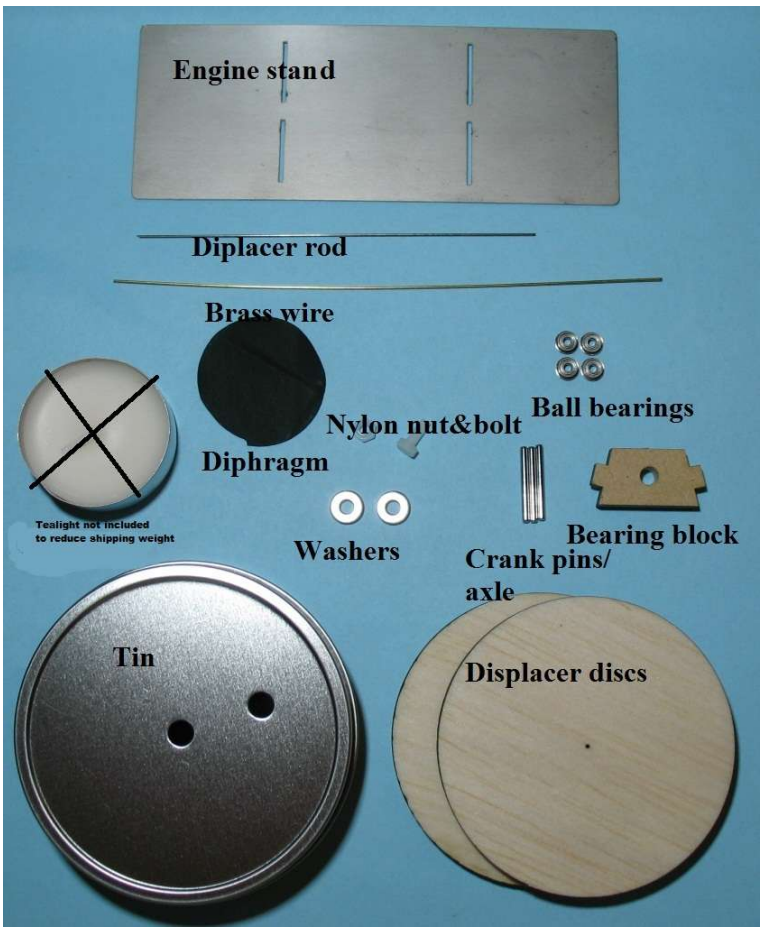
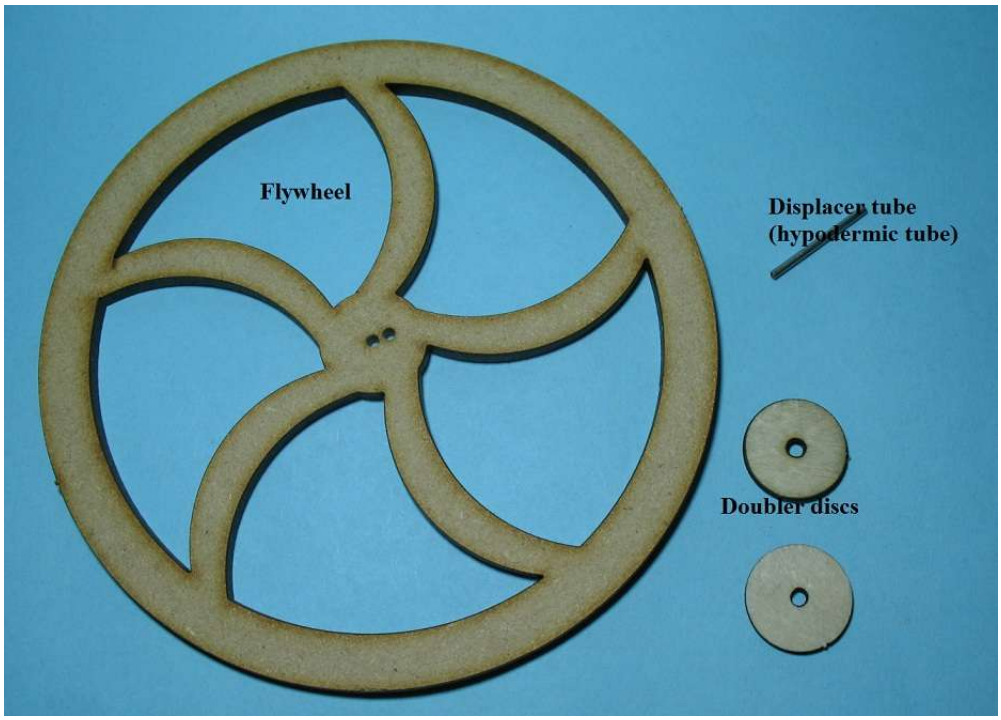
Assembly Instructions for the BB1 Mk.3 Stirling Engine

