



ShopBot PRTalpha: Assembly Manual

ShopBot Tools, Inc.

3333-B Industrial Drive

Durham, NC 27704

919-680-4800 (phone)

919-680-4900 (fax)

info@ShopBotTools.com

http://www.ShopBotTools.com

Copyright (c) 1996-2004 by ShopBot Tools, Inc.

All Rights Reserved.

Related software Copyright (c) 1996-2006 by W.G. Hall and ShopBot Tools, Inc.

All Rights Reserved.

ShopBot is a Registered Trademark of ShopBot Tools, Inc. Other brand and product names are trademarks or registered trademarks of their respective holders.

U.S. Patent 6,070,106

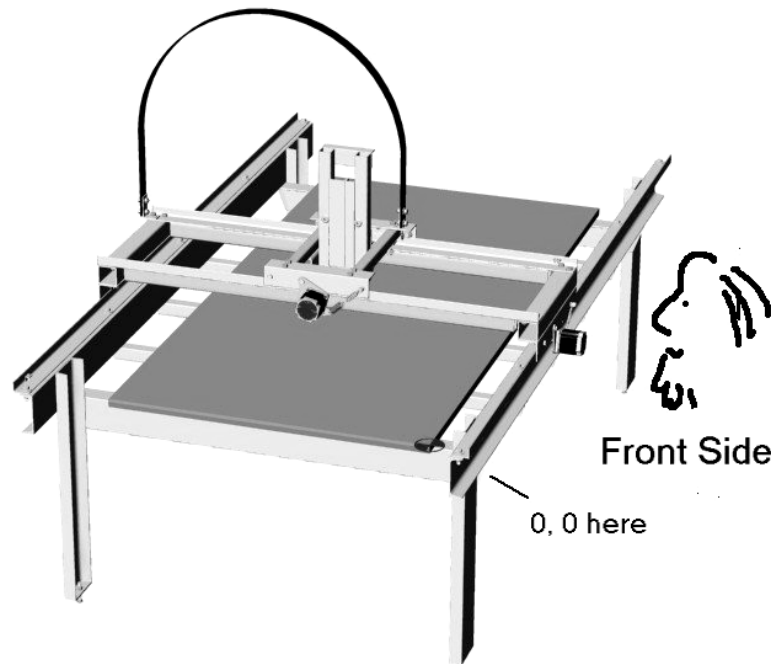
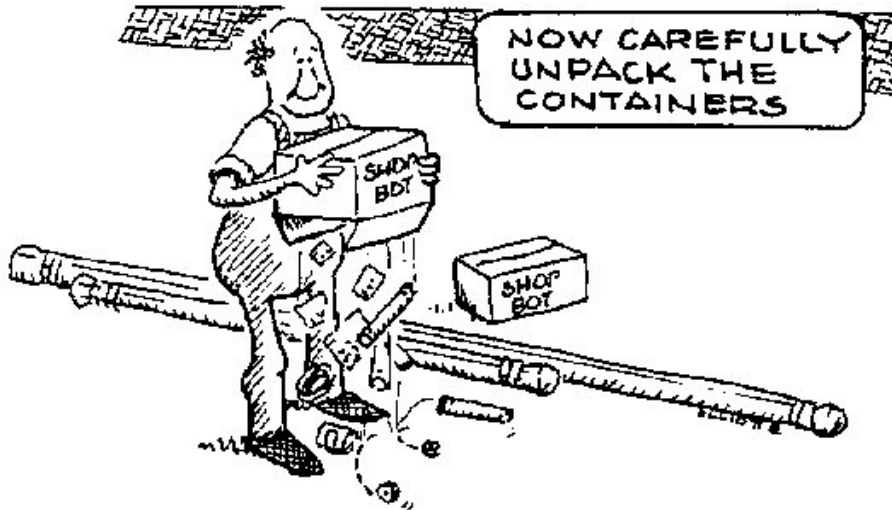
Manual Illustrations by Don Elliott.

{Assembly 20040729}

This manual is part of a suite of documents for your ShopBot Personal Robotic Tool that includes: the Users Guide on using your ShopBot and the ShopBot Control Software; the Command Reference documenting the specific format and usage for every ShopBot Command; and the Part Programming Handbook detailing the functions available in the ShopBot Part File Language and shows how these functions can be used in your own projects.

We are grateful for numerous helpful suggestions from early assemblers of ShopBots ... those who struggled with the first versions of this assembly guide and tools that were not partially-assembled. In particular, we would like to thank Bill Young, Steve Reed, Jim Turner, Jeff Milkey, Mike Goodwin and Jerry Malinski for their enthusiastic suggestions and encouragement. Don Elliott, Chris Burns, Tommy Murrah, Gordon Bergfors, Maria Ikenberry, and Sallye Coyle have worked hard to help create this version of the manual.

If you feel a need to unpack before you read the next part, skip ahead to the 'unpacking' section and we'll help you get your parts organized.



Overview of Your ShopBot PRTalpha

Before you unpack and start to assemble your ShopBot PRTalpha, let's go over some of the major components and get familiar with the terminology we'll be using:

THE TABLE. You've assembled the ShopBot Steel Table using the instructions in the Table Assembly section of the manual? Or perhaps made your own table? We will be mounting your ShopBot on whichever table that you built. So, if you have a standard size ShopBot, we should be looking at a sturdy table framework with overall outside dimensions of 120

inches by 64.5 inches wide. We'll follow slightly different procedures for steel tables and for wood tables.

As we begin putting your ShopBot together, you'll see that there are some options for configuring your tool with respect to where the wiring harness is placed, and where you set up your ShopBot Control Box and your computer. However, for consistency and clarity, in these instructions, we will assume a standard configuration. A standard layout also makes it easier for you to use down-loaded Part Files and to communicate with ShopBot Tech Support.

To get us located, refer to the orientation diagram above and imagine looking at the tool from the position of the little man in the drawing. Also imagine that you'll put your computer and Control Box about where the man is. From this position, we'll call the lower left hand corner of the work area the tool's 0,0 (or home) location. The X-axis is the long length of the table and values increase going to the right from where you are standing. The Y-axis is the narrow width of the table (or front to back from your position on the long side) and values increase as you move away towards the back. The Z-axis is the vertical movement or the plunging and withdrawal movement of your tool. Decreases in Z values are plunges down by your cutting tool. Increases pull the cutting tool up.

Still looking from the position of the little man, consider the furthest away X-axis track to be at the back of the tool, the track nearest the little man to be at the front, the left side the left, and so on. As you're positioning your tool in your shop, keep in mind that you will be loading sheet material from the left or right side so you should be sure to leave yourself some room to move around in one or both of these areas.

The sub-components of your ShopBot are highly modular. Once you've put one of a particular type part together, you'll find that the rest work pretty much the same way (with a few variations to keep things interesting). We'll use the words 'frame' and 'gantry' or 'car' to refer to the entire moving unit of a particular axis, with more specific terms for the sub-components of each axis.

The electrical cabling will be arranged along the back of the tool, so this is the part of the tool that can be placed nearer a wall, obstruction, or where there will generally be less action. Note, however, that it is best if you are able to walk around and access your tool from all sides. The wiring for the Y and Z axes is attached to a black plastic guide that will arch out from the back right hand corner of the X-axis carriage to the front right of the Y-axis carriage, as seen from the little man. The Y-axis frame with the gear rack mounted on it will go on the left, and thus the Y-axis motor will be mounted on the left side of the Y carriage. Finally, the Z-axis assembly will fit inside the Y-axis carriage with the router facing left in the tool bay. If you have two Z axes, the routers will face each other in the center of the tool bay.

