A Long-Term Survival Guide - Scrounging Metal, and Survival Blacksmithing:

In a long-term survival situation, knowing how to make simple tools and weapons by using primitive blacksmithing techniques can allow you to produce wealth by your own efforts, in the form of useful items, and trade goods.

Black sand containing iron can be collected by dragging a magnet through loose dirt, along a dirt road.

Of course, to make your own stuff from metal, using blacksmithing tools, you need a source of metal, both to make the basic blacksmithing tools from, and as raw materials for making into other tools and weapons. In almost every part of the U S, scrap metal can be found just about everywhere, but first let's quickly examine the worst-case scenario; how to make your own raw iron if scrap metal is not available.

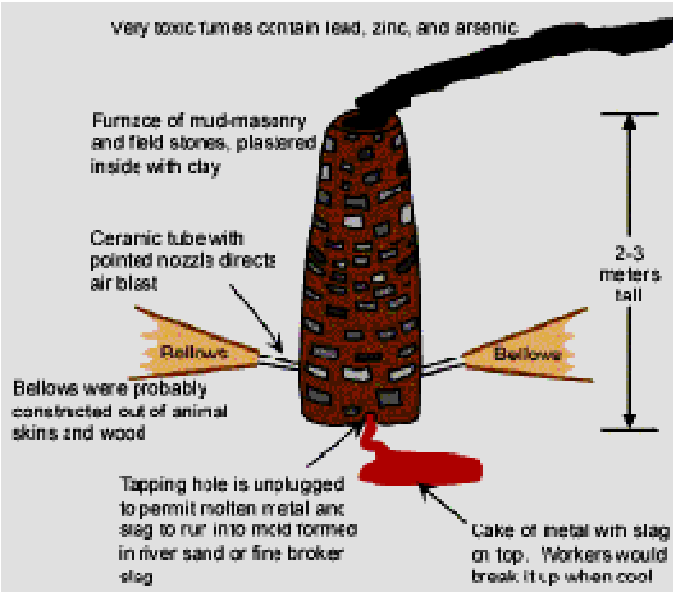
Making your own iron: It is possible to collect black sands containing iron, by dragging a magnet through loose sand, loose dirt, or along a dirt or gravel road. Frequently scrape the sand off the magnet into a 5-gallon bucket. When you have several gallons of ferrous sands, you are ready to start smelting.

If you don't have a magnet, you can search for bog iron ore instead.

If there is an iron-bearing spring in a boggy area anywhere nearby, a long rod (preferably tipped with metal) can be used to probe the mud for lumps of iron ore, which builds up over the centuries into chunks, that range from fist-sized, to head-sized. When you locate a chunk of bog iron, the ore is dug out of the mud by hand (what fun!), and a bucket-full of ore is enough to start smelting.

An iron-rich spring is a good place to probe the mud for lumps of bog iron ore, using a metal-tipped rod.

Starting from scratch like this is definitely an awful lot of work, and your final reward is a small lump of low-grade wrought iron. Finding old scrap metal to work with will almost always be a better use of your time and energy, and both time and energy will probably be in short supply, during survival situations.



Smelter diagram, and smelter in use. Bellows send air into pipes, making enough heat to melt metals.


Base of smelter. Note air pipes, which supply fire with oxygen. Molten metal, in base of smelter.

Once you have iron ore, you need fuel for smelting. Coal is the fuel of choice, but unless you are close to a coal seam the next best fuel is charcoal, which can be made from any type of wood, or from coconut husks in the tropics, or even from bamboo.

A bloom of iron, from an improvised smelter. Compacting the bloom, with a large wooden mallet.

The charcoal-making process is simple, but labor-intensive. Two or three tons of wood is piled into a dome shape, about ten feet across. This is covered with a layer of earth, and then lit by dumping campfire coals into a hole at the top. Once the wood is burning, the hole is covered with dirt, and the woodpile slowly turns into charcoal, over a period of roughly 100 hours.

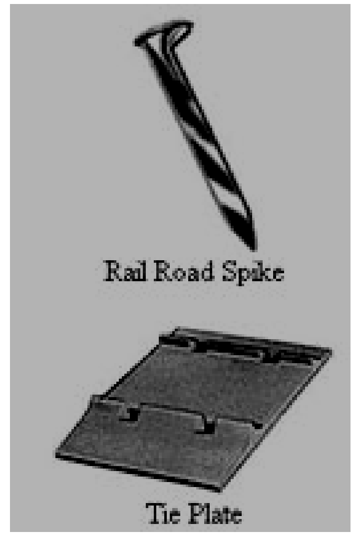
During this time, the pile has to be watched all day and all night, so any holes that develop can be filled in with dirt. If this is not done, the whole pile will go up in flames, leaving ash instead of charcoal. Once the charcoal is finished, it is raked out of the dirt, and is ready to fuel the forge. Smaller amounts can also be made, in a similar way.

Wooden mallets are easy to make. The edges can be wrapped with wire or cordage, to reduce splitting.

Blooms from iron ore are soft, and can be hammered out on a stump, using a wooden mallet, or heavy club. A large stone will also do for a crude anvil, and a stone hammer can also work the bloom. Tongs made from green wood can be used to hold the blooms, until you have enough iron to make metal blacksmith's tongs. Your wooden tools will catch on fire, but they can be doused with water, or just replaced when they get too burned up. They only need to last long enough to hammer out the item you need, whether it is a knife, axe, or other tool.

There are three types of basic iron; bog iron, wrought iron, and charcoal iron. Lets look at each one:

Bog Iron Ore: Bog Iron is impure iron deposits that develop in bogs or swamps by the oxidation of iron. It was discovered during the Pre-Roman Iron Age, and most Viking era iron was smelted from bog iron. The iron-bearing groundwater typically emerges as a spring. The iron is oxidized when it reaches the surface, often producing a reddish mud from the oxidized iron. To find the bog iron, a long metal rod, or metal-tipped rod, was shoved into the bog mud over and over, until it eventually struck a lump of ore, making a clunking noise. The ore was then dug out of the mud by hand. It took about six good-sized chunks of bog ore to smelt into one axe head.



Railways offer a lifetime supply of scrap metal, from the track, spikes, and tie plates.

Wrought Iron: Wrought iron is one of the most misunderstood terms in all of blacksmithing. This has to do with the fact that it was first made by striking with large hammers, and so it was wrought, or made, by hand. Though this method of iron making has fallen out of use, the term "wrought" stayed with us because blacksmiths still shape and form their work by striking it with a hammer. True wrought iron is defined this way: Originally, iron ore, black sand containing iron, or lumps of bog iron (dug from the mud around iron-rich springs) were placed in a crude blast furnace with charcoal and crushed limestone. The charcoal was set afire, bellows pumped air into the furnace, and the heat melted the iron from its ore. As blooms of molten iron were pulled from the furnace with tongs, they were placed on an anvil and then flattened and squared by striking with large wooden mallets, or sledge hammers. As the iron started to stretch into a ribbon, it was doubled over and beaten again. And again, and again. This would gradually form the iron into a bar. The process of continually hammering and re-heating reduced the amount of impurities in the iron bar. It also caused the iron to become layered, or laminated. Wrought iron also retained impurities from the smelting process, giving it unique characteristics.

Charcoal Iron: Before 1800, all wrought iron was charcoal iron. Charcoal, iron ore, and crushed limestone were loaded into a crude blast furnace, and the charcoal set afire. The iron formed blooms, and the soft blooms were hammered into ingots. Charcoal iron contained impurities, mostly in the form of silica or carbides. Iron silicate is the main impurity. These glass-like impurities form in strands, much like fiber optic cable strands. Charcoal iron contains up to 5% silicates, and these silicates do not bond with the iron. Instead, they remain separate, and give the iron a fibrous appearance. Since silicates do not oxidize, they give charcoal iron a high degree of rust-proofing. There are works made of charcoal iron that have been exposed to the weather for many centuries, and show very little sign of rusting. The silicates also gave the charcoal iron more workability. This let the blacksmiths of old create superior suits of armor, which just cannot be duplicated with modern iron and steel.

Survival Blacksmithing, Using Scrap Metal:

Finding scrap metal to forge is a hundred times easier than smelting iron ore, and most scrap metal is steel, which is a better material for making tools than iron. My favorite scrap is railroad spikes, and sections of railroad track.

Old railroad spikes have several potential survival blacksmithing uses.

Damaged or abandoned railways can afford you with a lifetime supply of scrap metal, in the form of railroad track, spikes, and tie plates. You can usually find spikes lying around loose beside active rails, or left embedded in old railroad ties.

A railroad spike can be driven into a tree stump, and then the head can be used as a very small anvil. You can do a surprising amount of work on a tiny little anvil like this, including shaping other spikes into knives and hatchets. A railroad spike can also be set into the head of a wooden mallet, to create a crude but workable hammering tool. Wrap the mallet head with wire of cordage before hammering in the spike, to keep the mallet from splitting.

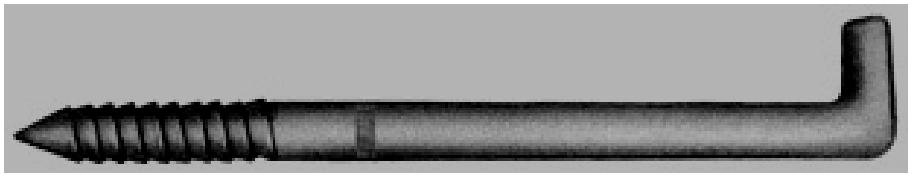
A section of railroad track works ok as an improvised anvil, and can be shaped into a better anvil.

This anvil was made from a length of railroad track, using a cutting torch disk grinder, and drill. The same job can be done using a hacksaw, file, and hand drill – it just takes longer. Note: To cut track with a hacksaw, start at the bottom. Train wheels can compact the metal molecules on top of the rail, making it much harder to cut through.

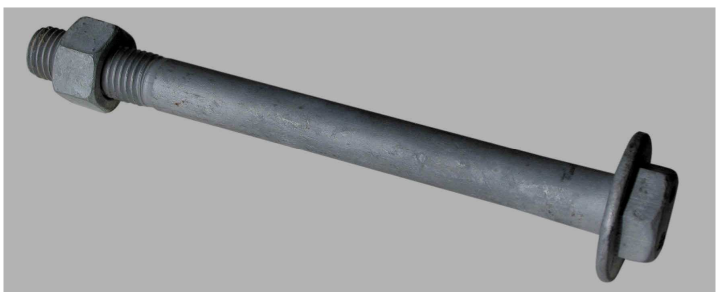
Railroad spikes are good for survival blacksmithing, and can be made into many useful items.

A railroad spike contains enough good steel to forge into a lightweight hatchet or knife. Don't expect your tools to be as elegant as these examples, they are shown just to demonstrate what you can do with these humble spikes. You can make a basic forged knife without the decorative twisted handle, and it will still cut just as well. You can make a hatchet head without an eye hole for the handle, and mount the head in a split green wooden handle, lashing it with sinew or cordage. Railroad spikes can also be shaped into chisels, punches, hammers, and many other simple tools. Once you have basic workable tools, you can then make better ones, if you wish.

Hunters often leave tree-climbing steps like these in the trees where they place their tree stands. These are good-quality steel, and they just screw into the tree. They are easy to remove, if you find any while survival scrounging.



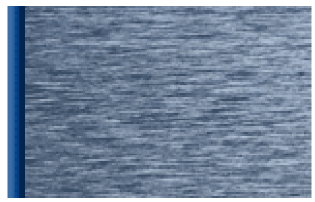
Telephone poles and power poles often have metal climbing steps, which can be removed and used for survival blacksmithing. There are two basic types; one screws into the wood, and the other is driven in with a hammer.



Metal poles are less common, but they should also be examined for climbing steps that could be used for survival blacksmithing in a long-term crisis. These steps are usually large bolts, so they are harder to remove without tools.

Even if no railroad tracks are in your area, you can still find spikes, in old ties used as fence posts.

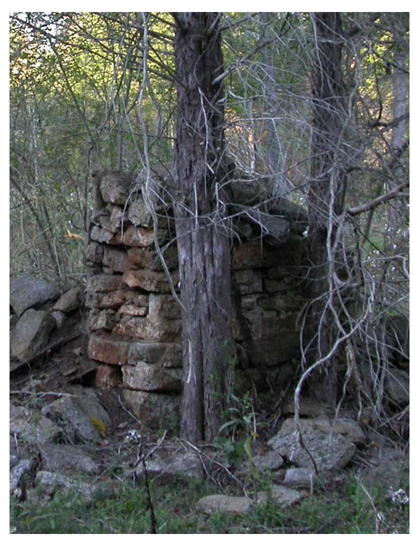
Metal road signs have sharp edges, and can be used as improvised cutting tools, until you make better tools. One way to do this is to remove smaller signs from their poles, and sharpen one edge on a rock.


Metal signs can be made into crude knives, and arrowheads, by breaking or cutting off triangular pieces of the sign, and then sharpening them. I prefer to make my arrowheads from signs with arrows on them.

Larger signs can be set in a fire to burn off the paint, then cleaned by scrubbing with sand. The clean metal plate can then be used as an improvised cooking grill surface, set on rocks to position it above a campfire. (Or you could copy this design for an adjustable grill, made from sheet metal, and a stake.)

Abandoned buildings offer a wealth of metal to the survival blacksmith. Look for hinges and hardware, metal pipes, electrical wiring, junk piles, nails and staples (in fence posts), railroad spikes in old railroad ties (often used as corner posts, or for heavy-duty corrals or pig pens), wire fencing, rebar (concrete reinforcing rod), and tin roofing (this is sheet steel). If there are any telephone poles around, look for the metal climbing stakes used on some poles.



Old ruins (or the ground around them) often contain abandoned scrap metal. This collapsed chimney is proof that there used to be a cabin here at one time, so this would also be a good place to look for scrap metal.


A collapsed tin roof offers a good supply of sheet metal, and ruins like these may hide a lot more scrap underneath.


Back when metal was scarce, pioneers would sometimes burn their cabins when they moved, so that they could recover the nails used to make the building. After the fire was out, they would rake the nails from the cold ashes, and reuse them. You can still do the same thing today, if you need metal. When a modern cabin burns, there is a huge pile of metal objects left behind, so homes destroyed by war or disaster are always a good place to find scrap.


Wrecked or abandoned vehicles contain more metal than you can carry, and a junkyard is a lifetime supply of scrap for the survival blacksmith. Cars and trucks contain sheet metal, screws, nuts and bolts, leaf springs and other springs, hose clamps, wiring, handles, hinges, bearings, blower motors, and many other useful parts. They may also have lug wrenches, bumper jacks, or other tools left inside, as well as batteries and alternators.


Wrecked aircraft offer many of the same opportunities for salvaging scrap metal as other vehicles, but planes often have a lot of aircraft cable (wire rope) in them as well, a very good material for making cable snares for large game.


Bush planes and military aircraft often carry survival kits, so check wrecked planes and copters for any such items. Most large planes carry a crash axe in the cockpit. In a war or major disaster, you may see more downed aircraft than you might expect, and odds are that no one will be cleaning up the wreckage.


Tropical jungles cover up wreckage quickly, so a wrecked plane may look something like this.

Wrecked boats can contain anything; tools, supplies, rope or guy wires (wire ropes on the mast).

A metal ship is a mountain of scrap metal; just what you need if stranded on a desert island.

Once you know how, you can make tools from an abandoned tank, or even an abandoned tank.

Once you have a supply of metal, you need a way to heat it up enough to soften it, so it can be reshaped.

Improvised Blacksmithing Forges: A forge is required for blacksmithing, because iron is too hard to work cold. To get a fire hot enough to heat iron (1650 degrees F), extra air must be supplied to the coals. The tool that supplies the air and controls the fire is called a forge. You can heat metal with an acetylene torch and tanks, if you have them, but you can improvise a primitive forge from local materials, and make your own charcoal to fuel it, as well.

There are many ways to make a forge. Early man used two or three hollow reeds or bamboo canes, each tipped with a clay pipe end piece, and a shallow depression in the ground. A fire was built in the depression, and several men sat around blowing into the fire, until the iron or other metal was hot enough to work.

This primitive forge is just a fire in a hole. Air is blown into the fire, through clay pipe-tipped reeds.

The forge is actually a two-part tool; a fire pot, and an air supply. The fire pot can be anything from a hole in the ground, to a box lined with firebrick, or lined with fire-resistant refractory. A wooden box containing clay with a depression or hole in the middle was commonly used for many centuries.

A rock-lined hole can be used as a forge by adding an improvised bellows, using charcoal as fuel.

A tin can lid with holes in it makes a good air grate, and this forge easily reaches forging temps.

Almost any large tin can or metal bucket can be used as a forge. Pack the inside with mud or clay for insulation, and leave a hole for the charcoal. Air tubes can be improvised from scrap pipe, bamboo or reed stalks, baked clay pipes, or even the leg bones of large game animals. An air channel can also be just a narrow covered trench, leading from the bellows to the forge, or an above-ground channel made from bricks or rocks that are mortared with mud or clay. Shown here is such a can forge, which can be elevated on a mud-covered platform. This is more convenient than working from a hole in the ground.

The bellows for a forge is a bit more difficult to improvise, but still do-able. Hollow blowing tubes are the simplest way to supply air to a forge, but they will give you a big headache from all of the blowing.

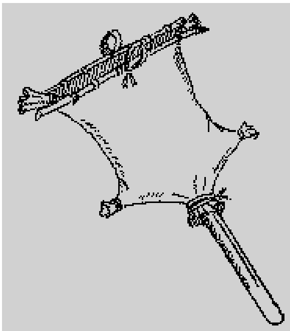


Figure 1

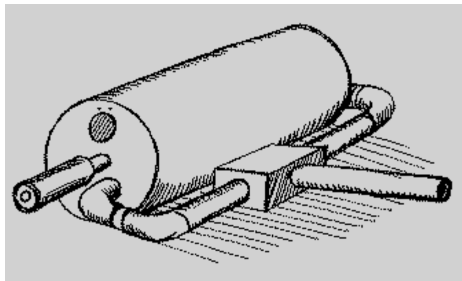


Figure 2

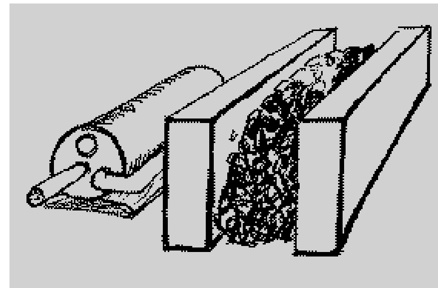


Figure 3

A couple of goat skins sealed at the leg openings, a pipe tied into the neck, and sticks fastened across a split between the hind legs with loops makes a simple bellows. See Figure 1.

The Chinese air pump is a double-ended cylinder made of bamboo, metal, clay, or wood. Valves at each end allow air intake, and pipes at each end connect to a valve chamber and a blow tube. This allows a single piston to produce a continuous air blast. The piston is made to fit loosely, and leather or other materials make a gasket, to insure against air leakage. See Figure 2.

The Japanese sword forge consists of two walls of mud, clay, bricks, or stones, about 10 inches apart, and two or three feet long. The cylinder blower pumps a blast of air into the center of one side, into a charcoal fire. This forge is simple and efficient; it is used to make Samurai swords. See Figure 3.

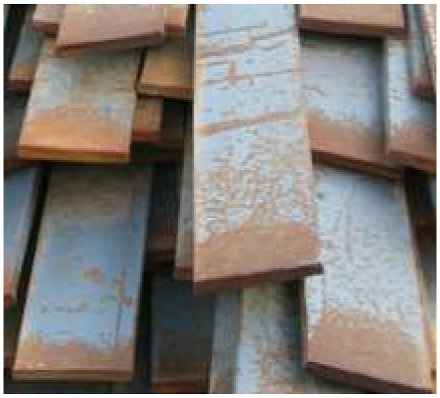
This forge uses a wooden block to connect two bellows to a tuyeer, made from a rock with a hole in it.

A fan type blower could also be made, much like a squirrel cage fan. Pieces of wood, sheet metal, or even dried rawhide could be fashioned together to make a rotary fan shape, and then improvised large and small pulleys and a belt or rope can be used to increase the rpm's from a hand crank or foot pedal.

This old burn barrel will make a good forge, after a bellows, air pipe, and insulation are added to it.

The anvil is the foundation of blacksmithing, because that is where the shaping is done. The simplest anvil to use would be a rock, but a railroad spike set into a stump would be even better. Almost any heavy chunk of iron can be used, and you would probably be surprised at the great work that can be done with a small piece of railroad track.

The tools that go along with the primitive forge and anvil are hammers, punches, and bending and cutting tools.



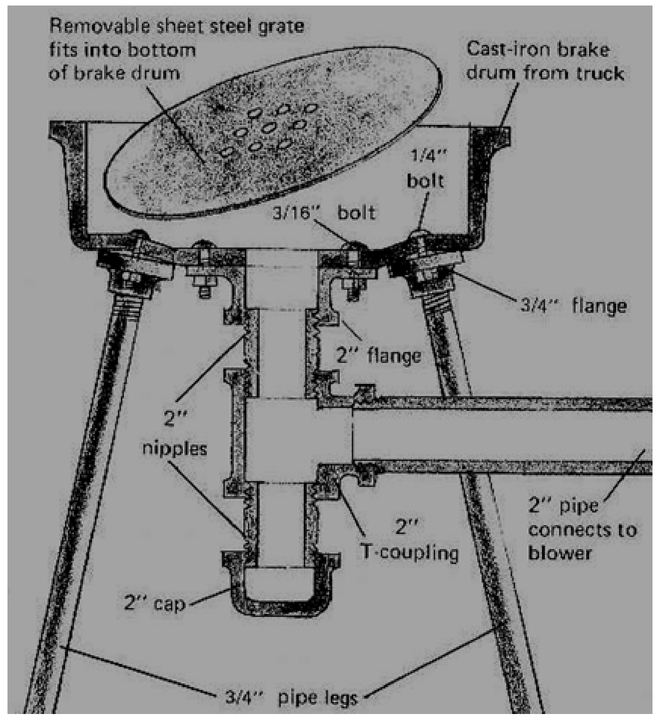
A length of steel rod, or steel bar, is heavy enough to work as an improvised hammer.

