Watching Simon, a friend of mine, using a vacuum chucking system which, he said, had cost around £900 I was impressed by its performance, but couldn't help thinking that I could make one cheaper myself.

A vacuum chuck is a device for holding a workpiece by means of air pressure, and its biggest advantage is that it can hold work without marking it in any way. It is less useful for very small pieces or pieces that let air through them because they are very thin, porous or have holes in them.

I made my chuck from a piece of 4" plastic soil pipe and some offcuts of MDF that had been kicking round in the workshop for ages. I managed to acquire a length of thick-walled rubber tubing from a friend, but it could probably be purchased from shops that sell bottled gas heaters as it is used to connect the gas bottle up to the heater. Other odds and ends were found as needed. The whole thing is permanently mounted on a 4" faceplate to fit the lathe spindle. **Diagram 1 and Photos 1 & 2** are probably sufficient to show how the chuck was constructed. None of the dimensions given are critical.

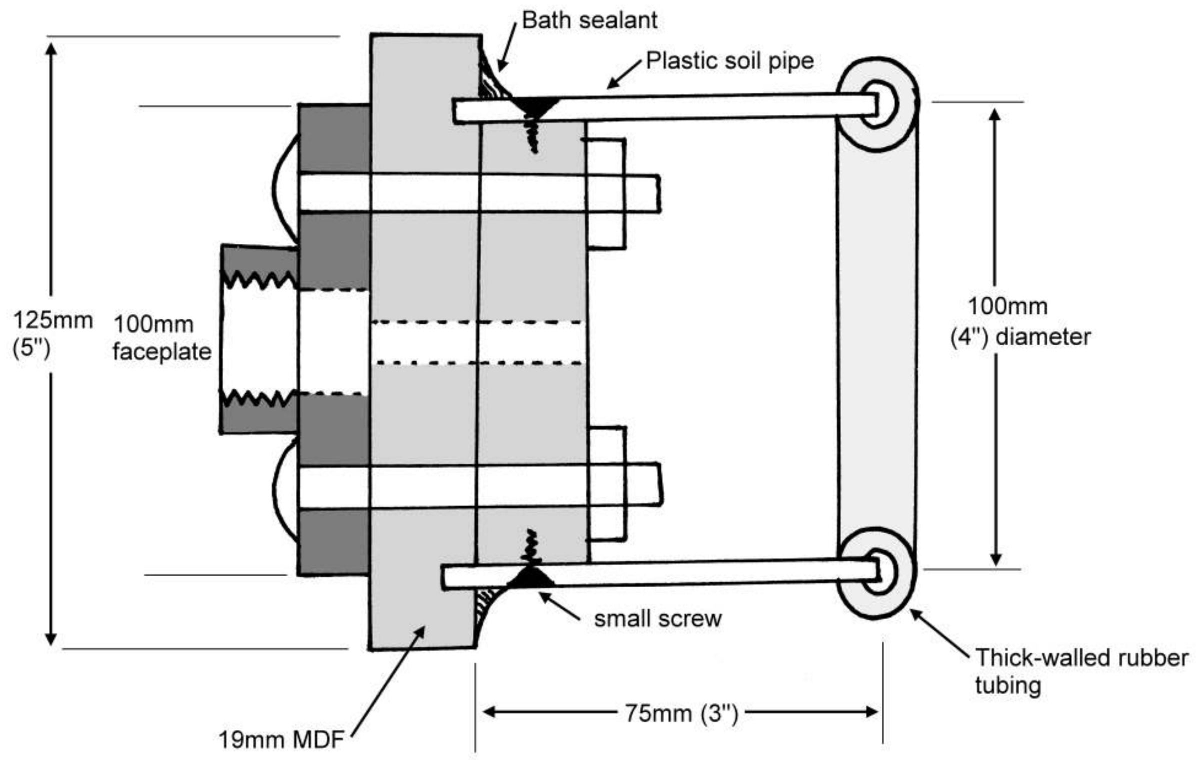

Diagram 1

photo 1

photo 2

It is important to cut the ends of the plastic soil pipe cleanly and square to the sides. To mark the pipe for cutting, wrap a sheet of newspaper around the pipe making sure the edges of the paper line up where they overlap. Use this edge to mark a line around the pipe, and cut to it carefully.

