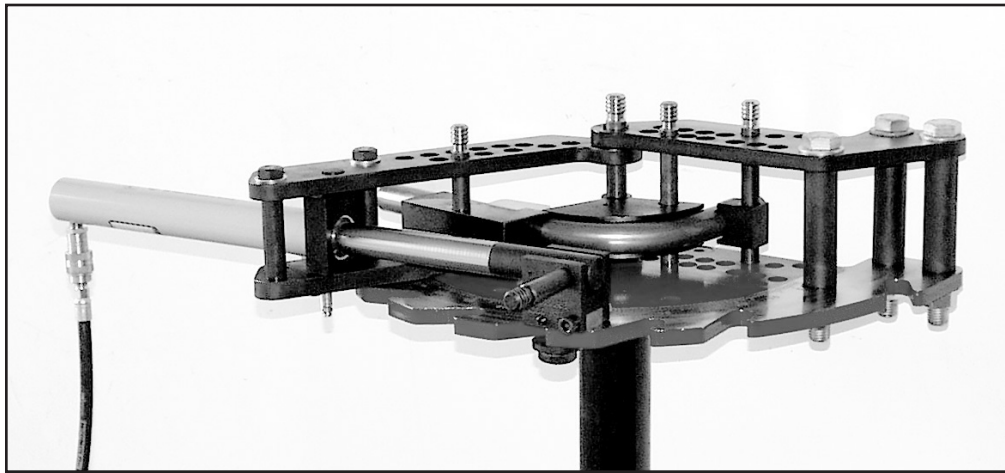


# ***MODEL 4 TUBE BENDER***

## ***Assembly & Operating Instructions***

*Revision 4 (7/10/2008)*



### ***J D Squared Inc.***

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# *Unpacking & Parts List*

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The basic Model 4 bender is shipped in 2 packages. Package 1 contains the lower frame only. Package 2 contains all other parts needed for assembly, excluding the hydraulic cylinder, pump and hose. If these items were also ordered with the bender, they will arrive in their own separate boxes. Upon receiving both packages verify that neither package shows any signs of damage and that all parts are present. If a package has been damaged and parts are either missing or damaged, you must immediately contact our sales office.

## **PACKAGE 1 CONTENTS:**

1 Lower frame

## **PACKAGE 2 CONTENTS:**

1 Instruction manual  
-----

1 Upper frame

11 3/4" S.A.E. washers

3 3/4" x 2" flat head screws

3 3/4" nuts

3 1 1/2" diameter frame sleeves

3 1" x 8" bolts

6 1" S.A.E. washers

3 1" nuts

1 1" x 8" diameter frame pin

2 7/8" x 8" frame link pins  
-----

1 7/8" x 6 1/4" drive link pins

1 Drive link - Lower

1 Drive link - Upper

1 3/4"-16 x 5" long bolt (Outside drive link bolt)

1 3/4"-16 x 4 1/2" long bolt (Inside drive link bolt)

2 1" diameter drive link sleeves

1 Hydraulic swivel block  
-----

1 Pusher block with 1" diameter flange bolt welded in place

1 Pusher block handle

1 3/16" x 1 1/4" long roll pin

1 1 1/2" diameter pushrod (screws into hydraulic cylinder)

1 Bronze pivot block

2 1/2" diameter shoulder bolts

1 3/8" nylock nut

1 Anti-Springback lever

1 1/2"-20 x 1" long bolt

1 1/2" S.A.E. washer

1 3/4" diameter x 3/8" long sleeve (for anti-springback lever)

1 1/2" threaded spring pin

1 1/2"-20 fine thread nut (will be installed on spring pin)

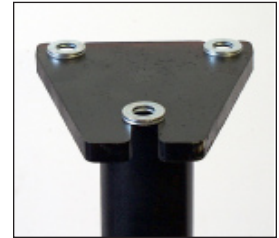
1 spring

1 1/4" x 1 1/2" long socket head bolt

2 1/4" nuts

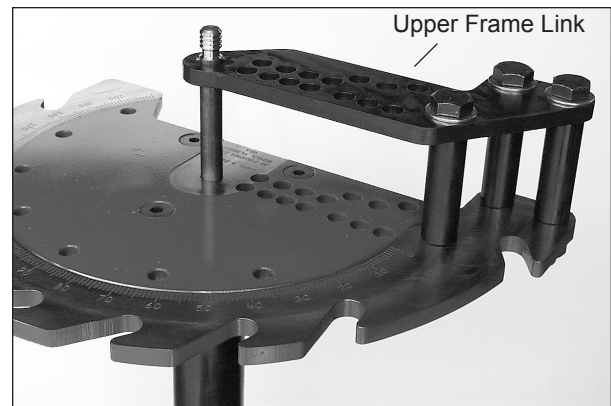
# Assembly

1) The bender may be mounted to anything rigid enough not to twist or move during the bending operation. To mount the bender, drill three 3/4" holes through your mounting surface. You can use the frame holes as a guide. Place two 3/4" washers on the top of each drilled hole. These washers will act as spacers to insure that the bender pins, when installed, will be completely pass through the lower frame holes. If you purchased the optional pedestal, position the washers over the slots as shown in figure 1.



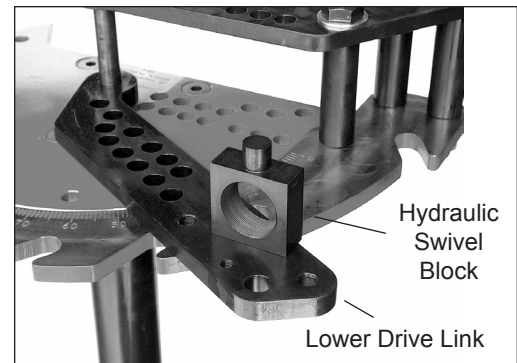
*Figure 1*

2) Refer to figure 2. Using three 3/4" x 2" long flat head bolts, three 3/4" nuts and three 3/4" washers, tightly secure the frame to your mounting surface/pedestal. Using three 1 1/2" diameter frame sleeves, three 1" diameter x 8" long bolts, six 1" washers and three 1" nuts, install the upper frame onto the lower frame. Lightly tighten the bolts. Next install the 1" frame pin as shown in figure 2. Using a small square placed against the 1" pin, move the upper frame around until the frame pin is perfectly vertical. Tighten all three 1" bolts.



*Figure 2 - Upper frame installed*

3) Remove the 1" frame pin. Locate the lower drive link. It will have two 3/4" tapped holes in it and a recess milled out of its bottom side's center. Place it on the lower frame with its inside 1" hole over the lower frame's 1" center hole and its milled recess facing down. Replace the 1" frame pin. Locate the hydraulic cylinder's swivel block. Examining the swivel block you will see the word 'TOP' stamped into it. Insert the swivel block into the lower drive link's remaining 1" hole. Your Model 4 should now look like figure 3.



*Figure 3*

4) Refer to figure 4 for this step. Remove the 1" frame pin. Locate the upper drive link. Place it in the bender so that it aligns with the lower drive link and engages the swivel block's upper shaft. Reinstall the 1" frame pin. Place the two 1" diameter drive link sleeves between the two drive links aligned with the 3/4" holes. Place a 3/4" washer onto the 3/4"-20 x 5" long bolt. Install it into the outside 3/4" sleeve and lightly tighten. Place a 3/4" washer onto the 3/4"-20 x 4 1/2" long bolt. Install it into the inside 3/4" sleeve and tighten securely. Remove the whole drive link assembly and turn upside down. Look on the bottom side of the lower link and verify that the inside 3/4" bolt threads do NOT protrude out of the link. If it does, it will severely scratch the frame's machined surface. Also the bender's links will not ride properly on the lower frame. The only way this should be able to occur would be if the longer 5" bolt was installed where the 4 1/2" bolt should be.



*Figure 4 - Drive links installed*

5) Invert the drive link assembly as shown in figure 7.

Locate the parts listed below:

- 1 Anti-Springback lever
- 1 1/2"-20 x 1" long bolt
- 1 1/2" S.A.E. washer
- 1 3/4" diameter x 3/8" long sleeve
- 1 1/2" threaded spring pin
- 1 1/2"-20 fine thread nut
- 1 1/4" x 2" long socket head bolt
- 2 1/4" nuts
- 1 Spring

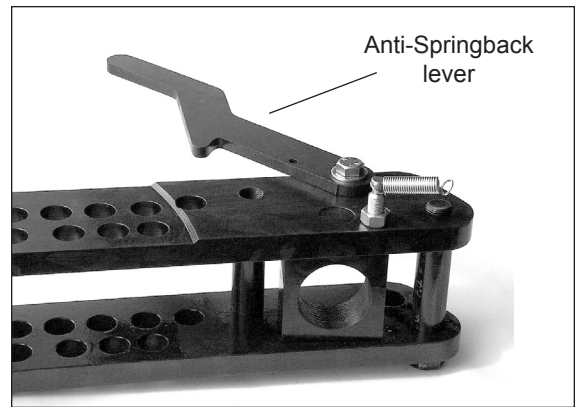
Place the 1/2" washer onto the 1/2"-20 x 1" long bolt. Next place the 3/4" diameter sleeve onto the bolt also. This sleeve acts as a spacer. Study figures 5 and 7 carefully and then position the anti-springback lever as shown. Install the bolt, washer and sleeve through the anti-springback lever and into the lower drive link. Tighten securely. Verify that the lever rotates freely.

Install the 1/2"-20 fine thread nut onto the spring pin about half way up. Install the spring onto the spring pin as shown in figure 6. Screw the spring pin into the lower link until it starts to protrude out the other side of the drive link. Back it off 1 to 2 turns, to make sure it doesn't protrude, and tighten the 1/2" nut.

