# 15

# Warp Pile Fabrics Produced with the Aid of Wires

In this type of construction, frequently referred to as positive warp pile, only one kind of weft is required but at least two series of warp threads, separately beamed and tensioned, are essential, viz. ground ends and pile ends. The former produce with the weft the ground cloth from which the pile ends project and in which they are anchored.

To produce the pile a wire is inserted across the width of the warp into a shed formed only by the pile ends. When the pile ends are subsequently dropped into the bottom shed and interlaced with the weft they remain draped over the wires as shown at A and B in *Figure 15.1*. Thus, the cross-sectional dimensions of the wire determine the height of the pile. After the insertion of a number of picks (and wires) the wire furthest away from the cloth fell is withdrawn leaving the loops which were formed over its shank as a surface feature in the cloth as shown at C and D. The withdrawn wire is re-inserted at the front there being between 12 to 50 wires between the point of withdrawal and insertion. The special mechanism which controls the wire movement is designed to insert the wire rapidly, as fast as it takes to insert a pick of weft, and to withdraw it slowly. The large number of wires between the two points is necessary mainly to prevent the loops being pulled back by the tension on the pile yarn. The difference between the actual number of wires depends primarily on the weight of the fabric, fewer wires being required in lighter fabrics, and on the frictional characteristics of the pile warp.

The pile may be looped, if plain wires are used, or cut, if the wire has a cutting blade at its tip end. Both types are produced in exactly the same way, i.e. by draping the pile ends over the wires, and the difference in the nature of the pile is created only upon the withdrawal of the wire, the plain wire leaving in the cloth upon withdrawal the loops, whilst the cutting wire severs the loops formed upon its shank as it is withdrawn thus leaving the cut tufts in the cloth. This is shown schematically at E in *Figure 15.1*. The upper part of E and the cross-sectional shed diagram at F in *Figure 15.1* also show the normal shedding arrangements used in the manufacture of these fabrics. It will be noted that the wire is inserted into a special high shed formed by the pile yarn, simultaneously with the shuttle which inserts the weft into a low shed formed by the ground yarns. On occasions, to obtain special effects, it is necessary to insert the wire alone, but this is generally avoided as the wire insertion occupies the same length of time as the insertion of weft but by itself it does not add to the length of cloth woven because the take up is only operative during picking.

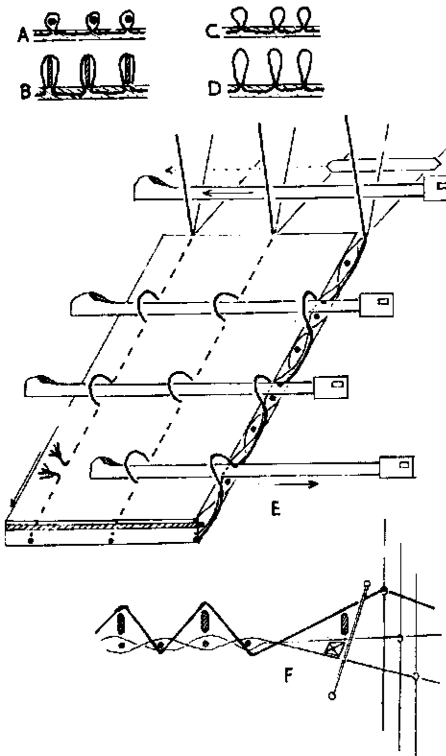
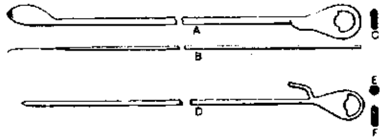



*Figure 15.1*

In dobby or jacquard shedding the high shed for wire insertion is obtained by special lifting arrangements. In cam shedding it can be achieved either by the use of tappets with a stroke bigger than that of the ground warp tappets or by suitable leverage connections to the heald shaft which controls the pile warp.

The wires vary in shape, as already mentioned, according to whether the pile is to be looped or cut. A and B in *Figure 15.2* represent the elevation and plan respectively of one form of a cutting wire whilst the cross-sectional appearance of it is given at C. It can be observed at B that to prevent damage to the reed the tip of the blade is turned slightly inwards. At present most of the cutting wires are made to operate with a disposable razor-type cutting edge which fits into a slot at the tip. This is done to save the time and the labour otherwise necessary for the frequent re-grinding and re-honing of the fixed blades. The appearance of a plain or looping wire is shown at D with two different cross-sections at E and F. The circular cross-section wire is only suitable for the production of short pile, long pile is produced on wires with a rectangular cross-section. The depth of the wires differs considerably and ranges from 1·5 mm for the short pile fabrics to as much as 25 mm for imitation fur fabrics and carpetings. As shown at A and D in *Figure 15.2* each wire has a shaped handle at its extremity by means of which the wire mechanism can insert and withdraw the wires. It will be appreciated that this mechanism requires at the side of the loom a space which is at least equal to the width of the cloth being woven. This adds considerably to the overall floor area required for each machine in the weaving of positive warp pile fabrics.

*Figure 15.2*




The loop pile fabrics in this system of weaving are produced mainly for upholstery purposes and are known as uncut moquettes, or for carpetings, which are termed Brussels, cord or boucle. The cut pile effects are used for apparel wear, curtainings and upholsteries and are known as velvets, plushes and cut moquettes, and also for carpets of the Wilton or velvet pile class. Very effective figured styles are also produced by combining in one cloth the loop with the cut pile. This form of figuring is used mainly in upholstery fabrics and in carpets.

The pile warp during weaving takes up much more rapidly than the ground warp, the difference in length varying according to the depth of the wires and the frequency in which the pile threads are raised over the wires. In an all-over pile structure the pile warp may require to be from five to twelve times the length of the ground warp. During weaving, in order that the pile face will not be injured, the temples act only on the selvedges, and in winding the cloth on to the cloth roller the underside is brought in contact with the friction roller. When the pile is long, however, the cloth is not wound on to a roller, but is passed directly into a box or other receptacle.

Apart from differentiating between the loop and cut pile and the different length of pile, the ratio of ground to pile ends and picks to wires may be varied to a considerable extent. Normally the ground weaves are very simple repeating on two, three or four picks but in some figured styles in which large amount of the ground is exposed more ornate ground constructions may be used. The wire to weft ratios are most commonly one wire to two, three or four picks. The fabrics can be grouped in three main classes depending on the surface effect formed:

(1) All-over or continuous pile effects.
(2) Figured effects with one series of pile threads which may consist of loop and cut pile figuring or pile and ground figuring.
(3) Figured constructions with up to five series of differentially coloured threads in which the ornament is chiefly due to colour.

## ALL-OVER OR CONTINUOUS PILE STRUCTURES

The majority of cut pile effects produced for the apparel and upholstery fabrics in the all-over structures are at present made on the face-to-face principle (see Chapter 16); the constructions given in this section are representative of the effects still produced with the aid of wires.

*All the pile over each wire*

The term velvet is applied to the structures in which all the pile ends are raised over every wire as opposed to the term plush which refers to such pile effects in which alternate pile ends are raised over alternate wires, cut pile being produced in both instances.

A and B in *Figure 15.3* represent the weave and the weft cross-section respectively of a simple velvet structure with 2 picks to 1 wire and 2 ground, 1 pile ratio of the ends. At A the lifts of the ground warp are indicated by the dots and the lifts of the pile ends by the crosses where they are raised over the weft and by the solid marks where they are raised over the wire. It will be appreciated that when a pick of weft and a wire are introduced simultaneously, the former into a normal shed and the latter into a special high shed, as depicted at F in *Figure 15.1*, the high lift of the pile end results automatically in the end being over the pick of the weft. Nevertheless, a lift over the pick in question must be separately indicated on the design paper as otherwise the lifting instructions are liable to be misunderstood.

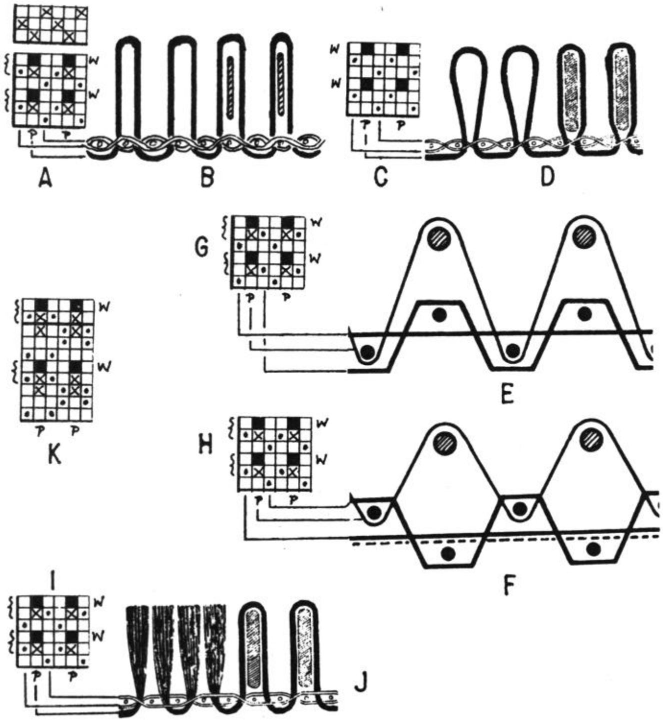



*Figure 15.3*

C and D in *Figure 15.3* show the construction which results when the wire is introduced on its own. Basically, there is very little difference between A and C; the ratio of picks to wires and ground to pile ends is identical in both cases, and so is the ground weave. Yet, the structure is quite different, as will be noted from the comparison of B with D. In the former the pile end is anchored under one pick of weft, in the latter it floats under two successive picks. Due to the longer back float construction D is inferior in respect of tuft anchorage there being a greater likelihood of tuft dislodgment by rubbing on the back of the cloth. As this construction is also slower to produce, the take up not being operative upon the insertion of wire alone, most plain ground velvets are produced as shown at A and B.

In velvets for furnishing fabrics the plain weave ground is also often used but the resultant construction is different from those depicted at B and D because the alternate ground ends which make the plain weave are taken from separate beams of which one is heavily tensioned and the other comparatively slack. A form of rib is thus produced in which the picks lie alternately above and below taut ends, as shown at E and F in *Figure 15.3*, whilst the slack warp is crimped to a considerable extent being made to operate over the top and under the bottom picks. In this manner a more secure pile anchorage is formed, especially in the construction E in which the pile yarn is woven through to the back. Apart from velvets both constructions are also used for uncut moquette self-colour upholstery fabrics for which purpose the cloths are often made heavier by additional warp stuffing yarns which form the same sheds as the taut ground yarns. The position of the stuffers in the structure is indicated by the dotted line at F which is more often employed for the uncut or loop pile effect than E. Although E results in a superior pile anchorage it is costlier to produce because greater length of pile yarn is required for the same surface depth of pile. The weaves for the two constructions are shown at G and H alongside the respective cross-sectional diagrams.