The hammer is the most fundamental tool that you will use. Just as with the anvil, a rock works very well. Most early blacksmiths used a wooden mallet to start hammering a fresh bloom of iron, and switched to stone or metal hammers as the bloom became more compacted. Any kind of iron hammering tool is more efficient than wood or stone. Even without a handle, a metal bar or rod can perform several functions of more advanced hammers. An engineer's hammer causes iron to flow in two directions, because the striking surface is narrow and long. A rod performs the same way as this kind of hammer. The end, if cut off squarely, acts as a normal hammer face. A bar also acts much like a hammer face.

Some type of chisel is needed to cut the metal. This can be as simple as tapering an end on a bar and hardening it. A punch is made the same way. With these two tools and a hammer, you can make most of the tools you will need, tongs included. Once you learn to make tools, you can make almost anything; one skill builds upon another.

If you don't have an iron anvil, or any metal substitute, a large rock makes an ok anvil. If you don't have a metal hammer, a rock, or even a green wooden club, will get the job done. A good improvised hammer is a heavy steel bar, and an anvil can be as simple as an old railroad spike driven into a stump (use the exposed head as a small anvil), or a big chunk of metal can be used as an anvil, like an old engine block.

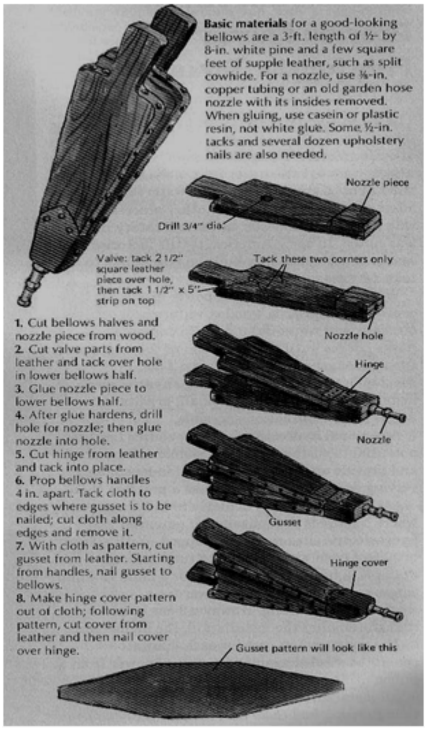
Large pliers make good blacksmithing tongs, and so do smaller pliers with handle extenders added onto them, but if you don't have any metal tongs, make tongs from green wood, or wood soaked in water, and ignore it when the working end catches on fire (dunk them in water, after putting the hot metal back in the fire). Use whatever you can find, and be creative.



Improvised Forge: Three items are needed to make a primitive forge; a fire box, a bellows, or air pump, and a tuyeer, or air pipe. This example is made from an old automobile brake drum, and some pipe parts.

Tuyeers vary greatly. One type is a tapered clay tube. Several of these could be nested together to make a longer tube, to reach from air pit or bellows, to a fire pit. These were a cheap, almost disposable item that were used for glass furnaces, ceramics kilns, smelting furnaces and forges, from the beginning of time. But if you can scrounge them, a couple of pieces of pipe or electrical conduit will also do.

The Viking forges used a soapstone shield stone "tuyeer", but any rock with a hole in it can be used. Some of these have been built with pipes connecting the bellows to the stone, but in traditional use the nozzles of the bellows just pointed at the hole in the stone, from less than an inch away. They were not connected directly to it. (Nozzles can be made from pipe, clay tubes, bamboo, hollow horns or bones, or even rawhide that was formed into a cone shape, or tube shape, and dried until it hardened.)



Here is a design for a fireplace-style bellows, and a finished example.

One problem with primitive forges is that they were usually in or on the ground. This was a common working position up until modern times, and is still common in the Mid East, and Asia. However, Westerners are used to working standing up. But you can build your forge on an elevated platform, coated with a thick layer of mud or clay, or set into a clay embankment, if you prefer.

Pit forges can be a narrow ditch, with the air coming in from the side, like a Japanese bladesmith forge. The narrow width keeps the fire small, and the length provides space for extra fuel, and longer blades.



These manual pumps, designed for inflating air mattresses and water toys, can also supply air to a forge.

Building a temporary make-do forge used to be a common thing, that every blacksmith knew how to do, and had lots of practice doing. But if you don't want to dig a hole everywhere you go, then you can make a portable forge, such as a brake drum forge.


This brake drum forge is made from a large truck brake drum, with pipe parts for the blower pipe.


Here is the completed forge, and the forge in use, with a 30 gallon drum, used as a wind shield.

This is another design for a portable forge, called a tub forge, because the firebox is a metal tub.

All of the materials needed to make this forge are available at your local hardware store. The tuyere is 1" black iron pipe, 18 inches long. The oval tub is about 4 gallons, but larger ones work as well. Quarter-inch holes are drilled in the pipe, every inch. A piece of angle iron works great as a straight edge for scribing a line on the pipe. There's an end cap on the left end of the tuyere pipe, for removing clinkers.

The other end of the tuyere pipe has a coupling for connecting a blower, which can be any small squirrel cage blower from a junkyard car (12 volt powered, or modified for hand cranking), or any other type of bellows, or any hand-powered or foot-powered air pump (such as those used to inflate boats and water toys), or even an old hair dryer, if you have AC available.

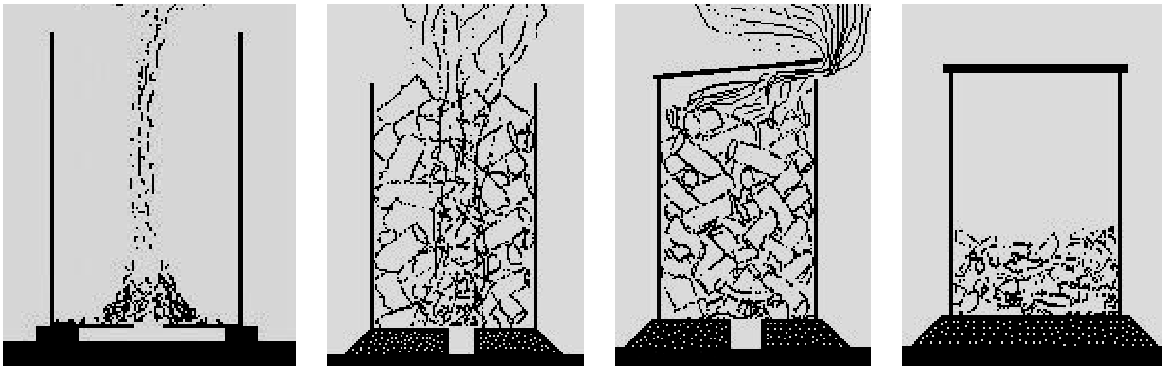
Most forges are designed for general blacksmithing using coal as fuel, and have round designs and a central blast. This forge is designed for working long material, such as blades and gun barrels, using natural charcoal as fuel. The forge is an oval metal tub with an air pipe inside (with a line of holes drilled in it, facing up), and a coating of mud or clay for insulation, and it is connected to a hand crank blower.

A good material for use as the insulation, is made from 1/2 clay and 1/2 sand, with a couple handfuls of wood ashes added in. You can also use clay kitty litter as a substitute for the clay portion of the mix. But there are two different kinds, and sometimes it's not marked on the bag. Some of it works great and breaks down with water into a clay, like you would expect, but the other is treated with a sealer and it won't dissolve.

This forge will handle up to 15 inch (overall length) blades or barrels comfortably. It burns the natural charcoal evenly, due to the horizontal row of holes in the tuyere. It can also be used for small things, like arrowheads, by blocking some of the holes with clay.

How To Make Your Own Charcoal, For Survival Blacksmithing, Using A 55 Gallon Drum:

(This method of charcoal production is just a larger-scale version of making your own char cloth.)



If you have a 55 gallon drum, large ammo can, or other metal container, you can use it to make charcoal.

Using a cold chisel, prepare the drum by making five 2in holes in one end, and completely removing the other (Or you can use a drum with a removable top, if one is available). Knock-up the cut edge of the open end, to form a ledge (Note, the lid will have to placed back on this ledge and made airtight).

Position the drum, open end upwards, on rocks or bricks, to allow an air flow to the holes in the base. Put paper, kindling, and incompletely charred butts from the last burn in the bottom of the drum, and light. Once it is burning well, load dry wood at random (to allow air spaces) until the drum is completely full. Keep the pieces to a fairly even diameter, but put any larger ones to the bottom, where they will burn the longest.

When the fire is hot and will clearly not go out, restrict the air access around the base by using earth placed against it, but leaving one 4in gap. Also place the lid on top, leaving a (small) gap at one side for smoke to exit. Dense white smoke will issue during the charring process. When this visibly slows, bang the drum (with a hammer or club), to settle the wood down, creating more white smoke.

When the smoke turns from white (mainly water being driven off) to thin blue (charcoal starting to burn) stop the burn by firstly closing off all air access to the base using more earth, and secondly by placing the lid firmly on its ledge, and making it airtight by the addition of dirt, as required. The burn will take three or four hours.

(NOTE: NEVER open the drum to check on your charcoal, or you may cause a dangerous flash fire!)

After cooling for 24 hours, the drum can be tipped over and emptied out, for grading and packing.
You can also make charcoal in several drums at once, if you want to, and if you have extra drums.

Making charcoal in a 55 gallon drum, and view of completed charcoal.

How to Make Your Own Charcoal, For Survival Blacksmithing, Using The Earth Mound Method:

This is the traditional way to make charcoal, used when you don't have any metal containers.

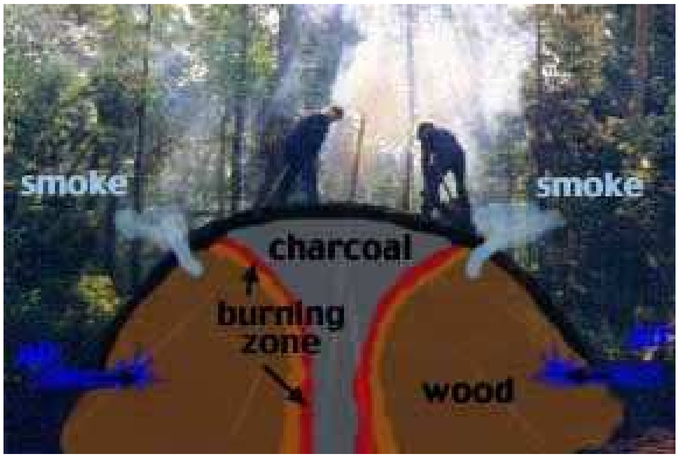


First set a center pole in the ground, then stack wood around it, until you have a dome-shaped pile.



Cover the wood with a layer of leaves, then a layer of dirt, then a layer of moss or sod, if available.


Leave a hole at the top to light the pile, using campfire coals, then wait for the fire to spread.

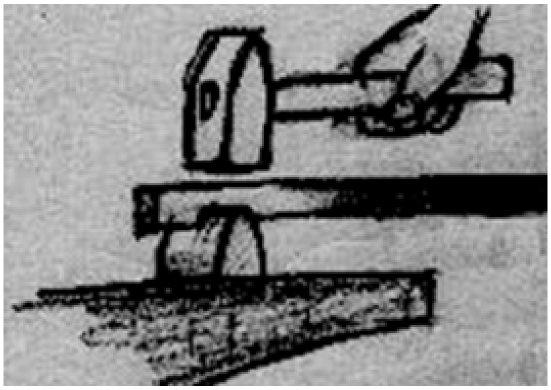


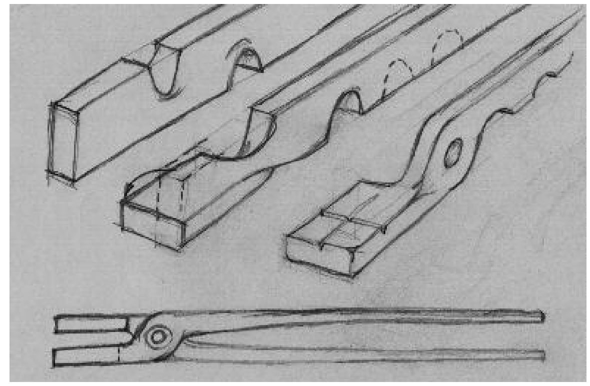
Once the pile is well-lit, cover the hole with dirt, then watch the pile burn (for up to 100 hours), sealing any holes that develop with more dirt. When the process is finished, rake the charcoal from the dirt, and it is done.

Smaller batches of charcoal can be made using smaller woodpiles. Charcoal can also be made by digging a trench, filling it with wood, partially covering the wood, setting it on fire, and then covering it with more dirt.

Charcoal can be made from any organic material, such as corn cobs, sugar cane, coconut husks, or bamboo. When making bamboo charcoal, never leave any intact nodes, or the bamboo sections will explode in the fire.

One Way To Make Your Own Blacksmith's Tongs:





Making tongs is a good project, as they are a tool you cannot do without for long, This method uses fullering, or hammering the hot metal against a curved surface, instead of against the flat of an anvil.

For general purpose tongs start with a piece of 3/8" x 1" flat bar, about two feet long or a little longer. For small light duty tongs start with 1/4" x 1" flat bar. Mild steel (or even wrought iron) is satisfactory for tongs. If you intend to make gooseneck or offset tongs, start further up the bar, leaving extra material to shape, after the tongs are assembled. You can always take material off, but it is harder to put back on.

Work one end first (the bar is long enough for both halves). Fuller two notches in the bar, as shown. The depth of the first notch should leave a bar thickness, or a little more. The handle end fullering should only go half way through. Now twist the "jaw" 90°. Remember BOTH side of the tongs are alike. There is no right and left side.

Fuller the "handle" end behind the joint. Your fuller depressions should be equally spaced, the width of the fullered depression. Then hammer out the high spots. These, being small, work easier than forging directly with the hammer. Don't worry about finishing the full length of the reins (handles) at this point.

When one joint looks pretty good, cool the bar and do the same thing on the other end. This way you don't need a set of tongs to make your first set of tongs! When the second joint is finished NOW finish the reins, which are now in the middle of the bar. Remember, the reins should taper from about half the joint height (bar width) to an octagon or round, equal to the bar thickness. On long tongs you may need to cut the bar in two before finishing the reins, but on small general purpose tongs there is no need.

You may punch or drill the rivet hole. Hot punching leaves a little more material in the joint but is hard to control if you are not a practiced smith. My rule of thumb is to use a rivet about the same diameter as the thickness of the bar you started with, or one size bigger. A useful trick is to put a layer of heavy brown paper (grocery bag) in the joint when you rivet the tongs. When this burns out it leaves some clearance in the joint. If the joint is too loose it is easy to tighten, but if it is too tight it is hard to loosen. The only way to loosen a joint that is too tight is to heat the rivet with a torch or heat the joint in the forge, and then work them back and forth.

When your tongs are finished they must be adjusted. Find a short sample of the material thickness you are going to work with. Heat the jaws and the joint up to the taper in the reins. Grip the sample in the tongs, and either clamp the jaws and the sample in a vise, or tap the jaws square to the sample on the anvil. I like using the vise, because then you can spread the reins to a comfortable distance. When adjusting on the anvil you must hold the reins apart, or put them into a little block of wood with two holes drilled at the right spacing.

Another Way To Make Your Own Blacksmith's Tongs:



Here is an easy way to make a pair of light-weight tongs. Start with 2 pieces of 1/4" x 3/4" x 20" long flat bar. Drill (or heat and punch) a 1/4" hole, 3 inches from one end, and in the center of the bar. To be sure both pieces match, clamp the bars together and make the hole in both bars at the same time (if you are drilling). Insert a piece of 1/4" round rod into the hole. Put a vise grip on the handle end to hold the two pieces together. Heat the tong end (the jaws) to orange in the forge.



Place the tong end in a vise. Put a crescent wrench just under the piece of 1/4" round rod and adjust the vise so there is about 1 inch of space between the bottom of the wrench and the top of the vise. Turn the wrench 90 degrees, or 1/4 turn. Turn BOTH pieces of bar stock at the same time. This is how it should look at this point.



Remove the rod. Heat the tong end in the forge and then shape it for what you want it to do. This set of tongs was being built to hold 1/4" round stock. The tongs can be taken apart and worked easily in the forge. When you want to see how you did, put them back together with the rod.

When you have the tongs shaped the way you want, heat the end of the 1/4" round rod and put it in the hole in the tongs. Clamp it in the vise and pein the end of the rod to form a rivet head. Once you have made a rivet head from the end of the rod, cut the other end of the rod off, leaving enough rod to make a rivet head on that side too.

Put the whole thing in the fire (while assembled) and get just the end of the rivet hot. You can make the rivet head with the rod cold, but a little bit of heat makes it work a lot better. Put it on the anvil and pein the end over to form a rivet head.

Be careful not to get it too tight. You can always make it tighter later, just pein it again, but you can't make it loosen up by hitting it with the hammer. Note: For the rivet, leave about 1-1/2 times the diameter of the rod to make the rivet head.

These tongs have just about the right space at the end of the handle. You can heat and bend the handles to adjust the space, to fit your hands.

The handles can also be forged down into round rods, if desired, or they can be given a 90 degree twist, like the jaws, so that you squeeze on the flat of the bars, not the edge. (This is much easier on your hands.)

These are not heavy tongs, and will not do heavy work, but you can use these light tongs to hold thicker iron bars, when you are ready to make some heavy tongs.

There are many good books on blacksmithing skills which are available for free download, on the internet. Check my list of 460 useful books, for suggestions, or search for blacksmithing at archive.com. But just in case you can't get at any other info, here is a condensed version of a book on blacksmithing:

Blacksmithing Equipment and Techniques:

Although blacksmithing under many conditions should occupy a minor place in a farm shop course, no such course can be considered complete without at least some instruction in this work. Blacksmithing is generally more difficult than woodwork. Almost any high school boy with average mechanical ability, however, can soon learn to do simple blacksmithing and feel well repaid for his efforts, if he will set himself diligently to the task. In all mechanical work, much more rapid and satisfactory progress can be made if the student will carefully study the theory and principles along with his practice. This is particularly true of blacksmithing.

The Forge.-The forge for the farm shop should have a gear driven blower operated by a crank, and it should have a hearth at least 18 in. wide, preferably somewhat larger. Probably the cheapest way of providing a good forge is to buy a good blower and tuyere (that part in the bottom of the hearth through which the blast comes) and make a hearth and stand of concrete, brick, or other masonry. The forge should be provided with a hood and pipe connection for taking away the smoke.

The Anvil.-Anvils are of two general grades: cast iron and steel. Steel anvils are much better and should be used if they can be afforded, The two kinds can be distinguished by striking with a hammer. A cast anvil has a dead sound while a steel one has a clear ring.
Anvils are commonly available in sizes ranging from 50 to 200 lb. An anvil weighing 100 or 125 lb. would be quite satisfactory for the average farm shop. A piece of railroad iron 20 to 30 in. long, mounted on a suitable block or stand, will serve fairly well for light hammering and riveting, although a much greater variety of work can be done on a regular anvil.

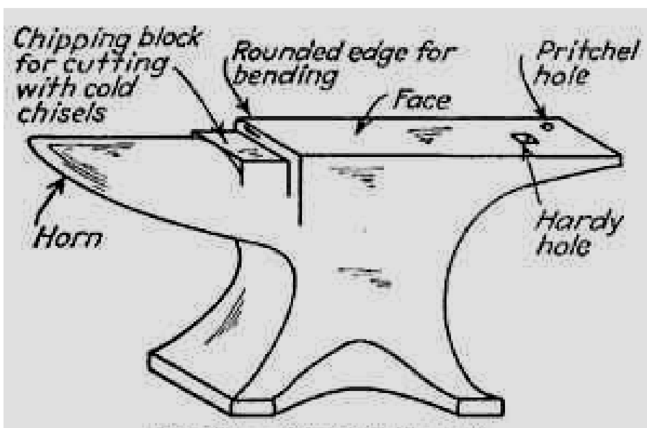


Fig. 243.—Parts of the anvil.

Use of Different Parts of Anvil.-- The horn of the anvil is used for making bends and shaping curved pieces; and the flat face is used for general hammering. The flat depressed surface near the horn is the chipping block, and here all cutting with cold chisels and similar tools should be done, rather than on the face of the anvil. The chipping block is soft and will not damage the chisel if it cuts through. The face is hardened and cutting into it with a chisel would damage both the chisel and the face, which should be kept smooth for good blacksmithing.

The better anvils have a comer of the face next to the horn slightly rounded, so that sharp bends may be made in rods and bars without unduly marring or galling the iron. The round hole in the face of the anvil is used for punching holes. It is called the **pritchel hole**, taking its name from the sharp punch used by smiths in punching nail holes in horseshoes. The square hole in the face is called the **hardy hole** and is used for holding the hardy and other tools, such as swages and fullers.

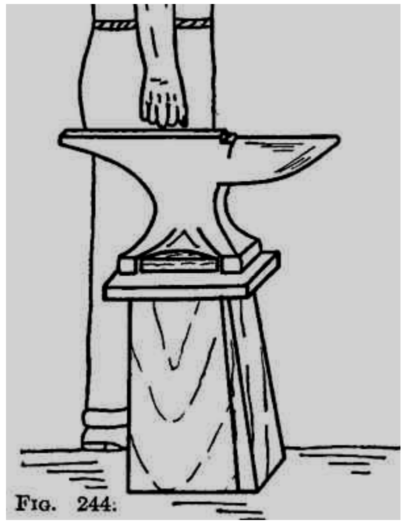


Fig. 244.--The anvil should be mounted on a solid block and at such a height that the face of the anvil can just be reached with the knuckles of the clenched fist when standing erect.

Mounting the Anvil. -- The anvil should be mounted on a solid block, preferably of wood. It should be so located in front of the forge that the workman can take the irons from the fire and place them on the anvil by making a short turn and without the necessity of taking even a full step. The horn should be to the workman's left (unless he is left-handed, in which case it should be to his right). The face of the anvil should be at such a height that it can be touched with the knuckles of the clenched fist when standing erect and swinging the arm straight down.

Tongs.-At least one or two pairs of tongs will be needed. Various types are available, but the hollow-bit, curved-lip bolt tongs are probably the most useful. Flat bars as well as round rods and bolts can be held in them, and the curved part back of the tip makes it possible to reshape them easily to fit different sizes of stock. By grinding, filing, or sawing a groove crosswise in each of the lips, the tongs can be made to hold links practically as well as regular link tongs (see Fig. 245). Tongs 18 to 20 in. long are a good size for average work.

