

1. Basic Concepts

Basics are basics. What was basic yesterday will be basic tomorrow. Basics are the constants, the unchanging foundations upon which creative work can be built.

This chapter explains the basics of folding paper. The general concepts it introduces are the most important and the most useful in the book. Time spent learning them will be well rewarded when you progress to later chapters and when you create your own folded designs. If you are new to folding, or have only limited experience, you are encouraged to spend quality time with this chapter. However, do not just look at its contents – fold them!

Basic concepts are not only useful, but are also very adaptable. This is because they are necessarily generic and can thus be modified in an infinite number of ways. By contrast, ideas for folding which are more specific, are less adaptable. So, somewhat paradoxically, this is perhaps the book's least showy chapter, but it also offers the most creativity. 'Basic' should not be mistaken for 'uncreative'.

1. BASIC CONCEPTS

1.1. Dividing the Paper

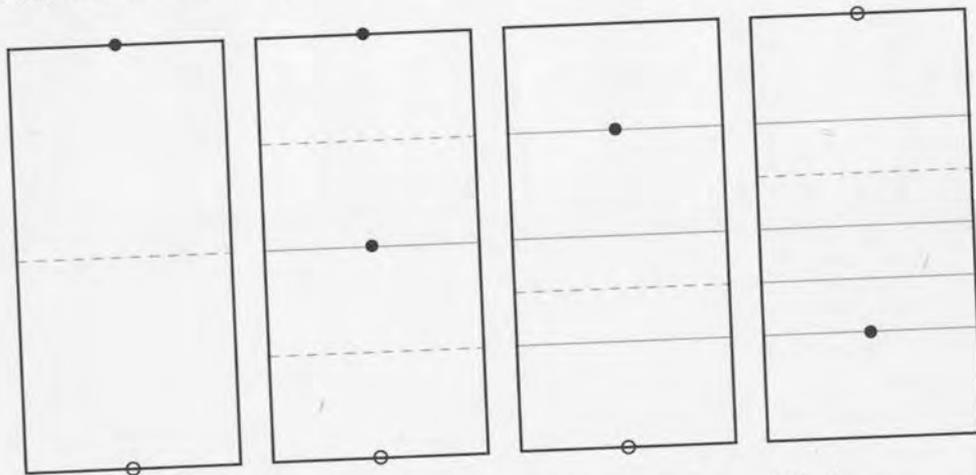
1.1.1. Linear Divisions: Sixteenths

1.1. Dividing the Paper

Dividing paper into exactly equal lengths or angles enables many other techniques to be performed. The position of the folds can be marked with a ruler and pencil, but it is much quicker and much more accurate to make them by hand, dividing the paper into halves, then quarters, then eighths...and so on, using a simple and precise sequence of folds. It is the hand-made method that is explained here.

There is nothing inherently special about the sixteenths, thirty-seconds or sixty-fourths shown in this section, other than that they divide the paper many times and are easy divisions to explain. In your own work, it may be that you need to divide the paper into tenths, twenty-sixths, fifty-fourths, or whatever, in which case it is better to divide it into 16, 32 or 64 and then trim off the excess. Do not be a slave to the divisions shown here.

1.1.1. Linear Divisions: Sixteenths



1.1.1_1
Fold the \circ edge to the \bullet edge, folding the paper in half. Open the paper.

1.1.1_2
Fold the edges to the centre line. Open the paper.

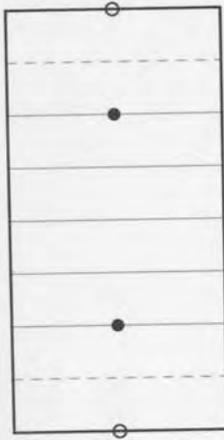
1.1.1_3
Fold the \circ edge to the \bullet crease. Open the paper.

1.1.1_4
Repeat Step 3 with the other edge.

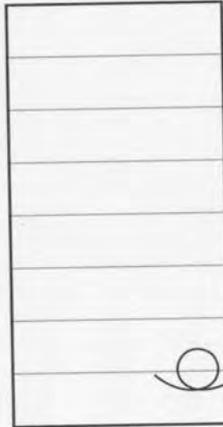
1. BASIC CONCEPTS

1.1. Dividing the Paper

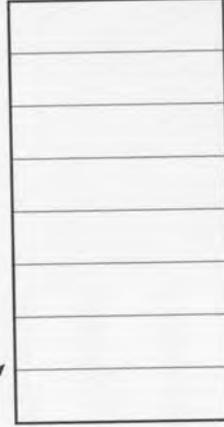
1.1.1. Linear Divisions: Sixteenths



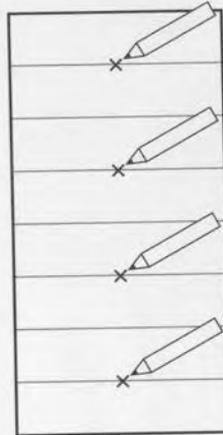
1.1.1_5
Fold the \circ edges to the \bullet creases. Open the paper.



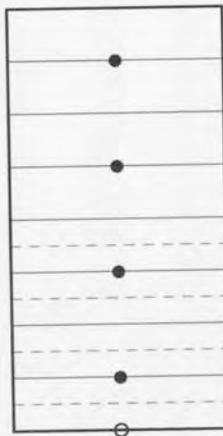
1.1.1_6
There are now seven valley folds that divide the paper into equal eighths. Turn the paper over.



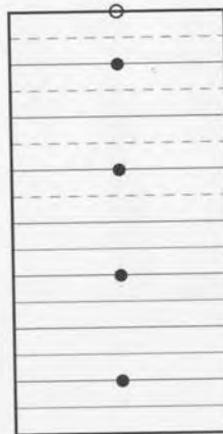
1.1.1_7
There are now seven mountain folds.



1.1.1_8
With a pencil, discreetly mark each alternate mountain crease.



1.1.1_9
Fold the \circ edge in turn to all the \bullet creases marked in Step 8, making four new folds. Open the paper after each new fold.

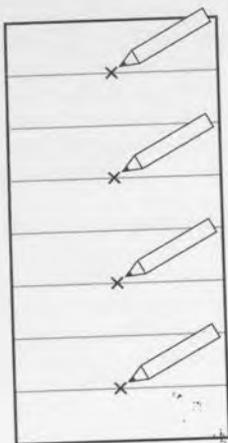


1.1.1_10
Repeat Step 9 with the other edge of the paper.

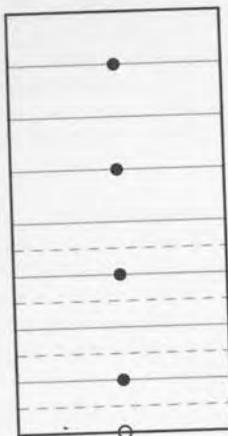


1.1.1_11
The paper is now divided into equal sixteenths, using creases which alternate mountain-valley-mountain-valley... across the paper (see photo on page 14).

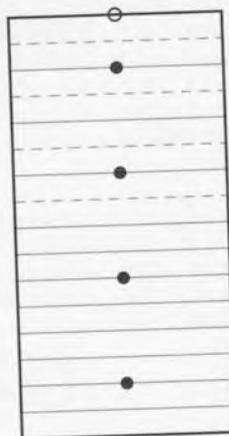
1.1.1 Linear Thirty-seconds



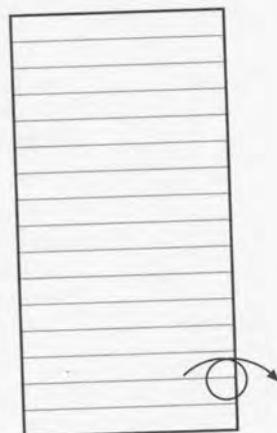
1.1.1_1
Begin with Step 6 of the Linear Sixteenths method (see page 17). Using a pencil, discreetly mark each alternate valley crease.



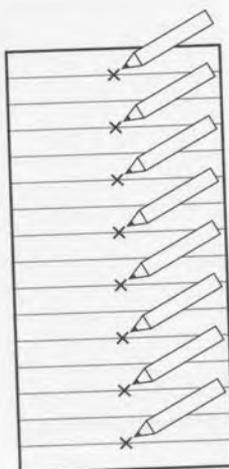
1.1.1_2
Fold the \circ edge in turn to all the \bullet creases marked in Step 1, making four new folds. Open the paper after each new fold.



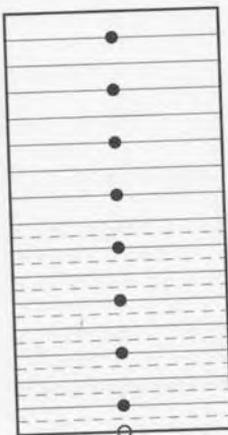
1.1.1_3
Repeat Step 2 with the other edge of the paper.



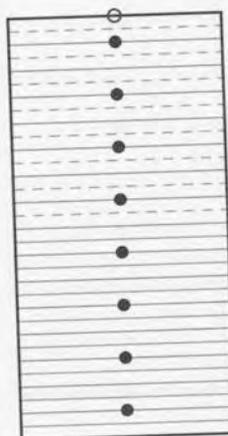
1.1.1_4
There are now 15 valley folds. Turn the paper over.



1.1.1_5
With a pencil, discreetly mark each alternate mountain crease.



1.1.1_6
Fold the \circ edge in turn to all the \bullet creases marked in Step 5, making eight new folds. Open the paper after each new fold.



1.1.1_7
Repeat Step 6 with the other edge of the paper.



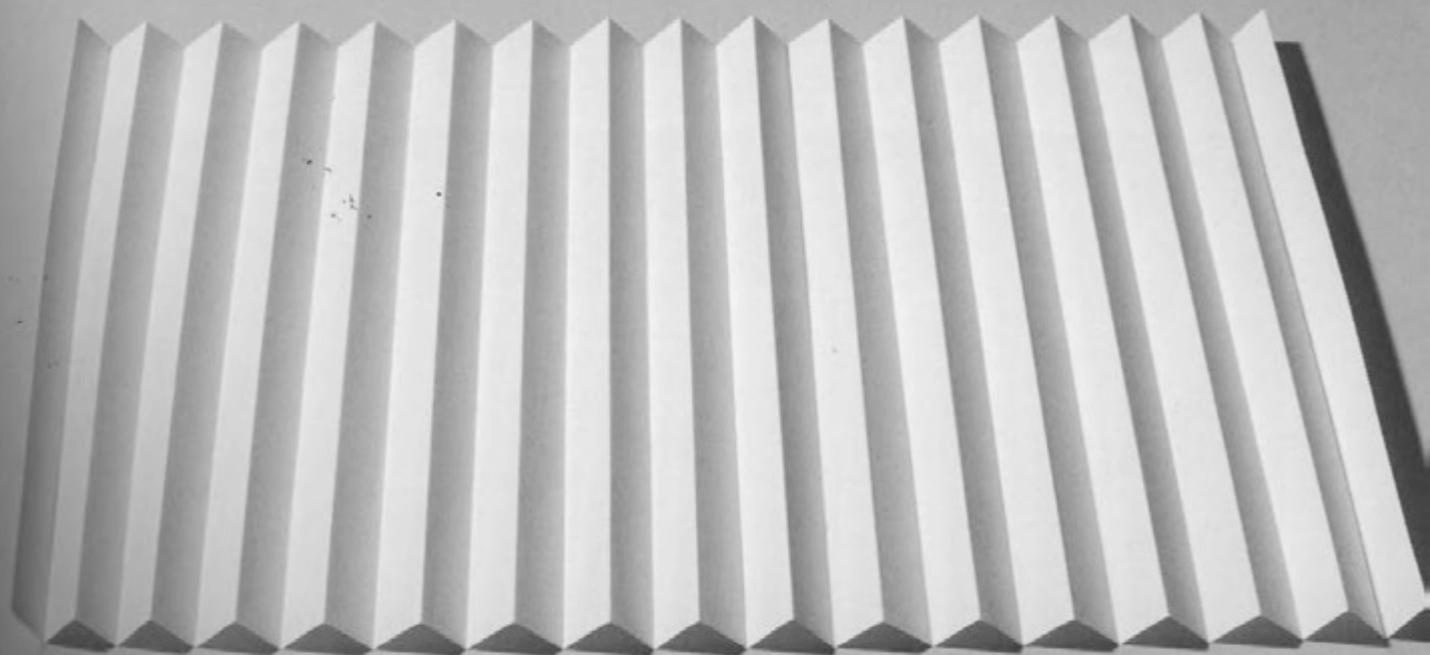
1.1.1_8
The paper is now divided into equal thirty-seconds, using creases which alternate mountain-valley-mountain-valley (see photo opposite).

1 BASIC
CONCEPTS

2.1 Dividing
the Paper

2.1.1 Linear Thirty-
seconds

2.1.1. Linear Divisions into thirty-seconds



1. BASIC
CONCEPTS

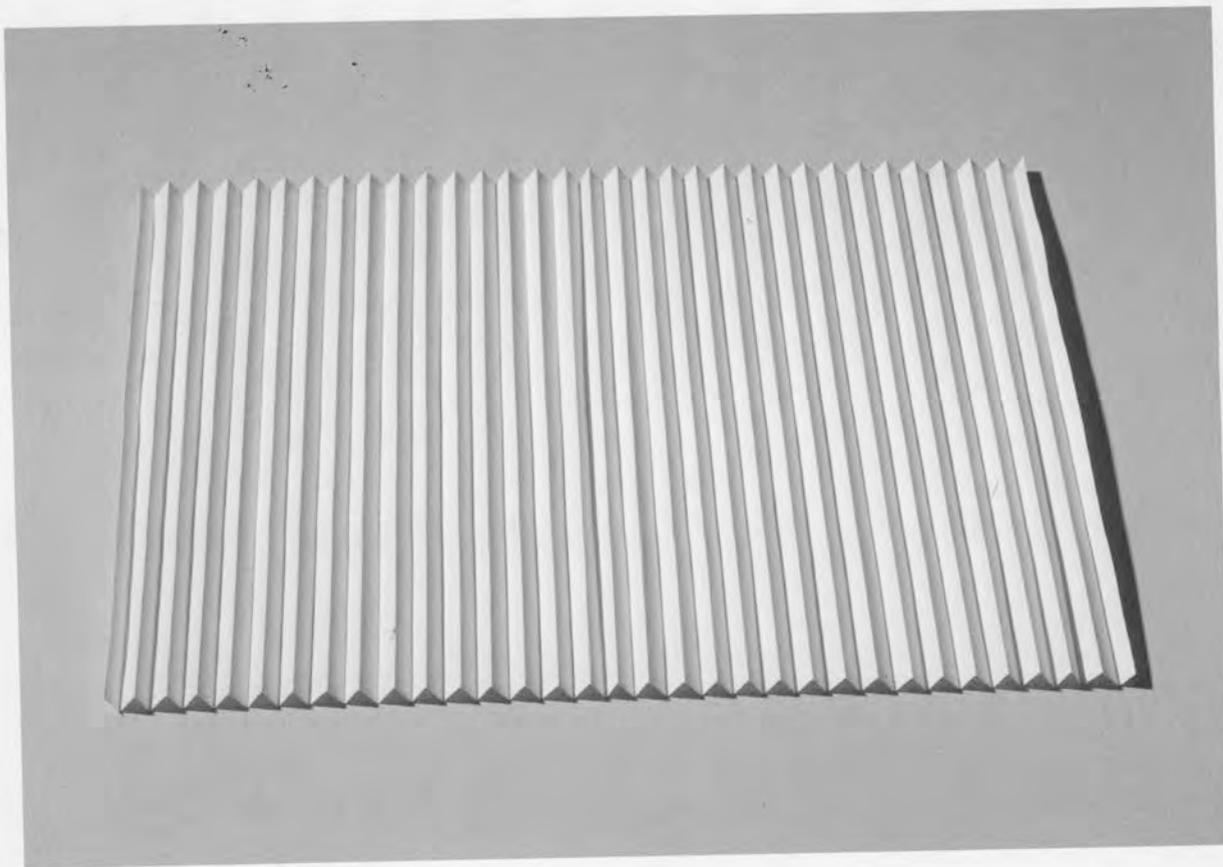
1.1. **Dividing
the Paper**

1.1.1. Linear Sixty-
fourths

1.1.1. Linear Sixty-fourths

To divide the paper into 64, fold up to Step 4 of the Linear Thirty-seconds method (see page 18). Then, instead of turning the paper over, continue on the same side, completing all the thirty-seconds as valley folds. Now turn the paper over. Mark the alternate mountain folds and make valleys between the mountains by folding the edges to the marked creases. This will complete the division into sixty-fourths.

If a piece of paper is first divided into equal thirds rather than in half, it can then be divided into accurate sixths, twelfths, twenty-fourths and so on, which may be more useful than 16, 32 or 64.



1.1.1 Linear Divisions into sixty-fourths

1.1. Dividing
the Paper

1.1.2. Rotational
Divisions:
Sixteenths

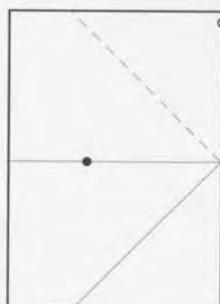
1.1.2. Rotational Divisions: Sixteenths



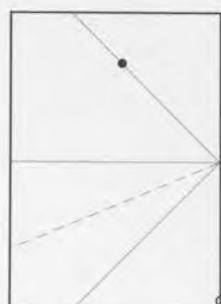
1.1.2_1
Divide the paper into two
 90° angles by folding the
o edge to the • edge.
Open the paper.



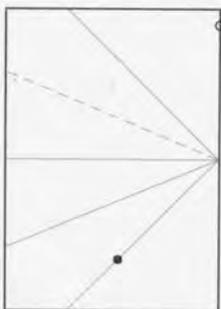
1.1.2_2
Fold the o edge to the •
crease. Open the paper.



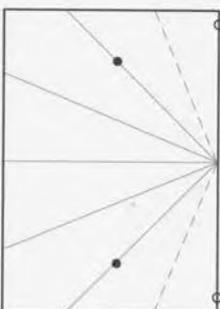
1.1.2_3
Repeat Step 2 with the top
half of the paper. Open
the paper.



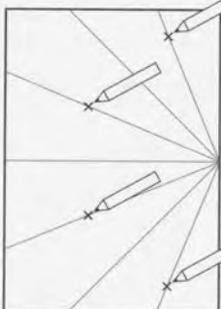
1.1.2_4
Fold the o edge to the •
crease. Open the paper.



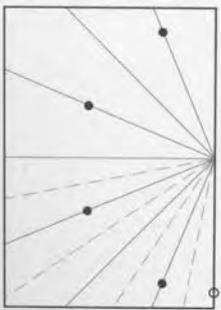
1.1.2_5
Repeat Step 4 with the
top half of the paper.
Open the paper.



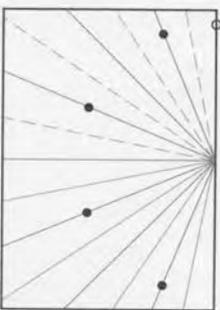
1.1.2_6
Fold the o edges to the •
creases. There are now
seven valley folds and
eight equal angles.



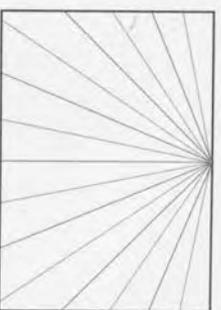
1.1.2_7
On the reverse side of
the paper, discreetly mark
each alternate mountain
crease with a pencil.



1.1.2_8
Fold the o edge in turn to
all the • creases marked
in Step 7, making four new
folds. Open the paper after
each new fold.

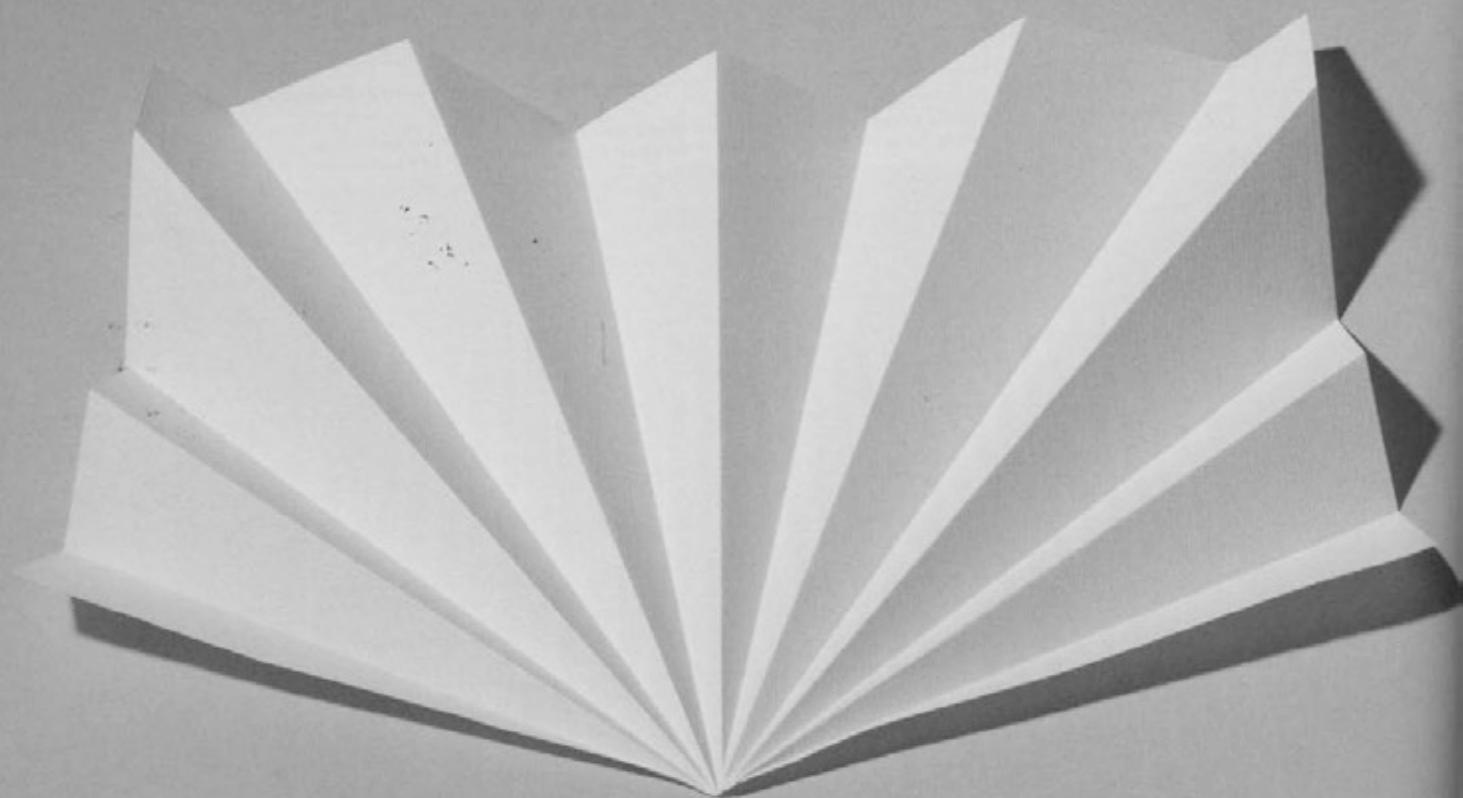


1.1.2_9
Repeat Step 8 with the
top half of the paper.



1.1.2_10
The paper has now been
divided into 16 equal
angles, using creases
which alternate mountain-
valley-mountain-valley (see
photo overleaf on page 22).

- 1. BASIC CONCEPTS
- 1.1. Dividing the Paper
- 1.1.2. Rotational Divisions: Sixteenths



1. BASIC CONCEPTS

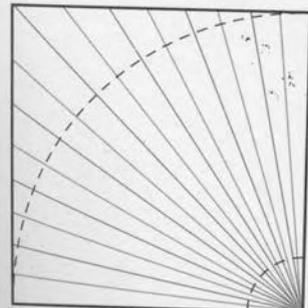
1.1. Dividing the Paper

1.1.2. Rotational Sixteenths Variations

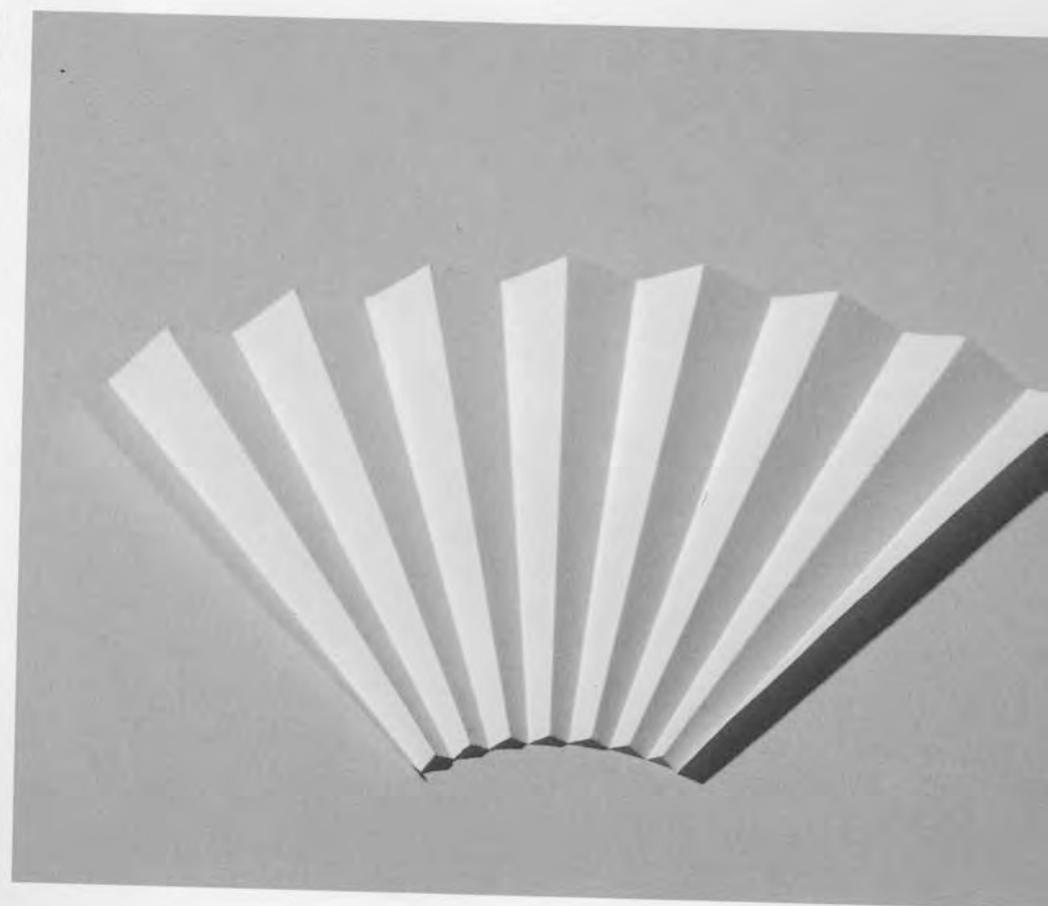
1.1.2. Rotational Sixteenths Variations

With Linear Sixteenths (see pages 16–17), the spacing between the parallel folds depends wholly on the length of the paper being divided. However, with Rotational Sixteenths, the spacing between the angled folds depends wholly on the number of degrees of paper around the point where all the folds meet.

Here are some further examples. The methods of construction are identical to the Rotational Sixteenths method (see page 21).



1.1.2_11
An angle of 90° is divided into sixteenths.

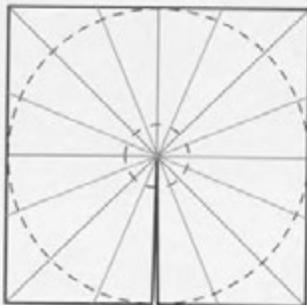
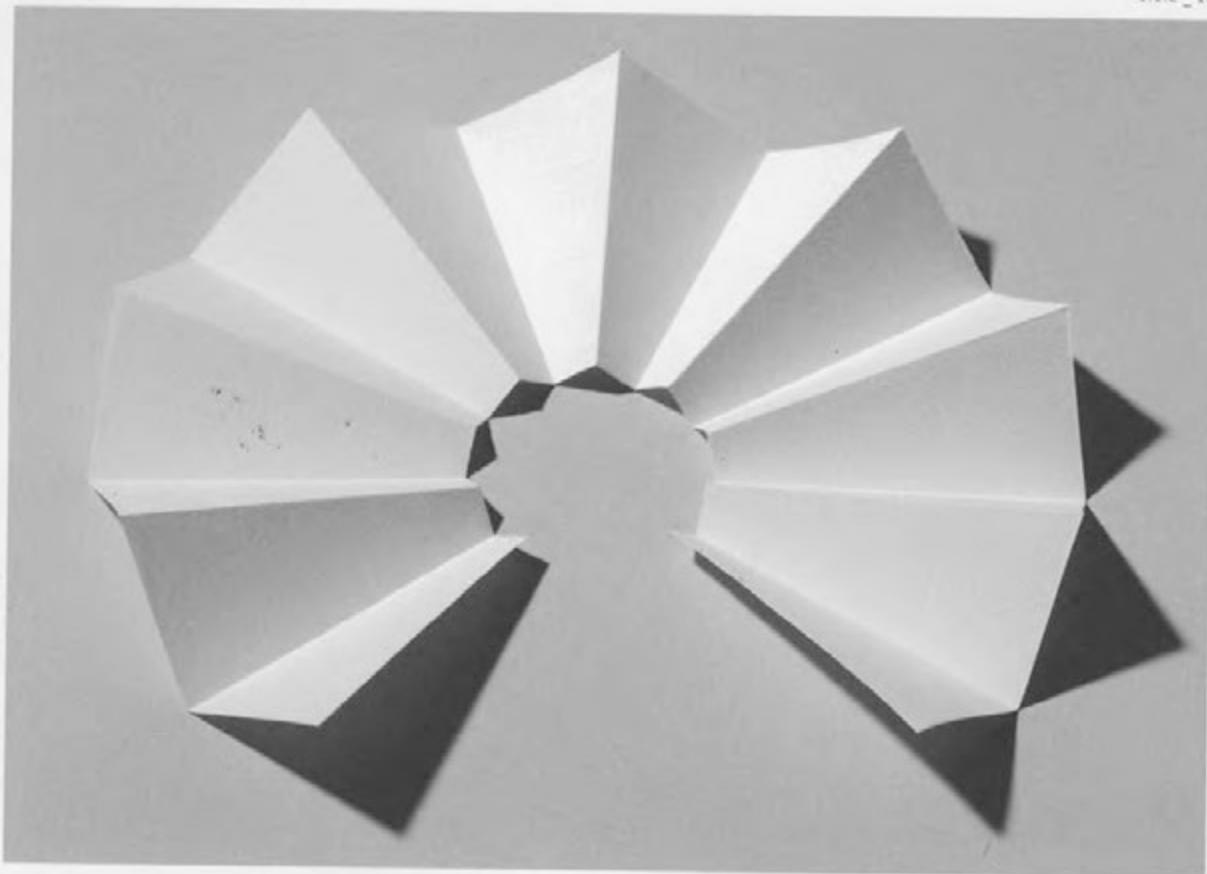


1. BASICS
CONCEPTS

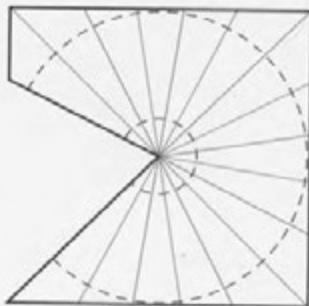
1.1. Dividing
the Paper

1.1.2. Rotational
Sixteenths
Variations

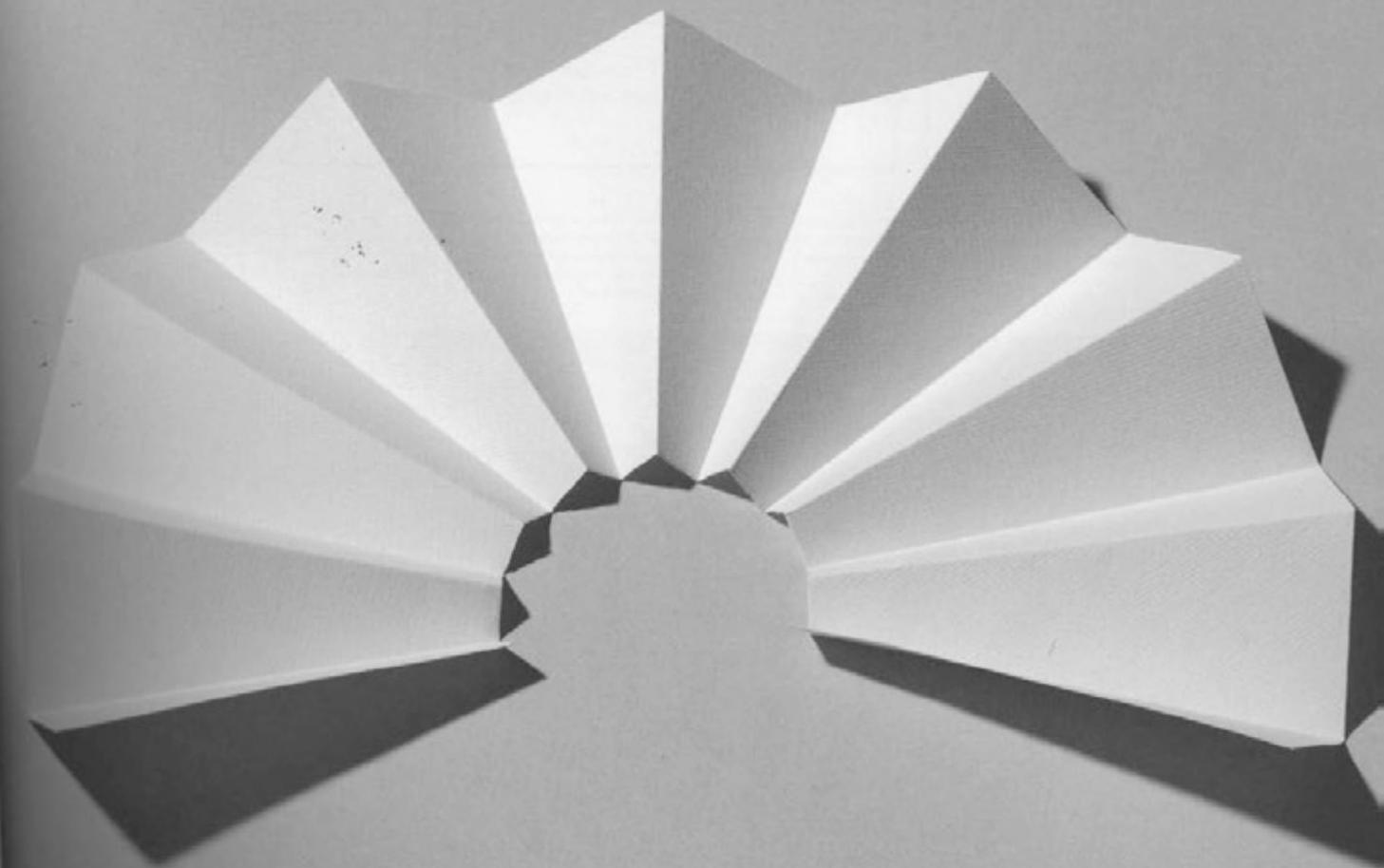
1.1.2_12



1.1.2_12
An angle of 360° is divided into sixteenths. The angle can be increased to 720° . If two identical sheets are prepared and folded as shown, then overlapped and glued together, rather like the shavings from a sharpened pencil. When the folds from this 720° surface are bunched up, they will sit flat in a 360° arc. More than two sheets may be glued together for even greater angles.



1.1.2_13
An arbitrary angle is divided into sixteenths (see photo opposite).



1. BASIC CONCEPTS

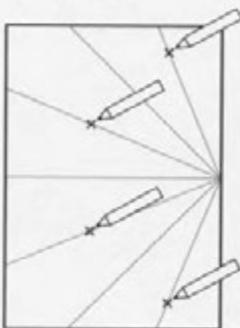
1.1. Dividing the Paper

1.1.2. Rotational Thirty-seconds

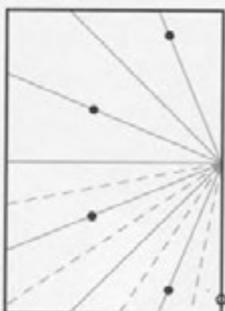
1.1.2. Rotational Thirty-seconds



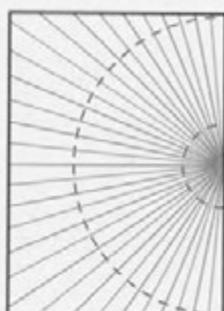
1.1.2_14
Begin with Step 6 of the Rotational Sixteenths method (see page 21).



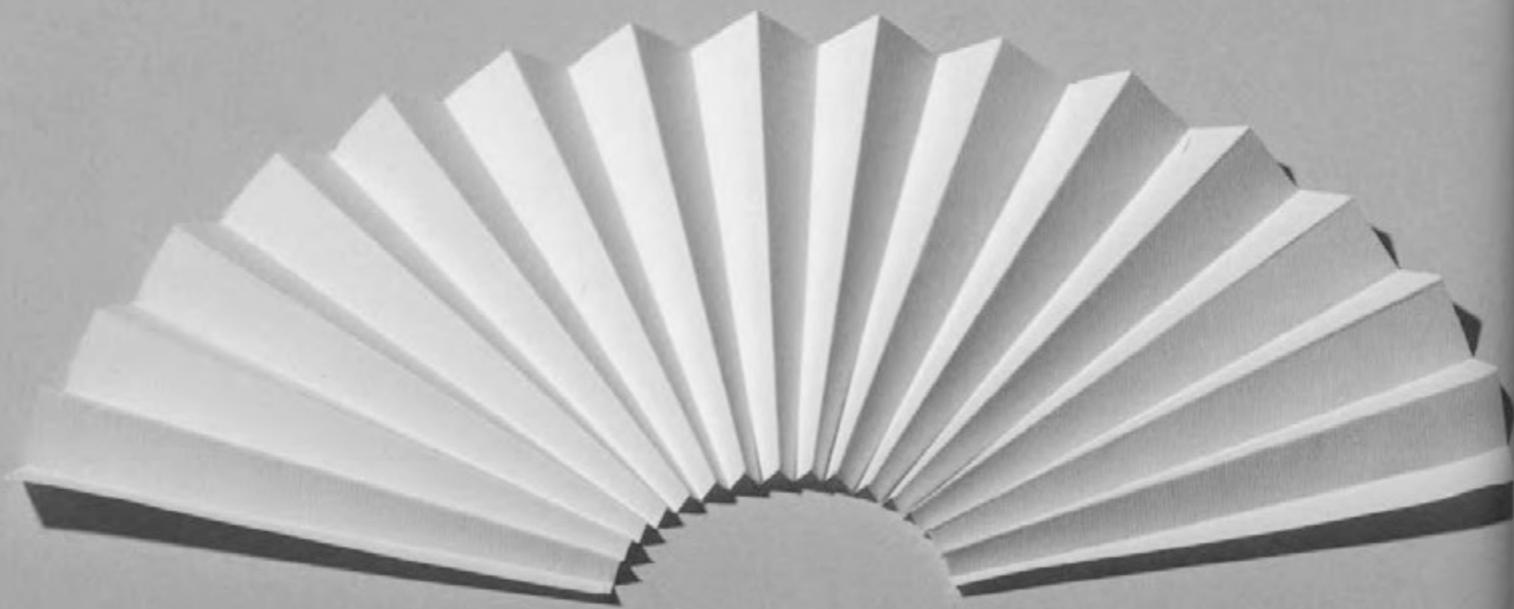
1.1.2_15
With a pencil, discreetly mark each alternate valley crease.



1.1.2_16
Fold the \circ edge in turn to all the \bullet creases, making four new folds. Repeat for the top half, then turn the paper over.



1.1.2_17
Continue, following exactly the method described for Linear Thirty-seconds (see page 18).

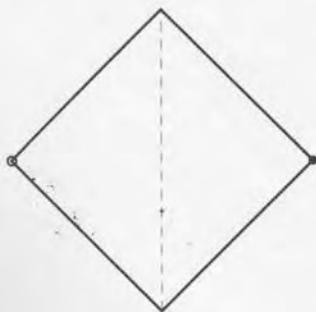


1.1.2_17

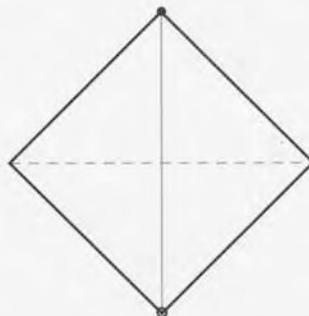
1.1.3. Diagonal Divisions

So far, this chapter has shown how to divide paper by always bringing an edge to an existing crease so that the divisions are parallel to the edge of the paper. However, it is equally possible to divide paper by always bringing a corner to an existing crease so that the divisions are parallel to the diagonal. The two methods of construction are exactly the same, but the results look very different.

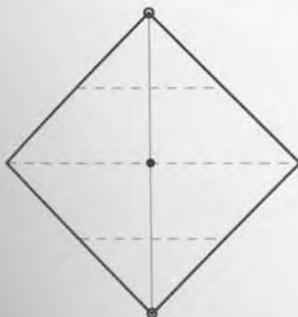
The method shown here divides the paper into diagonal sixteenths, but the methods described previously to divide paper into 32 or 64 could also be used.



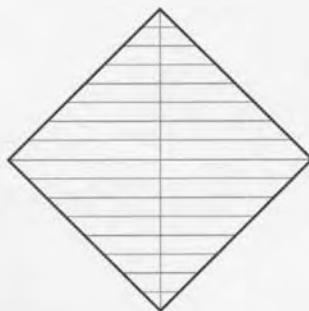
1.1.3_1
Begin with a square of paper. Fold the \circ corner to the \bullet corner. Open the paper.



1.1.3_2
Similarly, fold the \circ corner to the \bullet corner, then open the paper.



1.1.3_3
Fold the \circ corners to the \bullet intersection. Open the paper. This will divide the vertical diagonal into quarters. Turn the paper over.

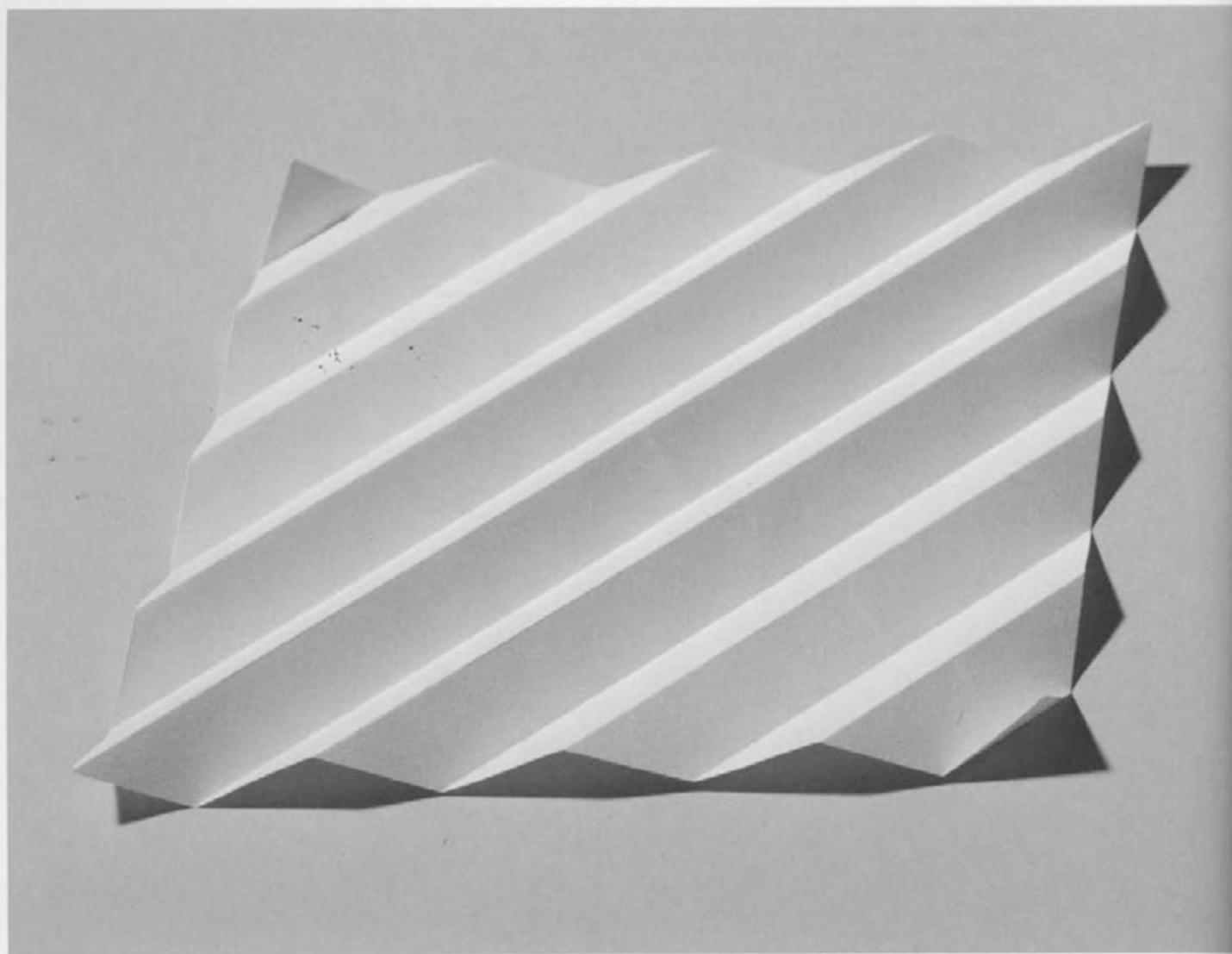


1.1.3_4
Continue, following exactly the method used for Linear Sixteenths (see page 17). The paper is now divided into equal sixteenths, using creases which alternate mountain-valley-mountain-valley along the length of the vertical diagonal (see photo overleaf).

1. BASIC
CONCEPTS

1.1. **Dividing
the Paper**

1.1.3. Diagonal
Divisions



1.1.3_4

1.1.4. Grid Divisions

The linear divisions described on pages 16–20 can follow more than one direction on the same sheet to create a grid of creases. There are too many possibilities to illustrate here, but most commonly, the two directions are perpendicular to each other and equally spaced, so that with square paper the grid becomes square.

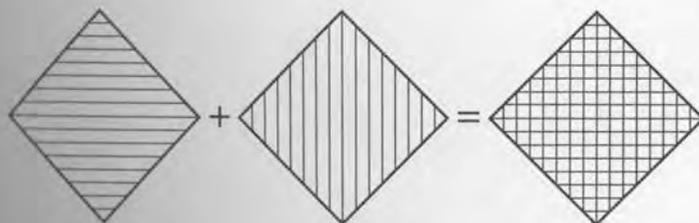
It is also possible to create different divisions in the two directions (for example, eighths and sixteenths), so that the grid becomes rectangular, not square. Likewise, the paper can be rectangular, not square, to stretch or compress a grid.

Further, it is possible to superimpose two grids – most commonly, a grid parallel to the edges and a grid parallel to the diagonals – to create a dense multidirectional grid of great versatility.

Finally, by exchanging square or rectangular paper for paper of another shape – most commonly a hexagon – non-square and non-rectangular grids can be made. This 60° hexagonal geometry comprised of three lines of linear divisions that divide the paper into equilateral triangles (triangles in which all the angles are 60°) is just as versatile as the ubiquitous 90° grid, but is much, much less commonly used. The student of folding who is looking to develop new forms is well advised to take forms seen in 90° geometry and try to fold an equivalent with 60° geometry. If you have never folded and played with a 60° grid, try it – it is like entering a parallel universe of folding!



1.1.4_1
Linear Sixteenths,
parallel to the edges.



1.1.4_2
Linear Sixteenths,
parallel to the diagonals.

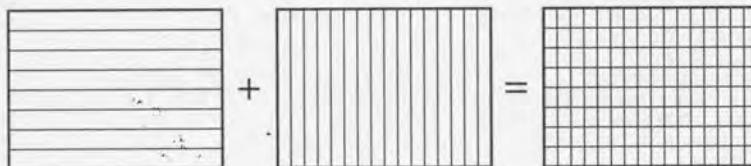
1. BASIC CONCEPTS

1.1. Dividing the Paper

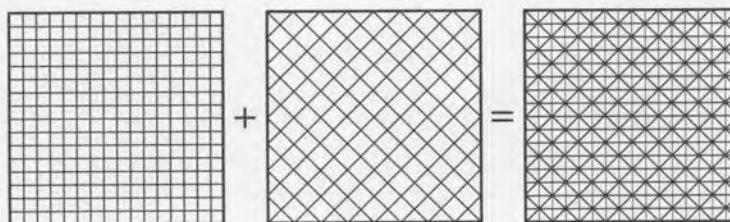
1.1.4 Grid Divisions



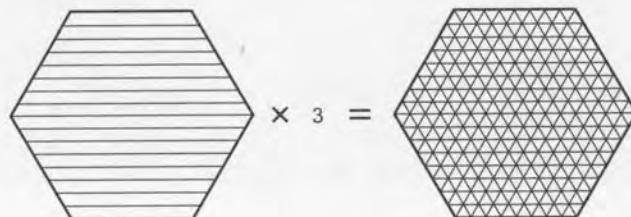
1.1.4_3
Linear Eighths and Linear Sixteenths, parallel to the edges.



1.1.4_4
Linear Eighths and Linear Sixteenths, parallel to the edges.



1.1.4_5
Two grids (one parallel to the edges and the other parallel to the diagonals) superimposed.



1.1.4_6
Linear Sixteenths on a hexagon, repeated three times.

1.	BASIC CONCEPTS
1.2.	Symmetrical Repeats
1.2.1.	Translation

1.2. Symmetrical Repeats

One way to describe a folded design is as a two-dimensional surface design of crease lines, given form. Any study of surface design will quickly introduce the topic of pattern, in which a motif is repeated in a regular arrangement. Folded forms are often made from repeat patterns, some are more easy to see than others.

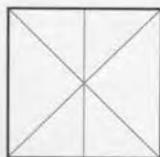
The essence of pattern making, including crease patterns, is symmetry. There are four basic types of two-dimensional symmetry – translation, reflection, rotation and glide reflection – all of which can be used to great effect when developing new folded forms. An understanding of these four types will generate a remarkable number of usable crease patterns from even the simplest motif. Generating these patterns is a pencil and paper game, though of course there is no substitute for eventually folding the drawings to see what you have created.

1.2.1. Translation

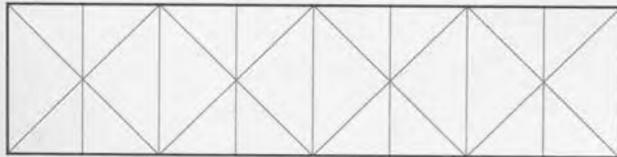
Definition: a motif is repeated exactly in one direction.

This is the simplest form of symmetry. A motif is repeated in a straight line without overlap. When applied to a square of paper (or other polygon), the squares are simply repeated side by side and the crease pattern repeated.

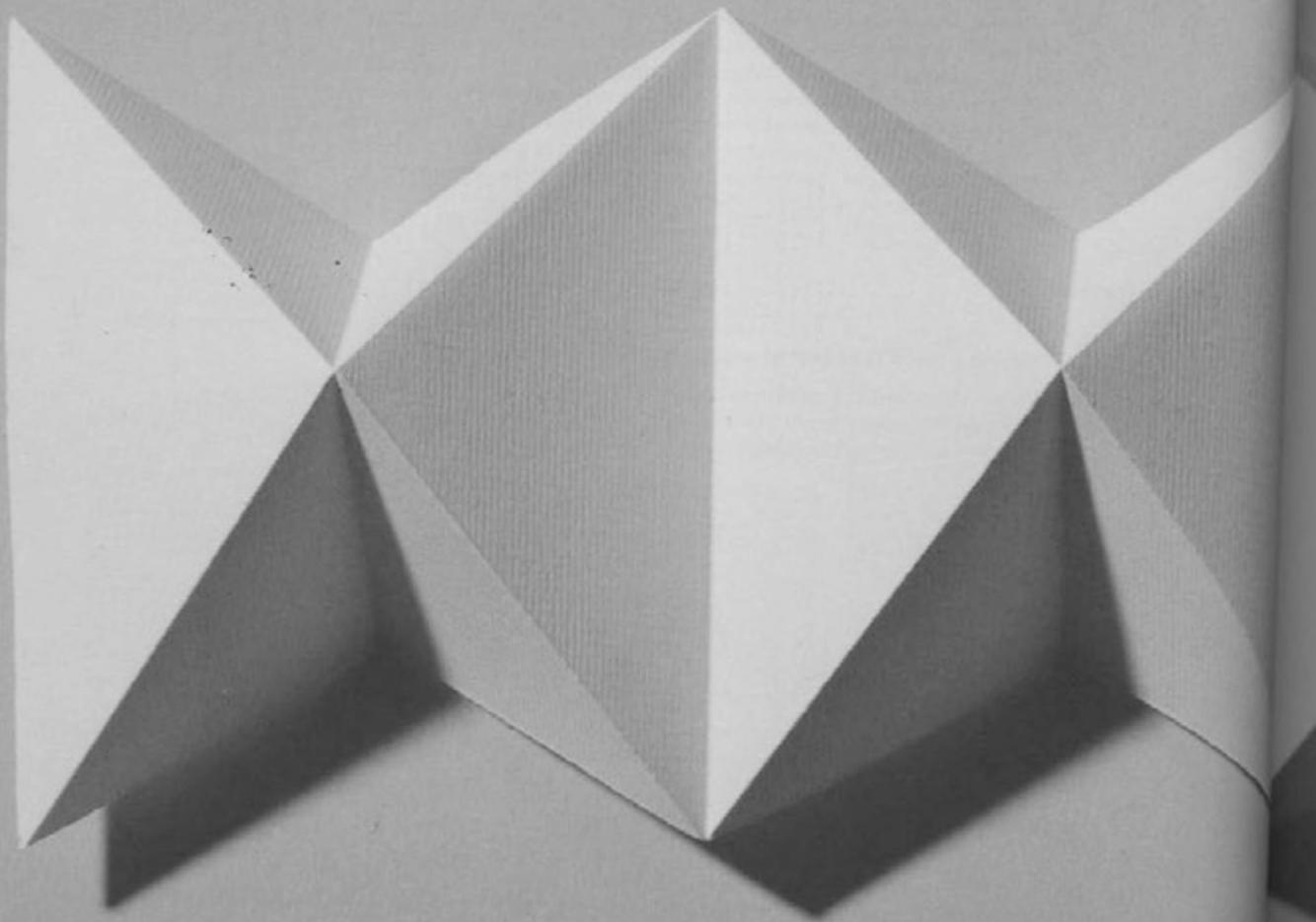
Folded motif

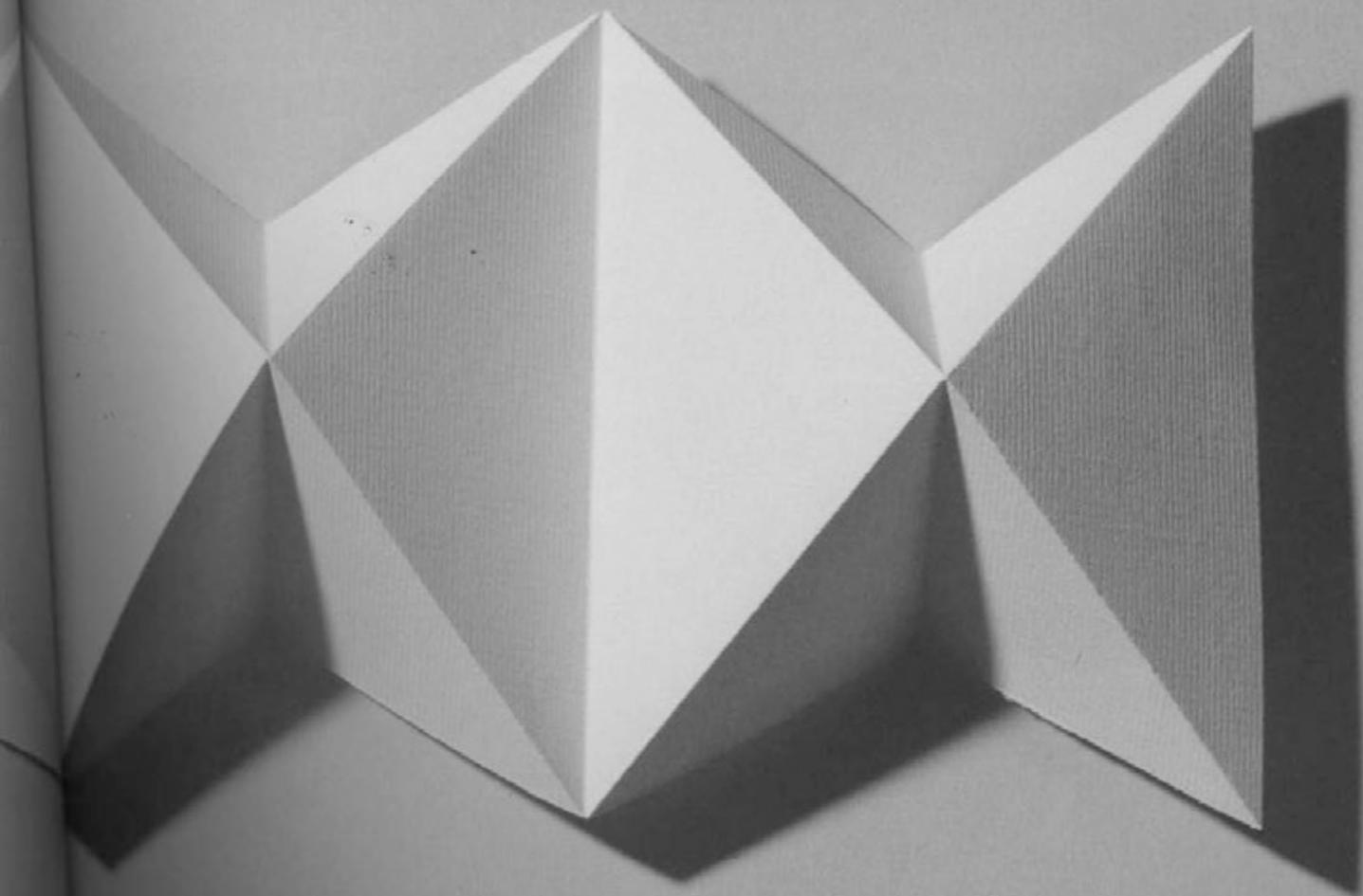


1.2.1_1
An example of translation symmetry (see photo overleaf).



- 1 BASIC CONCEPTS
- 1.2 Symmetrical Repeats
- 1.2.1 Translation





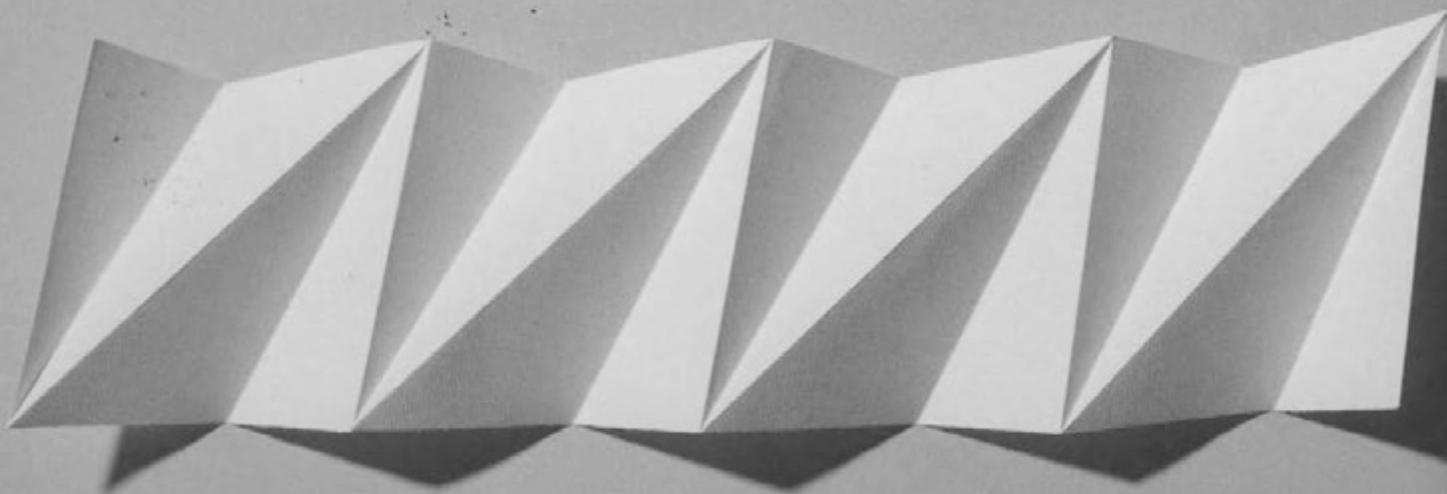
1. BASIC
CONCEPTS

1.2. **Symmetrical
Repeats**

1.2.1. Translation

Folded motif

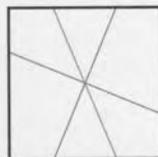
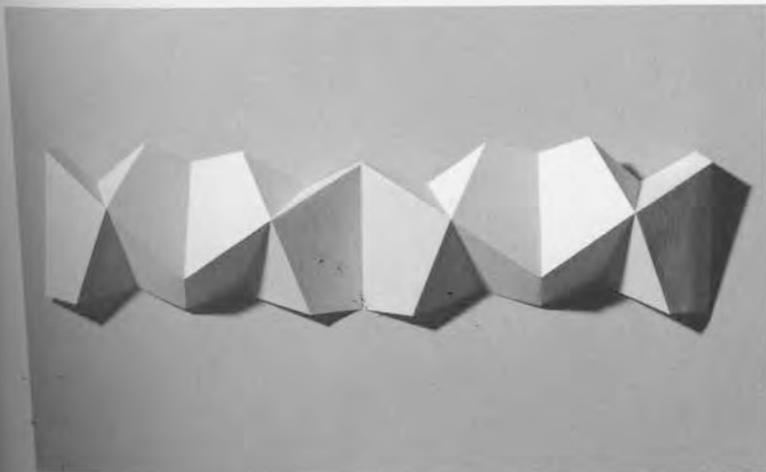
1.2.1_2
An example of
translation symmetry.



1.2.2. Reflection

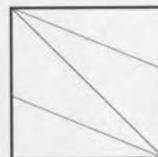
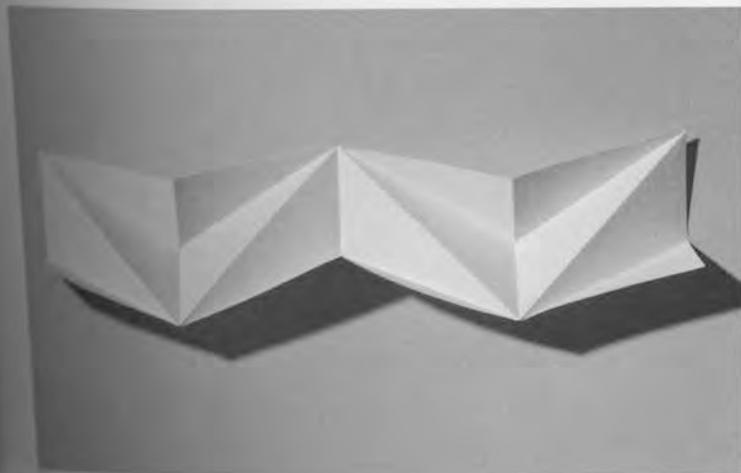
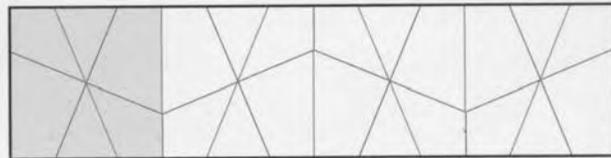
Definition: a motif is repeated exactly in one direction, but each time as a mirror image of the preceding motif.

Reflection symmetry makes possible crease patterns more complex than those made with translation symmetry, because it becomes easier to connect motifs together across the line of symmetry with a common crease.



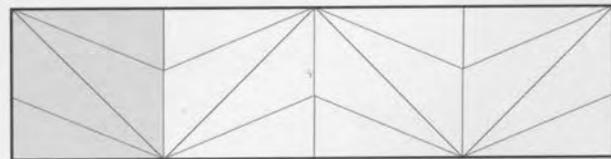
Folded motif

1.2.2_1
An example of
reflection symmetry.



Folded motif

1.2.2_2
An example of
reflection symmetry.

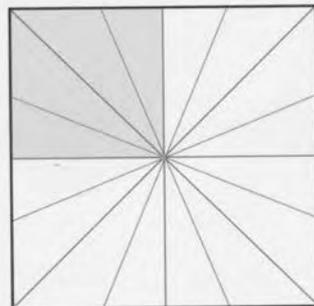
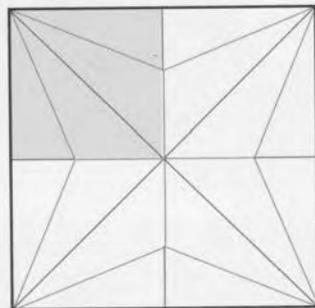
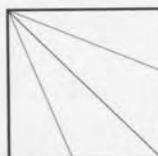
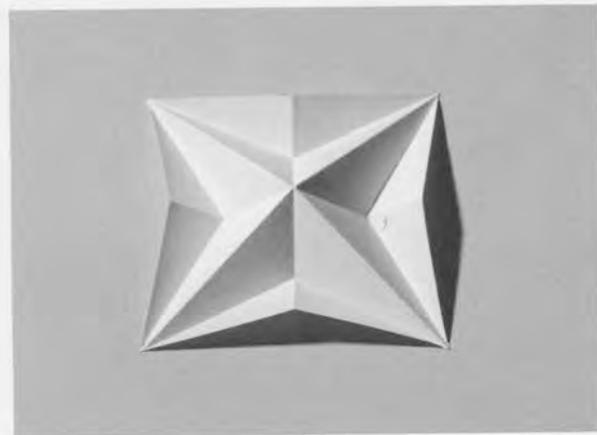
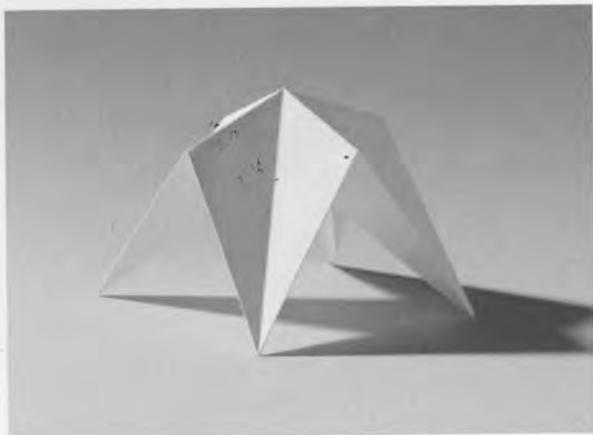


1.2.3. Rotation

Definition: a motif is exactly repeated around one common point.

