{4}'') + (2 \times \tfrac{1}{2}'') = 3{\cdot}41 \text{ inches.}$$

Another inch would be necessary on the extreme edge of the wheel for strength, and to permit of sufficient wood for cutting the teeth. The minimum radius for such a wheel would therefore be,—$3{\cdot}41 + 1{\cdot}00 = 4{\cdot}41$ inches.

It is sometimes possible, on account of the configuration of the grooves, as in the case of the key stripe in Fig. 288, to arrange the grooves closer together than is indicated in the above general statement, but such cases can only be considered as they arise.

Fig. 289 shows in a graphic manner the interlacing of one complete repeat of 66 ground threads and 26 picks of the specimen illustrated in Fig. 288, in addition to the ornament shown in heavy zigzag lines, and developed by the whip threads or the lappet needle frames. A, B, and C, Fig. 289, indicate respectively the effects obtained by the three different needle frames. When the pattern is detached as demonstrated by effect C, the part of the whip thread which joins the figures, and shown in outline only, must be removed after the piece leaves the loom.

A more concise and simpler method of indicating the same pattern would be that of placing on design paper the figuring whip thread only; indeed, there is no necessity whatever for introducing the plain ground weave. The patterns, therefore, are generally marked in solid squares only, as is done for most types of textile design. If the lappet wheel is moved every pick, there is not much difficulty attached to the preparation of the design, beyond that which arises from the intricacies of the design itself, since the ordinary ruling of design paper may still be taken to represent individual threads and picks. If, on the other hand, the design is intended to be cut on a common wheel, which moves once in two picks, one horizontal line of the design paper may serve for two picks; and, for symmetry, one vertical line may serve for two warp threads, or one split of the reed: in this case some difficulty may be

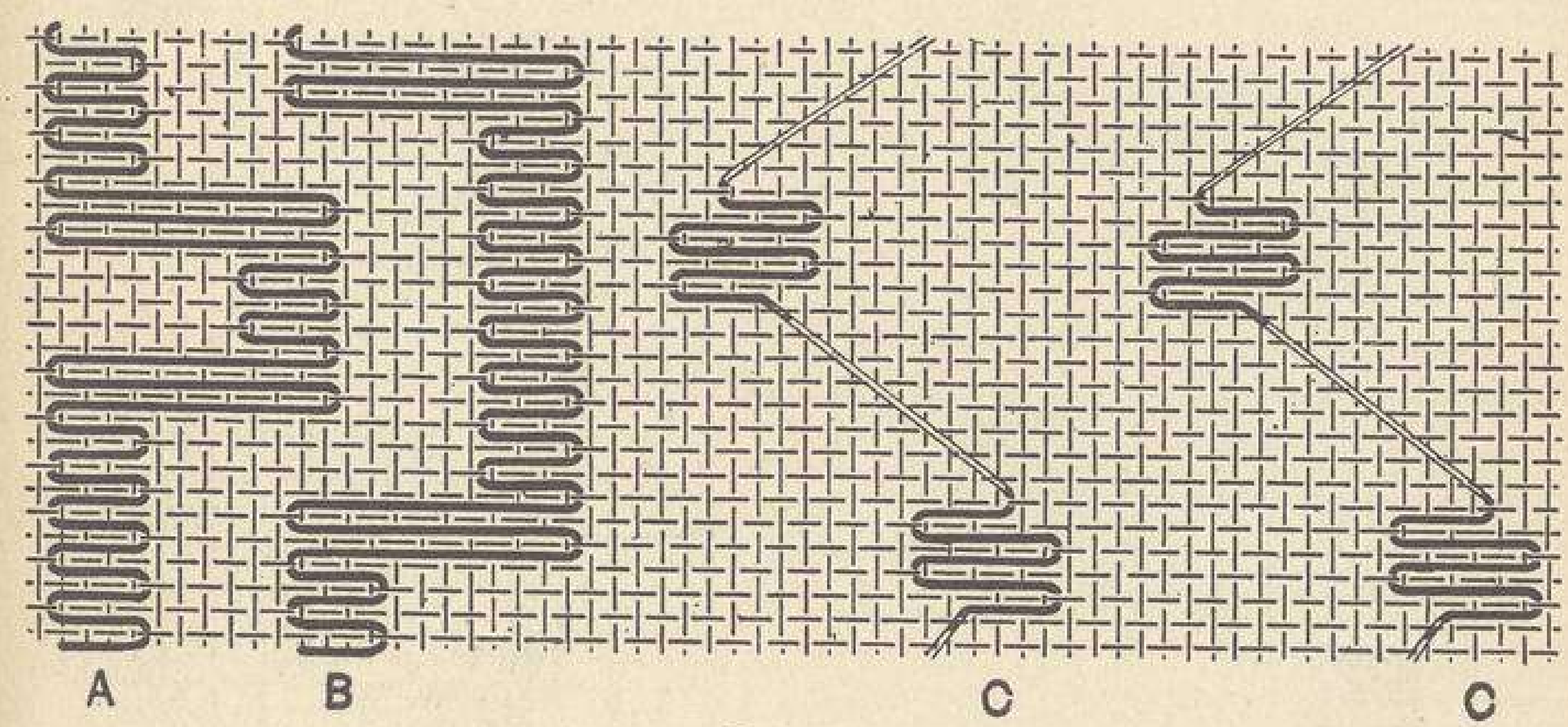


FIG. 289.

experienced. The rotation of the lappet wheel may take place when the needle frames are moving from left to right, or when moving from right to left. To avoid misunderstanding, we shall assume that the wheel is rotated, tooth by tooth, when the frames are moving from right to left, and that the solid marks in Fig. 290, beginning at the top of the figure, represent the odd picks when the lappet frames travel from left to right, while the crosses represent the even picks when the lappet wheel is turned and when the frames travel from right to left. The design paper is ruled in faint lines and heavy lines alternately to indicate

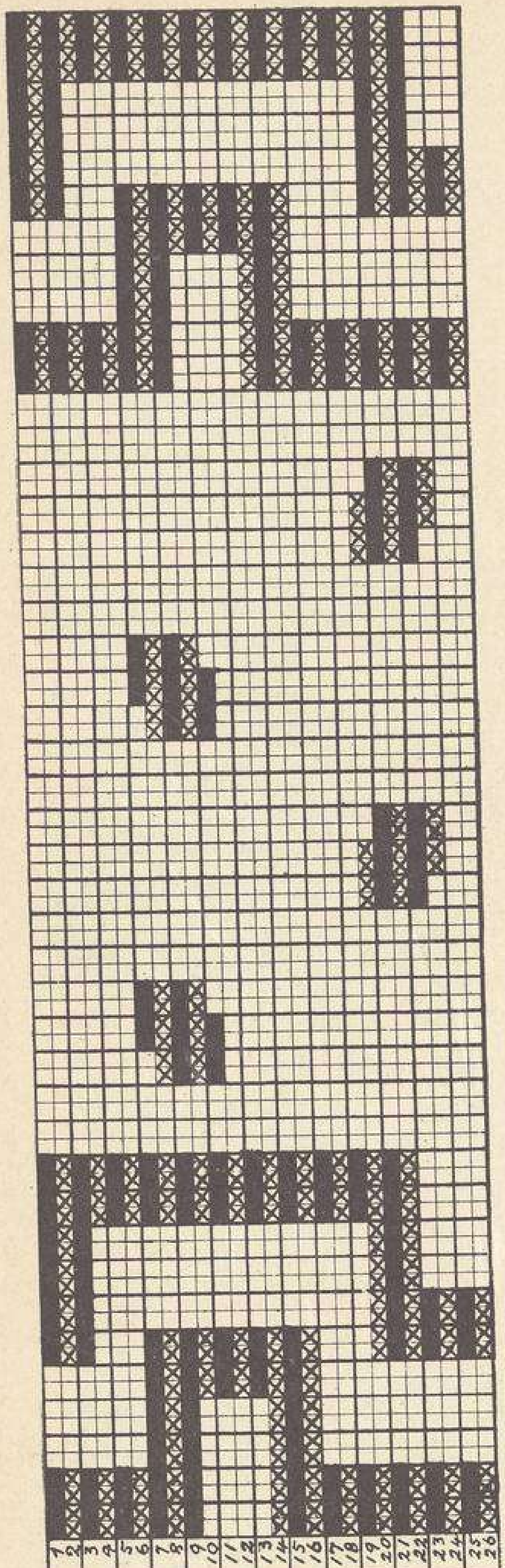


Fig. 290.

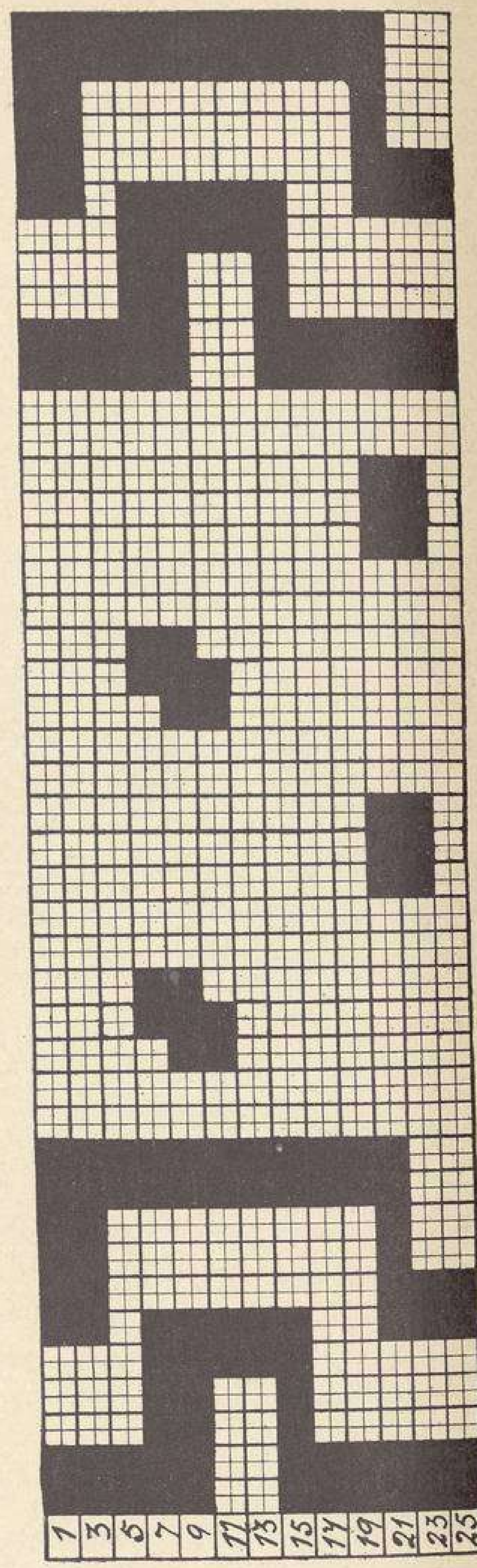


Fig. 291.