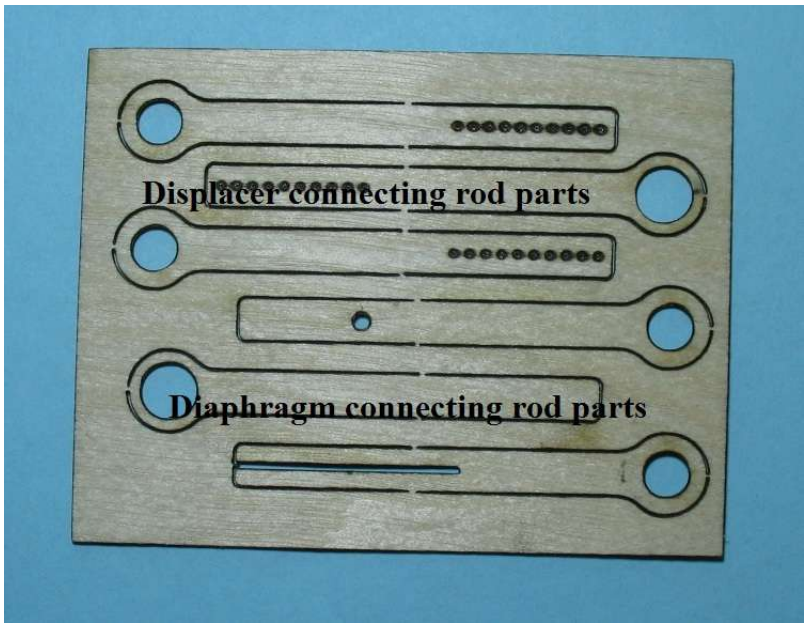
Required tools/materials:

Sharp modelling knife
Ruler
Abrasive paper
Flat nosed pliers
Wire cutters
Slow cure epoxy glue (15-30 minute cure)
PVA glue for the woodden parts (epoxy can be used instead)
Clamps or weights

