

TWILL WEAVES AND DERIVATIVES

Serial 506

Edition 1

TWILL WEAVES

GENERAL CONSIDERATION

1. Introductory.—Certain weaves, because of the similarity of their construction and of the effects that they produce in the fabric, are grouped in classes. They partake of the nature of fundamental, or standard, weaves, not only on account of the simplicity of their construction, but also because of their wide and varied use in almost every class of textile fabrics. For instance, the plain weave may be considered as a standard construction, since it is widely used in weaving fabrics composed of any material. One of the largest of these classes is that of **twill weaves**, which are so called because of the peculiar effect they form on the surface of the fabric. Many of the simpler twills have, like the plain weave, acquired distinctive names by which they are readily recognized by experienced designers.

2. Construction of Twills.—In the plain weave, each end is alternately raised and lowered, but in a twill the warp ends are so raised that the warp and filling floats form diagonal lines across the cloth, known as *twill lines*. In a twill each warp end must be either over or under the filling for at least 2 picks in succession and at least 2 successive warp ends must be raised or lowered on each pick, in order to make the twill line across the cloth. On this

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account at least 3 harnesses are necessary to weave a twill, or in other words three is the smallest number of harnesses on which a twill effect can be formed in the cloth. Thus, the 3-harness, or *prunelle, twill*, as it is called, is the simplest twill that can be made.

As shown in Fig. 1, the first end of this weave is down on the first pick, but floats over the second and third picks; the second end is down on the second pick but floats over the third and first picks; the third end is down on the third pick but floats over the first and second picks.



FIG. 1

Each end in this weave therefore floats over 2 picks in succession. This constitutes one repeat of the weave; that is, if the fourth end were shown, it would be found to be similar to the first end, while the fifth end would be like the second, and the sixth like the third. It will also be noted in Fig. 1 that on the first pick the second and third warp ends are raised, on the second pick the first and third warp ends are raised, and on the third pick the first and second warp ends are raised. Thus it will be seen that in this weave all the requirements of a twill weave are met.



FIG. 2

With this weave a twill, or diagonal, line is formed running up to the right. Weaves may be twilled either to the right or to the left, although in the majority of cases they are so constructed as to form twill lines running up to the right, as in the case of Fig. 1. Fig. 2 shows a warp-flush prunelle twill running to the left.



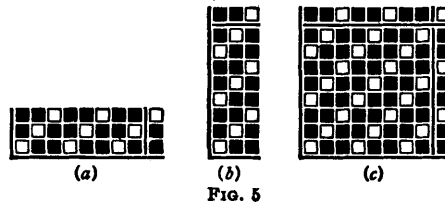
FIG. 3

3. A weave may be *warp flush, filling flush, or equally flush*, depending on whether a preponderance of warp or filling or an equal amount of each is brought to the face of the cloth; thus, Fig. 1 is a warp-flush prunelle twill, while Fig. 3 shows a filling-flush prunelle twilled to the right and Fig. 4 shows a filling-flush prunelle twilled to the left. A cloth woven with a warp-flush weave shows a filling-flush weave on the back, and if woven with a filling-flush weave shows a warp-flush weave on the back. Thus it will be seen that these terms simply refer to the effect on the face of the cloth.



FIG. 4

4. Repeat of the Weave.—One of the most important things in designing and probably one of the most difficult for the beginner to understand is the repeat of the weave; especially is this of importance in dealing with twills. It will be found a great aid, when only one repeat of a weave is given, to practice extending the weave on design paper for several repeats. By this means one repeat of any weave will more readily be found when it becomes necessary to distinguish a single repeat from several repeats. Weaves may be repeated on design paper either in their ends or in their picks, or they may be repeated in both the ends and



the picks. Suppose, for example, that it is desired to extend Fig. 1 for three repeats in its ends. As already stated, this weave is complete on 3 ends; consequently, three repeats will occupy three times this number, or 9 ends. If it is desired to repeat the weave in its picks three times, it will occupy 9 picks; while if it is repeated three times in both ends and picks, it will occupy 9 ends and 9 picks.

When repeating a weave it is simply necessary to copy the weave exactly as it is; that is, if Fig. 1 were to be repeated in its ends, one repeat of the weave would first be set down and the other repeats copied. The fourth end would be the same as the first; the fifth end, the same as the second; and the sixth end, the same as the third. This would make two repeats. If another repeat is required, the ends will simply be copied again in their proper order. If the weave is to be repeated in its picks, the picks will be copied in the same manner as were the ends when repeating in its ends. Fig. 5 (a) shows the weave Fig. 1 repeated three times in its ends; Fig. 5 (b) shows the weave repeated three times in its picks; and Fig. 5 (c) shows the weave repeated three times in both ends and picks.

REGULAR TWILLS

5. **Regular twills** are those that run in regular order; it is, therefore, simply necessary to know the interlacing of any one end or pick, say the first, of a regular twill in order to show the entire weave on design paper.

The interlacings of the first end or pick of any regular twill are conveniently shown by writing numbers above and below a horizontal line; thus, for example, $\begin{smallmatrix} 2 \\ \hline 3 \end{smallmatrix} \begin{smallmatrix} 1 \\ \hline 2 \end{smallmatrix}$ shows that the first end is up 2 picks, down 3, up 1, and down 2. The interlacing of a regular twill weave shown in this manner is called the *base* of the twill. Since in regular twill weaves the ends interlace with the picks in exactly the same manner as the picks interlace with the ends, the base also shows the interlacing of the first pick, as it indicates that on the first pick the first 2 ends are up, the next 3 are down, the next 1 is up, and the next 2 are down. The sum of these numbers, eight, shows that the twill repeats on 8 ends and 8 picks.

Suppose that it is desired to show the $\begin{smallmatrix} 2 \\ \hline 3 \end{smallmatrix} \begin{smallmatrix} 1 \\ \hline 2 \end{smallmatrix}$ twill on design paper. The first step is to mark the first end or first pick in the manner indicated by the base; the twill will be the same whichever is marked. If the first end is marked, it should be marked from top to bottom; if the first pick, it should be marked from left to right. One method, however, should be adopted; consequently, the system of marking the first pick will be used here. Marking this pick shows that the first 2 ends are up, the next 3 ends down, the next end up, and the next 2 ends down, as shown in Fig. 6. The next step is to run up the twill in regular order; that is, if an end is up on one pick, on the next pick the next end in the direction in which the twill is to run is up.

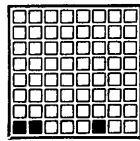


FIG. 6

That this method of making a twill may be more readily understood, each end will be run up separately and afterwards the complete design will be shown. Commencing with the first end and the first pick, which is at the lower left-hand corner, this first end is raised on the first pick; then

on the next pick the next end to the right, if the twill is run to the right, will be raised; that is, the second end will be raised on the second pick, and the third end will be raised on the third pick. This is continued for the 8 ends and 8 picks with the result shown in Fig. 7.

Next taking the second end and dealing with it in exactly the same manner will give the result shown in Fig. 8. It should be noted in connection with this figure that when running these marks up on the design

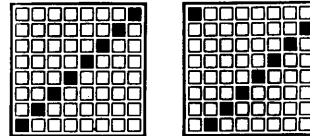


FIG. 7 FIG. 8

paper the eighth end is raised on the seventh pick. If this were continued in a regular line for the 8 picks, the next mark would come on the ninth end, but the weave is complete on 8 ends; consequently, the mark for the ninth end is placed on the first end, since the ninth end will be the first end of the next repeat, which of course is exactly like the first end of the repeat under consideration. That this is correct will be seen if two repeats of the weave are made.

In Fig. 6, the third, fourth, and fifth ends are lowered on the first pick; these blank squares will consequently run up in the same manner as the filled-in squares, but it is not necessary to consider them since, if the

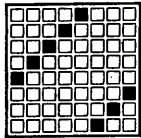


FIG. 9

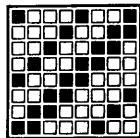


FIG. 10

filled-in squares are run up correctly, the blank ones must be correct. Since the sixth end is raised on the first pick, the seventh end will be raised on the second pick and so on, as shown in Fig. 9.

