11

Elements of Jacquard Shedding

A jacquard shedding motion is used in weaving designs that are beyond the scope of dobby shedding, i.e. designs which consist of more than about 24 different orders of interlacing. In practice, jacquards are mainly used for large and intricate figured designs with several hundreds, or even several thousands, of ends working in different fashion and repeating upon a similar number of picks. The facility with which the jacquard machine is able to cope with such large arrangements, and the comparatively small size of the machine itself, are the principal features of the system. An additional advantage is the simplicity of the draft of the warp threads and the fact that the draft does not, as a rule, require altering when the design is changed.

Although the principle of jacquard selection remains unchanged many different types can be distinguished and a preliminary division into ordinary and special jacquards is frequently made. Ordinary machines are extremely versatile and can be used to produce figured designs in almost any construction. Special jacquards are built, each, for a specific construction which limits their applicability but which may result in certain advantages within their own field of operation. These special machines include leno brocade, inverted hook, sectional harness, and self-twilling jacquards (among many others), and are described along with the structures of cloths for which they are used in *Watson's Advanced Textile Design*. In addition to this broad division the jacquards may be further classified under the following headings: (1) type of shed formed; (2) pitch; and (3) figuring capacity.

(1) Type of shed formed: (a) single lift—bottom closed shed; (b) centre shed jacquard—centre closed shed; (c) double lift single cylinder and double lift double cylinder—modified open shed; (d) double lift—open shed machine. Shed formation is dependent upon the mechanical action of the jacquard and determines largely the speed at which the machine can be operated. On occasion the shedding system may have a bearing upon the construction and for some structures one particular system may be preferable to others.

(2) Pitch: this refers to the density of setting of the selection elements in the machine which may be set in a variety of pitches broadly distinguished as the 'coarse', and the 'fine' pitch. The pitch determines the actual dimensions of the machine. Any of the jacquards classified

above under 'shed formation' could be set in any pitch, but traditionally certain types are more commonly associated with certain pitch settings than others.

(3) Figuring capacity: or the 'size' of the jacquard refers to the number of different orders of interlacing of which the machine is capable. This is normally given as a number and it may range from 100 (normally only employed in the weaving of trade names in the selvedges) to 1792.

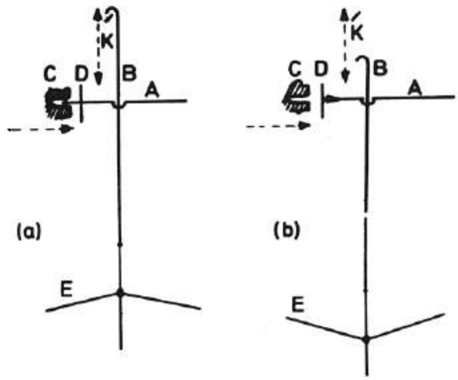
With the exception of the figuring capacity, the variations in the ordinary jacquards do not affect the designer to any extent, but the principle of operation of the various jacquard systems should be understood thoroughly in order to exploit fully their capabilities and to comprehend exactly the meaning of such terms as 'harness ties', 'repeats', 'setts', etc.

ORDINARY JACQUARD MACHINES

Principle of operation

The design is transferred from squared paper to pattern cards in the form of holes and blanks. In ordinary jacquards a hole indicates a lift of an end and is, therefore, analogous with a mark on design paper (using the normal convention); and, by converse, a blank indicates a fall of an end into the bottom shed line and is equivalent to a blank in design paper: One card controls the selection of all the ends in the cloth for one pick. *Figure 11.1* shows the principle of operation involved. At (a) needle A is shown opposed by a hole in the card D. As the cylinder C moves in, presenting the card to the needle, the needle encountering the perforation in the card enters the

Figure 11.1



corresponding hole in the cylinder and no action takes place. This allows hook B, connected to the needle, to remain over knife K which in its upward movement takes the hook with it, thus lifting end E into the top shed line. At (b) the needle is opposed by a blank in the pattern card. As the cylinder C moves in again the blank forces the needle back and this in turn presses the hook clear of the knife just prior to the commencement of its upward movement. The knife moves up but the hook which has been pressed clear remains down and, therefore, the end controlled by this hook also stays down in the bottom shed line.

The single lift jacquard

This is the simplest type of jacquard which serves admirably to show the general arrangement of parts and to indicate the role of the selection device in achieving the control over the operation of the warp threads. The principle of selection is the same as described above and, therefore, is not repeated. The diagram in *Figure 11.2* shows the layout and the connections between the machine and the harness in a simplified, schematic manner. The horizontal needles A are each connected to a vertical hook B by forming a loop or a half-bend round the latter, and are supported by a needle-board I, through

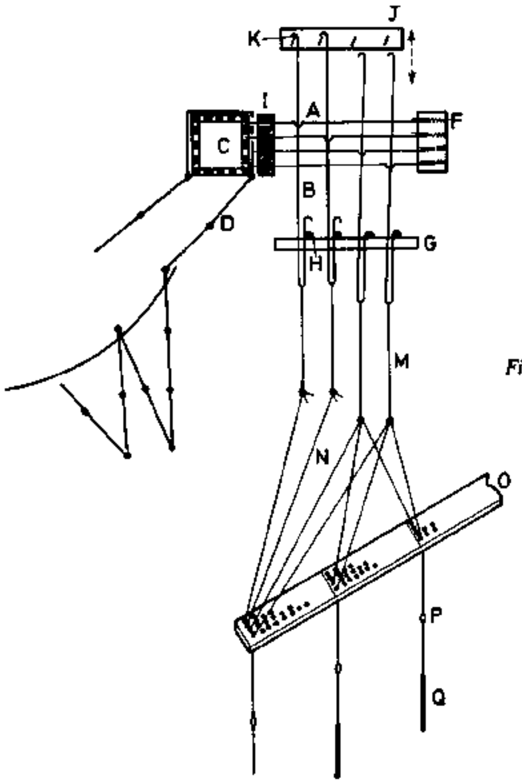


Figure 11.2

which they project slightly. The rear end of each needle, which is formed into a narrow loop is pressed by a spiral spring F to ensure the return of the needle to the original position after each selection. The hooks are prevented from turning sideways by doubling-up their lower ends and passing them through narrow slits in grate G with the bent ends resting on spindles H when the hooks are in the low position. The number of needles in each short row varies from 4 (as shown in *Figure 11.2*) to 16 and the number of short rows is multiplied to give the required size of machine. It is a general rule to connect the needles and hooks in the order shown in *Figure 11.2*, the top needle being connected to the hook nearest to, and the bottom needle to the hook farthest from the cylinder C. The same number of inclined lifting knives K are carried in an iron frame or griffe J as there are hooks B in a short row. A card-cylinder C, over which the pattern cards D pass, contains on each surface a hole opposite the end of each needle. Each face of the cylinder is provided with two pegs which act as the locating points to ensure proper registration of the card against the cylinder perforations. The cards D, the number of which is equal to the number of picks in the complete repeat of a design, are laced together at the sides and in the middle; then the last card is joined to the first so that an endless chain is formed. The pitch of the needles, and the holes in the card-cylinder, and cards is exactly the same. Long 'sets' or 'packs' of cards have to be suspended in proper position in relation to the cylinder, and in one method a wire, which is about $1\frac{1}{2}$ inches longer than a card, is tied at intervals of twelve or more cards to the twine with which the cards are laced together. By means of the wires the cards hang from a frame or 'cradle' which consists of two parallel iron bars that are rather further apart than the width of the cards, and the latter pass over supporting rollers. When long sets of cards are not used—say below 200 in a set—the cradle may consist of a curved tin channel in which the cards rest, the wires then being dispensed with.

The harness consists of neck cords M that are suspended from the hooks B; harness cords N, which are connected to the neck cords and passed separately through holes in a comber-board O; mails P; and lingoes or weights Q. The number of harness cords, mails, and lingoes, connected to each neck-cord M, varies according to the 'tie' and 'sett' of the harness. By means of the lingoes Q, the warp threads, cords, and hooks are returned to their original position after they have been raised.

The purpose of the comber-board O is to keep the harness cords in position to determine the number of cords per unit space.

Suitable connections from the loom provide the rising and falling movement to the knives, and the in-and-out movement to the card cylinder ensuring correct synchronisation of the jacquard action with the loom cycle. The cylinder is turned one quarter of a revolution as it moves back thus presenting a new card for selection each time it moves in to press against the needles. It will be noted from *Figure 11.2* that each hook controls as many warp threads as there are harness cords connected to the corresponding neck-cord. Warp threads are moved from the bottom of the shed to the top and back again, or twice the depth of the shed at every pick; and on account of the great distance traversed by the threads and the consequent strain put upon them, and the absence of counterpoise in the machine, the single-lift jacquard is not suitable for high speeds. As a result, this system has been largely discarded being retained only in certain highly specialised fields.

The centre shed jacquard

The main difference between this and the previous type of jacquard lies in the manner of shed formation. The warp threads, when at rest, are in the centre of the shed; where there are holes in the cards the corresponding hooks are raised to the top through the action of the rising griffe, while the remaining hooks are lowered to the bottom by means of the descending griffe. The threads move only half the distance that they move in bottom closed shedding, and the rising shed is balanced by the falling shed, but as every thread is in motion a detrimental swinging movement may be set up in the harness at high speeds. Despite the above disadvantage this method of shedding is recommended for the delicate types of yarns and has been adopted as standard in the Verdol fine pitch machines which were originally developed for the silk brocade weaving, but owing mainly to their large figuring capacity they are now widely used for all types of materials, both natural and man-made.

As the Verdol system uses continuous paper roll instead of paste-board cards to operate the selection mechanism, the pressure of the pattern roll cannot be applied directly against the needles, but requires an intermediate selection device to prevent damage to the roll. The method of operation used in this system is shown in *Figure 11.3* and it will be noted that the principle of jacquard selection is basically the same here as in the previous system.

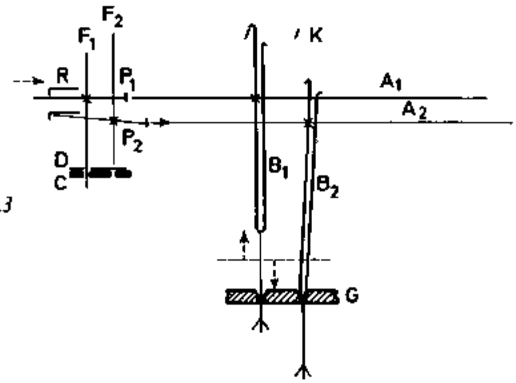


Figure 11.3

Feeler F_1 is shown opposed to a perforation in the pattern roll D which allows it to enter a corresponding hole in the cylinder plate C. The poker P_1 controlled by the feeler remains at rest and, therefore, the pusher grid R moves forward without acting upon the poker; the corresponding needle A_1 also remains undisturbed leaving the hook which it controls over the knife K. The knife in its movement upwards will take the hook and with it the harness cord and the warp end from the centre up to the top shed level. Feeler F_2 opposed by a blank raises the poker end P_2 into the path of the pusher grid which forces the poker forward against needle A_2. This movement presses hook B_2 clear off the knife and allows the hook to fall down with the top board G as it moves from the centre to the bottom shed position.

The double lift single cylinder jacquard

The term 'double lift' indicates that the jacquard has two sets of lifting knives which operate on alternate picks. Each needle controls a pair of hooks selecting one to act on odd picks in conjunction with the first set of knives, and the other to act, in conjunction with the second set of knives, on even picks. Every end, therefore, is controlled alternately by one of the hooks in a pair. The principle of selection remains unchanged and the basis of the operation is as follows: the cylinder presents the first card to the needles and whilst one set of knives implements the first selection the cylinder moves out and in again to present a fresh card for the subsequent selection; the other set of knives now commences to move up taking with it those hooks which were selected by the presentation of the second card and simultaneously the first set of knives starts moving down. This arrangement permits the formation of a modified open shed which reduces the unnecessary movements of ends in as much as any ends required to remain up for several picks in succession do not return to their original rest position between picks, but remain up except for a slight downward movement. This downward movement is due to the fact that the descending knife carries one hook of a pair, and, therefore, the corresponding end down until the other hook carried by the ascending knife is able to assume control over the end in question and return it again to the top. The transfer of the control over warp threads takes place approximately half-way through the shed. The situation described above is shown in *Figure 11.4* by the first pair of hooks A_1 and A_2. A_1 is up by virtue of the previous selection and A_2 is being selected to rise on the next pick (hole in the card), but the end controlled by this pair of hooks will fall until A_2 draws level with A_1. B_1 and B_2 show the situation when an end is required to remain down on two picks in succession where B_1 is down by virtue of the first selection and its twin is also being pressed clear of the knife (blank in the card) for the current selection. Yet another situation arises when an end which was up by previous selection is required to stay down for the following pick. This is shown at C_1 and C_2, where C_1 is at the top but its twin is being pressed off. As the two hooks are controlled by the same needle, the needle impinges upon both, and C_1 yielding to the pressure, bends to permit the deflection of C_2. Although hooks are sufficiently flexible to bend easily, this action nevertheless tends to increase the wear on cards, needles and the hooks themselves.

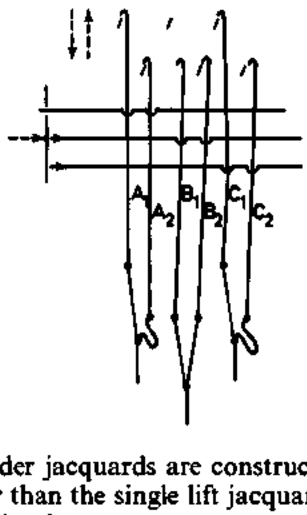


Figure 11.4

The double lift single cylinder jacquards are constructed in all sizes and pitches and can operate faster than the single lift jacquards as the sheds are formed in less time due to simultaneous movement of rising and falling threads. They also require less power as the lifting knives are compensated to some extent by those that are falling. Their main disadvantage lies in the rapid movement of the cylinder which has to provide a selection for each pick and operates at twice the speed of the knives. The violent turning movement caused the cards to be thrown off on occasion, and this led to the introduction in modern machines of pentagonal or hexagonal cylinders to reduce the angular velocity at the moment of turning.

The double lift double cylinder jacquard

This machine produces the same type of shed as the previous one and is in many aspects similar in action. The main difference is in the presence of the second cylinder which operates alternately with the first. This necessitates the separation of the pattern cards for each design into two sets laced individually, one operating the selection on odd picks, and the other on even picks. Although the system results in reducing the speed of the cylinder action it introduces the problem of correct order of card presentation and cards between the two sets are liable to get out of sequence especially during pick finding. To prevent this elaborate controls are introduced to stop the loom should the cards be incorrectly presented. A further disadvantage is the additional obstruction to light offered by the second pack of cards and the difficulty of storing two sets of cards for each design.

The open shed jacquard

This system can be regarded as a further development of the ordinary double lift principle of operation and its main advantage is that it eliminates completely any unnecessary movement of warp threads between shed forming cycles. The open shed system is nowadays employed mostly in fine pitch jacquards and these machines built with the highest degree of precision can operate successfully at speeds of up to 250 picks per minute.

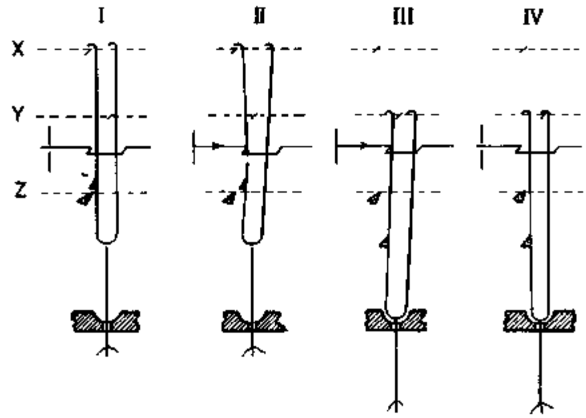


Figure 11.5

Several different methods are used to achieve the open shed and the diagram in *Figure 11.5* shows one in which a stationary griffe Z, additional to the two normal griffes X and Y, retains a double hook in the top shed position when it is required to remain up for several picks in succession (position I). At II a situation is shown in which the hook is ready to drop into the bottom shed line following the pressure by a blank opposite the needle. Position III shows the effect of two successive blanks, and at IV the end which was down by virtue of the previous selection is now ready to move up following a hole opposite the needle.

The open shed system is particularly valuable in weaving warp faced fabrics the right side up without materially increasing the power requirements of the driving mechanism.

Sizes of jacquards and cards

The English coarse pitch machines range in size from 100 to 600, and occasionally 900 hooks (in double lift machines the two hooks of a pair are counted as one). The common sizes and hook arrangements are shown in the following Table 11.

Table 11

100 size,	with 26 rows of	4 hooks per row	=	104 hooks
300 ,,	,, 38 ,, ,,	8 ,, ,, ,,	=	304 ,,
400 ,,	,, 51 ,, ,,	8 ,, ,, ,,	=	408 ,,
500 ,,	,, 51 ,, ,,	10 ,, ,, ,,	=	510 ,,
600 ,,	,, 51 ,, ,,	12 ,, ,, ,,	=	612 ,,

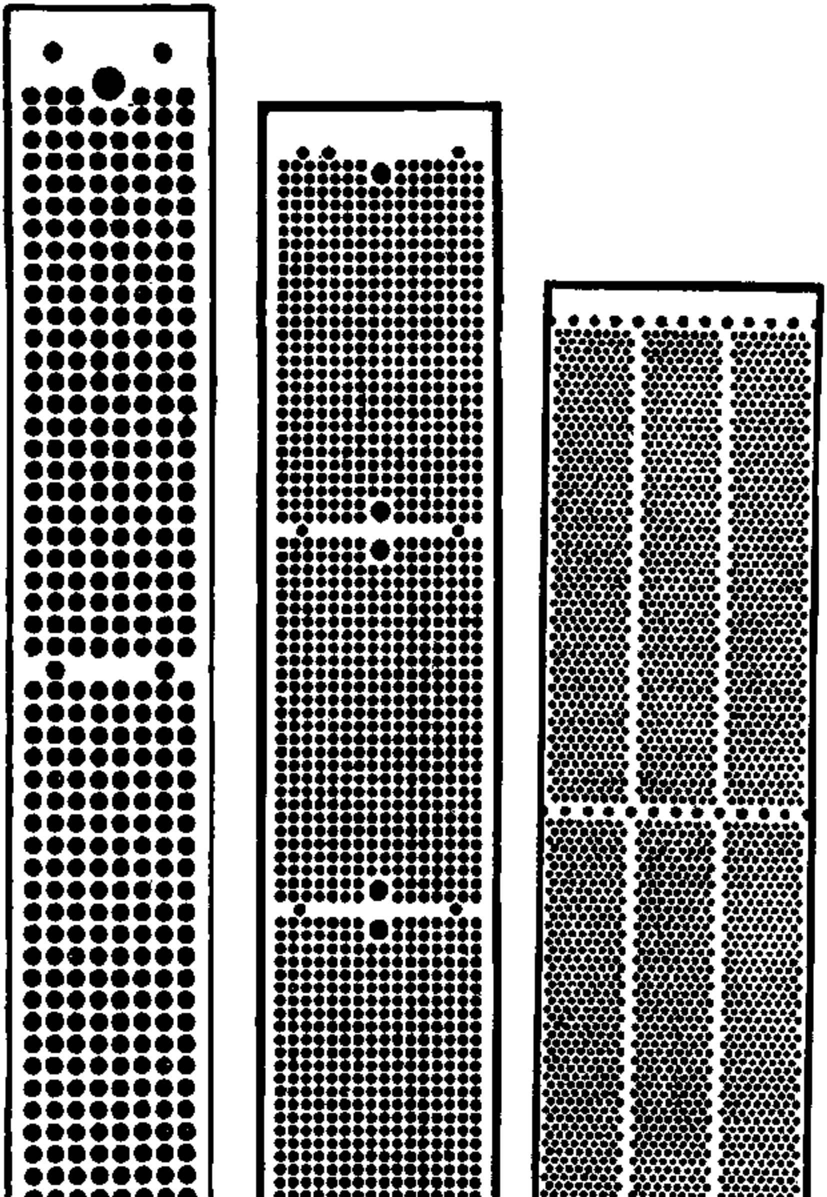
The fine pitch machines, of which there are several types, are normally built in much larger sizes. The Verdol pitch jacquards are made in multiples of 448 hooks, the three common sizes being 896, 1344, and 1792 hooks. In this system there are 16 hooks in each short row controlled by two rows of 8 needles, each staggered in respect of the other. The Vincenzi pitch machines are made in similar sizes in multiples of 440 hooks arranged with 16 needles and hooks per short row.

The number of hooks in the machine indicates its maximum figuring capacity, i.e. the number of warp threads that can be operated independently of each other if all the hooks are utilised. In practice not all the hooks are used for figuring and some are left empty whilst others may be employed to operate the selvedge threads, the box motion or various other devices as necessary. Usually the number of hooks tied up is a multiple of several smaller numbers as this facilitates the arrangement of various ground weaves and auxiliary figures. For instance, in the 408 size machine frequently only 384 hooks are tied-up as this figure is a multiple of 12 and 16 which permits the use of most common weaves for the ground. In addition, auxiliary motifs repeating over, say, 64, 96, or 128 ends could be fitted in with the main figure without difficulty.