Kit Contents




Flywheel
Displacer tube
(hypodermic tube)
Doubler discs

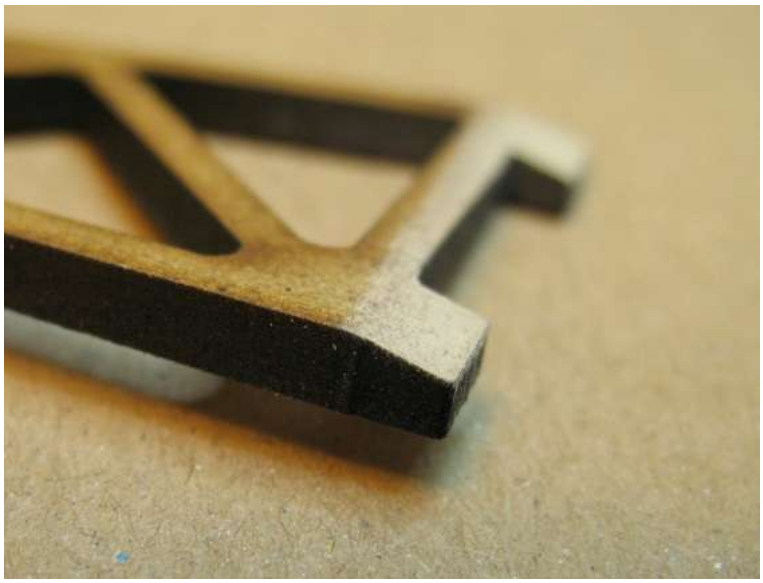

Displacer connecting rod parts
Diaphragm connecting rod parts

Frame assembly

Start by separating the parts from the carrier sheet. A light wriggle should be enough to break the retaining tabs. Sand all the pips off.

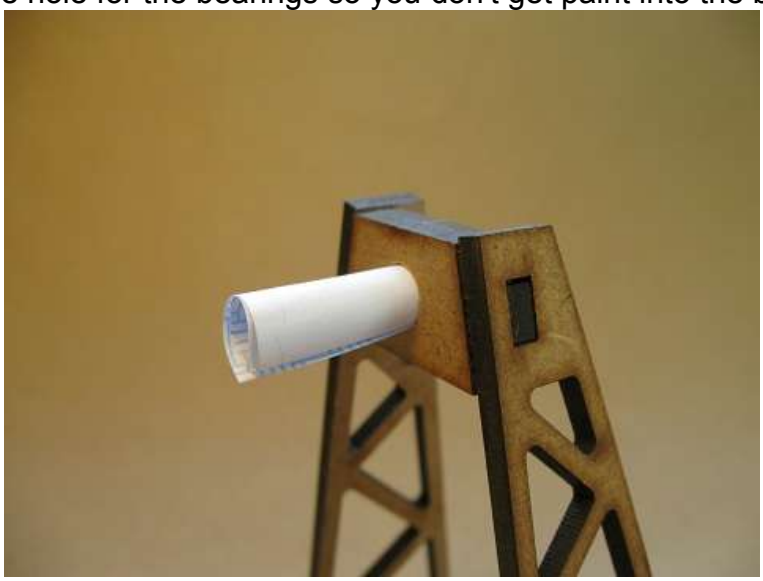
Glue the two smaller diameter rings together and then glue them to the base plate. The larger rings are used for holding the diaphragm in place and should not be glued together.

Chamfer the outside of the tabs on the uprights so they fit in the base.



The bearing block is pre-assembled and has the hole for the bearings drilled to the correct size for a press fit. Glue the bearing block to the uprights and glue the uprights onto the base.

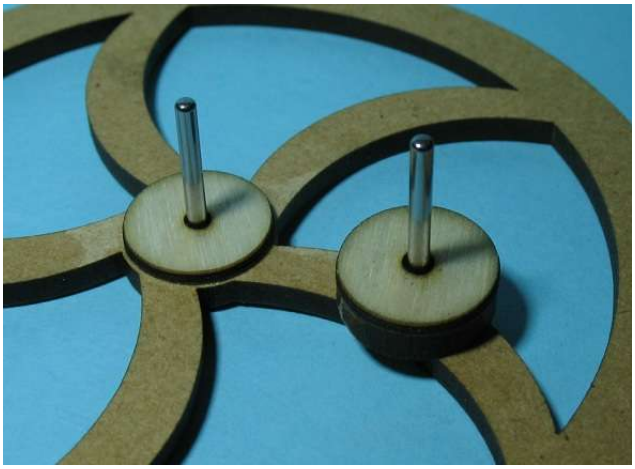
MDF is not moisture resistant so now is a good time to paint the engine parts. If you prefer the plain MDF look you can use a clear lacquer or MDF sealer. For colour, acrylic automotive paint in a “rattle can” works well. If you use spray paint, roll up a piece of paper and insert it into the hole for the bearings so you don't get paint into the bore.



Press the ball bearings in place in the block.

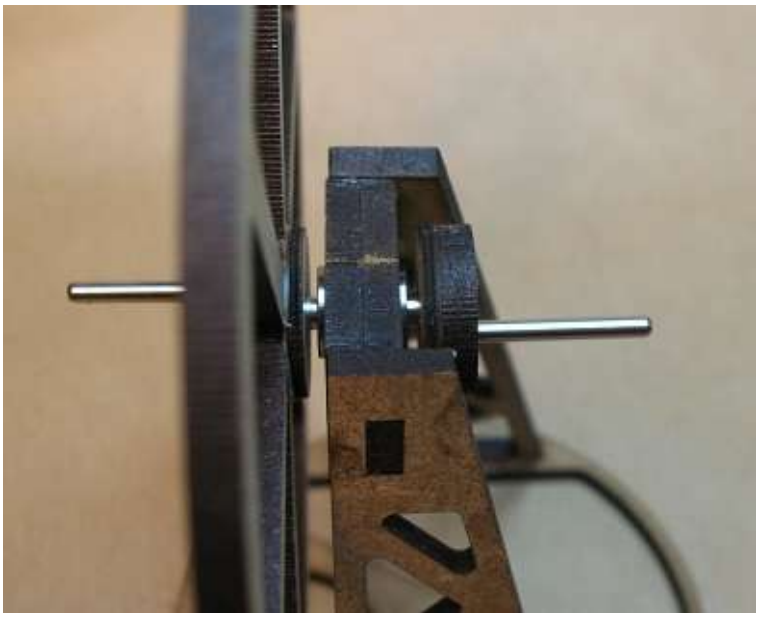
Insert the 2mm axle so it protrudes an equal amount on each side. Check that the axle spins freely. If it doesn't there may be a bit of misalignment between the bearings. Wriggling the axle from side to side and up and down to align them.

Glue the plywood doublers onto the flywheel and crank disc. Use the 2mm pins to ensure they are properly aligned.

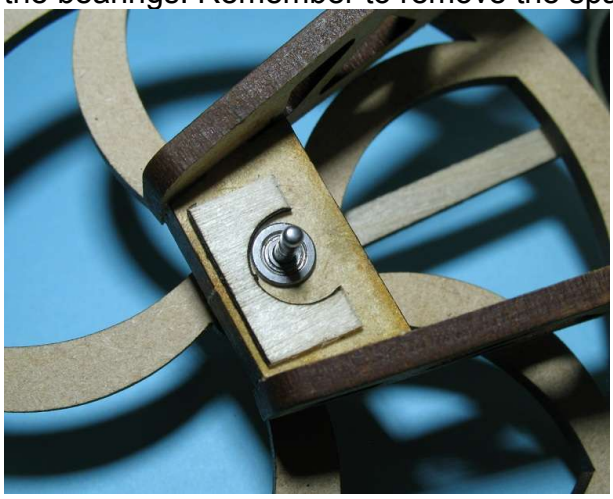


Fit the 2mm crank pins into the flywheel and crank disc. If using pliers to push them in, the pliers should have smooth jaws so they don't damage the pins. Alternatively you can tap them in with a small hammer. Put a scrap piece of MDF between the pin and the hammer so you don't damage the pin. Take care to ensure they go in at right angles to the crank disc and flywheel and that you don't break the thin wall between the holes.

Push the crank disc and flywheel onto the axle. Make sure they don't rub against the bearings.



You can use an off-cut from the 0.8mm plywood sheet that holds the connecting rods as a spacer when you mount crank disc and flywheel. It will give you the desired gap between crank disc/flywheel and the bearings. Remember to remove the spacer afterwards



Displacer Rod Tube

A pre-cut length of hypodermic needle tube is supplied with the kit. Clean the ends up on a piece of sandpaper and push out any burrs with the displacer rod. Glue the tube in place using the alignment procedure described below. In order to avoid getting glue into the tube it is a good idea to have it protrude 1-2mm from the bottom of the base (do not exceed 2mm as it will then affect the movement of the displacer). You can prop up the base on a couple of coins while the tube rests on the table during the curing of the glue.

Insert the hypo in the base plate from the underside. Push it in so it sits flush with the underside. Do not add glue at this point. Use the piano wire displacer rod to ensure the hypodermic tube aligns with the centre of the axle and is square to the base plate. If it is not aligned properly the displacer will be tilted and could rub against the side of the tin. Once you are sure it is properly aligned, glue it in place with epoxy and add the doubler to reinforce the joint.

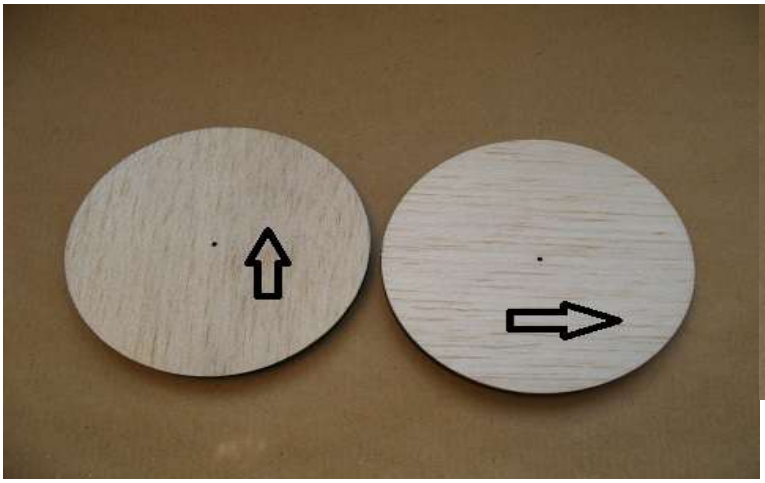
Attaching the base to the tin lid

Glue the frame onto the tin lid using a 15-30 minute cure epoxy. Use a generous amount so you are sure to get an airtight seal against the tin lid. **IMPORTANT: Thoroughly coat the inside and the rim of the diaphragm rings with the epoxy. In operation it is possible to have a little condensation forming here and without the epoxy coating the MDF could swell and de-laminate.**

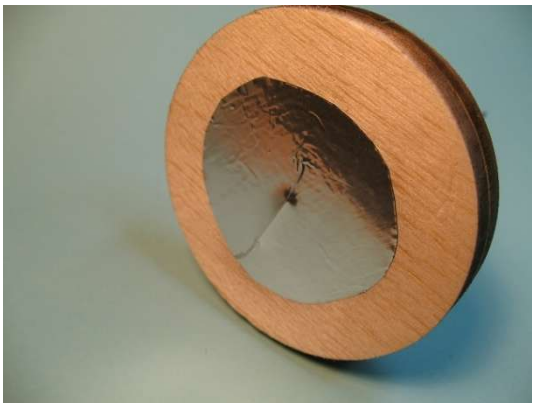
It is recommended that you sand the areas of the lid that will be covered by the base with coarse sandpaper. You can hold the base in place on the lid and scratch the outline with a pin so you don't sand the areas of the lid that will be visible. By sanding the lid you ensure the best possible adhesion of the base. **IMPORTANT: Although the epoxy will be set in about 30 minutes it takes 24 hours to harden fully. Do not be tempted to run the engine before the epoxy is fully set.** If the base de-laminates from the lid it may be hard to detect but it will cause an air leak that will prevent the engine from running

Displacer Assembly

Glue the two displacer halves together. It is important that the grain is at 90 degrees to each other as this will prevent warping once in use in the hot tin. Also make sure the whole area is covered with glue so the halves don't split when they become hot.



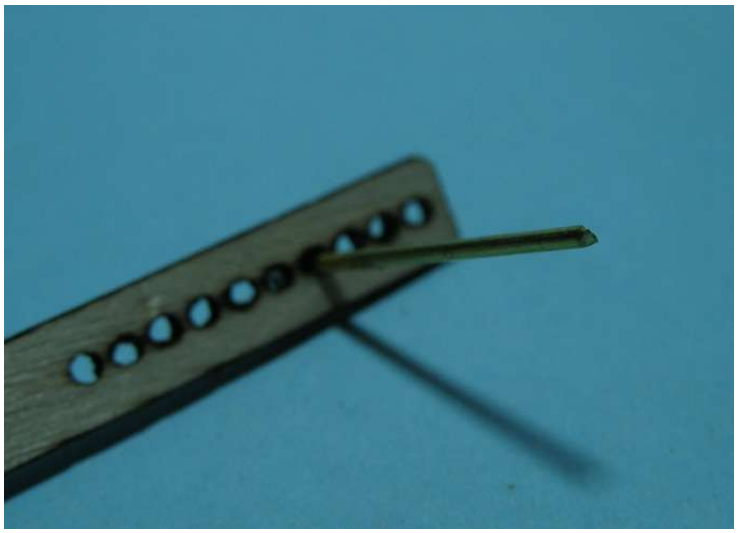
Make a 90 degree bend in the piano wire as per the picture, slide through the centre hole in the displacer and secure in place with a round piece of alu tape, cut from the supplied tape. Rub the tape down well. Make sure the rod is square to the displacer.



Push the displacer rod through the displacer tube. Put the lid on the tin ensuring it is firmly in place and the displacer rests on the bottom of the tin. Make a 90 degree bend in the displacer rod, app. 25mm above the top of the base.

Connecting Rods

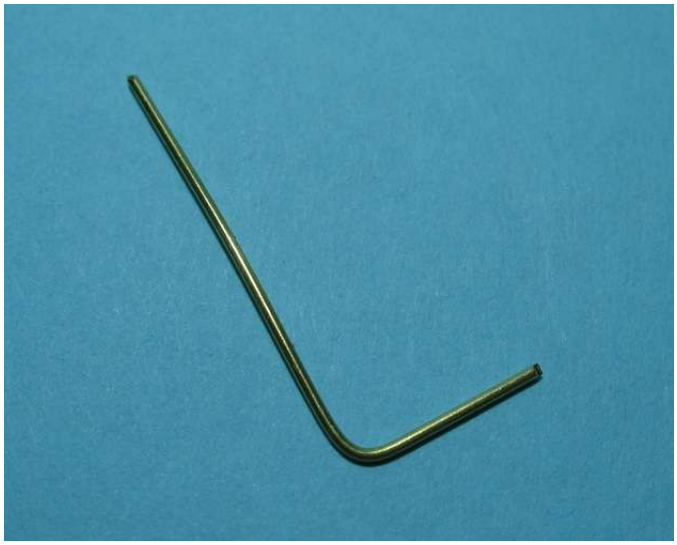
Displacer side:
Use a small length of the supplied brass wire to push out the charred wood from the laser cut holes.



Glue the parts together using a ball bearing and the brass wire to keep parts aligned. Use glue sparingly so it does not fill up the small holes and/or gets into the ball bearing.

Diaphragm side:
Glue the three parts together. The part with the long, narrow slot should be in the centre. Use a ball bearing to align the “eyes” of the connecting rod as you did for the displace side.

Cut a 40mm length of brass wire. Make a 90 degree bend 10mm from one end. Insert the long section of the wire into the slot in the connecting rod. If it is a loose fit, bend it slightly so it is a firm sliding fit.



Diaphragm Assembly

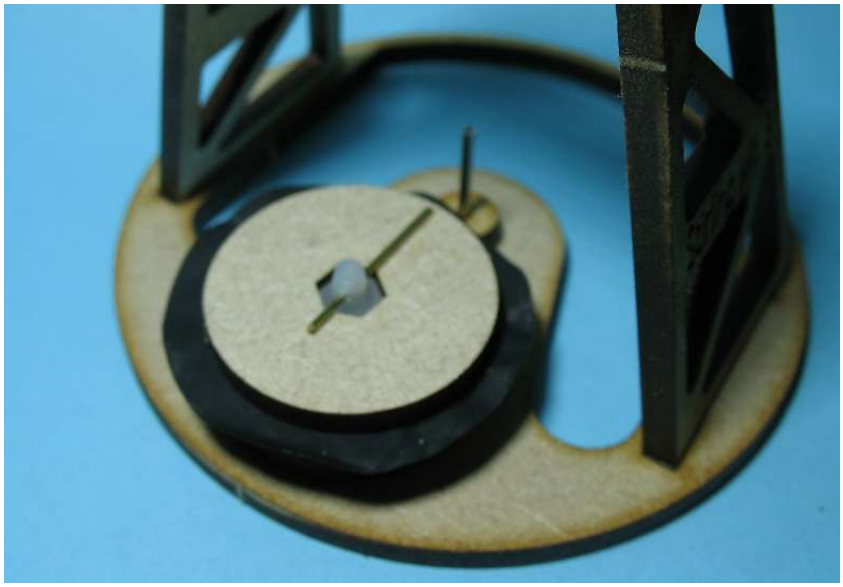
Supplied with the kit is a 35mm diameter latex diaphragm (plus two spares). Carefully pierce a hole in the centre (you can use the piano wire for this). The alignment disc can assist you with finding the centre of the diaphragm.

Put a washer on the nylon bolt and place the bolt on its head on the table. You will notice the one side of the washer has sharp edges and the other side has rounded edges. The rounded edges should be the ones in contact with the diaphragm.

Stretch the latex so the hole is enlarged and slide it over the nylon bolt. Take your time so you don't rip the diaphragm. Two spares are included with the kit if you manage to rip one. Extra diaphragms can be purchased from our shop or you can cut your own from a latex or nitrile glove.

Fit the second washer and the nylon nut. The nut should be finger tight on the assembly, not more, as this could cause the bolt to shear.

Place the alignment disc over the nut and bolt and push a short piece of brass wire through the hole in the bolt. Place it on top of the rings that are glued to the base. The brass wire should point towards the displacer rod.



Slide the disc around until it aligns with the rings. You can now fit the diaphragm retainer rings. Once they are in place, slide out the brass wire and remove the alignment disc.

The diaphragm should not have any wrinkles but it does not need to be super taut either.

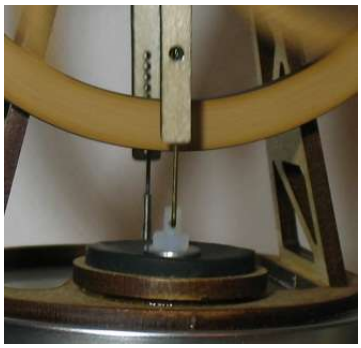
Final Assembly

Cut a 10-15mm wide strip from the supplied aluminium tape. Carefully apply it to the tin/lid. If you keep it taut while you apply it, it is possible to have it go on with a minimum of wrinkles. If you don't get it right the first time there is enough tape for several more tries. Rub the tape down thoroughly with a napkin or similar to ensure it is well bonded to the tin. The engine will not function if there is an air leak.

The displacer should not touch the can at each end of its travel. Insert the bent section of the displacer rod into a hole in the connecting rod so the displacer does not touch the bottom or top of the tin at the ends of travel

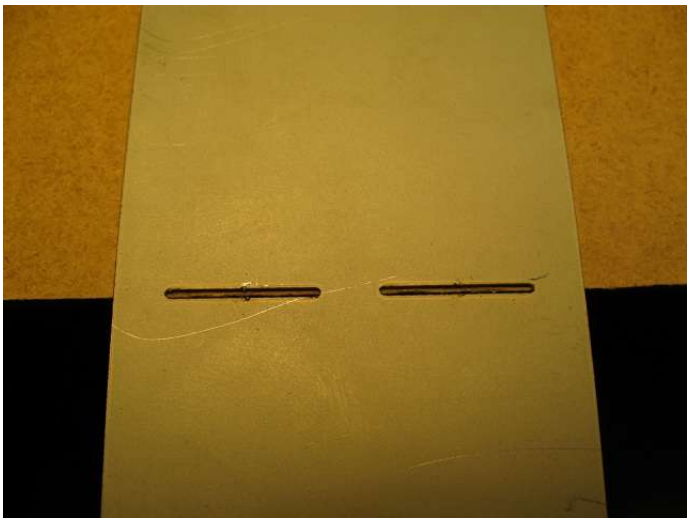
Once the displacer side connecting rod is in place but before the diaphragm side connecting rod is mounted, you can balance the engine. A piece of lead with adhesive backing is supplied for this purpose. Peel off the protective backing and stick the lead to the back of the flywheel, near the rim. It should be placed opposite the displacer crank pin; with the pin at the 3 o'clock position the lead should be at the 9 o'clock position. Cut off small pieces of lead until it counters the weight of the displacer.

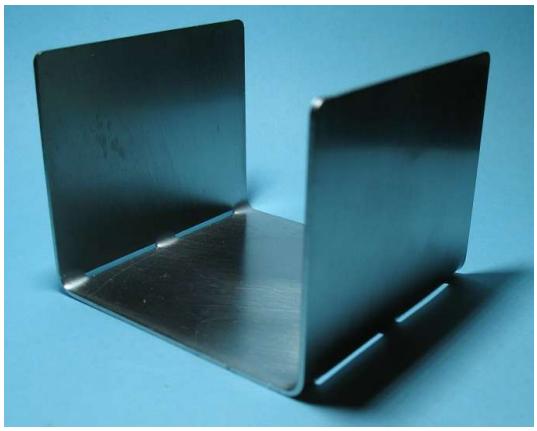
With the diaphragm side crank pin at the 9 or 3 o'clock position the diaphragm should be level. Slide the brass wire in/out of the connecting rod until this is achieved. Once in the correct position, fix the wire in place by adding a drop of glue into the hole in the connecting rod



Candle stand

A laser cut stainless steel engine stand is supplied with the kit. Sanding it with a fine grit sandpaper will give it a nice brushed finish. Do this before bending the stand. To bend, place it over the edge of a table so you can just see the edge of the table through the slits in the steel. Bend 90 degrees.





Running your Engine

First of all set the timing. Cranks must be 90 degrees out of phase. With one crank pin at the 12 o'clock position the other should be at 3 or 9 o'clock. It doesn't matter if it is at 3 or 9 o'clock – this just affects the direction of rotation.

Place the candle holder on a non-flammable surface like a dinner plate. Never use more than one candle and always keep an eye on the engine while it is running. If the flame becomes tall and starts to soot the bottom of the tin, extinguish the candle and reduce the length of the wick. The engine should only take around 20 seconds to heat up enough to start running. Give the flywheel a spin and away it goes. If it does, job well done! If not, read the troubleshooting guide below. A bit of tweaking is usually required to get the engine to run perfectly. In normal use lubrication is not required. However the first time you run the engine a tiny drop of oil can be applied to the displacer rod to reduce friction in the hypo tube. Use a needle to apply the drop. Any light oil will do.

Troubleshooting

Low heat Stirling engines have two enemies: friction and air leaks.

Check that the flywheel and crank discs do not rub against the bearings. Check that the bearings on the connecting rods are free moving.

If you've checked for friction and the engine still won't run it may have an air leak. With the connecting rods removed, place the engine over the candle. Wait a few seconds then slowly pull the displacer rod up and down. The diaphragm should move up and down as well. If it doesn't the engine has a leak. Check the glue joint between the base and tin lid. Also make sure the tape seal is rubbed down properly so the lid is sealed against the tin. If that doesn't help check the diaphragm. It could have a pin prick hole. The only way to see that is to remove the diaphragm and stretch it to check for holes/rips.

Not all tea lights are of good quality and the height of the flame can vary a lot. If you have a very low flame the engine may struggle to run initially. Try a different candle. The tealights from Ikea are better (and cheaper) than many of the candles from supermarkets.