Cooking with the Sun

www.underthechokotree.com
Sustainable Living in the Suburbs

By Nev Sweeney

TABLE OF CONTENTS

1.0 Introduction

When I think about cooking with the sun, I think of two possible ways to go –

a) The higher tech indirect method, and
b) The lower tech direct method.

The higher tech method requires quite a few bits and pieces including solar electric panels, batteries, a solar charge controller such as an MPPT (Maximum Power Point Tracker) and an inverter to convert the 12vac or 24vac from the batteries into 240vac. As well as this you need a whole lot of copper wire to transfer the power around your system, but it allows you to use your standard home appliances (depending on the size of your system) like an electric benchtop oven or induction cooker. This represents a fair bit of cash and requires work by licensed electricians to make it all come together but pays dividends in terms of convenience and allows you to 'cook with the sun' even after the sun has gone down!

In contrast, cooking with the sun using the sun directly is much simpler. There are many different designs out there of direct solar cookers and I have made and used quite a few. You don't need any assistance from tradies, you can do all the work yourself and the materials are comparatively inexpensive. Having said that, I do make use of professional glass cutters where glass and/or mirror cutting is required, but if you are, as they say 'skilled in the art' that might not be an issue for you. The rest of the construction requires only moderate DIY skills and I figure if I can do it, almost anyone can. There is also a certain satisfaction in cooking food using only the sun in a device you have build yourself. Every time I cook a meal in the solar oven I am amazed that it has been cooked wholly using the heat coming directly from the sun.

The downside is, of course, that you need a sunny day to do the cooking, plus you can only cook while the sun is shining and high enough in the sky to provide sufficient heat. Our main meal of the day is our evening meal and the low tech route can cause difficulties for that approach. However, by teaming up with another low tech cooking method – cooking with stored heat, it is still possible to have that hot evening meal even if the time of year means cooking with the sun will finish a bit early.

We have and use both approaches here, although I will admit that the convenience of the high tech method makes things easier, it does not have the satisfaction associated with the low tech method. Also, we had direct solar cooking appliances many years before we had the money to put the higher tech cooking methods in place.

Hence the writing of this eBook. I want to enable people who don't have the means to put their own solar electricity system in place to still be able to save money and energy, reduce waste and pollution, as well as increasing personal satisfaction by cooking directly with the sun.

2.0 The 'No Tech' Solar Oven

I love the idea of using the sun's energy directly, no pollution, no waste and no (energy) cost, it's fun to experiment with to dry or cook food or generate electricity and helps you become more independent from the power grid. Over twenty years ago I became interested in solar cookers, they are the obvious answer for when you have no fuel to cook your meals with, you want to increase your level of self-sufficiency and/or sustainability, do something good for the planet or you just want save money. It was one of those ideas that was just so good!

After a quick trip around the net I found www.solarcooking.org with plenty of low or no tech plans for building solar ovens and after some consideration I decided I wanted to build solar box cooker, this is basically one cardboard box inside another, with a clear panel to let the sun in (construction details to follow). It was mind bogglingly, cheap and easy to build, real alternative technology ....and it worked like a heap of crap!

I made it as per instructions, tried to cook a number of dishes using several different food containers and the best that I could do was attain 60°C and that was in full sun! All it would do was warm the food and after a full day in the sun I still had to do most of the cooking in the gas oven.

The principle or theory that I was working on was that the inside box was insulated by then outside box and the inside box was then lined with aluminium foil to reflect the sunlight back onto the cooking pot once it had made it through the clear panel. So much for that theory! So I put it away in the shed and forgot about it for a while.

After doing some more searching on the net I found a small footnote on another website where a bloke who had been experimenting on his own account said that the secret was to have thin walled, matt black painted cooking pots and a matt black steel panel in the bottom to absorb the heat. This heat was then passed on to the cooking pot, in direct contact with it by conduction. This was exciting stuff and sounded like a serviceable new theory, but would it work?

Well, I put in a matt black steel panel and believe it or not, it did! All of a sudden I could get up to 90°C and was able to cook an aluminium billy full of spuds perfectly in less than two hours. This technology made sense and worked fine if you set it up right.

Here is how I made the no-tech solar oven –

2.1 Construction details

1. Get hold of a large cardboard box, a smaller cardboard box (one which allows at least an inch of dead space all around once it is inserted in the larger box) a Glad® or equivalent brand oven bag, some aluminium foil, PVA glue and the steel

plate with some matt black paint. Car engine enamel works well and puts up with the high temperatures.

2. Centre the bottom of the smaller box over the top of the larger one and, using a Stanley knife or equivalent, cut a hole in the top of the larger box so that the smaller one can slide into the larger one.

3. Now line the larger box with aluminium foil, shiny side out. This can most easily be done by getting hold of some PVA glue and a paint brush and painting the glue onto the cardboard and then smoothing on the foil. If the glue is a bit thick to use a brush, thin it down by mixing in a bit of water.

4. Cut the corners of the top of the smaller box into flaps and fold them out so that they support the smaller box centrally in the larger box. If you are going to insert insulation this should be done before the flaps are glued into place, locking the smaller box into the larger one. The insulation could be crumpled newspaper, straw, wool, polystyrene beads or what-have-you, anything that provides insulating dead-air spaces.

5. The smaller box may now be lined with aluminium foil, also shiny side out.

6. Once the inner and outer box are assembled and glued, the lid can be made by placing a flat piece of cardboard over the top of the double box and cutting it to leave a 25mm edge all around. The line where the box sits can then be scored and the ends cut to form flaps, the flaps are then folded down and around at the

corners and glued, forming a tray shaped lid. This lid then has a three sided cut to put in the top of it to form a large flap the size of the inner box and then tape an oven bag over the hole to form a clear window to let the sun in.

7. The bottom of the flap should also be lined with aluminium foil to act as a mirror to reflect sunlight into the oven. A Z-shaped piece of wire is then inserted in the

edge of the flap and the top of the box to keep the flap open at the right angle to act as a reflector.

8. To finish off the oven cut a piece of sheet metal to fit the bottom of the inner box, and hit it with some non-toxic matt black aerosol spray. Install the plate and you're ready to cook!

No Tech Cardboard Box Solar Oven

All it took was a couple of hours work and very little outlay (mostly for the oven bag) and I had raised my level of self reliance a notch! Well worth a go..... and as I said at the start - if I can do it, anyone can.

Inside the outer box showing alfoil lining and wool used as insulation

Inside the inner box showing alfoil lining and matt black metal plate

3.0 Our Main Solar Oven

3.1 Original Build

So having now found out how to make a solar oven work, it was time to get serious. A cardboard no-tech oven (see above) is one thing, but I wanted something that would last and would be more efficient. Having said that, I still have the original oven and it must be almost 15 years old now, it hasn't had a lot of use but is very valuable for demonstrating the principles of solar cooking.

I had picked up a book called "The Solar Cookery Book" by Beth and Dan Halacy yonks ago, and in it was a description of how to make a more efficient, and more permanent, solar oven. The oven was an angled box made out of 3/4" plywood with a glass front and reflectors to make use of the sunlight over a greater surface area than just the top of the box itself. Here was a solar oven of substance! I have seen similar designs that require the glass front to be fixed and a door to be cut in the back of the oven through which the food is put in the oven and retrieved. This seems to me to create immediate problems with sealing the oven, so I much prefer the simpler design described below, where the glass front is openable and the main body of the oven is a sealed unit.

The only time I seem to find to complete these major projects is over the Christmas break, and so it was with this one, it took about two full days of work to put together as well as some running around to get the glass front. The main body of the oven is constructed of ¾ " thick marine plywood, and I was lucky enough to have a couple of three foot by four foot sheets of the stuff in my garage. A friend of mine in the business was able to get me some 25mm thick compressed fibreglass batts and I had some thin, galvanised steel sheet left over from a previous project.

CONSTRUCTION DETAILS

The box

The carcase of the cooker was made out of 3 sheets of 20mm marine plywood, the base was cut to 500mm x 440mm, the two sloping sides were made by cutting diagonally across a 440mm x 440mm sheet to give a long end of 330mm and short end of 90mm. The third sheet was to form the front and back of the cooker, it was originally 435mm x 540mm and a cut at an angle of 60° was made in the 435mm side 90mm from one end. All cuts were made with a hand held, 200mm circular saw, the guide being tilted to achieve the 60° cut.

The solar oven hot box without glass

These were assembled into an open topped, angle sided box by fitting the front, back and sides to the outside of the base and then gluing and screwing them into position. Once this was completed I cut the 25mm fibreglass insulation using a metal ruler and Stanley knife, first the one to go over the base and then the sides, back and front. To hold the base pad in place I secured it with four flat head nails about 50mm in from each corner, the other pieces rested in place temporarily.

Using tin snips I cut thin galvanised sheet to be placed over the fibreglass insulation, the one fitted to the base just rested on the four flat head nails, but the front, back and both sides were nailed in place using two flat head nails each that passed through the metal and fibreglass and into the wood, holding the entire assembly secure.