Weaves other than plain are sometimes also used for the ground and I and J show the design and the section respectively of a cloth with a 2-and-2 rib ground structure. In this case a higher warp sett can be used and the ends are often arranged in a 2 ground to 1 pile ratio. K in *Figure 15.3* shows a construction in which a 2-and-2 hopsack ground is employed with 2 ground: 1 pile ratio of ends and with 4 picks to 1 wire.

### *Fast pile anchorage.*

The ordinary 'U' binding of the tuft shown in the previous constructions is adequate for most purposes especially when short, dense pile is produced. This type of binding may be further improved by using the alternate tight and slack ends as demonstrated at E and F in *Figure 15.3.* However, in some circumstances when the cloth is expected to be subjected to a degree of rubbing and particularly when long pile is produced a superior 'W' binding is used in which each pile is additionally interlaced with the weft between the wires. A plain or similar tight interlacing is used to anchor each tuft firmly in the ground structure so that it cannot be easily pulled out.

A typical fast pile structure based on a 2-and-1 rib ground weave is given at A and B in *Figure 15.4*. It will be noted from the cross-section B that between each wire shed the pile end is bound in the ground in a down-up-down order providing a very secure anchorage. Using the weave A the wire is inserted into a separate shed without simultaneous insertion of the weft, therefore, to simplify the weaving arrangements, a 3-and-1 rib may be used as shown at C and D without in any way weakening the binding of the pile yarns. A is woven with three, and C with four picks to one wire, whilst the ratio of ground to pile ends is in both cases 2:1.

*Alternate pile ends over alternate wires.*

These constructions are particularly suitable for the upholstery plushes because fast pile binding can be easily arranged and the tufts, not being regimented in horizontal rows, are staggered and provide a more uniform pile cover. A construction of this type is shown at E and F in *Figure 15.4* which has a 2-and-2 rib ground arranged 1 ground, 1 pile. There are two picks to one wire and this, in effect, means that there are four picks between the wires over which each pile thread is raised. A fast pile bind is obtained as indicated clearly in the cross-section F. A similar fast pile plush effect can also be produced on a 2-and-1

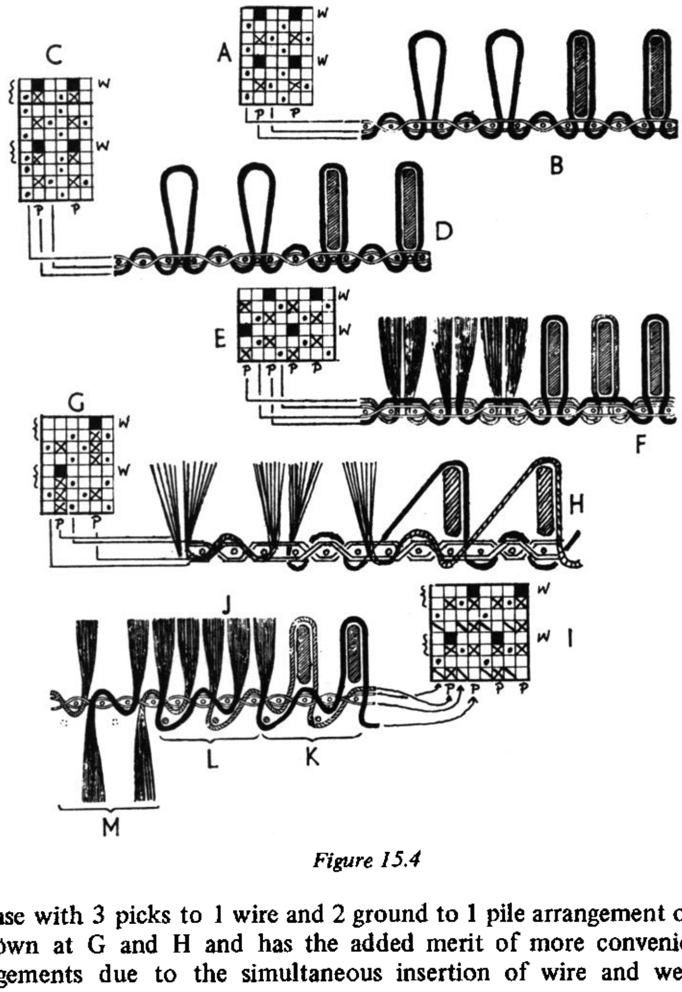



*Figure 15.4*

rib base with 3 picks to 1 wire and 2 ground to 1 pile arrangement of ends. This is shown at G and H and has the added merit of more convenient weaving arrangements due to the simultaneous insertion of wire and weft. In both structures the pile warp may be brought from the same beam, but the weaving is facilitated by using separate slackening of easer bars for the odd and even pile ends.

At one time plush structures were also produced upon warp-backed or double ground cloths. This was useful in overcoating fabrics where raised finish on the back was desired. The raising operation in such cloths could be carried out without any fear of pulling out the tufts from the back as the pile anchorage points were fully protected by another continuous yarn or cloth layer. Such constructions, however, are at present produced only very infrequently.

*Reversible warp pile structures.*

Warp pile cloths that are to be used as hangings are sometimes made with a cut pile on both sides. A method of accomplishing this is illustrated at I, in *Figure 15.4* and the corresponding section given at J, which shows how the warp threads interlace. Half the pile is over each wire, and in this case, after the insertion of a wire, an extra pick is introduced on which all the ground ends are raised (as shown by the diagonal marks in I), and alternate pile ends. In the section J the extra picks are indicated below the level of the plain ground threads, while one pile thread is shown shaded and the other solid in order that the system of interlacing may be readily seen. Exact repeats of the weave are indicated by the brackets, the portion lettered K representing the cloth previous to, and L following, the withdrawal of the wires. After the cloth is woven, the extra picks, which are usually thicker than the ground picks, are drawn away from the underside of the cloth; this causes one-half of each double tuft to pass to the reverse side, as shown in the section M, where the dotted circles indicate the positions which the extra picks previously occupied.

*Settings of warp pile fabrics.*

As mentioned earlier the density of thread spacing, the thickness of the yarns and height of pile in this group of structures can be varied to a considerable extent depending on the end uses of the cloths. In the following several typical qualities are given for a variety of purposes. Other settings are given in further parts of this chapter connected with certain specific uses of some of the structures dealt with.

(1) Dress velvets: Warp setting–10 to 16 pile ends per cm the number of ground ends per cm depending on the ratio of pile to ground ends; ground warp–20/2 tex to 32/2 tex cotton; pile warp–10 to 20 tex single or two-fold in a variety of materials such as mercerised cotton, filament rayon, synthetic yarns and occasionally spun silk; weft settings–6 to 12 wires per cm the number of picks per cm depending on the ratio of picks to wires; weft yarn counts–20/2 tex to 32/2 tex cotton; pile height–1·5 to 3mm.

(2) Upholstery plushes: Warp setting–10 to 12 pile ends per cm; ground warp–60/2 tex cotton or staple viscose rayon; pile warp–50/2 tex to 72/2 tex worsted or equivalent counts in polyamide, acrylic or polypropylene yarns; weft settings–8 to 12 wires per cm; weft counts 60 tex two-fold or single cotton or staple viscose rayon; pile height 2 to 5 mm.

(3) Upholstery uncut moquette: Warp setting–13 pile and 13 ground ends per cm; ground and pile warp–74/2 tex cotton; weft settings–6 wires and 12 picks per cm; weft counts–120 tex cotton or staple viscose rayon; loop height–1·5 to 2 mm; construction as at F, *Figure 15.3* (without stuffer yarns).

*Ornamentation of all-over warp pile fabrics.*

Continuous warp pile structures can be ornamented in a variety of ways during manufacture or during finishing. Stripe effects can be readily achieved by introducing differently coloured pile threads. Horizontal bars, which add considerable interest to the appearance of the cloth, can be obtained by employing both cutting and looping wires which may be arranged in different sequences, such as eight of each, or ten cutting followed by six looping wires, and so on, as shown schematically at A and B in *Figure 15.5*. Stepped or waved pile effect can be

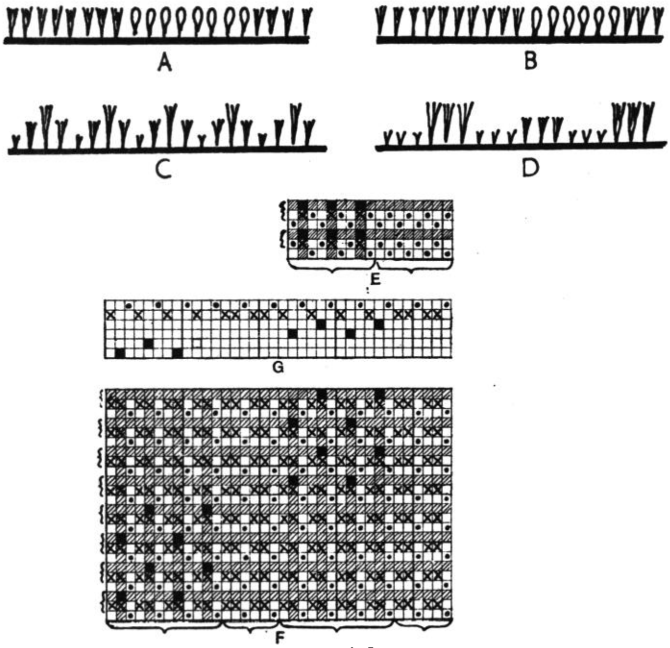



*Figure 15.5*

created by using different heights of wire in varying arrangements as indicated in the schematic diagrams at C and D in *Figure 15.5*. Other modifications may include a combination of small diameter looping wires with tall cutting wires and so on. Specially prepared and constructed pile yarns may be used which upon cutting are capable of curling tightly in various directions to produce an imitation Astrakhan fur surface.

*Figure 15.6*

Most of the ornamentation of the continuous pile fabric is at present carried out during finishing. Varied surface effects can be achieved by subjecting a cloth to the pressure of embossing rollers. Frequently, heat is utilised in conjunction with various thermoplastic yarns. Incorporation in a construction of synthetic yarns with different thermal properties followed by an application of heat results in many excellent effects due to the differential heat shrinkage. The cloth given in *Figure 15.6* represents one example of an imitation fur achieved by the above technique but there are numerous other possibilities of obtaining spectacular surface textures by utilising the knowledge of the cloth structure in combination with an appreciation of the behaviour of the different materials in varying conditions of heat, moisture or susceptibility to chemical agents.