more distinctly that two threads, or one split of the reed, and two picks are contained between each pair of heavy lines. If the pattern were painted on single rows of squares, ignoring the faint lines, it would evidently be complete on 33 vertical and 13 horizontal spaces. When the faint line appears between each pair of thick lines, the pattern is identical with that shown in Fig. 289, but if painted on single squares, it would appear as illustrated in Fig. 291, where the solid marks from Fig. 290, *i.e.*, the odd picks only, have been reproduced. The even picks are not shown in Fig. 291, and on comparing this figure with Fig. 290 it will be seen that the three successive long floats in the key portion of Fig. 290 are represented in some parts of Fig. 291 by two picks, and in other parts by only one pick. Similarly, in the spot effect, a difference is found; these apparent irregularities are due entirely to the fact that the even picks are omitted. Since one row of the spot patterns begins on odd picks, and the other on even picks, it is necessary (although we have not done so in the figure) to indicate this in some way on the design paper, if the squares of such paper are not divided by faint lines: for continuous patterns, no such indication is required.

Fig. 292 represents the full wheel necessary for the production of the above pattern. Three grooves are shown—inner, central, and outer—the two former being for the key stripes, and the latter for the spot effect. The numbers 1, 3, 5, etc. up to 25 correspond with the same numbers to the left of Figs. 290 and 291; while the dots within the grooves indicate the extreme positions of the centre of the corresponding peck on the respective odd picks. Short radial lines joining any two dots indicate the travel of that peck from left to right, *i.e.*, while the wheel is stationary, and diagonal lines joining two peck centres indicate the movement of the peck from right to left, *i.e.*, when the wheel is being advanced one tooth. Peck centres, of course, always move horizontally on one or other of the radial lines when the latter are in the

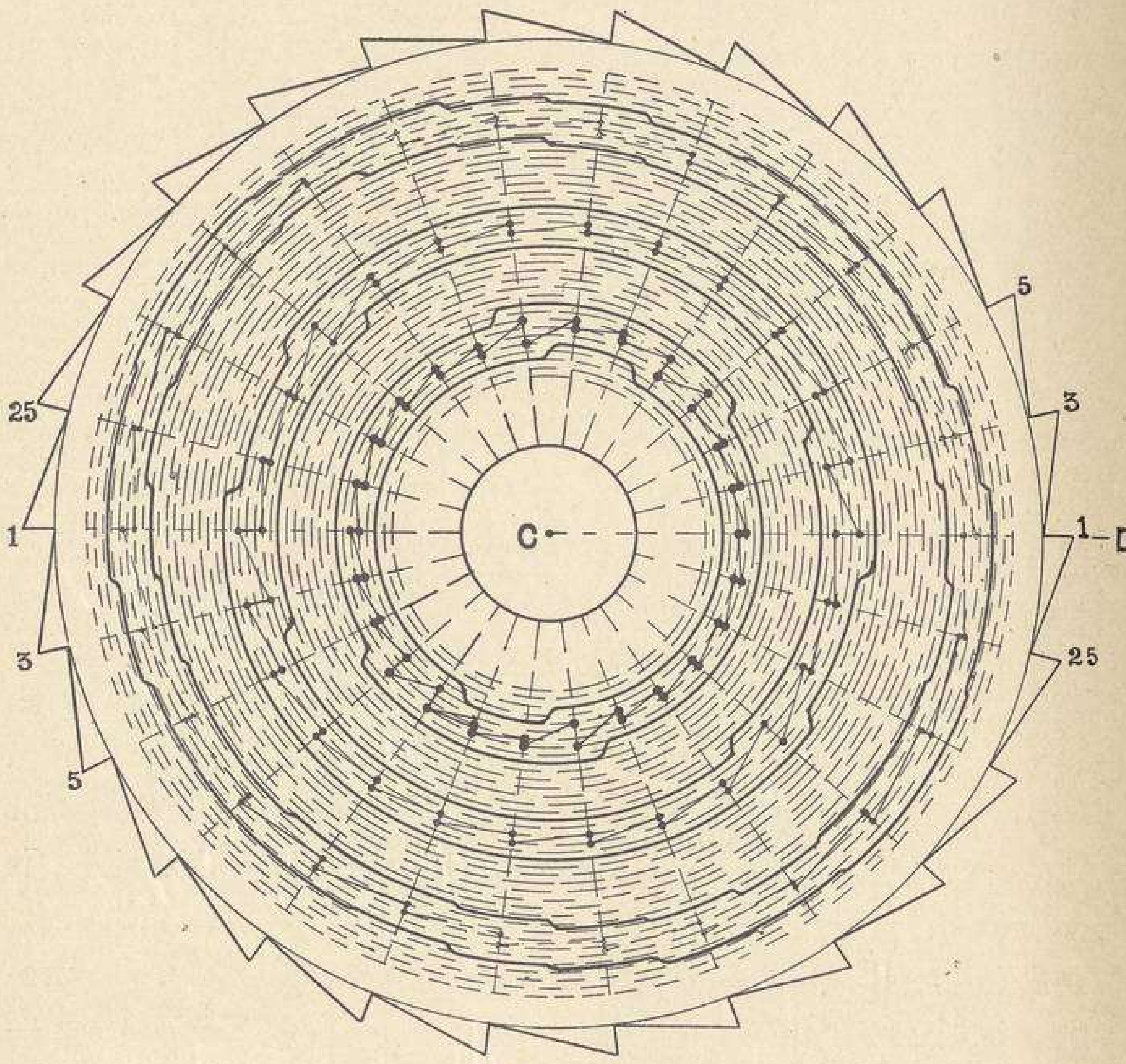


FIG. 292.

position shown by CD—in which position they are to the right of the wheel centre. The wheel in this case is placed at the left hand end of the lay of the loom as viewed from the weaver's position. Dotted concentric circles in the wheel illustrated have been spaced, chiefly for greater clearness, the distance of two splits apart, so that one concentric space on the wheel represents two splits in the reed (4 threads) and two large vertical spaces in Figs. 290 and 291. Consequently, since 7 splits are required for the diameter of the peck ($\frac{1}{4}'' = \frac{7}{28}''$) and 2 splits for the travel, we have,—9 splits $\div 2 = 4\frac{1}{2}$ spaces of the wheel for the narrow part of the key stripe. (In Fig. 292 we have made this $4\frac{1}{2}$ into 5 in order to avoid complications in drawing.) All other portions may be calculated in a similar manner. In the outer groove, the peck centres are shown solid where the frame is lifted to form the spot pattern, but dotted where that frame, although traversed, is not lifted at that time. The frame is lifted or not lifted according to the presence or absence of a metal ring which is properly fixed in a circular groove formed in the back of the wheel; we have not attempted to show this in the drawing.

Figs. 293 and 294 are reproductions of two "presser" wheel types of ornament. The former repeats on 68 threads and 80 picks, and is produced by two frames working continuously—two colours of whip thread being used. The pattern of the cloth illustrated in Fig. 294 is complete on 32 threads and 30 picks, and is also produced by two frames which work continuously; at intervals, however, the needles of both frames overlap for a short distance in order to produce the heavy or thick portion of the net work.

Figs. 295 and 296 show special types of lappet ornament. The original of Fig. 295 is a 3-frame presser wheel production, one frame being used for the central zigzag stripe, which is of the usual character of lappet ornament. For the open-work side stripes, however, two frames are necessary, both of which rise for 6 picks in succession without moving to right or to left, and thus place the whip threads on the face side over the weft; but between the 6th and 7th picks they change positions, crossing their respective whip threads to right and to left, under the same 8 threads, and then rise again for 6 successive picks in the new position. Between the 12th and 13th picks they

Fig. 293.

again rise, or rather return, to the original lateral position. The general effect is enhanced, and a leno-like effect obtained by the omission of warp threads from several splits of the reed at the proper points. The complete pattern repeats on 48 picks, and the open-work part on 12 picks. Although two frames are necessary for the latter effect, it will be seen that only one whip roll will