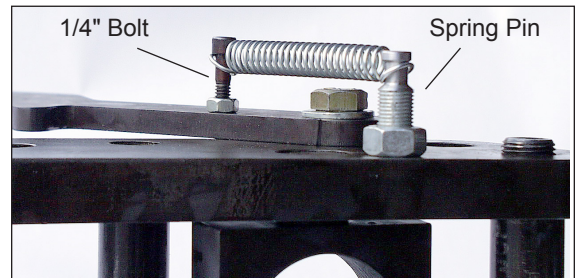
Install a 1/4" nut onto the 1/4" x 2" long socket head bolt. Adjust the 1/4" nut so that when the bolt is installed in the anti-springback lever, the 1/4" nut on the other side of the anti-springback lever can be completely installed with only 1 thread visible. This will put the bolt's head roughly even with the spring pin's head. Remove the 1/4" bolt. Being careful not to turn the 1/4" nut already installed, insert the bolt's head through the open loop of the spring. Holding the bolt, stretch the spring and insert the bolt back into the 1/4" hole in the anti-springback lever. Install the other 1/4" nut onto the bolt from the top side of the anti-springback lever and tighten. Remember that only one thread of the 1/4" bolt should be visible from the top side of the anti-springback lever. Figures 6 and 7 show the complete assembly correctly installed. Note that the outside 3/4" bolt protrudes out of the bottom of the lower drive link and that the inside 3/4" bolt does NOT.

Install the completed drive link assembly into the bender. The easiest way to do this is from the rear of the bender. Insert the drive link assembly with the open 1" holes between the 1" holes in the frame. Insert the 1" frame pin. Now rotate the drive link assembly counterclockwise until it rest on the machined upper surface of the frame. If it does lay flat, the upper frame link will need to be loosened and repositioned until the 1" frame pin is perfectly vertical. Rotate assembly until the degree scale reads 30 to 60 degrees on the right side of the lower drive link.

*Figure 8*



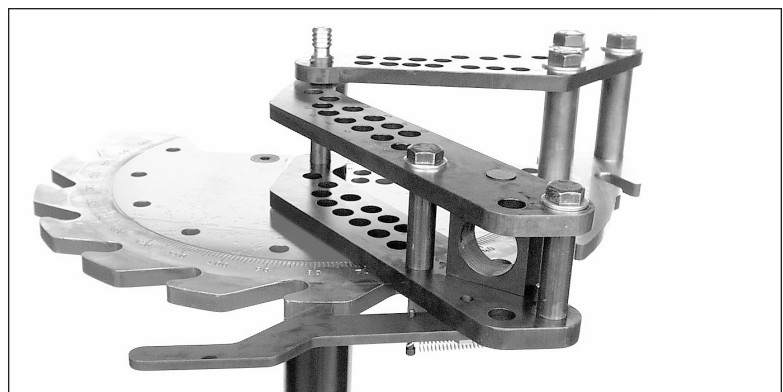
*Figure 5 - Anti-springback lever*



*Figure 6 - Spring installation*



*Figure 7 - Lever system installed*

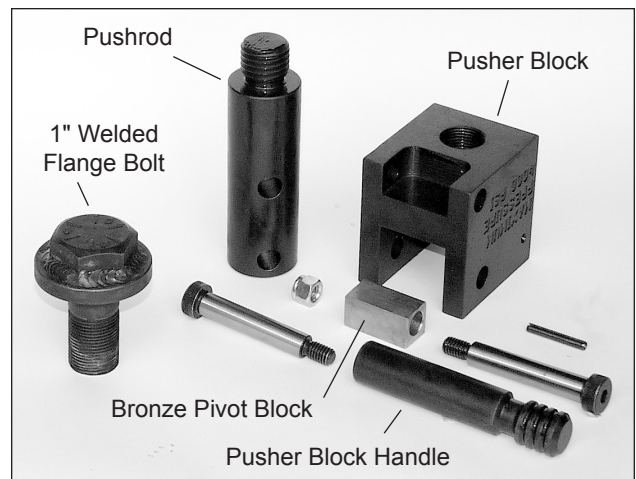




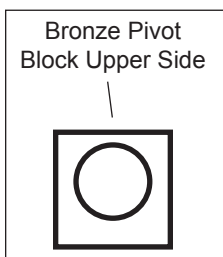
6) Locate the parts shown in figure 9 and listed below:

- 1 Pusher Block
- 1 Pusher Block Handle
- 1 Bronze Pivot Block
- 1 Pushrod (1 1/2" diameter)
- 2 1/2" x 2 1/2" long shoulder bolts
- 1 3/16" roll pin
- 1 3/8" nylock nut
- 1 1" diameter welded flange bolt

*NOTE: This bolt is shown as a separate item in figure 9 for easier identification. However, it has already been welded into the Pusher Block.*



**Figure 9 - Pusher assembly**

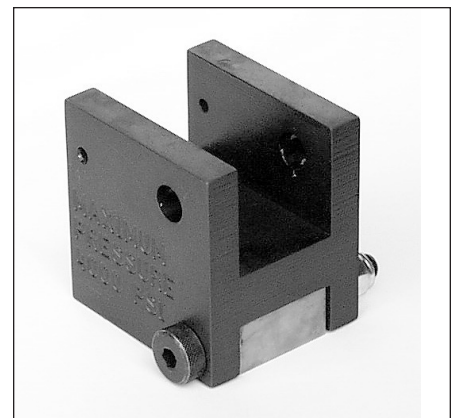


**Figure 10**

Examine the bronze pivot block. You will notice that the 1/2" hole has been offset drilled to one side as shown in figure 10. The distance from the hole's edge to the pivot block's side will be less than the other three sides. This is the pivot block's upper side. Now examine the pusher block. You will see a 1 1/2" slot milled completely through its top surface and on its bottom you will see a smaller recess milled into its front edge.

Note: The pusher block shown in figure 9 is bottom side up so that the milled recess can be clearly seen. This recessed area is where the bronze pivot block is installed. Hold the pusher block so that the engraving on its side is right side up and facing you. Position the bronze pivot block into the lower recess so that its upper surface is facing up (the hole is offset to the top). From the engraved side of the pusher block, insert one of the two 1/2" shoulder bolt and secure tightly with the 3/8" nylock nut. When completed it should look like figure 11. The pivot block must also be protruding out of the bottom of the pusher block approximately 1/16" as shown in figure 12. If it's not, it's installed wrong and must be reinstalled.

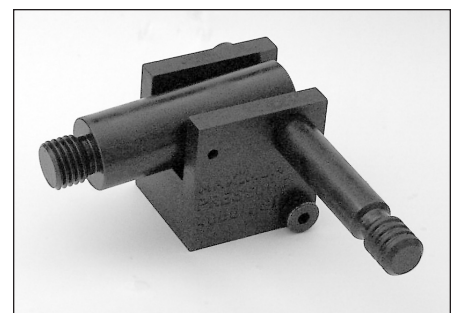
As shown in figure 13, position the pushrod into the pusher block's upper slot. The 1/2" hole in the pushrod nearest to the end should be lined up with the 1/2" hole in the pusher block. Insert a 1/2" shoulder bolt into the pusher block from the side opposite the engraving. Install the pusher block handle onto this shoulder bolt and tighten. Lay the pusher block down on the side opposite the engraving. Slightly rotate the pushrod so that the 1/2" hole in its middle is under the 3/16" hole drilled into the engraved side of the pusher block. Being careful not to mar the engraved face of the pusher block, hammer in the 3/16" roll pin until it is flush with the pusher block's surface. Figure 11 shows this step completed.



**Figure 11 - Pusher block**



**Figure 12**

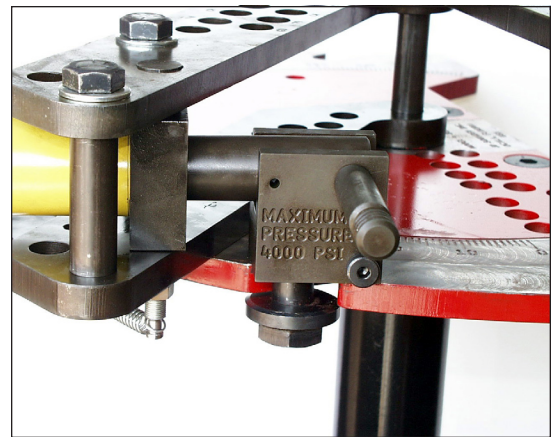


**Figure 13  
Pusher assembly complete**

7) Screw the hydraulic cylinder completely into the hydraulic swivel block. If when tightened the cylinder's quick disconnect hose fitting is not facing in the downward direction, loosen the cylinder until it does face in the downward direction. The cylinder will have a little play in its threads. This is normal and will not cause any problems.

Screw the completed pusher block assembly into the cylinder. You may need to rotate the drive links to the rear of the bender in order for the handle to clear the main frame as the pusher block is screwed into the cylinder. Rotate the pusher block so that the handle is facing toward you. Rotate the drive links until the pusher block is positioned approximately as shown in figure 14.

Using the handle, move the 1" welded flange bolt into one of the lower frame's teeth. When the bender is under load, the rear of the pusher block should rise approximately 1/16" above the face milled flat of the lower frame. With the bronze pivot block protruding out of the bottom of the pusher block 1/16", this should make the pusher block ride flat when bending. This will eliminate any side loads on the hydraulic cylinder, therefore preventing any unnecessary wear in the cylinder.

