The Art of Sculpture Welding

From Concept to Creation

Kristi Richardson McCoy

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Introduction

Too many times, students are put into a classroom situation where all they do is practice welding joint after joint and run bead after bead. Being the artistic person that I am, teaching welding in this fashion is not for me. In my experience, if students WANT to be in the classroom, they will work harder. In turn, my job becomes easier and more enjoyable. The projects in this book are designed to teach every facet of welding in a more interesting way so that students stay on task and are excited every day to walk into my classroom.

Whether you are a student or a home hobbyist looking for something to build, the projects in this book provide learning experiences that not only are fun and challenging but also will help to develop your welding skills.

This book includes 13 projects for the novice welder; they are designed with specific welding applications in mind including GMAW, GTAW, SMAW and oxyacetylene welding. While constructing these projects, beginners do more than practice welding. They also:

- Develop better measuring skills.
- Identify types of steel.
- Align joints properly.
- Use the tools of the trade including scribes, squares, plasma and cutting torches.
- Work with grinders and polishers during and after fabrication.
- Learn the importance of final clean-up.
- Experiment with different types of metal finishes.

The chapters in this book include projects that were designed with each specific welding discipline in mind so that the reader gets hands-on practical experience. Each project includes a detailed list of parts that are needed for that project, a set of plans showing the layout and dimensions for the part, and detailed instructions on how to build the project accompanied by numerous full-color photographs taken especially for this text. The chapters include Helpful Hints, which provide advice on how to properly construct the project so that optimal learning takes place throughout the fabrication process. Additional Notes provide interesting background information. Safety Tips also appear throughout the book.

The book is organized into the following units:

Part 1: Beginning Gas Metal Arc Welding Projects
Part 2: Beginning Shielded Metal Arc Welding Projects
Part 3: Beginning Gas Welding Projects
Part 4: Beginning Gas Tungsten Arc Welding Projects
Part 5: Heating, Bending, Rolling and Wrought Iron Projects

Gas Metal Arc Welding tends to be less intimidating to beginners than the other slightly more complicated welding processes. Therefore, it provides a great way to begin learning metal fusion. Both projects in Part 1 introduce a large variety of tools in the welding shop and initiate novice welders to the basics of part layout, which is a vital step in the metal working process.

The Shielded Metal Arc Welding projects in Part 2 concentrate on learning and practicing the proper use of the oxyacetylene cutting torch along with mastering the more complicated bead laying process that comes with stick welding. Three projects, all with similar difficulty levels, are included in this part to provide beginners with choices as they learn to become proficient with this process.

The Oxyacetylene Welding projects in Part 3 and Gas Tungsten Arc Welding projects in Part 4 will develop hand-eye coordination skills. Each of the two parts begins with a very simple project that concentrates more on mastering the welding skill itself. In each case, the second more complicated projects are designed to concentrate on welding skills along with construction techniques.

The final projects in Part 5 are designed to teach skills related to shaping parts with heat and with the use of specialty tools. The target and decorative vase projects introduce beginners to heating and bending techniques with oxyacetylene and hydraulics. The dinner bell and tricycle plant stand incorporate the use of wrought iron benders and ring rollers to complete the projects.

This book teaches all aspects of the welding environment and will help shape beginning welders into well-rounded individuals. When beginners are focused on a goal at hand and are interested in achieving the end result, they focus on their work. The learning that takes place within a welding technology classroom or home shop is evident every hour of every day.

Acknowledgements

I have been surprised many times in my life with crazy opportunities that are thrown my way out of the blue that I just can't believe are happening. The most memorable was being told three years into my teaching career that I would be teaching welding. I can honestly say, at the time, I was anything but "qualified," even though my teaching certificate said otherwise. But, I have never been afraid to learn, and 17 years later, welding has become my passion.

I want to thank Mr. Golz, my high school shop teacher, who has always been encouraging and who has helped me along the way, as well as all the administrators over the years at Spearfish High School who have shown nothing but faith in my abilities. For that I am grateful.

I am thankful for the opportunity my publisher Industrial Press has enabled me to share with others what I do in my classroom to make each day an enjoyable experience for myself and my students. Who would have thought that a 15-minute conversation at a teaching conference would turn into a year's full of work? Thank you, Christine Ott, for introducing me to the publishing team in New York and Connecticut. Thank you, Jim Dodd, for having faith in a shop teacher who hadn't written even an essay since college some 20 years ago. Thank you, Janet Romano, for the helpful encouragement and for doing such a great job putting my words and images onto paper. And thank you, Robert Weinstein, for having the patience to be my editor.

Thanks to all my friends for their encouragement and for sharing in the excitement of my new adventure. Most important — thank you to my husband and my two wonderful children for allowing me the time to write. I love you guys!

PART I

Beginning Gas Metal Arc Welding Projects

Gas Metal Arc Welding (GMAW), sometimes referred to as MIG (Metal Inert Gas) welding, was invented over a century ago, but it took until the late 1950s and early 1960s before the process was affordable and versatile enough to be extensively used. Today, MIG welding is the most common method of welding, especially in industry.

Many people think that MIG welding is as simple as picking up the gun and pushing the trigger. This is a huge misconception. As with other welding processes, a person needs to know how to set the welder for proper penetration, which way to aim the gun, how to move and advance down the weld joint, and how to identify and maintain the proper arc distance, as well as how to care for and clean the machine and its many parts.

This section provides the beginner welder an opportunity to build something fun and learn the MIG welding process. Both projects provide the same learning experiences and can be very beneficial in understanding the basic fabrication processes.



CHAPTER 1

Truck

While assembling the truck, you will learn and develop a variety of proficiencies in the welding shop environment. These include a working knowledge of welding equipment, power tools, hand tools, layout tools, and machinery. You will become familiar with identifying steel, using a plasma cutter and its accessories, and how to properly assemble a basic welding project. The project will supply plenty of practice using a MIG welder to tack parts and weld the basic joints.

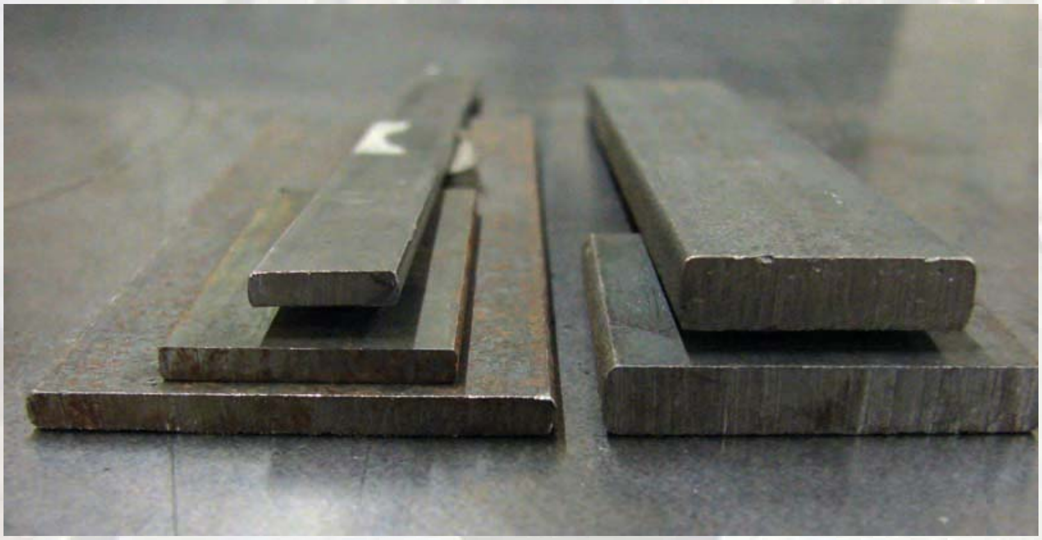
Specifically, this project focuses on proper layout of parts, proper cleanup after cutting, and the importance of tacking parts together prior to welding joints solid. At times, the truck may seem tedious to build due to the large amount of parts, but is rewarding when complete.

STEP 1. Identify the steel needed for truck fabrication.

Before building any project, a person must be able to identify different types of pre-fabricated steel shapes. Without properly knowing how to identify steel, costly and time consuming mistakes can be made.

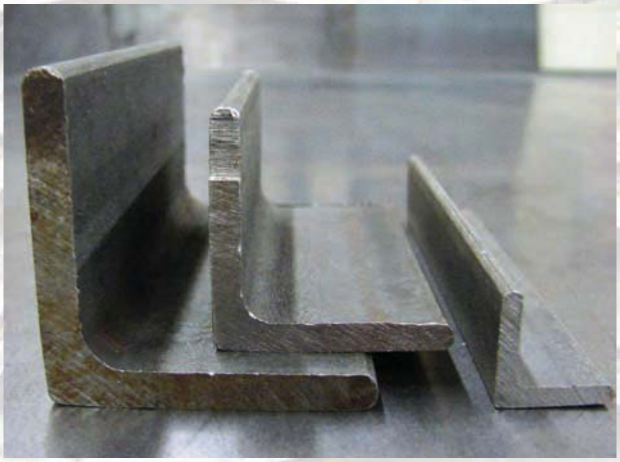
There are a variety of shapes, most of which can be identified by thickness, width, height, or diameter. Some of the more common and familiar shapes include; square tube, flat bar (strap), round bar (rod), angle iron, rectangular tube, pipe, square bar, and expanded metal (Figure 1-1). Other commonly used products are sheet metals, channel iron, and W-beams.

Figure 1-1. a. Square tube is identified by height, width, and thickness. Example: 1" x 1" x 10ga sq tube.



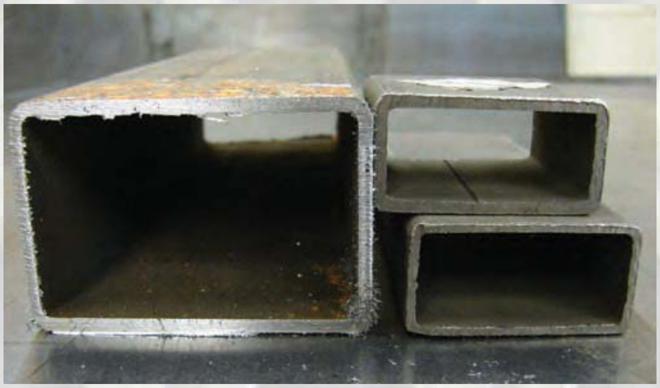
b. Flat bar, also known as strap, is identified by thickness and width. Example: 1/4" x 1" strap.

c. Round bar, also referred to as rod, is identified by its diameter. Example: 1/4" rod.

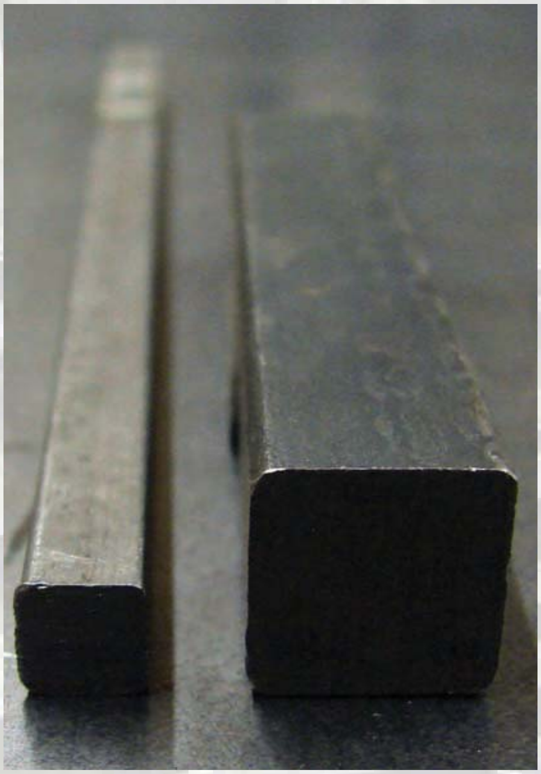


d. Angle iron is identified by height, width, and thickness. Example: 1" x 1" x 3/16" angle.

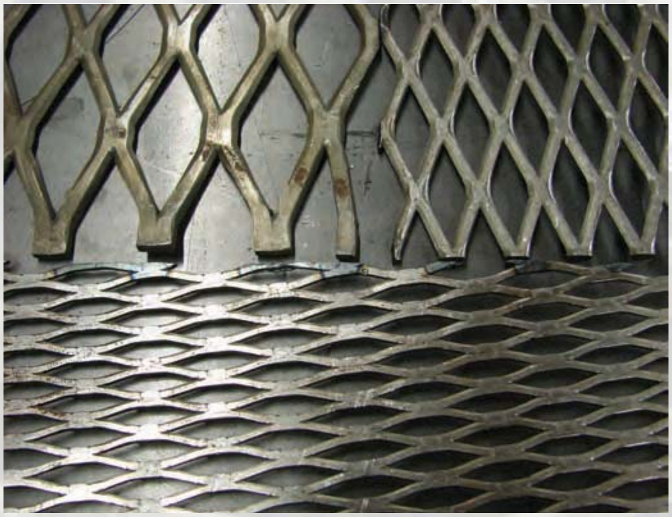
e. Rectangular tube is identified by height, width, and thickness.
Example 1"x 2" x 14ga rectangular tube.



f. Pipe is identified by inside and outside diameters as well as wall thickness.



g. Square bar is identified by its height and width. Example: 1/4" x 1/4" square bar.



h. Expanded metal is a sheet product that comes in a variety of sizes. It is identified by its web distance, metal thickness, and the sheet size. Example: 4' x 8'- 3/4" x 9ga Expanded or Expanded Flush. Expanded metal has raised webs whereas expanded flush has a smooth surface.

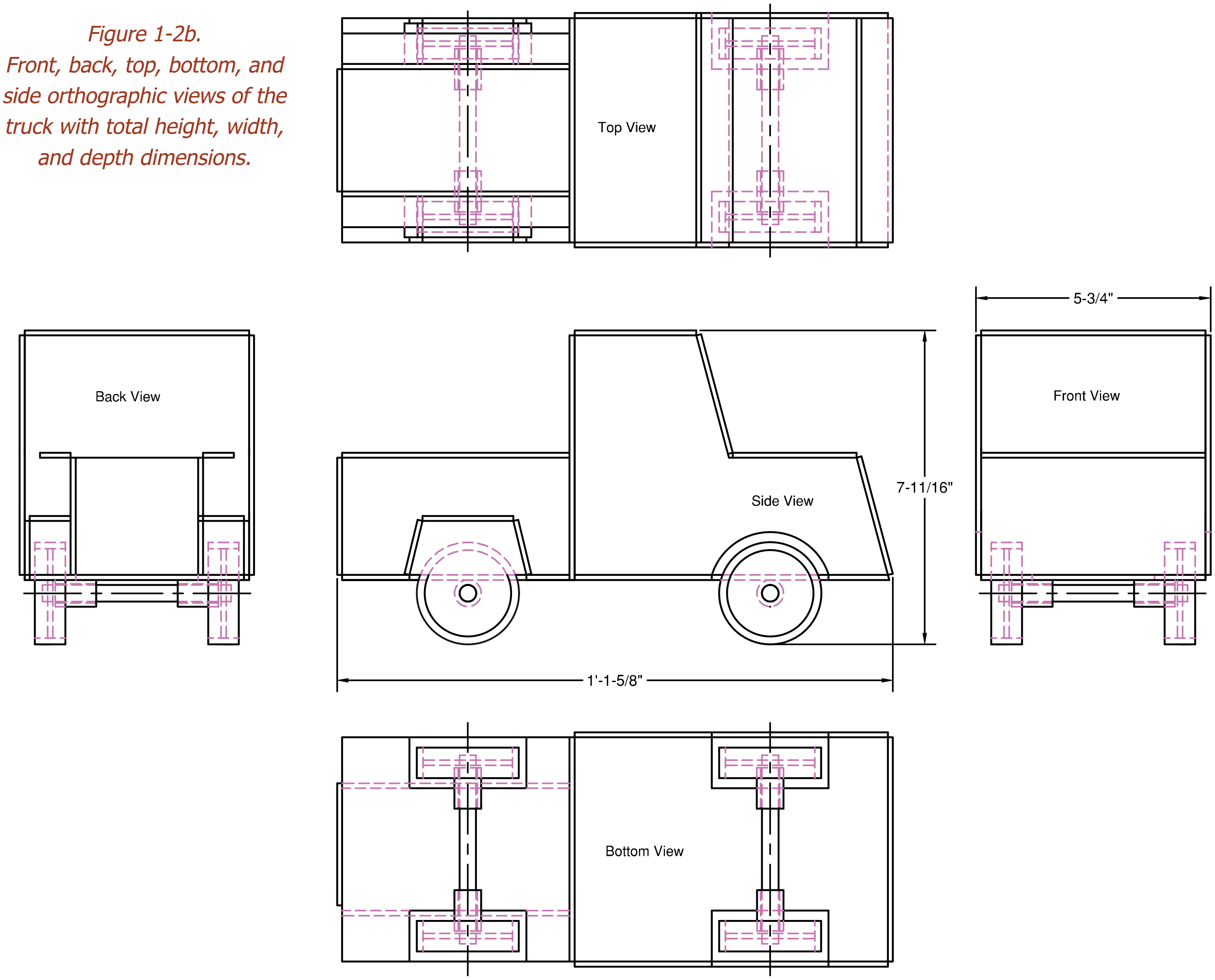
When building a project it is helpful to refer to a parts list (Figure 1-2a). It can help you determine your total steel requirements, including types of steel you will need. It will also allow you to easily find individual lengths and widths of different parts.

Before beginning a project, it is also helpful to review the plan views. These views help to identify how parts fit together as a whole (Figure 1-2b).

Truck Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
2	Cab Sides	Sheet Metal	10ga	0'-5 7/8"	0'-7 11/16"
1	Cab Bottom	Sheet Metal	10ga	0'-5 1/2"	0'-7 11/16"
1	Cab Back	Sheet Metal	10ga	0'-5 1/2"	0'-5 7/8"
1	Cab Top	Sheet Metal	10ga	0'-5 1/2"	0'-3"
1	Cab Windsheild	Sheet Metal	10ga	0'-5 1/2"	0'-3"
1	Cab Hood	Sheet Metal	10ga	0'-5 1/2"	0'-3"
1	Cab Front	Sheet Metal	10ga	0'-5 1/2"	0'-3"
1	Box Bottom	Sheet Metal	10ga	0'-5 1/2"	0'-5 9/16"
2	Box Sides	Sheet Metal	10ga	0'-2 7/8"	0'-5 9/16"
2	Box Rails	Flat Bar	1/8	0'-0 3/4"	0'-5 9/16"
1	Box Tailgate	Sheet Metal	10ga	0'-3"	0'-2 7/8"
2	Hub Sides	Sheet Metal	10ga	0'-1 7/16"	0'-2 7/8"
2	Hub Front	Flat Bar	1/8	0'-1"	0'-1 3/8"
2	Hub Back	Flat Bar	1/8	0'-1"	0'-1 3/8"
2	Hub Top	Flat Bar	1/8	0'-1"	0'-2 1/4"
4	Outside Wheel	2" Sch40 Pipe	0.154000	2.375 OD / 2.067 ID	0'-3/4"
4	Wheel center	Sheet Metal	10ga	0'-2 1/16" Ø	-
2	Axle	Round Bar	7/16Ø	-	0'-4 5/8"
4	Axle Support	3/8" Sch40 Pipe	0.091000	.675 OD / .493 ID	0'-1"

Figure 1-2a. Parts List.

Figure 1-2b.
Front, back, top, bottom, and side orthographic views of the truck with total height, width, and depth dimensions.



Note: Some hidden lines were left out of views for clarity.

When ordering pipe, you should refer to a pipe reference chart to be sure of what you are getting. For example, 2" schedule 40 pipe has a 2.375 outside diameter and 2.06 inside diameter with a wall thickness of .154. 3/8 schedule 40 pipe has a .675 outside diameter and .091 inside diameter with a wall thickness of .091. The size of pipe doesn't match the diameter of pipe until it reaches 6" or larger.

HELPFUL HINT

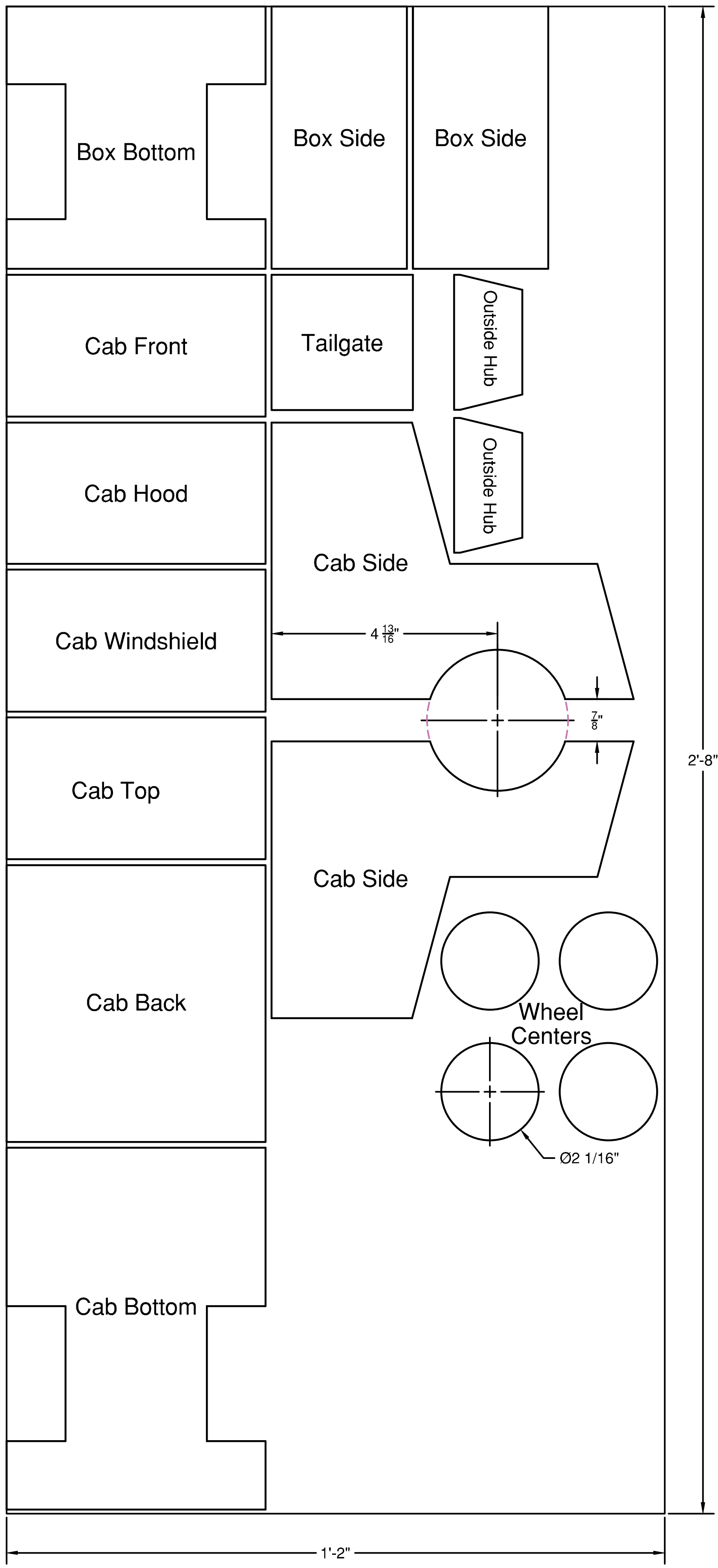


Figure 1-3.
Parts layout guide.

STEP 2. Collect the needed steel.

After reviewing the parts list and plan views, make a list of the types of steel needed to build the project. List the amount of feet or square feet needed and order the steel that isn't currently available in your shop.

STEP 3. Lay out your sheet metal parts.

Before you begin locating and marking lines, consider the following points.

First, when laying out parts, you should make use of the sheet metal as efficiently as possible. The suggested layout plan in Figure 1-3 utilizes the sheet of steel with minimal waste. Notice that there is 1/8" gap between each part. By laying out parts in this manner, you limit the number of required cuts because when you cut a side of one part, you are also cutting a side of another. Most plasma kerf widths are approximately 1/16" or slightly larger. If you cut down the center of the 1/8" gap, there will be 1/32" for final clean up on both edges. This can be helpful if you are a beginner at using the plasma torch with a straight edge guide. If the torch is not slid along the straight edge smoothly, your line can be jagged. If the torch is not held perpendicular to the surface of the sheet metal, the kerf will be beveled. Having a little room for error in cutting will minimize the likelihood of having to re-cut later.

Second, choose the most accurate method possible for marking your lines. Common marking tools consist of scribes (Fig. 1-4), soapstone pencils (Fig. 1-5), and permanent markers. Due to the line width of markers and soapstone, sometimes as thick as 1/8" or more, I recommend using a scribe that produces a very thin accurate line (Fig.1-6). Because a scribed line is so thin, it can be difficult to see. It may be helpful to use a marker to place a guide line just inside of your scribed line so that it is easier to locate later when lining up your straight edge for plasma cutting, as in Fig.1-7.

Figure 1-4. A scribe is a pointed instrument used to mark or score a line that is used as a guide for cutting. Holding the scribe at a slight angle allows you to scratch the surface of the metal right next to your straight edge guide.

Figure 1-5. Soapstone pencil.

Figure 1-6. Lines drawn with a scribe.

Figure 1-7. A line drawn with a marker can be helpful in locating scribed lines more easily.

Last, when measuring and marking your cut paths, you should have both a tape measure that has been checked for accuracy and a good quality combination square. Measuring accurately cannot be overlooked when fabricating.

Now, using the most accurate tools available, lay out your parts as the layout guide suggests in Figure 1-3. (See Figures 1-8, 1-9, and 1-10 for part dimensions.)

You may find it easiest to first cut a piece of steel 2′-8″ x 1′-2″ prior to laying out your parts. That way, if you don't complete your part layout in the time period you've set aside, the metal sheet can easily be laid aside for completion on another day. Make sure to keep the steel square when cutting; this will save time when laying out parts.

HELPFUL HINT

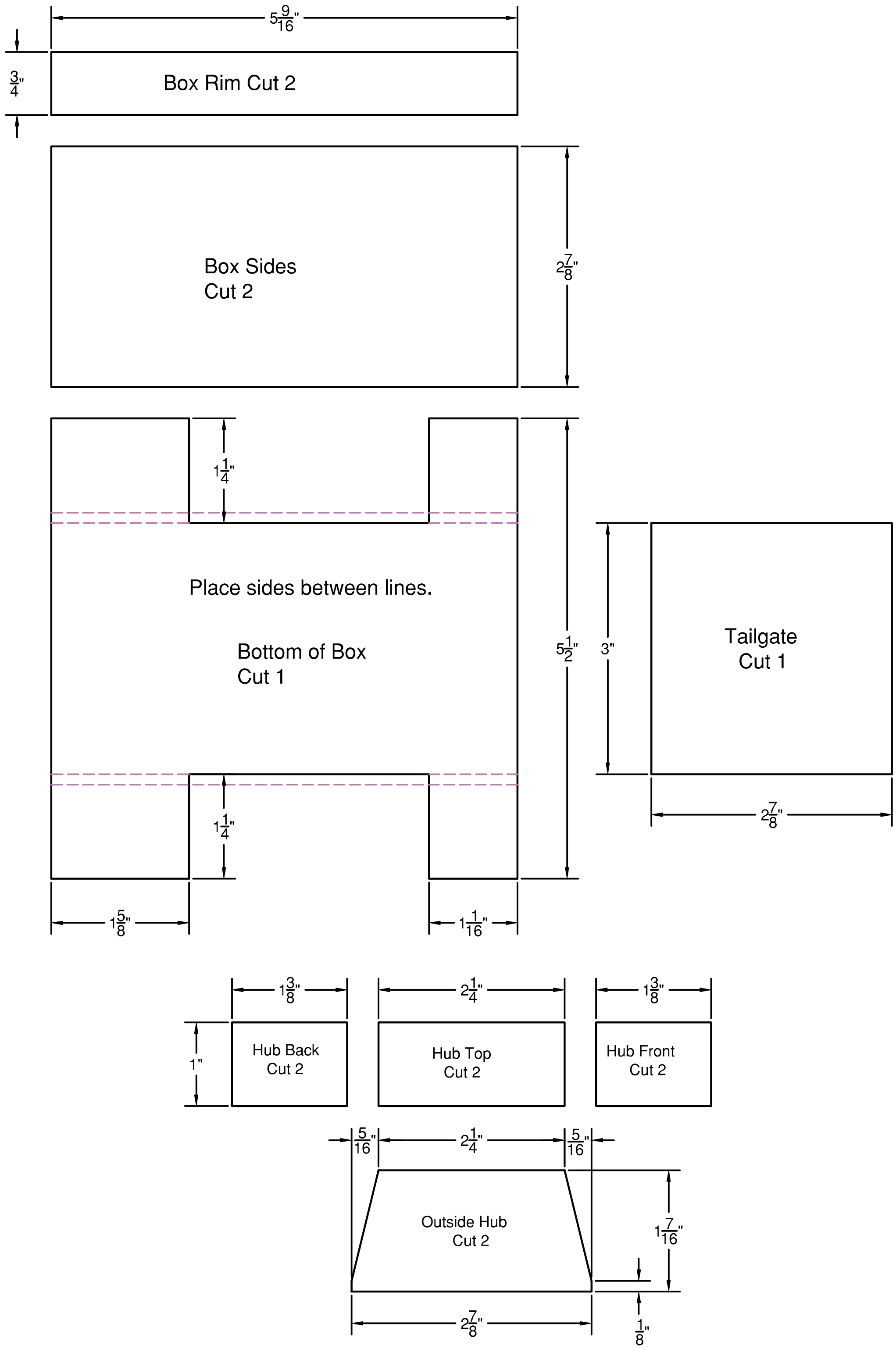


Figure 1-8. Truck parts and dimensions.

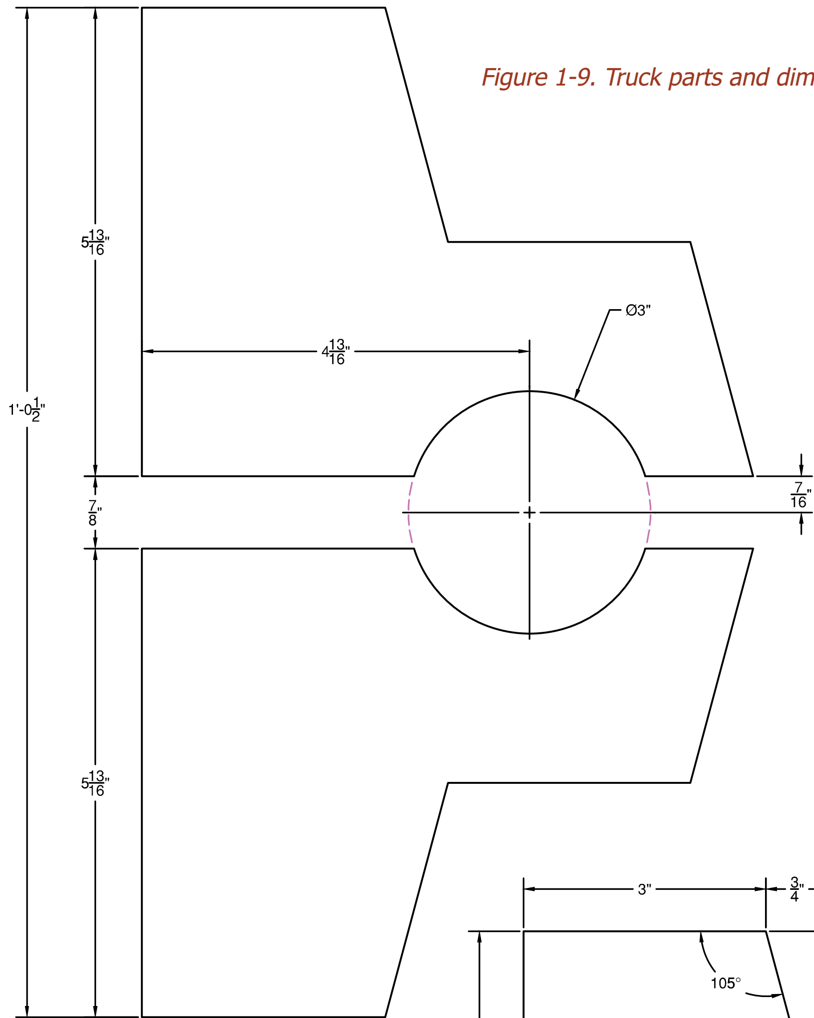


Figure 1-9. Truck parts and dimensions continued.

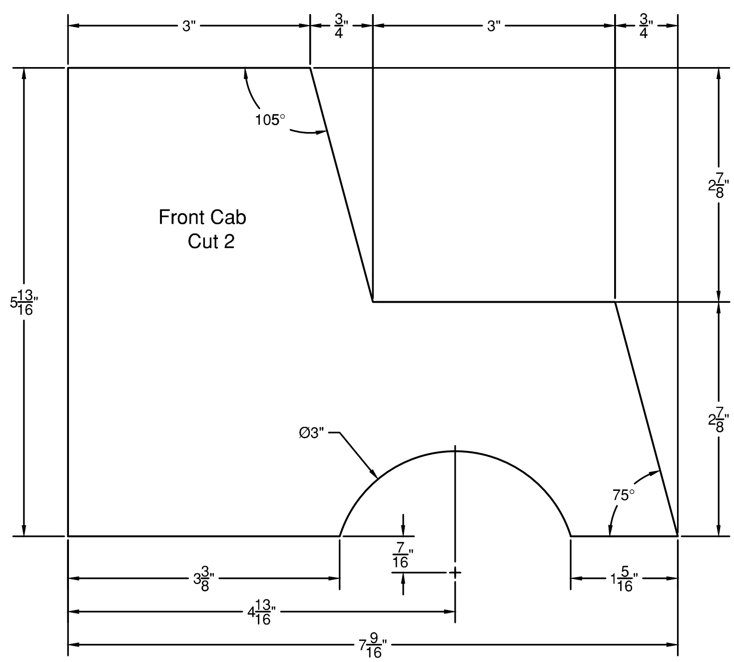
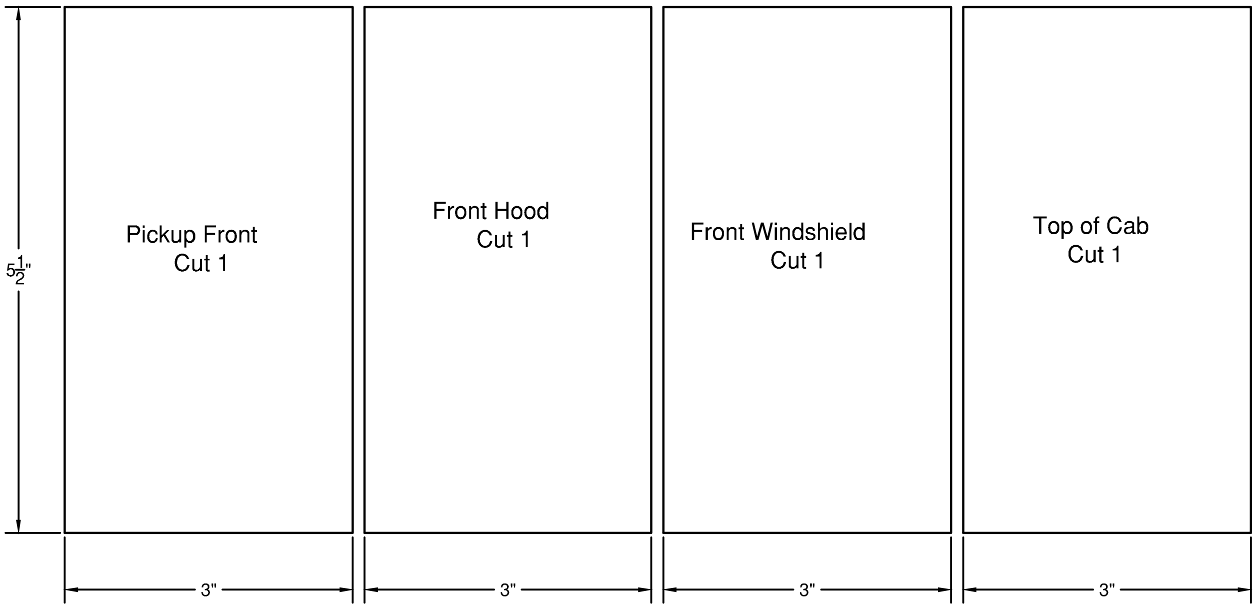
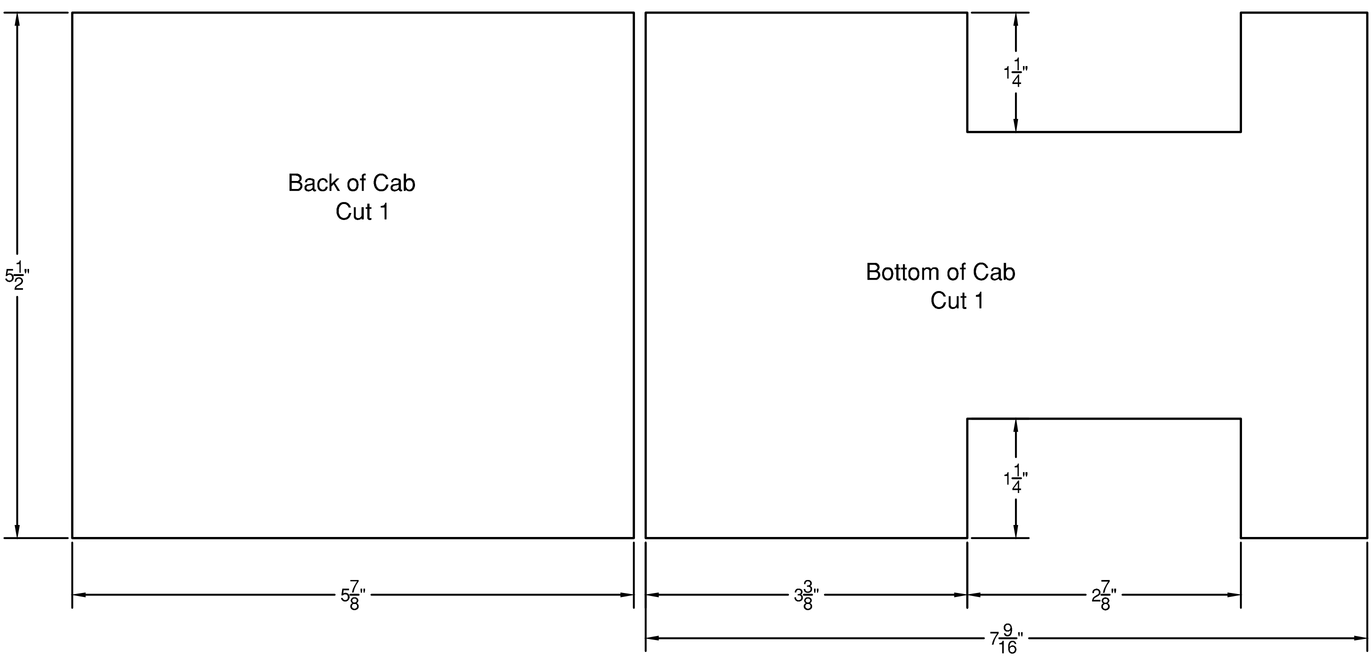


Figure 1-10. Truck parts and dimensions continued.

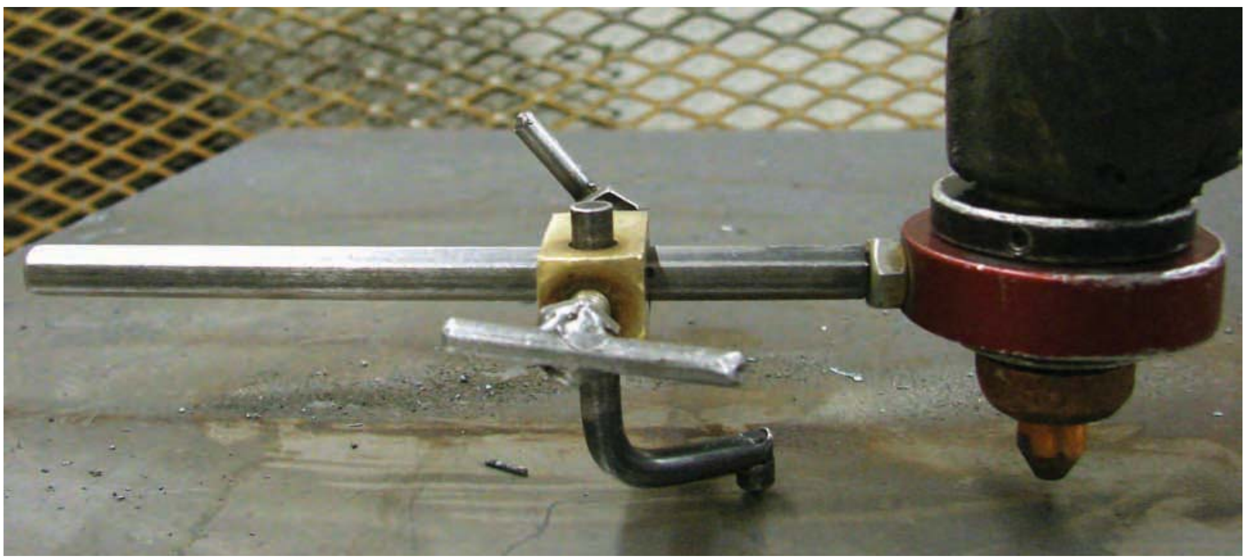




STEP 4. Cut out your circular parts.

The first parts to be cut out after the layout is complete are the wheel centers and the arcs in the cab sides. If available, use a circle cutting attachment. With this attachment, your circles can be cut out quickly and accurately (Figure 1-11).

To begin, use a hammer and a punch to mark your circle centers, with the steel placed on a solid surface (Figure 1-12). Then, adjust your circle cutting attachment. Two settings will need to be made. First adjust the pivot point so that it extends 1/8" farther out than the plasma torch nozzle. Second, adjust the attachment so that the proper radius is set (1" for the wheel centers and 1-1/2" for the cab sides). When setting this distance, measure from the pivot point of the circle cutting attachment to the inside of the hole in the nozzle on the plasma torch.



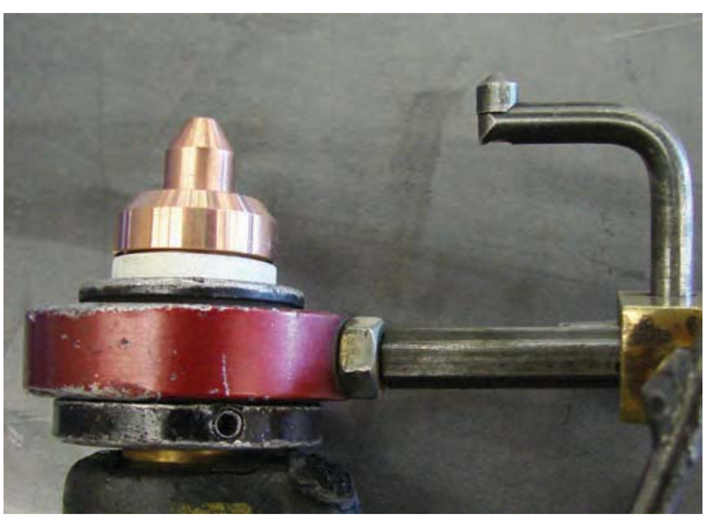


Figure 1-11. a) A circle cutting attachment for a plasma cutter is a helpful tool for cutting smooth accurate circles and arcs. You need two hands to swing the arc and it can be tricky to learn to use properly. It may take some practice. b) Bottom view of the circle cutting attachment and inserted plasma torch.

Prior to actually cutting, place the pivot point in your punched divot and swing the arm a full turn to insure a full rotation can be obtained smoothly and easily. If this is not possible, the attachment height may need to be raised or lowered so that the torch tip rides approximately 1/8" above the metal. Also, insure that the torch lead doesn't cause too much pull downward as you are cutting and that it does not bind on anything as you perform your rotation. If height adjustments were necessary, the arc distance will also need to be re-measured and re-set.

At this point, you are ready to cut. Set the pivot point in the divot. Be relaxed and light handed, which will allow movement around the circle to remain smooth and precise. The only part of your body that should be tense is the finger squeezing the plasma torch trigger (Figure 1-13a and 1-13b).

If you do not have a circle cutting attachment, hand cut out your circles as accurately as possible. Some grinding of the edges will be necessary after cutting.

Figure 1-12. Using a punch and hammer to mark circle centers requires a solid surface and a steady hand. When making your punch mark, hit the punch one time only. Back to back hits can give you two divots. If the divot is not deep enough from the first hit, reset the punch and then strike again with a single blow.

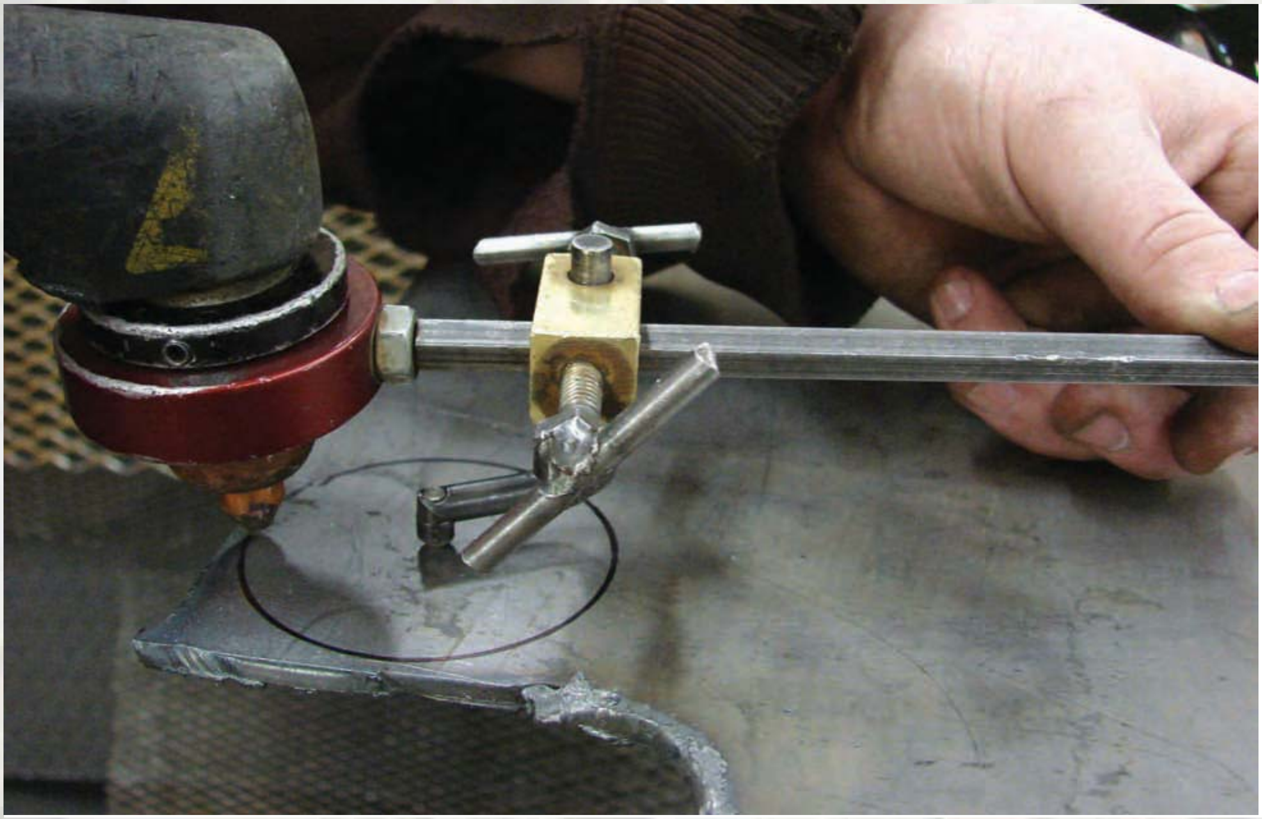


Figure 1-13a. Ready to begin cutting a circle.

Figure 1-13b. Cutting a circle with a plasma circle cutting attachment.

Figure 1-14. Shade 5 cutting glasses.

SAFETY TIP

Plasma arcs produce dangerous UV rays. Wear colored safely glasses to eliminate damaging your eyes (Figure 1-14). When you drag cut, the torch hides most of the arc flash and shade 5 is adequate. When you are free hand cutting without a straight edge or circle cutter, you may want to use a darker shade for proper eye protection, depending on the amperage setting and thickness of steel that is being cut. Refer to your owner's manual for safety specifications for your machine.

To eliminate the risk of fires, remove all flammables from the area. To reduce the risk of burns, make sure you are wearing the proper foot wear and clothing.

STEP 5. Cut the remaining sheet metal parts.

Next, collect a scrap piece of 1/4" flat bar at least 1" wide and some C-Clamp locking pliers. Clamp your sheet of steel to a sturdy table if it was pre-cut to size. Use the other locking pliers to clamp your straight edge to your sheet. To determine the distance your kerf will be from the straight edge when drag cutting, set up a test cut in a place where your parts are not laid out. To measure the distance to the center of your kerf, use a steel rule that measures in sixteenths of an inch (Figure 1-15). Use this distance to accurately place your straight edge for each cut.

During this cutting process, it is easiest to pull the torch toward you, rather than trying to push or go side to side along the straight edge(Figure 1-16).

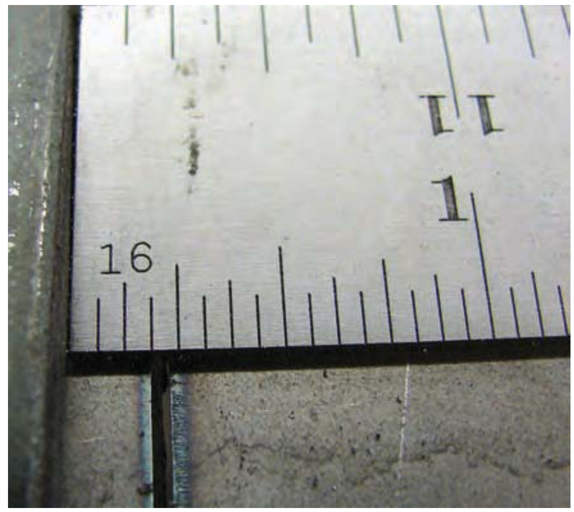


Figure 1-15. Use a steel rule for measuring the kerf (width of your cut) and distance from your straight edge. In this example, it is 3/16" from the straight edge to the inside of the kerf. If you wish to leave the line, place the straight edge to the inside of the line and set it 3/16" from your scribed line.

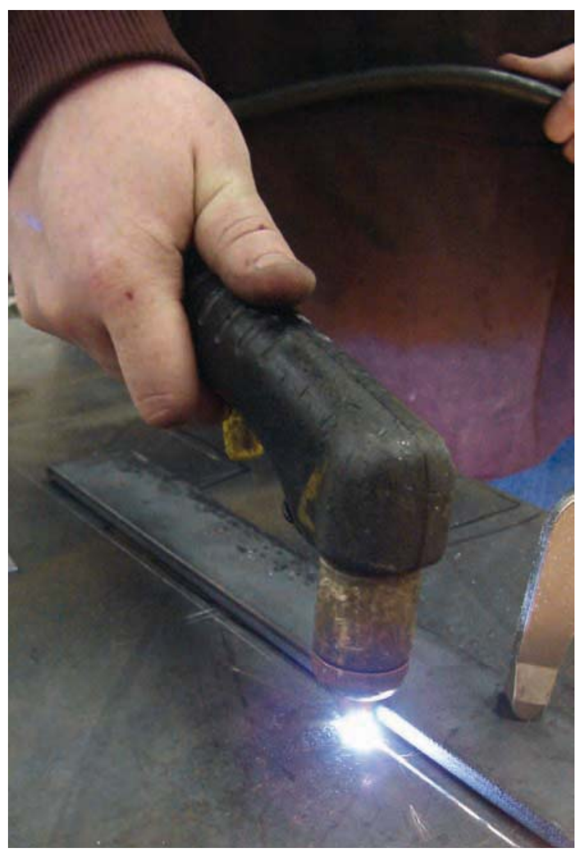


Figure 1-16. In this example, the person cutting is set up to pull along the straight edge while cutting.

Note:
These parts could easily be cut using a CNC plasma Cutter. If you choose this method, the same layout plan would still prove to be the most economical. However, if you haven't used a plasma machine before, this project is a good way to learn to hand cut with accuracy. It is a skill that needs to be practiced in order to be proficient. Computerized plasma cutters are not always available or may not always be an option in every welding shop situation.

While freehand drag cutting with a plasma cutter, always use a straight edge guide. Without a guide, the accuracy of the cut would be tremendously reduced.

HELPFUL HINT

When plasma cutting, avoid piercing a hole in the middle of the sheet if you can start your cut on an edge. This is recommended for three reasons:

1. Starting on an edge will produce a pierce point that is clean and unnoticeable.
2. Starting on an edge will preserve the life of your consumable plasma torch parts because molten steel is less likely to shoot up into the nozzle of the cutter and damage the electrode.
3. Starting a cut on an edge reduces, if not eliminates, the amount of molten steel shooting upwards towards your face when beginning a cut.

HELPFUL HINT

SAFETY TIP

Clamping the straight edge is highly recommended for safety as well as accuracy. You can easily slip while hand holding a straight edge. If you slip and the arc contacts bare skin, serious burns can occur.

STEP 6. Clean your parts.

After all parts have been cut, they will require some clean-up. When cutting with a plasma cutter, there is always a certain amount of dross (slag) that forms on the bottom side of the steel. The amount of dross build-up will depend on how well your travel speed matches the amperage setting you chose for the thickness of metal being cut. Most dross can easily be removed by sliding a scrap piece of flat bar with a clean sharp end across the surface toward the edge. Sometimes it takes a small tap and sometimes you may need to slide the flat bar across the steel toward the edge with extra force (Figure 1-17) For more difficult areas, a chisel and a hammer will be needed to remove dross (Figure 1-18). If you use this method, clamp your steel to a table first. You will need to use two hands for this method; securing the steel will allow you to hit the chisel with more force.

After you have removed the dross from the surfaces, you may need to use a grinder to clean up the edges that aren't square. For safety purposes, clamp your pieces to a table or put them in a vise so that you can use two hands when using a portable hand grinder.

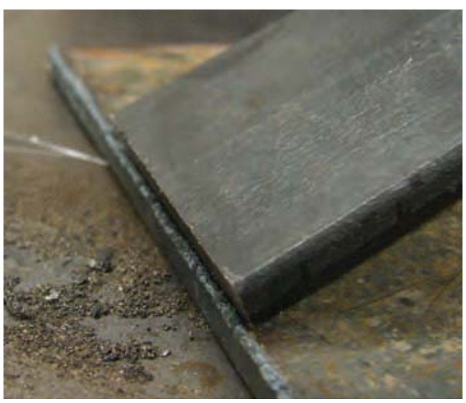


Figure 1-17. Removing dross from plasma cut steel with flat bar.

Figure 1-18. Removing dross from plasma cut steel with a chisel and hammer.

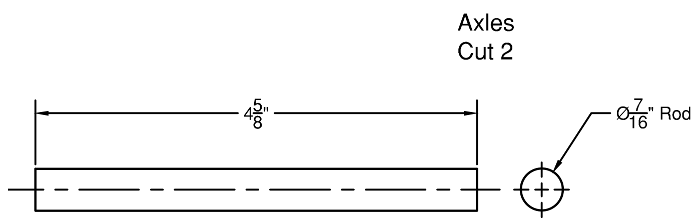
SAFETY TIP

Always remember to wear safety glasses during the cleaning process (as well as during all steps in the fabricating process). Dross tends to snap off of the sheet and fly in all directions.

STEP 7. Cut your strap, pipe, and rod.

Now that you have cleaned your sheet metal parts, you should cut your flat bar, pipe, and rod. (Refer to Figure 1-1 and Figure 1-19 for part descriptions and dimensions.) A band saw or cold cut saw will give you the most accurate results. If these tools are not available, an abrasive cut-off saw (also known as a chop saw) will work, but your accuracy will be reduced.

After cutting, there will most likely be a sharp lip at the bottom of the cut that will need to be removed either with a grinder or a metal file.



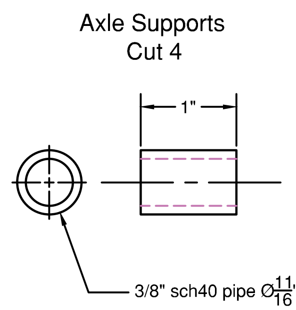
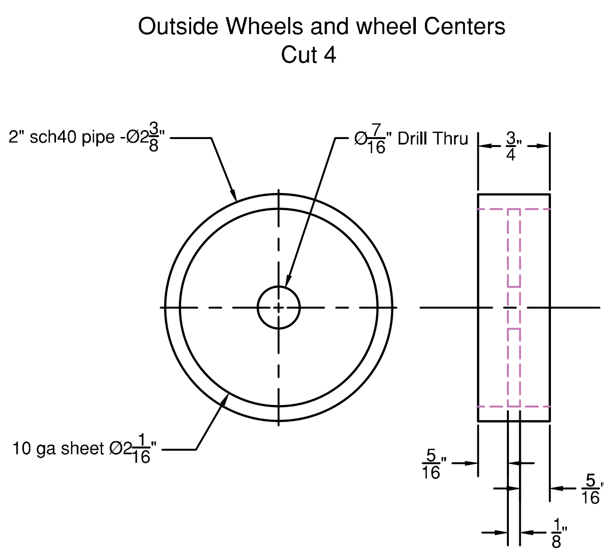


Figure 1-19. Wheel assembly and dimensions.



STEP 8. Check for part accuracy.

After all parts are cut and free of sharp edges and dross, you should check for part accuracy. A quick layout will reveal errors in cutting. At this point, you may need to grind some edges or even re-cut parts if the proper alignment was not achieved. (See Fig.1-20.)

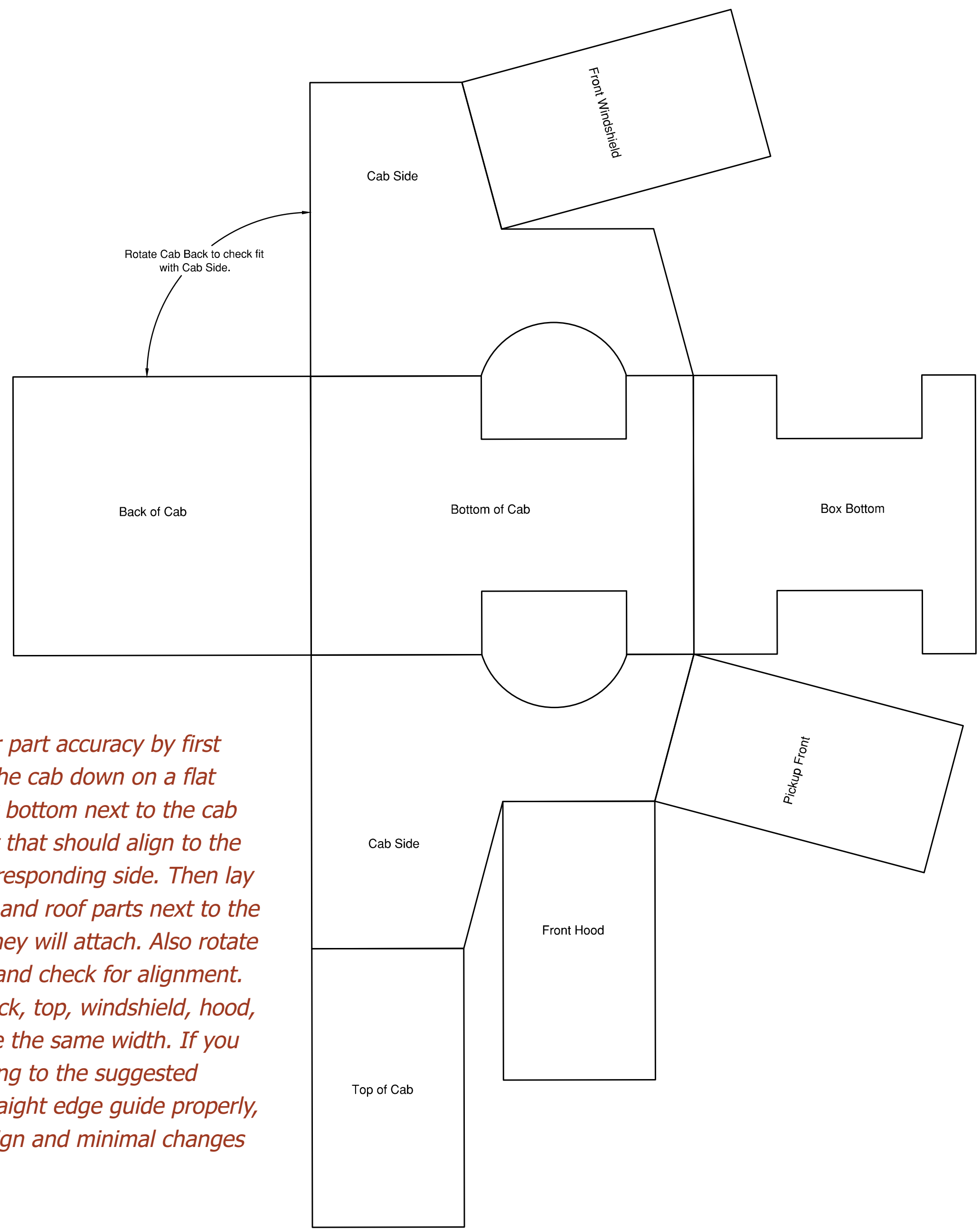


Figure 1-20. Check for part accuracy by first laying the bottom of the cab down on a flat surface. Place the box bottom next to the cab bottom. Lay each part that should align to the bottom next to its corresponding side. Then lay the hood, windshield, and roof parts next to the side edges to which they will attach. Also rotate the back to the sides and check for alignment. Finally the bottom, back, top, windshield, hood, and front should all be the same width. If you cut your parts according to the suggested layout, and used a straight edge guide properly, the parts should all align and minimal changes should be required.

STEP 9. Tack the main cab of the truck together.

To help in assembly, collect a clean piece of 2" x 2" square tubing approximately 4–5" long. This tubing will be used to keep your parts square during the assembly. Make sure the ends are cut square.

To make it easier to align your parts, clean the work area where you will set your parts while tacking. It should be flat and free of welding berries and debris.

To begin assembly, attach one of the sides to the back of the truck using C-clamp locking pliers and the piece of 2 x 2 scrap square tubing. Align the parts so they form an edge-to-edge outside corner joint (Figure 1-21).

Figure 1-21. a) Clamping your parts to something square while tacking will insure a good square corner during the assembly of the truck. b) Examine the joint area to make sure the alignment is tight.

Set your welder to the proper wire feed and amperage for the metal thickness being used and turn on the gas. These steps are often overlooked by beginning welders. In a shop environment where more than one person may be using the equipment, it is important to always check your welder settings.

With your welder set, tack the two parts together. The tack should be at least an inch or more in from the start of the joint. Allow the weld to cool before unclamping the square tubing. Next, tack the other side of the cab onto the back. Use a square after unclamping your tubing to insure your parts have remained square. If the parts have pulled out of square, bend the parts until they are 90 degrees. Good tacks will allow a certain amount of bending before they break, making adjustments possible. Next, tack on the front of the cab. The tubing shouldn't be necessary if the first three parts were squared. You may want a partner to hold the part for you while tacking. Continue on by tacking the hood, windshield, and top of the cab to the first four parts. Finally, turn the cab over and attach the bottom (Figure 1-22).

If all parts fit well, place at least one or two additional tacks in each joint to secure the parts and minimize possible distortion that could occur as the metal cools after the welding process.

Figure 1-22. Truck cab tacked and ready to be welded solid.

Tacking all parts of a box together prior to any solid welding helps to limit the effects of shrinkage as welds cool. It will also insure that your parts maintain the desired 90° angle. Attempting to weld two parts together at a time will result in parts that are extremely out of square.

HELPFUL HINT

Your tack welds should be small but strong (Figure 1-23). A tack that is too large will be difficult to weld across. A tack that is off center may be weak. A tack that is too small may break too easily. A good tack should be solid enough so that you can bend your parts back into square without them breaking when necessary, but not so strong that you have to cut or grind the tack apart to accomplish this task.

HELPFUL HINT

a b c

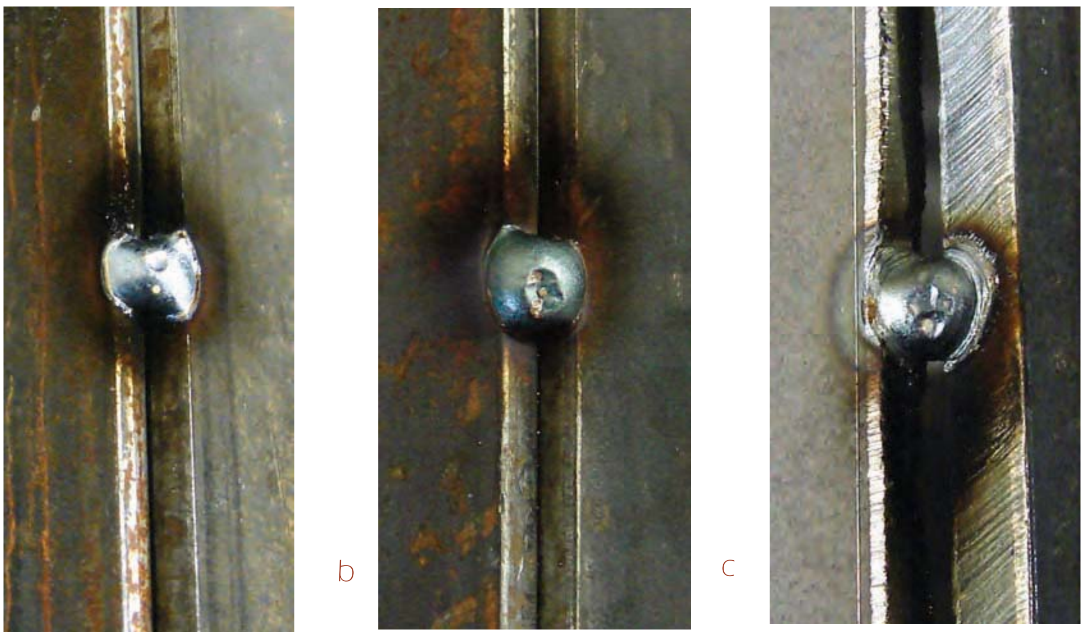


Figure 1-23. a) A properly tacked outside corner joint. b) An over-welded tack. c) Off-center tack.

SAFETY TIP

When using partners to tack welds, they should also wear a welding helmet. Just because they aren't doing the welding doesn't mean they can't be burned from the harmful rays that are given off during the welding process.

Many times after finishing a weld, a small berry will form on the end of your wire that feeds out the end of the tip. (Figure 1-24) When beginning your next weld, this berry can interrupt current flow, causing the wire to jump and spatter briefly. To minimize spatter and help insure a solid ground when tacking, clip the end of the wire before each tack with MIG pliers. The end of the pliers are pointed so that you can use them to clean spatter from the inside of the nozzle (Figure 1-25)

HELPFUL HINT

Figure 1-24. Berry on end of MIG wire.

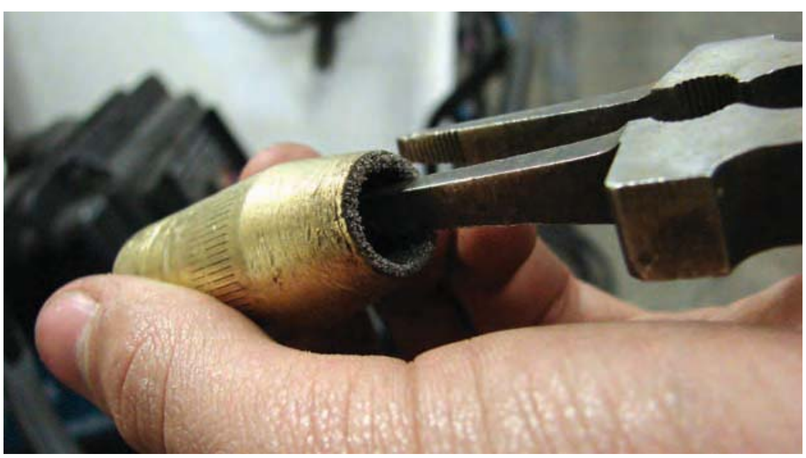


Figure 1-25. a)Clean the nozzle regularly to allow maximum gas flow from the nozzle. b) MIG pliers are specially designed to help you tighten or remove consumable parts in the wire feed gun, clean the nozzle, and clip wire.

STEP 10. Weld the cab together.

Now that the tack welding on the cab is complete, it is time to weld the cab solid. When welding thinner sheet metal using a wire feed welder, it is sometimes difficult to see your weld placement area due to the size of the nozzle. Here are several tips to make this process easier:

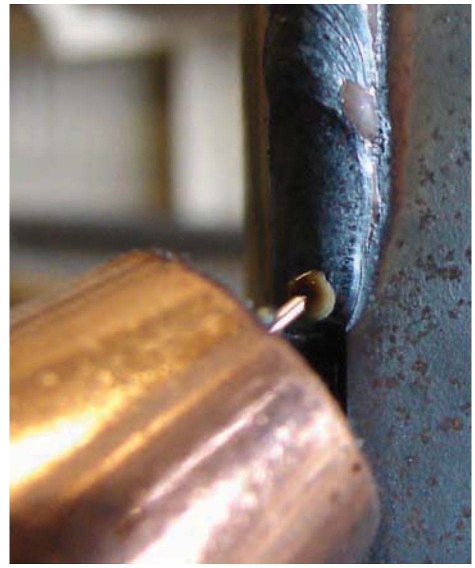


Figure 1-26. Proper angle when MIG welding vertical down on thin sheet metal.

1. Make sure you have good lighting.
2. It may be helpful to take a piece of soapstone and drag it up and down the inside length of the outside corner joint. The white color makes it easier to see the edges of the corner joint.
3. Weld vertical down while angling your gun slightly upward into your weld puddle (Fig. 1-26).
4. Position yourself above or just off to the side of the joint area so you can easily see the wire feeding into the molten puddle.
5. Your wire stick-out and distance from the welding surface should be 3/8" to 1/2".
6. Insure your welder is set properly and that you maintain the proper welding distance across the entire joint. Excessive spatter after weld completion is a sign that your welder was not set properly or you were welding too far away.
7. Make sure your hands are positioned so that you can weld the entire length of the weld without restarting.
8. This will be a quick fill. Be careful not to go so slow that you over fill the corner. Over-welding can require grinding and excessive clean up time. As a rule, if you have to grind a weld, it was most likely a poor weld. Grinding cost money and takes time; it should not be necessary (Fig. 1-27).
9. For more information and helpful hints on the MIG welding process, refer to Chapter 5 in *The Art of Welding* by William Galvery.

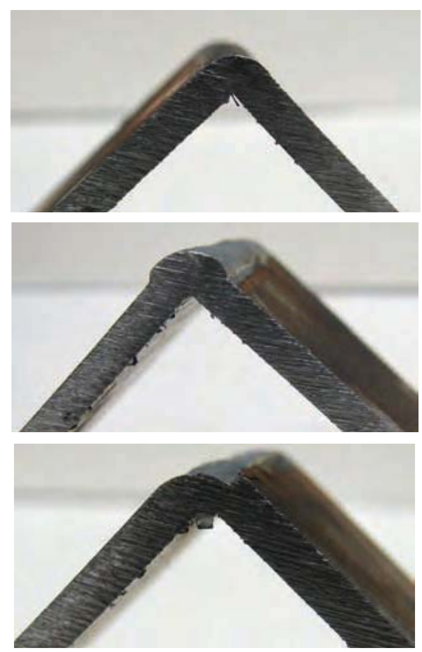


Figure 1-27. a) A good weld.
b) An overfilled weld.
c) An under-filled weld.

During the welding process, avoid welding in a circular pattern around the parts. Instead, try to weld kitty-corner to the first weld. For example, if you weld the bottom front joint of the cab first, then the second weld should be the top back joint of the cab.This will allow the front parts to cool and weld distortion should be minimal.

HELPFUL HINT

STEP 11. Clean up.

After the cab has been welded, some cleanup will be necessary. Berry spatter will need to be removed; if a joint has been over-welded, some grinding may be needed. The easiest way to remove berries is with a chisel and hammer or using a scraper similar to what was used when chipping the plasma dross (slag) from the truck parts (See Step 6).

STEP 12. Assemble the box and hubs.

When building the box and hubs, follow the same procedure that was used to assemble the cab. Tack first, then weld solid.

Begin with the hubs. Tack them together one piece at a time, using c-clamp locking pliers and a small piece of square tubing (Figure 1-28). Next, tack the box sides and tailgate to the box bottom, then weld the tailgate solid (Figure 1-29).

a)

b)

c)

Figure 1-28. a) Use locking pliers and 1″x 1″ square tubing when tacking the hub parts.
b) Hubs tacked together.
c) Completed hubs.

Figure 1-29.
a) Use tubing again to align the sides and tack them square to the bottom.
b) After tacking the sides, place the tailgate in place and make sure it is the correct width.
c) Flip the parts over and tack on the tailgate.
d) Weld the tailgate solid to the sides and bottom.

Attach the hubs and weld the sides to the base. These welds will provide some good practice welding in tight places. Do not weld the hubs on the underside of the truck. The wheel well needs to stay open to allow the wheels to sit inside and turn freely (Figure 1-30).

The final step in completing the truck box is to attach the rails. Again use square tubing and locking pliers to tack your part in place (Figure 1-31). After completing the welds on the truck box, clean-up will be necessary. Remove berries and grind any areas with excess weld.

a)

b)

c)

Figure 1-30. a) Hubs tacked in place. b) Hubs and sides welded solid. c) Underside of the hub free of any weld.

STEP 13. Attach the box to the cab.

Tack the box to the cab by placing both parts on a clean flat surface and sliding them together. Tack the two parts in place. Next, make two fillet welds up the side of the truck where the sides meet the back of the cab (Figure 1-32) and then a butt weld on the bottom base of the truck.

Figure 1-32. Fillet weld joining the cab to the box.

STEP 14. Assemble the wheels and attach to the axles.

The last parts to assemble are the wheels and axles. Lay out your parts and make sure that you haven't misplaced any of them. If the parts have any burrs or slag, remove it. A rattail file works well to get inside the pipe (Figure 1-33a). Look over the assembly drawing to get a clear understanding of how the parts will be attached together (Figure 1-33b).

Assemble the wheels first. Use shims to lift the wheel centers up into place when tacking. Then weld a fillet weld around the entire inside ring of the wheel. Clean any berries from the part that may have accumulated during welding. Place the wheels in a drill press and drill a 7/16" diameter hole in the center of each wheel. Use a small rattail file to clean the burrs from the holes after drilling (Figure 1-34).

Figure 1-33a. Wheel and axle parts.

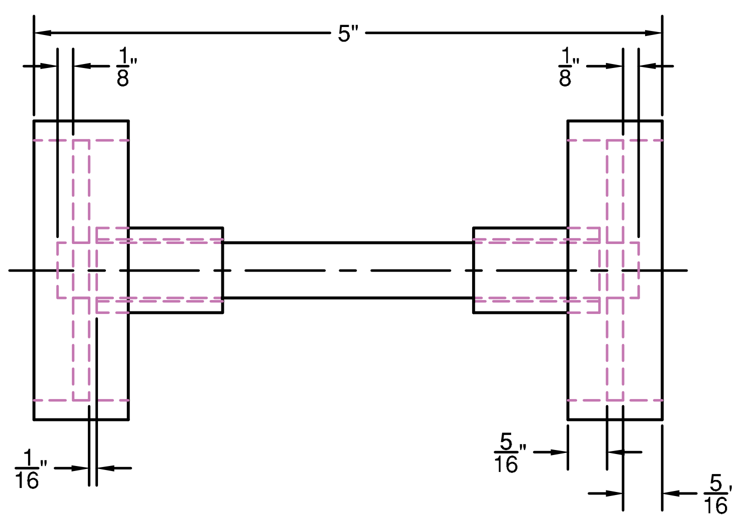


Figure 1-33b. Wheel assembly drawing.

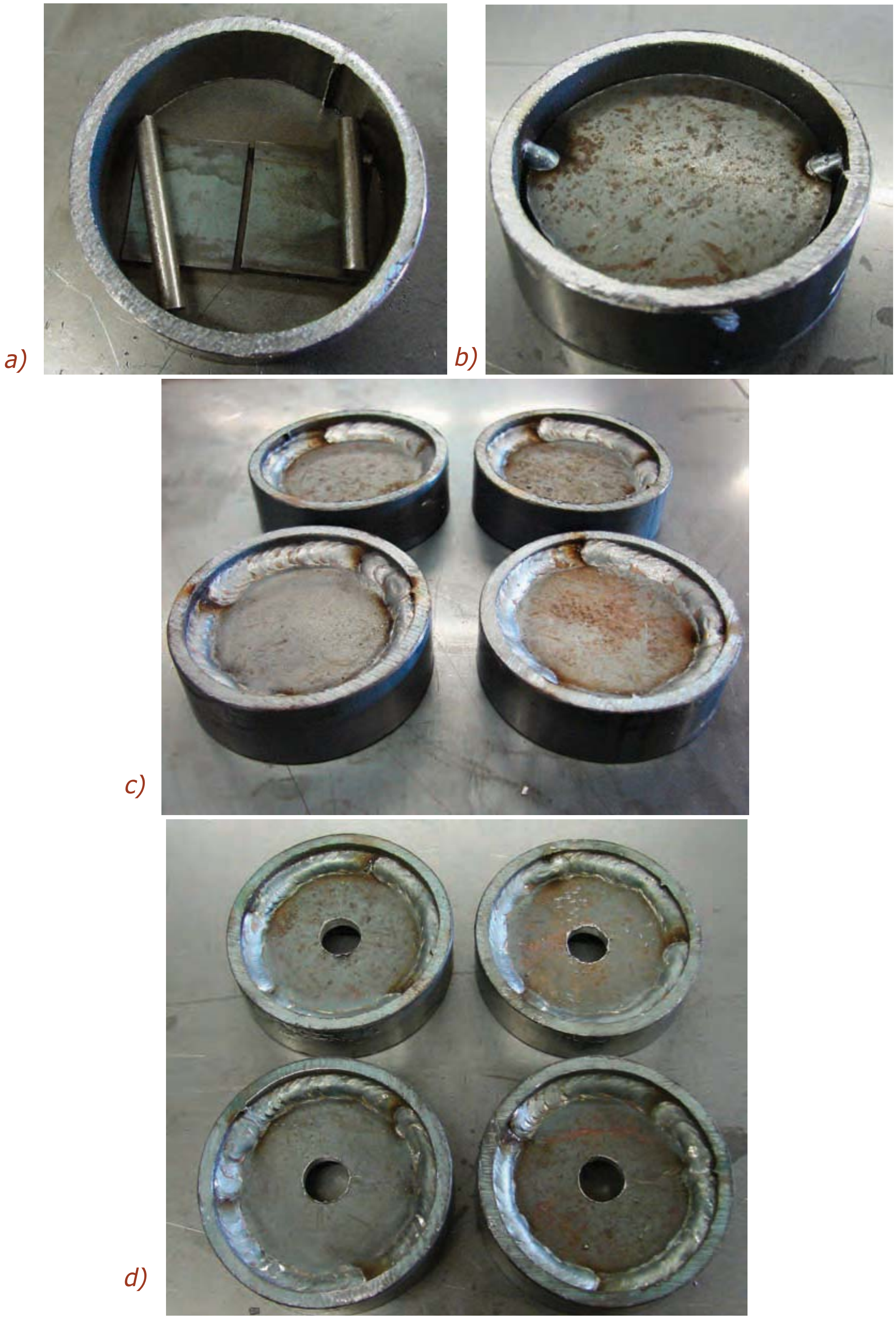


Figure 1-34. a) Use 1/8″ flat bar and 3/16″ rod for shims to place the wheel center in the right location. b) Tack the wheel center to the outside wheel. c) Completed fillet welds around wheels. d) Completed wheels with holes for axle placement.

Now that the wheels are complete, the axle will need to be attached. Begin by tapping the axle through the hole in one wheel (Figure 1-35). Slip two axle supports onto the axle then tap the other wheel onto the axle (Figure 1-36). Before doing any welding, flip the body of the truck over and place the wheel assembly in place and check to see that the axle is long enough and that the wheel will fit in the hub openings properly. Widen or shorten the wheel spread on the axle until the wheels are centered in the hub openings and the axle sticks out the outside of the wheels the same distance. Do this for both the front and back wheel assemblies. Next, use a square to make sure the wheels are aligned square and not twisted (Figure 1-37). When the assembly is square and the proper wheel location is set on the axles, tack the axle to the wheel centers on the outside only. Re-check for squareness after tacking, then weld the wheel center to the axle all the way around.

Clean any welding berries and the wheel assembly is complete.

Figure 1-35. Axle through the wheel center and axle supports slid onto axle.

Figure 1-36. Wheel assembly slid together.

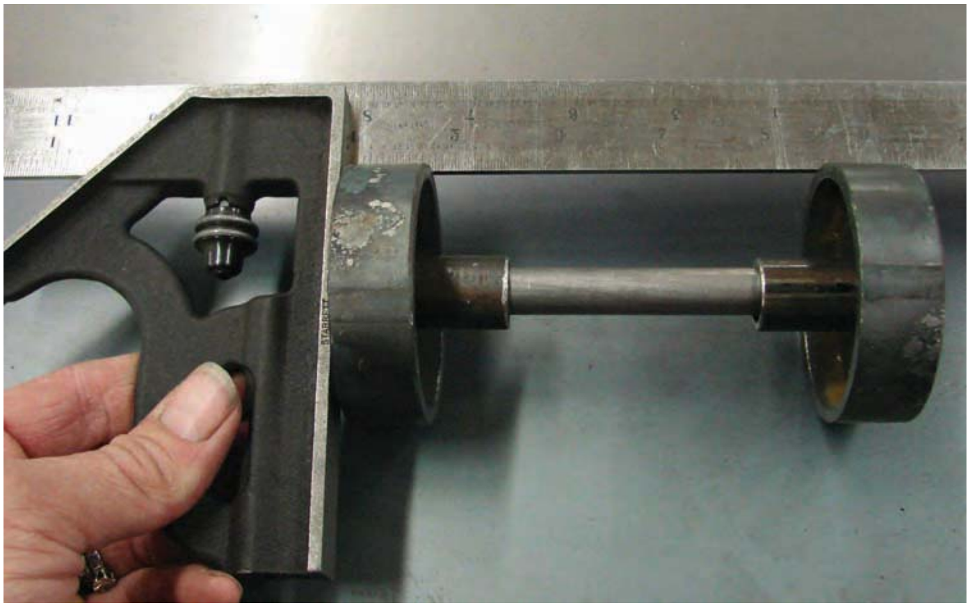


Figure 1-37. Squaring the wheels.