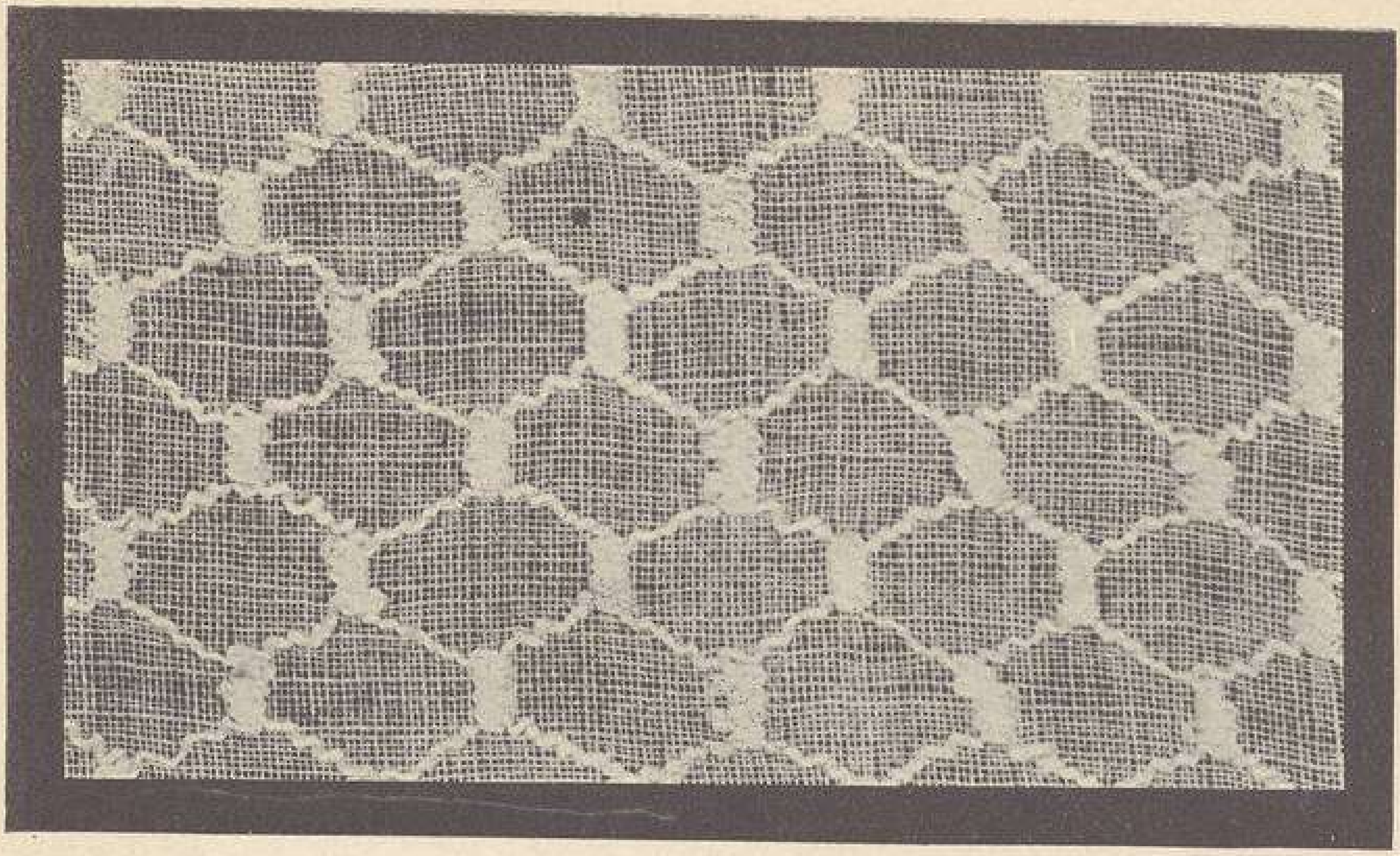


Fig. 294.

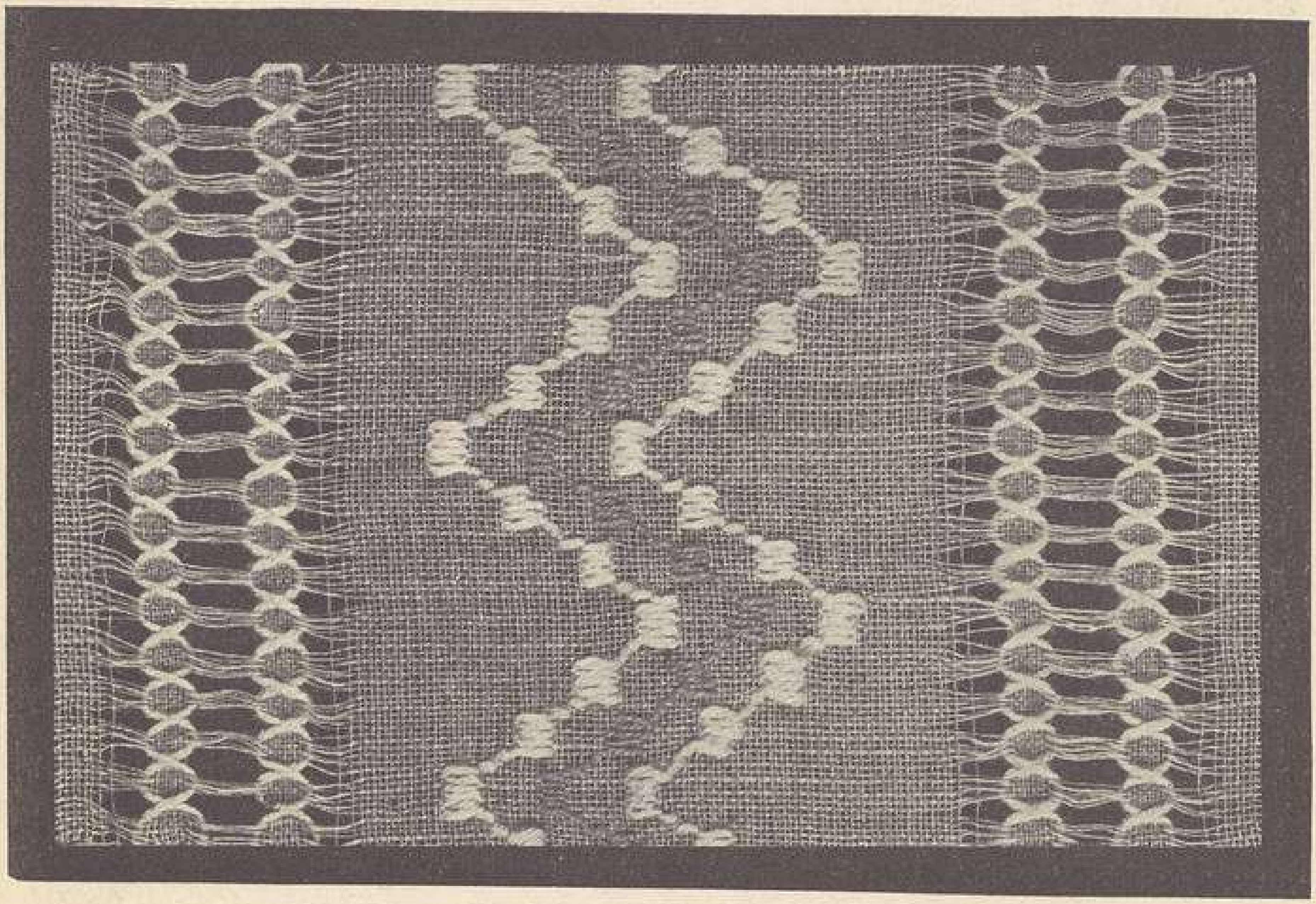


Fig. 295.

be required for both, since the movement of both whip threads is exactly alike in extent, although different in direction.

Fig. 296 illustrates a corded stripe effect, complete on 54 picks, and produced with difficulty, but perhaps most readily, by a common wheel arranged for two frames. One frame with shortened teeth, or else a plate with holes, carries the cord threads—3 strands of 2-fold cotton—close

FIG. 296.

up to the under side of the cloth; the other frame carries the real lappet or stitching thread, which is lifted over the weft every pick as usual, but which also passes underneath the cord thread in the interval, and thus binds the latter to the fabric. Two successive stitches are made in the same split of the reed—one on each side of the cord thread—and to enable this to be done, the frame or plate, which controls these threads, is moved alternately to right and to left of this position by the usual common wheel movement, as well as being moved gradually from position to position in order to form the wave-like line. It will be apparent that very accurate spacing of the needles, and careful adjusting of the positions of the respective frames, are necessary in a case like this if satisfactory work is to be obtained. Indeed, in all cases care is essential, for it will be seen from the photographical reproduction of the cloth in Fig. 288 that the outline of the whip figure is not nearly so accurate as that in Fig. 289.

Presser wheels are constructed on the same general lines as common wheels, with the following differences in detail: radial lines must be drawn and a tooth formed for every pick in the repeat of the weave; concentric lines may again indicate splits or pairs of splits in the reed, according as the sett of the latter is coarse or fine. The full movement of the frame, pick by pick, must be indicated on the outside of the groove to be formed in the wheel—the inside contour being of little importance provided that sufficient space is left for the free movement of the peck.

Swivel Designs.—Figure development by means of swivels is simply a particular method of figuring with extra weft. One or more small shuttles, at least one, is used for each spot developed in the width of the fabric. But, since mechanical operations form no part of this treatise, little can be said respecting this type of weaving beyond what has already been said in regard to the ordinary methods of figuring with extra weft. The general methods of designing for swivel fabrics are identical with those illustrated and described in Chapter XIV. pp. 286 to 297, but the size and distribution of the small extra weft figures on this cloth is in a considerable measure restricted and determined by the actual spacing of the extra shuttles in the loom. Assuming that a swivel shuttle is arranged for every two inches of the width of the fabric, then extra weft spots may occur every two inches of the width in any one line, or every four inches of the width if alternate shuttles only are used. Most swivel looms are so arranged that all shuttles and carriers may be moved laterally to right or to left, so that spots on successive lines for one row of figures may be formed intermediate to those formed for the previous row of figures. By this arrangement any simple system of distribution of the spots or small figures may be obtained. Since each shuttle is independent and may carry its own colour of weft, it is evident that the spots in one horizontal row may be developed in two or more colours at the will of the designer; but when two or more colours are required for the development of any one spot, it is usual to arrange the various shuttles in parallel lines in front of the reed, so that each colour may be inserted in turn in its proper sectional shed, before the insertion of the following ground pick.

Attempts have been made to form a double shed so that an ordinary shuttle may cross the web at the same time as the swivel shuttles are in motion; but in most cases the ordinary picking is suspended during the insertion of the extra weft. This fact, coupled with the reduction of speed which naturally accompanies complicated mechanism, reduces the productive capacity of the loom, and consequently increases the cost of manufacture. The system, however, has the distinct economical advantage of introducing the extra figuring weft only where it is required. In consequence, waste of material is prevented, no dark lines show through the fabric, and the spotting weft is more securely held in position, since it does not cross gaps between the figures, but simply travels from side to side of the spot. Further, the necessity for binding long floats at the back of the figure does not arise, since no long floats are formed except the single threads which join the spots in successive horizontal rows.