*Stripe and check effects.*

A form of ornamentation obtained without having recourse to a jacquard machine consists of combining the pile structure with other forms of interlacing in stripe and check form. The design E in *Figure 15.5* is an illustration of a stripe composed of pile and 2-and-2 warp rib. The pile interlacing corresponds with I and J in *Figure 15.3*, while the rib stripe is simply a continuation of the weave of the ground threads, and can, therefore, be produced by the same healds. Different widths of stripes can be obtained by repeating the sections enclosed by brackets.

The design F illustrated the formation of alternate squares of pile on a warp rib ground, with longitudinal spaces of ground between, which may be coloured differently from the pile sections. There are two picks to each wire, and the warp is arranged 1 worsted ground, 1 worsted pile, and 1 cotton ground; the worsted threads work in pairs except on the wire sheds, in order to develop the rib formation. The rib structure is made more pronounced by weaving the cotton ground threads at greater tension than the worsted ground threads, and by wefting one pick fine, one pick coarse. Fine warp beams are necessary—viz. two for the pile threads and one each for the worsted and cotton ground threads, while six shafts are required, as shown in the draft indicated at G. The pile ends and the wires in both, E and F, are indicated by the shaded lines.

*Continuous pile carpet structures.*

Warp pile carpets produced with the aid of wires are classified in two main groups, viz. Brussels, in which a loop pile is produced, and Wilton in which the surface consists of cut pile. The ornate, multi-colour carpets are described in a subsequent section of this chapter but the technique of weaving the all-over or continuous pile carpets of this group is, apart from the weight of the cloth, similar to that already described in connection with the velvets and plushes.

Self-colour Brussels carpets, also known as cord or boucle, are woven in two-shot structures, i.e. 2 picks to 1 wire, using plain wires. Most of the self-colour Wilton or velvet carpets are also woven in identical two-shot structures only with cutting wires. Some of the better qualities of velvet pile carpets are, however, woven in three shot, i.e. 3 picks to 1 wire, structures which, although slower to produce, offer the advantage of superior pile anchorage.

A standard self-colour two-shot structure is shown at A and B in *Figure 15.7*. The weft cross-section at A shows clearly that the construction, in addition to the ground or chain ends and the pile ends, also embodies stuffer warp yarns, the stuffer being a heavy and stiff jute yarn which separates the weft into two layers. Each vertical row of pile encompassed within a reed dent contains one pile end, two chain (ground) ends and two or three stuffers. The weave repeats over four picks. Usually, the construction is woven in three heald shafts. The front shaft, which has a greater movement than the other ones, carries the pile and the stuffer ends in special mail eyes shown at C in *Figure 15.7*. On pick 1 of the structure, when only the weft is inserted, the front heald is down lowering the pile ends and the stuffers to the bottom shed line. The second chain heald shaft is also down so that the top shed line is formed only by the odd chain ends as depicted at D. On the following pick of the sequence the weft is inserted simultaneously with the wire. It will be noted from the diagram E in *Figure 15.7* that the pile ends are raised high to form an upper shed for the insertion of the wire by virtue of being controlled by the eye in the special mail whilst the stuffers being operated by the slot are raised to only half that height. They thus form together with the odd chain ends the bottom line of the upper shed and the top line of the lower shed into which the weft is inserted. The manipulations of the front heald repeat over two picks, therefore, the positions of this shaft on picks 3 and 4 are the same as on picks 1 and 2 respectively. The chain ends, however, operate in a 2 up, 2 down sequence and whilst on the first two picks the odd chains are up and the even ones are down on picks 3 and 4 these positions are reversed. The lifts of the healds can be easily traced in the full weave given at B in *Figure 15.7* in which the appropriate ends are connected by lines to their counterpart in the cross-section A. The high lift of the pile ends on the even picks is denoted by the solid squares at B whilst the low lift of the stuffer ends is indicated by the double vertical lines. The operation of the chains is shown by the circles in B. It will be appreciated that exactly the same procedure will apply when the two-shot cut or velvet pile carpeting is produced the only difference in the manufacture between the two being in the type of wire used. Occasionally the same type of structure as described above is produced on four healds, separate shafts being used for the pile and the stuffer ends.

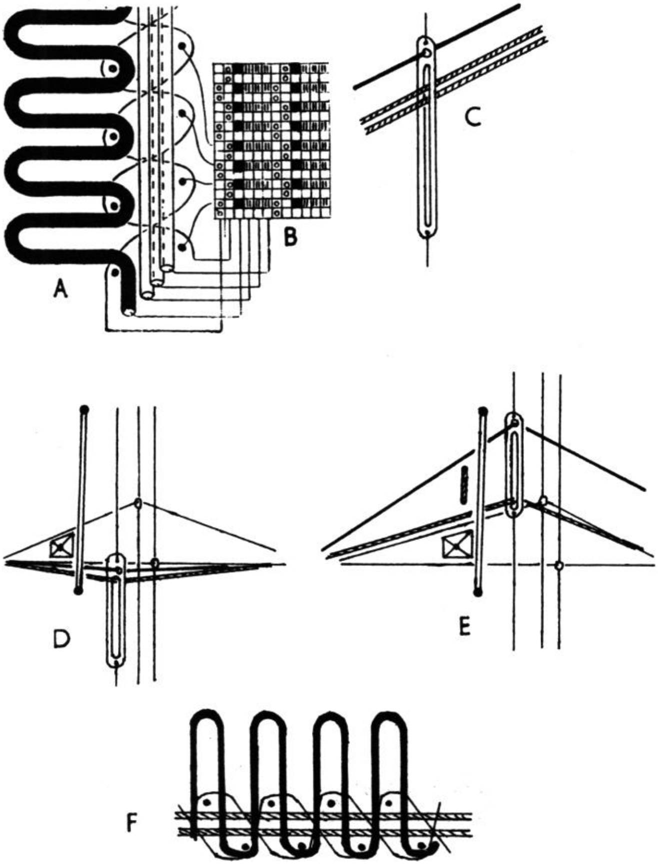



*Figure 15.7*

In areas of high wear such as hotels, public institutions, offices, etc., the standard self-colour Brussels structure provides insufficiently good pile anchorage. The loops are liable to be pulled and are said to 'sprout' when, due to pulling, a loop of an enormous length is created by robbing the neighbouring loops in the same row of all their length. To prevent this the loops are anchored around the back pick by weaving them through to the back as indicated at F in *Figure 15.7*. The construction is known as the 'wool back' construction because the pile yarn is clearly visible on the back of the carpet. The basic difference in the weaving is that the wire in this system is inserted together with pick 1, and not pick 2 as in the standard structure, and four healds must be used because the lifts of the stuffers do not synchronise with the lifts of the pile ends as they did previously. Due to the method of anchorage greater length of pile yarn is required to produce the same surface height of pile as in the standard structure.

Most carpets are produced in a standard pitch, i.e. with a set number of pile ends per unit space and the pitch is rarely changed, therefore, the quality is varied by changes of the pile yarn quality, the number of wires per unit space and the height of wires. A good quality self-colour loop pile carpet may be produced with 32 pile ends per 10 cm, using 350/2/3 tex pile yarn (80 per cent wool, 20 per cent polyamide fibre), 220/3 tex cotton chain and 480 tex jute stuffer with 36 wires per 10 cm and 280 tex jute or hemp weft; about 250 to 260 m of pile yarn being required to produce 100 m of carpet. Lower qualities may be produced with only 26 wires of lower height per 10 cm.

Many different materials are used for the pile—in addition to pure wool worsted or woollen spun yarns, wool is used in blended yarns, frequently with an admixture of polyamide fibres, and purely synthetic materials such as the acrylics, polyamides and polypropylene are also employed as well as staple viscose rayon yarns.

The two-shot Brussels construction was at one time ornamented by yarn printing to produce definite pattern effects. Carpets of that type were known as tapestry carpets and a section through this type of effect is shown at A in *Figure 15.8*. It will be noted that the construction of this type of carpet is identical with the standard structure given at A in *Figure 15.7* except that the pile yarn is differently coloured in small portions along its length. Each pile thread was coloured in a developing design sequence so that when they were all beamed together a complete colour design would result. Due to the vagaries of yarn movement during weaving these designs rarely achieved absolutely perfect registration and the outlines of the figures were usually somewhat hazy in the lengthwise direction. Also, each loop instead of being uniformly coloured would occasionally consist of half of one colour and half of another. Despite these faults the designs had their specific charm and were popular as cheap substitutes for the true multi-coloured Brussels constructions (see p. 307). However, the printing and beaming of these yarns was so time and labour consuming that the gains achieved by weaving what was virtually a continuous pile effect in preference to jacquard ornamented effects were eventually insufficient. For this reason the yarn printed tapestry carpets are no longer produced.

Although many cut pile effects are produced in the two-shot weave by the use of cutting wires in very similar settings to those employed for the loop pile carpets the three-shot structure is not equally interchangeable. It is used only for the finer qualities of Wilton or velvet pile carpets where improved tuft anchorage is desired. The construction is given at B and C in *Figure 15.8* from which it will be seen that there are 3 picks to 1 wire and that the chain warp ends operate in a 3 up, 3 down order. The stuffers lie in the middle of the construction separating the weft into two layers as before. The wire is introduced into the upper shed simultaneous with the second pick in each group of three the double shed technique being identical with the one used in the two-shot structure. Similar to the latter it can be produced with either three or four heald frames both drafts being shown above C. The first draft is, of course, only applicable when the front heald is equipped with the special eyed and slotted mails.

The velvet pile carpets are often woven with 32 to 38 pile ends per 10 cm using pile yarns ranging between the fine 350/2/3 tex worsted and the coarser

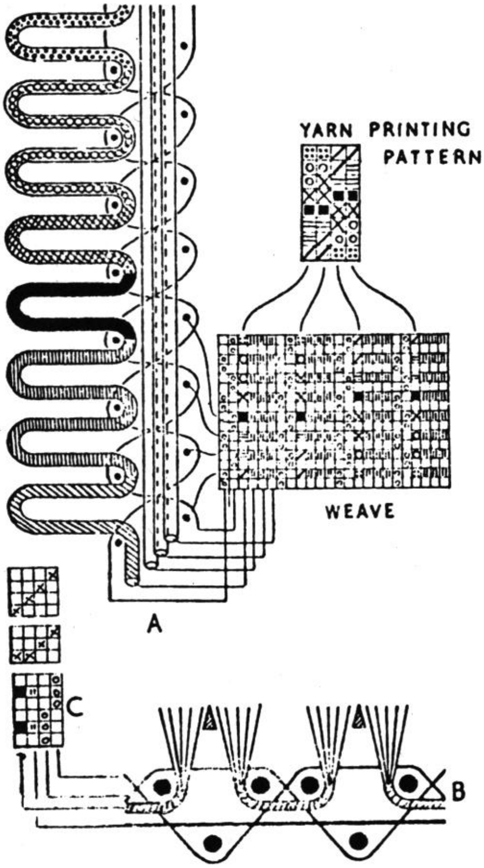



*Figure 15.8*

620/2 tex woollen spun qualities. The number of wires per 10 cm varies between 32 and 40. The pile height is generally greater than in the loop pile carpeting and may be as high as 12 or 15 mm but the commonest varieties are produced with the pile height of 5 mm.