STEP 15. Attach the axle supports to the truck body.

To attach the axle supports, lay the wheel assembly into the hub openings and center them from front to back. Then use a square to make sure they align square with the sides of the truck box (Figure 1-38). Before tacking the axle supports to the bottom of the truck, make sure they are pushed out next to the wheel centers, leaving just enough room for the wheel to turn but not slide more than 1/16" back and forth. When the parts are in place, tack the axle supports to the base of the truck. Check to make sure the wheels turn freely, then weld the axle supports on both sides with a 1/4" to 1/2" weld.

Figure 1-38. Use a square to position your wheel assembly on the truck properly.

STEP 16. Additions can be made to the truck.

Now that the truck is complete, you can paint your project or consider making some additions to the original plans first. You can easily modify the plans after the basic parts have been assembled. Some simple additions include front and rear bumpers, lights, mirrors, and a ball for a trailer hookup. Figures 1-39, 1-40, and 1-41 provides examples and placement dimensions.

Lights and mirrors are cut from 3/8" sch40 pipe 1/4" long with a 1/4" piece of 3/16" round bar attached.

Bumpers are made from 1/2 x 1/2 x 1/8 angle iron 5-1/2" long.

The ball is 3/16 rod 1/4" long welded to a 3/8" steel ball. The ball is welded to a piece of 1/8 x 1/2 strap 1" long with corners chamfered 1/4" x 1/4". Weld the ball to the plate by drilling a hole in the plate and welding the rod to the plate from the bottom side.

To fill in the mirror, weld a thin piece of 3/8" rod about 1/8" long to the inside. Your imagination and creativity are the only limits to what can be added to this simple truck!

Figure 1-40. Truck front with lights and a bumper and mirrors off the sides of the door area.

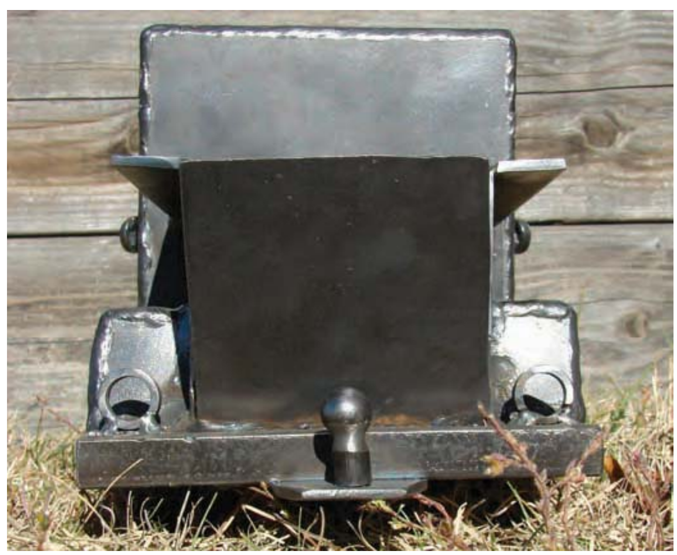
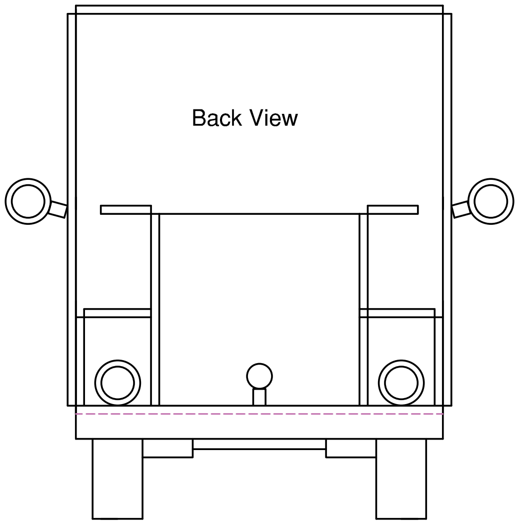
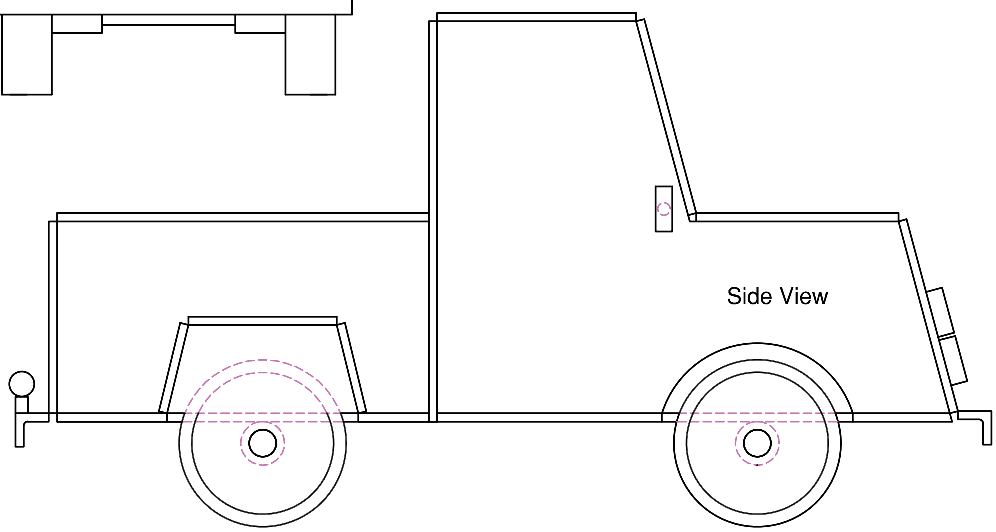


Figure 1-41. Truck back with bumper, ball, and tail lights.





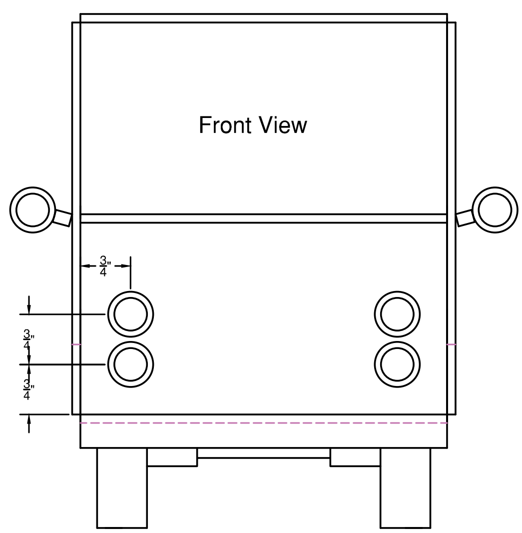


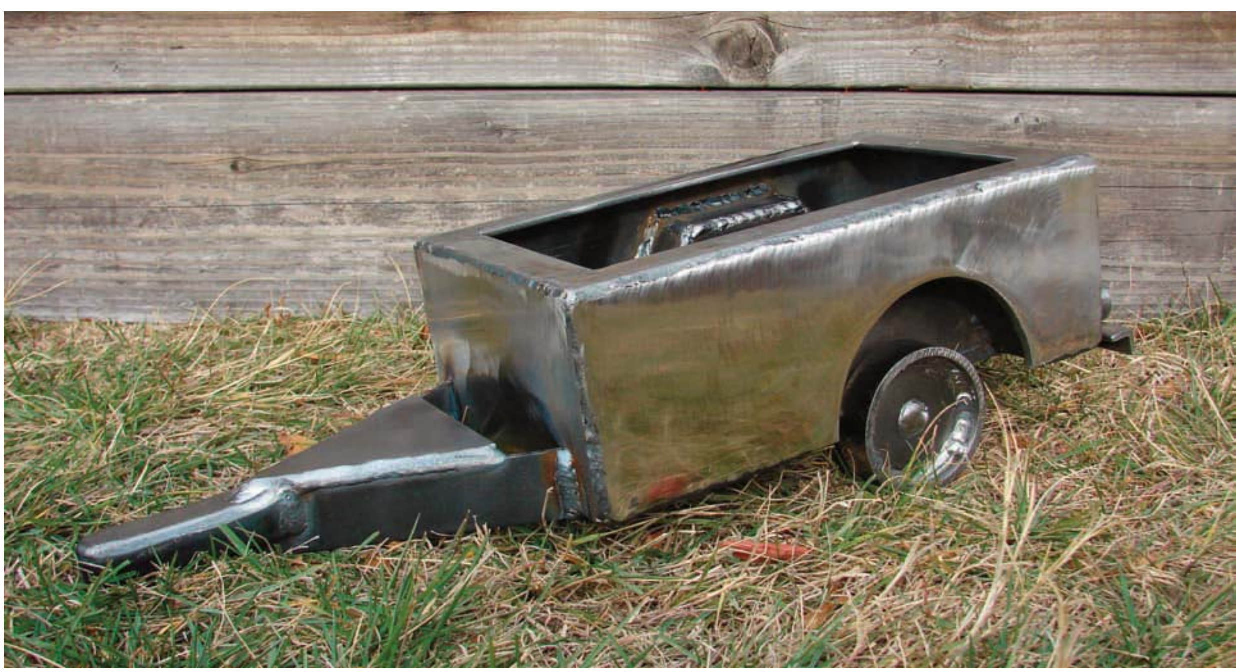
Figure 1-39. Truck views with added features.

CHAPTER 2

Wagon

The wagon was designed to be either a standalone project or an add-on to the truck. It is less difficult and time consuming to build than the truck, yet utilizes the same construction processes. You can save time by using prefabricated material, such as flat bar, rather than laying out parts on sheet metal and plasma cutting each piece.

Like the truck, this project was designed for the beginner MIG welder. It provides practice welding the basic joints and teaches proper joint alignment and the importance of accurate measuring. The project also provides helpful hints and proper techniques for working with a variety of tools you may use in the welding shop environment.



Wagon Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
2	Sides	Flat Bar	1/8"	3"	0'-9"
1	Bottom	Sheet Metal	10ga	0'-5 1/2"	0'-9"
2	Front & Back	Flat Bar	1/8"	3"	0'-5-1/2"
2	Side Rails	Flat Bar	1/8"	3/4"	0'-9"
2	Front & Back Rail	Flat Bar	1/8"	3/4"	0'-3-7/8"
2	Hitch Sides	Flat Bar	1/8"	1"	0'-3-3/4"
1	Hitch Top	Sheet Metal	10ga	0'-2 7/8"	0'-2-1/2"
1	Tongue Side	Flat Bar	1/8"	1/2"	0'-5-7/8"
1	Tongue Top	Flat Bar	1/8"	3/4"	0'-8"
2	Hub Sides	Sheet Metal	10ga	0'-1 5/16"	0'-2-7/8"
4	Hub Front & Back	Flat Bar	1/8"	1-1/4"	0'-1-3/8"
2	Hub Top	Flat Bar	1/8"	1-1/4"	0'-2-1/4"
2	Outside Wheel	2" Sch40 Pipe	.154	2.375 OD / 2.067 ID	0"-3/4"
2	Wheel center	Sheet Metal	10ga	2 1/16" Ø	-
1	Axle	Rod	7/16" Ø	-	0'-4-5/8"
2	Axle Support	$\frac{3}{8}$" Sch40 Pipe	.091	.675 OD / .493 ID	0'-1"
1	Rear Bumper	Angle	1/8"	1/2" x 1/2"	0'-5-1/2"
2	Bumper mounts	Rod	3/16"Ø	-	0'-1-1/8"
2	Rear Tail Lights	3/8 Sch40 Pipe	.091	.675 OD / .493 ID	0'-1/4"

Figure 2-1.

STEP 1. Purchase material needed for wagon construction.

Before starting the project, look over the parts list (Figure 2-1) and identify the material needed to construct the project. The wagon will require the purchase of 10ga (1/8") sheet metal, 3/8Sch40 pipe, 7/16" rod, 1/2" x 1/2" angle iron, and various widths of 1/8" flat bar material.

It may also be helpful to review the plan views before beginning construction (Figure 2-2).

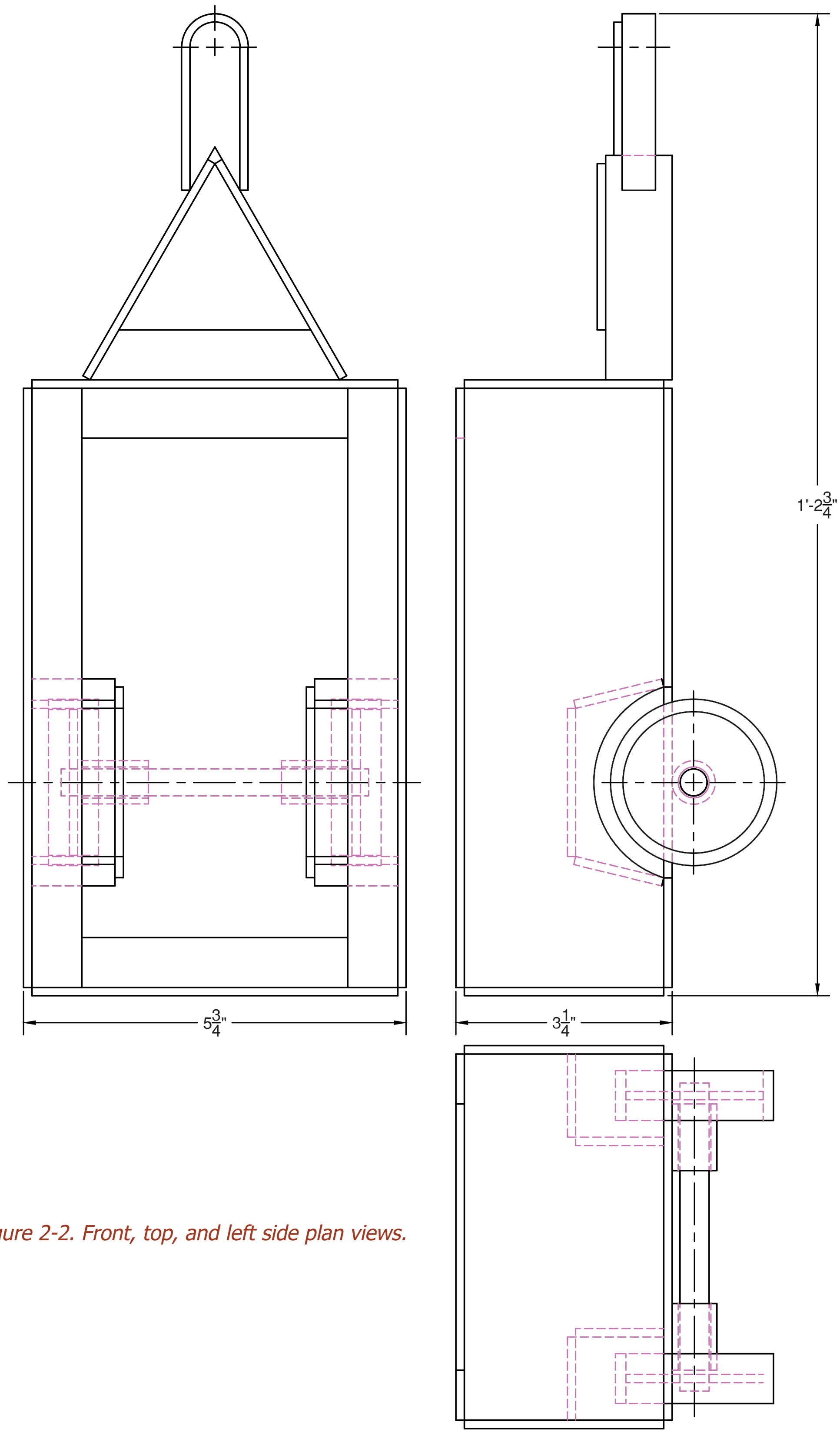


Figure 2-2. Front, top, and left side plan views.

STEP 2. Lay out sheet metal parts, cut to size, and remove dross.

Less than one square foot of material will be needed for the bottom, hitch top, hub sides, and wheel centers. These parts should be cut out of 10ga sheet metal using a plasma cutter. Figure 2-3 provides a suggested layout plan that may be followed. Use a scribe and square to outline your parts, being as accurate as possible when measuring.

When layout is complete, use a plasma cutter and a circle cutting attachment, if available. Otherwise, trace the circles with a metal compass and hand cut your circles.

Cut the remaining parts with the plasma cutter. Clamp a straight edge to your plate

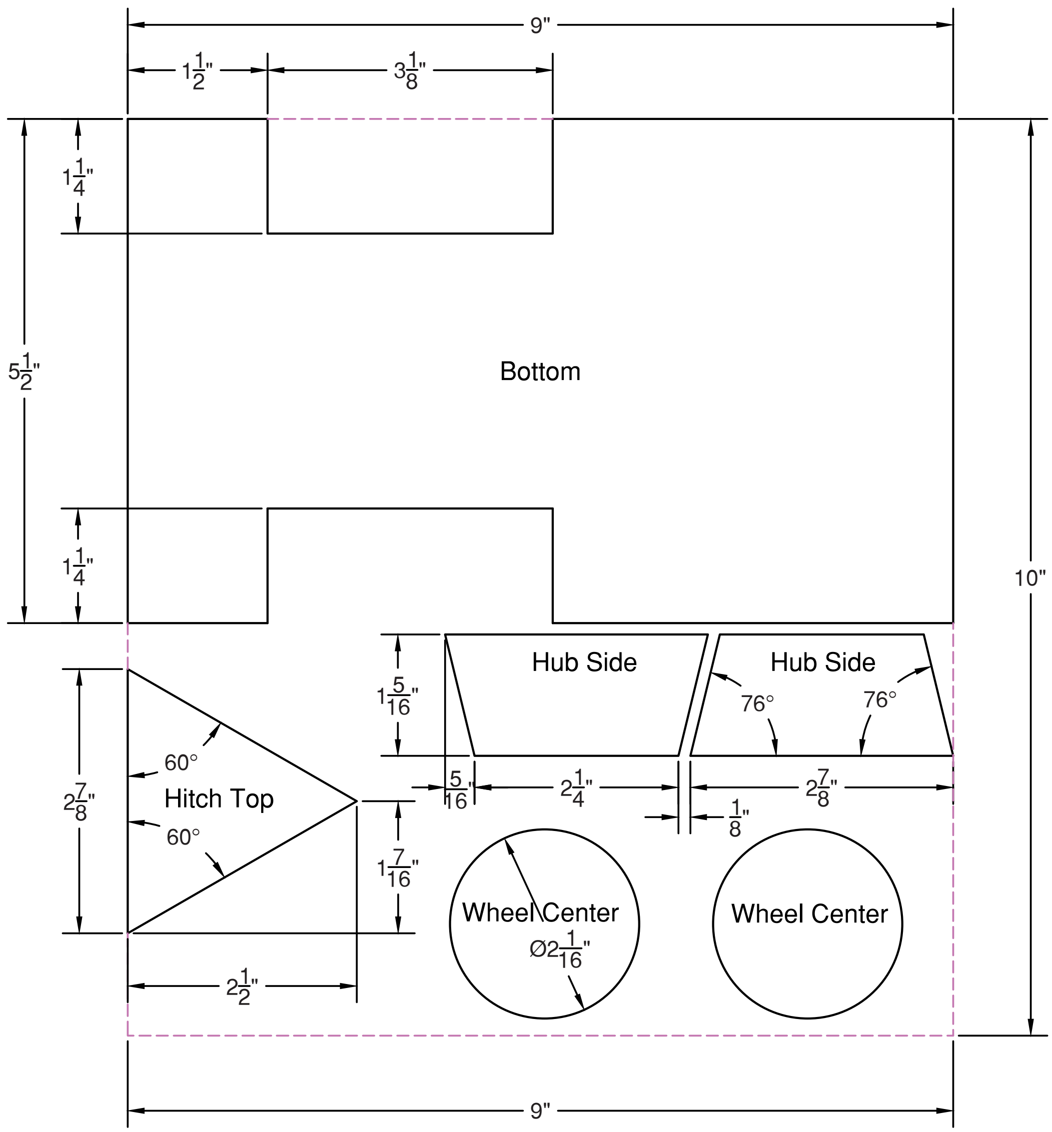


Figure 2-3. Suggested layout plan.

with locking c-clamp pliers to act as a straight edge guide. After cutting, remove the dross (slag) from the bottom side of the parts. Then polish the surfaces if needed to remove any rust that may be visible.

Notes:
For instructions and helpful hints on lay-out procedures and plasma cutting techniques, refer to the truck plans in Chapter 1, Steps 3–6.

STEP 3. Cut the remaining parts; then clean the ends.

With any project that you build, part accuracy is the key to proper fitting weld joints. Wide gaps are more difficult to weld and produce issues with weld appearance. Cleanup time can be increased tenfold with poor fitting joints.

The remaining parts are cut from strap, pipe, and round bar. If more than one part of the same length is required, use a parts stop, which is an attachment to a cutting machine that provides a stopping point for metal as it is slid into and past the vice. A stop allows a fabricator the means to cut multiple parts exactly the same length.

Most brands of cutting machines come with or have options to purchase a material stop (Figures 2-4). But if your saw is not set up for a stop, you can improvise. If your saw is mounted solid to a table or the floor, or is heavy enough that it does not move during operation, a scrap piece of steel or even a metal saw horse can be used as a stop with moderate accuracy. If your parts are short enough that they do not extend past the jaws of the vise, a combination square can be used as a stop instead (Figure 2-5). With a little creativity, any cutting device can be set up with a stop of some sort.

After the cutting process is complete, all parts will need some cleanup, depending on the saw that was used. Sharp burrs left at the end of the cut will need to be ground off (Figure 2-6). To clean the inside of the pipe, use a rattail or half round metal file.

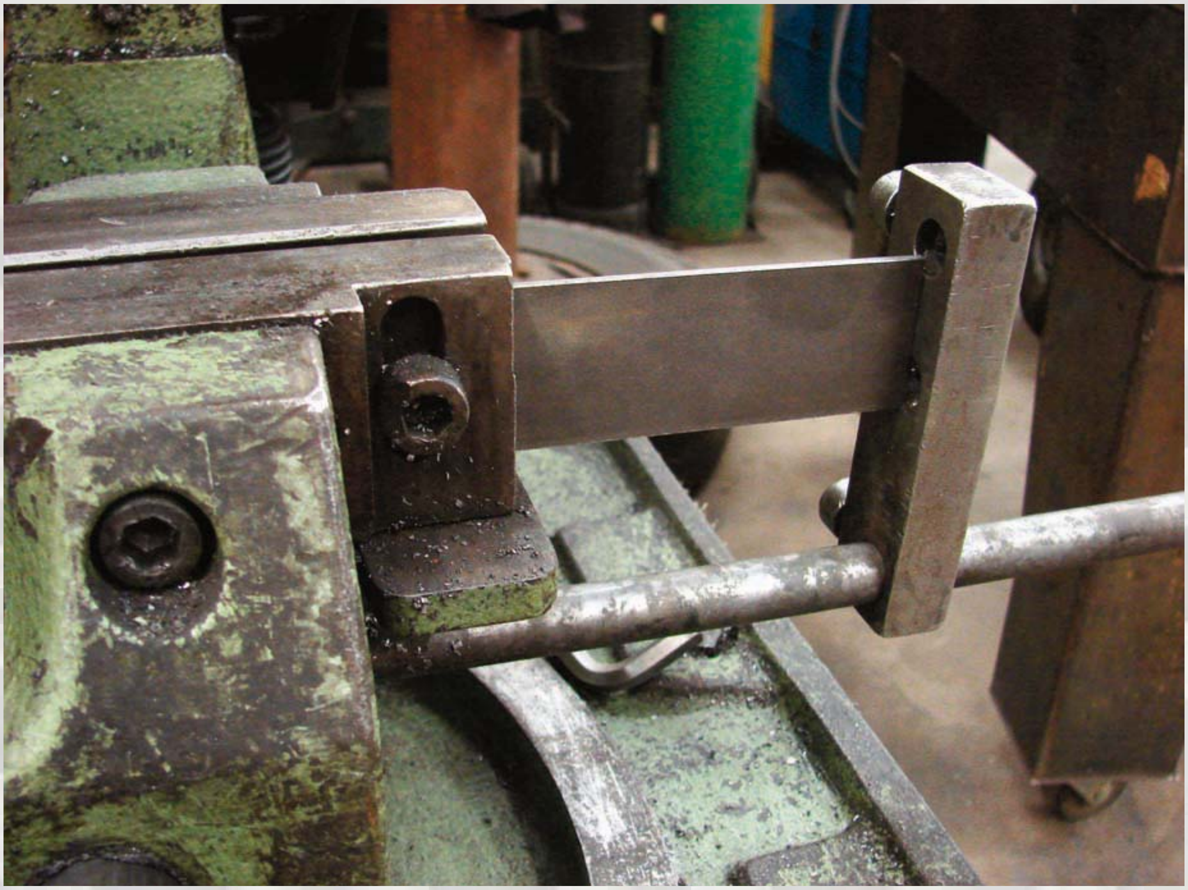
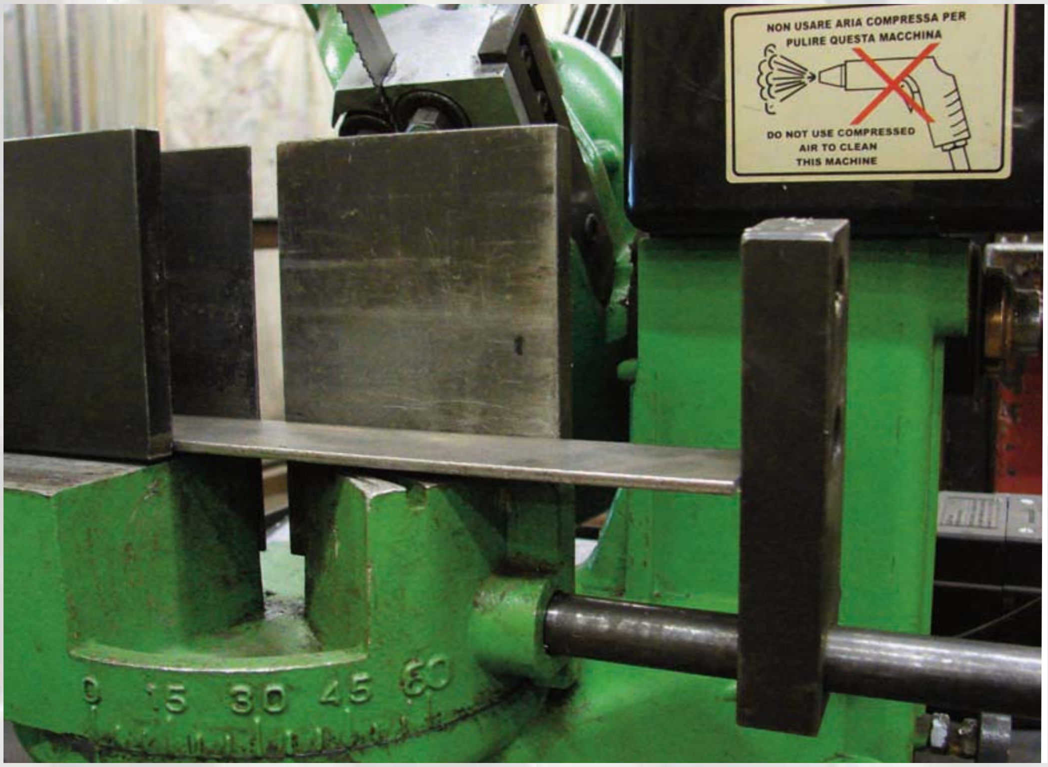


Figure 2-4. a) Example of a material stop attached to a cold cut saw.



b) Example of a material stop attached to a band saw.

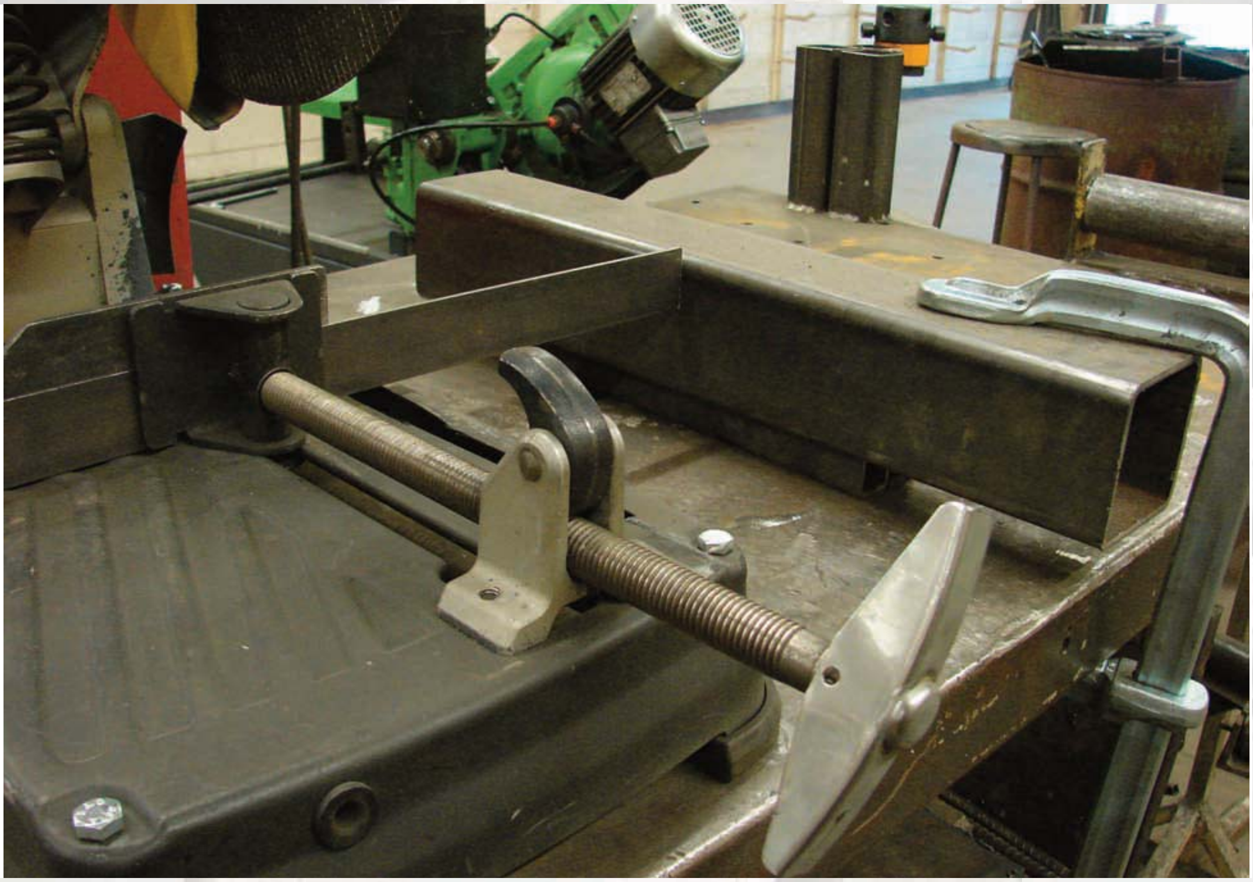
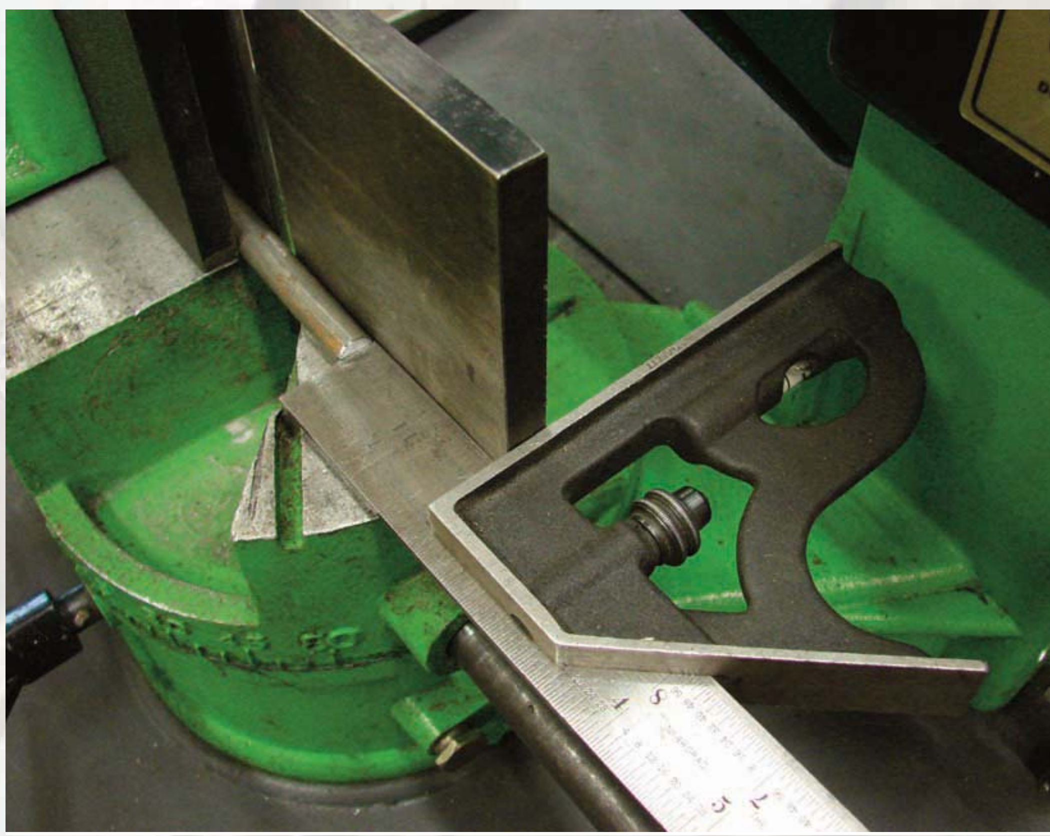


Figure 2-5. a) An abrasive cut-off saw set up with a stop to cut multiple parts the same length.



b) A combination square being used as a stop for short parts in a band saw. This type of stop is fairly simple to set up. First, align the stock in the saw for the first cut and tighten the vise. Slide the end of the ruler on the square up to the stopping point of your material, keeping the square against the solid end of the vise. Tighten the rule so that it can no longer slide. When you are ready to cut your next part, just slide the stock up to the end of the rule and tighten the vise again.

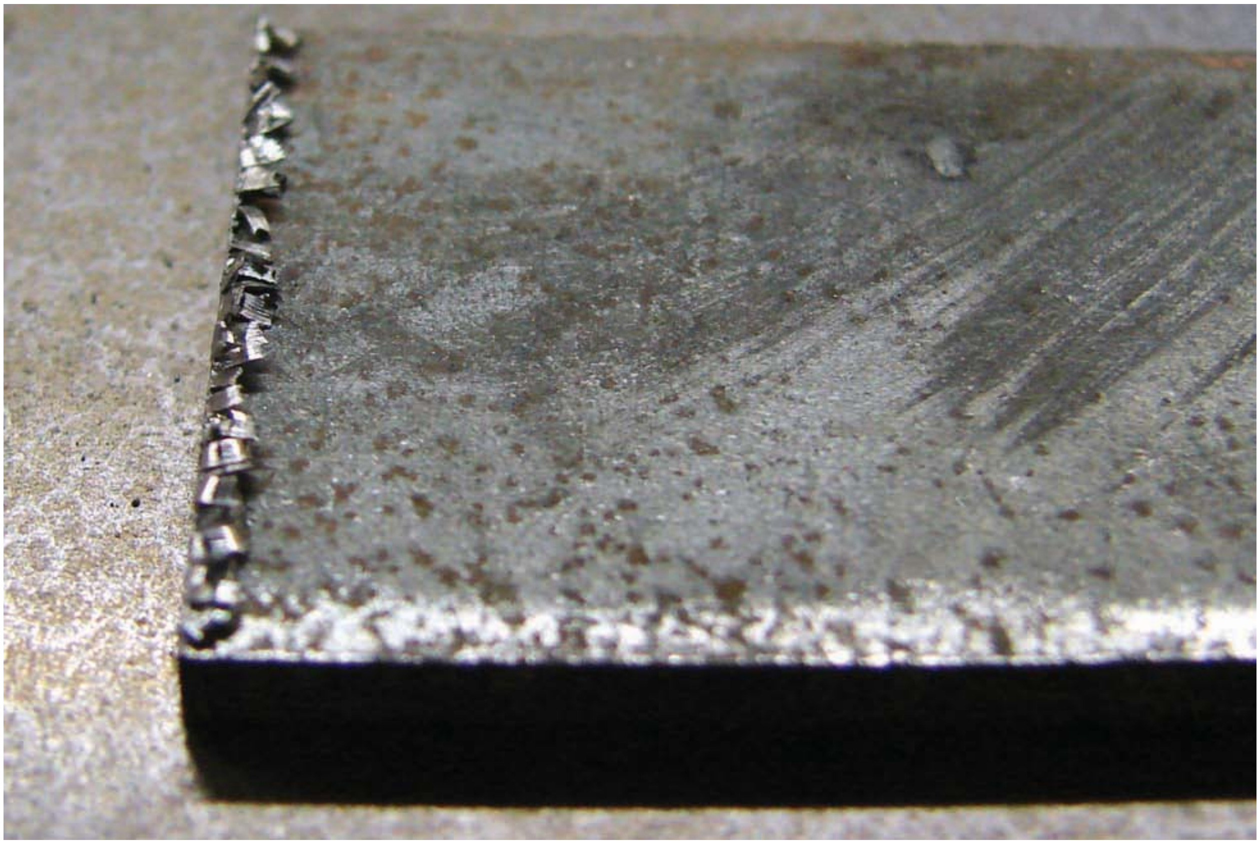


Figure 2-6. A piece of strap that was cut on a band saw. Notice the burrs left at the end of the cut. Remove these with a stationary grinder, portable hand grinder, metal belt sander, or metal file.

STEP 4. Check the main body parts for part accuracy.

As with all box-type projects, parts should be checked for accuracy in length and width to insure your weld joints will be tight. The easiest way to check for accuracy is to lay your parts down side by side on a flat surface (Figure 2-7). If the lengths match, you are ready to assemble the project.

Because most of the parts for this project are made from strap, the width will automatically align, making it unnecessary to rotate the back to the sides to check for fit. The length measurements will be the main focus when checking alignment. If you are off by more than 1/8", new parts should be cut, or the plans should be altered to fit the shortest piece.

HELPFUL HINT

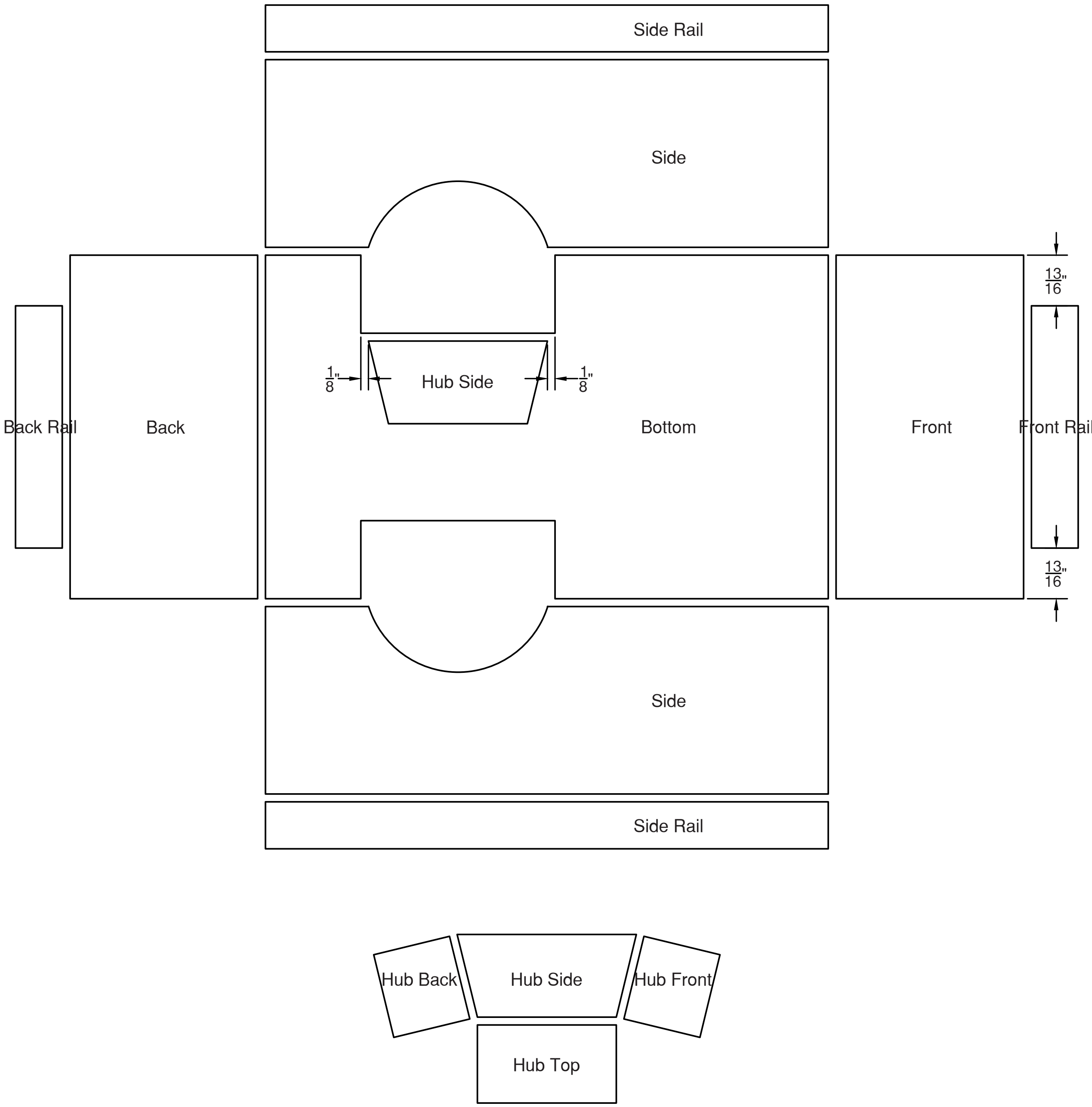


Figure 2-7. Checking parts for accuracy.

STEP 5. Cut hub openings in sides.

To cut out the arcs that will be the hub openings in the sides, you can either plasma cut the radii by hand or use a plasma circle cutting attachment. If you plan on using a circle cutting attachment, which is the most accurate way of cutting your hub openings, some extra setup will be required (Figure 2-8).

Notice in Figure 2-8 that a piece of 3/4" flat bar 9" long is placed between the two sides and tacked in four places, with the overall gap between the sides being 7/8". When that setup has been completed, use the dimensions given in the drawing to punch a divot for a pivot point for the circle cutting attachment. Next, set up the circle cutting attachment to the proper stick out and radius; then cut out the circle. After cutting the circle, break the tacks on the strap. Then remove the tacks with a stationary or hand held grinder. Clean the dross from the back side of the part where the circle was cut and your hub openings are complete.

Notes:
If you have never used a circle cutting attachment with a plasma cutter, refer to the Truck plans in Chapter 1, Step 4, for details on circle cutting instructions and helpful hints.

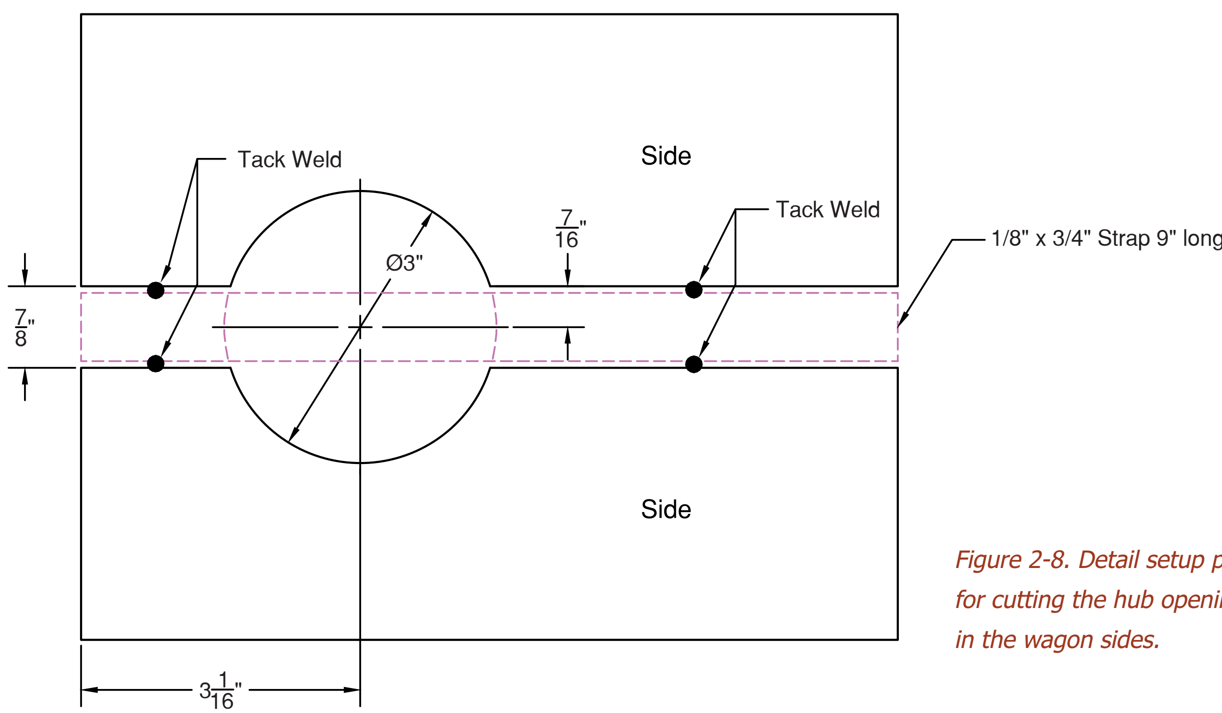


Figure 2-8. Detail setup plan for cutting the hub openings in the wagon sides.

STEP 6. Tack the body of the wagon together and weld solid.

Some key points to keep in mind. First, most of the parts for this project fit together as outside corner joints (Figure 2-9). Second, when building a box, it is important to tack all parts together prior to welding the joints solid in order to ensure the parts hold square. If you weld the parts solid one at a time, then when the welds cool, the parts will pull towards or away from each other, depending on which side the weld was on, and become out of square. It is then virtually impossible to square them back up. As a result, when each sequential part is added, the joints become more difficult to properly align.

With these points in mind, begin by tacking the four parts of each hub together. Begin by tacking the top to the side using a small piece of square tubing to hold the parts in line and square. Continue on by tacking the two sides in place. Repeat these steps for the other hub, then weld the hub outside corner joints solid. (For hub assembly illustrations, refer to the truck plans, Figures 1-28a, 1-28b, and 1-28c, in Chapter 1).

Now the main parts of the box can be tacked together. First tack the front to the bottom. To align the joint so that it is an outside corner joint, use a piece of 2" x 2" square tubing and two locking c-clamp pliers to hold the parts square and in place while tacking. Continue on by attaching the back to the bottom, followed by both sides (Figure 2-10). If everything has been joined properly, weld all outside corner welds of the box solid.

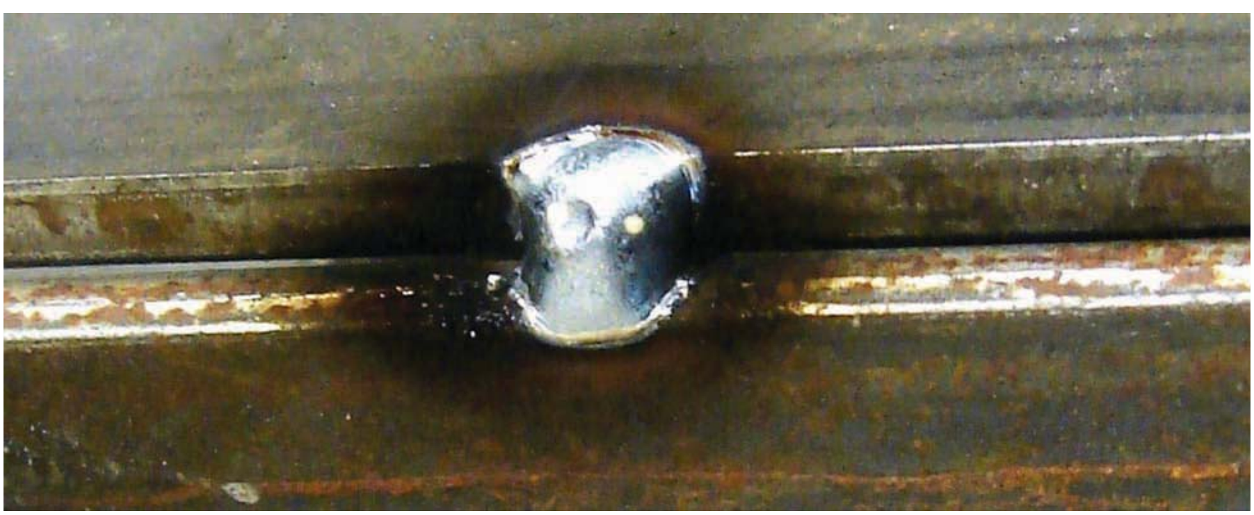


Figure 2-9. Example outside corner joint.

Then move to the inside of the box where the hubs should be put in place, tacked, and welded solid. Weld only around the hubs where they attach to the box bottom on the inside. There should be no welds made on the outside bottom of the wagon. This will eliminate the chance of any weld getting in the way of the rotation of the wheels after they are put in place.

Finally, attach the rails. Tack the side rails to the box first using a small 3/4" x 3/4" piece of square tubing and locking c-clamp pliers to aid in proper placement of the two parts. Follow that by tacking the front and back rails to the box. If the rails are the correct length, there should be a gap of about 1/16" where the side rails meet the front and back rails (Figure 2-11).

Figure 2-10.
a) Use locking c-clamp pliers to align joints prior to tacking.

This gap will allow for proper penetration of the butt weld joint between the parts. With everything in place, weld the rails to the box solid and the main part of the box is complete.

Notes:
For helpful hints and a guide to
tacking and welding your wagon parts together,
refer to the truck plans in Chapter 1, Steps 9 and 10.

Figure 2-10.
b) Wagon box tacked together.

Figure 2-11. Proper butt joint spacing between the front and side rails.

STEP 7. Clean the parts.

At this point, the main body of the wagon is complete and some cleanup will be necessary. Remove any berries that may have attached to the inside and outside of the box with a chisel and hammer. To shine your parts in the welded areas, use a wire wheel. The butt joints on the top rails should be ground flush with the surface of the flat bar.

STEP 8. Construct the hitch and tongue assembly.

The hitch will require some bending and grinding of parts and may prove to be the most difficult step when building the wagon. But, if care is taken to prepare your parts correctly, it can be done with accuracy. (Refer to the detail views of the hitch and tongue in Figure 2-12 for placement dimensions and reference when constructing this section of the project.)

To begin, tack the triangle-shaped hitch top to the hitch sides (Figure 2-13). Do not weld the parts solid until the tongue is attached.

The tongue top will need to be fabricated next. One end requires some rounding and the other, a V-groove. The finished length will be 2-1/2".

Note:
The tongue top length listed in the parts list is longer than the finished length to make it easier handle when constructing the part.

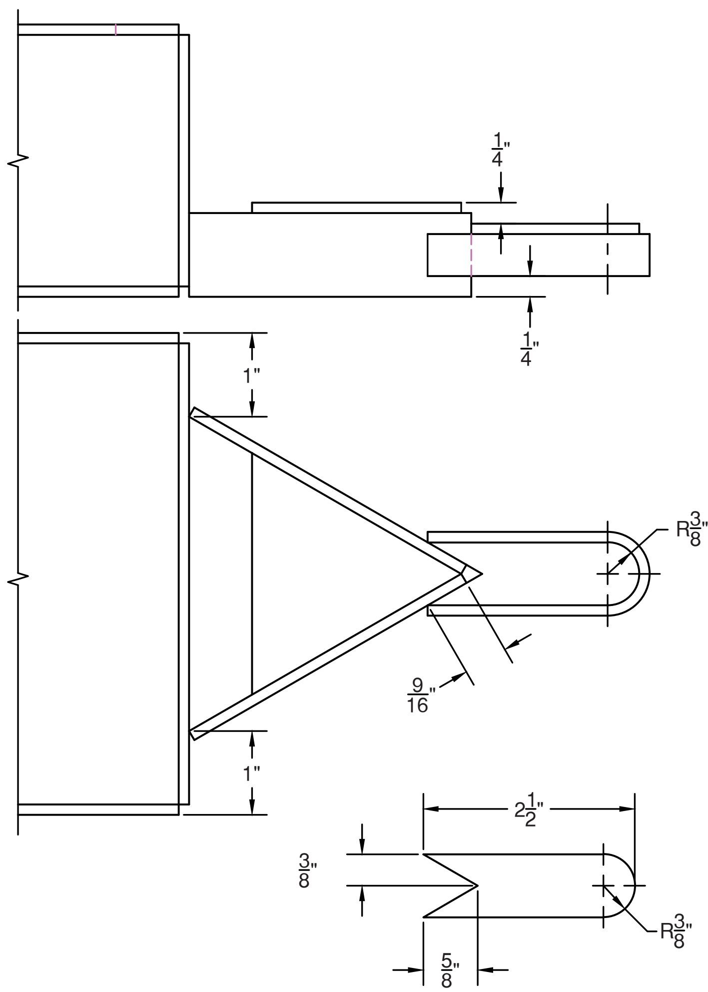


Figure 2-12. Hitch and tongue detail view.

Figure 2-13 a) Use 1"x 1" sq. tube and locking C-clamp pliers to align the hitch parts before tacking.

b) Hitch top and sides tacked.

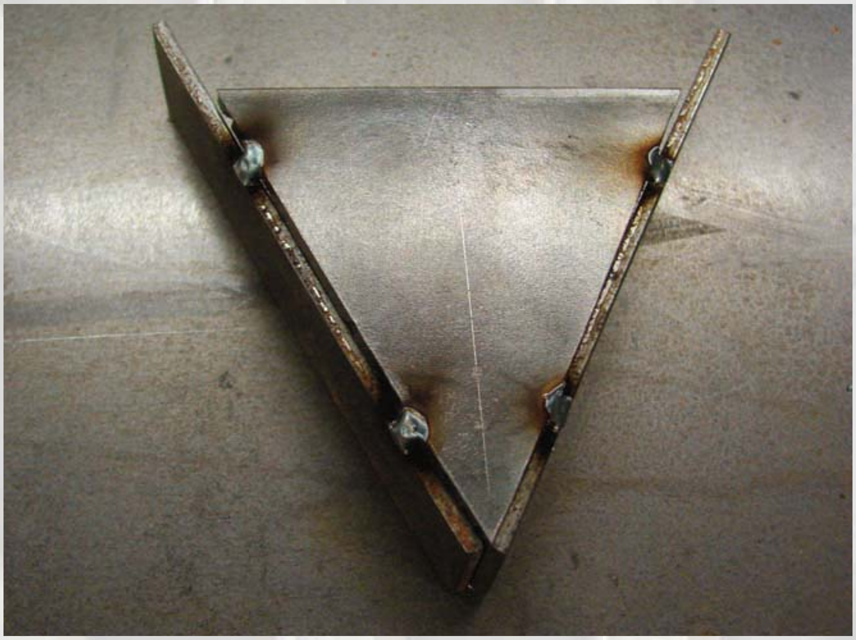


Figure 2-14. a) Use C-Clamp locking pliers and a straight edge to make a straight cut in the hitch tongue top.

b) Finished V-groove in hitch tongue top.

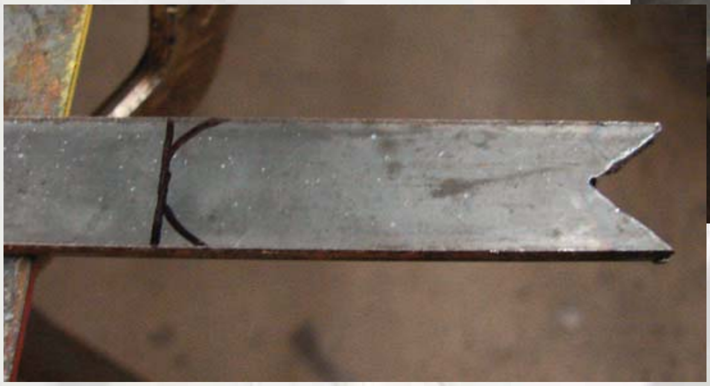


Figure 2-15. Shape the rounded end of the tongue.

To begin, measure and mark the finished length of the tongue. Scribe the lines for the V-groove and use a circle template to trace the end radius. To cut the V-groove, use a plasma cutter and a small piece of 1/4" strap as a straight edge (Figure 2-14); then cut the part to length. To finish the part, use a stationary grinder to round the end with the aid of some locking pliers for safety purposes (Figure 2-15).

When the tongue top is complete, attach it to the tongue side with 1/4" extended past the start of the V-groove. A piece of scrap 1/2" x 1/2" square bar can be used to keep your parts square and in place during this step. Tack the parts in two places — one just past the V-groove and the other at the point where the bending should occur (Figure 2-16).

Figure 2-16. Tongue top and sides tacked and ready for bending.

Next, set up an oxyacetylene station with a gas welding tip. The size of the tip doesn't necessarily matter; however, too large of a tip could cause you to overheat your part as you are bending. A smaller tip, typically used to gas weld 1/8" material, would work best.

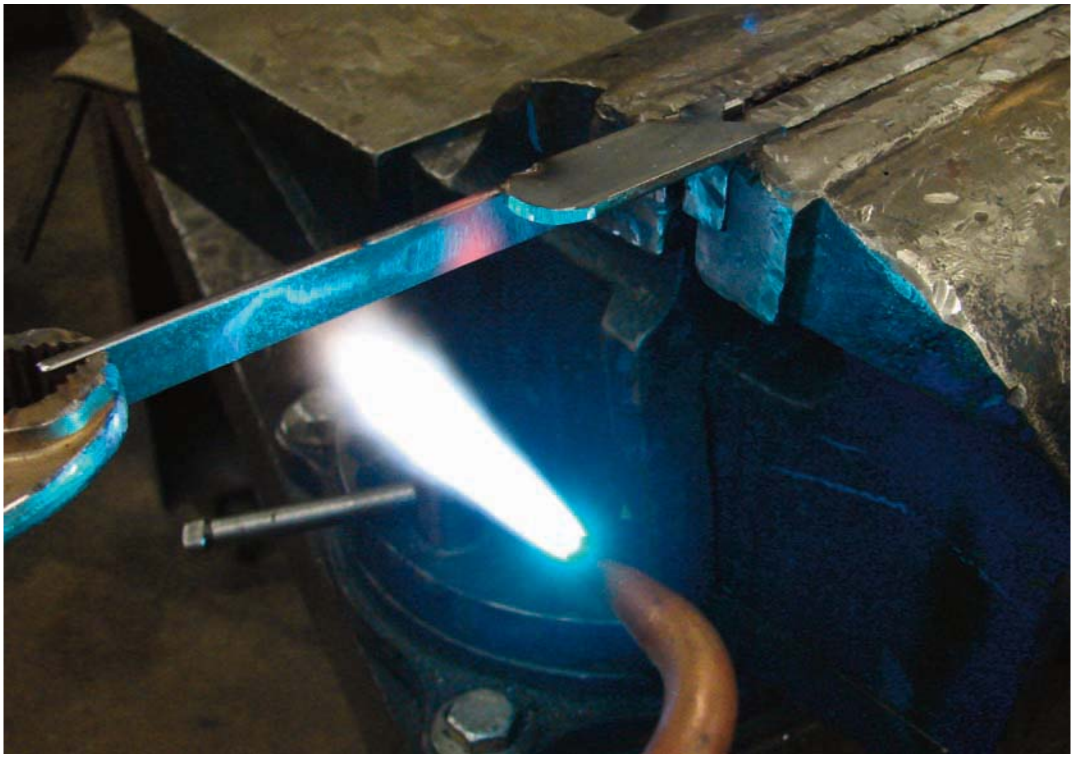


Figure 2-17. Heating the tongue side so that it can be bent around the front of the tongue top.

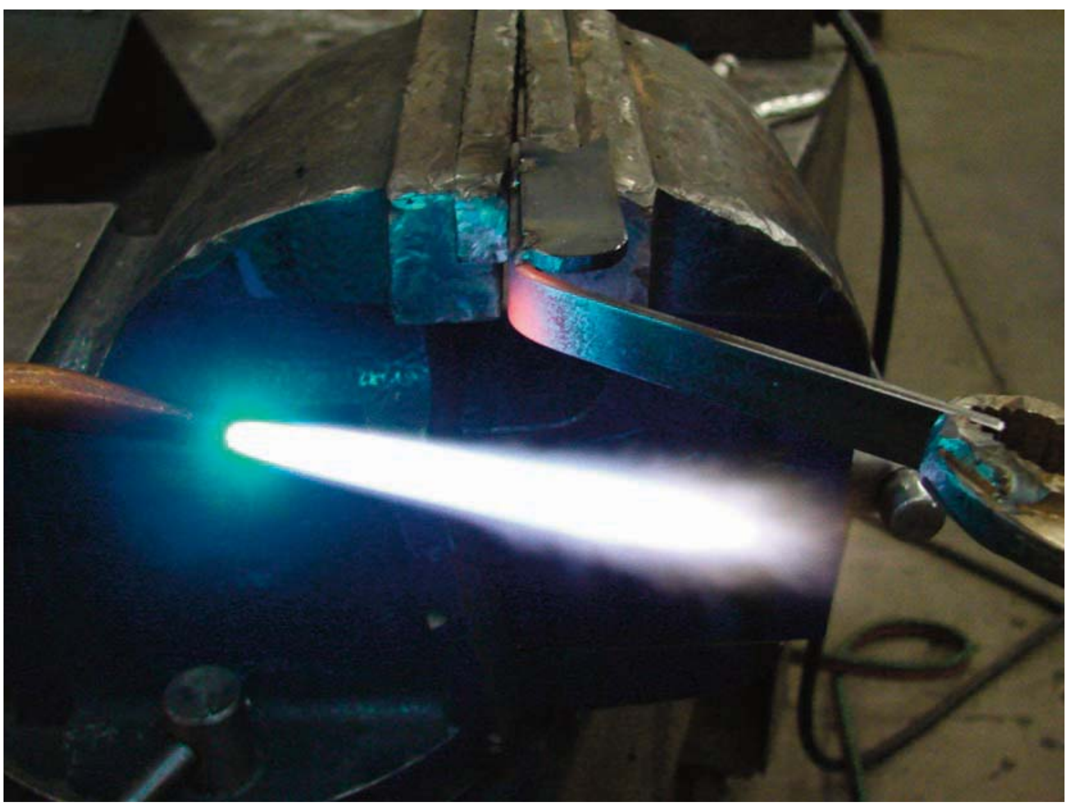


Figure 2-18. Bending the tongue side.

a)

b)

*Figure 2-19. a) Tongue parts removed from the vise and ready for final bending.
b) Completed bend on tongue side. Notice the proper outside corner alignment.*

Before bending, place your part in a vise. Clamp a pair of locking pliers to the end of the strap. They will keep your hands away from the extremely hot metal and be used for leverage when bending. Using the oxyacetylene gas torch, heat the tongue side until it is cherry red; then begin bending (Figure 2-17). Using the locking pliers, pull on the end of the tongue side as it is being heated and bend it around the end of your tongue top (Figures 2-18). Bend the tongue side around the top as far as possible while the parts are clamped in the vise. Then remove them and complete the bend (Figure 2-19). Tack the tongue side to the tongue top in two places on the side that was just bent.

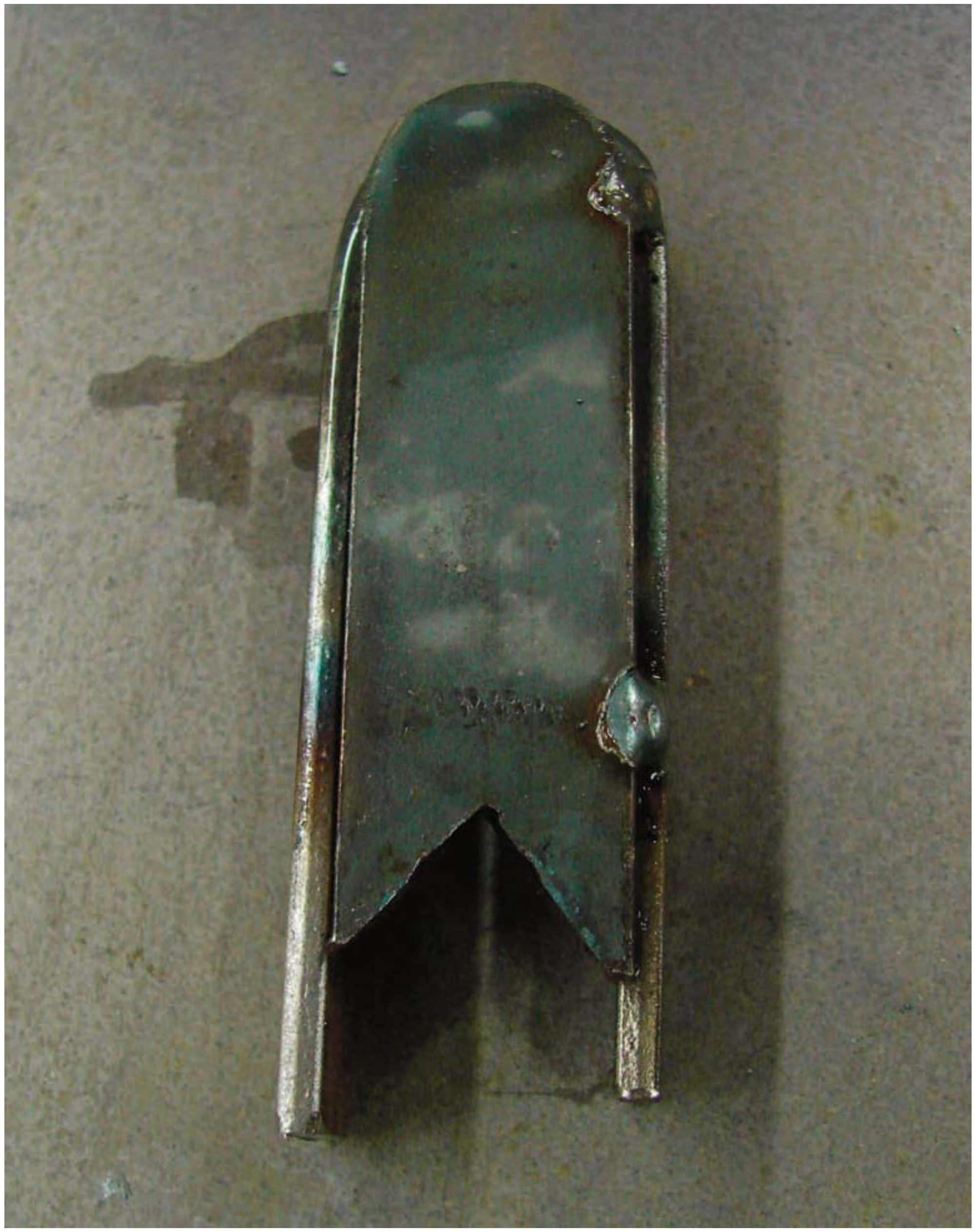


Figure 2-20. Trim the long end to complete the tongue side bending process.

The ends of the tongue sides may not be equal when the bending is complete (Figure 2-20). If this is the case, plasma cut or grind off the long end, matching the length of the end that was tacked to the tongue top first.

Finally, tack the tongue to the hitch. The tongue attaches to the hitch 1/4" up from the bottom of the hitch sides. A 1/4" piece of scrap can aid in proper placement. Before tacking, use a square to make sure the tongue runs straight with the hitch. Place one tack on the side and recheck to make sure that after the tack cooled, the tongue did not pull out of alignment. If it did, try bending the tongue back into place. If this doesn't work, break the tack and try again. (Figure 2-21).

After all parts are aligned and in place, weld all the outside corner joints and t-welds solid on the hitch assembly.

When heating, be conscious of where the bending point should take place. If the hot spot is too far back or ahead of the bending point, your side part will not align with the end of the top part.
Also be aware that if the metal gets too hot, the result may be a sharp corner rather than a radius.
This process takes skill.
If this is a first attempt at bending steel, it may take a couple of tries to get it right.

HELPFUL HINT

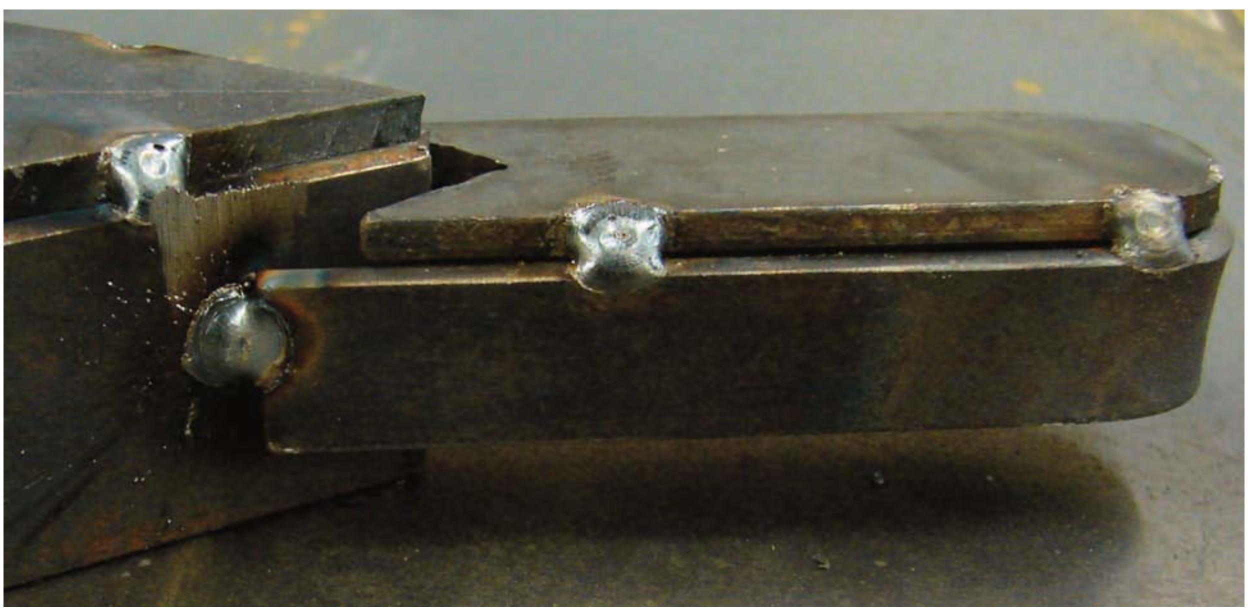


Figure 2-21. Tongue tacked to the hitch.

STEP 9. Attach the hitch assembly to the wagon box.

The hitch and wagon attachment is as simple as setting both parts on a flat surface, aligning the hitch in place, tacking, and welding solid (Figure 2-22). See Figure 2-12 for placement dimensions.

Figure 2-22. Completed hitch aligned and ready to be welded to the wagon body.

STEP 10. Clean the project.

At this point, the project is nearly complete. All berries should be chipped or ground off before assembling and attaching the wheels.

STEP 11. Assemble and attach the wheels.

To assemble the wheels, start by attaching the wheel centers to the outside wheels and then drilling the 7/16" holes in the centers. Place the axle through one wheel, slide on the axle supports, then put the other wheel in place. Square the wheels and weld the axle to the wheel centers (Figure 2-23). Place the wheels on the bottom of the wagon, aligned square to the sides of the wagon. Slide the axle supports in place and weld to the bottom of the box. (For detailed instructions on wheel and axle construction and assembly, refer to the truck plans in Chapter 1, Steps 14–15.)

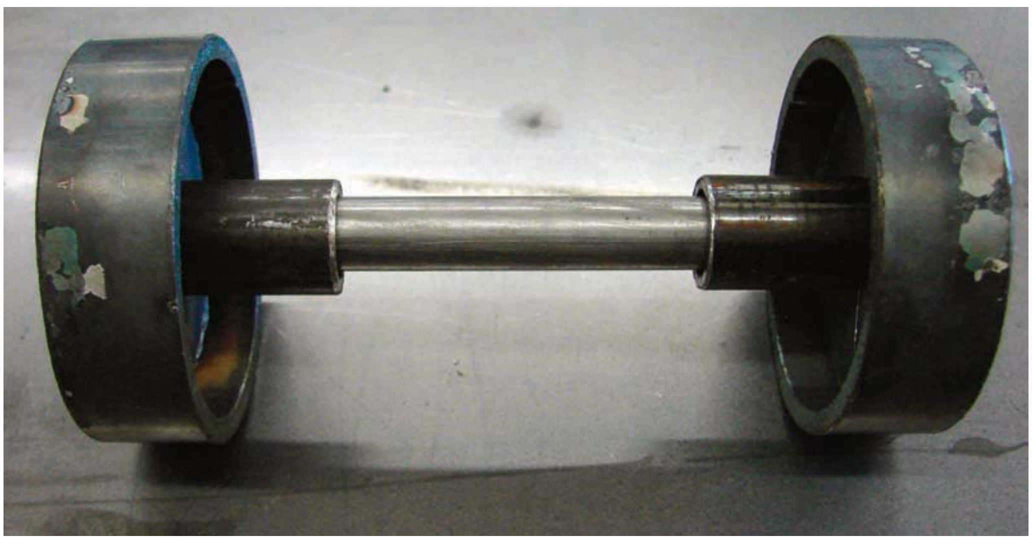


Figure 2-23. Wheels for wagon.

STEP 12. Attach the tail lights and rear bumper.

Attach the bumper made from 1/2" angle iron first. It is attached to the rear of the wagon box using two pieces of 3/16" diameter rod. Begin by tacking the rod to the angle iron, using some 1/8" shims to keep the rod level. Place the rod square to the side of the angle iron and in 3/4" from each end; then place a tack on each side of the rod (Figure 2-24). When attaching the bumper to the wagon, use a piece of scrap 1/8" flat bar as a shim to space the bumper the proper distance away from the back of the wagon box. Tack the rod to the bottom of the box with two tacks on each side of the rod, the same way it was tacked to the bumper (Figure 2-25).

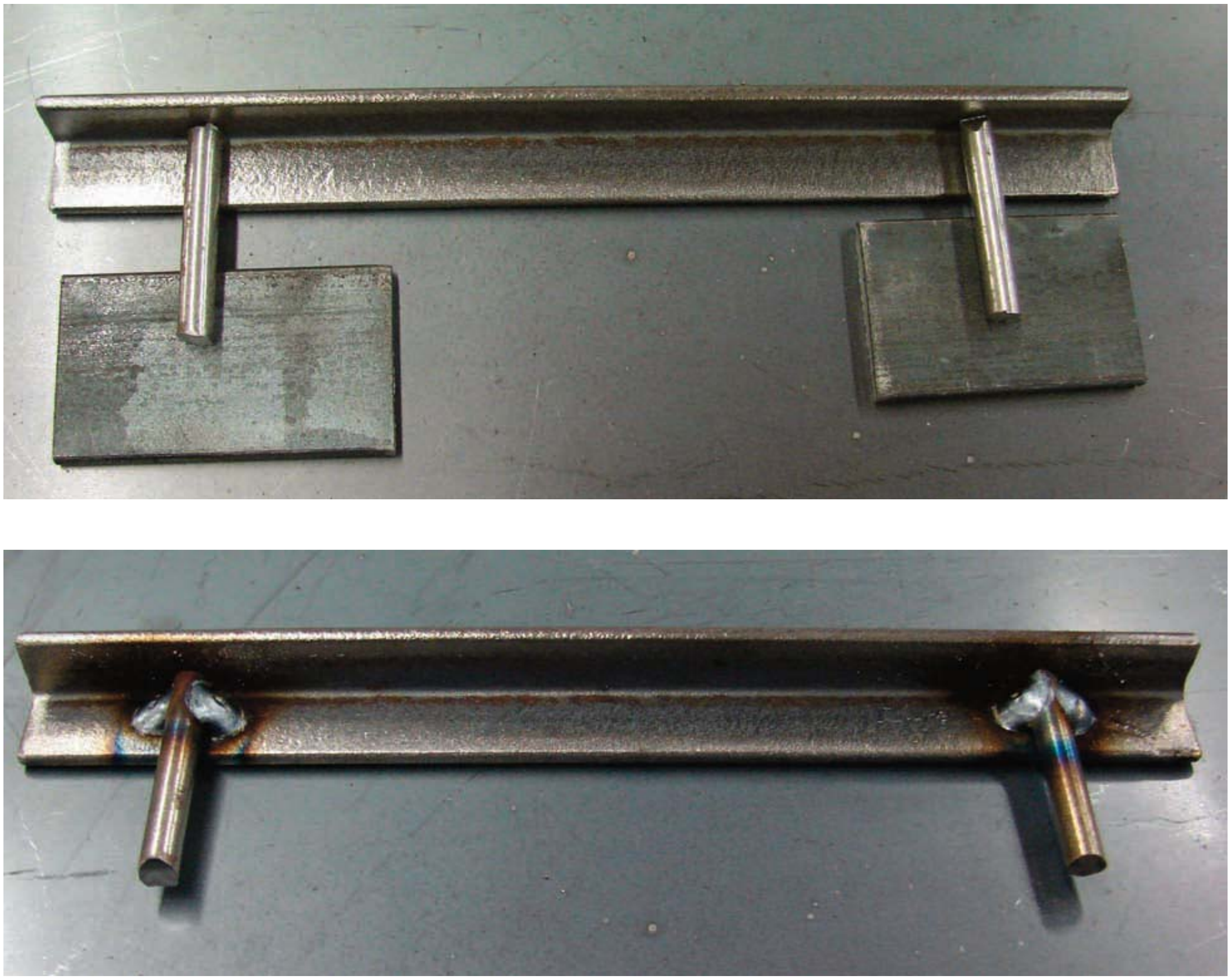


Figure 2-24. a) Bumper mounts in place and ready to be tacked. b) Attached bumper mounts.

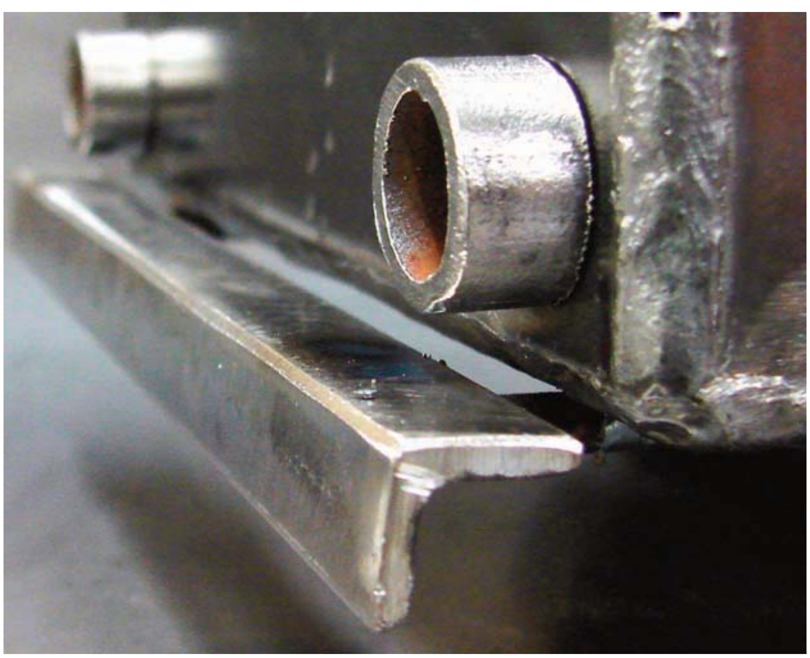


Figure 2-25. Bumper attached to rear of wagon.

To attach the tail lights, prop the wagon up on end and center of the tail lights, made from 3/8 Sch40 pipe, approximately 5/8" above the bumper and 5/8" in from the sides of the trailer. Weld a small fillet weld around the interior of the pipe, giving the lights some depth (Figures 2-26).

STEP 13. Final cleanup.

Once you perform one last cleanup of any remaining welding berries and sharp edges, the wagon is complete.

Figure 2-26. Completed back view of wagon.

PART 2

Beginning Shielded Metal Arc Welding Projects


KM
TEACHER

Electric arc welding, also referred to as stick welding, was developed in the early 1800s. However, it wasn't used extensively until the onset of World War I a century later. One of the first important uses of the stick welding process occurred in New York Harbor when a fleet of German war ships were successfully repaired by welding. After the process was tried and proven successful in repairing those 109 sabotaged ships, welding on large war ships and other war machines became common practice.

All of these uses could not have been possible if it hadn't been for the newly developed electrode flux coverings that now protected the weld puddle from outside impurities in the air. The flux was designed to give off a vapor that would shield the molten puddle as well as provide a layer of slag to protect the weld as it cools. Prior to this, the process often left brittle and porous welds that were unsafe; thus, stick welding was considered unsuitable. With the improvements, new companies arose across the United States and Europe to manufacture the machines and electrodes. Today, stick welding, also referred to as shielded metal arc welding (SMAW), remains the most commonly used welding process for industrial and outdoor applications.

The process can be difficult to learn. Beginners typically encounter problems with starting arcs, maintaining the proper arc length, and holding the proper electrode angle to the base metal as the electrode burns away. All of these issues can make for a very frustrating learning experience. With practice, however, a person can learn to overcome these problems.

This section covers three projects: a bank (Chapter 3), a bowl (Chapter 4), and a three-dimension number one (Chapter 5). These projects offer the beginner welder valuable practice stick welding the basic weld joints, laying out sheet metal parts, and using a hand held cutting torch.

CHAPTER 3

Bank

At first look, the bank probably appears to be a simple project due to its small size and limited amount of parts. However, the slanted sides add to the undertaking a degree of difficulty that will challenge most beginners and even many experienced welders. The angled sides will test competency skills related to part layout precision, accurate cutting methods using an oxyacetylene cutting torch, and proper tacking and stick welding techniques. Being a good welder comes hand in hand with being a good fabricator; each of these skills is as important as the other.

STEP 1. Collect needed steel and lay out the bank parts.

The bank utilizes 1/4" plate steel, 1/4" x 6" flat bar, and a short piece of 3/16" rod. (See Figure 3-1 for a parts list and Figure 3-2 for the front and bottom views.)

DC Bank Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
4	Sides	Flat Bar	1/4"	0'-6"	0'-5 9/16"
1	Bottom	Plate	1/4"	0'-5 1/4"	0'-5 1/4"
1	Top	Plate	1/4"	0'-2 11/16"	2 11/16"
1	Bottom Hole Closure	Plate	1/4"	2 1/2" Ø	-
1	Hole Closure Pin	Rod	3/16" Ø	-	5/8"

Figure 3-1.

