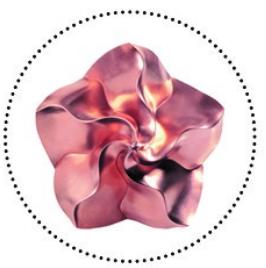
Anastasia Young & Paul Wells

new jewellery techniques

Curved Scoring and Folding for Metalwork and Silversmithing







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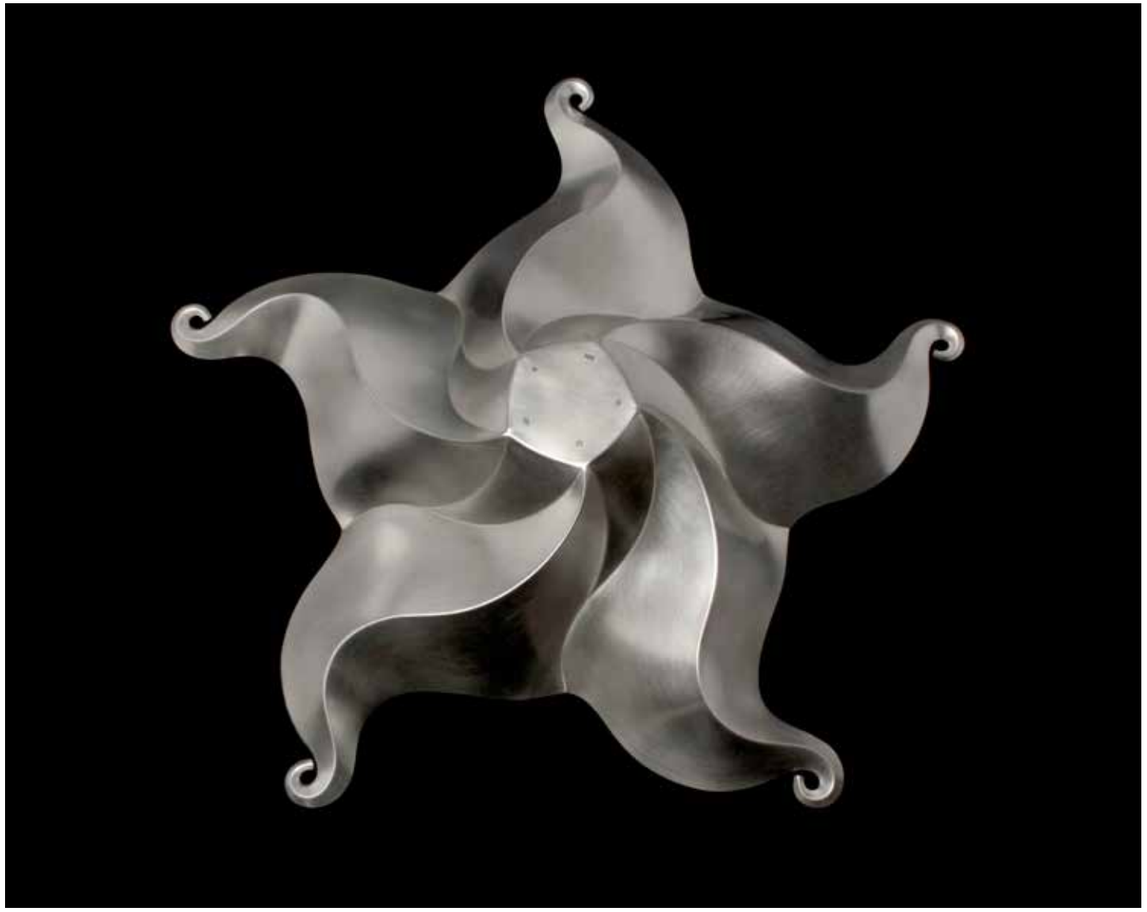


About This Book

For Paul Wells, the real breakthrough moment concerning Curved Score Folding occurred when he was asked by a student how to make a fortune cookie from sheet metal. Paul had been teaching fold forming and other direct metal-working techniques including wire scoring, for more than two decades, but until this point had not seen the wider potential of the technique. With the fortune cookie, Paul devised a template to score the thin sheet metal that would allow the form to fold and curve around itself to create an exact replica of the required form—and it is shared as a project in this book.

From then on, Paul explored as many possibilities for this technique as he could dream of; first through expressing his own ideas which produced the series 'Funnels', 'Insects' and 'Eyes', and then through geometric variations as a means of exploring form to fully understand the ways in which the metal could be encouraged to move.

Our natural inclination as educators and makers is to share our enthusiasm for these discoveries so that others may learn and explore. We are all products of the generosity of our peers and teachers, whose knowledge forms the foundation of our own; and we wish to continue in the spirit of this culture of shared knowledge for the benefit of all.

Already the interest from the metalsmithing community and further afield has been a great source of motivation and we are excited to share Paul's work alongside contemporary examples of jewellery, metalsmithing and sculpture so generously provided by practitioners of scoring and folding from around the world.

We wish to thank the Goldsmiths' Company (in all its facets) for their continuing support and encouragement; for recognising Paul's work with Gold Awards for Technological Innovation in the annual Craftsmanship and Design Awards of 2019 and 2020, for selecting his work to be showcased at Goldsmiths' Fair, and for researching and providing images for this book. The acknowledgement of Paul's work by such a prestigious organisation has given us the confidence to be assured that we are doing something special in sharing Paul's knowledge through this book.

We also want to express our gratitude to Joaquim Canet for his vision in agreeing to publish this book, and to Lola Mercader and the team at Hoaki (Promopress) for their work and support during this project.

Paul Wells &
Anastasia Young

Contemporary Influences

Jewellers, metalsmiths and artists are using curved and straight score folding in innovative ways, using a wide range materials. Their ideas are expressed as figurative, abstract, geometric and organic in both functional and sculptural objects.

← Kinga Sulej
Earrings (Untitled)
Patinated silver.

← Jessica Jue
Sand Dune Box
Sterling silver.

↑ Hiroki Iwata
Gold Flare Box
Gold-plated silver.

← Ekaterina Lukasheva
Heptagram, opus T-207
Paper, acrylic paint, spray paint.

↑ Ilan Garibi
Rounded Cubes Pendant
Gold-plated brass.

← Anne Bader
Piega Earrings
Sterling silver, partially gilded.

Samples of curved score folds made in aluminium, mild steel and pewter.

PART TWO Directory of Tools and Materials

Tools, materials and facilities are three important aspects for any maker and in this chapter each is explored in detail with the emphasis on the relevance to curved score folding.
The choice of metal for a particular project is based on considerations such as material properties like malleability and density, as well as cost and availability.
It is possible to create amazing work with very few tools and quite basic facilities; however, heating larger pieces of metal will require more resources than are necessary for jewellery-scale objects, and it is advisable for those starting out in metalwork to seek a local college or workshop where they can learn to work safely under supervision.