The continuous pile Wiltons made in the two-shot construction are sometimes ornamented by stripe designs, occasionally described as 'candy stripe' Wiltons. These are frequently the result of utilising large and varied pile yarn remnants and are sold more cheaply than similar self-colour qualities being produced in comparatively short runs.

## FIGURING WITH ONE SERIES OF PILE THREADS

Small quantities of high quality furnishing fabrics are produced in which the pile warp is jacquard controlled to produce figured effects. Although only one series of pile yarns is used several different groups of structures can be made which may be classified as follows:

(1) Pile figure on ordinary weave ground; several sub-types exist in this group as the pile may be cut or uncut and different ground weaves may be used.
(2) Loop pile figure on cut pile ground.
(3) Loop and cut pile figure on ordinary weave ground.

As the above fabrics are invariably used in furnishings the ground ends are normally taken from two differently tensioned beams to produce the alternate tight and slack end ground construction already described with reference to A and B in *Figure 15.4*. In most instances the ground ends are controlled by two heald shafts mounted at the back of the harness so that the jacquard controls only the pile ends. Often, the jacquard arrangement is such that the knives provide the high lift for the insertion of the wire whilst the comber-board is capable of lifting the pile ends which are not selected to go over the wires into the middle shed as indicated at B in *Figure 15.9*. Where loop and cut pile effects are produced looping and cutting wires are inserted alternately.

*Pile figure on ordinary weave ground.*

As shown in the fabric illustrated in *Figure 15.10* the pile threads in these styles are not forming pile continuously and the amount of take up of the pile ends may vary considerably. It is, therefore, necessary for each pile end in the repeat of a design to be 'beamed' on a separate bobbin; each bobbin may carry as many ends as there are repeats in the width of the fabric but in a large single repeat design each bobbin can carry only one end. The bobbins are mounted in a creel at the rear of the weaving machine and are individually tensioned.

The alternate ground ends are placed on different beams of which one is heavily tensioned and the other lightly weighted. The ground weave may be varied according to requirements but most frequently the ground ends are operated in the plain, or in the 2-and-2 rib weaves. The appearance of the ground cloth in these constructions is important because portions of it are exposed to view and often the ribbed effect is emphasised deliberately by using considerable density of warp setting and fine warp yarns as opposed to low shottings and coarse weft yarns. The healds which control the ground ends are usually operated from a tappet assembly and are placed at the back of the harness as shown by the comber-board diagram at C in *Figure 15.9* and by the operational diagram at A and B. In most constructions one wire is inserted to two picks.

The jacquard is normally of the single-lift type, it controls only the pile warp and is arranged to lift the selected pile ends into a high shed for wire insertion. The sequence of operation is shown at A and B in *Figure 15.9* and may be described as follows. During the insertion of pick 1 of the construction–diagram A–a card is presented to the needles and a selection takes place. On pick 2–diagram B–the knives lift the previously selected hooks and, therefore, pile ends to form the top line of the high shed into which a wire is inserted simultaneously with the pick of weft which is introduced into the lower shed. The unselected pile ends are taken on the same pick to the top of the lower shed by the working comber-board which is normally controlled by a positive tappet. The comber-board is capable of lifting the harness because the harness cords are knotted

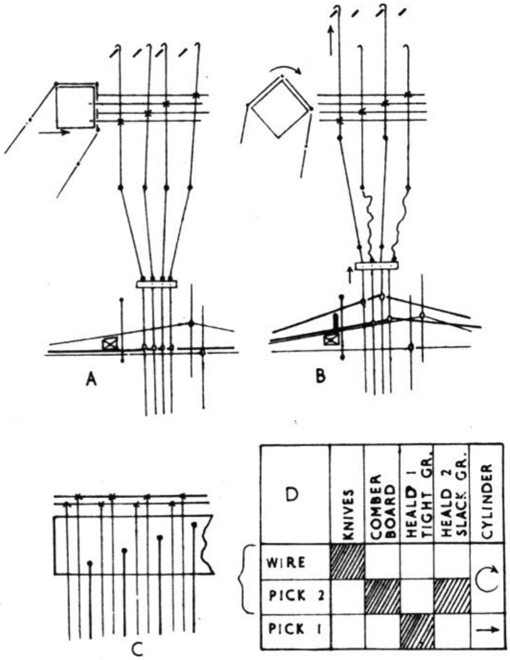



*Figure 15.9*

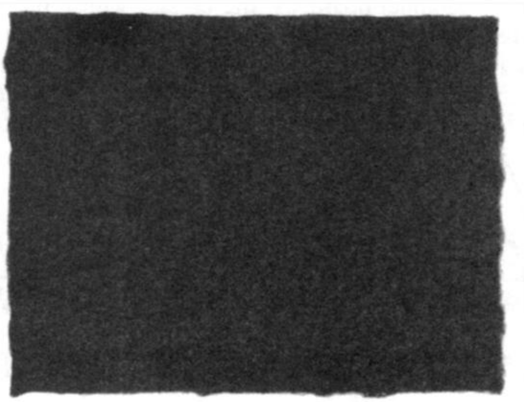


*Figure 15.10*

above the holes in the board and cannot slip through them when the lift takes place. The selected pile harness cords are not affected by the comber-board lift because they are lifted higher by the knives as shown at B. Some manufacturers prefer to use jacquards in which the function of the comber-board is performed by a bottom-board; i.e. the board upon which the hook bottoms rest in the jacquard engine. This has the advantage of obviating the slackening of the harness cords which is unavoidable when a working comber-board is used as clearly shown at B in *Figure 15.9*. The single-lift jacquard does not in this case represent a speed limit factor as it does in normal applications because, as may be noted from A and B, it operates at half the speed of the weaving machine. The selection takes place during the first pick of the sequence, the lifting action during the second pick at which time the cylinder is turned to present the new card for the following pick. At any rate, in all these structures it is usually the wire motion which represents the main impediment towards higher operating speeds. The lifting sequence of the various shed forming elements in this system is given at D in *Figure 15.9* in which the lifts are indicated by the shaded squares. The same diagram also relates the operation of the jacquard cylinder to the picking sequence showing the selection on pick 1 and the turning of the cylinder on pick 2/wire.

The resultant construction is given in the section at A in *Figure 15.11* in which the pile figure may be looped or cut depending on the type of wire used. It will be noted that when the pile ends are not selected to lift over the wires they operate by virtue of the working comber-board lifts in the same order as the slack ground ends thereby adding to the ribbed appearance of the ground already emphasised by a suitable warp to weft ratio and the alternate slack and tight ends. The method of painting is represented by the small portion of design shown at B which is related to the fabric in *Figure 15.10*. In the design each horizontal row represents a wire and each vertical row a pile end and, therefore, the marks in the design are cut as they stand as they represent the only lifts for which the jacquard itself is responsible. The full construction for the painted and the blank portions of B which results from the combined lifts of the jacquard hooks, the working comber-board and the healds is given respectively at C and D. The lifts of the selected hooks are denoted by the solid marks, those of the comber-board by the crosses whilst the operation of the healds is indicated by the dots. The ratios of 2 ground ends to 1 pile and 2 picks to 1 wire represent the usual arrangements in this type of structure. E and F in *Figure 15.11* correspond respectively to C and D and show the same design developed in the alternative 2-and-2 rib ground structure. The change in

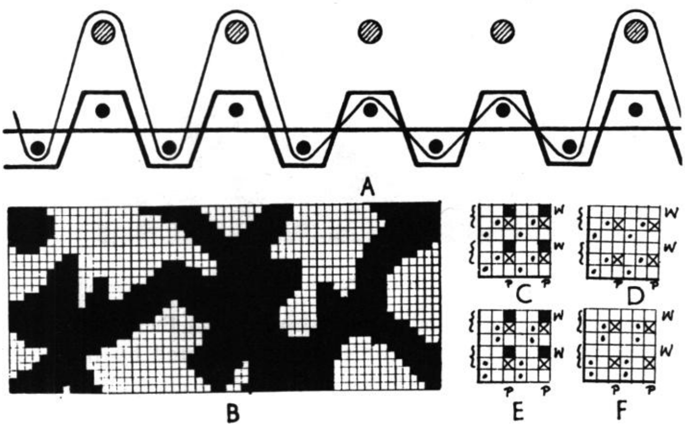



*Figure 15.11*

the ground structure does not affect the operation sequence for the jacquard and the comber-board, the only change occurs in the order of manipulation of the ground healds.

The form of heald and harness mounting described above and the system of jacquard operation are suitable only when simple ground weaves are used. Ornate, figured weaves in the exposed ground areas usually demand jacquard control of all the ends, ground as well as pile, and jacquard selection on every pick and not only on the alternate picks. Such arrangements are more often employed when more than one series of pile threads is used in the structure and are described in a subsequent section of this chapter.

*Loop pile figure on cut pile ground.*

This type of structure, illustrated in *Figure 15.12*, is used mainly for upholstery purposes. The ground structure may be plain or 2-and-2 rib with alternate tight and slack ground ends controlled, as previously, by two healds placed at the back of the jacquard harness. The jacquard arrangement may be exactly the same as described with reference to *Figure 15.9*. The construction is achieved by the insertion of alternate looping and cutting wires so that one structural unit in the weft-wise direction consists of four picks and two wires. Within this unit a given pile end will be raised only once—either on the looping or on the cutting wire, but not on both. As every pile end is raised on one of the two wires which are all the same in height the take-up of all pile ends is identical and they can be beamed on the same beam without the need for bobbins and creels necessary in the construction illustrated in *Figure 15.10*.