Swivel ornament may be applied to almost any ground texture, although it is mostly used to decorate dress and

FIG. 297.

simple fabrics, the ground of which is usually plain or other simple weave. In Fig. 297, however, we illustrate a slightly more elaborate swivel effect, in which three swivel shuttles are necessary for the proper development of each spot. The ground texture is a modified gauze or leno effect, two threads crossing two, three picks in a gauze shed. The gauze ground is relieved and embellished at intervals by jacquard figures developed in warp on a plain $\frac{1}{1}$ ground. The swivel spot is developed in dark green, pink, and bright gold on a plain black ground, and occupies about 165 threads and 155 picks of the ground texture. The warp is worsted, the ground weft cotton, and the swivel weft soft spun silk. The smaller slip to the left of the illustration shows the appearance of the back of the fabric.

CHAPTER XXV

SILK PICTURE DESIGNS AND FABRICS

THE principles involved in the development of pictures in silk by weaving are closely associated with those enunciated in connection with figuring with extra weft (see Chapter XIV. pp. 286 to 297). The designs for the latter type of fabrics show clearly that the figures are due, not so much to weave effect as to a simple method of floating the yarns over the desired width of the figure. Some system of interlacing the figuring weft with the warp is naturally employed when the figures assume large proportions. In silk picture weaving, however, every part of the subject is developed by means of weave effects; and the prominence of any particular colour of weft is due, mainly, to its degree of floating, but partly also to the manner in which the floats are arranged.

These pictures are almost invariably developed in solid masses of black and white wefts, intermingled with the various greys which may be obtained by a judicious combination of interweaving of the black and white wefts with a white warp. The high lights of a picture are displayed by the weaves which allow a maximum amount of white weft or of white warp to float on the surface; the dark patches by a maximum of black weft; and all intermediate greys by a proper blending of the yarns combined with the scheme of interlacing. The extent of the gradation of these grey tones depends in a measure upon the size of the unit weave.

One type of shading has already been demonstrated (see pp. 40 and 41, and Figs. 128, 129, and 130, pp. 206, 208, and 224), and greys may be developed by these designs, or by similar ones made from the 12-thread sateen. Thus, if white warp and black weft be used in conjunction with the 8-thread sateens, there are seven different weaves (1 to 7, Fig. 37, p. 41), which change gradually from a practically solid black effect to an equally practically solid white effect; while with the 12-thread sateen there would be eleven different shades in the gradation from black to white. The available number of shades obviously increases with the increased size of the unit weave, but, on the other hand, the objection to this method of obtaining increased gradation by using larger unit weaves is the fact that the fabric suffers in consequence of the increase in the looseness of the structure. The ordinary silk pictures are rarely, if ever, made with these single or simple weaves; they are made, as already indicated, by a process somewhat analogous to double weft-faced fabrics, and to fabrics figured with extra weft.

Many elegant examples of this type of artistic textures are used for decorative work, and Fig. 298 is a typical example of such a product. Since the original contains at least 2000 threads and 2500 picks, it is clearly impossible to reproduce in the space at our disposal a sectional

Fig. 298.

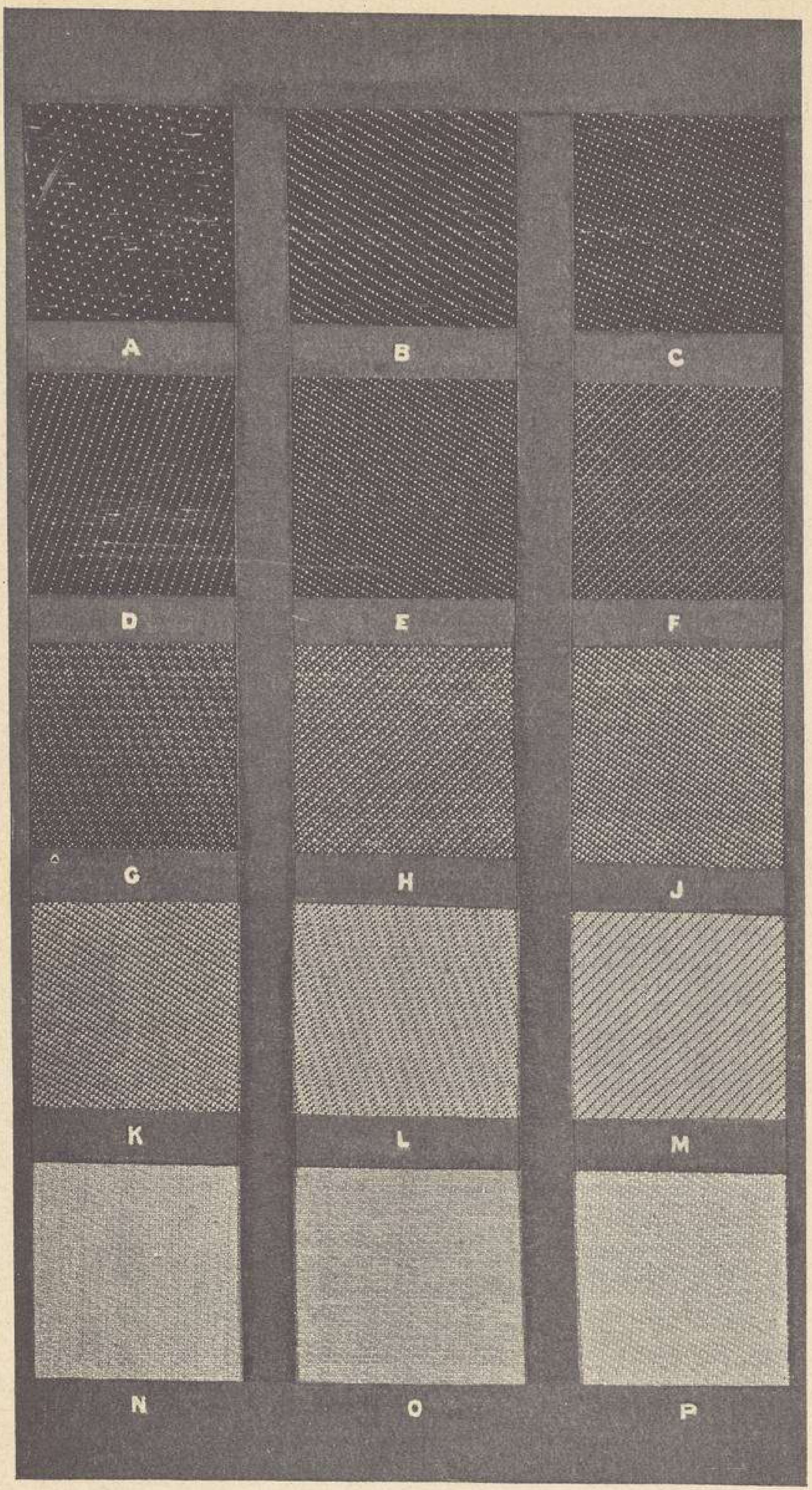


FIG. 299.

design of this example which would contain all the different

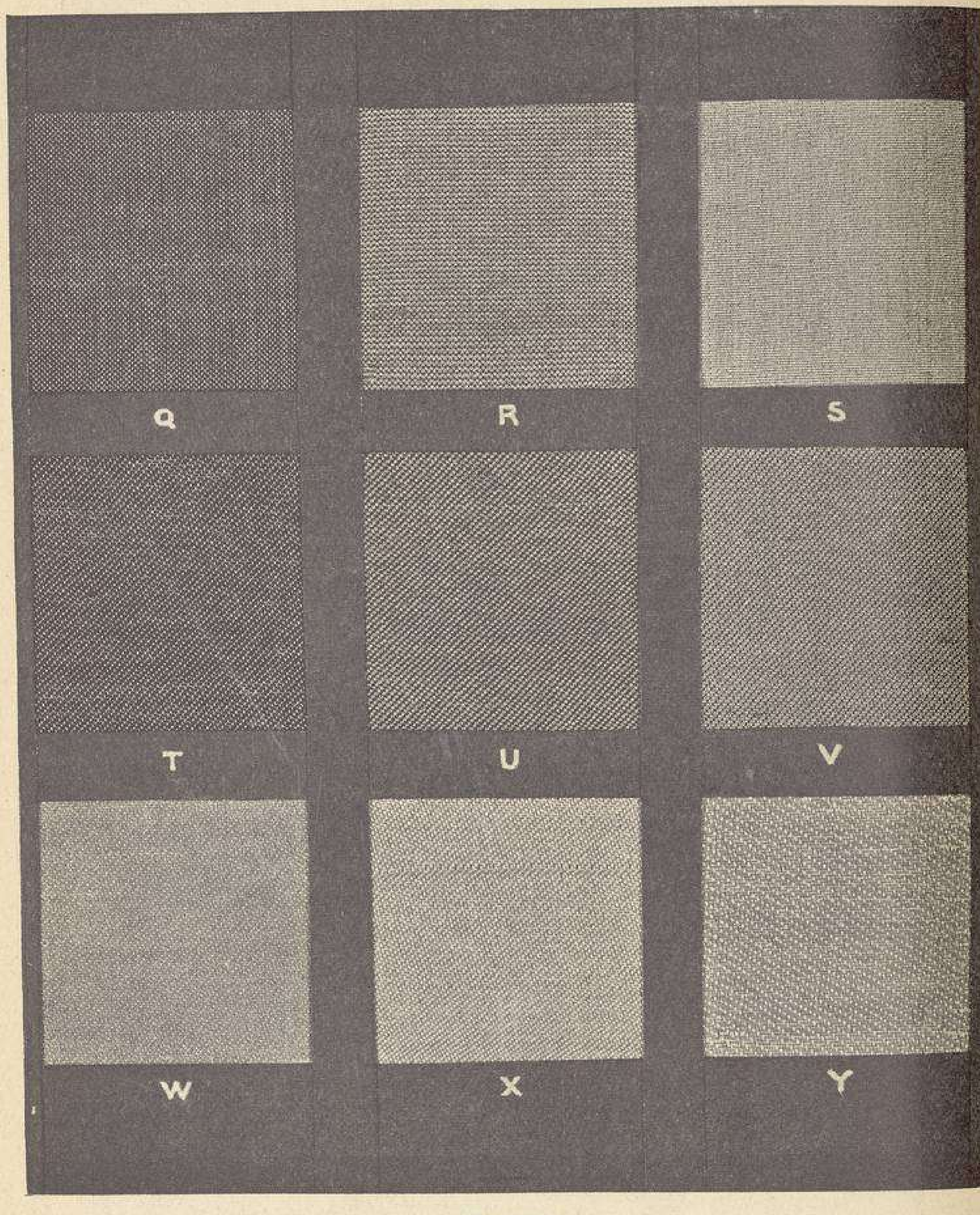


Fig. 300.