As the chuck was constructed, bath sealant was smeared between the layers of MDF and between them and the faceplate. A liberal amount was put in the bolt holes to seal them as the bolts were tightened. The same sealant was put in the groove before the tube was pushed in. Four evenly spaced screws were used to secure the plastic pipe in place, and more sealant was used outside and inside around this joint. Put the chuck on the lathe and, with the lathe on, check that the front edge of the pipe is rotating truly. If not, true it up with a sharp gouge before fitting the rubber seal.

The most critical part of the chuck is the rubber tubing on the open end. To make a good, air-tight seal with the workpiece, you need something which is firm but flexible enough to conform to any slight variations in the surface of the workpiece. I experimented with all sorts of possible materials before I hit on the idea of using rubber tubing. It’s been in use for three years now and still performs perfectly.

To make the rubber seal, measure the diameter of the soil pipe and use this to calculate the circumference of the pipe

$$\text{Circumference} = 3.142 \times \text{diameter}$$

Cut this length of rubber tubing, taking care to get neat, straight cuts at the ends. Bend the tube round and superglue the ends together to make a ring. Superglue bonds rubber wonderfully well and will make a good strong joint. When the glue is set, lay the rubber ring flat and use a craft knife to cut vertically through the top surface into the central hole in the tube. Push the end of the soil pipe into this cut. When you do this the cut edges of the tube will ‘splay out’ a little, and I filled the resulting groove with thick superglue and left it to set hard. The whole assembly, except the rubber ring, was then painted with several coats of ‘Hammerite’ paint to seal the MDF which is much more porous than you might imagine **(Photo 3).**

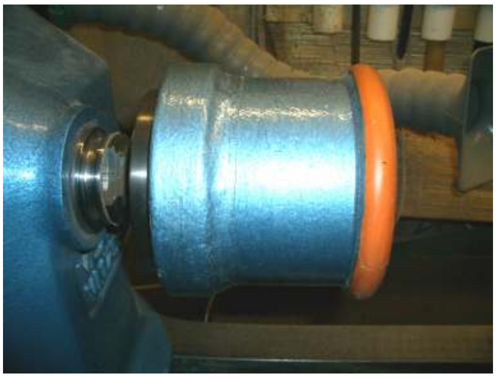

photo 3

To explain how the chuck works, a little science is necessary. Air pressure is the weight of all the tiny air molecules in the atmosphere above us. At sea-level this adds up to almost exactly 15 pounds weight on every square inch of surface i.e. 15lb/in^2. It gets less if we climb a mountain, because there is less air weighing down on us, and it increases if we go down a mineshaft because there is more. At 15lb/in^2 the total air pressure on our bodies adds up to several tons, but it doesn't squash us because the air inside our bodies exerts an equal pressure outwards and balances everything up. We remain blissfully unaware of the immense forces acting on our bodies all the time.

A vacuum chuck allows the air to be removed from one side of the workpiece so that the air pressure on the other side has nothing to counteract it. In a perfect situation this would result in a force of 15lb weight on every square inch of the unbalanced surface. **(Diagram 2)**