When very large designs are wanted several jacquards can be combined together to work in tandem, thus further increasing the figuring capacity—e.g. 2688 size can be obtained by combining two 1344 hook machines, or 2240 size by placing a 1344 hook machine in tandem with an 896 hook model.

The cards (fully perforated) for different sizes and pitches of machines are shown in *Figure 11.6* and serve to illustrate the differences in the closeness of needle settings between the various systems. A represents 408 English coarse pitch size and measures 412 mm × 60 mm. B shows the 1320 Vincenzi pitch card which is 377 mm long × 69 mm broad, C represents the equivalent of three cards in the Verdol pitch for 896 size, each of which occupies the space of 320 mm × 27 mm. This comparison illustrates the saving which can be achieved in the weight, and also in the storage capacity when fine pitch machines are adopted instead of the coarse pitch.

With the exception of the Verdol type shown at C the cards illustrated in *Figure 11.6* show how the hooks and needles are arranged in the machines, and will make clear the meaning of the terms 'short row', and 'long row', as applied to the needles, hooks and harness cords. In looking at a fully punched card the holes (with the exception of the peg and lace holes) represent the tops of the hooks, and the ends of the needles; or, in other words, each hole



A B C

Figure 11.6

represents the connection of a needle to a hook (or a pair of hooks in a double-lift jacquard). Further, a card represents one pick, or one horizontal space of the design paper, and each hole (or position where a hole may be punched) a small square of a horizontal space. A card is perforated and left blank in the order indicated by the painting of the design; if certain marks represent warp up, a hole is cut to correspond with each small square thus indicated (as shown in *Figure 11.9*).

Ordinary harness ties

A jacquard may be placed in relation to the loom with the card cylinder at the right or left side, or at the back or front. If the cylinder is at one side the long rows of hooks are at right angles to the length of the comber-board, therefore the harness cords are crossed with each other in passing from the neck-cords to the holes in the comber-board. This arrangement, which is illustrated in *Figure 11.7*, is termed a London, crossed, or quarter-twist tie.

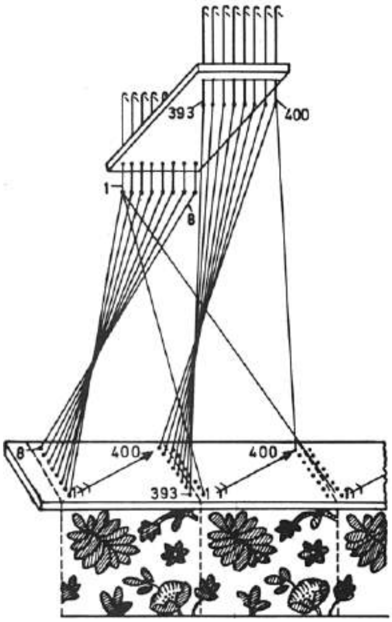


Figure 11.7

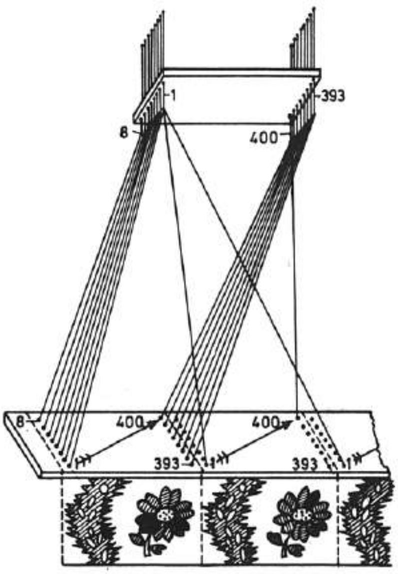


Figure 11.8

If, however, the card cylinder is at the back or front of the loom, the long rows of hooks are parallel with the length of the comber-board, so that the harness cords are not crossed. This tie is illustrated in *Figure 11.8*, and the term Norwich or straight tie is applied to the arrangement.

In tying up a harness the first hook in the row nearest the head of the cylinder (which is invariably on the right when facing the cylinder) is taken as the first hook in the machine. The other hooks in the same row follow in consecutive order from 2 to 8, as indicated by the numbers in *Figures 11.7* and *11.8*; then the hooks 9 and 16 are the first and last in the second row; the hooks 17 and 24, the first and last in the third row, and so on. If the jacquard contains as many hooks as there are figuring threads in the full width of the cloth, as, for instance, in certain classes of carpet jacquards, only one harness cord is connected to each hook, and the tie is termed a *single* tie. The most commonly used arrangement, however, is the *lay-over* or *repeating* tie, which is illustrated in *Figures 11.7* and *11.8*, and is also represented in the lower portion of *Figure 11.2*. In this tie, commencing with the first hook (or neck-cord) of the machine, the first harness cord is connected to it, the second harness cord to the second hook, the third to the third, and so on in succession until each hook has one harness cord connected to it. This gives one 'division' or 'repeat' of the harness, which occupies a certain width of the comber-board and contains as many harness cords as there are hooks tied up. The process is then repeated—commencing with the first hook, and a second harness cord is successively connected to each, a second division of the harness being thus formed in the comber-board. Again the process is repeated (and again and again if necessary) until the required width of the harness in the comber-board is obtained.

In *Figures 11.2*, *11.7*, and *11.8* the divisions of the comber-board are clearly indicated, and it will be readily understood, that as in each division the harness cords are attached in exactly the same order to the hooks (or neck-cords), the figure formed by the first division will be repeated exactly by each subsequent division in the manner illustrated by the designs below the comber-boards in *Figures 11.7* and *11.8*. In the lay-over tie the number of hooks tied up gives the maximum number of threads in the repeat in width of a design; by casting out (see page 191) designs may be woven which repeat upon a lesser number, while any smaller designs repeating on the number of threads which is a factor of the total number of hooks tied-up can be accommodated.

Harness drawing in, card cutting, and card lacing

The warp threads may be drawn through the harness mails in the order shown at A in *Figure 11.9*, or as indicated at B. In the former method the first thread in a design (at the left as viewed from the front of the loom) is drawn upon a harness cord at the front of the comber-board, and if the card cylinder is at the back of the loom (which is common) the needle that controls the first thread is at the bottom of the first short row. In the latter method, under similar conditions, the first thread is drawn upon a harness cord at the back of the comber-board, and the needle which controls it is at the top of the first short row.

The construction of a design is not affected by the way in which the threads are drawn in, but a difference is made in the card-cutting. This is illustrated in *Figure 11.9* in which C shows a small design, and D portions of two cards which are cut to correspond with the first and second horizontal spaces, or picks of C—assuming that the harness draft A is employed and that the marks of the design indicate warp up. The design is placed in front of the card-cutter in the position that it has been constructed and as it is required to appear in the cloth. The bottom horizontal space corresponds with the first card, and the card-cutter follows it from left to right, each series of spaces between the thick lines of the paper coinciding with a short row of the card. If the draft indicated at B in *Figure 11.9* be employed, the design is turned one-half round, as shown at E. The first horizontal space is then at the top,

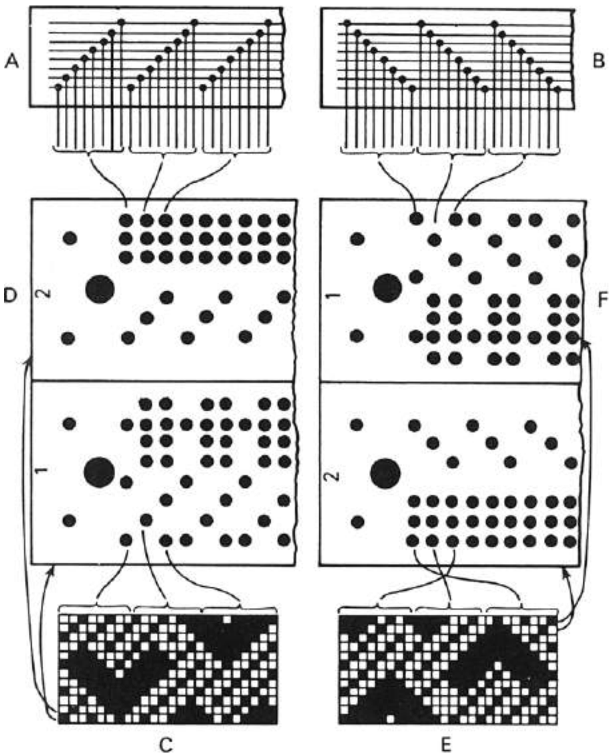


Figure 11.9

and the first card is cut from it by reading from right to left. Thus, F shows sections of cards cut from the two top horizontal spaces of E.

The cards are numbered at the end where the cutting is commenced to correspond with the numbers of the horizontal spaces of the design, and they are laced together with the numbers arranged in consecutive order. Generally the numbers follow each other from one upward in the direction shown at D in *Figure 11.9*, which is termed 'lacing forwards'. Sometimes, however, as for instance in order to reverse the direction of a twill-ground weave, they follow each other in the opposite direction as shown at F, which is termed 'lacing backwards'. As a rule the numbered ends of the cards are placed at the right (when facing the cylinder) side of the cylinder, and if the cards are laced forwards they rotate in order from the first to the last, whereas if they are laced backwards they rotate from the last to the first. An exception to this occurs when two cylinders are employed at opposite sides of the jacquard.

HARNESS AND DESIGN CALCULATIONS

Sett of the harness

The number of harness mails per unit space is decided by the rate at which the rows of holes are formed in the comber-board, and the number of holes in each row. Usually there are as many holes in each row of the comber-board as there are hooks in each short row of the jacquard. Thus, in an 8-row machine there are 8 holes in each row, and in wooden comber-boards in coarse setts, the holes may be pierced as indicated at G in *Figure 11.10*, whereas in medium setts, in order to give as much space as possible between the holes, they are staggered, as shown at H. In very fine sett harnesses, however, in order that there will be sufficient space between the rows, each row in the comber-board mostly contains twice as many holes as there are hooks in a short row of the jacquard. The arrangement for an 8-row machine is then as shown at K in *Figure 11.10*, and in tying up the harness the cords from the first row of hooks are passed through the odd holes, and from the second row through the even holes, as represented on the right of K. The

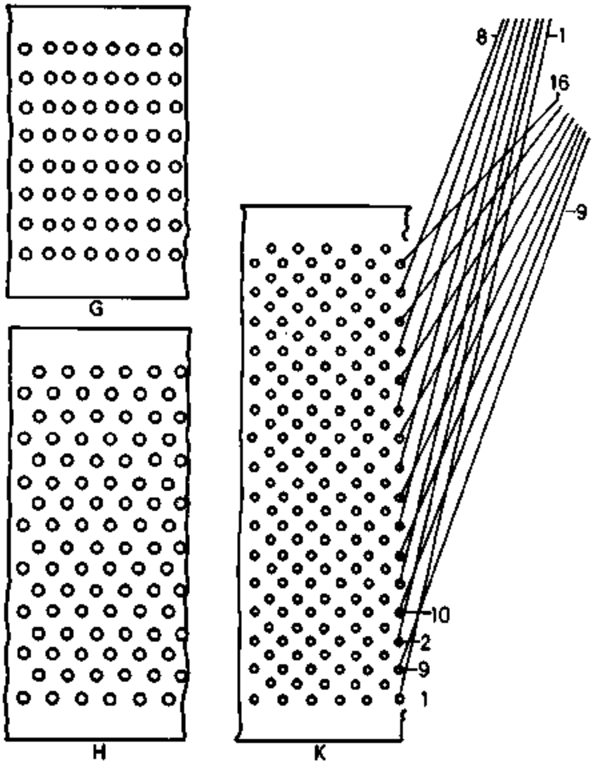


Figure 11.10

warp threads are drawn through the harness mails in corresponding order—threads 1 to 8 on the odd mails in succession, and threads 9 to 16 on the even mails, and so on.

Sometimes, for special purposes, as for instance in weaving broad crammed stripes, the comber-board is pierced at different rates to conform with the sett and width of the respective sections of the warp threads. Such an arrangement, however, is seldom necessary. For instance, a warp might be dented in the reed in the order of 200 threads, 4 per split, and 200 threads, 2 per split, but a uniform distribution of the harness cords in the comber-board would cause no difficulty in weaving, because the cords yield readily to the draw of the reed.

The number of harness cords per cm is equal to the number of rows per cm multiplied by the number of holes per row. For example, if 48 harness cords per cm are required—in an 8-row machine there will be 48 ÷ 8 = 6 rows of holes per cm, and in a 12-row machine—48 ÷ 12 = 4 rows per cm.

Number of harness cords to each hook

In a lay-over or repeating tie the number of hooks tied up, and the width and sett of the harness, determine the number of harness cords to each hook. For instance, assuming that 400 hooks are tied up, 120 cm wide in the harness, with 40 harness cords per cm—the total number of harness cords in the full width = 120 × 40 = 4800; and 4800 cords ÷ 400 hooks = 12 harness cords to each hook. That is, the harness will be in 12 divisions, and will produce 12 repeats of a design that is constructed upon 400 threads. As a further illustration, let it be assumed that 304 hooks are tied up, 72 cm wide, with 40 harness cords per cm. In this case there will be 40 × 72 = 2880 cords, and 2880 ÷ 304 = 9 divisions + 144 cords. It is customary to tie one-half of the remainder at one side of the jacquard, and the other half at the other side, and the arrangement shown in Table 12 will therefore be suitable.

Table 12

Hooks 233 to 304	=	72	harness	cords
,, 1 to 304 × 9 repeats	=	2 736	,,	,,
,, 1 to 72	=	72	,,	,,
		2 880	,,	,,

Thus, 144 hooks will be tied up with 10 cords per hook and 160 hooks with 9 cords per hook. In the foregoing, no provision is made for the selvages, but assuming that 4 hooks are employed for the purpose, and that 24 cords are tied up at each side, each selvage hook will have (24 + 24) ÷ 4 hooks = 12 cords attached to it.

Casting-out in jacquards

Casting-out consists of leaving empty a portion of the mails in each repeat of the harness, and of allowing the corresponding needles, hooks, and harness cords in the machine to remain idle. The warp threads should occupy the same width in the harness as in the reed; the sett of a harness, however, is fixed when it is tied up, whereas the sett of the warp in the reed is changed according to requirements (except that it should not be finer than the sett of the harness). Casting-out may therefore be defined as a process by which a jacquard is adapted, without retying, to suit conditions that are different from those for which the harness was constructed. For instance, if a harness is tied up to 400 hooks, with 40 harness cords per cm, the conditions are perfectly suited to weaving designs repeating upon 400 threads with 40 threads per cm. It may, however, be found necessary to use the machine—(a) in weaving designs that repeat upon a smaller number of threads than 400; and (b) in weaving cloths with less than 40 threads per cm. These are the two chief purposes of casting-out; but, in addition, the process is employed to some extent in producing special effects in a straight repeating tie.

It is possible to weave designs that repeat upon any number of threads less than the number of hooks tied up, but it is obviously impossible to employ a higher number. Very small designs can be repeated across the cards a number of times—e.g., in a 400-tie, a design repeating upon 64 threads can be carried across the cards five times, with a remainder of 80 hooks cast out, or six times with 16 hooks cast out. The examples C and D, or E and F, in *Figure 11.9* illustrate the method in which a small design is repeated across the cards. Casting out 80 hooks, in a jacquard in which 400 hooks are tied up, leaves only 320 hooks in use, and under these conditions the machine is limited to designs which repeat upon 320 threads, or a number which is a factor of 320.

It is important to note that the sett of the harness is reduced in ratio proportionate to the number of hooks that are cast out; and the sett of the warp in the reed should be the same (or very nearly the same) as the reduced sett of the harness. By means of the following formula, which is of general application, an unknown factor can be readily found: The sett of the harness : the sett of the warp in the reed : : the number of hooks tied up : the number of hooks employed, or the number of threads in the design.

Two problems arise in weaving designs that repeat upon a smaller number of threads than the number of hooks tied up: (1) To find the sett of warp to suit a given sett of harness. (2) To find the sett of harness to suit a given sett of warp. In illustration of both problems let it be assumed that it is desired to weave a design repeating upon 320 threads in a 400-tie. (1) Taking the sett of the harness as 45 cords per cm, the sett of the warp should be:

400 : 320 : : 45 : 36 threads per cm.

(2) Taking the sett of the warp as 40 per cm, the sett of the harness should be:

320 : 400 : : 40 : 50 cords per cm.

When it is desired to weave a cloth with fewer threads per inch in the reed than there are harness cords per inch, it is necessary to find the number of threads in the repeat of the design relative to the number of hooks tied up. For example, assuming that a warp with 32 threads per cm in the reed, has to be woven in a 304-tie, with 40 harness cords per cm, the number of threads in the repeat of the design will be:

40 : 32 : : 304 : 242 threads.

In this case, however, a more convenient number is 240 threads, then the number of hooks cast out = 304 − 240 = 64.

In some special cases the hooks are cast out in long rows, which, as regards the card cutting, reduces the number of hooks in each short row—e.g., if two long rows are cast out, a 12-row machine is reduced to 10 rows, and an 8-row machine to 6 rows. Most frequently, however, the casting out is done in short rows, and if a considerable number of rows are cast out, they should be distributed as regularly as possible across the card. Also, a definite system should be employed in selecting the rows for ease of drawing-in. *Figure 11.11* illustrates a principle upon which the cast out rows may be selected. A represents one long row of a 304-card, which is in two halves, each consisting of 19 rows, and it will be understood that each black circle corresponds to a short row of eight. For a cast out of 32 hooks the 1st and 19th rows in each half are cast out, as shown at B. To increase the cast out to one of 48 hooks, the 10th row in each half is added, as indicated at C. For a cast out of 80 hooks the 7th and 13th rows in each half are also added, as shown at D; to which the 4th and 16th rows in each half are added for a cast out of 112 hooks, as shown at E. This is further increased to a cast out of 144 hooks by adding the 6th and 14th rows in each half, as represented at F.

Another important point to note in selecting the rows to be cast out is to arrange them, if possible, in such a manner that they are in the same order when counted from either end of the card. This has been kept in view in selecting the rows for the cast outs shown at B to F in *Figure 11.11*. For example, from whichever side of cast out E the rows are counted, the numbers are 1, 4, 7, 10, 13, 16, 19, in each half. The advantage of this arrangement is that the cards will fit on the cast out when turned round, which, in certain of the most common arrangements of figures, enables the cards for the second half of the design to be repeated from the cards which are cut from the first half, thus saving time both in the designing and card cutting.

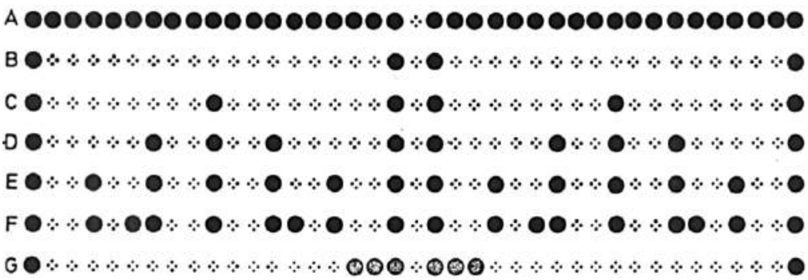


Figure 11.11

When only a given size and sett of jacquard is available for producing a design, it sometimes occurs that the proper number of ends for the repeat, obtained by calculation, is different from the number of ends in one or more repeats of the design. For example, assuming that a 33 sett warp is required to be woven in a 38 sett 304 jacquard, the correct number of ends for the repeat =

$$38:33::304:264 \text{ ends}$$

and the correct cast out =

$$304 - 264 = 40 \text{ hooks.}$$

In practice, the number of ends (264) for the repeat can be varied from about 256 to 272, but a large design, repeating on, say, 288 ends, or one repeating on, say, 240 ends, will require to be modified in size to suit the size of repeat which can be obtained in the given jacquard. Small designs may also require to be modified in size, as, for example, a design repeating on 48 ends may be altered to repeat on (264 ÷ 6 repeats) = 44 ends, or (260 ÷ 5 repeats) = 52 ends. When, however, it is impossible for the repeat of a small design to be altered in size, the warp may be kept straight between the harness and the reed by casting out in the following manner.

Assuming that the calculation number of ends for the repeat is 264, and that the design repeats on 48 ends, the design is carried out on a larger number of ends than the calculation number. Thus, in this case, by repeating the design six times, the size of the repeat = 288 ends, which in the 304 jacquard gives a cast out of 16 hooks, or two rows for the card cutting. The number of harness mails (16) which are cast out in every division of the harness is then too little by (288 − 264) = 24 mails; but as the design repeats on 48 ends only, it is possible, without injury to the weaving, and without causing a break in the pattern, to cast out a block of 48 harness mails in addition to the 16 mails in any division of the harness. The number of times it will be necessary to cast out in blocks of 48 may be found as follows.

Assuming that the warp contains 3200 ends, the number of divisions which the warp requires to occupy in the harness =

$$3200 \div 264 = 12 \text{ divisions and } 32 \text{ ends.}$$

$$\frac{12 \text{ divisions} \times 24 \text{ mails cast out too little}}{48 \text{ mails in each block}} = 6 \text{ times.}$$

It is necessary to assort the 6 places regularly across the 12 divisions which the warp occupies; therefore, in this case, the odd divisions may be cast out 16, and the even divisions 16 + 48 = 64 mails. The plan of the cast-out card is shown at G, *Figure 11.11*, the shaded circles indicating a convenient position for the 48 mails or 6 rows which are cast out or filled in according to requirements. It will be understood that the cards for weaving the design must be cut as though the harness was cast out only on the first and last rows.