THE X-AXIS. The X-axis is the basis for your tool's right and left moves (as seen by you as the little man in the front of the diagram) -- it's the long axis on a standard ShopBot. Note that the distance between the tracks on the X-axis is wide. Because of this span, we power the X-axis carriage movement with 2 motors, one on each side. We call the 22" steel-angle/square-tube unit that the motors are mounted on 'motor carriers'. These pieces also form the short sides of the X-axis frame or carriage. The carriage is driven by a rack and pinion power transmission system. The gear rack is mounted on the bottom of the long X rails and engaged by the pinion gear on the motor shaft. The motors are 'alphaStep' motors that provide precise, discrete, incremental movements in the X, Y and Z-axis.

THE Y-AXIS. The Y-axis provides the front to back movement of your ShopBot (the short axis for a standard ShopBot). Note that the Y-axis rides on the X-axis. In fact, the rails of the X-axis frame become the track for the Y-axis. With the exception of only having a single

motor, the Y-axis works like the X-axis. It is just a smaller version working in a different direction. The gear rack for the Y-axis is on the bottom of the left hand track as you face the tool from the little man and the motor is on the left hand side.

THE Z-AXIS. The Z-axis is vertical and moves the cutting tool up and down. The Z-axis is mounted on the Y-axis frame, perpendicularly. It is organized a bit differently than the X and Y-axis but its rolling gear is fundamentally the same. The drive system for the Z-axis is also rack and pinion. The Z axis is spring-loaded to counterbalance the weight of your router.

THE ROLLING GEAR. Steel-angle rails form the tracks or 'ways' for the movement of your ShopBot's carriages. X, Y, and Z-axis gantries roll on bearings that are mounted to ride on the top beveled edge of the track beneath them. Similar bearings are used to capture the Y axis laterally.

THE CONTROLS. Your ShopBot is moved and controlled by an IBM-style personal computer that you provide. In Version 3 of the ShopBot Control software, signals are streamed from the PC's USB port through a USB cable to the USB to serial port adapter and to the ShopBot Control Box. The Control Box is placed near the tool and provides the output power to the motors. It also receives incoming information from optional switches. See the TAB labeled software installation and tutorials for more information about the computer requirements.

LAYOUT OF ASSEMBLY STEPS. What we've tried to do in this Assembly Manual is to lay out how to put your ShopBot together in terms of major 'Steps.' For each Step we provide an overview, a parts list, relevant diagrams and photographs, and a detailed set of instructions for working through that Step. The end of each Step represents a good break point if you need to stop work for a bit.

GETTING HELP

If you are having trouble with an assembly step, e-mail is a particularly good way to get us 'after-hours'. We check e-mail and the tech support line several times a day including evenings and weekends.

If you are having an assembly, mechanical, or electronic problem with your ShopBot, we suggest you first have a look at the trouble shooting section of the ShopBot User's Guide. You will find suggestions for diagnosing your problem there.

As an initial step anytime you are having a problem getting your ShopBot to respond properly, try restarting your ShopBot Control Box, your computer, and the ShopBot software. It may also be useful to reset the tool to its default settings using the [UR] Command.

Whenever you communicate with us about it problem (especially one related to the ShopBot not connecting or a file not running properly), it is useful to:

- 1) provide information about when you purchased your machine and all the detail that you can about the exact steps that led up to a particular problem
- 2) send along the file named PROBLEM.LOG that you will find in your ShopBot Folder/Directory (this file allows us to re-create your exact set-up). (You can find the problem.log from the Windows START menu using the Search or Find option. Choose "files or folders" and type problem.log, then search. Open the file in notepad, and print it out or email it to us.)
- 3) e-mail us a sample of any file that may be related to the problem or illustrate the problem

SHOPBOT SUPPORT IS AVAILABLE:
 BY email: support@shopbottools.com

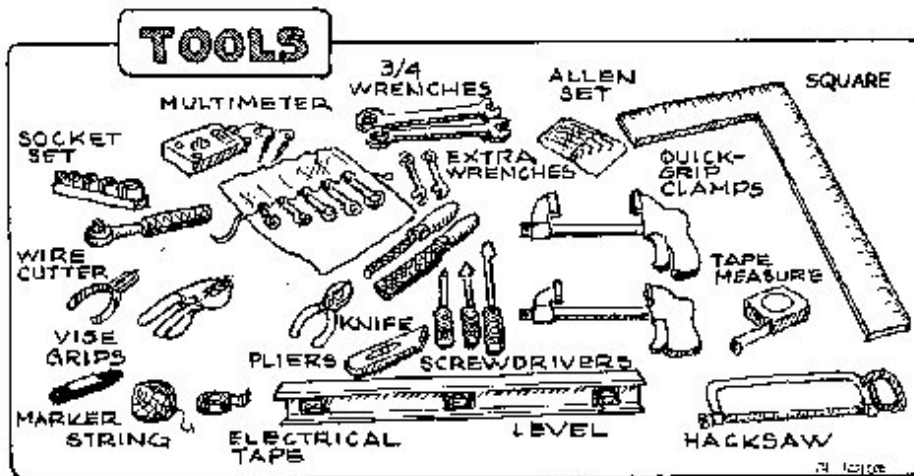
BY phone: **919-680-4800 ext 113**
 BY fax: **919-680-4900**

You may also want to check the ShopBot Forum on our web site for ideas on handling problems: <http://www.shopbottools.com>.

Assembling Your ShopBot

Well, after that little orientation we're ready to put your ShopBot together. Assembling a ShopBot is not a difficult task if you take it Step-by-Step. In fact, in the all-American spirit of Sears and Roebuck, we were tempted to just put "Some Assembly Required" on the ShopBot box and leave it at that ...

We do think, though, that it's reasonable to view the process as no more involved than putting together an adult 'Erector Set.' The construction is modular, and once you get the hang of it, the assembly will go quickly. You shouldn't have to do any serious cutting, drilling, or grinding (we hope).



TOOLS YOU'LL NEED:

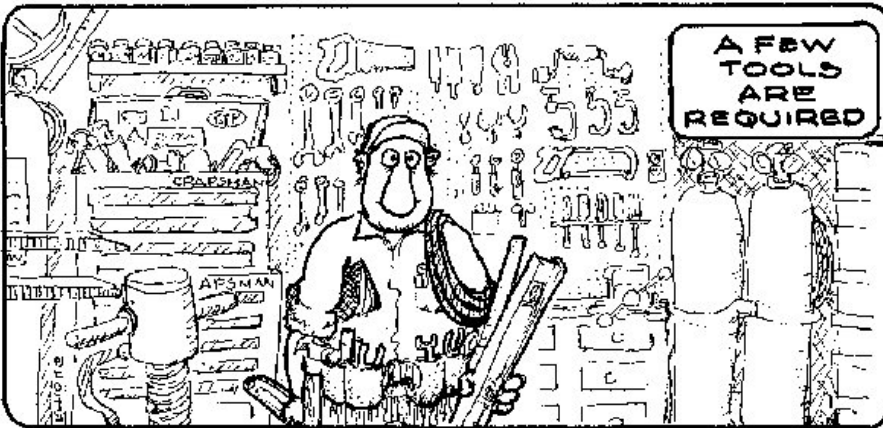
- a wrench set with TWO 7/16", 2-9/16", and 2-3/4" (the type with box end on one side and open end on the other works well).
- a socket wrench set
- an Allen wrench set
- a drill for a couple of holes (1/4", 7/16", and 1/2" bits; + 9/32" for wood table)
- a good tape measure, a carpenter's square, and a level (a six foot one is great, but we can get along with a shorter one and a very straight board)
- (optional) a six-foot long pipe clamp or bar clamp can be very helpful
- 50 feet of 14-18 gauge wire to use for grounding the dust collection hose

- Misc: the odd screwdriver, adjustable wrench and pliers, utility knife, electrical tape (in a color that you can mark on) or masking tape, marking pen, a 12' piece of string to use to align the X track, your wits, etc.

