Center for International Rehabilitation

Chapter 12 Making the Front Wheels


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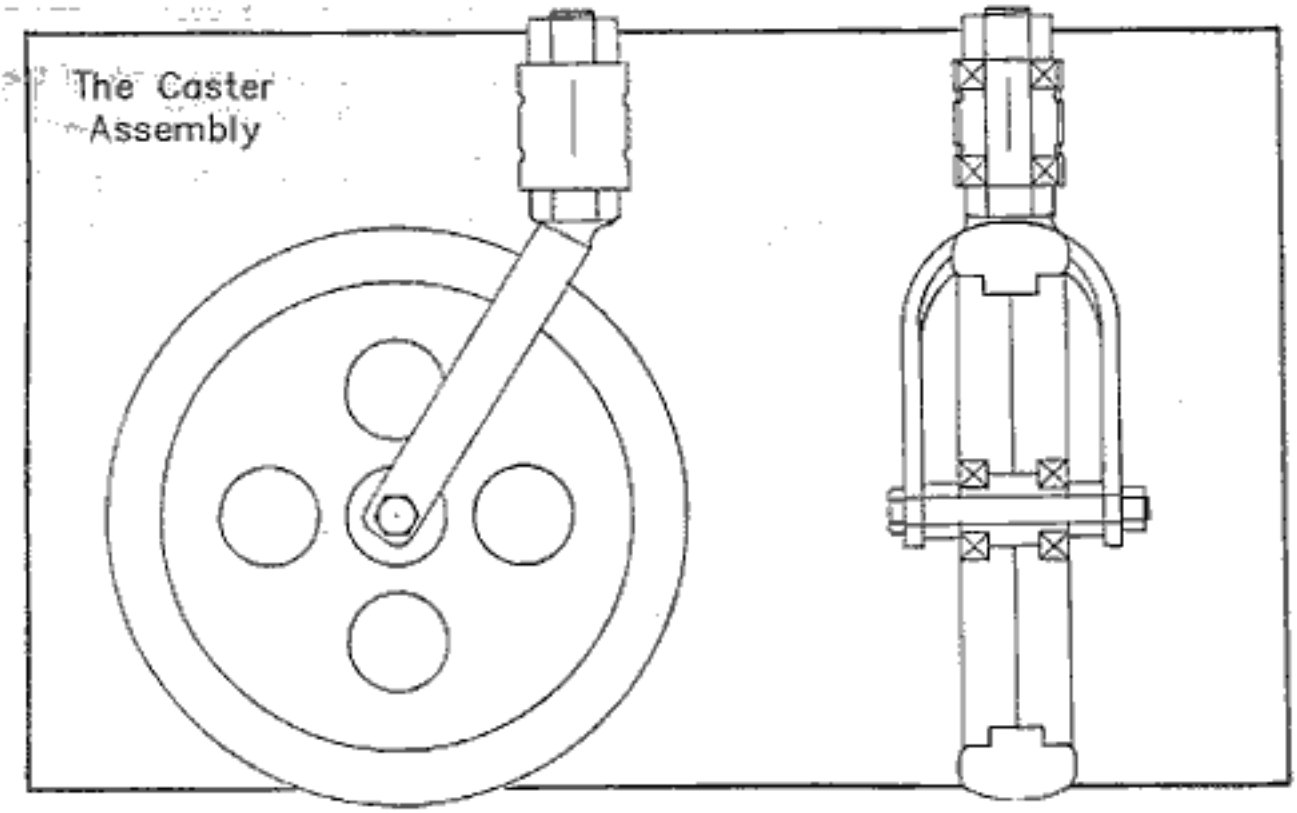
While the rear wheels are fixed to the frame in one position, the front wheels pivot on a bolt and allow the rider to steer the chair. The pivoting front wheel is called a caster. Each caster is made up of two main parts, the wheel and the caster fork assembly.

Our wheel is made of two hardwood discs. Each disc is indented to hold a sealed ball bearing, with one bearing on each side of the wheel. Extra-wide solid rubber or pneumatic tires can be used with the wooden wheels.