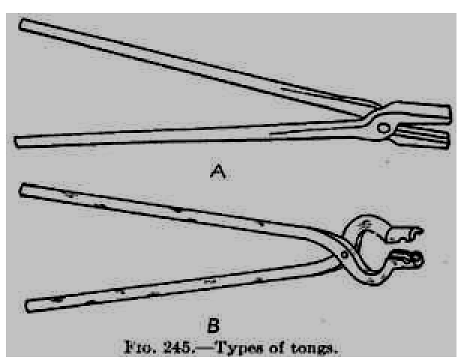


Fig. 245.-Types of tongs. (A). Flat-jawed hollow-bit tongs. (B). Hollow-bit curved-lip tongs. This style is very good for the farm shop. Flat bars as well as round rods and bolts can be held in them.

Hammers.-A blacksmith's hand hammer weighing 1 1/2 or 2 lb. and another weighing 3 or 3 1/2 lb. will handle all ordinary work very satisfactorily.

Hardy, Chisels, Punches.-There should be a hardy to fit the hole in the anvil, and there should be a fair assortment of hand cold chisels and punches. The chisels and punches may be made in the shop. If considerable blacksmithing is to be done, it would be well to have a hot cutter and a cold cutter (simply large chisels with handles on them) for heavy cutting with a sledge hammer. It would be well, also to have one or two large punches with handles on them for punching holes in hot metal. Punches for making holes 3/8 in. and 1/2 in. in diameter are probably most useful.

Vise.-One vise can well serve for all metal work in the farm shop, including blacksmithing if it is heavy and strong enough. A heavy blacksmith's steel-leg vise with jaws 4 to 5 in. wide is generally preferred as an all-purpose vise in the farm shop. A leg vise is one that has one leg extending down to be anchored or fastened into the floor. Such a vise can be used for heavy hammering and bending better than other types. If there is a strong steel machinist's box vise in the shop, it can be used for blacksmithing work if care is used not to do too heavy hammering or bending with it.

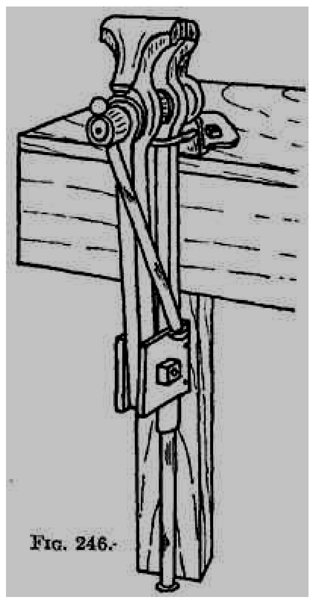


Fig. 246.-A heavy blacksmith's steel-leg vise is a good type of vise for the farm shop.

Fire Tools.-A small shovel and poker or rake will be needed for use on the forge fire. These can easily be made in the shop. A flat piece of heavy sheet iron about 3 or 4 in. wide by 4 or 5 in. long, riveted to a bar or rod for a handle, makes a good shovel. A 1/2-in. round rod,with an oblong eye in one end to serve as a handle and the other end flattened and curved, makes a good combination poker and rake.

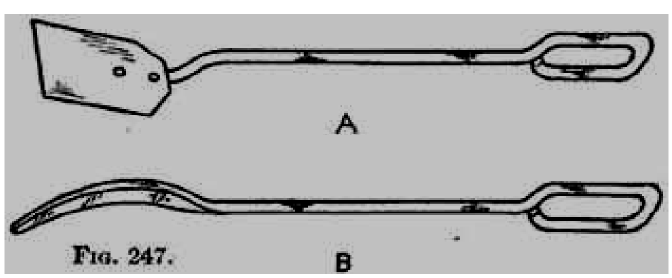


Fig. 247.-Homemade forge fire tools. A, shovel; B, poker.

Measuring Tools.-Some kind of metal rule will be needed for measuring and checking pieces being forged. A small steel square is very good for both measuring lengths and checking angles and bends. A wooden rule should not be used to measure hot iron. A caliper, or a caliper rule, for measuring diameter of rods and thickness of parts, although not a necessity, will be found very convenient.

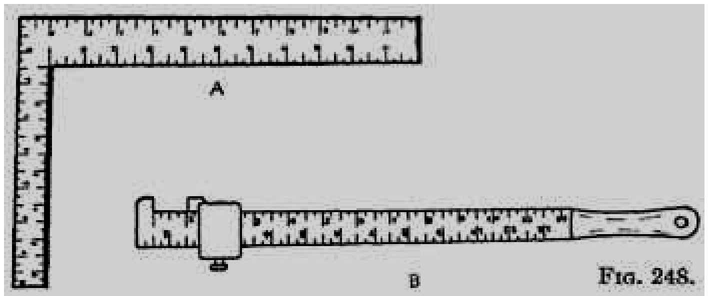


Fig. 248.-Metal measuring tools should be used in blacksmithing. (A). The small steel square is very useful for checking bends and angles as well as for measuring. (B). The caliper rule is especially good for measuring the diameter or thickness of bolts, rods, and bars; as well as for general measuring.

THE FORGE FIRE: A good fire is the first requirement for good blacksmithing. Many beginners do poor work simply because they do not recognize the importance of a good fire. A good forge fire has three characteristics. **It is clean**, that is, free from clinkers, cinders, etc. **It is deep**, with a big center of live burning coke. And **it is compact**, being well-banked with dampened coal.

Fuel for the Forge Fire.-Blacksmithing coal is used in the forge. It is a high-quality soft coal that is practically free from sulphur, phosphorus, and other objectionable impurities. When dampened and packed down around the fire, it readily cakes and changes to coke, which is a lightweight material that burns with a clean, intense flame. Ordinary stove or furnace coal will not work satisfactorily in a forge.

Building the Fire.-To start a fire, first clean the fire bowl with the hands, pushing all coal and coke back on the hearth and throwing out all clinkers. Clinkers are heavy and metallic and have sharp, hard corners or projections and are therefore easily distinguished from the coke, which is light in weight and easily crumbled. Fine cinders and ashes are easily shaken through the grate into the ashpit.
After cleaning the fire bowl, dump the ashpit below the tuyere and then try the blower and make sure a good strong blast comes through. Sometimes ashes work back into the blower pipe and obstruct the blast.

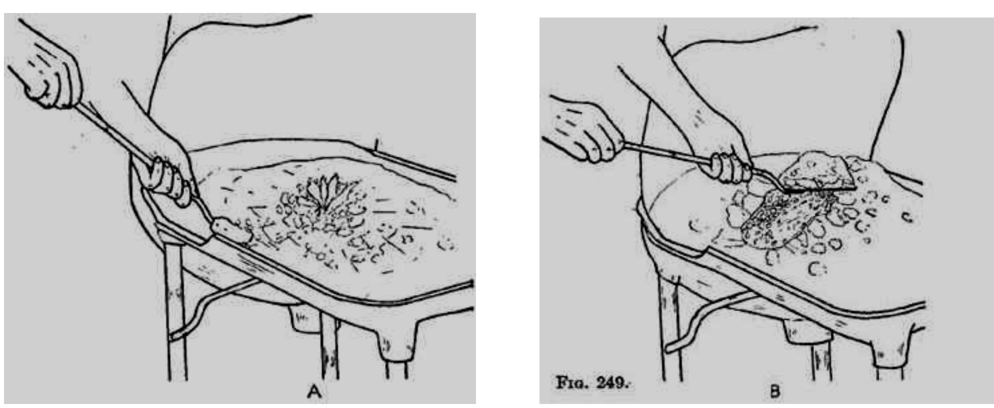


Fig. 249.-The forge fire should be cleaned by pushing the shovel along the bottom of the hearth to the center of the fire, as at A, and then lifting it straight up, as at B. The clinker and ashes, if any, will be exposed and can be easily removed.

Next light a small handful of shavings or kindling **from the bottom** and drop onto the tuyere. Give the blower a gentle turn and rake fuel, preferably coke left from the previous fire, onto the burning kindling. Once the fire is burning well, rake more coke onto it, and bank the fire on both sides and on the back with dampened coal. This forms a mound with burning coke at the center, and the heat is concentrated in the center by the dampened coal on the outside. In a little while this dampened coal, sometimes called **green coal**, has gases driven off and it changes to coke.

Maintaining the Fire.-When the coke at the center of the fire burns up, additional coke from the hearth or the underside of the mound is forced into the center, and from time to time green coal is added to the outer parts of the mound to keep the fire well banked. Do Dot continually poke at the fire; simply keep the center well supplied with coke and the outside packed down with dampened coal.
If the fire tends to spread too much or becomes open and loose, throw or sprinkle water on the edges and pack it down with the shovel. Only a gentle blast of air should be used. Excessive air makes an oxidizing fire and causes the iron to scale badly.

Cleaning the Fire.-From time to time-usually every half hour when welding-the clinkers and cinders that accumulate over the tuyere should be removed. This can be done by passing the shovel along the bottom of the hearth to the center of the fire and then raising it straight up through the fire. The clinkers can then be easily seen and removed. Most of them will stay on the shovel. The burning coke is then raked back into the center and the outside packed down, using green coal on the outer edges if needed.

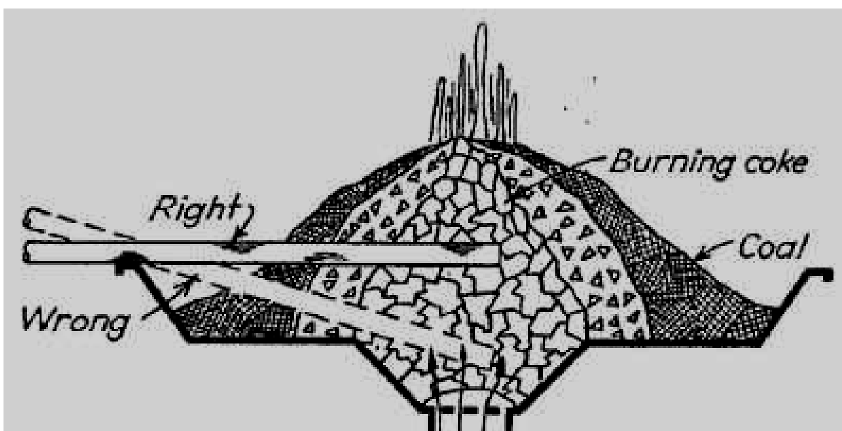


FIG. 250.-

Fig. 250.-In heating irons in the forge, they should be placed level-never pointed down. There should be burning coke below them, on top of them, and on all sides of them.

Heating the Irons.-To heat irons in a forge, they should be placed in the fire in a **horizontal position**, not pointing down. There should be burning coke **below the irons, on both sides of them, and on top of them**. Irons heated in a deep, compact fire heat much more rapidly and oxidize or scale off less than when heated in a shallow, burned-out fire. Some scale will form in spite of a good fire, but it should be kept to a minimum. A good blacksmith keeps the scale brushed from the face of the anvil with his hands.

Small thin parts heat much more rapidly than heavier and thicker parts. To prevent burning the thinner parts, they may be pushed on through the fire to a cooler place, or the position of the irons otherwise changed to make all parts heat uniformly. Mild steel should be heated to a good, bright-red heat for forging. It should not be allowed to get white hot and sparkle, as it is then burning.

Fitting Tongs; Holding the Work.-If tongs cannot be found to fit the work, a pair should be reshaped by heating and hammering the jaws over the piece to be held. Poorly fitting tongs are a source of continual trouble and should not be used.

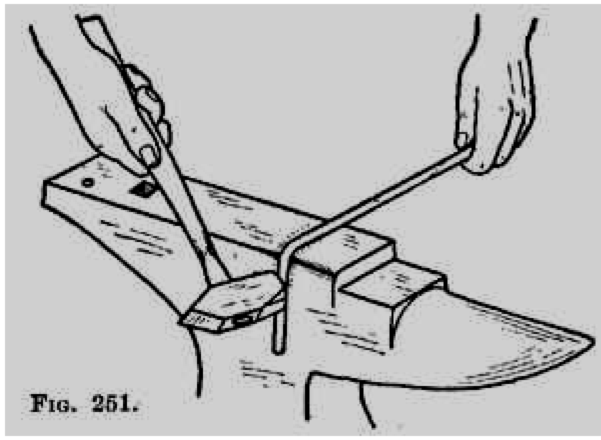


Fig. 251.-By careful planning, many blacksmithing jobs can be done almost, if not altogether, without the use of tongs.

Some Work Done without Tongs.-A considerable amount of work can be done without tongs. An eyebolt, for instance, can be made on the end of a rod 20 or 30 in. long and then cut off when finished.

FUNDAMENTAL FORGING OPERATIONS: Forging may be defined as changing the shape of a piece of metal by heating and hammering. All the various operations that a blacksmith performs in forging iron may be classified into a surprisingly small number of fundamental or basic processes. Once these are mastered, the beginner is well on his way to success, and he can do practically any ordinary piece of forge work. These fundamental operations are (1) bending and straightening; (2) drawing, or making a piece longer and thinner; (3) upsetting, the opposite of drawing, or making a piece shorter and thicker; (4) twisting; and (5) punching. Other operations commonly done by a blacksmith, but which are not strictly forging, are welding, tempering, drilling, threading, filing, etc.

Bending and Straightening.--In bending at the anvil, two things are most important:
1. Heat the iron to a good bright-red heat, almost but not quite white hot, throughout the section to be bent. 2. Use bending or leverage blows-not mashing blows.

The iron should be so placed on the anvil and so struck that it can bend down under the hammer blow without being forced against the anvil and mashed. If the iron is struck at a place where it is resting firmly on the anvil, it will be mashed instead of bent. A few moderately sharp blows are better than several lighter blows.

Abrupt square bends can be made over the face of the anvil near the chipping block where the corner of the anvil is rounded to prevent marring or galling the iron.

Care should be taken to keep the iron at the proper bending heat. If it gets below a red heat, it should be put back in the fire and heated again. To bend a piece at a certain point, without bending the adjacent section, the piece may be heated to a high red heat and then quickly cooled up to the point of bending by dipping in water. Bending is then done quickly by hammering, or other suitable methods.

Bending may be accomplished in several ways besides hammering over the anvil. The iron may be heated and then put in the pritchel or hardy hole and bent by pulling; or it may be clamped in a vise and bent.

Straightening can usually best be done on the face of the anvil. The stock should always be firmly held and then struck with the hammer at points where it does not touch the face. Sighting is the best way to test for straightness and to locate the high points that need striking.

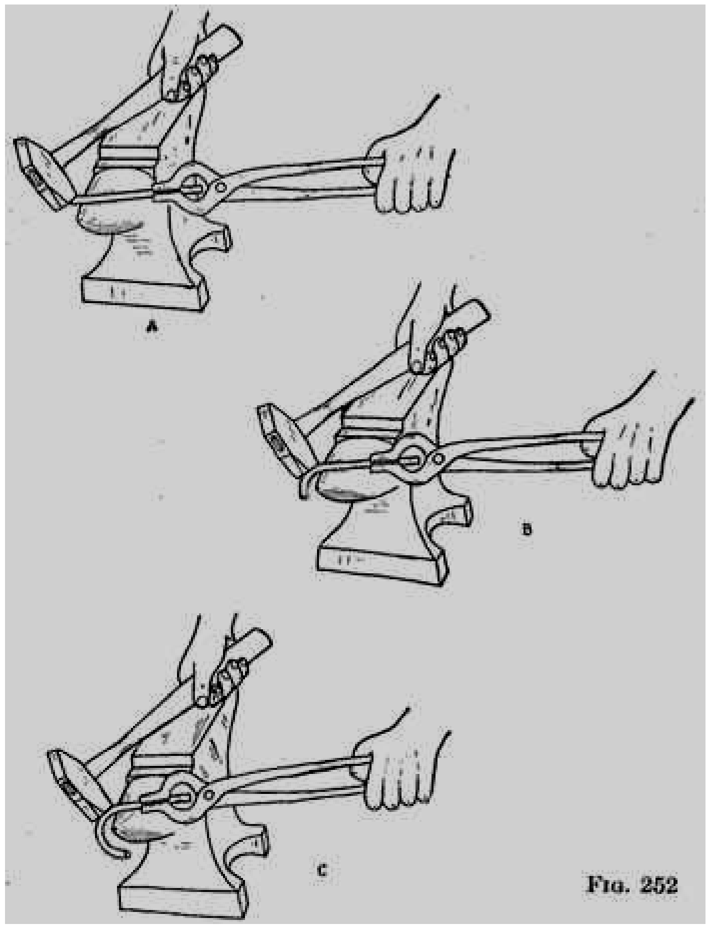


Fig. 252.-To make a uniform bend in the end of a rod, strike the Part that projects beyond the horn and keep feeding the rod forward with the tongs as the bending progresses. Keep the iron at a good working heat and do not strike the rod where it rests on the horn.

Bending Flat Bars Edgeways.-A flat bar can usually be easily bent edgeways by heating and placing over the horn and bending the two ends down slowly, using the hands if the piece is long enough, or two pairs of tongs in the case of short pieces (see Fig. 253). Sometimes the bending can be done easily by putting one end of the piece in the hardy hole and pulling on the other end (see Fig. 254). If the stock starts to buckle, it should be laid flat on the anvil and straightened. Hammering the outside edge of the iron when laid flat will tend to stretch it and therefore help with the beading. Once the bend is well started, hammering the piece on edge around the horn is not so difficult. The stock should always be firmly held, either by hands or with tongs, and the parts to be bent should be at a high red heat. Places not to be bent should be comparatively cold.

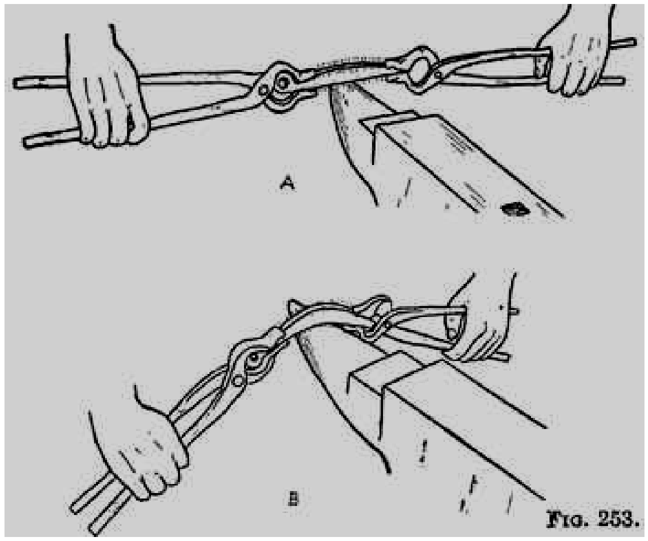


Fig. 253.-Flat iron may be bent edgewise by heating to nearly a white heat and bending slowly with tongs. This method is good in making flat chain hooks.

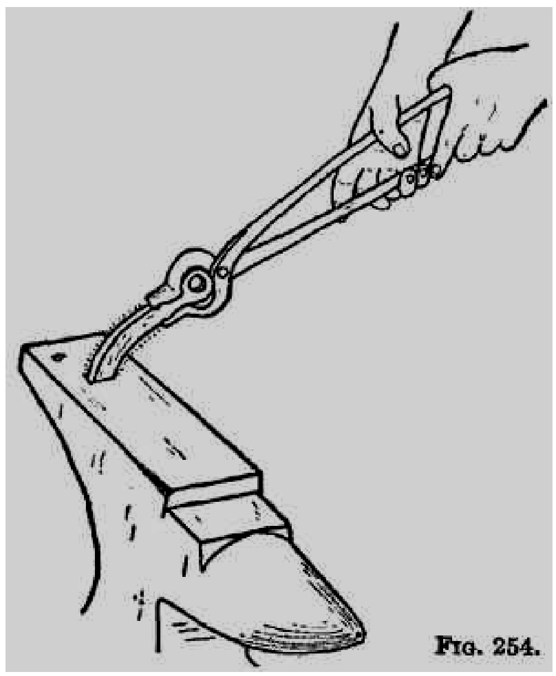


Fig. 254.-Bending of heavy pieces can sometimes be best accomplished in the hardy hole.

Bending and Forming an Eye.-One of the most common bending jobs in the blacksmith shop is that of forming an eye on the end of a rod. The following is a good method of making such an eye:

1. Heat the rod to a good red heat back for a distance of about 5 to 8 in., depending on the size of the eye.

2. Quickly place the rod across the face of the anvil with just enough of the heated end projecting beyond the edge of the anvil to form the eye. For exact work the length of hot iron that is to project over may be quickly measured with a metal rule. The iron should be placed across the anvil well up near the horn where the edge is rounded.

3. Bend the end down, forming a square bend, with a few well-directed blows. Work rapidly before the iron cools.

4. Heat the end of the stock and start bending the. tip end around the horn. Work from the tip back toward the stem. Keep the iron hot throughout the part being bent; otherwise the bending will be slow and difficult, and the iron will not bend at just the places desired. If the square bend at the juncture of the stem and eye tends to straighten out, it is an indication that the end of the stock is not being kept hot enough while being bent.

5. Round the eye by driving it back over the point of the horn, noting carefully where it does not rest against the horn and striking down lightly in these places. Keep the iron well heated.

6. Center the eye on the stem, if necessary, by placing the stem flat on the anvil face with the eye projecting over the edge, and striking the. eye. The stock should be well heated at the juncture of the stem and eye, but the eye itself should be practically cold. Such a condition can be produced by heating the whole eye and then quickly cooling most of the rounded part by dipping in water.

Drawing.-Drawing is the process of making a piece longer and thinner. Two important points should be kept in mind while drawing:

1. The iron must be kept at a good forging heat, a high red or nearly white.

2. **Heavy, straight-down, square** blows should be struck.
Many beginners make the mistake of striking a combination down-and-forward pushing blow, thinking that the pushing helps to stretch the metal.