It should be noted that the eighth end is raised on the third pick and that in order to continue for the 8 picks, the first end must be raised on the next pick and the marks run from this point to complete the 8 picks, as shown. As the seventh and eighth ends are down on the first pick it is not necessary to consider these. If Figs. 7, 8, and 9 are combined, the complete twill will be obtained, as shown in Fig. 10. When constructing a twill, it is not necessary to run up each twill line

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separately as in Figs. 7, 8, and 9 and then combine them as in Fig. 10 since it is perfectly feasible to construct the

entire twill as shown in Fig. 10 at one operation. The method of running up each twill line separately is adopted only to explain the construction of the complete twill.

6. A rule for making any regular twill when the interlacings of the first pick are given is as follows:

Rule.—Mark on the first pick of the weave the ends that are to be lifted on that pick; then above on the second pick place similar marks, moving them one square to the right if the twill is to run to the right, or one square to the left if the twill is to run to the left. Proceed with each pick in the same way, moving one to the right or left,

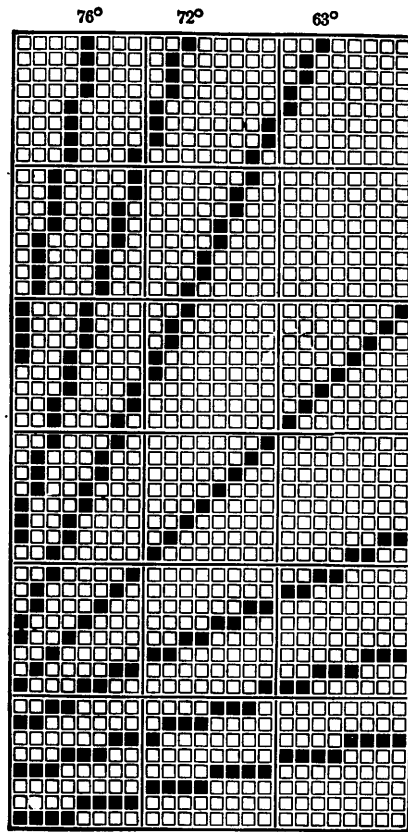


FIG. 11

as the case may be, until there are as many picks as ends, when the weave will be completed.

7. **Angles of Twills.**—The angle of a twill is affected: (1) by the manner in which the ends and picks interlace; (2) by the relative number of ends and picks per inch.

Fig. 11 illustrates the method of running up twill lines on design paper so as to form different angles.

In the first twill line at the bottom, the twill moves four squares filling way, or across the design, and then one square up; by this means an angle of 14° is formed. In the next case the twill moves three squares filling way and then one square warp way, forming an angle of 18° . In the next case the twill moves two squares filling way and then one warp way, which gives an angle of 27° . By carefully noting each twill line, the method of forming different angles will be readily understood. Twills are spoken of as being such a degree twill, the 45° twill being the most common, as it is the angle formed by all regular twills.

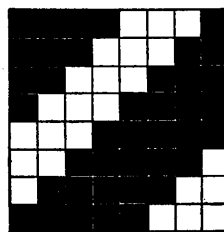


FIG. 12

A twill that forms a certain angle on regular 8×8 design paper will not form that same angle in the cloth unless the number of ends and picks per inch and the counts of the warp and filling yarns are the same. For example, the 45° twill shown in Fig. 12 is shown on 8×8 design paper; that is, the design paper has eight vertical rows of squares and eight horizontal rows in the same distance, warp or filling way. Since a row of squares across the paper represents

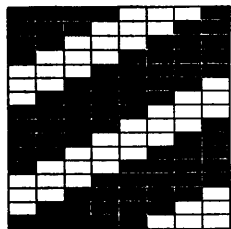


FIG. 13

a pick and a row of squares vertically represents a warp end, a twill or any design on this kind of design paper shows the weave as it would appear in the cloth if the same number of picks per inch as ends per inch is inserted. Suppose that twice as many picks are placed in 1 inch of the cloth as there are ends per inch; then in order to give a correct representation of this on design paper, a paper should be used that contains twice as many horizontal rows of squares in a given space as it has vertical rows of squares. Fig. 13 shows the twill in Fig. 12 on design paper of this kind; it will be noticed that an angle of 27° is formed. On the other hand, if there are twice as many ends per inch in the cloth as there are picks, an angle

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of 63° will be formed with this same twill; Fig. 14 illustrates this point. It will be noticed that in both Figs. 13 and 14 two repeats of the weave are shown. Ordinarily, however, 8 × 8 design paper is used in constructing designs even if the fabric is to be woven with more picks than ends per inch or vice versa. It is only in jacquard designing and for some

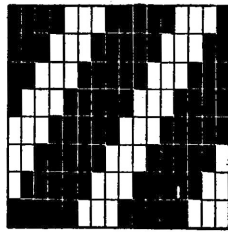


FIG. 14

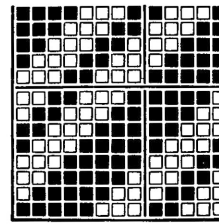


FIG. 15

special fabrics where it is desired to preserve the symmetry of a figure, or pattern, that a design paper is used corresponding to the relative number of ends and picks per inch in the fabric.

When working out twill weaves on design paper it should be understood that whatever kind of twill the weave may be, the

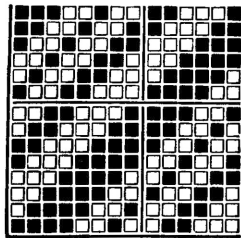


FIG. 16

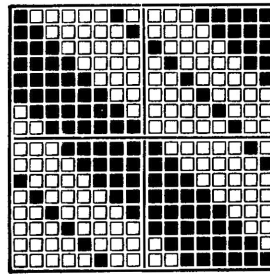


FIG. 17

marks or blanks for one repeat should not be extended beyond the number of ends and picks that has been decided on. For instance, if one repeat of the weave occupies 4 ends and 4 picks, the fifth end would be like the first, and so on; also the fifth pick would be like the first pick, and so on. Consequently, to

show one repeat only 4 ends and 4 picks are necessary. All regular 45° twills repeat on the same number of picks as ends, so that if the base of such a twill occupies 12 ends, it repeats on 12 ends and 12 picks. Twills that form an angle of more than 45° are known as *upright twills*, while those that form an angle of less than 45° are called *oblique*, or *reclining*, twills.



(a)



(b)



(c)



(d)



(e)



(f)



(g)

FIG. 18

8. By carefully studying the following regular 45° twills and the explanations previously given, a good understanding of the method of working out twills may be obtained. Fig. 15 is a regular 45° twill $\frac{5}{3} \frac{2}{3}$ twilled to the right; Fig. 16 is a regular 45° twill $\frac{4}{2} \frac{1}{2} \frac{2}{3}$ twilled to the right; Fig. 17 is a regular 45° twill with the base $\frac{1}{5} \frac{6}{4}$ twilled to the left. Several twills that are constantly used in the construction of the more common fabrics are known by definite names. Among them are the *filling-flush prunelle*, Fig. 18 (a); the *warp-flush prunelle*, Fig. 18 (b); the *cassimere*, Fig. 18 (c); the *filling-flush crow*, Fig. 18 (d); the *warp-flush crow*, Fig. 18 (e); the *filling-flush Albert twill*, Fig. 18 (f); the *warp-flush Albert twill*, Fig. 18 (g); the *filling-flush broken crow*, Fig. 19 (a); the *warp-flush broken crow*, Fig. 19 (b); the *Venetian twill*, Fig. 19 (c); and the *Mayo*, or *Campbell, twill*, Fig. 19 (d). The



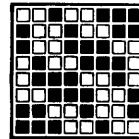
(a)



(b)



(c)



(d)

FIG. 19

weaves shown in Fig. 19 are not regular twill weaves but are weaves that are well known.

EXAMPLES FOR PRACTICE

1. A regular 45° twill is arranged $\frac{2}{1} \frac{1}{2} \frac{3}{1}$; show the complete weave on design paper.
2. State what angle the above twill would form in the cloth if woven with 54 ends and 27 picks per inch, using the same counts of warp and filling.

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3. Show two repeats in both ends and picks of a regular 45° twill having the first pick arranged $\frac{2}{3}1$.

4. State what angle the twill given in answer to question 3 would form in the cloth if woven with 30 ends and 60 picks per inch, using the same counts of warp and filling.

