

Center for International Rehabilitation

Chapter 6 Metalworking Techniques



To build a wheelchair, tubing, bar, and rod must be cut, bent, drilled, and brazed. Occasionally, the tubing will need to be enlarged or reduced to enable one piece to fit over another. Many pieces must be bolted together using locknuts. Rather than stopping in the middle of the building instructions in each chapter to explain these procedures, we have chosen to devote this chapter to describing all the basic techniques involved in building the wheelchair.

Before trying to build a chair, take some time to practice the basic techniques described in this chapter. It will save you a lot of time and frustration in the long run. This chapter includes descriptions of how to bend tubing, steel bar, and rod, how to measure the bends accurately, how to make tubing larger or smaller, how to drill holes accurately, and how to make your own locknuts. This manual is not designed to teach you how to weld. Welding is a skill that should be taught first hand. We would, nevertheless, like to remind you to follow

simple safety procedures: wear welding goggles, leather gloves and shoes, and a leather apron. Damage to your eyes, red hot brass in your lap, and burned fingers are all injuries that can be prevented.

THE HOSSFELD STYLE BENDER

The Hossfeld Style bender is made up of a bending frame, bending dies, and special parts that are used when bending bar or rod. (A description of how to make and assemble the bending frame is found in Appendix A at the end of the book). The photo and list on the next page should identify each part.

You may wish to refer back to this list when following the different directions for setting up the bender to bend tubing, bar, or rod.

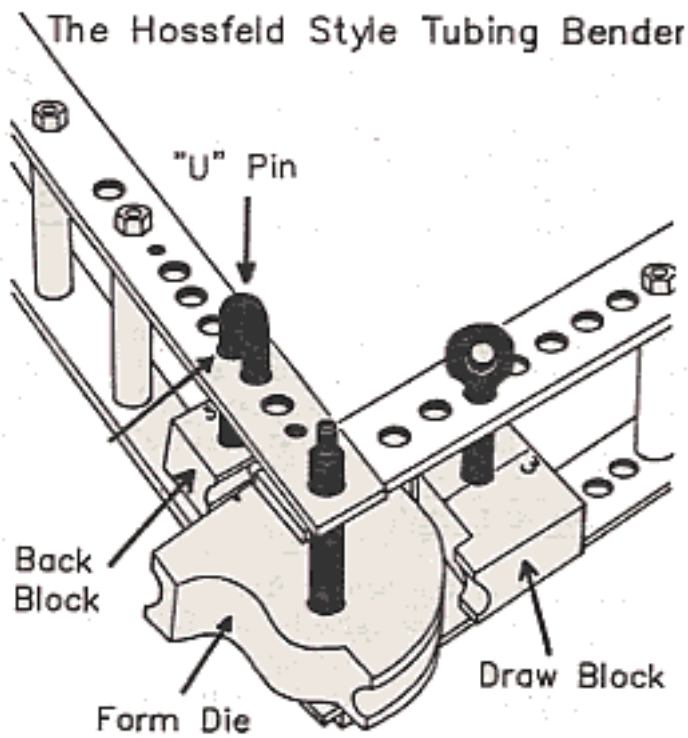
- 1) Bending Frame
- 2) Die Set:
 - a) Draw Block
 - b) Form Die
 - c) Back Block
- 3) Auto Jack
- 4) Center Pin
- 5) U-Shaped Pin

- 6) U-Pin Roller
- 7) Eye Bolt Bending Dog
- 8) Flat Head Pin
- 9) Eye Pin
- 10) Thumb Nut
- 11) Caster Fork Bending Die
- 12) Center Pin Support Plate

SETTING UP THE BENDER TO BEND TUBING

To set up the bender, you will need an already assembled frame, a "U" shaped pin, an eye pin, and a bending die set (back block, draw block, and form die). Be sure to store each bending die set together; they are not interchangeable.

Both the diameter of the tubing and the radius of the bend will affect the size of die set needed for each bend. The following directions will work for any size die set.



1) Mount the back block, with the numbered side on top, between the steel bars of the outer arm using the U-shaped pin as shown. The long shaft of the U-shaped pin should pass through the hole that corresponds to the number stamped on the back block.

2) Mount the draw block, with the numbered side up, between the steel bars of the inner arm. As with the back block, the number on the block corresponds to the number of the hole. Put a little wax or grease on the draw block. Be careful not to get any on the back block or form die.