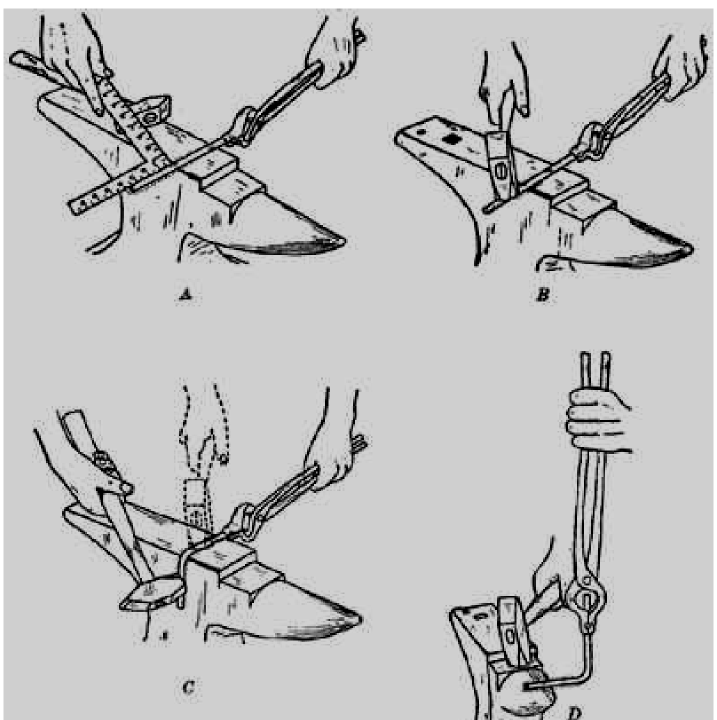


FIG. 255.—Steps in making an eye.

A. Place a well-heated iron across the anvil with. enough stock projecting over -to form the eye. Where the eye must be made accurately to size, use a metal rule or square for measuring. Work rapidly. I

B. Bend the projecting portion down, forming a right angle.

C. Finish the right angle bend by striking alternately on top and on the side, keeping the iron at a good working heat all the while.

D. Start bending the tip end around the horn, being careful to strike "overhanging" or bending blows.

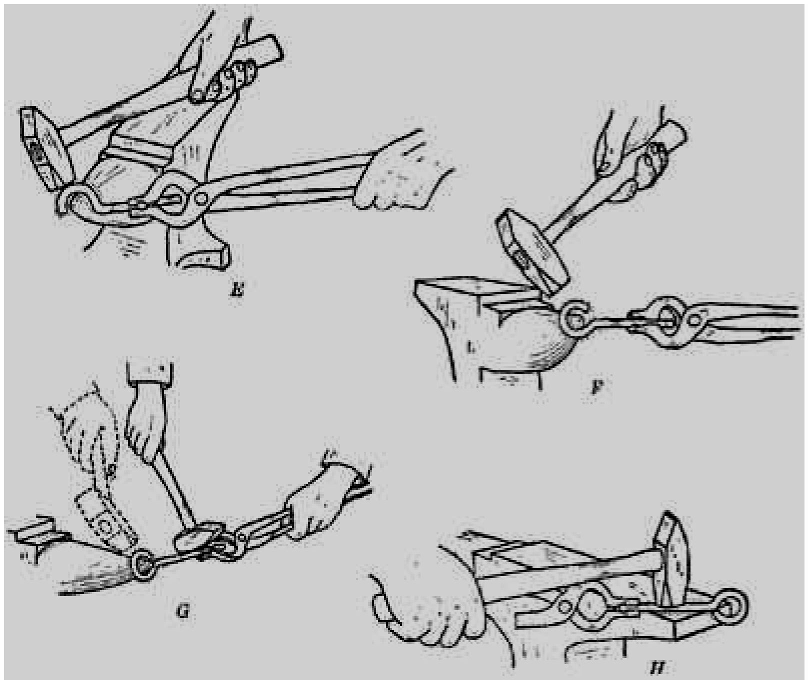


FIG. 255a. Steps in making an eye (*continued*).

E. Gradually work back from the end to the square bend.

F. Turn the eye over and close it up. Exert considerable back pull on the tongs to keep the upper part of the eye up off the horn. In this position the hammer can strike bending blows instead of flattening or mashing blows.

G. Round the eye by driving it back over the point of the horn. Carefully note where the eye does not touch the horn, and strike down lightly in these places.

H. To straighten the stem of an eye, place it across the corner of the anvil face and strike the high points while the iron is at a good working heat.

Drawing can be done more rapidly over the horn than on the face of the anvil, as the round horn wedges up into the metal and lengthens it, and there is less tendency for it to stretch in all directions. If a piece tends to get too wide it may be placed on edge and hammered.

Hammering after the red heat leaves is hard work and accomplishes little. Also, the iron is apt to split or crack if hammered too cold.

Drawing Round Rods.-To make a round rod smaller, the following steps should be carefully followed.

1. Make it four-sided, or square in cross section.

2. Draw it to approximately the desired size **while it is square**.

3. Make it **distinctly eight-sided** by hammering on the corners **after it is drawn sufficiently.**

4. Make it round again by rolling it **slowly** on the anvil and hammering **rapidly** with **light** blows or taps.

An attempt to draw round rods without first going to the square section not only requires a lot of extra work but usually results in a badly distorted and misshaped piece.

Pointing a Rod.-If a round point is desired on a rod, a square tapered point should first be made. It is then easy to make it eight-sided and finally round.

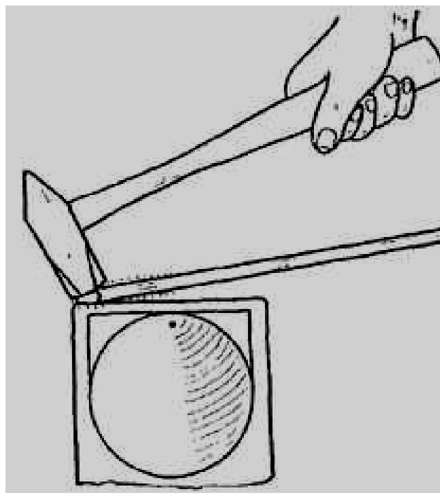


FIG. 256.

Fig. 256.--In pointing a rod d or bar, raise the back end, tilt the toe of the hammer down, and work on the far edge of the anvil. Round points should be made square first, then eight-sided, and finally round.

In making a point the rod should not be held flat on the anvil, but the back end should be raised somewhat. Also, the hammering should be done with the toe of the hammer lower than the heel, so that the desired angle for the point is formed between the hammer face and the anvil. The hammering should be done on the far edge of the anvil, so that the toe of the hammer will not leave marks in the anvil face.

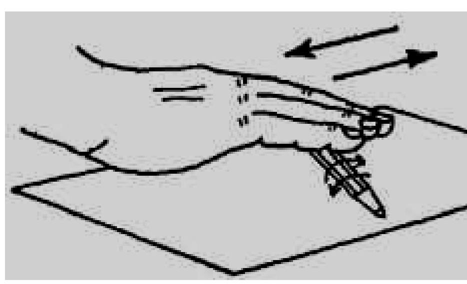


FIG. 257.

Fig. 257.-Rolling a punch or pointed round rod on a flat surface and watching the point will tell whether it is straight and the point is centered. If the point wobbles, it is off center.

Upsetting.-Upsetting is simply the reverse of drawing, or the process of making a piece shorter and thicker. It is done when more metal is needed to give extra strength, as when a hole is to be punched for an eye. There are two main points to be observed in upsetting:

1. Heat the bar or rod to a high red or nearly white heat throughout the section to be upset.

2. Strike **extremely heavy** well-directed blows.

Light blows simply flatten and burr the end instead of upsetting the piece throughout the heated section. The extra-heavy blows needed for upsetting can best be struck by first striking A light blow or two to get the direction of striking and then following with an extra-hard blow.

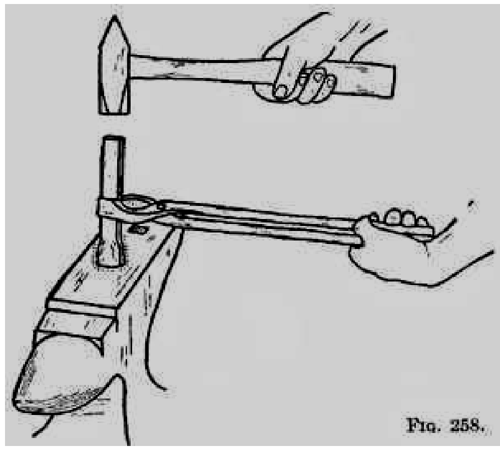


Fig. 258.-To insure success in upsetting, work the iron just under a white heat and strike tremendously heavy blows. Light blows simply flare the end without upsetting very far back from the end.

Probably the best way to upset a short piece is to place the hot end down on the anvil and strike the cold end. The hot end, of course, may be up, but it is usually easier to upset without bending if the hot end is down. If the bar starts to bend it should be straightened at once. Further hammering will simply bend it more instead of upsetting it.

In order to heat thoroughly the part to be upset, and yet confine the heat to this part, it is sometimes better to heat the work somewhat further than the upsetting is to go and then cool it quickly back to the line of upsetting by dipping in the water.

The end of a long bar may be upset by laying it on the anvil face with the hot end projecting beyond the edge, and striking heavy blows endways with the hammer. If the bar is long and heavy enough, it may be upset easily by ramming the hot end against the face or the side of the anvil.

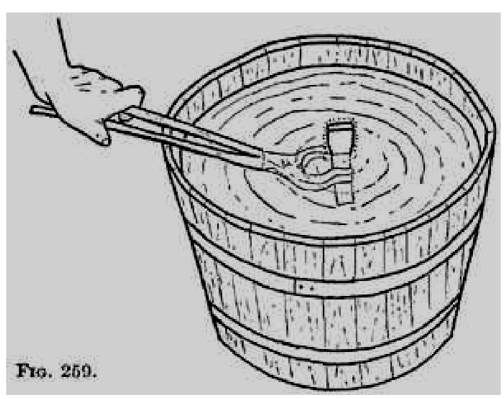


Fig. 259.-When it is desired to heat only a small portion of an iron, as in upsetting only the end of a piece, it is sometimes necessary to heat a larger portion, and then cool back to the desired point by dipping in water.

Twisting.-Twisting is really a form of bending. Small pieces may be twisted by heating the section to be twisted to a uniform red heat, clamping a pair of tongs at each end of the section and applying a turning or twisting force. If the piece is too large to be twisted this way (say more than about 1/4 in. thick by 1 in. wide), it may be clamped in a vise and twisted with a pair of tongs or a monkey wrench, the jaws of the vise and the wrench being carefully placed at the ends of the section to be twisted. It is important that the work be done rapidly before the iron cools too much. For a uniform twist, the iron must be at a uniform temperature.

If the twist must be confined to a very definite section of the stock, it is a good plan to place center-punch marks at the ends of the section before the iron is heated.

Care must be exercised in twisting so as not to get the piece out of ,alignment. If it becomes necessary to straighten the bar after twisting, it may be done by striking with a wooden mallet, rather than a hammer, in order to prevent marring the sharp corners of the twisted part.

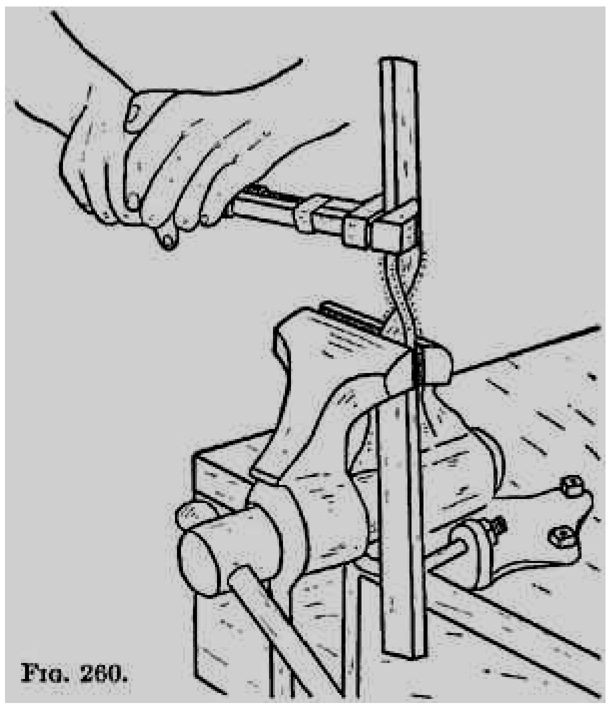


Fig. 260.-Heavy bars may be twisted by heating to a good working heat, clamping in a vise, and twisting with a wrench or pair of tongs.

Punching Holes.-It is sometimes easier to punch a hole in a piece of iron than to drill it; and for some purposes a punched hole is better. For instance, in forming an eye on the end of a bar in making a hook or a clevis, punching makes a stronger eye. A small or medium.size hole is first punched and then expanded by driving the tapered punch on further through the hole, first from one side and then the other. Thus less material is wasted than if the hole were drilled, and a stronger eye results.

The steps in punching a hole in hot iron are as follows:

1. Heat the iron to a good working temperature, a high red or nearly white heat.

2. Place the hot iron quickly on the flat face of the anvil-not over the pritchel hole or hardy hole. Punching over a hole would stretch and bulge the iron.

3. Carefully place the punch where the hole is to be and drive it straight down into the, metal with heavy blows until it is about two-thirds of the way through.

4. Turn the iron over and drive the punch back through from the other side. Reheat the iron and cool the punch if needed. The punch should be carefully located so as to line up with the hole punched on the other side.

5. Just as the punch is about to go through, move the piece over the pritchel hole or hardy hole to allow the small pellet or slug to be punched out.

6. Enlarge the hole to the desired size by driving the punch through the hole first from one side and then the other. Always keep the metal at a good working temperature, reheating as may be necessary.

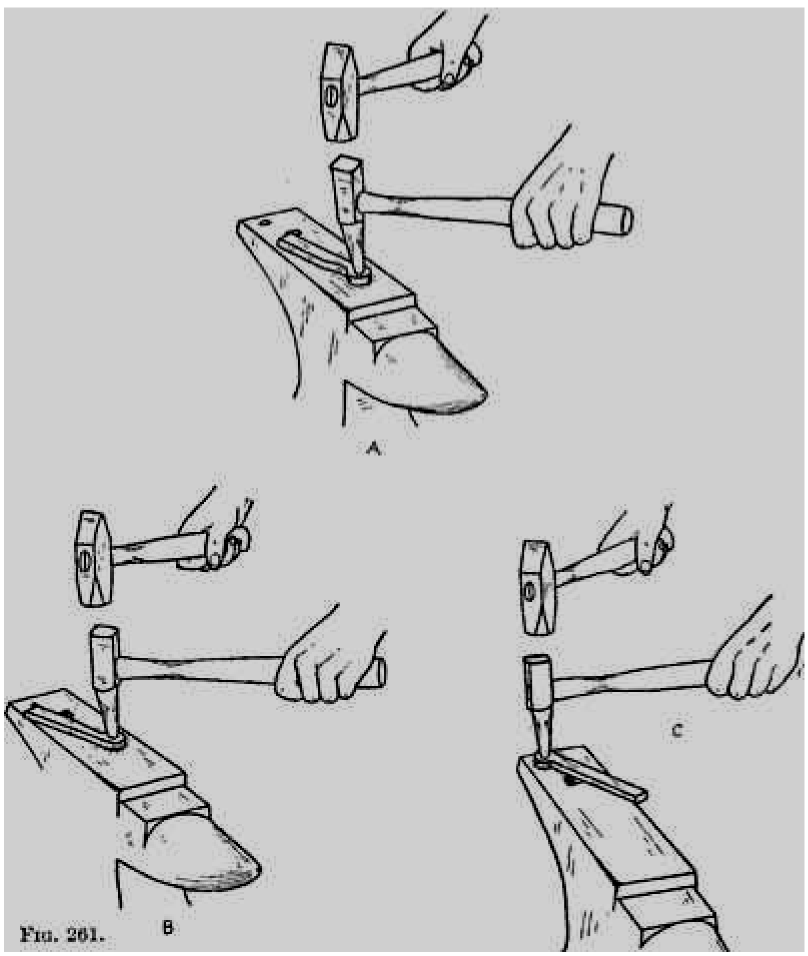


Fig. 261-In punching holes in hot iron, work it just under a white heat.

A. Carefully locate the punch and drive it about two-thirds of the way through.

B. Then turn the iron over and drive it back through from the other side.

C. Finally move the piece over the pritchel hole or hardy hole to allow the slug or pellet to be driven through.

The end of the punch should be dipped in water frequently to keep it from getting too hot. A little powdered dry coal dropped into the hole will help to keep the punch from sticking.

Fig. 262.-In punching hot iron, the punch should be cooled frequently by dipping into water.
Most beginners have difficulty in placing the punch so as to get the hole centered in a bar. If, in placing the punch, it is found to be off center, it may be leaned and twisted slightly until it is in the correct position. In punching hot iron, it is much better to use a punch with a handle in it, as it is uncomfortable to hold a short punch on a red-hot bar.

Forming Punched Eyes.-Usually, although not always, when a hole is to be punched for an eye, as in a chain hook or a clevis, it is best to upset the stock first so as to give more metal and make a stronger eye.

After upsetting, the end is shaped and the corners are rounded before punching. This can best be done by forming a neck or shoulder just -back of the eye by hammering over the far edge of the anvil, as shown in Fig. 263A. The end is then further shaped and the corners rounded by working over the anvil as suggested in the various other views of Fig. 263. Having the end thus shaped, the hole may be punched in the usual fashion.

In a clevis, the holes are punched with straight sides to fit the clevis pin. For holes in chain hooks, however, it is desirable to have the edges and corners rounded. This can be done by placing the eye at an angle on the end of the horn and making the stock approximately eight-sided and then finally round by rolling slowly while striking light, rapid blows (see Fig. 264).

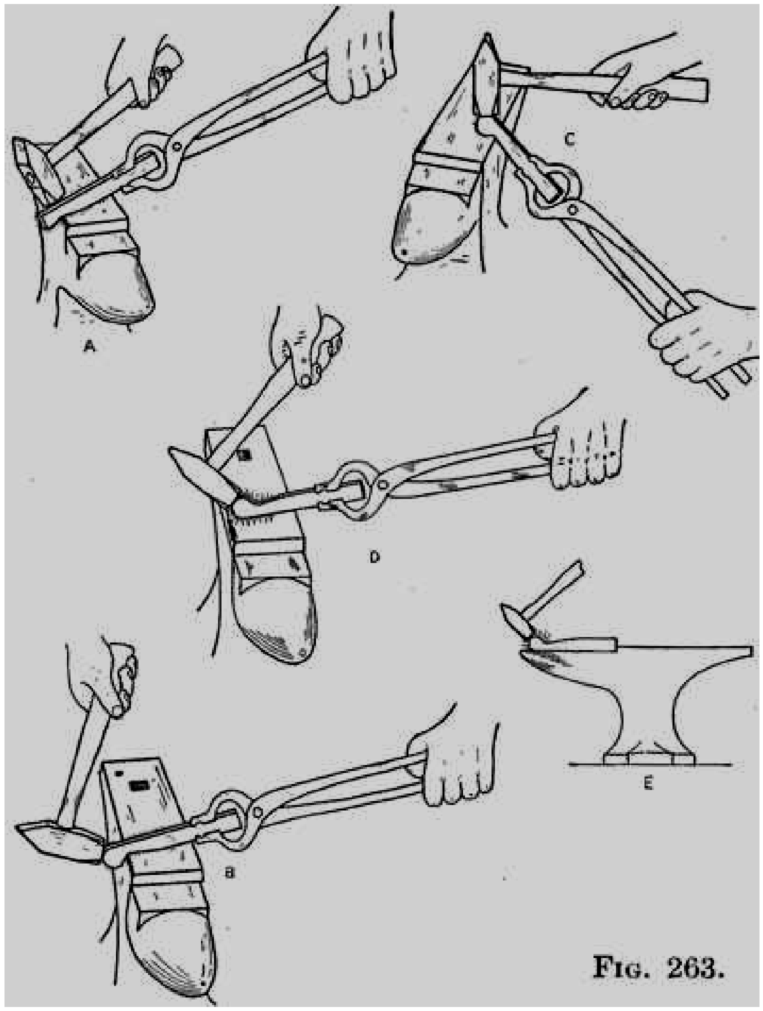


Fig. 263.-Forming a shoulder or neck, preparatory to punching a hole for an eye. The iron is first driven down against a corner of the anvil, as shown at (A). The end of the piece is then shaped and rounded by working over the corners and the horn of the anvil, as suggested in the various other views.

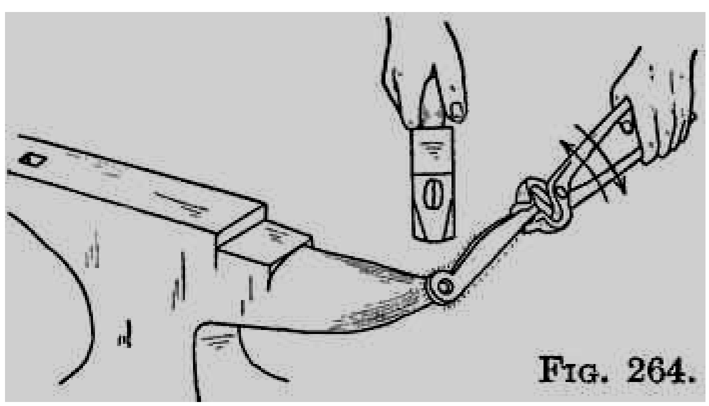


Fig. 264.-Smoothing both the inside and the outside edges of a punched eye. The eye is placed on the horn at an angle and the stock made approximately eight-sided. It is then rounded by rolling it slowly on the horn and striking fast light blows.

Cutting with the Hardy.- The blacksmith does most of his cutting of iron and steel on the hardy rather than with a hack saw. Although the hardy does not leave quite so smooth a cut as a saw, it is quite satisfactory for most work. It cuts faster and easier than a saw and is less expensive to use, as there are no blades to wear out or break.

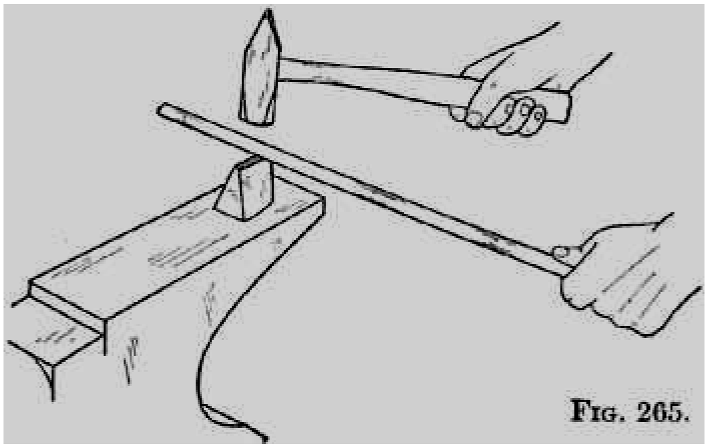


Fig. 265.

