# Building a Vacuum Chuck on a Budget

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Four Corners Woodturning

Vacuum chucking is fast becoming the preferred method for finishing the bottoms of bowls and other lathe turned objects. Commercially available systems are either expensive or require an external air source of sufficient volume and pressure. By utilizing a little creativity, some off the shelf parts, and by sourcing a inexpensive or second-hand vacuum source we can build a system that is affordable, flexible, and easy to use.

One disclaimer before we get started – If it doesn't feel safe **don't do it**. If you're unfamiliar or uncomfortable with electricity or wiring; particularly when dealing with 220v; hire an electrician.

Most vacuum chucks are made up of 3 major components

- Vacuum generator
- Rotary Adapter
- Drum chuck

**Vacuum generator:**
There are two basic types of vacuum generators available. Dedicated vacuum pumps and venturi vacuum generators. Venturi generators require a constant supply of air from an air compressor in order to generate and maintain a vacuum. Holdfast brand Venturi generators are available from Craft Supplies USA (CSUSA) and Woodcraft and run $129-159 depending on the model. Both models include a built in vacuum gauge and the more expensive model includes a built in regulator. Both Holdfast models require 2.5 CFM @ 55-65 PSI to generate and maintain 19+ inches of mercury. Harbor Freight has a no-frills model (96677-0VGA) available for $16 but it requires 4.2 CFM @ 90 PSI to generate and maintain up to 28" of mercury.

Dedicated vacuum pumps can be found both new and used. New pumps are available from multiple sources, including CSUSA, Woodcraft, Timber Woodworking Machinery, and McMaster-Carr and typically run $250 - $400. Harbor Freight has a model intended for use in the air conditioning industry for $80 (98076-0VGA). Used pumps are also available from multiple sources, including Ebay, Craigslist, and various surplus supply houses. Prices vary from $25 - $150 depending on the model and condition. 220v pumps tend to be less expensive than 110v pumps. Surpluscenter.com has a 220v Gast 0522 (Item 4-1669) for just $55 + shipping (stock is extremely limited, less than 10 units in stock as of 5/20).

**Rotary Adapter:**
The purpose of the rotary adapter is to isolate the motion of the rotating lathe spindle from rest of the system which will remain static. Commercially available rotary adapters are available from Oneway, E-Z, and Holdfast via CSUSA, Woodcraft, Packard, and more. The Oneway model is $99, E-Z is $83, and the Holdfast is $57. Using off the shelf parts and a bit of elbow grease we can create our own for less than $20. See pages 2-3

**Drum Chuck:**
The drum chuck acts as the interface between the lathe and the object that we are attempting to secure to the lathe. As above commercial drums are available from Oneway and Holdfast and range from $60 - $280 depending on manufacturer and size. We can build our first one for approximately $30 and each additional size can be made for less than $5 each. See page 4

**Vacuum basics:**
Creating a vacuum within the headstock of the lathe and within the drum chuck will give us a pressure differential between the interior of the drum and the outside air. This will effectively allow us to use the existing air pressure already surrounding us to secure an object to the lathe. Being primarily shop made my system isn't intended for roughing or heavy cuts. My primary use is for removing the tenon and final sanding on

the bottom of a bowl. Caution should always be used as there is nothing securing the piece to the lathe other than air.