DERIVATIVES OF TWILL WEAVES

9. Derivatives Formed by Rearranging Ends or Picks.—The number of what may be termed fundamental weaves is comparatively small, but the weaves that may be derived from them are innumerable. Thus, if a simple twill weave is shown on design paper, several other weaves may be obtained from it by rearranging either the ends or the picks. Designs thus obtained are termed **derivatives**.

To illustrate how derivative weaves are obtained, a regular 45° twill, Fig. 20, is taken and three other weaves formed from it. Suppose that it is desired to form a derivative weave by rearranging the ends of Fig. 20 in 1, 4, 7, 2, 5, 8, 3, 6 order; that is, the first end of the new weave is to be like

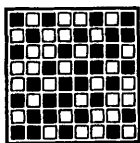


FIG. 20

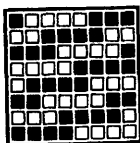


FIG. 21

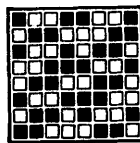


FIG. 22

the first end in Fig. 20, the second end of the new weave like the fourth end of Fig. 20, the third end like the seventh, the fourth like the second, and so on. It will be seen that commencing with the first end of Fig. 20, every third end is taken until by this method the first end is reached again, when the design commences to repeat. Fig. 21 shows the twill in Fig. 20 rearranged in this order.

Suppose that it is desired to arrange the ends in the twill in Fig. 20 in 1, 2, 5, 6, 3, 4, 7, 8 order. Fig. 22 shows that the first and second ends are like the first and second ends in Fig. 20; that the third end is like the fifth in Fig. 20; the fourth is like the sixth; the fifth like the third, and so on.

These two examples show that a number of weaves may be obtained from a regular twill weave, or in fact from any weave. After deriving a weave from a twill still other weaves may be obtained by rearranging the ends of the derivative.

When a weave is to be rearranged in its picks, the same process is employed as when rearranging the ends. Suppose, for example, that it is desired to rearrange the picks of Fig. 20 by taking the first 3 picks, missing the next 3, taking the next 3, and so on until the weave repeats. Fig. 23 shows the twill in Fig. 20 rearranged in this manner; the first 3 picks of Fig. 20 are copied for the first 3 picks of Fig. 23; the next 3 picks of Fig. 20 are skipped; the next 3, that is the seventh, eighth, and first, are copied for the fourth, fifth, and sixth picks of Fig. 23; and so on until the weave repeats.

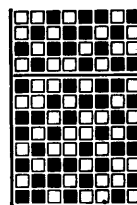


FIG. 23

In rearranging any weave in either its ends or picks, the repeat becomes an important matter and should always be carefully considered. Taking, for example, Fig. 23, it will be noticed that the first pick of this figure is like the first pick of Fig. 20, and also that in working out this new weave the sixth pick of Fig. 23 will be the same as the first pick, but the weave does not repeat on this pick, since the next pick, the seventh, is not like the second. However, after working out 12 picks, the weave repeats, since the next, or thirteenth, pick is like the first, the fourteenth like the second, the fifteenth like the third, and so on.

10. In selecting an order by which to rearrange either the ends or the picks of a weave, care should be taken to select one that will cause the weave to repeat correctly. For example, suppose that it was attempted to rearrange the ends of an 8-end twill by moving in twos; that is, taking one and skipping one; the order would be 1, 3, 5, 7, when it would come back to 1 again and continue in the same order. This, of course, would be a repeat in a certain sense of the

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word but would not be a repeat of the weave, since all of the ends of the original weave would not be used.

When it is desired to learn in what order the ends may be taken to make the weave repeat when rearranging the ends or picks of a weave by means of taking one end and skipping a certain number, find two numbers that, when added together, will equal the number of ends or picks on which the weave is complete but that cannot be divided into each other or into the number of ends or picks of the weave without a remainder. When twills are rearranged in this manner they are said to be rearranged in *satın order*.

Suppose that it is desired to rearrange the ends of a twill that is complete on 12 ends and 12 picks. It will be seen that 7 and 5 are two numbers that cannot be divided into each other or into 12 without a remainder but that when added together will equal 12. Therefore, the ends of the weave may be rearranged by moving in sevens or fives. That is, if the ends are arranged on a base of 7, the first end of the weave is copied, while the next six are missed, and so on, which will give the following order: 1, 8, 3, 10, 5, 12, 7, 2, 9, 4, 11, 6; here the weave will commence to repeat and consequently will not need to be continued. On the other hand, take two numbers such as 8 and 4; these added together make 12, but it will be noticed that 4 can be divided into 8 and also into 12. It would not therefore be possible to rearrange a 12-end twill with either of these numbers. To show that this is correct suppose that it is attempted to rearrange the ends of a 12-end weave on a basis of 4, that is, taking the first end and missing the next 3 ends. The order will be 1, 5, 9, and if the next 3 ends are missed it will be seen that it is necessary to take the first end again, when exactly the same ends will be taken, and consequently only these 3 ends will be used, which will not give a repeat of the weave.

11. Derivatives Formed by Combining Twills.

Another method of obtaining derivative weaves and one quite generally adopted is that of combining two weaves either in their ends or picks. Suppose that from the two

weaves shown in Figs. 24 and 25 it is desired to form a new weave by combining them pick and pick; that is, first taking a pick of one weave and then a pick of the other, as in Fig. 26. It will be noticed that the first pick of Fig. 26 is the first pick of Fig. 24; the second pick of Fig. 26 is the first pick of Fig. 25; the third pick of Fig. 26 is the second pick of Fig. 24; the fourth pick of Fig. 26 is the second pick of Fig. 25. This is continued until the picks in both Figs. 24 and 25 are all used, when the weave will be complete.

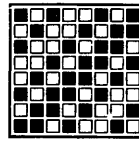


FIG. 24

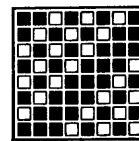


FIG. 25

There are numerous other weaves that may be obtained by combining these two weaves pick and pick. Take for example Fig. 27, which is different from the weave shown in Fig. 26 and yet is obtained by combining Figs. 24 and 25 pick and pick. By carefully noticing Fig. 27, it will be seen that in this case the second pick of Fig. 25, instead of the first, is the first pick taken, as was the case with Fig. 26. Thus, the first pick of Fig. 27 is the first pick of Fig. 24; the second pick of Fig. 27 is the second pick of Fig. 25; the third pick of

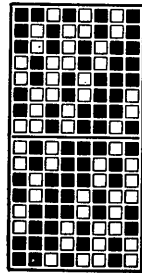


FIG. 26

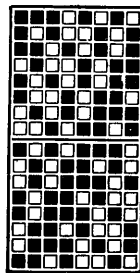


FIG. 27

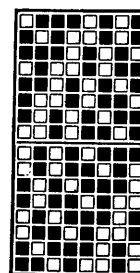


FIG. 28

Fig. 27 is the second pick of Fig. 24; the fourth pick of Fig. 27 is the third pick of Fig. 25; and this is continued until all the picks in both weaves are used, when the new weave will commence to repeat.

Still another weave may be obtained by commencing with the first pick of Fig. 24 but having for the second pick of the new

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weave the third pick of Fig. 25. Fig. 28 shows such a weave, and by carefully studying each pick it will be noticed that the first pick of Fig. 28 is the first pick of Fig. 24; the second pick of Fig. 28 is the third pick of Fig. 25; the third pick of Fig. 28 is the second pick of Fig. 24; the fourth pick of Fig. 28 is the fourth pick of Fig. 25; the fifth pick of Fig. 28 is the third pick of Fig. 24; the sixth pick of Fig. 28 is the fifth pick of Fig. 25; and so on until all of the picks in both Figs. 24 and 25 are used, whereupon the weave commences to repeat.

In addition to combining weaves pick and pick, they may also be combined by taking 2 picks of one weave and 1 pick of the other or by taking 2 picks of one weave and 2 picks of the other; or in short, almost any method may be adopted, and consequently the number of weaves that may be obtained is almost without a limit. Weaves should be combined in such a manner that long floats of either warp or filling will be avoided. If the combining of different weaves is practiced, it will be seen that frequently when two weaves are combined by one method long floats will appear, but that by starting on a different pick or by using a different method of combination the same two weaves may be combined without this defect.