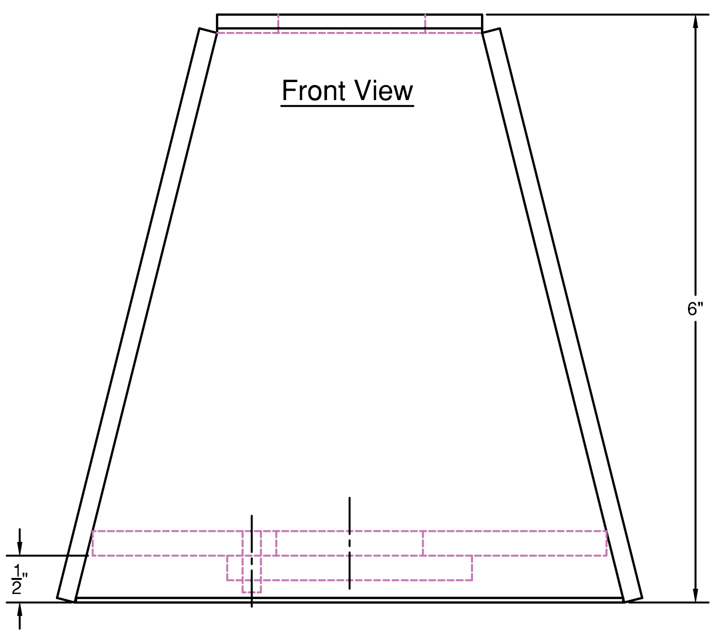
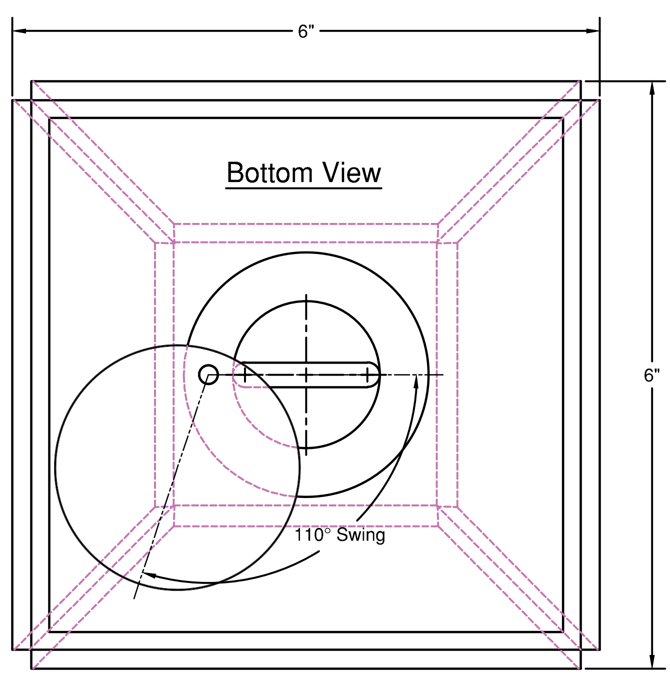


Figure 3-2. Front and bottom view of bank.



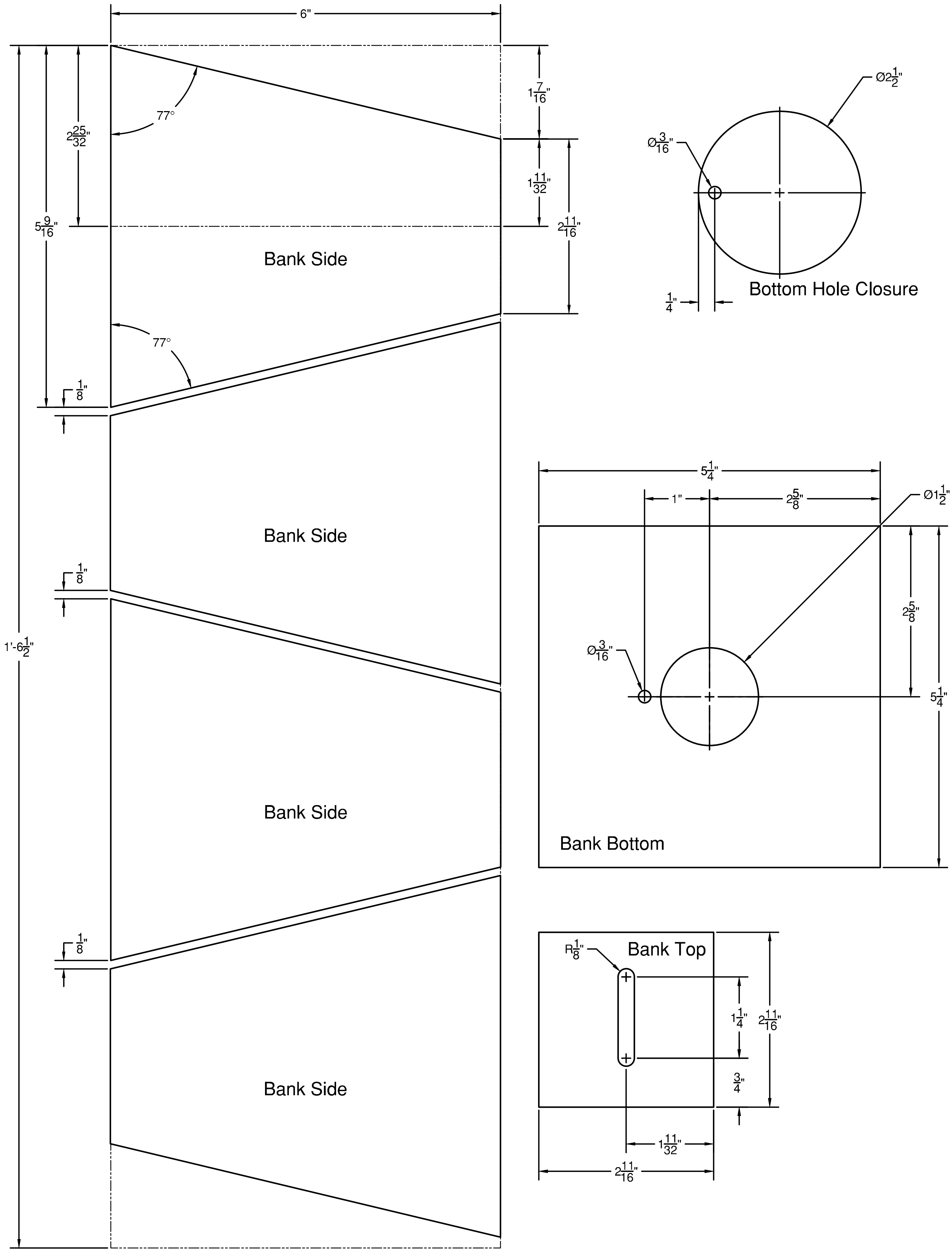


Figure 3-3. Parts layout guide and dimensions.

Figure 3-4. Proper layout of a side using a scribe.

When applicable, lay out parts side by side with a gap just slightly larger than the width of the kerf (the width of the cut produced during the cutting process). This saves valuable time and materials.

HELPFUL HINT

After collecting the needed steel, lay out the sides first. Follow the layout plan in Figure 3-3, which illustrates the positioning of the parts next to each other in opposite directions and spaced 1/8" apart (Figure 3-4).

Next, lay out the top, bottom, and bottom hole closure. There is no specific layout plan for these parts. However, utilize the plate of steel efficiently by placing the parts side by side, on an edge and in the corner to minimize the amount of waste produced. Using a scribe, find the centers of your circles and holes for drilling. Then place your plate on a solid surface and use a center punch to mark the exact centers.

It is important to draw or lay out the parts on the sheet metal as accurately as possible. Even if the cutting is done poorly, if the parts were laid out correctly, most likely they will fit together without having to be re-cut.

Notes:
The importance of using a scribe rather than soapstone or a permanent marker cannot be emphasized enough when laying out parts on sheet metal.

STEP 2. Cut out your parts.

The two most common methods for cutting out sheet metal parts are plasma arc and oxyacetylene cutting torch. Most people tend to choose the plasma cutting method because it's easier. However, a plasma machine is not always available or practical in real world applications. Having experience and proficiency with an oxyacetylene cutting torch is a skill that every fabricator should acquire. For that reason, I recommend using a cutting torch for the practical experience.

Before cutting, you need to choose a torch tip size recommended for cutting 1/4" thick material. Tip sizes are not standardized and vary from brand to brand. Refer to a

Notes:
If you are new at the oxyacetylene process, refer to Chapter 7 in The Art of Welding, by William Galvery, for more information on system setup and helpful hints.

manufacturer's guide when deciding on which tip is appropriate for each individual cutting application.

Regardless of the brand, if your torch has previously been used, it is a good idea to clean the cutting and oxygen orifices with a tip cleaner (Figure 3-5). In order to do this, you will need to remove the cutting tip from the torch assembly. Some brands have a nut on the back side of the tip that will also need to be removed; this nut should be fingertip tight and not require the use of a wrench to remove (Figure 3-6).

Clean the orifices from the back side in. If you try cleaning from the end of the tip in, you can easily break the tiny file off in the orifice; they are difficult if not impossible to remove. You should start with a file size smaller than the orifice and work your way up to the actual hole diameter. This will allow the file to move in and out freely and thoroughly clean the hole. A clean cutting torch tip works noticeably better then a dirty one.

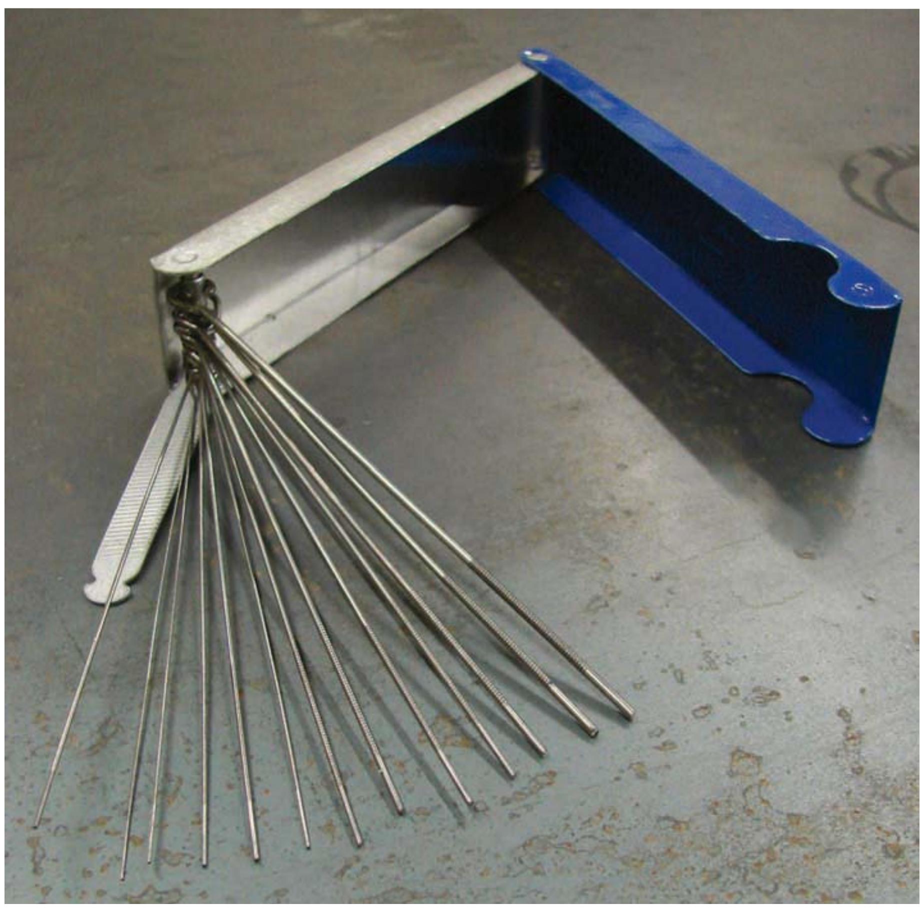


Figure 3-5. Oxyacetylene cutting torch tip cleaner.

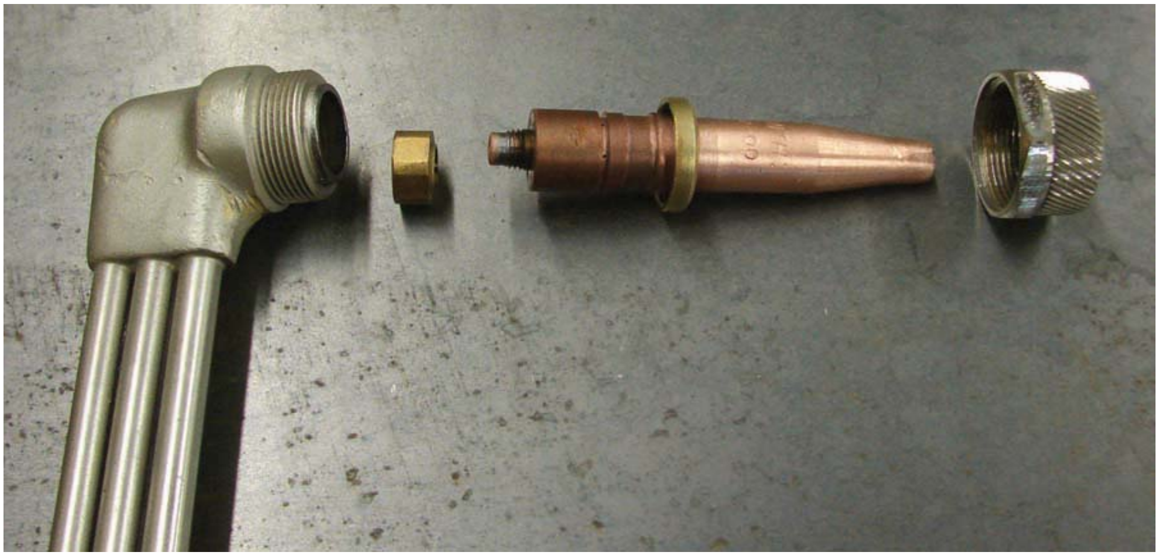


Figure 3-6. Cutting torch tip removed from the torch head.

Before cutting, the following tools will need to be collected to aid in the cutting process;

- Straight edge — used as a guide to aid in the cutting process (Figure 3-7).
- Flint and steel striker — used to ignite the oxyacetylene gases.
- Gloves — to protect your hands from burns.
- Cutting glasses — Shade #5 glasses are recommended to protect your eyes from the intense ultraviolet (UV) and infrared (IR) light emitted during the cutting process.
- Pliers — used to avoid burns when picking up parts that fall after cutting. Parts remain hot long after the cherry red color has disappeared.
- Locking C-clamp pliers — used to clamp smaller sheet metal parts to the table and to clamp straight edges if magnetic guides are not available.

With your supplies at hand, set up the oxyacetylene station with the proper regulator pressures. Cut 1/4" steel with 3–5 lbs of acetylene pressure and 20–35 lbs of oxygen pressure. *(Refer to an owner's manual for specific cutting torch pressures.)*

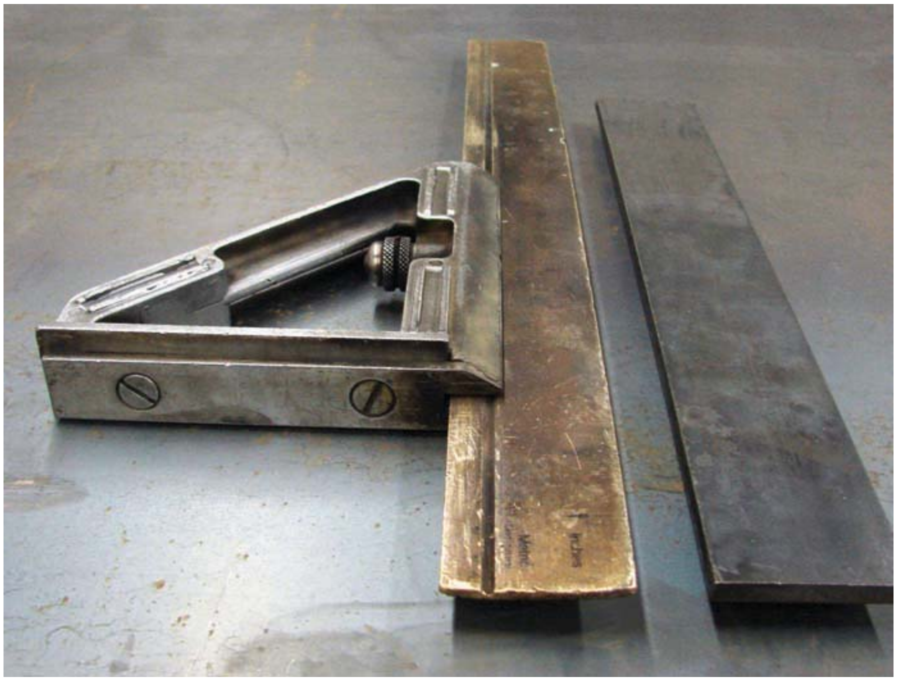


Figure 3-7. The tool on the right is a magnetic straight edge specifically designed for use with a cutting torch. It can be purchased in various lengths up to 8'-0". The magnets eliminate the need for clamping. The tool on the right is a home-made cutting guide constructed with 1/4" x 2" flat bar. The top piece of bar is lifted up off the surface of the steel by welding a second piece of 1/4" bar to the bottom and offsetting it 1/2" from the edge. These can be made in any length, are re-usable, are more affordable, and are just as easy to use. The only disadvantage is the need for C-clamp locking pliers to hold the guide in place.

The most common error made by beginners when using a cutting torch is setting the acetylene low pressure regulator incorrectly. When setting the low pressure, set it as a working pressure (valve open on the torch handle) rather than a stable pressure (valve closed on the torch handle). First turn the adjusting screw on the acetylene regulator to read the desired pressure. Then crack open the valve on the torch handle a half of a turn and check the working pressure. Notice the significant drop in pressure on the low pressure gauge. Close the valve and increase the acetylene pressure by turning the adjusting screw clockwise; then check the working pressure again. Repeat this process until the required working pressure is set. The low pressure gauge on the acetylene may read as high as 7 or 8 psi as a stable pressure when the desired working pressure is 4 psi. (For examples and illustrations on setting a working pressure, see Chapter 6, Step 5.)

HELPFUL HINT

Don't forget to check the working pressure of the oxygen as well. Check it with both the cutting lever down and the oxygen valve open about a half a turn. The working pressure and the stable pressure difference will be minimal compared to the acetylene but still should not be ignored.

Be prepared when cutting. Leather boots should be worn at all times and work jeans free of holes and frayed ends are a must. Hot molten metal will be shooting down at your feet and if the proper foot wear and clothing are not worn, serious burns can occur (Figure 3-8).

SAFETY TIP

Figure 3-8

Before cutting your first part, I suggest making a test cut and measuring the distance from the edge of the *kerf* (the width of the cut) to the straight edge. This test will give you an idea on how far away from the line to place the straight edge in order to cut on the correct side of the line (Figure 3-9). As with plasma cutting, always pull the torch parallel along the straight edge rather than attempting to go side to side or perpendicular to the cutting guide.

With everything set up and the proper tools at hand, cut your side parts. While cutting, the torch tip should be approximately 1/4" above the surface of the steel. Moving the tip too close or even on top of the hot cutting area can permanently block orifices and even melt the end of your cutting torch tip. Cutting too far away can give you an uneven kerf and cause other issues such as not cutting all the way through. (For a helpful guide to correcting defective edges, refer to Page 159, in *The Art of Welding,* by William Galvery.)

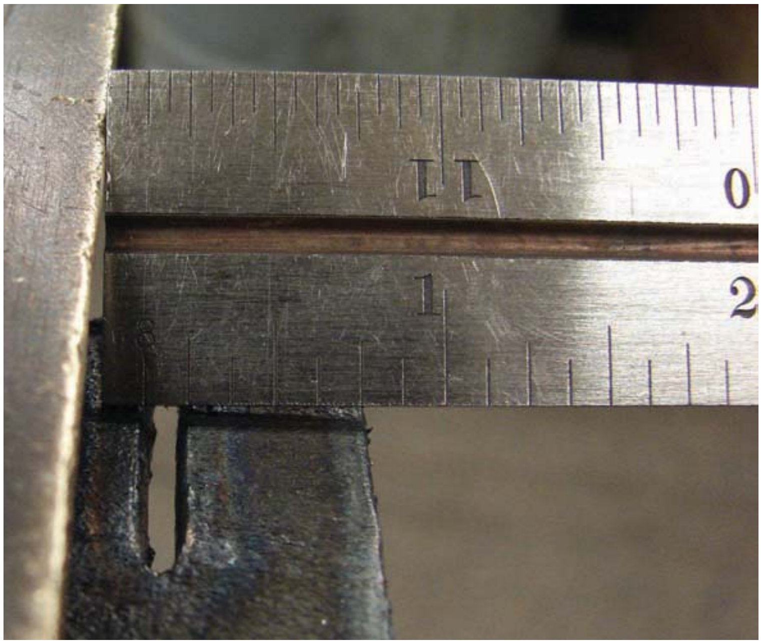


Figure 3-9. Accuracy is important. Take the time to measure and place your straight edge properly.

Next, cut the remaining parts. Use a straight edge for the top and bottom parts and a circle cutting attachment set to the radius of 1-1/4" to cut out the bottom hole closure (Figure 3-10). If you have little or no experience with this tool, you may need to cut more than one part to get a good clean-cut circle —this is a very small circle which tends to be more difficult to cut out.

If a circle cutting attachment is not available, draw a 2-1/2" circle on the steel with a circle template; then free-hand cut the circle. Cut just outside the line. Free-hand cutting tends to be very jagged, especially for beginners. Leaving the line will allow room for grinding. The desired diameter will be reached after grinding is complete.

STEP 3. Clean the slag from the bottom side of your parts.

After cutting, your parts will need to be cleaned up once they have cooled enough to handle with your hands. The amount of slag build-up will depend on how well you set your regulator pressures, how well you cleaned the tip, and how well you maintained the proper cutting speed (Figure 3-11). Some areas of slag can be removed with a chipping hammer whereas others may be attached so securely that some grinding will be required.

After the surfaces are clean, the edges will need some grinding, depending on how well you did during the cutting process. There should be minimal grinding if you cut with the proper gas mixture, the proper speed, and a 90-degree cut angle, and used a straight edge and circle cutting attachment.

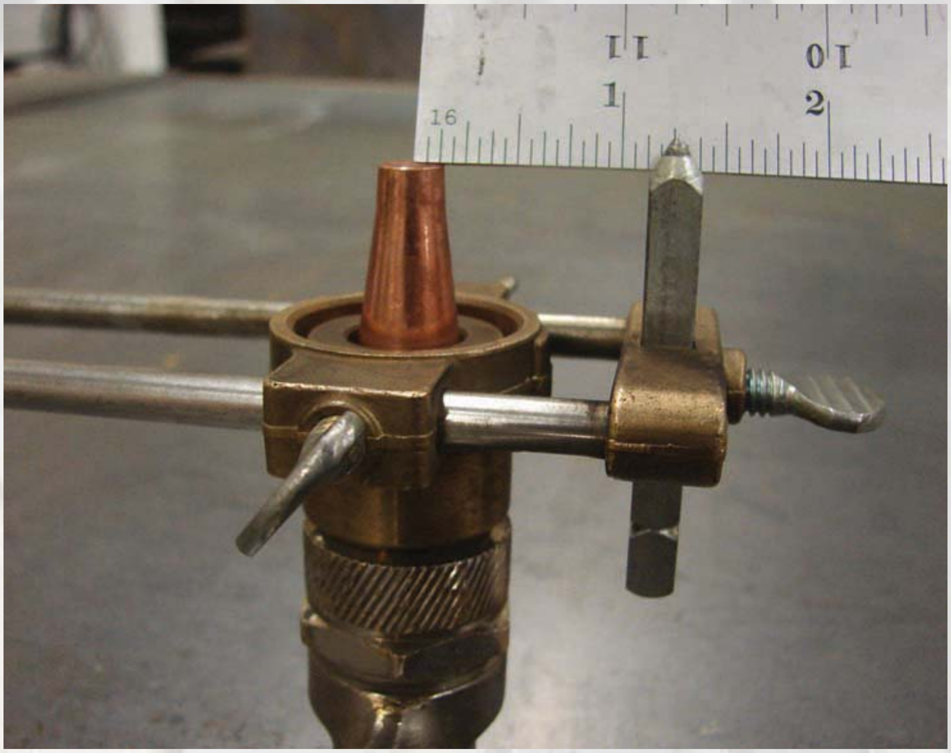
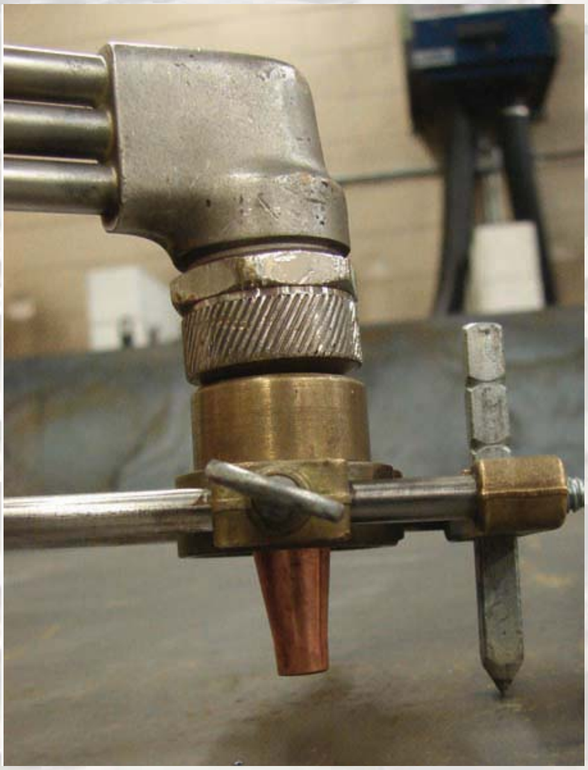


Figure 3-10. a) Use a ruler to set your radius for the circle cutting attachment. Measure from the pivot point to the outside of the center oxygen orifice.



b) When the cutting tip is in position in the circle cutting attachment, the bottom of the tip should be approximately 1/4" above the steel.

Figure 3-11. Example of slag buildup on the bottom side of a cut part.

When using a grinder to clean your parts, be aware of your surroundings. Avoid shooting the sparks and slag in the direction of others and always wear the proper safety attire and glasses.

SAFETY TIP

STEP 4. Cut and drill holes in the top, bottom, and hole closure.

Due to its size, the 1-1/2" hole in the bank bottom will need to be cut by hand. Before cutting, draw the outline of the circle using a circle template and a scribe. Because a scribed line can be difficult to see, draw a circle to the inside of your line with a permanent marker to use as a reference. Then drill a 3/16" hole somewhere inside the boundary of the circle. This will give you an edge to begin your cutting, which will eliminate the need to purge through the 1/4" plate. Purging can cause blockages in the cutting orifices; it can also force molten steel to be thrown upward toward your face. While at the drill press, also drill the 3/16" hole for the pin that attaches the hole closure to the bank bottom. (Figure 3-12).

Free-hand cutting with a torch can be difficult. It's a good idea to practice on a scrap piece prior to actually cutting out the hole in the bottom plate. After practicing, cut the circle in the bank bottom. Begin on the edge of the pre-drilled hole, then work toward the edge in an arced direction, making sure not to go over the scribed line. After cutting, the cut path will most likely be jagged. Place the plate in a vise and remove the slag from the back side. Then use a die grinder with a metal burr to clean and smooth the edges. While grinding, check your progress often so the hole ends up round, not oval (Figure 3-13). After finishing the edges of the hole, remove any burrs from the surface that may have formed while smoothing the hole.

Make the slot in the bank top next. Begin by drilling in the top two 1/4" diameter holes that will be the ends of the slot. (Refer to Figure 3-3 for placement dimensions.) After drilling the holes, use a cutting torch and a straight edge to finish forming the slot (Figure 3-14). Chip or grind off the slag on the back side. Then smooth the straight edges of the slot with a flat metal file.

Finally, drill a 3/16" hole in the bottom hole closure to accommodate the pin that will attach the bottom to the swinging hole closure (Figure 3-15). Remove any burrs after drilling.

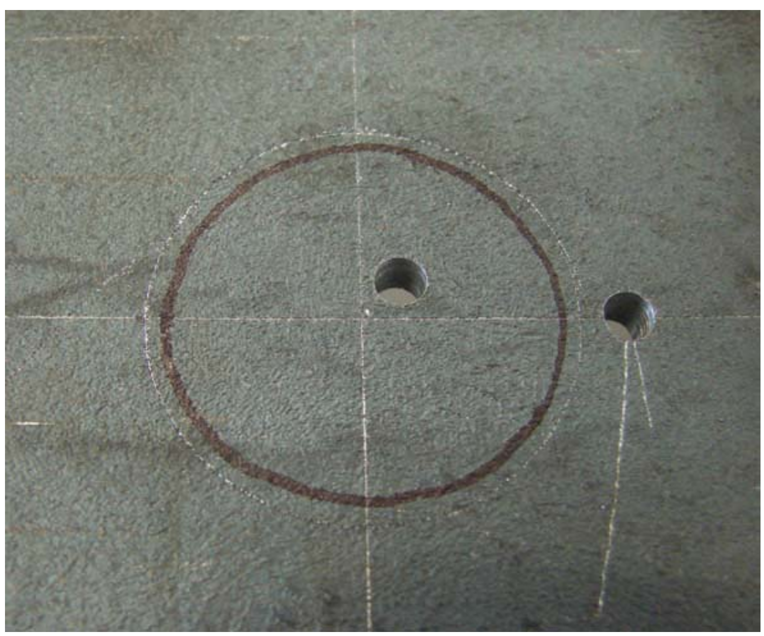


Figure 3-12. Bank bottom prepared with layout lines and drilled holes.

Figures 3-13.
a) Beginning the cut for the circle should arc towards the edge.
b) Hole cut in the bank bottom.
c) Die grinder with a metal burr.
d) Finished holes in the bank bottom.

a)

b)

c)

d)

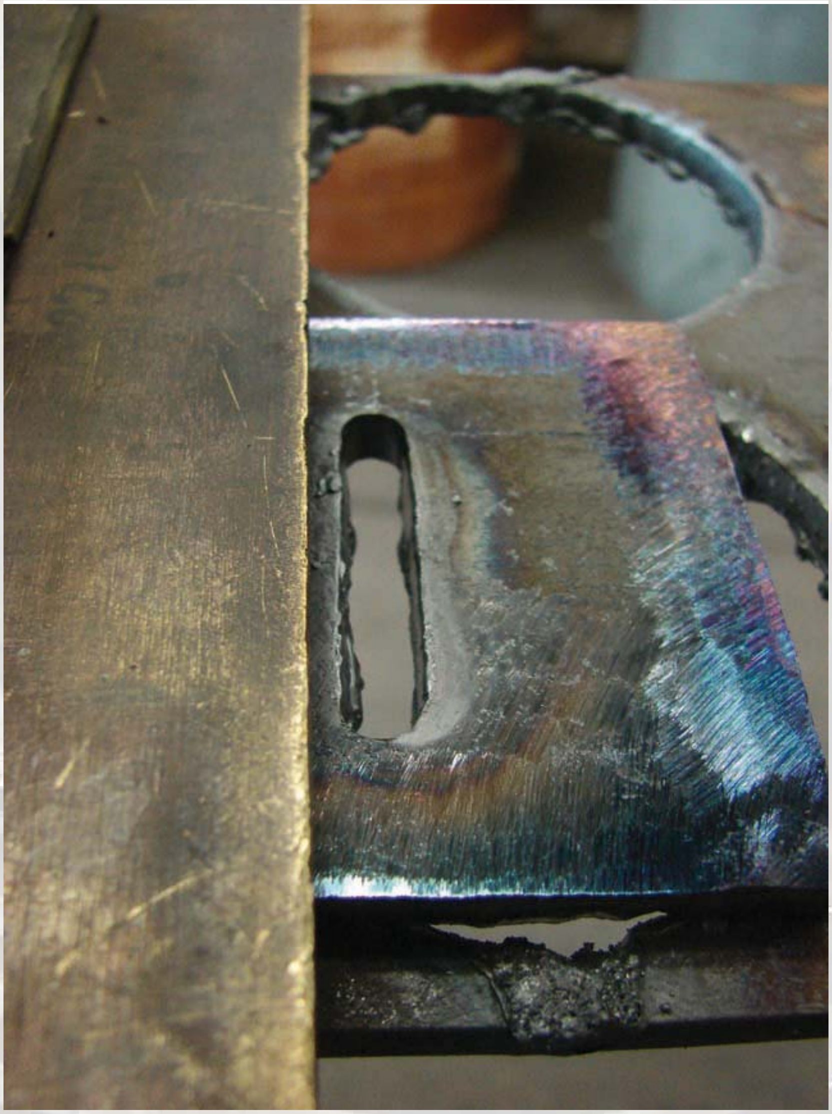


Figure 3-14. Completed slot in bank top with straight edge still in place.

Figure 3-15. Finished bottom hole closure.

STEP 5. Tack the sides together.

Before tacking the sides together, secure the parts in the proper position using a piece of 2” square tubing and two locking C-clamp pliers (Figure 3-16). Tack each set of sides, then tack the two sets together to form the bank body (Figure 3-17). Give the tacks time to cool before removing the clamps in order to minimize the amount of pull that can draw the parts out of square.

After tacking, check the bottoms for squareness. If they need adjustment, place the bank body on an anvil or solid surface; tap on the parts at the seam, forcing the box open or closed, whichever is necessary. If the tacks are solid, they should bend without breaking. If your parts are extremely out of square and cannot be properly adjusted, break the tacks, grind them off, and repeat the assembly process for the sides.

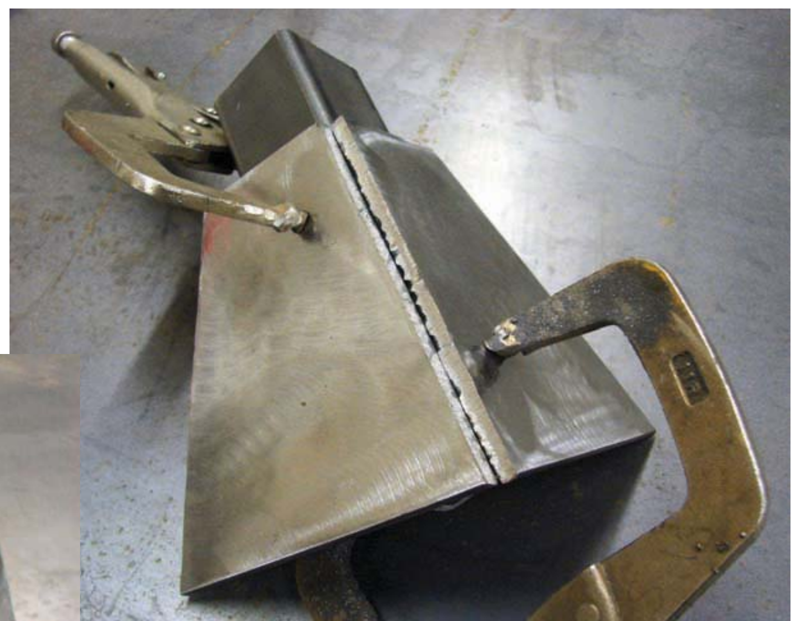


Figure 3-16. Two sides clamped in position and ready to be tacked.

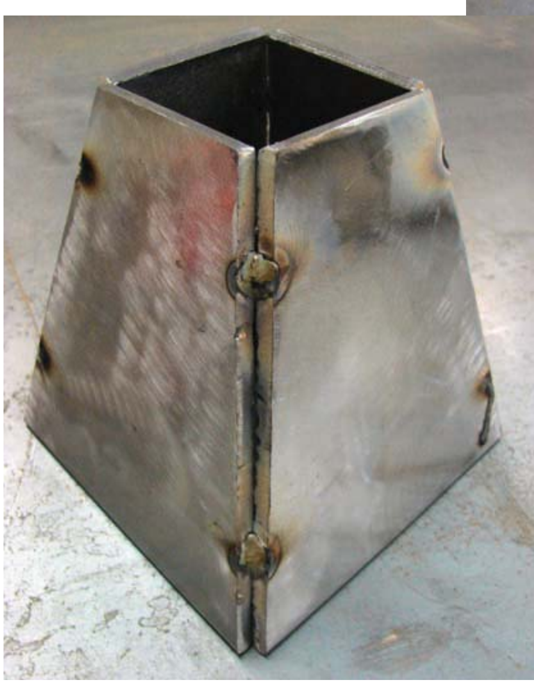


Figure 3-17. Bank body tacked and squared.

STEP 6. Attach the bottom hole closure to the bank bottom.

To attach the hole closure, first insert the 3/16" pin into the bank bottom, flush with the inside surface. You may need to grind the end of the pin slightly so it will slide into the hole. It will be a tight fit (Figure 3-18a). Turn the bottom over and weld the pin in place. Chip the slag from the weld and clean any berries from the inside bottom surface (Figure 3-18b).

a)

b)

Figure 3-18.
a) Pin in bank bottom.
b) Pin welded on the back side. Do not grind the weld. It will be on the inside of the bank and will not be seen. Grinding could weaken the hold on the 3/16 pin.

Next, turn the part back over and slip the bottom hole closure onto the pin. Place the part on a solid surface such as an anvil. Using the rounded end of a ball peen hammer, tap the end of the pin, causing it to mushroom out. Check that the hole closure can still rotate side to side with some resistance after every few hits. Check this often so as not to over tighten. When complete, the closure should rotate easily, but with some resistance (Figure 3-19).

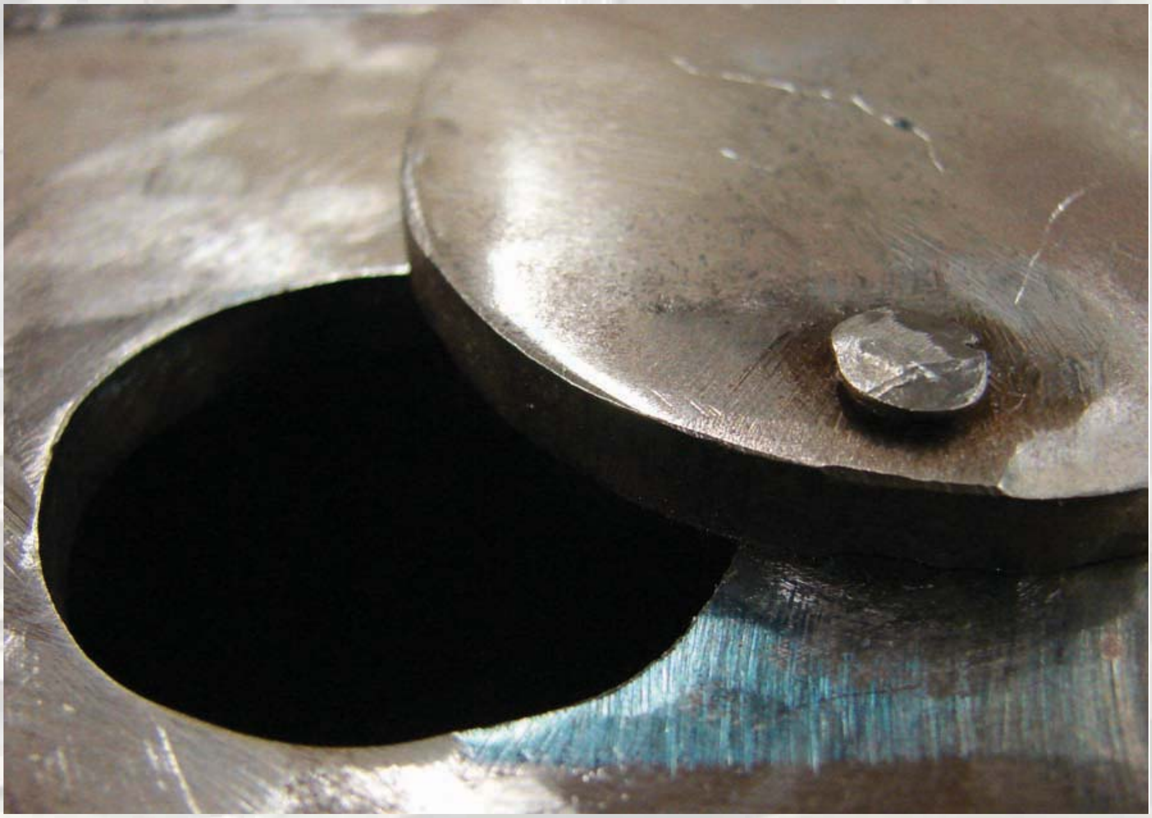


Figure 3-19. Complete bank bottom with attached hole closure.

STEP 7. Attach Top and Bottom.

Tack the bank top on all four sides to the already attached sides. Then flip the bank over and place the bank bottom into place, making sure the hole closer is on the outside. Check for clearance with the mushroomed pin with a straight edge or steel rule (Figure 3-20). If the pin is below the height of the bank edges, tack the bottom in place. If the pin is too high, it will cause your bank to sit on a surface unevenly. If this is the case, grind a bevel on the bottom edges to allow the part to fall deeper into the underside of the bank. Then tack the four sides of the bottom to the sides (Figure 3-21).

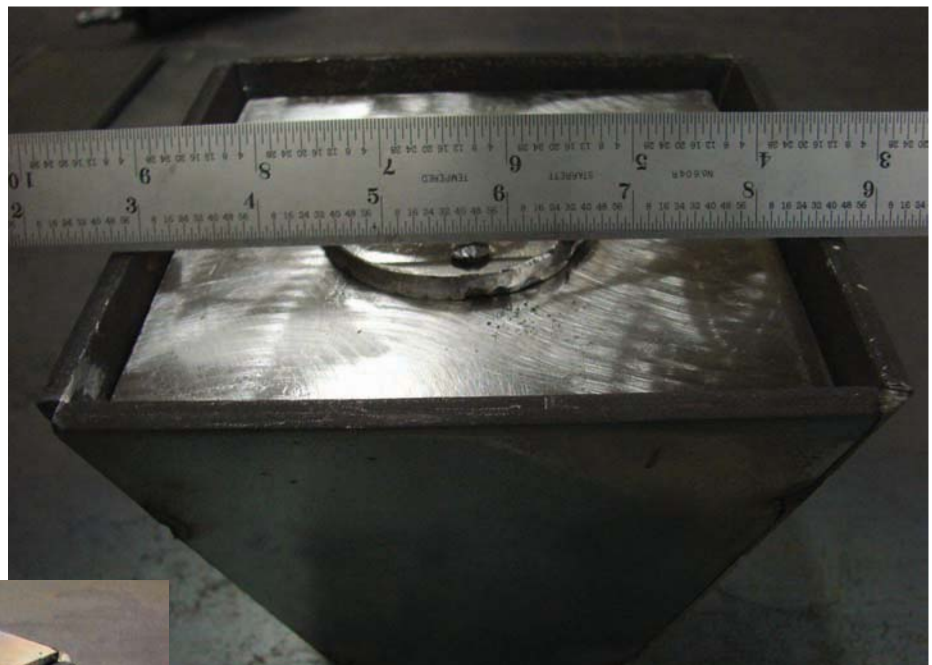


Figure 3-20. Check for clearance so that the bank will sit flat on all four sides rather than resting on the mushroomed pin.

Figure 3-21. Bank tacked and ready to be welded solid.

STEP 8. Weld the bank solid.

With everything secure and square, weld the outside corners on the sides first, using 7018 electrodes, 3/32" or 1/8" diameter. This rod has low spatter, is an all-position electrode, and will provide a clear view of the weld puddle when the proper arc length is maintained. (For more information about electrodes and their properties, refer to Chapter 4 in *The Art of Welding*, by William Galvery). Next, chip the slag from the ends that are closest to the top of the bank and weld the top outside corners.

The last welds to complete will be the fillet welds on the bank bottom. These welds are almost always the most challenging for beginners. When two surfaces are being joined, more movement and more heat is necessary than with the previous outside corner welds, because surfaces melt slower than edges. Two mistakes to avoid are going too fast, which leaves voids in the weld pool, and holding too long of an arc length, which makes it hard to see the molten puddle. Remember: aim at what you want to join together. Stay there long enough for fusion to occur; allow the welding rod to deposit enough filler metal to secure the two parts together.

Beginners may encounter the following problems when stick welding.

Problem: *Starting an arc with an already-used electrode.* A new electrode has an end prepared with a small portion of the filler metal exposed to allow for an easy arc connection. However, a rod already-used many times will have a coating of slag over the end, which can make that arc jump difficult.

Solution: Tap the end of the rod on a surface that is not grounded to the welding surface. Tapping will break off the slag and allow the arc connection.

Problem: *Sticking the rod to the base metal.* Many times a rod will stick if the proper heat setting is not adjusted or if a hot-enough puddle is not established before proceeding down the weld joint.

Solution: When starting an arc, hold a long arc while counting anywhere from 2-6 seconds. Then move into the molten puddle and down the weld joint. This allows the surface to heat up and build a weld puddle.

Problem: *Maintaining the proper arc length.* It can be difficult to judge 1/8" or even 3/32" arc gap distance. The drop down as you weld with a stick electrode can be difficult to keep constant. An improper arc length, especially one that is too long, can make it impossible to clearly see the weld pool.

Solution: Once a puddle has been established, relax your arms and bury your rod in the puddle. It is better to be too close and have an open view of your molten puddle than to be 1/2" away and not be able to see anything but a flashing arc. As long as you keep the rod in the puddle and don't move too fast down the joint, sticking will not be an issue. With experience, the proper arc gap will be easier to maintain and will come naturally.

HELPFUL HINT

STEP 9. Chip your slag and clean your surfaces.

At this point, the project is nearly complete. Chip off all slag, clean off any spatter, and re-polish your parts. If any of the outside corner welds are poor, grind the welds from the corner joints with a portable hand grinder and re-weld. The bottom fillet welds will not be able to be removed for re-welding. Try to make the first attempt a good attempt.

STEP 10. Weld your outside flat welds.

Personalize your bank by welding on the flat surfaces of the sides. Draw a dollar sign on one of the sides and your initials on the opposite. If you are not good at drawing letters and the dollar symbol free-handed, trace them using a letter template.

While welding, it may be hard to see the lines. Therefore, plan your welds and the direction you will need to travel prior to actually welding. Practicing on some scrap steel is a good idea. (Figure 3-22).

Figure 3-22. Completed bank with initials added to the side.

STEP 11. Final clean up.

All welding should now be complete. Finish clean-up with a wire wheel, a polishing disc, and a chisel and hammer if necessary to remove any challenging spatter. Ideally, very little if any grinding should be done. If you need to grind your welds, they were most likely poor. However, if they are poor, it is better to grind off the mistakes than to leave them.

CHAPTER 4

Bowl

Practicing welding is more enjoyable when the activity involves creating something useful. The bowl is a great project for practicing stick welding and can serve as an eye-catching container when complete.

STEP 1. Collect steel needed for the project.

This project requires the use of 1/4" plate for the bottom octagon, 1/4" x 1/2" strap for the 45-degree sides, 1/4" x 1" strap for the top edge, and four 1/4" steel balls. Refer to Figure 4-1 for a complete parts list and the front and top views of the bowl.

Note:
The 1/4" steel balls can be purchased online at King Architectural Metals or MSC Industrial Supply Co.

STEP 2. Layout the center octagon.

In order for all parts to fit properly, it is important to be exact when laying out and cutting the octagon. To begin, draw a 6 5/8" square. Then mark the 45-degree angle points and scribe those lines (Figure 4-2). When all lines of the octagon have been drawn, check that all sides are exactly 2 3/4" long.

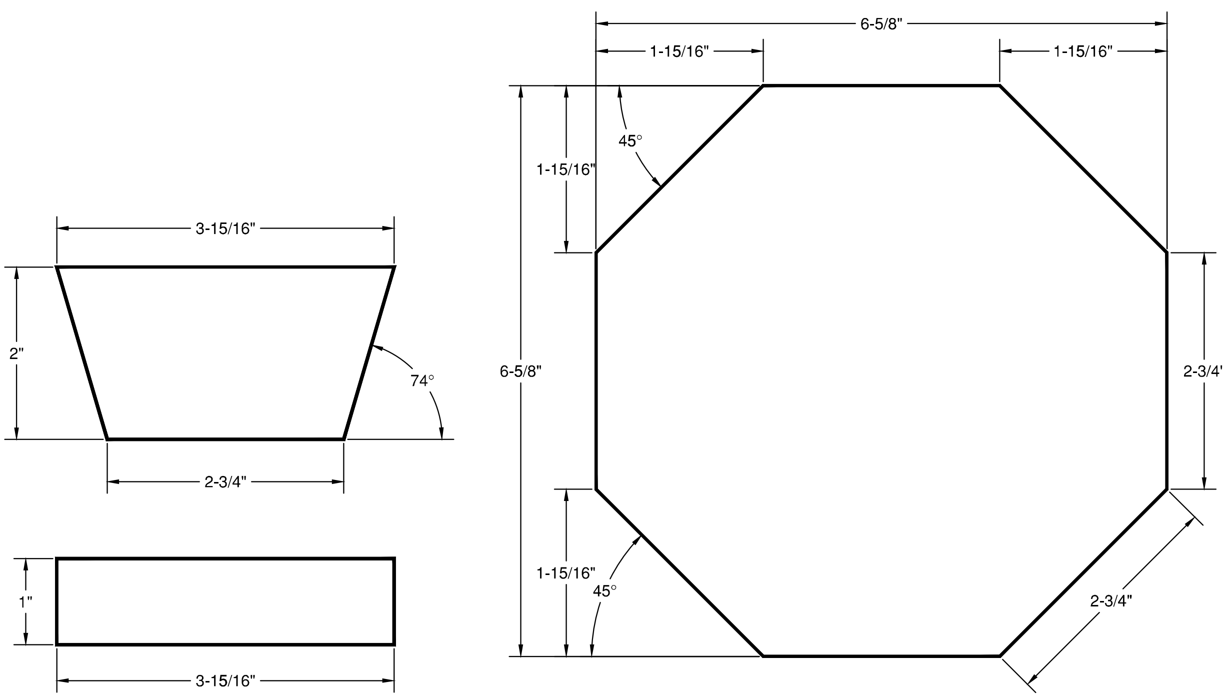
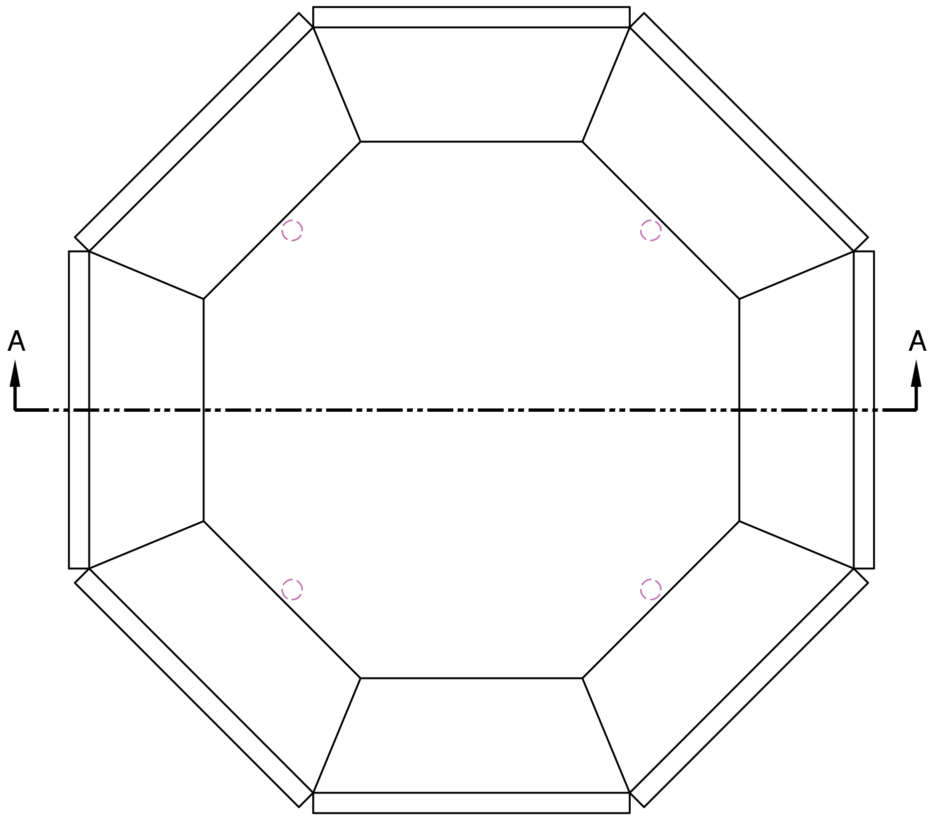


Figure 4-2 DC bowl part dimensions.

Bowl Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	Bowl Bottom	Plate	1/4"	6 5/8"	6 5/8"
8	Bowl Angled Sides	Flat Bar	1/4"	2"	3 15/16"
8	Bowl Top Sides	Flat Bar	1/4"	1"	3 15/16"
4	Steel Balls	-	1/4" Ø	-	-

Top View



Section A

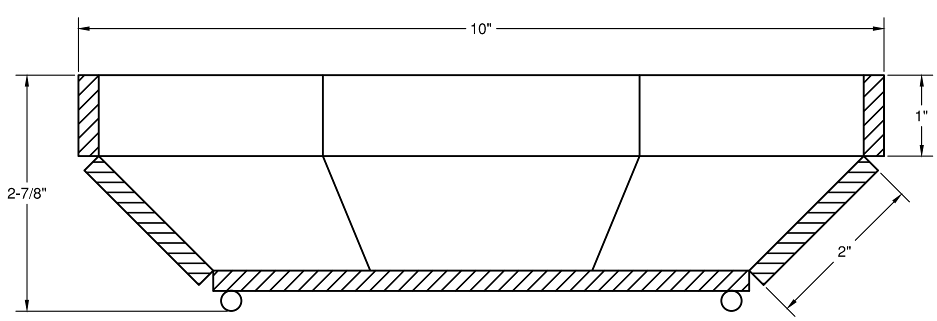


Figure 4-1

STEP 3. Cut out the octagon.

There are three options for cutting the bottom octagon part: plasma torch, cutting torch, or torch and band saw combination.

Plasma Torch: The first option is to use a plasma torch rated to cut at least 1/4" thick plate or more. This option may be the easiest. Make sure to use a straight edge as a guide to help maintain accuracy when cutting. (For helpful hints on this process, refer to Step 5 of the truck plans in Chapter 1.) After cutting, clean the dross from the back side of the octagon and grind the edges smooth.

Cutting Torch: If a plasma torch is not available, a cutting torch is your next option. Remember: when cutting, it is important to always use a straight edge. (For helpful hints on using a cutting torch, refer to Steps 2 and 3 of the Bank project in Chapter 3.) After cutting the octagon, clean the slag from the back of the part and grind the edges smooth.

Torch and Band Saw Combination: The third option for cutting the bottom octagon is using a combination of a cutting torch or plasma cutter with a band saw. This approach can be a time saver because there will be very little cleanup after the edges have been cut. If your band saw has a vise that will hold a flat piece of steel 6-5/8" wide, I recommend choosing this option. It will be the most accurate, the kerf will be 100% square, and the edges will require very little if any grinding.

To begin, cut the square the width and height of the octagon. If the plate of steel has a square corner with factory edges, use it; then half the work is done and only two sides will need to be cut. Next, use a grinder to remove the slag from the bottom of the plate and clean up the edges.

When the square is complete, take the plate to the band saw and cut off the corners to complete the octagon (Figure 4-3).

Figure 4-3. This octagon was cut from some scrap material that just happen to be 6-5/8" wide. The first two corners were cut off first; then the width was cut, and finally the last two corners.

STEP 4. Cut the angled side parts.

Before cutting the angled sides, measure the octagon sides to insure that they were all accurately cut to length. As you cut each side part, if the bottom octagon sides measure short or long, make length modifications to the 1/4" x 2" flat bar to adjust for the error. As long as the corner angles are 45 degrees, errors in length will not affect the fit of your parts. If your part lengths are modified, label each part to match the side of the octagon that it coincides with to avoid confusion later during the assembly process.

Use a band saw set to 74 degrees to cut the parts (Figure 4-4). Be as accurate as possible to ensure the corners of the edges touch. The short width should match your side width on the octagon.

If your octagon is true to size, use a stop to cut all parts the same length without having to re-measure each time (Figure 4-5).

After cutting, remove any sharp edges.

Alternate cutting method: If a band saw is not available, the parts can be cut just as accurately with a cutting torch. To make these cuts, a jig should be made first (Figure 4-6).

To build the jig, use a cold cut saw or chop saw to cut the rectangular tube the proper length, cutting one end at 74 degrees. Weld the two pieces of 1/8" x 1" flat bar to each side, making sure it extends down past the tubing 1/2". When attaching the flat bar, do not place any welds on the bottom side of the jig. The welds would interfere with the function of the jig.

The 1/4" x 1" flat bar should be welded to the angled end, level with the top of the tube. It will act as the cutting torch guide. It is lifted off of the surface of the steel to allow the sparks produced when cutting to escape.

After the jig is constructed, clamp it to the end of the 1/4" x 2" flat bar, placing it far enough in that a complete cut will be made across the material. Next, flip the steel over, measure and mark the length of the first side to be cut, then align the jig and make the second cut. Repeat until all sides are cut to length.

To complete the parts, chip and/or grind the slag from the surface of the parts. Grind the edges if necessary.

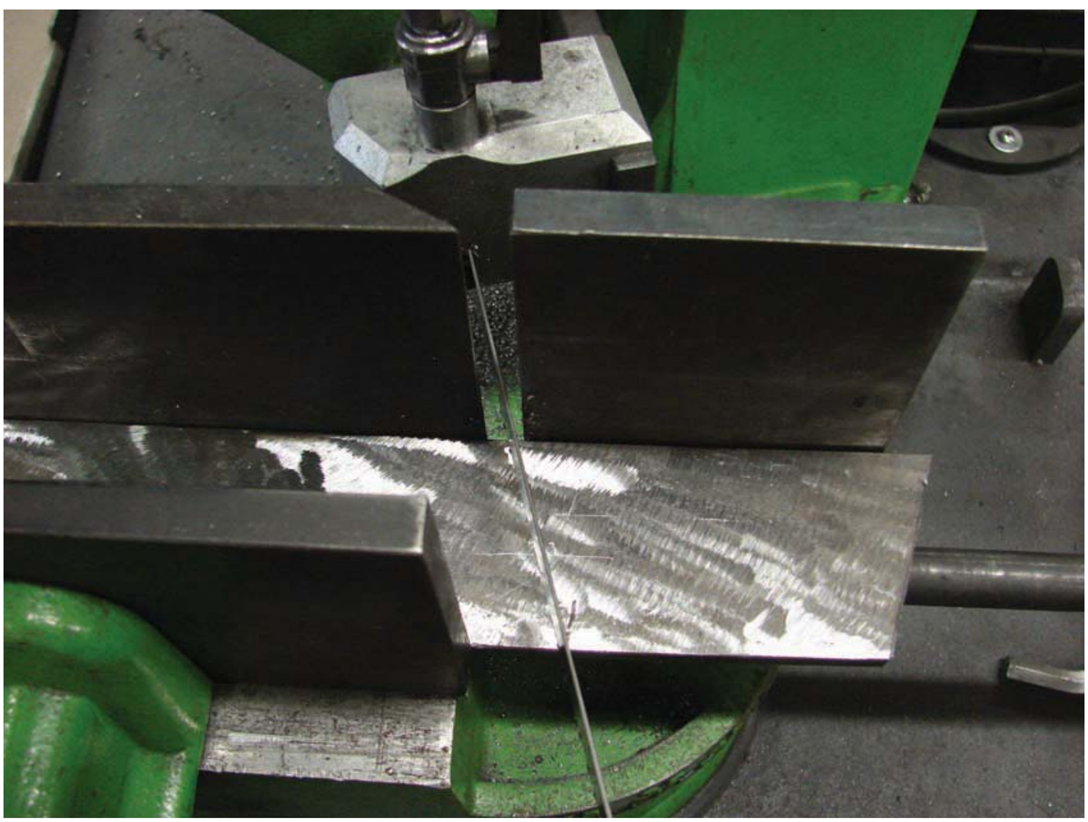
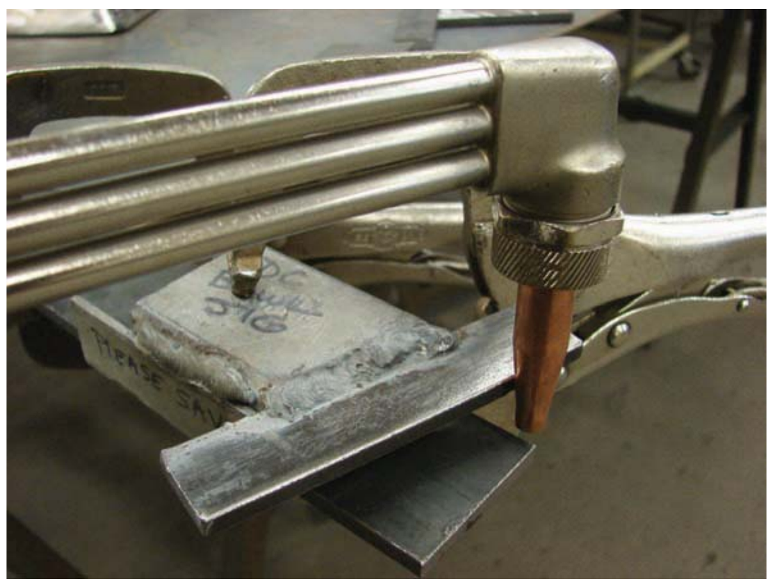


Figure 4-4. The band saw makes it easy to be perfect in your length and will provide perfectly straight edges.

Figure 4-5. A band saw parts stop allows for multiple parts being cut the same length, quickly and accurately.

Jig definition: A plate, box, or open frame for holding work and for guiding a machine tool to the work.



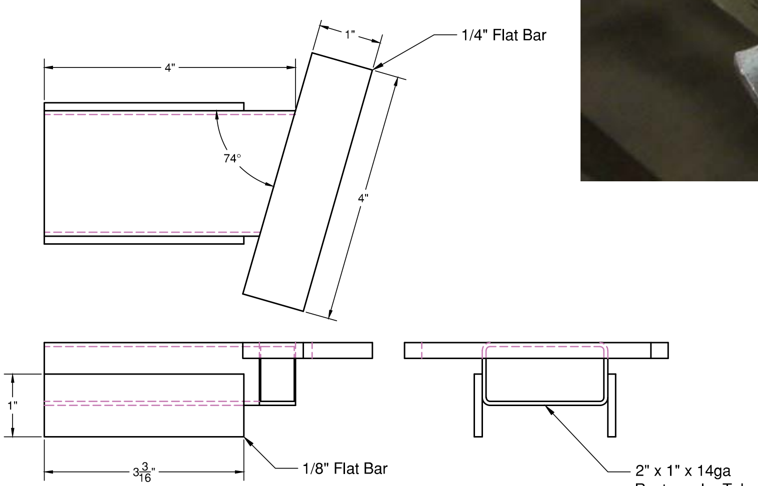


Figure 4-6. a) Plan views of the cutting torch jig used to cut the angled sides.
b) Constructed jig, clamped to 1/4" x 2" flat bar, ready to be cut.

STEP 5. Attach the angled sides.

The angled sides should be tacked to the octagon at a 45-degree angle. To help attach these parts, use a scrap piece of square tubing cut at a 45-degree angle and have a partner hold the pieces in place while they are tacked to the bowl bottom.

If a partner is not available, a jig can be made to assist in this step (Fig. 4-7). To construct the jig, cut the parts to length using the plan view for part descriptions and dimensions, then weld the jig parts together.

After constructing the jig, use locking pliers to hold the angled side parts in position while tacking them to the bowl bottom.

As the tacks cool, the metal parts may pull out of position. A good tack will allow the part to be bent back in place with a slight tap from a hammer. After tacking all the parts, check the outside corner joints to ensure they all fit tightly together. The gap between edges should be no more than 1/16".

Note:
The jig used in Figure 4-7 will also be used in Step 8.

When tacking parts, if possible, tack in from the edge at least an inch. Placing a tack at the start of a joint can make it difficult to start an arc. Tacks placed in the middle of a joint are easily covered when the joint is welded solid.
Do not over-weld when tacking. The more heat produced while tacking, the more the metal will pull out of position when cooling.
A good tack is solid enough to allow for some bending without breaking, yet not so solid that it can't be broken easily with minimal force.
If a grinder has to be used to break a tack, it was over-welded.
If it breaks when you try to do some slight bending, it was not welded solid enough.

HELPFUL HINT

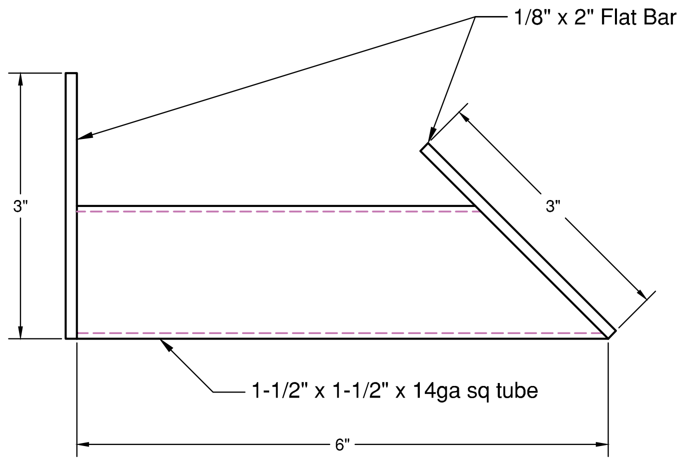
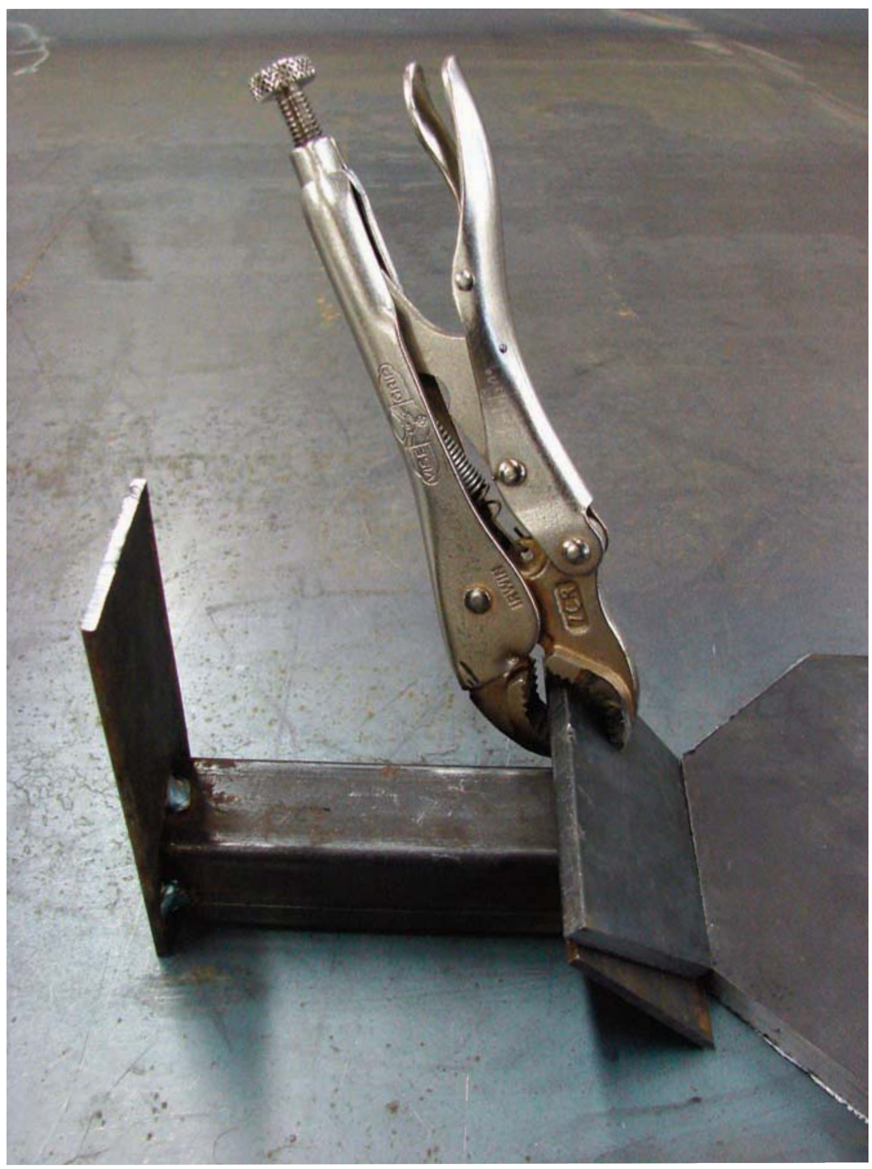


Figure 4-7. a) Plan view of jig used to attach the angled sides.

b) The first side clamped with a pair of locking pliers, aligned, and ready to be tacked.



STEP 6. Cut the top side parts.

If any of the angled side parts have to be adjusted in length, the straight side part lengths will also need to be adjusted to match. Cut one part at a time if necessary. Otherwise, if all the angled parts are cut to the correct length according to the plans, set up a stop on a saw and cut all side top parts to the same length quickly and accurately.

STEP 7. Attach the side top parts.

Using a partner and a square, connect the side top parts to the angled sides with a small tack in the center of the parts.

If no one is available to help, the jig in Step 5 should be used (Figure 4-8). Hold the parts in place with locking pliers and tack the parts in place (Figures 4-9).

When tacking is complete, check the joints on the outside. They should align with all corners touching, with very little gap between each part (Figure 4-10).

Figure 4-8. Before using the jig, check to make sure the 1/8″ x 2″ flat bar is attached at a 90-degree angle.

a)

b)

*Figure 4-9. a) Top Side clamped in place.
b) Top side parts tacked.*

Figure 4-10. Outside corner joints of bowl ready to be filled with weld.

STEP 8. Weld the bowl solid.

When tacking is complete and it's time to complete the finish welds, plan ahead. Think about which welds should be completed first and last in order to achieve the best results. In addition, consider the effects that a cooling weld will have on the squareness of the project. Even with the entire project tacked together, a cooling weld still shrinks — and shrinking causes weld distortion. To counteract this effect, weld in a pattern that is opposite of the last weld. For example, after completing the first weld joint on the bowl, skip to the opposite side and weld the next. By skipping to opposite sides, the heat buildup is limited in any one area and the amount of distortion to the project will be minimal.

With this project, it works well to start with the seams going up and down on the outside of the bowl first, starting at the bottom and working to the top. It will be easier to prop the bowl up in a position to weld as flat as possible, eliminating the amount of vertical welding.

When welding the seam that goes around the octagon shape, weld over the up and down seams quickly so as not to form too high of a weld at the intersection.

If any of the welds on the outside of the bowl are not satisfactory, a grinder can be used to grind out the weld and redo it.

When the outside is complete, follow the same steps to cover the seams on the inside of the bowl. Before welding, chip any slag buildup on the inside of the bowl that may have bled through when welding the outside of the bowl.

These welds will be easier to complete because they are basically a flat cover weld used to hide the seams and imperfections from any poor fitting joints. However simple, take care to do a good job on the inside welds — grinding and re-welding will not be an option (Fig. 4-11).

For more information on arc welding techniques, refer to Chapter 4 in *The Art of Welding,* by William Galvery.

Figure 4-11. Inside welds of the bowl.

STEP 9. Clean and chip all slag and welding spatter.

When all welds are complete, the bowl will need to be cleaned of all slag and welding spatter. Chip the slag with a chipping hammer. Slag that chips off easily with a slight tap of the hammer is a sure sign of a good weld. If more aggressive solid hitting is required, it may be possible that the weld has some holes or undercutting. Use a chisel and hammer to remove larger berries and a wire wheel cup brush to clean and polish the inside of the bowl. On the outside of the bowl, a straight knot wire wheel will work best (Figure 4-12).

SAFETY TIP

When using wire wheels on angle grinders, the wires tend to fly off in the air. Take special precautions to be safe. Grind in an area away from others and wear a clear face shield with safety glasses to protect yourself.

Figure 4-12. Examples of wire wheels that can be used in a die grinder and an angle grinder for finish clean up. From left to right: A cup brush attached to a die grinder, a straight knot wire wheel designed to be used in an angle grinder, a smaller die grinder straight wire wheel, and a round head wire brush.

STEP 10. Add the steel balls to the bottom of the bowl.

After clean-up, locate a point 1/2" from the edge of four opposing sides for the placement of the steel balls. Use a hammer and punch to mark the ball placement locations. Place the bowl on the table of a drill press and use a 1/4" drill bit to make a small divot the depth of the tip of the bit at each ball location. These divots will be used to keep the ball in place while tacking. Weld the ball in place with a strong secure tack weld on the side facing the center of the bowl only(Figure 4-13).

After welding on the balls, turn your bowl over and make sure it sits solid on a flat surface and there is no rocking. If it rocks, you can add weld to the bottom of the low ball or grind off a small portion of a high ball.

Figure 4-13. Steel balls attached with strong solid tack welds.

STEP 11. Final Cleanup.

Clean the weld area around the steel balls and the bowl is complete.

CHAPTER 5

Number One

This project is a money saver. It uses very little steel, yet still gives a person the opportunity to use a variety of different tools while learning tacking techniques and providing practice stick welding outside corner joints and T-welds.

STEP 1. Collect needed steel and lay out front and back faces (Parts A).

This project utilizes 1/4" plate steel and 1/4" x 1" flat bar. (See Figure 5-1 for the parts list and Figure 5-2 for the front and side view.)

After acquiring the necessary steel, lay out the front and back faces (Parts A). Lay the parts out in opposite orientation from each other and place them in the corner of the steel plate if possible (Figure 5-3). Having a mirror image is important because when cutting, the top surface is generally the most accurate representation of the original part. When cutting thicker steel, the kerf may not be perpendicular to the surface of the steel, giving it a slight angle in one or both directions, depending on how well the cutting operation was performed. If the parts are laid out in opposite orientation, the best sides can be positioned so that they are both on the outside of the project.

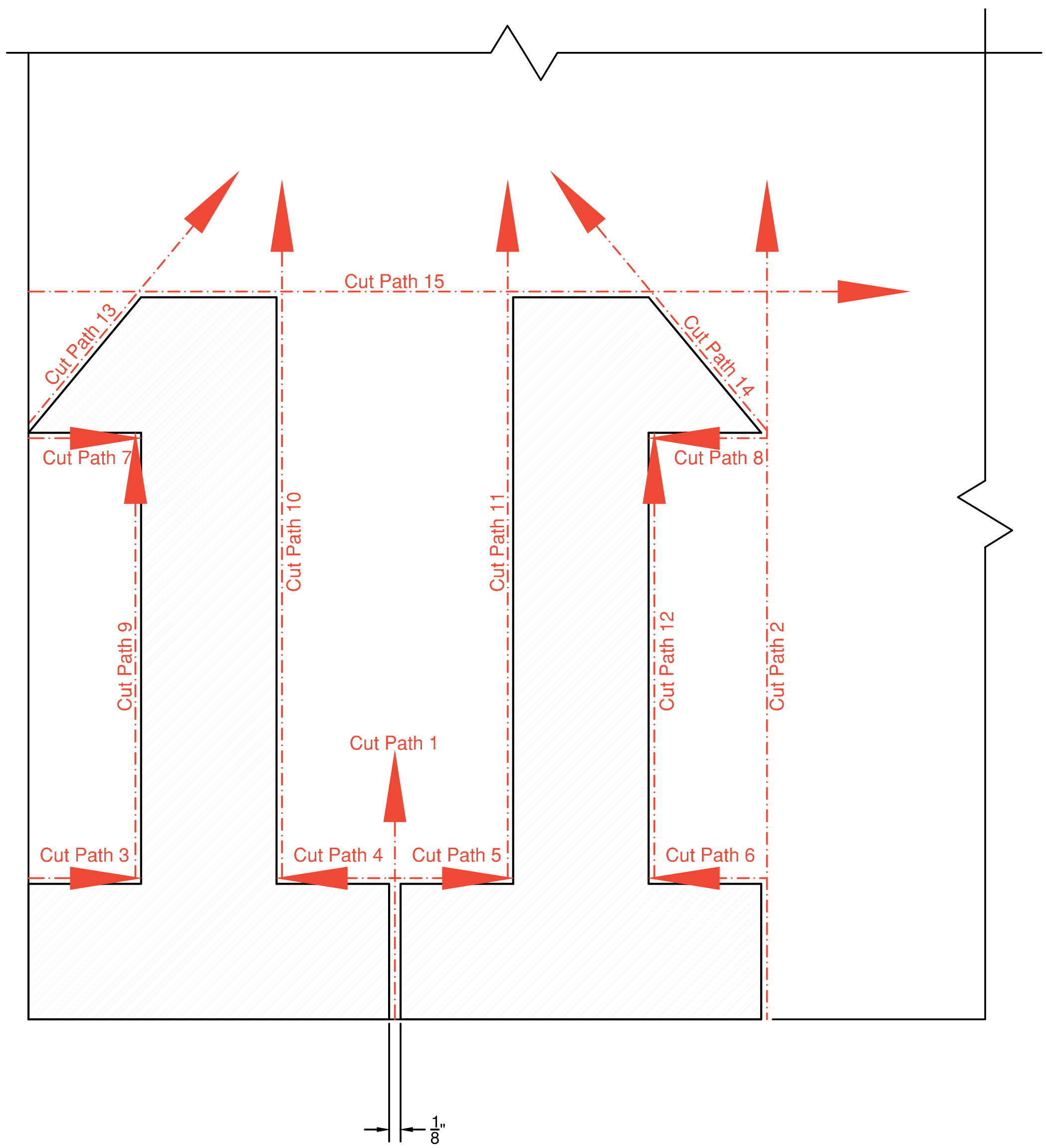


Figure 5-3. Layout orientation and cut path order for the Number One front and back faces.

Number One Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
2	A - Front & Back Face	Plate	1/4"	0'-4"	0'-8"
3	B - Side	Flat Bar	1/4"	0'-1"	0'-1 1/2"
1	C - Side	Flat Bar	1/4"	0'-1"	0'-6 1/2"
3	D - Side	Flat Bar	1/4"	0'-1"	0'-1"
1	E - Side	Flat Bar	1/4 "	0'-1"	0'-4"
1	F - Side	Flat Bar	1/4"	0'-1"	0'-5"
1	G - Side	Flat Bar	1/4"	0'-1"	0'-1 15/16"
1	*H - Base	Plate	1/4"	-	-

*Note: The base width and height will vary depending on the chosen design.

Figure 5-1.

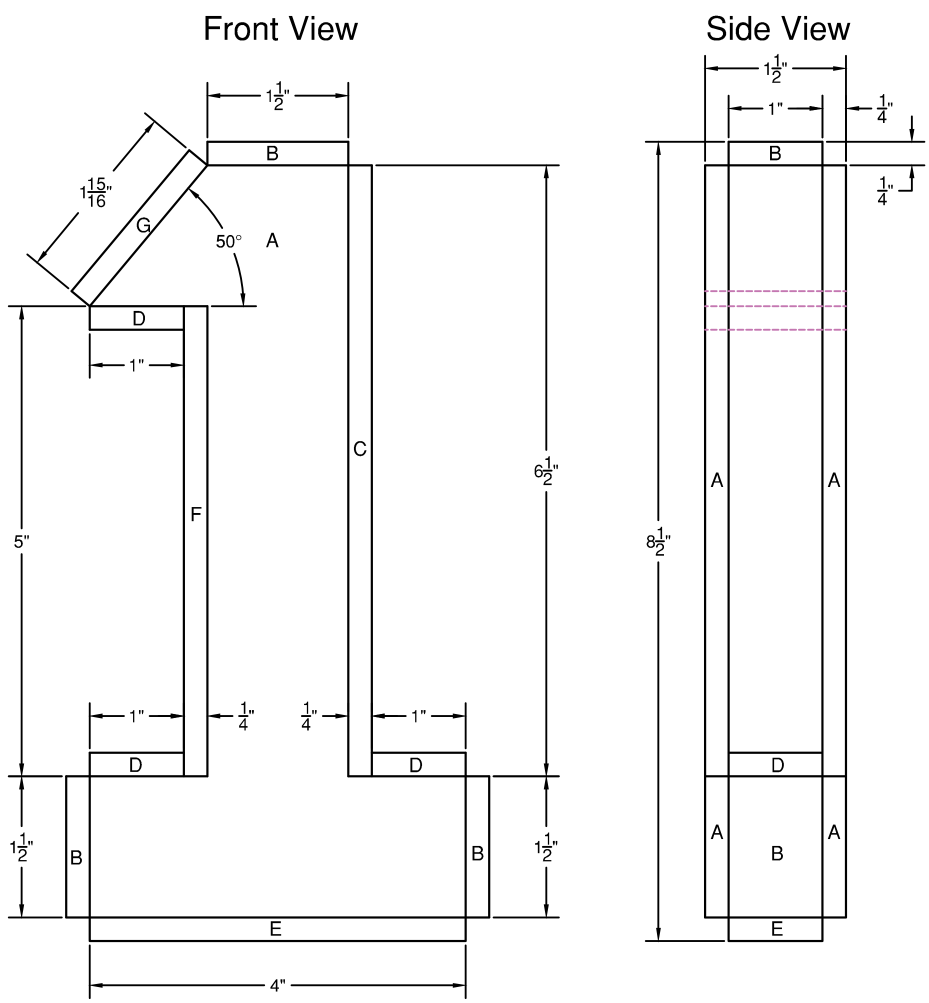


Figure 5-2. Front and side view of Number One.

STEP 2. Cut the front and back faces.

As with the previous Bank and Bowl, this project provides an excellent opportunity to practice using a cutting torch.

In order to achieve the best results when cutting, it is helpful to plan the cutting order first. Pre-planning can save time and help to produce a better end product. Figure 5-3 provides a cut path order for the front and back faces. The order was set up so that all cuts could be started on an edge or in the middle of an existing kerf, eliminating the need to purge through the surface of the material. Starting on an edge will speed up the cutting process because edges heat up faster than surfaces and limit the possibility of damaging the torch tip with hot molten steel.

For more detailed information on using a cutting torch, see Step 2 of the Bank in Chapter 3.

Note:
If you use a plasma torch, use a straight edge as a cutting guide. Follow the same cut path order given in Figure 5-3.