Size of repeat

Cloths contract in weaving and also in most cases in finishing, hence in the finished state a fabric contains more threads per unit space than are inserted in the loom. A jacquard design requires to be constructed in accordance with the finished conditions of the cloth for which it is intended, and if a cloth, when finished, contains 30 picks and 40 ends per cm, a design 16 cm long by 10 cm wide will repeat upon 30 × 16 = 480 picks or cards, and 40 × 10 = 400 ends.

The length of repeat that can be obtained in a jacquard is theoretically unrestricted, but in practice there is a limit to the number of pattern cards that can be conveniently suspended and made to work satisfactorily in a machine. In addition to mechanical considerations the question of economics is important, and it should be taken into account that the cost of a design is about in proportion to the number of cards that are required. In ordinary jacquards a separate card is required for each pick, and if it be assumed that the maximum number that can be conveniently used in a given machine is say 2000, the designer should endeavour to restrict his designs accordingly. Thus, in this case, in designing for a cloth with 40 picks per cm, the length of the repeat should not exceed 50 cm, and for a cloth containing 60 picks per cm, 33 cm; any smaller length of repeat, of course, being readily obtained.
readily obtained.

The width of repeat that can be woven in an ordinary jacquard and tie is much more restricted than the length, as in the loom it cannot (in ordinary circumstances) exceed the space occupied by one division of the harness in the comber-board. The number of hooks tied up, the sett of the harness, and the contraction of the cloth, are the governing factors. For example, assuming that a cloth contracts 10 per cent from the reed width to the finished width —a 400 tie with 40 harness cords per cm will give: $(400 \div 40) - 10$ per cent $= 9$ cm width of repeat in the finished cloth. The result is not affected if a cloth is woven with fewer threads per inch in the reed than the number of harness cords per inch, because the hooks require to be cast out to correspond with the difference in the setts. Thus, if a cloth is woven in the foregoing tie with 30 ends per cm in the reed, there will be

$$40:30::400:300 \text{ hooks employed,}$$

and $(300 \div 30) - 10$ per cent $= 9$ cm width of repeat as before.

Methods of modifying the repeat in a lay-over tie

Although, in a general way it is true that the figure produced in one division of a lay-over tie will be produced exactly the same in each succeeding division, and that the width of the repeat is correspondingly limited, yet it is possible by means of special methods of drawing in and casting out to modify the size of the repeat and to obtain special effects. For instance, when the sett of the warp is not more than half the sett of the harness, the following method of casting out may be employed in order to double the size of the repeat of the jacquard. Assuming that it is required to weave a warp with 27 ends per cm in a 304-tie with 57 mails per cm, the number of mails in each division which require to be filled in =

$$57 \text{ mails}:27 \text{ ends}::304:144;$$

and the number of mails cast out in each division of the harness =

$$304 - 144 = 160.$$

Instead, however, of throwing 160 hooks entirely out of action, 288 hooks may be employed for figuring by making the design on $144 \times 2 = 288$ ends (which for the card cutting gives a cast out of $304 - 288 = 16$ ends), and by arranging the rows in the harness as follows: The first and last rows of hooks are cast out in every division of the harness; in alternate divisions of the harness half of the remaining rows, say the even rows, are cast out, and the odd rows are filled in; then in the other divisions the odd rows are cast out, and the even rows are filled in. One repeat of the figure will thus extend across two divisions of the harness. In order to cut the cards conveniently from the design the sheet of point paper may be cut into longitudinal strips and arranged with a strip from the first half alternating with a strip from the second half. Alternatively, the cutter may be instructed to cut the first half of the design on odd rows only, and then return the card back to the original starting point, and cut the second half of the design on the even rows.

This method may be employed in various ways in the production of special effects in an ordinary machine. For example, the figured skirting fabric, represented in *Figure 11.12*, was produced in an ordinary 304-jacquard by using the odd rows of hooks for the figure and the even rows for the ground. Where the border figure appears the even rows were cast out, while in the ground of the fabric the odd rows were cast out. The sett of the warp was half of that of the harness. In designing such a style the chief points to note are that the position of each part of the ornament on the point paper corresponds with the hooks which are available for its production, and that the warping plan coincides with the width and form of the border which can be obtained.

Figure 11.12

In figuring with two colours of warp arranged 1-and-1 in the harness it is possible by casting out an odd number of mails to obtain a repeat of figure which is apparently double the width of the repeat of the jacquard. For example, if one harness mail of a 304-tie be cast out, the number of ends in the repeat of the design paper plan = 303, and, as the 1-and-1 warping plan repeats on two ends, the design in the cloth will repeat on a number of ends which is common to 303 and 2—i.e., 606. The ends of the first colour will be on the odd mails in one division, and on the even mails in the next division of the harness, and correspondingly the ends of the second colour will be on

Figure 11.13

the even mails and then on the odd mails. The result of such an arrangement will be understood from an examination of the design shown in *Figure 11.13*, only half the repeat of which needs to be painted out on the design paper.

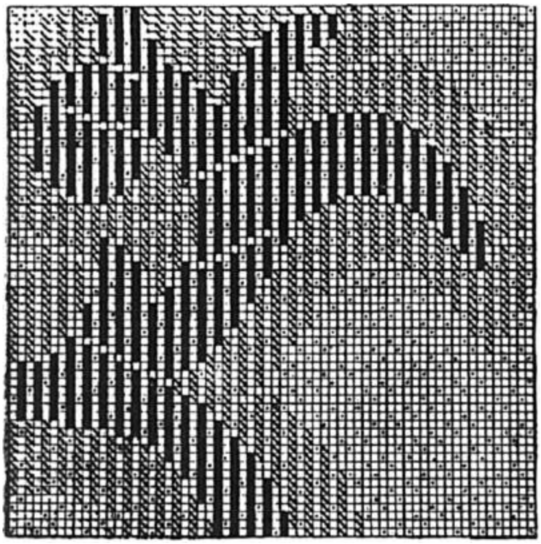


Figure 11.14

The two colours of warp, in which the figure is intended to be developed, will replace each other in succeeding divisions of the harness, hence the repeat of the design in the cloth will be on twice as many ends as the design paper plan. A portion of the design is shown at *Figure 11.14*, which illustrates the end-and-end arrangement of the figure.

Counts of design paper

Design paper is divided by thick lines usually into square blocks, each of which is subdivided into horizontal and vertical spaces. Each horizontal space corresponds to a pick of weft, and each vertical space to a warp thread and a hook of the jacquard. For convenience in the designing and card cutting the vertical ruling of the paper is arranged to coincide with the arrangement of the jacquard hooks—that is, each large square is divided vertically into as many spaces as there are hooks in a short row of the jacquard. Thus, in the design paper used for an 8-row machine there are 8 vertical spaces between each pair of thick lines, and for a 12-row jacquard, 12 spaces, so that in each case the number of vertical spaces between the vertical thick lines corresponds to one row of the card. In order to retain the correct proportions and shape of figure designs, the number of horizontal spaces in each large square requires to be in the same proportion to the number of vertical spaces as the picks are to the ends per unit space in the finished cloth. Since, however, the number of vertical spaces is fixed by the arrangement of the hooks in the jacquard, it is necessary for the number of horizontal spaces in each square to be varied according to the ratio of picks to ends in the cloth. Design paper can be purchased to suit practically any conditions, and in *Figure 11.15* a number of different rulings are illustrated. A and B represents 8 × 8 design paper which is used in designing for cloths in which the ends and picks per unit space are equal, while C shows 8 × 4 paper which is suitable for a cloth which contains twice as many ends as picks per unit space. The first number of the count of the paper indicates the vertical ruling.

In order to illustrate the necessity of using properly ruled paper a small spot is indicated at A, B, and C in *Figure 11.15*; and, assuming that the spot is required to be 0·5 cm in diameter in a cloth containing 32 ends and 32 picks per cm, it will extend over 16 ends and 16 picks, as shown at A. If, however,

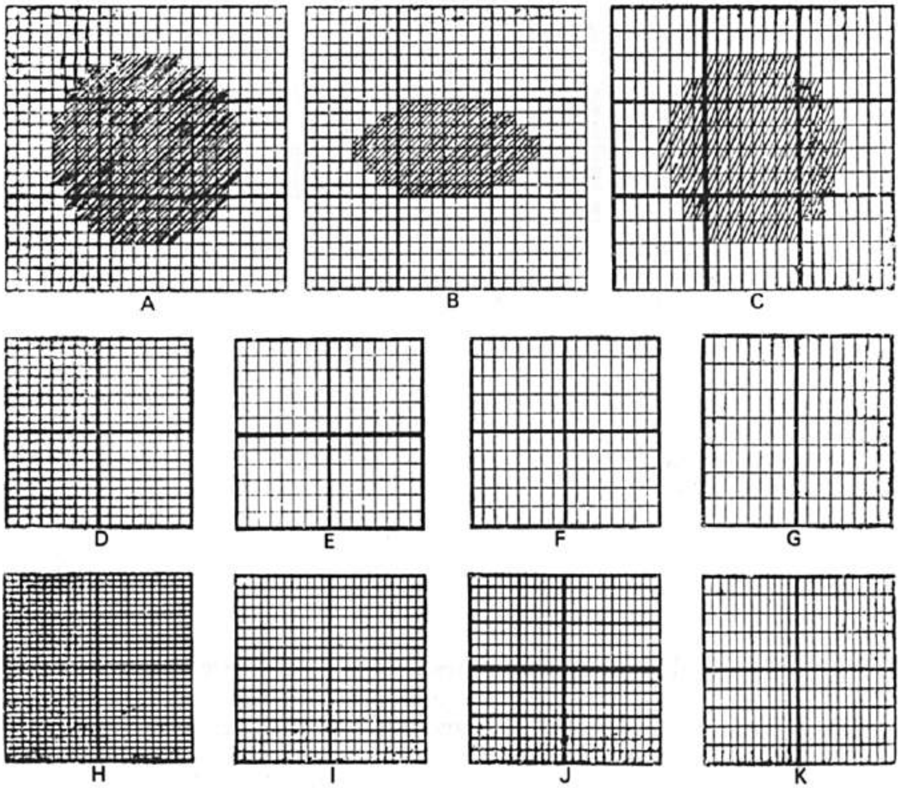


Figure 11.15

the same size of spot is required in a cloth containing 32 ends and 16 picks per cm, it will extend over 16 ends and 8 picks, as indicated at B, in which, however, the 8 × 8 paper shows the spot entirely out of proportion. On the other hand, by using paper that is ruled 8 × 4 to suit the ratio of 32 ends to 16 picks per cm in the cloth the spot is in proper proportion, as shown at C.

The proper counts of design paper to suit any given particulars of cloth (finished) may be found from the formula:

Ends per cm : Picks per cm :: Vertical spaces : Horizontal spaces.

The examples D to G in *Figure 11.15* are suitable for 8-row jacquards, and respectively show 8 × 10, 8 × 6, 8 × 5, and 8 × 3½ papers; while H to K are suitable for 12-row machines and are ruled respectively—12 × 15, 12 × 9, 12 × 8, and 12 × 5. D and H are in proper ratio, for instance, for a cloth with 40 ends and 50 picks per cm; E and I for a cloth with 48 ends and 36 picks; F and J for 44 ends and 28 picks; and G and K for 60 ends and 25 picks. In some cases 12-row paper is ruled with a line in the centre which is intermediate in thickness, as shown at J. It is generally near enough for practical purposes to take the nearest whole number for the horizontal spaces, but sometimes the paper is specially ruled to include a fraction. Thus at G the horizontal thick lines are twice as far apart as the vertical thick lines, and the paper is equivalent to 16 × 7, or 8 × $3\frac{1}{2}$.

Summary of calculations

In the following, which is chiefly a summary of the foregoing in a practical form, the calculations that are involved in designing, and the conditions to be observed are illustrated. Assuming that the design represented in *Figure 11.16* (in which the lines indicate exactly one repeat) is required to be woven

Figure 11.16

in a cloth that counts, when finished, 50 ends and 38 picks per cm, and has shrunk 8 per cent from the reed width to the finished width, while the ground weave repeats upon 20 ends and 12 picks—the particulars may be ascertained as follows.

(a) Number of ends and picks (or cards) in one repeat of the design.
(b) Number of ends per cm in the reed.
(c) Suitable capacity of jacquard and sett of harness to produce the design exact in size.
(d) Counts of design paper.

(a) The repeat is 4·8 cm in width and 6 cm in length. The number of ends in the repeat—50 × 4·8 = 240.
The number of picks in the repeat—38 × 6 = 228.

(b) The number of ends per cm in the reed—50 − 8 per cent = 46.

(c) A suitable standard capacity of jacquard is an 8-row 304-tie which will require to be cast out: 304 − 240 = 64 hooks.

The sett of the harness requires to be finer than the sett of the warp, because 304 harness cords have to occupy the same width in the comber-board as 240 ends in the reed, and the proportion is therefore—

240 ends : 304 hooks :: 50 ends per cm : 63 harness cords per cm.

As it is most unlikely that, in practice, a jacquard of almost the right size will be found for every design, and as it is the modern usage to employ large jacquards to obtain the versatility of application, a more practical approach would be as follows.

A standard 1344 hook Verdol pitch jacquard is available—determine the number of hooks to be cast out and the sett of the harness. A design repeating on 240 ends will be accommodated five times by one division of the tie. therefore, the casting out calculation in this case would be:

$$1344 - (240 \times 5) = 144 \text{ hooks.}$$

Similarly, the sett of the harness would be found as follows:

1200 ends : 1344 hooks :: 50 ends per cm : 56 harness cords per cm.

(d) The count of the design paper—

50 ends : 38 picks = 8 : 6.

The example may be used in further illustration of practical conditions, by assuming that the design shown in *Figure 11.16* is required to be woven in the same cloth as before, but in a 304-jacquard, which is tied up with 51 harness cords per cm. In this case the number of ends in the repeat of the design will be less than 304 in the proportion of 51 (the harness sett) to 46 (the reed sett). The number of ends is therefore—

51 : 46 :: 304 : 274,

which it is necessary to modify to 280 to coincide with the repeat of the ground weave. This causes the repeat in width of the design to be increased from the preceding by 40 ends, and a corresponding increase in length should be made in order that the design will be in the same proportion as the original. The number of picks will therefore be—

240 : 280 :: 228 : 266,

which, to fit with the 12 picks in the repeat of the ground weave, should be modified to 264 picks.

Irregularly dented jacquard designs

In designing figured crammed stripes, extra warp figures, etc., a suitable capacity of jacquard may be decided upon from the number of threads in the repeat of a pattern, but such calculations as the following are involved in maintaining an even balance between the harness and the reed. The calculations vary in different circumstances, but usually the factors to consider are the number of ends and splits in the repeat, and the setts of the reed and the harness.

1. With a given order of denting and a given sett of reed, to find the sett of the harness.
2. With a given order of denting and a given sett of harness to find the sett of the reed.
3. With a given sett of reed and a given sett of harness, to find the degree of cramming or number of extra threads which may be introduced.

By dividing one side into the other an unknown factor can be obtained from the formula

$$\frac{\text{Hooks tied up in jacquard} \times \text{splits per cm in reed}}{\text{Mails per cm in harness} \times \text{splits in repeat of design}}$$

In illustration, a stripe fabric is represented in *Figure 11.17*, which is dented as in Table 13.

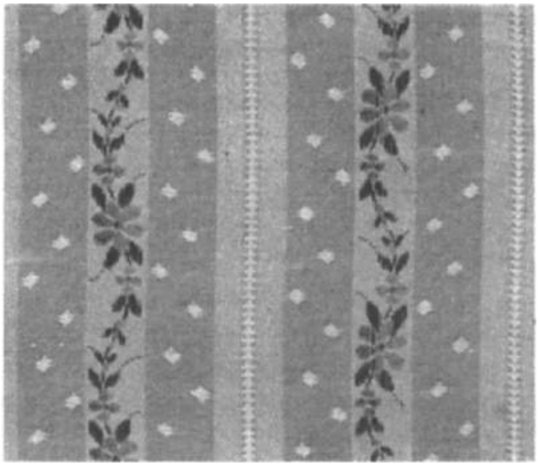


Figure 11.17

Table 13

30 ends	—spot stripe	—2 ends per split	=	15 splits	
72 ,,	—figure stripe	—6 ,, ,, ,,	=	12 ,,	
30 ,,	—spot stripe	—2 ,, ,, ,,	=	15 ,,	
24 ,,	—plain stripe	—4 ,, ,, ,,	=	6 ,,	
12 ,,	—cord	—4 ,, ,, ,,	=	3 ,,	
24 ,,	—plain stripe	—4 ,, ,, ,,	=	6 ,,	
30 ,,	—spot stripe	—2 ,, ,, ,,	=	15 ,,	
72 ,,	—figure stripe	—6 ,, ,, ,,	=	12 ,,	
30 ,,	—spot stripe	—2 ,, ,, ,,	=	15 ,,	
24 ,,	—plain stripe	—4 ,, ,, ,,	=	6 ,,	
12 ,,	—cord	—4 ,, ,, ,,	=	3 ,,	
24 ,,	—plain stripe	—4 ,, ,, ,,	=	6 ,,	
384 ends				114 splits	

The design repeats on 384 ends, so that a 400s jacquard tied on 384 hooks is suitable.

1. Assuming that the reed contains 19 splits per cm, and the sett of the harness is required—

$$\frac{\text{Hooks tied up} \times \text{splits per cm in reed}}{\text{Splits in repeat of design}} = \frac{384 \times 19}{114} = 64 \text{ mails per cm.}$$

2. Assuming that the sett of the harness is 64 mails per cm and the sett of the reed is required—

$$\frac{\text{Mails per cm in harness} \times \text{splits in repeat of stripe}}{\text{Hooks tied up}} = \frac{64 \times 114}{384}$$

$$= 19 \text{ splits per cm.}$$

3. Assuming that the sett of the harness is 64 mails per cm, and the reed has 19 splits per cm, the number of extra ends may be obtained by first finding the number of splits in the width of one repeat of the harness—

$$\frac{\text{Hooks tied up} \times \text{splits per cm in reed}}{\text{Mails per cm in harness}} = \frac{384 \times 19}{64} = 114 \text{ splits in repeat.}$$

Taking the normal distribution to be 2 ends per split, the number of extra ends which may be added to form the crammed stripes = 384 hooks − (114 splits × 2) = 156. Thus the number of splits which may be arranged with 2 extra ends per split is 78; or, with 3 extra ends per split—52; or, with 4 extra ends per split—39; while a combination of one, two, three, etc., extra ends per split may be employed, so long as not more than 156 ends are added, and the total number of splits per repeat does not exceed 114.

Any smaller amount of additional ends than the 156 used in the above example may be introduced by casting out a number of hooks to correspond with the reduced number of ends.

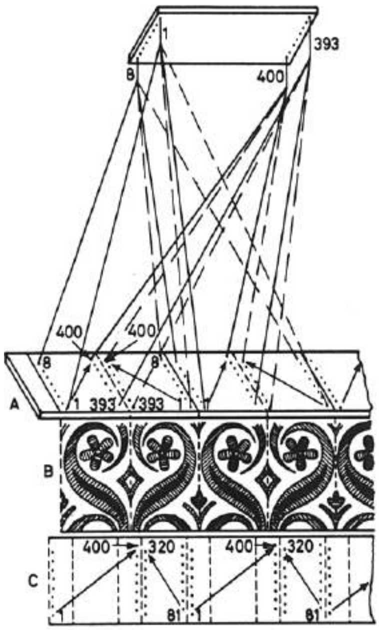
SPECIAL HARNESS TIES

From an examination of *Figures 11.7* and *11.8* it will be readily understood that the harness cords do not necessarily require to be passed through the holes in the comber-board in the same order that they are connected to the hooks (or neck-cords), but that they may be passed from one to the other in different orders according to requirements. That is, in tying up a harness various orders of 'drafting' the cords may be employed for the purpose of enabling special forms of designs to be woven economically. The special ties must be thoroughly understood by the designer as they materially affect the designing techniques, but it should be realised that they are not very commonly employed. Of the total number of harnesses built annually all the special ties together do not account for more than about 5 per cent of the production. The decline of the special harness tie is connected with the decline of the coarse pitch machine in which the special tie was valuable as a means for increasing the comparatively small figuring capacity of that type of jacquard. The capacity of a modern fine pitch machine is so large that the special tie is, in most cases, unnecessary to increase the scope, and becomes a hindrance through curtailing the versatility of the system by limiting it to the production of only such effects for which the tie was specifically designed. In the days of rapid changes in design tastes and constant demand for novelty, such rigid system is not generally acceptable and finds its applications only in very highly specialised fields. The principal variations from the ordinary lay-over tie are: (1) centre or point ties; (2) mixed ties; (3) ties for bordered fabrics; (4) sectional ties (see *Watson's Advanced Textile Design*). Two or more of the systems may be used in combination.