Fig. 265.-Iron may be cut either er hot or cold on the hardy. Cold iron may be nicked deeply on two or three sides and broken by bending. In cutting hot iron, cut all the way through from one side, being careful to strike overhanging blows at the last to prevent the hammer from striking the cutting edge.

To use a hardy, the rod or bar to be cut is simply placed on it and hammered down against the sharp edge. Hardies may be used for either hot or cold cutting. Some smiths prefer to keep two hardies, one that is thick and stocky and tempered for cutting cold iron and one that is thin for, cutting hot iron. The hardy, like any other Cutting tool, works much better if kept sharp. It may be ground like a cold chisel.

In cutting cold iron, the bar may be deeply nicked on two or more sides and then broken off by bending.

In cutting hot iron, it is common practice to cut clear through from one side. Care must be taken, of course, not to let the hammer strike the cutting edge of the hardy, or else both the hammer and the hardy may be damaged. In finishing a cut, the last two or three blows should be struck just beyond the cutting edge and not directly over it.

Cutting Tool Steel.-No attempt should be made to cut tool steel in the hardened state. It should always be annealed or softened. To cut it on the hardy, it should be cut hot-not cold-and handled just like other iron or steel.

Where it is important to have a smooth cut, a bar of tool steel may be sawed about a quarter of the way through and then broken by clamping in a vise at the sawing line and hammering.

Estimating Amount of Stock Required.-To estimate the amount of stock required for bends and curves, estimate the length of the center line. For example, suppose it is desired to know how much will be needed for making a ring of 1/2-inch round stock and of 3 in. inside diameter. The length needed will be the length of the mid-line, halfway between the inside and the outside edges. Its length is equal to the mid-diameter, 3 1/2 in. times 3.1416, or 11 in.

To determine the length required for pieces of irregular shape, small wire can be bent into the desired shape and then straightened out and measured.

Striking with the Hammer.-Success in blacksmithing depends largely upon ability to strike effectively with the hammer. Most blacksmithing requires heavy, well-directed blows. Where light blows are better, however, they should be used.

Light blows are struck mostly with motion from the wrist; while heavier blows require both wrist and elbow action; and very heavy blows require action from the shoulder in addition to wrist and elbow motion.

To direct hammer blows accurately, strike one or two. light taps first, to get the proper direction and feel of the hammer, and then follow with quick, sharp blows of appropriate force or strength. It is also important to use a hammer of appropriate size. A heavy hammer on light work is awkward, and blows cannot be accurately placed. And using a light hammer on heavy work is very slow and tedious.

Blacking.-After forging a piece of iron it is a good plan to black it by heating it slightly and rubbing with an oily rag. The iron should not be red, yet it should be hot enough to burn the oil off and prevent a greasy appearance. Blacking the piece gives a better appearance and provides some protection against rusting. Tempered tools, of course, should not be blacked in this manner, as heating will draw the temper.

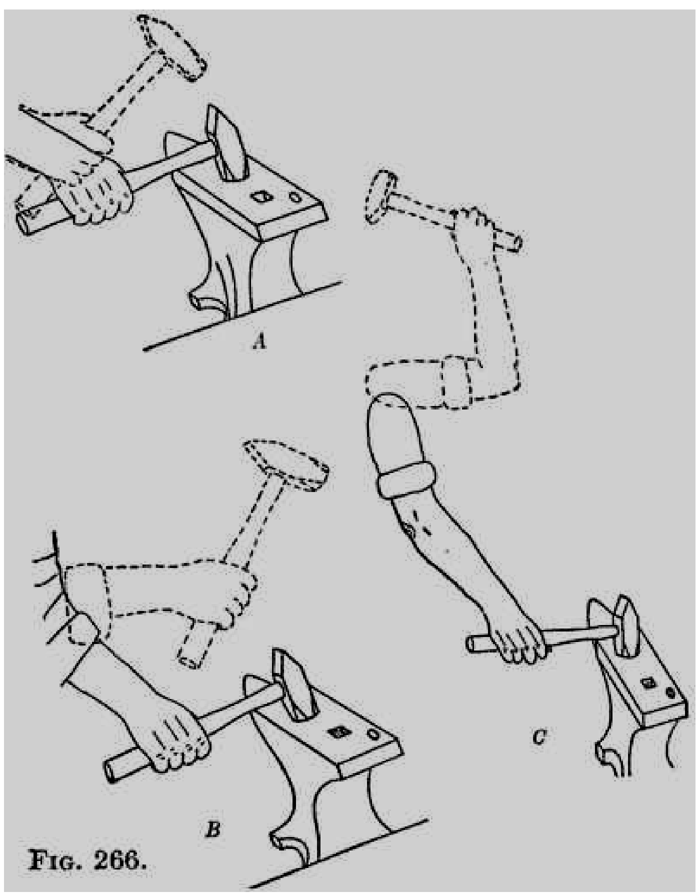


Fig. 266.-Striking with the hammer.

A. Light blows are struck largely with wrist motion.

B. Moderate blows require both elbow and wrist action.

C. Heavy blows require shoulder action as well as wrist and elbow motion.

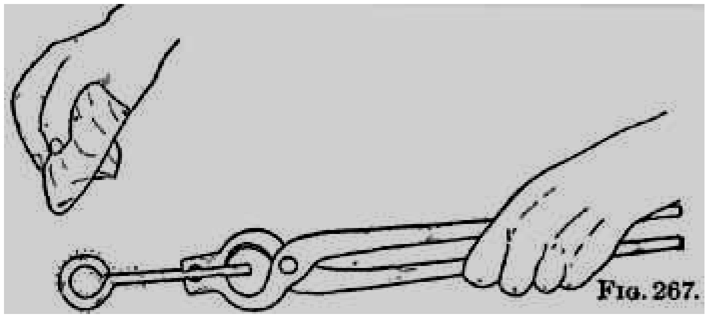


FIG. 267.

Fig. 267.-An iron may be blacked by heating it slightly and rubbing I ing it with an oily rag. The iron should be just hot enough to make the rag smoke. Blacking improves the appearance and affords some protection against
rusting.

Points on Blacksmithing

1. A clean, deep, compact fire is the first requirement for good blacksmithing.

2. Put the irons in the fire in a horizontal position-never point them down into the fire.

3. Use tongs that fit the work. If they do not fit, heat them and reshape the jaws over the piece to be held.

4. Always work the irons at a good forging heat-a bright red or nearly white heat for mild steel.

5. Never allow the irons to get hot enough to sparkle, except in welding, and even then very little.

6. In bending, use bending or leverage blows-not mashing blows.

7. In drawing, strike square, direct blows straight down-not forward-pushing, or glancing blows.

8. In drawing round rods, always make them square first and do the drawing while square. When drawn sufficiently, make them eightsided and finally round.

9. To smooth up a round rod, roll it **slowly** on the anvil while striking a series of light, quick blows.

10. In pointing rods, work on the far edge of the anvil. Raise the back end of the rod and strike with the toe of the hammer tilted down.

11. In upsetting use a high heat, and strike **extra-heavy** blows.

12. To make a good twist, have the section to be twisted at a uniform temperature.

13. To punch a hole in a hot iron, start in on the flat face of the anvil. Then turn it over and drive the punch back from the other side. Move the iron over a hole in the anvil face for finally driving out the pellet.

14. In cutting on the hardy, be careful not to let the hammer strike the cutting edge.

15. Use the chipping block for cutting with the cold chisel-not the flat face of the anvil.

16. To estimate the amount of stock required for curved pieces estimate the length of the mid-line.

17. Strike light hammer blows with wrist motion only; medium blows' with motion from both the wrist and the elbow; and heavy blows with motion from the shoulder, wrist, and elbow.

18. Blacking a forging gives it a better appearance and provides some protection against rust. To black, simply rub the piece with an oily rag when it is just hot enough to make the rag smoke.

FORGING AND TEMPERING TOOL STEEL: One of the main advantages of having a forge in the farm shop is to be able to redress and make and temper tools like cold chisels, punches, screw drivers, picks, wrecking bars, etc. Tool steel for making cold chisels and punches and similar tools may be bought from a blacksmith or ordered through a hardware store; or it may be secured from parts of old machines, such as hay rake teeth, pitchfork tines, axles and drive shafts from old automobiles.

Nature of Tool Steel.-Tool steel contains more carbon than mild steel, and it is granular, while mild steel is fibrous or stringy. The smaller the size of the grains or particles in tool steel, the tougher and stronger it is. When tool steel is heated above a certain temperature, called the critical temperature, the grain size increases. (The critical temperature is usually between 1300 and 1600 F., depending upon the carbon content, and for practical purposes is indicated by a dark-red color.) If the steel is heated only slightly above the critical temperature, the fine grain size may be restored by allowing it to cool slowly and then reheating it to just the critical temperature. If the steel is heated to a white heat, however, the grain size will be permanently enlarged and the steel damaged or possibly ruined. If tool steel is hammered with heavy blows while it is just above the critical temperature, the grain size will be made smaller, and the steel thereby refined and improved. It is evident, therefore, that a piece of steel may be improved or damaged or even ruined, depending upon how it is heated and forged.

Heating Tool Steel.-Tool steel should be heated slowly and evenly in a good, clean, deep, coke fire. Uneven heating, which is usually caused by heating in poor shallow fire or by too rapid heating, results in unequal expansion, which in turn may cause internal cracks and flaws.

Tool steel should not be heated above a bright-red or low-orange heat, and to this temperature only for heavy hammering. Heating higher is likely to ruin the grain structure. In case a piece of steel is accidentally heated a little too hot, the grain size may be restored by (1) allowing it to cool slowly and then reheating, being careful not to overheat it again, or (2) by heavy hammering at a bright-red or low-orange heat. The damage done by overheating will depend upon the temperature to which it was heated, how carefully it is subsequently heated and handled.

Forging Tool Steel.-Since the making of a satisfactory tool depends so largely upon the proper heating and handling of the steel, the following points should be kept in mind when forging with it.

1. Tool steel has a much narrower range of forging temperatures than mild steel. Hammering below a red heat may cause cracking or splitting, while temperatures above a bright red or dark orange may damage the grain structure.

2. Tool steel should always be uniformly heated throughout before it is hammered. Otherwise the outside parts, which are hotter, may stretch away from the inside parts, which are colder, and thus cause internal flaws.

3. Very light hammering should be avoided, even when the steel is well heated, because this may likewise draw the outer surface without affecting the inner parts.

4. As much of the forging as possible should be done by heavy hammering at a bright-red or dark-orange heat--slightly above the critical temperature-as this will make the grain size smaller and thus refine and improve the steel.

5. When a piece is being finished and smoothed by moderate blows, it should not be above a dark-red heat.

Annealing Tool Steel.-After a tool has been forged, it is best to anneal it, or soften it, before hardening and tempering. This is to relieve' any strains that may have been set up by alternate heating and cooling and by hammering. Annealing is done by heating the tool to a uniform dark-red heat and placing it somewhere out of drafts, as in dry ashes, or lime, and allowing it to cool very slowly. (Copper and brass may be softened by heating to a red heat and plunging quickly into water.)

Hardening and Tempering Tool Steel.-If tool steel is heated to a dark red, or the critical temperature, and then quenched (cooled quickly by dipping in water or other solution), it will be made very hard,the degree of hardness depending upon the carbon content of the steel and the rapidity of cooling. The higher the carbon content, the harder it will be; and the more rapid the cooling, the harder it will be.

A tool thus hardened is too hard and brittle and must be tempered, or softened somewhat. This is done by reheating the tool to a certain temperature (always below the hardening temperature) and quickly cooling it again. The amount of softening accomplished will depend upon the temperature to which the tool is reheated. For practical purposes the farm shop, these temperatures are judged by the color of the oxide or scale on the steel as it is being reheated. A straw color, for example, indicates that the tool has been reheated to a comparatively low temperature, and if quenched on a straw color, it will be rather hard. A blue color, on the other hand, indicates that the tool has been reheated considerably higher, and, if quenched on a blue, it will be softer.

Hardening and Tempering a Cold Chisel.-After a cold chisel is forged and annealed, it may be hardened and tempered as follows:

1. Heat the end to a dark red, back 2 or 3 in. from the cutting edge.

2. Cool about half of this heated part by dipping in clean water and moving it about quickly up and down and sideways, until the end is cold enough to hold in the hands.

3. Quickly polish one side of the cutting end by rubbing with emery cloth, a piece of an old grinding wheel, a piece of brick, or an old file.

4. Carefully watch the colors pass toward the cutting end. The first color to pass down will be yellow, followed in turn by straw, brown, purple, dark blue, and light blue.

5. When the dark blue reaches the cutting edge, dip the end quickly into water and move it about rapidly. If much heat is left in the shank above the cutting edge, cool this part slowly so as not to harden the shank and make it brittle. This is don by simply dipping only the cutting end and keeping it cool -while the heat in the shank above slowly dissipates into the air.

6. When all redness has left the shank drop the tool into the bucket or tub until it is entirely cool.

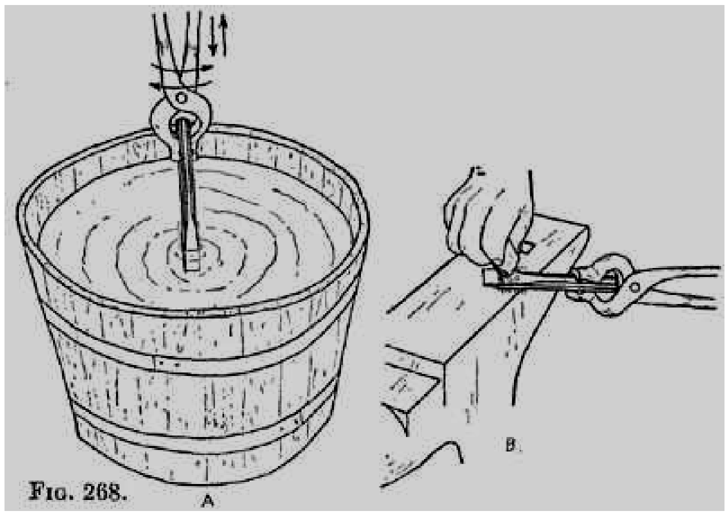


Fig. 268.-Tempering a cold chisel.

A. The end is heated to cherry red back about 3 in. from the cutting edge. Then about half the heated portion is cooled in clean water, moving the tool about rapidly, up and down and sideways, to prevent too sharp demarcation between the hot and cold parts.

B. The end is then quickly polished by vigorous rubbing with emery cloth or other abrasive to enable the colors to be seen as they pass down. When a dark blue appears at the cutting edge, the end of the tool-and only the end-is again dipped, working it up and down and around, and keeping it cold while any heat in the shank of the tool is slowly given up to the air.

When the tool is first dipped, it is important that it be moved up and down to prevent the formation of a sharp line between the hardened and unhardened parts, as such a line might cause the tool to break at this point sometime later when in use.

If the colors come down too rapidly, the tool may be dipped into the water and out again quickly to retard their movement. When they move down slowly it is easier to watch them and do a good job of tempering.

Dipping the end at the first of the hardening and tempering process makes it very hard. The heat left up in the shank of the tool, however, gradually moves down to the cutting end and softens it; and when it is softened to the desired degree of hardness, as indicated by the color, the tool is then quickly quenched to prevent any further softening. The various colors are simply indications of different temperatures.

If a tool is tried and found to be too soft, a as indicated by denting, it should be retempered and the final quenching made before the colors have gone out quite as far as they did originally-that is, before the end has been softened quite as much. In case a tool proves to be too hard and the edge chips or crumbles, it should be retempered and the colors allowed to go out a little further.

Tempering Punches, Screw Drivers, and Similar Tools.-Tools like punches, screw drivers, scratch awls, etc., may be tempered in the same manner as a cold chisel, but may be made harder or softer according to the requirements of the tool. A scratch awl should be made somewhat harder than a cold chisel, a rock drill somewhat harder, a center punch just a little harder, a punch for lining up holes somewhat softer, a screw driver somewhat softer, etc.

Different grades of tool steel will have different degrees of hardness when quenched at the same color. Therefore, it may be necessary to experiment a little with the first piece of a new lot of steel in order to secure the desired degree of hardness.

Tempering Knives.-Knives and tools with delicate parts are usually hardened and tempered in a manner slightly different from that used for cold chisels, in order to avoid the danger of overheating and warping and to insure uniform hardening and tempering of the cutting edges.

After a knife is forged, it should be annealed. It is then heated slowly and uniformly to a dark red, or the critical temperature. It is then quickly cooled by dipping edgeways in clean tepid water or oil, thick edge first. This method of dipping helps to insure uniform cooling and therefore uniform hardening and freedom from warping. It is then polished and reheated by drawing it back and forth through a flame, or by laying it against a large piece of red hot iron and turning it frequently to insure uniform heating. When the desired color, usually blue, appears, it is again quickly cooled.

Another method of heating knives and similar tools for hardening and tempering is to draw them slowly back and forth inside a pipe in the forge fire. The pipe should first be uniformly heated in a big fire and then turned frequently to keep it uniformly heated on all. sides. The knife should not be allowed to touch the pipe.

Points on Forge and Tempering Tool Steel

1. Use a good, clean, deep, coke fire for heating tool steel and heat it slowly and evenly.

2. Heating in a poor shallow fire, or heating too rapidly, is likely to cause uneven heating, which results in unequal expansion, which in turn may cause internal flaws or cracks.

3. Proper hammering of tool steel at the proper temperature refines it, making the grain size smaller.

4. Do riot hammer tool steel unless it is at least at a dark-red heat, and heated uniformly clear through.

5. Hammering below a red heat is likely to cause cracking and splitting.

6. Hammering when not heated clear through may cause the outer parts to stretch away from the inner parts and cause internal flaws or cracks.

7. Light hammering should be avoided even when the steel is well heated, because of danger of drawing the outer surface without affecting the inner parts.

8. Never heat tool steel above a bright-red or low-orange heat, and then only for heavy hammering.

9. For moderate hammering, as in finishing and smoothing a job, do not heat above a dark red.

10. Tool steel is ruined if it gets white hot.

11. In case tool steel is accidently overheated somewhat, allow it to cool slowly and then reheat, being careful not to overheat it again; or heat it to a bright-red or low-orange heat and forge by heavy hammering to restore the fine grain size.

12. After a tool is forged, it should be annealed by heating to a uniform low red and placing it in dry ashes or similar material to cool slowly.

13. In quenching a tool like a cold chisel, move it about rapidly-up and down and around-to prevent a sharp line of demarcation between the hot and cold parts.

14. Tempering colors should move slowly so they may be easily seen. If they move too fast, dip the tool quickly into water for an instant.

15. In the final quenching of a tool like a cold chisel, cool the end quickly but dissipate any, heat left in the shank very slowly. Otherwise the shank may be hard and brittle.

16. In case a tool is found to be too hard, retemper it and allow the temper colors to go out a little further before final quenching.

17. In case the tool is too soft, quench before the colors go so far.

WELDING

The Welding Fire.-A good fire is the first requirement for welding. It is important for any blacksmithing work, but for welding it is indispensable.

The fire must be clean, that is, free from clinkers, brass, babbitt, etc., as such impurities tend to make the irons slippery instead of sticky at the welding temperature. Lots of good coke is needed, as fresh coal not only makes a smoky fire but may also introduce some sulphur, which will make welding difficult, if not impossible.

The fire should be deep, with at least 4 in. of burning coke below the irons. There should also be burning coke on both sides and above the irons. Thus enough heat can be provided for thorough heating of the irons before the fire burns down.

The fire should be compact and well banked with dampened coal so as to confine. and concentrate the heat and to prevent too much air from going through the fire and causing the irons to oxidize or scale unduly.

The fire should be thoroughly cleaned about every half hour while welding.

Scarfing the Irons.-Ends to be welded together should first be properly shaped or scarfed. Scarfed ends should be short, usually not over 1 1/2 times the thickness of the stock; and they should have rounded or convex surfaces, so that when they come together any slag or impurities will be squeezed out rather than trapped in the weld. Long, thin, tapering scarfs are to be avoided because they are easily burnt in the fire and because they cool and lose their welding heat very rapidly when removed from the fire, thus making welding exceedingly difficult.

In order to counteract the wasting away of the irons by scaling and the tendency to draw out from hammering when they are welded, the ends are commonly upset before scarfing. Scarfs on the ends of bars are made by working on the far edge of the anvil, striking backing-up or semi-upsetting blows with the toe of the hammer lower than the heel. (See Art. 314, page 235, for instructions on the link scarf.)

Welding Flux.-Borax or clean sand, or a mixture of the two, may be used as a welding flux. Commercial welding flux, however, such as may be bought from hardware stores, is usually more satisfactory; and since but a little is needed, it is probably best to buy a small package for the farm shop.

Flux is applied to the pieces to be welded after they are at a red or white heat and just before the welding heat is to be taken. It covers the irons and causes the oxide to melt at a lower temperature. The oxide must be melted before the irons can be welded.

Flux is not needed in welding wrought iron, as it may be heated above the melting temperature of the oxide without danger of burning. Although it is possible to weld mild steel without flux, it is much easier to do a good job with it. Tool steel cannot be welded without flux.

Heating the Irons.-The irons should be heated slowly at first, so they will heat thoroughly and uniformly throughout. The irons should be turned over once or twice during the heating to insure equal heating of all sides and parts.

After the irons reach a bright-red heat, remove them and dip the scarfed ends into flux, or sprinkle the flux on them with the fingers. Replace the irons in the fire and continue to heat, being careful not to brush the flux off the irons before it melts. Pull a few lumps of coke on top of the irons and raise the coke occasionally with the poker to see how the heating is progressing.

Care must be taken to see that both irons reach the welding heat at the same time. If one heats faster, pull it back into the edge of the fire for a few seconds. During the last part of the heating, have the scarfed sides of the irons down so they will be fully as hot as the other parts of the pieces.

The Welding Heat.-When the irons reach the welding temperature, they will be a brilliant, dazzling white; their surfaces will appear molten, much like a melting snowball; and a few explosive sparks will be given off. When the sparks start to come from the fire a little more violently, it is time to remove them and weld them together.

Welding a Link or Ring.-To make a link or ring, the stock is first heated and bent into a horseshoe or U-shape. The ends are then scarfed by placing on the anvil, with one end diagonally across the shoulder between the anvil face and the chipping block, and with the other end against the vertical side of the anvil.