Forming Tools

The tools used to shape metal are often quite specific to their task, and a range of shapes and sizes is usually required. Although most of the tools on this page are available in metal form, using wooden versions not only allows work to be shaped with less risk of damaging it, but the tools are far more easily adapted as required.

Many of these tools can be made in the studio; hardwoods such as beech are better for tools that require strength and durability, whereas softwoods are much easier to work but tend to have a shorter lifespan if used for heavy forming. Pine is a useful material for making recessed tools for forming sheet metal and also for the base of jigs for shaping score wires.

Wooden Pushers

These are important tools for score folding, for helping to open or close folds, to smooth areas of metal and to move edges of forms.
Wooden pushers are easily made from scraps of hardwood, and a range of shapes and sizes will be useful. The best shapes will be discovered by experimenting; play with the rate of curve, width or shape of point until the tools fit requirements.

Mallets

Mallets will move metal without marking it and are invaluable for aiding the bending and forming of pieces. Flat faced mallets are most readily available, in a range of materials including rawhide leather, nylon, rubber, wood and Delrin. Wedge-shaped mallets are useful for accessing narrow areas.

Wooden Punches

Hardwood doming punches are useful for curving and adjusting sheet metal forms and because the stems of the punches are in incrementally sized diameters, they also make very useful formers for shaping score wires. Sizes up to 40 mm are readily available and larger sizes can be improvised with table legs or rolling pins.

Other Formers

Doming blocks and swage blocks are available in both wood and metal. It is often necessary to make or adapt this kind of tool for a specific task. Grooves can be filed into hardwood to create a custom swage block, and pine blocks can be beaten with a metal hammer on their end grain to make shaped recesses for hollowing sheet metal forms into.

Pliers

A good selection of pliers will be used both to shape scoring wires and to adjust the folded forms themselves. A few adaptations may be necessary to ensure that the pliers do not leave marks in the metal being shaped, whether it involves using masking tape or heat-shrink tubing around the jaws, or more permanent adaptations.

Steel Pliers

Scissor-action pliers open more at the top of the jaws, whereas parallel pliers always maintain the same distance. A wide variety of shapes and sizes is available in both types—and at least one pair of scissor-action pliers in each shape is advisable. Parallel pliers are most useful in flat and half round.
Steel pliers can be adapted to make them less damaging. Round off the corners and edges of jaws by grinding them or using abrasives, working up through the grades until a finer finish is achieved.

Nylon Pliers

Pliers with plastic faces are useful for manipulating awkward areas of metal without leaving marks. The force required to move the metal can often damage the plastic jaws, but replacements are cheap and easy to source.
Many shapes of nylon pliers can be found in both parallel and scissor versions; half-round versions are probably the most useful, and 'double half-round' can be made by putting two curved faces on one pair of pliers.

Other Types of Pliers

There are many types of non-standard pliers available now, and some will be very useful for helping with specific tasks; others, less so –this depends on personal practise.
Self-locking vice grips can be used to hold wire securely whilst it is straightened.
Hole-punching pliers will make holes in thin metal instead of drilling.

For wire, memory and flush cutters, see page 47.

Workshop Facilities

It is possible to create curved score folds with very little equipment and limited space but there are a few basic requirements that should be considered, particularly if larger scale work will be made.

Comfortable Working

Whether using the kitchen table, the corner of a spare room, or a shed or garage, adequate space to work safely and comfortably will need a little planning.
A workbench fixed to the wall is the ideal base for many of the heavier tools such as vices and rolling mills, but a heavy table will also be suitable. Vices, rolling mills and presses are operated whilst standing, so give consideration to the height at which they are set, and the orientation of and clearance for the handle. An extra supporting leg set underneath the bench will provide support for the tool and help to prevent vibration when working.
Clear table space for planning designs and laying out work in progress is important, but often overlooked, especially when space is at a premium.

A chair with adjustable height is useful as some tasks are more easily carried out on a table-top, and most work done at a jewellers' bench requires the seat to be relatively low so that the work is almost at eye level.
Try to maintain good posture and sit at the correct height, taking regular breaks as necessary.
Good, even lighting is necessary for accuracy of work—an angle-poise lamp can be easily moved where needed.
Consideration should be given to storage for tools, as well as to storage for test pieces and finished work.
Boxes, drawers and display cases are all very useful.
If the workspace is susceptible to damp, as in the case of a shed, extra care must be taken to prevent tools from going rusty. Check equipment regularly and apply oil to protect exposed steel surfaces every few weeks. Iron binding wire can also rust, so should be stored in sealed bags.

The Jewellers' Bench

The use of hand tools is mostly done at a jewellers' bench. Saw piercing, filing and cleaning up are all facilitated by supporting the metal (or the hand holding it) on the benchpeg, which has a 'V' cut into it to aid working. Benchpegs that can be clamped to a table are a good option for a versatile workspace.
A micromotor can be set up on the bench for drilling and polishing, and when operated with a foot pedal will leave both hands free.
Small scale soldering of jewellery components is sometimes carried out on the bench top, but for larger work it is safer to have a separate heating area.

A jewellers' bench has at least one bench peg to support work whilst cutting and filing. The curved cut-out allows metal dust and scraps to be caught underneath in a tray or 'skin'.

Left: A heating area should be well insulated and have enough space to safely anneal and solder pieces of metal.

Below: Tree stumps absorb noise very well and make good bases for hammering on. Tools that require sideways force to operate them, such as a vice or rolling mill, will need to be bolted to a fixed surface to use them safely.

Creating A Hearth Area

It is important to ensure that the heating area is adequately insulated and fire-proof, and this should be done with a layer of house bricks, especially if a wooden table is being used. A steel surround will protect anything behind the hearth from becoming scorched, and this can be lined with heat-proof mats to increase protection. A mat used as a cover, or lid will keep the area dim and also stop some heat from dissipating.
The size of torch that is being used will determine the set-up, to some degree.
Good ventilation is also necessary, so if there is no access to a fume extraction system, then a window that can be opened to create an airflow through the room to clear fumes is a must.
Water for quenching should be nearby.

Overview of Scoring Techniques

Although the focus of this book is on wire scoring techniques, several alternative methods of creating score lines are discussed in order to contrast and compare. The type of score that is used may depend on several factors, and a number of different processes can be applied to the same piece of metal if required.