Unlike translation and reflection symmetries, which are linear repeats, rotation symmetry makes possible repetition across a plane, around a common point. Using a square, any of the four corners can be used as the common point of rotation, enabling many forms to be generated from the same motif.

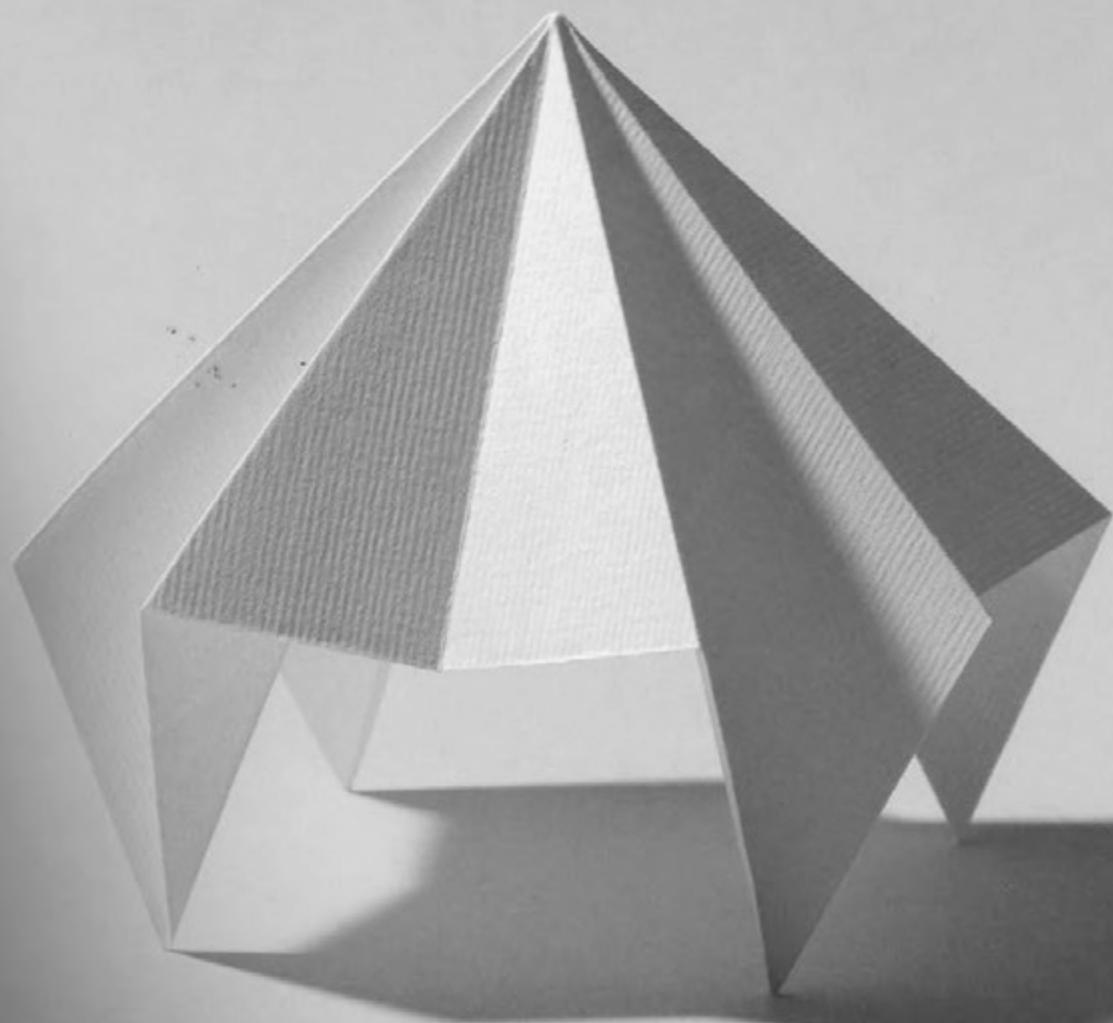
1.2.3_1 Motif 1 Variations



Folded motif

Repetition of the motif to create a star pattern of folds. The forms in the two photographs on the left are both folded from this single pattern. Each form is the other turned inside out.

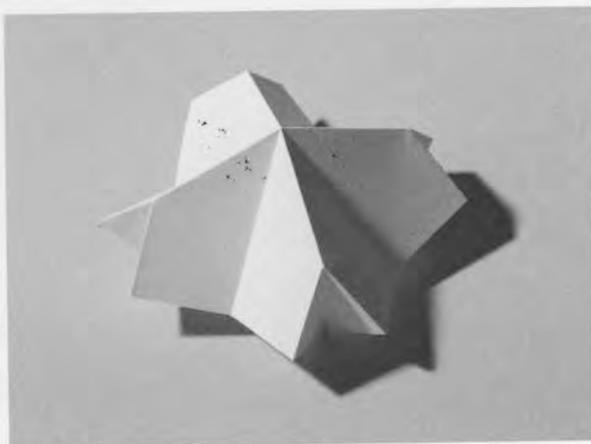
Repetition of the motif to create a radial pattern of folds. See photo opposite. Note that, like the example above and left, this form may also be turned inside out, though the difference is less dramatic.



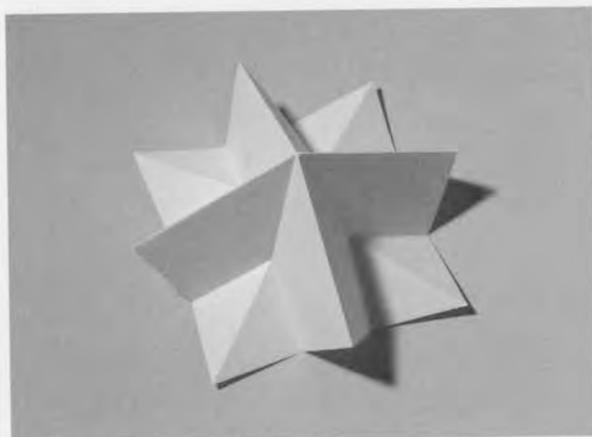
- 1. BASIC CONCEPTS
- 1.2. Symmetrical Repeats
- 1.2.3. Rotation

1.2.3 _ Motif 2 Variations

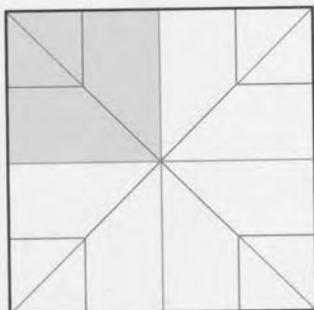
In both Motif 1 and Motif 2, many forms are possible, depending on how each form is collapsed. If a different corner of each motif is used as the common point of rotation, very different forms can be generated. Each rotational pattern of four motifs can itself be repeated around a common point to create surfaces and forms of great complexity and beauty, but from a simple motif.



1.2.3 _ 2/1

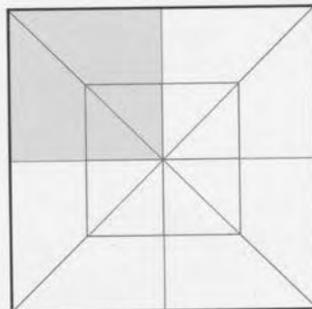


1.2.3 _ 2/2



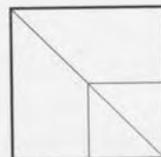
1.2.3 _ 2/1

In the two photos above, each form is the other turned inside out. They are both folded from this rotational configuration of the motif.



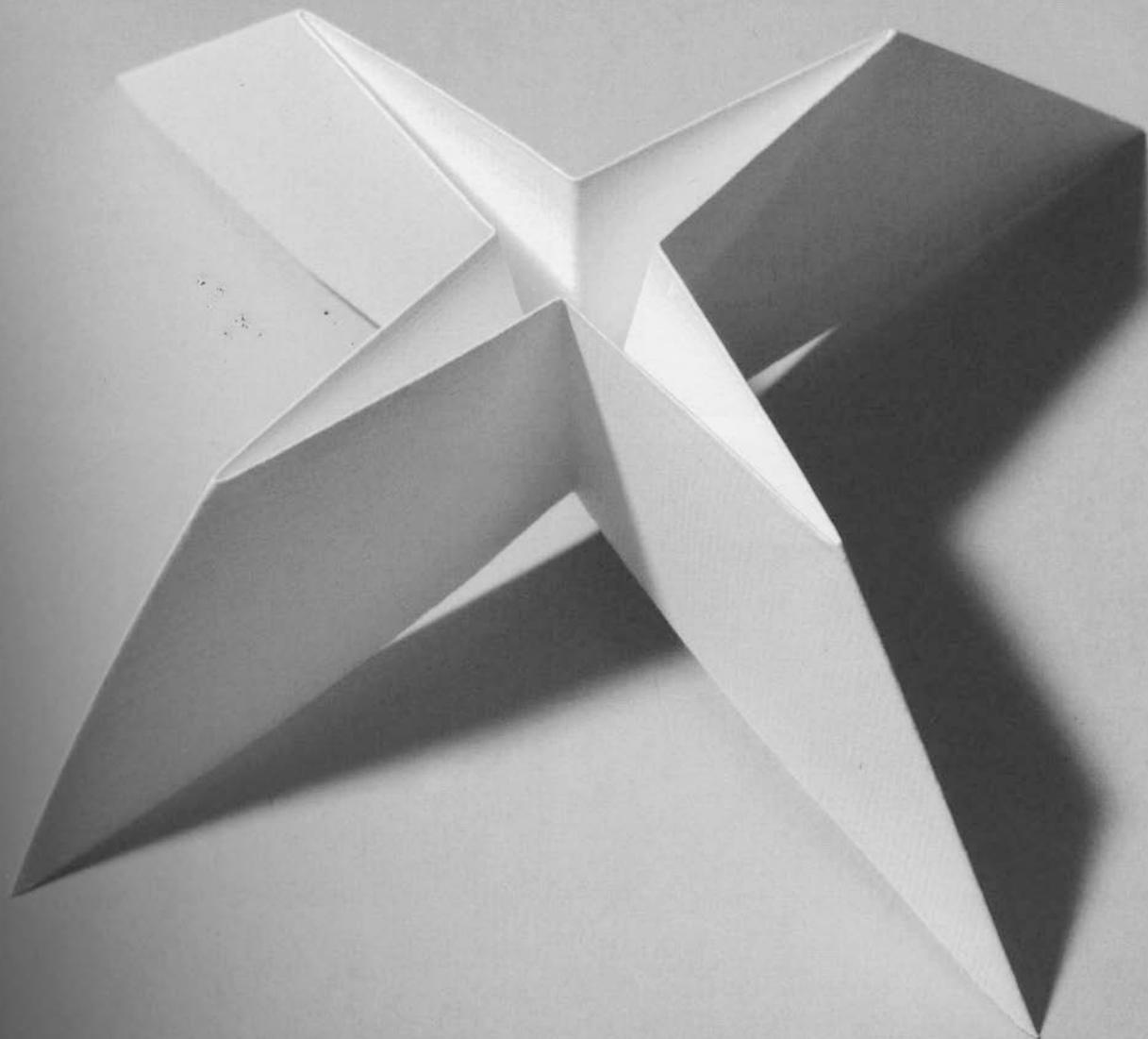
1.2.3 _ 2/2

Here the small, folded square in the bottom right-hand corner of the motif is grouped with others around the centre to create a large, mountain-fold square which can be inverted into the paper. See photo opposite.



Folded motif

- Symmetrical
- Repeats
- Rotation



1. BASIC
CONCEPTS

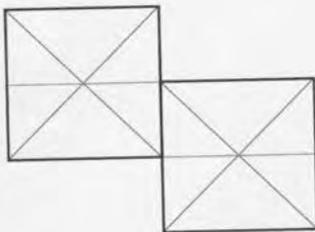
1.2. Symmetrical
Repeats

1.2.4. Glide Reflection

1.2.4. Glide Reflection

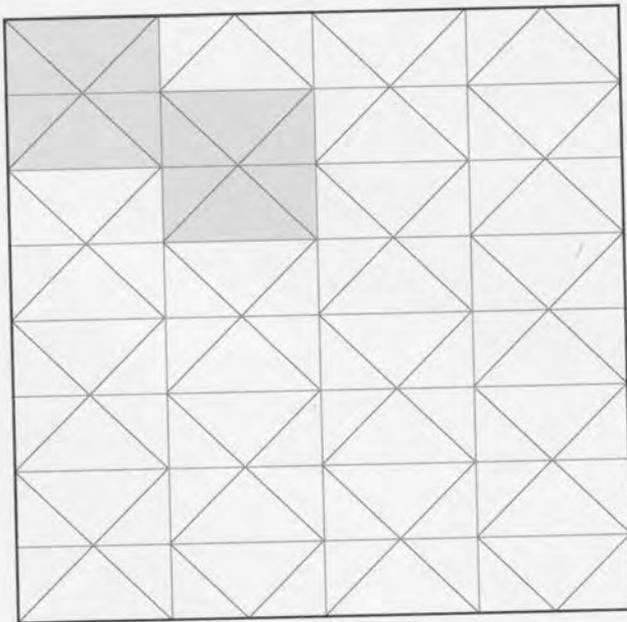
Definition: a motif is translated and reflected, not necessarily in a straight line.

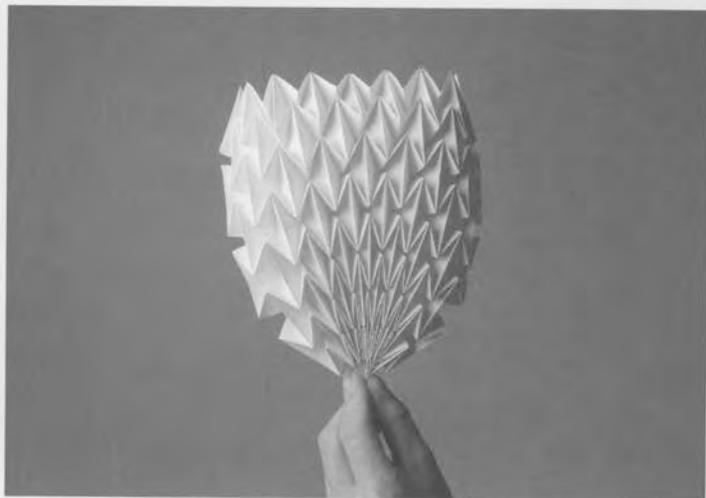
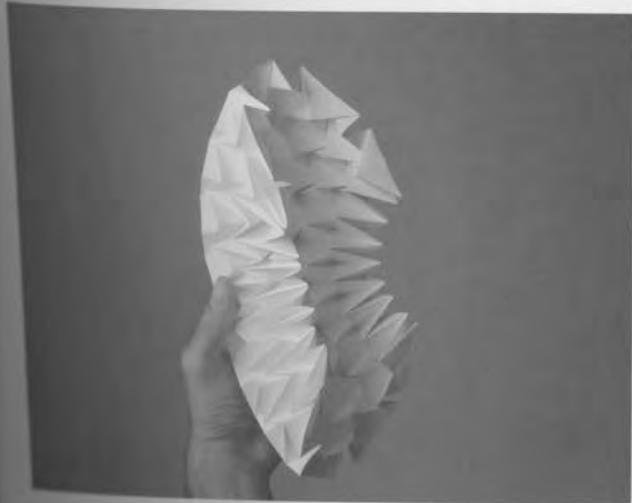
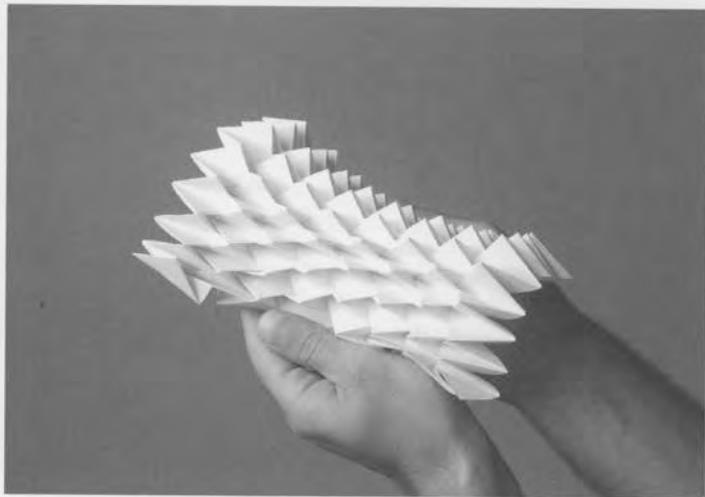
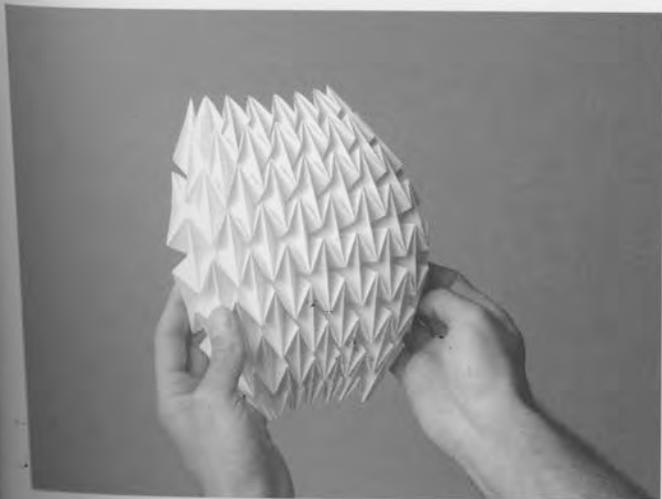
This is the most complex form of symmetry and the one which can take the most time to understand fully. The definition given above is the strictest and most correct definition, but it is often relaxed to include any combination of translation and reflection symmetries. Rules are made to be broken and glide reflection symmetry is a prime example of how designs can be evolved by learning and then disregarding what has been learnt. Essentially, anything goes, but respect, not disrespect, for the rules of symmetry will give you the tools to design patterns of glide reflection symmetry beyond those which are immediately obvious.



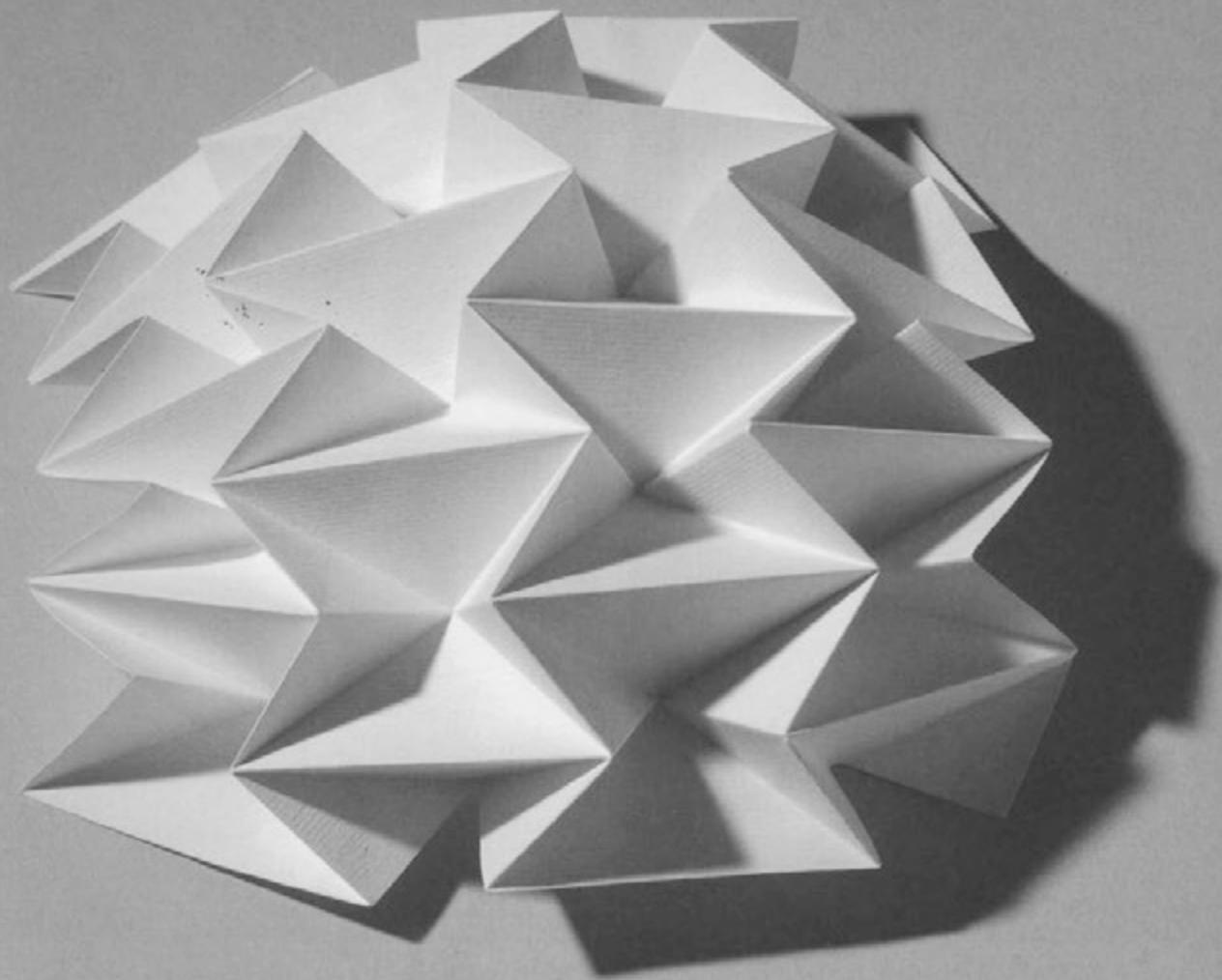
1.2.4. 1

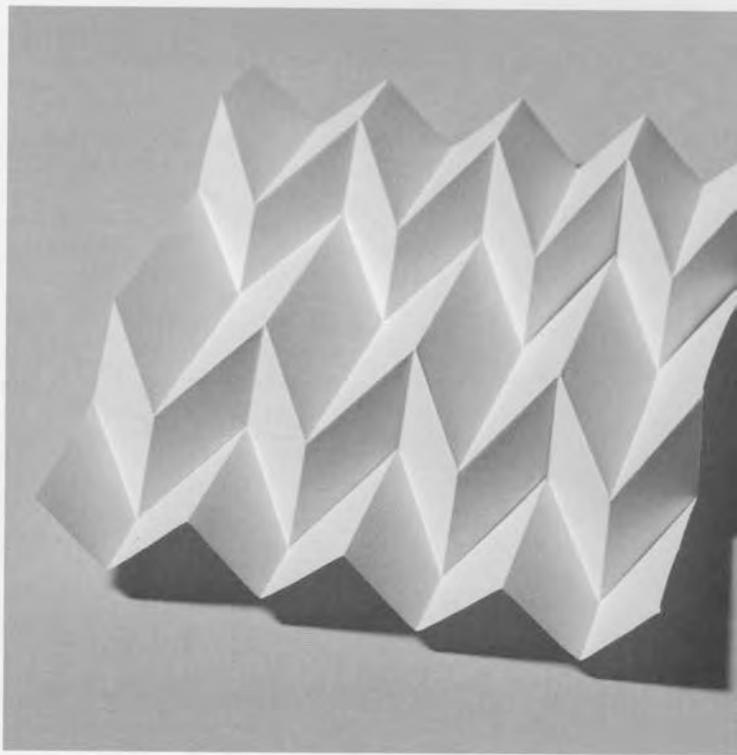
In this simple example of glide reflection, the symmetry of the motif means that it is not apparently reflected. When the two-square motif is repeated across a plane, a complex and extraordinarily flexible surface is created, perhaps one of the most remarkable of all folded forms. See photo on page 42.





Here are some of the many forms which this motif can assume. Note that for extra flexibility this example has four times as many repeats as the diagrammed example opposite.





1.2.4_2

Here, the glide reflection clearly includes a reflection. However, the original motif has also been flipped front to back, so that all the valley and mountain folds have switched. When repeated across a plane, this complex symmetry creates an interesting crease pattern in which the symmetrical repeat is difficult to identify.

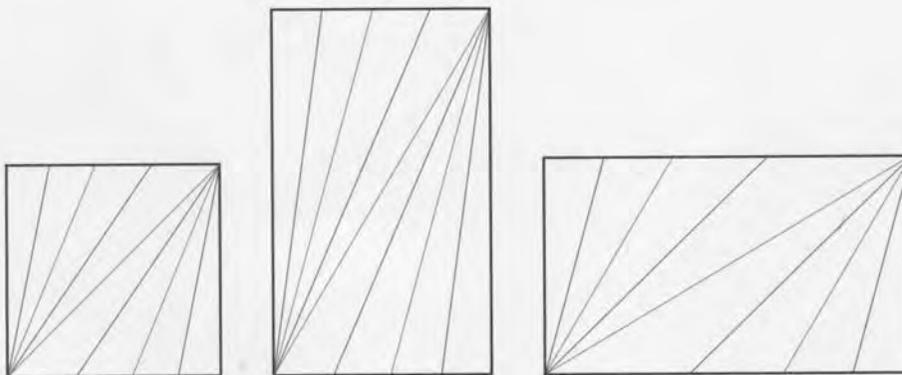
1.3. Stretch and Skew

Stretching and skewing are two simple techniques which do not generate new folded forms when applied, but which create variations of an original form, perhaps better suited to design aspirations. The most natural paper shape to use is a square, but a square might also be considered a cliché, even a tyranny. To transform a square into another shape will transform a folded form into something more bespoke and original.

Stretching and skewing can be combined very effectively with other basic concepts in this chapter, to create forms that are two or three times removed from an original crease pattern motif on a square of paper. These new folded forms can be highly sophisticated and unusual or – frankly – they can be rather contrived and tawdry. Only working with the paper in your hands will separate the good results from the not so good.

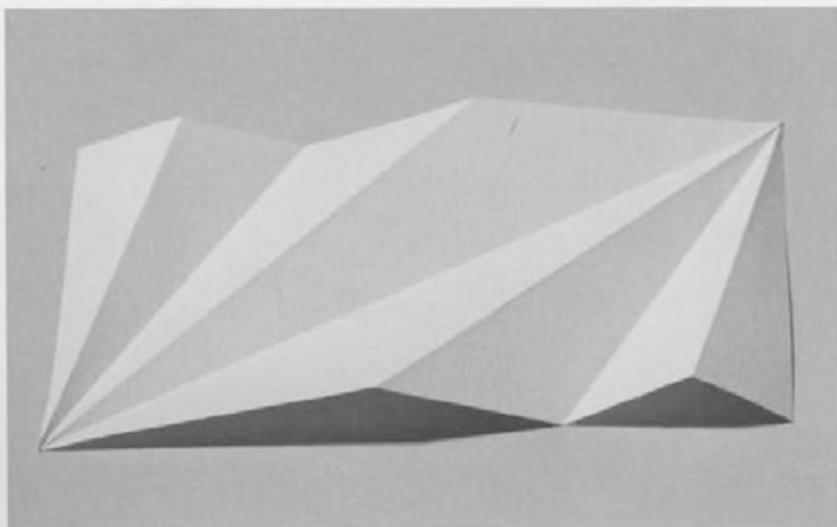
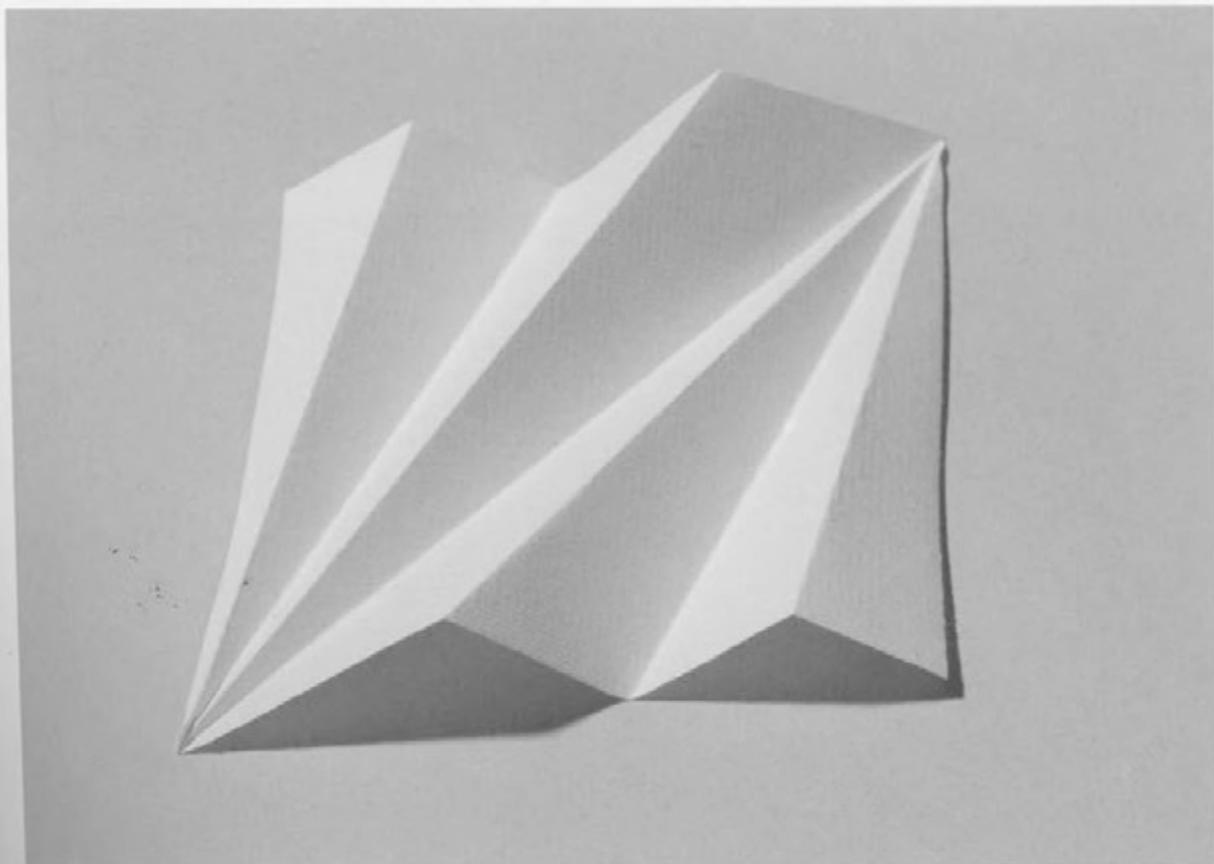
1.3.1. Stretch

A square, when stretched in one specific direction, will create a rectangle. Depending on the original crease pattern, the pattern will transform differently if stretched vertically or horizontally, or it will transform in the same way in whichever direction it is stretched.



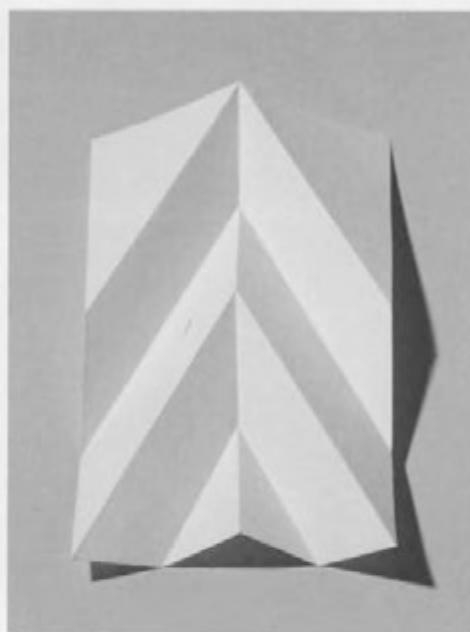
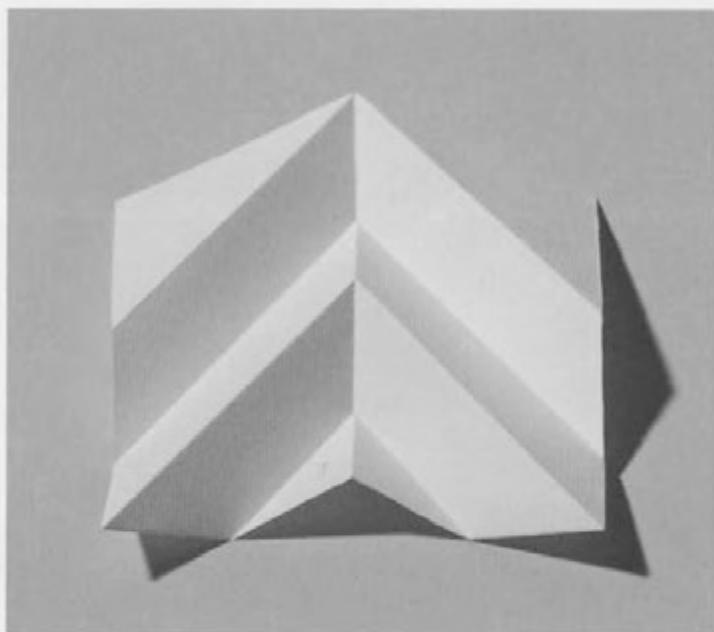
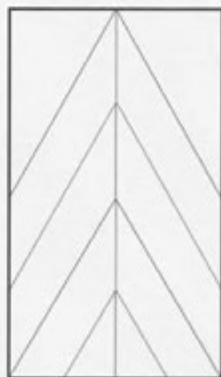
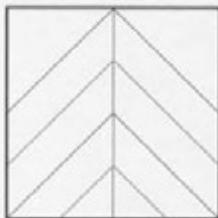
Examples: Set 1

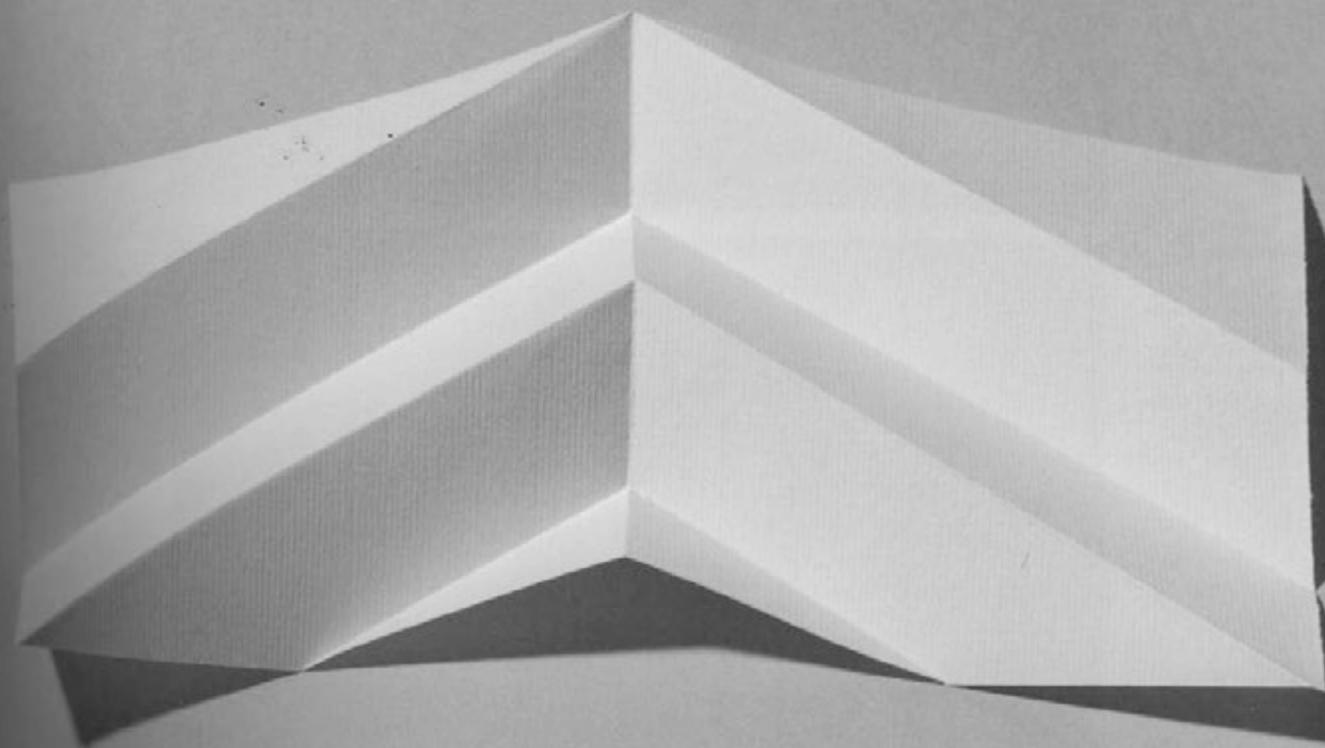
The left-hand illustration above shows a crease pattern made on a square. That square is then stretched vertically (centre illustration) and then horizontally (right-hand illustration) to create stretched variations. See the photos on the opposite page.



Examples: Set 2

In the same way as in Set 1 on page 44 a crease pattern made on a square is stretched vertically and horizontally. The photos below and opposite show how the folded form changes as a result of this process.





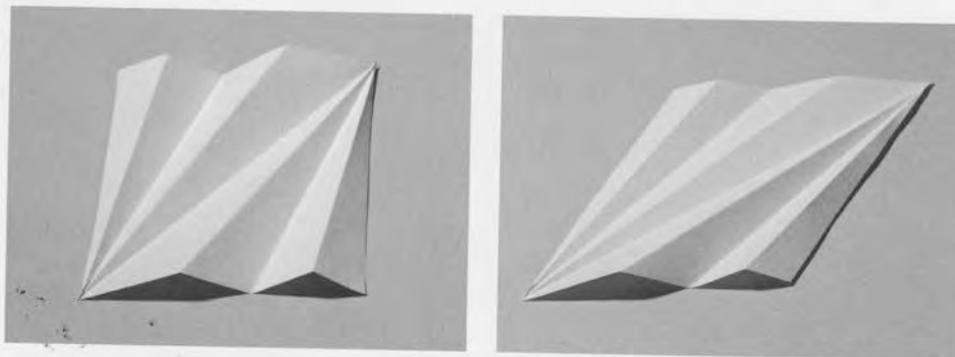
1. BASIC CONCEPTS

1.3. Stretch and Skew

1.3.2. Skew

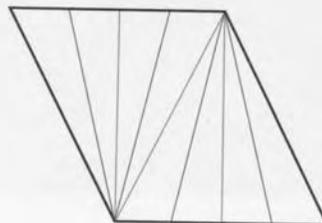
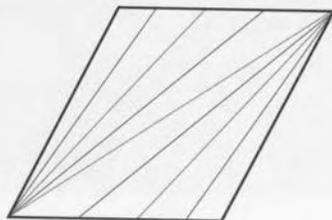
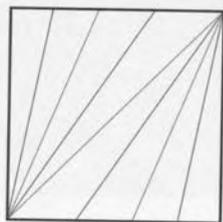
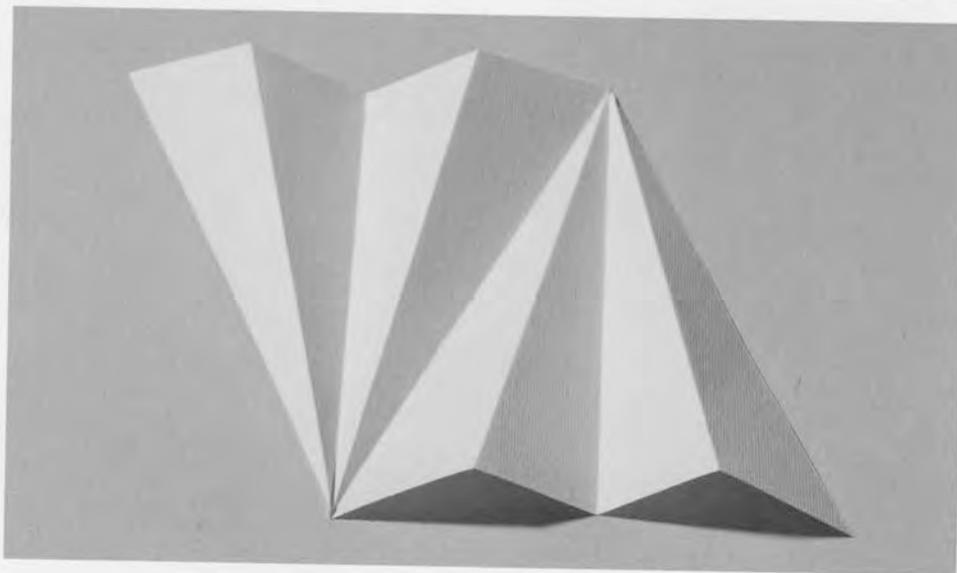
1.3.2. Skew

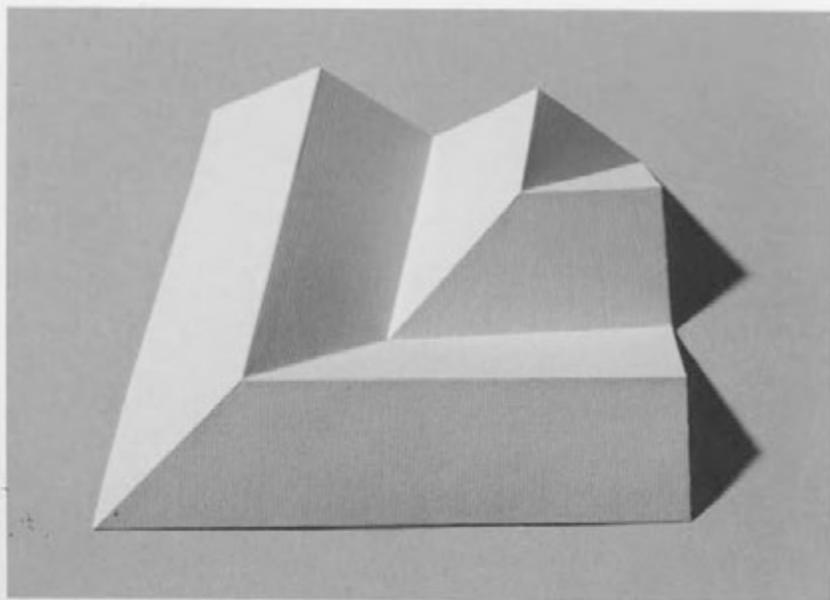
A square skewed to one side will create opposite sides of equal length, but no angle of 90° . The transformations made to a form folded first in square paper are more dramatic than if the square is stretched first (see pages 44–47).



Examples: Set 1

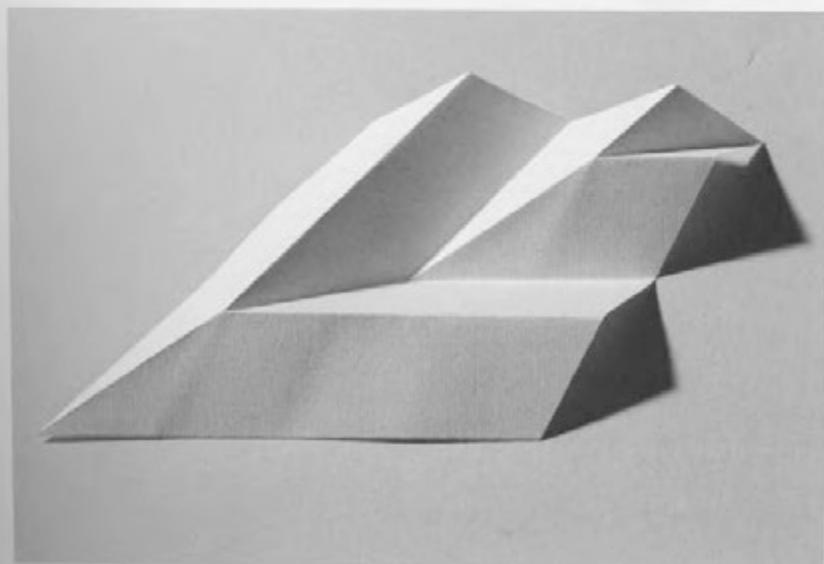
This set takes Set 1 from the Stretch examples (see page 44) and skews the square motif first to the right and then to the left.





Examples: Set 2

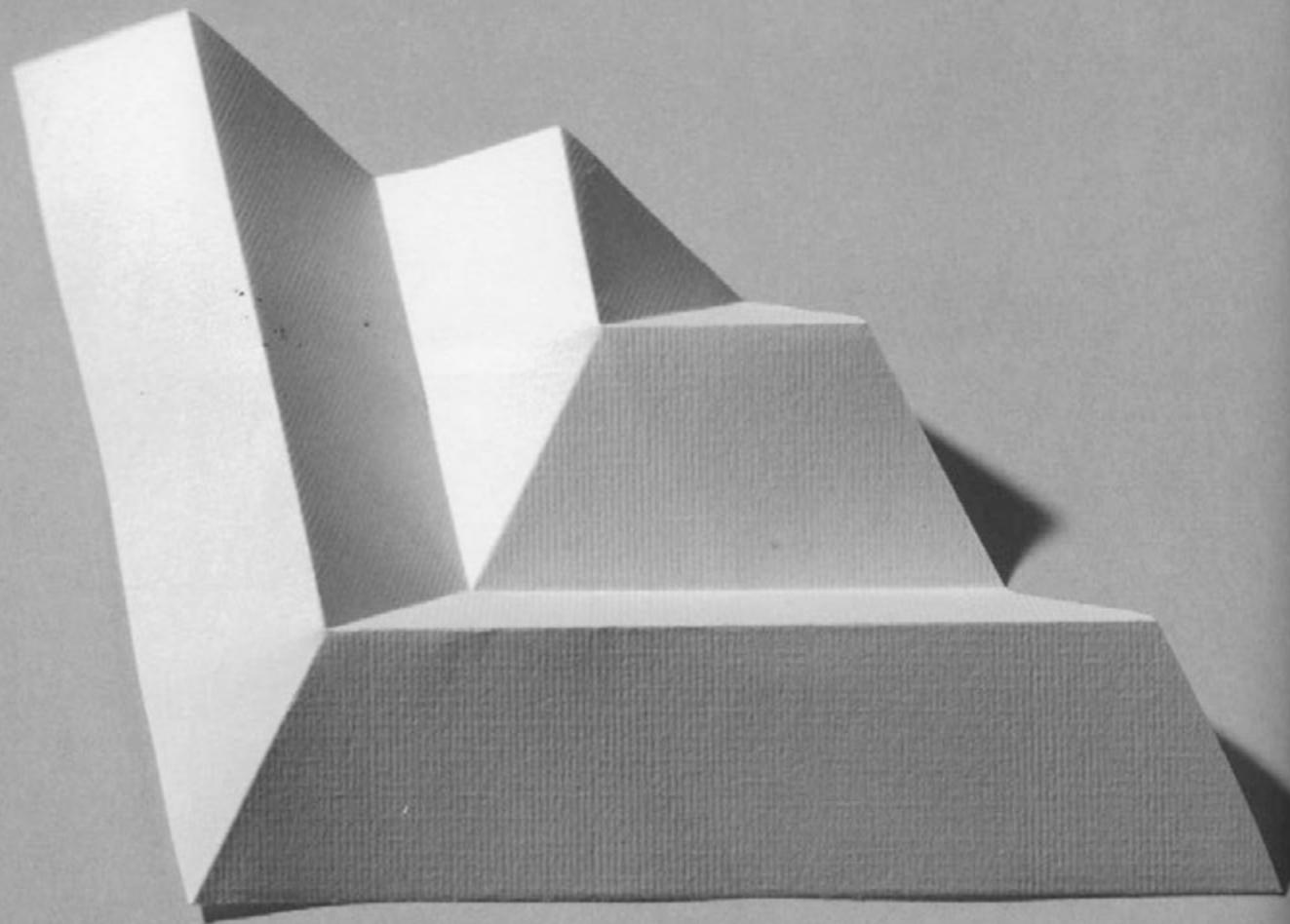
This set takes Set 2 from the Stretch examples (see page 48) and skews the square motif first to the right and then to the left. Two of the photos are on this page. The third photo is overleaf.



1. BASIC
CONCEPTS

1.1. Stretch
and Skew

1.1.2 Skew



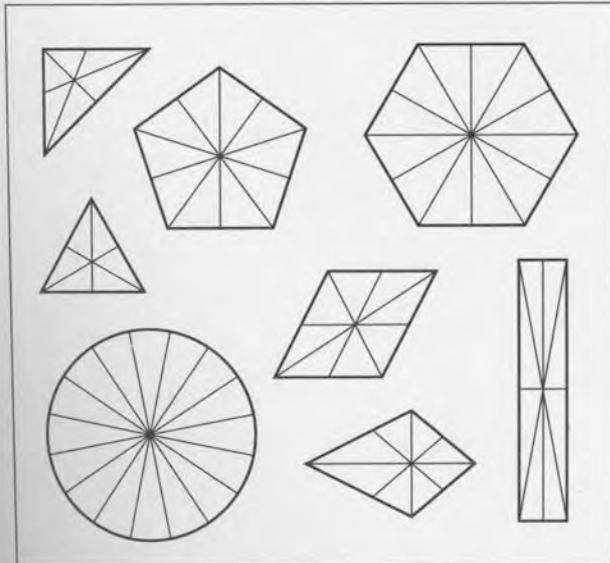
1.4. Polygons

We live in a world of 90° corners. Look up from this book (which itself has 90° corners) and see how many you can find in your immediate surroundings – unless you are sitting under a shady tree surrounded by curvy nature, there are probably more than you would want to count. Occasionally, our choice of this shape is guided by manufacturing constraints or cost, but more often, it is made without thought, as though anything 90° is automatically right.

This automatic choice is also true when folding paper. Every type of paper comes with 90° corners. This is for very practical reasons – mostly concerned with the requirements of different printing processes – but when we fold paper as designers, these 90° corners need not be used at all, or even considered. We are free to use corners of any angle and, by extension, polygons with any number of sides, not just four.

To fold triangles, parallelograms, pentagons, hexagons, circles and papers of any irregular shape can be a liberating experience, but is also somewhat disorientating in our 90° world. However, if you are looking for ways to develop folded forms that don't use squares and rectangles, you are strongly encouraged to adapt them to non- 90° polygons. Sometimes the results will not be worthwhile, but occasionally they will be superb – as always, diligent experimentation is the key to developing quality work.

1.4.1
Here are a few examples
of polygons to consider
when developing new folded
forms. Most do not have
 90° corners.



2. Basic Pleats

Pleats are the most common, versatile and easy-to-use of all folding techniques. This chapter describes how to make the four basic types – Accordion, Knife, Box and Incremental pleats – and shows how even this basic knowledge can be used to create a great diversity of sophisticated surfaces and forms. Although clearly related, these four types of pleat create very different results, so it is worthwhile learning them all.

Techniques of folding are often interconnected. Some of the techniques in later chapters develop the basic pleat patterns introduced here, so time spent on this chapter will enable you to use much of the rest of the book.

The step-by-step diagrammatic instructions here assume a good knowledge of how to divide paper, explained in the 'Dividing the Paper' section (pages 16–30). If you have not read this section and folded the examples it contains, you are strongly recommended to do so before beginning this chapter. You can also use the information in Basic Concepts to develop the examples shown here, by stretching and skewing, and by using other polygons and symmetrical repeats.

2.1. Accordion Pleats

Accordion pleats are basic mountain-valley-mountain-valley pleats in which the folds are spaced equally in either a linear or rotational progression. The equality of spacing makes them particularly easy to fold and creates a satisfying, rhythmic repetition of light and shade.

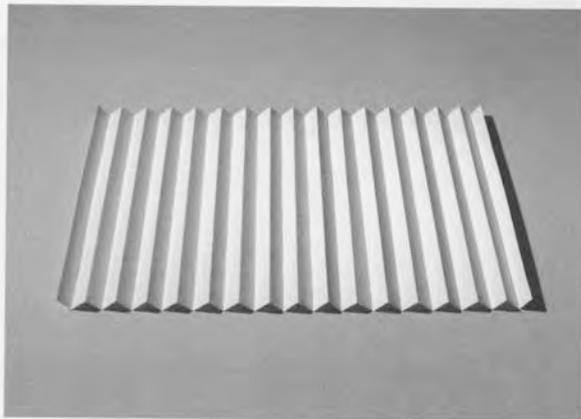
Their simplicity also means that instead of focusing your creativity on the folding pattern, you can give your attention to the relationship between the pleats and the shape of the paper (or other material) from which they are made. The paper shapes shown here are just a few of the very many which, with a little imagination and experimentation, can be developed.

2.1.1 Linear



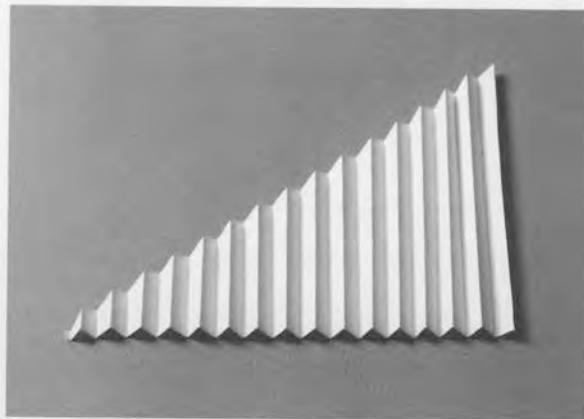
2.1.1.1

This is the simplest example of an Accordion pleat – actually a recreation of the Linear Thirty-seconds example on page 19 of the Basic Concepts chapter.



2.1.1.2

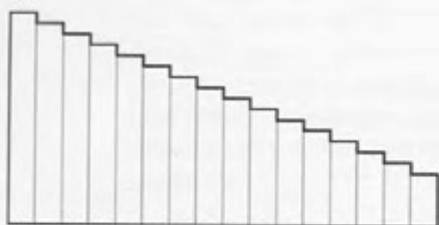
A slope creates a complex zigzag edge when the pleats are gathered together. Try mirroring the shape to the left or below to create extra zigzag edges.



2. BASIC PLEATS

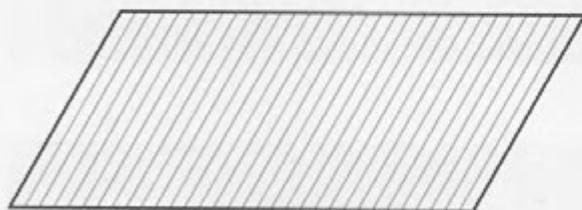
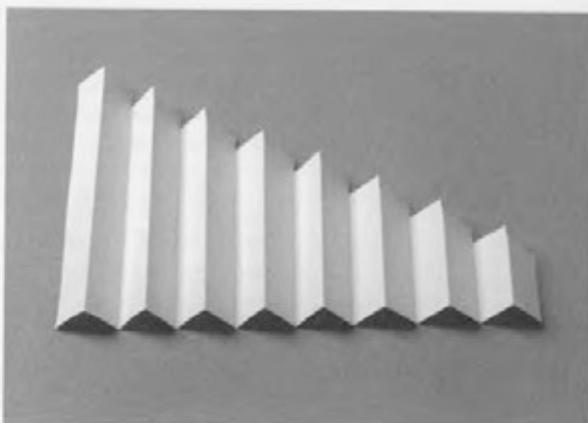
2.1. Accordion Pleats

2.1.1 Linear



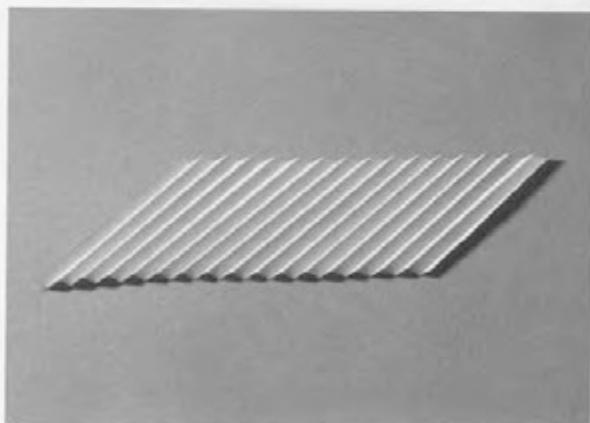
2.1.1_3

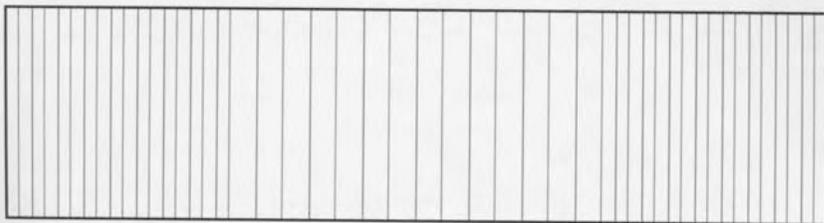
Instead of a sloping edge, create a stepped edge. Experiment widely with the shape of the cut edge – it can become extremely complex, perhaps even figurative or typographic.



2.1.1_4

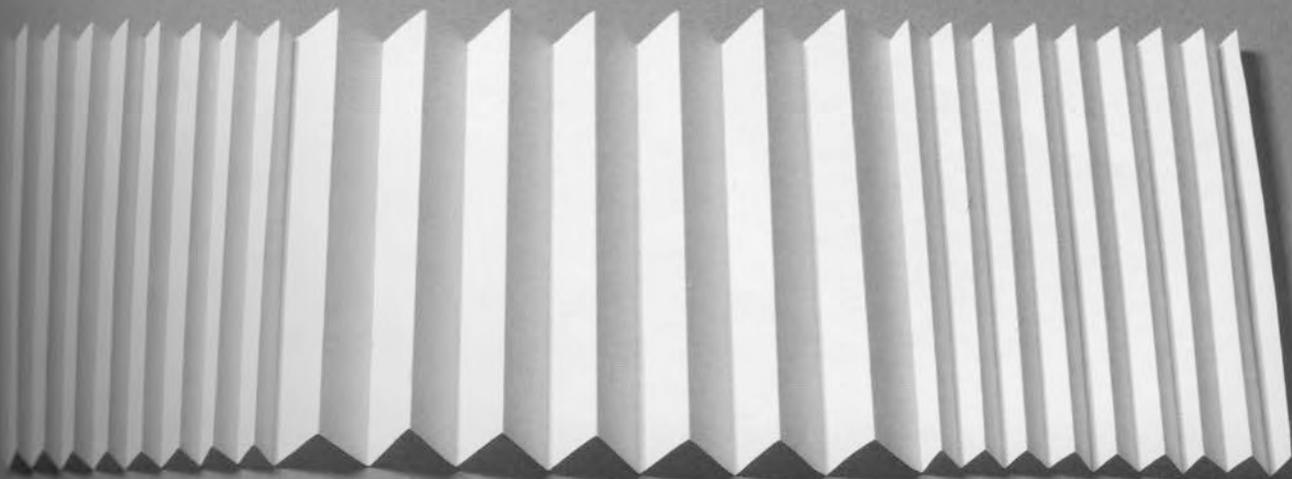
A basic rectangle may be skewed to create a parallelogram (see page 40). Experiment with the angle of skew and the spacing of the pleats to create different effects.

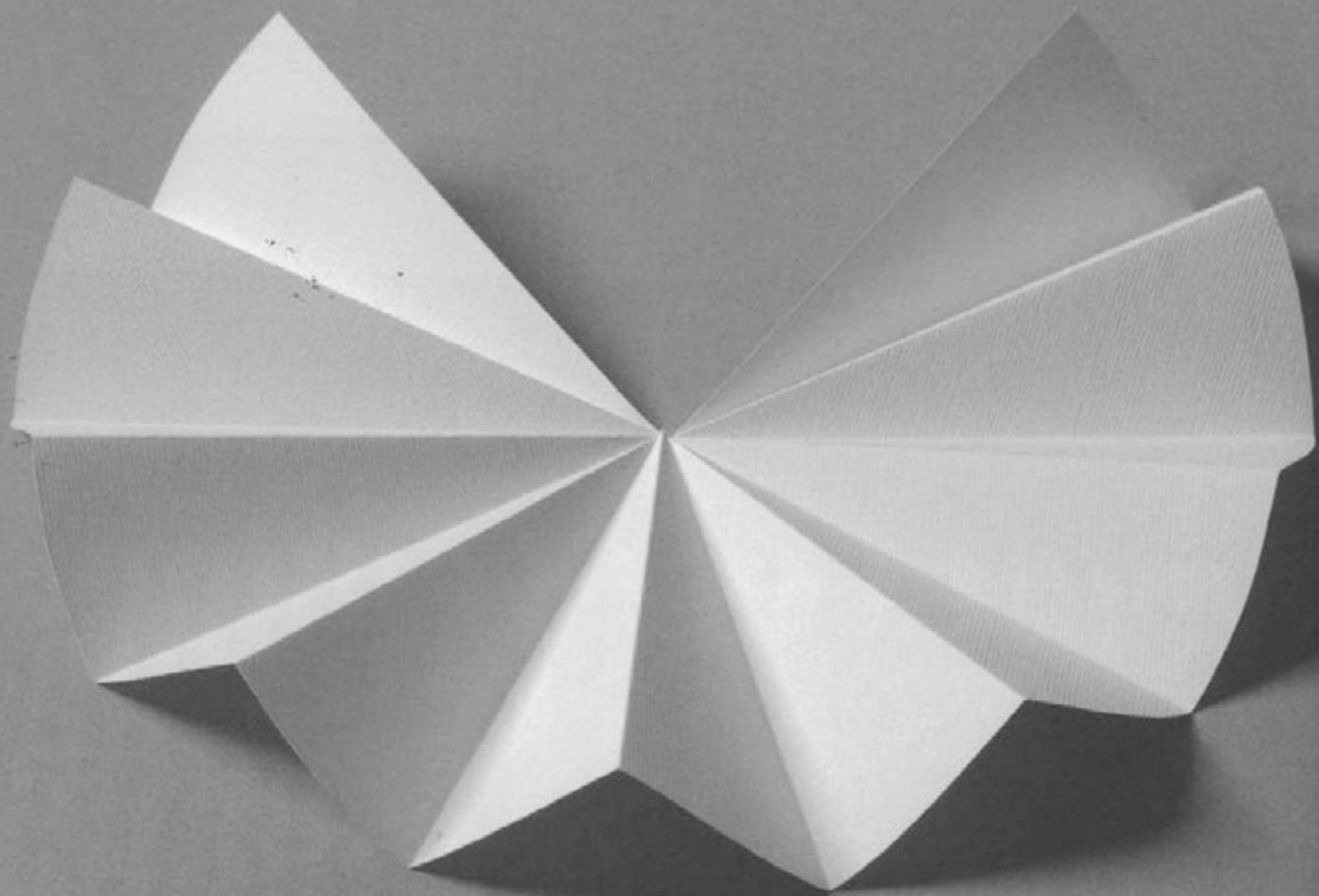




2.1.1_5

Accordion pleats, although defined as regularly spaced, can nevertheless be grouped together in a sequence of spacings. In this example, the larger pleats in the centre are twice the size of the flanking pleats, though a great number of other patterns could be devised.





2.1.2 Rotational

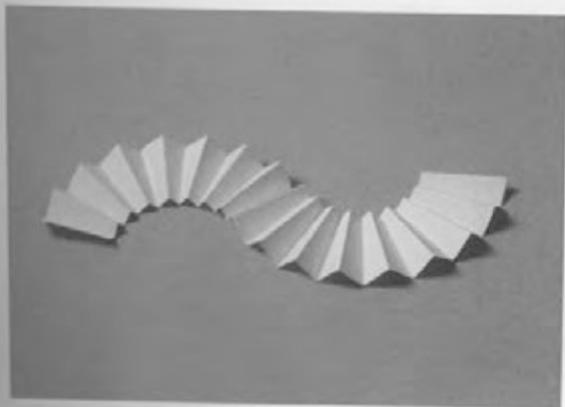
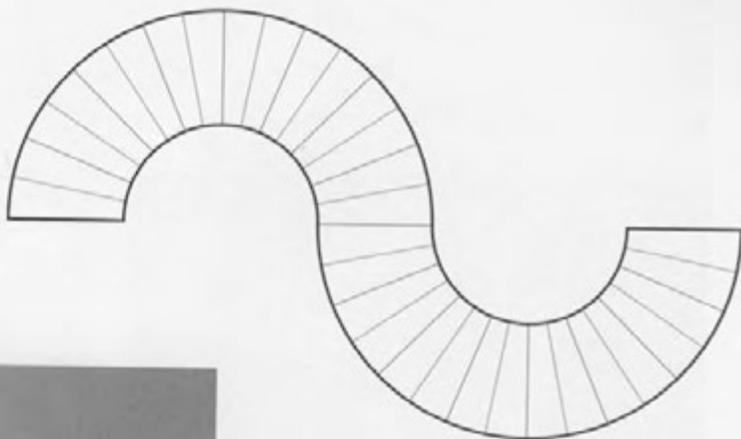
2.1.2_1

This basic rotational Accordion pleat divides a 360° circle into 16 equal angles, recreating the Rotational Sixteenths examples on pages 24–25.



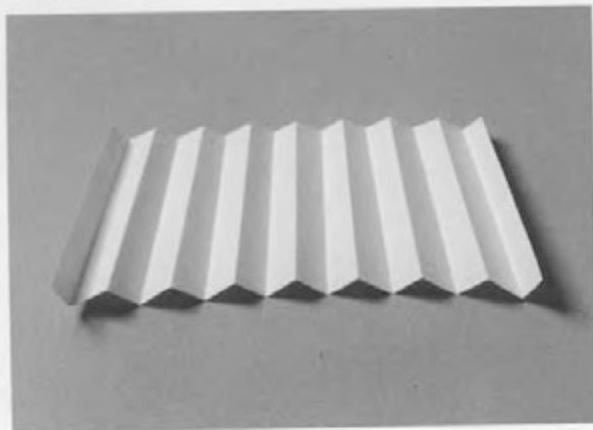
2.1.2_2

Two semicircles are divided into sixteenths and joined end to end to create a letter 'S'. The pattern could continue infinitely.



