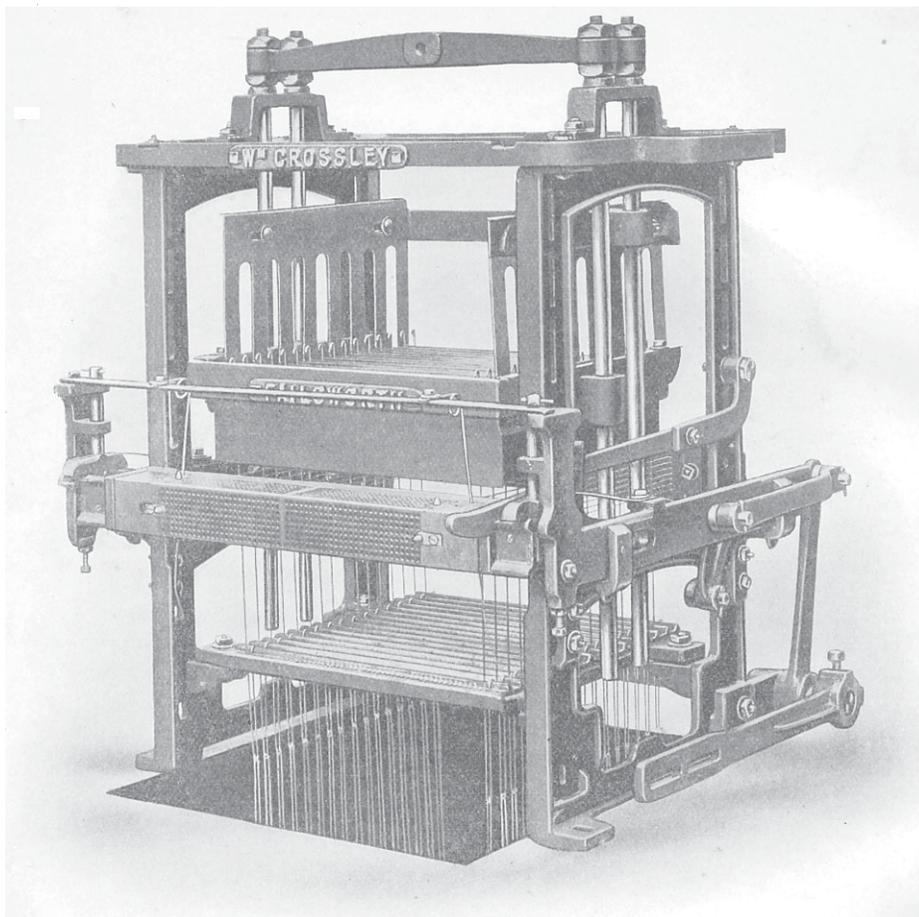


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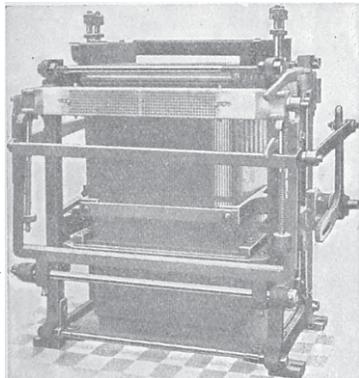
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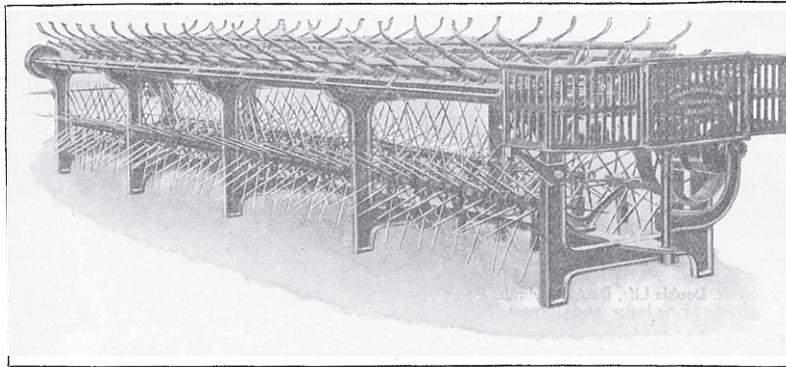
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AUTHOR OF

"HEALDS AND REEDS FOR WEAVING: SETTS AND PORTERS"

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JOINT AUTHOR OF

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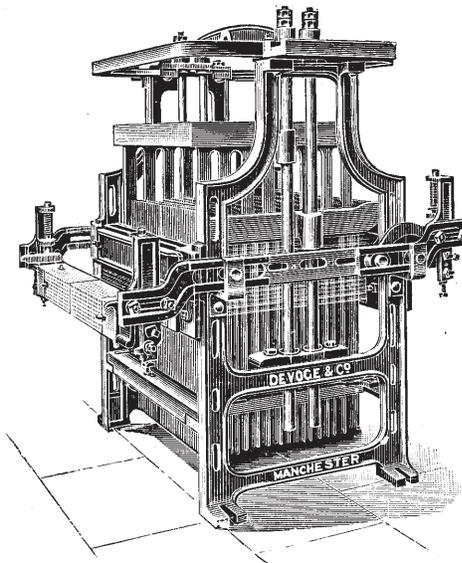
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Railway Press	„ 350	p. 372

PREFACE

THE specialisation of the literature of a subject very often proceeds unequally, so that whilst comprehensive treatises may be found in certain branches, the special treatment of others has not been adequately handled—an unequal development which has occurred in the literature of Textile Technology. The present volume is intended to remedy one such defect; it deals exhaustively with a large number of machines which are used for the preparation of jacquard cards for weaving carpets, damasks, tapestries, brocades, quilts, lace, and similar textures, and contains many elaborate designs with full instructions regarding harness ties, and all operations that are essential for the cutting, lacing, repeating, wiring, and repairing of jacquard cards. Particular attention is given to the various positions which the cards may occupy on right- and left-hand looms and to the changes required to produce the design correctly on the cloth.

Numerous figures (over 400, many of them large and full of detail) illustrative of the different pitches of machines have been introduced with the object of rendering the book useful to all who are engaged directly or indirectly in the manufacture of the various kinds of decorative textile fabrics.

The range of machines described and illustrated by photographs and line drawings is extensive, since it embodies several systems of card-cutting, and it is believed that few well-known machines have been omitted.

With the exception of twenty-nine new illustrations near the beginning of the book, and the relevant text, the whole of the work appeared serially from 1912 to 1923 in the *Textile Manufacturer*, while twenty-four illustrations have been introduced from the Author's work, *The Designing and Weaving of Decorative Fabrics*, which is still appearing serially in the above Journal.

The Author takes this opportunity of expressing his thanks to past and present colleagues of the Textile Department of the Dundee Technical College and School of Art for aid in the preparation of photographs, in the measurement of machinery, and in proof reading; to several Firms for kind permission to publish descriptions and photographs of machines; and to the publishers and printers for their consideration as the work was passing through their hands.

THOMAS WOODHOUSE.

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CHAPTER I

INTRODUCTORY

FROM the point of view of weave structure, the manufacture of figured decorative textile fabrics necessitates the employment of more or less elaborate parts by means of which the customary jacquard cards, or their equivalent, may be punched or cut in order to complete the connection between the point-paper design and the actual shedding mechanism of the loom. This method of providing the selecting medium for the pattern is applicable to both hand and power looms, and there is perhaps no type of mechanism where more accuracy is required than in the various machines which are employed for the preparation of jacquard cards for the loom.

Although tappet looms are used mostly in the weaving of plain, twill, and similar fabrics where the weave effect is comparatively simple, and dobbie looms are employed for the production of rather more complicated patterns on the surface of the cloth, the shedding apparatus of either or both of these types of loom may be desirable, and perhaps indispensable, in the production of certain types of decorative fabrics. And in some cases, one or both of these types of shedding may be used in conjunction with the jacquard.

A detailed description of the jacquard machine parts is not introduced, but it will be necessary to illustrate several of the chief parts of the jacquard in order to show, as clearly as possible, the connection between the jacquard itself and the cards which operate the needles; as is well known, these cards are prepared or punched by special machinery.

In the first case, it should be pointed out that, since the number of needles in a jacquard may vary from say 100 to 1300 or more, it is natural to find that the disposition of these needles in the various machines also varies. Thus, in what is known as the short row of the machine, and this is of more importance than the long row in regard to the preparation of the cards, there may be 4, 8, 10, 12, or 16 needles, and, consequently, provision on the jacquard card for a corresponding number of long rows of holes. The numbers in most frequent use are 8, 12, and 16; and since any of these numbers will suit our present purpose, we shall adopt the smallest number. This number, 8, is used in all so-called 400's jacquards.

These machines, which have 51 short rows, have evidently $51 \times 8 = 408$ needles and 408 hooks in the simplest kind of jacquard.

Figs. 1 and 2 represent respectively the first and last rows of such a machine, with the harness cords passing through the outermost row of eight holes in the comberboard. The figures, although partly diagram-

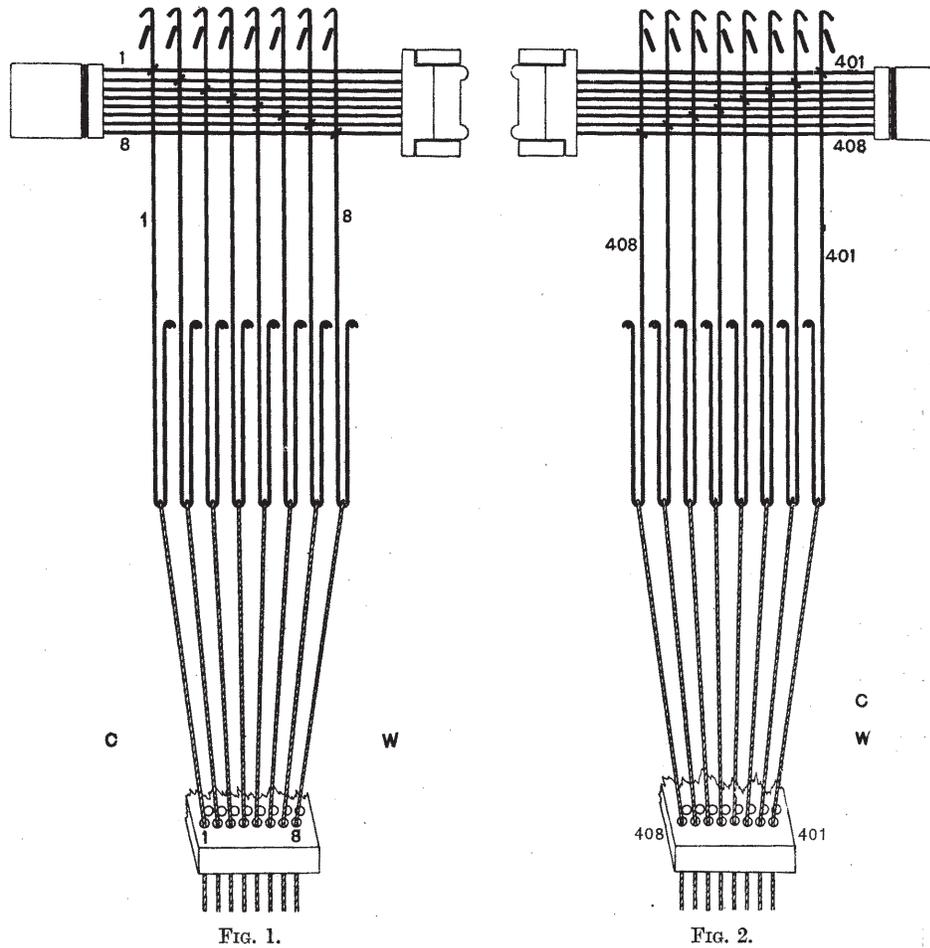


FIG. 1.

FIG. 2.

matic, are drawn to scale, with the exception of the thickness of the needles and hooks, and the distance between the bottom of the hooks and the top of the comberboard; this distance has been made short purposely to minimise the length of the drawings.

If the reader views the machine from one end of the loom he would see the first short row of needles and hooks, Nos. 1 to 8, as indicated in Fig. 1,

with the cylinder on the left-hand side. The view from the opposite end of the loom would be that of the last short row of needles and hooks, Nos. 401 to 408, and the cylinder on the right-hand side as in Fig. 2.

In practically all jacquard machines the top needle controls the hook nearest the needle board and cylinder, as shown by Nos. 1 and 401 in Figs. 1 and 2. The second needle down controls the second hook from the cylinder, and so on as indicated in both figures until the bottom row of needles is reached; hence, needles 8 and 408 control the hooks farthest away from the cylinder. If, therefore, the letter W, Fig. 1, represents the position of the weaver, the outside thread at the left of the warp must

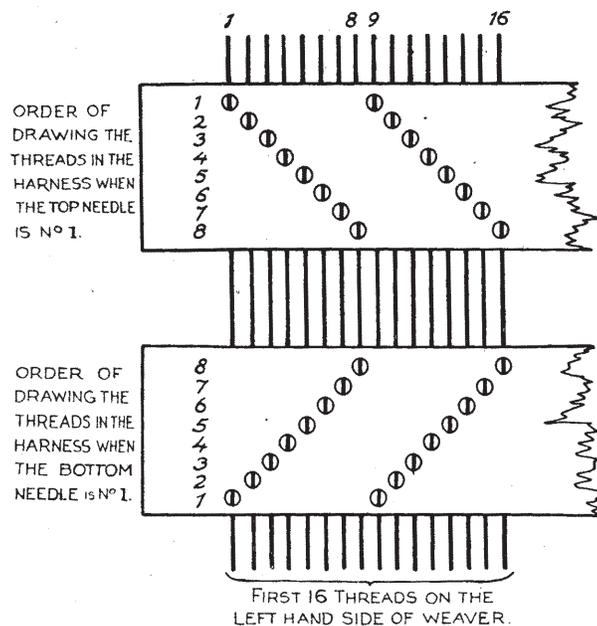


Fig. 3.

be drawn through the first mail belonging to the back long row of the comberboard.

The above is the method adopted in several districts, but in other districts, on the other hand, the bottom needle—the one marked No. 8 in Fig. 1—is considered as the first needle. In such a case, it is evident that the first thread on the weaver's left hand would be controlled by the hook marked No. 8. The two methods are illustrated diagrammatically in Fig. 3, with particulars on the left of the comberboard. It will be understood, however, that the 16 threads shown would occupy a very narrow width in general, and that in practice all the 8 holes in each short row of the comberboard are in a line parallel to the edge of the board, and not at an angle as

illustrated. Hence, when the jacquard harness is tied up from the lingoes to the hooks, say of the jacquard in Fig. 1, the warp threads could be drawn through the mails of the harness either backward or forward as demonstrated in Fig. 3. It will be seen later, however, that the two distinct orders of drawing-in the threads involve different methods of cutting the cards and of reading the horizontal lines of the point-paper design.

As already mentioned, each 400's jacquard machine contains 51 short rows of needles and hooks, 8 of each kind in each short row. The heads of the 408 hooks form a rectangle with an area of about $13\frac{1}{2}$ in. by 7 in. The general arrangement of the needles, hooks, needle board, spring box, hook-rest and hook-rest support are illustrated in perspective in the lower part of Fig. 4, while the upper illustration, marked A, represents the hook-rest, and indicates the relative lengths of the long sides and short sides of the above-mentioned rectangle. If the needle board in Fig. 4 were situated over the cloth and the weaver's head, the position of the jacquard would be identical with that illustrated in Fig. 2.

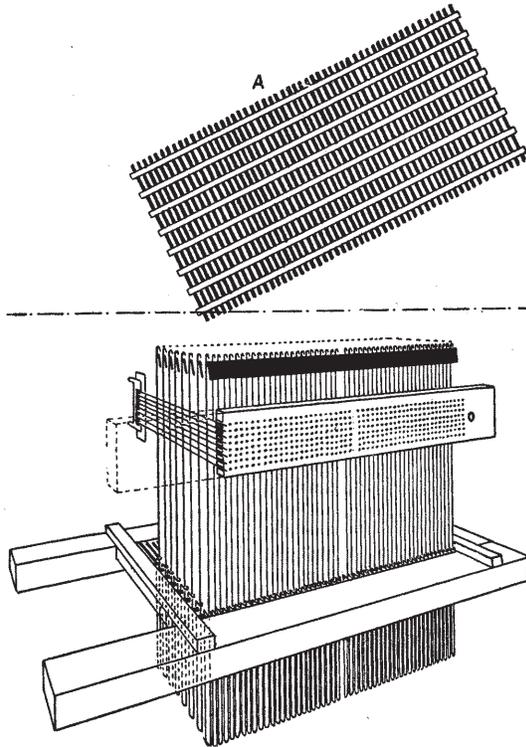


FIG. 4.

The views in Figs. 1 and 2 indicate, as just stated, the same jacquard viewed from the two ends of the same loom. They may, however, represent two different positions of the jacquard with respect to the front of the loom. Thus, if the needle board and the cylinder were situated over the cloth and the weaver's head, as in Fig. 43, and the loom in Fig. 2 viewed from the reader's position, the front of the loom and the position of the weaver is represented by the letter W. In this case, the numbers of the needles, hooks, and cords nearest the reader would be as marked, *i.e.* 401 and 408; but the first row of needles, hooks, and

cards, Nos. 1 to 8, would clearly be at the other end of the loom. Consequently, the views in Figs. 1 and 2 may, when desired, be taken to represent two different jacquards on two adjoining looms in which the jacquard cylinder is on the left-hand side in Fig. 1, and on the right-hand side in Fig. 2. Hence, since the letter W represents the position of the weaver with respect to the front of the loom, it is clear that with the arrangement indicated in Fig. 1, the jacquard cards would hang over the warp beam, whereas with the parts in the positions shown in Fig. 2, the jacquard cards would hang over the weaver's head and the cloth. Both arrangements are adopted in practice, wherever it is possible, for the sake of economising floor space. In both cases, the long sides of the comberboard are parallel to the long sides of the cylinder and jacquard.

It is impossible to alter the positions of the comberboard, or the equivalent harness-reed, in the loom, but, on the other hand, it is possible to alter the position of the jacquard with respect to the comberboard. The jacquard may, for example, be turned one-quarter round from the position indicated in Fig. 1 or Fig. 2. This change would obviously place the long sides of the cylinder and the jacquard parallel to the ends or short sides of the comberboard, in which case the cards would hang at or near one end of the loom.

CHAPTER II

THE JACQUARD HARNESS : STRAIGHT-THROUGH, REPEATING, AND CENTRE TIES

SINCE there are two distinct ways of arranging the jacquard in relation to the comberboard, there will be two general and distinct dispositions of the harness cords which bridge the gap between the comberboard and the bottom bends of the hooks or uprights. These two distinct dispositions are known by the terms :

1. Norwich or Straight Tie.
2. London or Crossed Tie.

When the card cylinder and the needle board (the long sides of the jacquard) are parallel to the long sides of the comberboard, the harness tie for any kind of pattern is termed the "Norwich Tie" or the "Straight Tie," but when the card cylinder and the needle board are at right angles to the long sides of the comberboard, the harness tie for any kind of pattern is termed the "London Tie" or the "Crossed Tie."

A little consideration will show that there are, in reality, four different positions that any jacquard machine may occupy with respect to a comberboard. For instance, the cylinder may be at the back of the loom, at the front of the loom, on the left-hand side or on the right-hand side. It is essential that those who have charge of the card-cutting department should know the effect which any of these positions will have upon the design on the woven fabric. This phase of the question is, indeed, a very important one, and it is dealt with more fully at a later stage of this work (see pp. 219 to 234, Chapter XII.).

The particular ways in which the harness cords are "tied" or "mounted" to the hooks, irrespective of the position of the jacquard machine, are defined by special names—"harness ties." Such names result in general from the type of ornament which has to be developed on the surface of the cloth. Thus, there are the following :

1. Straight-through Tie : this title is given when there is no repetition of the pattern between the selvages of the cloth, *i.e.* when there is one unit only of the design in the width.

2. Repeating Tie : this term is used when there are two or more repetitions of the same pattern in the width of the cloth.
3. Centre or Pointed Tie (also termed the "lay-over tie") : this tie is suitable only for symmetrical patterns.
4. Mixed Ties or Compound Ties : these ties involve the use of two or all of the foregoing ties.

We shall illustrate in different ways all the above-mentioned four types, and, in addition, we shall supply other particulars concerning the general relation between the various parts involved.