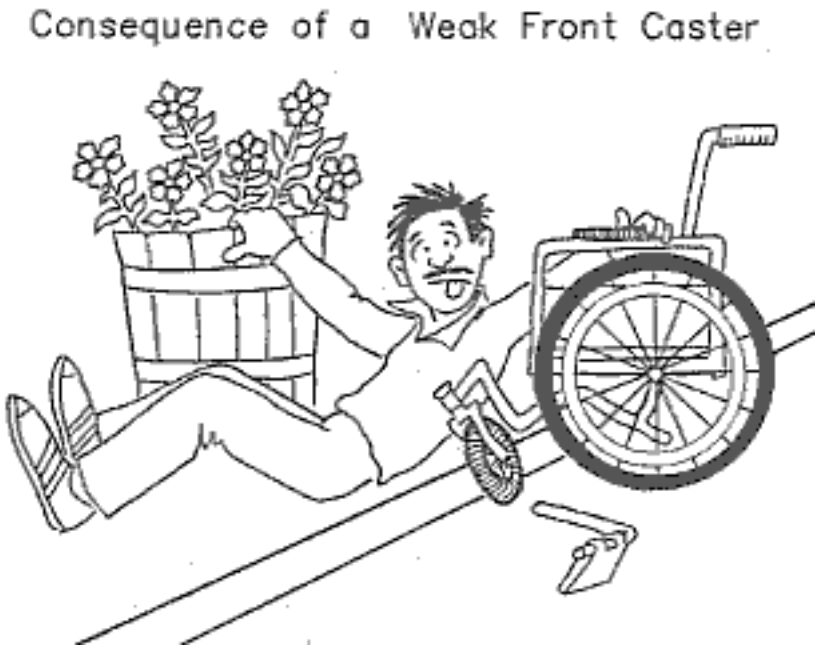
Each caster fork assembly includes a caster barrel which is welded to the frame. The caster barrel encases the bearings and the pivot bolt. The pivot bolt is welded to the arms of the caster fork which, in turn, support the wheel axle.



CASTER WHEEL DESIGN

If the front wheels are too small, the chair will have difficulty traveling over rough ground. If they are too big, they may bump into the back wheels and the footrests when they swivel. Lengthening the frame to accommodate larger front wheels is possible, but this makes the chair longer and thus much more difficult to maneuver. Most wheelchair riders have found that a wheel with a 7" to 9" (18 cm to 23 cm) diameter is a good compromise -- small enough to fit the frame, and large enough not to get stuck in rough terrain.

The front wheels must be strong enough to bump into curbs and hit potholes without breaking. While the front wheels must be sturdy, they must also be light. The heavier they are, the more likely they are to flutter from side to side when the chair is moving quickly. Fluttering front wheels can slow the chair so suddenly that the rider is spilled to the ground.



Finally, the front wheels must be inexpensive and easy to make. Many wheelchair makers have been making front wheels out of metal hubs and rims with short pieces of heavy duty spokes welded in between. While these wheels are strong, lightweight and are made from inexpensive materials, they can take a long time to make, and thus are too costly.

Our current design of wheel is made of two hardwood disks bolted together to hold either a pneumatic or solid rubber tire. While there is still room for improvement, the hardwood wheels are inexpensive, lightweight, sturdy, and fairly easy to make.

Good front wheels can also be sand cast of aluminum. Take a sample of a commercial aluminum wheel to a casting shop. They will make a mold around the sample, remove it, and pour in molten aluminum to mold a new wheel. It is usually necessary to have the holes for the bearings machined on a lathe to prevent the wheel from wobbling.

TIRES

It is important that the front tires have some flexibility. A chair with hard tires is uncomfortable to ride and difficult to push. In addition, a chair with hard tires will not last as long. Pneumatic tires have many advantages. They cushion the ride much better than a solid rubber tire, and they provide so little resistance to the forward motion of the chair that they will almost float over gritty pavement. Pneumatic tires are also very light. This is important because any extra weight in the outer part of the wheel will contribute to caster flutter. On the other hand, pneumatic tires will need to be pumped up regularly, patched occasionally, and replaced more often than solid rubber tires.

At this writing the 8" x 1-1/4" and 8" x 2" tires and tubes are not available in many countries. They can be ordered in quantities of several hundred or more for about U.S.$2.50 per tire and tube (1983 price) from:

Mady Enterprise Co., Ltd.
4th Fl. Ming Yen Building
No. 512 Sec 4. Chung Hsiao
E. Rd. Tapei, Taiwan
Republic of China

Telephone # (02) 703-0282-5

Import duties, broker's fees, and shipping costs are additional.