TOOLS WE HOPE YOU WON'T NEED:

... (but you never can tell when it would be nice to have them nearby)

- assorted files
- hack saw
- volt/ohmmeter



Unpacking and Getting Your Work Area Organized:

We find it works well to just put a piece of plywood or something similar (about 4'x4' or bigger) on top of your table to use as a work area if you have not already put a top on the table. You will receive a large shipping crate with the already-assembled X and Y carriages and the Z axis. One of the large cartons inside the crate holds the ShopBot Control Box. The motors and motor cables are packaged together. The long package with the rails and (if applicable) table sides may be strapped to the top of the shipping crate. You can unpack the rails and X and Y carriages so that you can identify them and have them ready. Be careful not to damage the gear rack on the bottom of the rails. Unpack and lay out the parts bags on your work surface.

Don't worry about the Control Box for the moment, you can set it aside until we're ready to connect your ShopBot.



Figure 1 Shipping the ShopBot PRTalpha

When your ShopBot PRTalpha arrives, you will find that the X and Y carriages have been assembled in the factory, and all you have to do is lift them onto the rails.

Some Standard Techniques:

There are a few standard procedures we should discuss in the beginning. Then if we forget to remind you about them in any particular step, you'll be able to cover for us anyway.

1/2 INCH HARDWARE ... the main frame members of your ShopBot are bolted with 1/2" nuts and bolts. Make sure in your final tightening of these fittings with this hardware that you torque down the 1/2" bolts extremely tight.

CHANNEL NUTS ... These are nifty little chunks of metal that span two ridges are used in places that you can't reach with a wrench, like mounting the Z axis. They are designed so that you can start the nut onto the bolt, then shove it up into position and turn the bolt to bring the nut into position as you are tightening it. They work pretty well once you get used to them. Note that one side is grooved to ride on and retain the lip of the bottom of the strut. The channel nuts come in different thread sizes.

CALLING A HEX BOLT A BOLT ... most of the bolts we will be using are hex bolts, the kind you put a wrench on the head of. Whenever we mention a bolt in the following sections, we usually mean a HEX bolt. We'll try and let you know when this is not the case.

DRILLING HOLES ... in situations where you may need to drill a large hole in steel, it usually works best to mark the hole with a center-punch. Then drill with a small bit (1/4" or less). Then bring the hole to full size with a large bit. Be careful of the kick from the drill as you break through the final portion of the hole with the large bit.

OTHER THOUGHTS. There are some aspects of the assembly process that need to be done in a specific order to avoid later frustration. So we encourage you to go through this with us step-by-step. Nonetheless, we realize there will be some people who can assemble their

ShopBot after just having taken a look at the pictures. That's fine ... but we'd suggest you skim through the order of things so that you don't have to undo a lot of your work to get some part you overlooked into the right place.

We've pre-assembled several components of your tool to make things go a little more smoothly. In some places, bolts are loosely fit in place to show you their location, though you will have to remove them to attach the part.

It takes one of us a half day of work to assemble a ShopBot. So we think you should be able to put your ShopBot together over a pleasant weekend if the table is ready to go and you've already read through this Assembly Manual. Of course, the IRS thinks that preparing your 1040 should take 2 hours and 43 minutes, with a further 23 minutes for copying, assembling, and mailing the form!!

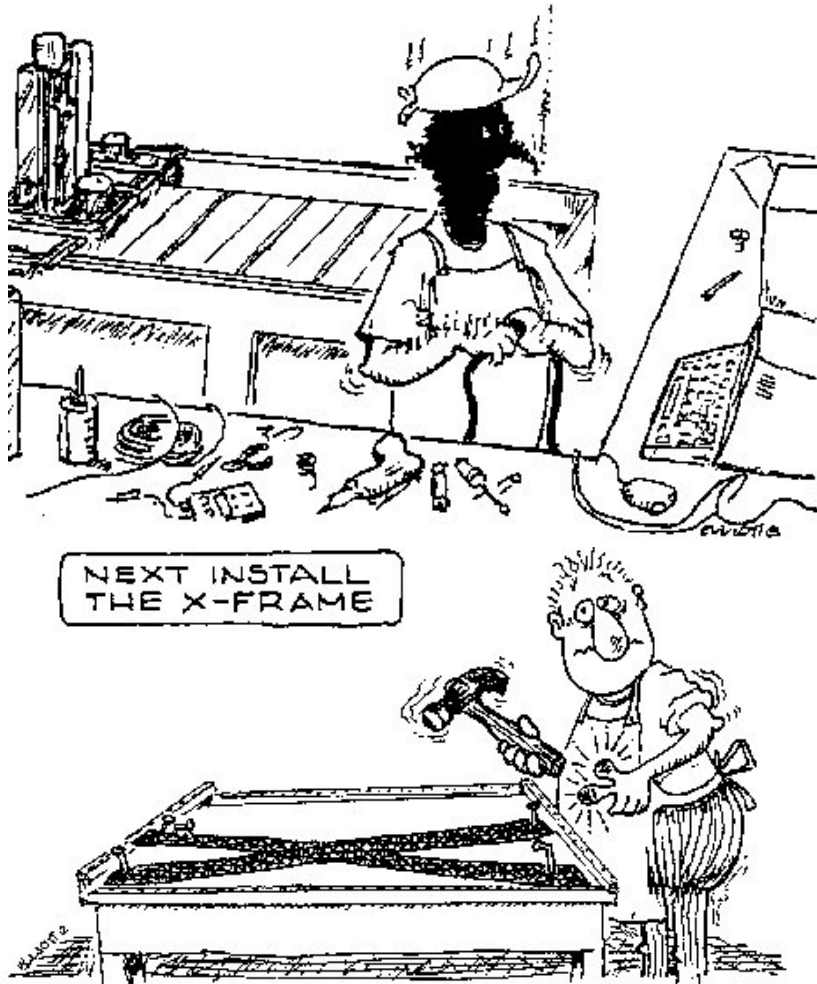
There is a fine line between not paying enough attention to a step and overly sweating a detail. If you feel like you've gotten overly bogged down in a step, you probably have, just move on in the process and it will probably become clearer whether the problem you were having will require attention at a later point. However it goes, we'd like to hear about your experiences. An assembly manual is always a work in progress, so please feel free to contact us with helpful suggestions to make the assembly go as easily as possible.

ELECTRICAL PRECAUTIONS

MOTOR CONNECTIONS - DO NOT CONNECT OR DISCONNECT ANY MOTOR WIRE CONNECTORS WHILE YOUR CONTROL BOX IS TURNED ON !! During the process of a 'hot' connect or disconnect there is a high load put on the current driver circuitry which is very likely to damage the driver. A damaged driver means that motor does not run correctly. Also, do not unwrap the heat-shrink surround that keeps your motor cables connected to the motors. Doing so may void your warranty for the drivers in the ShopBot PRTalpha Control Box.

STATIC DISCHARGES - Electronic circuits are very sensitive to static and power surges, and your Control Box is no exception. Please have your electrician follow the wiring and grounding instructions in the wiring section to help prevent static from damaging components of your tool. In particular, avoid doing any vacuuming around your tool before you have grounded both the tool and your vacuum system. Large static build-ups can occur inside a vacuum collection system and discharge accidentally through the wiring of your ShopBot.

INDUCED CURRENTS - The stepper motors on your tool become significant little generators if they are manually turned. They can generate sizable voltages in your control box if you push the X or Y-axis of your tool around physically. Occasionally it may be necessary to move the tool by hand, but try to minimize such movement and when you must do it, make the move slowly. If you need to do a lot of manual movement, unplug the motors on the axis you are moving -- having shut down the power first as noted above.



Step 1: Aligning the X-rails and X carriage to the table



Figure 2 Level and square the table.

The top flange of the C-Channel that makes up the Table Sides should be level across the top of the flange and across the span of the table. You do not have the opportunity to cant the table legs to adjust the top surface of the Table Sides, so mark where there are inconsistencies, and use shims to level the X rails when you place them on the Table Sides.