**How much of a vacuum can we create?** The strength of the vacuum that can be generated depends on a number of factors, the most important factors being the vacuum source used and the integrity of the system. A perfect vacuum is 30" of mercury (Hg) but that can't affectively be achieved on the earth. Realistically we can expect to generate a vacuum of 20-28" Hg. **How do we measure it?** The most common way to measure a vacuum is with an in-line vacuum gauge that measures in inches of mercury the same way a weatherman will uses a barometer to measure atmospheric pressure in inches of mercury. Normal atmospheric pressure is 29-30" Hg. When referring to a vacuum when we say 20" Hg we actually mean -20" Hg. **What does that measurement mean?** To convert Inches of mercury into a number that we can more readily understand we multiply by .491 to get PSI. For our purposes dividing it by 2 is accurate enough. If your pump is pulling a vacuum that measures -20" Hg it is generating approximately -10 PSI. **That doesn't sound like much. Is that enough to sufficiently secure a piece to the lathe?** -10 PSI isn't very much pressure. But that's pounds per square inch. We can easily calculate the area inside the drum where -10 PSI will be applied by using basic geometry. The area of a circle is $\pi r^2$. If we're using a drum chuck with a 3" diameter PVC coupler we know that the radius is 1.5" so the area is just over 7 square inches ($\pi * 1.5^2$). That means there's right at 70 pounds of air pressure securing the piece to the lathe. Increasing the drum to 4" diameter will increase the surface area to 12.5 square inches and the pressure to 125 pounds at -10PSI. I recommend installing a bleeder valve into your system so you can regulate the amount of vacuum being generated by allowing a controlled amount of air into the system. Too much vacuum pressure can cause fragile pieces to implode.

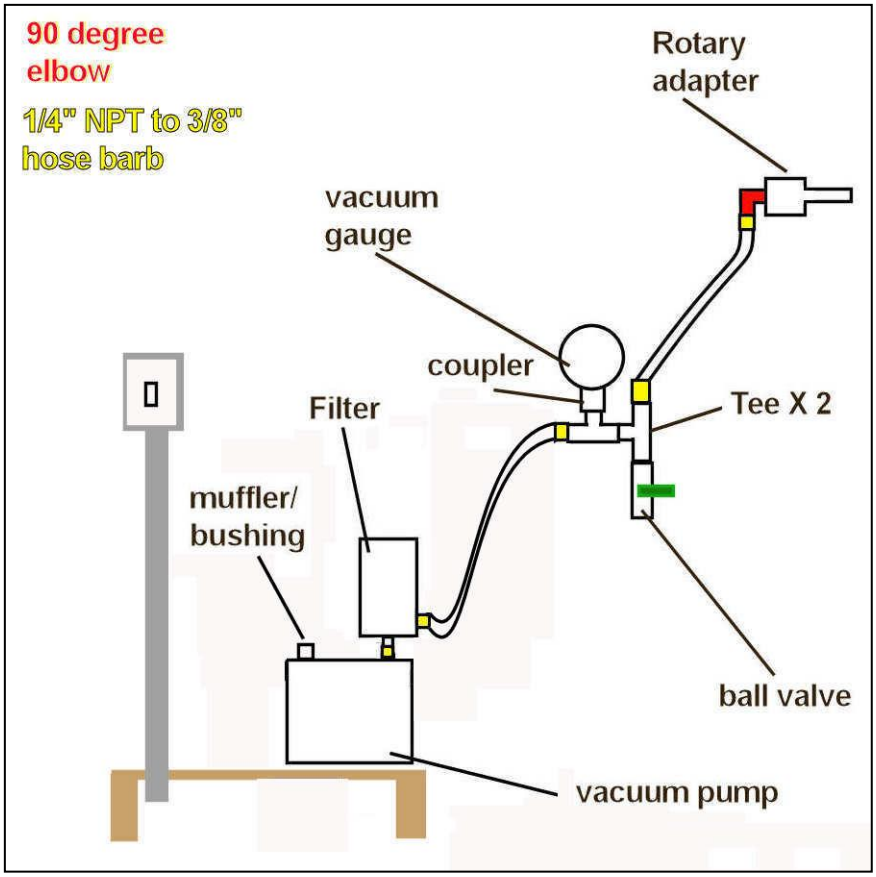



Figure 1 - Basic plumbing diagram

**Building a rotary adapter:**

My plans for a shop made rotary adapter include a limited number of parts. 2X2X4 closed grained wood such as hard maple, 2 rubber O rings (size will vary depending on the lathe the rotary adapter is being made for), double sealed bearing for Ace Pump (Lowe's Part #99502-H, located on the hardware aisle, Drawer K10), 1 3/8" forstner bit, 5/16 - 3/8" drill bit, a ¼" NPT 90 degree elbow, ½" to ¼" bushing, and a ¼" NPT to 3/8" ID Hose barb.