3) Mount the form die at the pivot point using the center pin. As with the two blocks, the die is mounted with the numbering on top. The straight edge of the form die should be set parallel to the back block as shown.

BENDING THE TUBING

Now that the bender is set up, you are ready to begin bending.

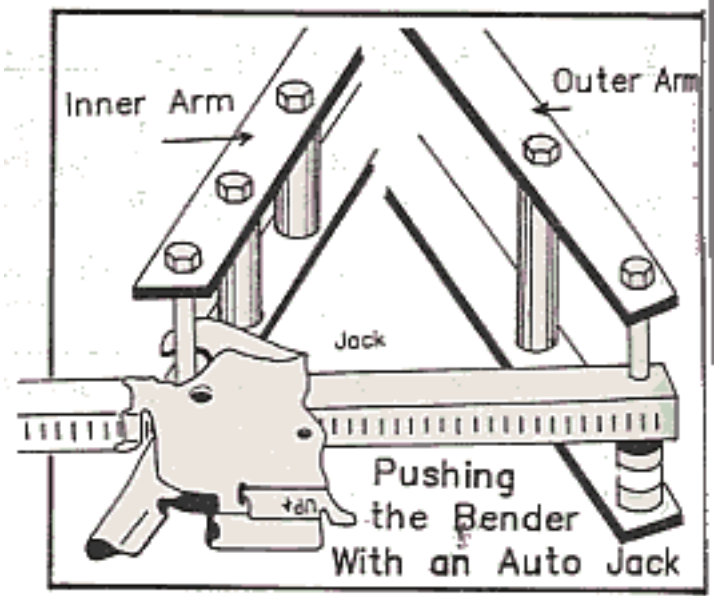
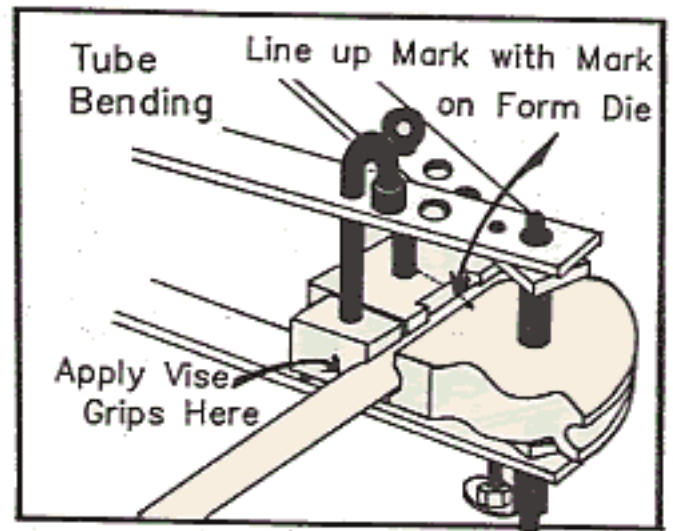
1) To insert the tubing, fold the bender back on itself as far as it will go. Adjust the channels in the back block and the draw block until they form a straight line.

2) Insert the tubing between the back block and form die. Line up the bending mark on the tubing with the bending mark on the form die. Tap the straight edge of the form die firmly against the tubing. If any space is left, the tubing may kink.

3) Clamp vise grips onto the tubing (as shown on the previous page) to prevent it from being drawn into the bender.

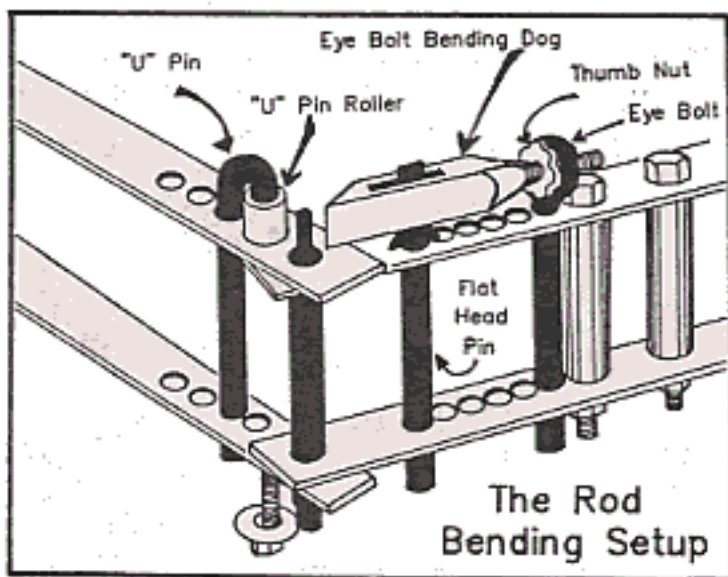
4) Using a "cheater pipe" for leverage, bend the tubing around the form die.