If you wish to use solid rubber tires, you can have them made locally by a rubber molding company. First hire a skilled machinist who specializes in making molds for rubber to make your molds. The cost of making the mold for the rubber tires has varied from about U.S.$300 to U.S.$500. Then find a rubber molding company that can mold the tires using a high latex content rubber of about 55 durometer (durometer is a measure of rubber hardness). A hardness rating of 55 durometer is very important because the harder rubber (65-80 durometer) that is used on most chairs gives a rough ride and is harder to push over rough roads and the softer rubber (30-40 durometer) used in the Philippines wears out fairly quickly. The cost of molding good tires has varied from about U.S.$1.50 in Peru and Honduras to U.S.$4.00 in Costa Rica.

The dimensions of the standard solid rubber tires that are made in several American countries are about 5-7/8" (14.9 cm) inside diameter, 7-7/8" (20 cm) outside diameter, and 1" (2.5 cm) wide. We prefer tires which are molded 1-1/2" (3.8 cm) wide (see the diagram at the beginning of this chapter) because they roll more easily over rough ground and they protect the wooden wheel. See page 147 for a tire mold design.

8" x 1-1/4" pneumatic tires use a smaller wheel than is needed for the common size of solid tires described above. If a solid tire is needed to fit the same wheel as the pneumatic tire, the solid tire should have a 5-1/4" (13.3 cm) I.D. and a 7-1/2" (19 cm) O.D. When mounted, solid tires will stretch to a slightly larger diameter.

MAKING HARDWOOD FRONT WHEELS

MATERIALS:

ITEM	QUANTITY	PART OF CHAIR
3/4" (18 or 20 cm) hardwood or marine plywood	7" x 28" (17.8 cm x 71 cm)	Wheel Disks
5/16" (8 mm) bolts with nuts	2 bolts, 3-1/2" (9 cm) long 4 nuts	Axle Bolt
1-3/8" O.D., 5/8" I.D. bearings*	4	Wheel Bearings
3/8" hexnut	4	Bearing Spacers
3/16" (5 mm) bolts and nuts	8 sets; bolts 2" (5 cm) long	Wheel Disk Bolts
washers (5/16" I.D.)	12	Spacers

* See bearing chart on page 79 for bearing numbers and other bearing sizes that work.

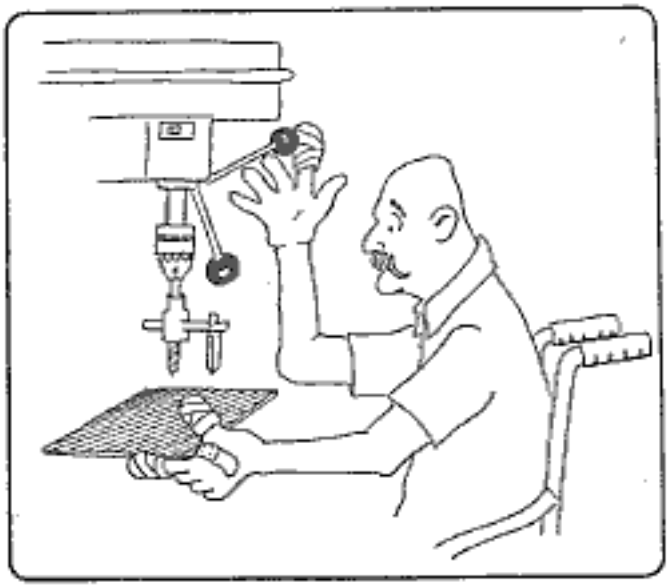
DIRECTIONS

Each wheel is made of two wooden disks. The inner edge of each disk is slightly smaller, creating a channel to hold the tire.

The following directions are for making the hardwood disks for the 6" I.D. x 8" O.D. solid rubber tires. Smaller disks of the same design will work for pneumatic tires.

1) To make the wheel disks, cut the 3/4" (18 or 20 mm) hardwood into 4' x 7" (122 cm x 17.8 cm) pieces.