All jacquards control the threads of the warp, when the latter are rising and falling, through the medium of a series of cords which connect the lower ends of the jacquard hooks with the glass, brass, or other similar metal mails through which the warp threads are drawn. Each cord may consist of two or more distinct parts—viz., neckband or tailcord, long cord or harness cord, and the prepared lingoe ; but at present we shall assume that the constituent parts of the connection between the jacquard hook and the mail are one cord, to which is applied the general name, "harness cord." In some extreme cases each jacquard hook carries only one such cord, and controls only one thread of the warp ; hence the total number of threads in the warp, excluding selvage threads, must be the same as the number of hooks in the jacquard. In order, however, to produce fabrics of suitable and various widths, it is customary for reasons of economy to arrange that each jacquard hook shall carry two or more such harness cords, and thus control two or more threads of the warp at different points in the width of the fabric, the said points being predetermined in accordance with the type of pattern to be produced. By this means practically any desired width of fabric may be produced with a reasonable number of needles and hooks.

The system or method by which these harness cords are arranged in their respective positions in the comberboard or in the harness reed is termed the "harness tie," or "harness mount." Owing to the very extensive range of jacquard-figured textiles there is an infinite number of ways in which any complete group of harness cords may be arranged to form a tie, but the differences are more in detail than in principle, and all harness ties may be classed in one or other of the above-mentioned four groups. In the machine illustrated in Fig. 4, the cylinder is not shown, and the end of the needle board is shown cut off flush with the last row of needles and hooks (the first row being on the right hand when facing the cylinder or needle board), but otherwise the illustration provides a fair idea of the relative positions of the component parts of the machine. It would, however, be clearly unwise to attempt to show in true perspective, and from the same position as that indicated in Fig. 4, all the connections from the bottom of the hooks to the warp threads. At the best we could show

distinctly hooks from only one short row or one long row of the machine. When the object is to show harness ties in which both of these rows appear, we may show them as if viewed from a similar position, but instead of attempting to illustrate them in pure perspective we shall adopt some modified form so as to display the necessary parts to advantage. When the height of the eye is between the comberboard and the jacquard machine—the normal position—the underside of the machine is exposed to view, and the position of any particular hook, with its connections to the comberboard, through the medium of the harness cords, may be plainly seen.

The repeating tie, often called the all-over repeating tie, is of the simplest kind ; it really embraces all ties in which the threads of the warp are drawn through the mails of the harness in regular succession from the back of the comberboard to the front, or *vice versa*, as exemplified in Fig. 3. This system corresponds in a sense to the straight drafts in shaft work, but the total number of hooks used in harness work corresponds to the number of shafts used for tappet or dobby work ; the number of long rows in the comberboard must not be confused with the same number of shafts. As has already been mentioned, there may be only one complete unit of the draft in the harness—no repetition ; and this, the very simplest type of harness tie, the straight-through tie, is illustrated in Fig. 5. It is also termed “the all-single tie,” although it is precisely of the same type as repeating ties. The machine is a 400's jacquard of the English type, where a wooden or iron bottom grate A, with the necessary transverse rods, forms the support of the hooks when the latter are in their lowest position, and in this particular illustration there is no gap between the 26th and 27th short rows of hooks ; in practice a gap is left, as will be seen later, to provide room for the centre lacing of the cards. The cylinder in Fig. 5 is at the back of the loom, hence the first or leading thread is at the weaver's left hand and at the back of the comberboard. The first eight threads of the warp are operated by the first short row of cords, which are shown as being attached to the second row of hooks in the machine, 9th to 16th inclusive. The first row of hooks has been purposely omitted, as indicated by the eight unfilled holes at the left-hand side of the bottom board A, because this row is almost invariably left for special work when one jacquard only is in use. A neckband B is attached to the lower end of each hook D, and a single harness cord C is tied to each neckband B, and then shown as passing through a hole in the comberboard E. Further connections are considered unnecessary at this stage, the object being to show the distribution of the harness cords for pattern purposes only. No selvage cords are included, although these would naturally be required for the fabric ; the corresponding selvage threads at each side of the texture would be controlled in this case by the same hooks, and all the selvage hooks would be in the

first row of the machine, unless special hooks and needles are provided in addition to the normal complement of the machine. The wires for the heck

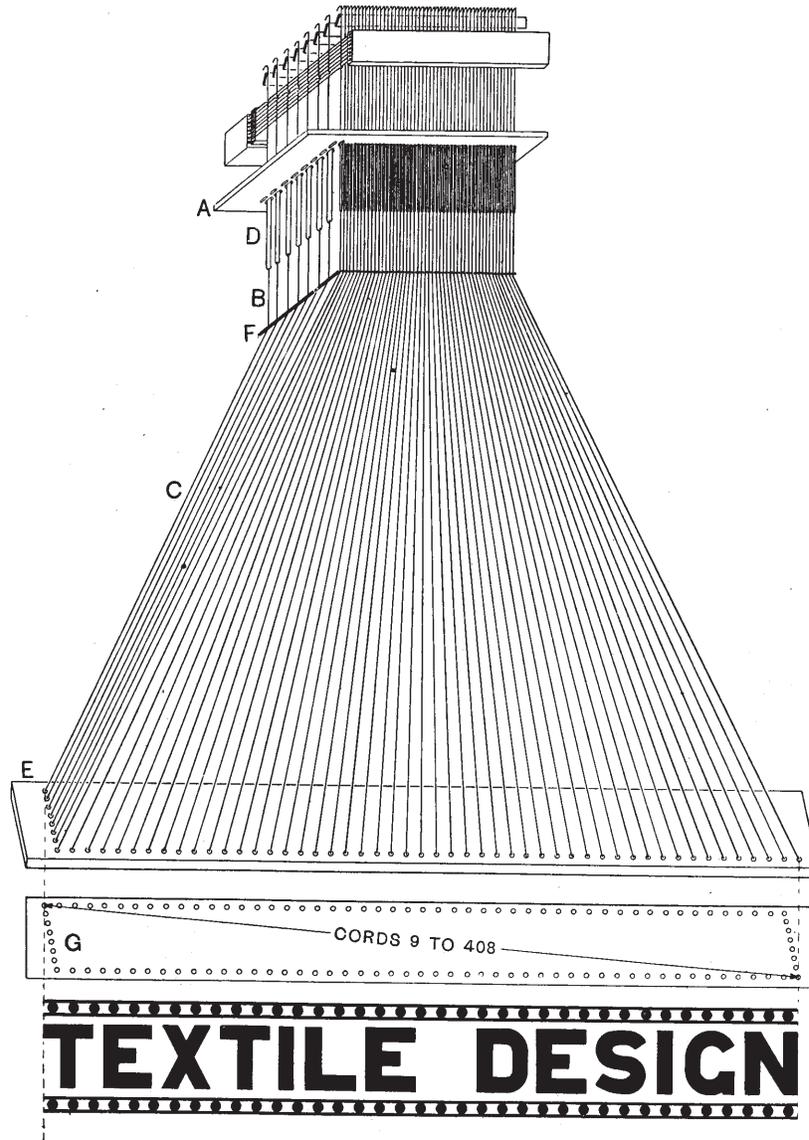


FIG. 5.

are shown at F, the purpose of which is to secure a uniform lift of the threads from selvage to selvage.

A plan of the comberboard appears at G, and it will be seen that there are in all 400 cords (9 to 408 inclusive), while immediately under the plan we have introduced a simple design, composed mostly of letters, to show that there is no repetition of the pattern at any point of the design if we except the repetition of the letters T, E, and I. The dotted lines from the first and the last hooks show clearly that 400 different threads are required to reproduce the design. Now, in actual work 400 threads would form only a very narrow fabric, unless in a coarse set; but nevertheless this figure

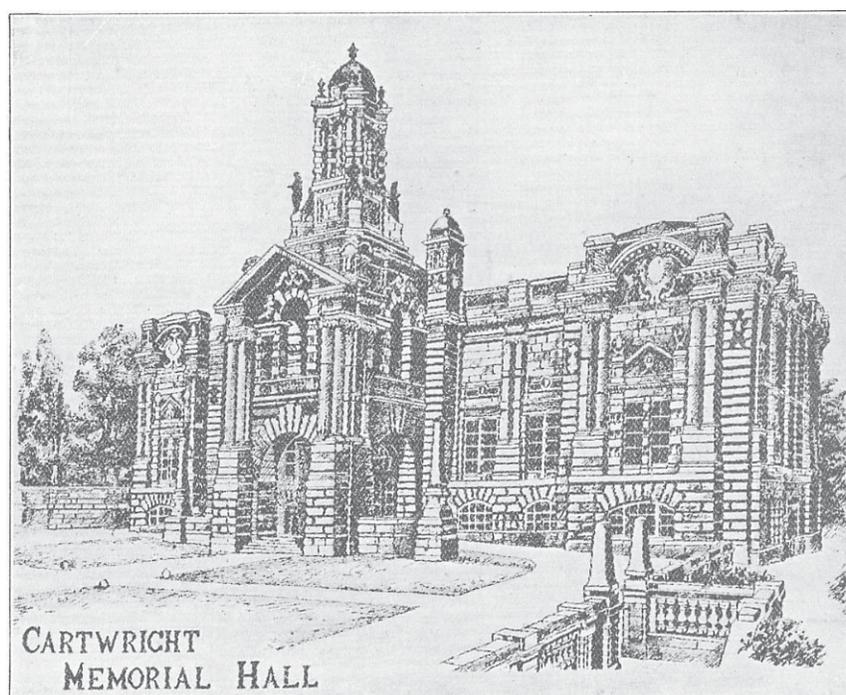


FIG. 6.

illustrates not only the method and tie adopted for narrow ribbons or bands of simple design in various kinds of fabrics, but also the harness tie adopted for the most elaborate silk designs as woven for banners and similar articles, where every thread is worked independently of any other. It would probably be impossible to develop the words "Textile Design" with such a small number of hooks. The principle, however, would be the same if a machine with 1200 needles and hooks were used.

If the words "Textile Design" were to be woven in a narrow fabric in the vertical direction instead of the horizontal, perhaps not more than 70

to 100 threads would be required (and consequently a jacquard of 100 hooks capacity would be sufficient). It is a common practice in the weaving of certain fabrics to adopt this method of developing the ornament since a minimum number of needles and hooks is required. Thus, the reproduction of the woven silk picture illustrated in Fig. 6 shows that the height of the pattern is much less than the width. The figure is a representation of the Cartwright Memorial Hall in Manningham Park, Bradford. During the weaving process the cloth appeared 90 degrees farther round, and even then the narrower width required 1200 needles and 1200 hooks for the work, with a straight-through tie. If the cloth had been woven in the position represented in Fig. 6, *i.e.* with the warp threads for the width, it would have been necessary to employ 1728 needles and 1728 hooks.

Fig. 7 is a photographical reproduction of a unique patent quilt fabric, 19 in. wide by 39 in. long, made by Messrs. Barlow and Jones, Ltd., Manchester, the sole makers of the well-known "Osman" cloths. A glance at this figure shows at once that the ornament on the cloth was developed by means of the "straight-through tie-up"; moreover, it was woven

with the warp threads parallel to the length of the cloth. Four jacquard machines (two of 612 needles and two of 312 needles) were utilised for the work, and yet, as already stated, the tie-up contained only one unit. Altogether 22,600 individual jacquard cards were used, 5650 for each

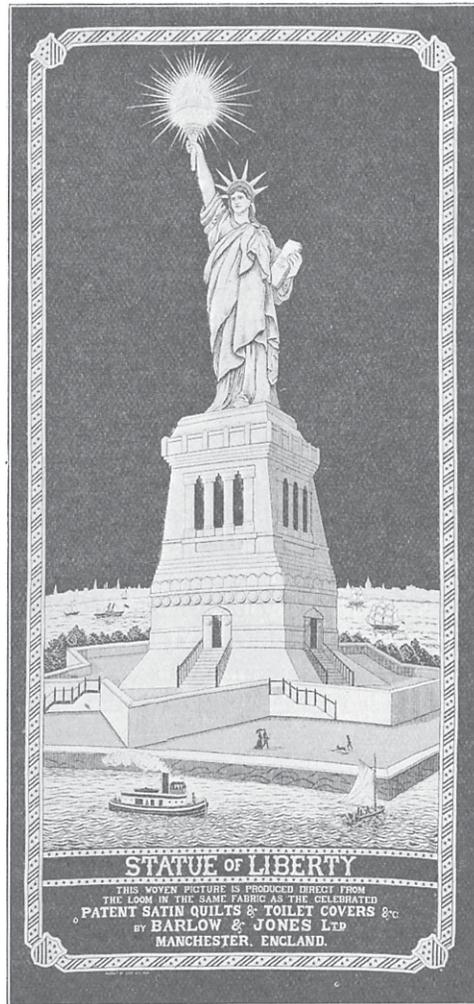


FIG. 7.

machine, and since each row of four cards served for two picks, the cloth contains 11,300 shots of weft.

For certain elaborate designs of the straight-through character there may be thousands of independent threads, involving the use of as many individual hooks and needles in one or more jacquards. An interesting silk picture was made several years ago (the early part of this century) by means of 6 jacquard machines, each with 1312 needles, or 7872 needles in all, and 43,776 cards. The harness tie for this remarkable picture was on the straight-through principle.

Of all the so-called repeating ties the one just described and illustrated is used least, if we except narrow wares. Even if 400 threads are required for one unit of the design, it generally happens that two or more of these units are required to make up the given width. Whatever number of repeats is required, however, the same principle is observed in the harness tie. Thus, suppose that it were desired to reproduce the simple repeating design in Fig. 8 in each of the parts marked :

FIRST REPEAT. SECOND REPEAT. THIRD REPEAT.

It is evident that in the portion marked "First Repeat," which is the unit design in the width (about $1\frac{1}{2}$ repeats of the unit appear in the way of the weft), there could be formed no two vertical divisions, however narrow, which would be identically the same. Therefore, whatever number of harness cords and threads are used to reproduce this unit pattern, each one must be operated by its own needle and hook. In practice, the pattern may be developed on almost any number of threads, large or small, provided that the minimum number used is sufficiently great to develop every detail in the design in the desired width ; but to demonstrate the principle upon which the harness tie for this pattern is based, we shall assume that every row of a 400's jacquard (all the 408 needles and hooks) are to be utilised for the production of the ornament, and that the selvages and other narrow strips outside the pattern proper are to be obtained by parts not yet described. It will thus be seen that it is intended to utilise 408 needles and hooks for the reproduction of the ornament represented in Fig. 8 above the words "First Repeat." Now both the second and third repeats in this figure are identical from point to point with the first repeat, so that the 408 hooks, which control the 408 harness cords C (see Fig. 5) and the 408 threads for the first repeat in Fig. 8 may also be utilised to control the corresponding threads of the warp in the second and third repeats, or indeed, of any higher number of repeats, if a greater width of cloth is required in the same sett or porter.

To accomplish this, it will obviously be necessary to have 408×3 repeats = 1224 threads controlled by 1224 distinct mails and harness cords ; hence,

each of the 408 hooks must actuate three harness cords and three threads of the warp (one in each repeat of the pattern in Fig. 8). These three threads, one in each section, must naturally rise and fall in unison with the hook ; consequently the three corresponding harness cords must be attached to the hook or rather to the neckband B, Fig. 5, which depends from the hook.

The manner in which this extension or duplication of the pattern is obtained is illustrated in Fig. 9. In this view the hooks D are typical of those used in Scottish jacquards in which the bends on the hooks rest, when in their lowest position, on the rods H ; in this machine, the rods H serve the same purpose as the hook-rests on board A, Fig. 5.

If the three harness cords from the bottom of No. 1 neckband B, Fig. 9, be followed from the knot marked C¹, it will be found that each separate

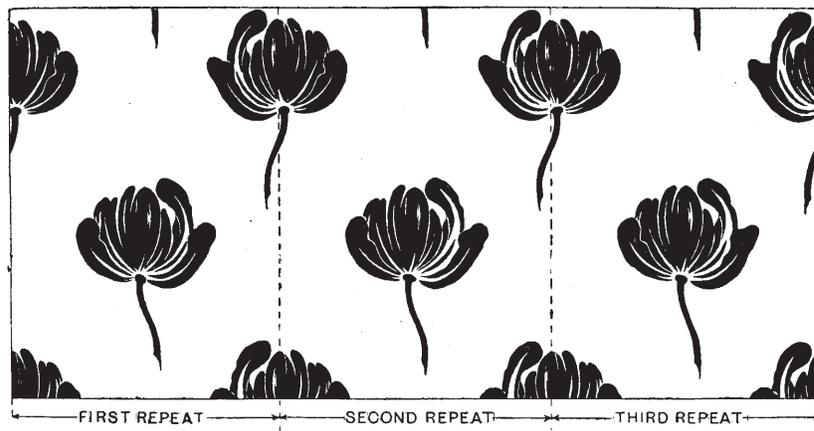


FIG. 8.

cord C passes to the back of the comberboard E, and that each individual cord passes through the back hole in the corresponding short rows, and therefore occupies the first position in its respective section or repeat. Numbers 2, 3 . . . 8 follow in regular succession until the front hole in the comberboard is reached. It is unnecessary, and indeed impracticable, to draw all the cords ; as a matter of fact not a single cord need be drawn to indicate the nature of the tie-up. All this information can be exhibited by drawing a simple rectangular figure as at E¹ to represent the comberboard, and to mark in clearly the first and last short rows, or even only the first and last holes, and to join the latter as exemplified. Thus, in each of the repeats in the diagram E¹ an arrow joins the back hole in the first short row to the front hole in the last short row, and the direction pointed by the arrow indicates, as it were, the draft. In the present instance, the drafts of all three repeats or sections are from back to front.

The general arrangement of the parts in Fig. 9 shows that the tie is a

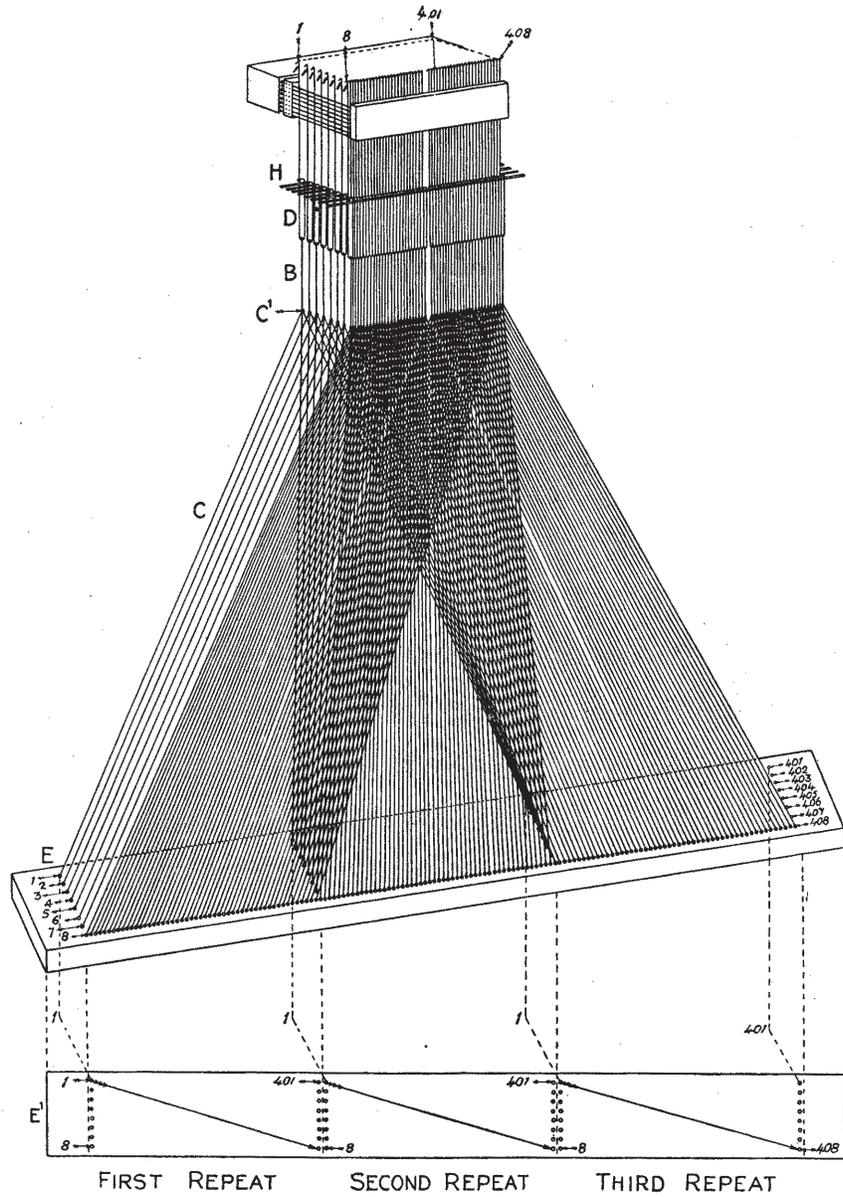


FIG. 9.