5) To bend large-diameter tubing, attach a ratchet-type auto jack to the bender frame and use it to pull the inner arm around the die. To attach the auto jack to the bender frame, drill a 1/2" hole in the auto jack. Bolt it to the frame using the last bolt in the stationary outer arm of the frame. Hook the other end of the jack to the last bolt in the moveable inner arm.



SETTING UP THE BENDER TO BEND ROD AND BAR

Unlike tubing, which is bent between the arms of the bender frame, rod and bar are bent on top of the frame. To set up the bender use the same bender frame, U pin, and eye pin that you used to bend tubing. Instead of using the tubing die sets, use the eye bolt bending dog, the thumb nut, the flat head pin, and either the U-pin roller or the caster fork bending die.



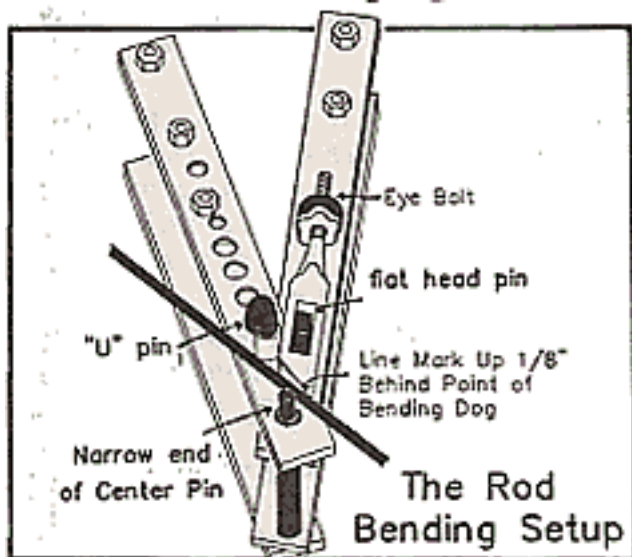
BENDING ROD

The following set up will bend the brake out of 5/16" (8 mm) rod.

- 1) Insert the center pin so that the small end is on top.
- 2) Insert the main shaft of the U pin through the second set of 5/8" holes on the outer arm of the frame. Mount the U-pin roller on the short end of the U pin.
- 3) Insert the eye pin into the sixth set of holes in the inner arm of the frame.

4) Insert the flat head pin into the first set of holes in the inner arm of the frame.

5) The eye bolt bending dog is held in place by the flat head pin on one end and the eye bolt on the other. Screw the thumb nut onto the eye bolt bending dog. Slip the square hole in the eye bolt bending dog over the flat head pin and slip the threaded end into the eye bolt. Be sure that the indented side of the flathead pin faces the longer side of the bending dog.



6) Fold the bender back on itself and insert the rod. Position the rod back about 1/8" (3 mm) from where the bend should begin. (The rod will be drawn slightly into the bender as it is bent.)

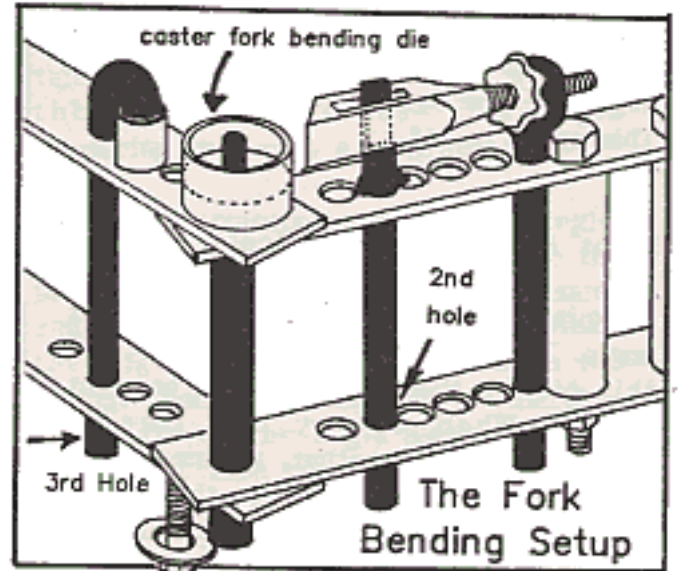
7) Tighten the thumb nut on the eye bolt bending dog to hold the rod tightly in place.