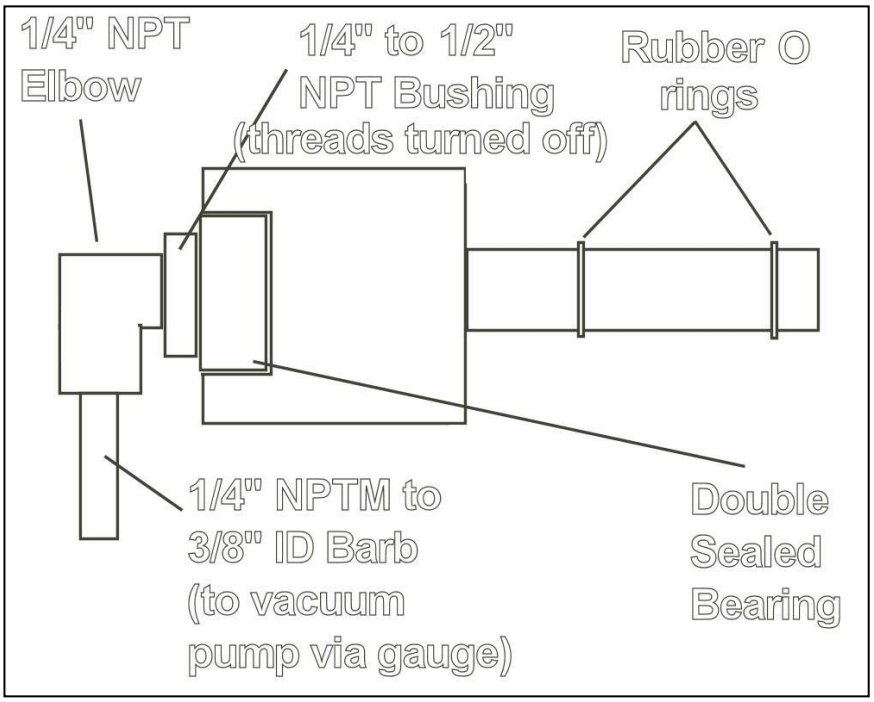
Step 1. Mount the wood between centers and turn to a cylinder. Turn a tenon on one end.

# Building a Vacuum Chuck on a Budget

Step 2. Mount the cylinder in a chuck and using a Jacobs chuck in the tailstock drill a 1 3/8” diameter recess in the end that is 3/8” deep. This recess will accept the bearing. Next drill a 5/16”-3/8” diameter hole in the center of the blank as deeply as possible. It’s not necessary to drill all of the way through.

Step 3. Temporarily insert the bearing into the recess and engage the tailstock. Turn the basic profile on the adapter and turn the shaft down to the slightly larger than your finished size (this diameter will be specific to your lathe)

Step 4. Carefully turn a taper to match your headstock on the end opposite the bearing. A section 3/4” – 1” long and tapering from 5/8” up to 3/4” is a good approximation of MT2. This taper will next be fitted to the headstock.




Step 5. Carefully Part the piece from the lathe. Remove the chuck from the lathe, and insert the taper you turned into the headstock. With the bearing still in place engage the tailstock and turn the shaft down to the final diameter. (this diameter will vary depending on your lathe).

Step 6. Turn 2 coves of the appropriate width and depth to accept the rubber O rings. The size of these O rings depends on your specific lathe. Once again carefully part the piece from the lathe.