To finish off I applied two coats of matt black, high temperature enamel from a spray can over the metal lining, the edges of the fibreglass and the edge of the wood. To fully dry the enamel and remove any trace of solvents I then sat the whole box in the hot sun for a couple of days.

The next part was to get hold of the glass front, so I approached a local glasscutter and explained what I wanted. The Halacy book specified double strength window glass, which meant nothing to my glazier. Considering the temperatures that I hoped to develop (160°C+) he suggested special high temperature glass at a cost of over $200 for the 520mm x 520mm sheet that I wanted. After picking myself up off the floor I suggested that this was a tad outside my price range and was there no alternative? We agreed to try double thickness window glass (ie 6mm instead of the standard 3mm) but he was somewhat sceptical that it would work. At a price of $20 for the piece, I could afford a few mistakes!

Solar Oven Hot Box with Glass in Place

The case had by now dried sufficiently to continue work on it and I fitted some brown felt strips to the top edge of the box to seal the edge where the glass sat on it. The felt works well but faded to a light brown/crappy colour with the first use, so much for that idea. OK now comes the test for your cabinet making skills, the glass is absolutely flat and will show up any irregularities in the edge of your box…………..mercilessly. Yes, I did have a bit of fill in at the lower left hand corner, where the 60° started out a bit wonky, so I shaved down a bit of thin wooden moulding that I had hanging around and glued and tacked it in place with panel pins.

This left a 10mm strip around the outside between the glass and the edge of the top of the box, by tacking on some split moulding, this formed a frame for the glass to sit in, and sit it did…… reasonably well anyway. Of course the question could be asked "how the hell do you get the glass on and off?" and I'm glad you asked, because thereby hangs a tale! The ultimate idea was to drill a hole through the glass and fit a wooden knob secured by a screw, but at this time I lacked a glass drill so I quickly bent up a bit of galvanised steel into a U shape, drilled a hole for the knob, which I installed and then fitted the whole thing over the glass, it looked chatty but was serviceable.

Detail of corner showing steel, insulation, felt and timber

When I finally did get around to drilling the hole and fitting the knob, it was only a matter of weeks before there was a split through the centre of the glass plate, which seemed to originate at the hole. Hmmm……that glazier may have been right……..bugger! I did think that it may have been due to the metal screw and the glass expanding and contracting under heat at different rates, but to be sure (after going back, cap in hand to get a new $20 piece of glass) I re-fitted the chatty but serviceable steel and have had no further problems (that was over 8 years ago).

So, now that I had completed the box itself, I was impatient to try it out and in full sun I found that I has able to get to 90°C to 100°C…………but I wanted more!

The Reflectors

To increase the efficiency of the oven by increasing the area harvesting the sunlight, I made some reflectors. The more of the suns' heat reflected into the oven, the higher the possible temperatures and I considered making the reflectors out of mirrors, but mirrors are heavy, expensive and fragile. Other possibilities are polished aluminium or mirror stainless, but these also tend to be expensive. To keep costs and weight down, I decided to use aluminium foil glued to 3mm medium density fibreboard (MDF) which has white melamine applied to one side.

The reflector was made up of two different shaped sections, with four pieces of each section. The rectangular sections were 540mm x 610mm, these were screwed onto the box with the 540mm side against the side of the box. When these were screwed on, it left four triangular spaces in between the rectangular reflectors, these were filled by triangular sections 610mm x 610mm x 390mm. The rectangular sections were fixed to the solar oven using two galvanised sheet metal brackets about 40mm x 100mm, bent to the required angle. The triangular sections were initially taped to the rectangular sections with packaging tape for testing, but this started to fall off and has now been replaced with two 50mm galvanised hinges bolted between each section.

Prior to fitting, the reflector sections had to be covered with aluminium foil (you guessed it…..shiny side out!) glued to the plain side of the MDF sheets. The best and most wrinkle free way of doing this is to paint the MDF with glue (in this case PVA) and then set it down on the already laid out aluminium foil. This worked well with the triangular sections, but because of the size of the rectangular sections they could only be partially covered this way. The rest had to be applied by placing the foil onto the pre-glued surface, which resulted in more wrinkles.

There is an aluminium foil tape available at hardware stores, and I have intentions of getting hold of some and using it to tape up the joints, to reflect more light and give a neater appearance. The reflector is then attached to the solar oven box by self-tapping screws. If built to size the angles should work out pretty well correct but to help in setting up, the angle between the back of the side panels and side of the cooker box should be 150°, the angle between the back of the top panel and the back of the cooker should be 180°(ie a straight line is formed) and the angle between the lower panel and the front side of the cooker (not the glass face) should be 120°. I used an ex-school protractor and the angles worked out OK.

The oven, once assembled, takes up a lot of space, and unless your have large amounts of free space (which we don't) it is handy to be able to separate and flatten out the reflector into sections for storage. As my elder daughter's boyfriend asked when he went out into the backyard and saw the completed solar oven – "Wow! What are you doing with the satellite dish?"

The oven works pretty well and in summer will develop 160°C to 180°C. It has produced some wonderful roasts and casseroles, and I think that it could do a lot more. The next trick will be to try baking bread in it. The oven is designed to be tipped up in winter, with what is normally the base of the oven becoming the back wall. This allows the lower angle of the suns rays to be made use of more effectively, but even so the best I have been able to do in mid winter is 120°C. This is still hot enough to cook most things, even though it takes somewhat longer.

Although quite a bit of work, the building and using of both ovens has been both educative and fun, and when the sun shines we can use it directly and cut down our use of fossil fuels, which is a win for us and the environment.

Update

The oven has now been in service for many and is still working well. The main problem that has emerged is that is it big, bulky and a pain in the bum to manoeuvre. When pulled apart it takes two people about 10 minutes to re-assemble, which reduces the likelihood of reassembly (especially seeing as I am the only one who does it!). So it tends to sit on the back deck partially in the weather and this is starting to have a detrimental effect on the ply, I consequently have applied 3 coats of oil based gloss paint (fire engine red!) and it now looks a lot happier. To make using it easier I have now installed it on a small trolley and store it under in one of the sheds so that to use it means it only needs to be wheeled out and turned towards the sun.

Over the last 3 years I have been using it to bake solar (sourdough) bread, and it turns out beautiful bread all year round, contrary to my initial expectations. The bread tin that I use was my wife's grandmother's and is ideal for solar making, it is made out of thin tin plate, it has a flat bottom and is sprayed black on the outside. I don't time the bread but just keep an eye on it until it looks browned enough. The only concession to using the sun is that you need to turn the tin around so that the other long surface faces the sun about half way through otherwise one side is perfectly cooked and the other is still a bit doughy – a trap for young players!

The aluminium foil – not as reflective as it once was

After 3 years in service the aluminium foil was starting to look a bit worse for wear, so I have covered it with a thin sliver coated plastic wrap, the type sold by the roll to wrap presents in. I haven't used the whole roll yet and it only cost me about a dollar – good value. It appears to be more reflective than the alfoil. I used the same old faithful PVA glue to attach it straight over the alfoil and it appears to have stuck so far. The problem was that I was unable to place the reflectors on the silver film so it looks like the surface of the moon in reverse (bubbles not craters!), but that notwithstanding it works well.

3.2 2015 Refurb

Our solar oven has been in regular use for over 15 years and has been starting to look a bit ……. worn. The reflectors are not flat anymore and are not so reflective anymore either. The reflective surface becomes dusty and oxidised over time and just doesn't work as well, some of the hinges holding the reflectors in place have come off also. The main box of the oven is still in good nick, although the felt edge seal is a bit worse for wear too. All up it is time for a refurb.

The oven as it was

The original set of reflectors were made from 6mm MDF (Medium Density Fibreboard) with a melamine coating on one side. They worked pretty well and were light enough but over time they have warped so that not all of the light falling on them is reflected into the oven box, reducing the oven's efficiency. This time I am having a go with 6mm 3 ply plywood which is a bit heavier but is also more rigid and resistant to warping because of the laminations. The plywood is also a bit more expensive. I was able to pick up 3 600mm x 1200mm sheets which is more than enough to make the four square main reflectors and four triangular corner reflectors.

To start I removed the originals from the oven box and recovered as much of the hardware (screws and hinges) as possible. I then marked out the new reflectors based on the dimensions of the originals with a one metre stainless steel rule and pencil, then made the required cuts with my hand circular saw. There was a bit of damage to the sharp points of the triangular corner sections but generally the approach worked fairly well.

The carcase of the oven with reflector attachments in place

After some consideration I decided it was easier to apply the reflecting material to the reflectors before installing them on the oven. The reflecting material which I used was the same as last time ie metallised plastic film gift wrap, with the unprinted reflective side facing out. It must be going out of fashion because I found it much more difficult to locate this time, so if you are going to make one of these ovens, start looking in newsagents and "el cheapo" shops now. If you can't find the metallised plastic film then use aluminium foil with the shiny side out.