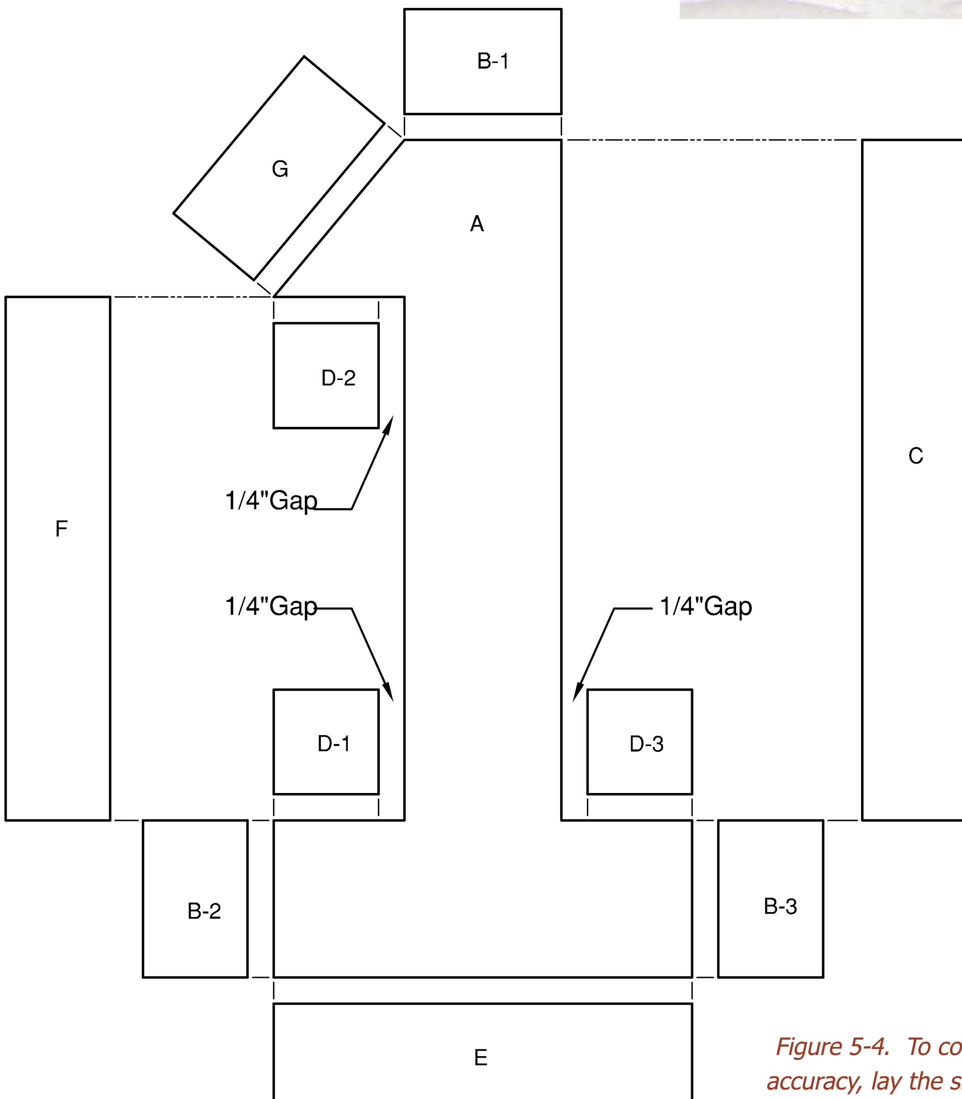


Figure 5-4. To confirm cutting accuracy, lay the side parts next to their corresponding sides.

STEP 3. Clear the surfaces and edges of the front and back faces

After cutting, there will be slag build up on the back surface of the front and back faces. Use a chipping hammer first to remove the looser material, then a portable hand grinder to finish the clean-up. The edges will need some touch up as well. The most accurate and efficient way of completing this task is to clamp the two faces together and grind the edges of the two parts at the same time. This will produce identical parts, which is important for assembly purposes in later steps. Try not to grind more than necessary in order to keep the project as close to the original size as possible

STEP 4. Cut the side parts.

Prior to cutting the individual side parts, take some time to check the side lengths of the faces. Make a quick sketch of the Number One on a piece of scratch paper and use it to record the lengths. After the measurements have been completed, compare them with the dimensions provided in the front view of Figure 5-2. Place a check mark next to the sides that can be cut to the correct length and circle the sides that need to be cut longer or shorter.

With the check list nearby for reference, cut the parts to length one at a time. Be as accurate as possible. As each part is cut, lay them next to the side of their corresponding face in order to verify the part was cut to the proper length (Figure 5-4).

If there are any burrs on the back side of the parts after cutting, remove them.

STEP 5. Attach the angled sides.

Before tacking, clean the work surface area so that it is flat and free of welding berries and other debris. Next, collect a couple short pieces of 1" x 1" square tubing. These scraps will be used to place the side parts in the proper position and angle while tacking and to lift the face off the work surface the proper height (Figure 5-5).

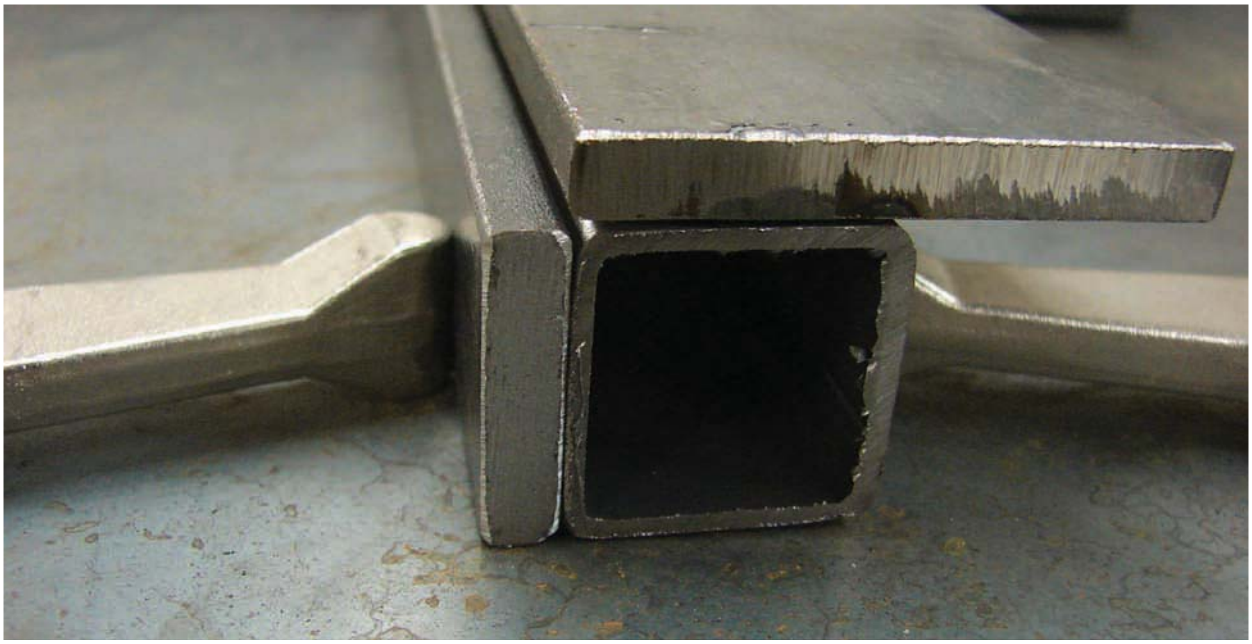


Figure 5-5. Square tubing provides an accurate way of temporarily holding parts at the proper angle and height while tacking.

Refer to Figure 5-4 for part references during the following tacking sequence. Begin by tacking part F to the top face followed by parts D-1 and D-2. Next, tack parts G and B-1 on the top end of the face. Move to the bottom end and tack parts B-2, E, and B-3. Then tack part C in place and finally D-3. By moving in this sequence, locking C-clamp pliers can be used to hold the majority of the parts square against the scrap tubing while tacking.

After tacking, some or all of the parts may need to be tapped back into square due to the pulling effect of the weld as it cools.

After the sides have been tacked and squared on the front face, flip the project over and position the back face on the sides. Connect each side part to the back face with a small tack the same as was done when connecting the sides to the top face. This will secure the parts so that they cannot pull out of place when welding the joints solid.

Finally, use a chipping hammer to remove the slag from the tacks.

When tacking, keep two things in mind:

1. Tacks should be small. The less heat the parts are subjected to, the less they will pull out of square while cooling.

2. Tacks should be placed in the center of joints rather than on the ends. Tacking on the ends can make starting an arc more difficult when completing a welded joint.

HELPFUL HINT

STEP 6. Weld the joints solid.

Begin by welding the outside corner joints and T-welds on the 1" sides. Make sure the welds begin and end slightly past the ends of the joints to eliminate the chance of having holes at the intersecting corners. Chip the slag from the side welds. Then weld the outside corner joints around the front and back faces. When complete, the corners should all be closed and free of holes at the intersections (Figure 5-6).

Figure 5-6. Completed weld intersection.

STEP 7. Remove the slag and spatter.

Clean the slag from all welds and remove any welding spatter. Inspect your welds for porosity, under-fill, and over-fill. Most areas that are poorly welded can be ground out with an angle grinder and re-welded if necessary. Areas that are over-welded should be ground down flush to the front and back surfaces.

STEP 8. Personalize the project and build a base.

This project was designed to allow you to demonstrate your ability to be creative. The letters welded to the front face and the base used to hold the One in an upright position can be designed with a theme in mind, adding a unique touch to the finished product. The theme for the Number One in this example is "Teacher" — hence the word *TEACHER* welded to the front face and the apple-shaped base. A sports theme could easily be incorporated into this project by welding a team's name on the face and cutting the base in the shape of the team mascot. For example, you might weld *Mustangs* on the face and cut the base in the shape of a horse that matches the team's logo.

After choosing a theme, use a permanent marker or soapstone to draw the letters on the front face. Before actually welding the letters on the project, use the smaller 3/32" diameter electrode; to practice welding the letters on some scrap. When you have confidence in your writing abilities with a stick electrode, weld the letters onto the front face of the Number One (Figure 5-7). Then clean the slag and remove any welding spatter.

Due to the narrow depth of the One, a base should be constructed to hold it upright when displaying it. The base is basically unlimited as far as the shape, however the overall size should not exceed 6-1/2" square.

Trace the base pattern onto 1/4" plate. If you aim to have smooth square edges, when free-hand cutting around irregular shapes, make sure to leave your line so you can grind up to it. In some instances, a jagged cut around the edges may be the intended look. If so, no edge grinding will be necessary and leaving the line will be of lesser importance. After cutting, remove the slag, polish the surface, and finish the edges if necessary.

Figure 5-7. Letters welded to the front face of the Number One.

To weld the base securely to the Number One, it's more appealing to attach it from the bottom using two plug welds. To determine the placing of the holes in the base, first cut out a paper pattern 1-1/2" x 4-1/2" — this is the size of the bottom of the One. Measure and mark where the center of the holes are on the pattern. Lay the paper pattern on the base and center it, ensuring that there is at least 1/4" of the base sticking out past the edge of the pattern.

When the location is determined, tape the pattern to the base; then use a punch and hammer to mark the hole centers (Figure 5-8). After the holes are located on the base, use a drill press to bore the two 1/2" diameter holes. (Figure 5-9).

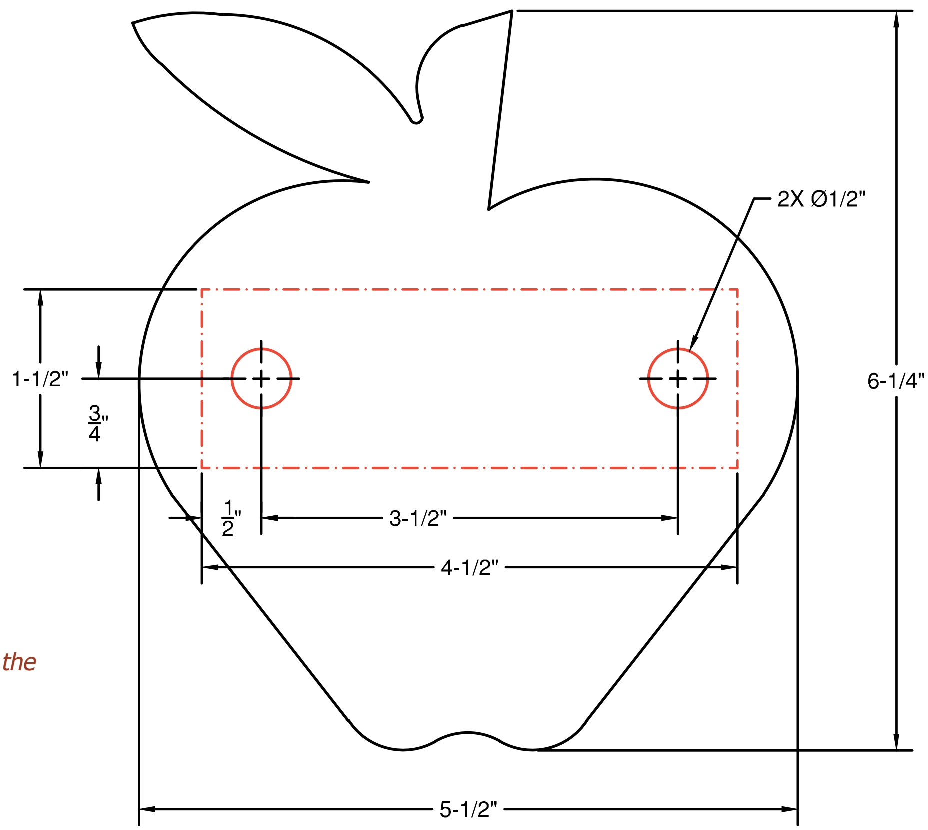


Figure 5-8. Guide to placing the holes in the base for the two plug welds.

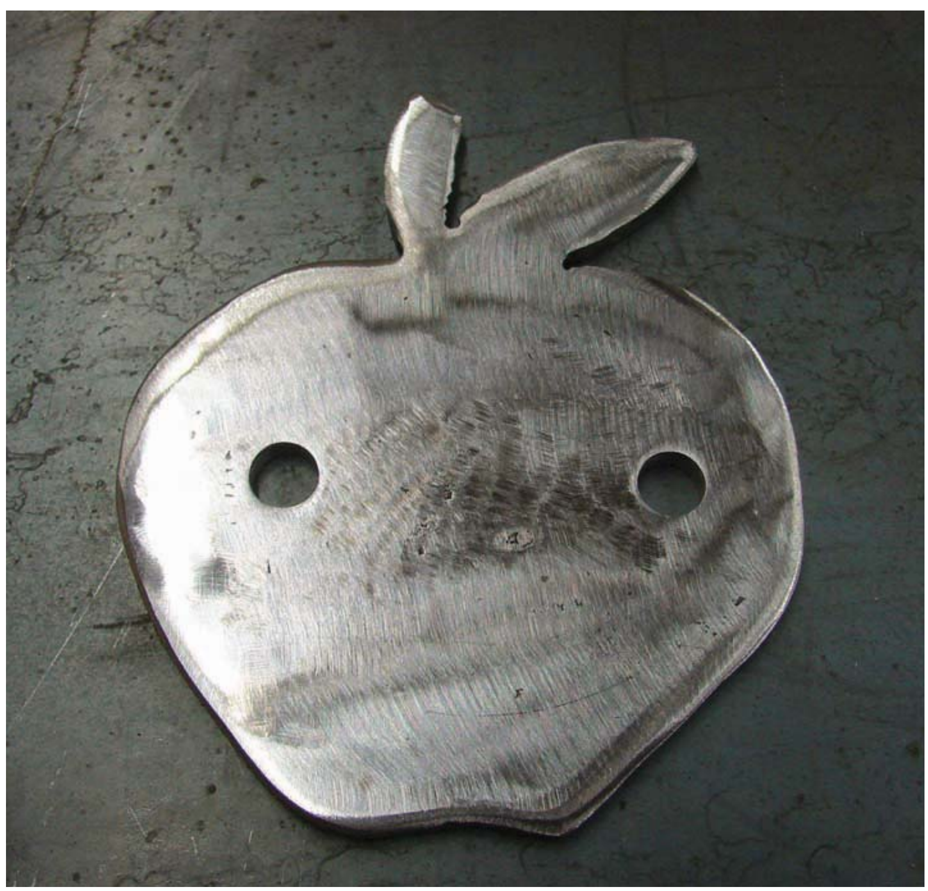


Figure 5-9. A base with two 1/2" holes

STEP 9. Weld the base to the Number One.

To begin, place the One in a vise with the bottom side up. Position the base on the bottom of the Number One (Figure 5-10). If the bottom of the Number One is not flat, grind the edges of the corner welds until a flat surface is obtained; then place the base back on the One. Tack the base to the One and remove it from the vise to check for proper placement. If the placement is acceptable, place the project back in the vise. Fill the hole by welding a bead around the diameter of the hole, letting the weld cool, chipping the slag, and then repeating the process until the hole is filled with filler metal just above the surface of the steel. (Figure 5-11).

Figure 5-10. Positioning the base on the bottom of the One.

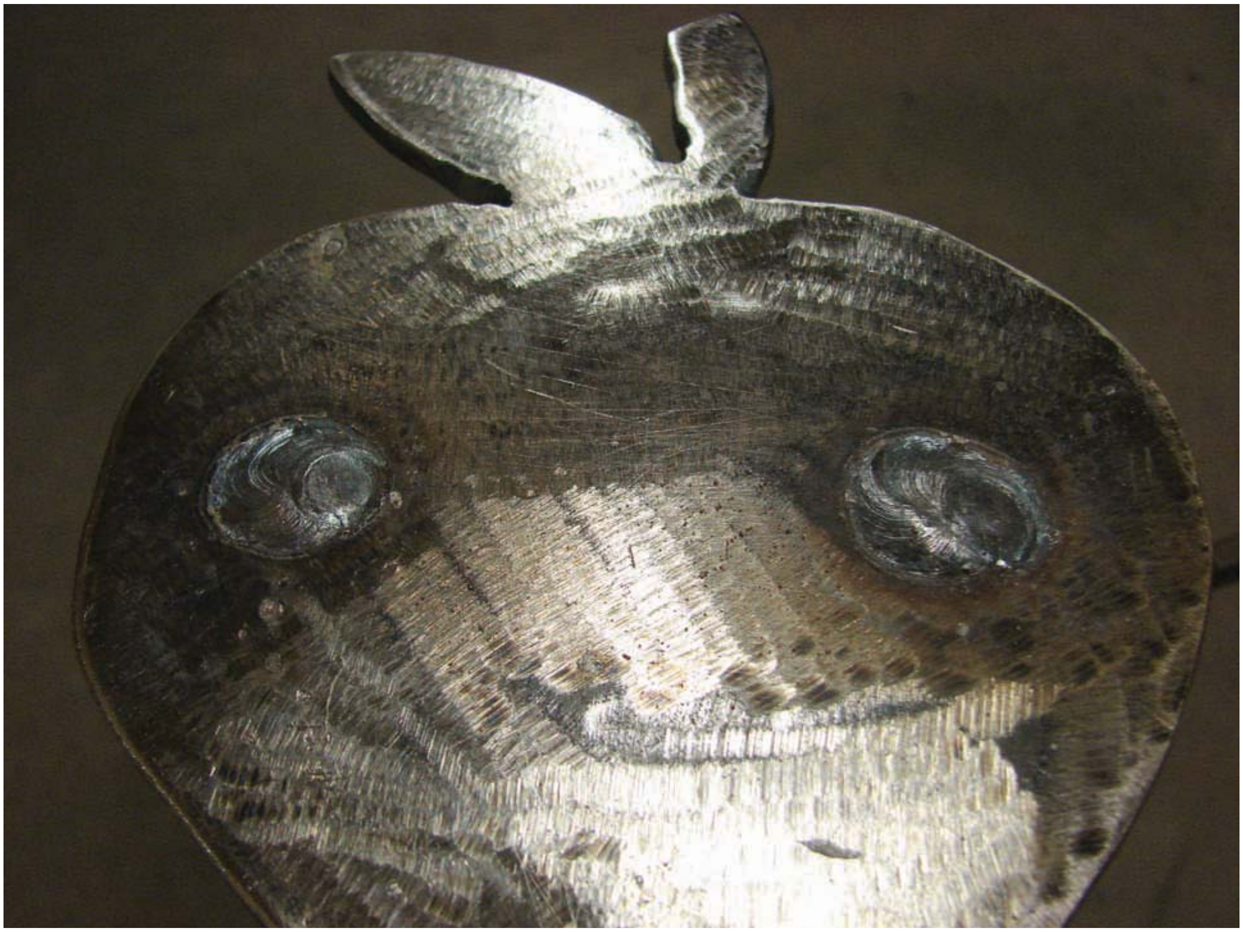


Figure 5-11. Completed plug welds.

STEP 10. Final Clean up.

Grind the bottom plug welds flush with the surface of the base bottom and the project is complete.

PART 3

Gas Welding Projects

Acetylene, the fuel that allows an oxyacetylene flame to reach temperatures as high as 6330 degrees Fahrenheit has a history that dates back to 1836 when Edmund Davy, a chemistry professor at the Royal Dublin Society, accidentally discovered this gas. It was later discovered that burning the fuel with a pure oxygen source provided a flame hotter than any available heat source to date. But widespread use of the oxy-fuel combination did not come about until 1902 when German scientist Carl Con Linde began building oxygen separation plants in Europe. He then later moved to the United States, where he founded the Linde Air Products Company in Cleveland, Ohio. By 1920, with the availability of both gases, almost every repair shop in the United States was fitted with oxyacetylene stations. The extremely high temperature that could be reached when acetylene was mixed with pure oxygen revolutionized the metal cutting process. A cutting job that once took days to complete now took a matter of hours or less.

With the technological advances in SMAW, TMAW, and GMAW, the use of oxyacetylene as a useful welding process has become mostly obsolete; it is now used mainly for cutting purposes. However, gas welding with an oxyacetylene torch is a great way for a beginning welder to learn how to control the molten weld puddle. The process is slow and the molten puddle is clearly visible at all times. All flaws in a weld are detectable and, in most cases, correctable.

Gas welding can also be used as a stepping stone for learning to TIG weld. The two processes are basically performed in the same manner other than one uses a gas mixture as the heat source and the other electricity.

The gas projects in this section are designed to provide the beginner gas welder with a fun way of practicing gas welding skills. After construction, the projects can be polished and clear coated, with the welds left alone or completely smoothed with a polishing wheel. The projects can also be embellished with unique finishes. In the case of the vase, flowers can also be added.

CHAPTER 6

Dice

The dice is an excellent beginner project for practicing skills with an oxyacetylene gas welding torch and for learning a variety of fabrication skills such as measuring, plasma cutting, and hole drilling.

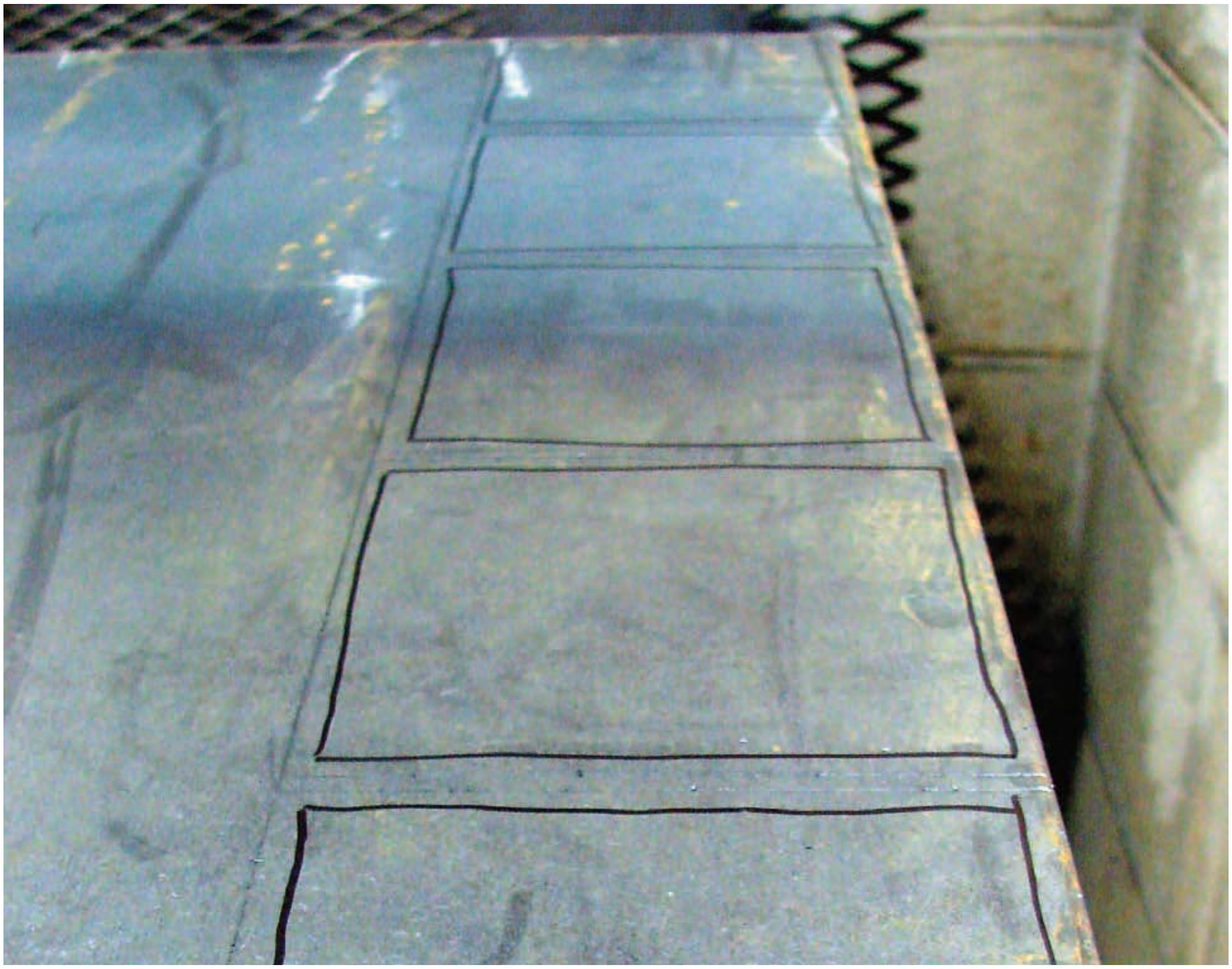


Figure 6-1. Use a scribe for maximum accuracy when laying out parts.

STEP 1. Select needed steel for project and layout parts.

The parts for the dice consist solely of six 4"x4"squares cut from a sheet of 10 gauge steel.

Using a scribe, lay out the parts in a line of six squares along a straight edge, spacing the parts 1/8" apart to compensate for the width of the kerf and to leave some room for error. The excess can easily be ground down after cutting. After scribing the parts, use a permanent marker to draw lines just to the inside of the scribed lines to aid in locating the lighter, more difficult-to-see scribed lines when cutting (Figure 6-1).

STEP 2. Cut the parts.

Using a plasma cutter and a straight edge clamped to the steel, cut out the parts. Ideally, the kerf should run right down the center of the 1/8" spacing between the parts (Figure 6-2).

NOTE :
If you've never used a plasma cutter with a straight edge, refer to Step 5 of the truck plans in Chapter 1 for instructions on placing the straight edge in the proper location as well as helpful hints for using the plasma torch.

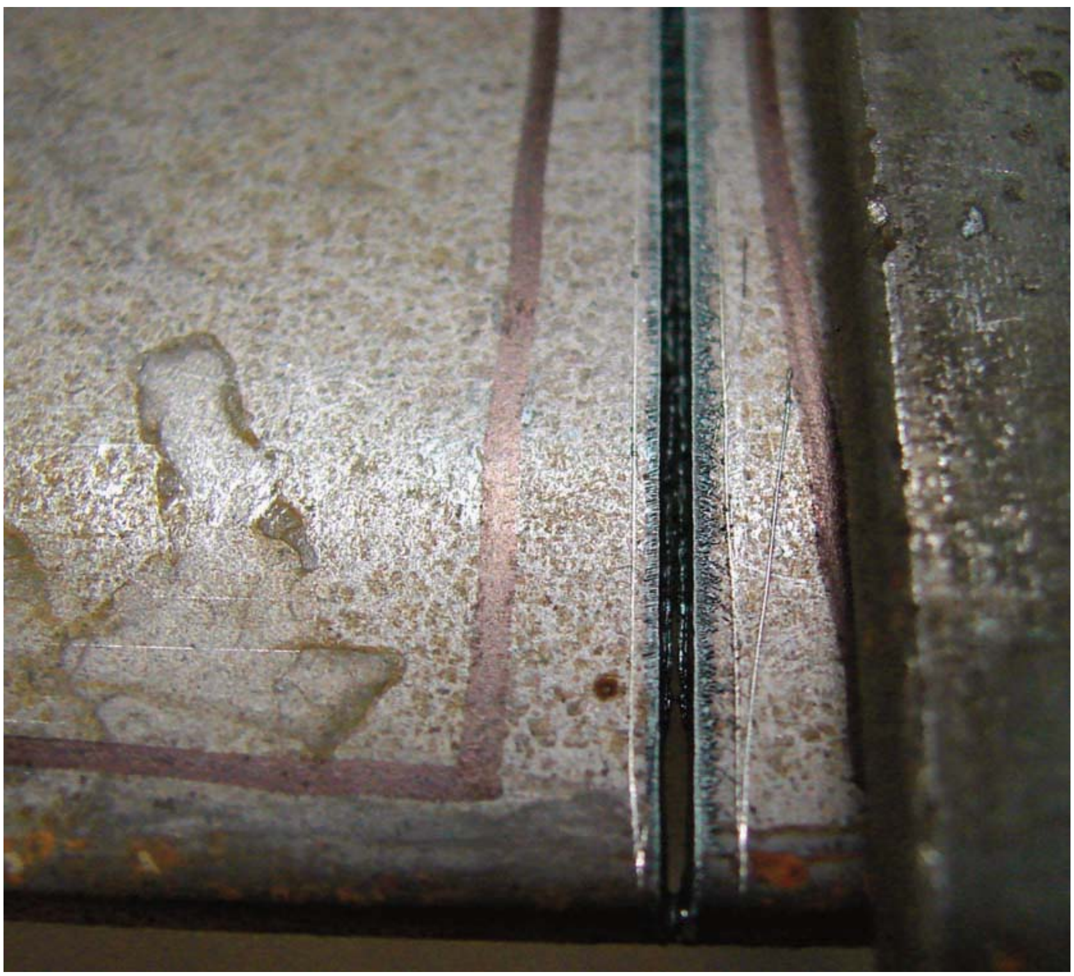


Figure 6-2. In this example, the kerf is correctly centered between the scribed lines.

STEP 3. Cut the remaining parts; then clean the ends.

After cutting, remove the dross (slag) from the back of the parts; also remove the mill scale from the surface on one side of each of the six parts. The dross and mill scale add impurities to the weld puddle. Eliminating the impurities will make the welding process much easier and will allow the finished dice to have a polished steel finish when the project is complete.

To remove the mill scale, first grind the surface with an angle grinder, then use a polishing wheel to smooth the surface and eliminate the scratches made by the course grinding wheel.

To finish the edges, clamp all six parts together with locking C-clamp pliers. Ensure the edges are flush on the bottom and on one side. Align the best edges to reduce the amount of grinding required (Figure 6-3).

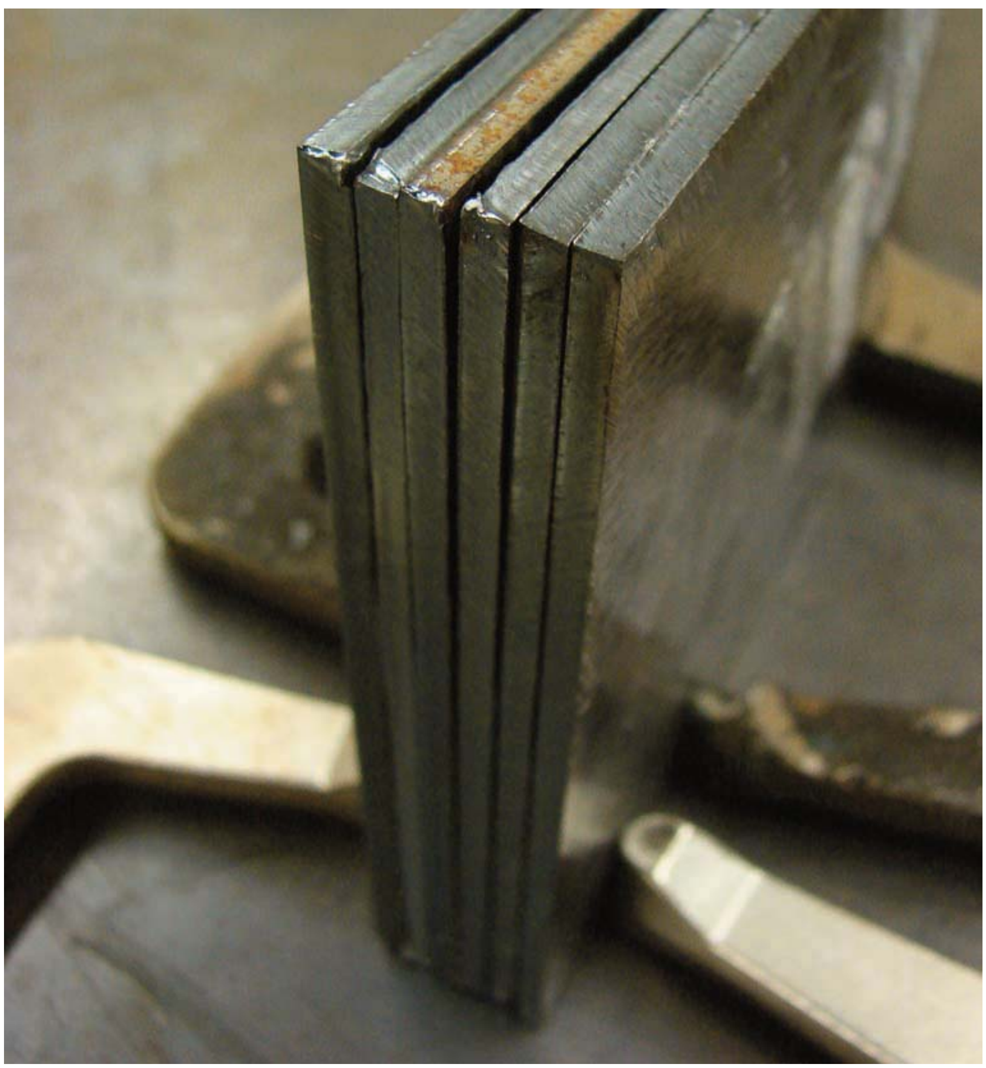


Figure 6-3 Parts aligned and clamped with locking pliers.

NOTE:
Refer to Step 6 of the truck plans in Chapter 1 for helpful hints and proper techniques for cleaning dross from the back of plasma cut parts.

Figure 6-4 Grind the edges as close as possible to 4" square.

Clamp the parts in a vise, leaving the locking pliers in place to keep the parts in the same orientation throughout the entire grinding process. Grind the edges with an angle grinder until all edges are flush and the height and width of the parts are equal (Figure 6-4). If the parts measure slightly over or under 4" x 4", don't worry; as long as they are square and have an equal width and height, the cube will fit together properly.

STEP 4. Collect needed tools for gas welding.

To complete the dice, the following tools will be needed: pliers, locking pliers, locking C-clamp pliers, a striker, a gas torch tip, a tip cleaner, gloves, shade #5 glasses, and an oxyacetylene station.

SAFTEY

To avoid burns, get in the habit of always using pliers to handle steel when gas welding. The steel remains hot enough to cause serious burns long after the cherry red color has faded.

Figure 6-5 a) Flint and steel striker.

Figure 6-5 b) Keep the striker in good condition so that it produces a strong spark.

The locking pliers and locking C-clamp pliers will be used to handle the parts and hold them in place while tacking.

A flint and steel striker is used to ignite the torch flame (Figure 6-5a). Check that the flint is in good condition and that when you strike it, a flashing spark appears. If a spark cannot be obtained easily, remove the old flint and replace it. (Figure 6-5b).

Torch tips come in various sizes. The proper tip size is determined by the metal thickness and the joint design (Figure 6-6).

It is important that the gas torch tip orifice is clean and free of berries. Clean the orifice with a tip cleaner before every use (Figure 6-7). A dirty tip will produce an uneven and unstable flame that is difficult to use.

Figures 6-6. a) The orifice of a 207 and 205 Smith gas welding tip. The larger the orifice, the more gas that is released and the hotter the flame. b) 205 and 207 Smith gas welding tips. The body of the 207 is larger to allow more gas to flow and to allow the welder to be farther away while welding due to the greater amount of heat produced.

b)

Figure 6-7. A shorter tip cleaner is easier to use when cleaning a gas welding tip. When cleaning, have the tip attached to the torch handle and have the oxygen valve on the handle open 1/4 of a turn so that the slag and dirt particles can be blown out of the tip while cleaning.

Even if pliers are handy and you always try to use them, gloves are a must. There is always that one time that you need to move something ever so slightly and, without thinking, you touch or even grab the hot steel. Burning gloves beats the alternative.

Safety is always something that should be thought about when welding. Safety glasses and proper eye protection should never be forgotten. When gas welding, wear clear glasses while setting up, and #5 dark glasses or a #5 tinted face shield to protect your eyes from sparks and the high intensity light. If using dark glasses, there should be no more than 3 seconds of time elapsing between taking the clear glasses off and putting the dark glasses on. Prior to switching, check your surroundings for possible dangers. Eye injuries are one of the most common occurring accidents seen in a shop environment.

The oxyacetylene station should be close to the work area; the hoses should be laid out so no one will be stepping on them while welding. The regulators should be working properly and the hoses should be free of any leaks (Figure 6-8). If you suspect a leak, spray the area in question with soapy water and look for bubbles. If bubbles are visible, that is a sign of a loose or bad fitting or a hole in a hose. If a leak is apparent, repair it before welding.

For detailed information on oxyacetylene setup, refer to Chapter 3 in *The Art of Welding* by William Galvery.

Figure 6-8. An oxyacetylene station includes an oxygen cylinder with attached regulator, an acetylene tank with attached regulator, hoses, and a torch handle. The setup is color coordinated. The green hose is always attached to the oxygen cylinder and all fittings for the setup are right hand threaded. Red hoses attach to the acetylene and the fittings are left hand threaded. These pairings ensure proper hookups without any confusion.

STEP 5. Set up the oxyacetylene station.

When setting up the station, prior to attaching the gas torch to the torch handle, inspect the O-rings on the torch head to make sure they are present and in good condition. Worn or missing o-rings can allow gas to leak out of the fitting and a flame can ignite near the area where the torch handle will be held (Figure 6-9). Also inspect the tightness of the gas tip to the torch head. This screw joint sometimes loosens when the gas tip is attached or detached to the torch handle incorrectly. A loose fitting will allow gases to leak out and ignite (Figure 6-10).

Figure 6-9. The O-rings on a gas torch tip should be inspected prior to using.

Figure 6-10. The gas torch should be tightly screwed into the torch head to prevent gases from leaking out of the fitting.

After inspecting the gas tip assembly, attach it to the torch handle. When the tip is on properly, the fitting is tight, the valves are in the up position and the end of the gas tip should be angled in the direction that the weld will be performed. A right handed person should position the tip so that it is pointing left, and the opposite for left handers. The degree of angle depends on the person, the weld being performed, and what feels most comfortable (Figure 6-11).

Figure 2-8.Figure 6-11. Pointing the torch in the direction of the weld will provide a comfortable hold while welding.

Next open your cylinder valves and set the low pressure regulators on the oxygen and acetylene to the proper settings. This step is very important; if not completed properly, welding with oxy-acetylene can be very difficult. The number one mistake most beginners make when gas welding is setting their pressures incorrectly.

For welding 1/8" steel, use a working pressure of 5 psi for acetylene and 20 psi for oxygen. A working pressure is the psi that is read on the low pressure gage when the torch handle valve is open. A stable pressure is the psi read when the valve on the torch handle is closed. The acetylene low pressure gauge will display a noticeable drop when the valve is open. The oxygen will also drop but not as significantly (Figure 6-12). Do not ignore the importance of setting a working pressure. When gas welding, your heat is generated by burning gases. If there is not enough gas, there will not be enough heat and the welding process will be difficult, if not impossible with incorrect settings.

Figure 6-12.

a) Acetylene low pressure. The gauge reads 9.5 PSI as a stable pressure when the torch valve is closed.

b) Acetylene low pressure. The gauge reads just under 7 PSI as a working pressure when the torch valve is open.

a)

b)

c)

c) Oxygen low pressure. The gauge reads 25 PSI as a stable pressure with the torch valve closed.

d) Oxygen low pressure. The gauge reads 20 PSI as a working pressure with the torch valve open

d)

STEP 6. Tack the project together.

Before welding, always clean the work station by sweeping the surface, grinding off any welding berries and removing all flammable materials.

To begin assembly, secure two sides together using a short piece of 2" x 2" square tubing and two pair of locking C-clamp pliers (Figure 6-13). Align the parts so they form an outside corner joint. The inside edges should touch or be very close along the entire length of the joint (Figure 6-14).

After the proper alignment has been established, tack the parts together at each end using 3/32" diameter filler rod. Keep the tack small (Figure 6-15). Allow the tack welds to cool for a minute before removing the clamps. This will help to minimize the pull that is caused when the welds cool.

Repeat the same process for two more sides.

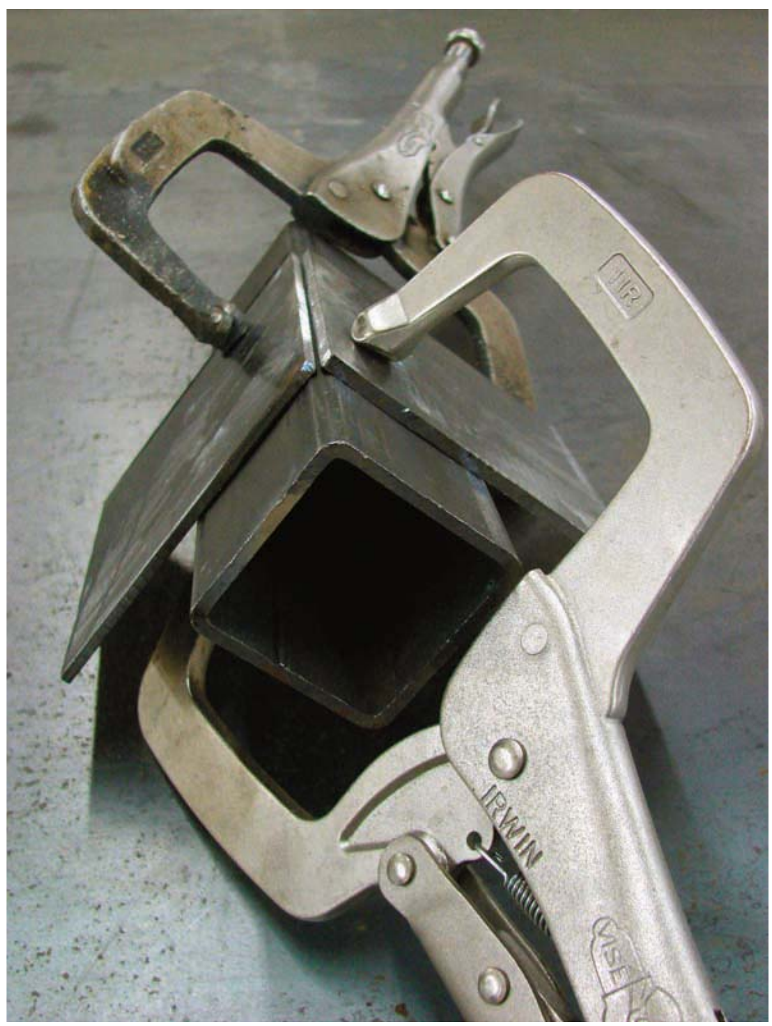


Figure 6-13. Using a piece of square tubing helps to maintain a square corner while tacking.

Figure 6-14. Properly aligned outside corner joint.

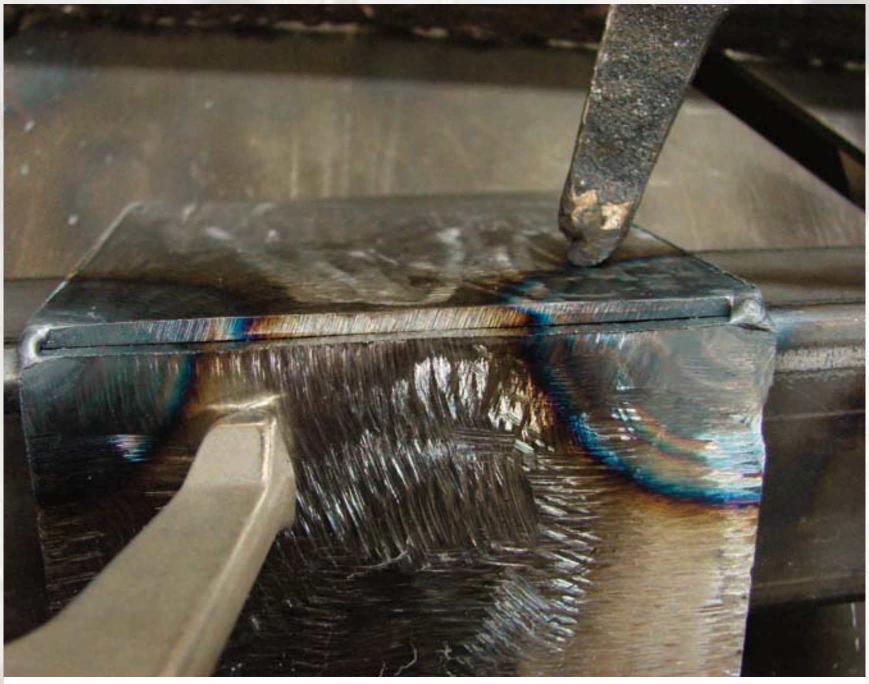


Figure 6-15. Two sides properly tacked.

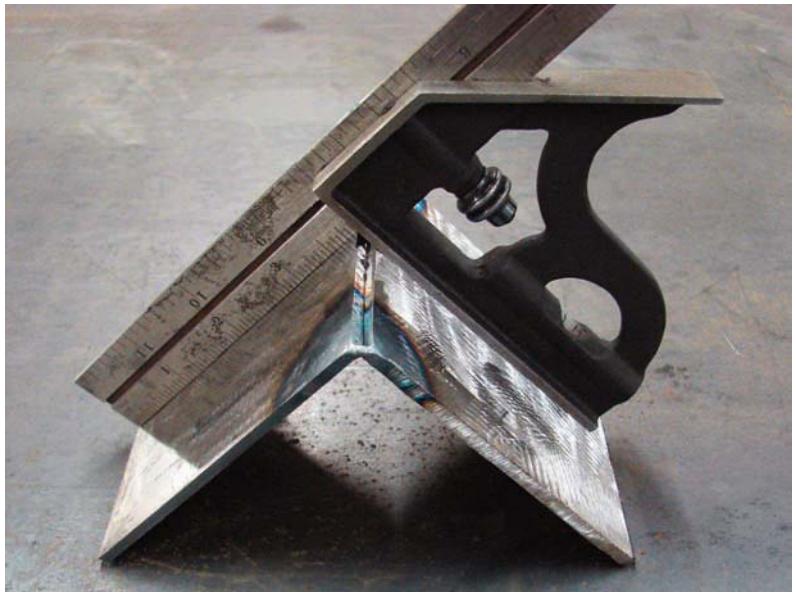


Figure 6-16 Check for squareness and adjust as necessary.

Next, use a square to check to see if the parts are at a 90-degree angle (Figure 6-16). If the parts are out of square, bend them back into place by pushing or pulling on the joint. Push or pull a little at a time, checking for squareness often.

Continue on by tacking the two sets of sides together. A piece of 2" x 2" angle iron and some locking pliers work well to hold the parts in the proper position while tacking (Figure 6-17).

If the first four sides were put together properly, the corners of the next side should rest on the corner tacks, preventing it from falling into the box (Figure 6-18). If the part is cut too small and it falls into the box, a small magnet can be helpful to use as a handle when setting the part in place. Once the fifth side is properly placed, tack all four corners. Then turn the box over and tack the sixth side of the cube in place.

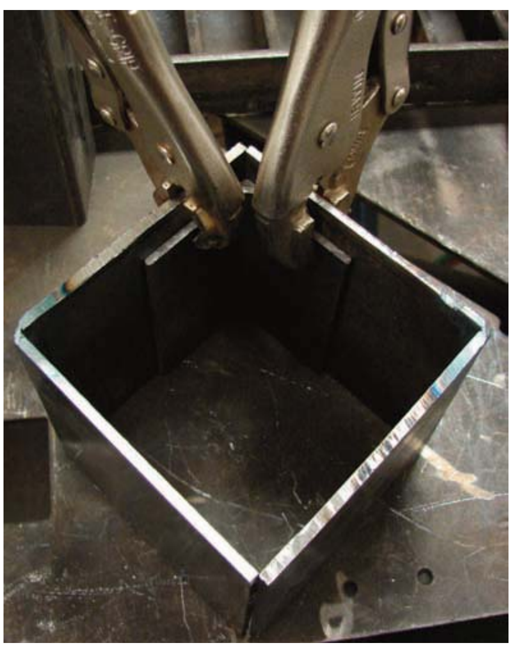


Figure 6-17. Use locking pliers to hold the sides together while tacking.

Figure 6-18. Positioning the fifth side on the box.

STEP 7. Clean the parts.

Before welding the cube, it would be advantageous to build a simple jig to hold the cube in the flat position. Construct the jig by welding a 3" long piece of 2" x 2" angle iron with the outside corner down and lying perpendicular to a 4" piece of 1/8" x 2" flat bar (Figure 6-19).

To complete the project, 3 or 4 sticks of filler rod will be used. The rod comes in diameters of 1/16", 1/8" and 3/32". For this project, 3/32" diameter rod is ideal (Figure 6-20).

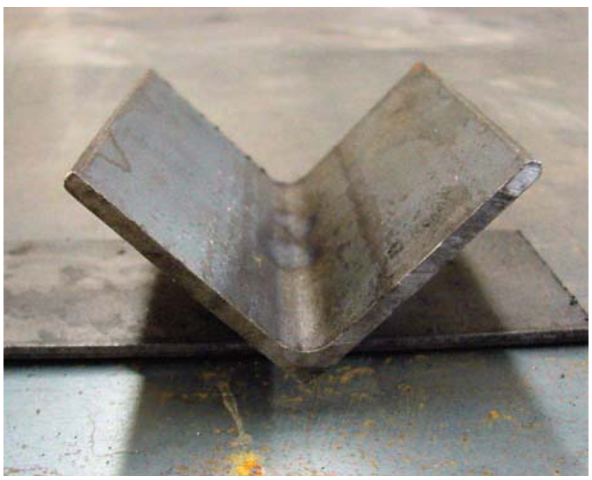


Figure 6-19. Jig used to hold the cube so that all welds can be done in the flat position.

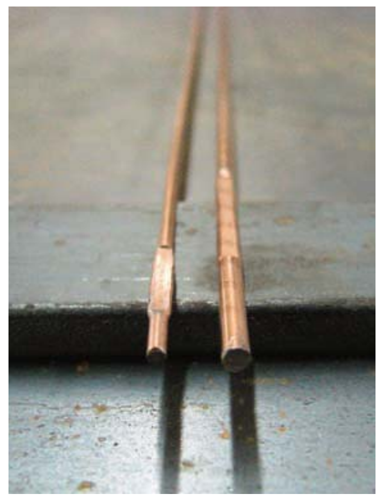


Figure 6-20. End view of 1/8" and 3/32" gas welding rod. Don't be fooled by the copper color. The rod is composed mainly of mild steel and is merely coated with a thin layer of copper to prevent oxidation.

HELPFUL HINTS

1. The gas welding process requires the use of two hands and good eye-hand coordination. It is helpful to be sitting in a sturdy chair at a comfortable height. When welding, hold your elbows against your side to help hold your arms as steady as possible.

2. The torch should be held at an angle in the direction you are welding and the inner cone should be aiming at the center of the joint. The end of the filler rod should be held near the weld puddle at all times, keeping it just under the melting point until you are ready to dip the rod. If you hold it too far away, when you attempt to add the filler metal, it will take longer to heat the rod and it tends to stick.

3. Set the torch with a neutral flame. When welding, very few sparks should emit from the weld puddle; the molten steel should be glossy and easy to read. (Reading a weld puddle means you are able to identify where the weld pool should be and you can identify problems with the puddle as they arise.) If the weld puddle seems to be boiling and excessive amounts of sparks are shooting out from the weld puddle, this is an indicator that the torch was set with too much oxygen causing an oxidizing flame. Welding with an oxidizing flame will permanently alter the composition of your molten metal in that area and make re-welding difficult, if not impossible.

4. It is important to take the time to find the correct heat setting. There is a fine line in which the flame is too hot or too cold. If it's too hot, the weld area can be over-heated, causing a fallout in which a large area of the joint collapses, creating a large hole. When the flame is too cold, it takes an excessive amount of time to form a puddle and it is difficult to dip the filler rod without sticking. Adjust the amount of acetylene at the torch handle to set the proper heat setting.

5. The distance the inner cone can be from the weld puddle will be determined by the amount of heat the torch is emitting. Ideally, when the gas pressures are set correctly, the inner cone should be around 1/4" to 3/8" from the weld puddle. THE INNER CONE SHOULD NEVER TOUCH THE MOLTEN PUDDLE. This can ruin a welding tip in a hurry by over-heating the end.

When ready to begin welding, place the cube in the jig (Figure 6-21) and heat the metal until a glossy puddle has formed. Weld from right to left if you are right-handed and vice versa if you are a lefty. Move back and forth slightly from edge to edge as you weld, pushing the puddle as you go and adding filler metal along the way. To avoid over-heating and warping the cube, when the first weld is complete, rotate the cube 180 degrees and weld the outside corner joint on the opposite side. Adding too much heat to one area for an extended period of time can permanently warp sheet metal projects; switching to opposing sides helps to avoid this problem. As the corners are joined, make sure not to leave any holes (Figure 6-22).

After completing all outside corner welds, allow the cube to sit and cool.

Inspect the welds for porosity, under-fill, and over-fill. Areas that are poorly welded can be ground out and re-welded if necessary. Holes can easily be filled by re-forming a molten puddle and pushing it across the area with the hole, adding a small amount of filler metal if necessary.

You may find gas welding difficult to master, but once you are able to read the weld puddle and know how to adjust the flame and torch distance, gas welding is really quite easy.

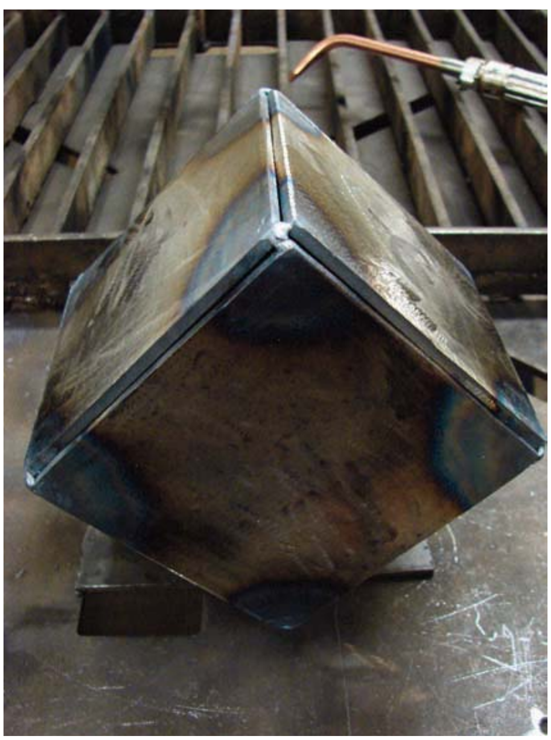


Figure 6-21. Place the cube in a jig in order to weld all joints in a flat position.

Figure 6-22. Finished cube before polishing and adding the holes. Corners are closed and free from holes. The outside edge joints are filled and the weld has evenly spaced ripples.

STEP 8. Clean the project.

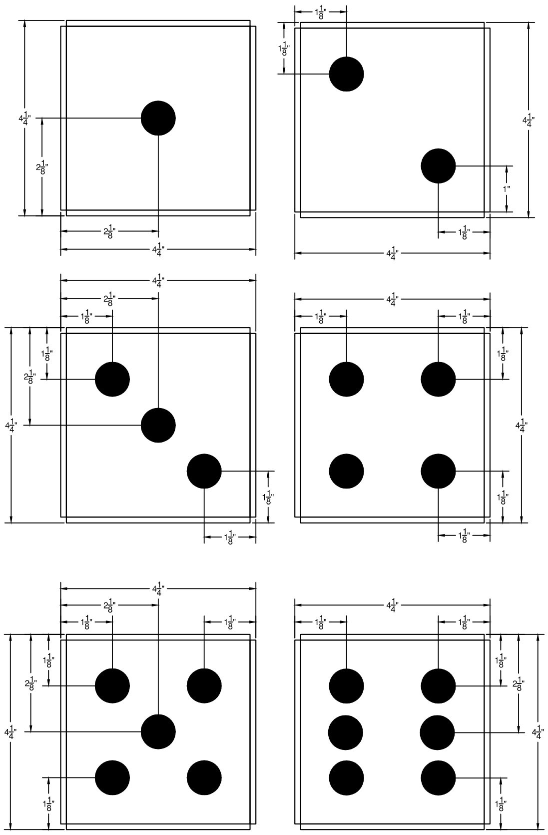
After welding, a thin layer of mill scale will be evident and will need to be removed. A polishing wheel or an angle grinder can easily re-polish the surfaces of the parts and can also be used to completely smooth out the welds as well (Figure 6-23). If the welds are to be left as is, use a wire wheel to remove the mill scale instead of a polishing wheel. A project with well performed welds is more impressive to display than one that has all the welds ground down and polished.

Figure 6-23. Polished cube after welding.

STEP 9. Add the numbers to the dice.

The final step in building the dice is to add the holes in the cube. Using Figure 6-24 as a guide, locate the holes using a fine permanent marker or sharpened soapstone. A scribe works as well but will add scratches to your already polished steel that may take more time to clean up. Remember, as the dots are added to the sides of the dice, the six and one, five and two, and three and four are opposite from one another (Figure 6-25).

After the hole locations have been marked, place the dice in a drill press vise, making sure the front side of the dice is flush with the front side of the vise. Any straight edge will work to align the cube in the vice (Figure 6-26). Align the 1/2" drill bit to



Note: All holes are 1/2" Diameter.

Figure 6-24. Dimensions for number placement.

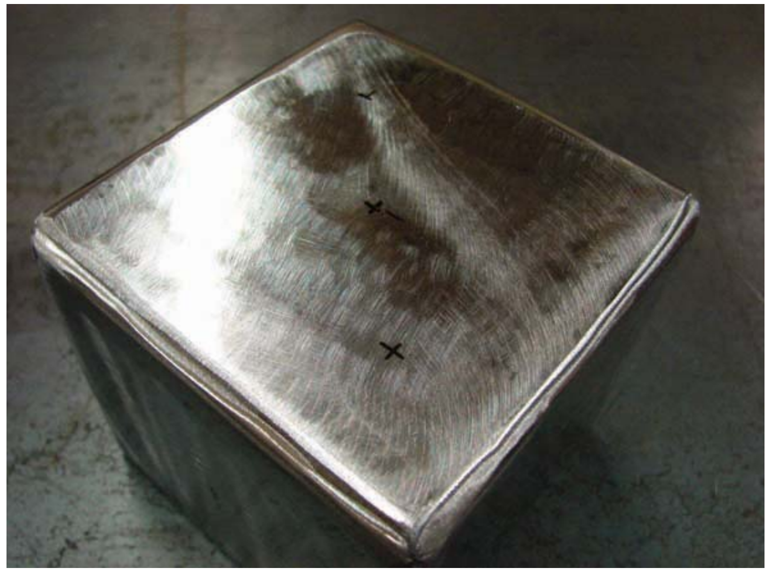


Figure 6-25. The number three hole positions marked with a permanent marker.

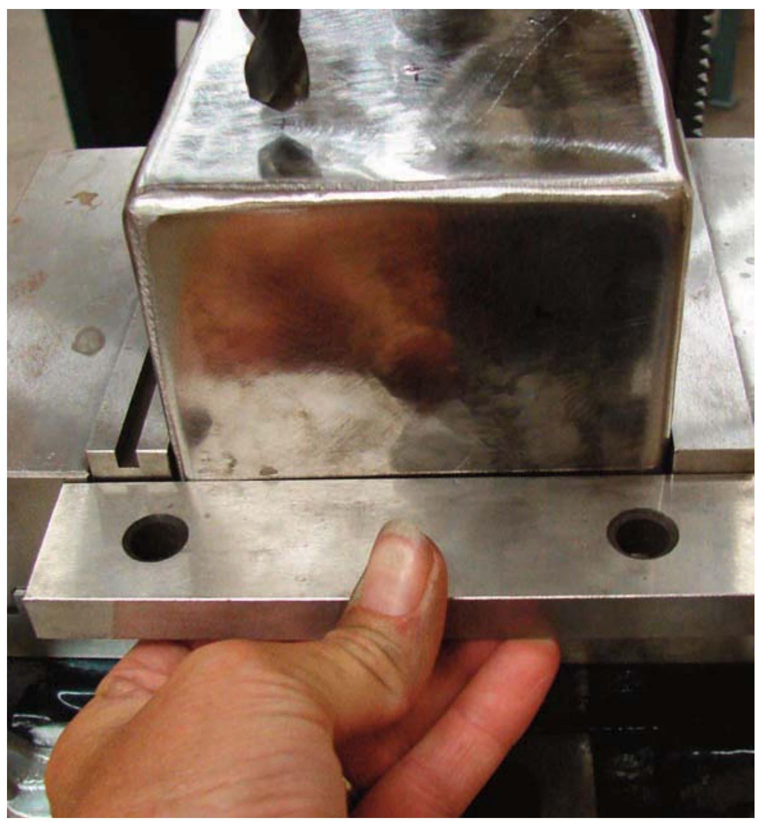


Figure 6-26. Use a straight edge to place the side of the dice flush with the edge of the vise.

bore any one of the corner holes. With the bit in line to drill the first corner hole, clamp the vise to the table and make sure the table is locked in place at the pole (Figure 6-27).

If available, set up an air system to cool the bit and clear shavings while cutting. If air is not available, collect some cutting oil, which can be brushed on the bit occasionally while drilling to cool the bit and help the bit cut.

Drill the first corner hole, then loosen the vice, rotate the dice, align it with the edge of the vice again, and drill the second hole. Repeat this step until all corner holes have been drilled in the sides that have holes located in the corners (6, 5, 4, 3 and 2). With the vice and table in a locked position, drilling these holes is quick and easy (Figure 6-28).

After drilling the corner holes, unclamp and re-align the vice for the center holes (5, 3 and 1); then drill (Figure 6-29). Finally, repeat the alignment process for the middle holes in the 6, which should be the last two holes to drill.

Figure 6-27. Dice in position and ready for the first corner hole to be drilled with the vise secured in place with two clamps.

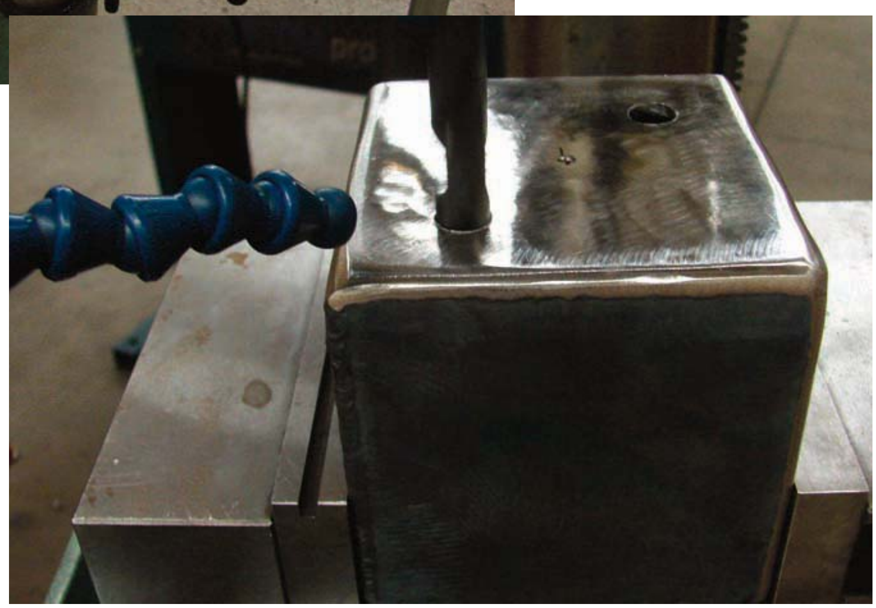


Figure 6-28. The second corner hole of the number three being drilled.

After drilling, use a round or rattail file to remove any burrs that may be connected to the inside of the holes. This will eliminate the chance of someone cutting themselves if they poke their finger through the hole.

Figure 6-29. Drilling the center holes

Figure 6-30. Compressed air will help remove shavings that accumulated inside the dice during drilling.

There will be chips on the inside of the dice that can be removed by shaking the dice and blowing into the dice with compressed air. During this process, wear a clear face shield for safety (Figure 6-30).

With the numbers added, do any final polishing that is needed and the project is complete (Figure 6-31)

Figure 6-31. Completed dice, polished and ready to display.

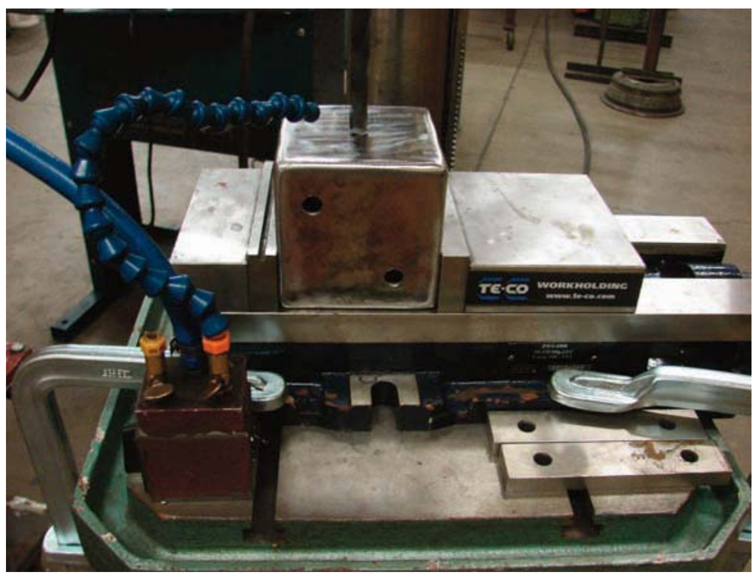


Figure 6-32. Using a compressed air system to cool the bit is a cleaner alternative then cutting oil.

Beginning fabricators tend to overuse cutting oil, making the drilling area messy and difficult to clean. Compressed air is a cleaner alternative to cool the bit and remove the shavings as the bit cuts. The air blower pictured in Figure 6-32 has a magnetic base, a snap-lock hose to allow bending and positioning of the nozzle, an air flow adjuster near the base of the hose, and a quick attach fitting that connects to any 3/8" air hose.

HELPFUL HINT

CHAPTER 7

Gas Vase

The vase project is designed as a practice project for oxyacetylene gas welding. During the fabrication, the builder is introduced to the use of a metal shear, a metal break, a simple way of welding an outside corner joint without using filler metal, and an effortless way of applying a patina finish.

STEP 1. Collect the needed steel.

When building the vase, the body will be constructed out of 16 gauge sheet metal. The rim will be made from 1/4" square bar. Refer to Figure 7-1 for the parts list.

Vase Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
2	Front/Back Faces	Sheet	16 gauge	0'-6"	0'-5"
2	Sides	Sheet	16 gauge	0'-1 3/4"	0'-6 7/16"
1	Bottom	Sheet	16 gauge	0'-1 3/4"	0'-2 3/4"
2	Front & Back Rim	Sq Bar	1/4"	1/4"	*
2	Left & Right Side Rim	Sq Bar	1/4"	1/4"	*

*Note: The four Rim part lengths have been purposely left out of the parts list. The exact length will be determined after the main body of the Vase is completed.

Figure 7-1.

Figure 7-2. The bottom half of this image is hot-rolled steel. The mill scale gives the steel a blue-gray finish and the surface can feel slightly rough. At the top is cold-rolled steel. The finish is gray and the surface is smooth

When purchasing steel, you can purchase cold-rolled or hot-rolled steel. The steel varies in surface finish, strength, malleability, and cost. For this project, the main consideration is the surface finish.

When steel is hot rolled, a chemical reaction occurs as it is heated and then cooled. This reaction forms a thin layer of oxides on the surface of the steel, called mill scale. Although mill scale helps to protect the steel from rusting, it is undesirable when welding because it adds impurities to the weld puddle. If you paint over mill scale, some areas of the paint may in time chip off when the mill scale loosens from underneath.

Cold-rolled steel is formed at room temperature so the steel does not go through the recrystallization stage, which causes the formation of mill scale. Without the mill scale, cold-rolled is much quicker to clean and prepare for welding.

Because 16 gauge steel is so thin — and this project is so small — strength and malleability are not a concern. Due to the small size of the project, the price difference is insignificant. However, be aware that cold-rolled steel is generally more expensive (Figure 7-2).

Both hot-rolled and cold-rolled sheet metal will work for this project. Just keep in mind when selecting the sheet metal that the hot-rolled will accept a finish differently than cold-rolled and will take more time to polish.

HELPFUL HINT

STEP 2. Lay out the sheet metal parts.

When laying out the parts, start on a straight edge of the sheet. Use a scribe and a combination square to accurately mark the cut paths; use a permanent marker to draw lines just inside to help locate the cut paths more easily when shearing and cutting the parts (Figure 7-3). Refer to Figure 7-4 for part dimensions and angles and to Figure 7-5 for the sheet metal layout guide.

Take note in the layout guide, only one area has a space left between the part edges for kerf compensation, unlike previous plans in this book. These parts will be sheared rather than plasma cut, thus eliminating the need for any kerf compensation between the part edges. Using a shear will save time during cutting and cleanup.

Note:
If an iron worker is not available and a plasma cutter is used to cut all parts, lay them out with a 1/16" gap between all adjoining edges to compensate for the width of the kerf.

Figure 7-3. When using a permanent marker to help locate lines, make sure to stay inside the lines. Drawing on the lines will make the lines difficult to see and defeat the purpose of using the marker.

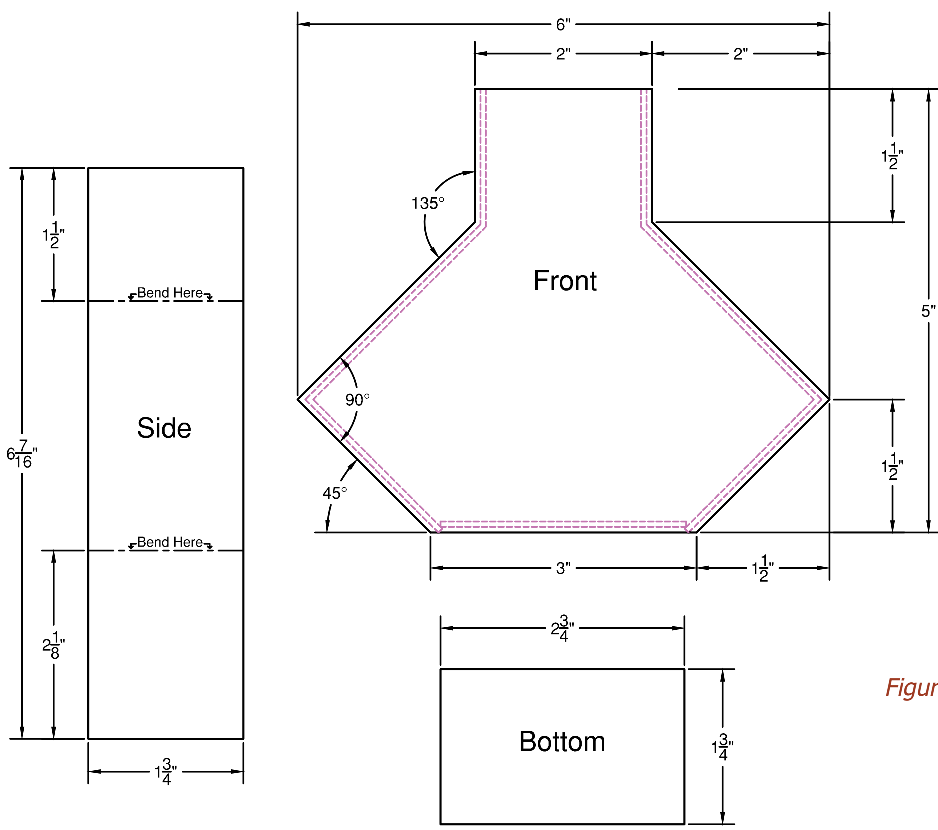


Figure 7-4. Part dimensions.

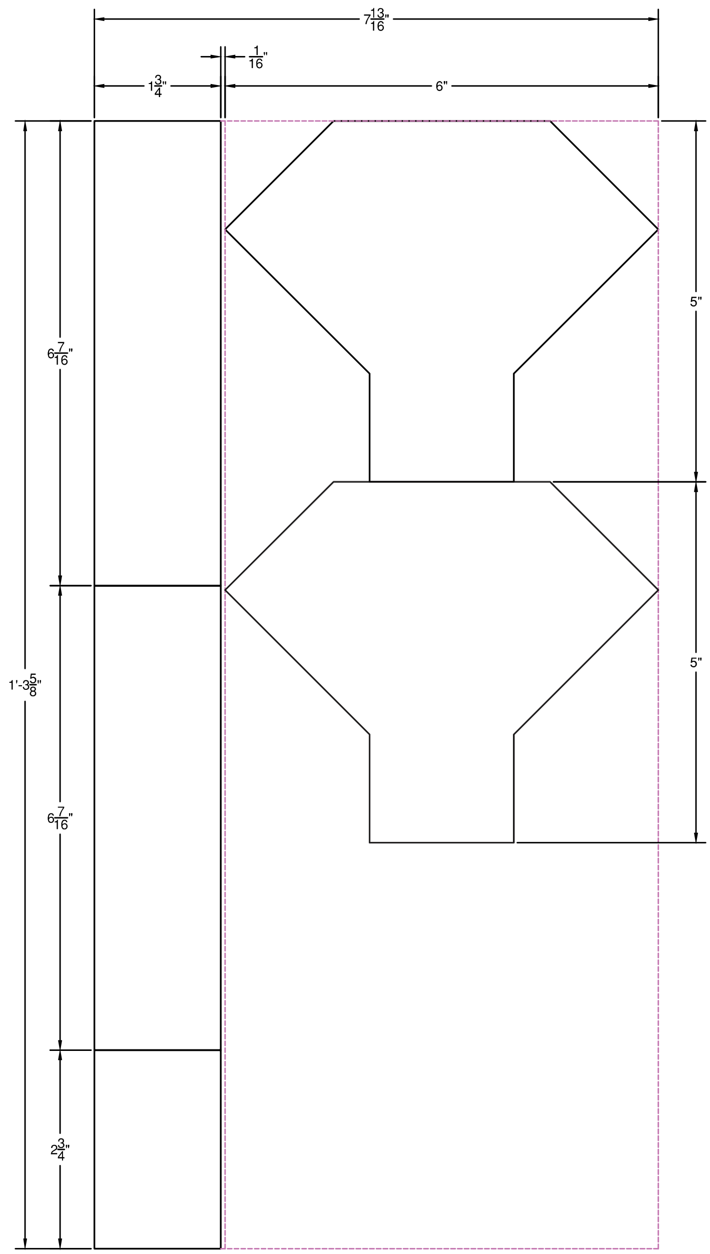


Figure 7-5. There are two sets of parts: the sides/bottom and the front/back. Lay out the sides and bottom in a straight line along the edge of the sheet metal with no gap between the separate parts. Then leave a 1/16" gap and lay out the front and back as illustrated.

STEP 3. Cut and clean the sheet metal parts.

If an iron worker with a notcher attachment is available, the cutting and cleanup time can be cut in half for this project (Figure 7-6).

Before using the shear, cut the parts into two blocks using a plasma cutter and a straight edge for a guide (Figure 7-7). It is important to use a straight edge because it provides a smooth and accurate method of plasma cutting. For helpful hints on using a plasma cutter, refer to Step 5 in Chapter 1, *Truck Plans.*

After plasma cutting the two part blocks, chip the dross (slag) from the bottom edges. Next, use a metal shear equipped with a notcher to finish cutting the individual parts (Figure 7-8). After shearing the parts, align the front and back parts together and make sure they are equal in size. If they vary, grind the edges until they match.

a)

b)

Figure 7-6. a) Iron workers come in many different sizes, shapes, and manufacturers. They are handy to have around the shop and can be used to shear parts of various shapes and thicknesses, as well as punch holes and notch sheet metal and angle iron. Each machine has a maximum metal thickness that can be cut. This particular machine's notcher attachment can shear up to 1/4" plate. b) Most iron workers have foot pedal controls, leaving both hands free to support the metal during operation.

If cold-rolled steel was used, no further cleanup is necessary. However, if using hot-rolled steel, it can be beneficial to use a polishing wheel to remove the mill scale on the outside of the parts next to the part edges before welding. This will provide a cleaner weld puddle and make the welding process easier.

Note:
If an iron worker is not available, cut all parts out with a plasma cutter using a straight edge for a guide. Then clean the dross (slag) from the back side of the parts.

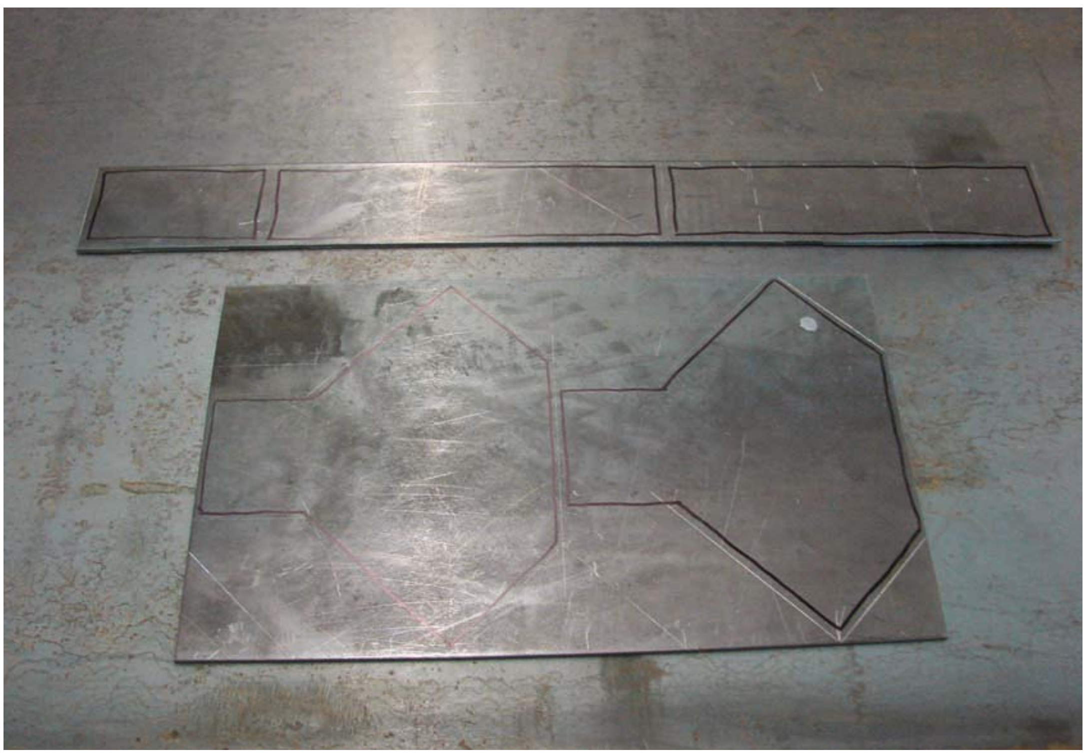


Figure 7-7. Parts cut into two blocks. Notice a permanent marker was used to outline the part edges just inside the scribed lines. This will make locating the cut lines easy.

a)

c)

d)

b)

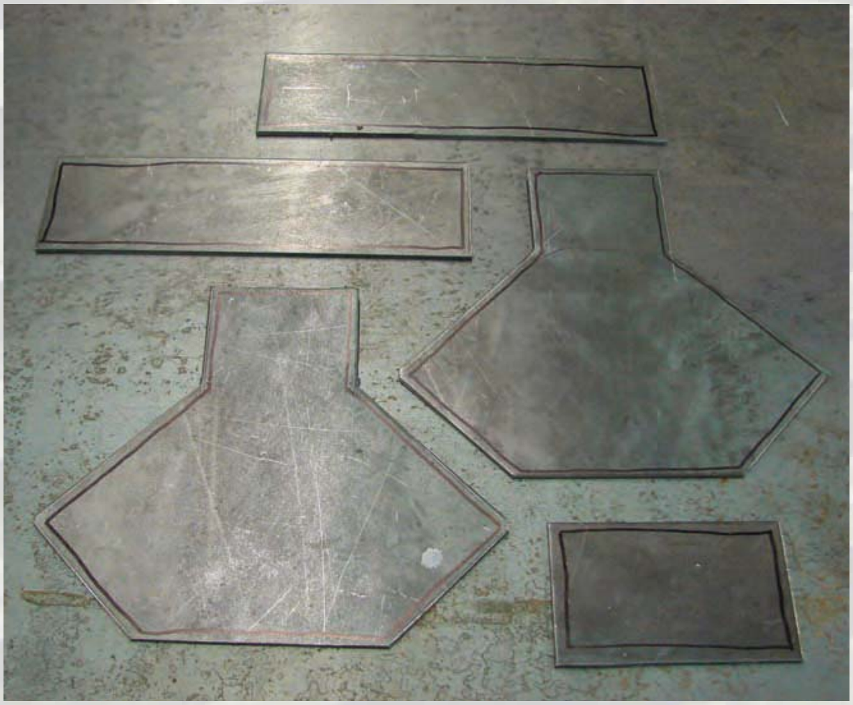
Figure 7-8. a) Cut the front and backs apart with the shear. b) Shear the bottom corners off of the front and back parts. c) Never reach into the throat of the shear to remove scraps. Instead, use a magnet or tap the part out of the throat with a piece of steel. d) Notch the top square out of the front and back faces. e) Notch the triangle shaped piece out of the front and back faces. f) Shear the sides and bottom pieces apart. g) Completed sheet metal parts.


DO NOT SIDE LOAD
5/16" MAXIMUM MATERIAL THICKNESS

e)


DO NOT SIDE LOAD
5/16" MAXIMUM MATERIAL THICKNESS

f)



g)

STEP 4. Bend the side parts.

With the aid of a metal break, both side parts can easily be bent to match the angles in the front and back parts. As with iron workers, breaks have recommended maximum thickness capabilities. Bending something thicker than recommended can permanently damage your equipment (Figure 7-9). Always refer to the owner's manual before using.

To begin, slide the side parts into the break and align the end that requires the 45-degree bend square with the hold down. Slide in the parts just far enough so that the scribed line is aligned with the point of the hold down where the bending will take place (Figure 7-10).

Figure 7-9. For this fairly inexpensive, light duty break, it is not recommended to bend anything thicker than 16 gauge sheet metal.

Figure 7-10. Use a square on the break to align the parts. Notice the marker lines used to help locate the bending points.