“Repeating Tie,” and that it is arranged on the Norwich or Straight system, and so is that in Fig. 5. If the position of the weaver is represented

by that of the reader, the cards would be situated over the warp. If the cards were intended to hang above the weaver, the jacquard would be turned through 180 degrees. The hooks are numbered as well as the comberboard, while the connection between the hooks and the needles is clearly illustrated. The gap left for the centre lacing is shown quite plainly in this figure.

The machine in the foreground of Fig. 10 is a 400's double-lift, single cylinder jacquard; the harness is tied up on the Norwich principle for three repeats or units of the pattern in the width of the cloth; in this particular case the units are in different colours as shown by the woven cloth. The harness cords and the comberboard are clearly seen. The loom behind is a single-lift 25-row twilling jacquard, and in both cases the cards hang over the warp. The looms are driven electrically by small individual motors supported by the stands on the left.

If, before the mounting of the harness took place, the jacquard were turned through 90 degrees, then the mounting for the design shown in Fig. 8 would be as exemplified in Fig. 11. In this illustration, the cylinder of the jacquard has been omitted, but the needle board J is shown, as well as the spring box S, the hook-rest board A, and a bottom board K. All the hooks of one long row and the hooks of one short row are shown, as well as the needles for the latter, and again the full 408 needles and hooks have been utilised, but the tie-up is shown only to a few short rows of the comberboard. No. 1 hook is identical with that in Fig. 9, but it occupies a different position with respect to the comberboard.

As in Fig. 9, the three cords from hook No. 1 in Fig. 11, and shown in heavy lines, pass to the back holes of the first short rows in the three sections or repeats, and, in each case thereafter, the cords in regular succession occupy the holes 2, 3, 4, 5, 6, 7 and finally 8, the latter being in the front row of the comberboard. Similar heavy lines indicate the connection between the last short row of the jacquards (hooks 401 to 408 inclusive) and the three corresponding short rows in the comberboard E. In addition, a series of light lines are drawn from the middle short row (the 26th) of hooks in the jacquard to the middle short row of each section or repeat in the comberboard. The various parts are numbered in order that the tie-up may be easily followed.

In Figs. 5, 9 and 11, the comberboard is shown as a solid block, and no provision is illustrated for fastening it in its correct position; slots near the ends of the board or else in its supports are provided for this purpose. Instead of a solid block comberboard, thin sectional strips, similar to the illustration at L, in the lower part of Fig. 11, are often used. When these strips are closed together, they serve the same purpose as a solid board, and they possess advantages over the solid board, which shall be discussed in

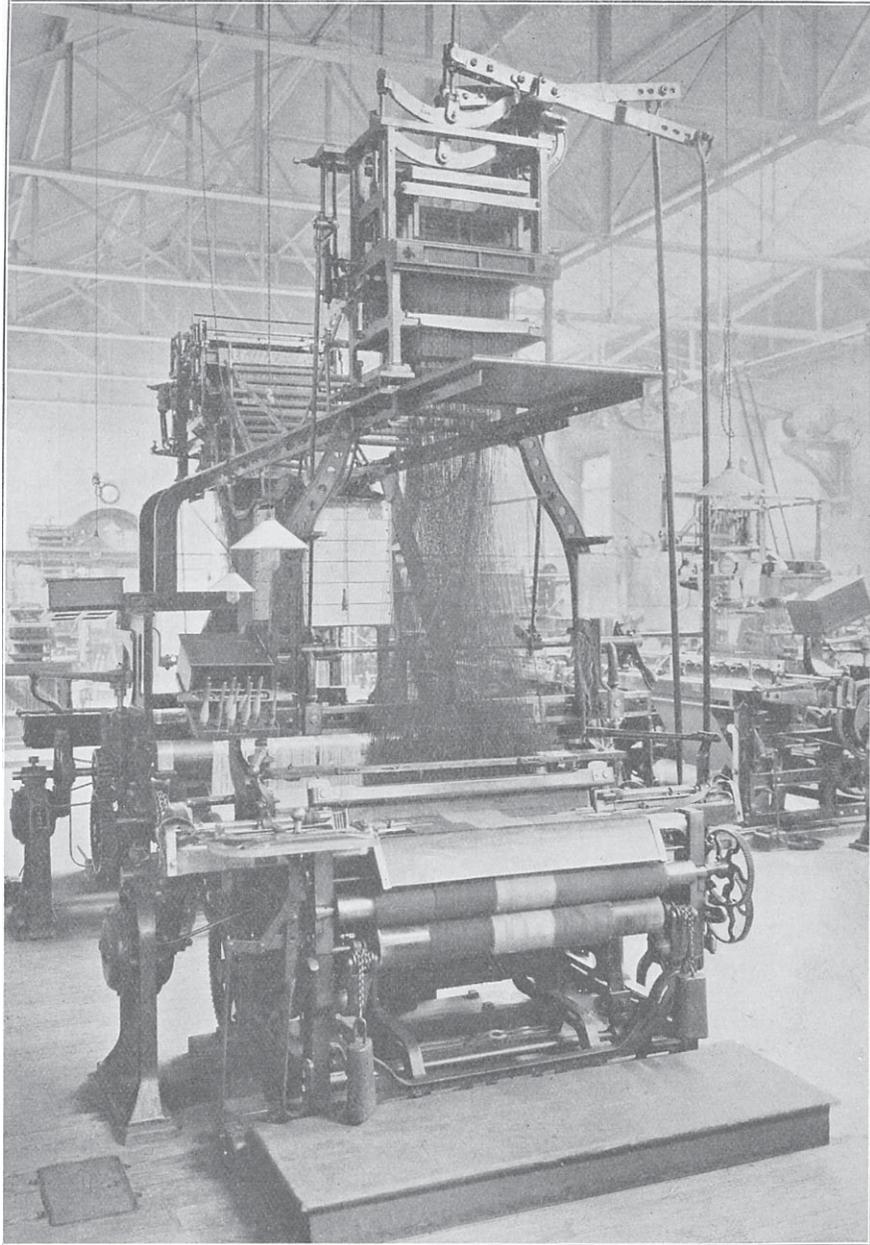


FIG. 10.

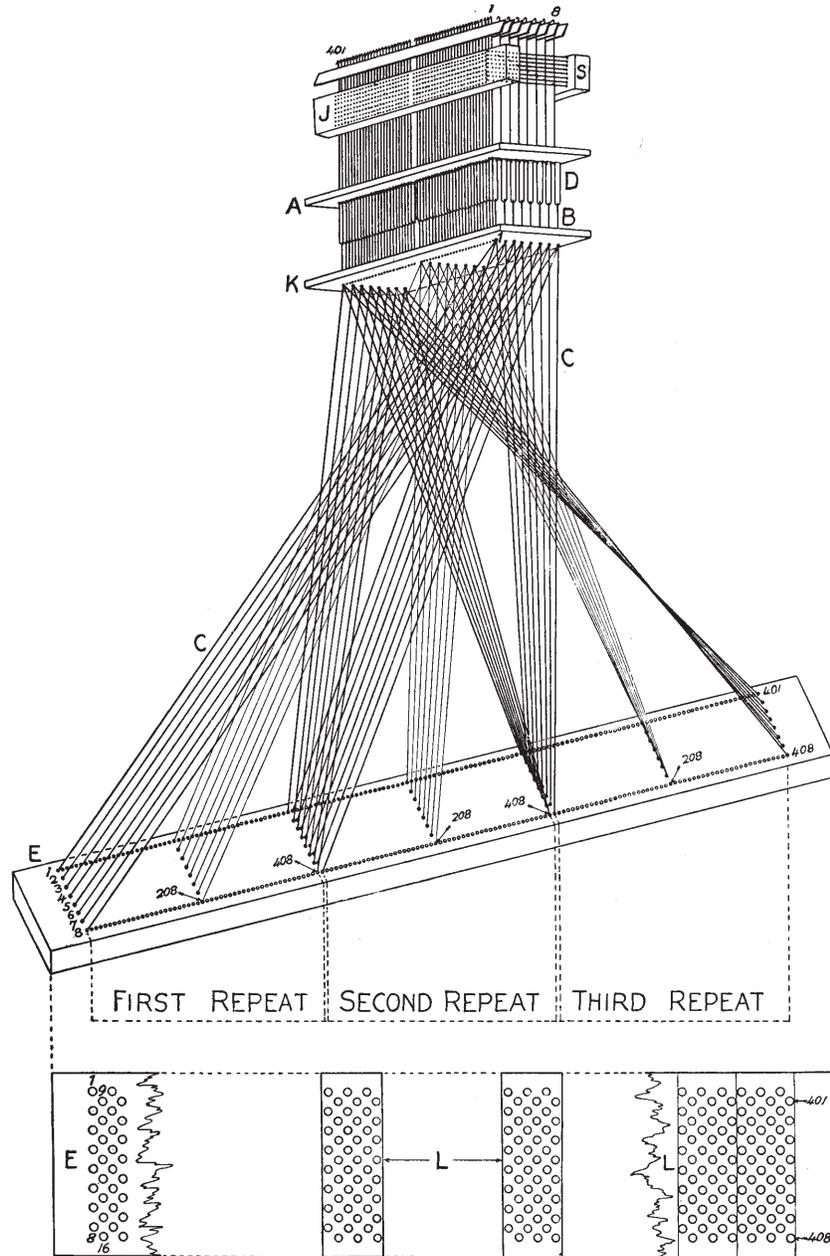


FIG. 11.

the proper place. These slips have specially prepared frames to support them, and the frame is fixed in a similar manner to that employed for solid boards. Two slips are shown in position on the extreme right in the lower diagram in Fig. 11. All the parts in this lower diagram are drawn to a much larger scale than the remaining parts of the figure, and, in practically all cases, the holes are staggered or zigzagged as shown.

The method of mounting or tying-up illustrated in Figs. 5 and 9 has many advantages over that illustrated in Fig. 11, *inter alia*, the simplicity of mounting, and the introduction of the minimum amount of friction amongst the harness cords.

It has, however, the disadvantage of fixing No. 1 hook, or the leading harness cord, at the weaver's left hand or at the right hand, according as the cards fall over the warp or over the weaver's head respectively. With the London tie, Fig. 11, on the other hand—*i.e.* where the long rows of the jacquard are at right angles to the long rows of the comberboard—the leading harness cord, and therefore the leading thread of the warp, may be arranged when tying up the harness, either at the weaver's left hand or at her right hand as desired, independently of whether the cards fall to her right or to her left. A number of looms with the jacquards arranged for the London tie are illustrated in Fig. 12.

In Fig. 11, and as already pointed out, No. 1 hook is connected to a harness cord which passes to the weaver's left and through a hole in the back row of the comberboard. Similarly, the two other cords attached to No. 1 hook pass to holes in the back row. But little consideration is required to see that these cords might have been equally well passed to the weaver's right hand, and to holes in the front row of the board at present numbered 408. In like manner cords from hook No. 8 would have been taken to the right and to the back row instead of to the left and to the front row as illustrated. In this way the leading cord of the harness would have controlled threads to the right hand of the weaver, and succeeding threads would have followed from right to left.

In many cases it is immaterial as to whether a pattern is developed from left to right, or *vice versa*, but in other cases it is essential that this point should receive consideration. The London tie has the advantage that by means of it a jacquard can be tied up to read either from left to right or from right to left, no matter at which hand of the weaver it is necessary that the cards should fall.

Where jacquards are extensively used for the production of all-over or repeating patterns of the type indicated—*e.g.* in the production of dress goods and similar fabrics where the size of the pattern is comparatively small, and where a large number of different weaves are used (not necessarily for the same fabric, but in the same loom for different fabrics)—it is

a very common practice to leave out of action a certain number of the hooks

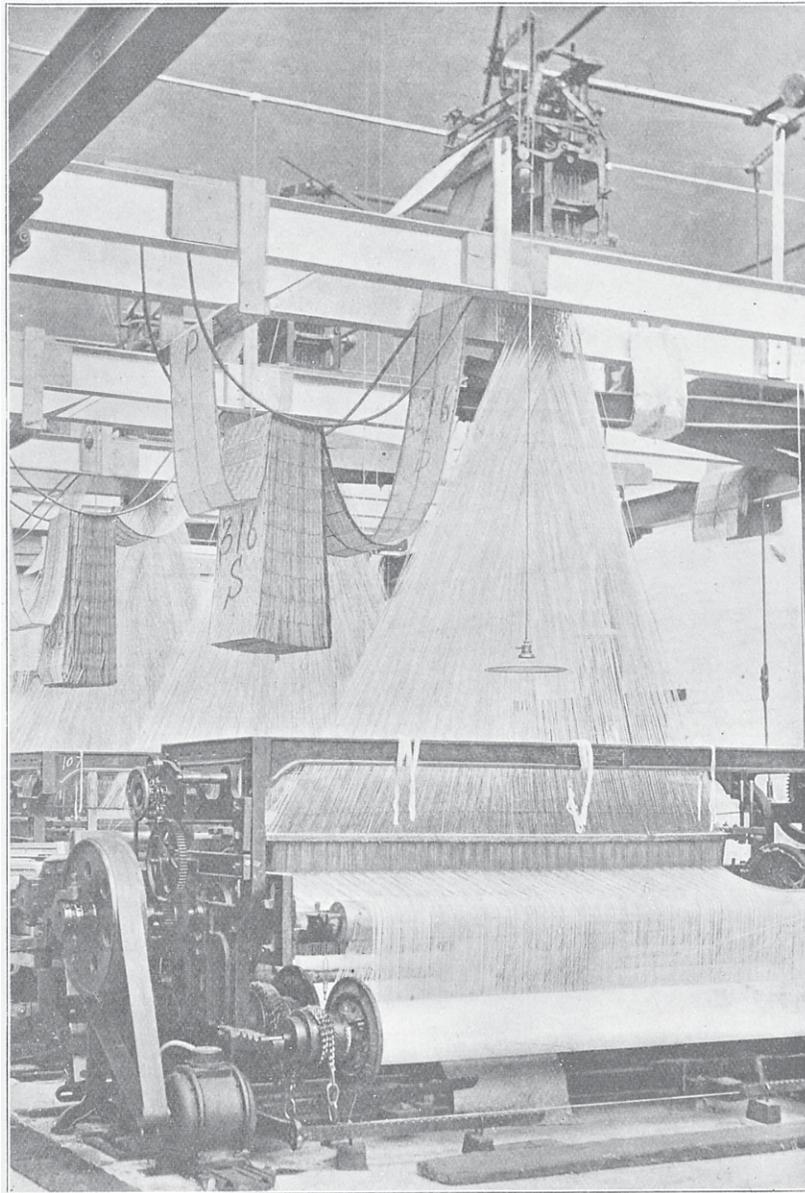


FIG. 12.

in order that a fabric having a different number of threads per inch may be

woven by the machine. Take, for example, the jacquards in common use in Bradford and other districts where similar goods are manufactured; these machines usually contain 304 needles—a number which is found to be ample for the weaving of the majority of such fabrics—and they are often tied up so that the working capacity of the machine, or the number of needles in use, is suitable for a comparatively large number of ground weaves. For this reason the straight repeating ties are seldom mounted in multiples of ten, but generally in multiples of eight or twelve. Leaving aside the character of the design for the time being, it is quite evident that most of the useful small weaves are on 2, 3, 4, 5, 6, and 8 threads; and of these weaves those on 5 threads, excepting those for damasks, are perhaps the least employed. It is therefore not surprising to find that the above machines are often tied up to be suitable for weaving fabrics, the grounds of which may be developed in 2, 3, 4, 6, 8 or 12 thread weaves. Such being

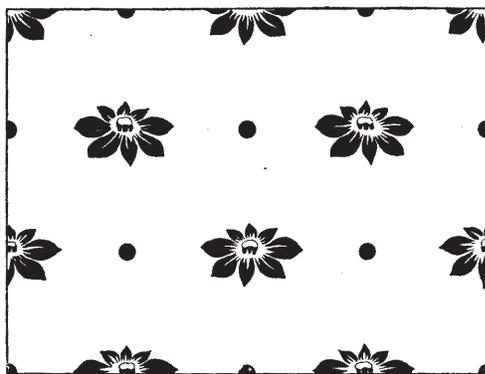


FIG. 13.

the case, it is evident that a tie-up of 288 hooks is, on the whole, the most useful one; while for similar reasons 200's and 400's machines are often tied up to 192 and 384 hooks respectively when intended for the same type of goods. The 384 tie-up is exceedingly useful for these fabrics and for experimental weaving, since all weaves on 2, 3, 4, 6, 8, 12, 16, 24, 32, 48, 64, 96, 192, and 384 threads may

be woven without any break between the various repeats.

The absolute necessity for the number of hooks employed being a multiple of the unit weave depends, however, upon the character of the design. If the figures in the design are detached as illustrated in Fig. 13, then it is essential that the ground weave unit should be a measure of the number of needles and hooks in use. It is easy to see that this is the case, for the ground weave must be continuous from side to side, as well as from bottom to top of the design, otherwise a break in the pattern would clearly obtain in each repeat. If, however, the main figures in Fig. 13 be surrounded by any kind of continuous ornament—*e.g.* ribbon work, diagonal lines in both directions or only in one direction, ogee forms, or, say, circles as illustrated in Fig. 14—then the conditions are entirely different. It is obvious that in such cases each enclosed area formed by the interlacing or encircling ornament may be treated as an isolated section, and conse-

quently the number of hooks need not necessarily be a multiple of the unit weave. Moreover, with such a design, it is evident that different ground weaves may be used in the various sections without in any way impairing the beauty of the design or the woven fabric; indeed, in many cases such a recourse may have the opposite effect, and may greatly enhance the value of the textile product. Nevertheless, it is always a distinct advantage to have the machine tied up so that it is suitable for the majority of useful weaves, because it is quite clear that such an arrangement is equally adapted for the groundwork of detached or enclosed figures.

The number of threads or harness cords per inch in the comberboard or harness reed depends partly upon the kind of fibre used, partly upon the structure of the cloth, and partly upon the weaves used and the effect desired in the fabric. Theoretically any number per inch may be used, and the machine tied up for this number; but when once tied up for any particular number, that number is fixed within very slight limits for all patterns in which all the hooks and needles of the tie-up are in operation. In other words, the sett of the fabric is fixed unless some of the needles and hooks remain inoperative. To illustrate this point clearly let us take a concrete case, say, of a 300's

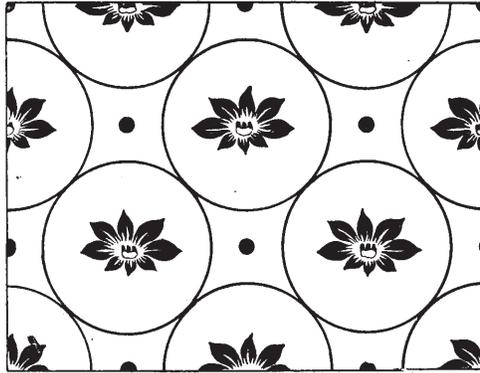


FIG. 14.

machine tied up with 288 hooks per repeat and mounted for a 27 in. cloth with 96 threads per inch in the reed.

$$\frac{288 \text{ hooks}}{96 \text{ per inch}} = 3 \text{ in. of cloth in each repeat of the pattern,}$$

$$\text{and } \frac{27 \text{ in. width}}{3 \text{ in. pattern}} = 9 \text{ repeats of pattern in the cloth;}$$

$$\text{or } \frac{96 \text{ threads per inch} \times 27 \text{ in. wide}}{288 \text{ hooks}} = 9 \text{ repeats of pattern in 27 in.}$$

Consequently for this mounting each hook of the jacquard would require to be furnished with nine harness cords, one cord for each repeat of the pattern, and the tie-up would be a repeating one similar to Fig. 9 or Fig. 10.

