# 14

# Terry Pile Structures

The terry pile, also known as the Turkish towelling, is a class of warp pile structure in which certain warp ends are made to form loops on the surface of the cloth. Only one series of weft threads is used but the warp consists of two series of threads, the ground and the pile. The former produces with the weft the ground cloth from which the loops formed by the pile ends project. The loops may be formed on one side only or on both sides of the cloth thus producing single-sided and double-sided structures respectively. Any one pile thread may alternate between the face and the back of the cloth a possibility that is frequently utilised for the purpose of ornamentation. The schematic diagrams in *Figure 14.1* show at A the single-sided and at B the double-sided continuous terry structures. C conveys the idea of a pile thread alternating between the face and the back which permits the formation of pile figure on exposed ground whilst at D the ornamentation is carried further by having two differently coloured sets of threads which mutually alternate between the face and the back thus forming a figure in one colour on the background of another. All the structures, apart from A, are reversible.

Structure A has been used for the production of mats, curtainings, ladies' overcoats and dressing gowns. Structures B, C, and D represent typical towellings which form by far the most important outlet for these fabrics. The looped structure is eminently suitable for towelling purposes as the long, free floats of yarn, if made from absorbent materials, are capable of wicking-up readily large amounts of moisture. The material best suited for the purpose is cotton which not only absorbs moisture easily but also stands up well to frequent and severe launderings which the towelling fabrics have to undergo. Linen is used for the pile when, either, the slightly harsh feel is desired as in athletic towellings, or, an article capable of withstanding very hard wear is required as in public institutions, etc. Viscose rayon staple yarns are also employed and whilst they possess adequate moisture absorption capacity their ability to resist frequent laundering is poorer than that of cotton yarns.

*Formation of the pile.*

The formation of terry pile depends on the creation of a gap between the fell of the cloth and two succeeding picks of weft. The gap, the length of which

depends on the height of pile required, results in the formation of uninterlaced warp floats. To form the gap two succeeding picks are beaten up short of the true cloth fell and produce a temporary false fell as indicated schematically at E in *Figure 14.1*. On the third pick of the group full beat up takes place the

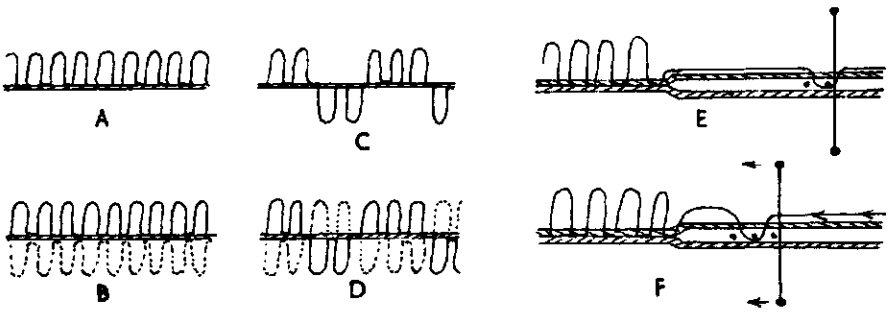


*Figure 14.1*

three picks being pushed forward together to the true fell position. During this action the three picks are capable of sliding between the ground ends, which are kept very taut, as depicted at F. However, they cannot slide similarly between the pile ends, firstly, because they are structurally locked with them and, secondly, because the pile warp at that moment is slack. Therefore, as they are pushed forward after the third pick they pull a length of pile warp from the beam and at the same time force the excess length of pile yarn in front of them into a loop. If the pile warp float is formed on the surface a loop is made on the face and if the float is on the back of the cloth a back loop results. From the description it will be obvious that in this construction two beams are necessary. The ground beam is very heavily tensioned whilst the pile beam is only under slight tension and in some systems it is, in fact, rotated forward positively during the full beat-up, i.e. after the insertion of the third pick of the group, to deliver exactly the length of yarn required for a loop.