12. When combining or copying twills, the natural tendency is to look from the designs to be copied to the design being made; this method occupies considerable time and is liable to cause errors. A better method is to mark the first pick of the twill and then run it up in the same manner as regular twills. When two twills are to be combined in their picks, it is a good plan to indicate on the design paper the picks on which one twill is to be placed and then run up each twill separately, placing each on its own picks.

Though the two weaves that have been combined are complete on the same number of ends and picks, yet it frequently occurs that weaves are combined that are not complete on the same number of ends and picks; in these cases it is important to know when the weave formed by the combination commences to repeat. To illustrate this point, suppose

that it is desired to combine pick and pick an 8×8 twill with a 6×6 twill. When the 8 picks of the first weave have been used, all 6 picks of the second weave will have been used once and in addition 2 of them will have been used the second time; therefore, the weave will not repeat here. When the 8 picks of the first weave have been used twice, the 6 picks of the second weave will have been used twice and 4 of them the third time; therefore, the weave does not repeat as yet. When the 8 picks of the first weave have been used three times, all the picks of the second weave will have been used exactly four times, and consequently the weave will repeat at this point. Thus the first weave will be repeated in its picks three times, making 24 picks, and the second weave will be repeated four times, making 24 picks, and since these two weaves are combined pick and pick the resulting weave will occupy 48 picks.

On the other hand, 24 ends will be occupied by the resulting weave in order to have the weave repeat in its ends. Therefore, any weave formed by combining pick and pick an 8×8 twill with a 6×6 twill will occupy 24 ends and 48 picks before it will commence to repeat. In other words, weaves when combined pick and pick will occupy a number of ends equal to the least common multiple of the number of ends on which each individual weave is complete, and a number of picks equal to twice the least common multiple of the number of picks in one repeat of each of the original weaves. In the above example the least common multiple of 8 and 6 is 24; therefore, the completed weave, as stated, will occupy 24 ends and $2 \times 24 = 48$ picks.

13. Derivative weaves are also formed by combining the ends of two weaves. The principles governing the combining of twills in their picks, also govern this case. Figs. 29 and 30 show two twills that it is desired to combine in this manner. Since they occupy a different number of ends, both the method of combining twills end and end and the method of determining the repeat of a weave formed by combining twills that occupy a different number of ends or picks will be

understood. Fig. 29 occupies 10 ends, while Fig. 30 occupies only 5 ends; consequently, Fig. 30 must be repeated twice in its ends in order to have it occupy the same number of ends as Fig. 29. It must also be repeated twice in its picks in order to have it occupy the same number of picks as Fig. 29. When Fig. 30 has been repeated in both ends and picks it will occupy 10 ends and 10 picks; there will then be two

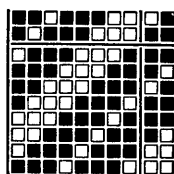


FIG. 29



FIG. 30

weaves each occupying 10 ends and 10 picks that are to be combined end and end. Consequently, the resulting weave will occupy 20 ends and 10 picks. If these two weaves were combined pick and pick, the resulting weave would occupy 10 ends and 20 picks.

Fig. 31 shows the weave obtained by combining Figs. 29 and 30 end and end, commencing with the first end of Fig. 29 and the second end of Fig. 30. It will be seen that the first end of Fig. 31 is the first end of Fig. 29; the second end of Fig. 31 is the second end of Fig. 30; the third end of Fig. 31 is the second end of Fig. 29; the fourth end of Fig. 31 is the third end of Fig. 30; and so on until the weave repeats. It will be noticed that when all the ends of Fig. 30 have been used once they are used the second time in regular order to make the weave repeat.

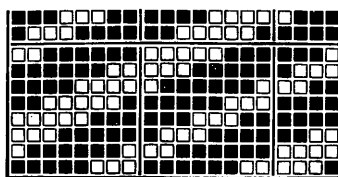


FIG. 31

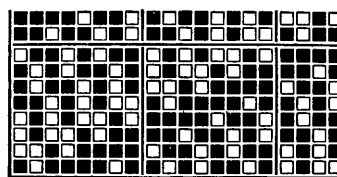


FIG. 32

Fig. 32 shows another weave formed by combining Figs. 29 and 30 end and end. In this case the first end of Fig. 29 is the first end of that weave taken, while the fifth end of Fig. 30 is the first end of that weave taken. Since the principles of producing different weaves when combining them pick and pick apply equally well to combining weaves end and end,

the number of different weaves that it is possible to produce by this method is as varied as the number that may be obtained by combining weaves in their picks. Moreover, the weaves that are combined may be rearranged in either their ends or picks after the manner described and then combined, etc., so that the number of weaves that may be obtained in this manner is almost without limit.

When twills are combined the angle is changed. Thus, if two regular 45° twills are combined end and end they form a 27° twill; if they are combined pick and pick they form a 63° twill. If three regular 45° twills are combined by taking a pick of each in regular order they form a 72° twill; if they are combined by taking an end of each in regular order they form an 18° twill.

EXAMPLES FOR PRACTICE

1. Show one repeat of the regular $\frac{4}{4} \frac{8}{8}$ twill on design paper.
2. From the weave formed in answer to question 1 form a weave by arranging the ends in the following order: taking the first end, skipping 2, taking the next, skipping 2, and so on until the new weave repeats.
3. Take the two weaves given in answer to questions 1 and 2 and combine them pick and pick, taking the first pick of the weave given for question 1, then the first pick of the weave given for question 2, and so on.
4. If a 10×10 twill is combined pick and pick with a 6×6 twill, on how many ends and picks will the new weave be complete?
5. If a 16×16 weave is combined end and end with an 8×8 weave, how many ends and picks will the new weave occupy?

FANCY TWILLS

14. In addition to the regular 45° twills there are many other twill weaves that may be considered as subdivisions of regular twills; these are very useful in many classes of fabrics. The first of these weaves that will be considered are those known as **fancy twills**. These weaves generally consist of a regular twill weave between the twill lines of which are placed sometimes other twills running in the

18 TWILL WEAVES AND DERIVATIVES

opposite direction, sometimes small spots, and sometimes other small weaves.

The first step in making such weaves is to construct a bold line of twill running across the design, as shown in Fig. 33. In order to change this regular twill into a fancy twill, it is

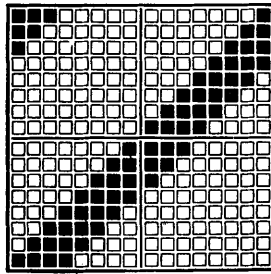


FIG. 33

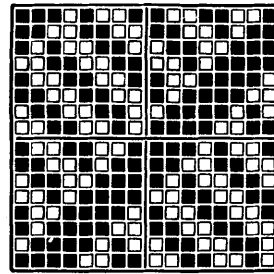


FIG. 34

necessary to insert some other weave on the blank squares. Fig. 34 shows this twill changed to a fancy twill; the method employed is that of running short lines of twill in a direction opposite to that of the main line of twill.

Figs. 35 and 36 show two other fancy twills. In Fig. 35, the fancy twill is formed by placing small spots between the

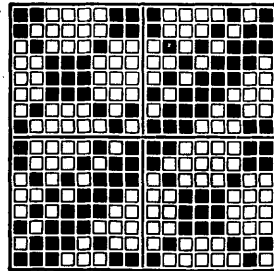


FIG. 35

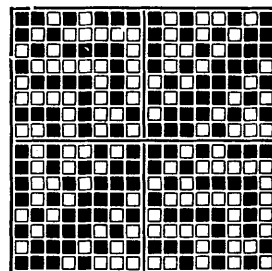


FIG. 36

main lines of twill; while in Fig. 36, the fancy twill is formed by placing a small weave, as shown, between the main lines of twill.

In making these weaves it should be noted that the entire weave runs up in a twill line and that it is essential to have

the first and last ends and also the first and last picks match; that is, the first end of the weave should be a continuation of the last end and the first pick should be a continuation of the last pick, so that the weave will continue perfectly when repeated in either direction. In order to accomplish this, it is necessary to have the spot or weave that is inserted occupy a number of picks that can be divided into the number of picks on which the entire weave is complete; otherwise, it will be necessary to continue the twill and spot weaves until a point is reached where they repeat together, which will occur on a number of picks equal to the least common multiple of the number of picks required by the twill and by the spot weave.