So long as the cloth requires to have 96 threads per inch, the above conditions would remain intact, and the full complement of tied-up hooks

would be used ; but if a similar fabric were required to contain a different number of threads per inch, then it is obvious that some alteration would be necessary. It is clearly impossible to make a cloth with more threads per inch without re-tying the harness to suit, but cloths with fewer threads per inch may be, and often are, woven in such a loom. Any such reduction of sett, however, must be accompanied by a reduction in the number of hooks in use, and those hooks or cords which for the time being remain inoperative are said to be "cast out," or "filed." Since the number of complete rows cast out in the harness is proportional to the sett or porter of the fabric, the width of the fabric for the reduced sett will be the same as that of the original. Thus, 36 rows of 8 hooks per row give a 3 in. pattern on 96 threads per inch ; therefore 35 rows would give

$$\frac{96 \text{ threads} \times 35 \text{ rows}}{36 \text{ rows}} = 93\frac{1}{3} \text{ threads per inch.}$$

This shows the method of finding the resulting sett from any reduction in the number of rows per repeat, but it does not follow that every reduction will prove satisfactory. For instance, in the above case one row cast out in 36 means that there are 35 rows of hooks and needles to be used—that is, the hooks and needles in actual work are to be reduced from 288 to 280. Now this particular reduction gives a number which, unfortunately, reduces the general value of the tie, since weaves repeating on 3, 6, 9, 12, etc., cannot be used except for patterns similar in nature to that in Fig. 14. Besides, a reduction in sett from 96 per inch to $93\frac{1}{3}$ per inch is scarcely perceptible in the cloth, and therefore such a reduction in this sett would be rarely attempted.

The first satisfactory reduction in the above-mentioned tie-up is obtained by leaving three idle rows in the machine in addition to those already left out—that is, leaving idle three rows or twenty-four hooks per repeat, thus reducing the number in the repeat from 288 to 264, and making the sett equal to

$$\frac{264}{3} = 88 \text{ threads per inch.}$$

Similar satisfactory reductions may be made by casting out additional groups in multiples of 3 rows or 24 hooks at a time, thus reducing the sett each time by 8 threads per inch. By proceeding in this manner the total number of hooks still left in the repeat will be some multiple of 24, and will therefore be satisfactory for any weave which repeats on 2, 3, 4, 6, 8, 12, or 24 threads. Casting out by such a method, if practised systematically, may be made to give a 3 in. pattern in any of the seven setts in Table I. :

TABLE I

	1	2	3	4	5	6	7
Threads per inch	96	88	80	72	64	56	48
Width of pattern	3 in.						
Threads per repeat	288	264	240	216	192	168	144
No. of rows employed	36	33	30	27	24	21	18
	1	1	1	1	1	1	1
	2	2	2	2	2	2	—
	3	3	3	3	—	—	3
	4	4	4	4	4	4	—
	5	5	5	5	5	5	5
	6	6	—	—	—	—	—
	7	7	7	7	7	7	7
	8	8	8	8	8	—	—
	9	9	9	—	—	9	9
	10	10	10	10	10	—	—
	11	11	11	11	11	11	11
	12	—	—	—	—	—	—
	13	13	13	13	13	13	13
	14	14	14	14	14	14	—
	15	15	15	15	—	—	15
	16	16	16	16	16	16	—
	17	17	17	17	17	17	17
Rows of jacquard in use.	18	18	—	—	—	—	—
Dashes (—) represent rows cast out.	19	19	19	19	19	19	19
	20	20	20	20	20	—	—
	21	21	21	—	—	21	21
	22	22	22	22	22	—	—
	23	23	23	23	23	23	23
	24	—	—	—	—	—	—
	25	25	25	25	25	25	25
	26	26	26	26	26	26	—
	27	27	27	27	—	—	27
	28	28	28	28	28	28	—
	29	29	29	29	29	29	29
	30	30	—	—	—	—	—
	31	31	31	31	31	31	31
	32	32	32	32	32	—	—
	33	33	33	—	—	33	33
	34	34	34	34	34	—	—
	35	35	35	35	35	35	35
	36	—	—	—	—	—	—

Further reductions might be made, but they would be warranted only in extreme cases, since any greater reduction than that shown in the last column would clearly necessitate the casting out of two consecutive rows of hooks—a most undesirable expedient. For the coarser setts it would be much more satisfactory to tie up the harness, say, for a maximum of 64 threads per inch on 24 rows, or 192 hooks, of a 200's jacquard, for it must be remembered that however few rows are cast out, the card used is

theoretically in all cases, and practically in some cases, greater than what is actually required for the reduced number of needles in use.

If 192 hooks of a 200's jacquard be tied up for 64 threads per inch, the principle of reduction just described may obtain, as shown in Table II.

TABLE II

—	1	2	3	4	5
Threads per inch	64	56	48	40	32
Width of pattern	3 in.				
Threads per repeat	192	168	144	120	96
No. of rows employed . . .	24	21	18	15	12
Rows of jacquard in use. Dashes (—) = cast out rows.	1	1	1	1	1
	2	2	2	2	—
	3	3	3	3	3
	4	4	—	—	—
	5	5	5	5	5
	6	6	6	—	—
	7	7	7	7	7
	8	—	—	—	—
	9	9	9	9	9
	10	10	10	10	—
	11	11	11	11	11
	12	12	—	—	—
	13	13	13	13	13
	14	14	14	—	—
	15	15	15	15	15
	16	—	—	—	—
	17	17	17	17	17
	18	18	18	18	—
	19	19	19	19	19
	20	20	—	—	—
	21	21	21	21	21
	22	22	22	—	—
	23	23	23	23	23
	24	—	—	—	—

Should this arrangement not prove sufficiently flexible, or permit of a sufficiently fine gradation of setts—a drop of 8 threads per inch in the lower grades is perhaps too much—reduction may be made by casting out single rows of 8 at a time on a similar system, although this system would necessarily, in certain cases, prevent the use of some ground weaves. For example, suppose 192 hooks of a 200's jacquard were tied up with 72 threads per inch, the pattern would clearly be

$$\frac{192 \text{ hooks}}{72 \text{ threads}} = 2\frac{2}{3} \text{ in. wide ;}$$

but by casting out one row of 8 hooks for each decrease in the sett, a differ-

ence of 3 threads only would obtain between successive setts. The following Table III. shows this, but weaves on 3, 6, 9, or 12 threads cannot be used with those setts marked with an asterisk.

TABLE III

—	1	2	3	4	5	6	7	8	9
Threads per inch .	72	69*	66*	63	60*	57*	54	51*	48*
Width of pattern .	2 $\frac{2}{3}$ in.								
Threads per repeat .	192	184	176	168	160	152	144	136	128
No. of rows employed .	24	23	22	21	20	19	18	17	16
	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	—	—	—	—
	4	4	4	4	4	4	4	4	4
	5	5	5	5	5	5	5	5	5
	6	6	6	—	—	—	—	—	—
	7	7	7	7	7	7	7	7	7
	8	8	8	8	8	8	8	8	8
	9	9	9	9	9	9	9	—	—
	10	10	10	10	10	10	10	10	10
Rows of jacquard in use.	11	11	11	11	11	11	11	11	11
	12	12	—	—	—	—	—	—	—
Dashes (—) = rows cast out.	13	13	13	13	13	13	13	13	13
	14	14	14	14	14	14	14	14	14
	15	15	15	15	15	15	15	15	—
	16	16	16	16	16	16	16	16	16
	17	17	17	17	17	17	17	17	17
	18	18	18	18	—	—	—	—	—
	19	19	19	19	19	19	19	19	19
	20	20	20	20	20	20	20	20	20
	21	21	21	21	21	21	—	—	—
	22	22	22	22	22	22	22	22	22
	23	23	23	23	23	23	23	23	23
	24	—	—	—	—	—	—	—	—

These methods of casting out present no difficulty with regard to the painting of the design. The design is enlarged or transferred to point-paper on the requisite number of blocks, but the card-cutter must be instructed with regard to the number and the positions of the rows which are to be idle, so that whenever he comes to one of these numbers he may give a blank tread. The pegs, corresponding to the missed rows, may be withdrawn from the piano rack; or separate milled racks, with teeth omitted at the desired places, may be provided for the different orders of casting out. The ordinary index card on the piano would then be dispensed with, and special arrangements made for facilitating the reading of the design; if the ordinary index card is used, the design would probably be cut into

strips at those points where the rows are cast out, and unpainted blocks of design-paper inserted, so that no cutting could take place on blank rows.

In certain cases there appear at first sight to be simpler methods of casting out than those mentioned. For example, where one-eighth or one-quarter of the harness is to be dropped in a 300's or 400's machine, it would seem simpler to drop one long row or two long rows respectively. The objection to this system would be the fact that the design-paper would have to contain 6 or 7 rows of small squares between each pair of vertical heavy lines, and the weave in most cases would be more difficult to insert on such paper. If suitably ruled paper could not be obtained, then special hand ruling in 6's or 7's in a distinctive colour of ink would be necessary. It also appears simpler to leave all the idle hooks at the two ends of the machine, thus simplifying card-cutting; but this method naturally leaves large groups of unoccupied mails after each repeat, and the space occupied by these groups causes the threads near the beginning and finish of each repeat "to draw" on account of their path not being perfectly perpendicular or square to the reed. Several rows, at any particular part, say at one or both ends, may be omitted when re-tying is necessary. This method, however, is a little outside the present discussion.

Harness Ties for Striped Designs.—These may be divided into two general classes, thus :

1. Those in which the whole of the warp is controlled by the joint action of the jacquard or jacquards and the harness.
2. Those in which a number of the stripes, often alternate ones, are controlled by the jacquard and harness, and the remainder of the stripes controlled by shafts or healds.

The breadth of the stripes may, of course, be broad or narrow, depending upon the sett, the extent of the design, the use to which the fabric has to be put, and upon the capacity of the jacquard.

The great majority of the designs intended to come under Class 1 are of such a nature that, although they are termed, and actually are, striped designs, the tie-ups are subject to exactly the same conditions as those for many designs in which the ornament has no resemblance whatever to a stripe nature. In such cases, the tie-ups shown in Figs. 5, 9, and 11 would meet the requirements.

Consider, for example, Fig. 15; the single unit or repeat of the design is, obviously, of a very pronounced stripe character, since it consists of :

- (a) A black figure on a white ground, alternating with
- (b) A white figure on a black ground.

These sections, fully worked out, are marked respectively L and D, and the repeats, two of each, would appear in the blank rectangles to the right; these are distinguished by the same letters L and D. The positions which

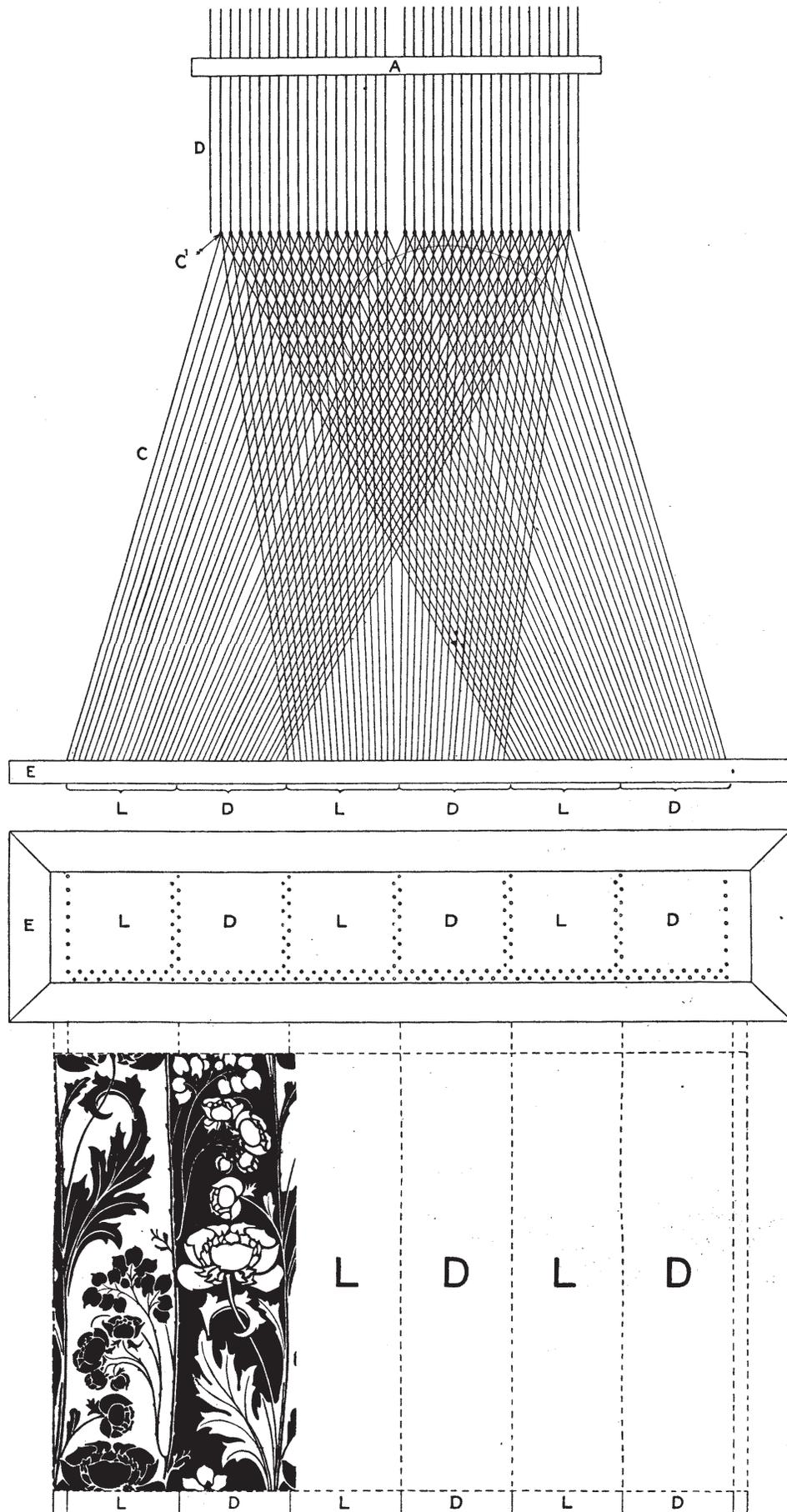


FIG. 15

To face page 27.

Foldout reduced to 90% and rotated 90° to fit on page.

their controlling harness cords C would occupy, are also indicated by the same letters on the comberboard E, where the staggered holes represent the first and last short rows in each section as well as the front staggered row. This latter row could, of course, represent cords from No. 9 needle and hook and all others in the corresponding long row, or No. 16 needle and hook with the full complement in the same long row, depending upon the method of drawing-in the harness, see Fig. 3. (The first short row and last short row have been omitted in Fig. 15 as stated.)

The comberboard E is shown arranged for three complete repeats to correspond with the three repeats (six sections) occupied by the design and its adjoining places of repetition below the comberboard E. A small strip is shown near each selvage, but no cords are shown descending to them; cords would be necessary at these places, however, in order that the woven texture would exhibit an unbroken curved outline at the edges of the design.

In Fig. 15 we have purposely omitted the jacquard itself, but have introduced the hook-rest board A, the hooks D of one long row, the harness cords C from these hooks—neglecting the first and last—and the knots C¹ where three separate harness cords are indicated as being tied to each hook. Since there are 38 hooks D in the row, the illustration represents a 300's jacquard (38 hooks × 8 per row = 304 hooks), with 36 hooks tied up, or a mounting of 36 × 8 per row = 288 cords and hooks.

A tie-up of a compound character appears in Fig. 16, in which there are three distinct stripes :

1. The narrow stripe marked N.
2. The broad stripe marked B.
3. The medium stripe marked M.

In this example, the narrow stripe N appears six times, the broad stripe B three times, and the medium stripe M twice. The comberboard E is shown above the design, and marked out for the first and last rows and the front row in each section. It is arranged for a 600's or 12-row jacquard, to be tied up as follows :

48	hooks for 1st	stripe N,	3	harness	cords per	hook =	144	
360	„	„	stripe B,	3	„	„	„	= 1080
144	„	„	stripe M,	2	„	„	„	= 288
48	„	„	2nd stripe N,	3	„	„	„	= 144
<hr style="width: 100%;"/>								
<u>600</u>								<u>1656</u>

i.e. 600 hooks utilised for the figure, and 12 hooks reserved for selvage threads, tape selvages, or the like.

The measurements of the various sections in the design and in the comberboard E are as under :

1st stripe N is 0·5 in. wide.
 stripe B is 3·75 in. „
 stripe M is 1·5 in. „
 2nd stripe N is 0·5 in. „

—————
 6·25 in. width of unit R.
 —————

Hence

$$\frac{600 \text{ cords}}{6\cdot25 \text{ in.}} = 96 \text{ cords per inch, and } 96 \text{ threads per in. in the reed.}$$

It will be noticed that there is scarcely one complete repeat or unit of the broad stripe B in the way of the weft, whereas two repeats are shown in the medium-width stripe ; no indication of the pattern is exhibited in the narrow stripes.

It will be apparent that if all the narrow stripes contained exactly the same design, it would be possible to tie up the machine so that 552 hooks and needles would be sufficient for the work ; thus

$$\begin{aligned} & N + B + M \\ & 48 + 360 + 144 = 552. \end{aligned}$$

In such a case, all the harness cords from the six narrow stripes would be controlled by 48 hooks instead of by 96 hooks as illustrated. Or a similar but wider pattern could be obtained by utilising all the 600 hooks of the machine, and making the stripe B, the stripe M, or both, a little wider, for there would evidently be 48 available hooks for such an increase in the figuring capacity. It need hardly be said that these 48 available hooks could, if desired, be utilised for increasing the width of each stripe N, and thus still further increase the width of the cloth without disturbing the sett or the general disposition of the various ornamental sections.

It will thus be seen that designs of the nature of that exhibited in Fig. 16 can be treated in different ways. In the first case, such designs may be woven on a loom in which the harness is a straight tie covering the extent of one complete unit of the design, in which case, with a set of 96 threads per inch, 600 needles and hooks would be in use ; in the second case, those stripes which repeat themselves in any one unit can be reproduced by a number of needles and hooks which corresponds to the requirements for one such stripe only.

The former method may not appear so economical as the latter, inasmuch as it requires the greater number of needles and hooks—one for each separate thread of the pattern ; moreover, in some cases, it incurs more expense in designing, as well as in cards and card-cutting. Nevertheless it is, in general, preferred, since the tie-up is capable of being utilised for patterns of all kinds which come within the capacity of the number of needles employed.

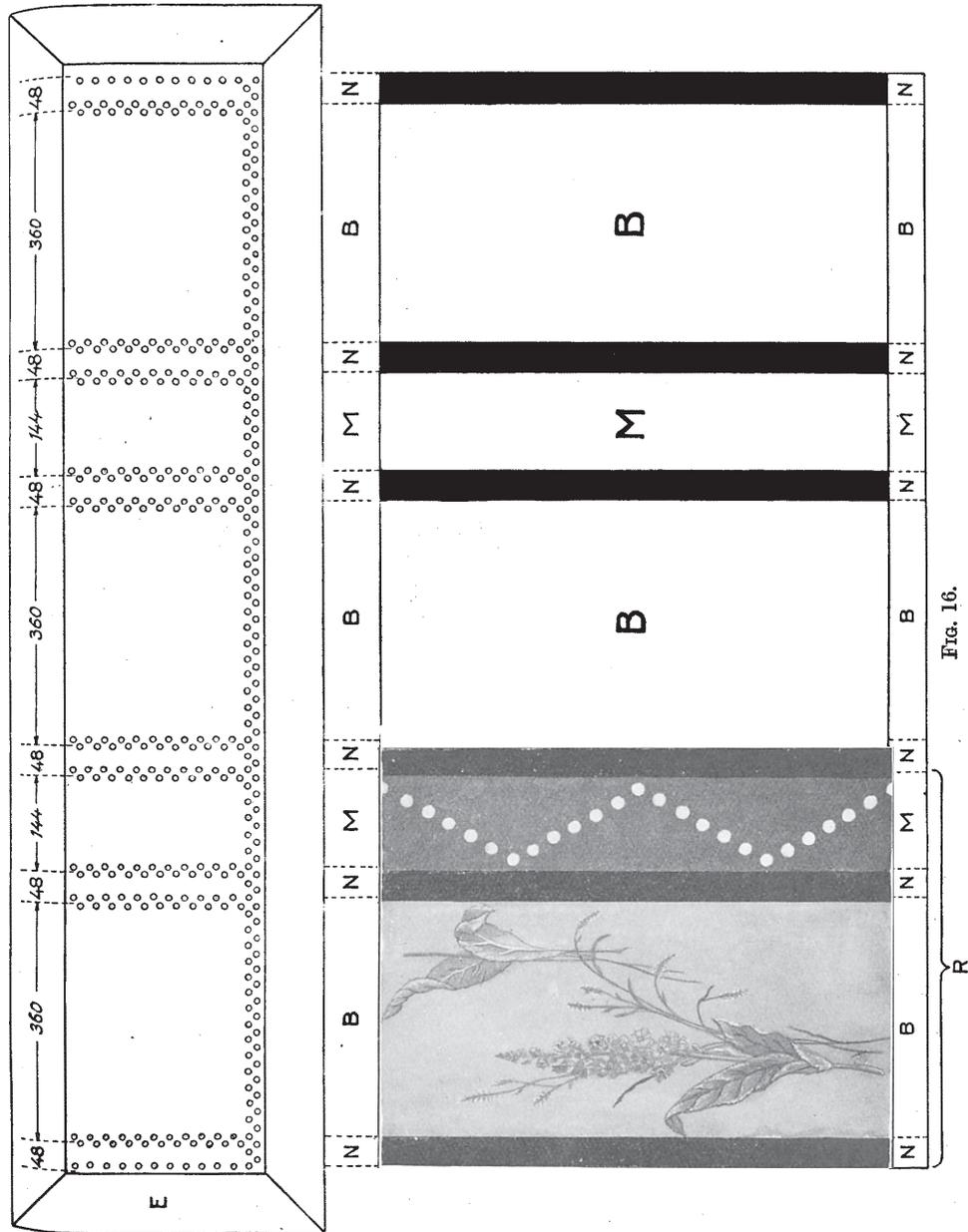


FIG. 16.