Centre or point ties

This class of tie is the simplest modification of the ordinary straight tie, and is the same in principle as point-drafting in healds. The object of the arrangement is to enable bi-symmetrical designs to be woven which repeat upon twice as many ends as there are hooks in the jacquard. The cost of painting out and card cutting is comparatively small, as the full design is obtained from one-half of the width of the repeat. *Figure 11.18* illustrates the principle in reference to a 400-hook jacquard; the harness cords are tied up consecutively from the first to the last hook, and then in reverse order from the last to the first hook. The cords which are tied in reverse order are indicated by dotted lines. The figure formed in the first half of the tie is reproduced in the second half but turned the opposite way in the manner illustrated by the sketch B below the comber-board A. The fabrics represented in *Figures 12.47* and *13.6* also illustrate the form of centre tie designs. Although a 400-centre tie will produce a design repeating upon 800 ends, it is customary to leave out one end where the tie reverses, in order to avoid having two consecutive ends

Figure 11.18



working alike. The actual full repeat is therefore 798 ends produced from a plan painted out upon 400 ends. The reversing of the tie also reverses the direction of twill and other ground weaves, and in some cases more than one thread is left out in order to prevent the formation of long floats where the ground weave is turned.

One repeat of a centre tie may extend the full width of the harness and cloth (in which case only two cords are connected to each hook) or the tie may be repeated two or more times across the width, as shown in *Figure 11.18*. The arrangement of the cords illustrated is suitable when the short rows of hooks are parallel with the short rows of holes in the comber-board (the Norwich system), but it is necessary in drawing in the warp to draw from front to back in one half of the tie, and from back to front in the other half. When, however, the short rows of hooks are at right angles to the short rows in the comber-board (the London tie—see *Figure 11.7*) it is quite convenient to connect the first hook to the front hole and the last hook to the back hole of the comber-board in both halves of the tie, which enables the ends to be drawn in in the same order throughout the full width of the harness.

In the case of designs which turn over vertically as well as horizontally (illustrations of the type are given in *Figures 11.21*, *12.39*, and *12.46*), it is only necessary to paint out and cut the cards from one-fourth of the complete repeat. The figure is turned over horizontally by means of the harness tie (as previously explained), and vertically by causing the cards to turn first clockwise and then anticlockwise. In one method of accomplishing this, the last but one of the cards that form the half repeat in length, is perforated so that a special hook is raised. This, by releasing a weighted cord, causes the upper catch of the card cylinder to be made inoperative and the lower catch to be put into action, and vice versa.

Mixed ties

This class of tie is used in various ways; one useful arrangement consisting of a modification of a point tie that is employed for designs which, although partly pointed, are required to be less stiff and formal than the pure bi-symmetrical patterns. Thus, a modification of the tie shown at A in *Figure 11.18* might be arranged with—say, 40 cords on each side of the middle positions tied to separate hooks, which would enable one side of each centre to be designed differently from the other side. The arrangement of the tie would then be 1 to 400, 320—81, as indicated at C in *Figure 11.18*, a design repeating upon 640 ends being obtained from a plan painted out upon 400 ends.

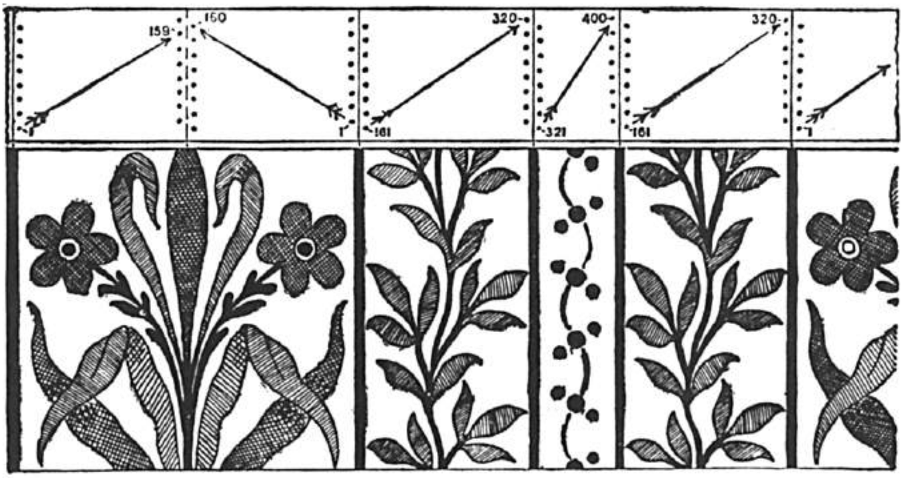


Figure 11.19

A mixed system of tie-up is employed for the purpose of enabling a certain portion of figure to be introduced more or less frequently than another portion. The principle is illustrated by the sketch shown in the lower portion of *Figure 11.19*, and the tie (for a 400-hook jacquard) in the upper portion. The complete design repeats upon 719 ends (allowing for casting-out one end in the centre of the bi-symmetrical stripe), and results from a plan painted out upon 400 ends.

Ties for bordered fabrics

In a bordered fabric the figure at one or both sides of the cloth is different from that formed in the centre. If the ornament in neither border nor centre is repeated, which is generally the case in the better qualities of table cloths,

Table 14

Left Border Tie	*Centre Tie*	*Right Border Tie*
Straight Hooks 1–200	Straight Hooks 201–400	Straight Hooks 1–200
Straight Hooks 1–200	Straight Hooks 201–400	Turned-over Hooks 200–1
Straight Hooks 1–200	Pointed Hooks 201–400 and 400–201	Straight Hooks 1–200
Straight Hooks 1–200	Pointed Hooks 201–400 and 400–201	Turned-over Hooks 200–1
Pointed Hooks 1–200 and 200–1	Straight Hooks 201–400	Pointed Hooks 1–200 and 200–1
Pointed Hooks 1–200 and 200–1	Pointed Hooks 201–400 and 400–201	Pointed Hooks 1–200 and 200–1

quilts, etc., an ordinary single, a pointed, or a mixed-pointed tie may be employed. Many cloths are made, however, in which the central figure is repeated a number of times, but, as a rule, only one repeat of the border figure is made at each side. The following list comprises the principal ties for cloths, with or without repeating centres, and with a similar border at each side; the

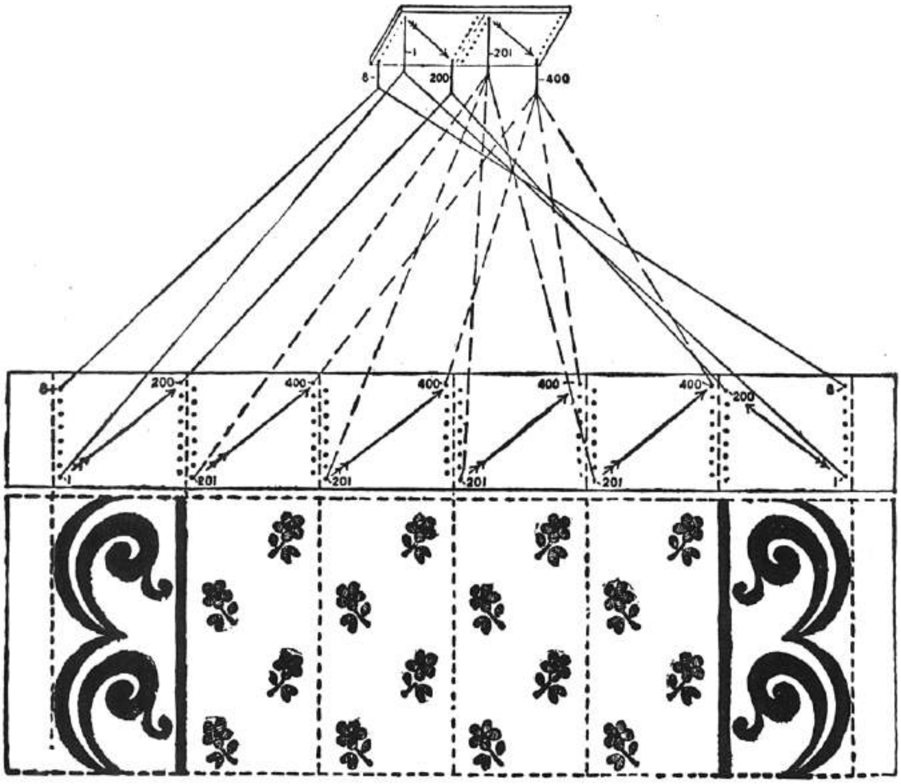


Figure 11.20

order of tying is given, assuming that a 400-hook jacquard is employed, and that one half of the hooks are employed for the borders and the other half for the centre (Table 14).

Any proportionate number of the available hooks may be employed for the border and centre—e.g., one-third for the border and two-thirds for the centre while a mixed order for tying may be introduced. Very frequently considerable ingenuity is necessary in adapting a design and the tie to suit the size of jacquard that is available.

The form of design and the tie illustrated in *Figure 11.20* corresponds with the second example in the above list. The border figure is turned over, and the centre is repeated four times, and in order that the different sections may be more readily distinguished the lines which represent the centre harness cards are shown dotted. The complete design will be formed by painting out one border and one repeat of the centre each upon 200 ends.

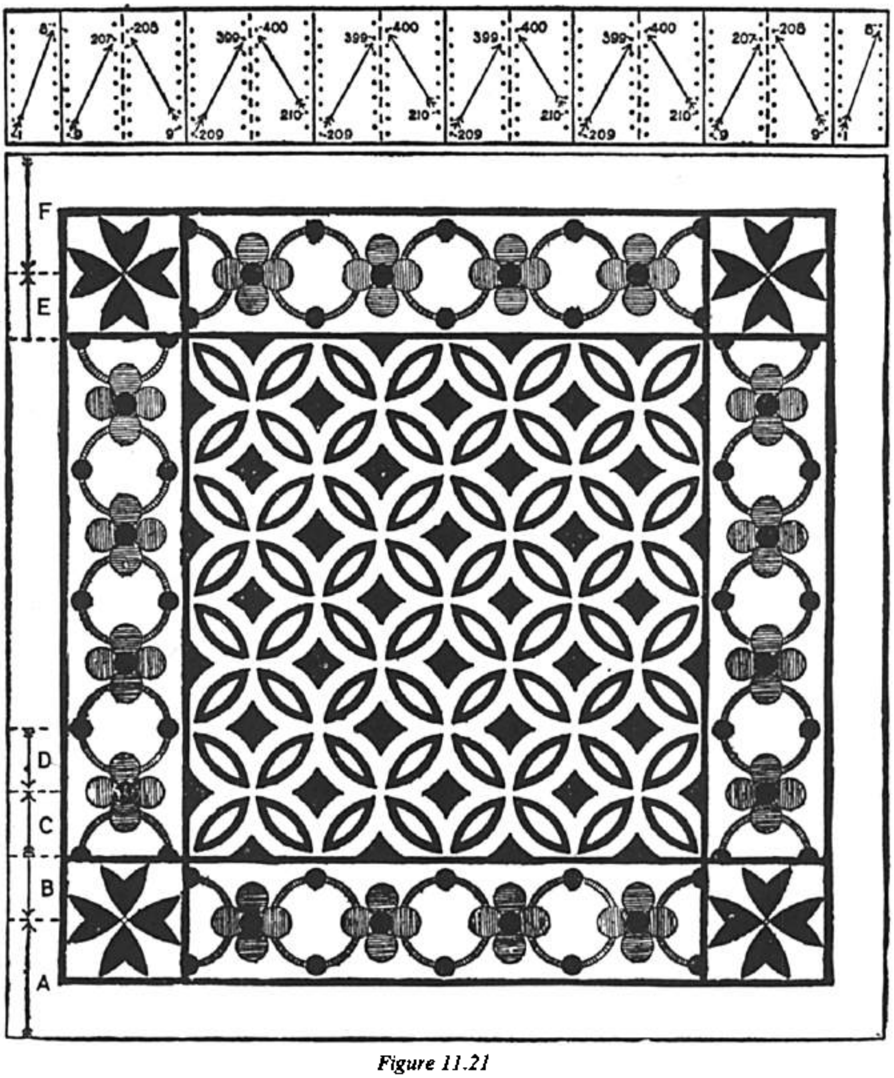


Figure 11.21

Figure 11.21 corresponds with the last example in the foregoing list in which both the border and the centre are pointed. In this case a square is represented in which a central repeating figure is surrounded by a border figure, and the latter by a narrow unfigured portion. Usually the unfigured portion is woven in a twill or sateen weave, and in the tie indicated in the upper portion of *Figure 11.21* the hooks 1–8 are set aside for the purpose. 200 hooks are used for the borders, and the same number for the centre, and if a plain or other selvage is also required the hooks that are in line with the peg-holes may be utilised.

Different methods are employed in weaving cross-border fabrics in which the figure is repeated several times, with the idea of using as few cards as possible. One method is to use a special cross-border jacquard made on the double-lift, single-cylinder principle with an extra cylinder upon which the border cards are placed. The centre cards act on the needles and hooks in the ordinary manner, while the border cards connected to the ordinary needles by suitable links produce the same result as if they had been placed upon the other cylinder.

The complete square, shown in *Figure 11.21*, contains, both vertically and horizontally, two repeats of the border and four repeats of the central figure. The repetition and arrangement of the different sections across the design is due to the special harness tie that is employed. A similar repetition and arrangement can be obtained lengthwise by employing two sets of cards, which are brought into action in turn. One set forms the corner and the cross-border figures, and the horizontal unfigured portions, and the other set the side-border and central figures. All the cards require to be cut to operate the selvages and the unfigured portion at the sides.

The complete square shown in *Figure 11.21* might be woven by cutting as many cross-border cards as will weave the portion indicated by the arrow A, and as many centre cards as will produce the portion represented by the arrow C. The two sets of cards are then brought into operation in turn as follows: First—the border cards turning towards the machine, as indicated by the arrow A, and then away from the machine until the border figure is completed, as indicated by the arrow B. Second—the centre cards turning alternately towards and away from the machine, as indicated by the arrows C and D respectively, for four repeats. Third—the border cards turning towards the machine to weave the figure portion, as indicated by the arrow E, and then away from the machine, as represented by the arrow F. The border cards are then retained in operation, while the first border of the next square is woven.

12

Construction and Development of Jacquard Designs

CONSTRUCTION OF SQUARED PAPER DESIGNS

The construction of jacquard designs includes the preparation of a card cutting plan on squared paper, which in most cases when an ordinary jacquard is used shows the complete working of every thread in the repeat. As opposed to the above system of detailed designing there exist forms of condensed design preparation where only the main motif is shown in block outline, and where the detailed weaves for each part of the motif are automatically introduced by the use of either, the special card cutting machines such as the Uhlig or the Dactyliseuse, or, the special jacquards. The methods of condensed design construction are explained in *Watson's Advanced Textile Design.*

In the detailed form of designing the point-paper design may be constructed from an original sketch, or from a woven sample of which the design is required to be reproduced. In either case the process generally involves an enlargement of the design, the degree of increase in size varying, in the same pitch of design paper, according to the fineness in sett of the cloth.

It is first necessary to ascertain the proper counts of the design paper and the most convenient number of ends and picks, or vertical and horizontal spaces of the design paper, upon which to draft the design, as previously described. It is shown in the calculations that the number of ends and picks, found by multiplying the ends and picks per inch respectively in the finished cloth by the width and length in inches of the repeat, may require to be modified to suit the sett and capacity of the jacquard and the repeat of the ground weave. That is, it is necessary to either select a jacquard which will give the width of repeat of the design, or to construct the design upon a number of ends that is suitable for a given jacquard. The formula

$$\frac{\text{hooks in jacquard} \times \text{sett of warp in reed}}{\text{sett of harness}}$$

gives the number of ends upon which the design should be made in order that the warp will be perfectly straight between the harness and the reed. In practice, however, the calculated number is not rigidly adhered to, as it is found that it can be varied, within limits, to suit the conditions of manufacture with practically no deteriorating effect upon the weaving of the warp.

It is a good method to decide upon a number of ends for a repeat which is a multiple of several smaller numbers, and to use this number for cloths which vary slightly in fineness. For example, a 36 sett warp is perfectly straight between the harness and the reed when woven in a 38 sett 304-tie jacquard with the design repeating on 288 ends; and designs repeating upon 288 ends, or a factor of 288, can be woven in the machine in cloths which vary in sett from 34 to 38. Again, with the same sett of harness, 240 is the calculation number for a 30-sett warp, which may be employed for cloths varying in sett from 28 to 32. The limits given are frequently exceeded in practice. This principle of working enables the same design to be applied to slightly different setts without re-making.

After the number of ends and picks required for one repeat of the design have been decided upon, the design paper work may be divided into the following processes: (1) An enlarged outline of the figure is drawn in pencil or chalk on the squared paper; (2) the figure is painted in with colour which is strong yet transparent; (3) the necessary weaves for the suitable development or binding of the figure are inserted in a second colour; (4) the ground weave is painted in. The work is frequently very tedious and occupies a large amount of time, and considerable skill and experience are required in reproducing a design to the best advantage. Much of the work, however, is almost mechanical, and ingenious methods have been adopted to reduce the amount of time and labour involved.

Process of drafting a sketch design

Previous to drawing the outline of the figure it is necessary to prepare one repeat of the design so that it can be enlarged exactly to the required scale. *Figure 12.1* illustrates the method of procedure in drafting a sketch design. It is assumed that the repeat is upon 288 ends and 352 picks, and in a square sett cloth the design paper could be 8 × 8. One exact repeat is indicated by ruling vertical and horizontal lines which respectively pass through similar parts of the figure. If the sketch has been correctly constructed, these lines are at right angles to each other. The repeat is then divided into small spaces, each of which represents a certain number of ends and picks in the cloth and of small squares on the point-paper. Any number of threads may be represented by each small space, but usually a sketch is ruled so that each space corresponds to one, two, or more of the large squares of the design paper. In designing for medium and low-sett cloths, it is very convenient to so rule the the sketch that the lines correspond with the thick lines of the design paper. With the same rate of ruling for fine-sett cloths, however, the spaces in the sketch are so small that they are difficult to follow and for cloths which count over 32 threads per cm the method illustrated in *Figure 12.1* will be found useful. The repeat of the sketch is so divided that each space represents 2 × 2 large squares, or 16 ends and 16 picks in this case. The repeat in width is thus divided into 18 spaces of 16 ends each to correspond with the repeat of 288 ends, and in length into 22 spaces of 16 picks each to correspond with the repeat of 352 picks.

The different stages of drafting a figure are illustrated in *Figure 12.2*, which corresponds with the bottom left-hand corner of *Figure 12.1*. The portion A in *Figure 12.2* shows how the outline is copied from the sketch to the scale of

16 ends and 16 picks to each space in *Figure 12.1.* The process of drawing the outline is very much facilitated by indicating distinctive lines at regular intervals in ruling the sketch, and by ruling lines at corresponding distances apart on the design paper. Thus, in *Figure 12.1* alternate lines are thicker than the others, while in *Figure 12.2* lines are lightly indicated, to correspond with the thicker lines, upon the last space of every fourth square. The distinctive

Figure 12.1

Figure 12.2

lines enable corresponding portions of the figure in the sketch and point-paper to be readily found and retained.

The second stage of working, which is illustrated at B in *Figure 12.2*, consists of painting in the small squares along the outline, and then filling in the figure solid with a wash of transparent colour. The parts lettered C illustrate the third stage in which the long floats are stopped and the figure developed by inserting marks in various orders in a colour that is in contrast with the first colour. Vermilion is chiefly used for painting the figure, and blue for the binding weaves.

Drafting designs from woven fabrics

Woven patterns are employed in two ways by the designer. In some instances the design is required to be reproduced exact in every aspect to the original and in a similar cloth; in other cases the patterns are only intended to serve as indications, the designs being modified and adapted to suit cloths which, perhaps, have very little resemblance to the original textures. In the former case it is essential that—(1) A suitable jacquard be employed to get the same size of repeat; (2) an exact copy of the form be obtained on the squared paper; (3) the weaves in the figure and ground respectively of the pattern are correctly analysed and reproduced in the new design.

The second method of using woven patterns is much more common than the first, and it is probably due to such a large variety of effects being now required for a comparatively short length of cloth that the system has recently attained such prominence. The patterns are purchased by manufacturers and merchants from firms who make a speciality of collecting the latest productions, and when a range of designs is required in a given cloth a number of suitable samples are selected to be reproduced. Only a portion of the ornament in a cloth may be used, and sometimes a portion from one sample is combined with a portion from another. From the manufacturer's point of view the question as to whether such a system should or should not be employed simply resolves itself into one of economy and expediency. The time which would otherwise be occupied in sketching new figures is saved, while a larger variety of effects can usually be obtained in any given range than when the designer's creative skill solely is relied upon. Further, the advantage to the designer of seeing and studying the various combinations of forms, colours, and materials observable in these patterns, cannot be over-estimated.

The character of the cloth in which a design is reproduced is an important factor in deciding how much resemblance there is between the new design and the original. The new cloth may be composed of different materials; it may be necessary to increase or decrease the amount of detail in drawing the outline of the figure on the point-paper; also various weave changes may be required in the figure and ground in order to adapt the design to the new texture. The result is that frequently an effect is produced in which the original design cannot be recognised.