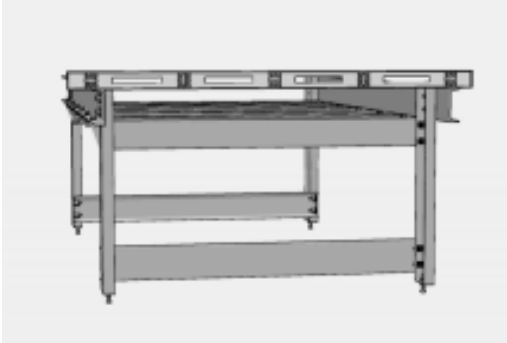


Figure 3

It is very important that you note where the top surfaces of the Table Sides are not horizontal and flat. Measure at each hole where the rail will attach to the Table Sides. There should be no gaps between the top of the side rails and the bottom of your straight edge. Mark where there are gaps.

Mount X-Rails

Mount the X-rails with 5/16 bolts and T-nuts the same way as the table legs.

LEVEL THE X-RAILS





Figure 4

- Level the top of the X rails, working one rail at a time. Sight down the length of the top of the X rails to look for any noticeable dips or humps in the rail. Take your straight edge and lay it across the top of the rail. Mark any hills or valleys with the marker or tape.
- Don't forget to shim where necessary to account for the Table Sides not being level.

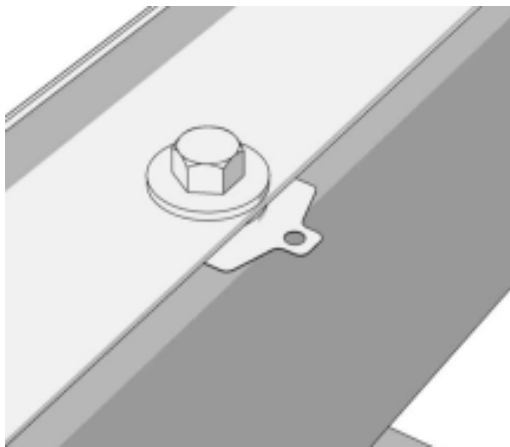


Figure 5

Shim the rails as needed to level them.

- If there is a dip in the rail: loosen the bolt nearest the dip and place a shim of the appropriate thickness shim between the flat washer and the table to raise the dip. Hint: this is where a slightly fatter flat washer can come in handy. Replace the thinner washer with the fatter one and recheck for straightness. Shim more if necessary.
- If there is a hump in the rail: work the bolts on either side of the hump. Place shims between the flat washer and the table to raise the low spots on either side up to the level of the hump. Hint: If the hump is right over a bolt, check the washer at that bolt. You may be able to replace a thicker washer with a thinner one. You catch the drift.

STRAIGHTEN THE FIRST X RAIL



Figure 6

Begin straightening your rails. Slide your 6' level or straight edge along the outside of the rail to look for "waviness" in the rail. If one rail is straighter than the other, start with that rail. Hint: Keep handy a magic marker or small pieces of tape to mark the high and low points.

Straighten the first X rail.

- Starting at the center bolt, adjust the rail in or out to remove any "waves" in the rail. Hand tighten.
- Repeat at each spacer bolt, working from the center to the ends. Hint: To prevent an "S" bend, every time that you make an adjustment to an interior bolt on the rail, you will need to release the nearest end bolt (both ends for the center bolt). Loosen the end bolts, check the distance to the opposite rail and retighten.
- Look for "light" between the straight edge and the rail or "rocking" of the straight edge to indicate that the rail is not perfectly straight. Move the straight edge up and down the rail and check at many, many points.

LIFT THE X AND Y CARRIAGE INTO POSITION ON THE X RAILS



The X carriage is fully assembled with the hardware for the wire guide attached. The Y carriage is assembled and in place on the X carriage

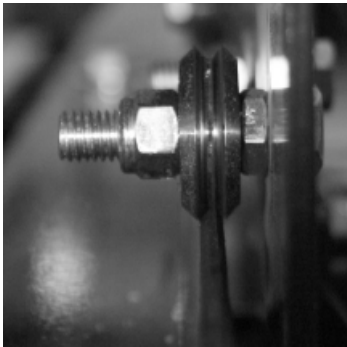
The photo shows the X and Y carriages packed into the shipping container.

- Remove both and lift the both carriages onto the X rails so that the wheels are riding on the X-rail that you just straightened.



Which way does it go? The photo is of the X carriage with the X2 motor attached:

- The operator facing the table like the little man on Page 3 of the Assembly Manual should be able to read the two caution labels.
- The Y rail with the rack should be on the left side. This is very important!!!
- The bolt assembly that will receive the turnbuckle for the X2 motor mount (it sticks out from the car) should be on the right (photo shows motor mounted to give you an idea of where you are going with this.)
- The wire guide hardware is at the back of the carriage



The V-groove wheels on the X carriage should be centered on the straight X rail, and should ride up and down the entire length of the straight X rail smoothly.

USE X CARRIAGE AS A GUIDE TO STRAIGHTEN THE SECOND X RAIL

NOTE: the weight and rigidity of the carriages, their wide wheel base, and the self-centering nature of the V-groove wheels will take care of slight errors in the rails, but you want to get the rails as straight as you can.



- Roll the carriage down to the middle bolt of the X rail so that you start the process from the center of the table and work out to the ends.
- Clamp the side of the X carriage on the straightened rail and move to the second rail.



In this photo, the wheel is not riding on the rail correctly (too far to the right or toward the center of the table.)

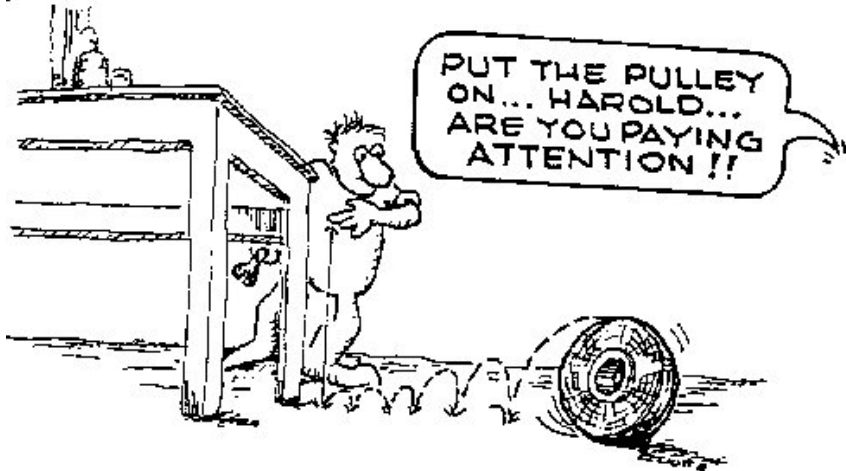
- In this case, loosen the bolts on the second X rail and tap it towards the other X rail so that the rail comes into alignment under the wheel.
- When the both wheels are riding on the rail correctly, move the carriage out of the way and measure the distance across the two rails. This is your target distance for each of the other bolts.

Hint: Pick a point that you can use as a reference point to consistently measure up and down the rails...for example, the ridge in the center of the rail or the outside edge of the rail.



- Measure the distance across the rails at each of the bolts and straighten the second X rail.
- Roll the carriage up and down the X rails, straightening the rail under the carriage.
- Sometimes, extreme measures are necessary, such as a pipe clamp across the table to pull a rail into position or push it out.

- Check the first X rail frequently also to be sure that you still think it is straight.
- This is the hardest step, so take a deep breath and congratulate yourself when it is done!!!!



Step 2: Align the Y carriage

The frame for the Y carriage is one solid piece that has already been mounted on the X carriage. Follow the instructions if you need to square the Y carriage after shipping..