My original idea was to use some double sided tape to secure the film to the reflectors – bad idea! First off if I pulled it off the reel too fast it left most of the adhesive of the other surface and my double sided tape became single sided. Even when I was able to secure it to the reflector with an adhesive side out, id did not stick very well to the plywood so as I tried to apply the film the tape came away from the plywood and of course stuck to itself and to the reflecting film making one big mess!

The plywood reflectors cut out and ready to coat

I ended up by going back to the way I made the first one, painting each of the boards with a mix of PVE glue and water (50:50). The PVA is not an instant stick to you can remove and re-fix the film if there is a problem and by rubbing the surface over with a cloth you can move air bubbles to the edge of the plastic film and then out, making the surface flatter. To make the job easier I also cut the film oversized, then once the glue was set and the film stuck to the plywood well and truly I trimmed off the edges with a VERY sharp knife.

With the reflectors now in good shape I had a look at the bent steel brackets which connected the main square reflector panels to the plywood carcase of the oven. There a two of these on each side, each one connected by a single screw fixed into the side of the oven. They had become a bit deformed and bent out after being well used for 15 years or more so I unscrewed them and panel beat them back into shape with my trusty ball pein hammer and using the flat spot on the back of one of my engineers' vises as an anvil. The ones on each side of the oven had a tendency to slip back and forward if I tugged on the reflectors because they were only secured by a single screw, so I installed a second screw on each one to prevent this happening again.

Installing the second screw to stop the attachment from rotating

To fix the triangular corner reflectors to the main square side ones I used hinges at the top and bottom of each reflector. The easiest way to put the oven back together is to screw the square reflectors back into place on the oven carcase, affix the hinges to the triangular sections and then screw the triangular sections onto the square sections, thereby tying everything together (I hope!).

The freshly coated reflectors

The one downside of reassembling the oven with the film in place on the reflectors is that I do it by placing each hinge on the outside (uncoated) surface of the reflectors and then drilling through from the outside to the inside (coated surface) of the reflectors and then putting a bolt through each of the holes. Why is this a problem I hear you ask? Well, drilling the hole in from the uncoated side means that, more often than not, the drill dislodges and mangles the film rather than cutting through it cleanly. The only way I have found to do it without screwing it up is to hold a piece of wood firmly over the film and then drill through the reflector and film into the wood block. If you can hold the wood in place the hole is very neat and no other damage is done. (if you can't it still screws up!)

I worked my way around, first securing the square reflector which stands vertically at the back of the oven, and then the one on the right-hand side. I then then secured the corner reflector between the two squared ones. I then fitted the next square reflector in the series and the next corner one until they were all fitted.

The Finished Article

With the reflectors replaced the oven looks more like its old self, and is working better than ever. It has been well worth the effort and was long overdue!

4.0 Parabolic Reflecting Solar Cooker

We have had the solar oven for many years and it will do most things that a normal oven would do, but I also wanted a solar cooker that would allow me to fry onions or boil up soup or other things that are traditionally done on the stovetop. I found the design for a parabolic reflector style solar cooker in the book “Cooking with the Sun” by Beth and Dan Halacy and used that as a basis for the cooker I put together.

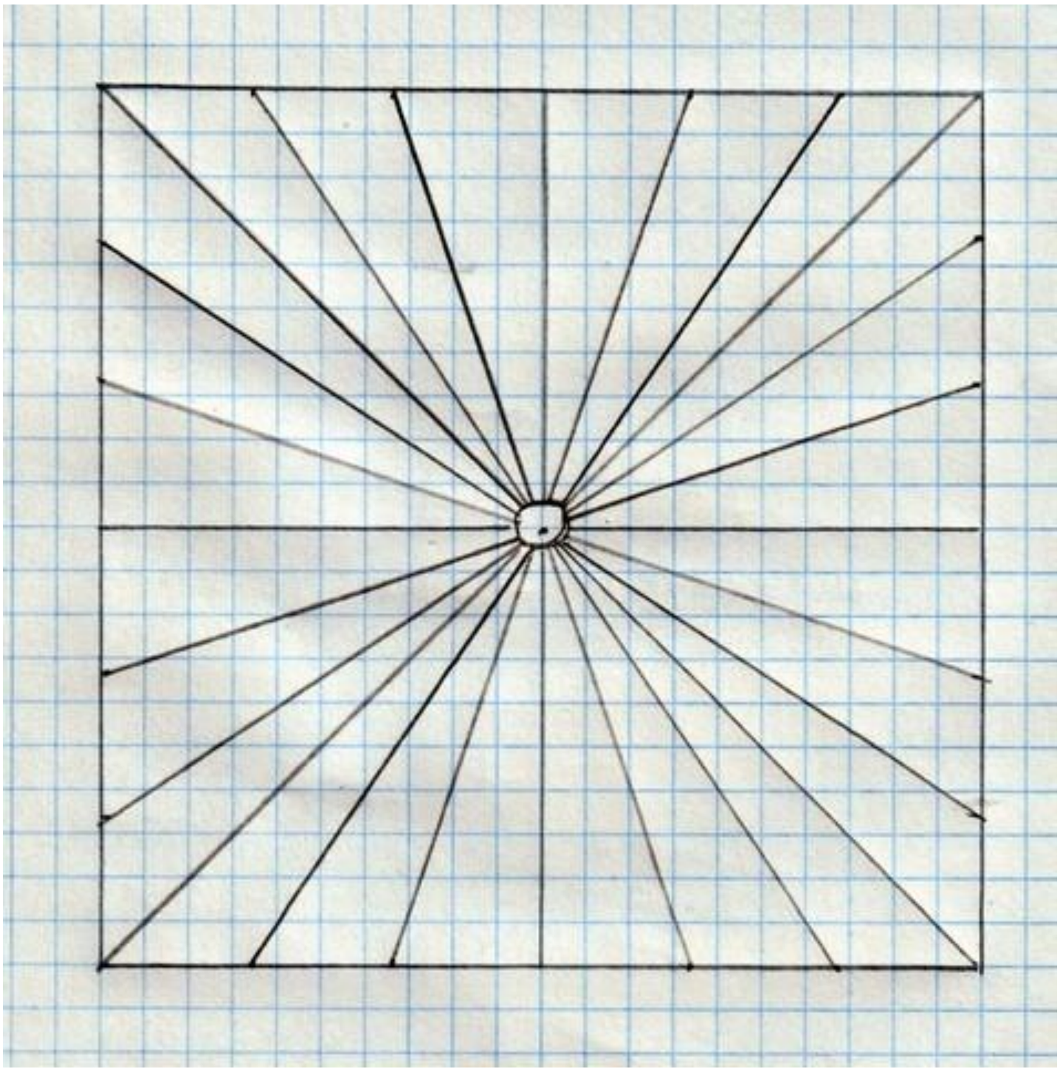
The way it works is that the reflective surface of the dish is pointed towards the sun and all the light (and heat) falling on the dish is reflected onto a single focal point. This is the point at which the cooking pot (or whatever) is placed, harvesting the heat coming off the reflector.

4.1 The base

In the original design, the primary material of construction was corrugated cardboard, but I was after something a little more robust and so I decided to use 6mm MDF for the base and 3mm MDF for the ribs. The original design also called for sides to be installed as well but I never bothered with those. In hindsight, they would probably be a good idea!

I bought a sheet of MDF and then cut it down to 820mm x 820mm with my circular saw. With the base now cut to size I needed to mark out where the ribs were to go and to fit the pipe flange (which would allow the pipe to be fitted which supports the cooking equipment).

To mark out the base I took a pencil and my one metre stainless steel rule and drew a line between each of the diagonals on the base, and then drew in lines joining the midpoint of each side, so that I had the positions for 8 ribs now in place. With these lines in place it was now just a case of measuring between each set of lines (which was, of course 410mm) dividing it into thirds and making a mark at each point. I then drew a pencil line from each marked point into the centre.

