Blacksmith

Unit 6 (Proposed)
Spreading Out Into
The Many Specialties

Unit 5a
Supplemental Tooling

Unit 4
Designing Your Projects

Unit 3
Intermediate
Projects

Unit 2
Beginning
Projects

Unit 5
Basic Tooling

Unit 1
The Basics

Novice

The

BLACKSMITHING

STUDY GUIDE

An Educational Guide
Prepared by:
Bob Fredell & Pete Stanaitis
for the Guild of Metalsmiths,
an ABANA Chapter

We Want Your Feedback

We view the development of this program, The Blacksmithing Study Guide, to be in the beginning stages. We need your help to write improvements in the program. The manual is written on three hole paper and placed in a three ring binder so that we may easily make additions and deletions.

After you have used this program and have become familiar with it, send us your comments. Remember, the more specific your comments, the more useful they will be for us.

Be sure to include your name, address and phone number with your comments.

Mail your Comments to:

Bob Fredell
3500 45th Avenue South
Minneapolis MN 55406-2927

Thanks for your help.

Pete Stanaitis

Pete

Bob Fredell

Bob

The Blacksmithing Study Guide

Prepared by:
Bob Fredell,
Pete Stanaitis
and Friends

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NOTE TO ABANA CHAPTERS

The Blacksmithing Study Guide is written for the use of members of the Guild of Metalsmiths. However, permission may be given to other chapters to photocopy and use this study guide either partially or in its entirety. We wish to emphasize two points.

1. The Blacksmithing Study Guide should be used as part of the total program as described in the study guide. In other words, this study guide should not be seen as just one more book on blacksmithing to be used without the involvement of the local chapter of ABANA.

2. Chapters of ABANA that photocopy The Blacksmithing Study Guide assume the obligation to send a copy of all additions or changes to The Guild of Metalsmiths. This requirement will enable us to incorporate improvements into the master copy. Mail to Bob Fredell 3500 45th Avenue South Minneapolis MN 55406-2927.

Chapters wishing to use this program may obtain a copy of The Blacksmithing Study Guide by having the chapter president send us a self addressed 12" X 15" envelope with $2.25 in postage affixed to the envelope. Include a check for $20.00 payable to the Guild of Metalsmiths. Since this offer is non profit and we do not want to sell to individuals, we will respond only to chapter presidents. Write to the above address.

One more thought related to our request for changes. The authors see this program as a beginning. It would be a wonderful thing if someone would step forward to write additional units. Each new unit would be devoted to one of the many specific subjects such as (1)early 19th Century cooking utensils, (2)fireplace screens, (3) wall sconces, (4)window grills - the list goes on and on.

ACKNOWLEDGMENTS

The authors received much assistance from a number of persons. Without all this help the task would have been more difficult and the product would not be as useful.

During the early stages of planning a number of persons provided useful feedback as to the general organization of this program. We wish to thank these people for their advice.

Francis Bauer	Curt Engstrom	Doug Hendrickson
Bob Bergman	David Feterl	Tom Latane'
Monte Bygd	Robb Gunter	Dave Mariette
George Dixon	Myron Hanson	Bob Walsh

Several persons assisted in the writing of directions on making the projects. We wish to thank them for their contributions.

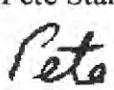
Monte Bygd	Keith Johnson	Tom Sanders
Curt Engstrom	Tom Latane'	Bob Walsh

Mary Fredell helped to make this study guide possible by all of her typing and proof reading.

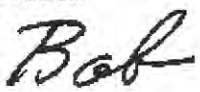
Lou Mueller, on behalf of BAM & ABANA, gave us permission to use First Fires, (PP 10-46)

Thanks so much to all you fine folks.

Pete Stanaitis



Bob Fredell



A Blacksmithing Study Guide, The Basics and Beyond

Introduction

The old axiom "I hear and I forget, I see and I remember, I do and I understand" couldn't be more true as it relates to blacksmithing education. There will never be a total replacement for the "Master/apprentice" process. This is where the Master performs a process for the Apprentice and then the Apprentice practices it before the Master until the Apprentice him or herself "Masters" it. This Study Guide provides the "map" on the road from novice to accomplished blacksmith. Many projects are suggested and referenced, but if one can avail him or herself of a "Master" so much the better. Lacking that path, read on.

There are many good books on Blacksmithing. Some are how-to books, some are picture books and some are a little of both. Many of them are heavy on instruction, but the heavier they get, the more focused they get! None of them cover the whole field. So how is an interested learner to know how far they've come along the lengthy road to becoming a true "Blacksmith"?

This Guide attempts to "Map" the blacksmith training process in a logical order adding self evaluation "mileposts" along the way for those who want them.

Since many of the members of our chapters are hobbyists and others who aren't relying upon blacksmithing for their entire living, we didn't feel comfortable just digging up the lessons and the testing processes that went on in the old "Guild/Apprentice days" when the student was almost a indentured servant for many years. We may not cover EVERY part of blacksmithing, but we DO cover a wide range of skills and put them into a logical sequence for the aspiring smith. This guide takes the smith through a number of logical projects within each unit and connects the units together in a logical way. In doing this, we reference many of the existing books, filling in the blanks as necessary with projects needed to maintain the flow, rather than just writing another book on blacksmithing.

An important aspect of this program is that students will receive a certificate of accomplishment upon completion of each unit. Also. a critique of the completed items is offered, if requested.

This study guide treats blacksmithing from the traditional view rather than the modern hi-tech viewpoint. The reason for this is simply that the authors are primarily interested in guiding development in traditional blacksmithing skills. More modern and "fab shop" related skills are readily available elsewhere. We acknowledge that it is perfectly acceptable to use modern technology when making traditional blacksmithing projects.

This study guide includes some projects that are artistic and others that are purely utilitarian. Some of the projects may not be of the highest interest to all students. That's OK. But if you really want to learn, perform them anyway. Remember: the skill development occurs no matter what the project may be.

The authors fully realize that this study guide is not "complete". And therefore encourage other educational groups to expand it as the opportunity arises.

One must realize that the very act of walking into a blacksmith shop can put a person at risk of personal injury. You must take the safety of yourself and others into your own hands. We are presenting processes that have the potential of becoming dangerous. You must determine the proper precautions to take at every step of the way. The authors take no responsibility for any mishaps arising out of the misuse or miscalculation in interpreting any of this study guide.

The following is a list of generally accepted safety tips for the blacksmith. Although fairly comprehensive, it is not presented as an exhaustive list. The student must at all times use common sense in determining what safety precautions are required. Take the time to read this short list and commit the concepts to memory.

1. Proper clothing: Wear long, cuffless pants and boots or high shoes. Pants should overlap shoe tops to prevent sparks or hot metal from falling into shoes. Cotton denim clothing is best.
2. Safety glasses or a face shield is required in the shop.
3. Protect your hearing. Wear earplugs or other approved ear protection devices.
4. No intoxicants.
5. No horseplay.
6. Always lay hot metal under the forge if it is being allowed to air cool. This reduces the chances of someone touching it.
7. NEVER grab hold of metal in a shop unless you know it is cold. Metal can LOOK cold and still be at 500 degrees Fahrenheit. If there is any doubt, test the temperature by passing the back of your hand near the metal before you touch it.
8. Always use tongs that fit the work. Don't hammer on work that is not tightly held.
9. If you need to move through the shop with heated work, warn others of your intent by saying "Hot Metal".
10. Always pick up and cool pieces of hot metal that have been cut off and fall to the floor.
11. Use gloves when applying hot oil finishes. The oil usually soaks through the rag and onto the hand.
12. Wear gloves when hot rasping: the rasp can grab and slip very easily causing a burn.
13. Give others room to work: don't crowd around someone who is working hot metal, especially stay on the far side of the anvil from the person working. Hot metal is constantly being moved between fire, anvil, and vise so stay out of that area.
14. Safety is common sense: no list of rules can cover everything and minor spark burns are a part of Blacksmith work, but paying attention to what you and others are doing will prevent most injuries.

The Blacksmithing Study Guide

Using this Study Guide

1. Beginning blacksmiths should start with Unit 1. Conquering The Basics.
Those persons with some experience may want to begin with a subsequent unit. You choose what is best for you.

2. Upon completing each unit we encourage, but do not require you to bring your items to a regular meeting of the Guild of Metalsmiths to display them.

3. You may choose to request a private critique of your items by one or more experienced blacksmiths at a regular meeting of the Guild of Metalsmiths.

4. Upon completion of each unit you will be recognized at a regular meeting of the Guild of Metalsmiths by receiving an achievement award.

5. It is important for you to complete each unit in the order it is presented so you follow an orderly approach in developing your blacksmithing skills. There is one exception to this recommendation - if you do not have the tools to complete the projects, you may want to make some of the tools in Unit 5, Basic Hand Tools early on in the sequence of instructions.

6. The projects within each unit may be completed in any order with the exception of Unit 4, Designing Your Own Metalwork Project. This unit should not be undertaken until you have completed Units 1, 2 and 3 or have the equivalent skills.

7. Unit 5a goes beyond the basic course of self instruction. It is included for those persons who want to expand their line of tools and increase their tool making ability.

Unit 1, Conquering The Basics

Unit 2, Projects For Beginners

Unit 3 Intermediate Projects

Unit 5 Making Basic Hand Tools

Unit 4 Designing your own Metalwork Project

Unit 5a Supplemental Hand Tools

CONQUERING THE BASICS

UNIT 1

The directions for this unit is a reprint of First Fires, the manual that accompanies ABANA's traveling teaching station.

We encourage you to practice each of the basic processes enough times so that you may move on to the next unit with a fair amount of confidence in your basic skills. Remember, this program is not a book on ideas of things to make. This program is an aid to you gaining a comprehensive understanding of all the basic processes.

As you progress through the units, you will be called upon to make use of the skills that you have learned in this unit. Be sure to remember - when making an item in one of the following units and you forget how to execute one of the basic processes, refer back to this unit.

Don't short change yourself by rushing through this unit so you can get on to the "fun stuff" in the following units. As one of the great football coaches of all time repeatedly said, "Learn the basics."

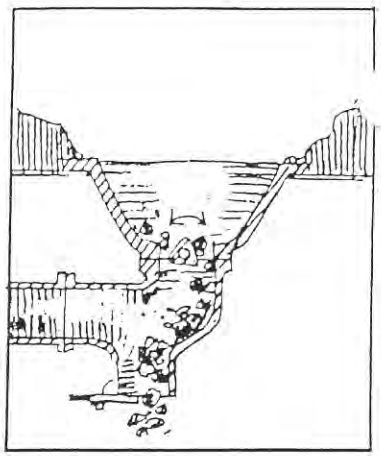
Upon completion of this unit we encourage you to bring the items that you have made to a meeting of the Guild of Metalsmiths. If you live a great distance from our meeting places and cannot come to a Guild meeting, at least show your items to local blacksmiths.

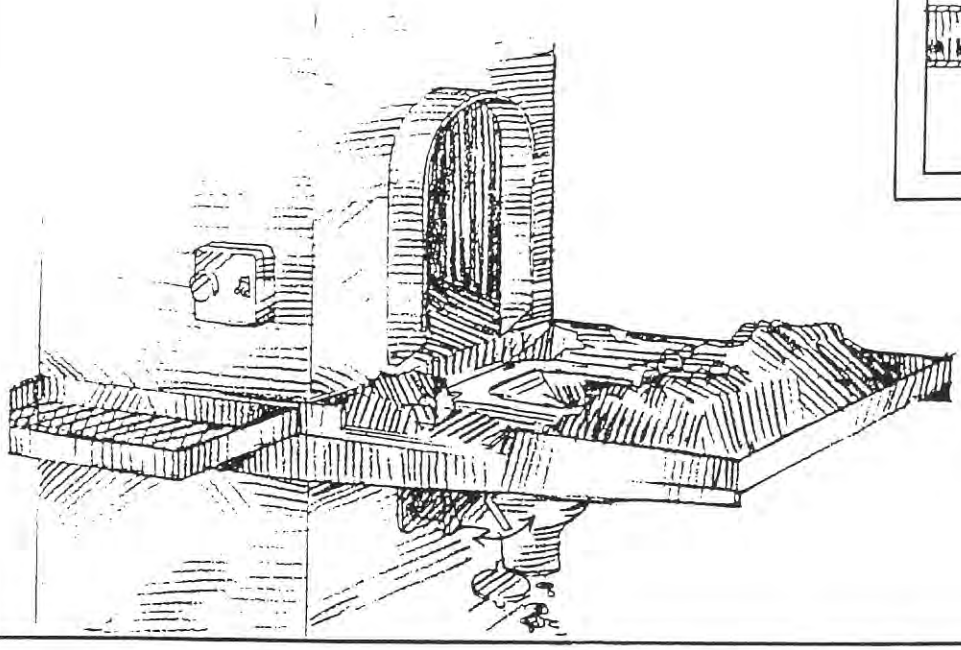
Persons completing this and subsequent units will be recognized at a regular meeting of the Guild of Metalsmiths. You will receive a walnut plaque with a brass plate affixed to it stating that you have completed this first unit. As you complete subsequent units you will receive at a regular Guild meeting additional brass plates to be affixed to your plaque.

FIRST PERIOD

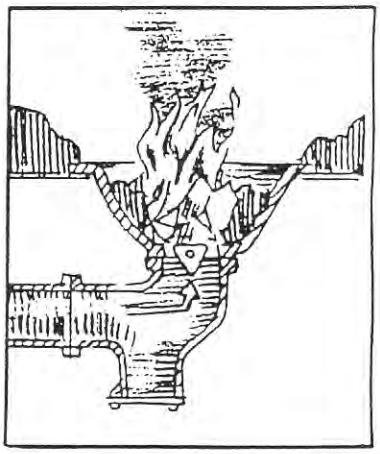
STARTING A FIRE

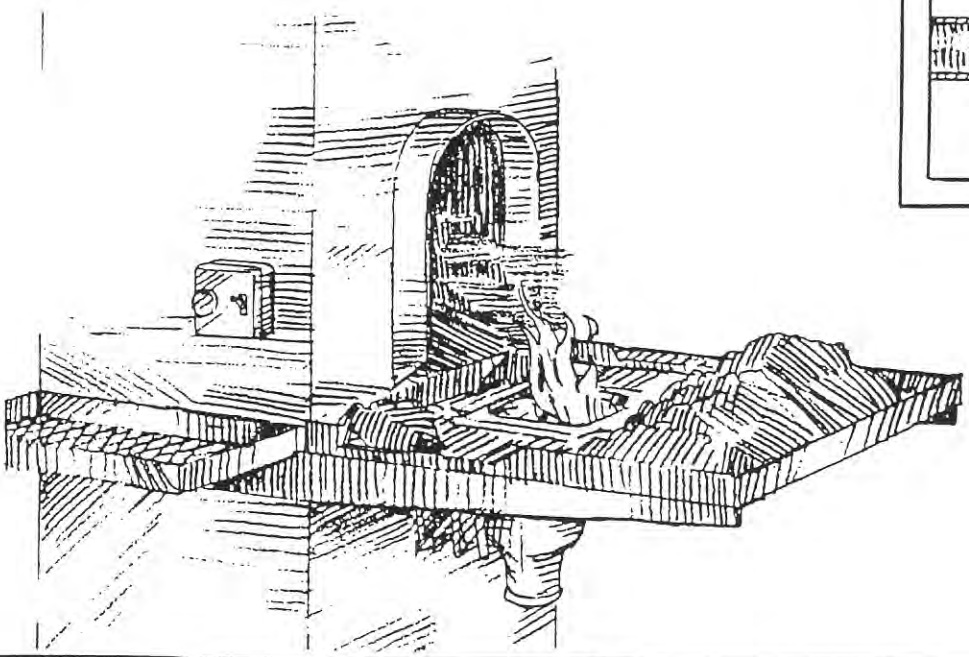
Clean out. Usually, the previous day's fire must be cleaned out before restarting a new one. First move all the remaining coal to the side and then pile the coke on top of it. Shovel out clinkers from the fire pot and dump ash & clinkers from the ash chamber.



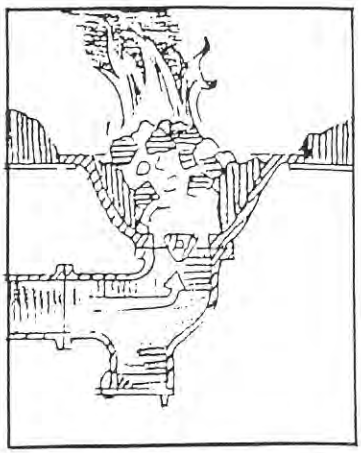


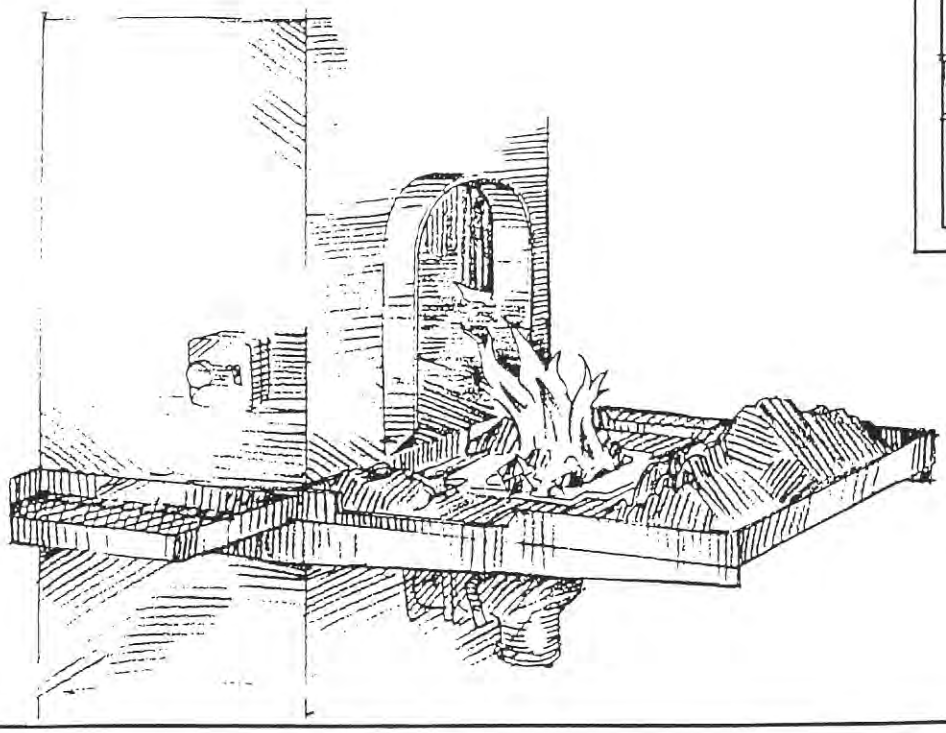
Starting the fire. Light two sheets of wadded newspaper and place in the fire pot. Shovel fresh coal into the fire pot around the newspaper and start the blast at low speed.



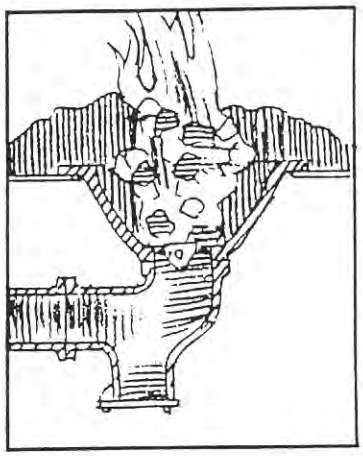


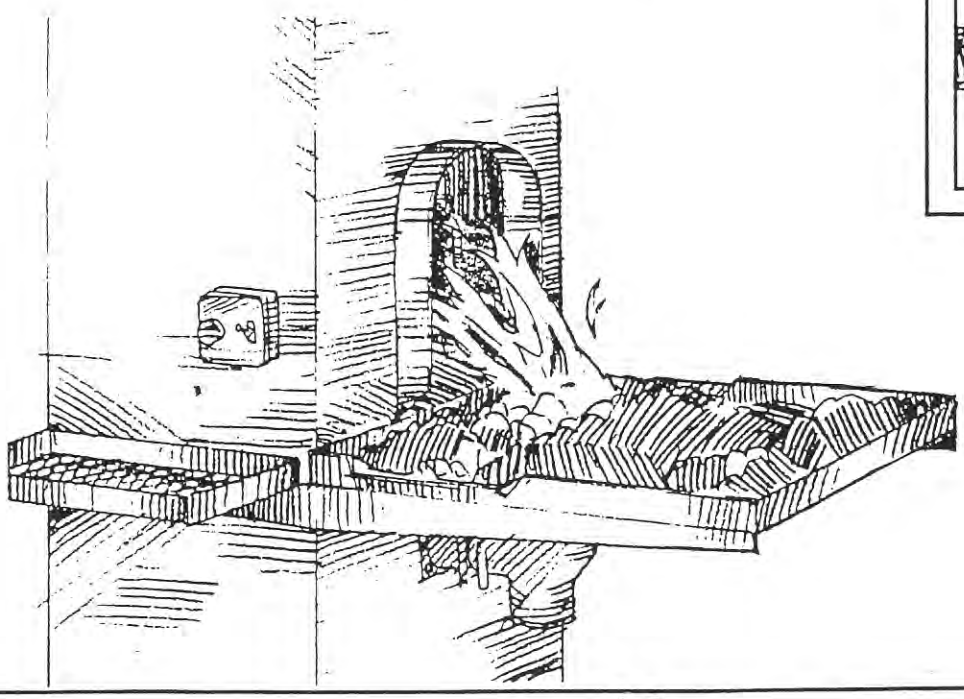
Add coke. Shovel coke on top of the fire and increase the blast slightly. Allow to burn until the fire is well established.



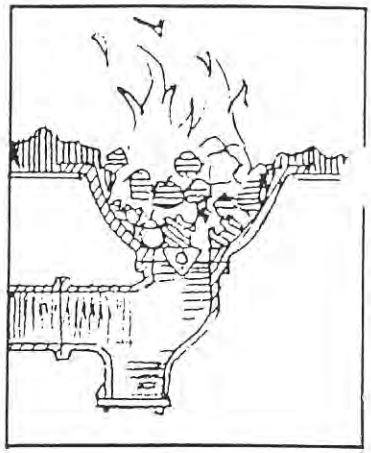


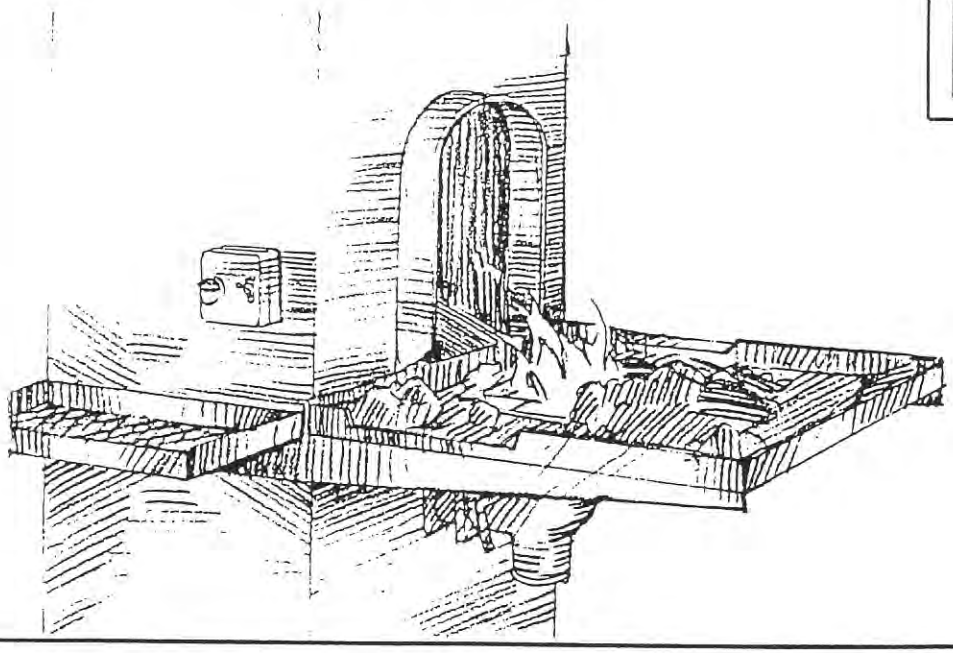
Add coal. Use a poker to cave in the cavity left by the burned out newspaper, then bank the fire with coal on each side. The amount of coal you use and where you place it on the fire will be determined by the size and type of work you are doing.

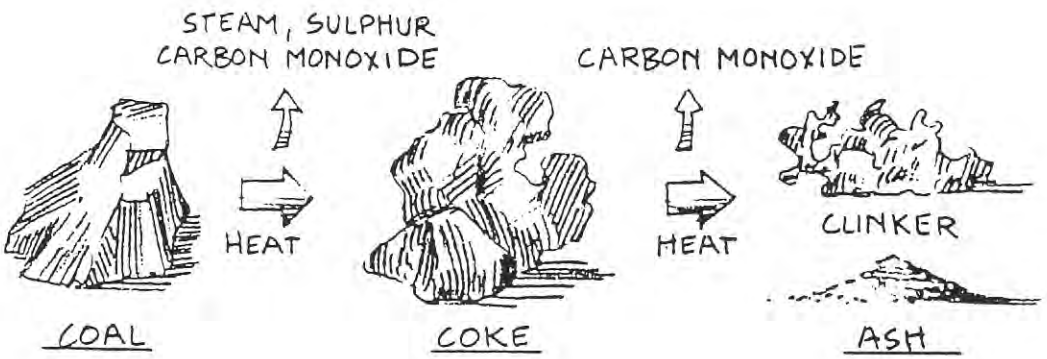




Oxidizing fire. As the coal and coke are consumed, more coal must be added to the fire. A steady supply of fuel to a clean fire maintains a reducing atmosphere in which metal oxidation is held to a minimum, and high heat levels are possible. Failure to remove build up of clinkers or replenish the fuel supply will result in a oxidizing fire in which there is low heat and high metal oxidation levels.







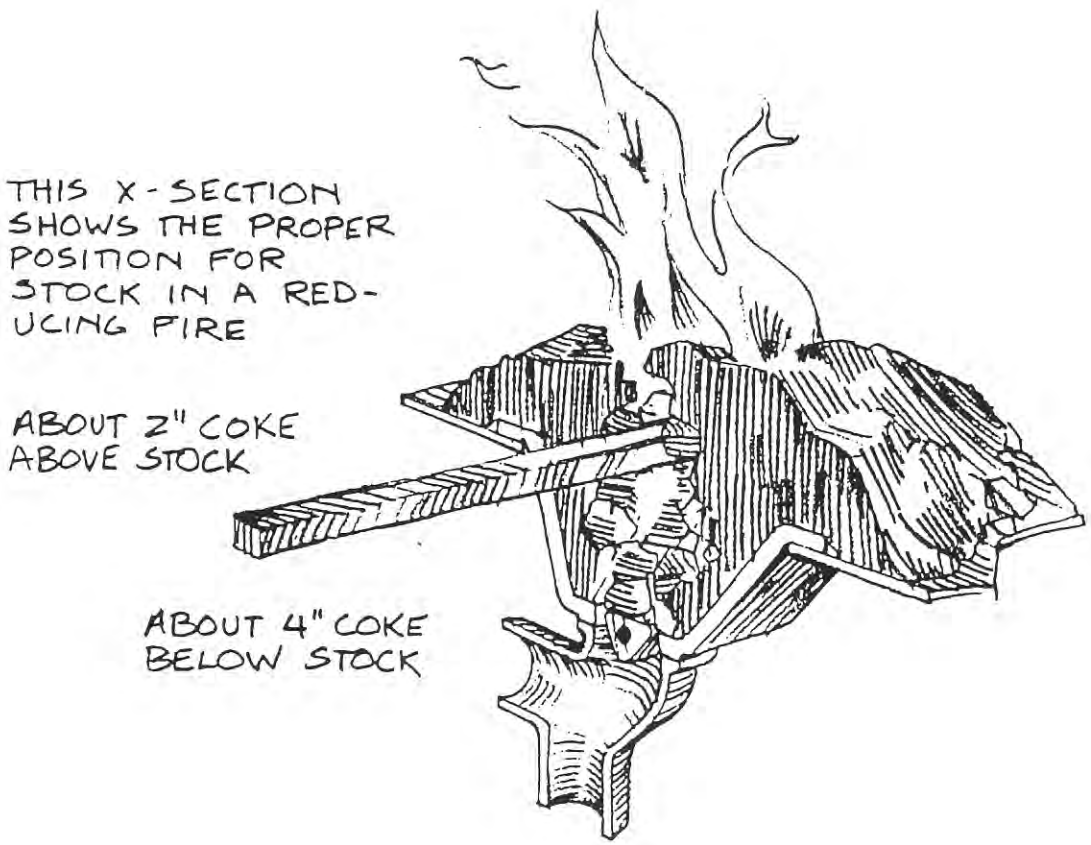
FUEL COMPARISON CHART

Fuel	Heat level	Oxidation at Forging Temp.	Lap Welding	Production Capacity	Cost to Operate
Coal	high	moderate	good	moderate	low
Coke	high	moderate	good	moderate	moderate
Charcoal	high	low	good	low	high
Propane	moderate	high	fair	high	high
Natural Gas	moderate	high	fair	high	low

FORGING HEATS FOR MILD STEEL

Color	Heat (°F)	Uses
Black	700° -1000°	Planishing; Chamfering; Chiseling; etc.
Red	1000° -1250°	Bending; Chamfering; Stress relieving.
Cherry	1250° -1400°	Light forging, bending, twisting; Chamfering
Bright cherry	1400° -1600°	Light forging, bending, twisting; Hot cutting & punching
Orange	1600° -1900°	General forging, bending, twisting; Hot cutting & punching
Yellow	1900° -2100°	Heavy forging, bending, twisting
Welding	2100° -2300°	Welding; Heavy forging

These colors are only true in a dark area



Steel designations have changed over the years. For a long time a four digit number was used to describe the composition of a given type of steel. The first two numbers describe the alloy (eg; 10 = straight carbon steel, 41 = chrom-moly steel, etc.); and the last two numbers describe the carbon content (eg; 20 = 0.20%). Although these numbers are still used, some new ones such as A36 (a 0.26 - 0.29% carbon structural grade) have been added. Most tool steels now use a letter/number designation that indicates it's characteristics rather than it's actual composition. The best steel for general forging is a straight low carbon (0.10-0.20%) steel.

Hot rolled steel is milled hot into various shapes and sizes. Bar sizes are milled slightly oversize so that they can be cold rolled to more exact tolerances. Generally, blacksmiths don't need the fine tolerance of cold rolled, but buy it because of it's availability in low carbon and odd sizes.

Carbon content gives iron it's strength; however it does pose some problems for blacksmiths in the medium (0.35%) to high (0.95%) range. These problems include reduced forging and welding heat ranges, less malleability, and higher oxidation levels.

Although oxidation rates of low carbon steels are lower, it is still important to protect against their occurrence. Be sure to maintain a reducing fire (8-5,p.25), keep the backside of your work down in the fire and avoid using high forging heats when they are not necessary.

MILD STEEL & IRON COMPARISON CHART

Stock	Advantages	Disadvantages
A36 Hot Rolled Steel	Widely available in standard bar & structural shapes. Inexpensive.	Harder to forge and forge weld than 1020. Harder to work cold. Low corrosion resistance
1020 Hot Rolled Steel	Easy to forge and forge weld. Stronger and more consistant quality than wrought iron.	Hard to find in most stock sizes.
1018 Cold Rolled Steel	Same as 1020 hot rolled.	High cost.
Wrought Iron	Very easy to forge and forge weld. High corrosion resistance.	Hard to find. No longer mass produced. Inconsistent quality.

STOCK & HEATS

Hand forging is a process of refinement; orange, Yellow and welding heats are used when a relatively large mass of metal must be upset or drawn out. Black red and cherry heats are used for finer work after basic shapes have been forged to size.

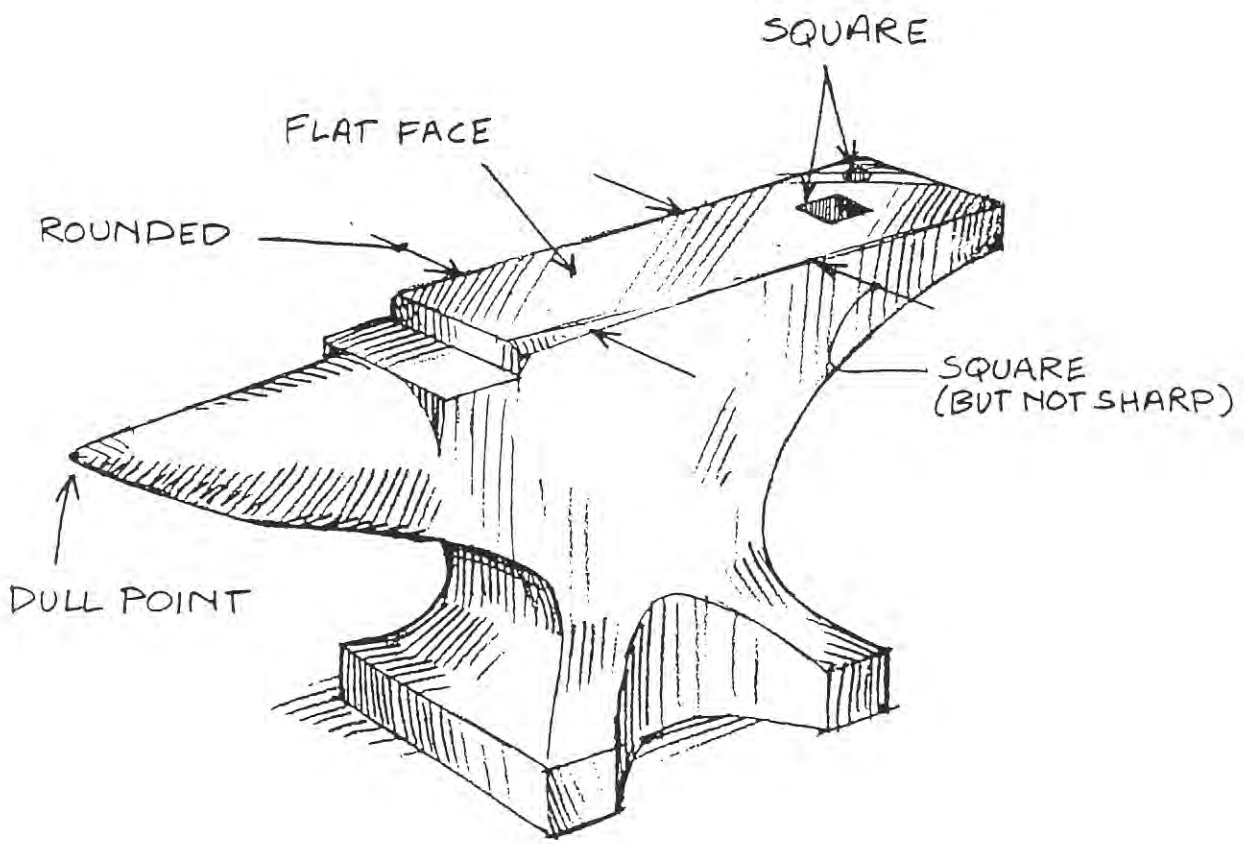
It must be remembered that what is happening on the top is often different than what is happening on the bottom or sides of the stock as it is being forged.

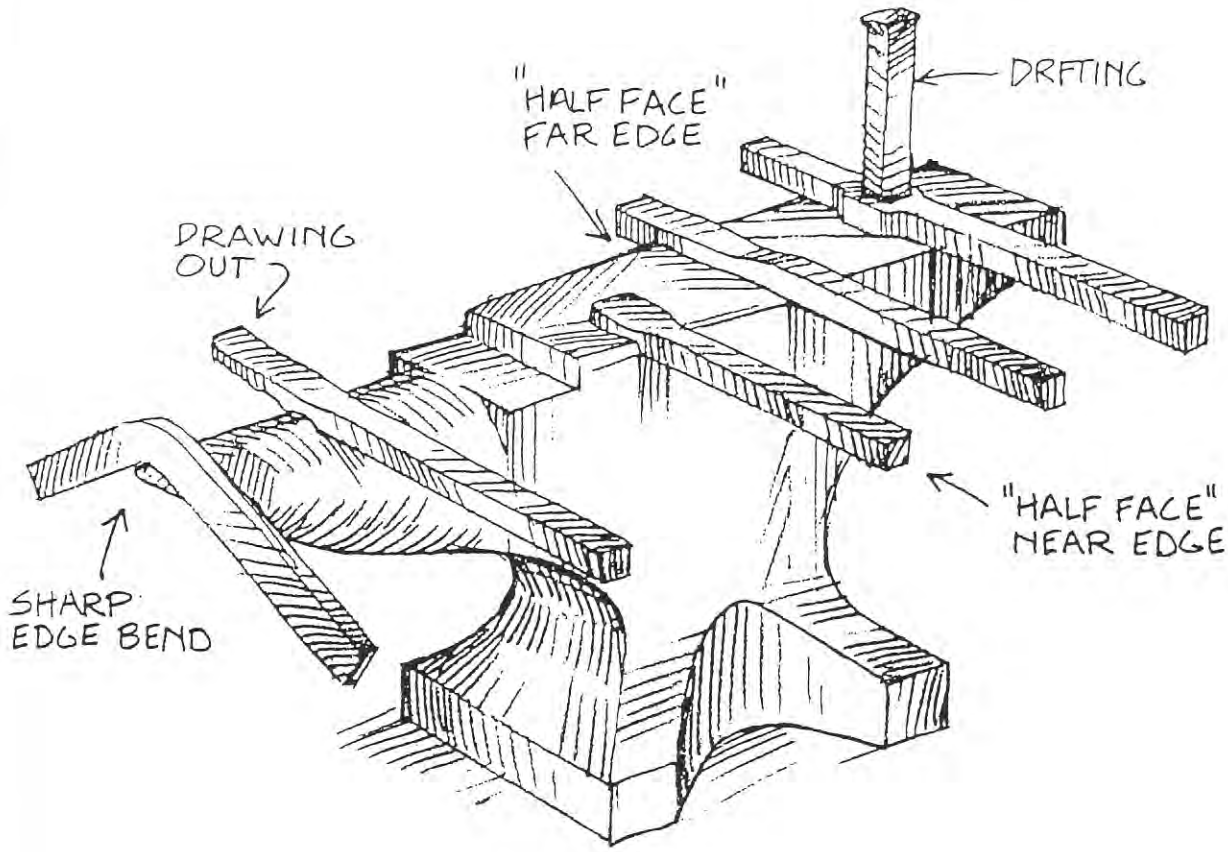
HAMMER & ANVIL

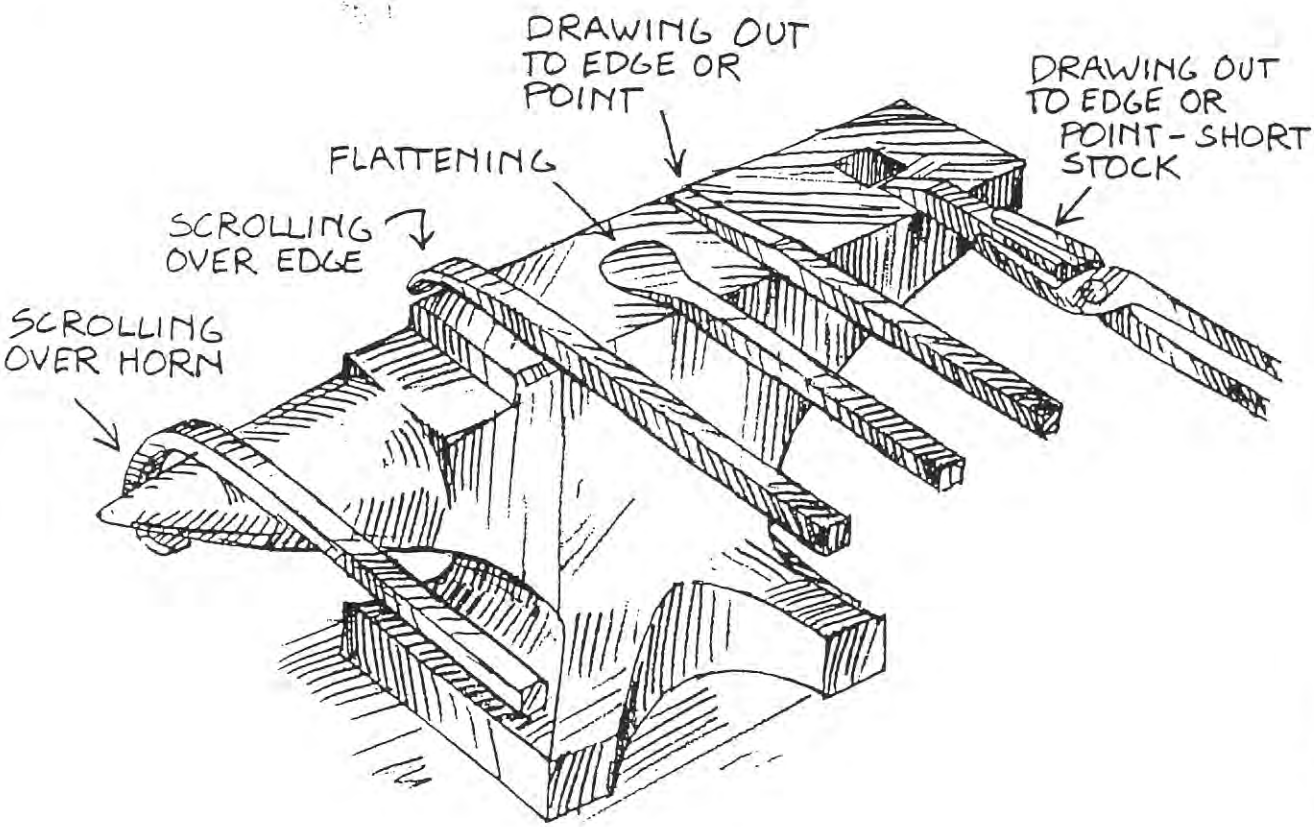
The most basic of top and bottom tools are your hammer and anvil. Hammers and various other top tools will be covered in another issue, but there is one point to be made about them here. Hand held hammer faces must have at least a slight crown and rounded edges to prevent "edge impressions" from occurring.

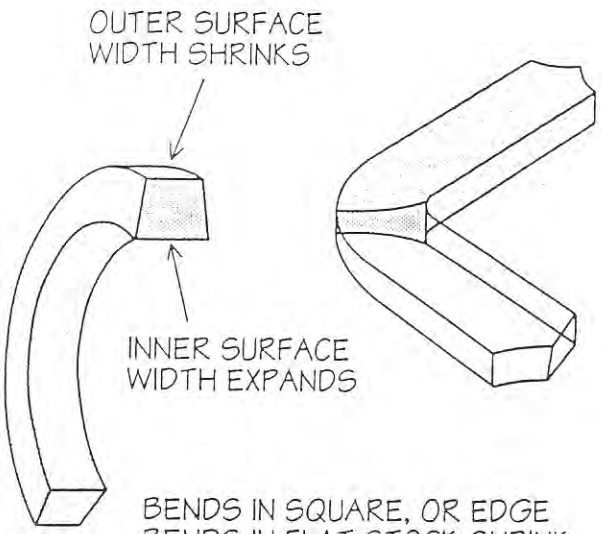
Everybody has his individual preferences on how to dress an anvil. Basically you need rounded and square edges on both the near and far edge of the face, square edges around the hardy and pritchel holes, and a horn that comes to a fairly sharp point. Ill. 20-2 & 20-3 show some ways of using the surfaces and edges of an anvil.

Anvils are readily available new from suppliers such as Centaur Forge in Burlington, Wisconsin, or used from dealers and equipment sales. The new ones are of excellent quality and made of cast or drop forged alloy tool steel. The older ones are made of cast or wrought iron with a welded steel face. The best of the old ones include those manufactured by Hay-Budden and Trenton.



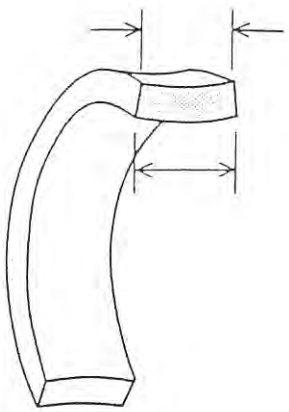

DRFTING
"HALF FACE"
FAR EDGE
DRAWING
OUT
"HALF FACE"
NEAR EDGE
SHARP
EDGE BEND


DRAWING OUT
TO EDGE OR
POINT
DRAWING OUT
TO EDGE OR
POINT - SHORT
STOCK
FLATTENING
SCROLLING
OVER EDGE
SCROLLING
OVER HORN

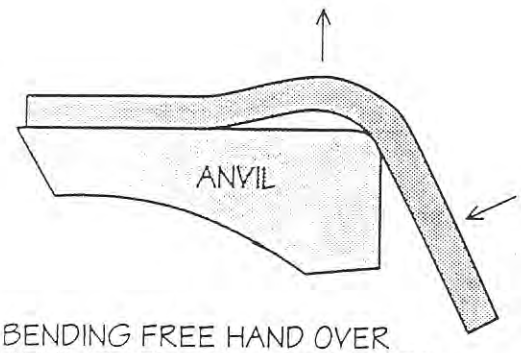


BENDS IN SQUARE, OR EDGE BENDS IN FLAT STOCK SHRINK THE WIDTH OF THE OUTER SURFACE AND EXPAND THE WIDTH OF THE INNER SURFACE.

BENDING

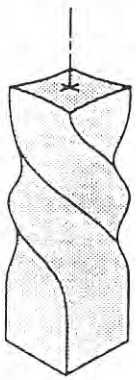


BENDS IN THE FLAT STOCK SHRINK THE OUTER SURFACE MAKING IT CONCAVE, AND EXPAND THE INNER SURFACE MAKING IT CONVEX.



BENDING FREE HAND OVER ANVIL EDGE OR HORN CAUSES HEATED AREAS BEHIND THE BEND TO BUCKLE

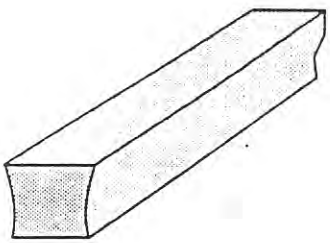
TWISTING



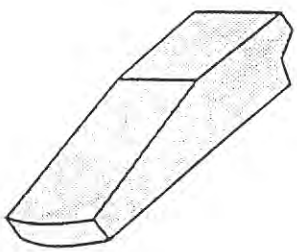
TWISTING MAKES FLAT SURFACES CONCAVE. THE LENGTH OF THE BAR REMAINS THE SAME BECAUSE THE AXIS REMAINS UNDISTURBED.

IMPRESSIONS STRETCH ALONG THE LENGTH & SHRINK ON THE WIDTH OF THE SURFACES.

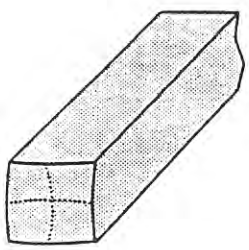
DRAWING OUT
(SHALLOW PENETRATION)



HAMMER TOP, ANVIL BOTTOM BLOWS MAKE THE TOP SURFACE WIDER THAN THE BOTTOM.

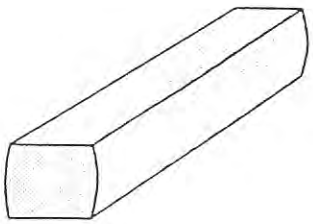


HAMMER TOP, ANVIL BOTTOM BLOWS MAKE THE END TAPER FROM THE TOP TO THE BOTTOM.

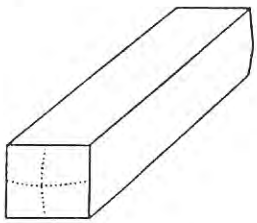


LIGHT TO MEDIUM BLOWS TO ALL FOUR SIDES MAKE THE END CONCAVE.

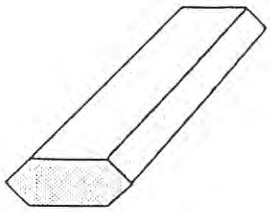
DRAWING OUT (DEEP PENETRATION)



HEAVY, DEEPLY PENETRATING BLOWS ON TWO SIDES MAKE THE EDGES CONVEX.



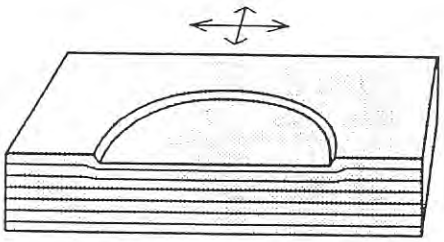
HEAVY, DEEPLY PENETRATING BLOWS ON ALL FOUR SIDES MAKE THE END CONVEX.



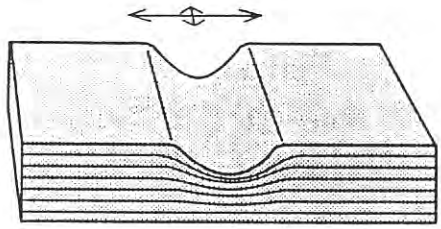
FORGING ON THE DIAMOND OR FORGING ROUNDS PERMITS DEEPER INITIAL PENETRATION.

THE RATIO BETWEEN THE AMOUNT OF FORCE AND PENETRATING ABILITY OF THE TOOL WILL DETERMINE THE WAY IN WHICH SURROUNDING MATERIAL WILL MOVE. DEEP PENETRATION TENDS TO MOVE MATERIAL FROM THE CENTER OF THE STOCK OUTWARD, SHALLOW PENETRATION TENDS TO MOVE MATERIAL NEAR THE SURFACE OF THE STOCK OUTWARD.

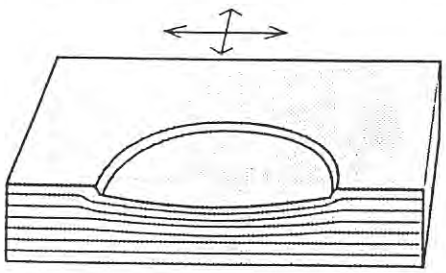
IMPRESSIONS (EQUAL FORCE)



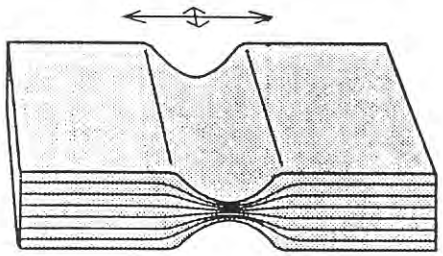
FLAT IMPRESSIONS IN FLAT SURFACES MAKE SHALLOW PENETRATION DISPLACING SMALL AMOUNTS OF STOCK RADIALLY.



HALF-ROUND IMPRESSIONS IN FLAT SURFACES MAKE DEEP PENETRATION DISPLACING LARGE AMOUNTS OF STOCK IN OPPOSING DIRECTIONS.



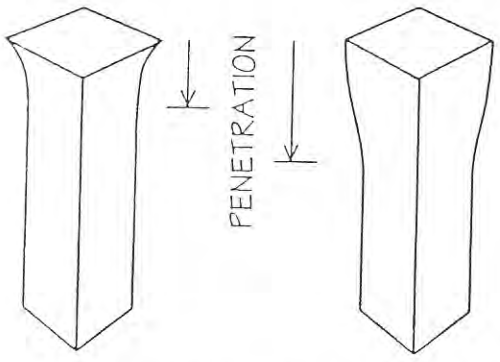
CONVEX IMPERESSIONS IN FLAT SURFACES MAKE MODERATE PENETRATION DISPLACING MODERATE AMOUNTS OF STOCK RADIALLY.



HALF-ROUND IMPRESSIONS, TOP AND BOTTOM, IN FLAT SURFACES MAKE VERY DEEP PENETRATION DISPLACING LARGE AMOUNTS OF STOCK IN OPPOSING DIRECTIONS.

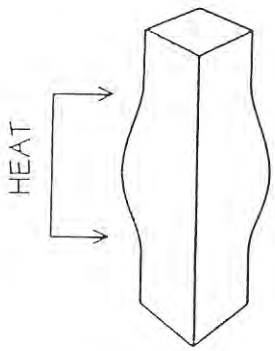
FORGING DYNAMICS

UPSETTING

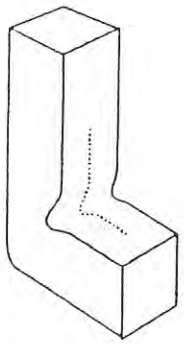


LIGHT BLOWS FORM ENDS INTO A BELL SHAPE.

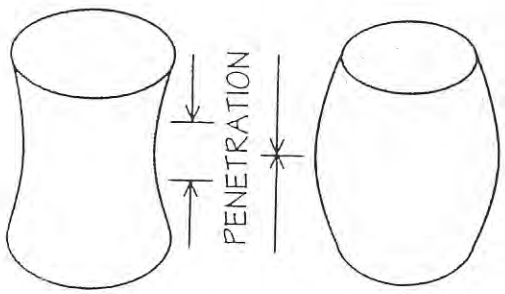
HEAVY BLOWS FORM ENDS DEEPER INTO THE STOCK.



HEATED AREAS AWAY FROM THE END OF A BAR UPSET UNIFORMLY.

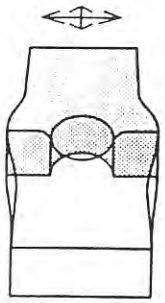


UPSET CORNERS TEND TO FOLD IN-WARD ON THE INSIDE.



