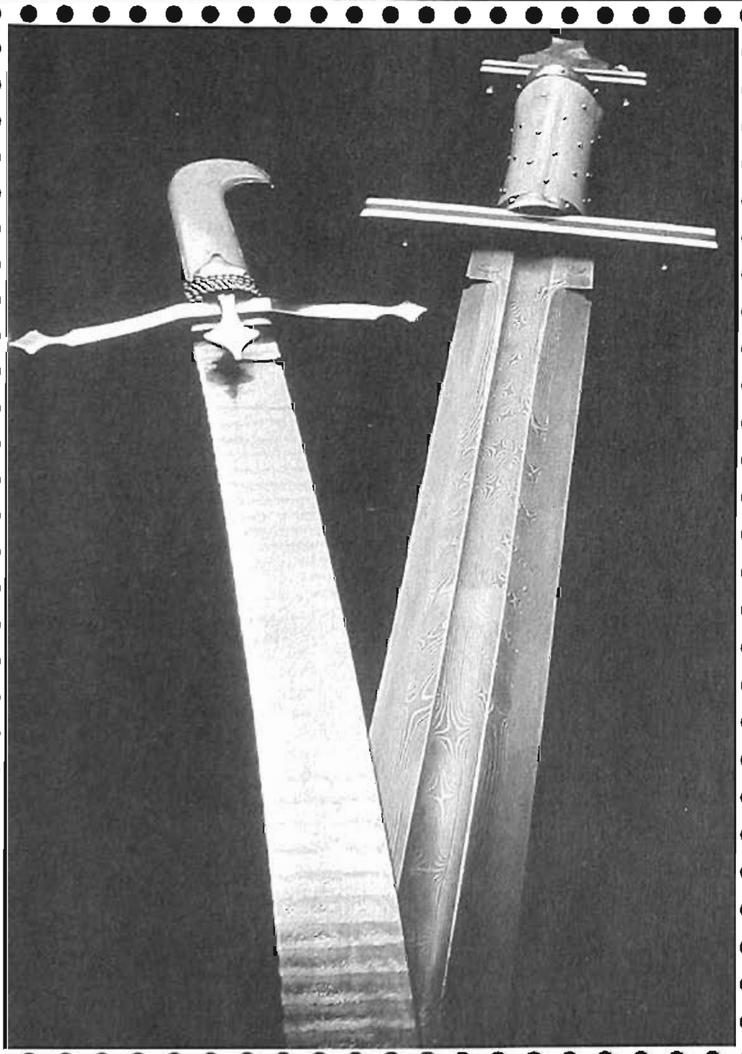
The Pattern-Welded BLADE

Artistry in Iron



Jim Hrisoulas

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by Jim Hrisoulas

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Preface

This work is truly a labor of love. The information contained herein has taken over two decades to compile, develop, and, to some extent, perfect to the point where the desired results are not only obtainable but repeatable as well.

The quest for the perfect blade continues on its never-ending path. Yet with each success, with each barrier overcome, perfection is no nearer to this mere mortal. Each blade is a learning experience unto itself. When we quit learning, we in essence cease to grow in our skills and knowledge, and this, in a way, is far worse than one can imagine.

The pattern-welded blade is a challenge to the patience, ability, and inspiration of the smith. We all, at one time or another, have felt the inner fire of the steel, seen its soul birthed in the flames of the forge, given it power by our labor and sweat, and seen the beauty of our efforts come to life in our hands when we finished our first successful pattern-welded blade.

This work is dedicated to those who, like myself, have chosen the way of the forge as our own path. There are those who would discount our chosen avocation, scoffing at it as old fashioned, archaic, or simply a fad of nostalgia. But if you have the burning desire within your soul to pick up hammer and tongs and toil in an ancient art, then it is for you that this book is written.

There are no secrets in this art, only skills that have yet to be mastered. These skills are within the reach of any serious student of the forge, if the patience and discipline are there.

So it is to you, the sons and daughters of Tubal Cain, that this book was written. I have tried to set down all of my experiments and research on paper in a manner that can be understood and followed easily. Only you, my reader, will be able to tell if I have succeeded in my efforts.

I leave you with this: *Illegitimati non carburundum.*

Jim Hrisoulas, 1993

Acknowledgments

To those who have helped me in my studies, be it by purchasing my work or by simply listening to the ramblings on of a more than slightly demented bladesmith, I say thank you.

To Bob Engnath, the man who gave me the nickname "Demented Jim," thanks a lot, Bob. I *owe* you one for that.

To those ancient smiths who have gone before, those who have long since ceased to cast a shadow in this mortal world, I say thank you for your fellowship of spirit. I hope that my endeavors please you, for when it is my turn to pass from this mortal plane, I trust that you will welcome me into your midst, with forges glowing red and iron hot, ready for the smith's touch.

To my mother, I say thank you for letting me get started in this craft so many years ago.

And in closing, I would like to deeply thank my beloved wife, Trudi, who has stood by my side through all of the trials and tribulations of this haphazard existence we all call life. I love you, Trudi. Thank you for the years we have had, and for those yet to come.

Introduction

There have been many books written on the subject of forging blades, most of which simply do not cover the ancient art of pattern-welding iron and steel. A few go into the general process, while even fewer cover it with enough detail and information to allow for the serious student of the forge to actually make a laminated blade. This volume is dedicated solely to the pattern-welded blade.

This is not a "how to forge a blade" book. You should already know how. Rather, this is a volume for the advanced maker, one who already knows more than the basics needed to make a high-quality, good-looking blade. This book is for those who wish to expand their talents into the realm of the pattern-welded blade.

There are processes and techniques covered here that only the more experienced smith will be able to comprehend. If you are not familiar with these, then you simply will not understand the contents of this work. I suggest you look elsewhere for this information and then come back to this book.

There has been a lot of disinformation spread about how difficult it is to make a pattern-welded blade and how the process is accomplished in general. This book is meant to dispel the rumors and misrepresentations and let those who are interested find out exactly how to make a pattern-welded blade successfully, be it a simple lamination or one of the more complex, composite blades.

Granted, a pattern-welded blade is a lot of work. Hard, hot, sweaty work. But it is not impossible, as some would lead you to believe. Why these people do this I have no idea. Maybe they are insecure or ornery. Regardless, there is no real reason to be frightened of the process.