Fabrics which are ornamented at intervals by jacquard designs on clearly defined stripes are of two general types: (a) Those in which the stripes form an integral part of the fabric; and (b) those in which the stripe

is of an extra warp nature and forming some type of ornament which is superimposed on the surface of a foundation cloth, the threads of which are operated by healds or shafts.

Each of these groups covers an immense variety of fabrics, and it often happens that, in order to simplify the working of the loom, the whole of the warp, both for the foundation cloth and for the warp figured stripe, is controlled from the jacquard. In examples of this kind, where all the threads pass through the mails of the harness, complications sometimes arise because the sett of the cloth in the pure ground portions is coarser than that in the figured stripe. When this



FIG. 17.

occurs the sett of the harness in the comberboard must be varied in accordance with that of the warp in the different portions of the fabric, or else the sett all through must be as high as that required for the figured stripe, and the remainder cast out as required. In other cases the nature of the ground weave, or perhaps the character of the fabric, is such that the best results cannot be obtained by controlling the harness exclusively by the ordinary jacquard, and it becomes desirable, if not imperative, to use shafts and harness in combination. When such a departure is adopted, the harness tie is generally some modification of an all-over repeating tie, and the shafts are actuated either from a few spare hooks at each side of the jacquard, or independently by means of tappet or dobby mechanism. If the fabric is to be woven by the jacquard alone, it is usual so to arrange the tie-up, as already stated, that any simple weave repeating on a small number—say, four threads and four picks—may be introduced into the ground stripes without affecting the figured portion of the cloth or changing the cards which control it.

Fig. 17 illustrates a fabric of the type in which the figured stripe forms an integral part of the fabric. It is about five-eighths of an inch wide in the reed, and consists of 44 threads of two-fold mercerised cotton, with an

edging of four threads of artificial silk, all drawn three threads per split. In the plain portion, however, which is made up of 44 threads per inch of the two-fold mercerised cotton and woven $\frac{1}{1}$ plain, alternate splits of the reed are left empty, and the remaining ones contain three threads each ; this arrangement of reeding the threads imparts a stripe-like character in the plain section not unlike bad reed-marking. The complete pattern contains three figured stripes, and therefore three plain stripes, but little more than half of the repeat appears in the illustration.

Now, on first sight it would appear quite probable that the fabric had been woven with a combination mounting of harness and shafts, since shafts undoubtedly conduce to better results in plain work than does the harness, and the plain-weave stripe in Fig. 17 is devoid of interlacing faults. A closer examination of the pattern, however, would probably lead to the conclusion that all the warp threads had been controlled by a jacquard. For instance, there are three figured stripes in the complete pattern, disposed in three different planes, although the ornament in all the three stripes is the same ; hence, since each figured stripe contains 44 threads, the total number of figuring threads per pattern is $44 \times 3 = 132$ plus the artificial silk edging threads, four on each side, which are also controlled by the jacquard. If all the edging threads were controlled by 4 hooks, and the plain stripe neglected for the time being, there would be $4 + 132 = 136$ hooks required as a minimum. Consequently, unless some odd size of jacquard were used, a 200's machine would be necessary for the reproduction of the pattern, approximately 70 hooks being idle.

Suppose, on the other hand, that the threads of the plain stripe were also controlled by the jacquard, in the way illustrated by one repeat of the pattern in Fig. 18 plus 4 threads at the end. The solid black circles show where the edging threads appear. The arrangement is as under :

4 edging threads	}	operated by 48 hooks.
44 threads for plain weave		
4 edging threads	}	operated by 48 hooks.
44 threads for figured stripe		

This order is repeated for three times, but, although the plain part and the four edging threads in each section P, Fig. 18, are controlled by the same 48 needles and hooks, the four edging threads and the 44 figured threads in the section F¹ differ from those in F², and both differ from those in F³. Hence, one could still employ a 200's machine as under :

48 hooks for one edging and plain threads three times repeated per pattern,
 3 × 48 or 144 hooks for three plain edgings and three figured stripes,

thus utilising $48 + 144 = 192$ hooks out of a total of 208 hooks in an 8-row 200's machine.

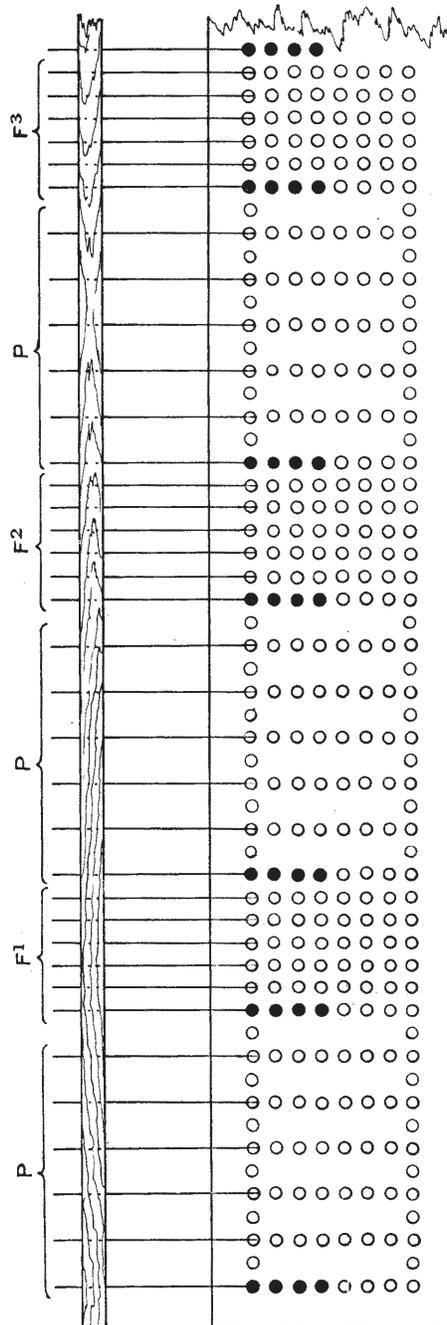


FIG. 18.

It has already been pointed out that the plain stripe is only half the sett of the figured stripe, so that alternate rows of the comber-board or harness reed would be empty as indicated in sections P, Fig. 18, provided that the sett of the comber-board throughout was equal to that required by the figuring stripes.

For the above method of tying up, the hooks of the machine would require harness cords as follows for each repeat of the pattern :

Hooks.	Harness Cords per Repeat.
1- 16 = 16 idle or utilised for selvages, etc.	
17- 64 = 48 for edging and plain cloth × 3 cords each = 144	
65-208 = 144 for edging and figured stripes × 1 cord each = 144	
<hr style="width: 20px; margin: 0 auto;"/> 208 <hr style="width: 20px; margin: 0 auto;"/>	<hr style="width: 20px; margin: 0 auto;"/> 288 <hr style="width: 20px; margin: 0 auto;"/>

If the cloth were made to contain seven repeats, each hook controlling the cords in sections P, Fig. 18, would require 21 cords, while each hook in the figuring sections, F¹, F², and F³, would have only 7 cords.

We have already pointed out, in connection with Figs. 13 and 14, the advantages which obtain when a jacquard machine is tied up to a number

of hooks which is a multiple of 2, 4, 6, 8, etc., and we have also mentioned the fact that when the figured patterns are separated by any kind of continuous band, it is not absolutely essential that the number of threads in the weave should be a measure of the number of hooks in use. The pattern illustrated in Fig. 17 clearly belongs to that class in which the relation between the threads in the weave and the number of hooks is unimportant, since each of the three distinct patterns forms a band which effectively separates the others. The continuity of the various weaves is therefore important only in the way of the weft, but this is independent of the number of hooks. Such being the case, the pattern partly illustrated in Fig. 17 could be produced quite easily if an ordinary 300's jacquard be used in which the tie-up was of the straight-through repeating kind illustrated in Figs. 9 and 11, but with seven repeats instead of only three as illustrated in the above two figures. Thus :

	4	threads	artificial	silk	for	edge
44	„		plain	weave	P	
4	„		artificial	silk	for	edge
44	„		figure	weave	F ¹	
4	„		artificial	silk	for	edge
44	„		plain	weave	P	
4	„		artificial	silk	for	edge
44	„		figure	weave	F ²	
4	„		artificial	silk	for	edge
44	„		plain	weave	P	
4	„		artificial	silk	for	edge
44	„		figure	weave	F ³	

288 threads, cords, and hooks for each pattern.

The two edges of the cloth, near the selvages, would be developed with about half a pattern of the plain-weave stripe.

On page 26 we stated that fabrics ornamented by jacquard-figured stripes were of two general types—(a) those in which the stripes formed an integral part of the fabric ; and (b) those in which the stripe was of an extra warp nature and formed ornament superimposed on a foundation cloth, the threads of which were operated by shafts. To that brief definition should be added the words, “ or other suitable shedding mechanism.” The chief point of difference between the two types is that in the former the threads which form the jacquard-figured stripe also help to build up the fabric proper, whereas in the latter type the stripe threads are used exclusively for the figure.

In connection with Figs. 17 and 18 we discussed an example which might be regarded as typical of the former class of stripe, but a discussion of any example of the latter type involves practically the whole question of extra warp figuring by means of a jacquard or jacquards independently of how

the ground warp may be controlled. Further, it is sometimes difficult to differentiate between those examples of extra warp figuring where, on the one hand, the extra warp is utilised for figuring purposes pure and simple, and, on the other hand, where the warp is so controlled that the fabric produced becomes less or more compound in nature as an indirect result of the method of figuring and also of stitching the loose figuring threads when they are on the back of the fabric. As examples of this class of fabric we may mention the cloths which are known generally in the cotton trade as toilettings and toilets, an elaborate example of which appears in Fig. 7. The variety in the structure of these fabrics forms a very fine gradation from what might

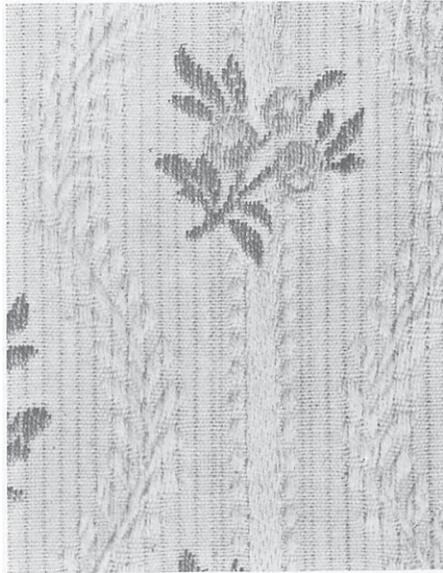


FIG. 19.

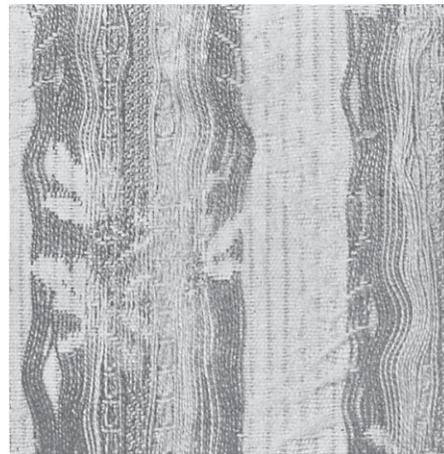


FIG. 20.

cloth, in which the figuring is produced by the stitching together of the two fabrics. In the meantime, however, we shall confine our remarks to specimens of the former type, since the latter are usually produced by means of special compound harness mountings, designed to economise in the cost of designing and card-cutting.

Figs. 19 and 20 show respectively the face and back views of a cotton tapestry fabric of a simple type in which the chief ornament is developed with extra warp threads. The ground fabric is for the most part composed of the $\frac{1}{1}$ plain weave, but relief is given to what would otherwise be a plain white surface by the introduction of green-coloured threads, and of floral ogee lines developed in ordinary white warp flush or float. A white satin

stripe, about one-quarter of an inch in width, is situated centrally between each pair of ogee lines, but these white stripes are broken at regular intervals by extra warp spots developed in green, red, helio, pink, orange, and yellow threads. The spots, which point to right and left alternately, are arranged in diamond form, or turned over drop order, and only one weft is used. The ground pattern repeats on 300 threads exactly; the sett of the ground warp throughout is 96 threads per inch, and the repeat, therefore, measures $3\frac{1}{8}$ in. It would be possible to operate part of the ground warp by shafts, but since the ogee ornament necessitates a jacquard, there would be little gained by adopting a compound arrangement; hence the ground warp would be controlled by 300 hooks. The white satin stripe threads in the centre change the order of weaving to $\frac{1}{1}$ plain at those places where the coloured extra warp threads appear on the surface; this decrease in the length of float of the white threads enables the main figure to be developed more distinctly by the coloured threads. Each vertical line of extra warp spots consists of 80 threads—that is, 160 threads per repeat of the pattern. The order of warping is

1 thread figure { where green figuring threads only appear near the edges of
2 threads ground { the figure;

1 thread figure { where two colours of figuring threads appear in the same
1 thread ground { line.

As will be observed from the back view in Fig. 20, the extra warp threads have been stitched or bound by the weft wherever possible—especially is this noticeable in the satin stripes—but near the tips of the leaves the extra warp has been permitted to float loosely between successive spots. There are approximately 56 picks per inch, and the pattern is complete on 144 picks, or $2\frac{1}{4}$ in.

Altogether 300 + 160, or 460 hooks, are required to control the warp threads; if only one jacquard machine were to be used it would be of that capacity, or, say, a 500's jacquard. The jacquard and harness would probably be mounted on the London or quarter-turn principle, and the first 300 hooks tied up as a simple repeating tie, with a sufficient number of repeats to make up the width desired. The comberboard would be divided into two horizontal sections of 10 rows each—the front section being utilised for the ground harness and warp, and the back section for the extra figuring warp, or vice versa, as is found to be most convenient. If, however, only one jacquard is used as indicated above, both ground design and extra warp figure would require to be painted on the separate parts of the design-paper, corresponding exactly with the positions of the needles of the jacquard which are to be so employed. This would be necessary in order that the whole card might be cut in one continuous operation. And

further, only one ground effect—that one designed—could be used with a given figure, since both would be cut on the same set of cards.

Another, and perhaps a preferable, method of harness mounting would be to employ two 8-row-jacquards, one, say, of 300 hooks, to control the ground warp threads, and the other, of 200 hooks, to operate the extra figuring-warp threads. Both machines would be mounted side by side on the London principle as mentioned above for the single machine of 500 hooks, and the comberboard would also be similarly divided into two longitudinal sections, but of 8 rows each instead of 10 rows each, for the ground and figuring warps respectively. Since two jacquards are to be employed, it is necessary to use two sets of cards, but both sets may be cut from the same sheet of design-paper if desired, although many designers prefer to make two separate designs, especially where the two designs are for machines of different capacities. If the former method is adopted, the ground pattern only is painted, and the card-cutter cuts the cards for the ground. After these cards have been cut, the extra warp figure is superimposed in its correct position on the ground design, and a separate set of cards are cut for this portion. Each set of cards must, of course, contain the same number of cards, or else be a measure or a multiple of the other set, and naturally they must move in unison card by card. To ensure simultaneous and accurate movements, it is usual to couple up the cylinders of the two machines (this is done in different ways) so that both cylinders cannot fail to turn as one. With this method of mounting, either the ground pattern or the extra warp-figuring design may be changed or modified without necessarily involving the recutting of the other set of cards.

When extra warp figures, such as that illustrated in Figs. 19 and 20, are produced by means of the London tie, in which the front comberboard, say, is utilised for the foundation threads and the back comberboard for the extra figuring threads, the number of holes per inch in the two boards may be the same, although the requirements in the two sections of the cloth may vary. The number of holes per inch in the comberboard for the foundation cloth if all the holes are occupied, would correspond to the number of ground threads per inch, and if in the extra warp sections the threads were arranged

1 thread foundation,
1 thread extra warp,

the pitch of the back comberboard should be as fine as that of the front one. All the holes in the front comberboard would be filled and the harness cords in work, but those in work in the back comberboard would correspond only to the width of the longitudinal extra warp stripes in the cloth, although every hole may be provided with a harness cord. This arrangement permits of any width of stripe, and at any place in the width of the fabric, being

made; any change in width or position would obviously necessitate the re-drawing in of the whole or part of the warp threads through the mails of the back or figuring comber-board.

The design-paper required would depend upon the ratio of the threads per inch to picks per inch, but the vertical ruling would be fixed according to the number of needles per short row in the machines.

Centre-ties.—As already mentioned, the centre- or pointed-tie is used for symmetrical patterns, although many symmetrical patterns are woven by the straight-through tie arrangement.

The advantage which obtains in regard to the use of the centre-tie is that a much smaller number of needles and hooks



FIG. 21.

are required; indeed, approximately one-half of the number required for the production of the same design by the straight-through tie.

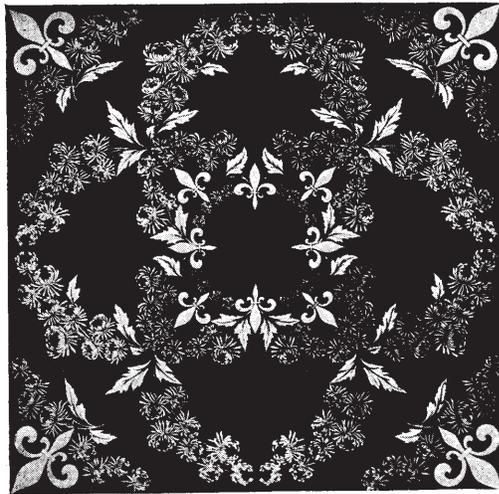


FIG. 22.

Consider Fig. 21, which is a practical sketch for a figured fabric. With various degrees of modification, this sketch might be utilised for the production of designs which differ slightly in general form, but, of course, developed by the same types of ornament. There is one outstanding design, however, for which the sketch is

suitable, and for which it is actually intended. That design is the one

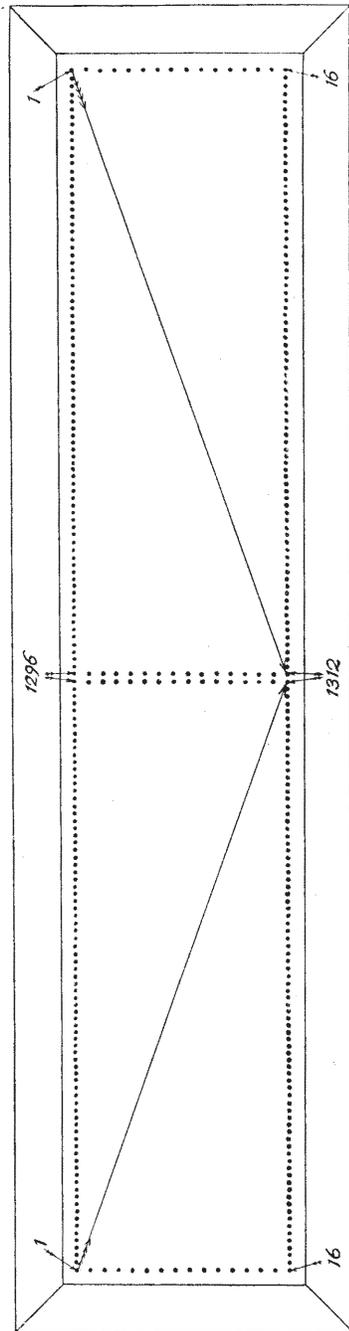


FIG. 23.

exhibited in Fig. 22, which illustrates a complete pattern.