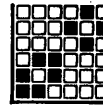


FIG. 37

In Fig. 34, the small twill weave may be said to occupy 4 picks, which is exactly divisible into 16, the number of picks that one repeat of the completed weave occupies. In

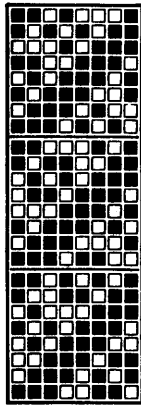


FIG. 38

Figs. 35 and 36, each inserted weave may be said to occupy 4 picks; this number is exactly divisible into 16, the number of picks that the complete weaves occupy.

When the weave that is inserted between the twill lines repeats on a different number of picks, the twill and inserted weave are both repeated in the picks until they repeat together, which occurs on a number of picks equal to the least common multiple of the number of picks on which the twill and spot weave are complete. For instance, suppose that it is desired to make a fancy twill weave by inserting Fig. 37 between the twill lines of a $\frac{3}{8}$ twill. Fig. 37 is complete on 6 picks, while the twill requires 8 picks; therefore, the completed fancy twill will require 24 picks, since 24 is the least common multiple of 6 and 8 and both will not commence to repeat together until the twenty-fifth pick. Fig. 38 shows the fancy twill thus obtained.

ENTWINING TWILLS

15. Entwining twills are constructed from regular twills by running sections of twill lines both to the right and to the left so that each section meets other sections at right angles. As their name indicates, the effects produced by these twills have an entwined or interlaced appearance; the more perfect ones are obtained when the separate sections are composed of equally flushed twills, although in some cases unequally flushed twills give good results. Fig. 39 shows an entwining twill constructed by running two twill lines of the cassimere to the right and two to the left, the weave repeating on 8 ends and 8 picks. Although two

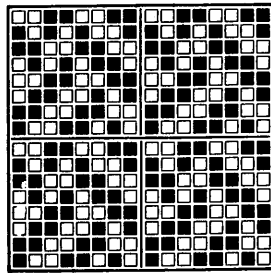


FIG. 39

repeats in the ends and two in the picks are shown here, when constructing these twills, the number of ends and picks that one repeat of the weave will occupy must be ascertained at the start. This may be found by multiplying the number of ends and picks required for one repeat of the weave used by the number of twill lines in each section; thus, since in Fig. 39 two twill lines of the cassimere, or $\frac{2}{2}$, twill are used, the completed entwining twill occupies 8 ends and 8 picks ($2 \times 4 = 8$). If it is desired to construct an entwining twill with the cassimere twill and have three twill lines in each section, 12 ends and 12 picks ($3 \times 4 = 12$) will be required to show one repeat; if four twill lines in a section are wanted, 16 ends and 16 picks will be required, and so on. If the 6-end regular twill $\frac{2}{3}$ is used as a base instead of the cassimere and three twill lines are desired in each section, 18 ends and 18 picks ($3 \times 6 = 18$) will be required for one repeat of the completed entwining twill. In constructing an entwining twill, therefore, it is first necessary to decide on the twill weave to be used as a base and also on the number of twill lines to be used in each section, from which the number of ends and picks required for one repeat can be found.

To illustrate the method of constructing these weaves, suppose that it is desired to make an entwining twill with the cassimere twill $\frac{2}{5}$, having five twill lines in each section, which will give an entwining twill complete on 20 ends and 20 picks ($5 \times 4 = 20$). The first step is to run up the first twill line of one section, as shown in Fig. 40 (a), continuing

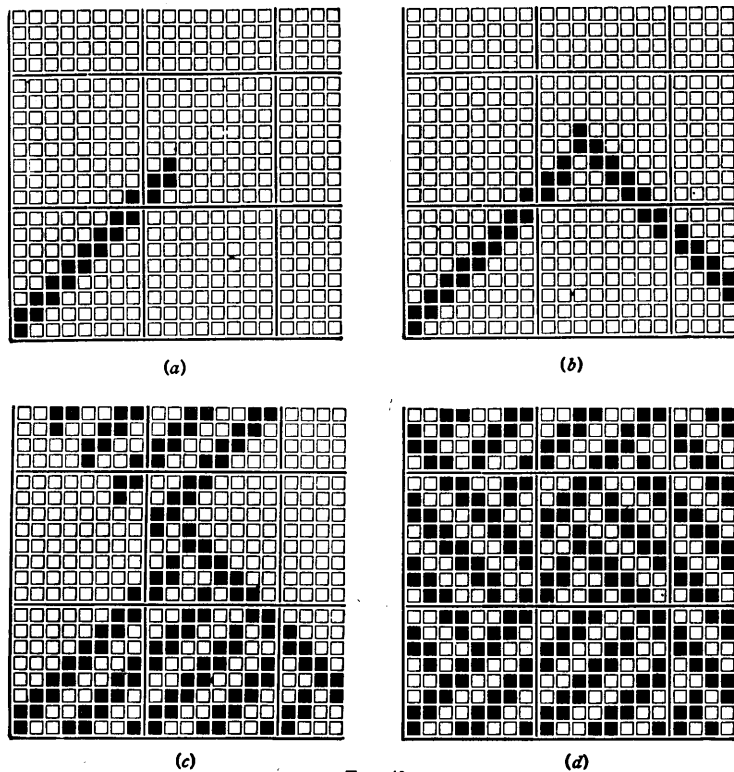
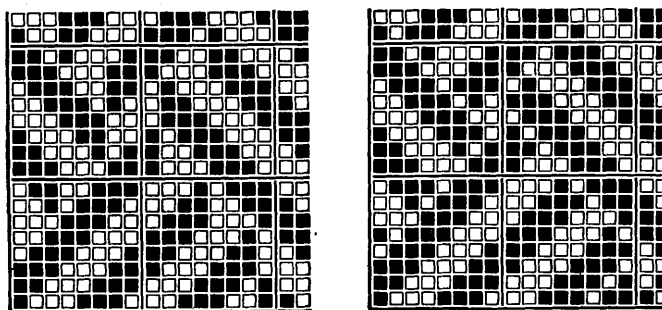


FIG. 40

it for a number of ends equal to one-half the total number of ends to be occupied by the repeat. Next insert the first twill line of the section of twill lines that run in the opposite direction, starting it on the next end to and just above the last riser of the first twill line and running it down in the opposite direction, as shown in Fig. 40 (b). Next return to the

first section, that is, the one running to the right, and complete it by running the four other twill lines parallel to the first twill line that has already been obtained. Each twill line must be continued, as shown in Fig. 40 (c), until it



(a) FIG. 41 (b)

occupies the same number of ends as the first twill line; namely, a number of ends equal to one-half of the number occupied by the completed weave, or in this case 10 ends.

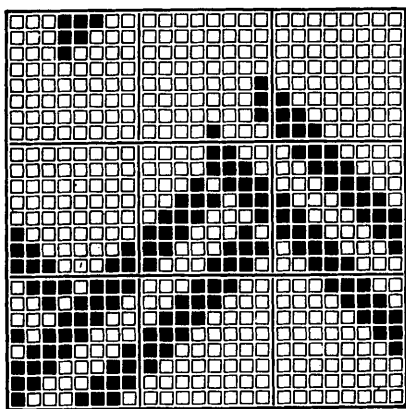


FIG. 42 (a)

By completing the section of twill lines running to the left in the same manner, that is, by adding the other four twill lines parallel to the one already obtained, the completed weave is obtained, as shown in Fig. 40 (d).

When the warp floats over more than 2 picks in a twill used as the base of an entwining twill, it is usually advisable to add one or more extra risers to the ends of each warp twill line in order to make the twill lines meet each other better and also to shorten the warp floats on the back of the cloth at the junction of the right and left twill lines. For instance, Fig. 41 (a) shows an entwining

twill constructed with three lines of the $\frac{3}{3}$ regular twill in each section, and while this weave is perfectly constructed, if one extra riser is added to each end of every twill line, as shown in Fig. 41 (b), the weave will be enhanced in value. It is very often necessary to alter the ends of each twill line, either by adding or taking out risers in order to make each twill line meet others in the best possible manner; especially is this true in the case of entwining twills based on unequally flushed weaves.

