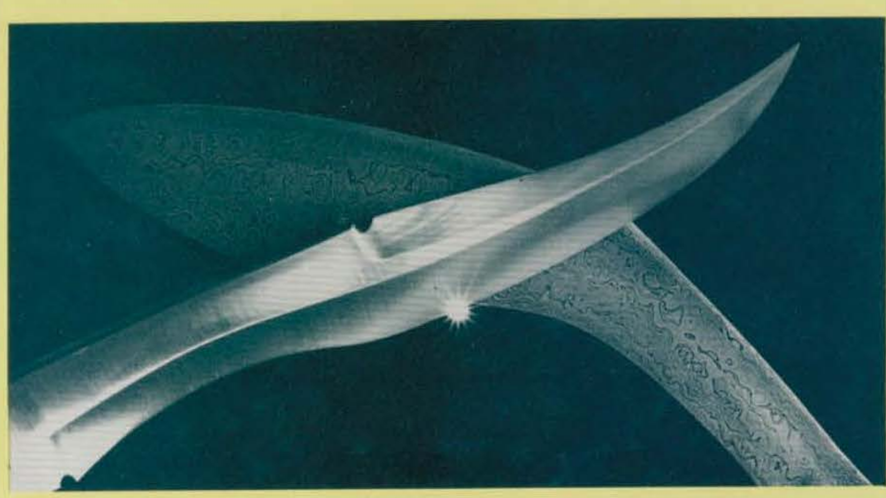
# THE MASTER BLADESMITH

## ADVANCED STUDIES IN STEEL



JIM HRISOULAS

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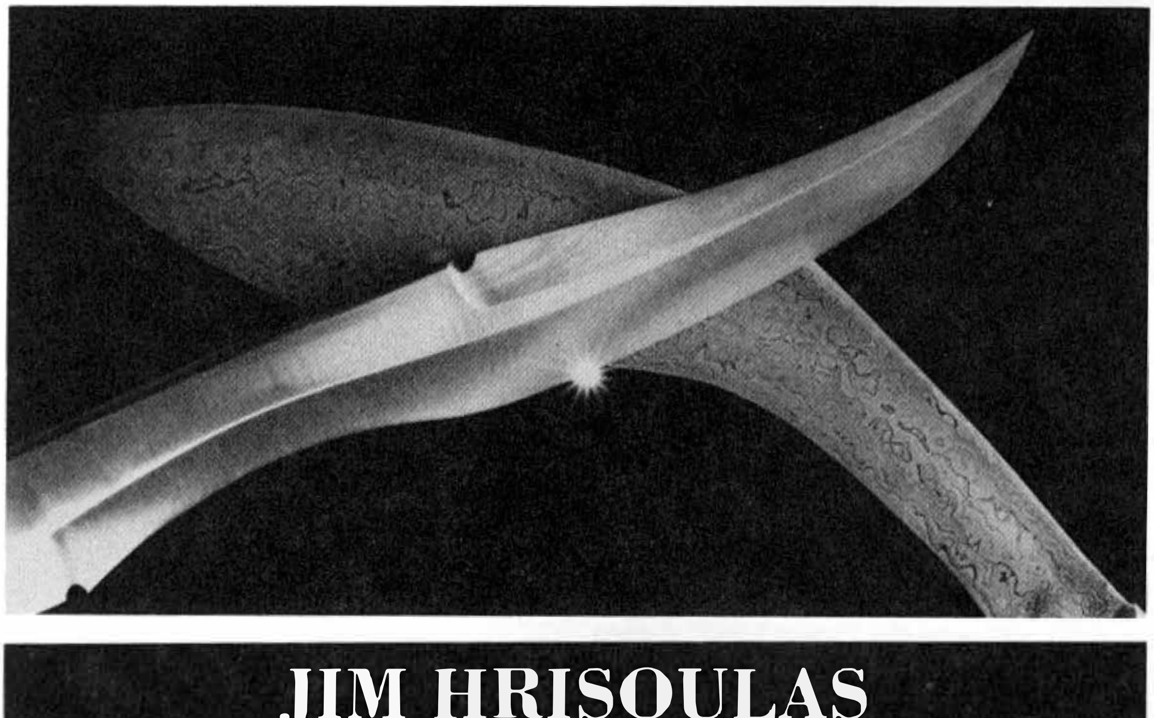

JIM HRISOULAS

PALADIN PRESS
BOULDER, COLORADO

**Also by Jim Hrisoulas:**

The Complete Bladesmith: Forging Your Way to Perfection

Forging Damascus: How to Create Pattern-Welded Blades (video)

The Pattern-Welded Blade: Artistry in Iron

*The Master Bladesmith:*
*Advanced Studies in Steel*
by Jim Hrisoulas



ISBN 0-87364-6`12-6
Printed in the United States of America

Published by Paladin Press, a division of
Paladin Enterprises, Inc., P.O. Box 1307,
Boulder, Colorado 80306, USA.
(303) 443-7250

Direct inquiries and/or orders to the above address.



Illustrations by Joyce Morris
Jacket photos by Stephen Jacobson

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# ACKNOWLEDGMENTS

I would like to thank the following people, who have been of great help in my completing this volume.

Bob Engnath, who is a great friend and a good listener.

Alex Bellanger, a friend in need.

Jan Ake Lundstrom, for help in researching Viking swords.

Last but not least, my dear, beloved Trudi, who was there in the darkest time of my life, and to whom I owe, literally, my life. I have to thank her for the ability and the will to write this book.

# PREFACE

The study of bladesmithing can be rewarding and somewhat frustrating. Most of the information available today is meant for the novice knifemaker. Little has been written for the more experienced craftsman. To answer this need, I have written this book for the more advanced student of the custom blade.

Numerous techniques and materials available to today's artisans were once revealed only to the chosen few who were within the inner circles of this craft. This secretive tendency, while more or less still in effect, is the last bastion of the old medieval guilds. There is no need for this secrecy. The free exchange of information and techniques enriches rather than lessens the craft.

