FOLDFORMING

Charles Lewton-Brain

Brynmorgen Press

All designs are the property of the artists.

Edited by Tim McCreight & Abby Johnston.

Illustrations by Jeff McCreight.

All photos by Charles Lewton-Brain unless otherwise noted.

For ordering visit
www.brynmorgen.com

ISBN 978-1-929565-26-9

Printed in Hong Kong

Committed to protecting our environment through reforestation, offsets, and education.

Dedication

To Erhard Brepohl, Dee Fontans,
Aniko Lewton-Brain, Erika Kulnys.

This book is, literally, the culmination of 30 years of work. The development of foldforming would not have been possible without many people, and it will not be feasible to list all the people who have contributed over the years. That said, there are some who were essential to its development and to the creation of this book.

Klaus Ullrich, my German teacher, taught me that the marks of process are compositional design choices. Every hammer or file mark is a design decision as well as part of a process. This emphasis on watching process and truly seeing the metal led directly to foldforming.

Kurt Matzdorf was my advisor in graduate school and fostered the first codification and documentation of the process. Bob Ebendorf, John Cogswell, and Jamie Bennett all contributed at this time. Family supported me then as well, Daina Kulnys, Erika and Aniko.

Dee Fontans, my spouse, has been a beautiful part of my life, and a complete pillar supporting me and my activities. I have been a lucky man.

Many professionals, colleagues, and advisors helped as well. Alan Revere, Robert Kaylor, Thomas Mann, Tom Joyce, and Kate Wolf have all been pivotal influences for me.

Tim McCreight, besides being a vital role model for me, has been the driving force and, along with Abby Johnston, a patient editor of this book. I thank them for all their hard work and suggestions as we brought this book together.

Contents

Introduction 11

Before We Get Started…
Mental Pictures
Foldforming and Natural Forms

1 **Overview of the Folds** 17

Categories of Fold-Forms
- Line-Folds 19
- T-Folds & Chasing on T-Folds, 20
- Cross-Folds, 21
- Rolled-Folds, 22
- Woven-Folds, 23
- Scored- and Bent-Folds, 24
- Shear- and Forge-Folds, 25

2 **Materials & Tools** 27

Properties of Metal, 27
Deformation, 28
Annealing, 29
Working Metals Hot, 30
Metals for Foldforming, 31
Tools
- Hammers, 33
- Mallets, 35
- Opening Tools, 36
- Anvils, Stakes & Vises, 36
- Additional Studio Tools, 40

3 **Basic Line Folds** 43

Basic Line-Folds, 45
Other Kinds of Line-Folds, 48
Alternate Line-Folds, 52
Miscellaneous Line-Folds, 54

4 T-Folds 75

Techniques, Principles & Variations

Basic T-Fold, 77

Unfolding variations, 79

Variables in T-Folds, 80

Wedge T-Folds, 88

5 Miscellaneous Folds 103

Cross-Folds, 104

Rolled-Folds, 111

Pleated M-Folds, 114

Pleated-Folds, 118

Woven-Folds, 122

Hydraulic Press-Folds, 124

Tube Forming, 128

Belly Buttons, 132

Hardness Dams, 134

Folds derived from paper models, 136

Forge and Shear-Folds, 146

Corrugations, 148

Combination Folds, 150

Appendix 152

Family Tree of Foldforming, 153

Health & Safety, 154

Equivalent Numbers, 155

Temperature Conversions, 156

Suppliers, 157

Index, 158

Betty Helen Longhi, *pleated copper*

Introduction

Foldforming is a conceptual, physical, and intuitive approach to metalsmithing that is informed by the natural characteristics of metals. Rather than forcing form upon a material, this system exploits the inherent qualities of plasticity, ductility, and elasticity in metals, offering a significant new series of procedures that are extremely efficient for generating hundreds of unique, three-dimensional forms. Using the inherent characteristics of metal to generate forms teaches a deep understanding of the material and instructs us in the way forms develop in nature. Foldforming presents innovative and time-saving techniques that can replace or augment traditional goldsmithing procedures. Foldforming has been recognized by the British Museum Research Laboratory as a completely new approach to working metals with hand tools, chosen by the Rolex Awards for Enterprise Committee, and has been featured in a book on innovative developments in science and invention in the world.