weaves employed in the fabric. Instead, therefore, of following the usual process of illustrating any particular

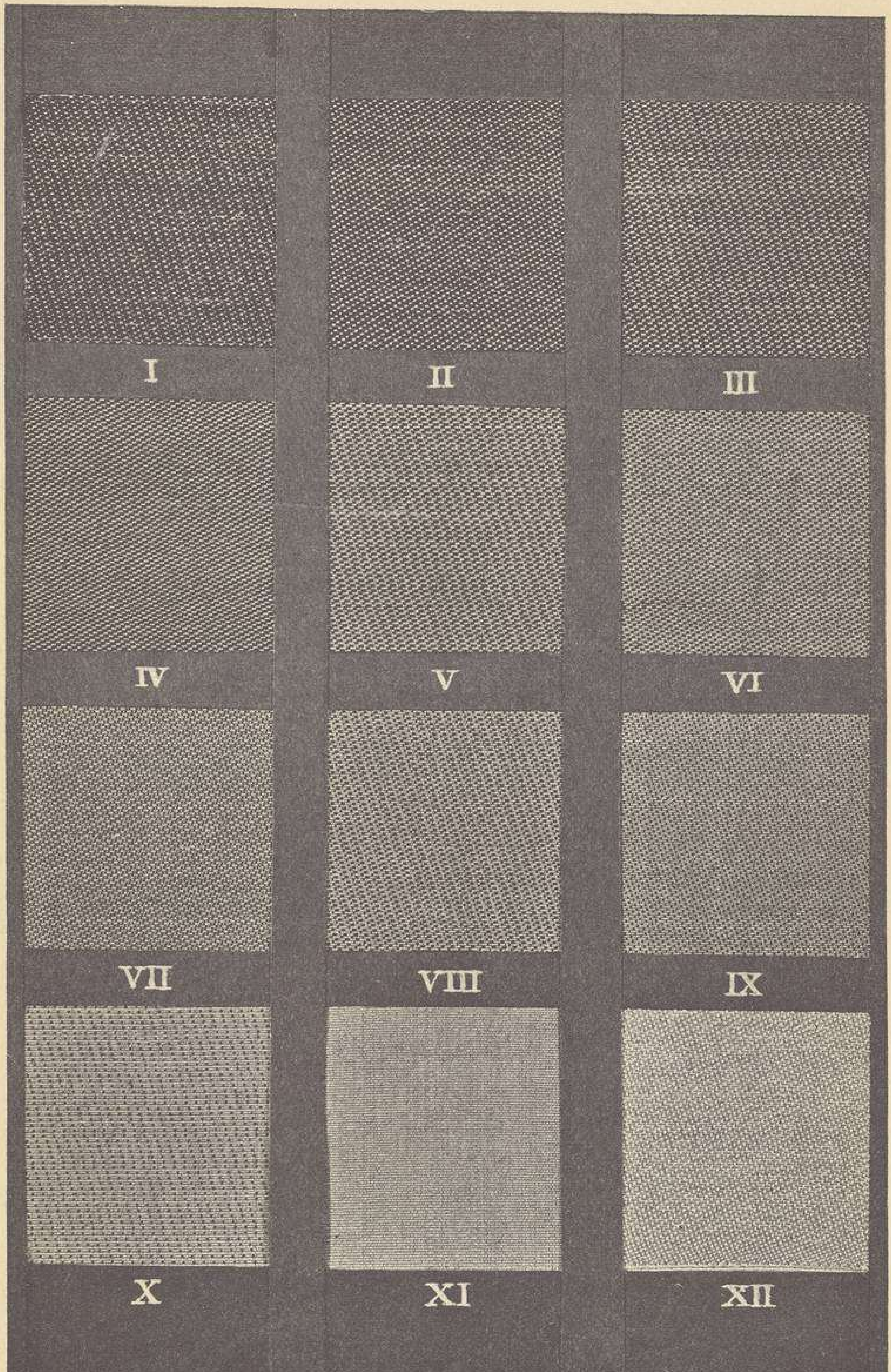
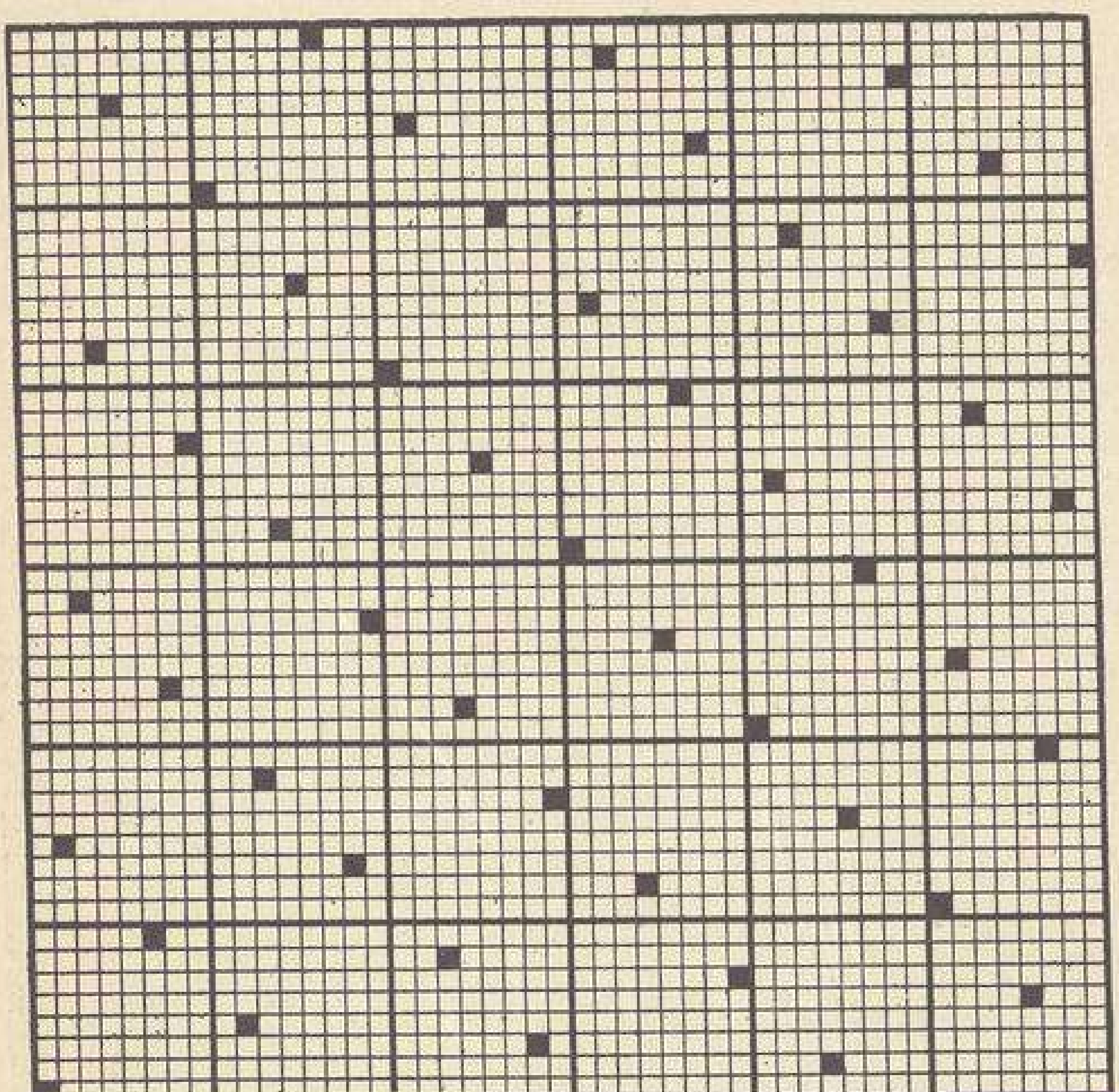


