PANTOGRAPH SHAPE CUTTING MACHINE PLANS

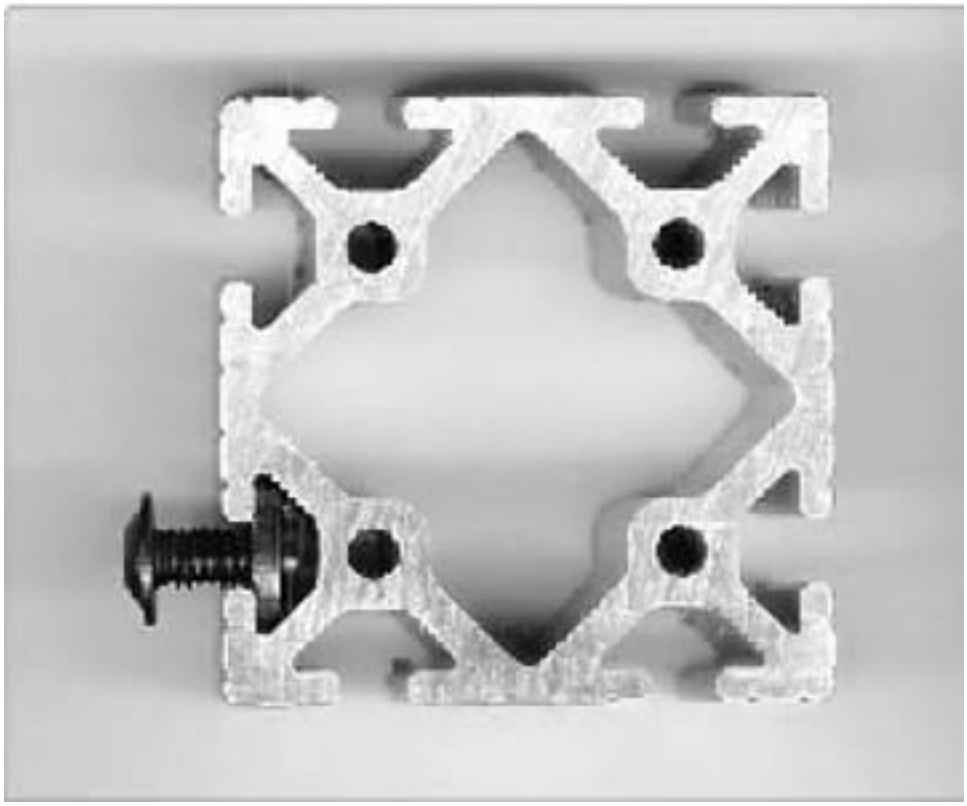
INTRODUCTION

Congratulations on having purchased our Pantograph Shape Cutting Machine Plans. The term pantograph refers to the folding metal arms that support both the driving mechanism and the torch. The first pantograph cutting machine was patented in 1917, and served as the principal means of cutting shapes for almost 60 years.. Note that the background on this page shows an illustration from a 1921 patent for a refined pantograph machine.

The pantograph machine utilizes a motorized, variable speed, magnetic tracing rotor that follows the perimeter of a steel template of the shape that is to be cut. As the rotor rolls around the template the torch tip, directly below, duplicates the shape in metal. The torch tip must be precisely aligned with the center of the tracing rotor in order to produce accurate replicas. We provide you with a method of accomplishing this.

Your unit will be constructed of a combination of off-the-shelf items, and components which you will fabricate yourself. You will need access to a band saw, metal lathe, drill press, welder, and common shop tools to complete the project. The plans include a complete list of materials, and source information.

Overview



Your Torchmate machine will be constructed largely from aluminum extrusions and brackets manufactured by the 8020 Company in Columbia City, Indiana. Their products are available on eBay.

The extrusions are fastened together with brackets using button head cap screws, and “ t-nuts ” that slide into grooves in the extrusions as pictured above.

Note that one side of the t-nuts is convex to provide sufficient thread surface. The convex side of the t-nut always goes toward the bottom of the slot, as shown in the cross section photo above.

Generally, it is easiest to assemble the cap screws and t-nuts loosely to the bracket to be mounted, and then slide the bracket so the t-nuts enter the slots.

The brackets required for assembling the frame of the machine are shown below. The top five will be purchased from the 8020 Company, along with the t-nut fasteners shown. You will fabricate the bottom piece from ¼" x 1" hot roll steel. Details about making this and other fabricated pieces will be covered later.

The t-nut fasters shown here are not included with the brackets and will be covered in the materials list in the last pages of this document.

The 8020 part numbers for the above 5 brackets from left to right are:

Base plate #2387N (this comes as one assembly) February 2019 price: $33.10

Eight hole gusseted inside corner bracket #4238N February 2019 price: $7.45

Eight hole inside corner bracket #4286N February 2019 price: $6.90

Six hole inside corner bracket #4111N (2 required) February 2019 price each: $6.90
(note that these pieces are shown here with bushings installed – explained later)

While not technically considered a bracket, you will also require 8020 part #2132N, which is priced in February 2019 at: $13.65. It is shown below.

You will need a length of extrusion #2040 (2” x 4”) 25” long. It is recommended that you have 8020 cut this for you, as the ends must be cut precisely at a right angle to the length of the piece. The preciseness of the cut is more important than the preciseness of the length. A cross section of this piece is shown below:

You will also need a length of extrusion #2020 (2” x 2”) 17” long. The preciseness of this cut is not quite as critical, although for appearance sake it should be as neat as possible. A cross section is shown below.

You will need a length of extrusion #1010 (1” x 1”) 10” long. A cross section is shown below:

It is fairly apparent from the photo on Page 1 how these pieces will fit together. The 2” x 4” piece is the vertical column. The 2” x 2” piece is the overhead arm. The 1” x 1” piece provides the height adjustment for the torch holder.

The only parts that you need to fabricate are the swinging arm components, the motor mount, and the torch mounting plate. These are made of commonly available materials which can be located locally or ordered over the Internet. We can supply an optional package containing the swinging arm parts cut to length, if desired.

The motor mount and torch mounting plate you will fabricate from 3/16” hot roll steel. This is the same material you will use to make your templates, so you might want to stock up on it. I you prefer, we can supply a small piece sufficiently large to make the above parts.

We also have available an optional small parts package containing all the button head and socket head cap screws, t-nuts, bushings, shaft collars, dowel pins, etc., necessary to complete this project. This prevents your having to go to multiple sources, buying boxes of 50 when you only need 4 or so, and paying multiple separate shipping charges.

IMPORTANT: Note that when assembling the extrusions and brackets it is necessary to do it in the order shown. Once the end of an extrusion slot is blocked, no additional t-nuts can be slid into it. All pieces that use extrusion slots must be installed prior to blocking the end of a slot.

Installing the Bronze Bushings

You will need to drill one hole oversize using a drill press with a 7/16” drill bit in each of the two six hole inside corner brackets #4111N. This will accommodate the oil impregnated flange bushings as shown below. If possible, use an arbor press to press in the bushings, and make sure the flange goes to the outside of the bracket as shown.

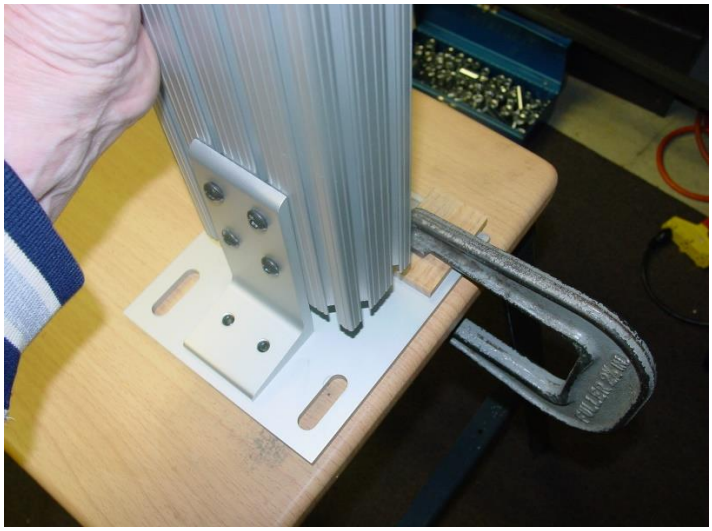
Assembling the Frame

Start by pre-fitting cap screws and t-nuts to the above brackets as shown above. Again, the protruding side of the t-nuts goes away from the bracket. Note that the two brackets at the upper right are identical, even though the bronze bushing in one of them cannot be clearly seen here.