The seeds of foldforming originated in Pforzeim, West Germany during the 1950s and 1960s at the Fachhochschule für Gestaltung. The approach of using process as a trigger for design, was explored by professors Klaus Ullrich, Reinhold Reiling, and others. In the case of fusing, for instance, this turns the mistake, "I melted it" into the discovery, "What a lovely surface." Before this innovative approach, jewelry education was bound up in tradition, preciousness, and old trade attitudes that discouraged experimentation and sharing of information. The German government reformed the educational system in the 1970s, merging the "trade" system (the Fachhochschule) with the "university" system.

Changes in the school system made it more difficult to gain admittance without having a high school diploma, and, in some cases, instructors who did not have a high school diploma were terminated. This caused a shift in the student population from skilled working professionals, to younger, inexperienced, unskilled middle- and upper middle-class students.

Ullrich was now teaching students who only had a couple of years of art training, poor technical skills, and who found working in metal a struggle. Ullrich instructed his students to play with the metal and to use the marks of that process as design elements in their work—to consider the scratches and hammer blows as graphic marks that could contribute to the design process. This more spontaneous, process-driven approach reduced working time because the characteristics of the metal were allowed to direct the forms as they developed. Professor Ullrich found that energetic discussion of design could begin almost immediately. Even students with limited technical skills could quickly acquire a vocabulary of design elements with which to work.

During the 1960s and 70s, *Gasthörer* or, visiting students, were attracted from all over the world to study under Ullrich and Reiling. I remember hearing that at this time as much as eighty percent of the student body was made up of people who had already completed apprenticeships and masters programs but who came to the Fachhochschule für Gestaltung to improve their own design and compositional skills. After completing their periods of study, many of these people returned to their workshops and galleries, while others entered the industry as educators, designers, and technicians.

As a student of Professor Ullrich, I, too, learned the concept that the shapes and surfaces resulting from process can lead to design choices. Since 1980, I have pursued this concept of "forming using metal characteristics" into a recognized system. I conducted many workshops, using them as informal research labs where ideas and experiments led to exciting results with great potential. By 1983, this process-oriented approach had yielded a vast number of forms and textures. In 1984, I enrolled in the State University of New York at New Paltz where I undertook graduate studies. With Professor Kurt Matzdorf's support, I began an intensive investigation of folding sheet material, manipulating it, and unfolding it. It was there that "forming using metal characteristics" was structured into a system, and foldforming developed into a distinct branch of that system. My work has since expanded to include forms that are not derived from folds, but are related because they rely on exploiting the metal's inherent characteristics. Examples include the use of hardness dams and selective collapsing of tubing by selective annealing.

Currently, there are hundreds of people using foldforming in a number of countries including Australia, Canada, England, Germany, and the United States. There are now a number of discrete avenues of research available involving folding techniques. Each avenue provides great numbers of individual marks or process elements that are distinct enough to be worthy of naming.

Dee Fontans
Bracelet
Sterling silver,
garnets, moonstones
Mixed T- and line folds

Before We Get Started…

As a teacher with several decades of experience, I have found it useful to complement technical instruction with reflection on the way we process ideas. The bulk of this book is devoted to the process, procedures, and results of foldforming, but before we get started, I'd like to take a few pages to set the stage because these ideas and considerations helped engender foldforming.

Tradition

Tradition is at once a great strength for goldsmiths and a terrible trap. Traditions exist for a reason, and the original reason is always a good one. Unfortunately, conditions change and sometimes, even though the reason no longer applies, we continue to blindly use the same procedure or technique.