*Figure 15.12*

The cross-sectional appearance of the construction is given at A in *Figure 15.13* with each structural unit being separated from its neighbour by the dotted lines. The looping wires, represented by the oval shapes, are inserted together with pick 2 of each unit whilst the cutting wires, indicated by the triangular shapes, are inserted simultaneously with pick 4 of each structural unit. The working comber-board is also raised on picks 2 and 4, therefore, any pile ends not selected to lift over a given wire will be nevertheless raised on the pick which accompanies that wire. This is clearly shown in the section. Cut pile, being the richer in appearance, occupies the greater proportion of the repeat area. In preparing the design it is usual to paint the loop pile and at B a small portion of design is shown in which the loop pile figure is represented by the solid marks the blanks indicating the cut pile. Each horizontal row, therefore, represents a looping and a cutting wire and each vertical row corresponds to one pile end. Two cards are cut from each horizontal row and the cutting instructions can be formulated as follows:

Looping wire – cut all marks
Cutting wire – cut all blanks

The two bottom horizontal rows are expanded at C in *Figure 15.13* to show the full construction which results from the co-ordinated action of the jacquard selection mechanism, the comber-board, and the two healds. The lifts of the hooks on the looping wires are indicated by the circles, on the cutting wires by the solid marks whilst the comber-board lifts are represented by the crosses and the heald lifts by the dots.

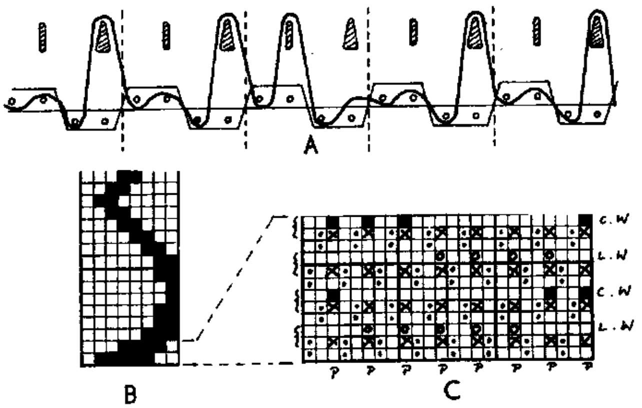



*Figure 15.13*

The quality of these fabrics varies considerably and whilst the ground yarns are usually cotton or staple viscose rayon the pile yarns may be worsted, acrylic, polyamide, or polypropylene. A good quality upholstery fabric may be constructed as follows: Pile warp–6 double ends (two ends weaving as one in decked harness mails) of 60/2 tex worsted per cm; ground warp–12 ends (6 slack, 6 tight) of 74/2 tex cotton per cm; weft–24 picks of 40 tex cotton per cm; 12 wires (6 looping, 6 cutting) per cm, each 3mm high; density–36 double loops or tufts per $cm^2$.

*Loop and cut pile effects on ordinary weave ground.*

This construction, which is used for upholstery purposes, may be regarded as a combination of the previous two effects. The shedding and the wire insertion order may be exactly as described for the loop and cut pile figuring but in addition selected pile ends are occasionally left down on both wires to produce sunk ground effects. The cross-sectional view of the structure is represented at A in *Figure 15.14*. At B a small portion of design is shown in which the blank spaces correspond to cut pile, the solid squares to loop pile, and the crosses to sunk ground. As in the design B in *Figure 15.13* each horizontal row corresponds to two wires and each vertical row to one pile end. The cut pile occupies usually the greatest area in the repeat being the richest in appearance and to save time and labour it is used to paint the loop pile and the sunk ground areas leaving the cut pile portions blank. The card-cutting instructions, using the harness mounting previously described, are as follows:

| | | |
|---|---|---|
| Looping wire | – | cut all solid marks |
| Cutting wire | – | cut all blanks |

The two bottom horizontal rows are expanded at C to show the full construction in which the lifts of the pile ends on the cutting wires are indicated by the solid marks, on the looping wires by the circles whilst the comber-board lifts are designated by the crosses and the ground heald lifts by the dots.

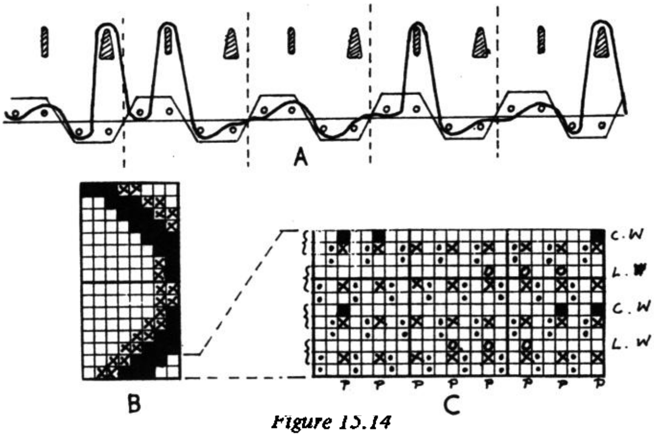



*Figure 15.14*

The operational system described above represents one of a number of methods in use. Other systems with different shedding arrangements also exist but all are designed to result in similar structural effects. Fancier constructions with two different heights of pile and greater structural variety are also sometimes produced but usually the more elaborate effects are made with more than one series of pile threads and are, therefore, described in the following section of this chapter.

## FIGURING WITH SEVERAL SERIES OF PILE THREADS

In this form of figuring the effect is due primarily to colour. As opposed to previously described constructions in which one longitudinal row of loops or tufts consisted of one pile end, in multi-coloured arrangements one row of pile contains from two to five differently coloured pile ends. Only one end is raised over any given wire whilst the remaining pile ends at that point lie 'dead', simply awaiting the occasion when they will be required to form the surface effect in further portions of the design. Each vertical row of pile thus consists of a group of threads which are technically referred to as 'frames' and the cloths are classified as two, three, four or five frame constructions depending on the number of pile threads per group. The term frame is applied because each pile is on a separate package–bobbin or cheese–placed in a creel or 'frame' at the back of the loom. Separate packages are necessary because each pile thread may have a vastly different take up from any other thread within a group and between the groups. Each group will contain one thread from each creel or frame and the total number of groups used is equal to the number of loops or tufts in a horizontal row of pile in the cloth width.

The greater the number of pile threads in a group the greater is the consumption of the pile yarns and, therefore, the cost of the fabric. The benefits of the increased number of pile ends per group are in improved design and colour scope and better resiliency combined with higher bulk of the cloth. The quantity of pile yarn used is not in direct proportion to the number of the frames because no matter how many frames, i.e. pile ends per group, are employed only one thread of a group is raised over a wire. For example, assuming that 300 m of continuous pile are required to produce 100 m of cloth and 104 m of stuffer yarn (the dead pile assumes the same configuration as the stuffer being raised and lowered together with it) each group of threads in a 5-frame structure will require (1 x 300) + (4 x 104) = 716 m of pile yarn, whereas a 3-frame pattern will require (1 x 300) + (2 x 104) = 508 m of yarn.

The multi-frame constructions are employed in the manufacture of loop pile effects for upholstery work, usually referred to as uncut moquettes, and for the Brussels carpets. Cut pile effects are also produced for both the above purposes, the carpets being known as Wilton carpets and the upholstery fabrics as moquettes. In addition, mixed effects are also made in which cut and loop pile may be combined with sunk ground areas and the structural diversity may be further extended by producing effects with high and low pile due to different heights of wire. The upholstery cloths, obviously, differ from the carpet structures in the weight, degree of rigidity or pliability, and the pile height, the difference being mainly due to the thickness of constituent yarns. Some structural differences between the two groups of constructions also exist and these are detailed subsequently but the method of designing is common to both. It must not be understood that the design styles or sizes are similar between the carpet and the upholstery structures. It is only the procedures of design preparation which are the same. The jacquard mountings are also similar in principle although the machines may vary considerably in weight or size. Multi-frame carpets are produced in a variety of settings the finest containing as many as 40 groups of threads and 52 wires per 10 cm, and the coarsest, 20 groups of pile threads and 28 wires per 10 cm. The upholstery cloths are made in finer settings ranging from 72 to 56 groups of threads and wires per 10 cm.

### *Standard multi-frame structures.*

A two-shot structure with four differently coloured pile ends in a longitudinal row (4-frame) suitable for Brussels or Wilton carpets is depicted at C in *Figure 15.15*. The section shows one vertical row of pile and the yarns are appropriately connected by lines to the corresponding rows of the fully worked-out weave at B in which the circles denote the lifts of the chains (or ground ends), the double vertical strokes the stuffers, the solid marks the high jacquard lifts of the selected