A series of three or four medium or light blows -are struck on the end on the shoulder, swinging the tongs a little between each blow. In this manner the end of the U is given a short, blunt, angling taper with a slightly roughened surface. The piece is then turned over and the other end scarfed in the same manner. The scarfs may be finished by striking lightly with the cross peen of the hammer.

Fig. 269.-Steps in making a link.

The legs of the U are next bent over the horn, lapped together, and hammered shut. It is important that the link or ring be somewhat egg-shaped at this stage-not round. The ends should cross each other at an angle of about 90 deg. This insures plenty of material at the joint for finishing the link and prevents a thin, weak section at the weld.

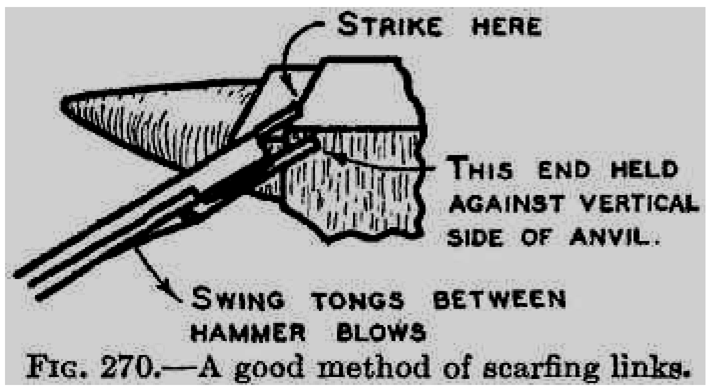


Fig. 270.-A good method of scarfing links.

The link is then placed in a good welding fire and heated, flux being applied after a red heat is reached. The link may need to be turned over in the fire a time or two in order to insure even heating.

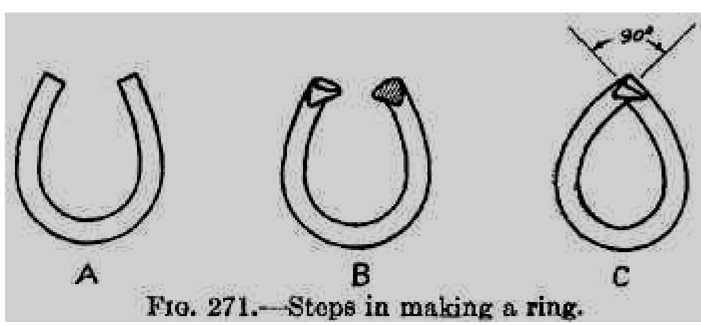


Fig. 271-Steps in making a ring.

A. Bend to horseshoe shape. B. Scarf same as chain link. C. Bend egg-shaped and weld.

When the welding heat is reached, the work is quickly removed from the fire, given a quick rap over the anvil to shake off any slag or impurities, and then put in place on the face of the anvil and the ends hammered together. The link is struck two or three quick, medium blows on one side, then turned over and struck on the other side.

Medium blows are used because the iron at welding heat is soft, and heavy blows would mash it out of shape. Forcing the parts firmly together is all that is required. It is essential to work fast before the iron loses the welding heat. A second or even a third welding heat may be taken if necessary to completely weld the ends down.

After the ends are welded together, the link is finished by rolling it slowly on the horn (by twisting or swinging the tongs back and forth) while hammering rapidly with light blows. In case of a large ring, the weld can best be finished by making the stock square, then eight-sided and finally round as in drawing round rods.

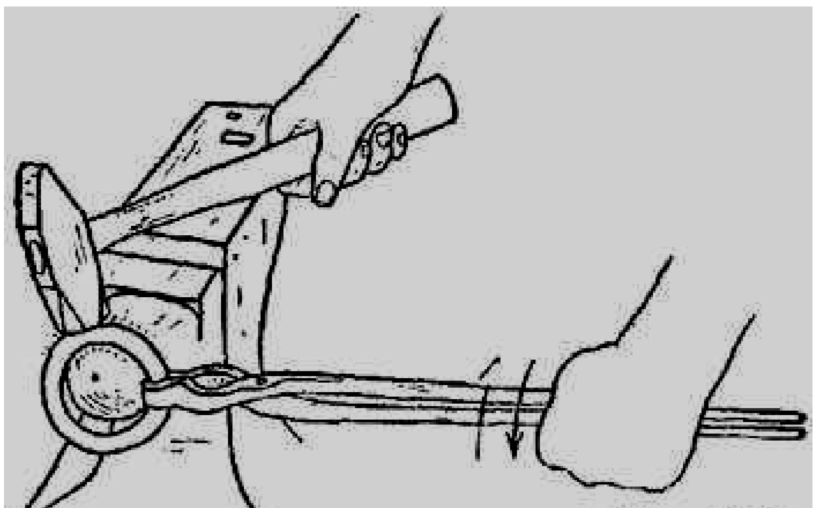


FIG. 272.

Fig. 272.-The weld on a link or ring should be finished by rolling it slowly on the horn while hammering with a series of rapid, light blows. Large rings may be finished by making the stock square, then eight-sided, and finally round.

Welding Rods or Bars.-To weld rods or bars, it is best to upset the ends somewhat before scarfing. The scarfs should be short and thick and with rounded convex surfaces (see Fig. 273). The irons are fluxed and brought up to the welding heat in the usual manner.

When they reach the welding heat, they are removed from the fire, struck quickly over the edge of the anvil to shake off any slag or impurities, put in place on the anvil and hammered together first on one side and then the other with light or medium blows, followed by heavier ones.

After the first blow or two to stick the irons, the ends of the scarfs should be welded down next because they are thin and lose their welding temperature rapidly.

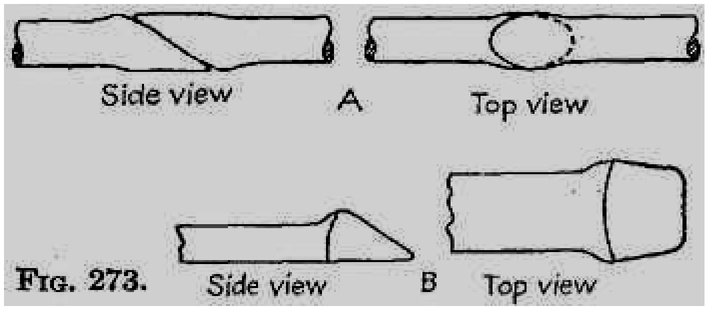


FIG. 273.

Fig. 273.-A. Round rods upset, scarfed, and in position for welding. B. Flat bar upset and scarfed for welding.

Getting Irons in Place on Anvil.-The irons are put in place on the anvil face with the scarfed surfaces together, and with the left-hand piece on top. The pieces can thus be held together with only one hand, leaving the right hand free to use the hammer. Steadying the pieces over the edges of the anvil will help get them accurately and quickly placed together (see Fig. 275).

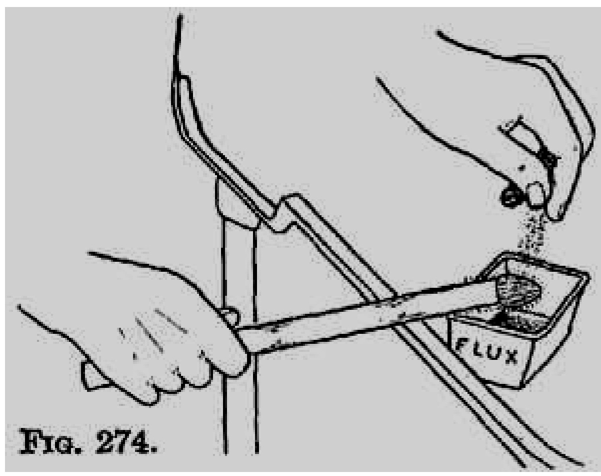


FIG. 274.

Fig. 274.-Apply welding flux with irons at a red heat, and just before the welding heat is taken.

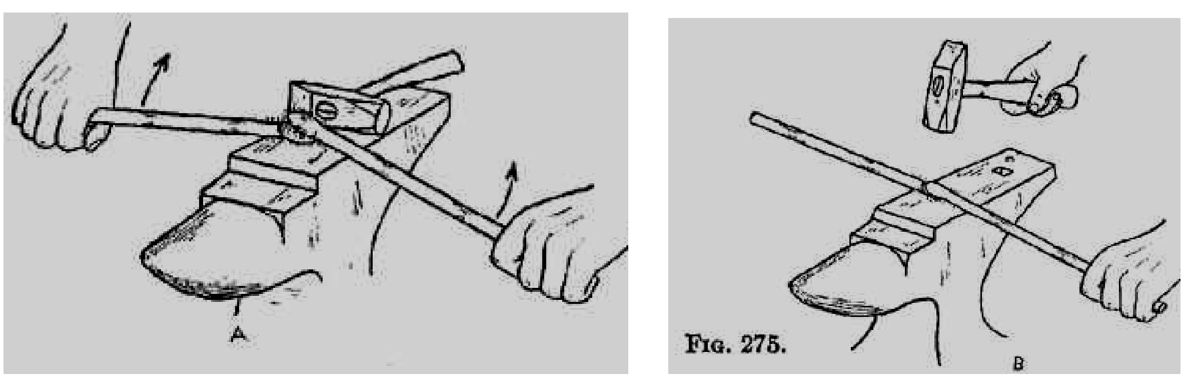


FIG. 275.

Fig. 275.-Placing irons together and welding. Steady the irons over the edges of the anvil, the one in the left hand being on top, as at A. Gradually raise the hands until the iron in the left hand holds the other one against the anvil, as at B, while the right hand strikes with the hammer.

It is a good plan for the beginner to practice bringing the irons out of the fire and placing them together a few times before taking the welding heat. Pieces that are long enough to be held in the hands without tongs are more easily handled than short pieces.

Finishing the Weld.-If it is not possible to get all parts welded down at the first heat, then flux is reapplied and another heat taken. Once the pieces are stuck well enough to hold together, however, they are much more easily handled. In welding small pieces, it is frequently necessary to take two extra heats, one on each side of the irons. In taking an extra heat to weld down a lap, the lap should be on the underside in the fire just before removing. This insures thorough heating.

After the weld is completed in a round rod, the welded section should then be smoothed and brought to size by first making the section square, as in drawing round rods, and keeping it square until drawn down to size. It is then finished by making it eight-sided, and finally round by rolling it slowly on the anvil while striking a series of light, rapid blows.

In Case of Failure.-If the irons do not stick at the first attempt, do not continue hammering but reshape the scarfs and try again, being sure that the fire is clean and that it is deep and compact. Irons will not stick if there is clinker in the fire, or if it has burnt low and hollow. Be sure, also, that the irons are brought well up to the welding temperature. It is generally not possible to make irons stick after two or three unsuccessful attempts because they will most likely be burnt somewhat, and burnt irons are difficult or impossible to weld. In such cases the ends should be cut off and rescarfed.

Welding an Eyebolt.-To make a welded eyebolt, a short, blunt, square-pointed scarf is made as shown in Fig. 276. The welding heat is taken in the usual manner, having the scarfed end down in the fire just before removing and hammering. By doing the hammering over the horn instead of the flat surface of the anvil, there will be less danger of marring and drawing the stem of the bolt next to the eye and thus making it weak at this point.

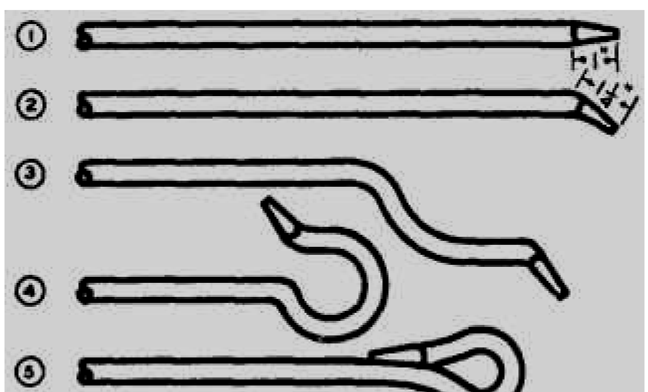


FIG. 276.

Fig. 276.-Steps in scarfing and preparing to weld an eye on the end of a rod.

Points on Welding

1. Use a clean, deep, compact coke fire.

2. Clean the fire every half hour.

3. Make the scarfs short and thick, rather than long and thin. Scarfs should not be longer than 1 1/2 times the thickness of the stock.

4. Round the surfaces of scarfs so slag will be squeezed out rather than trapped in the weld.

5. Heat the irons to a good welding heat, yet do not burn them.

6. Bring both irons up to the welding heat at the same time.

7. Have the scarfed sides of the irons down in the fire just before removing them,

8. Before welding the irons together, shake off any slag or impurities by quickly rapping the tongs against the edge of the anvil.

9. Steadying the pieces over the edges of the anvil will help get them accurately and quickly placed.

10. Strike light or medium blows when irons are at the welding heat. Simply forcing the parts together is all that is necessary. Heavy blows mash the irons.

11. Work fast; keep the hammer on the anvil within easy reach.

12. In case of failure to stick, do not continue hammering. Reflux and try again, being sure the fire is in good shape, and that you heat the irons hot enough.

PLOW SHARPENING

Drawing and Shaping Steel Shares.-Steel plowshares are sharpened by heating and drawing the edge.

The share should be placed in the fire so that only the portion to be drawn is heated. This is best done by placing the share flat with the edge over the center of the fire, and by banking up under the share with green coal. The share should not be placed in a vertical position with the edge down.

The share should be hammered on top, beginning at the point and working back toward the heel, beating and hammering only a small section at a time. The share should not be heated above a cherry red, and care should be exercised not to dent the top side of the share with hammer marks any more than necessary.

It is important in sharpening a share to get the point shaped so that it will have the proper suction. It should slope downward until the tip end is about 1/4 to 3/8 in. below the lower edge of the landside. The point should also be bent out toward the land slightly, usually about 1/8 to 1/4 in., to give the plow what is known as land suction. In case of a walking plow, the outer corner or wing of the share should have a small flat surface that bears on the ground and helps to support the outer side of the plow. Sulky or tractor plowshares require little or no such wing bearing.

Hardening the Share.-A soft-center steel share may be hardened by heating about 2 in. along the cutting edge to a dull red and then dipping it in water, cutting edge straight down. Some smiths heat the whole share to a dull red before dipping.

Solid crucible-steel shares should be hardened very little if at all. There is danger of breaking during hardening. Also, it is easy to get them too hard and brittle, which may result in breakage in use.

Sharpening Chilled Shares.-Chilled iron shares cannot be forged. They must be sharpened by grinding or chipping on the top side. Chilled iron shares are comparatively cheap and are commonly discarded after they are sharpened once or twice.

Sharpening Harrow Teeth.-Spike-tooth harrow teeth that have sharp points and sharp square edges are much more effective than teeth that have become blunt and rounded from long use. Harrow teeth are easily sharpened by forging at a cherry-red heat.

They will stay sharp longer if hardened by heating the points back from 1 to 3 in. to a dull red and dipping in water. There is some danger, however, of making them so hard and brittle that they may break in use.

KINDS OF IRON AND STEEL

There are many different kinds and grades of iron and steel used in implements and other farm equipment. To be better enabled to repair such equipment, a mechanic should know something about the different kinds of iron and steel and their properties and uses.

Pig Iron.-The first step in the manufacture of iron and steel is to extract the iron from the iron ore, which is mined in various parts of the world. This is done by means of the modern blast furnace. The molten iron accumulates at the bottom of the furnace and is drawn off into sand molds and allowed to cool and form short, thick bars known as pig iron. Pig iron is then used as the source from which other kinds of iron and steel are made.

Cast Iron.-To make castings, the pig iron is remelted, together with small amounts of scrap iron, and poured into molds of the desired shape and then allowed to solidify. Cast iron is used extensively because it is cheap and can be readily molded into complicated shapes. It is hard and brittle and cannot be bent. It cannot be forged or welded in the forge fire, but it can be welded with the oxyacetylene torch. It crumbles when it is heated to a bright red or white heat. It can be drilled and sawed easily and also filed easily after the hard outer shell is removed. The quality of cast iron can be controlled by varying the amounts of scrap iron and steel mixed with pig iron when it is melted.

Chilled Iron.-Chilled iron is cast iron that has been made in special molds, sometimes water-cooled molds, that cool the outer portions of the casting rapidly, thus making the surface of the casting very hard and wear resistant. Chilled iron is used for bearings on certain farm machines and for shares and moldboards of plows that are to be used in gravelly or stony soils.

Malleable Iron.-Malleable iron is cast iron of special composition that has been treated, after casting, by heating for a long period. This prolonged heating removes some of the carbon from the surface of the casting and reduces its brittleness. Malleable castings are softer and tougher than plain castings and can be bent a certain amount without breaking. They are also more shock resistant.

Wrought Iron.-Wrought iron is practically pure iron with only very small amounts of carbon or impurities. It is made by removing the carbon and impurities from pig iron. The best grade of wrought iron comes from Norway and Sweden where the purest iron ores are mined.

Wrought iron was formerly used extensively by blacksmiths, but, because of its high price, its use at present is quite limited. Wrought iron has about 0.04 per cent carbon.

Mild Steel.-Mild steel, also known variously as machine steel, low-carbon steel, soft steel, and blacksmith iron, is the common material used by blacksmiths. It is made by removing practically, but not quite, all the carbon from pig iron. To remove it all would be much more expensive. It contains from about 0.1 to 0.3 per cent carbon, not enough to enable it to be hardened to any appreciable extent by heating and quenching in water. It can be bent and hammered cold to some extent and can be forged and welded in the forge. It is a little more difficult to weld than wrought iron.

Tool Steel.-Tool steel is made from pig iron by first removing all the carbon and practically all the impurities and then adding a definite, known amount of carbon. Tool steel contains from about 0.5 to about 1.5 per cent carbon. It is granular in structure instead of fibrous or stringy. It must not be heated higher than a bright-red or low-orange heat, or it will become honeycombed and therefore weak and brittle. The higher the percentage of carbon the harder the steel may be tempered, an the more difficult it is to weld. Blacksmiths' tools, such as hammers and cold chisels, are commonly made of steel having from 0.5 to 0.9 per cent carbon. Taps and dies and such tools are made of steel having 1 to 1.25 per cent carbon. The carbon content of iron and steel is designated by points, one point being one-hundredth of 1 percent of carbon. Thus a 50-point carbon steel contains 50/100 or one-half of 1 per cent of carbon.

Distinguishing between Grades of Steel.-A good way to distinguish between the various grades of steel is to grind them on a grinding wheel and note the sparks that are given off. Sparks from wrought iron are light yellow or red and follow straight lines. Sparks from mild steel are similar but more explosive or sprangled. Tool steel gives off sparks that are lighter in color and still more explosive. The higher the percentage of carbon in steel the brighter and more explosive are the sparks.

Soft-center steel consists of a layer of mild steel welded between two layers of high-carbon steel. The outside surfaces can therefore be hardened, while the center remains comparatively soft and tough. It is used in moldboards of plows and in cultivator shovels where it is desired to have a very hard outer wearing surface combined with toughness and strength.

Alloy Steels.-Small amounts of one or more other metals, such as tungsten, nickel, chromium, silicon, vanadium, etc., are commonly mixed with steel to form alloy steels. These metals are used in steel to give certain desirable properties, such as great strength, resistance to corrosion, toughness, and resistance to shock.

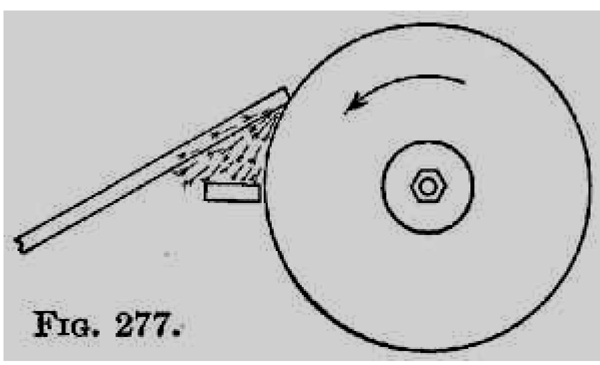
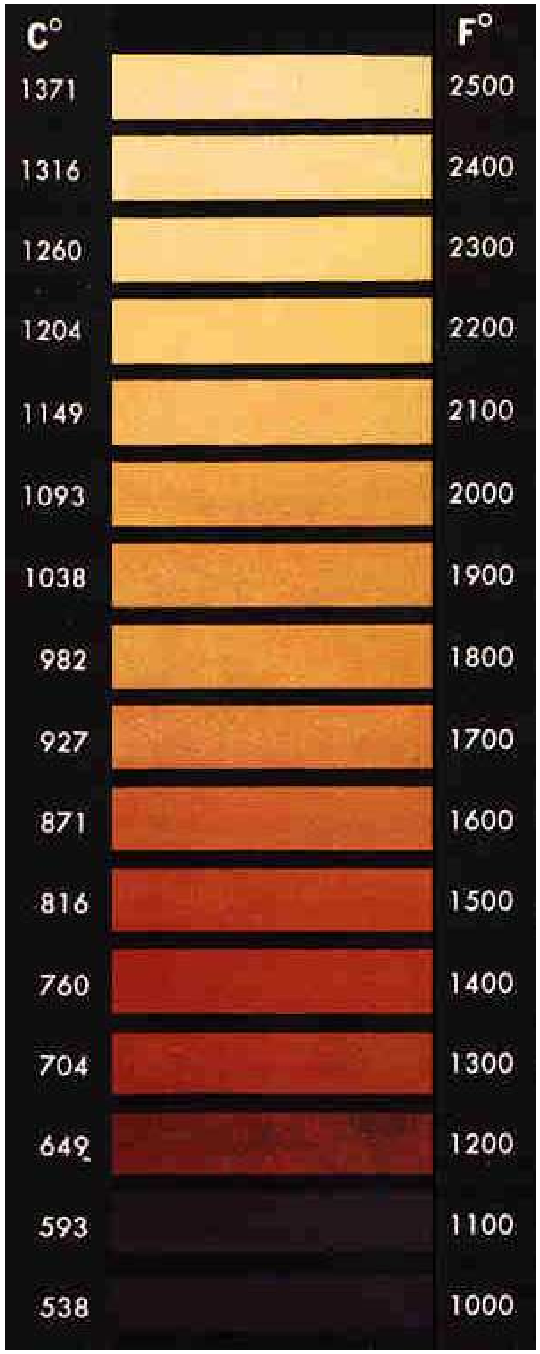


FIG. 277.

Fig. 277.-Different grades of iron and steel may be distinguished by the sparks produced when ground on a grinding wheel. The higher the carbon content of the steel, the brighter and more explosive are the sparks.