Sharing knowledge and technique improves the teacher as well as the student. All of us should strive for perfection and learn our chosen craft as fully as we possibly can. That is the intention of this book, to share knowledge—and a few secrets as well.

I leave you with this quote:

*"There is no deed greater than the passing of knowledge from one to another, for without it, we would all be lost in ignorance."*

—Atar Bakhtar

Only you, my reader, will know if I have succeeded in this endeavour. *Illegitimati non carburundum.*

Jim Hrisoulas
1991

# SETTING UP THE WORKSHOP

Beginning bladesmiths may have difficulty understanding some of the terms and techniques in this book. As I stated in my preface, this book was written for experienced blacksmiths, so I assumed a certain level of knowledge on the part of readers. If you have any trouble with any of the terms or concepts, my first book, *The Complete Bladesmith*, should help prepare you for this text.

Now, let's get down to basics. First, you need a place to work, and your work area must meet certain requirements, including adequate space, proper ventilation, and good lighting.

## SPACE

If you are starting out from scratch, you should lay out the shop according to your needs and the space to which you have access. If you are already set up for blade work, then you may need additional space for the kilns, caster, extra hammers, tools, materials, and supplies. A large-enough work space is a must. Although most work can be done in a confined area, there is no sense in trying to work over and around crowded equipment. This situation is at best a nuisance and at worst a hazard. So shop layout is important.

## VENTILATION

Forges need a lot of air because they produce carbon monoxide gas at an alarming rate. This gas is highly toxic and can be fatal in enclosed areas. So your workshop must get rid of fumes quickly and effectively, as well as provide a free-flowing fresh-air supply. This is especially important for a gas-fired forge because the fumes produced are colorless and, for the most part, odorless as well.

## LIGHTING

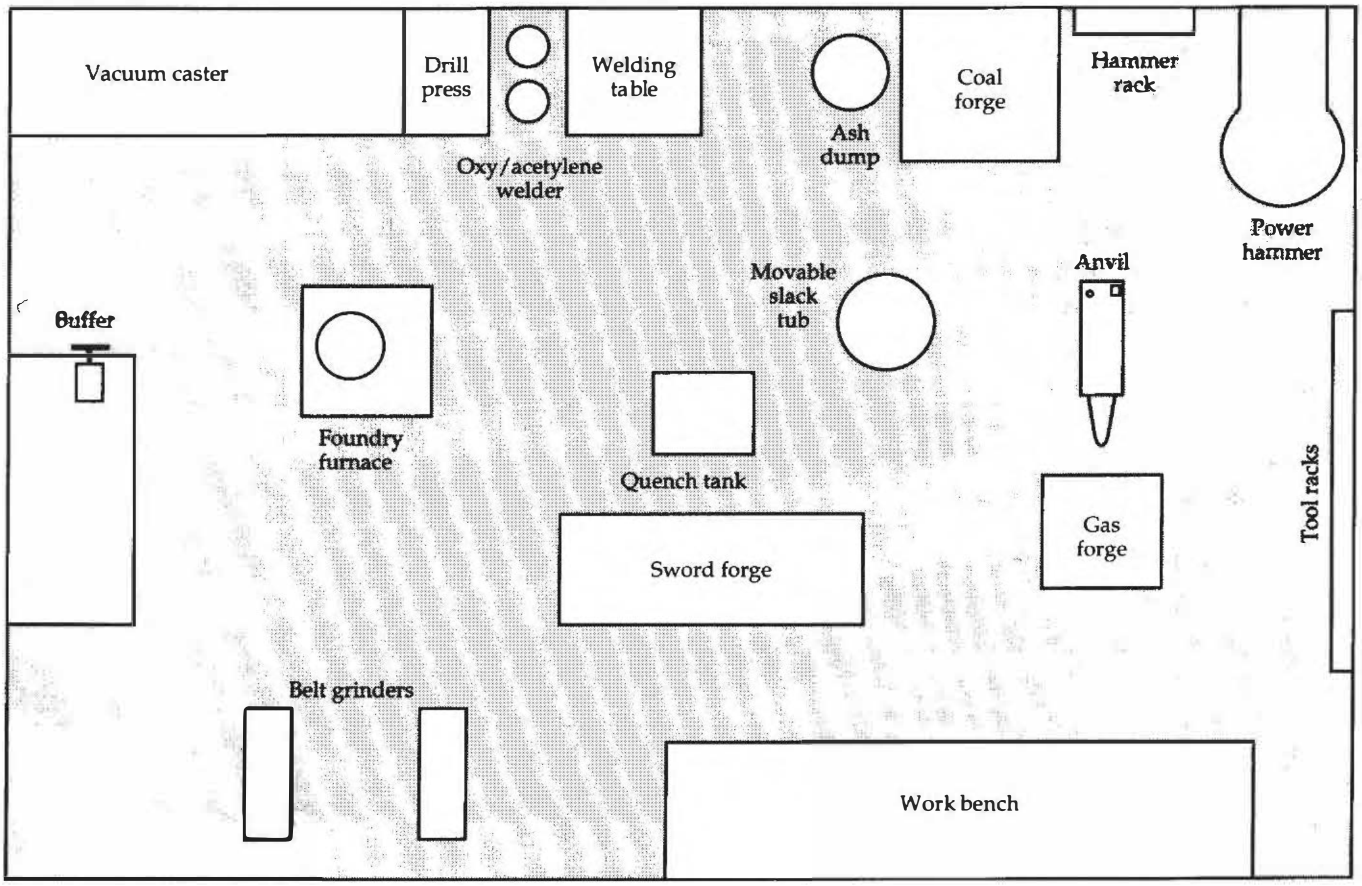
Once you have met your space and ventilation requirements, adequate lighting is next. Proper lighting makes your work a lot easier. The forge area should be dim (but not dark) to allow for proper judgment of metal color, while the rest of the shop, especially the grinding and fitting areas, should be well-lit so you can see what you're doing. The best lighting is natural background light, but this is not always available. The next best source is overhead fluorescent light. Any lighting that allows you to see clearly without eyestrain is acceptable.