LIGHT BLOWS FORM THE ENDS OF SHORT STOCK INTO A BELL SHAPE; HEAVEY BLOWS UPSET THE CENTER UNIFORMLY.

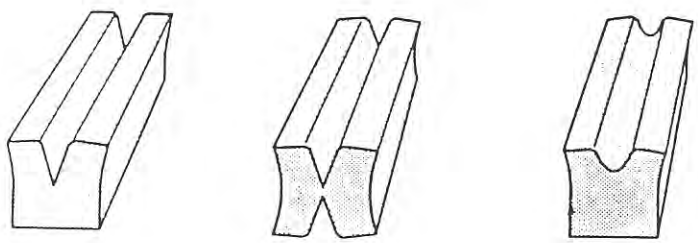
PUNCHING



PUNCHING DRAWS STOCK DOWN INTO THE HOLE MAKING THE SURFACE CON-CAVE, SPREADING THE STOCK OWTWARD FROM THE HOLE.

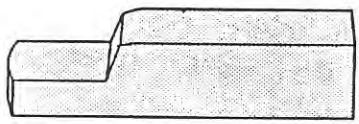
AWARENESS OF FORGING DYNAMICS ENABLES YOU TO USE THEM TO YOUR ADVANTAGE AND PREDICT THEIR OCCURENCE. EFFICIENT APPLICATION OF FORCE AND USE OF EFFECTIVE TOP AND BOTTOM TOOLS SAVES TIME AND EFFORT IN THE LONG RUN.

CUTTING & GROOVING



GROOVING AND FULLERING ALONG THE LENGTH OF A BAR MAKES THE EDGES CONVEX AS THEY MOVE AWAY FROM THE SHAPE OF THE IMPRESSION.

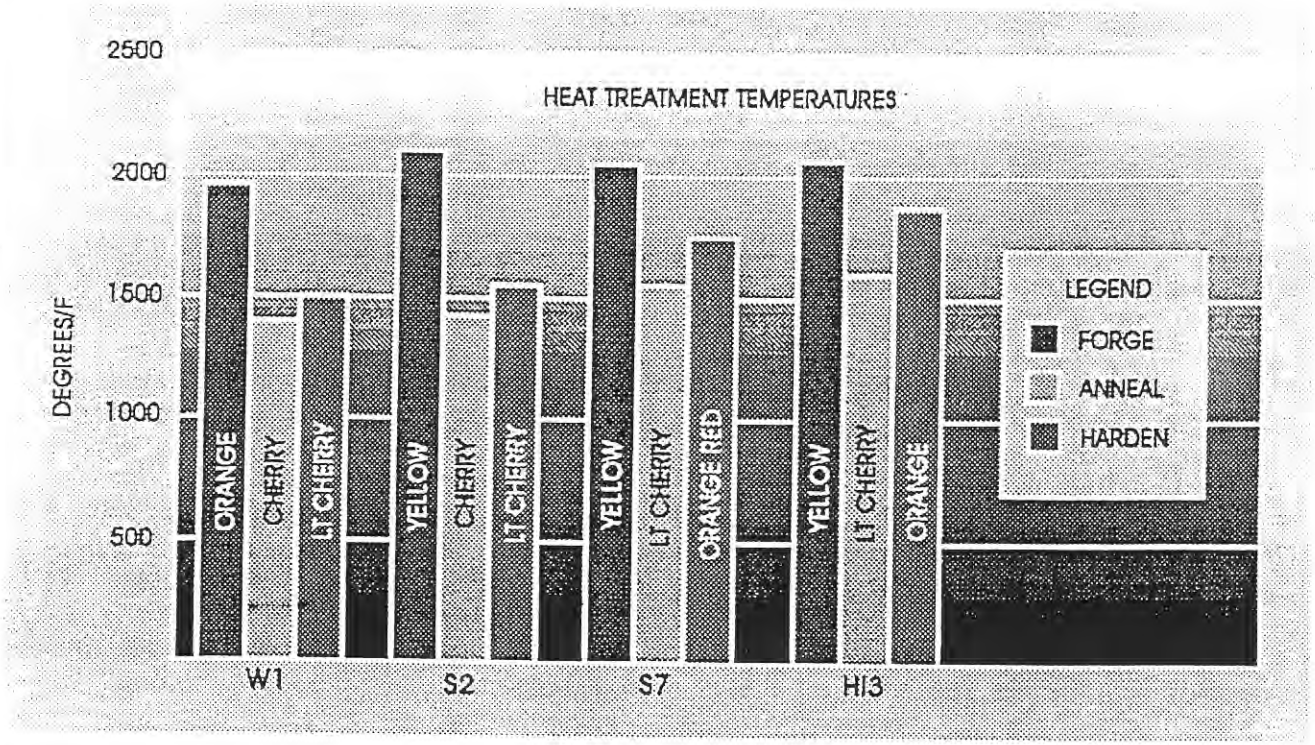
SHOULDERS



SOULDERS FORM AT AN ANGLE AS THE DRAWING OUT FORCE OF THE END PUSHES MATERIAL AWAY FROM THE TOOL. MATERIAL DRAWS DOWN BETWEEN THE TOOL AND SHOLDER, DEMENISHING STOCK THICKNESS NEAR THE SHOULDER

being air, oil or water hardening. Air hardening is accomplished by simply allowing the tool to cool in still air (never use forced air). Quenching oils are used by immersing the heated steel in the oil and can be found at machine shop supply companies. A 5-10% brine solution is recommended for water cooling to insure overall hardness and prevent soft spots. A simple test to check to see that hardening was successful is to try to cut the steel with a file. The file will "skate" across any hardened portion.

Temper: Hardening will produce the maximum possible hardness for each grade of steel. Because the steel is usually too brittle for practical use at this stage, it must be softened (tempered) to a degree of hardness that will match it's intended use. This is accomplished by reheating to a specified temperature. Mediums such as sand or lead can be heated and used to control the evenness of the temper. An ordinary oven works well for overall tempering of items up to 500°F.



SCRAP STEEL

Scrap tool steel, in the form of old files, springs, axles, etc., is useful material for tools used around the shop. However, basic tools, or those used often, are best made from new steel. Problems with using scrap include limited choice of size (cross section & length), and limited knowledge of type or composition.

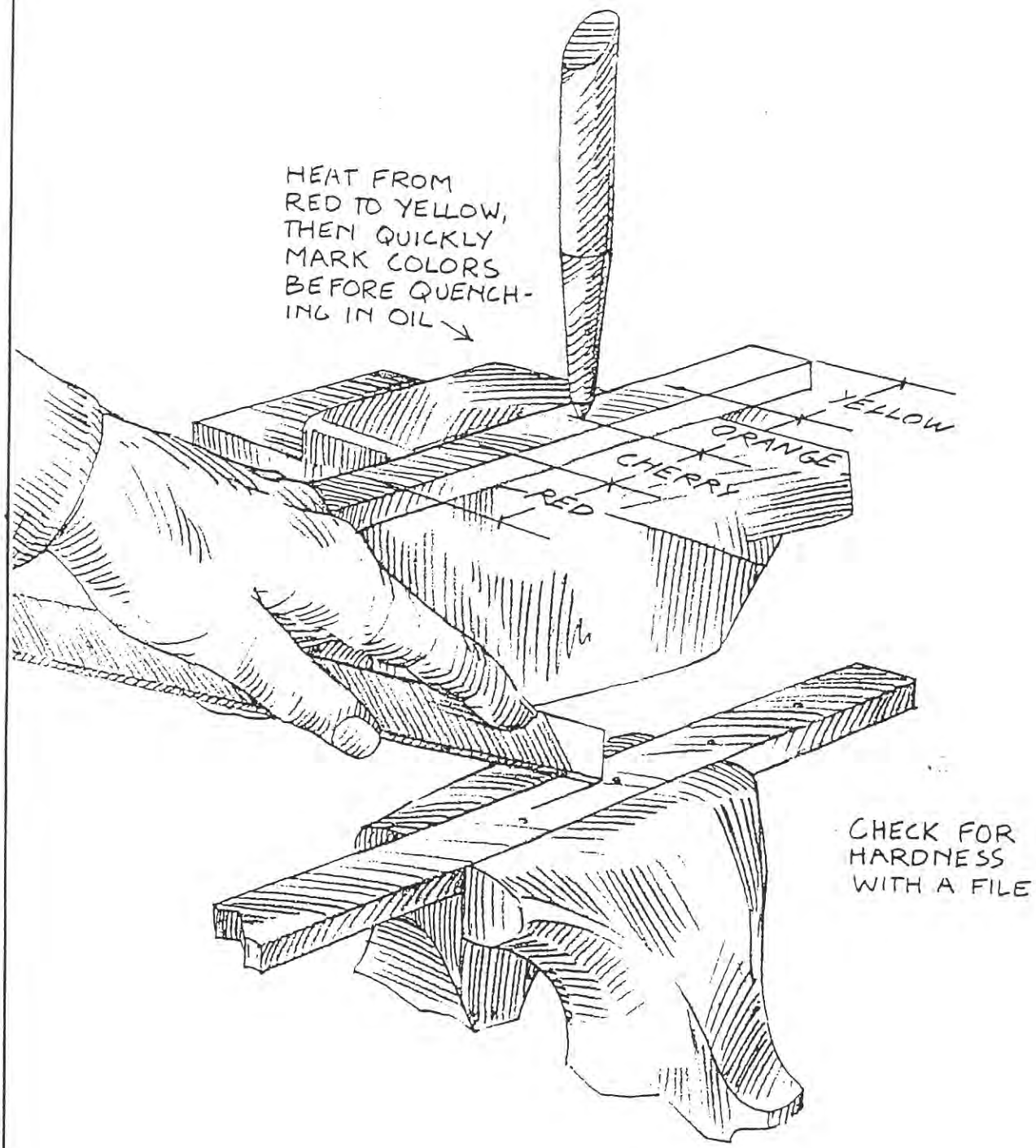
It is possible to determine the type of scrap steel you have by considering its origin. In most instances, scrap is found in the form of worn out tool and machinery parts. By knowing what it was used for originally, you can assess its usefulness for a new application. Another factor to consider is the age of the steel in question. For instance, old horse drawn farm equipment (still easy to find) will most likely contain straight high carbon steel because its manufacture occurred before the advent of modern alloy steels.

Determining specific heat treating procedures for scrap is difficult because the exact composition is generally unknown. A straight carbon steel can be recognized by spark testing. More "exploding" sparks indicate higher levels of carbon. Use steel with a known carbon content to establish a standard for testing other pieces. High alloy steels are more difficult to recognize, but hardening and tempering ranges can be found by performing a heat treatment test.

To do this test, heat a sample piece so that it has a color range of yellow at one end

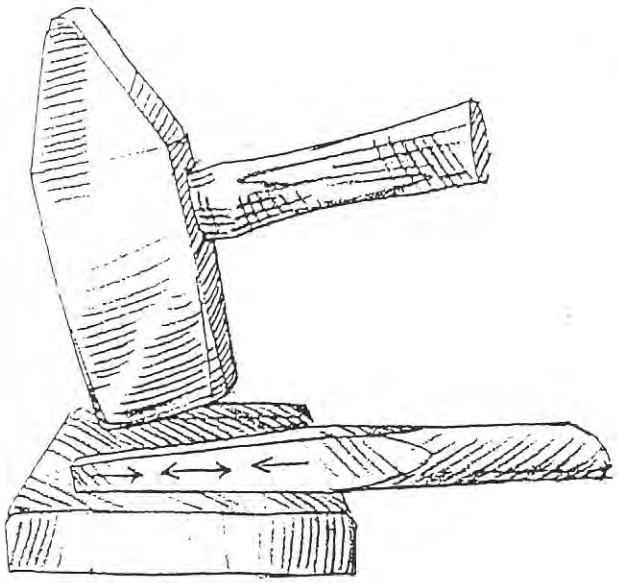
and red at the other. You might want to make some marks in the steel to show where one color ends and another begins. Quench the heated portion in oil and then test for hardness by running the tip of a new file from the "red" to the "yellow" portion of the steel. If the file skates from the light cherry to the yellow portion, it is probably O2. If it skates from red orange to yellow or if you notice fracture lines, it is probably an air hardening alloy. If the file cuts from red to yellow it is probably water hardening.

Once you have an idea of what the steel might be, harden and temper it to a hardness based on your test piece. Use it for a while to see how it holds up; if it is too soft or too brittle, re-harden if necessary and adjust the amount of tempering heat to correct the problem.



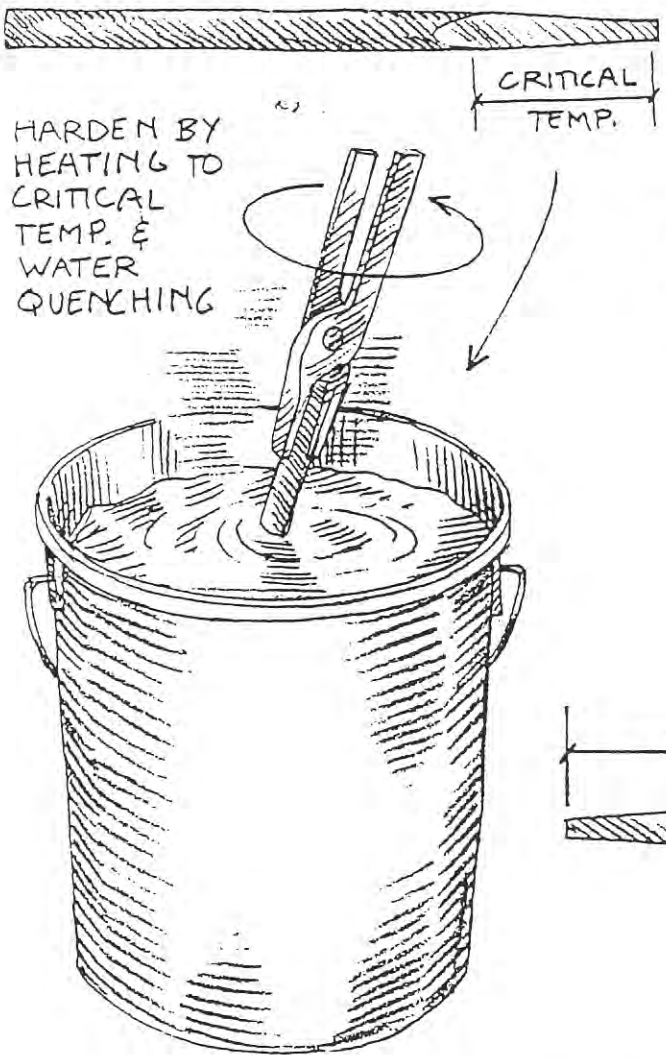
HEAT TREATING

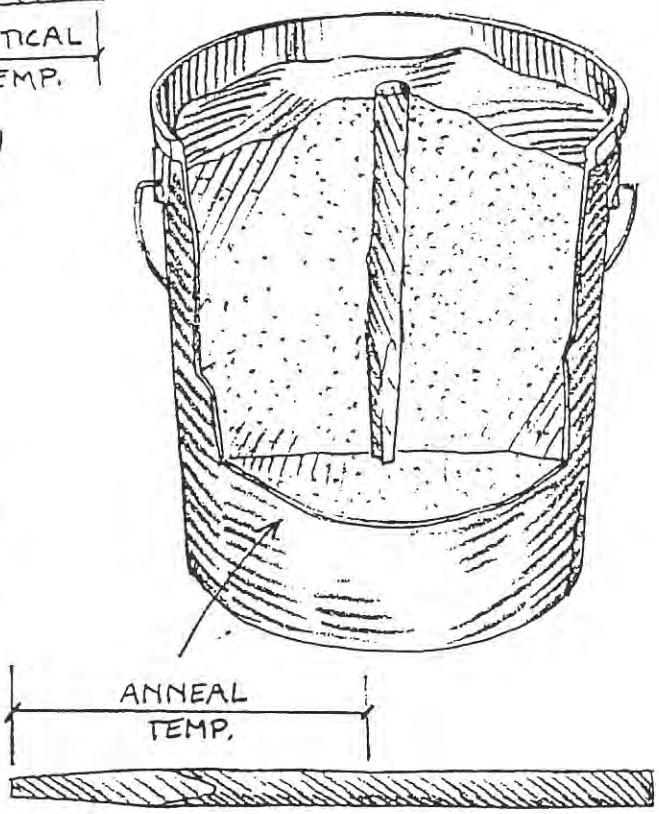
Following is the procedure for forging and heat treating a square punch. The stock is 5/8"x11" W1 tool steel. Refer to the charts [illegible] 23. and [illegible] for proper heat colors and temperatures.



FORGING CREATES STRESSES THAT ARE REMOVED BY NORMALIZING AND ANNEALING

ANNEAL BY HEATING & PACKING IN HARD-WOOD ASHES OR AG-LIME





W1

Type Water hardening straight carbon.

Characteristics
- ❑ Sections larger than 1/2" will not harden all the way through, giving the case wear resistance and the core toughness.
- ❑ W1 will tend to crack and break rather than bend.
- ❑ Very thin sections can be oil hardened all the way through.

Advantages
- ❑ Forge weldable.
- ❑ Easy to heat treat in average shop.
- ❑ Inexpensive.

Disadvantages
- ❑ Tendency to chip and break poses a possible safety hazard.
- ❑ Low red hardness.

Forge 1950°, reheat at 1450°.

Normalize 1600°, then air cool.

Anneal 1400°, pack in hardwood ashes or agricultural lime; cool to black.

Harden 1500 , quench in 5-10% brine solution.

Temper

Color	Temperature	Rockwell C
Blue	590°	54
Violet	545°	57
Purple	525°	59
Brown	490°	60†
Dark Straw	465°	61
Light Straw	425°	62

S2

Type Water hardening alloy.

Characteristics
- ❑ Extreme toughness; will generally bend before breaking.
- ❑ Hard case, tough core in larger sizes

Advantages
- ❑ Toughness makes it safe to use.
- ❑ Relatively inexpensive.

Disadvantages
- ❑ Will not "hold an edge" as well as W1.
- ❑ Low red hardness.

Forge 2100°,reheat at 1550°.

Normalize 1650 , then air cool.

Anneal 1400°, cool in a controlled atmosphere furnace @ 20°/hr., or pack in vented reducing coal or charcoal fire, and allow to cool over night.

Harden 1550°, quench in 5-10% brine solution.

Temper

Color	Temperature	Rockwell C
Blue	600°	54
Violet	565°	55
Purple	520°	56
Brown	500°	55
Dark Straw	465°	57†
Light Straw	400°	58
None	350°	59

Note: All temperatures shown in °F

† Best temper for general use

S7

Type Air hardening alloy

Characteristics
- ❑ High impact and shock resistance.
- ❑ Good for both hot and cold work.
- ❑ Air or oil hardening; should not be water quenched.

Advantages
- ❑ Hard to chip or break.
- ❑ Good combination of hardness and toughness.
- ❑ Good red hardness

Disadvantages
- ❑ Difficult to hand forge.
- ❑ Difficult to properly heat treat in average shop.

Forge 2050°, reheat at 1700°

Anneal 1550°, cool in a controlled atmosphere furnace @ 20°/hr., or pack in vented reducing coal or charcoal fire, and allow to cool over night.*

Harden 1750°, air quench; oil quench for extra hardness.

Temper

Color	Temperature	Rockwell C
Faint red	900°	51
Black red	800°	51
✗	700°	51
✗	600°	52†
✗	500°	53
✗	400°	55

H13

Type Air hardening alloy

Characteristics
- ❑ Extreme toughness with better red hardness than S7.
- ❑ Better for hot work than cold work.
- ❑ Air or oil hardening; should not be water quenched.

Advantages
- ❑ Extremely tough; will bend before breaking.
- ❑ Very good red hardness

Disadvantages
- ❑ Difficult to hand forge.
- ❑ Difficult to properly heat treat in average shop.
- ❑ Low wear resistance.

Forge 2075°, reheat at 1650°

Anneal 1600°, cool in a controlled atmosphere furnace @ 30°/hr., or pack in vented reducing coal or charcoal fire, and allow to cool over night.*

Harden 1875°, air quench; oil quench for extra hardness.

Temper

Color	Temperature	Rockwell C
Dark red	1100°	49
Very dark red	1000°	52†
Faint red	900°	51
Black red	800°	51
✗	700°	51
✗	600°	51

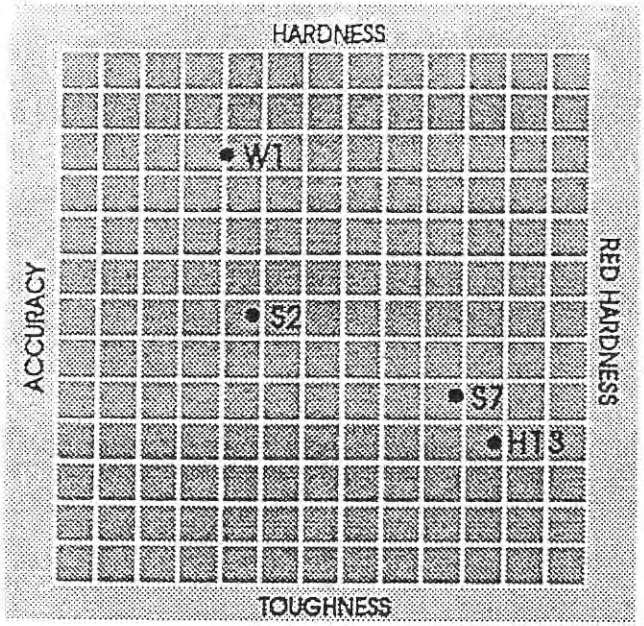
Note: All temperatures shown in °F

* A "soft skin" may occur by packing in coal or charcoal. Remove by grinding critical surfaces.

† Best temper for general use

HEAT TREATING

The average blacksmith shop has the required equipment for the heat treatment of many tool steels, and most grades can be made serviceable by using a modified version the manufacturers recommended technique. However, more sophisticated equipment is needed to take full advantage of the hardening characteristics of each type of steel.



Tool steel types generally trade one quality for another. These qualities fall into two basic categories: wear resistance (hardness) vs. toughness, and accuracy vs. Red hardness. Wear resistance is desirable when a tool must hold an edge or stand up under continuous service. Toughness is needed for tools used under stresses that might cause breakage. Accuracy addresses machinability and ability to retain size and shape when hardened. Red hardness is the ability to remain hard when used at high temperatures.

I have selected four tool steels useful in a blacksmith shop based on the characteristics mentioned above. Also considered is the ease with which they can be heat treated. O2, a widely used general purpose steel, has not been included but is similar to W1 with the exception of being oil rather than water hardening. See pp.123-124 for a description and specifications of these four steels. For information on other grades, contact your local tool steel distributor.

Following is a general description of each process required for forging and heat treatment of most alloys:

Forge: Tool steels must be heated and forged within specific temperature ranges to prevent decarburization if too hot, and fracturing if too cold. Alloy steels such as S7 and H13 contain chromium and are difficult to hand forge. Use a reducing fire and avoid taking more heats than necessary to help prevent decarburization.

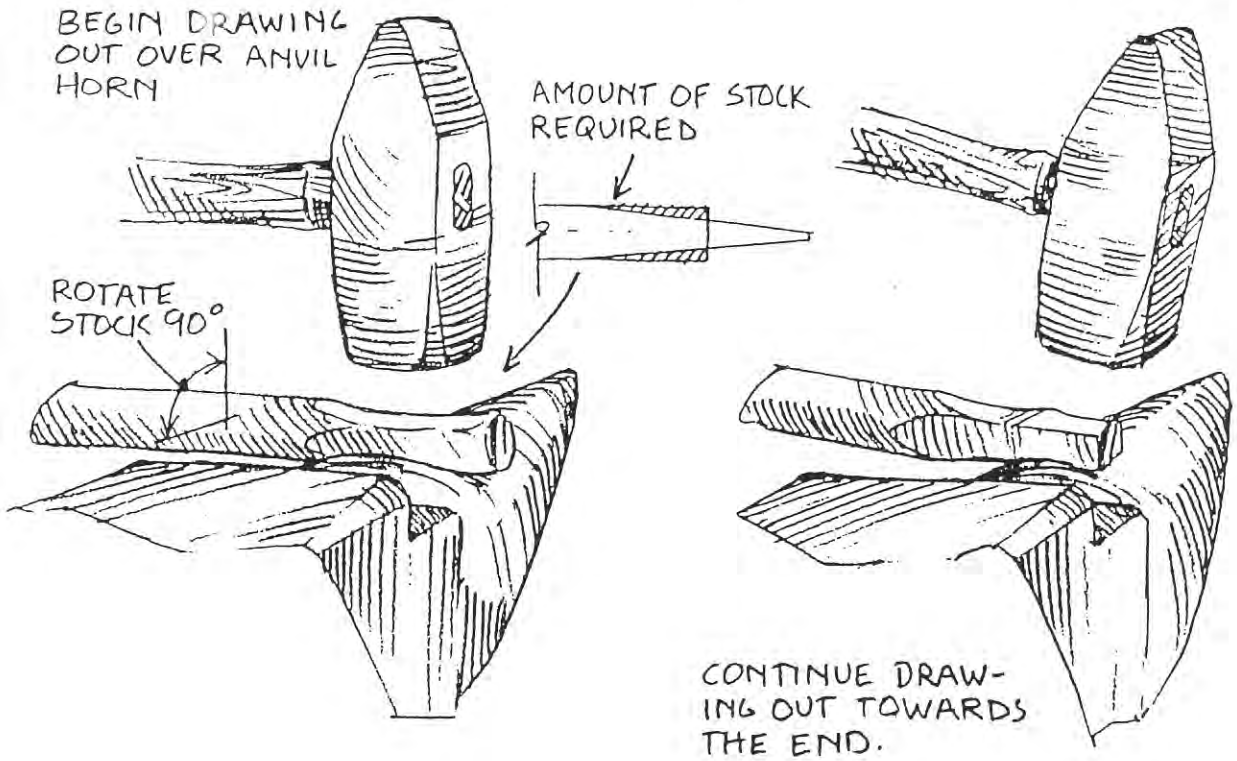
Normalize: Normalizing is a process where by the steel is air cooled from its hardening temperature after forging. Normalizing will remove much of the stress introduced by the forging process. Air hardening steels cannot be normalized.

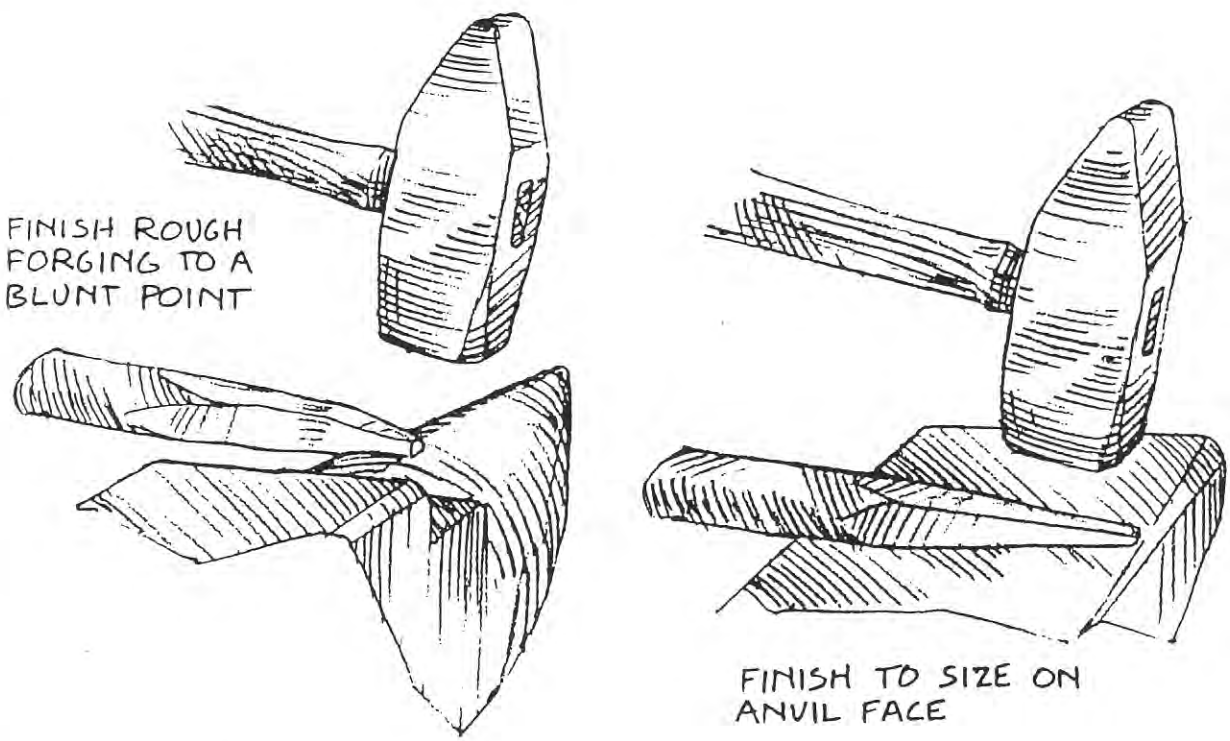
Anneal: Heating beyond the critical (hardening) temperature and air cooling will create varying degrees of hardness in tool steel. Slow cooling (annealing) returns it to its softest possible condition. Some steels such as S7 and H13 require very slow cooling rates that can be difficult to control without a furnace. Softness can be tested by comparing how well a file can cut steel that has been heated beyond the critical temperature, then annealed, and one that has not.

Machine: Most tools that you make will require some grinding and filing after forging. This should be done before hardening when the steel is soft and easy to cut.

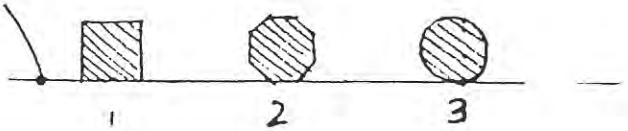
Harden: Heating to a specified (critical) temperature and quenching in a suitable medium will harden tool steel. Steels are classified as

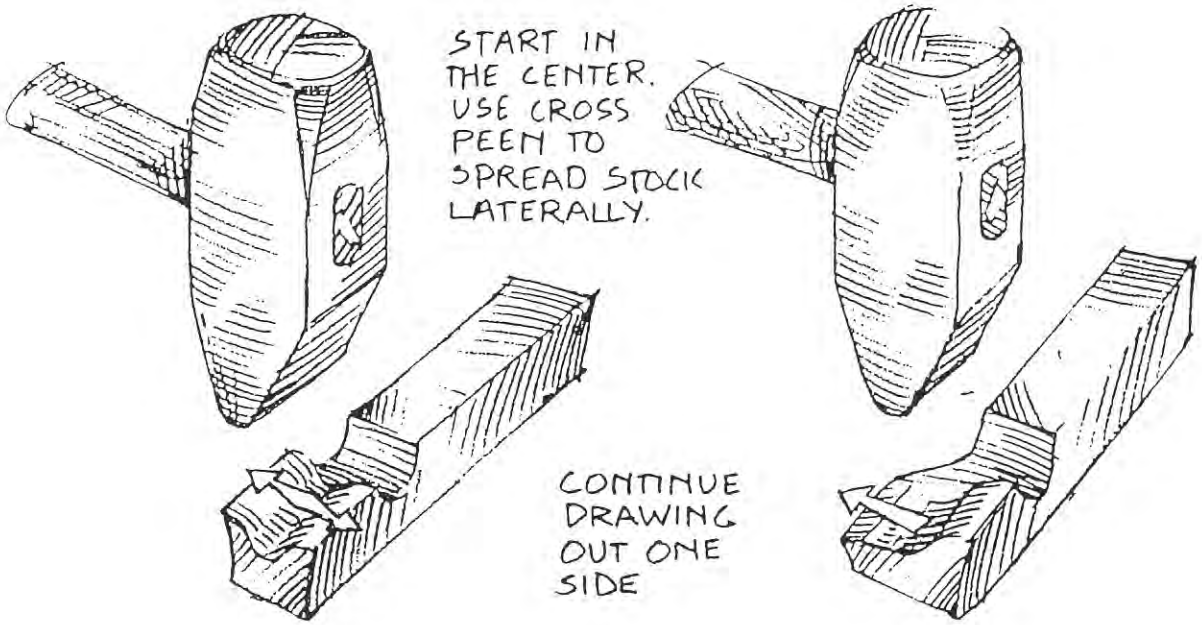
DRAWING OUT

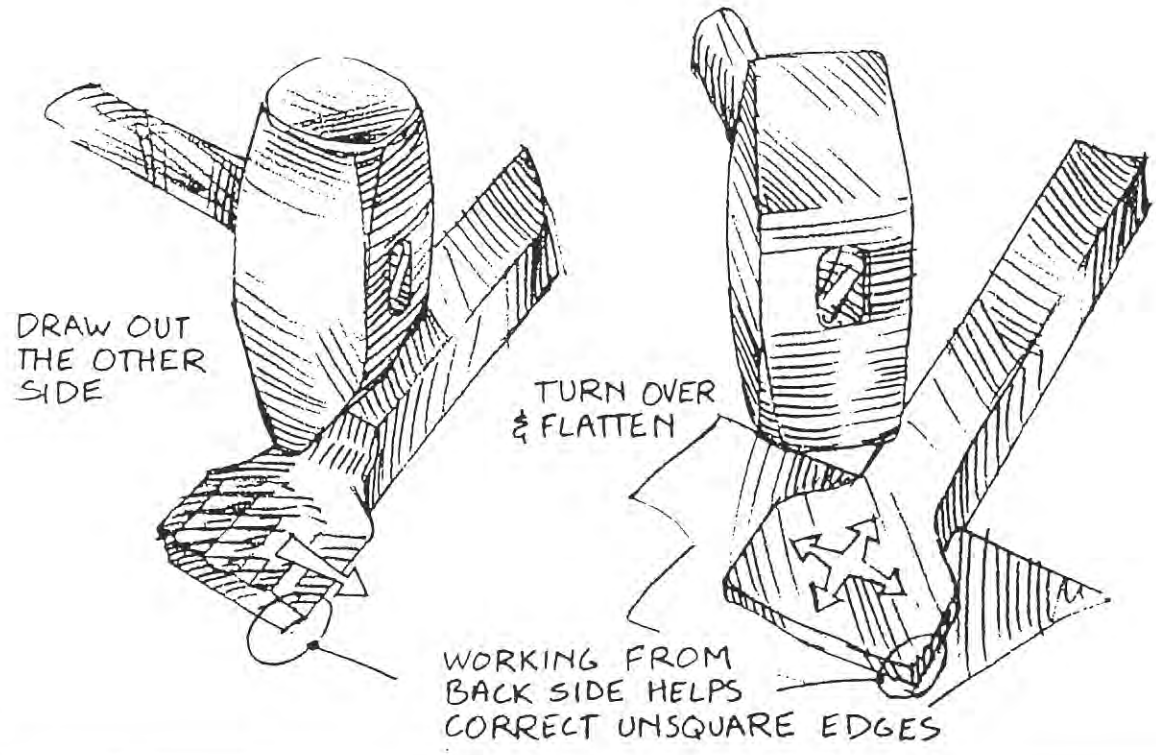




TO MAKE A ϕ TAPER, CONTINUE FORGING INTO AN OCTAGON SHAPE - THEN ROUND

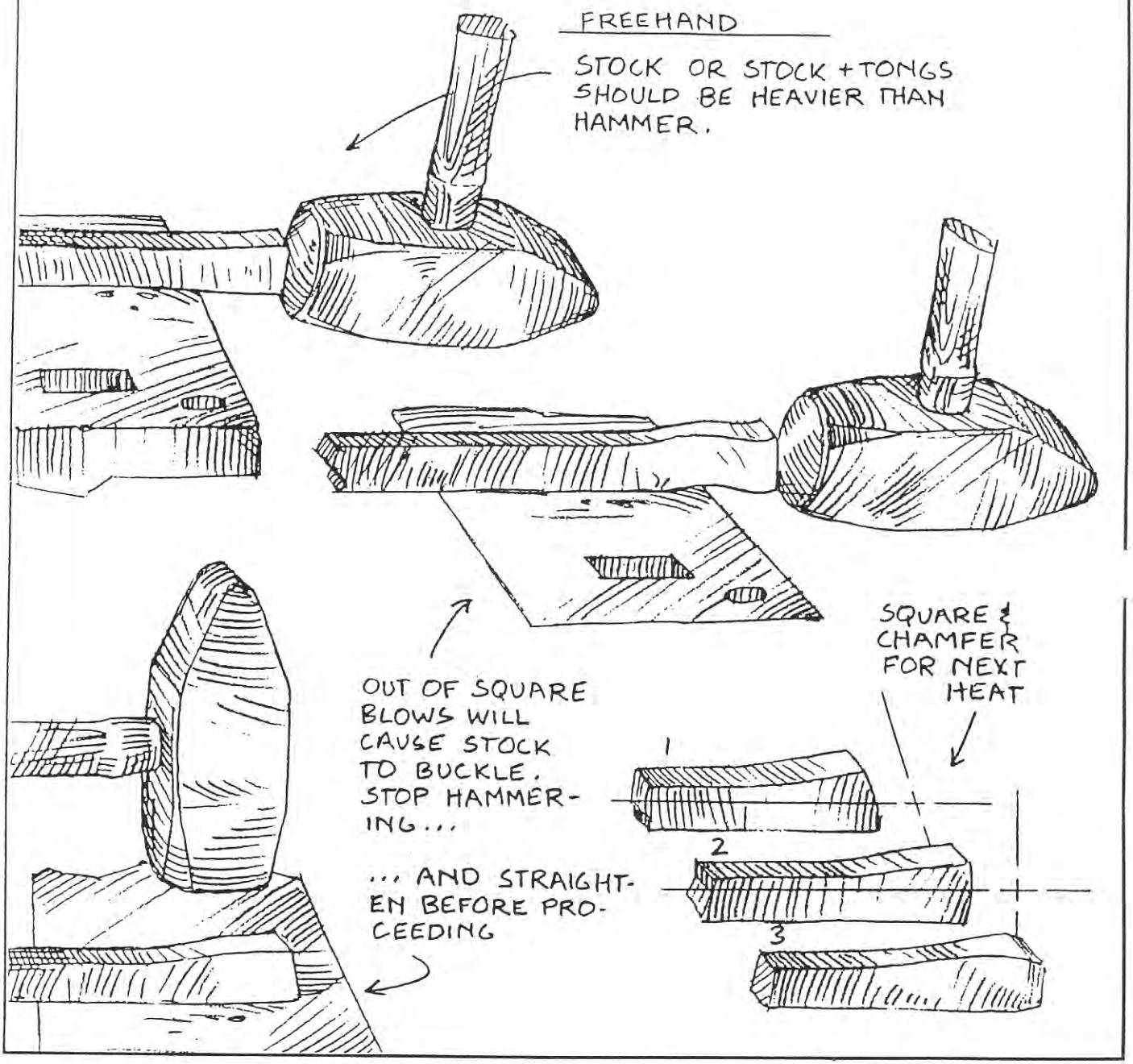


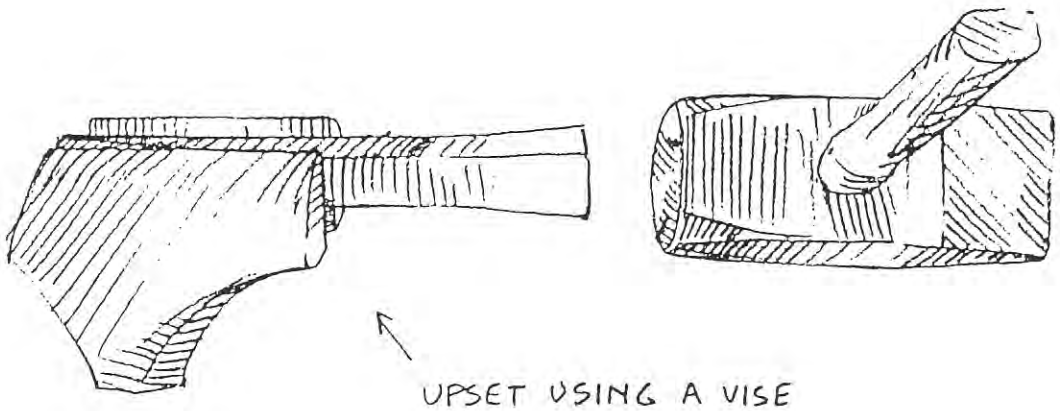

START IN THE CENTER. USE CROSS PEEN TO SPREAD STOCK LATERALLY.
CONTINUE DRAWING OUT ONE SIDE


DRAW OUT THE OTHER SIDE
TURN OVER & FLATTEN
WORKING FROM BACK SIDE HELPS CORRECT UNSQUARE EDGES

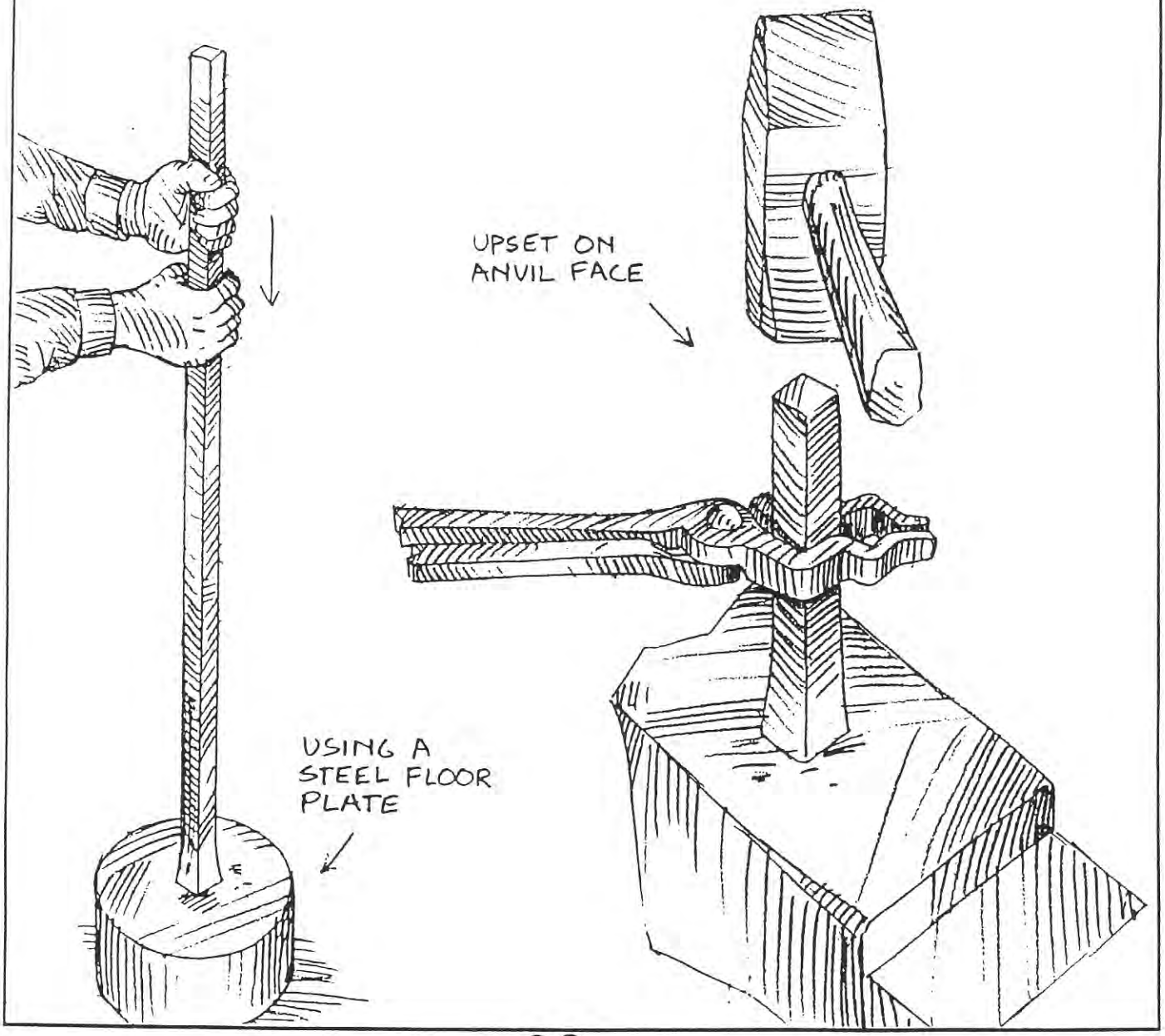
UPSETTING

Upsetting is a process in which the stock becomes thicker and shorter as a result of hammering on one end. It is most commonly used for preparing scarfs (111.2-1), forming rivet heads & rosettes and for other applications where extra mass is needed. Upsetting does have it's limitations, and it is sometimes easier to forge weld more material to the piece than it is to upset it.



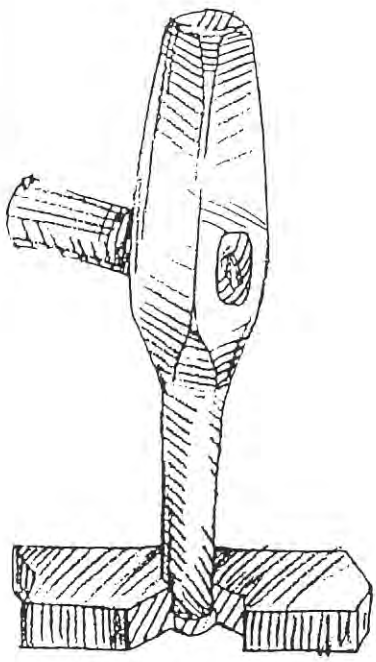


UPSET USING A VISE

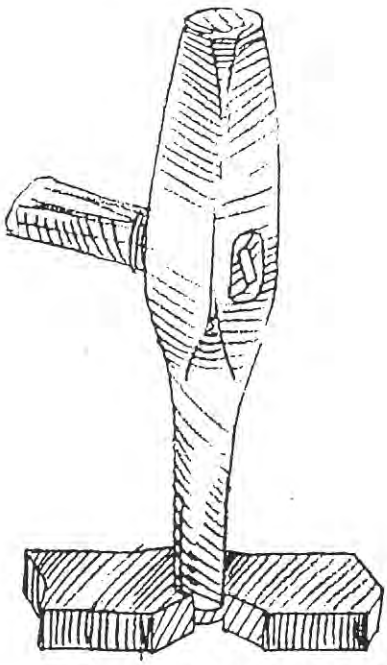


PUNCHING

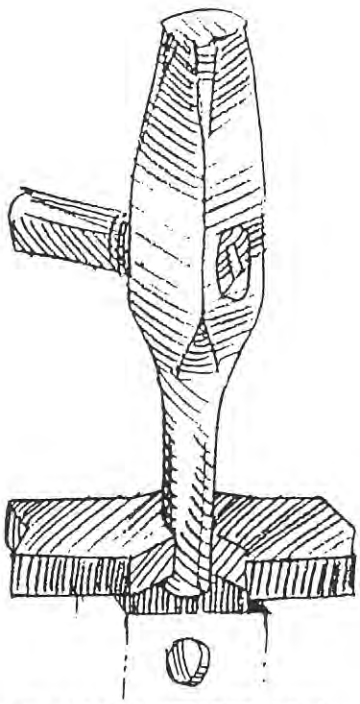
Hot punching enables you to punch relatively thick stock, using hand held tools, with less material loss than if you were cold punching or drilling. Holes can also be slot punched; this technique combines splitting and drifting to make holes with little or no material loss. Slot punched holes do not weaken the stock as much as holes made by other methods.