When the parts are aligned, lock the hold down in place and pull up on the brace slowly until a 45-degree angle is achieved. This break does not provide a way of indicating when the desired angle has been reached, so a little guess work is involved. A 45/90 triangle can be used to help achieve the proper angle. After breaking, remove the part; check to see if the correct angle was achieved by laying the part on either side of the front or back face (Figure 7-11). If a sharper angle is needed, place the side back in the break and bend it farther. If the angle is too small, place the sides on a flat surface and push down on the points of the angle to open the corners up.

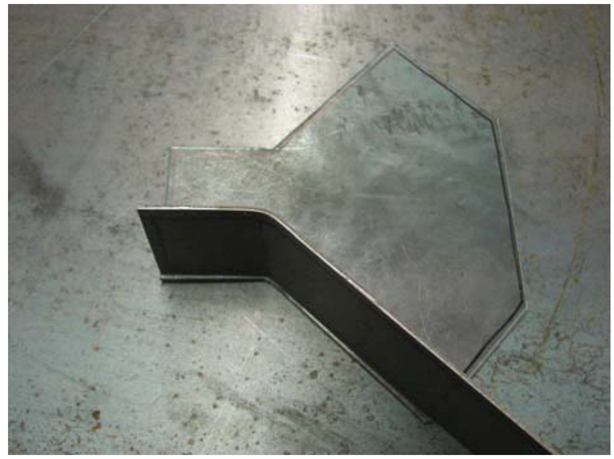


Figure 7-11.
Proper angle alignment for the 45-degree corner.

To make the 90-degree bend, place the parts back in the break with the already bent ends facing down. Again, use a square to align the parts (Figure 7-12). Secure the hold down and pull up on the break until a 90-degree angle has been achieved (Figure 7-13).

Figure 7-12. Preparing to make the 90-degree bend in the two side parts.

Figure 7-13. 90-degree angle bend.

Once again, remove the parts from the break and check to see how the angles align with the front and back faces (Figure 7-14). To be properly aligned, there should be approximately 1/16" to 1/8" of the face sticking out along the entire length of the side. This material will be used as filler metal during the welding process. The alignment does not have to be perfect. Filler metal can be added in areas that are lacking and areas with excessive stick out can be taken down with an angle grinder later during fabrication.

If alignment cannot be achieved for the majority of the sides, the bending points may not have been correct. In this case, straighten the sides by pounding them flat on an anvil, then return to the break and repeat the bending steps again with the proper bending points laid out.

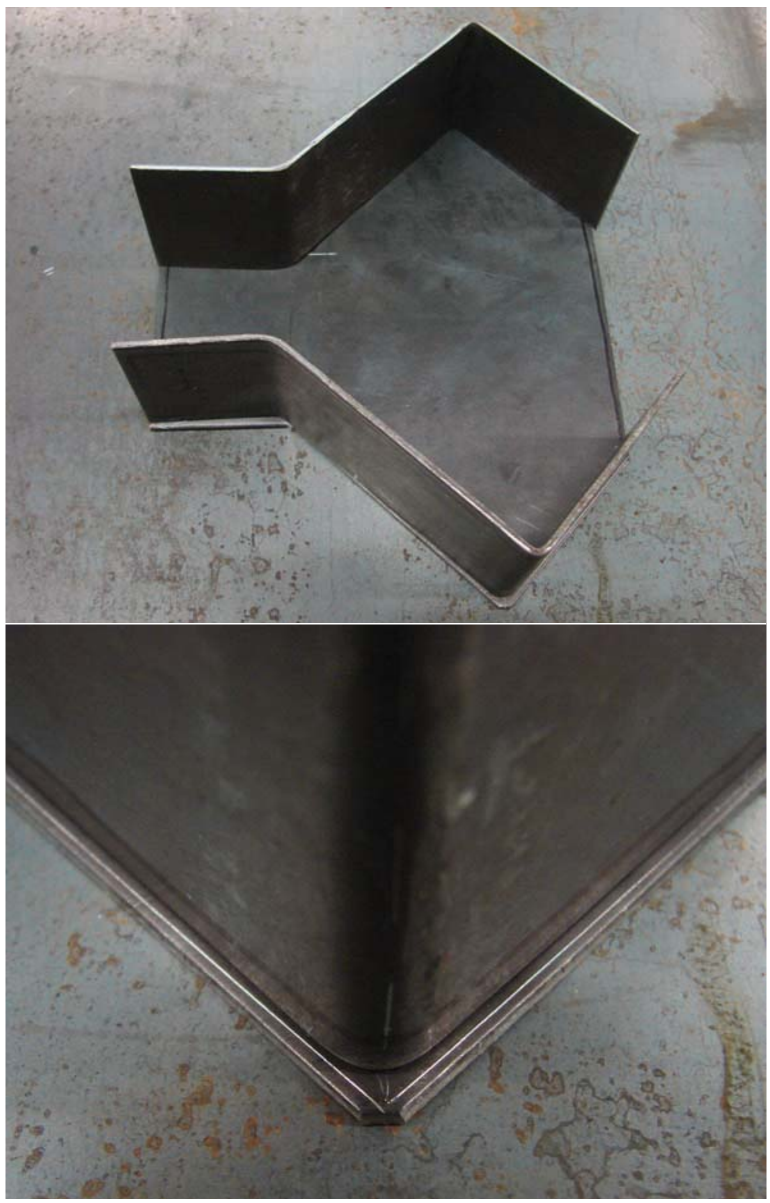


Figure 7-14.

a) Check the sides for angle accuracy and proper alignment.

b) Proper stick out between the side and face.

STEP 5. Check that the bottom fits properly.

The next step is to trim the bottom to fit properly. It may be too long, depending on how well the sides fit on the face. To check the length, set both sides on the back face and position the bottom between the two sides. A piece of square tubing can be used to keep the bottom standing straight up and down while placing it in position and checking the length (Figure 7-15). When properly fitted, the bottom face should stick out 1/8" past the edge of the bottom part.

Figure 7-15.

a) Aligning the bottom with the sides and the face.

b) In this example, the bottom part fits well, other than a slight gap on the left side. The gap can easily be filled when the weld puddle is pushed across that joint.

STEP 6. Check that the front face fits properly.

Set the front face onto the sides and bottom, leaving the square tubing in place for support of the bottom while checking for part accuracy and fit (Figure 7-16).

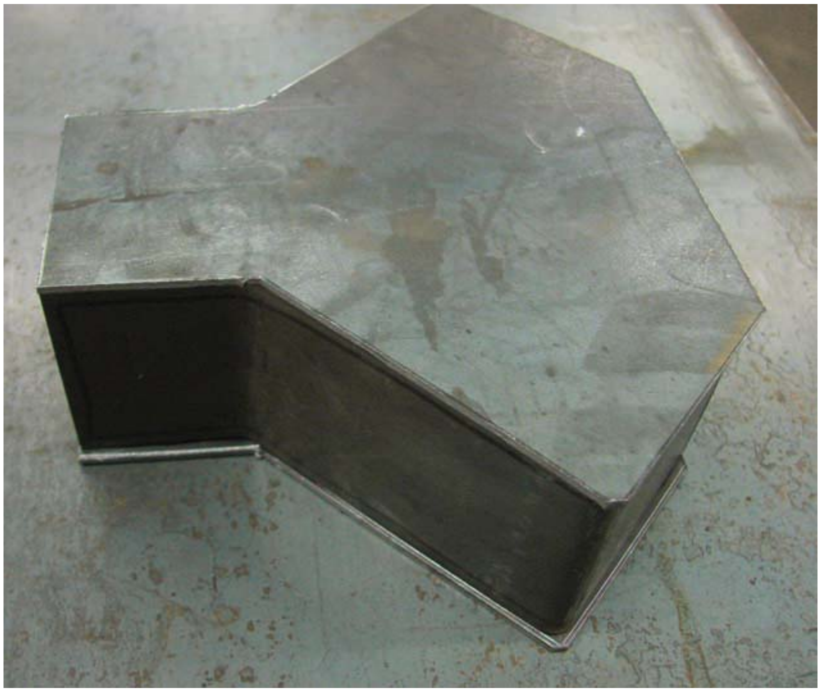


Figure 7-16. Vase sheet metal parts cut, bent, and ready for welding.

STEP 7. Practice welding an outside corner joint without filler rod.

If you have never attempted an outside corner joint without filler rod, it would be a good idea to practice this joint before welding the vase. To set up a practice joint, cut two pieces of 1/8" x 1" flat bar 4" in length. Clamp one piece of flat bar to the back of a piece of 3/4" square tube and lay the other piece on top of the tubing (Figure 7-17).

Choose a gas welding tip specified to weld 1/8" steel and set up an oxyacetylene station with the proper gas pressure settings. Collect the tools and safely attire needed to complete the practice weld.

Begin by tacking the two pieces of flat bar together at each end. Remove the joined parts from the tubing and use locking C-clamp pliers to hold the part in the flat position for welding.

Using the oxyacetylene setup with a neutral flame, join the parts by simply pushing a puddle across the seam of the joint. The torch should be held so that the flame is pointing in the direction you want to push the puddle; about a 45-degree angle. The puddle should be glossy with very little sparks emitting from the molten puddle. A proper bead will be twice the thickness of the steel being welded (Figure 7-18). If it is difficult to acquire and maintain a puddle of this size, some adjustments should be made to the oxyacetylene gas pressures.

Note:
For helpful hints and instructions on oxyacetylene setup, safety, and welding tips, refer to Steps 4 through 7 from Chapter 6, Gas Dice.

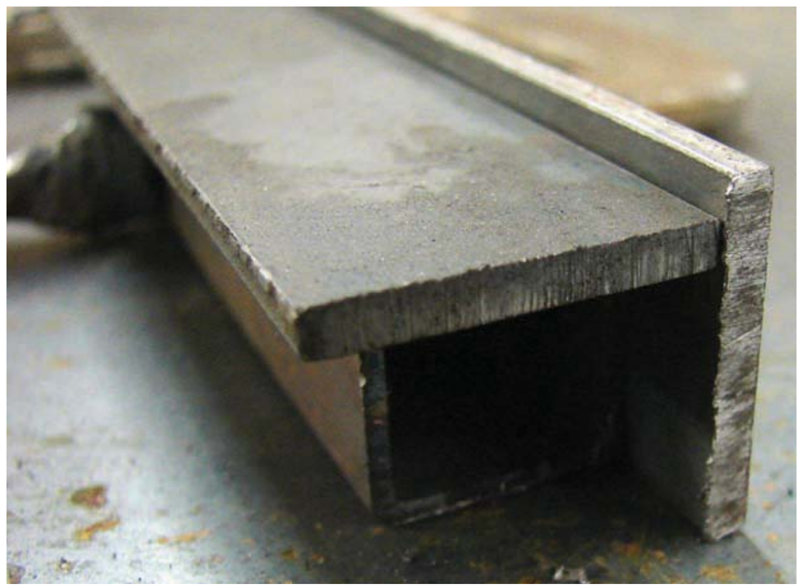


Figure 7-17. Setting up to practice an outside corner joint.

Figure 7-18. Practice outside corner joint without filler rod.

STEP 8. Set up the oxyacetylene station.

If the practice joint in Step 7 was just completed, the station will need to be adjusted to weld 16 gauge (1/16") steel. A smaller tip size will be required because the metal is half the thickness as the practice joint; the low pressure gauge on the acetylene regulator will need to be reduced accordingly.

If the welding tip has been used previously by someone other than yourself, take the time to use a tip cleaner to clean the gas torch orifice. The oxygen should be cracked open slightly during this process so that the debris will be blown out during the cleaning process (Figure 7-19).

Figure 7-19. Cleaning a tip before every use is very important. Dirty tips produce uneven and a hard to maintain flame.

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STEP 9. Tack the parts of the vase together.

Begin by tacking the bottom to the sides of the vase. Have filler metal handy just in case an area needs more filler than what was provided by the stick-out of the face. Use 1/16" filler metal rather than 1/8", which may add more filler metal than necessary. Use a piece of square tubing to hold the bottom in place while tacking (Figure 7-20).

The tack should be small enough that it just joins both parts. The less heat, the better (Figure 7-21).

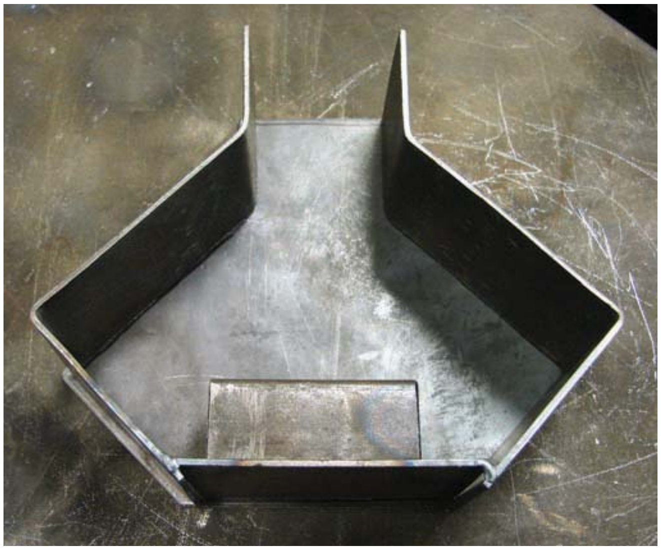


Figure 7-20. Tack the bottom to the sides in the top corners.

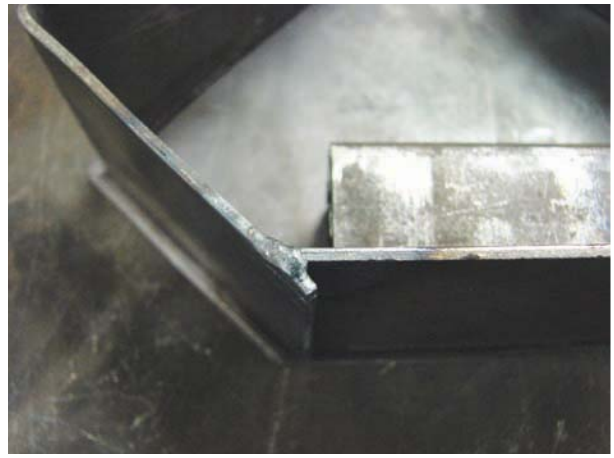


Figure 7-21. A small but strong gas weld tack.

Next tack the bottom to the two sides. Slide the parts slightly off the edge of the table and point the torch upward toward the parts — they need to be sitting down on the table at this point to keep the alignment accurate (Figure 7-22).

Rotate the parts that are tacked together, place the front face in the proper position, and tack the four corners of the vase spout (Figure 7-23).

Figure 7-22. Tacks joining the bottom face to both sides.

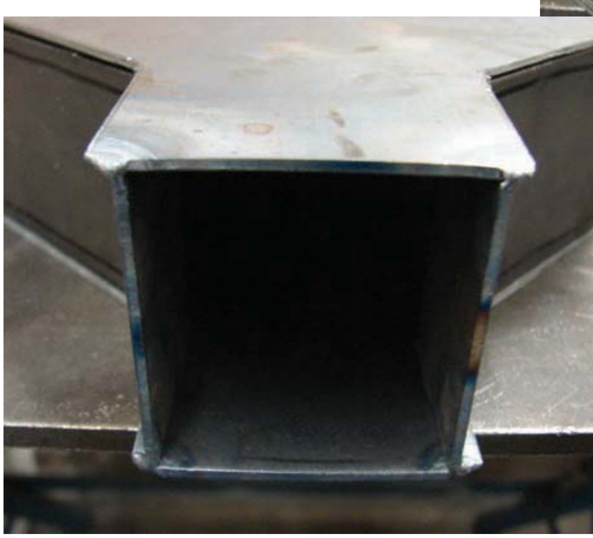


Figure 7-23. Tacks made to join the four corners of the spout.

At this point, all parts are attached. However, it is important to weld a few more tacks to help hold the joints secure and reduce the effects of the weld pull that could force the parts out of square when the joints are finished. Place tacks on the outer points along with the bottom corners of the top face that was not previously tacked (Figure 7-24). When tacking, a pair of C-clamp locking pliers can be used between the back and front faces to keep the front face tight against the sides while finishing the welds (Figure 7-25). The pliers will also aid in positioning the vase so that it is always sitting in the flat position during welding.

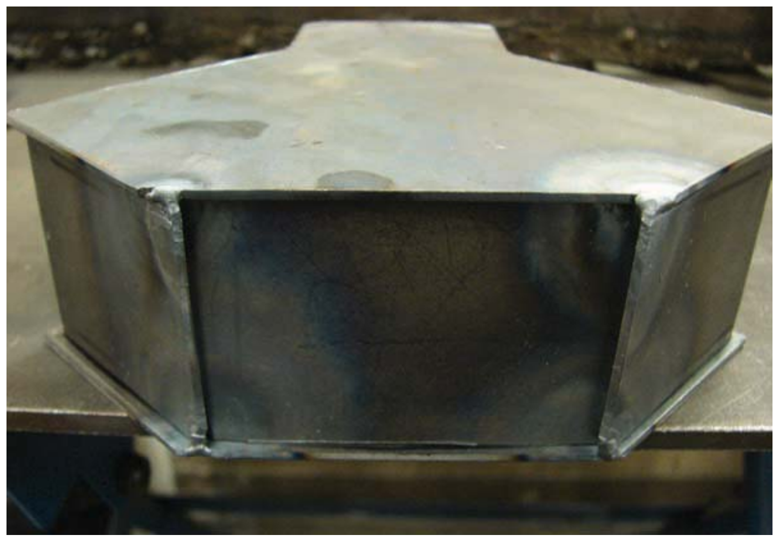


Figure 7-24. Tacks complete in the four corners of the bottom of the vase.

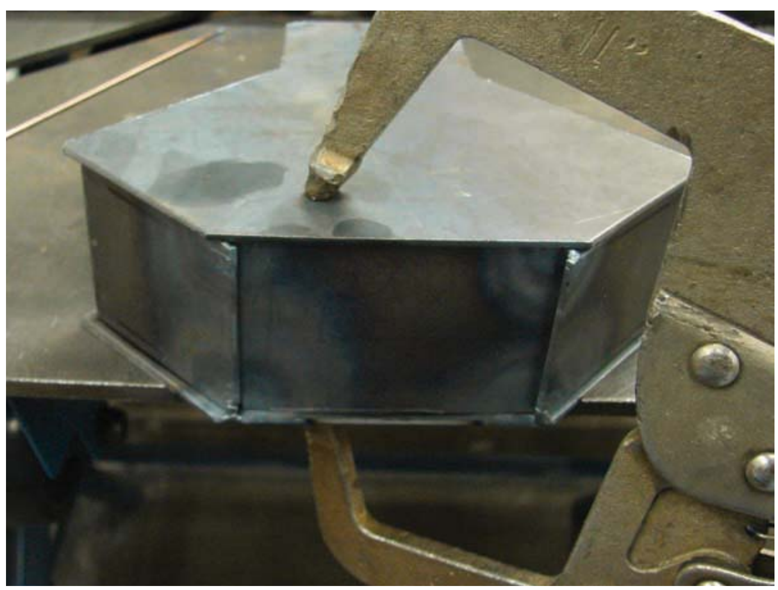


Figure 7-25. Locking C-clamp pliers used to hold the vase faces tight against the sides.

STEP 10. Examine the edge joints and grind any excess filler metal away.

After the tack welds have cooled, examine the vase joints for consistency. The front and back faces should overlap past the sides and the bottom about 1/16" to 1/8". If the stick out is more than the recommended stick out, place the vase in a vise and use an angle grinder to even up the distance along all edges (Figure 7-26).

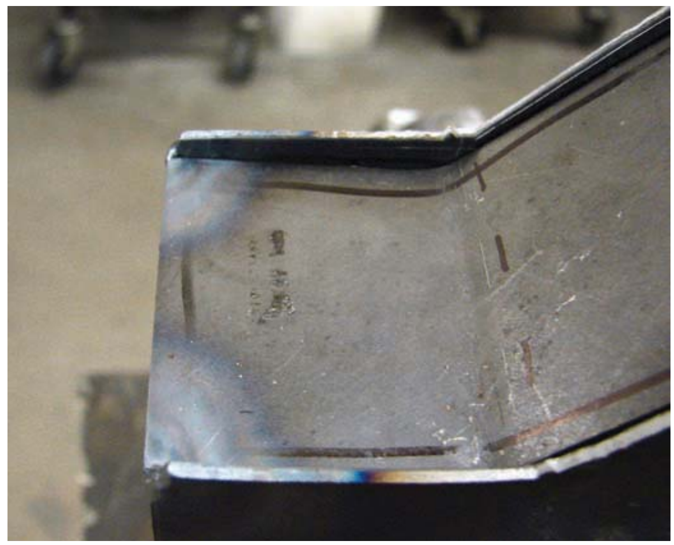
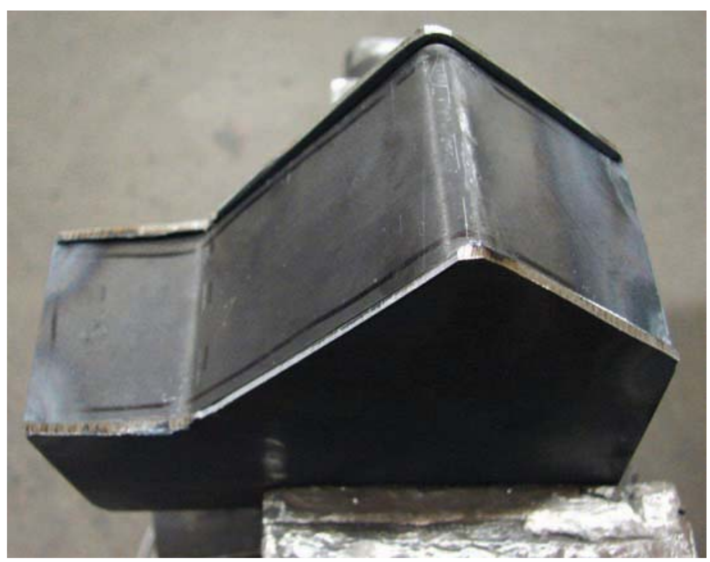


Figure 7-26.

a) The edge of the face in this example is sticking out past the side about 1/4" in places. An angle grinder should be used to remove the excess material. When grinding, take a little at a time making sure not to remove more metal than necessary.



b) When the edge grinding is complete, the stick out past the sides should be consistent and even which will make it easy to maintain an even bead when welding.

STEP 11. Weld the vase together.

When welding this thin sheet metal project, avoid welding one complete side at a time. Too much heat build-up in an area can cause the vase to warp. To avoid this problem, weld small sections of each joint; then stop and weld in an area opposite from that area.

Before beginning, use a pair of C-clamp locking pliers to position the vase so that the top spout of the vase is in the flat position. This will be the first two welds (Figure 7-27). Run beads along

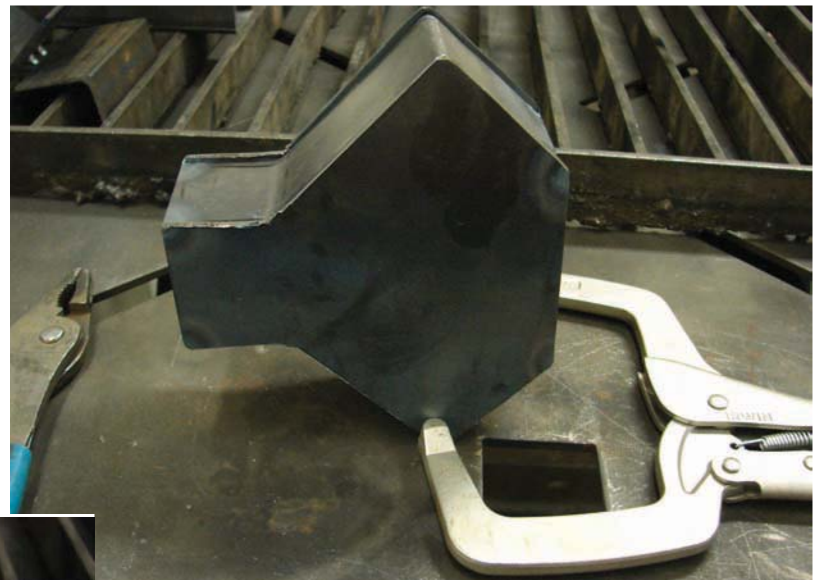


Figure 7-27. Positioning the vase to weld in the flat position.

Figure 7-28. Run the two welds on the side of the spout.

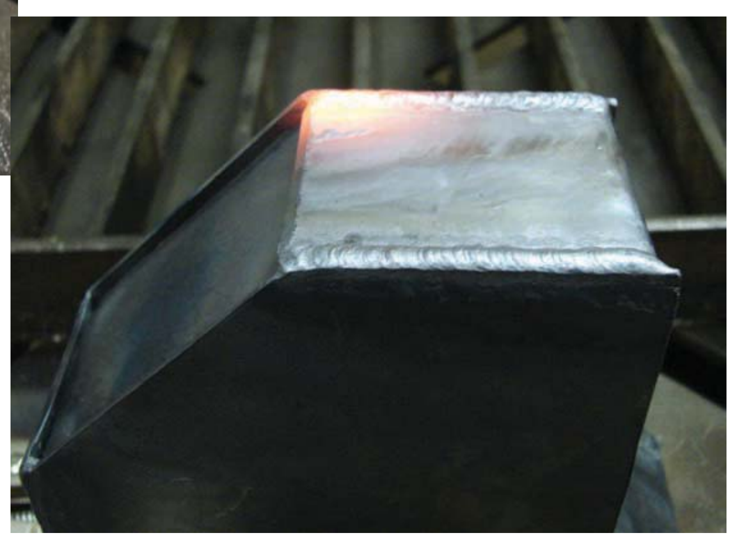


Figure 7-29. Weld the lower section of the 90-degree angled part.

Figure 7-30. Weld the four welds on the bottom of the vase, rotating from side to side with each weld.

the sides of the top spout, stopping at the 45-degree corners (Figure 7-28). Rotate the vase and run a bead on the lower section of the 90-degree angled part on both sides (Figure 7-29). Rotate again and do the other side of the spout; then move back to the opposite 90-degree angled part.

Next, weld the bottom joints solid, making sure to weld the front, then the back, then the right side and the left (Figure 7-30).

Finally, move to the upper portion of the 90-degree angled side, again welding from side to side to reduce heat build-up (Figure 7-31).

Figure 7-31. Weld the upper section of the 90-degree angled part..

STEP 12. Remove the mill scale.

As a piece of metal is heated up and allowed to cool, mill scale forms on the surface of the steel (Figure 7-32). To remove this, use a wire wheel on a stationary grinder or secure the vase in a vise, and use a portable angle grinder with an attached beaded brush.

Figure 7-32. Remove all mill scale from the welded areas of the vase.

STEP 13. Attach the top, front and side rims.

The rim will require a larger welding tip due to the increased thickness of the metal being welded. The acetylene low pressure psi will again need to be adjusted. Normally, metal as thick as 1/4" would not be welded using oxyacetylene gases, but for this project, it is the right tool for the job. The time it takes to produce a molten puddle will be increased due to the increased thickness of the metal.

After changing the regulator pressures, measure the vase opening for the two sides and determine the length of 1/4" square bar needed (Figure 7-33). When the length is determined, cut the square bar 1/8" longer than the measured length. This will provide room for the ends to hang over. Later they can be ground off and fit flush with the surface of the front and back faces (Figure 7-34).

Using a pair of locking pliers, clamp the rim sides to the sides of the vase and tack them to the spout in two places (Figure 7-35). After they are tacked in place, transfer the vase to a vise and grind the ends off flush with the surface of the front and back faces.

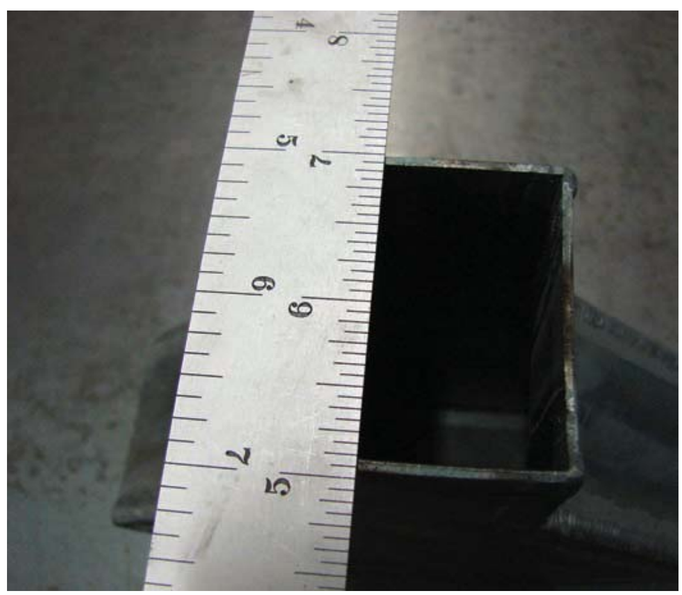


Figure 7-33. Measure the outside distance across the spout of the vase. This distance was left out of the parts list in Figure 7-1 so that the part length could be cut to fit.

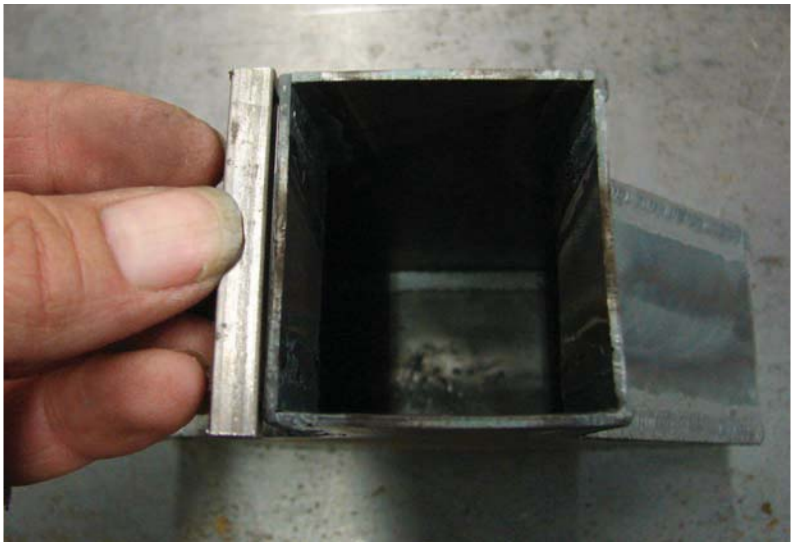


Figure 7-34. Cut the rim sides slightly longer than the width of the spout.

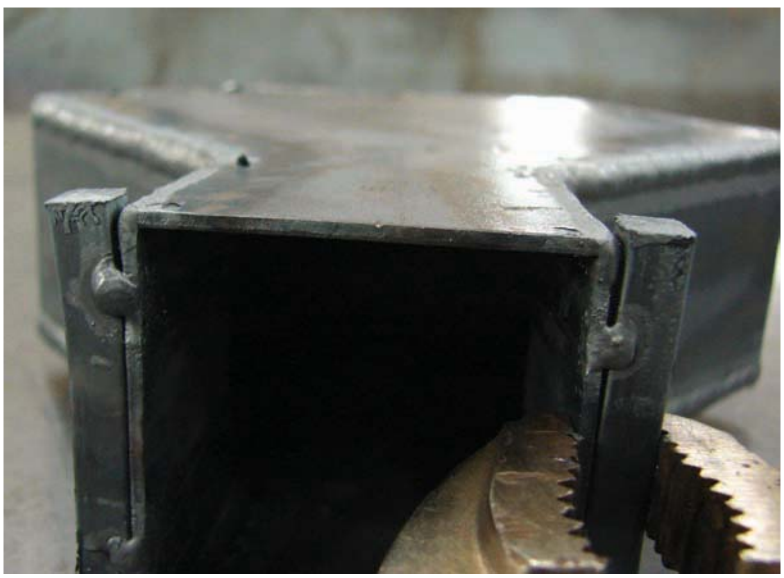


Figure 7-35. Side rims attached.

Measure the distance from the front to the back of the spout, add 1/8", then cut the last two square bar parts.

Again using locking pliers, clamp the front and back rims to the vase spout and tack them in place with two tacks near each end (Figure 7-36). Place the vase back in the vice and grind the ends flush with the sides (Figure 7-37). You may notice that the square bar that was attached to the sides has a slight inward curve. This is due to the weld on that edge; it is acceptable to have a slight curve to these parts.

Figure 7-36. Front and back side rims attached. The parts will look rough at this point, but it's nothing that a little cleanup can't fix.

Figure 7-37. Grind the ends flush.

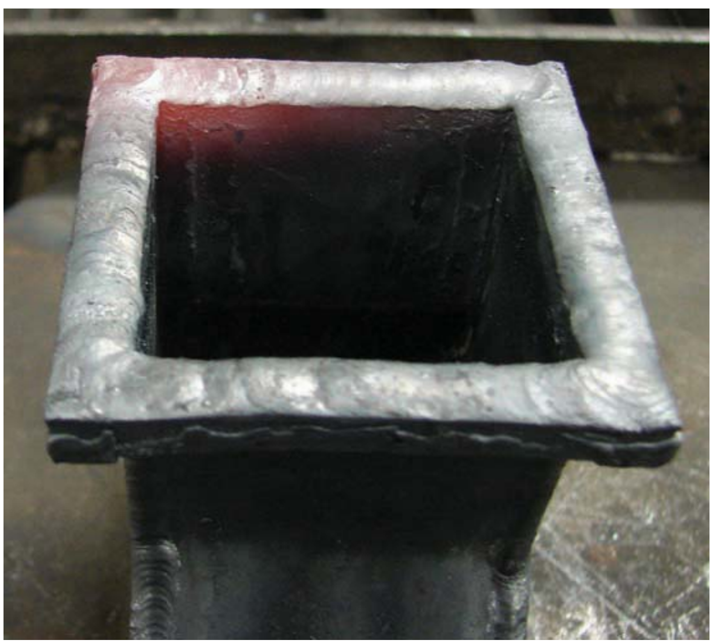


Figure 7-38. A finished weld around the top rim ready for cleanup after cooling.

Before welding the rim solid to the vase opening, clean the mill scale from the top of the rim with a wire wheel. With the top of the rim clean, weld the rim to the vase opening by pushing a puddle across the entire surface of the square bar and adding filler metal as needed. The finished edge weld across the rim should have a smooth, even bead around all four edges (Figure 7-38).

STEP 14. Clean up the vase.

After all welds have been complete, use a wire wheel mounted to a stationary grinder along with a hand held wire brush to remove the mill scale from the vase (Figure 7-39). Ideally, the welds should not be ground down. They should be smooth, free of mill scale, with evenly spaced ripples throughout.

Figure 7-39. Using a wire brush to clean the hard to reach areas of the vase.

STEP 15. Making the vase more than just a vase.

Sometimes a project just isn't complete without making it your own. There are lots of things that can be done to this vase to make it unique.

A more challenging idea may be to construct life-like steel flowers to go inside the vase. The vase in figure 7-40 was embellished with steel orchids and had an additional heavy steel base attached to the bottom to counteract the effects of the extra weight of the flowers.

Another appealing alternative might be to apply an acid finish to the vase. The vase in Figure 7-41 was finished with a patina acid and was sprayed with a couple coats of spray on clear coat.

Finishing metal with an acid finish verses the traditional spray paint is relatively easy and has become quite popular in the world of metal art and sculpture. Finding the products is as easy as logging onto the internet and searching for acid metal finishes. For the patina finish, search; "Patina finish on steel."

Figure 7-40. The vase can be embellished by adding flowers constructed of steel. This idea allows the fabricator to be creative and design something unique.

There are lots of products out there and the step-by-step instructions are generally posted on the website along with videos so you can learn how to use them before purchasing.

Figure 7-41. This vase was finished with an acid patina finish. This process is relatively easy to do.

HOW TO APPLY A PATINA ACID FINISH:

1. Clean the project, removing any loose mill scale, welding berries, and sharp edges (Figure 7-42).

2. Paint the surface with a metallic brass paint and allow time to completely dry (Figure 7-43).

3. Apply a second coat of metallic brass paint. Allow the second coat of paint to dry until it feels tacky to the touch. Then spray on the patina acid finish (Figure 7-44).

4. Let the project sit for 24 hours, allowing the finish to dry completely.

5. Apply a couple coats of spray on clear-coat and the project is complete (Figure 7-41).

HELPFUL HINT

Figure 7-42. Vase cleaned and ready for paint.

Figure 7-43. Brass paint applied to the vase.

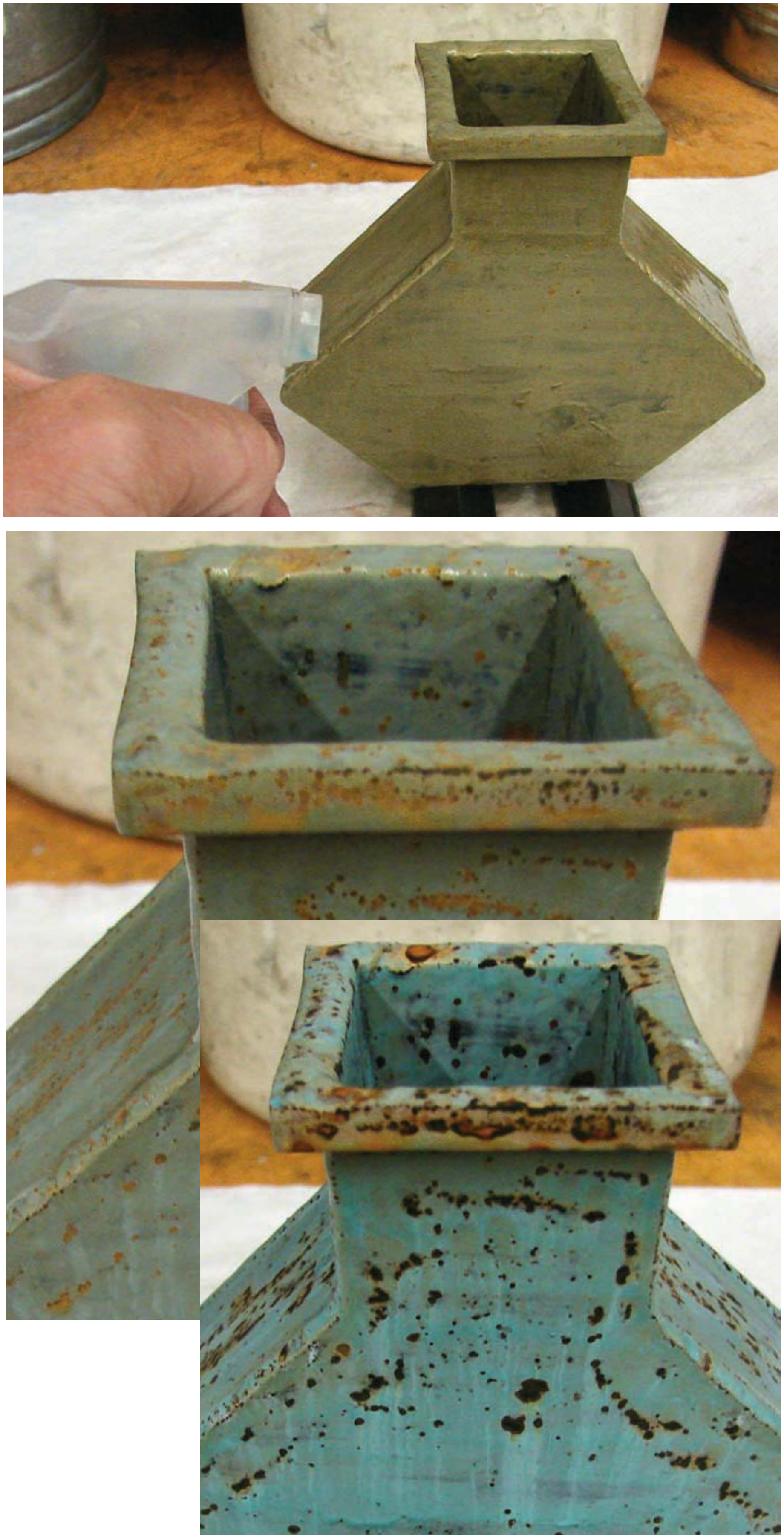
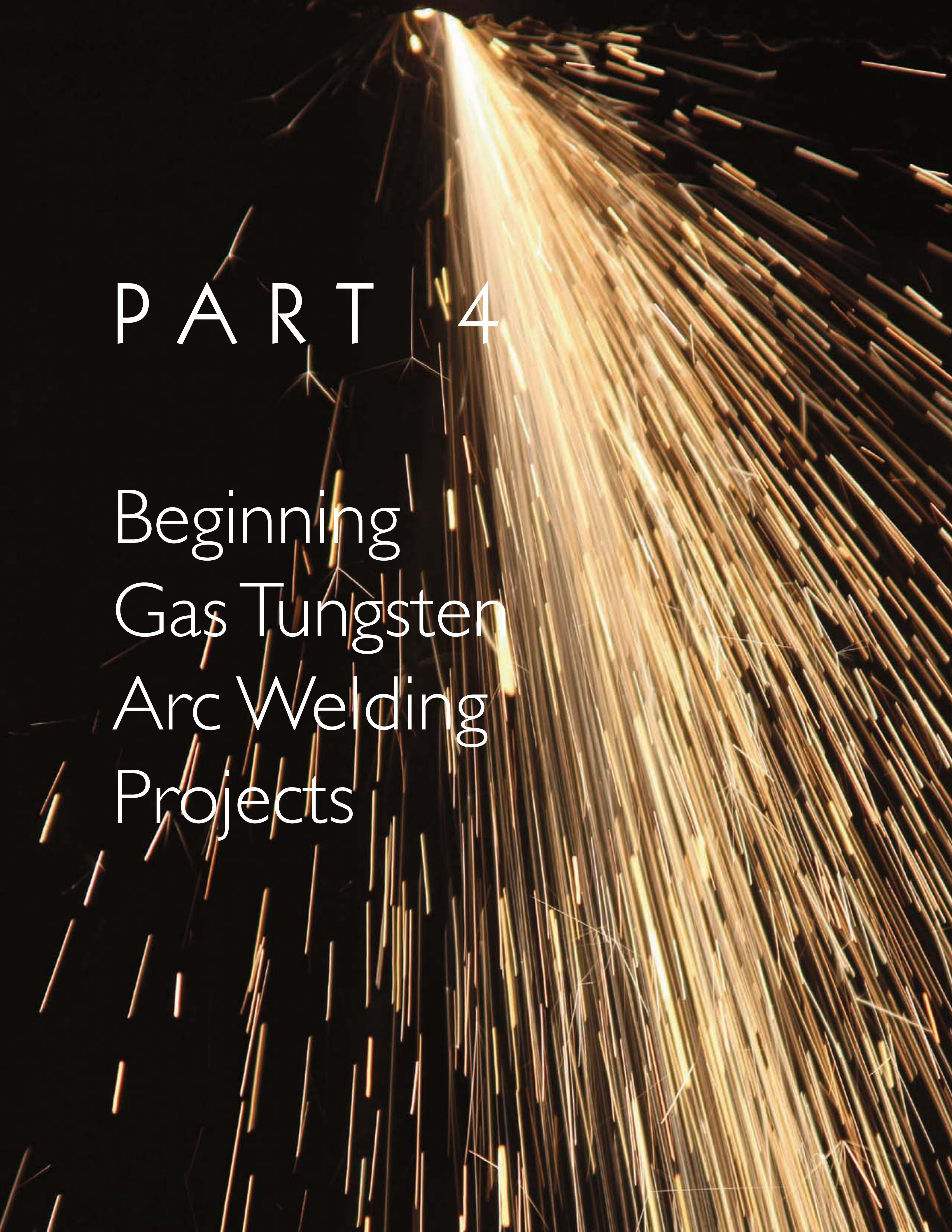


Figure 7-44.

a) Spraying on the patina acid finish.

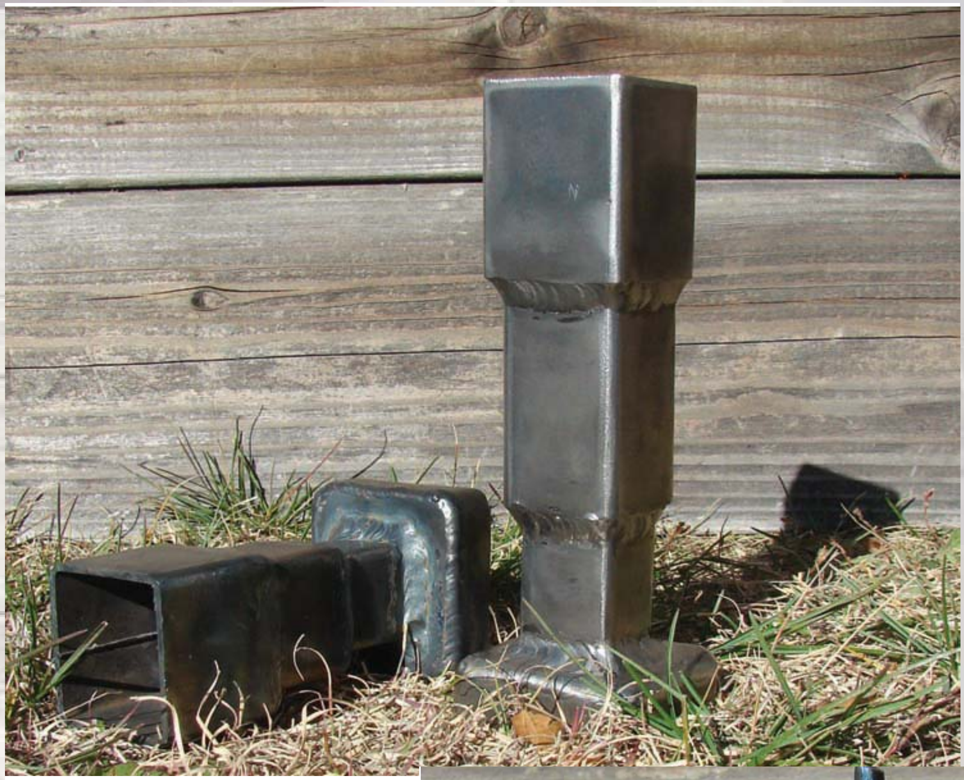
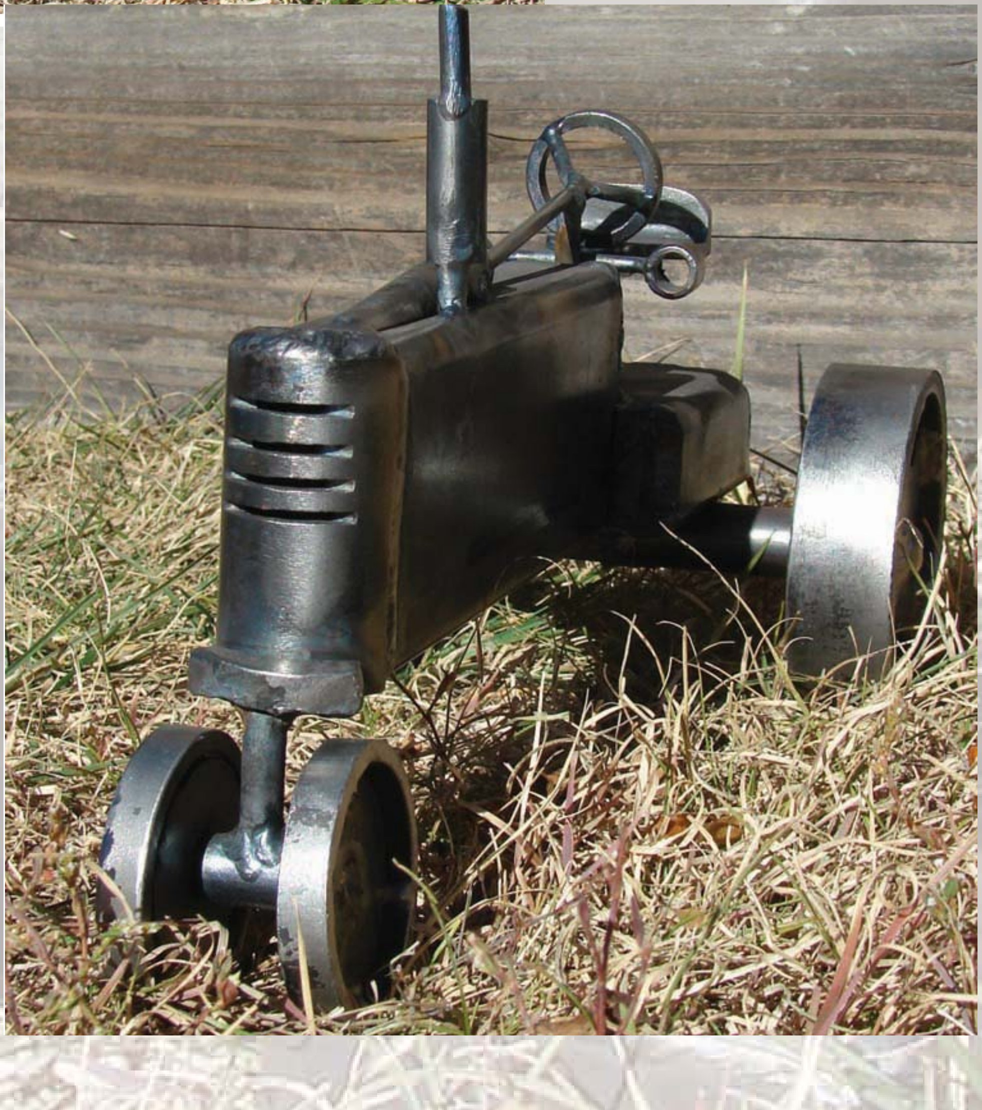
b) Patina acid reaction after 5 minutes.

c) Patina acid reaction after 30 minutes.



PART 4

Beginning Gas Tungsten Arc Welding Projects

The process of welding that uses tungsten as an electrode and an inert gas to protect the weld can be referred to as Gas Tungsten Arc Welding (GTAW), Tungsten Inert Gas (TIG) welding, Heliarc welding, and (least often) Wolfram Inert Gas (WIG) welding. The most common reference labels to describe the welding process are GTAW and TIG. Heliarc welding was the first terminology used and most often used by people who have been in the welding trades for a number of years. WIG is a European reference — the W stands for Wolfram, which is how tungsten is referenced in some foreign languages. No matter the terminology, they all refer to the same process in which a tungsten electrode, with the highest melting point among pure metals (6192^0), is used to transfer an electric arc to the work piece with the aid of an inert gas, either argon or helium. The gas protects the weld from impurities in the air and prevents oxidation.

The TIG welding process is considered one of the most difficult because of the short arc length that must be maintained. It is also a two-handed process requiring more hand-eye coordination than other welding processes, which typically require only one. It was initially designed as a way of welding non-ferrous metals such as aluminum and magnesium; however, it also has its place for welding mild and stainless steel.

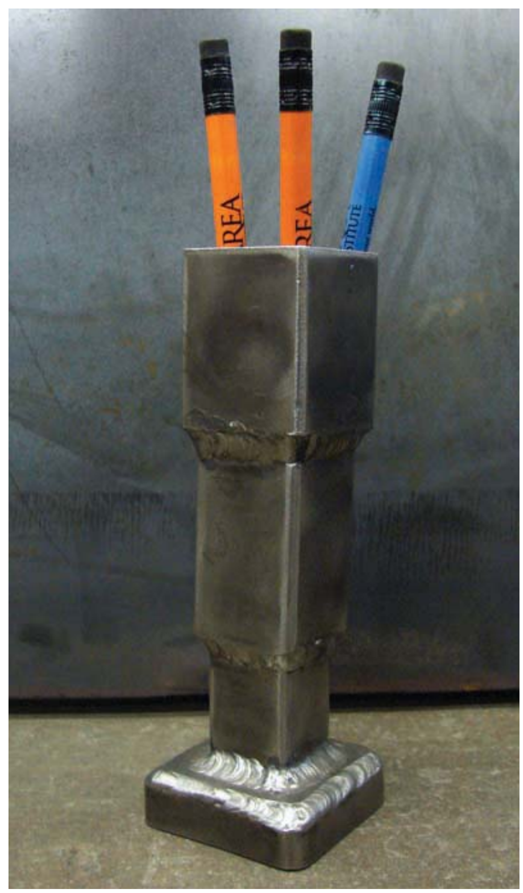
An excellent stepping stone to use before attempting TIG welding is first to become proficient welding mild steel with an oxyacetylene gas welding torch. The two processes work basically the same, TIG just adds a third component with either a foot pedal or hand roller on the handle to control the amount of heat being transferred to the metal.

This section includes two projects: a pencil holder (which is a beginner project) and a tractor (which will require a more advanced fabricating and TIG welding skill level). Both projects are constructed out of mild steel, rather than a non-ferrous material such as aluminum, due to the cost and availability of the materials.

CHAPTER 8

Pencil Holder

The pencil holder is a project that allows the beginning welder to focus mainly on practicing TIG welding skills rather than spending time cutting and preparing parts. The five parts that make up the project are cut from prefabricated steel; they take only a matter of minutes to cut to size. The project is inexpensive to build due its small size. It provides practice welding three of the four basic weld joints: lap joint, t-joint, and outside corner joint.



STEP 1. Collect the needed steel.

Refer to the parts list in Figure 8-1 when gathering the square tubing and flat bar parts for this project. However, if the exact sizes shown are not available, larger or smaller sizes of square tubing can be easily substituted as long as they slide together with no more than 1/16" gap between the parts.

Flat bar is listed as the material needed for the base top, but if the material is not readily available, a 1-3/4" square part can be cut from a sheet of 10 gauge steel.

TIG Pencil Holder Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	Top Tube	Sq Tube	14 gauge	1 1/2" x 1 1/2"	0'-2"
1	Center Tube	Sq Tube	14 gauge	1 1/4" x 1 1/4"	0'-2"
1	Bottom Tube	Sq Tube	14 gauge	1" x 1"	0'-2"
1	Base Bottom	Sq Tube	10 gauge	2" x 2"	0'-0 1/2"
1	Base Top	Flat Bar	1/8"	0'-1 3/4"	0'-1 3/4"

Figure 8-1.

STEP 2. Cut and clean the parts.

Cut the parts using a cold cut saw or band saw. Then remove the sharp edges from the tubing, using a metal file or a die grinder with a small metal burr.

After removing the sharp edges, clamp each part in a vise, and use an angle grinder to clean any mill scale or rust from the outside surfaces (Figure 8-2). If a smoother finish is preferred, use a polishing wheel after grinding. When TIG welding, there is a noticeable difference in the quality of the weld puddle when welding on clean steel versus steel covered in rust and mill scale (Figure 8-3).

Figure 8-2. Parts cut to size with all rust and mill scale removed using an angle grinder.

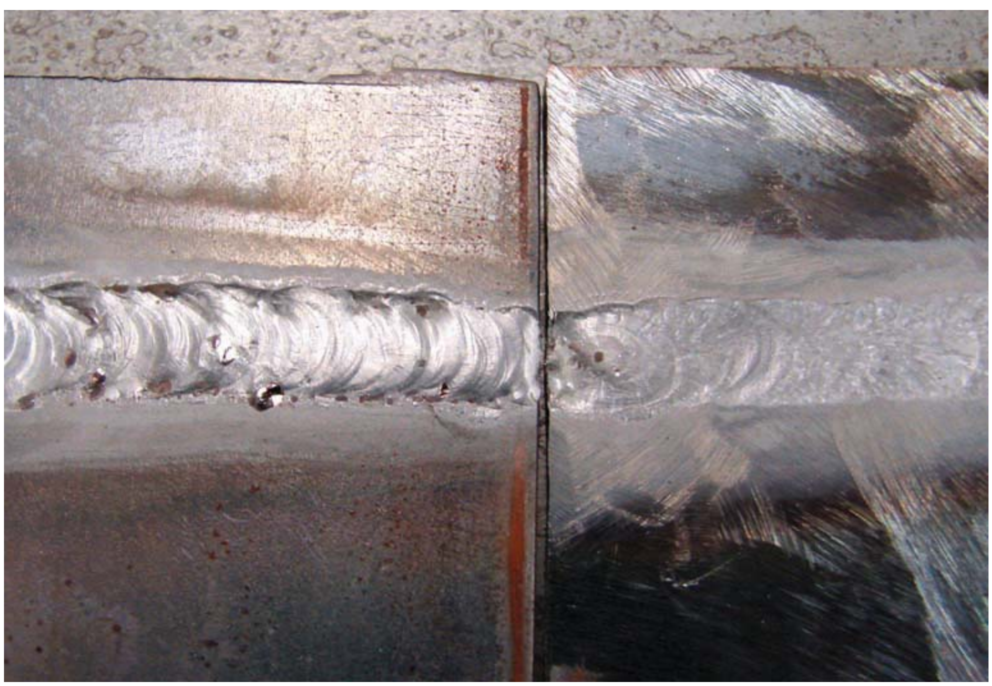


Figure 8-3. Notice the smoothness of the puddle on the right; it was pushed on clean steel compared to the puddle on the left, which was pushed on rusty unpolished steel.

STEP 3. Set up the TIG welder and collect needed tools.

Set up the TIG machine to weld 1/8" steel. Obtain a pair of pliers to handle the hot material, a piece of flat bar scrap 1/8" thick to use as a shim when tacking the parts together, and 1/16" or 3/32" steel welding rod. Prepare a clean flat surface to work on.

For safety purposes, a welding helmet set to shade 10 will need to be worn, along with welding gloves and protective clothing to protect your skin from the harmful ultraviolet (UV) and infrared (IR) rays emitted during the welding process.

Before welding, make sure the TIG torch has the proper electrode. To do this, remove the electrode from the torch and identify the color band at the end. This color band will indicate the composition and what type of metal it was designed to weld. When welding steel, the tip should be ground to a sharp point that has a length that is approximately 2-1/2 times the diameter of the electrode (Fig. 8-4). The welder should be set to weld DC negative polarity.

Note:
For detailed information on the TIG welding process and machine setup, refer to Chapter 6 in The Art of Welding, by William Galvery.

Figure 8-4. TIG nozzle and properly pointed tungsten electrode.

STEP 4. Tack the parts together.

As with most projects, this project should be tacked together prior to welding joints solid. (Refer to Figure 8-5 for construction dimensions.)

Begin by attaching the top tube to the center tube. If the parts are cut out of the same material as listed in the parts list, the base top can be used as a shim and a guide for part placement by sliding it under the center tube and aligning it flush with the edge (Figure 8-6). Place a tack in the middle of the joint; then check the parts for proper alignment.

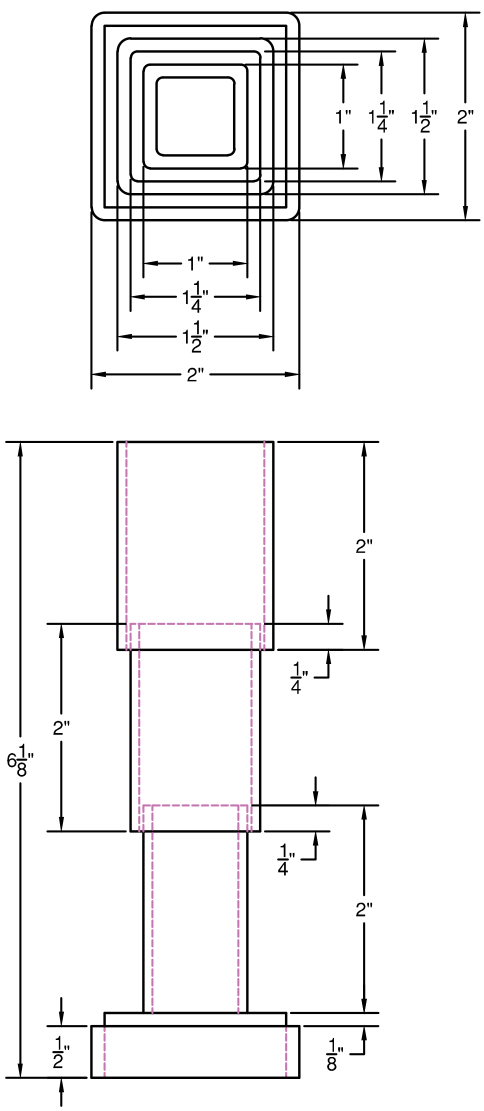


Figure 8-5. Pencil holder front and top views with dimensions.

Figure 8-6. Attaching the Top and Center Tubes.

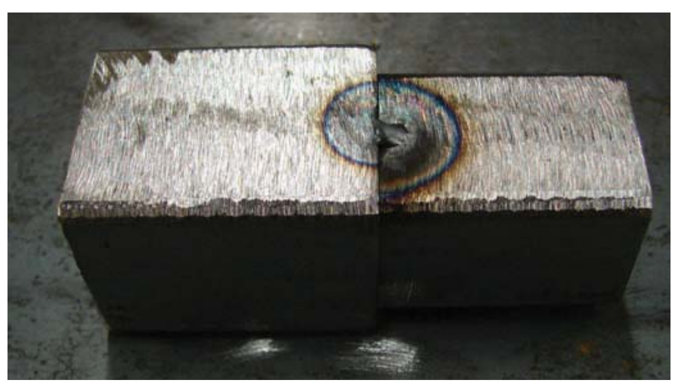


Figure 8-7. Top and Center Tubes tacked and aligned properly.

If the parts are square, tack the opposite side. If they are not square, prior to tacking the other side, tap on the parts in the direction needed until alignment is achieved (Figure 8-7).

Next, attach the bottom tube to the center and top tubes. Use both a 1/8" shim and the base top to support and align the bottom tube (Figure 8-8). Place a tack on one side. Check to make sure the parts are aligned properly. If necessary, make the proper adjustments; then tack the other side (Figure 8-9).

Now attach the base top to the base bottom by tacking it on two sides (Figure 8-10).

Figure 8-8. Center and bottom tubes ready to be tacked.

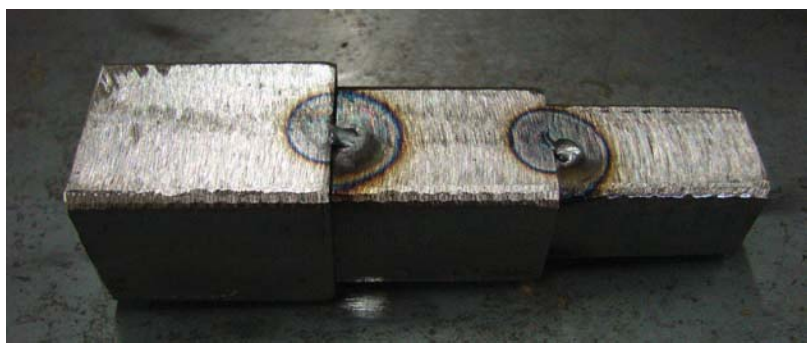


Figure 8-9. Top, center, and bottom tubes tacked and ready to be welded.

Figure 8-10. Base top attached to the base bottom with two small tacks on each side.

STEP 5. Weld the parts solid.

At this point, the parts can be welded together. It doesn't matter which joint is welded first. However, if you are new to the TIG welding process, begin with the bottom outside corner welds (Figure 8-11). Next, weld the lap joints in the top section (Figure 8-12), and save the T-welds until last because they will be the most difficult (Figure 8-13). Welding in order from the easiest joint to the most difficult will provide time to get used to the TIG welding process, feeding filler metal properly, and welding a smooth consistent puddle.

Figure 8-11. Outside corner welds completed on two sides of the bottom base using 1/8" filler rod.

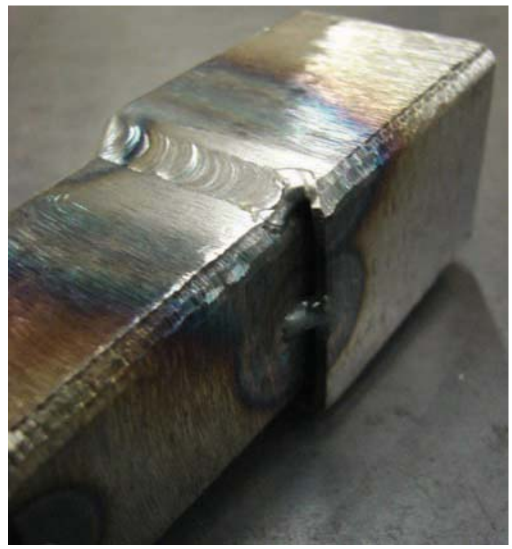


Figure 8-12. Lap welds completed on one side of the top and center tube. Make sure to end the weld by lapping around the corner, which will make it easier to proceed to the next weld.

Figure 8-13. Completed T-weld at the base of the pencil holder.

STEP 6. Cleanup.

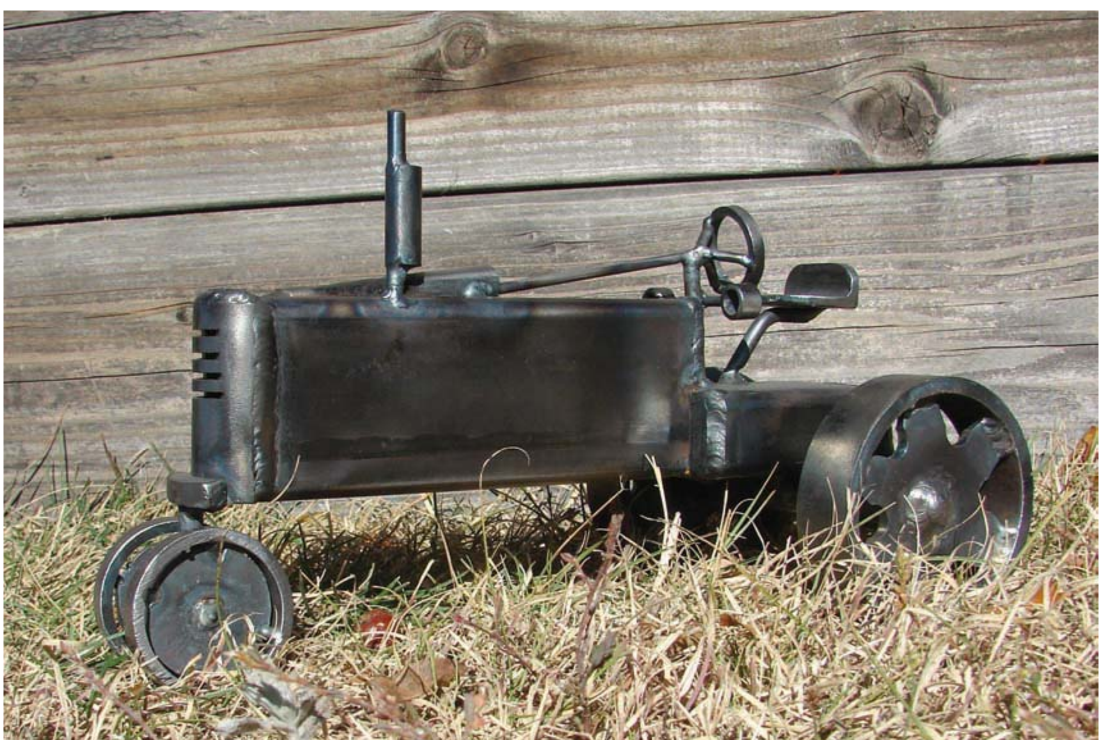
The pencil holder is now complete (Figure 8-14). An advantage of TIG welding is the absence of welding spatter, making cleanup much quicker. Cleanup is generally as easy as a quick brush over with a wire wheel and the project is complete.

Figure 8-14. Ready for pencils!

CHAPTER 9

Tractor

With 37 parts to cut, shape, and weld together, this project offers many challenges and will test your gas tungsten arc welding (GTAW) skills. The project will provide practice welding most of the basic weld joints as well as practice joining metals of two different thicknesses together.



STEP 1. Study the plan views and parts list and collect the needed material.

The tractor project is made up of a large variety of structural steel shapes including pipe, rectangular tube, flat bar, angle, and rod along with some sheet metal. Due to the intricate design of this project, it is important to use the exact material listed in the parts list in Figure 9-1. The plan views in Figure 9-2 provide detailed views of the tractor, displaying how the parts fit together as well as providing some location dimensions.

When reviewing the parts list, identifying the pipe may be somewhat confusing if you are not familiar with the NPS (Nominal Pipe Size) system of pipe size designation. For example, 1/8" Sch40 pipe does not have an inside or outside dimension of 1/8".
In fact, the inside diameter is .27, which is just slightly larger than 1/4", and the outside diameter is .41, which is close to being 3/8". When designating pipe size, the NPS and the outside diameter (OD) are not equal until you get into very large 14" pipe diameters. Due to this fact, when choosing pipe for a project, refer to a Nominal Pipe Size (NPS) table for actual sizes for outside diameter (OD), inside diameter (ID), and wall thicknesses. Be aware that there are also different wall thicknesses for most pipe; that designation is indicated as a schedule. There are as many as 16 different wall thicknesses for steel pipe and fittings. Some are referred to as schedules such as sch40 or sch80 whereas others are indicated as Light Wall, X-Stg (Extra Strong), and XX-Stg (Extra Extra Strong). When chososing a schedule of pipe, typically schedule 40 is readily available at most local steel retailers.

HELPFUL HINT

Tractor Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	Main Body	Rectangular Tube	14 gauge	2" x 1"	0'-5 1/4"
1	Body Front	3/4 Sch 40 Pipe	.083	1.05 OD/.804 ID	0'-2"
1	Seat Base	Rectangular Tube	14 gauge	2" x 1"	0'-2 5/8" (Cut one end @ 70°)
1	Seat Base Back Cap	Flat Bar	1/8"	1"	0'-1 3/4"
2	Seat Base Front Side Caps	Flat Bar	1/8"	1"	0'-3/8"
1	Main Body Back Cap	Flat Bar	1/8"	1"	0'-0 7/8"
1	Body Front Top Cap	Flat Bar	1/8"	1"	0'-7/16"
1	Seat	Angle	1/8"	1" x 1"	0'-1"
1	Seat Support	Rod	3/16"	-	0'-1 5/8"
1	Steering Wheel	3/4 Sch 40 Pipe	.113	1.05 OD/.804 ID	0'-1/8"
1	Steering Wheel Frame 1	Rod	1/8"	-	0'-1"
1	Steering Wheel Frame 2	Rod	1/8"	-	0'-1/2"
1	Steering Support	Rod	3/16"	-	0'-1 1/2"
1	Steering Support T-Rod	Rod	1/8"	-	0'-1 1/4"
2	T-Rod Lights	1/8 Sch 40 Pipe	.07	.41 OD/.27 ID	0'-1/4"
2	Lg Outer Tires	2 1/2" Sch 40 Pipe	.20	2.88 OD/2.47 ID	0'-3/4"
2	Sm Outer Tires	1 1/4" Sch 40 Pipe	.14	1.66 OD/1.38 ID	0'-5/16"
2	Lg Tire Centers	Sheet	10 ga	2-7/16" Ø	-
2	Sm Tire Centers	Sheet	10 ga	1-5/16" Ø	-
1	Lg Tire Axle	Rod	3/8"	-	0'-5"
1	Lg Tire Axle Support	1/4" Sch 40 Pipe	.09	.54 OD/.36 ID	0'-4 3/8"
1	Sm Tire Axle	Rod	1/4"	-	0'-1"
1	Sm Tire Axle Support	1/8 Sch 40 Pipe	.07	.41 OD/.27 ID	0'-5/8"
1	Sm Tire Axle Support T	Rod	1/4"	-	0'-3/4"
1	Front Bumper	Sq Bar	1/4"	1/4"	0'-1"
1	Steering Bar	Rod	1/8"	-	0'-3"
1	Steering Bar Cover	1/8 Sch 40 Pipe	.07	.41 OD/.27 ID	0'-2 1/2"
1	Rear Hitch	Flat Bar	1/8"	1/2"	0'-1 1/2"
1	Smoke Stack Bottom	Rod	3/16"	-	0'-3/4"
1	Smoke Stack Center	Rod	3/8"	-	0'-1"
1	Smoke Stack Top	Rod	3/16"	-	0'-1"

Figure 9-1

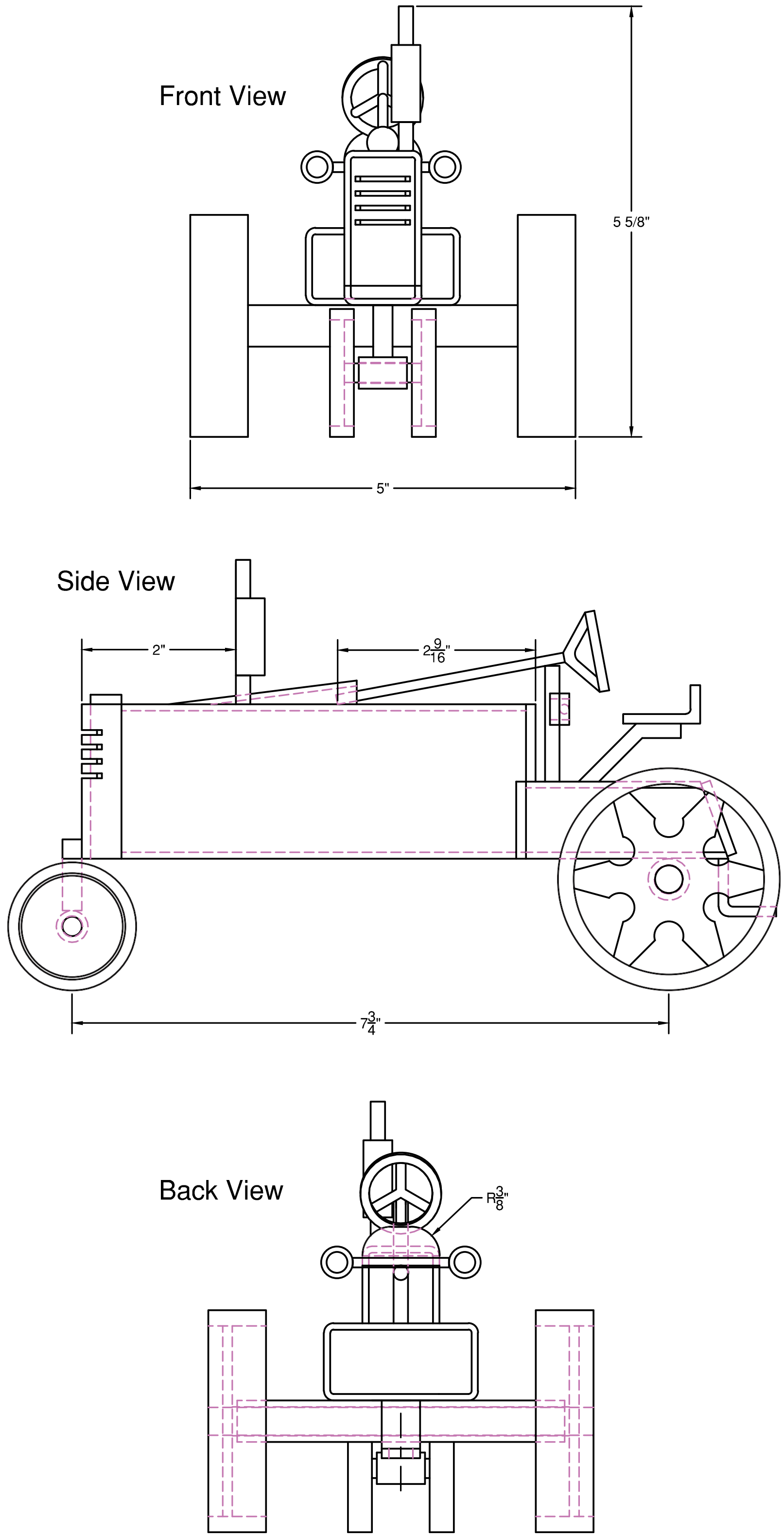


Figure 9-2. Side View, Front View, and Back View of the Tractor. The front and back views have many hidden lines omitted for clarity.

STEP 2. Cut the parts for the main body of the tractor.

In this step, the following parts should be cut to size: main body, body front, seat base, seat base back cap, seat base front side caps, main body back cap, and the body front top cap.

Begin by cutting the parts that require no special treatment other than to be cut to length at a 90-degree angle. These include the main body, seat base back cap, seat base front side caps, and main body back cap. Next, cut the seat base, which requires one end to be cut at a 70-degree angle (the parts list indicates the length from the longest point of the tube).

The next step will be to cut the body front, which will need to be cut to length, split in half, and embellished with slits. First cut the 3/4 sch40 pipe to length. Then, tack the pipe to a piece of rectangular tube (Figure 9-3). The tube needs to be approximately 6" long so that it will fit securely into a band saw vise, and your tacks need to be solid enough that they don't break during the cutting process. Place the tube into the vise and align the pipe so the blade cuts down the center of the pipe (Figure 9-4).

Figure 9-3. The body front tacked securely to rectangular tube.

Figure 9-4. The body front secure in the vise and ready to be cut in half using a band saw.

When the cut is complete, the side that was not tacked to the rectangular tube will be used as your tractor body front. The part will have some sharp burrs that will need to be removed (Figure 9-5). Using a marker and a square, indicate where the four front slits will be located on the part. The first slit begins 1/4" from the top and the others are spaced 3/16" apart on-center. Place the half round part, rounded side up in the band saw vise, and cut the slits into the part, going approximately 1/4" deep. Make sure the drop down with the band saw is very slow so as not to pull too much on the part while cutting. Excessive down pressure when cutting could potentially force the part to come loose from the vise and damage the blade (Figure 9-6).

Figure 9-5. The body front cut in half.

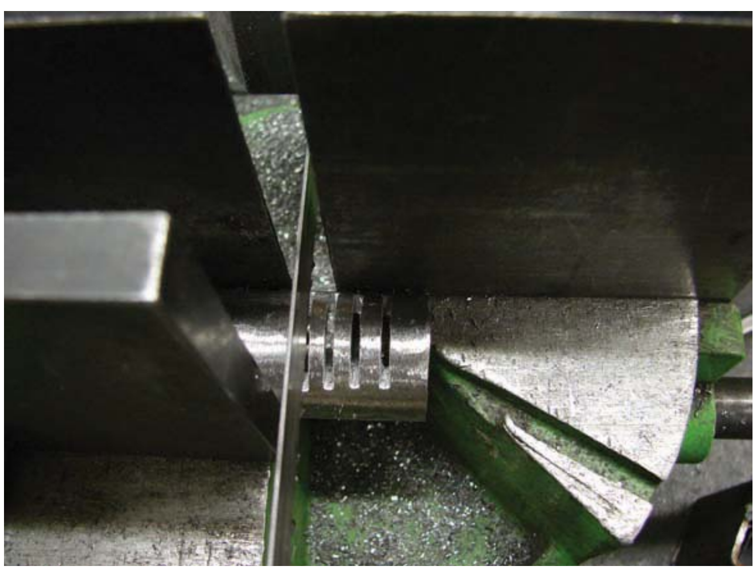


Figure 9-6. Use a band saw to cut slits in the body front.

The last part to be cut in this section is the body front top cap. Because the final part size is small, it will be easier to work with a long piece of flat bar to shape the part before cutting it to length. To prepare the part for shaping, set the half round body front onto the end of a piece of 1" flat bar and trace the needed shape with a permanent marker at the end of the bar (Figure 9-7). Using a stationary grinder and a pair of locking pliers to hold your material solid, grind the curved shape into the end of the flat bar (Figure 9-8). Using a saw or a metal shear, cut your part to length (Figure 9-9). Finally, clean the parts removing any mill scale and sharp burrs left after cutting.

Figure 9-7. Use the body front to trace the shape needed for the body front top cap.

Figure 9-8. The body front, top cap rounded and ready to be cut to size.

Figure 9-9. A metal shear provides a quick option for cutting the small part to size with no additional clean-up necessary.

STEP 3. Weld the main body of the tractor together.

Before welding these main parts together, the TIG welder should be set to negative DC polarity, the proper tungsten should be placed into the TIG torch, and some 1/8" diameter steel filler rod should be obtained. If 1/8" filler rod is not available, 3/32" filler rod will work; however, it can be more challenging to use because it may add more filler than necessary for many of the joints.

Note:
For detailed information on gas tungsten arc welding (GTAW) and machine setup, refer to Chapter 6 in *The Art of Welding*, by William Galvery.

To begin, tack the body front to the main body part. Weld it solid on both sides (Figure 9-10). Then place the body front top cap onto the body front and weld around the part (Figure 9-11). Proceed to the back of the tractor by welding the seat base back cap to the seat base. Make sure you attach the cap to the angled end of the seat base, not the square end (Figure 9-12).

Figure 9-10. Butt weld joining the body front to the main body.

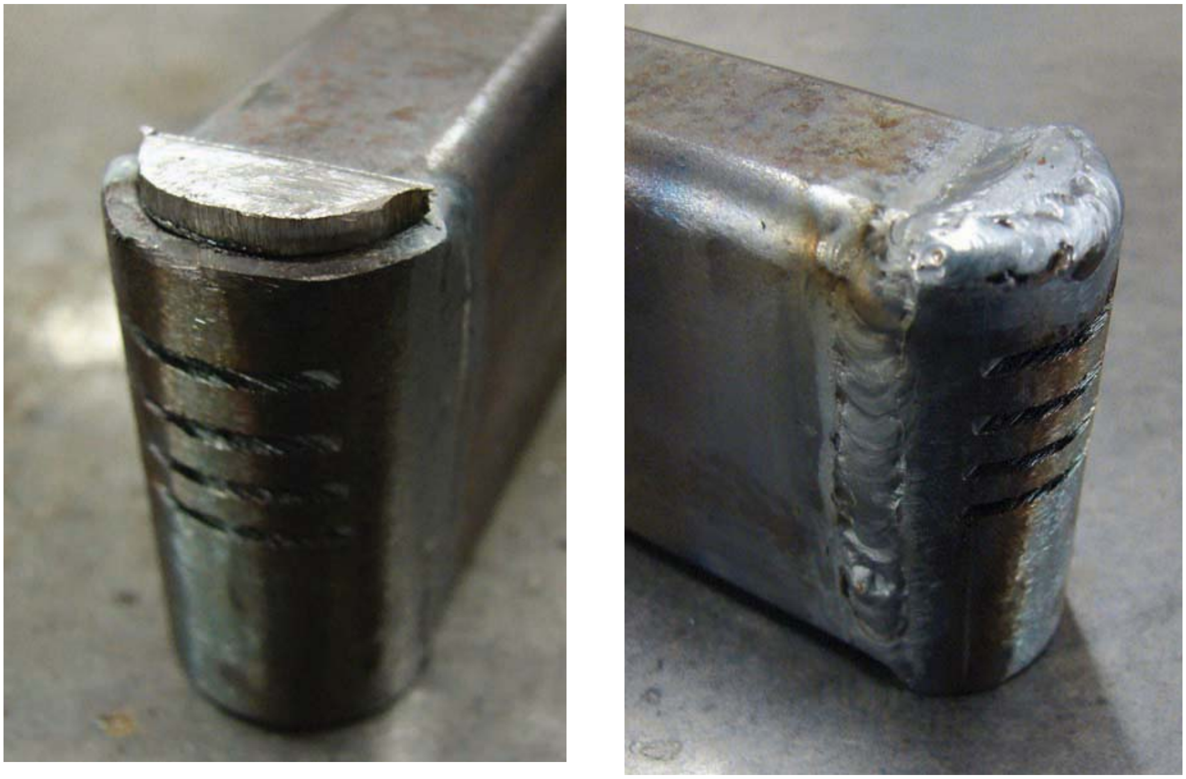


Figure 9-11. a) Body front top cap ready to be welded to the body front. b) Welded body front top cap.