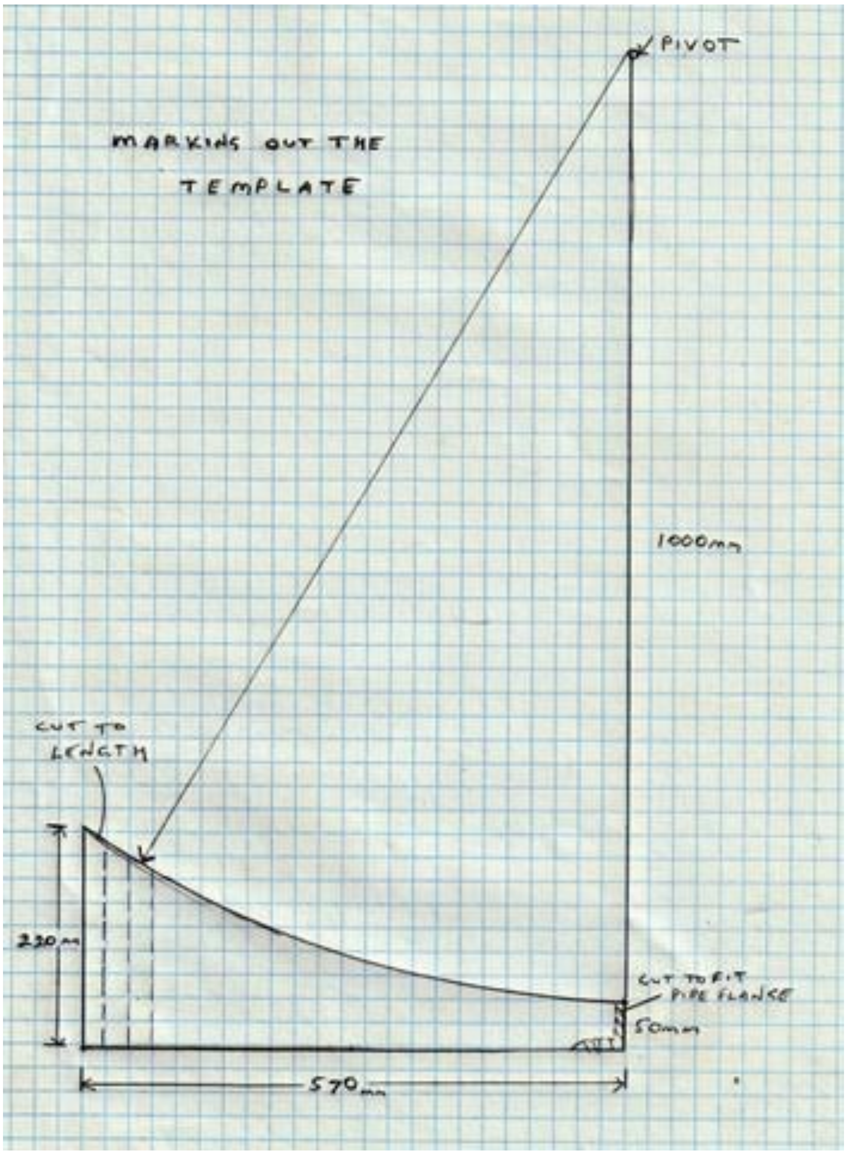


Thus, the base now had lines marked for 24 ribs.

The next trick was to install the centre pipe flange. The flange itself was 100mm in diameter and was set up to take 25mm diameter galvanised pipe. (Well, that is what you would get nowadays, the stuff I had was sitting around for years and was all imperial, the new stuff works just as well). I sat the centre of the flange over the centre of the base, where all the radiating lines converged, and then marked where two opposing bolt-holes were onto the base, drilled them out then bolted the flange in place. We were on our way!

4.2 Making the ribs

To mark out the ribs, the first thing to do is construct a template for the longest rib, which can then be used to mark out all the other ribs. The longest rib will be 220mm high at the highest end, 50mm high at the low end and 570mm long. Draw it out onto the material you wish to use as the template, (I used the 3mm MDF but you could use corrugated cardboard) get hold of a thin strip of wood a bit over a metre long and secure it such that one end pivots one metre away from the low end. Holding a pencil or pen at the end of the wood closest to the rib, use it to draw a curved line between the high and low ends of the rib. That is my best description of the process, but for a bit of clarity see the pic below.



With the rib set out, cut it along the lines with a knife, saw or if you have one, a band saw, making sure to stick exactly to the line. If all else fails cut the rib out a bit larger than the line, then use sandpaper to remove the material outside the line. Obviously, the more accurate the template is, the better all the ribs will be. There will also need to be a cut out from the bottom of the low end so that it can be fitted over the pipe flange in the centre of the baseboard.

To make the rest of the ribs it is just a case of using the template to mark them out and then cutting them out using a knife, hand saw, band saw or whatever you have on hand. Since only the diagonal ribs will be as long as the longest one, all the other ribs will need to be cut back so that they will fit on the baseboard.

4.3 Assembling the ribs

This means attaching the pre-cut rubs to the baseboard, which already has the pipe flange in place. To do that I used a construction adhesive, liquid nails. It was just a case of running a bead of adhesive along the bottom of the rib, putting it in place that then holding it for a short time to give the adhesive some time to set up, then moving on to the next rib. They can be done in stages or all at once, it is then best to leave the set up for at least 24 hours or even better for 7 days to give the glue time to reach full strength.

4.4 Applying the Reflective Surface

There are a number of ways to do this, but the one I used and which seems to work best is to get hold of some mirror finish card from our local newsagent.
To make the sections of the mirror I measured up the longest triangle and made a pattern from cardboard, overhanging the ribs on each side. I used this to cut out four triangles from the mirror card, then turned it over and cut out four triangles of the opposite side. I then followed the same process (measure, pattern, cut from one side then cut from the other) to make the rest of the mirror triangles. There is no need to get too finicky with cutting and gluing the pointy ends, they will be covered once the mirror is finished.

To apply the mirror card reflective surface to the ribs, it is just a case of applying adhesive (construction adhesive will work) to the ribs and then placing the mirror card, face up onto the ribs on each side, smoothing it out and holding it for a few minutes so it will stick. It works best if only every second set of ribs is used first, and then left to cure. The next day the infill mirror card between each existing mirror card can be applied. To finish off I cut a 100mm disc of the mirror card, then cut a 25mm hole in the centre. I then glued the ring of mirror card over the centre of the mirror (mirror side up of course!) so that the centre of the reflective area was tidied up and covered with reflective surface.

4.5 Cooking surface mount

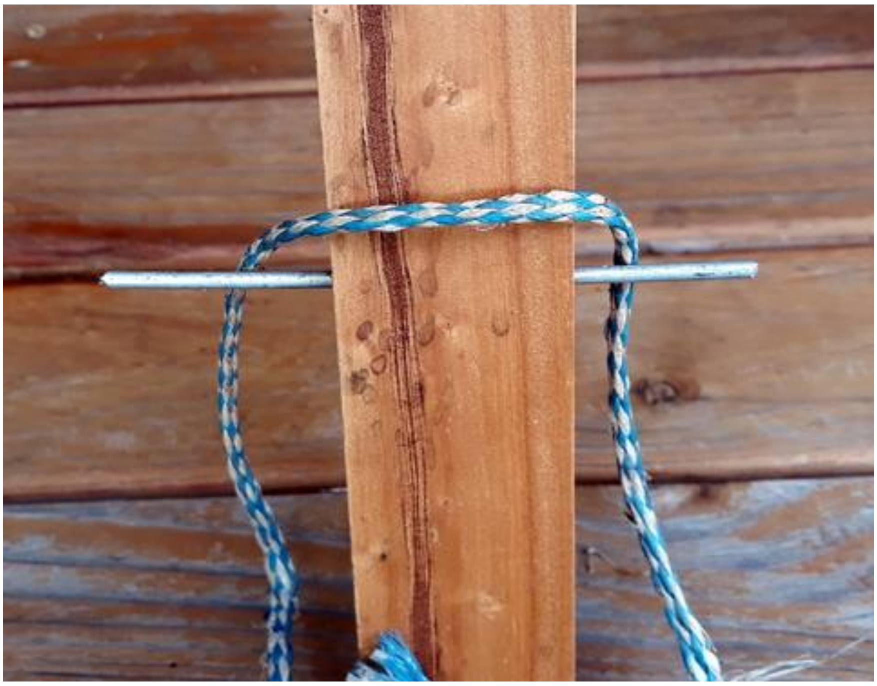
The idea is that the focal point on which the sun's rays are to be concentrated is on the bottom of the cooking pot or hotplate to be used. To achieve this, I screwed the 25mm steel tubing into the galvanised pipe flange in the centre of the completed parabolic dish, then using the shadow of the pipe on the mirror surface to point the dish directly at the sun. The curve of the dish is based around a 1 metre radius curve so the focal point of the reflected light should be around 500mm along the steel tubing (so your steel tubing should be 550mm to 600mm long to allow for some variation).

I made a mark around the pipe where the focal point was (quickly! It heated up remarkably fast!) then turned the cooker out of the sun. When the pipe had cooled I traced around the pipe at the focal point parallel to the ground, removed and then cut the end of the pipe off with my angle grinder. That way the end of the pipe would be flat when I wanted to put anything on it.

Obviously, sitting a pot on the end of the pipe would be anything but secure so I welded a piece of 330mm x 3mm threaded rod and 290mm x 6mm steel bar (it was what I had available) into a cross formation on the end of the tube to support the cooking pots etc.

4.6 Cooker support

Unless you live on the equator, having the cooker lying flat on the ground won't achieve much so there has to be a way to set the correct angle of the cooker so that the focal point is on the bottom of the cooking pot.