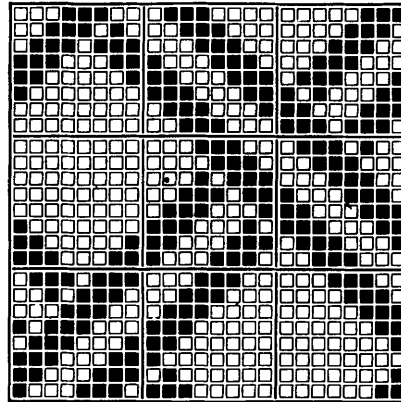


FIG. 42 (b)

As the repeat of the weave is already determined, the addition of extra risers will not alter the number of ends and picks in the repeat nor the number of harnesses necessary to weave the design.

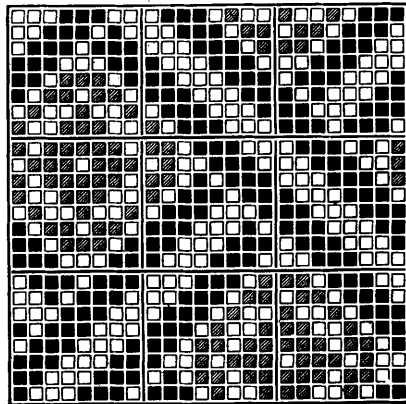


FIG. 42 (c)

Fancy entwining-twill effects are obtained by omitting one or more twill lines from each section and continuing the remaining twill lines of each section until they meet those of the other section. By this means two blank spaces are made in the weave, in which other weaves may be inserted. To illustrate the

construction of these weaves, suppose that it is desired to make a fancy entwining-twill effect on 24 ends and 24 picks with the $\frac{3}{3}$ twill. In an ordinary entwining twill, this would

require four twill lines in each section, but since this is to be a fancy effect two of the twill lines in each section will be omitted. Fig. 42 (*a*) shows the weave constructed up to this point, but since two twill lines have been omitted from each section it is necessary to continue the two remaining twill lines across the space that would have been occupied by the other twill lines until they meet those of the other section, as shown in Fig. 42 (*b*). This leaves two blank spaces, as shown, in which any desired weave may be inserted, thus producing a fancy entwining twill, as shown in Fig. 42 (*c*), where the inserted weave is indicated by the shaded risers.

CURVED TWILLS

16. Curved twills are those in which the twill lines have a wavy, or curved, nature instead of being perfectly straight as in an ordinary twill weave. There are two methods of constructing these weaves, although the results are very similar in either case.

The first method consists of amalgamating several sections of twill weaves running at different angles, while by the second method the curved effect is obtained with a regular twill weave for a chain draft and a drawing-in draft so arranged as to produce the desired effect. Fig. 43 shows several repeats of a curved twill constructed in accordance with the first method. This weave repeats on 32 ends and 8 picks and is composed of four sections of 8 ends each; the first section is the regular 8-end 45° twill $\frac{4}{4}$; the second section is a twill having an angle of 63° ; the third section is a twill with an angle of 72° ; and the fourth section is like the second. It will be noticed that each end of the weave interlaces in the same manner as some one of the first 8 ends; therefore, the weave may be woven with 8 harnesses and the first 8 ends as a chain draft if the proper drawing-in draft is used; this shows that the second method of constructing curved twills is really based on the first.

Fig. 44 (*a*) shows several repeats of a curved twill constructed by the second method with the chain draft shown in

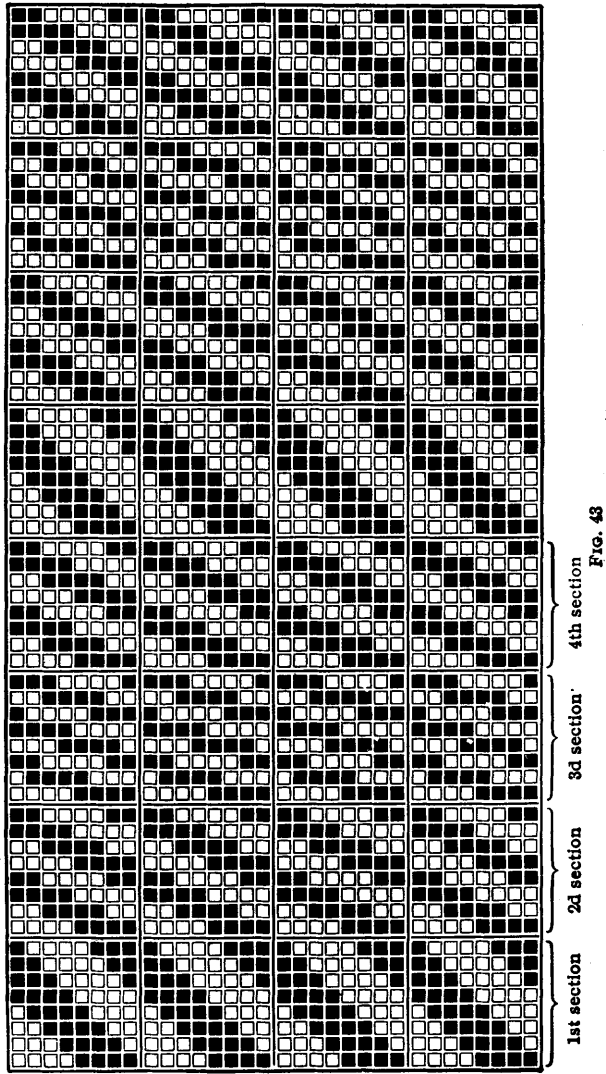
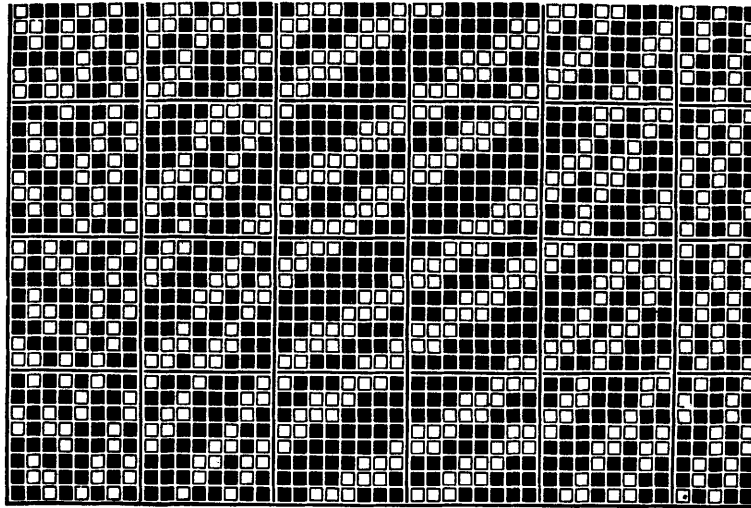
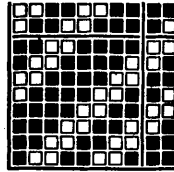


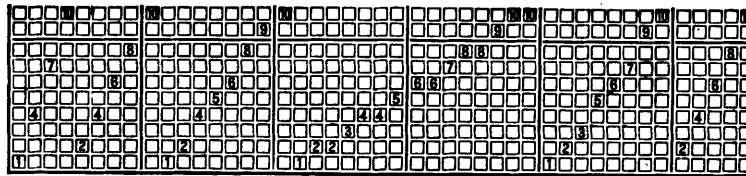
Fig. 44 (b) and the drawing-in draft Fig. 44 (c). The first end of the effect in Fig. 44 (a) is like the first end of Fig. 44 (b); the second end is like the fourth end; the third,



(a)



(b)



(c)

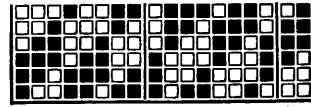
FIG. 44

like the seventh; the fourth, like the tenth; and so on, each end of Fig. 44 (b) being taken in the order indicated by the drawing-in draft in Fig. 44 (c).