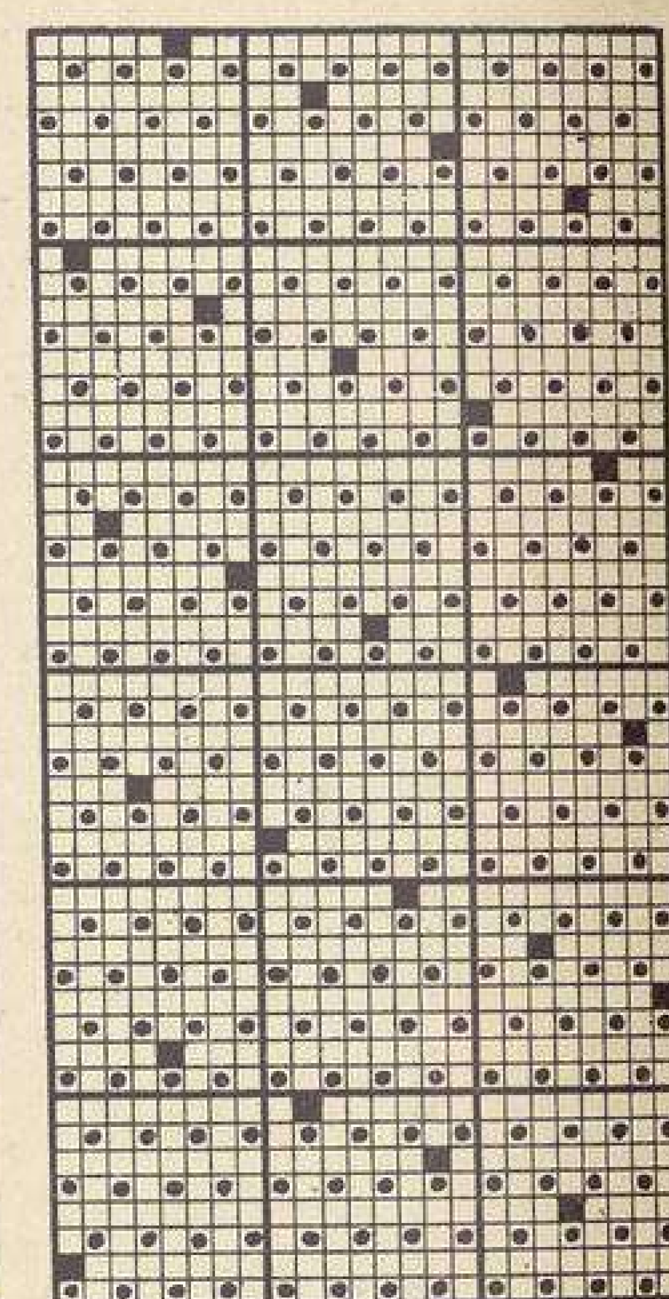
Fig. 301.

part of the structure, we have chosen, what appears to us, the more satisfactory way of showing how the various gradations or shades may be obtained by introducing photographical reproductions of several small pieces of silk fabrics with the corresponding weaves which were used to produce them.

Figs. 299, 300, and 301 are reproductions of thirty-six



A



B

Fig. 302.

different silk fabrics. In Fig. 299, the 15 small samples are graded from almost pure black to pure white, and in the preparation of the point paper design, the designer would introduce into the various parts the weaves which correspond to the depth of shadow required. Fig. 301 shows twelve cloths graded from black to white, while Fig. 300 contains nine patterns which will be explained shortly. Cloths E to P, Fig. 299, are made from 16-thread weaves;

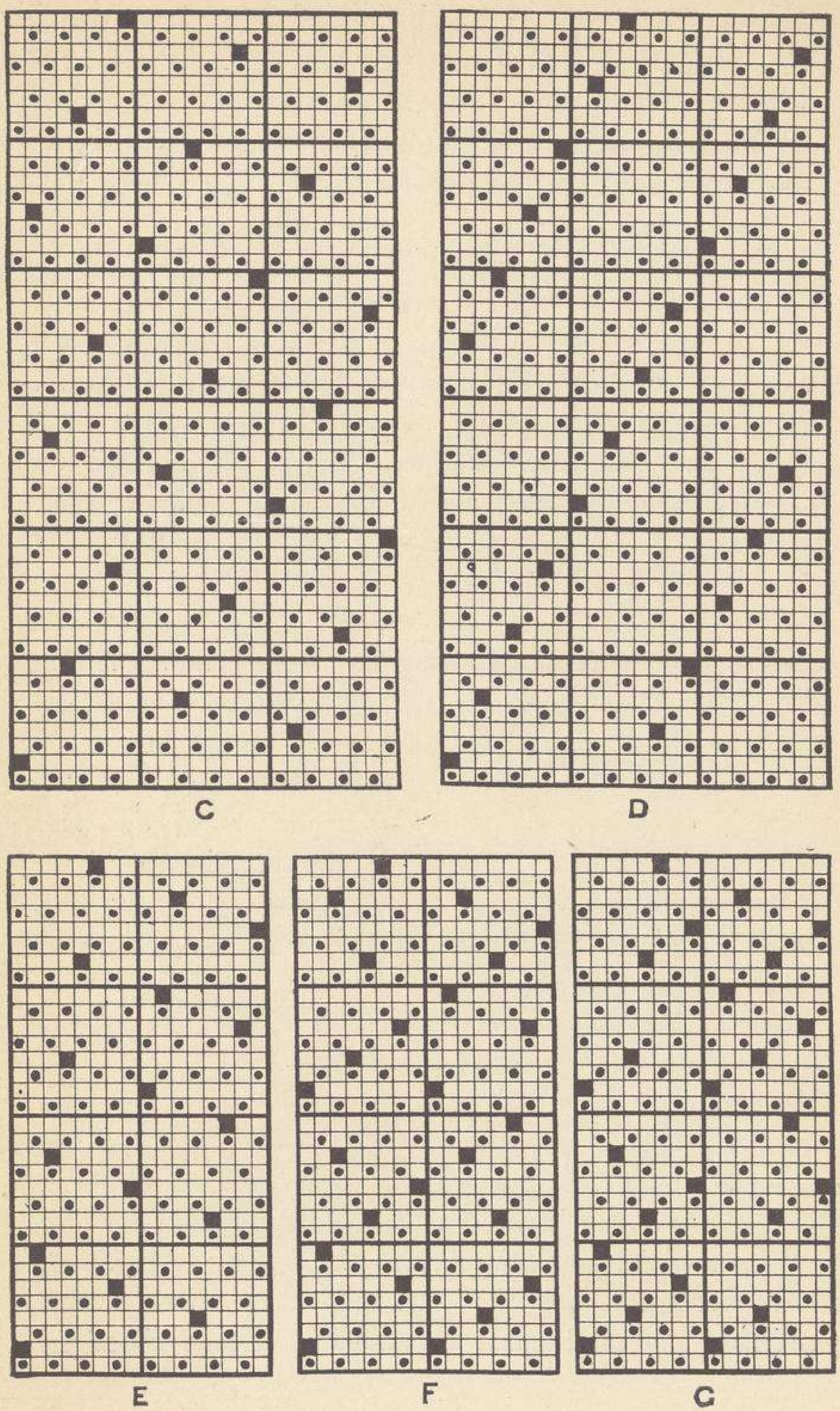
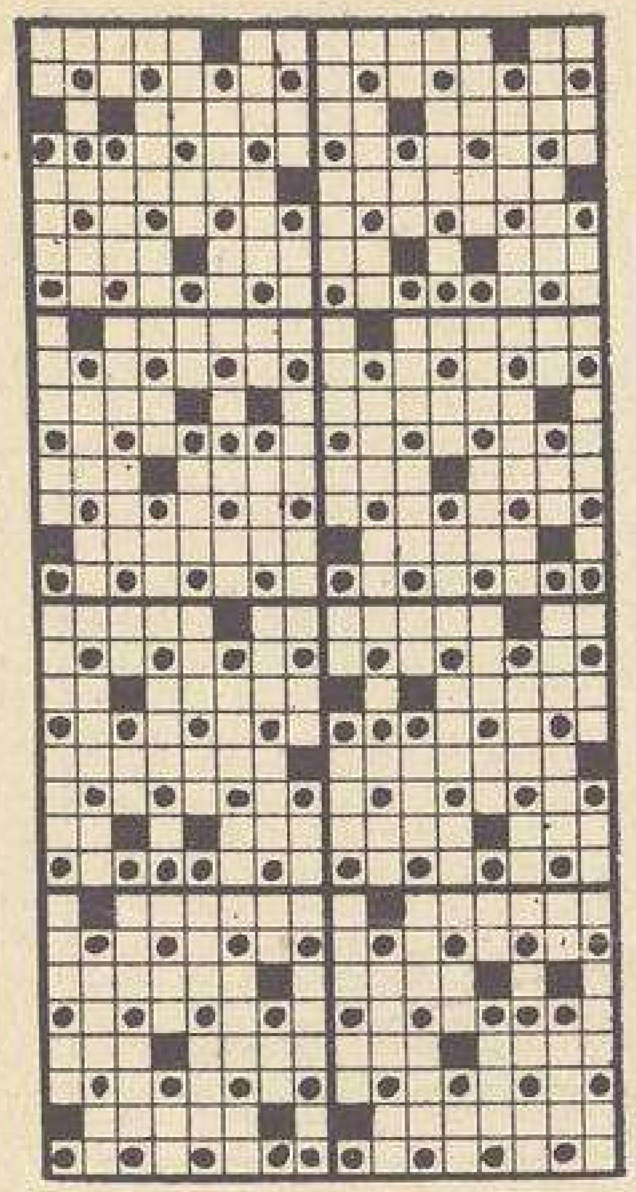


Fig. 303.

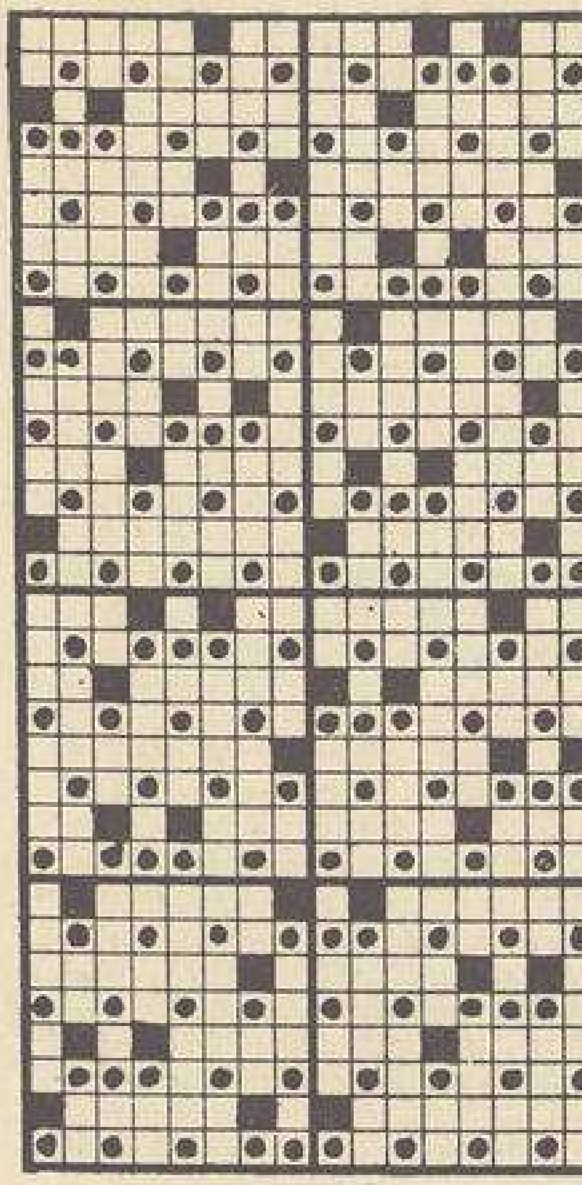
B, C, and D from 24-thread weaves; and A from a weave which is complete on 48 threads. The weaves for cloths A and B appear in Fig. 302, and are respectively the 48-thread and the 24-thread sateens. Weave B is complete, and it will be seen that all odd picks of white weft are plain, while the even picks show that the black weft is floating on the surface in 24-thread sateen order. The plain picks are omitted in design A because of the space which they would occupy; they should appear, however, in the corresponding positions, and for the same purpose, as those in design B. All through these designs for silk picture weaving, the dots are placed on white picks and the solid marks on black picks—all marks indicating lifted threads.