Designs which are entirely geometrical in form, such as that shown in *Figure 12.3*, can be reproduced from woven patterns directly on to the design paper with the aid of compasses and ruler. The positions of the base lines and centres can be obtained by calculation after the number of threads in the repeat have been determined; also the number of squares to allot on the point paper for any portion of the figure can be found by measuring and calculating from the number of ends and picks per cm to which the design is being worked out. *Figure 12.4* illustrates, in a very reduced form, the method

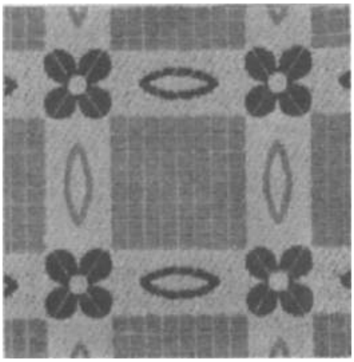


Figure 12.3

of drawing the base lines directly upon design paper from the pattern represented in *Figure 12.3*. After these have been indicated it is only necessary to clothe the lines with the calculated size of float.

In drafting woven designs that are not geometrical in form it is necessary to divide one repeat into small spaces in the same manner as in drafting a sketch design. Different methods of accomplishing this are employed, one of

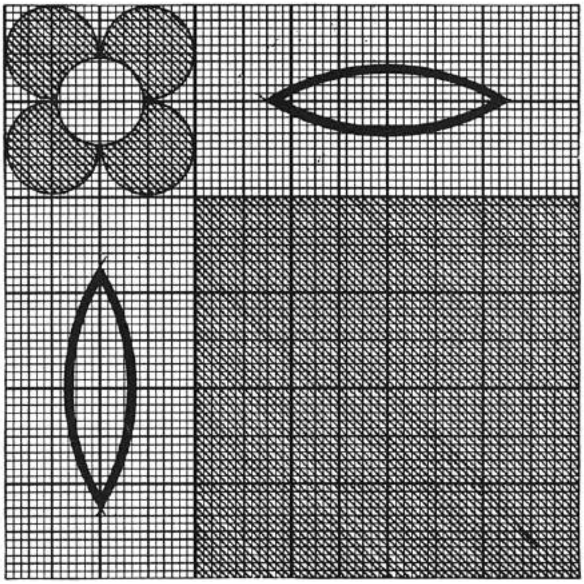


Figure 12.4

which consists of first making a sketch of the figure. A copy is readily made upon transparent tracing paper if the figure can be seen through it. If tracing paper is impracticable the method illustrated in *Figure 12.5* may be employed. The sample of cloth is pinned or pasted, at two opposite edges, on to a sheet of plain paper, and the outline of the figure is pricked round with a fine needle.

By placing a piece of carbon paper between the cloth and the sheet of paper the outline of the figure is shown in small black dots. A line is then drawn through the dots to complete the sketch, as shown in the bottom left-hand corner of *Figure 12.5*. Rather more than one repeat should be made, in order that two lines parallel with the weft and two parallel with the warp may be drawn which pass through similar parts of the figure and enclose one complete repeat. This is then divided up by drawing other lines, at regular distances apart, in the manner previously described in reference to a sketch design. It is frequently found that the warp and weft threads are not exactly

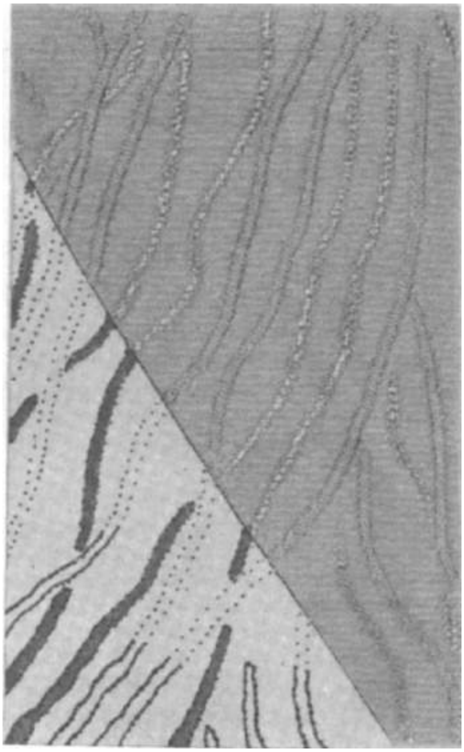


Figure 12.5

at right angles to each other, as the finishing processes have a tendency to distort the cloth, and for this reason care should be taken in dividing up the repeat to have the two series of lines parallel with the warp and weft threads respectively, or the figure will not join up correctly at the sides and at the top and bottom of the sheet of design paper. In drawing the outline on the design paper the shape of the figure should be observed in the cloth as well as in the sketch.

The construction of a sketch from a woven pattern is chiefly useful when changes in the design have to be made, and when the sketch has to be submitted for approval. If the method is used solely for the purpose of enabling a repeat to be squared out, it is really a waste of time, as other methods may be employed in which the design is made directly from the cloth.

A very quick method of squaring out woven designs is illustrated in *Figure 12.6*. An apparatus is used that consists of a wood frame A, which is nicked at regular intervals along the outer edges. Threads are passed vertically and horizontally along the under side of the frame, in such a manner that its interior is divided into small squares. The frame A rests on a flat board B, and is hinged to the latter at C, so that the opposite end of A can be raised while the pattern is placed on the board. The frame is then dropped so that

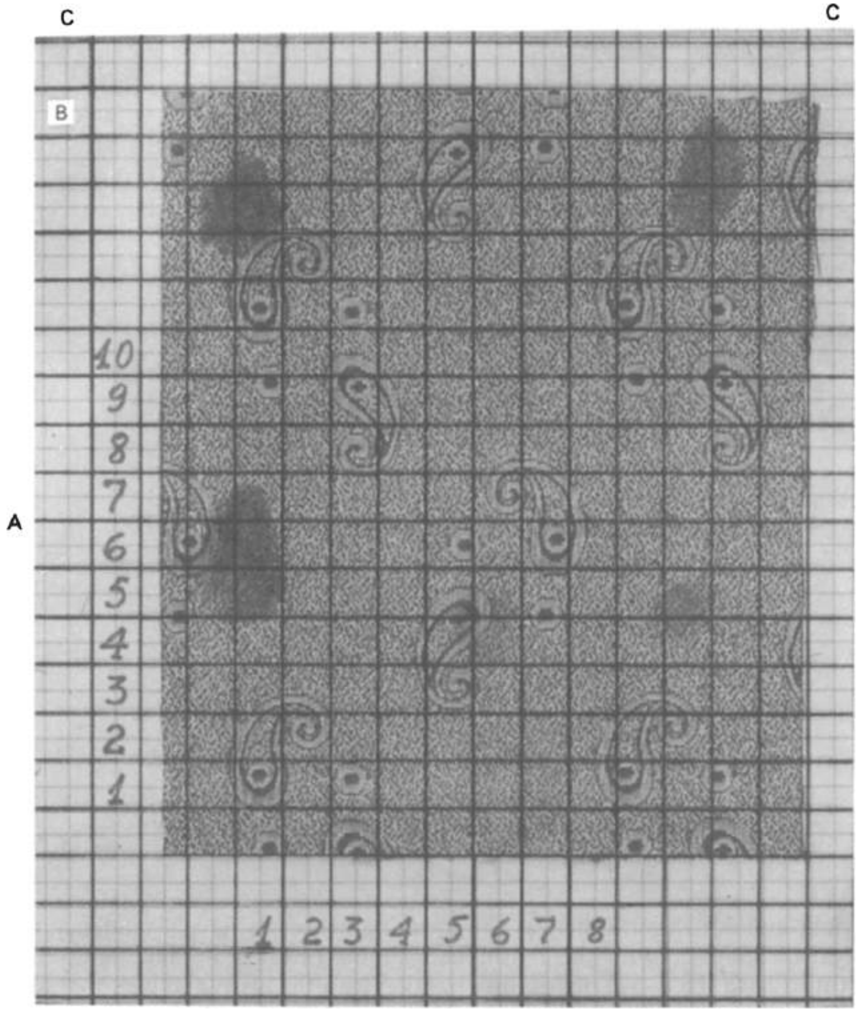


Figure 12.6

the threads rest lightly on the cloth until the latter has been drawn with a needle into such a position that the picks are parallel with the horizontal threads of the frame, and the ends parallel with the vertical threads, after which the frame is pressed down and secured with a small catch. No difficulty is found in squaring out patterns which are distorted, as the pressure of the threads retains the cloth in any position into which it has been pulled before the frame is pressed down.

The threads are wound at fixed, equal distances apart, so that surface of the cloth is divided into equal spaces. Taking the spaces to be 0·5 cm square, which is a convenient distance apart of the threads, the number of squares of the design paper, which each division of the pattern represents, may be found as follows: Assuming that a design has to be worked out at the rate of 32 ends and picks per cm, each division represents 16 squares on the design paper. Again, assuming that the pattern shown in *Figure 12.6* has to be made upon 184 ends and 174 picks—the repeat occupies $7\frac{2}{3}$ divisions in width, and $9\frac{2}{3}$ divisions in length, therefore, each division will represent $184 \div 7\frac{2}{3} = 24$ ends, and $174 \div 9\frac{2}{3} = 18$ picks. A figure is drawn on the design paper much more readily if the threads are passed across the frame in alternate colours, the design paper being then ruled, at the required intervals, with alternate colours of pencil to correspond.

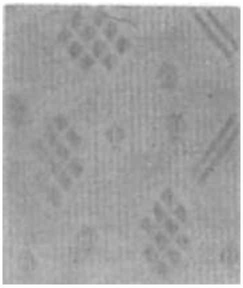
DEVELOPMENT OF FIGURES

After a figure has been correctly painted in with transparent colour the next process is, usually, to insert suitable weaves upon it. The weaves should be selected with the following objects in view: (1) To produce a good texture—that is, a texture in which the threads are interwoven to such a degree that they are not liable to slip or fray when the fabric is subjected to strain and friction during wear. (2) To develop the figure in such a manner that the form is shown to the best advantage in the finished cloth.

Prevention of long floats

In some designs, of which an example is given in *Figure 12.7*, the form breaks up the mass of the figure to such a degree that no weave is required to be inserted either for stopping the floats of yarn or for developing the effect.

Figure 12.7



This condition occurs particularly when lustrous yarns are employed in forming small figures, which, if broken up too much, appear less bold and effective. *Figure 12.8* shows the squared paper design of a portion of *Figure 12.7*. The example illustrates the necessity of painting in the squares in odd numbers on the edge of a figure when plain ground, or a ground based upon plain weave, is employed, in order to ensure perfect joining of the ground weave with the figure.

When boldness of effect is required in large figures very frequently binding marks are inserted only where the floats on the face or back of the fabric will otherwise be too long. Such a method of development is illustrated by the

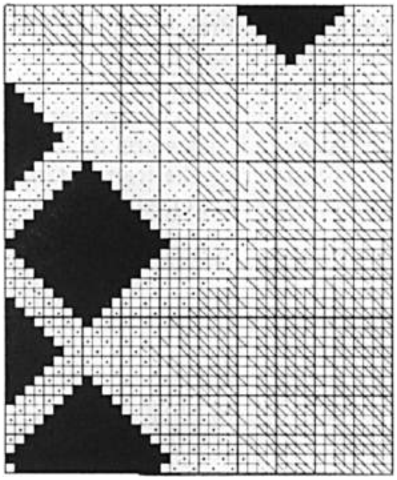


Figure 12.8

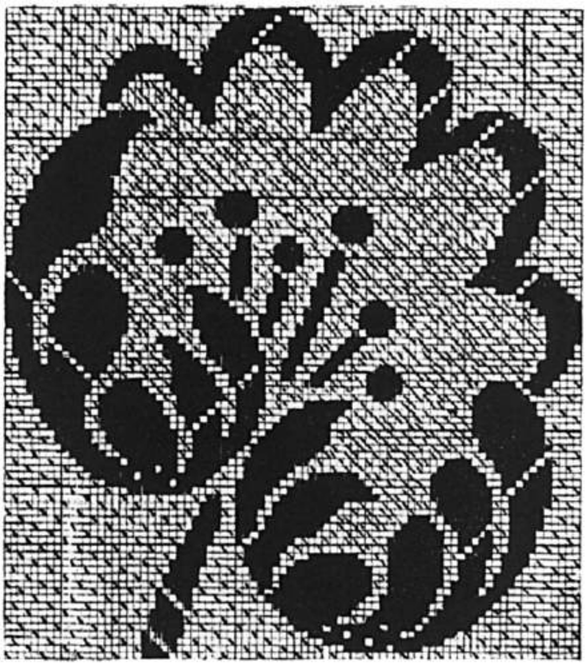


Figure 12.9

plan given in *Figure 12.9*, which represents a weft figure surrounded by warp satin ground. The example also illustrates how an open figure may be made to appear massive by inserting in the interior a weave—in this case a crêpe—which contrasts well with the ground weave (Note: marks = warp down).

Bold and flat development

In some massive styles the form can be effectively developed by inserting a large twill or sateen weave regularly over the surface of the figure, the former being employed when a lustrous and bold appearance is required, and the latter in producing a flat and less prominent effect. *Figure 12.10* shows how both twill and sateen weaves may be employed in developing the same figure,

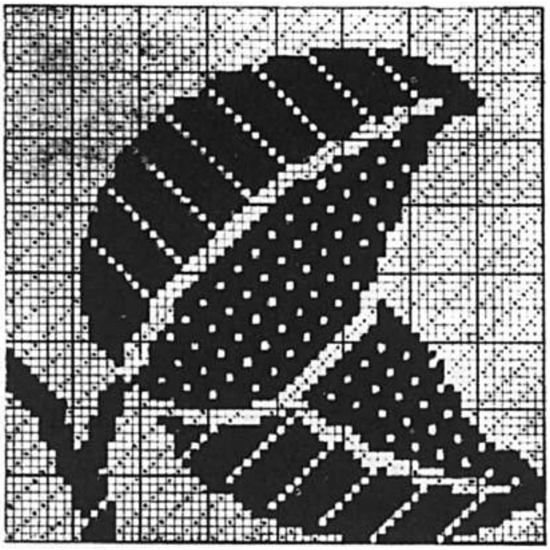


Figure 12.10

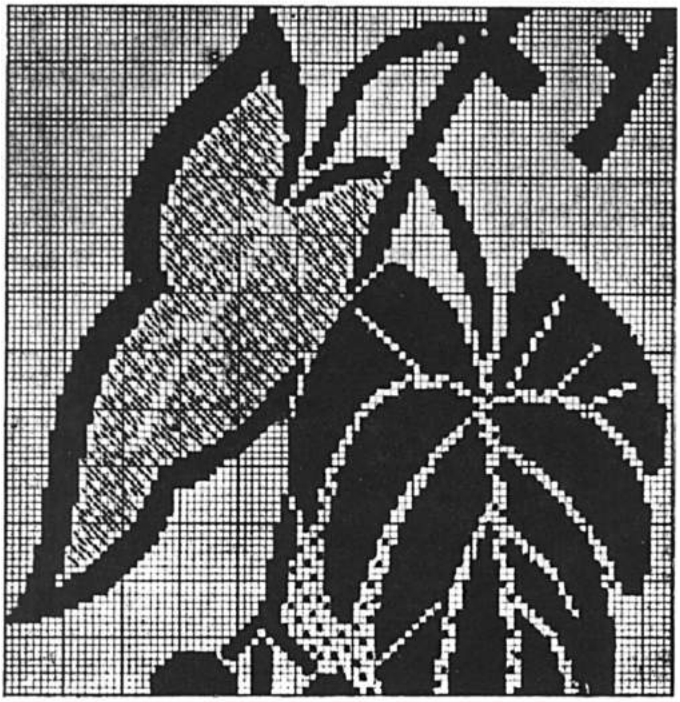


Figure 12.11

the effect in this case being to bring out the twilled portion of each leaf more prominently and with a brighter appearance than the other portion.

Another method of developing leaves, which is similar in principle to the foregoing, is shown in *Figure 12.11*. In this example one of each pair of leaves is brought up massive and bold, while the other appears much less prominent but its distinctive shape is yet retained. The form of the bold leaf is developed (marks = warp down), by simply bringing up the veins in warp flush with a few additional binding places inserted to stop the floats which are too long. The other leaf is developed in fairly bold weft flush along the outer edges, and the interior is filled in with a four-thread weft satinette, except where the veins are shown in warp flush. This plan also shows the correct method of developing the fine lines which form the veins and stems. It is important that these show up distinctly and at the same time that they do not detract from the prominence of the main feature of the design, which in this case, is formed by the leaves.

Development of large figures

The pattern shown in *Figure 12.12* illustrates how a large number of weaves may be employed in developing a massive figure. The contrast in the appearance and the variation in the light and shade of the different weaves give interest to the effect, and assist in showing up the parts of the form clearly.

Figure 12.12

Figure 12.13

A design paper plan of a figure of this type is given in *Figure 12.13* (convention reversed). Such a combination of weaves in one figure is specially suitable for fabrics composed of dull warp and lustrous weft, which, if woven with plain ground, should be set with from 24 to 32 ends and picks per cm to show the detail clearly.

The design shown in *Figure 12.14* is in decided contrast to the preceding example as here only one weave is employed in developing the figure. Such a weave can only be suitably applied to a massive style, in which considerable latitude may be taken in following the outline. A portion of squared paper design given in *Figure 12.15* shows clearly that the figure is developed in the form of solid areas of plain weave separated from each other by a loose and open outline obtained through the use of mock leno structure. The general

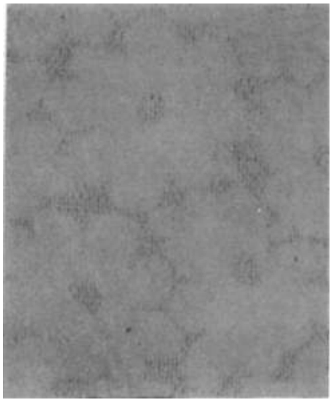


Figure 12.14

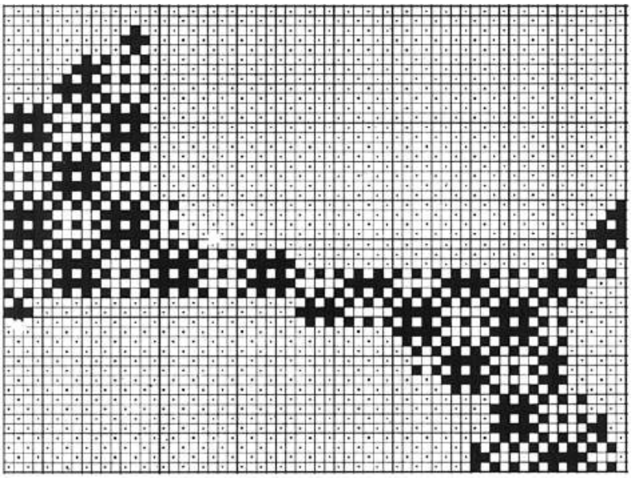


Figure 12.15

effect is that of an opaque figure on transparent ground, and the manner of development employed achieves a distinctly flat appearance which is characteristic of all designs in which only two weaves arranged in well defined areas are utilised.

Use of warp and weft float in figure development

The development of a figure in both warp and weft float is illustrated in *Figure 12.16*. This method is particularly applicable to cloths in which there is a good degree of contrast between the colours of warp and weft. A squared paper design of a portion of *Figure 12.16* is given in *Figure 12.17*. In drafting a figure formed in warp and weft float, the outline is drawn in the ordinary way, then the warp float is indicated in one colour and the weft float is either left blank, or, it may be painted in another colour. In the example given the warp figure is indicated by solid marks and the weft figure by shaded squares.

Figure 12.16

Floats of excessive length in either the warp or the weft faced areas are stopped by the opposite marks and the ground weave, or weaves, are indicated by colours or marks which are different from those used for the figure. It will be appreciated that as in *Figure 12.17* all marks, except the shaded squares, indicate warp up the card cutting instructions will be: cut all marks except the shaded squares.

It will be observed from *Figures 12.16* and *12.17* that the ground weave in this cloth is an 8-shaft warp satin (indicated by dots), and as this is a warp

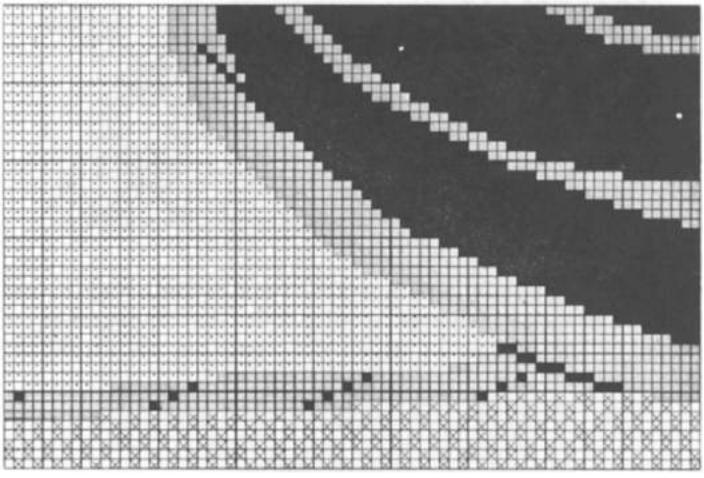


Figure 12.17

faced structure it must be rigidly separated from the warp float figure in order to achieve the necessary clarity of effect. This is achieved by ensuring that the outer outline of the figure is invariably composed of the weft float. An auxiliary effect in a rib weave surrounds the main figure and this is indicated by the crosses in *Figure 12.17*.

