# 3. Woven fabric design

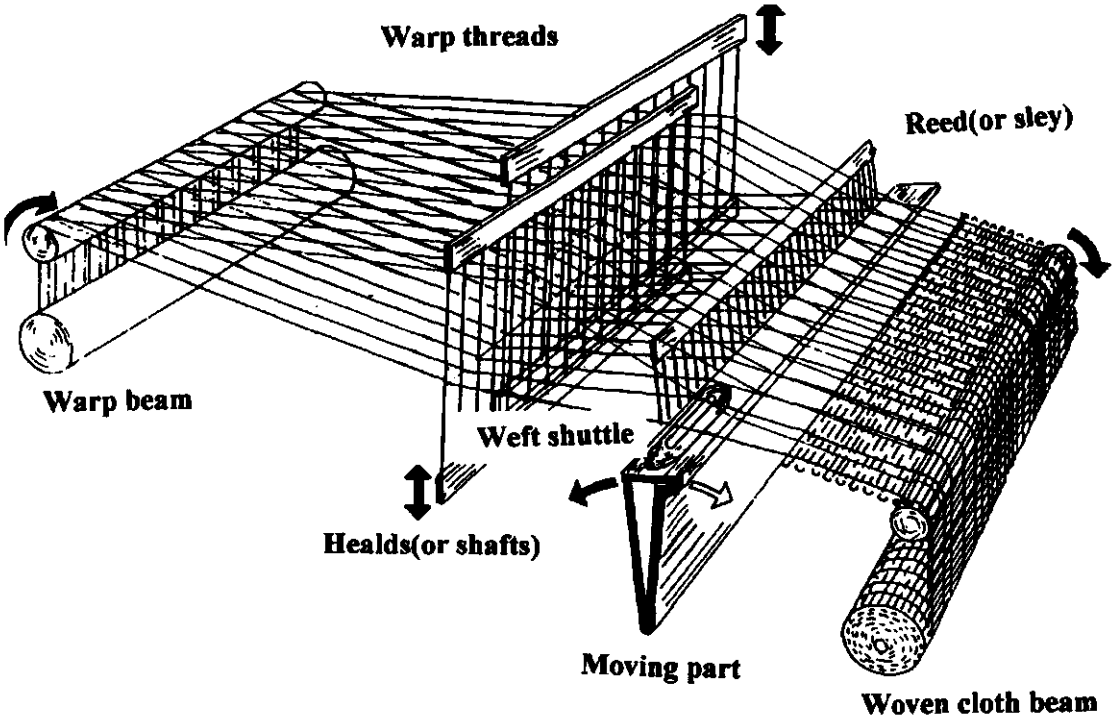
## 3.1 Introduction

With the aid of a simple sketch this chapter begins by explaining the function of the different parts of the loom during the weaving process. It then covers a wide selection of weaves that can be used in the construction of woven fabrics, each one represented on point paper with the first thread of the design at the extreme left-hand side, and the first pick along the bottom edge. Instruction is also given on how to construct simple colour and weave effects together with examples.

The English system of drafting and pegging is explained in detail with examples provided. At first sight this seems to be a very complicated business indeed, but after careful study it will begin to appear less so. Sleying (or Denting) which is a part of the drawing process is also explained in some detail.

## 3.2 The weaving process

Warp, healds (or shafts), reed (or sley), weft, a warp beam and a woven cloth beam are shown in figure 3.1. Warp is the collective name given to threads that lie vertically in the loom and might be arranged in a predetermined order of different colours. They may form a stripe or check design but in a self-coloured fabric they are all of one colour. If the design is to be a dogtooth check for instance, warp threads will be arranged four of colour A and four of colour B across the entire warp.




3.1 The basic requirements and principles of the weaving process

In a Prince of Wales or glen check design the warp threads might be arranged as follows:

| | | | | |
|---|---|---|---|---|
| Colour A | 2 | 2 | 4 | 4 |
| Colour B | 2 | 3 | 4 | 3 |
| | 48 | | 40 | |

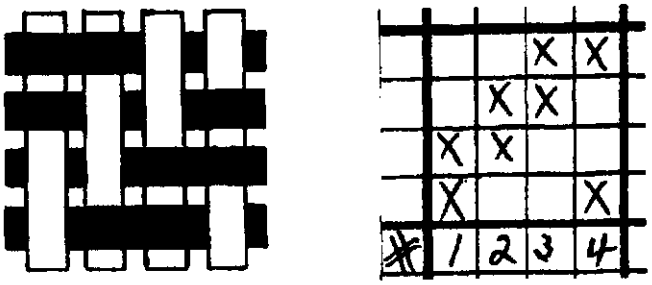
In tartan designs up to as many as five or six different yarn colours might be arranged in a complex sequence in order to achieve the desired effect.

The warp is first arranged in sections of equal length on a large cylinder (warp mill) it is then transferred onto a warp beam, which is ultimately placed at the back of the loom for the weaving process. After warping, drawing and sleying take place before placing the warp beam in the loom. In the drawing operation each individual warp end is drawn through the metal eye of a heald on any one of a number of shafts, in a predetermined order according to the draft. When drawing is complete, warp ends are then gathered 2, 3 or 4 at a time depending on the cloth sett and weave to be used, and pulled through a space (or split) in the reed.

During the weaving process weft yarn is projected across the warp one pick at a time in a predetermined sequence of colours that will balance or compliment the warp colouring arrangement. Each time a pick goes across the loom it passes through a 'shed' or tunnel formed by the raised and lowered shafts carrying the warp threads. After each pick is inserted the reed beats it up once against the already woven fabric, then the shafts move into a new position forming another 'shed' for the next pick to go through. This operation is repeated thousands of times at considerable speed during the weaving of a 70 metre piece of cloth. The variables to be addressed in constructing a woven fabric are as follows and will be dealt with throughout the book:

- Warp and weft yarn counts
- Number of warp ends per centimetre in loom
- Number of weft picks per centimetre in loom
- Density of reed required
- Total warp ends in loom to give standard finished cloth width of 150 cms
- Sequence of warp end colours (warp set-in)
- Sequence of weft pick colours (weft set-in)
- Weave to be used
- Number of shafts required to reproduce the weave
- Sequence of drawing individual warp ends through eyes on the shafts (Draft)
- Number of warp ends to be sleyed together in each dent of the reed
- Instructions to raise or lower every shaft (Peg plan).

### 3.3 Basic weaves




3.2 Terms used to describe fabric interlacings.

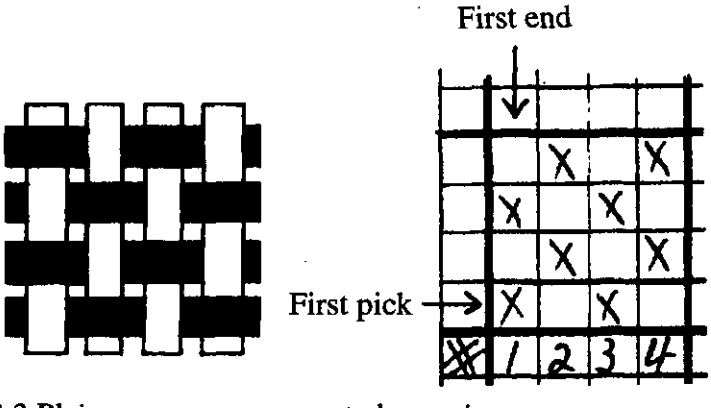
The woven fabric or structure consists of two series of yarns (warp and weft) that interlace at right angles to each other.

In figure 3.2 the term 'weave' refers to the way in which warp and weft threads interlace with each other and the term 'design' refers to the method by which a weave is represented on squared or point paper. The vertical spaces between lines on point paper represent warp ends and horizontal spaces between lines represent weft picks. A mark or cross in a square indicates warp lifted over weft and a square left blank indicates weft over warp.

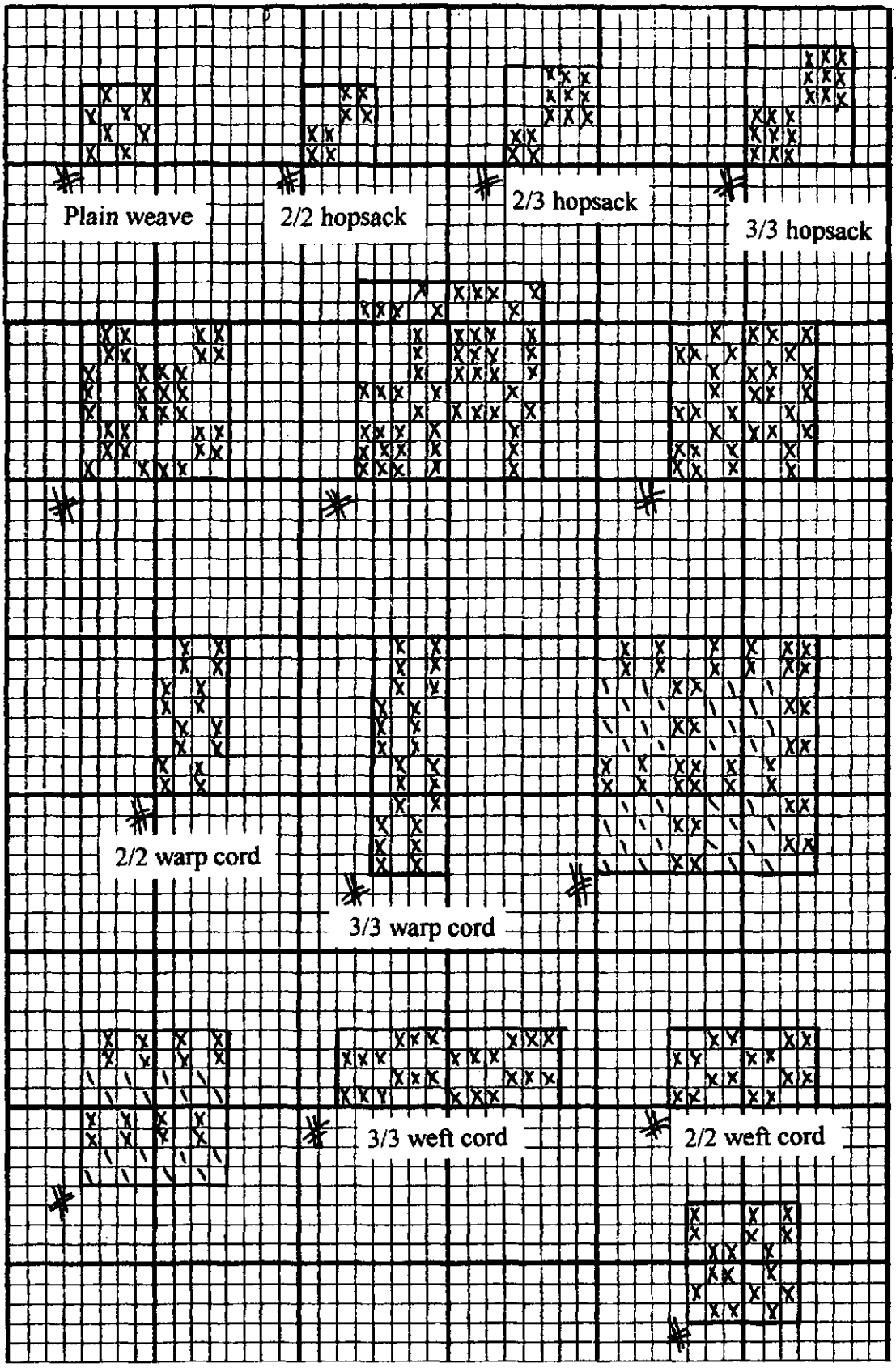
Every weave repeats on a certain number of ends and picks and normally only one repeat of the design is shown on point paper. The number of ends and picks in a repeat can be equal or unequal, but in either case the complete weave must be in the form of a square or rectangle. Each end and pick should ideally have approximately the same number of interlacings in one repeat of the weave to ensure a sound and balanced fabric.

The most commonly used weaves are plain, twill and sateen. They are the elementary weaves from which nearly all others are derived.

As illustrated in figure 3.3, plain weave is the simplest and most basic of all weaves and has the maximum number of interlacings thereby making it the strongest. Plain weave is used to make the lightest practical weight of fabric in any yarn count. It can be modified by using two or more ends and/or picks as one, enabling the threads to be more densely packed and this produces fabrics with more body and substance than in plain weave. In the larger hopsack weaves, warp and weft threads tend to lie flat on the surface to give a more lustrous appearance and smoother handle. Various examples of modified plain weave are shown in figure 3.4.