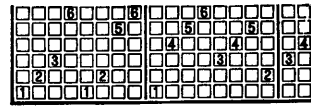
SKIP TWILLS

17. Skip twills are a type of broken twill effects formed by a skip drawing-in draft and a regular twill weave as a chain draft. The drawing-in draft is made so that the ends are drawn in straight for a certain number of harnesses; a number of harnesses are then missed; and afterwards the ends are again drawn in straight. The draft is so constructed that when the harnesses are skipped, the end in the harness just before the skip will rise and fall exactly opposite to the next end; by this means a broken effect is formed in the cloth. In Fig. 45 (a) is shown a skip twill that is made with the 6-end regular twill $\frac{3}{2}$, Fig. 45 (c), as a chain draft and the skip drawing-in draft shown in Fig. 45 (b). In this draft the first 3 ends are drawn straight; then 2 harnesses are skipped; 3 more ends are then drawn straight, and so on until a repeat is found.

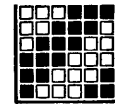
In this weave the fourth end rises and falls exactly opposite to the third end. This is accomplished by means of drawing the fourth end through the sixth harness instead of the fourth, as would be done with a straight draft. The seventh end rises and falls exactly opposite to the sixth, the tenth end opposes the ninth in the same manner, and so on until the eighteenth end is reached, which rises and falls exactly opposite to the first end. One end rising and falling in opposition to another in this manner is termed *cutting*. Skip twills are best constructed from equally flushed twills.



(a)



(b)

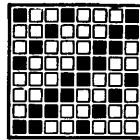


(c)

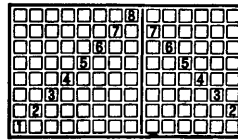
FIG. 45

POINTED TWILLS

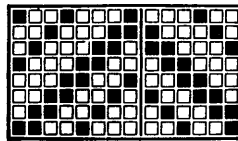
18. Another class of twill weaves obtained by means of the harness draft includes those weaves obtained by point drafts, which form wave effects across the cloth known as **pointed twills**.



(a)



(b)

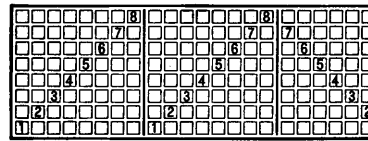


(c)

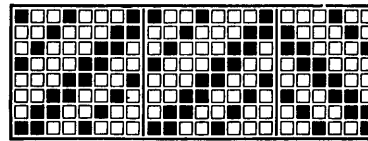
FIG. 46

These effects are also frequently spoken of as *herring bones*, or *herring-bone stripes*, because the radiating twill lines suggest the radiating bones of a fish's backbone. Suppose that it is desired to make a pointed, or wave, effect with the 45° twill shown in Fig. 46 (a) as the chain draft; Fig. 46 (b) shows the harness draft that will be used, while Fig. 46 (c) shows the effect obtained in the cloth.

One important point in connection with point drafts is that they always end on the second harness and not on the first, that is, assuming that the draft begins on the first harness. For instance, in Fig. 46 (b), the ends are drawn straight for the first 8 harnesses, when they are reversed, commencing with the seventh harness; when the harness draft reaches the second harness after being reversed, one repeat of the draft is obtained. If the last end of the draft were drawn through the first harness, the first and last ends of each repeat would work exactly alike, which would give in the cloth 2 ends side by side working alike. This would cause a serious defect in the fabric. If the weave shown in Fig. 46 (c) is repeated two or



(a)



(b)

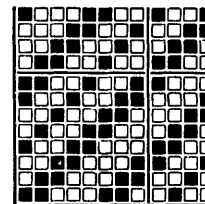
FIG. 47

three times in both ends and picks, a better idea of the waves formed by these weaves will be obtained.

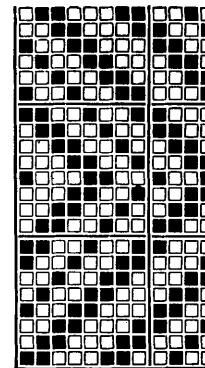
Many good effects can be obtained by this method by changing the harness draft and using the same chain draft. Thus, instead of using a regular point draft like that shown in Fig. 46 (b), a draft like that shown in Fig. 47 (a) may be used; the effect, or weave, in this case, will be similar to that shown in Fig. 47 (b).

19. The point twills thus far described will make waves across, or widthwise of, the cloth. The same effects, however, may be made to extend lengthwise of the cloth by simply reversing the chain draft in the same manner that the harness draft was reversed when making waves across the cloth.

Suppose that it is desired to make a chain draft that will give a wave running lengthwise of the cloth from the twill shown in Fig. 48 (a). It is simply necessary to make a chain draft that will have the first 12 picks similar to Fig. 48 (a) and the remaining picks made by reversing these first 12 picks; that is, the thirteenth pick will be like the eleventh; the fourteenth, like the tenth; the fifteenth, like the ninth; the sixteenth, like the eighth; the seventeenth, like the seventh; the eighteenth, like the sixth; the nineteenth, like the fifth; the twentieth, like the fourth; the twenty-first, like the third; and the twenty-second, like the second. Here the chain draft will stop, in order to avoid having the first and last picks alike, on the same principle that the harness drafts of weaves making waves across the cloth stop on the second harness. Fig. 48 (b) shows the chain draft to give the wave lengthwise of the cloth; the harness draft will be a 12-harness straight draft.



(a)

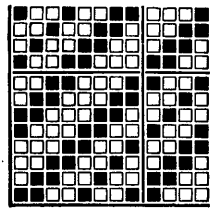


(b)

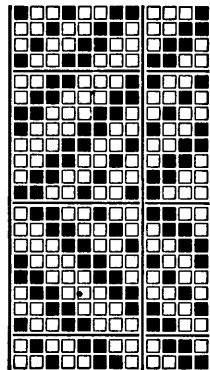
FIG. 48

DIAMOND WEAVES

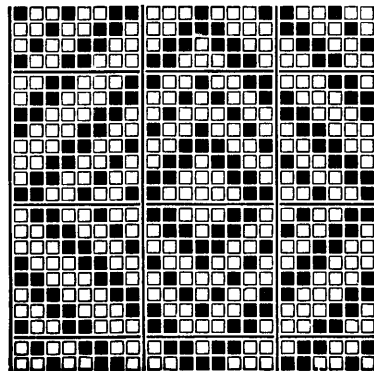
20. By reversing both the harness and chain drafts of any regular twill, another class of weaves that is very largely used, and known as **diamond weaves** from the effects formed in the cloth, will result.



(a)



(b)



(c)

FIG. 49

Fig. 49 (a) shows a regular twill from which it is desired to construct a diamond weave. First build the chain draft by reversing the picks exactly as when forming waves lengthwise of the cloth. For the purpose of illustration, however, the picks will be reversed from the first pick, instead of from the last as in the previous illustration. It should be understood that in either case the weave will be the same. Fig. 49 (b) shows Fig. 49 (a) reversed in this manner. Fig. 49 (b) should be considered as the chain draft of the desired weave, while the drawing-in draft will be a regular point draft made on the same principle as the drawing-in drafts for the regular weaves that were made into waves extending across the cloth. The chain draft occupies 12 harnesses and consequently the drawing-in draft will be the 12-harness regular point draft. In other words, the ends will be drawn in the following order: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2. It should be noticed that in this case, as well as in weaves forming wave effects, the last

pick joins perfectly with the first; also the last end with the first. In order to show the effect that will be formed in the cloth when using Fig. 49 (b) for the chain draft and drawing in the warp ends as described, the weave has been worked out and is shown in Fig. 49 (c).