Next, locate a suitable assembly table such as the one pictured. Of course, the finished machine will be situated on a mounting surface suitable for cutting.

Using a C-clamp, secure the corner of the base plate to the table surface, as shown. The vertical column will extend into the area to the left of the C-clamp, when put into place.

Aligning the t-nuts vertically with the slots on the long aluminum extrusion, slide the column down until it sits on the base plate. There must be enough play in the cap screws and t-nuts for them to slide freely without coming loose.



Using a 5/32 ” hex (allen) wrench, tighten down the cap screws. Tighten securely, but take care not to over-tighten.

Slide one of the two brackets with the oil-impregnated bushings down the opposite side of the column from the C-clamp, so the t-nuts engage the slots. The bracket should be lowered until top of the bushing flange is exactly 9 1/4 ” from the top of the base plate. Then tighten the cap screws into the t-nights. They will need to be readjusted later, when aligning the pantograph pins through the bushings.

Next, slide the matching bracket down the column so the two bushing flanges face each other. There should be approximately 11 1/8 ” between the two bushing flanges.

The photo below shows both brackets with the bushings secured into place on the column.

Slide the gusseted angle bracket down so its top surface is even with the top of the column. Secure in in place with one or two cap screws, as it will have to be adjusted again. Note that when installing the 8 hole gusseted inside corner bracket shown

below, standard (rather than 8020) button head cap screws must be used on the 4 inside holes to prevent interference with one another.

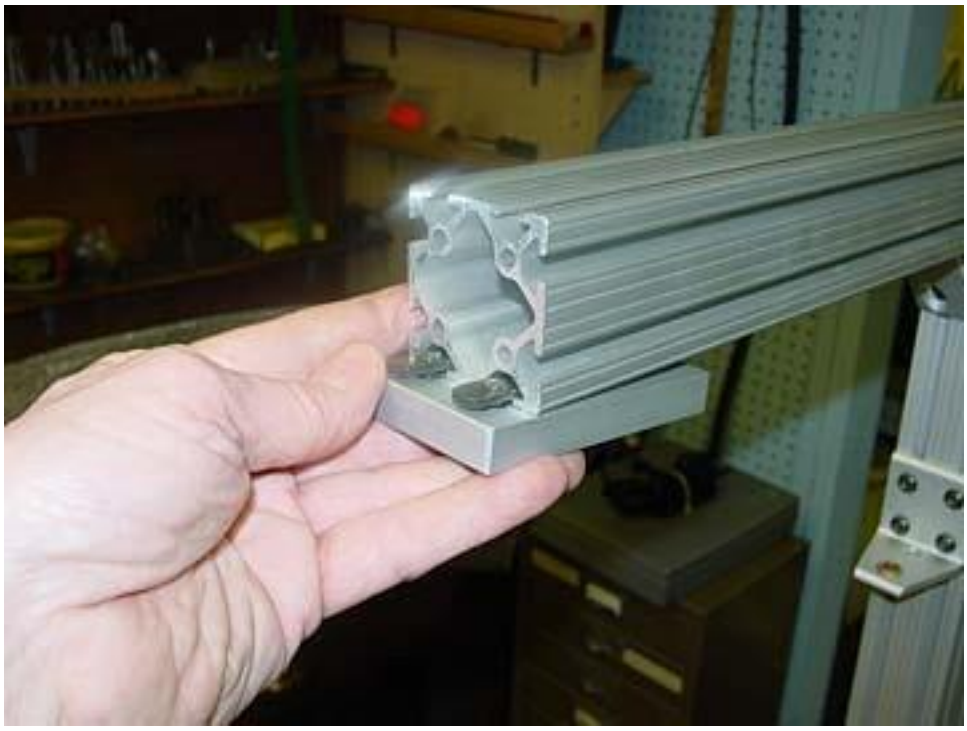
Slide the non-gusseted angle bracket down the side of the column as shown. The top of the bracket (with the thumb seen on it here) should be approximately 2 1/2 ” down from the top of the column — closer to the top than seen here.

Slide the threaded end of the 2 ” square extrusion back over the t-nuts in the gusseted corner bracket.

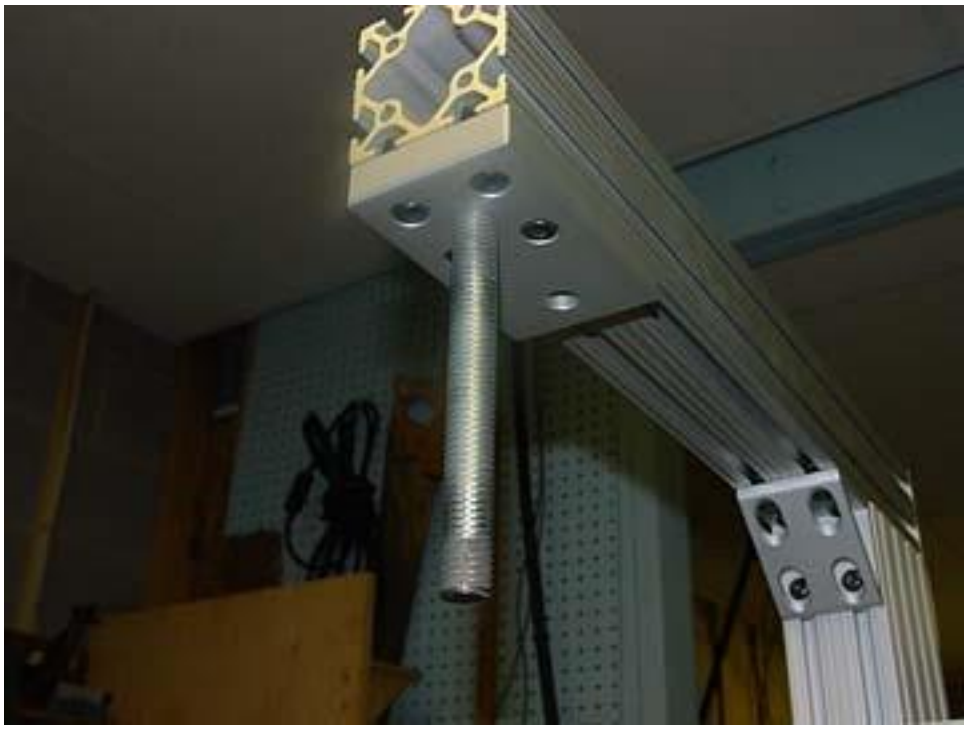
Secure the horizontal extrusion in place with four cap screws, and re-tighten the bottom four cap screws in the flat bracket. Re-adjust cap screws in gusseted corner bracket so that it fits flush against the top of the horizontal extrusion.

Insert four socket head cap screws into the counter-bored side of the piece shown below bracket, and loosely attach four t-nuts. Again, the protruding side of the t-nuts face away from the bracket.

Slide the t-nuts into the slots on the bottom side of the horizontal extrusion until the outside end of the piece is flush with the end of the extrusion. Bracket shown here has an unused hole at the rear. Please disregard.



Tighten the four cap screws in place.



Screw a 4 ½” length of 1/2 ” diameter all-thread into the bottom of the flange you just installed. Tighten it securely into place. You can double-nut the lower end of it in order to tighten it. This all-thread will support your templates.

This is what your assembly should look like so far.