8) Pull the moveable inner arm of the bender around until the rod is bent to the angle desired.

BENDING FLAT BAR STOCK

The front caster forks and the handrim brackets use bent flat bar. To bend the caster fork, use the same parts as for bending rod plus the caster fork bending die. The caster fork bending die can be purchased as part of the Basic Tool Kit or it can be made out of 2" waterpipe (actual 2 3/8" O.D.) and a 3/4" I.D. washer. Directions for making the caster fork bending die can be found in Appendix B.

- 1) Adjust the 7/16" bolt and center pin support plate (or washer) until the center pin sticks up approximately 1-1/2" (4 cm) on top.
- 2) Mount the U pin, with or without the U-pin roller, through the 2nd or 3rd holes in the outer arm of the frame.
- 3) Mount the flat head pin through the second set of holes on the inner arm of the frame. The indented side of the pin goes on top and faces the longer side of the eye bolt bending dog.
- 4) Mount the eye bolt through the last 5/8" hole on the inner arm of the frame.
- 5) Put the threaded end of the eye bolt bending dog through the eye bolt, and slip the square hole over the flat head pin.
- 6) Mount the caster fork bending die on top of the center pin.
- 7) Fold the bender back on itself and insert the flat bar. Line the bending mark on the bar up with the point of the bending dog.
- 8) Tighten the thumb nut on the eye bolt bending dog until it holds the bar firmly against the die. Pull on the moveable arm to bend the bar around the die.



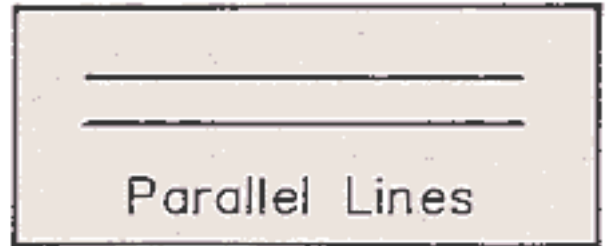
MEASURING THE BEND

When bending tubing, steel bar, or rod, you will need to measure accurately how far it has been bent. The following section defines the terms we will use and describes techniques for measuring the bends.

MEASURING TERMS

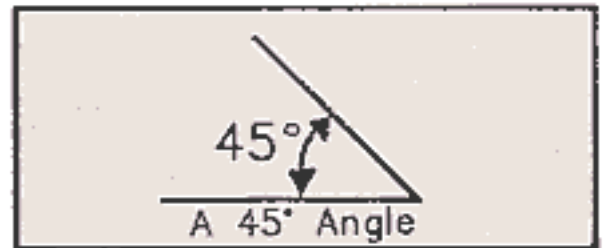
Parallel

Two straight lines are parallel when the distance between them remains the same all along the lines.



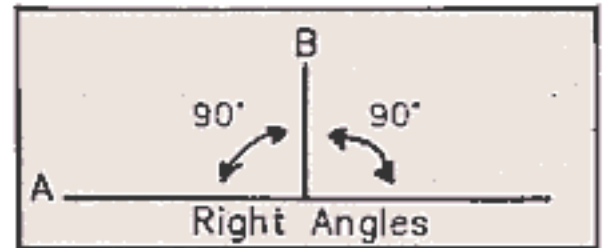
Angle and Degrees

When two lines meet they form an angle. The size of an angle can be measured in degrees. The symbol for degrees is $^{\circ}$. This angle is 45° .