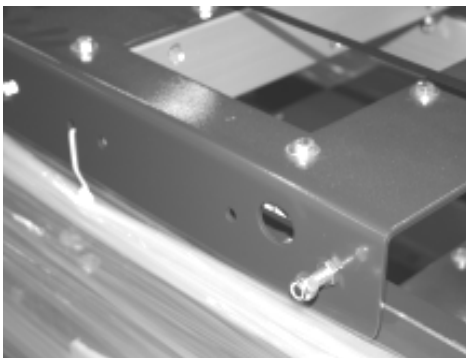
Parts from ShopBot for a PRTalpha

- 1 Y carriage
- 1 Bag of shims to adjust horizontal holddowns

Other things to make the job easier

- Framing square
- Smooth surfaced board or panel about 11 x 2'
- 4 or more C-Clamps or Quick Grips clamps

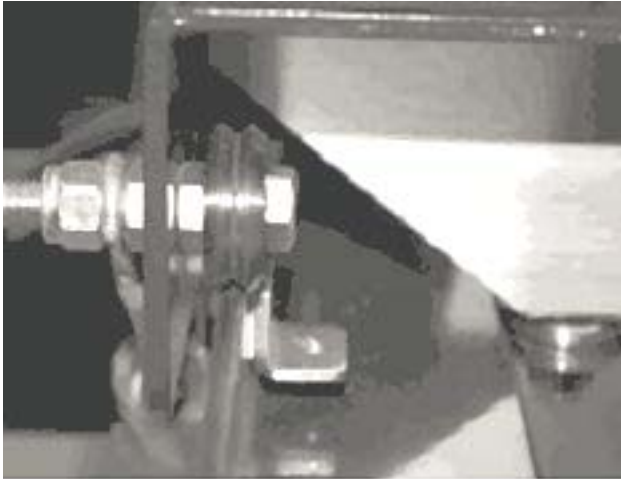
CHECK THE Y CARRIAGE POSITION ON THE Y RAILS



Which way does it go? The photo shows a closeup of the Y carriage from the perspective of the hardware for the Y motor.

- The Y motor will mount on the left side to match the rack on the X carriage
- The wire guide hardware is on the right

CHECK THE ALIGNMENT OF THE Y CARRIAGE ON THE Y RAILS



The vertical V-groove wheels should ride smoothly and evenly across the entire span of the Y rails

(This photo has the target for the proximity switch and the motor mounted)



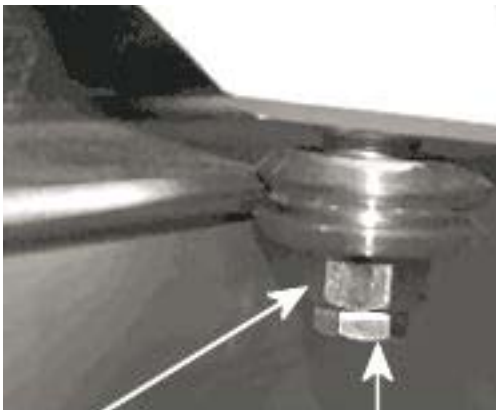
If you need to adjust the Y rails, loosen the bolts holding the rail to the aluminum strut 1/4 turn and bring the rail into alignment under the wheels. Don't forget to retighten the hardware after adjusting the Y rails.

ALIGN THE HOLD DOWN WHEELS AGAINST THE Y RAIL



- Using a 7/16" and a 9/16" wrench, loosen the bottom bolt on the wheel assembly just enough to be able to slide the assembly in the aluminum strut
- Rotate the eccentric bushing so that you can see the black line on the bushing
- Slide the wheel over to the Y rail.
- The wheels should meet the rail at the center of the V with both the upper and lower surfaces of the V contacting the rail. If you have to choose, it is better that the wheels make contact with the underside of the track.
- Adjust where the wheels meet the rail by changing the number of shim washers in the washer stack. Remove the locknut and slide out the entire bearing bolt stack. Adjust height by either removing a washer from the stack, or adding additional washers. Reassemble the bearing bolt stack and hand tighten before checking alignment again.

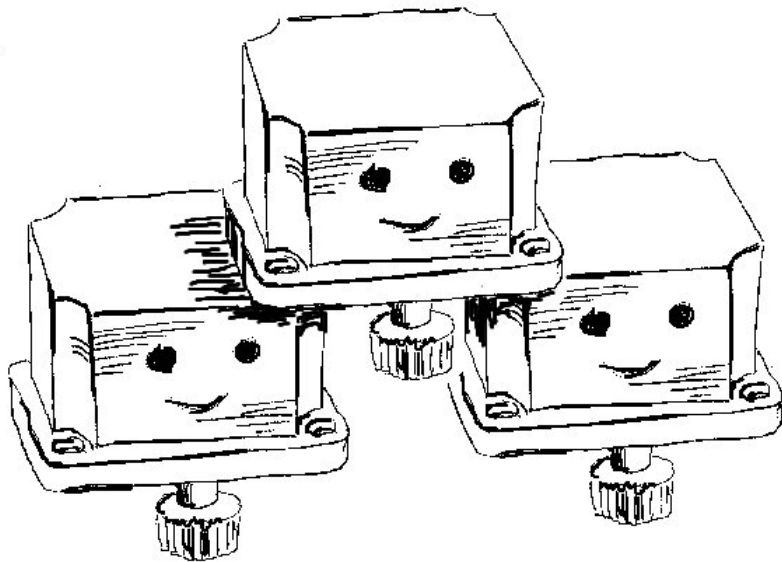
Position the Wheel against the Y Rail



Eccentric Nut
Bottom Nut

- When the height of the wheel is correct, rotate the eccentric nut so that the black line faces the rail
- Using a 9/16" wrench, hold the eccentric nut in position with the black line against the rail and tighten the bottom nut with a 7/16" wrench

- Run the Y Carriage back and forth the width of the tool to check that the wheels ride smoothly at all points. Adjust the bearings and/or rail until all four horizontal and all four vertical wheels on the Y rails run smoothly
- Tighten down the hardware. Alternate sides so that you don't tighten any one wheel too much at one time and bring the tool out of balance
- You can roll the carriage to the far side of the table to adjust the other two wheels
- When all are in position, tighten all 4 hold down wheel assemblies



Step 3: Mount the alphaStep Motors

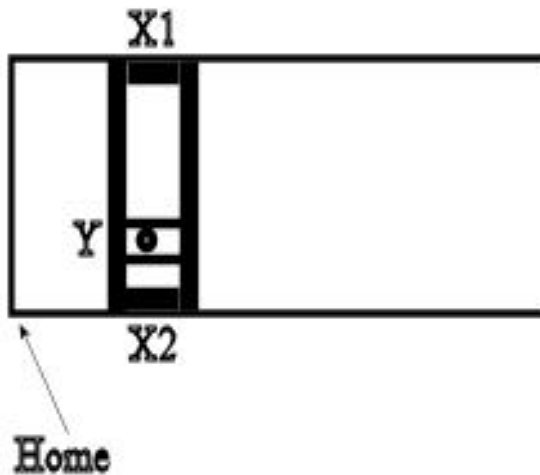
Parts from ShopBot

- 2 - X -motors with mounting and tensioning hardware attached (marked with red tape)
- 1 - Y motor with mounting and tensioning hardware attached (marked with blue tape)
- 3 - Pinion gears and Allen wrench
- 1 - Small tube of grease for gear rack



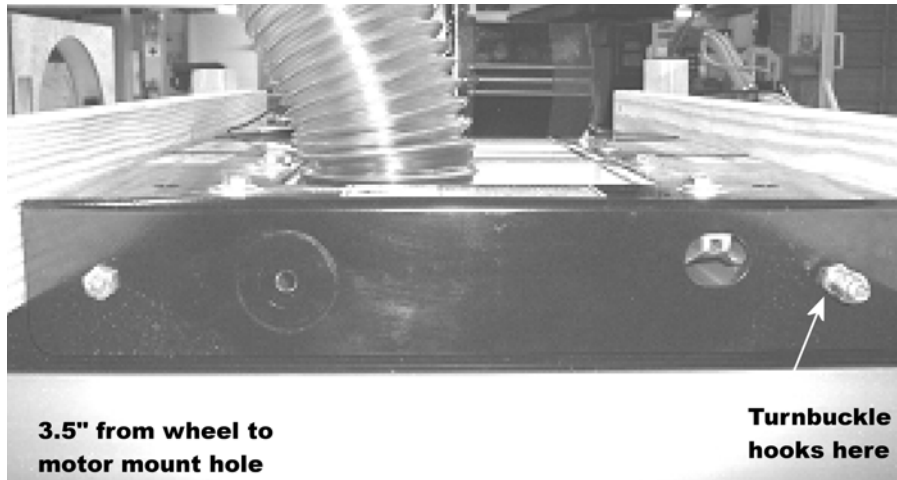
An alphaStep motor (model ASMP11AA) and its heat-shrink wrapped cable connectors are shown at right.