The gap is created by a variety of devices which can be divided into two main classes, viz.: (1) Those in which the reed is drawn back the required distance before reaching the fell on the two picks in question (used in most of the conventional looms); and (2) Those in which the fell of the cloth itself is made to

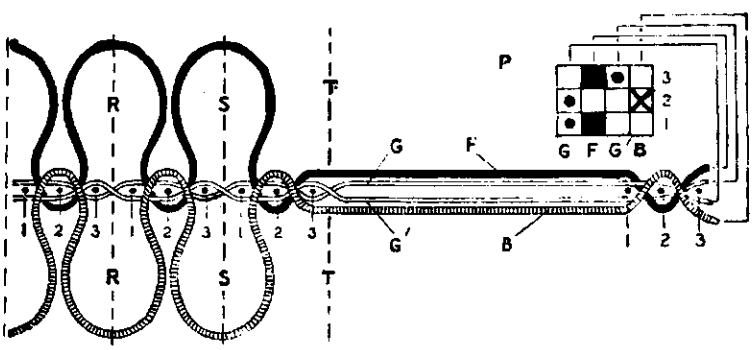


*Figure 14.2*

recede away from the on-coming reed during the insertion of the two succeeding picks (used in gripper and rapier machines).

The exact relation of the weft to the two warps and the principle of loop formation is depicted by means of the weft section in *Figure 14.2*. The broken vertical lines RR, SS, and TT divide the picks 1, 2, and 3 into repeating groups of three, line TT indicating the position of the fell of the cloth. On the right of the diagram, a group of three picks, which compose a repeat, is represented previous to being beaten up to the fell of the cloth. The ground threads G, $G^1$, and the face and back pile threads F and B are shown connected by lines with the respective spaces in the corresponding weave given at P. In weaving the cloth the group warp beam carrying the threads G and $G^1$, is heavily tensioned, as stated earlier so that these threads are held tight all the time. The picks 1 and 2 are first woven into the proper sheds, but are not beaten fully up to the fell of the cloth at the time of insertion in their sheds; but when the pick No. 3 is inserted the mechanisms are so operated that the three picks are driven together into the cloth at the fell TT. During the beating up of the third pick the pile warp threads F and B are either given in slack, or are placed under very slight tension.

The picks 1 and 2 are in the same shed made by the tight ground threads G and $G^1$, which, therefore, offer no obstruction to the two picks being driven forward at the same time with the third pick. The pile threads F and B, on the other hand, change from one side of the cloth to the other between the picks 1 and 2, and they are, therefore, gripped at the point of contact with the two picks. As the three picks are beaten up this point of contact is moved forward to the fell of the cloth, with the result that the slack pile warp threads are drawn forward and two horizontal rows of loops are formed one projecting from the upper and the other from the lower surface of the cloth in the manner represented in *Figure 14.2*.

In order to produce the loops on the three picks during the insertion of which the terry motion is in operation, the pile and ground threads must be interwoven with the weft in the exact order represented in *Figure 14.2*. The 3-pick terry structure is employed most extensively, but sometimes four, five, and even six picks are inserted in making each horizontal row of loops. The interweaving of the threads, on the subsequent picks, is, however, of little consequence so long as the cloth has the necessary firmness, and a natural connection is made with the weave of the three picks particularly referred to.

### *Terry Weaves*

A number of standard weaves for producing the fabrics is given in *Figure 14.3*. These constructions have been grouped so that comparisons can be readily made. The dots in the designs represented the interlacings of the ground warp threads; the full squares show the interweaving of the face pile threads and the crosses, of the back pile threads. In A, B, C, D, and E the loops are formed uniformly on the face side of the cloth only, whereas the remaining structures are for producing a pile surface on both sides of the cloth. In A, B, C, D, and E, the warp threads are arranged 1 ground, 1 pile, and in F, G, H, I, J, and K, 1 ground, 1 face pile, 1

ground, 1 back pile. The weaves L, M, N, O, P, and Q produce corresponding effects to the designs F to K respectively, but they are arranged 1 ground, 1 face pile, 1 back pile, 1 ground.

In each structure A to E in *Figure 14.3* there is a pile end on the surface to each ground end, but in the weaves F to Q, the proportion is one pile end on each side of the cloth in two ground ends. The single-sided pile cloths can, however, be made with 1 pile to 2 ground by leaving out the last thread in each of the constructions A to E. The plans A, F, and L are for producing one horizontal row of pile loops on three picks; B, G, and M on four picks; C, H, N, D, I, O, J, and P on five picks; and E, K, and Q on six picks.