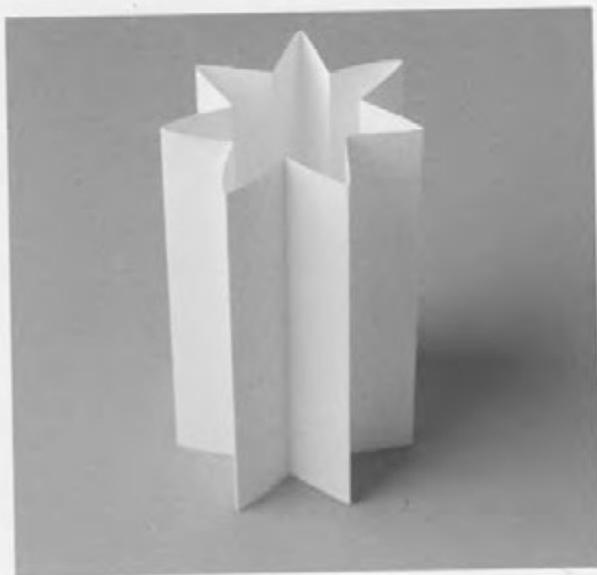
2.1.2_2

- 2. BASIC PLEATS
- 2.1. **Accordion Pleats**
- 2.1.2. Rotational
- 2.1.3. Cylinders and Cones



2.1.2_3
 Although the folds are rotational, no curved edges are used here. Note how all the folds would meet at an imaginary point. This example can be made quickly, without measuring any angles, using the Linear Sixteenths method (see pages 16-17).

2.1.3 Cylinders and Cones

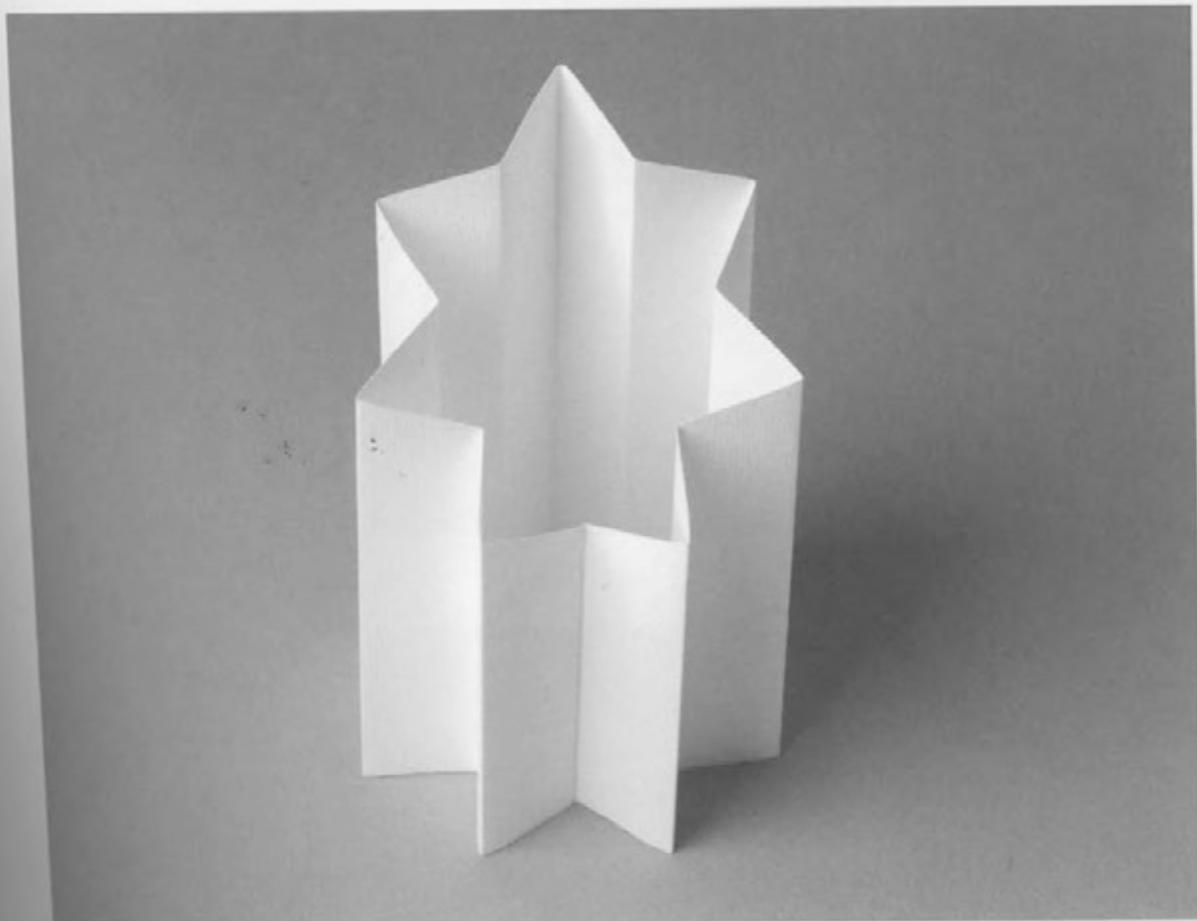


2.1.3_1
 A simple cylinder can be made by gluing one end of a line of Accordion pleats to the other. The example here shows the paper divided into sixteenths, but with one division cut off to leave an odd number - fifteenths. By creating an odd number of pleats, only one division needs to be glued and overlapped, not two divisions, so the paper will more readily assume a symmetrical star shape.

BASIC PLEATS

21. Accordion Pleats

21.3. Cylinders
and Cones



21.3_2

The paper can also be cut to create an angle rather than a level edge. It may be cut into a silhouette that is much more complex than the simple one shown here. The bottom edge may also be cut. Note that as in the previous example, the paper is divided into fifteenths, not sixteenths, and only one division is overlapped and glued.



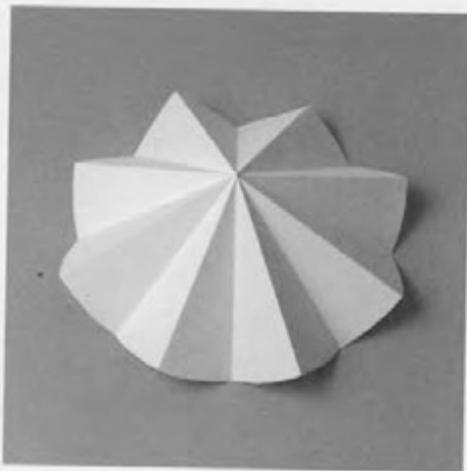
2. BASIC PLEATS

2.1. Accordion Pleats

2.1.3. Cylinders and Cones

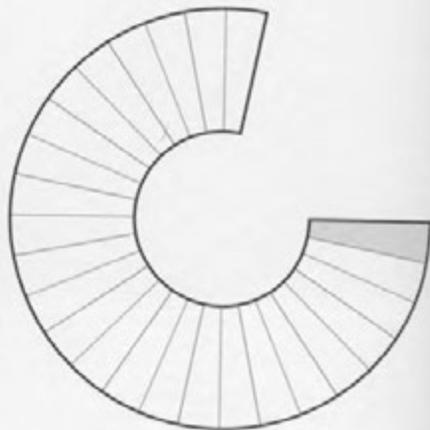
2.1.3.3

A circle of paper is divided into 16 equal angles. The paper may be divided into any even number of angles, though the greater the number, the messier the centre point where all the folds meet will become. The circular shape of the paper may also be cut into a more complex shape.



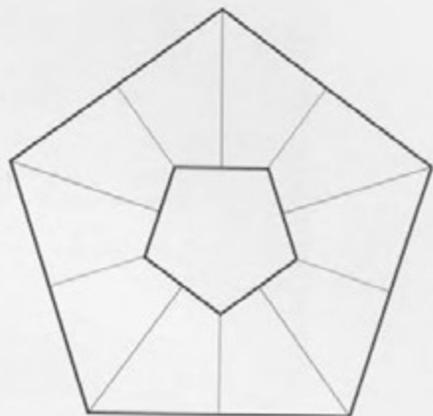
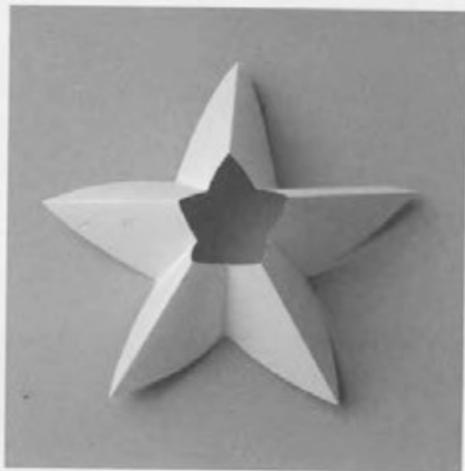
2.1.3.4

A solid circle may also be cut as a doughnut. Removing the centre of the paper makes it easier to add more folds and the shape has much more flexibility. Removing part of the 360° circle and glueing the ends together converts a flat zigzag into a cone.



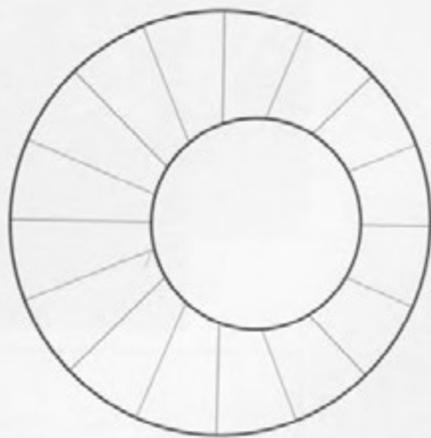
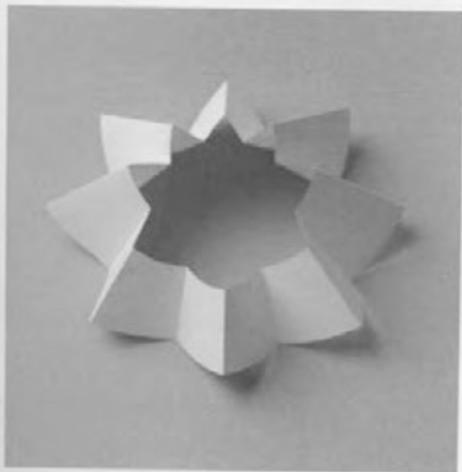
2.1.3.5

Here, the paper is cut into the shape of a pentagon and the 360° angle is divided into ten equal angles. For added interest, the small cut-out pentagon in the centre is rotated through 36° in relation to the outer pentagon.



2.1.3.6

When making doughnuts, the inner cut-out shape need not be placed symmetrically in the centre – it can be moved off centre. The result is subtle and somewhat curious.

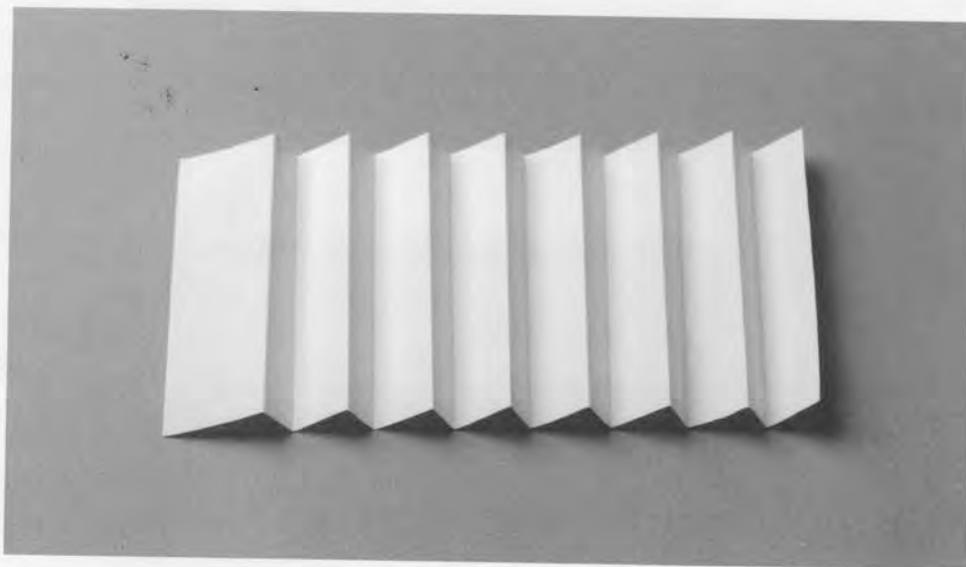


2.2. Knife Pleats

Knife pleats are basic mountain-valley-mountain-valley... pleats placed in either a linear or rotational progression, but the spacing between the mountain-valley pairings differs from the spacing between the valley-mountain pairings.

Whereas the equality of the spacing of Accordion pleats makes them compress into a 3-D zigzag pile, the inequality of the spacing of Knife pleats means the pile will travel to the left or right, to create a 2-D surface. Being able to create a surface, plus the ability to define or change the inequality of the spacing between the folds, means Knife pleats are generally more useful – and so more commonly used – than Accordion pleats.

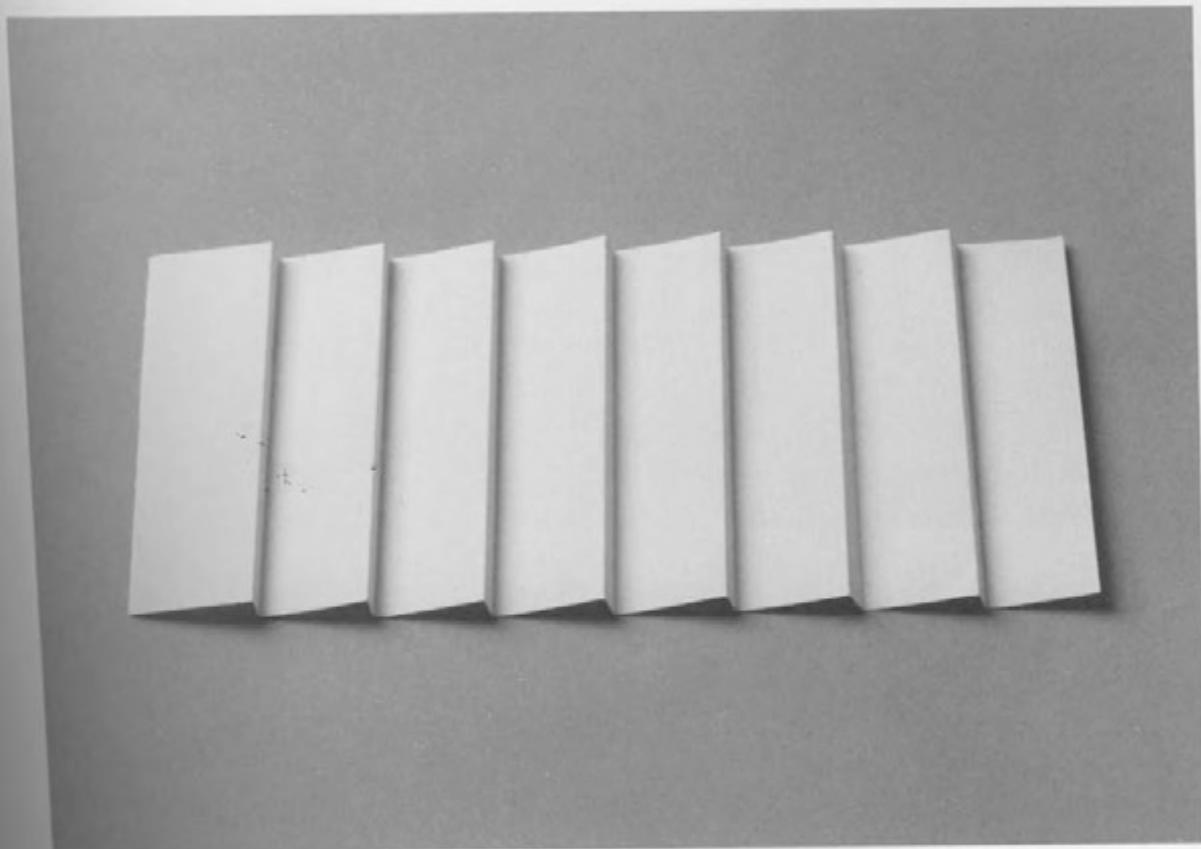
2.2.1. Linear



2.2.1_1

A strip of paper is divided into eighths with mountain folds, then valley folds are placed one-third of the way between each mountain to create a 1-2-1-2-1-2 rhythm of Knife pleats across the paper. This may all be done by eye, or you may choose to measure the accurate placement of the valleys with a ruler.





2.1.2

Here, the mountain eighths have valley folds placed one-fifth of the way between them, to create a 5-1-4-1-4-1-4-1-4-1-4-1-4 rhythm across the paper. The effect is to space the knife pleats farther apart than in the first example and to create an undulating surface.

5 1 4 1 4 1 4 1 4 1 4 1 4

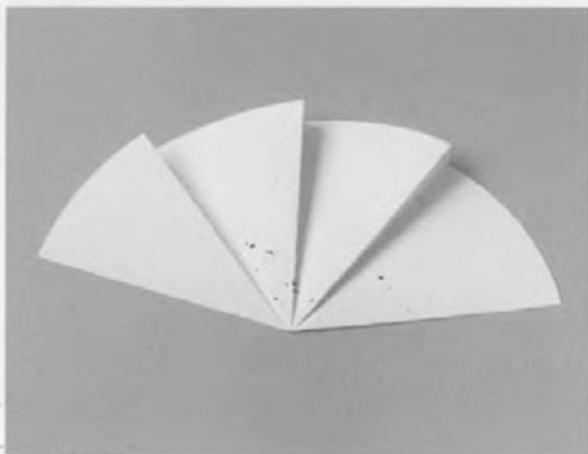


2. BASIC PLEATS

2.2. Knife Pleats

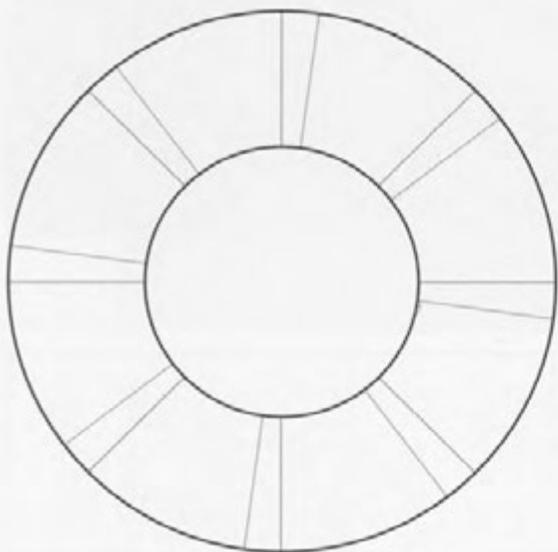
2.2.2. Rotational

2.2.2. Rotational



2.2.2_1

Here, Knife pleats are arranged around a semicircle. The shape could also be a full circle or a polygon, and the distance between the mountain and valley folds that make the pleat could also change.



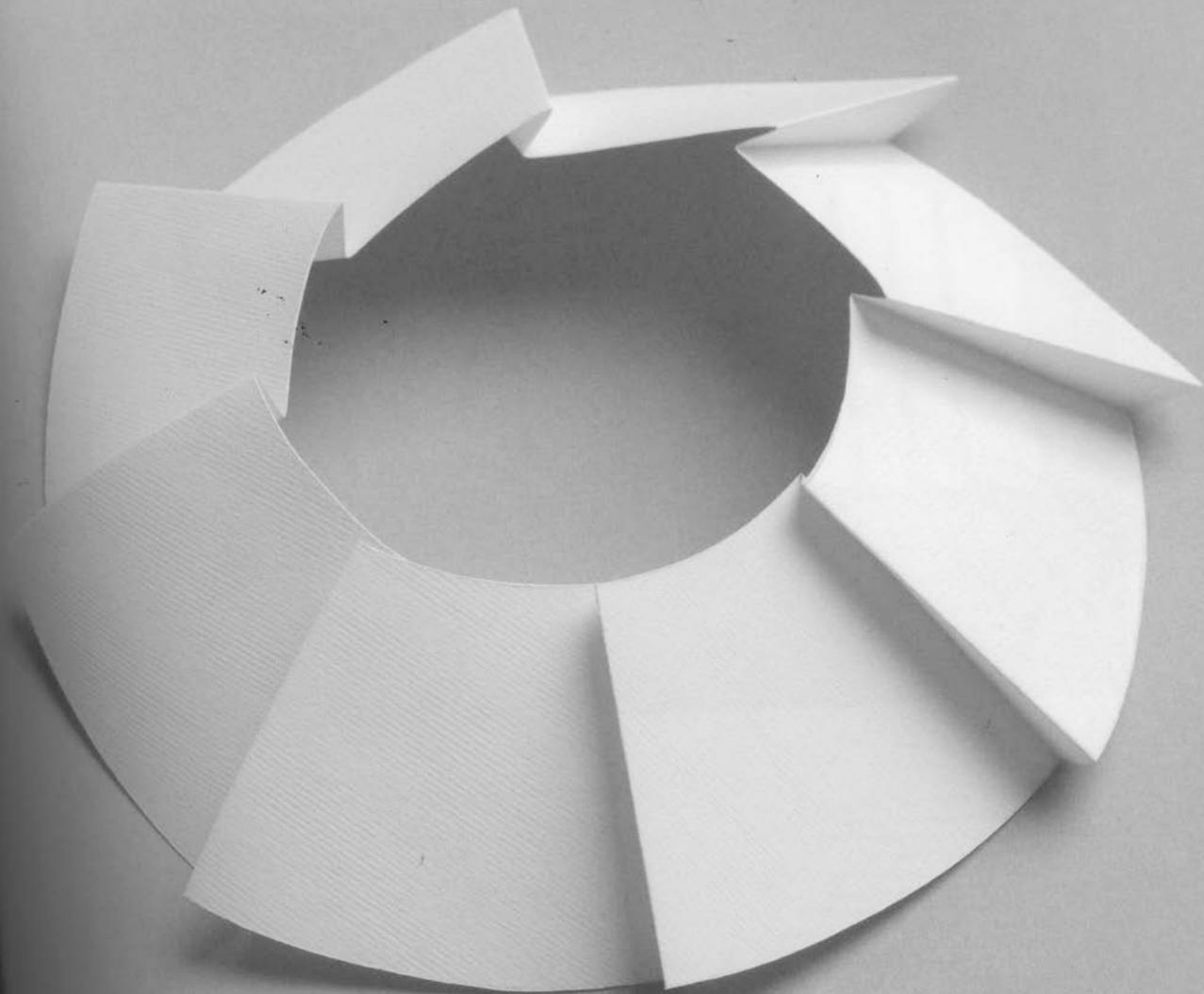
2.2.2_2

This doughnut has eight Knife pleats arranged around the rim. Note how all the folds would converge at the imaginary centre and how the two folds in each pair are not parallel to each other.

BASIC PLEATS

Knife Pleats

Rotational

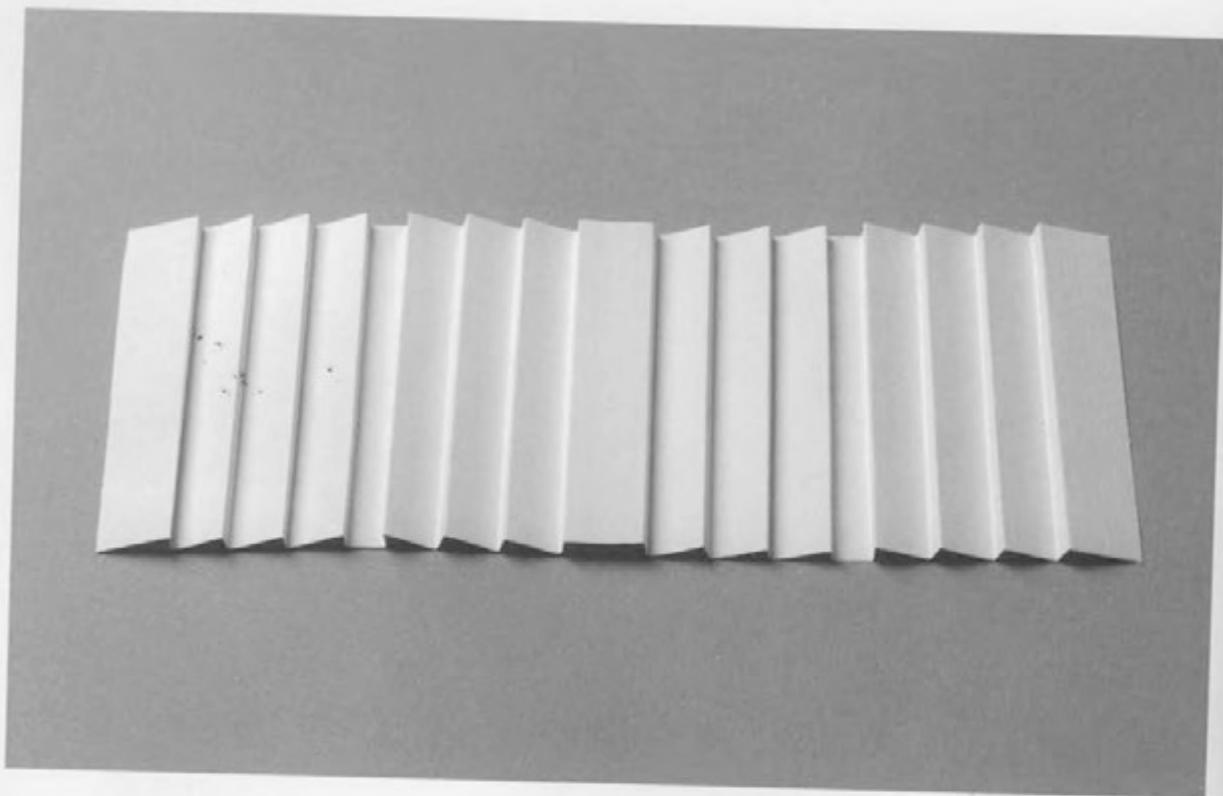


2. BASIC PLEATS

2.2. Knife Pleats

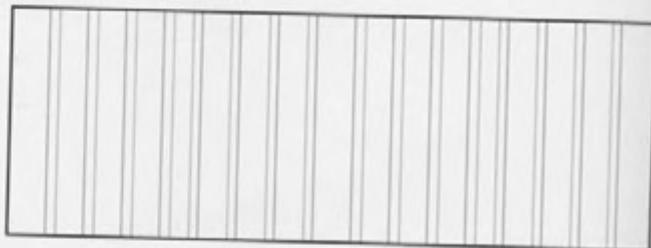
2.2.3. Reflected

2.2.3. Reflected

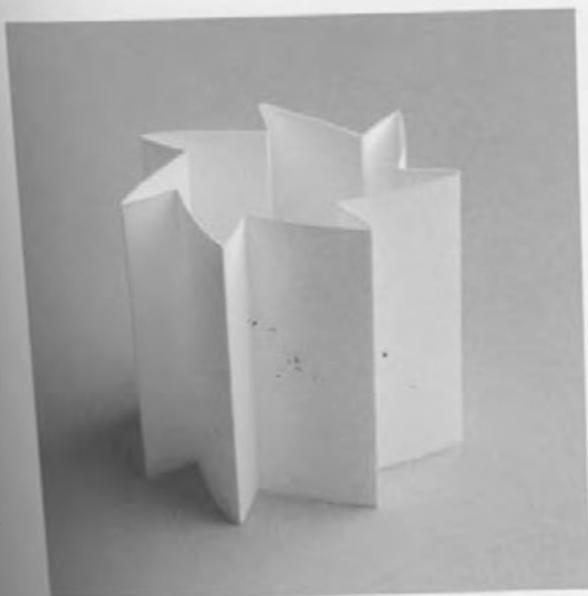


2.2.3_1

A succession of Knife pleats can run in a linear or rotational progression, then be reflected (see 'Reflection' section on page 35). In effect, the reflection symmetry creates a mirror image, so that a descending line of Knife pleats suddenly ascends again (or vice versa). The example shown here divides a paper strip into 17 equally spaced mountain folds. The valley folds are one-quarter of the way between each mountain. Many other reflected Knife pleat patterns are possible.



2.2.4. Cylinders and Cones



2.2.4_1

A line of conventional Knife pleats can create a cylinder if one end is glued and joined to the other end. The top and bottom edges can be cut into a variety of complex shapes.



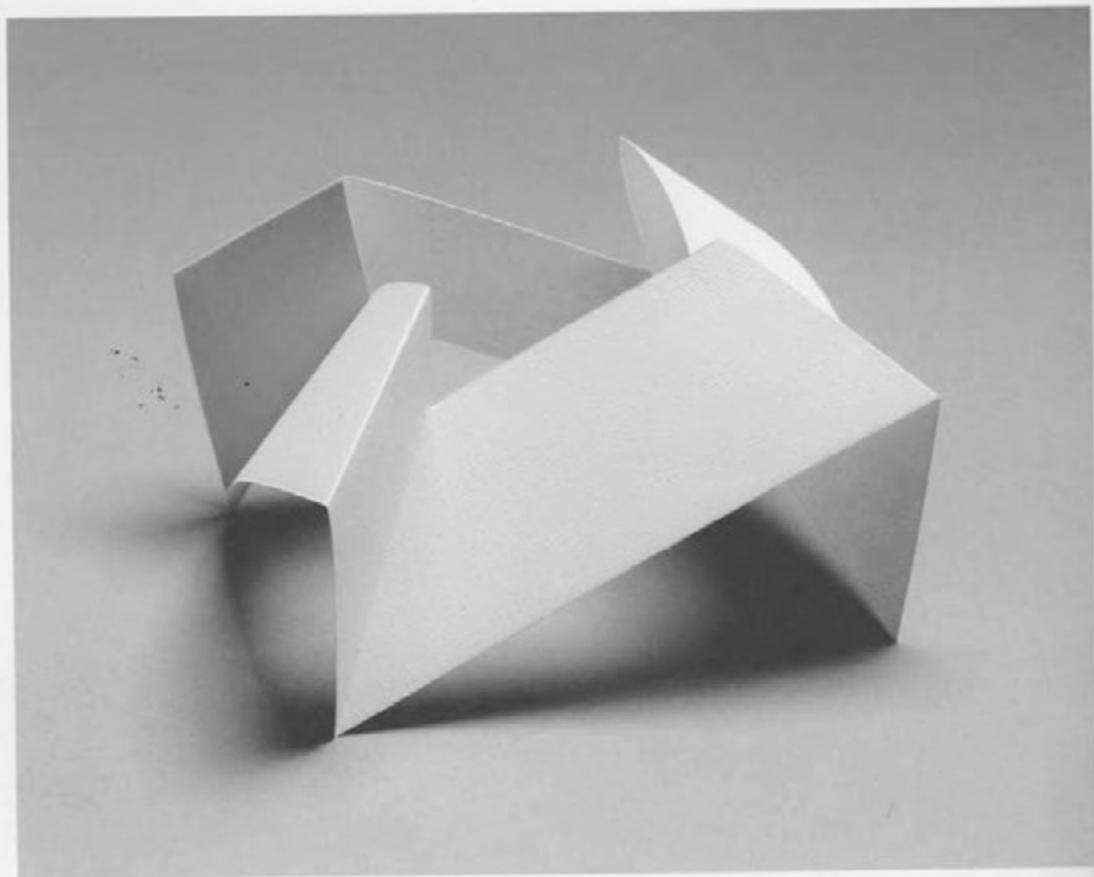
2.2.4_2

Rotational Knife pleats will create a cone. The greater the number of Knife pleats and the closer they are together, the more vertical the cone will be. Conversely, fewer, narrower pleats will create a relatively flat cone.

2. BASIC PLEATS

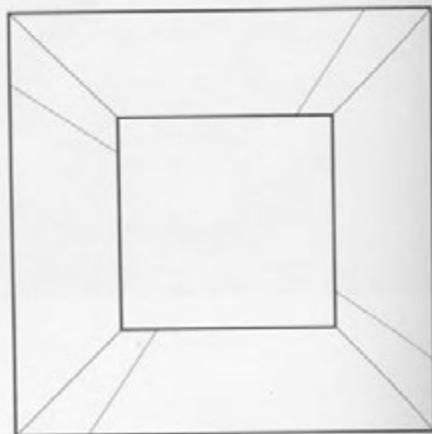
2.2. Knife Pleats

2.2.4. Cylinders
and Cones



2.2.4_3

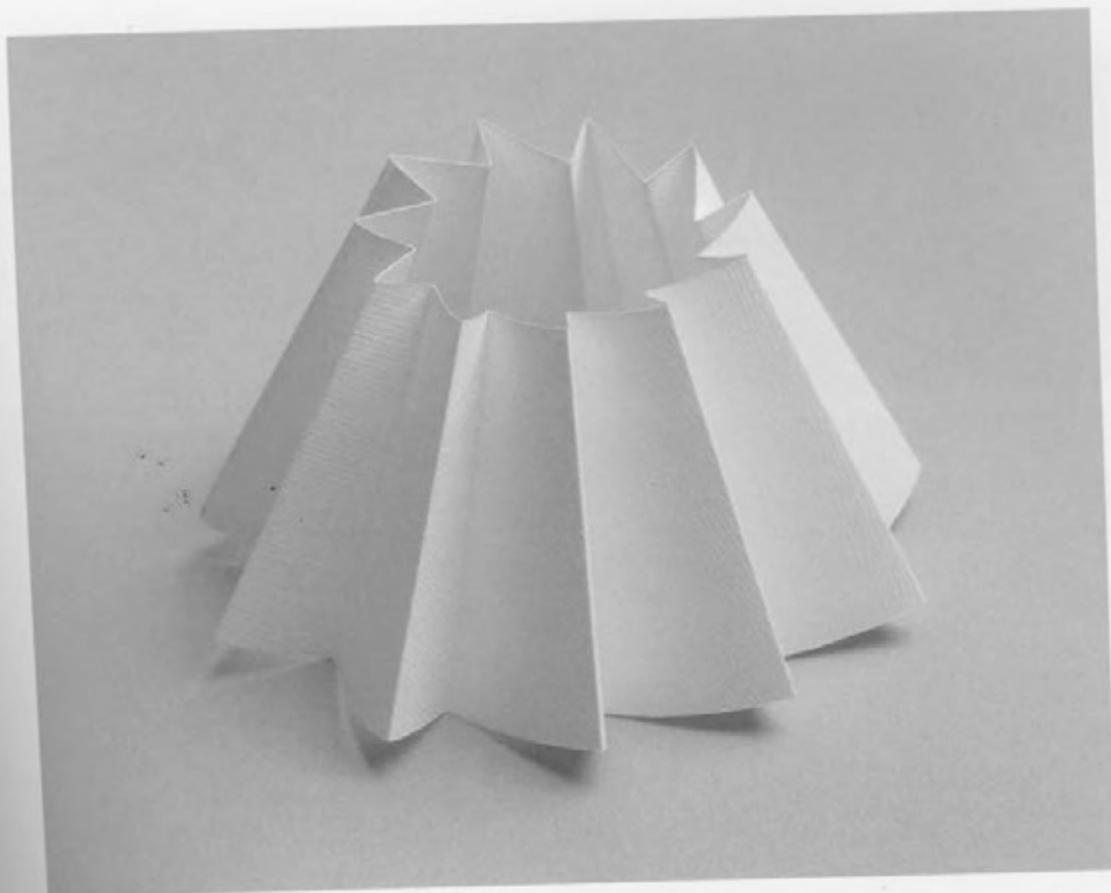
A circular cone can instead be cut as a straight-sided polygon, to create a pyramid effect. Here, the top of the pyramid has been removed. Pyramids can be made with any number of sides, though the more sides they have, the more they will resemble a circular cone.



BASIC PLEATS

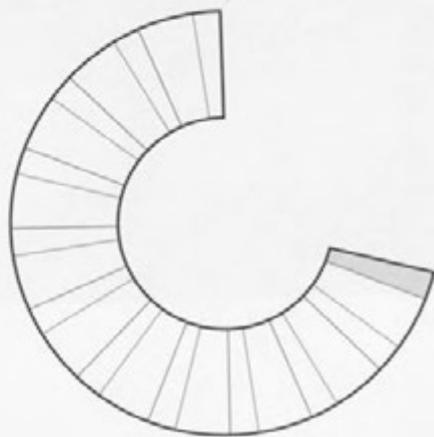
Knife Pleats

Cylinders
and Cones



2.2.4_4

The exact slope of a cone can be carefully controlled by using not a full circle but part of one, and by changing the number and frequency of the Knife pleats. When the ends are joined, cones of a precise shape can be created.



2. BASIC PLEATS

2.3. Box Pleats

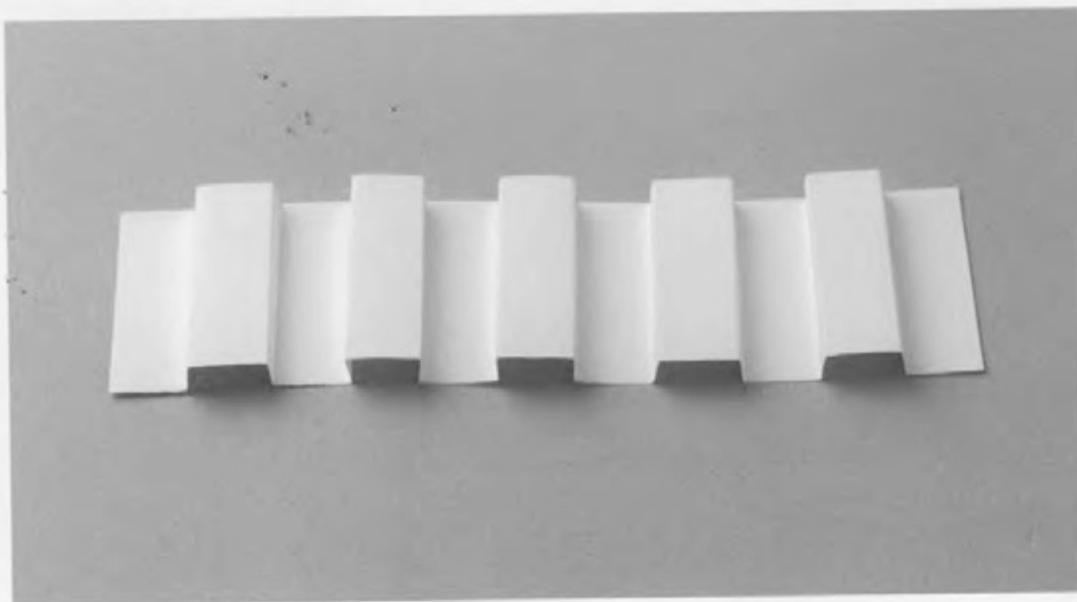
2.3.1. Linear

2.3. Box Pleats

Box pleats are a group of four folds, repeated in either a linear or rotational progression across a surface. The group begins with a simple Knife pleat valley-mountain pairing, which is then mirrored as a mountain-valley pairing, to create a valley-mountain-mountain-valley pattern which can be repeated across a surface.

Like Knife pleats, Box pleats have the ability to create a 2-D surface. However, whereas Knife pleats appear to ascend or descend across the surface like a flight of steps, Box pleats remain on a level and are thus less visually dynamic but more stable.

2.3.1. Linear



2.3.1_1

This is the most basic Box pleat pattern, visually identical on the back. Note the alternating pairs of valley-mountain and mountain-valley pleats. The columns will nestle against each other when the paper is completely flat.

2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2



BASIC PLEATS

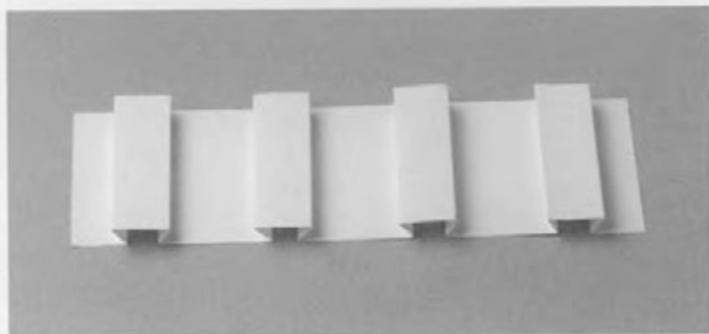
Box Pleats

Linear

2.3.1_2

The pattern of valley-mountain and mountain-valley folds is identical to the previous example, but the columns will separate when the paper is flattened. They could be further separated. Note that when the columns are separated, the back is no longer identical to the front.

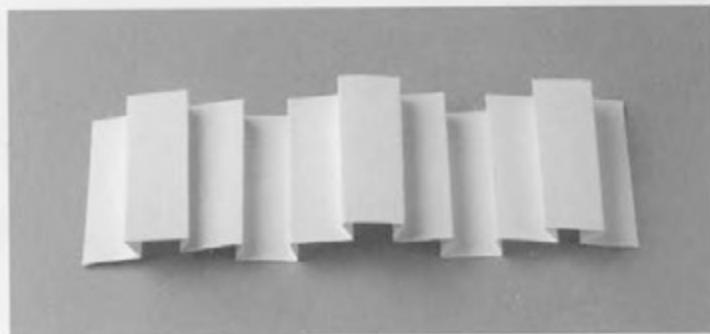
2 1 2 1 4 1 2 1 4 1 2 1 4 1 2 1 2



2.3.1_3

In this example, the columns alternate from the front to the back along the strip. This separates the columns and also makes the front and back visually identical.

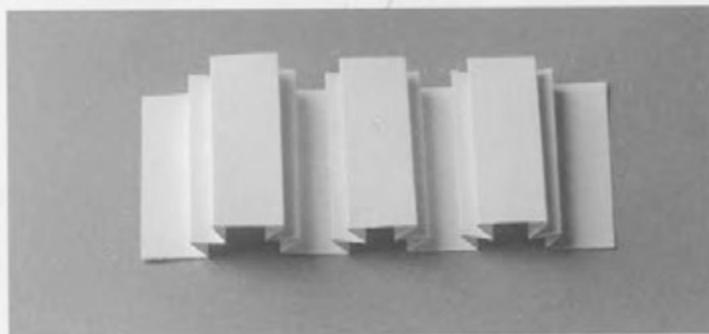
2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2



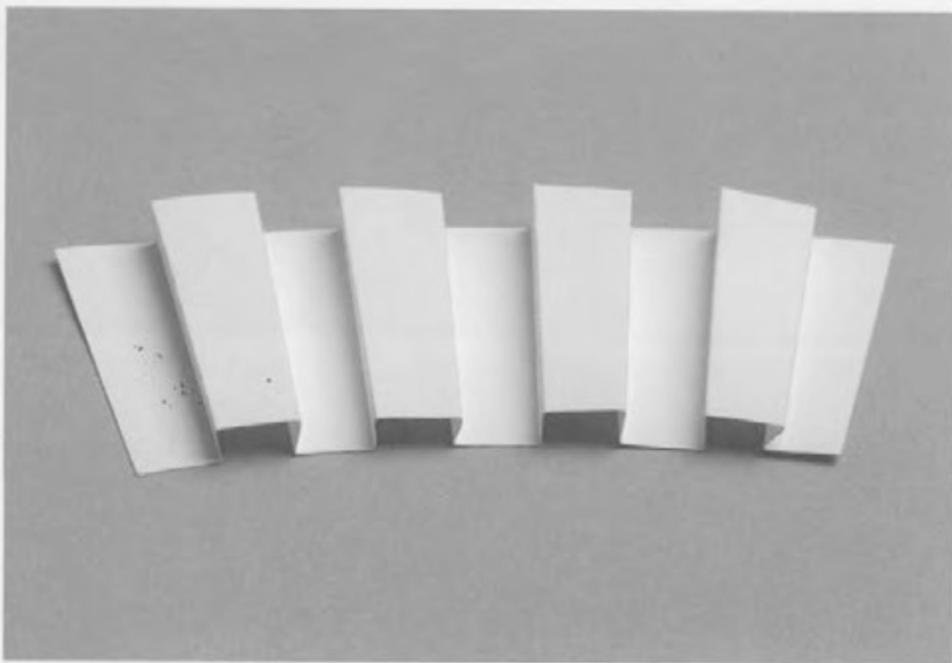
2.3.1_4

Two pleats can be given an extra pleat (or two or more) to create very complex variations. The possibilities of these extra pleats are immense and can be applied to most of the examples in this section.

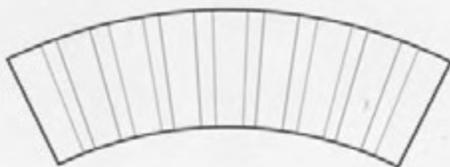
2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 2 1 1 1 2



2.3.2. Rotational

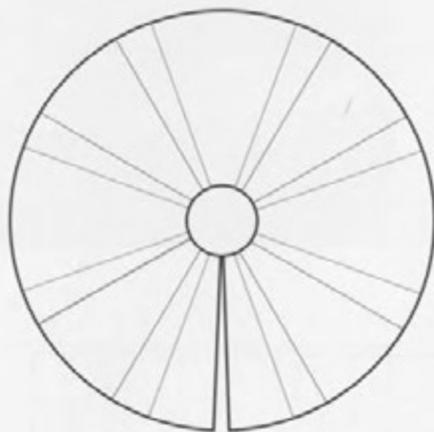


2.3.2_1



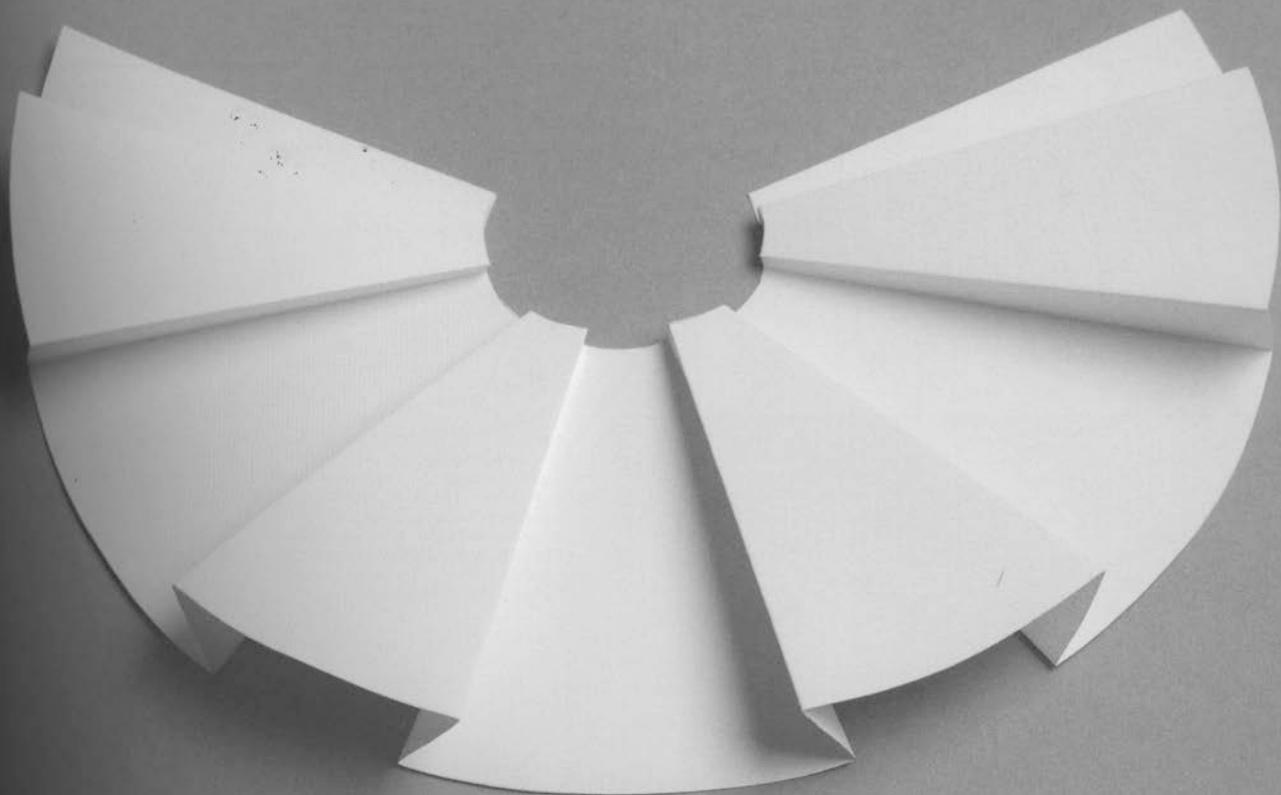
2.3.2_1

Here, a basic Box pleat pattern is configured around the arc of a circle. Note how all the folds would extend to converge at the imaginary centre of the circle.



2.3.2_2

Four large Box pleats are arranged around a full circle. The convergence of 16 folds in the centre could potentially be very unattractive, so a small circle has been cut away in the middle.

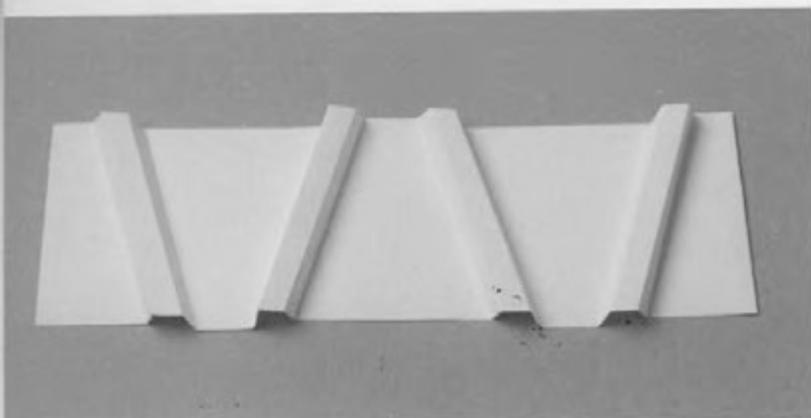


2. BASIC PLEATS

2.3. Box Pleats

2.3.2. Rotational

2.3.3. Cylinders and Cones

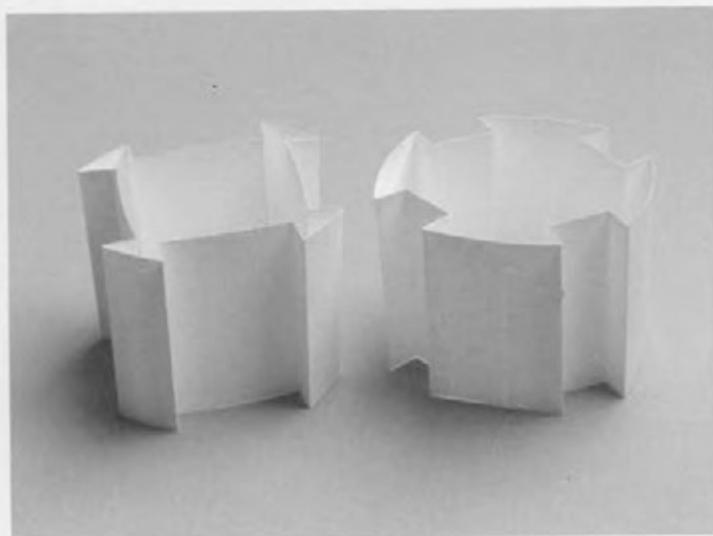


2.3.2_3

Box pleats – or any other form of pleat – need not be placed perpendicularly on a strip. They may instead be placed at an angle to create a less formal effect. Here, the pattern uses reflection symmetry (see page 35).



2.3.3. Cylinders and Cones



2.3.3_1

Box pleats can create many cylindrical and box shapes when one end of a strip is glued to another. In most instances, very different results will be created depending on which surface of the paper – the front or the back – is on the inside or the outside of the strip. In this example, two pieces are folded in the same way but each is the other turned inside out.

1 4 1 2 1 4 1 2 1 4 1 2 1 4 1 2 1



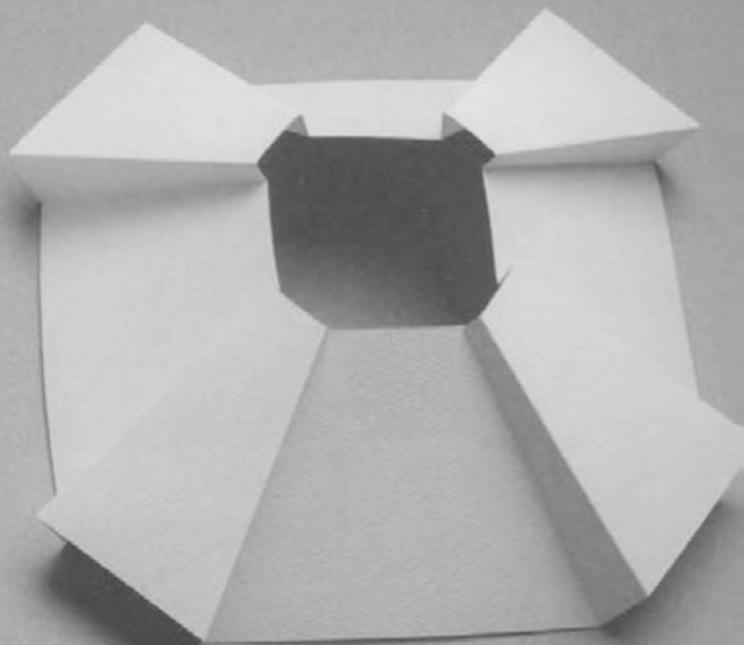
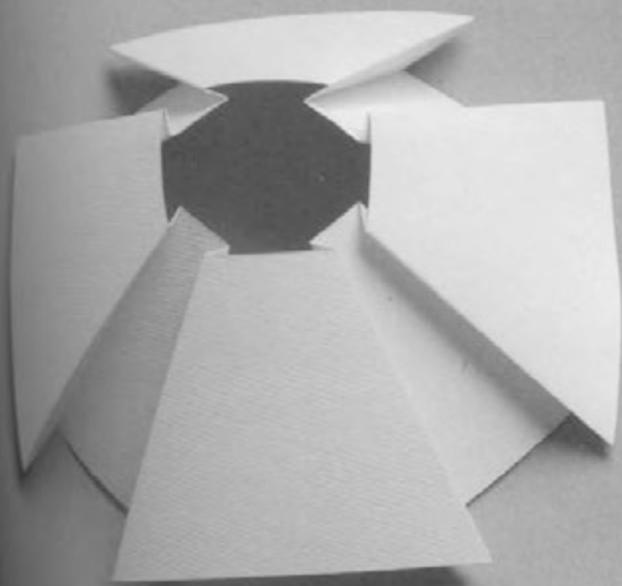
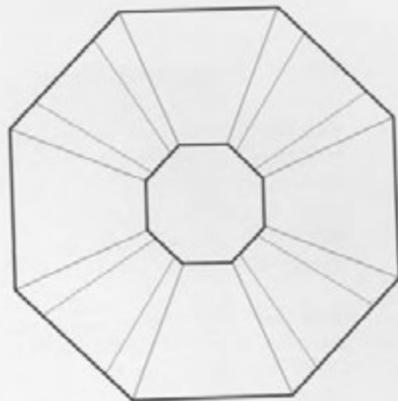
BASIC PLEATS

Box Pleats

Cylinders
and Cones

2.3.3_2

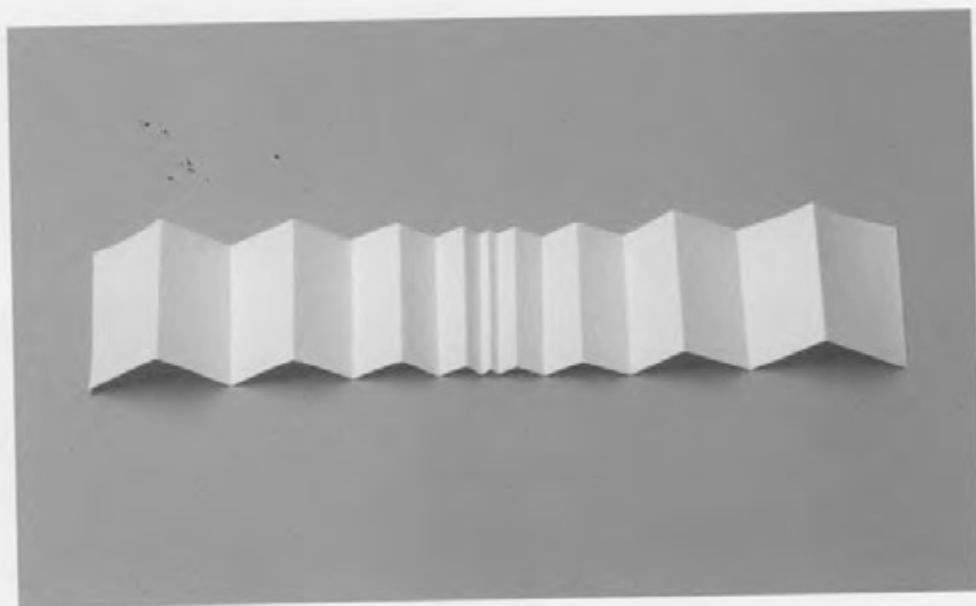
Circles or polygons (here, an octagon) can be used to support patterns of Box pleats. Try 'popping' a completed example inside out; inverting the paper will make it look very different. Thus, for every pattern of folds that creates a conical or pyramidal form, there are two possible 3-D forms, each one the inverse of the other, like the two pieces shown below. This is true not only for Box pleating, but for any pleat pattern.



2.4. Incremental Pleats

Incremental pleats are pleats in which the spacing between the folds progressively increases or decreases. For example, the spacings could increase 10mm each time, from 10mm to 20mm, then 30mm, then 40mm, then 50mm and so on, or perhaps the increase could be exponential, using a Fibonacci or logarithmic sequence, for example. The progressions could also be irregular, though this tends to create unaesthetic, confused-looking surfaces and forms.

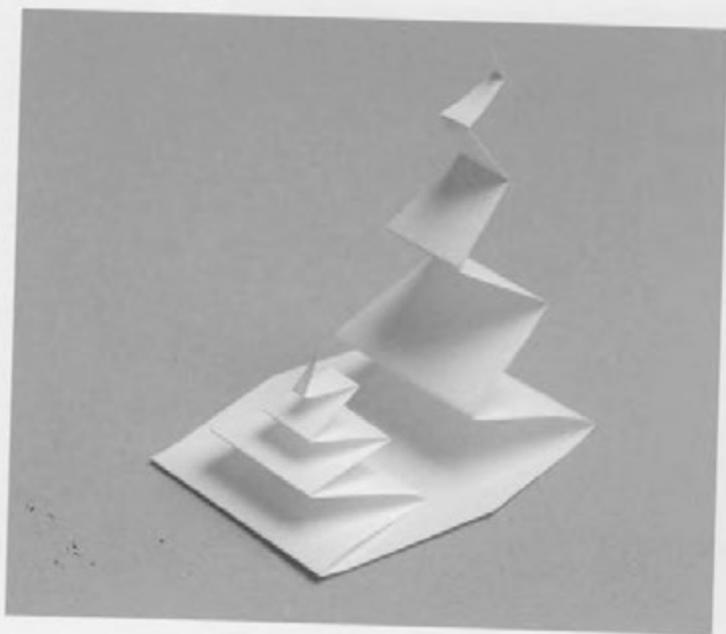
Used well, Incremental pleats have the potential to create limitless pleated patterns, particularly if combined with unusual material shapes and a creative use of Accordion, Knife or Box pleat patterns. The pleat patterns in the following chapter may also be made incrementally.



2.4_1

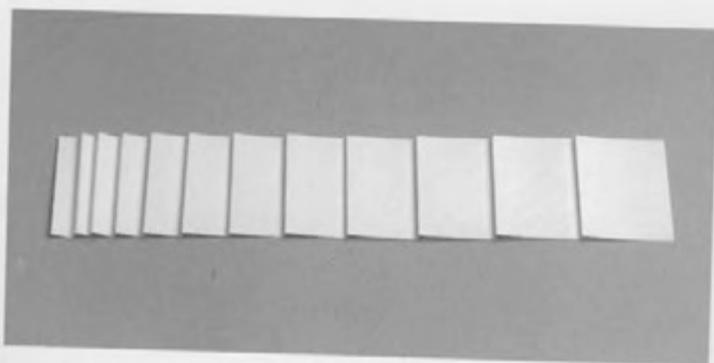
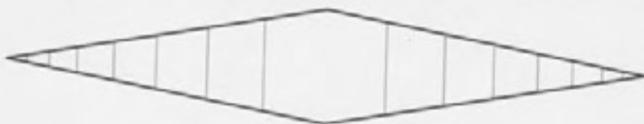
Here, the distance between the pleats is decreasing from the edge to the centre and then is reflected to the opposite edge. Complex topographic surfaces – not necessarily symmetrical – can be made in this way.





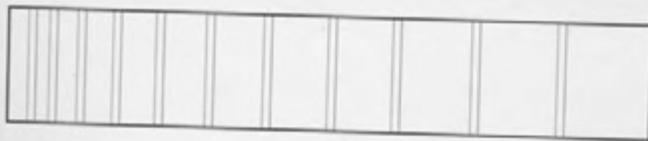
2.4_2

Elaborate layering patterns are achieved by reflecting a triangular shape of incremental pleats. The decorative effect could be enhanced by using a sheet material with a different colour or texture on its two surfaces.



2.4_3

These Knife pleats maintain a consistent shape, but are spaced farther and farther apart incrementally. The same effect could be achieved with Box pleats.



3. Other Pleats

The previous chapter introduced the four basic types of pleat and the next one shows how they can be used to create a huge array of surfaces and forms. This short chapter is transitional. It introduces concepts that are a little less basic, but which are still generic. As such, they deserve a chapter of their own.

Although short, this chapter could easily expand to become the longest in the book. A great number of variations can be derived from any set of basic techniques. The ones included here (Spiral pleats, Gathered pleats and Twisted pleats) are those which experience has shown to be the most useful and most versatile. However, in your own explorations you may well find other variations – even many others. As always, there is no substitute for picking up a sheet of paper and, using this book as a guide, beginning to fold and experiment.

3.1. Spiral Pleats

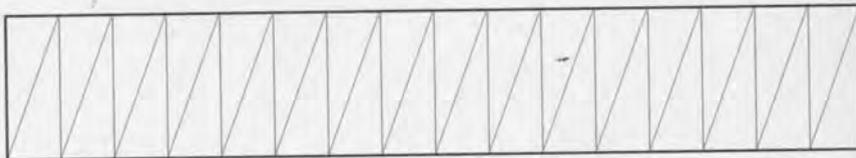
Spiral pleats and Box Spirals are generally simple to make and have essentially the same folding pattern: a strip of rectangles or trapeziums is divided by equally spaced mountain folds, then sloping parallel valley folds are placed diagonally between the mountains to connect them. The complete pattern of folds can be drawn in one continuous zigzag line.

3.1.1. Simple Spirals

A simple but beautiful spiralling pleat can be made by dividing a strip of paper into equal linear divisions with mountain folds (see pages 16–17), then folding a valley diagonal across each rectangle.

3.1.1_1

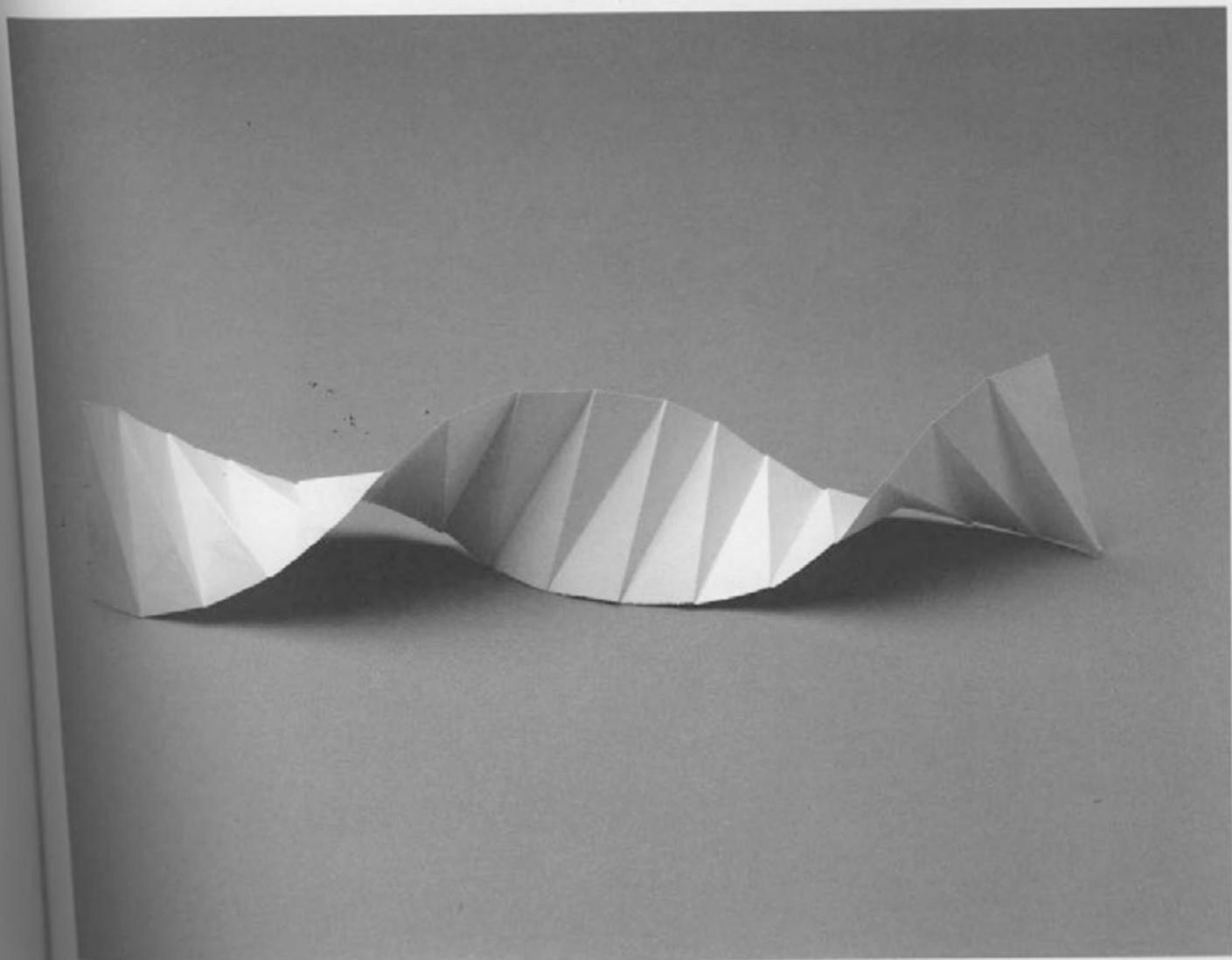
The spiral here is laid horizontal, but suspended in moving air, it will revolve very gracefully. Collapsed flat, it will resemble a circular rosette. It can also be made from shapes other than a rectangular strip, such as a very long triangle or a very long rhombus.