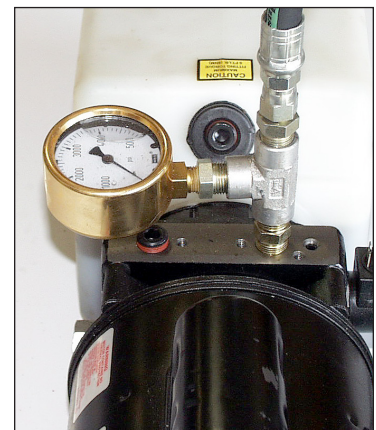


*Figure 14 - Pusher block engaged*

8) Next attach the hose to the pump in its correct port. If you have your own pump or purchased a pump with your bender and it wasn't the 2 HP model, follow the directions included with the pump. If you purchased the preferred 2 HP pump as shown in figure 15, you can look at the photo as a reference. Wrap 2 to 3 layers of teflon tape around the male threads on the hydraulic hose. Looking at the bender from the electric motor side, screw the hose into the right side upper port. Wrap 2 to 3 layers of teflon tape around the 1/2" pipe plug and screw it into the left side upper port. Make sure both are tightened snugly.

Attach the hose to the cylinder's quick disconnect fitting and hand tighten only. Plug the pump into the proper electrical outlet. Note: Upon start up, if the pump acts like it's not getting enough current, take these steps to fix the problem. First use a heavy gauge (12 gauge or heavier), short electrical extension cord. The shorter the better. If using 110 volts, make sure the electrical circuit breaker is rated at least 30 amps. As a general rule, if when the bender is operating, the electrical extension cord feels hot, it's too small. Also if the electrical relay operates erratically when pressed, it's probably a sign of an electrical supply problem.

Pressing the pump control buttons will extend the cylinder under pressure or release the pressure, thereby retracting the cylinder using its internal spring return. If neither button is pressed the cylinder will hold its position. The 2 HP pump is relatively fast. It's easy to overshoot the desired bend angle. To prevent this from happening, follow this procedure: Press the cylinder extend button and hold down until the bender is 3-5 degrees before the desired angle. Now quickly tap the button on and off until the bender edges up to the proper degree. With practice you should easily be able to advance the cylinder as little as 1/5 of a degree. Note the 5000 p.s.i. pressure gauge shown in figure 15. This gauge is not included with the pump, but is highly recommended. A good quality gauge can be purchased at any hydraulic supply business. Simply tee it into the pressure hose as shown in figure 15.



*Figure 15*

# Installing Die Sets

The Model 4 bender comes with 4 pins. Locate the pins listed below:

- 1 1" Diameter x 8" Frame Pin
- 2 7/8" Diameter x 8" Long Frame Pins (Long Pin)
- 1 7/8" Diameter x 6 1/4" Long Drive Pin (Short Pin)

A Die Set consists of the 3 parts listed below:

- 1 Forming Die (Circular in shape, usually with a groove)
- 1 Pressure Die (The part that slides along the workpiece)
- 1 U-Block (A small square block that retains the workpiece, also usually has a groove)

## **STEP 1 - INSTALL THE FORMING DIE**

### **Forming Die Installation**

There are two styles of forming dies. One has a square block welded to its backside as shown in left side of figure 17. The other doesn't as shown in right side of figure 17. The method of die installation depends on what style you have.

#### **Installing a Die without a welded block:**

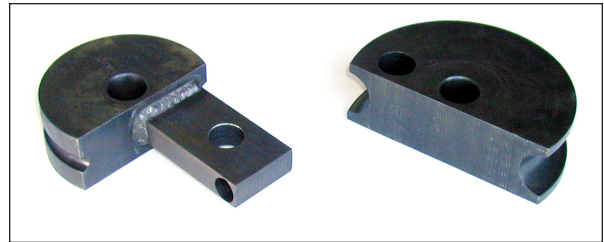
Using the 1" frame pin, place the forming die into the bender with its rounded side forward as shown in figure 18. The forming die will normally only have one other hole drilled through it, as shown on the right side of figure 17. This hole is very close to the die's edge, usually within a 1/8"-1/4". If there is more than one hole, use the hole closest to the die's edge. Model 1, 2 and 3 die sets will work in the Model 4, however they usually will have 3 to 5 holes drilled through them. So with those dies you would only use the hole closest to the flat side of the die.

Rotate the die until the hole in the die lines up with one of the **NUMBERED** holes 1 - 4 in the frame (not the lettered holes). Insert one of the two long 7/8" frame pins through the frame and die. This pin will prevent the die from rotating when the bender is operating.

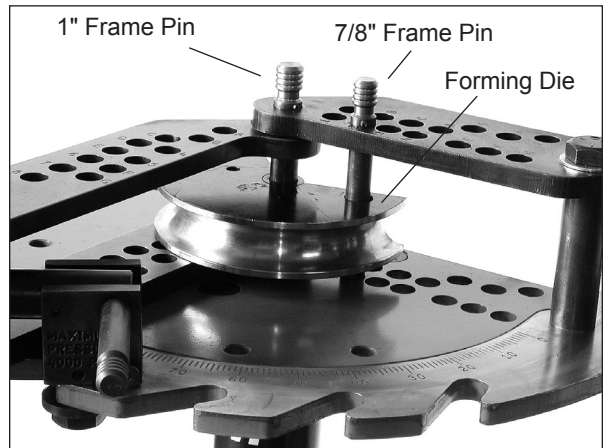
#### **Installing a Die with the welded block:**

Using the 1" frame pin, place the forming die into the bender as shown in figure 19 with the welded block closest to the frame bolts. The die shown has multiple drive holes drilled in it. Only the one closest to the die's flat side (it will be the one nearest to the welded block) needs to be used. A long 7/8" frame pin has been installed in the hole closest to the die's welded block. Installed this way the welded block serves no function. This would be the case if a Model 3 die set was being used in the Model 4.

If the forming die does NOT have any drive holes, only a welded block, then install the die as shown but do not use a 7/8" pin. In this case, when the bender is operating, the welded block on the die will rotate clockwise and contact the workpiece, thus preventing the die from rotating. Note that if the die has a welded block and drilled drive holes you can use either the welded block or the first drive hole.



*Figure 16 - Die styles*



*Figure 17 - Die installed*



*Figure 18 - Die with welded block*



## **STEP 2 - INSTALL THE PRESSURE DIE**

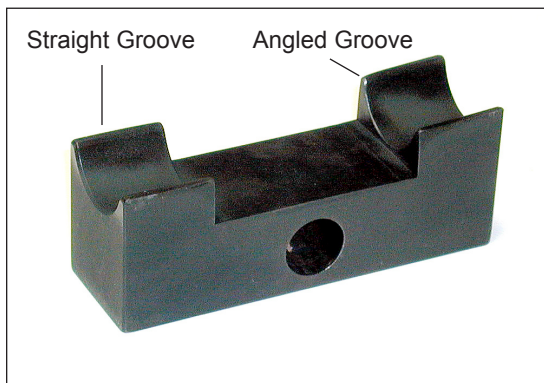
### **Pressure Die Installation**

Pressure dies are machined to exacting standards and must be installed in the proper orientation. Depending on whether the die set is for pipe, round or square tubing follow the appropriate directions below.

### **ROUND TUBING OR PIPE**

The pressure die is shown in figure 19. For round tubing and pipe, the pressure die will have two circular grooves machined on each end, a leading and a trailing groove. The trailing side groove is machined at an angle. This angled groove provides better control of the workpiece than a straight groove, resulting in a better bend quality. However, the pressure die **MUST** be installed in the bender's drive links with the angled groove closest to the forming die. If the pressure die is installed upside down, that is with the angled groove forward, it will try to dig into the workpiece and bend quality will suffer.

Engraved into the pressure die will be the O.D. size of the tubing or pipe and the correct hole number that it should be installed into the drive links with.

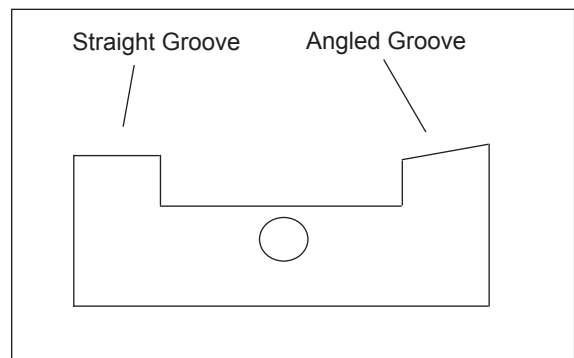


***Figure 19 - Tube or pipe Pressure Die***

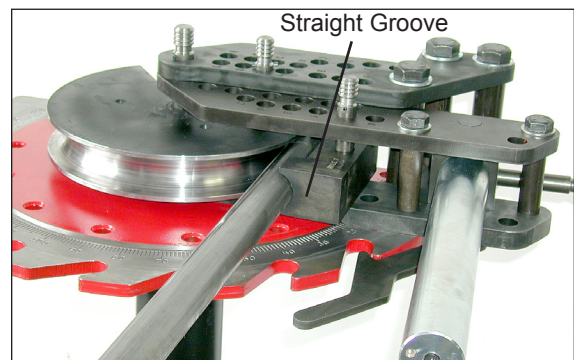
Referring to figures 21 and 22. After the forming die has been installed, rotate the drive links counter-clockwise until they are parallel with the upper frame link. Place the tubing or pipe to be bent through the middle of the drive links as shown. Next place the pressure die between the drive links with the angled groove closest to the forming die. The angled groove should now be towards the rear of the bender and on your right side. Insert a short 7/8" pin through the drive links and the pressure die in the exact hole number engraved into the pressure die.