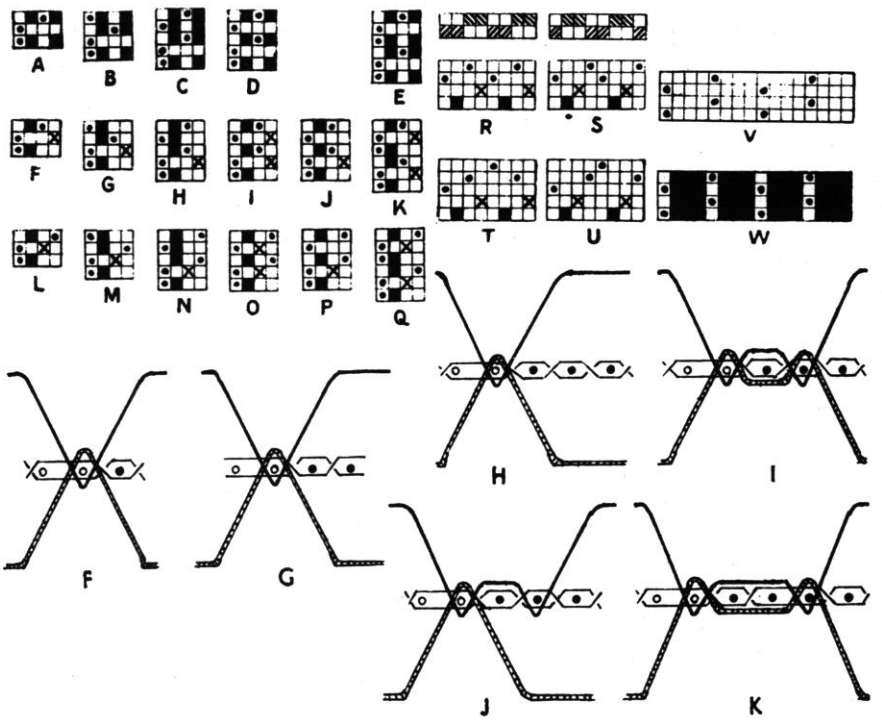


*Figure 14.3*

Every plan in *Figure 14.3* is constructed for the first and second picks to remain back from the edge of the cloth when they are first inserted, and for the full beat up to occur on the third and subsequent picks in the repeat. A comparison of the designs will show that in each case the interweaving of the respective threads is exactly the same on the picks 1, 2, and 3, and corresponds with the order of interlacing illustrated in *Figure 14.2*. Thus, on the picks 1 and 2, the odd ground threads are raised and the even ground threads depressed, while on the third pick they are in the reverse positions. The face pile threads are raised on the picks 1 and 3, and depressed on the second pick; the back pile threads being operated in the reverse order.

In the lower portion of *Figure 14.3* cross-sectional views of one loop unit of every structure F to K are given, and these are lettered to correspond with the

squared paper plans. It will be noted that whilst in most of the constructions the loops are anchored around one pick of weft, I and K represent the fast pile anchorage in which the pile ends between each loop are interlaced in a tight weave order such as 1 up, 1 down, 1 up, or 1 up, 2 down, 1 up, or the reverse of it. This prevents the occurrence of one of the most undersirable faults in these fabrics which is loop 'sprouting' (i.e. formation, due to pulling, of an enormously elongated loop at the cost of the disappearance of some loops in front and behind it), and is used in fabrics expected to withstand particularly severe conditions of wear.

Most of the terry cloth is produced in the 3-pick structures, 4-pick weaves are used occasionally but the amount of 5-pick or 6-pick cloth made at present is very small being restricted by the high cost of production. It will be appreciated that in a 6-pick fabric six picks need to be inserted to make one horizontal row of loops as opposed to only three in a 3-pick fabric. Also, to produce the same pile coverage in a 6-piek, as in a 3-pick cloth twice as many picks per cm are required.