An illustration of this tells of an American general observing a motorized British artillery team in action during the Second World War. The American leaned over to the British general and said, "What does that man do?" pointing to a man who stood at attention behind the gun and busy crew. The British general did not know and when he looked into it, he found that the man was there to keep the horses from bolting, horses that were, by that time, long gone from the team.

There are many things we do in everyday life and in the workshop that make almost as little sense as this. It is important to evaluate tradition and procedure in the knowledge of process. We should all periodically examine the working procedures and traditions that we learned in school to be sure we are not accidentally adding unnecessary steps or missing opportunities for innovation. This doesn't mean that we should throw out all our habits, but that we remember to re-evaluate them every once in a while.

Preciousness and Serendipity

Preciousness is an issue of some importance to metalsmiths and especially jewelers. It is in the nature of our field that the cost of materials and the time involved end up placing a high value on the objects we make. By contrast, a potter may smash many pieces from a kiln load to avoid having unsuccessful work live on in their history (a policy I find vaguely suspect, as if those pieces weren't part of you as well). Jewelers would have difficulty in doing that with many of their pieces, at least if the decision was based solely on design reasons. I notice that I work freely and surely when I work with copper, and find myself somewhat hampered when I am working with sterling silver and gold. Therefore, copper and other throwaway metals are especially useful for working out artistic ideas and sketching in metal. The results can then be translated into precious metals.

Preciousness is also a saving grace that forms a special characteristic of metalsmithing because it forces us to choose serendipity—the lucky accident or golden chance. Imagine this situation: You have finished a piece after untold hours of work, and take it to the rouge buff one last time, only to have it snatched from your fingers and sent caroming around the polishing hood. Presented with a gouge across the surface, you realize that repair would be extremely difficult so you look at it again and say, "Nice gouge." You then proceed to gouge up the surrounding surface to match, wipe your brow and think, "…saved that one." By making the accidental moment intentional, by choosing it and altering the piece to match the accident, we bring the work into some kind of balance again. We usually do not stop to realize that we now have discovered a gouging tool; a new way to texture metal that is extremely fast, (though, in this case, too hazardous to use). This unwillingness to scrap a piece is influenced by the preciousness of the materials we use. This is our advantage; that preciousness itself forces us to choose serendipity.

Serendipity is, I believe, the driving force behind most innovations in the arts, science, and every field of human endeavor. Many anecdotal examples could be given, but what interests me is that serendipity refers not to the event itself, but to the perception of it. Without someone choosing the serendipitous moment, it does not exist. Recognizing or synthesizing serendipitous moments can tell us things that may be useful in our work. Being open to observe what is happening and comparing that event with others helps me to stay fresh. With each recurrence, I become more likely to use these moments, and faster at connecting these observations to others.

Process and Procedure

There is a fundamental difference between process and procedure. Process is what really goes on, what actually happens when we work with a material. Process can be described in scientific terms or paraphrased to create an easily understood mental model of what is occurring. Examples of process include using heat, squishing a material so that it flows like clay, using subtractive removal by abrasion.

A procedure is a way of affecting a process; it is a recipe, a technique. For any single process, there may be dozens of procedures to obtain a similar end result. Mixing chocolate flavoring into milk is a process; stirring, shaking, whipping, and so on, are all procedures.

If we know only procedures, we can be stopped by a technical problem. If, on the other hand, we can come at a problem through its process, we find that we have creative options for solving technical problems. To illustrate this, imagine a person who was taught how to cook an egg only by frying it (a procedure). Armed with only that information, this person is doomed to a rather boring menu. If he looks past that single procedure and instead thinks of the process (How can I cook an egg?), then he will be led to all the possible procedures for cooking an egg. These might include piling gunpowder over the egg and setting fire to it, using a magnifying glass, or even the proverbial sidewalk. By going to the process, he discovers almost unlimited procedural options. Some will not be appropriate for one reason or another (eggs cooked by gunpowder might leave something to be desired), so the next task is to make the appropriate technical choices.