Figure shading

The shaded development of figures enables different degrees of light and shade to be obtained in a graduated manner, so that a natural form—flower, leaf, etc., can be represented in a natural way. In *Figure 12.18* the petals of a flower and the body of a bird are shaded so as to form a subdued but pleasing contrast with the parts which are developed in bold floats. The principle is applied most successfully to fine textures composed of smooth and even yarns.

Figure 12.18

The most common forms of shading are produced by using a twill or sateen weave as the base and varying the floats of weft and warp, as shown in *Figures 12.19* and *12.20*. For instance, a 6-thread twill basis enables five changes to be made i.e., 1-and-5, 2-and-4, 3-and-3, 4-and-2, and 5-and-1, as shown at A in *Figure 12.19*. The space to be shaded, in this case 36 ends, is divided into five sections, and the 1-and-5 twill is marked in, as shown by the crosses. The first section is left as it is, one mark is added in the 2nd section, two marks in the 3rd, three marks in the 4th, and four marks in the 5th, with the result that the weft float is gradually reduced, and the warp float correspondingly increased, and 5 degrees of light and shade are produced.

In the method shown at A in *Figure 12.19*, the warp and weft are brought about equally to the surface of the cloth, hence both series of threads should be of good quality. B illustrates a shaded weave, based upon six threads, which is suitable for shading a cloth in which, taking the marks to indicate warp, the warp is better material than the weft. There is less variation in light and shade, however, than in the former method. The 1-and-5 twill, indicated by the crosses, is changed to the 1-and-2, 2-and-1, 5-and-1, and 11-and-1 twills in succeeding sections. The last weave is suitable to use in forming the edge of a figure when a prominent outline is required.

C in *Figure 12.19* shows, in the first three sections, how a 4-thread twill may be changed from weft to warp surface, and, in the 4th section, to 7-and-1 twill.

In the form of shading shown at D in *Figure 12.19*, the floats on the face are arranged to fit with plain ground. This method is suitable for fabrics in which only one yarn shows prominently on the face. The end section shows how the 4-thread twill may be changed to the 8-thread satin.

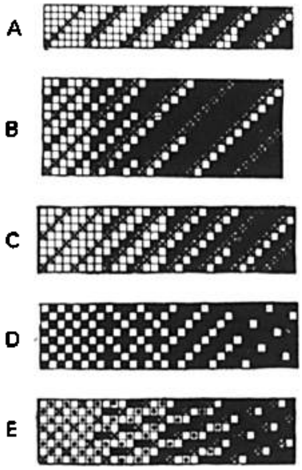


Figure 12.19

E in *Figure 12.19* illustrates the principle of shading the 8-thread satin to fit with plain ground. The 10-thread satin may be shaded in a similar manner.

F and G in *Figure 12.20* show two methods of shading the 8-thread sateen weave, each of which gives seven degrees of light and shade. The sateen base weave is indicated by the crosses; in F the marks are added at the top, and in

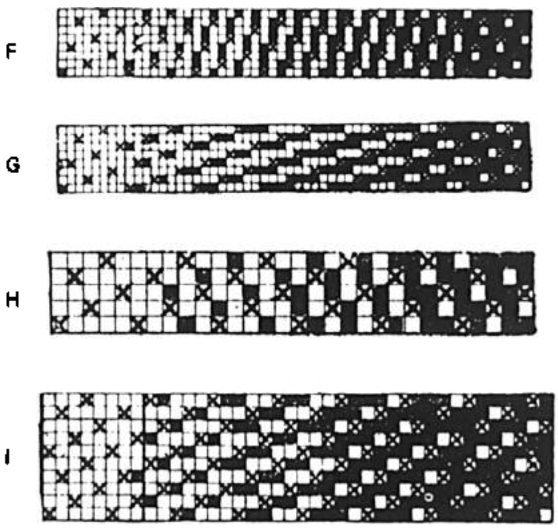


Figure 12.20

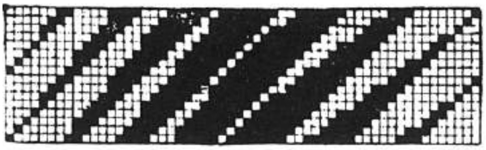
G at the side of the base marks. A comparison of the warp and weft floats in the centre five sections of F and G will show that the method of adding the marks influences the appearance of the weave. In F the marks are arranged mainly in the vertical direction and, therefore, this method is used when it is intended to display the warp on the surface, whilst the method shown in G is employed when it is desired to show the weft, as the horizontal arrangement of marks tends to make the weft more prominent than the warp.

H and I in *Figure 12.20* illustrate two methods of shading applied to the 5-sateen weave. In H the marks are added to the top of the base marks, and four degrees of light and shade are formed. I is similar to H except that the marks are added at the side, while the 5-sateen is changed to the 10-satin in the end section in order to give further variety.

Double shading

The examples given in *Figures 12.19* and *12.20* illustrate the principles upon which figure areas are shaded, but in the form shown, the designs may be used on their own in the production of shaded weave stripes. Only single-shading, however, is represented—that is, the weaves are shaded only in one direction, so that a complete change from weft to warp surface is made where

J



K

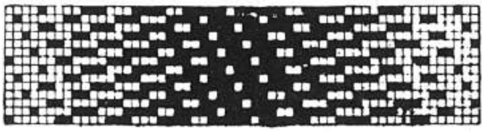


Figure 12.21

the first and last ends join. In double-shading, which is illustrated at J and K in *Figure 12.21*, the severe contrast in light and shade, produced in single-shading, is avoided, as the weaves gradually merge into each other in both directions. J shows the combination of 8-thread twills, running from 1-and-7 to 7-and-1 by adding one mark more in each section, and then back again to 1-and-7 by subtracting one mark in each section. K in *Figure 12.21* is based upon a 7-thread sateen weave, and is constructed in a similar manner to J, the additional marks being placed at the side of the base marks.

Shaded development of figures

Figure 12.22 illustrates, step by step, the method of developing a figure in 5-sateen weaves as a shaded effect after the outline of the figure has been indicated on the design paper. (1) As shown at A, the space to be shaded is divided into as many sections as there are changes in the base weave, and the latter is inserted entirely over the space. The sections need not be equal in size as the given space may be divided up unequally so as to allow either warp or weft to predominate on the surface. (2) As shown at B, the weave in the first section is left as it is, and a mark is added to each sateen mark in the 2nd, 3rd, and 4th sections. (3) As indicated at C, a second mark is added in the 3rd and 4th sections; and (4) as shown at D, a third mark is added in the 4th section.

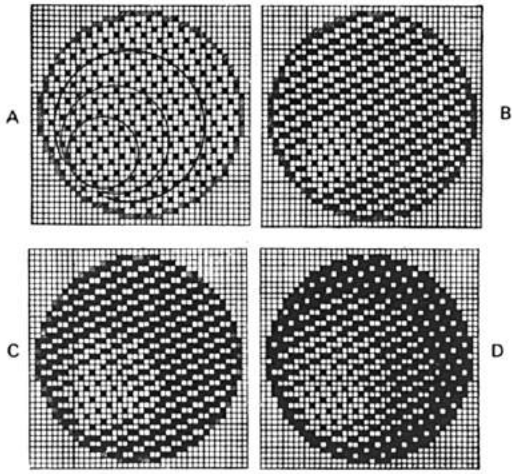


Figure 12.22

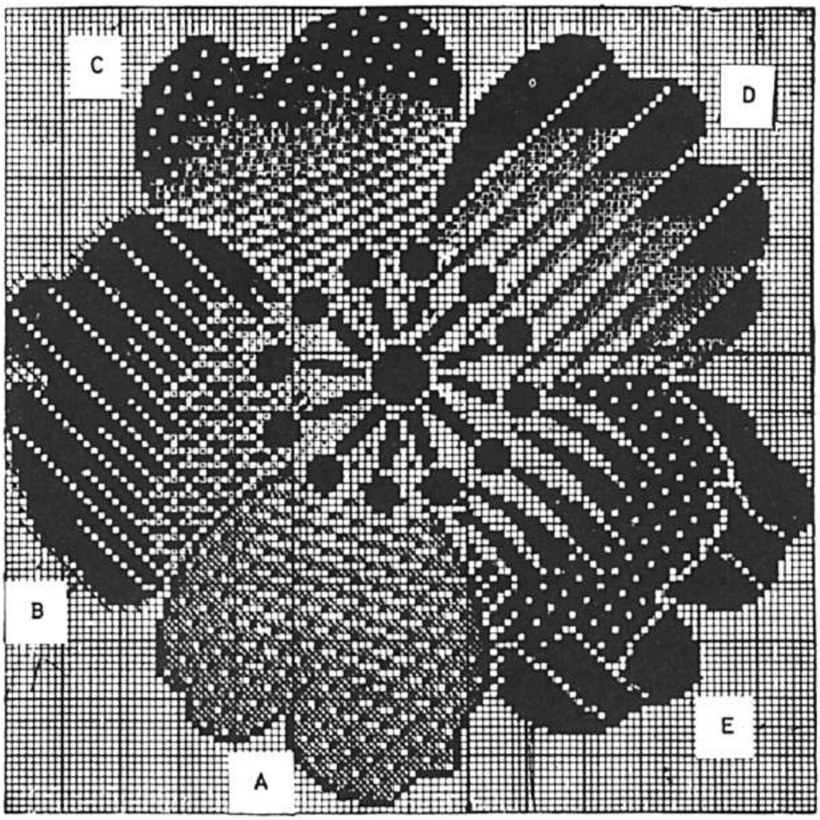


Figure 12.23

It is better to add the marks always at the same side of the base marks, and it is usually more convenient to add them gradually, as shown, than to paint over the whole of the figure in one colour, and put in the shaded weave in a second colour.

For the purpose of illustration, several different methods of shading a figure are shown in *Figure 12.23.* At A the 8-sateen weave is employed for the base, and the warp is brought mostly to the surface. The twill method of shading, indicated at B, is suitable for a somewhat coarse texture in which a plain ground, or a ground weave based upon plain, is employed. The binding of the figure in twill order brings out the effect more boldly than when a sateen weave is employed. The shading shown at C is based upon the 5 thread sateen, and as this weave is firmer in structure than the 8-thread sateen, it may be used in a lower texture than the latter. Boldness of outline and variety of effect are obtained in C by changing the 5-sateen to the 10-satin along the outer edge of the figure. At D the 6-thread twill is employed as the base; this weave being changed to the 11-and-1 twill along the outer edge of the figure. A, B, C, and D correspond with the methods illustrated in *Figures 12.19* and *12.20*; but E shows another system of development, which is sometimes employed when boldness and variety of effect are required. The 8-satin weave about the centre of E produces a rather flat effect compared with the outer edge and the shaded portion of the figure.

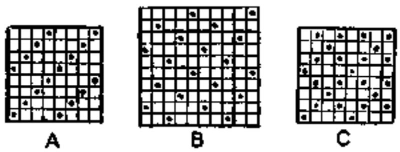
INSERTION OF GROUND WEAVES

The difference in appearance between the figure and ground of a design is due chiefly to contrasting weave development of the two areas; the distinction should always be sufficiently pronounced for the figure to show clearly. Therefore, it is usually necessary to avoid weaves that will produce a bold effect in the ground areas, in order that the prominence of the figure will not be reduced.

Printed ground weaves

Design paper can be purchased upon which the most commonly used ground weaves are printed in small dots, as shown at A, B, and C in *Figure 12.24.*

Figure 12.24



The 1-and-3 twill dot shown at A is chiefly employed for plain and 1-and-3 twill grounds. In addition to enabling the cards to be cut without laboriously filling in the ground weave, the dots enable the outline of the figure to be easily painted in so as to fit with the ground weave.

Joining of figure and ground

In using design paper upon which the 5-sateen weave is printed, as shown at B in *Figure 12.24*, certain of the ground dots that are in contact with the edge of the figure require to be taken out, in order that a proper junction will be made between the figure and the ground. Also, when this causes a float of more than five to be formed it is necessary for the float to be broken by the insertion of an additional mark. This is illustrated by the design shown in

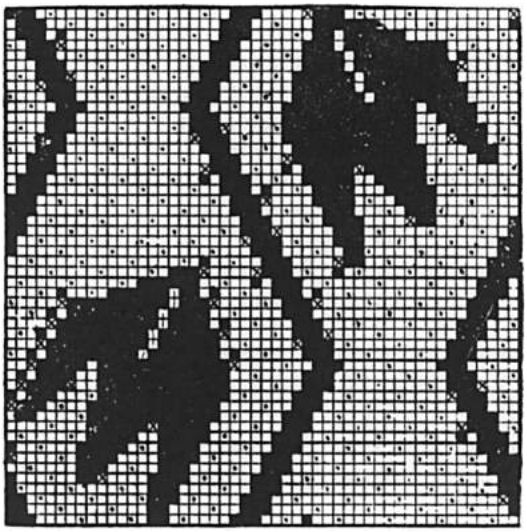


Figure 12.25

Figure 12.25, which is arranged with the lines of the figure running at different angles. The crosses indicate the dots which require to be taken out, and the full squares the marks which are then inserted to stop the long warp floats (marks = weft up) which would otherwise appear as stitching marks on the face of the cloth. In inserting any ground weave which does not fit with the moves at the edge of the figure, modifications require to be

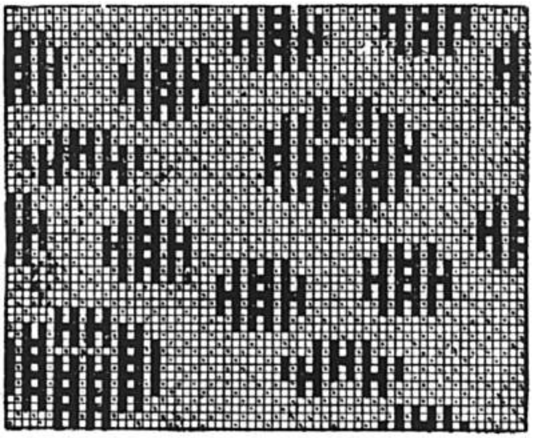


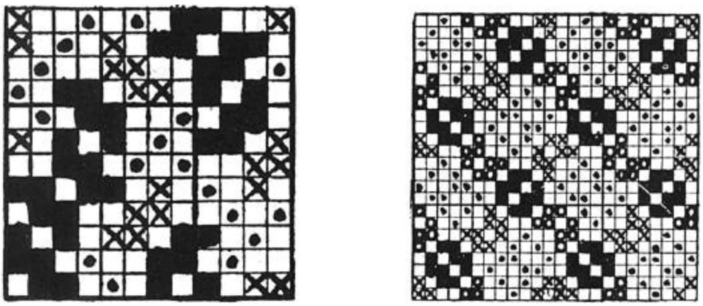
Figure 12.26

made at the junction of the figure and ground, as shown in *Figure 12.25*, in order to stop floats that are too long, and to ensure that a clear edge to the figure is formed.

The style of printed design paper, shown at C in *Figure 12.24*, is chiefly used for ordinary fabrics woven with plain ground, in place of the 1-and-3 twill dotted paper. It is, however, specially useful in designing for plain ground cloths in which alternate warp threads are composed of a special yarn which is employed in forming the figure. The dots serve as a guide in painting in the warp figure to fit with the plain ground, and also enable the figuring threads to be readily distinguished from the others. The design shown in *Figure 12.26* illustrates these points, and shows how the dots on the alternate even threads should be modified under the figure to prevent the formation of long floats of weft on the back of the cloth.

Crêpe ground weaves

The insertion of ground weaves of a crêpe character, such as those shown at D and E in *Figure 12.27*, is usually a tedious process unless a special method of working is employed. A careful examination will usually show that the weave marks have not been put together in a haphazard fashion in a crêpe,



D E

Figure 12.27

but that a definite system of construction has been employed which can be made use of in filling in the weave as a ground effect. In the examples different marks are used for the different parts of the weaves, in order that in each the basis of construction may be more readily seen. Thus both D and E are arranged on the turnover or reversed principle, and by inserting the weaves, step by step, in the order in which the different marks are indicated a complex effect may be made to appear simple, as the different parts can be put together from memory. For example, the weave shown at E may be inserted at four stages. First, that portion of the weave which is shown by the full squares is filled in over the required surface. This is followed by the portion indicated by the crosses, and the ground at this stage has a diagonal appearance, which is afterwards converted into a diamond shape by inserting the portion shown by the circles. The space which remains is then readily filled in by inserting the weave represented by the dots.

When the different parts of a figure are detached from each other, so that a fair amount of ground space is left between them, the method shown in *Figure 12.28* may be adopted with advantage in inserting a difficult weave. The ground weave is first indicated upon a separate piece of point-paper cut the full width of the design, and upon a convenient number of picks. A line is then drawn as close to the figure as is convenient for the correct joining of the figure with the ground, and the ground is inserted around the figure within the lines. Commencing with the first portion of the design the ground sheet of point paper is doubled to fit the space in which there is no ground inserted, and it is pinned to the design until the cards have been cut from this

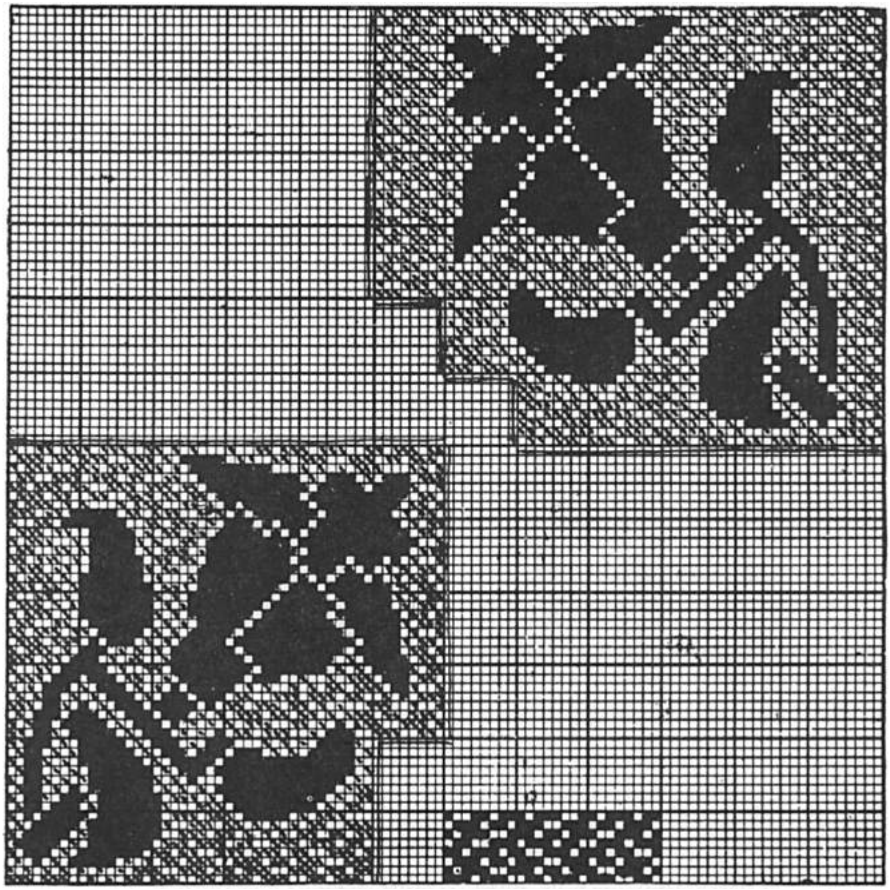


Figure 12.28

section. It is then moved to the next position, redoubled (if necessary) to fit the space between the parts of the figure, and another section of the design is cut, the process being repeated until the cutting is completed.

Stencilling ground weaves

In another method of inserting difficult ground weaves, the weave is indicated upon a separate piece of design paper, and small holes are punched in the squares where marks are shown. The separate piece is then placed on the design sheet and brushed over with a wash of colour, and the process is repeated until the whole of the ground has been stencilled in except at the edges of the figure. The joining of the ground and the figure is afterwards readily effected.

The value of an automatic arrangement for the insertion of the ground weaves will be readily appreciated at this point and in modern systems once the figure area has been carefully marked, repetition of the ground weave can be frequently left to the special card cutting machine provided with a mechanical selector.

CORRECT AND INCORRECT DESIGN DRAFTING

The chief points to note in painting in a figure on the design paper are (1) to form a good outline, and (2) to have the figure sufficiently massive and without weak places caused by fine lines. To obtain these results it is not always advisable to strictly follow the outline drawing, but to modify the form of the figure in painting it in. Typical illustrations of defective and good design paper work are given for comparison at A and B in *Figure 12.29*. In A the outline is defective because, in following the curves—say, in moving from the horizontal or the perpendicular to the angle of 45°, as shown at 1—the moves are not properly graduated. For example, commencing with the bottom pick of the figure shown at A, a float of 8 is followed by moves of 3, 4, 2, 3, 1, 2, on succeeding picks. The proper outline, as shown at B, is obtained by moves of 4, 3, 3, 2, 2, 1; that is, the distance moved at each succeeding pick is gradually reduced as the curve approaches the angle of 45°, after which the distance moved is gradually increased on succeeding ends until the perpendicular is reached.