Fabricating the Pantograph (folding arms)

To fabricate the two pantograph, or folding arms parts of the machine, you will need the following materials:

1 ea. - 1” diameter cold roll round steel bar exactly 11” long (piece G)

1 ea. - 1” diameter cold roll round steel bar exactly 9” long (piece F)

2 ea. - 1” x 1/2” cold roll flat steel bar exactly 10” long (pieces H & I)

1 ea. – 1” x 3/8” cold roll flat steel bar exactly 5” long (piece J)

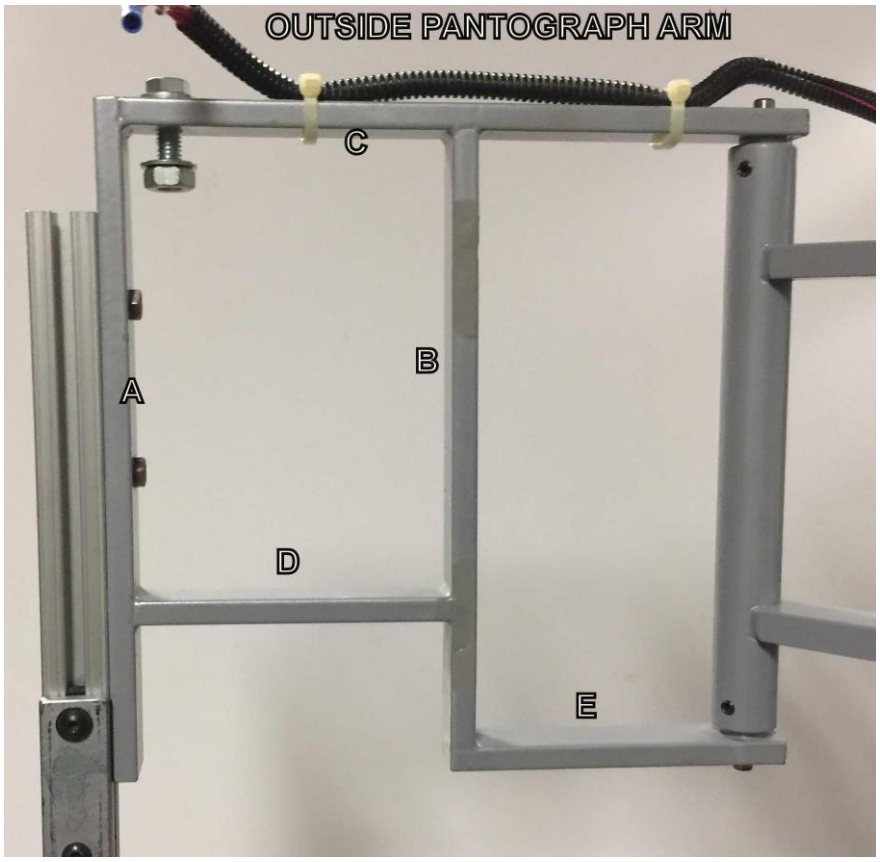
2 ea. - 1” x 3/8” cold roll flat steel bar exactly 10” long (pieces A & C)

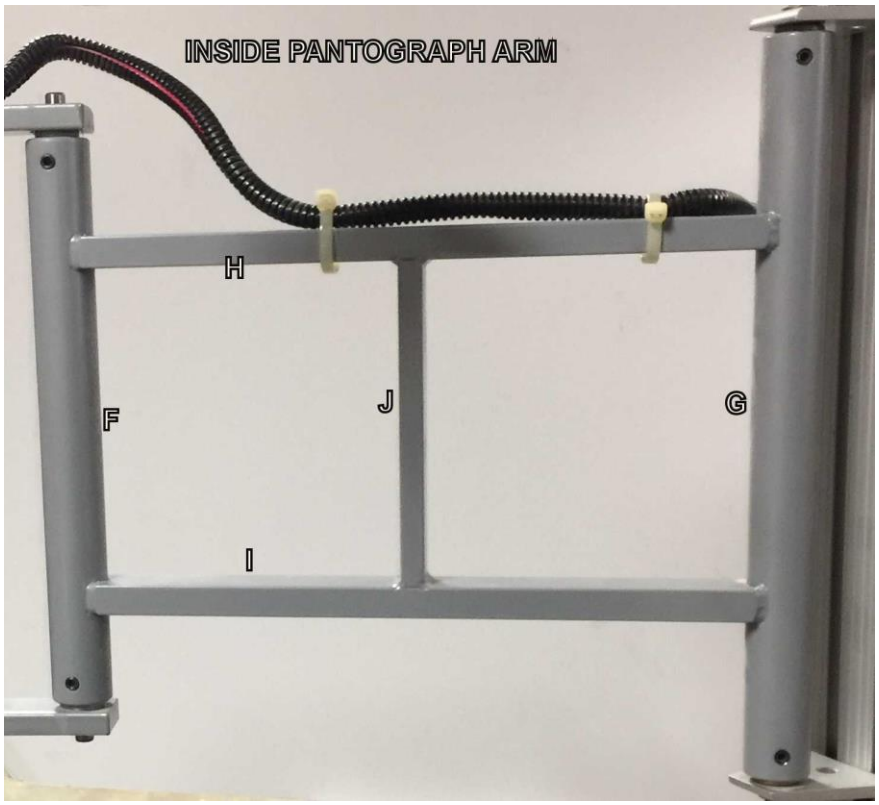
1 ea. - 1” x 3/8” cold roll flat steel bar exactly 5 1/4” long (piece E)

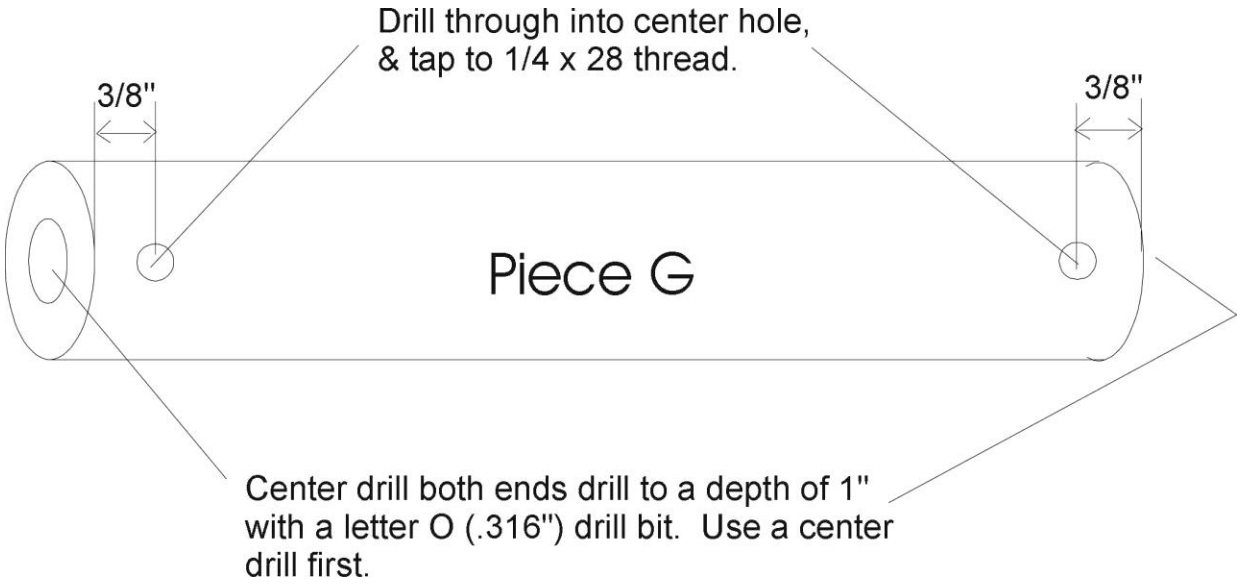
1 ea. - 1” x 3/8” cold roll flat steel bar exactly 9 1/4" long (piece B)

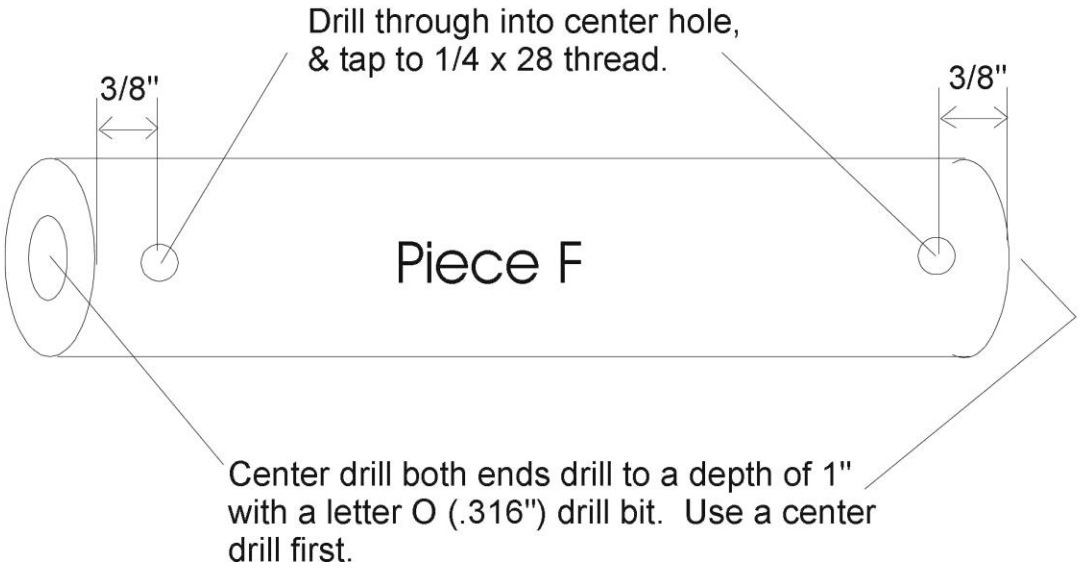
1 ea. - 1” x 3/8” cold roll flat steel bar exactly 4 3/4" long (piece D)