***NOTE: The angled groove supports the tube during the bending process, thereby preventing it from excessively flattening on the outside. Never install the pressure die upside-down with the angled groove not at the point of bend (closest to the forming die). It can damage the pressure die and severely gouge your tube or pipe. Also, if the pressure die is placed in a hole# other than the one marked on it, bend quality will suffer. If the tube or pipe is flattening a large amount on the outside, check to make sure the pressure die is installed in the correct drive link hole.***

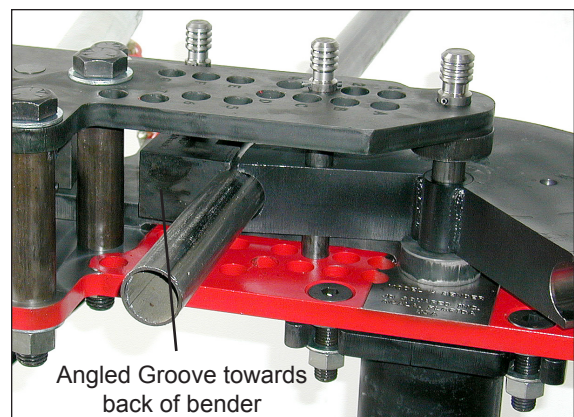
***Figure 22 - Pressure Die installed - back***



***Figure 20 - Top view drawing***



***Figure 21 - Pressure Die installed - front***





### **STEP 3 - INSTALL THE U-BLOCK**

Shown in figure 23 is the U-Block installed in the bender. Normally the pressure die would have already been installed, but for a clearer view of the u-block it has been removed.

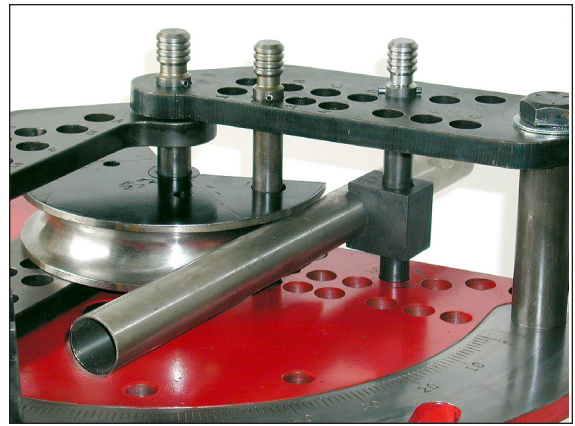
Looking at the top of the upper frame you will see two rows of 7/8" holes with letters or numbers beside them. The front seven row holes (1,2,3,4,E,F,G) are in a straight line and the back seven holes (A,B,C,D,5,6,7) are staggered. The back side holes are the ones where the U-Block pin is normally installed as shown in figure 23.

#### **PROCEDURE:**

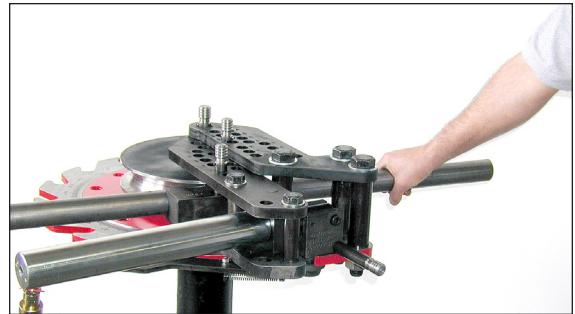
The forming die, pressure die and workpiece (tube or pipe) have already been installed in the bender in the previous two steps.

Position the workpiece where you want it bent. Referring to figure 24, push the workpiece away from you firmly. This will seat the workpiece in between the forming die and pressure die, removing any play.

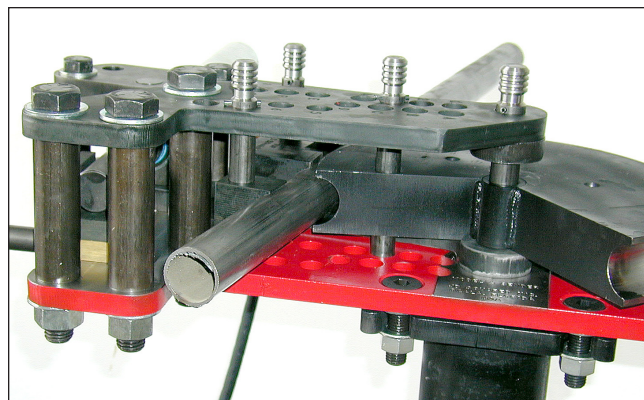
Install the u-block and long 7/8" frame pin into one of the 7/8" back side holes AS CLOSE TO THE 1" FRAME PIN AS POSSIBLE. This is why you had to push the workpiece away from you. Figure 26 shows the complete die set installed as seen from the back side of the bender.



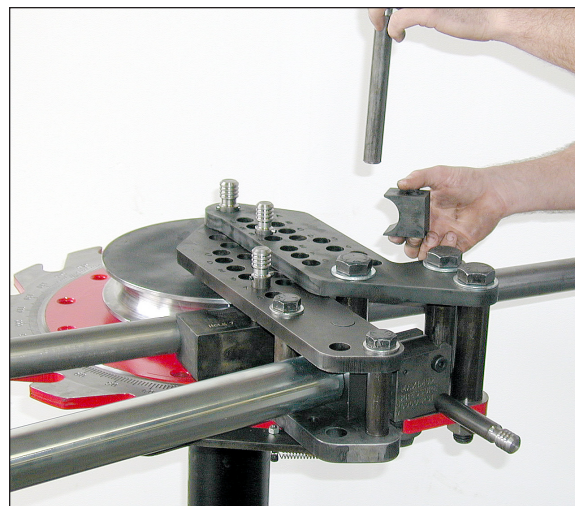
*Figure 23 - U-block installed*



*Figure 24 - Pushing workpiece*



*Figure 26 - Die set installed as seen from back side of bender*



*Figure 25 - Installing pin in back hole*

### **SQUARE TUBING**

Square tube die sets are installed in the same way as round tube die sets with the exception of the pressure die. Square tube pressure dies do not have an angled groove, just one long straight groove. Therefore, all you need to do is install it in the correct hole# as marked on it.

# Operation

## **STEP 1 - Figure 27 & 28**

Using your hands, rotate the drive links clockwise until the workpiece is firmly seated in the die set with no play. With the cylinder fully retracted, extend the cylinder while guiding the pusher block into the first ratchet tooth on the frame. **DO NOT PLACE YOUR HANDS ANYWHERE ON THE PUSHER BLOCK EXCEPT ON THE HANDLE. THIS WILL PREVENT ANY POSSIBLE PINCH POINT. ALWAYS KEEP YOUR HANDS OUTBOARD OF THE BENDER WHEN OPERATING. BE CAREFUL!!!**

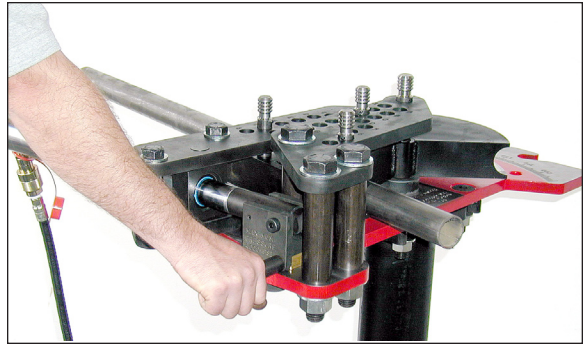
Extend the cylinder lightly until the workpiece is securely seated in the die set but has NOT started to bend. Look on the lower rightside of the lower drive link and note the degree reading as shown in figure 28. Two to eight degrees is normal, but may vary. This initial degree reading is called the lead-in angle. You need to add 3 angles together in order to obtain a correct bend angle.

- 1) The lead-in angle. This accounts for the bender and die set clearances.
- 2) The desired bend angle. This is the actual angle of bend you want the finished bend to be.
- 3) The springback angle. All workpieces will springback when pressure is removed after bending. Usually on the order of 2-8 degrees, depending on the yield strength of the workpiece and the amount of bend. A tube that springs back 3 degrees at 90 degrees of bend may spring back 5-6 degrees at 180 degrees of bend. The only way to determine springback values is by trial and error. Once you know the correct values for a specific workpiece (material, wall thickness, angle of bend) write it down so you can use the same value next time.

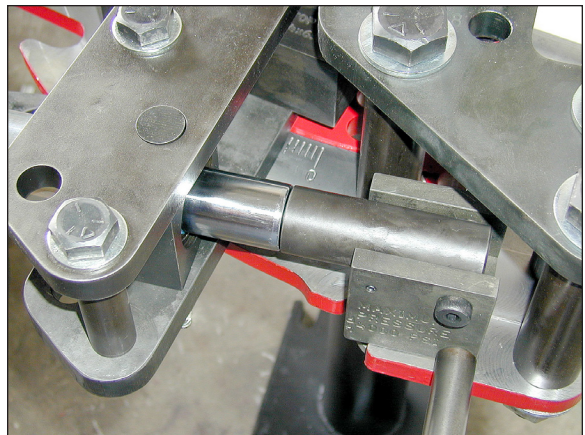
$$\text{Lead-In} + \text{Desired bend angle} + \text{Springback angle} = \text{Degree reading on bender when finished}$$

## **STEP 2 - Figure 29 & 30**

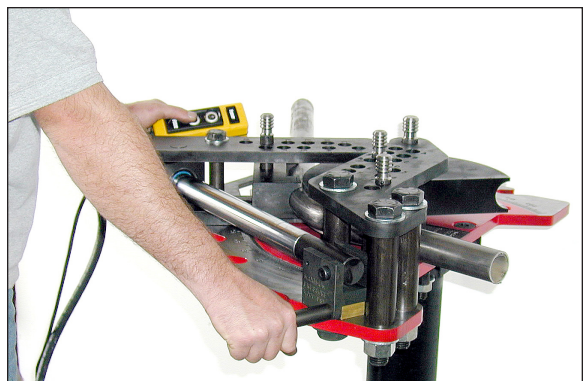
Engage the anti-springback lever by pushing it in towards the frame teeth. While watching the degree markings on the bender start extending the cylinder. If making a bend over 55 degrees go ahead and quickly stroke out the cylinder until around 50 degrees or so. Just before the anti-springback lever engages the frame's ratchet teeth stop the cylinder. Try to stop it as close as you can without the anti-springback lever actually clicking into the frame tooth. Now rapidly tap the cylinder extend button until the anti-springback lever engages the frame tooth. You do not want to go too far, because that would defeat the purpose of the lever. You want to be able to retract the ram with as little springback as possible. Refer to figure 30.