Right Angle or Perpendicular

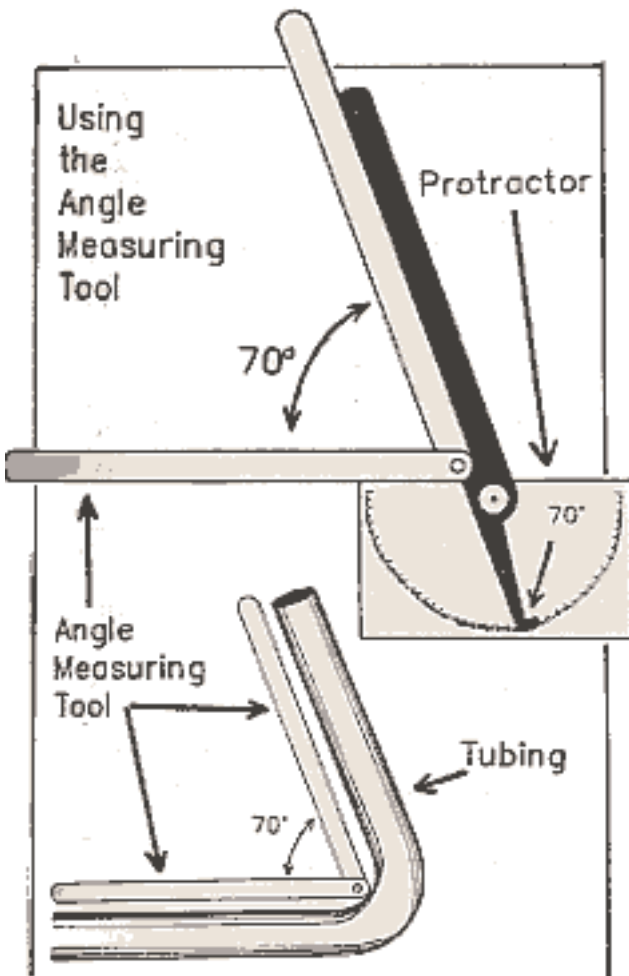
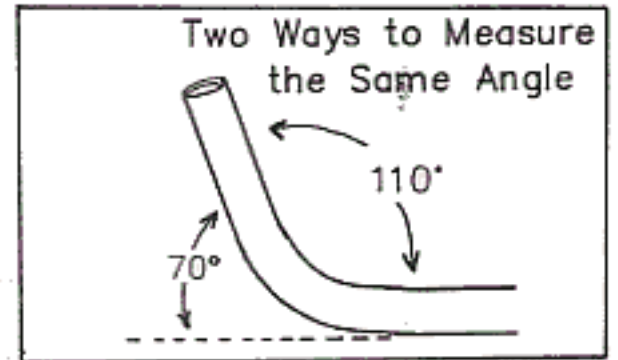
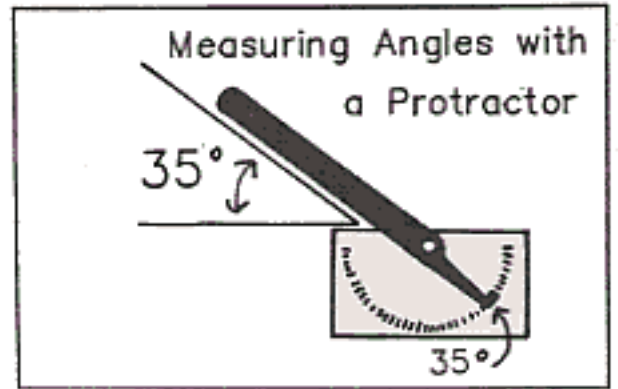
A square corner is also called a right angle. It measures 90° (90 degrees). In this picture there are two 90° or right angles. When we say one line is perpendicular to another, we mean that they form right angles where they meet. In the picture line B is perpendicular to line A.



HOW TO MEASURE AN ANGLE

To measure the size of an angle use a protractor. Line up the straight edge and the moveable arm of the protractor with the two lines that form the angle. The end of the arm of the protractor will point to the number of degrees on the scale. This number is the size of the angle.

Any angle can be measured in two ways, either from one side or from the other. For example, the angle of the bend in this footrest tube is 70~ or 110~ depending on which side it was measured from. After measuring the angle of a piece, hold that piece up to a similar piece to be sure they have the same angle.