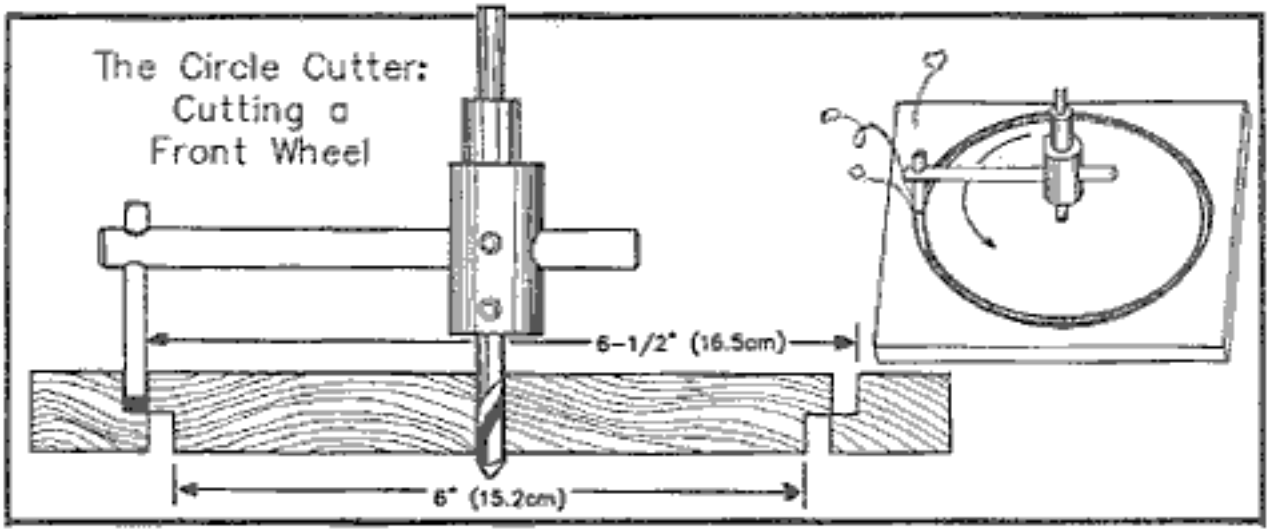
2) On top of a scrap piece of plywood, clamp one of the hardwood pieces onto the drill press table. This will hold the hardwood flat and level while you cut out the circle.



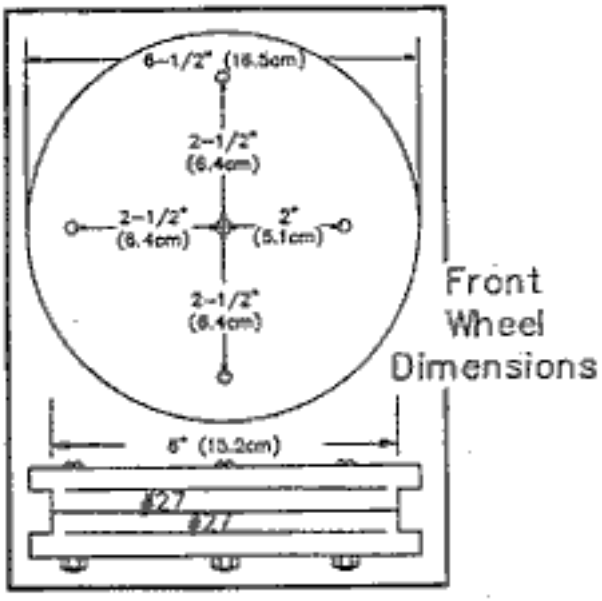
3) Using the circle cutter, cut four 6" (15.2 cm) diameter circles. ONLY CUT HALFWAY THROUGH THE HARDWOOD!

BE CAREFUL WHILE USING THE CIRCLE CUTTER; IT CAN EASILY CUT OFF STRAY FINGERS!

4) Turn the hardwood over, and clamp it to the drill press table. Using the same center holes to guide the circle cutter, cut four 6-1/2" (16.5 cm) diameter circles in the same location (but from the other side) as the holes above. (See diagram.)



5) For each wheel, bolt two disks together as in the drawing by inserting a 1/4" (6 mm) diameter bolt through the holes that were left by the circle cutter in the center of each disk. Tighten the bolt to hold the disks together. Then drill four 3/16" (5 mm) holes as shown. Note that one of these holes is closer to the center of the wheel than the other holes. This ensures that the two halves of the wheel can only be assembled the same way they were drilled. If they were put back together differently, the wheel might wobble. Put a number on each disk to prevent them from being mixed up with disks from other wheels.



6) Insert and tighten four 3/16" x 2" (5 mm x 5 cm) bolts as shown. Remove the 1/4" (6 mm) bolt from the center of the wheel.