In drawing-in the two warps for weaving the pile threads may be on two healds at the front, and the ground threads (if looped formation is to be continuous) on two healds at the back, as shown at R in *Figure 14.3* for the 1 ground, 1 pile order of arrangement, and as indicated at S for the 2-and-2 order. When, however, the cloths are made in short lengths with a cross-border at each end, the drafts given at T and U are frequently employed. This arrangement enables a weave with a weft float over seven warp threads to be obtained by the alternate lifting of the third and fifth heald, the remaining healds being left down in forming the float on the face, and lifted in forming the float on the reverse side, as shown respectively at V and W. In dobby shedding specially crammed and coloured cross-over headings can be readily formed in the borders in this manner.

Usually two threads are placed in each split of the reed, and in the 1 ground, 1 pile order, one of each series is placed in the same split, as shown above R in *Figure 14.3*. In the 2 ground, 2 pile order, however, two ends of the same series are placed together, as shown above S. The two arrangements produce practically identical results, but the 2-and-2 arrangement has the advantage that by reeding as described, the threads in each split work opposite to each other, and at the same time the pile and ground threads, which on some picks work alike, are separated by the wires of the reed, so that a clear shed is more readily obtained.

The loom particulars of a good quality all cotton 3-pick terry cloth are as follows: Pile warp, two ends of 60/2 tex; ground warp, 66/2 tex; weft, 38 tex; ends per cm, 20; picks per cm, 22; 500m of pile warp and 120m of ground warp are required for producing 100m of terry. The shrinkage in width is about 12 per cent. In cheaper cloths the weft may be 30 tex and the picks 14 per cm and upwards; the pile warp 38 tex and the ground warp 42 tex; 300m and upwards of pile warp for 100m of cloth. The ground ends are usually slightly thicker than the pile ends. The feel of the texture varies according to the depth of the pile loops, a deep pile handling softer than a short pile. The depth of the pile is determined by the distance that the two picks are left away from the fell of the cloth, which is usually about 10 to 15mm. To assist the absorption of moisture the pile yarns are of low twist and, therefore, must be manufactured from reasonably long stapled fibres to prevent excessive fibre shedding during use.

*Special mechanisms required in terry weaving*

Most of the terry fabrics are produced in either dobby or jacquard machines. Cam shedding is used infrequently even when continuous self-coloured styles are manufactured although the weave repeats of such constructions fall well within the capacity range of cam motions. The reason for this is that most towels have a cross-border heading at each end which demands changes in the operation of various mechanisms at widely separated intervals which are impossible to achieve in cam-controlled shedding systems. At one time to avoid long pattern chains of lags, two, or three barrel cross-border dobbies were used with different portions of the towel pegged on different barrel chains. These are still sometimes employed but more commonly at present high-speed paper-roll dobbies are used in which the length of pattern does not create the same encumbrance as it does when the lags constitute the pattern chain.

For the production of the figured terries the inverted hook jacquard with a heald mounting was at one time highly favoured (see Appendix I), but at present the machine used most frequently is the fine pitch, large capacity jacquard capable of running at appreciably greater speeds than the coarse pitch machines.

The variable beat-up motions are an essential part of the terry pile weaving and they fall into two main categories. The function of these motions is, as mentioned earlier, to create a gap between the cloth fell and the first two picks of a pile forming a group of picks termed 'loose' picks, as opposed to the picks beaten up fully which are known as 'fast' picks. In the first category are those mechanisms in which the reed itself is drawn back on the loose picks thereby leaving them a small distance short of the cloth fell. A variety of devices exist to achieve this purpose in some of which the reed only and in others the sley itself may be controlled to provide a 'short' beat-up. On the following pick the reed or sley is locked fast so that the preceding loose picks and the fast pick are pushed together into the cloth fell proper. The two reed positions are shown at A and B respectively in *Figure 14.4*. In the second category of mechanisms, such as are used at present in some gripper and rapier machines, the reed is permanently fixed in position and has a constant stroke. To create the gap on the loose picks the cloth itself is drawn away from the advancing reed so that the two loose picks cannot reach the normal cloth fell position. On the third pick the cloth is brought forward again so that the three picks of a group join together with the previously woven cloth at the normal cloth fell point. These operations are illustrated schematically at C and D in *Figure 14.4*. All the above motions must be capable of precise adjustment to vary the size of the gap in order to produce shorter or longer pile. They are also normally controlled by a dobby or a jacquard to determine the occurrence of the loose and fast picks as the ratio of the loose to the fast picks varies in different structures. Thus, in a 3-pick structure two loose picks are followed by one fast one, in a 4-pick terry the order of operation is two loose, two fast, and so on. Also, when pile-less headings are produced the loose pick action is unnecessary and must be disengaged.