Suitability of different methods

The principle aim of scoring sheet metal is to create a point of weakness so that the metal will bend accurately, with the score forming a guide. The score line creates space for the metal to fold, so the wider the line, the tighter the angle that can be folded.
Scores are created either by displacing metal and pushing it aside, as with wire scoring, or by removing metal to create a linear groove. The techniques used to imprint wire into sheet metal are all reasonably similar, and a decision to use one rather than another may depend on the equipment that is to hand, or the size of the project. Another important consideration is that displacement techniques usually mark the reverse side of the metal, so if the surface has been textured then this shows as a shiny line. Scores made by removing metal often do not have this issue and may be an option for preserving surface effects.

Displacement of Metal

Hammer and Block
Rolling mill
Vice and Blocks
Planishing Press
Fly Press
Hydraulic Press
Nicking (with a chisel)

Removal of Metal

Scoring Tool
Filing
Engraving
Milling Machine
Motorised tools: Burrs, Parting Discs
Etching and Photo-etching
CNC

Scoring with a Hammer and Block

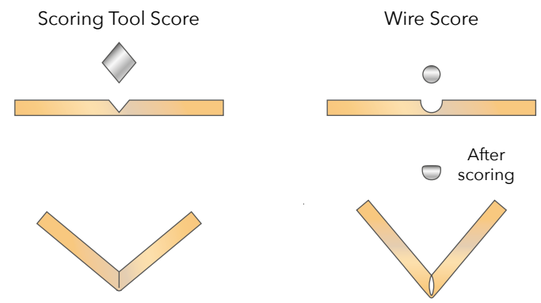
Using a Planishing Press

Scoring with a Rolling Mill

All of these techniques have benefits and drawbacks, and each maker must find their own best way of working; perseverance is an important skill here because it will take many trials to understand the process well. One attempt is not enough to predict reliable outcomes, but fear of failure should not prevent playful experimentation. There are many variables that play a part in the outcomes, from the depth and width of score or the gauges of wire and sheet, to the amount of physical force required and even noise levels!

The Effect of Score Profiles

The shape of the scored groove is determined by the way the score is made. Scoring tools create a v-shaped recess which will give a sharp corner when folded, but the majority of the stress is concentrated at the narrowest part of the score because it offers the least resistance. Scores made with wires have a u-shaped profile which spreads the stress more gradually throughout the curve, and as the metal is folded the curve can stretch and adapt to the new form.



Cross-sectional Diagram of Score Profiles

Using a Scoring Tool to Cut a Curved Score

Scoring with a Computer Numeric Controlled (CNC) Router

Traditional Scoring Methods

Straight scores have traditionally been cut into sheet metal using the sharpened point of a scoring tool to remove metal slivers along a line. Files and chisels can also be used to create grooves suitable for bending, and all of these methods allow for sharp-angled folds to be made.

One area of metalwork that often requires scoring and folding is box-making, although there are plenty of other applications. Accuracy is important for creating straight folds, both in the position of the score and in its execution.

Filed Score Lines

For scores of a shorter length, a needle file can be used to create a suitable recess.
Mark the position of the score line accurately with a scribe and engineers' square. A piercing saw can be used to make a shallow mark at one end of the scribed line to help the file get started. Use a triangular file first, as

it is easier to cut a narrow angle and there is less risk of slipping. When filing, change sides every so often so that the cut is of equal depth. If a right-angled fold is required then a square needle file should be used to continue filing to the correct depth, which is about two-thirds of the thickness of the sheet metal.
Anneal the metal before bending. Check the angle and solder the fold to reinforce it at the first opportunity.

Nicking

A chisel with a sharp 90° end is used make an impressed groove by striking it with a hammer. The position of the first blow on a scribed line is crucial for the accuracy of the score, as all subsequent hammer blows follow on from this one. Reposition the chisel at one end of the last mark made, before giving the chisel a firm strike, rather than using it like a chasing tool and pulling it along. With practise, the correct depth of score can be struck with one well-judged hammer blow, and this should ensure a cleaner line. The score can be tidied with a triangular needle file if necessary.
Anneal the piece once scored as it will have become work-hardened during the process; this method of creating score lines does mark the back of the metal.

Scored Lines

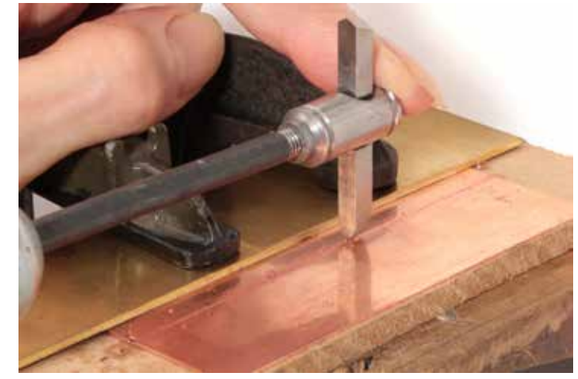
Scoring tools can be used to remove metal very accurately and to a precise angle. The cutting edge must be very sharp for the tools to work effectively; clamping the metal down will help to maintain precision by holding it securely, but also to prevent the tool from slipping and causing injury.
After scribing the metal deeply against a fixed edge, use a tool with a narrow angle to start the cut. This technique does take practise, and it is very easy to slip out of the groove and make deep scratches into the surface. Once a few passes have been made, the metal should be turned around so that the cut can be started from the other end as it is more difficult to remove metal at the start of the cut.
The depth of cut should be consistent if long, evenly pressured strokes are made with the scoring tool. The cut score line is visible from the edge of the metal, allowing the depth to be assessed—it should be two-thirds of the way through, regardless of the angle of the cut.

Scoring a Straight Line

Clamp down the piece of copper, with a straight-edged piece of brass forming a guide for where the score will be made. Use a sharp pointed scribe to firmly draw a line into the copper, and repeat this until a deep mark has been made.
Move the brass guide away from the line and clamp the metal again. The scoring tool can be used to cut a groove by dragging it backwards along the deeply scribed line. Lubricate the tool with oil regularly to ensure a clean cut.

Scoring Tools

These tools are often hand made from old files or square steel stock, but these bought versions, shown above, illustrate the different angles that are traditionally required for creating 90° folds. In the inset image, it can be seen that one side of the cutting bit is angled more acutely than the other, to 60°. It is easier to start the cut with the narrower end, and once the groove is well-established, to change to a bit of the same angle as the fold requires.

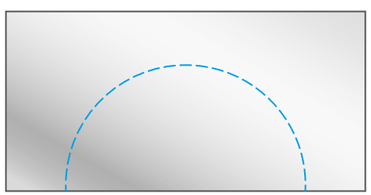


Squares and Rectangles

Single Curved Score Fold

In this first sample, a single curved score is applied to a rectangle of copper to radically alter the structure and create a robust three-dimensional form.