4 ea. – oil impregnated bronze flange bushings 5/16” ID x 7/16” OD 1/2" long (MSC part #06454425)


OUTSIDE PANTOGRAPH ARM
C
B
A
D
E


INSIDE PANTOGRAPH ARM
H
F
J
G
I

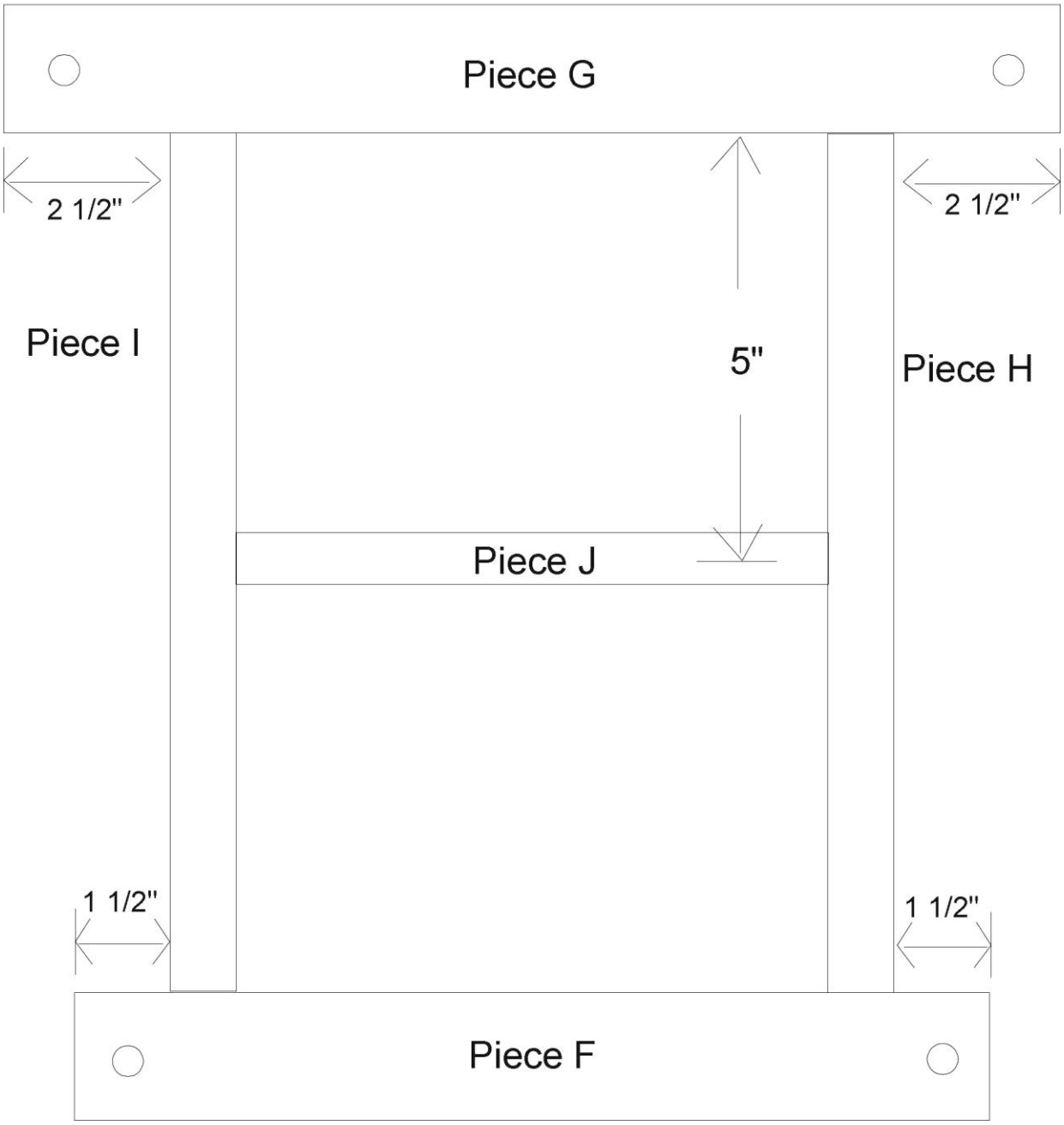




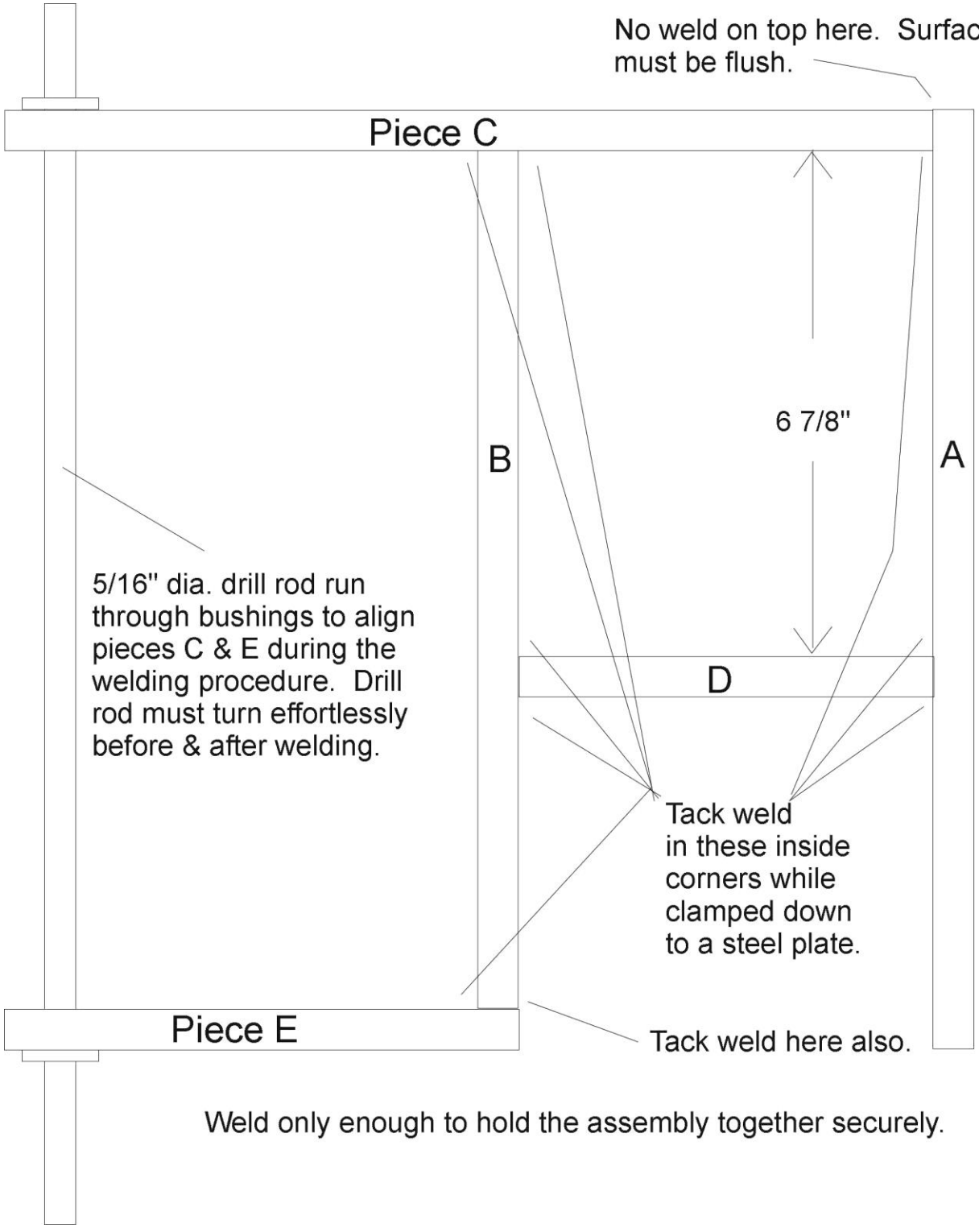
Drill the holes in the ends of the pieces before drilling and tapping the set screw holes. Bevel the end holes slightly to clean them up. Pieces H, I, & J require no work other than being cut to length and the ends de-burred.