Another necessary adjunct in the formation of terry pile is the proper control of the pile yarn tension. The pile yarn must be slack when the first three picks of a group are being beaten up, i.e. at the point at which the loop is being formed, as otherwise the tension would pull the loops out. Imperfect tension control at this stage does, in fact, result in variable loop height. In some systems

the necessary slackness is achieved by a very slight degree of tensioning of the pile yarn, the beam being only just sufficiently weighted to form a clear shed.

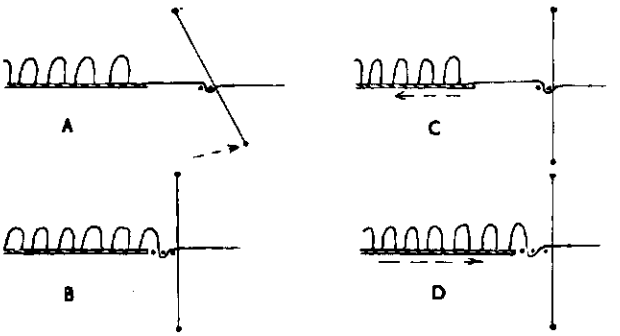


*Figure 14.4*

In other systems the pile warp is tensioned normally throughout but on the beat-up following the first fast pick in the group a length of the pile warp equal to the distance of the gap is delivered positively which results in more regular loop height along the length of a towel than can be usually achieved in the former method. When the plain, i.e. pile-less, headings are being produced extra weighting of the pile beam is required to ensure that the crimp of the pile ends in those portions of the towel is the same as that of the highly tensioned ground ends. In the second system during the weaving of the headings the positive delivery after every third pick must be stopped. For this reason the pile warp tension control motions must also be governed selectably through a dobby or a jacquard connection.

During the production of towel headings in which no pile is formed it is also usual to operate a cramming device to increase the density of shotting. This is often necessary because the number of picks per cm in the body of the towel is usually comparatively low. This does not give the appearance of a poorly set cloth because these areas are densely covered by the pile, a pile-less heading, however, would look unsubstantial at the same weft setting and to prevent this in such portions of the cloth the cramming device or the interrupted take-up device is brought into operation.

Some makers of terry weaving machines also include a fringing mechanism as one of the special devices. This is, in effect, an express speed take-up motion capable of pulling the cloth forward 30 to 60 mm in the space of time taken to insert two to four picks thus producing an almost uninterlaced gap between two towel lengths. This is employed when the towel is to be finished with a tasselled fringe instead of a hem.

## TERRY ORNAMENTATION

When continuously repeating terry weaves are used, such as those given in *Figure 14.3*, the only possible form of ornamentation consists of introducing coloured pile threads to form stripes, but if the loops are formed on both sides of

the cloth one side may be coloured independently of the other. In producing more elaborate ornamentation the pile yarns are caused to form loops first on one side and then on the other side of the cloth in the manner represented at C and D in *Figures 14.1* and *14.5*. This system may be employed either with one or two series of pile threads, and styles be produced ranging from simple checks to complex figures. The principle of ornamentation, in which certain pile threads form loops while others lie straight in the cloth, cannot be employed, since all the pile yarn is brought from one warp beam, and it is, therefore, necessary for all the threads either to form pile or to lie straight simultaneously.

When only one series of pile threads is used the pattern is due to the pile threads forming loops on the face and back in turn, so that alternate sections of pile and ground are produced on both sides of the cloth. In *Figure 14.5*, weft section A illustrates this method of interlacing, while the weave which forms the loops on the face is given at B, and on the back at C. In this system of ornamentation colours may be introduced either in the pile or in the ground threads.