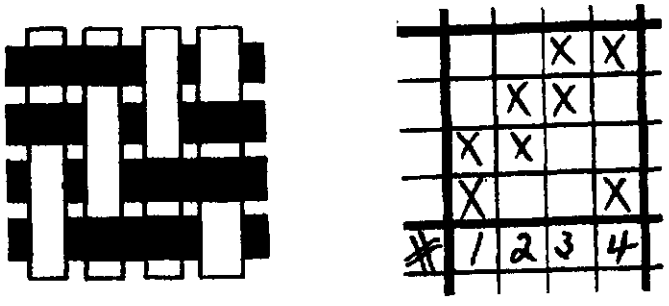



3.3 Plain weave as represented on point paper




3.4 Plain weave and derivatives

Twill weaves



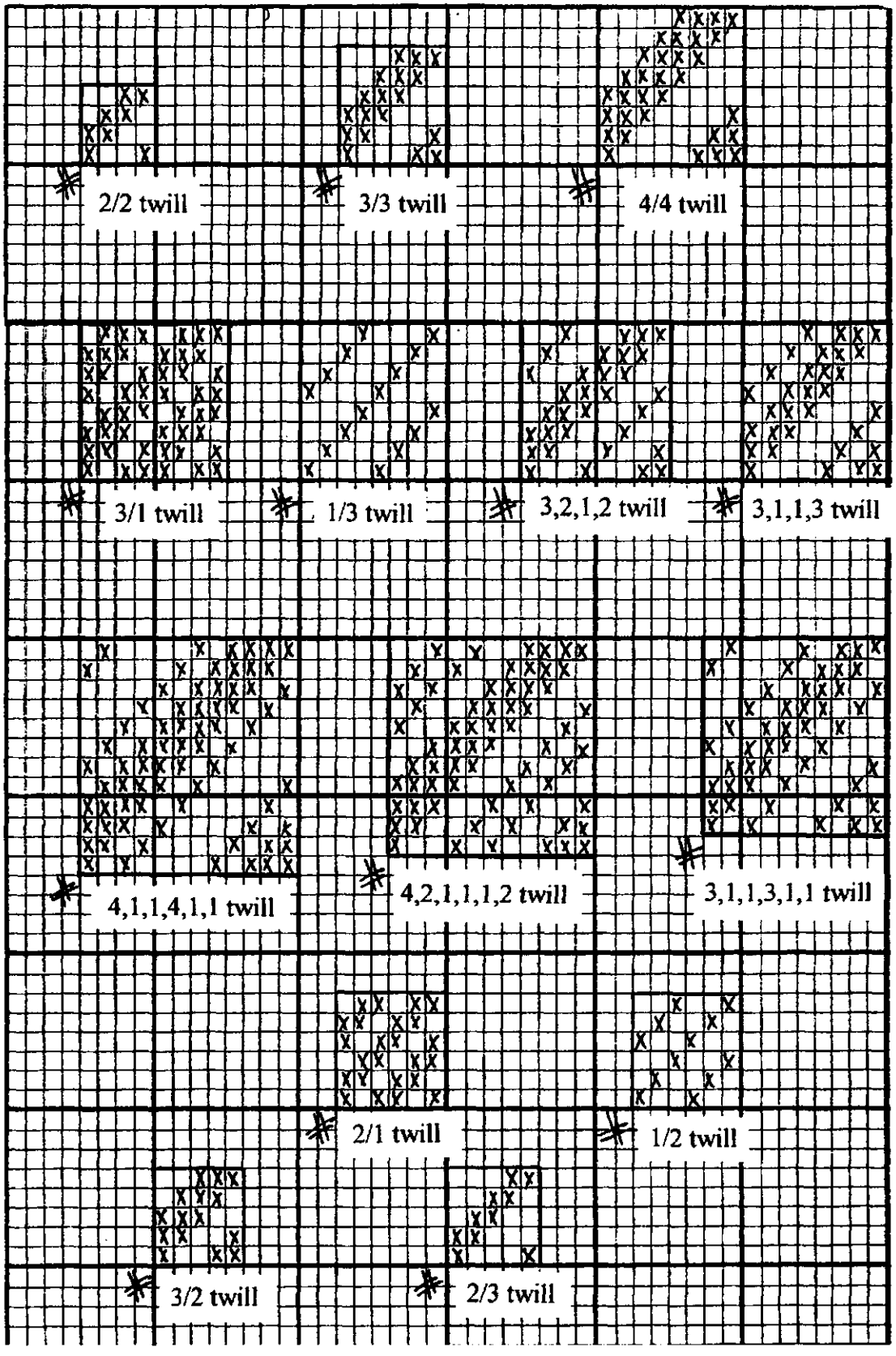

3.5 Common twill as represented on point paper

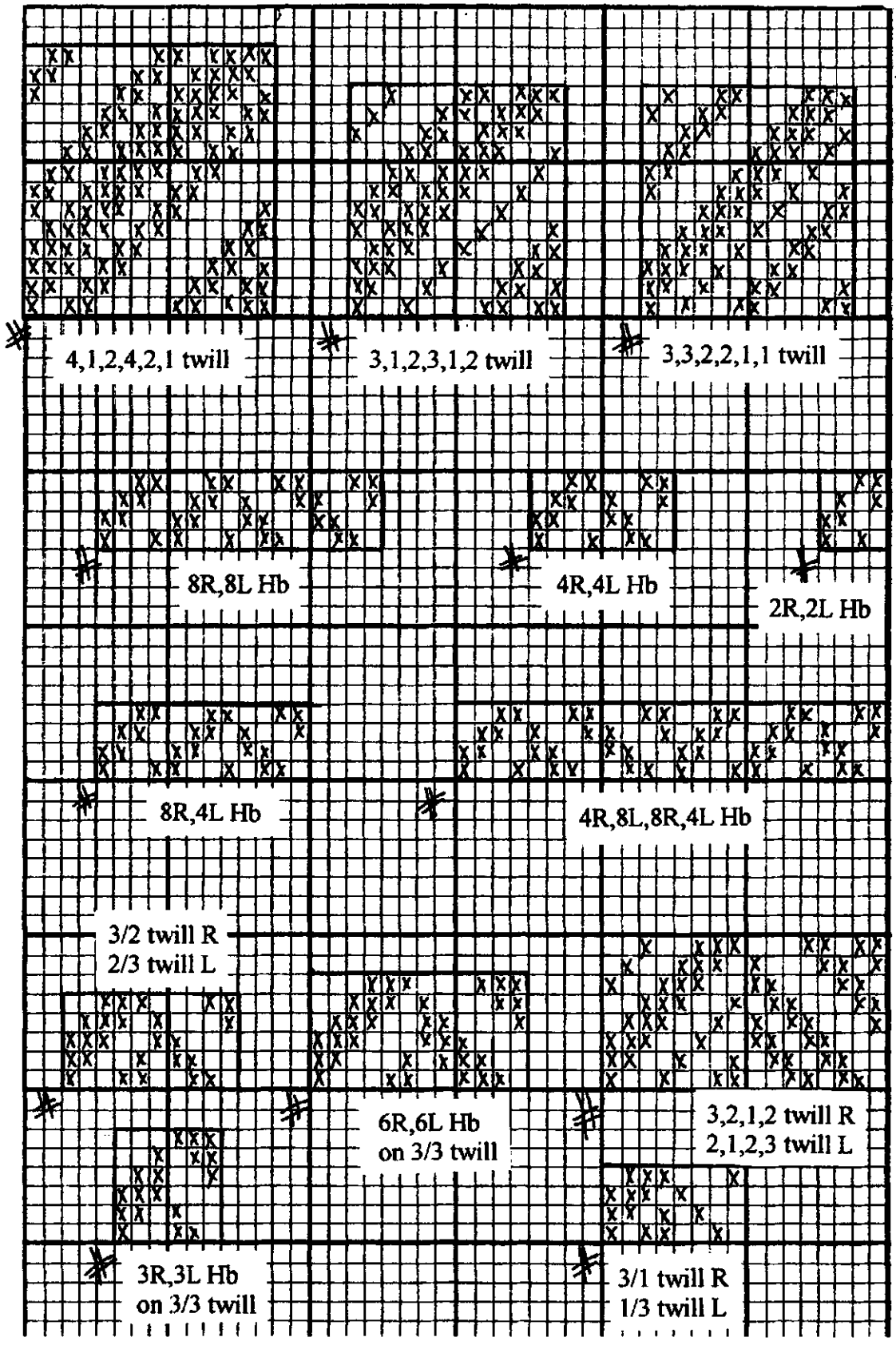
Twill weaves take the form of diagonal lines running upwards from left to right at an angle of 45° as shown in figure 3.5 above. The most frequently used twill is common or 2/2 twill where each thread (warp and weft) interlaces 2 up, 2 down. The larger twill weaves, like the larger hopsack weaves, produce fabrics with more lustre, smoother handle and greater substance. Twills can run to the right, left, or right *and* left as in a herringbone or chevron effect.

The floats of twill weaves can be arranged to show a preponderance of warp or weft to the face of the cloth, for example, 3/2 or 2/3 twills. To obtain broad twill effects without sacrificing firmness of interlacings, the floats can be variable in length within the weave repeat, for example, 3 up, 2 down, 1 up, 2 down twill.

In constructing double, treble and other multiple twills consideration has to be given to the breadth of effect wanted. Also whether it is preferable to show more warp or weft to the face and whether the ultimate effect is worthy of the dimensions.

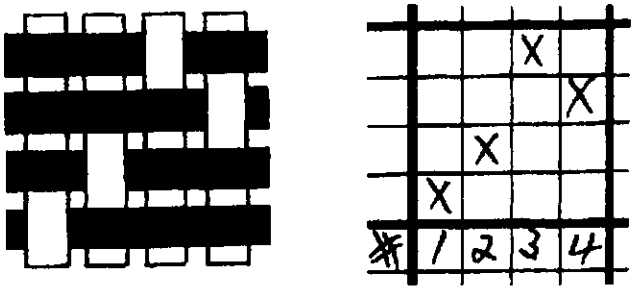
Examples of these and other twill weaves are shown in the following figures 3.6 and 3.7.


2/2 twill
3/3 twill
4/4 twill
3/1 twill
1/3 twill
3,2,1,2 twill
3,1,1,3 twill
4,1,1,4,1,1 twill
4,2,1,1,1,2 twill
3,1,1,3,1,1 twill
2/1 twill
1/2 twill
3/2 twill
2/3 twill




3.7 Twill weaves (continued)

Sateen weaves




3.8 A sateen weave as represented on point paper

Sateen weaves are amongst the oldest weaves known. Their main feature is the single interlacing on every end and pick, distributed in such a way that they are all more or less completely hidden. The result is an almost unbroken warp surface in the case of warp sateens and an almost unbroken weft surface in weft sateens. Sateen weaves may be regular or irregular – in the former sateen number and move number have no greater common factor than unity. In irregular sateens however, the move is broken at least twice in the repeat and marks may be distributed in any way that permits one mark on each warp end and weft pick as in figure 3.8.

Figure 3.9 shows examples of sateen weaves and derivatives that feature steep twills of warp as well as flat twills of weft.

Secondary weaves

A selection of weaves suitable for womenswear and menswear fabrics are shown in figures 3.10 and 3.11. They belong to no particular category but are featured as practical weaves which might be used from time to time.

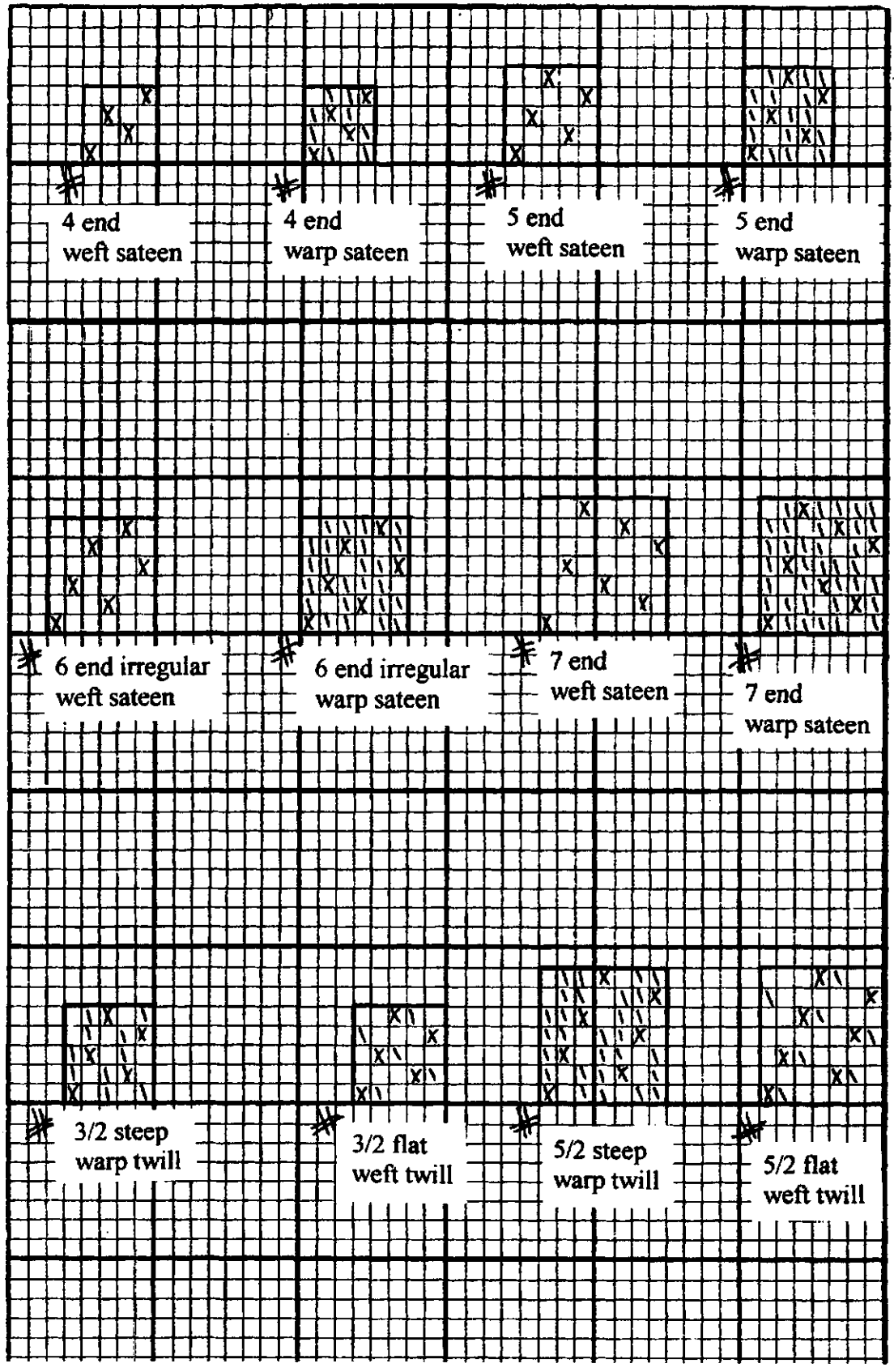
Basket weaves (or entwining twills)

Figure 3.12 gives examples of weaves constructed with standard interlacings in the warp where every alternate end in each of the six designs interlaces 2 up, 2 down. All the designs can be woven on one warp with the same ten shaft draft.

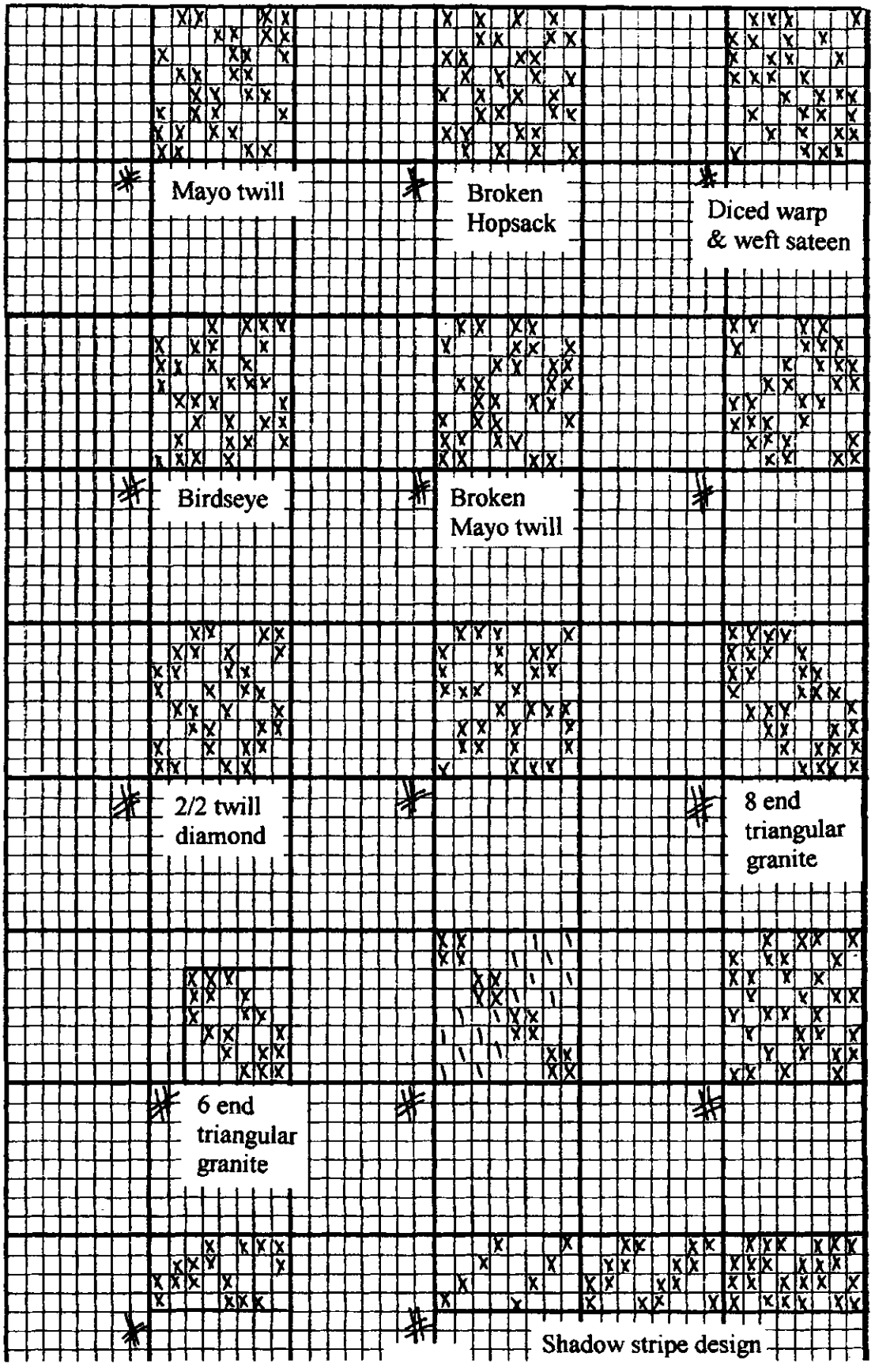
Whipcords

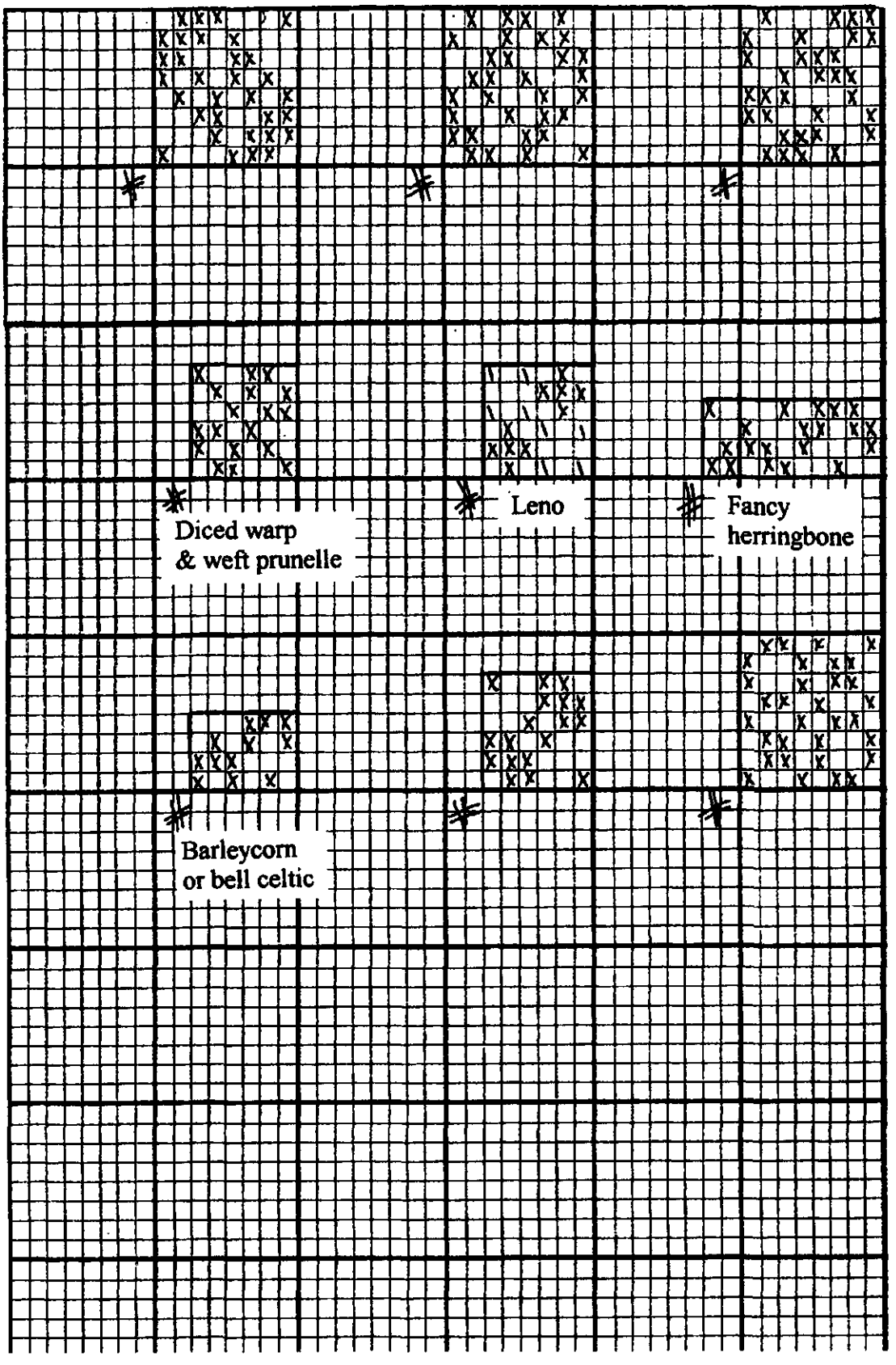
Steep twill effects can be made either by using weaves with long warp floats, each end in the design stepping two or more, or by using a simple twill weave and oversetting the number of warp ends in relation to the number of weft picks. Such cloths show steep, bold twills of warp and are called whipcords.