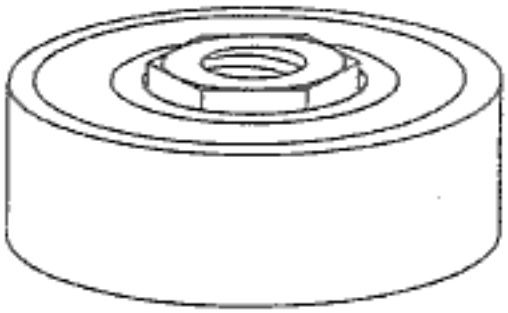
7) Using the circle cutter, cut some sample 1-3/8" holes in scraps of hardwood. Insert a 1-3/8" O.D. bearing and see how it fits. If it doesn't fit tightly, adjust the diameter of the circle cutter until the bearing fits very tightly.

8) Once the circle cutter is properly adjusted, starting on the outside of each disk, cut a 1-3/8" hole half way through the center of both disks. If you want to lighten the wheel, cut four more 1-3/8" diameter holes all the way through both disks in an evenly spaced pattern around the wheel.

9) Cut 1" (2.5 cm) holes all the way through the centers of both disks.

10) If you are using 1-3/8" O.D. by 5/8" I.D. bearings or #6202 bearings with an inside diameter of 16mm in your front wheels, press a 3/8" hexnut into the middle of each bearing with a vise. The 3/8" nut will serve as a spacer between the bearing and a 5/16" (8mm) diameter axle bolt.

If your wheels are using #6202 bearings with an inside diameter of 15mm, you will have to grind or turn a 3/8" nut or a piece of hardwood, steel, or other solid material to the right size. Unfortunately, there is no standard size nut that will fit tightly in a 15mm hole.



A nut can serve as a bearing spacer.

11) The wheels are now ready for sanding, painting, and final assembly. When the paint is dry, assemble the wheel around a solid tire and hammer the bearings carefully into place.

CASTER DESIGN

The caster assembly allows the front wheel to swivel so it will go in the direction you push it. Each caster includes a caster barrel welded to the wheelchair frame, bearings, and a caster fork (a pivot bolt welded to arms bent out of solid bar).

CASTER FORK FAILURE

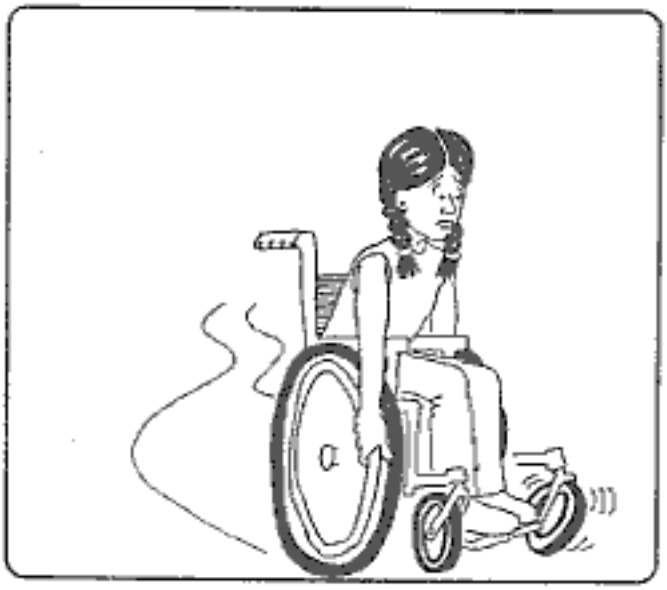
Caster forks made by some of the larger wheelchair companies are easily broken or bent when the wheelchair runs into a rock or curb. A caster fork that has been bent can cause the wheelchair to swerve crazily to one side or to stop suddenly, dumping the rider to the ground. Wheelchairs with bent caster forks are a common sight in wheelchair repair shops.

When any wheelchair runs into a curb or chuckhole at a fast walking pace, its fork can be pushed back with over 300 pounds (136 kg) of force. Many commercial forks fail when subjected to impacts of less than 200 pounds (91 kg). The fork we have designed, if it is well made, should withstand impact forces of over 400 pounds (182 kg).

When a fork does fail, it is safer if the fork fails by bending rather than fracturing. If a pivot bolt of 1/2" (13 mm) diameter or less is used, it must be made of hardened steel to prevent bending. Using a hardened steel bolt can be risky - if the bolt is a little too hard, it will break before it bends. Our caster fork design uses larger 5/8" (16 mm) pivot bolts made out of mild steel. They are safer and less expensive.