A line drawn down the centre of Fig. 22 would yield two halves, each of which is the mirror image of the other. A horizontal line drawn through the centre would also divide the design into two halves, which are almost the mirror image of each other. The bottom left-hand quarter is identical with Fig. 21, and the design could be made, if desired, perfectly symmetrical about the above two lines.

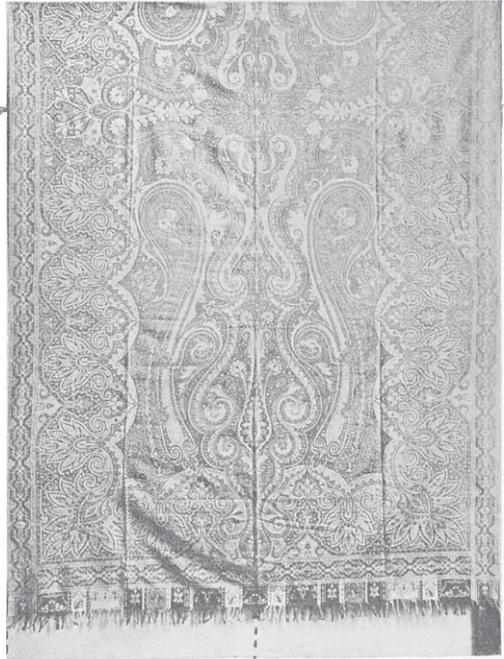
If a $27\frac{1}{2}$ -inch fabric were required with 96 threads per inch, and ornamented as shown in Fig. 22, it is clear that a total of $27\frac{1}{2} \times 96$ or 2640 threads would be necessary. On the straight tie-up principle, and with the full-harness method of weaving, it would be essential to employ jacquard machines with a total capacity of 2640 needles and 2640 hooks. But if the centre-tie principle be adopted, one machine with 1320 needles and 1320 hooks would be sufficient for the purpose.

Machines of such a high number of needles and hooks have 16 needles and 16 hooks per short row, and the centre-tie for such a machine is represented in the simplest manner in Fig. 23, utilising only 1312 needles, or 82 full rows of 16. These 1320-needle machines have actually a number of broken rows (see the card in Fig. 105, p. 135).

The first hook in the machine controls the first thread in the back row of the comberboard, as well as the last thread in the back row, while the last hook (1312) of the jacquard is shown

as controlling two threads in the middle of the front row of the comber-board. Although two holes are shown, it is usual to have only one cord and one thread in the middle, for if two were used as indicated, there would be a "flat" (two threads working as one) in the middle of the cloth.

The magnificent example illustrated in Fig. 24 could be, and probably was, woven on the centre-tie principle. The reproduction represents little more than one-half of a Paisley plaid in the possession of the author; the middle of the plaid is indicated by the two small arrows near the top of the illustration. The design abounds in detail which can only be seen in the photograph by the aid of a lens. There are eight different colours (black, white, green, yellow, blue, heliotrope, red and dark red) in the fabric beautifully blended, and the whole forms a type of texture which the Paisley designers and weavers of old have made world-famous.



Immediately above the fringe, near the bottom of the plaid, is a series of figures enclosed in different-sized rectangles. Near the top of the second rectangle from the left selvage are the letters JC, which might represent

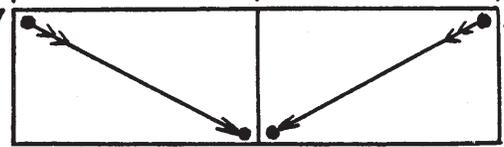


FIG. 24.

the initials of the designer; while near the top of the second rectangle from the right selvage the two letters are reversed and appear thus—CJ. This feature alone is practically sufficient to confirm the statement that the harness would be centre-tied and, as indicated in Fig. 24, immediately below the illustration of the plaid. In passing, it might be stated that whereas a Paisley shawl is usually 2 yards by 2 yards, a Paisley plaid is usually 2 yards by 2 yards. There are therefore more than 4 square yards

illustrated in Fig. 24 ; hence the impossibility of seeing the very fine detail. The designs illustrated in Figs. 22 and 24 are extensive ones, and each is complete as demonstrated by one straight or single part up to the middle of the fabric, and then a similar but reversed half. As a matter of fact, the two designs mentioned are neither intended nor suitable for repetition. On the other hand, there are several designs of the centre-tied type in which there is a plurality of complete ornaments between the selvages.

Fig. 25 is a photographic reproduction of a reversible double cloth in which the figure, a comparatively simple one, appears as a coarse plain jute cloth upon a finer striped plain cotton cloth. There are two repeats illustrated, but any number of units could be utilised in the loom to make up the desired width of fabric. The cloth was actually woven in a 400's full-harness jacquard, although the design is complete on 200 threads. The fabric could therefore have been woven in a 200's jacquard, with the harness tied up on the repeating-tie principle, and as illustrated by the comberboard immediately above the cloth in Fig. 25. With a very slight modification in the weaves on the point-paper design the working design could have been made symmetrical, like the ornament, and hence the cloth could have been produced by a centre-tie on 100 hooks, as demonstrated by the comberboard diagram below the fabric.

When the designs are more or less extensive, as in Figs. 22 and 24, or even such as the one for Fig. 25, it is a distinct advantage from the economic side to use the centre-tie ; but in several cases there is a defective part in that longitudinal area bordering on the centre line. The employment of certain weaves—*e.g.* that in Fig. 25—does not introduce a defect, but these cases are more the exceptions than the rule. In other instances means can be taken to minimise the fault. We shall refer to this shortly. In spite of the defects, the centre- or pointed-tie is usually employed in whole or in part, where the ornament is similar in disposition to that in Figs. 22, 24, and 25.

The true centre-tie, as exemplified in Fig. 23, is not always used for the type of design shown in Fig. 22, because such designs, as well as others of a modified form, can be produced more economically by means of one standard type of tie-up or mounting. Thus the reproduction of the damask napkin or serviette in Fig. 26 shows clearly that the design is perfectly symmetrical, and could therefore be reproduced in a loom provided with the true centre-tie harness shown in Fig. 23 by choosing a sett or width of cloth to suit.

The fabric illustrated in Fig. 26 is typical in structure to those which are usually woven by means of jacquards of the self-twill type—that is, twilling jacquards or Bessbrook jacquards—in which each needle of the jacquard controls two or more of the hooks or uprights. Since the warp threads are lifted in pairs (if there are two hooks per needle) it follows that

the contour of the ornament must be a little more rugged than if the cloth



FIG. 25.

were woven by means of a full-harness jacquard. If the latter were employed for the sake of obtaining the best possible outline, a much larger

weight of cards would be required, unless some type of fine-pitch machine were used (see Figs. 99 to 107, for relative pitches of machines). In some of the twilling jacquards there are 3 or 4 hooks per needle, and 3 or 4 picks per card. But when each needle controls so many hooks, and each card serves for so many picks, the cloths have a considerable number of threads and picks per inch, and the defect in the outline of the pattern is



FIG. 26.

not very noticeable; indeed, it diminishes as the sett of the cloth increases.

The cloth represented by Fig. 26 is approximately 24 in. wide and contains in all 1920 figuring threads. If the harness were of the straight-through tie kind, and there were two hooks per needle, the arrangement would be equivalent to

$$1920 \text{ threads} \div 2 \text{ hooks per needle} = 960 \text{ needles.}$$

Again, if the harness had been true centre-tied—*i.e.* typical of that in Fig. 23, then the number of needles required would have been

$$960 \div 2 = 480 \text{ needles for centre-tie.}$$

In practice, a twilling jacquard of 600 needles, with 2 hooks per needle, was used—that is, 1200 hooks in all—but the harness was not tied up on the centre-tie principle, but on one variety of a mixed tie.

CHAPTER III

THE JACQUARD HARNESS : MIXED OR COMPOUND TIES

Mixed or Compound Ties.—Although the pattern in Fig. 26 could have been woven by means of a true centre-tie harness, it was, as stated, actually produced in a loom mounted with a mixed or compound tie. A tie of this type is a combination of a straight-through tie and a centre-tie; the two inner threads of the centre-tie are sufficiently far apart in the comberboard to admit of the whole of the straight-through tie being placed between them.

Fig. 27 is a diagrammatic view of the actual comberboard arrangement which obtained in the loom in which the fabric illustrated in Fig. 26 was woven. The two outer quadrilaterals represent the centre-tied part, while the smaller or middle quadrilateral is the straight-through part; they are placed obliquely for the sake of clearness. As indicated above the diagram, the terms "centre-tie" and "straight-through tie" are often distinguished by the terms "double" and "single." The holes in the boards are marked in four different ways, as shown by the particulars below the board.

The photographic reproduction in Fig. 28 is that of another cloth which was woven in the same loom as the cloth in Fig. 26, and also by means of the same tie-up as that represented in Fig. 27. It will be observed that, with the exception of a very narrow strip in the central part of Fig. 28, the pattern is symmetrical. Nevertheless, the narrow strip referred to makes it impossible to weave a cloth with this pattern by means of a true centre-tie. The narrow strip necessitates a corresponding width of single tie, but not necessarily as wide as the central part in Fig. 27.

The pattern in Fig. 28 is, as stated above, almost perfectly symmetrical in design, measures just under 24 in. in width, and contains 1920 warp threads. Additional threads are added near each selvage, which brings up the total width to 26 in. To weave the above cloth, as well as that in Fig. 26, both of which were woven in the Textile Department of the Dundee Technical College and School of Art, a 600's-needle jacquard of the self-twilling type was employed, in which each needle controlled two hooks. A figuring capacity of 1200 hooks was thus provided, but, since each needle

controlled two hooks, and therefore two contiguous threads of the warp, the outline of the figure must necessarily move in steps of two threads, although both threads are represented as one thread on the design-paper.

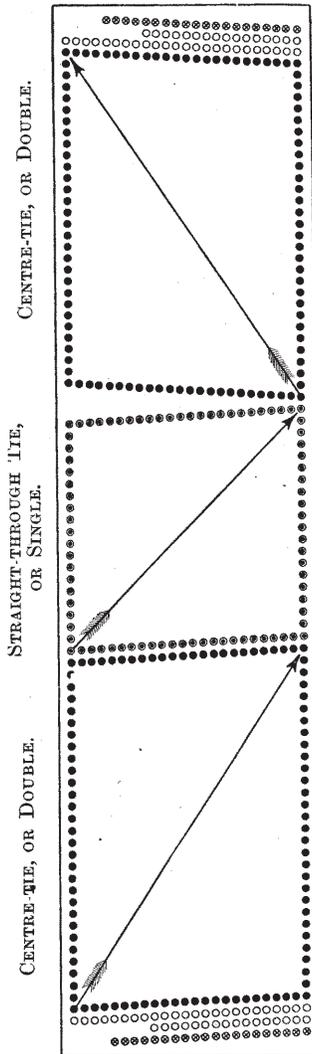


FIG. 27.

- 4 threads plain weave, and 16 threads $\frac{2}{2}$ twill at each selvage operated by a small dobby at the side of the jacquard.
- 40 threads 8 leaf sateen twill near each selvage operated by needles 1 to 12 and hooks 1 to 24.
- 1440 threads for left hand and right-hand borders, and operated by needles 13 to 372 and hooks 25 to 744.
- 480 threads for centre or straight portion, and operated by needles 373 to 612 and hooks 745 to 1224.

Similarly, the pattern must move in steps of two picks of weft since each card was presented to the needles for two successive picks. In addition to these unavoidable defects in twilling jacquards, which, however, are not very pronounced in this fine sett, it may perhaps be observed from the reproduction that the threads on one side of vertical straight lines are more

or less imperfectly bound, and have a tendency to move away slightly from their proper positions in the cloth.

The harness mounting employed to weave the cloths in Figs. 26 and 28 was of the part-centred and part-straight-through single-tie order, as demonstrated in Fig. 27. Of the whole 1200 hooks, the first 720 were tied-up centred, doubled, or turned over to produce the outside or side border

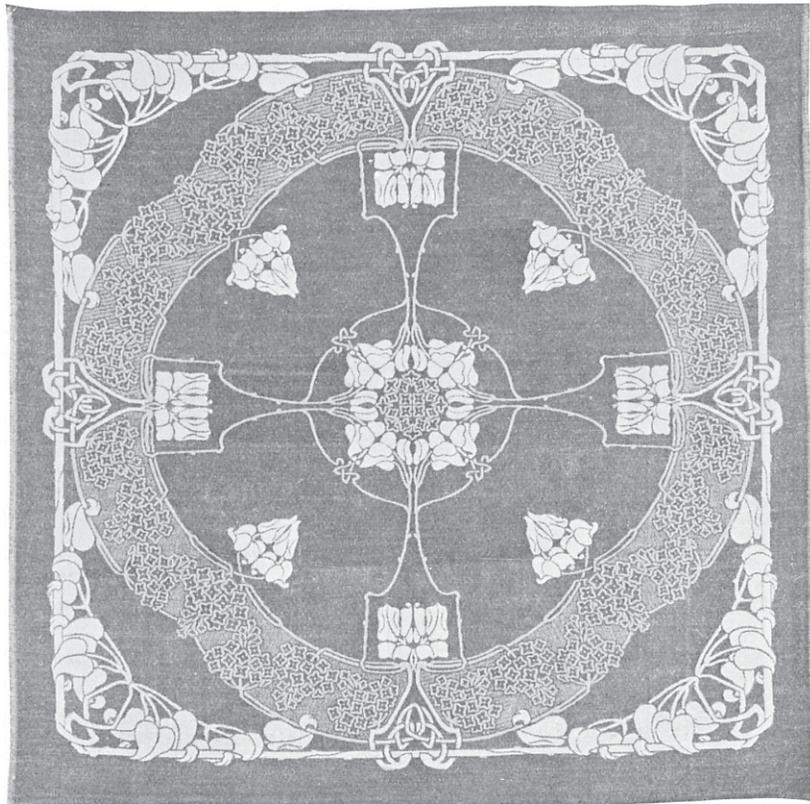


FIG. 28.

portions, and the remaining 480 hooks tied-up all single, or with only one harness cord each for the central portion of the design. Since this jacquard (the back one in Fig. 10) has 24 hooks per short row from back to front, 30 short rows would be required for the turned-over portion and 20 rows for the single part, leaving one row of 24 hooks for side satins, etc. The comberboard or harness reed would necessarily have 24 holes in one row from back to front, as shown in Fig. 27, the succeeding rows being spaced

to give the required number of threads per inch in the reed. The different marks in Fig. 27 show where the various portions of the tie-up start and finish. The arrow in the right-hand quadrilateral points in the opposite way to that in Figs. 23 and 24, but in both cases the inference is that the draft is from front to back so far as the numerical order of the threads is concerned.

From a study of the design reproduced in Fig. 28, and as already stated, it will be evident that only a very small portion in the centre of the cloth is of an unsymmetrical nature, and therefore very few hooks and needles would have sufficed for its production—considerably less than the 480 hooks and 240 needles which were actually used in this case. While this is quite true, it must also be understood that if the jacquard had been mounted straight in the central part with only that number of hooks which the unsymmetrical part of Fig. 28 demanded, the central portion of all other designs for the same loom would have been limited as a maximum to the same number. By tying up the harness as indicated in Fig. 27, the jacquard is capable of producing any design of the general style shown in Fig. 28, from those which are perfectly symmetrical as exemplified in Fig. 26, to those in which the central non-repeating or single part, Fig. 27, occupies 480 threads. In the sett under notice this would mean that a central pattern of any type of ornament could occupy practically 6 in. in width.

$$480 \text{ threads} \div 81 \text{ threads per inch} = 5\frac{2}{7} \text{ in.}$$

To arrange a harness tie of a similar scope on the full-harness system would require at least $720 + 480$, or 1200 hooks. With the standard British pitch, two 600's jacquards would be necessary, but one Continental jacquard of 1320 hooks capacity would be more than sufficient, and would be much more economical than the two 600's machines in regard to cards, although not so economical in this respect as one 600's self-twiller or common harness jacquard. The designing of the pattern for the latter machine would also be much simpler, and the cost much less than that for either of the other methods, although the resulting fabric and the outline of the figure are inferior to those which result from using the full-harness system.

Continental 1320's jacquards are usually composed of three sections of 440 hooks each; the whole machine contains 28 rows, each complete row consisting of 16 hooks. The first two rows and the last two rows of each section contain, however, only 14 hooks each, thus reducing what would otherwise be a 1344's jacquard to a 1320's. The omission of these four hooks at the beginning and at the end of each section takes place in the centre of the rows—*i.e.* the 8th and 9th hooks and needles—and it is essential that this should be the place, because the card cylinder and the

cards are designed with the pegs and peg-holes respectively in these positions. Each section of the jacquard cylinder is thus complete in itself, since it is provided with its own pegs, but the cylinder is all in one piece, and the corresponding card, although made up of three sections, is also in one piece. The very fact that rows of hooks, and therefore of needles, are incomplete at intermediate points, has a tendency to make designing and card-cutting difficult if these broken rows are included in the harness tie. The simplest method of overcoming the difficulty is to use 8-row paper, since there are 16 needles and hooks per row; and, since there are 4 successive rows of 14 hooks each—two rows at the end of one section and two rows at the beginning of the next section, or 56 hooks and needles in all—7 blocks of eight are used by the designer, and then ruled into 8 blocks of seven for the card-cutter.

In mounting such a machine, however, it is quite good policy to leave the first two and the last two incomplete rows for weaving selvages, satins, and such-like parts of the cloth, which are independent of the pattern proper, and to mount the harness with the remaining 1264 hooks. 1320 hooks – 56 for selvages, etc. = 1264 for the development of the ornament. When dividing this total number of hooks into two sections in the approximate proportions of 3 and 2 for the double or turned-over mounting and the single mounting respectively, it must be remembered that these sections must each be a multiple of the twill to be employed—the 8-thread twill in this case—and also that each section should, if possible, be complete on full rows of the jacquard. The former condition is essential for the correct repetition of the ground weave, while the latter minimises any tendency to error on the part of the harness tier or of the weaver. Both conditions are fulfilled if we select 760 hooks for the double mounting and 504 hooks for the single mounting. The machine would therefore be arranged as follows:

2 rows side satins, selvages, etc.	$2 \times 14 = 28$	=	28	hooks
48 „ double mounting	$\left. \begin{array}{l} 24 \times 16 = 384 \\ 4 \times 14 = 56 \\ 20 \times 16 = 320 \end{array} \right\}$		= 760	„
32 „ single mounting	$\left. \begin{array}{l} 4 \times 16 = 64 \\ 4 \times 14 = 56 \\ 24 \times 16 = 384 \end{array} \right\}$		= 504	„
2 „ side satins, selvages, etc.	$2 \times 14 = 28$	=	28	„
			<hr style="width: 50%; margin: 0 auto;"/>	
			1320	„

The ornamental part of the fabric is thus developed by

760 hooks double mounting, <i>i.e.</i> 2 cords per hook	= 1520 threads
504 „ single „ <i>i.e.</i> 1 cord „	= 504 „
<hr style="width: 50%; margin: 0 auto;"/>	<hr style="width: 50%; margin: 0 auto;"/>
1264 „	2024 „

Hence

$$\frac{2024 \text{ threads}}{81 \text{ threads per inch}} = \text{approximately } 25 \text{ in. of cloth in all for the figured portion,}$$

while for the development of the unsymmetrical part of the figure, or rather for that part allotted to the single tie, there are 504 threads, and therefore

$$\frac{504 \text{ threads}}{81 \text{ threads per inch}} = 6\frac{2}{3} \text{ in. of cloth.}$$

The side satins, selvages, etc., for which 56 hooks have been allotted, would be practically identical with those in Fig. 27, except that the threads for these parts, as well as for all the others, would be in a comberboard arranged for 16 per short row instead of 24. The arrangement of the double and single portions would also be similar, although differing slightly in numbers.