The 11-end Indian whipcord weave is used for riding fabrics in woollens and worsteds as well as in looser sett fabrics for womenswear coatings. They can also be constructed in simple twill weaves with oversett warp ends. See figure 3.13 for various examples.

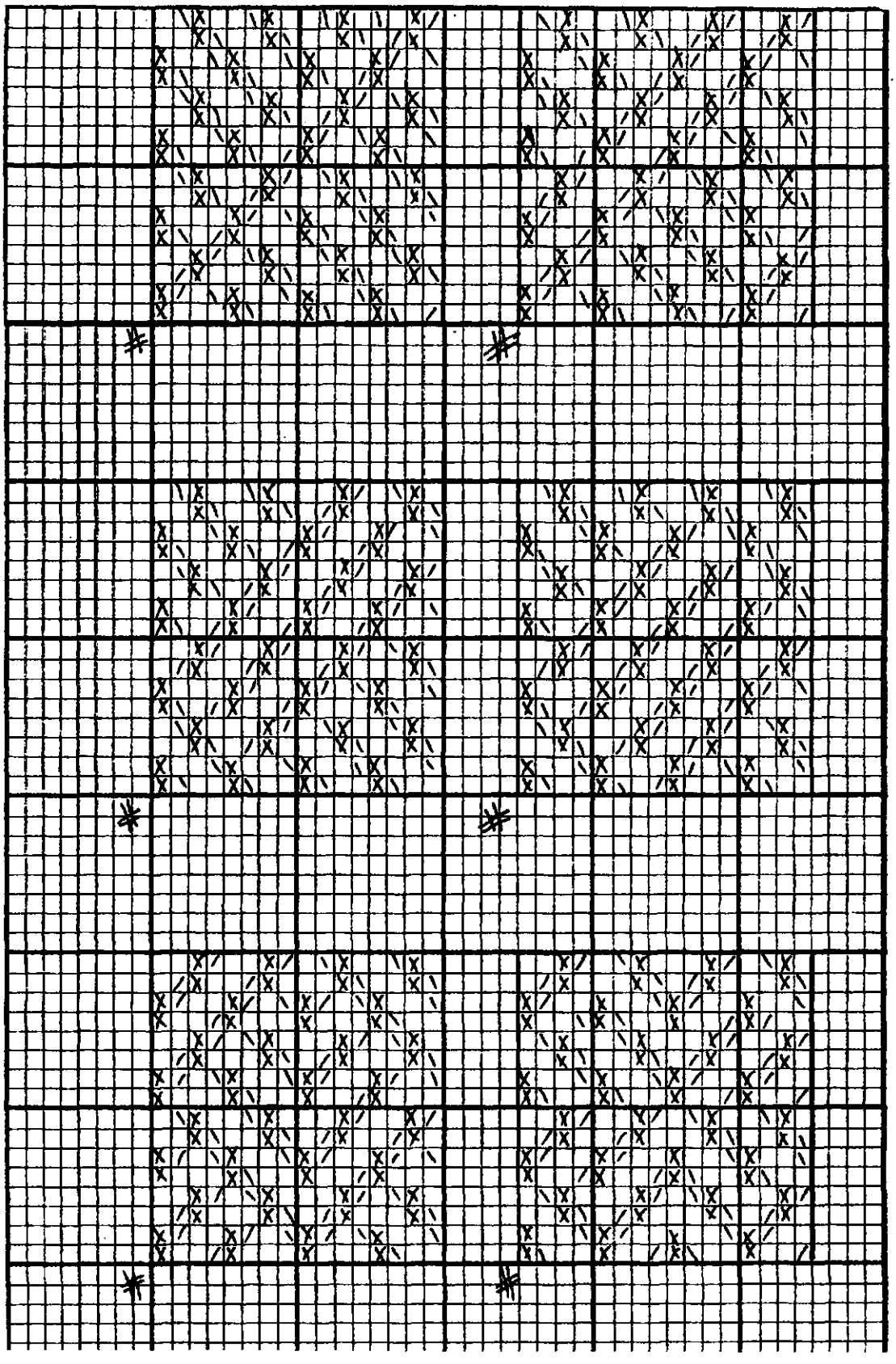



3.9 Sateen weaves

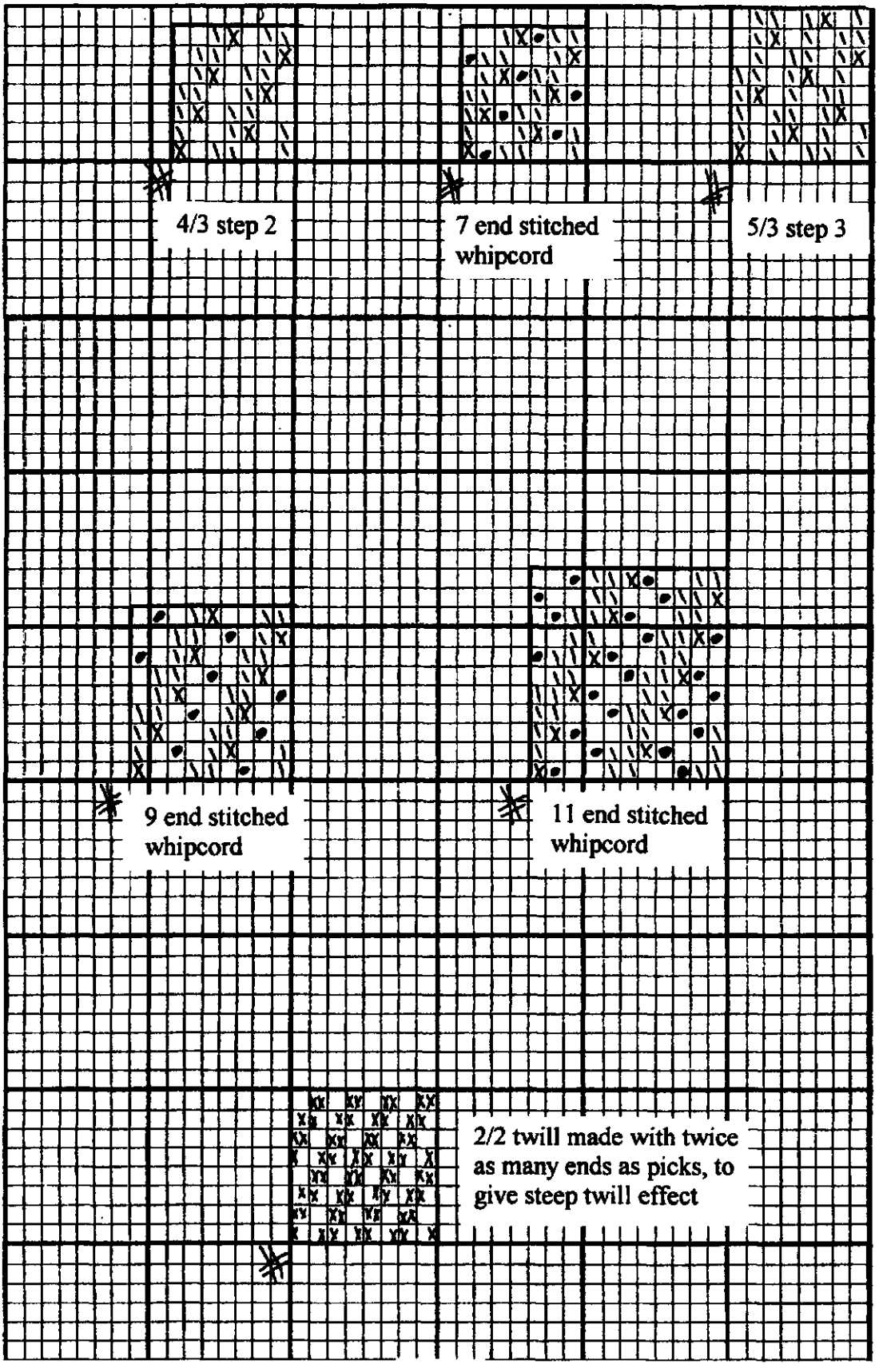

Mayo twill
Broken Hopsack
Diced warp & weft sateen
Birdseye
Broken Mayo twill
2/2 twill diamond
8 end triangular granite
6 end triangular granite
Shadow stripe design




3.11 Secondary weaves (continued)



3.12 Basket weaves (or entwining twills)




3.13 Whipcords

## Backed cloths

For greater weight and substance in texture without appreciably changing the fineness of the face appearance, extra warp ends or picks can be woven onto the back of the cloth. In warp backed cloths the principle in stitching is to lift the backing end over a weft pick, where the face warp is uppermost on either side. For example, a stitching mark is placed between two marks of the face weave. The backing warp ends 'hang' on the back of the woven cloth but must be tacked to the face as described in a regular order.

Distribution of stitching is very important and frequency must be adequate. Good binding and distribution should be free of any irregularity or inequality that could give rise to a surface defect such as double twill or cross twill. The backing ends may be introduced with face ends in a ratio of 1 face, 1 back, or 2 face, 1 back etc. Stitches or ties can be distributed in twill order if the face weave is twill, sateen order if the face weave is sateen or a sateen derivative. Plain or alternate order and irregular distribution are used if no regular order is possible. See figure 3.14 for examples.

## Extra warp figuring

Extra warp ends can be arranged to form decorative spots on the face of a fabric with a single float at a time, or a group of floats to form a larger and more prominent spot. When the extra warp ends are not required for figuring they lie on the back of the cloth where they are suitably tacked. Spots can be distributed in plain, twill or sateen order as the design permits.

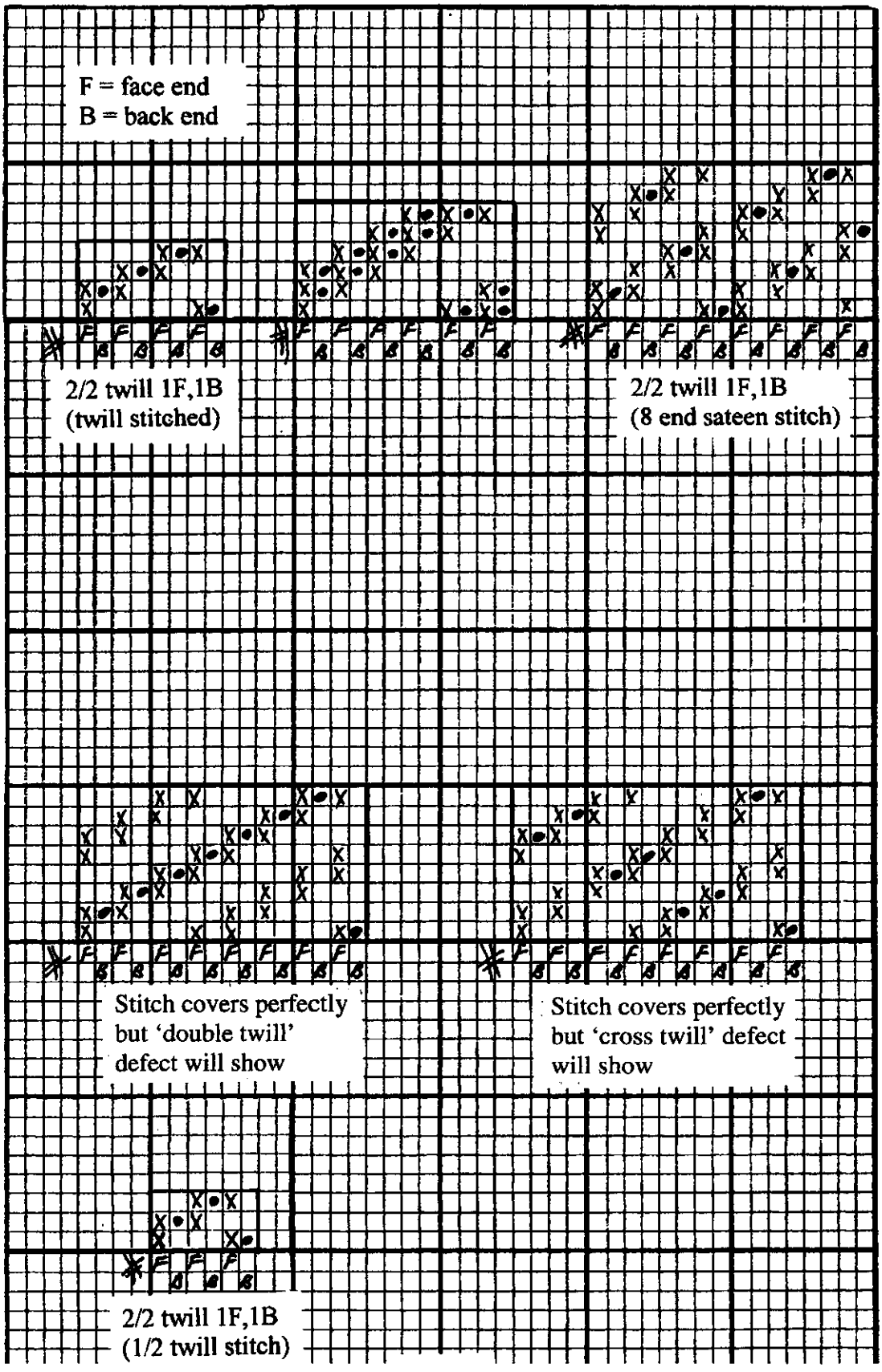
Further variations can be made by using different colours for different spots, or by having two or more colours introduced to a group of spots. Effect yarns show to greater advantage when they are more lustrous than the yarns used in the base fabric. With extra ends in the warp, additional shafts are required for weaving and tension must be carefully controlled, otherwise figuring ends may work slack. A second warp beam might even be necessary. Figure 3.15 gives examples of extra warp figuring.

## Double plains

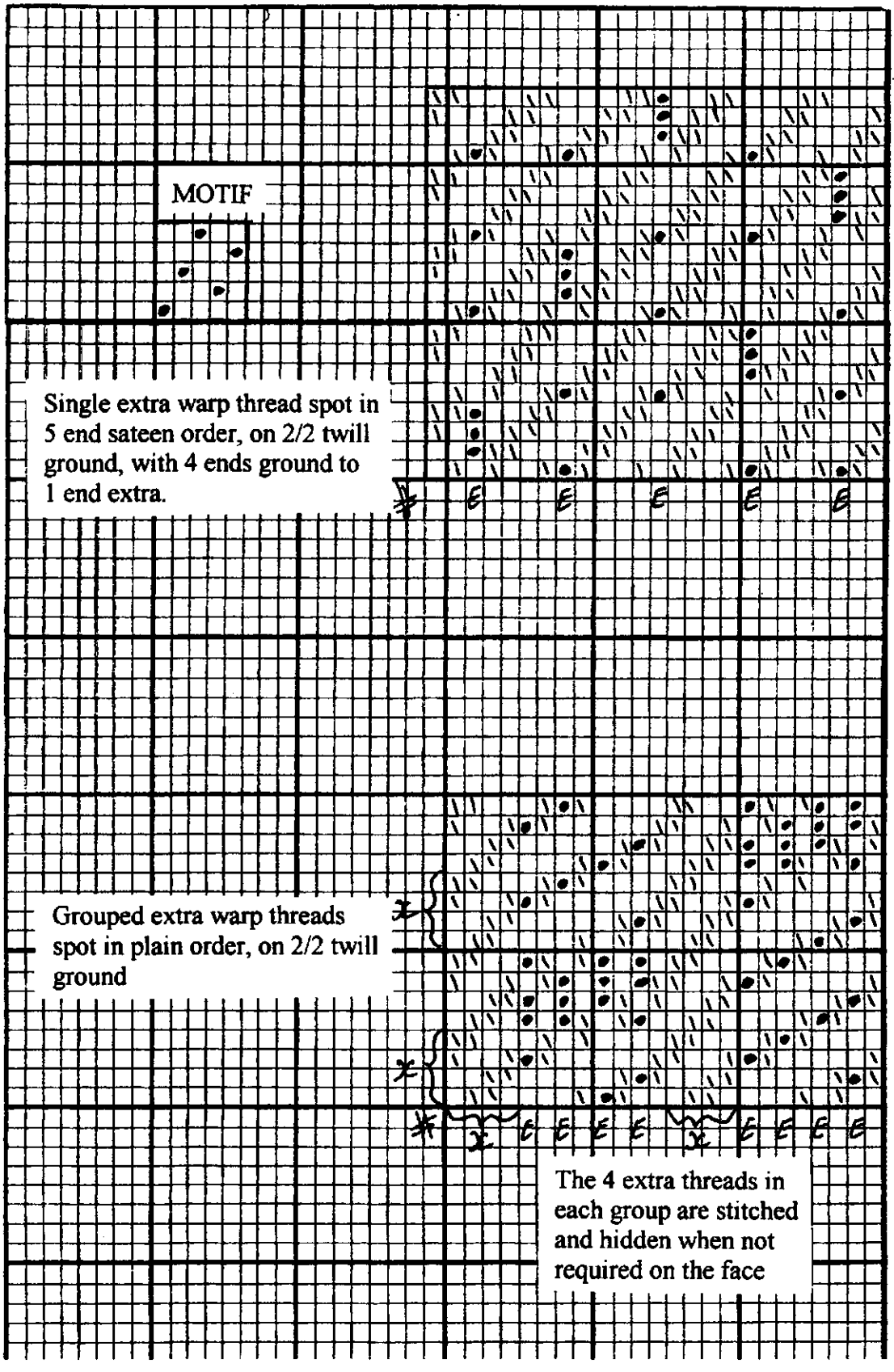
These are double cloths with plain weave for face and plain weave for back, interchanging for effect and texture. They are used for both womenswear and menswear fabrics. Interesting figured effects can be developed with unbroken and varied sections of colour, which are particularly attractive in womenswear designs and colours. The principles for constructing double plain weaves are described in figure 3.16. Self-stitching takes place in warp or weft.