REDUCING CASTER FLUTTER

Whenever a wheelchair with a front caster of typical design is moving at a fast walking pace, its caster can begin to flutter or vibrate violently. This vibration can slow a chair down so suddenly that the chair tips forward, dumping the rider to the ground. Every time a wheelchair rider pushes at high speed or coasts down a hill, there is a possibility that he or she will suddenly lose control and be seriously injured. The caster fork can be designed to greatly decrease the risk of caster flutter. The easiest way to stop flutter at moderate to high wheelchair speeds is to increase the amount of trail of the caster fork. Caster fork trail is a measure of how far the center of the front wheel trails behind the pivot line of the caster fork. Many commercial chairs use as little as 2" (5.1 cm) of trail; however, the casters on these chairs can flutter severely at moderate speeds. In our opinion, a normal chair needs 2-1/2 " (6.3 cm) of trail, and a racing chair needs 3" (7.6 cm) or more.



Unfortunately, the more trail the caster fork has, the more space the caster needs in order to swivel. If you give the caster more swivel space by lengthening the frame or extending the footrests, you also make the chair more cumbersome. The Torbellino wheelchair has a caster fork trail of 2-1/2" (6.3 cm). This is long enough to diminish flutter and short enough to fit within the standard size frame.

Caster flutter can be reduced even further by increasing the friction where the pivot bolt swivels. First add a soft leather washer under the nut on the pivot bolt. Then, underneath the bottom bearing, add a 5/8" (16mm) I.D. steel washer with the side next to the bearing slightly indented. Because this washeR doesn't touch the inner race of the bearing, the entire weight of the chair presses the outer race of the bearing against the washer and the pivot bolt. This prevents the pivot bolt from swiveling as easily. The friction increases as the weight on the front of the chair increases. Anytime the caster begins to flutter, it slows the chair and shifts weight to the front. This presses the washers against the bearings and stops the flutter.

MAKING THE CASTER ASSEMBLY

MATERIALS

ITEM	SIZE	QUANTITY	PART OF CHAIR
1/4" x 3/4" (6mm x 20mm) solid bar	11" (30 cm) long	2	caster forks
5/8" (16mm) O.D. fine thread bolts	2-1/2" (6.4 cm) long	2	pivot bolts
locknuts	5/8" (16mm) fine thread	2	for pivot bolts
5/8" (16mm) I.D. washers	1-3/8" (35mm) O.D.	2	for pivot bolts
bearings*	#99502h(1-3/8"x 5/8")*	4	in caster barrels
casterbarrels		2	caster barrels
	(already attached to main sideframe pieces)		

*As in the rear wheels, other bearings with similar dimensions will also work. See chart in Chapter 11, page 79.

JIGS AND BENDERS FOR MAKING THE CASTER ASSEMBLY

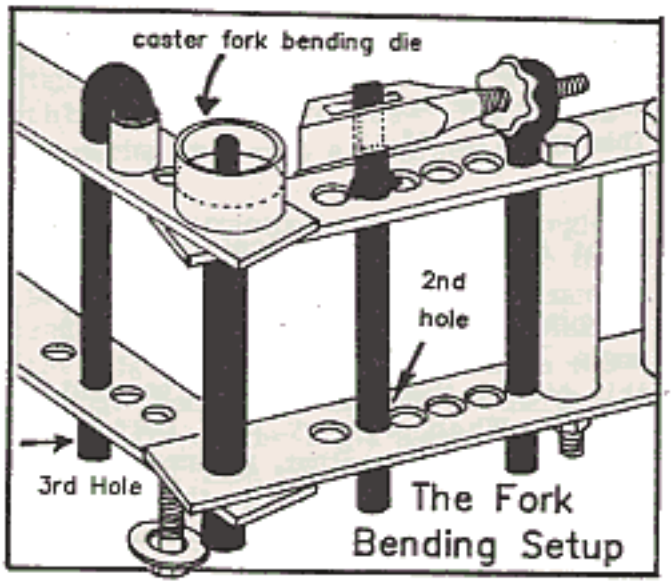
- Hossfeld Type Bender and Caster Fork Die
- Caster Fork Welding Jig

Instructions for making the caster fork bending die and the caster fork welding jig can be found at the end of this chapter. Both can also be purchased ready made as part of the Basic Tool Kit.

DIRECTIONS

1) Set up the bender to bend bar using the eye pin, flat-head pin, eye bolt bending dog, "U" pin, "U" pin roller, and caster fork die. See Chapter 6 for more detailed instructions on how to set up the bender to bend bar.