Pattern-welded blades have been made for centuries. The process was never "lost" or even rediscovered. The ancient bladesmiths made pattern-welded blades, as did German smiths working in Solingen during World War II for the presentation daggers given out by heads of state. As for today, there are more makers than ever making quality pattern-welded blades, and this alone should bolster your confidence in your endeavors.

These blades are beautiful, durable, and well worth the time, effort, and skills required to make them. They are the greatest attribute to a smith's skill, a skill that is well worth the patience, frustration, and tribulation involved in its mastery.

The Workshop

The workshop for the Damascus smith is more or less identical to a basic bladesmith shop. But there are some additional pieces of equipment that the majority of bladesmith shops do not have which, in my opinion, you will need if you are serious about making pattern-welded steel.

THE POWER HAMMER

The power hammer is perhaps the greatest labor-saving machine ever devised for the blacksmith. Power hammers come in all shapes, sizes, and designs. They can be mechanical or pneumatic. Mechanical hammers are the most common, while the more elaborate and expensive pneumatic hammers are easier to control and operate.

The older mechanical iron bangers are no longer being made, partially because they are capable of serious injury if operated improperly. But they were made by the thousands—tens of thousands actually—and there are quite a few still being used safely without injury or incident by blade-smiths around the world.

Mechanical hammers are inefficient and slow, yet they are the "standard" power hammers found in most shops. Even if they are considered obsolete, a lot of fine, world-class work is done under them every day. They are far more effective than any striker when it comes to moving metal. And maybe it's nostalgia, but there is "something" about using an old-fashioned iron smasher that the modern pneumatic hammers simply don't have.

Pneumatic hammers are very expensive, and this is a factor when considering tooling for the smith. Granted, they are very efficient and highly controllable in terms of stroke strength and length. In fact, the amount of control is amazing. They also allow for a more versatile strike, as the strength of the blow can be varied without slowing the speed of the strike as the power hammers do.

Regardless of the type of hammer used, they are highly recommended for the Damascus smith. I have two power hammers, both Little Giants—one a 25-pound machine and the other a 50-pounder. I use them both extensively, and even the small 25-pounder can do more work in an hour than I can in six. They are labor-saving devices beyond compare.

WARNING: You should already be familiar with the safe operation of power hammers. If not, I strongly suggest that you become so before attempting to use one. There are several references on the subject, and I suggest you study them prior to proceeding.

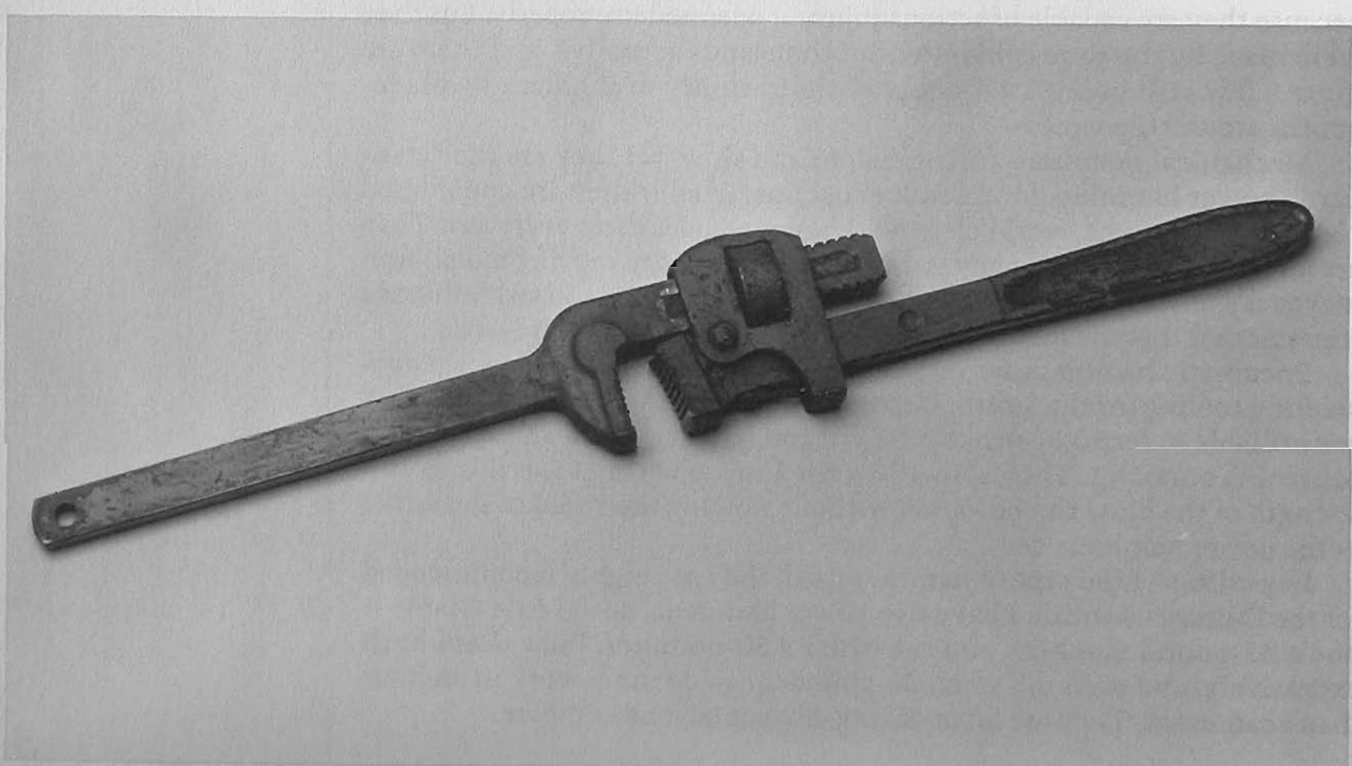
Safety is no light-hearted matter. It is up to you, the individual smith, to make certain that all safety procedures are followed every time you use a mechanical hammer or any other power tool. This includes face/eye protection, leather gloves, apron, and leathers. Leathers are a long-sleeved leather shirt used mostly by welders to keep sparks and welding berries off their skin and clothes. Because their impacts are quite severe, power hammers spray red-hot flux, slag, and scale in a 360-degree radius, so you must take the proper precautions or you may end up looking like a B-grade movie monster or worse.