Welding the Inner Pantograph Arm

Clamp all pieces down to a flat steel plate, after squaring all the joints with a machinist's square. Tack weld and tweak them as necessary for them to remain square and flat against the plate after welding. Just put on enough weld to hold it together securely. Pieces F and G must be perfectly parallel to each other after welding. This is the most critical part of the operation.



Since this will be clamped down while welding, it is probably easiest for you tack weld the inside of the mating joints, rather than the outer edges as shown in the earlier photo.



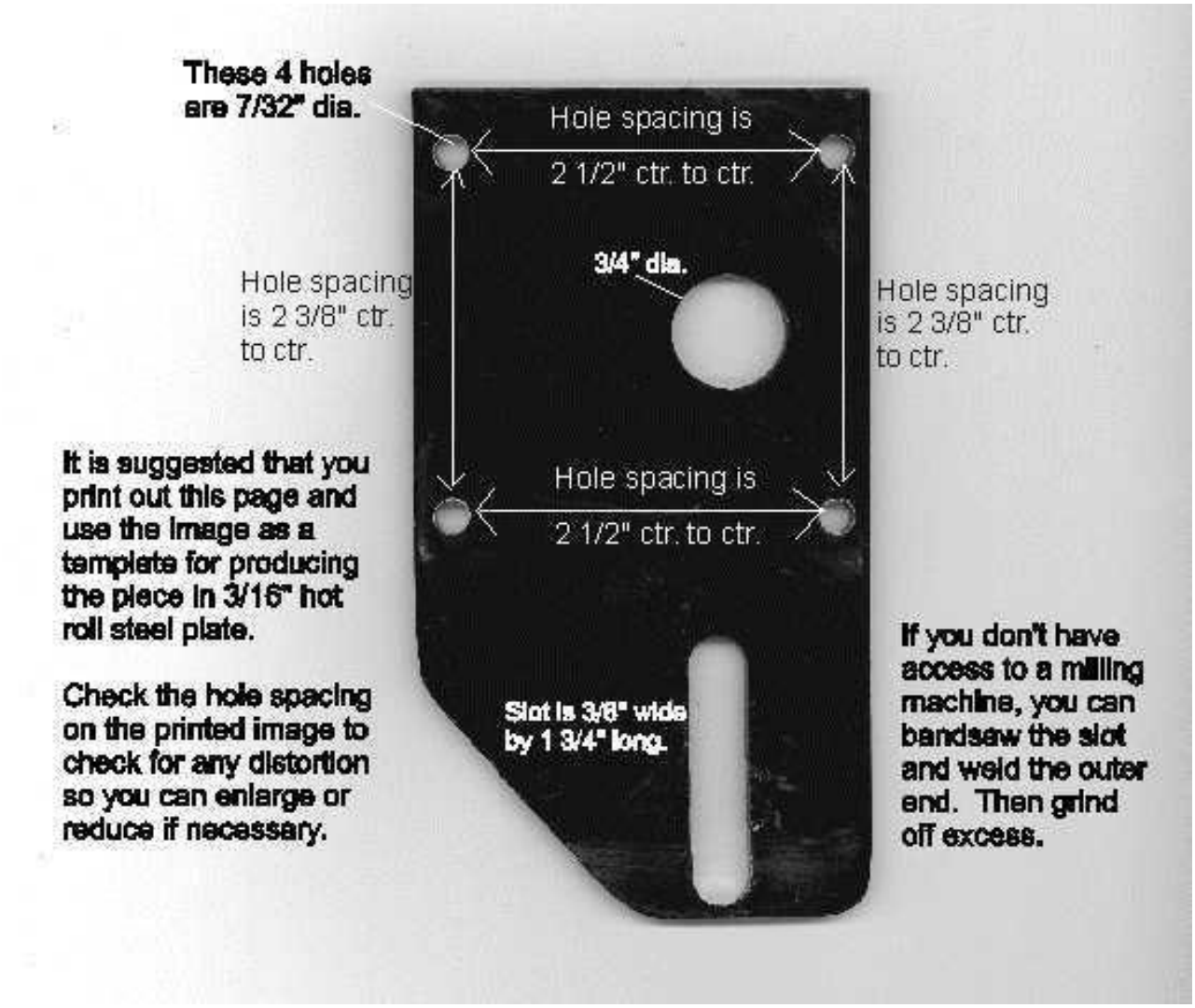
Weld only enough to hold the assembly together securely.

It is now time to install the pantograph. Insert the supplied setscrews in the 1/4 ” x 28 holes in the round inside bar of the pantograph. Have a friend or co-worker hold the pantograph in place, while you insert the 5/16” diameter dowel pins through the top and bottom bushings. Then tighten the set screws to the dowel pins. Adjust the alignment of the brackets so the pantograph swings freely.

Slide two t-nuts into the top slot in the horizontal extrusion as shown. Insert one of the supplied plastic tie strips through the two t-nuts as shown, and then start the second tie strip over the first to serve as an extension.

Place the power supply on the bracket as shown, and then pull the tie strips tight around it, and clip the protruding ends. The power supply can now be removed and/or replaced simply by lifting or lowering it.

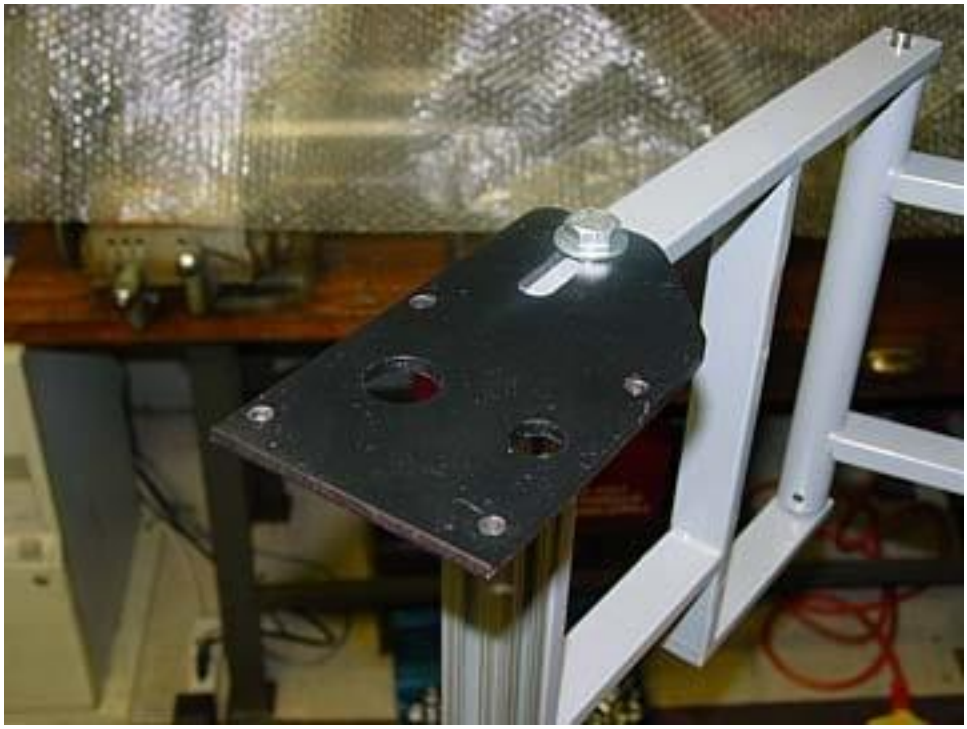
Fabricating the motor mount



Use the image on the following page as a template for the motor mount shown above. Note that the additional hole shown in some of the photos was used for a different motor, and is not needed in this application.