The shop layout below is one that I recommend.

## TOOLING

In addition to space, ventilation, and lighting, you also need tooling. Most of the tooling used in general bladesmithing can be used for making swords, daggers, axes, spears, and other advanced projects. Aside from specialized dies and a few other specialty tools, there is little difference

## WORKSHOP LAYOUT



between a beginner's shop and that of an advanced smith's.

The first tool we'll discuss is the forge. A forge provides a means of heating steel to the desired temperature to shape it. The two most common types of forges used by blacksmiths are coal-fired and gas-fired. Of course, there are electric furnaces and oil-fired forges, but these are far too complicated and costly for the average individual, so I will not discuss them.

**Coal Forge**

This is the classic forge that everyone imagines when the term blacksmith is mentioned. Coal-fired forges were the first ones made, and a lot of quality work has been done in them. They are easily fabricated, and, while I will not go into great detail about their construction or use, I have included a set of plans for you to study. I built mine out of a truck brake drum, and I have used it for years without complaint. These plans are for the fire pot only, as this allows you to modify the height and position to meet your needs.

Of course, commercial coal-fired forges are available, and some are very good. If you would rather purchase a coal forge, these are the points that you should consider before doing so.

• *Fire box shape and size*. The box should be rectangular and deep enough to allow for an even heat in the fire. Its depth should be at least 5 inches, with 7 inches being even better. The hearth should be large enough to hold enough coal for sustained operation and to accommodate the heating of larger pieces.

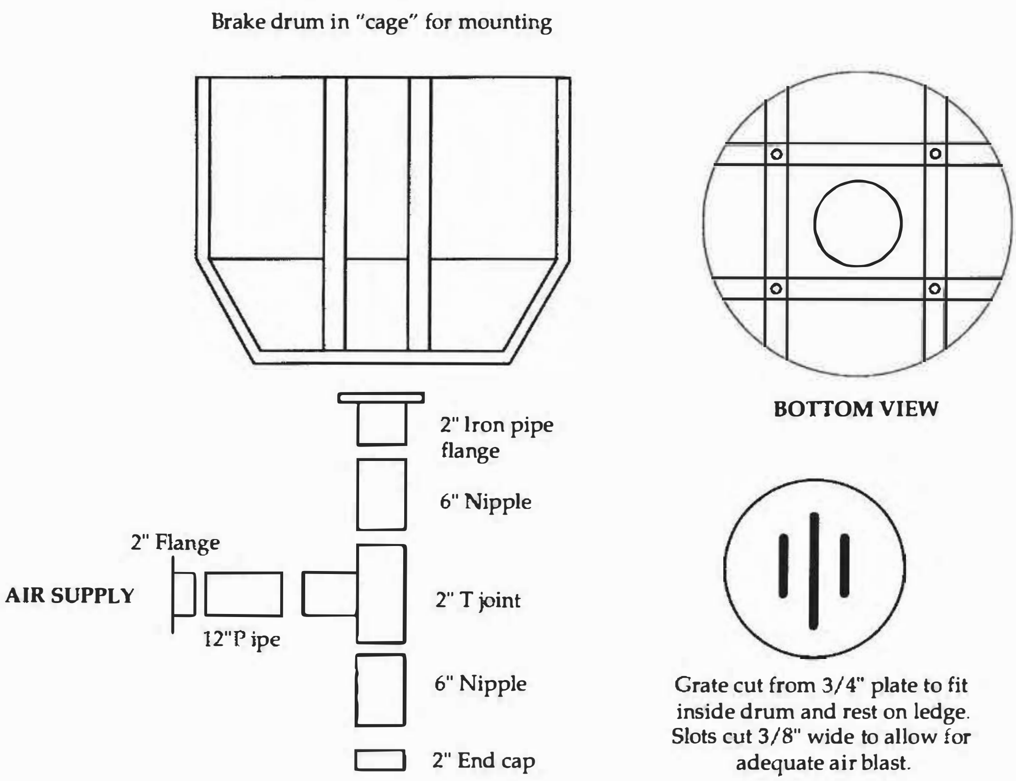
• *Clinker breaker*. This handy little item lets you clean the fire of clinkers without disturbing it. There are numerous types of clinker breakers to choose from, but the most common is the rotating ball design that not only breaks up the clinker but also directs the air blast. It can give a blast to the right, left, or center of the fire pot, depending on where the ball is placed in the tuyere.

• *Ash dump*. The ash dump should be deep yet easy to access and open. These are usually of the lever-open/gravity-close type.

• *Air supply*. You can use either an electric blower/fan or a manual blower/fan. The electric fan should have a positive speed/air blast control, either a rheostat for fan speed or a "butterfly" valve/sliding gate in the airway to regulate air flow. I used an electric blower for many years, and I must say that they are effective. Recently, I went back to a hand crank, which gives me better heat and more control.

As for the hand blower, the primary consideration is ease of operation. The crank should move smoothly and evenly without any free play. The volume of air is far more important than the amount of air pressure that comes up through the tuyere. The air volume moved by the blower should be more than you would ever expect to use. A low-

## BRAKE DRUM FORGE




pressure, large-volume movement of air produces a better fire than a high-pressure, small-volume blast.

Regardless of the type of air supply you use, coal forges do have one big drawback: smoke. They are dirty and sooty and can be quite an attention-getter when first fired up. At that time, they need a stack vent to deal with the billowing clouds. But once they are going, the amount of smoke diminishes to no more than a fireplace produces, and, if you build an efficient fire, then there is hardly any smoke at all. Included are plans for a retractable hood/stack arrangement that has worked very well for me over the years.

Coal forges give you a lot of control, and in spite of the problems with smoke, fire tending, and clinkers, they should be considered. After all, coal-fired forges of one type or another have been used since the dawn of ironworking. They are the traditional forges of the bladesmith.