In addition to the mechanical/electrical power hammers, there are several designs of foot-operated (manual) hammers available in preassembled and kit/blueprint form. I have used the design published by the Artist Blacksmith Association of North America (ABANA) and have found it to be very useful for most work. Foot-operated hammers can get a bit tiring when you are making a big billet, but for those who simply cannot or will not use a power hammer, they are a viable alternative. They do take some getting use to, as most designs do not allow for the use of dies. Rather, they require top/bottom tooling, and using this setup takes some practice.

A common pipe or monkey wrench is easily modified to provide a secure hold by welding on an additional handle. (Photo by Gary Thompson)

TWISTING TOOLING

Twisting tooling is used to twist billets, blade core sections, and other pieces that will be incorporated into a blade later in the pattern-welding process, and it is an absolute must in the Damascus workshop. It can be as simple as a monkey wrench with an extra handle welded on or as elabo-



rate as an adjustable-jawed "T" handle. Regardless, one or more of these is required in order to make more than a few patterns.

You can also modify a pair of vise grips (locking pliers) by welding an additional handle on the stationary handle, although I do not feel that it is in any way superior to the wrench shown in the photo. I have tried this modification, and it seemed that every time I tried to use this tool, the vise grips came undone. It was a bit troublesome to work with, to say the least.

There is another way to make twist/countertwist patterns, and that is to use a "twist jig" made from two pieces of square tubing and two adjustable wrenches, as illustrated in Figure 1.

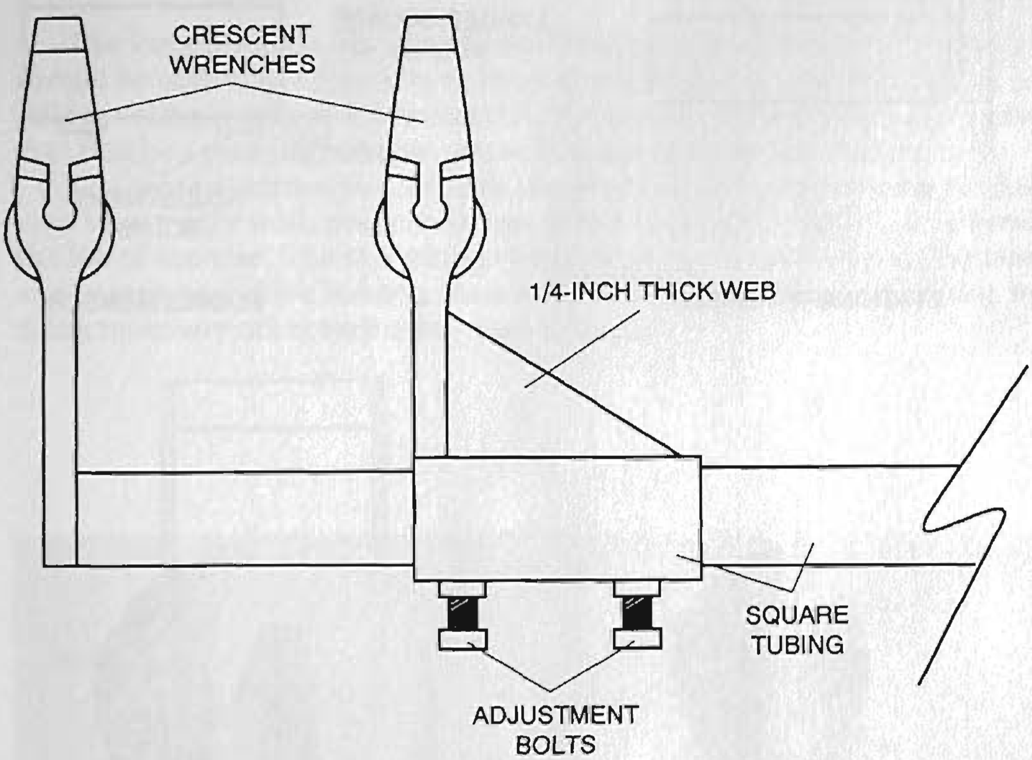


Figure 1. The twisting jig allows for even double-helix twisting of various pattern-welded materials.

The two pieces of square tubing must be sized so the smaller of the two fits snugly fit inside the larger. Weld the top (working) end of a wrench to one end of the smaller tube, as shown in Figure 2. Weld the other wrench head to the outside end of the larger piece of tubing (which should be no shorter than 6 inches in length), making certain that the opening is not obstructed. Also, make certain that the jaws open in the same direction and align in both planes so the piece will fit properly.

WARNING: Any welding operation should be conducted with adequate ventilation, and the welding of any plated metal should be approached with extreme caution. Common plating materials such as zinc, cadmium, and tin release toxic fumes at welding temperatures. If you scrounge iron piles for old iron, you may come up with lead or arsenic-plated iron, which can kill or at best permanently contaminate your work area. In addition, nearly all plating materials will only forge weld poorly, if at all.