One simple score can facilitate an astonishing amount of movement in a sheet of metal. This exercise introduces the principles of applying a wire score to sheet metal and using the score to define the fold. The amount of curvature which can be achieved will improve with practise - regular annealing of the copper will help to keep it malleable.



Template for Single Score Rectangle (Actual size)

For this exercise you will need:

- Copper sheet 0.5 mm sheet (24 gauge) - 60 x 30 mm (2¼ x 1¼ in)
- Iron binding wire 0.8mm diameter (20 gauge)
- A 34 mm (1¼ in) former, to give a 40 mm (1½ in) curve

1.
Use a 15 cm length of straightened wire to form the scoring wire. Coil it smoothly around the 34 mm diameter former. Cut a cleanly curved section to use which is a bit longer than half a full circle.

2.
Stick the wire on to the piece of annealed copper sheet using masking tape. Measure the position of the wire to check the accuracy of the spacing, relative to the edges of the copper.

3.
Set the rolling mill to the correct depth for the gauge of metal that is being used (see page 52), and roll the sheet through the mill. Note the direction of milling - this reduces distortion and movement of the wire.

4.
Remove the tape and draw round the copper sheet in a technical notebook, marking the position of the wire to make a diagram. The wire can be stuck down on the page, too.
Note down the copper gauge and any other relevant information.

5.
Roll the copper sheet through the rolling mill again, this time with the rollers set at a neutral distance so that the copper is only flattened, not stretched. This is the "flatting pass".
Anneal and pickle the copper to remove the oxides.

6.
The compression of the sheet can now begin. With the scored side facing down, use your thumbs to begin to fold the sheet down around the curve of the score. Use firm even pressure, and do not try to work too fast.

7.
Once the fold is established, other tools such as curved wooden pushers can be used to aid the smooth bending and compression of the fold.

8.
Continue to compress the copper sheet around the score, annealing the piece when it begins to get more difficult to move, as required.

9.
It is possible to bring the two ends of the scored line together so that they are touching, but the stage at which this is considered a finished form is a matter of opinion!

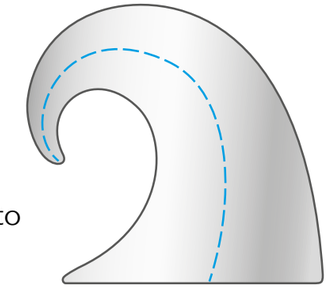
The Golden Spiral

Creating this kind of score allows the metal to take on an organic relationship with its forming - the more tightly it is compressed, the more it will curl. This gives a natural look to the form, as if it had grown.

This classic mathematical form, found in nature abundantly, is one of a series of geometrically differing spirals – logarithmic and Archimedean. The spirals used here are free drawn by hand, but spirals generated on a computer will also work well. Biomorphism is discussed in more detail on page 142.

For this exercise you will need:

- Copper sheet 0.5 mm (24 gauge) - 40 x 60 mm (1½ x 2 ½in)
- Iron binding wire 0.8 mm diameter (20 gauge)
- A 75 mm (3 in) former, to give a 115 mm (4½ in) curve
- Round and half-round pliers, both steel and nylon.



Template for Golden Spiral
(Actual size)

1.
Custom shapes such a spirals will need to be pierced out from a larger piece of sheet metal. Use a 2/0 blade in a jeweller's saw frame and work on a flat benchpeg. Rotate the copper sheet into the path of the blade as the frame is moved up and down; cut outside the line and file the edge to neaten it back to the line.

2.
Form the score wire using a 75 mm former to create a gentle curve. Then hold the wire down on the template and begin to pull the curve tighter where it needs to curl.

3.
Work along the wire, curving it more tightly as it progresses. It will create a smoother curve if the wire is bent by hand as much as possible– pliers can make kinks in the curve which are visually apparent.

4.
To create the fine curl at the end of the score wire, it will be necessary to use half round piers to hold the wire whilst it is pulled tighter with the fingers.

5.
Secure the wire onto the annealed copper form and score - with rolling mill, planishing press or hammer and block.
Anneal, pickle and clean.
Begin to bend the form at the wider end first.

6.
Continue compressing along the score line towards the curl, taking care not to go too far too quickly. As the fold is compresses, the more difficult it will become to form by hand alone.

7.
Use half-round nylon pliers to help close the curl. Place the curved side on the inside of the curl, and gently squeeze to close and fold. The spiral will want to travel upwards like a spring, which also gives easier access with the pliers.

8.
Round nose nylon pliers will aid the formation of an even tighter curl. Pull the spiral around as it is compressed to close the end more.
The small end of the spiral can be pulled open to make the form more 3D, or pushed flatter for a classic spiral form.

A spiral on each end of this copper dish forms pleasing terminals; the angled sides of the dish are pulled up and around when the spirals are formed.

Double Sided Scores

The application of scores to both sides of the metal allows more complex forms to be created as the metal can folded in opposing directions. This method of working opens up another world of creative possibilities.

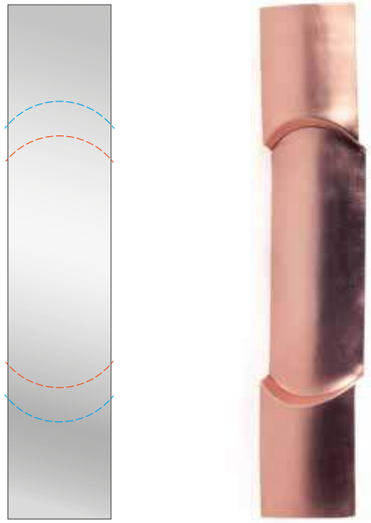
Radical dimensional changes to sheet metal can be achieved when the metal is allowed to form peaks and troughs. More sophisticated designs become possible, and with careful planning, quite complex score formations can be used. The scores do not have to be symmetrical—either parallel, rotational or mirroring, but this can be a good place to start.

Double sided scores don't have to be complex in order to create stunning results, and some very impressive effects can be made with simple configurations of scored lines.

This oxidised silver cuff by Paul Wells uses double sided curved scores in a tapered linear formation to create the structure.

LINEAR SCORES

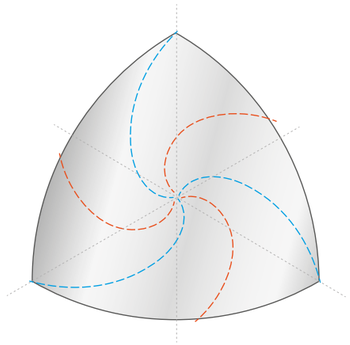
(see page 84)



Linear scores allow dimensional changes to be made along the length of a strip of metal. The frequency and spacing of these scores will dictate the resulting form and curves can be created through the segmentation of the folds.