Heat Colors of Steel:



These are the colors of steel, at different temperatures.

Heat Colors: Iron and steel become softer and easier to forge when heated to red and higher temperatures. The higher the heat and brighter the color, the softer and easier to forge the steel and iron. There is often a specific temperature or color range to which a smith heats the iron, to get the best results for each type of forging task. Wrought iron can be worked at the higher temperatures and is welded at higher temperatures and brighter colors than mild steel, while alloy steels must be forged at lower temperatures (lower colors) than mild steel.

The beginner should note that the higher the alloy content of the steel, the smaller the window of temperatures at which it could be heated and worked. The color chart shows the colors and approximate heat temperatures of those colors. Keep in mind that it is nearly impossible to show an accurate depiction of the visual effect of the colors as they actually appear to the smith in the workshop. Sizzling heat is not shown in the chart.

The metal stiffens as it cools down, and cannot be worked as easily when it cools to lower temperatures. A good rule of thumb for most shaping of mild steel and wrought iron is to work it when heated yellow, and put it back in the fire when it cools to red.

The cooler or darker red temperatures do have limited value in forging. The smith takes advantage of the stiffer condition of the iron at a lower temperature, by doing his finish forging and smoothing at the lower red heat. At the lower temperatures the hammer won't leave such deep marks and the hammer is more likely to level the high spots than it is to create new deep depressions and marks. If the iron became bent or warped during forging, the smith straightens it before putting back in the fire, while still red.

These are the heats, and what each is used for:

Sparkling or Sizzling heat. Never used. Destroys the metal alloy content and grain structure.

White heat or welding heat. For welding mild steel and iron. Remove from fire when sparks begin to fly and stop forge welding when down to light yellow heat.

Light Yellow heat. Best heat for forging wrought iron and mild steel. Try to obtain this heat before removing from the fire for forging. Sometimes this is described as a light welding heat.

Yellow heat. For forging wrought iron and mild steel.

Bright red or Light red (Orange) heat. Forging of alloy steels is done at this color. Forging of mild steel and wrought iron at this temperature is beginning to become more difficult than at yellow heat.

Full Red heat. For final straightening of wrought iron and mild steel. Put back in fire at this heat.

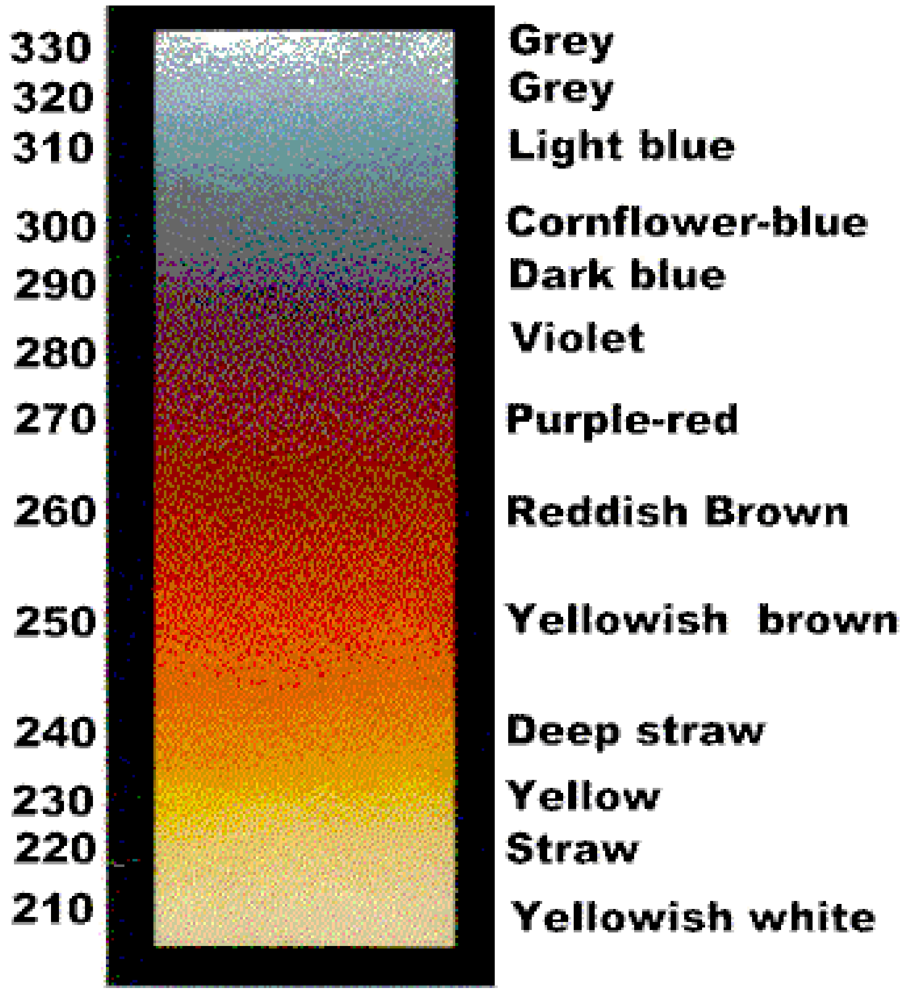
Dark Red or Dull Red heat. For finish forging which means smoothing out dents and sharp corners. Do not forge alloy steels below this temperature. Mild steel and wrought iron may still be worked somewhat.

Black heat or Dark Blood Red heat. Not used for working iron. Black heat describes a temperature range from a an almost undetectable red heat (not bright enough to be visible except in a darkened place) to well below red-heat.

For safety reasons all iron and tools not glowing red hot, should be treated as black hot until proven otherwise. New smiths should take note that any metal that is still cooling and no longer red hot, is still dangerous. And all tools which come into contact with the hot metal are also heated and dangerous.

Sparkling or sizzling heat should be avoided. The sizzling heat pretty much describes the visual effect. Bright sparks similar to those from grinding steel are flying off the material and the effected area is making a sizzling noise. The sizzling is literally the steel burning. At this point the steel should be considered-destroyed, and the effected area is of no further use. Cut off the effected area from the bar and throw it away. To try to save it or use it will end in failure of the piece because the grain structure is destroyed, and the metal will crumble during forging and be brittle when cooled. Avoid sizzling heat.

Tempering Colors Of Steel:



This chart shows the approximate temperature (Celcius) of each color oxide.

Tempering Colors: If you grind or sand a length of steel to expose the untarnished metal, then slowly heat it, you'll notice a stream of colors creep across the surface.

These colors occur from different types of oxides (rust) forming, as the steel reacts with the air. Each different color indicates a different temperature. This is important, because after steel is hardened by quenching, it must be tempered (softened) to some degree, depending on its use.

The higher the temperature you heat hardened steel to, the softer (and springier) it gets. The cutting edge of a razor or knife, for example, needs to be tempered only slightly, since you want it to remain hard enough to hold a sharp edge.

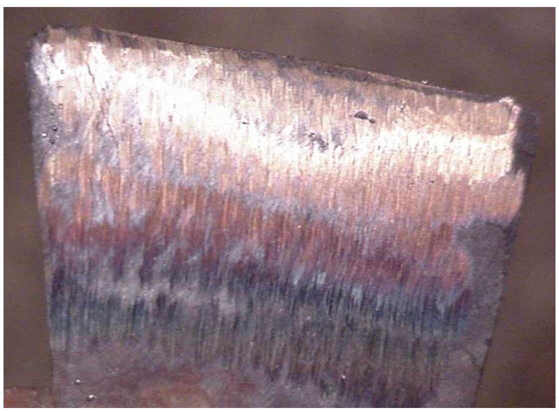
Hard steel is also brittle steel, so items that are subject to shock and wear must be tempered further.

Finally, items that need flexibility, such as springs, are tempered full up to the blue-grey areas, where they've lost most of their hardness.

Here is a polished metal bar, heated from one end, to show the tempering colors.

Uses for each color:

230°C, light straw/yellow: Very hard cutting tools, engraving tools, and files. (Brittle)
260°C, dark yellow to brownish red: Lathe tools, cutting edges of knives and axes.
270°C, reddish brown: drills, screwcutting taps, middle of blades.
290°C, blue: springs, back of blades, striking ends of chisels and punches.



Here is a tempered hatchet, and a tempered chisel, showing the tempering colors.

Quenching: Quenching is the rapid cooling of metal, usually done in water or oil or some other medium suitable for the specific type of material being cooled. Some exotic alloys are even hardened in an air quench. For the purposes of this article, the only quenches to be discussed are water and oil.

The type of quenching liquid used depends on the material being quenched. Wrought iron and many of the less expensive steels can be cooled (quenched) in water, but many of the high alloy steels cannot for risk of fracture.

An example of this is mild steel, which can be cooled in water when needed, but steels made of molybdenum or chromium must never be quenched in water or the steel will crack. What this means to the beginner is that you can quench your normal stuff made of cheap steel in water, but those tools you make from coil springs would crack if you cooled them in anything but oil.

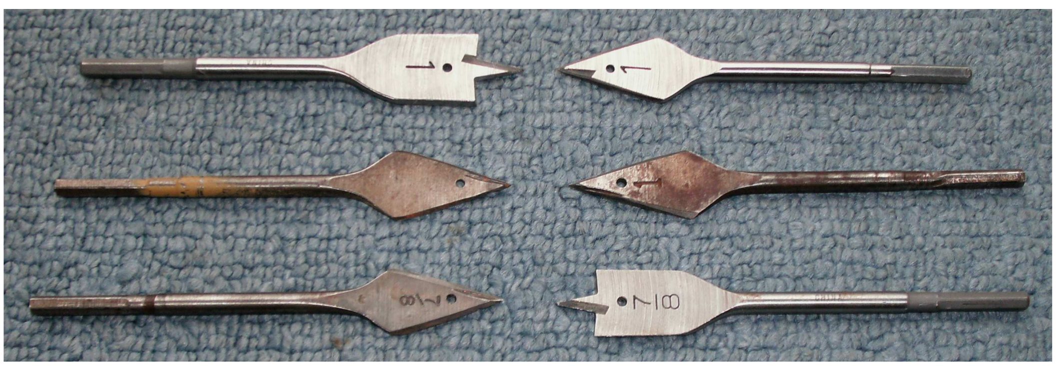
There are two reasons to quench steel. The first is to harden the steel as the first step in the heat treatment process before tempering. The second reason is for local cooling of a small part of a forging when that forging has irregular sizes and shapes which would get burned (overheated) in the fire while heating other areas of the material. For example, when heating a forging possessing a large and small area, the area of the smallest mass would heat long before the area of the greatest mass and would therefore burn off. By local cooling (quenching a small area of the piece) the smith can control the excess heating of parts of the forging.

How To Make Your Own Polearms:

Now that you know how to make a set of improvised blacksmithing tools, produce your own charcoal, and use basic blacksmithing techniques, you should know what kinds of things you can make, using this skill set. So here is a collection of designs for edged weapons that are designed to mount on long spear shafts. These types of weapons are called polearms, and the most basic polearm is the spear.

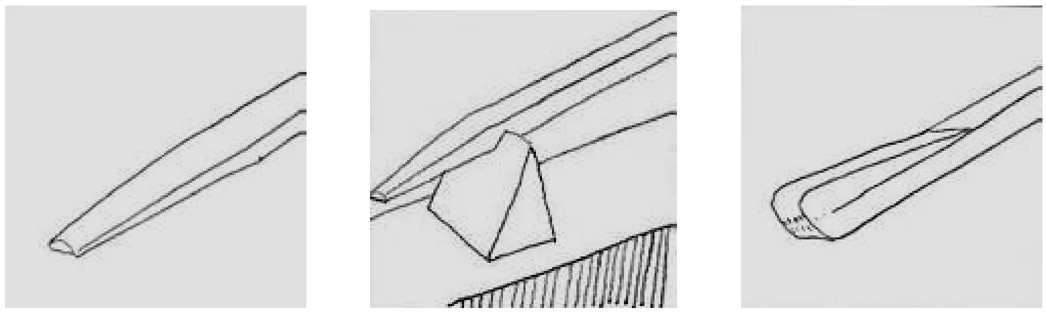
Spears:

The easiest way to make spear heads is to reshape spade drill bits, using a bench grinder.



If you don't have a grinder, you can forge your own spears, using blacksmithing tools.

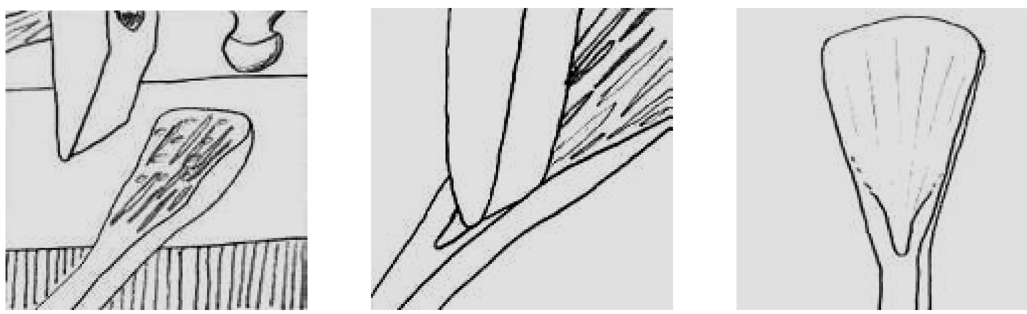
A railroad spike or other scrap steel can be used to make spearheads. A spear is a very good defense against bears and other large predators, if you don't have any firearms available, or for times when ammo is scarce.



1) Using a 1/2" bar of lower medium carbon steel (40 pts. would be ideal), taper and scarf about 4" of one end for faggot welding.

2) Cut about 2/3 through on the underside of the bar on the hardy.

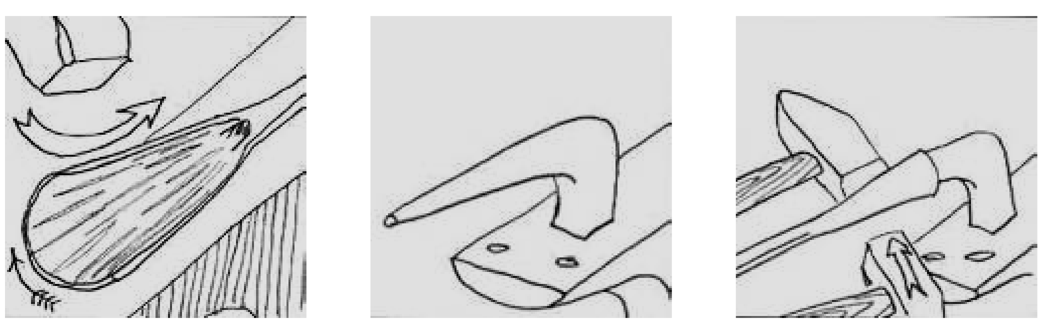
3) Fold over and faggot weld back on itself. This is for the socket.



4) With a cross or straight peen hammer, start spreading the socket in a flair. An occasional work-over with a ball peen will help to thin the metal.

5) Use a narrow fuller up near the "pointy" end, to thin and create a pocket. (You can also clamp a thin fuller in a vise and hammer the stock down on it.)

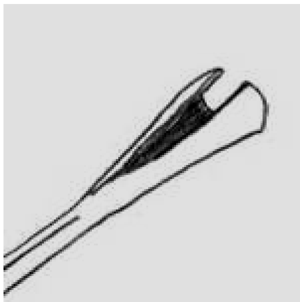
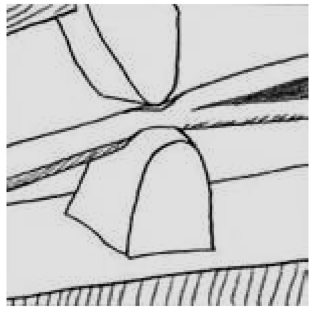
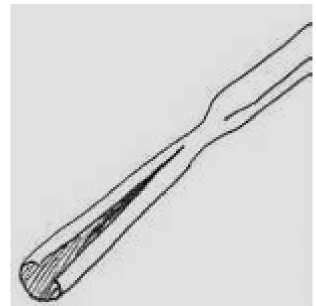
6) The socket should start to take a fan shape. You may want to make a paper template, wrapping paper around the proposed shaft, and draw the pattern on your anvil, or a piece of plate or sheet metal. Anglo-Saxon spear shafts are thin, almost always under 1" and down to ½". I usually aim for ¾", which, times pi, gives a base measurement for the bottom of the spread socket of a bit less than 2 ¼", but you may want to leave some leeway. This is also a good time to profile the socket, since some edges may be a little rough. These may be evened up by forging, filing or grinding.



7) Start rounding-in the socket on the anvil, forcing it closed. If you have a swage block, this can be handy, but you can also lightly crimp the middle of the socket on the anvil step, to get it started.

8) The only tool you might have to custom-make is a socket bick. Mine was formed from an alignment tool, picked up at the flea market. I forged the back end to fit the hardy hole, and then bent it to a right angle using a long pipe sized to near the point of the bend. (Useful wrenches, pipes.)

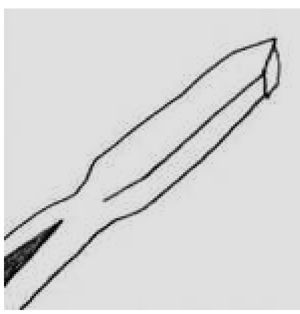
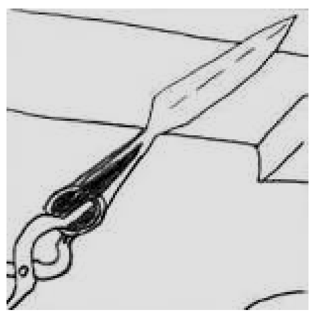
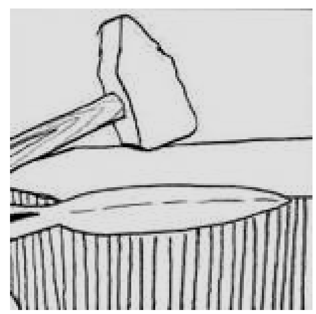
9) Buck the socket with a heavy hammer, and close it up with another hammer. When shy a helper, I've braced the cold end against my chest on the leather apron. (Useful folks, helpers.) The socket bick is also useful for opening the socket, if you've rounded-in too tight.

10) The socket should look something like this. So much for the hard part.

11) Fuller down the corners ahead of the socket to a nice round, or an octagonal. DON'T OVERDO IT!

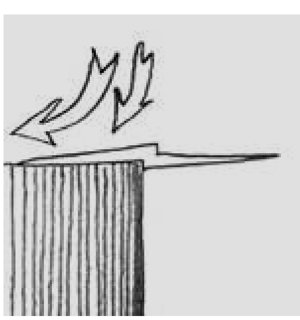
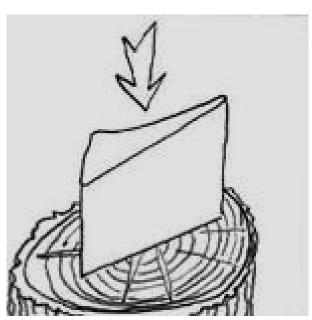
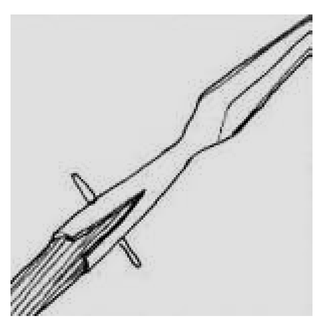
12) Now we are ready to work on the "pointy" end.

13) Proceed 4-5" beyond the neck, and cut off on the hardy from both sides, to start forming a point. Note that the socket slit should be at a right angle to the plane of the blade.

14) Draw out and flatten the blade according to taste. A leaf-shaped profile seems to come naturally. If you're somewhat inexperienced, "forge thick and grind thin", using files or grinders for shaping. Remember, you can forge too thin.

15) One method for drawing down the sides into an edge is to hammer with one side of the blade off the anvil.

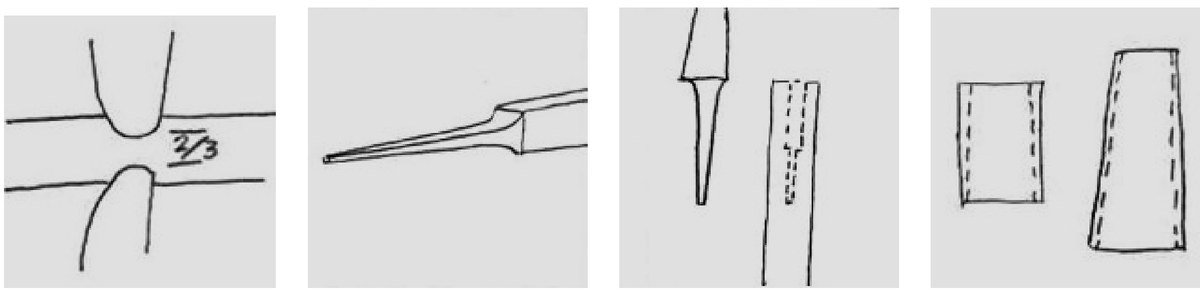




16) This shows a cross section to be aimed for.

17) One method to make a "strickened" or indented profile seen on some spearheads is to prepare a special fuller, and hammer each "wing" of the spearhead down over it. A good blow with a heavy sledge may do the trick, especially to get it established. The bigger the profile of the fuller, the more force that will be required.

18) The head was attached to the shaft (ash preferred, but they also used hazel, willow, and a variety of whatever-was-handy) by a metal pin, or rivet. I prefer a pin, since it can be pulled out to simplify the changing of the shaft when the spear was broken. Be sure that the holes are aligned through the middle of the socket, and at right angles to the socket slit and the axis of the blade and shaft.

Tang Spears:



Using 3/8" (9.5 mm) or 1/2" (12.7 mm) bar, fuller to about 2/3 the width of the bar and about one or two inches (25.4-50.8 mm) from what will become the blunt pointy end. (For the sake of clarity the business end of the spearhead is noted as the "sharp pointy end", and the tang end is the "blunt pointy end". This is a transference from the longship where the bow is known as the "pointy end", and the stern is known as the "other pointy end".) Fullers with a slight offset towards the sharp end are good, and spring fullers will suffice. You do not want a sharp corner, due to the propagation of stress cracks.

Keeping the shoulder area off the anvil, forge the tang out into a long, even taper about two to four inches (~50 - 100 mm) long. Keep the sides even and square. Forge out the sharp pointy end for the spearhead as per part I and harden and temper.