2) Cut two 11" (27.9 cm) pieces of 1/4" x 3/4" (6mm x 20mm) solid steel bar and mark each piece 3" (7.6 cm) from one end.



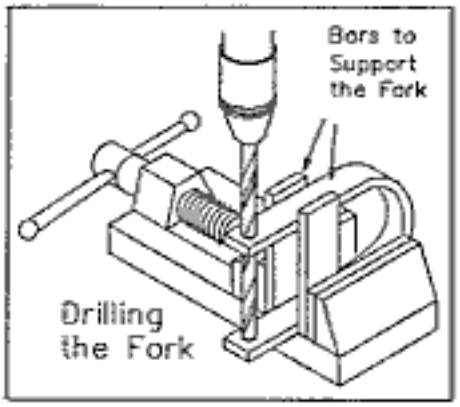
3) Place the bar in the bender. Line up the mark on the bar with the tip of the bending dog.

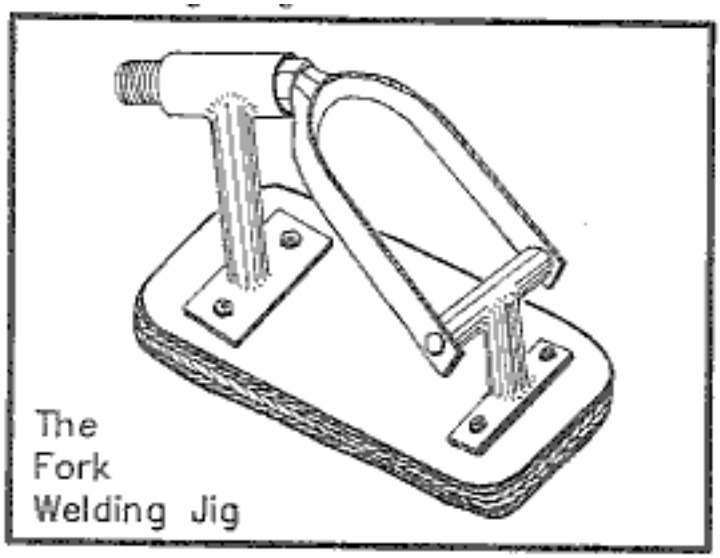
4) Bend the bar 180~ around the caster fork die until the fork arms are parallel with each other. When you are finished bending, the fork arms should be nearly the same length. It doesn't matter if one is 1/4" (6 mm) longer than the other.

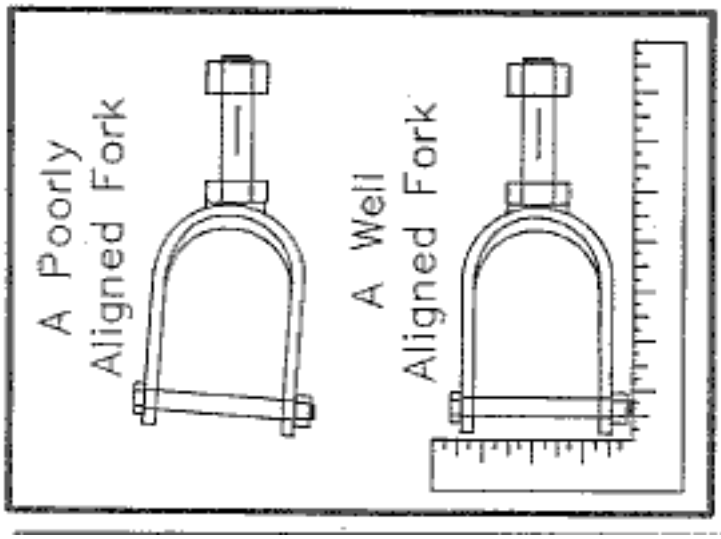
5) Make a mark 3/8" (10 mm) in from the end of the shorter arm, and drill a 5/16" hole for the axle bolt.

6) Place the fork in the drill press vise between two blocks of metal or wood as shown. Make sure that the fork is flat in the vise.

7) Put the drill through the hole in the top arm and drill a hole in the bottom arm. Make sure that the drill is at right angles to the arms of the caster fork.







8) Before brazing the pivot bolt to the caster fork arms, be sure to sand, wire brush, or file both parts down to bare metal. The strength of a dirty weld is always unpredictable, even though it may appear well bonded! It is very important to weld the fork securely. If the caster fork arms were to break loose from their pivot bolt, the wheelchair rider could be seriously injured.