Figure 9-12. Welded seat base back cap.

The next step will be to weld the main body back cap to the main body and to the seat base. The easiest way to do this will be to align the main body with the seat base, then set the cap in place. It should stand there without any clamping. Tack the top of the main body back cap to the main body and also at the bottom touching the seat base. After tacking, weld the outside corner welds around the main body and then the T-weld between the cap and the seat base (Figure 9-13).

Finally, weld the seat base front side caps in place. To tack these, it is best to stand the body on end so that you can set the parts in place while tacking, and welding them solid (Figure 9-14). Weld around the caps and across the bottom, securing the main body to the seat base. It is not necessary to weld the edge that connects to the main body (Figure 9-15).

Figure 9-13. The main body attached to the seat base.

Figure 9-14. C-clamp locking pliers work well to hold the base upright while welding the seat base front side caps in place.

Figure 9-15. Final welds made to the main body of the tractor.

STEP 4. Build the front and back wheels.

Begin the wheel construction by cutting the large and small outer tires. A band saw will help you achieve a straight, clean cut. After cutting, use a file or die grinder with a metal burr to smooth the edges and remove any sharp burrs.

The large and small tire centers should be cut next. Use the plasma cutter with a circle cutting attachment for best results. (For detailed instructions on using a circle cutting attachment, refer to Chapter 1, Step 4 of the Truck project.) If a circle cutting attachment is not available and free-hand cutting is the only option, trace around the inside edge of the outer tires with a permanent marker. Then use the plasma cutter to cut out the circles.

Chip the plasma dross from the backs of the circles, smooth the edges with a grinder if you free-hand cut the parts, and clean the surfaces.

The holes in the large tire centers will need to be drilled next. Use a protractor and a scribe to mark the center lines. Refer to Figure 9-16 for hole placement. After the circle centers have been located, use a punch and hammer to place a divot in the circle centers. Place the large tire centers in a drill press vice and drill all seven holes using a 3/8" drill bit. Make sure the vise is tight so that the part doesn't come free while drilling (Figure 9-17).

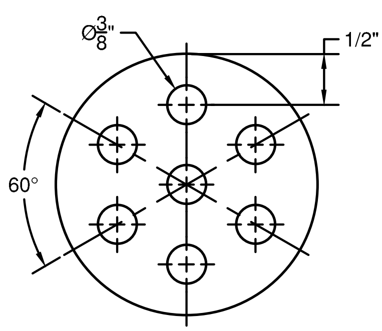


Figure 9-16. Hole pattern template with dimensions for large tire centers.

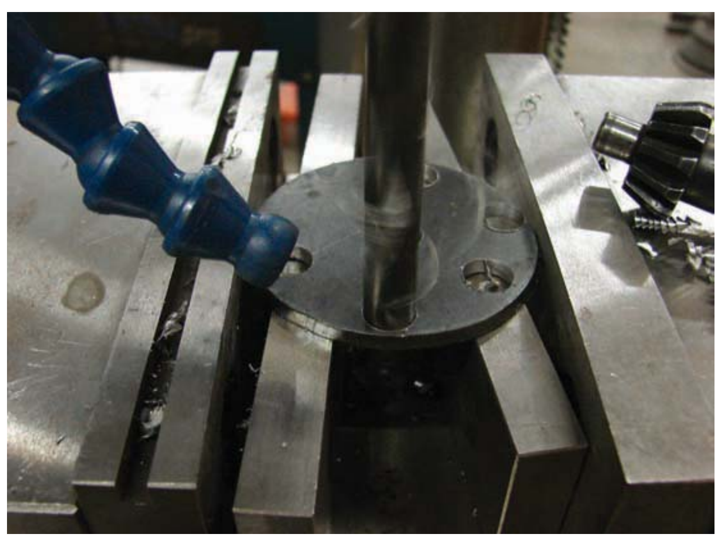


Figure 9-17. Drilling the holes in the large tire centers.

Using the same drill bit, drill a hole in the center of the small tire centers. If a circle cutting attachment was used with the plasma cutter, the circle center will already have a punch mark (Figure 9-18). Clean the burrs from the back of all wheel centers.

To finish the spoke pattern in the large tire centers, use an iron worker with a notcher attachment. Simply place the tire center into the jaws of the notcher so that the point just misses touching the inside edge of the circle, and notch out the part (Figure 9-19). If an iron worker is not available, the spokes can be completed with a plasma cutter. It will be necessary to make layout lines using a square. Refer to Figure 9-20 for the notch layout guide and dimensions.

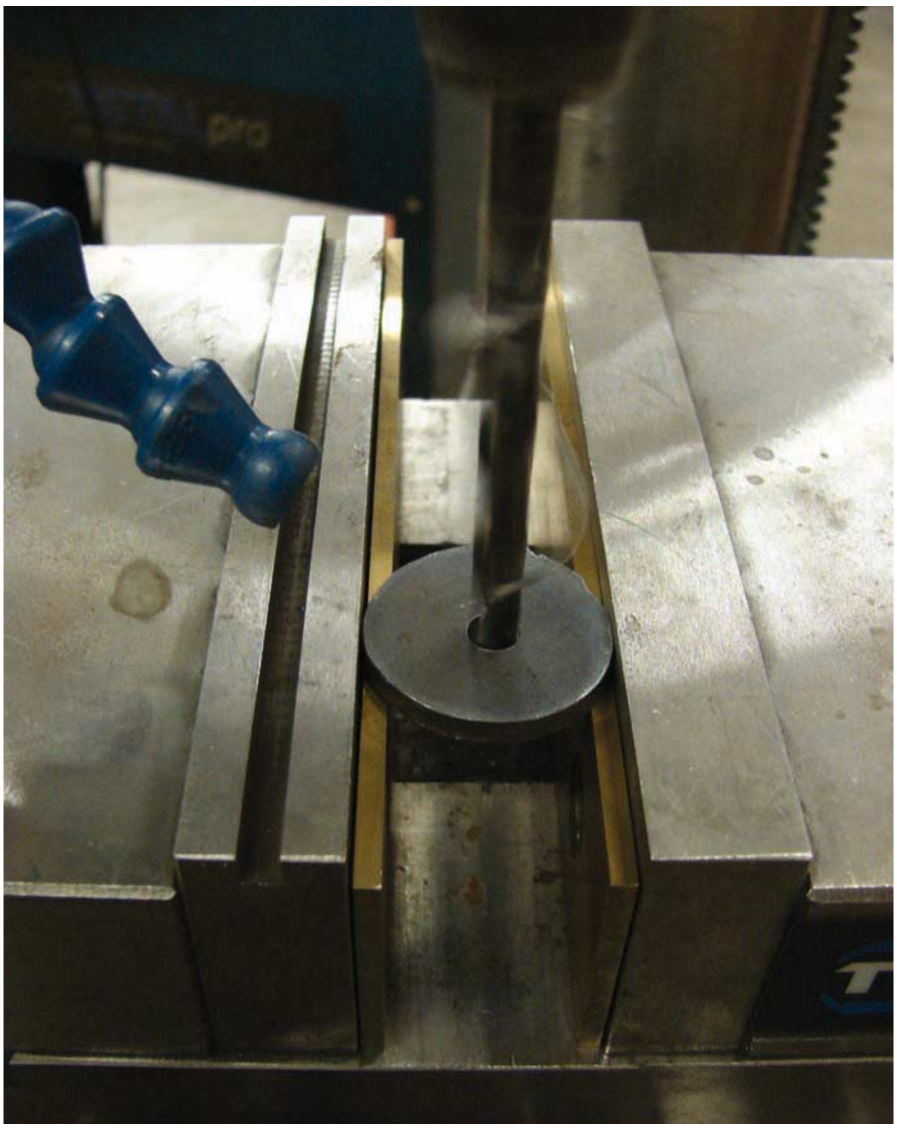


Figure 9-18. Drilling the holes in the small tire centers.

Figure 9-19. A notcher attachment on an iron worker can make finishing the spokes on the large tire centers quick and easy.

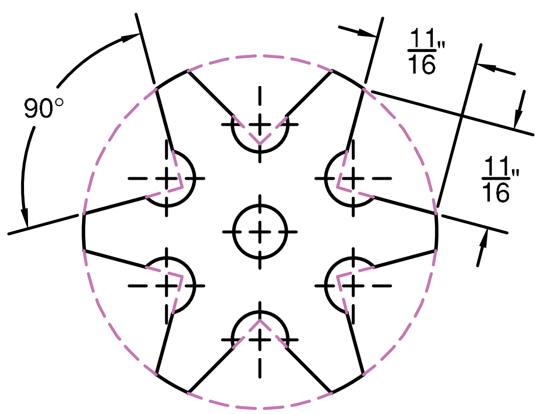


Figure 9-20. Spoke notch layout guide and dimensions.

If an iron worker was used, no cleanup is necessary. If a plasma cutter was used, remove the dross and polish the surfaces.

To complete the wheels, weld the tire centers to the outer tires. When welding the small tire parts, place the tire on a clean flat surface and place the tire center down into the 5/16" section of pipe. Weld a tack in all four quadrants of the pipe. When welding the large tires to the tire centers, the tire centers need to be lifted 1/2" from the bottom of the tire. Two small pieces of 1/2" x 1/2" square tube or square bar can be used to hold the tire centers in place. Weld the two parts solid at each spoke, running a T-weld the entire length of each spoke (Figure 9-21). A tack on each spoke would suffice, but the wheel will look better with a solid bead. When the parts have cooled, clean the mill scale with a wire wheel.

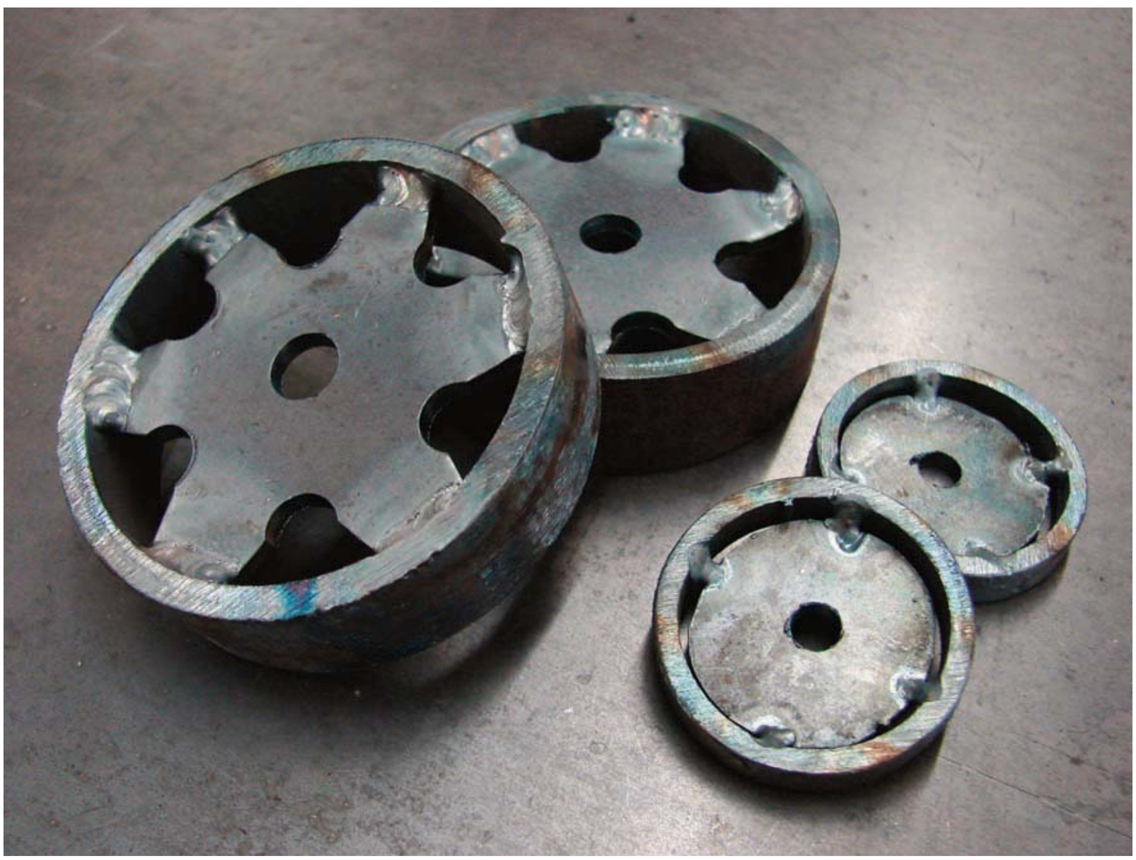


Figure 9-21. Completed large and small tractor wheels.

STEP 5. Cut and weld the seat parts.

The seat consists of two parts: a seat and a seat support. The seat is made from a piece of angle iron. After it is cut to length, 1/2" of one side of the angle iron will need to be cut off using an iron worker or a plasma cutter and the corners will need to be rounded to a 3/8" radius using a grinder. Next cut the seat support and bend it 1/2" from one end at a 45-degree angle.

Weld the two parts together using some locking pliers, one of the small tires, and a scrap piece of 1/8" strap as props to hold the seat and support while welding (Figure 9-22). When the seat is complete, polish the parts with a wire wheel (Figure 9-23).

Figure 9-22. Sometimes you have to get creative when welding parts together. In this example, the odd shape and small size of the part made it difficult to hold the parts for tacking. A pair of locking pliers and parts that were already made for the project came in handy as a support for tacking purposes.

Figure 9-23. Attached seat parts.

STEP 6. Cut and weld the steering wheel assembly.

Begin by cutting the four parts that make up the steering wheel assembly to length: steering wheel, steering wheel frame 1, steering wheel frame 2, and the steering bar. Then clean any burrs from the edges.

Next, bend the steering wheel frame 1 at the center to a 90-degree angle by placing the part in a vise with slightly over half the length sticking out and tapping it over with a hammer.

At this point, the steering wheel parts can be welded together. The most challenging part will be to hold the parts at the proper location and angle for tacking. Locking pliers and the small wheel will come in handy for this weld (Figure 9-24). With these parts being so small, be careful not to over-heat them when welding. A small tack that fuses both the edge of the steering wheel and the steering wheel frame will be all that is necessary to hold these tiny parts together. The steering wheel frame 2 can now be attached using the locking pliers to hold them in place while welding. Then carefully polish the steering wheel with a wire wheel (Figure 9-25).

Next the steering bar can be attached to the steering wheel frame. Have a partner hold the part in place while welding, or use a method of holding the rod similar to what was used earlier (Figure 9-26). Clean the weld area with a wire wheel to clean any mill scale build up.

Figure 9-24. Use locking pliers to hold your part in place while welding.

Figure 9-25. Completed steering wheel with supports.

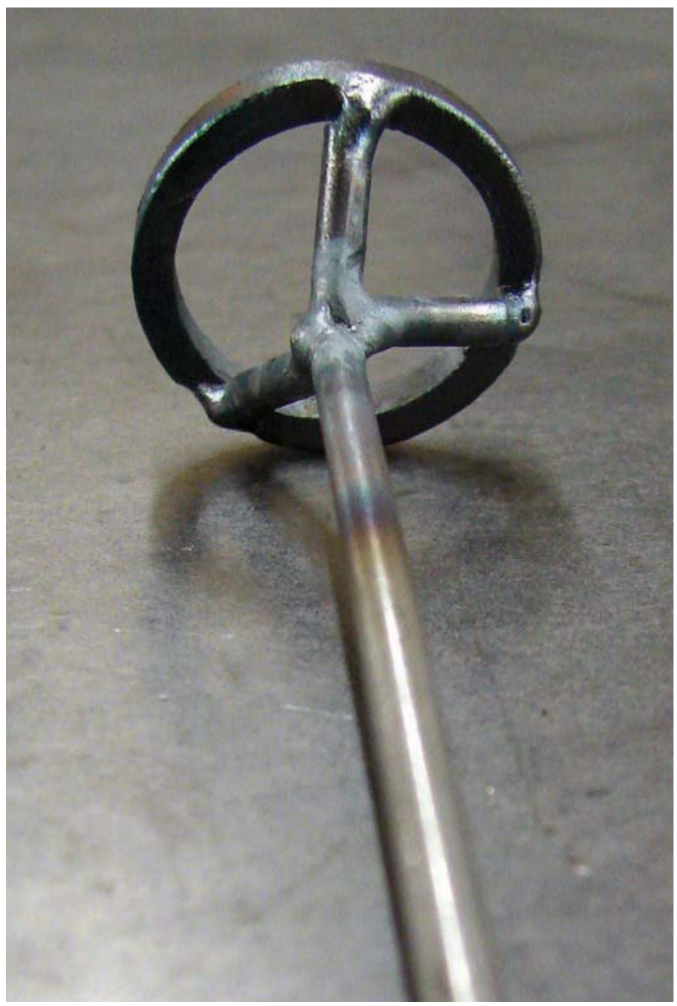


Figure 9-26. Steering bar connected to the steering wheel frame.

STEP 7. Attach the steering support to the light bar.

Cut the steering support, the steering support t-rod, and the t-rod lights. Remove any sharp burrs from the ends and the inside of the pipe.

Weld the lights to the t-rod by laying them on a flat surface and placing a small tack weld on the top and bottom of the t-rod rod (Figure 9-27).

Next, weld the t-rod to the steering support (Figure 9-28). Clean the parts with a wire wheel.

Figure 9-27. Finished light bar.

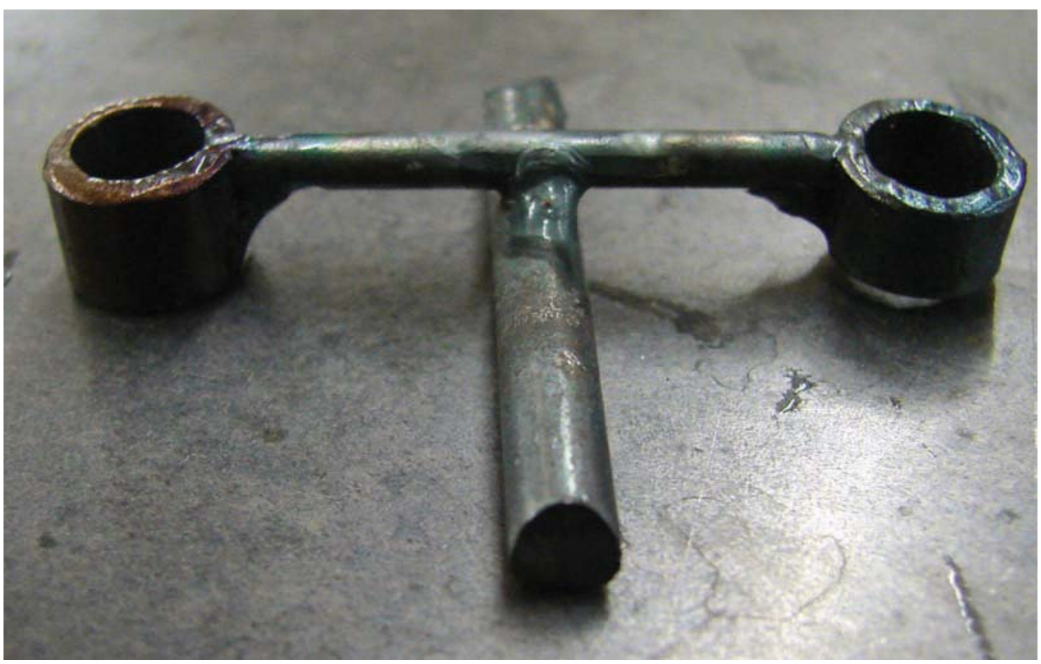


Figure 9-28. Steering support welded to the light bar.

STEP 8. Attach the steering bar and steering bar cover to the top of the tractor body.

At this point, the steering wheel is ready to be attached to the main body of the tractor. Locate a point that is 2-9/16" from the main body cap (refer to Side View of the tractor in Figure 9-2). After the location dimension has been marked, prop your steering wheel up with a piece of 1-1/4" square tubing and align it properly on the top of the main body (Figure 9-29). The only weld necessary will be a small tack weld at the end of the steering bar (Figure 9-30).

Figure 9-29. Steering bar in place on the main body.

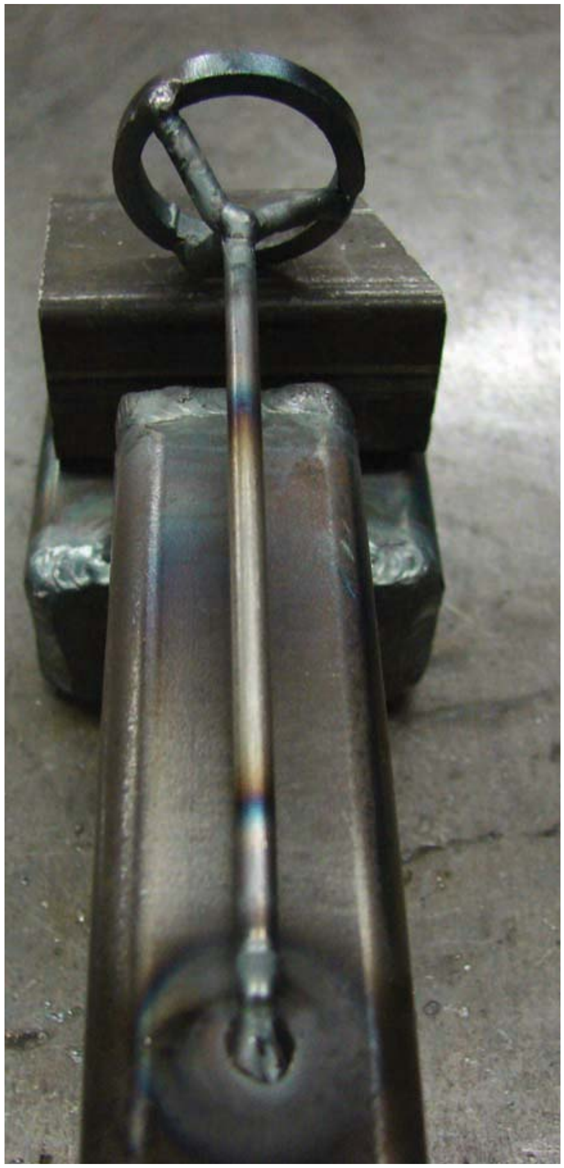
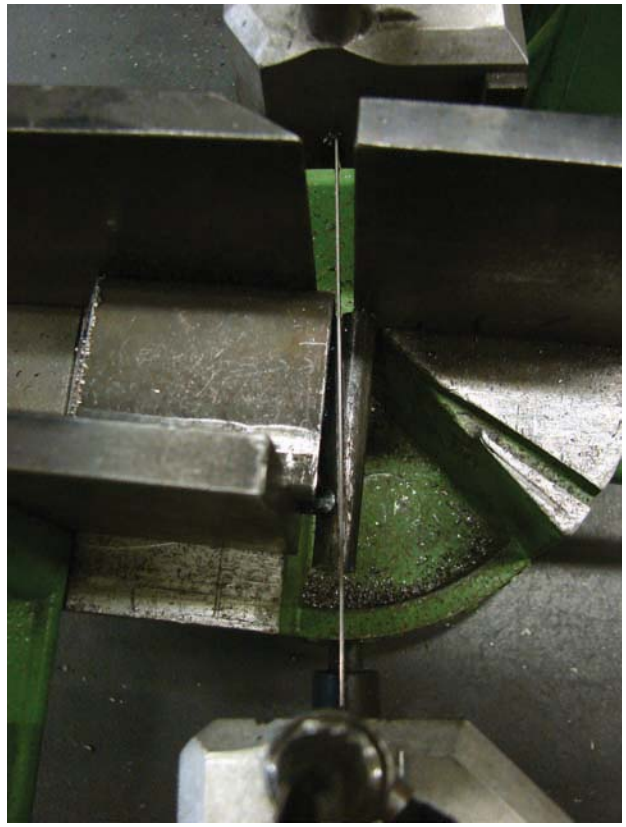


Figure 9-30. Steering bar attached to the main body with a small tack weld.

The next step will be to cut your steering bar cover. Begin by cutting it to length. Then cut the part in half using the band saw and the same method that was used at the beginning of this project to cut the pipe in half for the body front (Figure 9-31). Overlap the steering bar with the steering cover by 1/4", align it down the middle of the main body, and weld it in place (Figure 9-32).

a)

b)



c)

d)

Figure 9-31. a) Tack the 1/8" sch40 pipe to a scrap piece of rectangular tube.
b) Turn the tubing over and place three strong tacks on the back side.
c) Place the part in the band saw and split it in half using approximately a 7 ^{o} angle.
d) Remove any sharp edges and excessive mill scale from the half section of pipe.

STEP 9. Attach the steering support with light bar and seat to the seat base.

Attaching these parts is a matter of holding them in place and welding small tack welds to secure the small rod that was used to make the parts. Weld the steering support to the seat base and steering bar first (Fig. 9-33).

When attaching the seat, prop it up using some scraps so that it can be welded in the right position. There may be a small gap between the end of the rod and the surface of the seat base. This can easily be filled when welding (Fig. 9-34). Weld the support to the base (Fig. 9-35).

Figure 9-32. Attached steering bar cover.

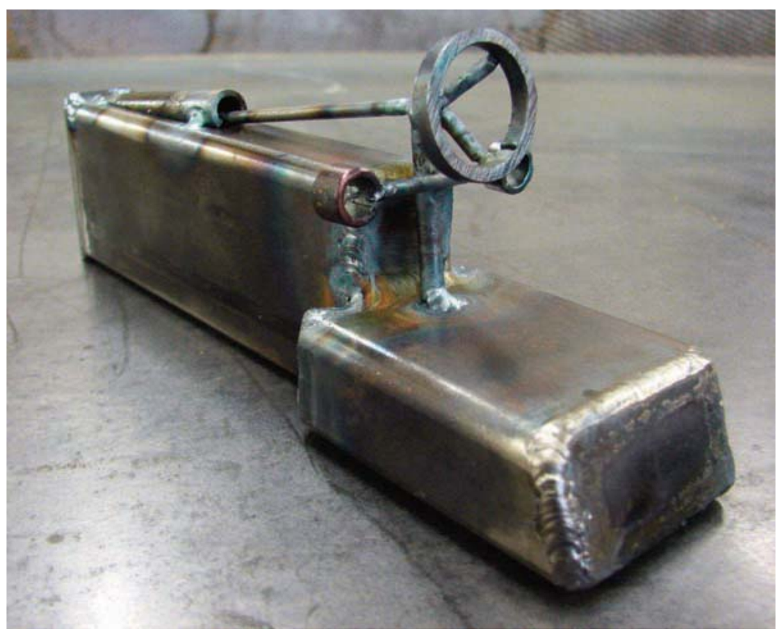


Figure 9-33. Attached steering support.

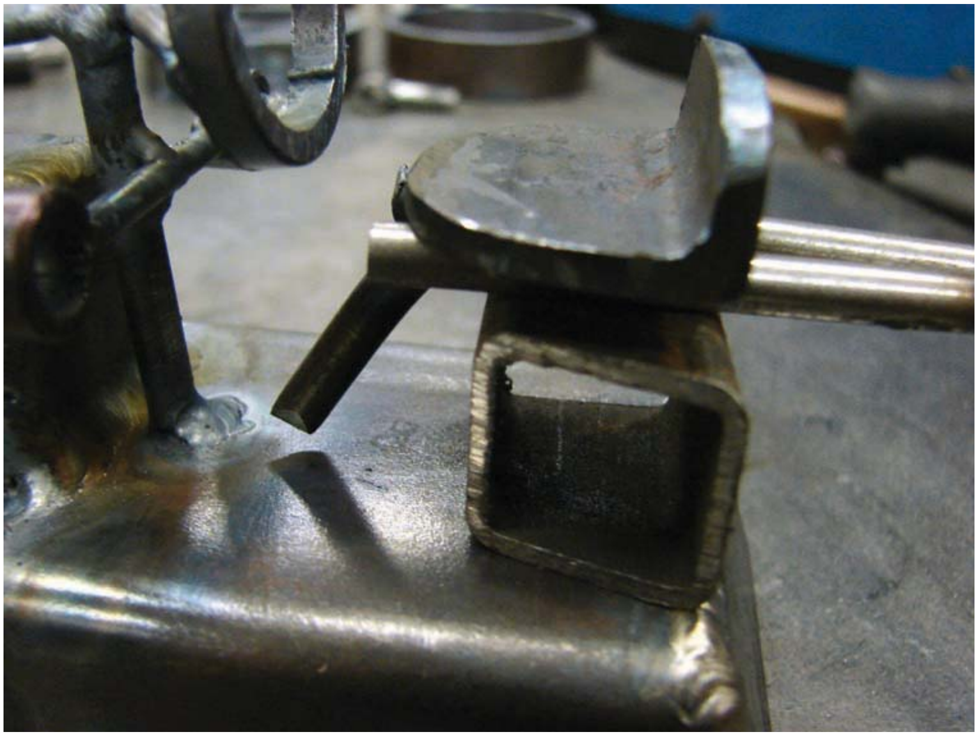


Figure 9-34. Use 3/4" square tubing and two small pieces of 3/16" rod to prop up the seat for welding.

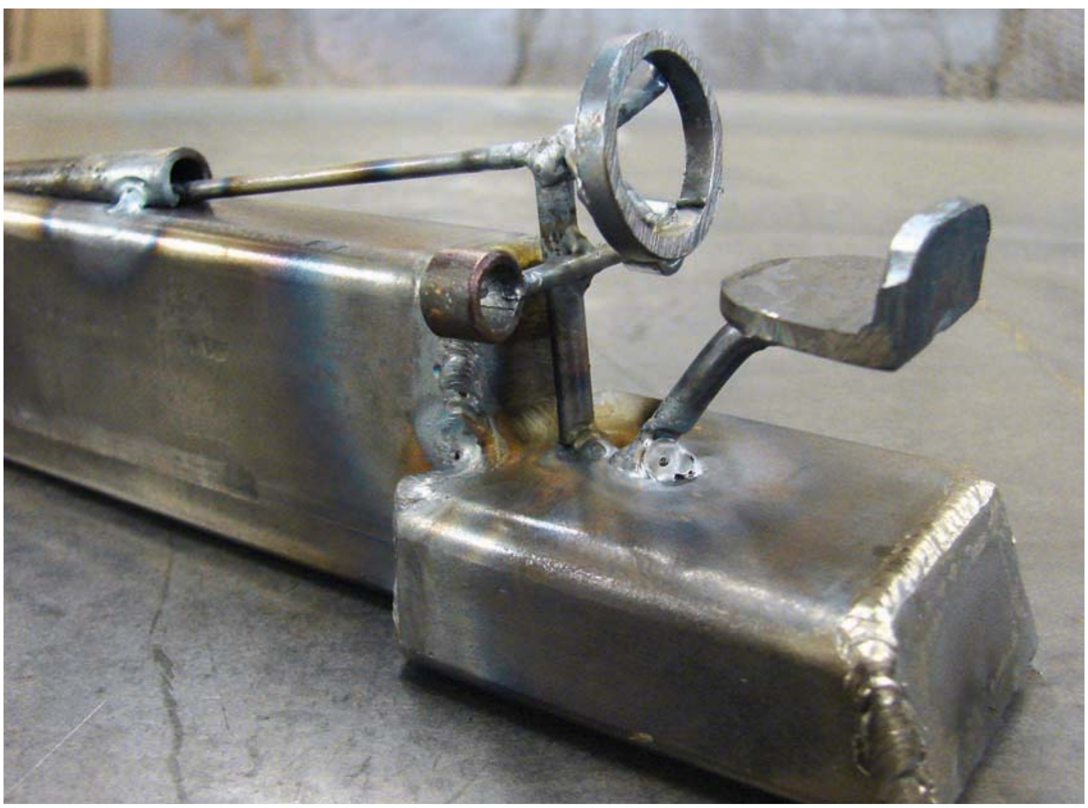


Figure 9-35. Completed seat welds.

STEP 10. Bend the bumper and attach to the body front.

Cut the bumper to size and then bend it in the shape of the front of the tractor. The easiest way to acquire the same arc as the front of the tractor is to heat the small piece of 1/4" square bar with a large gas tip, clamp hold of it with locking pliers, and then use a hammer and an anvil to make the slight bend in the part. Have the tractor near the anvil so you can check the fit as you form the shape.

Once the rounded shape is achieved, cool the part. Then weld the bumper to the front of the tractor on the bottom side. To make tacking the parts together easier, add a small drop of filler metal to the bottom side of the front before attempting to weld the two parts together. If there is a large difference in part thickness; the thinner part will tend to want to melt faster than the thicker part. Having that extra filler metal there will make forming a bond easier and quicker (Figure 9-36). When you begin to form the weld pool, try to form it on the square bar first; then wash in the tack and front pipe material into one solid puddle. Place a weld along the entire bottom side of the square bar and body front. For aesthetic purposes, no weld should be placed on the top side of the bumper (Figure 9-37).

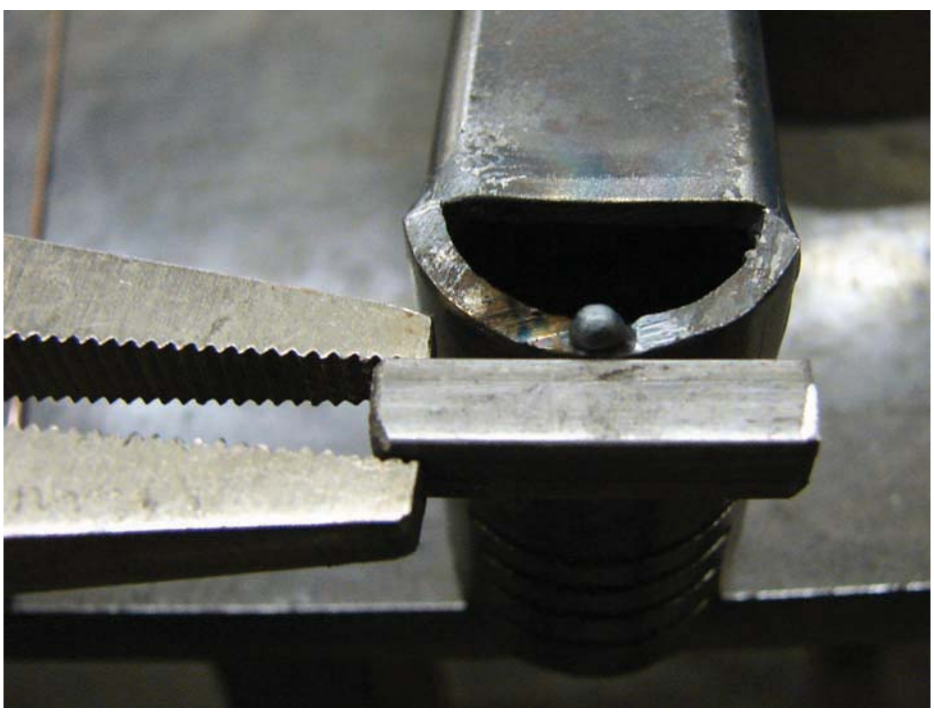


Figure 9-36. Extra bead of filler metal placed on tractor bottom front. Bumper ready to be bent.

Figure 9-37. The front bumper welded in place.

STEP 11. Assemble and attach the front tires and axle.

Begin the assembly of the front tires by first cutting the small tire axle, small tire axle support, and small tire axle support T. Weld the axle support and axle support T together. This will take a little propping up to free up both your hands for welding (Figure 9-38). Weld completely around the rod (Figure 9-39).

Figure 9-38. Use a piece of 1/8 strap to lift the 1/4" rod into the proper location for attaching the two parts together.

Figure 9-39. Completed welds on the axle and support parts.

Next, attach the axle support and T to the bottom side of the front bumper. Again, you will need to prop the parts up. A piece of 1/8" flat bar and a small scrap of 1/4" rod work well for holding the axle support parts at the correct height for welding (Figure 9-40).

After the axle support has been welded, place the axle through the hole in the axle support and place one of the small tires on top of the axle. The tire center should be almost flush with the end of the axle (Figure 9-41). Weld the axle to the tire center.

Lay the tractor body upside down and slide the second tire into place (Figure 9-42). Tack the axle to the second tire center. Then position the tractor on its side, make sure the second tire is straight with the first and weld the axle solid to the center.

Note:
Most welds performed in this project are done for aesthetic purposes and to practice the TIG welding process, not for purposes of strength.

Figure 9-40. The axle parts supported and ready to be welded to the bumper. Observe that the main body of the tractor is laying flush on the table without any supports. This is achieved by hanging the seat base off the edge of the work table.

STEP 12. Assemble and attach the back tires and axle.

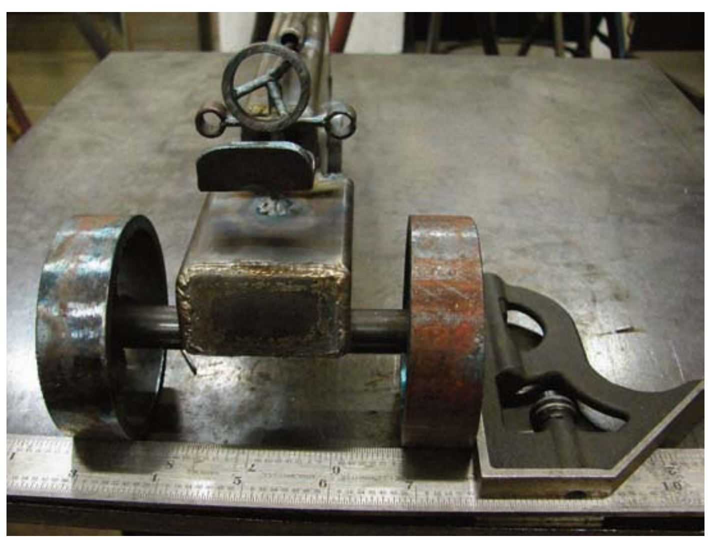
To begin, cut the large tire axle and axle support to length.

Slip the axle through the support and slide the tires onto the axle on both ends, centering the axle support equally between the tires and leaving approximately 1/32" gap between the large tire center and the axle support. Make sure the axle extends out the outsides of the large tires equal distances and that you have the tires turned so that the welded sides of the axle centers face the outside of the tractor. Use a square to make sure the tires align properly (Figure 9-43). After the proper alignment has been achieved, tack both sides of the axles to the tire centers (Figure 9-44). When the axles have been tacked, check to make sure the tires roll straight. Then weld around both axles (Figure 9-45).

Figure 9-41. The first small tire in place and ready to be welded to the axle.

Figure 9-42. The second small tire in place and ready to be welded to the axle.

Figure 9-43. Use a square to align the tires before tacking the axles to the large tire centers.



Now it is time to connect the axle support to the bottom of the seat base. To make this process easy, prop the tractor on its back and use a pair of C-clamp locking pliers to hold it in place. Use some square tube under the locking pliers on each side to stabilize the tractor body. Use a second pair of locking C-clamp pliers to attach a piece of 1/4" x 1" strap 1-1/4" away from the back of the seat base (Figure 9-46). Make sure the strap is clamped square to the bottom of the seat base. The strap is used to place the axle support in the proper position for welding (Figure 9-47). Weld the entire length of the axle support to the seat base on the back side (Figure 9-48). On the front side, only a single tack is necessary (Figure 9-49).

Figure 9-44. Large tire axle tacked to large tire center.

Figure 9-45. Completed large tire axle assembly.

Figure 9-46. Use locking pliers to aid in accurately placing the axle support.

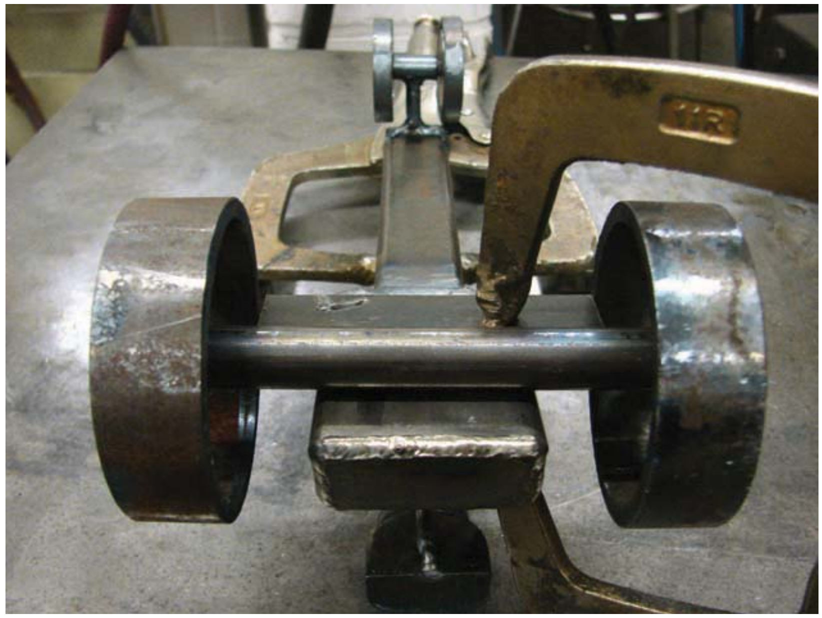


Figure 9-47. The large tire and axle parts in place and ready to be welded.

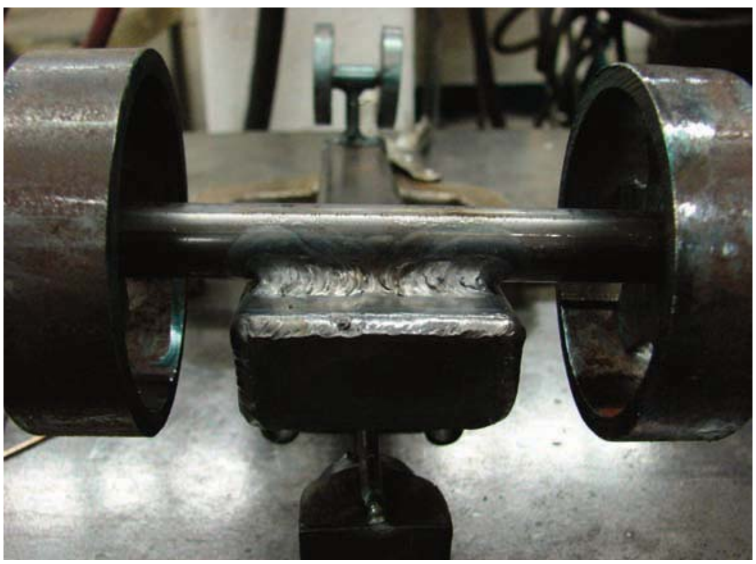


Figure 9-48. The back side of the axle support welded to the seat base.

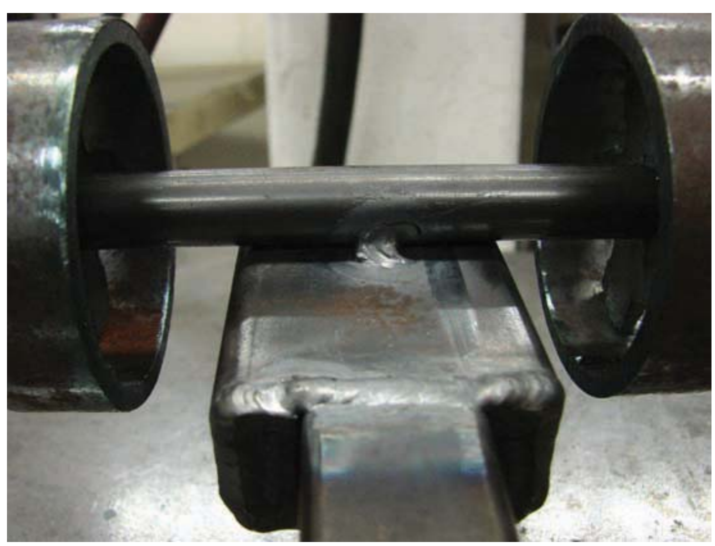


Figure 9-49. The front side of the axle support after placing a tack.

STEP 13. Build the rear hitch and attach to the seat base.

When building the rear hitch, start with a long piece of 1/8" x 1/2" strap about 10" long. Then trim to size after the part features have been completed.

Start by drilling a 5/16" diameter hole at the end of the flat bar 1/4" in from the end and centered (Figure 9-50). Next, bend the hitch at a 90-degree angle by placing the end with the hole into a vise 3/4" in and clamping it tight. Use a hammer to bend the flat bar to the proper angle (Figure 9-51).

Remove the flat bar from the vise and cut the excess flat bar off so that the end without the hole is also 3/4" long (Figure 9-52).

Figure 9-50. 5/16" hole drilled in rear hitch.

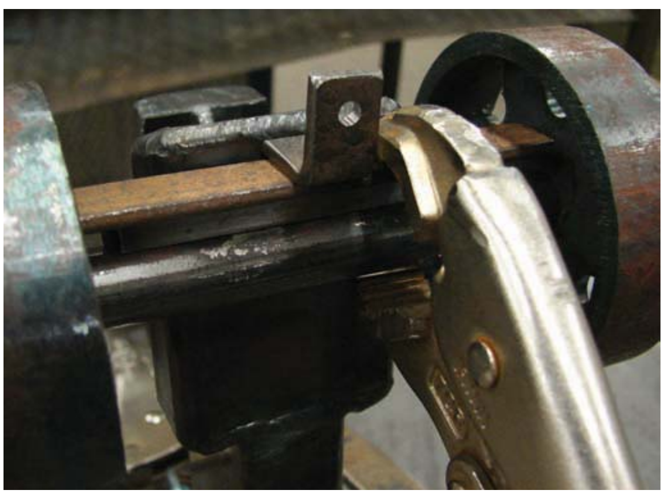
Figure 9-51. Hammering the angle on the rear hitch

Figure 9-52. Finished rear hitch.

To attach the hitch to the seat base, prop the tractor up in a standing position. Next, clamp some shims to the rear axle support. Center the hitch in the middle of the seat base on top of the shims; then weld a tack to attach the part (Figure 9-53). After tacking, check the part placement by setting the tractor on its wheels and visually insure that the bottom part of the hitch is straight. If not, bend it into place. Then weld the end of the flat bar to the seat base (Figure 9-54).

Figure 9-53.

a) The tractor propped up for hitch assembly.



b) Use 1/4" x 1/4" square bar and 1/8" x 3/4" flat bar clamped to the rear axle support as shims.

c) Hitch tacked in place.

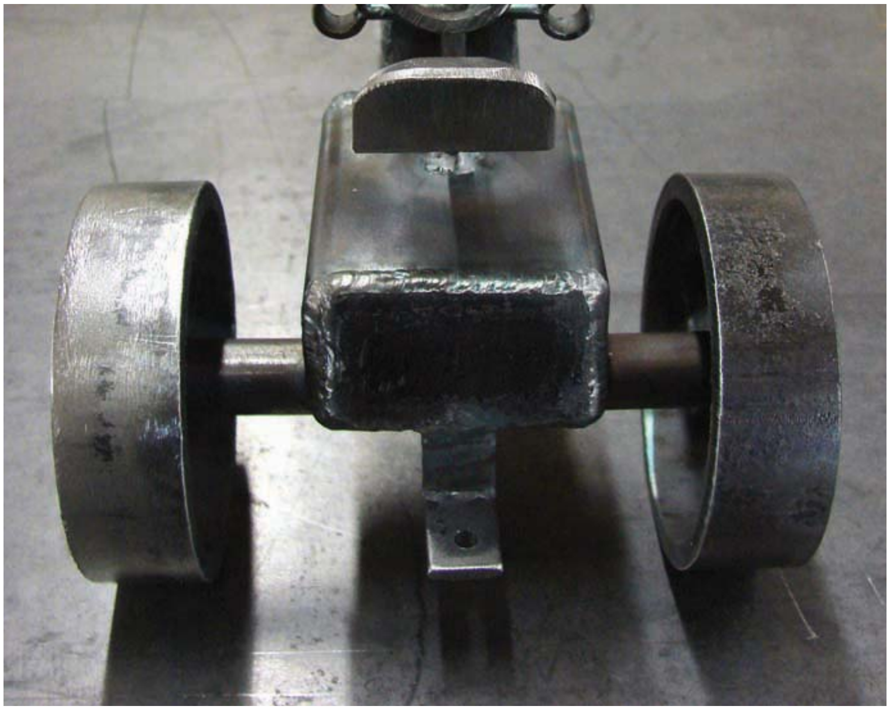


Figure 9-54. Welded hitch.

STEP 14. Cut and weld the smoke stack parts together and attach to the tractor.

The smoke stack parts are relatively easy to weld together. Start by cutting the smoke stack parts and removing any burrs that remain. Next, lay them out on a flat surface and attach the three parts together, making sure the 3/8" diameter rod is in the center. Weld all the way around each section, being careful not to add too much filler metal to the outside of the joint where the parts are all in a line.

After welding, the two ends will need to be trimmed so that the smoke stack bottom is only 3/8" long and the top smoke stack section is 5/8" long (Figure 9-55).

Weld the smoke stack to the top of the main body 2" in from the front, as indicated in Figure 9-2. The stack should be located on the left side of the tractor steering bar cover (Figure 9-56).

Figure 9-55. Welded smoke stack with marks made where the ends of the top and bottom sections need to be trimmed.

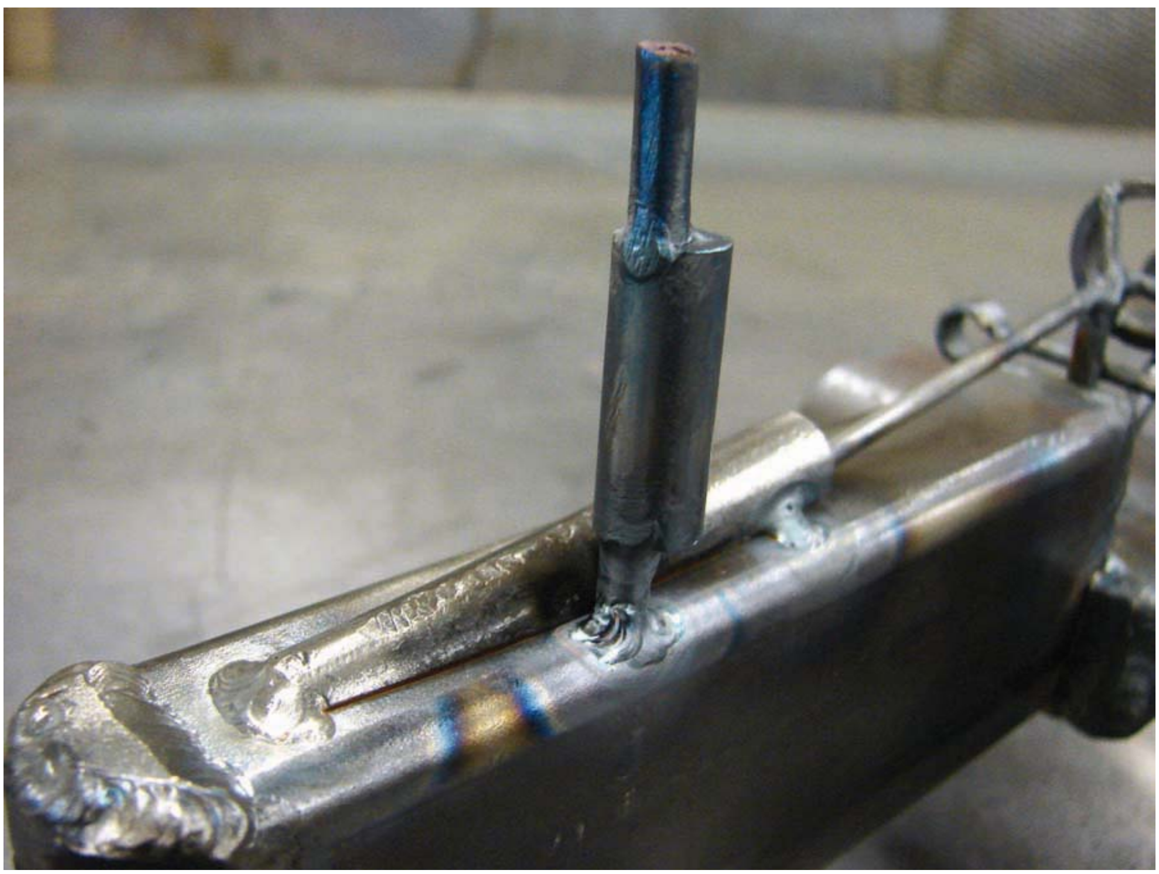


Figure 9-56. Smoke stack welded to the main body.

STEP 15. Clean the weld area with a wire wheel.

No weld spatter is produced when TIG welding. Therefore, the cleanup is as simple as removing the mill scale that has formed from the heating and cooling of the metal during the welding process. Use wire wheels of different sizes to remove the unwanted flakes of mill scale and the project is complete (Figure 9-57).

Note:
Some people like to paint their projects when complete. Instead, I like to leave my projects the natural color of the steel. A nicely welded project is something to be proud of. If your welds are exceptional, they are easier to see and show off without a coat of paint. If you decide to go this route, apply a few coats of clear coat to keep the project from rusting over time from the humidity in the air.

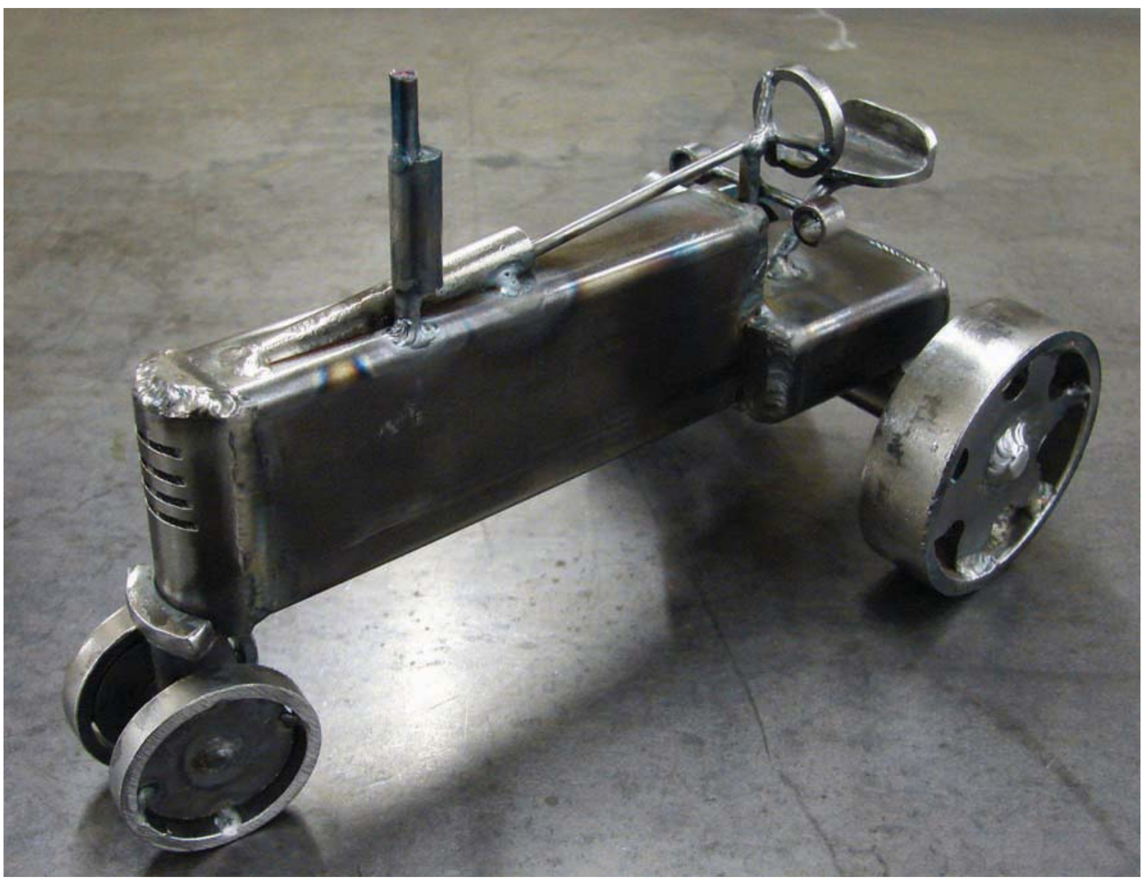
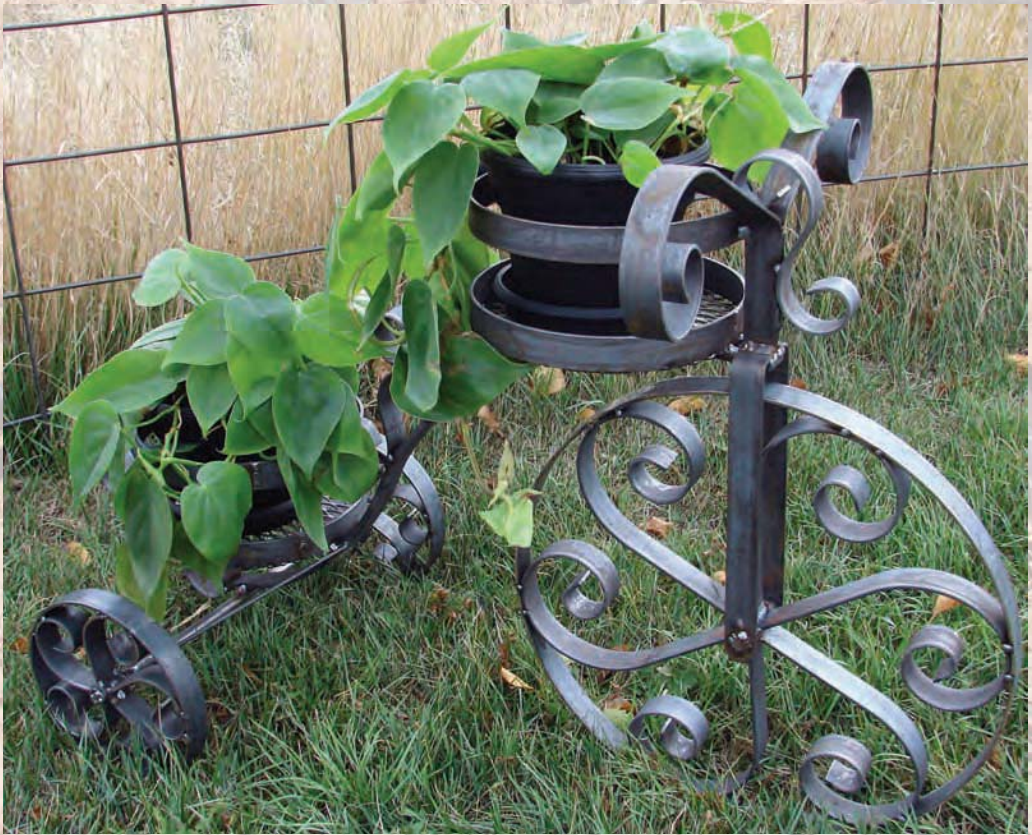


Figure 9-57. Completed TIG welded tractor.

PART 5

Heating, Bending, Rolling, and Wrought Iron


K
M



When it comes to working with metal, things aren't always straight and square. Sometimes metal needs to be bent at an angle or in an arc or circle. Other times, a project may need to be embellished to dress up its appearance. In this section, the projects incorporate different heating and bending techniques, and introduce the fabricator to the use of ring rollers and to wrought iron bending.

CHAPTER 10

Shooting Target

Rebar (reinforcing bar) and plate are the main materials used in this project. Often these materials can be found in the scrap iron bin of your local steel retailer. Some retailers offer scrap material to patrons for a reduced cost and sometimes even free. This kind of an offer can make the project very affordable.

When working with rebar, there are considerations to take into account. As a general rule, rebar is not ideally suited for welding due to its low carbon content, which makes it soft and brittle. It is made mostly from recycled steel, making it somewhat unpredictable to work with and to weld. However, for the target project, which will most likely be destroyed by bullets anyway, it is the perfect material.

STEP 1. Collect the steel needed for the target and review the plan views.

This project utilizes plate, rebar, rod, and pipe. Review the parts list for material sizes and to determine the total amount of steel needed to purchase when building this project (Figure 10-1).

Look over the target front and base top views to clarify how the parts connect together to form the shooting target (Figure 10-2).

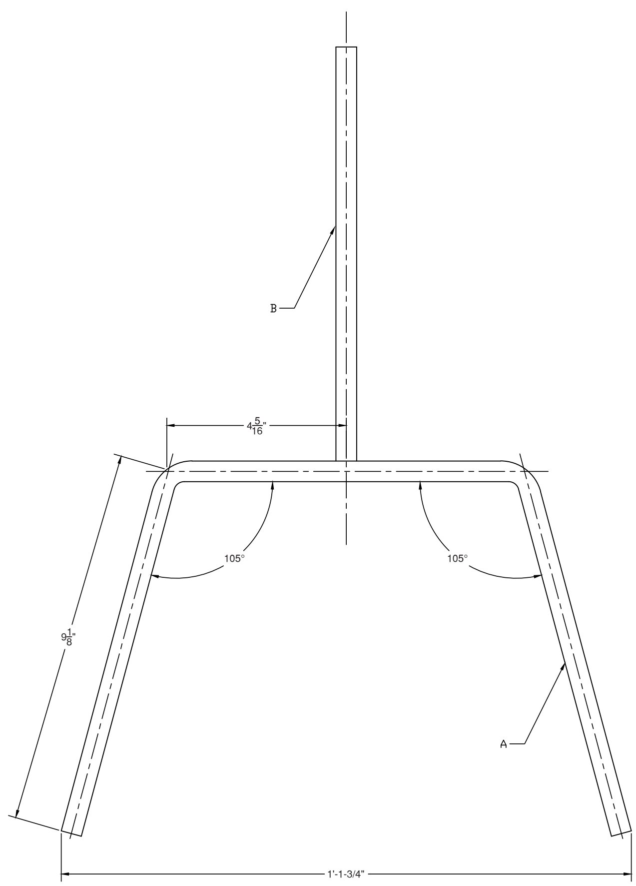


Figure 10-2. a) Top View of the shooting target base.

Shooting Target Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	A (Target Base)	#4 Rebar	1/2"Ø	-	2'-3"
1	B (Base Stabilizer)	#4 Rebar	1/2"Ø	-	0'-10"
1	C (Main Pole)	#4 Rebar	1/2"Ø	-	1'-1"
2	D (Center Arms)	#4 Rebar	1/2"Ø	-	0'-7 3/8"
6	E (Stops)	1/2" Sch40 Pipe	.109 wall thickness	.840 OD / .602 ID	0'-0 1/2"
3	F (Rotation Rings)	1/2" Sch40 Pipe	.109 wall thickness	.840 OD / .602 ID	0'-1"
1	G (Upper Target)	Plate	1/4"	0'-3"	0'-8"
2	H (Lower Targets)	Plate	1/4"	3"Ø	-
2	J (Lower Target Mounts)	Rod	3/8"Ø	-	0'-2 3/4"

Note: The size of rebar is indicated by a number which indicates the diameter in units of 1/8 inch, so that #4 = 4/8 inch = 1/2 inch diameter.

Figure 10-1.

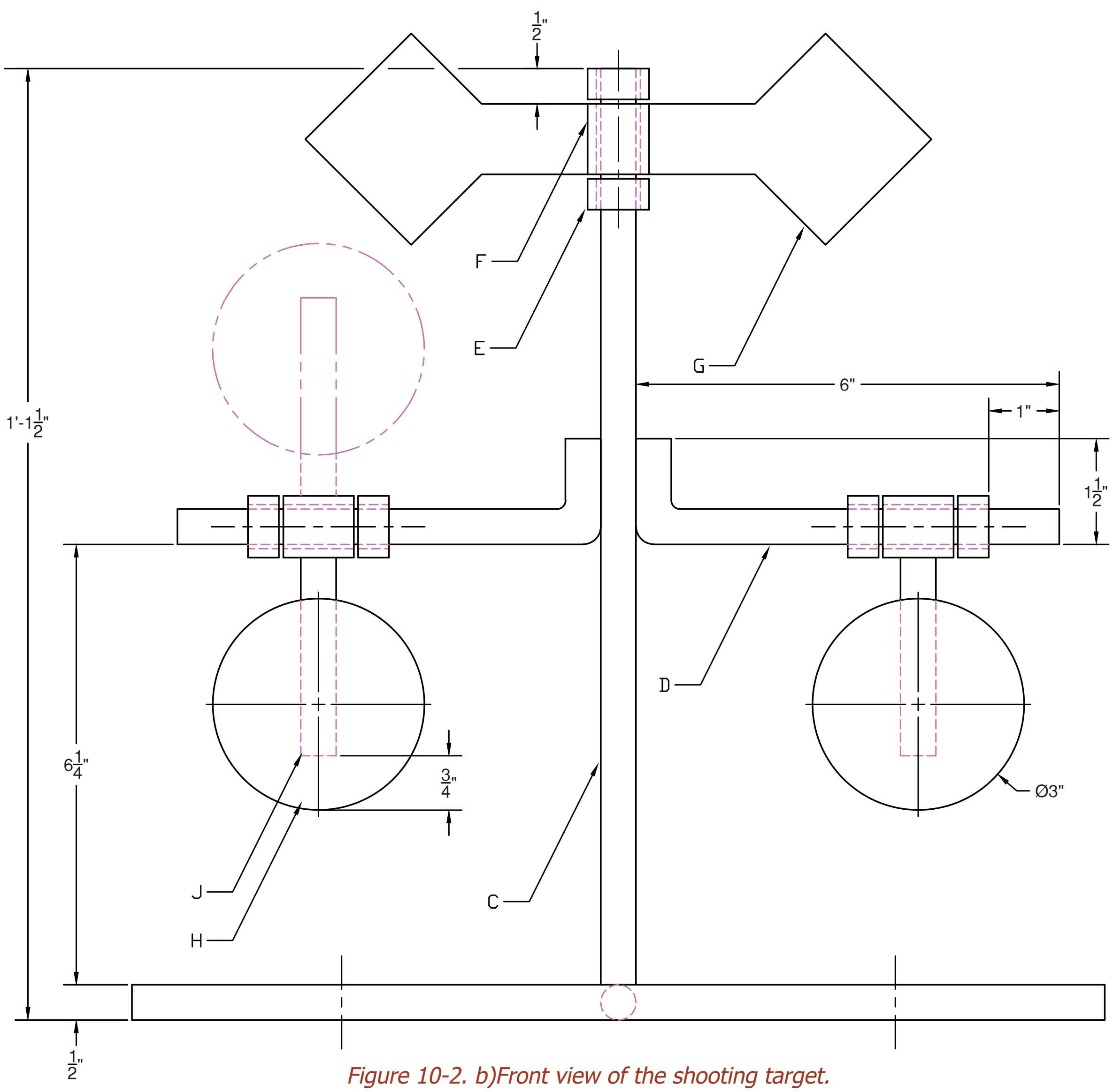


Figure 10-2. b)Front view of the shooting target.

Rebar, also known as reinforcing bar, is most commonly used in masonry construction to strengthen and hold the concrete in tension. The surface usually has a ribbed pattern to help form a secure bond between the two materials. The composition of rebar varies, depending on its grade.

HELPFUL HINT

STEP 2. Cut rebar and rod parts to length.

Because of the outer surface of rebar, an abrasive chop saw would work best to cut the parts to size. A chop saw may not be as accurate as a band saw or cold cut saw, but for this particular project, precise accuracy is not essential.

After cutting the rebar and rod, use a stationary grinder to remove any sharp burrs from the ends of the parts.

STEP 3. Bend the target base and center arms.

When bending parts using oxyacetylene as the heat source, choosing the proper torch attachment is important. Torch attachments come in different sizes with a varying number of orifices. As a general rule, attachments with the largest orifices and the most orifices will produce the greatest amount of heat. The most common attachments are gas welding torches, cutting torches, and rosebud torches.

A rosebud torch is best suited for larger heating projects. The gas welding tip is best for smaller more delicate heating applications, and the cutting torch works best somewhere in the middle. For example, if a 1" diameter shaft needs to be heated and bent, a rosebud should be used. If a 3/16" piece of rod needs to be bent, then a gas welding torch works best. So, for something with a 1/2" diameter, a cutting torch is the best choice. Choosing the right tool for the job saves time and eliminates the chance of overheating and destroying a part (Figure 10-3).

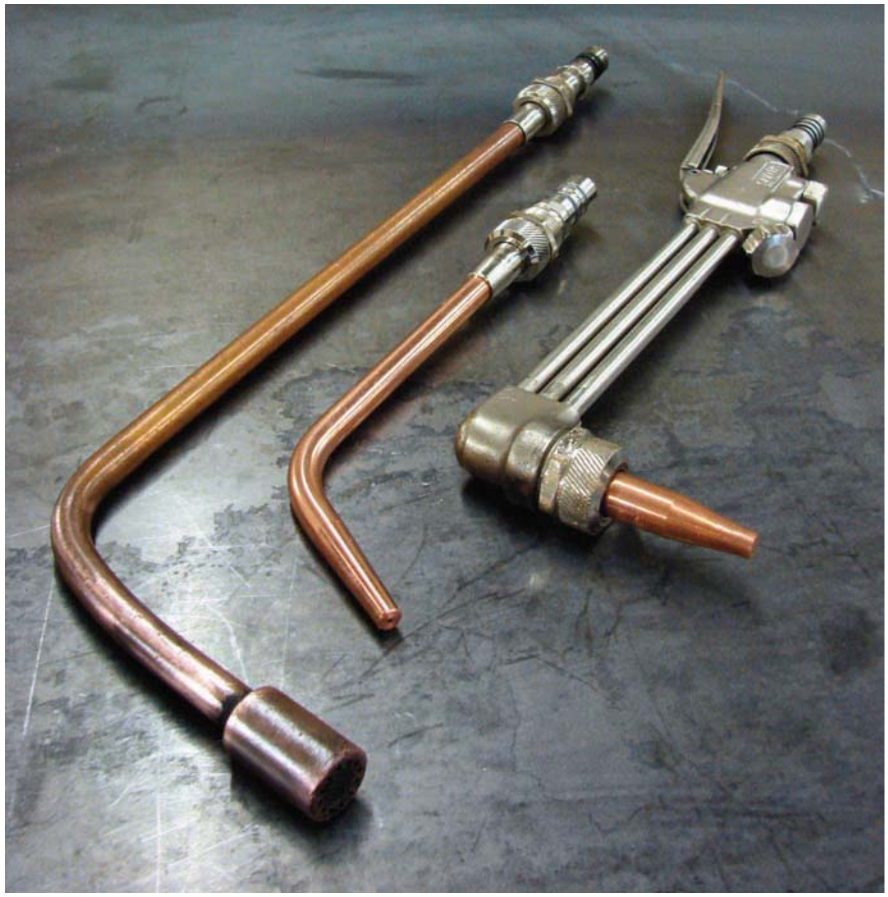


Figure 10-3. In order from left to right are a rosebud torch, a gas welding torch, and a cutting torch.

To begin, center the target base in a vise and mark 9-1/4" from each end. Before heating the rebar, cut a piece of 2" x 2" square tubing at a 75-degree angle to use as a guide when bending. Acquire a pair of locking pliers and clamp them to the end of the rebar that will be bent. The metal is going to get very hot. The pliers will get your hands farther away from the heat source and provide extra leverage when bending the part. Light the torch and heat the rebar in the location that was marked. Pull on the end of the rebar with the locking pliers after the metal has turned a bright red color (Figure 10-4).

While bending the part, place the square tubing in the corner of the rebar so that the angle can be checked as the steel is pulled into place (Figure 10-5). After completing the bend on one side, switch to the opposite side and repeat the process. Using pliers, remove the hot rebar from the vise and allow it to cool.

Next place one of the center arms into a vise with 1" of the material clamped securely in the jaws. Heat the arm just above the jaws of the vise. With locking pliers, bend the part to a 90-degree angle (Figure 10-6). Remove the part from the vise and check that the angle is correct. If it is not, return it to the vise for more bending. Repeat the process for the other arm and allow the parts to cool.

Figure 10-4. Bending the rebar base using a cutting torch.

Figure 10-5. Use a template when bending the rebar to help achieve the intended angle.

Figure 10-6. a) Heating the rebar with a cutting torch. b) Rebar bent at a 90-degree angle.

When bending steel, it generally takes two people to complete the task — one to hold the torch and apply heat while the other does the pulling and bending as the metal reaches a bright red color and becomes malleable. Especially with rebar, make sure not to overheat the metal. If sparks begin to shoot out from the heated area, that is a sign that things are getting too hot. If this happens, increase the distance between the pre-heat flames and the steel being bent. The metal only needs to be hot enough to bend without excessive pulling.

HELPFUL HINT

(Figure 10-7) The number of orifices and their diameters determines the heating capabilities of an oxyacetylene attachment. The gas tip pictured in this example has only one orifice the same diameter as all 12 pre-heating orifices in the rosebud tip. Because of this fact, the rosebud tip will produce a greater amount of heat. When comparing the cutting torch tip to the other two tips, the outer 6 orifices, which are the heat producing chambers, are very small. Therefore, they may not produce much more heat than the pictured gas tip. With this in mind, when bending steel, choose a tip that fits the job at hand.

HELPFUL HINT

Figure 10-7.

STEP 4. Attach the target base to the base stabilizer.

Lay the target base and the base stabilizer on a clean flat surface and tack the parts together, using a square for alignment. Turn the parts over, make adjustments if necessary, and weld around the entire joint.

STEP 5. Attach the center arms to the main pole.

Align the center arms 6-1/4" up from the bottom of the main pole on a flat surface. Use a square to confirm the arms are perpendicular to the pole. Tack the arms in place; then flip the assembly over and weld the joint solid. Then return to the opposite side and weld it solid (Figure 10-8).

Figure 10-8. Center arms welded to main pole.

STEP 6. Attach the main pole to the base.

To attach the main pole to the base, first clamp the rebar to a piece of 2" x 2" square tubing. Make sure the tubing has square ends. Use a square when clamping the pole so that it stands straight up and down. With the rebar clamped to the tubing, place it in the center of the target base in the same place that the stabilizer attaches. Tack the parts together, remove the clamp and tubing, and check for squareness. With the part in place, weld around the joint (Figure 10-9).

Figure 10-9. Completed welds around pole and base.

STEP 7. Cut the stops and rotation rings.

Cut the pipe parts. Then file off any burrs on the inside of the pipe with a rat-tail metal file. Any burrs on the outside of the pipe can be removed by holding them securely with pliers and grinding them off with a stationary grinder.

SAFETY TIP

Never grind small pieces of metal without using pliers and wearing gloves. If the metal should catch and your bare knuckles or fingers are pulled into the rotating grinding stone, serious injury can occur. Grinding a hole in your gloves is a less painful alternative to grinding the skin off of your fingers.

STEP 8. Cut the upper and lower targets.

Using 1/4" plate, lay out the upper target by first scribing a 3" x 8" rectangle. Then use a combination square to mark the 45-degree angled lines and the center parallel lines (Figure 10-10). Cut out the upper target using a straight edge and a cutting torch set up to cut 1/4" plate.

Next, use a punch and hammer to locate the center of the circles for the lower targets. Use a tape measure to locate the circle centers while keeping them as close to the edge of the steel as possible, limiting the amount of waste produced.

Using a cutting torch and a circle cutting attachment (Figure 10-11), cut out the two lower targets. Clean the slag from the bottom surface of all parts and smooth up the edges if necessary. Finally, cut the upper target in half with the cutting torch; then clean the edges and surfaces across the newly cut area.

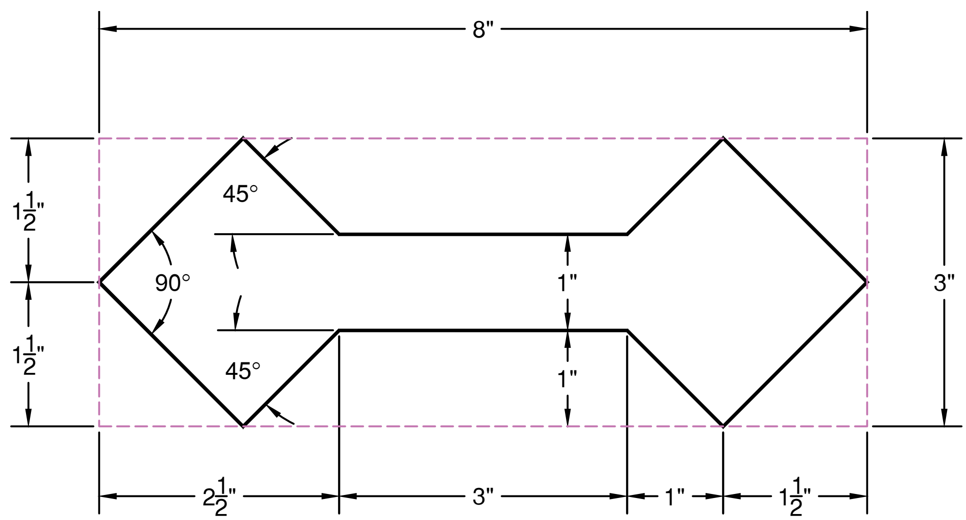


Figure 10-10. Dimensions for upper target layout.

Figure 10-11. Circle cutting attachment for a cutting torch.

Note:
A cutting torch circle cutting attachment works the same as a plasma circle cutting attachment. The only distinct difference is that the cutting torch circle cutter should be adjusted so that the cutting head does not come in contact with the steel. A plasma torch can drag on the steel without costly damage to the tip. Allowing a cutting torch tip to get too close to the extremely hot kerf can plug the orifices and sometimes permanently damage the end of the tip. If you are a first-time user with a circle cutting attachment, refer to Step 4 in the Truck plans (Chapter 1) for helpful hints and a user guide. These steps refer to using a plasma cutter attachment, however the setup and operating procedures are basically the same.

The plans for this target are specifically designed for .22 caliber or smaller target practice. If you are wanting something that can withstand a larger caliber round, increase the thickness of the targets.

HELPFUL HINT

STEP 9. Weld the upper target to its rotation ring.

Before connecting the upper target to the rotation ring, collect two pieces of 1/4" scrap to use as shims for lifting the upper target to the proper height. Place the rotation ring on a flat surface with the two shims on each side. Take the two halves of the upper target and slide the ends up next to the rotation ring. Tack the target halves to the ring; then flip them over and weld the opposite side solid. Invert the assembly and weld the other side (Fig. 10-12).

Figure 10-12. Upper target welded and attached to target framework.

STEP 10. Weld the lower targets to the lower target mounts and rotation rings.

Place the lower target mounts in place on top of the lower targets and weld in place. (Refer to Figure 10-2a for location dimensions.) Weld the mounts along both sides because these are targets, tacks may not be secure enough once you start using the project for target practice. A full weld on both sides will lengthen the life of the target.

Next, center the rotation ring at the end of the rod and tack in place. Then weld around the entire circumference of the rod (Fig. 10-13).

Figure 10-13. Lower target welded and attached to target framework.

STEP 11. Weld the stops and place the upper target in position on the main pole.

Lay the target on its back, with the base stabilizer hanging off the edge of the work table. Slide the stops and the upper target attached to the rotation ring onto the main pole. Space the stops 1/16" away from the rotation ring, with the upper stop flush with the end of the main pole.

Tack, then weld solid (Figure 10-12).

STEP 12. Weld the stops and place the lower targets in position on center arms.

Slide the stops and targets attached to the rotation rings onto the center arms and place 1" from the end of each arm. Space the stops away from the rotation rings approximately 1/16". This will give the rotation ring room to rotate freely around the arm. Tack, then weld solid. Refer to Figure 10-2a for location dimensions and Figure 10-13 for a view of the finished assembly.

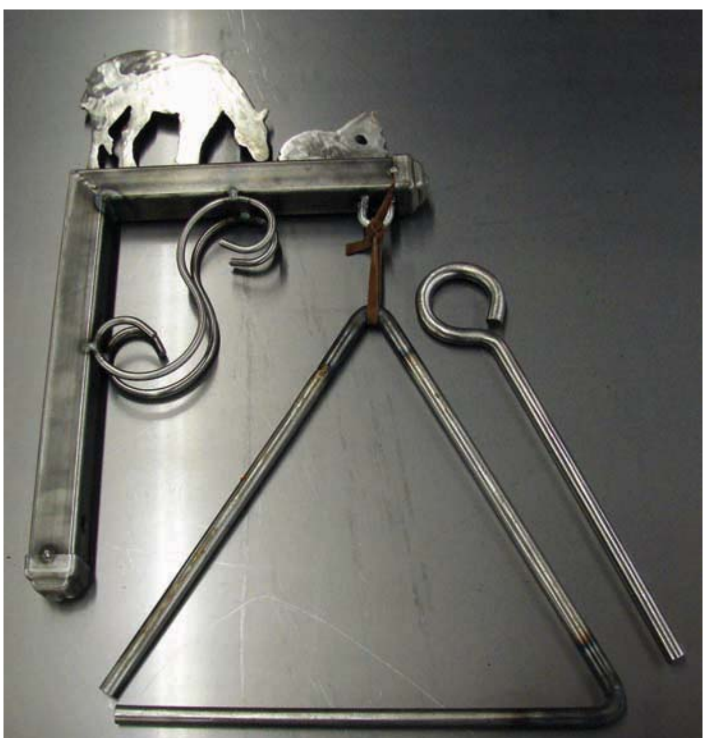
STEP 13. Final cleanup of all parts.

After all parts are welded solid, remove the sharp edges or burrs from the project and any remaining welding berries.

CHAPTER 11

Dinner Bell

The dinner bell is a quick and easy project that introduces the fabricator to the wrought iron bender. Wrought iron can be used in just about any project to give it the "WOW" factor. A project that is simple and plain can quickly be turned into a work of art with a few of turns of a handle.