RADIAL SCORES

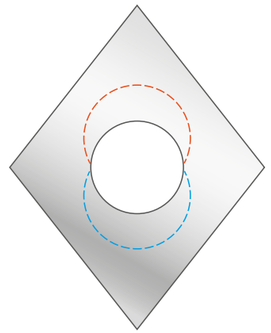
(see page 88)



Curves which radiate from a central point will always create attractive forms. Alternating the scores on both sides of the sheet allows the metal to move in patterns of rotational symmetry.

CUT-OUTS

(see page 94)

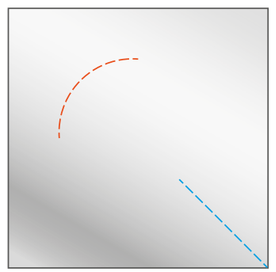


Removing internal areas from the metal can help to create unique design solutions. These cut-outs allow compression of the interior edges and have a significant impact on the resulting form.

PARTIAL SCORES

(see page 96)

Scoring the metal partially will give more subtle results for the overall form. The areas of sheet without scores tend to have a more fluid appearance which contrasts with the sharp bends of the scored areas.



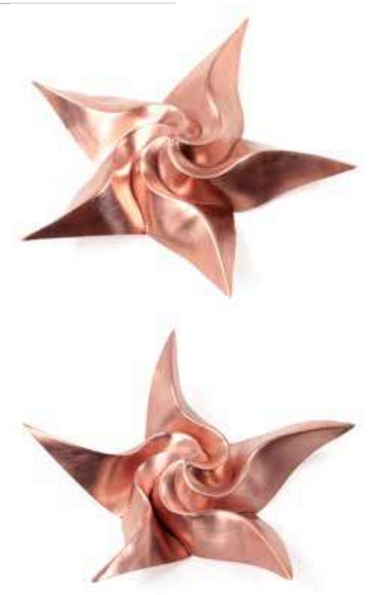
7.
Anneal and pickle the star.
It should now be possible to begin to 'twist' each point of the star to increase the compression around the form. The force comes from the right-hand thumb, pushing the internal corner forwards.

8.
A wooden pusher can be used to help smooth down the concave (right-hand) side of each point where it bulges out. Note the difference in appearance between the uppermost point, and the one on the left of the image.

9.
The star now appears very three-dimensional and can be left at this stage.
If more forming is required, anneal and continue to compress the form.

10.
The compression of the folds will mean that they begin to close around themselves. Each point can be squeezed to tighten it, and the internal corners pushed inwards to help the process.

11.
The internal faces of the points may need to be rubbed with the wooden pusher to move the metal more neatly along the score line - this will allow the points of the star to become more narrow.

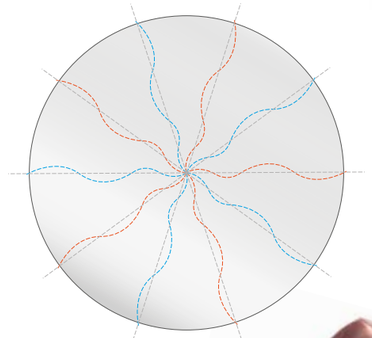


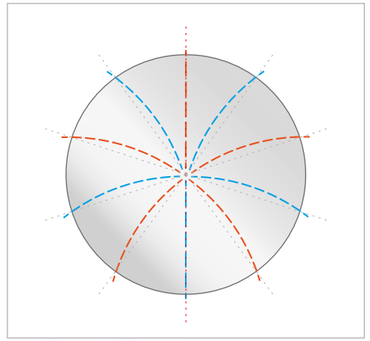
Two further stages of forming the star are shown, above.

MORE RADIAL VARIATIONS

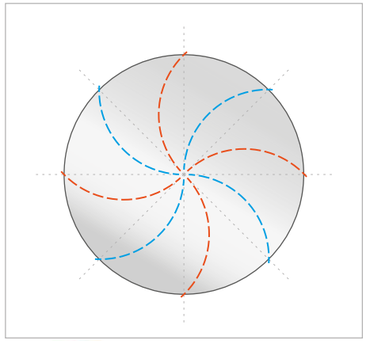
Radial scores can be used with almost any shape of metal sheet - whether geometric or organic. Variations on circles are shown here to display the range of different effects that can be achieved by just varying the score curvature and arrangement. Changing the position of the point at which the scores rotate to off-centre will make significant changes to the results. More complex formations of scores are best explored on larger pieces of metal so that there is enough leverage and space for forming to be effected, but small samples can also lead to deceptively complex outcomes. The samples at the bottom of this page were all made starting with a 40 mm (1½ in) copper disc, whereas the large piece (right) was made from a 150 mm (6 in) disc.

It should be noted that separate wires must always be used for scores on one side (blue) and the other (orange). Even stainless wire compresses and flattens during scoring, and it will not give a good score if flipped over to impress a second set of scores on the other side.

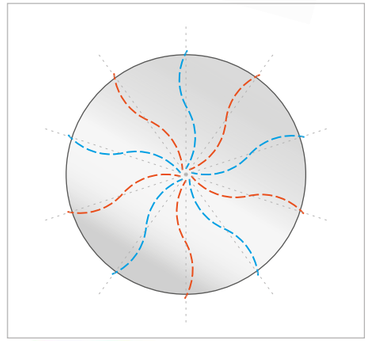




The five scores on each side of this sample are arranged using mirror symmetry (along the red dotted line), rather than rotational symmetry.



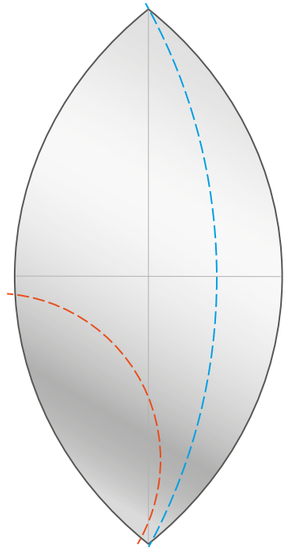
Four scores on each side of a circular sample, will yield an almost square form when the scores are compressed.



This sample has five rotational scores on each side; the adaptation to the curve of the score wire gives rise to an elegant flower-like form when folded, even on a small scale.

Project One: Navette Brooch

The range of processes involved in this project demonstrate the versatility of score folded forms. Converting sculptural forms into functional objects can be challenging, but the addition of a simple brooch pin creates a large yet lightweight brooch which is embellished with texture and a patinated surface.