9) Place the caster fork and the pivot bolt in the caster fork welding jig as shown. Weld the bolt to the fork using electric arc welding equipment if available. Bronze brazing also works well, but it is more expensive. Let the fork cool slowly so that it does not crack.

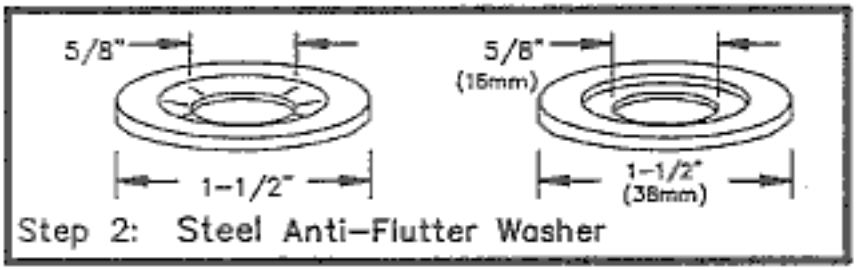
10) Check the finished part for good alignment. Bend it into alignment if necessary. A poorly aligned fork will cause the chair to pull to one side.

11) Before adding the caster forks to the frame, paint or plate them. Since the caster forks will take a lot of abuse, plating is the better method of protection.

MAKING THE ANTI-FLUTTER WASHERS

1) Make the upper anti-flutter washer by cutting a hole in a piece of leather with a 5/8" (16mm) leather punch. Put this washer under the nut on the caster pivot bolt.

2) If you have a large drill bit (7/8" [22 mm] or larger), make the lower anti-flutter washer by placing a 5/8" (16mm) steel washer in the drill press vise and boring half way through the washer. Be sure to set the drill press at a very slow speed. If your drill press doesn't have a slow speed, turn the drill press by hand.



If you don't have access to a large drill bit, make the lower washer by welding a 5/8" (16mm) I.D. washer under a 7/8" (22mm) I.D. (or larger) washer.

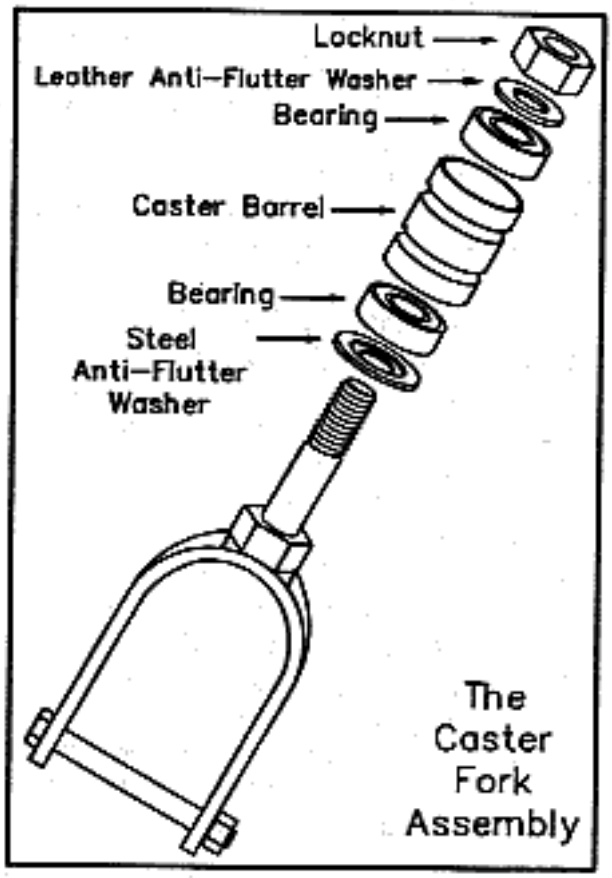
ASSEMBLING THE CASTERS

1) Now that the caster forks and washers have been made, they can be attached to the frame. Slip a bearing into each end of the caster barrel. The indentations will hold them in place; use of a spacer tube is optional.

2) Slide the lower anti-flutter washer onto the pivot bolt. Be sure that the indented side of the washer faces away from the fork.

3) Insert the 5/8" (16mm) pivot bolt into the bearings. Slide a leather washer over the top of the pivot bolt, then gently tighten down the locknut. Chapter 6 describes how to make locknuts.

4) Attach the wheels to the caster forks using axles made from 5/16" (8mm) x 3-1/2" (9cm) bolts with locknuts.



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