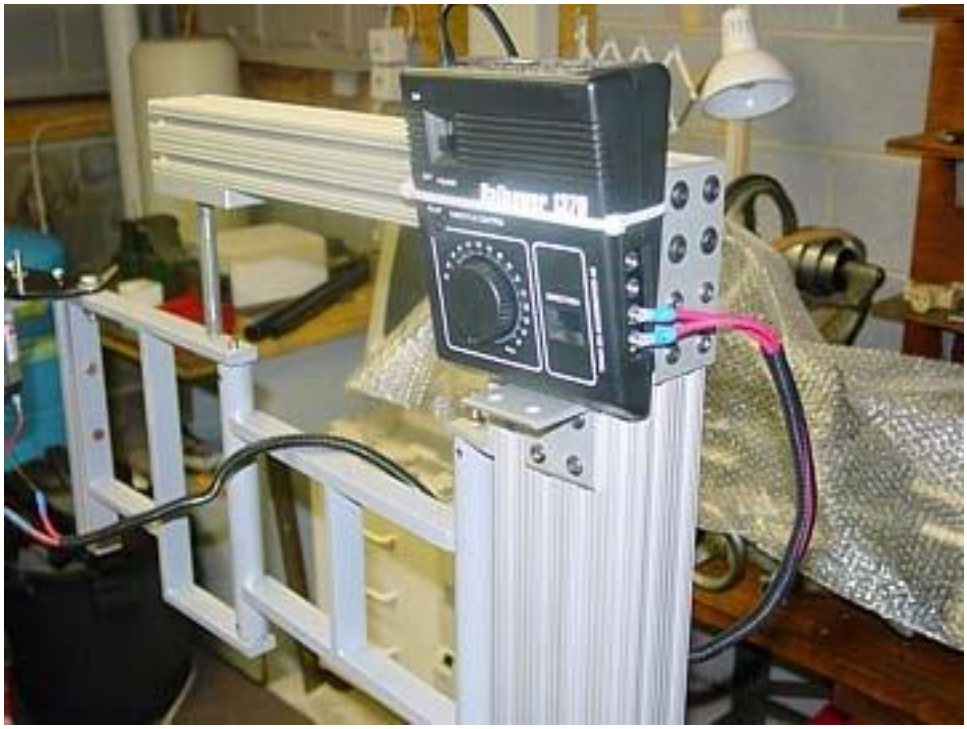
Insert the two 1/4 ” x 3/4 ” diameter bolts through the front of the pantograph, and loosely screw two t-nuts in place.

Slide the 1” square x 10 ” long extrusion down on the t-nuts until it is flush with the top of the pantograph. Then tighten the bolts into the t-nuts.



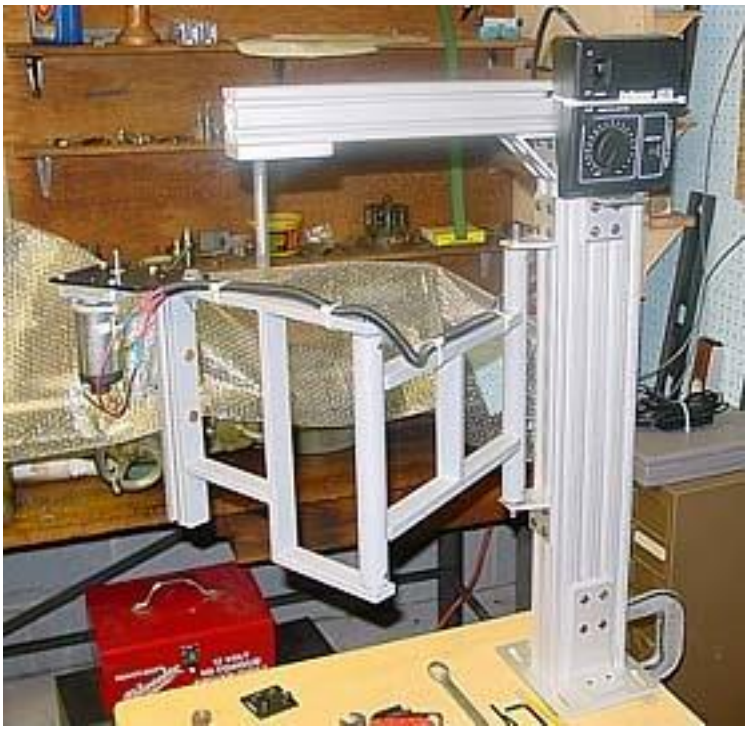
Install the motor mount bracket using a 5/16 ” x 1 ” long hex head bolt and nut, with a flat washer on the top and bottom of bracket. Only hand tighten it, as it will need to be swiveled and adjusted in or out to align the tracing rotor with the torch tip.

Secure the motor to the motor mount using the supplied screws. Note that both the motor and power supply box may vary in appearance from those shown in these instructions.

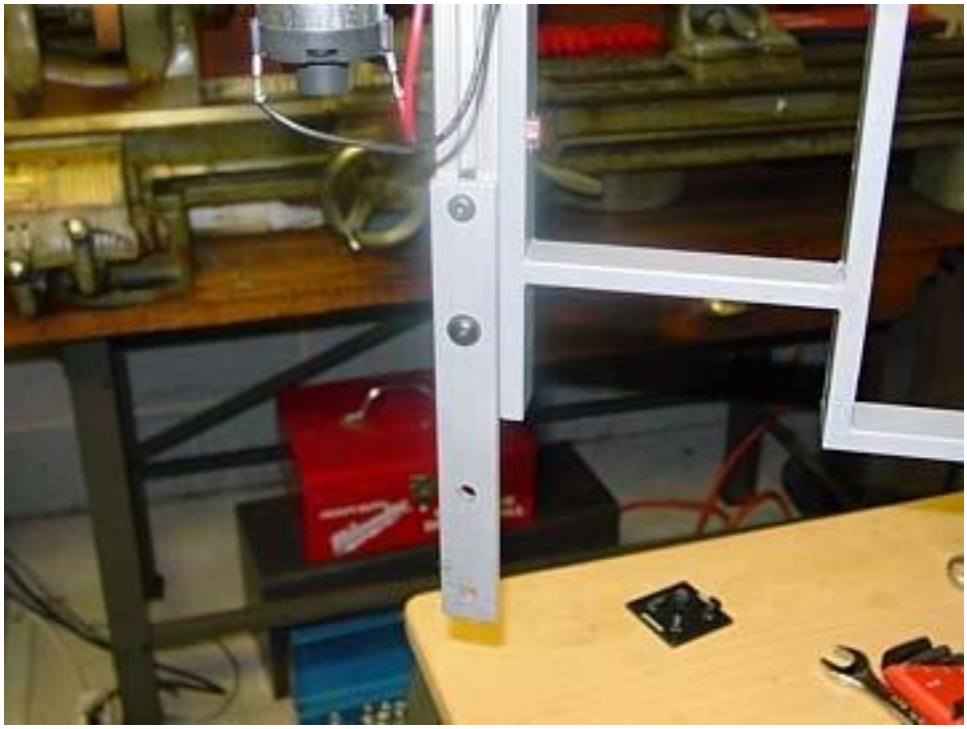


Insert the two supplied wires through the flexible plastic wire sheathing, using two crimp fittings to attach them to the motor leads on one end, and the two crimp spade connectors to attach the other ends of the wires to the **power supply 's D.C. terminals.**