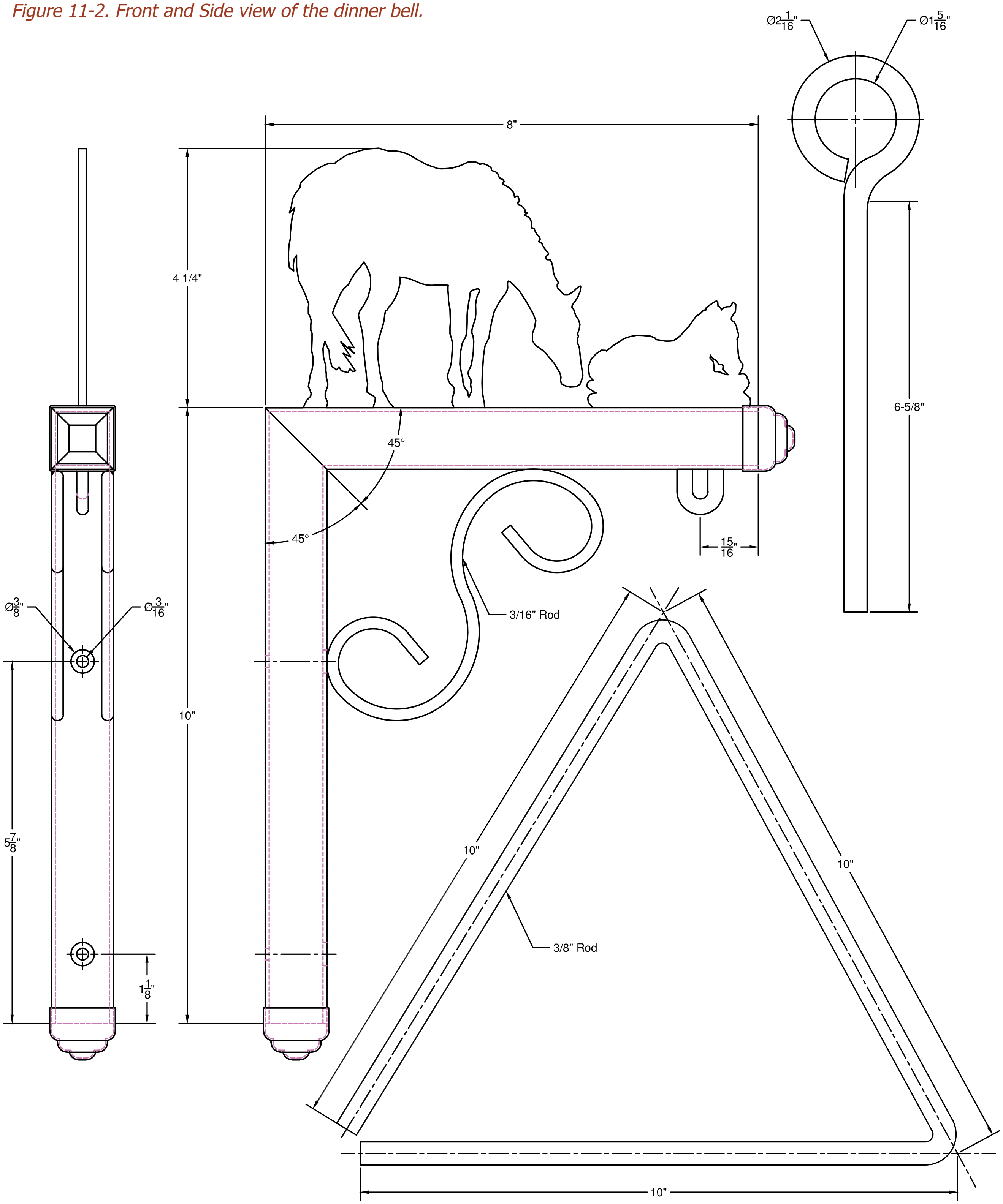
STEP 1. Review the plan views and parts list; then collect the needed steel.

Refer to the parts list in Figure 11-1 and the plan views in Figure 11-2 when purchasing the steel needed for this project.

Dinner Bell Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	Side Support	Sq Tube	14 gauge	1" x 1"	0'-10"
1	Top Support	Sq Tube	14 gauge	1" x 1"	0'-8"
1	Silhouette	Sheet	10 gauge	0'-8"	0'-4 1/4"
1	Bell	Rod	Ø3/8"	-	2'-6"
1	Bell Ringer	Rod	Ø3/8"	-	1'-1"
2	Wrought Iron Parts	Rod	Ø3/16"	-	1'-0"
2	Newell Post Cap	Mild Steel	18 gauge	1" x 1"	-

Figure 11-1.

Figure 11-2. Front and Side view of the dinner bell.



STEP 2. Cut and clean the parts.

Cut all the parts to length except the silhouette. Remove any rust with a polishing wheel and grind or file off any burrs that remain after cutting.

STEP 3. Drill holes and weld the side and top supports.

Before welding the supports together, drill the holes in the side support. Screws will be placed in these holes for mounting the dinner bell to a wooden structure. Make sure the larger 3/8" diameter hole is on the front side of the part and the 3/16" hole is on the back side. There is an obvious front and back because one corner is cut at a 45-degree angle. The 3/8" hole will allow the head of the screw to slip all the way through to the inside back and be hidden (Figure 11-3).

Any one of the four basic welding processes will work to join these parts, but I suggest using TIG or oxyacetylene gas welding. They will produce the smoothest, cleanest weld and will require the least amount of cleanup (Figure 11-4).

Figure 11-3. Holes drilled in the back support.

Figure 11-4. Supports welded using the TIG welding process.

STEP 4. Build a jig to use when bending the bell ringer.

The most accurate way to form a smooth rounded end on the ringer is to fabricate a jig that will act as a guide. The prefabricated steel needed for the jig includes steel plate, square tube, square bar, rod, and pipe (Figure 11-5).

Begin building the jig by cutting all the parts to size. Remove the burrs from the part ends and slag from the plate bottom.

Using Figure 11-6, locate the hole centers and drill the 1/2" and two 3/8" holes through the plate (Figure 11-7).

Bell Ringer Jig Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	Base Plate	Plate	1/4"	0'-6"	0'-6"
1	Clamping Block	Sq Tube	14 gauge	1" x 1"	0'-3"
1	Bend Template	1" Sch40 Pipe	.133	1.315 OD / 1.049 ID	0'-3/4"
1	Square Stop	Sq Bar	1/2" x 1/;2"	-	0'-0 1/2"
2	Pin Stops	Rod	Ø3/8"	-	0'-1 1/2"

Figure 11-5. Parts list for jig.

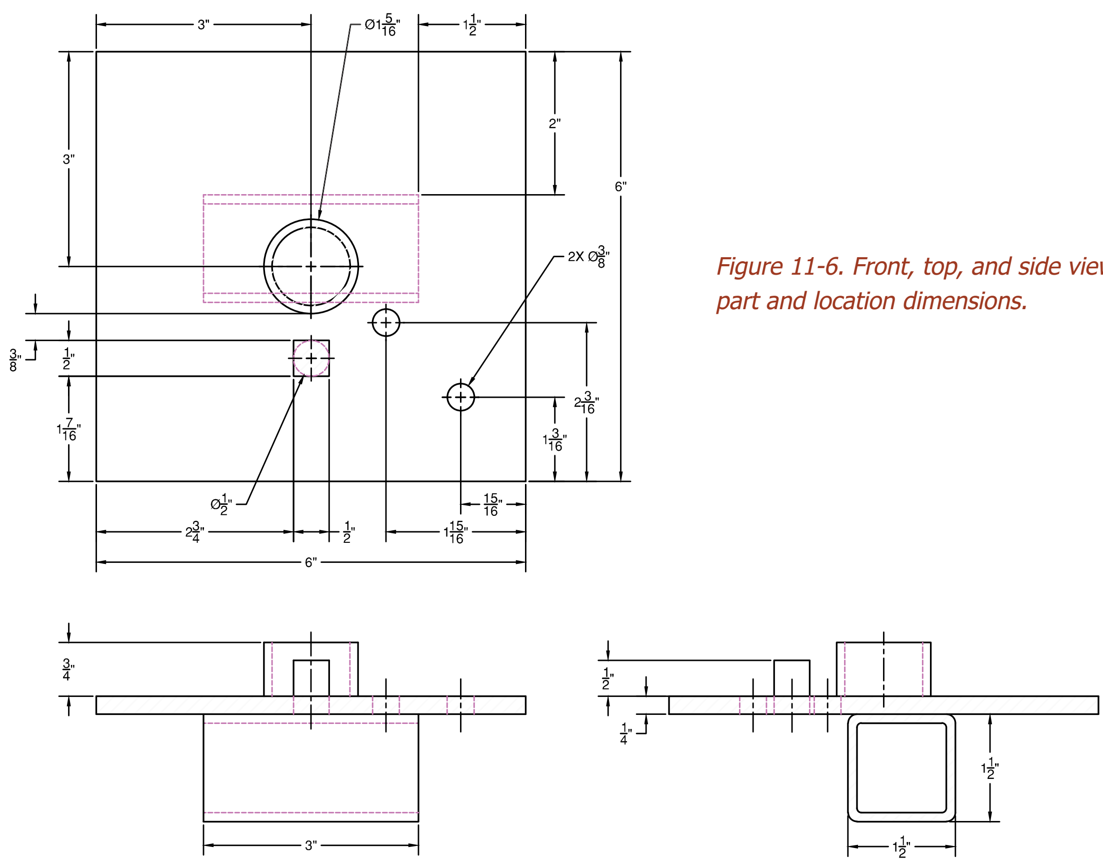


Figure 11-6. Front, top, and side view of jig with part and location dimensions.

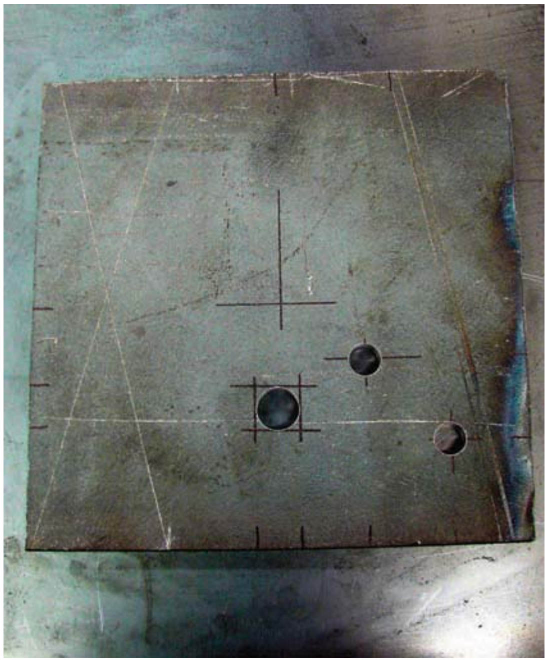


Figure 11-7. Holes drilled thru 1/4" plate.

Begin assembling the jig by first welding the square bar in place. Take extra care when attaching the bar to the plate, keeping it square to the plate. If it is attached crooked, it will not hold the 3/8" rod securely during the bending process. A plug weld is used to secure the part to eliminate any weld on the face of the jig that could get in the way when bending the ringer. To attach the bar to the plate, flip the plate over onto the back side setting it on top of two pieces of 1/2" x 1/2" square tubing and positioning the square bar in place (Figure 11-8). Tack the square bar; then check to make sure the placement is correct. If proper alignment has been achieved, finish the plug weld (Figure 11-9).

Figure 11-8. Preparing to tack the square bar to the plate.

Figure 11-9. Completed plug weld.

Next, attach the pipe to the plate. To place it in the proper location, use the 3/8" rod that will be used for the pins and the 3/8" rod cut for the bell ringer (Figure 11-10). Weld the pipe to the plate on the inside only. This will keep all welds out of the way of the 3/8" rod when it is bent around the template (Figure 11-11).

Finally, attach the square tube to the bottom of the plate. This part will be used to clamp the jig in a vise when bending the dinner bell ringer. The exact placement isn't exactly critical; however, avoid placing it over any of the pin holes. Access to the bottom side of the holes may be necessary when removing the pins after bending (Figure 11-12).

Figure 11-10. Align the pipe in the proper location using the previously cut 3/8" rod.

Figure 11-11. Pipe welded securely to the plate.

Figure 11-12. Square tubing welded to the bottom of the jig. Notice, only the ends were welded. Welds on the sides can affect how flat the jig will set in a vise.

STEP 5. Bend the bell ringer.

Using oxyacetylene as your heat source, bend the ringer around the pipe template following a five step process:

A. Place the bell ringer rod into the jig using one of the pins as a stop (Figure 11-13).

B. Apply heat to the rod and begin bending the pipe, using a pair of vise grips clamped to the end of the rod (Figure 11-14). The vice grips will supply extra leverage and help reduce the risk of burning your hands as the heat transfers down the end of the rod during the bending procedure. Bend the rod all the way around the pipe until it hits the square bar (Figure 11-15).

C. Insert the two pins into their respective holes (Figure 11-16).

D. Heat the rod at the point next to the pin closest to the center and bend until the rod contacts the second pin (Figure 11-17).

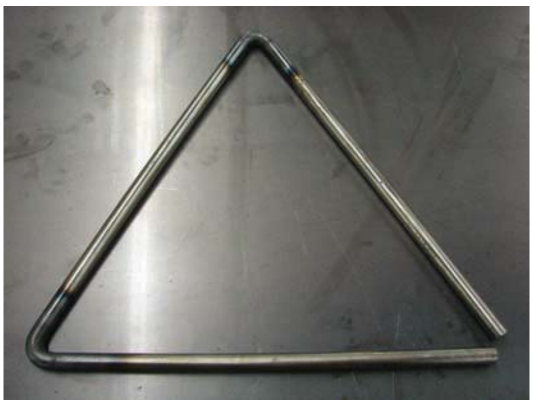
E. Allow the bell ringer to cool to room temperature in the jig. As the part cools, it will expand and most likely be impossible to remove from the jig without some prying. Use a pry bar or flat head screwdriver to force the ringer up and out of the jig (Figure 11-18). If the ringer doesn't come out of the jig easily, remove the jig from the vise and place it back in on end. Use a punch and hammer to tap out the two 3/8" pins (Figure 11-19). With the pins removed, it should be less difficult to pry the ringer out of the jig.

Bending parts around pipe can be tricky. It is important to control the amount of heat applied to the rod and where the heat is applied. Avoid heating too far ahead of where the part is touching the pipe template. If the material gets too hot too far down the part where you want the bending to occur, the part will be bent at an angle rather than a curve. To fix this problem, if or when it occurs, continue applying heat to the part while tapping the rod with a hammer until it's once again tight against the pipe.

HELPFUL HINT

STEP 6. Bend the bell.

Before bending, mark 10" from each end of the 3/8" rod. Center the rod in a vise. Using oxy-acetylene as the heat source, bend the ends until there is only a 1/8" space between them. The bell has a more distinct sound when the ends are open (Fig. 11-20).

a) 

b) 

Figure 11-20. a) Bell bent with a 1/8" gap between the ends. b) Bending the bell.

STEP 7. Design, cut, and weld the silhouette to the top support.

To make this project your own, hand cut or use a CNC plasma machine to produce a silhouette of something that interests you. Suggestions: a favorite sports team logo, a cattle brand, logos related to hobbies such as snowboarding or riding motorcycles. Limit the size of the silhouette to no larger than 8" (W) x 6" (H).

After cutting the silhouette, clean the slag from the back side and polish the edges (Figure 11-21).

Next, lay the welded supports on a clean flat surface. Position the silhouette in place next to the top support with some 3/8" shims underneath the part to lift it to the center position on the top support (Figure 11-22). Tack the silhouette in place and inspect the part for squareness. Tacking often causes the part to pull out of square as the weld cools. Do any necessary corrections in part placement; then complete two 1/4" welds on the opposite side of the tack. Flip the parts back to the original position and place a 1/4" weld on the original side. Do not weld the entire length of the silhouette. This is unnecessary and would merely be over-welding.

After tacking, remove any welding berries that may have accumulated with a chisel and hammer.

Figure 11-21. Horse and colt silhouette cut and polished.

Figure 11-22. Use shims to lift the silhouette into the proper location before welding.

STEP 8. Bend the wrought iron parts and weld to the side and top supports.

Before bending the wrought iron parts, put a mark in the centers of the 3/16" rod with a permanent marker. This will provide a stopping point when bending the parts.

Place the first part in the bender, making sure it is level (Figure 11-23). Then turn the handle until the center point touches the wrought iron template (Figure 11-24).

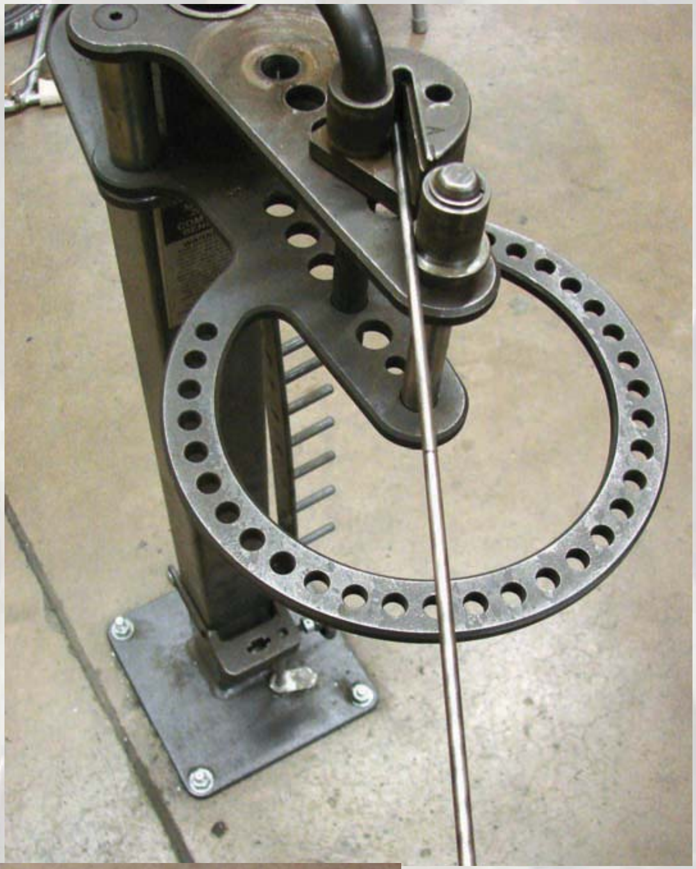


Figure 11-23. Part that has the center marked and placed level in the bender.

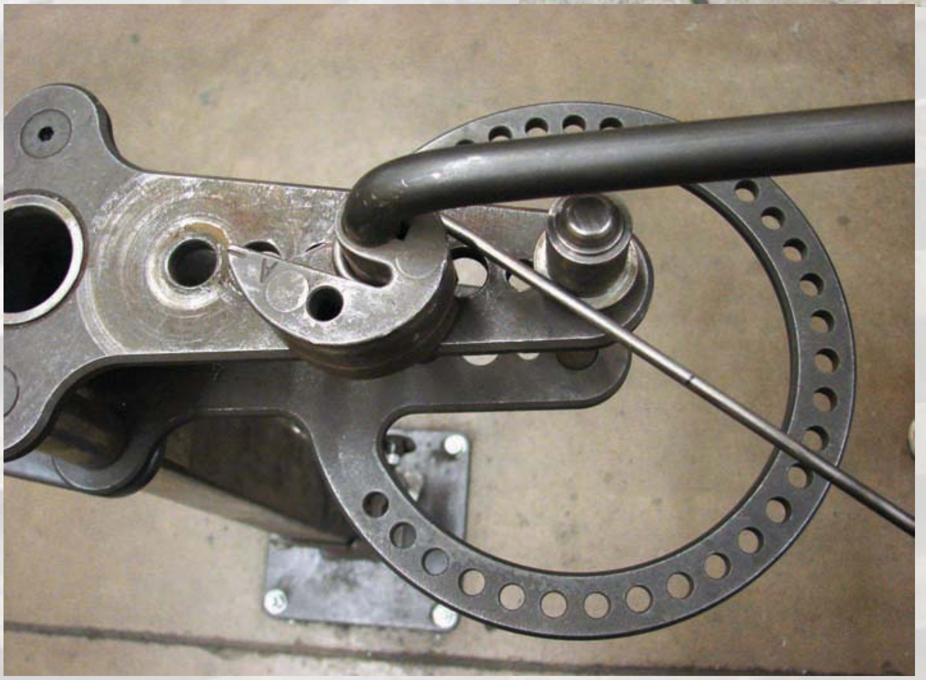


Figure 11-24. Bend the part until the permanent marker line touches the bender template.

Remove the part and insert the opposite end into the bender. Make sure the end that was bent is facing away from you as you stand at the bender (Figure 11-25). Make sure the part is level; otherwise, when complete, it will be somewhat twisted (Figure 11-26). If a completed part does turn out to be misshaped, take it to the anvil and use a hammer to flatten the arc.

After bending the wrought iron parts, weld them in place. The location of the parts is a judgment call. Place them where you think they look best, making sure they are flush to the outsides of the side and top supports and that they are identically placed (Fig. 11-27).

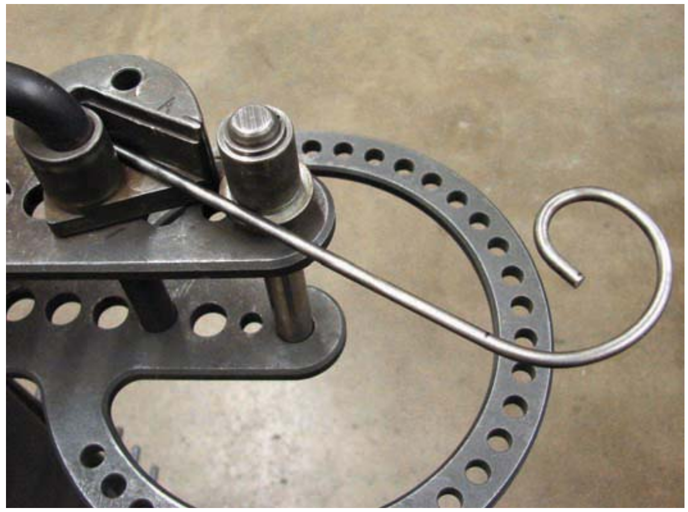


Figure 11-25. Place the 3/16" rod level in the bender with the first half facing the proper direction.

Figure 11-26. This part was not placed in the bender correctly and as a result has a slight arch in the middle.

Figure 11-27. Wrought iron parts welded in place.

Note:
Today's definition of wrought iron has changed since it was defined in the 1600s. Dictionary.com defines wrought iron as a form of iron, almost entirely free of carbon and having a fibrous structure including a uniformly distributed slag content that is readily forged and welded. This type of steel is no longer produced on a commercial scale. Today's definition of wrought iron generally refers to mild steel that has been bent or formed using hand or mechanical machines identified as wrought iron benders.

There is an array of wrought iron benders on the market from which to choose. Some are electric motor driven and can be quite costly. Other manual-operated machines can be purchased for much less. For a small shop, a less expensive hand-operated bender is more than adequate.

HELPFUL HINT

STEP 9. Attach the metal caps.

Prefabricated metal caps add an appealing finished look to the ends of the tubing; they can be purchased on-line from SharpeProducts.com. The newel post caps come in many different sizes ranging from 3/4" to 5" widths as well as in aluminum, stainless steel, and steel (Figure 11-28).

Before attaching the caps, grind the ends of the square tubing at a slight bevel, which allows the caps to more easily slide onto the ends. Tap them onto the ends of the square tube. Then place tacks on two opposing sides (Figure 11-29).

Figure 11-28. Newel post caps in sizes starting at 1" and stepping up 1/4" each time..

Figure 11-29. Attached newel cap.

STEP 10. Weld a loop on the top support.

To hang the bell on the support, a chain link cut in half works perfectly. Position the link in the middle of the square tube and place a solid tack weld on both ends. Make sure the link is parallel with the support (Figure 11-30).

Figure 11-30. Attached chain link with a piece of leather tied from the link to hang the bell.

STEP 11. Complete the final cleanup.

The last step includes removing any berries made from the MIG welder, filing off any sharp edges, and polishing any parts that were discolored when welding with a wire brush.

CHAPTER 12

Decorative Vase

Sometimes mistakes are made when ordering steel. This project came about because of a misordered piece of 6" Sch40 Pipe. In a small welding shop, there are not a lot of projects that utilize pipe that size, let alone that expensive. This project was designed to utilize that pipe 1/4" at a time. Over a 10-year period, that pipe has been used to make hundreds of decorative vases in various shapes; it has encaged items such as large rocks, antique bottles, baseballs, golf balls, and wrestling metals, just to name a few.

STEP 1. Collect the steel needed for project and review the plan views.

The pipe needed for this project is expensive, but keep in mind, it takes only a 1/4" section of pipe to make one vase. If possible, only purchase a 4'-0" section for ease of handing. After deducting the amount of waste and the end length, which will be too short to cut in most band saws, a 4'-0" section of pipe should make approximately 72 rings.

The other pre-fabricated steel parts are common and inexpensive to purchase. Refer to the parts list in Figure 12-1 for material sizes and the plan views in Figure 12-2 for the vase shape.

Decorative Vase Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	Bottom Outside Ring	6" Sch 40 Pipe	.280	6.625 OD / 6.065 ID	0'-0 1/4"
1	Bottom Inside Ring	3/4" Sch 40 Pipe	.113	1.050 OD / .824 ID	0'-0 1/4"
1	Spout	3/4" Sch 40 Pipe	.113	1.050 OD / .824 ID	0'-3"
1	Spout Rim	Sq Bar	1/4"	1/4"	0'-5"
16	Bottom Spokes	Rod	Ø3/16"	-	0'-2 7/16"
16	Side Spokes	Rod	Ø3/16"	-	0'-11 5/8"

Figure 12-1.

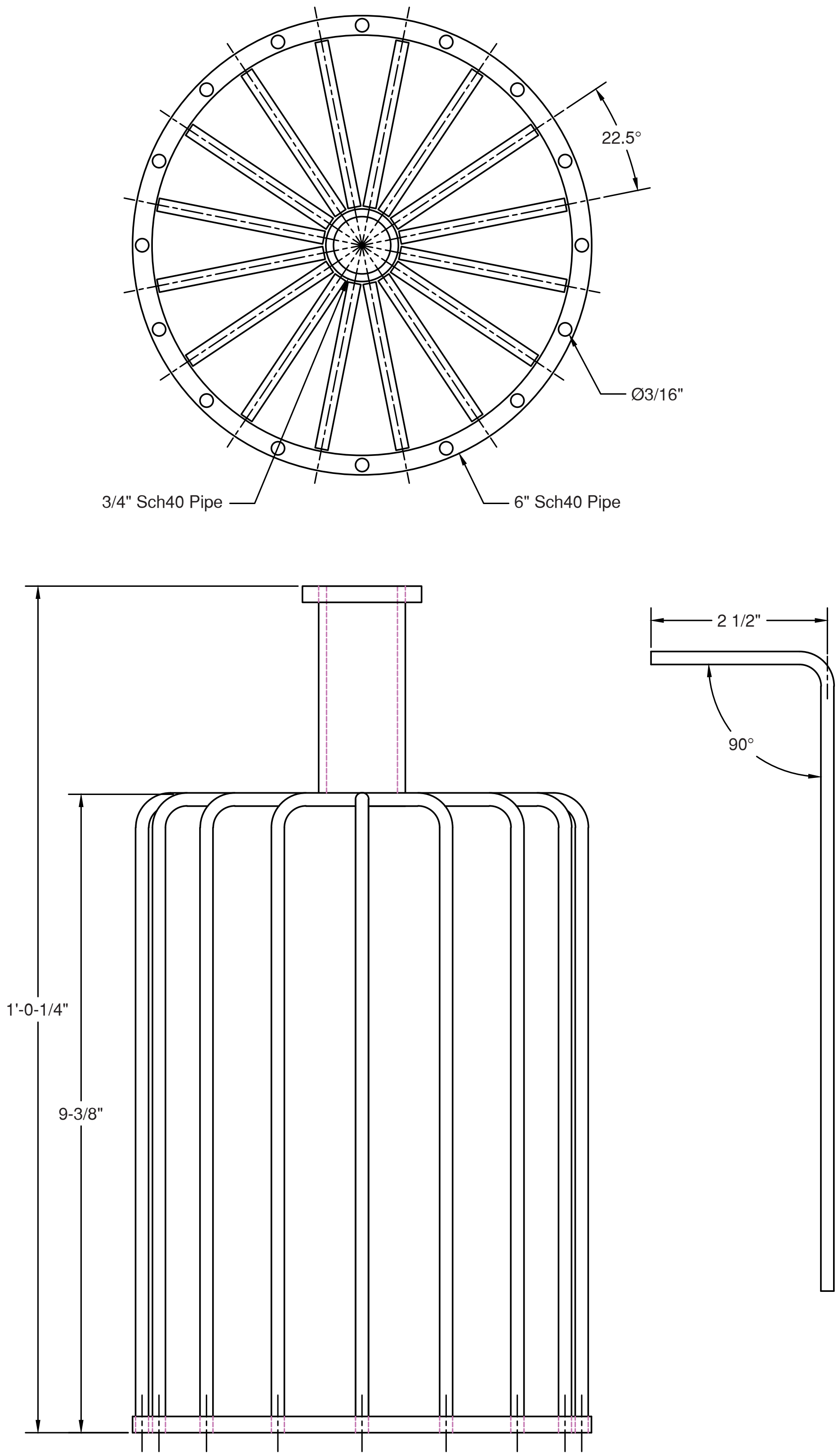


Figure 12-2. Front view,bottom detail and side spoke detail.

STEP 2. Cut all the parts to length.

First cut the 1/4" section of the 6" pipe in a band saw (Figure 12-3). When cutting, make sure the pipe is sitting flat on the base of the saw. If not, the ring will be thicker on one side than the other. Remove the sharp edges from the ring after cutting with a metal file. Do not use a grinder. It could remove too much material and cause problems drilling the holes in the ring later on during construction. A grinder should be used only to remove the small section of seam inside the pipe.

The rest of the parts would be best cut in a cold cut saw. When cutting the side and bottom spokes, use a material stop to ensure all parts are exactly the same length. Check the part lengths after making the first cut — especially the bottom spokes, which need to be exact. If the length is incorrect, make adjustments in the material stop and make another cut. Repeat the checking process until the correct length is achieved (Figure 12-4).

After the parts have been cut to length, remove the sharp burrs from the ends. Don't over-grind.

Figure 12-3. 6" Sch40 pipe in place in the band saw ready to be cut.

Figure 12-4. Parts cut and ready for construction. Notice the ring already has holes drilled in it. This will be completed in Step 4.

Cutting thin steel in a band saw can be hard on the small thin teeth. As a rule, cut thick stock in a band saw and thin stock in a cold cut or chop saw.

HELPFUL HINT

STEP 3. Build a jig for drilling the holes in the bottom outside ring.

Building a jig to hold the ring in place while drilling the holes is a necessity (Figure 12-5). Refer to Figure 12-6 for a parts list and plan views when building the jig.

This will be the first of three jigs that are necessary for construction of the vase.

When building the jig, start by cutting the parts; then drill the 3/8" hole in the base. Before attaching the ring stops, place the bottom outside ring on the plate as shown in the plan view, making sure that it centers the 3/8" hole. Tack the ring stops in place. The exact location of the stops is not important as long as they are spread out similar to what is shown in the top plan view — and that they are not too tight against the ring. A tiny space between the ring and ring stops will allow for an easy fit every time you move the ring to the next hole. The fit should not be so tight that the ring has to be forced in and pried out.

To complete the jig, attach the square tube to the bottom of the plate. This will be used to clamp the jig securely in the vise when drilling the holes in the ring.

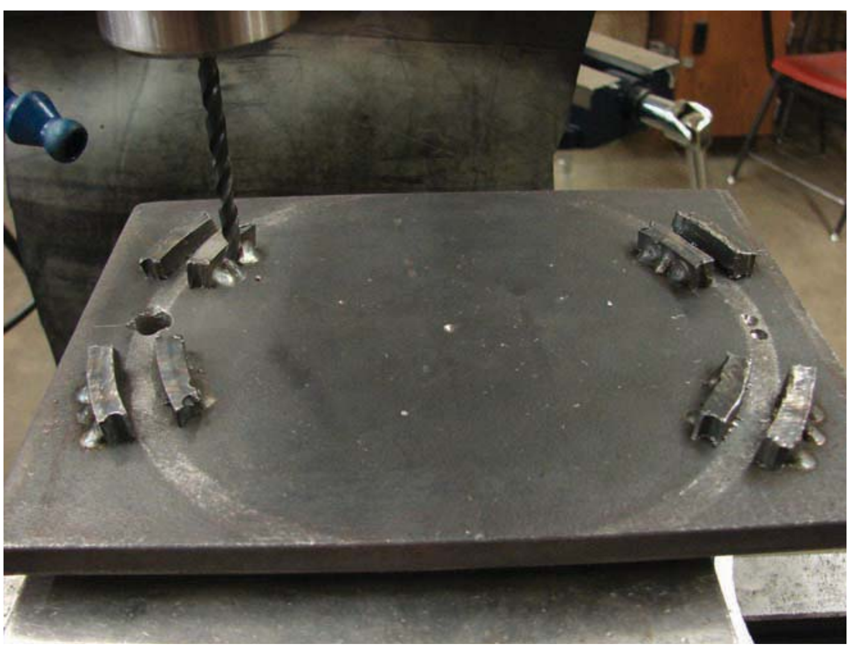
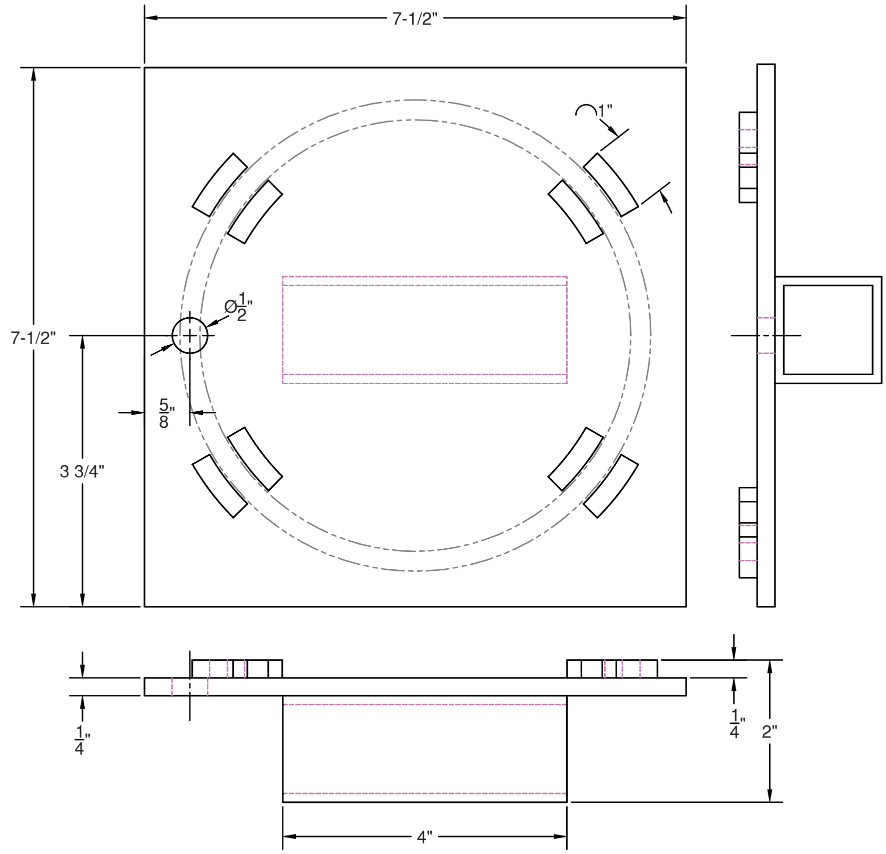


Figure 12-5. Jig used to secure the ring when drilling the holes in the bottom outside ring.



Decorative Vase Jig #1 - Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	Base	Plate	1/4"	0'-7 1/2"	0'-7 1/2"
1	Jig Holder	Square Tube	14 gauge	1-1/2" x 1-1/2"	0'-4"
8	*Ring Stops	3/4" Sch 40 Pipe	.280	6.625 OD / 6.065 ID	0'-0 1/4" (1" Sections)

*The ring stops are made from a ring cut the same as the ring used for the base of the vase.
Cut the 1" sections using a plasma cutter.

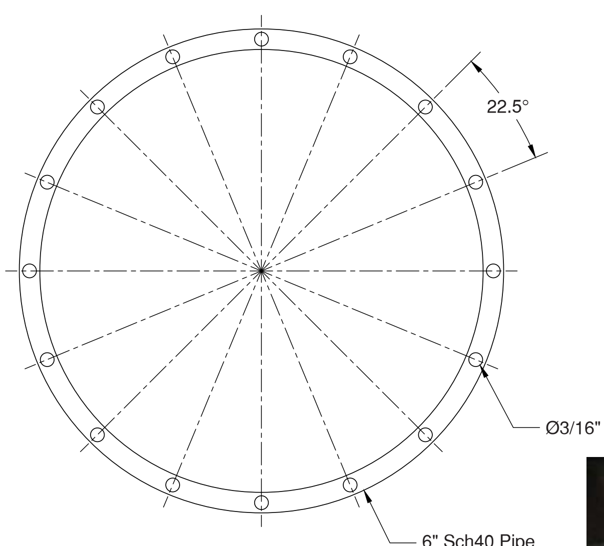
Figure 12-6. a) Plan views and part list for jig #1.

STEP 4. Mark and drill the holes in the ring.

Before drilling the holes in the bottom outside ring, the hole positions need to be located. To do this, make a copy of Figure 12-7a and use it to transfer the holes, or use a protractor to mark the 22.5 degree lines. The exact centers of the holes across the width of the ring do not need to be located, the jig will take care of that when drilling.

After marking the holes, place jig #1 in a milling machine or drill press vice, clamping the jaws tight against the square tube on the bottom. Center the 3/16" drill bit above the 3/8" hole in the jig base. This will keep the bit from contacting the base of the jig when drilling.

Place the ring in the jig and line up one of the marked holes with the end of the drill bit and over the 3/8" hole in the base. To keep the ring from lifting up from the pressure applied when drilling, place some locking pliers over the ring and one of the sets of ring stops on the opposite side of the jig (Figure 12-7b).



To clean the bit and help cool the bit when drilling, a magnetic cooling hose unit is quite handy. They are detachable, have on/off valves, and are a cleaner option to cooling rather than using cutting oil. Many options are available on-line — just google magnetic cooling hose units.

HELPFUL HINT

Figure 12-7. a) Bottom ring hole pattern. b) Bottom outside ring in place in jig #1 with locking pliers to hold it down when drilling.

With the ring in place, center the bit between the two edges of the ring (Figure 12-8). If not already secure, clamp the vice to the table then set up an air cooling system if available.

Drill the holes, proceeding slowly at the beginning to allow the tip of the bit to start cutting and to help avoid breaking the bit or sliding it off the side of the small surface width of the ring. After the bit is cutting the full bit diameter, drilling can advance a little faster. As you drill, the chips should spiral or curl and they should be silver and shiny. If the chips look discolored or brown, the drilling is too fast and the pressure put on the bit should be reduced. After drilling the first hole, check for proper centering and adjust the bit placement in the next hole if necessary (Figure 12-9).

After all holes have been drilled, remove the burrs from the bottom side of the ring.

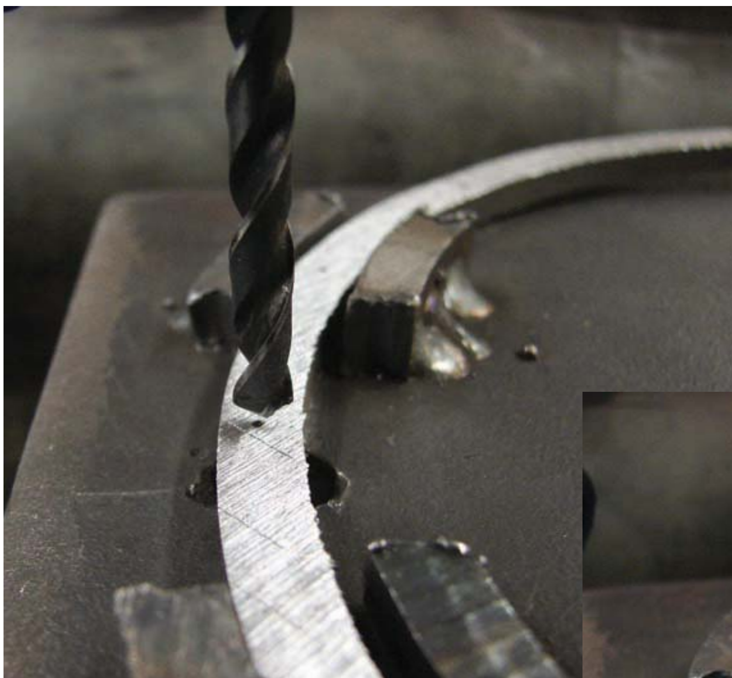


Figure 12-8. Bit centered and ready to drill through the ring.

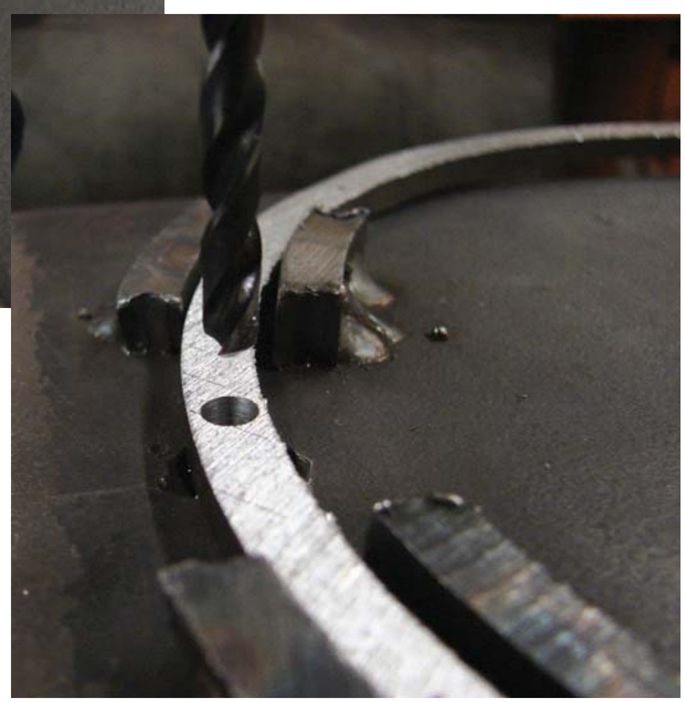


Figure 12-9. Checking for hole centering after drilling the first hole.

STEP 5. Build Jig #2.

The next jig that will need to be built is used to weld the bottom spokes to the bottom inside ring. For a parts list and plan view of the jig, see Figure 12-10.

Begin by cutting the parts and removing the slag and burrs afterwards.

To attach the rod stops, some layout will be necessary. Start by placing the bottom outside ring on the base; then trace the inside diameter with chalk or a permanent marker. Using a circle centering square and a plastic triangle, divide the circle into four quadrants (Figure 12-11).

Next set an adjustable protractor to 22.5 degrees and divide each 90-degree section into four equal sections (Figure 12-12).

With the divisions marked, the rod stops can be welded into place one at a time. To place them in the proper location, center a piece of 3/16" rod on a division line and carefully set a stop next to it. Secure the stop in place with locking C-clamp pliers and tack both ends (Figure 12-13). Do not place any weld on the sides of the stops.

Decorative Vase Jig #2 - Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	Base	Plate	1/4"	0'-7 1/2"	0'-7 1/2"
16	Rod Stops	Square Bar	1/4"	1/4"	0'-1"

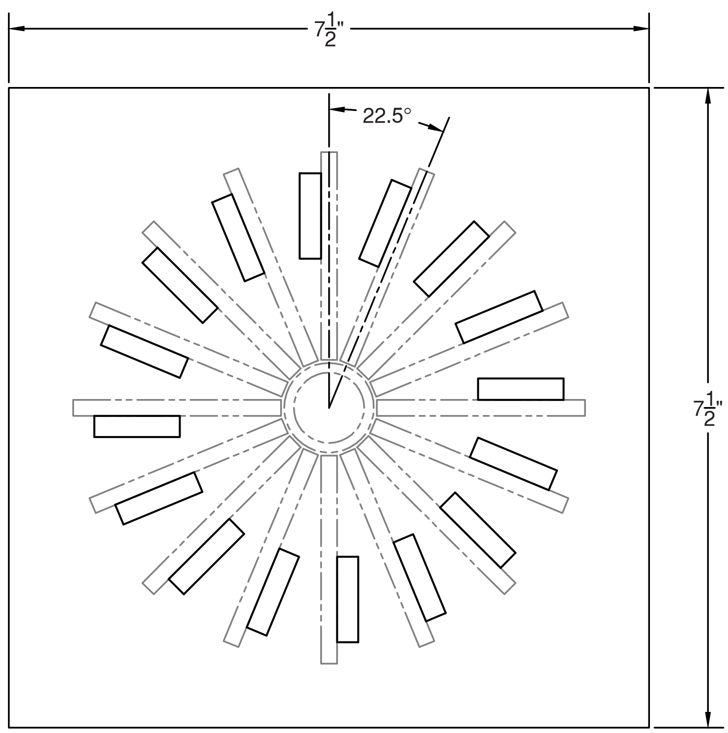


Figure 12-10. Plan view of Jig #2.

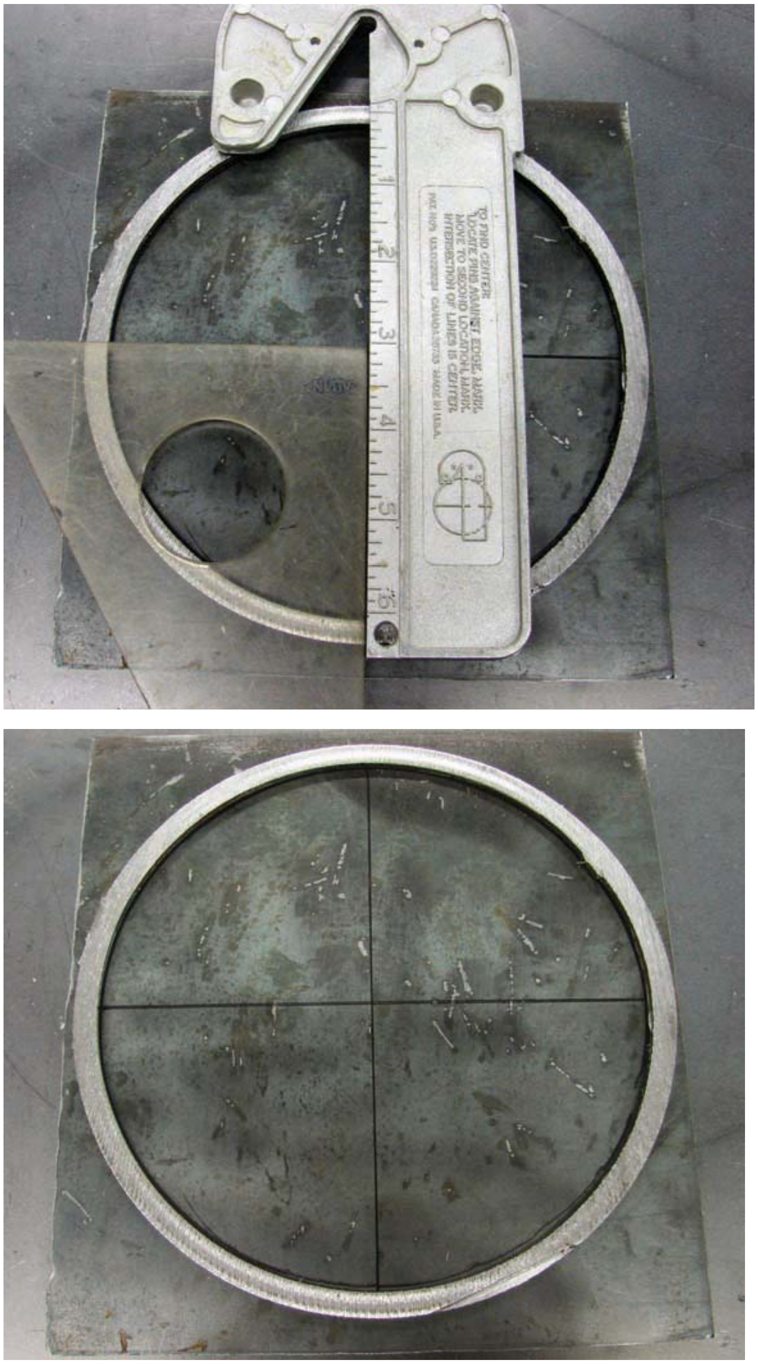


Figure 12-11.
a) Dividing the circle into four equal sections.
b) Four sections of the circle.

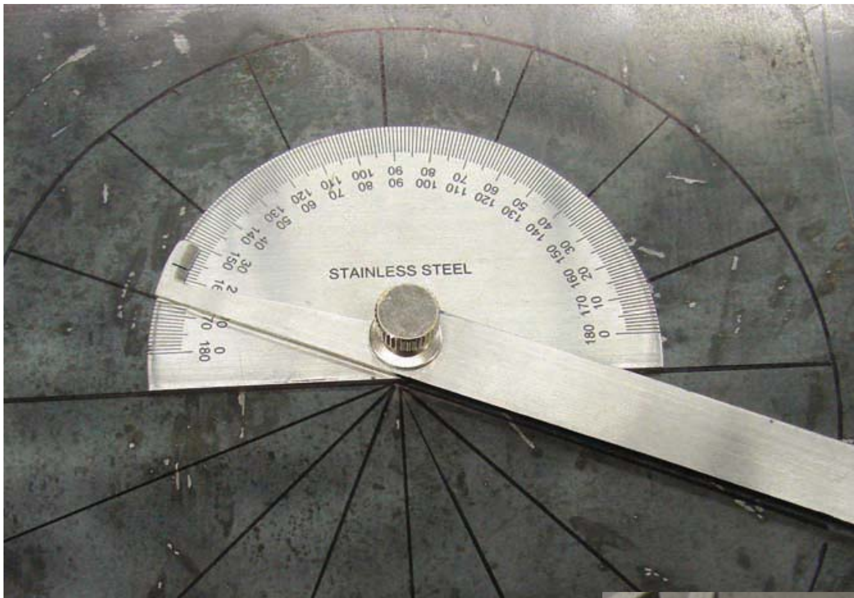


Figure 12-12. Use a protractor and a permanent marker to divide the circle into 22.5-degree sections.

Figure 12-13.
a) Attaching the stops on Jig #2.
b) Completed Jig #2.

STEP 6. Weld the bottom spokes to the bottom inside ring.

With jig #2 to aid in placing the parts, this is a very easy step to complete. First place the bottom outside and inside rings on the base of the jig. Place each spoke between the rings and push them up against the stops. Begin with the four quadrant spokes; then add the others (Figure 12-14).

With a MIG welder, ***tack the spokes to the inside ring only*** (Figure 12-15). The bottom spokes will be welded to the outside ring later during construction. After tacking, allow the welds to cool. Next, remove the parts from the jig, using a flat head screwdriver if necessary to pry it out, a little at a time, to avoid bending the spokes or breaking the small tack welds. Turn the assembly over and place a solid tack weld in the center of each spoke on the bottom (Figure 12-16).

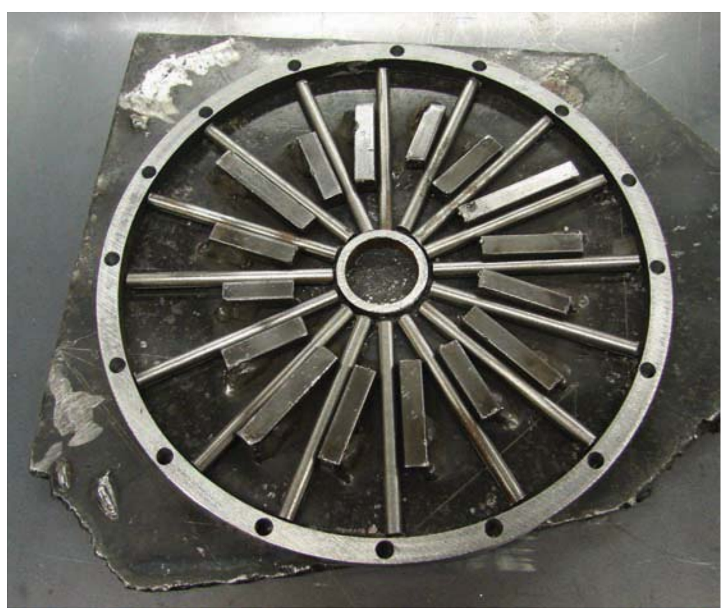
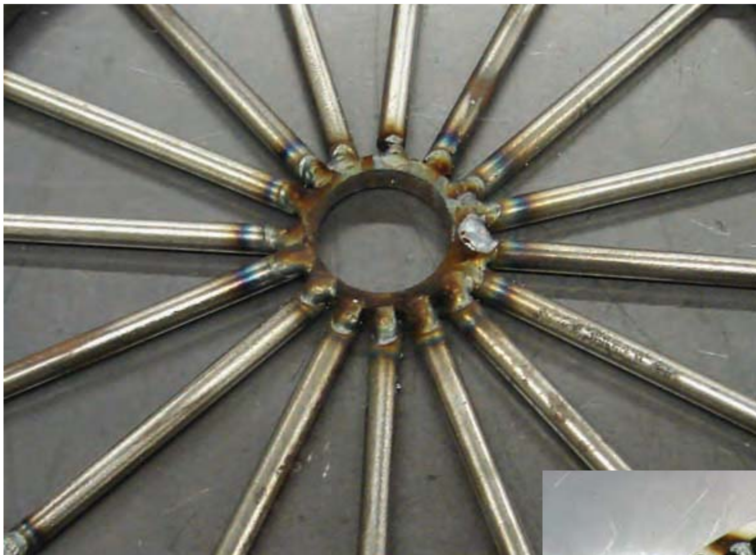


Figure 12-14.
a) Aligning the first four bottom spokes.
b) All spokes aligned and ready to be welded.



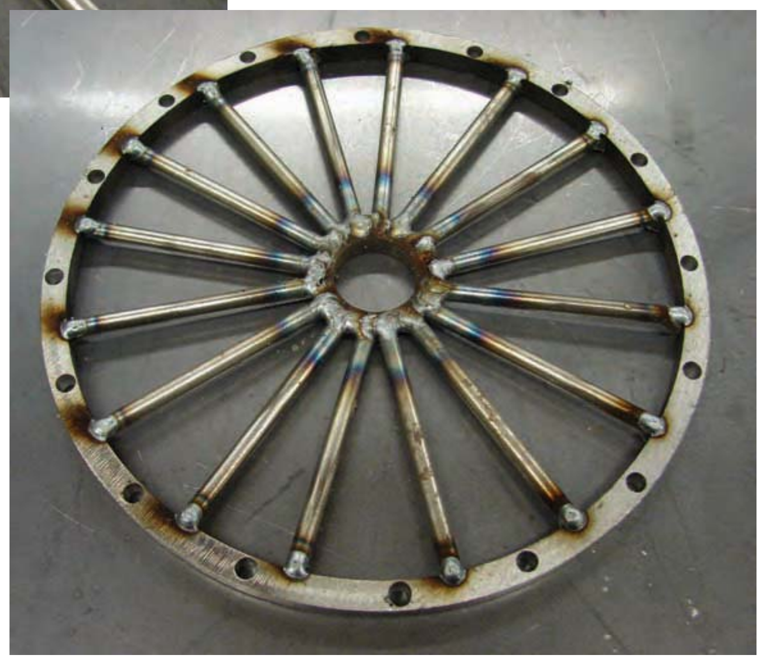


Figure 12-15.
a) Bottom spokes welded to the inside ring on the top side.

b) ***DO NOT*** *weld the spokes to the outside ring, as seen in this figure. If the outer ring is not removable, it will be impossible to encage anything within the vase in the final steps of construction.*

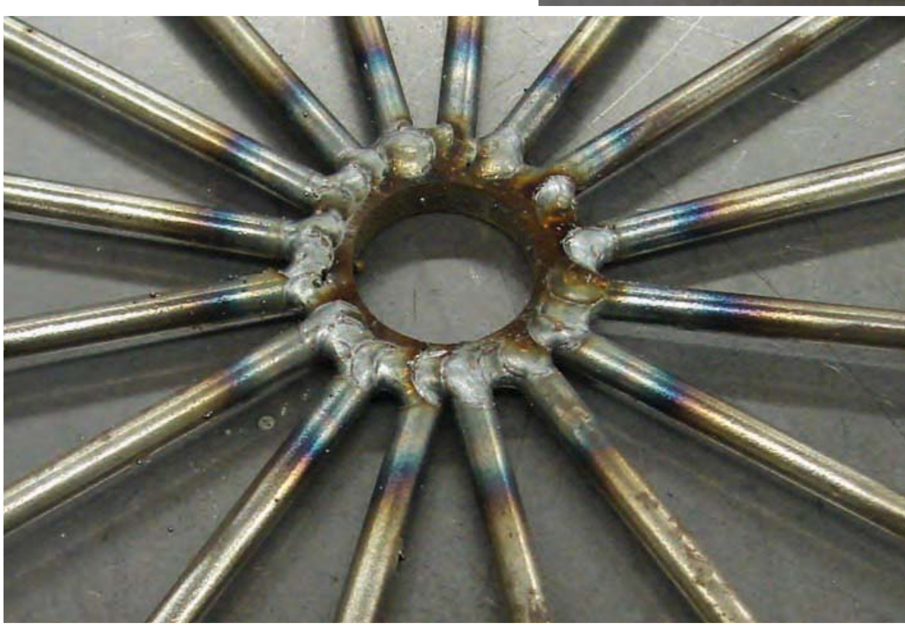


Figure 12-16. Bottom spokes welded on the bottom side.

STEP 7. Brake the side spokes.

Figure 12-17. Metal bending brake press.

The side spokes can be bent in one easy step with a metal brake (Figure 12-17). To prepare the parts for bending, lay them on a clean flat surface side by side, straight and square. Measure and mark the bending point, using a square and a permanent marker. Tape the parts together in two places to keep them lined up and make handling them easier (Figure 12-18).

Place the parts in the brake, using a combination square to place them at a 90-degree angle to the bending tooth. Lower the bending unit until it is close but not touching the parts being bent, and remove the square (Figure 12-19).

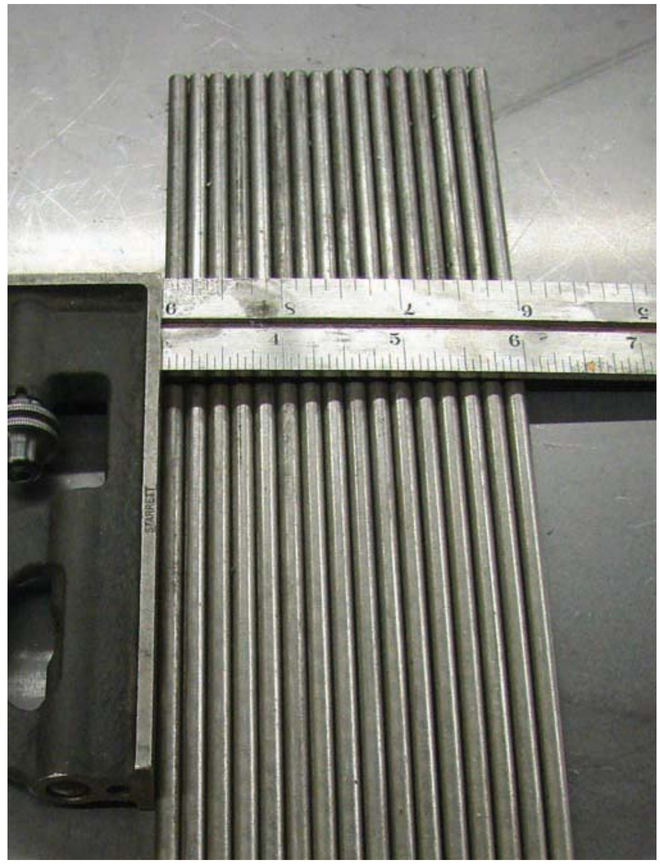
Bend the parts until they form a 90-degree angle. Eye down the side of the brake while pumping the jack until the parts are close to 90 degrees. Measure the distance the brake has dropped. Then remove the parts from the brake. Measuring the drop distance will allow for an easy re-set if the parts are not bent far enough after checking the angle. If 90 degrees has not been achieved, replace the parts and bend farther past the last bend point. Check often so as not to go past to the desired angle (Figure 12-20).

When 90 degrees has been met, remove the masking tape and proceed to the next step.

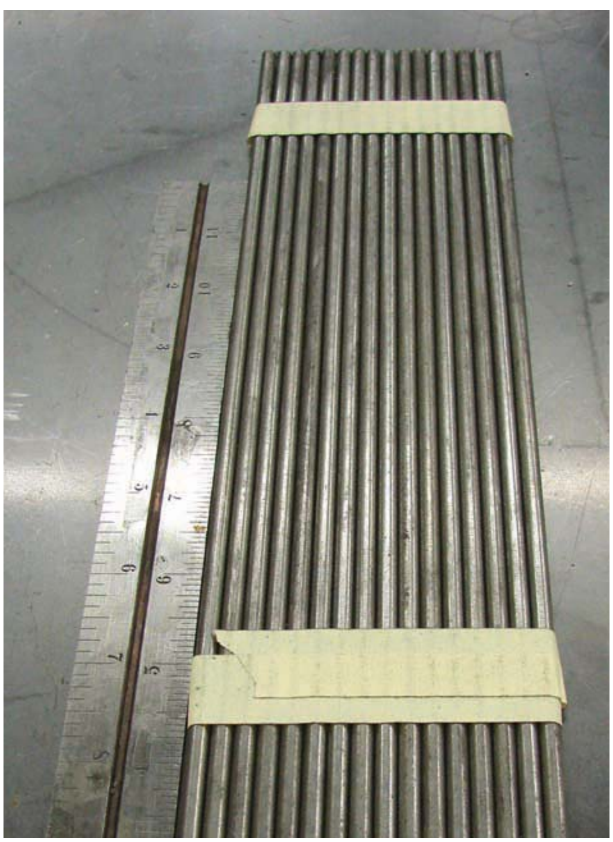
A brake is a metal working device that allows for the bending of steel, generally flat sheets. There are many metal bending brake presses available on the market, some suitable for heavy duty projects and others for lighter gauge small projects.
To avoid permanent damage, never bend more than the maximum rating for any given machine.
The brake press used for this decorative vase is a heavy duty brake with a 20-ton hydraulic bottle jack supplying the energy to do the work. Its bending capabilities range from 1/4" plate - 10" wide to 5/8" plate - 2-1/2" wide. The parts for the vase are significantly less than either rating and can easily be bent with this machine.

HELPFUL HINT

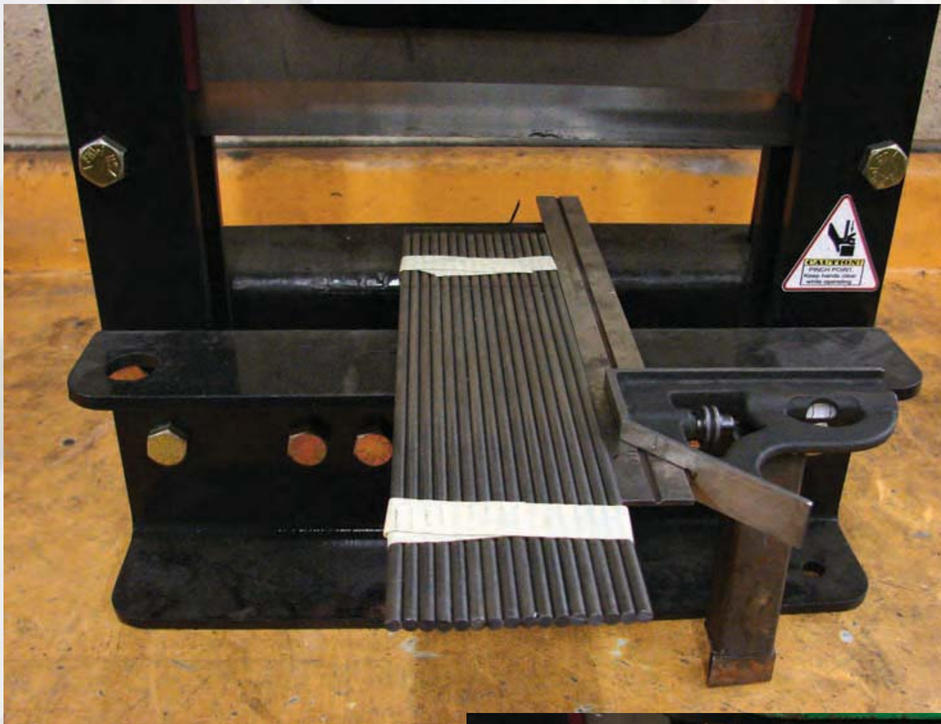
Figure 12-18. a) Sides aligned and square.



b) Marking the bending point on the sides.



c) Sides taped together and ready for bending.



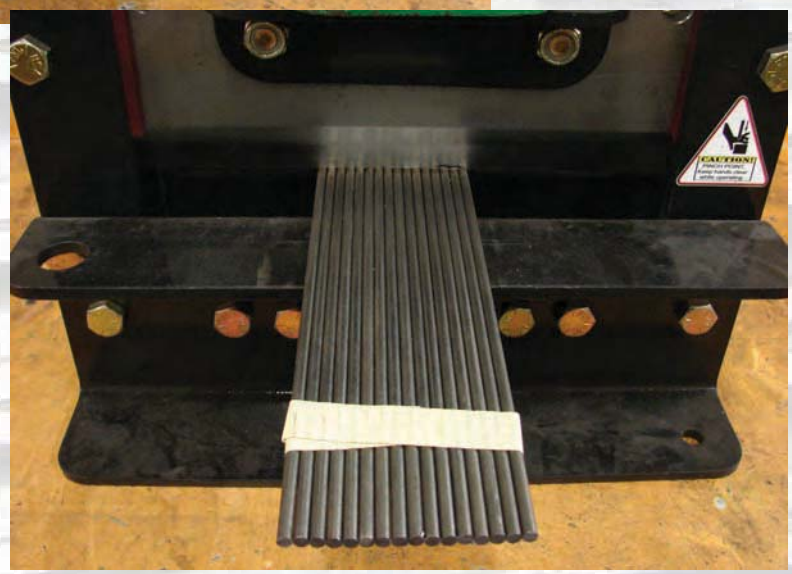
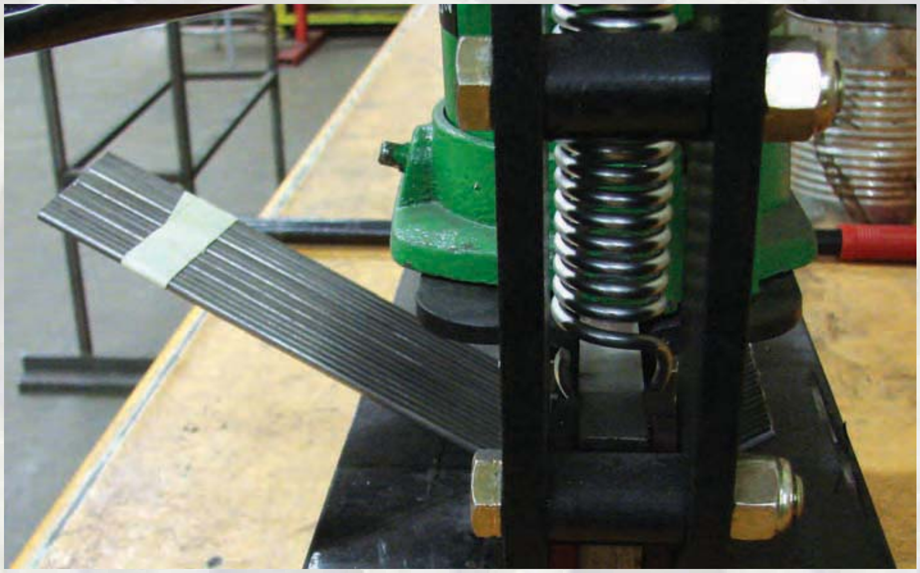


Figure 12-19.
a) Placing the parts in the brake square.
b) Ready to bend the sides.

Figure 12-20.
a) Bend the parts until they are close to 90 degrees.



b) Measure the distance the brake has been dropped.

c) Check bending angle.

d) Finished 90-degree angle.

STEP 8. Construct Jig #3.

The last jig needed to help aid in construction of the decorative vase is used to center the spout while tacking the sides to it.

To begin, review the plan view and parts list in Figure 12-21. Collect some 1/2" x 1/2" square bar and cut the parts to length. Before welding the parts together, lay the bottom outside ring on a flat surface. Next lay out the parts inside the ring, making sure that the jig will fit loose enough for easy removal. If the parts fit, weld them together, using a square while tacking to keep everything lined up correctly (Figure 12-22). If the parts do not fit, grind about 1/32" off of each base spoke, then re-assemble and check the fit.

Decorative Vase Jig #3 - Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
4	Base Spokes	Square Bar	1/2"	1/2"	0'-2 3/4"
1	Centering Bar	Square Bar	1/2"	1/2"	1'-3"

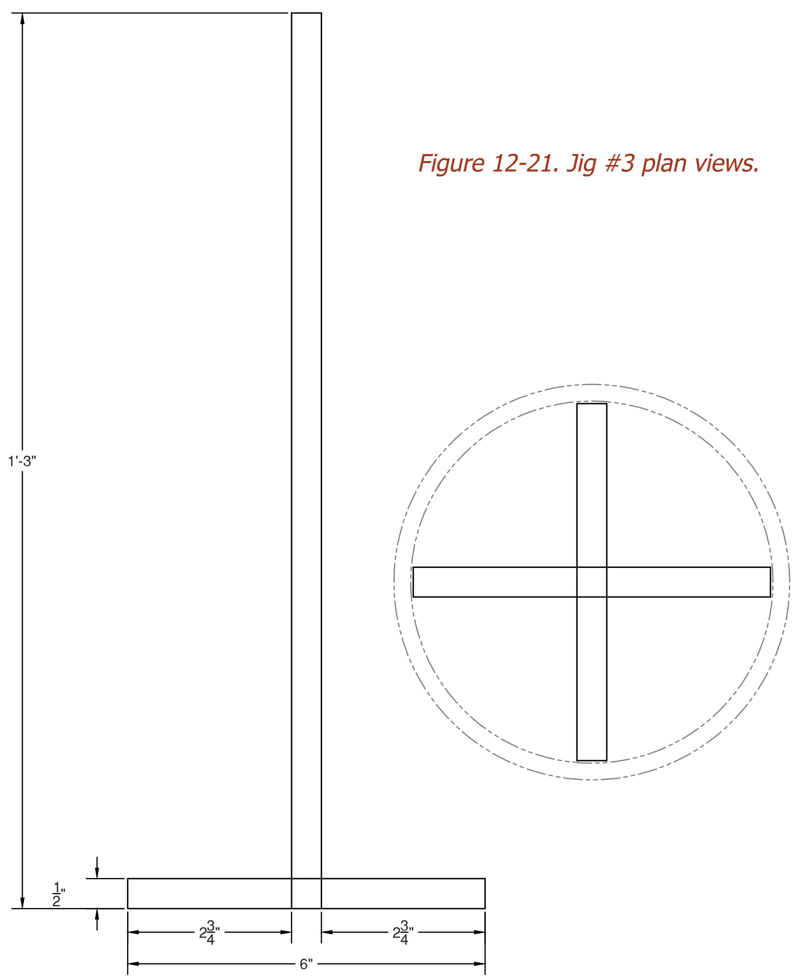


Figure 12-21. Jig #3 plan views.

STEP 9. Attach the side spokes to the bottom outside ring and the spout.

To attach the side spokes, place the bottom outside ring on a clean flat surface and set jig #3 inside the ring. Place four of the side spokes in the four quadrants of the ring, making sure they go all the way in the hole. The ends may need to be ground down a little in order for the ends to completely slide into the holes. Align the ends that will connect to the spout so they all face the centering bar of the jig. Slide the 3" section of pipe over the centering bar and allow it to sit on top of the rods (Figure 12-23).

With the first four sides ready to be tacked to the spout, align the spokes one at a time and tack to them to the spout. Eye down the centering bar when tacking making sure that the opposing sides are straight across from one another. After tacking the first two sides, examine the straightness of the pipe with the centering bar. If the pipe appears to lean to one side or the other, use an oxyacetylene gas welding tip to heat up the tack welds enough so that the pipe can be bent into alignment. Tack the other two sides to the pipe, again eyeing down the centering bar to make sure they are placed half way between the first two sides (Figure 12-24).

Figure 12-22. Completed jig #3.

Figure 12-23. Preparing to weld the spokes to the spout and bottom outside ring.

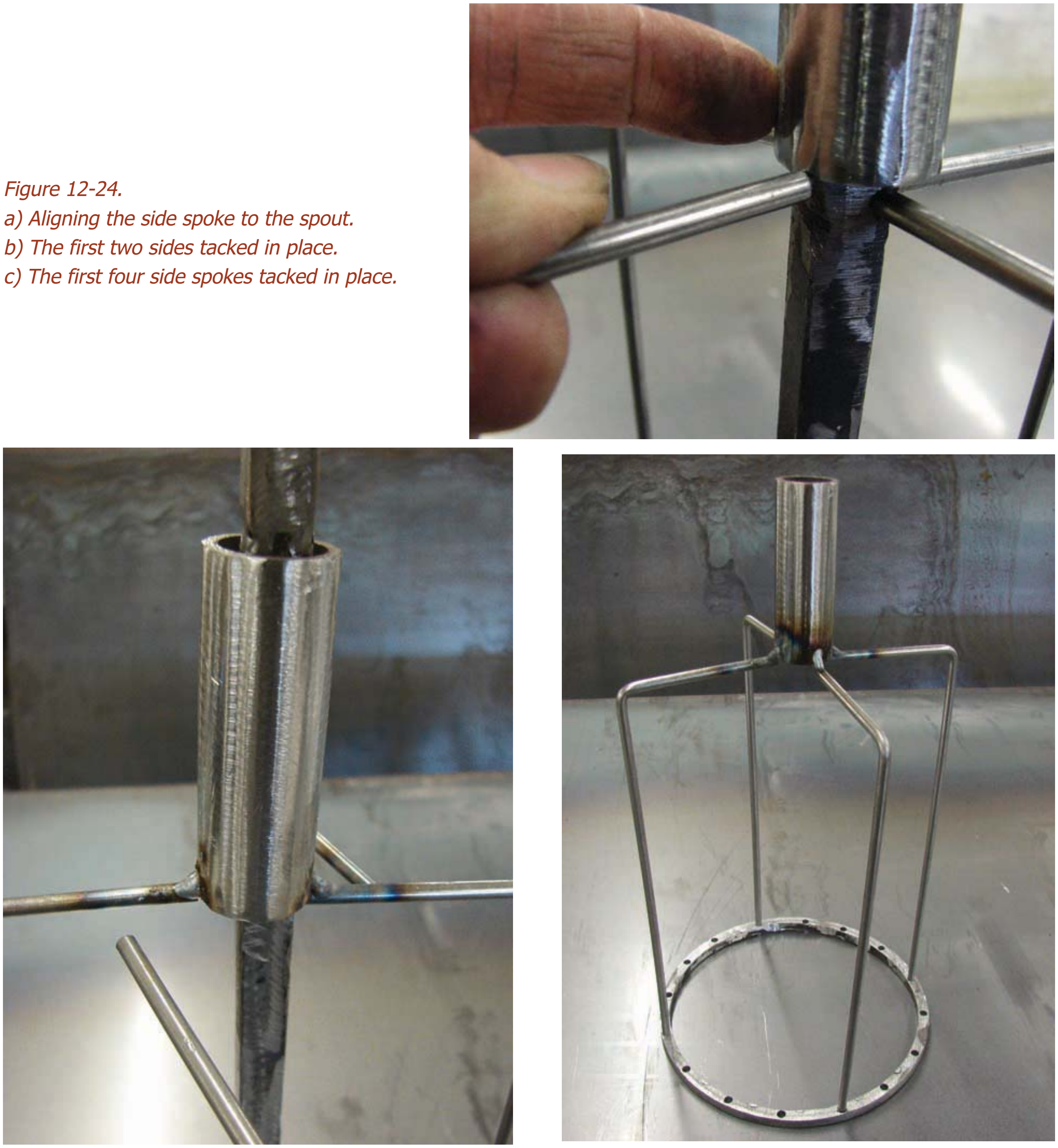


Figure 12-24.
a) Aligning the side spoke to the spout.
b) The first two sides tacked in place.
c) The first four side spokes tacked in place.

The next parts to tack in place will be the four spokes that divide the sections in half. As you place these parts, try to keep from lifting the vase up off the surface of the table. It is possible to pull the spokes out of the holes with too much moving (Figure 12-25).

To complete the side spoke assembly, insert the last eight spokes, center them between the others and tack in place (Figure 12-26).

Figure 12-25. The first 8 spokes tacked in place.

Figure 12-26. All side spokes attached to the spout.

After tacking the sides, the spokes will need to be secured to the bottom of the ring. Carefully tip the vase over on its side and examine the bottom of the ring — some spokes may stick out the bottom farther than others (Figure 12-27). This is not a problem. The spokes that don't go all the way through should be welded with a small tack (Figure 12-28). The ones that poke out past the surface of the ring should be ground off flush with the bottom of the ring. Grind down the tacks placed on the bottom so they are flush as well. As long as at least four spokes on opposite sides of the bottom ring are tacked, all spokes should remain intact.

To improve the looks of the welds around the spout, place a series of tacks between each already tacked spoke. Do not attempt to weld a continuous bead. This generally ends up looking over-welded. If you wish to have the appearance of a continuous bead, use a wire wheel to clean the weld area, then either use an oxyacetylene gas welding tip or a TIG welder to push a continuous puddle around the bottom of the spout without using any filler rod (Figure 12-29). This can improve the looks of the weld without adding unnecessary weld build-up.

Figure 12-27. Bottom side of the bottom outside ring after the side spokes have been inserted.

Figure 12.28. Tacks on bottom ring used to hold the side spokes in place.

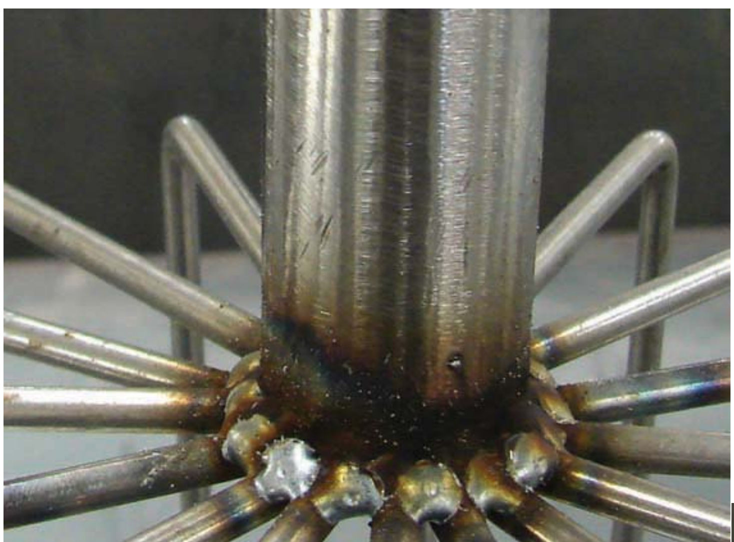
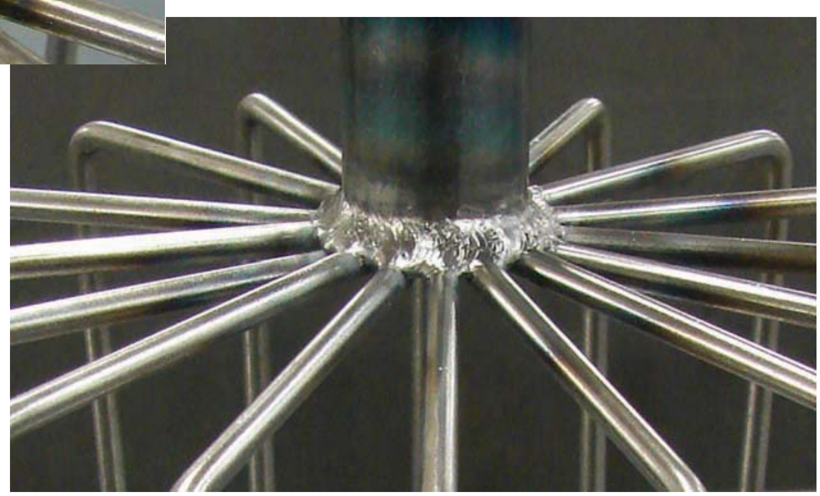


Figure 12-29. a) Tacks made around spout.

b) Continuous TIG weld around spout.



STEP 10. Attach the Spout Rim.

The spout rim requires some welding, some bending, and some cutting. Begin by welding the 1/4" x 1/4" square bar to the top of the spout, keeping it level with the top (Figure 12-30). Make sure the weld is well penetrated or the part could detach when the part is heated and bent around the spout.

Next, set up an oxyacetylene torch with a gas tip or cutting torch tip attached. Before bending, clamp the bottom ring to the work table in two places to keep it from moving. Apply heat to the square bar and use a pair of pliers to pull on the end of the square bar after the metal has reached a cherry red color. As you bend the square bar around the spout, keep the red area behind where the rim is touching the spout. If you get ahead of this point, a gap can be left between the two parts. If this happens, back up the cherry red area and tap the rim with a hammer to help put it back in place. If all goes well, the rim should contact the spout tightly around the entire diameter, except where the weld was placed (Figure 12-31).

After bending, the excess rim material needs to be cut off using a plasma cutter or cutting torch. Cut the part off where the rim comes in contact with the weld that initially secured the rim to the spout. Clean the slag from the bottom of the part. Then fill in the missing area of the rim using an MIG welder. Place small tacks, one on top of the other, allowing a few seconds of cooling time between each tack. After filling the vacant area with weld, grind the top and side with an angle grinder until the weld area looks like it is part of the square bar and is smooth. Only grind the welded area. Any other grinding is unnecessary and could damage the clean appearance of the square bar that was bent around the spout (Figure 12-32). Use a wire wheel to remove any mill scale build up that may have formed after heating the parts.

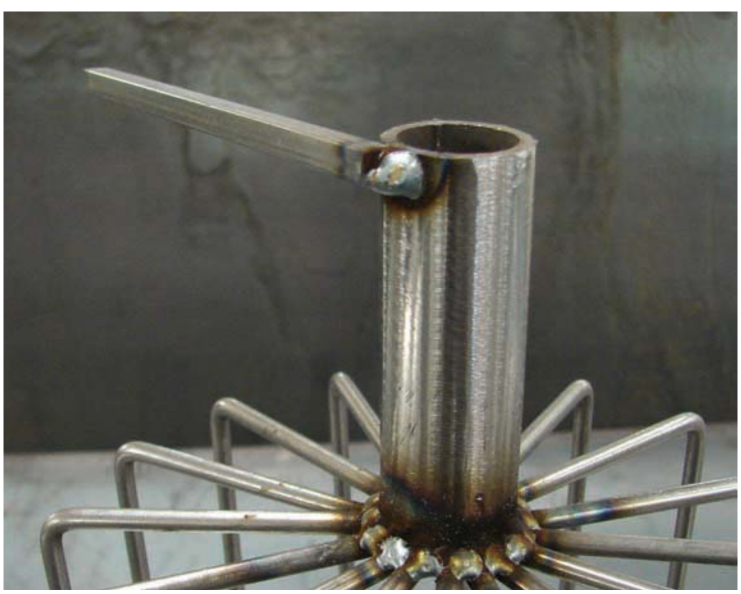


Figure 12-30. Spout rim tacked to the spout.