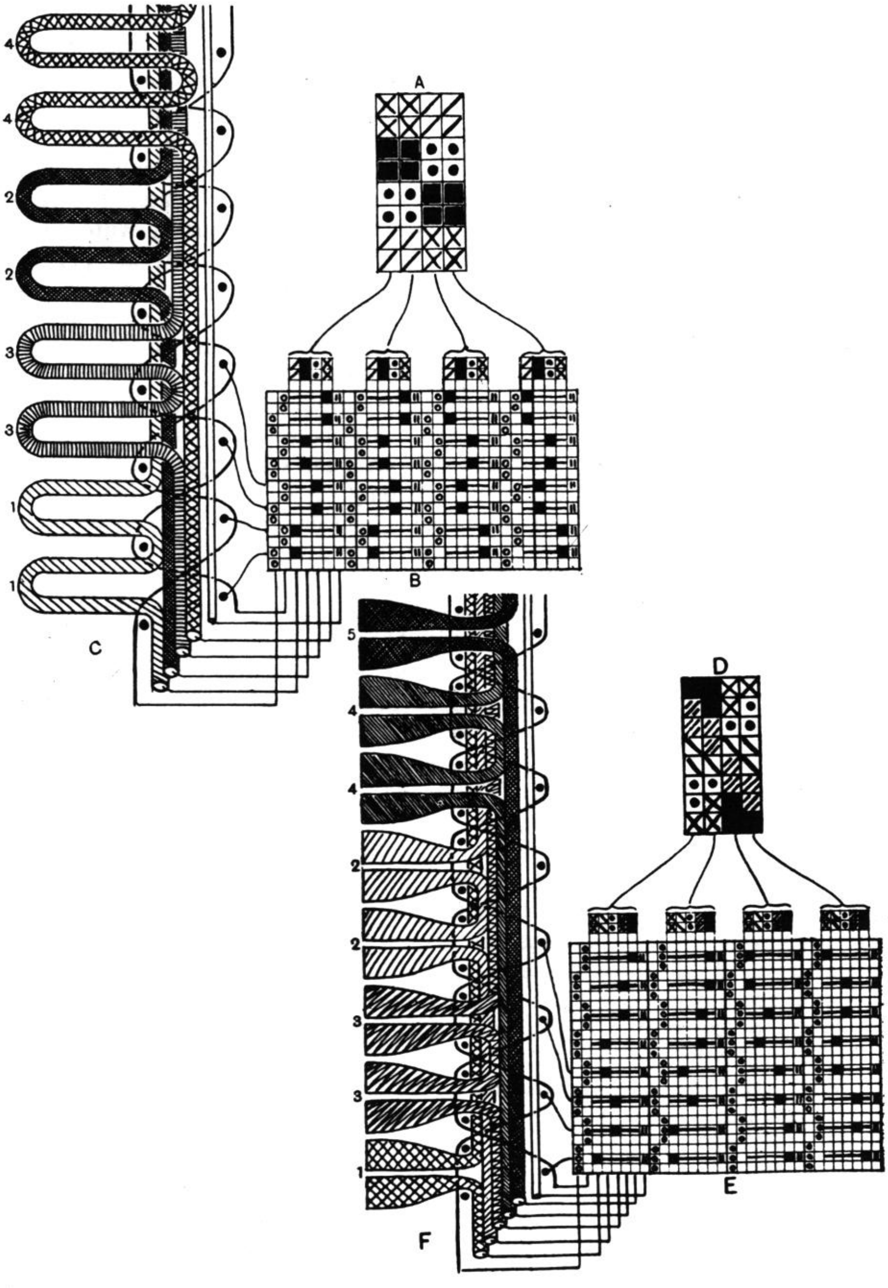



*Figure 15.15*

pile over the wires, and horizontal lines the comber-board lifts of the unselected or dead pile yarns. The wire is inserted simultaneously with pick 2. The simplified design A indicates where a given colour of pile is raised upon a wire and is condensed by 7 warp-wise (4 pile ends, 2 chains, 1 stuffer) and by 2 weft-wise. Each group of pile ends with the attendant chains and stuffer occupies one dent in the reed. Suitable particulars for a high quality loop pile carpet in the two-shot structure as shown at C are as follows: Pile warp 340/2/3 tex worsted, chain warp 220/3 tex cotton, stuffer warp 420 tex jute, weft 280 tex linen; 36 groups of pile threads and 36 wires per 10 cm resulting in 13 loops per $cm^2$. A similar high quality cut pile carpet in a two-shot structure could be similarly set although slightly finer pile yarns combined with a slightly greater density of settings and a higher pile are also frequently made. Lower quality Wiltons with coarser woollen spun yarns are produced often with as few as 10 tufts per $cm^2$.

A three-shot Wilton carpet construction using five pile ends in each vertical row is given at F in *Figure 15.15*. The simplified design at D and the fully worked-out weave at E are similarly arranged to A and B only in this case the degree of condensation in the design is by 8 warp-wise and by 3 weft-wise and each vertical row of pile consists of five differently coloured threads eight ends in all occupying one reed dent. The chain ends operate in a 3 up, 3 down order and the wire is introduced simultaneously with the second pick in each group of three. The three-shot structure is used only for cut pile constructions and offers superior pile anchorage the tuft being held under two picks of weft each of which belongs to a different group of three as can be seen at F. It is an expensive cloth to produce due to a reduced rate of production one horizontal row being made in three picks as opposed to one row in only two picks in the two-shot structure. Consequently, it is only made for situations in which the higher degree of wear demands the improved binding of the pile as, for example, in stair carpeting, and for hotels, stores and other public institutions. A good quality three-shot Wilton may be produced in accordance with the following specifications: Pile warp 300/2/3 tex worsted, chain warp 220/3 tex cotton, stuffer warp 560 tex jute, weft 280 tex linen; 40 groups of pile threads and 40 wires per 10 cm resulting in 16 tufts per $cm^2$. On occasions 2-frame, or 3-frame Wilton structures are produced which contain two or three permanently dead pile yarns per vertical row in addition to the two or three which actually participate in the formation of figure. For this purpose pile yarn remnants are used which would otherwise be disposed of as waste. Although the permanently dead pile threads cannot be used for figuring as they may consist of an odd assortment of colours they improve considerably the bulk and the resiliency of carpets thus effectively raising the low frame construction into a higher quality bracket.

Multi-frame upholstery moquettes or uncut moquettes are produced in two-shot structures as a rule but with a different ground weave than the one shown at C in *Figure 15.15*. Usually the ground weave is plain with the alternate tight and slack ground ends. Two structures suitable for upholstery cloths are shown at C and F in *Figure 15.16*. Both are 3-frame constructions and can be used for loop and cut pile effects. Customarily, however, the structure C is more often used for the uncut pile effects, whilst the structure F, in which pile is woven through to the back, is employed for the cut pile fabrics. The construction F, as already observed in connection with self-coloured effects, results in better pile anchorage than C but requires greater length of yarn for the same height of pile on the surface. A good quality loop pile upholstery cloth can be produced as follows: Pile warp 98/2 tex worsted, ground warp 74/2 tex cotton, stuffer warp 98/2 tex cotton or staple viscose rayon, weft 98 tex cotton or staple viscose rayon; 64 groups of pile threads and 64 wires per 10 cm, 41 loops per $cm^2$. Cut pile cloths are sometimes produced in slightly denser settings than loop pile structures and polypropylene and acrylic yarns are often used instead of worsted for the pile with excellent results. The following represent the particulars of a high quality cut pile upholstery fabric: Pile warp 125/2 tex worsted, ground warp 118/2 tex cotton, weft 98 tex cotton or staple viscose rayon; 68 groups of pile threads and 64 wires per 10 cm, 44 tufts per $cm^2$. It will be noted that no stuffer yarn is employed in this structure. The heavy pile and ground yarns provide sufficient rigidity and as the taut ground ends assume the same position in the cloth as the stuffer the need for the latter is obviated. The simplified and the fully worked-out designs at A and B, and at D and E refer respectively to the sections C and F. The marks used in the fully worked-out weaves correspond with those employed in *Figure 15.15* for the carpet structures.

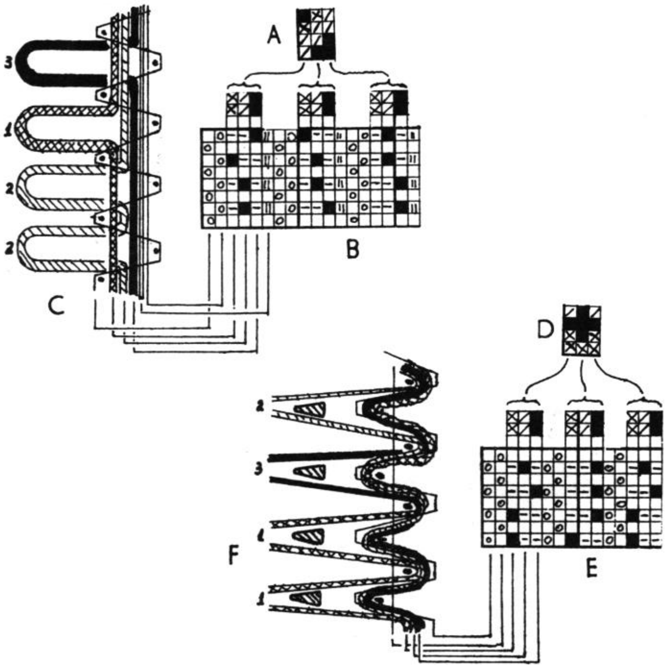



*Figure 15.16*

All the four constructions described in the foregoing can be embellished further by the exposure of the ground structure, or, in other words, by the creation of sunk places. This is achieved by deliberately failing to lift any pile ends in a group on some wires in selected areas. The sunk portions add effectively to the ornamentation and are useful for emphasising certain design features as shown in the fabric given in *Figure 15.10*. Used in excess, however, they reduce the quality of the cloth in respect of its resiliency and wear resistance by reducing the total number of pile points per area. As the use of sunk portions reduces the total length of pile warp required it makes it possible to produce constructions of pleasing appearance more cheaply.

*Planting*

The number of colours in the width of a fabric is not limited to the number of frames employed; the threads in different groups may be differently coloured, in which case one, two or more of the frames each contains more than one colour of pile. Thus, in a 5-frame structure one portion of a design may require the colours, 1, 2, 3, 4 and 5, and another portion the colours 1, 2, 3, 6 and 7, and yet another portion the colours 1, 2, 3, 8 and 7; the colours 1, 2 and 3 being constant, while the colours 4 and 5 are replaced by the colours 6 and 7, and then the colour 6 by the colour 8. The substitution of one colour for another is termed 'planting' and if this is judiciously performed a design may be produced in a 4-frame or 5-frame cloth which contains as many as, say 20 colours. In the same quality the higher the number of frames the more costly is the cloth on account of the greater quantity of pile yarn required and frequently a cloth, by successful planting, is given the appearance of being produced with a higher number of frames, and therefore, appears more costly than is actually the case. The chief point to note in planting is to avoid the formation of stripes in the woven design, and for this reason a planted colour is sometimes graduated at both sides towards the adjacent colours in the frame.

*Method of Designing*

In originating a large design a sketch of the figure is usually first made in pencil to a reduced scale on plain paper, and the proper colours are then indicated more or less roughly on the different portions. In transferring the design to squared paper it is customary to use paper that is ruled according to the pitch of the cloth, so that in drawing and painting the figure it is shown exactly the

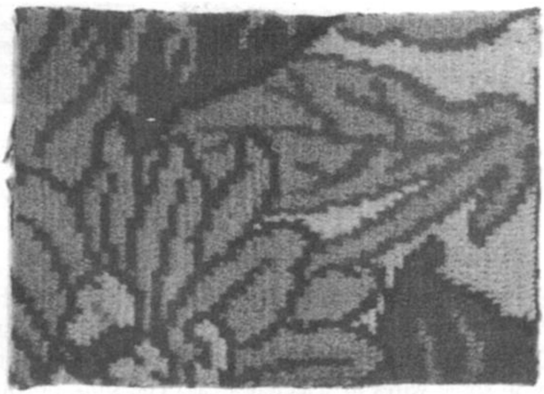


*Figure 15.17*

size it will appear when woven. Also, it is usual to paint-in the several parts of the ornament in the exact colours that it is intended to employ in the cloth, although subsequently the colours of the woven design may be changed by substituting other threads in the loom. Each vertical space of the design paper represents a group of pile threads, and each horizontal space a wire, hence each small square of the paper represents a loop or tuft. An illustration of a 5-frame cut pile structure is given in *Figure 15.17*, in which the same five colours

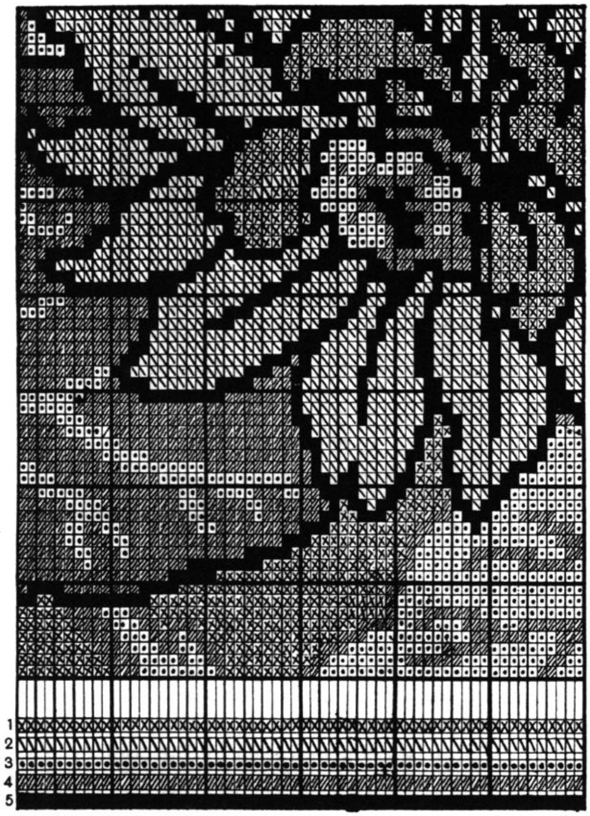



*Figure 15.18*

are employed throughout. In *Figure 15.18*, which corresponds with a portion of the design given in *Figure 15.17*, the five colours are represented by different kinds of marks, as shown in the 'gamut' below the plan; each mark in the plan indicated a pile tuft formed in the corresponding colour.