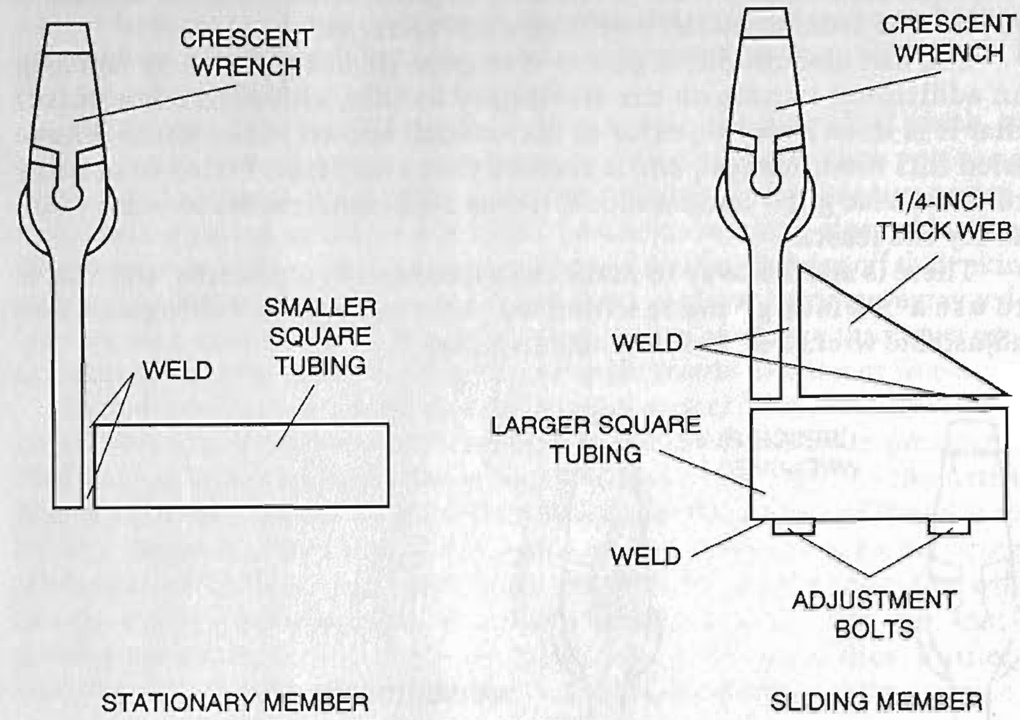
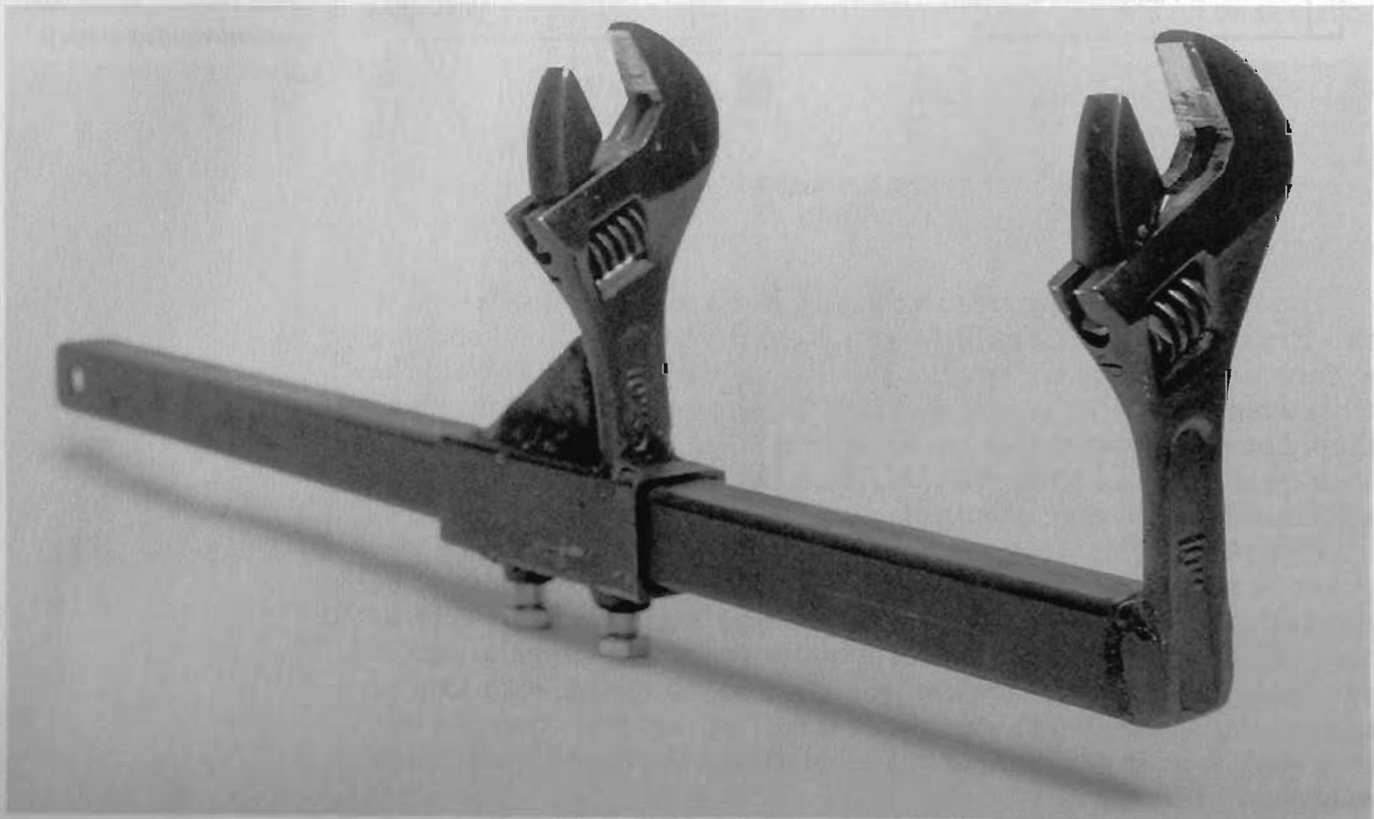


Figure 2. When welding the wrenches on the twisting jig, make certain that the wrench jaws align in both the horizontal and vertical planes.

The twisting jig allows for uniform twist/countertwists to be formed simultaneously. Its adjustable length allows for a variety of twisted sections. (Photo by Gary Thompson)



I have used 1-inch-square and 3/4-inch-square heavy wall tube for my tooling and have found that they work great.

For added strength, I suggest that you weld a 1/4-inch-thick "web" between the upright and the larger tube, making certain that the wrench's adjustment screw is still workable.

To allow for locking adjustments, weld two 3/8 x 16-inch nuts to the larger tube and drill and tap the holes on the bottom side of the slider.

I have found the twisting jig almost indispensable in doing traditional European-style pattern-welded sword cores. I will describe how to use this tool in Chapter 5.

BENCH VISES

The bench vise is also an absolute requirement, and one (or more) should be mounted very close to the forge to ensure a good, tight twist, as billet cooling can have a detrimental effect on the twisting rate. I suggest that this be a post (leg) vise, as you will be doing some hammering on it.

The more common machinist's vise is not designed to withstand this type of use very well; you can shear off the drive screw and that will end the life of the vise. The machinist vise is, however, a good all-purpose vise and is very useful for holding the work while you are filing, soldering, or doing most any other task other than forging.