Figure 3.17 shows weaves forming unbroken geometric shapes in two or more solid colours, where warp and weft interchanging makes self-stitching unnecessary. If the unbroken sections of colour are too large then self-stitching becomes necessary otherwise face and back weaves might be partially separated.

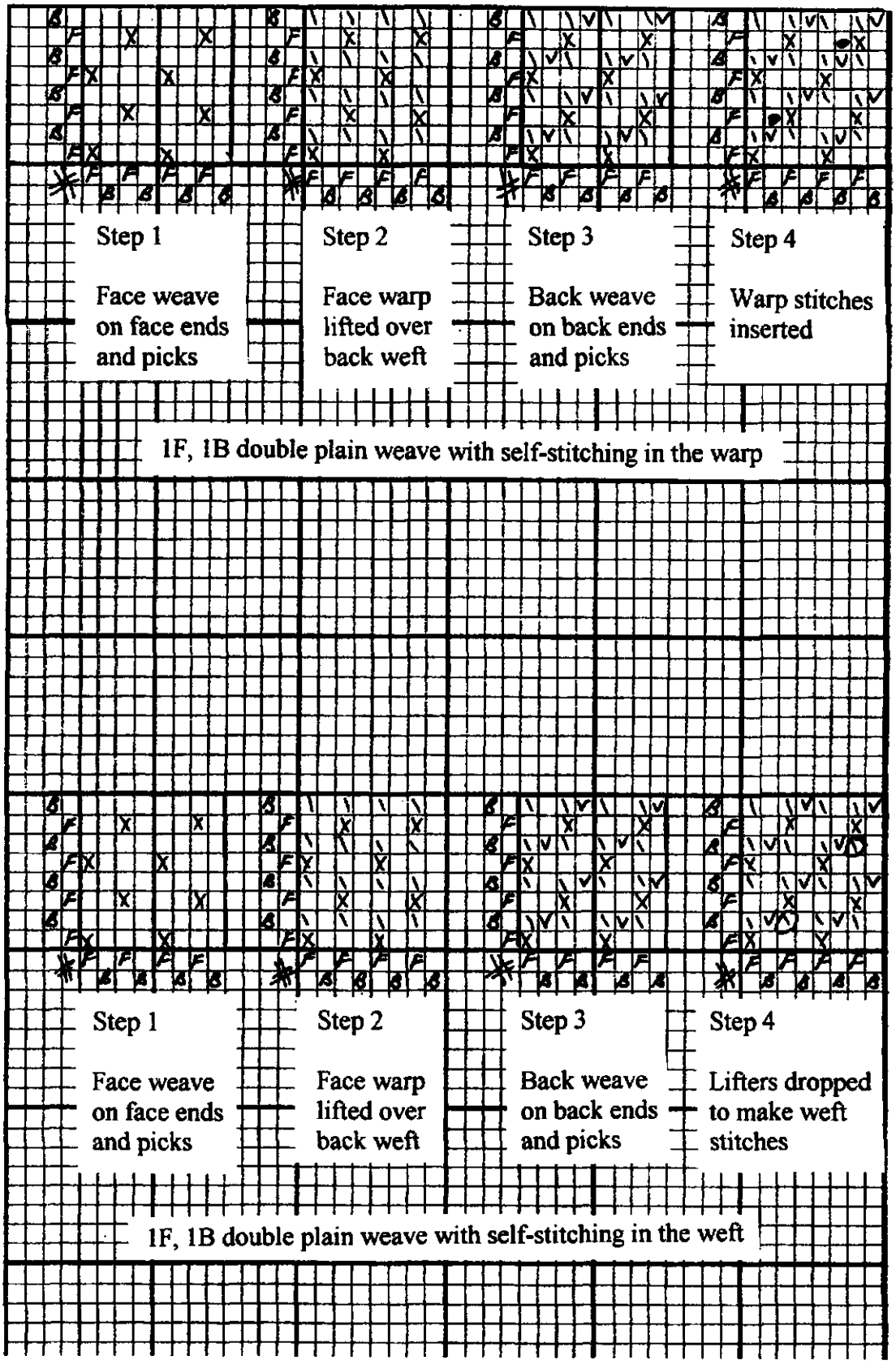
In figures 3.18 and 3.19, four different motifs can be reproduced by using double plain structures coloured 1 thread of light, 1 thread of dark, warp and weft. The sections can be increased in size warpways and/or weftways, but not too much otherwise partial separation might take place. All four designs can be woven from the same warp, using the same 16 shaft straight-over draft, with four different peg plans.



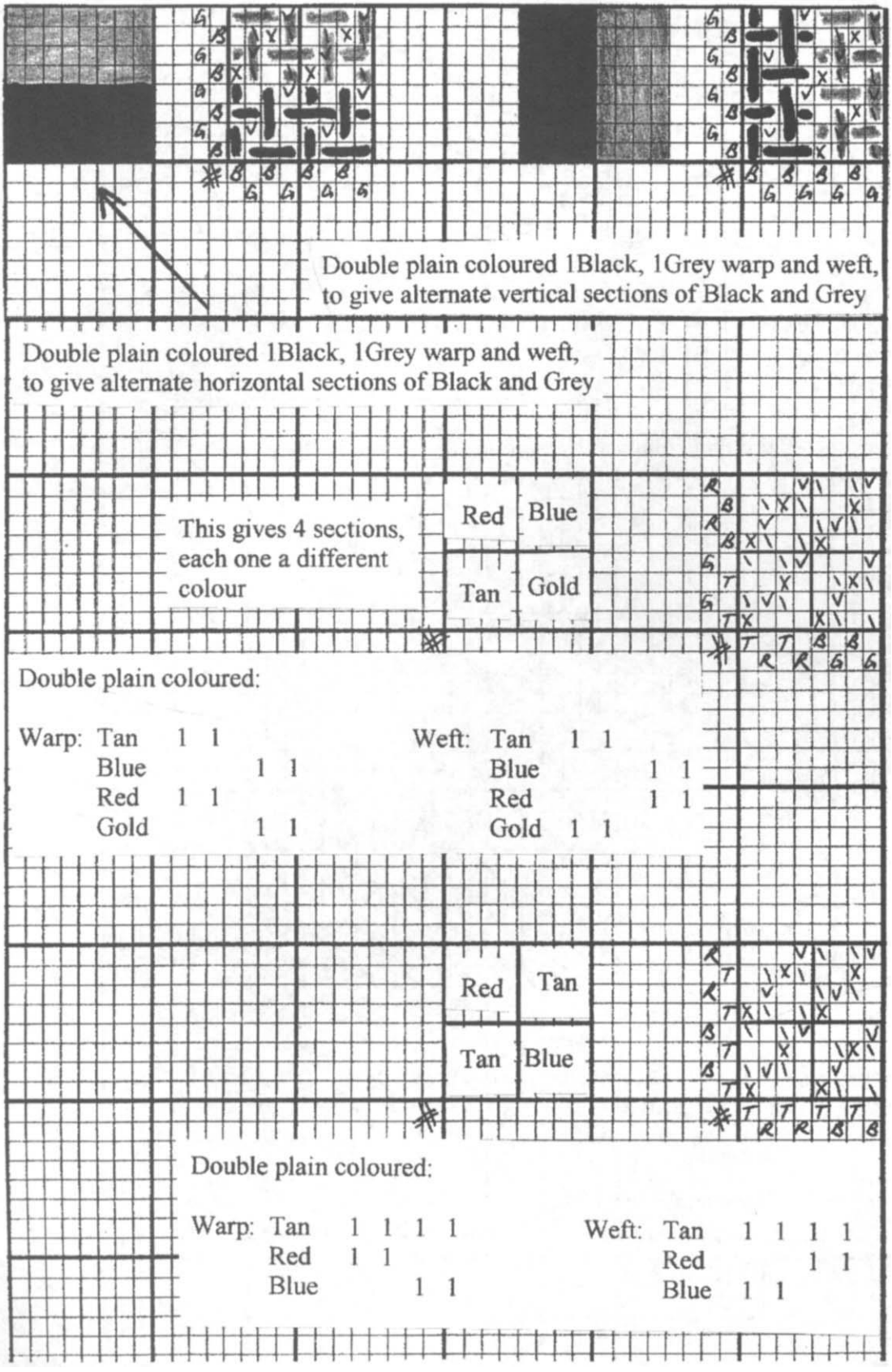

3.14 Backed cloths



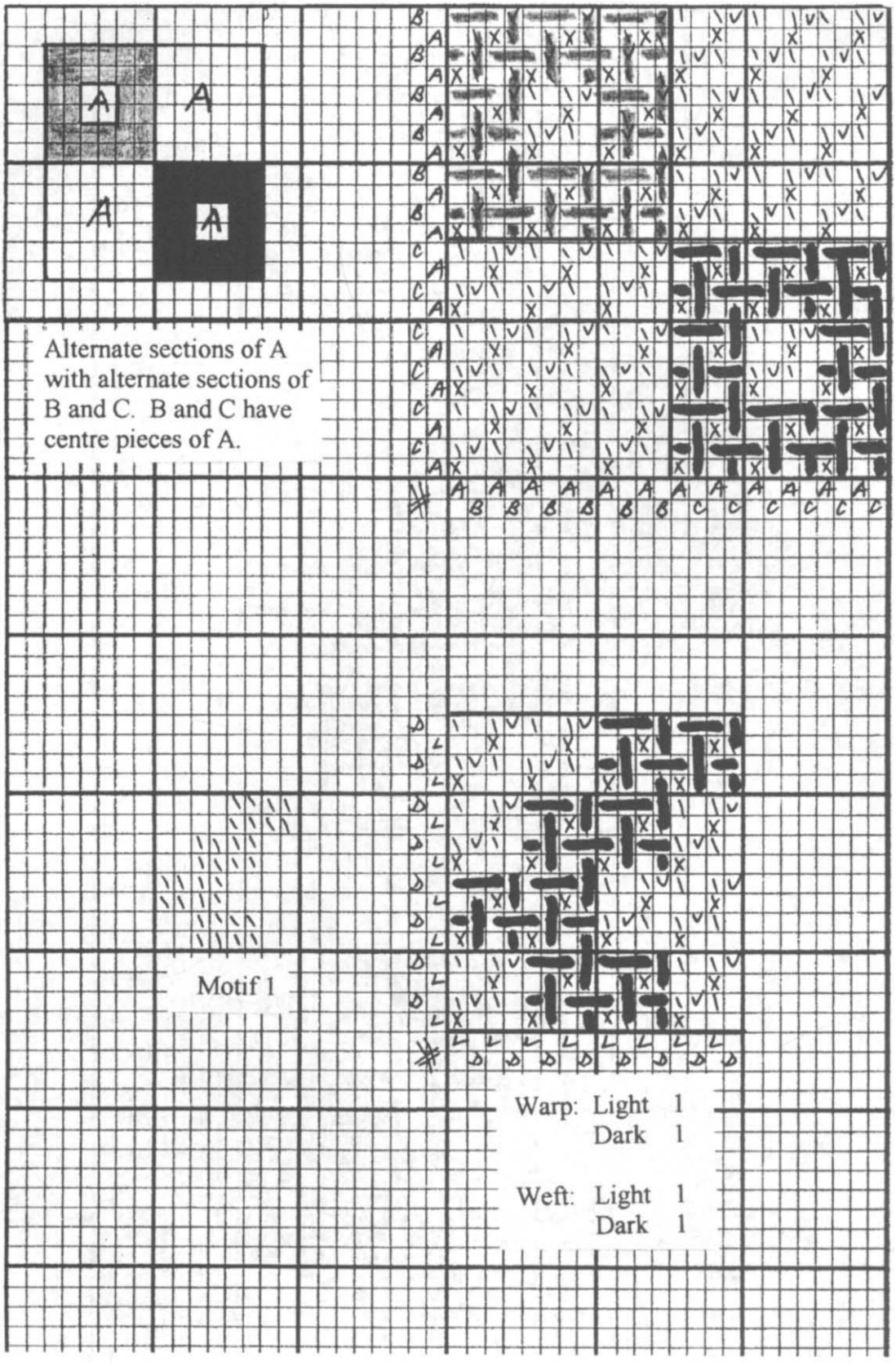

3.15 Extra warp figuring



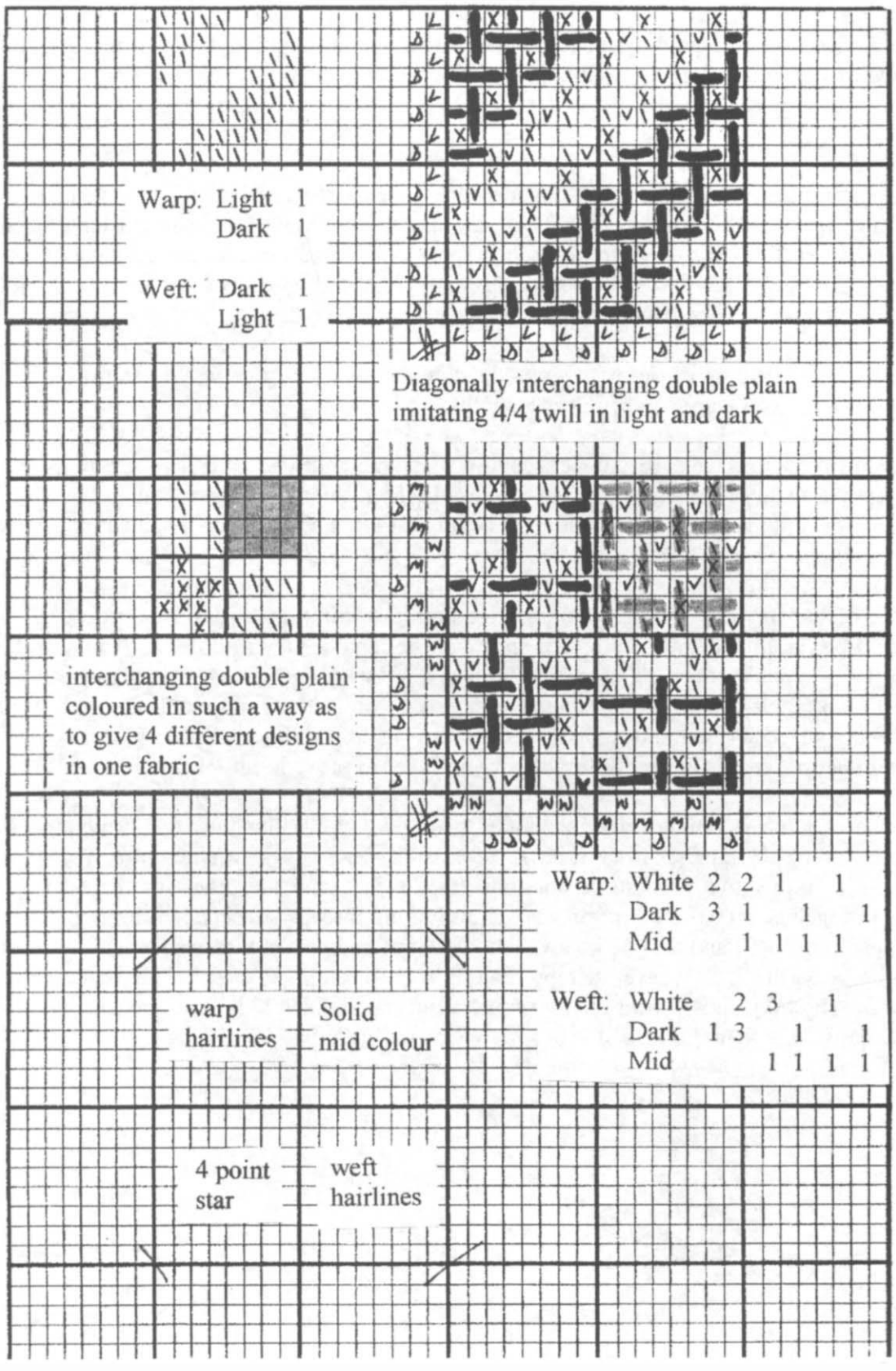

3.16 Double plains




3.17 Double plains (continued)




3.18 Double plains (continued)




3.19 Double plains (continued)

Figure 3.20 shows a diagonally interchanging double plain imitating 4/4 twill in light and dark, as well as an interchanging double plain coloured in such a way as to give 4 different designs in one fabric – warp hairlines, weft hairlines, solid colour section and 4-point star effect.