Template for Project One
(Actual size)

For this project you will need

- Sterling silver sheet 0.5 mm (24 gauge) - 90 x 45 mm (3½ x 1 ¾ in)
- Iron binding wire 0.8 mm diameter (20 gauge)
- 45 mm (1¾in) former, to give a 56 mm (2 ¼ in) diameter curve
- 110 mm (4¼ in) former, to give a 190 mm (7½ in) diameter curve

- 1.0 mm (18 gauge) silver wire for a brooch pin fittings
- 1.0 mm (18 gauge) former (steel rod)

1.
It is strongly advisable to work through this project in copper first!

Anneal the piece of silver sheet and pickle to clean.
Use the rolling mill to impress a texture into one side of the silver; fabric or paper textures are perfect for this. Flatten the curved sheet by hand and anneal and pickle it again.

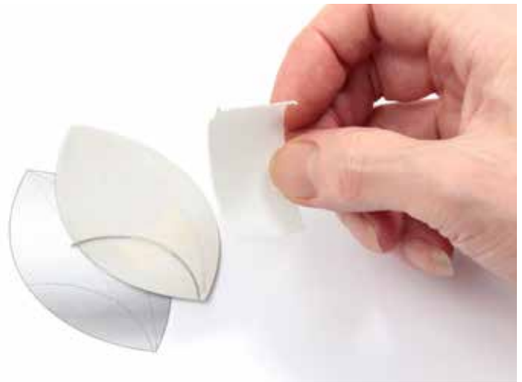
2.
Copy the outline of the brooch from the template and stick it onto the textured silver sheet with double-sided tape.
Use a piercing saw to cut around the outline, then file to true the form. Abrasive sticks can be used to refine and smooth the edge so that it is clean and not sharp.

3.
Create the score wires.
The longer wire has a very gradual curve, so a large former is required—a plastic container with a diameter of 11 cm is used here to wrap the straightened binding wire around smoothly.

4.
Secure the long wire to the (untextured) reverse of the silver shape. Tack the wire into position first and check the placement, before using a longer piece of tape to secure the whole wire.

5.
Lightly score the wire using a planishing press (or vice and blocks). This will impress the wire into position so that there is less chance of it moving in the rolling mill.

6.
Use the rolling mill to score the wire to the correct depth. Try out the roller settings with an off-cut from the silver to ensure that the score will be at the correct depth before milling the actual piece!



7.
Anneal the silver again so that it is soft enough to receive the second wire impression.
Use the template as a guide and position the shorter score relative to the orange dotted line, ensuring that it is on the opposite (textured) side of the silver to the first score line.

8.
Once scoring is complete, draw round the silver shape in a sketchbook, marking the position of the wires as they exit the edges. Stick the score wires down, and make a note of technical information such as metal type, thickness, wire gauge and rolling mill settings, as well as what works well and what doesn't. This will provide a useful reference for the future.

Textures

Creating a textured surface on forms will enhance the visual language of pieces, whether subtle or bold. A number of techniques can be used to effect textures, with some better applied before scoring and some before folding.

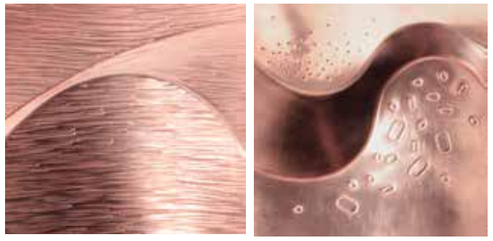
Opal Spiral by Mary Watson features a mesmerising oxidised rolling mill texture on the silver body of the brooch.

The Benefits of Textured Surfaces

The nature of curved score folding enables surface effects that are applied to metal sheet to be preserved throughout the making process. Impressed textures made on the metal before scoring will not be damaged by the process, except along the reverse of the score line, and the gentle folding and forming of the sheet can be done without the use of hammers or metal tools that would spoil the metal's surface qualities.

Textures can help to hide small discrepancies in surface and form, meaning that the time spent cleaning up a piece can be significantly reduced. The extra surface area created by most textures will hold patinas well, which can be used to accentuate contrasts, communicate a concept or emphasise a design feature.

Experiment with these techniques and test them out on base metal until the process is well understood. Some of these techniques can be quite labour intensive on larger pieces of metal, but the effects that can be produced are often stunning in combination with the folded forms.



Hammer Textures, Stamps and Punches

Hammers and stamps can be used to create a field of texture over a sheet of metal. This is most easily done when the metal is flat and annealed.

The shape of the hammer head will directly affect the type of mark that it makes, and the direction in which it displaces metal.

Textures made with steel pattern stamps can also be applied once the scores have been made, but care should be taken not to damage the lines.

Letter and number punches work well and can be used to add details to specific areas of a design.

Rolling Mill Textures

Use fine, even materials such as fabric mesh, abrasive papers, textiles or watercolour paper to imprint subtle textures on annealed metal.

Smaller pieces of metal will texture far more readily than large ones, which create resistance and a spread of force that prevents the texture from being so successful.

If the texture is applied to only one area then ensure the difference in thickness of the metal sheet won't cause problems when folding. Thinner areas will bend more readily, so avoid using materials that are likely to imprint deeply.

Rolling mill textures should be applied before scoring the metal.

Datura metel Dish by Paul Wells was textured with hand engraved wriggled lines and punched details to decorate the flower-like form.

Displacement Textures

Methods of texturing metal that involve displacing material include hammers, punches and rolling mill textures. These techniques will deform metal sheet, particularly the rolling mill which will stretch the sheet in the direction that it is being rolled.

Large, even fields of texture are most easily applied with a rolling mill, and will work well with score folding; uneven surfaces created by deep or contrasting textures will have an effect on how the metal bends, perhaps causing unwanted consequences.

Subtractive Textures

Processes which remove metal are also suitable for creating interesting textures across a surface, or for areas of decoration. Etching utilises chemicals to dissolve exposed metal, leaving precise patterns or abstract textures determined by a physical barrier to the action of the chemical mordant. This is a good technique for applying large areas of texture to flat sheet, but it is much more difficult to achieve reliable results on formed pieces as masking off is more challenging.

Sharp tools can be used to cut away metal, and the use of a micro-motor will allow many different types of attachments to be used, from coarse abrasives to cutting tools such as burrs. Traditional techniques of hand engraving can also be employed, and can add pattern and light reflecting effects to accentuate forms. It is much easier to apply these textures accurately to just a small area of a piece, and with little risk of damaging the score lines, these techniques can be applied after the scoring is completed.

As all three of these texturing techniques could in themselves be used to cut lines for scores, it is important not to texture the metal too deeply otherwise the sheet may be encouraged to fold in undesirable ways.