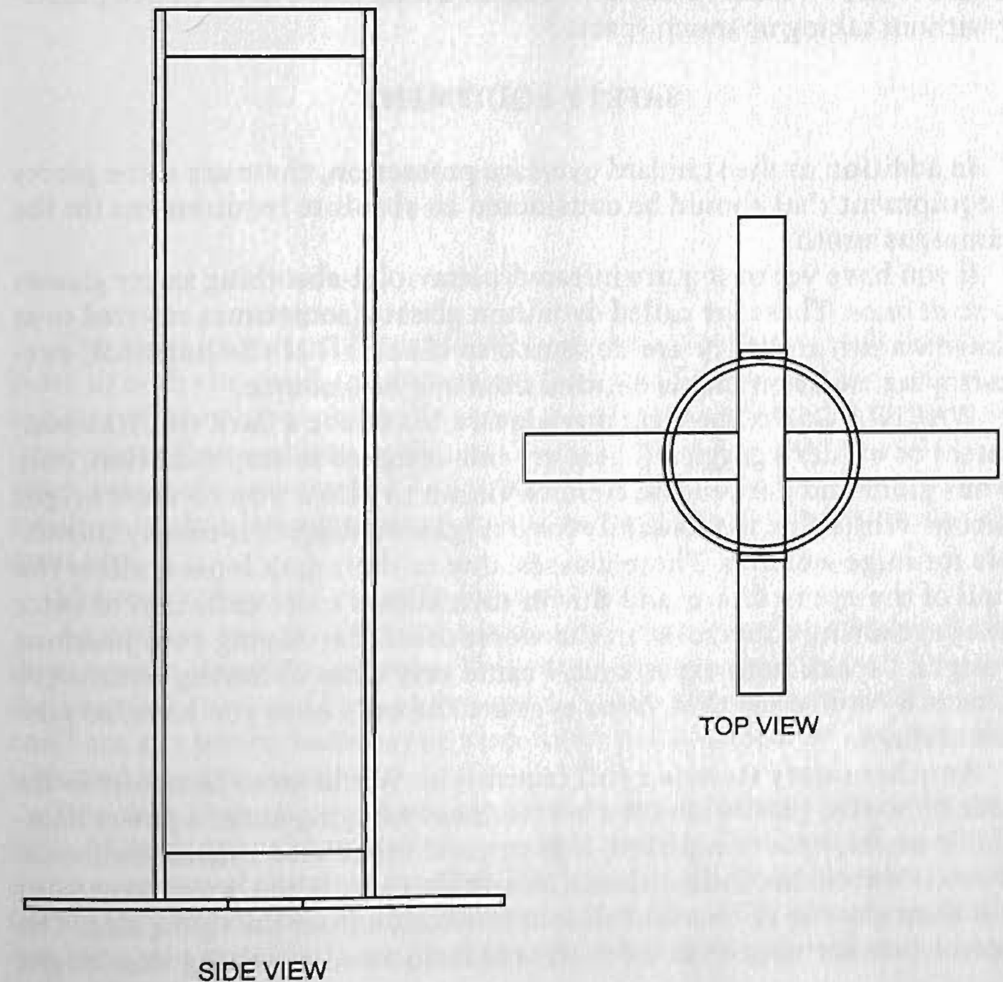


Figure 3. This pipe stand can be made to fit almost any PVC pipe. It's best to make it from 1/8 x 1-inch mild steel strapping.

Your machinist vise should be the largest and heaviest you can find. Also, make certain that it comes with replaceable jaws. This feature makes the vise more versatile, as extra jaws are easy to make and use. I have several different jaws made of smooth mild steel, smooth brass, knurled brass, and even leather to hold blades I do not wish to have marked.

ETCHING EQUIPMENT

Your etching equipment consists of two "tanks," one to do the actual etching in and the other to neutralize the action of the etchant. The tanks should be large enough to allow for a complete immersion of the area to be etched, with enough room to allow for circulation of the etchant around the workpiece.

For the tanks' materials, use anything that will not react to the etchant. This means either glass or plastic. I recommend PVC pipe sealed off with an end cap. PVC is available in a large selection of sizes. I have several tanks in various lengths made from 1 1/2-, 2-, and 3-inch-diameter pipe. This way I can etch just about any blade, ranging from a small dagger to a full-size Bastardsword.

You will need to build some sort of stand arrangement to hold the pipe sections vertical. This is easily made from iron strapping, as shown in Figure 3. Make at least two stands, one for each tank. This way you will be able to use a vertical etch, allowing for a long blade to be etched properly without taking up much space.

SAFETY EQUIPMENT

In addition to the standard eye/face protection, there are some pieces of equipment that should be considered an absolute requirement for the Damascus smith.

If you have yet to acquire infrared/ultraviolet-absorbing safety glasses *do so at once.* These are called dydidium glasses (sometimes referred to as Thermanon), and they are designed to block all of the harmful, eye-destroying radiation that is emitted from any heat source.

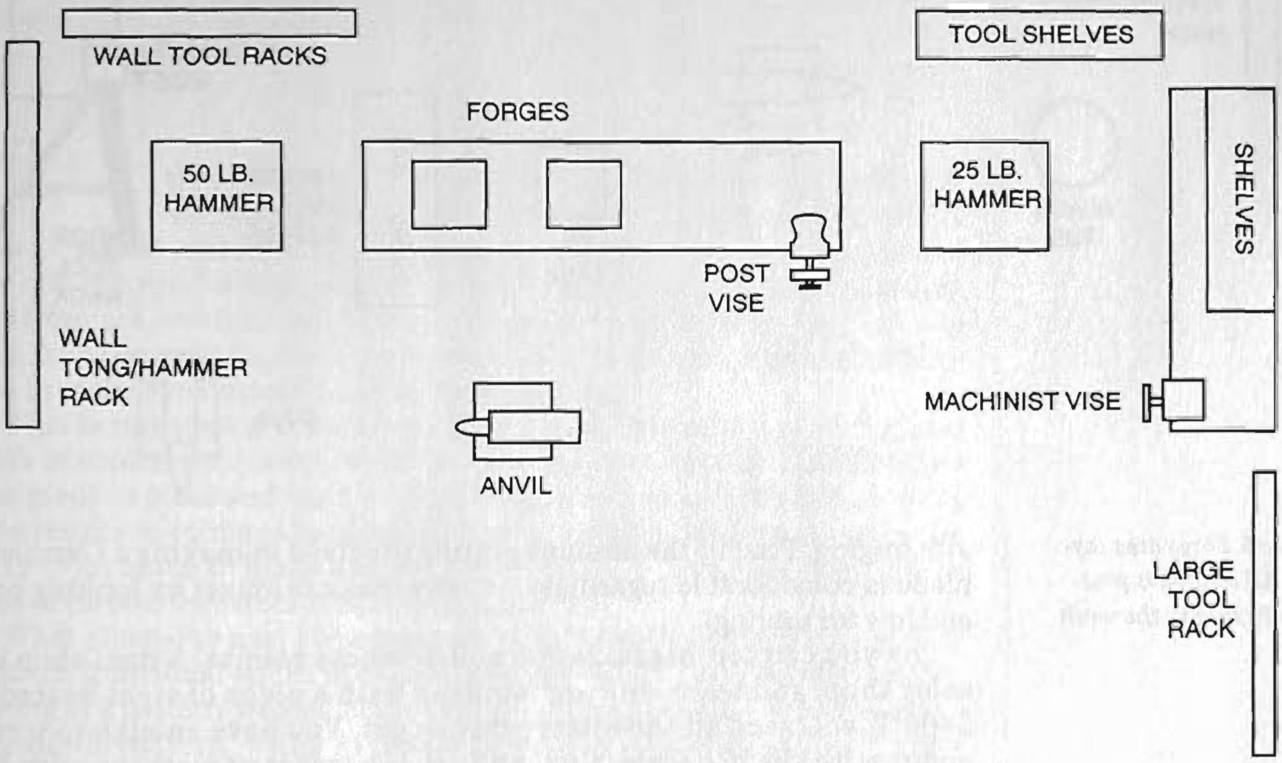
WARNING: *Do not* wear any glasses that have a dark tint like sunglasses or welder's goggles. These are not designed to stop radiation, only to cut glare and darken the field of vision to allow you to view bright objects. While this works safely for oxy/gas welding, it is totally unsuitable for forge welding. These glasses, due to their dark lenses, allow the pupil of the eye to dilate, and this in turn allows more radiation to enter the eye, causing damage or, in the worst cases, destroying your precious eyesight. I speak from experience; I came very close to having serious eye damage by doing just that. Your eyes are the only ones you have, so take care of them.