*Figure 27 - Engaging 1st ratchet tooth*

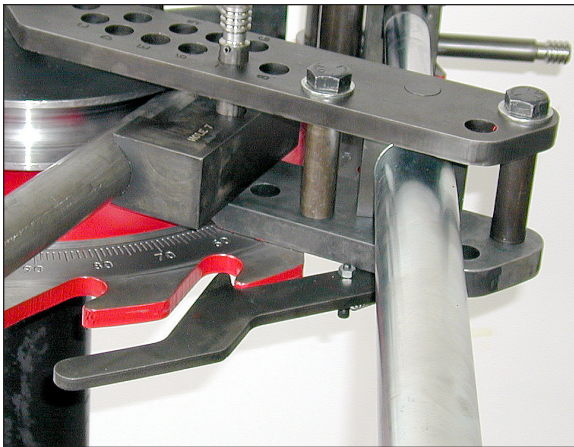


*Figure 28 - Lead-in degree reading*



*Figure 29 - Ram extended*

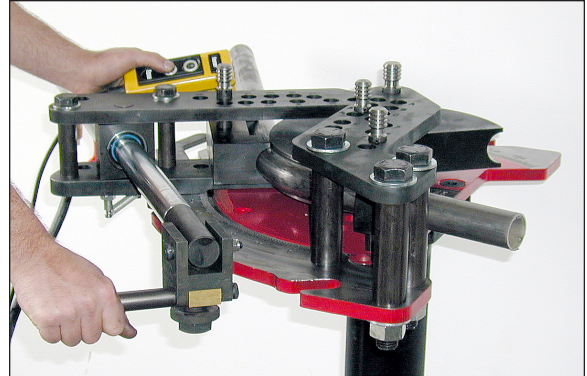




*Figure 30 - Lever engaged*

**STEP 3 - Figure 31**

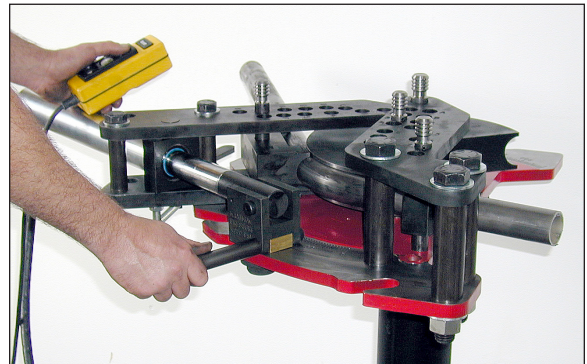
Fully retract the hydraulic ram as shown in figure 31.



*Figure 31 - Retracting cylinder*

**STEP 4 - Figure 32**

Engage the next tooth and continue. The second stroke of the ram will take the bend to over 90 degrees. Bends of 120 - 130 degrees will generally require another stroke.



*Figure 32 - Engaging next tooth*

**A QUICK EXAMPLE BEND**

As an example, let's say you want to bend a piece of 1 1/4" schedule 40 pipe 90 degrees. Place a mark on the pipe where you want the bend to start. Install the pipe and the die set into the bender. Position the mark on the pipe at the point on the forming die where the bend will start. Engage the first tooth and preload the pipe by lightly extending the ram. As shown in figure 28, note the lead-in angle. Let's say it shows 4 degrees. For this size pipe, a springback angle of 3-4 degrees is normal is average. So let's use 3 1/2 degrees. Now add up the 3 degree values.

4 degrees of lead-in angle	
90 degrees of desired bend angle	
3 1/2 degrees of springback	
<b>97 1/2 Degrees total</b>	

Extend the ram out until the degree reading is over 50 degrees and just before the lever engages stop the ram. Quickly tap the ram extend button until the anti-springback lever fully engages, but just barely. Retract and reengage the ram as shown in figure 32. Continue bending until around 95-96 degrees and stop. Quickly tap the button until the degree reading is 97 1/2. Disengage the lever and remove the finished pipe.

# Bending Method #1 - Using Template Bends

## The Easy Way To Position Bends

Learning the operation of a bender is fairly easy. The real challenge is accurately placing the tubing into the bender so that the bend comes out in the right position. This short tutorial explains the simple process of template bending.

Make a sample bend called the *Template* as shown in Figure 33. A permanent mark scribed on the template allows you to measure and visualize where the bend should be placed in the tubing. Once bent the tubing will spring out to a larger radius than the forming die's size indicates. The larger the O.D. or the stronger the tubing, the greater the springback. For instance, chromemoly tubing will springback roughly twice as far as the exact same size and wall thickness of welded seam mild steel tubing. By using a template bend with the same kind of tubing you are going to bend, you do not have to worry about this springback because the template has already sprung out to its finished size.

You may ask if buying bending software is a good idea. I believe bending software can only be justified for two reasons: Creating part drawings if the software supports that function and for setting up a fully automatic CNC bender for the initial test of a part with multiple bends. Even using the software the bend locations usually need to be hand tweaked for accuracy before going into production. Most professional fabricators use a method similar to what is described here. It is extremely easy, accurate and fast. However, what if you need to bend 500 pieces. How would you use this process? Don't worry, it's a simple technique that I will explain later but first let's just complete a single piece job. To do this I'm going to go through the whole process that I use to make a four bend rollbar for a racecar as shown in Figure 34. This is a great example because it's a common request, there are no simple 90 degree bends, and it is generally a one-off piece. So hold on to your lug nuts, here we go.

### Let's Make A Bend Template...

First, you need to make a template. For our example, we are going to use 1 1/2" o.d. x .120" wall welded seam mild steel tubing. As shown in Figure 15, the template is a piece of tubing bent to 90 degrees with approximately 6" of straight tubing on each side of the bend. Cut a piece of tubing roughly 30" long. Next, scribe an accurate line all the way around this tubing 6" from the end. An accurate and easy way to do this is to use an inexpensive pipe cutter. Your local home supply store should carry them in the plumbing department. A small lathe with a sharp cutter also does a good job. Scribe the line deep enough, roughly .015", so that when you paint the template, the line is still clearly visible. Hand scribing this line is difficult and not recommended. The tube should now resemble Figure 35.

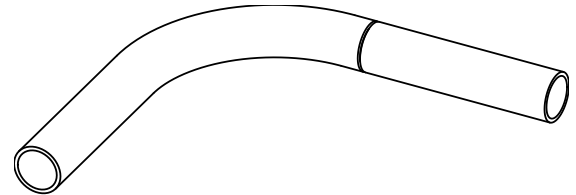


Figure 33 - Sample Template Bend

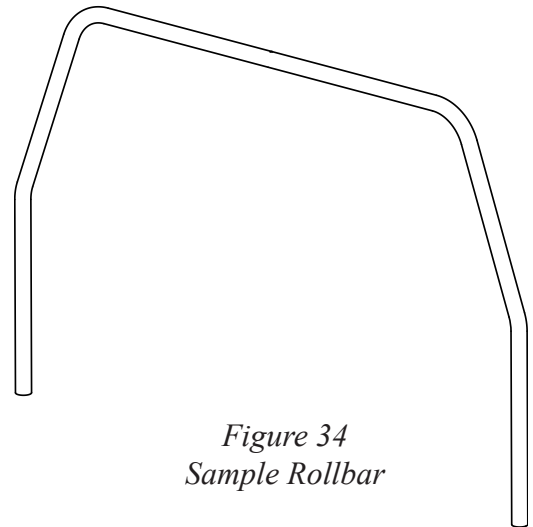


Figure 34  
Sample Rollbar

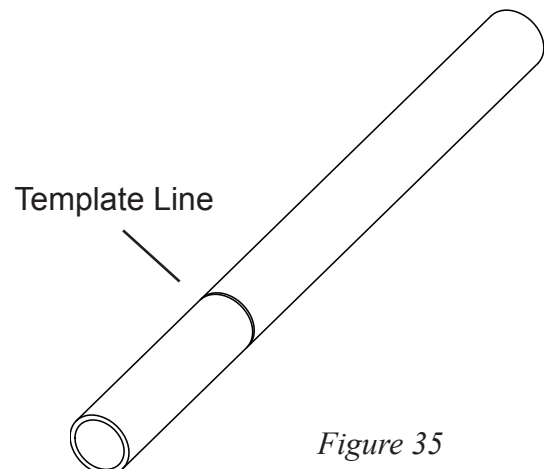


Figure 35



Load this tube into your bender as shown in Figure 36. Note that only the die set and tubing are visible in the figure. The actual bender and the die set's u-strap are not shown so that you can see what we're trying to achieve. Place the scribed line at the flat edge of the forming die. Never use the followbar as a reference. If the forming die has a lock bolt on it, use it to securely tighten the tubing in place. It's very important that this mark stays in line with the die's flat edge during the bending process or template will not give you accurate results later.

