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Designing and Card-cutting Systems

Until comparatively recently, most of the jacquard fabric weaving was done on coarse pitch machines many of which were using harness arrangements deliberately designed to weave efficiently only one class of construction and no other. There were two main factors which led to the development of the specialised types of jacquard harness.

The first factor was the comparatively small figuring capacity of the coarse pitch machine. This meant that, in the production of certain traditional goods such as table cloths, bed covers etc., where single-repeat design was often desired, several jacquards had to be used in tandem above the loom to provide the necessary figuring scope. This method uses vast amounts of cards, increases the cost of card cutting and introduces faults due to the difficulty of synchronising perfectly the several shedding motions and card presentation systems. The packs of cards obstruct light and make access to the machines more difficult. To obviate the disadvantages, selection systems were devised to make one needle control several ends simultaneously (see Appendix I), and thus expand the size of the repeat in width. Also, special motions were invented to make one card serve for several picks in succession thus increasing the length of the repeat obtainable from a given number of cards.

The second factor was connected with the difficulty of preparing compound structure designs for an ordinary jacquard machine. An ordinary jacquard is a most versatile machine, capable of producing any structure but in order to do that, the operation of each end must be worked out in full over the complete length of the repeat. Considering that a repeat size of, say, 1000 ends × 1000 picks is not uncommon, working a design out fully and painting every weave mark on design paper is a laborious and tedious task. To reduce the tedium tappet-controlled healds were added to take care of such ends in the structure which performed a regular interlacing repeating over a short length. Thus, in a structure in which alternate ends operate in a simple order, say, plain weave, and only the other alternate ends perform intricate figuring lifts, repeating over hundreds of picks, the jacquard is made to operate only the intricately working ends. In this way the figuring capacity of the machine is increased because a 400s jacquard takes control of half the total number of the ends and designs repeating on 800 ends can be produced as the other 400 ends are controlled by the healds. Also, the design painting becomes very much simplified; the alternate plain weaving ends need not be indicated as their operation has nothing to do with the jacquard mechanism and the design can be painted solid, the marks indicating the lifts of the intricately figuring ends only. Card cutting of such solid painted designs is also easier and faster. The difference in the work involved in the preparation of designs for the ordinary jacquards and for the heald and harness systems will be readily appreciated by reference to A and B in *Figure 1.1* which respectively show a fully worked-out design, and one in which only the intricately

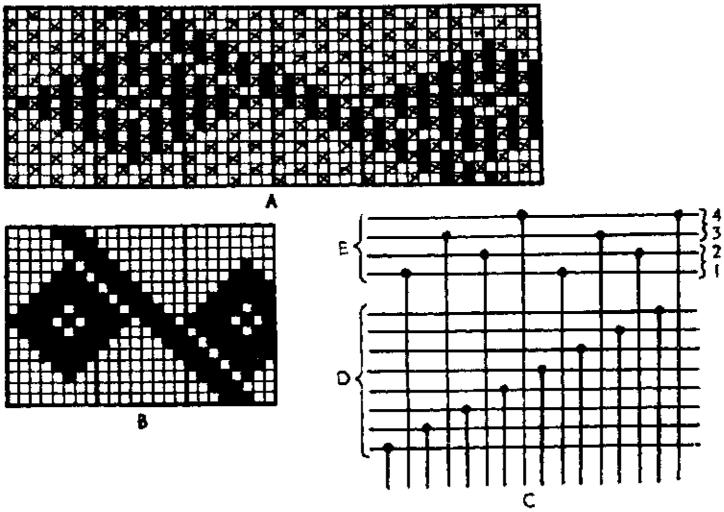

Figure 1.1

figuring ends are jacquard-controlled. An example of a heald and harness system which makes the reduction of work achieved at B possible is given at C in the form of a comber-board draft diagram in which D represents one row of jacquard harness cords and E a set of four healds used to operate the plain weaving ends. The healds are tappet-controlled and, therefore, the plain weaving ends, not being operated from the jacquard, need not be considered when the design is painted as already stated above.