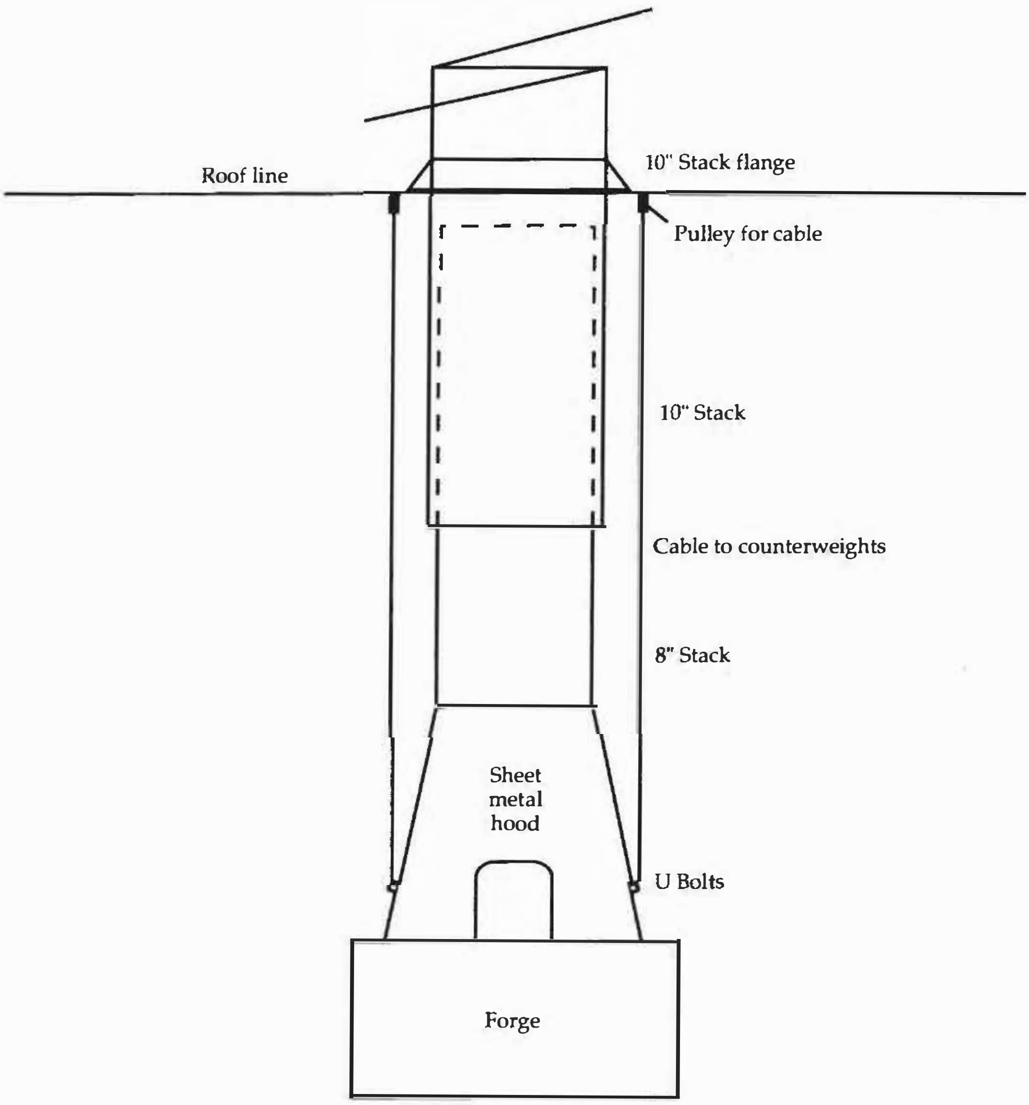
### Gas Forge

If you are in a space that makes a coal-fired forge out of the question, what heat source do you use? The answer could lie in a gas forge.

Gas forges are a bit more complicated in their construction than coal-fired ones, but they do offer simpler operation, no billowing clouds of smoke, and no clinkers, ash, or dust with which to cope. However, they must be vented to ensure that there is no buildup of carbon monoxide gas. This gas, as I said before, is very hazardous and can be fatal. A poorly vented forge can kill you. So be certain that the air flow and ventilation are more than adequate for your needs.

Many of the gas-fired forges on the market can use liquefied petroleum gas (LPG, or propane) or natural gas. They burn cleanly and work quite nicely for most forging operations.

## STACK/HOOD




Stack/hood telescopes into the larger stack
that goes through the roof and must extend
at least 2 feet into the stack pipe when hood is down.

Other significant factors in their favor are speed of operation and lack of fire care. A gas forge can be up to heat from a cold start in 5 to 10 minutes. A coal-fired forge takes considerably longer to get ready when coking and fire building are considered. Also, gas forges take no time away from work (as do coal forges) to add fuel, coke it down, or remove clinkers, ashes, or culls.

A gas forge can save time and energy during production work, especially when it comes to heat-treating or forging long pieces. It is easy to get and maintain an even heat on bigger pieces, and a gas forge can be built to suit almost any size or shape of work to be done.

Gas forges have their drawbacks as well. A gas fire tends to oxidize steel a bit more when the steel is first removed, and this can adversely affect the welding. Also, because gas forges produce an even heat, a localized heat is difficult to get. I find it easier and more effective to weld in a coal forge than a gas-fired one, but this is just a personal preference.

The gas itself presents some problems. Although economical to run, you are still dealing with compressed, highly flammable gas. You can easily damage the forge or seriously injure or kill yourself if you don't follow the proper safety precautions to the letter.

LPG storage tanks are highly pressurized and must be stored in accordance with local laws and fire regulations. So check with your fire department for tank placement and operation guidelines.

Even with the hazards, gas forges operate safely and effectively every day without any accidents or injuries. Common-sense safety practices recommended by firemen or veteran smithies are easy to follow and soon become habit, part of your everyday work schedule.

