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DEPTH SOUNDER FOR BOATS

DATUM 6800 COMPUTER TO BUILD

SOLAR POWERED FOUNTAIN

Harness the sun for tranquillity with a

Solar-powered Fountain

Over the last few years small ornamental fountains and garden pools have become very popular with Australian householders. And with good reason. Bright sunshine and trickling water go together to add sparkle and charm to any garden. But there is a way to add more charm and interest and that is to run the fountain from solar power.

by LEO SIMPSON

When the sun shines the fountain runs. That is the concept used here in applying silicon solar cells to run a fountain pump.

In a way, the concept of using solar power to run a fountain is a return to the original method used by the early Greeks and Romans. They used water from mountain streams and springs and brought it long distances in aqueducts to supply their needs for fresh water and incidentally, to provide the cooling and soothing effects of fountains. That was an early use of stored solar energy.

Up till now, if you had a yen for a cascading garden pool or fountain, it had to be mains-powered. This meant the need for a full mains installation or a power supply for a low voltage installation. As well as that, you would have to remember to turn the pump on and off or use a mains timer. For many people this probably amounts to too much trouble and after a while the fountain is likely to fall into disuse.

When the sun shines your fountain runs, the process is completely automatic. You don't have to remember to turn on anything and there is no cost, (apart from the initial investment). And there is a further benefit. The amount of water going through the fountain is proportional to the amount of sunlight actually present from moment to moment. If a cloud partially obscures the sun, the flow will drop to a trickle and then stop altogether if the sun is totally covered. Then it will burst into life as the sun comes out again.

In designing this project, "Electronics Australia" has arranged with Amtex Electronics for the supply of a suitable pump and the principal parts for a solar array consisting of 14 75mm diameter solar cells and Lexan or similar polycarbonate glazing sheets.

The pump which is to be supplied for this project is designed as a bilge pump. Called the "Bilge Mate", it is a submersible impeller pump with a sealed permanent-magnet motor. It is rated at 1400 litres/per hour for an input of 12 volts DC at 3.2 amps. A particular advantage of this pump is that the motor itself is not cooled by the water being pumped and is thus less likely to be clogged by vegetable matter in the water.

When used at 12 volts the Bilge Mate pumps far more water than is likely to be desired for a small garden fountain or pool. Operating the pump at a lower voltage reduces the volume of flow as can be expected but it also reduces the current drain appreciably. At below six volts the current drain is less than one amp which is within the capacity of the supplied solar cells.

While solar cells normally have a nominal open circuit voltage (when fully illuminated) of 0.6 volts, this normally drops to around 0.4 volts under load. With fourteen cells, the total supply voltage varies between 5.5 and 6.4 volts, depending on the available sunlight. This is sufficient to give an adequate flow of water for most small fountains and recirculating garden pools. We estimate the volume to be around 300-500 litres per hour.

This assumes that the pump is working against a head of about 30cm or so. If working against zero head the pump is less efficient. Maximum head is about 1.2 metres. At around 6 volts, the pump is considerably derated so it should have a long life.

Construction of the Array

A number of problems must be taken care of in making an array of the 14 solar cells. First, they must be held securely and protected from any flexing which would crack them. No strain must be placed on the grid (negative) connections otherwise they may be damaged.

The principles of solar cells

Silicon solar cells are photovoltaic. They generate a voltage in response to light falling upon them. The cell is a pn junction as shown in Fig. 1. Light falling on the cell generates hole-electron pairs which are swept away to the two electrodes to produce a voltage between them.

The amount of energy needed to release electrons is called the band gap of the material and this is expressed in electron-volts. Silicon has a band gap of 1.12eV and this gives a cell with a maximum open circuit voltage of 0.6V.

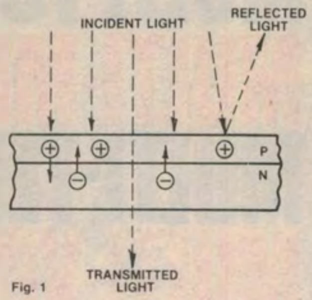


Fig. 1

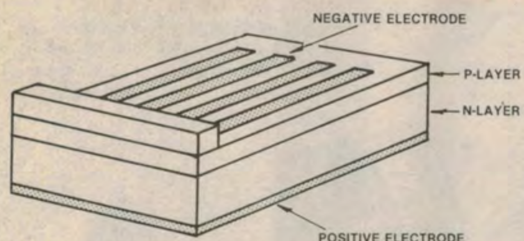


Fig. 2

The characteristics of a silicon solar cell are shown in Fig. 3. When not illuminated, the cell behaves like an ordinary diode with heavy currents flowing for forward voltages in excess of 0.6 volts. For reverse voltages relatively small currents flow. This is shown on the dark characteristic curve.