OTHER PLEATS

Spiral Pleats

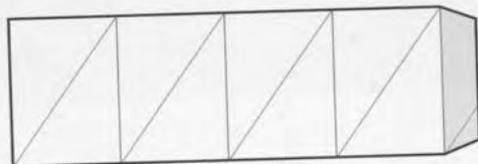
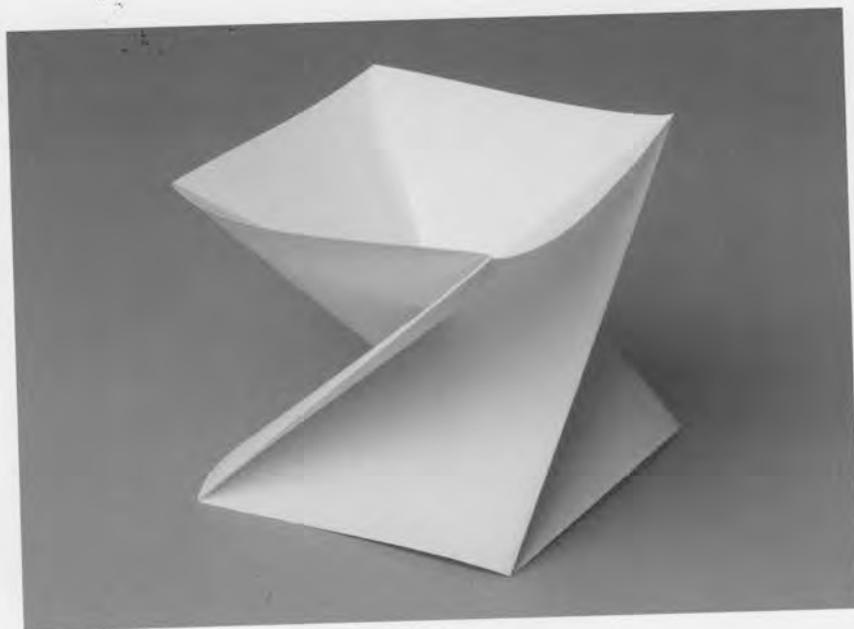
Simple Spirals



3.1.2. Box Spirals

Box Spirals have the same folded configuration as the Simple Spiral on the preceding page, but are glued into box forms. This creates an overlapping of planes visually similar to the closed-up iris of a camera – but in 3-D, not 2-D – around the central point of the box. The structure resembles an hourglass.

The key to success is the precise control of the angle of the sloping valley fold, relative to the number of sides of the box. If the angle is too large, the box will be too tall; if too small, the box will be flat. It is worth taking as much time as possible to experiment with the angle, because even a few degrees can make a big difference to the final shape of the structure.

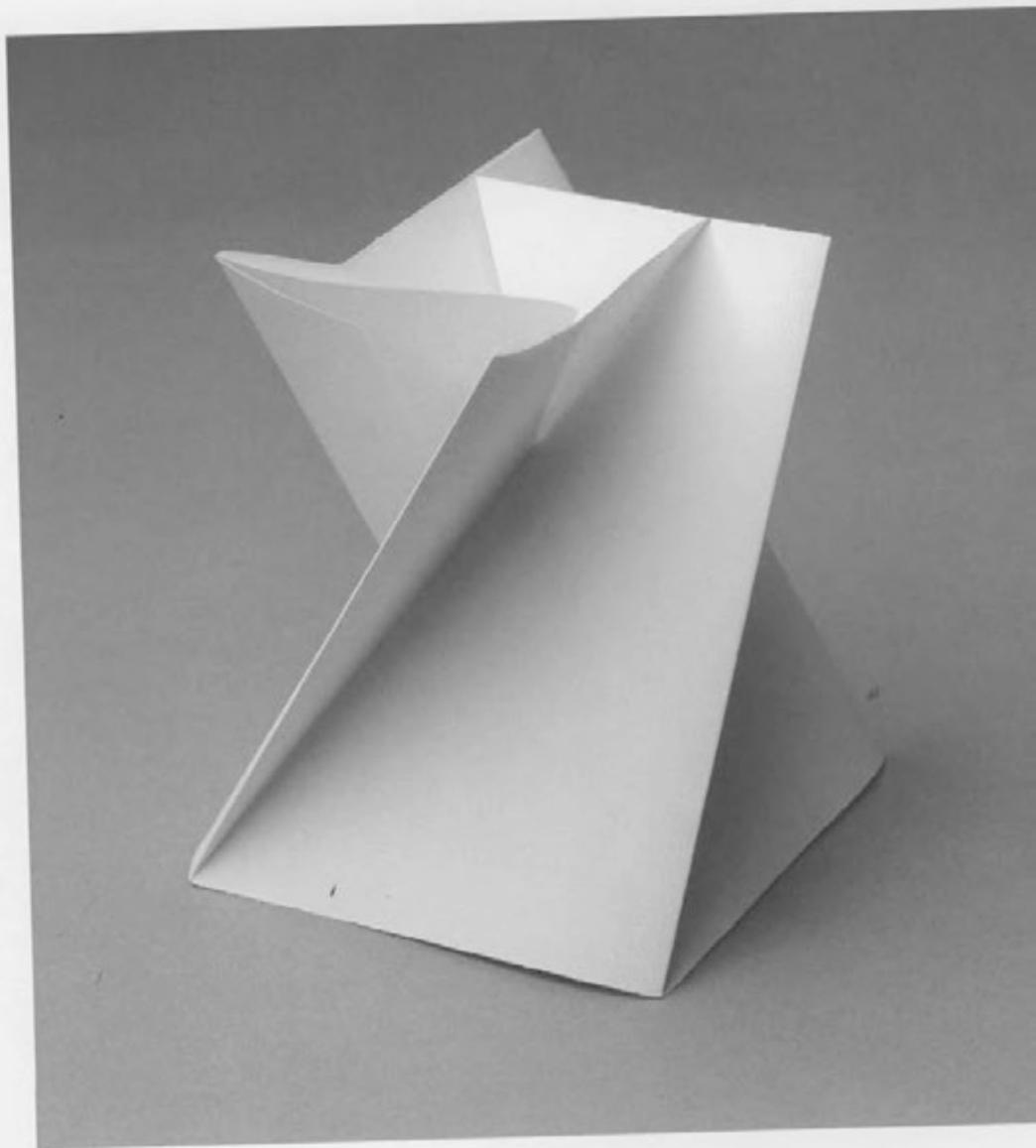


3.1.2_1

This is a basic four-sided box form. Crease the mountains and valleys as shown, then apply glue to the tab and stick this tab to the opposite edge of the box. The box will assume its 'hourglass' form when the rectangular box form is twisted, as though closing the lid of a screw-top jar. There is a definite knack to the twisting, which becomes progressively more difficult as the number of sides increases.

3.1.2_2

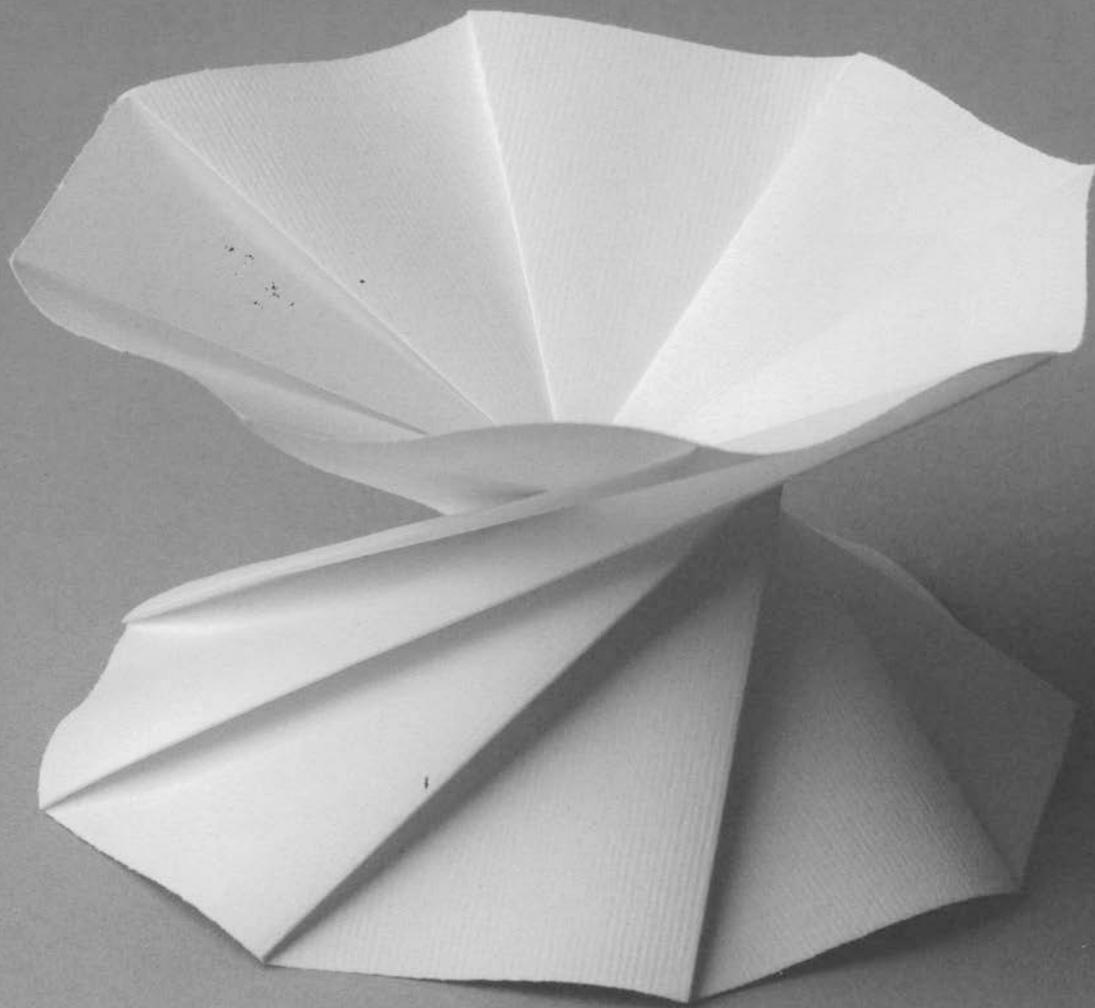
This is similar to the previous example, except that a little of the top edge has been cut away so that the valley and mountain folds do not meet at the top edge. The effect is to create an Iris above the centre point of the box and a more decorative top edge.



3. OTHER PLEATS

3.1. Spiral Pleats

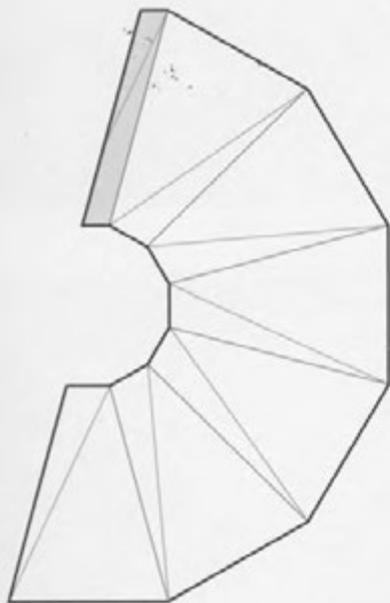
3.1.2. Box Spirals





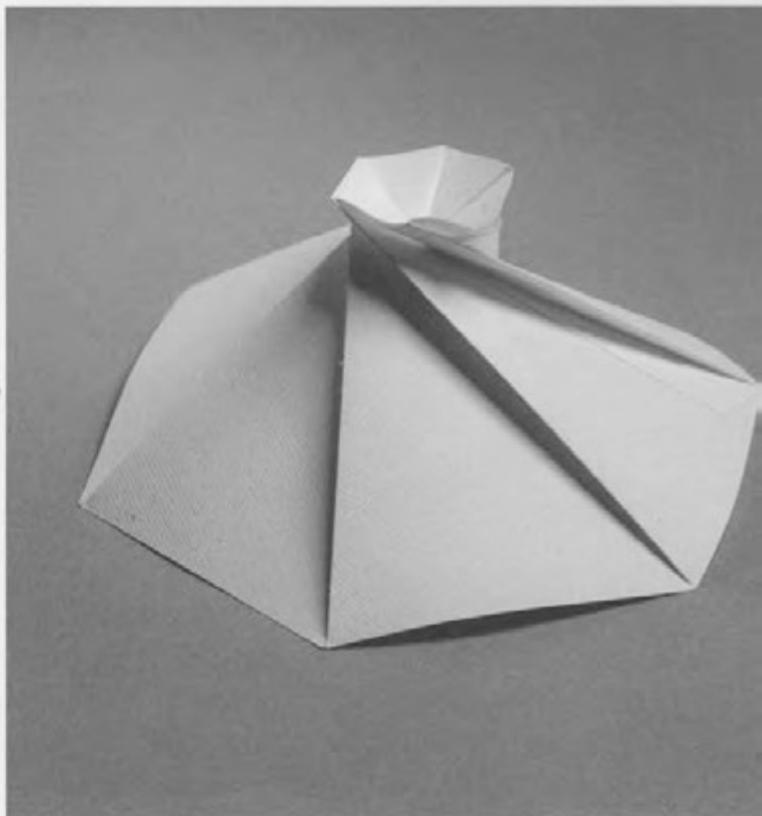
3.1.2_3

The box can have any number of sides. Here there are eight. The advantage of a box with an even number of sides (such as four, six or eight) is that it can be pressed flat from left to right (or from front to back) and erected instantly. Try it – the transformation from 2-D to 3-D is extraordinary! The angle of the sloping valley fold is 70° . See photo opposite.



3.1.2_4

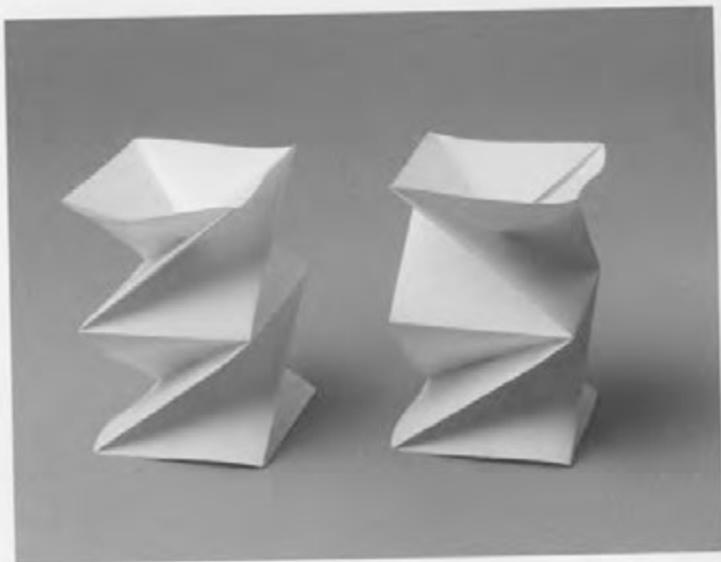
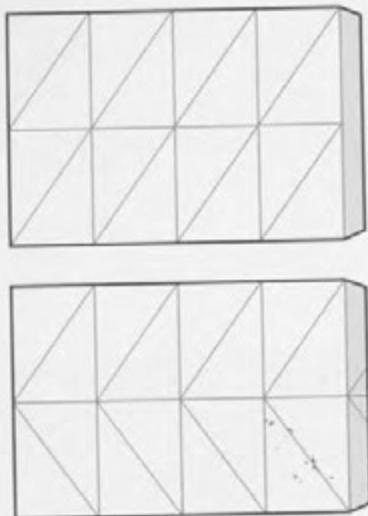
Instead of dividing the paper into rectangles with parallel mountain folds, trapeziums may be created. In this example, six trapeziums connect, with their sides sloping at 75° . The valley folds slope at 65° relative to the bottom edge of each trapezium. The effect is to create a form that tapers towards the top.



3. OTHER PLEATS

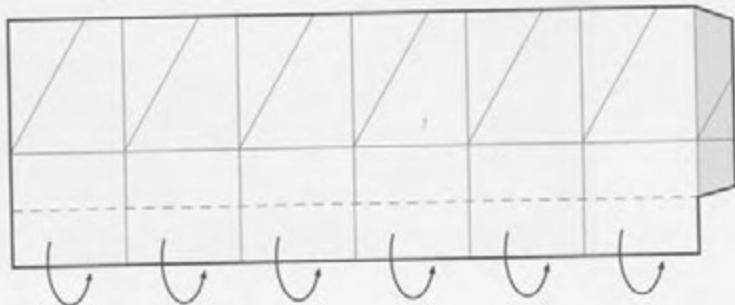
3.1. Spiral Pleats

3.1.2. Box Spirals



3.1.2_5

Box Spirals can be stacked one on another many times, to create towers of great strength. Here, one four-sided box is stacked on another, but in two different ways. In the first example, the two boxes use sloping valleys placed on the same diagonal; in the second example, the two boxes use sloping valleys placed on different diagonals. When connecting boxes together, either example may be used.



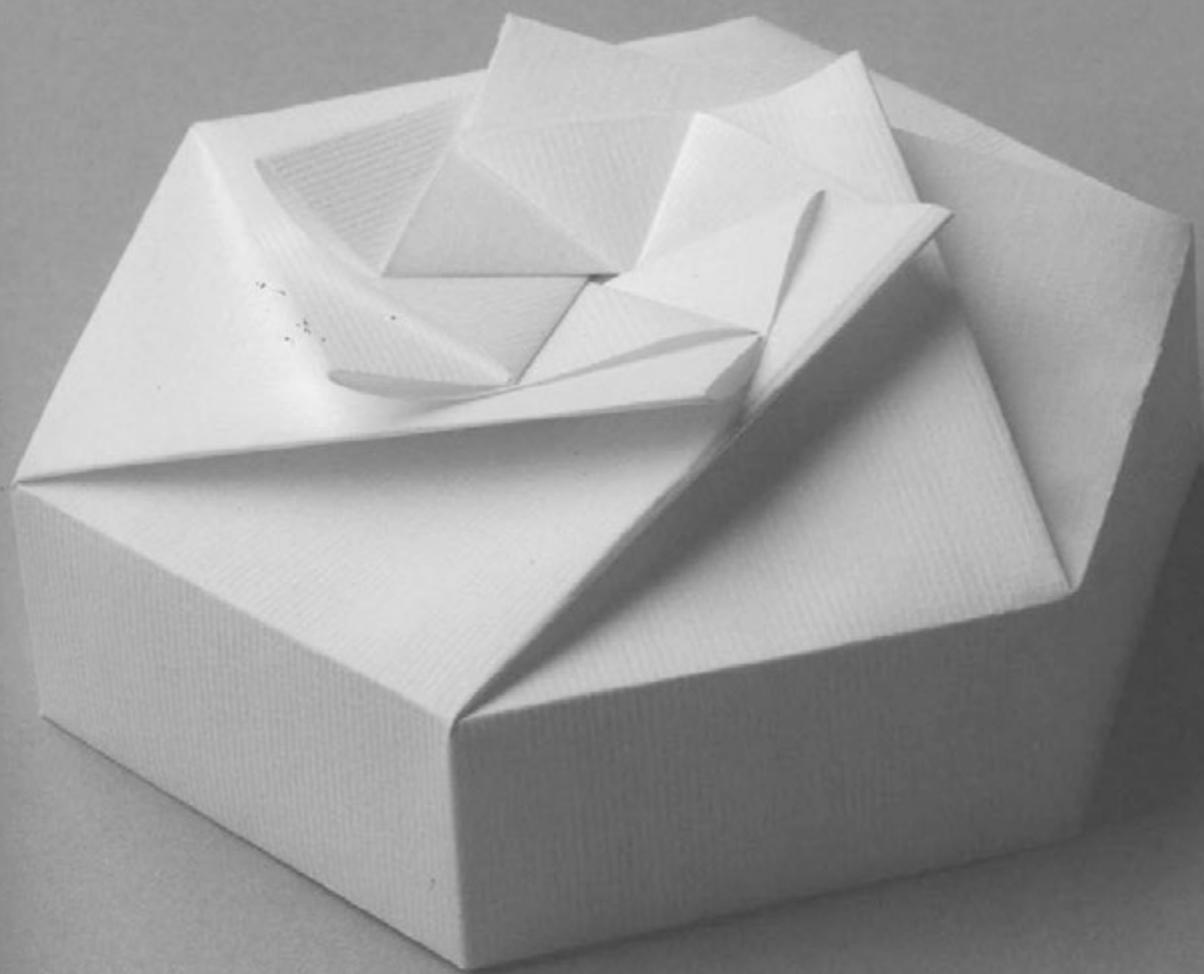
3.1.2_6

Box Spirals may be used to create decorative lids. This lid is six-sided and the sloping valley is at an angle of 60° to the horizontal. A 3-D 'hourglass' lid may be created by increasing the angle to 61° , 62° etc. The greater the number of degrees, the taller the lid will become. Fold the bottom edge behind along the dotted line. This will give extra strength to the sides of the lid. See photo opposite.

OTHER PLEATS

Spiral Pleats

Box Spirals

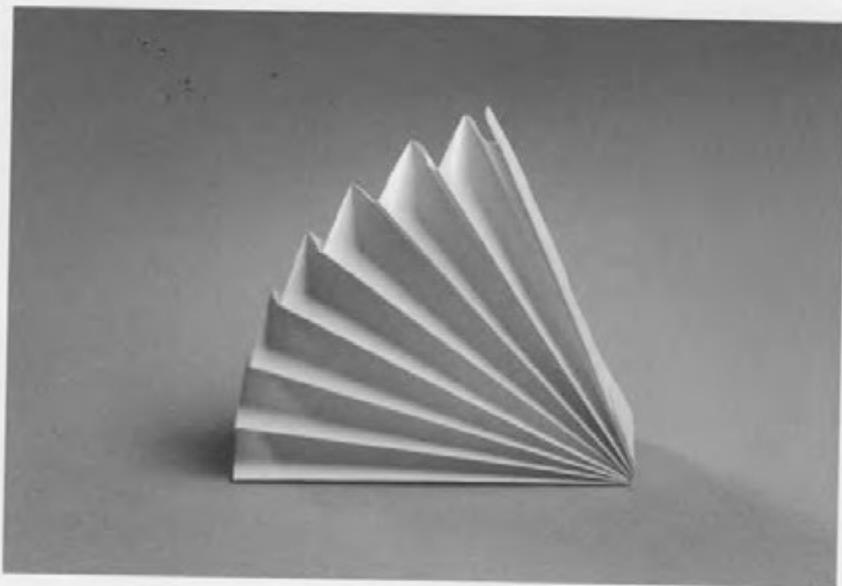


3.2. Gathered Pleats

Linear or rotational pleats may be left open, or may be gathered together at one or both edges. When gathered together, many new forms and relief surfaces become possible.

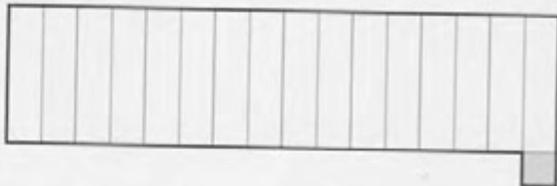
There are many ways to hold Gathered pleats together. The examples described here use paper glue-tabs, but you could find other ways, such as binding, riveting, stitching or stapling, depending on your choice of material(s). As always, although the book presents paper and folding in visually 'pure' ways, you are encouraged to be as disrespectful as you wish, in order to make a design work for you.

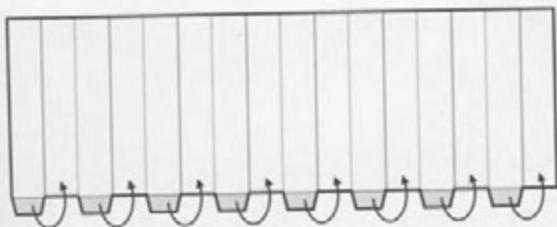
3.2.1 Accordion Pleats



3.2.1_1

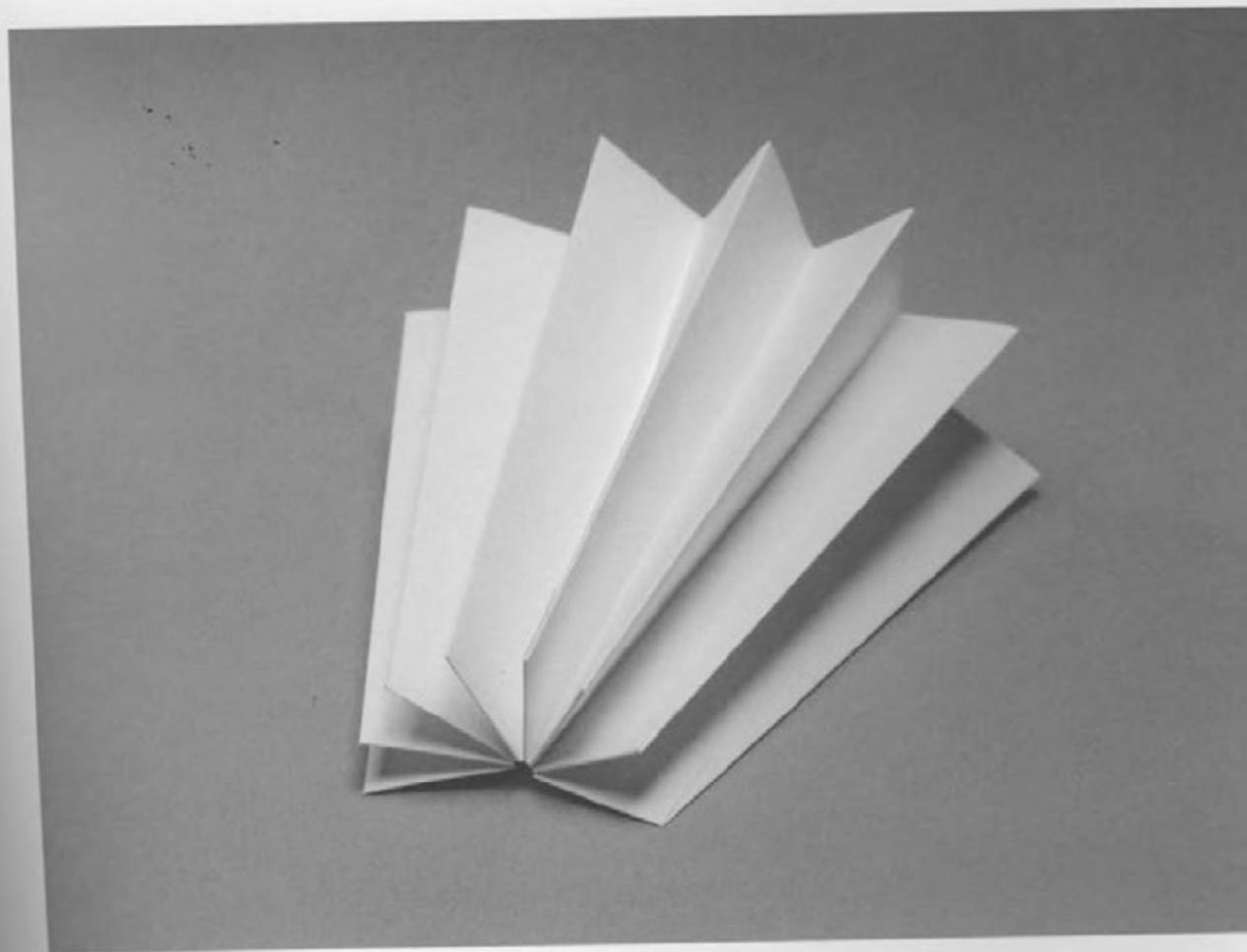
This is a repeat of 1:1.1.six_11 (see page 17), but with the addition of a glue tab. Concertina all the pleats tightly together, apply adhesive to the tab and glue it to the pleat at the far end of the concertina. This will gather one edge of the concertina together to create a form resembling a fan.





3.2.1_2

Whereas one edge of the concertina was fully closed in the previous example, here just one row of corners is held together along a concertinaed edge. This enables the flat fan to become a 3-D cone. Apply adhesive to the tabs, then concertina the pleat. Glue each tab on to the next pleat, thus half closing the concertinaed edge.



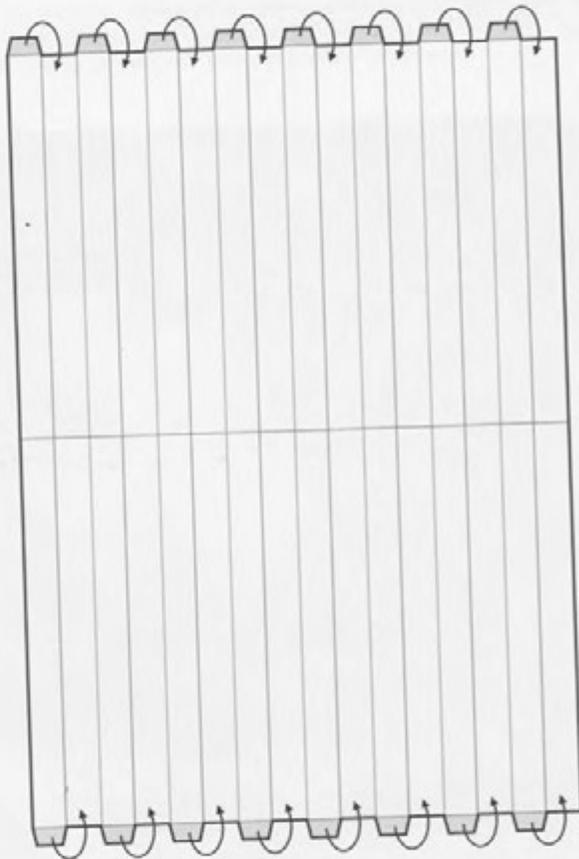
3. OTHER PLEATS

3.2. Gathered Pleats

3.2.1. Accordion Pleats

3.2.1_3

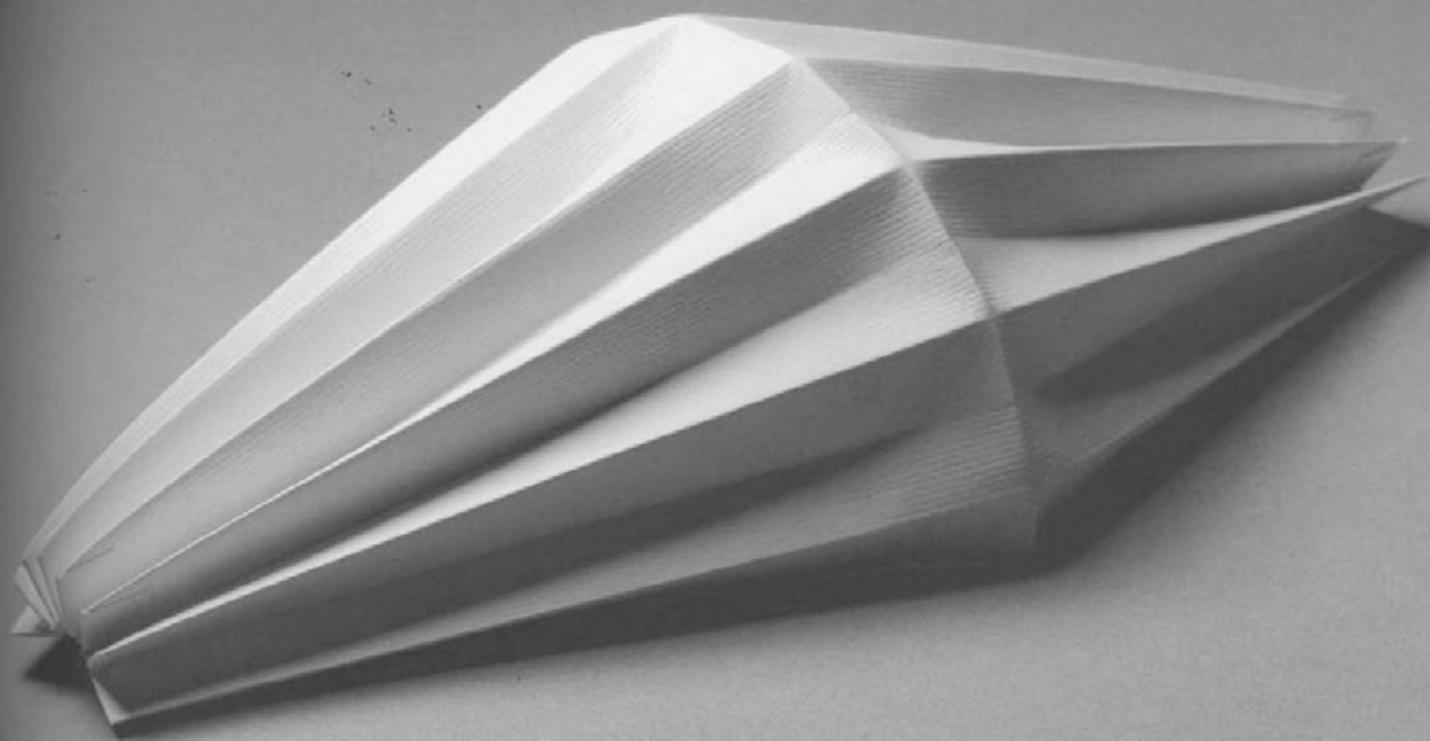
The techniques described in the previous two examples may also be used at the other concertinaed edge of the pleats, thus closing or half closing both edges. An additional fold across the middle of the paper will keep the pleats open at the midpoint.



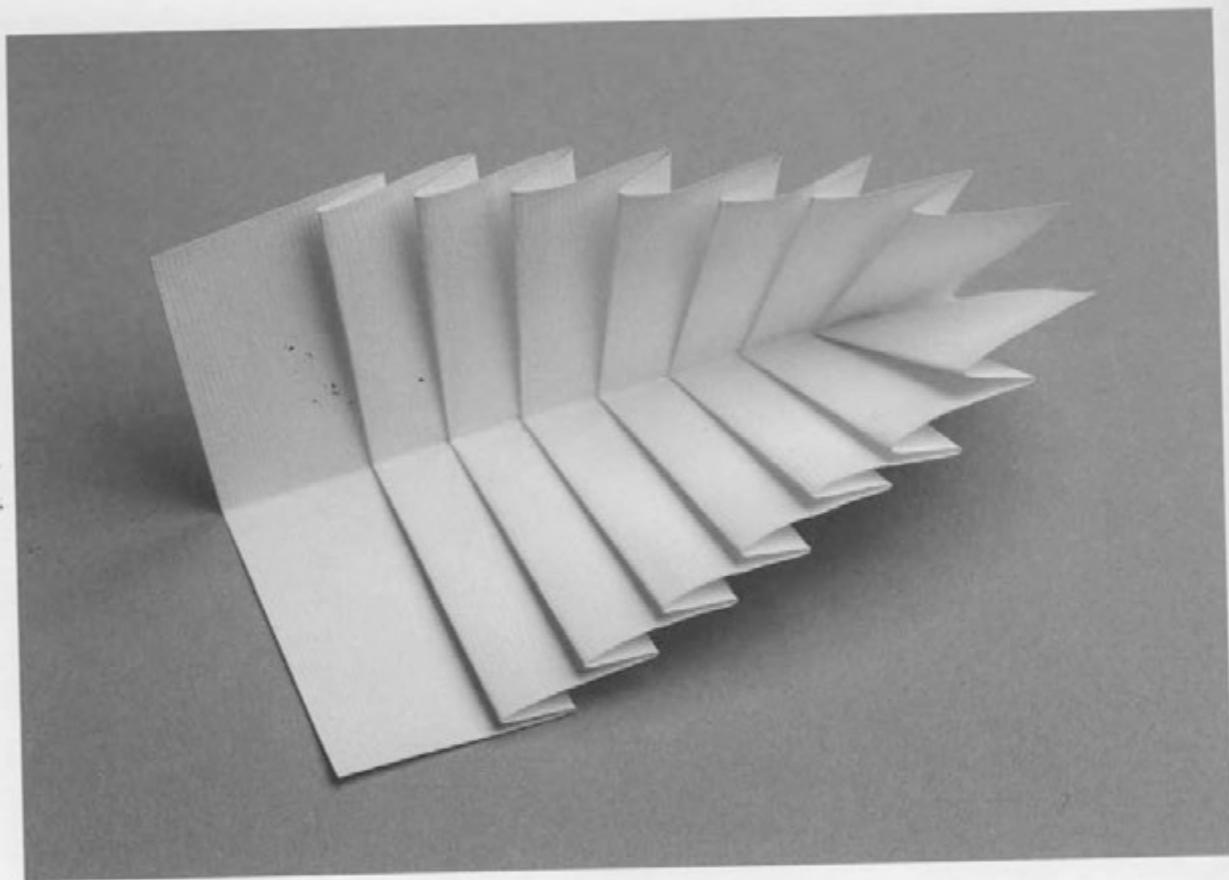
OTHER PLEATS

02 Gathered Pleats

01 Accordion Pleats

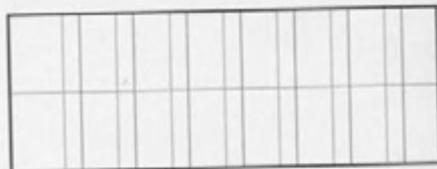


3.2.2. Knife Pleats



3.2.2_1

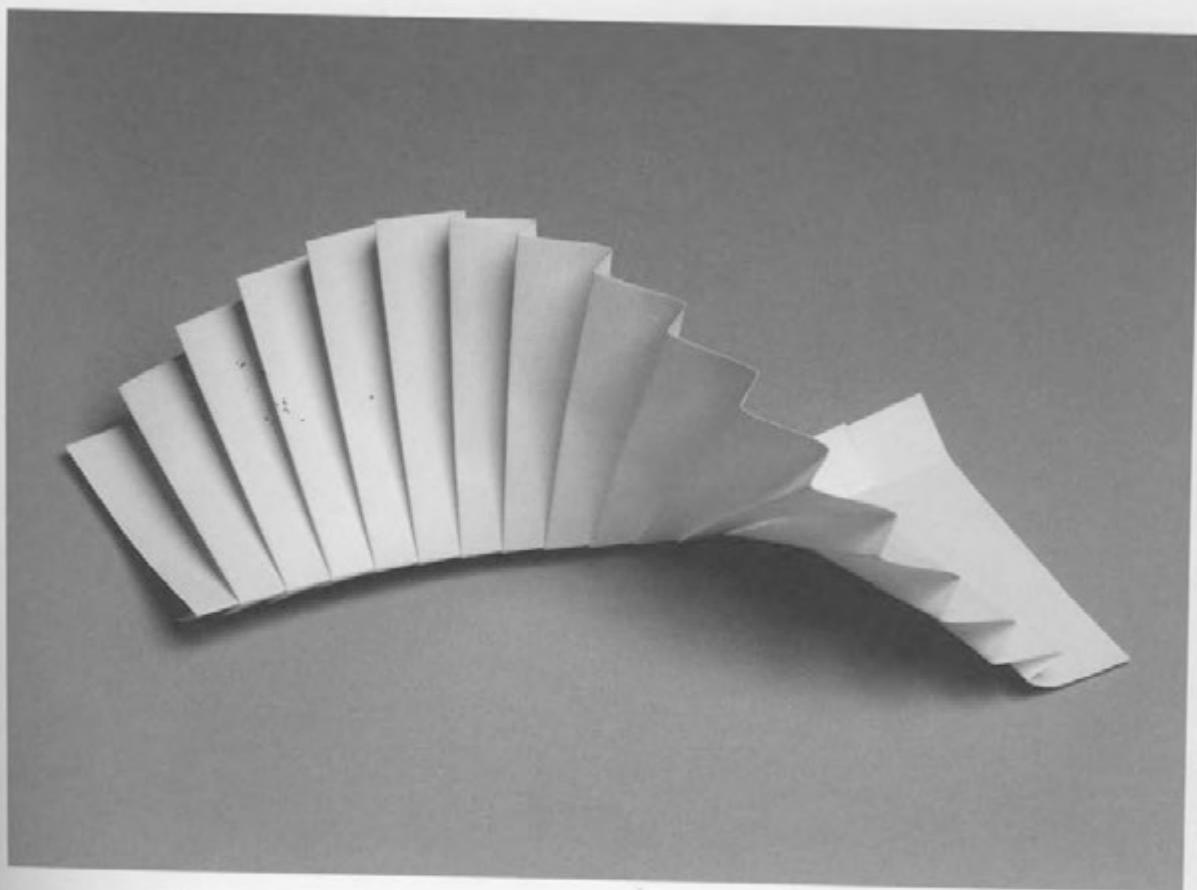
This is a repeat of 2.2.1_1 (see page 64), but with an additional valley fold across the middle, made after the Knife pleats have been folded. This additional fold gathers the pleats together along the midpoint, but allows the edges to open. The effect is to create a form closed at one end and progressively more open towards the other.



OTHER PLEATS

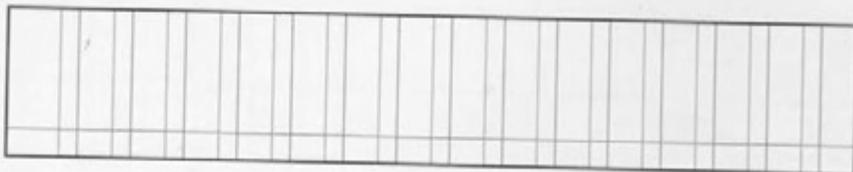
Gathered Pleats

3.2.2. Knife Pleats

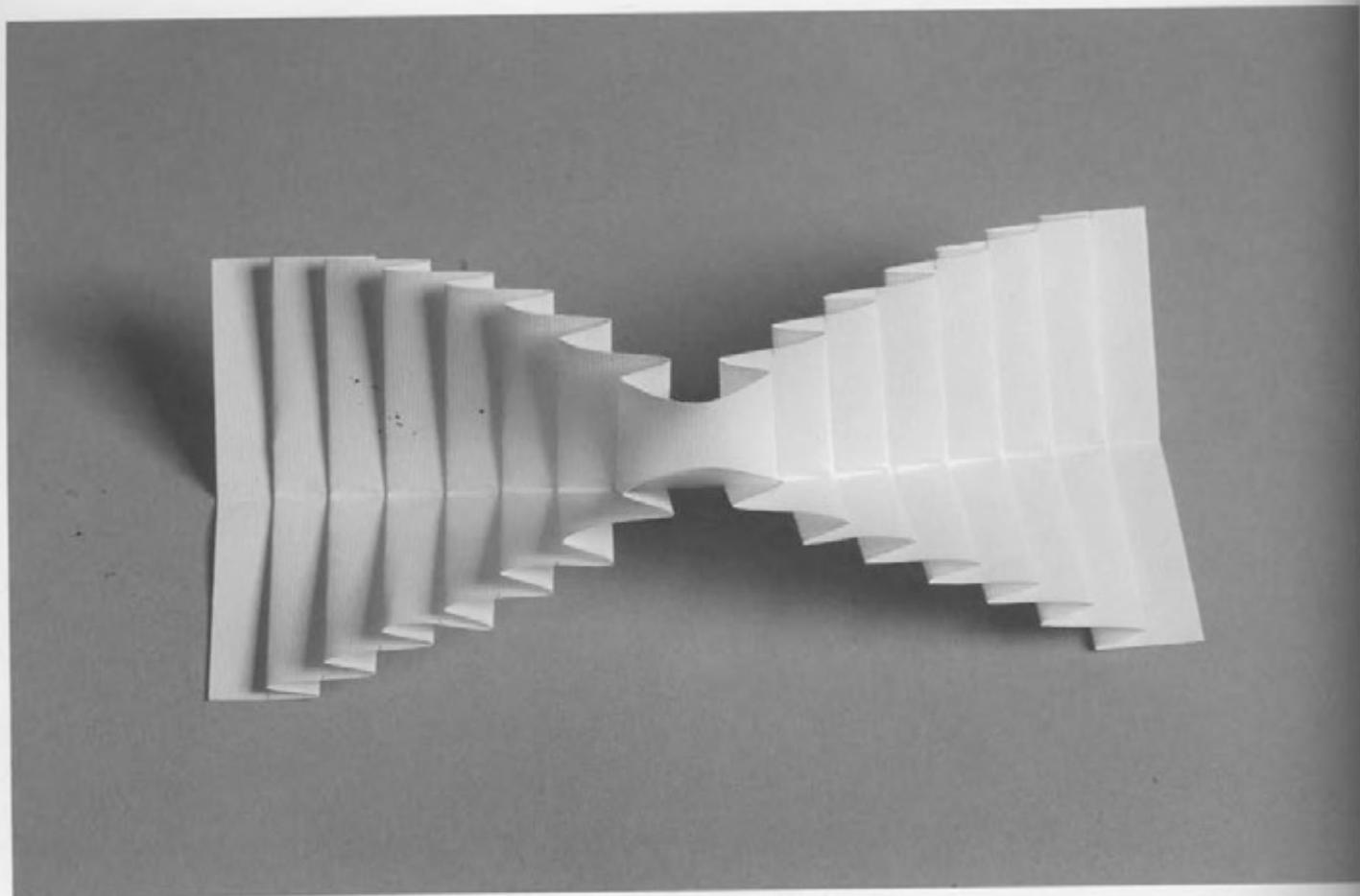


3.2.2.2

Here, a line of 16 Knife pleats is gathered along one edge. This allows the ungathered edge to splay open and spiral around the gathered edge, to create a form resembling a spiral staircase. Instead of being folded, the edge could be closed with stitches, tape, staples, etc.



- 3. OTHER PLEATS
- 3.2. Gathered Pleats
- 3.2.2. Knife Pleats



3.2.2_3

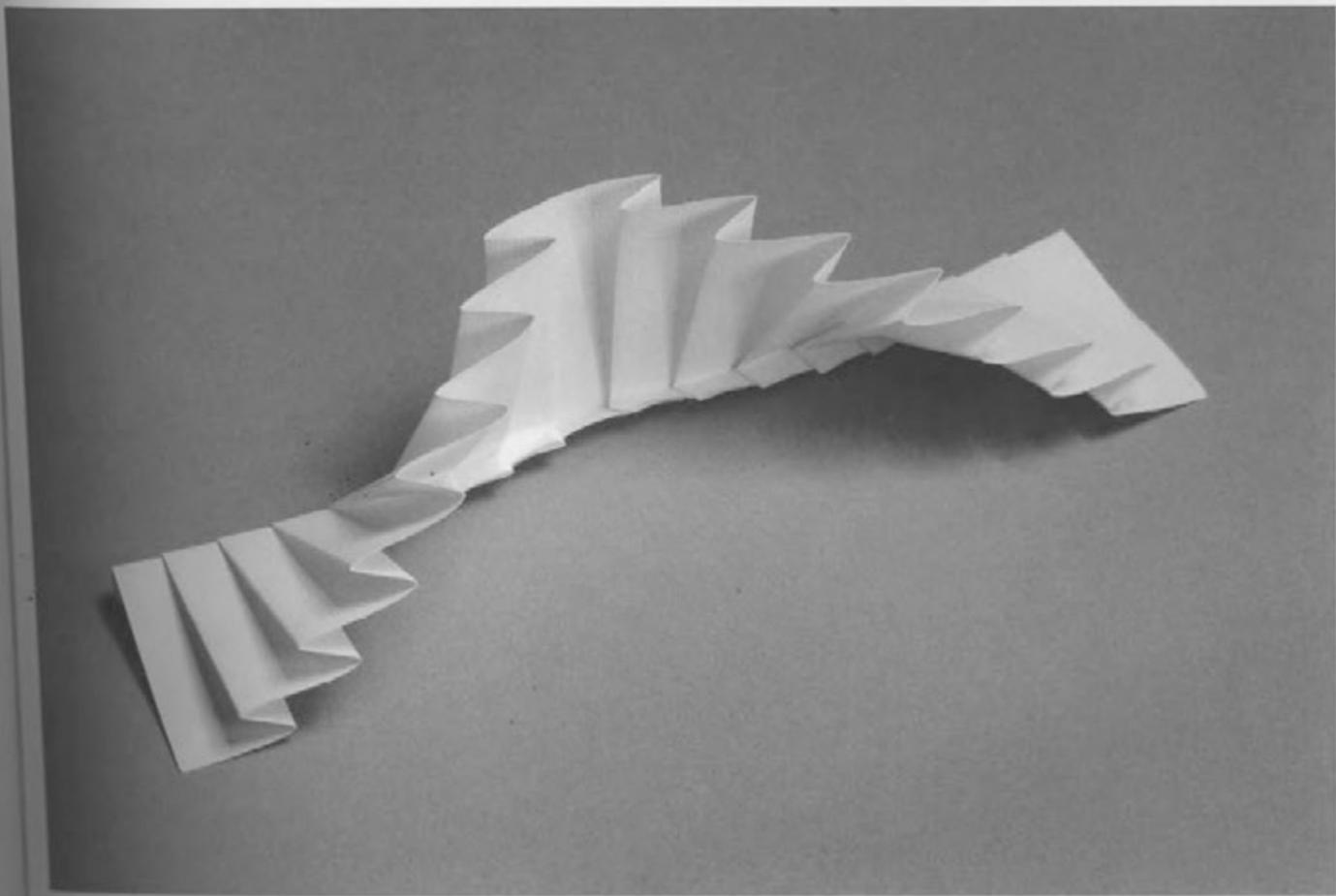
Seven Knife pleats on the left of the strip are mirrored on the right, to create a form which is two examples of 3.2.2_1 (see page 94) placed back to back. The effect is to make a form that is open at the left and right, but closed in the middle. If more mirror fold patterns were created on an extended strip, the pleated pattern would open and close repeatedly.



OTHER PLEATS

1. Gathered Pleats

2. Knife Pleats



ILL. 4

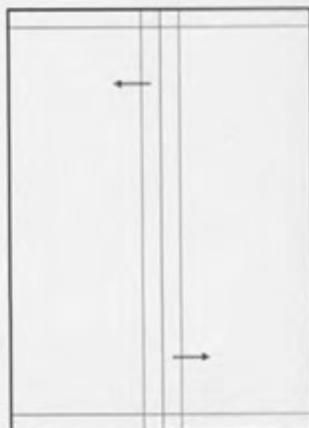
Two knife pleats on the left are shown on the right, gathered together with a long mountain fold near the top edge. This is effectively half of the previous example, but it is a relief which is a 3-D form.



3.3. Twisted Pleats

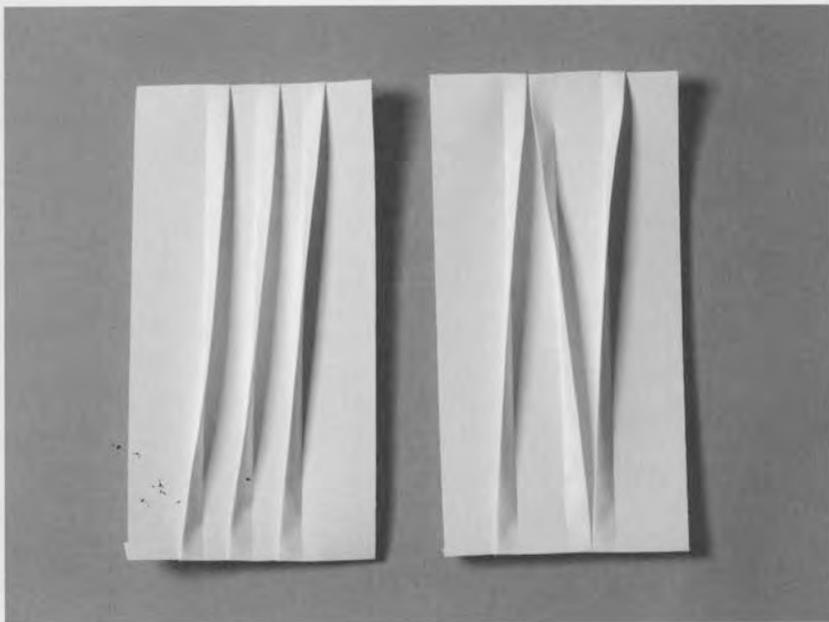
Twisted pleats are an excellent way to create visual interest on a flat surface. They can look a little stressed if made in paper or another stiff material, but made in something soft, such as fabric, they look much more relaxed and natural. For this reason, they are much used in apparel and in fashion accessories (bags, belts, hats, shoes, etc).

The examples here show the basic ways in which Twisted pleats can be used but, as always, you are encouraged to experiment widely, especially with reference to the Basic Concepts and Basic Pleats chapters.



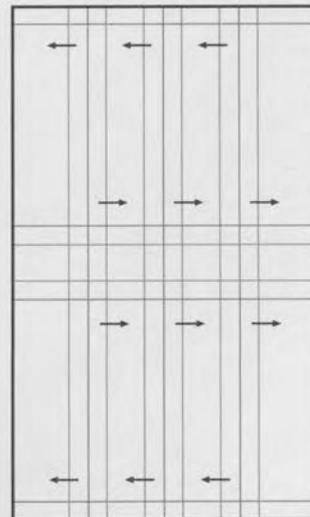
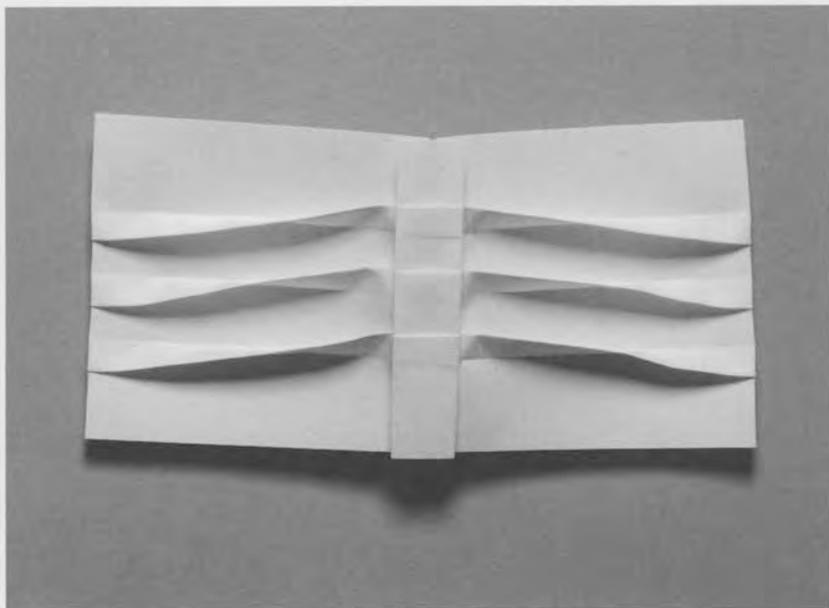
3.3_1

This is the basic technique. Make three folds down the centre, so that the pleat stands upright like a shallow tennis net. Open the paper. Make and unfold horizontal mountain folds near the top and bottom edges. Reform the net. Flatten it to the left side at the top, trapping it flat with the horizontal fold. At the bottom, flatten it to the right side, trapping it flat with the horizontal fold. Instead of making horizontal folds to trap the pleat flat, you may use stitches, rivets, staples, etc.



3.3_2

A Linear progression of Twisted pleats can follow one of two patterns. Either all the pleats can twist in the same direction, or each pleat can be twisted in the opposite direction to its immediate neighbours. The photograph shows an example of each.



3.3_3

The addition of a Box pleat (see page 72) can further trap the pleats so that they can be twisted, be held flat by the Box pleat and then be twisted back. If the material is long enough, a pleat may be twisted back and forth many times along its length. Instead of using Box pleats, you can use stitches, rivets, staples, etc. to secure the pleats.

4. V-pleats

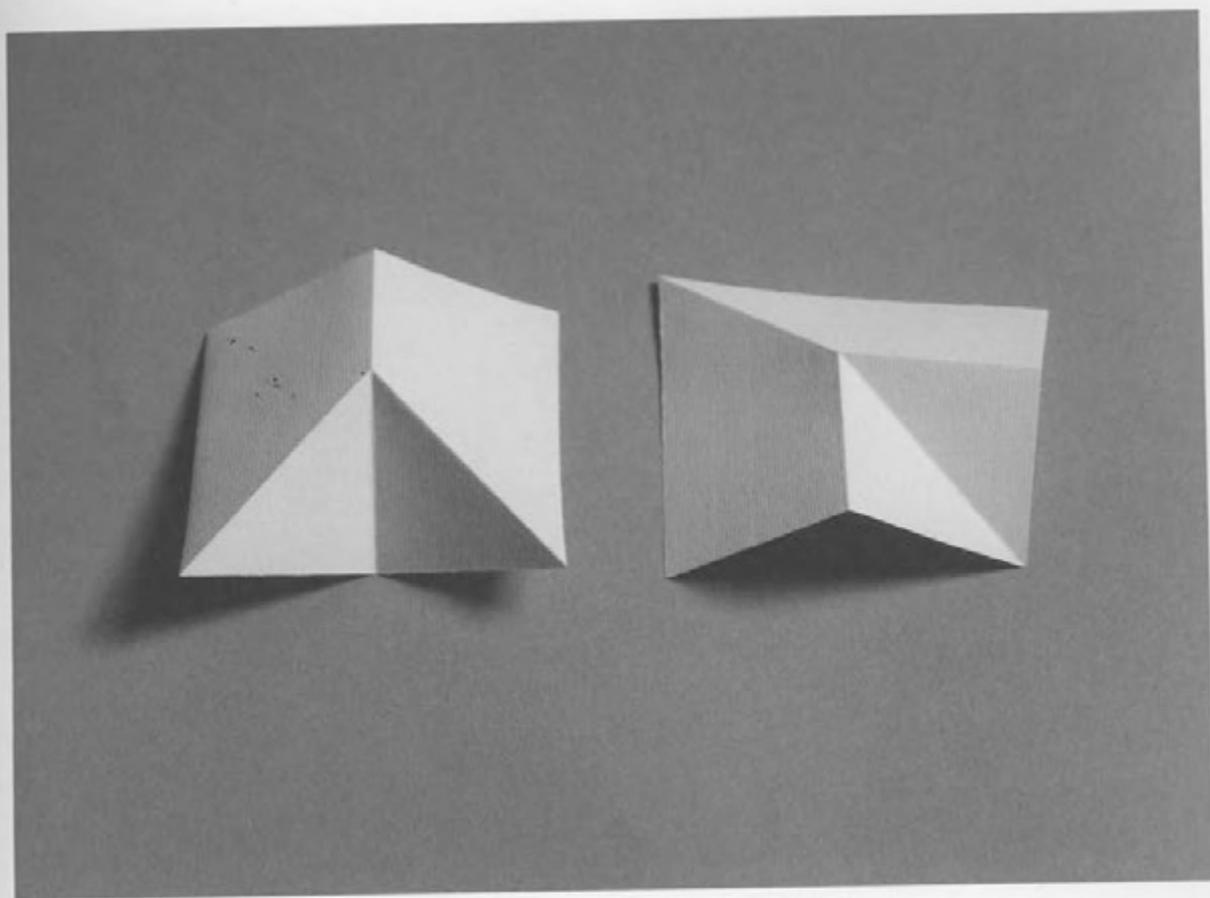
This chapter has the potential to turn the technique of pleating into an extreme sport. The concepts it presents can be developed to ever greater levels of difficulty, to create relief surfaces and 3-D forms of impressive complexity.

But do not panic! Remarkable results can be achieved with even the simplest V-pleating. This is because almost all V-pleats are dynamic: they have the ability to make a surface expand and contract, and bend and twist in many directions. They have no fixed form, permitting movement in a wide variety of ways, depending on the placement of the folds.

V-pleats are fascinating to explore, and this exploration is potentially addictive. The pursuit of ever more complex patterns, with more folds, more repetitions and increasingly complex geometry, can be very seductive, consuming unnecessary design time with little result. It is easy to become lost in the labyrinth of technical possibilities, exploring simply for the sake of it. If you have time to explore, then this origami nirvana is enviable. But if your time is limited, it is crucial to be clear about what you wish to achieve.

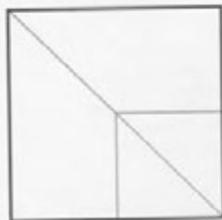
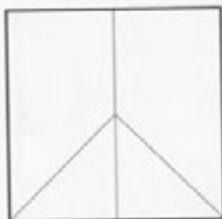
4.1. Basic V-pleats

V-pleats are characterized by their distinctive 'V' shape, in which three mountain folds and one valley fold (or one mountain fold and three valley folds) meet at a node. A linear progression of V-pleats can extend infinitely across a sheet. In most instances, all the folds can be manipulated simultaneously so that the paper can concertina into a small, flat shape.



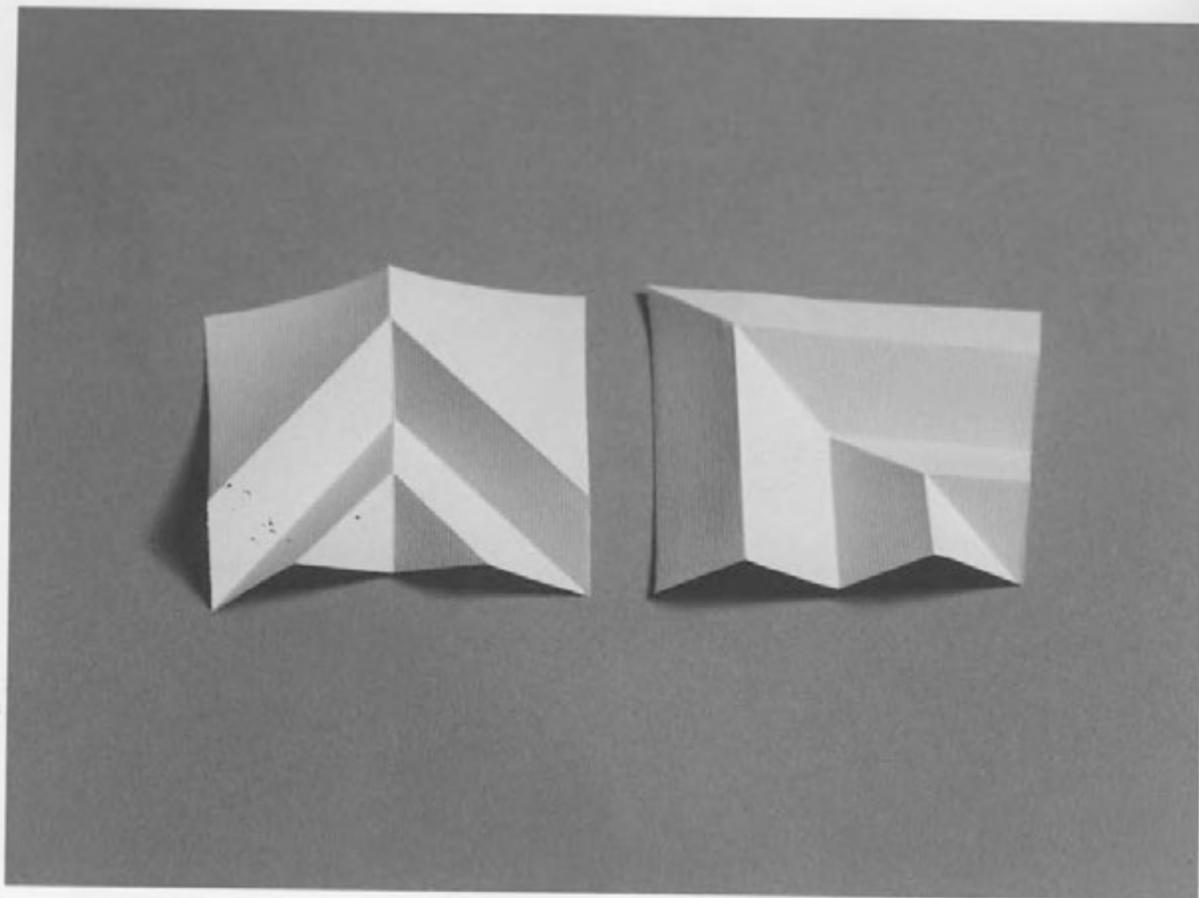
4.1 - 1

This is the most basic V-pleat. Note the symmetry of the crease pattern and the precise configuration of mountains and valleys. The central line - called the 'line of symmetry' - may be placed anywhere on the sheet, but the V-folds must be placed symmetrically to each side of the line.



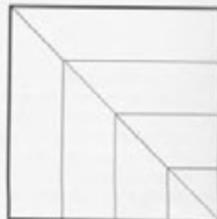
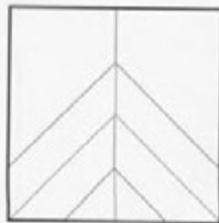
4. V-PLEATS

4.1. Basic V-pleats



4.1_2

V-pleats need not be made singularly, but may progress infinitely along the line of symmetry. The Vs must alternate mountain-valley-mountain-valley along the line. Note, too, how the line of symmetry alternates between mountain and valley between successive pleats.

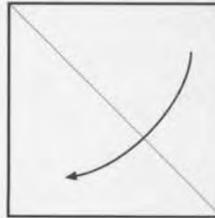


4.2. Making by Hand

V-pleats create complex crease patterns of many small mountain and valley folds. These patterns may be drawn in a computer, then printed out and folded, or drawn directly on the sheet with geometry equipment, but it is often much easier and quicker to make them by hand. This is surprisingly easy, though, as usual, you will need to extrapolate the method given here into other crease patterns of your own design.

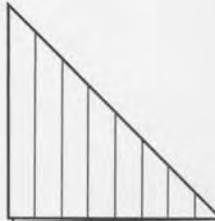
4.2_1

Fold a square along a diagonal. Open the paper and turn the fold inside out so that it may fold as a mountain or a valley, without preference. This is called a 'universal' fold. See page 8 for a more detailed explanation of how to make a universal fold.



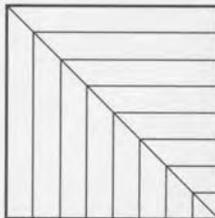
4.2_2

Fold the paper in either direction along the diagonal, then divide this triangle into eighths through both layers, making each crease a universal fold.



4.2_3

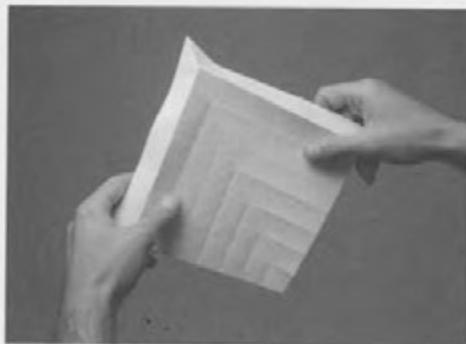
This is the completed crease pattern. Whatever the design of the pattern, it is always most helpful to make all the folds universal so that the paper will collapse easily.



How to Collapse the Creased Paper

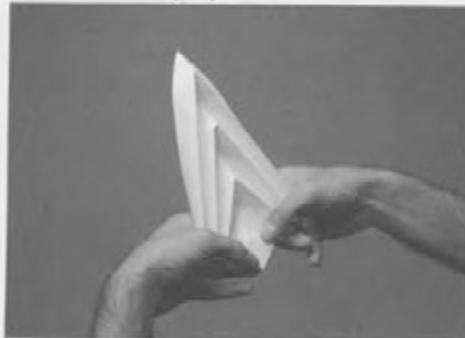
4.2_4

Hold the paper as shown – symmetrically, with thumbs on the front and fingers behind, and the longest V-fold across the top of the paper. Use your fingers and thumbs to help the longest upturned V become a mountain fold.