The simple heald and harness mounting was followed by other modifications such as the working comber-boards, lifting rods, inverted hook operation etc. (see Appendix I), each adding a degree of sophistication devised to simplify the task of designing and card cutting until highly specialised types of machines were evolved, each of which was fitted specifically to produce one particular structure. At present very few of the special harness mountings are still in operation and these are dealt with under appropriate chapter headings. The majority of them, and this includes mountings which are only very rarely encountered as well as those no longer in use, are grouped together mainly for historical interest in Appendix I.

The decline of the special mountings was due to several causes. One of them was the general reduction in demand for some classes of jacquard work, arising out of improvements in the cloth printing and finishing techniques and in other methods of fabrication whereby imitations could be produced more cheaply. Due to greater concentration there was less room for specialisation. Another reason was the more frequent changes in the fashion or taste, so that some structures enjoying a vogue over a period of time were quickly replaced by others and a manufacturer who could not easily adapt to the required changes would have idle machinery. Therefore, versatile, rather than specialised machinery became necessary. Yet another cause of the decline of the special harness mounting was connected with the low speed of operation of most of these systems. Although they were admirably suited to reduce the labour of design painting and to increase the figuring scope they were generally cumbersome and many could only operate satisfactorily using the single-lift principle of action which made them uncompetitive compared with other systems of weaving where speeds of operation were generally rising in a spectacular manner.

At present most jacquard cloth manufacturers use modern ordinary harness machines providing complete versatility in respect of the type of structure produced and built in a fine pitch to give a large figuring capacity. (See *Watson's Textile Design and Colour* published by Newnes-Butterworths). These machines may be constructed to provide double-lift open-shed action and, selecting from a continuous paper roll, can operate satisfactorily at speeds of up to 300 picks per min and thus become competitive in the respect of speed with other types of shedding motions. However, as they are normally built with ordinary repeating ties without auxiliary shedding devices to take care of repetitive operation of ends outwith the jacquard, it would seem that the preparation of designs for such machines would need to revert to the laborious system of painting-in the lifting sequence of each end in the repeat in full. If this were so then the advantage of versatility which these machines possess would be partially destroyed, as laboriously prepared designs would require long runs to spread the high cost of designing over as great a length of cloth as possible. Frequent changes in design styles and short runs demanded by the modern market would tend to overburden the cloth with high designing charges to the point of non-competitiveness. Fortunately, developments in card-cutting machinery have kept pace with the developments in the jacquards, and specialised semi-automatic systems exist which can interpret a condensed, solid painted design into a fully worked-out structure. Indeed, recently a system has been devised in which a designer's sketch can be correctly developed into a fully worked-out design with the aid of a computer which when linked with a card-cutting machine makes the whole process automatic after the sketch has been provided.

Simplified and condensed designing

Almost every figured fabric, whether a single-cloth brocade or a compound structure, is built up of well-defined areas of design in which certain basic weaves are employed. Thus, in a floral brocade the ground may be woven in the plain weave, the petals in a weft sateen, the leaves in a warp twill, the stem in a weft twill, etc., the parts, all distinct and different, forming a harmonious whole. If a designer, instead of entering every weave mark in each different area, which is known as producing a fully worked-out design, adopted a colour code to denote each weave his task would be very much simplified as each area could then be painted solid in a different colour without tediously marking-in every weave interlacing. The burden of correct interpretation of the design in ordinary card-cutting systems would rest upon the card cutter who would have a very difficult task indeed. Considering the following colour code with reference to the floral brocade given as an example above, paper (unpainted area of design paper) = plain weave; red = weft sateen; blue = warp-faced twill; black = weft-faced twill, the card cutter, on reading the design across and encountering a given colour area would need to change the pattern of selection from one weave to another remembering at which point of its own repeat each weave existed in any given horizontal row of the design. If the weaves as mentioned above repeated on two, eight, six and four picks respectively then when cutting for example the seventh horizontal row of the