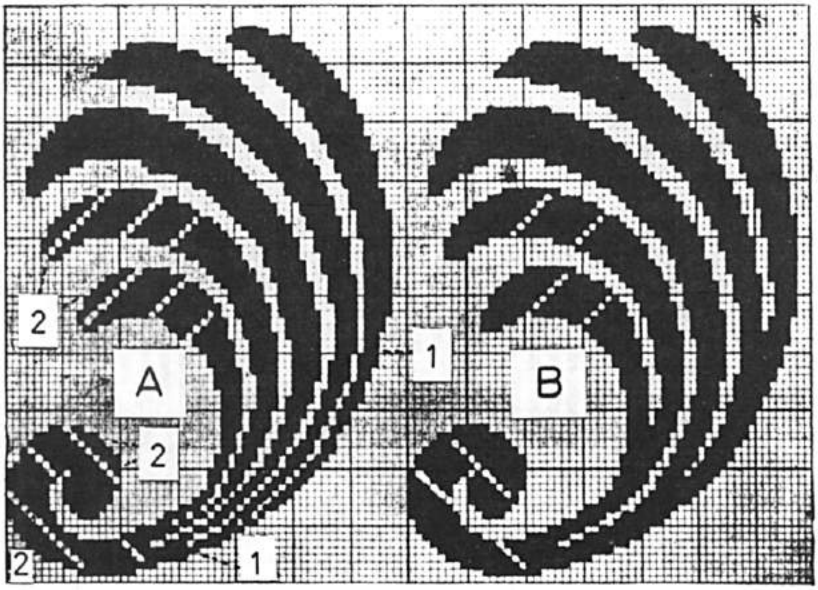


Figure 12.29

In binding the long floats of the figure in twill order, a good outline and mass may be made weak if the binding weave is inserted too near the edge of the figure. This defect is shown at the places marked 2 in A, *Figure 12.29*, whereas B shows the binding weave inserted in such positions on the figure that the outline and mass are preserved. Further, a comparison of the lower portion of A and B will show how weakness of outline and of mass, due to fine lines, may be avoided.

An unsuitable method of designing a figure on the point-paper is sometimes the cause of an otherwise well-balanced design showing a line or bar in the woven effect. This may occur under the following conditions: (1) When both the warp and weft yarns are floated in turn on the face of the fabric, or when two colours of warp or weft are used in producing the figure, without sufficient care being taken to ensure that each kind of float is regularly distributed. The defect is made more pronounced when there is a strong contrast between the figuring colours. (2) When a horizontal section of the design is given a longer float, and consequently made to show more prominently than the succeeding section, although there may be an equal amount of ornament in each section. (3) When the ground of the fabric is very firmly woven, the ground picks which precede and follow a portion of figure, tend to crowd the loosely bound picks

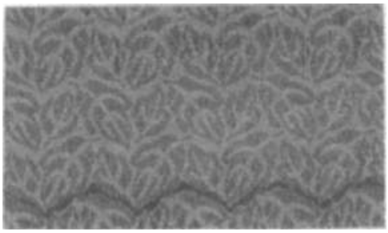


Figure 12.30

of the latter together, and barriness is thus promoted, because the space occupied by the figure is reduced. In the texture shown in *Figure 12.30*, a wavy bar appears, which may be said to be due to the combined influences of the preceding. In one section of the cloth the bar has been deliberately darkened in order to emphasise the effect that it produces in the design. As shown in the corresponding portion of design given in *Figure 12.31* the leaves are developed in warp float, which instead of being regularly distributed,

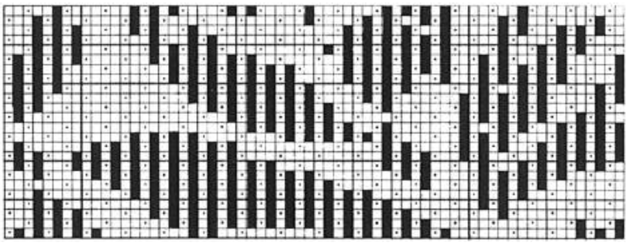


Figure 12.31

occurs in broad bands. This arrangement creates a gap between the bands, which, although undulating, shows quite distinctly. Furthermore, as the warp float along the line of the gap is all on the back of the cloth it tends to pull it up into a welt thus emphasising its presence more clearly. A suitable method of improving the design would be to incline the figure so that the gap was bridged at several points with the warp floats thus interrupting continuity of the bar.

The construction of a design upon squared paper can, in most cases, be greatly simplified by employing a method of working that is appropriate to the basis upon which the design is constructed. For this reason, in the following chapters, the designing of figures upon the recognised bases is considered along with convenient methods of design paper construction.

COMPOSITION OF DESIGNS

Methods of composing jacquard designs

There are three chief ways in which figure designs for textile fabrics are composed, viz.:

(1) By geometric ornamentation.
(2) By the conventional treatment of natural or artificial forms.
(3) By the adaptation or reproduction of earlier designs.

(1) Designs which are purely geometric in form result from the embellishment of intersecting vertical, horizontal, diagonal, circular, and radiating lines; and from the creation of spaces by the lines. Such designs may include conventionalised forms, or they may be adaptations of earlier styles.

(2) In 'conventionalising' a natural or artificial object the form is treated in a manner that renders it a suitable ornamental feature of the texture upon which it is displayed. It is generally necessary to simplify the form of an

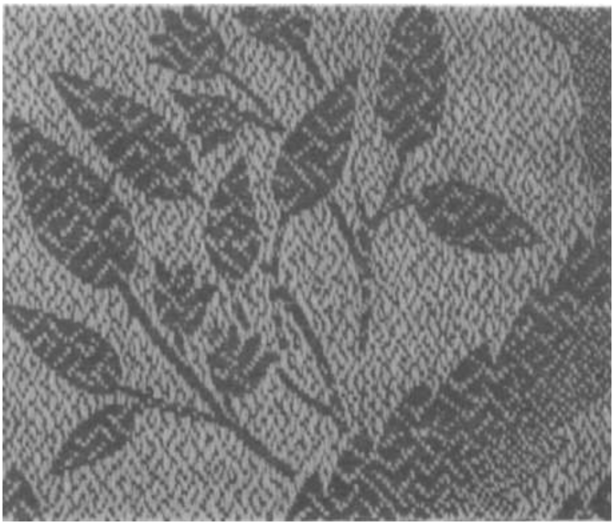


Figure 12.32

object, only the essential and characteristic features being abstracted; and, as a rule, the most important and beautiful parts are emphasised at the same time that they are made subservient to the general arrangement of the design. Realistic treatment in the cloth, except in such textures as 'woven pictures', should not be practised beyond what will assist in showing the form to advantage. As an example, the conventional treatment of leaves is illustrated in *Figure 12.32* (which represents a cotton furnishing fabric), in which the 'weave development' imparts a certain degree of realism to the form. The different weaves in the figure have the effect of showing the ornament more clearly by causing the light to be reflected in a varying manner from the different parts. If all the figure had been treated in the same way it would have appeared flat and uninteresting, and would have been less suitable for the purpose of the cloth. In contrast with *Figure 12.32*, the flat treatment of a flower is illustrated in *Figure 12.14*, which suits the structure and purpose of the cloth, and the means by which it has been woven.

In some cases woven forms are used to convey a meaning, as in representations of the thistle, the shamrock, a lover's knot, etc., the term 'symbolic' being then applied to the treatment. Most frequently, however, the sole object of employing conventional forms is to beautify the material, in which case, the treatment is termed 'aesthetic'. Sometimes, conventionalised natural forms are combined with forms that are 'invented', as shown in *Figure 13.4*, while again designs are sometimes composed entirely of abstract forms.

(3) The adaptation of earlier designs has been practised from the earliest periods, and it may be said that almost all modern styles have resulted from previous ones by the process of evolution. 'To adapt' is a more rational method of procedure than to endeavour to work entirely originally by putting aside all that has been previously accomplished. There are innumerable ways in which former designs may be modified and applied; by small variations new styles may be gradually evolved which finally possess few of the original features.

The term 'traditional' is applied to ornament which has been handed down from age to age without losing its original characteristics, although it may have been modified from time to time to suit the requirements of different periods. More or less exact reproductions of historic designs are yet made from famous rugs, tapestries, altar cloths, etc., while copies of recent designs are made by competitors in the same market, and when similar effects are required in cloths that are cheaper than the originals. At the present time, however, designs are most frequently adapted from cloths with the idea of reproducing the ornament in a new form.

Conditions to observe in designing figured fabrics

The following is a summary of the principal conditions that have to be observed in designing figured fabrics:

(1) The ornament should be applicable to the construction of the cloth, the nature of the materials employed, and the mechanical means of production, and be suitable for the purpose of the fabric. A style of ornament, that is appropriate to one class of cloth, may be quite unsuited to another class; the same form may, however, be suitable for different classes of cloths, but it may require to be treated in a different manner in each case.

(2) With some few exceptions, the ornament should be chiefly in solid form or mass, and not in outline. The structure of a woven texture makes it necessary for even the finest lines of a design to be massive (to a greater or lesser degree according to the cloth) in order that they will show in proper contrast with the ground.

(3) One complete repeat of a design (as in all mechanically repeated designs) must be capable of being enclosed within a rectangular space, the boundary lines of which correspond vertically and horizontally with the direction of the warp and weft threads. The rectangular shape makes it necessary for all textile designs to conform, to some extent, to a geometric basis of construction, but the ornament itself need not be geometrical.

(4) The ornament must join perfectly at the top and bottom, and at the sides of the repeat, in order that when the design is repeated longitudinally and transversely, the pattern will be continuous and unbroken. 'Woven squares', in which the ends and sides are not required to join, as in carpets and tablecloths, are an exception to this rule, but usually in these cloths a central figure is required to join to a border. In stripe designs it is only necessary to ensure that the figure joins correctly at the top and bottom of the repeat. This is illustrated in *Figure 12.44*, the dotted horizontal line in which indicates the position where repetition occurs. The width of a stripe must, however, be suitable for the repeat in width of the complete design, while the figures in each stripe must be in proper relation to those in the neighbouring stripes.

(5) The ornament should be properly balanced. A design is defective if the repetition of the figure causes vertical, horizontal, or diagonal lines to be formed in the cloth when such are not desired. Uniform distribution of the primary masses is first necessary, then any details that are added should be arranged to give even balance of the ground spaces. The analysis of good textile designs will show that the orderly arrangement of the parts is almost invariably due to certain bases or principles having been employed in their construction. Previous to sketching a design, base lines may be drawn within the rectangular repeat area in order to divide the latter into spaces in systematic order. The lines of the figure can be arranged to follow distinctly the base lines, or the latter may be partly or entirely eliminated. In the last case the use of the base lines is simply to ensure that proper balance and accurate repetition are secured.

Factors which influence woven design

In textile fabrics the style of the ornament and the way in which it should be developed are largely influenced by the following:

(1) The purpose of the cloth.
(2) The comparative smoothness, lustre, fineness, and sett (or number per unit space) of the threads.
(3) The mechanical means of production.
(4) The kind of finish that is applied to the cloth.

(1) The effect that the purpose of a cloth has upon the style of ornamentation will be readily evident from a comparison of figured textures that are in regular use such as, carpets, hangings, table-cloths, bed-covers, dress fabrics, mantles, etc. A fabric that is used to cover a flat surface, and is observed from many different points of view, requires different decorative treatment from a texture that has to hang in folds; while the necessity to cut up cloths foı certain uses will render a particular style of ornament totally unfit, whereas another style is quite appropriate.

The use to which a cloth is to be applied, in many cases, largely influences its structure, and the ornament requires to be adapted to the structure as well as the use. Further, cloths that are used for similar purposes may vary extremely in structure, and different treatment of the ornament may be necessary in each case.

(2) Filament yarn fabrics, owing to the lustrous nature of the material, the smoothness and fineness of the threads, and the large number of threads per unit space that are generally employed, lend themselves in the highest degree to elaborate figure ornamentation. It is possible in these fabrics, to obtain extreme fineness of detail, but, as a general rule, the rich, lustrous quality of the material is displayed to the greatest advantage by treating the ornament boldly, and varying the weave development of the figure in the manner illustrated by the example given in *Figure 12.33*.

Figure 12.33

Elaborate ornamentation and minute weave detail of the type shown in *Figure 12.33* can also be introduced in fibre yarn fabrics that are fine in structure and finished with a clear surface. On the other hand, in coarse fabrics fine weave variations cannot be introduced. In order to illustrate how the relative number of threads per unit space in a cloth influences the weave development and the amount of detail that can be used in a design, a portion of the figure, represented in *Figure 12.33*, is shown worked out on design paper in *Figures 12.34* and *12.35*. *Figure 12.34* shows the figure drafted on 8 × 10 design paper which corresponds with the sett of 38 ends and 48 picks per cm, whereas in *Figure 12.35* the sett is taken as 26 ends and 26 picks per cm. The plans will produce exactly the same size of figure in the respective setts; but while in the finer structure it is possible to get a figure intricately developed and graceful in outline, in the coarser fabric the curves of the figure turn more rapidly, and there are fewer spaces to work upon, so that it is necessary for simpler treatment to be employed. The example, further, is illustrative of the adaptation of a design from a fine to a coarser fabric.

Certain special classes of materials require specialised treatment, e.g.—in figuring with mohair or other coarse but lustrous yarns it is desirable that the brightness of the material be developed as much as possible. These yarns are frequently employed in conjunction with cotton yarns, and the cloths are not usually fine in structure. The ornament, as a rule, should be developed boldly in fairly long floats of the lustrous threads. A cloth of this type is represented in *Figure 12.36*, and a portion of the design to correspond is given in *Figure 12.37*. The ground weave is plain which ensures that the prominence of the

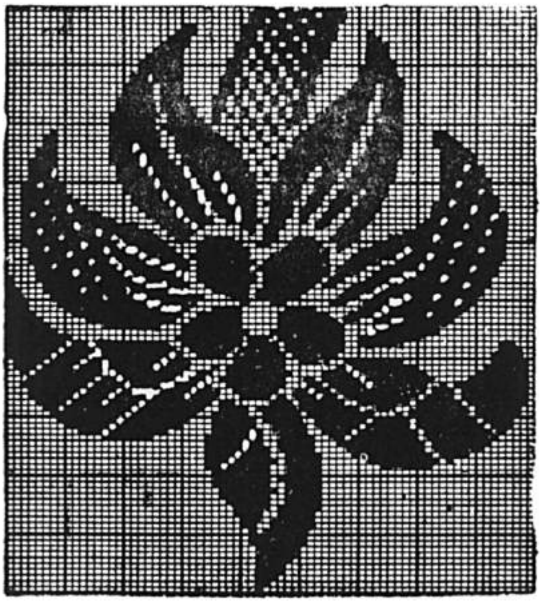


Figure 12.34

main lines of the figure is not detracted from. The warp is arranged with 1 end of mercerised cotton alternating with 1 end of ordinary cotton and only the lustrous mercerised cotton ends are used in forming the figure. The ground

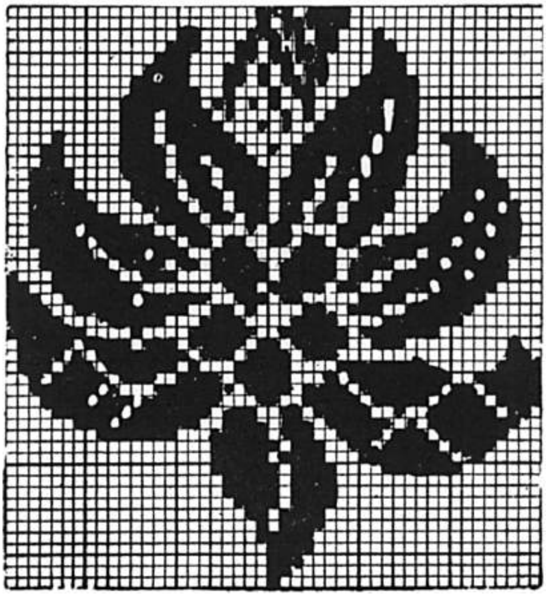


Figure 12.35

assumes a ribbed appearance due to lifting of the different sets of ends on alternate picks but where the figure is formed the ordinary cotton ends are made to weave plain by themselves underneath the figure to prevent the formation of unsighly weft floats on the reverse side of the fabric. In *Figure 12.37* lifts of the lustrous ends are indicated by the solid marks and lifts of the ordinary ends by the dots.

(3) The mechanical means employed in producing cloths impose very varying limitations, and an intimate knowledge of the type of loom and loom

Figure 12.36

mounting that will be employed is essential to successful designing for most classes of fabrics. Brief consideration will, in most cases, enable the limitations to be realised. For instance, in a plain box loom only one kind or colour of weft can be employed, and in a loom with changing boxes at only one end,

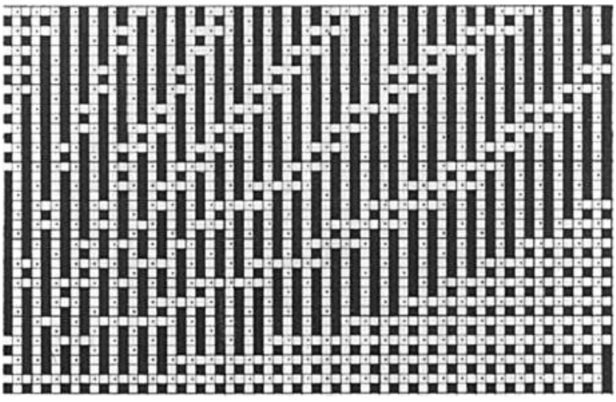


Figure 12.37

the picks of each kind of weft require to be inserted in even numbers; while the number of boxes limits the number of different kinds of weft that can be used.

Different types of shedding mechanism have different limitations: A dobby will operate only a certain number of healds; the size of repeat of a jacquard is limited; only a certain maximum number of ends per unit space can be woven in a given harness; a certain harness tie compels a definite form of ornamentation; a combination of healds with a harness limits the order in which certain ends can be operated; in jacquards and harnesses that are specially constructed to produce certain weave structures prescribed orders of interlacing are necessary, etc.

(4) The influence of the finish that is applied to a cloth, in deciding the style of ornament and weave development that are suitable, will be understood by comparing a figured rug which has a raised surface with a clear finished cloth. The pile or nap, formed on the surface by raising, completely conceals the thread structure, so that the introduction of fancy weaves or fine detail in the figure is useless, and only flat massive ornament is suitable.

Construction of sketch designs

In sketching a jacquard design the width of repeat that is employed should be equal to, or a factor of that of the machine in which the design will be

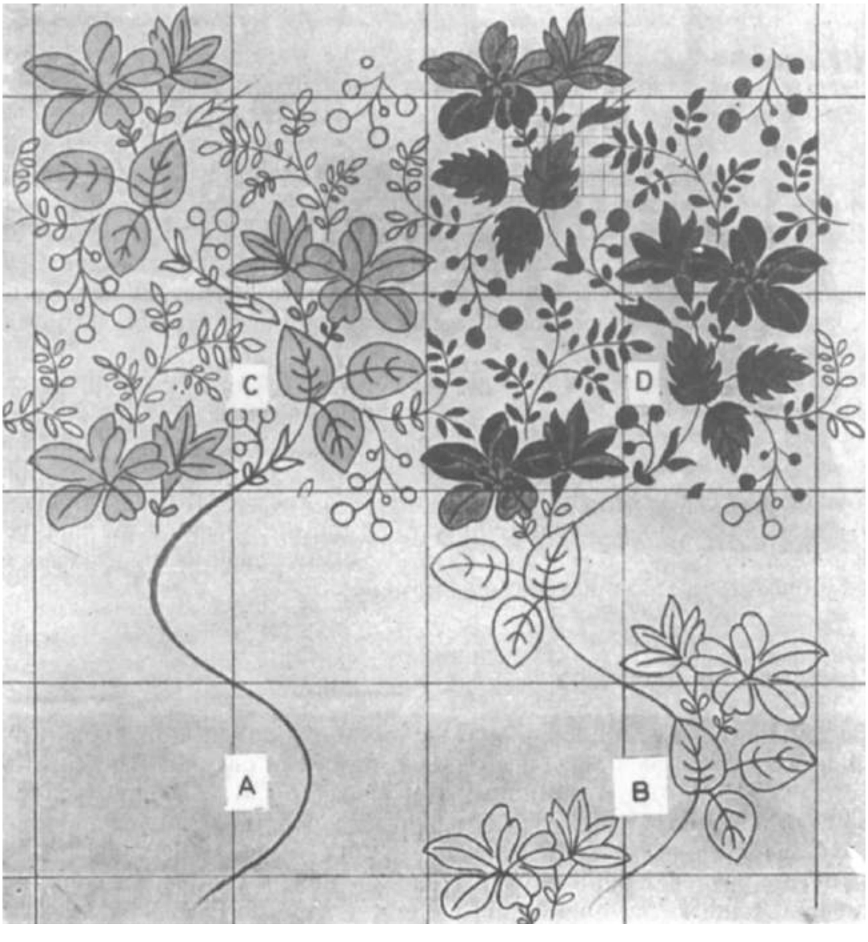


Figure 12.38

woven. The size of a design can be readily increased or decreased in the process of drafting the figure from the sketch, but obviously the nearer the repeat of the design is to the proper size, the truer is the resemblance of the woven effect to the original sketch. It is frequently very difficult to guard against the formation of improper stripes or bars in the cloth if only one repeat of a sketch design is made, a defect sometimes not becoming visible until the figure is repeated in width and length in the loom. As a general rule, therefore, it is advisable to roughly sketch several repeats of a design in each direction in order that the relation of the different parts of the ornament to each other in succeeding repeats may be seen. A simple illustration is given in *Figure 12.38* which will serve as a general indication of the method of preparing a sketch of a repeating figure. A number of rectangular spaces (in this case two in each direction) are first marked out by drawing lines at the proper distances apart to give the required size of repeat. A vertical waved line is used as the basis of construction in the example, and as this naturally divides the design into two similar parts, each repeat is bisected by drawing vertical and horizontal lines through the centre. The waved line is then drawn in, as shown at A, and repeated in every repeat of the sketch. The chief feature of the ornament, or the 'mass', is next introduced, as shown at B, and here great care is necessary. The lines that bisect the repeats enable the position of each mass to be correctly judged, so that approximately equal spaces, in every direction, between the masses, are obtained. When the masses have been traced into each repeat their relative positions can be still more accurately observed, and any imperfection of balance remedied. The next process is the introduction of the detail, as shown at C, and this should be less pronounced in character than the main object, in order that the prominence of the latter will not be detracted from. The detail should be added and copied into each repeat by degrees until the design is complete, care being taken that the different parts balance each other and produce a regular distribution of figure in any given straight line of the sketch.

