

Solar Steam Generator

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The Main Collector

What does it do?

The Collector is what receives the solar energy which you'll be using to run your applications.

How does it do it?

When a parabolic trough, like this one, is pointed directly at the sun it focuses any light which enters it into a line. You can then place something like a black copper tube at that focus, and pass vegetable oil, water, etc to carry that energy to where you want to use it.

Tools

Bench Vice



Power Drill



3mm, 6mm metal drill bits



Jigsaw



Adjustable Grips



Hacksaw



Hammer



Screwdriver



Craft knife



Marker pen



Printer



Materials

Note: the dimensions given in this tutorial are assuming you'll be using two 60cm x 90cm aluminium plates, which is a standard but not universal size. If your reflective surface has different measurements you may need to adapt the lengths of wood used.



2 Aluminium lithographic offset printing plates or similar

These are pure aluminium sheets, usually about half a square meter by less than half a millimeter thick, used in a printing process fairly common with newspapers and magazines. A medium sized printing company may scrap hundreds of plates a week, so it's usually easy to pick them up cheap. They're pure aluminium, very reflective, and a nice thickness to work with.

If you absolutely cannot get your hands on any (try, they're worth it), then stand by for an alternative version of this tutorial using other materials.



Compression fittings, or something.

I'd love to be able to tell you exactly what to use to attach the copper collector pipe to your applications, but it depends entirely on what you're going to be doing with the energy. Compression fittings are easy to work with and flexible in what they can be attached to, but are generally quite expensive. There are other options, but like I say, it all depends...

Whatever you use, you want a straight connection for one end, and a 90 degree (or elbow) for the other.



Cooper Pipe

90cm long by preferably 22mm outer diameter, but anything between 18mm and 25mm should be fine.



Metal pipe

About 4cm diameter x 8cm long.
A section of bike frame would work well.



Hoseclamp, At least 3cm diameter.



Most bikes have something like this, usually under the seat or handlebars. You may have to cut it free if it's welded on, and remove the bolt if there is one. Metal is best, as plastic may melt. If you can't find one, use whatever seems like it would work.



2 pieces of 100cm x 48cm Plywood, OSB, or similar

Just needs to be something flat that you can cut with a jigsaw and probably should be reasonably rain proof.



4 pieces of 3cm x 3cm wood

The length should be a couple of centimetres shorter than the long edge of your reflective surface. Ie, if you're using a standard 60cm x 90cm aluminium plate your wood should be about 86cm long.



3 pieces of 2cm x 2cm wood
Same length as the 3x3 above.



32 Medium length wood screws



2 Wood screws, roughly 6cm long



2 M6 bolts, one roughly 6cm long, one 2.5cm long.
Get ones that are threaded all the way to the head.



2 M6 nuts



1 large washer



4 pieces 3cm x 3cm flat metal



3 large plastic bottles

About 2-3 litre, must be clear and uncoloured.



Aluminium drinks can



High Temperature Black Spray Paint



Some kind of adhesive tape

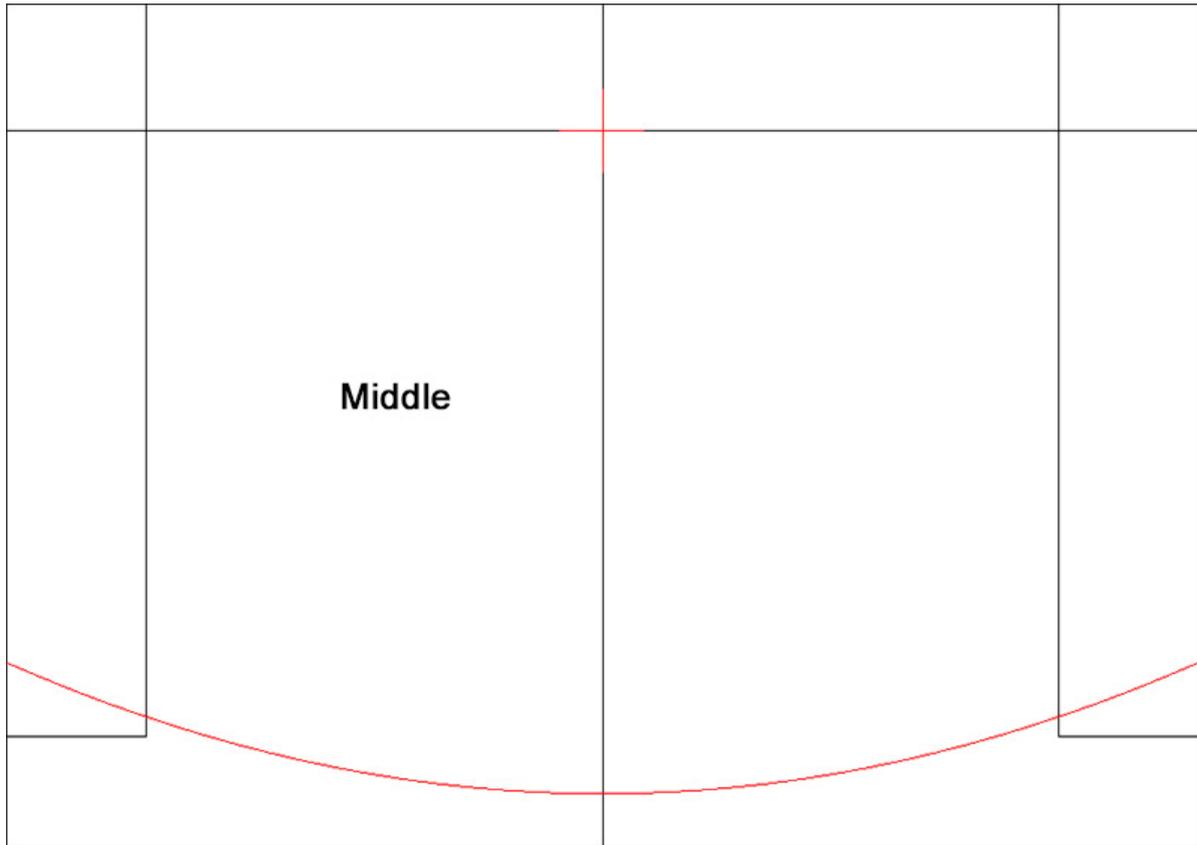


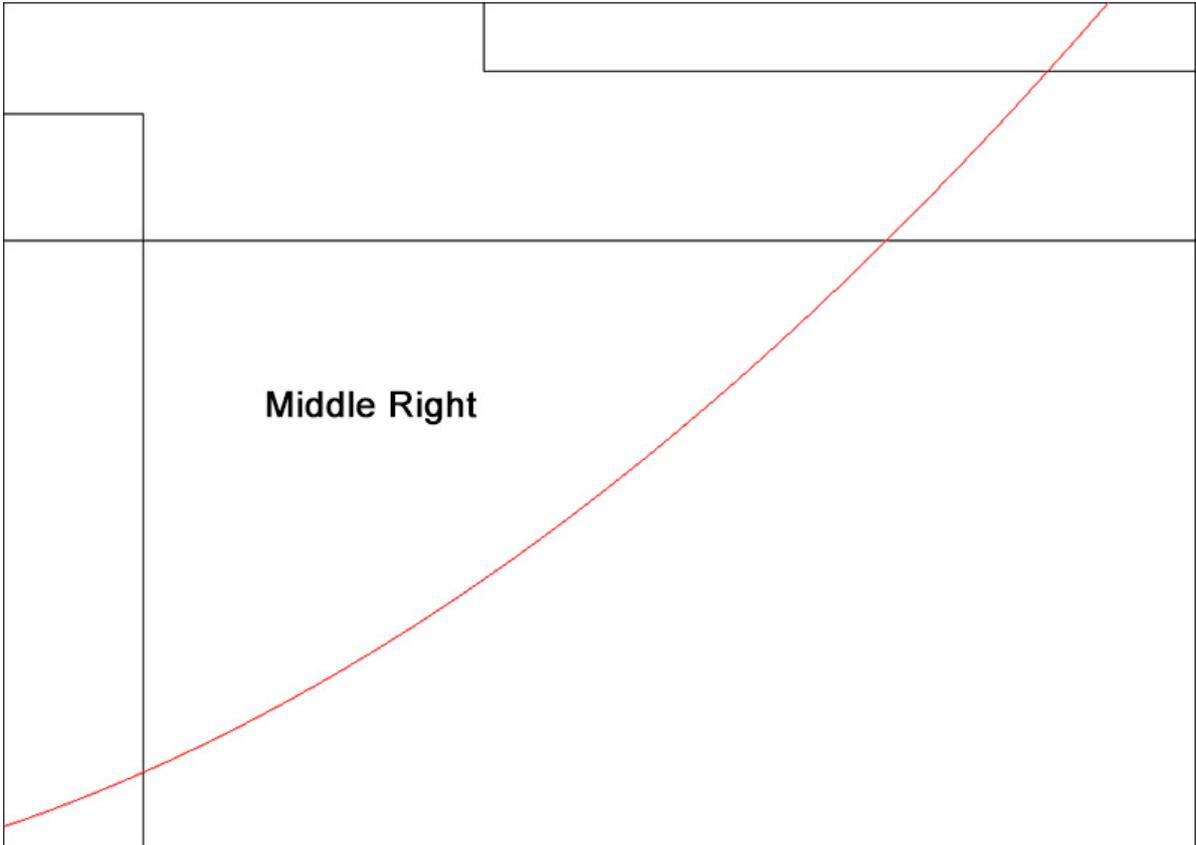
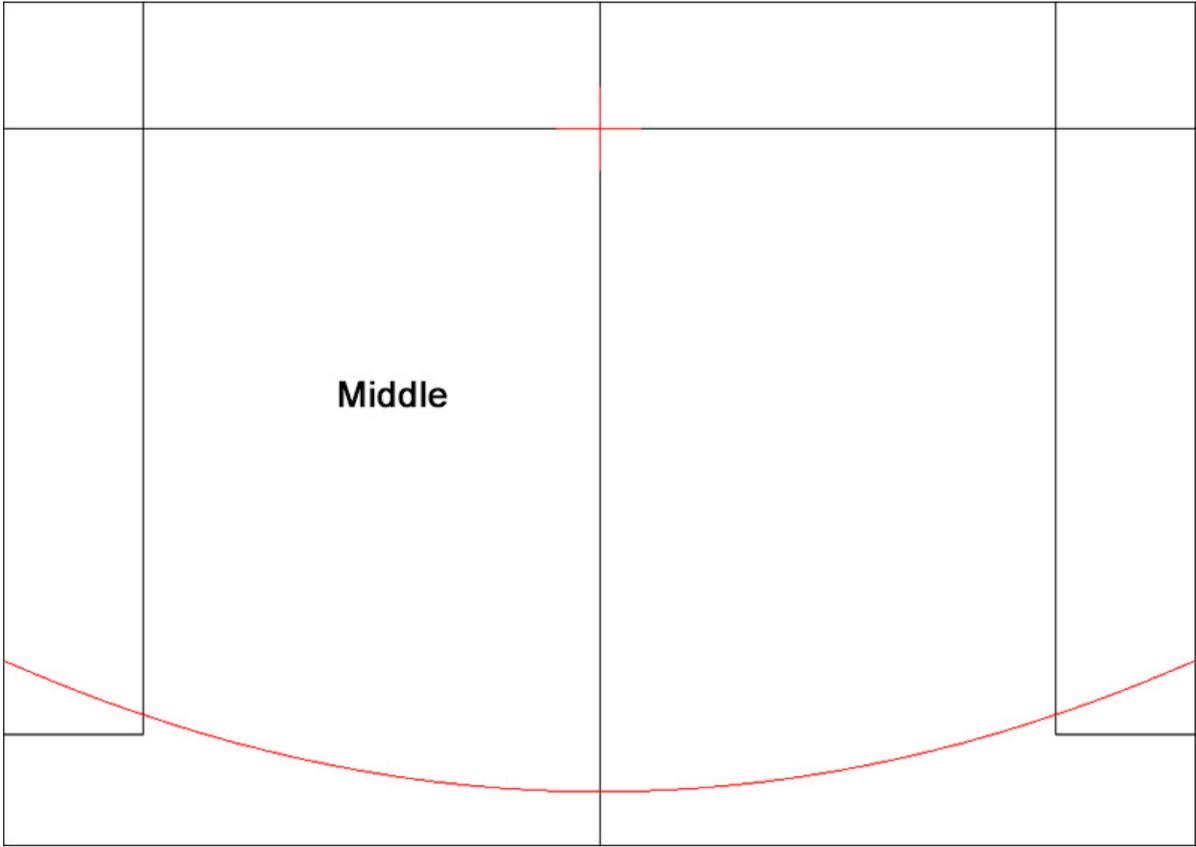
5 pieces of A4 paper

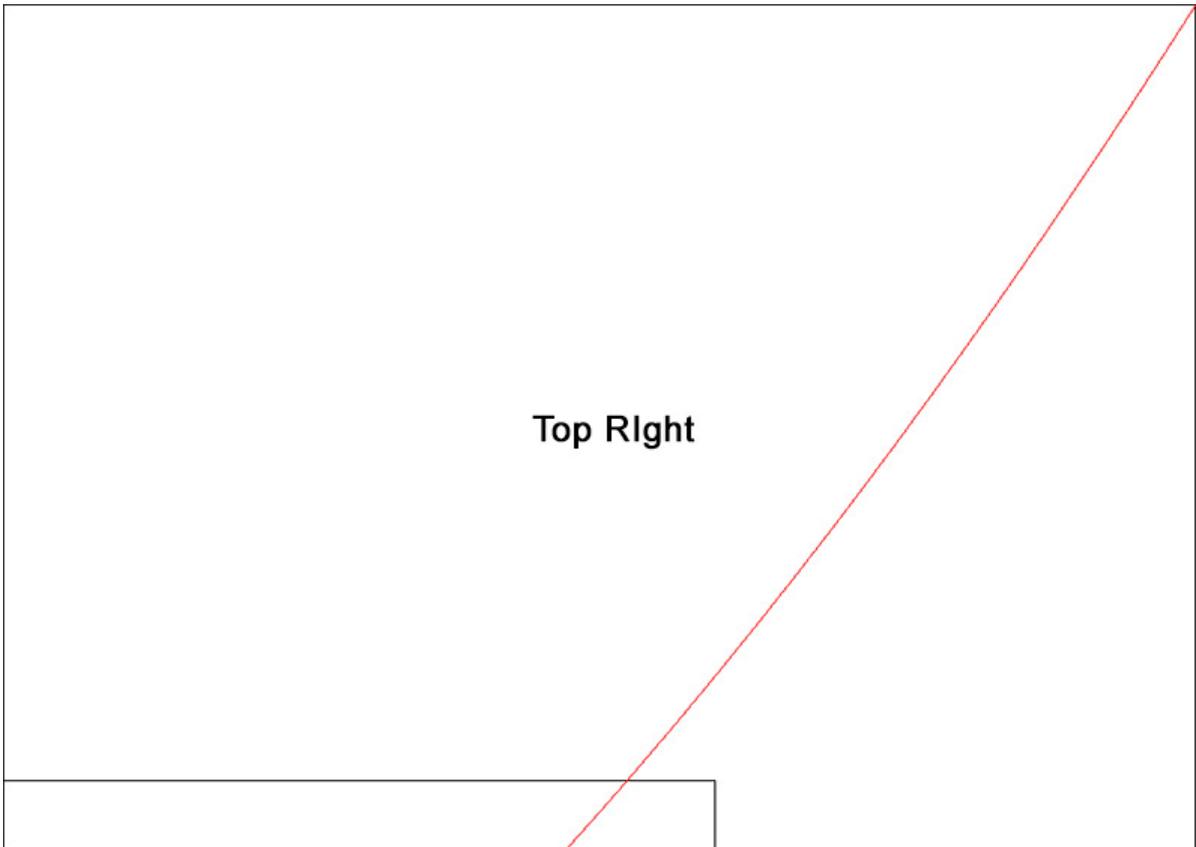
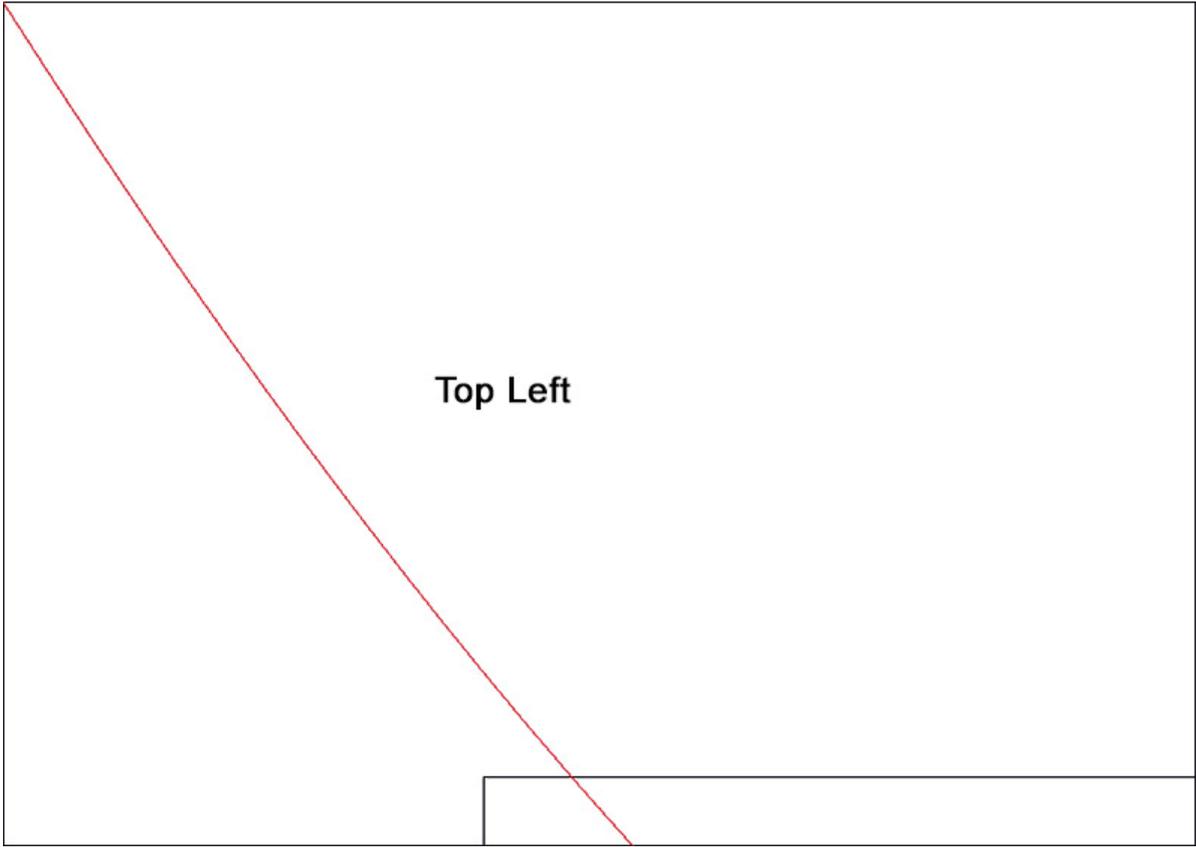
Step-By-Step Instructions

Step 1 :

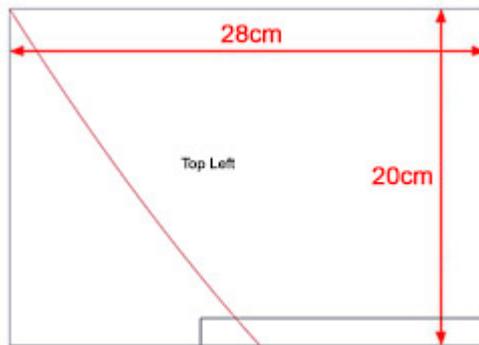
Please print the following 5 schematics.







Make sure that they print out full size and undistorted, the box border should measure exactly 28cm wide by 20cm tall, like so:



Step 2 :

Lay out the five pages and tape them together so that all the lines overlap. The easiest way to do this is on a window during the day, so that the lines show through. It's important that this all be as accurate as possible.

Cut the red curved line with a craft knife or scissors, as accurately as possible. Discard the outer concave part.

Step 3:

Draw lines from each corner of the plywood (or OSB, or whatever you're using) to the opposite corner, and from the middle of each edge to the point directly opposite.

Step 4:

Tape the paper curve template to one of the pieces of plywood, make sure the centre and corners are lined up properly.

With a thick pen, mark the edge of the paper on the plywood. Be careful not to shift the paper.

When done, remove the paper.

Step 5:

Carefully cut the curve with a jigsaw. Do not deviate by more than a couple of millimetres.

Step 6:

Repeat steps 4 and 5 on the other piece of plywood.

Keep the template, it can be used to make further troughs.

Step 7:

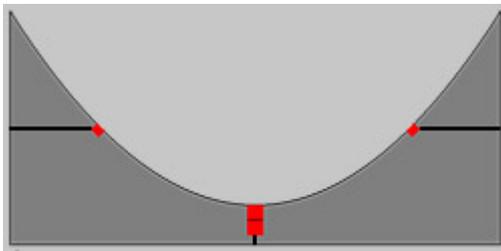
Take 2 lengths of 3cm x 3cm wood, and two of the 2cm x 2cm.

Screw the first 3x3 to each concave piece of plywood so that its top surface sits on the midpoint of the curve.

Attach the second 3x3 directly underneath it. This doesn't serve any structural purpose but will act as a counterweight.

Screw both of the 2x2s so that they sit on the point where the parabola curve meets the middle horizontal line, angled so that a face is sitting flat on the curve.

It should all look like this:

**Step 8:**

Place your reflective surface in the trough so that their edge rests on the middle 3x3 wood, and they have a couple of centimetres overlapping the plywood on both sides.

Again, this tutorial assumes you're using aluminium lithographic offset printing plates. There is at least one other option which will be documented when available, but the printing plates are by far the best if you can get them.

Step 9:

Screw the other two pieces of 3x3 wood so that the outer long edge of the plates is resting against them. You want that top edge as straight as possible, so make sure the 3x3 neither pushes it up from where the plate rests on the plywood, or allows it to sag.

Use two screws to secure, so that the wood can't twist.

Step 10:

Take your 4 3cm by 3cm pieces of flat metal and bend them to a right angle. Drill two 6mm holes in one face of each, near the edges, and one 6mm hole in the other face, near the right side on two pieces, and near

the left on the other two.

Screw each of these pieces to the corners of the convex pieces of plywood, so that they can be screwed to the top outer 3x3 wood. If you don't want sharp screw ends poking out, wrap them in tape or similar.

Step 11:

Cut a 3cm x 3cm x 3cm cube of wood and drill a 6mm hole through the middle. Attach to the convex plywood so that it sits just above the middle of the bottom edge.

Step 12:

Drop the convex plywood into the concave. With a long screw between the aluminium plates, attach the 3cm cube to the middle 3x3 wood. Screw the right angle metal pieces to the top 3x3 wood. You want this connection to be tight, so that the aluminium can't slip.

Step 13:

Drill a 6mm hole in the centre of the front plywood.

Step 14:

Cut a hole in the centre of the back plywood, a couple of millimetres larger than your copper pipe. If you don't have a hole cutter drill a circle of small holes and carefully pop out with a hammer. It doesn't need to be particularly smooth.

Step 15:

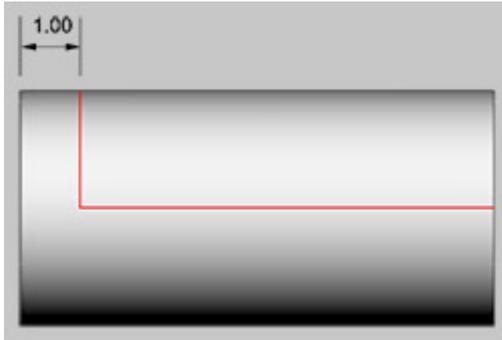
With high temperature black spray paint, paint the length of copper pipe.

Step 16:

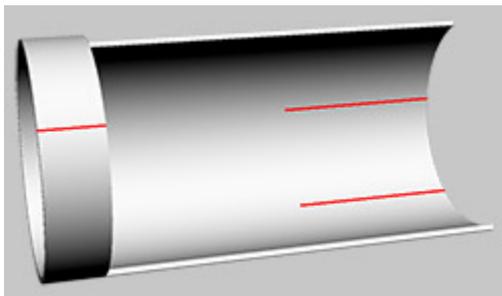
Attach your 90 degree elbow compression fitting (or whatever you're using) to one end of the copper.

Step 17:

Take your 10cm metal pipe and make two cuts like so:



and then three more :



Bend the three bits on the end inwards by 90 degrees so that they overlap each other.

Drill a 6mm hole through all three as close as possible to the centre point of the pipe.

Step 18:

Put a 2.5cm bolt through the hole, thread facing outwards. Place a large washer on the bolt, followed by a M6 nut. Don't tighten the nut.

Step 19:

Bend out the two quarter circle flaps at the top of the cut pipe so that they can be placed over the elbow fitting. Once in place bend them back down, and attach firmly with a hose clamp.

Make sure the whole assembly is rigid and doesn't rattle or shift.

Step 20:

Take a large plastic bottle, clean, and remove any labels etc.

Cut off the neck so that the hole is slightly larger than your copper pipe.

With a hole saw or otherwise, cut a hole just larger than the copper in the base of the bottle. Best if this is as close to evenly circular as you can reasonably get it.

Place the bottle over the copper, with the neck against the fitting. Be careful not to scratch the paint too much.

Step 21:

Repeat with as many extra bottles as required to cover the length of your copper that will be within the trough.

For the last bottle, cut off the top and place over the base of the previous bottle so that it will sit a couple of centimetres from the plywood wall when in place.

As the bottles are heated they should shrink somewhat and seal their ends onto the copper.

Step 22:

Place the end of the copper without the fitting through the hole in the back plywood, drop the pipe into the trough, and insert the 2.5cm bolt through the hole in the front plywood.

Step 23:

From a drinks can, cut a 12cm by 3cm strip of aluminium, bend into a circle, and place between the copper and the hole in the back plywood. Bend up the corners so that it can't slide out of place. This is to reduce friction as the trough turns on the copper.

Step 24:

Take a bike clamp ring (or similar) and secure with a bolt and nut to the copper pip, just above the aluminium ring.

Step 25:

Attach the other compression fitting (or whatever) to the top of the copper.

Step 26:

Place the third length of 2cm x 2cm wood on the front of the trough, so that its bottom edge sits 2cm above where the 2.5cm bolt pokes through. Cut little troughs into the wood so that the reflective surface can sit in them, and the wood can be tightly secured to the plywood. Either that, or cut the reflective surface and bend it out of the way.

This is to stop the plywood flexing from the weight of the trough. If you're using OSB or something more rigid, you may not need to include this.

Step 27:

Attach the 2x2 with a screw near each end in the concave plywood, and two closer to the middle in the convex.

The Box Collector

What does it do?

The Box provides both the energy and accuracy for the tracking system. It's effectively a small solar oven which boils and pumps the liquid ethanol in order to turn The Wheel, which turns The Gearing, which turns The Main Collector into the sun.

How does it do it?

The sides of The Box are parabolic curves, which means that the sunlight which bounces off them is focused to a point. When The Main Collector is pointed directly into the sun this focus sits just off the edge of The Box's copper boiler pipe, which contains ethanol (alcohol).

As the sun moves off the focus shifts onto the boiler, which after a minute or two starts to boil the ethanol, which produces vapour, which forces liquid ethanol out of the tin attached to the boiler and onto The Wheel, which turns the whole device towards the sun.

Now that the focused sunlight has shifted back off the boiler the ethanol vapour starts to condense back into a liquid, which creates a vacuum and sucks more ethanol through the boiler and refills the system.

Tools

Hacksaw



Power Drill (Corded is best, battery will do)



3mm, 6mm metal drill bits



Bench Vice (the bigger the better)



Needle nose pliers

(Or normal pliers if that's all you can find)



Hammer



Craft knife



Paper stapler and staples



Printer



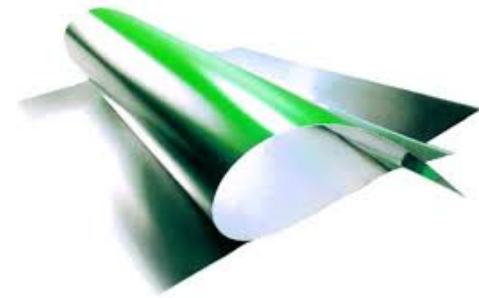
Small measuring cup



Something to boil water



Materials



1 Aluminium lithographic offset printing plates or similar

These are pure aluminium sheets, usually about half a square meter by less than half a millimeter thick, used in a printing process fairly common with newspapers and magazines. A medium sized printing company may scrap hundreds of plates a week, so it's usually easy to pick them up cheap. They're pure aluminium, very reflective, and a nice thickness to work with.

If you absolutely cannot get your hands on any (try, they're worth it), then stand by for an alternative version of this tutorial using other materials.



Cooper Pipe



2 bicycle cable tensioner bolts, also called cable adjusters



1 bicycle Woods valve, also called a Dunlop valve or English valve

These are common in parts of Europe and other places, but you might need to have a bike shop order them in or buy them online.

The above left image is how it will look on the wheel before being taken apart, which is just a matter of unscrewing the cap and pulling out the valve. Make sure the inner tube is deflated first...



4 M6 nuts



Bike inner tube rubber

One inner tube will be more than enough. Other similar rubber will also be fine.



1 metal tin

With removable, replaceable lid, about 400 ml volume. Coffee or hot chocolate tins are good, make sure they're metal.



1 plastic drinks bottle



2 pieces of corrugated plastic (coroplast)

measuring 36cm by 29cm, and 36cm by about 46cm.

Make sure the ribs of plastic run along the 29cm and 46cm lengths, this will make the box stronger and the bits that need to bend easier to do so.

The best place to get this is somewhere like a real-estate agent or supermarket where they use it for signs. They usually give it away free if you ask.



High Temperature Black Spray Paint



High temperature Araldite or resin glue

Must remain hard to at least 100 C



Double Sided Tape



Clear PVC Tube

Step-By-Step Instructions

Step 1:

Take your 20cm length of copper pipe.

Step 2:

Drill a 6mm hole in the pipe, about 2cm from one end.

Step 3:

Take a cable tensioner bolt.

Step 4:

Cut the top bit off the tensioner bolt. This is so it takes up less space when you flatten the copper pipe.

Step 5:

Cut a small circle of inner tube rubber, just enough to be slightly larger than the head of the tensioner bolt. Cut a small circle in the center and push the tensioner bolt through it. This is to make sure the pipe will be airtight.

NOTE: if you are braising or soldering the pipe closed then you don't need to do this.

Step 6:

With a hacksaw, put two cuts into the top of the tensioner bolt, so that when it's pressed tight within the pipe liquid can still run through it.

Step 7:

Place the tensioner bolt through the hole you just drilled in the copper. Depending on the size of your pipe it might be a bit fiddly getting it in there, feel free to squash the pipe a bit to make more room. Put an M6 nut on the tensioner bolt and tighten with pliers or a spanner.

Step 8:

In a vice, or carefully with a hammer (preferably the vice) squash the

pipe to about half it's width, so that the bolt you just placed is in the middle of one flat side. This doesn't need to be too precise.

Step 9:

Flatten one of the corners in the pipe's opposite end. You want the flat area to be about 4cm long. The easiest way to do this is to put something metal about 1cm wide in the vice, place the end of the copper over it, and hit with a hammer until reasonably flat.

Step 10:

Drill a 6mm hole in the flat bit, about 2cm from the end.

Step 11:

Place a tensioner bolt, with rubber the same as the other one, through the hole and put on a M6 nut, tight. You don't need to cut the top off or make cross cuts.

(If you're soldering or braising you don't need the rubber.)

Step 12:

Cut two strips of inner tube rubber about 1-1.5cm wide and just long enough that they fit nicely into the inside of the ends of the copper pipe. A little bit of overlap is better than not being quite long enough.

(If you're soldering or braising you won't need to do this.)

Step 13:

Flatten the ends of the pipe. The easiest way is to squash them in the vice, then finish with a hammer. Make sure the rubber stays in place, poking out a couple of millimeters, and pay attention to the corners, making sure they're completely sealed.

If you're sealing the pipe by soldering or braising, do that now. Do both ends and the joins around the tensioner bolts.

Step 14:

Flatten the whole tube so it contains about 10 milliliters. This is easily done with a hammer on a flat solid surface, such as an anvil or your bench vice.

Check the volume by placing a short length of 6mm PVC tube onto one of the tensioner bolts, putting some water in your mouth, and slowly squirting the water into the pipe while holding it flat. When the water starts coming out the other bolt take off the pvc tube and drain the water from the pipe into a small measuring cup. Continue to flatten with a hammer until the volume is about 10ml, give or take. It's easier to decrease the volume than increase it, so take your time and don't overshoot.

You can increase the volume by placing the pipe in your vice flat side up, so that it squeezes the edges back together.

Don't suck water out of the pipe into your mouth, as it might not be clean.

Now test the seal on the pipe to ensure it's airtight. Do this by placing the PVC tube on one tensioner bolt, put you finger tight over the other, and suck as much air out as you can with your mouth. Without letting any air in, put the end of your tongue over the pipe so you can feel the vacuum and hold it there. If after 10-15 seconds or more the pipe is still stuck to your tongue then the seal is good, if you can feel the vacuum lessening and the pipe falls off your tongue then you have a leak.

If you do, put the pipe in a container of water and blow air into it, looking for any bubbles.

If the leak is at an end of the pipe hit it with a hammer until it stops.

If the leak is around a tensioner bolt, try tightening the nut.

When you're confident the pipe is airtight cover both ends and the joins around the tensioner bolts with Araldite or other resin glue. Allow to harden.

Or, if you're soldering/braising, just redo any areas that are leaking.

It's important that the pipe not leak at all, so take your time to make sure this is done right.

Step 15:

Spraypaint the copper black. It's ok to also spray the tensioner bolts.

Step 16:

Take the plastic bottle and remove any wrapping. You'll need to pre-

shrink the plastic, otherwise it will buckle and distort when heated by the sun. The easiest way is to just fill the bottle with boiling water. Cut off the top and bottom of the bottle so only the flat walled area is left.

Step 17:

Cut what's left of the bottle vertically and flatten, then fold in half long-ways and flatten again. If it's somewhat bumpy and uneven from being shrunk, that's fine.

Step 18:

Cut two small holes so that the plastic can be wrapped around the copper pipe, with the tensioner bolts poking through. You want the fold in the plastic close to the edge of the copper with the tensioner bolt, and about 1.5cm of plastic past the bottom of the copper. There needs to be at least 7cm plastic on the top.

Step 19:

Staple the top, bottom, and side of the plastic, reasonably close to the copper. Since the plastic hardens when it shrinks you may have a little difficulty getting the staples through, but it should work. It is possible to use glue or tape instead, but it will be damaged by the heat.

Step 20:

Cut off the long side of the plastic about 5 millimeters past the staples.

Step 21:

Put an M6 nut on the tensioner bolt coming out of the pipe's edge, and a small circle of innertube rubber. Tighten the nut until it just touches the edge of the plastic.

Step 22:

Take the metal tin and remove any wrapping or labels, and the lid. Drill a 6mm hole in a flat surface on the base, 2-3mm in from as close to the edge as possible.

Step 23:

Insert the tensioner bolt into the hole in the tin and hold in place with

an M6 nut. If you don't have a nut driver this can be a bit fiddly, best way is using needlenose pliers and patience.

Step 24:

Drill a 6mm hole in a flat surface on the tin's lid, 2-3mm in from as close to the edge as possible.

Step 25:

Insert the Woods valve into the hole, with the thread facing inwards.

Secure tightly with a circle of rubber and M6 nut.

The thread on the valve isn't quite M6, so some nuts will slip off. Find one that doesn't.

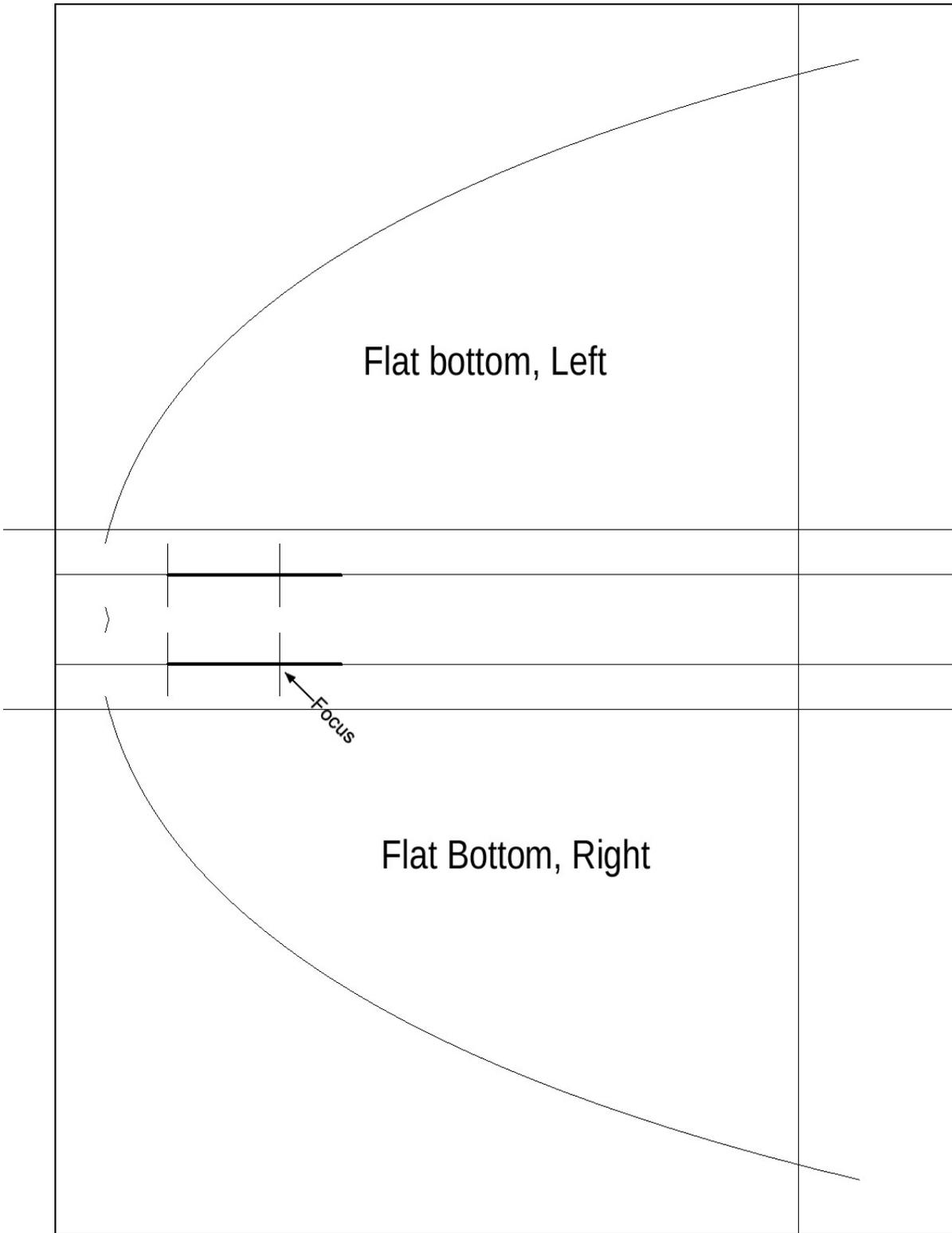
Step 26:

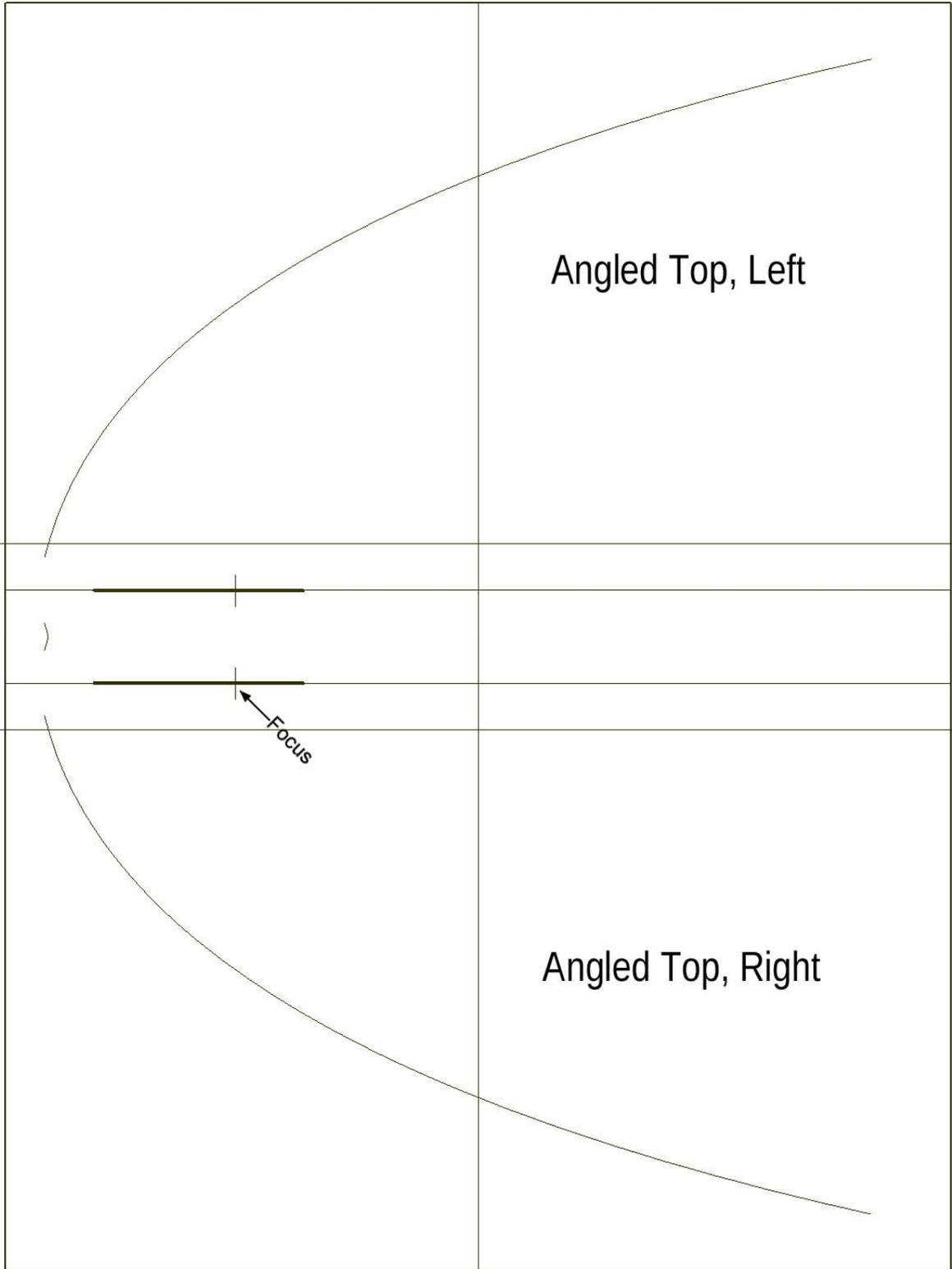
Place the lid on the tin so that the Woods valve is on the opposite side of it from the tensioner bolt. Fill the edges of the lid with Araldite or other resin glue, so that the tin is completely airtight.

Step 27:

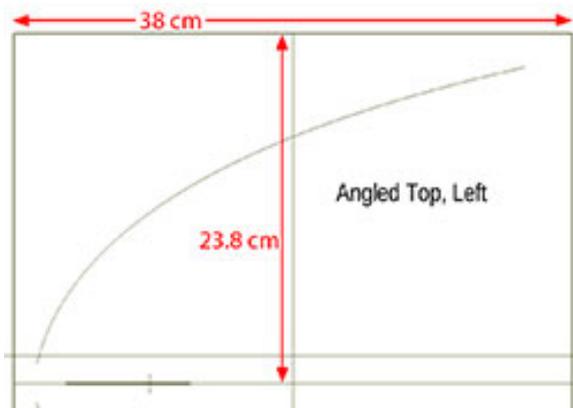
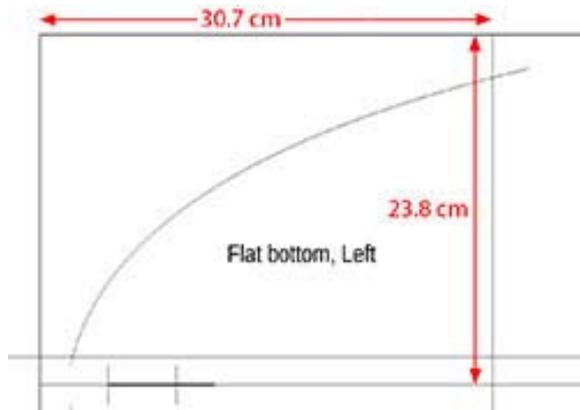
Take the two pieces of corrugated plastic.

Print out the four template images below :





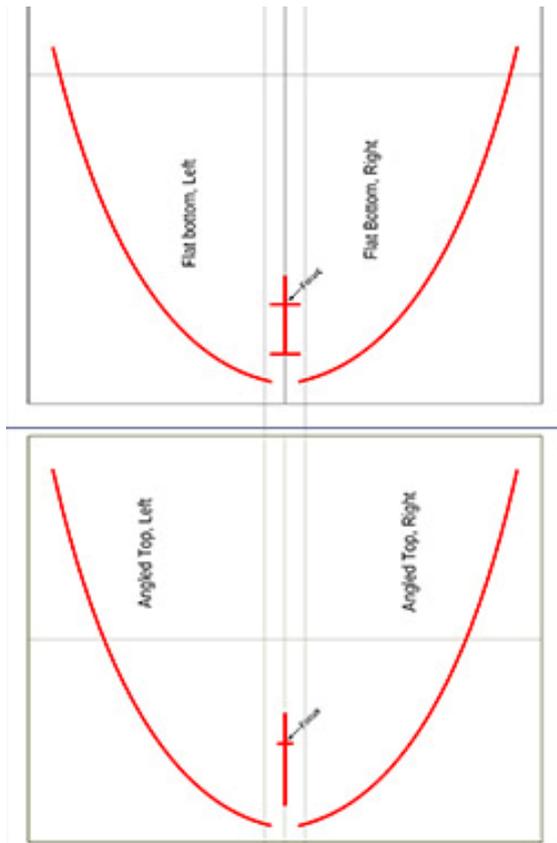
Measure the printouts as below to make sure they've been printed full size and not distorted:



Tape the two tops and two bottoms together. Place them up on a window or screen to make sure they're lined up and overlap properly. Tape the Tops to the smaller bit of corrugated plastic, and the Bottoms to one end of the larger.

Step28:

With a craft knife / scalpel or similar cut the lines marked in red below, making sure to cut completely through the plastic.

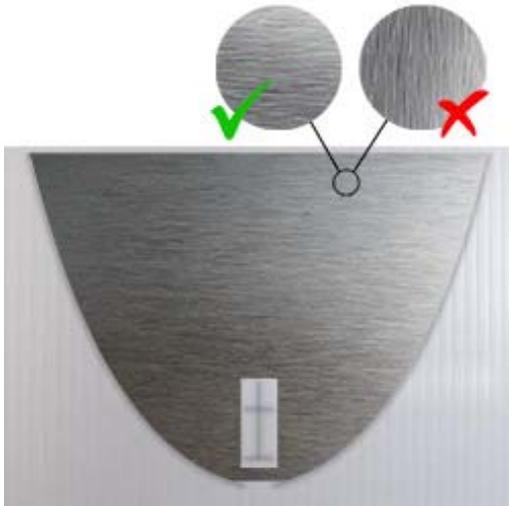


Remove the paper templates.

Step 29:

Cut two pieces of aluminium plate so they cover the area within the cut lines of each piece of corrugated plastic and stick them down with glue or doublesided tape. This doesn't need to be super precise, as long as they don't overlap the cuts.

IMPORTANT NOTE: make sure you have the grain of the aluminium running sideways across the box, rather than from the front to the back.



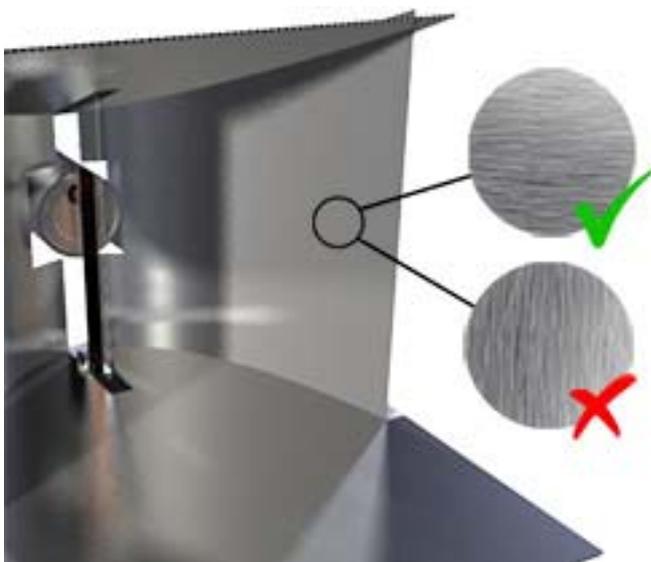
This is because the grain scatters the light, but only in one direction. If the grain is running the wrong way it will disrupt the optical precision needed for the device to track accurately.

Step 30:

Cut two pieces of aluminium, measuring 29cm by 32cm, making sure the metal grain is running parallel to the 29cm edge.

Insert the short edge of both pieces into the curved cuts in the larger, bottom panel of corrugated plastic, with about 1cm poking through. These will form the sides of the box.

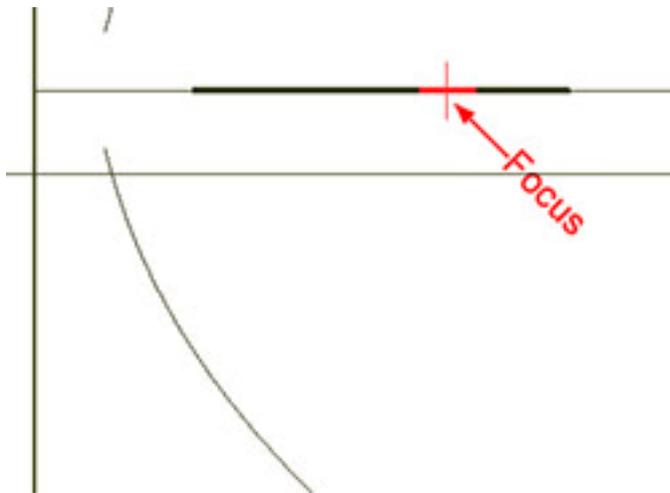
Check that the aluminium grain is running across the curvature of the sides, ie pointing from the front of the box to the back, as opposed to vertically from the bottom to the top:



Step 31:

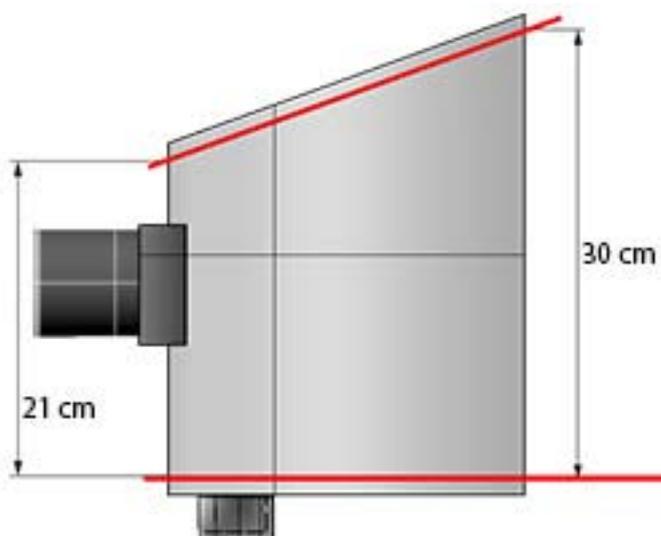
Insert the copper pipe + tin assembly into the same panel, so that the bottom tensioner bolt is underneath it. You will need to fold out the flaps of plastic around the cut (which may be easier if you cut rough one layer of the plastic board), and may need to cut a hole for the tensioner bolt to go through. You will also need to cut flaps in the aluminium sides to accommodate the tin. The size and placing of these will depend on the tin.

Make sure the front edge of the copper pipe is level with the focus point:



Step 32:

Insert the aluminium sides through the curved cuts in the top panel, so that the metal stuck to it is facing inwards. The top panel needs to be angled so that the distance between them at the back of the box is 21 cm, and 30 cm at the front:



which should give an angle of 20 degrees.

33:

Cut the aluminium sides and the copper pipe's clear plastic housing in a line roughly parallel to the top panel, so that about 1cm pokes through.

The Wheel

What does it do?

Basically just a simple water wheel, The Wheel is what provides the rotation to turn the Solar Steam Generator towards the sun.

How does it do it?

Ethanol is pumped by The Box and pours into the cups of The Wheel, which turns The Gearing, which turns The Collector.

Tools

Hacksaw



Power Drill



3mm, 6mm, 10mm metal drill bits



Adjustable Grips



Crescent spanner



Pliers



Small flathead screwdriver



Bolt cutters



Scissors



Materials



3 Aluminium drinks cans



1 Bicycle wheel hub

Take a bike wheel, cut the spokes close to the hub with a hacksaw/angle grinder/bolt cutters.

Easiest is to use a front wheel, but if you have to use a rear one don't use anything that has internal gears, and if there are any sprockets or ratchets involved, remove them.

Remove the nuts and axle and give the insides a good clean with some paper tissue, and re-grease if possible. Be careful not to lose any of the ball bearings.

There should be 2 cone nuts and 4 normal nuts on the axle, if there are less than that you'll need to get more from somewhere else.



6 bike spoke nipples

Unscrew with a small flathead screwdriver from the wheel rim. They may be wrapped in a loop of rubber tape, remove that first. Yes, they're called nipples.



3 bike spokes

Cut to about 16cm long, keep the threaded end, not the hooked end.



4 M3 bolts, about 40mm long



8 M3 nuts



3 pieces flat metal

65mm long by roughly 15mm wide.



2 bicycle cable tensioner bolts, also called cable adjusters

Most bikes have these to keep the brake and gear cables tight. There are two kinds, the larger ones with a cut down one side, and the smaller ones without. Don't use the ones with the cut.



1 bicycle Woods valve, also called a Dunlop valve or English valve

These are common in parts of Europe and other places, but you might need to have a bike shop order them in or buy them online.

The above left image is how it will look on the wheel before being taken apart, which is just a matter of unscrewing the cap and pulling out the valve. Make sure the inner tube is deflated first...



Bike inner tube rubber

One inner tube will be more than enough. Other similar rubber will also be fine.



Can be square or round, must be at least 16cm diameter and at least 15cm deep, and be sealable.

Doesn't have to be clear, but somewhat helpful if it is.



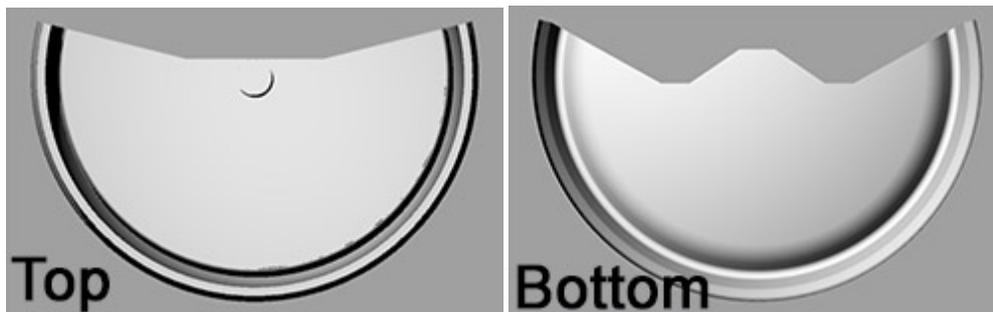
Plastic jar with a lid, about 500ml

Something like a peanut butter jar. Clean well.

Step-By-Step Instructions

Step 1:

Take one of the aluminium cans and remove the tab. With a hacksaw and scissors, tin snips if you have them, cut the can so that it looks something like this:



Step 2:

Drill a 3mm hole in the small raised circle to which the can's tab was attached, and another in the centre of the can's base.

Step 3:

Take one of the bike spokes and with a vice and hammer, or with two pairs of pliers, bend it like so:



Insert the spoke through the holes you drilled, with the threaded end at the top of the can.

Step 4:

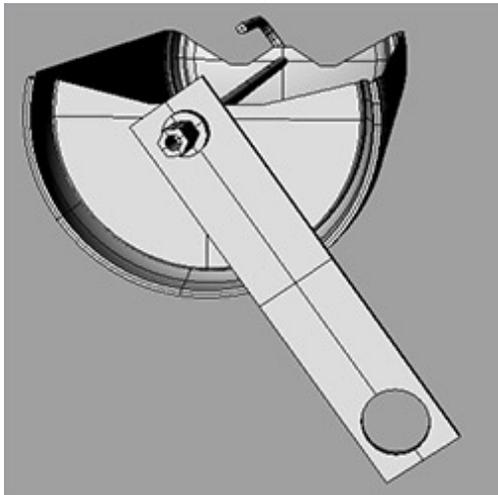
Screw a nipple down onto the spoke so that there is at least 5mm of thread showing above it.

Step 5:

Take one of the 15mm x 65mm pieces of flat metal and drill a 10mm (or the size of your bike wheel axle) hole 55mm from one end and a 3mm hole 5mm from the other.

Insert the end of the spoke through the smaller hole and secure tightly with a second nipple. It's best if you have the nipple heads against the metal.

Turn the bent end of the spoke so that it's pointing at the nearest edge of the metal, like so:



Step 6:

Repeat these first five steps twice more so that you have three cans+spokes+flats.

Step 7:

Wind a cone nut about a third of the way down the bike axle, then two nuts. Take the three cans and place the tip of the axle through each of the 10mm holes in the flat metal. Arrange them so that they are as close to evenly spaced (120 degrees between) as possible, then tightly secure with another nut.

Step 8:

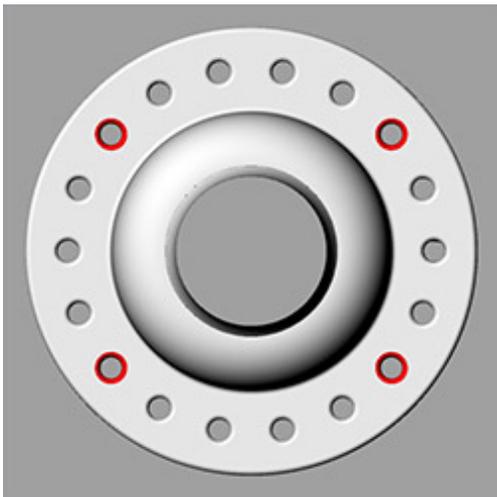
Place the wheel hub over the axle, making sure all the ball bearings are where they should be. You want the base of the cans sitting slightly forward of the base of the hub, so place the hub as such and wind down the cone and nut to meet it. Tighten the cone and nut well against each other so that they can't slip as the axle turns. (This is much easier with a bike cone spanner, if you don't have one grab the cone in a pair of adjustable grips or vice, and tighten the nut with a spanner. You may need to remove the axle from the cans to be able to reach.)

Step 9:

Wind the second cone nut and nut against the hub so that the axle turns without friction but doesn't rattle. Tighten the cone and nut against each other.

Step 10:

Your hub probably has 18 spoke holes, and you're going to be putting M3 bolts through four of them:



If there's some other number of holes just space them as evenly as you can. You may need to drill them first with a 3mm drill.

Cut a circle of innertube rubber large enough to cover the base of the hub, and cut holes in it for the axle+nuts, and for the M3 bolts.

Step 11:

Cut a hole in the centre of the base of your sealable plastic container large enough that the nuts on the axle won't touch it as they turn. The easiest way is with a hole cutter, but if you don't have one either drill a circle of small holes, or cut with a knife, or something. Be careful not to split the plastic. The hole doesn't need to be precisely round, but make sure it isn't larger than the base of the hub.

Step 12:

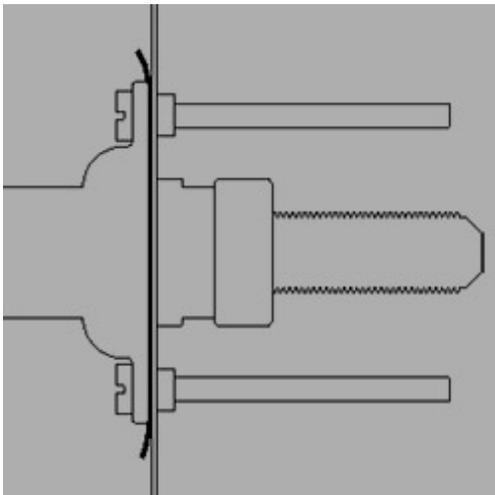
Drill four 3mm holes for the M3 bolts. This is simple to line up if the plastic is clear, otherwise the easiest way is to secure your bolts to the hub with nuts, place some kind of tape around the hole in the container,

then align the axle within the hole and press the ends of the bolts into the tape. Drill where they leave an impression.

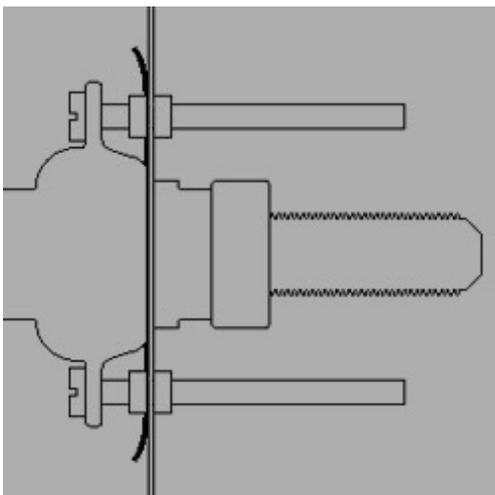
Step 13:

Place the bolts through the spoke holes in the hub, place the innertube rubber over the bolts, put the whole thing inside the container and secure with nuts.

If your hub has a flat face contacting the plastic then the configuration will look like this:



If not, then like this:



Position the nuts so that they and the hub are tight against the plastic and form a good airtight seal. Test by pouring some water into the container. If any leaks out anywhere, adjust.

Step 14:

Drill a 6mm hole in the wall of the container, just far enough from the front edge that the lid of your plastic jar won't hit on anything when it's placed there.

This will be facing downwards when the wheel is in place and the Solar Steam Generator tilted to the sun, but since you can attach the wheel any way round you like, it shouldn't really matter where you put this.

Step 15:

Take a cable tensioner bolt. Cut a small circle of innertube rubber, cut a small hole in its centre and push the tensioner bolt through. Put this through the hole in the container with the thread facing outward.

This is where the ethanol will drain from the wheel into the jar, so if you want to cut off the top of head of the tensioner bolt so that it drains better, do that now.

Step 16:

Drill a 6mm hole in the plastic jar lid.

Step 17:

Place the lid onto the tensioner bolt and secure with an M6 nut.

Step 18:

Drill a 6mm hole in the base of the plastic jar.

Step 19:

Take a Woods valve. Cut a small circle of innertube rubber, cut a small hole in its centre and push the valve through. Put this through the hole in the container with the thread facing inward. Secure with an M6 nut.

Step 20:

Screw the jar onto its lid.

Step 21:

Place the lid on the large plastic container. If it's not completely watertight you may need to pack the seal with tape or similar. Test that it doesn't leak with a little water.

It should take practically no force to turn the axle+cans. If there's any friction at all check that nothing is rubbing, and that the cone nuts aren't too tight against the hub.

The Gearing Assembly

What does it do?

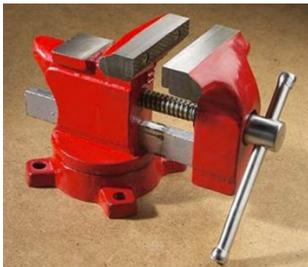
The Gearing allows The Wheel to turn the Main Collector, and attaches both to The Frame.

How does it do it?

The Gearing is basically a worm drive, which gears the rotation down about 90 times, so that a one turn of The Wheel results in a roughly 4 degree turn of the collector, greatly decreasing the amount of force required. It's also one-directional, so The Wheel can turn The Collector, but not visa versa. This means the Solar Steam Generator is unaffected by wind or other interference.

Tools

Bench Vice



Power Drill



4mm, 6mm, 10mm metal drill bits



Adjustable Grips



Hacksaw



Allen key, also called Hex key

Sized No.8, 9/64, or 3.5mm, or to fit the long bolt in the bike stem as listed below.



Hammer



Metal file

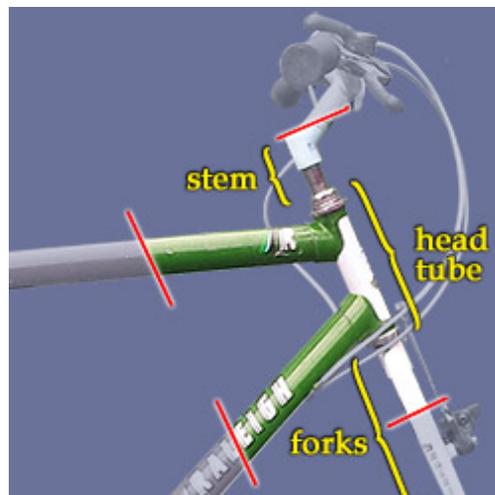
Circular or Half round is best



M6 Spanner



Materials



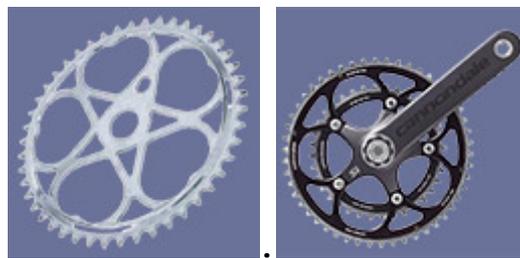
Bicycle handlebar assembly

First get yourself an old bike you don't mind destroying. With a hacksaw or preferably an angle grinder, make the cuts illustrated in red in the image above. The forks and frame can be cut anywhere in that general vicinity, but it's important that the handlebars be cut flat across the stem, ie at as close to 90 degrees as possible. Every bike is different, but

most should work ok.

With an Allen key, remove and keep the long bolt that runs down the inside of the stem (if your bike uses that system, which it probably does), so as not to damage it. Remove and discard any cables, gear shifters, brakes etc.

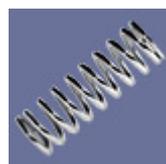
You'll be taking this to pieces during the tutorial anyway, so it might be a good idea before you start to strip it all down and clean everything with some paper tissue, which will also let you see what it looks like on the inside.



Bicycle large front sprocket (gear)

The sprocket pictured on the left is ideal, and fairly common on older European style bikes. There's a proper way to remove it, but the easiest is just cut free it and the pedal to which it's attached, then pop it off the pedal shaft with a hammer. Again, all bikes are different, so you'll need to figure the best way with what you have.

The sprocket set pictured right is more common on newer bikes and trickier to work with. Try to get the other type.

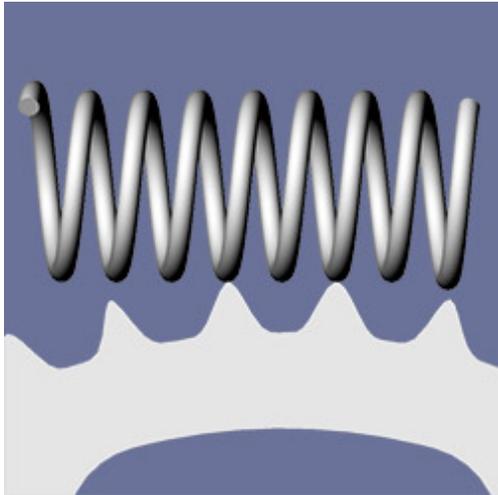


1 Spring

This needs to fit your sprocket, be at least 5cm long, 2 - 2.5cm diameter, and be as smooth as possible. Best to buy it new, unless you can find one just the right size without any rust.

Pretty much every bike sprocket in the world has a tooth spacing of half an inch (12.7mm), and you want two spring windings per tooth, so a quarter inch (6.35mm) spring would be ideal.

It's easy to check, just hold your spring against your sprocket and make sure that it lines up like so:



It needs to be fairly precise, but if the spring is slightly too widely spaced it can be compressed down to fit.



Bike wheel axle

Actually any threaded shaft at least 12cm long should work. Best if the axle is threaded its entire length, but most have a flat section in the middle, which is fine if that's what you've got.



2 nuts to fit the axle above

Must be larger diameter than the spring.



2 cones or other small nuts to fit the axle

Must be smaller diameter than the spring, ie be able to fit inside it.
Most cone nuts (pictured on the left, part of all bike wheels) have a little round metal skirt which can usually be popped off.

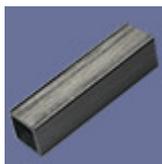


2 M6 bolts, at least 70mm long

Get ones that are threaded all the way to the head.



10 M6 nuts



Square section metal

Roughly 3 - 4cm square by 8cm long.



2 pieces Flat metal

Roughly 3 - 4cm wide by roughly 30cm long,
roughly 3 - 4cm wide by at least 16cm long.



2 cable ties, also called **zip ties**

You can also use twisting wire.



Gaffer tape, also called **duct tape**, **cloth tape**

Step-By-Step Instructions

Step 1:

Remove the stem (straight pipe that the handlebars were attached to) from the head tube. It should just slide out after you've removed the long bolt that was holding it in place. Also remove the short metal cylinder cut at an angle (called a wedge) which the bolt screws into. Your bike probably uses this system, if not; adapt.

Step 2:

Using adjustable grips or an appropriately sized spanner, remove the top nut from the head tube.

Step 3:

Place the large sprocket over the head tube's thread. The sprocket hole will probably be slightly too small, in which case use a metal file to enlarge it until it fits. It's important that the sprocket be centred as accurately as possible.

Step 4:

Replace and tighten the top nut. Check that the sprocket is centred by spinning it. If it describes a perfect circle then it's centred, if it seems to be wobbling in and out even a little tap with a hammer until it's centred. You may need to file part of the hole larger.

(To avoid damaging the sprocket teeth with the hammer place something thin, such as a piece of flat metal, between two teeth and hit that instead.)

It's important to get this reasonably accurate. Once in place tighten the top nut as much as possible, to ensure the sprocket doesn't slip. Recheck that it's still centred.

Check that the top nuts aren't too tight against the head tube, and that everything can rotate freely. If there's any friction wind the nuts back slightly. Too loose is better than too tight.

Step 5:

Take the square section steel and cut so that it's about the same length as the cut top of the bike stem.

Step 6:

Drill a 6mm hole through the top and bottom walls, about a centimeter from one side.

Step 7:

Drill a 6mm hole about a centimeter from the other side, through the top wall only.

Step 8:

Drill a 4mm hole through the bottom wall only, so that it lines up with the previous hole.

Step 9:

Place the square steel over the top of the stem, so that the 4mm hole is in the center of the pipe.

Step 10:

Insert the long bolt and screw partially into the wedge. The head of the

bolt should be able to pass through the top 6mm hole (if it doesn't, make it larger), but not the 4mm one.

Step 11:

Drill a 6mm hole in the bit of metal sticking out the side of the stem, so that it lines up with the other holes in the square steel.

Step 12:

Reinsert the stem into the head tube, just enough that it's stable.

Step 13:

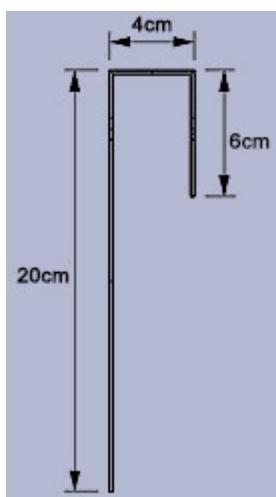
Tighten the long bolt with an Allen key until it's all locked in place.

Step 14:

Drill 10mm holes in each of the two bits of remaining bike frame, so that they're about 1.5cm past the edge of the sprocket, vertically.

Step 15:

Take the 30cm length of flat metal and bend it with a vice and hammer, more or less like so:



Step 16:

Drill two 6mm holes in the flat metal so that they line up with the 10mm holes in the bike frame, with the top of the flat metal sitting about 3cm above the level of the sprocket.

Step 17:

Insert a 6mm bolts through each of the two holes in the flat metal.

Step 18:

Place two nuts on each bolt, one tight against the metal, the other with about a 1.5cm gap.

Step 19:

Insert the two bolts through the two 10mm holes in the bike frame.

Step 20:

Place another nut on each bolt on the other side of the frame and tighten. You want the bolts sitting more or less in the center of the larger holes so that you can adjust their position later.

Step 21:

Take the bike wheel axle and wind on the two cone nuts or other small nuts so they sit more or less in the middle, about 2cm apart. If the axle has a flat section you may need to force the nuts onto it by placing the flat section tight in a bench vice and turning the nuts with a spanner or similar, so that they cut their own threads into the axle.

Whatever works.

Step 22:

If necessary, wrap the nuts in gaffer tape or similar, so that when you place the spring over them it fits tightly, without rattling or shifting.

Step 23:

Place the spring.

Step 24:

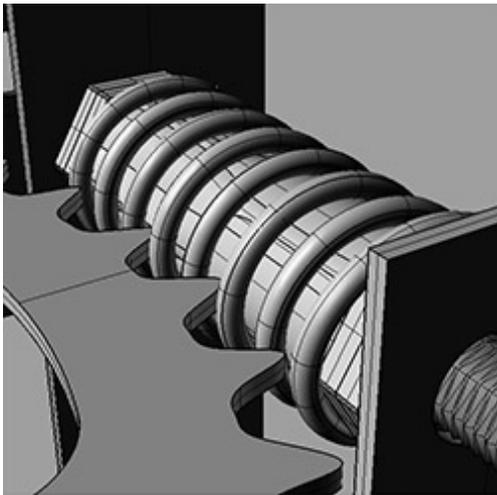
Place the two larger nuts so that the spring is immobilised. Make sure not to compress the spring, unless it's too widely spaced for the sprocket, in which case use the nuts to squeeze it til it matches.

Step 25:

Cut one end of the axle so that about 1.5cm is left after the nut.

Step 26:

Perhaps the most important part of the whole Solar Steam Generator is the interface between the spring worm gear and the sprocket. If the teeth of the sprocket mesh too tightly with the spring they'll rub, but too loose and it may detach and slip. They need to be flat on the same plane, and meet halfway up the spring, like this:



So you need to drill a hole in the bent piece of flat metal very slightly larger than the axle diameter (probably 10mm, but check) so that the axle can sit in this sweet spot. However, you will be able to tune this later by shifting the metal, so it doesn't need to be millimeter accurate at this stage.

But get it as close as you can.

Step 27:

Place the axle in the hole and check that it and the sprocket can turn without friction while meshed.

Step 28:

Place a nut on each of the M6 bolts, about 1.5cm away from the bike frame.

Step 29:

Take the other piece of flat metal. The width isn't greatly important, but it needs to be long enough that it can be attached to the two M6 bolts with enough space above to drill a hole for the axle.

Step 30:

Drill two holes that line up with the M6 bolts.

Drill a hole for the axle (probably 10mm) in such a place that it will sit in the sweet spot with the sprocket.

Step 31:

Place the flat metal on the M6 bolts and axle, and secure with nuts.

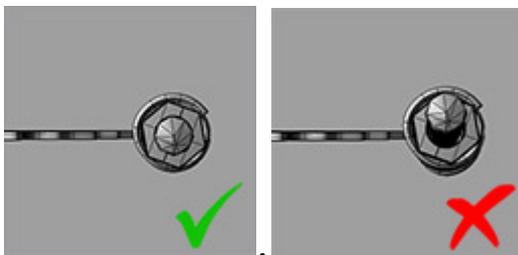
Step 32:

Drill 6mm holes near the ends of the two pieces of bike frame, through both sides. This is where you'll attach the gearing to the wooden frame later.

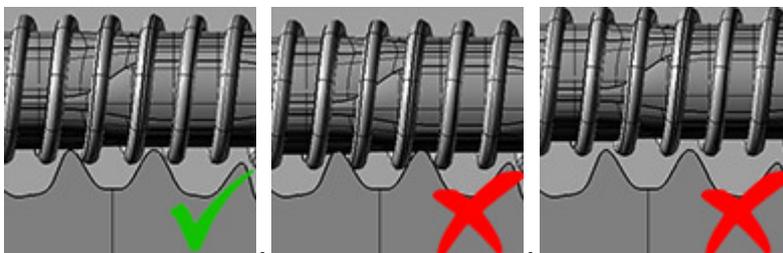
Finalizing and tuning

There should be only a couple of millimeter gap between the nuts holding the spring and the two pieces of metal holding the axle. Adjust by shifting the nuts on the M6 bolts which hold the metal.

The spring worm gear needs to sit on the same plane as the sprocket:



And they need to mesh well, not too tight, not too loose:



To achieve this, tap the two pieces of flat metal with a hammer until aligned correctly. Tighten all the nuts firmly, then recheck. The spring should be able to turn the sprocket practically without friction, the sprocket should not be able to slip against the spring.

This is something you will want to check periodically while the Solar Steam Generator is running.

The Frame

What does it do?

The frame is what holds everything together, sets the collector to the right angle, and allows for seasonal adjustment through the year.

Wood Saw



Power Drill



6mm metal drill bit



Angle level

Or similar. You can make one easily from a protractor, string, and a small weight.



Tape measure



Materials



About 5 metres of thickish wood

Something like 4cm x 6cm. Exact lengths will depend on where you are in the world, explained below.



About 3 metres of thinnish wood

Something like 2cm x 4cm. Again, lengths will depend.



16 Wood screws, about 60mm long



2 medium to long M6 bolts

Step-by-Step Instructions

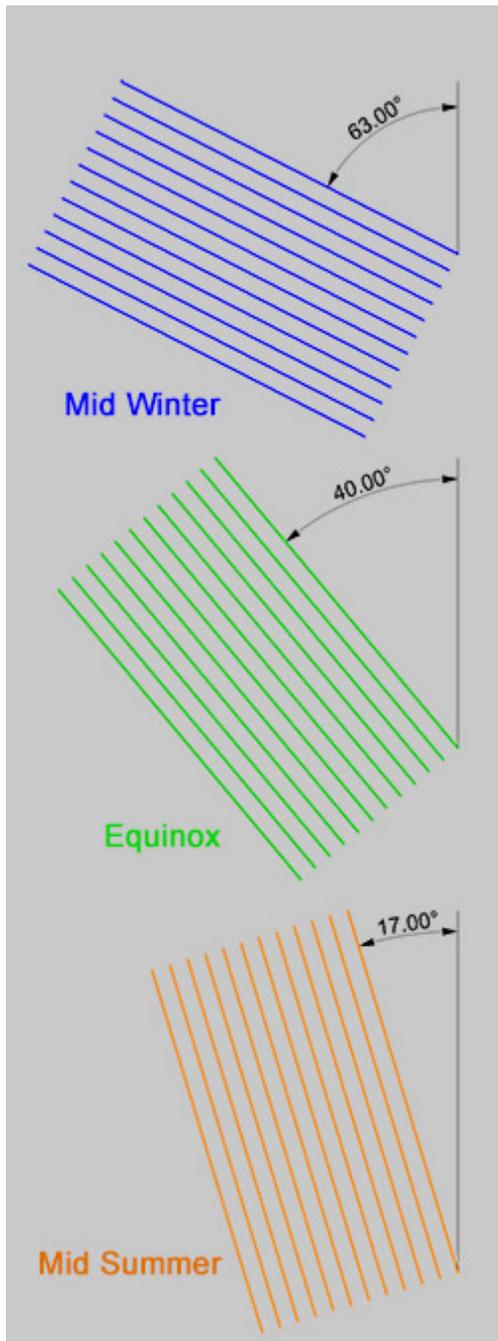
The Frame is the most basic Solar Steam Generator component, but its exact dimensions depends on where you are in the world. Specifically, your latitude, as this determines the angle of the sun. This is easy to find in various ways.

- Go to [Google Maps](#), right click on your location and select 'What's here?'. You'll see two numbers in the location bar, the first one is your latitude. So, if for example you click on Madrid, Spain, and get the result 40.446947,-3.704589 then your latitude is 40.45 degrees.

- Look at an atlas or something.

Axial mounted parabolic troughs, like the Solar Steam Generator uses, are pretty forgiving with variations in the sun's elevation, so the angle you set it at doesn't need to be that precise. You can round your latitude to the nearest five degrees.

During the year the sun rises and falls in the sky by about 46 degrees. At the Spring and Autumnal Equinox the sun's angle equals your latitude. So if you're in Madrid, during that day the sun will be at 40.45 degrees from vertical. On the Winter Solstice it will be at about 63 degrees (40+23), and on the Summer Solstice it will be at about 17 degrees (40-23).



Making a seasonal adjustment setting for the Solar Stem Generator is very easy, just drill two holes, and you can have as many settings as you like. Generally two is enough, one that splits the difference between mid summer and the equinox, and one that does the same for winter, if you're lucky enough to live somewhere with sun the whole year.

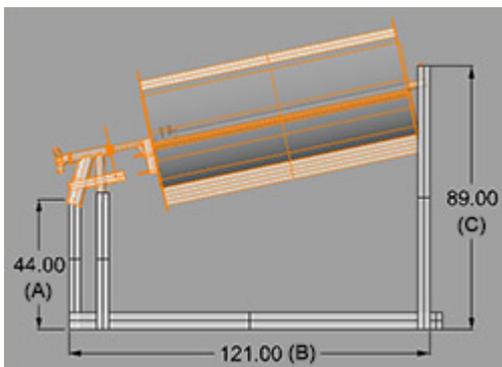
So, using Madrid as an example, you'd have one setting at 52 degrees (about halfway between 40 and 63), and one at 28. Around the spring

equinox you set it to the summer setting, and at the autumnal equinox, winter.

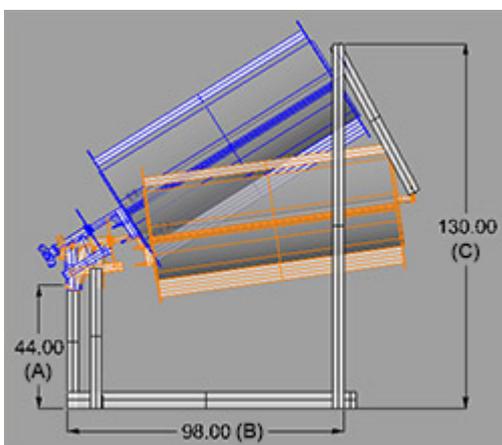
Step-By-Step Instructions

The first thing to do is select the dimensions for your latitude from the options below :

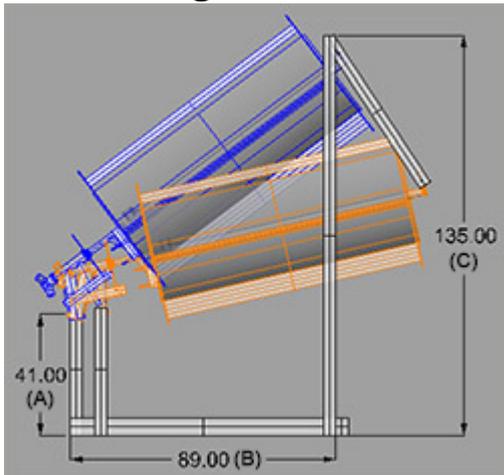
- **15 degrees**



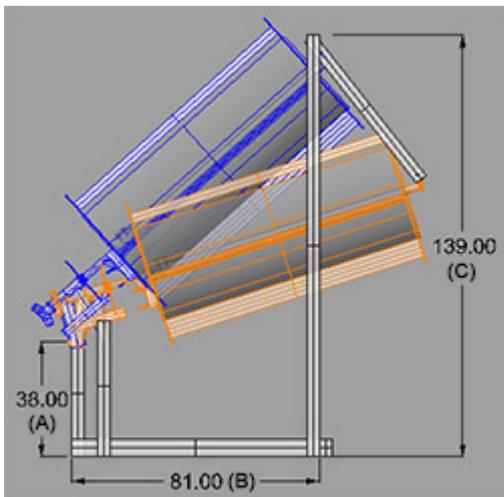
- **20 degrees**



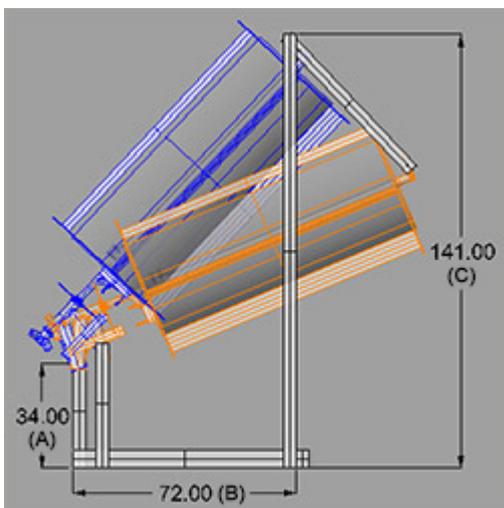
- 25 degrees



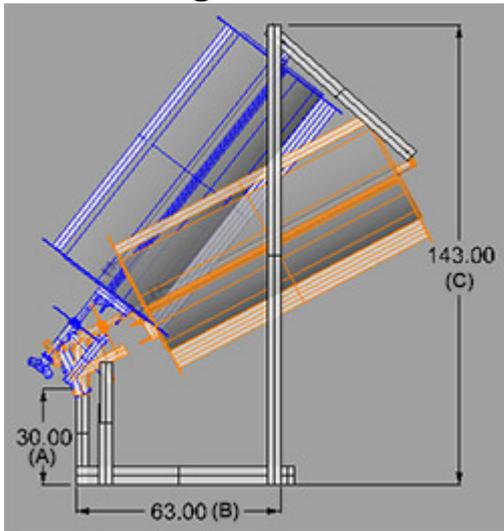
- 30 degrees



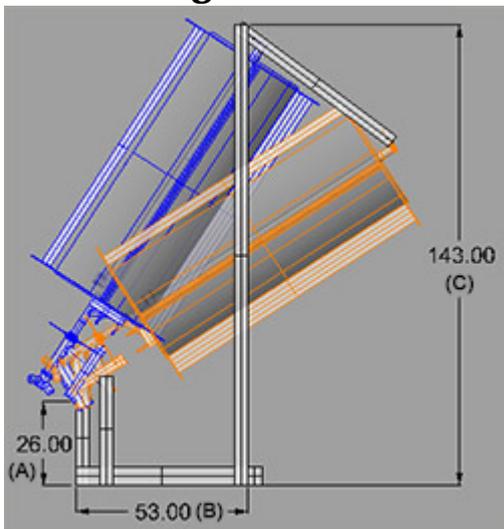
- 35 degrees



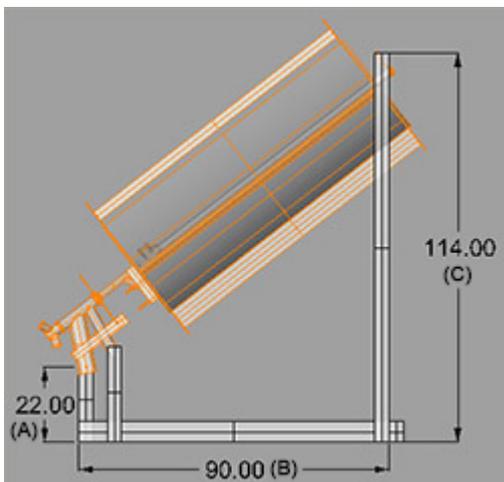
- 40 degrees



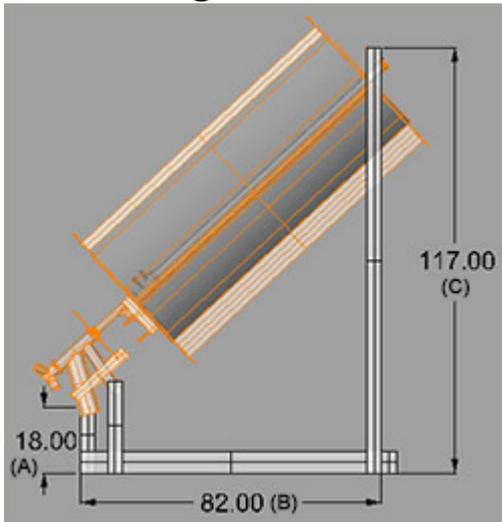
- 45 degrees



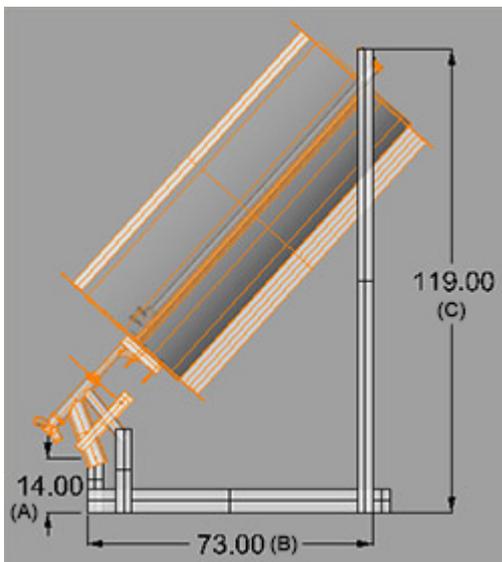
- 50 degrees



- 55 degrees



- 60 degrees



It's important to note that because the sizes of your reflective surface and other parts will likely vary at least a little, these dimensions are meant only as a guide. Basically the frame needs to be whatever size will hold the rest of the device at the angles you want.

Some things to be aware of:

The main collector should be held high enough that it can turn fully without hitting the ground or any part of the frame.

It's best not to have the collector flat, as you'll probably be running some kind of liquid through the pipe, and it will need to rise as it heats.

So if you're less than about 15 degrees from the equator just have the one angle setting and turn the whole device north or south during the year.

Step 1:

Take a section of your thicker wood, the length of dimension B in the image above.

To one end vertically attach with screws a second section the length of the dimension A, plus an extra couple of centimetres.

Step 2:

Drill the vertical wood at height A.

Step 3:

On the other side attach a second vertical with a spacer between it and the base wood. This needs to be placed so that the second bit of bike frame can be bolted to it at each of your seasonal angle settings. Feel free to place it later when you're attaching the Gearing to the Frame, to be able to see the best position.

Step 4:

Take a piece of wood long enough that your Collector won't hit anything as it rotates (about 135cm if your Collector is 100cm wide), and screw it perpendicular to the first base wood.

Step 5:

Diagonally brace the connection between these two lengths of wood. This can be with anything; a short length of wood, a triangle of plywood, a piece of metal, etc.

Step 6:

Attach verticals of length C to the inside of each end of the second base wood.

Step 7:

To the inside of the top of these verticals screw a piece of your smaller

thickness wood, long enough so they can accommodate your seasonal angle settings, probably about 60cm.

Step 8:

Take a length of smaller wood long enough to fit between these two pieces and drill a 6mm hole in each end.

Step 9:

Drill your seasonal setting holes. Unless you've worked all this out on paper, the easiest way is to save this for when you're assembling the Solar Steam Generator and directly measure the angle of the Collector with an angle level or similar.

Step 10:

Attach the cross beam with an M6 bolt in each end.

Step 11:

Drill a 6mm hole in the beam for the bolt which will attach it to the top of the Collector's copper tube. Keep in mind this will be offset from the center by some amount, depending on your setup.

Assembling the Components

Tools

Power Drill



Hacksaw



3mm, 6mm, 12mm metal drill bits



Screwdriver



Wood Saw



Hammer



Needle nose pliers



Materials



50-60cm small wood plank

Something a couple of centimetres by a couple of centimetres.



2 bicycle cable tensioner bolts, also called cable adjusters

Most bikes have these to keep the brake and gear cables tight. There are two kinds, the larger ones with a cut down one side, and the smaller ones without. Don't use the ones with the cut.



8 M6 bolts. Get ones that are threaded all the way to the head.



9 M6 nuts
4 M3 nuts



2 medium / large washers.
With holes small enough to hold the wood screw heads.



32 Medium length wood screws



6mm clear PVC tubing

One length of 80-90cm, one of about 30cm.



6 small / medium cable ties, also called zip ties

You can also use thin twisting wire.



Teflon tape



Gaffer tape, also called duct tape, cloth tape



Flat metal

To be cut into squares for weights.



1 litre of ethanol

You can get this from a lot of camping stores, pharmacies, discount stores, etc. Make sure it's definitely at least 95% actual ethanol! Don't use isopropyl alcohol, methanol, or anything else. It's often also called denatured alcohol, or methylated spirits. If in any doubt, contact the manufacturer and check.

Do not drink it.

Do not expose to naked flame.

The fumes won't do you too much damage, but try not to inhale massive amounts of the stuff.

Step-By-Step Instructions

Step 1:

Take the finished Gearing assembly and Main Collector.

Step 2:

Put the bolt emerging from the middle of the collector's front face through the hole in the square metal at the top of the Gearing's shaft.

Wind a nut onto the bolt, but don't tighten completely, leave a couple millimetres of space between it and the metal. This may be bit fiddly, depending on the position of the wooden cross beam above the bolt, which you may need to temporarily remove it if you can't reach in with needle nose pliers.

Step 3:

With a thin spanner or needle nose pliers, tighten the nut on the inside of the collector, so that the bolt is now locked to the collector wall. Make sure that the copper collector pipe can rotate freely around it, without much friction.

Step 4:

Drill a 6mm hole in the collector panel to line up with the other hole in the square metal.

Step 5:

Insert a 6mm bolt through the hole and tighten with a nut. The Gearing shaft and Main Collector should now be locked firmly together.

Step 6:

Take the finished Wheel assembly.

Step 7:

Drill a 12 mm hole which lines up as closely as possibly with the Gearing's spring worm gear shaft.

Drill four 3mm holes for the bolts protruding out the back of the Wheel. The easiest way to do this is put some kind of adhesive tape on the metal, insert the Wheel's shaft into the 12mm hole so that it's lined up with the worm gear shaft, then press the 3mm bolts into the tape so that they leave an impression, which you then drill.

Make sure the 3mm bolts are protruding straight from the back of the wheel. Bend them with pliers if they're crooked.

And make sure the jar attached to the wheel is going to be more or less pointing down when the Solar Steam Generator is tilted up to the sun.

Step 8:

Bolt the wheel in place. Adjust the height of the 3mm nuts on both sides of the metal so that the Wheel sits straight, lines up with the worm gear shaft, and that the cans can turn freely without the nuts on the shaft touching the metal.

Step 9:

Attach the Wheel shaft to the worm gear shaft with several tight turns of gaffer tape, held firmly in place with cable ties or twisted wire. The forces on this won't be large, so it shouldn't slip, but if it does replace with something like plastic tube glued in place. It's best though to use something that can be removed if you want to take the wheel off for some reason, and make sure to use a connection which is at least slightly flexible to accommodate any misalignment of the shafts.

Step 10:

Take the finished Frame.

Step 11:

Attach the Gearing to the Frame with a bolt, as shown. If you want you can attach firmly with nuts, but it shouldn't be necessary.

Step 12:

Lift the Collector plus Gearing so that it's over the cross beam at the back off the Frame.

If you didn't drill your seasonal setting holes when you were constructing the Frame, do that now, measuring the angle of the Collector with an angle level or similar.

Step 13:

Insert the collector pipe's bolt through the hole drilled in the cross beam and attach with a nut.

Step 14:

Attach the Gearing to the Frame with a final bolt, as shown. Screw on the wood and drill a hole for it if you haven't already.

It's important that the device not sag at the connection between the Gearing and Collector, so make sure that with this bolt the Gearing shaft and copper collector pipe are in as straight a line as possible.

Now reset the device to each of your seasonal settings by unscrewing and repositioning the cross beam at the top of the frame. Drill an additional hole at the front, as above, for each.

Step 15:

Take the finished Box Collector and a 50cm length of thin wood, and attach as shown with two short wood screws with large washers. If you're in the southern hemisphere this will be with the long bit of wood to the left, as shown, if you're in the north it will be on the right.

Step 16:

Place the Box against the front face of the Collector so that the short end of the 50cm wood sits just above the Collector's cross beam with about a 20 degree angle between them and the Box's metal tin tucked against the Gearing's shaft. The closer it is the less it will unbalance the device, and the less counterbalancing you'll have to do. The Box will be more precisely positioned in a later step.

Step 17:

Drill a hole in the short end of the thin wood and through the face of the Collector.
Attach with a bolt and nut.

Step 18:

Attach the thin wood's long end with a short wood screw.

Step 19:

In the top of the wheel drill holes for and attach cable tensioner bolts as outlets from which the ethanol will pour into the cans. You'll need one for each seasonal setting you plan to use (two is recommended, one for summer, one for winter, or just one if you only plan to use the device for

part of the year), and they'll need to be positioned so that the stream of ethanol is always pouring into a can, as shown below:



If the outlet is outside the green area then it will be possible for the ethanol to miss a can and the device will stall. This doesn't need to be extremely precise, and if you think you've not put it in the right place just drill another hole and relocate the outlet. (Make sure to tape the old hole to prevent the ethanol evaporating.)

NOTE: whether the outlet goes on the left or right side of the wheel depends on your hemisphere, which side of the gearing you put the wheel, and whether your spring winds clockwise or anticlockwise. Turn the wheel with your finger and see which way the collector goes. Put the outlet on whichever side will result in it tracking from east to west when it's facing the sun.

Set the device to each of your seasonal settings and insert an outlet for each.

Step 20:

Attach an 80-90cm length of 6mm PVC tube between the valve in the base of the reservoir under the wheel and the cable tensioner bolt at the bottom of the Box's boiler. Wrap the bolt's thread with a few turns of Teflon tape and secure with cable ties or twisted wire.

Repeat with a roughly 30cm length of PVC between the valve at the back of the Box's metal tin and whichever of the Wheel's outlets you will be

using for this time of year.

Block off the other outlet(s) with a dome nut, tape, or similar to prevent the ethanol from evaporating.

Step 21:

Test that everything is working properly by turning the wheel with your finger. It won't be perfect until the device is counterbalanced, but watch out for any rubbing or excessive friction.

Filling:

To fill the device detach the shorter PVC tube from the top of the wheel, then remove the bolt attaching the Box to the Collector and flip the Box upside down. Unscrew the reservoir from beneath the Wheel and pour in about 600ml of ethanol, then lift it above the level of the Box so that ethanol starts draining into the tin. If your reservoir doesn't hold that much, refill it while it's draining.

When ethanol starts coming out the tube attached to the tin screw the reservoir back onto the wheel, then reattach the Box to the Collector and the tube to the Wheel.

Orienting:

The device doesn't need to be oriented extremely precisely, but the closer the better.

If you're in the northern hemisphere you want it pointing due south (as in, polar south, not magnetic south) and north for the southern hemisphere.

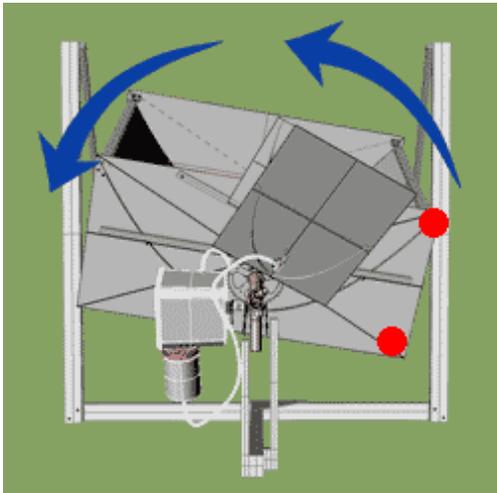
The easiest way to do this is find solar noon (the time at which the sun is highest in the sky) for that day, thing that can be easily by searching the Internet, or by getting the times of sunset and sunrise where you are and calculating the point halfway between. These are easy to find online or in your local newspaper.

For example, if on the day you plan to orient the device the sun will rise at 6:00 am and set at 8:38 pm, then solar noon would be at 1:19 pm. Then just place the device out where you want it at that time and turn it towards the sun until the shadow from the collector pipe is running exactly down the center line of the Collector trough.

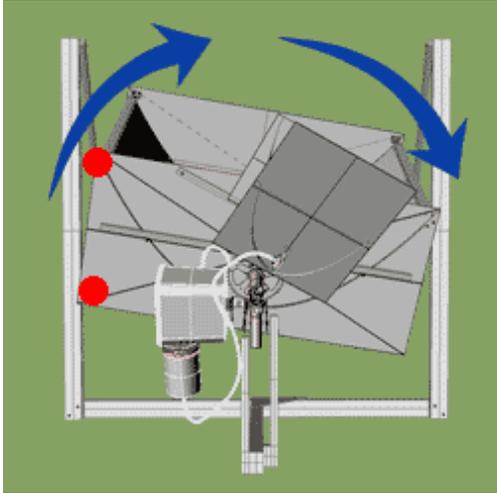
But even if you're off by several degrees, it shouldn't make a huge difference.

Counterbalancing:

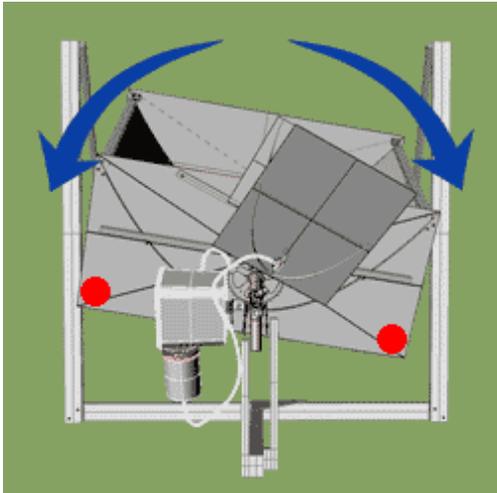
This is something you want to get right. If the device is well balanced it will be practically frictionless and require very little force to turn. To do so, knock the pieces of metal holding the Gearing's worm gear shaft away from the large bike gear (called a sprocket) with a hammer so that they no longer touch and the Main Collector can turn freely. Drill a hole in the four corners of one of the Collector's plywood faces and insert a long bolt in each. Take some flat scrap metal, cut into squares, and drill a hole to fit the bolt in the center. These are your weights. Refer to the images below as to where you want to add them:



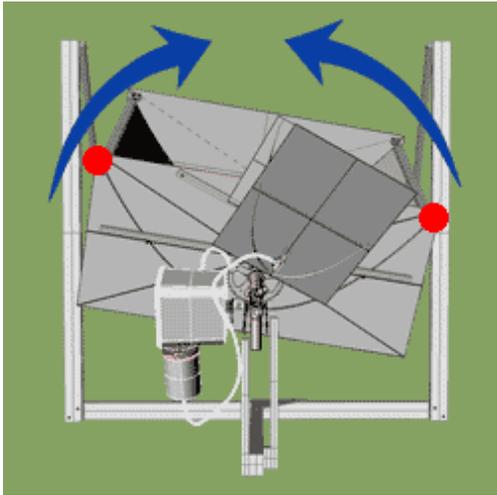
If the Collector falls to the left, add weights to the bolts on the top right and bottom right.



If it falls to the right, add weight to the left.



If both sides fall away from center then it's top heavy, so add weight to the bottom left and bottom right.



If it falls towards center on both sides it's heavy on the bottom, so add weight to the top.

Keep turning the collector and letting it settle, adding and removing weight, until it no longer falls in any particular direction and stays where you leave it.

Put a nut on any bolts with weights to stop them sliding off, and return the spring worm gear to the sprocket.

Tuning:

It should take about 10-30 grams of force to turn the collector, two or three large metal nuts in one of the cans should be able to do it.

If not, check that the shafts are not rubbing or catching on anything, and that the spacing between the spring worm gear and sprocket is such that there's a small amount of wobble; not so tight that they grab on each other, but not so loose that they can detach and slip. Tune with a hammer, lightly knocking the two pieces of flat metal holding the worm gear shaft in place, moving the spring towards or away from the sprocket.

This is the main point where friction and other problems can arise, so it's worth taking your time to get it nice. Check back every so often as the device is working to make sure this is still as it should be.

The Box needs to be at a precisely 20 degree angle to the Collector. You can do this by measuring, but the best way is to rotate the Collector so that it is pointing directly at the sun, remove the screw holding the Box in place and adjust its angle so that the focused light is sitting just off the edge of the flattened copper boiler. As the sun moves off the Box's

focus should shift onto the boiler before the Collector's focus has left the collector pipe.

Return the screw to lock the angle. This is the setting of the Solar Steam Generator's overall accuracy, so it's important to get it right. If you later find that the angle is slightly off just remove the screw, adjust, and reattach.

And finally; the wheel should be pretty much airtight, but you want to keep evaporation of the ethanol to a minimum, so it might be a good idea to paint white any faces of the plastic container which are going to be facing the sun.