DO NOT REMOVE THE HEAT SHRINK THAT ENCASES THE CONNECTION BETWEEN THE MOTOR AND CABLES. DISCONNECTING THE MOTOR AND CABLES FROM EACH OTHER MAY VOID YOUR WARRANTY ON THE ALPHASTEP DRIVER!!!!



The hardware for attaching the motors has already been placed on the brackets. There is a pivot bolt at the top, with washers and nut. And, there is a spring and turnbuckle attached at the bottom.

Since the motor cables have already been attached to the motors, it is important that the motors and brackets be mounted in their correct location. Check that the cables are correct and orient the bracket so that the spring and turnbuckle leads off to the side that will allow it to hook up with the wheel bolt protruding from the motor carrier

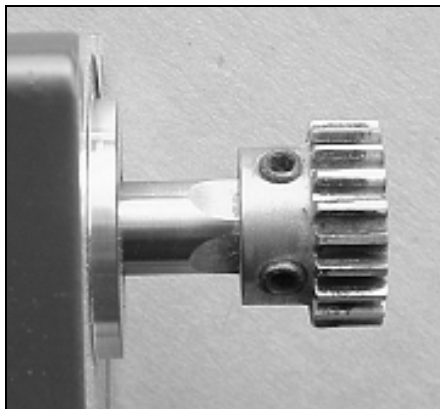


The alphaStep motors mount into the small hole that is 3.5" from the wheel bolt. The turnbuckle hooks on the bolt that is on the opposite of the motor mount hole from the wheel.

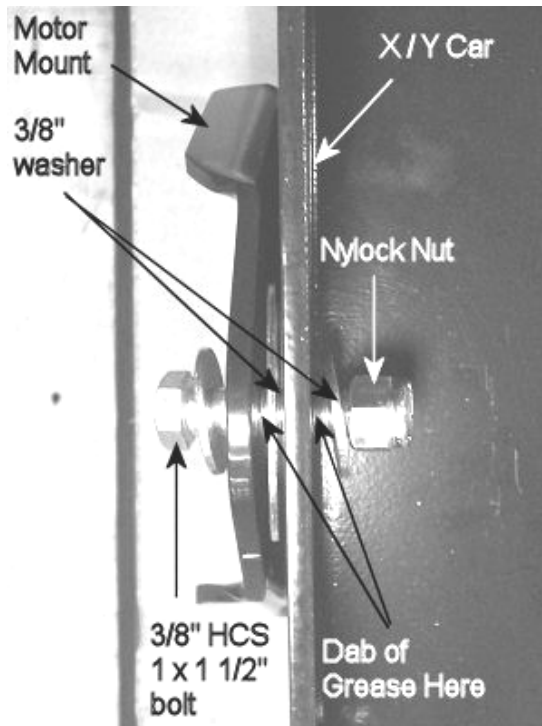
The X2 (two red tapes) and Y (blue tape) motors mount with the turnbuckle hardware reaching to the right, while the X1 (one red tape) motor mounts with the turnbuckle hardware facing to the left. If you mount the motors incorrectly, the ShopBot will run backwards!!! Rewiring the alphaStep cables is not an option.

Before you tighten the hardware, check to be sure that the turnbuckle assembly from the motor will reach the correct bolt assembly on the motor car.

MOUNT THE PINION GEARS AND MOTORS

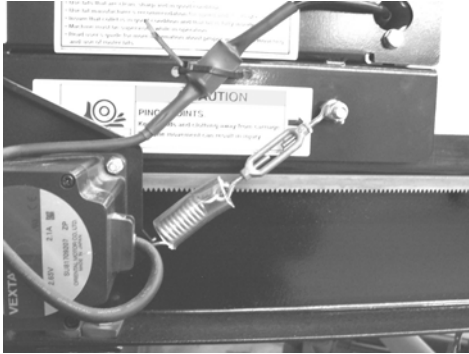


- Locate the pinion gear in the right place on the motor shaft. Slide a pinion gear over the motor shaft with the hub towards the motor and the set-screws against the flat sides of the shaft. Don't tighten the set screws in the gear until you are sure it is lined up correctly with the rack.



- Fit the motor to the car using the pivot bolt (note that this bolt fits tightly in the holes). The pivot bolt should go through a washer, bracket, another washer and finally through the hole in the car. Hold the motor and bracket in position to check for the location of the pinion gear. Later you will attach it with a washer and Nylock nut on the inside.
- Temporarily hold the bracket tightly against the car and swing the motor up so that the pinion gear engages the rack. Slide the gear in or out on the shaft so that it is exactly centered on the rack. Note: Run the carriage up and down the entire length of the rail and watch how each pinion gear meets the rack at all points. If necessary, adjust the location of the gear on the shaft.
- Note or mark the location on the shaft.
- Take the motor and bracket off and permanently install the pinion gear at the location on the shaft you've marked by tightening down the set screws on the flats of the motor shaft. The gear position will usually fall about 1/16" beyond the end of the shaft.
- Swing the motor bracket so that the pinion comes up to engage the gear rack. Release the set screws and adjust the pinion so that it is exactly aligned with the gear rack. With the pinion aligned, slowly tighten the setscrews, oscillating the pinion in your fingers so that you can be sure that the screws are centered on the flats of the motor shaft.
- The set-screw is treated with an encapsulated locking agent that is activated as you tighten it; so make sure it is seated on the flat -- and tighten it hard using the long end of the Allen wrench for leverage. You only get one chance to really set this screw right.

- Mount the Motor. Put a little grease on the pinion gear, and a dab of grease on the back of the bracket near the pivot bolt. Now put the motor bracket back on, putting a washer and then nylock nut on the backside, inside the car. Tighten the pivot bolt until the bracket is firmly seated and not freely swinging or wiggling, only loose enough that with a little force the motor and bracket can be pivoted back and forth to fully engage the rack

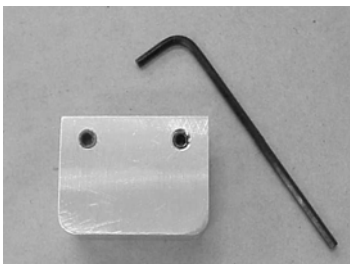


- Loop the turnbuckle assembly hardware over the hardware on the motor car. (If there are two hex nuts and a nylock nut on the motor car hardware, remove one of the hex nuts.)
- To tighten the turnbuckle, you will need to slide the hook out, away from the car (you may have to loosen the car hardware to slide the hook away from the car.) Tighten the turnbuckle 4 full turns.
- Tighten the set screw at the top of the turnbuckle and slide the hook back towards the car.
- Retighten the car hardware as necessary.