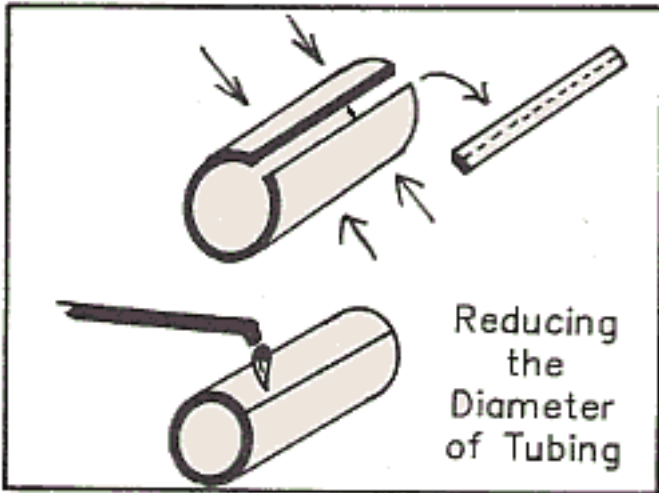


When measuring the angle of a piece of tubing you are bending, it is easier to use an angle measuring tool with longer arms rather than a protractor. You can make your own angle measuring tool out of two thin steel bars about 6" to 8" (15 to 20 cm) long, a bolt, and a nut. The nut should be loose enough so that you can open and close the steel bars and tight enough so that they will stay at the desired angle. Use this angle measuring tool with a protractor.

Set your protractor to the desired angle. Hold the angle-measuring tool up to the protractor and adjust it to the same angle. As you bend the tubing, place the angle measuring tool next to the tubing. Bend the tubing until it matches the angle of the angle measuring tool. A pre-bent tube can be used instead of the measuring tool.

TECHNIQUES FOR REDUCING TUBING DIAMETER

The tubing of the X-brace and the footrest must fit snugly over the sideframe tubing. The following techniques can be used whenever it is necessary to slightly reduce the diameter of tubing.



CUT AND WELD

- 1) Cut a section out of the tubing. It is best to remove the section that includes the seam.
- 2) Squeeze the tube together.
- 3) Weld the new seam using a steel welding rod.

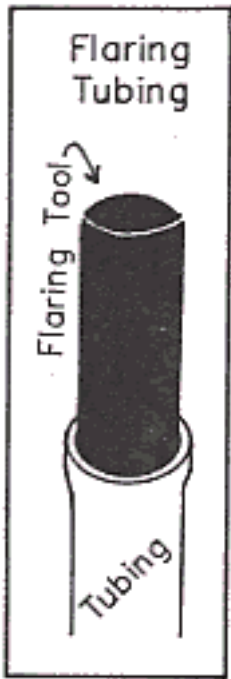
INDENT THE TUBING

Another way to reduce a piece of tubing to fit snugly over the sideframe tubing is to make an indentation in the tube as close to each end as possible.

- 1) Use the tubing cutter with an indenting wheel instead of a blade. The indenting wheel will make an indentation about 1/4" (6 mm) wide. The indenting wheel can be purchased as part of the Basic Tool Kit (see Chapter 2).
- 2) Put a solid steel bar inside the tube you are going to reduce. The solid bar will prevent you from indenting the tube too far. The solid bar should be slightly smaller in diameter than the sideframe tubing.
- 3) Roll the tubing cutter around the tube as close to each end as possible. Continue rolling and tightening the tubing cutter until the tube fits snugly on the solid bar.
- 4) Remove the solid bar and test the tube on the sideframe tubing.

This method of indenting can also be used to tighten tubing around ball bearings (Chapter 11) or to make a good seat for ball bearings (Chapter 12).

ENLARGING TUBING DIAMETER



- 1) Slide the tubing over a piece of solid steel rod. This rod should fit fairly snugly inside the tubing. Lay the rod between two blocks of wood.
- 2) Hammer on the side of the tube, striking evenly from one end to the other, until the tube is stretched to the right size.

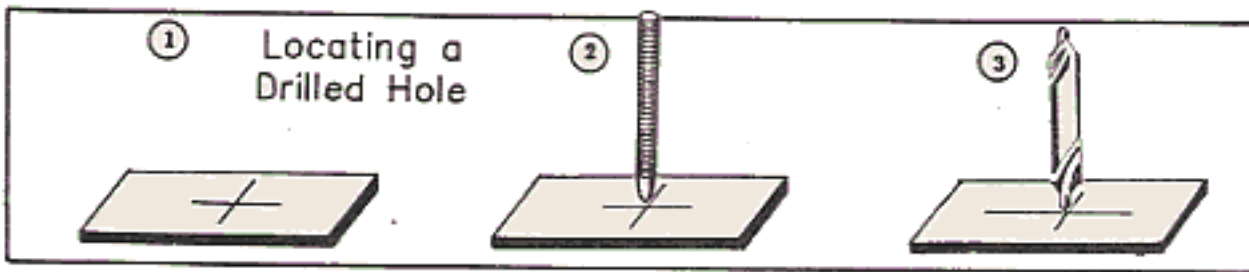
FLARING THE ENDS OF TUBING

If only the end of the tube needs to be enlarged (to fit a ball bearing, for example) a flaring tool can be used. A flaring tool is a piece of solid rod which has been turned in a lathe to just the right size. If you need to flare the end more than a very small amount, several flaring tools of increasing size can be used.