I believe that goldsmithing skills should be taught through the use of process rather than procedure. This allows a student to build an understanding of process without feeling trapped by techniques or lack of skills. As we know, there is no right way to do things, merely variations of more or less appropriate approaches to the technical problem at hand. By attempting to always define the process, new and different solutions to problems present themselves. Eventually, the apparently ridiculous answers you may have come across could prove to be the correct solution under a different set of conditions. By mentally listing some possible answers, you begin to develop an understanding of process, and what is occurring in a technical procedure. This can lead to faster solutions for the technical problems that we all experience. Craftsmanship is also enhanced with this approach to working.

Conducting experimental series can be a useful process to help learn about the working properties of materials. The idea is to perform a series of related experiments where only one variable is changed in each piece in the series. This allows us to observe and understand the nature of the material being tested. This was the method I used to explore foldforming, and clearly it has been a valuable tool for me.

Mental Pictures

I find it helpful, both in teaching and as I pursue my own experiments, to have a mental image of what's going on beneath my fingers. Here are a few mental models that may prove useful as you explore foldforming.

METAL AS CLAY

Most people have, at some point, in their life held a handful of clay or dough. It is more like metal than you might think. When metal is folded or hammered, it flows. A colloid like clay is a mass of particles in a lubricant, a fluid that allows them to move in response to pressure. To make the point, compare it to paper. If you fold a piece of paper, the fibers in that specific location become bent, period. Regardless of how you work the paper in one spot, adjacent areas will not get thicker or thinner; there is no flow.

Metal is supremely pliable. Traditional silversmiths have been proving this for centuries. A tall cylindrical vase can be hammered up from a flat disk of metal. Nothing is removed and nothing is added; the radical transformation from disk to vase is the result of movement within the metal itself. It is not a metaphor but an accurate description to say that the metal has flowed.

METAL AS GEL-FILLED BALLOON

Here's another mental picture, not meant to confuse the metal-as-clay image, but presented to illustrate another important aspect of metalworking. Imagine holding in your hands a balloon filled with jelly, or one of those blue icepacks before freezing it. When you push your thumb against the bag, the effect is transmitted throughout the entire lump. Press straight down on a piece of paper and not much happens. Press straight down on the balloon and it will transform into a thinner, flatter, larger form. So it is with metal too. We can affect areas some distance from the working area—a push on one place will distort areas distant from the spot being pushed.

Metal distributes force throughout its mass. Pressure on one spot will translate to movement elsewhere

STRESS POINTS AS FORMING TOOLS

It is possible to use work hardness to build a structural tool in the very sheet itself. When we strike metal with a hammer, the blow creates a tough spot, a "frozen" section that is harder than the un-struck areas around it. To say it another way, annealed metal has a given amount of capacity to move. Each hardening event (and this would include hammer blows, twisting, pressing in a die, etc.) will use up some of this capacity. This occurs locally, which means we can control the location of the hardening and use it to our advantage. In foldforming we call such work hardened places "dams." Levering a work hardened area against a malleable area is a common tactic in foldforming. One example of a dam is the ruffling effect in a line-fold where the open side has been forged.

Foldforming and Natural Forms

MODELING NATURE

As you'll see throughout this book, the results of foldforming frequently look like forms found in nature—seashells, animal horns, leaves, flowers, folded blades of grass, and other organic growths. This demonstrates that foldforming works at the boundaries of the natural limits of the material, where nature's rules begin to show. The same laws that dictate form in nature are reflected and reiterated in foldformed metal. I think this phenomenon lends foldforms a kind of natural beauty that transcends the results more often obtained through the traditional process of imposing a shape on material.