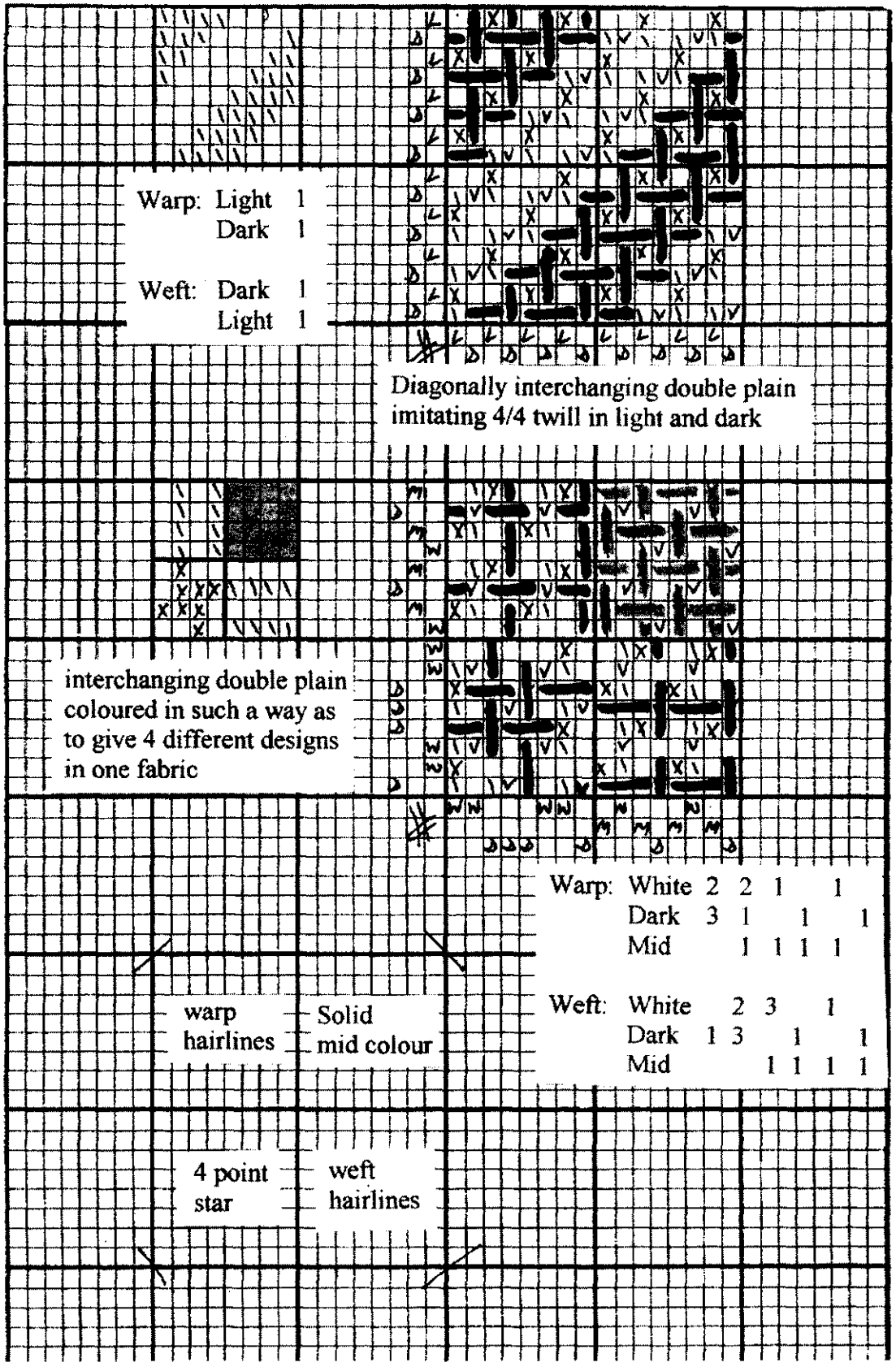
The foregoing pages of this section cover the basic weaves with which the woven fabric designer must quickly become familiar. There are many other weaves that might have been included in this section, but they are generally more complex and seldom used. Today there are surprisingly few weaves used and by far the greatest number of womenswear and menswear woven fabrics are constructed in plain weave or 2/2 twill.

However no publication of this type would be complete without touching on crammed line stripe designs and extra warp stitched double cloths.

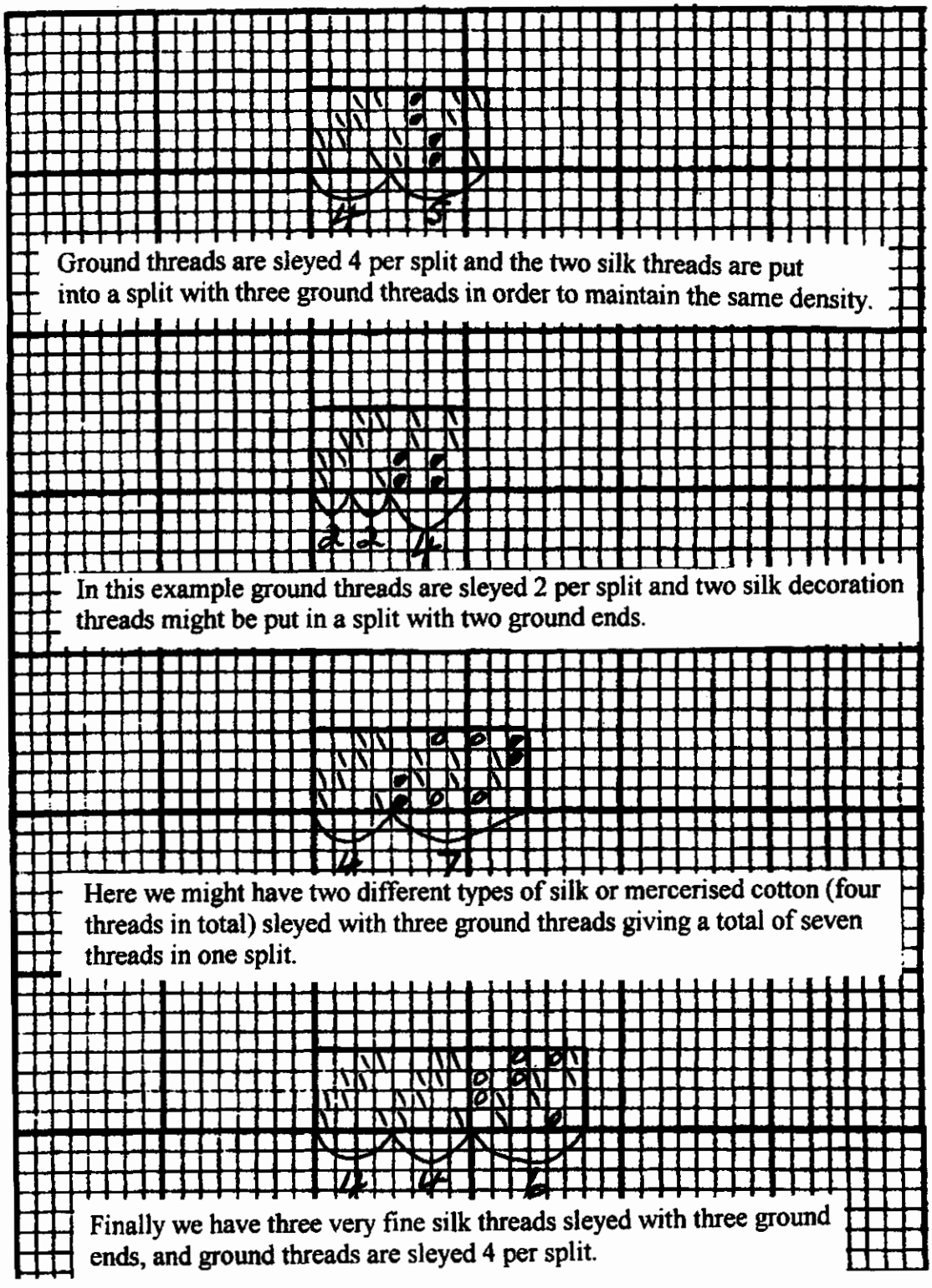
Crammed line stripes were very popular many years ago and who is to say they might not become popular again one day. As is often the case in the fashion world something that is old can suddenly become very 'new' to another generation. Figure 3.21 gives some examples and explanations in anticipation.

Because of the fineness of silk or mercerised cotton decoration yarns in a stripe design, they have to be 'crammed' into a split (or splits) in the reed or sley in order to maintain the same density in every split across the warp. If this is not done properly two fine silk threads in a split with two much thicker ground threads in splits before and after it would create a 'thin space' at every stripe across the warp. This has to be avoided and the examples will show how the total number of threads in each split will vary in order to prevent thin places.

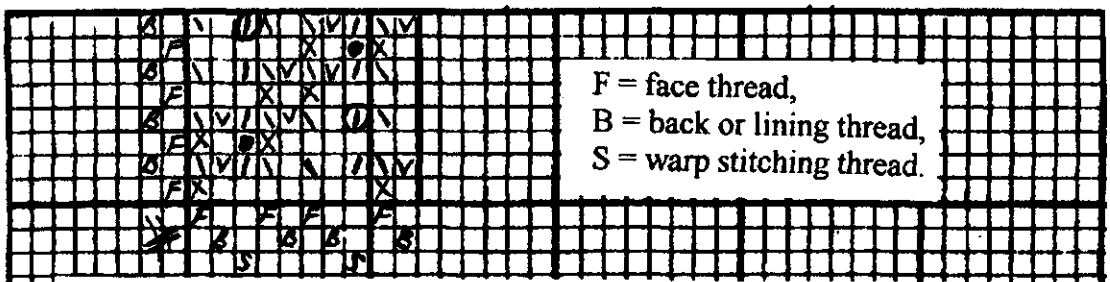
Extra warp stitched double cloth examples in figure 3.22 illustrate the principles in successfully hiding the stitches to both back and face surfaces of the double cloth. This type of structure is simply two separate cloths, one for the face and the other for the back (or lining), held together by extra warp threads. The stitching threads lie between the two cloths but are alternately lifted and dropped between two warp floats of the face weave and between two weft floats on the back weave, thereby pinning the two cloths together. This ensures that no sign of the stitching ends appear on either surface of the double cloth. As the back or lining fabric is usually finer than the face, it is normally woven 'back up'.




3.20 Double plains (continued)

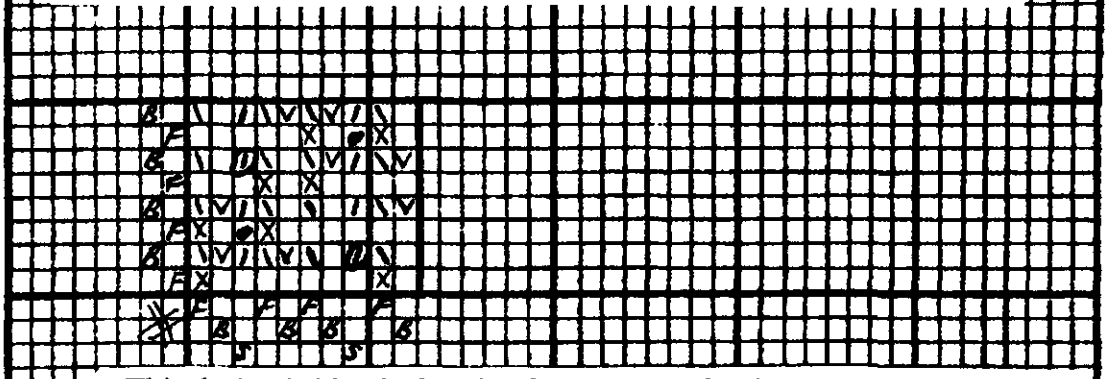



3.21 Crammed line stripes

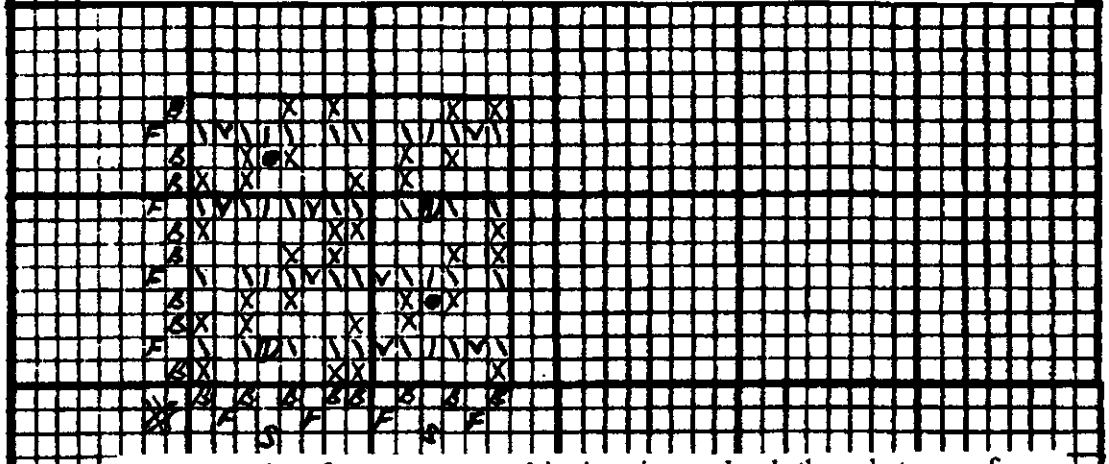


F = face thread,
B = back or lining thread,
S = warp stitching thread.

Design shows 2/2 twill right on face and 2/2 twill left on back when turned over. Stitching ends are lifted alternately between two marks of the face weave, then dropped between two blanks of the back weave (which are actually marks when the cloth is turned over). This ensures perfect cover for stitches on both sides of the fabric.



This design is identical to the above except that it shows 2/2 twill right on the back as well when it is turned over, thereby showing 2/2 twill right face and back



Warp and weft arrangement this time is two back threads to one face thread. Because the fabric on the back is finer than that of the face, it is normal to weave the structure 'back up' as in this example.