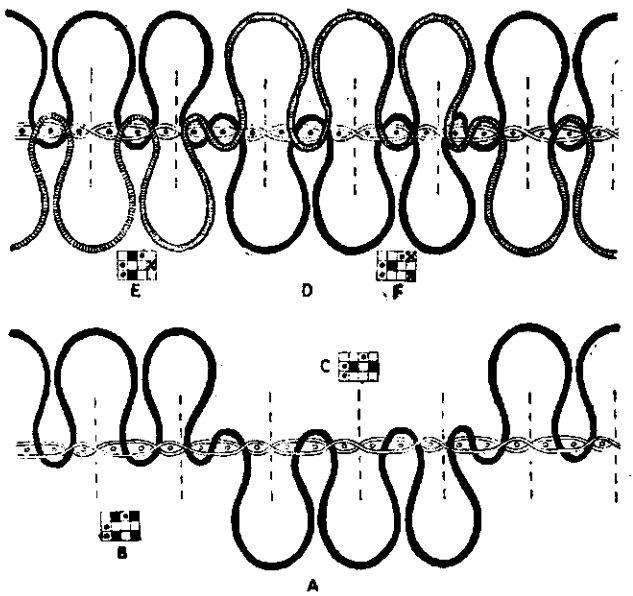


*Figure 14.5*

In *Figure 14.5* weft section D shows how the pile yarns interchange from face to back when two series are employed. In this case both sides of the cloth are covered by the loops, but one series of threads is differently coloured from the other series, so that alternate sections in different colours are formed. With the weave E, the loops are formed by the dark threads on the face and by the light threads on the back; and with the weave F they are formed by the light threads on the face and the dark threads on the back.

### *Stripe and check dobby patterns*

With dobby shedding simple reversible designs are obtained usually of a check character, and an example is given in *Figure 14.6*, which shows an effect produced

by a single series of pile threads, on the principle illustrated at A in *Figure 14.5*. In this case, however, the threads are arranged in the order of 2 ground, 2 pile. The design of the cloth is shown in *Figure 14.7*, in which sections G form

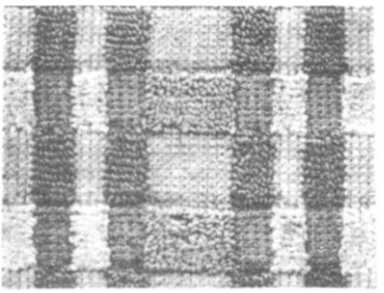

*Figure 14.6*

pile on the face and ground on the back, and sections H form ground on the face and pile on the back. The draft is shown at I and the lifting plan at J. In producing a given size of check, each section is repeated the required number of times.

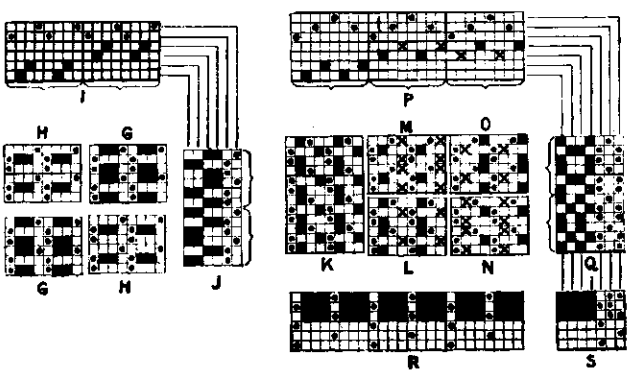


*Figure 14.7*

*Figure 14.8* shows a check pattern produced in two series of pile yarns, on the principle illustrated at D in *Figure 14.5*. There is also a continuous stripe effect at each side of the check pattern. One series of pile threads is differently coloured from the other series, and in the corresponding design and draft given in *Figure 14.7*, the black squares represent red pile while the crosses indicate white pile. Section K shows the weave used in producing the continuous stripe, while sections L and O form red loops on the face and white loops on the back, and sections M and N form white loops on the face and red loops on the back. The change of effect between sections L and M, and also between N and O, is due to a change in the weave. In the sections L and N, however, and also in sections M and O, the weave is exactly the same, the change of effect in this case being due to a change in the order of colouring. Thus, as indicated by the black squares and crosses respectively, the pile yarns in sections L and M are arranged 1 red, 1 white, and in N and O, 1 white, 1 red, two white pile threads coming together in the centre. The drawing-in draft is shown at P—three healds being used for the ground threads, and the lifting plan at Q.