An example of this is the Rueger Fold that resembles a ram's horn or seashell. In both the metal and the natural object, spiral forms develop because of greater growth or stretch on one side than the other. It is not a coincidence that these forms resemble each other—they're being built according to the same rules. The breadth of this observation is vast. A geologist who was learning about foldforming told me that the flow, displacement, and surface resistance that we were exploring in metal were similar in several ways to geological processes. The earth itself, according to him, exhibits many of the same effects that occur in foldforming.

When something looks like something else, there is most likely a relationship. Many foldforms model nature so closely that I believe they offer the potential for greater understanding of the mechanics and constraints of organic growth. This aspect of foldforming is one of the reasons I continue to be fascinated with the process.

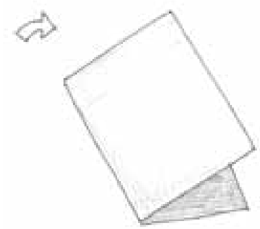
LOW ENERGY, HIGH ENTROPY FORMS

When nature makes a shape, she usually expends the least amount of energy possible on it. Nature does not waste a calorie. Biologists call these structures low energy, high entropy forms, and they have found them in a wide range of sizes, shapes, and materials. The efficiency of these naturally occurring forms is demonstrated in pod and plant-like foldforms. These shapes can be made in metal incredibly quickly, often in a matter of minutes. The simple process of folding, working, annealing, and unfolding often results in forms that cannot be produced by any other method, and that are frequently new to the field.

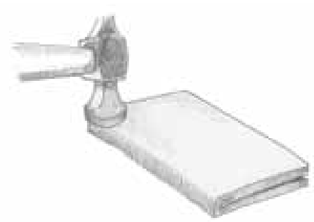
Rauni Higson
Lotus Candlesticks
Sterling silver
12 inches tall
photo by The Metal Gallery

Chapter One
An Overview of the Folds

Most foldforming involves four basic steps:

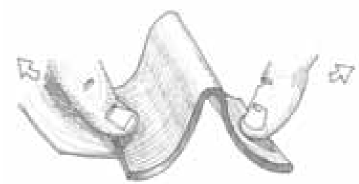


1. Fold the sheet metal over onto itself.



2. Forge or roll the folded sheet.

3. Anneal.



4. Unfold the sheet to obtain a form.

Principal variations include the style of the fold, the number of folds, and the ways a series of folds react to each other. Some types of foldforming (scoring and bending, for instance), involve setting up a weaker place in sheet metal so that the metal will bend or fold on a specific line. Other avenues of related folds include interwoven and tube folds.

Because this process uses the metal's own characteristics—basically doing what the metal wants to do anyway—radical changes in cross section and surface can be made in only a few minutes. The speed with which flat sheet metal can become a three-dimensional form can seem like magic. The tools used for this are familiar to most metalsmiths: hammers, mallets, anvils, and sometimes a rolling mill. Complex high-relief forms are produced from single sheets of metal often with a single annealing. These shapes can resemble chased, constructed, and soldered forms, but are produced in a fraction of the time they would take by conventional techniques. For instance, the traditional way to make a square ridge on a piece of sheet is to solder on a square wire, a process that not only anneals the sheet, but threatens firescale and solder spills. In the foldforming technique called Line-folds, we can obtain an almost identical look that avoids those problems, does not involve soldering, and usually takes half the time.

Foldforms are often so beautiful that they can be used as finished objects by themselves, but I think their best use is as starting points or components of more complex pieces. An example of this might be slicing up a foldform, manipulating the elements and reattaching them, or soldering a foldform as an element in a constructed structure. It is also possible to "chase on air" using a T-fold technique, a process that can shorten a chasing procedure by hours. Foldforming offers a major new series of procedures for production work, creating unique textures and surfaces that work well as components for casting. A number of production shops now use foldforming as part of their working vocabulary.

Starting with Paper Models

There is an important difference between the malleability of metal and the way that paper bends, but even so, I've found that paper or sheets of thin plastic can be used to find ideas for starting foldforms. Working with paper allows rapid investigation of starting folds for metal.