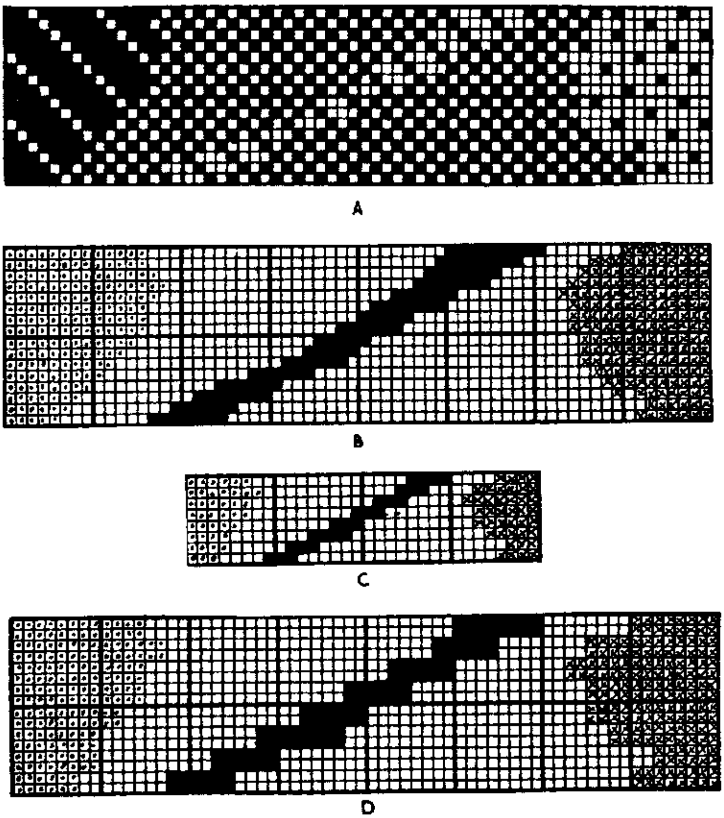

Figure 1.2

simplified design the card cutter would need to remember that, paper = first pick of the plain, red = seventh pick of the sateen, blue = first pick of the warp-faced twill, and black = third pick of the weft-faced twill. This is not an easy task, especially if not four, but eight, ten or more colours are used and if the constituent weaves are more complex than the four simple structures given by way of an example. This argument can be followed more clearly by reference to *Figure 1.2,* where at A, a small portion of a fully worked-out design, and at B, an equal portion of the identical design in simplified form, are shown. The code adopted at B is as follows: paper = plain weave, crosses = weft sateen, dots = warp-faced twill, solid marks = weft-faced twill.

The point of the argument outlined above is that merely to transfer the burden of fully working-out a design from the designer to the card cutter is not likely to be a profitable proposition. However, if the simplified design can be interpreted by mechanical means then the designer's task is made easier without transferring the problem to someone else and this, in fact, is the way in which the modern card-cutting systems operate.

Simplification of a design by colour coding the different weave areas reduces the labour of design preparation considerably but it does not reduce the scale over which the design has to be painted. Reduction of the size of a design can be obtained, however, by a process of condensation in which two or more ends are represented by one vertical row, and two or more picks, by one horizontal row of the design. The actual size of the repeat in the cloth is not diminished, as the design itself is only scaled down temporarily and is reconstituted in full again during card cutting by mechanical means which ensure that the multiplying factor in both directions used in the reconstitution is equal to the one used originally for the condensation. The condensation results in a further saving of labour during design painting and even a very small degree of condensation of, say, two in each direction means that a design formerly requiring 1320 vertical and horizontal rows of design paper can now be produced on only 660 vertical and horizontal rows, or, one quarter of the previous area. This can be observed by reference to *Figure 1.2* where at C, a design condensed according to the above formula, can be compared with the uncondensed original at B.

In compound fabrics the degree of condensation used is frequently dictated by the nature of the construction and, thus, in a cloth in which 3 figuring ends and 1 stitching end, and 2 figuring picks and 1 stitching pick form one structural unit the condensation by 4 warp-wise and by 3 weft-wise is natural. In simple cloth structures, however, such as brocades and damasks the degree of condensation permissible depends primarily on the density of the settings. This is due to the fact that although the design is reconstituted in the full size after card cutting, it will have lost in the process of condensation the fine definition of the outlines and become coarser in appearance. The reason for the coarser appearance is that in condensing by, say, two in each direction, the smallest step available is that of two instead of the step of one available in designing to the full size. This is shown by comparing B with D in *Figure 1.2* in which B is the original full size simplified design and D is reconstituted in simplified form from the condensed version shown at C. Although the general shape of the figures in both designs is the same, B is finer than D. In very finely set fabrics a considerable degree of condensation is possible without detriment to the appearance. For example if a brocade is set with 100 ends per cm and 60 picks per cm then it could be condensed by 3 warp-wise and by 2 weft-wise and still retain a sufficiently fine appearance because the minimum size of step under the above circumstances would be approximately 0.3 mm in both directions which is small enough to permit accurate definition of figure outline. Usually, fabrics composed of staple fibre yarns can stand somewhat coarser treatment than filament yarn fabrics where any inaccuracy in figure development is more easily discernible due to the general clarity of effect.