*System of loom mounting*

A form of harness and heald mounting is shown at A in *Figure 15.19* which may be used in weaving the textures. In each short row of the jacquard there are 10 hooks and needles which are connected in the same manner as in an ordinary single-lift machine. The arrangement of 10 per short row is convenient for 5-frame designs, and any smaller number of frames can be woven by casting out in long rows. The harness is knotted over the comber-board, and the comber-board M is supported at each side by a flat bar N to which a vertical movement is given by means of a cam, all the harness being thus capable of being raised by

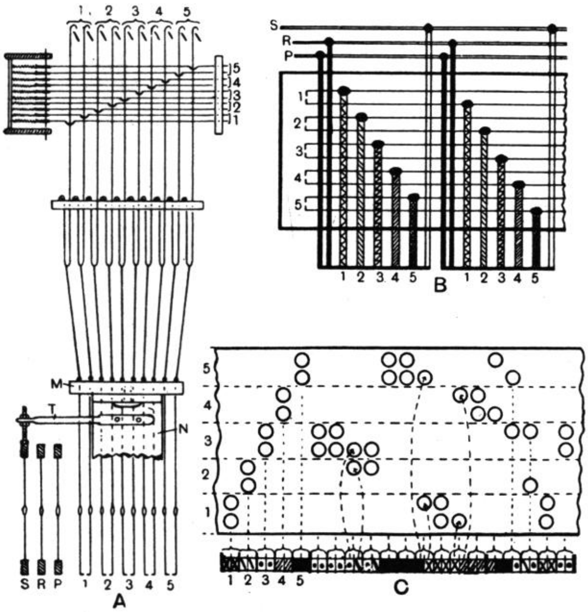



*Figure 15.19*

the comber-board M at regular intervals. Behind the harness there are two ground (or chin) healds P and R, and a stuffer heald S, the latter being connected at each side to a bar N by means of a rod T, so that the stuffer ends are lifted at the same time as the harness ends are raised by the comber-board. The ground healds P and R are operated in reverse order by means of positive tappets.

In the diagram A in *Figure 15.19* the hooks, needles, and harness cords are shown bracketed together in pairs, and numbered to indicate the numbers of the frames–i.e., the several colours of the pile warp that the respective parts control. At B, which represents how the warp threads are drawn on the healds and harness, the pile threads are correspondingly numbered; and the order of denting is indicated by the horizontal lines which connect the lower ends of the threads–two ground (or chain) threads, five pile threads, and one stuffer thread being passed through each split of the reed. In one split the five pile threads are drawn on the odd rows of the harness, and in the next split on the even rows, each colour being thus allocated to two consecutive rows of the harness, as shown by the numbers at the side of the harness draft. A comparison of the harness draft with the arrangement of the hooks and needles will show that the numbers coincide, and that each short row of the jacquard controls two pile threads of each colour.

Each vertical space of the design given in *Figure 15.18* represents one pile thread of each colour, so that two vertical spaces are equivalent to one row of needles and hooks, and one row of a card which is 10 holes deep. The size of the jacquard depends on the number of vertical rows of pile per repeat. Thus, if the repeat is 1 m wide and there are 40 rows of pile per 10 cm the required size of jacquard is 40 x 10 x 5 (frames) = 2000. For very wide looms several jacquards working in tandem may be necessary to cope with large design repeats. In upholstery fabrics single repeat designs are not normally made so that although the density of setting is higher (60 to 80 groups of pile threads per 10 cm) smaller jacquards may be adequate because the width of the repeat does not usually exceed 30 cm.

*Card cutting*

The system of card cutting which corresponds with the draft B is illustrated at C in *Figure 15.19*, where a portion of card is represented as having been cut to coincide with one horizontal space of a 5-frame design in which the same marks are used in *Figure 15.18*. A card may be considered to be in five longitudinal sections of two rows each, each section corresponding with a distinct colour of pile warp (a frame), as indicated by the numbers at the side of the example shown. The spaces in the card-cutting plan are bracketed together in pairs to coincide with the rows on the card, and two holes are cut in each row, the several colours or marks of the design being cut on the corresponding sections of the card. On the left of C the marks of the plan are arranged in the order of the frames, and numbered from one to five in order that they may be readily compared with the position of the corresponding holes in the card. Dotted lines also connect certain marks with the corresponding holes, and it will be seen that the first mark of a pair is cut on an odd row of the card, and the second mark on an even row. One card corresponds to one wire and the selected pile ends form the top line of the high shed underneath which the wires are inserted.

The effect of casting out in long rows on the card cutting when fewer frames than the maximum of five are used, and the method of dealing with planted designs, are shown in *Figure 15.20*. The second, third, and fourth frames are each in the same colour throughout but the first frame is planted in several colours, as shown in the gamut below the design at A. The system of designing is the same as in the previous example, each section of the design being painted out in the proper colour; and the foregoing system of jacquard mounting may be employed with the two unwanted long rows of the harness cast out. The system of card cutting is also the same, but all the colours of the planted frame are cut on the longitudinal rows of the card which belong to frame 1. As the card cutter reads the design he checks with the gamut to find out to which frame any colour has been allocated. Thus, in planted designs the gamut is an essential reference chart as there may be, say, 10 colours planted upon different frames and without the gamut the card cutter would be unable to tell what colours to cut on which longitudinal rows of the card.

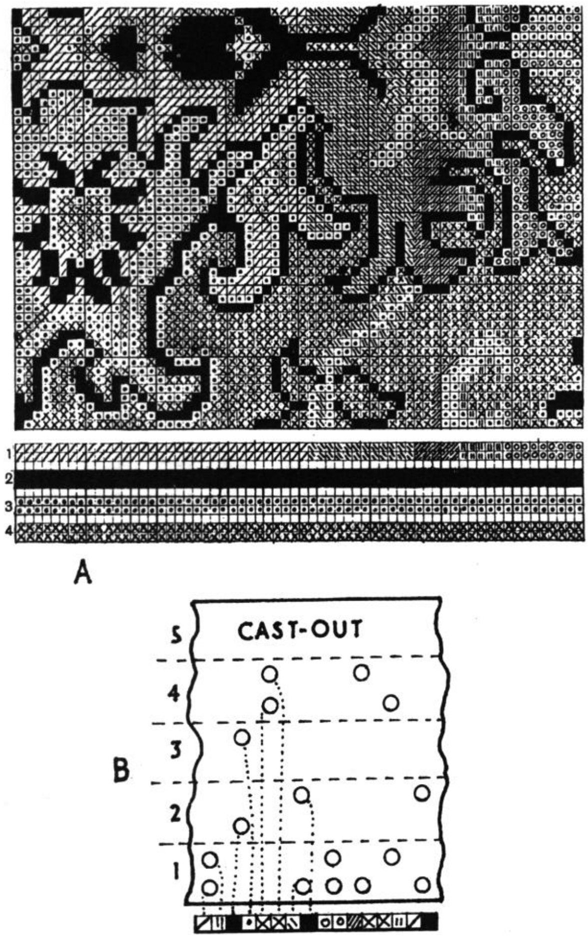



*Figure 15.20*

The diagram B in *Figure 15.20* shows a small portion of one row of a planted 4-frame design, marked as at A, and its relation to a corresponding portion of the card.

### *The cordage jacquard*

In the carpet industry many manufacturers, instead of using the common jacquard system with wire hooks and lifting knives, favour the cordage machine. In this version of the jacquard the principle of selection is the same as in any other jacquard and depends on cards and needles. The method of lifting is, however, different. The needles act upon cords knotted above a lifting board which performs the same function as the knives. The lifting board, the plan of which is shown at A in *Figure 15.21*, is drilled with apertures in the shape of keyholes. When the lifting board is raised it lifts the knotted cords which are placed over the slits of the keyholes but the knots which remain over the round portions of the keyholes slip through and are not lifted. The lifting board provides the high shed line for wire insertion, x, whilst the working comber-board takes the unselected or dead pile ends to the middle shed line, y, as shown at B in *Figure 15.21*. The tilted lift of the lifting board ensures correct shed angle for the pile ends between the front and the back harness cord rows.