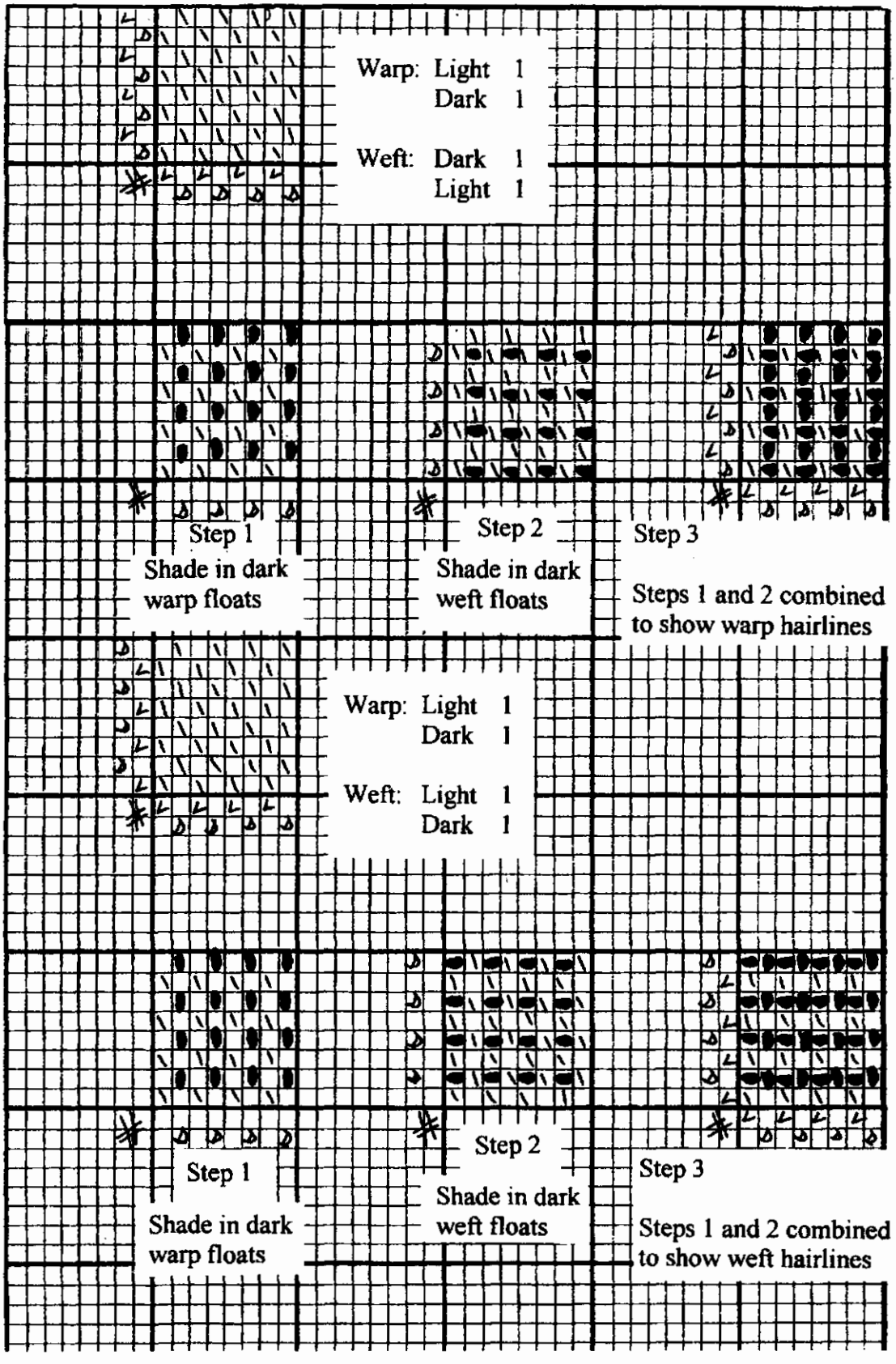
3.22 Extra warp stitched double cloths

### 3.4 Simple warp and weft colour effects

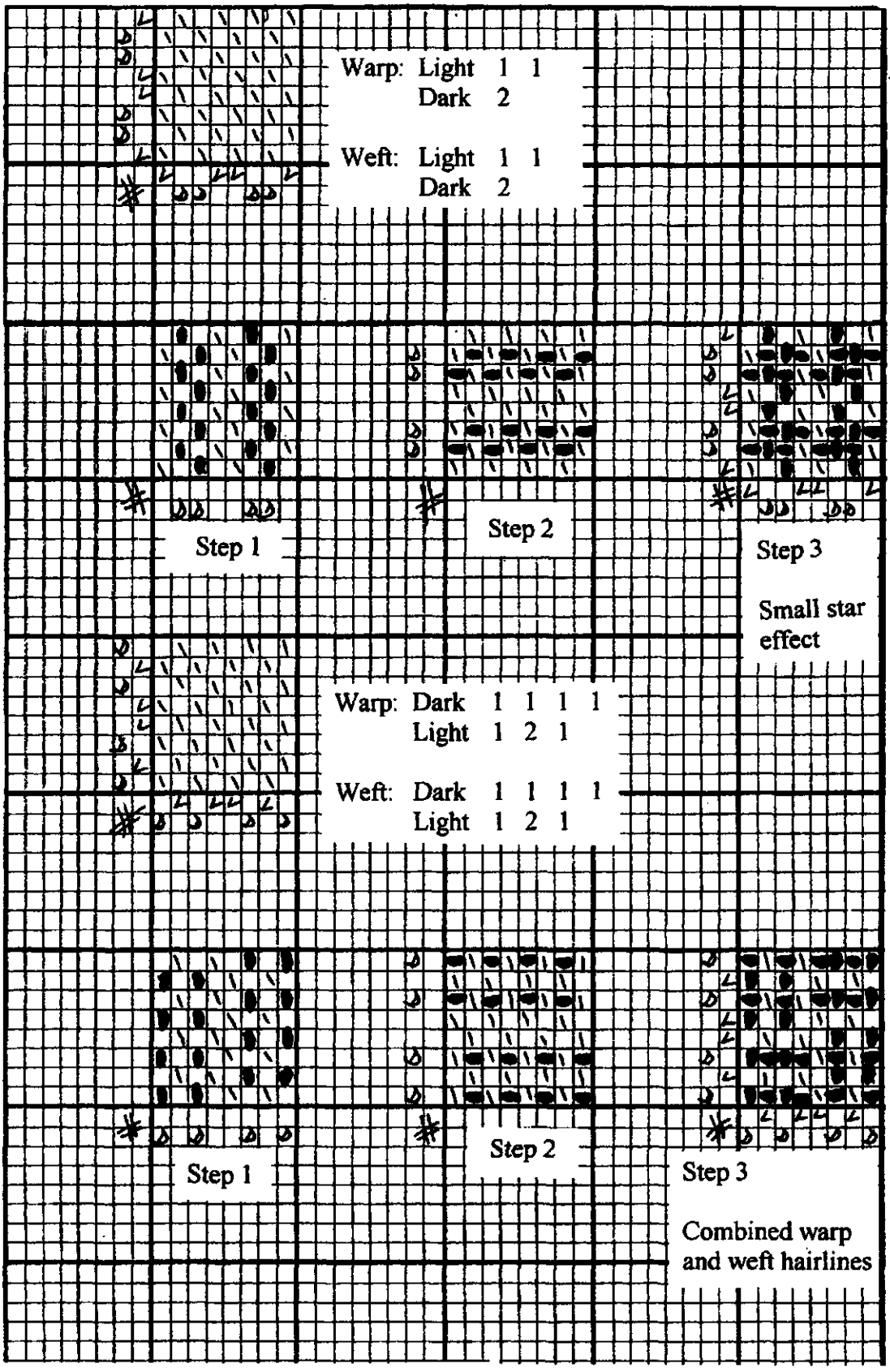
Colour can be added at any one of the following stages in woven fabric manufacture:

- By loose fibre dyeing, prior to carding and spinning processes
- By top dyeing the white sliver from which the worsted yarn will be spun
- By yarn package dyeing white or ecru woollen or worsted yarns
- By piece dyeing white or ecru woollen or worsted woven fabric
- By the arrangement of different coloured warp and weft yarns during weaving.

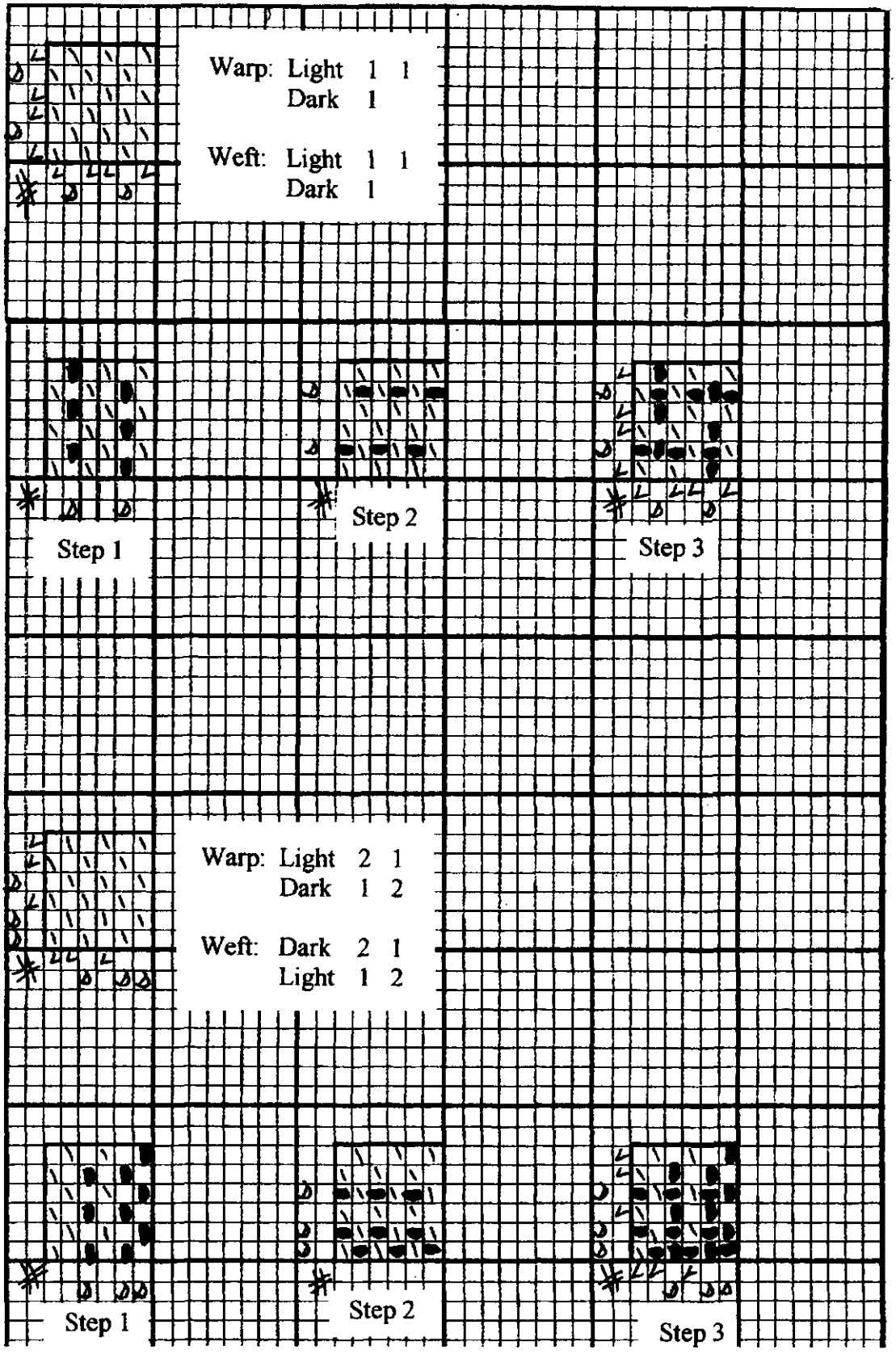
This chapter deals with the latter method and figures 3.23 to 3.29 inclusive give step by step guides on how to colour up basic, standard weave effects.