Card-cutting systems for continuous paper roll jacquards

There are several systems of card cutting such as the Lisage, the Dactyliseuse and the Uhlig, specially adapted to permit speedy punching of large designs for fine pitch jacquards. They range from comparatively simple manually controlled machines to quite complex devices in which operational control is obtained from punched card information rolls. The speed with which they can produce fully cut cards ranges from about 200 to 600 per shift depending on the type of machine used and on the complexity of the design. Faster operation is obtained from the more sophisticated and, therefore, more expensive systems. The high cost of the machines and their high production capacity has meant that the smaller jacquard fabric manufacturers would have to suffer the considerable

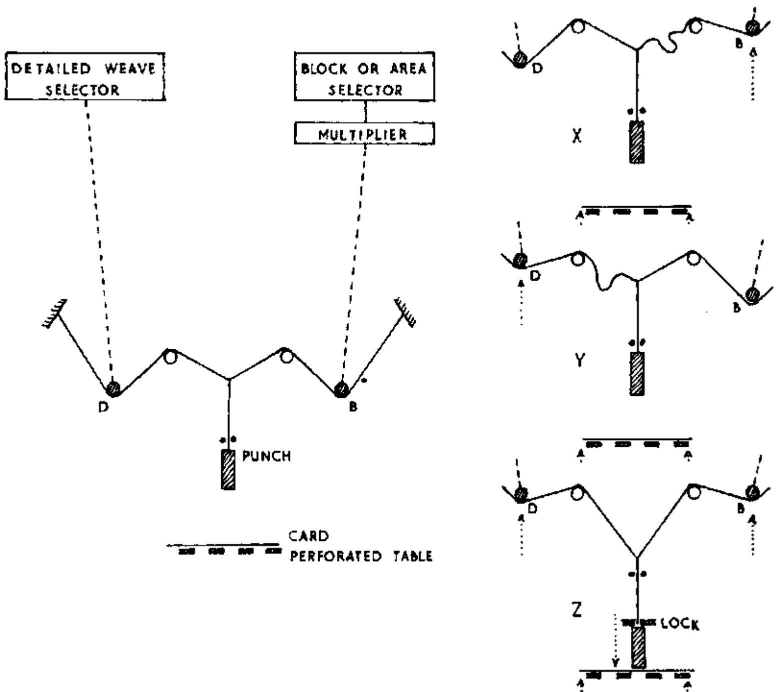

Figure 1.3

expense of installing such a machine without being able to utilise it fully. This has led to the establishment of specialist card-cutting firms who are able to install and utilise in full, the most efficient systems by providing a service to a number of manufacturers.

Each of the many systems available uses its own specific version of punch control and there is no intention here to describe the intricate mechanisms involved. As, however, they all use a similar basic principle of operation the explanation of it will provide sufficient information to appreciate the procedures involved.

The purely schematic diagram in *Figure 1.3* shows that the punch is controlled from two sources simultaneously. If only one of the two punch-connection supports is raised (D or B) the punch cannot descend into an operative position against the card because it is still suspended by the other support. The two alternative situations of the above order are shown at X and Y. It is only when both the supports are raised that the punch can descend to a position in which it is locked fast. *Figure 1.3Z*, and the card on pressing against it is perforated. It will be appreciated that although reference is made to one punch in each case their number is equal to the figuring capacity of the machine for which the cards are being cut so that for a 1200s jacquard, 1200 punches will be in operation.