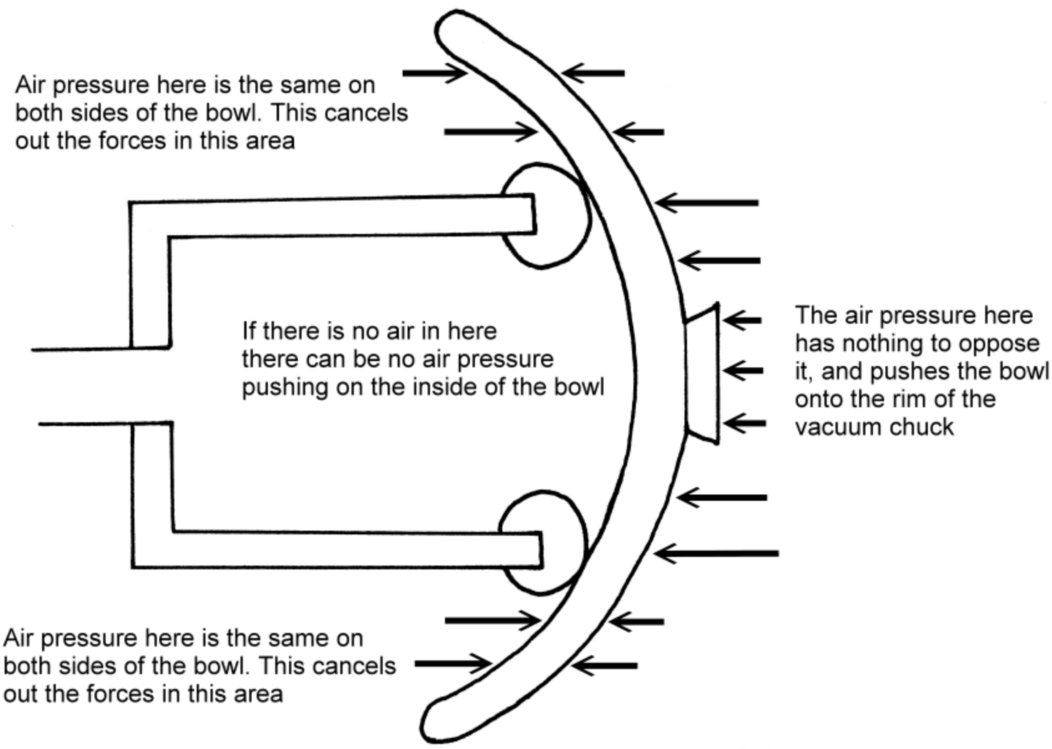

Diagram 2

Note that it is only the part of the workpiece which is over the chuck opening that has a force acting on it. The total force on the workpiece depends on the area of the chuck opening.

Well, that's the science lesson over, now for the maths. My chuck was made from a piece of 4" diameter soil pipe. The cross-sectional area of a pipe is

$$\text{Area} = 3.142 \times (\text{radius})^2$$

For a 4" diameter (2" radius) pipe, this shows the area is 12.6 square inches.

At 15lb/in^2 the maximum force on the surface would be

$$\text{Force} = 15 \times 12.6 \text{ lb} = 189 \text{ lb}$$

Unfortunately this is only true if you can create a perfect vacuum inside the chuck and this is unlikely to be the case. With the pump I have I can achieve a little over 70% vacuum, so the force on my workpiece is only 70% of 189 lb, i.e. only 132lb.

Only 132lb? That's over a hundredweight holding the workpiece in place – more than adequate for most tasks!

Earlier I said that the chuck is less useful for small pieces. Obviously the workpiece must be big enough to cover the open end of the chuck. A small workpiece therefore requires a small chuck. Imagine a chuck only two inches in diameter. Without going through all the arithmetic again, the force holding the workpiece in place is now only 33lb. Although I've never used such a small chuck, I can't help wondering how well this much smaller force would hold a workpiece. Conversely a bigger chuck gives a bigger holding force. A 6" diameter chuck has a holding force of around 300lb – getting on for three hundredweight. Again, I've no first-hand experience of such a large chuck, but wonder if there is a danger of overdoing it.

To make any use of the vacuum chuck you must have some means of producing the vacuum inside it.

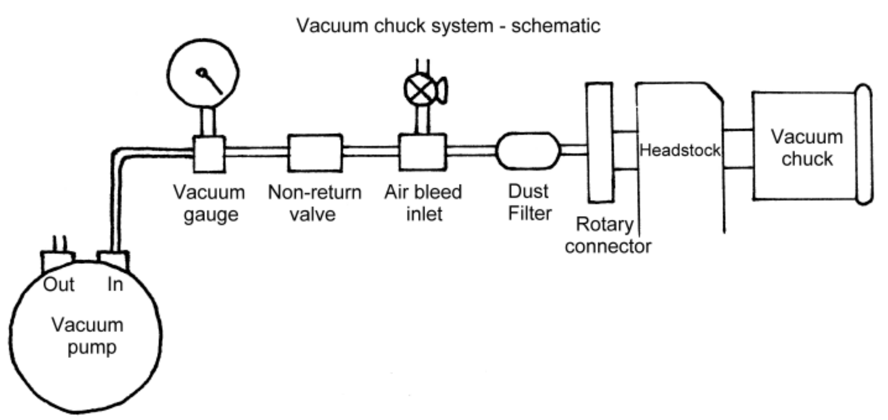

Diagram 3

Diagram 3 shows the layout in principle but when I actually put it together I 'folded' it to make it smaller and neater **(Photo 4).**

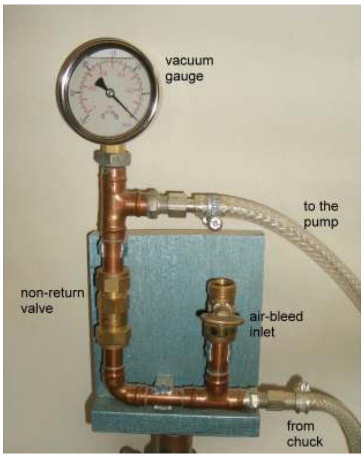

photo 4

Most of the system is straightforward but a crucial part of the system is the bit I have called the 'rotary connector'. This allows the pipework and fittings to remain stationary while the lathe spindle and chuck rotate at whatever speed. I pondered this problem for quite a while until, one day when I was buying a bearing for another job, I asked the stockist if there was such a thing as an airtight bearing. Well, yes there is. It's called a 'double rubber sealed' bearing and, as the name suggests, it has an airtight rubber seal on each side of the bearing. I asked for one with a central hole about ½" diameter, and I didn't care what the outside diameter was. *"We don't get many as don't care what size the bearings are"* he said (you have to imagine this pronounced with a broad Yorkshire accent). It cost me about a fiver.

To make the rotary connector **(Diagram 4)** a hole was turned in a piece of MDF to take the bearing as a close push fit.

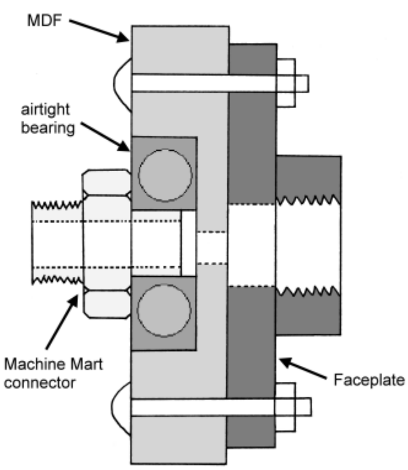

Diagram 4

A few drops of superglue were smeared round the edge of the hole and the bearing was pushed into place. Another hole was drilled through the centre of the MDF in line with the centre of the bearing.

My local branch of Machine Mart carries a wide range of air hoses and fittings intended for compressed air systems. Designed to keep air inside the system, they work equally well at keeping it out. Amongst these fittings I found a double male-threaded connector about ⅝" diameter. Using a metalwork lathe I turned one side of this connector to be a good push fit inside the bearing. (If you work carefully and are prepared to keep sharpening your tools, you might be able to do this on a woodworking lathe.) The connector was then superglued in place. At the time I wasn't sure how well superglue would stand up to this task, but it's been working for about three years now and I have had no problems with it.

The whole assembly was bolted to another faceplate and the MDF given several coats of paint to seal it. **(Photo 5)**

Photo 5

When screwed on the outboard spindle of the lathe it provides an airtight pathway from the chuck to the outboard connector. The fact that my lathe has a hollow spindle made life easier for me. If yours hasn't, then you will need to apply more ingenuity, or purchase an adaptor ready made.

Using standard compressed air connectors, the rotary connector can be attached to the vacuum pump by flexible hose, and the air drawn out of the vacuum chuck. The system would work at this point, but it is advisable to include a few other components.

An *in-line filter* **(Photo 6)** removes any dust in the air before it reaches the pump, where it might do damage. It's a good idea to have this as the first component after the rotary connector. Mine certainly does collect dust, and must be emptied every now and then.

photo 6

It is impossible to adjust the position of the workpiece when it is held by the vacuum. The *air-bleed valve* **(Photo 7)** is used to allow a controlled amount of air into the system, thus reducing the vacuum while adjustments are made. It is a gas tap, obtained from the local plumbers merchants.

photo 7

I included a *non-return valve* in the system **(Photo 8)** in the hope of retaining the vacuum in the event of the pump stopping unexpectedly, for example in a power-cut.

I got it from the plumbers merchants. Make sure it is for gas, not water, and be careful to connect it the right way round. It should prevent air returning to the chuck if the pump stops. It was fairly cheap – again, about a fiver, but it doesn't work especially well and will only hold the work for a few seconds after the pump stops. It depends how quickly your lathe stops whether you will have time to grab the workpiece before it comes off. My lathe takes too long, I know to my cost.

photo 8

The most expensive item in the system, after the pump itself is the *vacuum gauge* **(Photo 9).**

photo 9

It's not a vital component but it is very reassuring to see the needle go round the dial when you switch on the pump, and it gives you warning if your vacuum isn't up to scratch for some reason. It cost £17 from www.miniaturepressuregauge.com

The *vacuum pump* itself was, of course, the most costly item in the system. **(Photo 10)**

A brand new vacuum pump will cost anything from about £300 upwards. For this you also get all the peace of mind that a warranty can bring. On the other hand, I bought mine for £75 on eBay. It's given me no trouble whatever, and I'm more than happy with it. In use it is kept in a plastic box under the lathe, sitting on some bubble-wrap to absorb vibrations. It is very quiet. If you want to try this approach, then you might like to check the following points with the seller.

- Make sure it uses a 220/240v supply as some of the gear on eBay doesn't.

- Check that it is rated for continuous use, and that it can continue to pull against a 'dead end'. What this means is that the motor doesn't need a continuous flow of air through the system to cool it, and it will continue to work after the vacuum has been formed.

- A 'rotary vane' type is maintenance free, a 'sliding vane' type needs an oil reservoir, but gives a better vacuum (I think). Mine is a rotary vane.

photo 10

- You should also check how good a vacuum it will produce, but don't expect anything near perfection.

Unfortunately air pressure is measured in a multitude of different units, but a common one is ‘inches of mercury’ (chemical symbol Hg). If we take normal air pressure as our scale zero, then a total vacuum would be *minus* 30in Hg. The best my pump has ever achieved is minus 23in Hg, or about 76% of a full vacuum, and this has been perfectly adequate. Incidentally it varies with the weather! Air pressure is one of the factors that influences the weather, that’s why the weatherman talks about it on TV. As the pressure varies, so does the degree of vacuum achieved by the pump. Oh, and by the way, you **can’t** use a vacuum cleaner, it’s not powerful enough and can’t pull against a dead end.

Using the chuck

I use it most for removing the spigots and turning the feet of bowls. When turning the outside of the bowl, remember to mark the centre of the spigot. When the time comes, you can use this mark, with a tailstock centre, to locate the bowl centrally on the vacuum chuck. Annoyingly, I often forget and its then a bit of a game getting the bowl centred. I still haven’t found a satisfactory way of centring a bowl with the actual bowl facing outwards, and am open to suggestions. Fortunately I don’t often need to.

Simon says he uses his vacuum chuck for the whole job, from start to finish, but there doesn’t seem any point holding a heavy blank by vacuum when there are more obviously secure, and no less convenient, alternatives.

Burrs, and other pieces with holes in them, create obvious problems. I have held burrs on the vacuum chuck by using plastic insulating tape to cover over all the holes. Keep checking the tape and keep an eye on the vacuum gauge.

I don’t know how I ever managed without my vacuum chuck. When you really need it, nothing else will do, and from time to time it’s got me out of some very difficult workholding situations. In total it cost me about £140 to build the whole system, and that’s *less* than the price of many conventional chucks. Money well spent.