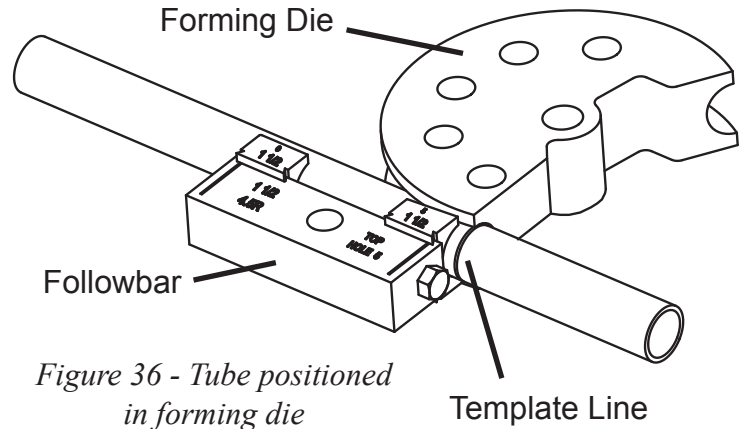


Figure 36 - Tube positioned in forming die

Bend the tube to a finished bend of exactly 90 degrees. On this example, I had to bend to 94 degrees to achieve a true 90 degree bend after the tubing relaxed. Cut the straight length of tubing that is not scribed to 6" long so that it matches the scribed side. This is not really necessary but it does look nice. Deburr both ends and then paint the template an easily visible color. Why does it need paint? It doesn't. But after losing this thing a few times you'll get the idea. The template is finished.

If you work with different types of tubing that are of the same size but differ in the amount of springback they produce, possibly because of a different material or wall thickness, you may need to make a separate template for each one. You can decide later if this necessary depending on the accuracy that you require.

Figure 37 shows a finished template bend still in the die. Note the position of the scribed line on the tube.

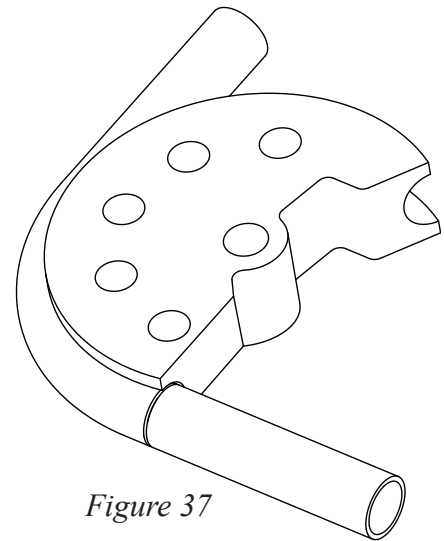


Figure 37

## Time To Start Bending...

As shown in Figure 38, the rollbar will be 40" tall from the floor to its UPPER side. It will be 62" wide outside to outside. The top two bends are 70° each and the two lower bends are 20° each. I recommend that you purchase an adjustable carpenter's protractor to help determine the degree of bend for your specific job. They are made of clear plastic and have legs approximately 12" long.

To determine the total length of tubing needed, you could sit down and calculate it. This is described in the next section "Bending Method #2" which presents a more mathematical method to bend tubing. However, for this application, I think it's a waste of time. Time usually cost more than tubing, so here's the fast way: Take the total width of the rollbar (62") and add it to twice the height (40") which gives us a length of 142" (62" + 40" + 40"). This is slightly too long, maybe a foot or so, but there's a popular rule in fabricating: It is easier to remove material than to add it. Through experience you will learn how much extra tubing you must leave to complete the part.

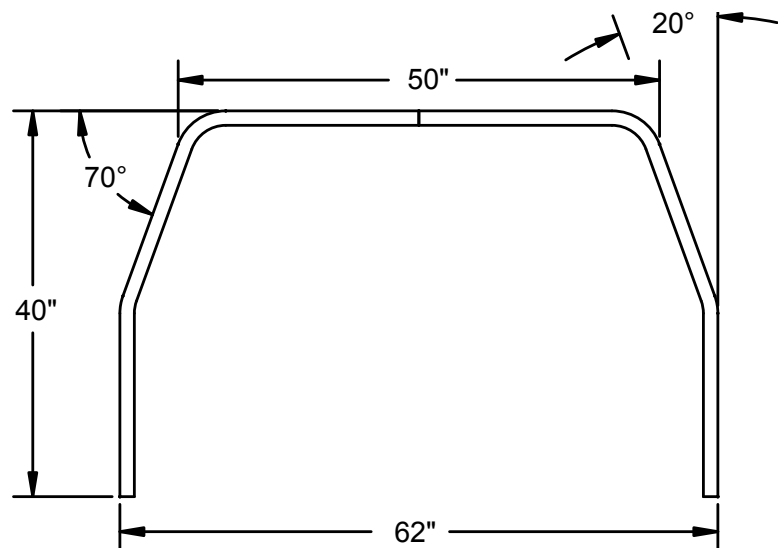


Figure 38

An important rule of bending is to, if possible, always make the bends closest to the center first and work your way out. This allows you to make measurement corrections between bends. Based on this rule, place a mark at the center of the rollbar tube. This is shown Figure 39.

**BEND 1:**

The first bend will be the upper right side bend. Referring to Figure 38, the upper dimension of the rollbar is 50". From the center of the rollbar to the outside of the bend is 25" (50" divided by 2). Lay the tubing to be bent on the floor and hold the template with the scribed side parallel to the rollbar tubing and directly above it, as shown in Figure 39 . The scribed side of the template will always face towards the center of the tubing being bent. Using a tape measure, slide the template left or right until it is 25" from its outside edge, shown by the right arrow in Figure 39, to the rollbar's center mark.

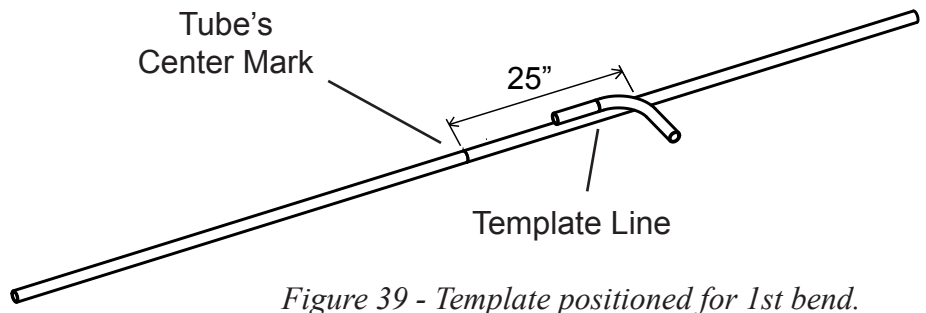


Figure 39 - Template positioned for 1st bend.

Using a marker, draw a small line on the rollbar directly below the scribed line. Take note of what side of this mark the bend needs to be and draw an 'X' there so that when you load the tube into the bender you'll be bending on the correct side. Since the desired bend is only 70° and the template is 90°, you will have to use your best judgement of when the template is 25" out. This gets easier with experience. Now, load the tube into the bender and make the first bend. Don't forget to over bend a little to account for tube springback. For this material 3 to 4 degrees should be sufficient. Since all J D Squared benders are equipped with degree of bend indicators this is easily accomplished. Once you know the correct over bend required, you may want to record it for future reference.

**BEND 2:**

Place the template above the rollbar tube with the template line facing bend 1 as shown in figure 40. Using a tape measure, position it for the desired 50" outside to outside of the two top rollbar bends. DO NOT use the tube's center mark as a reference and place the template 25" left of center. The reason for this is that if the first bend was not made at the exact right spot to achieve 25" from center you can correct for the error in the second bend's position.

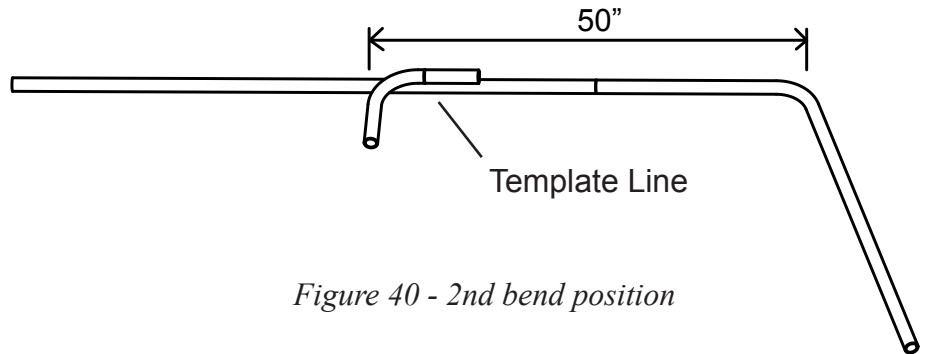


Figure 40 - 2nd bend position

Once again, since the bend will be 70° and the template is 90° you must use your judgement as to where to position the template. Place a mark on the rollbar tube exactly underneath the template line. Load the tube in the bender so that the bend will be made on the CORRECT side of the tube and make the 70° bend.

Erase the center mark on the rollbar tube. Using the tape measure, place a new center mark exactly midway between the outside of the two bends. Why? Let's say your measurement shows the two top bends are really 50 1/4" wide instead of the desired 50". In that case, your old center mark could be off by as much as a 1/4". The NEW center mark corrects this error. That's the cool part about template bending. Your errors can generally be fixed with the next bend. Also note that if you had not started your bending from the center of the rollbar you would not have been able to make the correction. Every bend adds a little more error and you end up with a rollbar that does not fit.

### BEND 3:

At this step you may want to use a large 90° square to help position the template. Position the template above the rollbar tube with the template line facing up towards the top of the rollbar as shown in figure 41. Slide the template up or down the rollbar tube until its outside is 31" from the rollbar's center. Mark your tube and make the bend.