Because paper and metal behave differently, there are some limits in working with paper models. Still, paper can offer valuable insights. I remember a ten-hour plane flight in which my experiments with napkins and notepaper yeild several new folds. This Ward Fold shows the difference between paper models and metal forms.

Categories of Foldforms

Over the last two decades, foldforming has yielded hundreds of diverse forms. In fact, it is so easy to work up ideas for foldforming that my original policy of naming new folds after the originator has become unwieldy. In the early days, when a person came up with a new direction in foldforming (not merely a variation on an existing fold), I named that fold for them. Some of those names will appear later in this book. Other folds, such as line, star-pod, T-folds, boat, etc. are ones I have discovered.

In an attempt to make this information easier to understand, I have grouped the folds into categories, or families. Each of these is discussed in greater detail later in this book, but I think it will be helpful to include a short introduction here. It is important to point out, though, that the real power of foldforming comes from the combinations of multiple folds. Just as we teach language by breaking it down into words and letters, the objective in the end is to reassemble those parts into a unique new structure. That's where the magic happens!

Line-Folds

A basic line-fold is made by folding a piece of metal, flattening the fold edge, annealing the metal, and unfolding it.

Several varieties of line-folds.

T-Folds

T-Folds represent an enormous number of starting points for investigation of form. The primary advantage of a T-fold is that two fold edges are formed at once, which immediately makes the forms more complex. They also offer a wide range of options, including the size, shape, and location of the three flanges or panels of the "T." Using a vise to pin the legs (or not) as the metal is hammered influences the outcome considerably.

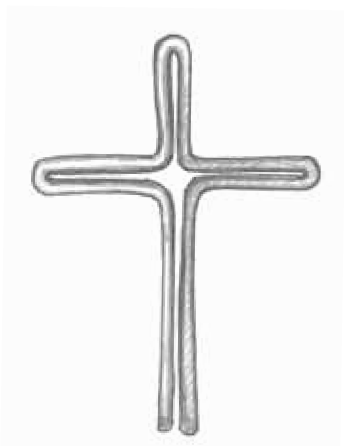
T-Folds. Primary variables are achieved by whether the fold edges are forged and how the sheet is unfolded.

In this cross section view of a T-fold the fold edges are marked with arrows. Most foldforms have fold edges.

Cross-Folds

While a T-fold has two fold edges, and is thus more efficient than a plain line-fold, if you are trying to make fold edges, a cross-fold will give you three at once. Cross-folds can be used to make three parallel line-folds much closer together than possible any other way.

Cross-folds are made by creating a structure with the cross section of a cross, or plus sign: +. In this example, two folds have been made, the second running at a right angle to the first.



The cross section view of this fold shows where the name comes from.

Rolled-Folds

Rolled-folds owe their name to the fact that they are made with a rolling mill. Rolled-folds are either a package folded up evenly and put through the mill (as with the Heistad Cup) or are folded so that one side has more layers of metal than the other.

Heistad Cup, showing several views of the cup simultaneously.

Good Fold (rolled-fold variation). This illustrates the smooth curves typical of this form.

Woven-Folds

Woven-folds involve simple interweavings that are used to lock different parts together (as in an Adams Fold) or are worked while interlocked, or even just left folded together as a shape. An example of this last is "Boondoggle," which many children learned in summer camp. People who know a lot about simple interweavings that can be adapted for foldforming include those who do chair caning, pastry work, sewing and ribbon work, leather strip work, and basket makers. Children's rainy day book projects are a source for ideas. Everything you learned to do with gum wrappers as a child can be brought into metal.

This example of a woven-fold is made by interlacing two strips of metal, in the same way that many of us wove lanyards with boon-doggle at summer camp.

Adams Fold. This complex form illustrates what can happen when combining foldforming techniques. In this case, line-folds were woven together.