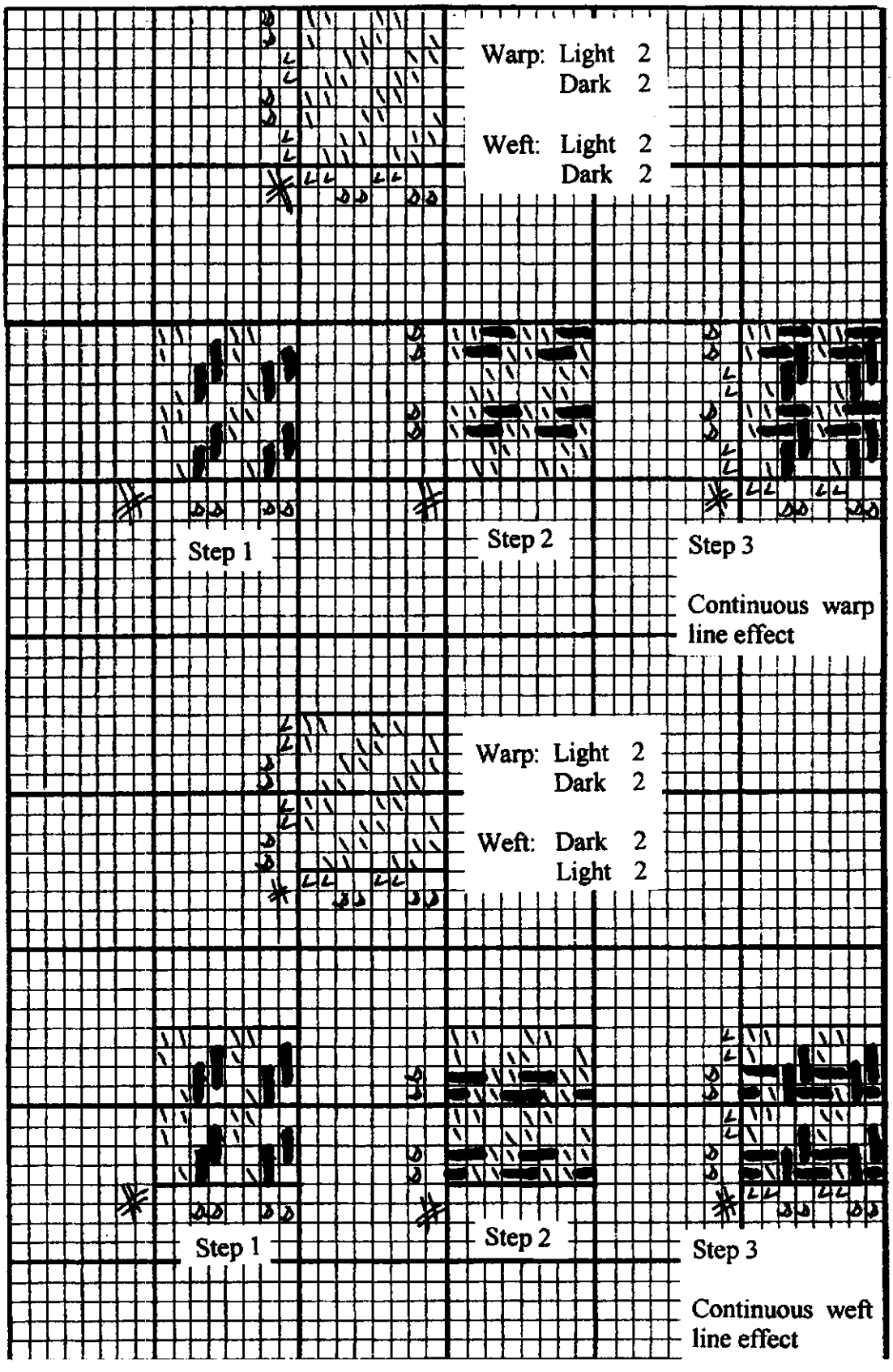

3.23 Plain weave colouring arrangements



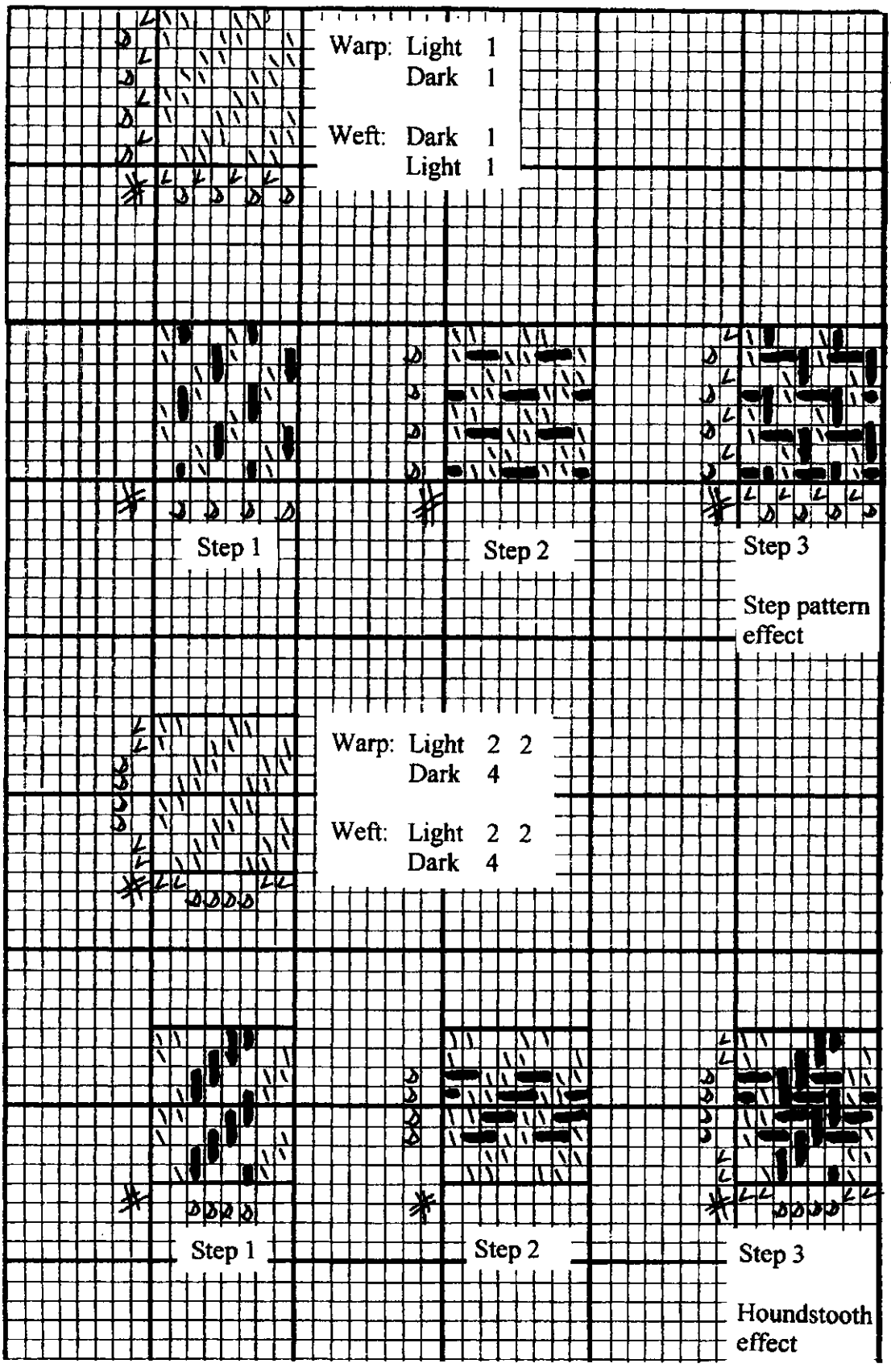

3.24 Plain weave colouring arrangements (continued)



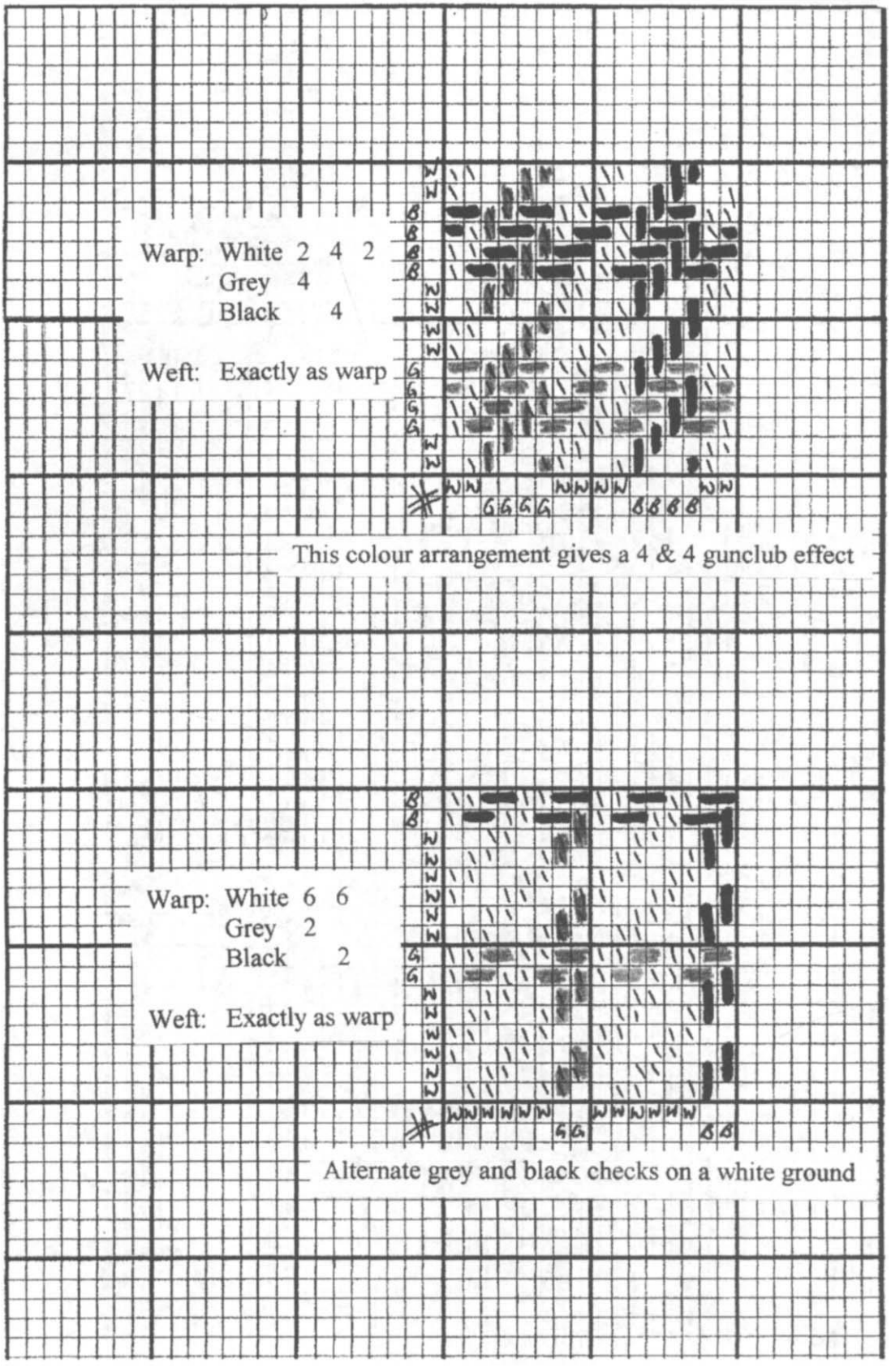

3.25 Plain weave colouring arrangements (continued)



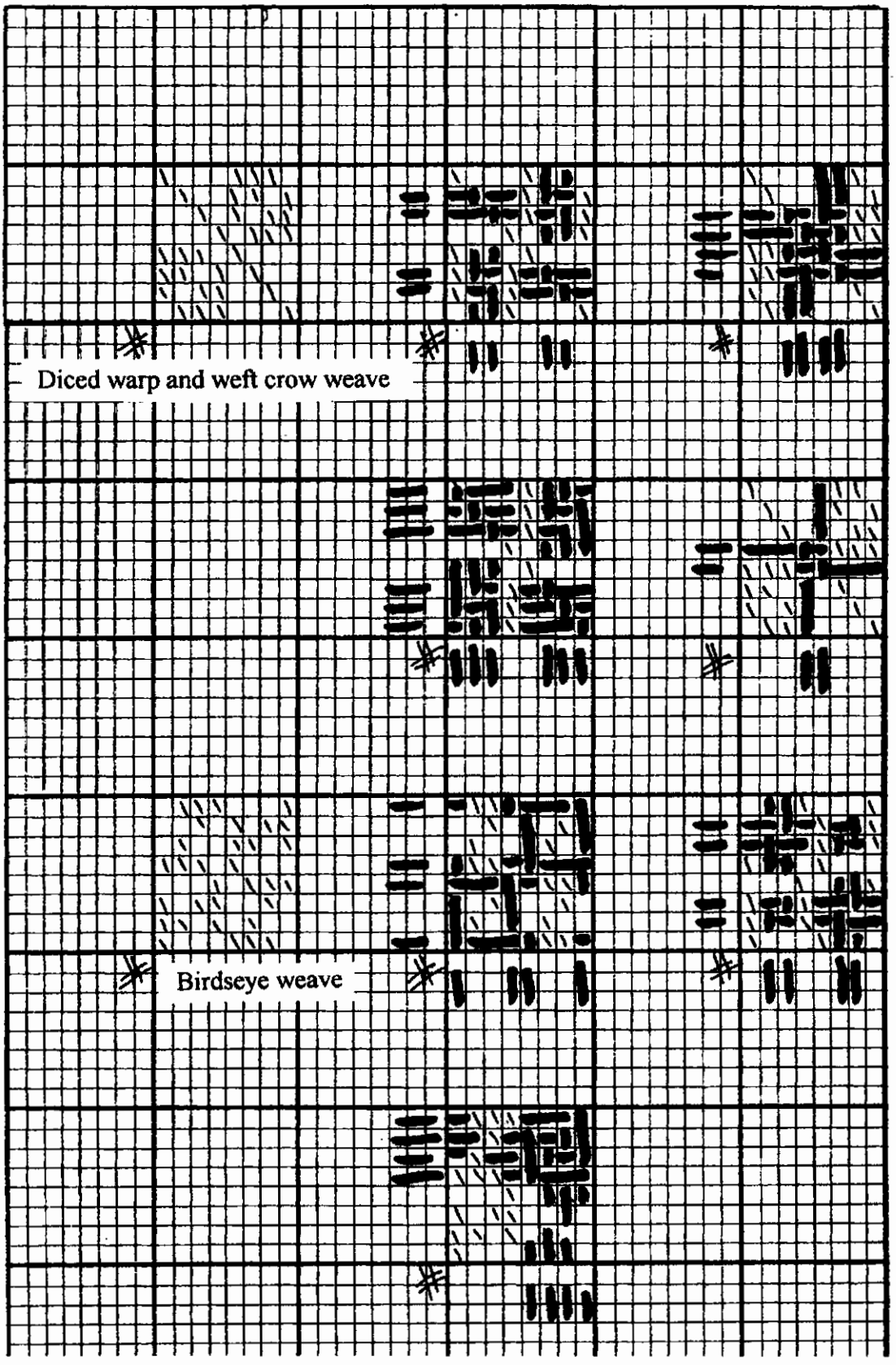

3.26 2/2 twill colouring arrangements




3.27 2/2 twill colouring arrangements (continued)




3.28 2/2 twill colouring arrangements (continued)




3.29 Colouring arrangements for other weaves

### 3.5 Drafting and pegging (English system)

The weaving operation consists of three primary motions described as follows:

**Shedding:** The separation of warp ends into upper and lower layers to form a 'shed' or tunnel through which the individual weft pick is projected. The 'shed' changes after the insertion of each pick.

**Picking:** The insertion of each pick through the 'shed' or tunnel.

**Beating up:** The movement of the sley in forcing the newly inserted pick up into the already woven cloth.

Picking and beating up actions are fixed – regardless of the weave used, but the shedding motion is variable. The lifting or lowering of the warp ends is done by shafts (or healds) that carry a number of wire eyes through which every individual warp end is drawn, in a pre-arranged order. The process of putting warp ends through the wire eyes is known as drawing.

In Drafting and pegging, three separate questions have to be addressed:

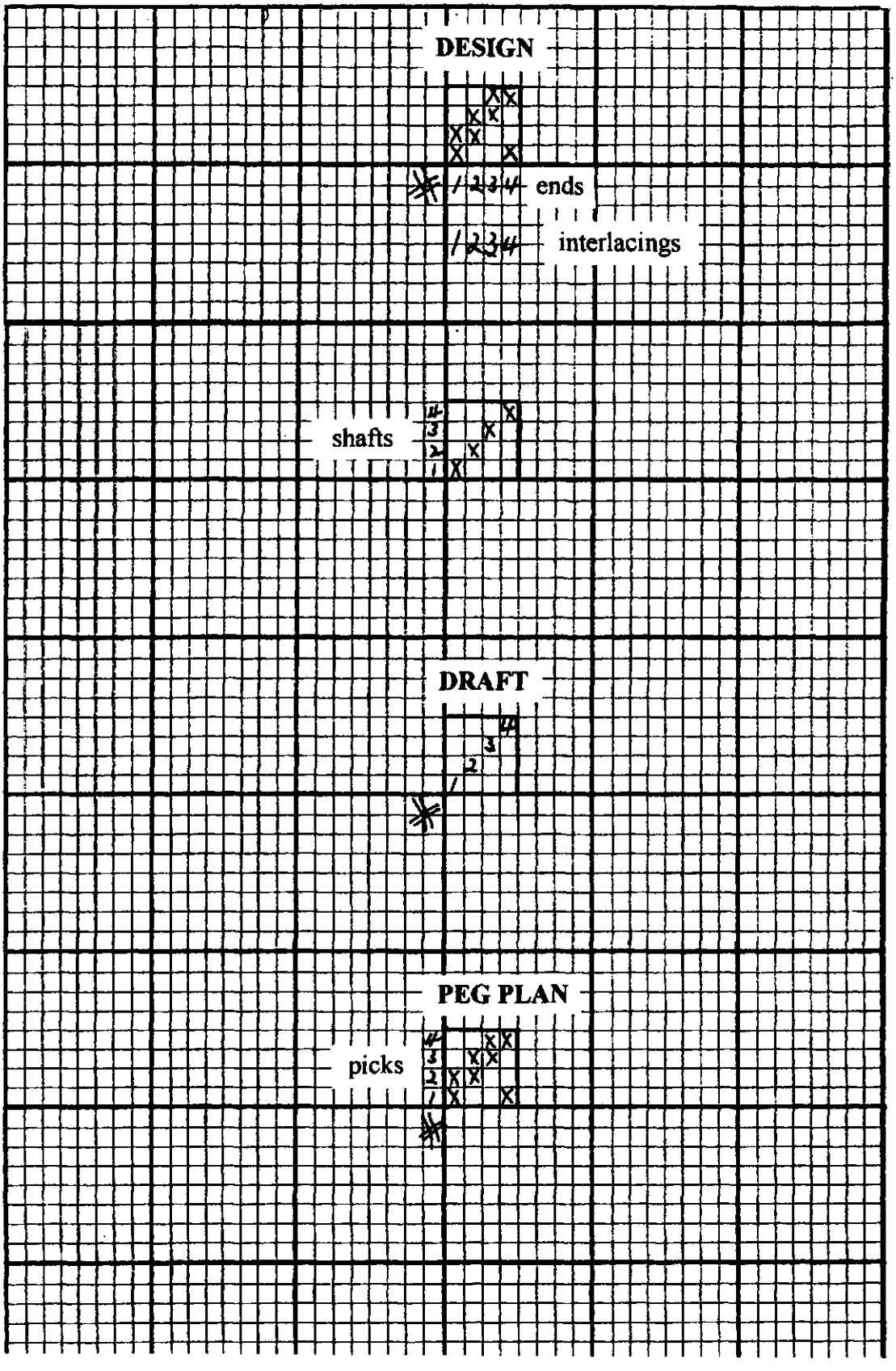
1. How many shafts are required in the loom to reproduce a particular weave?

2. How is the sequence of drawing each end separately through an eye on a particular shaft arranged, namely, the Draft?

3. How is the peg plan constructed to raise or lower each shaft in sequence during weaving in order to reproduce the required weave?

The shafts are numbered from the front of the loom to the back; therefore, shaft number 1 is nearest to the loom operative. The warp ends run in sequence from extreme left to right, across the complete warp. The total number of shafts required to form a particular weave is the same as the number of different warp end interlacings in one repeat of the weave.

The most elementary example is shown in figure 3.30.




3.30 Elementary example of design, draft and peg plan

In **Design,** starting with the first warp end which is always on the extreme left hand side of the design, the vertical interlacing of each warp end is examined in turn.

End number 1 interlaces 2 up, 2 down

End number 2 interlaces 1 down, 2 up, 1 down *(different to end 1)*

End number 3 interlaces 2 down, 2 up *(different to both ends 1 and 2)*

End number 4 interlaces 1 up, 2 down, 1 up *(different to ends 1, 2 and 3).*

This means that the **draft** requires four shafts (because of the four different interlacings) and gives the following information to the drawer (or healder):

Warp end number 1 has to be drawn through an eye on shaft 1

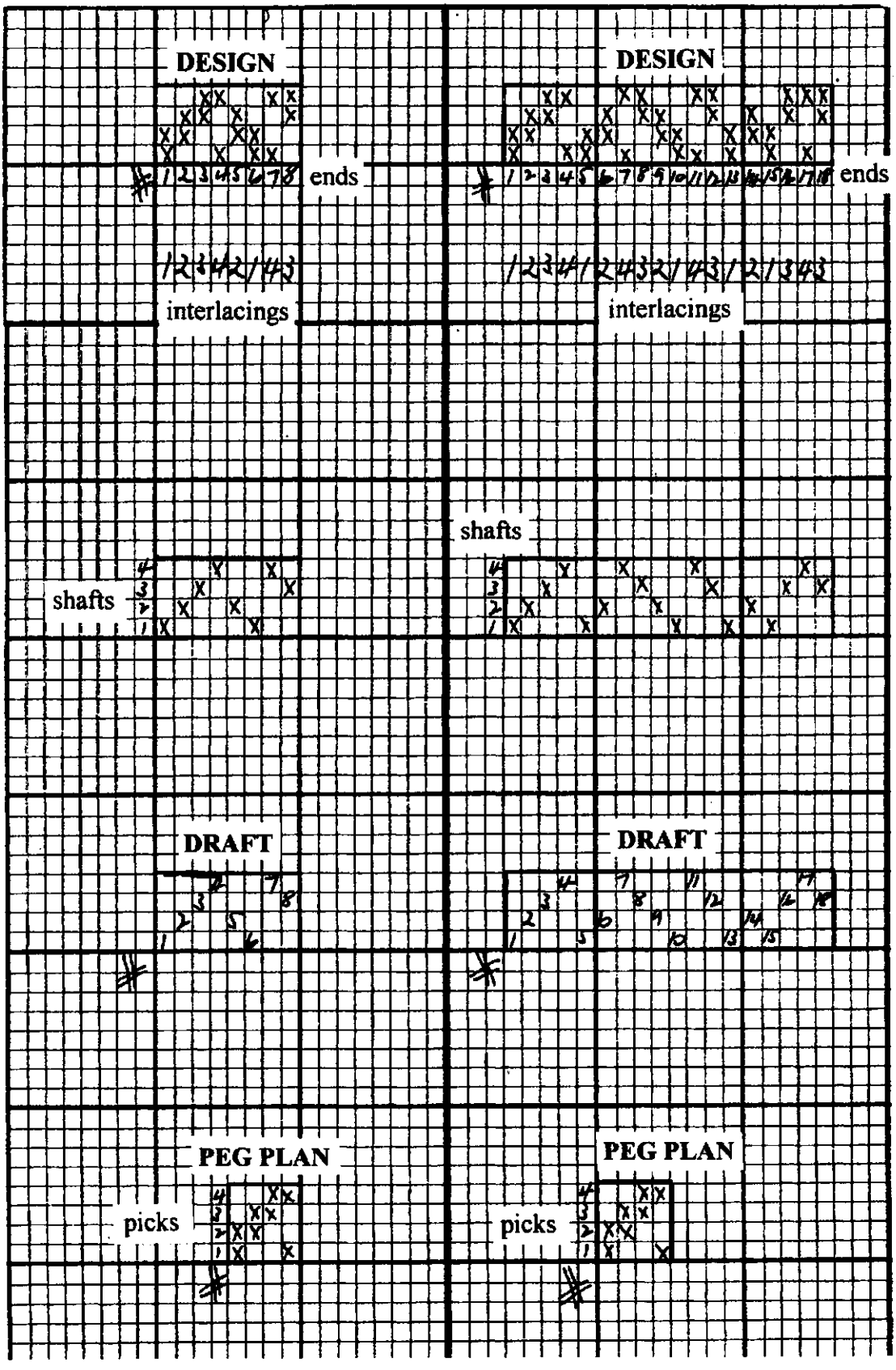
Warp end number 2 has to be drawn through an eye on shaft 2

Warp end number 3 has to be drawn through an eye on shaft 3

Warp end number 4 has to be drawn through an eye on shaft 4.