To make the support I got hold of some 42mm x 19mm DAR pine about 1100mm long. I then drilled a series of 4mm holes through the 19mm sides of the pine, starting at 600mm from the ground and then every 30mm for seven holes. I then inserted a length of mm aluminium welding rod 120mm long to secure the twine to. To hold the reflector and support together I cut 450mm of twine and tied both ends together to form a circle. To hold the twine onto the reflector I screwed a small rope cleat to the back of the reflector at the top.

To use the support it is just a case of hooking the twine over the cleat and then around the aluminium welding rod through the pine support. The angle can be varied by moving the aluminium rod through a higher or lower hole, depending on the angle of the sun.

4.7 How does it work?

It actually works very well! I used to do some work with paraffin wax and used the parabolic cooker to melt the wax on many occasions. I did also use it for cooking, usually as a way of boiling water and making soups or stews, but I also used it for frying in a frypan and that worked well too. As far as I could see there were three drawbacks to this type of solar cooker and the first one may be (OK, was) due to my crap design –

1. The location of the pot on the supports was not hugely secure. The pot or pan could slide about a bit when being inspected or stirred. In fact one day a billy can full of wax fell of due to the effect of wind and paraffin coated a part of the reflective surface. This can also cause problems when trying to move the apparatus so that it continues to face the sun during the cooking period. It would be better to remove the pot, move the reflector, then replace the pot on the support. Not a big issue, but an issue nevertheless. A better pot support design could fix the problem I am sure!

2. Speaking of wind, due to the particular design of the cooker, the pot or pan in use sticks out and away from the cooker so that on a day with good sun, but a cool or cold wind, some of the heat is taken away resulting in the pot being cooled by the wind and the cooking time extended.

3. As with other solar cookers, you need to be careful when looking at the pot to ensure you don't cop a face full of reflected solar. Dark glasses should always be worn and care taken when performing such operations.

Bearing the above points the parabolic solar cooker has given us many years of faithful service and I would highly recommend it, either as a standalone or in conjunction with a solar oven

4.8 Postscript

I have heard it said that all good things must come to an end and so it has proven with our parabolic reflecting solar cooker. Recently, we were subjected to three years of La Nina, or in other words – long spells of very wet weather. This meant there was not much use for our solar cookers and so they mostly stayed in the shed. What I did not know is that the shed had also developed a leak over the area where the cooker was stored. When I finally removed it from the shed, it was so water damaged (the MDF had expanded and broken apart) as to be irrecoverable. It is, therefore, with heavy heart that I announce that our parabolic reflecting solar cooker is no longer with us.

5.0 The 'Primrose' Reflecting Panel Solar Cooker

I first came across this type of solar cook about 20 years ago and determined to make one. I saw similar constructions on two websites, one was French and the other German, one referred to it as the 'Nelpa' (an anagram of 'panel' evidently) and the other called it a 'Primrose' (no idea where they got the name!). The thing I found interesting was that, while each site had plans, they left out certain critical dimensions. Fortunately (for me) they left out *different* dimensions so that I was able to put the two plans together and build one for myself!

The cooker may be broken down into two pieces:

– The carcase – which supports both the cooking gear, consisting of a matt black painted pot, and the reflector, and
- The reflector unit itself

The way it works is that the reflector is a series of rectangular glass mirrors mounted in such a way that, when faced towards the sun, the reflection of the suns' heat from the mirrors all hit the bottom of the cooking pot. The carcase has a glass bottom on the box that supports the cooking pot allowing the suns rays to heat the bottom, and some of the sides, of the pot. The reflector is mounted in the carcase so that its angle can be changed to ensure that the heat hits the pot. It is also constructed so that the reflector can be pulled up against the carcase to make storage and transport easier.

5.1 How I built the Carcase

The carcase is composed of four legs with a plywood box at the top that has a glass bottom and supports the cooking pot. There is some insulation inside and outside the box to reduce heat loss.

I made the two sides (each consisting of two legs) from 42mm x 18mm DAR pine. I cut two 910mm lengths of the pine to form the vertical legs and joined them together with two 395mm horizontal braces, one 115mm up from the bottom and the second one across the top, all of them being screwed into place with a single countersunk wood screw, in from each end. I then added in another piece of pine, angled so that the top of the pine was 100mm from the top on one side and 200mm from the top in the other. This would form the support for the glass bottom of the box. I then made the second side, same as the first!

On the legs closest to the reflector I attached on each a piece of thin galvanised steel sheet that was 110mm x 42 mm on the outside of the leg about 200mm up from the bottom end of the leg with two screws. I then drilled a 6mm hole through the leg and steel sheeting 50mm up from the bottom of the plate. This is to act as the pivot point for the reflector.

I then joined each side together using a single piece of 19mm thick DAR pine which was 660mm long by 220mm wide and held in place by 4 countersunk wood screws. The sides of the box are rounded out by a piece of DAR pine 620mm x 112mm x 20mm which is angled back slightly from the bottom to the top to allow the reflector to rest against it when it is folded up. It is covered by 20mm thick fibreglass insulation 600mm x 120mm and secured by two wood screws and washers.

Insulation removed

Insulation in place

The side with cover removed showing insulation in place

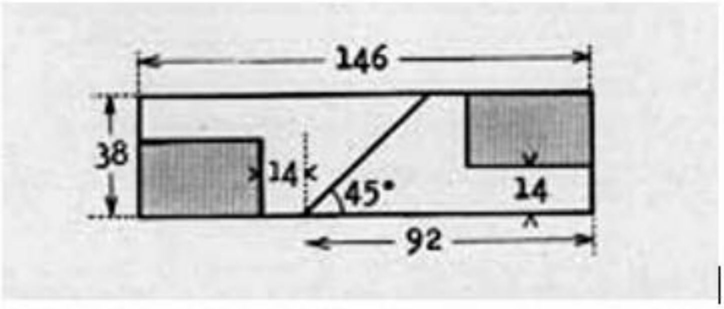
The bottom of the box is formed by a piece of 3mm glass, 620mm x 350mm in size, secured against the bottom of the box by 5mm plywood tacked in place all the way around it. The top of the box is formed by a piece of 10mm plywood 720mm long x 400mm wide. The top has a 205mm hole to support the cooking pot and a cutout on the front of 620mm x 20mm also to allow the reflector to be folded up against the face of the carcase. To make a better seal but still allow the top to be removable, I put some felt between the top and rest of the carcase to prevent the heat escaping.

Looking down into the carcase, top removed, through the glass bottom

The top from above

Due to the cooking pot being so much smaller than the width of the cooker, there is also a fitting each side holding a piece of mirror angled at 45° to reflect more of the suns heat onto the sides of the pot. The diagrams below show the dimensions of the fittings (two per side mirror) and where they are fixed in place.

How the fittings are fixed to the underside of the top



Dimensions of the fittings

The pot is a 205mm stainless steel pot and lid, with the outside of the pot painted with matt black engine enamel. I removed the handle of the pot so it would fit into the hole and made sure the pot I used had a flange on the top edge so most of the pot would sit down into the cooker but not fall through.

I probably could have made the cooker a bit narrower, but I wanted to make sure that things were stable, and it was unlikely to tip over.

5.2 How I built the reflector

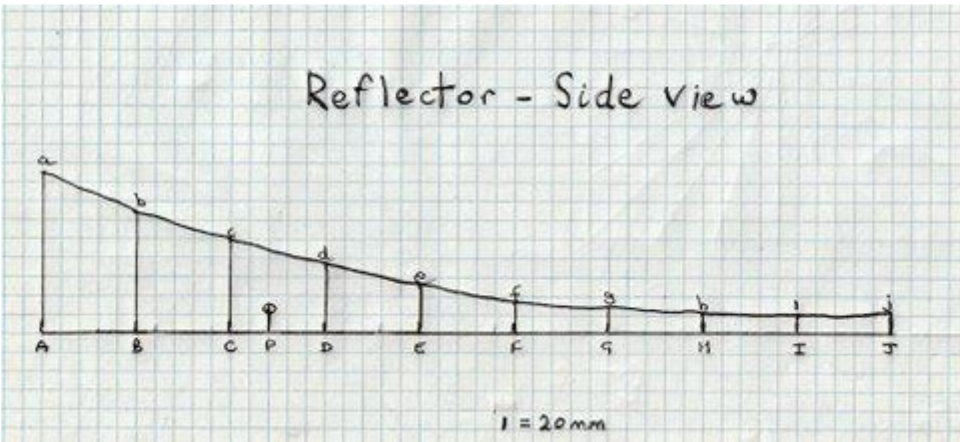
The reflector is a box 900mm long by 620mm wide, and the sides are graduated from 20mm thick at its thinnest point up to 172mm at its deepest point. It is made from 10mm 5 ply. Mounted on the reflector are 9 x 100mm wide by 595mm long pieces of mirror glass. Due to the mirrors I had available there are a number of different thicknesses of glass. (hint: thicker is more robust, so better).