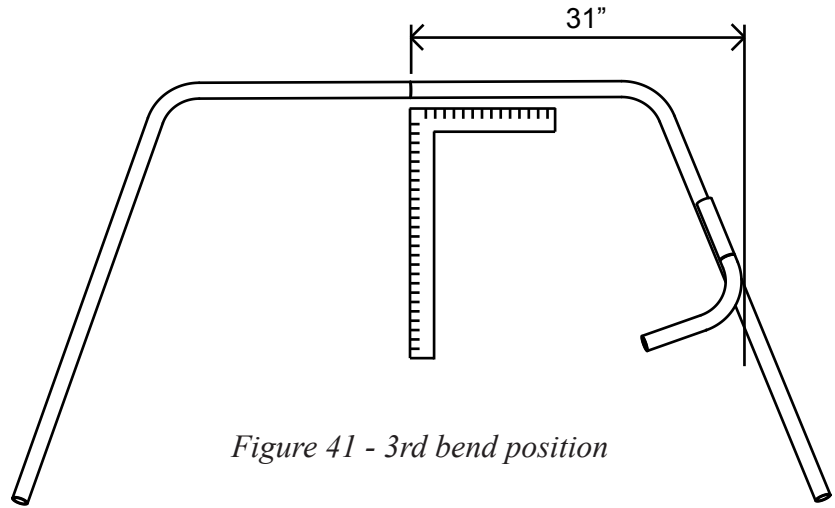


Figure 41 - 3rd bend position

### BEND 4:

Position the template with the template line facing up towards the top of the rollbar as shown in figure 42. Slide the template up or down the rollbar tube until its outside is 62" from the outside of the 3rd bend. Also, verify the bend is the same distance down the tube from the top of the rollbar. If all is correct mark the tube and make the bend.

Lastly, cut the ends of the tube to make the rollbar 40" tall and your done.

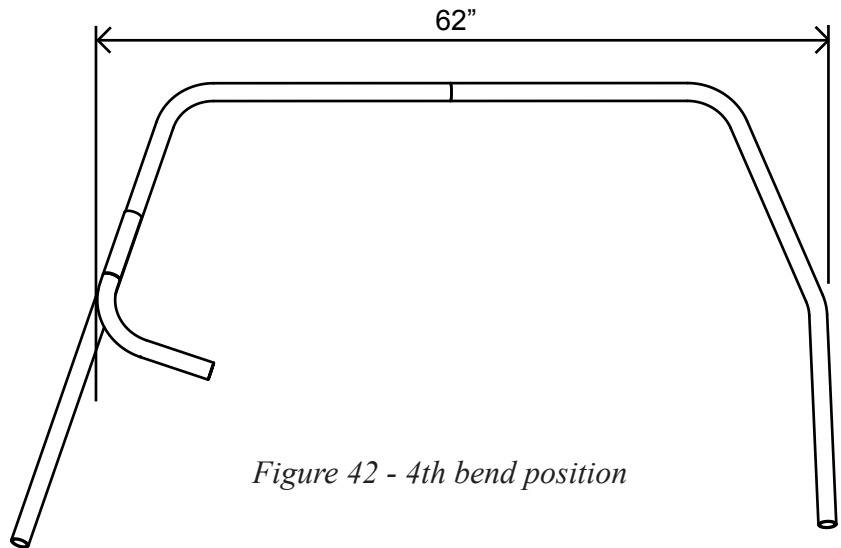


Figure 42 - 4th bend position

**Finished!**

### PROCEDURE FOR SETTING UP A PRODUCTION BENDER USING THE TEMPLATE METHOD

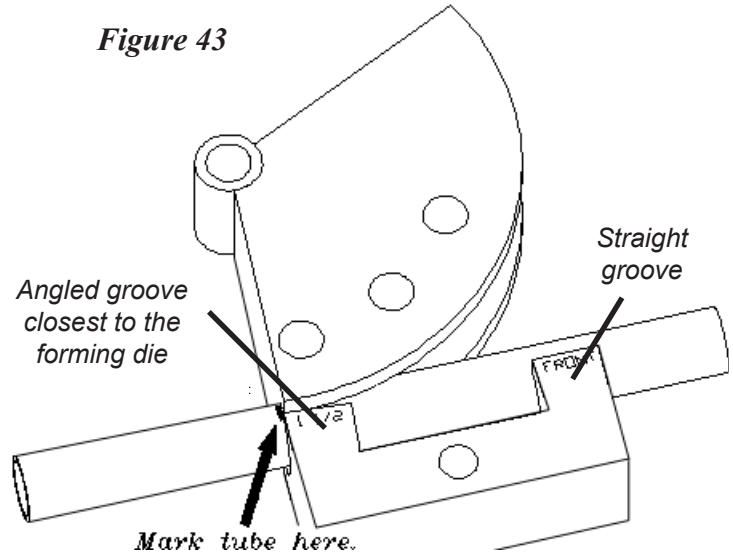
As I stated earlier, this method can be used for production bending. The idea of making the bends from the center out doesn't usually work well in production. Most production bending is done by feeding the tube through the bender and making each bend as needed, thereby eliminating the need to remove the tube from the bender and flip it around. For this you would want a setup sheet with the locations of where to place the marks on the tubing for each bend location. The problem with template bending is that the template has the tube stretch and springback already in it. Since the tubing will grow in length as you make bends in it, how can you measure it accurately once it's bent? Unfortunately, you can't. What you must do is place marks down the tube, for example 10" apart, starting at the one end before you start bending. Now whenever you transfer the mark from the template to the tube being bent you can easily measure the distance from one of the 10" marks to determine where the mark would of been placed on an unbent piece of tube.

# Bending Method #2 - Using Math Formulas

The first thing you need to do is to determine the actual starting location of a bend produced by the Bending Die you installed in the bender. This can vary between die sets and must be checked for every die set purchased. In the below example we are using 1 1/2" O.D. tubing and a Bending Die with a Center Line Radius of 6 1/2".

Here's the procedure:

- A) Place a piece of tubing (app. 2 1/2' long) into the bender so that exactly 12" extends out from the edge of the die to the end of the tubing when the tubing is fully seated in the Bending Die's groove. Place a little bending pressure on the tube so as to seat the tubing in the Bending Die. Not enough to start bending the tubing just enough to seat it in the groove. *NOTE: If you lay a small length of tubing in the groove of a Bending Die you will notice the tubing does not seat to the bottom of the groove. The Bending Dies are deliberately machined this way so that during the bending operation a side force is developed in the tubing. This helps to reduce flat spotting and wrinkles.*
- B) Using a Black Magic Marker mark a line on the tubing precisely at the edge of the die. See figure 43.
- C) Bend the tube to an exact 90 degrees. Use a carpenter's square to check the angle. You will have to over bend the tube a little to account for springback. How much to over bend will come with practice. If you over bend the tube a little don't worry. Because cold worked steel has memory, you can place the tube in a vise or anything else that will retain it, and simply unbend it. Obviously this only works for small amounts of over bend. If the tubing is under bent, it will be necessary to put it back into the bender.
- D) With the tube bent correctly to 90 degrees locate the actual start of the bend. To do this, measure from the end of the tube to the far end of the 90 degree bend. In the example in figure 44 this came out at 20 1/4". Subtract 6 1/2" for the centerline radius (CLR) of the Bending Die, another 3/4" for the radius of the tubing not seated in the die, and 1/8" for springback. (Substitute the CLR and tube radius to match your die set). The 1/8" figure for springback is an approximation, not an exact figure. However it is usually very close to the real thing and may be used without worry to determine the actual starting location of the bend. So:



$$20 \frac{1}{4}'' - 6 \frac{1}{2}'' - \frac{3}{4}'' - \frac{1}{8}'' = 12 \frac{7}{8}''$$

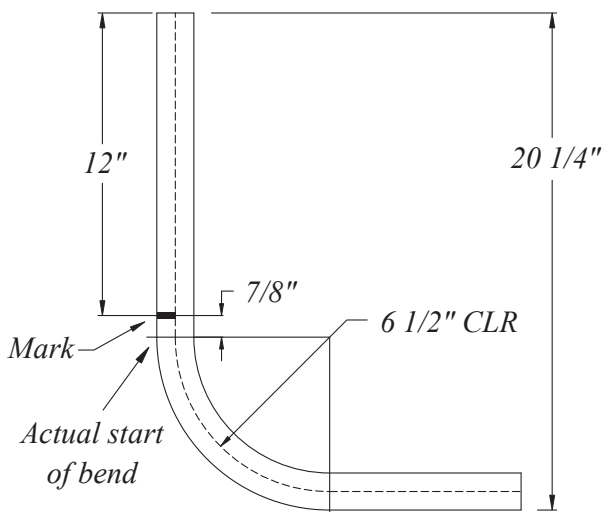


Figure 44

Now subtract from the 12 7/8" the original 12" we had marked earlier and you find that the bend will actually start 7/8" in from the edge of the bending die. Now we know for example, if we want 40" from the end of the tubing to the start of the bend, we must subtract 7/8" from 40" and set the tubing 39 1/8" from the edge of the Bending Die.