Finally, the four different warp interlacings in one repeat of the weave form the **peg plan**, reading as always from left to right.

Figure 3.31 gives two further examples, one a simple herringbone design, the other a herringbone plus barleycorn design.




3.31 Designs, drafts and peg plans for two simple herringbone effects

The **Design** in figure 3.32 is slightly more complex but the same procedure is carried out. Starting from the left hand side of the **Design**, each warp end interlacing is examined in sequence. It can be seen that warp ends 1, 5, 9 and 13 all have the same interlacing of 2 up, 2 down and will all be threaded individually on shaft number 1. Warp ends 3, 7, 11 and 15 have the same interlacing of 2 down, 2 up and so they will be threaded individually in turn on shaft 2.

Warp ends 2, 4, 6, 8, 10, 12, 14 and 16 each have different interlacings, which means that although there are 16 warp ends in one repeat of the **Design**, there are only 10 different interlacings therefore 10 shafts are required for the **Draft.**

The drawer (or healder) will then proceed as follows:

Warp end 1 will be threaded through an eye on shaft number 1,

| | |
|---|---|
| 2 | 3 |
| 3 | 2 |
| 4 | 4 |
| 5 | 1 |
| 6 | 5 |
| 7 | 2 |
| 8 | 6 |
| 9 | 1 |
| 10 | 7 |
| 11 | 2 |
| 12 | 8 |
| 13 | 1 |
| 14 | 9 |
| 15 | 2 |
| 16 | 10 |

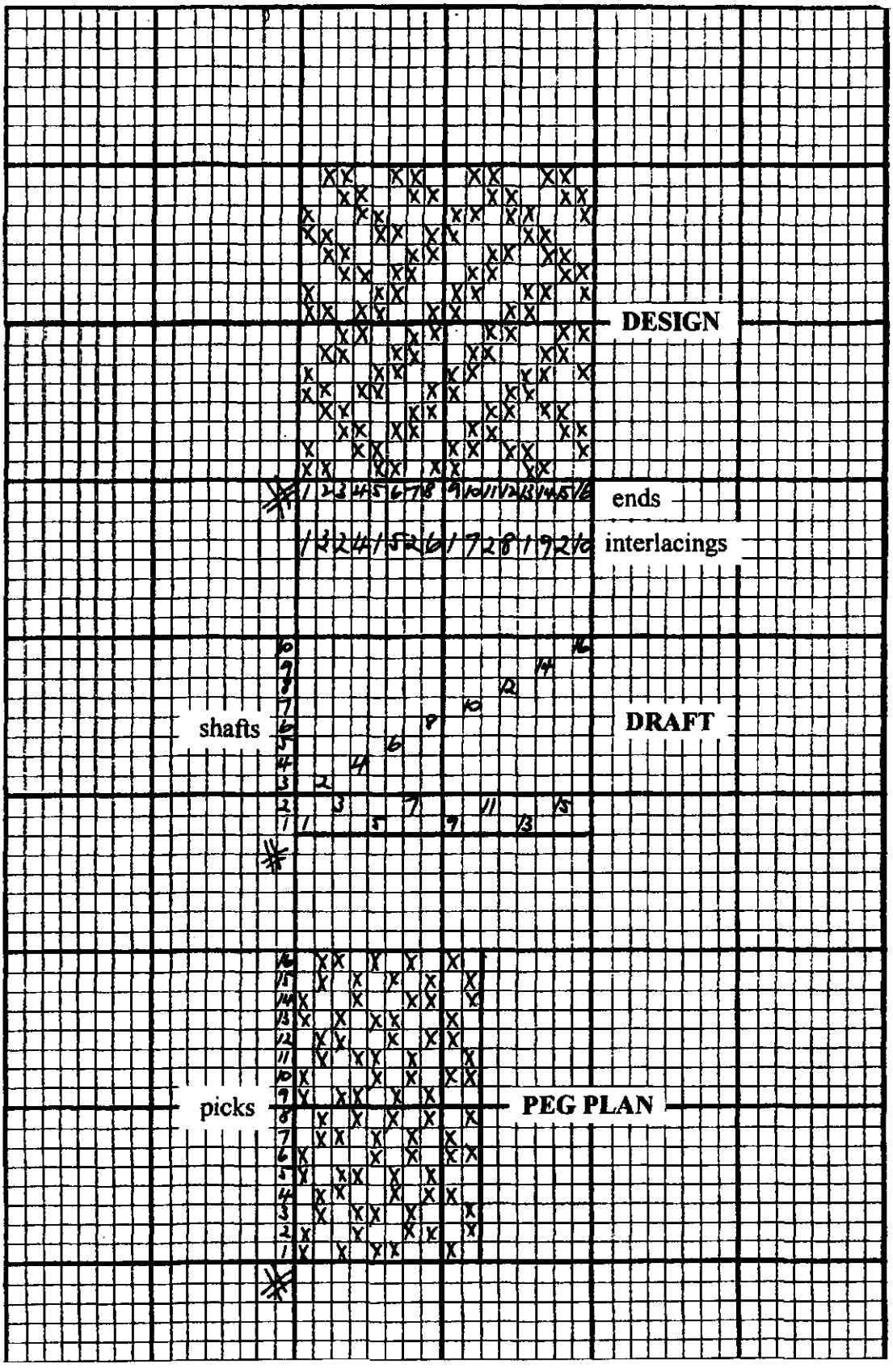
Finally, the 10 different warp end interlacings reading from left to right in the **Design** will form the **Peg plan**.

The following is an explanation of what each shaft actually does during the weaving operation, when using the **Draft** and **Peg plan** in figure 3.32.

When pick number 1 is inserted, shafts 1, 3, 5, 6 and 9 are raised and shafts 2, 4, 7, 8 and 10 are lowered.

When pick number 2 is inserted, shafts 1, 4, 7, 8 and 10 are raised and shafts 2, 3, 5, 6 and 9 are lowered.

When pick number 3 is inserted, shafts 2, 4, 5, 7 and 10 are raised and shafts 1, 3, 6, 8 and 9 are lowered – and so on.




3.32 Example of a slightly more complex draft

Different types of **Drafts** might be explained as follows:

1) **Straight over** where warp ends are threaded in strict sequence.

2) **Herringbone** or **Chevron** which can be straight over and reverse alternately with groups or sections of threads narrower or wider as required with clean cut junctions preferable.

3) **Pointed** or **reverse herringbone** where the reverse section meets the obverse to form a point.

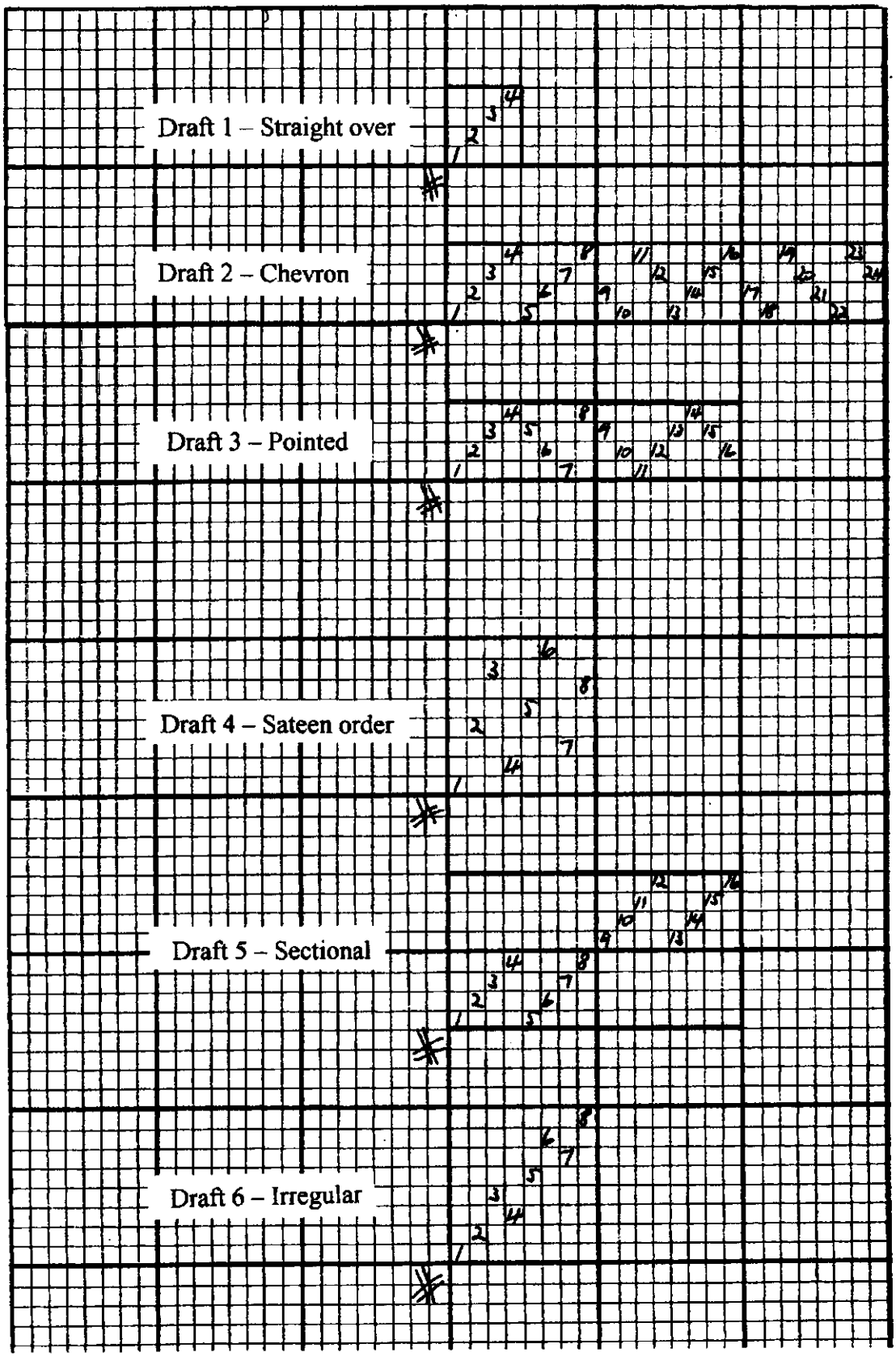
4) **Sateen** or **skipshaft** order where a warp end is threaded on one shaft then one or more shafts are 'skipped' before selecting the next shaft.

5) **Sectional** in which several warp ends are individually threaded on a group of shafts and others threaded on another group.

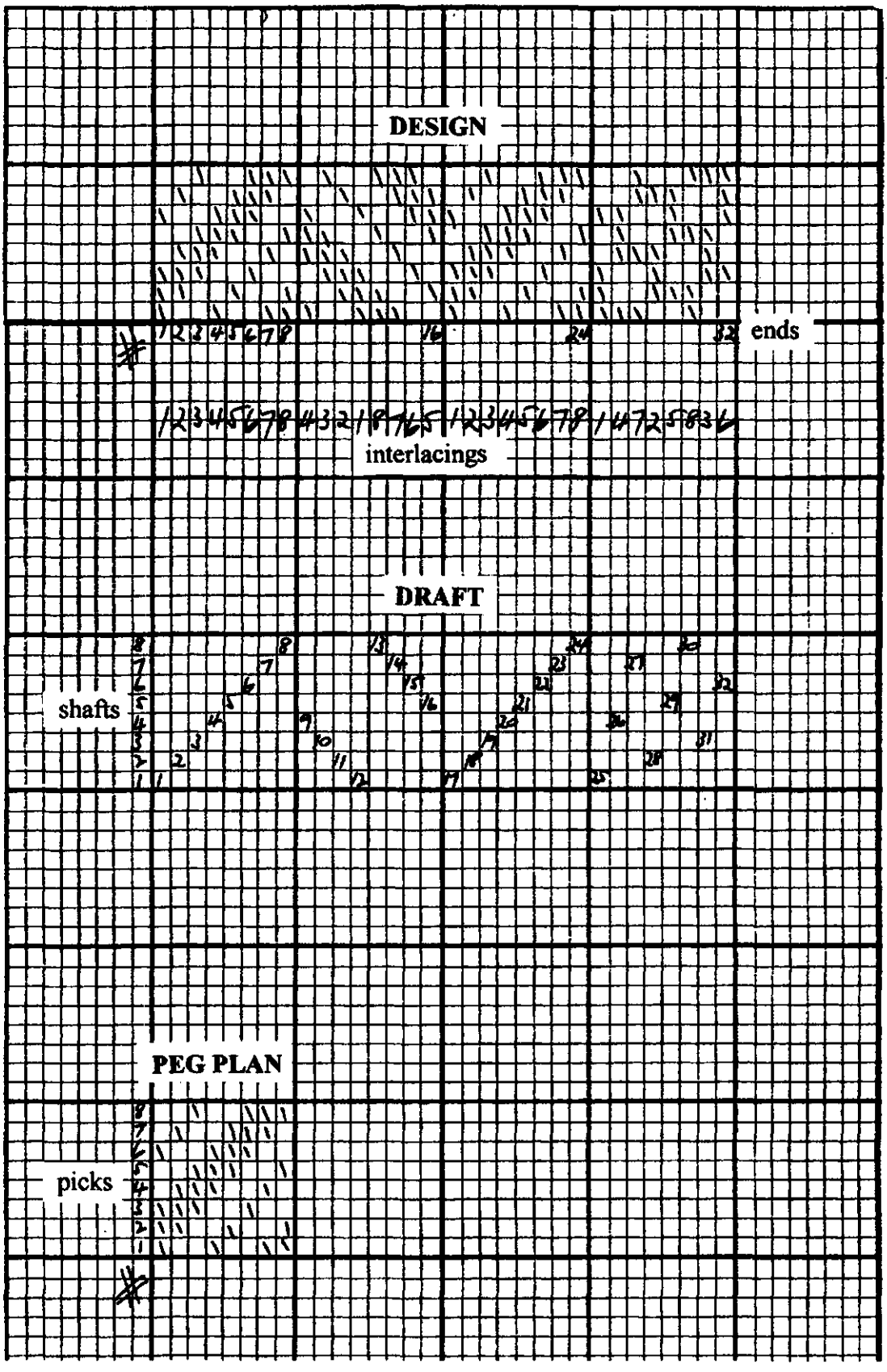
6) **Irregular** where no regular sequence is possible.

See figure 3.33 for examples of the above.

A final example in figure 3.34 shows a clean cut herringbone **Design** combined with another weave and the appropriate **Draft** and **Peg plan.**




3.33 Various types of drafts




3.34 Design, draft and peg plan for herringbone design combined with another

### 3.6 Sleying (or Denting)

After the warp ends have been threaded individually through wire eyes on the shafts, they are sleyed collectively through each split in the reed (or sley). The reed then fits into the front part of the loom that moves backwards and forwards during the weaving process.

The ends may be sleyed 2, 3 or 4 at a time in each split depending on the density of the warp setting and the weave used. For example, in plain weave they will normally be sleyed 2 ends to a split, regardless of the warp setting. In 2/2 twill they could be sleyed 2 or 4 ends to a split and in weaves such as 2/1 twill and barleycorn, 3 ends to a split.

There are three different reed numbering systems used today, namely **Metric**, **Huddersfield** and **Scottish.**

**Metric:** Where the reed number indicates the number of splits in 10cms.

For example, 43 reed indicates 43 splits in 10cms.

43/2 reed indicates there are 2 ends per split, giving 86 ends in 10cms,
43/4 reed indicates there are 4 ends per split, giving 172 ends in 10cms.

**Huddersfield:** Reed number indicates the number of splits in one inch.

For example, 16 reed indicates 16 splits in one inch.

16/2 reed indicates there are 2 ends per split, giving 32 ends per inch,
16/4 reed indicates there are 4 ends per split, giving 64 ends per inch.

**Scottish:** The reed number here indicates the number of splits in 1.85 inches.

For example, 21 reed indicates there are 21 splits in 1.85 inches.

21/2 reed gives 42 ends in 1.85 inches which is equivalent to 22.7 ends per inch,
21/4 reed gives 84 ends in 1.85 inches which is equivalent to 45.4 ends per inch.

Basic weaves, simple warp and weft colouring effects and the weaving process itself are relatively straightforward and easy to understand in this chapter. Drafting and pegging however are more complex and every attempt has been made to explain them in uncomplicated terms with clear examples. A fuller understanding of this subject might only come about through frequent reading and study of the relevant parts.