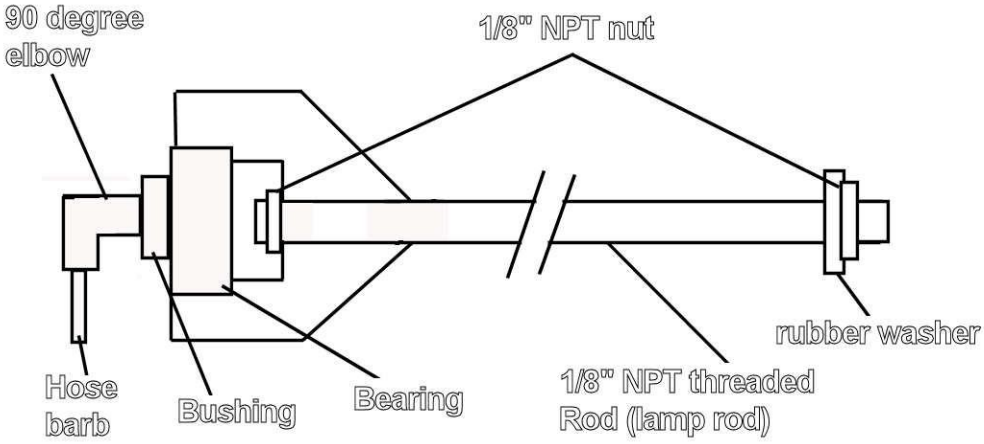
Step 7. Mount the ½” to ¼” bushing on the lathe using a set of pin jaws in a chuck and turn away the threads until it fits the inner bore of the bearing. Test the fit often. I found a parting tool to be the best tool for this job.

Step 8. Mount the bushing in the bore of the bearing. If needed it can be epoxied in place.

Step 9. Glue the bearing into the recess of the rotary adapter; I prefer 5 minute 2 part epoxy. Be careful to not glue the two halves of the bearing to each other.

Step 10. Using Teflon tape thread the 90 degree elbow into the bushing. Thread the ¼” NPT to 3/8” hose barb into the other end of the elbow.

The rotary adapter is now complete.




An alternate design is shown to the left. This design works well for lathes that have a through hole that is threaded on the outboard side or lathes like the Jet mini that have a through hole that is a small diameter. Rubber and/or leather washers are used to create the air tight seal at each end of the threaded rod.

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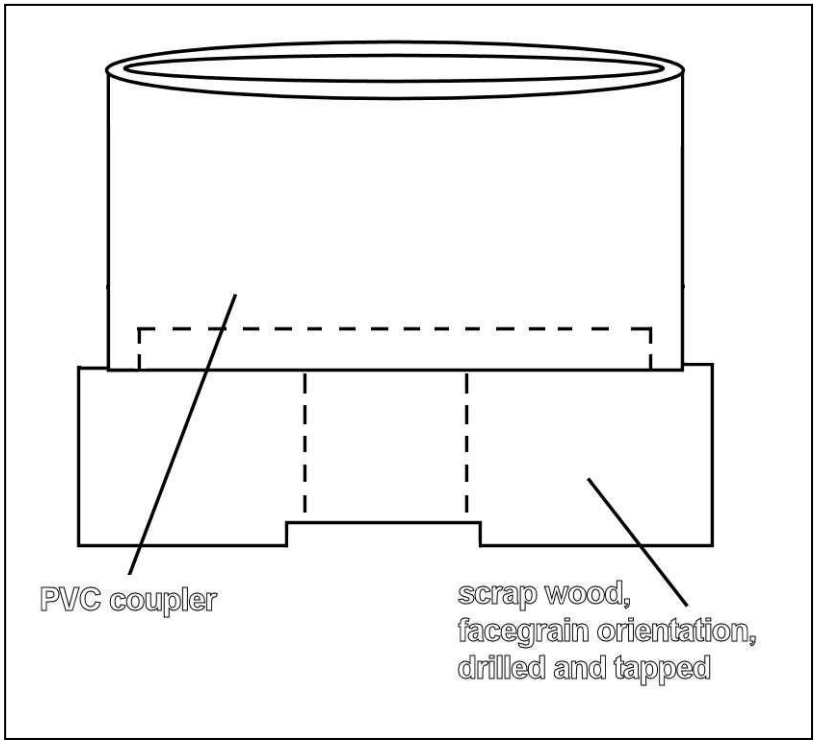
**Building a drum chuck:**