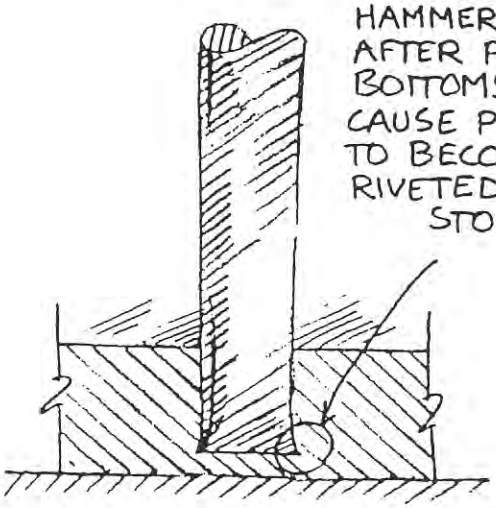
PUNCH 2/3 THROUGH OR UNTIL PUNCH BOTTOMS (BECOMES HARD TO DRIVE)



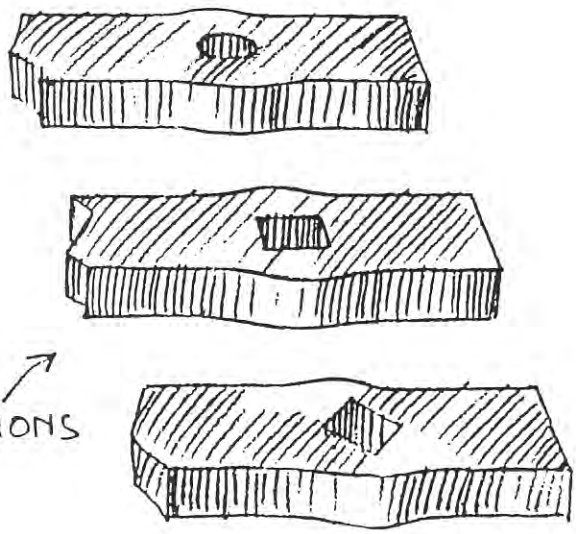
TURN STOCK OVER, LOCATE MARK MADE BY ANVIL FACE & PUNCH



PUNCH THROUGH

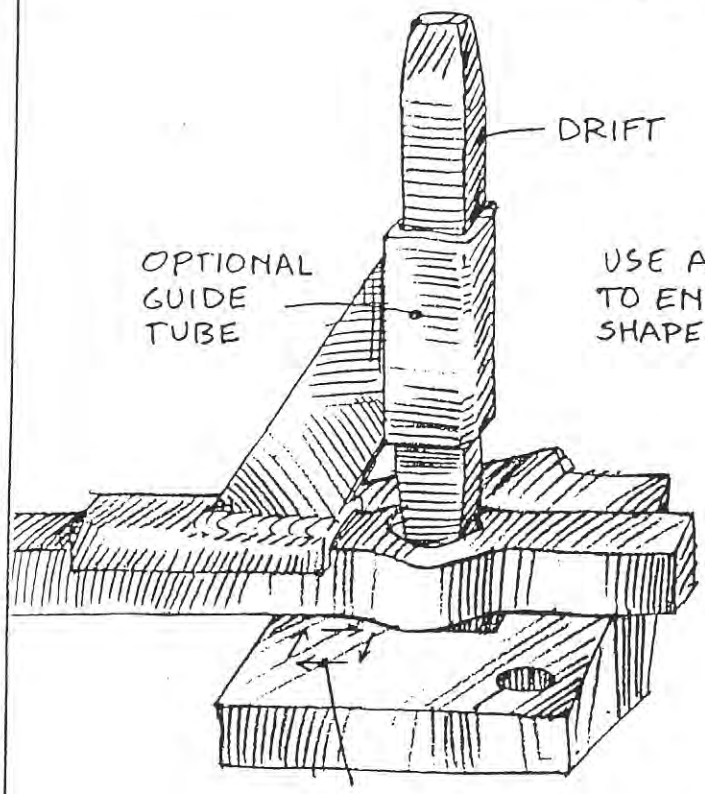


CONTINUED HAMMERING AFTER PUNCH BOTTOMS MAY CAUSE PUNCH TO BECOME RIVETED TO STOCK



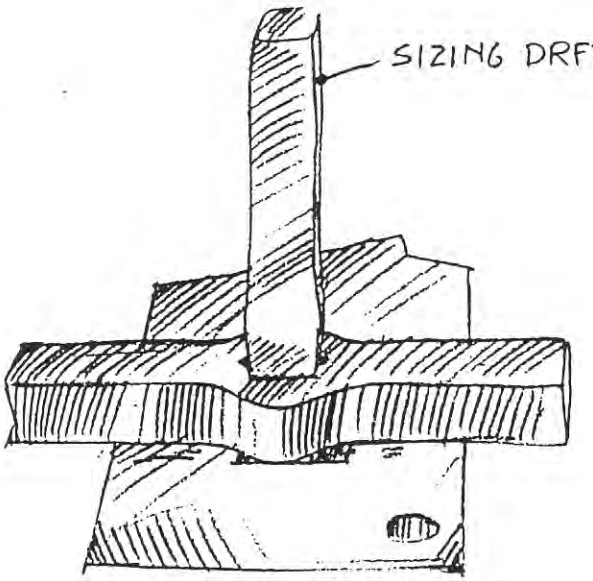
VARIATIONS

DRIFTING

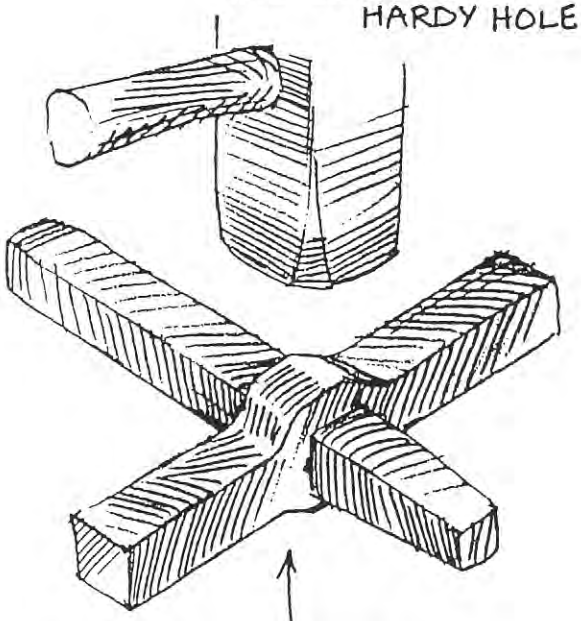


USE A DRIFT TO ENLARGE & SHAPE THE HOLE

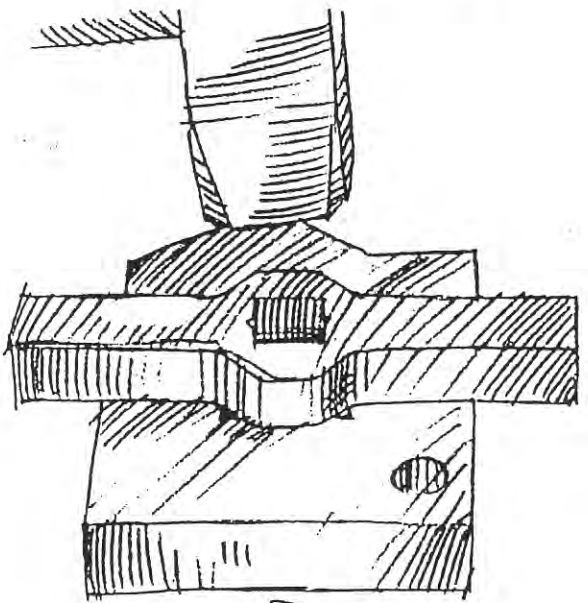
DRIFT TO FINISHED SIZE



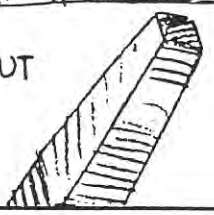
BACK UP IN ALTERNATING CORNERS OF HARDY HOLE



HAMMER "FLATS" BEFORE DRIVING DRIFT ALL THE WAY

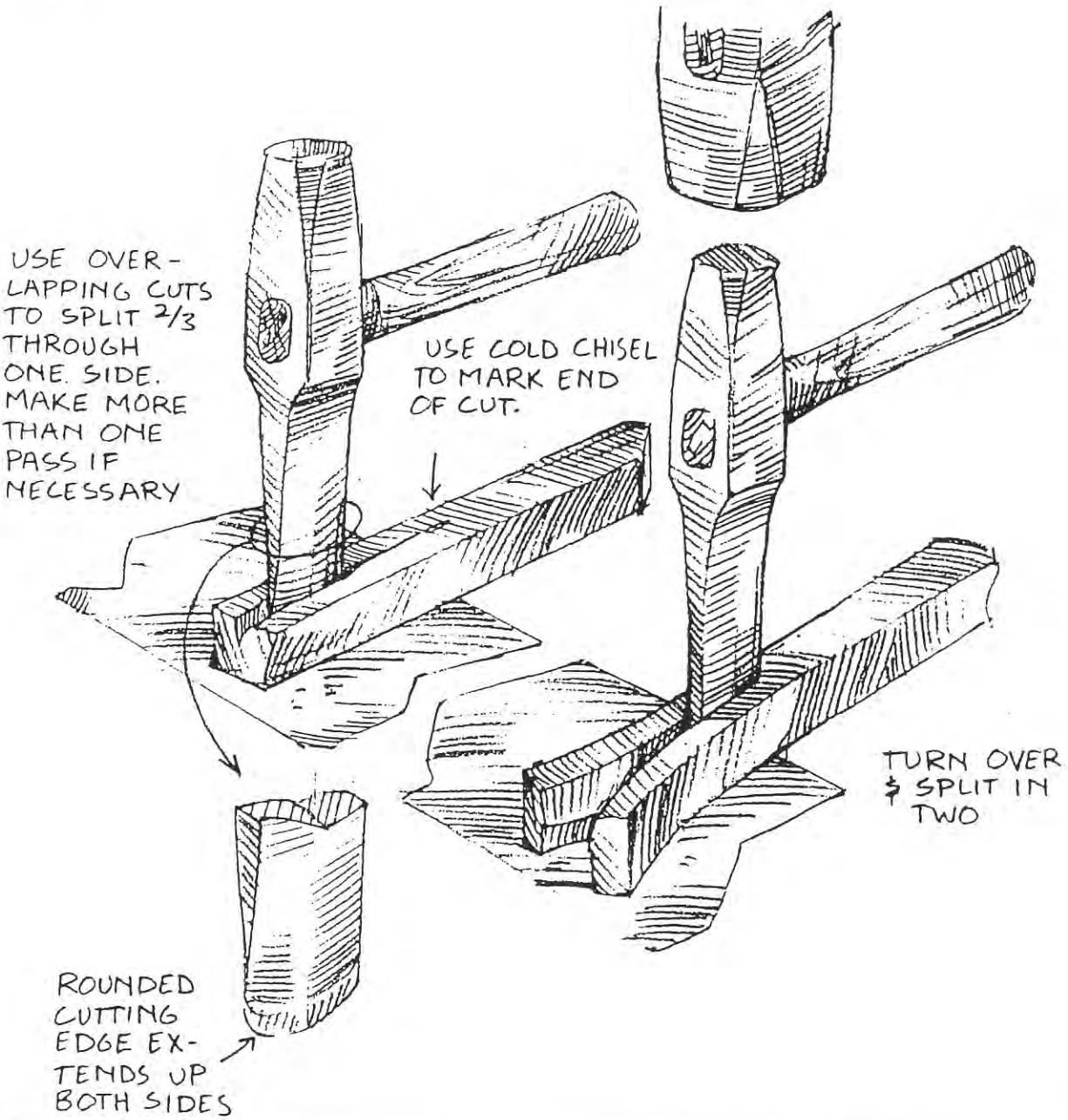


KNOCK OUT DRIFT

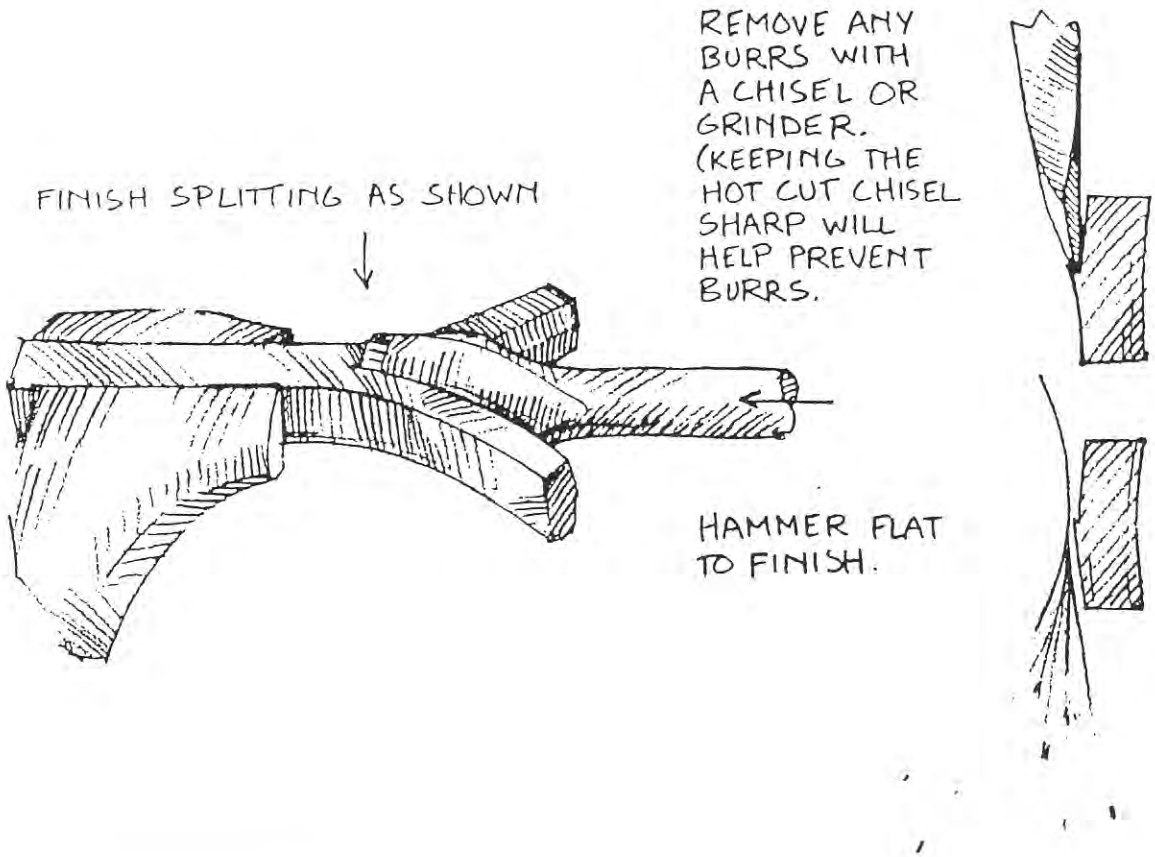


SPLITTING

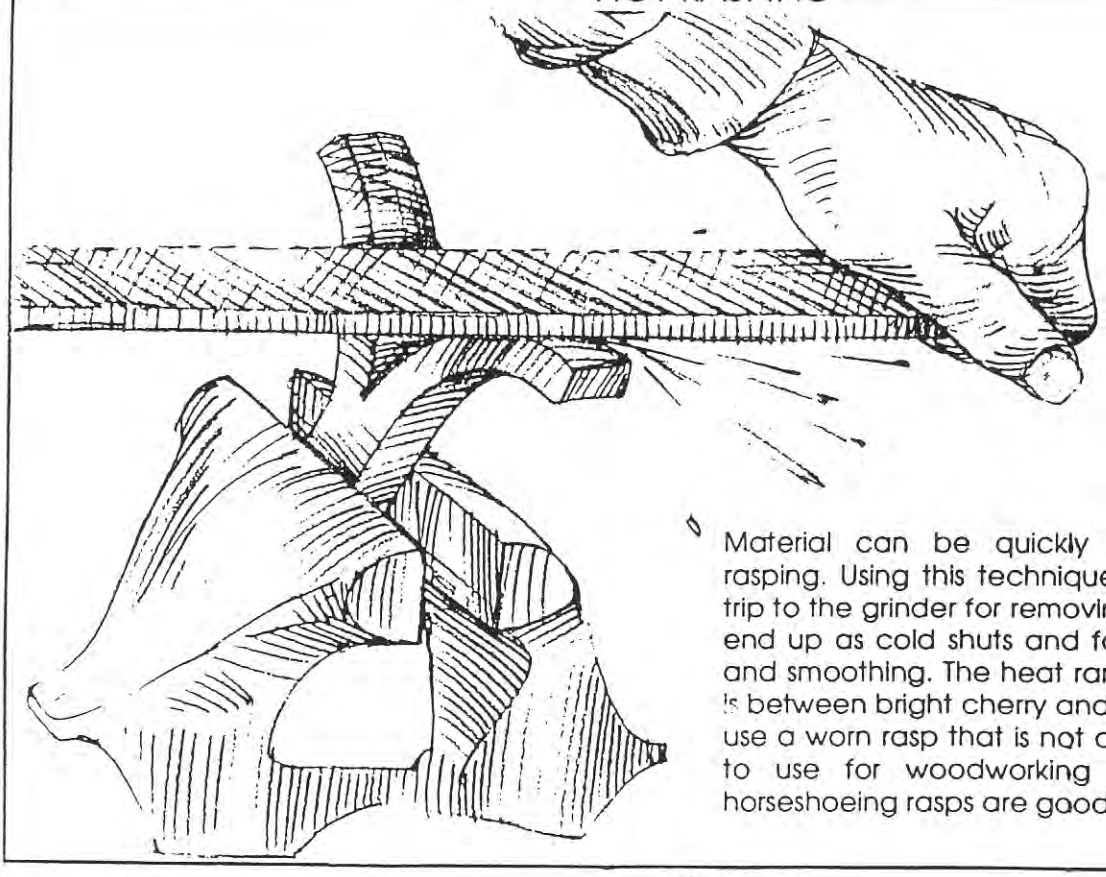
The "hot cut" chisel is one of a blacksmith's most versatile tools. it can be used for splitting the end or middle of a bar, cutting barbs and scroll shapes on edges, and making grooves. It's rounded blade penetrates easily, and enables the user to split any length section using overlapping cuts. A hot cut should not be confused with a cut off chisel used for trimming stock with a straight blade.



SPLITTING



HOT RASPING



Material can be quickly removed by hot rasping. Using this technique will often save a trip to the grinder for removing edges that may end up as cold shuts and for general shaping and smoothing. The heat range for hot rasping is between bright cherry and yellow. It is best to use a worn rasp that is not quite good enough to use for woodworking any more. Used horseshoeing rasps are good for this purpose.

EXERCISE IN SPLITTING

Making a 1/2" hole through 1/2" square stock.

1. Split with splitting chisel.

2. Use "opener" - a tapered drift with flattened end and gradual transition to oval or round cross section. Just open partially in this step.

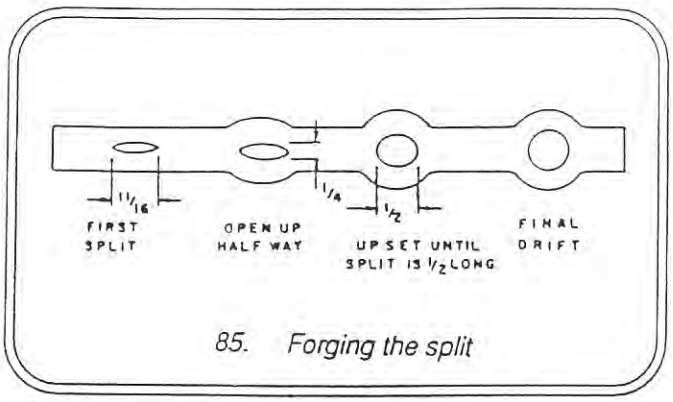
3. Upset from the end. This step is important. It preserves the thickness of the sides of the hole while making them bulge out.

4. Finally, drive a round drift through for accurate size.

5. Note that the bar loses length in this process. For dimensional work, make a test piece and determine the amount of shrinkage, as measured to the center of the hole.

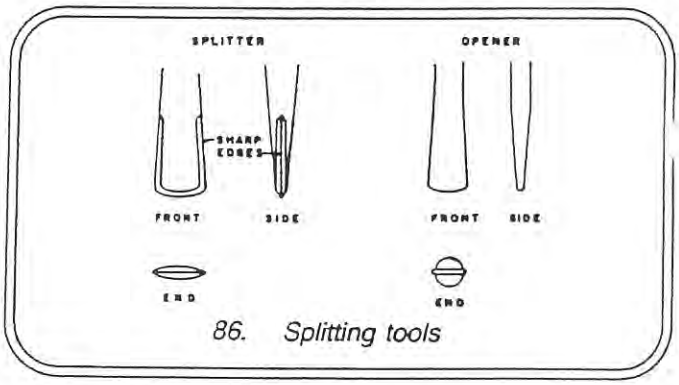
6. Note also that the edge-length of the appropriate chisel is greater than the diameter of the finished hole: **about 40% longer**, which is a little **less** than half the circumference of the finished hole, to allow for stretching. (It works out to 89.29% of 1/2 the circumference. See table following.)

* A nice way to collar scrollwork to a gate frame or attach chain to a chandelier, is to split and open a hole just a little in from one edge of the *flat stock* frame. This



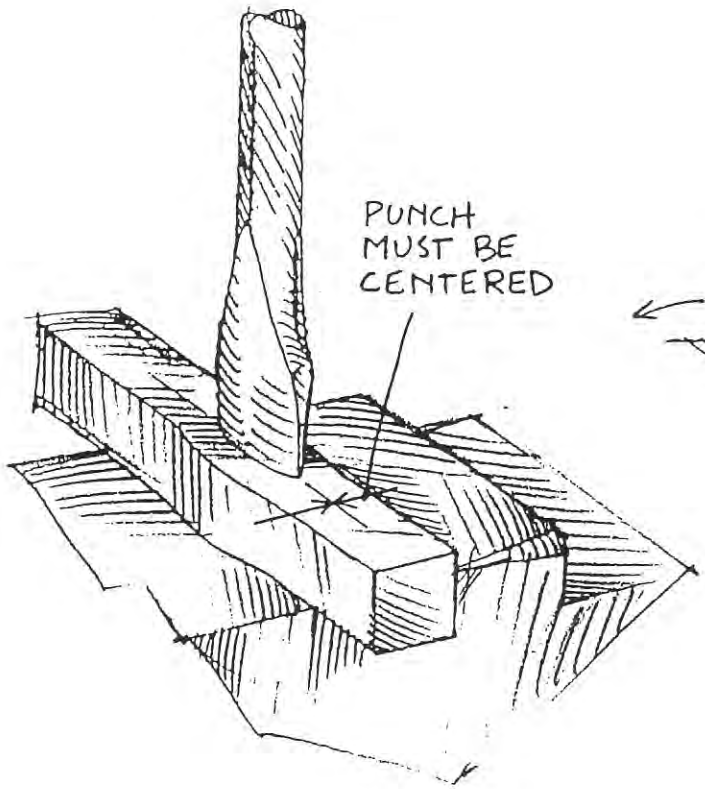
85. Forging the split

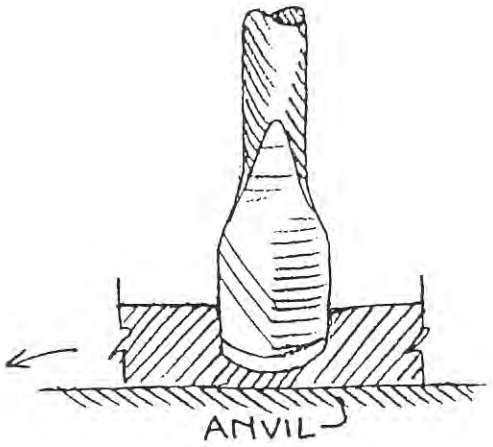
requires a splitting chisel the right size (with rounded corners and a sharp edge) , a tapered drift to open up the split, and sometimes another drift to shape the hole round or rectangular. Dress a rectangular slot as you would a hammer eye, with a tapered rectangular drift put in first from one side and then the other.



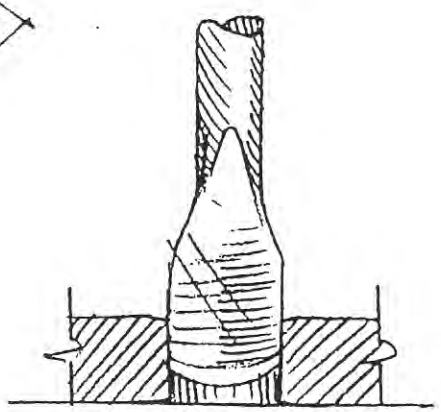
86. Splitting tools

MAKING AN EYE

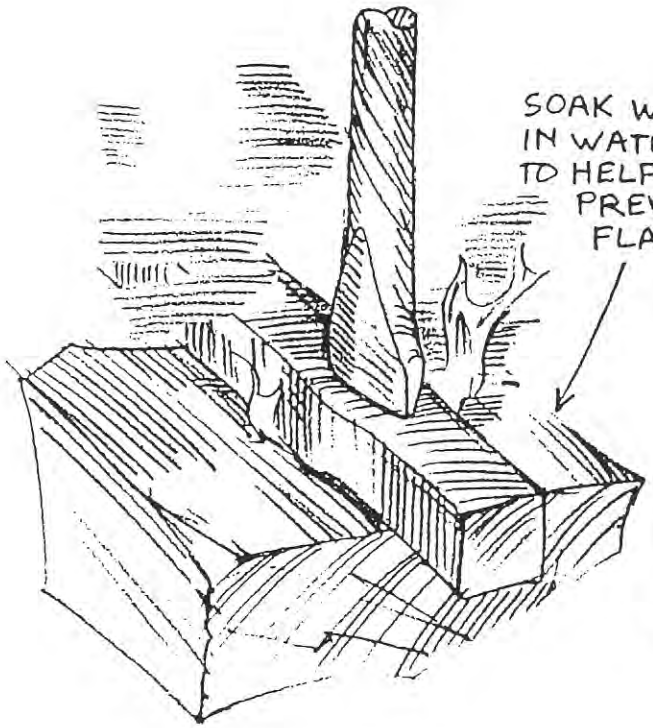




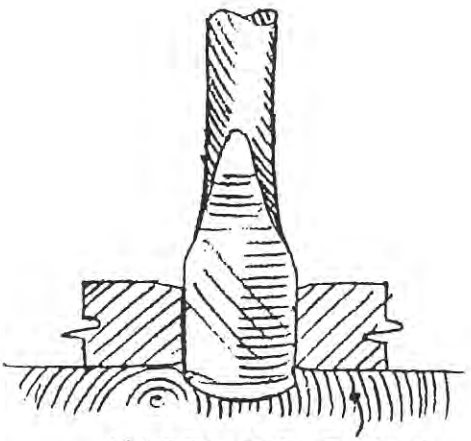
1. PUNCH 2/3 THROUGH



2. TURN OVER & PUNCH

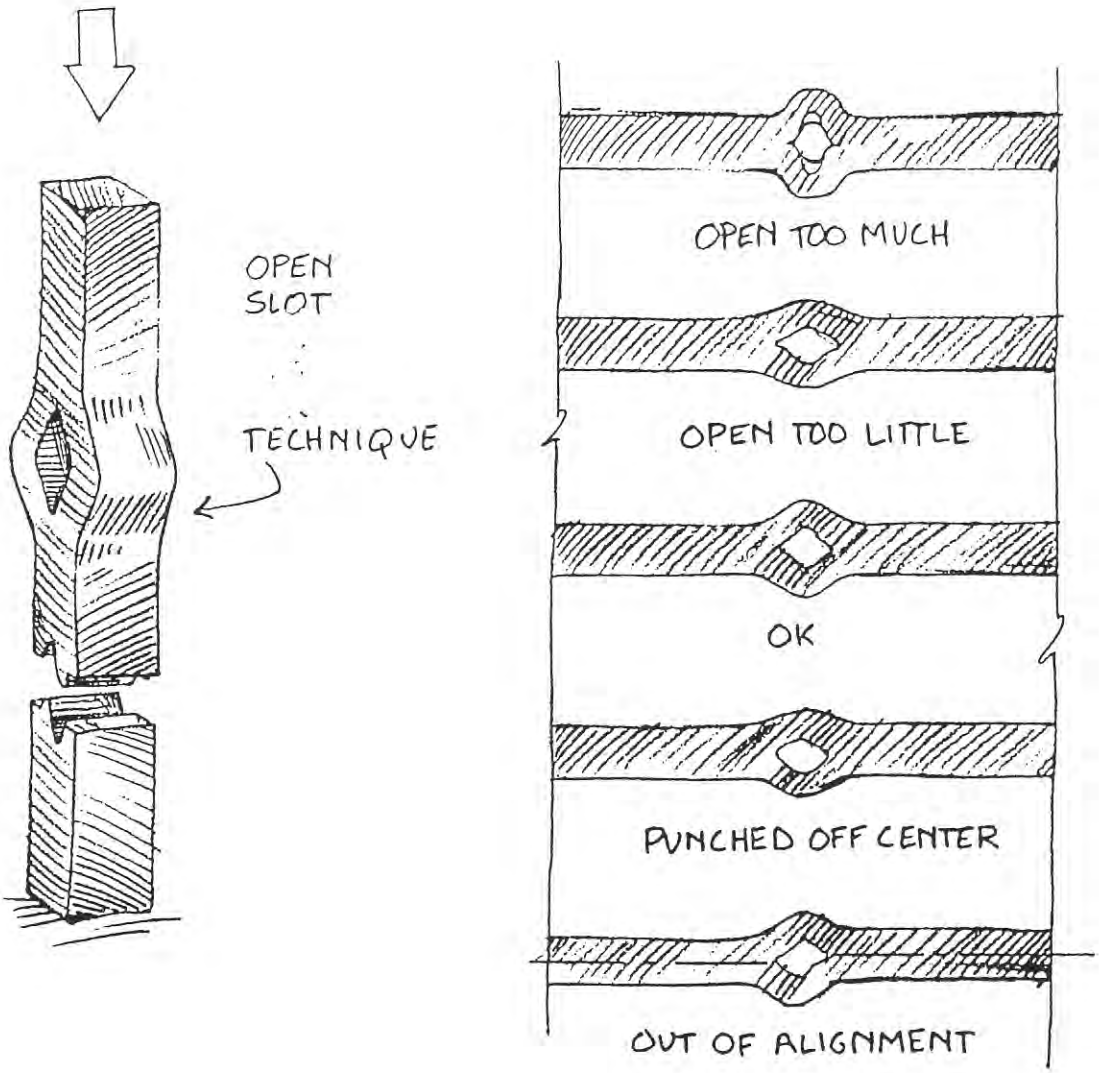


Hard wood block or copper plate



HARDWOOD BLOCK

3. DRIFT


OPEN SLOT
TECHNIQUE
OPEN TOO MUCH
OPEN TOO LITTLE
OK
PUNCHED OFF CENTER
OUT OF ALIGNMENT

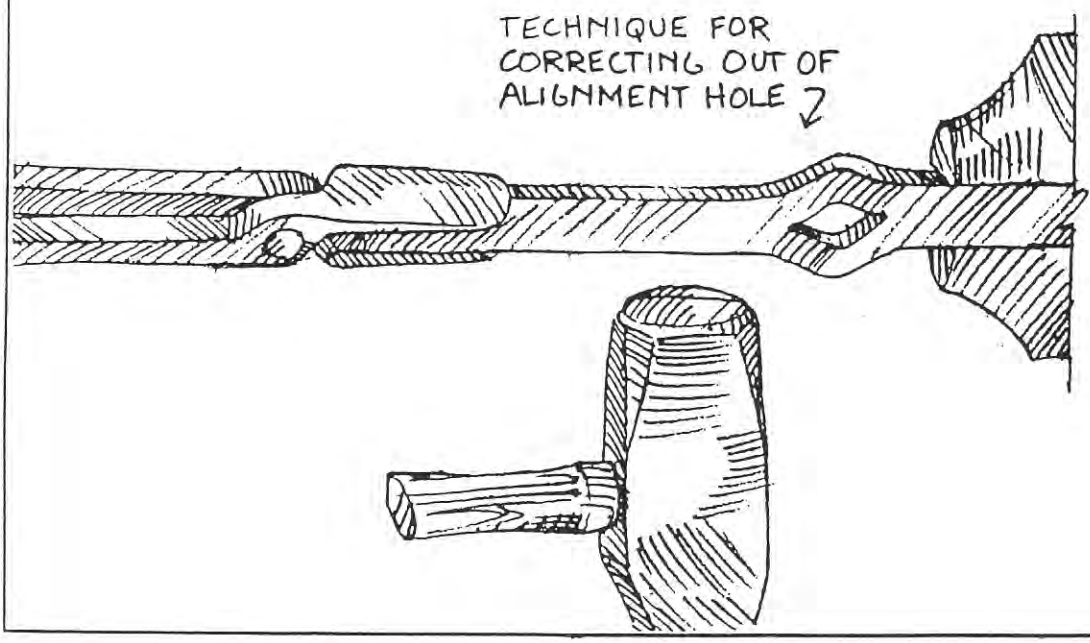

TECHNIQUE FOR CORRECTING OUT OF ALIGNMENT HOLE

TABLE I

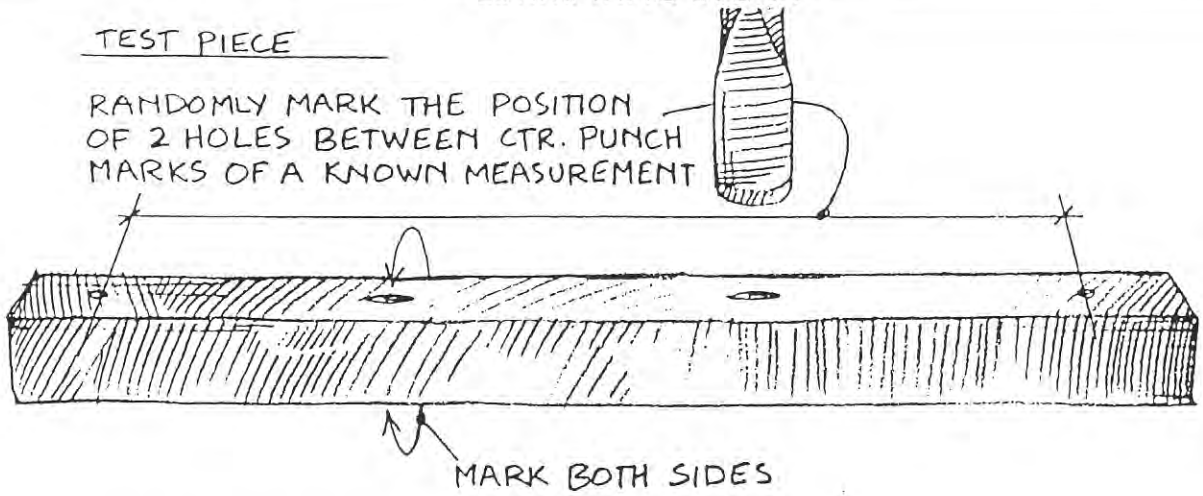
SLITTING CHISEL EDGE-LENGTH FOR DRIFTED HOLES

	round holes: Diam. +40%		Square holes:Perimeter + 45%	
HOLE SIZE	DECIMAL	FRACTION	DECIMAL	FRACTION
3/8	.525	17/32	.668	21/32
1/2	.700	45/64	.890	57/64
5/8	.875	7/8	1.113	1-7/64
3/4	1.050	1-3/64	1.335	1-21/64
7/8	1.225	1-7/32	1.558	1-35/64
1	1.400	1-13/32	1.780	1-25/32
1-1/8	1.575	1-37/64	2.003	2
1-1/4	1.750	1-3/4	2.225	2-7/32
1-3/8	1.925	1-59/64	2.448	2-7/16
1-1/2	2.100	2-7/64	2.670	2-43/64
1-5/8	2.275	2-17/64	2.893	2-57/64
1-3/4	2.450	2-29/64	3.115	3-7/64
1-7/8	2.625	2-5/8	3.338	3-21/64
2	2.800	2-13/16	3.560	3-9/16
2-1/4	3.150	3-5/32	4.005	4
2-1/2	3.500	3-1/2	4.450	4-29/64
2-3/4	3.850	3-27/32	4.895	4-57/64
3	4.200	4-13/64	5.340	5-11/32
3-1/4	4.550	4-9/16	5.785	5-25/32
3-1/2	4.900	4-57/64	6.230	6-15/64
3-3/4	5.250	5-1/4	6.675	6-43/64
4	5.600	5-39/64	7.120	7-1/8

NOTES:
1. The figures for square holes are an extension of the same rule, but I haven't tested it in practice so be careful and do a test piece.
2. In practice all these crazy 64ths should probably be rounded down to the closest 1/32 or 1/16.

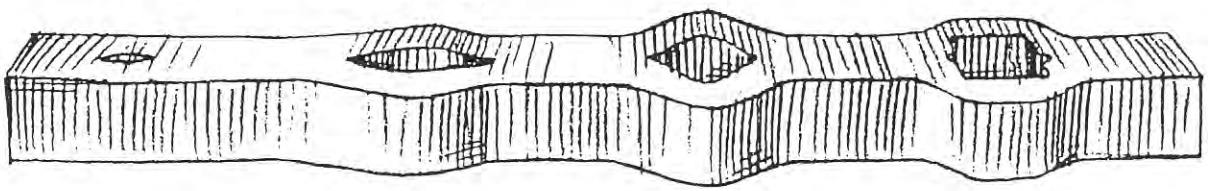
TEST PIECE

RANDOMLY MARK THE POSITION OF 2 HOLES BETWEEN CTR. PUNCH MARKS OF A KNOWN MEASUREMENT

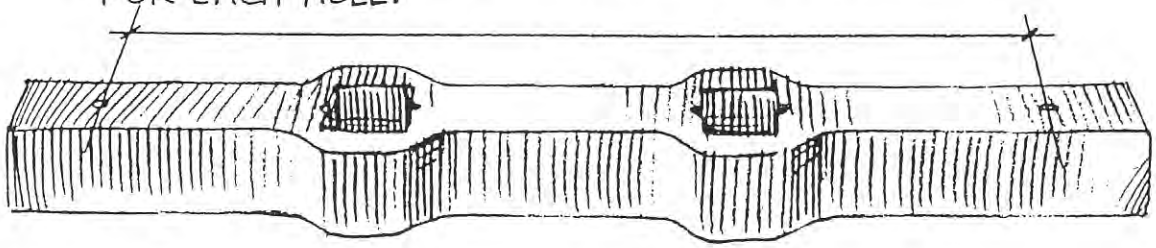


MARK BOTH SIDES

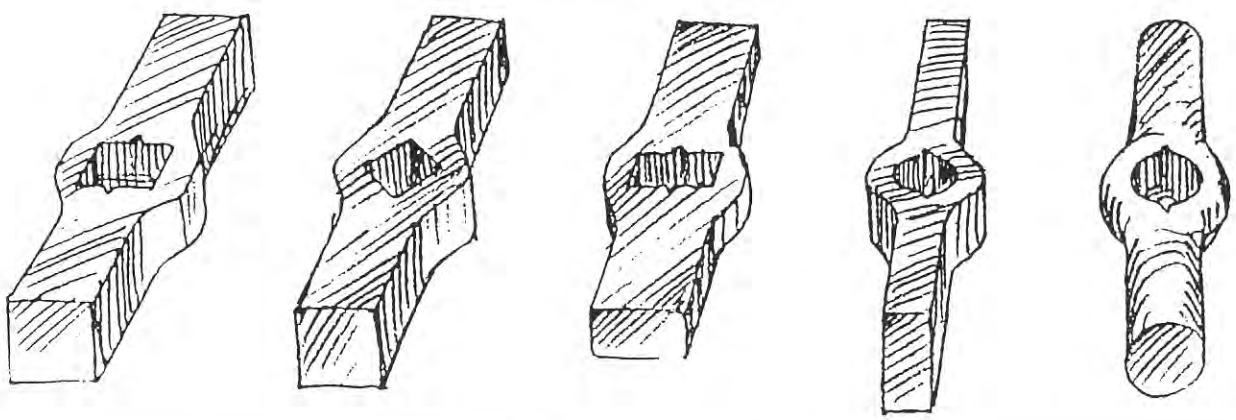
PUNCH THE TWO HOLES!

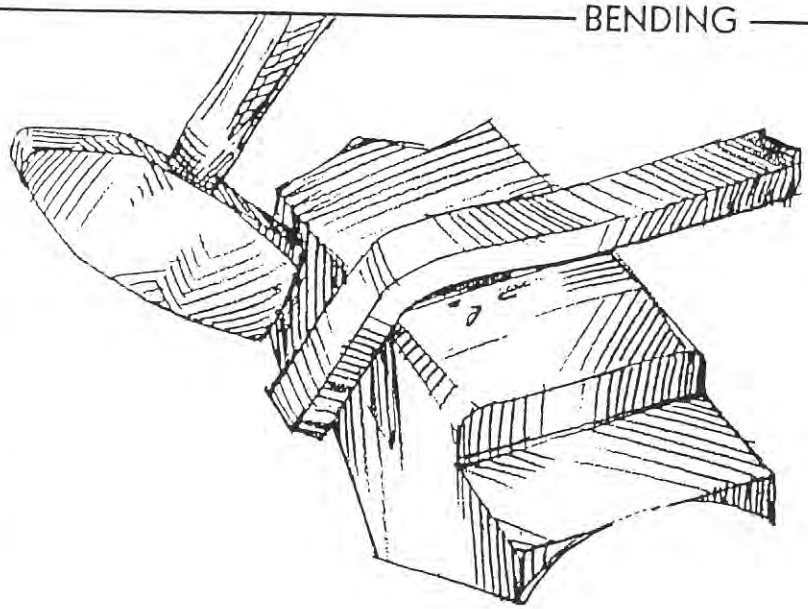


MEASURE BETWEEN MARKS AGAIN, SUBTRACT FROM KNOWN MEASUREMENT, & DIVIDE X 2 TO FIND AMOUNT OF SHRINKAGE FOR EACH HOLE.



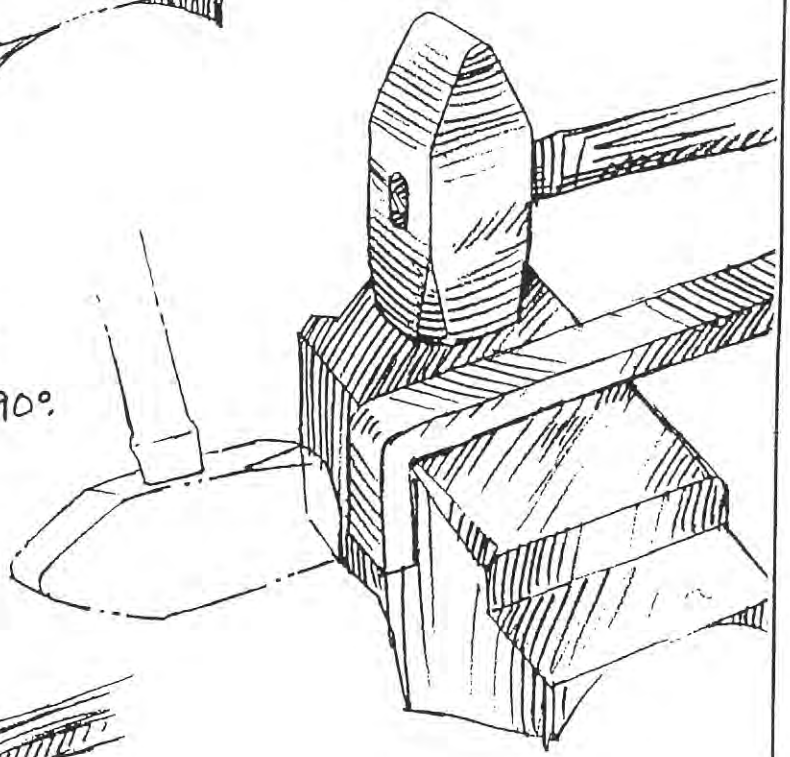
VARIATIONS



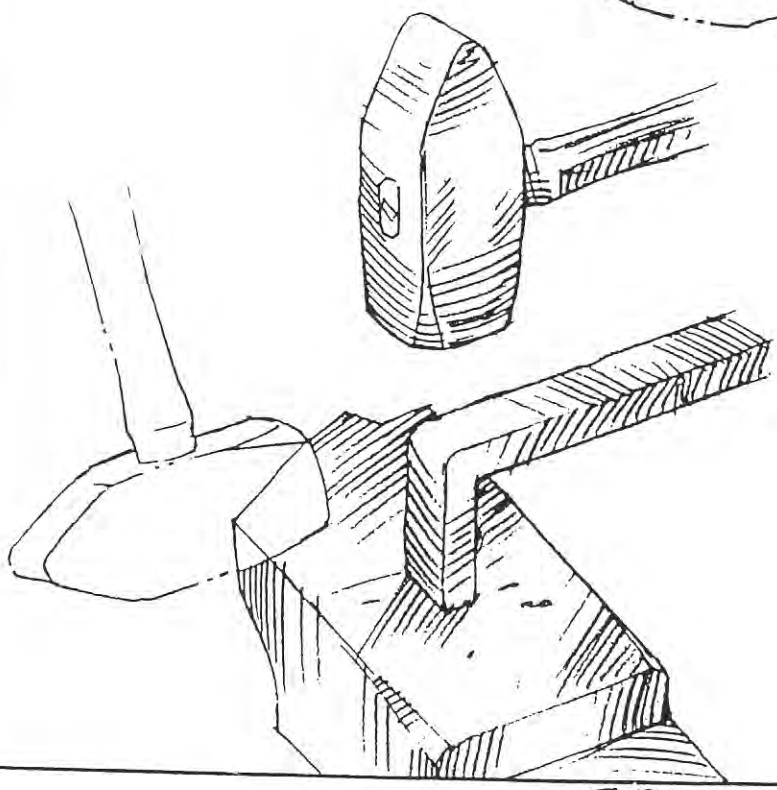


RIGHT ANGLE BEND

START OVER SLIGHTLY ROUND EDGE OF ANVIL. HAMMER JUST BEYOND THE BEND.



STRAIGHTEN THE STOCK BEHIND THE BEND BEFORE FINISHING @ 90°.



HAMMER AS SHOWN TO TIGHTEN UP THE BEND A LITTLE BIT.

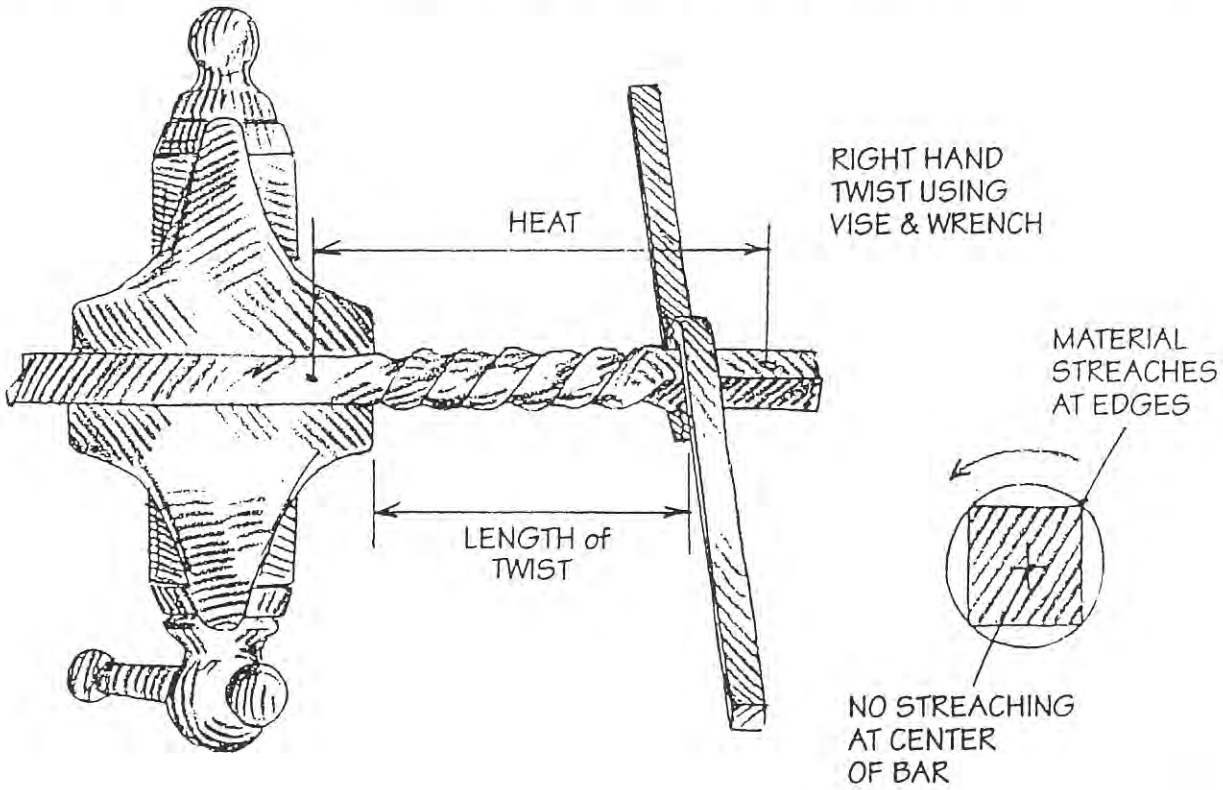
TWISTING

Twisting is an important technique, unique to our medium, that enables us to create complex helical designs using just basic tools. Following are some fundamental considerations for twisting square bars.

Ill. 74-2 shows how the edges of the bar stretch while the center of the bar remains unchanged. The same effect occurs in round bars but it is not visible unless the surface is out of round, grooved, or changed in another way. In Ill. 74-3 you see the effect of the number of revolutions in a twist vs. its length. Because the center of the bar does not twist, the length of the bar always remains the same.

Using a vise and wrench (as opposed to a twisting jig or machine) makes it more difficult to keep the stock straight as it is twisted. Twist the stock in a horizontal position and use equal force on the wrench; always straighten before returning stock to the forge as shown in Ill. 74-7 & 74-8. Use a torch to heat areas of a twist that need to be tightened, and cool areas already tight enough with water (see 22-1 & 22-2).

It is often necessary to take more than one heat to complete a long twist due to the heating limitations of a forge. To keep twists uniform, the last section of the twist from the first heat is not tightened all the way. On the second heat this section is "blended" into the first section of the second heat.



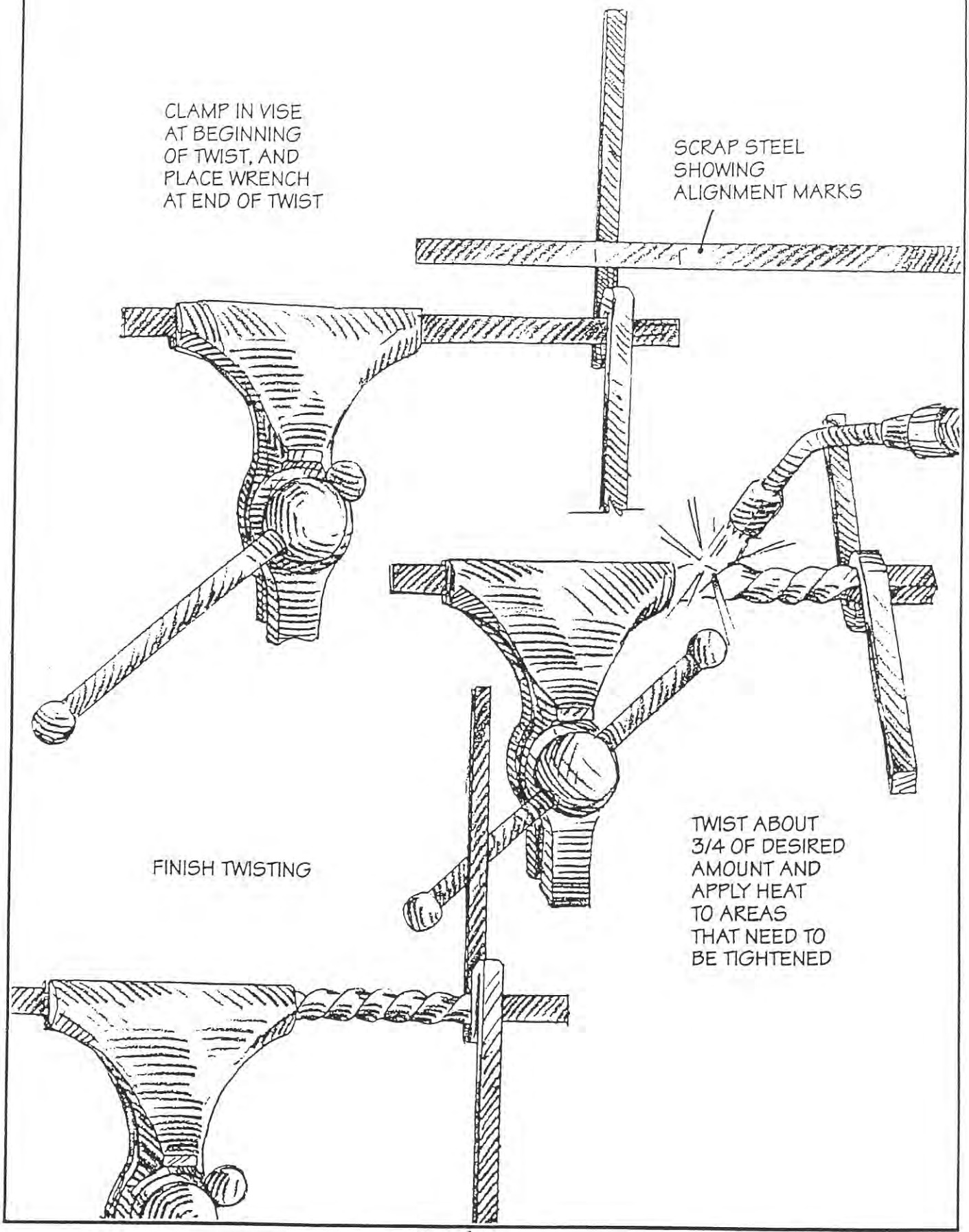

1 REVOLUTION, 1x LENGTH

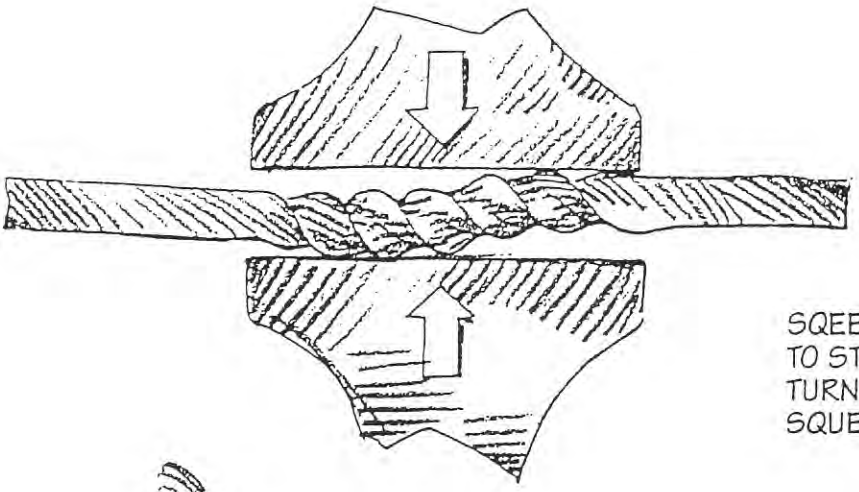

2 REVOLUTIONS, 1x LENGTH


2 REVOLUTIONS, 2x LENGTH

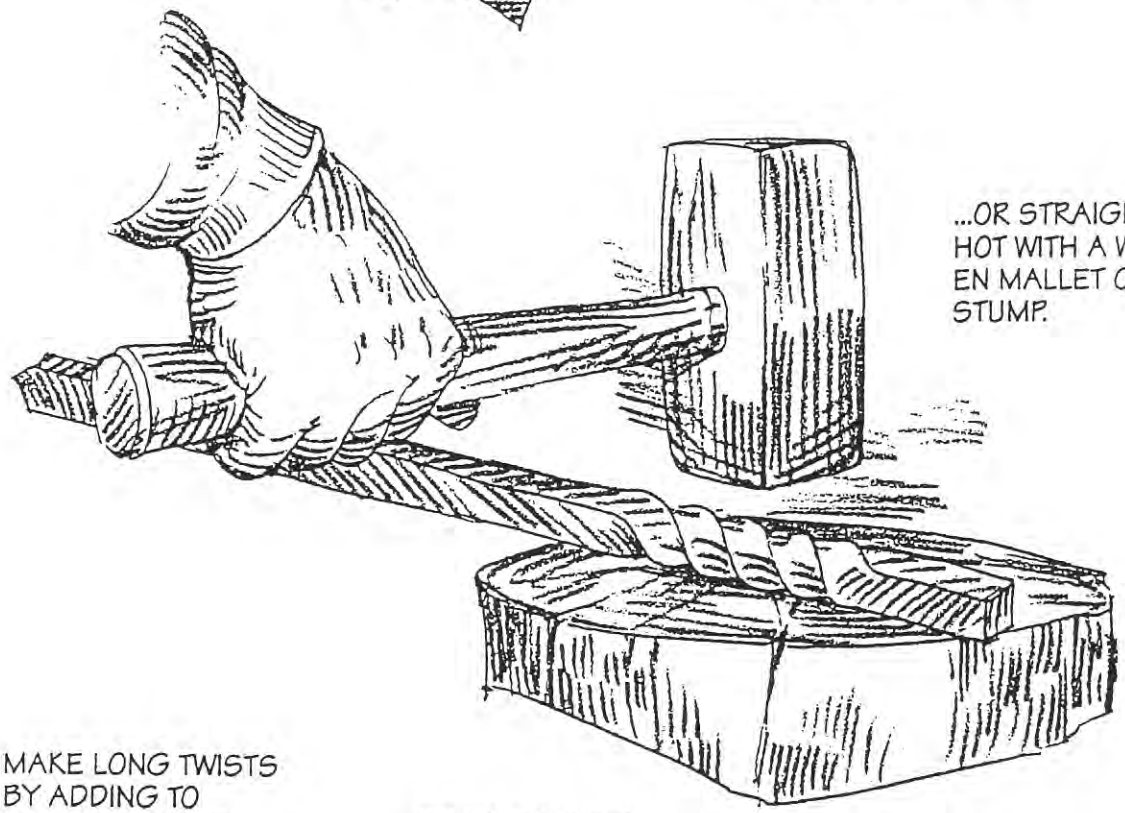

3 REVOLUTIONS, 1x LENGTH

TWISTING


CLAMP IN VISE AT BEGINNING OF TWIST, AND PLACE WRENCH AT END OF TWIST
SCRAP STEEL SHOWING ALIGNMENT MARKS
TWIST ABOUT 3/4 OF DESIRED AMOUNT AND APPLY HEAT TO AREAS THAT NEED TO BE TIGHTENED
FINISH TWISTING



SQEEZE IN VISE
TO STRAIGHTEN TWIST.
TURN 90° AND
SQUEEZE AGAIN...



...OR STRAIGHTEN
HOT WITH A WOOD-
EN MALLET ON A
STUMP.