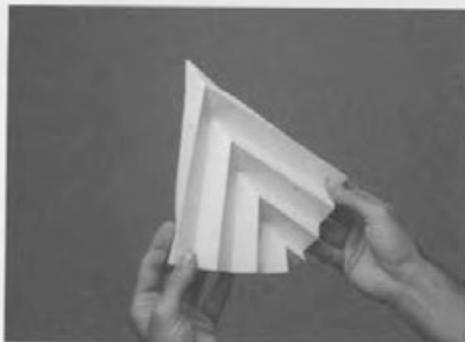
4.2_6

Continue to make more V-folds, alternating them mountain-valley/mountain-valley. They will become progressively shorter and shorter. Keep the folded Vs gathered between your fingers and thumbs; never allow the paper to become flat.



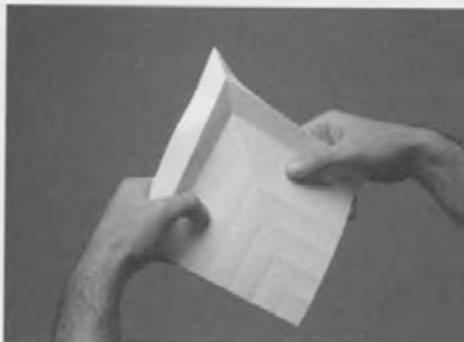
4.2_8

The flat stick can be pulled open to reveal the V-folds inside.



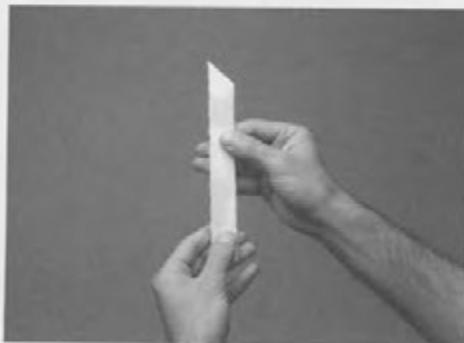
4.2_5

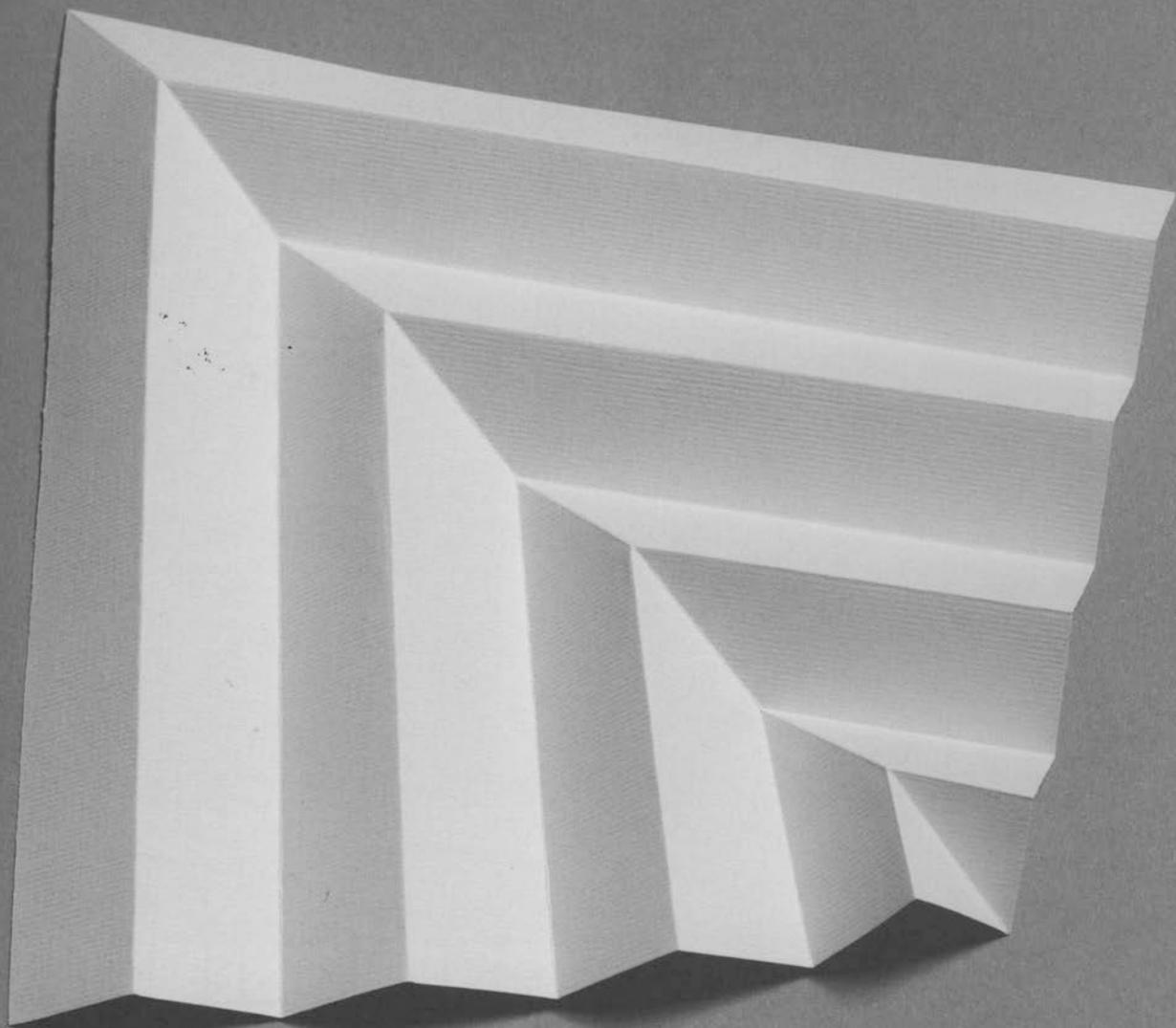
The V-fold below the mountain V just formed should now be creased as a valley. Again, work front and back on the paper, using your fingers and thumbs to create the valley fold.



4.2_7

The folds will collapse to create a flat stick.





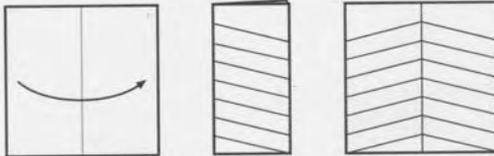
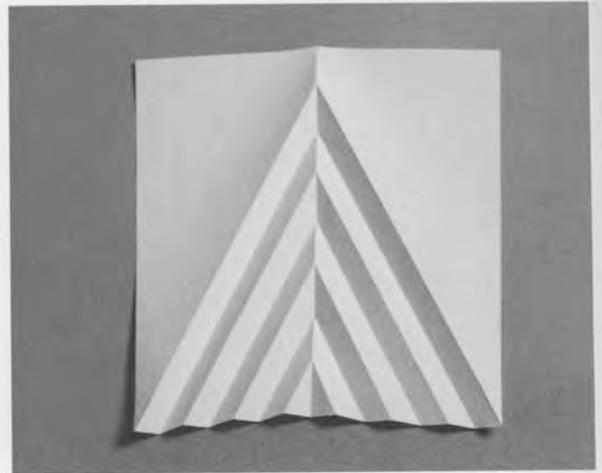
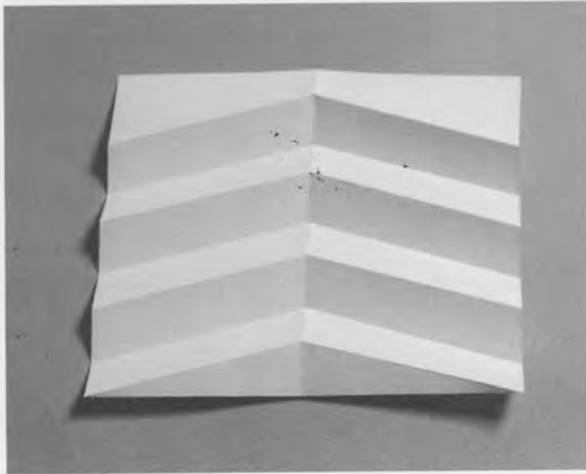
4. V-PLEATS

4.3. Variations

4.3.2. Changing the Angle of the V-pleats

4.3.2. Changing the Angle of the V-pleats

So far, almost all the examples given have been with the V-pleats at 45° to the line of symmetry. However, the angle can be anything between a few degrees more than 0° and a few degrees less than 90° , and can even change along the line.



4.3.2_1
Here the angle is approximately 75° . When all the pleats are collapsed, the sheet will become much smaller than it would be if the pleats were placed at a tighter angle.

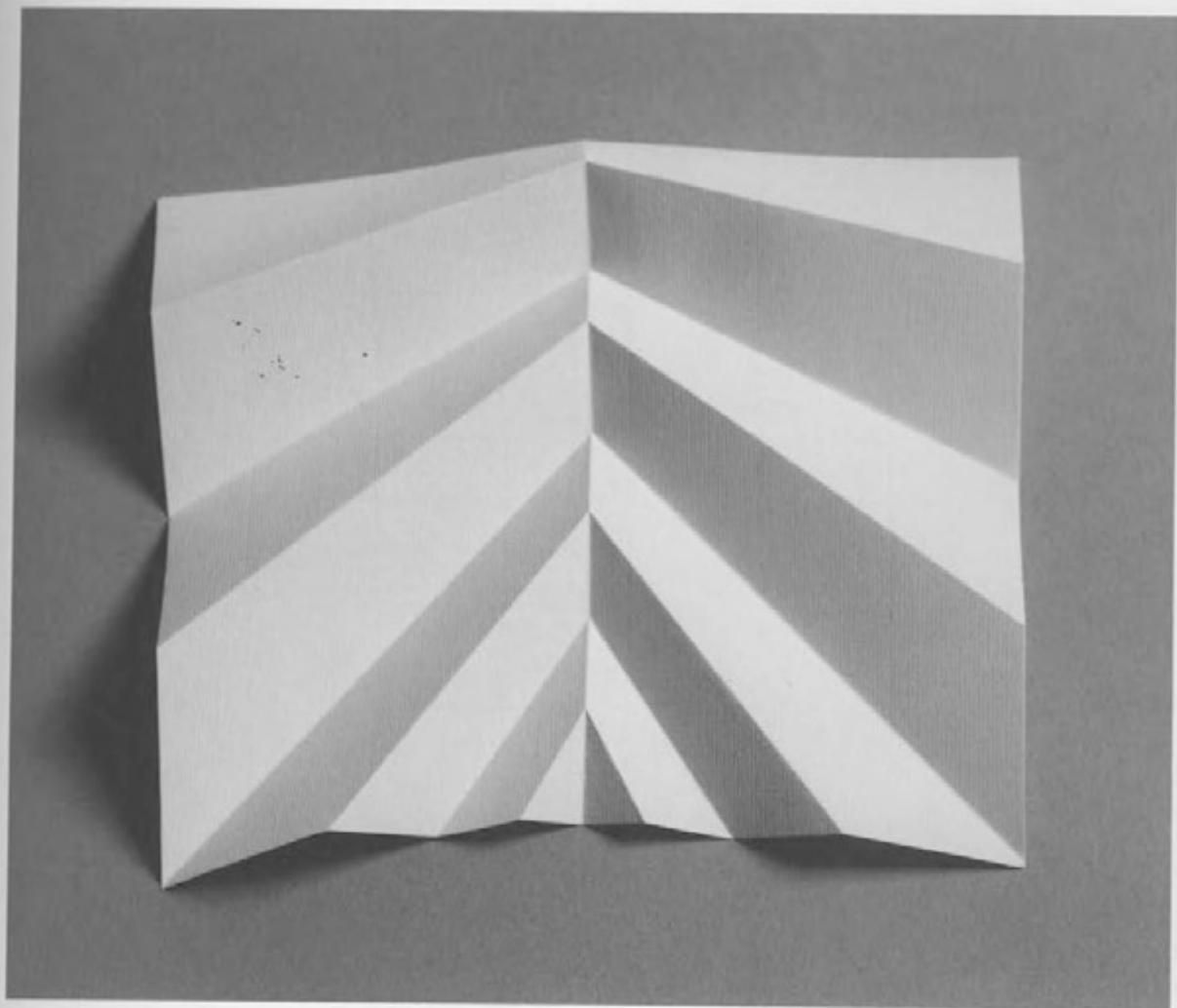


4.3.2_2
Here, the angle is approximately 30° . Compare this example with the previous one. A simple change of angle makes a radical difference to the collapsed form.

V-PLEATS

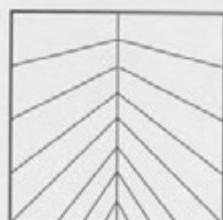
Variations

Changing the Angle of the V-pleats



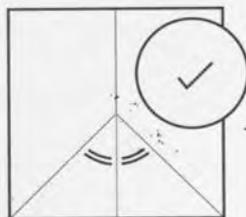
4.3.2_3

The angles of the V-pleats may change along the line of symmetry. There are, however, certain limitations to this system, since it will not always permit the sheet to collapse totally flat. As always, experimentation will help you separate the possible from the impossible.

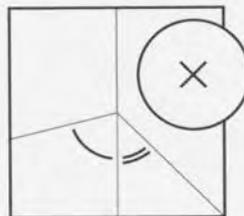


4.3.3. Breaking Symmetry

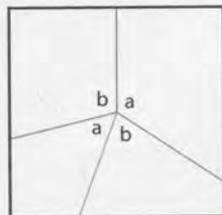
So far, the angle of a V-pleat on one side of the line of symmetry has been mirrored on the other side, so the folding patterns have been symmetrical. However, symmetry is optional. The Japanese origami master Toshikazu Kawasaki developed what is known as the Kawasaki Theorem, which permits V-pleat asymmetry if certain other conditions are met.



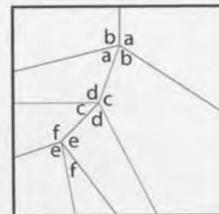
4.3.3_1
In this basic example, the paper will fold in half along the V-pleat because the two marked angles are equal. The crease pattern is symmetrical.



4.3.3_2
Here, the same marked angles on the two sides of the line of symmetry are unequal. Although this crease pattern can of course be folded, the paper will not collapse flat.



4.3.3_3
In order for paper to collapse flat with an asymmetric crease pattern, the Kawasaki Theorem states that there must be an even number of angles around the node (four, six, eight, etc.) and alternate angles must total 180° . Thus, $a + a = b + b = 180^\circ$. Note that for this formula to work, the line of symmetry must change direction through the node.



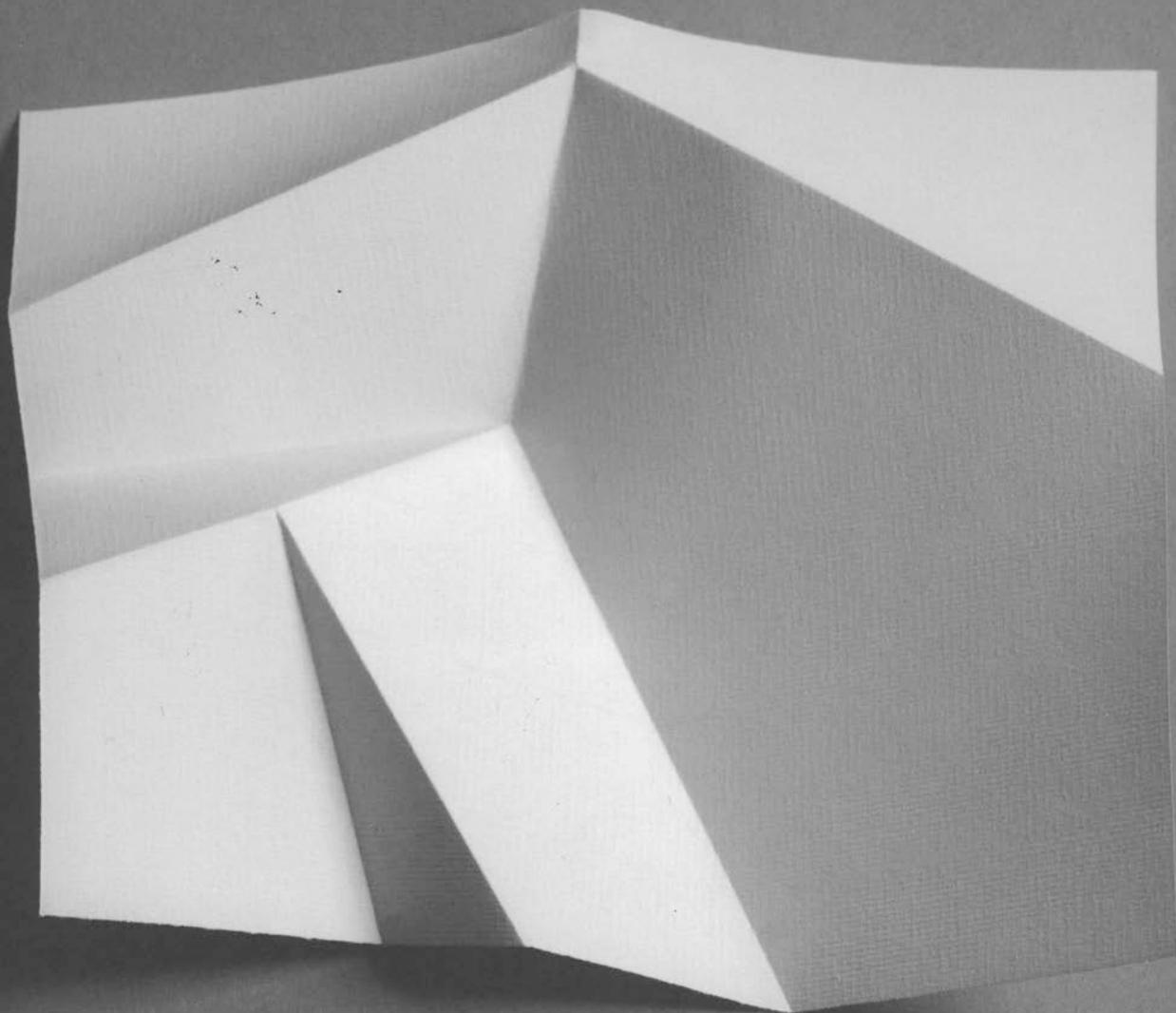
4.3.3_4
The formula will work for any number of V-pleats along a line of symmetry. Some care must be taken with the positioning of the folds so that the result does not look like a chaotic doodle (unless that is what you want, of course). $a + a = b + b = c + c = d + d = e + e = f + f = 180^\circ$.

4-PLEATS

Variations

Breaking

Symmetry

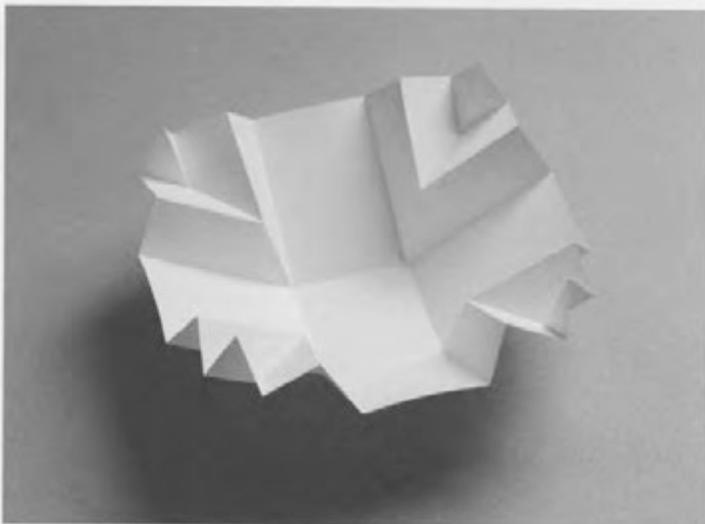
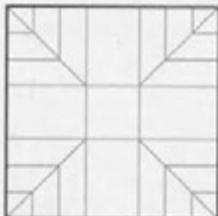


4.3.4. Coexisting Vs

Separate lines of V-pleats can exist independently on the same sheet, though some care must be taken to place them accurately so that they do not touch or interfere with each other. Separate lines may also be built one on another in a succession of V-pleat generations, to create a crease pattern somewhat resembling the forking of a tree trunk into ever smaller branches.

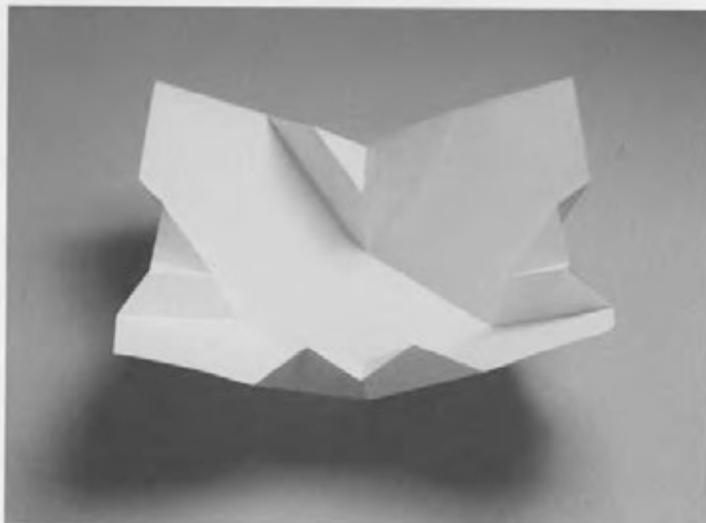
4.3.4_1

Here, four separate lines of V-pleats recede into the corners, leaving the edges and centre unpleated. The same crease pattern can be tried with other polygons.



4.3.4_2

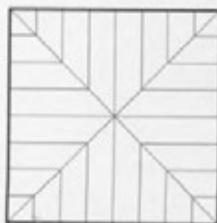
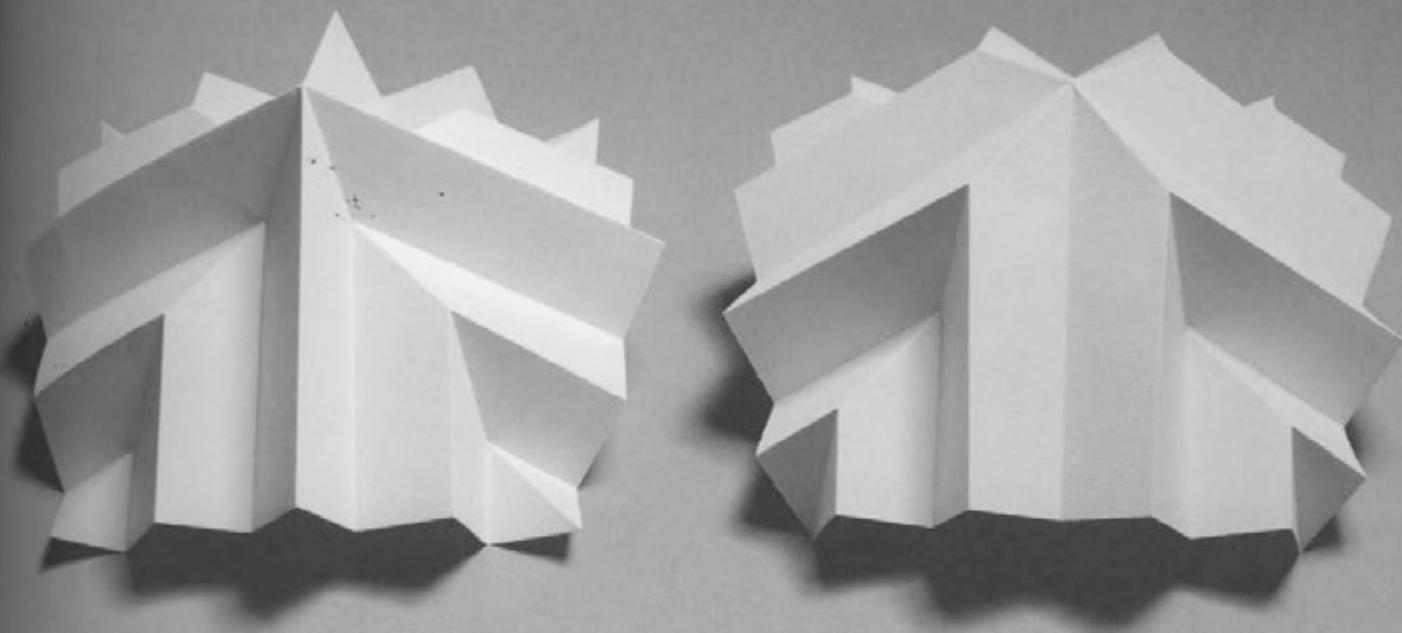
Similarly, four lines of V-pleats recede to the edges, leaving the diagonals and centre unpleated.



V-PLEATS

Variations

4.3.4 Coexisting Vs



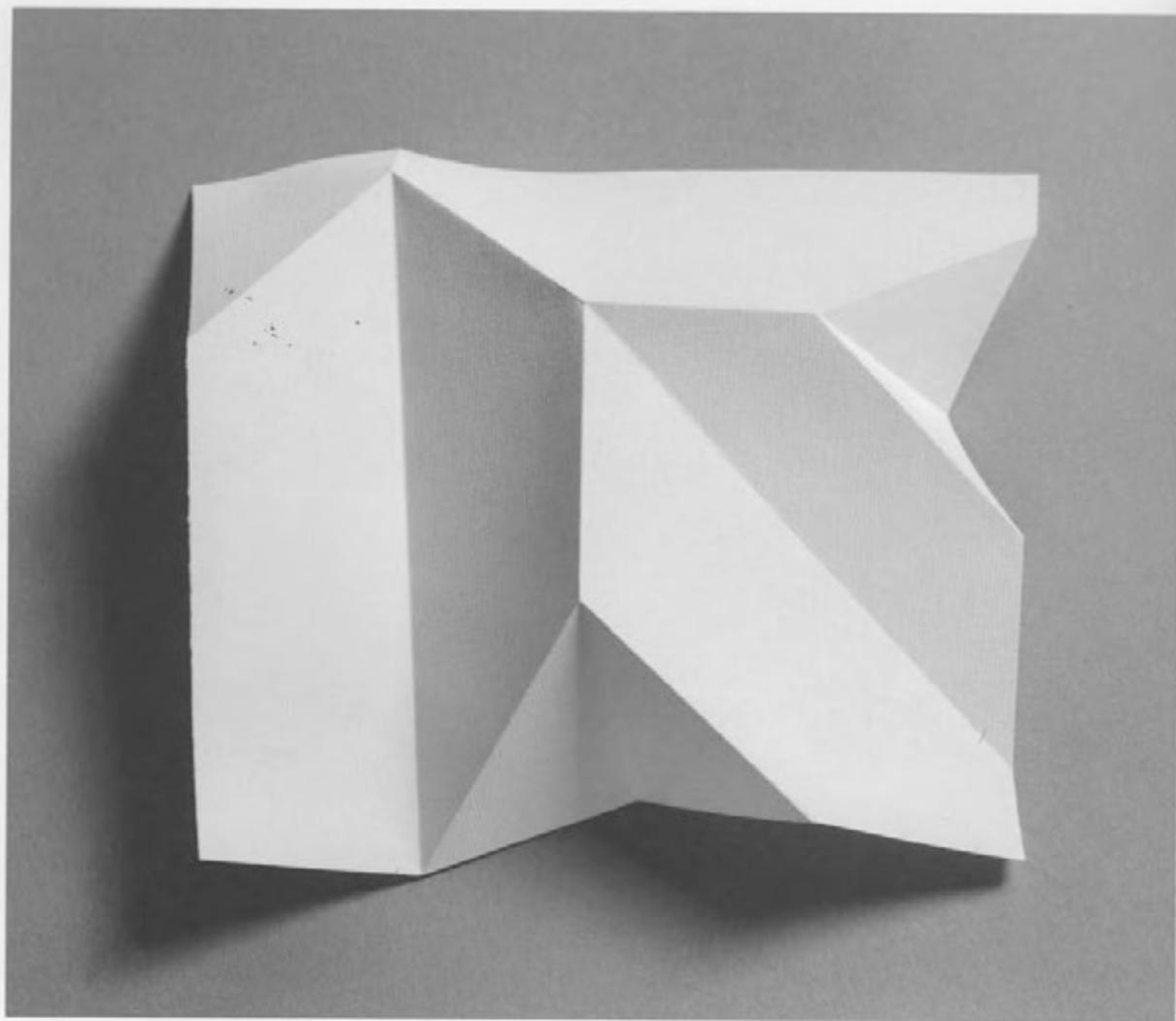
4.3.4_3

The four lines of V-pleats meet at the centre point of the sheet, enabling the final form to take two entirely different forms – each is the other 'popped' inside out (inverted).

4. V-PLEATS

4.3. Variations

4.3.4. Coexisting Vs

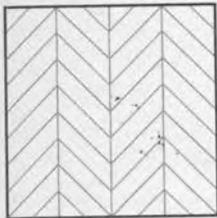


4.3.4 . 4

First, the 1st generation V-pleat is made near the top-left corner of the sheet. Then, the 2nd generation pleat is made near the centre, after which two 3rd generation pleats are made. Other generations may be added. Any of the variations discussed above may be used with this generations idea. The sheet will collapse to create a flat stick.

4.4. Multiple V's

This is the point in the chapter when making V-pleats can become an extreme sport. The V-pleats made on pages 103–106 will now duplicate themselves sideways, so that a V-form becomes a W or M. They are connected by new lines of symmetry, arranged in linear, radial or random patterns. In the example shown here (4.4.1 _ 1), three lines of symmetry connect two lines of Vs to create an M-form. As before, these Multiple Vs will collapse flat if the conditions of the Kawasaki Theorem are observed.

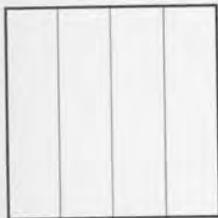


4.4.1 _ 1



4.4.2. Making by Hand

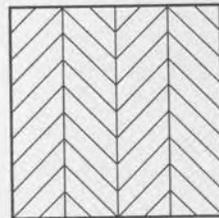
Like the simple V-pleats earlier in the chapter, Multiple Vs may also be folded by hand. The method is fundamentally the same, though it entails more work and a greater commitment to accuracy.



4.4.2 _ 1
Fold the sheet into quarters. It will be helpful if these are made as universal folds (see page 105).



4.4.2 _ 2
Create angled folds through all four layers of the paper, again as universal folds.



4.4.2 _ 3
Open the paper. This is the completed crease pattern.

4. V-PLEATS

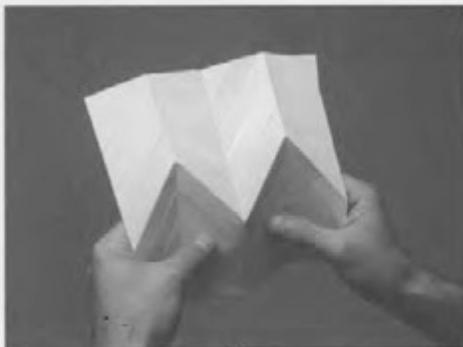
4.4. Multiple Vs

4.4.2. Making by Hand

How to Collapse the Creased Paper

4.4.2_4

Hold the paper in the air, symmetrically, with thumbs on the front and fingers on the back. Select an M-fold approximately in the middle of the paper. Using your fingers and thumbs, pop and press the creases to make a mountain M from left to right across the paper, while at the same time defining the three vertical folds (the lines of symmetry) as mountains or valleys. Do not allow the paper to flatten – this will lose all the newly made folds.



4.4.2_5

Continue to make successive lines of M-pleats that alternate mountain-valley-mountain-valley down the paper to the bottom edge.



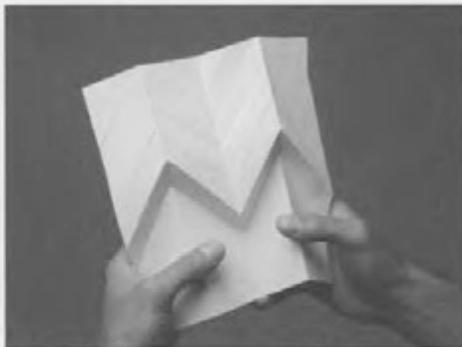
4.4.2_8

When all the folds have been made, collapse the paper into a narrow stick and press it flat with some force in order to sharpen all the folds.



4.4.2_5

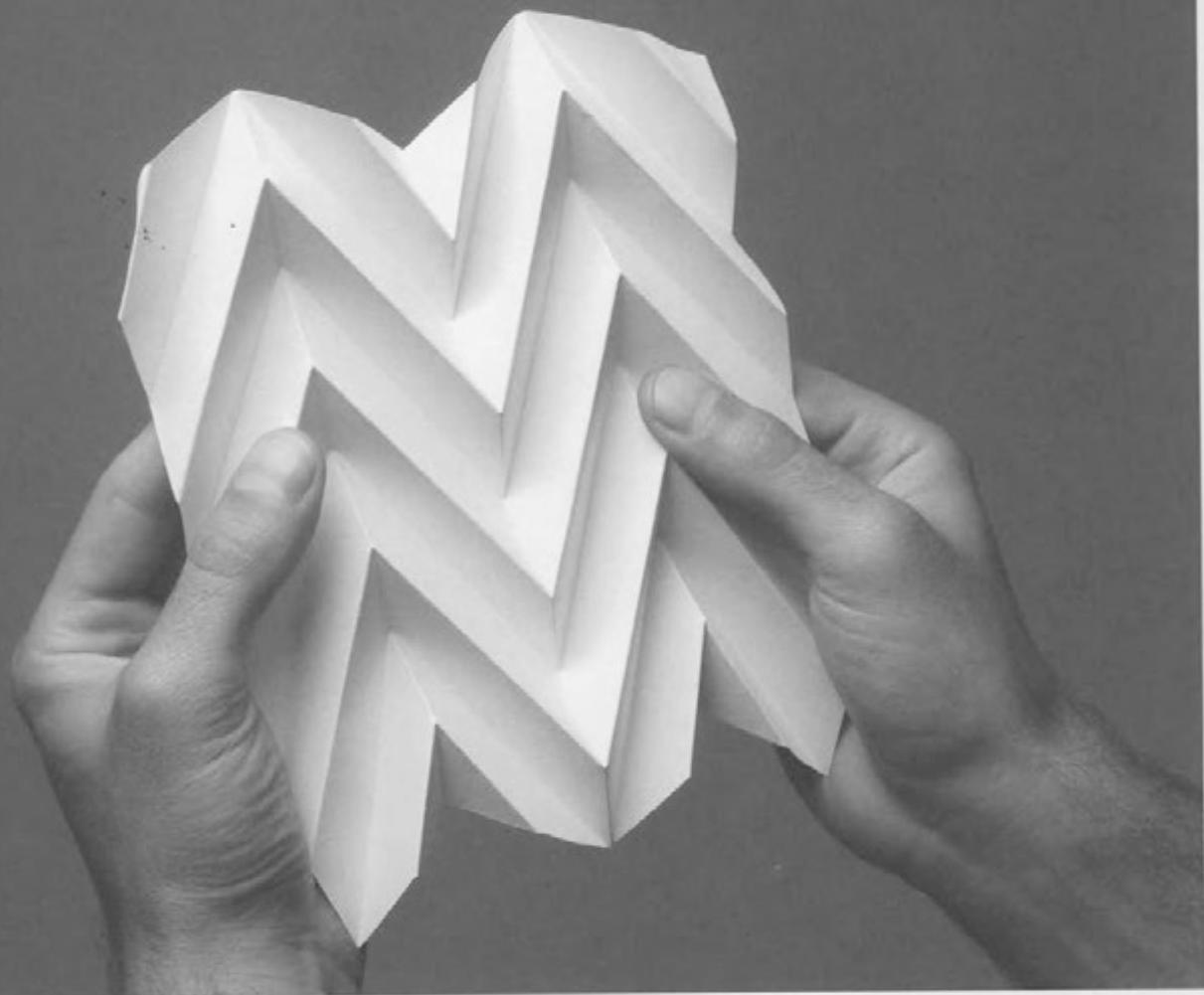
Repeat, but this time make a valley M. Note that the three vertical lines of symmetry below the valley M must be allowed to be from valley to mountain and from mountain to valley. All three folds are the opposite to the folds seen in the previous step.



4.4.2_7

Similarly, now make the remaining M-pleats, working from the first M-pleat made up to the top edge of the paper.



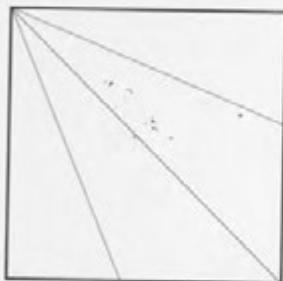


4.4.2_9
The stick can be pulled open to reveal the M-pleats inside.

4.4.3. Variations

The folding of several lines of symmetry on to which angled folds are superimposed can take many forms. Here are examples to make by hand, which explore the three most basic themes. As before, it is most helpful to fold all the creases as universal folds.

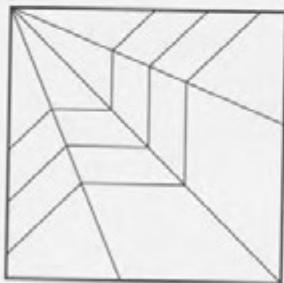
4.4.3.1 Radial



4.4.3.1_1
Divide the corner into four equal angles of 22.5° .



4.4.3.1_2
Place three (or more) angled folds across the paper.

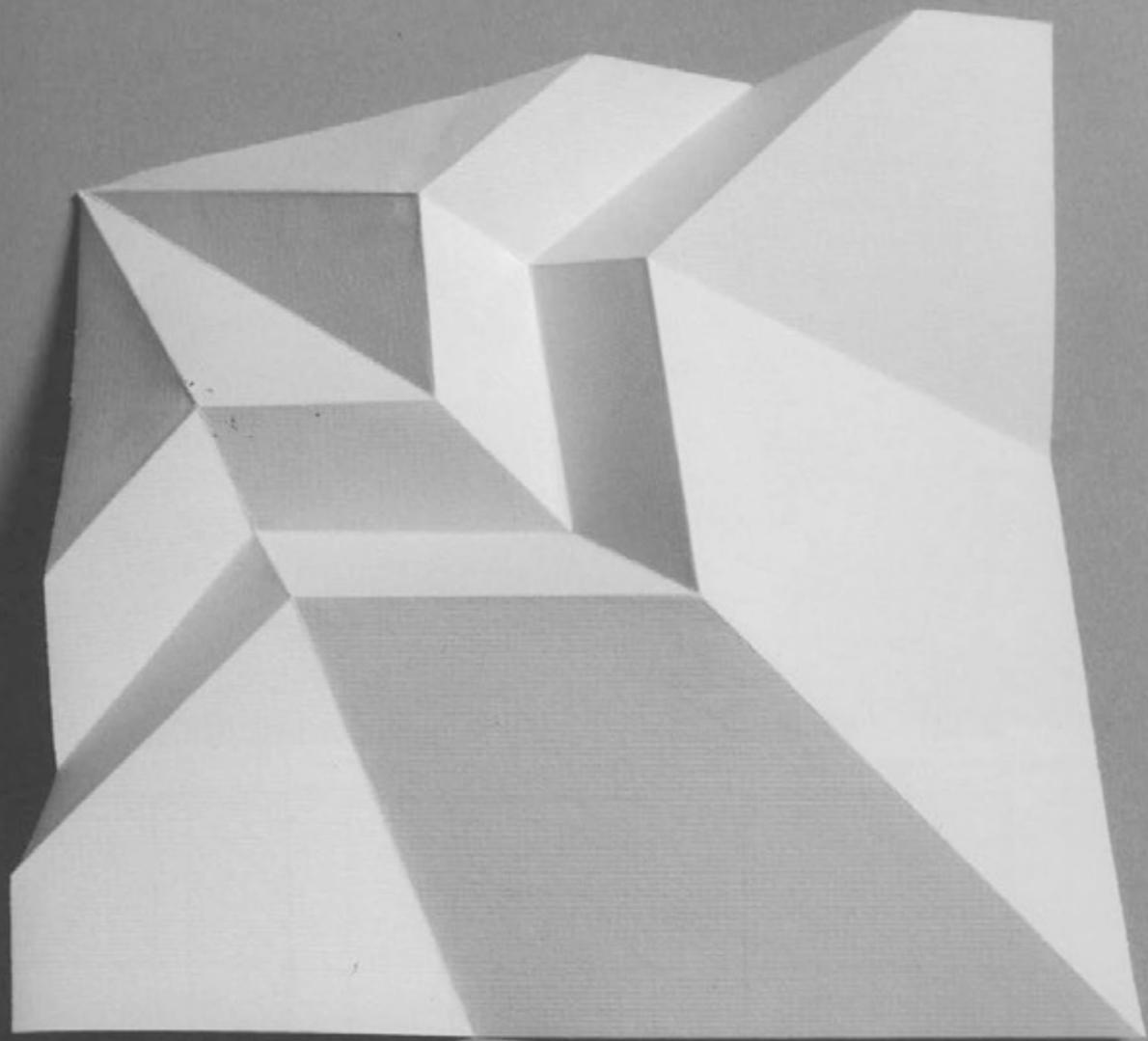


4.4.3.1_3
Open the paper and collapse the folds as described on page 118. See photo opposite.

V-PLEATS

Multiple V's

Variations

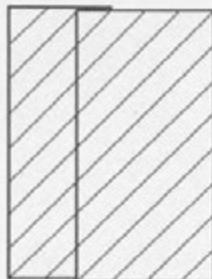


4.4.3.2. Parallel, but Unequal

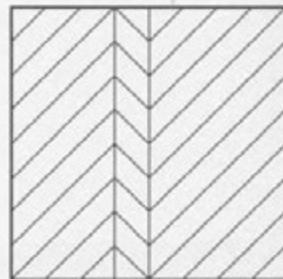
4.4.3.2_3



4.4.3.2_1
Make two parallel lines of
symmetry folds.



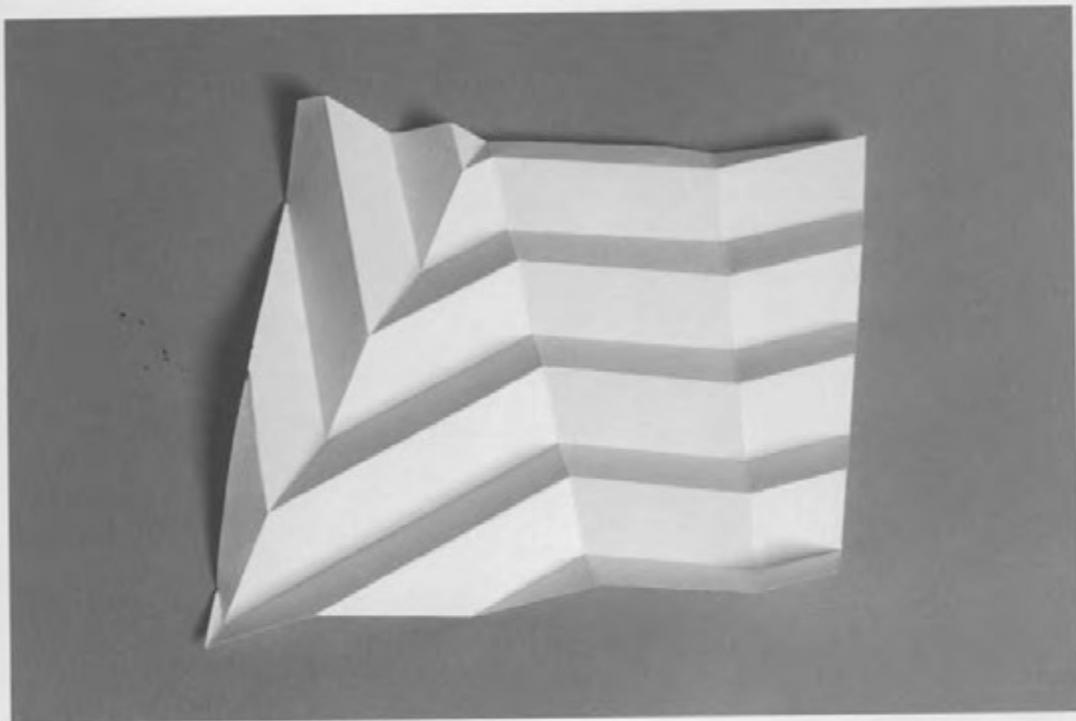
4.4.3.2_2
Make a progression of
angled folds across
the paper.



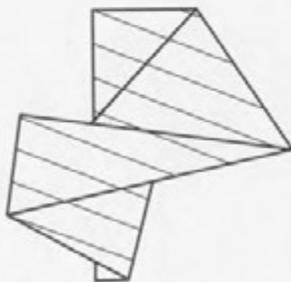
4.4.3.2_3
Open the paper and
collapse the folds as
described on page 118.

4.4.3.3 Random Lines of Symmetry

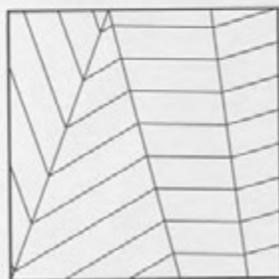
4.4.3.3_3



4.4.3.3_1
The lines of symmetry can be placed randomly (or seemingly so) on the sheet.



4.4.3.3_2
Take care to place the angled lines in such a way that they do not cross a line of symmetry at an angle approaching 0° or 90° . It can take a few attempts to do this correctly.



4.4.3.3_3
Open the paper and collapse the folds as described on page 118.

4.5. Grid Vs

Multiple V's can have many more lines of symmetry than the two or three described earlier, which creates the effect of a grid of repeated Vs. The simplest way to achieve this effect is to first fold the grid by hand, then collapse the paper along only some of the folds to create countless V-pleats variations. The grid needs to be folded with accuracy.

4.5.1. Making by Hand

The method described here divides the sheet diagonally into 32 and horizontally into 16. For a simpler effect, divide the paper diagonally into 16 and horizontally into 8.

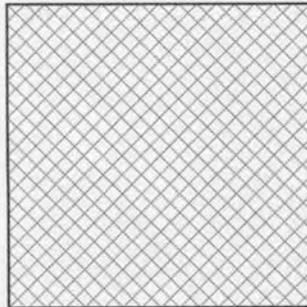
4.5.1_1

Using the method described on page 27, divide the paper into 32 along a diagonal. The folds may be left as mountain-valley pleats, or you may convert all of them to universal folds (see page 105).



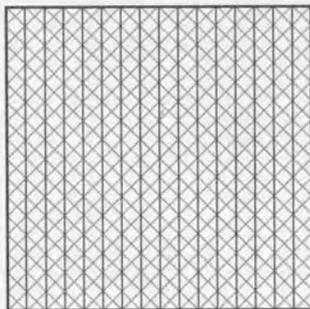
4.5.1_2

Similarly, divide the other diagonal into 32.



4.5.1_3

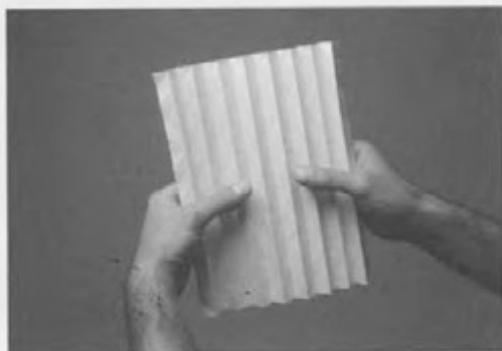
Now divide the paper into vertical sixteenths from left to right. Convert these folds to universal folds. You may also add sixteenths as horizontal folds, though this is not essential. This is the completed grid, from which many Multiple V designs can be created. The photo opposite shows the maximum number of Vs that can be created from the crease pattern made on this page. See also page 128.



PIZZA
BY HAND



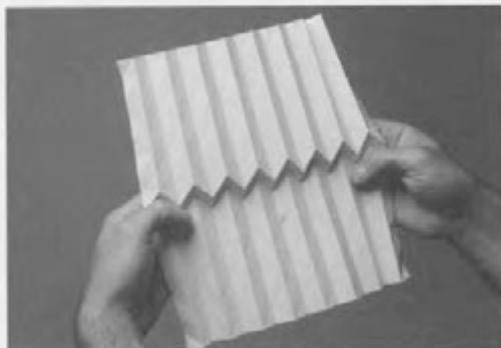
How to Collapse the Creased Paper



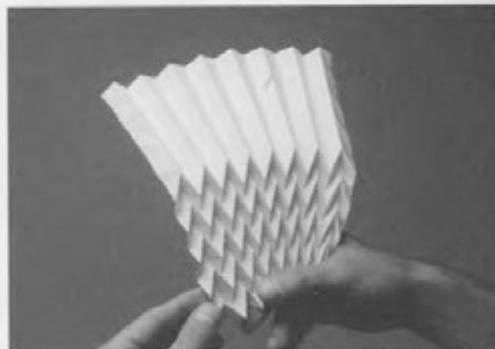
4.5.1_4
Crease the 15 vertical lines of symmetry to make simple accordion pleats. Hold the creased paper symmetrically as shown, with thumbs on the front and fingers on the back.



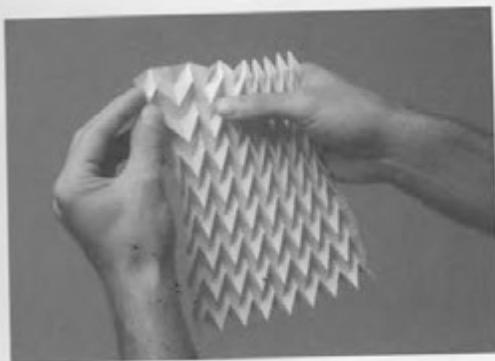
4.5.1_5
Use your fingers and thumbs to pop and press a double row of zigzags. The upper line is a mountain zigzag; the lower line is a valley zigzag. Use existing mountain and valley folds to find these folds. You do not need to invent any new folds! Work across the paper from edge to edge, opening only the part of the paper where you are working. The remainder of the paper can be conscientiously closed.



4.5.1_6
This is the double row of zigzags, completed. It can take some time to acquire the knack of how to make them.



4.5.1_7
Continue to make these double rows of zigzags until you reach the bottom edge of the paper.



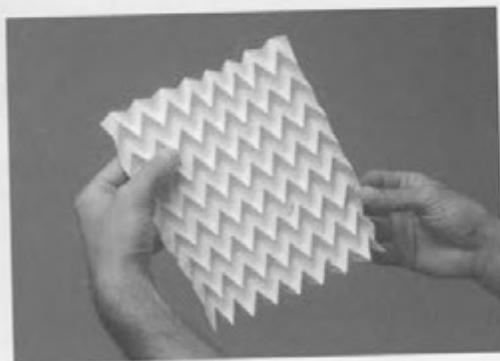
4.5.1_8

Now go back to the middle of the paper and work upwards, creating more double rows of zigzags until the top edge of the paper is reached.



4.5.1_9

Collapse the paper into a very narrow, thick stick. Press it flat to sharpen all the folds.

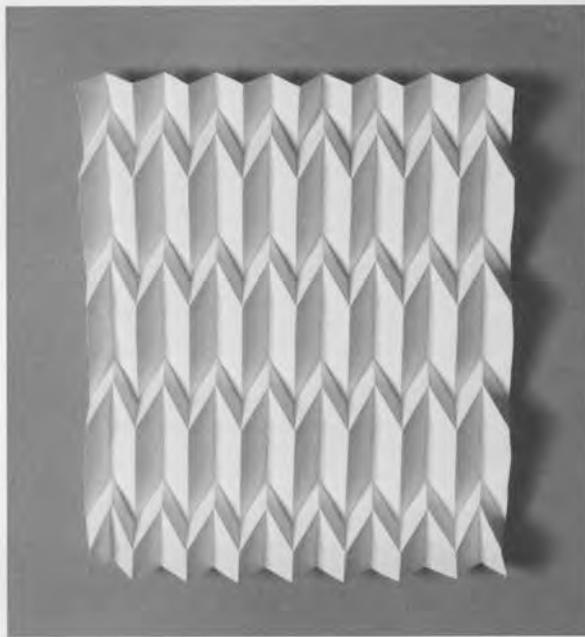


4.5.1_10

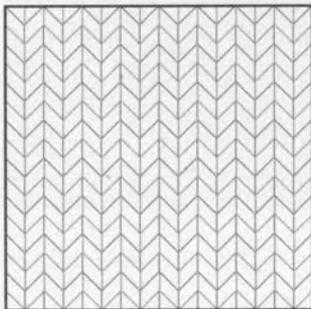
Pull open the stick to reveal the zigzags inside. Pour yourself a drink.

4.5.2. Variations

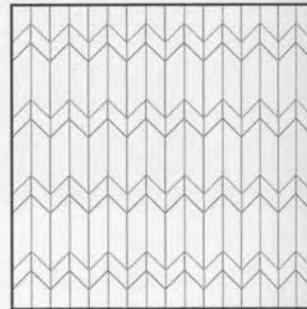
Here are just a very few of the many variations that can be made by selecting some or all of the lines of symmetry and some or all of the V-pleats. All the creases already exist on the grid.



4.5.2_1
This is the full Multiple V grid, using all the lines of symmetry and all the V-pleats. It becomes an extraordinarily flexible parabolic surface.

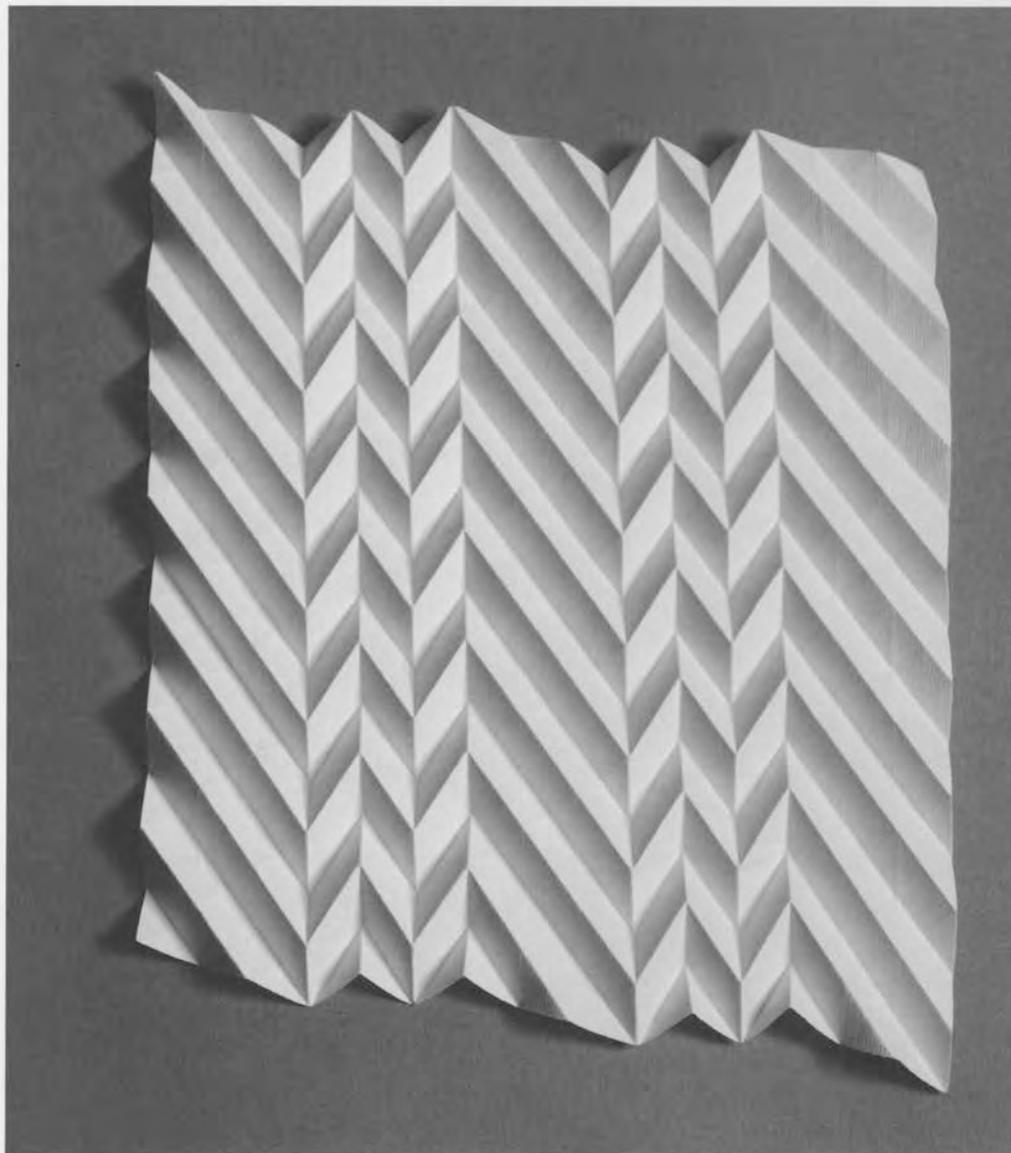


4.5.2_2
Some of the V-pleats may be omitted to create a pattern that is less dense.



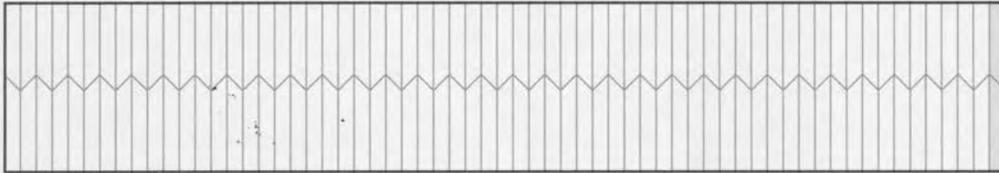
4.5.2_3

Alternatively, some of the lines of symmetry may be omitted, so that in places the V-pleats may extend in length.



4.6 Cylindrical Vs

The relief surfaces of V-pleats will flex in many directions. One obvious way to flex them is to bend the surface into a cylinder, then glue the ends together to make the cylinder permanent. Here are two simple examples, though you could design many others. You will find that these designs become very flexible, almost like toys.



4.6_1

This rectangle is proportioned approximately 6 x 1 and is divided into 64. One division is cut off, so that when the paper is folded and bent into a cylinder, there is a glued overlap of just one division. The long V-pleat can be made from a pre-folded grid of diagonals, or drawn and folded by hand.

Flexing by Hand

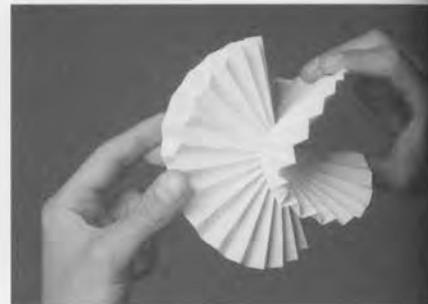
This sequence of photographs shows a few of the many different positions into which the cylinder can be flexed. With a little practice, it can be made to move continuously in the hand!



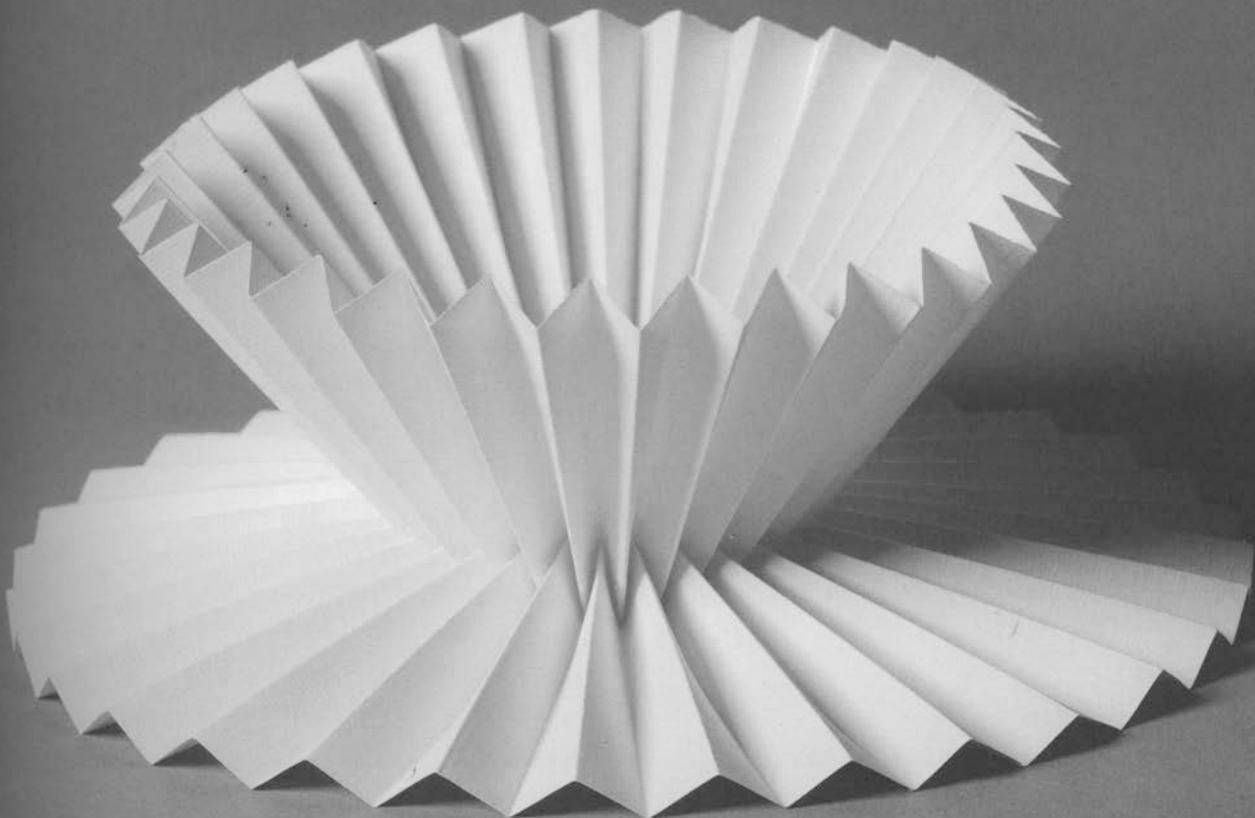
4.6_2

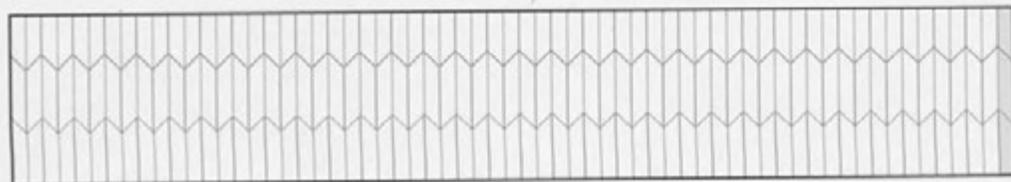
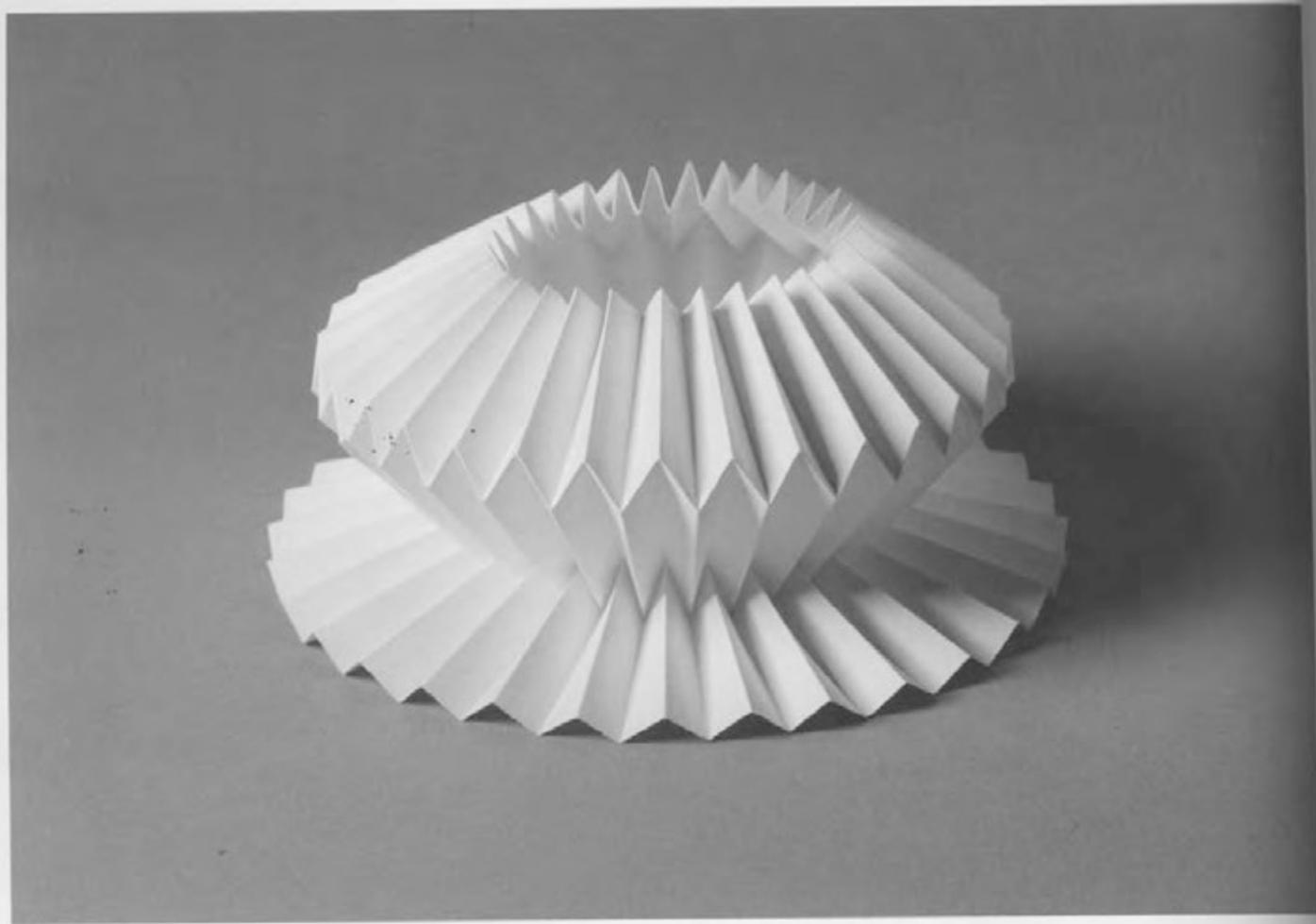


4.6_3



4.6_4





4.6_6
This is similar in many respects to the previous example, except that there are now two lines of V-pleats that divide the sheet into approximate thirds. The extra pleated section allows for more play and for flexed forms of greater intricacy. A more complex version, with four lines of V-pleats, is used for the 19th-century parlour entertainment, 'Troublewit'. This version will bend and flex to make many recognizable objects. Look for details online, or in books on traditional magic.