My shop made drum chucks are also incredibly simple, ending up with just 3 parts. 8/4 Scrap wood, closed grained wood such as maple or mesquite in facegrain orientation, PVC coupler in various diameters, craft foam, spray adhesive, forstner bit, Beall spindle tap ($20-$27).




Step 1. Mount the scrap wood in a facegrain orientation between centers and turn to a cylinder approximately ½" larger than your PVC coupler. Turn a Tenon on one end to grip the piece in a chuck.

Step 2. Mount the blank in a chuck and drill a hole through the piece that is 1/8" smaller than the tap size. If using a 1 ¼" tap; drill with a 1 1/8" forstner bit. Square the face of the blank. Depending on your spindle it may necessary to turn a small recess on this face so the blank will seat properly once tapped.

Step 3. After locking the spindle; engage the spindle tap, support the end with the tailstock and maintain pressure with the tailstock as the tap is slowly threaded into the wood.

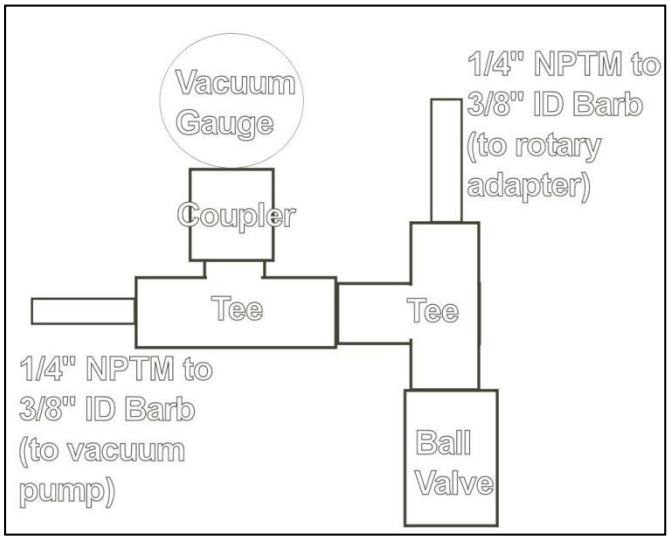
Step 4. Continue tapping the blank until the tap exits the headstock side of the blank. You may need to remove the blank from the chuck in order to finish tapping the block.

Step 5. Remove the blank from the chuck and remove the chuck from the lathe. Thread the block directly onto the spindle and turn the other face square.

Step 6. Turn a rabbit around the blank to fit the PVC coupler. If necessary epoxy the coupler in place.

Step 7. Cut and glue craft foam around the end of the PVC. This will provide an airtight seal and will protect the wood from any damage from the PVC coupler. Alternate materials include closed cell packing foam, neoprene mouse pads, or leather.

A faceplate can be used instead of tapping the block. Place craft foam between the faceplate and the blank to create an air tight seal.




**Additional parts:**

A number of additional plumbing parts are required for final assembly. These include a filter, a ball valve, a vacuum gauge, Tees, coupler, hose barbs, a small bushing and muffler, and 2 lengths of hose. Sources and part numbers for these and most other parts used in this assembly can be found on page 5.

The diagram to the left shows the assembly of the tees, vacuum gauge, and the ball valve used to reduce the vacuum pressure.