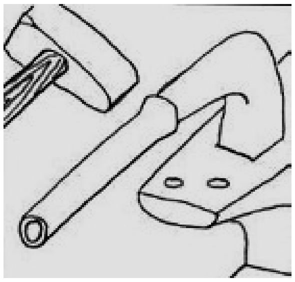
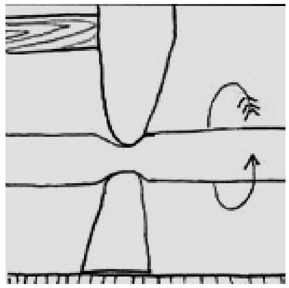
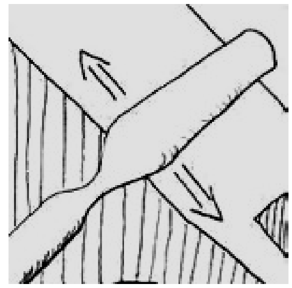
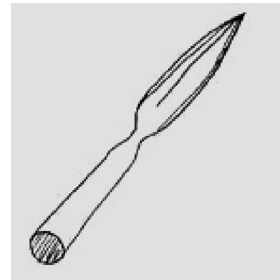
Select an appropriate shaft, ash being preferred. I usually drill tang holes in two stages, the deeper one just a little narrower and a touch shallower than the end of the tang, and then using the first drilling as a pilot hole, a slightly wider one to accommodate the thicker upper part of the tang.

Wrap the spearhead in wet rags and heat the tang to a black heat. Wearing heavy leather gloves to protect from ejected hot gasses and steam, insert the tang into the shaft. This may take a couple of heats to get it all the way in.

Do not overheat the tang to a red. Too hot results in excessive charring, and a loose fit. It's also a good idea to wrap some layers of sturdy cardboard or cloth around the blade and point if it's at all sharp, to protect your hands from a slip-cut.

Ferrules are frequently used to reinforce the spear shaft and to keep the head from splitting out. The two types that I've used have been straight ferrules tapered on the inside, and conic ferrules. The later are frequently found on garden implements, which commonly use tang connections to their wooden handles. Unless your blade is narrower than the shaft, you should put the ferrule loosely over the shaft before burning-in the tang.

Steel Pipe Spears:

Select a piece of Schedule 40 or other thick-walled steel pipe, heat to a good yellow and start to flare it on the socket bick. Most of the work is accomplished by using a light to medium weight straight peen as the pipe is rotated. Hammering the pipe onto the bick end-on is of limited usefulness, and frequently results in the pipe stuck on the bick. The amount of taper achieved is a matter of patience and personal choice.

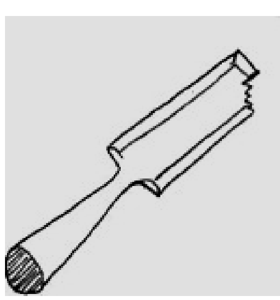
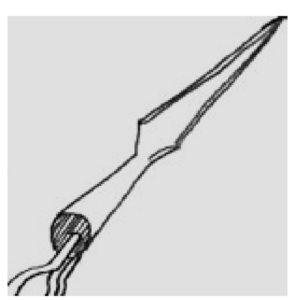
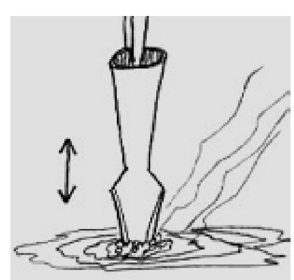
SPECIAL NOTE: When cooling pipe in the slack tub, be sure to point the "cool" end away from your face and body. The hot shower of scalding water and steam that sometimes erupts from doused pipes will do nothing to enhance your day.

Using fullers or a bottom fuller and similar peen on your hammer, fuller down the pipe to create the neck of the spearhead, rotating as you go. The pipe does not need to be completely closed, depending upon the proportions that you're looking for.

Cut the pipe so that the unit is about eight to ten inches (~20 - 25 cm) long. (Remember, very long blades put a lot of stress on the neck if they're thrown.) Bring the blade end up to a bright red, lay it on the anvil and start to flatten from the back to the front. Avoid overheating and scaling, since you're going to have to weld it. When you have the inside cavity down to about 1/4" (6.35 mm) or a touch less, sprinkle borax down the pipe with a spoon, bring it up to a welding heat and weld it up 2 to 3" (~6 - 8 cm) at a time from back to front. Once the pointy end is welded up, you can start forging it into a proper spear blade, grind, harden, temper and sharpen. Most of the pipe I've dealt with has been low to medium carbon steel, so quenching and tempering should take that into account. On the other claw, tough is better than sharp if it's a throwing spear.

The spear blade profile is somewhat restricted by the size/volume of metal in the pipe, but it should prove sufficient for anything that is not too outlandish.

Spears Made From Broken Tools:

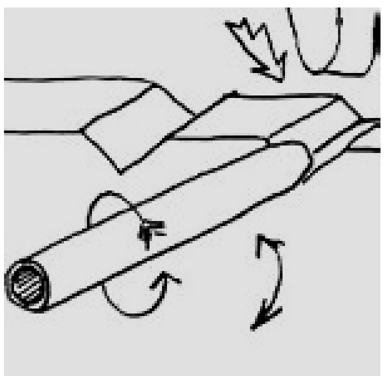





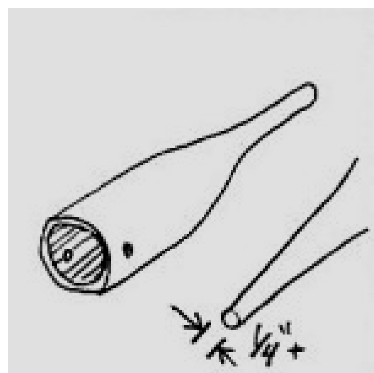
Search garage sales and flea marts for damaged tools that you can buy cheap. A broken, socketed woodworkers chisel is ideal for making spears, and hoes, rakes, and other tools can be made into workable weapons, as well.

Forge out the chisel (or other tool head) into a spear blade. Since a chisel is high carbon steel, do not overheat (no more than bright red or lowest of oranges), and be willing to take your time about it. Forge thick and grind thin to eliminate any decarburization. (Or you can leave it "cased" in the decarburized steel for extra toughness, and just grind down the edges.)

Heat to critical temper and quench in oil dipping the pointy end up and down to the socket. Do not quench the socket. Temper to blue. Remember, you want tough rather than hard.

Spear Butt Spikes, Or End Ferrules:





These were fairly common on spears from the classical era to the 19th century, and their positions in grave finds are one of the methods by which we know how long some spears actually were. The best things about them is it gives you a safe way to park your spear when there's nothing secure to lean it against.

Take a piece of appropriate diameter thick walled pipe. On a swage block, deep anvil step, or other appropriate angled surface start drawing the end down with the peen of the hammer, rotating and rocking a bit as you go. Start drawing the end out as spike as you go.

While you can still see a touch of light through the end, sprinkle some borax down the pipe, tapping it down so that if gets to the end. Bring to a welding heat and forge weld it closed on the anvil.

Draw the spike out until it's no less than ¼" (6.35 mm) at the end. There are two reasons not to make the spike on the end ferrule too sharp: It's a BAD idea to have any weapon as dangerous on your end as on the business end, and this is the end that goes in the dirt all of the time.

A thinner end, upon meeting a rock, could bend or "J-hook" and get ugly. Drill a cross-hole (straight through with the spear shaft in place, if possible) and rivet to the shaft. As opposed to the cross pins illustrated in Spearheads I, these should be closed down tight to the ferrule to keep from snagging on anything or anyone.

More Pole Arms:

There are a number of other simple weapons you can make using a forge and anvil, called pole arms. Pole arms are long weapons, that allow you to strike your opponent before they can strike you. To be correctly termed a pole arm requires only a fairly long pole (5 to 20 feet or more), with some sort of cutting or thrusting weapon mounted on its end. Here are some examples to give you ideas:

Spear:



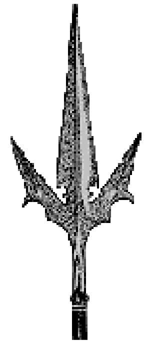
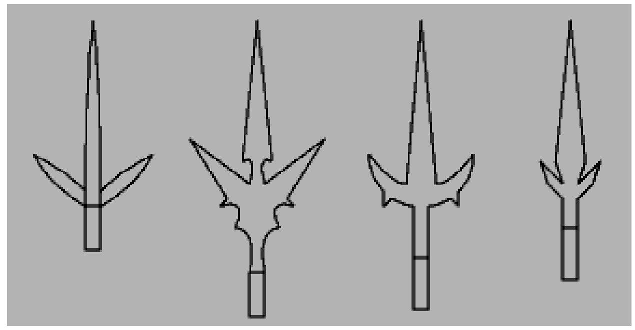
The spear is a dagger set atop a pole. It is so ancient a pole arm that it is often not mentioned in the class, but the spear is such a weapon. It is principally a thrusting weapon, but if a broad blade is used it can also have a secondary cutting function, especially when the blade is lengthened considerably. Spear heads can also be lashed to short handles, so that they can be used as knives, or they can be made with integral handles, like the example on the right.

Pike:


Although there is no set rule, any spear with a shaft of 15' or longer is considered to be a pike. The pike is designed to deliver a thrusting attack at an opponent at a long range, and its great length was used to keep him there, as the weapon was always used in mass. One of the most common forms of pike is the awl pike, a strictly piercing weapon, although there are many other forms of blades which were used. Swiss and German pikes were fashioned so that metal protected the wooden shaft up to 2 feet from the head, so that an enemy could not easily lop the blade off, and make the weapon useless.

Other Members of the Spear Family: We now come to the many specialized and combination forms of the dagger on a stick. This is not to say that all pole arms equipped with a spear head (dagger) should be considered as spears, or variations of spears. To the contrary, this is a common error, identifying the weapon by a secondary, rather than a primary function, and losing all sense of what the weapon was for. The primary function of a spear is thrusting; thus, the specialized and combination pole arms belonging in the spear family should be primarily used as thrusting weapons.

Spetum:

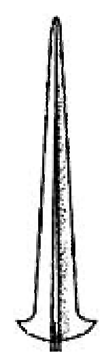
The spetum was probably designed to increase both offensive and defensive capabilities of a normal spear. To a sharp, tapering point two blades which point forward at about 45° are added to provide secondary attack modes, deflect opponents' weapons, and catch and hold opponents at a distance if penetration with one of the blades is not achieved.

Ranseur:

At first glance, a ranseur appears to be a form of spetum, or vice versa, but the purpose of the design of the former weapon is more complex than that of the latter. A ranseur's secondary blades have backward-hooking projections set well below the large central blade. The spearing function of the weapon is apparent, and the deflection includes the trapping of opponent weapons in the space below the main blade, where a twist of the shaft would apply pressure from it or the secondary projections to either break the caught weapon or disarm its wielder. Additionally, the side projections provide both a means of holding an opponent at long range, or of pulling mounted opponents off their horse.

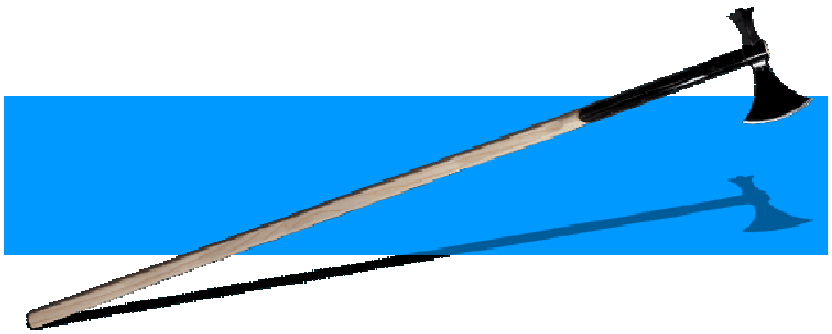
Partisan:

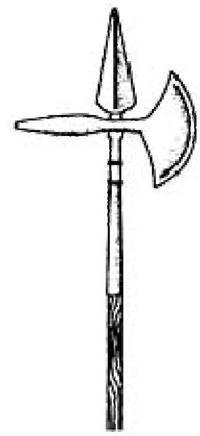
  

This form of pole arm is basically a spear - often with an ox-tongue blade, to which a pair of small axe heads were added below the dagger blade. To the thrusting stab of the spear was added the defensive use of the side axe blades, and their cutting potential. Later versions of the partisan yielded a gradual change in the axe blades, so that they became almost unrecognizable as such.

Thus, the spear family is composed of the spear proper; the long spear, or pike; the spetum; the ranseur; and the partisan. All weapons in this class are basically daggers atop a sturdy pole, with trimmings added to make the weapon more efficient in one way or another.

The Pole Axe:

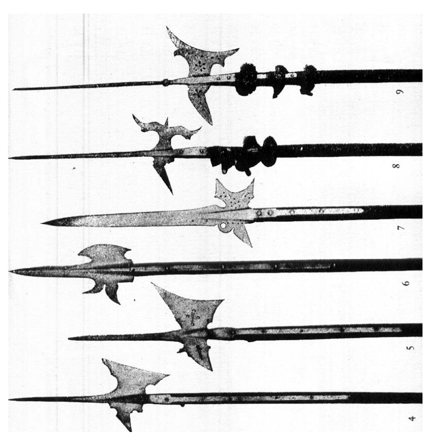


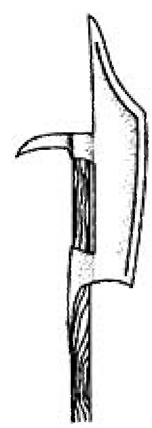


The axe took many forms and was combined with many basic forms of weapon. The axe has two basic head forms, broad and narrow. A related form of the axe is the cleaver, a butchering tool which was adapted for military use also. Many pole arms in the axe and cleaver families also had spear points, to provide some secondary thrusting capability, but again the primary use of the weapons of these types was chopping.

Strictly speaking, a pole axe is nothing more than an axe head of any sort on a long haft, used to deliver a forceful blow. It can be double-bitted, backed by a spike, and/or topped off by a dagger (spear) point.

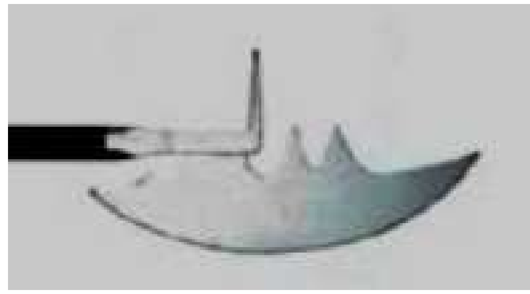
Halberd:





This form of a pole axe is seen as a convex-headed broad axe in early examples, but the head is set at a convenient angle (considering the point where the blade is most likely to impact upon an enemy), so this alone makes it quite distinct from an ordinary long hafted axe. The whole weapon reached 8 feet in length. It was also always topped with a fairly long spear point and backed by a spike, which was often angled or hooked slightly downward. The spear point is, of course, designed to keep opponents at bay, and deliver a thrusting attack. The opposing spike was for penetration of heavy plate armor, with a secondary function as a hook for dismounting opponents.

Bardiche:

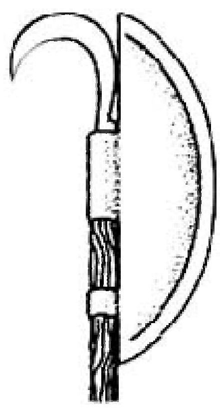


This very broad and heavy axe links the pole axes to the pole cleavers as a sort of transitional step between the two forms, although its only obvious use is as a military arm. A bardiche head ranged from about 2 feet to over 3 feet in length, and it was attached to its haft with two rings or a single one in those examples where the blade is shorter and backed with a hammer head or spike. The bardiche in all of its forms was very heavy and cumbersome - more so by far than a halberd.

The Pole Cleavers:

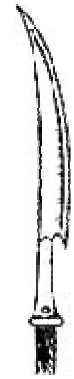
It seems quite likely that some outraged peasant fastened his meat cleaver to the end of a stave in order to protect himself and his family, and thereby created a weapon form which was to be widely used in both Europe and the British Isles for several centuries. The same derivation holds true for the majority of the other pole arms which will be discussed; they are simple agricultural tools converted to a warlike use, and their form is easily distinguishable and identifiable.

Voulge, or Lochaber Axe:



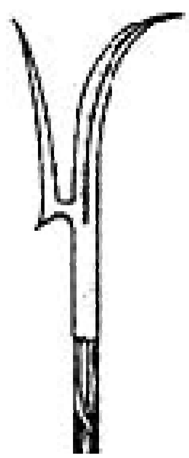
Place a hefty cleaver at the end of a long, stout shaft, and the leverage which the pole gives the wielder will enable him to cleave through armor. The voulge has no provision to keep the enemy at a distance in its simple form, but if the top front or back edge is ground down so as to provide a pointed dagger-like tip, the weapon assumes a more complete form. The voulge was sometimes backed with a spike, or hooked spike, to make a crude guisarme-voulge, a combination-form weapon.

Glaive:

Having employed just about everything else, there was no reason not to add the single-edged knife at the end of a staff also. The glaive is a knife-bladed spear. It has the thrusting function of the spear, and the secondary cutting function of the convex blade of the knife. The weapon was rapidly enlarged in the blade in order to give it a greater cutting function as well as a cleaving attack. As with a spear, however, it was not overly effective at holding opponents back, nor did it have the piercing or dismounting capabilities, so modifications produced the glaive-guisarme. The increase in the size of the blade of these weapons brought some to the point where they nearly merged with cleaver-type weapons.

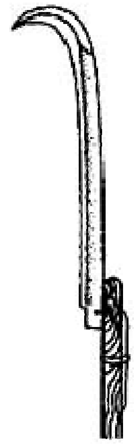
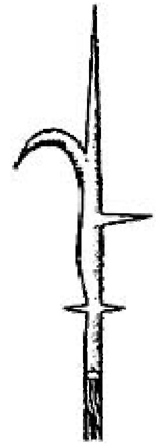
Guisarme:



Medieval peasants discovered that their pruning hooks made reasonably effective pole arms. The provocation which necessitated such development was undoubtedly considerable, but the upshot was likely to have been as unsatisfactory as having no weapons. Pole arms of this sort, called guisarmes, were soon modified into highly efficient combination weapons.

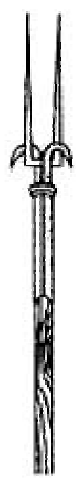
The guisarme was furnished with a sharp cutting edge along its convex side, probably from reverse spike to hook. The spike, of course, could be used to penetrate armor when the weapon was swung, and the curved hook provided an ample means of pulling horsemen to the ground. Deficiencies in this form of pole arm are apparent - no spear point for thrusting and only one projection for penetrating. The guisarme was soon combined with other forms of peasant weapons to make a second generation of highly effective, all-purpose pole arms.

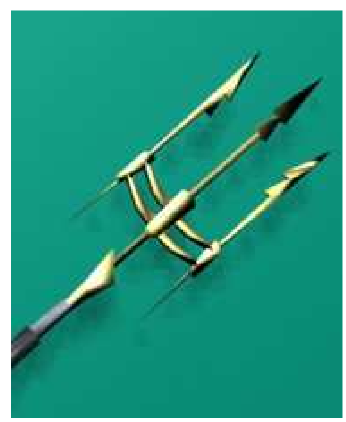
Bill Hook:

The English bill hook was almost exactly the same as the French guisarme, but its concave (hook) edge was the sharp one, and rather than a straight back spike it typically had an L-shaped tine projecting forward. This arrangement was slightly more effective than the European guisarme.

Military Fork:

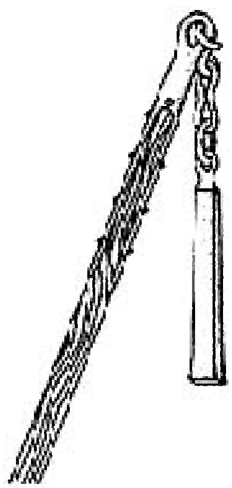



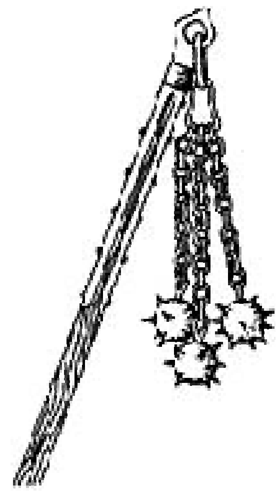


The lowly hay fork was straightened and strengthened to provide a very potent weapon, the military fork. This pole arm had two or more efficient piercing points, for holding off an enemy, and sometimes a shorter third tine in the crotch of the fork, so that opponents were channeled into a third attack. The major drawback to this pole arm was its lack of effective penetrating power with respect to heavily armored targets. The fork principle was soon combined with other pole arms to form very efficient tools of war.

Special Cases:
A few other designs can also be mentioned here, more or less in passing, as they pertain to weapons that are not true pole arms, but their size is such that they are sometimes considered in the general class.

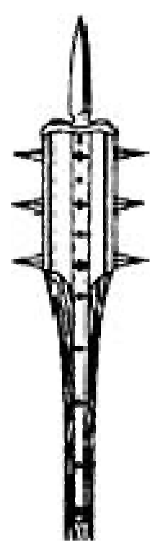
Flail:





The threshing flail, a wooden handle on another billet of wood attached to it by a swivel or several links of chain, was easily adapted and modified to become a ghastly weapon. Horsemen commonly employed a short-handed flail with one or more chains ending in smooth or spiked iron balls. The peasant's tool made a far more effective weapon when swung by a strong man. From a heavy shaft of about 3 to 4 feet in length was hung one or two rods of metal shod and spiked wood or iron. The whole weapon was over 5 feet long and had tremendous penetration and crushing power.

Morning Star:



The other weapon which is a borderline case is the morning star. This club adaptation was typically a heavy wooden haft from 3' to 5' or more in length, atop which was set a cylinder, barrel, or truncated cone, also of wood, metal-bound, and set with vicious metal spikes. Also called the holy water sprinkler it was a favorite of the peasants, for it was easy to make and could lay low the best armored opponent at a blow. For some time it was used extensively by the Swiss, although the halberd eventually replaced it. The weapon was often tipped with a spear point in its longer form, so that some models were long enough to be pole arms. Some military picks were also pole-mounted, having shafts of 5 feet or longer.