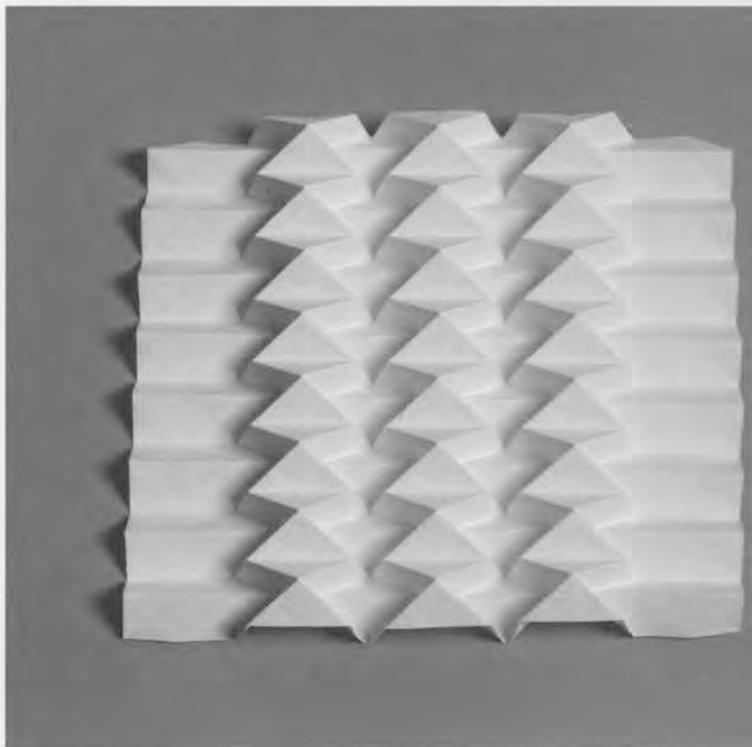
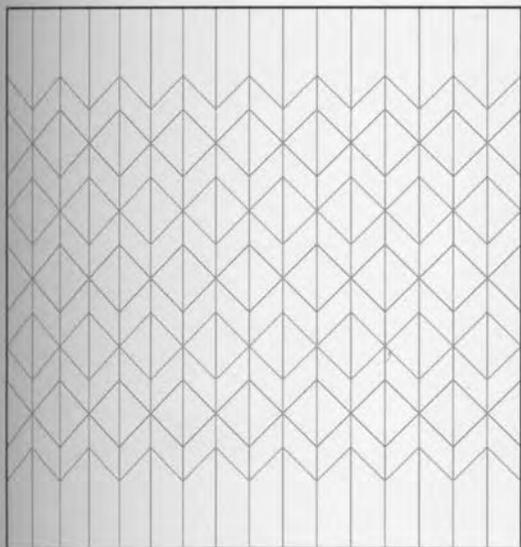
4.7. Complex Surfaces

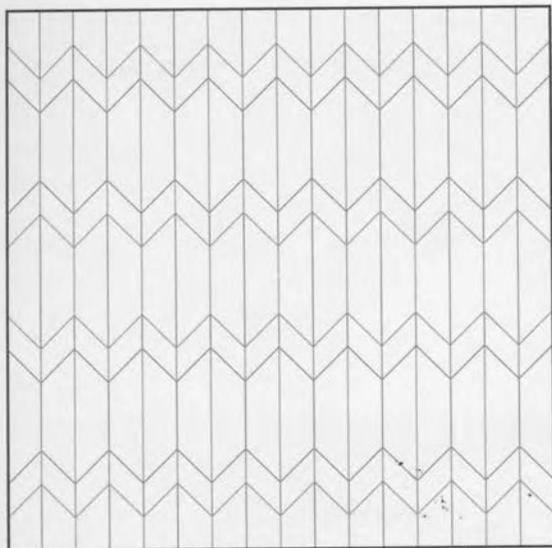
The folded grid can be used to create many extraordinary surfaces that are even more complex than the relatively simple V-pleat ones made in the two previous sections. There are no limits here, other than your time, technical prowess and imagination.

An interesting alternative to the 45° diagonal grid used here is a grid of 60° diagonals, which cover the paper with equilateral triangles. No examples are given here – the possibilities of this grid are left as a challenge.

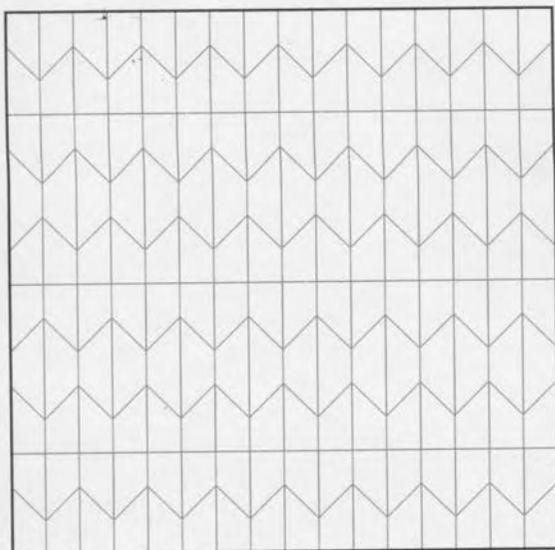
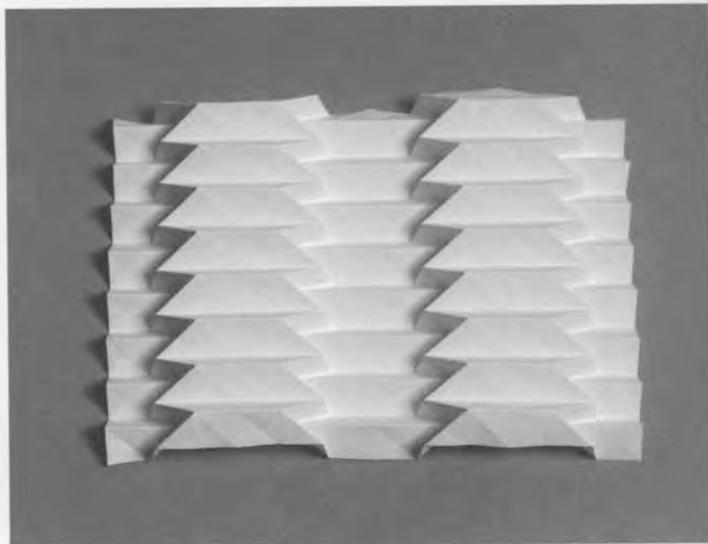
Grids of 45° and 60° create what origami enthusiasts call 'tessellations'. Entering 'origami tessellations' into an online search engine or photo site will bring up many remarkable examples of geometric folding.

4.7_1

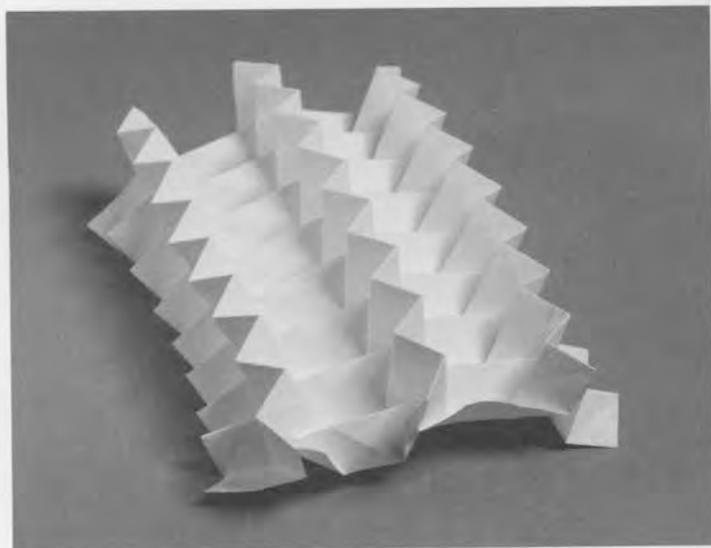


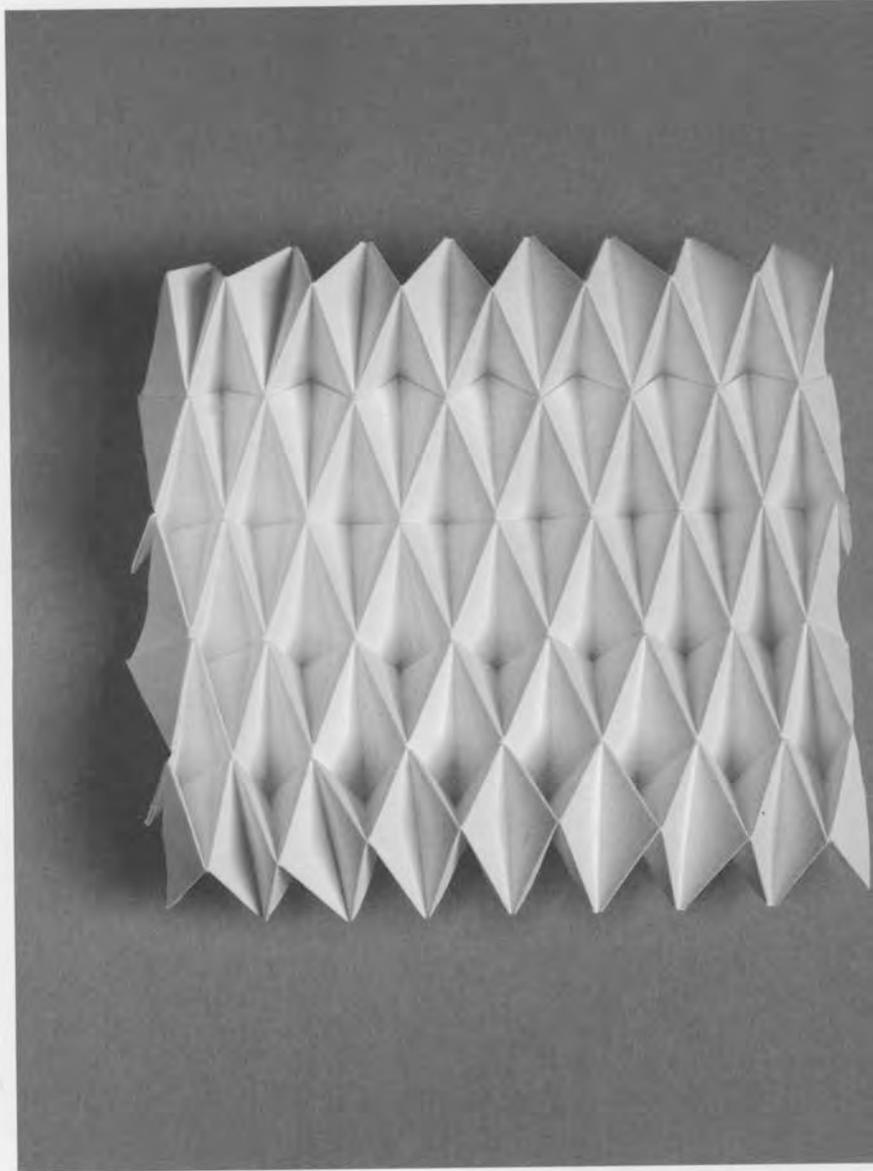
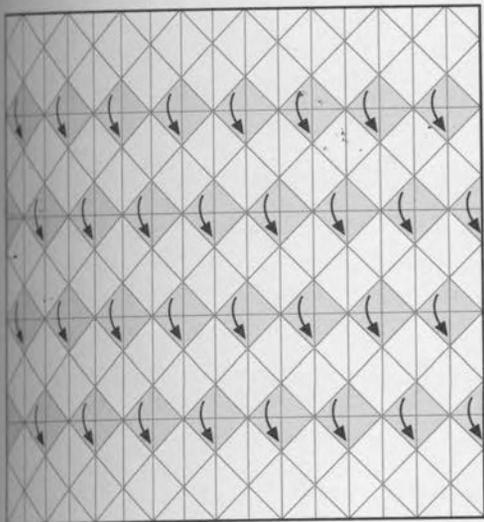


4.7_2



4.7_3





4.7.4
The grey diamonds shown in the diagram are folded in half so that each top corner touches each bottom corner, closing them up. The paper has also been trimmed from a 16 x 16 grid to a 16 x 15 grid, solely to make the folded surface, top and bottom, appear more balanced.

5. Spans & Parabolas

This final chapter about pleats shows how a sheet can be used to create spans and parabolas that touch the ground along an edge or at a corner, and then, through a progression of folded angles, rise upwards, across and down to create a form which resembles a canopy, roof or span.

Whereas most folded spans are 'simple curves' which curve in only one direction, like a cylinder, a folded parabola is a 'complex curve' which curves in two directions, like a sphere. Of course, the apparent curves of a folded span or parabola are purely illusory, since all the folded edges are straight and the planes between them are flat.

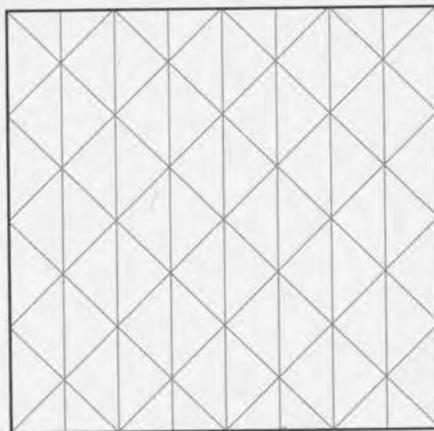
The natural curvature of the folded sheet in these span and parabolic forms gives them great strength, although they are usually only one layer thick. The occurrence of many triangles bounded by folds adds further to the strength of the structures (the triangle is the strongest and most stable of all polygons). Intriguingly, although they display 100 per cent of the surface area of the sheet, many of these structures can be concertinaed flat into a narrow stick.

5.1. X-form Spans

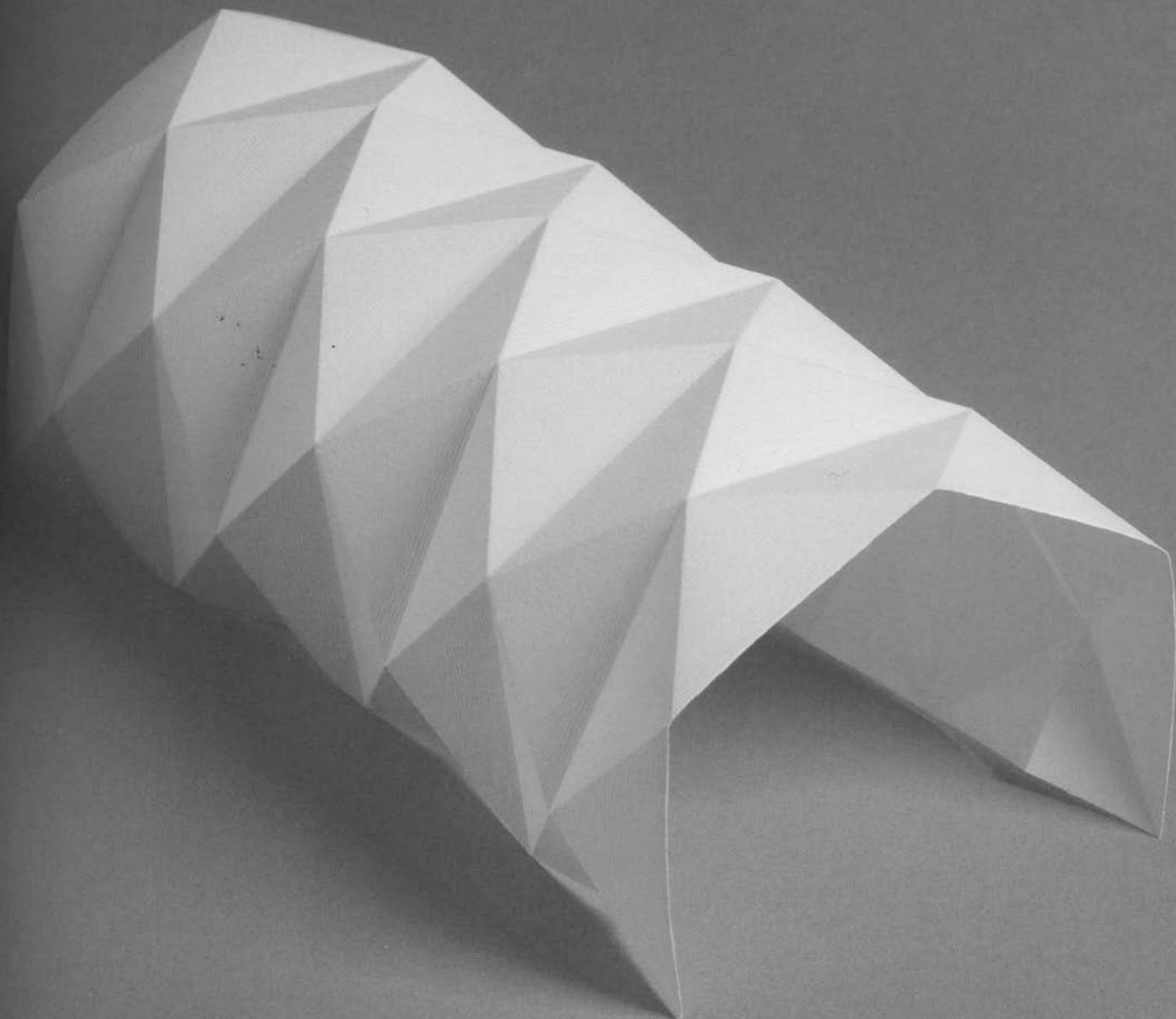
These spans are made from a repeated pattern of folds which resemble an X. In each case, the crease pattern is the same, but it is compressed or stretched to change the geometry of the span, and hence its curvature. Each span is a section of a cylinder.

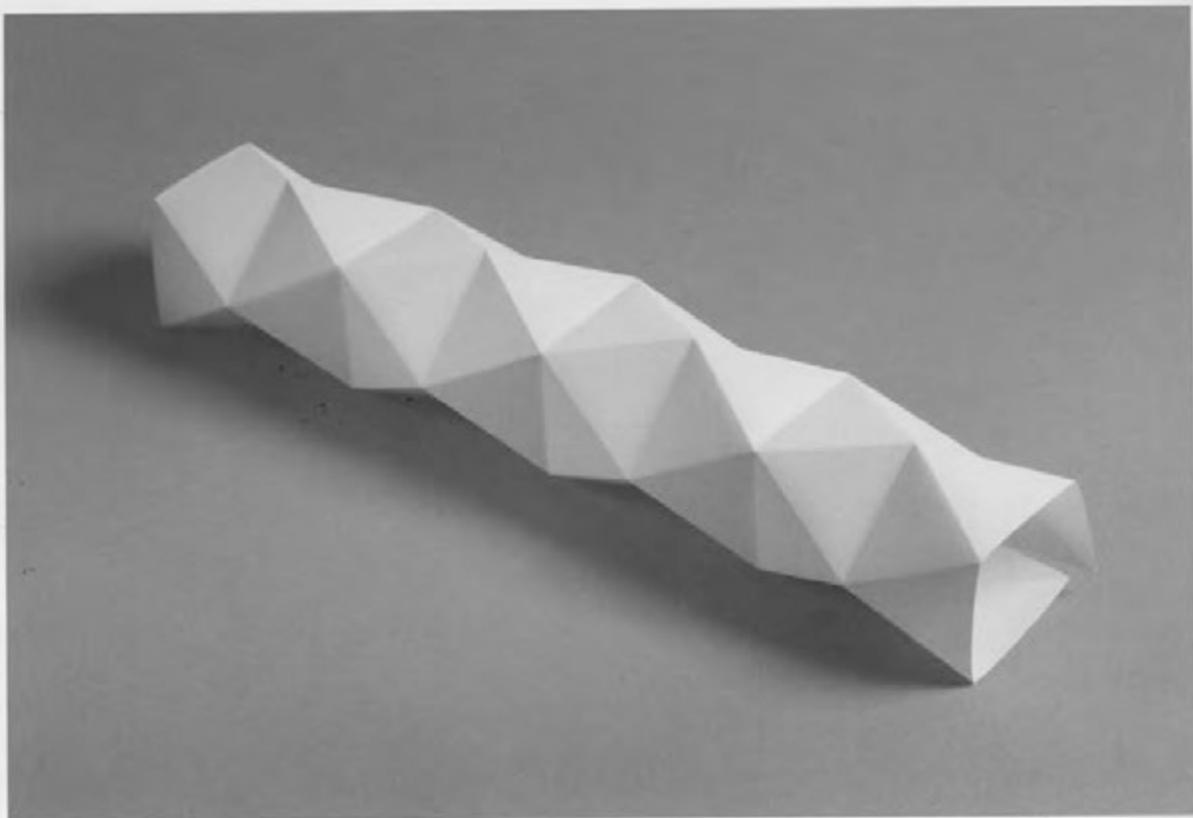
5.1_1

This is the basic X-form on a square sheet, made by dividing the paper horizontally and diagonally into eighths (see pages 16-17 and 27). For the span to form, the centre point of every X must be convex - that is, rise up towards you. See photo opposite.



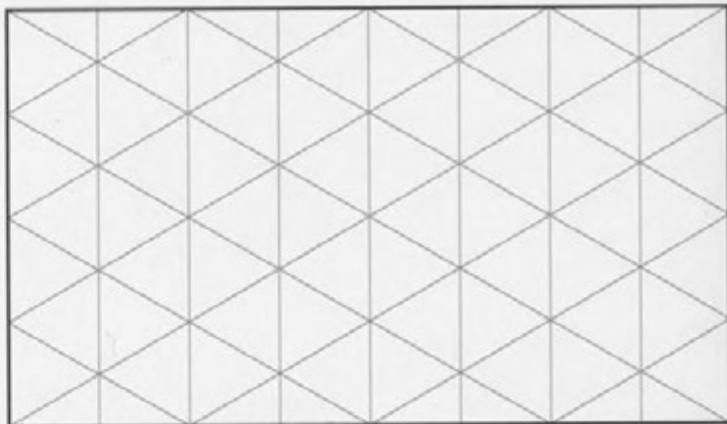
Blank Space

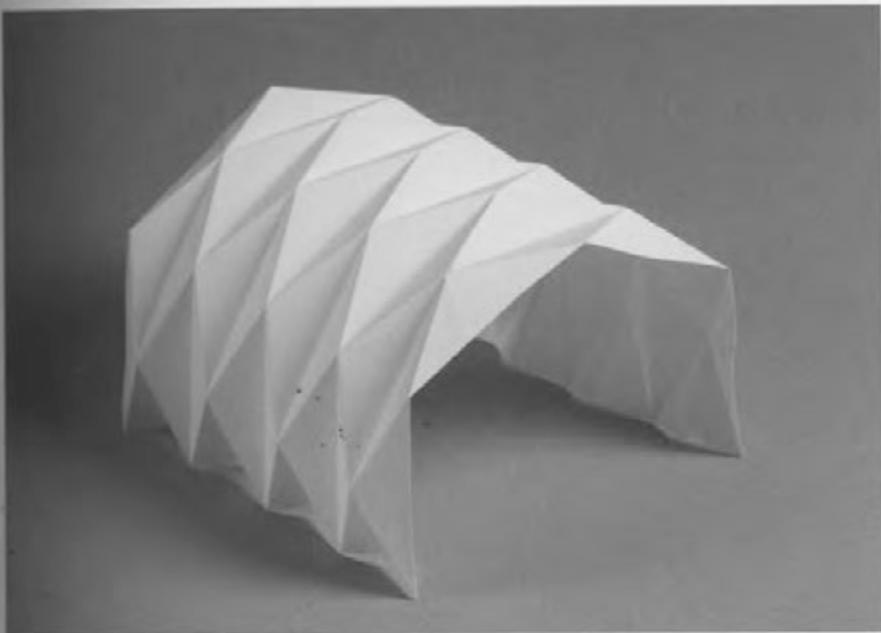




5.1_2

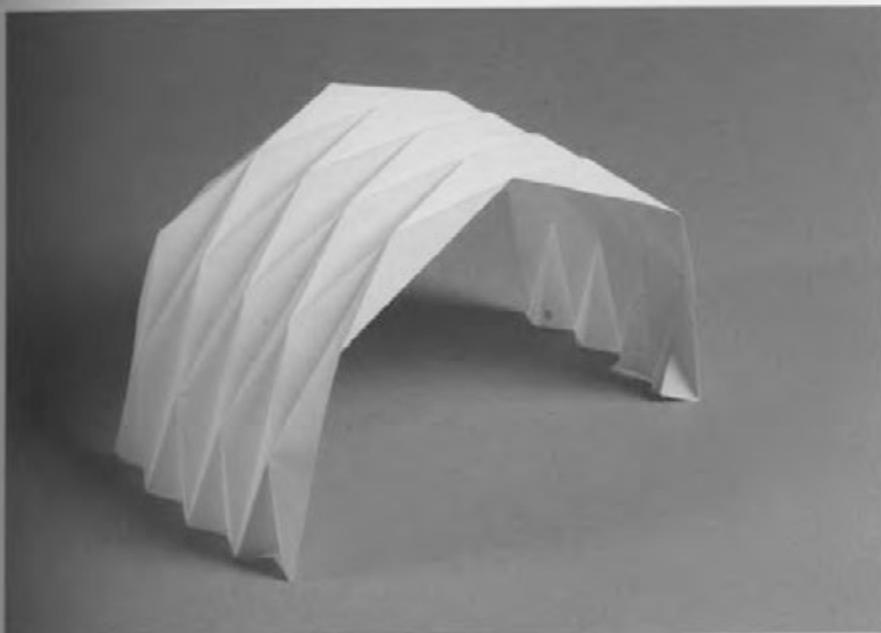
The crease pattern here is the same as in 5.1_1, but is stretched horizontally so that the angle between the strokes of each X is 60° , not 90° as before. The result is to make a span that curls so quickly back on itself that it hardly makes a span at all; rather, it is a narrow, faceted tube.





5.1_3

By stretching the 5.1_1 crease pattern vertically to create an angle of 120° between the strokes of each X, the span becomes considerably more open than before. It is now open enough to allow the pleats to be concertinaed flat.



5.1_4

Stretching the pleats vertically still more to create an angle of approximately 130° between the strokes of each X, opens the span still more. As with the previous example, the pleats will concertina flat.

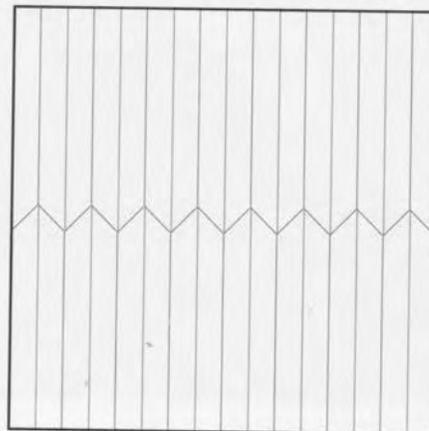
5.2. V-fold Spans

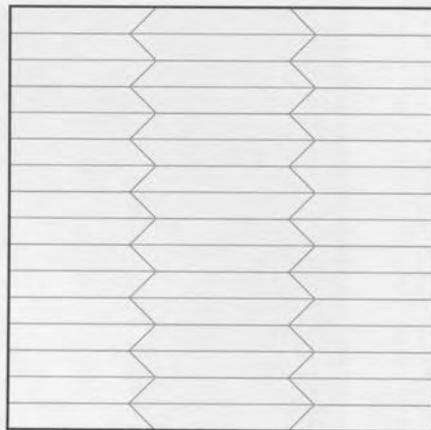
V-fold spans are created from V-pleats (see pages 102–135). Specifically, they use the Cylindrical V technique (see pages 130–132). V-fold spans are as versatile as the X-form spans on the previous page, and all the structures can be concertinaed flat. In contrast, though, V-fold spans create more box-like structures than X-form ones.



5.2_1

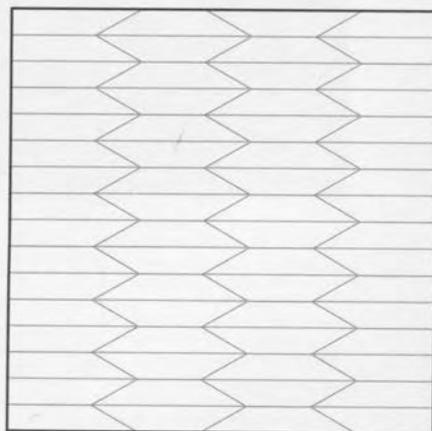
A single line of V-folds is the simplest way to create a V-fold span, though the result is relatively crude. The angle between the strokes of each V shown here is 90°. However, the angle could be greater or smaller, thus opening or closing the span.





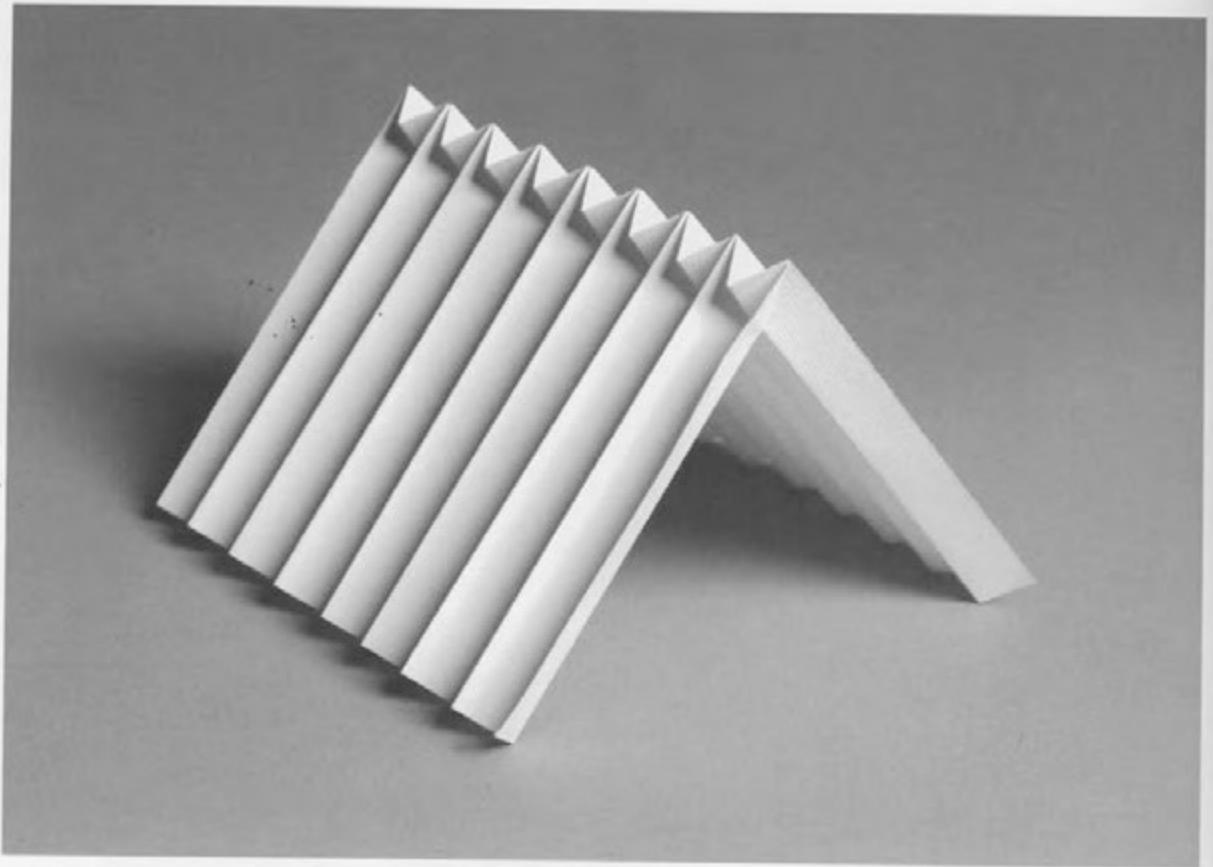
5.2_2

The use of two lines of V-folds creates a span with a flat 'roof'. Note how the two lines are mirror images of each other.



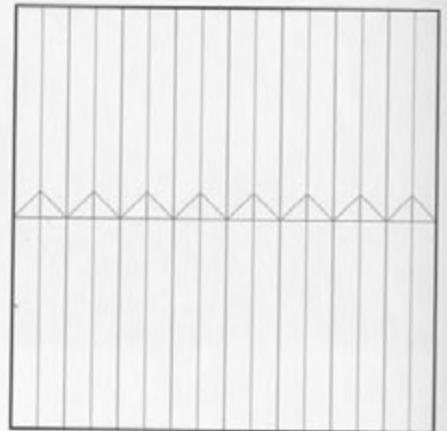
5.2_3

Here, three lines of V-folds are used. The angle between the strokes of each V is 60° , not 90° as before, which stretches the span and makes it more open. This structure begins to resemble the X-form spans.



5.2_4

This V-fold span variation creates a square corner along the line of the V-folds, instead of a filleted corner, as before. Note the long horizontal mountain fold, the valley Vs (not mountains, as before) and how mountains and valleys above the line of Vs remain the same below the line.

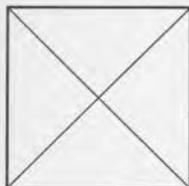


5.3. Parabolas

Few would dispute the observation that of all folded forms parabolas (or more correctly, 'hyperbolic paraboloids') are among the most beautiful. They are also structurally complex to define, very strong and remarkably flexible. If you want to impress someone with a folded structure that fascinates both the eye and the mind, a parabola has to be a contender.

5.3.1 Basic Parabola

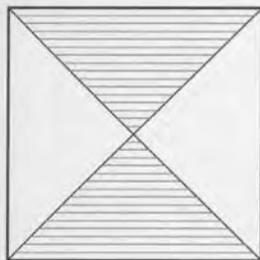
Here is the basic hyperbolic parabola. It is imperative to master this before you attempt any of the others. All the folds must be made with care so that every concentric square is made with great accuracy. If you become a little lost placing the folds and your sheet is messy, it is better to start afresh rather than continue.



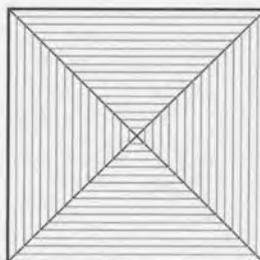
5.3.1_1
On a perfect square, make both diagonals as universal folds (see page 8).



5.3.1_2
This diagram is a copy of 1.1.1_8 on page 18, which teaches you how to divide a length of paper into 32 equal divisions. Please turn to the page and learn (or relearn) how to do this. You cannot proceed until you know how to divide a sheet into 32.



5.3.1_3
Divide the sheet into 32, using the method described in the previous step. Notice three important things: how each fold is contained entirely within either the top or the bottom triangle; how no fold touches the edge of the square; and how there is no centre fold (the centre point of the sheet is defined by the crossing of the two diagonals).



5.3.1_4
Divide the other two triangles into 32. Make sure that each concentric square is made only of mountain or valley folds (not a mixture of the two) and that the squares alternate valley-mountain-valley-mountain between the edge of the sheet and the centre point.

5. SPANS & PARABOLAS

5.3. Parabolas

5.3.1. Basic Parabola

How to Collapse the Creased Paper

5.3.1_5

Starting at the perimeter, carefully fold the four sides of the largest creased square. To do this, hold the paper in the air, thumbs on the front and fingers on the back, and continuously rotate the paper like a windmill, folding the square bit by bit as you go round. Then, begin to fold the square inside the first. If the first square was a valley, this second square will be a mountain, or vice versa.

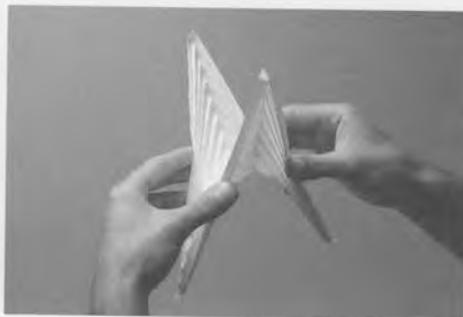


5.3.1_6

Continue to fold square after concentric square, rotating the paper all the time. Note how each corner collapses to make a familiar V-pleat.

5.3.1_7

After eight or so squares have been folded, the paper will begin to buckle – it will not want to lie flat. Note how a pair of opposite corners will gradually rise up, while the other pair will dip down. This is the start of the parabola. As you fold more and more concentric squares, the parabola will become more and more 3-D.



5.3.1_8

Near the middle, the first few concentric squares can only be gently pressed and popped into place, not folded strongly. This is best done by making the paper more and more stick-like, rather than by trying to keep it flat.

5.3.1_9

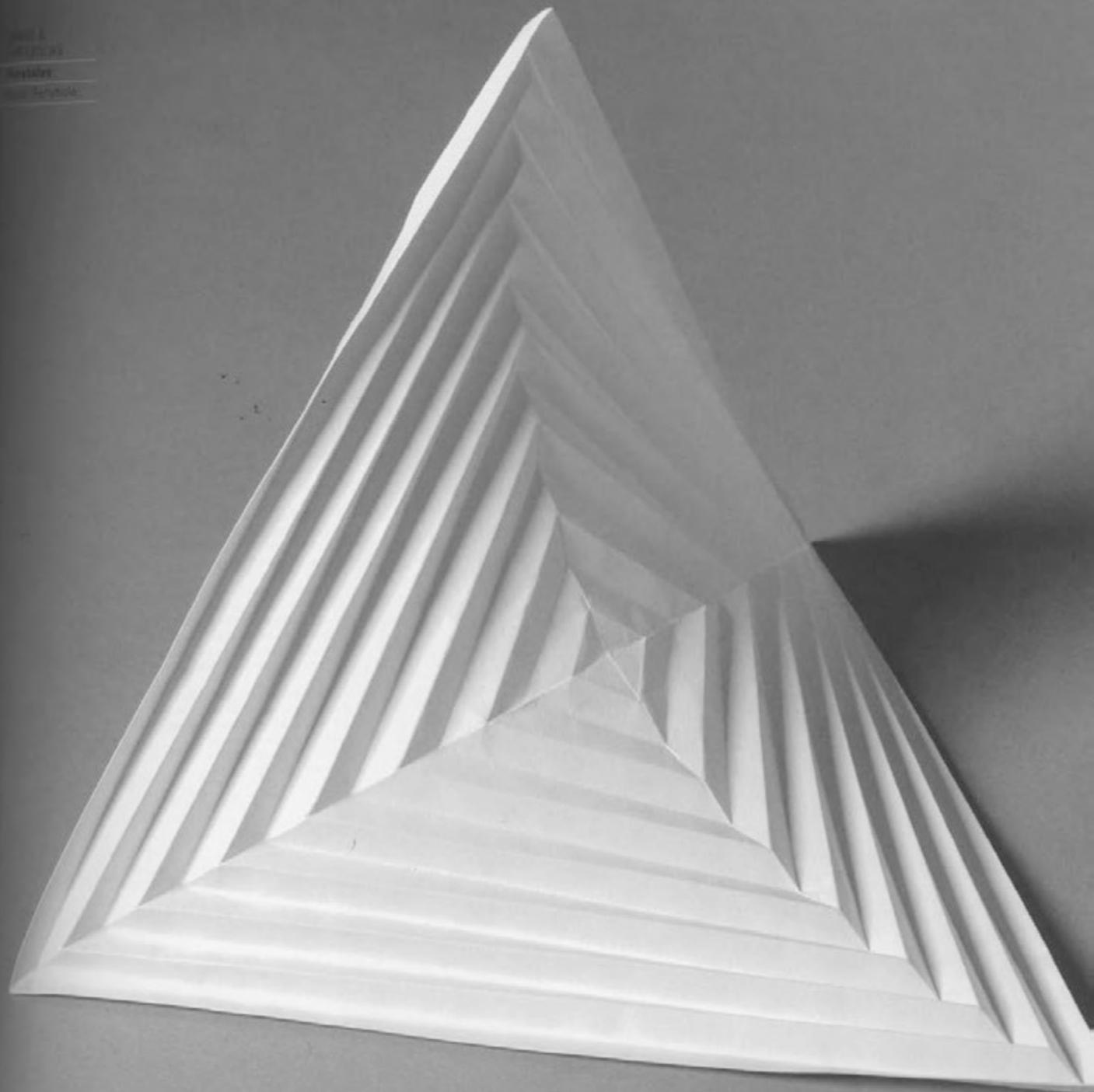
Eventually, all the concentric squares will have been folded and the paper will collapse into a narrow stick form. Press the four arms very strongly to strengthen the folds.



5.3.1_10

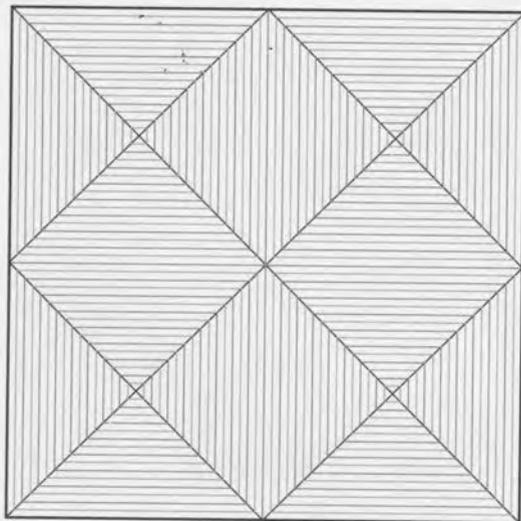
Open the parabola by pulling the middle of a pair of opposite edges, then pulling the middle of the other pair of opposite edges. The more the parabola is opened, the more beautiful it will look. For transportation or storage, collapse it back to the stick form.

0147
0147
0147
0147



5.3.2. Variations

Once the basic square parabola has been mastered, it is possible to make many variations, using the same principle of dividing the sheet into 16 from the edge to the middle. The greater the number of edges the polygon has, the more flexible and fascinating the final parabola becomes.



5.3.2_1

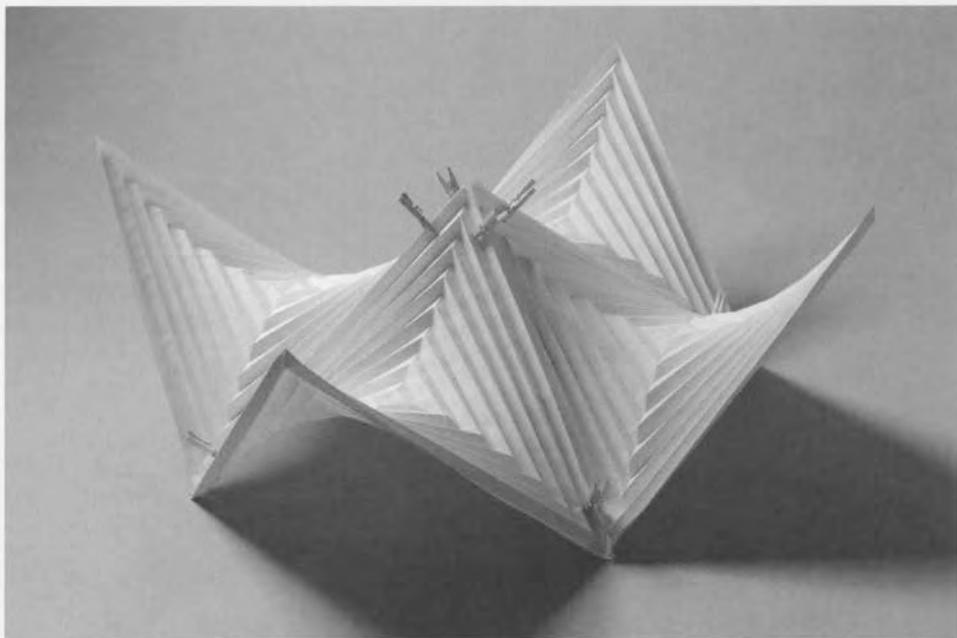
A characteristic of the basic parabola – and actually, any parabola – is that all the edges of the sheet remain straight and unfolded. This means that the edge of one parabola can be fully connected to the edge of another, allowing complex structures to be built up from many joined parabolas.

Not for the faint-hearted, this is a one-sheet crease pattern for four basic parabolas in a 2×2 grid, so that four parabolas meet at the centre point. The grid could extend infinitely. It is possible to remove one of the parabolas from the 2×2 grid and close the gap by glueing the edges together, thus allowing only three parabolas to meet at the centre point. Similarly, five or six may be allowed to meet at the centre point, or just two.

If you have the time and interest, it is well worth making a dozen or more basic parabolas and spending some time joining them together temporarily in many configurations. The possibilities are immense and surprising.

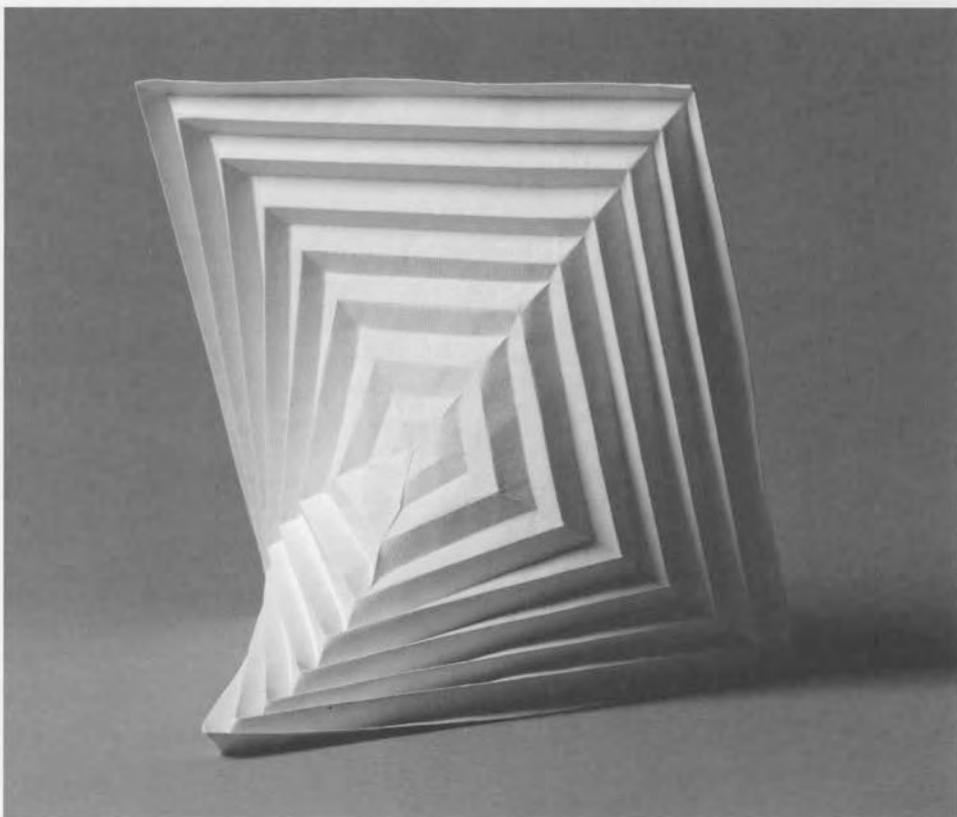
5.3.2_1

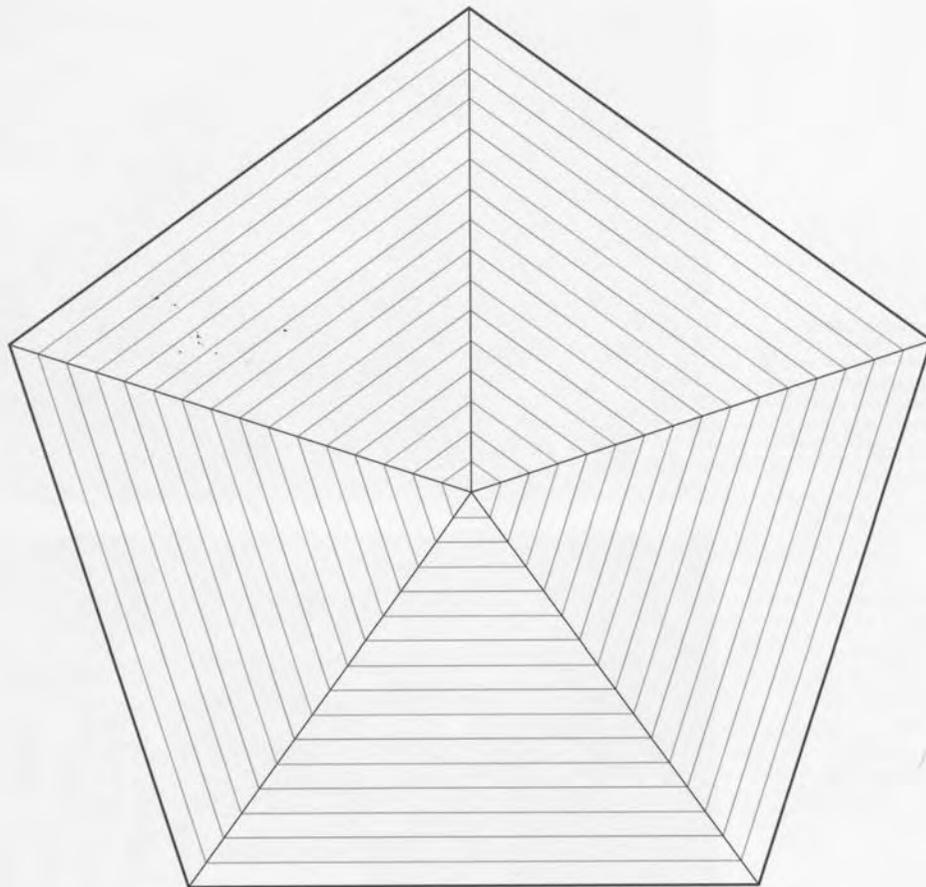
Instead of folding these complex structures from one sheet, the parabolas can first be folded separately and then joined temporarily with mini pegs, paper clips or staples. The example right shows four separately folded parabolas joined with pegs.



5.3.2_2

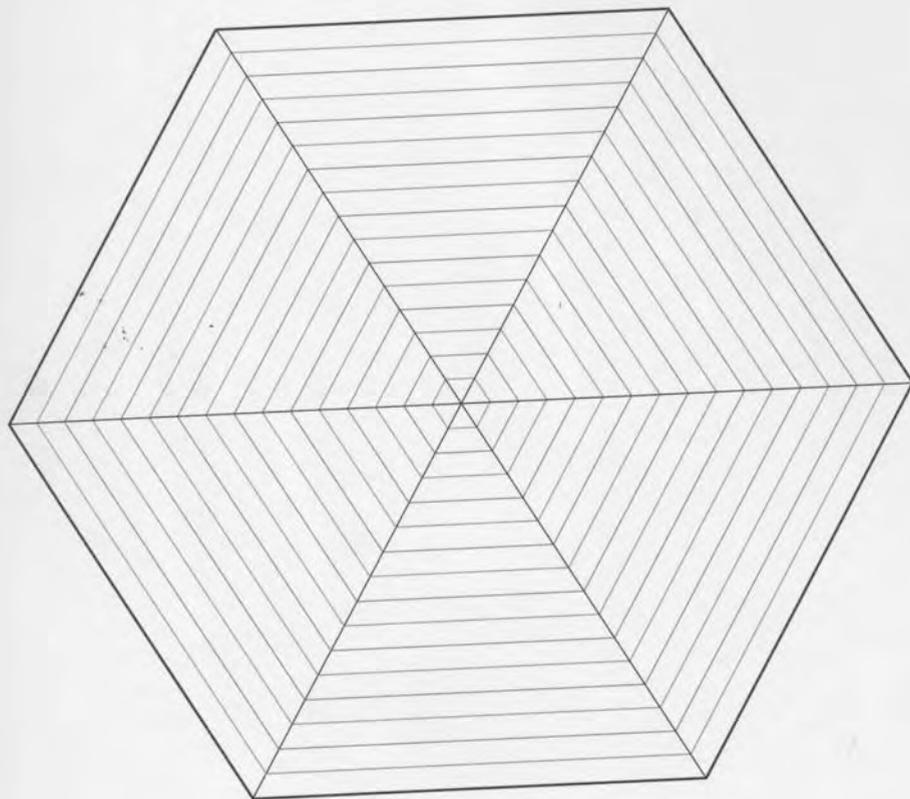
For caption, see diagram caption overleaf.





5.3.2_2

Polygons other than squares may be used, such as a pentagon. If you are folding it by hand, you may need to draw extra construction lines in light pencil to help you keep all the folds parallel and equidistant. Remember to play with the final result – it is a very flexible and strangely unresolved structure. See photo on previous page.



5.3.2_3

The hexagonal parabola (above) is particularly appealing. It is simple to construct by hand and has the curious property of flipping between a form with three alternate corners on the floor (see overleaf) and a form with four corners on the floor, or two opposite edges. Manoeuvring from one to the other can be difficult!

The more sides the polygon has, the more the corners can be flipped up and down in different combinations to create an increasing number of different forms; the hexagonal parabola has just the two described above, whereas the octagonal parabola, for example, has four or five, including forms which describe a cube, tetrahedron or octahedron. As always when folding, the key to finding these variations is to play with the paper as much as possible.

6. Boxes & Bowls

In origami, boxes and bowls abound. There are hundreds of different designs that could be described variously as boxes (lidded or unlidded), trays, bowls, bags, dishes, pots, vases or containers. Some are simple, square and functional; others are very decorative. They can be made from squares or rectangles, or from other polygons. Origami hats may be considered box forms, and vice versa.

The basic box-making technique is always the same: by folding, to reduce the flat 360° of material around a given point on the sheet so that it creates a 3-D corner, then to create more corners, connect them with folds and lock everything strongly in place. How the sheet is reduced from 360° to a smaller angle is the essence of box making. Making boxes is the art of making corners.

This chapter presents just a very few of the ways to make square, vertical-sided boxes. A little research will reveal many more.

Bowl forms are less like specific origami models in concept than boxes. Consequently, it is easier to create your own bowl designs than ones for boxes.

6.1. Boxes

6.1.1. Masu Box

The Masu box (see photo opposite) is a traditional Japanese design. It is a classic folded box; strong, adaptable, functional, and elegant in construction and final form.

The instructions here show how the classic Masu box is folded, and the following section, 'Masu Variations', shows how the same sequence of folds can create a family of different boxes.

6. Boxes & Bowls

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6.1. Boxes

6.1.1. Masu Box

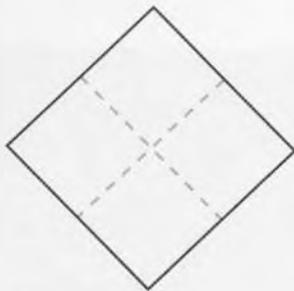
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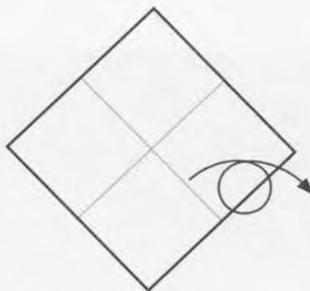
6. BOXES & BOWLS

6.1. Boxes

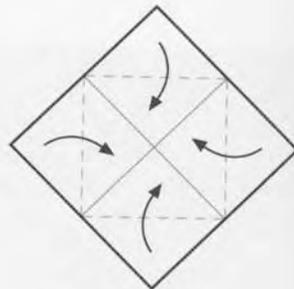
6.1.1. Masu Box



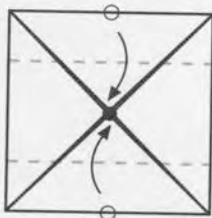
6.1.1_1
Fold and unfold two separate creases that divide the sheet into four small squares.



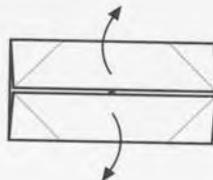
6.1.1_2
Note the two long valley folds. Turn the paper over.



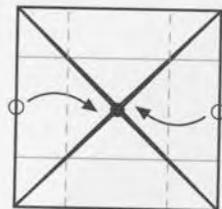
6.1.1_3
The existing folds are now mountain folds. Fold the corners to the centre.



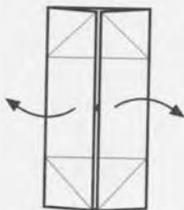
6.1.1_4
Fold the top and bottom edges to the centre point.



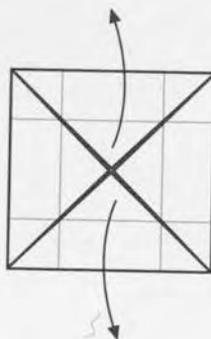
6.1.1_5
Unfold Step 4.



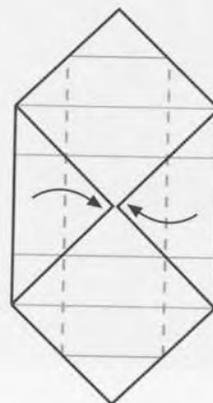
6.1.1_6
Similarly, fold the left and right edges in to the centre point.



6.1.1_7
Unfold Step 6.



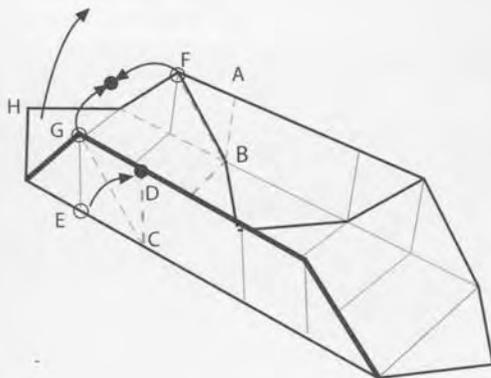
6.1.1_8
Unfold the top and bottom triangles only.



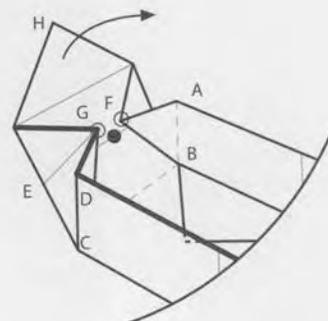
6.1.1_9
Fold the left and right edges to the centre line.



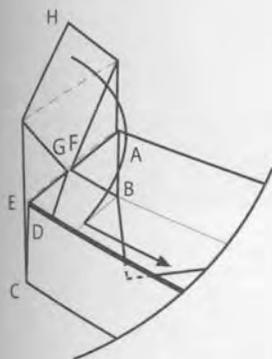
6.1.1_10
Half unfold Step 9 so that the edges stand up at 90°.



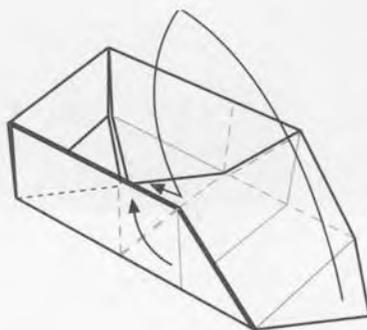
6.1.1_11
This is the crucial step. Several things happen at the same time. Corner H lifts up to the vertical. Corners F and G come together and touch. Crease A,B,C,D is one long crease that defines the sides and base of the box. E touches D.



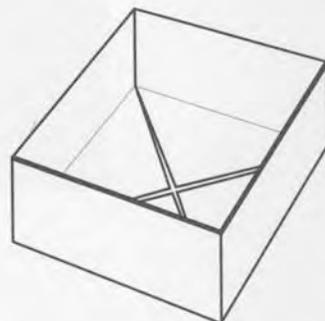
6.1.1_12
This is halfway. Note that H is lifting to the vertical, F and G are almost touching, the crease A,B,C,D is now defined and E is coming up to touch D.



6.1.1_13
The collapse is complete. H is vertical, F and G are touching, crease A,B,C,D has defined the end of the box and E is touching D. Lock the end of the box tightly by wrapping corner H over the top of the box.



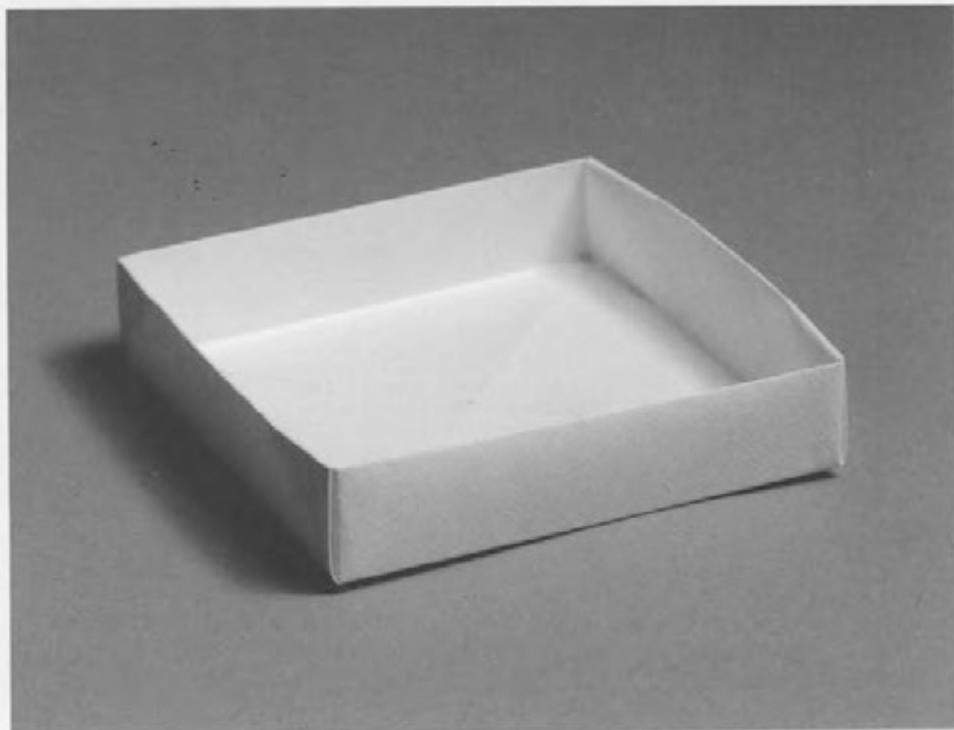
6.1.1_14
Repeat Steps 11-13 with the other end of the box.



6.1.1_15
The Masu box is complete. Note how all the corners of the original paper square meet in the middle of the box.

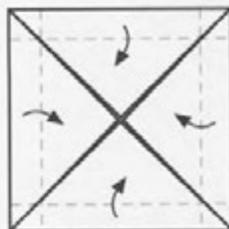
6.1.2. Masu Variations

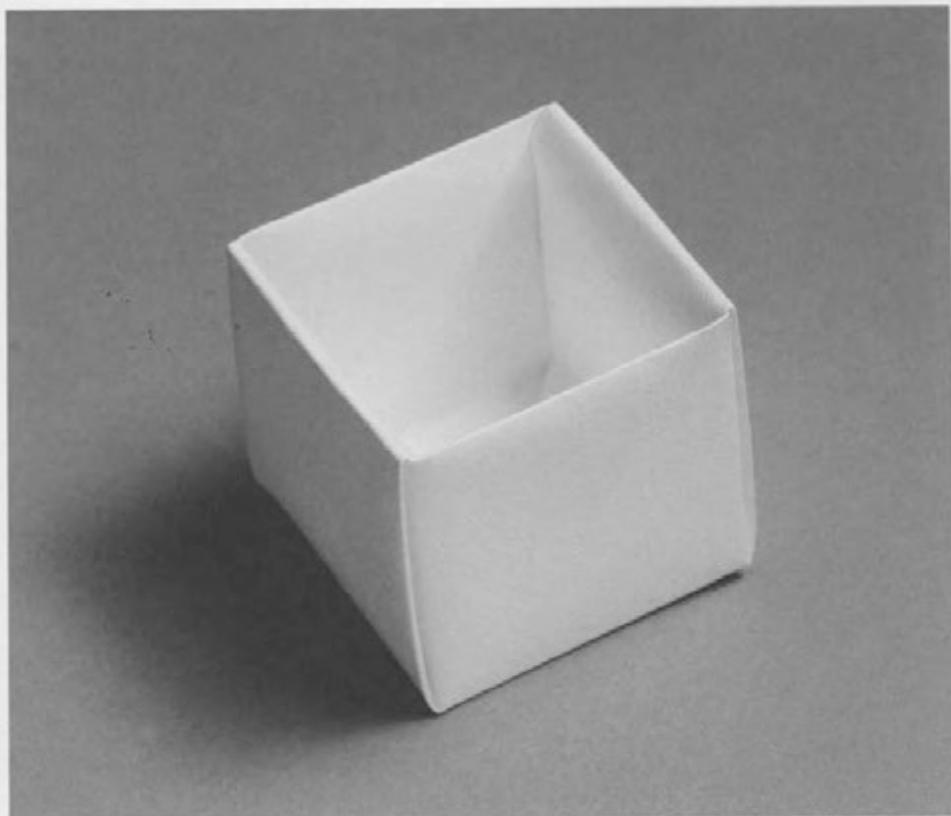
The previous section gave the basic method for making the Masu box. However, by changing the position of the folds in Steps 4 and 6 (folding the edges to the centre point), the shape of the final box can be changed. Here are two examples.



6.1.2_1

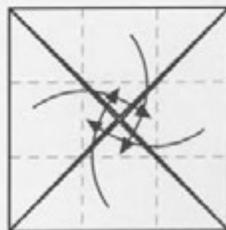
Instead of folding each edge to the centre point, fold them to a pre-defined point closer to the edge than the centre. This will make a shallower box. The method for completing the box is exactly the same as for the basic Masu except that corners F and G will not fold in far enough to touch.





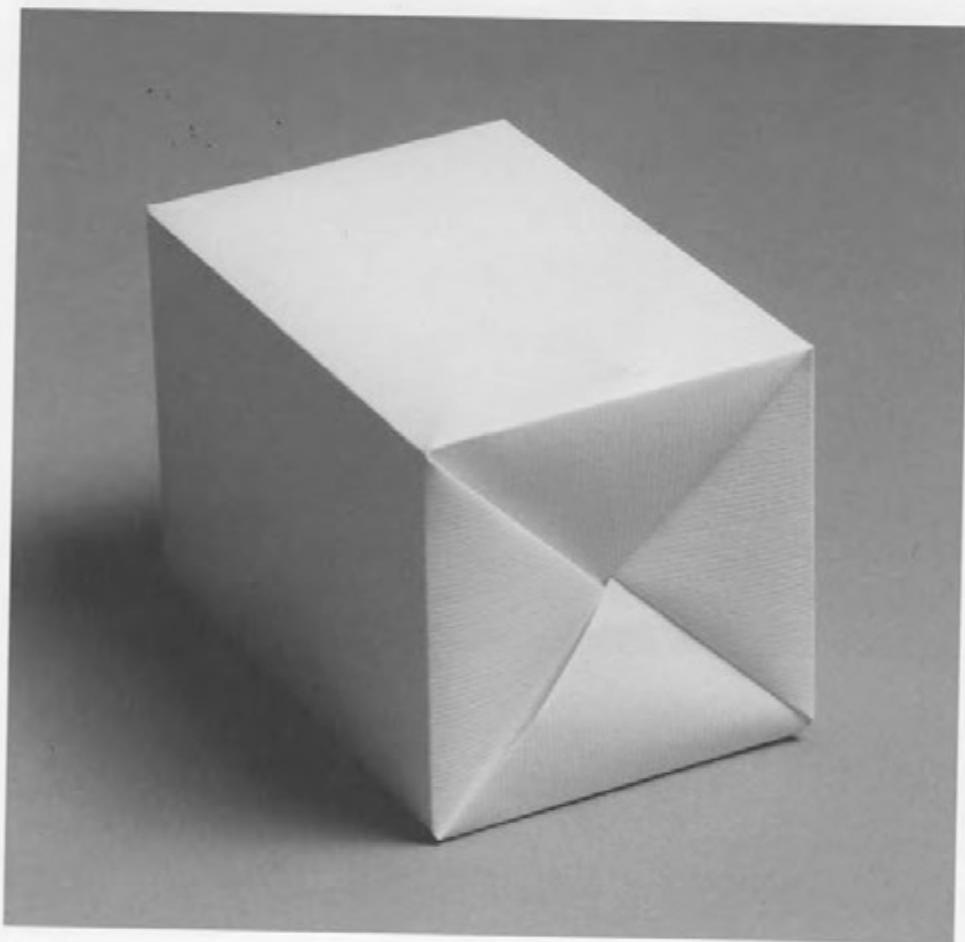
6.1.2_2

Alternatively, fold each edge beyond the centre point. If the folds are made along the D divisions, the box will be a lidless cube. The method for completing the box is exactly the same as for the basic Masu except that corners F and G will overlap, not touch.