Regarding the mirror glass reflectors, it had been my intention to cut them to size myself, using a hand glass cutter. I had enough mirror glass to cut the 9 pieces I needed for the reflector plus some spares. Having irretrievable stuffed the first couple I had tried to cut, I decided this was a job for a professional and approached a local glazier to cut them for me, which they did. I can't remember how much it cost, but it wasn't too much and being 20 years or so ago would be no indication of what that might cost today. Moral of story: there is no shame in getting help with the more technical parts of a project!

The sides of the reflector are graduated so that the reflection from each individual mirror will hit the same spot, ie the bottom of the pot through the glass bottom of the carcase.

To build the reflector I got hold of some 10mm plywood as mentioned above. Three pieces were required – 2 x 879mm long by 172mm wide to make the sides and 1 x 600mm long by 172 wide. For the fourth part of the reflector box (at the thin end) I used some 20mm x 20mm pine.

To make the curve on the sides of the reflector box and thus ensure the mirrors were at the correct angle, I marked what would be the bottom of the reflector at intervals as per the 'Horizontal Distances' in the table below. I then measured out the 'vertical distances' as per the table below. By joining up the tops of the lines, this gave me the correct curve to place the mirrors on and I then cut out the curve from both sides of the reflector box.



Horizontal Distances		Vertical Distances	
A-B	91.5mm	A-a	172mm
B-C	94.5mm	B-b	131.5mm
C-D	96.5mm	C-c	99mm
D-E	98mm	D-d	73mm
E-F	99mm	E-e	53mm
F-G	99.5mm	F-f	38.5mm
G-H	100mm	G-g	28.5mm
H-I	100mm	H-h	22.5mm
I-J	100mm	I-i	20mm
A-P*	240mm	J-j	21mm
		P*	27mm

Using some 20mm x 20mm pine in the corners as braces I put the reflector box together using wood screws and added a 20mm x 20mm pine brace 365mm from the high end of the reflector box.

To put the mirrors in I screwed supports made from 20mm x 5mm rounded edge moulding with one side sawn off to make it flat, to the inside of the sides of the reflector box so that the mirror could be put in place inside the reflector box and at the correct angle. Once the mirrors were in place I secured them by screwing more 20mm x 5mm rounded edge moulding along over the top of the ends of the mirrors.

I drilled a 6mm hole in each side of the reflector at point 'P*' (P standing for 'pivot!) and then slid in a 6mm x 50mm bolt with a wingnut on the outside to tighten the pivot and secure the reflector to ensure it remained at the correct angle.

5.3 Advantages and disadvantages

Advantages of this design

- The lid is accessible (as opposed to a solar oven where the whole pot is enclosed) allowing the food to be tasted, added to, stirred etc.
- The bottom of the pot is heated, allowing parts of the recipe to be fried before putting the lid on eg, when making spaghetti Bolognese the onions and garlic can be fried off, then the mince added and browned before adding sauces etc. This is impractical when using a solar oven style cooker.
- Steam escaping when the food is heated does not condense on the reflector.

Disadvantages of this design

- It is far and away the most complex design I have ever put together.
- Some heat will be lost to the system in the steam escaping from the lid and through the uninsulated lid itself.

While it is a complex build, it was a lot of fun and has now been in existence for 20 years and still is working perfectly. There has only ever been one issue, when we had an open day and it was out for inspection, the child of one couple decided it was built to be climbed in and when our backs were turned, he did just that, breaking one of the mirrors. It was only a minor hiccup as I had spare mirrors prepared for just such an occasion.

Note the missing mirror

6.0 Solar dehydrator

While this is not a solar cooker, it is another way to use the suns rays but, in this case, to preserve food by drying rather than cooking it!

For some time I have been interested in food preservation and tried pickling, bottling, smoking etc. but was not really happy with the results, the flavours were not really to my liking. I found the commercially dried products and home produced ones to be palatable, although some commercially dried materials contain sulphites as preservatives. I therefore decided that I wanted to use drying as my major means of home food preservation. I still wanted to use the sun as my power source but rather than use the direct rays I wanted to use the sun to heat the air and then use the hot air to dry the food. It was time to do some research.

My library is a reasonable one but most of the designs for solar driers that I had were the direct rather than indirect type, with one exception – "Reclaim Recycle Reuse" by Alan B. Hayes published by Sally Milner Publishing (My copy 1982) – which gave a good diagram of an indirect solar drier. I wanted more information and put a query on the Internet and found an Article out of the American magazine Home Power #57 (Feb/Mar 1997) called "Design, Construction and Use of and Indirect, Through-Pass Solar Food Drier". The article was very technical and in depth (I saw it reproduced on a number of solar cooking sites so just put "Solar Food Drier" into your search engine) and gave detailed plans for a high efficiency unit 7 foot long by 6 foot high. For me this was overkill in the extreme so I used it as the basis for mine and sacrificed "efficiency" for manageability. I figured that in Sydney with our abundance of hot sun (especially in Summer) I could de-tune it a bit and it would still do what I wanted it to.

My main criteria for design were that the drier should –

- Be not too expensive
- Be manageable by one person
- Dismantle for storage
- Actually dry the food!

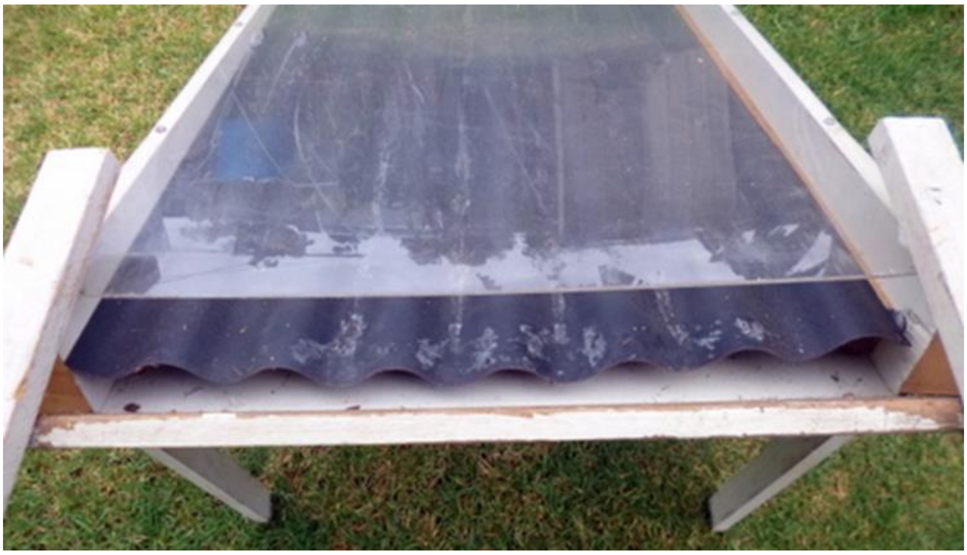
The drier was designed in two modules, the solar collector and the drier cabinet itself, these could be separated to store the drier so that I did not clog up my already severely constipated garage/workshop even more.

6.1 The Solar Collector

I am a simple man, as I am sure that any of my family or friends reading this will agree, and so I did not get involved in any arcane calculations when working out the size of the collector, it was based around the size of the glazing material. I used a 1200mm x 600mm sheet of Laserlite® Handipanel which was available, light, robust and easily worked but at $40.00 it was the most expensive single piece of the drier. The backing was likewise a 1200mm x 600mm sheet of 6mm medium density fibreboard (MDF), and to form the sides connecting the two I used 90mm x 19mm pine.

After I screwed the sides onto the base and I then screwed in three one metre lengths of 42mm x 19mm pine, one on each side and one roughly in the middle. This is to support the absorber plate so that air on both sides of the plate will be heated. I also put in two 90mm x 19mm x 100mm pieces of pine in the air intake area to support the end of the glazing material. I cut the absorber plate to fit the inside of the collector from a standard sheet of that wonderful, all purpose material – corrugated iron.

Before I installed the absorber I gave it two coats of matt black paint with a spray can, it was solvent based so I put the finished plate out in the sun for a couple of days to make sure that all of the solvent had evaporated. I didn't want to get my healthy, organically grown vegies contaminated by solvent materials. It would be possible to use soot or other blacking material but the paint was quick and easy, time is of the essence these days.



The collector then got a coat of primer inside and out, and I drilled outsized holes in the glazing material and used self tapping screws to attach the glazing material to the collector once the absorber plate was installed. When I first used the set up, a trap for young players was revealed – the glazing material expanded in the sun, causing some bowing and air gaps between the mounting screws. The best thing would be to widen the holes into slots to allow for some lateral movement as the absorber heats up.
So that the absorber is on an incline, which improves airflow and heat absorption, I installed a leg each side of the absorber. These were made out of 45mm x 90mm pine that was 580mm long and were attached by 6mm bolts so that they would swing back in line with the absorber when it was stood up, making for easier storage.

6.2 The Drier Cabinet

From the front

From the side

How big to make the drier cabinet? I did some research on the cost of trays, these are usually made to order from flywire and fly screen surround. To get all the gear to make up four reasonable size trays was $60-$80, a bit of slug, so I kept looking. In my local hardware (Bunnings) there was available a set of two readymade screens that were held together by two pressed steel rails, designed to go into the old wooden casement window as an expandable fly screen. They were all metal and while it wouldn't be a good idea to use them for a trampoline, they were robust enough to carry a good load of fruit or vegetables for drying, and even better, they were about $12 a pair. Also at 295mm x 475mm they looked about the right size, so I designed the drier cabinet around them.

For the drier case I had some old 20mm thick plywood lying around, so that's what I used for the top, sides and back door, the rest was constructed of 6mm MDF. The top of the cabinet slopes up toward the front, both to shed rain and to direct the escaping hot air to the front of the unit, where there is an 85mm high, full width gap. Not being a total fool I screened this gap to prevent access to flies and other insects, but at the back access flap there were some 5-6mm cracks that I did not think would be a problem. After the first use of the drier, I found flies in there, so now these are screened also (standard fibreglass fly screen material).

The back access flap where the drier screens are put in was also 20mm plywood and, because the unit may have to stand up to the rain, the hinges and catch were both made of brass to prevent corrosion. A wooden knob was also put on to pull the door open (funny about that!). I then screwed a strip of 6mm MDF and some 90mm wide pine onto the bottom of the cabinet so that there was only an opening wide enough for the hot air coming out of the absorber to fit in.

The only thing left to do was then mount the cabinet on the absorber unit. After some considerable thought I screwed a 45mm x 19mm rail on each side of the outlet of the absorber, which worked out to be the right width for the cabinet. The cabinet now slides between the two rails until the gap in the bottom lines up with the air outlet on the absorber.

So, how does it work?

Very nicely thank you! Here in Sydney the weather has not been as hot as usual for this time of year (Jan 2002) and in full sun the cabinet gets up to a temperature of 55°C to 60°C by mid afternoon, the morning temperature being about 45°C to 50°C. This has proved very effective in drying vegetables and so far I have successfully dried – carrots; corn kernels; cauliflower; cabbage; onion; potato; tomato; zucchini; mushrooms and some pre-cooked rice. The "aroma" of the cauliflower and the cabbage have been concentrated considerably and the cauliflower has gone brownish but everything tastes OK. There are lots of other things that can be dried this way including fruits, fruit leathers, soups and made dishes as well as jerky and biltong etc.

More information

While there is a considerable amount of information about drying food on the Internet, I did find an Australian book that covers the subject well, it is called simply "Drying Food" by Ricky M. Gribling (Hyland House, 112 pages, 1997). While I disagree with the authors' comments at the start that the only way to dry food is to use an electric dehydrator (everywhere else is too polluted), the book is quite comprehensive and has many good ideas. Another book that I have found to be handy (although it is American and based on electric dehydrators as well) is– Mary Bell's Complete Dehydrator Cookbook, William Morrow & Co 1994 - it gives a huge amount of detail (280 pages).

From the back

Cabinet empty

Appendix 1

Yes, I know, all the measurements are in imperial. I made the oven many years ago and these are the measurements I followed, so get used to it!

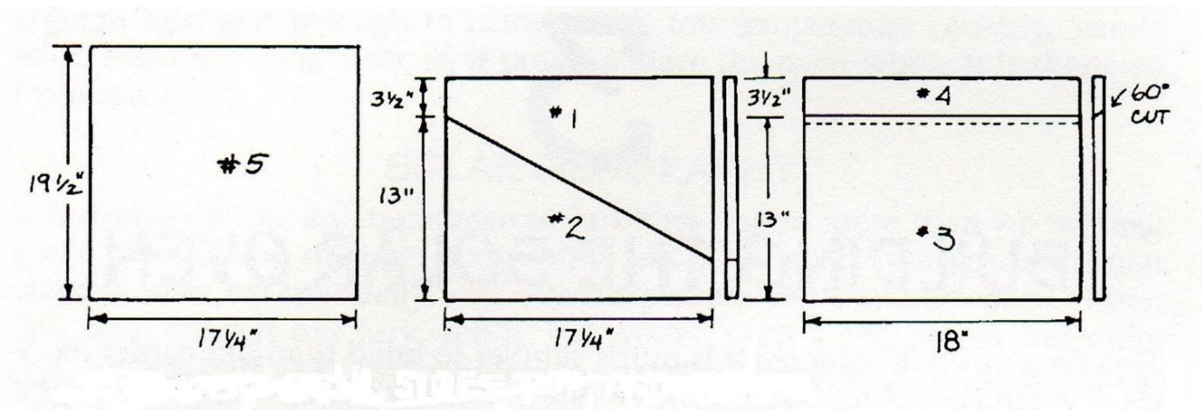
Materials List

Plywood
1 off 16 ½”x 17 ¼” by ¾” thick (to make the sides)
1 off 16 ½”x 18” by ¾”thick (to make the top and bottom)
1 off 19 ½”x 17 ¼”by ¾”thick (to make the back)
4 off 18”x 18” by ¼”thick (to make the main panel reflectors)
4 off 15”x 18”x18”by ¼” thick (to make triangular corner panel reflectors)

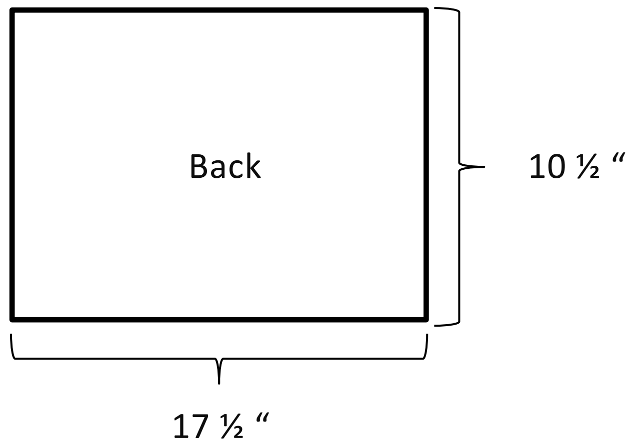
Galvanised Sheet Steel
1 off 10 ½”x 17 ½” by 1/32” (0.5mm) thick (back)
1 off 15 ¼”x 17 ½”by 1/32” (0.5mm) thick (base)
2 off 10 ½”x 15 3/8” x 3”x 16” x 1 ¼” by 1/32” (0.5mm) (sides) – see diagram

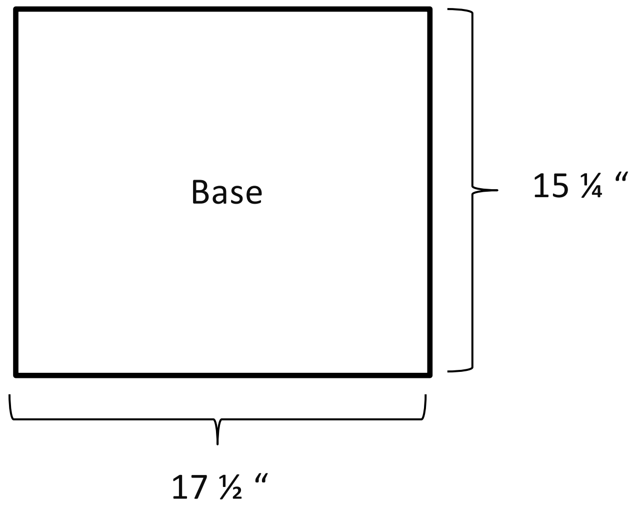
Other stuff
8 square feet of compressed glasswool insulation 1” thick
1 off ¼” (6mm) thick window glass 18 7/8” x 18 7/8”
4 off wood strips 1/8”x 3/8”x 20”
8 off aluminium or sheet steel 1” x 4” for attaching reflectors to oven body
1 off wooden drawer knob and attachment screw
Assorted screws and nails
A can of matt black engine enamel

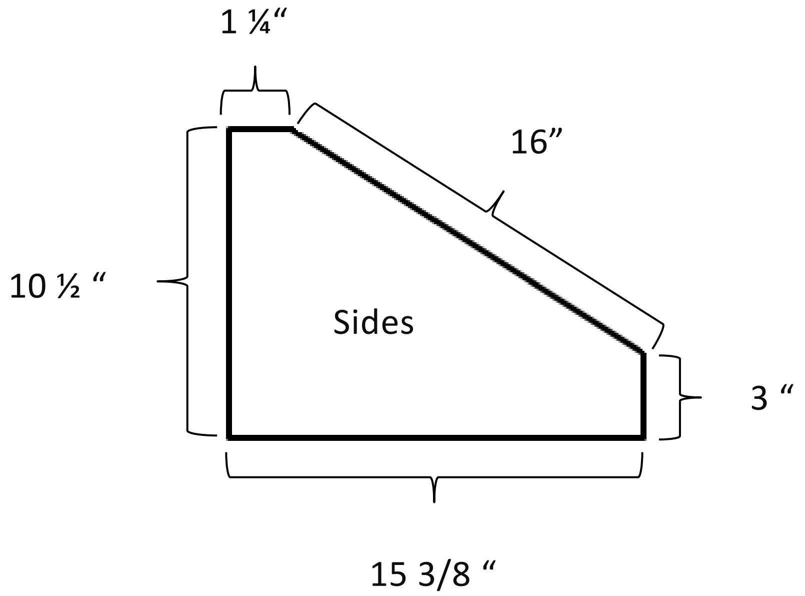
Plywood Shapes



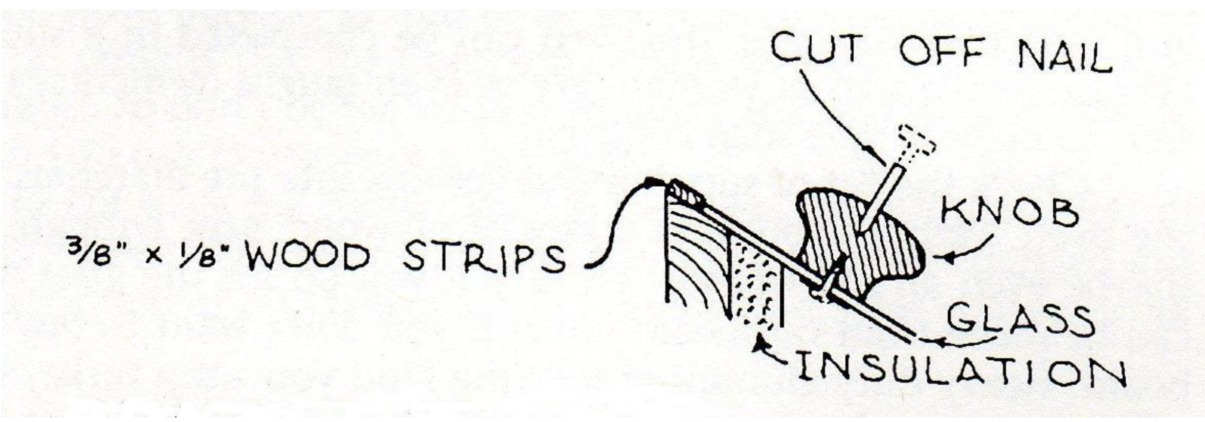
Sheet Steel Shapes



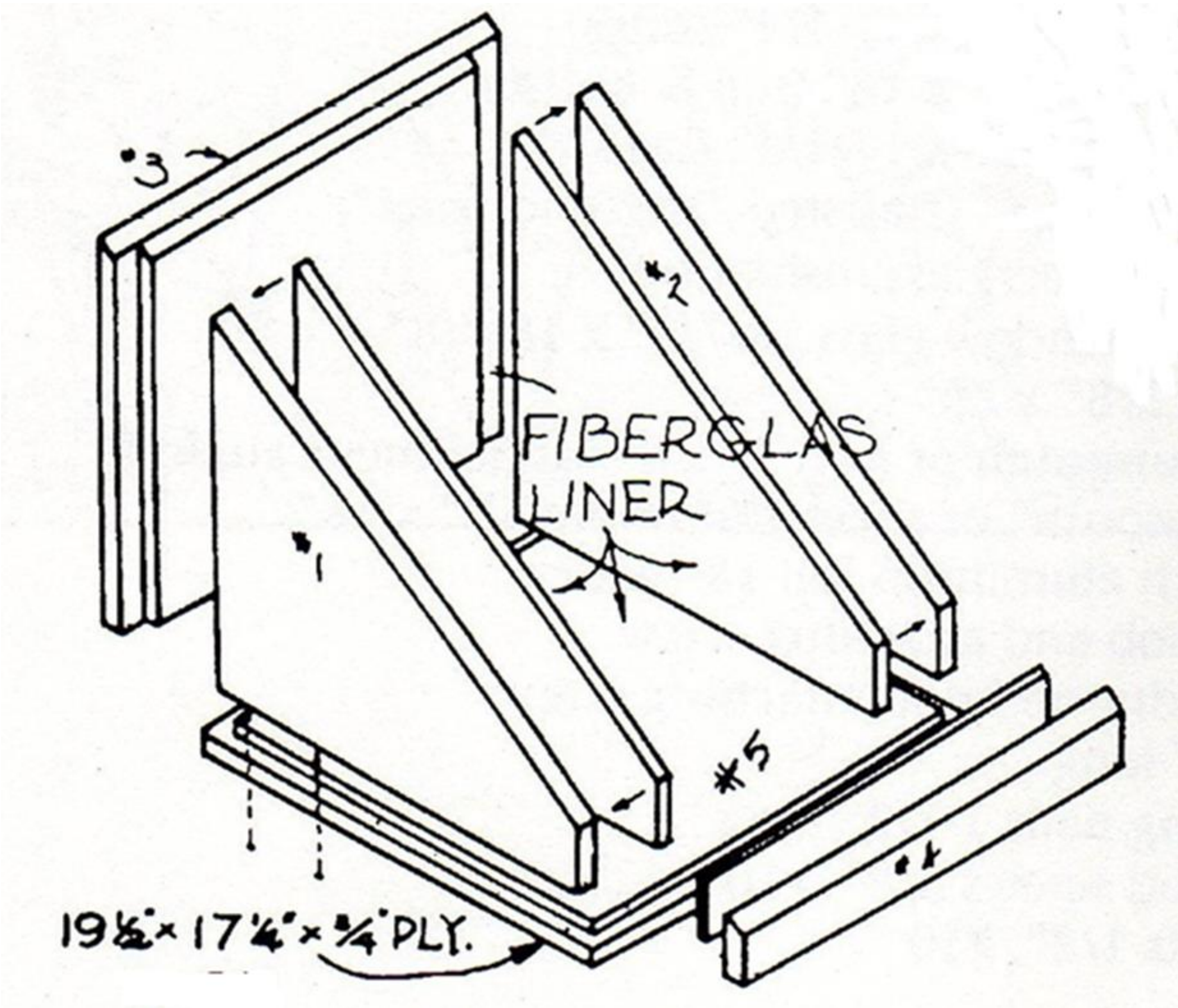




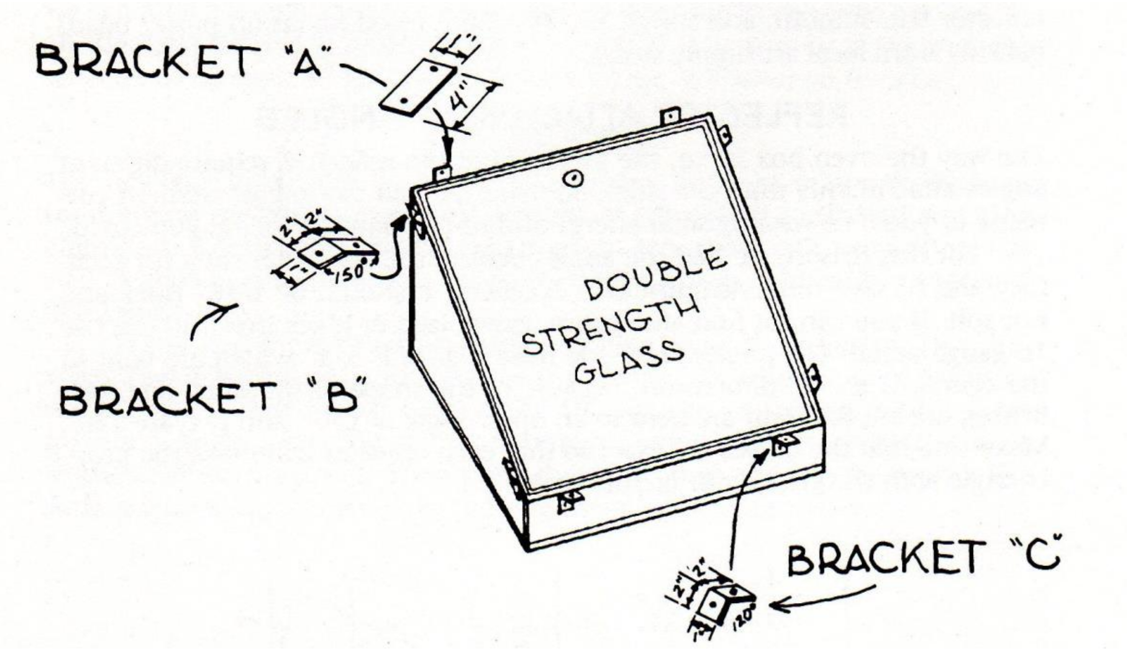
Wood Strip and Knob Attachment



Oven Body Assembly



Fitting Brackets to the Stove Body



Reflectors Fitted to the Oven