Another safety item is a full faceshield. While most faceshields are made of plastic, plastic isn't the best for heavy forging under a power hammer. It melts, becomes pitted, fogs up, and otherwise causes problems. There is a steel mesh faceshield available that, when worn over your dydidium glasses, allows for full face protection from the flying slag. The glasses protect your eyes from the radiation and anything that might make it through the mesh shield. The mesh doesn't fog, and it allows for good visibility while affording excellent protection to your natural good looks. None of us wants to wind up looking like Frankenstein's monster. So the time to take safety measures is *before* anything unfortunate happens, not after.

With the lecture over, we can get back to the subject at hand.

Figure 4. General shop layout. All machines must have adequate working space.

FORGE AREA LAYOUT



The most important layout is the forge area. The forge itself should be close to both the anvil and the power hammer. This way there will be no excessive heat loss while the work is being transferred. This is very important when welding, as the steel temperature drops very quickly, and you have on the average 5 to 7 seconds of welding time. You can do a lot of welding in that length of time, but it still isn't very long, so make the most of it.

I have my shop laid out as in Figures 4 and 5.

As you can see, the forge area is close but not crowded, placing everything within three or four steps. This way when I am welding, all I have to do is simply turn and I am at my anvil. A step or two to the left or right and I am at a power hammer or vise. Everything should be laid out with time and location in mind.

It is very important to have a good "working relationship" with your tools. Having everything in close proximity and at hand will allow for the maximum use of the time involved during the welding processes. As for the rest of the process, having the tools close is still an advantage, as the less time you spend looking for them, the more time you will spend actu-

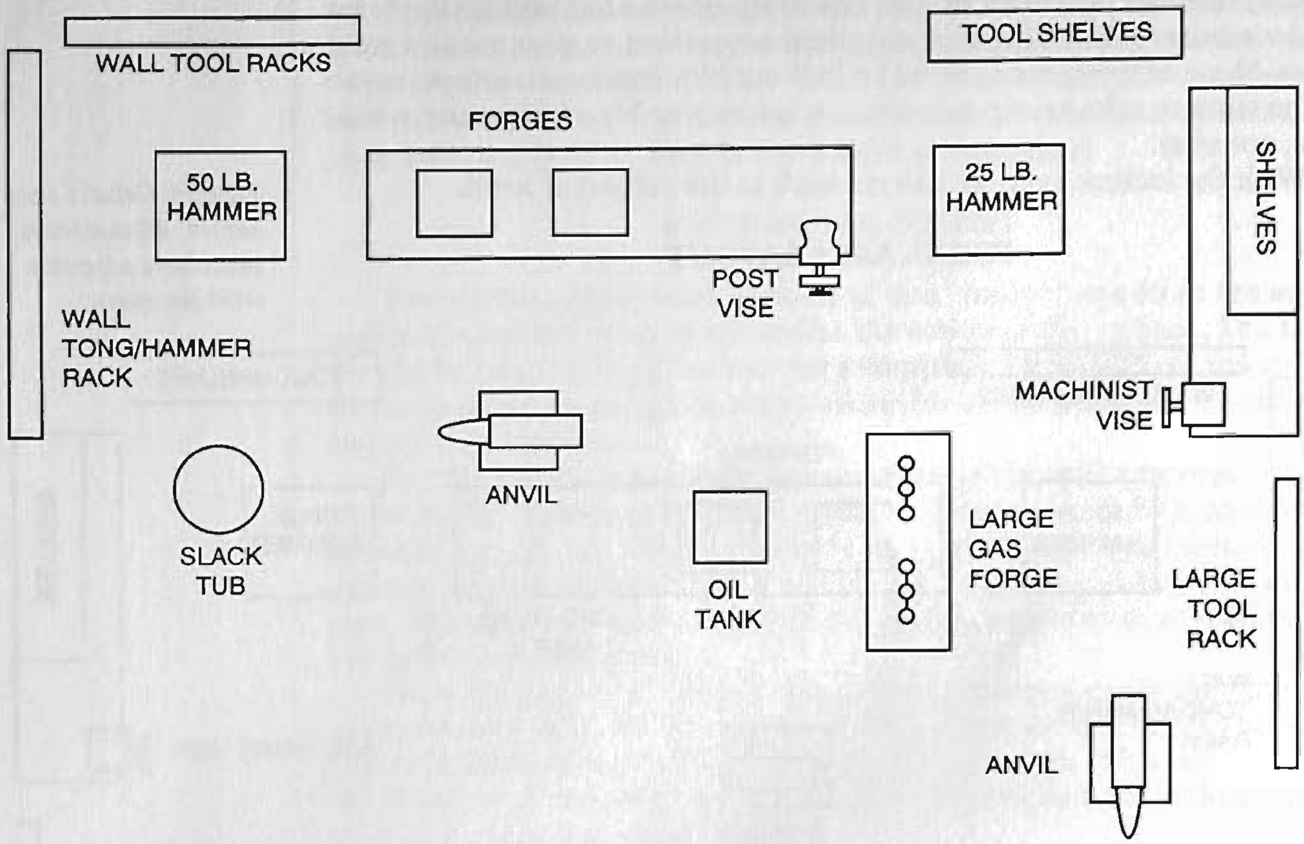


Figure 5. Forge area layout. All tooling is positioned close to the work area.

ally forging. Face it, the amount of time involved in making a Damascus blade is considerable regardless, so why make it longer by looking high and low for tooling?