The diagrammatic view of the comberboard above the design in Fig. 29, which is a different kind of design from the above, but arranged for the same kind of tie and the same numbers in each part, shows that the board would be divided into 8 sections : 3 sections at each side for the double part, and marked A, B, and C, and 2 sections in the middle for the single part, and marked D and E.

With a fixed number of threads per inch, the maximum width of cloth is obtained when the minimum number of hooks is used for the single part, and the maximum limit is therefore reached when the true centre-tie is employed, that is, when there is only one hook in the machine operating a single harness cord, the rest, of course, operating two harness cords each. The minimum width of cloth results when the design is produced by means of the straight-through tie. Any width of cloth between these two extremes can be obtained with designs such as that in Fig. 26.

The harness tie above the design in Fig. 29 is for a cloth which is neither a maximum nor a minimum in width. The tie and the preceding particulars show clearly that there are 504 hooks set apart for the single, while the harness tie below the design indicates that there are one-half of the total number of hooks in the jacquard allotted for the single. The adoption of the lower harness tie would therefore result in a narrower fabric than obtains with the upper harness tie. Indeed, the arrangement would be as under :

[TABLE

E

2 rows side satins, selvages, etc.	•	$2 \times 14 = 28 = 28$	hooks
40 rows double mounting	. . .	$\left. \begin{array}{l} 24 \times 16 = 384 \\ 4 \times 14 = 56 \\ 12 \times 16 = 192 \end{array} \right\} = 632$,,
40 ,, single mounting	. . .	$\left. \begin{array}{l} 12 \times 16 = 192 \\ 4 \times 14 = 56 \\ 24 \times 16 = 384 \end{array} \right\} = 632$,,
2 ,, side satins, selvages, etc.	.	$2 \times 14 = 28 = 28$,,
			1320

Then

632 hooks double mounting, <i>i.e.</i> 2 cords per hook	= 1264 threads
632 ,, single ,, <i>i.e.</i> 1 cord	= 632 ,,
1264	1896

as compared with 2024 figuring threads required by the upper tie in Fig. 29. $2024 - 1896 = 128$ threads, or approximately $1\frac{1}{2}$ in. narrower cloth resulting from the lower tie as compared with the upper tie in the same figure. The same width, 25 in., could of course be obtained by using a lower sett of cloth for the lower tie.

The design in Fig. 30 is identical in ornament with that in Fig. 29, but black areas in one are represented by white areas in the other and *vice versa*. The harness tie below the design in Fig. 30 illustrates the minimum number of hooks and needles, and, of course, the maximum width of fabric which can be obtained in any given sett. The single part is the figure enclosed between the two vertical lines which pass through the design, and from it to the lower comberboard to denote the relative width B on the latter. The relative widths of the double part A and the single part B are 62 to 24; hence

$$1264 \text{ hooks} \times \frac{62}{86} = \text{approximately } 912 \text{ hooks for the double part A, and}$$

$$1264 \text{ hooks} \times \frac{24}{86} = \text{approximately } 352 \text{ hooks for the single part B.}$$

Altogether $912 + 352 = 1264$ hooks as before.

Therefore, we have

57 rows $\times 16 = 912$ double $\times 2$ cords per hook	= 1824 threads
22 ,, $\times 16 = 352$ single $\times 1$ cord	,, ,, = 352 ,,
,, 1264 hooks	2176 ,,

In the three tie-ups already considered with respect to Figs. 29 and 30, we have assumed a 1320's jacquard of a fine pitch. Suppose, however, it were desired to make a fabric of the same width, but with a large number of threads per inch, say one that required 1800 hooks. Two fine-pitch

machines would, of course, be ample, but for a change we shall assume that the British pitch is used. Here again, two 900's jacquards would be sufficient, but instead of using these large British-pitch machines we shall utilise three ordinary 600's machines.

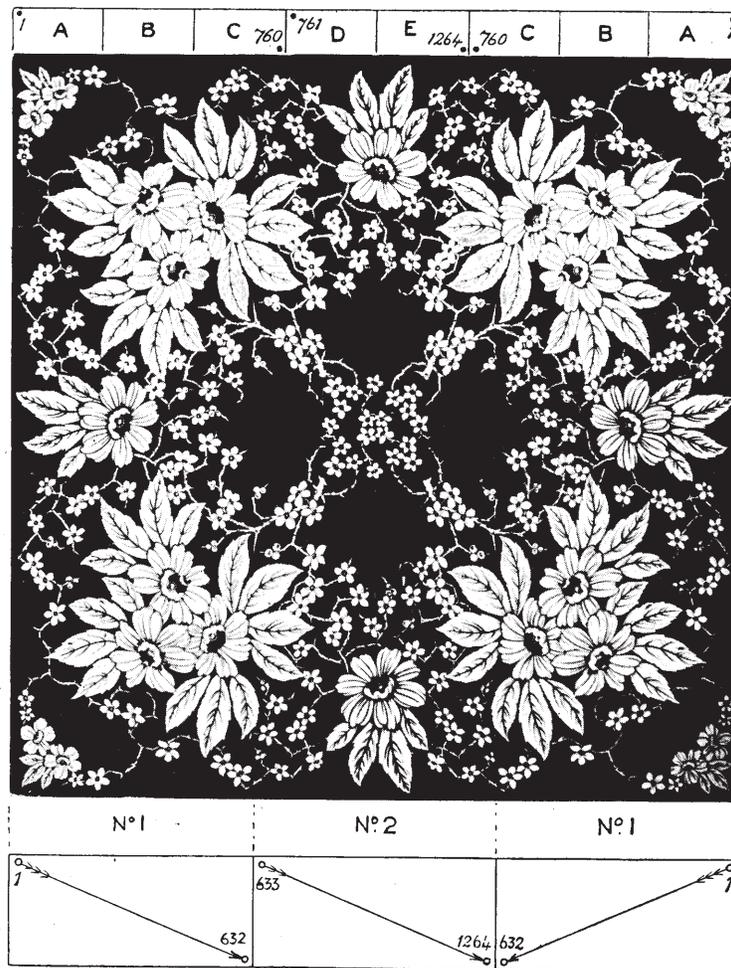


FIG. 29.

Three 600's British-pitch machines take up a considerable width on the loom gantry or rails, and it is desirable that the harness cords should make as big an inside angle as possible with respect to the comberboard. Hence, it is a common practice to arrange the three machines as indicated above the design in Fig. 30. No. 1 machine controls the harness cords and threads

on the outsides, *i.e.* towards the two selvages of the cloth. If this machine were placed on the extreme left, instead of as indicated, a very small angle would be made on one side of the loom between the harness cords and the comberboard. In the upper diagram in Fig. 30 it will be seen that the

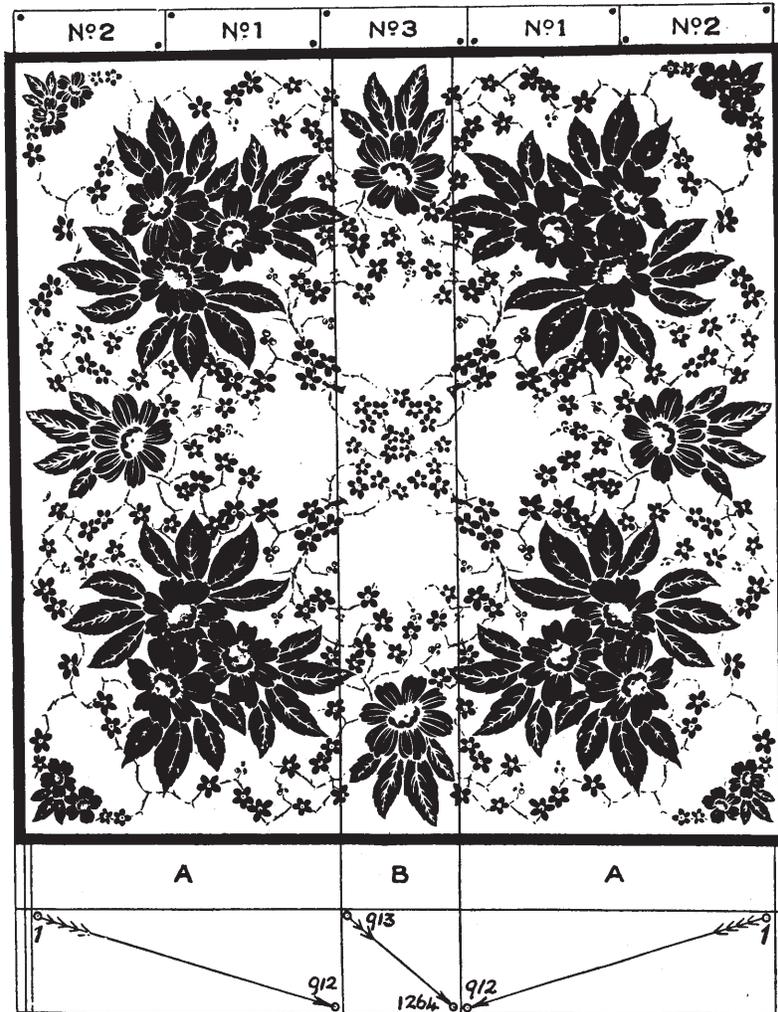


FIG 30.

third machine is utilised for the single, and that this single part is greater than the minimum. If the cloth is exceedingly wide, it is often desirable to introduce an extra 600's jacquard, or four machines in all, so that the disposition of the four jacquards would be as represented in Fig. 31. Indeed,

in order to make a perfect design of certain types on the fabric, it would be essential, as will be demonstrated shortly, to adopt the method illustrated in Fig. 31. In such cases, Nos. 1 and 4 appear on the outsides because each machine controls only those harness cords and threads near the selvage at the same end of the loom as the jacquard is situated.

Bordered designs of the type illustrated in Figs. 22, 24, 26, 28, 29, and 30 are certainly elaborate, but whatever system of weaving is adopted, the particular type of harness mounting which is necessary for their reproduction in cloth is comparatively simple. And, although the expense in designing, cards, and card-cutting for such fabrics is considerable in connection with common harness weaving by twilling jacquard looms, it is very much more increased, as shown on p. 67, when the fabrics are produced by the full-harness or brocade method of weaving. Consequently, the above-mentioned patterns, especially when applied to wide cloths, are developed by specialised forms of weaving, such as the self-twilling jacquard in the fine linen damask industry, the compound jacquard and multiple movable comberboards in the Scotch carpet industry, the similar combination in the quilt industry, and other combinations for somewhat similar fabrics, for

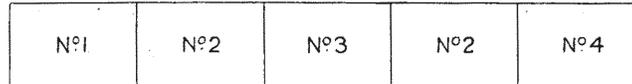


FIG. 31.

which the cost of designing and card-cutting and the number of cards required are reduced to a minimum. For such work it is not uncommon to find extensive patterns of the type indicated made in several different widths.

On the other hand, the greatest economy prevails when the width of the cloth in bordered fabrics is obtained by repetition of one or more parts of the ornament, chiefly the filling or field of the cloth. Perhaps the commonest form in this respect is where a comparatively bold border, centre-tied, is accompanied by some simple ornament in the field or filling of which several repeats are introduced usually on the repeating-tie principle, but occasionally on the centre-tied principle.

Consider, for example, the illustration in Fig. 32, the upper part of which represents approximately one-half of a lace curtain. There are different ways of arranging the harness for the production of such a texture, but for the purpose of illustrating the above-mentioned principle in regard to bordered designs, we have introduced a diagram of a comberboard arrangement below the lace design. It is assumed, for demonstration purposes only, that the pattern is to be developed by means of one 600's jacquard; 400 needles and hooks, or two-thirds of the machine, are utilised for the

border or double part, and 200 needles and hooks for the repeating part in the filling or field. Two repeats of the latter are illustrated, but it is evident that if, for any reason, it were required to make a wider curtain with the same 600's jacquard, it could be done by inserting one or more extra units of the filling repeat; all these repeats, however many were introduced, could be controlled by needles and hooks 401 to 600 inclusive.

It is not difficult to see that the harness for the filling or field part of the

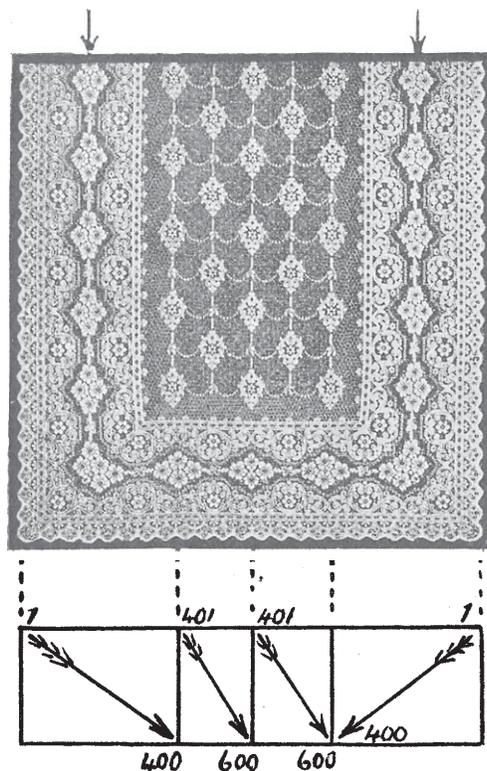


FIG. 32.

illustrated suggests that it has been made in comparatively narrow widths, say 27 in. wide, and then these narrow widths are sewn together. Moreover, the widths are probably equal to the divisions in the upper comberboard diagram, all the sections of which are the same size.

The four sections of cloth indicated, *e.g.* the left-hand border, the two repeats of the field, and the right-hand border, were probably woven at different times with a straight-through tie-up equal in width to any one of the sections. Indeed, if the carpet happened to be a Brussels or Wilton make, the various widths would be woven separately in a loom similar to

the design could be tied up on the centre-tie principle, in which case 100 hooks would be sufficient for that section of the cloth, or 500 hooks in all instead of 600 as illustrated.

At first sight it looks as if an even further reduction could be made, because the greater part of the side border is symmetrical about the vertical division indicated by the short arrows at the top of the design. It will be seen, however, that the corner figure is not symmetrical about the above vertical division, and hence no reduction in the number of needles and hooks can be made in the border.

A photographic reproduction of a carpet is shown in Fig. 33. Such carpets may be made in what are called "squares," that is, woven full width in the loom, but the one



FIG. 33.

that illustrated in Fig. 34. A very interesting feature about this loom is that the original is a perfect model on a small scale of a Brussels or Wilton carpet jacquard, and that all the wood patterns were made, and the loom erected for exhibition by a Dundee carpet weaver named John Grant. The result is a splendid tribute to patience and skill.

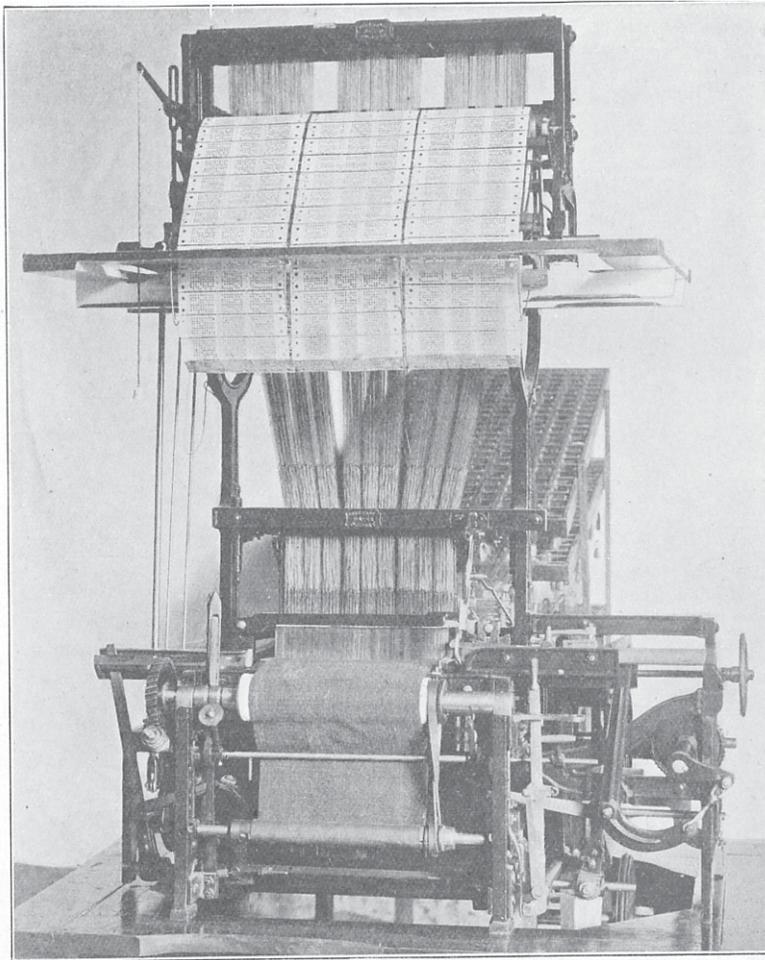


FIG. 34.

The three sets of cards shown near the top of the machine in Fig. 34 are required for one 27-in. width of carpet, say the left-hand border represented by the comberboard above the fabric in Fig. 33. A different group of three sets of cards would be required for the right-hand border; while a further group of three sets of cards would be used for the two central

widths. If a carpet were required for a wider room, one or more extra widths could be woven with the third group of cards, and these extra widths, which would be identical with the two central widths, would be introduced between the two side borders to make up the desired width. The place of introduction of the corner pieces and the cross border would be determined by the length of the carpet. The loom in Fig. 34 will be referred to again in connection with the cutting of cards for such looms.

There is a second comberboard diagram below the main illustration in Fig. 33. If for demonstration purposes we suppose that the design is to be developed for a brocade or ordinary full-harness loom we can utilise any kind of tie-up. It will be noticed from the lower comberboard diagram that the pattern or design lends itself to a great reduction in the number of needles and hooks as compared with the straight-through method of mounting; indeed, the diagram shows that there may be three distinct sections arranged with centre-ties. It might not be advisable, however, to adopt such a method of mounting in practice, for it will be well known that if such a course were followed, all designs woven in that particular loom would require to be similar in symmetry to that illustrated. Nevertheless, with the tie-up illustrated, and with a 1200's jacquard, either of the two following arrangements could be used:

	Part A.	Part B.	Part C.	
Arrangement I.	624	384	192	= 1200
Arrangement II.	600	400	200	= 1200

and each part would be centre-tied as indicated in the lower diagram in Fig. 33.

Fig. 35 is an elaborate sketch for a very fine linen damask intended to be woven by three 600's twilling or Bessbrook jacquards, or 1800 hooks in all, each needle to control two hooks. This method of weaving is somewhat similar to that obtaining in "pressure-harness" weaving. Most, although not quite all, of the design which is necessary for transference to design or point-paper is shown in this sketch. The parts were intended to be allocated to the three machines A, B, and C, but in the positions indicated by these letters immediately below the sketch. The two parts B and A are centre-tied or double, but the part C is single. Consequently, there would be five sections in the complete cloth, as well as in the comberboard; the tie-up is really identical with that illustrated in the upper comberboard diagram in Fig. 30. Since there are two hooks per needle in each jacquard, it follows that there would be

600 hooks \times 2 cords \times 5 sections = 6000 figuring threads in the cloth.

The total number of hooks in the three machines is 3600, and these are equivalent to six ordinary 600's jacquards, or nine ordinary 400's

jacquards, or their equivalents, for the full-harness or brocade method of weaving.

The sketch in Fig. 35, besides being marked B, A, and C for the three 600's twilling jacquards and for 3600 warp threads, or three-fifths of the total 6000 figuring threads, is also marked D, E, and F on the left to represent three similar sections in the direction of the weft. If there were no repetitions in the different parts of the working sketch in Fig. 35, nine sheets of 600-by-600 design-paper, or 600 by some other suitable number, would, as will be seen, be necessary for the card-cutter. The corresponding nine squares in Fig. 35 have not been marked by horizontal and vertical lines, but they are represented by the undermentioned combinations of intercepting letters :

BD	}	first three vertical squares controlled by machine B.
BE		
BF		
AD	}	second " " " " A.
AE		
AF		
CD	}	third " " " " C.
CE		
CF		

Fig. 36 represents diagrammatically the above nine squares, as well as the remaining six on the right which would be obtained by the duplication of the harness for the two parts B and A. The ornament in the two sets of vertical squares on the right would, of course, be reversed, as is indicated by the changed effect of the letters. This sketch shows at once the difficulties met with in regard to the introduction of letters and words.