We recommend applying grease to the rack and pinions. A good quality bearing, lithium, or Teflon grease will work well. The grease will keep the rack motion smooth and reduce gear wear. (Surprising little debris actually collects in the grease.) Apply it by squeezing a little into the rack every few inches. Moving the tool around will spread the grease and you can wipe off any excess.

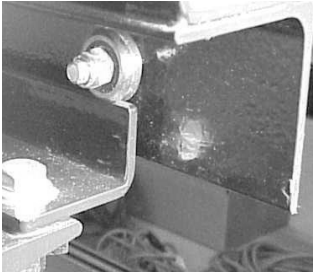
SET THE MECHANICAL STOPS

DO NOT PLUG THE MOTOR CABLES INTO THE CONTROL BOX!!! Take a moment to be sure that all 4 X carriage wheels are running smoothly along the length of the X rails. Double check that the X carriage is square, and that the pinion gears are seated firmly against the rack.



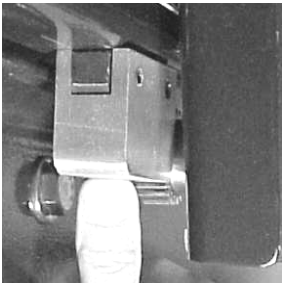
- Lay out the 4 mechanical stops, one at each end of the rack on the X rails. Check to make sure that the stops slide firmly into place over the 1/2" rack.

- Place an 1/8" long arm Allen wrench, supplied with pinion gear pack, near your work area.

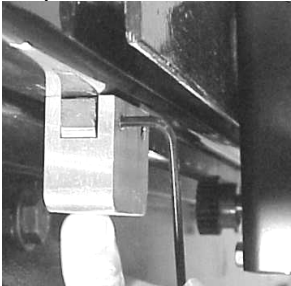


- Carefully roll the X carriage to one end of the X rails, watching the inside of the X rail. Roll the carriage until the wheels are resting within 1/4" of the end of the X-rails. Put a clamp on the rail to hold the carriage in place at that position.

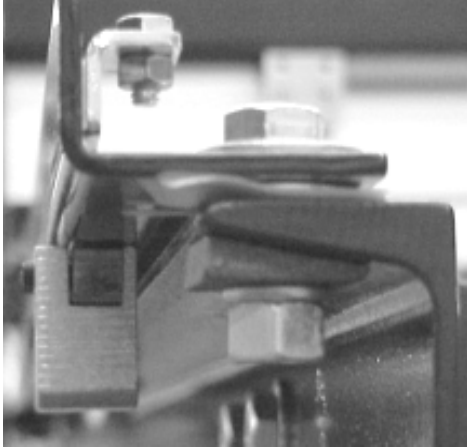
NOTE: if you are planning to use a double Z setup, please read the information on using a double Z in the Accessories section of the manual.



- Set the first stop in place at the end of the rack with set screws facing out. Move the stop until it touches the pinion gear.



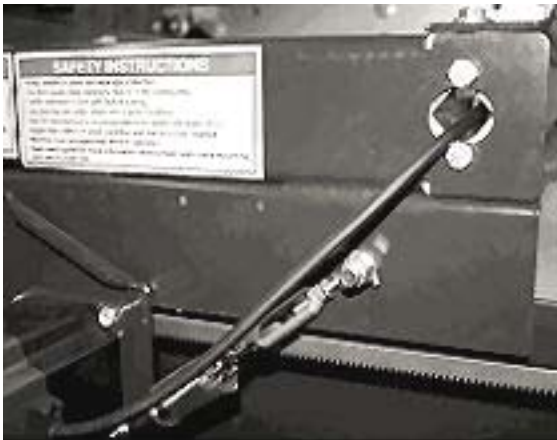
- Move the carriage out of the way, holding the stop in place.
- Use the Allen wrench to tighten one set screw; just until the stop holds against the rack...do not over tighten at this point.
- Gently roll the carriage back into position so that the pinion gear is resting against the stop.
- Move to the other side of the table and slide the second stop against the pinion. Roll the carriage out of the way and tighten one set screw.
- With both stops at one end of the table in place, gently roll the carriage back and forth so that the carriage hits the stops. LISTEN and FEEL to check that both sides of the carriage hit the stops at the same time. If the pinion gears don't hit both stops at the same time, loosen the set screws and adjust the stops until both sides of the X carriage hit the stops at the same time. Note: If you are not careful with this step, and your ShopBot hits the stops at full power, you may rack the X carriage out of square.



Move the X carriage to the other end of the table and set the stops. When you are sure that all of the stops are in the correct position, tighten all the set screws on all stops.

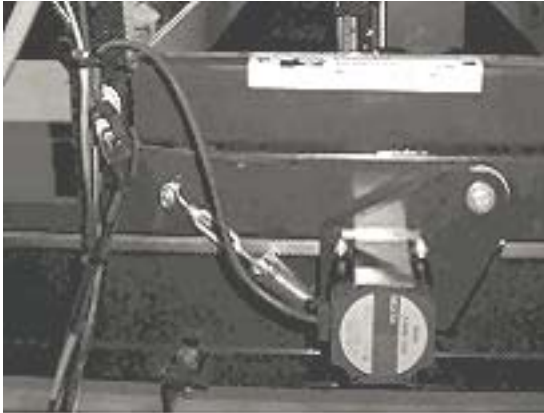
RUN THE X2 AND THE Y MOTOR CABLES THROUGH ALUMINUM STRUT

- The X2 cable from the motor on the front side (according to the "Little Man") of the ShopBot runs through the X carriage aluminum strut to the back side of the ShopBot before going to the Control box
- The Y motor cable runs from the motor side of the Y carriage to the wire guide side of the Y carriage through the strut and over the wire guide



- Locate the X2 motor and cable. The X2 cable is marked with two pieces of red tape.
- Starting at the X2 car at the near side of the ShopBot, run the free end of the cable through the hole in the motor car, then the middle diamond of the aluminum strut and out through the X1 motor car. The connection between the motor and motor cable will lie inside the aluminum strut.
- Locate the Y motor and cable. The Y cable is marked with a single piece of blue tape.
- Starting at the Y car with the motor attached, run the free end of the cable through the hole in the motor car, then the middle diamond of the aluminum strut and out

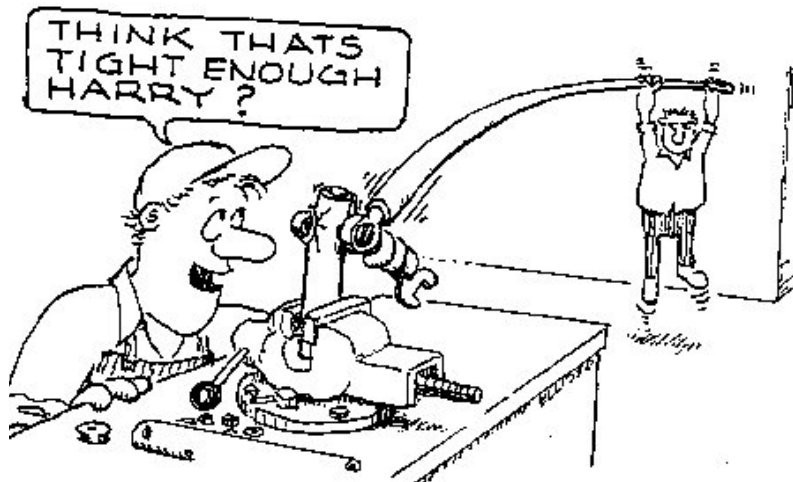
through the Y car without the motor. The motor cable will then run over the wire guide to the far side of the ShopBot.



Important: On the X1 car (far side of the ShopBot), provide strain relieve above the connection between the motor and the motor cable. Attach the X1 motor cable to the bundle coming over the wire guide with wire ties above and below the connectors.



(Optional) Wire tie the motor cables to the cars. Each of the motor cars has two small holes. Run a wire tie through the holes and around the motor cable to provide strain relief for the motor and cable.