The two sources of punch control are the area or block selector and the weave selector. The area selector selects punches which correspond to a given colour of paint in the simplified design in a horizontal row so that, for example, punches 400 to 820 are selected in a given design. Simultaneously the weave selector carries a card which indicates what weave is to be worked in this area, the weave selection being given for all the punches in the repeat so that if the weave for the area being cut is the plain weave then every odd punch of the 1200 punches will be positively activated. However, as only those punches which receive a positive activation from both control sources at once can cut, the card will be perforated only by the odd punches in the area of 400 to 820 because only these punches are free to descend into an operative position. This principle of operation is illustrated in *Figure 1.4*, where an example based on the simplified design given at B, in *Figure 1.2* is used.

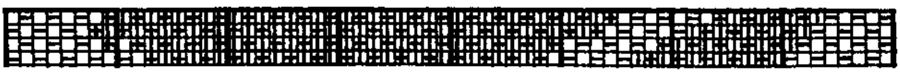

Figure 1.4

In this example it is assumed that the block selector has been programmed to select the unpainted (paper) area for cutting; therefore, supports B *(Figure 1.3)* are raised and correspond with the unpainted area of the first horizontal row; this is shown by the vertical dashes. The full horizontal row is now overlaid with the weave selection which is the first pick of the plain weave and this is indicated by the horizontal dashes and represents the lifts of supports D in *Figure 1.3*. The actual cutting can, therefore, take place only in respect of ends indicated by crosses, as in *Figure 1.4*, which result from the overlap of the vertical with the horizontal dashes because it is only at these points that a dual 'affirmative', necessary to drop a punch, is given. Hence the first card is cut with the plain weave inserted in the required area. The second card is now presented, the area selector activates punches in accordance with the second row of the design, the weave selector activates all the even punches for the second pick of the plain weave and the second card is punched providing plain weave working for the required area, and so on until all the cards are perforated. By the end of the repeat all the areas requiring plain weave working will have been cut correctly. The cards are now brought back to card 1 position, the area selector is now programmed to select the second weave area, say, the warp-faced twill; on the weave selector the plain weave indicator cards are replaced by the 5 up, 1 down twill cards and the jacquard cards run through the machine again. Now the areas in which the warp-faced twill working is required will be cut, and so on; the number of times the cards pass through the machine being equal to the number of different weave areas in the design.

The example described above represents a simple brocade structure but it will be readily appreciated that the system is equally applicable to all structures, including compound cloths, and the only difference in operation will be the substitution of a compound weave on the detailed weave selector head for a simple weave.

If the simplified design, which serves as a programming guide for the area selector has been condensed in the warp direction then the multiplier, indicated in *Figure 1.3*, is brought into use to reconstitute the design in full size. In uncondensed designs the multiplier is not used as each unit of control in the area selector controls its own punch directly. If a design has been condensed by 2 warp-wise then a repeat of 600 vertical rows of design represents 1200 ends which require 1200 punches to ensure that each end works the detailed weave correctly. The area selector, however, has been programmed for 600 units of design and if the previous 'one to one' connections were retained then only 600 punches could be activated. To obviate this the multiplier is brought into operation which ensures, when suitable connections are made, that one control unit in the area selector activates two adjacent punches; if the warp-wise condensation was by three then the multiplier connections are trebled, and so on.

When the design has been condensed weft-wise then to obtain the correct reconstitution of the length of the repeat the same area selection is retained for a number of cards equal to the degree of condensation.

As the detailed weave selector controls every punch individually and presents the correct weave lifts for every end and every card it will operate correctly irrespective of the manipulations in the area selector associated with the design condensation and reconstitution. The change over from one weave to another on the detailed weave selector occupies very little time in the operation because after a comparatively short period all the standard weave combinations are accumulated in a form of 'library' from which they are drawn as required. Any new, unusual weave not held must be punched out manually before the commencement of the card-cutting operation so that it can be inserted upon the detailed weave control and applied to the appropriate area selected by the area selector.