The lower diagram in Fig. 36 represents the plan of the comberboard, the arrow heads being marked in three different ways to distinguish the relation between the three distinct parts.

The three squares in each vertical group in Fig 35 are quite different in regard to the sectional designs which they embrace, but it will be observed that the square in Fig. 35, corresponding to the square marked CD in Fig. 36, is practically identical with that square in Fig. 35 which corresponds to the square denoted by BF in Fig. 36, provided that the square immediately above C in Fig. 35 be turned 90 degrees clockwise and thus placed in the position of that square immediately to the right of F (see also Fig. 36). Then what represents warp in CD may represent weft in BF and *vice versa*, and the altered position of the former square would place it in the correct position for the latter square.

A section of the design in the cross border (say CD in the horizontal direction of the design) controlled by one machine, say C, can be utilised

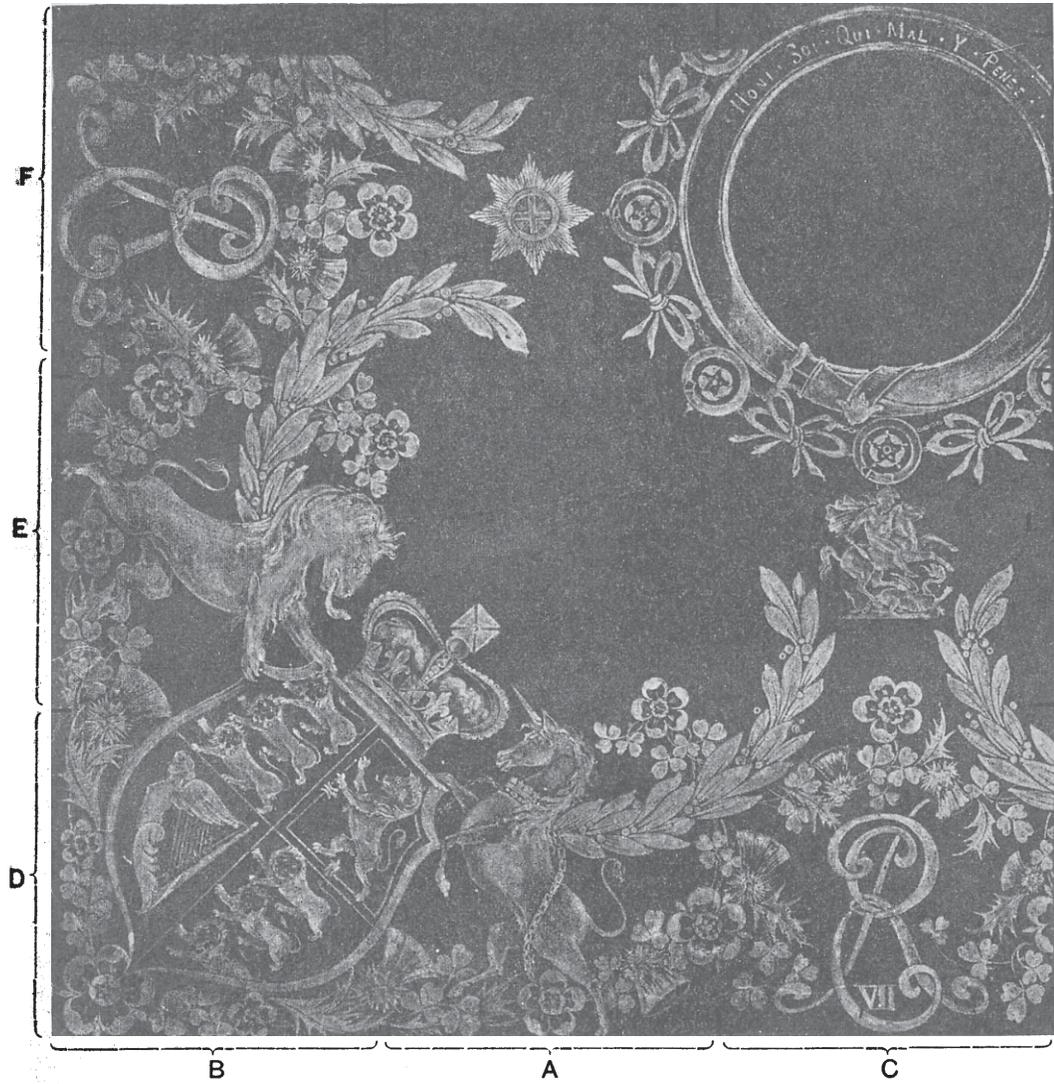


FIG. 35.

To face page 58.

for a section in the side border (say BF in the vertical direction of the design) and controlled by a different machine, say B, when the design-paper is ruled the same in both directions, thus, 12-by-12, 16-by-16, or any other suitable number according to the kind of jacquards which happen to be employed. But if the ruling of the design-paper in the vertical direction differs from the ruling in the horizontal direction, a special sheet of design-paper would have to be prepared for each, although the ornament in the two sections was identical in form, but differing in direction, as is emphasised by the above two squares in Fig. 35, represented in Fig. 36 by the two squares CD and BF. Hence, under the most favourable conditions, the design in Fig. 35 would require eight large sheets of 50-by-50 large blocks in each direction, or 600-by-600 small squares ; while nine similar large sheets of 50-by-50 large blocks would be essential if the ruling of the paper in the two directions were different. The ruling of each large block for a 600's machine may be 12-by-12, 12-by-13, 12-by-14, 12-by-15, 12-by-16, or 12-by-18, depending upon the excess of weft required over the amount of warp. When any of these conditions, other than the 12-by-12, obtain, the cloth is said to be overshotted.

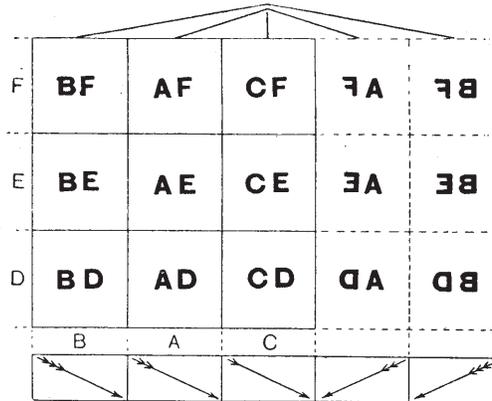


FIG. 36.

When an ornamental sketch, such as that illustrated in Fig. 35, has been prepared as the subject to be reproduced on cloth, it is often desirable, and sometimes necessary, to make alterations in order that the sketch may be more suitable or practicable for reproduction than it was in its original state. Perhaps the chief cause for alteration is that for changing the sketch in detail so that the point-paper design may suit a loom which is already mounted with a particular harness tie. This demand for a change in proportion will be met mostly by commission designers, and not often by those who are in more direct touch with the factory requirements. Again, the reconstruction of certain parts is often suggested and carried out with the object of improving the general effect. This was done with the medalion in section CF, Figs. 35 and 36, as is emphasised by the corresponding portion of the design which occupies the central part of the complete design illustrated in Fig. 37. Thus, while the general treatment of the outer circle

of ribbons, chain, and medals is the same in both cases, the introduction of the visor in the upper part of the ornament with the lower section overlapping the garter made it essential to change the order or position of the words in the motto "Honi soit qui mal y pense" as demonstrated. The central figure of the design will, of course, be recognised as the portrait of the late King Edward VII., and the delineation of the Royal Sovereign, as well as all the ornament which surrounds it, comes out beautifully in the cloth, of which Fig. 37 is a facsimile.

This particular illustration is a reproduction from a fine linen damask tablecloth, and such twilling jacquard designs are almost invariably made with more picks per inch than threads per inch or overshotted, in order to show up the figure. If 12-by-18 paper were used, and two picks per card adopted, it is evident that the cloth would be 50 per cent overshotted. It so happens, however, that the point-paper design for this cloth was made on 12-by-12 paper, and hence to obtain the same relation of picks to threads—*i.e.* 50 per cent more picks per inch than threads per inch—three picks for each card had to be inserted during the process of weaving. The effect on the cloth, as already stated, is splendid, but an even better effect would clearly have resulted if the design had been made on 12-by-18 paper with two picks per card, for then the steps on the contour of the ornament would have been in two of warp and two of weft, whereas the method adopted resulted in steps of two in the warp and three in the weft.

The letters B, A, and C in the first three sections of the design in Fig. 37 correspond to the similar letters in Figs. 35 and 36, while the comberboard or harness reed arrangement in the latter figure, and the forward and reverse positions of the letters, emphasise the similar relations in Fig. 37. It will be noticed, however, that the letters D, E, and F in Figs. 35 and 36, which represent the length of the sheets of design-paper, do not appear in Fig. 37, but that the weft for the complete design in the latter is represented in the vertical direction by the sections G, H, and G. The two sections G show that the design in these parts is the same but oppositely directed, and therefore the cards for the lower section G can be utilised for the upper section G, provided that they are made to rotate in the forward direction for one section and in the backward direction for the other section; on the other hand, there is no repetition of the ornament in the central section marked H. In the actual process of weaving, the cards for section H, those for the upper section G, and those for part or half of the plain or simple twill portion between two successive cloths, would work in the forward direction, and would be reversed to weave the remaining half of the plain part between the cloths and the lower section G. Finally, it would be necessary to turn back the cards by hand, or to reel them back, until those

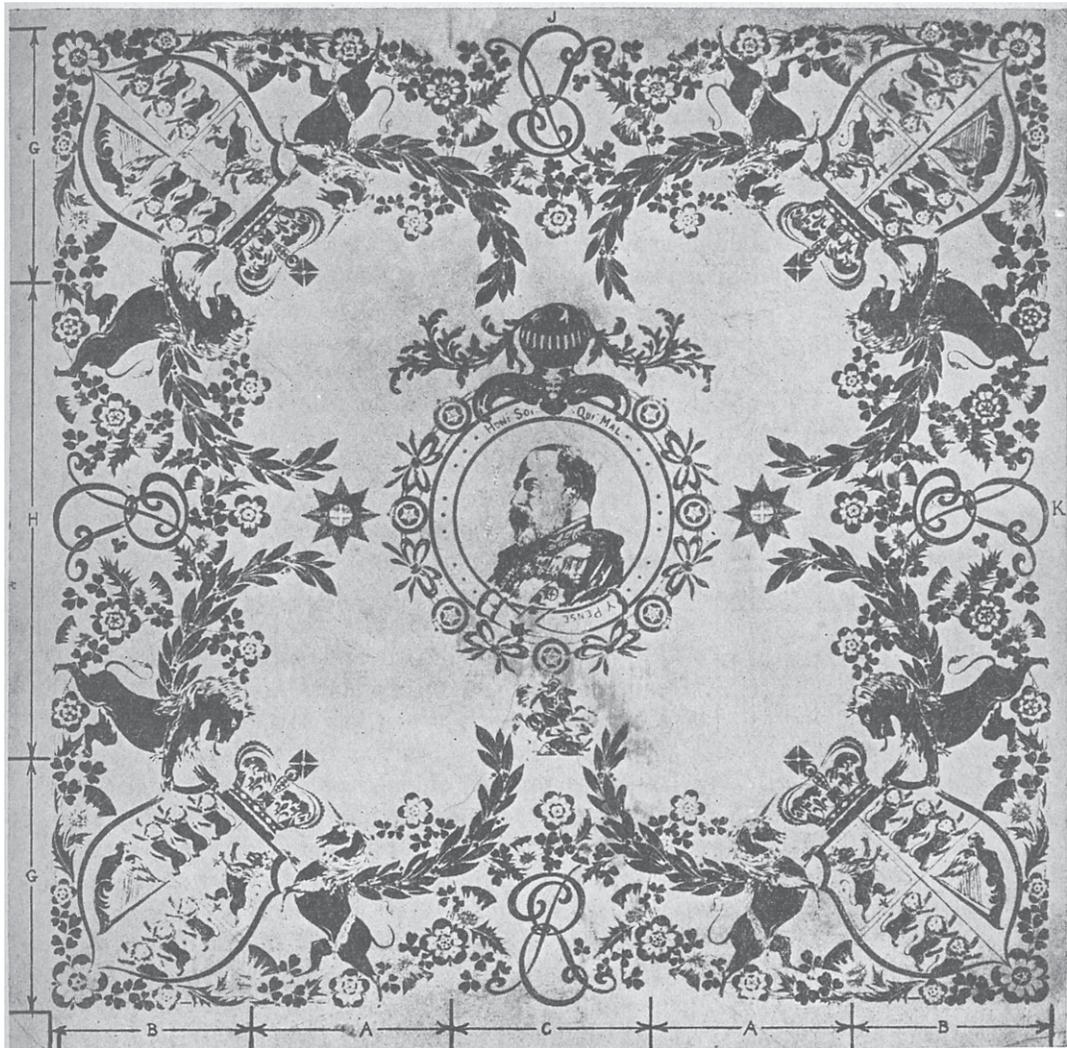


FIG. 37.

To face page 60.

cards for section H are opposite the needles, when the cycle of operations would be repeated.

The diagrammatic view in Fig. 38 will explain this operation. Here two complete cloths and part of a third are exhibited, and the short arrows indicate the centre of the plain or simple twill part which separates successive cloths, and where the fabric would be cut in the finishing department or in the warehouse to detach the individual cloths. Similar letters to those in Figs. 35 to 37 are used, and the two additional letters, L and M, indicate respectively the start and the finish of the cycle in regard to the manipulation of the cards. This particular place L of starting the cycle is advantageous in all weaving operations where cross-borders are necessary, and the method is probably more valuable in connection with the measurement of towels or cloths developed by simple weaves, than with those with artistic elaboration, for since both cross-borders—the finish of one cloth and the commencement of the next—are woven at the beginning of the cycle or measurement, it is evident that, in the case of simple weaves, the cycle may finish exactly when the tape, cord, or chain measurement reaches the point M, and thus all the cloths should be of equal length. The same accuracy could only, if at all, be achieved with great difficulty if the cycle started and finished at the actual beginning and end of each cloth.

We might now with advantage point out one or two objections to the free use of certain types of ornament displayed in Fig. 37, keeping in mind the fact that the objectionable features could be overcome only by a considerable increase in the expense of production, and in this discussion the design in Fig. 37 shall be compared with other designs which are of a pure floral character. Thus, Fig. 39 illustrates the working sketch of a design, while Fig. 40 shows what the design would be like when developed on the cloth; again, Fig. 41 is a similar working sketch to that in Fig. 39, but with a different subject for ornamentation. Both designs could be placed on point-paper for the same harness mounting to three machines as that which was adopted in the loom in which the cloth for Fig. 37 was woven.

The duplication of approximately two-thirds of the working design in Fig. 39 by the harness tie, and by the reversal of about the same proportion of the jacquard cards, introduces neither objectionable features nor faults in the complete design in Fig. 40; and if the working sketch in Fig. 41 were

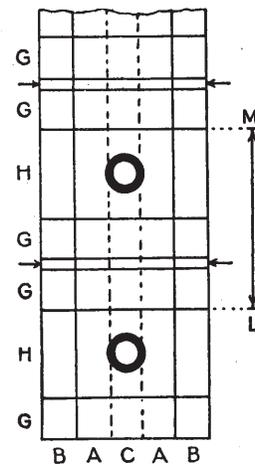


FIG. 38.

completed in a similar way, the result would be just as perfect as that in Fig. 40. This can easily be proved by placing the edge of a mirror along-



FIG. 39.



FIG. 40.

side the right-hand edge of the sketch, and then along the top edge, or



FIG. 41.

by placing a right-angled mirror along the two edges; the latter will show the effect of the double reversal of the harness tie and cards respectively. One cannot say the same for the corresponding treatment of the sketch in Fig. 35, and a close examination of the complete design in Fig. 37 will be sufficient to prove this statement. No faults are observable in Fig. 35; it is only when the duplication in the reverse order by the harness tie and by the cards takes place, as exemplified in Fig. 37, that the defects appear so distinctly.

The most glaring defect in Fig. 37 is the ornament which represents the

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monogram at J and at K ; in both cases the arrangement of the letters E R has been reversed, somewhat as illustrated by similar combinations in Fig. 36 ; the result is, therefore, quite wrong. The combination in the reversed order would have been even worse if the Roman numerals VII., which appear in Fig. 35, had not been omitted in Fig. 37.

Again, while the design of the Royal Arms is correct in two corners of the design, the effect in the other corners is wrong, because the ornament is not symmetrical about a diagonal line from the corner. The reason why the design of the Royal Arms in the upper right-hand corner is correct is because the equivalent of a double mirror image has taken place ; the first mirror image reverses all parts, while the succeeding image of this reversed order yields the original ornament.

It will thus be seen that, when any distinct order of the component parts of an unsymmetrical section of a design has to be maintained, that section should not be operated by centre-tied harness, but should be under the control of what is known technically as "single harness," *e.g.* a part similar to that lettered C in Fig. 37. It will be evident that even in this part it would be necessary to cut a new set of cards for the upper monogram. The only way of securing the correct positions of the letters at K would be by allocating the harness cords for that part of the design to another jacquard machine, as demonstrated in Fig. 31 ; and the same remark applies to the procedure which would be essential to obtain a facsimile of the Royal Arms on the right-hand side. This operation, in turn, would necessitate a new set of cards for the upper right-hand delineation of the Royal Arms, and hence it might be said that such a design as that illustrated in Fig. 37 could be made perfect only by the use of separate needles, hooks, and harness cords for the five sections, and therefore, in the same sett, by the employment of five jacquard machines, and a number of cards which correspond to the length of the design. If this equipment were adopted, the various twills could be inserted and reproduced in the cloth without any change in direction—a condition which is impossible to achieve in connection with the usual centre-tied harness ; but it is obvious that, unless in very rare circumstances, such a procedure would be prohibitive. It will now be clear why the mottoes "Honi soit qui mal y pense" and "Dieu et mon droit" have been omitted from the Royal Arms in the four corners of the design in Fig. 37, and from the sketch in Fig. 35.

As a matter of fact, it is usual to reduce the width of the single tie to a minimum in order that the most may be obtained from a minimum number of needles and hooks of the jacquards. To demonstrate this we shall refer again to Figs. 35 and 37. The motto on the two designs is arranged concentric with the circles of the garter, but if we place the lettering in straight

planes their dispositions are equivalent to the following. In Fig. 35 it appears as

Honi Soit Qui Mal y Pense.

In Fig. 37 it appears in two parts as

Honi Soit Qui Mal
y Pense.

If the only reason for changing the arrangement from that in Fig. 35 to that in Fig. 37 were that of allowing the lower part of the visor in 37 to overlap the garter, it is evident that the part "Honi Soit Qui" in Fig. 35 might have been moved counter-clockwise, and that "Mal y Pense" might have been moved clockwise to create the necessary gap for the bottom part of the visor in the centre, and thus obtain an almost perfect division of the words in the motto. It is equally evident that such an arrangement would have increased the number of needles and hooks which it would be necessary

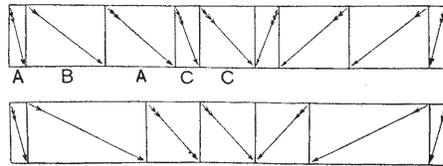


FIG. 42.

to employ in connection with the single tie for the development of this increased width of unsymmetrical ornament. On the other hand, the arrangement adopted in Fig. 37 actually decreases the width represented by the motto in Fig. 35, and

hence decreases the number of needles and hooks for the single tie. Consequently, instead of employing one complete 600's jacquard for the single tie, as demonstrated in Fig. 36, and as suggested by the letters C in Figs. 35 and 37, a much smaller number of needles and hooks were used in practice, and Fig. 42 illustrates the method of achieving the result in Fig. 37 by reducing the single tie to the lowest number of needles and hooks. Indeed, it is quite possible that a harness mounting was already in use on a loom, and that the modification of the sketch was made to suit the existing mounting.

The upper rectangle in Fig. 42 shows the comberboard or harness-reed arrangement for three 600's machines, while the lower rectangle shows the equivalent arrangement for two 900's machines. The letters B, A, and C under the upper comberboard or harness-reed diagram refer again to the parts of the harness controlled by the three different jacquards, while the lower similar diagram shows that one 900's machine takes all B and part of A, while the other 900's machine takes the remainder of A and all C. The narrow strips at the ends of both diagrams indicate the single-weave or "satin" stripes between the tape-edges of the cloth and the beginning and finish (left- and right-hand edges) of the ornament displayed in Fig. 37.