Another drawback to gas is that the volume needed is usually greater than a standard household natural gas or LPG line can provide. I urge you to use bottled LPG for firing instead of natural gas. This setup is far more agreeable to your pocketbook than to have your local gas company run a larger line from its main.

There are also semiportable tanks available that hold from 20 to 50 gallons. I operate a rather large custom forge with a 6 x 6 x 36 inch inside dimension on twin 25-gallon tanks with a coupling. That 50-gallon capacity can run my beast for almost a week of 6-hour-a-day operation.

Commercial gas forges are readily available, but they are often expensive and too small to sustain lengthy work, such as swordmaking. You can build your own at a much lower cost to fit your particular needs.

**How to Build a Gas Forge**

The basic building materials for a gas forge are refractory materials. These are available from ceramic suppliers that cater to the ceramic industry, rather than the hobbiest. Several types of refractories can be used, including fire brick, pourable refractory clays, mineral wools, and refractory boards. Developed for use in ceramic kilns and industrial burn-out ovens, they can also be used for gas forges. The following are some of the things you should look for in refractories.

• *Fire brick.* These are available in the standard brick size of 8 1/2 x 4 x 2 1/4 inches, as well as in special sizes and shapes. They are also rated for temperature ranges from 2000 degrees to 3000 degrees Fahrenheit (F). They come hard or soft, with the softer ones usually being the most temperature-resistant in the higher ranges. Masonry cutting blades that fit on a hand-held circular saw cut these bricks like crazy and are available from hardware/builder's supply stores.

As always, when you cut anything—but fire bricks especially—use eye protection and wear a respirator at all times. The ultrafine dust not only causes you to sneeze, it can get in your lungs and play holy hell with your health.

• *Fire brick mortar.* This is what it says: the mortar used between fire bricks. Although fine to use as is, I have found that if you add about 40 percent of ground fire brick and about 5 percent fire clay, it is even better. Fire bricks and mortar should be the basic building materials of the forge body, floor, and sides. The bricks are easy to lay and give many years of service.

• *Pourable refractories.* This is a type of fire clay formulated to withstand high temperatures without cracking, expanding, or shrinking, and forms a hard, durable surface. The big advantage to using this material is that you are not limited to shape and size as with with fire bricks. The drawbacks are that the material must be poured and used immediately, and proper curing procedures must be followed to the letter or problems may arise.

• *Rammable plastic refractories.* These are similar to pourable ones, but instead of being castable, they require physical placement and packing. Rammed into forms, they fill all open spaces and are efficient insulators and heat reflectors.

• *Mineral wools.* Perhaps the most efficient insulating material, mineral wool is also delicate and expensive. But a little of it goes a long way. A layer of 3/4-inch thick wool can be more effective than fire brick. Use it to seal between sections of a forge, such as between the removable top and the forge body, or as sides of the fire box. It works safely and efficiently as long as no work touches or bumps into the insulation.

Also, when cutting and handling this material, wear a respirator, eye protection, and gloves. The minute fibers are as abrasive as fiberglass, causing irritations and severe itching.

• *Fire clays.* Almost everyone in this business is familiar with this type of refractory. It should be used only for "mortaring" between bricks and making "patching grout" for furnace repair.

### *Repairing Refractories*

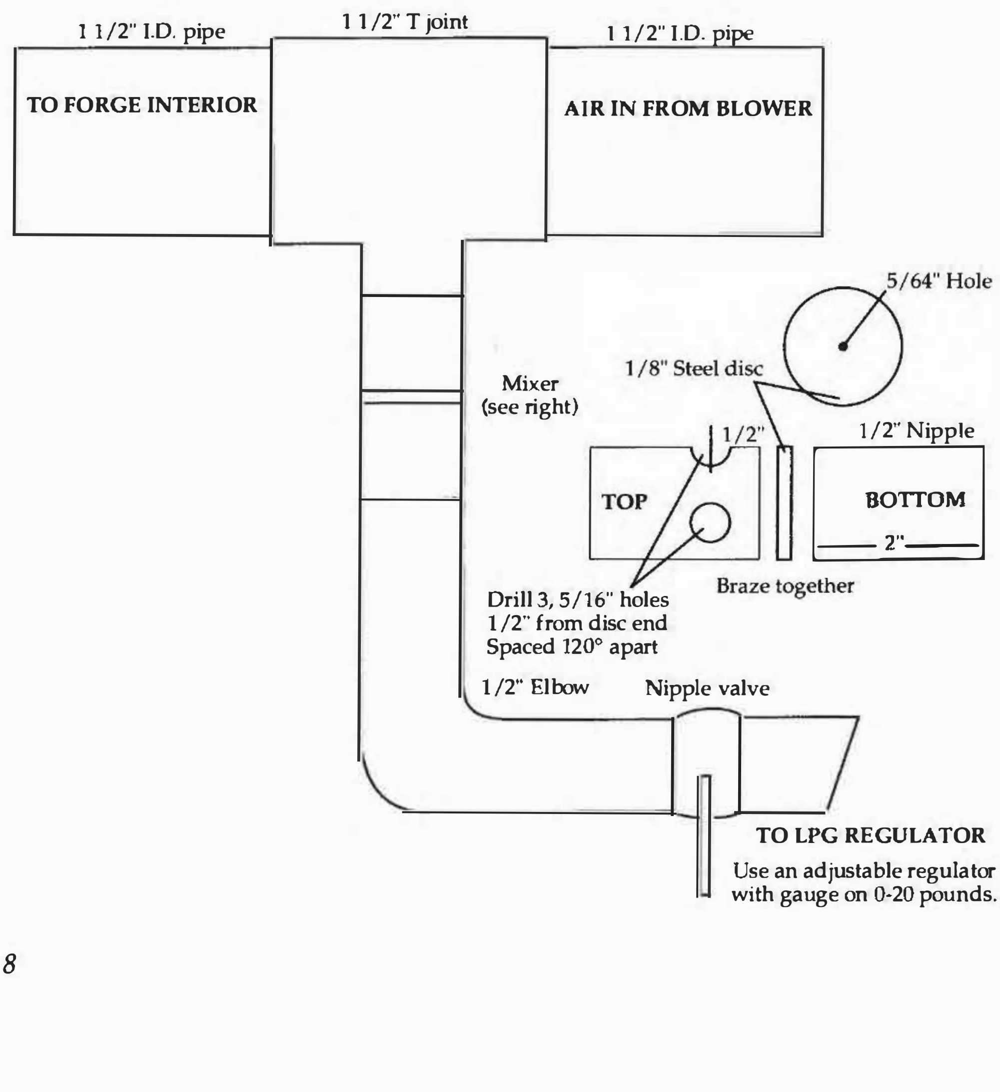
You can replace or repair a section of a poured refractory. A quick, effective, and serviceable repair can be made by using the following materials:

1 part fire clay
2 parts fire-brick mortar
4 parts finely ground fire brick

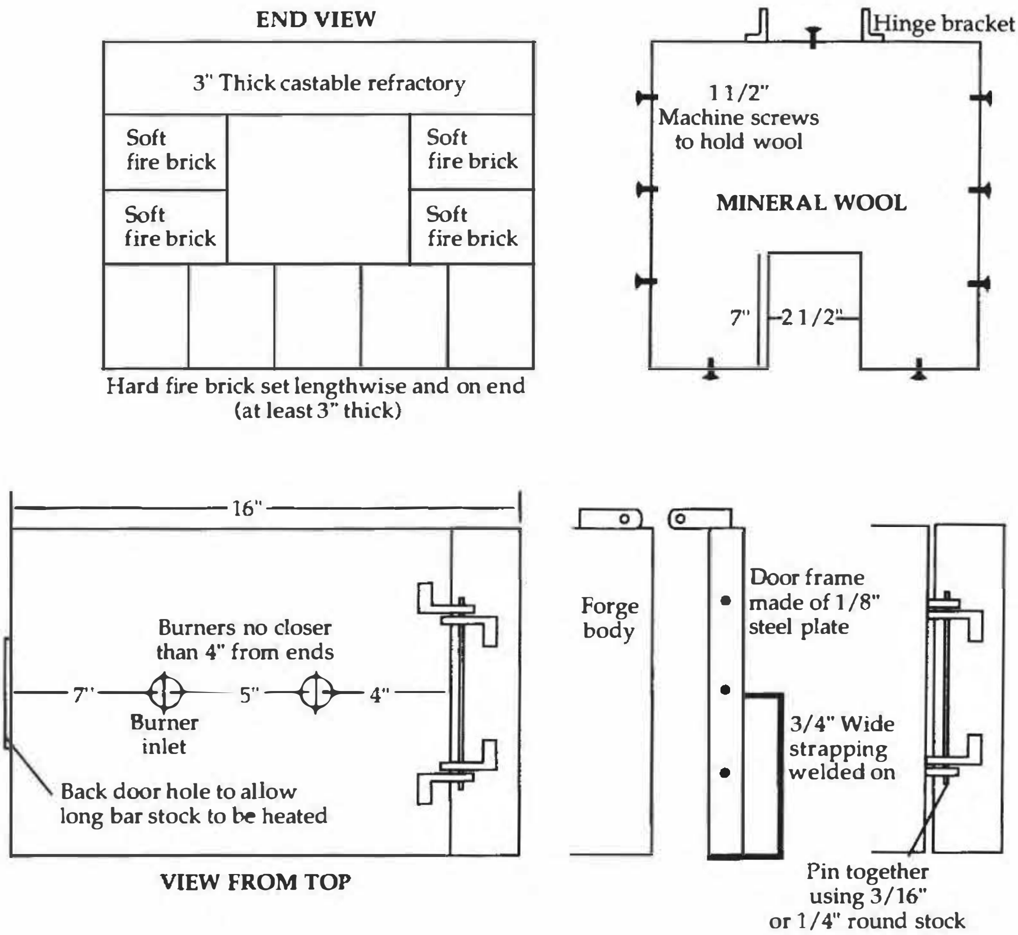
Mix well with enough water to form the consistency of a heavy cake frosting. *Slightly* moisten the area to be patched and apply the mixture. Let set overnight or until dry to the touch before firing.

• *Kiln shelves.* These are available in various thicknesses, lengths, and widths. Before doing any welding in a gas forge, I strongly suggest that you place a section of kiln shelf on the bottom of the forge to prevent any welding fluxes from coming into contact with the refractory. The