The lower portion of *Figure 14.8* shows a cross-border heading, the bulk of which is formed by continuing the centre weave with the terry motion out of action, but there is also a repp heading produced by floating thick picks over seven successive ends. The weave for the thick picks is shown at R in *Figure 14.7*, the lifting plan being indicated at S. Three picks float on the face and then three on the back, in order that the border will be reversible similar to the main body of the towel.

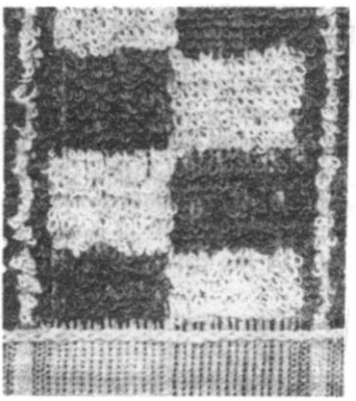

*Figure 14.8*

An interesting modification of the latter style of check pattern consists of separating the rectangular spaces from each other by narrow lines of ground, the longitudinal lines being formed by bringing six or eight ends consecutively from the ground warp beam, while the transverse lines are obtained by throwing the terry motion out of action for about six picks. This system of forming checks can also be employed when the pile threads are all of one colour, and when no interchange is made from one side of the cloth to the other.

### *Figured terry pile fabrics*

A representation of a figured terry pile texture, taken from the corner of a towel, is given in *Figure 14.9*. The example is simply an extension of the principle

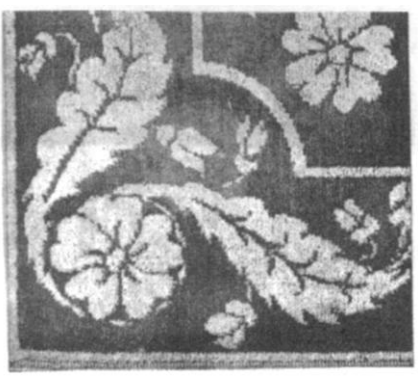

*Figure 14.9*

illustrated at D, E, and F in *Figure 14.5*, in which two series of differently coloured pile threads are interchanged. In the fabric represented a figure in white terry pile is formed on a blue ground on one side of the cloth, and a blue terry figure on a white terry ground on the other side. The warp threads are arranged in the cloth in the order of 1 ground, 1 white pile, 1 ground, 1 blue pile, and the structure is a 3-pick terry.

The design for the above fabric is given in *Figure 14.10* and shows the construction condensed by 4 warp-wise and by 3 weft-wise so that each square represents one loop on the face and one loop on the back. Filled squares represent white loops on the face and blue loops on the back whilst blank squares indicate blue loops on the face and white ones on the back. The detailed weaves for each colour are shown at A and B in *Figure 14.10*, in which the dots indicate the lifts of the ground ends, the solid marks, the blue pile ends and the crosses, the white pile ends. The cloth is produced with 20 ends and 21 picks per cm which results in five vertical and seven horizontal rows of loops of each colour per cm and this ratio determines the proper count of design paper to be used. In the case of the design in *Figure 14.10* the paper is 8 x 11 corresponding sufficiently closely to the ratio of 5 : 7.

The condensed design could be taken to represent any terry structure and, indeed, the same design could be used to produce towels in a 4-pick or a 5-pick quality if appropriate detailed weaves were substituted for the 3-pick structures given at A and B in *Figure 14.10*.