The last piece that needs to be made is the connection between the air filter and the vacuum

pump. The air filter listed on my parts list on page 5 is supplied with a non-standard 9/16" X 24 thread on the bottom. It is also supplied with a ½" diameter hose barb made out of aluminum. Rather than deal with an additional length ½" tubing and several additional bushings and ½" hose barbs I set about finding another method to add the filter to my system. What I discovered is that a 3/8" hose barb is only slightly larger than the inner diameter of the ½" aluminum hose barb that was supplied with the filter. I mounted a ¼" NPT to 3/8" hose barb on the lathe and turned off the ridges on the hose barb end. I found a parting tool to be the best tool for the job. The 3/8" hose barb is then inserted into the inner diameter of the ½" hose barb and the filter can now be mounted directly to the pump with the ¼" NPT thread.

Now all of the hose connections can be made. Teflon tape is recommended on every threaded connection; hose clamps on every hose connection are also recommended. After assembling all of the parts except for the rotary adapter turn on the pump and put your thumb over the end of the hose. If everything has been properly assembled your gauge should be reading at or near the maximum achievable vacuum for your pump. If after installing the rotary adapter and the drum chuck your vacuum gauge reads significantly lower you may have a leak in either the rotary adapter or in the drum chuck. Remove the drum chuck from the lathe and place your thumb over the through hole in the headstock. If the gauge still reads significantly lower than your maximum vacuum the leak is in the rotary adapter. If not the leak is in the drum chuck.

Surplus Center – Surpluscenter.com

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|---|---|---|---|---|
| Gast Vacuum Pump | 1 | 4-1669 | $54.95 | $54.95 |
| Air filter | 1 | 4-1565 | $5.99 | $5.99 |
| vacuum gauge | 1 | 2141 | $5.95 | $5.95 |
| muffler | 1 | 4-1749 | $0.79 | $0.79 |
| ¼ to 1/8 bushing | 1 | 455-hh | $0.55 | $0.55 |
| ball valve | 1 | 20-1486 | $2.99 | $2.99 |
| ¼ NPT to 3/8 barb | 5 | 455-bb | $0.90 | $4.50 |
| ¼ NPT coupler | 1 | 9-5000-4-4 | $0.95 | $0.95 |
| Hose clamps | 4 | 455-qq | $0.39 | $1.56 |
| 90 degree elbow | 1 | 9-5502-4-4 | $1.75 | $1.75 |
| Shipping (approx) | | | | $27.00 |

Home Depot

| | | | | |
|---|---|---|---|---|
| ¼" NPT Tee | 2 | | $2.49 | $4.98 |
| 3" PVC coupler | 1 | | $0.79 | $0.79 |
| ½" to ¼" NPT bushing | 1 | | $3.98 | $3.98 |
| Double Pole switch | 1 | | $8.00 | $8.00 |
| 12/2 romex | 12 | Feet | $0.66 | $7.92 |
| outlet cover | 1 | | $2.00 | $2.00 |
| switch plate | 1 | | $1.00 | $1.00 |
| PVC outlet box | 1 | | $4.00 | $4.00 |
| PVC tube | 1 | | $1.99 | $1.99 |

Lowes

| | | | | |
|---|---|---|---|---|
| 50' 3/8" ID air hose (only need about 10 feet) | 1 | | $12.95 | $12.95 |
| double sealed bearing for Ace Pump (Lowes Drawer #K10) | 1 | 99502-H | $7.10 | $7.10 |
| O rings (2) ½" ID, 5/8" OD, 1/16" wall | 1 | 0529 | $0.74 | $0.74 |

Walmart

| | | | | |
|---|---|---|---|---|
| Foamies craft foam sheet | 1 | | $0.40 | $0.40 |

Woodcraft

| | | | | |
|---|---|---|---|---|
| Beall Spindle tap | 1 | | $26.99 | $26.99 |

Misc (items already on hand)

| | | | | |
|---|---|---|---|---|
| Misc. scrap wood | | | | |
| 2 part epoxy | | | | |
| Teflon tape | | | | |
| spray adhesive | | TOTAL | | $189.82 |