As you can see, organization and neatness counts. A neat shop is a safer shop, and when you are working with a piece of steel heated to 2400°F, you need all the safety you can get. You have enough to worry about with the hot scale, flux, and other hazards of working with hot metal without having to deal with stumbling over equipment. Time and expedience should never replace safe working conditions. *Always* wear eye/face protection whenever you are working with any tool, be it hand or power, and always remember this old blacksmith saying: hand tools injure, power tools maim.

As stated before, these tools are in addition to the bladesmith tooling such as a good drill press, belt grinders, buffing/polishing equipment, and all the other gadgets and machines that seem to be so common among today's bladesmiths.

A well-organized and equipped shop is a pleasure to work in and a true mark of a professional. Add to your tooling carefully and learn to use them safely and you will soon find that you are not only working safer but faster as well.

Materials

A thousand years ago, the materials available to the bladesmith were limited to the steel/iron that he himself smelted. This was haphazard at best, as the quality of this raw material wasn't always as high as one would desire. Smelting iron from ore, even high-grade ore, is not an easy task. It takes a lot of time, an extremely high temperature, and considerable skill and experience to make even bloomery iron, let alone steel.

This is not the case in the modern world. We have at our disposal alloys of consistent quality, with various characteristics that are the same from piece to piece and melt to melt. What this means is we can have the same results in terms of hardenability, edge holding, toughness, and durability from blade to blade and bar to bar. Also, it is far easier to order a piece of carbon tool steel than it is to make one.

What alloy(s) to use? Here again, as with most things in this craft, it is up to the individual smith to choose which steels he cares to utilize in the making of a pattern-welded blade. Some combinations of steels result in a very subtle pattern, while in others the watering is vibrant and "jumps out" from the blade.

The alloys and materials described below are only some that are available to the bladesmith. This should serve only as a guide in selection. Although I have my personal favorites, my feelings shouldn't be the deciding factor for your choices.

To help you obtain the same alloys that I describe below, I have included the specification numbers.

HIGH-CARBON STEELS

The reason that a pattern-welded blade is so tough is the fact that one half of it is soft, unhardenable iron/mild steel while the other half is a higher carbon steel that will take and maintain its edge. It is this balance that has given the pattern-welded blade its fine reputation over the centuries. Up until a few years ago, it was the top material for blades to be forged from, but in today's world, with all of the ultrahigh-tech alloys, this is, sadly, no longer true. Regardless, you must start with a good high-carbon steel if you want to end up with a good blade when everything is done.

10xx Series Steels

I will start out with my old standby, the 10xx series steels. These are perhaps the finest all-around knife steels available to the bladesmith in terms of versatility and general use. While they are "simple" carbon steels without all of the fancy ingredients that other steels have, they offer the smith a very broad working range, are easy to weld, and resist overheating quite nicely, better than most of the richer alloys so commonly used by today's smith.

Any of these 10xx series steels will weld into a fine blade, but unless you use an alloy that contains some chrome, nickel, or other elemental differences, the watering will be based on carbon differences only and hence will be very subtle.

I have yet to encounter any difficulties in welding any 10xx series steel, and they work so nice under the hammer.

10xx series steel contain the following:

1060: Spec # ANSI/ASTM A 576 (1060)
(aka "Plowshare Steel")
C: 0.55%-0.65%
Mn: 0.60%-0.90%
P: 0.040% max
S: 0.050% max

1075: Spec # ANSI/ASTM A 29 (1075)
(aka "Improved Plowshare Steel")
C: 0.70%-0.80%
Mn: 0.40%-0.70%
P: 0.040% max
S: 0.050% max

1084: Spec # ANSI/ASTM A 29 (1084)
(aka "Extra Improved Plowshare Steel")
C: 0.80%-0.93%
Mn: 0.60%-0.90%
P: 0.040% max
S: 0.050% max

1095: Spec # ASTM A 108
(aka "Extra-Extra Improved Plowshare Steel")
C: 0.90%-1.03%
Mn: 0.30%-0.50%
P: 0.040% max
S: 0.050% max

All 10xx series steels harden in oil, but if severe carbon migration occurs, you may need to harden in brine. (See Chapter 8 for further information.)

5160

5160 (Spec # ASTM A 689) is a very tough steel that has *excellent* working abilities, but it is prone to oxidize (scale) so a neutral to slightly reducing atmosphere is best when welding. It produces nice contrast and is very forgiving when overheated. It is a good choice to laminate with 1010 or other low-alloy steel.

5160 should be oil-hardened only. It is best when tempered to approximately 53 Rc to 55 Rc.

5160 contains:

C: 0.56%-0.64%
Mn: 0.74%-1.00%
Si: 0.15%-0.30%
Cr: 0.70%-0.90%
P: 0.035% max
S: 0.040% max

52100

52100 (Spec # ASTM A 295) is a newcomer to most smiths and is usually found in the form of recycled roller mill balls. It is hard to find in bar form, but is does make for a very vibrant pattern, although it is prone to be a little red short. It can also be a little difficult to weld due to the molybdenum content, as well as a little red hard.

Scaling is a bit heavier but not as bad as L-6. It is a very good steel for the more advanced student, and it makes a decent blade when welded with a mild steel (1010/18).

52100 contains:

C: 0.98%-1.10%
Mn: 0.25%-0.45%
P: 0.025% max
S: 0.025% max
Si: 0.20%-0.35%
Cr: 0.90%-1.15%
Ni: 0.25%
Mo: 0.08%
Cu: 0.35% max

O-1

O-1 (Spec # ANSI/ASTM A 681) is one of old standards used for pattern welding. I do not care for this alloy particularly, as it is severely red short and does not withstand overheating very well. It can fracture, grain separate, or crack at the worst possible time, but some smiths love this steel.