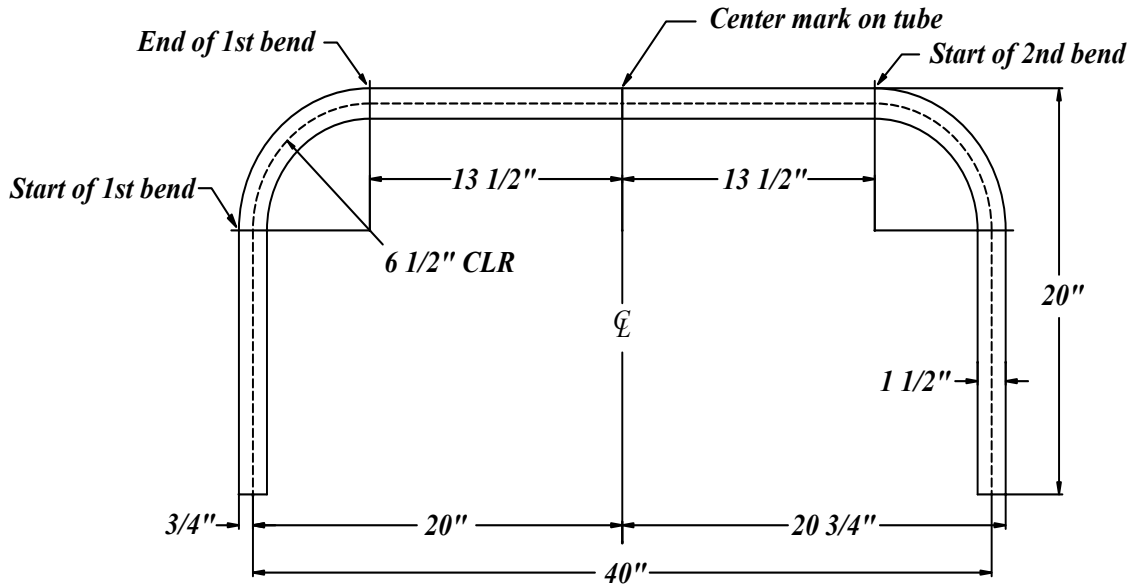
Another example, you want 36" from the bottom to the top of a rollbar. Tube size is 1 3/4" and you have an actual bend start 1/2" inside of the Bending Die's edge. The CLR of the Bending Die is 7 1/2". So: 36" - 1/2" (Actual Bend start) - 7 1/2" (CLR of die) - 7/8" (Half of the tubing diameter) - 1/8" (Springback) = 27". Set the tube 27" from the edge of the Bending Die and make the bend.



**Example hoop :**

Preparation is the key to making accurate bends. To make multiple bends in one section of tubing you will need a universal protractor. The protractor is then clamped, using a machinist v-block and a radiator hose clamp, to the tube. Make sure the pointer indicates '0' before making your first bend. Also using a carpenter's level, make sure the tube is entering the bender level. On the second bend if you turn the tube so that the pointer again reads '0' and the carpenter's level indicates the tube is level, both bends will be on the same plane with no noticeable twist.

First step is to draw a sketch of the intended shape and all measurements. Figure 45 below is the desired hoop. The Bending Die has a centerline radius (CLR) of 6 1/2". The tube O.D. is 1 1/2". We determined earlier that the Bend Start measurement is 3/4" behind the edge of this particular Bending Die set.



**Figure 45- Example hoop.**

1) Determine the total length of tubing needed. Using a calculator and the formula below let's add it all up.

$$6 \frac{1}{2}'' \text{ (CLR of bend)} \times 90 \text{ (Number of degrees of bend)} \times .0175 = \text{Length of tubing used in a bend.}$$

Using the formula above we get 6 1/2" (CLR of bend) x 90 (Degrees of bend) x .0175 = 10.2375. Let's round this off to 10 1/4" inches (10.250"). This is the amount of tubing used in the bend. We have two bends so we double this and get 20 1/2". Add to this the straight sections and we get 20 1/2" (tubing in bends) + 27 (the center section) + 13 1/2" for the left upright + 13 1/2" for the right upright = 74 1/2" of tubing needed. It's usually a good idea to leave a couple of inches extra on the end. Remember, it's easier to remove tubing then to add it. So let's add 2" to 74 1/2".

2) We cut our tube to 76 1/2". It's generally easier to work from the center out when making two bends in a tube. Divide 74 1/2" by 2 and our center point is 37 1/4" from the end of the tube. Place a mark on the tubing 37 1/4" in from one edge and mark the tubing so you will know which side is the 37 1/4" side and which side is 39 1/4". Notice we didn't use the 76 1/2" measurement that we cut our tubing to. This way we only have to cut 2" off one end of the finished tube instead of 1" off each end. The first bend is made on the short 37 1/4" side.

3) Using the method described on page 11 we determine that the tube should extend 12 5/8" from the edge of the Bending Die. Below is the equation from page 4.

$$20'' \text{ (Height of hoop)} - 6 \frac{1}{2}'' \text{ (CLR of die)} - \frac{3}{4}'' \text{ (1/2 of tube's diameter)} - \frac{1}{8}'' \text{ (Springback)} - \frac{3}{4}'' \text{ (Bend Start)} = 11 \frac{7}{8}''.$$

After making the bend we have half our hoop completed. The top of the bend is 20" from the bottom of the tube.

4) Now for the other bend. First we need to determine how much the tube stretched in the bend area. From figure 9 we see that the tube should be 20 3/4" from the outside edge to our 37 1/4" center mark. However after measuring from our center mark to the outside edge of the bend we now have 21" and not the planned 20 3/4". This 1/4" increase is due to springback and the tube stretching in the area of the bend.

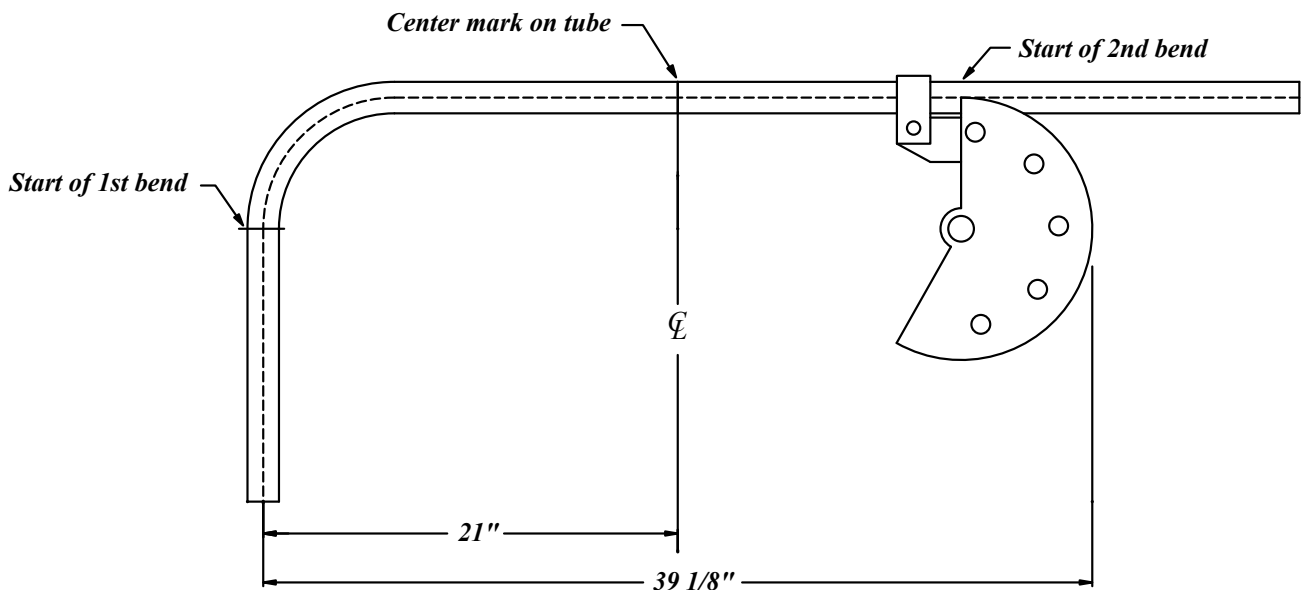
If we now repeated the second bend, using the same 12 5/8" from the end of the tubing + 2" for the extra tubing we allowed, we would end up with a hoop 1/2" too wide. This is because the 1/4" stretch developed in the first bend will also be developed in the second bend, giving us 1/2" total increase in width. Not a good deal if you only want a 40" wide hoop. So what's the solution. Actually there is two ways to do it.

**FIRST METHOD:**

Look at figure 45 and notice the second bend starts at the top of the hoop and not at the top of the upright as the first bend did. Also the start of the second bend is drawn as 13 1/2" from the center mark. If you take the 13 1/2" measurement and subtract the 1/4" of growth that was developed in the first bend and another 1/4" to compensate for the second bend's growth you end up with 13". Subtract another 3/4" to account for the 3/4" Bend Start location on the Bending Die set and we have a final setting of 12 1/4". Notice we did not subtract an 1/8" for springback. This is accounted for already in the 1/4" we added for the second bend's growth. Set the tube so that the Bending Dies edge is exactly 12 1/4" from the center mark. Make sure the universal protractor reads '0' and the carpenter's level is centered. As one final check you can also measure from the far side of the completed bend to the edge of the bending die. See figure 46. This measurement should read:

$$40" \text{ (width of hoop)} - 3/4" \text{ (radius of tube not in bending die)} - 1/8" \text{ (springback allowance)} = 39 1/8"$$

Make the second bend. Measure the height of the second upright and cut off the extra tubing we allowed for earlier.



**Figure 46**

**SECOND METHOD:**

The second method is basically the opposite of the first method. The second bend will start at the bottom of the upright and NOT at the top of the hoop as in the first method and as shown in figure 46. We use the same method as used to bend the first bend with a few exceptions. First calculate the starting point for the second bend as shown below:

$$20" \text{ (total height of hoop)} - 6 1/2" \text{ (CLR of bending die)} - 3/4" \text{ (Bend Start)} = 12 3/4"$$

Add 2" to account for the extra tubing we allowed earlier. Also add the 1/4" growth developed in the first bend and another 1/4" for the second bend. DO NOT ADD 1/8" SPRINGBACK. Once again this is already accounted for in the 1/4" growth of the second bend. We end up with:

$$12 3/4" + 2" \text{ (extra tubing)} + 1/2" \text{ (growth for both bends)} = 15 1/4"$$

Set the tube's end at 15 1/4" from the Bending Die's edge. Make sure the universal protractor reads '0' and the carpenter's level is centered. Make the second bend. Measure the height of the second upright and cut off the extra tubing we allowed for earlier.

Thank you for purchasing the Model 4 Bender. Any further questions please call.