DRILLING ACCURATE HOLES

Whether you are making jigs or drilling holes directly in parts of the wheelchair, it is very important that your holes are drilled in exactly the right spot.

- 1) Scribe an X to mark the exact center of the hole.
- 2) Punch the center of the X with a center punch.
- 3) Drill the center of the X with a center drill. If you don't have a center drill, you can whack the center punch hard enough to leave an indentation that will hold a 1/8" (3 mm) drill bit. A short wide drill bit is more accurate than a long thin one because it is less flexible.



- 4) When drilling a hole larger than 5/16" (8 mm) start by drilling a smaller hole. The smaller hole should be less than half of the diameter of the big one.

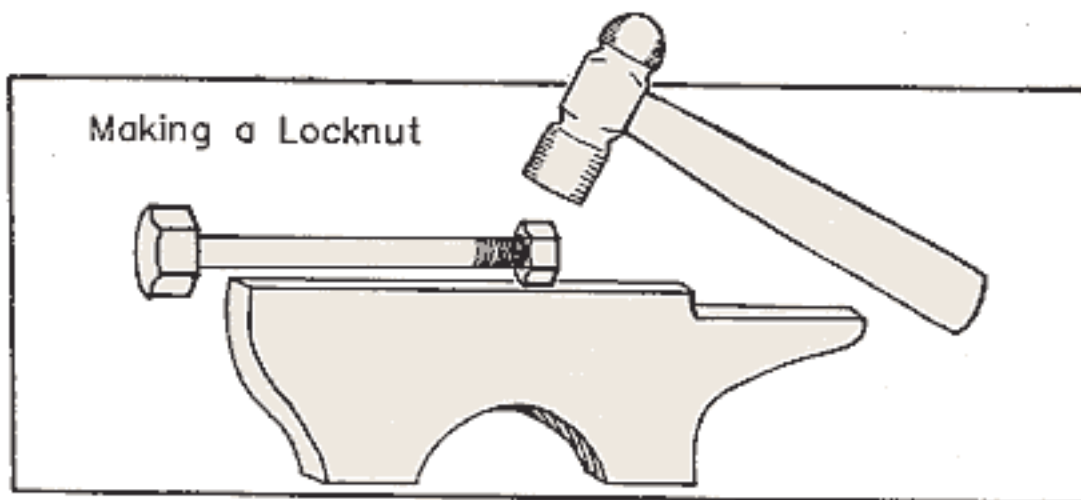
MAKING YOUR OWN LOCKNUTS

Nuts that don't loosen up easily are critical to a well-made wheelchair. The nuts on the axle bolts, the seat fabric bolts, the x-brace bolt, and the caster bolts should all be locked in place for the safety of the rider.

Lock washers placed under the nuts can help to keep them from loosening; however, there is so much vibration in a wheelchair, lock washers alone are often inadequate. A true locknut, one which will not spin freely even after it is loosened, is a better choice.

One type of commercial locknut that works well is a nylon lined locknut. Unfortunately, these nuts are expensive and are only available in some countries. If you are unable to purchase good quality locknuts in your area, a locknut can be made out of a standard, non-locking nut by bending the nut until it is difficult to put on or take off. The following method was developed by A.R.I.F.A. in Paraguay (Asociacion de Rehabilitacion del Impedido Fisico de Asuncion).

1) Screw a standard nut halfway onto the end of a bolt. Lay it on a vise or anvil and whack it with a heavy hammer.



Once a locknut has been turned on the bolt several times, it will lose some of its locking strength. Customers should be warned of this fact. Whenever a chair is disassembled, any nuts that turn easily should be bent or punched until they are difficult to turn.

There are several types of fluids available that lock nuts. We do not recommend these fluids to build wheelchairs; once these nuts have been loosened, their locking strength is gone.

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