Programming of the area selector in some systems takes longer and is one of the factors which reduces the speed of card preparation. The greater the number of different weave or constructional areas in the cloth the more complex the programming, although when the programming is carried out by means of punched paper strip the difference in time required to programme the area selector for, say, six weave areas as opposed to ten, is only marginal. The programming in most systems is carried out away from the actual cutting machine so that one design is being cut whilst another is being programmed. The main factor which determines the total time taken to cut a set of cards is the number of passages through the machine which each set has to undergo and that is dependent upon the number of weave areas, as already explained, because in one passage only one weave area is cut fully. In the more sophisticated systems facilities exist for programming as many as 17 different weave areas into the area selector which is usually more than satisfactory. In the manually-programmed systems there is no upper limit to the number of different structural areas which may be incorporated but as in such systems the programming operation is rather slow it usually becomes uneconomic as compared with the ordinary piano card-cutting machine to programme-in for more than four or five different weave areas.

Card repeating

The operations described in the above paragraphs are only required to produce an original design. If it is required to furnish several jacquard weaving machines with the same design then the original set is used for the purpose of obtaining replica sets by repeating, without the need to go through the time consuming operations as before. The replica sets can be produced on special repeating machines which are similar to the jacquards except that the harness cords are connected to the punches instead of the mail eyes in the loom and complete replica sets are obtained in a single run through.

Some of the special card-cutting systems can also be used as repeater machines if desired. This is achieved by activating all the punches at once in the area selector and by running the originally obtained set through the detailed weave selector whereupon all the punches corresponding to the holes in the original set will act, thus cutting each card correctly in a single passage.

Computerised card cutting

The latest development in card cutting consists of adapting a computer to process a design from the designer's sketch on squared paper onwards. As the computer can be made to shift a pattern unit, or reflect it about a horizontal or vertical axis, or displace it angularly the artist needs to provide only the basic minimum unit in all symmetrically constructed or repetitive patterns. This unit can be presented in solid painted simplified form and it can be condensed.

Computers and associated systems for this purpose are offered by a number of manufacturers and although the equipment from the various sources differs in some detailed aspects the basic method of operation is similar in each case. A design is painted solid in up to 12 colours to indicate different colour or constructional areas in the cloth and is placed upon a reading table. A photoelectronic scanner reading the design is capable of absorbing the information from one complete horizontal row of design in, at most, two seconds. This is transmitted to a control storage unit in an associated computer where it can be modified according to requirements as suggested in the foregoing paragraph. If the original design was condensed, e.g. by four warp-wise and by two weft-wise, it will be suitably expanded. Fully worked-out detailed weaves each associated with a different block colour area are transmitted from a previously assembled 'stock' of weaves stored on a 'floppy' disc or on magnetic tape to the central control where they are correctly superimposed. Clearly, after a few weeks of operation the stock of detailed weaves will become quite extensive and this can be drawn upon at any time; if, however, new structures are required they are digitised and simply added to the library as necessary. Full superimposition of all the detailed weaves on all the block colour areas takes place simultaneously for each horizontal row so that a complete card is punched in a single operation. If one row of the condensed design represents two, three, or four picks then the same row is held by the lock selection control whilst two, three, or four successive variants of the detailed weave are superimposed on it, each for a different successive card.

High-speed card-punching machines with, normally, 1344 punches are coupled to the computer. The punches in these machines are activated electro-magnetically and the rate of production achieved varies between 30 and 90 fully punched cards per min. Most makers also offer additional equipment for checking the design and for correcting the mistakes.

In essence this system is similar to the mechanical systems described earlier in as much as the dual activation of punches is concerned, and apart from the improved speed of operation it offers the very considerable advantage of high-speed conversion of the read-out into punch selection which cannot be achieved with the mechanical devices. It also simplifies the procedure by producing fully cut patterns in a single run through the machine. It is envisaged that due to the high cost and high production capacity of this type of equipment an even greater concentration of the specialised card punching services will occur than has taken place upon the introduction of the mechanically operated systems.

The ultimate in design computerisation consists of direct selection of jacquard needles from a simplified and condensed design via a minicomputer. This form of control has already been introduced in prototype versions. As one mini-computer per jacquard is likely to prove too costly studies are in progress to find out the number of jacquards that one computer can control by suitable programming and it is possible that an economically viable solution will emerge shortly in which case instant pattern changes will become a possibility.