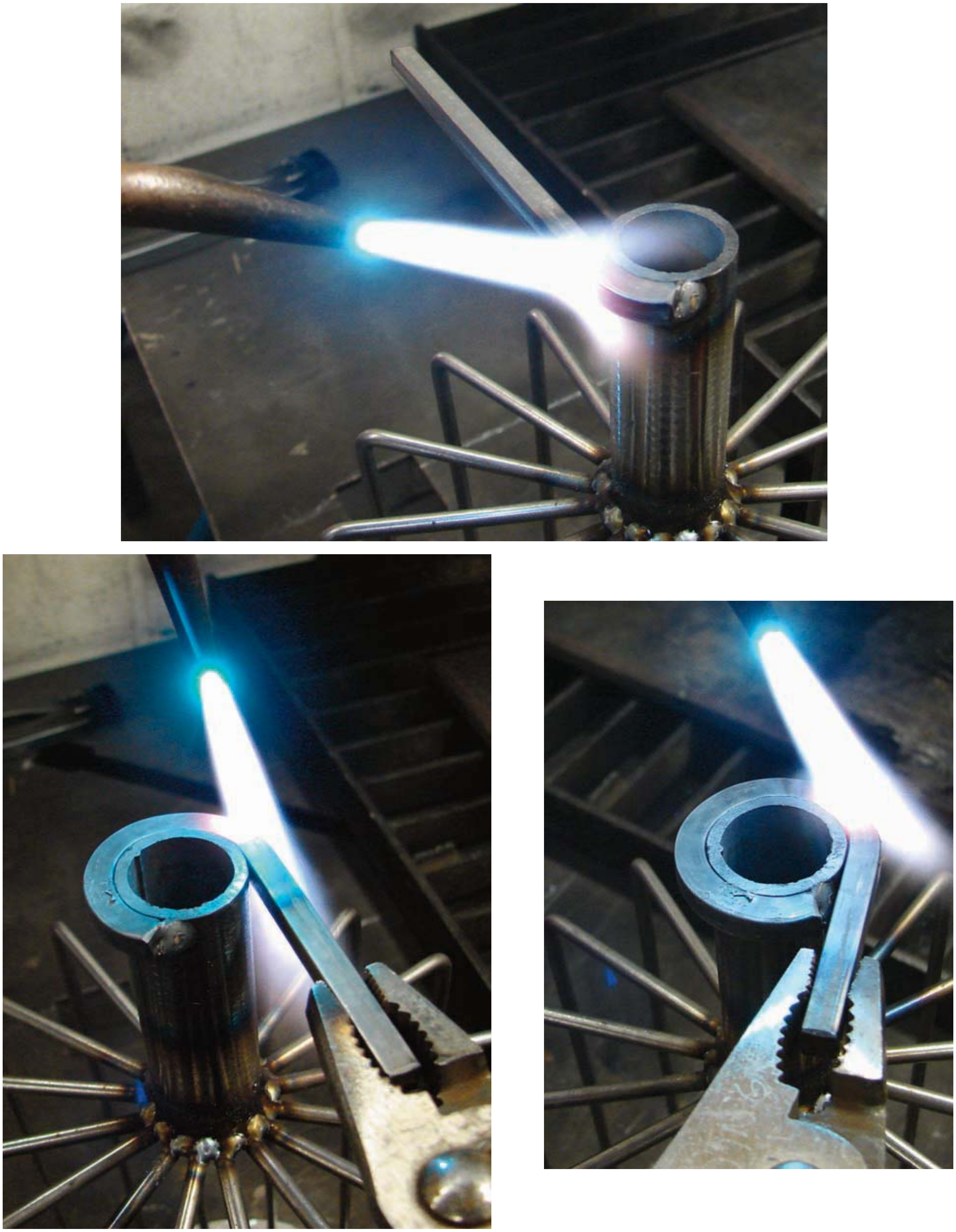


Figure 12-31. a) Beginning the bend. b) Rim almost around the spout with a tight fit between the two parts. c) Bending complete.

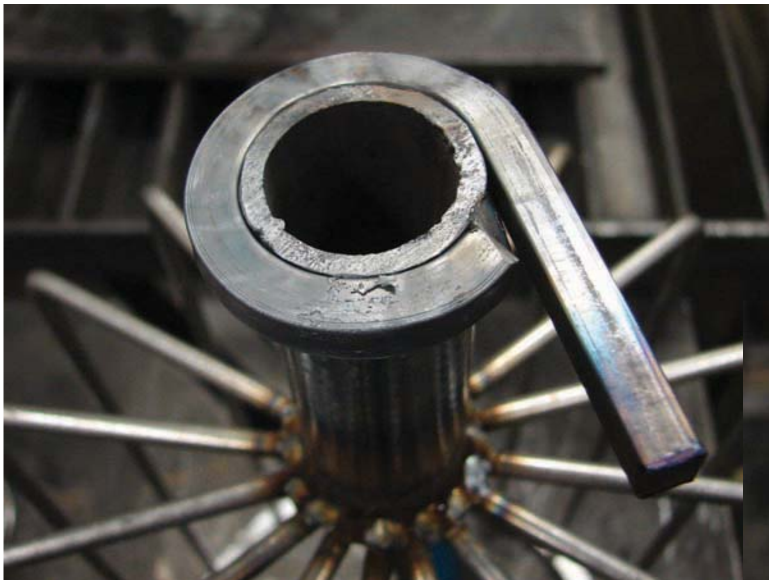
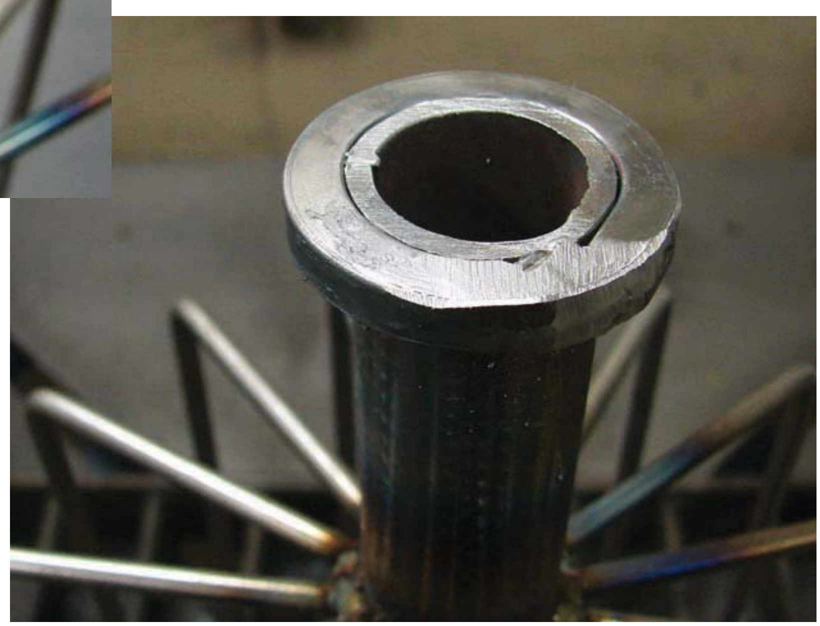


Figure 12-32. a) Excess rim material.

b) Excess rim material removed.

c) Void in rim filled with a series of small tacks.



d) Grind and polish the rim.

STEP 11. Clean up.

At this point, cleanup needs to be done. Use a wire wheel to remove any mill scale and a chisel and hammer to chip off welding berries that may have attached themselves to the vase while tacking the parts in place.

STEP 12. Choose what will be encaged within the decorative vase.

If it hasn't already been done, it is time to decide what to encage inside the vase. Be creative with your choice. When the decision has been made on what to place inside, some mounts may need to be attached to the sides or bottom to secure the item. For the example given, two tabs were welded to the bottom spoke assembly with holes drilled in them. Two screws were then inserted through the holes to attach the birds and weathered wood fence (Figure 12-33).

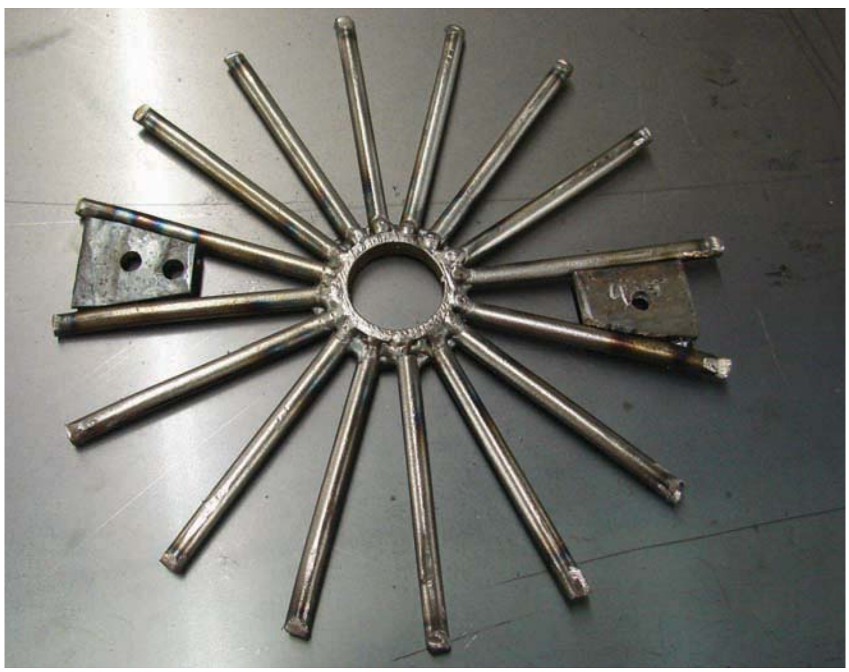


Figure 12-33. Tabs welded to the bottom spokes.

STEP 13. Paint the project.

If the project is to be painted, this is the time to do it, before encaging anything within the vase. Because this project is strictly decorative, a coat of primer is not necessary. A light coat or two of a good quality paint should be adequate to protect your work of art from rusting. On steel projects, the hammered type spray paints provide the best quality finish because they don't run as easily; even if they do, the runs don't appear as visible as they do with a smooth finish paint.

When painting, limit the amount of paint to the inside of the bottom outside ring and to the ends of the bottom spokes. Too much paint will make the last welding step more difficult. Allow the paint to cure over night before proceeding to the next step (Figure 12-34)

Note:
If the project is something decorative that may be put outside in a flower garden, leaving the steel bare and allowing the project to rust is also an option.

Figure 12-34. Vase painted with a good quality hammered finish spray paint.

STEP 14. Encage the selected item within the decorative vase.

The example given encages two birds sitting on a wooden fence. The fence is a piece of wood that was removed from some old barn wood boards that were lying around the shop. The fence was attached to the bottom with two screws inserted through the tabs that were welded to the bottom spokes and then drilled up into the wood (Figure 12-35). The birds were attached to the fence using two steel pins inserted into the wood and then slid through a hole in the bottom of the birds. Glue was used to tightly secure the birds to the wood and steel pins.

After attaching the items that will be enclosed in the vase to the bottom spokes, slip the top of the vase over the items and align the bottom spokes in between where the side spokes are attached to the bottom ring.

Place a small tack between each bottom spoke and the bottom outside ring (Figure 12-36). When tacking, grounding may be difficult. If this is the case, grind a small area of paint off one side spoke and clamp the ground clamp to that spoke.

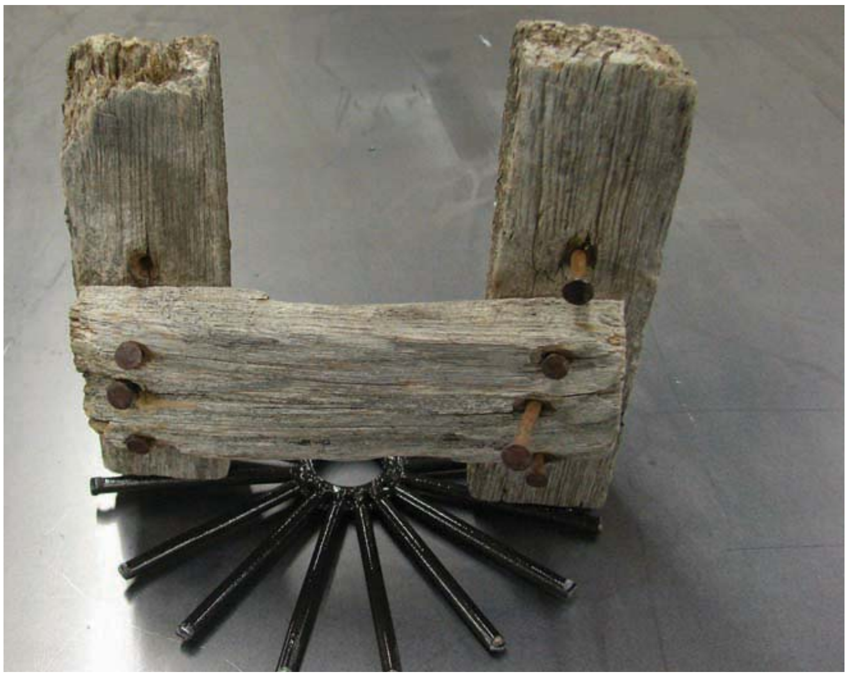


Figure 12-35. Fence attached to the bottom spokes.

Figure 12-36. Bottom spokes attached to the bottom outside ring.

STEP 15. Touch up the paint.

With all welds complete, touch up the paint that may have been removed for proper grounding and paint the tack welds on the bottom spokes. If you used spray paint, the easiest way to do this is to remove the cap from the spray can, turn the cap upside down, and spray some paint into the lid. Use a small paint brush to complete the touch-up painting.

Let the paint dry overnight and the project is complete (Figure 12-37).

Figure 12-37. Completed Vase with wine bottle lamp insert. Locate the lamp inserts on-line by searching "wine bottle lamp kits".

CHAPTER 13

Tricycle Plant Stand

One of the advantages of working with wrought iron is that if a part isn't formed or cut just right, it's easy to alter the plans and still make the piece work. This makes this project one of the least technically precise of all the projects in this book. In fact, if you compare the side view of the tricycle in Figure 13-2 with the finished product pictured on this page, the wrought iron parts that connect the pot holders are in a different position and the rings were placed an inch closer together than noted in the plan drawing.

The majority of parts will either be rolled or bent, which may tend to make you think that it will be a time consuming and lengthy project to construct. This is actually not the case. Because the parts can fit in alternate ways without compromising the appearance of the project, it actually goes together quite quickly. The tricycle is a very rewarding project that will teach the proper use of rolls, benders, and wrought iron machines.

STEP 1. Collect the needed steel.

Before beginning the tricycle, examine the parts list and the front and side views of the project to get familiar with the part names and locations within the project (Figures 13-1, 13-2, and 13-3). This project will be one of the more expensive ones in the book. Refer to the list below when ordering steel.

Material required for the tricycle:

1/8" x 1" flat bar	48'-0"
1/4" x 1" flat bar	3'-0"
3/8" Sch40 Pipe	1'-0"
7/16" rod	2'-0"
1/2" x 13ga XF	2 sq ft.

Note: These lengths were rounded to the nearest ft or sq ft.

When ordering steel from a supplier, it is more economical to order full sticks rather than just the amount needed for the project. Full sticks of flat bar and rod come in 20'-0" sticks, pipe generally comes in 21'-0" sticks, and sheet metal typically can be purchased in 4' x 8' sheets or larger. When purchasing only a short 3'-0" piece, the supplier will charge a cutting fee that many times can amount to as much as what it would cost to purchase a full stick.

HELPFUL HINT

Tricycle Plant Stand Parts List					
No of Parts	Part Description	Material	Thickness	Width	Length
1	*A - Large Wheel	Flat Bar	1/8"	1"	4'-2" + 4" added
2	*B - Small Wheel	Flat Bar	1/8"	1"	2'-1" + 4" added
6	C - Lg Wheel Wrought Iron Spokes	Flat Bar	1/8"	1"	1'-7"
5	D - Sm Wheel Wrought Iron Spokes	Flat Bar	1/8"	1"	0'-8 1/4"
1	E - Connector Arm	Flat Bar	1/4"	1"	2'-2"
6	F - Wrought Iron Pot Connectors	Flat Bar	1/8"	1"	1'-0"
2	G - Handle Bars	Flat Bar	1/8"	1"	1'-9"
1	H - Front Wheel Fork	Flat Bar	1/8"	1"	1'-9"
1	J - Back Wheel Axle	Rod	Ø7/16"	-	1'-5"
1	K - Front Wheel Axle	Rod	Ø7/16"	-	0'-2 3/4"
2	L - Back Wheel Axle Support	Pipe	3/8" Sch40	.675 OD / .493 ID	0'-1"
1	M - Front Wheel Axle Support	Pipe	3/8" Sch40	.675 OD / .493 ID	0'-1 3/4"
2	N - Back Wheel Gusset	Flat Bar	1/8"	0'-1"	0'-8"
4	P - Back Axle Stops	Pipe	3/8" Sch40	.675 OD / .493 ID	0'-0 1/4"
4	* R - Plant Holder Rings	Flat Bar	1/8"	1"	2'-1" + 4" added
2	S - Bottom Ring Bases	Flush Expanded Metal (XF)	1/2 x 13ga	0'-8"	0'-8"

*Note: Parts A, B, and R have added lengths to compensate for excess material that needs to be added when rolling rings. The added length may vary depending on the ring roller used. Adjust as needed.

Figure 13-1.

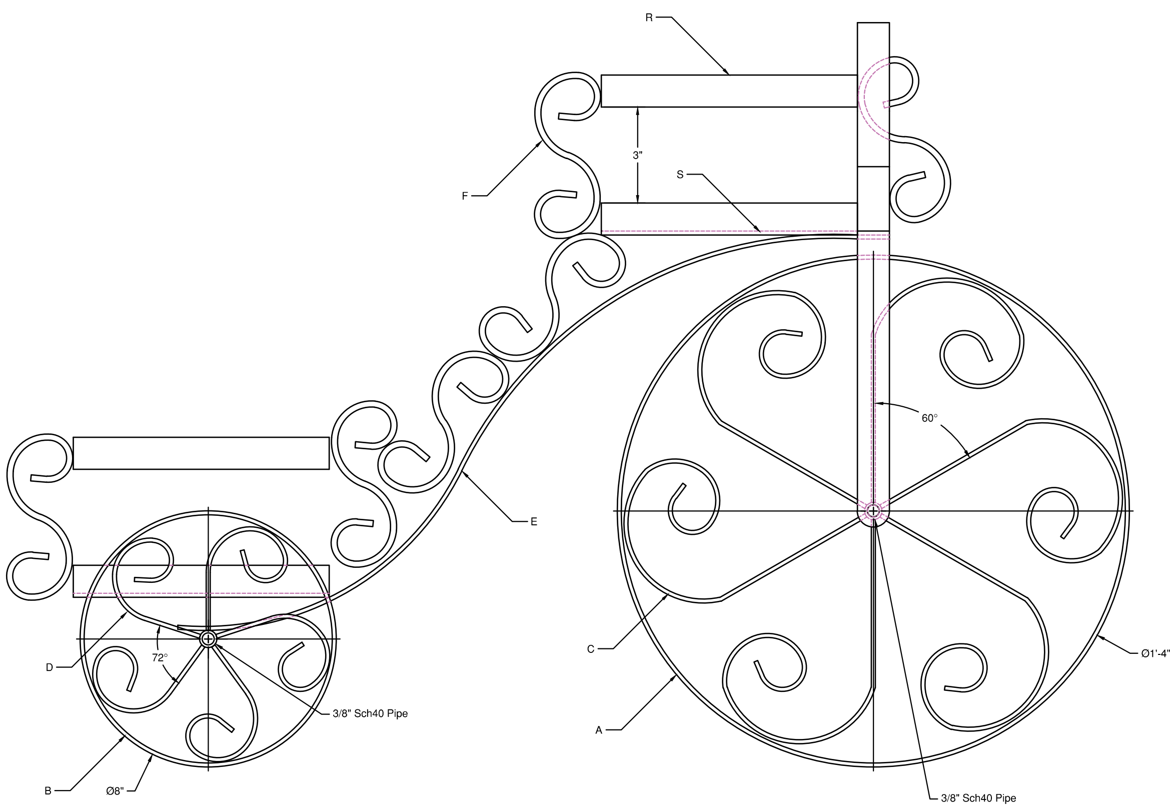


Figure 13-2. Side view of the tricycle.

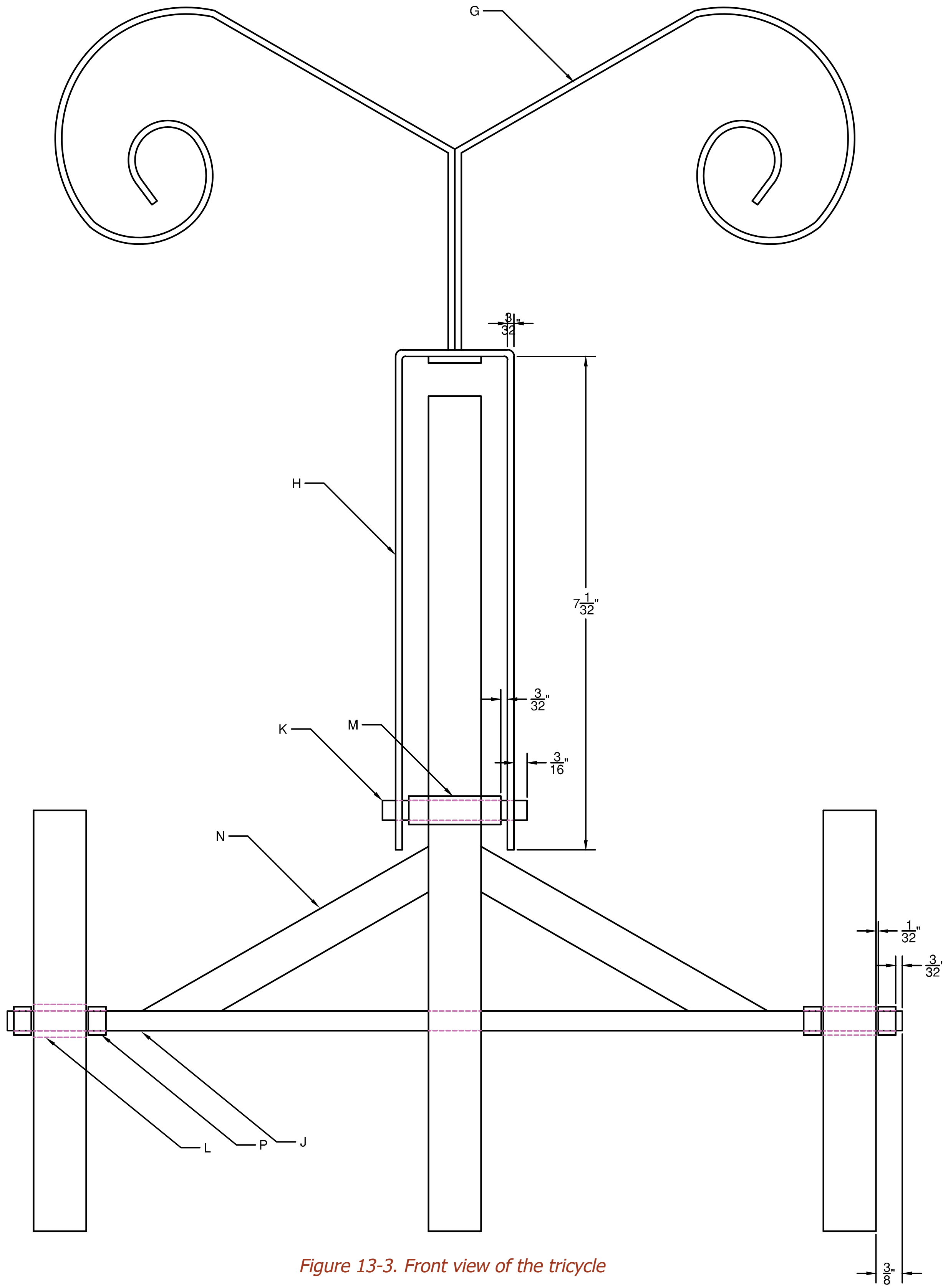


Figure 13-3. Front view of the tricycle

STEP 2. Cut the parts for the wheels (Parts A-D and L-M).

Before cutting the parts for the large and small wheels, which will be rolled into circles, some adjustments in length need to be made. These changes in length are necessary —when using a ring roller, a short portion of each end remains flat due to the nature of how the roller works (Figure 13-4). This distance varies depending on the size of the rollers and the distance the rollers are spaced apart. The added length required will equal twice the distance from the top quadrant of the center roller to the top quadrant of either outside roll.

After measuring your ring roller and calculating the necessary adjustments in length, cut all parts for the wheels to length and remove any sharp burrs on the ends.

Figure 13-4. Notice the flat ends on this completed ring.

STEP 3. Roll the large and small wheels into rings.

Before beginning, recognize that a ring roller (Figure 13-5) is a simple tool to use, yet mistakes can be made. The trick is to be patient. When in a hurry, it's easy to end up with a part shaped like a number six rather than a circle.

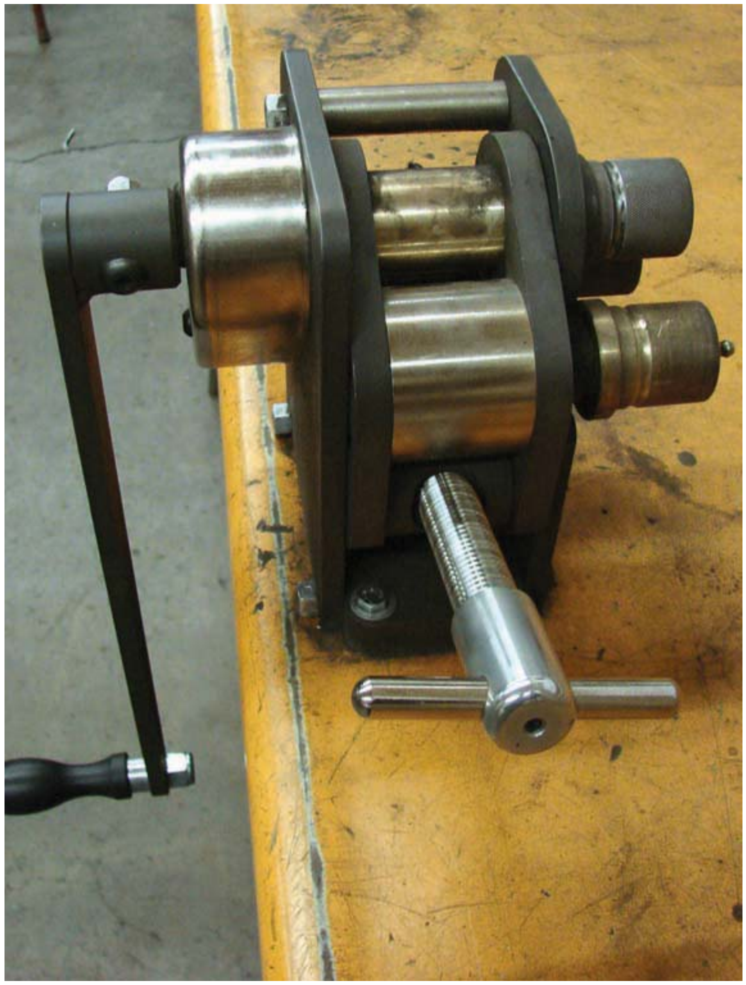
Ring rollers work by forcing the material between rollers, usually two rollers on the bottom and one on the top. The center roller position is adjustable and is the controlling part in determining just how large or small the ring will be. Some rollers adjust with a threaded assembly and others use hydraulic jacks, but essentially they all produce the same results. When choosing a ring roller, choose one that fits the job at hand.

HELPFUL HINT

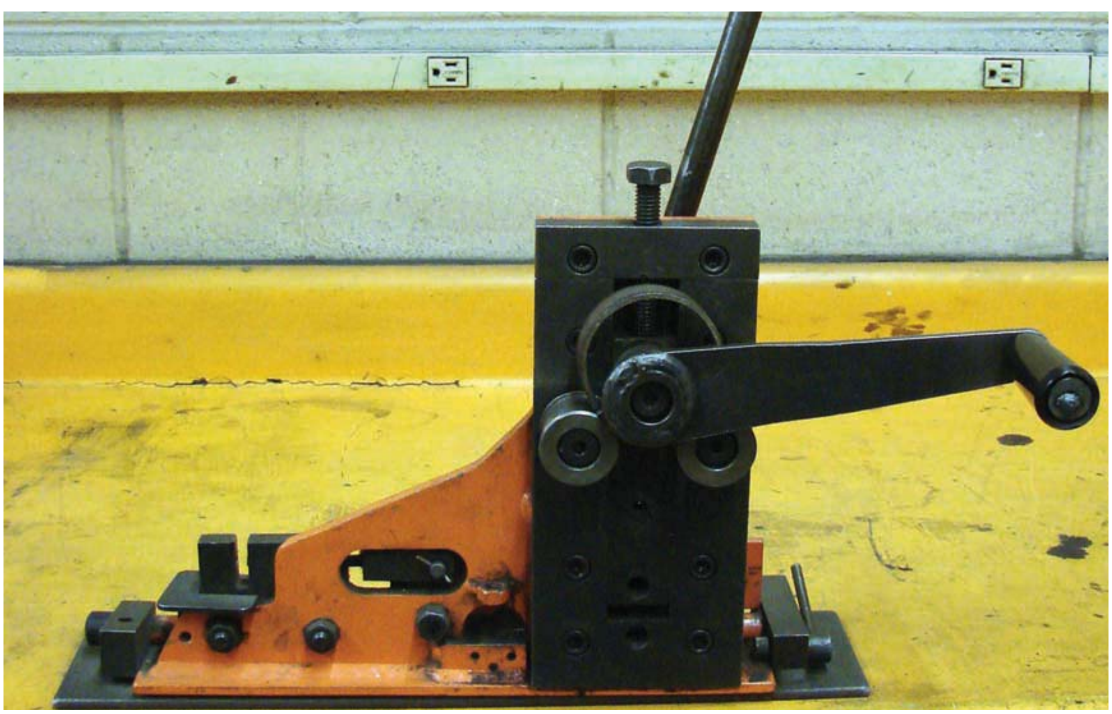

a)

Figure 13-5. Ring rollers come in various shapes and sizes. The rollers pictured have different capabilities. The roller in example a) can accommodate thicker wider material and will roll very large heavy rings, whereas examples b) and c) are reduced in size; they can handle only lighter material, but are capable of rolling much smaller diameter rings than example a).

b)



c)



To begin, measure and mark the distance that will remain flat when rolling with a permanent marker (Figure 13-6). After marking the ends, place the part in the roller with the sides that are marked facing downward. Then tighten the tension on the rolls until the flat bar is secure between the three rolls (Figure 13-7). With one end of the flat bar sitting on the top quadrant of a roll, adjust the tension, making sure not to over-tighten all at once. It will take several adjustments to complete the ring.

Figure 13-6.
Marking the ends that will remain flat after rolling

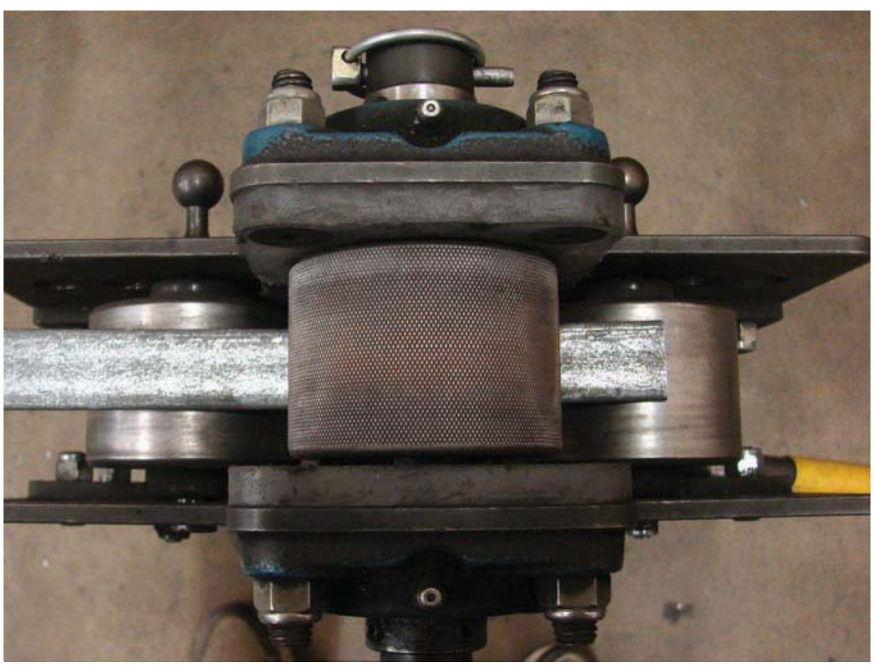


Figure 13-7.
Material placed properly between the rolls.

Turn the wheel or handle, depending on the type of roller used, until the flat bar has passed through the rolls, stopping when the other end gets to the top quadrant of the opposite side roll. Adjust the roller tension and continue to repeat the process until the ends come close to meeting (Figure 13-8). At this point, begin to make very small amounts of adjustments to the tension. Continue to roll the ring until the flat parts extend past each other and the marks made with the permanent marker are side by side (Figure 13-9).

With the ring complete, release the tension on the rollers and remove the ring. For this example, the wheel and top roller must be detached from the machine in order to remove the ring. Repeat the setup and rolling process for the remaining two rings.

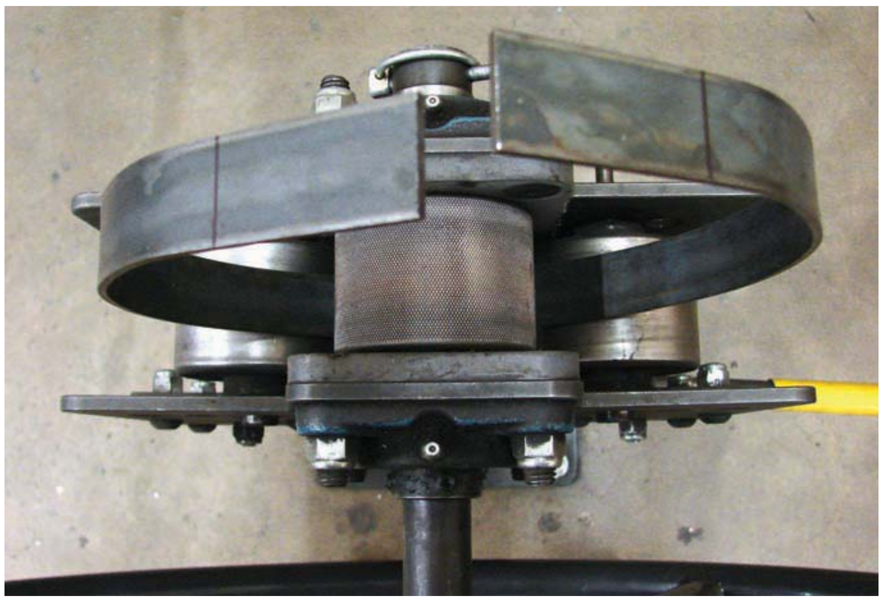


Figure 13-8.
Ring almost complete.

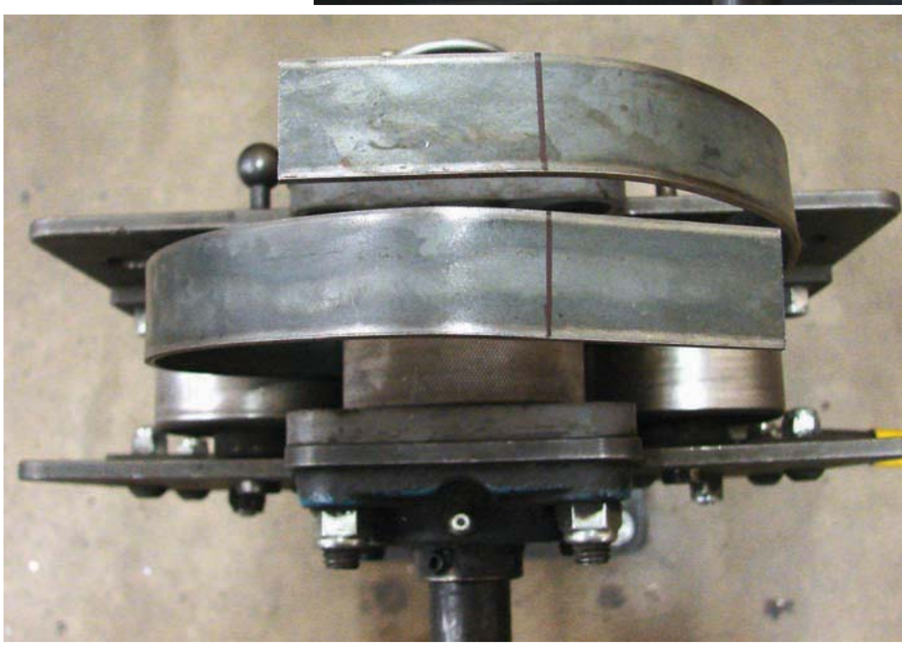


Figure 13-9.
Completed ring ready to be removed from the roller.

STEP 4. Cut off the flat ends of the rings and weld the ends together.

To remove the flat ends, use a plasma cutter, some C-clamp locking pliers, and a piece of 1/4" x 1" flat bar as a guide when cutting. Place the ring in a vise and clamp the flat bar to the ring, aligning it with the line drawn with the marker; be sure to compensate for the width of the kerf and the torch nozzle. Cut off both ends of the ring. The ring will be slightly twisted, but it can easily be pulled back into alignment (Figure 13-10).

After cutting, leave the ring in the vise and use a pair of u-shaped locking pliers to align the ends (Figure 13-11). Leave a 1/8" gap in the butt joint on the ring when clamping to allow for proper penetration. Weld the joint; then grind it flush on the inside and outside. Repeat the same steps with the other two rings (Figure 13-12).

After grinding, the rings may need a little shaping on the anvil near the weld area to produce a more perfectly round circle.

Figure 13-10. Use a plasma cutter to remove the flat ends on the ring.

Figure 13-11. Use u-shaped locking pliers to hold the ring while welding the butt joint.

Figure 13-12. Completed small wheel rings.

STEP 5. Construct the wrought iron spokes for the small wheels.

Before bending the spokes, use a permanent marker to locate three points on the five parts: two points that are 6" from each end and one in the center of the parts. Next, bend each end with a wrought iron bender. The point at which the bending should stop occurs when the 6" mark touches the edge of the bender template. By using the marks, all five parts should be nearly identical. After bending, clamp each part in a vise and use a straight edge and a plasma cutter to cut them in half (Figure 13-13).

Note:
All wrought iron benders are not created equal. Parts will vary with different machine manufacturers. Begin by bending one part and checking to see how the part fits. If it is too long or short, adjust accordingly to make the parts fit inside the rings.

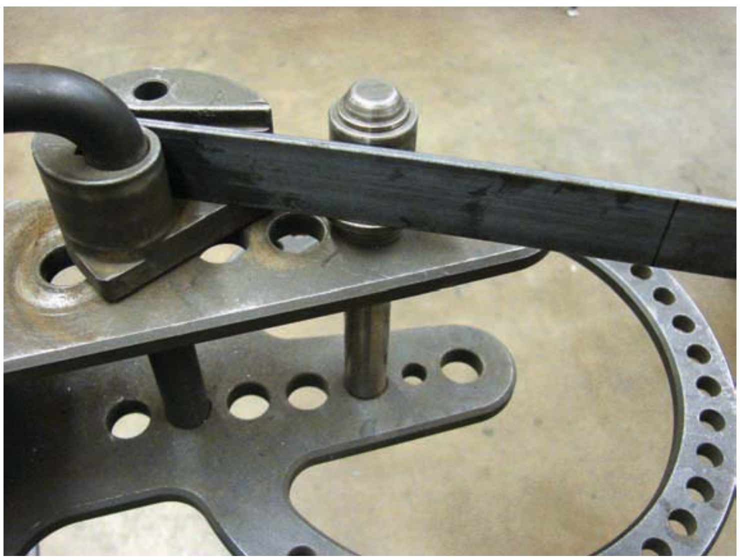
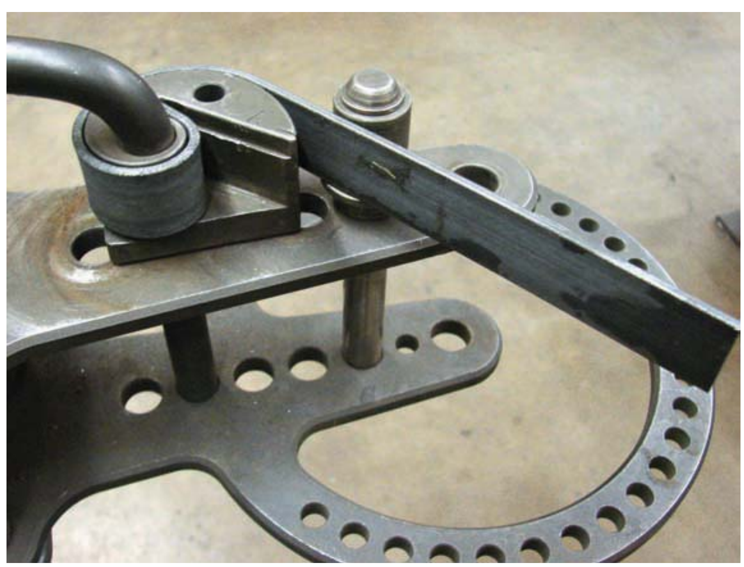
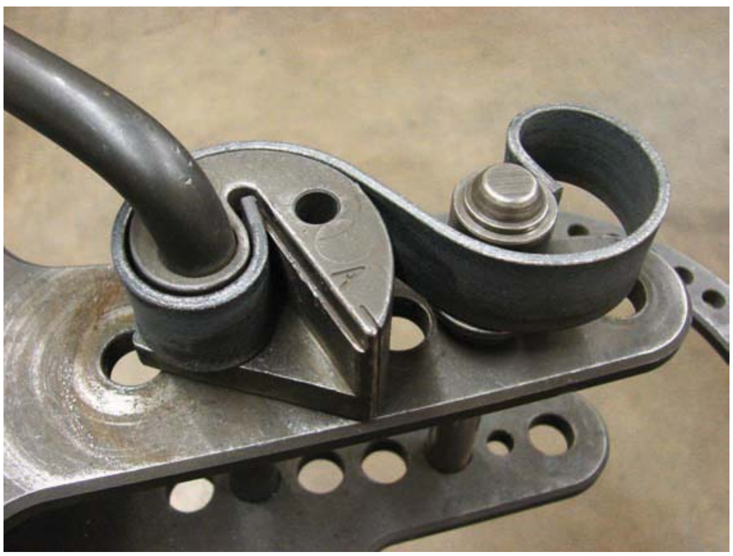


Figure 13-13. a) Place the flat bar in the wrought iron bender.



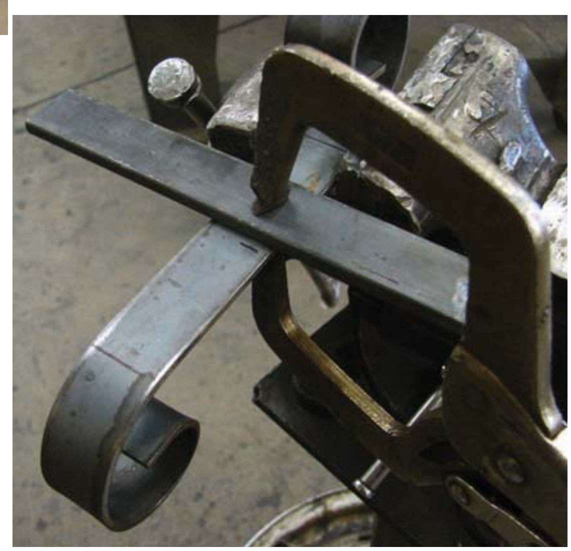
b) Turn the handle until the flat bar hits the template at the 6" mark.

c) Remove the flat bar and insert the other end.



d) Bend the second end.

e) Six duplicate parts.



f) Cut the wrought iron pieces in half using a straight edge and plasma cutter.

STEP 6. Trim the wrought iron spokes, then weld to the small wheels and axle support.

The wrought iron spokes were designed to be long to start with to accommodate changes in the wheel diameter as well as other benders that may not have exactly the same bending pattern as the one used in these illustrations. To help determine the proper length, first make a copy of Figure 13-14a. Lay the ring and the axle support on the paper pattern (Figure 13-14b). Then align a spoke and mark where it will need to be trimmed (Figure 13-15). Use a shear or plasma cutter to trim off the end. Repeat the same process for the other four spokes (Figure 13-16).

After laying out the spokes, tack them in place using a MIG welder. The paper may cause issues with grounding between the table and the parts. To solve this problem, carefully lay the ground on top of your parts and complete the five inside tacks, connecting each spoke to the axle support. Remove the paper, connect the ground to the work surface, and tack the spokes in two places where the spokes touch the wheel. Flip the wheel over and place the same solid tacks to the opposite side of the wheel. Repeat the same steps to complete the other wheel (Figure 13-17).

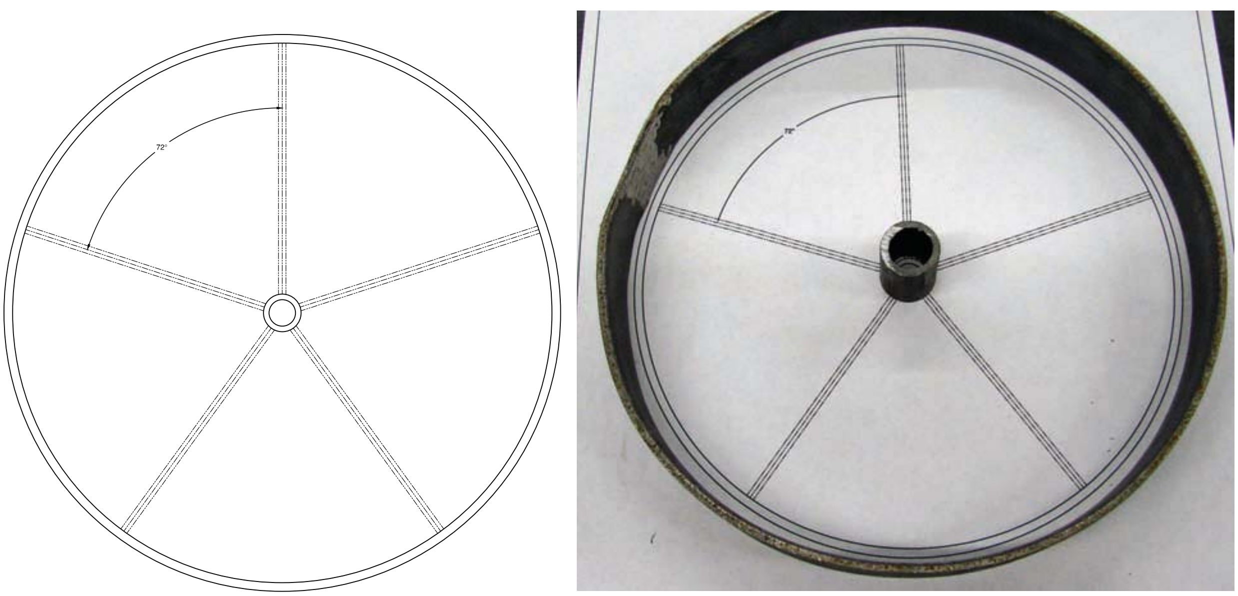


Figure 13-14. a) Small wheel spoke pattern. b) Small wheel ring and wheel axle support centered on the paper pattern.

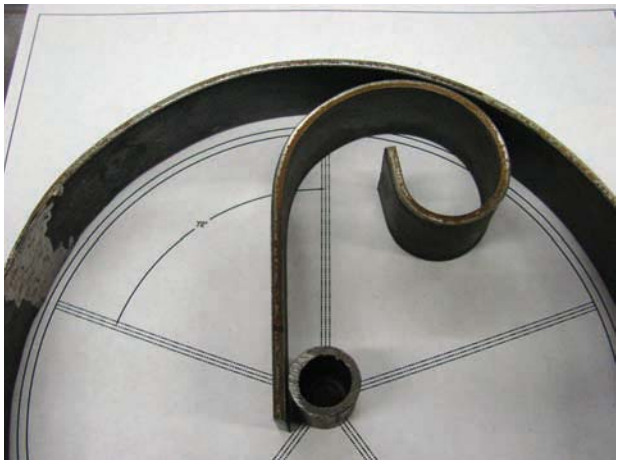


Figure 13-15. Determining the actual length of the small wheel spokes.

Figure 13-16. Spokes trimmed and ready to be welded.

Figure 13-17. Completed small tricycle wheels.

STEP 7. Weld the wrought iron spokes to the large wheel and axle support.

The process for completing the large wheel is similar to the small wheel; however, the pattern will need to be drawn on a flat surface in order to align the six spokes. To make the pattern, first trace the inside of the large wheel with a piece of soapstone. Then locate the center of the wheel using two framing squares. The center location is found when both framing squares sides are equal distance from the edge of the traced circle (Figure 13-18). Next trace a line across the center of the circle and remove the framing squares. Use the 60-degree side of a 30-60-90 triangle to draw the other two spoke locations (Figure 13-19).

Figure 13-18. Use framing squares to mark the center and draw a line dividing the circle.

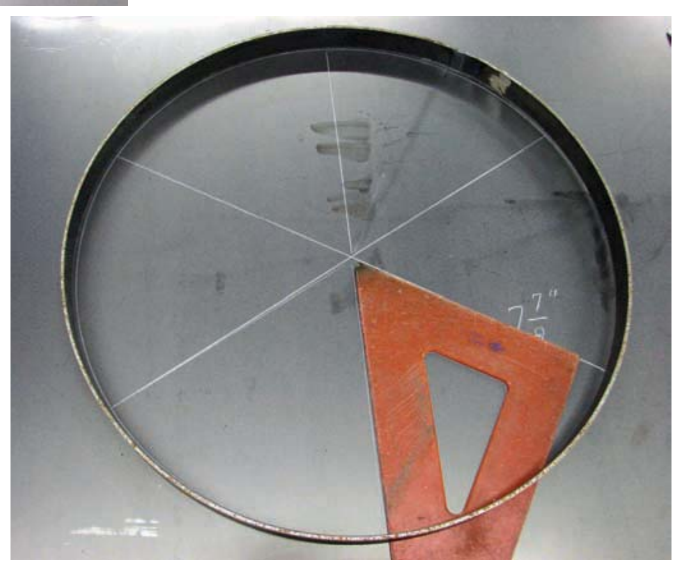


Figure 13-19. Use a 30-60-90 triangle to divide the circle into 6 equal sections.

With a pattern established, the large wheel spokes can be laid out and cut to the proper length using the same procedure used to mark and cut the spokes in the small wheels (Figure 13-20).

After the spokes have been cut to size and placed, *tack the outside — not the inside* — of the spokes first. This is important because the axle support is longer than 1"; the wheel and spokes need to be lifted up in order to center the support. After the spokes are tacked to the wheel, place two 3/8" pieces of round bar under the wheel to lift it up off the surface of the table, allowing the axle support to be centered properly. Now tack the inside of the spokes to the axle support. Then run a solid bead down one side of each spoke (Figure 13-21). Turn the wheel over place the same solid tacks on the other side of the wheel on the outside where the spokes touch the large wheel.

Figure 13-20. a) Lay out each spoke one at a time and mark where it needs to be trimmed. b) Large wheel spokes trimmed and in place.

Figure 13-21. Axle support centered and welded to the large wheel spokes.

STEP 8. Bend the connecter arm.

First cut the connecter arm to length. Then measure in 10" from one end and mark across the flat bar on both sides. This will be the stopping point when rolling. Refer to Figure 13-22 for bending dimensions.

To begin, place the flat bar in a heavy duty ring roller with the short end sitting on the top quadrant of the outside roll. Because the arc is not very extreme, adjust the tension a little at a time. Roll the part, stopping at the 10” mark. Then roll back and out of the bender and check the arc bend with a square and a tape measure (Figure 13-23). The bend is complete when the perpendicular measurement reads 1-9/32". Check the bend progress often so as not to go too far.

After bending the small arc, place the flat bar back in the roller, with the other end sitting on the top quadrant of the outside roll with the small arc down (Figure 13-24). Follow the same procedure for bending the large arc; be sure not to over bend by tightening the tension only a little at a time and checking your progress often (Figure 13-25).

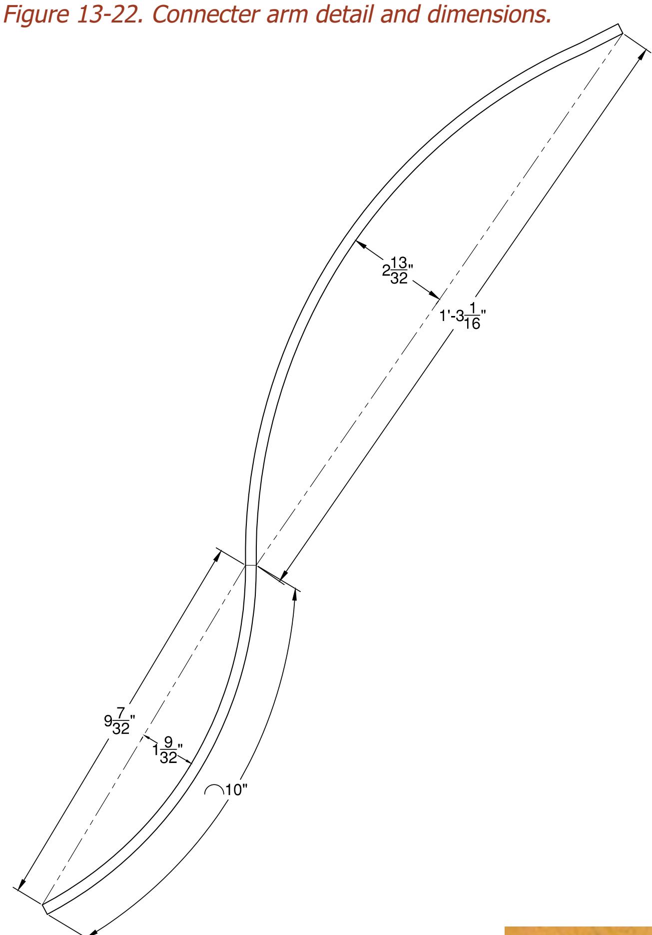


Figure 13-22. Connecter arm detail and dimensions.

Figure 13-23. Checking the arc bend.

Figure 13-24. Ready to bend the second arc in the connecter arm.

Figure 13-25. Completed connecter arm.

STEP 9. Cut the remaining flat bar parts to length.

The last flat bar parts that need to be cut to length are the wrought iron pot connecters, plant holder rings, handle bars, and front wheel fork (Refer to Figure 13-1 for lengths). Remove any burrs from the ends after cutting all the parts.

STEP 10. Bend the wrought iron pot connecters.

Before bending the wrought iron pot connecters, locate and mark the centers. Place them in the wrought iron bender one at a time and bend them around the template in the same manner used in Step 5 when building the spokes for the front and rear wheels.

STEP 11. Bend the wrought iron handle bars.

To begin, mark the bending point and the stopping point for the wrought iron bender, using the dimensions given in Figure 13-26. Using the wrought iron bender, bend the handle bars making sure to stop at the same point for each part.

The next step is to bend each part at the bending point 60 degrees. There are many types of benders available for this process. The one used in this example is a small bender meant for 1/8" or thinner material. Heavy material 1/4" or thicker would be impossible to bend with this small bender — any attempts to do so could permanently damage the machine.

To bend the part, place it in the bender with the wrought iron end up, line up the mark, and pull down on the handle until a 60-degree angle has been achieved (Figure 13-27). Use an adjustable protractor to check the bending progress often (Figure 13-28).

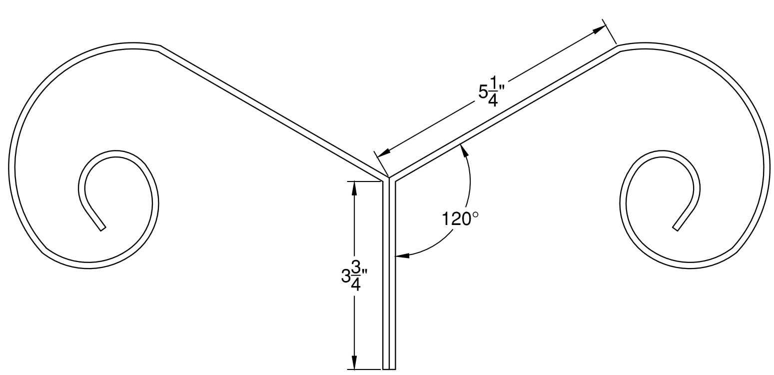


Figure 13-26. Handle bar detail.

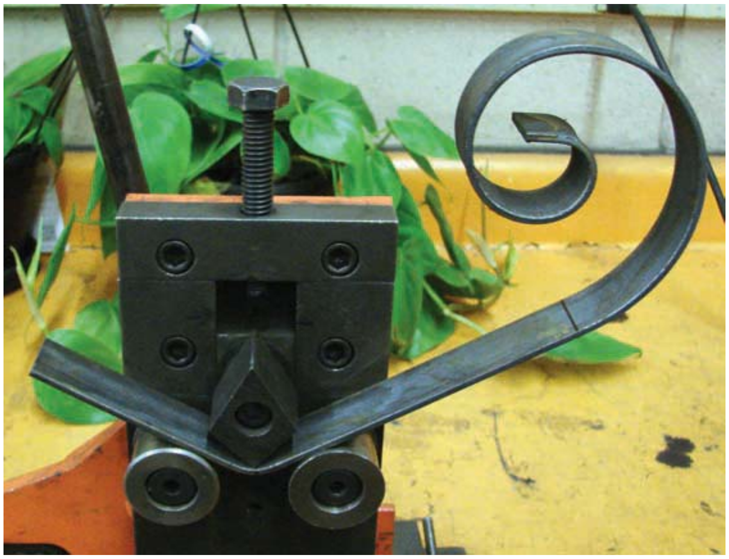


Figure 13-27.

Bend the handle bar with the wrought iron end up.

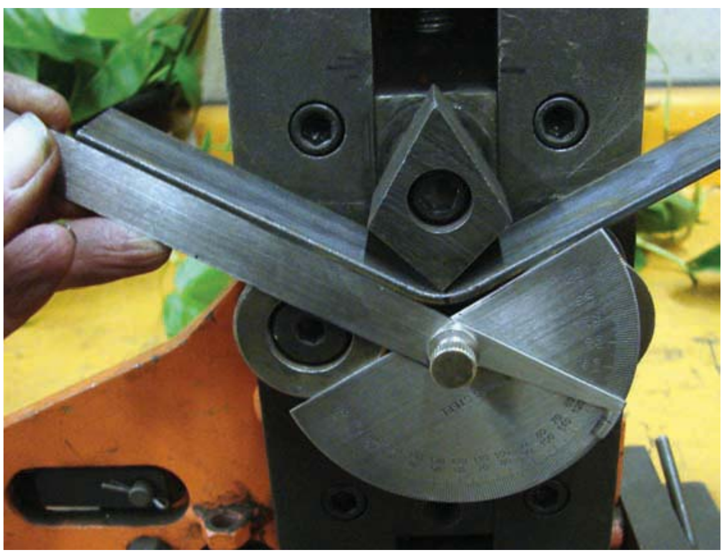


Figure 13-28.

a) Checking the bend angle with a protractor.

b) Completed handle bars.

STEP 12. Cut and prepare the front wheel fork.

The front wheel fork needs to have rounded ends; it must have holes drilled and it must be bent into its finished shape.

To begin, measure and mark the centers of the holes that the axle will slide through. Mark the bend point locations from each end, and use a 1" diameter circle template to trace the shape of the rounded ends (Refer to Figure 13-29 for location dimensions).

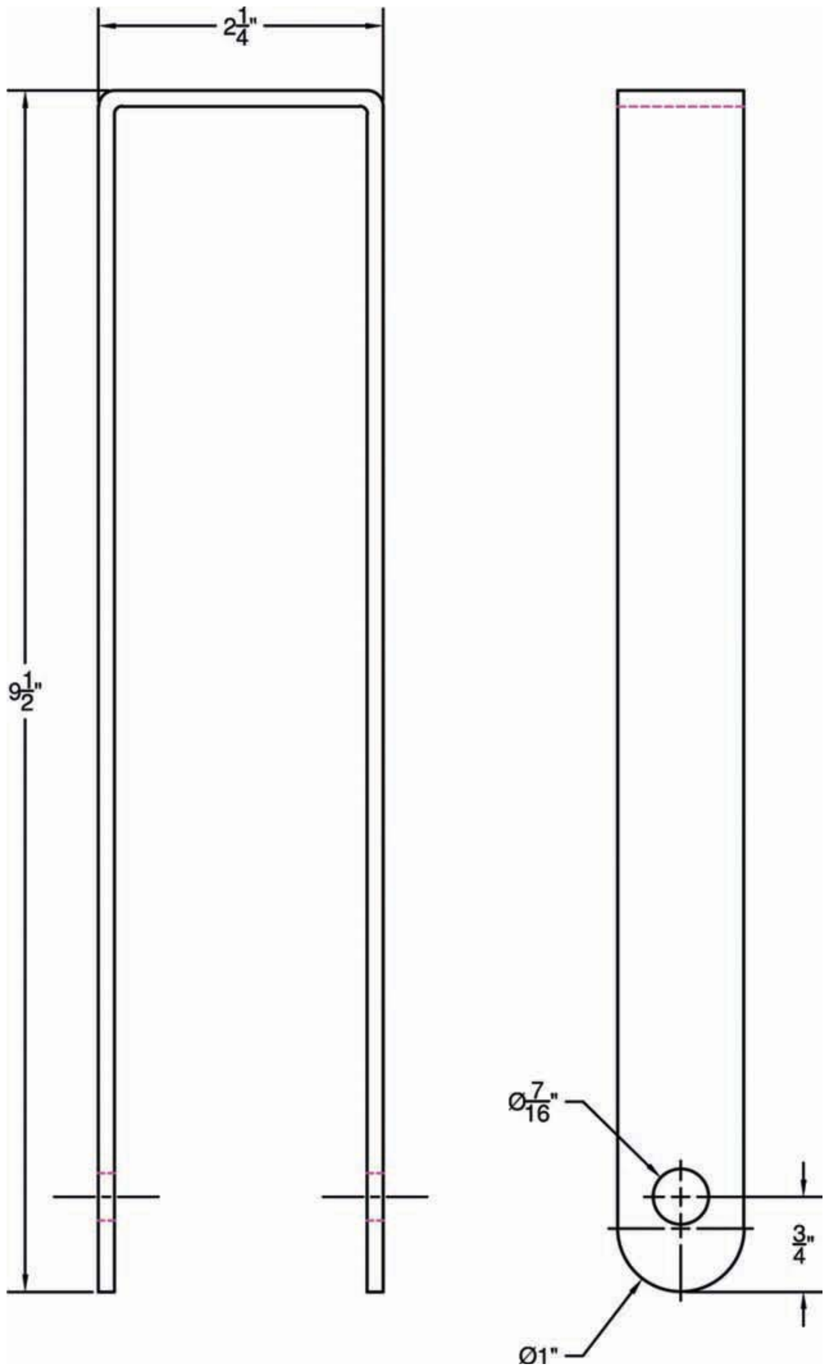


Figure 13-29. Front wheel fork detail.

Drill the 7/16" holes, using a drill press; then remove any burrs. Next, use a grinder to round the ends to their finished shape (Figure 13-30). To complete the fork, place it in a bender and bend each side to a 90-degree angle (Figure 13-31). If a small enough bender is not available to complete this step, the flat bar can be placed in a vice, heated with an oxyacetylene torch and bent to the proper angles.

Figure 13-30. Completed end on the front wheel fork.

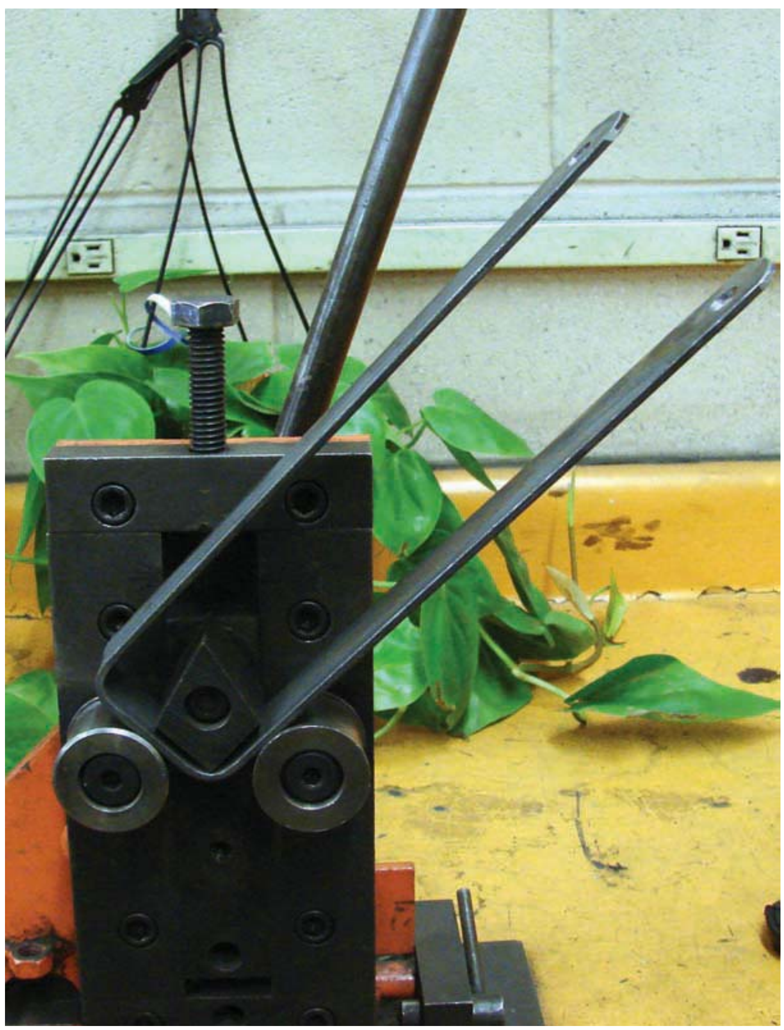


Figure 13-31. Bending the fork to 90-degree angles.

STEP 13. Fabricate the plant holder rings.

The plant holder rings are the same size as the rear wheels and can be rolled, trimmed, and welded using the same method (See Step 3 for details if necessary).

After the rings have been completed, two bottoms need to be cut out of the expanded flush material using a plasma cutter and circle cutting attachment. Before using the circle cutter, the circle centers need to be located and a tab with a divot will need to be tacked to the material in the center location. To locate the center of the circle, place the ring on the expanded metal and measure 4" to the center from at least two sides (Figure 13-32). Next, set up the circle cutting attachment to the proper radius and cut the circles. Afterwards, pry off the flat bar used as a pivot point and grind off the remaining part of the tack weld.

After the expanded metal circles have been cut, place them on the rings. Ideally, the expanded metal should just sit on top of the rings, forming a small outside corner joint at each point that the expanded metal touches. Weld the two parts together at each touching point with a small tack using a MIG welder (Figure 13-33).

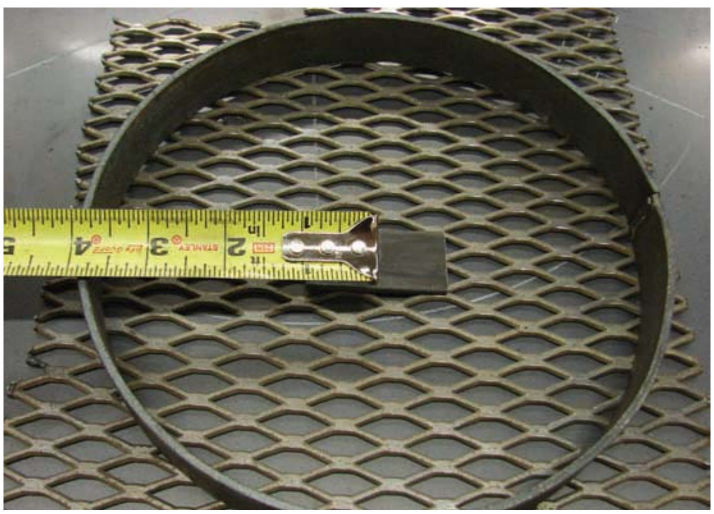


Figure 13-32. Centering the flat bar tab in the center of the ring.

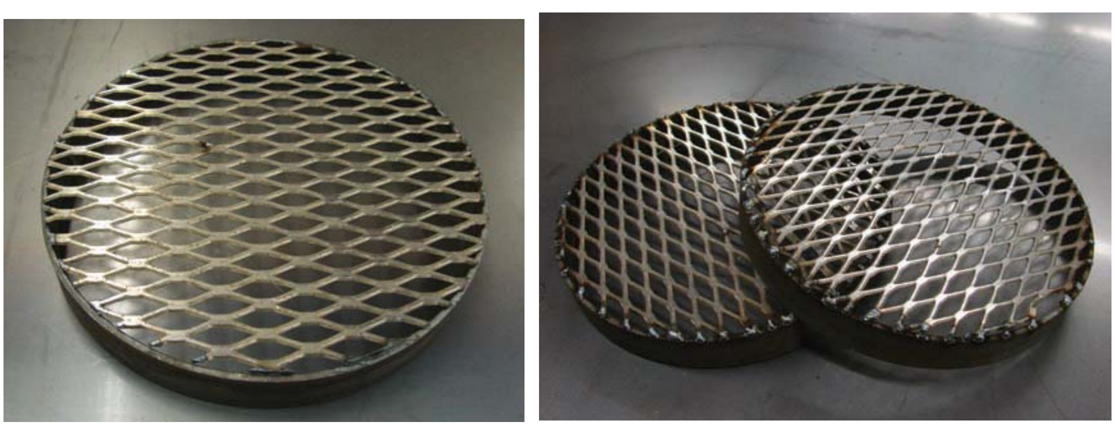
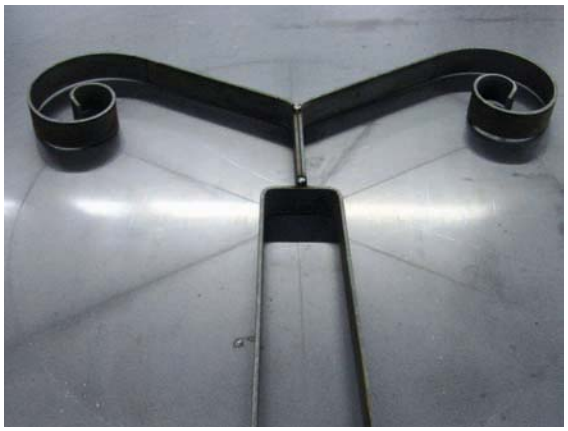


Figure 13-33. a) Properly fit expanded metal. b) Welded bottom plant holders.

STEP 14. Attach the handle bars to the front wheel fork.

The handle bars need to be welded together first by laying them side by side, lining up the ends, and placing a tack at the top and bottom. Then lay the front wheel fork against the end of the handle bars and align them so that they are centered and square. Next, tack the fork in place; then weld the parts together solid on both sides. Place a couple of one-inch beads along the edge of the forks as well (Figure 13-34).

a) 

b) 

Figure 13-34. a) Tacked handle bars with fork in place. b) Welded handle bars and fork assembly.

STEP 15. Attach the front wheel to the front wheel fork.

First cut the front wheel axle to length (Refer to Figure 13-1 for part information). After cutting, round both ends slightly to make it easier to slip the ends through the holes in the front wheel fork.

Next, place the wheel between the forks and slide the axle through the holes in the fork and the axle support in the front wheel. The axle should extend out past the surface of the fork 3/16" (Figure 13-35). With everything in place, weld around the axle on the outside of the fork to secure the front wheel in place (Figure 13-36).

Figure 13-35. Attaching the axle through the front wheel and fork.

STEP 16. Attach the rear wheels and axle stops to the axle.

To complete this step, slide the two inside axle stops onto the axle, then the wheels going through the axle supports that were welded to the center of the wheels, and finally the outside axle stops. Place the parts on a clean flat surface, with two pieces of angle iron setting web side up against the front and back of the wheels to keep them from rolling. Properly position the parts (Refer to Figure 13-3 for location dimensions), then tack the inner and outer axle stops in place. Check to see if the wheels roll freely. If so, weld the axle stops in place. Do not place any weld on the axle stop sides that touch the wheel axle supports (Figure 13-37).

Figure 13-36. Attached front wheel.

Figure 13-37. Completed back wheel and axle assembly.

STEP 17. Attach the connecter arm to the front wheel fork and rear wheel axle.

The connector arm should be tacked to the fork first. Make sure the long arc end is attached to the fork and the arc bends downwards. Use locking C-clamp pliers to hold the parts together while tacking. The arm should attach to the inside of the fork, be centered, and align parallel with the front wheel. If all of these requirements have been achieved, weld the arm with a solid weld on the front and back side of the fork (Figure 13-38).

Next attach the arm to the rear axle. First mark the place on the axle where the arm should attach. To keep the parts from rolling, lay the angle iron in front and back of the sides of the wheels and use locking C-clamp pliers to temporarily hold the connector arm in place on the back axle. The front assembly may be hard to hold steady while aligning these parts; therefore, it is a good idea to use a partner for this step. A square can be held next to the front wheel to keep it straight up and down. Another square should be used between the back axle and the point where the arm attaches (Figure 13-39). With everything in position, tack the parts in place, check for proper alignment, then weld the arm to the top of the axle in the front and back (Figure 13-40).

Figure 13-38. Connecter arm attached to front wheel fork.

Figure 13-39. Aligning the connecter arm and back wheel assembly with a square.

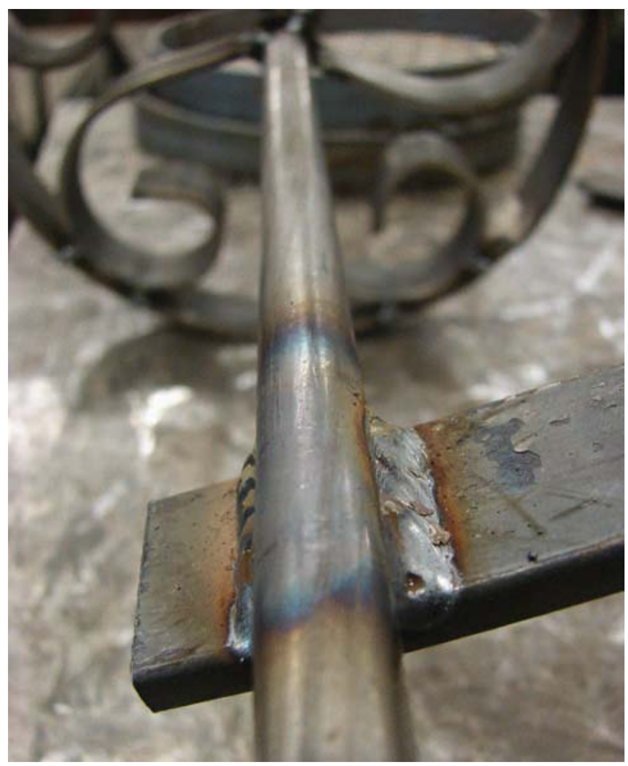


Figure 13-40. a) Tacked connecter arm. b) Connector arm welded to the back axle.

STEP 18. Cut, then attach the back wheel gusset to the connector arm and rear axle.

The back wheel gusset is cut with a 45-degree angle at both ends. It should measure 8" from point to point. The position of the gusset is not pertinent, but should be placed so that the angled ends are parallel with the rear axle and the connecter arm. When tacking, tack the end that attaches to the connector arm first, leaving a 1/8" gap for proper penetration of the butt weld (Figure 13-41). After tacking the gussets to the connecter arm and axle, weld the parts to the tricycle body solid (Figure 13-42).

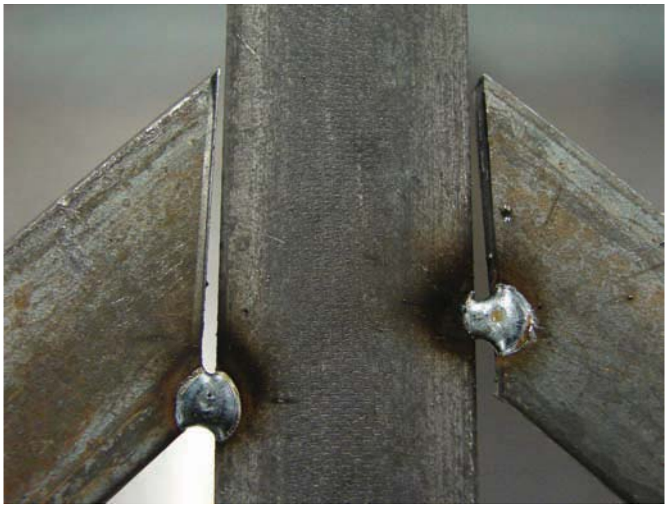


Figure 13-41. Gusset tacked to connecter arm.

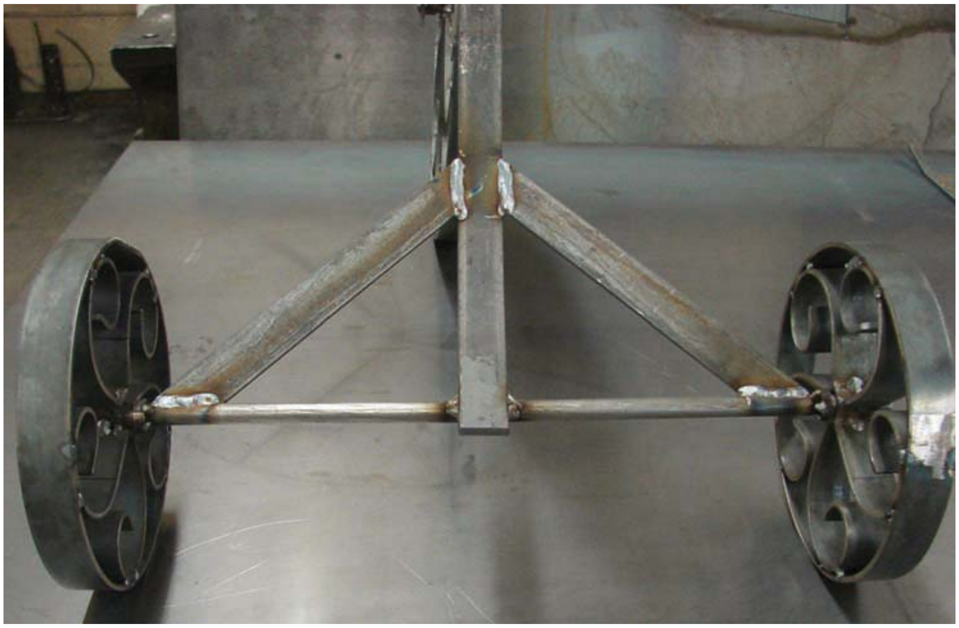


Figure 13-42. Completed gussets.

STEP 19. Attach the plant holder rings.

The bottom plant holder rings should be attached to the tricycle body first. To hold them in position while tacking, clamp two pieces of 1" x 1" angle iron to the rings. There should be 8" of space between the table surface and the bottom ring and equal distance between the back wheels and the edge of the ring (Figure 13-43).

With the part in place, tack one of the wrought iron pot connectors to the bottom of the ring and the connector arm. The exact placement is not important as long as it is in the middle of the connecter arm and tight up against both the arm and bottom ring (Figure 13-44). The exact location where the ring attaches to the connector arm is not that important. Just try to keep it close to centering over the top of the axle.

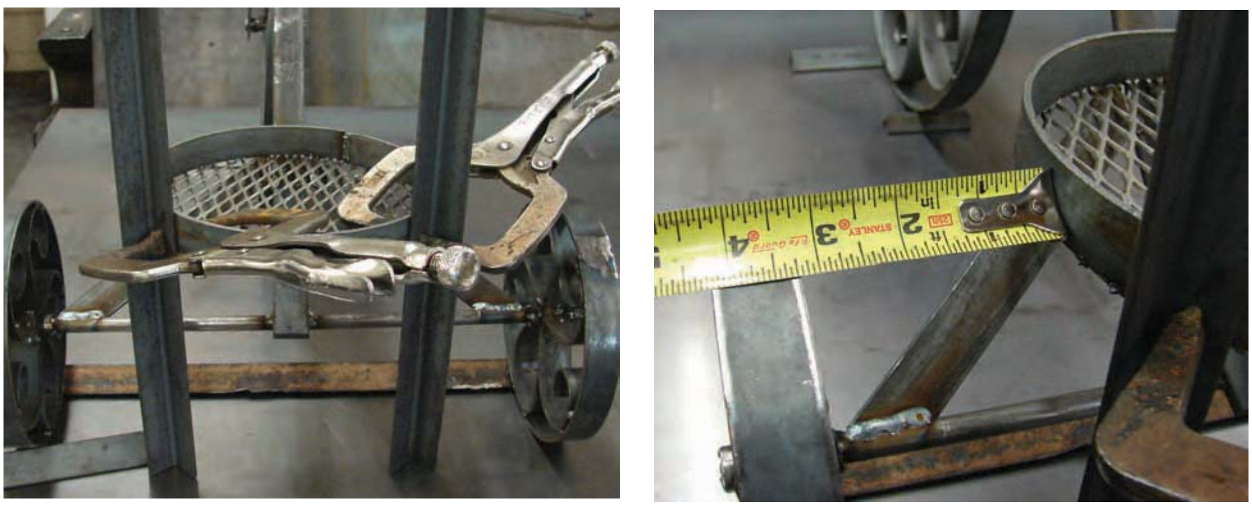


Figure 13-43. a) Positioning the lower, bottom plant holder ring. b) Centering the lower, bottom plant holder ring.

Figure 13-44. Lower, bottom ring tacked in place.

Figure 13-45. Lower, top ring clamped in place.

The next step will be to align the top ring and tack it in place. Again use locking pliers and an angle iron to place the upper ring 2" above the top edge of the bottom ring (Figure 13-45). (Note: The plan view in Figure 13-2 indicates a 3" space. The builder of this tricycle chose to alter the plans and move the rings closer together.) With the ring situated, use two wrought iron pot connectors to attach the ring to the body of the tricycle. Again, the placement of the connectors is not that crucial as long as they are in-line with the connector arm. Weld all connectors solid after tacking is complete (Figure 13-46).

Figure 13-46. Lower plant holder complete.

After the bottom plant holder rings have been attached, follow the same procedure to attach the top plant holders. Longer pieces of angle iron are required to attach these parts (Figure 13-47). The last three wrought iron connectors are used to attach the top plant holder rings. Again, place them in line with the connector arm and flush against the rings. Tack them in place first, then weld them solid (Figure 13-48).

Figure 13-47. Aligning the upper, bottom plant holder.

Figure 13-48. Upper rings and wrought iron pot connecters attached and welded solid.

STEP 20. Final cleanup and painting.

Because the parts were welded together with a wire feed welder, a certain amount of spatter will be present near all weld areas. Use a scraper and a chisel and hammer to remove the spatter. Use a metal file and a grinder if necessary to smooth any sharp edges (Figure 13-49). After the welding and cleanup are complete, the final step in completing the project is to apply a coat of primer and paint to protect the parts from rusting.

Figure 13-49. Project complete and ready for a paint job.

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