Designs C, D, E, F and G, Fig. 303, illustrate the designs for the fabrics bearing the corresponding letters, Fig. 299. The reader will probably see the development of F and G from the sateen unit in E. The prominence of the black picks is gradually reduced in these designs; while in designs H to P in Figs. 304 and 305 the same remark applies, and, in addition, the prominence of the white yarns is increased. The fifteen designs in Figs. 302, 303, 304 and 305 were prepared and used for weaving the cloths in Fig. 299.

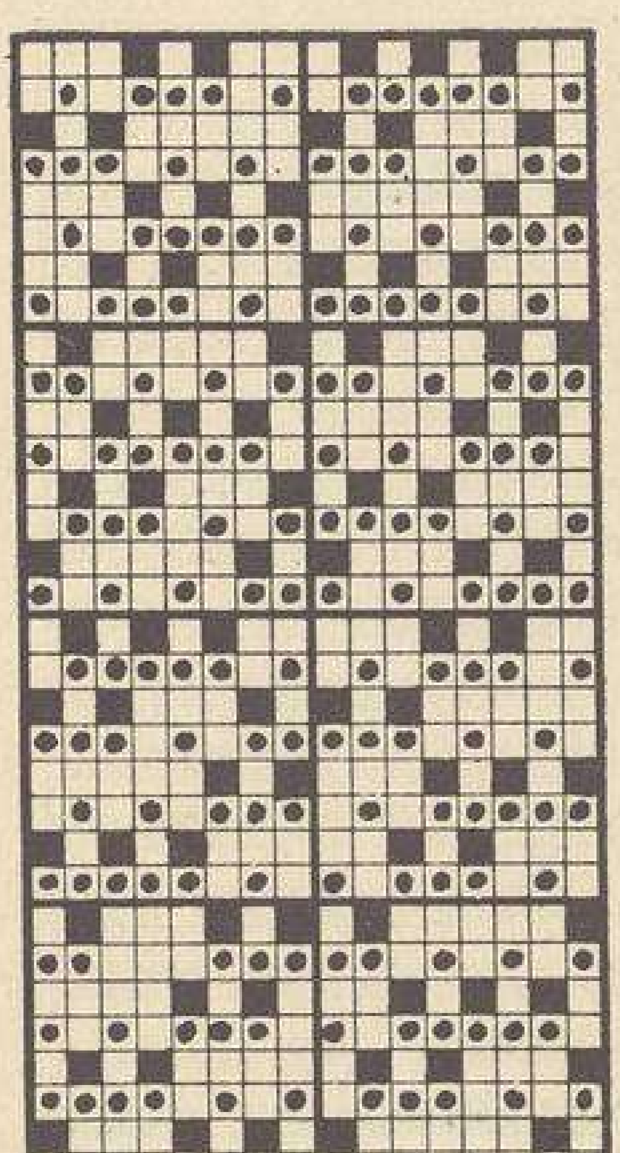
The fabrics reproduced in Fig. 301 were woven from the designs which appear in Fig. 306. All the designs in this figure are produced from the 12-thread sateen unit, and the change from dark to light is again more or less gradual. It will be observed that the darkest pattern in this set (Fig. 301) is not very black; the reason for this is easily explained by reference to the designs in Fig. 306, which were used for the construction of these twelve patterns. The solid marks are added in successive designs



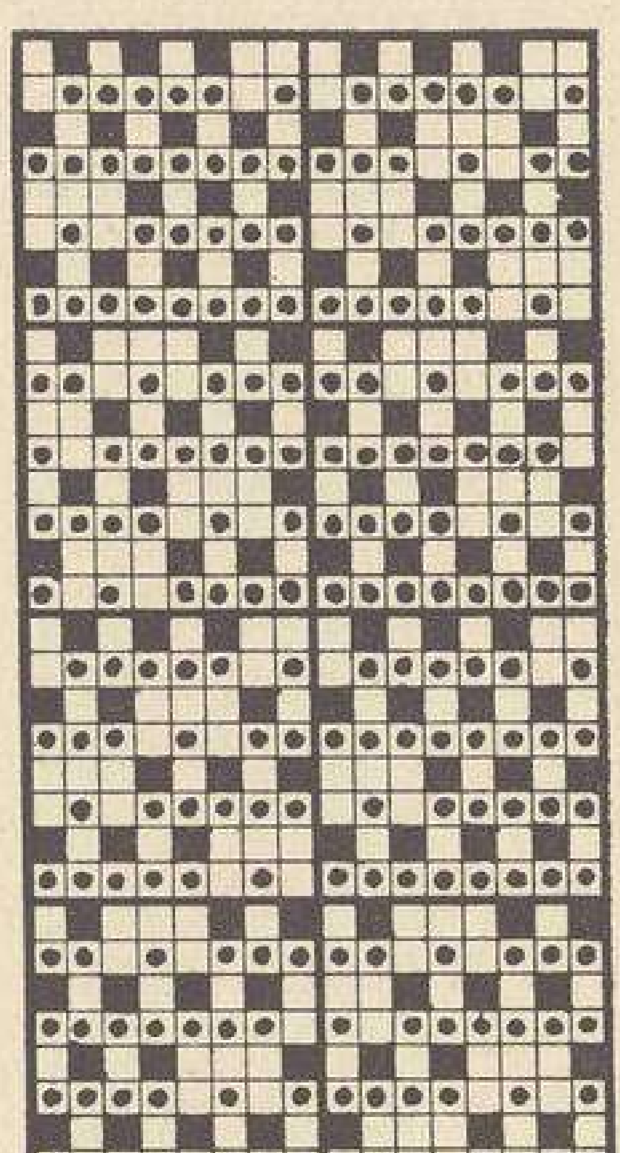
H



J



K



L

Fig. 304.

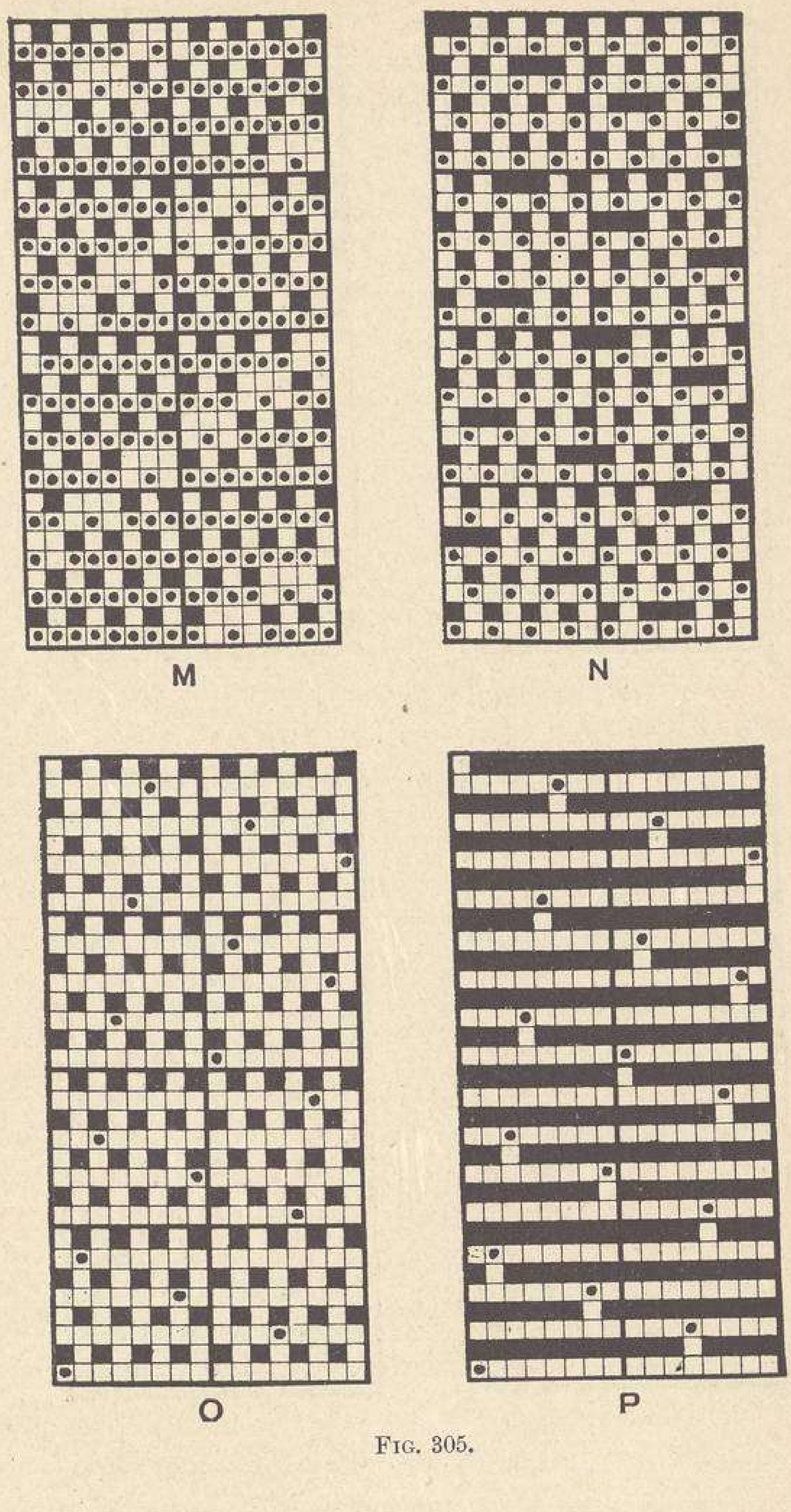


Fig. 305.