After a rough drawing of the complete effect has been made over the given number of repeats, it is only necessary for the outline in one repeat to be filled in, as shown at D, for the purpose of indicating how the design should be developed on the squared paper. The last process is necessary only when the sketch is required to be exhibited for approval, as the necessary development can be indicated upon the figure in painting out the design on the squared paper. In the portion D of *Figure 12.38* the places where the figure may be developed in bold float have been accentuated.

Design unit and design repeat

The difference between the unit and the repeat of a design should be clearly understood. In some designs the repeat is formed of one unit. This class of design is illustrated by the example given at A in *Figure 12.39*, in which the unit, forming one complete repeat, is shown shaded. In the same manner, in the design given in *Figure 12.1*, the unit and the repeat are the same.

When a portion of figure is used two or more times in producing a complete design, the unit forms only part of the repeat. Thus, in B, *Figure 12.39*, the portion shown shaded may be taken as the unit, which is used twice in the repeat. Also the unit forms half of the repeat of the design shown in *Figure*

12.28. In C, *Figure 12.39*, the unit, which is again shown shaded, is used eight times in the repeat of the design. A unit figure may thus be used practically any number of times in forming a design, and it may be of any shape, but if it is not rectangular in shape it must be so arranged that the complete repeat of the design is rectangular.

GEOMETRIC ORNAMENTATION

All textile designs require to be so far constructed on geometrical lines as to enable one exact repeat to be enclosed within a rectangular space, at one edge of which the ornament joins correctly with that at the opposite edge. A distinction may, however, be made between the construction of designs, such

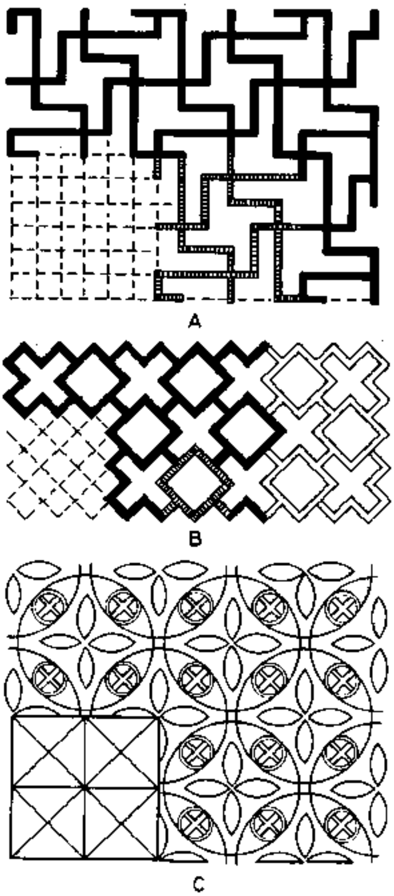


Figure 12.39

as are shown in *Figure 12.39*, which are purely geometric; and those in which the parts of the ornament consist of shapes in which no geometric form is visible, though the basis of arrangement may be of a geometric character. The purely geometric designs can be regarded, basically, as extensions of the basket, twill and diamond effects, which due to their size require the jacquard system of shedding.

At A in *Figure 12.39*, the square is used as the base of construction, as shown by the dotted lines. The design is constructed simply by thickening certain portions of the base lines and leaving other parts blank. This style of ornamentation is chiefly suitable for cloths in which special threads, arranged

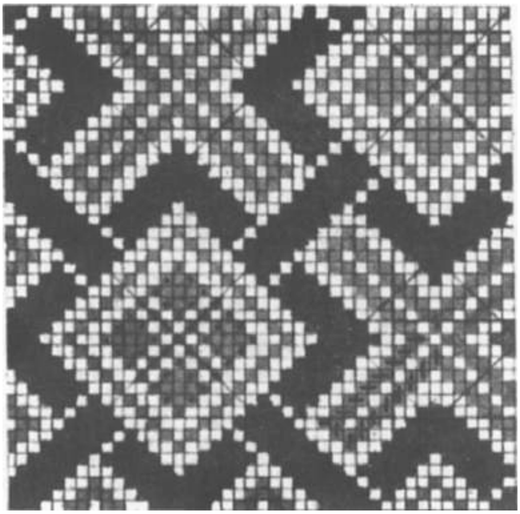


Figure 12.40

at regular intervals, are employed in forming the figure. A similar design to A is given in *Figure 10.18*, while such designs as those shown in *Figures 10.19* and *10.21* are readily constructed on the square basis to fit a given order of warping and wefting.

B in *Figure 12.39* shows a simple geometrical design constructed upon a diamond basis, the lines of which are thickened and left blank in the same manner as in A. The design given in *Figure 12.40* shows sketch B fully developed, the solid black figure corresponding with the lines of the sketch,

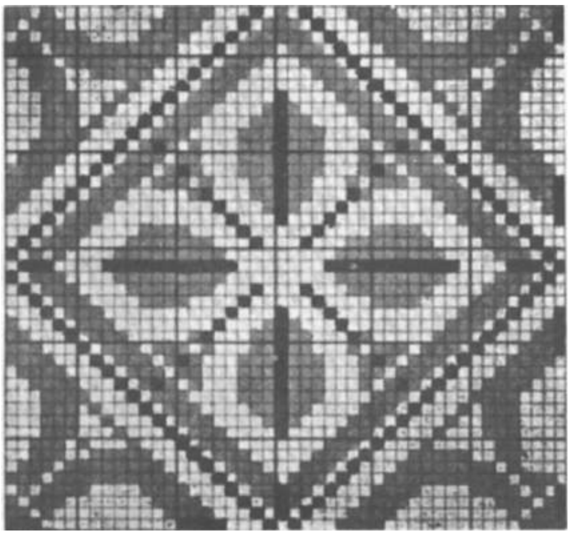


Figure 12.41

while the grey marks illustrate a method of filling in the ground spaces to give variety to the effect at the same time achieving firmer interlacing.

C in *Figure 12.39* shows in the bottom left-hand corner, a repeat divided into rectangles, diamonds, and triangles, which, in most cases, is sufficient to enable very elaborate geometric designs to be made. The design C is constructed by describing circles and arcs of circles, with the intersecting points of the lines taken as centres.

The base lines of the design given in *Figure 12.41* correspond with the vertical, horizontal, and diagonal lines shown in the bottom left-hand corner of C in *Figure 12.39*. This example illustrates the 'counter-change' principle of construction—the weft float in one diamond space corresponding with the warp float in the other.

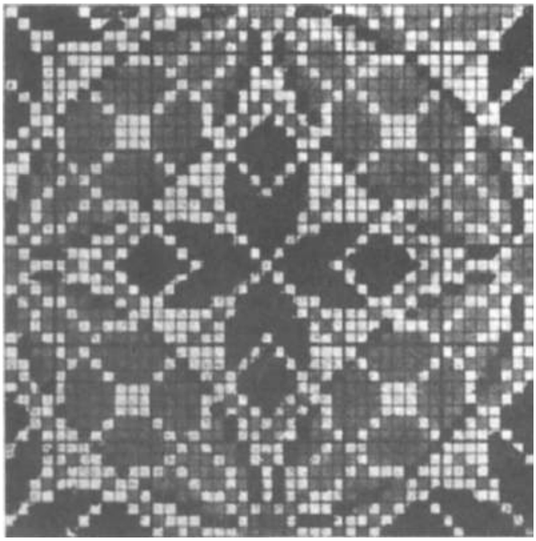


Figure 12.42

Figure 12.42 shows a suitable method of developing the design given at C in *Figure 12.39*. The design of a bordered fabric, shown in *Figure 11.21* is constructed upon vertical, horizontal, diagonal, and circular base lines, similar to those shown at C in *Figure 12.39*.

The use of any form of squared paper is very convenient in designing purely geometric forms, as the small spaces provide a ready means of dividing up a given size of repeat with any number of vertical, horizontal, diagonal, and circular lines, which may then be employed a. the framework upon which the pattern is constructed. When design paper is used, in order to avoid having two consecutive threads working alike, the centre of a small space should be taken as the turning point where the figure reverses, as shown in *Figures 12.40*, *12.41*, and *12.42*.

CONSTRUCTION OF SYMMETRICAL FIGURES

Symmetrical ornament may be arranged to form independent figures, or stripe patterns, or, as shown by the geometrical designs given at B and C in *Figure 12.39*, as continuous all-over effects. A given unit, which is used two or more times in forming a complete figure, is either reversed on opposite sides of a centre line, or is turned upon a central point. The most common arrangement is the 'bi-symmetrical' or ordinary 'turn-over' figure, the construction of which is illustrated in *Figure 12.43*. Two lines are drawn at right angles to each other, and the unit of the figure is built up on one side of the

Figure 12.43

vertical line, as shown by the portion hatched in. As the second half of the figure requires to be exactly like the first half turned over, it can be obtained by copying the unit and the vertical and horizontal lines in pencil upon tracing paper, which is then turned over and placed with the lines upon it coinciding with those of the sketch. By 'rubbing' the tracing paper the outline of the figure is transferred to the sketch. The appearance of the figure can be judged, before the second half is copied, by placing a piece of mirror

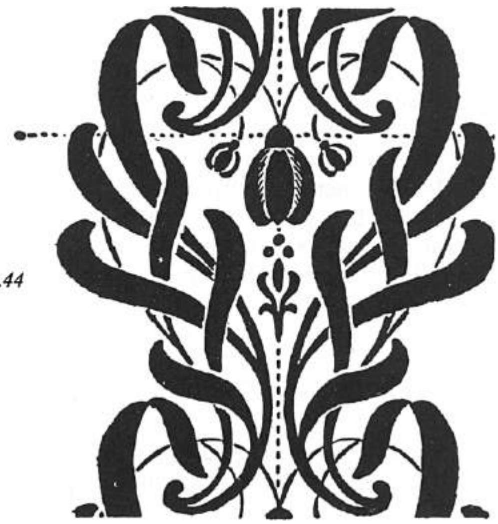


Figure 12.44

glass vertically with its lower edge along the vertical line. The arrangement of an independent bi-symmetrical figure, as a complete design, is illustrated in *Figure 13.12*.

The basis of construction of *Figure 12.44* is the same as that of *Figure 12.43*, but in the former the leaves overlap and interlace with each other in such a

Figure 12.45

manner that the figure forms a continuous stripe. The lengthwise repeat of the figure is indicated by the dotted horizontal line.

A multi-symmetrical figure is shown in *Figure 12.45*, which results from reversing a unit vertically, obliquely, and horizontally. In constructing the style two base lines are drawn crossing each other at right angles, and a

Figure 12.46

second pair crossing the first pair at 45° angle. The unit, shown by the portion hatched in, is sketched in the space of 45°, and thus forms one-eighth of the complete figure. The point where the construction lines cross one another is used as the axis upon which the unit is turned in transferring it to the various sections.

Figure 12.47

Figure 12.46 shows a multi-symmetrical figure arranged in stripe form, the unit of which is used four times in the repeat. The all-over design, given in the centre of *Figure 11.21*, is formed by 'quadruple reversing' in the same manner as *Figure 12.46*.

Figure 12.47 shows the application of the symmetrical principle of construction to a furnishing fabric in which an elaborate floral form is constructed bi-symmetrically, as shown in *Figures 12.43* and *12.44*.

In *Figure 12.48* the unit is not turned over, but is simply turned round. Three base lines are drawn which cross each other at 60° angle, as shown by the dotted lines. The point where the lines intersect is used as the axis upon which the unit is turned, and forms the centre of the figure. The central figure and the curved lines are the same in each space of 60°, but between the curved lines the design is varied by the introduction of a leaf and a flower alternately. The complete unit of the figure thus occupies the angle of 120°, and is turned in three positions.

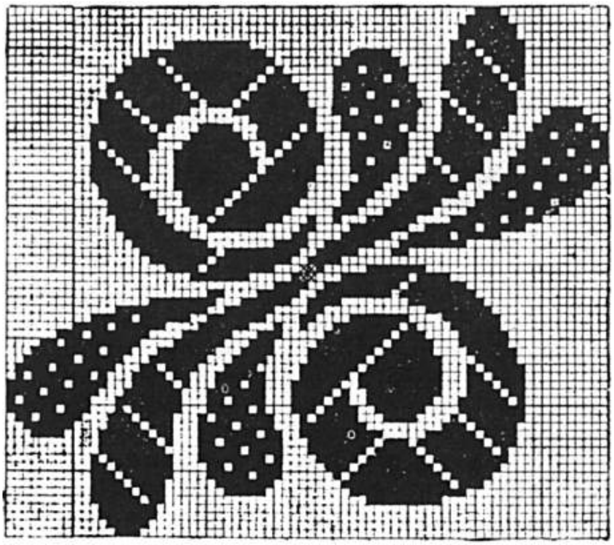
In the design shown in *Figure 12.49*, which is suitable for the corner of a fabric with a border all round, the unit of the figure is drawn from the corner of the square towards the centre, and is then turned round 90°, and copied in the same relative position from the remaining three corners.

Figure 12.49

In *Figure 12.50* a simple illustration is given which shows how the unit of a figure may be repeated on design paper. In this case the unit comprises one half of the complete figure, the second half being obtained by turning the unit round 180°. The centre of the figure is indicated by the crosses, and from this point the second half is copied square by square from the first half.

In constructing such styles as the foregoing, in order that the parts will fit correctly in the complete figure, it is generally necessary for the unit to be built up and copied in stages. Bi-symmetrical figures are specially suitable for

Figure 12.50



hanging fabrics, while multi-symmetrical designs are useful for textures which are viewed from every direction, as in the case of table-cloths and carpets.

REVERSING INCLINED FIGURES

When an inclined figure is used two or more times in a repeat it is customary to turn it in different ways in order to prevent it from forming twill lines, and to impart a more varied appearance to the design. *Figure 12.51* illustrates a method of placing a figure in different positions simply by turning it round, its centre being used as the axis; or, what is the same thing, by placing it each time as centrally as possible within a rectangular space.

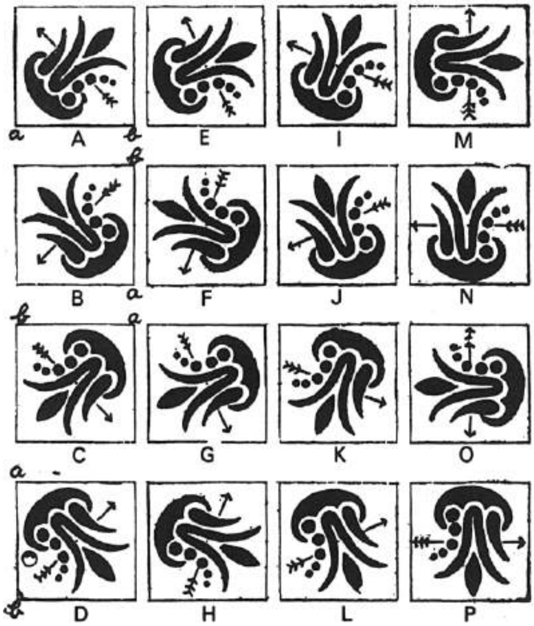


Figure 12.51

In single-ply fabrics, in which the figure is formed by interweaving the threads more loosely than in the ground of the texture, the angle of inclination has an effect upon the firmness of the cloth. The nearer the lines of figure approach the vertical or horizontal, the greater is the liability of the threads slipping or fraying when subjected to friction, while the nearer they approach the angle of 45° the firmer is the cloth structure. Of the examples given in *Figure 12.51*, A, B, C, and D, therefore, show the best positions, and M, N, O, and P the most undesirable. From an examination of A, B, C, and D, however, it will be seen that although the inclination of the figure as a whole is kept the same by turning the tracing round in each case a distance equal to 90°, the inclination of the parts of the figure is not the same in A and C as in B and D. Thus, in A and C the line formed by the small spots approaches the horizontal, and in B and D the vertical. The difference is due to the figure having been simply turned round on its centre, the line *a b* being placed in a horizontal and in a vertical direction alternately. This does not give a proper reversal of the figure.

A method of reversing is illustrated at R, S, T, and U in *Figure 12.52*, by which the same angle of inclination is obtained not only for the whole, but also for the parts of the figure. It will be seen that R and T are similar to A and C respectively in *Figure 12.51*, in which, however, no figure is placed the same as S and U. In this method S is obtained from R by turning the tracing

Figure 12.52

of the figure over horizontally. T is obtained from S by turning the tracing over vertically, or from R by turning the tracing round 180°. U is obtained from T by turning the tracing over horizontally, or from S by turning it round 180°, or from R by turning it over vertically. In each position the line *a b* is

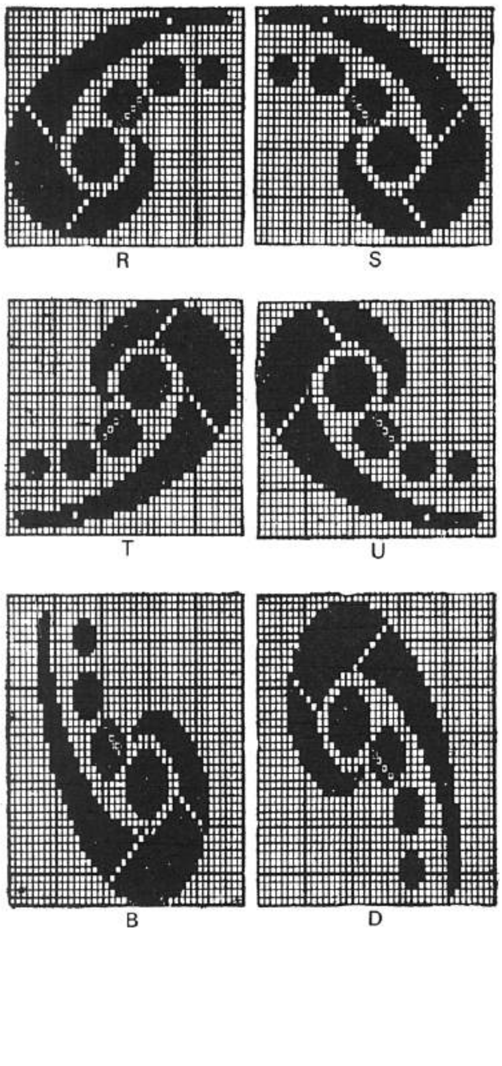


Figure 12.53

in a horizontal direction and parallel with the weft threads, therefore the parts of the figure are always in exactly the same relation to the ends and picks in the cloth. When the same figure is used a number of times in the repeat of a design, this method has the advantage that if the first figure is inclined at the most suitable angle, the remaining figures are equally correct. Also in most arrangements, the figures can be distributed over the given surface with less liability of producing lines or bars in the cloth. However, in some cases, a design appears less stiff and formal if the figure is placed in a multiplicity of different positions. For example, if there are six figures in the repeat four may be placed in different positions at 45° angle, and two at 60°; while with eight figures if four at an angle of 45° alternate with four at 30°, no two figures are placed the same.

R, S, T, and U in *Figure 12.53*, which correspond as to the angle of inclination of the figure with R, S, T, and U in *Figure 12.52*, show how a figure may be reversed on design paper by copying square by square from the first figure. For small effects this is probably the readiest method. In each case the approximate centre of the figure is indicated by the cross on the twentieth end and sixteenth pick, and a few dots are inserted diagonally from the cross to indicate the direction in which the figure is required to be inclined. The figure is reversed from the cross, the diagonal row of dots enabling the required direction to be readily obtained.

B and D in *Figure 12.53* are obtained by copying square by square from R, but in this case the figure is turned, as shown respectively at B and D in *Figure 12.51*. On square design paper the only disadvantage of thus turning the figure is that a horizontal line is changed to a vertical line, and vice versa. If, however, the cloth is not built on the square (8-by-6 paper is used in the example), this method of copying throws the figure out of its original shape, as will be seen by comparing the illustrations in *Figure 12.53*. Therefore, in changing the direction of a figure upon paper that is not square, it is necessary for the outline to be drawn or traced each time.