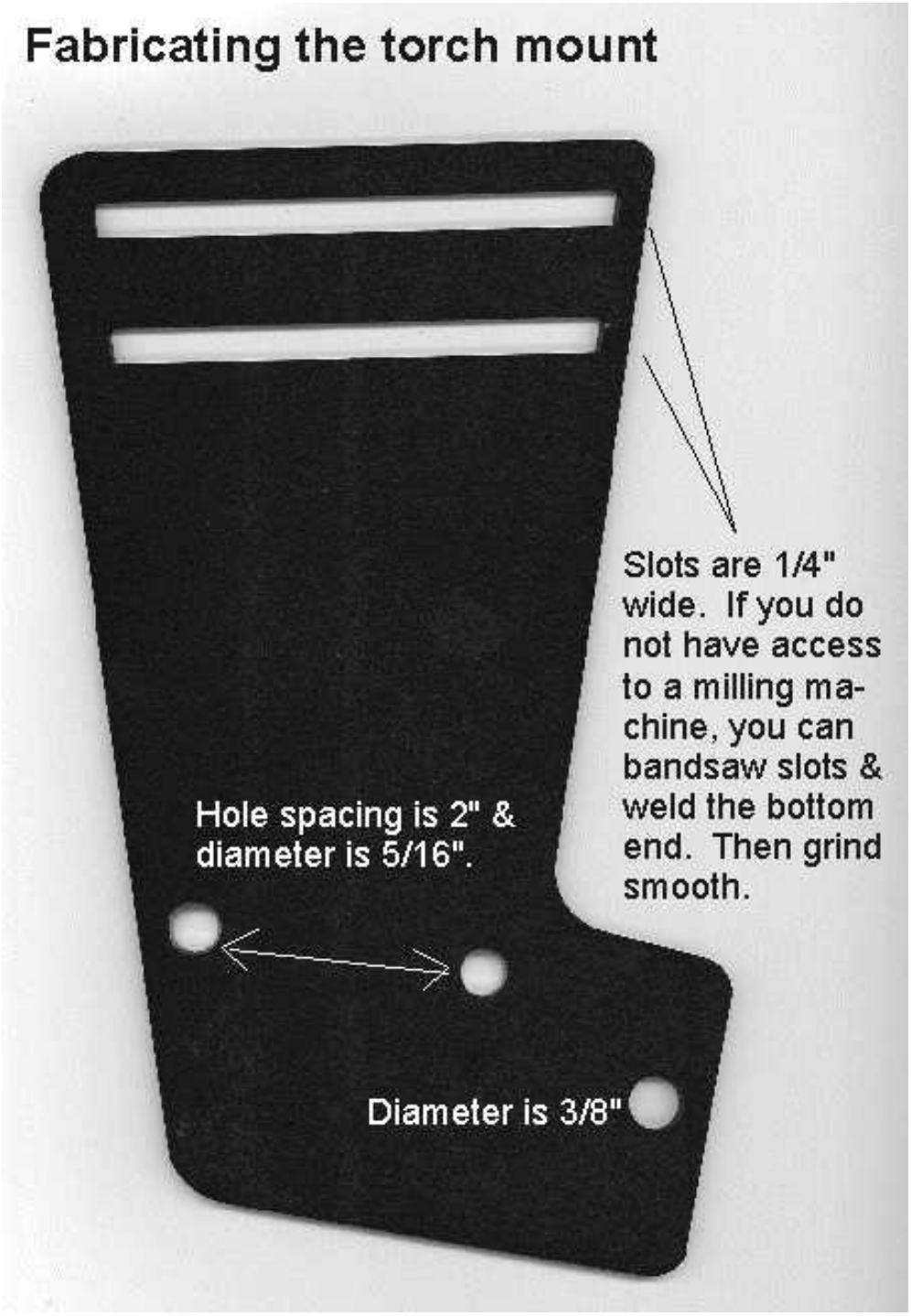
This is important, as connecting the wires to the A.C. terminals could ruin both the motor and power supply. Oversize wires are shown here for clarity sake.



Use the small plastic ties to secure the wire sheathing to the pantograph sections as shown.



Slide the 1/4 ” x 1 ” steel strip with four holes onto the 1 ” square x 10 ” extrusion on the end of the pantograph, using the supplied button head cap screws and t-nuts. The precise vertical location on the extrusion will be determined later.



Use the image on the following page as a template for fabricating this piece from 3/16” steel plate. 1/8” would probably also be sufficient. Check the 2” hole spacing on the printed sheet to check for any distortion during printing that might need to be corrected.

You might want to make the slots slightly wider than 1/4” so a 1/4” U-bolt will fit.

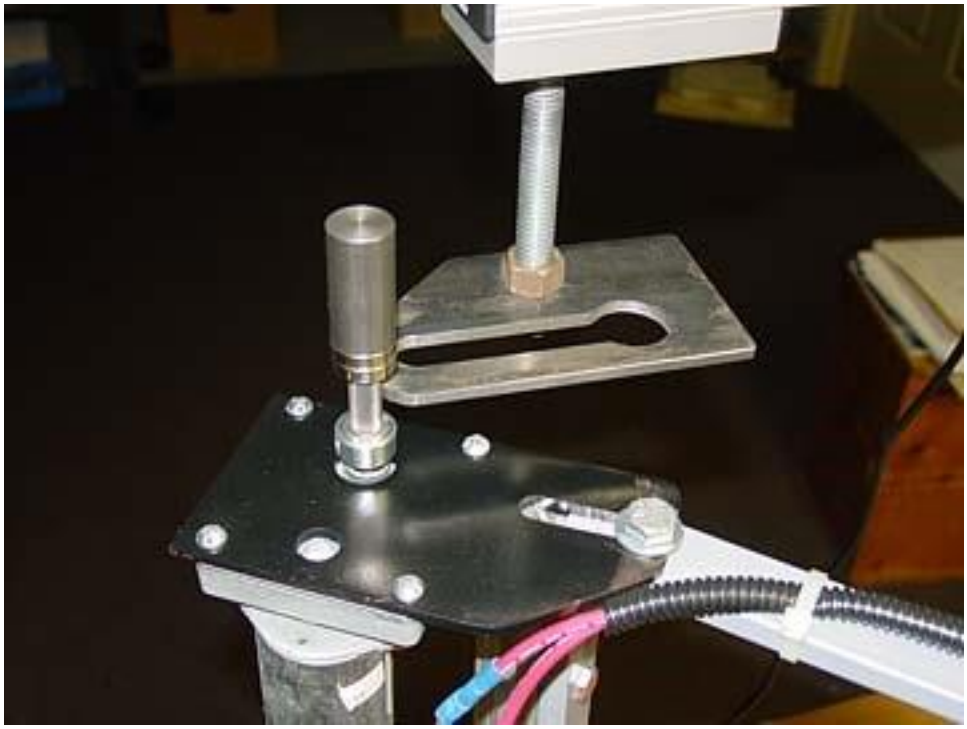
Bolt the torch support bracket to the steel strip using the supplied 5/16 ” x 1 ” hex bolts, nuts, and flat washers.

Loosen the set screw on the shaft collar with the welded bolt. Insert the bolt through the hole in the bottom of the bracket, and secure it with a nut and flat washer.

Insert your manual torch tip into the shaft collar, and secure its handle to the mounting bracket using the U-bolt and two nuts and flat washers. Note that you may have to massage the U-bolt a bit to get it to fit your particular torch handle. It is assumed that your torch has a 1 ” diameter tip assembly. If not, you will have to make up a shaft collar and welded bolt of the proper size. Adjust U-bolt until torch tip is vertical.

The magnetic tracer consists of the above parts: a 3/8” ID shaft collar, a specially machined knurled rotor, and two magnets attached to a short length of cold roll steel.

The shaft collar is placed over the smooth end of the rotor so the set screw can pass through the rotor ’s hole, and tighten down on the 5/16” diameter motor shaft.

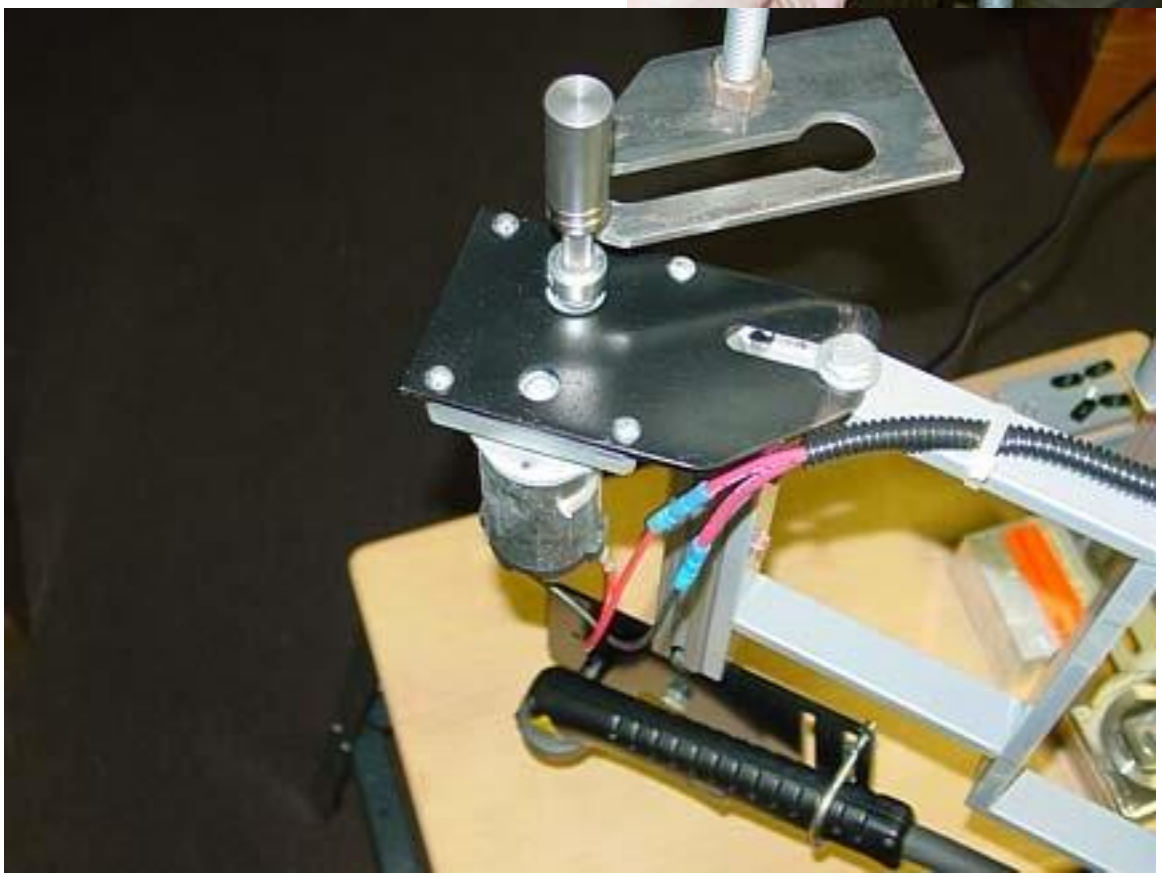


The rotor is placed over the motor shaft, and the set screw tightened down on the flat of the shaft. The magnet assembly is placed on top of the knurled rotor, and centered.