Step 4: Mount the Z Axis

Parts you need from ShopBot

- Z-Axis Assembly with bracket for mounting router or spindle
- Z mounting hardware: Hex bolts, washers, channel nuts
- Your router or spindle

Other items to help with the job

- 2 quick grip or C-clamps
- Framing square and torpedo level to check for square.



Where does it go? The Z mounts directly to the aluminum strut on the Y carriage. There are three holes in the aluminum strut on the Y carriage for mounting the Z axis

- The outermost holes are designed for mounting two Z axes as shown in the picture
- The middle holes are recommended for mounting a single Z with the router facing toward the Y motor (standard set up)
- A single Z could also be mounted in the hole closest to the Y motor with the router facing the center of the carriage.

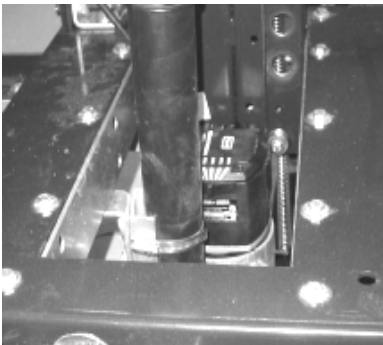


Figure 7 Y car bolts

Important!

- Before positioning and installing the Z axis, slightly loosen all of the bolts holding the aluminum cross-struts to the Y-axis car (there are 10 of these 5/16" bolts; use 1/2" wrench. See figure 12). This is done so that tightening the Z axis to the struts does not distort its shape.

This step definitely needs an extra pair of hands.

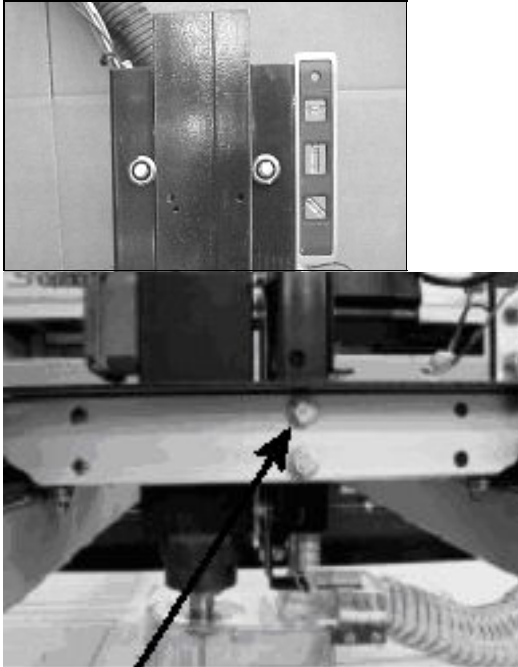
- Ready your hardware: Hex bolt, flat washer and channel nut for each hole
- From the top, insert the Z axis (it's harder to do with the router attached) into the Y cavity with the bracket for the router or spindle facing towards the Y motor
- Even if you have an extra set of hands, use clamps or quick grips to hold the Z in place while you attach the hardware.
- Insert the mounting hardware, top holes first: Hex bolt, flat washer, aluminum support strut, Z.



- Slide the channel nut that fits inside the Z into position and tighten. There is an access hole in the Z frame to insert the channel nuts.
- Straighten the Z in the Y carriage and tighten the mounting hardware.
- Re-tighten the ten bolts for the cross struts that you loosened in the first step.

ALIGN THE Z AXIS

At this point, we'll take some time to make the Z perpendicular to the table in both directions (side to side and front to back).



Loosen top bolt

Side to Side or lateral adjustment (parallel to the Y-rails).

- The Z has a top and bottom bolt. For this adjustment, loosen the top bolt on each side, and tighten the bottom bolt just past finger tight.
- Place a torpedo level on one side of the Z and nudge the Z-axis tracks side to side to get the alignment vertical.
- Place the level on the other side of the Z and do it again. When you're happy, tighten the lower bolts fairly firmly. (You can also use a framer's square with one leg resting firmly on the table surface and the other on the Z for this step. Do it with the square facing both directions.)



Fore and Aft (back and front) Alignment.

- Now use the torpedo level against the face of the Z-axis to make sure you are square in the other plane.

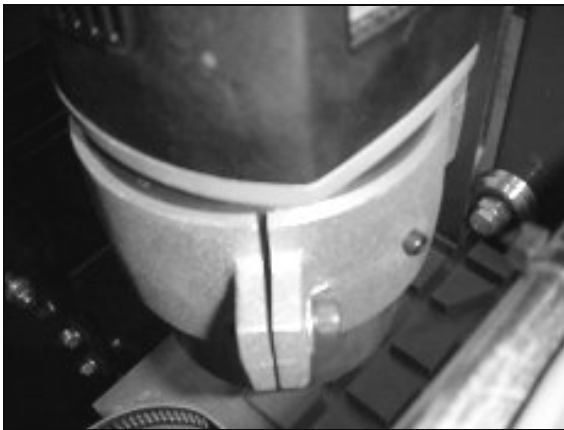
- Bump the top of the Z-axis to rotate it forwards and backwards to get it perpendicular to the table.
- Turn the level on the other side of the Z and do it again. When it's right, tighten the top bolts of the Z. (You can also use the framing square for this step...just do it with the bottom leg pointing both directions and take the average.)

This may not be the final adjustment of the Z axis. After you have your tool up and running, you will use the ShopBot to surface your table's working area to make sure it is perfectly flat in the plane of your ShopBot's movement. **After you surface or plane your table, do these alignment steps again to make sure the Z is perfectly vertical.** (Hint: Ridges in your work are often a sign of a Z out of vertical or an uneven table surface.)

The motor and motor cable for the Z axis are already attached to the Z. If you mount the Z axis in the center hole with the router facing the Y motor, run the Z motor cable (marked with one white tape) to the wire guide and to the back of the tool.

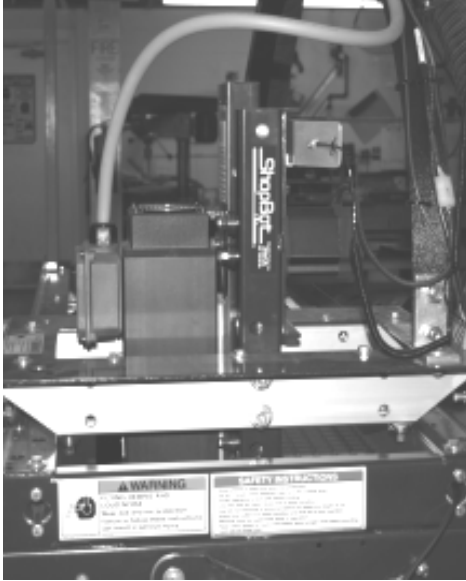
If you mount the Z with the Z axis motor facing the Y motor (router to the center), then run the Z motor cable through the same hole as the Y motor cable.

INSTALL YOUR ROUTER/SPINDLE



Porter Cable Router: The Porter Cable fits into its own specially manufactured aluminum sleeve. If you are using a router that has brackets for holding the router while hand routing, unscrew and remove the hand holds that come on the router.

- Remove the plastic insert from the router mount.
- Slide the barrel into the plastic insert and then into the aluminum sleeve.
- Use the allen wrench provided to tighten the router into the bracket.



Colombo Spindle: The Colombo Spindle is drop shipped from Precision Drive Systems, and will probably arrive separately from the rest of your system. Your Z has double springs, and a special mounting plate that allows you to mount the spindle to the Z with hardware screws (included in the package marked Colombo Spindle Mounting Hardware). **Please note that you will require the services of a licensed electrician to wire the Colombo and attach the plug to the spindle.** (Please call ShopBot before you retro-fit a Colombo on a Porter Cable Z to get the correct springs and mounting plate.)