DIAGONAL WEAVES

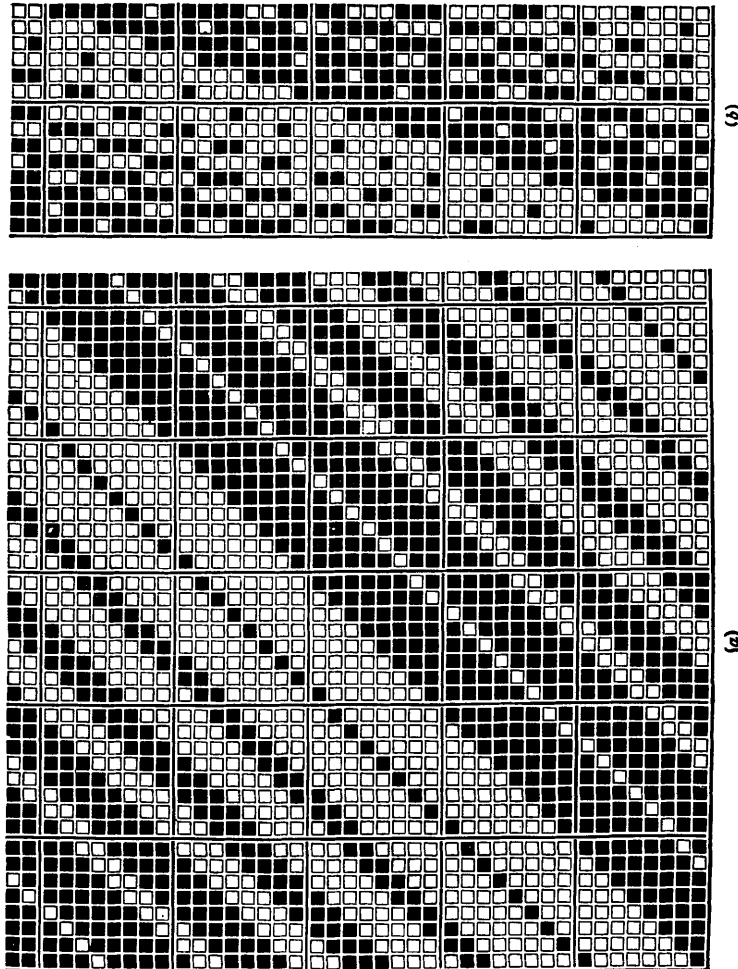
21. Shaded Diagonals.—Diagonal weaves may be considered as a type of twill weaves, the term being generally confined to bold twills running at angles greater than 45°, although often regular 45° twills are spoken of as diagonals; regular diagonals are generally formed by combining two regular 45° twills in their picks or ends. As the formation of other weaves by combining twills pick and pick or end and end has been fully explained, it will not be necessary to give further details of these weaves, but simply to state that all the examples under this method of forming weaves may be considered as diagonals.

There is, however, a subdivision known as **shaded diagonals**, which are formed on a twill basis by taking as the base of the twill a different number of risers and sinkers in the different sections, grading from light to dark or from dark to light. For instance, suppose that a shaded diagonal is to be made from a regular 45° twill that is complete on 42 ends and 42 picks. Divide the first pick of the weave into six sections of 7 ends each. Then beginning with the first section leave only 1 end down; that is, this part would be marked $\frac{6}{1}$. In the next section leave 2 ends down, making this section $\frac{5}{2}$. Continuing in this manner, the next section will be $\frac{4}{3}$; the next section, $\frac{3}{4}$; the next section, $\frac{2}{5}$; while the last section will be marked $\frac{1}{6}$; therefore, the first pick of this weave would be marked $\frac{6}{1} \frac{5}{2} \frac{4}{3} \frac{3}{4} \frac{2}{5} \frac{1}{6}$. It is next necessary to run up this twill in the regular 45° manner until it is complete; that is, until it occupies 42 ends and 42 picks. Fig. 50 (a) shows the complete weave.

After the regular twill has been formed it is necessary to decide what angle the diagonal shall form. If it is to be

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a 63° diagonal, every other end of the regular twill may be taken. If it is to form an angle of 72° , every third end of the regular twill will be taken, and so on. Suppose that in



this case it is desired to have the diagonal form an angle of 72° . Then every third end of the regular twill shown in Fig. 50 (a) will be taken. As 3 can divide evenly into 42,

the number of ends on which Fig. 50 (a) is complete, the diagonal is complete on $42 \div 3$, or 14, ends. Commencing then with the first end in Fig. 50 (a) and taking every third

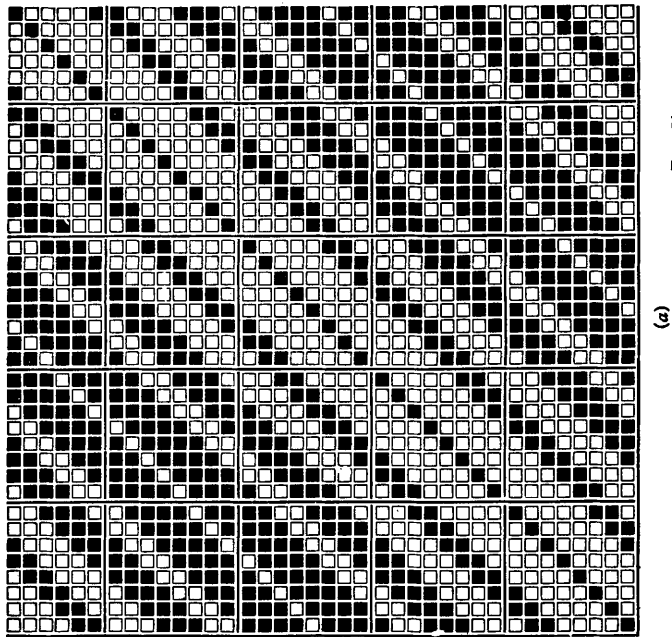
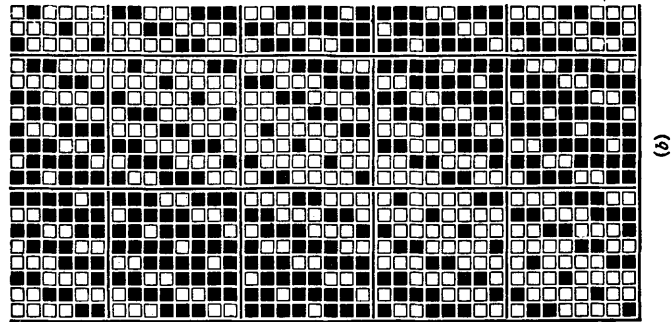


FIG. 51

end of the weave, Fig. 50 (b) will result. Thus, the first end of Fig. 50 (b) is the first end of Fig. 50 (a); the second end of Fig. 50 (b) is the fourth end of Fig. 50 (a); the third

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end of Fig. 50 (*b*) is the seventh end of Fig. 50 (*a*); and so on until every third end of the regular twill has been taken. Fig. 50 (*b*) will form a shaded effect in the cloth; that is, commencing with a certain part of the weave a large part of the warp will be found to float on the surface. The weave is then shaded gradually until a point is reached where the filling will be found to predominate largely on the surface.

In many cases these diagonals are made to shade in both directions; that is, the warp floats will be found gradually to grow less until the filling predominates, when the weave will again be shaded until the warp predominates, instead of breaking off suddenly as in Fig. 50 (*b*).

In making the regular twill weave for the base of a shaded diagonal, the most perfect results are obtained if the weave is equally flushed. In order to find this base, the following method is employed: Mark the numbers that indicate the number of warp ends to be lifted over the first pick, beginning with 1 and running up as high as desired, repeating the highest number and then grading down again but stopping with 2 instead of 1; thus, $\frac{1}{4} \frac{2}{3} \frac{3}{2} \frac{4}{1} \frac{4}{2} \frac{3}{3} \frac{2}{4}$. Then put 1 to represent one end down between the two highest numbers and grade in each direction until the highest number is reached at each end; thus, $\frac{1}{4} \frac{2}{3} \frac{3}{2} \frac{4}{1} \frac{4}{2} \frac{3}{3} \frac{2}{4}$. This method makes a perfect, equally flushed weave, since the same number of warp ends are up as are down, and also where 4 warp ends are up in succession 1 end is down between them, and where 4 warp ends are down in succession 1 warp end is up between them. Fig. 51 (*a*) shows the regular twill weave formed in this manner with the base given, and Fig. 51 (*b*) shows a 63° diagonal derived by taking every other end in proper rotation.

Shaded diagonal weaves are woven with a warp of one solid color and a filling of another solid color opposed to that of the warp, as for instance, a black warp and white filling, or vice versa; this brings out the shaded effect of the weave.

EXAMPLES FOR PRACTICE

1. Make a regular twill weave from the base $\frac{1}{5} \frac{2}{4} \frac{3}{3} \frac{4}{2} \frac{5}{1}$.
2. From the weave given in answer to question 1 construct a 72° shaded diagonal.
3. Extend the base of the twill given in question 1 and from the twill formed by this new base construct a 63° shaded diagonal that will be shaded in both directions.
4. Make an original diamond weave.