O-1 does forge a good blade all by itself, but I feel that it is not the best choice for a laminated blade due to its red short problems.

O-1 contains:

C: 0.85%-1.00%
Mn: 1.00%-1.40%
W: 0.40%-0.60%
Cr: 0.40%-0.60%
V: 0.30%

O-1 is an oil-only hardening steel and, when properly heat-treated, can make a very good blade. I suggest that you laminate this material with a simple alloy mild steel or a richer alloy tool steel such as L-6. When used in this manner, carbon migration is nonexistent.

L-6

L-6 (Spec # ANSI/ASTM A 681) is a chrome/nickel alloy steel with excellent toughness and shock resistance. It is a medium-carbon, oil-hardening alloy with excellent working characteristics. It will withstand some severe flexing and is a very tough laminate. L-6 can be very vibrant in contrast due to its makeup.

L-6 is somewhat hard to find, but it is available. It has been employed mostly for industrial lumbermill band saw blades, and these are a good source for this material.

L-6 contains:

C: 0.65%-0.75%
Mn: 0.30%
Cr: 0.60%-1.20%
Ni: 1.25%-2.00%
Mo: 0.35%
Si: 0.50%

L-6 works easily under the hammer, but it is prone to heavy scaling and oxidation. This material is best when used with a 10xx series steel (you can use either a low-carbon or a higher carbon 10xx series, as the watering will be due to alloy differences, not carbon content alone). You can also laminate this steel with O-1, which does produce some contrast, though not as vibrant as if a 10xx series was used.

W-1

W 1 (Spec # COPANT 337 W-1) has been around for a very long time both in the custom knife industry and the manufacturing world. It is a very simple alloy that is water hardening (hardens nicely in oil too). It is also a shallow hardening steel that can be laminated with 1018 for traditional Japanese-style construction, although it can be red short.

W-1 contains:

C: 0.60%-1.40%
Mn: 0.15%
Cr: 0.15%
P: 0.03%
S: 0.03%
Si: 0.10%-0.35%

W-2

Like its brother W-1, W-2 (Spec # COPANT 337 W-2) is another old-timer. It is tougher than W-1 and is less prone to cracking and warpage. W-2 is a water-hardening steel that can respond nicely to an oil quench, and here again it is a shallow-hardening alloy that welds very well to most other materials. It can be red short.

W-2 contains:

C: 0.60%-1.40%
Mn: 0.15%-0.40%
Cr: 0.15%
V: 0.03%
P: 0.03%
S: 0.03%
Si: 0.10%-0.35%

LOW-CARBON STEELS

Nearly everyone has covered the high-carbon alloys, but there has been little discussion of the lower-carbon alloys that are available to the bladesmith, which I refer to as "color" steels. These alloys not only give toughness but great contrast in the pattern as well.

While most of these steels do not contain enough carbon to harden well, they should be covered for the pattern-welding bladesmith because some of them can be very tricky to forge-weld effectively.

I feel that I should start out with the old standby: cold-rolled mild steel.

1018

1018 (Spec # ANSI/ASTM A 576) is very common in both hot-rolled and cold-rolled steel. 1018 is also referred to as structural iron, mild steel, and numerous other names. It works very easily, although it can cause severe carbon migration when laminated with higher-carbon alloys. It is very forgiving and will withstand severe overheating.

1018 contains the following:

C: 0.15%-.23%
Mn: 0.30%-0.60%
P: 0.040% max
S: 0.050% max

This material will weld to most anything, especially a higher carbon content 10xx series. It will cause carbon migration, so care should be taken to ensure that working temperatures are not high enough (in the bright orange/yellow ranges) to allow this to happen.

Since there is little carbon content, 1018 steel will not harden on its own, and it is what I consider a "neutral" material, as there are no alloying elements such as chrome, nickel, or anything else that could affect the action of the etchant. If this material is welded with a richer, higher-carbon alloy such as O-1 or 5160, the watering will be better than if 1095/84 is used.

A 203 E

A 203 E (Spec # ANSI/ASTM A 203 E) is a mild steel with a considerable amount of nickel, but not enough to render it a stainless steel or to cause any problems in welding. It is best used as a color steel in conjunction with a simpler high-carbon steel such as 1095/84, W-1, W-2, or WHC steels. It does not contain enough carbon to harden on its own, and it can cause carbon migration if the proper forging techniques are not followed to prevent this from occurring.

A 203 E is available in plate form only, so this material will have to be cut from heavy sheet (1/4-inch/5mm is the minimum thickness usually available) into usable strips before starting to laminate.

A 203 E contains the following:

C: 0.20%
Si: 0.13%-0.32%
Ni: 3.18%-3.82%
P: 0.040% max
S: 0.040% max

A 203 E can withstand some minor overheating, but it does scale heavier than a simpler alloy mild steel. It results in more vibrant watering due to the nickel content.

WROUGHT IRON

Wrought iron is perhaps the most traditional low-carbon material that can be used for pattern welding. It is no longer being made, with production having ceased in 1963. It was also known as bloomery iron and sponge iron after the methods of manufacture.

Wrought iron is semirefined iron with a considerable amount of silica slag in its composition. It has a "stringy" fibrous structure, and it is a gem to work with. It welds easily and contains a very small amount of carbon and nothing else.

Most wrought iron material available today comes from salvageable scraps such as old boiler plate, fencing, and other antique sources. All of the wrought iron that I have came from an iron fence made circa 1880. I use this material sparingly.

Wrought iron will not harden, but it can cause carbon migration, so this must be taken into account when working with it.

PURE NICKEL SHEET

While this isn't exactly a steel per se, it can be used for some downright dramatic patterning. Since the nickel is unaffected by most etchant processes, the mirrorlike surface of this material remains brilliant, while the other materials used are etched away slightly, darkened, and dulled. This makes for a very robust and easy-to-see pattern.

But this does have its price. Pure nickel sheet is very expensive, with prices ranging from $12 a pound on up! It is also a "picky" material in terms of working, and it will alloy with the steel and wash out the pattern if you laminate too finely. I get best results with approximately 175 to 300 layers per blade, depending upon the pattern involved.

Since nickel sheet does not form carbides, it will not cause carbon migration. While this is good, it does not produce a first-class cutting edge. I strongly suggest that this material be used for center cores in a composite blade such as traditional Viking/European blades or some