**BURNERS**
**(USE ONLY FOR LPG)**



## GAS FORGE PLANS #1




Forge body can be made from
12-gauge sheet.
*Do not use galvanized material.*

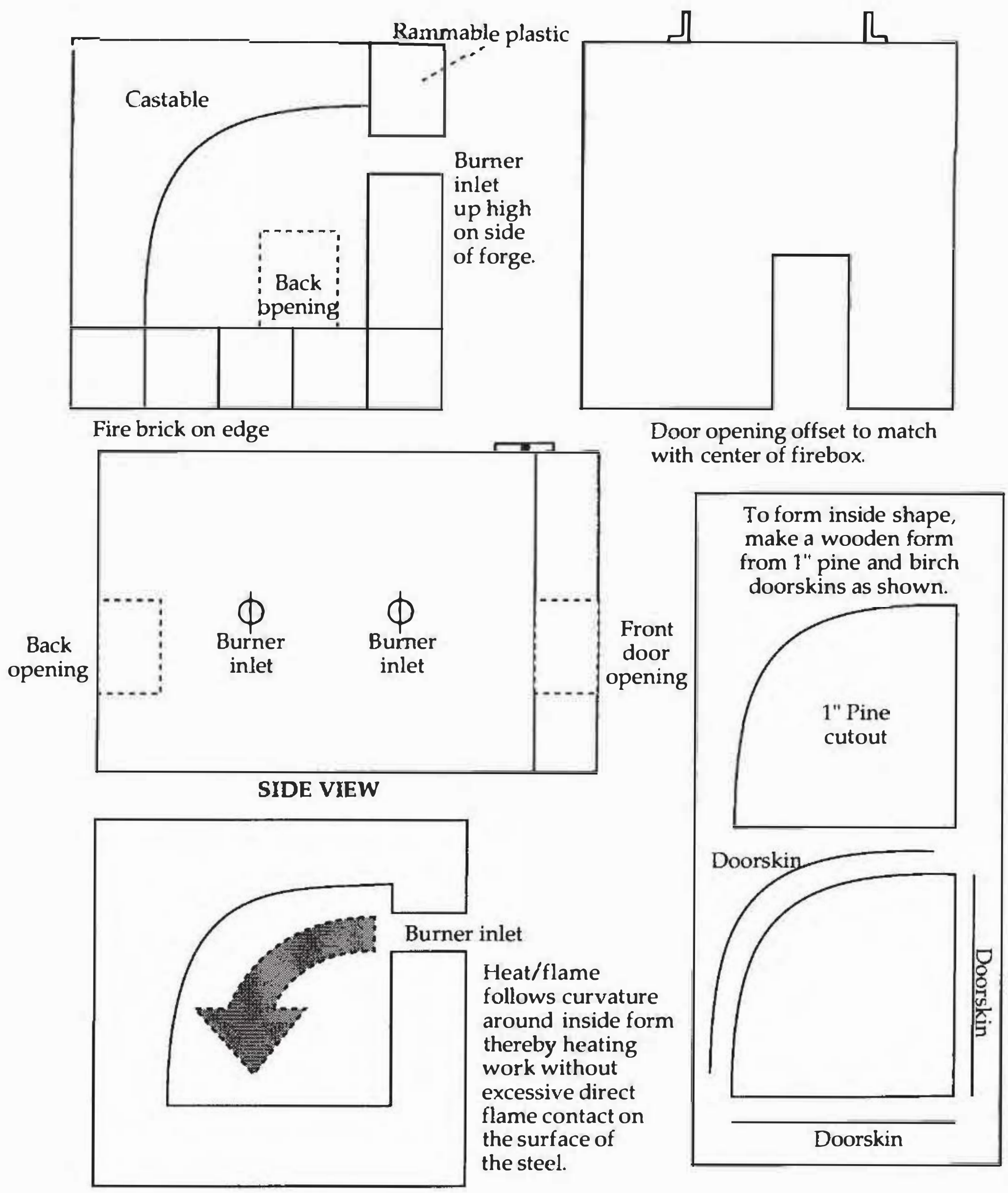
corrosive fluxes used in welding eat their way through refractories at an alarming rate. A kiln shelf stops the fluxes from reaching the refractory, and you can replace the shelf as needed to save the forge's refractory lining. (These shelves can be cut with the same masonry blade that you used for fire brick.)

These are all of the special materials you need to build a gas forge by the following plan. It can be changed to meet your particular needs. The the only component that I recommend *not* changing is the burner assembly. Of course, that can be changed if you wish, but I have found that burners made in this fashion are more efficient than other designs.

When properly designed, the forge can reach temperatures high enough to do most work, including forge brazing and welding.

## IMPROVED FORGE DESIGN

(Exact measurements are up to individual requirements of smith.)




### *Gas Forge Safety*

The most important safety precaution: when lighting the forge, put a piece of burning paper inside the forge, turn on the blast, and *then* turn on the gas. *If you don't remember to turn the air on before the gas, you very likely will blow yourself up.*

When shutting down the forge, turn the gas off first, then the air. This prevents gas from building, which could be hazardous.

Once you have your most important piece of tooling, a forge, you should look at some others. The following tools are ones you can fabricate, and while they may not be required, they will save you a great deal of time. They especially come in handy when forging heavy sections and specialized blades.

## Top and Bottom Tools

These useful tools allow a smith working alone to forge a variety of shapes, cross sections, and designs. They are placed into the the anvil's hardy hole and secured by a bracket that extends over both edges of the anvil, preventing any movement. With slight modification, they can be used with a power hammer. (See Chapter 4 for more information about the power hammer.) The most useful tools are the top and bottom fuller and the tenon tool.

### *Top and Bottom Fuller*

This tool can be used to forge or groove blades. It also simplifies tang drawing and other processes that require a heavy change in cross section.