6.1.3. Roll Box

The elegant rolling technique used here to create the box ends is a variation of the Box Spirals in 3.1.2 (see page 84). Many other box ends can be made by combining the examples shown in 3.1.2 with the example here. The box can be any length and only one end needs to be rolled closed – the other can be closed using another box-making technique, or simply left open.

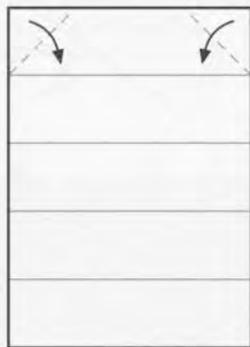


6.1.3_11



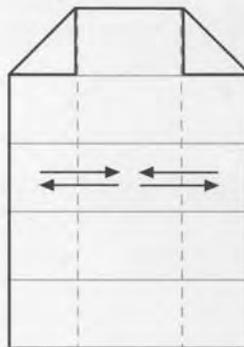
6.1.3_1

Divide a rectangle into fifths. An A4 sheet is a good shape and size for a first practice attempt.



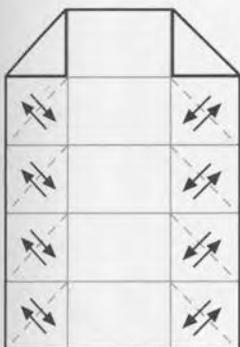
6.1.3_2

Fold in the top corners to the first crease.



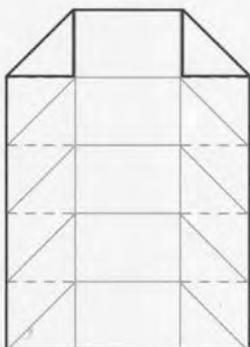
6.1.3_3

Use the vertical edges of the triangles as a guide, and make two long vertical folds. Open the folds.



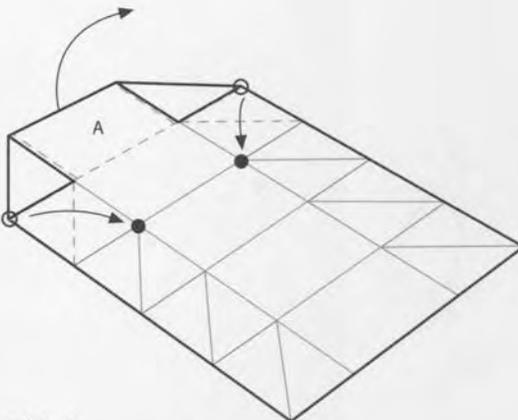
6.1.3_4

Beneath each triangle is a file of four squares. Individually fold a diagonal in each of the squares, parallel to the folded edge of the triangle above it.



6.1.3_5

Currently, all the folds are valley folds. Refold the left and right sections of the four horizontal valley folds as mountains.



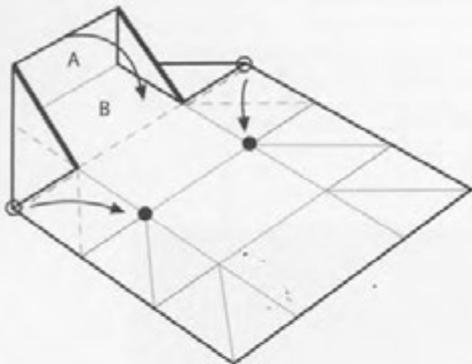
6.1.3_6

The box can now be rolled closed. Fold the top pair of left and right diagonals, as shown, rotating rectangle A to the vertical. The sheet becomes 3-D.

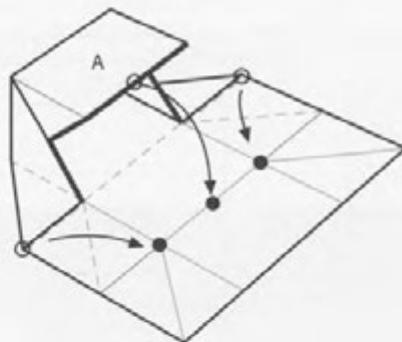
6. BOXES & BOWLS

6.1. Boxes

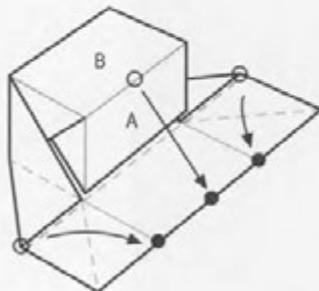
6.1.3. Roll Box



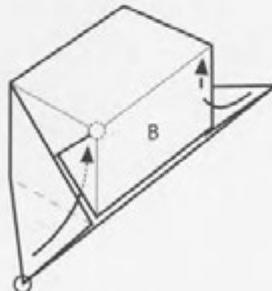
6.1.3_7
Repeat, folding the next pair of diagonals, so that B rotates to the vertical and A rotates to the horizontal. Note how the two ends of the box slowly create a series of triangles, each one on top of the one made previously.



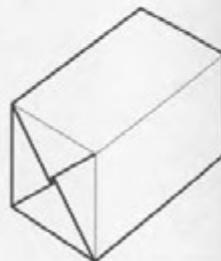
6.1.3_8
Repeat again, further rotating A and B.



6.1.3_9
Rotate A and B one final time, to leave a pair of triangles extending from the box ends.



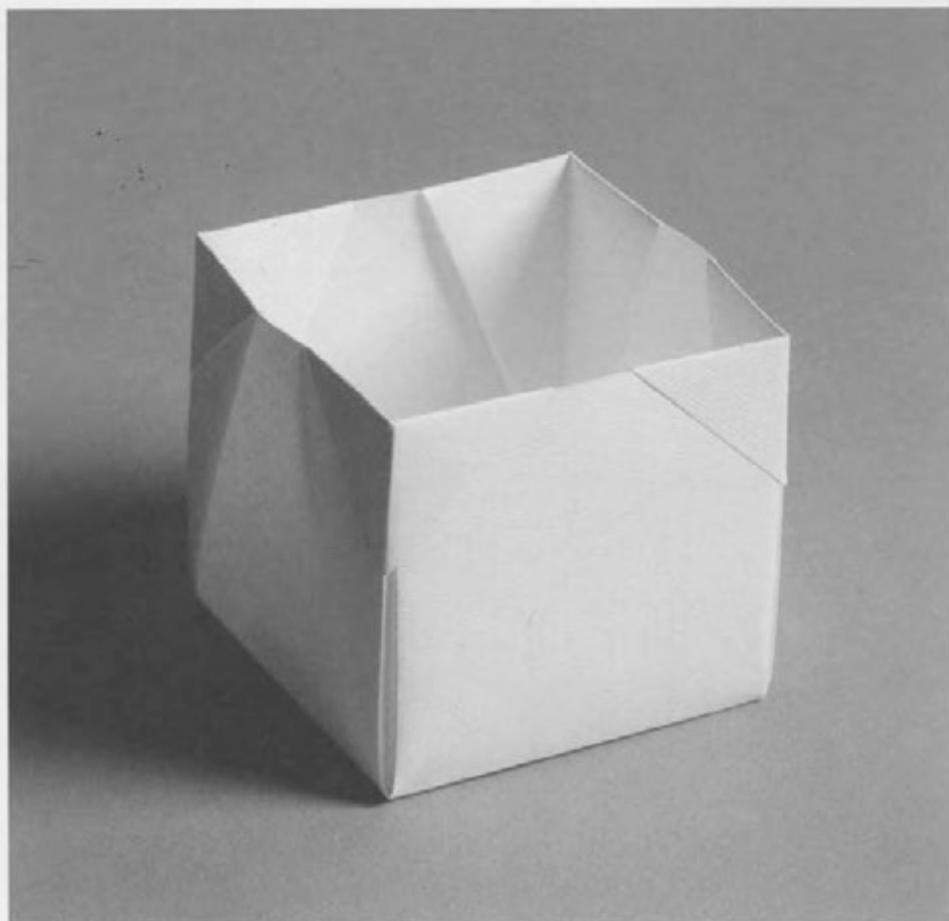
6.1.3_10
Lock the box by tucking the triangles under the rectangles connected to rectangle B. This will create a locked 'X' pattern on the two ends of the box.



6.1.3_11
This is the completed box.

6.1.4. Corner Gather

The technique shown here for gathering and locking a corner can be adapted to work with other polygons, not just a square. The sides can be made taller or shorter relative to the base, depending on where the folds in Steps 1 and 2 are placed. By changing the angles of the gather in Step 14, the sides can be made to splay out like a bowl, rather than rise vertically.

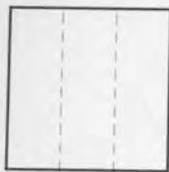


6.1.4_16

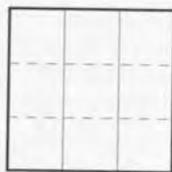
6. BOXES & BOWLS

6.1. Boxes

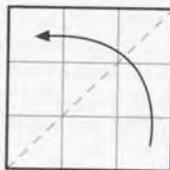
6.1.4. Corner Gather



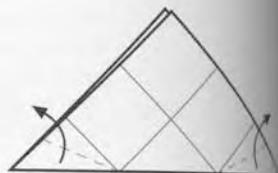
6.1.4_1
Divide a square into vertical thirds.



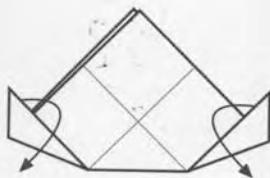
6.1.4_2
Similarly, divide the square into horizontal thirds.



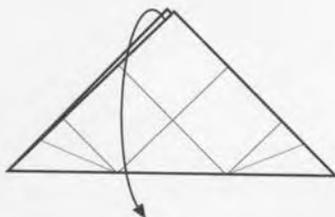
6.1.4_3
Fold corner to corner along a diagonal.



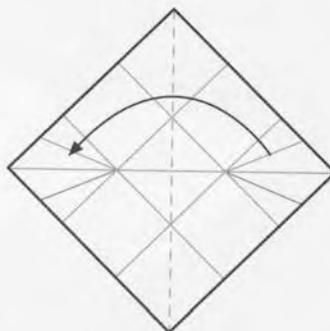
6.1.4_4
Fold up the 45° corners, so that the folded edge rests along the one third crease line ...



6.1.4_5
... like this. Unfold the small triangles.



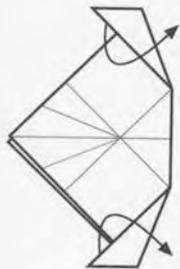
6.1.4_6
Unfold the diagonal.



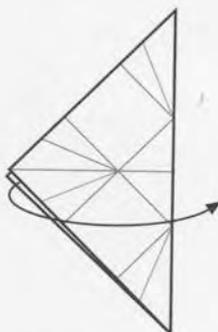
6.1.4_7
Fold corner to corner along the other diagonal.



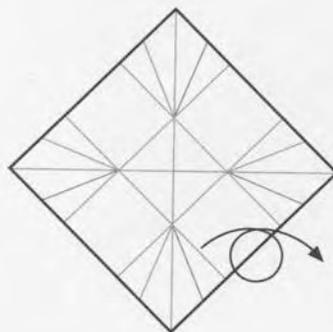
6.1.4_8
As in Step 4, fold up the 45° corners ...



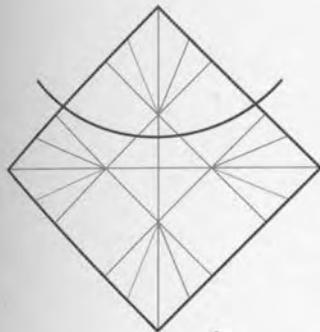
6.1.4_9
... and then unfold them.



6.1.4_10
Unfold the diagonal.

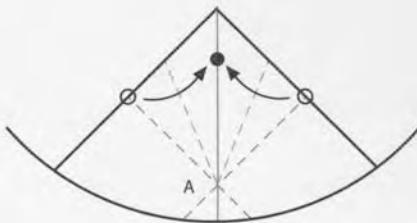


6.1.4_11
This is the pattern of valley folds made so far. Turn the paper over.



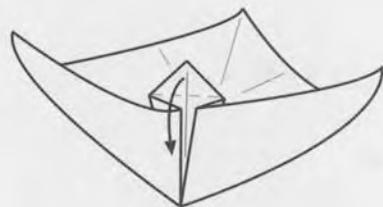
6.1.6.1.4_12

The valley folds are all now mountains. You are looking at the side of the sheet that will become the outside of the final box. The next step shows a close-up of the top corner.



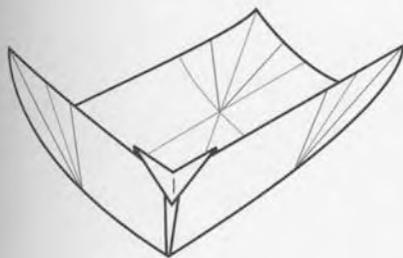
6.1.4_13

This is the crucial step. Create separately two valley folds from the small triangle folds made in Step 4 or Step 8 (one is already a valley, but strengthen it). Then, fold the \circ circles to the \bullet circle, allowing the two mountains and the two new valleys to collapse simultaneously. The paper will now become 3-D and make a convex corner at A.



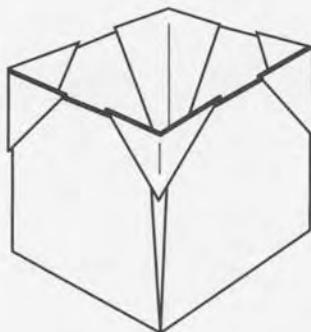
6.1.4_14

This is now the shape of the paper. Lock the 3-D gather by folding down the top triangle ...



6.1.4_15

... like this. The corner is now complete. Strengthen the fold up the side of the box and the folds along the bottom. Repeat Steps 13 and 14 with the remaining corners.



6.1.4_16

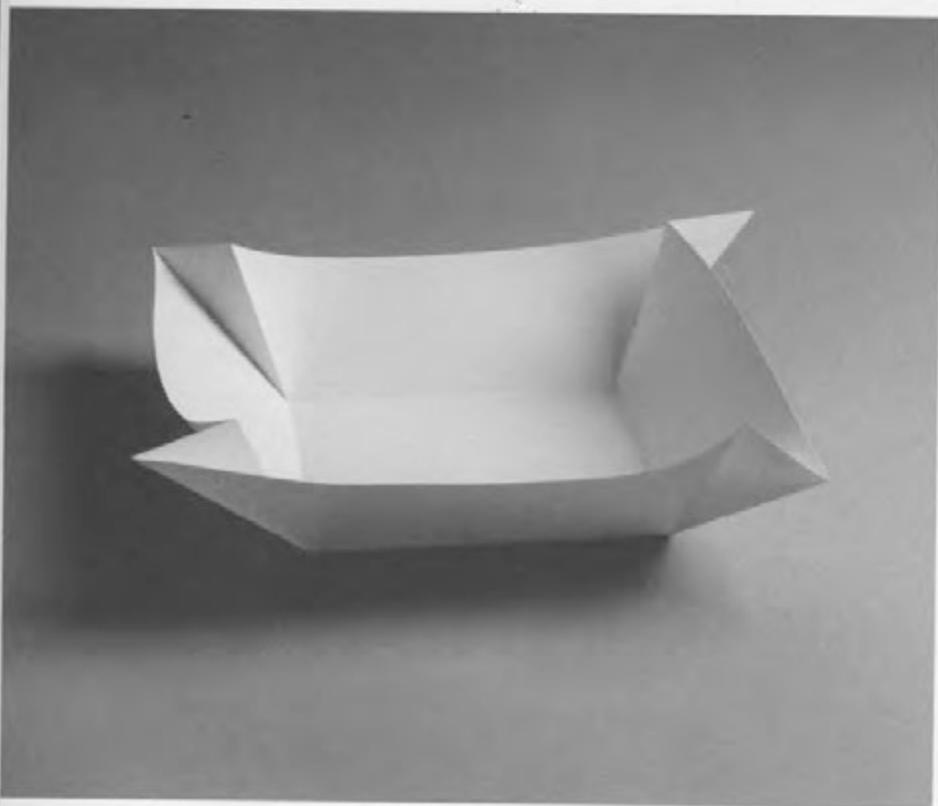
This is the completed box. Further strengthen and adjust all the folds until the box has flat faces and straight edges.

6.2. Bowl Forms

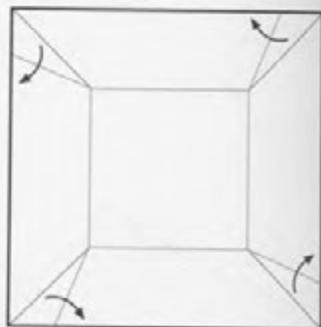
New bowl forms are easier to design than new boxes because the design parameters are wider. For example, it is possible to change the ratio of the base area to the height of the sides, change the square to another polygon, gather in the sides a lot or a little to create bowls that are closed up or almost flat, and reverse many folds from valley to mountain or vice versa, relative to other folds. When these variations are combined in different ways, even the simplest ideas can create many diverse forms.

The examples here represent ways to create bowl forms in a variety of styles from the minimal to the ornate. Looking through the other chapters of the book will provide you with many other ways to create shallowly indented corners, which when repeated around the sides of a polygon will create bowl forms.

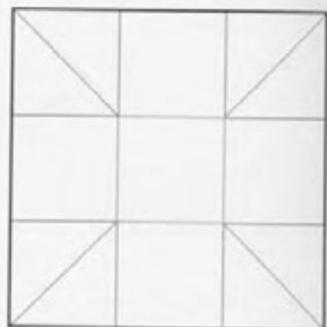
Of all the sections in the book, this one contains the ideas that can be most easily adapted for a wide variety of sheet materials.



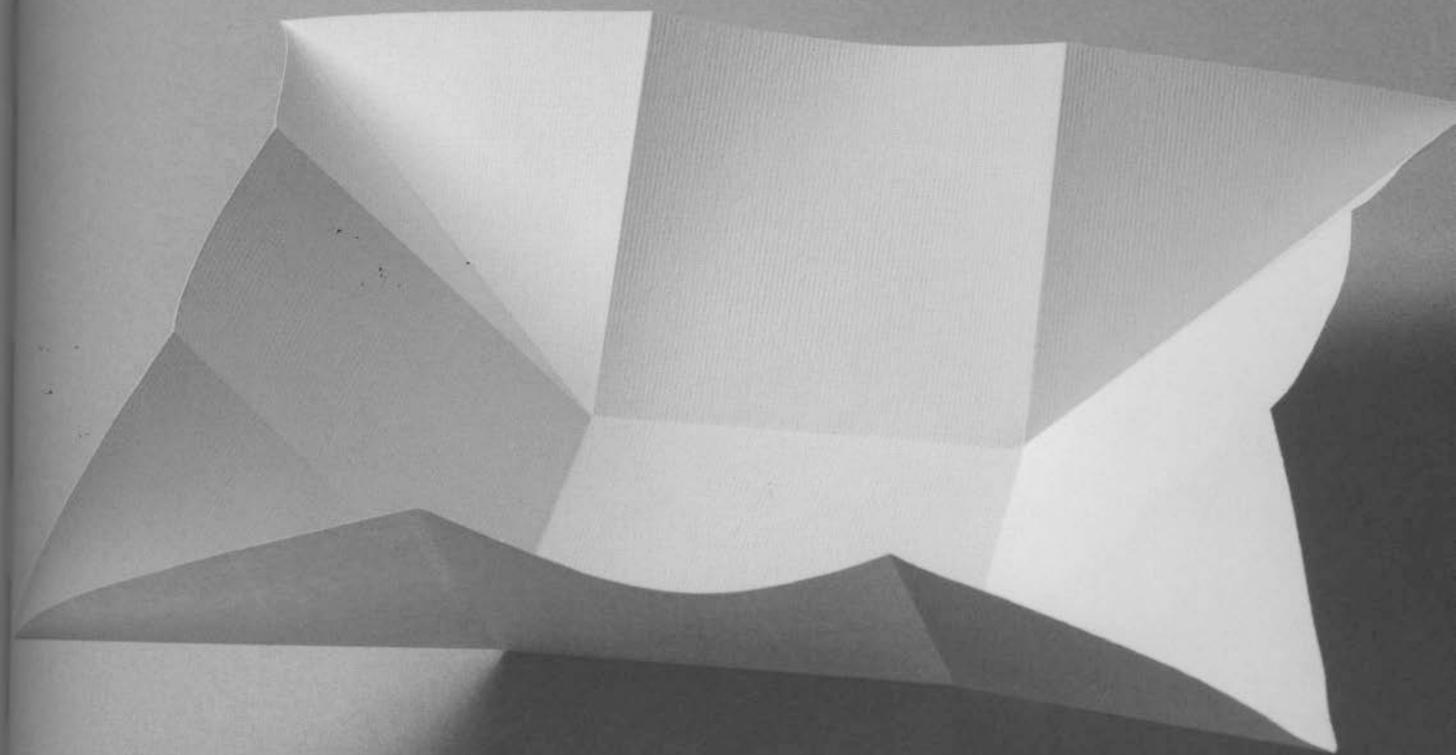
6.2_1

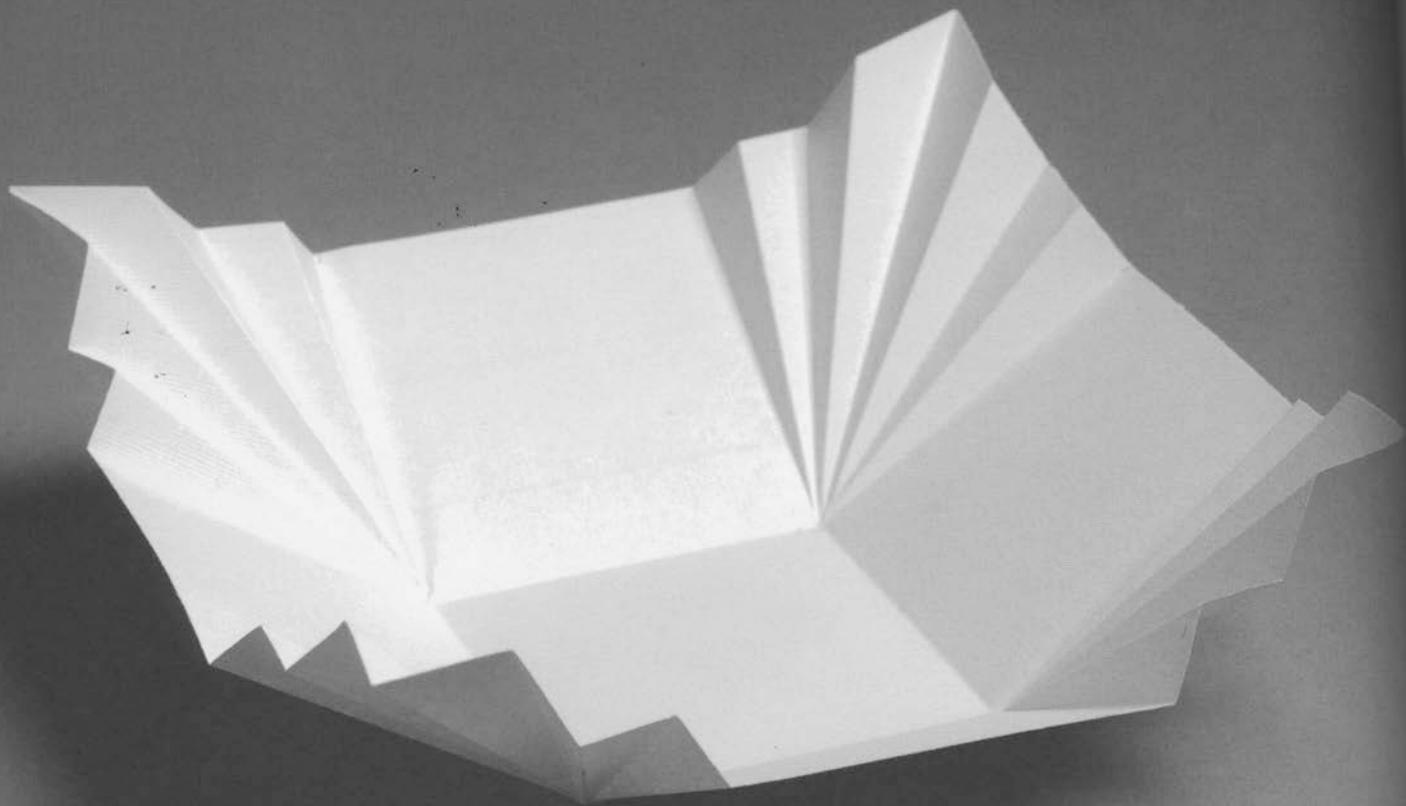


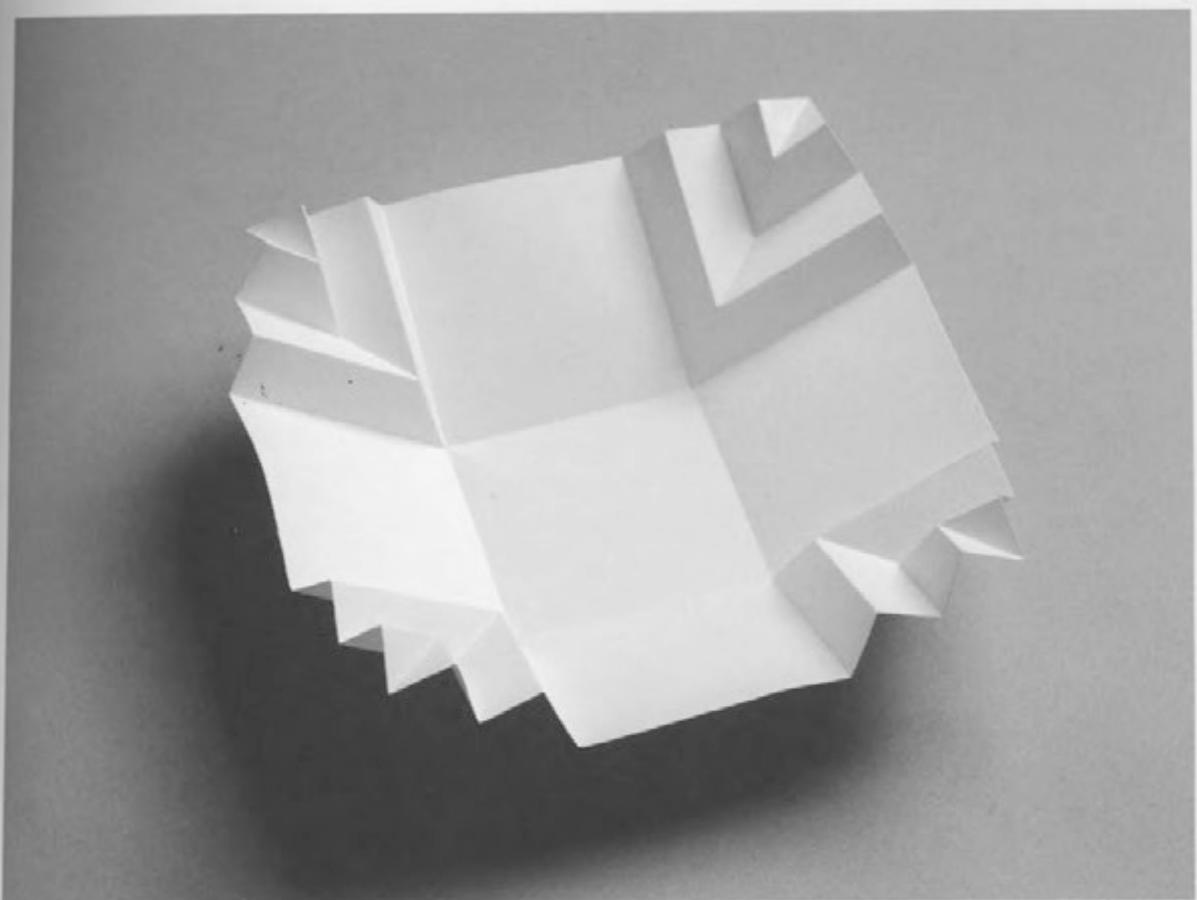
6.2_1



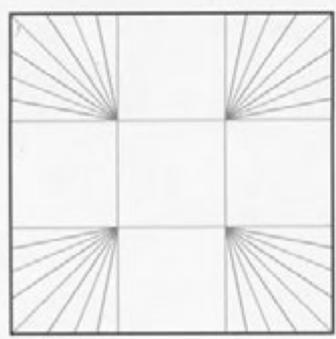
6.2_2







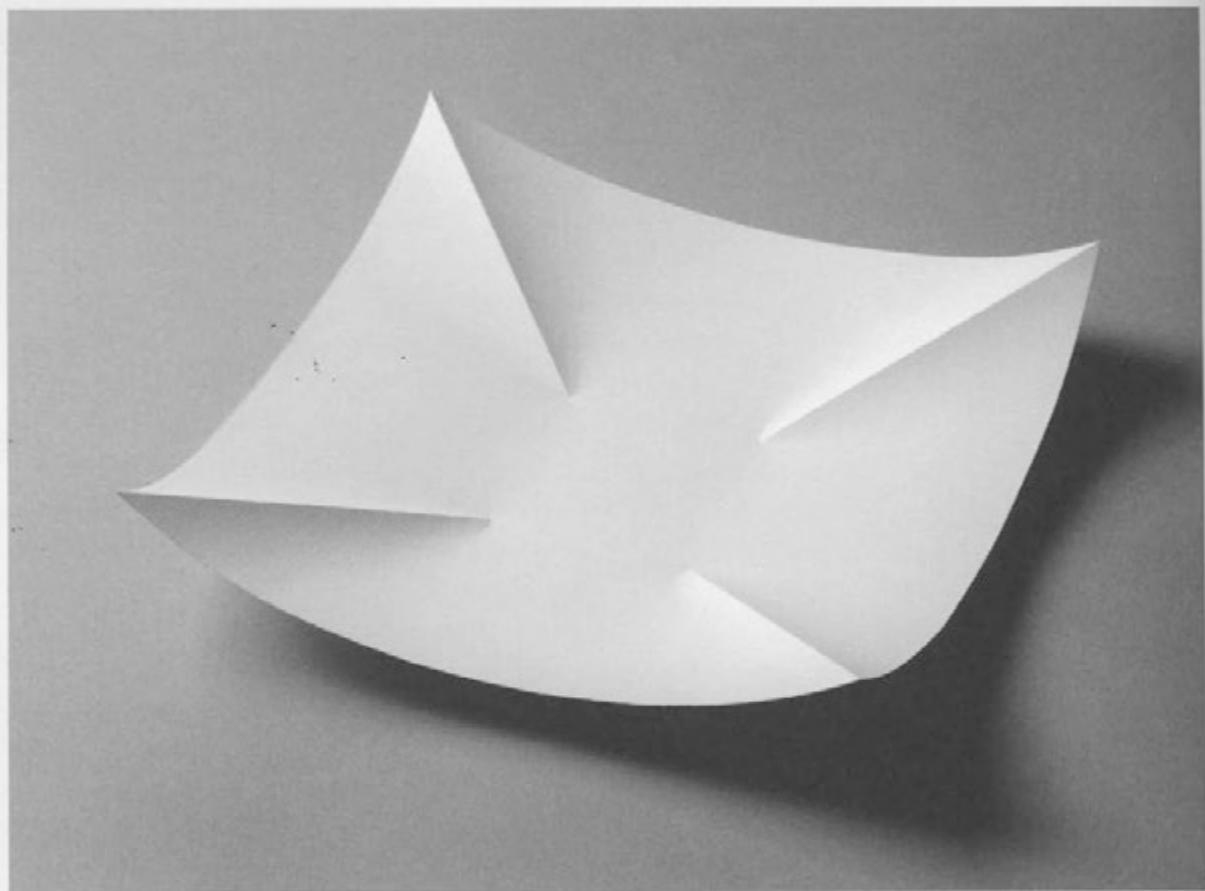
6.2_4



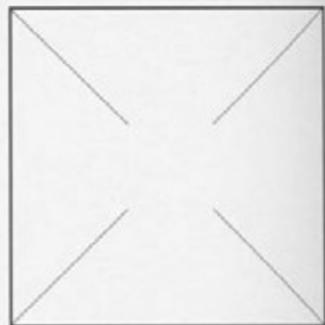
6.2_3

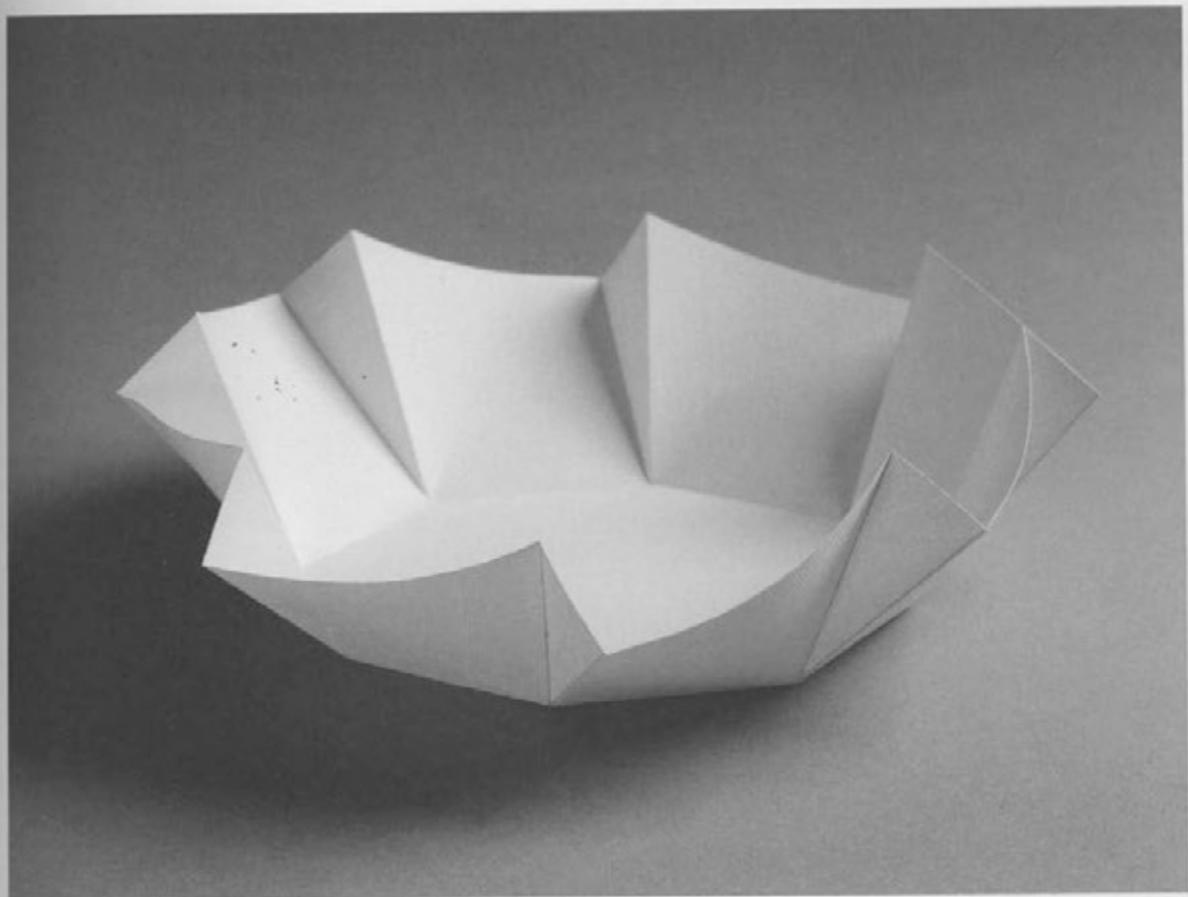


6.2_4

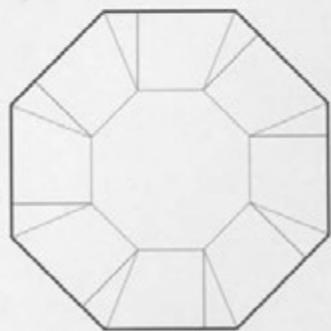


6.2_5





62_6



7. No Crease, One Crease

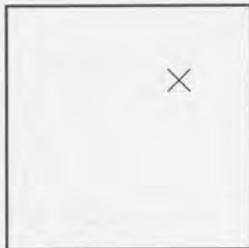
It is easy to assume that a sheet with no creases or just one crease will offer very few possibilities for creative folding. It may even seem to be a preposterous idea.

While it is true that the possibilities for forms and surfaces increase with the number of folds, there is a surprising richness in using no creases or just one crease. The key to creating these forms is a non-origami technique called the 'Break', which induces curvature in the sheet. Ironically, with two or more folds and Breaks, the array of coexisting curves can quickly turn a sheet of material into an over-complicated doodle. If ever a folding technique needed to be used with precision and restraint, this is the one.

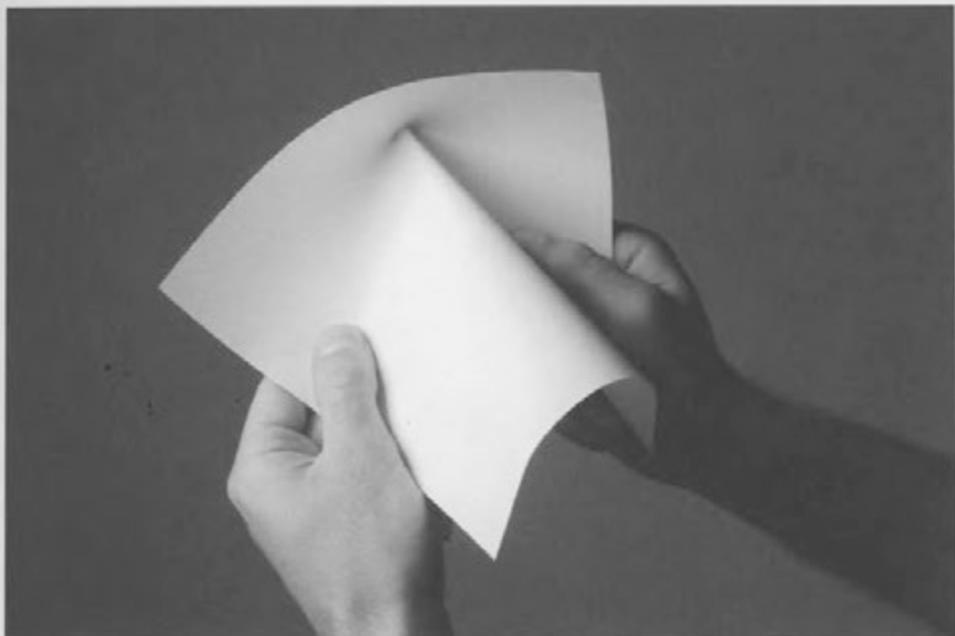
On another level, the extreme simplicity and directness of this technique offers a cleansing of the folding spirit when set against the examples in other chapters which require potentially dozens or hundreds of folds. In this way, No Crease, One Crease is not only a valuable technique, but also a respite from the rigours of complex folding. Less can be more.

7.1. No Crease

A 'crease' is a two-dimensional line. A No Crease is a one-dimensional point which creates a dent in the paper called a 'Break'. This generates complex curves in the paper, which can change from convex to concave and back again if the position of the curves is made to rotate around the Break. In this way, a simple Break – surely the most elemental of all manipulation techniques – creates not one form but many.

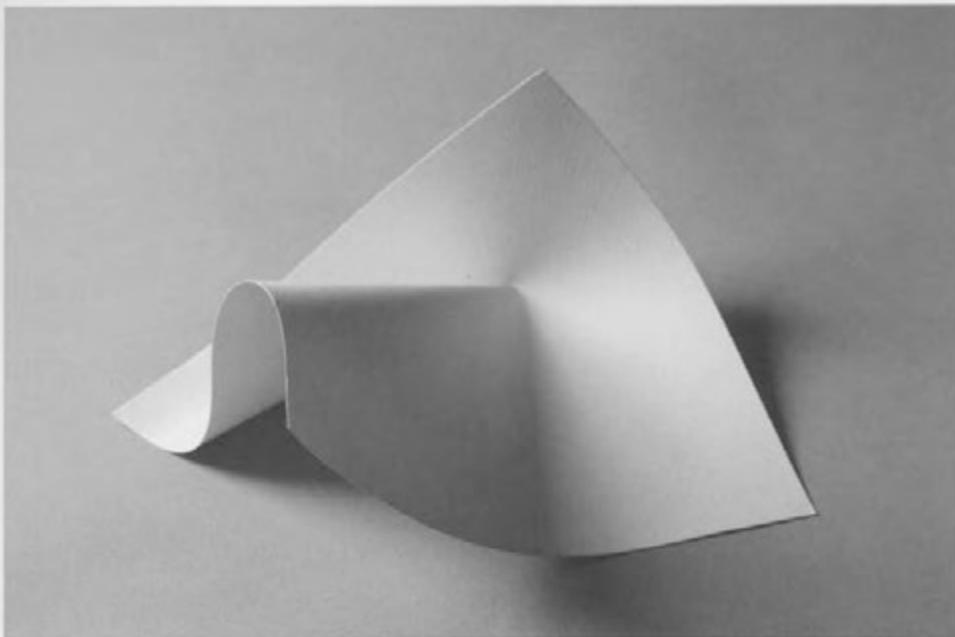


7.1_1
Here is a drawing of the
Break, represented by an X.



7.1 _ 2

To make the Break, push the back of the paper at the chosen place and simultaneously bring your hands closer together to create the convex curve. When made with paper about the weight of a page in this book, the Break takes form only when the paper is held in the hands. If it is released from the hands, it will resume its natural flat state.



7.1 _ 3

When heavy watercolour paper is used, wetted to make it pliable and allowed to dry (see 'Wet Folding' page 186), the curves retain their position.

7. NO CREASE,
ONE CREASE

7.1. No Crease

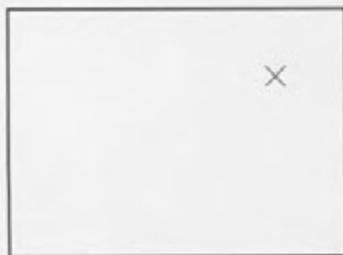
7.1.1. No Crease
Variations

7.1.1. No Crease Variations

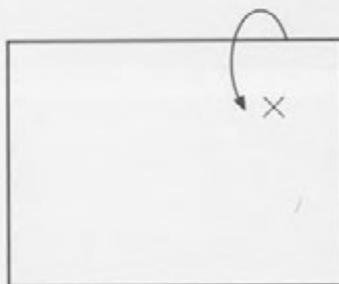
With a Break placed almost randomly on a sheet, the paper can assume a number of different curved forms depending on which of the four edges is pulled forwards to create the predominant convex curve.



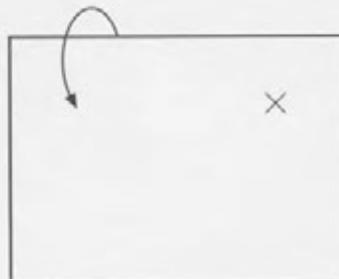
7.1.1_2_1



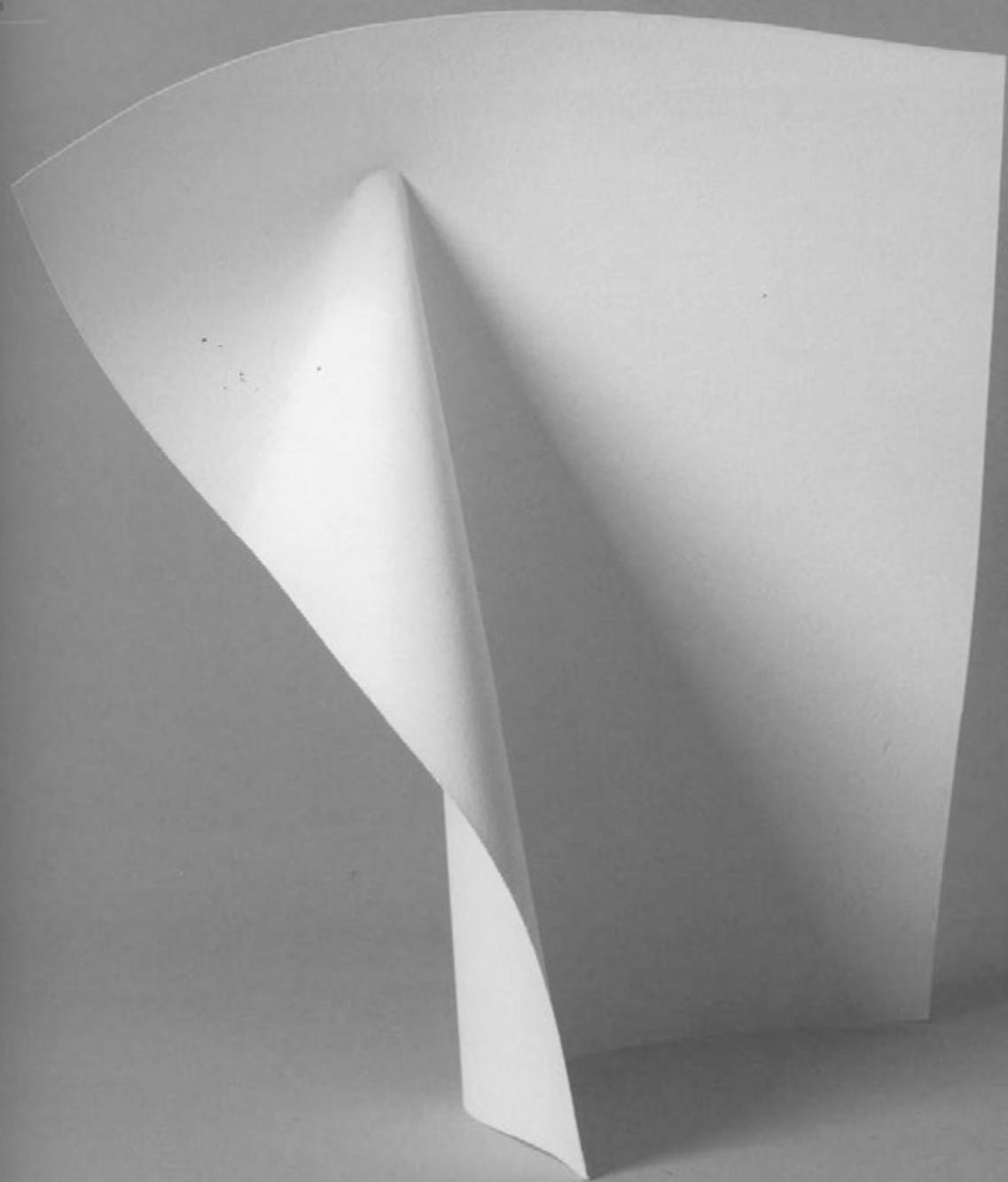
7.1.1_1
The position of the Break on the sheet remains the same for the following six examples.



7.1.1_2_1
These drawings and photographs show how different forms can be made from the same Break, when different parts of the edge are pulled forwards. The arrow on each drawing shows which part of the edge is pulled forwards and the corresponding photograph shows a possible result. With the Break in a different position on the sheet, other forms could be created. The paper is wet folded.



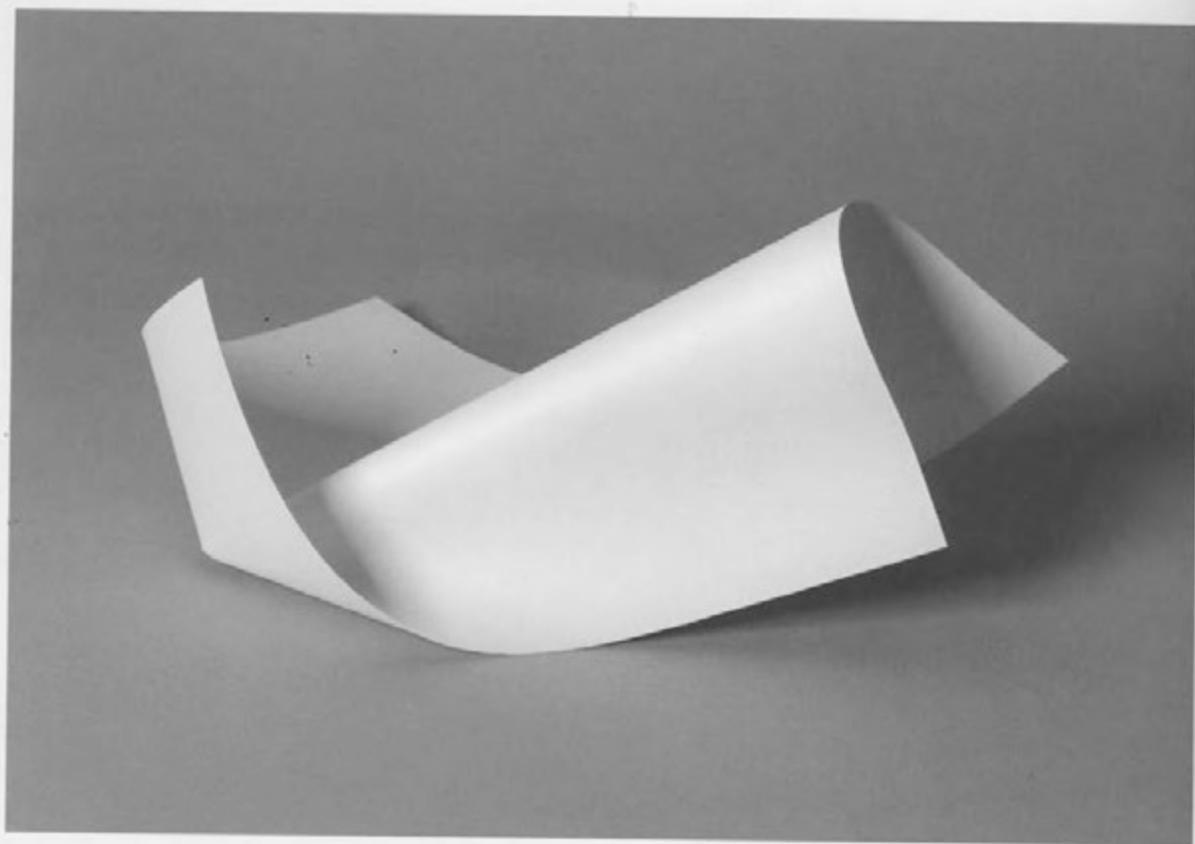
7.1.1_2_2



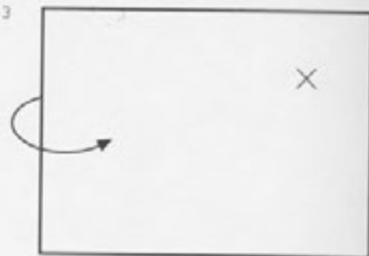
7. NO CREASE,
ONE CREASE

7.1. **No Crease**

7.1.1. No Crease
Variations



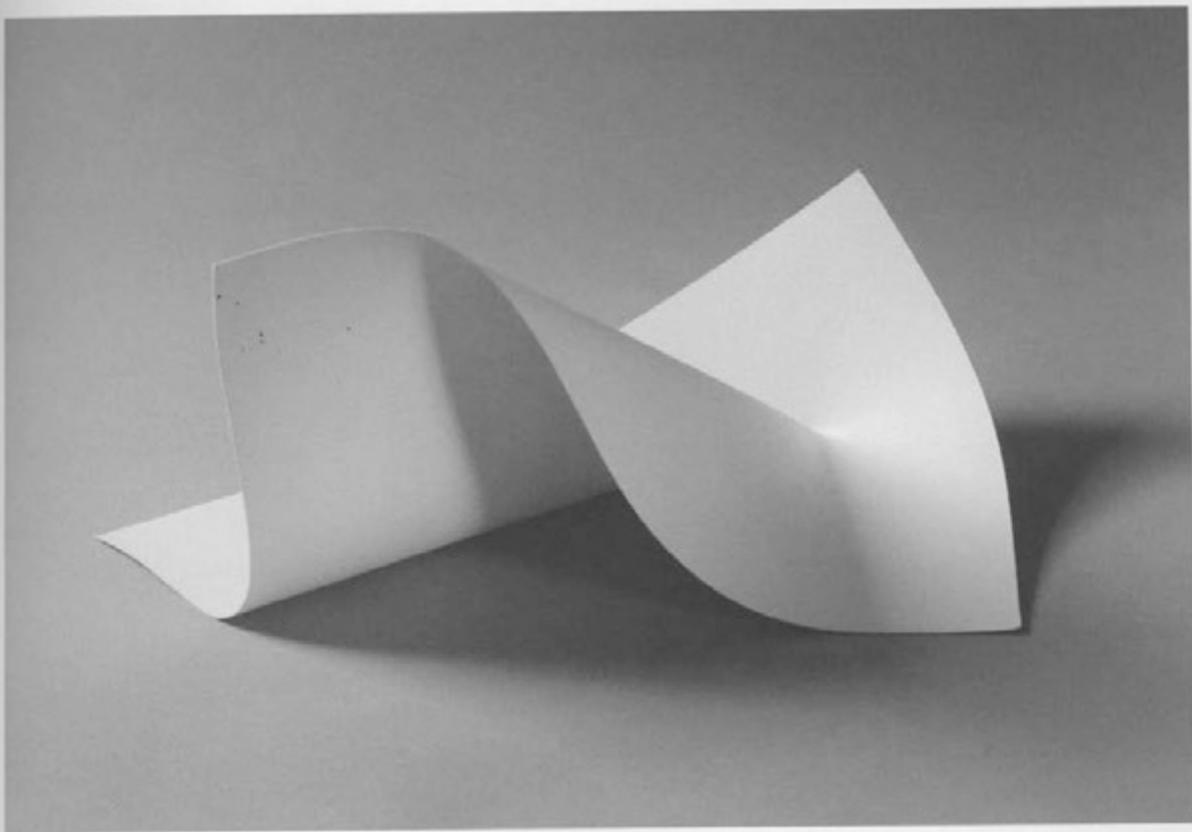
7.1.1_2_3



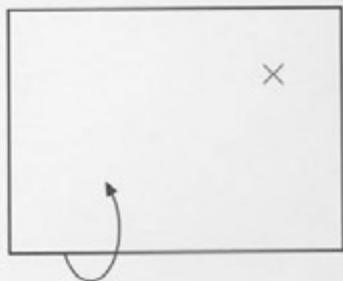
NO CREASE,
ONE CREASE

No Crease

No Crease
Variations



7.1.1_2_4



NO CREASE,
ONE CREASE

No Crease

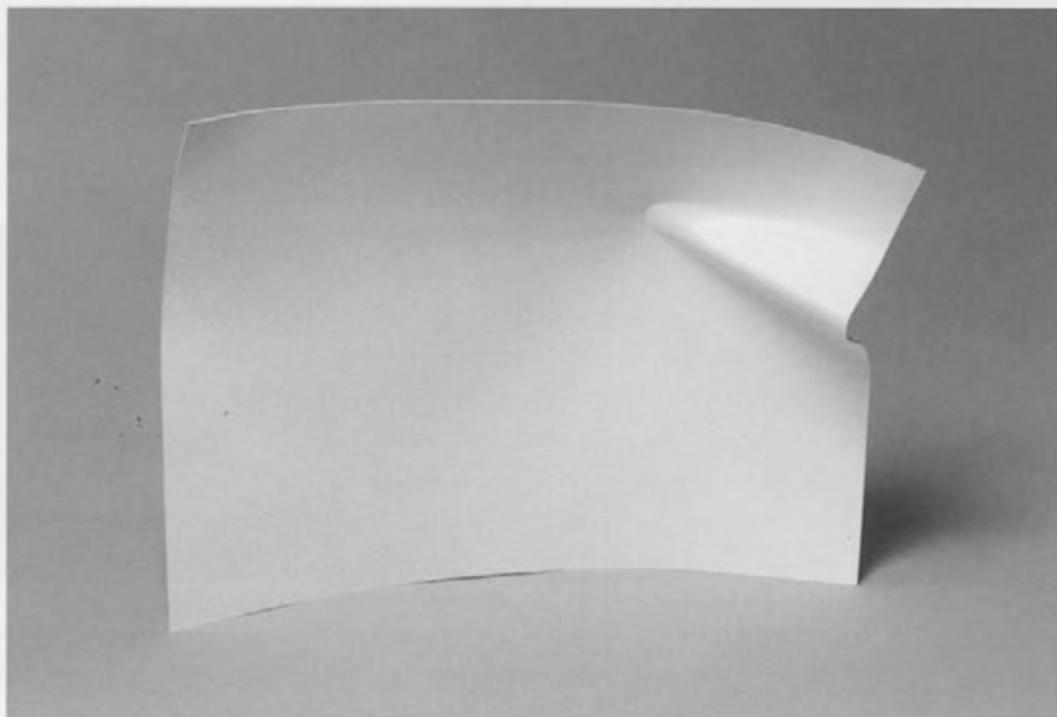
No Crease
Variations



NO CREASE,
ONE CREASE

No Crease

No Crease
Variations



7.1.1_2_5



7.1.1_2_6

7. NO CREASE,
ONE CREASE

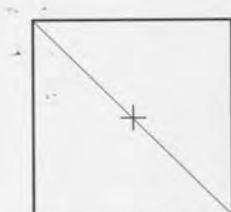
7.2. **One Crease**

7.2.1. How to Make
the Break

7.2. One Crease

With One Crease, the Break is made at a point along an existing mountain crease. In combination, the Break and the crease offer many more possibilities for forms than a No Crease Break. In the diagrams, the Break is represented by an X on a mountain fold.

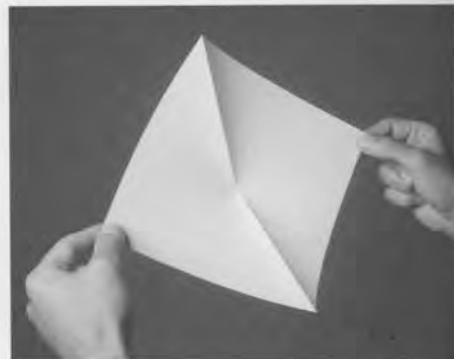
7.2.1. How to Make the Break



7.2_1
This is the symbol
for a Break.



7.2.1_1
Fold a square of paper along a diagonal. Open the fold and turn the paper over so that the crease is a mountain. Hold as shown, taking care not to flatten the crease.



7.2.1_2
Pull your hands apart so that the middle point of the fold 'breaks'. Alternatively, rest the paper on a flat surface, mountain fold up, then poke the fold with a finger.



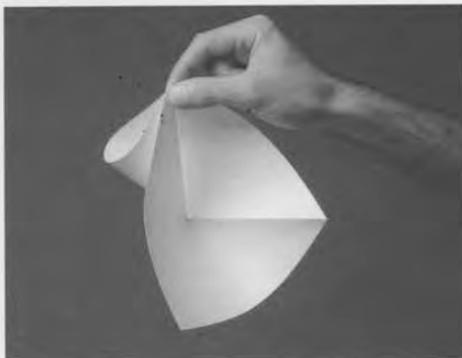
7.2.1_3
Hold the two ends of the diagonal fold between your fingers and thumbs. Now bring together the two corners until they meet in the middle.



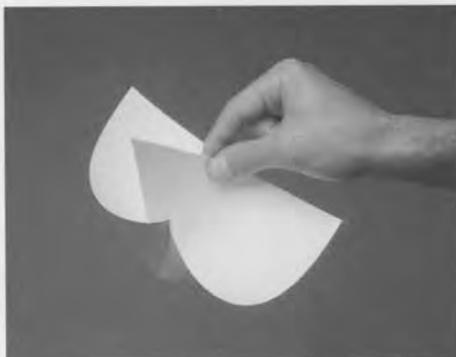
7.2.1_4
Hold both corners between the thumb and finger of one hand. This will open two cones and allow them to be as rounded as possible. If the Break is not exactly in the middle of the mountain fold (or at another exact required place), it can be slid up and down the fold. Ideally, it should be a sharp point. However, if it has widened to become part of the length of the fold, holding the paper as in Step 3 and pulling on the two halves of the fold will sharpen it to a point.

7.2.2. Break Variations

The Break technique allows the paper to assume many positions. Here are a few suggestions using the same diagonal crease and midpoint Break as opposite. A useful creative exercise is to prepare about 20 squares of paper with creases and Breaks in identical positions, then create different forms from them. Use small pieces of sticky tape to fix them to a vertical surface. The range of possibilities is immense.



7.2.2_1



7.2.2_2



7.2.2_3

7.	NO CREASE, ONE CREASE
7.2.	One Crease
7.2.3.	Making the Break Permanent

7.2.3. Making the Break Permanent

Wet Folding

The technique of wet folding paper was developed in the mid-twentieth century by the great Japanese origami master Akira Yoshizawa, to create soft folds and rounded three-dimensional bodies for his representations of living creatures, without the folds springing open. It has since become the technique of choice for many origami artists.

Wet folding is best done with unsized or minimally sized papers such as watercolour paper, Ingres paper or etching paper. Suitable papers as heavy as 1000+gsm may be wetted and folded. When dry, wet-folded paper of any weight will become stiffer than if it had remained unwetted. The stiffening will be very slight on lightweight paper, but heavier weights will dry to become exceptionally stiff and durable. Wet folding is ideally suited to the No Crease, One Crease technique, enabling forms which spring open when made from conventional papers to retain their forms permanently. The pieces in this chapter have all been folded from 300gsm Canson watercolour paper.

Though particularly suited for the No Crease, One Crease techniques shown in this chapter, wet folding may be used to make almost any of the folded examples in the book, with the possible exception of the Crumpling technique in the final chapter. Made this way, otherwise flexible or unstable folded forms will become remarkably rigid, strong and durable. Even the highly complex V-Pleat forms can be wet folded, then bent into unnatural positions to dry, thus retaining a new and unconventional shape. The basic rule here is an obvious one; the thicker the paper, the stronger will be the final form. For extra strength, thicker weights of wet folded paper may be given a coat of polyurethane varnish.

Despite its advantages, wet folding has disadvantages too. The thickness of the paper and the stiffness of the final form mean that examples can look rather lifeless, even clumsy. In contrast, the lightness and springiness of thinner papers folded dry can give freshness and vigour to a folded form. Folding the same form both dry and wet will soon give you information about the pros and cons of both techniques.

However, if you have never tried wet folding, the technique is highly recommended, particularly if you are trying to create a folded form of some strength. In this way, wet folding can be considered a good mimic of other, stronger materials, such as clay or sheet metal and is useful for making mock-ups of concepts that may eventually be made in non-flexible materials.

NO CREASE,
THE CREASE

No Crease

Making the Break
Permanent



7.2.3 _ 1

Fill a small bowl with clean water. Then, using a viscose kitchen cloth, apply water to both surfaces of the paper. The thicker the paper, the more water should be used. It is important to wet the paper thoroughly without over-soaking it. Make sure the work surface under the paper is very clean and waterproof.



7.2.3 _ 2

As deftly as possible, make a No Crease (shown here) or a Break. It is unwise to change your mind too often, as bending the paper this way and that will compromise the smoothness of the final curves. Speed and certainty will ensure your piece looks its best.



7.2.3 _ 3

The wet paper must be kept immovable until it is completely dry. It can be wedged tight between any combination of everyday objects – bottles, cans of food, a wall, heavy books etc. By allowing the paper to flatten a little here and tighten a little there, it can be held in shape with a high degree of precision. It is advisable to free the paper several times during the drying to smooth out any buckles and perhaps to adjust how it is being held.

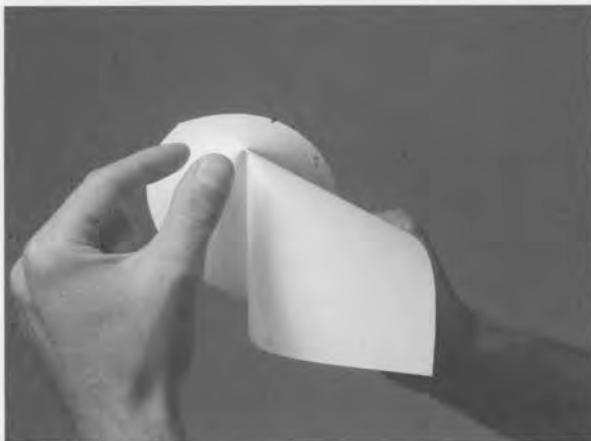
7. NO CREASE,
ONE CREASE

7.2. One Crease

7.2.3. Making the Break
Permanent

Dry Tension Folding

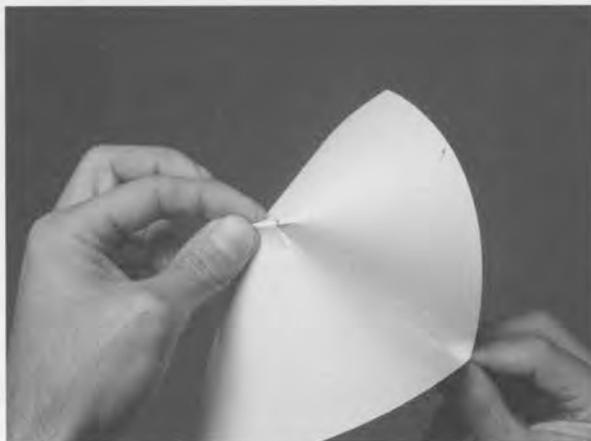
If the paper does not hold its shape by being wet folded, it may – in some cases – hold its shape by being folded dry. Dry-folded forms with curved surfaces, such as No Crease, One Crease forms, are often highly unstable, springing open when released. However, additional small creases will lock the paper in place under tension. These are easy to make, although a degree of dexterity is needed to avoid 'crow's feet' (unwanted and unsightly buckles) on the pristine curve.