MAKE LONG TWISTS
BY ADDING TO
PREVIOUS TWIST

DO NOT TIGHTEN
ALL THE WAY

TIGHTEN ON
NEXT HEAT

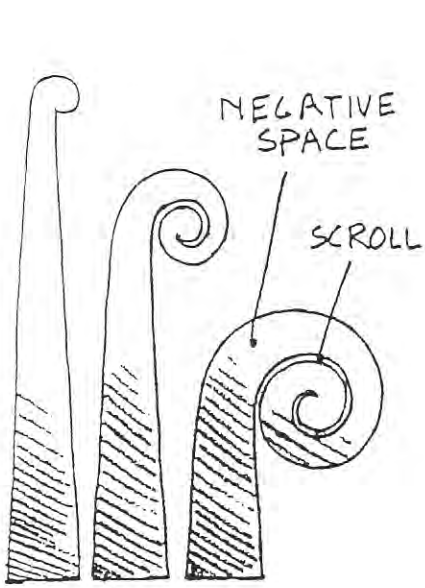
HEAT #1

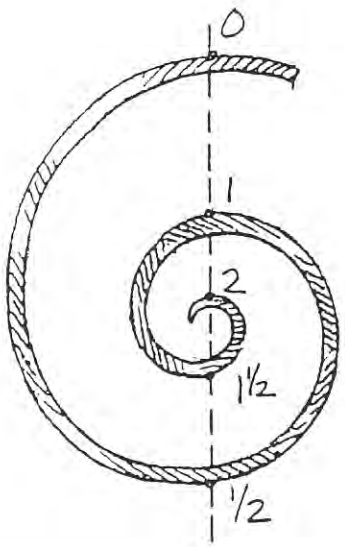
HEAT #2

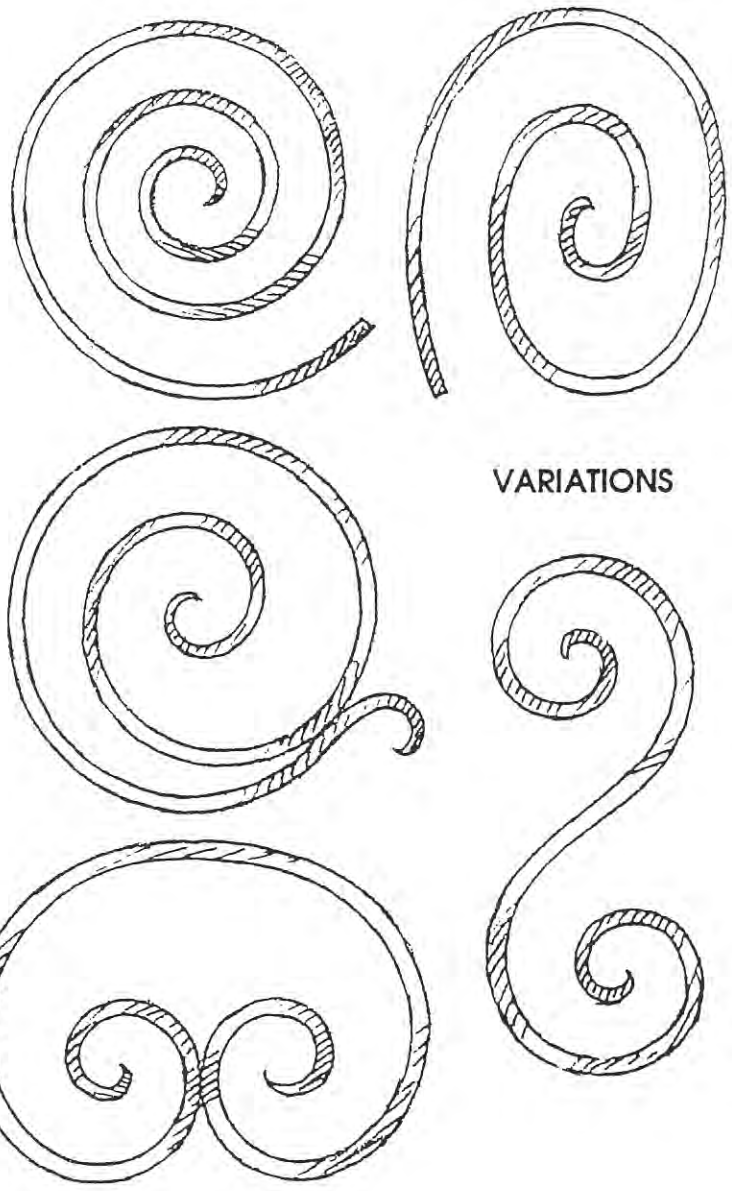
The size and shape of a scroll should be determined by the layout drawing of a particular design. See Ill. 30-4 & 39-2 for examples of scrolls made to fit specific designs. Attempting to make the design fit the scroll will often compromise the integrity of the work.

Take the time to make a scale drawing, and then re-draw full size on a steel layout surface (see Ill. 39-1–39-6). A scroll jig can then be made from your full scale drawing. Eventually you will have enough jigs to use for subsequent designs. Save one scroll made from each jig you have to use as a scroll drawing template for making full scale drawings. See page 142 for a full size drawing of a "generic" scroll that you can use as a guide for making a scroll jig (re-size on a copy machine if necessary).

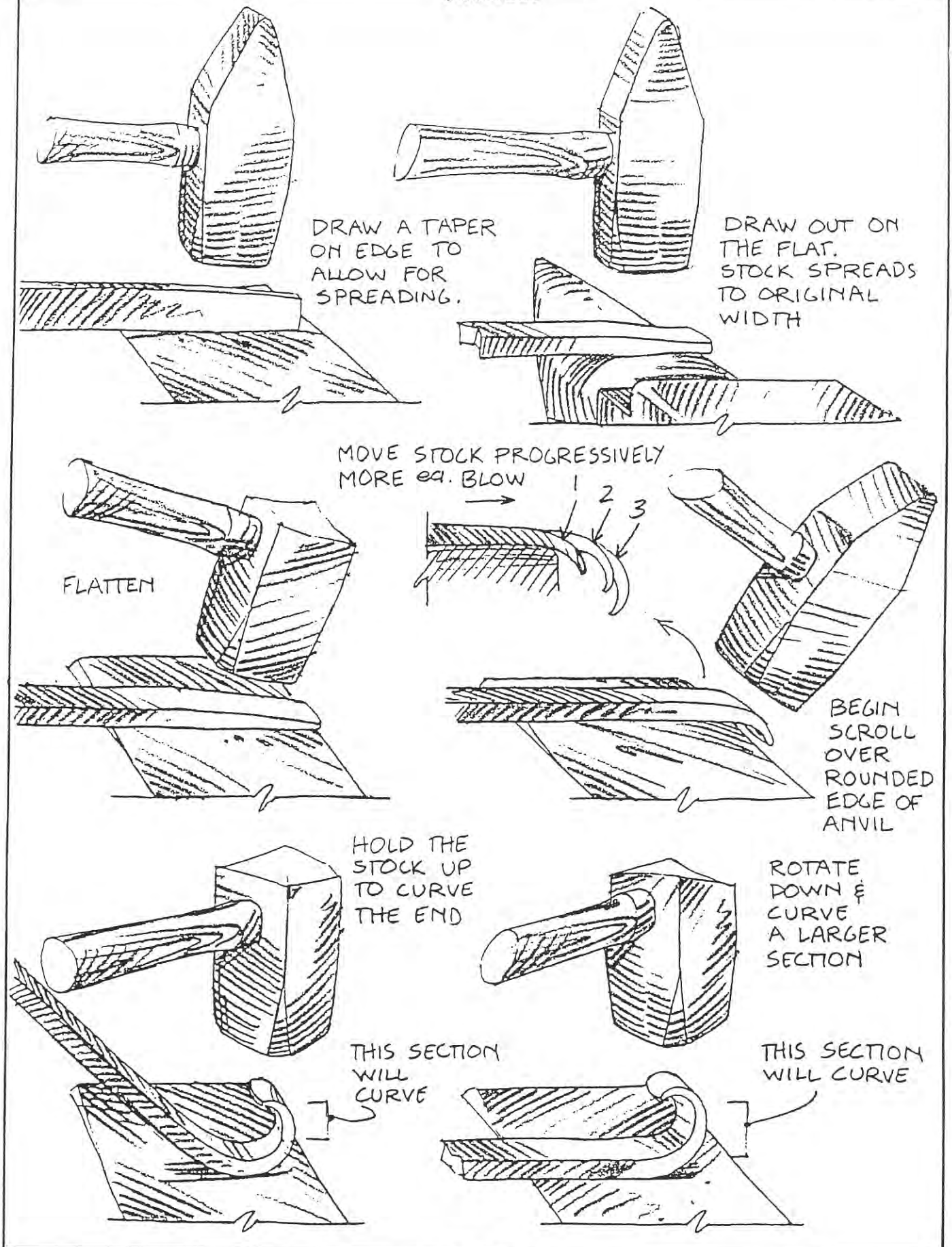
Although the shape of a scroll will vary depending on its specific use, there are some general rules that should be followed. If you look at the negative space in the spiral of a scroll, it should taper evenly to the center. Ill. 51-1 illustrates this point by changing the negative space to positive and unrolling it to reveal its shape as a straight taper. The proportion of negative space can be changed by varying the number of revolutions the spiral makes within a given space. Ill. 51-2 shows a scroll with two revolutions. The number of revolutions depends upon size, application and other design considerations.

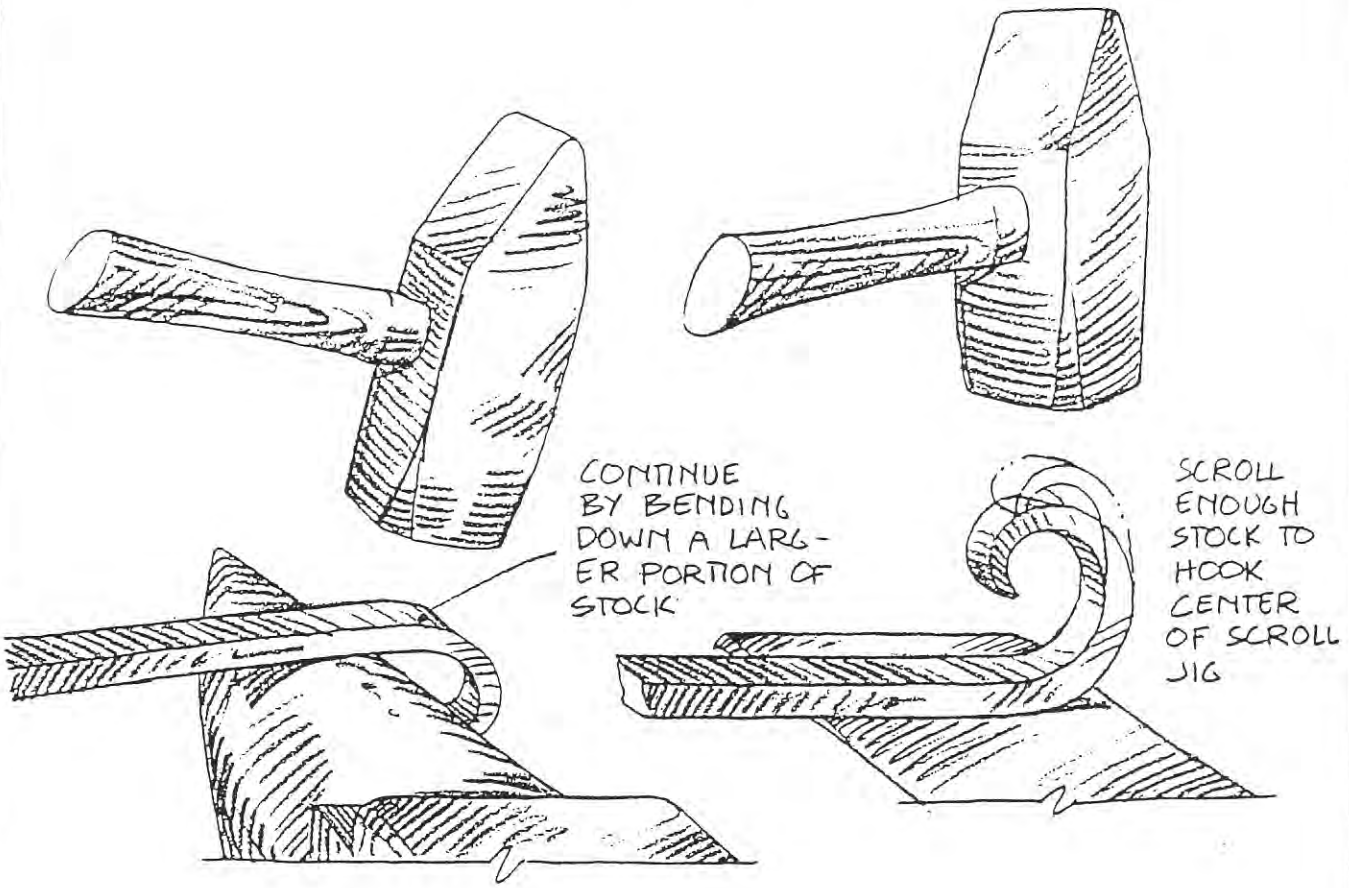


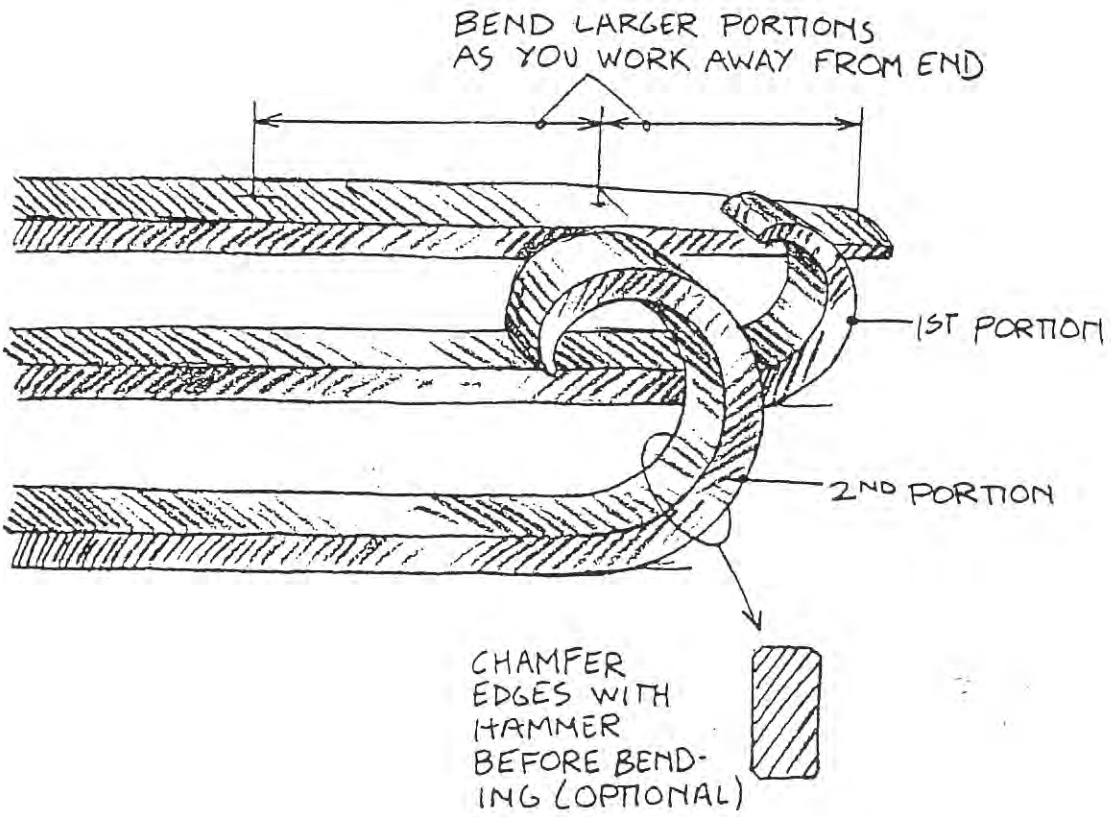


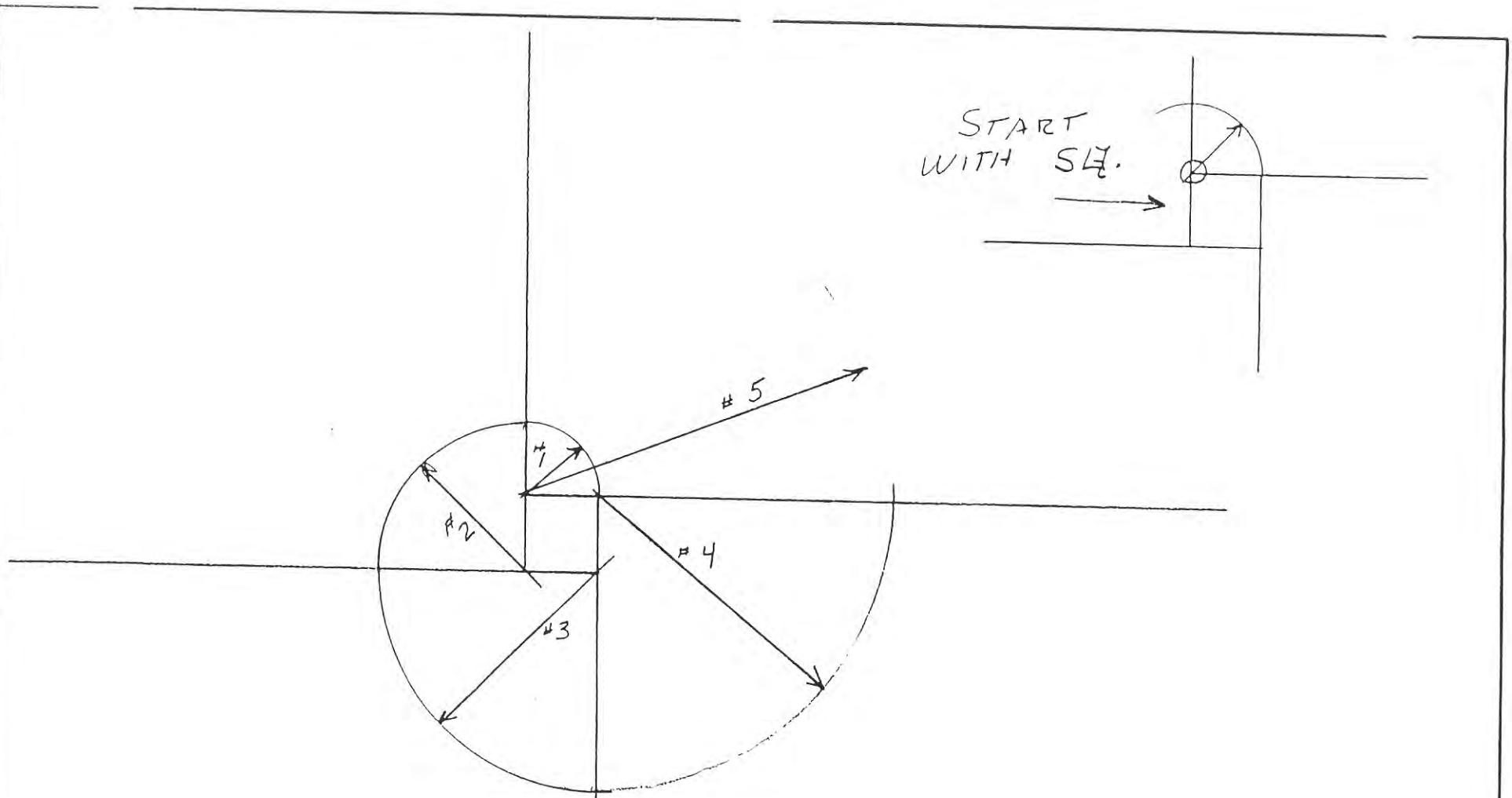


SCROLLS


DRAW A TAPER ON EDGE TO ALLOW FOR SPREADING.
DRAW OUT ON THE FLAT. STOCK SPREADS TO ORIGINAL WIDTH
MOVE STOCK PROGRESSIVELY MORE eq. BLOW
1
2
3
FLATTEN
BEGIN SCROLL OVER ROUNDED EDGE OF ANVIL
HOLD THE STOCK UP TO CURVE THE END
ROTATE DOWN & CURVE A LARGER SECTION
THIS SECTION WILL CURVE
THIS SECTION WILL CURVE


CONTINUE BY BENDING DOWN A LARGER PORTION OF STOCK
SCROLL ENOUGH STOCK TO HOOK CENTER OF SCROLL JIG


BEND LARGER PORTIONS AS YOU WORK AWAY FROM END
1ST PORTION
2ND PORTION
CHAMFER EDGES WITH HAMMER BEFORE BENDING (OPTIONAL)



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SCALE:	APPROVED BY:	DRAWN BY
DATE:		REVISED
		DRAWING NUMBER

PROJECTS FOR BEGINNERS

UNIT 2

Now that you have practiced the basic blacksmithing processes you are ready to make a few simple items. The projects in this unit will require you to use all of the basic processes you practiced in the first unit, Conquering the Basics.

Take your time. Don't rush things. If you need to take an extra heat, do it. Carefully follow the directions and pay attention to your work.

Three things to remember. First you may make the items within this unit in any order. Second, be sure to refer back to Conquering the Basics if you are unsure how to execute any of the basic processes. Third, if you are having difficulty be sure to talk with one, or more, of your fellow blacksmiths.

We are looking forward to seeing your completed projects at the next Guild meeting. And, of course, at that meeting you will receive the Projects for Beginners brass plate to be affixed to your plaque.

The project entitled, "Candle Holder" offers you two choices. You decide if you want to make candle holder A of candle holder B. As an option, some persons may choose to make both items.

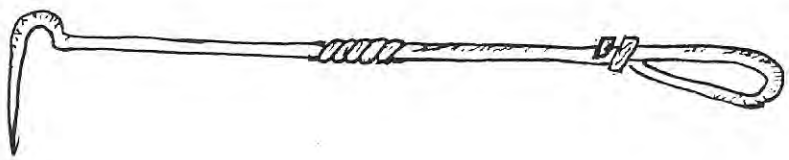
Blacksmithing Project FORGE RAKE

Basic Blacksmithing Processes to be Used

DRAWING OUT, BENDING, TWISTING

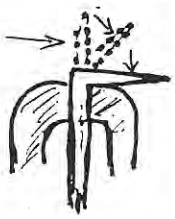
Stock Required 3/8" X 3/8" X 30"

Tools Required ANVIL, VISE, HAMMER, TWISTING WRENCH



1. Heat and draw one end of stock to a square tapered point about 3" long.

2. Heat the point, clamp it in the vise and bend it to a right angle to the rest of the stock.

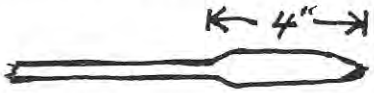


3. Over the anvil horn, bend a loop about 5" back from the corner in the same direction as the point. Do this hot.

4. Heat the point, clamp the handle vertically in the vise, wrap the point around the straight bar ahead of the handle.

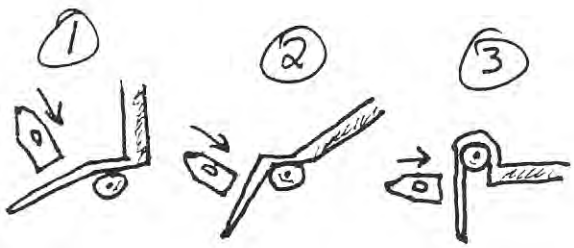
5. Heat the other end and draw to a square point about 1" long.

6. Heat and flatten on the face of the anvil for about 4" including the point.

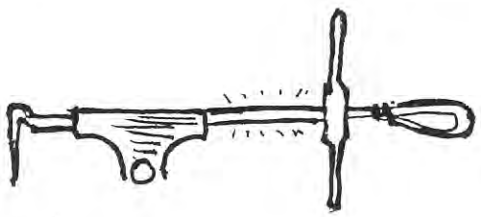


7. Heat and bend the flattened part to 90 degrees over the edge of the anvil.

8. Heat the flattened part near the bend. Quench with water the bend making it resistant to distortion. Place the hot iron over the tip of the anvil horn and bend in the sequence as shown.



9. Heat the center 8" of the rake handle, place in the vise and twist only the center 4" of the heat. This procedure will ensure an even heat that produces an even twist. Twist 1 or 2 turns - your choice. If part of the twist is twisting tighter than other parts, squirt water from a plastic soap bottle on the tightest area and continue twisting.



10. If the twisted part of the handle turns out to be crooked, straighten it in the vise. At a red heat, place the twist horizontally in the vise with the corners of the handle facing the jaws (known as "on the diamond") and lightly tighten the vise, rotate 180 degrees and lightly tighten, rotate 90 degrees (flat side of the handle facing the jaws) and lightly tighten, rotate 180 degrees and lightly tighten. While the handle is still in the vise you may need to tap the handle for further straightening.

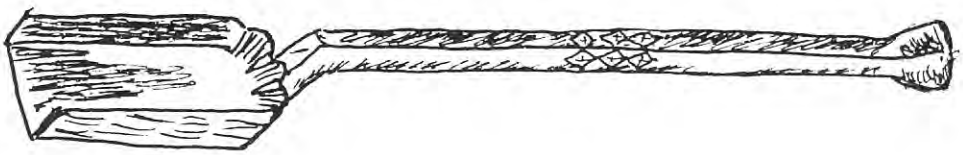
Blacksmithing Project FORGE SHOVEL

Basic Blacksmithing Processes to be Used

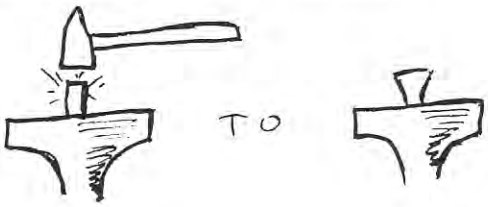
DRAWING OUT, UPSETTING, TWISTING, COLD FORMING SHEET IRON, DECORATE WITH PUNCH, BENDING, RIVETING

Stock Required 3/8" X 3/8" X 16", 16 GA SHEET 6" X 6", 3/16 RIVETS

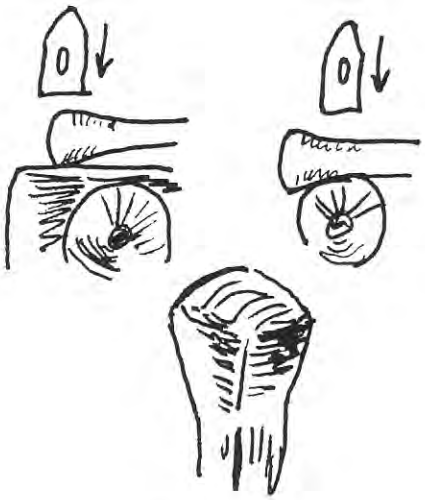
Tools Required HAMMER, 3/4" SWAGE, VISE, TWISTING WRENCH, SQUARE POINT PUNCH, DRILL AND 3/16" BIT



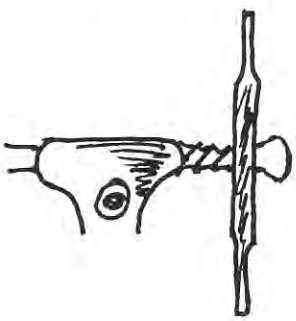
1. Heat the end of the 3/8 square stock, clamp it in the vise and upset the end until the stock is 15 inches.

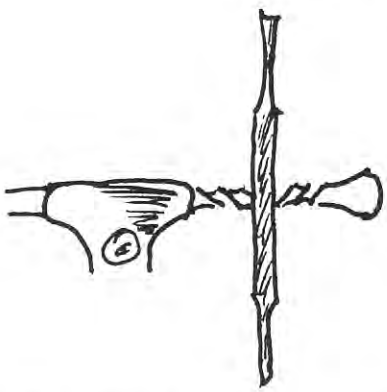


2. Carefully shape the upset portion using the face and/or the horn of the anvil. Make sure that the top is nicely rounded and the corners and edges are softened.



3. Heat 2" next to the square knob and twist one turn clockwise using the vise and twisting wrench.



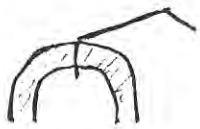


4. Heat another 2" adjacent to the previous twist and twist one turn counter clockwise.

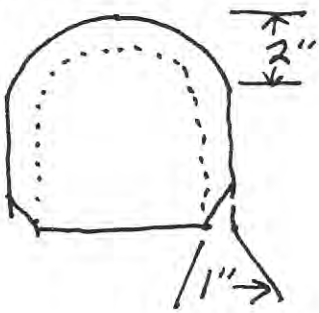
5. Punch just the one side that will be the front of the handle or punch all four sides. Your choice. (Note - Unit #5 tells you how to make a flat punch. This decorative punch is made the same way except you file or grind a blunt point.)

6. Flatten about 2 1/2" of the shovel blade end of the handle. using the face of the anvil and the face of the hammer.

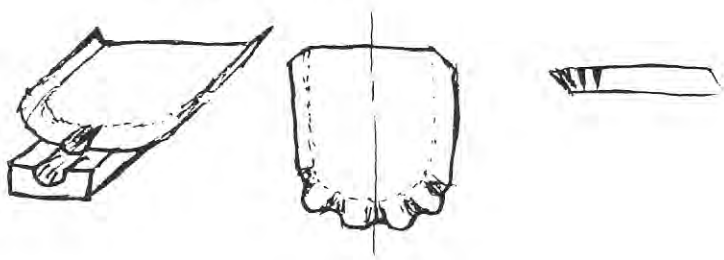
8. Use the vise and hammer to bend up 2 sides of the shovel. Steps 8 and 9 can be done cold.



7. Round off the corners of the shovel blank by chiseling, grinding or filing. Be sure to file off any burrs. Cut the other two corners at a 45 degree angle. Mark a line 1" from the edge as shown by the dotted lines.



9. Using the 3/4" swage and cross peen hammer, start an upwards wrinkle on the center line of the shovel blade. Continue wrinkling the back of the blade until it turns upward to the desired angle. If you do not have a 3/4" swage use the top of the vise with the jaws 3/4" apart.



10. Heat and bend the handle to fit the shovel blade. You may make these bends by placing the hot iron in the vise and striking with the hammer or you may bend over the edge of the anvil.

11. Punch a 3/16" hole as shown. This will give you experience in using the flat punch described in Unit 5. Use the handle as a guide to mark and drill a hole through the shovel blade. Rivet the blade to the handle.

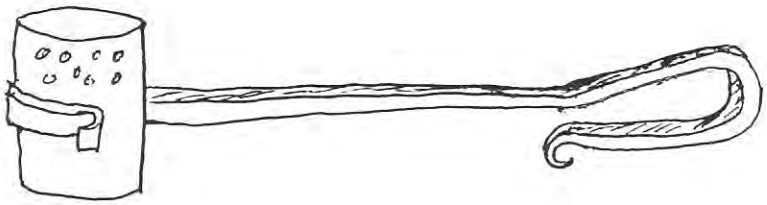
12. Mark, center punch and drill a 3/16" hole in the back of the shovel blade and handle to complete the project.

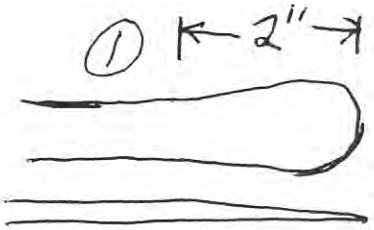
Blacksmithing Project WATERING CAN FOR THE FORGE

Basic Blacksmithing Processes to be Used
DRAW OUT, SCROLL, BENDING

Stock Required ½" x ½" x 29"

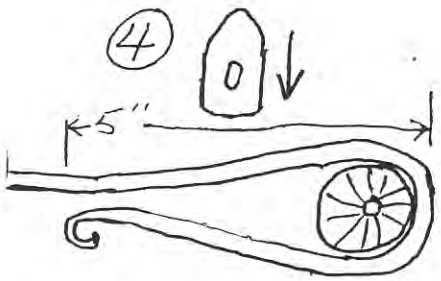
Tools Required HAMMER, TONGS THAT OPEN TO 1½"



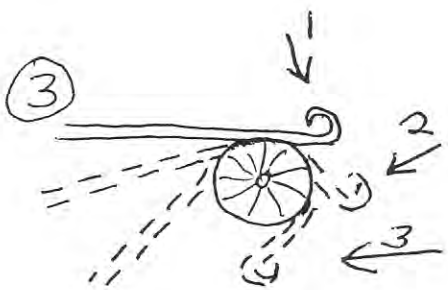


On the face of the anvil, draw out a taper using the face of the hammer.

Form a scroll about 1/2" diameter. (P.)

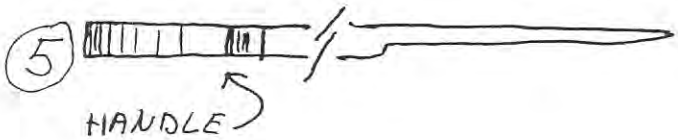


Make the final adjustment by striking as shown.



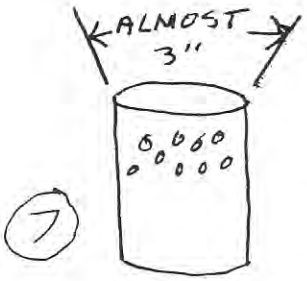
Quench the scroll so it will not become misshapen. Form the handle by placing the hot iron on the anvil horn. Strike as shown. If you lower the hand that holds the hot iron with each blow you can avoid standing on your head when making the final blows.

It may be necessary to gently tap any high spots on the handle where it curves around the horn.



On the face of the anvil draw out the last 5" to a length of 10". Keep the same width and 1/2 the thickness. Be sure to taper the last 2" thinner and to a 1/16" thick end.

Form a 1/2" scroll. (P.)



Using a tin can (not aluminum) the size of a 15 ounce can of corn punch five to ten holes in the upper 1/3 of the can on one side only.

Carefully form a round shape as in steps #3 and #4 to the same shape and size of the can.

9

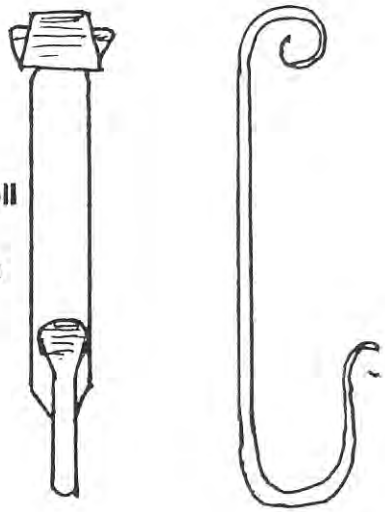
(a) Place the can on the workbench. (b) Fill it with water up to the holes. (c) Heat the round end of the handle. (d) Slightly open the round end. (e) Place the round end of the handle around the center of the can. (f) Close the round end with tongs to a snug fit. (g) The contraction of the hot iron will make a tight fit. (h) Add a decorative twist to the shank (P.) if you so choose.

Blacksmithing Project — **Fishtail Scroll Coat Hook**

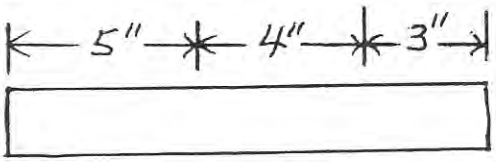
Basic Blacksmithing Processes to be Used — **Draw out, Upset, Rolling a scroll**

Stock Required — **3/16" x 1/2" Flat Bar, 12" Long**

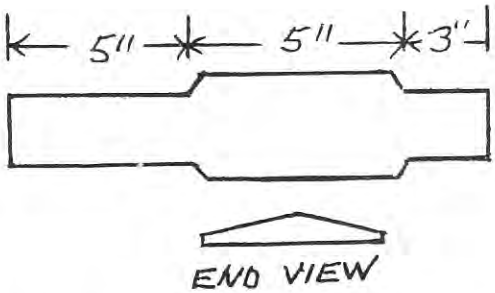
Tools Required — **Hammer, Anvil, Forge, Vise**



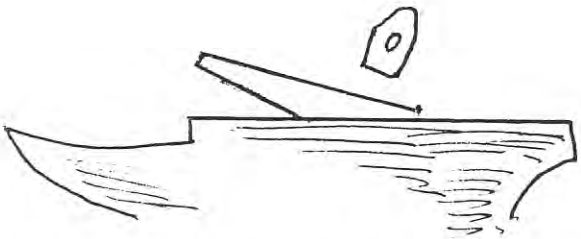
TIPS:
1. Before starting the project, practice making scrolls: use 3/16" x 1/2" flat bar for the top scroll and 5/16" round for the bottom scroll.
2. Always try keeping the piece straight; using the vise helps. Also: using two hammers, one for a backup will help.



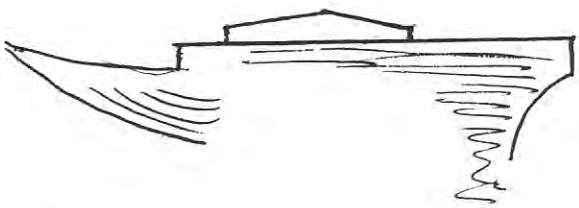
1. This coat hook is comprised of three parts: (a) the fishtail scroll (b) the center back plate (c) the bottom hook. The scroll is made from the 5" section, the backplate is made from the 4" section and the hook is made from the 3" section.



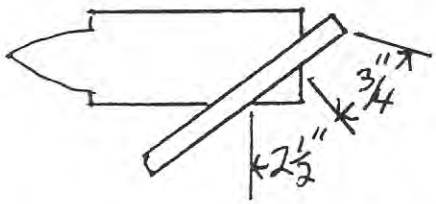
2. **To make the backplate.** Draw out on the face the center 4" to 11/16" wide and almost 5" long. Use the face of the hammer. Do not strike the center of the stock. Keep the center section at its original thickness. The edges should be about 1/16" thick.



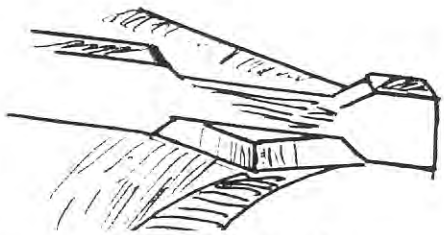
3. To straighten the center ridge line, place the hot iron face down on the anvil and strike the back side with the hammer.



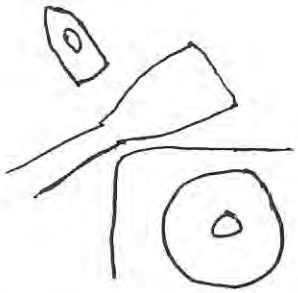
4. Straighten the edges by placing the edge of the piece on the anvil face and tap the other edge with the hammer. Do this hot. When the piece has cooled place it face up on the anvil and refine the center ridge with the hammer face.



5. **To make the bottom hook:** Start by making the round shaft. Place the 3" section crosswise on the corner of the face of the anvil leaving 3/4" extending over the heel of the anvil and 2 1/4" on the face of the anvil.



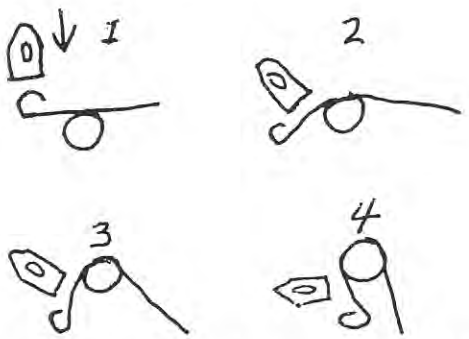
6. Draw out the 2 1/4" section to a square. Be sure to rotate the piece 180 degrees every 6 or so blows. Then form the square to an octagon and finally to a round. This round section will now be about 5" long.



7. Refine the transitions from round to flat at both ends of the round section.

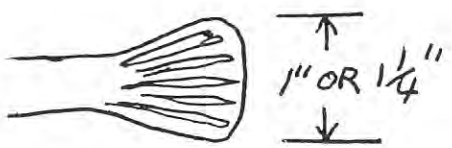
8. Using the face of the hammer, draw out the 3/4" section to a flared section on the face of the anvil. The end should be almost sharp. This section will be about 1 1/2" long and 3/8" wide.

9. Heat the flared section and form a scroll. (See page)



10.Form the hook by heating the round and quenching the scroll so as not to deform it. Place the scroll over the edge of the horn and strike down. With each blow feed the hot iron out and over the horn.

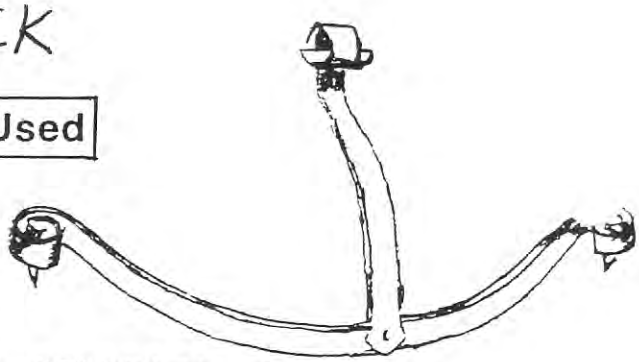
11.**To make the fishtail scroll:** Take a bright orange heat on the 5" section, place in the vise with 1" sticking out and upset with light blows. (See page) This process may take three heats. Straighten between each heat.



12.On the face anvil face draw the upset sideways with the peen of the hammer. Start in the center and work to both edges. If the hot iron draws to one side or the other, turn it over and work from the other side. File the edges smooth and symmetrical.

13.Heat the flared section and form a scroll. (See page)

Blacksmithing Project POT RACK

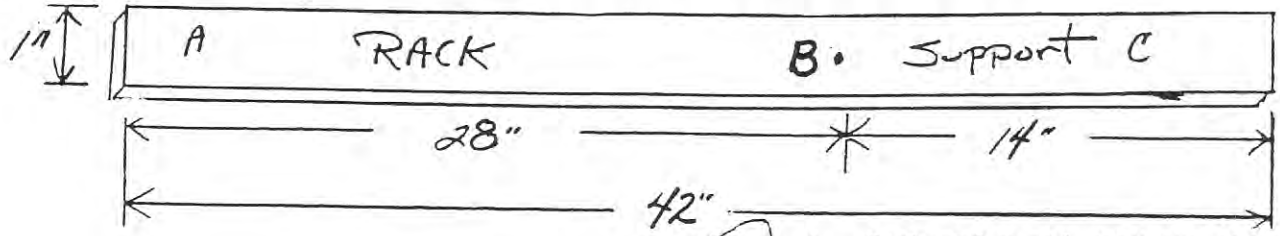


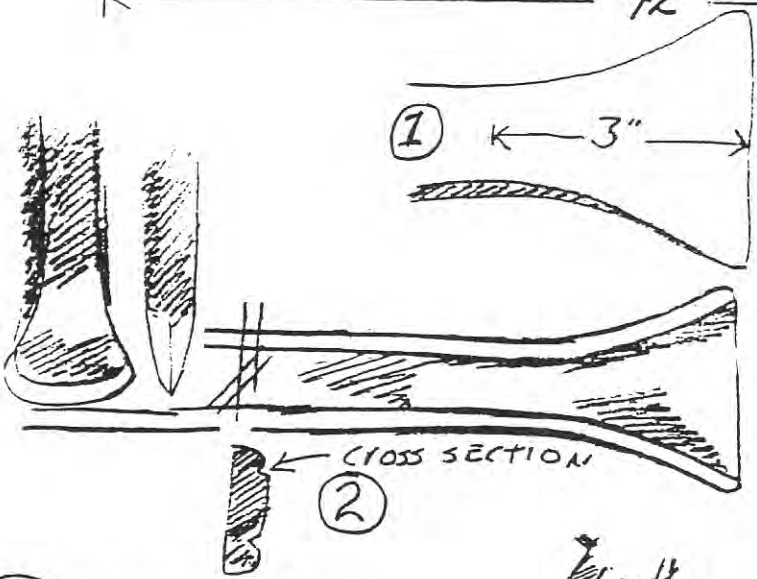
Basic Blacksmithing Processes to be Used

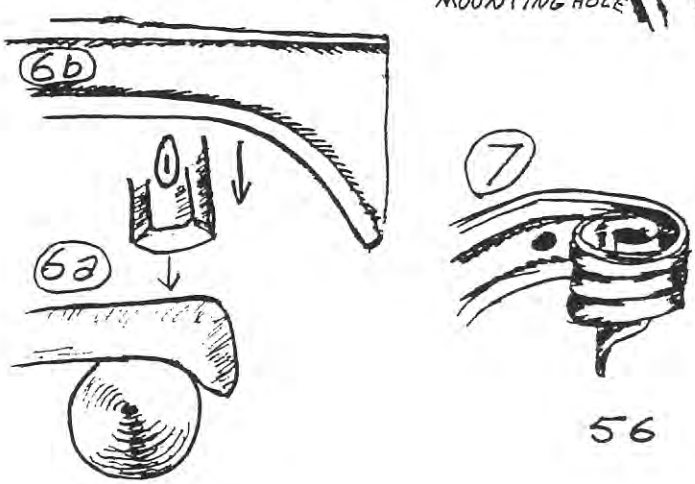
DRAWING OUT, UPSETTING, PUNCHING, RIVETING, SCROLLS, VEINING DECORATIVE PUNCHING

Stock Required 3/16" X 1" X 42"
1/4" ROUND 24" LONG

Tools Required HAMMER, PUNCH, HOT CHISEL, CENTER PUNCH







1. Heat end C and draw out the final 2" to a fish tail which will now be about 3". If necessary, file the fish tail to achieve the shape as illustrated. When drawing out use the anvil face and the hammer face.

2. Use the hot cut chisel to make decorative grooves along each edge to beyond D. Make grooves on each side of the portion to be scrolled.

3. Form a fish tail scroll.

4. Cut at B. Draw out and spread to a button shape.

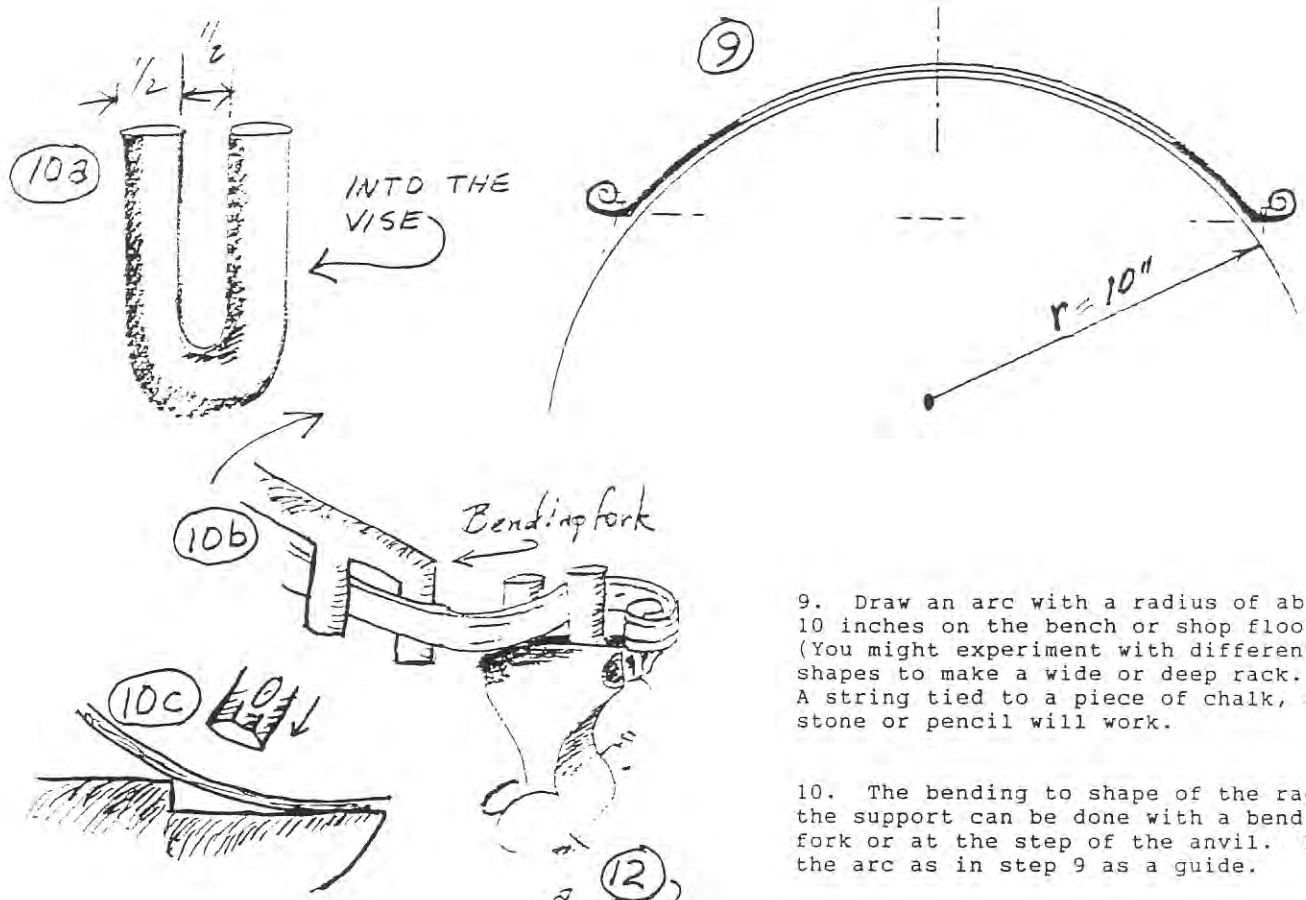
5. Punch two holes, one at each end. See illustrations 3 and 4 . Punch a hole near the scroll for the mounting screw. Punch a hole at the other end the same size as the rivet to be used.

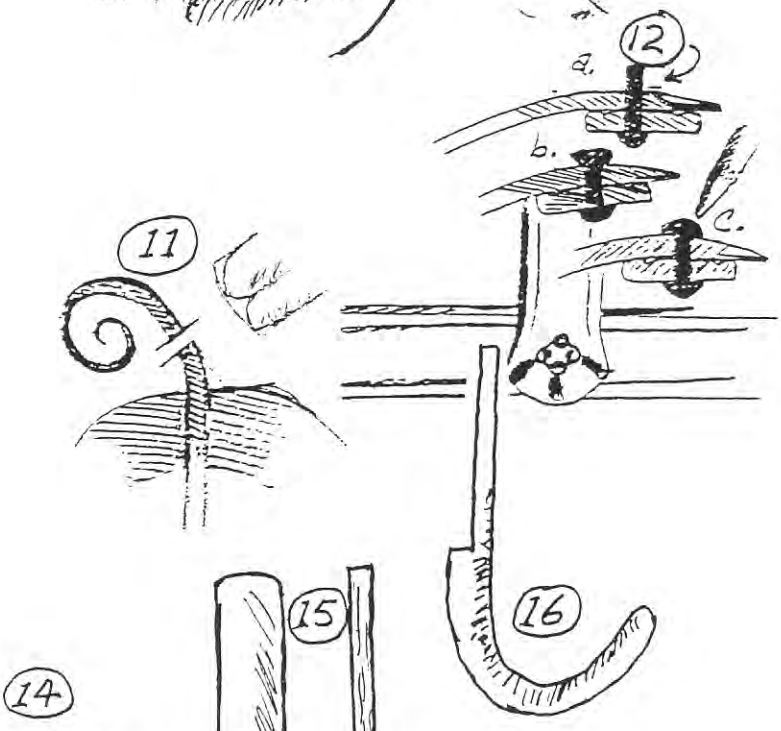
Part 2. After the support section of the stock is complete and cut (steps 1- ,) 28 inches remain for the rack portion.

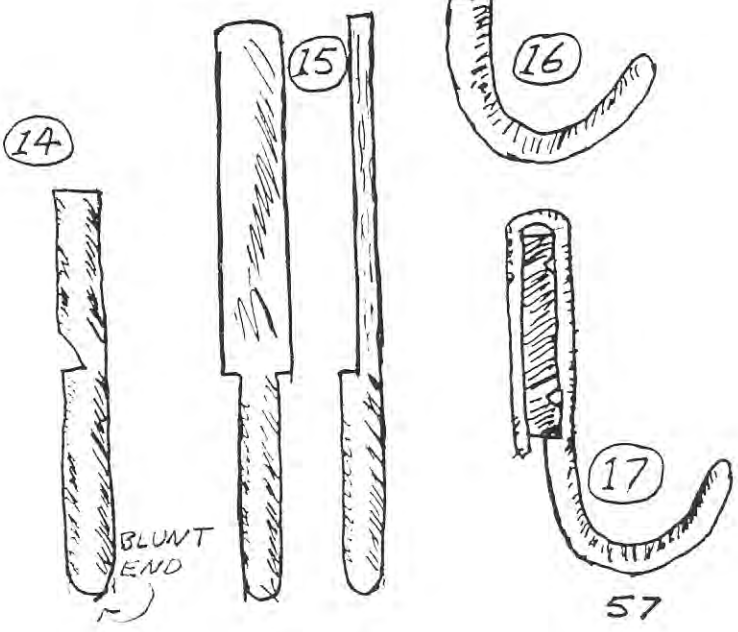
6. To make the one sided fish scroll place the hot iron on the anvil face and use the hammer face to begin to spread a button. When the iron begins to spread place it on the horn and drive down one edge of the spread. You will need to repeat this process several times using several heats. If necessary, file to shape. Repeat this process on end A. Form the decorative grooves as in step 3.

7. Form a scroll on each end much like figure 4b except keep the top of the scroll flush.

8. Punch holes near the scrolls for the mounting screws. See illustration #7. Punch a hole equidistant from the scrolls to accept a rivet.







9. Draw an arc with a radius of about 10 inches on the bench or shop floor. (You might experiment with different shapes to make a wide or deep rack.) A string tied to a piece of chalk, soapstone or pencil will work.

10. The bending to shape of the rack and the support can be done with a bending fork or at the step of the anvil. Use the arc as in step 9 as a guide.

11. Hold the rack in the vise and bend back the ends near the screw holes. Do the same for the support piece.

12. Rivet the support to the rack.
    a. the rivet should fit very tight in the hole.
    b. cut the length so that 1 1/2 times the diameter of the rivet extends through the hole.
    c. riveting can be hot or cold. Use a cross or ball peen to start and finish riveting with the flat face of the hammer. Decorative details can be added with a punch of your choice.

13. Using 1/4" round stock 4 " long form a blunt point on one end.

14. On the near edge of the anvil, form a shoulder 2" from the blunt end. The shoulder should be not quite half way through the stock.

15. Draw out the remainder of the stock to a length of 2 1/4" from the shoulder to the end.

16. Over the anvil horn form the round portion to a hook.

17. Bend the flattened portion to fit on the rack as shown. Make it fit tight so that it won't fall off when removing pots and pans.

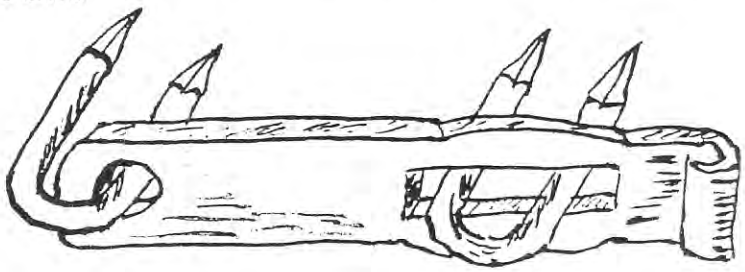
Blacksmithing Project HASP

Basic Blacksmithing Processes to be Used

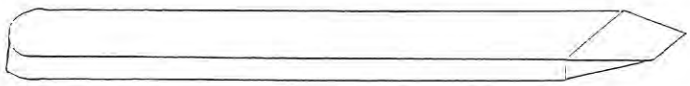
drawing, punching, bending, and filing

Stock Required ¼ " X 1 ¼ " X 7" mild steel and 3/8" round mild steel

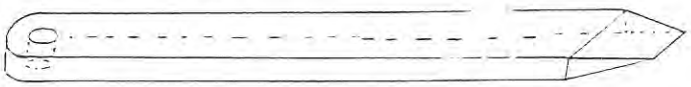
Tools Required flat-bit tongs, rule, vice, ½ " round punch, hot cut chisel that tapers to make a ½ "X 2' drift, hammer, and anvil



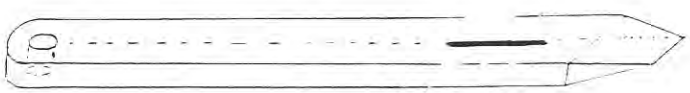
(1) Begin by rounding one end and a drawing a short taper on the other end.



(2) Next, punch a ½" round hole near the rounded end. Start the hole by placing the punch in the center of the rounded end and striking the punch once and removing it to observe if the hole is centered. If not, adjust here. Take a new heat (yellow) and hammer the punch in the previously made depression until you feel resistance. Turn the piece over and look for a small round raised area. This is the place to begin punching from the other side to complete the hole. This step is best done at a dull red heat. Hammer until you again feel resistance and place the hole over the pritchel hole of the anvil and drive out the small slug at a black heat, completing the process.

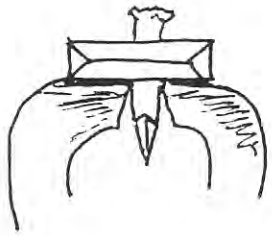


(3) Make the slot for the staple on the opposite end. Use a hot cut chisel that tapers to a 1/2" X 2" rectangular drift, and the cutting edge should taper with a 60 degree angle. Place the cutting edge centered edge to edge on the hot iron. Take one blow, check for centering and adjust as necessary.



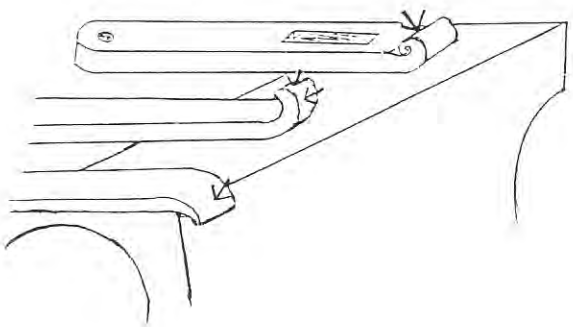
④

Then, take a yellow heat and place the piece over a vise open enough to allow the hot cut to pass through. Drive the chisel completely through the piece. This will open the slot to size. You will need to reheat the hasp and flatten it on the face of the anvil. Finish with a file.



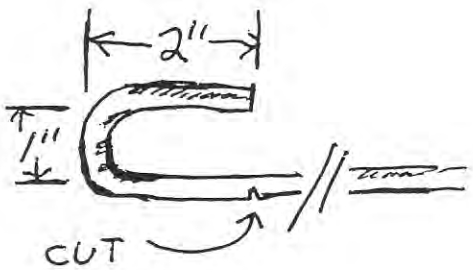
⑤

Now, a decorative scroll is forged on the tapered end of the hasp. Begin by rolling the tapered end over the edge of the anvil. Following the arrows for direction of hammer blows. Next flip the piece over and roll the scroll as illustrated below.



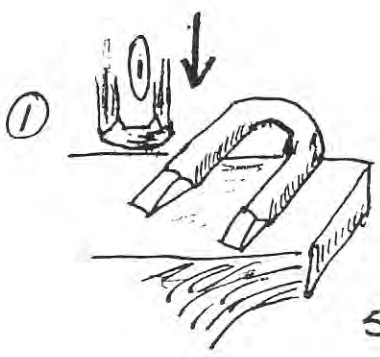
⑥

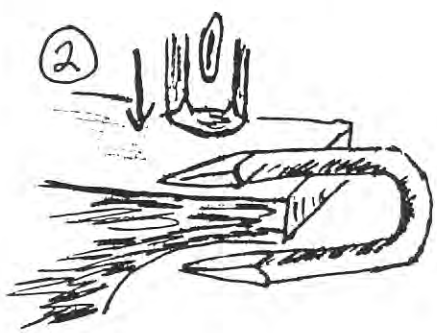
Make two identical staples, one to hold the hasp in place and one to hold the padlock or just a wooden peg. Heat and bend the round stock two inches from the end and using the long end as a handle. Then cut off the handle.



⑦

Draw each end to a point using the sequence as shown.





Blacksmithing Project — Candle Holder

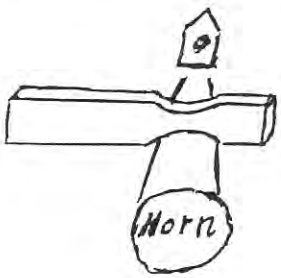
Basic Blacksmithing Processes to be Used — Upsetting, Drawing Out

Stock Required — 1/4" x 2" Flat Bar, 7" Long

Tools Required — 3# Hammer, Small Ballpeen Hammer, Anvil, Forge, Vice

NOTE: This project teaches hammer control to move metal different directions and will require patience and a lot of hammering. You will need a strong arm, so do some exercises to loosen the arm up before you start. If your arm gets tired, put the project aside for a while and come back to it later. You may want to cut the 1/4" x 2" stock longer so that you do not need tongs when starting out. Then cut it off so that you have 3" of stock to make the base.

After heating the bar up, place it on the horn of the anvil so there is 3 1/2" beyond the center of the horn and begin hammering the top down.

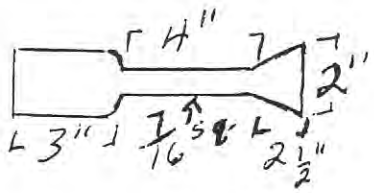


Turn the metal over quite often so that you draw it down even on both sides. Work the metal hot; when it gets to a red heat, it is too cold to work.

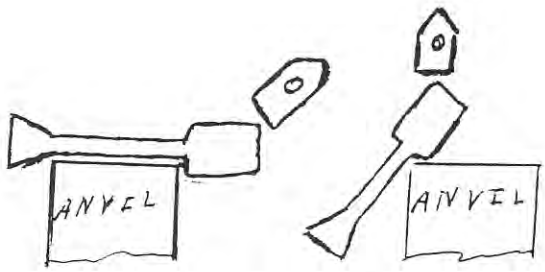
The top and the bottom edges will flair out and want to roll over. Keep hammering them back down so that you do not get a cold shut *(when the metal rolls over onto itself)*. If you do get a cold shut, stop and grind it out, or it will show up later looking like a crack or cut.

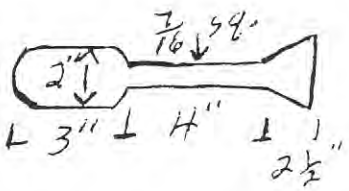
When the center of the metal has been hammered down to an inch or less, you can move to the edge of the anvil.

Using a nice rounded edge of the anvil, work the piece until it looks like this:

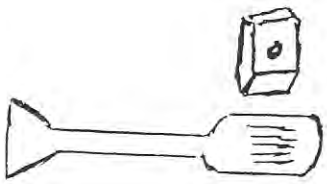


Turn the piece around and work the corners down on what will be the base. Place the base over the anvil and round the corners off.





Using a crosspeen hammer, draw out the base. Start in the center and work it both ways.

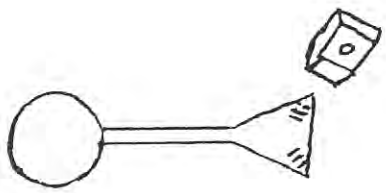


If you want a round base, you will have to keep hammering the corners back in as you move the center out. Be careful not to draw the edges too thin at this point, or they will want to burn.

If you want the base oblong, you won't have to work the corners in as much. Where there is a low spot or dip in the edge, peen the metal towards it like you would when you roll out dough for baking. Hammer all the high spots back in. You should end up with about a 4" circle or a 4 1/2" x 3 1/2" oblong base.

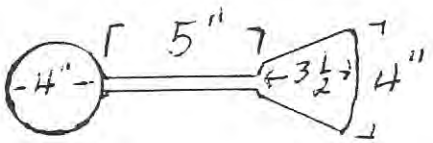
Next, draw the 7/16" square stem that comes off the base down to about 3/8" round for 1/2 of the stem length. When complete, hot file all of the edges of the base and stem that you have just worked.

Then, using the crosspeen, start to draw the candle cup out by starting in the center and working both ways. Keep it even on both sides of the center. Do not draw those edges too thin at first, and keep the upper corners drawn out.

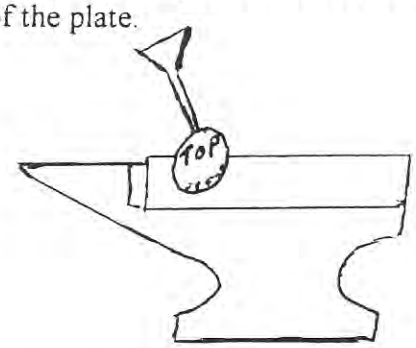


You will have to work the stem down a little or more to round it up as you work the cup. The cup should be 3 1/2" long and 4" wide at the top.

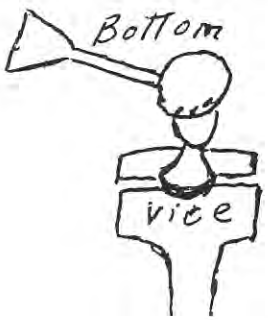
Draw and round out the rest of the stem to 3/8" round. You can leave it a little thicker near the cup; this gives you enough material to blend the stem into the cup after it has been rolled up. Hot file the rest of the edges.



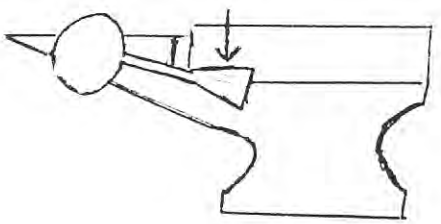
Return to the base again and roll the edges up a little (*This will help keep the dripping wax contained*). Using a medium ballpeen hammer, hammer on the inside of the plate.



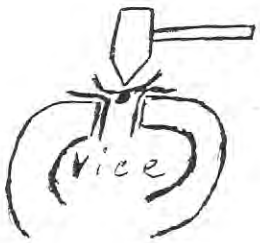
I use an old trailer hitch ball for finishing the edges.



The next step is to roll the cup up. Using a low heat to keep the scale down, start by rolling the outer edges a little. Do this over the horn or edge of the anvil.

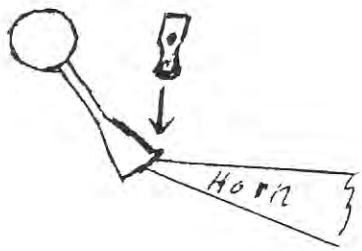


Using the peen of your hammer or a top fuller, start to roll the center of the cup. Do this by placing the cup over round jaws in your vice, putting it in the step of your anvil, or using an angle iron.

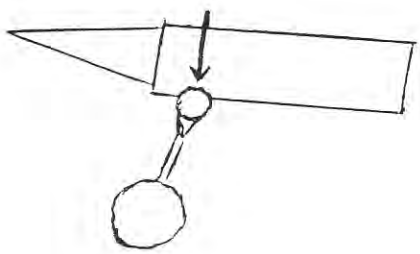


Roll the rest of the cup by tapping it around with the hammer. Leave about a 1" hole on top.

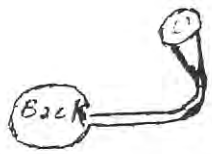
When the cup is all rolled up, flair the top out by placing it over the point of the horn and hammering the outside edge with a small ballpeen hammer.



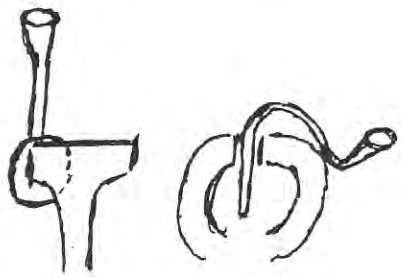
Turn it over and place it on the rounded edge of the anvil and hammer the inside.



To bend the stem, build the fire up so that it is quite deep; this will allow you to get the stem down into the fire. You will also need to use water to cool off the places you do not want to bend. *(If you have bending forks, they will help.)* Start at the cup, bending it beyond 90°. *Bend nice round bends.*



Heat the stem next to the base. Put the base in the vice and pull the stem around.



Try to end up with the stem and candle cup in the middle of the plate. *(This will take patience.)*

I use a wax finish on candle holders. This helps when cleaning dripped wax off from them.

Cleaning Tip for Candle Holders: Place them upside down on a cookie sheet in a 100° oven for about 15 minutes. Then take out and wipe off. They will be like new.

Blacksmithing Project CANDLE HOLDER

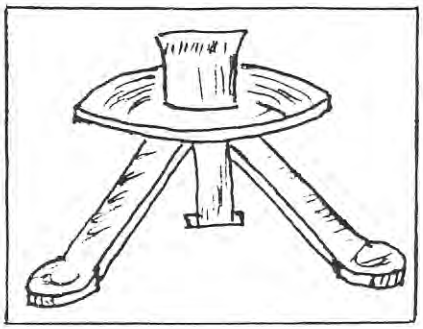
Basic Blacksmithing Processes to be Used

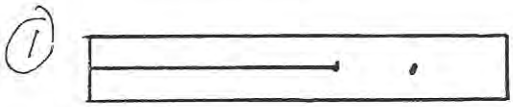
SLITTING, CENTER PONCHING, DRAWING OUT, SINKING, BENDING, RIVITING

Stock Required 3/16" X 1" X 5 1/2 MILD STEEL

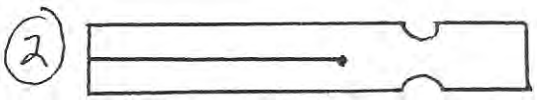
Tools Required

CROSS PEEN HAMMER, BALL PEEN HAMMER
FLAT LIP TONGS

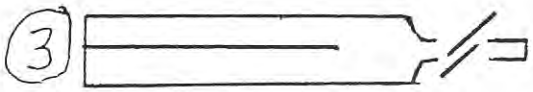




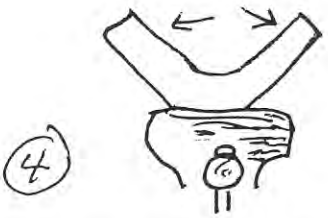
Mark with a white pencil the dots and line. Score the line with a chisel and center punch the dots. Do this cold.



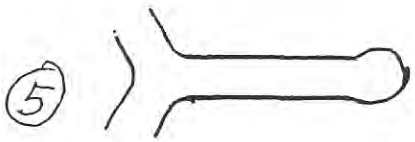
Using a spring fuller, form two notches 1/4" deep.



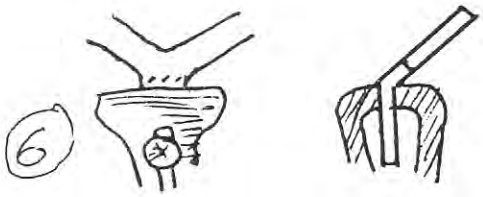
Draw out the 1 1/2" section to a length of 3" and 1/2" wide keeping the same thickness.



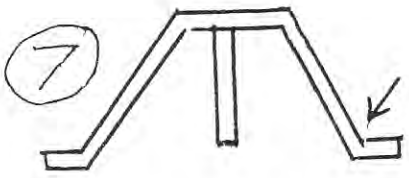
4 Cut the 3" line and bend the legs to 120 degree angle using the vise and anvil. You will need to bend and straighten several times using several heats. Forge and file a smooth transition between the legs and the center portion. Punch a hole in the center the size of the rivet that you will be using.



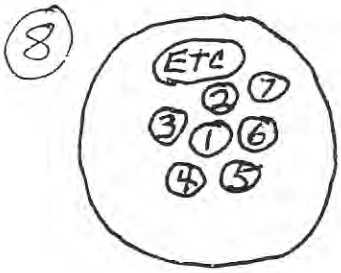
On the anvil face and using the face of the hammer draw out the ends of each leg to form a slightly rounded foot. File as necessary.



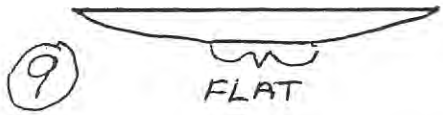
In the vise bend each leg to a 45 degree angle on the dotted line. Do this cold.



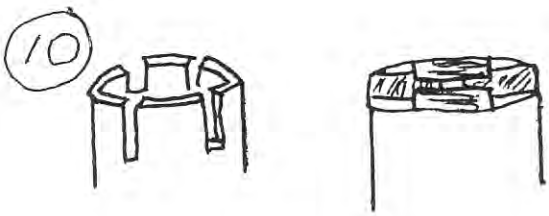
Bend the feet as shown in step #6.



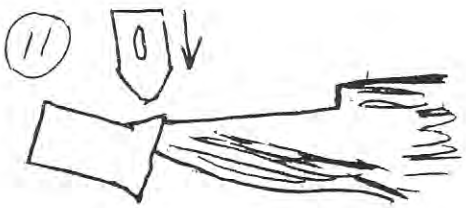
Form the wax catcher by using a large (2" - 3" diameter) washer with a small hole, or cut a round circle out of sheet iron. Heat the piece to an orange heat, hold it on the edge with tongs and place it on a block of wet wood. Strike the hot iron with a ball peen hammer starting in the center and working towards the edge in a spiral pattern. Do not strike the very edge. Do most of the striking near the center and gradually less towards the edge to form a bowl shape.



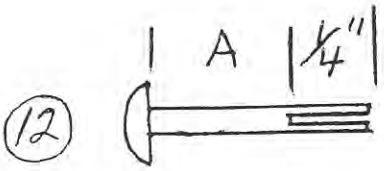
Using a piece of 3/4" round stock or a small hammer or a similar tool, flatten the center of the wax catcher on the anvil face. This is done to allow the candle cup to fit tight to the catcher. Drill a center hole.



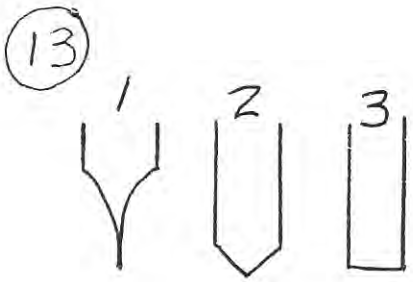
Make the candle cup using 3/4" thinwall steel tube. Using a hacksaw make four equally spaced cuts 1/4" long. Fold the tabs over and a hole will remain in the center to accept a rivet. The bottom is now somewhat square.



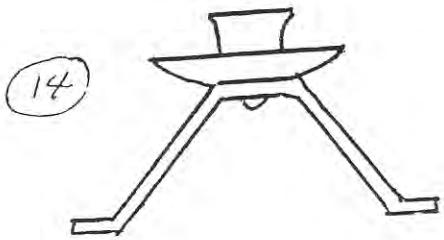
Cut the pipe to a length of 1 1/4". Bring it to an orange heat and stretch the top rim over the anvil horn using the cross peen hammer. (Don't use your fingers to hold the cup.)



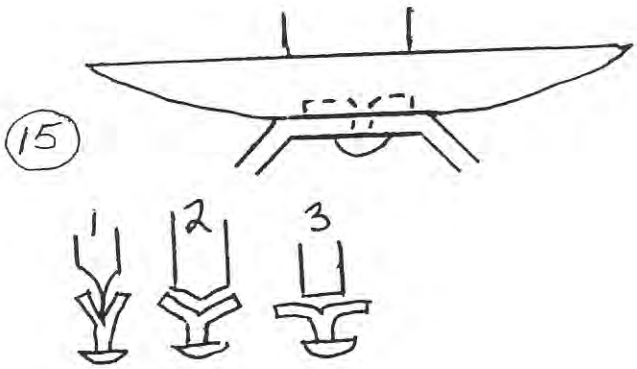
Carefully cut a slot lengthwise in the rivet so that "A" is equal to the layers of material to be riveted together.



Make three quick tools to clinch the rivet. Mild steel will do just fine. Number 1 is shaped like a thin chisel, Number 2 is a spreading tool and Number 3 is a set tool.



Assemble the three parts being careful to make them align straight and true. Check to see that the holes will accept the rivet.



Insert the rivet and clinch it by using the tools in order, 1, 2 and 3. Rap tool #3 sharply to tightly clinch the rivet. Be sure to place the rivet head on a firm support.

INTERMEDIATE PROJECTS

UNIT 3

You are now ready to move on to projects that are a bit more difficult. Some of the things that you will be required to do will be a real test of your ability. You will experience frustrations. Keep at it. Don't give up.

Remember to refer back to the first unit, Conquering the Basics, when necessary. Consult with other blacksmiths. Read books. Get help where ever you can.

As with other units, you may complete these items in any order. Except you should do the forge welding exercise before you make the trade axe. When you have completed this unit, be sure to bring the items to a Guild meeting for display. At the meeting you will receive the next brass plate, Intermediate Projects, to be affixed to your plaque.

Blacksmithing Project # FLESH FORK

Basic Blacksmithing Processes to be Used

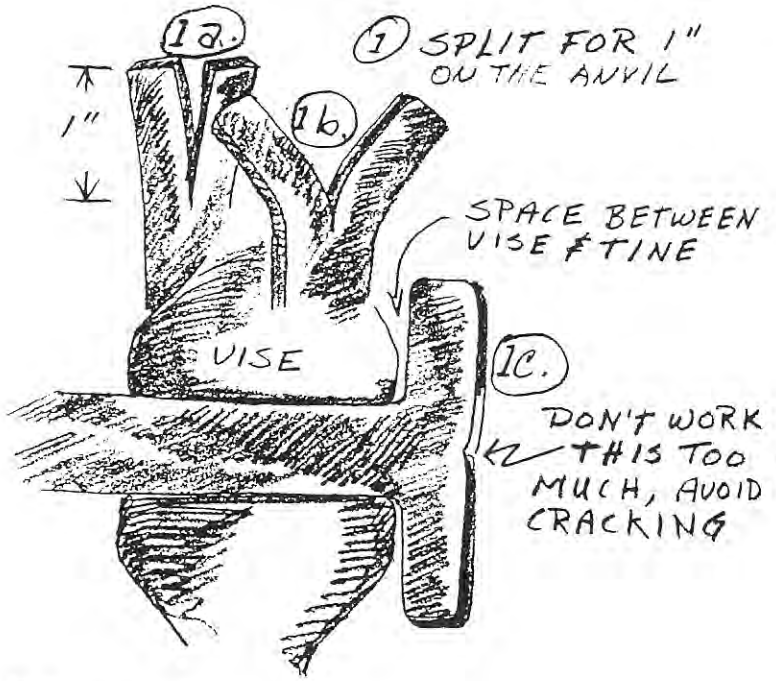
SPLIT, DRAW OUT, TWIST, BEND
FORM A ROUND SHAPE, FULLERING

Stock Required

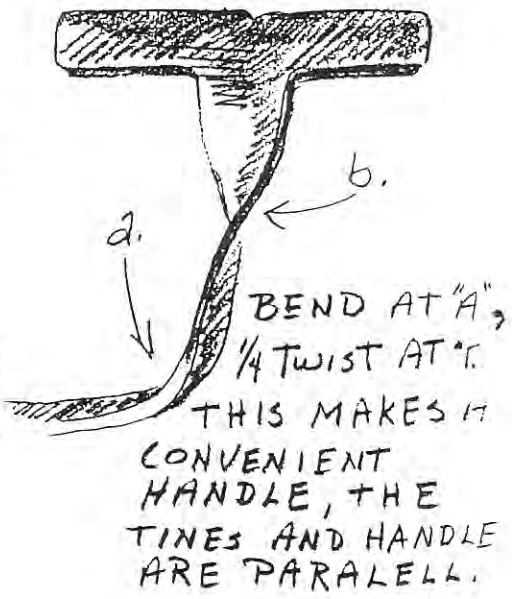
1/4" X 3/4" MILD STEEL, LONG ENOUGH TO FORM A HANDLE WHILE WORKING THE STOCK (ABOUT 2 FEET)

Tools Required

HOT CHISEL, HAMMER, TONGS



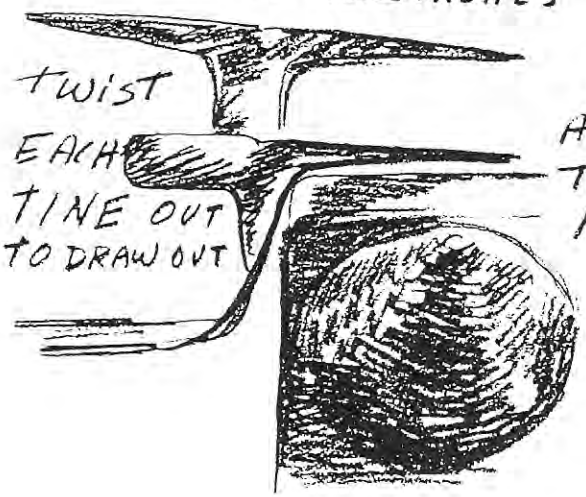
① SPLIT FOR 1" ON THE ANVIL



② TWIST & BEND

BEND AT "A", 1/4 TWIST AT "B". THIS MAKES A CONVENIENT HANDLE, THE TINES AND HANDLE ARE PARALELL.

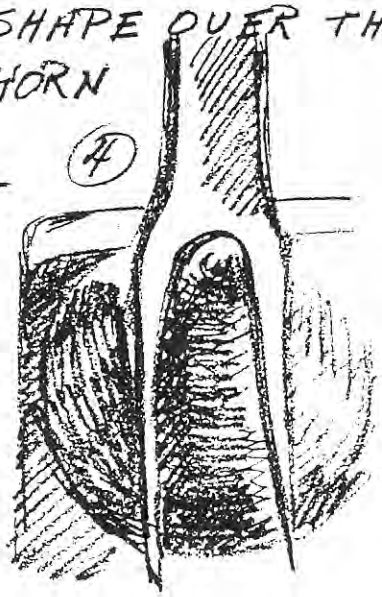
③ DRAW OUT THE TINES TO 2½ INCHES

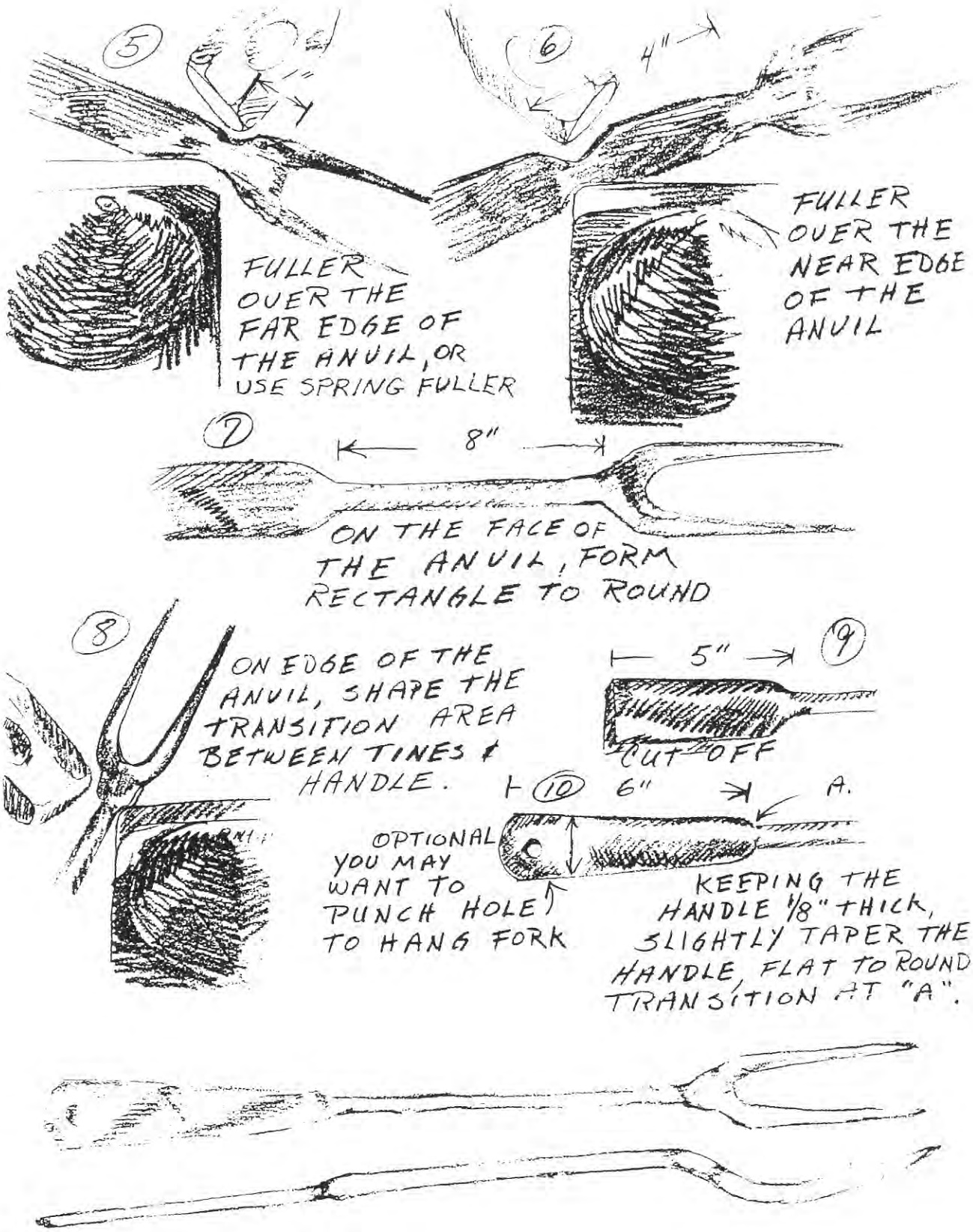


UNBEND AND UNTWIST THAT WAS MADE IN STEP 2

SHAPE OVER THE HORN

④




5
1"
6
4"
FULLER OVER THE FAR EDGE OF THE ANVIL, OR USE SPRING FULLER
FULLER OVER THE NEAR EDGE OF THE ANVIL
7
8"
ON THE FACE OF THE ANVIL, FORM RECTANGLE TO ROUND
8
ON EDGE OF THE ANVIL, SHAPE THE TRANSITION AREA BETWEEN TINES & HANDLE.
9
5"
CUT OFF
10
6"
A.
OPTIONAL YOU MAY WANT TO PUNCH HOLE TO HANG FORK
KEEPING THE HANDLE 1/8" THICK, SLIGHTLY TAPER THE HANDLE, FLAT TO ROUND TRANSITION AT "A".

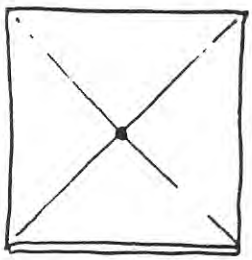
Blacksmithing Project (Escutcheon)

Basic Blacksmithing Processes to be Used

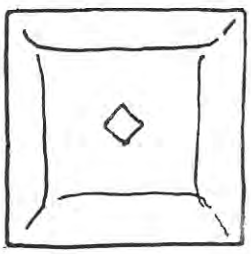
Punching, Chisel cutting, chasing

Stock Required $\frac{1}{8} \times 3''$ (can be done any size using thinner material for smaller sizes)

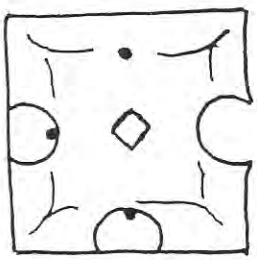
Tools Required straight chisel, curved chisel, square punch, curved chasing tool, teardrop chasing tool, half round file, round file



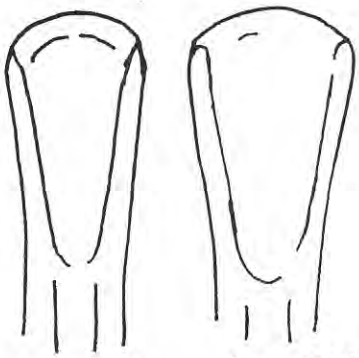
(1) Cut a 3" square from the stock. Scribe corner to corner and mark the center with a punch. File sharp edge left by chisel.

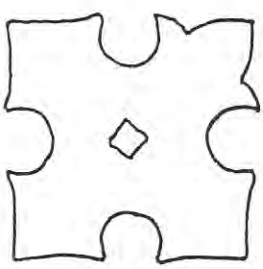


(2) Punch a square hole in the center of the heated piece. For most applications setting the punch to produce a hole on the diamond is most attractive.



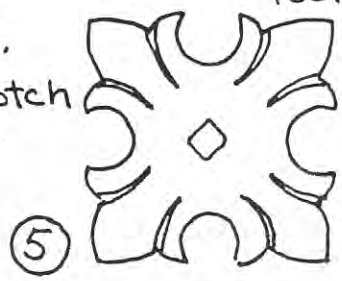
(3) $\frac{5}{8}''$ Mark center of each side, perhaps from edge, depending on radius of curved chisel to be used. With chisel of even curve and bevel equal inside and out mark a semi-circle in the cold steel. Heat the piece and cut out the semi-circles with several even passes. Ends of cut will stretch beyond the square enhancing appearance. Keep chisel cooled.





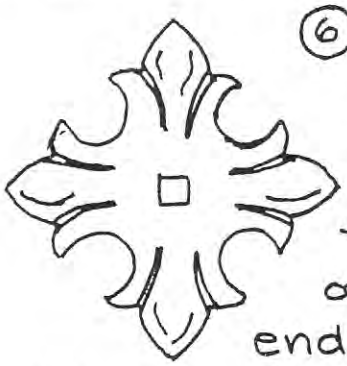
(4) File lesser notches with half round file. Clean chisel cuts with round file.

Stamp at each lesser notch with curved chasing tool. Tool must be of even symetrical curve to be reversed.

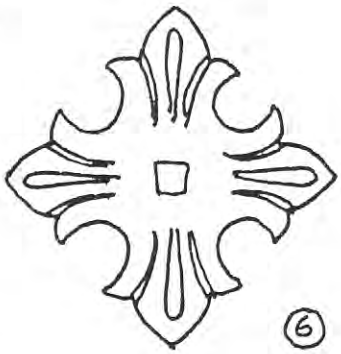


(5)

Tip chasing tool toward the outside so it sinks more deeply leaving a groove in the hot metal that is deeper and wider at the edge of the escutcheon and tapers toward the center.



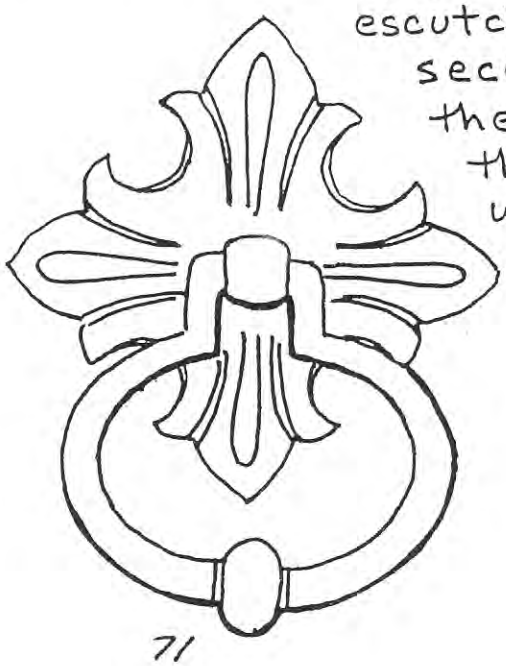
⑥ The tear drop shaped chasing tool can be used on the back of the heated piece to press the center of each lobe into the end grain of a hardwood block. This will produce a buldge on the front. The wood can be soaked in water so it is steam in your eyes rather than stinging smoke.



⑥ alternative

An alternative would be to use the teardrop tool on the front, over the anvil to chase a groove in the center of each lobe. A long teardrop tool should be forged to make multiple identical impressions. However, grooves of various lengths can be stamped with a shorter tear drop tool if it is rocked toward the narrow end as the groove trails off, and toward the wider end where the groove is bolder.

This type of escutcheon is usually secured only by the square pin through the center which anchors a knob or handle



Blacksmithing Project (Decorated Fork)

Basic Blacksmithing Processes to be Used

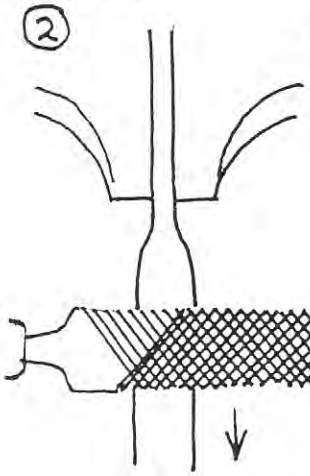
Scale removal; Flat, round, and contour filing

Stock Required Fork forged earlier

Tools Required Abrasive paper, Worn coarse file, Sharp half round bastard, Mill file, Round file

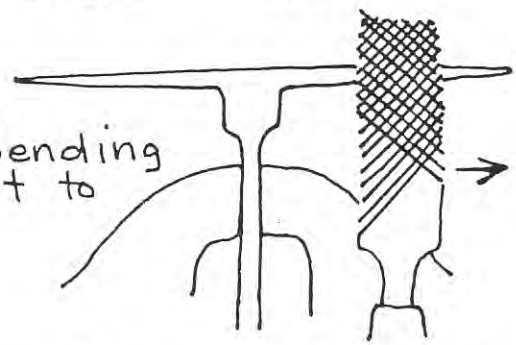
① Scale can be removed from small pieces by soaking in vinegar. Commercial vinegar can be concentrated by freezing and removing the ice. On larger work such as the fork the scale can broken, enough for a file to bite, with abrasive paper. If the work is to be filed bright, remove the scale with a worn file first to save the teeth of your better files. If you will be filing some details only skip to step ⑤ and finish by heating to scale surfaces evenly.

②



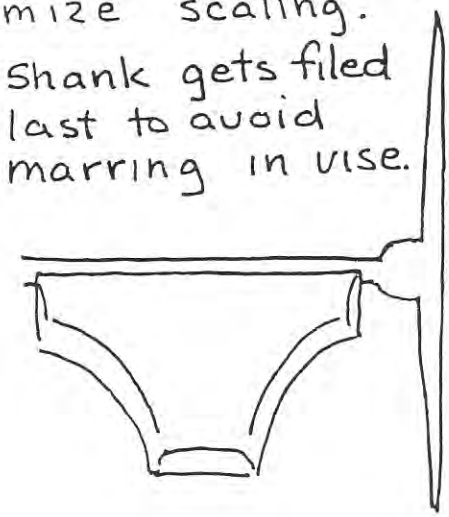
After most scale is removed hold shank of fork in vise and draw a sharp file held perpendicular to the handle down its length to produce a flat surface with even parallel scratches. Repeat with a mill file for a smoother surface. Do the same to the edges but leave the back of the handle alone.

③



File the fork tines before bending to shape. Bend at low heat to minimize scaling.

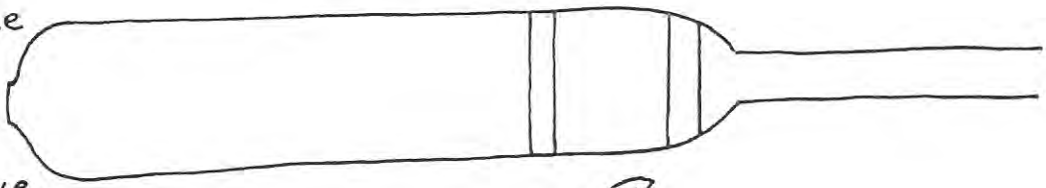
④ Shank gets filed last to avoid marring in vise.



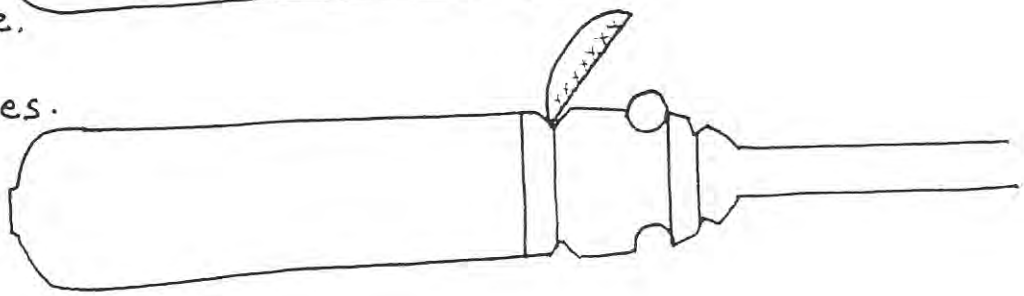
Open vise until fork shank rests securely in gap but will not fall through. File away from yourself as you roll shank toward yourself. with other h

Draw file shank to remove file marks.

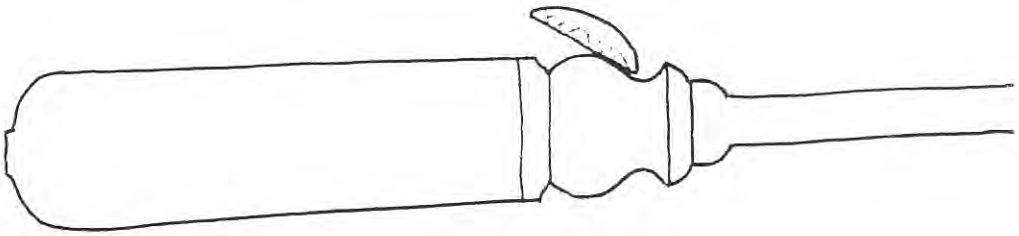
(5) Scribe handle to keep symetry. Curves can be cut by eye.



(6) Cut notches.

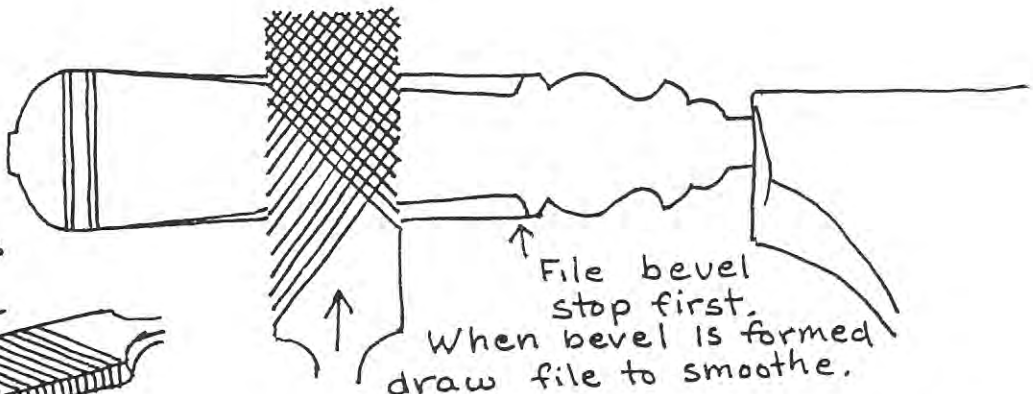


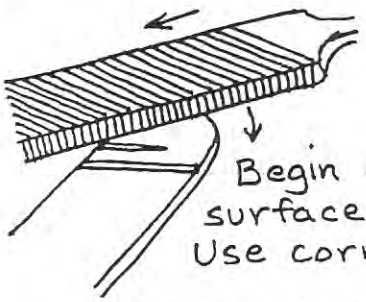
(7) File curves.



(8) Bevel

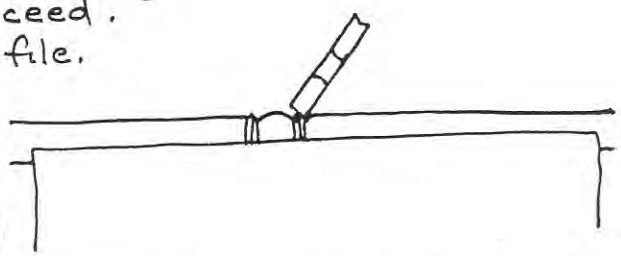
(9) Flat lines





(10) Round sharp edges slightly for comfort.

(11)



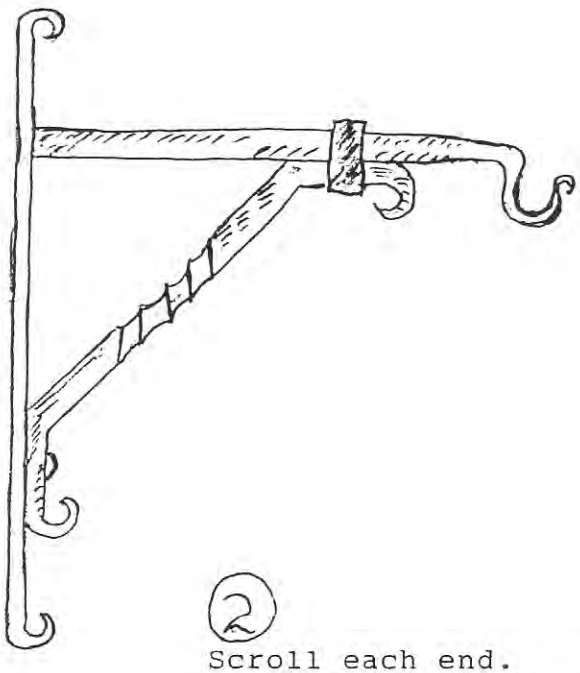
With shank supported on vise jaws file two sharp beads setting off a rounded section. Begin cutting on back and roll the shank until a light mark meets again on the back. File more deeply when all light grooves have ringed the shank.

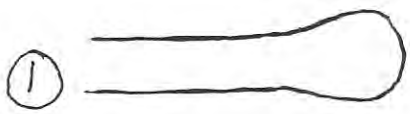
Blacksmithing Project PLANT HANGER

Basic Blacksmithing Processes to be Used DRAWING OUT, SCROLL, MORTICE + TENON, HOT COLLAR, PUNCHING, RIVITING, TWISTING, BENDING.

Stock Required $\frac{1}{4}$"x1"x19", $\frac{1}{2}$"x$\frac{1}{2}$"x8$\frac{1}{2}$", $\frac{1}{2}$"x$\frac{1}{2}$"x13$\frac{1}{2}$", $\frac{1}{8}$"x$\frac{3}{4}$"x3$\frac{1}{2}$"

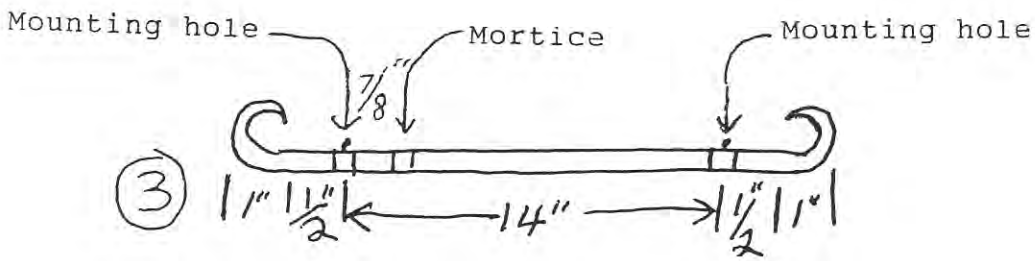
Tools Required HAMMER, VISE, PUNCH, MONKEY TOOL, TWISTING WRENCH





To make the vertical arm use the 1/4" X 1" X 19" stock. Make both ends the same. Draw the taper as shown. The tip is about 1/16" thick. File to shape if necessary. The piece is now 20" or slightly longer.

(2) Scroll each end. Each scroll is 1" dia. No illustration.



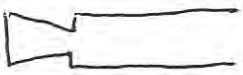
Punch 1/4" holes for mounting the hanger to the wall. If you use a flat punch start punching from the back side. If you slit and drift start from the front side. The latter method will make a wider bulge in the stock which you may find to be attractive.

Punch 1/4" hole for the mortice 7/8" from a mounting hole, measured center to center.

(4)

To form the horizontal arm use the 1/2" X 1/2" X 8 1/2" stock. Use one of the two following methods of making the tenon.

Chisel cut 1/16" deep on all four sides.

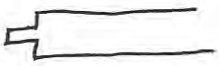


Draw out square with a butcher to almost 1/4" square.

Make round in a swage. If you do not have a swage draw out square on the anvil then make it round to 1/4" diameter.

OR

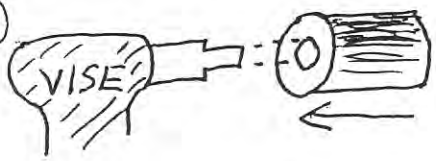
Fuller



Draw out square on the anvil then make it round to 1/4" diameter.

This method reduces the chances of breaking the tenon.

(5)



Make the shoulder of the tenon square by using a monkey tool. If you do not have a monkey tool and/or a swage (# 5 above) then you must file to shape.

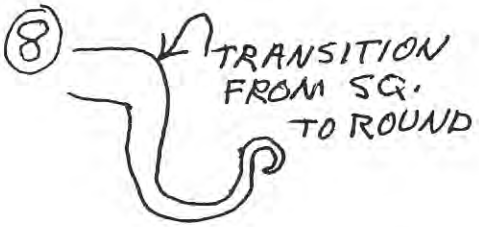
(6)

Center punch a mark 6" from the tenon shoulder. Draw out the remaining stock to a point and make it round. The over all length from tip to shoulder is 10 1/2".

(7)

Form a 1/4" scroll.

(8)

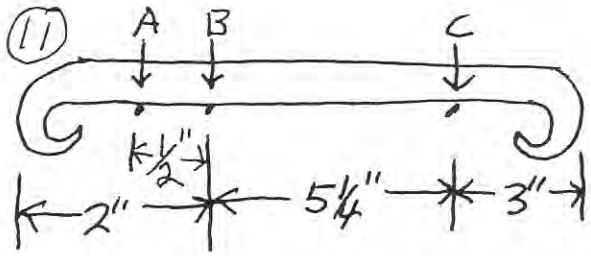


Form a loop over the anvil horn. Quench the tip before forming the loop.

(9) To form the diagonal arm use the 1/2" X 1/2" X 13 1/2" stock. Draw out each end as in step #1. The piece is now 15 1/2" long. No illustration.

(10) Scroll each end as in step #2. No illustration.

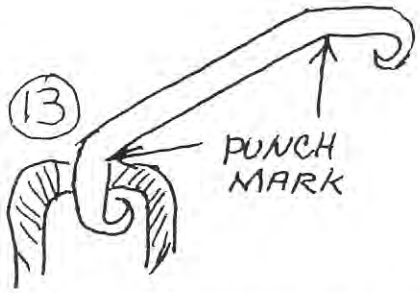
(11)



Center punch points A,B,C on the side of the stock as shown.

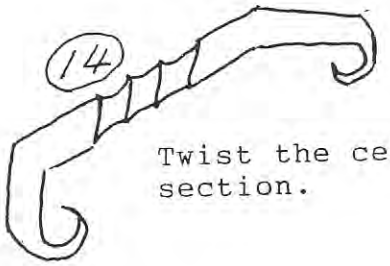
(12) Punch a 1/4" hole at point A. See illustration in step 3.

(13)



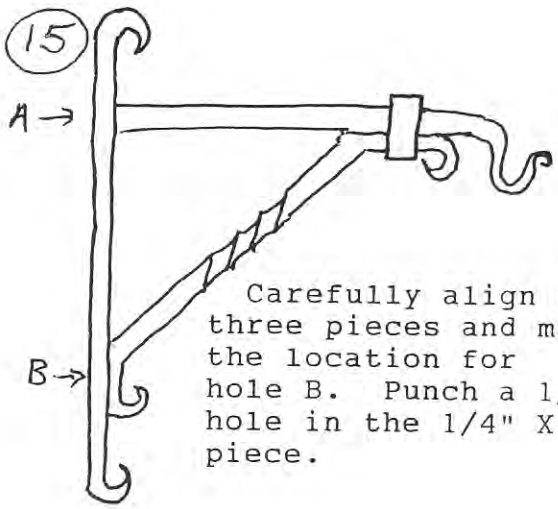
In the vise bend both ends to 45 degrees. Note position of punch marks.

(14)



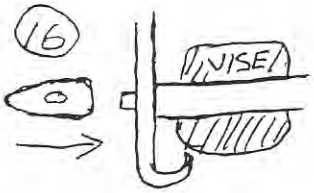
Twist the center section.

(15)



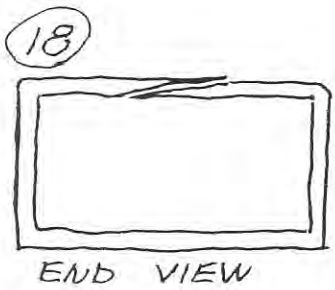
Carefully align the three pieces and mark the location for hole B. Punch a 1/4" hole in the 1/4" X 1" piece.

(16)

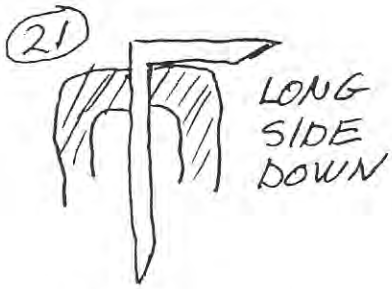


Heat the tenon and place it in the vise. Fit the mortice and tenon together and peen the tenon. File the tenon flat.

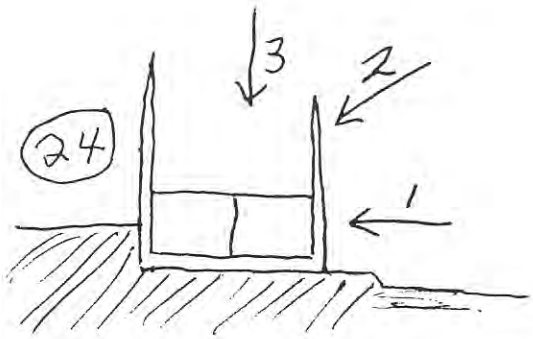
(17) Place a 1/4" rivet through the pieces at B. (See the drawing in step #15) The head is to show on the front of the plant hanger. Peen the rivet cold and file flat. When riveting you may want to place the rivet head in a rivet header to preserve the shape of the head. Or, you may choose to place the head on the tip of the anvil horn and allow the head to flatten.



Form a hot collar that will look like this when finished.



Bend in the vise cold. The center punch is at the inside of the bend.



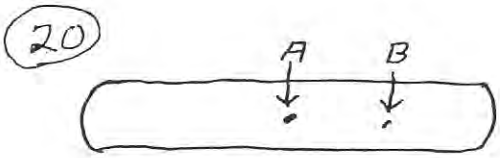
Place the very hot collar on the anvil step. Insert the stock to be joined and strike it down so that it is firmly seated into the hot collar. Fold the collar by (1) strike with the hammer side ways, (2) fold the collar over aiming the hammer diagonally, (3) finish by striking the collar straight down. Note - do not repeat steps 1 and 2 after step 3 has been completed.

Fold the second tang over using the same procedure as in folding over the first tang.

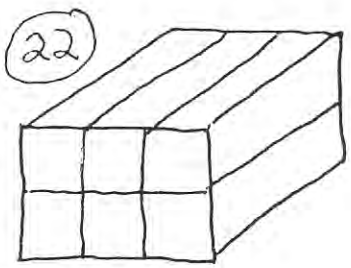
19

Cut a piece of stock 1/8" X 3/4" X 3 1/2". Taper each end to an overall length of 4". Each taper will be almost 1/2" long.

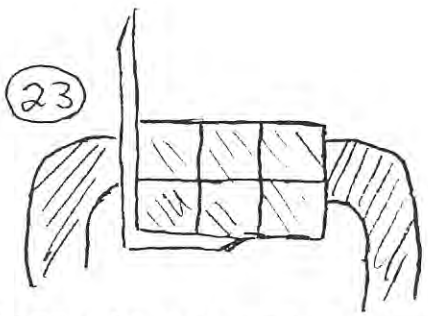
No illustration.



Find the center A and center punch B 1/2" from A.



You need to make a spacer for the next step. If you do not have stock of the proper size the spacer can be fabricated by using six pieces of 1/2" square about 2" long. Weld the ends together. Grind down the spacer a few thousands of an inch to make the collar fit tighter.



Place the hot collar and the spacer into the vise and bend 90 degrees. The inside width will now be a few thousands under 1".

Blacksmithing Project FORGE WELDING

Basic Blacksmithing Processes to be Used

UPSETTING, SCARFING, FIRE CONTROLL, WELDING

Stock Required ½" x ½" x 24"

Tools Required HAMMER

This exercise on forge welding should be used as an introduction to the next project of making a trade ax. Welding is used in making the ax. These instructions cover only the most elementary aspects of forge welding and are designed to help the beginner to pop his first weld.

Since there is so much more to forge welding, we encourage the reader to investigate other sources of information. For example, you will find it useful to receive instruction from an experienced blacksmith and to attend workshops and demonstrations. A number of good books have been written that give information on this subject. We suggest the following books:

The Art of Blacksmithing
by Alex Bealer

The Blacksmith's Craft
by Council For Small Industries In Rural Areas

The Blacksmith And His Craft
by J.E. Hawley

The Blacksmith: Iron Worker And Farrier
by Aldren Watson

The Edge Of The Anvil
by Jack Andrews

These books may be ordered from Norm Larson Books (805) 735-2095 or Centaur Forge (414) 763-9175. Call for a catalog. Norm Larson can also recommend other good books on forge welding and blacksmithing in general.

Important points to remember when forge welding.

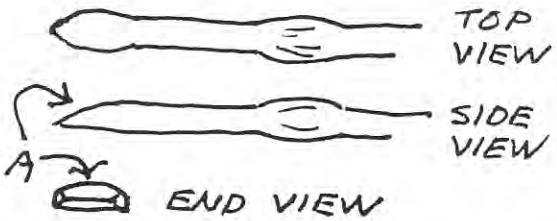
1. Use only a clean fire. This means clean out the ash and clinkers. The fire must be made up of burning coke 6" deep. A shallow fire will permit too much air to pass through the fire without being burned up. Oxygen in contact with the hot iron causes scale to form. Scale prevents the weld.
2. Properly scarf the iron. The parts to be joined must be properly shaped to allow for a weld. Each type of weld requires a different shaped scarf.
3. Work quickly but not in haste. The iron rapidly drops below the welding temperature.

4. The proper welding temperature is determined by the appearance of the iron when it is in the fire. It will look like a creamy white or have a wet appearance with just a hint of orange in its whiteness. Brilliant white is too hot.
5. Use a flux as it helps to protect the iron from the oxygen producing scale and lowers the melting point of any scale that does form. Use a commercial forge welding flux or borax.

The type of weld for this exercise is called an eye weld. It is the easiest weld to do. If you use stock two feet long, or even a bit longer, you will not need to use tongs, which is a good idea for a beginner.

1. Heat the stock to a light orange 4" - 5" from the end. Isolate the heat to a length on 2", place in the vise and upset to 1 1/2 times the original thickness. (For 1/2" stock this is 3/4".)

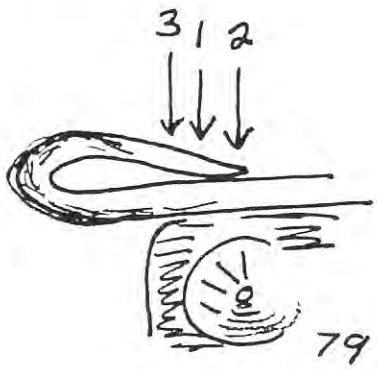
2. Scarf the end by drawing out to a short point. Carefully note the shape and dimensions in the drawing. Surfaces "A" will be folded back on to the upset area as seen in step 3. The scarf needs to be high in the center (see end view) to permit the slag to be forced out upon welding.



3. While hot, bend the scarf over on top of the upset area. The weld will become thinner as it is repeatedly struck by the hammer during the welding process. The additional material formed by the upset will prevent the weld from becoming too thin. Excessive thinning is most likely to be at point A.

4. Place the iron in the fire and cover it with coals. When the iron begins to turn orange, remove it from the fire and sprinkle flux on the area to be welded and return it to the fire.

5. Occasionally and briefly glance at the iron. Don't stare at it constantly. When the welding heat is reached withdraw the iron from the fire. With a sudden swinging motion sling off the slag or you may wish to tap the iron on the anvil to remove the slag. Place the iron on the anvil and strike with moderate blows in the sequence as shown in the illustration. Rotate the iron 90 degrees and strike the sides. Now you can use heavier hammer blows. You probably will need two or three heats.

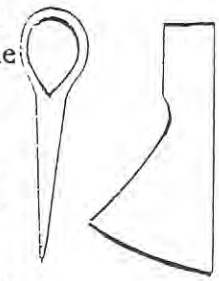


Blacksmith Project Trade Ax

Blacksmith Processes to be Used fulllering, spreading, welding, and filing

Stock Required ½ " X 1 ¼ " X 9" mild steel and ¼"X 1"X 1 ¼ " file fragment

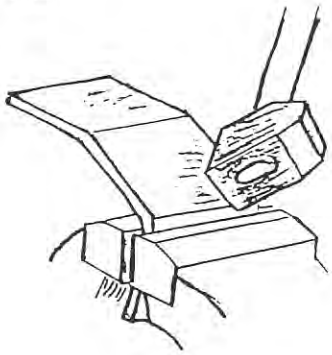
Tools Required flat-bit tongs, hoop tongs, rasp, rule, vice, hammer, and anvil



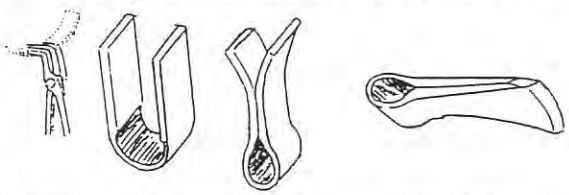
Nineteenth-century fur trader Paul H. Beaulieu characterized the trade ax as "a very clumsy pattern resembling in make, a screech owl with the feathers plucked off his body but not the head." Blacksmiths forged this staple of the fur trade in three sizes. Axes made by a single maker varied in size and shape. Also, the eye of trade axes varied in size and shape from to maker. The method described below does not require a drift. However, if you wish to use a modern trade ax handle found at muzzle loading supply houses, you might employ a drift to standardize eye-size -and shape.

Begin by fullering 4 ½ inches of center of the stock to ¼ inch thickness.

2 Then form a sharp corner of each end of the thinned center to a sharp 45 degree angle in the vise.

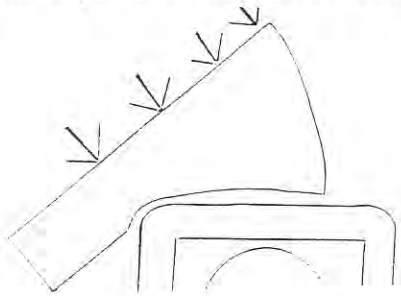


3 Then fold the stock until the sharp corners of the eye meet. Weld the section nearest eye first. Do not place the eye in the hottest part of the fire. Keep the eye out of the fire. Only put the bit in the fire. The eye is thin and will easily burn. Use a hoop tong to grip the ax.

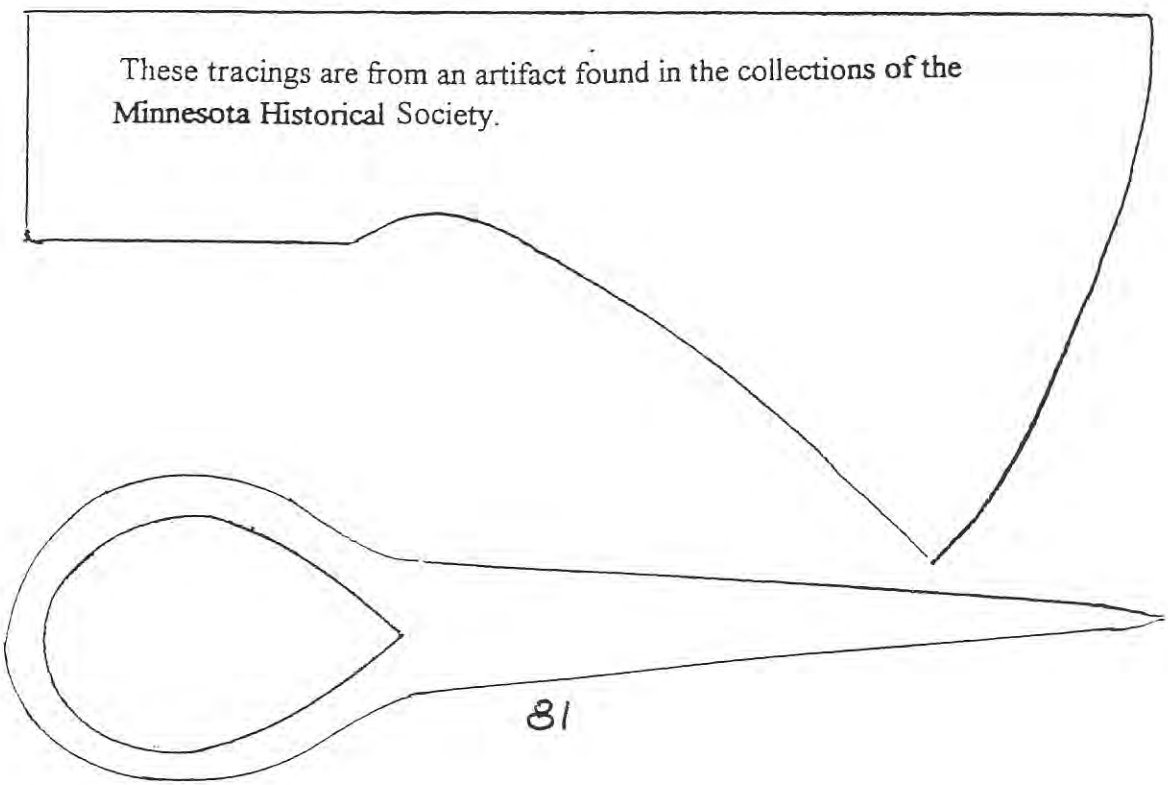


Next weld the steel and the bit of the ax. First, flux the open bit of the ax with borax and/or *Easy Weld*. Place the file fragment between the loose ends of the bit and hammer to clamp the steel in place. Do not weld at a sparkling heat. Files (W1) will weld a yellow heat, but burn at a white heat. After welding, spread the bit to the desired shape and hot rasp or grind the bit to a sharp edge.

To force the ax blade to spread in one direction, use the pien of the hammer as a fuller to get optimum lateral spread. Frequently during spreading, coerce the spread downward by straightening the top edge on the edge of the anvil, always keeping the spread in one direction, as illustrated below. The hammer blows are placed as the arrows suggest. Do this often during the spreading process. Do it at a yellow heat to keep the weld from splitting. Do not allow the ax to twist during this process to keep the weld from splitting. If you are careful, the eye will never need drifting to perfect its shape. However, if the eye becomes misshapen, you can round the eye over the horn of the anvil. Avoid using a drift. It can break the weld. Historically, trade ax eyes do not taper; they are straight. Also, trade ax handles were made by the buyer from the best available hardwood.



Harden and temper to a blue oxidation color. An ax, like all edge tools is hardened by quenching in the direction it will cut. File steel is usually W1, a water hardening alloy. Heat three inches of the bit to a cherry red. Quench half of the red end in plain water. Leave half of the heated red end out of the water. Move the ax up and down in the water with short rapid strokes of about a half inch in distance. This will break the steam envelope that forms around the steel in the water. This process will give a even quench that is less likely to crack. No more than one and a half inch should be quenched. When all of the color is gone from the end under the water and the unquenched end has a faint red color, pull the piece from the water and polish the quenched end with a file and watched for the oxidation colors as the cooled bit receives heat from hot body of the ax. First you will see a yellow, then a brown, next a purple, and last a blue. Quench the end when it reaches blue and you will have an edge that is hard but not brittle.



Blacksmithing Project # DOOR LATCH

Basic Blacksmithing Processes to be Used

DRAWING OUT, SHOULDERING, PUNCHING, BENDING, RIVETING

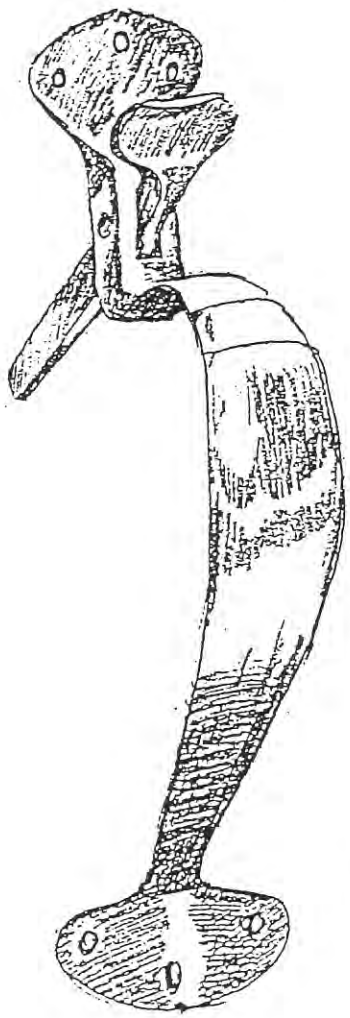
Stock Required

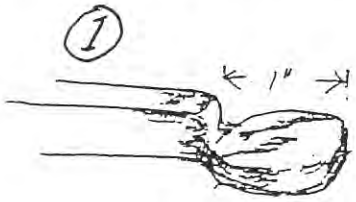
1/2" SQ, 1/8" RIVET,

Tools Required

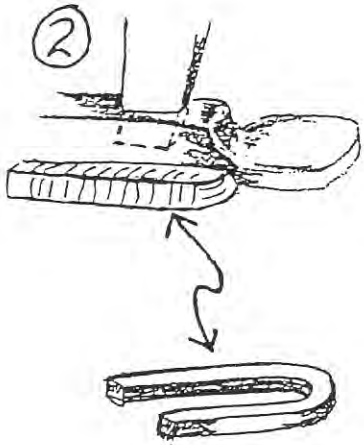
BOLSTER, 5/16" X 5/8" PUNCH, HAMMER, TONGS, VISE

This latch is authentic for the early 1800's. Typically, the parts would not fit closely and the holes for the rivet might not perfectly line up for an ordinary latch of this era. The front of the latch would be filed and the back left unfiled. You may choose to improve the workmanship.

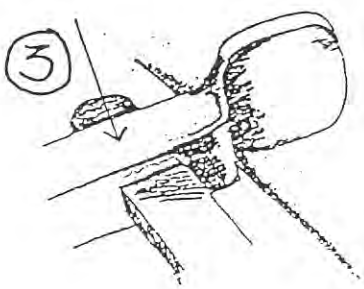




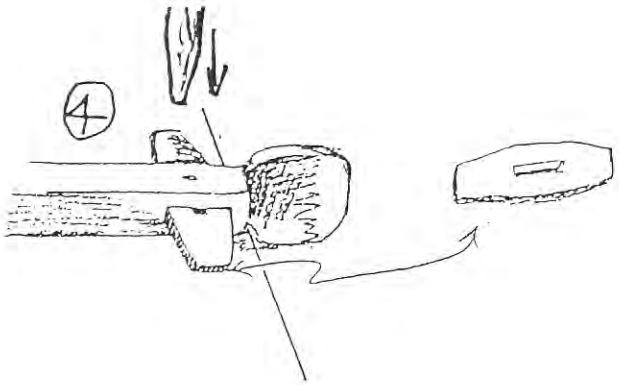
Using 1/2" square stock, shoulder over the edge of anvil to start making the handle.



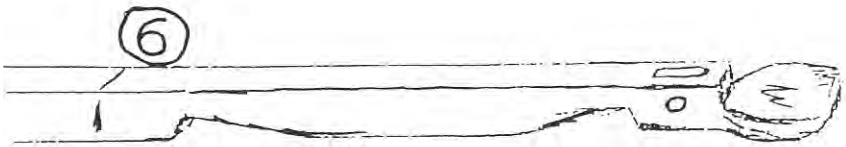
Punch a slot 3/16" X 5/8". Start the punch 1/4" from the shoulder. Punch from both sides. Be sure that your punch is sharp and square at the tip. Use the bolster that you will make from 1/2" square stock.



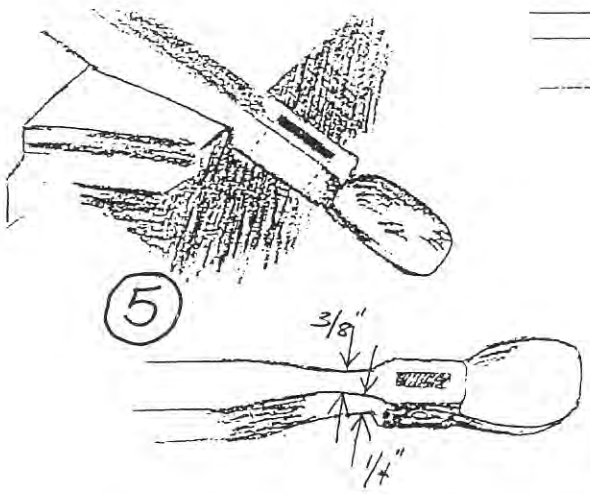
With the cusp over the edge of the anvil, strike down with the hammer keeping the punch in place. This is done to flatten out the bulge caused by punching.



With the cusp over the edge of the anvil, punch a 1/8" hole from each side. Support the material with a bolster that you will make. (Or, drill a hole.) The center of the bolster is the same size as the rectangular hole. The slot in the bolster is slightly larger than the round hole to be punched.

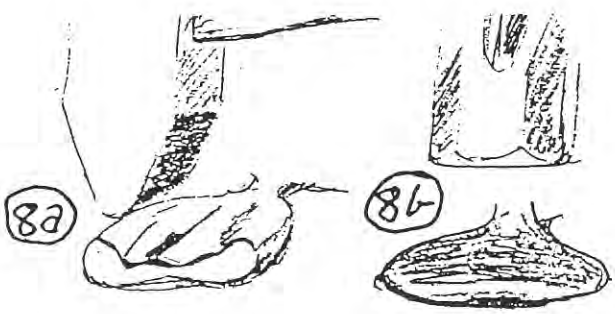


Shoulder the stock 6" from the 1st shoulder. This 6" section will grow to about 7".

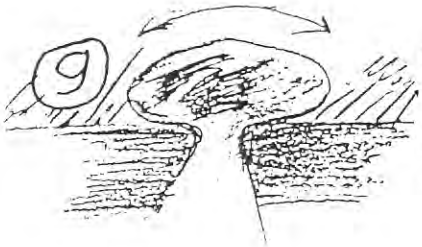


Over the far edge of the anvil, shoulder three sides of the stock. Start the shoulder 1/4" from the end of the rectangular slot.

Shape the handle by drawing the material sideways with the peen of the hammer. Make the cross section slightly rounded. The top side of this drawing shows the rounded side. Then cut off, leaving a 1" cube on the end.



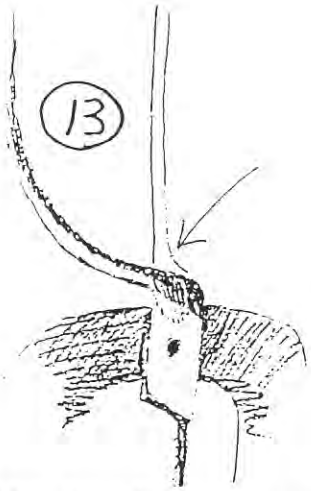
To form the cusp, draw out sideways the 1" cube using the cross peen of the hammer. Form a groove in the center (8a). Then flatten with the face of the hammer, to shape (8b).



On the anvil face at the near edge of the anvil, form thekidney shape by rotating the stock as you strike with the hammer. The material will eventually be quite thin (about 1/16") and about 2" wide.

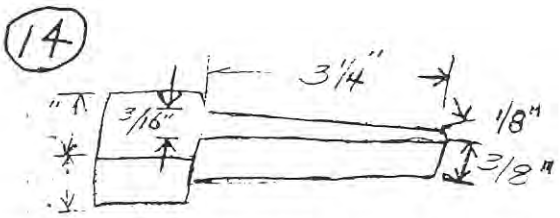
(10) Form the other cusp much the same way. (No illustration.)

(11) Punch or drill three holes in the cusps to accept the screws. Nails are more authentic. (No illustration.)

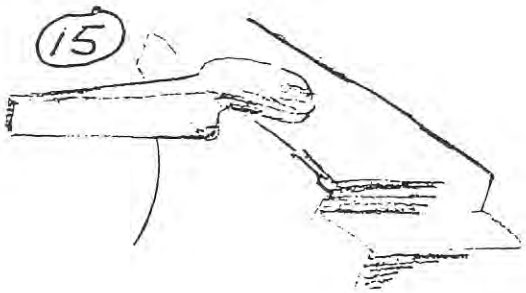


To shape the handle, place the handle in the vise as shown, strike down with the hammer in the direction of the arrow. At the same time, bend the top part of the handle up with tongs.

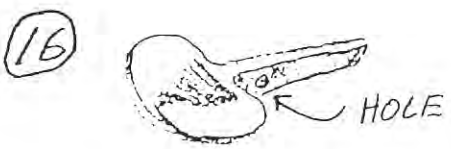
In the vise, bend the bottom cusp.



Using 1/2" square stock, make the thumb press by forming a shoulder on two opposite sides. Draw out to the dimensions in the drawing.



Form the cusp on the anvil face at the near edge of the anvil. Draw out sideways with the cross peen of the hammer.



Slightly cup the thumb cusp. Punch or drill a 1/8" hole.

(17) Assemble the handle and thumb press with a rivet.

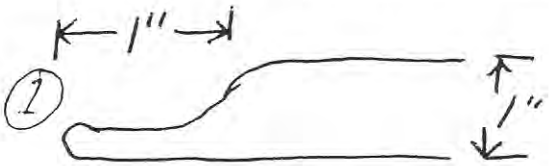
Blacksmithing Project DUCK HEAD

Basic Blacksmithing Processes to be Used

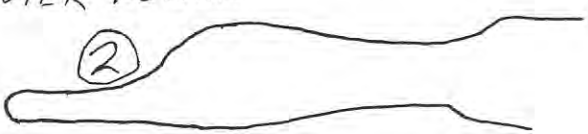
DRAW OUT, INCISING, DECORATIVE PUNCHING

Stock Required 3/4" X 1" X 24"

Tools Required HAMMER, EYE PUNCH, STRAIGHT CHISEL, CENTER PUNCH, CURVED CHISEL

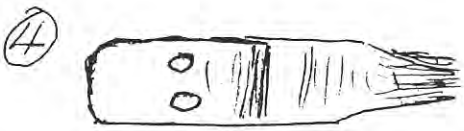


Form the bill on the anvil horn. The hammer will strike what will become the underside of the bill. Keep the 3/4" width of the stock.

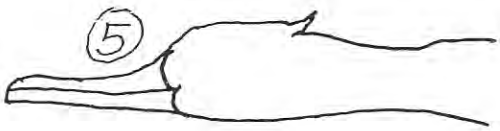


Form the neck near the tip of the anvil horn and make the neck round all the way around. Since we are mainly concerned with forming the duck's head the neck can be any length.

On the face of the anvil taper the top of the head to 1/2" keeping the bottom the full 3/4".



Punch in the nostrils with a center punch. If you have a tear drop shaped punch, so much the better.



Using a straight chisel, form the line where the upper and lower bills come together. Do this all the way around on three sides. Using a curved chisel (or a straight one if you don't have a curved chisel) form the lines between the bill and the head. Using a straight chisel nick the edge of the back of the head to form a feather sticking out.

You will need to make an eye punch for the next step. Using medium or high carbon steel (car coil spring will do) forge it to a 3/8" flat end. While it is hot drive a ball bearing or a blunt tool down into the 3/8" end. File the outside to shape.

Drive the eye punch into the head. Using a center punch lightly tap in the pupil.

DESIGNING YOUR OWN METALWORK PROJECT

UNIT 4

This unit is very different from the rest of the guide. It deals in personal philosophy and the art and science associated with creating a plan. Don't be tempted to skip this unit, because learning the process of design is vital to your development as a blacksmith.

So study the text until you are comfortable with the concepts that Bob Walsh is putting forth. Even though you aren't *required* to fill out the 6 resource sheets, we encourage you to start your own resource library right away. Even though this design process may sound complicated, you can use this same principles to design a small plant hanger.

After you have done the initial work to build your own design "inventory", begin working on your own first design. Prepare drawings, then produce the project

Part of the learning process for design involves taking "art" classes sooner or later. Many blacksmiths feel that "art class" isn't a very macho place to be and therefore avoid any settings where proportion, perspective, etc. are taught. These concepts are key to converting an idea or a rough sketch into a well crafted project, so consider this step if you are serious about becoming a blacksmith.

DO take the time to learn and expand upon the concepts that this unit has to offer. You CAN'T loose! When you have completed this unit, be sure to bring your project, complete with working drawings, to a regular meeting of the Guild of Metalsmiths. There you will receive this important brass plate, "Designing Your Own Project", to be affixed to your plaque.

DESIGNING HAND FORGED IRONWORK

(primarily gates & railings)

ESTABLISHING OUR RESOURCE LIBRARY

When I first became enamored with designing ornamental iron, quite frankly, I found the possibilities limitless and the whole subject overwhelming. Now, after 25 years of studying and practicing in this field, I find it is no longer overwhelming at all, but actually quite simple and straight forward.

Let me put 25 years of study into 25 pages (or less). But first, let me paint a word picture for you. This is how I see the subject of Art (linear gate and railing work) at this point.

Imagine this huge dense forest. This forest is <u>really huge.</u> The trees are very tall, and their umbrella shaped tops shade the whole forest floor. The forest floor is soft and inviting, covered with more ferns and other plant forms than you thought imaginable. There are a few hills, valleys & caves, the perfect place for exploration. This cool dark forest goes farther than you can see. This forest represents the art world, as I see it.

Now, we're standing on one edge of this forest. Our goal is to produce a successful piece of hand forged art. To achieve this goal, we need to get through the forest, and when we reach the other side, the successful piece of art will be our trophy.

In this forest (or art world) there are many many routes which will get you from one side to the other. There are also, just as many ways of getting lost in this theoretical wonderland, without <u>ever</u> getting to the other side (producing an artful product).

Let me show you two paths, that will get you very successfully from the concept side of the forest, to the successful completion side of the forest. Because this is the source of my livelihood, I stick on these two proven paths, in order to keep proficient. You may wish to experiment more than I do at this point.

What do we need to do, before we start out on our journey? Like any journey, we need to pack our bags. Before a cook would attempt to cook a meal, they would fill their pantry and refrigerator with resources. Designing ironwork is no different. The more resources we have to fall back on, the better the end product will probably end up being.

Here's your assignment list. Take 6 sheets of blank paper, and lay them out on a table in front of you. These will be the begining of your resource library. On top of these 6 sheets, label them.

Label number ---

#1, Dynamic Shapes in Metal.

#2, Static Shapes in Metal.

#3, Representational Shapes in Metal.

#4, Repetitive Design Concepts.

#5, Mechanical Details.

#6, Miscellaneous Details.

Now, on sheet #1, draw simple crude lines that represent every dynamic movement you can remember in metalwork. These might include "S" scrolls and all the variations you can think of. "C" scrolls and their many variations. Add all the different scroll end terminations, like fish tail ends, snub ends, leaf ends, rat tail ends, whip like ends, flared ends, animal head ends etc. etc. Next, sketch examples of other dynamic forms, tendrils, vines, Milwaukee style spaghetti, organic wiggly forms, etc. etc. If, from a distance, it can be read as having movement, sketch it.

Hopefully, this is where you can convince your spouse, that if the two of you were to take a European vacation this winter, this will help you with your research (good luck).

The next time you go to an ABANA conference, skip out on one of the demonstrations, and go into the gallery with your sketchbook. The first thing you will notice, is that there will already be other people in there, sketching details, do the same. I'm not suggesting that you copy or reproduce anybody's work per se. What I am suggesting, is that you continuously expand your resource library <u>of details</u>, and from this library of details, develop your own compositions. We will address composition later in this article. Very few people work from a total vacuum.

#2. Static Shapes in Metal. On this sheet, sketch all the static forms you can think of. In railings these would include, vertical balusters, diagonal balusters, herring bone patterns, chevron patterns, XXX patterns, dog bone patterns with upset ends on straight pieces, etc. etc. When I first started on page #2, I thought "how boring is this!". Actually, I found out that it's not so boring after all, once I opened up my eyes.

Now, in between some of the static patterns you have come up with, add the various twists you know about. Now, add to this, all the joining techniques you are familiar with. To really kick this category into passing gear, dig out some of your books which show Yellin's work. Look at what he has done to static work with detailing, it is beyond my imagination. There are many architectural styles where this geometric patternwork is very applicable. Geometric patternwork, is also very valuable as backup work for dynamic forms. I have come to highly respect geometric work, and how necessary it is in architectural projects.

#3. Representational Shapes in Metal. This is anything that looks like an identifiable thing. Leaves, both contemporary and acanthus, grapes and vines, oak leaves and acorns, figurative work, cherubs, sea forms, shells, floral forms, animals, etc. etc.

#4. Repetitive Forms. This repetitive category can be built using any of the above categories in a repetitive manner. A run of "C" scrolls or "S" scrolls, how they would join together etc. is applicable on this sheet.

#5. Mechanical Details. On this sheet, sketch all the interesting detailing you know of. Collars, mortise and tenons, wrapping of the joints with smaller stock, various joint preparation prior to riveting, rivet styles, offsets, joints held together with decorative drift keys, layering & bundling of members, slot punching, decorative rivet groupings, stampings, exaggerating joinery size for decorative purposes, etc. etc.

#6. Miscellaneous. This is the "catch all" sheet for anything you have a hard time categorizing. On my sheet, I have newel posts in different styles, rosettes, decorative gate heel & latch concepts, squashed ball spacers, anything that doesn't fit into a previous category, goes on page #6.

Adding to, and refining your resource library, is a never ending process. Because it does not have a ceiling, it never gets boring.

THE MORE YOU ADD TO YOUR RESOURCE LIBRARY, AND THE MORE YOU USE IT, THE MORE SKILLED YOU BECOME. THE MORE SKILLED YOU BECOME, THE BETTER YOU ARE ABLE TO SEE NEW DETAILING AND DESIGN POSSIBILITIES TO ADD TO YOUR RESOURCE LISTS. THE CYCLE ONLY GOES UP, AND YOU ARE THE WINNER!

From my perspective, my resource lists and the following steps for creating a design concept, are the most valuable tools in my shop. They give the shop, the ability to establish a project and sense of direction (what to do with all these tools!).

ESTABLISHING OUR DESIGN GOALS figuring out, exactly what our design assignment is???

At this point, so we can move forward, lets assume you have your 6 sheets filled out as far as your knowledge will allow (remember, this is a never ending process). With this resource bank in front of you, let's jump off the diving board and see if we can swim, so to speak. You can, anybody can, but first, think back in time.

Remember how your swimming instructor told you to remember to do certain things, so you wouldn't sink. Mine, Mr. Sabalka would say, "remember to kick your feet like this, move your arms like this, hold your head like this, or, if you don't sink, I'm going to flunk you!" Well, the design process is no different. With this design process, you can design any large architectural component (gates, railings etc.) but like swimming in the deep end, we need to remember and address 5 issues. I'll be your swimming instructor and let's walk through these 5 issues, one at a time.

Issue number 1, Establish what style of home you are designing metalwork for.

This can be done in a number of ways.

A. Ask the homeowner. Many homeowners know absolutely zero about architectural styles, but when they purchased their home, they were told what style it was.

B. For less than $20.00 you can buy a common architectural style identification book. These are available in most good book stores. They are usually purchased by architecture buffs, travelers (?) and people like you and I. With these simple picture books, you match the look of the house in question, with a similar home in the book, and then read a page or two about the style, and it's origin.

C. Ask the builder.

D. Ask the Architect.

E. Take some photos and ask an architect you know.

Once you identify the style of the home you are working with, if it is based on European roots, you can look in a book called

Wrought Iron in Architecture
by Gerald K. Geerlings
Available through Norm Larson Booksmith (805) 735-2095
evenings, west coast time.

Gerald Geerlings breaks ironwork down in his book, by country and then by century, with examples in photos or drawings. When it comes to being knowledgeable about classical metal, Starkie Gardner is the established king in the land of academia, but for my money, Gerald Geerlings is tops. The reason I say this, is because he writes so a metalworker can go right to the appropriate chapter and read three paragraphs, look at a few pictures, and then start designing.

If you're working with classic architecture which has European roots, the Geerlings book will get you going in the right direction.

Issue #2 <u>What if you are confronted with non-descript or MUDDLED architecture?</u>

Non-descript architecture is any dwelling that does not have a style or visual identity.

What is muddled architecture? This is the home that has been remodeled (re-muddled) so many times with the wrong styles of additions, that the home's original character is lost. This is the owner built home, that is a monument, to why a person building a house should hire a competent architect. This is the home, that would do well with a good insurance policy, and an appropriately timed flood!

So, how do you design for a non-descript or home without an identity?

Step back and look at the home and the surrounding environment. The house must have at least one notable characteristic, if only the roof pitch, and length of the eve overhang. Now look around the house. If there are oak trees, then design with oak leaves and acorns. Possibly you can work the element or feature you noticed on the house into the design. Or, just skip the architectural element or shape and stick with the oak leaves and branches. If the house is built in a swamp, then cattails and bulrush become the design elements you work with. If you're in the desert, then cactus and related plant forms will give you design elements to work with. If you're on the seacoast --- etc. etc.

New homes designed by builders are going up all over America. These homes, in my neighborhood are very large, have very high pitched roofs, and always have a three car garage on the front of the home. This style may differ in your neighborhood, but I suspect you have builders homes of some sort going up. These homes usually fall into the identity-less home category. Yesterday's builders homes were ramblers (in the upper midwest) today's builders home, (in the upper midwest) is a huge sheetrock castle.

If your design challenge has historical roots, stick with them, but if not, look at the surrounding environment for inspiration. Non-descript homes and sheetrock castles do very well with ornamentation derived from indigenous organic forms, as it warms them up.

An inexpensive book I find inspirational for floral work in metal, is --

A Treasury of Flower Designs
100 Garden Favorites by Susan Gaber
Dover # 0-486-24096-7
Available through Norm Larson Booksmith (805) 735- 2095
evenings west coast time.

Issue # 3, Coordinate the value of the metalwork with the value of the home.

A $20.00 per foot railing from the yellow pages is going to look pretty understated on a million dollar home. Conversely, a hand forged $650.00 per foot railing is going to be gross overkill, on that older rambler!

Metalwork needs to be designed so it's economic worth, is appropriate for the home it is being attached to. Hand forged iron is labor intensive and expensive. Does this mean you can't design something for the inexpensive home next door? The answer is not necessarily, no, but keep it simple. Don't let your enthusiasm for metalwork carry you away, and end up making a project that is too fine, to be either appropriate for your neighbor's house, or cost effective to make. Even if you're working for free, and cost is not a factor, you still want the work to look appropriate for it's application.

Issues #4&5 The successful composition

With issues #1 & 2, we have hopefully narrowed down the myriad of design elements to the select few classic or organic forms that are actually applicable to the design challenge at hand. It always amazes me, out of all the choices in your resource library of design elements, how few elements are actually applicable to any given project.

With issues #3, we have resolved how labor intensive this project should be, so it's economic worth will be (generally up-scaling) but appropriate for the structure the metal will be eventually a part of.

So, with our appropriate design elements and the complexity of the job in mind, let's move on to issues #4&5.

THE DESIGN PROCESS

It's time to pick a path to get us through the woods. We have two paths to pick from. There are little marker stakes at the start of these 2 paths. The sign on one marker stake says "Appropriate elements for the job, which HIGHLY CONTRAST each other". The other marker stake says, "Appropriate elements for the job, which have LITTLE OR NO CONTRAST with each other".

These are the two methods we are going to design with. Let's examine some examples, and identify the decision making behind their compositions.

Example #1. This is an example of a real classic gate, designed with highly contrasting elements. The top or cresting, is made up of curvilinear (dynamic) forms as per your resource library page #1. The line with the highest degree of contrast when compared with a dynamic line, would be a straight, or static line, as per your resource library sheet #2. Because of this, static lines are used below the cresting for contrast.

The center of the gates are broken up with meaningless filler. This filler, does not compete with the top, or bottom, it just keeps everything together.

The bottoms of the gates have two things going for them. First, they have solid plates going across them for visual weight (and strength) and then they have some three dimensional floral forms, the layered rosettes.

Now, this high contrast gate is a relatively simple gate. If we wanted to make it more ornate, I wouldn't change the basic design much. What I would do, is to replace the center circles with something more complex, probably remove the small generic leaves on the top cresting, and then start to layer up the gates with acanthus leaves. If you look at the classic European gatework that is so highly ornate, the basic design is often not so complex, under all that leafwork. The leafwork is often 2 layers thick, on both sides. Thick leafwork really changes the character of ironwork, from being linear, to having visual mass.

Example #2. This is a contemporary gate, for a wine tasting room in a new builders style home. It uses the same high contrast approach to it's design as the classical gate in example #1. This gate would benefit from a little more mass across the bottom.

Example #3 & 4. These are 2 examples of garden gates designed for builders homes, with no historic architectural design elements to fall back on. So, on the gate with the diamond pattern in the center, the diamond pattern was borrowed from some existing window boxes which have this pattern as part of their design.

The gate with the square pattern in the center, uses the square pattern because it reproduces some existing wood trim on the home (condominium). The flowers visually tie the gates in with the home owner's gardens, and the remaining elements tie the projects together with the owner's interior furnishings.

Examples #5,6,7 & 8. Now, let's shift over to the other path that goes through the woods and examine "Designing with little or no contrast". These examples, illustrate three things. First, these examples are not based on the high contrast method of designing. Second, they illustrate examples that become increasingly more complex, while still keeping within the minimal contrast design principles. Third, examples 5,6 & 7, are symmetrical in design, and #8 (which is going to require some imagination on your part) is asymmetrical. The left side of #8 is not a mirror image of the right side, or even close.

Let's examine the concepts behind these examples.

Example #5. This is a very simple railing for a 10th century Robin Hood style home (Norman). This railing does not rely on contrasting elements, but simplicity. To keep the railing from being boring, the balusters have an ornament in the center. The joinery provides interest, and the whole railing has a heavily hammered texture, which gives it a real sense of presence.

Example #6 is starting to get more ornate, without the addition of contrasting elements. It simply has more parts that #5, and more detailing. This is a section of railing for a log home.

Example #7. OK folks, now this is ornamental!!! The design is symmetrical and based on low or no contrasting elements. Some examples that would equal this, could be woven diamond patterns or square patterns, both with interesting intersections of some sort.

Example #8. In this grille or gate, imagine an asymmetrical panel, which is primarily based on a few elements that do not highly contrast each other.

Examples could be ---

A. A random Art Nouveau composition.

B. An organic scene of some sort, with a few animals.

C. An artist might randomly compose asymmetrical elements here, that reflect his/her own personal style.

D. Anything that is asymmetrical and not based on high contrast.

The last approach to design I would like to touch on, is repetition. You can successfully use the high, or low contrast method of composition when designing for projects with repetition. When using these two means of approach, I usually think "panels". With panels, you can combine your dynamic lines with representational work, and then separate the compositions with straight lines, examples 9 & 10.

A third alternative to repetitive work, is to have a rolling or continuous pattern, example #11. Let's compare example #11, with example #1, the large classic gates. In the gate description, we addressed how to make it more ornate, by layering it up with acanthus leaves. Conversely, if you look at example #11, you will see that it is really a simple rolling "S" scroll pattern. This simple pattern is overlaid with the acanthus leaves and rosettes. If this were going into a modest home, we could just remove, or reduce the amount of leafwork applied. The point being, really ornate ironwork, is not necessarily made up of more complex scrollwork. Highly ornate ironwork, is often created by adding, layering and doubling up the number of components in the project.

IN CONCLUSION

Up to this point, we have covered how to get through the woods. Let's talk about how to get stuck in the woods. I feel the failure of many design concepts, is that they were composed with elements that neither contrasted or complemented each other. An example of this might be combining a plaid with a diamond pattern, and then overlaying it with some character-less ornaments.

Composing metalwork is no different than dressing yourself. Would this shirt or blouse go with these slacks? Do they either complement or contrast each other? Does this belt or accessory detail out the composition? You do this daily.

With these basic design fundamentals, and the correct elements, I feel you can design any large architectural project. Now, let's downshift, and address smaller projects. These smaller projects might include tables, curtain hardware, fireplace tools and other interior furnishings.

Approaching these items can be done with the same design principles as previously outlined, but this does not necessarily need to be the case. Architectural compatibility is not always a factor, and these are accessories, not architectural components.

Accessories need to serve a function. Focus on the function and let the SPIRIT OF THE ENVIRONMENT help you make your design decisions. Be responsive to the spirit of the environment.

If the home is contemporary, then design a set of sleek fireplace tools (unless you are promoting your own artistic style). If the home is colonial, then dig out your Early American Iron book. You can still use the contrast or no-contrast principles, but now the spirit of the environment will pretty much dictate what needs to be done. Be sensitive, and respond to this.

I think once you get into the swing of designing with your resource library, and using the 5 check points for reference, you will find that architectural projects of size and complexity are not intimidating, but exciting and fun, Based on logic.

Now, we can really put that shop full of tools to work ---

possibly, even justify the purchase of a few more!

Good luck

Uncle Bob

Robert Walsh

EXH

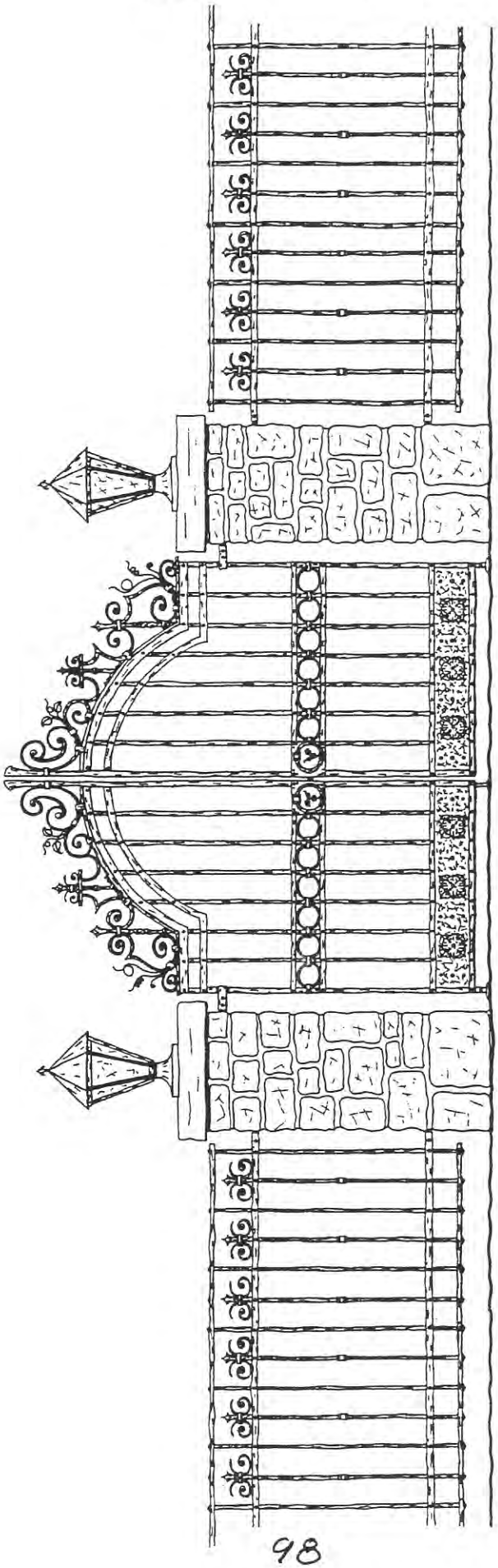
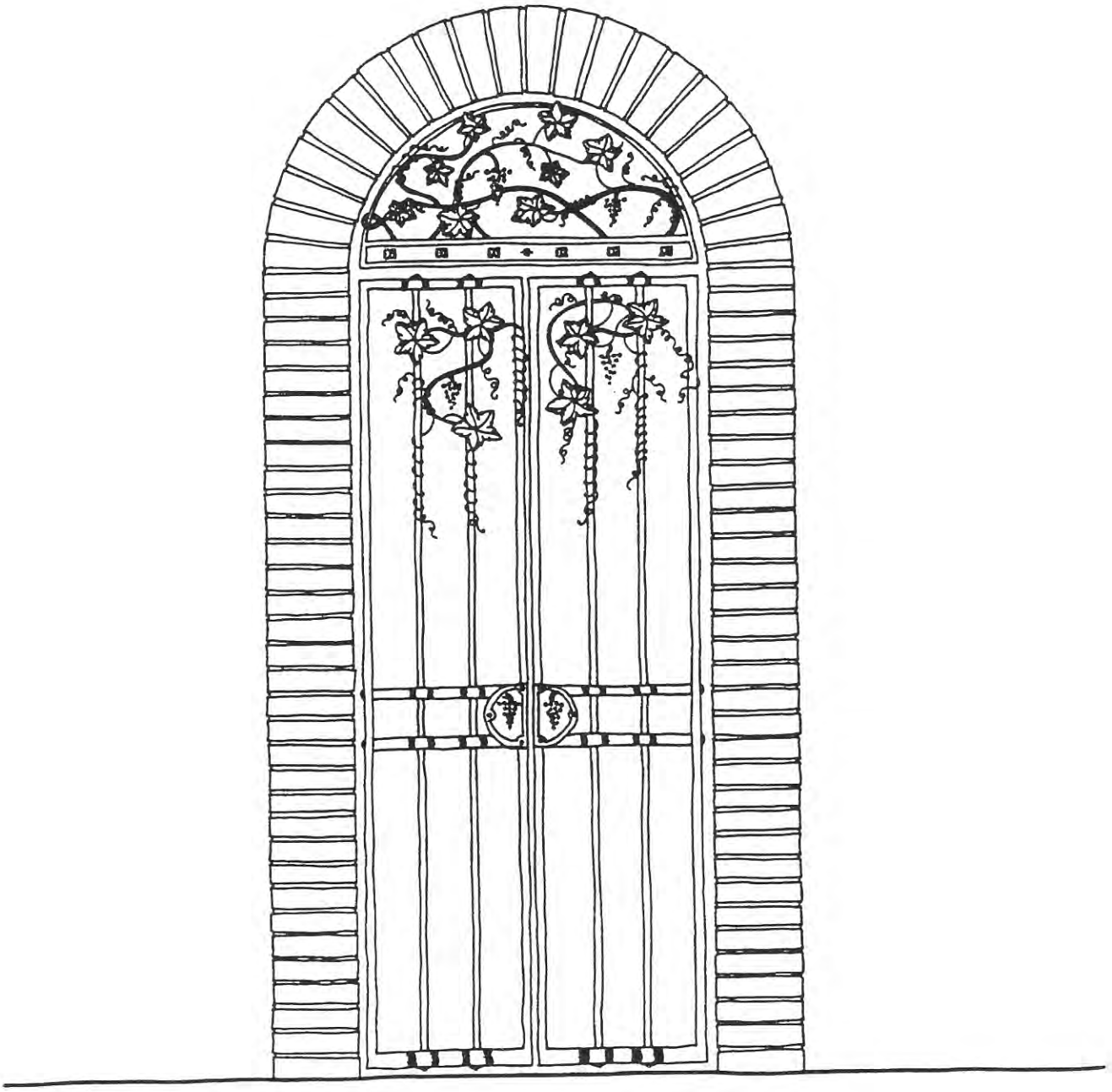
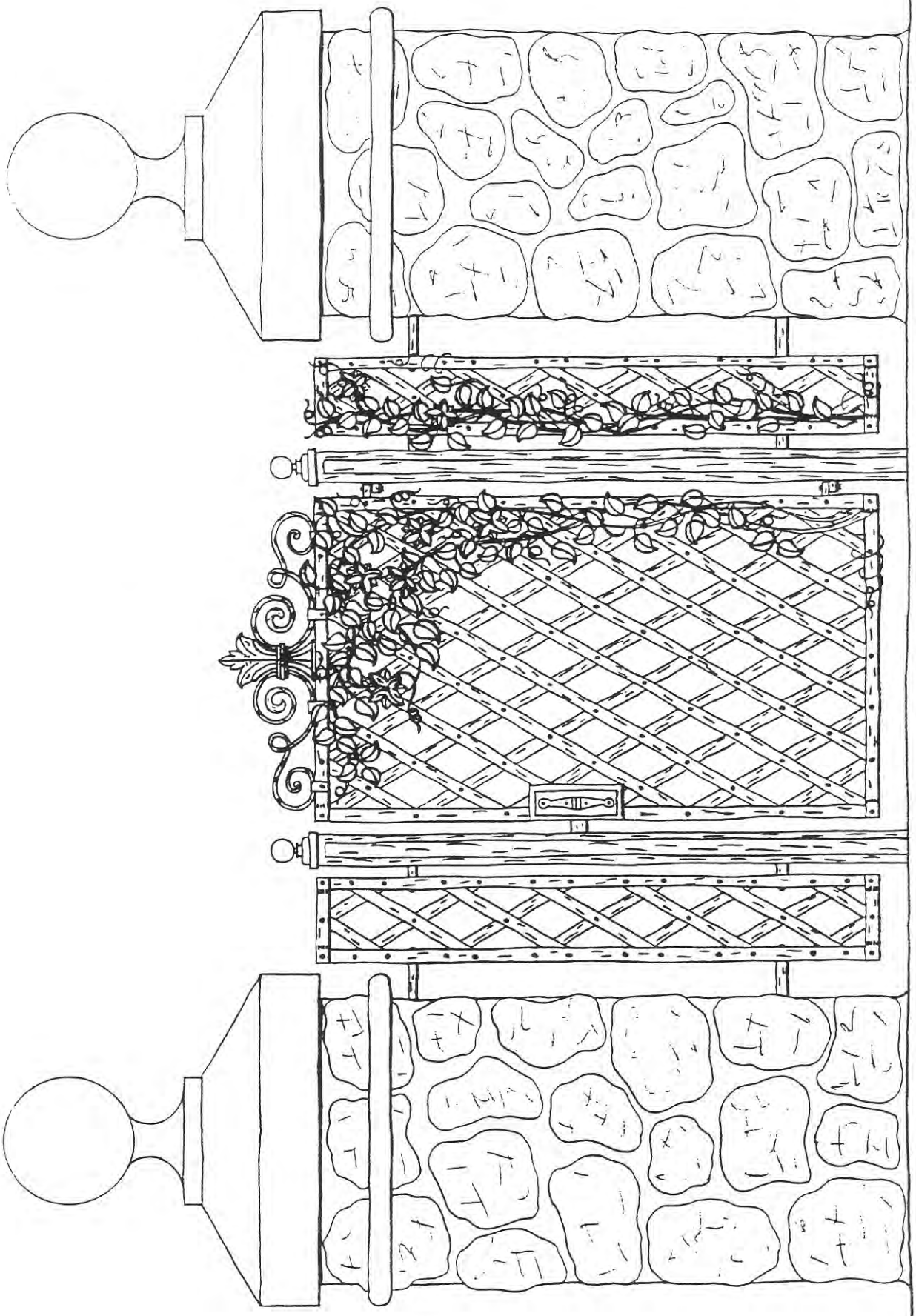


EXHIBIT 3



EXAMPLE 3



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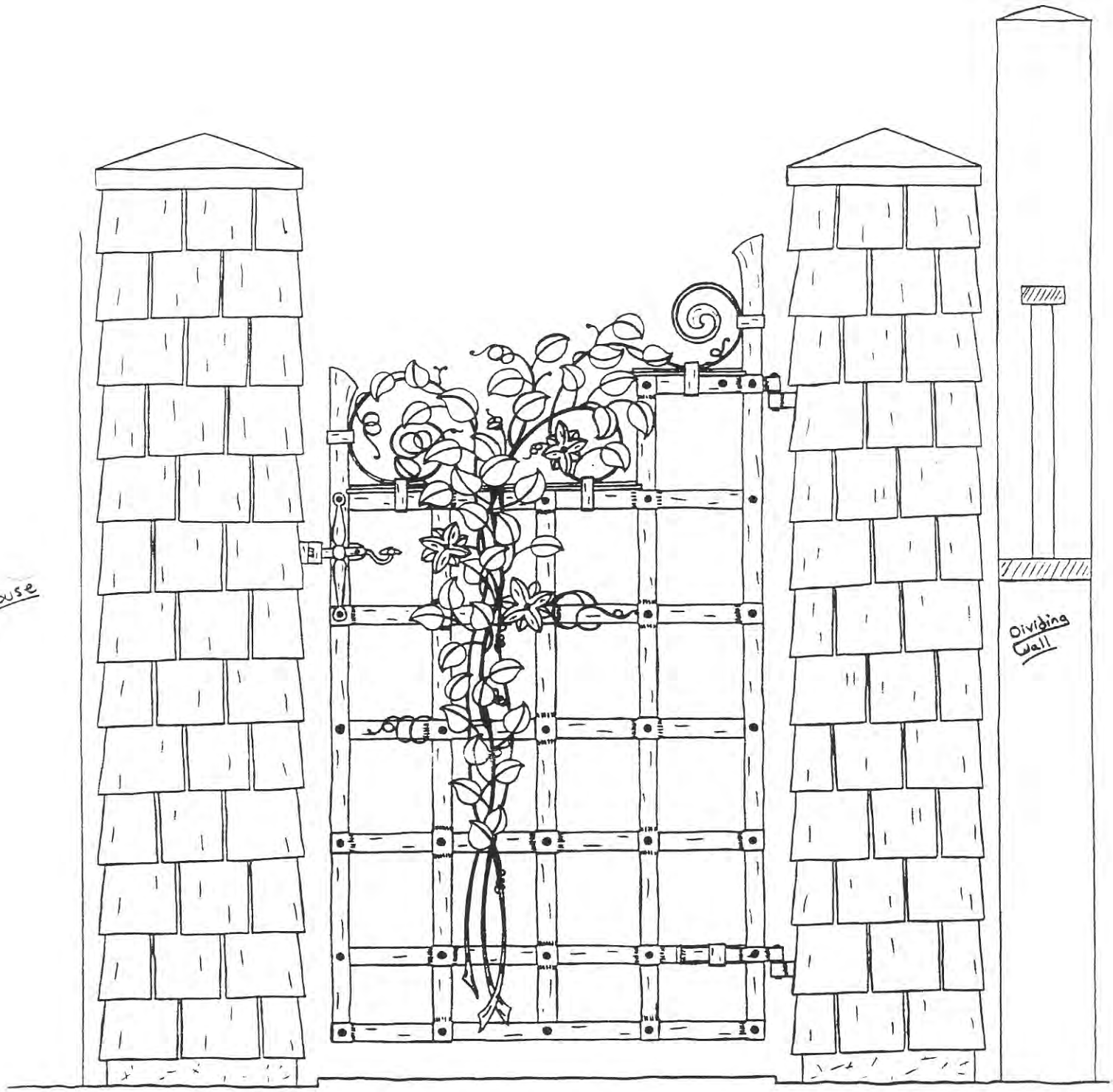
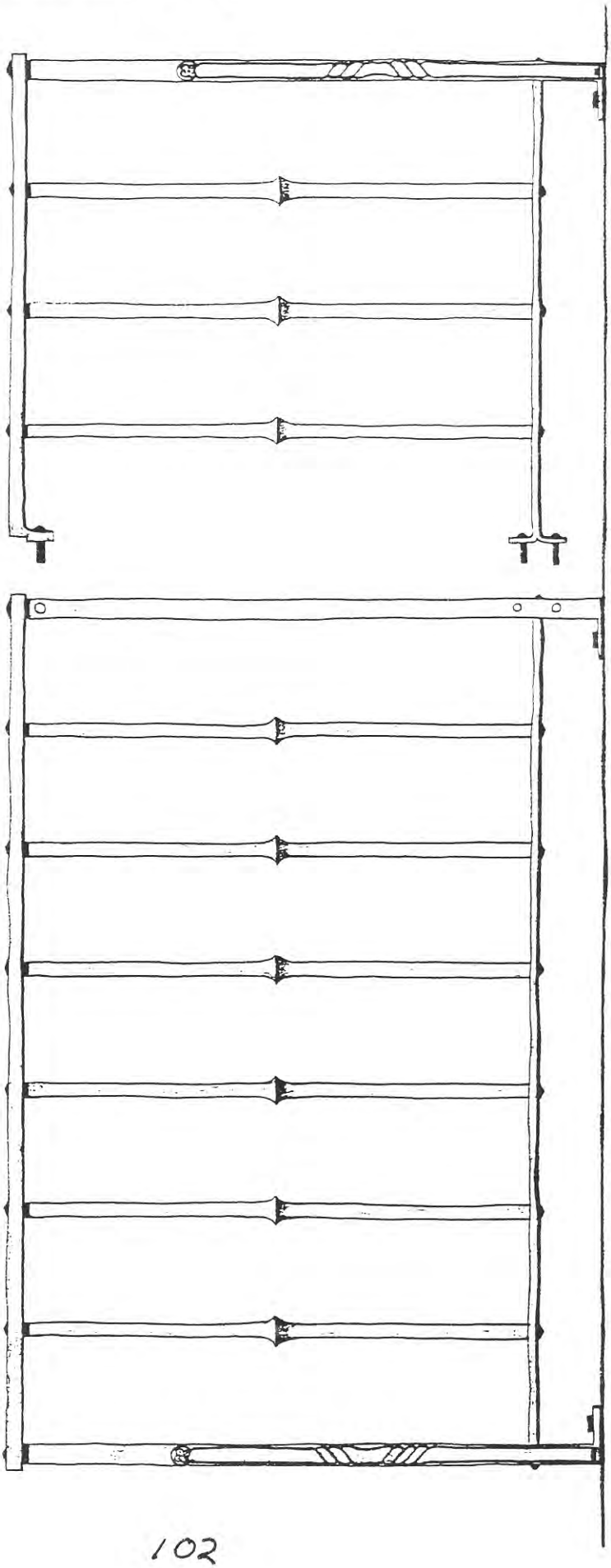


EXAMPLE 5



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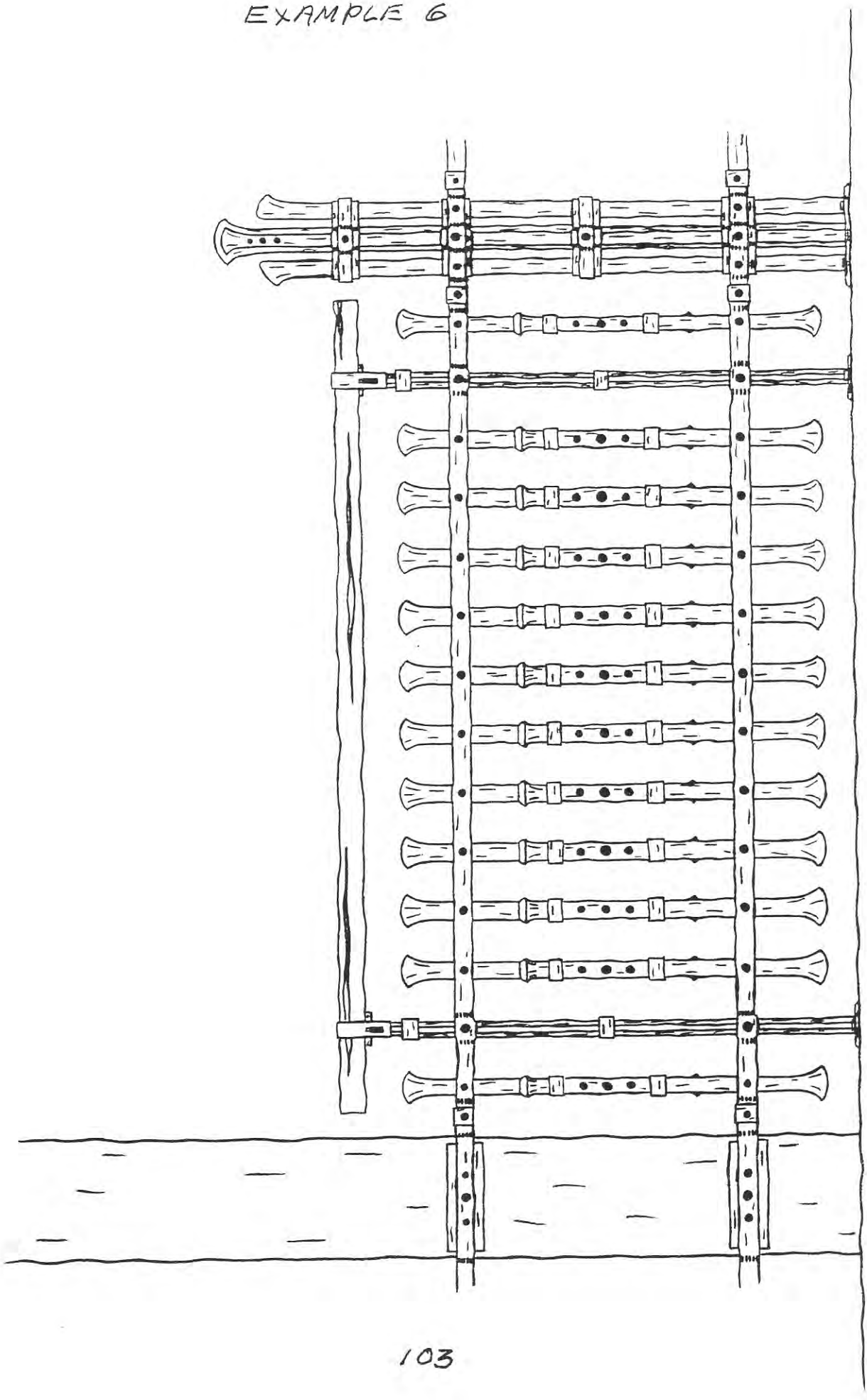
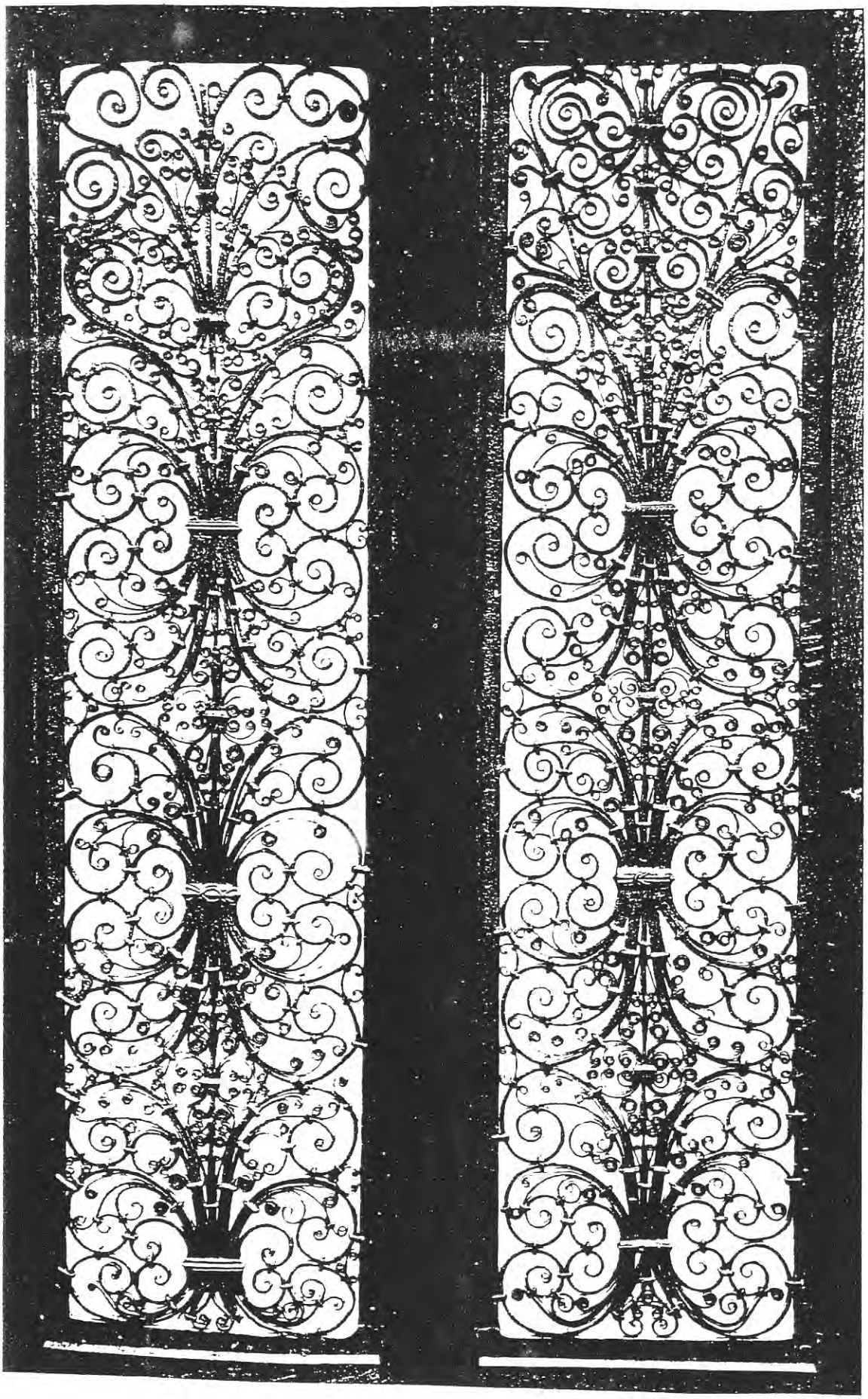


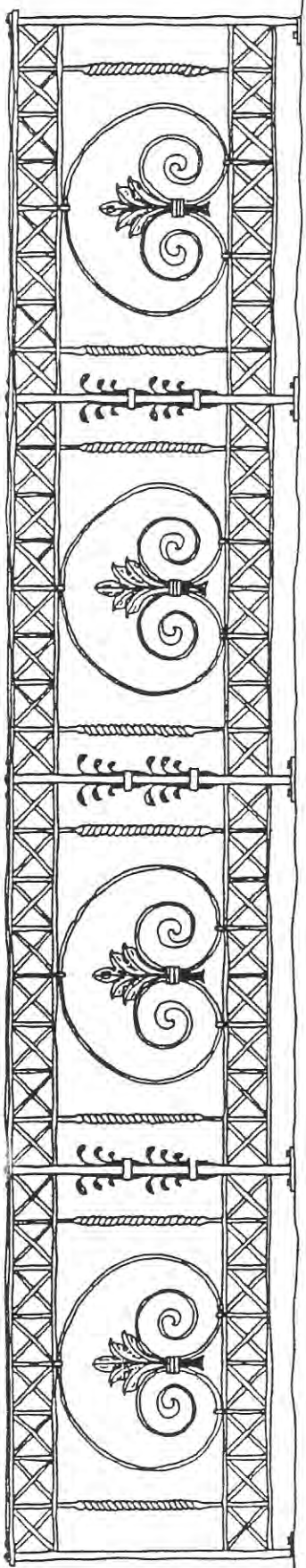
EXAMPLE 7



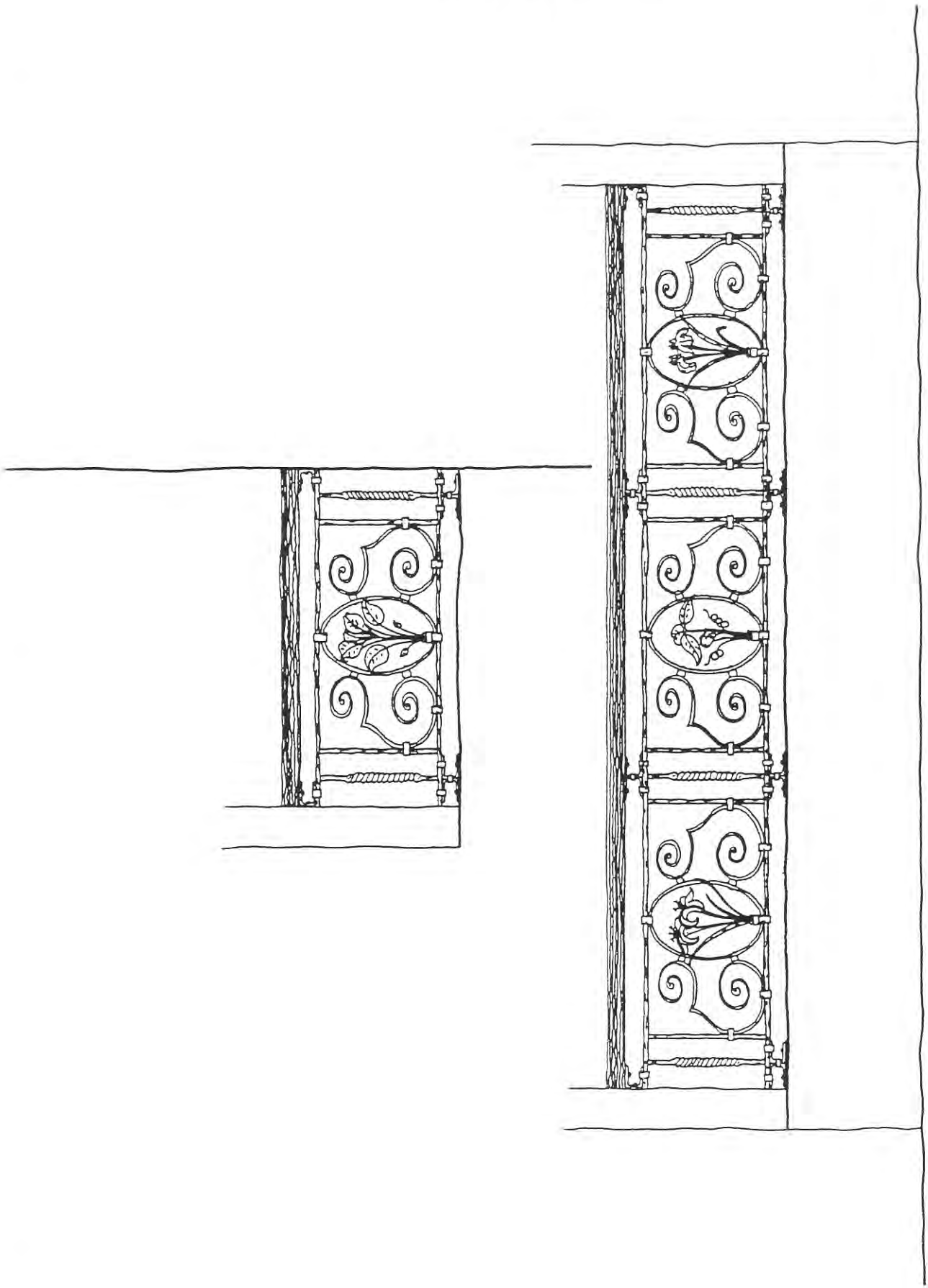
EXAMPLE 8

THE IMAGINARY GATE

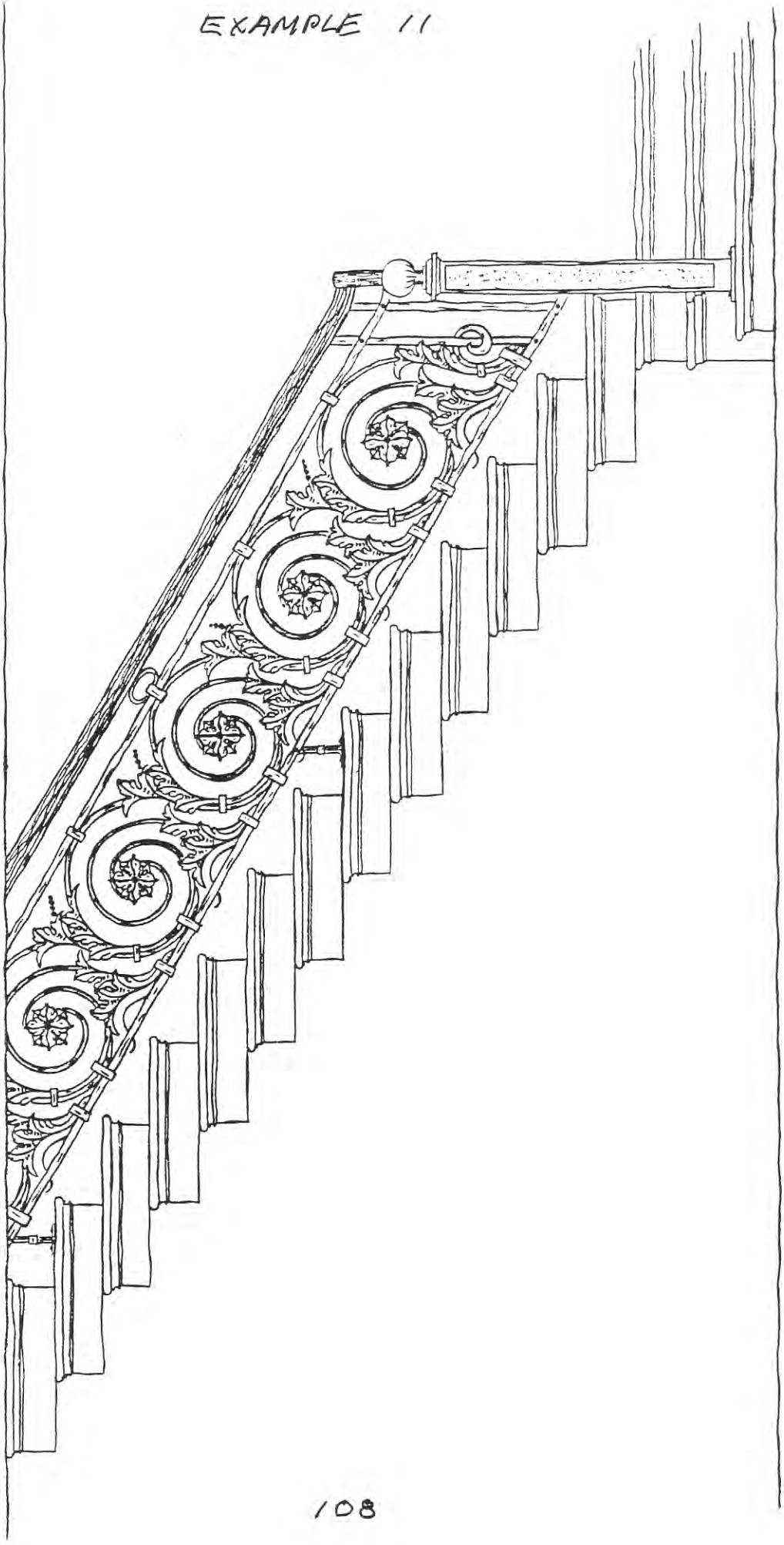
EXAMPLE 9



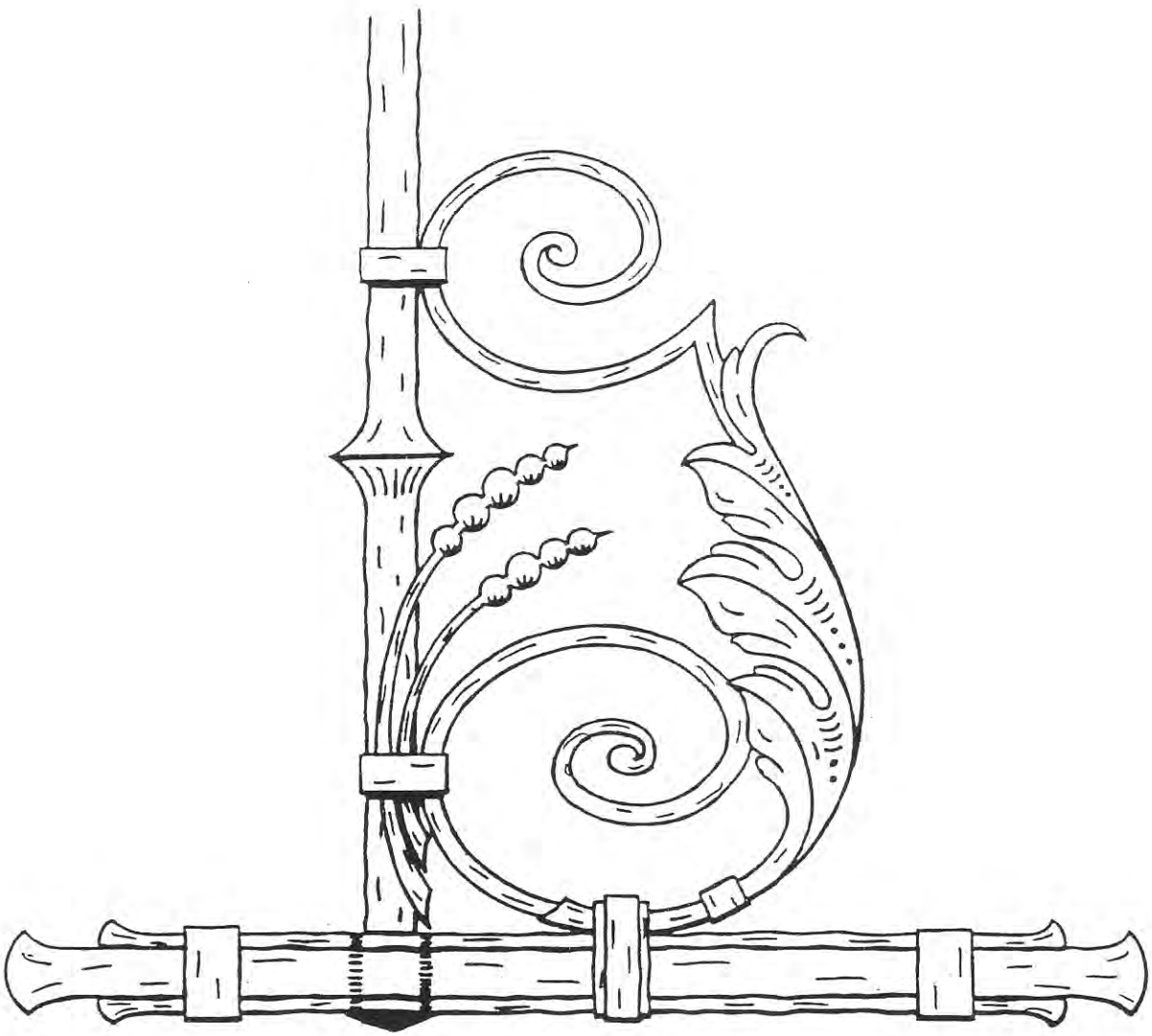
EXAMPLE 10



EXAMPLE 11



EXAMPLE 12



NOTES ON THE DRAWING PROCESS

The following information concerns some basic mechanics of drawing, as it pertains to the miscellaneous and ornamental iron trades.

Drawing can be a little frustrating at first, like any other skill (blacksmithing for example). But like blacksmithing, once you get your tools lined up, and a clear mental image of what your objectives are, it then becomes a matter of just going to work. Good drawings simply require practice, practice, practice (just like blacksmithing).

TOOLS NEEDED

1. Drawing board. I use a simple table top board (23"X31") and set this board on the kitchen table. Along with this portable board, use a clamp on lamp, for good lighting.
2. "T" square. (metal)
3. Scale ruler, Pickett, # P-232 A-ES or equivalent --- (architect's ruler, not an engineer's ruler)
4. Triangle, to make vertical lines off your "T" square.
5. Adjustable triangle for laying out stairs of various pitch.
6. Compass.
7. Drafting brush. This avoids smudging.
8. Mechanical pencil. .005 or so lead for general work.
9. Paper, I use 2 kinds of paper. The first is a good vellum (Bienfang Graphics # 360) for the concept drawing (sloppy copy). The second paper is for tracing and making a presentation copy (if needed). For this I use a Bienfang Graphics, satin #150H. There are many equivalents to these papers, and also, many less expensive papers. Your local art store will have a variety of papers and samples to pick from.
10. Drafting tape. This is basically masking tape, with half the stick power of regular masking tape. You can remove this from your paper, without tearing it.
11. Eraser. Your art store sells nice soft erasers, that erase without grinding down your paper.
12. Workable spray fixatif. This is a clear spray you can spray over a pencil drawing, to seal down the graphite, and keep it from smudging.

THE PROCESS

If you are making an object that does not have to be a specific size, like fireplace tools, wall sculptures, a wall sconce, even door hardware, I would suggest that you make a proportion drawing, a concept drawing (your sloppy copy on vellum) and if needed, a final presentation copy.

THE PROPORTION DRAWING.

On this drawing, if you were making a wall sculpture for example, draw the wall to scale. If your metalwork is going above a fireplace, then draw the wall with the fireplace, and anything else that is on the wall where your metal will be mounted. This does not need to be a very good drawing, but it does need to be to scale. This is where a good photograph of the spot in question is really a valuable tool for reference of details.

Now, sketch in your proposed object and play with the shape, until you get something that fits well in the space where it will be going. If you are making a hanging pot rack for a kitchen, then draw the floor plan, and draw the pot rack in the floor plan, looking from the top down. The whole point of this simple proportion drawing, is to make sure your product fits appropriately into it's designated spot. The small amount of time it takes to make this proportion drawing, is no comparison to the amount of time it will take to make your project a second time, because the first size was not correct!

THE CONCEPT DRAWING

Now, using a smaller scale on your ruler, let's make our concept drawing. With your proportion drawing, you established the overall size of the object you will be drawing. On a clean sheet of your paper, use your scale ruler, and experiment with the different scales, until you find one that will make your object about the right size for the piece of paper you are working on. I usually draw horizontal and vertical lines, marking the center of my paper, for reference. Then above, below, and on the sides of my center lines, mark the outside dimension points of the object, as established by your proportion drawing. Place your object a little below center, as it looks better than if centered.

Very roughly, sketch in your object, using your reference points. This can be really crude, we're just trying to get a feel for it on the paper. Now, with your scale ruler, refine, refine, refine. Erase as necessary. Add and use all the construction lines you find helpful. Your paper might get pretty sloppy, mine are often embarrassingly so. This is OK, as we can lay our transparent paper over our "sloppy copy" and trace the final Presentation Drawing, if needed.

If your project has to be a specific size, like a railing for example, then skip the proportion drawing, as the proportions are a given.

THE PRESENTATION DRAWING.

I use vellum paper for my concept (sloppy copies) for a number of reasons. The first, is because it is a good, tough, workable paper, that you can make blueprints from.

So, for our finished presentation drawing, we now have two choices. First, if your sloppy copy is not too sloppy, you can take an ink pen, and go over the pencil lines you want to keep. Later, after you are sure the ink has dried, go back with your soft eraser, and clean up your paper by removing all the pencil and construction lines.

Note --- ink takes an extra long time to dry on vellum paper, because the paper does not breathe. Before erasing, be sure to give this ink time to thoroughly dry.

If however, your sloppy copy has honestly lived up to it's name, then tape a sheet of tracing vellum over your sloppy copy, and trace your final presentation drawing, if you need one.

For the tracing, I use leads between an HB and a 3H, depending on how complex the drawing is. Your art store will have a chart and examples of the lines the different leads produce. The softer the lead, the darker the line, but the more smudging becomes an issue. The harder the lead, the less contrast you will have in your blueprints. Ink is great, but if you make a mistake, then you cannot use your original for making blueprints. Experiment, and find the combination that you feel the most comfortable with.

Once you get your vellum or overlay completed, take it to your lumber yard, or building supply store, and they will make blueprints for you. Architectural drafting supply houses often offer this service also.

If you are going to present your drawing to a client, your local art store can help you with a piece of presentation board, and a piece of cover stock, so you can make an attractive jacket to present your work in. I present my work, along with a couple sets of blueprints and hopefully sell the project, etc. etc.. When leaving the client, I then leave them with the blueprints, in the cover jacket, and keep the original for future reference.

Good luck.

Bob Walsh

MAKING BASIC HAND TOOLS

UNIT 5

Producing the projects in this unit gives the blacksmith-in-training a basic set of blacksmiths tools, a number of new skills and several opportunities to perfect skills already learned. Just as there are "many ways to skin a cat", there are many ways to make the tools described here. We think we have chosen the best information sources we could find for each of these projects, but feel free to investigate other sources.

Over the years you may make several more of any one of these tools, just modified somewhat for a special purpose. For instance, the 3/8" hole punch: You may want to make a set of hole punches all the way from 1/4" to 1". You may also want to combine the simple hand held design in this unit with the struck tools of unit 5a so that your hand is out of the way of the hammer and away from the heat.

Reference Books used in this unit:

Edge of the Anvil	©1991	Jack Andrews	Skipjack Press
Blacksmiths Craft	©1995	Rural Development Commission (Formerly Cosira)	Biddles, Ltd.
Blacksmith's Cookbook	©1986	Francis Whitaker	Jim Fleming Publ
Blacksmith's Journal	©1990-1997	Jerry Hoffman	Missourian Publ

In summary, this unit should be completed even if you already possess the tools described herein for the skill development benefit, if for nothing else. When you have completed the tools in this unit, be sure to bring them to a Guild of Metalsmiths meeting for display, so you can receive the next brass plate, Making Basic Hand Tools, to be affixed to your plaque.

UNIT 5 CONTENTS/SOURCES

Some of the directions for these projects are to be found within this unit, (example: Hole Punch and Twisting Wrench) but for others we simply make reference to appropriate project articles in well known blacksmithing how-to books.

1	Basic Tongs	Edge of the Anvil, P. 83 or Rural Development Commission, The Blacksmith's Craft, P. 100
2.	Hot Cutter	The Blacksmith's Cookbook, P. 83
3	Hole Punch	115
4.	Scroll Fork	Edge of the Anvil, P. 96 or The Blacksmith's Journal, #3
5.	Spring Fuller	Edge of the Anvil, P. 75
6	Cross Peen Hammer	The Blacksmith's Cookbook, P. 82
7	Cut Off Hardy	Edge of the Anvil, P. 89
8	Twisting Wrench	116

Blacksmithing Project 3/8" Diameter Hole Punch

Basic Blacksmithing Processes to be Used Saw, Grind, File

Stock Required 3/8" Diameter X 6" Long, S7 (Air Hardening Tool Steel)

Tools Required Hack Saw, File or Grinder

Explanation:

Long before twist drills were in common use, the blacksmith used a flat ended punch to "stamp" holes in metal. These punches can be handled punches or hand held.

This project produces a simple hand held punch 3/8" in diameter suitable for punching holes for tong hinges or the making holes in sheet metal and in bars up to about 1/4" in thickness. (Handled versions of this tool can punch through stock as thick as an inch or more).

Punches of this nature are sometimes tapered slightly, but remember that it is the flat face of the punch that does the work NOT the taper. The punch in this exercise has NO taper.

Process:

-Cut steel to length

-File or grind one end of the punch dead flat.

-File or grind a slight taper on the other end so you can tell at a glance that this is the end that you will strike with the hammer. You may want to paint this end.

This S7 steel is an air hardening steel, so no quenching or tempering is required. Heat the flattened 1/2 of the part gently to a medium orange color.

-Lay the part in a protected area to cool.

Notes:

A. S7 is an air hardening tool steel so once it has been heated and cooled, is and will remain hard.

B. This tool could be made form almost any other steel, but if you make it from mild steel or from tool steels that soften easily when hot, the flat end will mushroom and stick in the hole you are punching.

C. If the "Business end" becomes deformed, grind it back flat. The struck end can be filed occasionally to remove "mushrooms".

D. This punch has a constant diameter so that when it is driven through the stock it doesn't increase the diameter of the hole at all. So you need to make punches for each different size you need.

E. Handled punches usually have to be tapered because they have a lot of mass at the end where the eye is and where the hammer strikes the tool. But the taper is not part of the hole forming operation. If you make some of these punches, make sure that you have a constant diameter for at least the thickness of material you are punching.

To use this tool, center punch a mark in the position for the hole to be punched, get the stock hot (orange to yellow) and lay it on the anvil face. Quickly position the hole punch over the center punch mark and drive it at least 2/3 of the way through the stock. Recheck the position of the punch after each blow to make sure it hasn't shifted. Turn the stock over quickly and notice the dark spot where the punch cooled the metal. Center the punch on this spot and drive the punch down. This will actually punch a slug of metal back through the stock. The slug may not come out, so move the stock so the hole is directly over the pritchel hole. Drive the slug out with the punch. Note that this process "stamps out" a slug about the same size as the punch.

Blacksmithing Project Twisting Wrench

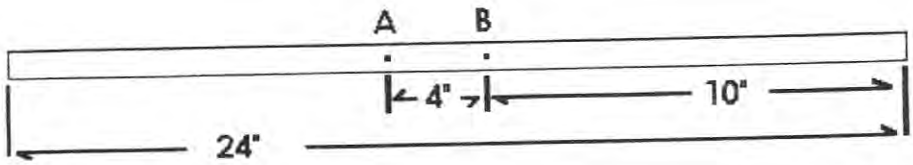
Basic Blacksmithing Processes to be Used Bending

Stock Required 5/8" Square X 24" long mild steel

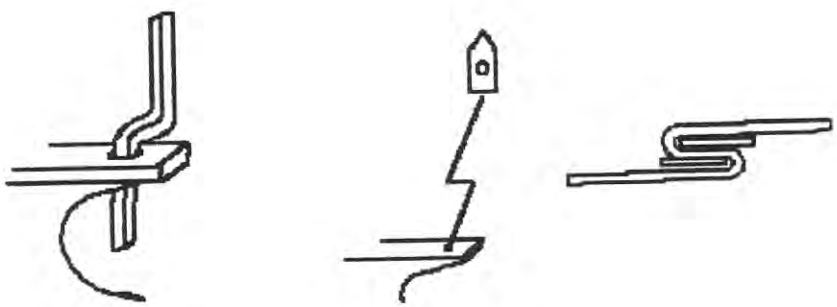
Tools Required Hammer, Anvil, Samples of Stock to be Twisted

Explanation: This Twisting Wrench is made by bending one piece of stock into a flattened "Z" shape so the slots formed will fit the stock to be twisted. By bending the material properly, one notch can be used for 3/8" and 1/2" square stock and the other notch can be used for 5/8" and 3/4" square stock.

Process:
-Mark stock as shown with center punch.



-Take a short heat at point A.
-Bend stock 90 degrees in hardy hole. Don't try to make the bend very tight. We will be tightening it up later.
-Take a short heat at point B. If there is any color at point A, pour a little water there so the stock won't bend at point A in the next step.
-Bend at 90 degrees at point B as shown. Again, don't try to make the bend too tight.



-Take a long heat covering both points A and B.
-Stand piece on end on anvil as shown with lower end at hardy hole (to keep it from sliding around).
-Drive down on the piece with heavy blows to close up the two 90 degree bends into two bends that are almost 180 degrees.
-Reheat the piece and insert a piece of 3/8" stock into the slot formed at point A and insert a piece of 5/8" stock into the slot formed at point B, as shown above.
-Drive the almost finished piece down over these two pieces of stock, leaving a little bit of an angle in each slot so that the next larger size stock can also be held in the slot.

SUPPLEMENTAL HAND TOOLS

UNIT 5a

This unit builds upon the skills gained in Units 1, 2, 3 and 5 to enhance the blacksmith's array of tooling. Many of the tool making projects described in this unit came from a four year series of workshops planned and managed by our own Bob Walsh of Walsh Forge and Foundry, Pepin, Wisconsin. These tools go beyond the very basics and begin to form the set of specialized tools that will support more advanced projects for many years to come.

As with the projects in Unit 5, there are many variations available to produce the tools described here so you should feel free to investigate other sources.

Again, as in Unit 5, you may need several variations of some of these tools, just modified somewhat for a special purpose. For instance, the top and bottom swages: You may want to make a set from 1/4" to 1" or even bigger if your work requires it. Another example is the Blacksmith's Helper (Jack Stand). In this project, the tripod is formed from one solid piece of stock. This takes considerable effort. The tripod could be made by forge welding one leg onto the other two. But understanding this severe forging process is important to one's overall skill development.

While this unit adds substantially to the smith's collection of useful tools, it is by no means complete. The serious blacksmith needs to become very comfortable with toolmaking so that the correct tool for the job, if not immediately at hand, can be produced "in the twinkling of an eye".

Reference Books used in this unit:

Edge of the Anvil	©1991	Jack Andrews	Skipjack Press

In summary, this unit must be completed by the serious blacksmith-in-training. Once you have completed these tools, be sure to bring them to a Guild of Metalsmiths meeting for display. There you will receive the brass plate entitled "Supplemental Hand Tools".

UNIT 5a CONTENTS/SOURCES

Some of the directions for these projects are to be found within this unit, (example: Hot Slitting and Hole Punch) but for others we simply make reference to appropriate project articles in well known blacksmithing how-to books.

Blacksmithing Project 4 Round Drifts

Basic Blacksmithing Processes to be Used Drawing Out/Tapering

Stock Required Round 1045 Tool Steel Stock, one each:
1" dia. X 8, 3/4" dia. X 5 1/2, 1/2" dia. X 3, 3/8" dia. X 2 1/2

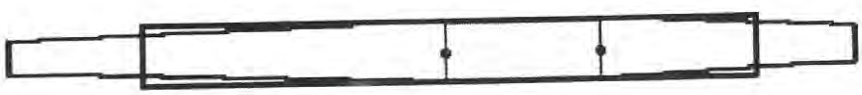
Tools Required Forge, Anvil, Hammer, Tongs, File or Grinder

Explanation: This project produces a set of four round drifts that can be used as general purpose tools for opening out round holes, aligning parts, driving out pins, etc.. The drift is basically a piece of stock which is tapered on both ends, leaving only an inch or two of full diameter stock in the midsection. There is usually a long taper on the end that is inserted into the part to be worked. On the "Struck" end, the taper only needs to be long enough to drive the full diameter portion through the work. In hot iron, the length of the full diameter only needs to be long enough to do the job of stretching the work to full size. Smaller diameter drifts are usually shorter than large diameter drifts.

Process: The instructions below will produce drifts for general shop use but dimensions may be adjusted to meet specific needs.

1. Begin with the 1" diameter drift.
2. Cut stock to 8" length.
3. Center punch at 4" from one end for the long taper and at 2" from the other end for the short taper.. Heat the "long" end to a bright orange to forge and reheat stock when color fades to red. Do NOT quench the part at any time during the forging process.
5. Draw out the long end to a square that tapers to 1/2" at the end, as shown below. Make sure not to work the shaded area at all!

6. Hammer the square taper into an octagonal cross section. Don't cheat here; make it a GOOD octagon. then round up the taper.
7. Draw out the short end to a square taper of 1/2" at the end, still being careful not to deform the shaded area.



8. Hammer this taper to an octagon cross section as was done for the other end, then round up the taper.
9. Reheat the part to a medium red and then allow it to slow cool in still air. This will relieve some of the stresses that were put into the steel during the forging process.
10. Finish smoothing the tapers with a file. This completes the first drift.

11. Since the drift has not been quenched during the process, it has not been hardened. You may use the tool as is. If you do choose to harden a drift, heat it to a medium red (to the point where a magnet is no longer attracted to it) and quench it in cool water. Polish it so it is shiny and then heat it gently until the red oxide color appears along the whole tool. Quench in water. The reason for tempering it this soft is so it won't chip or break in extended heavy use.

12. Make the other 3 drifts in the same manner as the 1" drift, using the table below for taper lengths:

Drift Diameter	Stock Length	Mark Off for : Long Taper	Short Taper	Full Size Area to be left Undisturbed
1"	8"	4"	2"	2"
3/4"	5 1/2"	3"	1"	1 1/2"
1/2"	3"	1 1/2"	1/2"	1"
3/8"	2 1/2"	1"	1/2"	1"

13. In use, grind off any mushrooming that occurs to avoid having chips of steel break off and fly through the air.

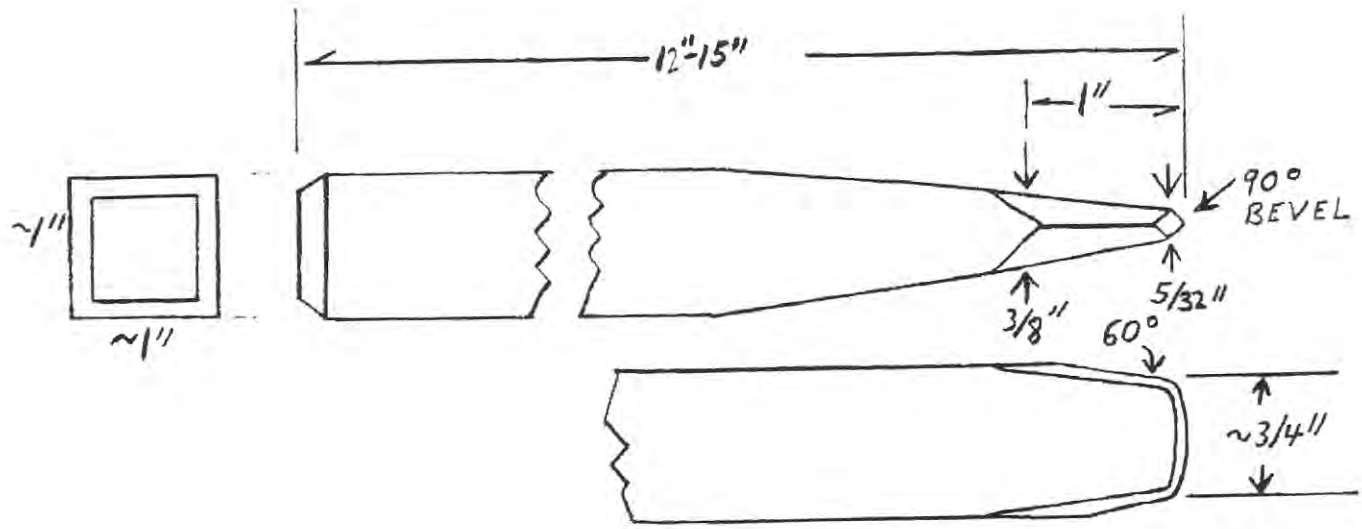
Blacksmithing Project **Hot Slitting Chisel**

Basic Blacksmithing Processes to be Used **Drawing Out, Grinding, Filing**

Stock Required 12" to 15" Length of 3/4" to 1" Dia. Torsion or Coil spring

Tools Required Forge, Anvil, Hammer, Files or Grinder

This slitting chisel is specifically designed for slitting struck tool blanks for eyes. The blanks for use with it will have been predrilled so the chisel only has to follow the drilled holes and open out the eye enough to get a drift into the hole. The sides don't need to be "sharpened" for any longer than an inch or so since the chisel never goes any deeper than half way through the eye it is slitting. The eyes are opened out to full size with a special drift, not with this tool.



-Straightening out a heavy coil spring (this step not needed for torsion bar): Heat about one coil of the spring as uniformly as possible in the forge to a bright orange and unwind it by straightening it out, short sections at a time by hammering it out on the anvil. Reheat the metal when the color fades to dull red. Once you have at least 12" of fairly straight material, cut it off with a hot cutter in the hardy hole and straighten it out the rest of the way.
-The drawing above shows the tool being squared up for its whole length, but it is only necessary to draw the last 3 or 4 inches down as shown. Don't quench this tool at any time that the metal shows any color. It is NOT to be hardened. In use, you hit it only twice, then quench, unless it gets red hot. Then let it air cool.

-Roughly shape the bevels on the anvil and finish them by grinding. The bevel at the end of the chisel is at 90 degrees to give it plenty of strength when cutting through the hot tool steel. The side bevels are at 60 degrees because they don't have as much work to do. Notice that the tool is tapered on every edge. This is done to minimize the possibility of the chisel sticking in the eye as the slitting proceeds.
-Lastly, cut the struck end off squarely and shape it as shown to minimize the possibility of chunks of metal flying off when the tool is struck.

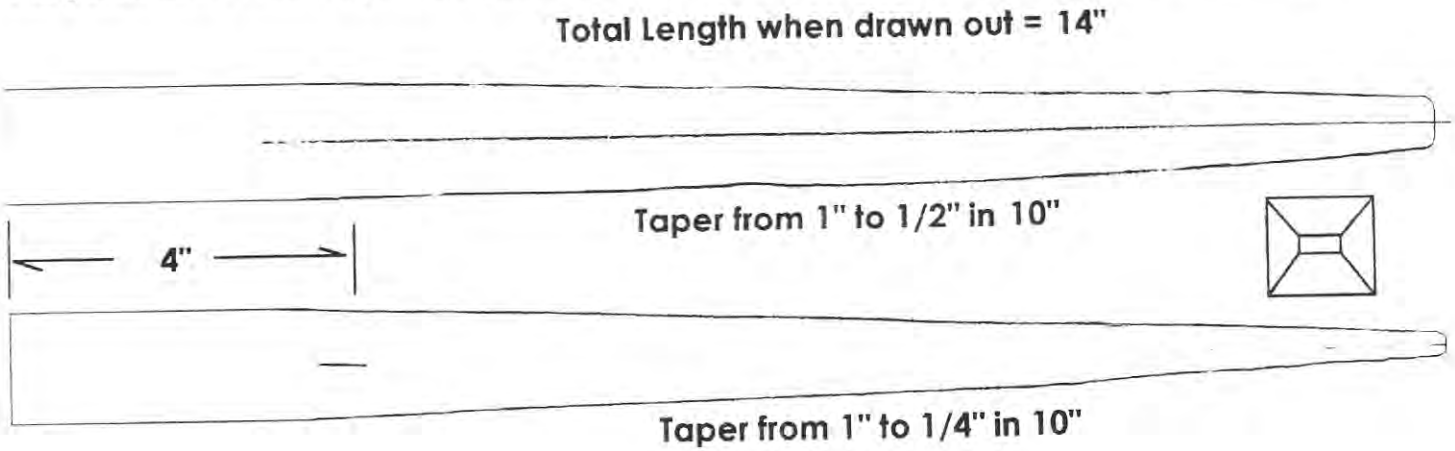
Blacksmithing Project Eye Punch

Basic Blacksmithing Processes to be Used Drawing, Grinding, Filing

Stock Required 1 Piece of 1" X 1" X 10" 1045 Steel

Tools Required Hammer, Anvil, Forge, Grinder

This punch will be used to open out eyes in blanks for struck tools and for hammers of up to about 3 pounds.



Mark the stock off 4" from one end. Leave that end full size. Heat the part to a bright orange and draw it down as shown, into a rectangular cross section. The tapers should be straight. It may help to clamp a couple of bars to a steel plate to the dimensions shown as a guide. The whole tool will grow in length to about 14" or so during the process. If you decide to forge part of the ellipse rather than grinding or filing (see next paragraph) the tool will become somewhat longer. Don't quench the part at any time during the drawing process.

Once the tapered rectangle is formed, file or grind the edges to form an ellipse all along the taper. right up to the 4" mark. This will give you a wide range of elliptical eye sizes depending upon how deeply you drive the drift into the eye. If you have a special eye shape in mind, now is the time to make sure your punch meets those needs.

Once the taper and elliptical shape have been completed, round the very end of the tool slightly. This drift will always be drivein into an existing hole, so there is no need for a cutting edge. Do not harden this tool.

In use, this drift will be driven into a prepunched or slit eye alternately from each side until the eye is opened out to the desired eye size. Don't allow the drift to overheat when it is in use. Put it into the hole, strike it two or three hard blows, remove it and cool it in cool water. If the drift shows any color from excess heating, simiply allow it to cool in still air before continuing. Since the drift is tapered, it will form an hourglass shaped hole that will capture the handle tightly from both directions once a wedge is driven in and locked in place. An eye of about 3/4" X 1" works well for the handled tools we will be making in this series.

Blacksmithing Project **Making a Set of Struck Tools, Part 1, Eyes**

Basic Blacksmithing Processes to be Used Slitting, Drifting, Drawing, Filing, Grinding, Heat treating

Stock Required 6 pieces: 1" X 1" X 4 1/2" 1045 or 1050 Steel

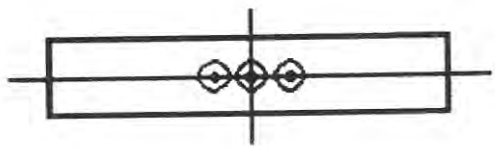
Tools Required Hammers, Tongs, Slitting Chisel, Special Drift, Anvil

Explanation: This is the beginning of a four part project where we will utilize tooling made earlier in the Guide in producing a very useful basic set of Handled "Struck Tools". This whole set of tools will be made from one inch square medium carbon tool steel. We will deal with the making of the eyes first, since that is common to all six tools. In Parts two through four, we will deal with the struck ends, the working ends, heat treating, and finally a bit about putting handles on these tools. The tools are:

-Set Hammer .
-A set of three fullers, 1/4", 1/2" and 3/4".
-90 Degree Vee Tool
-Butcher

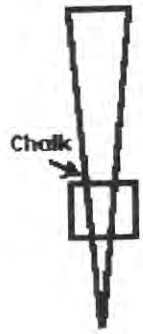
To make Eyes for Handles:

-Take a piece of the 1" X 1" X 4 1/2" stock and draw a line down the center of one face.



-Mark the center of the 4 1/2" length.
-Make a mark 5/16" on each side of this center intersection. Center punch all three intersections.
-Drill 1/4" holes at each of these three marks, all the way through.
-To open out the eye heat the blank to a bright orange.
-Line the hot splitting chisel up on the three 1/4" holes and drive it into the stock. Hit it twice, pull it from the work and quench it. This will keep the heated work piece from overheating the chisel. Do NOT quench the splitting chisel if it shows any red!. Since it is made of spring steel, it will crack if you do. This means that you can only hit the chisel TWICE then remove and cool between uses.
-Reheat the blank once the color fades to dull red.
-Continue the bang-bang-quench, bang-bang-quench process until the chisel is just over half way through the work. then turn the stock over and cut through from the other side until the two cuts meet.
-As you work, do your best to keep the chisel going straight through the work so that the two cuts will meet exactly centered. Reheat the stock as needed; up to a bright orange color, and quit working it at a dull red.
-Next, use the eye drift to open up the split to form the eye. Reheat the work and drive the drift into the eye an inch or so, over the hardy hole, remove the drift, then turn the work over and drive the drift in an inch or two from the other side. Cool the drift every two or three blows.

-Continue the drifting process until the eye is opened up to the desired size for the handles you intend to install. Many people in the upper midwest use pieces of broken hockey sticks as stock for handles of this nature since they are easy to get. An ellipse of about 1" long and 3/4" to 7/8" wide is a good size for these tools.
-When the drift has been driven approximately to the eye's final size, make a chalk mark on the drift where it



meets the work.
-Withdraw the drift, turn the work over and drive the drift in exactly to the chalk mark. This makes a symmetrical hourglass shape of the eye, with its waist exactly in the middle of the stock. Do not quench the work at any time during the making of the eye.
This completes the making of the eye. You may want to make all six eyes at once. That way you will improve your technique considerably in a short period of time.

In Part two, we will shape the struck ends of all six tools in an identical fashion then forge the working ends to meet their individual needs.

Blacksmithing Project **Making a Set of Struck Tools, Part 2, Forging Ends**

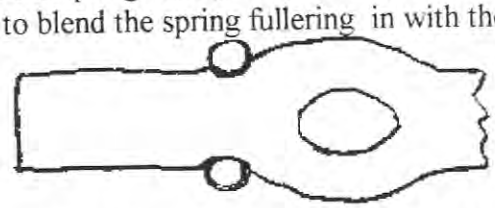
Basic Blacksmithing Processes to be Used Spring Fullering, Drawing, Filing Grinding, Drifting

Stock Required 6 Tool Blanks made in Part 1

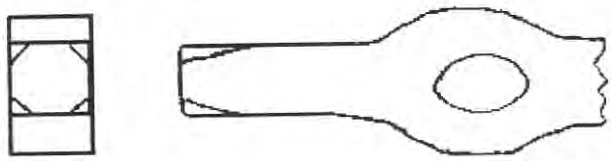
Tools Required Forge, Anvil, Hammer, Tongs, Spring Fuller Files, Grinder, Eye Drift

By now you have made eyes in all six blanks and are ready to finish all six of the tools. The next thing to do is to finish shaping the struck ends. We will describe the finishing of one struck end. Finish all the rest in the same way. Just as a reminder, all this forging is done at a bright orange heat, and the part is put back into the fire while still at a red heat.

The stock was originally 1" square, but the process of expanding the metal to form the eye will have squashed the cross section a little as the sides bulged out. This is okay, but don't reduce that dimension any more. First, choose an end to be the struck end and define the eye area a little with a spring fuller, as shown (the two circles in the drawings are the ends of the spring fuller). On this end, about 1/16" deep is enough to square the stock up. Now draw out the sides to blend the spring fullering in with the eye and square up the struck end.

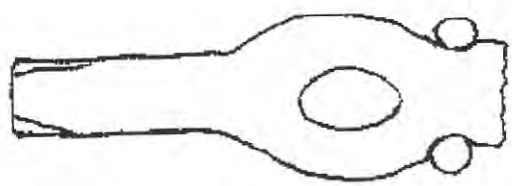


Finally, break the edges as shown so the cross section of the struck end goes from square close to the eye to somewhat octagonal at the end as shown below. You may want to clean up the edges with a file or at the grinding wheel.



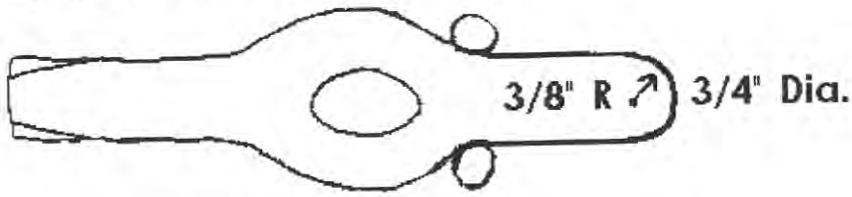
This completes the preparation of the struck end. Treat all six blanks in the same way.

On the working end, use the depth of the spring fullering to set the dimension for the particular tool you are making.



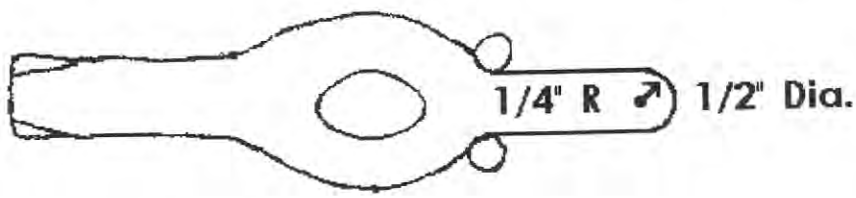
As we finish the working end of each of the struck tools in this group, we will be drawing out and tapering the material. This means that some of the tools will require all the stock and some will require that we cut off material as we go. Always leave the struck end full length and do your trimming on the working end. The finished length of each tool should be about 5". 1/4" more or less won't matter. Don't take too much time with polishing as you shape each tool. That can be done after heat treating is complete. As before, don't quench the work at any time during this tool shaping process.

Now let's make fullers. Start with the 3/4" fuller. Heat the blank to a bright orange and Spring fuller the working end of a new blank down to a little OVER 3/4" near the eye. Be careful here; the tendency is to go too deep with the spring fuller!!! If you do, use this piece for one of the smaller fullers, since it would be pretty hard to upset that area without effecting the eye. Reheat the piece whenever the color sinks to a dull red. Draw the rest of the working end to slightly over 3/4" thickness. Cut the material off at about 5" total tool length. Now file or grind the end to a 3/4" diameter. One way to get the curve right is to get a flat washer of the appropriate diameter, (3/4" in this case) and cut it exactly in half. Then use the shape of the hole in the washer to test the end of the fuller as you shape it. At the same time, curve the 1" dimension a little (make it a little convex) so that there won't be any sharp edges to dig if you use the fuller to incise a long groove.

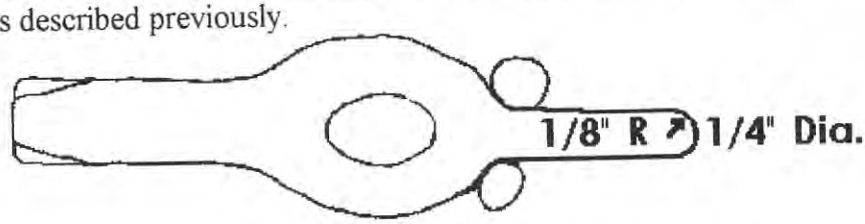


Before going on to the next fuller, check the eye with the eye drift. The eye may have become misshapen from the spring fullering process. If so, reheat the tool to bright orange and drive the eye drift into the eye up to the chalk mark from both sides. Do the same thing for all the other tools in this series once the forging is complete.

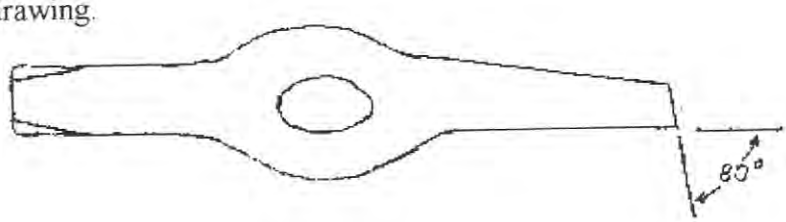
Make the 1/2" fuller. For this one, spring fuller the working end of a new blank near the eye down to a little over 1/2". Draw the rest of the working end down to this same dimension, the same way as for the 3/4" fuller. Cut the piece off at an overall length of about 5". Now grind and file a 1/2" diameter fuller on the end in the same way as for the 3/4" fuller.



Next, make the 1/4" fuller. Spring fuller the working end of a new blank down to about 5/16" close to the eye as was done previously. Again, draw the piece from the 5/16" thickness (to leave a little extra material near the eye) to 1/4" at a length of about 5". File or grind the end to a 1/4" diameter, making the 1" dimension of the fuller slightly convex on the end as described previously.

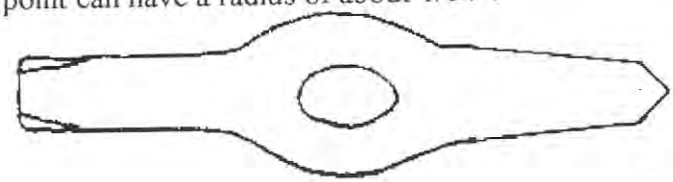


Butcher: The Butcher is primarily used to define a shoulder. Its working face is at about an 80 degree angle on one side as you can see in the drawing.

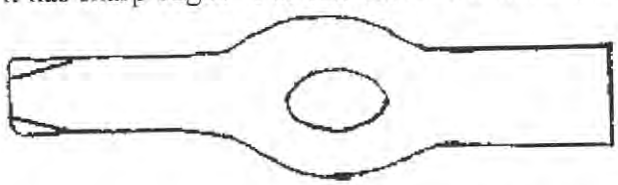


To make the butcher, heat the working end of a new blank to a bright orange and spring fuller about 1/8" deep ɔse to the eye. Reheat and drive the material over to one side, being careful not to smash the eye closed. If you do close it up somewhat, use the eye drift to true it up once the forming of the working end is complete. As you drive the material to the side, draw it to a taper as shown, but only in one dimension. The thickness of the tool should remain at one inch. Trim excess material. leaving the 80 degree face about 3/8" wide by 1" high and with an overall length at about 5". File or grind to final shape. The "point" of the butcher should not be as sharp as a chisel. Give it a radius of about 1/64"

90 Degree Vee Tool: This tool is made in exactly the same way as the 1/2" fuller, except that the working end is tapered from full width at the eye to about 1/2" wide at the end, then ground or filed to a 90 degree Vee as shown. As with the butcher, the point can have a radius of about 1/64".



The last tool in this project is the Set Hammer. This tool is used to true up flat surfaces and therefore has a dead flat face. It also is used to work up very close to an edge (to true up a shoulder, for example) with no or very little radius, and for this purpose, it has sharp edges. For this tool we will use all the material in the blank.



As was done before, heat the blank to a bright orange and slightly spring fuller the working end near the eye, to about 7/8". Now reheat the piece and carefully blend the fullered area with the end of the piece, being careful not to reduce the end of the work below the 1" square of the original stock. Let the piece cool slowly and file or grind the end dead flat.

The hard work is done. Now on to Part 3 to heat treat the tools.

Blacksmithing Project Making a Set of Struck Tools, Part 3, Heat Treatment

Basic Blacksmithing Processes to be Used Hardening, Tempering

Stock Required 6 Struck Tools made in Part 2

Tools Required Forge, Rosebud Torch, Magnet, Water, Stone

In this section we will cover two different methods of heat treating the struck tools made in Part 2. First we will describe the "traditional" one-heat method using a blacksmith forge then we will describe heat treatment using a modern acetylene torch with a rosebud head in a two-heat process. We suggest that if you have access to both sets of equipment, you try both methods. Use the traditional method on half the tools and the modern method on the others.

Although this project is not a course in heat treating, we will cover a few basics. The object of heat treating of carbon steels is heat the metal to a temperature where the structure changes to one that is highly stressed and therefore very tough, and brittle. Once the structure becomes properly stressed, we cool the part rapidly to "freeze" the structure that way. This part of the process is called "hardening". This usually (for carbon steels) requires very rapid cooling. There is only one "critical point" for these steels, so if we don't want the steel all that tough and brittle, we need to reheat it to a much lower temperature to "sneak up" on softening it a certain amount. This process is called "tempering" or "drawing".

Traditional Method:

In today's metal industries, there are dozens of hardenable alloys requiring as many different heat treatments. The technologies used to heat metals and to measure temperatures accurately have grown to meet their needs. A couple of hundred years ago the choices were much fewer and methods of sensing temperature were much less precise. The blacksmiths forge was about the only method around for heating.

So, this method approximates that used by the village blacksmith in the days before temperature meters, oxy-acetylene torches and fancy alloys.
We will use a permanent magnet to sense the "critical" temperature of the metal instead of a temperature metering device. This will work out okay for us since the steel in our struck tools is a simple carbon steel.
-Obtain a magnet and mount it on a handle about a foot long. The flywheel of a defunct lawn mower engine has a strong magnet which can be used for this purpose. Saw off or break out the section of the flywheel that holds the magnet and mount it on a 12" rod about 1/4" in diameter.
-Test the magnet on one of your cold struck tools. Hold the tool with tongs and bring the magnet up close to the end of the tool well away from the tongs (so the tongs aren't affecting the magnet). Notice how you can feel the attraction of the magnet for the part and how the magnet sticks to the part as it gets closer. When we heat the part to the "critical" temperature, the magnet will no longer be attracted to the part.

-Grasp one of the tools to be heat treated with tongs so that the tongs hold the struck end of that tool. Place the tool into a clean forge fire (with the working end away from you) and heat the whole tool gently to a dull red heat. Remove the part from the fire and check to see if the magnet is attracted to the part. If the magnet is attracted, put the part back in the fire and continue to slowly heat it. Check it frequently. When the temperature gets to "critical" the magnet will no longer be attracted to the part. (We want to be sure not to overheat the part, because if we heat it to several hundred degrees above critical, then when we quench it, it will cool a lot slower and miss the full hardening required for proper heat treatment). Now plunge about one inch of the

working end into a bucket of room temperature water and swish it around until the working end just no longer shows any radiation color (the red is all gone).

Quickly pull the part out of the water, still holding it with the tongs and polish one surface of that last one inch with an old piece of grindstone or a soft brick so that it is shiny. (You have only a few seconds to do this!) The heat from the end of the part that is held in the tongs will quickly start to travel down the part toward the polished end. As it does so, the freshly polished steel begins to oxidize and the color of the oxide tells us what the temperature of the part is. In the case of all six of these tools, we want the tip of the tool to get up to about 475 degrees F., which is equivalent to a dark straw color. (As these colors start to form, light straw is the lowest temperature, followed by dark straw, browns, reds, purples and blue). As soon as the dark straw color reaches the end of the tool, plunge the WHOLE tool into the water bucket and swish it around until the part is cool enough to hold in your hand. With one heat, we have both hardened and tempered the tool. The working end is hard and tough, not brittle and the struck end is soft since we did not quench it from the critical temperature. The struck end needs to be left "soft" so that it won't chip off as we use it.

This completes the heat treatment of the first tool. Repeat the process for the other five tools, unless you want to try the more modern method on some of them. Once all six have been heat treated, polish the working ends to mirror smoothness so that when they are used they won't impart any unwanted texture to the work at hand.

Modern Method:

In the traditional method, we heated the whole tool, but quenched only the working end. This left the struck end soft because it cooled slowly enough that it could return to the unstressed state.. For this process, we will heat only the working end, and therefore the struck end will never even have a chance to become hardened.

-Hardening: Grasp one of the tools with a pair of tongs by the struck end and GENTLY heat about one inch of the working end with an oxy-acetylene or oxy-propane rosebud torch to the "critical point" as determined by a magnet. Keep checking the temperature with the magnet as the tool heats up. The critical temperature occurs at a medium red heat, but the magnet is a much better sensor than the human eye since we all see colors somewhat differently. As soon as the magnet is no longer attracted to the part, quench it in water until it is cool enough to hold in your hand.

-Tempering: Polish both sides of the end you just hardened (the working end) with a piece of old grindstone or with a soft brick. Now, again holding the part in the tongs by the struck end, begin VERY GENTLY heating the piece FROM THE EYE so that the heat (and the oxide colors) will travel slowly down toward the working end. We are after a dark straw color. Heat both sides of the eye so that the colors move down the piece evenly. Quit heating the piece altogether if the eye gets to a purple color before the end gets to a straw or bronze color. When the tip of the working end turns dark straw, quickly quench the whole tool in water and swish it around until it is cool enough to hold in your hand.

-Finishing: Polish the working end until it has a mirror finish.

In part 4, we will conclude this project by attaching handles to the tools.

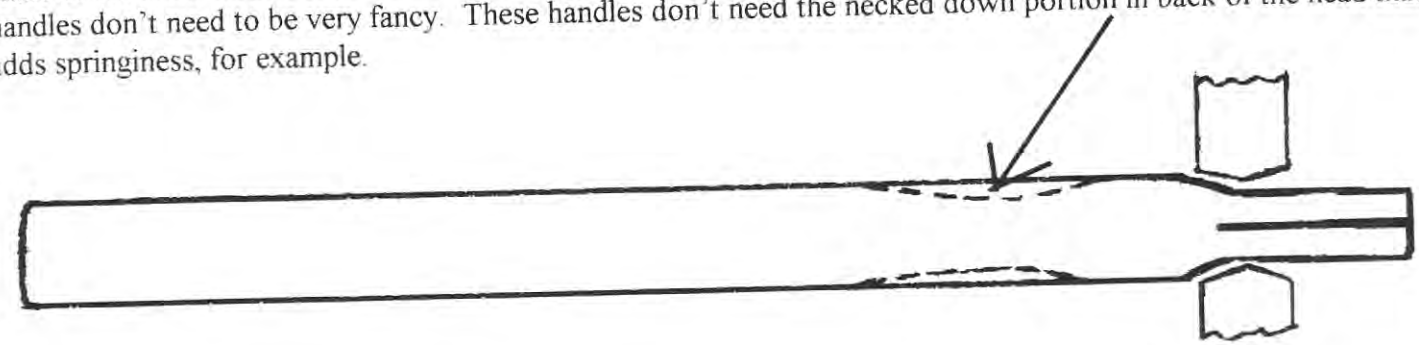
Blacksmithing Project **Making a Set of Struck Tools, Part 4, Handles**

Basic Blacksmithing Processes to be Used **Rasping, Grinding**

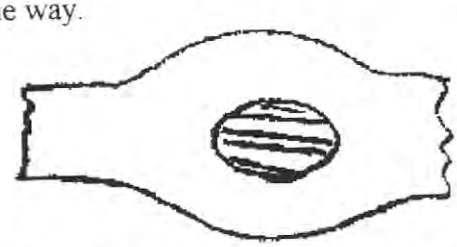
Stock Required 6 ea. 1 1/2" square X 16" Lengths of Straight Grained Dry Hickory, Red Elm, White Oak or white Ash Wood

Tools Required Horseshoer's Rasp, 7" Disk Grinder w/16 Grit Disk, Hand Saw

Handles for these struck tools will complete this project. Since struck tools are not swung like hammers, their handles don't need to be very fancy. These handles don't need the necked down portion in back of the head that adds springiness, for example.



1. Split a 16" long piece of straight grained wood to about 1" by 1 1/4" cross section. Choose a struck tool to "handle" and choose an end of the handle blank to fit to the head. Orient the handle blank so the end grain goes with the length of the tool as shown in the drawing below. Mark both the tool and the handle so you can always put them back together the same way.



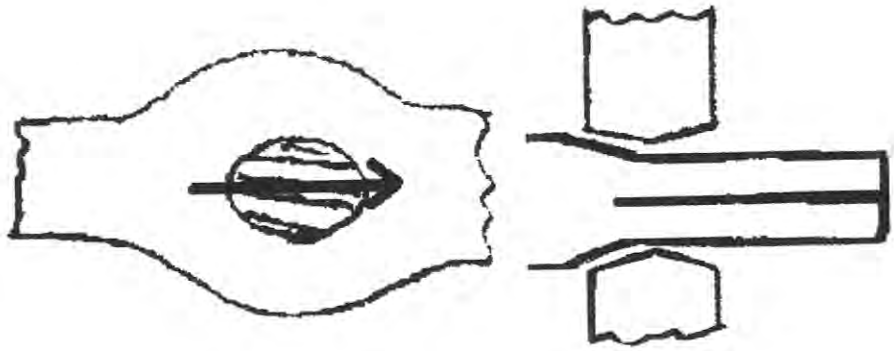
2. Work the very end of the handle blank down with the rasp or with the disk grinder until you can drive the handle 1/2" or so into the eye. Drive the tool off the handle and use the impression made by the eye as a guide for removing more wood. As you trim away wood, make sure you keep the stub centered on the wood blank.

3. Continue rasping and testing. Drive the handle into the eye fairly hard to cause the wood to peel back at the base of the eye as you drive it forward. Use the peeling areas as a further guide to stock removal.

4. keep going until the handle goes all the way through the eye and protrudes 1/2" or so from the far side. This assures that the shape of the handle exiting the eye to be a good tight fit.

5. Now begin shaping the rest of the handle. Maintain an elliptical shape to the handle. If you make it too round in cross section, the tool can rotate easily in a sweaty hand. This is more important in hammers than for these struck tools. Don't make the handles too large in diameter. A large diameter handle is harder to grip.

6. Once you are satisfied with the diameter and shape of the handle, cut a saw slot in the eye end of the handle, deep enough so that when the handle is driven all that way into the tool the slot will be 60% to 70% deep in the tool's eye, parallel with the end grain as shown:



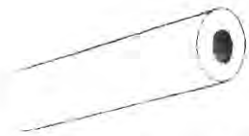
7. Sand the handle smooth enough so that there are no slivers. Give it a couple of coats of boiled linseed oil and let it dry for a couple of days if possible.

8. Drive the head on for the final time (make sure it's the right way after all that work). Saw off the part of the handle that protrudes through the eye.. Drive a wooden shim (yellow poplar works well) into the slot and lock it in place with a metal shim.

Do the same thing with the other 5 tools. Handles often loosen with time, particularly in the winter in northern climates. Some smiths put their tools in water to cause the handles to swell and tighten up. Automobile antifreeze works better and lasts longer, but never have an open container of antifreeze around where there is a possibility of children or pets ingesting it.

This ends the project. Now that you have these basics in hand, you can make additional struck tools as needed.

Blacksmithing Project Simple Monkey Tool



Basic Blacksmithing Processes to be Used Drilling

Stock Required 1 1/4" Round X 6" Long Medium Carbon Steel, Annealed

Tools Required Drill Press or Drill Motor, Bits to Drill 1/2" hole, 1" CTRSNK

Explanation: Simple Monkey Tools are used to true up shoulders made by forming round tenons on the end of a piece of stock. The Monkey Tool is no more than a suitable piece of tough , usually cylindrical stock with a hole drilled in one end. possibly all the way through. The diameter of the hole is the same as the finished tenon size or a few thousandths over.

Remember, the job of the Monkey Tool is to square up the shoulder and to straighten the tenon, not to size the tenon. If you have to drive the monkey tool onto the tenon very hard to get it up to the shoulder area, it may well STICK THERE!

Process: We will make a tenon tool for truing up a 1/2" diameter tenon which has been formed on the end of a 3/4" square bar. This means that we will have to use stock whose diameter is greater than the diagonal of the 3/4" stock. The diagonal of a square equals the length of the side multiplied by 1.414, so: .75 X 1.414 = 1.06". We could use 1 1/8" stock, but any size bigger will do. Let's use 1 1/4" stock, since it is a fairly common size. In this case, a piece of car axle would do fine. If you have a choice of material, 1045 would also work well. In this example, the finished tenon will only have to be one inch long. So we will need a hole that is at least 1 1/2" long to leave some room so the shoulder can be trued up before the tenon has to be trimmed to final length.

We could get away with a tool only 3" long, but we will make it 6" long so we can hold it with a gloved hand as we drive it onto the tenon when we use it.

Steps:
-Find and mark the center of one end of the stock.
-Drill a 1/4" hole at least 1 1/2" deep
-Open out the hole with a 3/8" bit
-Finish the hole with a 1/2" bit. Drill bits usually drill larger holes than they measure to be, so the hole will almost certainly be a few thousandths oversize.
-Use the 1" countersink to put a slight bevel on the edge of the hole. All we are looking for here is about a 1/64" radius so we don't create a sharp transition between the shoulder and the tenon when using the tool.

Alternative method:
-You can drill all the way through a 6 inch piece by going 3" from one end and then drilling 3" from the other end. Do your best to make the holes from the ends line up, but it is not critical.
-If you make your Monkey Tool by drilling all the way through, choose one end to drive and stick with it because that end will become mushroomed in use. Paint that end so it is easy to identify.

-The tool can be used as made or it can be hardened, then tempered to a brown or reddish brown color.

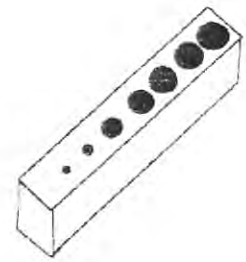
This is just one example. Be prepared to make monkey tools as needed for any size job.

Blacksmithing Project Multi-Size Monkey Tool

Basic Blacksmithing Processes to be Used Laying out, Drilling

Stock Required 1 1/2" X 1 1/2" X 12" 1045 Steel, Annealed

Tools Required Drill Press capable of drilling 1" Dia. Hole, Drill Bits: 1/4" to 1", in 1/16" Increments



Explanation: You will often need to true up shoulders on round tenons. This tool fits all sizes from 1/4" to 1" by eighths. That is; it has holes of 1/4", 3/8", 1/2", 5/8", 3/4", 7/8" and 1". In use, the tool is usually placed on the floor, the stock is heated, the tenon end of the stock is poked into the proper hole and the other end is struck with a suitable hammer to square up the shoulder.

Process:

-Layout the 12" piece of 1 1/2" square stock as follows:

-Select one 12" face and layout a center line along the whole 12" length.

-Mark the 12" line off in 1 1/2" increments. This should create seven intersections.

-Center punch each hole.

-Center drill each hole.

-Drill a 1/4" hole at all seven locations (See note 1).

-Drill out the 3/8" to 1" holes in steps to their final sizes.

Chamfer each hole slightly

Note 1: Drill bits usually produce holes that are slightly oversize. Since the main job of the monkey tool is to true up shoulders, 5 or 10 thousandths oversize is usually not a problem. If you desire accurately sized holes, it will be necessary to drill the larger holes to a 64th or so undersize and ream them to the final size.

Blacksmithing Project **Tenon Measuring Tool**

Basic Blacksmithing Processes to be Used **Drawing, Bending, Cutting, Chiseling**

Stock Required Mild Steel: 3/16" X 1 1/4" X 52", 3 /8" X 1 1/4" X 1 1/4"
Angle Iron: 3/16" X 1 1/4" X 1 1/4" X 4"

Tools Required Forge, Anvil, Vise, Hammer, Hot Cutter, Files
Drill Motor, Drill Bits, Tap, Welder

Explanation: When making several tenoned elements for a gate, railing, etc., you need some way to make sure they are all the same length between the tenon shoulders. This tool does just that. It is adjustable from less than 6" to about 46" in length. One fixed and one adjustable vee groove allow you to set a specific length for test fitting your work.

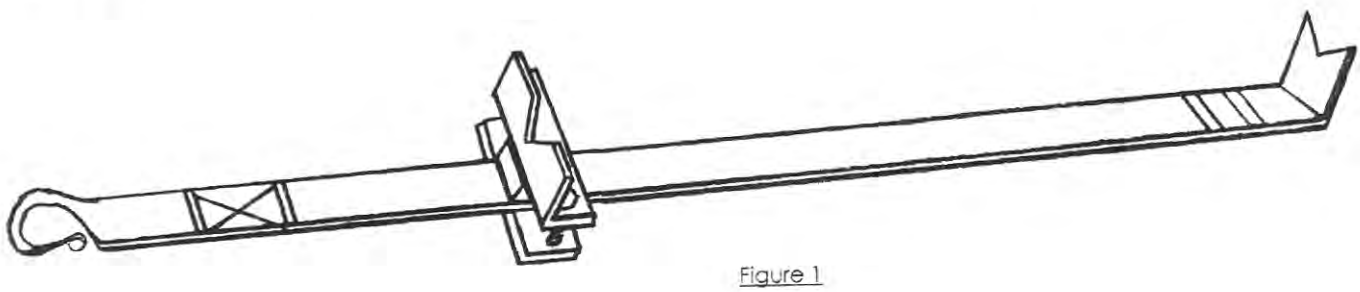


Figure 1

Process: Make the body of the tool by cutting 4" off of the 52" piece of 3/16" X 1 1/4" stock. Set the 4" piece aside. Take the 48" piece, measure back from one end 3/8" and mark the edge with a chisel. (See step 1 of Figure 2, the 6 step Figure 2, below). Heat the piece to yellow and, with a 1/4" diameter fuller, fuller down from the edge about 7/8" deep (Figure 2, steps 2 and 3). Reheat and draw this fullered portion out to about 4 1/2" long, tapering from about 1/4" at the base of the taper to a point (Figure 2, step 4).

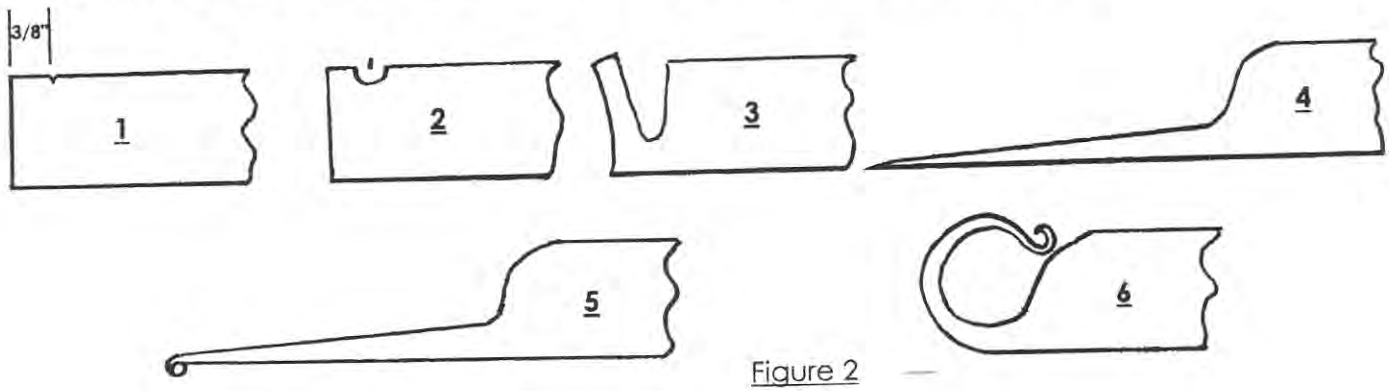


Figure 2

-Now, reheat an inch or so of the tapered end (carefully; it will burn easily) and turn a 1/4" scroll as shown in Figure 2, step 5. Reheat the whole tapered end, quench the little scroll quickly (so it won't deform when hit with the hammer, and turn the scroll end as shown in Figure 2, step 6. this scroll makes a handy "hole" to use in hanging your tenon measuring tool.

-Decorate the scrolled end of the body by cold marking it as shown in the Figure 1. The marks start about 6" om the scroll end. Make two parallel lines 1/4" apart. Measure 3" further along the piece and make 2 more parallel marks 1/4" apart. Now mark the "X" between the two sets of parallel lines. Cold chisel the marks in so you will be able to "feel" them with a hot cutter when the part is heated. Now heat the part and deepen the chisel marks with a hot cutter. One alternative to the hot cutter is to file the marks to deepen them.

-Decorate the other end of the body by measuring back about 4" and marking out a pair of parallel lines 1/4" as was done on the scrolled end. Measure 1/2" further and make another pair of parallel marks. Deepen them as was done on the scrolled end.

Mark out the vee in this end of the tool as shown in Figure 3, below. Heat 2 or 3 inches of this end to yellow and cut out the vee with a hot cutter or a sharp butcher. The cutting process will spread the vee somewhat, so once the vee has been cut out, reheat the part and reshape the vee. File out any sharp edges.

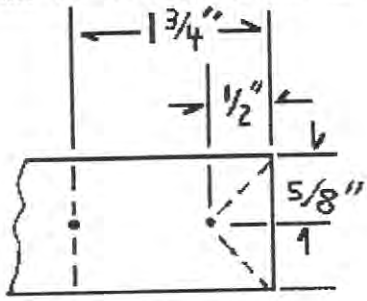


Figure 3

On the end you just decorated, measure back 1 3/4"" as shown in Figure 3 and mark with a center punch, on the same side as the decorations deep enough so you can see the mark when the part is hot. Set up a vise so you can clamp the short end quickly. Practice clamping the part in the vise so that you will bend the part TOWARD the decorations. Now heat the part up to yellow, quickly clamp it in the vise at the center punch mark, and using a hammer to keep the bend short and square, bend the body to a 90 degree angle.

-Make the adjustable vee. Take the 4" piece of 1 1/4" X 1 1/4" X 3/16" angle iron and mark it out as shown in figure 4, below. Heat the angle iron to yellow and cut the vee with a sharp butcher or hot cutter. Straighten the part out if needed.

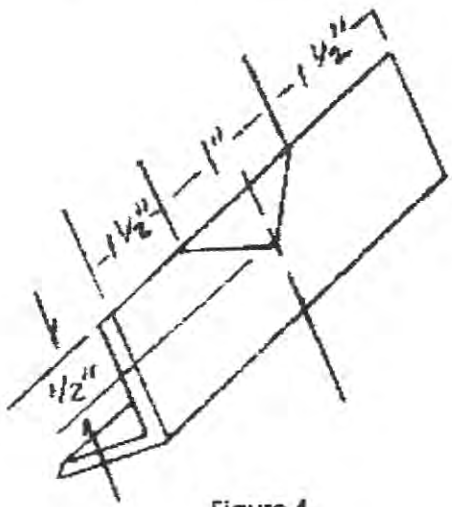


Figure 4

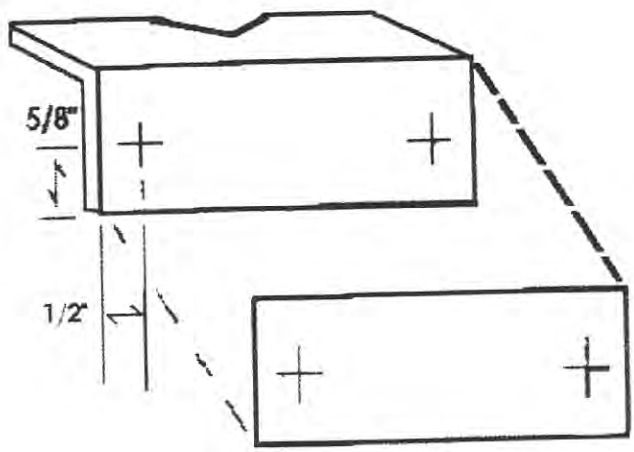


Figure 5

-Mark the leg of the angle iron that doesn't have the vee in it as shown in Figure 5. Clamp the 3/16" X 1 1/4 X 4" piece cut from the 52" piece of stock to the underside of the angle iron and drill 3/16" pilot holes in both places. Separate the pieces. Drill out the holes in the angle iron to 5/16". Drill out the holes in the 4" flat plate with a letter F drill bit or a 17/64" bit. Tap these holes 5/16-18.

-Finish the upper part of the clamping assembly by centering the 1 1/4" square piece of mild steel on the underside of the angle iron surface that has the drilled holes and tack weld it in place.

-Assemble the tenon measuring tool as shown in Figure 1 with 2 ea. 5/16-18 X 1" hex head screws.

Blacksmithing Project **Spring Tenon Tool for 1/4", 5/16", 3/8" & 1/2"**

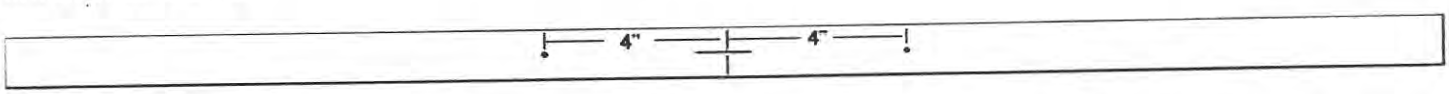
Basic Blacksmithing Processes to be Used **Bending, Drilling, Arc Welding, Filing**

Stock Required 1 ea. 1/4" X 1" X 30" Mild Steel Bar
2 ea. 1" X 1" X 4 1/2" pieces of 1045 Steel

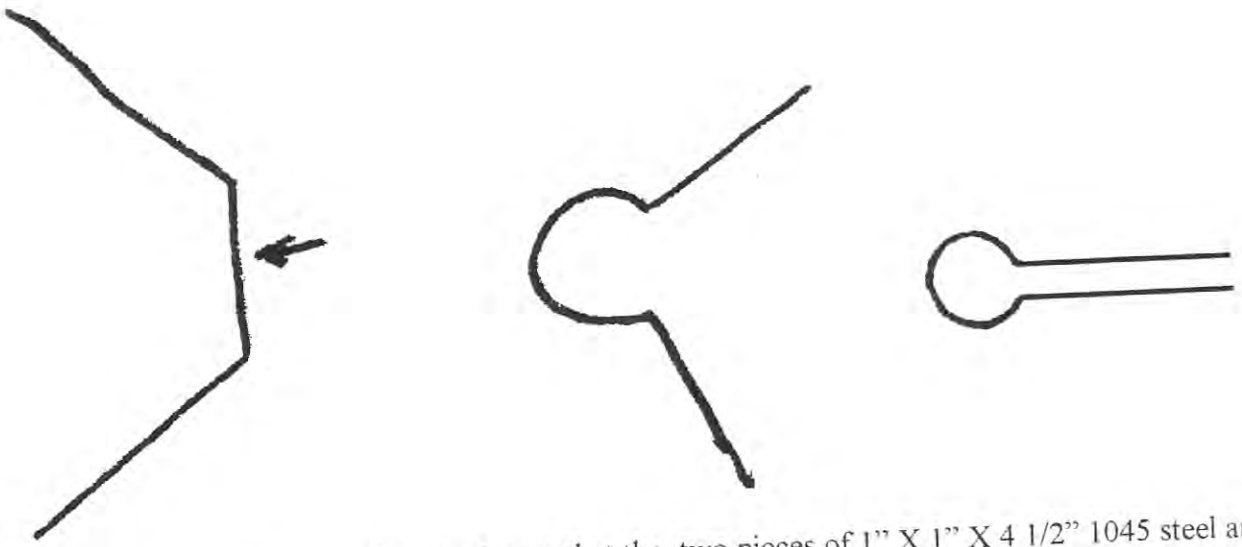
Tools Required Forge, Anvil, Hammer, Drill Press, Drill Bits, Arc Welder, Files

This tool will be very helpful in rounding up tenons in the four sizes mentioned in the heading. It can be used at the anvil or in the powerhammer.

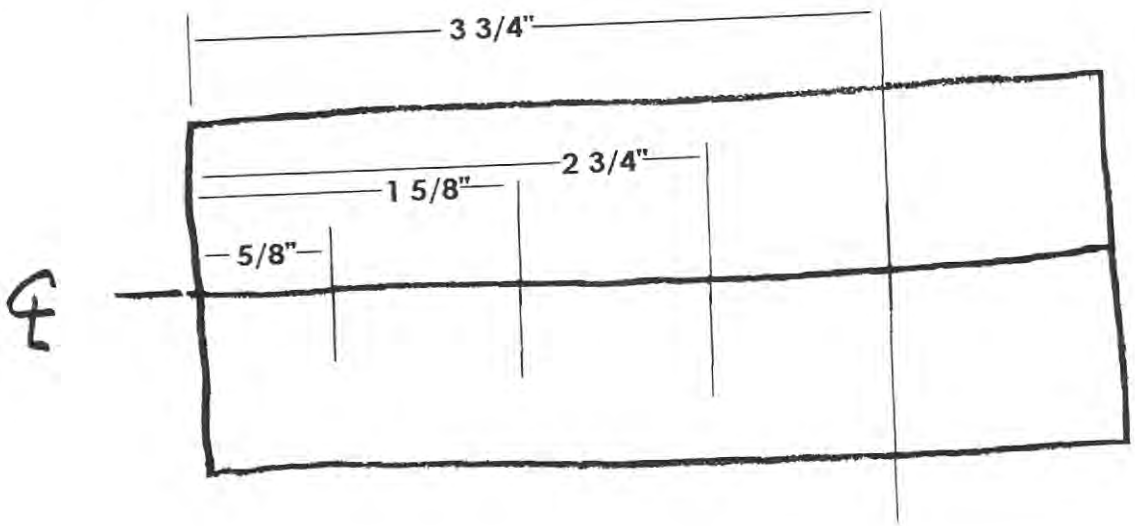
First we will make the "hairpin". This springy handle allows you to open up the swage to insert the rough forged tenon. It also keeps the individual swages in register.
-Mark the center of the 30" piece of mild steel with a center punch. Make center punch marks 4" to either side of center as shown.



-Now heat the piece at one four inch point and bend it at a 45 degree angle. (See the three sketch drawing, below). Then heat the other four inch point and bend it 45 degrees in the same direction as shown in the left hand sketch.
-Next reheat the part and start to shape the rounded part of the hairpin by bending it over the anvil's horn where the arrow is. The center sketch shows the spring partially formed. Now continue closing the circle that is forming. Work from both sides of the horn to compensate for the taper of the horn.
-Keep closing the circle until the two arms of the hairpin are parallel and about 1" apart (Right hand sketch). A little more than an inch is better than a little less, since you will eventually have to reach in between the arms with a welder to attach them to the swage blocks of the tenon tool. This completes the hairpin. Set it aside to cool. even though the stock is mild steel, don't quench it when it has any color because today's so-called "mild steels" have often have enough carbon to harden up to some degree. Any hard spots on the hairpin can cause stressed areas that can be subject to cracking, particularly since this is a struck tool.



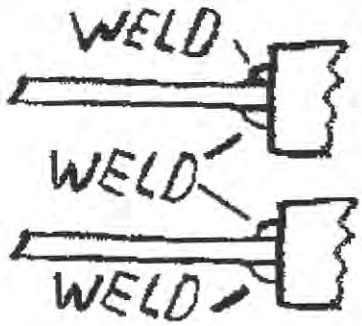
-Next make the swages. Grind, file or otherwise insure that the two pieces of 1" X 1" X 4 1/2" 1045 steel are the same length and that the ends are square. Clamp them together as shown below with a piece of paper in between them. The paper will help to keep the drill bits centered between the two pieces as we drill out the holes.



-Now center drill each hole. Drill each hole out to about 3/16". Now drill out each hole to its final size. From left to right, the suggested sizes are 1/4", 5/16", 3/8" and 1/2". As you drill each hole, slide a short piece of appropriate size rod into the hole to help maintain alignment.

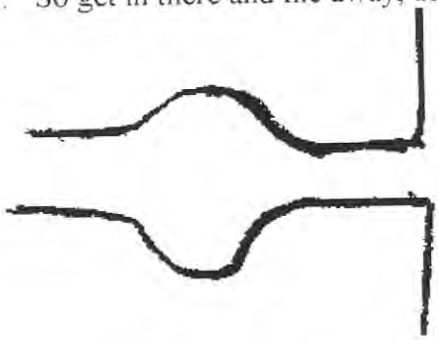
Drill bits tend to make oversize holes, especially if they have been resharpened with unequal flutes, so choose your bits carefully. Because of this tendency of the bits to make oversize holes, manufactures sometimes make them undersize on purpose, so if a micrometer is available, pick a bit that is 3 or 4 thousandths below the size you want. Of course, if you have machine shop capabilities, you will want to drill 1/32" or 1/64" undersize and ream to the final size. The reason for all this discussion is that you will be using this tool to produce tenons that have to go into drilled or punched holes that may be of exact sizes. So you don't want to produce tenons that are too large. If you do, you will have to file them to fit.

-Keep the swage halves clamped together. Now align the hairpin with the swages and weld them together. Weld on both sides of each arm as shown in the sketch below.



-If you have trouble getting the welding rod or gun into the inner joints, weld the outer joints first, then unclamp the swages and spread them slightly to make room.

-Now unclamp the swages and spread them apart enough to get a file in between them. Relieve the edges of the holes. This is necessary since the metal that is being moved as the tool squeezes down on a rough forged tenon HAS to have some place to go. The natural tendency is to leave the hole nice and round, but this will only cause gouges to form on the tenon. The gouges will act as stress points and may cause the tenon to fracture later. So get in there and file away, as shown:



This sketch may look like a severe amount of stock removal, but you only need about 90 degrees of the original hole left on each half.

This tool can be used without heat treating, but if you want to harden it, heat it to a medium red heat (non magnetic point) and quench in cool water. Polish the surface and slowly reheat until a brown to red oxide color forms, Quench at once in cool water until cold.

Blacksmithing Project **Blacksmith's Helper (Jack Stand)**

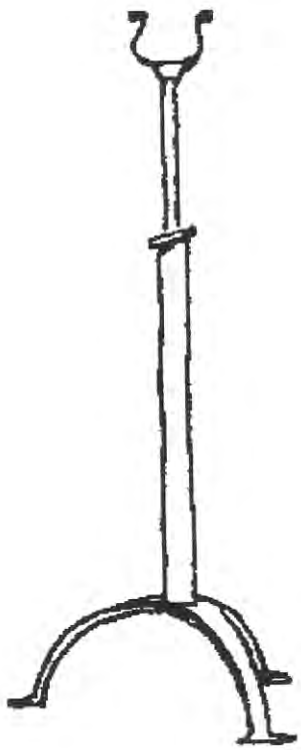
Basic Blacksmithing Processes to be Used **Fullering, Drawing, Splitting**

Stock Required Mild Steel: 1 pc. 3/8" X 3" X 18" Bar, 1 pc. 3/4" 1 pc. 3/4" Water Pipe X 24", 3/4" I.D. Flat Washer

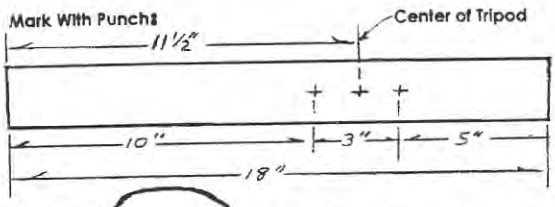
Tools Required Forge, Anvil, Hammer, 1/2" Fuller, Slitting Chisel, Drill and Bits, Hack Saw

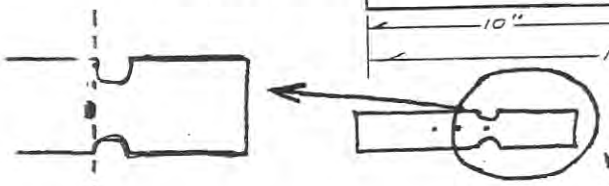
Tom Latane' designed this jack stand some years ago. It is an indispensable aid to the blacksmith working alone. Some people have since modified the design to attach the tube (3/4" pipe) to the base by drilling and tapping a hole in the side of the pipe about 1" from the bottom and inserting a bolt, instead of welding or riveting it on as the text states. Also, you will need a close fitting washer at the top to make the "stand" stay where you put it.

The splitting and fullering of the base will take considerable effort. It is important to get the center of the piece very hot! The metal must move all the way to the center of the base as the tripod takes shape.

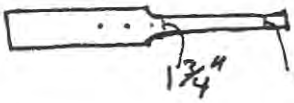


Tripod





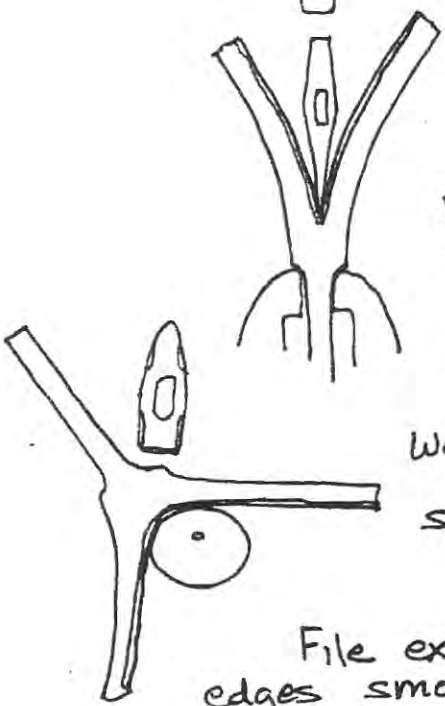
Fuller at outside of 5" mark to a thickness of 1¾"



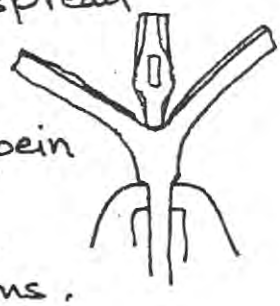
Draw most of the 1½" end to 1½" leaving wider near shoulder

Split with hot cutter to other outside mark cutting through from one side

Place in vise and begin to spread with hot cutter.



Fuller split with large fuller or rounded straight pein



Work shoulders out over horn — cut off part of shoulder if cold shut begins.

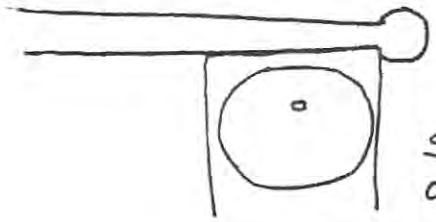
File excessive jagged edges then forge cut edges smooth.

Work junction over horn until legs are even width near center and seem to spread evenly from center. Draw legs to even width (probably a little under 1½")

Cut legs to even length measuring from center

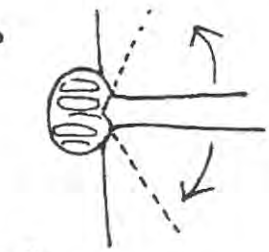
Fuller 1½" back from end of each leg leaving 1" or a little less, so that the fullered section is roughly a square.

Draw to taper leg behind foot



Work foot over edge of anvil

Spread foot with straight or cross pein on anvil edge turning from side to side to leave thickness of leg a little way into the foot. Upper face of foot is down.

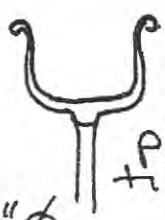


Bend feet
Drill ½" Hole in center
Shape curve of tripod legs by eye or bend to a form made from shaped scrap

Stand
Make ½" tenon at one end of 24" piece of ¾" ϕ stock
Trim tenon to about ⅝" long
Fasten in hole in center of tripod when all forging is done and a 6" piece is cut from tenon end
Cut one end of 20" length of ¾" pipe at a 45° angle
Rivet or weld pipe over 6" stud in tripod with angle cut up
Flatten 3" of the other end of the ¾" ϕ to about ⅜"

Split back 2½"

spread to form a "T" and pound out center of split
Draw ends to a flat taper and roll scrolls outward
Form "U" shape



This stand will slide through a ¾" washer and into the pipe on the tripod. The washer when tilted by the 45° angle will bind the ¾" ϕ.