### *Tenon Tool*

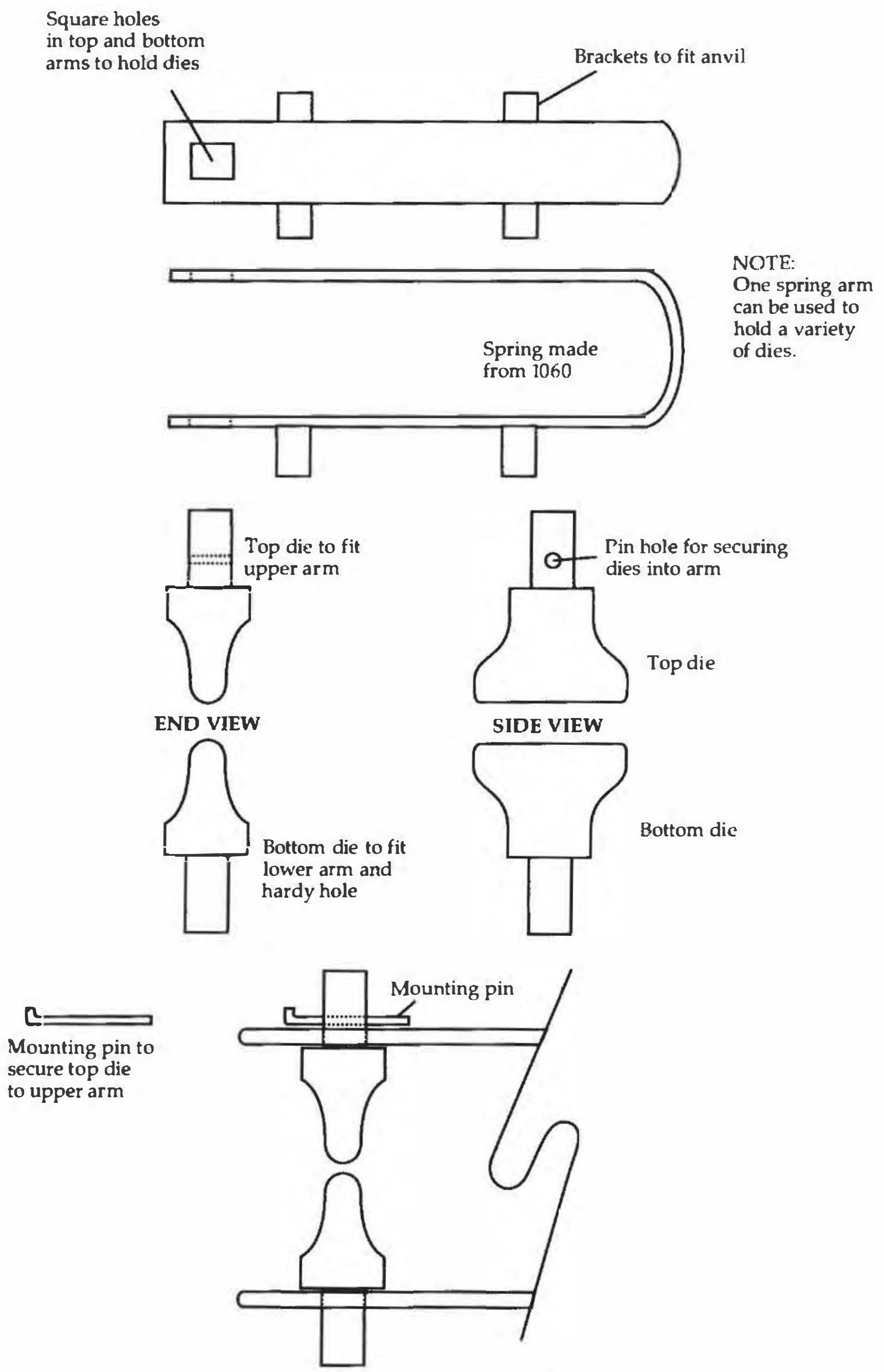
This is the opposite of a fullering tool. Depending on the dies, it can make a variety of shapes, but the most common ones are round and square. By using this tool, you can easily form tenons and—if used in the early forging—center ribs as well. It can also be used for rounding the ends of tangs prior to threading or for squaring-up tang sections (with a square-die cavity) before attaching the pommel.

These tools can be fashioned from any medium-carbon steel of 45 to 60 points. The springs should be made of 60-point steel at a full spring temper. Its working surfaces should be tempered dark brown to blue, while the remaining sections should be annealed to prevent chipping and damage to the sledgehammer's face. As illustrated on page 13, these dies can be made to interchange in a single framework.

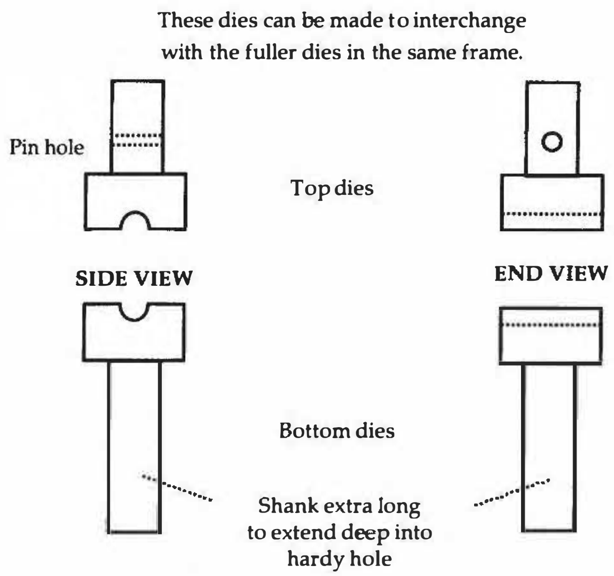
## Tongs

Tongs are the extension of one's hand and are used to hold items too hot for bare hands. They come in a wide variety of types and sizes. For gas-forge work, I recommend using ones with handles of at least 30 inches to prevent flash burns (and to save the hair on your arms as well). Tongs should fit the work and be sized according to the piece to be held. I have more than a dozen different-size tongs for my pattern-welding work alone.

## TOP AND BOTTOM FULLER TOOLING



## TENON DIES




### Hot Chisels

This tool enables you to make fast, accurate cuts on hot metal. It has a handle and looks like a cross between a hammer and a hatchet. Its edge is finer than a cold chisel's because hot metal is considerably softer than cold. While using, you should cool the chisel blade every three to four hits to prevent the edge from annealing. The blade absorbs heat from the hot metal. Hot chisels come in different weights. One in the 3- to 5-pound range should suffice for most work. Using a hot chisel, I have made 16-inch splits in 3/8-inch steel in no time at all.

### Cold Chisels

Cold chisels are used to cut cold metals, and their edges are considerably stouter than those on hot chisels. They can have handles, or they can be plain bars of steel edged on one end and flat on the other.

As with any tool struck with a hammer, users must regularly inspect the condition of the cold chisel to make certain that its ends have not mushroomed. If allowed to mushroom, fragments of the tool could fracture when struck, causing serious injuries. And, of course, when striking anything, always wear eye protection.

### Hammers

Except for a few specialized designs, any bladesmithing hammers used for basic smithing can be used for advanced work—as long as they are properly crowned with no square-shouldered edges. Square-shouldered edges leave hammer marks in the steel surface that are difficult to remove.

If you use top and bottom tools without a power hammer, you need at least a 6-pound sledge hammer, and an 8- or 10-pound one would be even better. However, a 10-pound hammer is too heavy for anvils under 250 to 300 pounds. A good rule to follow is for every 1