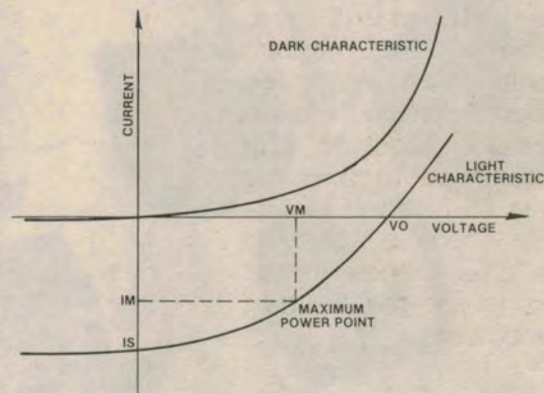


Fig. 3

When light falls upon the cell it generates an open-circuit voltage V_o, or delivers a short-circuit current I_s which is also the reverse current without any voltage applied. The maximum power output is at V_m and I_m, as shown on the light characteristic curve. For the cells in question this corresponds to an output voltage of 0.46V and a current of 1.1 amps.

The construction of typical solar cells is shown in Fig. 2. This shows a relatively thick base of n type silicon laid over the positive electrode. The top p-layer is an oxide of tin or indium or cadmium sulphide or gallium phosphide. This has a grid pattern for the negative electrode connection.

The cells must also be protected from the weather while being exposed to as much solar radiation as possible. This latter factor means that they cannot be housed under ordinary glass as its iron content will unduly attenuate ultraviolet radiation. The preferred glazing material for this application is Lexan (made by General Electric) or an equivalent transparent polycarbonate material.

Two sheets of this polycarbonate material will be supplied with the cells and the pump. Both sheets will measure 600×180mm, one 3mm thick and one 2mm thick. The thin sheet is the top cover while the thick sheet becomes the base.

A series of holes is drilled in the base sheet so that the connecting leads to the cells can be passed through it and interconnected. In practice this means that an 8mm (5/16-inch) hole should be drilled under each cell to make the positive connection while a small hole (about 2mm) adjacent to each cell allows the negative lead connection to pass through. Two holes are also drilled at one end of the array to take a pair of binding post terminals (one red, one black)

The "Bilge-Mate" pump must be fully immersed in the pool and should work against a head of at least 30cm for best results.

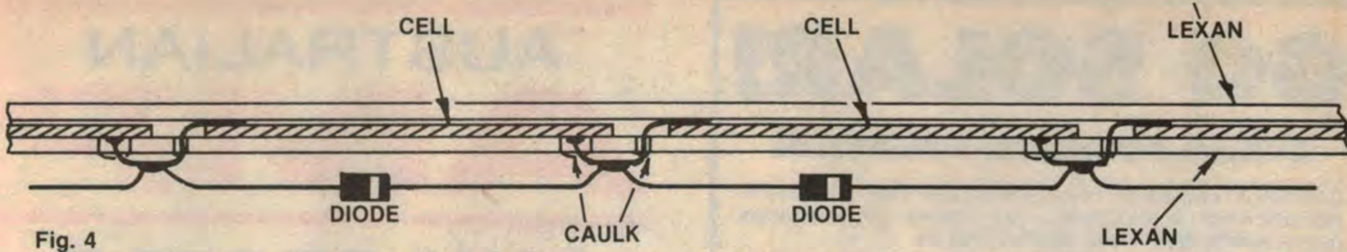


Fig. 4

This diagram shows the sandwich construction of the array with the cells held between two sheets of Lexan.

for the output connections to the pump.

The method of construction is as follows. The Lexan sheets are supplied with protective paper covering on both sides. This allows you to mark the positions of holes to be drilled with a soft pencil. Keep all holes in two straight lines so that the resulting wiring is neat and tidy. Do not remove the paper backing until all holes have been drilled and deburred. Do not use too high a drilling speed for this job otherwise the material will tend to melt.

Having drilled all the holes, remove the paper backing and place a dab of Dow-Corning silicone caulking compound in the centre of each cell mounting position on the sheet. Then place all cells in their respective positions and line them up so that their grids are oriented in the same direction. Be very gentle in handling the cells as they are very fragile. Squeeze the cells down on the sheet (very gently) so that they are held reasonably firmly by the suface tension of the caulking compound. (In time, the compound will cure.)

It is important that the top surface of the cells does not become contaminated by any foreign substance. Do not handle the top surface, and take care to ensure that the cells are not splashed with water or other liquids. Also, when soldering, avoid depositing flux sediment on the cell top surface.

Now solder a short length of stripped and tinned multi-strand insulated wire to the grid connection of each cell. Do not use single-strand insulated wire as it is too rigid and inclined to break or stress the cell connections. (We used a ribbon of tin foil for connections on our prototype but this is not available).

It is essential that you use a low-powered soldering iron with a small tip. Preferably, it should be a temperature controlled iron. Be very careful when making the solder connections to apply the very minimum of heat to the cell tab connections as they can easily lift from the cell surface.

Having made a connection to the top tab of each cell, pass each connecting wire through the Lexan sheet. Place the top Lexan sheet over the cells and then turn the entire sandwich assembly upside down so that the solder connections can be made to the underside of each cell, via the 8mm access holes.

Proceed until all the cells are connected in series. