Toe Studs for DIY Organ Consoles

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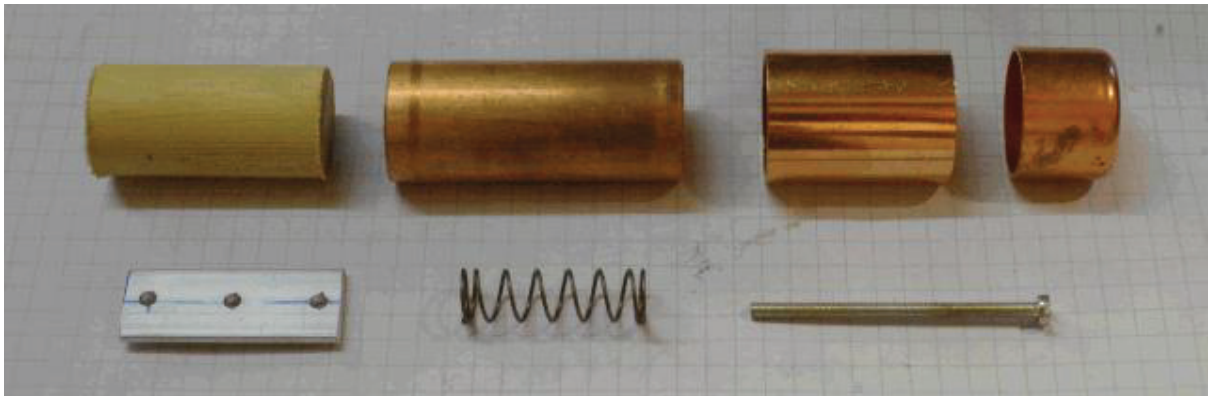
24th July 2012

This is a design for relatively inexpensive organ console toe studs (pistons). The aim is to produce something that is fit for the purpose and reliable, using readily available materials, and requiring only basic tools and constructional skills. The design is based around 22mm copper plumbing components. The advantage of this is that such materials are very easily available just about anywhere, are reasonably cheap (though copper is currently rather more expensive than it used to be), and are manufactured to quite close tolerances.

This is what is needed for the mechanical element of each toe stud:



Top row, left to right: a 43mm length of 20mm diameter softwood dowel; a 50mm length of 22mm tube; a 22mm end-feed slip coupling; a 22mm stop end.

Bottom row: a 40mm length of 15mm x 2mm aluminium strip; a spring of appropriate length, diameter and rate; a 50mm long M3 cheese-head machine screw.

Not shown are 2 chipboard screws ¾" / N° 4.

Approximate costs for these materials (and convenient sources within the UK) are at the end of this document.

Necessary tools are:

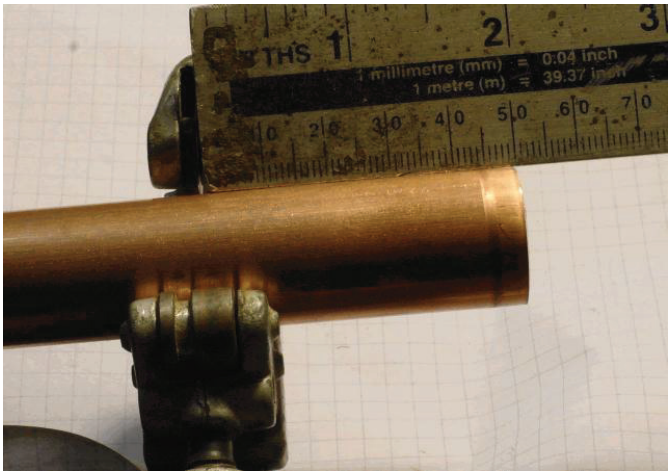
electric drill (preferably a pillar drill, but used with care a hand-held drill will do);
2.5mm, 3mm and 4mm, HSS drill bits;
steel wool;
hacksaw;
screwdriver;
2-part epoxy adhesive (e.g. Araldite Rapid);
24mm flat bit;
6" half-round file
pipe cutter

Constructional Details – Piston Assemblies

The following sequence is for one assembly. It's probably a good idea to go through the whole process once, using a scrap piece of the material used for the base-board, to get an idea of the overall sequence and where the tricky parts might be. If the construction of this first example goes well it can be used in the final assembly, so nothing is wasted except the piece of base-board.

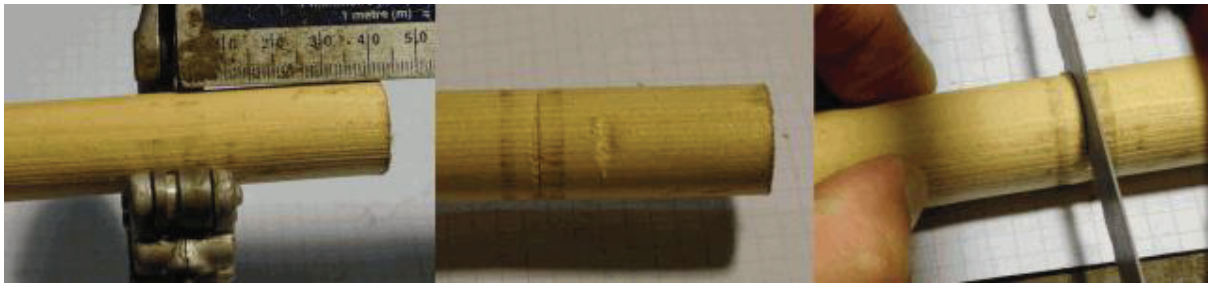
Assuming that you intend to construct more than one it will be better (once you have the sequence in mind) to do each step for all the pistons before moving to the next step. This will enhance the consistency of the overall result, be quicker in the long run and offer useful opportunities for tea-breaks etc.

Step 1: Cut a 50mm length of 22mm tube using a pipe cutter.

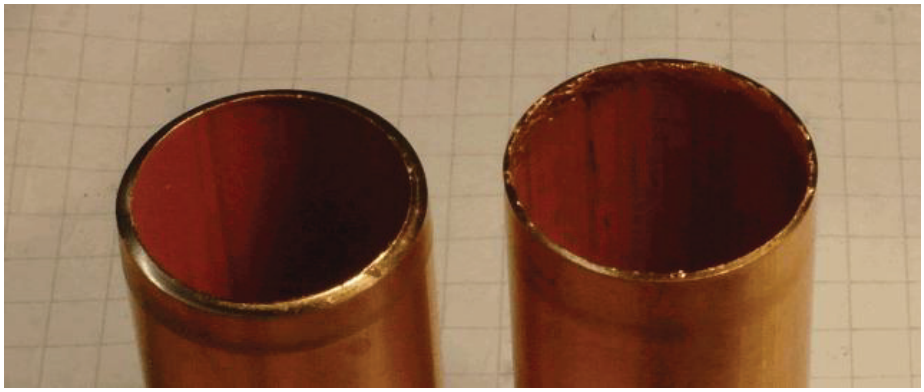


Step 2: Check that this piece of tube slides easily through a slip-coupling in all orientations. If it won't, or if it binds/rubs in places, cut a new length of tube.

Step 3: Cut the 43mm lengths of softwood dowel. This is most easily and accurately done with a band-saw if you have access to one. Otherwise use a hacksaw, marking the cut line using the pipe cutter if you want. You might consider making all the marks and then all the cuts. If so, remember to allow for the material removed by the saw by making the marks 1 mm or so further apart.



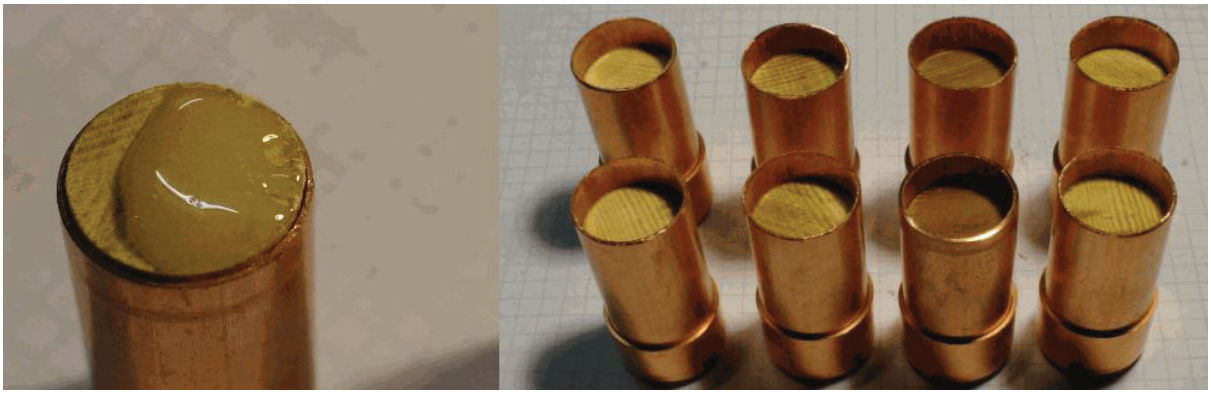
Step 4: ‘Deburr’ the inside of one end of the tube by filing away the turned-in edge left by the pipe cutter.



Step 5: Push the dowel into the end of the tube you have just deburred, but not all the way. Then push the whole assembly firmly into a stop end. This will set the dowel at the correct depth. Remove and check that just a little of the wood remains showing.

Step 6: Clean the inside of the stop end with steel wool. When all your piston parts are ready for assembly, mix the 2-part epoxy adhesive. I find that the ‘quick setting’ (15minute) variety is OK for this so long as you can complete all the pistons before the adhesive starts to gel.

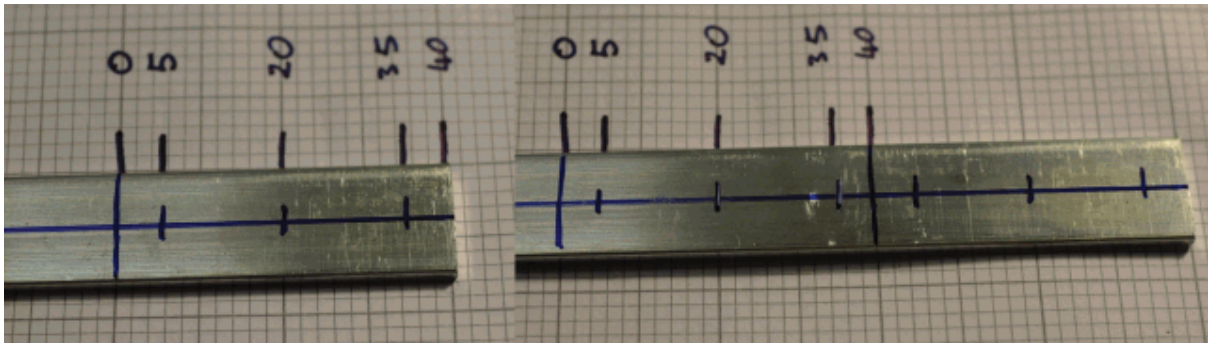
. Put a glob of adhesive on each protruding wooden end, push the assembly back into the stop end, set to one side and leave all the assemblies well alone in a warm place for at least an hour.



Constructional Details – Base-board

The base-board supporting the pistons needs to be stiff and heavy enough to withstand the equivalent of a regular, and possibly vigorous, kicking. For this reason I suggest something like 18mm birch plywood, MDF or chipboard. Before doing anything else decide what number of pistons you require, and how you are going to lay them out. Obviously this is up to you, but I would be reluctant to put them closer together than about 6cm.

Step 1: Drill and cut the aluminium strip. A quick way of marking up the strip is to put the drilling and cutting points for one item on a sheet of graph paper, transfer to the metal strip, move the strip along, mark the next section and repeat until you have marked up all the sections you need.

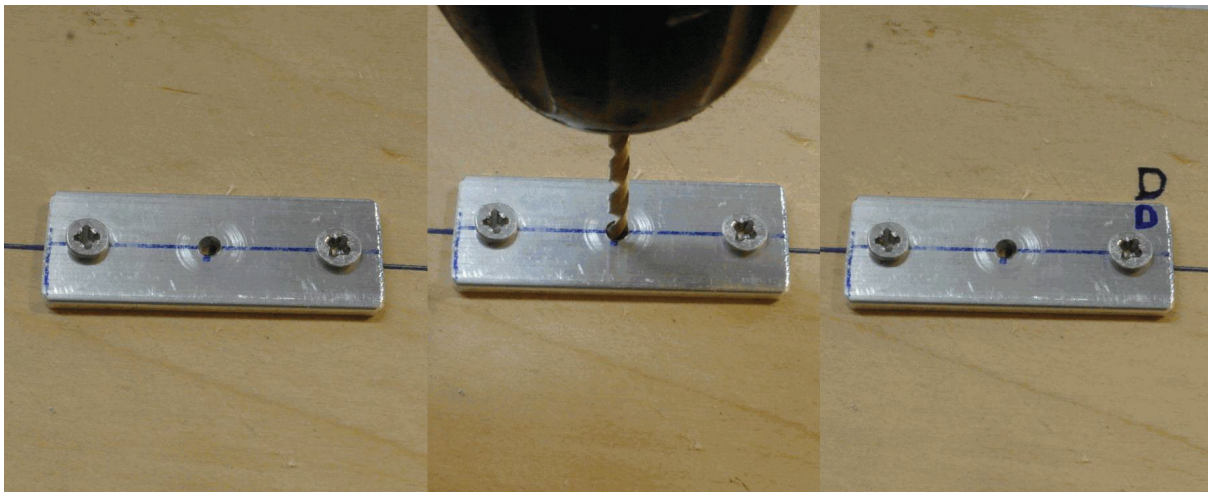


Step2: Drill the aluminium strip. The holes at each end of the finished section are 3mm, the one in the middle is 2.5mm. **Do not** be tempted to drill the middle one 3mm as well to save time. It is also important that the middle (2.5mm) hole is perpendicular to the strip. This is where a pillar drill will help if you have access to one. If doing it by hand, check the perpendicularity as carefully as you can.

Step3: Cut the drilled strip to the 40mm marks. Clean up the ends, any sharp corners and the backs of the drill holes with a file.

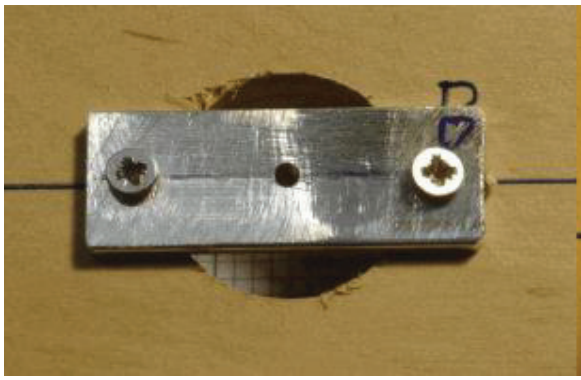
Step 4: Mark up the layout of the pistons' positions on the back of the board. **Remember that this will be a mirror image of the layout as seen from the front**. If the pattern is not symmetrical this matters!

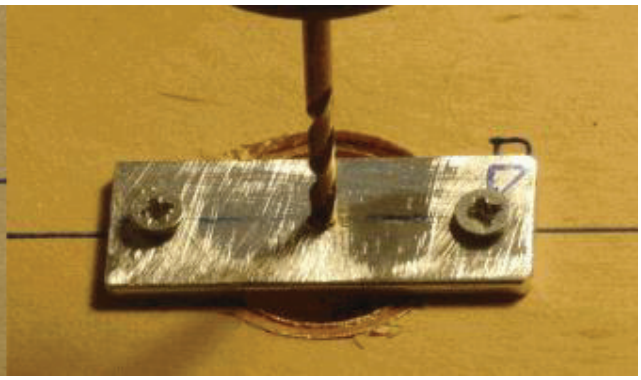
Step5: Screw the aluminium to the back of the board, being careful to locate the middle hole over the mark where you want the piston centred. Extend the 2.5mm hole right through the base board. Then mark one end of the plate and the baseboard. In the next step you will need to take the plate off, and you must be able to replace it in the same position and orientation.



Step 6: Unscrew all the plates, turn the board over and bore 24mm holes using the 2.5mm holes to locate the borer. It is helpful to clamp the board to a solid work bench if possible, and place some scrap material below the board if you don't want holes in your workbench (or kitchen table!). Again, it is important to keep the hole perpendicular to the base board.

Step7: Screw all the plates back on to the board being careful to replace them in their original position and orientation. Then push a slip coupling into the hole from the front. It should be a fairly tight push-fit, and may need a little jiggling and/or twisting to persuade it to settle against the plate. If it really won't go in, **do not try and hammer** it through as this will deform the coupling and render it useless instead a little light sanding or filing of the hole may be required. If, on the other hand, it seems too loose, you may need to (sparingly) glue it in place. Next insert a piston into the slip coupling and drill (still at 2.5mm) through the middle hole and into the wooden plug. Once again, it is vital to ensure that the hole is centred in the wooden plug and parallel with its axis by keeping the drill perpendicular to the board.

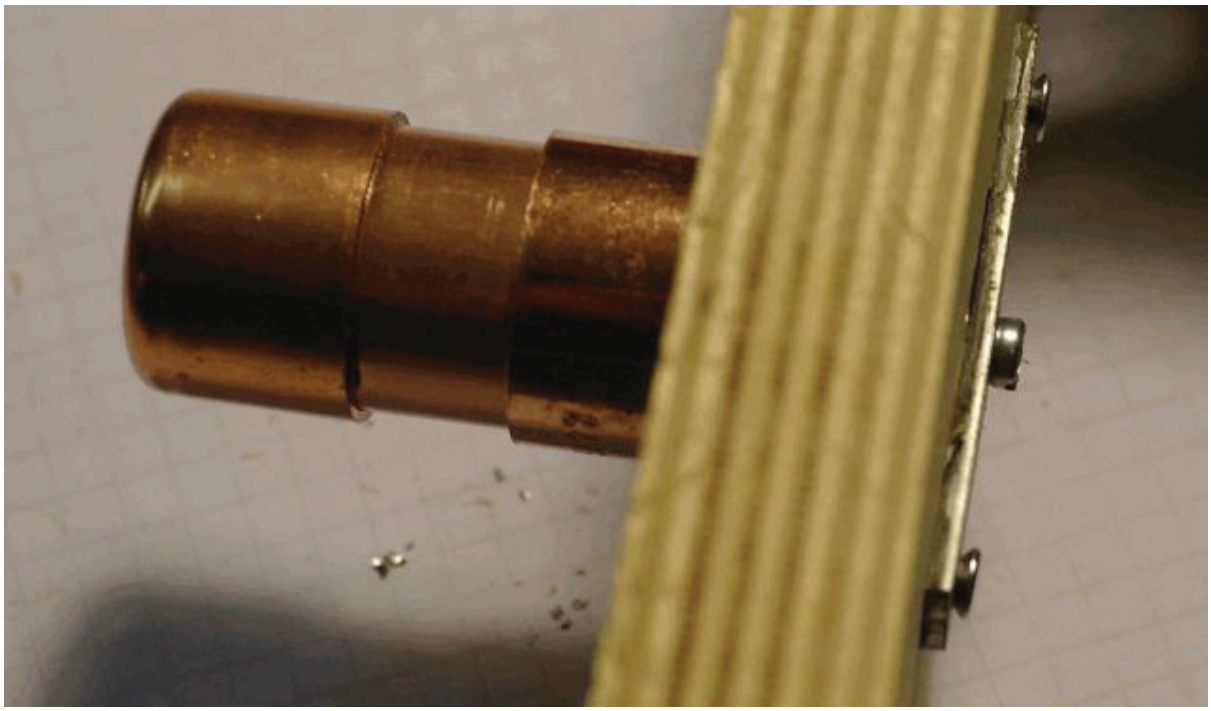




Step 8: Remove the piston from the front of the board and extend the hole in the wooden plug as far as you can (without actually drilling right through the end cap). While the piston is still out of the board, enlarge the central 2.5mm hole in the plate by drilling it out to 4mm.

Step 9: You can now assemble the mechanical part of the toe piston. Place a spring over the hole in the wooden plug, and insert the whole assembly into the slip coupling. Put the 3mm machine screw through the 4mm hole in the aluminium plate, down the inside of the spring and into the hole in the wooden plug. Turning the screw with a little pressure will engage it with the hole (which is slightly too small) and it will form its own thread as you keep screwing it in.

Step 10:Centre the spring by poking at the ends with a suitable long thin object. Check that the piston moves freely in the slip coupling and that the screw isn't rubbing on the hole in the aluminium plate. If it is rubbing, you may have to enlarge the hole slightly to cure this. The cause will be that the hole in the wood block is either off centre, not parallel with the axis of the core, or both of these.



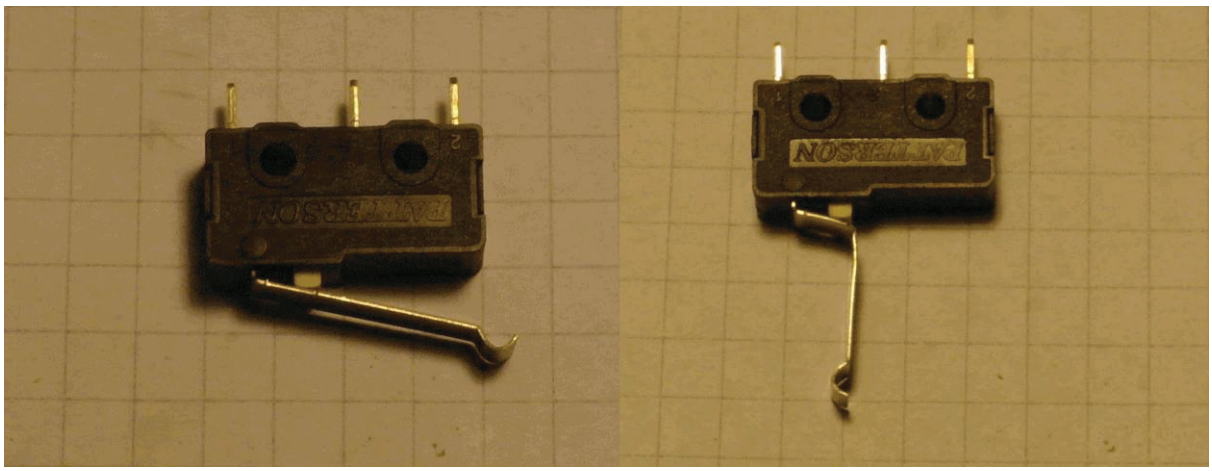
The machine screw may be used to adjust the amount of travel. I think a about a centimetre or so is reasonable.

The mechanism makes a distinctive 'clack' noise as it hits both ends of its travel. If you find this objectionable, just apply self-adhesive felt pads where the piston contacts the underside of the aluminium section and where the screw contacts the top of the plate.

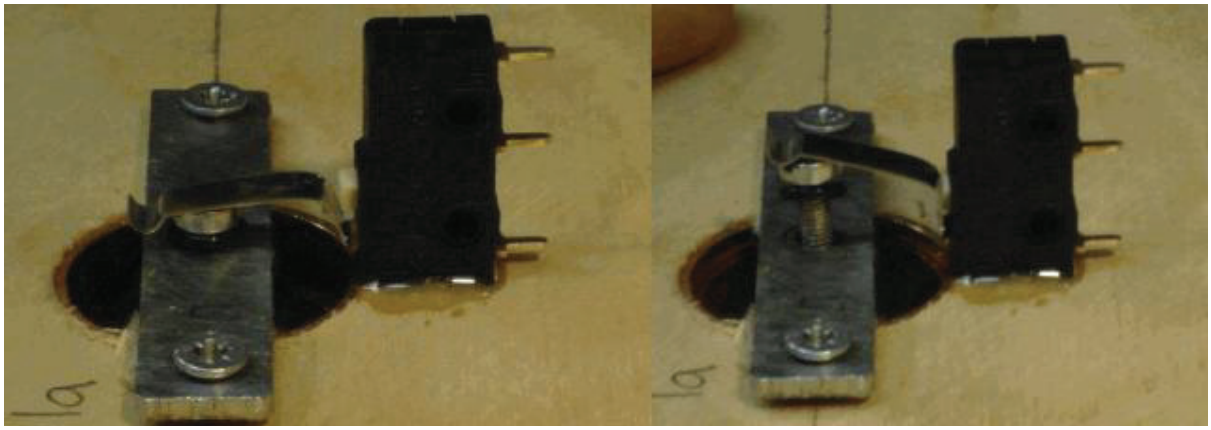
Electrical Contacts

There are any number of ways in which the movement of the screw could be sensed electrically, but the following approach seems to work reliably and is pretty cheap.

I use subminiature V4 microswitches (http://www.rapidonline.com part number 78-2471) with simulated roller actuators. As supplied the actuator is straight. The arm needs to be bent to interface with the piston.



The switch is then epoxied to the base-board after checking, and adjusting if necessary, both the position of the switch and the amount of bend of the arm so that the switch closes when the piston is about half way between the limits of its travel.



One issue with this approach is that it's not really possible to dismantle the assembly once the switch is glued on. A more sophisticated approach would be to glue the switch to a plate of its own screwed to the board allowing both adjustment of the switch position and complete removal.

Schedule of Materials (Per Piston)

Item	Quantity	Approx. cost	Source (and minimum buy)
22 mm Copper Tube	50mm	50p	B&Q (2m@£18) or Ebay (50cm lengths)
22mm Stop End	1	20p	http://www.copperpipefittings.co.uk
22 mm Slip Coupling	1	60p	http://www.copperpipefittings.co.uk
15mmx2mm Aluminium Strip	40mm	10p	1m length from B&Q (£2.51)
20 mm Pine Dowel	41mm	20p	2.4m length from Homebase (£11)
Machine Screw	m3x50mm	25p	Ebay (20 @ £5)
Spring	c1-4434-2m	50p (see below)	http://www.flexosprings.com
microswitch		50p	http://www.rapidonline.com
		____	
		£2.85	

Notes:

The slip coupling **must** be of the 'end feed' type and not of the 'Yorkshire' (solder ring) type. The stop end could be either, but I think the end feed version looks a lot better.

'Straight' couplers look superficially similar, but have a ridge built into them half way through. In other words, they are designed to prevent 22mm tube sliding easily all the way through. They won't do for this application.

The base-board will also need to be sourced, but taste, size, layout and what might happen to be available make its cost impossible to predict. If buying something for this particular application I'd recommend 18mm birch ply as appropriately thick, stiff and stable for the job.

The price breaks on the springs are rather extreme (and ambiguous if you want 12 for example).

QUANTITY	PRICE/EACH
1 - 4	1.00
5 - 10	0.89
15 - 29	0.68
30 - 49	0.51
50 - 99	0.42

However, since I have about 60 of these left over from a completely different project I could supply small quantities at the 42p rate (plus postage at cost). Anyone who is interested should contact me (NickNelson) via the HW forum. Similarly, I might be persuaded to supply modest quantities of pre-cut dowels at 20p each, also plus postage at cost.

The cost per piston is based on the amount of materials actually used. Depending on how many are made, there will be material left over which still has to be paid for. This will increase the cost per piston. For example, if you only wanted to make 8, the cost would be about £35, and there would be quite a bit of (nevertheless possibly useful) stuff left over.