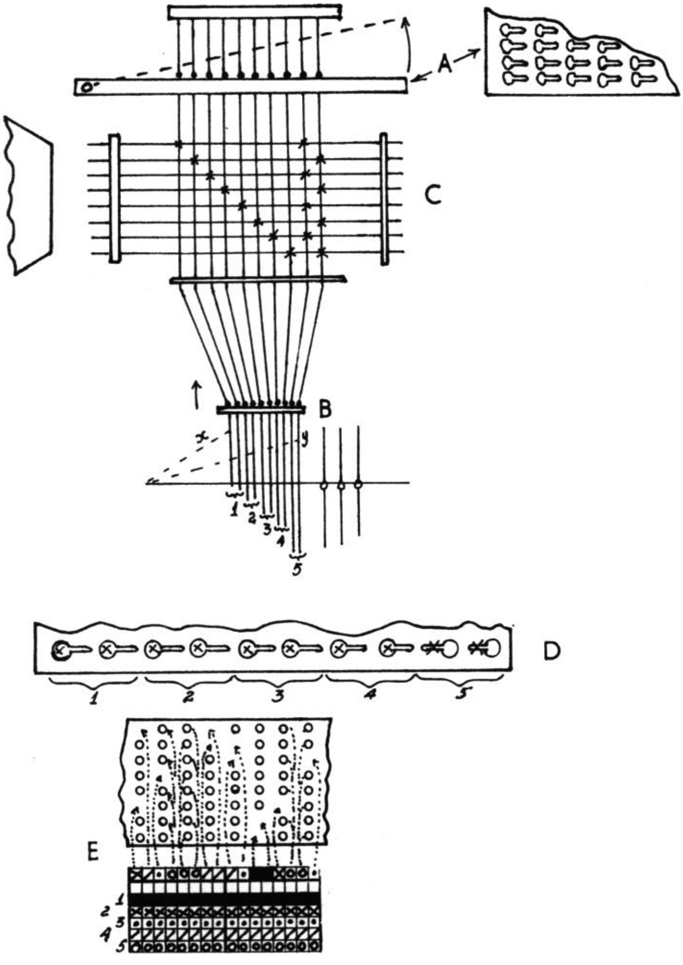



*Figure 15.21*

For five-frame work an eight-row card is used by arranging the lifting board on an inverted keyhole principle with suitable needle to cord controls. One short row of eight needles and ten cords (or bands) is given at C in *Figure 15.21* from which it can be seen that each needle acts against two cords, one of the front eight which control frames 1 to 4 and one of the back two which control frame 5. Odd needles control odd rows of pile threads and even needles even rows. A short row of keyholes in the lifting board is shown at D. In the first eight the slits are facing away from the cylinder and in the last two towards the cylinder. The normal resting position of the knots in the lifting cords is over the round portion of the keyhole for the first eight and over the slit in the last two as indicated by the crosses. It will be clear that if any one cord in the first eight is to be raised its knot must be pushed over the slit by the blank in a card, however, if one of the back two cords is to be raised its knot must remain over the slit which is achieved by leaving the needle immobile by presenting to it a hole in a card. Any two blanks in a short row, one against an odd and the other against an even needle, ensure that no lift of the back two cords will take place by pushing their knots over the round portions of the keyholes. If it is desired to lift the two back cords the short row of the card must be fully cut.

E in *Figure 15.21* shows a 5-frame gamut whilst at F a portion of one horizontal row of a five-colour design is given against a corresponding portion of a card. Studying the card in conjunction with the gamut it will be seen that in the first short row in the card a frame 2 end is lifted in the odd row of pile and frame 4 end in the even row. In the second short row there is only one blank and, therefore, the lifts are–odd row end from frame 3 and even row end from frame 5; in the third short row no blanks exist which means that both odd and even row ends from frame 5 are raised; and so on. For ease of identification the marks in the design are connected by fine lines to the operative portions of the card.

It should be appreciated that the above system of producing a 5-frame design from an eight-row instead of a ten-row card could be equally well adapted to a standard jacquard with hooks and lifting knives by using the inverted hook principle of operation instead of the inverted keyholes.

### *Methods of achieving textural variety in multi-colour pile fabrics*

The design in the multi-frame pile fabrics is due mainly to colour. However, in addition to colour effects it is possible to create textural effects either with the aid of the wire insertion mechanism alone or in combination with special selection or shedding devices. The use of the exposed ground in figuring has already been explained earlier. In *Figure 15.22* a 3-frame fabric is shown in

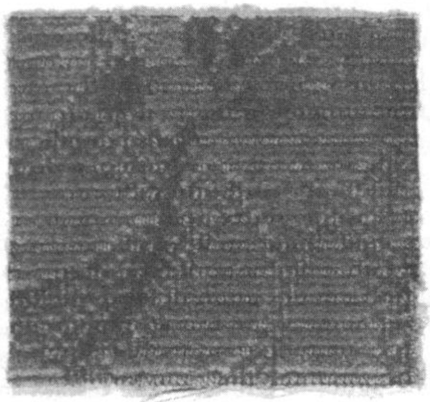


*Figure 15.22*

which the effect is due to colour, to the use of sunk places and to the sequence of wire insertion which consists of two cutting, followed by one plain wire. Another 3-frame structure is shown in *Figure 15.23* in which two short and two tall looping wires are inserted alternately thus resulting in a distinctly ridged appearance of the cloth. Such effects are produced by arranging the wire insertion according to a specific order disregarding the colour patterning which goes on notwithstanding the wiring sequence.

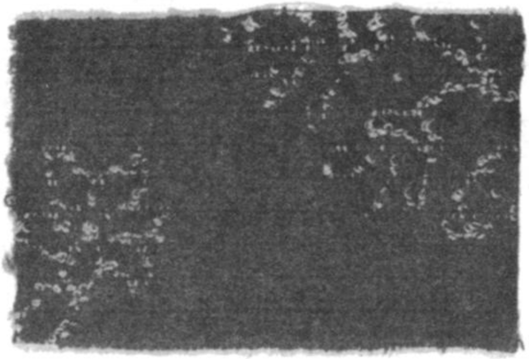


*Figure 15.23*

Other forms of embellishment consist of figuring in selected colours with cut and uncut pile so that in a 3-frame construction a three-coloured figure in loop pile could be produced on a three-coloured ornamental background of cut pile with sunk portions incorporated in the design as well. A cross-sectional view of the above type of design is given at A in *Figure 15.24* in which two frames are employed. The ground weave is a 2-and-2 rib with alternate tight and slack ends operated by healds. If stuffers are required they may be run-in together with the tight ground ends–in the example shown stuffer ends are not used. The jacquard operates on every pick and provides a high lift for the selected ends. The working comber-board may be employed but is not often used in this particular structure. A group of four picks forms a structural unit and a looping wire is inserted together with pick 2, and a cutting wire with pick 4 of each unit. Holes in the card cause a lift of the selected pile ends. The pile ends, to achieve the construction shown, are operated as follows:

Pick 1 – all pile ends down (a blank card)
Pick 2 and looping wire – ends selected to form loop and cut pile are raised
Pick 3 – all pile ends up (a fully perforated card)
Pick 4 and cutting wire – only ends selected to form cut pile are raised.

The working comber-board could be utilised to produce a wholesale lift of all pile ends on pick 3 of the sequence but in a system in which the jacquard operates on every pick the use of it is of insufficient benefit to offset the disadvantage of reduced versatility which the fixed movement of a shedding element invariably implies.

As a result of the manner of operation given in the foregoing description the pile ends selected to form loops are raised only over the looping wire (and pick 3), but the pile ends selected to form cut pile are raised over both the wires and the intervening pick 3 of each group which makes the cut pile slightly longer than the loop pile. In the section A four structural groups or units are

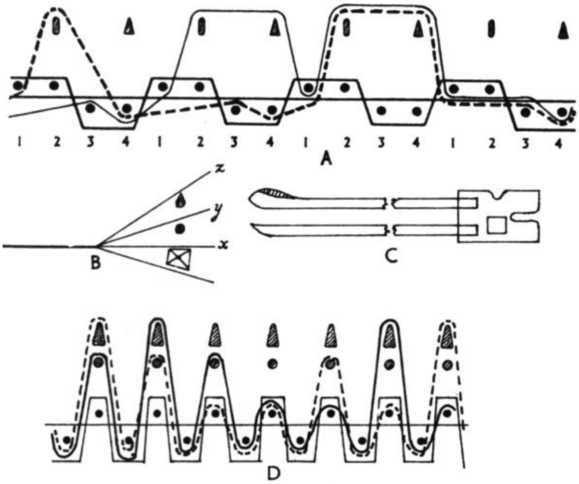



*Figure 15.24*

shown—in the first one an end from frame 1 makes a loop pile, in the second one an end from frame 2 makes a cut pile, in the third one both the pile ends make a cut pile tuft simultaneously whilst in the fourth unit both the ends are down on both wires which creates a sunk place in the design. The situation depicted in the third unit is used sometimes to produce mixed colour areas which are at the same time more heavily tufted than the single colour areas as two adjacent ends make the tuft instead of one. Such effects are described as moresque effects and are more often used in 3-frame designs in which any two out of three ends may be raised together which extends the colour range to six, i.e. three mixed and three pure colour areas. Other moresque effects were at one time also made in which the mixed and the pure colour areas were of the same density but these are not greatly favoured at present as the results are frequently somewhat indeterminate. Altogether figuring in colour with looping and cutting wires using the system described is not undertaken very often due to the expense involved in requiring four picks to produce one horizontal row of design. However, other systems which overcome this difficulty have been developed. Such systems depend on simultaneous insertion of two wires into separate sheds formed by a jacquard capable of lifting selected pile ends to two levels—high and very high—resulting in treble shed formation.

A treble shed is shown at B in *Figure 15.24*—the wire inserted into the middle shed is a plain or looping wire but the wire inserted into the top shed may be either looping or cutting. Thus, the possibility exists of figuring with low and high loop pile in selected colours or with low loop pile and high cut pile. In one system of operation the wire insertion mechanism is duplicated, i.e. a wire is inserted from the right-hand side into the middle shed whilst simultaneously another wire enters the top shed from the left. This is economically not a very desirable proposition because it effectively trebles the width of the loom. A more modern concept is to use a double-tier wire as shown at C in *Figure 15.24* inserted and withdrawn by a right-hand side mechanism. The construction which may be achieved with the high pile either looped or cut, is shown at D. The double wire is inserted together with pick 2 of the plain ground and the cross-section D shows all the possible combinations which may occur in a 2-frame construction. These consist of colour 1 high pile with colour 2 forming the low pile background and the reverse situation–these two possibilities are not often used due to a somewhat indeterminate colour resolution; the usual effects are–sunk places, either colour 1 or colour 2 over low wire, and either colour 1 or colour 2 over high wire. Excellent sculptured effects are produced with the high pile figure in one colour on the low pile ground in another colour. The construction is achieved with the aid of a jacquard with a working comber-board or bottom board the lifts of which raise the unselected pile on pick 2 over the weft only–level x at B in *Figure 15.24*. For lifts to the level y at B the hook is engaged upon a lower knife by one needle of a pair which control it and for lifts to the level z the hook is engaged by an upper knife.

### *Methods of weft insertion*

Although the shuttle still represents the most common mechanism for the insertion of weft in warp pile fabrics other devices are also coming into use. Carpet looms have been developed in which a single rigid rapier is employed inserting a double shot of weft from a stationary weft supply package. In the weaving of upholstery fabrics other systems such as double rigid or flexible rapiers are also used. The carrier or gripper shuttle method has also been adopted for both the carpet and the upholstery cloth production. Apart from higher speed of operation the great merit of the new systems lies in the fact that weft is in continuous supply from magazined stationary packages. This is particularly attractive in fabrics in which coarse weft yarns are used as it obviates the need for frequent replenishment which exists when conventional shuttles are used and for the costly operation of winding the weft on to numerous and quickly exhausted packages.