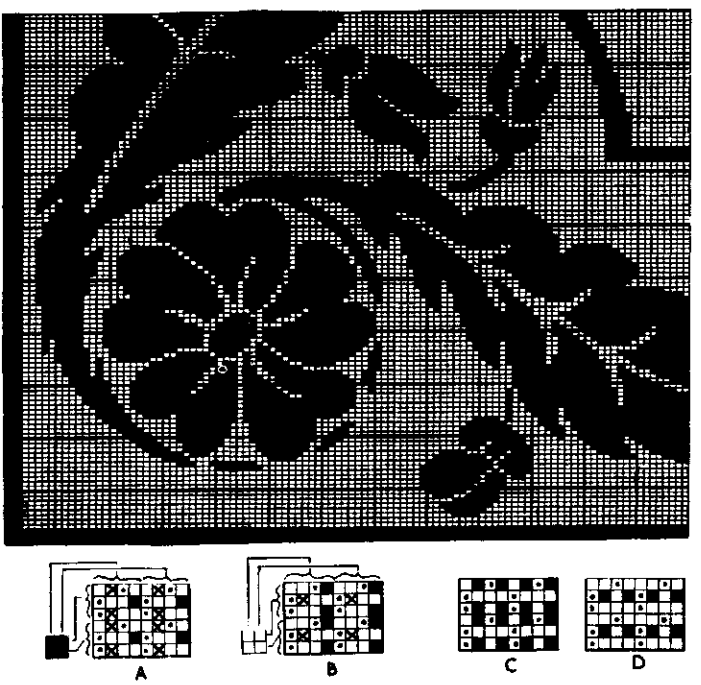


*Figure 14.10*

The system of designing, illustrated in *Figure 14.10*, is also suitable for the class of figured terry cloths in which there is only one series of pile threads.

In this case on one side a figure is formed in pile upon a ground of the foundation cloth, while on the other side the foundation forms in figure and the pile the ground. The principle is illustrated by the examples shown at A, B, and C in *Figure 14.5.* For the purpose of this structure one square of the condensed design represents a loop either on the face or on the back. If the paint is taken to indicate loops on the face, and the blank paper loops on the back, then the detailed weaves for the two different areas of the design will be, respectively, as shown at C and D in *Figure 14.10.*

*Mixed colour effects*

In a further development of the terry structure, which is applied to fancy towellings, beach wear, mats etc., white and two colours of pile warp are employed, and a design composed of four effects is produced. For instance, assuming that the pile threads are arranged 1 white, 1 pink, and 1 green, the ground may be formed in white pile loops and the figure by mixtures of pink and green, white and pink, and white and green loops in the different section of the design. There are really four series of pile threads in the cloth, two of which are on the surface and two on the back in every part.

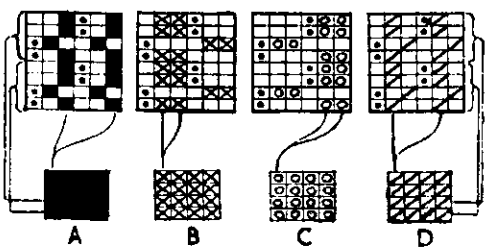


*Figure 14.11*

In the example given in *Figure 14.11* there are two pile ends to each ground end and the structure is a 4-pick terry in which the ground ends weave 2 up, 2 down. As there are four different effects the condensed design is painted in four colours represented by the different marks at A to D in *Figure 14.11.* The degree of condensation is by 6 warp-wise (4 pile and 2 ground ends) and by 4 weft-wise (2 loose, 2 fast picks) so that one square of the design equals two loops on the face and two on the back. The detailed weaves above the condensed design portions at A to D each correspond to one vertical and two horizontal rows of the designs.

The plan A represents the pink and green pile threads on the surface, and all the white pile threads on the back; B, white and pink on the surface and white and green on the back; C, white and green on the surface and white and pink on the back; and D, all the white on the surface and pink and green on the back.

*Cut pile terry fabrics*

Cut pile terry effects are sometimes produced by cropping, during a finishing operation, the tips of the loops in a terry cloth. Usually only one side of a

fabric is so treated the other retaining the normal loop formation. A very ornamental and rich appearance is thus created but the cloth is rendered less useful for the purpose intended. Although the cropping does not reduce the absorbency it reduces the frictional characteristics of the fabric so that instead of wiping the moisture off firmly the cloth tends to slide along a layer of moisture without removing it efficiently.