Note that the magnets are extremely powerful, and must be kept away from watches, heart pacemakers, computer diskettes, and anything else that might be affected by a strong magnetic field. Don ’t allow your fingers to be pinched when setting the magnet assembly down.

The short length of cold roll steel to which the magnets are affixed serves as a “ reflector plate ” and magnifies the magnetic field transmitted to the steel template.

Secure the black plastic end cap to the end of the horizontal extrusion by pushing the four plastic connectors into the holes in the extrusion.



It is essential to align the center (axis) of the tracing rotor vertically with the center of the torch tip. This is done by sliding the slot in the motor mount (painted black here) in or out from the pantograph, and rotating it left or right using the mounting bolt as a pivot.

Since it is not easy to visually achieve the degree of alignment necessary, you will need to do the following. Make a six inch square template out of sheet metal, drilling a 1/2 ” mounting hole in its center (not shown above). Tighten two 1/2 ” nuts down on the template (one on top and the other on the bottom) so it is supported on the end of the 1/2 ” all-thread. Remove the magnet assembly from the top of the tracing rotor., and place it on a surface away from any steel that might be attracted to it.

Tape a sheet of white typing paper to the table surface, and lower the torch until the torch tip almost touches the paper. The torch height can be adjusted by loosening the two bolts on the inside of the front of the pantograph, and sliding the 1 ” square extrusion up or down.

Have a friend move the tracing rotor to each corner of the template, while you scribe a circle around the torch tip on the paper at each location. Adjust the motor mount as described above until the four scribed circles form a perfect square when measured center to center and diagonally. If the alignment is incorrect, the four scribed circles will either be in a rectangular or diamond shaped pattern.

Ideas for Supporting your Machine

At right, an early Torchmate with an oxyacetylene torch is mounted on a steel grid that clamps to the top of a 55 gallon drum.

When the drum needs to be emptied, the grid is lifted off with the machine still bolted to it.

Here, an early Torchmate has been mounted on a fabricated stand with adjustable level screws on its base. The cutting surface quickly unbolts for replacement as necessary. It should be noted that any material support surface will eventually need to be replaced as it becomes damaged by the cutting process.

Making and UsingTemplates

The magnetic tracer is not practical for producing one-of-a-kind pieces, as the steel template required is generally harder to make than the piece you wish to cut. It is intended for production work involving multiple copies of the same shape.

The first step in using the magnetic tracer is to either bandsaw a piece of 1/4" to 3/8" thick steel plate to the desired shape, or flame-cut the piece using a wooden template. The edges are then ground perfectly straight and smooth using a belt or disk sander with a 90 degree table. Outside templates must be made slightly undersize to compensate for the diameter of the tracing rotor. Correspondingly, inside templates must be oversize. The formula is as follows:

SIZE REDUCTION = ½ THE ROTOR DIAMETER - ½ THE KERF WIDTH

Thus, if you wanted to cut a shape using a ½ inch tracing rotor, you would sutract .250" inch around the entire edge of the template to compensate for the rotor size, and add back in approximately .035" to compensate for the kerf width. The kerf is the gap the cutting torch creates when cutting. In other words, if you placed the template on top of the finished cut piece, you would see .215" of the cut piece protruding all around its perimeter. The more amperage you are using, the more significant the kerf allowance becomes.

When using a plywood template, either for making a subsequent steel template or for producing individual cut pieces, you hold the turning rotor against the template edge, changing the direction of pressure as you round corners. Cut smoothness is just as

good as with magnetic tracing, and if you are careful, you can cut perfect pieces. Bear in mind that if the rotor is allowed to slip, or free-wheel on the template, it will be reflected in the cut. The magnetic tracer takes the stress and worry out of the process. Remove the magnetic head when using wooden templates. Sheet metal or steel templates are generally too slippery for the rotor 's knurling to grip well, although sheet metal templates can be used for duplicating some shapes. Sheetmetal templates tend to wear rotors out more rapidly than steel templates. They almost never wear out when used only with wooden templates.

Use outside templates to make outside cuts, and inside (cut-out) templates to make inside cuts. Obviously, you must make all your inside cuts before cutting the outside of the piece. When moving between inside shapes and from an inside shape to an outside shape, you must remove the tracing rotor and replace it after the move. Take care not to disturb the rotor/torch alignment when doing this.
You will notice that if the magnetic tracer attempts to go around a sharp inside corner, it will slip due to the fact that it is being attracted to both sides of the corner. To prevent this, bevel the leading edge of the corner, so the rotor will be more attracted to the new edge. Obviously, this cannot be done when using sheet metal templates.

When cutting square pieces, use an inside (cut-out) square template. This will avoid the rounding of the corners of the finished cut. Recheck the alignment of the torch and tracing rotor (the paper exercise) before cutting expensive material.

Operating your Machine

It is beyond the scope of these instructions to cover the operation of your torch equipment. Be sure to follow the operation and safety recommendations of your torch equipment manufacturer. If there is any variation between those recommendations and this instruction material, follow the torch equipment manufacturer 's directions.

Always use proper eye protection and protective clothing when operating your torch or your Torchmate. Do not operate your torch or the Torchmate near combustible or inflammable materials. Do not use in a shop with a floor, walls, or furniture that might catch on fire. Always stand away from the cutting area, and use a suitable fire-proof

container to catch all molten steel and other waste materials. A machine-cut piece often drops out of the parent steel when the cut is finished. Make sure it falls into a suitable container so it can ’t accidentally strike you or an inflammable object.

Operation Steps:

Place your wooden or steel template on the template support shaft, double-nutting it securely to hold it. Plug the control box electrical cord into a nearby 115 volt outlet. Make sure the cord is routed away from any possible torch damage. Note that the control box has an on-off switch, a direction switch, and a speed control dial.

Most of the time you will only be using one direction. Always turn off the unit before changing directions. Always unplug the control box when you are not using your Torchmate.
Experiment with the speed control dial, and measure the travel of your rotor along a straight-edge at different speed settings within a given time frame, and make a note of your findings. This will help you dial-in the right speed setting for the material you are cutting. Your plasma cutter instructions should give you some idea of the speeds suited to different thickness of steel, but trial-and-error will be the best teacher. You will also need to experiment with different amperages and air pressure. In manual cutting, the human error factor overshadows these variables. In machine cutting, they become much more important.

Place the steel to be cut flat on your cutting surface.

Adjust the torch tip to the desired height as described in the section on torch-rotor alignment. Shim the work, if necessary to keep the tip height constant throughout the pantograph’ s range.

Adjust the template height so the knurled edge of the rotor fully contacts the template edge without the magnetic head, itself, touching the template.

Turn the control box on, and pre-set the speed control dial based on your previous experimentation. Make sure the tracing rotor is turning in the desired direction. Move the turning rotor close to the template edge, but not touching it. Initiate the arc, and when the material has been pierced, move the rotor until it contacts the template. At

the completion of the cut, turn off the torch and the control box. Do not handle the completed piece or waste material until it has cooled.

No matter how long you have been using a manual cutting torch, machine flame cutting will be a learning experience for you. With a little practice on your part, your Torchmate will produce cuts of the same quality as CNC controlled cutting machines on the market. We hope you enjoy the magic of machine plasma cutting as much as we enjoyed bringing it to you.