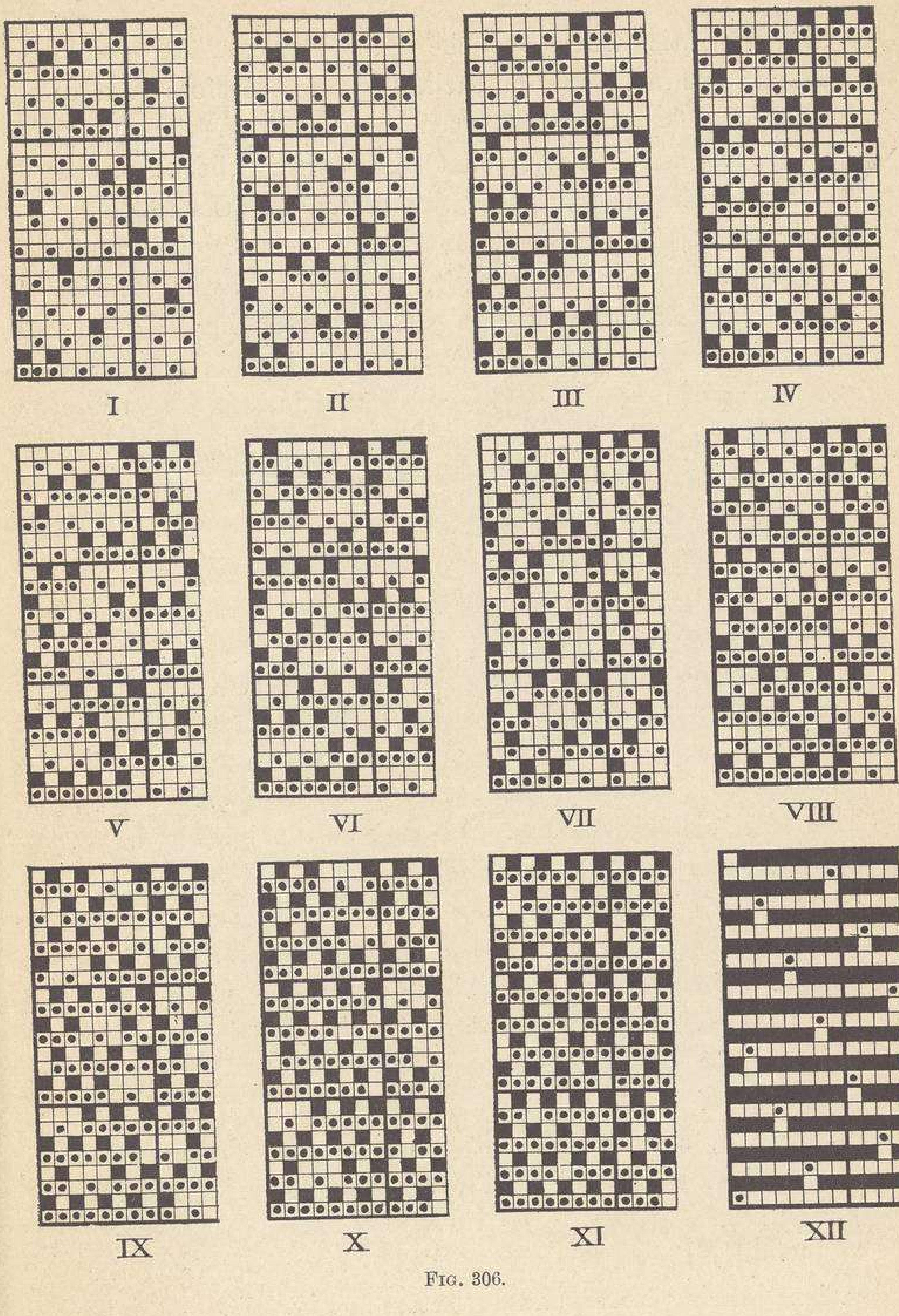


Fig. 306.

in systematic order, but the unit weave, which would contain one mark only on each pick, and therefore produce the darkest pattern, has been omitted from the group. It is evident, however, that this unit is the 12-thread sateen, with the marks on the threads in the following order—1, 6, 11, 4, 9, 2, 7, 12, 5, 10, 3, and 8. The white picks used in conjunction with this unit weave would be perfectly plain, but it will be observed from the designs in Fig. 306 that, as the black picks approach more and more towards plain weave, the length of the floats of the white picks is gradually increased, until finally we reproduce the last of the range, design XI, which shows white warp and white weft (rib weave) on the surface. This weave would not be bright enough for the high lights, but for these parts weave XII may be employed.

In preparing a design for a silk picture the weaves in Fig. 306, in addition to the unit weave, would produce practically all the shades required; but if, for any reason, it were necessary to produce some darker effects than it is possible to obtain by the use of the above unit weave, then effects C and A, Fig. 299, may be obtained by using the corresponding weaves from Figs. 303 and 302. Both of these weaves are multiples of the 12-thread unit, and would, consequently, fit in well in the preparation of the design. If still finer gradation be required when using the 12-thread unit, the designs Q, R, and S from Fig. 307 may be employed. Designs Q and S—the woven examples of which appear in Fig. 300—are very useful weaves, and may be used along with those weave effects illustrated in Fig. 301, when additional gradation is required.

The last six patterns in Fig. 300 are made from the designs bearing corresponding letters in Fig. 307. Designs

T to X are made, as shown, from an 8-thread sateen unit, while design Y is a 16-thread weave, and differs only from

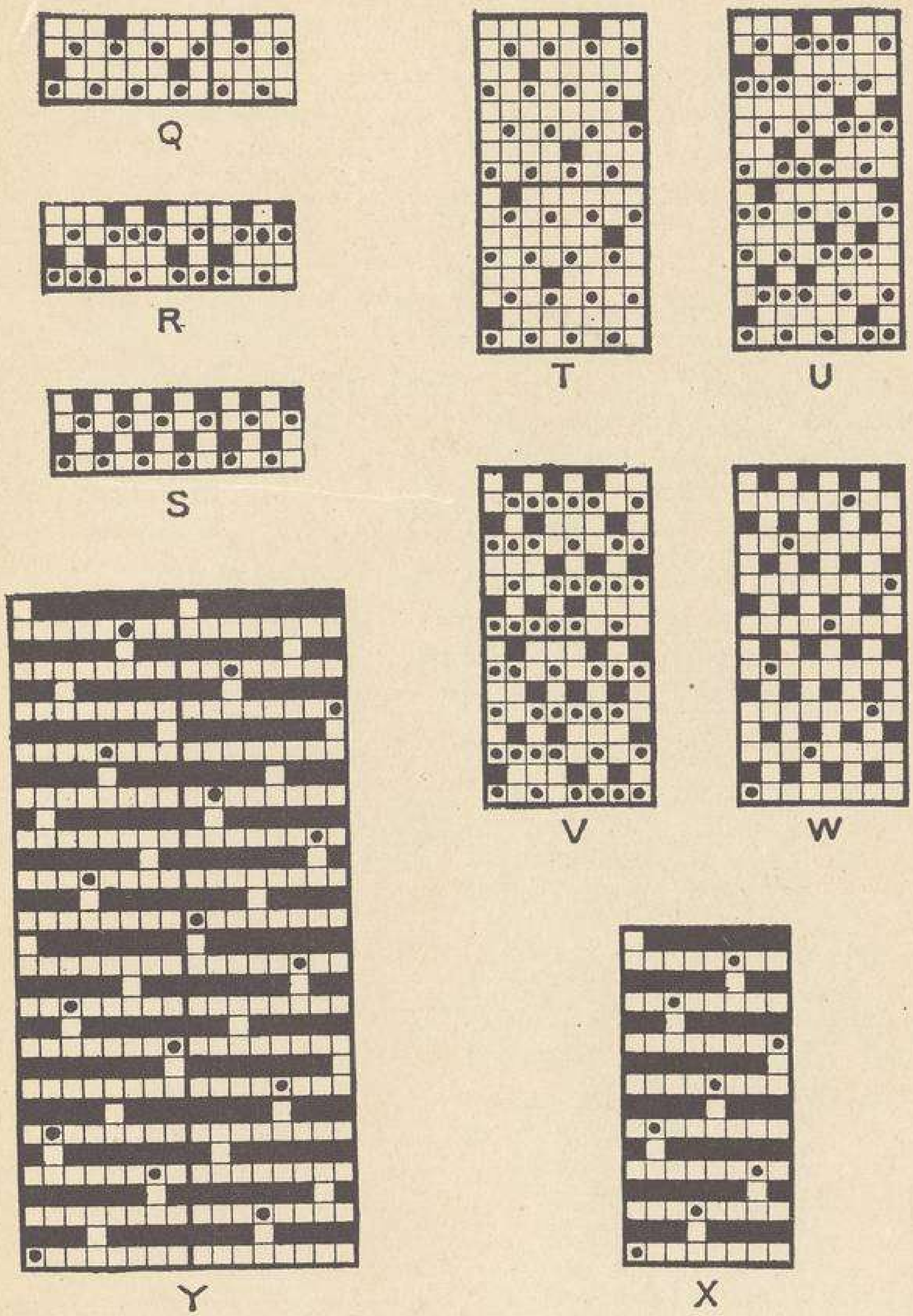


FIG. 307.

design P, Fig. 305, in regard to the black picks, which are, in both cases, at the back of the fabric.

INDEX

THE END

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