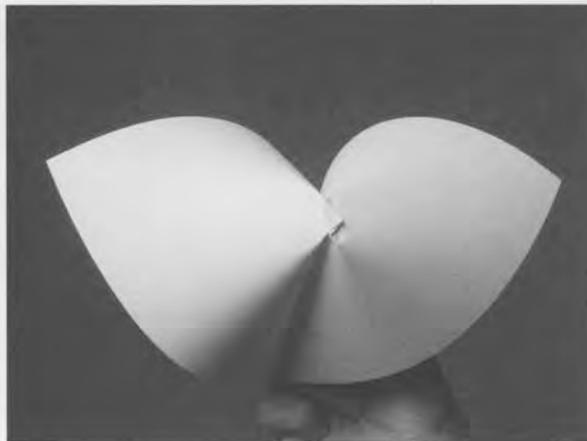
7.2.3_4
Fold the paper to look like 7.2.1_4 (see page 184). Turn it upside down so that the Break is at the top. Make sure the Break is a sharp point.



7.2.3_5
With finger and thumb, squeeze flat the paper on either side of the Break. This will create a flattened triangle of paper. Try to keep the folds just a few millimetres long.



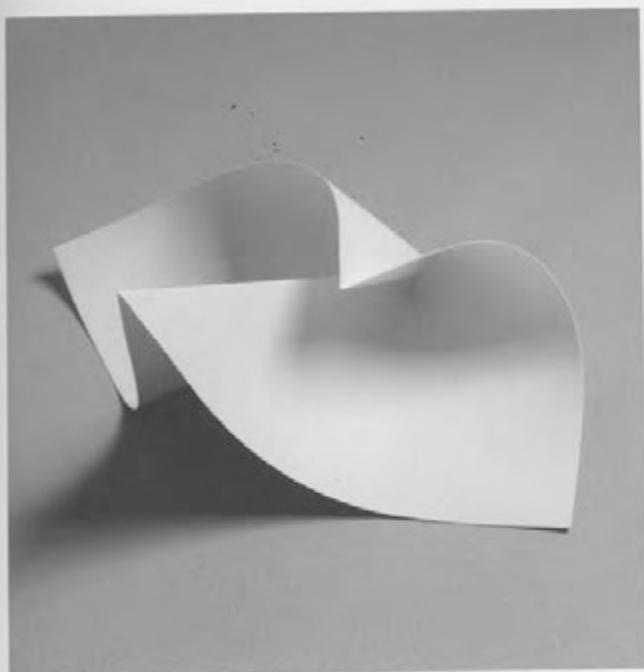
7.2.3_6
Fold the triangle across to the left or right (the direction is not crucial), flattening it against one of the cones.



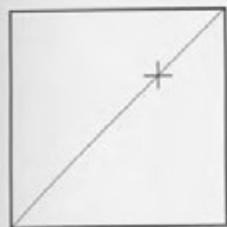
7.2.3_7
This flattened triangle will now prevent the paper from springing open, though it will nevertheless relax a little.

7.2.4. One Crease Variations

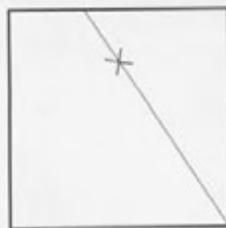
The Break can be made at any place on any mountain crease. Here are a few suggestions, though there are many others. It is important to remember that for every positional combination of Break and crease, the paper can be made to take many different forms, as shown in 7.2.2 (see page 185).



7.2.4_1



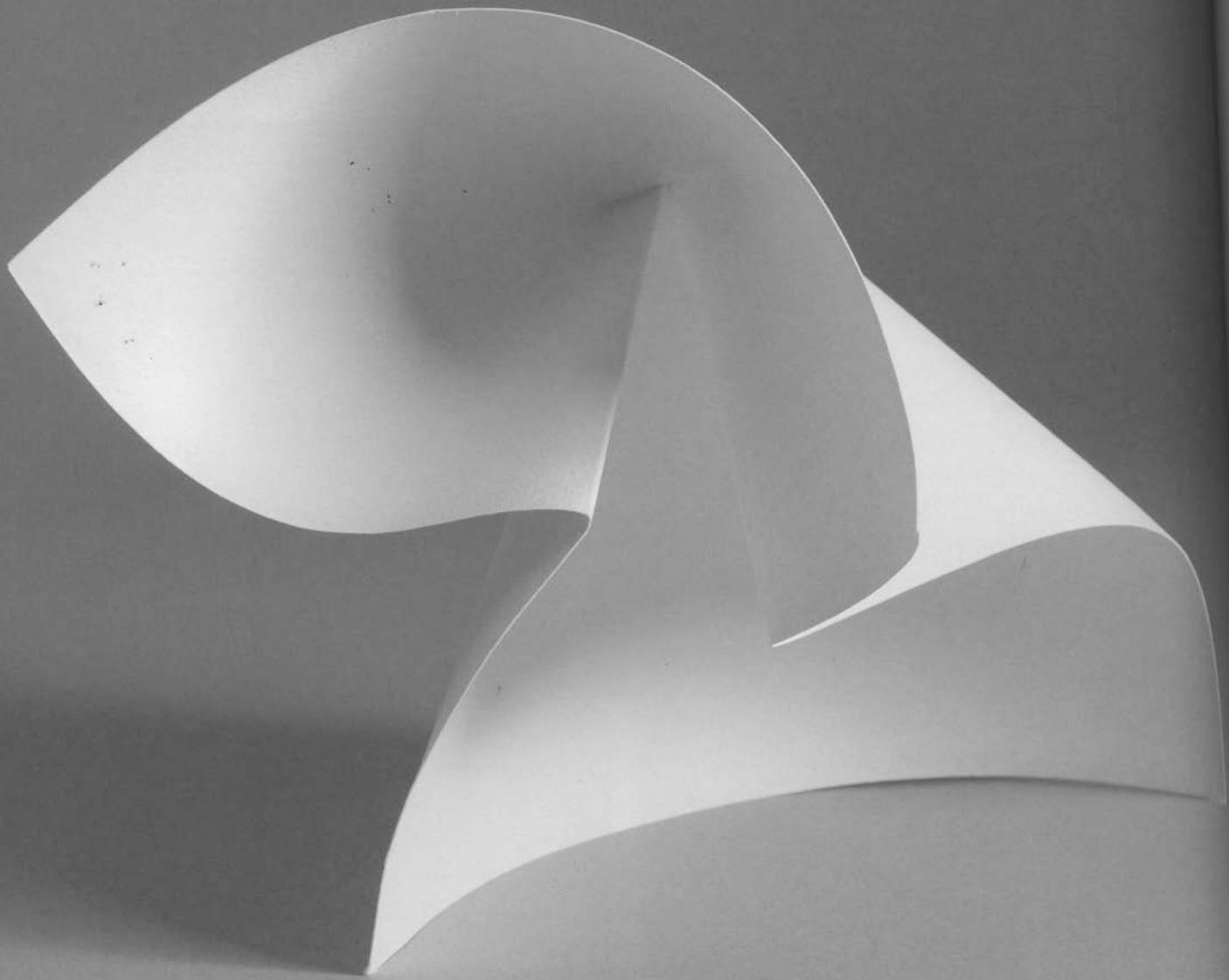
7.2.4_2

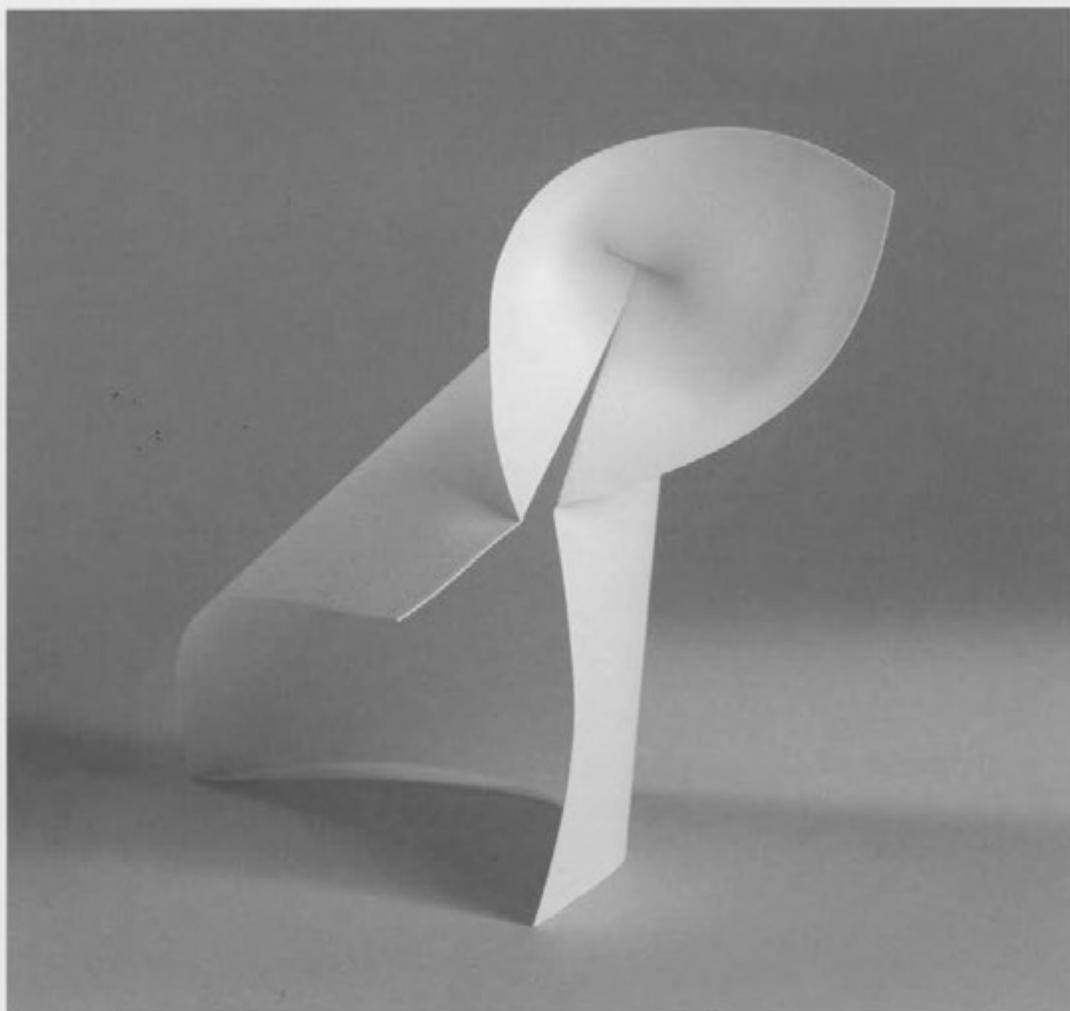


- 7. NO CREASE,
ONE CREASE

- 7.2. One Crease

- 7.2.4. One Crease
Variations





7.2.4_3



7.2.4_4



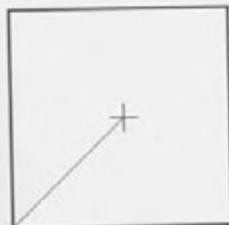
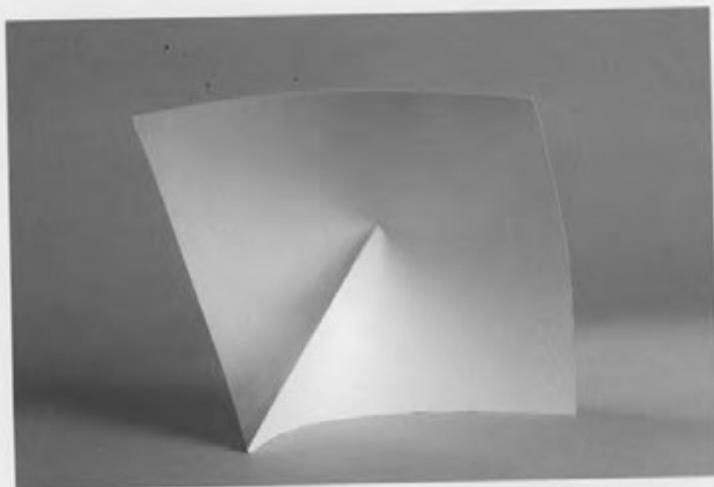
7. NO CREASE,
ONE CREASE

7.2. One Crease

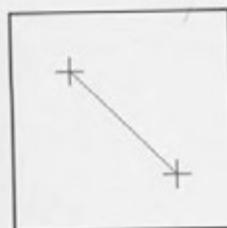
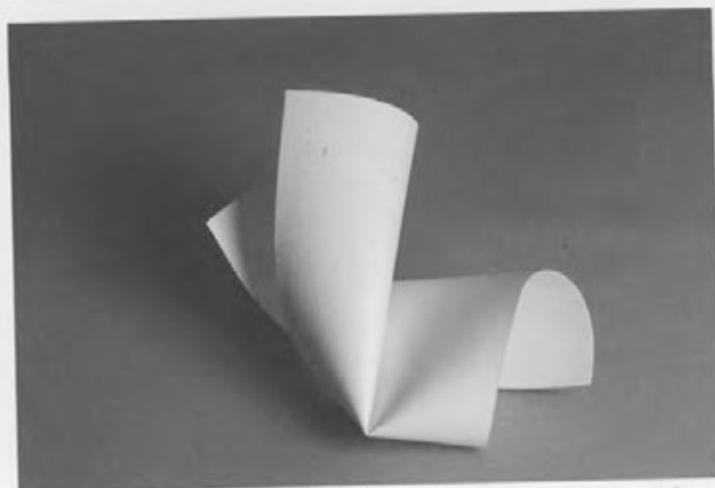
7.2.5. Less than One
Crease

7.2.5. Less than One Crease

So far in this chapter, a crease has run from an edge or corner to another edge or corner. However, it is also possible to reduce the length of the crease so that it stops somewhere within the plane, or indeed, remains within the plane and does not reach an edge or corner. Here are a few examples, but, as always, there are very many more variations.



7.2.5_1

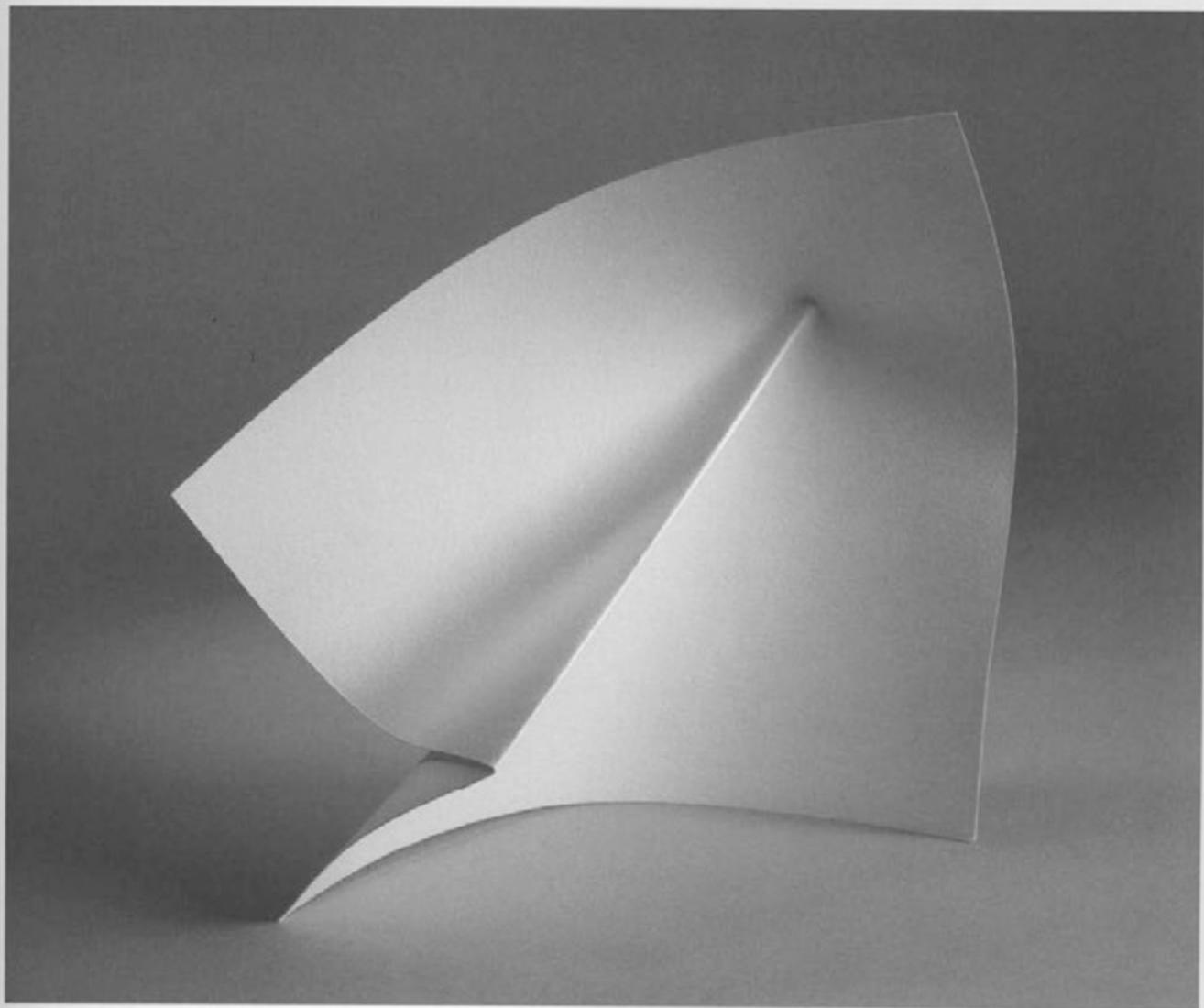


7.2.5_2

NO CREASE,
ONE CREASE

One Crease

Less than
One Crease



7.2.5_3



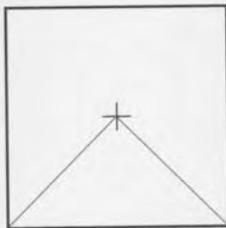
7. NO CREASE,
ONE CREASE

7.2. **One Crease**

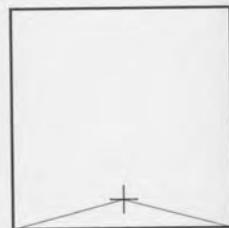
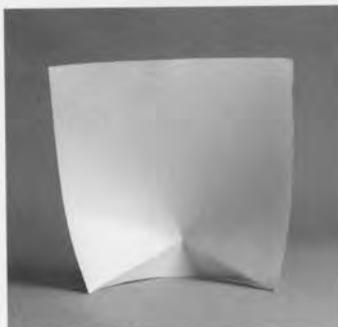
7.2.6. More than
One Crease

7.2.6. More than One Crease

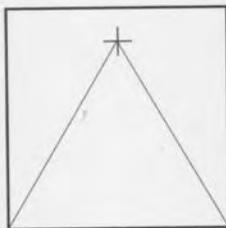
The natural tendency with the One Crease technique is to add a second and then a third crease to the sheet. Somewhat paradoxically, this will have only limited success! The curves induced by a single crease often conflict with those induced by a second, creating a sheet that is stressed and unresolved. So, when experimenting with the placement of more than one crease, consider where each one is placed with particular care.



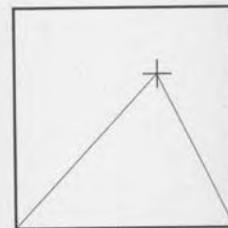
7.2.6_1



7.2.6_2



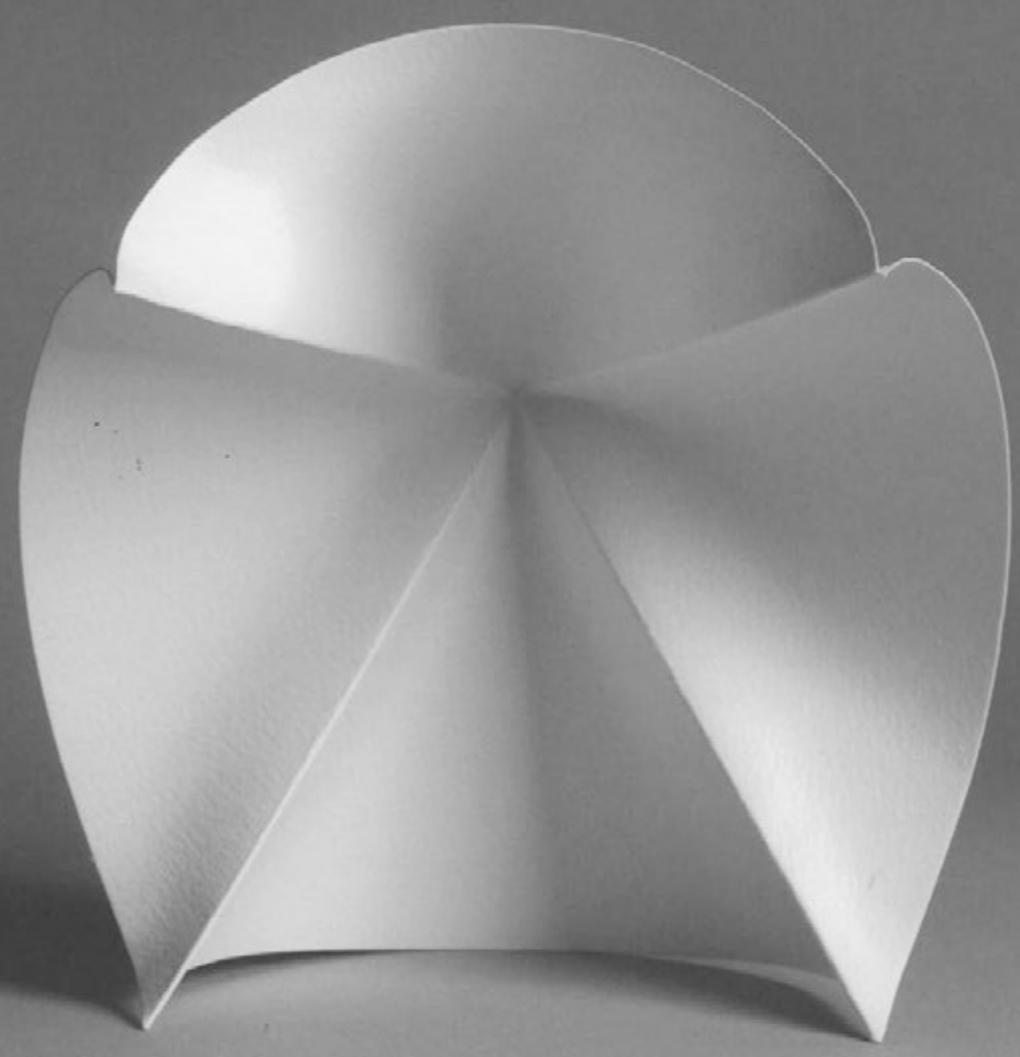
7.2.6_3



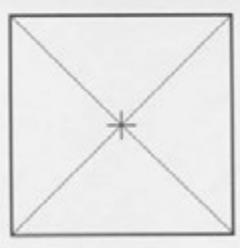
7.2.6_4

INCREASE,
DECREASE
No Crease
More than
No Crease

7.2.6_5



7.2.6_5

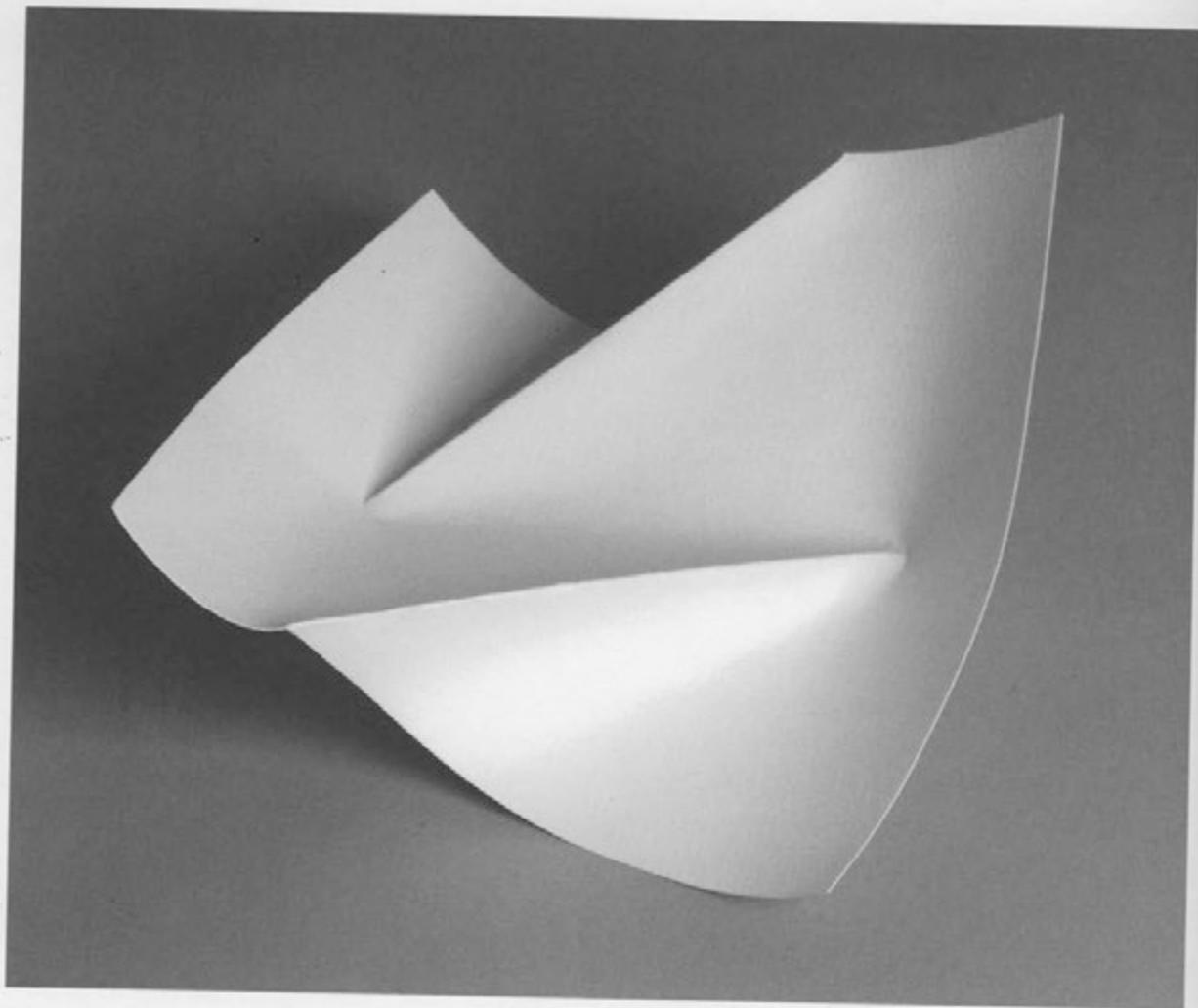


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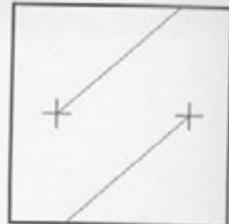
7. NO CREASE,
ONE CREASE

7.2. **One Crease**

7.2.6. More than
One Crease



7.2.6_6

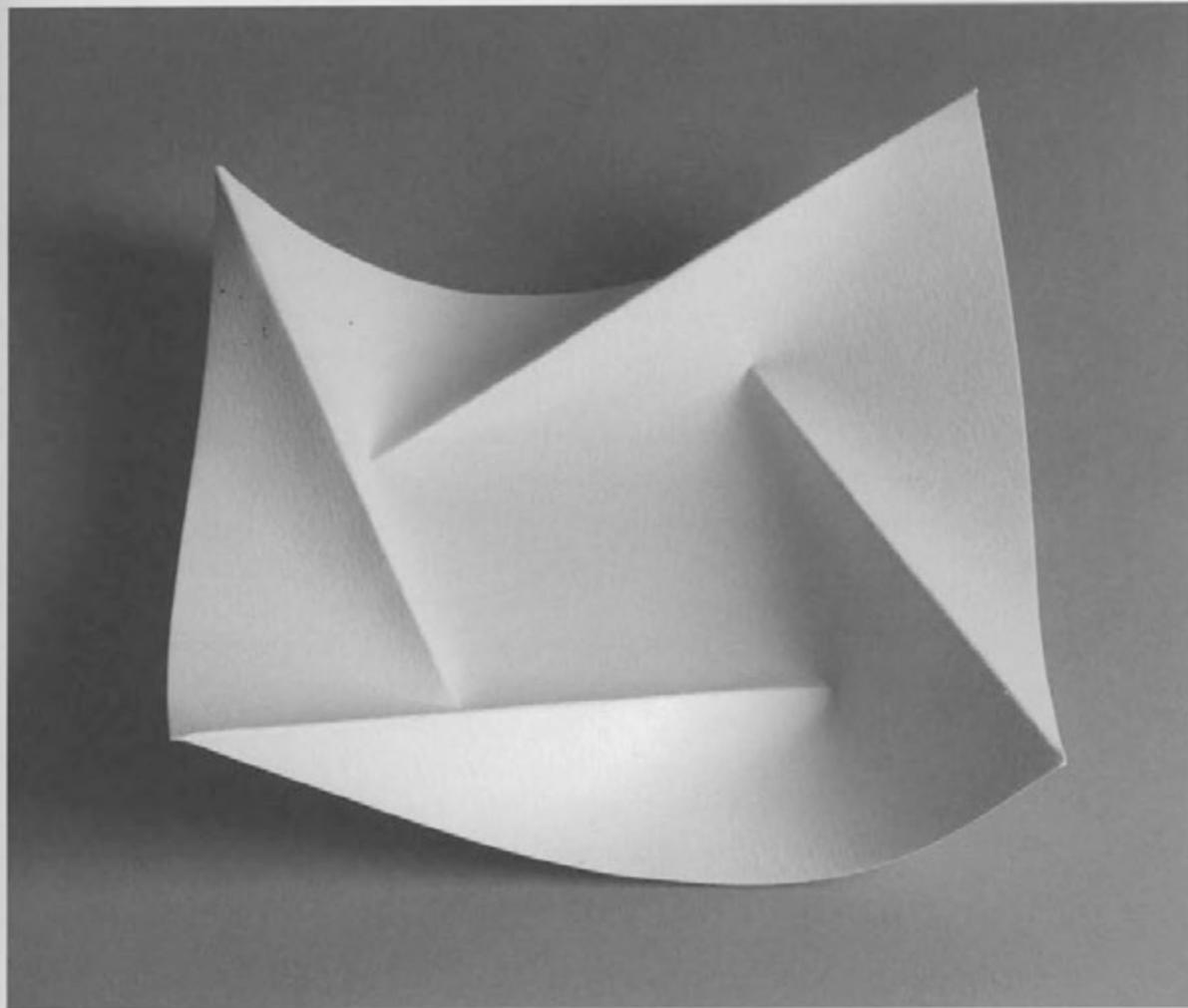


NO CREASE,
ONE CREASE

One Crease

More than
One Crease

7.2.6_7



7.2.6_7



8. Crumpling

Crumpling is an exercise in controlled anarchy and an antidote to the geometry of the preceding chapters. It has a distinctive organic aesthetic that appeals to people who have a natural aversion to measured, geometric folding. It is also a technique much used by nature – think of flower petals that uncrumple as they open, our crumpled brains, crumpled rock strata and so on. What may at first seem to be a somewhat jokey folding technique could perhaps be the most profound. It is also the least explored and the least understood.

The essence of the technique is to carefully crumple a sheet to reduce its apparent size, then to expand it along certain lines or in certain areas by selectively opening the crumpled surface. It could be described as the simplest of all techniques – what could be simpler than crumpling paper? – but it is also the most difficult to do well. It requires just the right material and, as it is the most tactile and least mechanical of all folding techniques, a special sensitivity of touch.

If you are planning to crumple for an extended period of time, it is advisable to wear thin cotton medical gloves to prevent your hands getting sore.

Selecting Papers

Whereas most of the examples in this book can be made with almost any paper that will retain a fold, crumpling can be done successfully only with specific papers, or your results will be very poor.

The key factors in choosing a paper are weight and foldability. Papers below 60gsm are best. The thinner they are, the better they will be for crumpling. This is because thinner papers hold more folds, so the apparent shrinkage of the sheet when it is crumpled will be greater. However, not all thin papers crumple well. It is essential to use only ones that retain a fold, so papers

such as tissue paper, although easy to find, are usually of little use. To find out whether a paper will retain a fold, crumple it tightly into as small a ball as possible, using quite some force. If it stays tight shut and opens only when pulled hard, it should be good for crumpling. Another way to test for a good paper is to hold a corner of the sheet and let it hang down vertically. Shake the sheet vigorously. If it rattles loudly, it will probably retain a fold well; if it is quiet, it will probably not.

Here is a partial list of suitable papers and sources:

Papers

- Onion-skin paper
- Bible paper
- Bank paper
- Gift-wrap paper
- Thin Kraft paper (brown wrapping paper)

Sources

- Paper merchants (for the papers listed above)
- Clothes shops (for the paper that wraps newly bought clothes)
- Wine merchants (for the paper that wraps bottles of wine)
- Florists (for the paper that wraps bunches of flowers)

If you are unable to find a good paper or have a spur-of-the-moment urge to crumple, regular 80gsm copier paper will suffice, though because the paper is a little too thick, the results will be relatively unimpressive. Use A3 paper in preference to A4. The examples that follow were made with 45gsm onion-skin paper.

8. CRUMPLING

8.1. **The Basic Technique**

8.1.1. The Basic Method

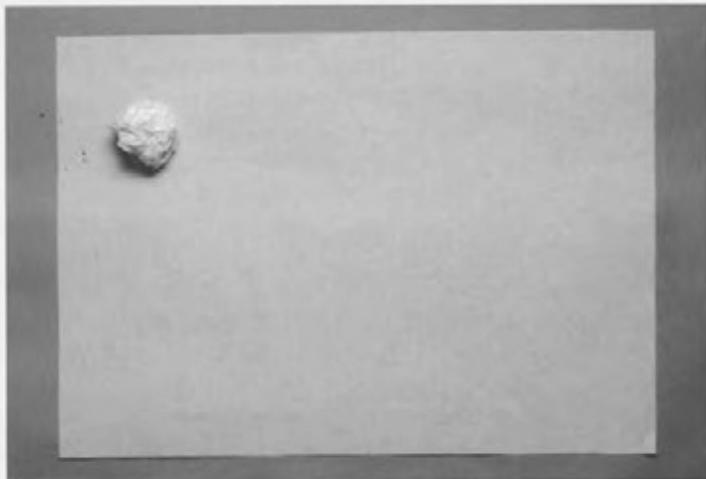
8.1. The Basic Technique

8.1.1. The Basic Method

This is the basic method for reducing paper to its crumpled state, ready to be stretched open.

8.1.1_1

Crumple the paper into as tight a ball as you can. Use as much pressure as possible! The photograph shows the size of the crumpled ball in relation to the size of the uncrumpled sheet.



8.1.1_2

Carefully pick open the ball until it is half open and no more. Try to open it evenly, all over. Note the size of the half-open sheet relative to the uncrumpled sheet – it is about half the area of the original.



8.1.1_3

Crumple the sheet again into another tight ball, using as much pressure as possible. Again, half open the sheet. The sheet will be about half the area of its previous crumpled size.



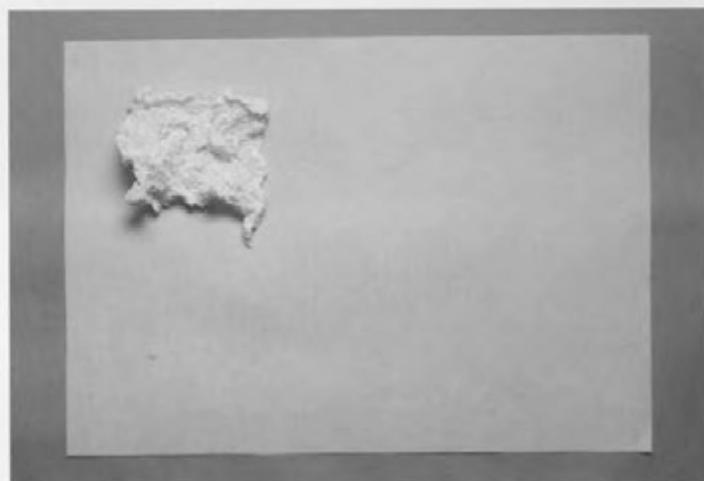
8.1.1_4

Repeat the process once again, crushing and half opening the sheet. The sheet will be about half the area of its previous crumpled size.



8.1.1_5

Repeat the process once again, and perhaps again and again, depending on several factors such as the weight of the paper, its size and how tightly you crush the paper into a ball.



8. CRUMPLING

8.1. **The Basic
Technique**

8.1.1. The Basic
Method



8.1.1_6

The final crumpled sheet. The smaller it becomes, the more dramatic will be the stretching, so it is important to reduce the size of the crumpled sheet as much as possible. However, the aim is to crumple it only until it stops reducing in size. If the sheet is crumpled and half opened too many times, it will become soft, the creases will lose their elasticity and the stretching will not work.

8.1.2. Making Ribs

The crumpled surface can now be stretched open in two distinct ways. The first way – to make ribs – is explained below.



8.1.2_1

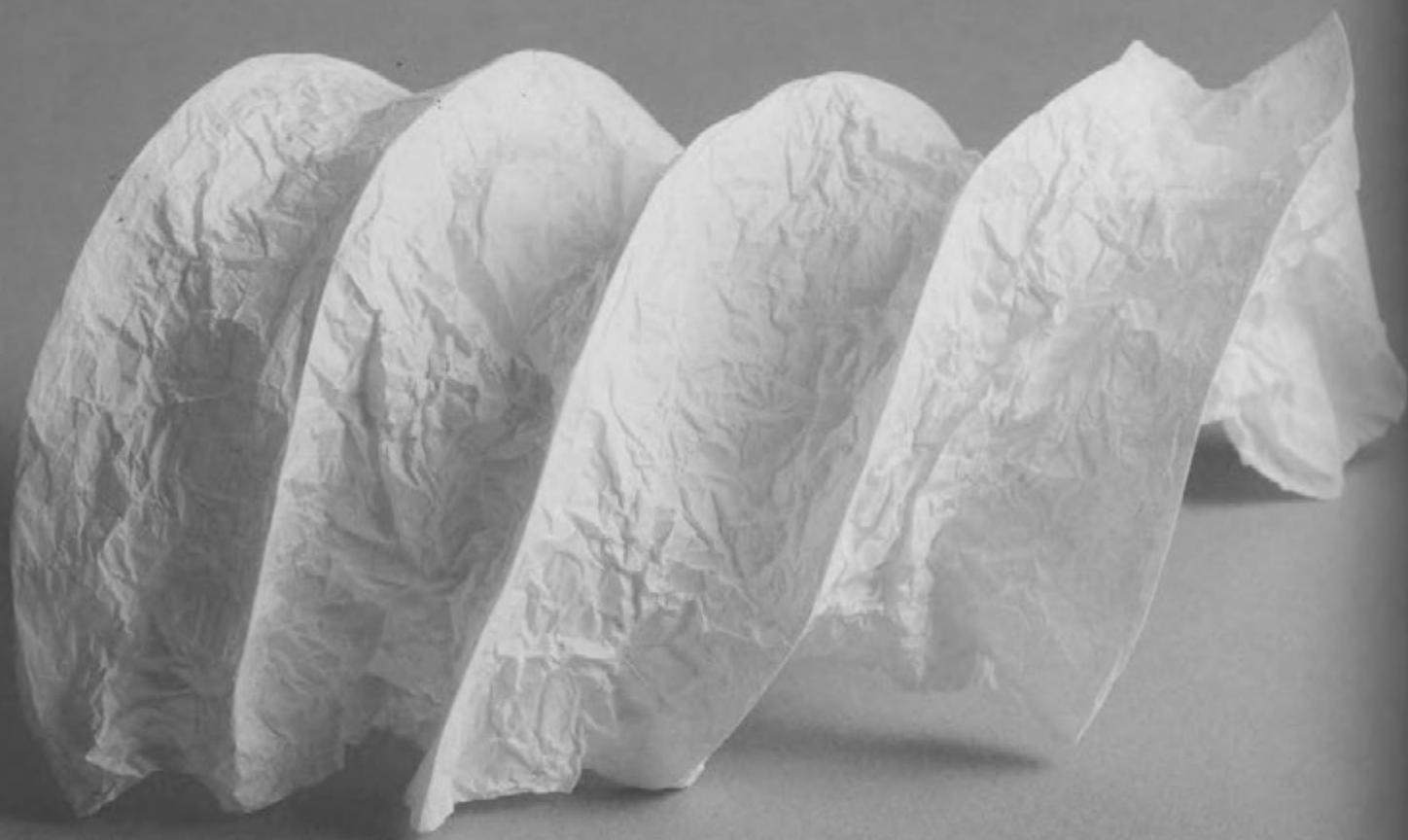
This is the basic rib. It is made by opening the crumpled surface a centimetre at a time, then creasing the paper as you go, creating a sharp, knife-like ridge. The effect will be more dramatic if as little paper as possible is opened (that is, uncrumpled) below the knife ridge, and if the ridge is creased with some force, to make it as sharp as possible. The ridge will not be straight and flat like a conventional origami fold, but will create an arch. The arch will curl more and more as the sheet increases in size and as it becomes more tightly crumpled.

8. CRUMPLING

8.1. The Basic
Technique

8.1.2. Making Ribs

8.1.2_2
When the technique is mastered, try
making a number of ribs in parallel.





8.1.2_3
Ribs can also be made
to meet at the centre
of the sheet, much like
an umbrella.



8.1.2_4
Here, the ribs have
been formed to isolate
an uncrumpled square.
There are a great many
ways to organize a number
of ribs to create 2-D
surfaces and 3-D forms.
With just a minimal amount
of experimentation, a
surprising variety of
surfaces and forms can
be developed, from the
small to the monumental.

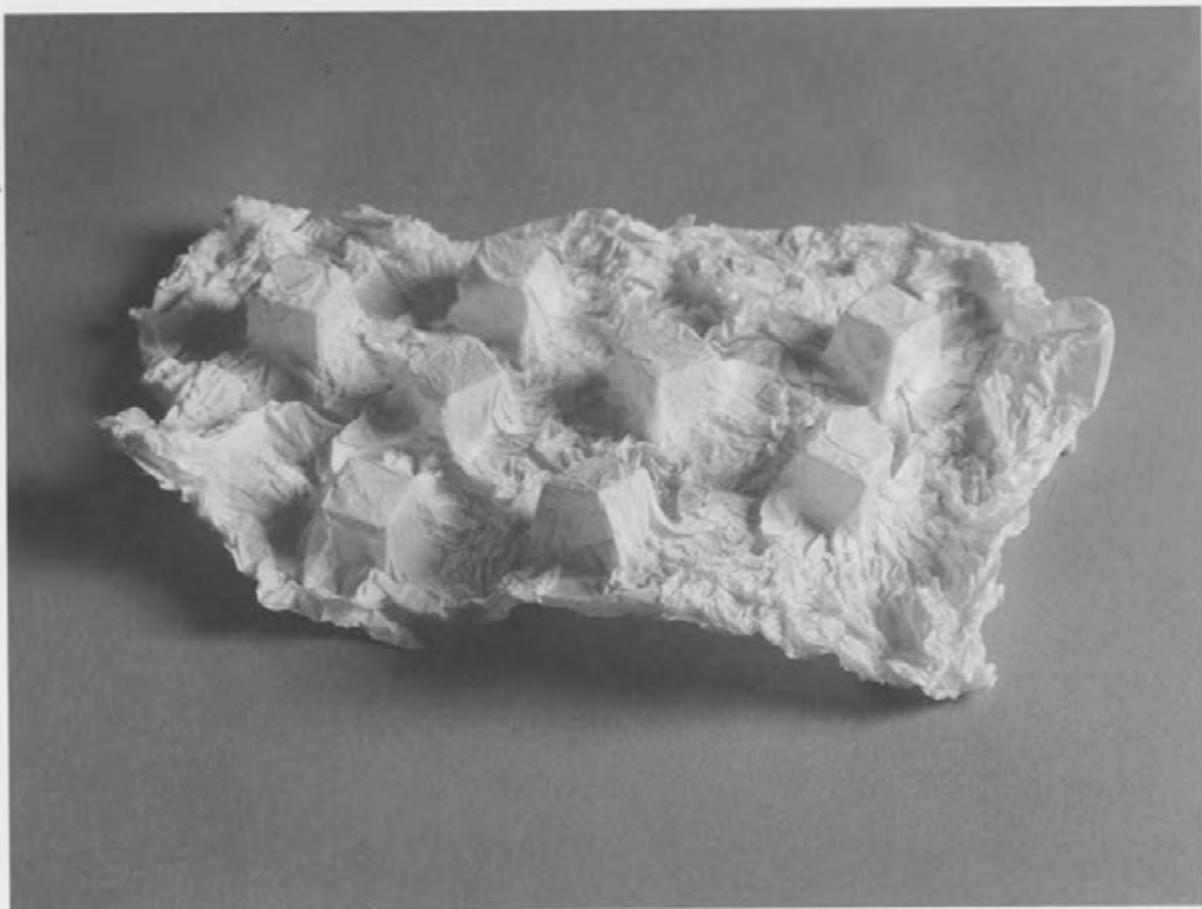
8. CRUMPLING

8.1. **The Basic
Technique**

8.1.3. Making a Mould

8.1.3. Making a Mould

The other stretching technique that can be used with a crumpled sheet is to make a mould that follows the contours of an object placed underneath the sheet. With the right paper and good crumpling, a surprising level of detail can be achieved.



8.1.3_1

Here, wooden cubes were placed under the crumpled sheet and the sheet stretched around them. Depending on the shape of the object underneath, a huge variety of abstract relief surfaces can be created.

CRUMPLING

The Basic
Technique

1 Making a Mould

8.1.3 _ 2

Moulds of recognizable objects can also be made. Look around the room to see what you can use! It is even possible to make moulds of a face or a whole body.



8. CRUMPLING

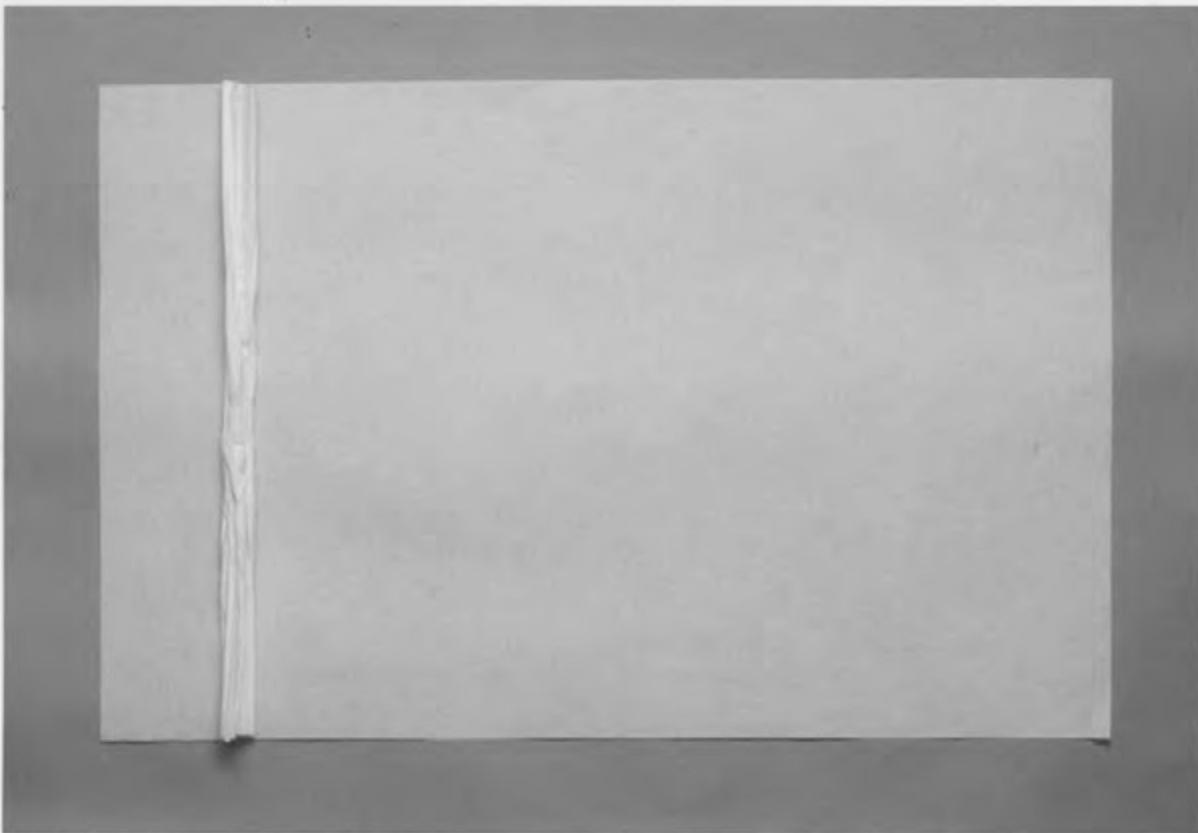
8.2. **Linear
Crumpling**

8.2.1. The Basic
Linear Method

8.2. Linear Crumpling

The Basic crumpling method described on the previous pages reduces a sheet equally in every direction, so that it can then be stretched open equally in every direction. By contrast, the Linear method described here crumples the sheet in one direction, so that it can be stretched open primarily only in one direction. This means that the Mould technique described earlier cannot be used, though the Rib technique works particularly well.

8.2.1. The Basic Linear Method



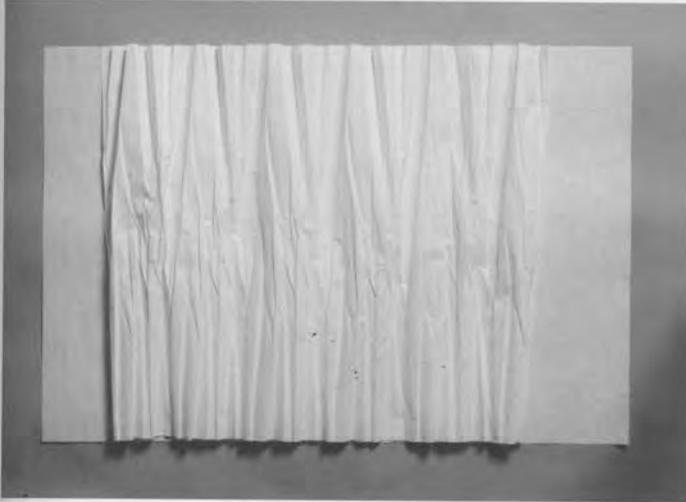
8.2.1_1

Roll the sheet into a cylinder with a diameter of approximately 3–4cm. Hold it tightly in your left hand just left of centre, then pull the right-hand half of the cylinder through your tightly clenched right hand. Repeat, but with your hands swapped. The result will be a narrow stick with many parallel crumples. The photograph shows the relative narrowness of the stick against the size of the uncrumpled sheet.

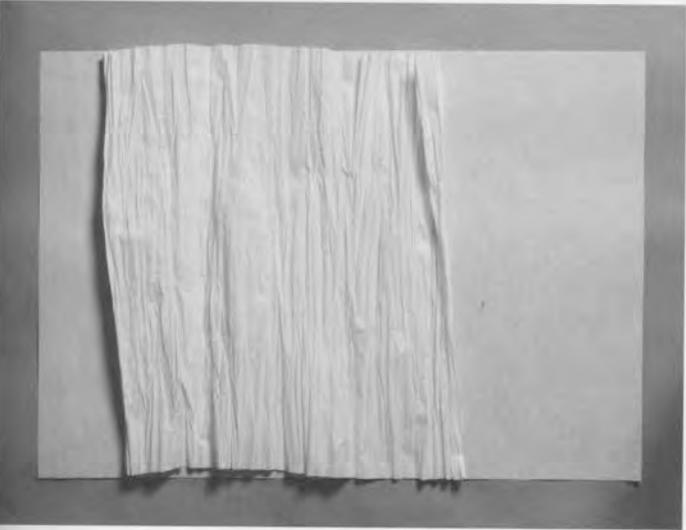
CRUMPLING

Linear Crumpling

The Basic Linear Method



8.2.1_2
Open the crumpled stick carefully. It will be about three-quarters the width of the original sheet.



8.2.1_3
Repeat Steps 1 and 2, being careful to press the folds very tightly as the stick runs through first one hand and then the other, and to only half open the stick. The stick will open to be about half the width of the original sheet. Repeat the process several more times, until the sheet is full of parallel folds and will not absorb any more.



8.2.1_4
This is the result. Be careful not to open and crumple the stick too many times. Stop when you see the stick is full of crumples and cannot absorb any more. This will maintain the freshness and elasticity of all the creases.

8.2.2. Linear Forms

As an alternative to the basic Ribs method described in 8.1.2, ribs can also be added to a sheet filled with parallel crumples. They are best added perpendicular to the direction of the crumples, because they become increasingly invisible as they rotate towards the direction of the crumples.



8.2.2.1
Ribs placed perpendicular to the direction of the parallel crumples create dramatic forms. Mountain and valley ribs may be placed together in combination.

1 CRUMPLING

1.2 Linear

Crumpling

1.2.2. Linear Forms

1.2.2.2

Short ribs, or ribs of various lengths, can be placed on a 2-D surface. Again, mountain and valley ribs may be used in combination.



8. CRUMPLING

8.3. **Rotational Crumpling**

8.3.1. The Basic Rotational Method

8.3. Rotational Crumpling

After the Basic and Linear crumpling methods described on previous pages, Rotational crumpling completes the trio of basic crumpling techniques.

8.3.1. The Basic Rotational Method

8.3.1_1

Hold the sheet at the centre point, allowing it to drape downwards. On smaller sheets, you might want to measure the exact centre, to ensure that the rotational effect is distributed equally within a relatively confined area.



8.3.1_2

Hold the apex tightly. Pull the draped sheet firmly through the tightly clenched fist of your other hand. If the drape snags when it is pulled, straighten out the paper so that the crumples radiate neatly from the apex.



8.3.1_3

Half open the paper, allowing the crumples to 'breathe' open.



8.3.1_4

Repeat Steps 2 and 3 three or four times until the paper is full of as many crumples as it can hold.



CRUMPLING

Rotational
Crumpling

The Basic
Rotational
Method

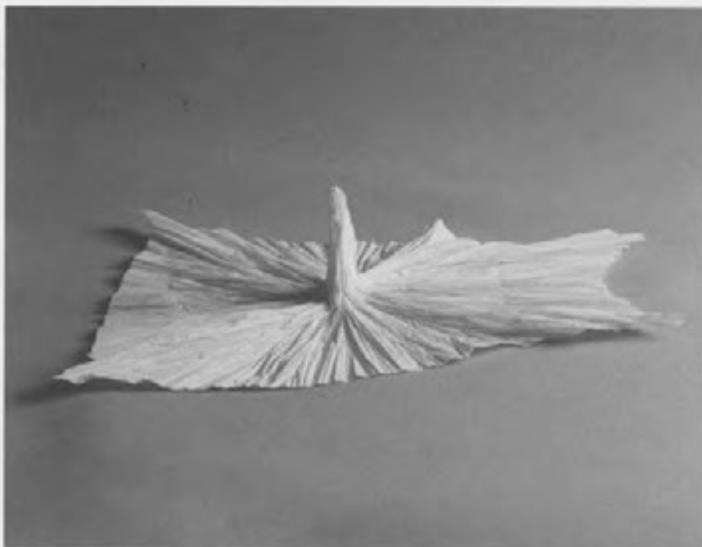


8.31_5

This is the finished result. It is sometimes possible to add more crumples if the paper is 'popped' inside out between each repeat of the crumpling.

8.3.2. Rotational Forms

A Rotational crumple differs from the Basic and Linear crumples in that it makes a 3-D form, not a 2-D surface. This means the vocabulary of possible forms and surfaces differs greatly from that of the other two techniques.



8.3.2_1
A spike can be created by holding the apex and splaying the paper out beneath until a flat surface is created.

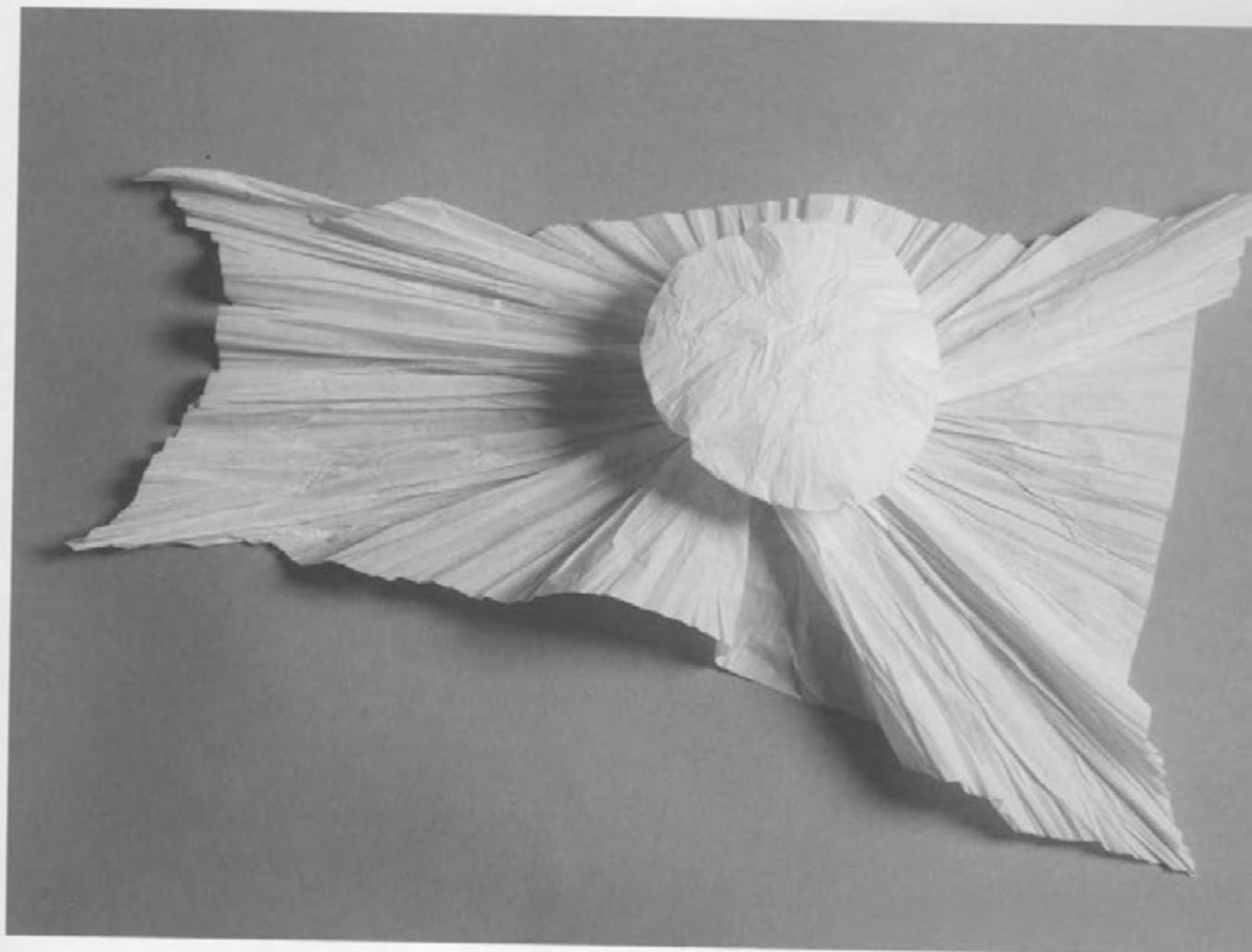


8.3.2_2
The rotational pattern of the creases means that it is difficult to create straight ribs. Instead, circular or spiral ribs should be made.

CRUMPLING

Rotational
Crumpling

Rotational
Forms



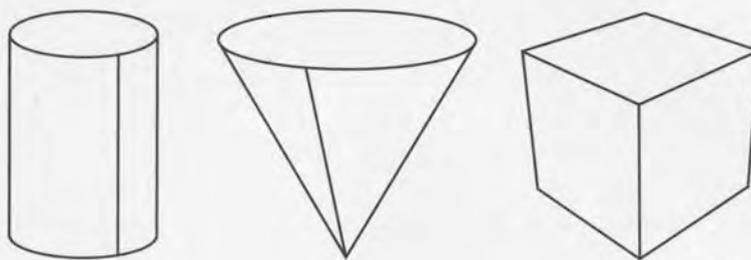
8.3.2_3

If the apex of the spike is inverted into itself and then opened, the spike form becomes more button-like, as seen here. If the paper below the button is gathered up into a stick, the form becomes remarkably like a mushroom.

8.4. Advanced Concepts**8.4.1. 3-D Forms**

Flat sheets were used for all the basic crumpling methods on the previous pages. However, crumpling can also be applied to sheets prepared as 3-D forms.

The easiest ones to prepare are simple geometric forms such as cylinders, cones or cubes. Use strong, liquid paper glue to hold the seams together and allow it to dry thoroughly before attempting to crumple the form. An overlap of 2cm is sufficient to create a strong seam. Prepare several simple, identical 3-D forms and crumple them using different techniques to see how they compare.



8.4_1

8.4.2. Super-sizing

Crumpling need not be limited by the size of a single sheet. It is quite possible to glue many sheets together to create a surface or form of giant proportions. It is crucial to join the sheets together before they are crumpled, not afterwards. Curiously, the overlapped seams become almost invisible after the sheet has been crumpled, so super-sizing does not diminish the aesthetics of what is made.

Crumpling large sheets can be physically tiring and time-consuming, and is best undertaken by a small team of people. The results though, can be remarkable.

8.4_2

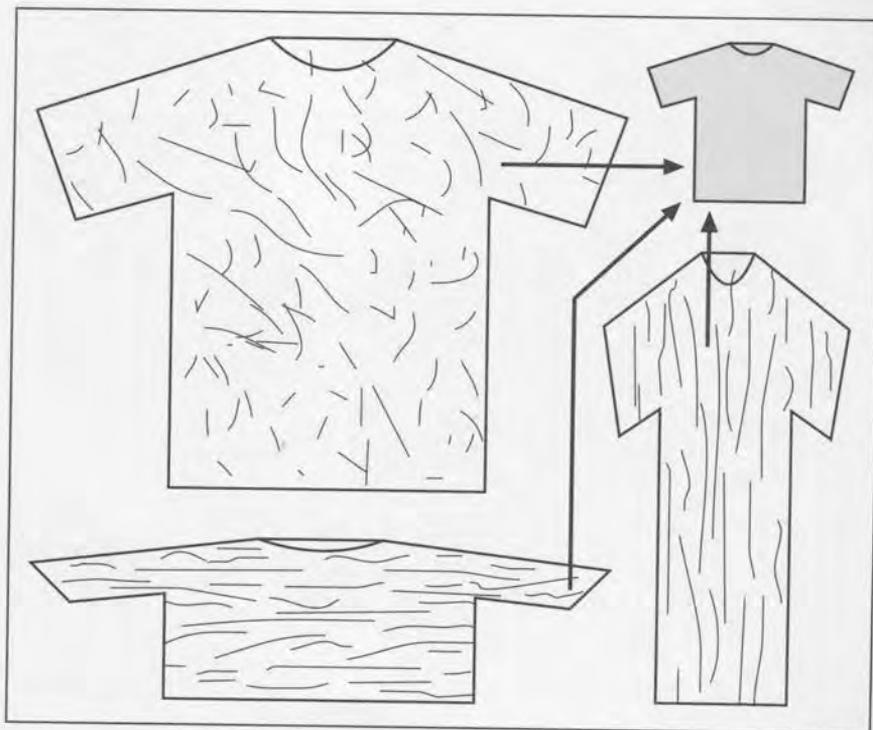


8.4.3. Crumpling and Morphing

If you intend to create something of a specific size and proportion – for example, a crumpled medium-sized T-shirt – you cannot simply crumple a T-shirt from a medium-sized sheet. The result will be a much-reduced crumpled shirt, which would fit only a small infant!

The sheet needs to be much larger than the finished T-shirt, so that it becomes the required size when crumpled. Its size and proportion will depend on which crumpling technique is used (Basic, Linear or Rotational) and by what percentage it reduces in size when crumpled. To an extent, these calculations are best resolved by trial and error, though a ballpark estimation will provide an initial guideline.

The basic T-shirt shape will have to enlarge equally in every direction if the Basic crumpling method is used. However, if the Linear method is used, the T-shirt shape will have to enlarge and morph horizontally or vertically, depending on the direction of the parallel crumples.

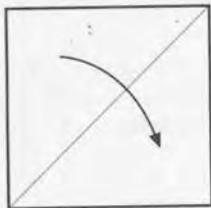


8.4.4. Multi Layers

Instead of crumpling one layer, or perhaps a double layer if a 3-D form is prepared (see page 218), it is possible to crumple through a multi-layered sheet. First, fold the sheet into a simple 2-D geometric shape, then crumple it using one of the methods described in this chapter. When opened, a complex pattern of crumples will be seen, divided into areas bounded by straight origami-like folds. Here is an example which creates a crumpled version of the Basic Parabola (see pages 145–147).

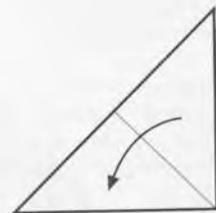
8.4.4_1

Fold a square of paper in half along a diagonal.



8.4.4_2

Fold the triangle in half again, to create a smaller triangle.



8.4.4_3

Now crumple the four layers as one, using the Linear crumpling method (see pages 210–211). Note that the crumples are parallel to the long edge of the triangle.



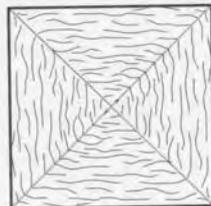
8.4.4_4

Open the triangle back out to the original square.



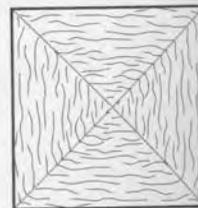
8.4.4_5

When opened, three of the four folds that radiate from the centre point will be valleys and one will be a mountain.



8.4.4_6

Carefully refold one of the radiating valley folds as a mountain, so that one full diagonal is a mountain and the other is a valley.



Now follow the technique used for the Basic Parabola, which collapses a geometrically creased square into an X-shaped stick. Of course, the crumpled square will not divide equally and evenly into concentric mountain or valley squares like the geometric version, but you can nevertheless lightly gather up the crumples as you go, working from the perimeter to the centre point. Be sure to create the buckled shape seen in 5.3.1_7 (see page 146), making use of the mountain and valley diagonals. Eventually, the X-shaped stick will be made. Only then should you create the crumples very firmly, strengthening all the folds.

This is the result. Interestingly, it may take a novice an hour to make the geometrically creased parabola, whereas this crumpled version should take only ten minutes.

In many ways, complex geometric folding – especially folding which creates many free points, such as some styles of complex origami – can be considered a form of controlled crumpling. 'Geometric folding as controlled crumpling' is a concept rich in creative possibilities.