Etching ⚠

Chemical solutions such as Ferric Chloride can be used to dissolve exposed metal, leaving a textured surface.

Patterns are created by using a resist to protect areas of metal from the action of the chemical, options include painted varnishes, aquatint, sticky-backed plastic.

See page 36 for information on working with chemicals safely.

Motorised Tools

Burrs, grinding tools, or frosting tools can be used in a micro motor.

These types of tools are more useful for creating small areas of mark-making, rather than a large field of texture. These effects can be applied to metal at any stage in the process, but flat sheet is easiest to work with.

Masking tape can be used to protect areas that will be left plain.

Hand Engraving

Gravers of different types can be used to cut patterns directly into metal sheet (which should be thicker than 0.5 mm / 24 gauge).

Square gravers cut lines and text, whilst gravers of other shapes can create marks or be rocked from side-to-side to create "wriggled" textures.

A great technique for fine details on a piece, and best applied to the metal before forming.

Finishing Techniques

A wide range of surface effects can be achieved with basic tools and an understanding of a few key processes. These essential skills are crucial for producing well-finished work and do take practise to perfect, but considered use will help to lift metal forms to another level.

Tridacna Dish by Paul Wells
Creating an even surface finish on large pieces of metal can be challenging, especially around complex score patterns.

The final finish that is applied to a piece of work should compliment the form and be appropriate for the design and the intended use. Curved score folding allows pieces to be created with minimal use of hammering and other disruptive processes, meaning that it is possible to retain clean, smooth or textured surfaces over a large area on the metal.
The importance of a surface which is sympathetic to a particular design cannot be stressed enough– not every form will suit a highly polished surface. Sometimes the reflections in a piece accentuate areas favourably, and sometimes a shine will distract too much from the nuances of form.

These finishes are a matter of personal preference, but other factors should be considered, too. The amount of time that it takes to create a perfectly polished surface may be too long and difficult to achieve satisfactorily, making a matte or satin finish a more suitable option.

Files

A key tool for metalworking, files are used to remove marks and alter the shape of metal edges and faces.
A half round hand file is the most versatile, as the flat side can be used to file flat surfaces and external curves, and the curved side is best for internal curves. Needle files are a good size for smaller work and fine detail. Work at a jewellers' benchpeg for steady and consistent results.

Abrasives

Abrasives are used to smooth and remove scratches on metal after filing, and are vital for de-sharpening the ends of wires and the edges of sheets. Usually, a coarse abrasive is used first, for example 600 grit, before successively finer grades are used to refine the area in preparation for polishing. Self-adhesive abrasive film can be fixed to wooden sticks to aid cleaning up, and loose paper can be used in micro motor attachments called split pins, allowing much faster working times.
Coarse abrasives can also be used as a final finish, leaving an attractive light-scattering effect or brushed finish, but it is often a good idea to ensure that the surface of the metal is almost as well prepared as if a polished finish were to be applied.

Refining Surfaces and Edges

After cutting metal in preparation to create a piece, the edges are usually rough or sharp. Hand files are used to refine the cut edge, remove any burrs and correct the outline of the shape, and this should done whilst the metal sheet is still flat. Sharp edges will be dangerous to handle during the folding process when pressure is exerted, so it is important to file the edges of test pieces, too. It is often necessary to do a bit of filing once a piece is formed, but this should be kept to a minimum as it is much more challenging and risks damage to other areas. The filed edges are then cleaned with abrasives of successively finer grades, until there are no visible marks and the edge feels smooth. Loose paper, sanding blocks and motorised tools can all be used for this purpose.

Firestain

This is a discolouration caused by heating in silver alloys containing copper and usually becomes visible when cleaning up or polishing is underway, as the outer surface of pure silver is removed to reveal a thin layer of oxidised copper. This can be removed by the use of files and abrasives, but is a very time consuming process. The best options are to anneal the piece after most of the cleaning

Fin Brooches by Annemarie Reinhold
A range of finishes used across a collection of pieces helps to create a harmonious variation of light play and colour; attention to detail is vital.

Polishing Motor ⚠

Many different styles of attachment can be used on a polishing motor, from aggressive abrasives and frosting wheels, to the finest polishing mops and brushes. These motors are best for achieving an even finish on larger areas of metal, particularly if a high shine is required.
Please seek professional advice on best practise, as these motors must be used safely.

Barrel Polisher

This method of polishing is most suitable for small pieces of jewellery, including chains. The steel shot burnishes and work-hardens precious and base metals, but can damage thin gauge sheet and will not effectively polish textures or close folds in scores. Pieces should be tumbled for an hour or two to achieve a satisfactory finish.

Magnetic Polisher

The fine steel pins used in this polishing machine brighten textures and fine details on work, but will leave a fine frosted surface on plain sheet metal.
The process often takes just ten or twenty minutes. The soap contains anti-tarnishing agent which slows the oxidising of copper and silver.

Soldering

It is entirely possible to create score folded forms without the use solder, but the possibilities that this technique offers expand the options greatly. From combining component parts or adding functional fittings, to reinforcing, repairing or creating structural joins, soldering is a metalworking fundamental.

A gold pin and catch were soldered onto this silver score-folded form to create a brooch.

Methods of Soldering

Silver solder is an alloy that can be used to join any base or precious metals with a higher melting point.
When metal is heated with solder in the presence of a flux, the solder will melt first and form a strong bond between areas that are touching.

The three main methods of soldering are pallion and sweat soldering, which are both described below, and stick feeding, which is more appropriate for large works with long seams.
All these methods of soldering rely on there being enough heat within the metal form to melt the solder successfully—it is not the flame itself that melts the solder but the metal, and this ensures a good join.

Other Considerations

Thin gauge sheet metal forms may be prone to overheating, particularly silver and brass. The colour changes that occur in silver are quite different to those of copper, so work in low light levels to better judge the temperature of the metal.
Any areas of the forms being joined that will be more difficult to access after soldering should have their final finish applied before soldering.
Soldering will, in effect, anneal work, so pieces may need to be work-hardened to prevent distortion. Forms can be annealed after they have been soldered, but prolonged, repeated or over-heating work will dry out the solder and can make it brittle and pitted.
Polished surfaces will become dull after the soldering and pickling process, but can be reapplied.

Repairs and Reinforcement

When repairing a split or tear in a score, it is usually better to solder the repair sooner rather than later in the forming process. Creating good contact between the parts to be joined may be a deciding factor in when to perform the repair; small gaps can be rubbed closed with a burnisher. In some cases it is necessary to solder a piece of wire into the score groove to repair it.
Scored metal is very thin along the fold, so soldering to strengthen and reinforce scores can be a good idea on functional items where wear or use may cause stress on folds. Solder flows along grooves very well, and can be drawn along scores with the flame, filling and reinforcing the recessed lines.

Silver solder can be used to repair splits in copper scored folds, but the colour difference may be apparent. This join has been cleaned with successive grades of abrasive paper to remove excess solder and improve the look of the surrounding metal.

Soldering a Seam

Large scale soldering can be problematic as there is the potential for movement of parts and preparing the join can be challenging.
Binding wire can be tied through a honeycomb brick to secure the two ends of the join. Ensure that the ends of the join are making good contact and that the whole piece is stable on the heating area.

Applying Solder

Paint the seam with borax all around, and whilst it is still wet, apply pallions (cut chips) of solder so that they sit across the join, touching both sides. Solder can be placed with a damp brush, or with tweezers; the amount of solder used will depend on the size of the seam.

Melting the Solder

Dry out the borax with a flame first, then bring the metal surrounding the join up to temperature. Heat from side-to-side until the solder melts and runs along the join—and then stop heating.
The piece will need to be quenched and then cleaned in pickle solution to remove oxides and borax residue.

Reinforcing a Score

Pallions of solder can be melted into a folded score line, to strengthen it and to fill the gap. Special care must be taken if the surface is textured, as solder that melts outside the line will be difficult to remove without damaging the texture. Excess solder on an inaccessible area without texture can be equally problematic!

Sweat Soldering

This method of soldering allows the accurate placement of component parts with much less risk of solder going where it's not wanted.
Solder is first melted onto the piece of tube that will form a pendant loop; apply borax and solder and heat until the solder melts. This piece does not need to be cleaned before the next stage.

Reheating Solder

Apply borax to both parts and carefully position the pieces so that they won't move when heated.
Bring both parts up to temperature, and when the solder melts and joins the tube to the folded form, stop heating. The position of the tube can be adjusted by reheating and moving when the solder is molten—not easy, but sometimes necessary.

Introduction to Design

Design is a tool that can be used to develop ideas, create unique aesthetics and practical solutions. Using design processes can open up strategies for developing a personal style that will enhance work and take it beyond the realm of technical exploration.

A New Approach

It felt important to include a design section in this book to encourage makers to interpret their own ideas and exploit the potential of this exciting technique. For those new to metalwork, there will be a freedom of approach that is not informed or restricted by traditional techniques for creating forms in metal - the theories in this book require a different way of thinking about form and construction than is typically used in fabricated metalwork, and in fact many rules can be broken.
Makers who are confident metalworkers will have a greater understanding of the behaviour and tolerances involved, but may still need to play with the processes of both scoring and folding in order to understand the full implications of what can be achieved. It seems likely that there is a far greater potential for the range of designs and applications that are possible than are described in this book.

Design as a Tool

In the simplest sense, designing with this technique can involve working through variations on a theme until a satisfactory endpoint is reached, and this is how many of the projects in this book have been devised—through trial and error and logical sequences. Consider the projects as starting points; use them to learn how to do the technique and then practise to gain an understanding of the process. This should develop a familiarity which will allow consideration of other ways in which these methods can be used. Everybody will begin to adapt the processes in ways which make sense to them, informed by skill level, past experience of making, aesthetic preferences and ultimate intention.
Mistakes and inconsistencies can be serendipitous, and should not be dismissed outright - interest is often derived from contrasting elements, and mistakes may be adapted so that they are made to 'work'. Much more is usually learned when things do not go to plan!

Getting Started

Possibilities lie in the combinations of ideas, forms and different techniques used to create metal score-folds. Be imaginative, and bring in inspiration from outside sources to inform designs. In order to justify decisions, it's useful to reference other visual information to help generate and refine ideas.
Areas of exploration which are concerned with the same kinds of questions that are asked when thinking about curved, scored forms will be immediately useful. Research curved origami, architecture, furniture design and parametric modelling to see how other designers are considering form. Is the work abstract or representational, sculptural or functional? Do designs reference geometry, natural forms or conceptualism?

← Energy-A, opus T-29 by Ekaterina Lukasheva
Curved origami is an important source of inspiration when considering the kinds of forms which may be produced in metal.

→ Studying objects will help to develop a feeling for the three-dimensional, particularly the way in which line describes form and volume. Natural and manufactured objects have different information to offer.

Naiad Brooch by Paul Wells
The inspiration for a piece can be subtle, or quite obvious, as is the case with this brooch. Aspects of the source material can influence the form, as well as the finish of a piece—here a colourful patina has been used to evoke the surface of a natural creature.

Record Keeping

Documenting the design and making of forms is an important part of the process, particularly for recording information that will allow pieces to be repeated. Designs are more readily adapted and evolved, and a better understanding of the process will be reinforced.

Notebooks And Images

Everyone will have a way of working that suits them depending on how they process information. Some people thrive on order, and others find it constricting. There is no right or wrong way to document work, but it is certainly advisable to keep some kind of record of what is made, how it was made, and even when.

The most useful record that can be made is also the easiest, fortunately. This is to draw around the metal form to create an outline before and after scoring, and to mark the positions of the score wires. As a minimum, this can be enough information to be able to repeat a design, but it is very easy to forget to make the tracing while the metal is still flat before folding starts! Mistakes can be learnt from, and designs can be altered to improve them much more readily if the score template can be referenced.

Score wire configurations can be stuck down on to these templates once they have been used, and it can be useful to create a system for accurately recording what goes where; different coloured pens for front and back.

Other information which is useful to note down:

- The thickness of the metal which is used, because thicker gauges will behave very differently to thinner ones.
- The type of metal—especially different silver alloys which can look very similar.
- The diameter of score wire and the type of metal—stainless steel, binding wire or brass.
- The date, which is just a useful reference.

Sketchbooks and Ideas

It's also a good idea to keep track of other useful information, such as online resources, suppliers, the work of other artists, inspirational images and anything else relevant or interesting. It is certainly practical to keep these resources digital, but it can be helpful to reference it alongside drawings and photographs of personal research to help give wider context.

Tabs made from tape can be used in a sketchbook to separate projects or series of work, making things easier to find when they are needed.

Test Pieces And Samples

Paper models in can be stored in hard boxes, or photographed and flattened out to be stuck in a sketchbook.

Photography is a good way of documenting the progress of the folding of pieces, with shots taken at different stages throughout the process. This can be useful if it is subsequently felt that the form was pushed too far and an earlier stage was preferred.

Copper models can be stored in hard boxes, and if they are sealed in bags the process of tarnishing will be slower; anti-tarnish products will also help with this.

↑Test pieces and prototypes are best stored in boxes to keep them in good condition.

← ↓ Sketchbooks can be used to record notes, stick down score wire formations and paper models.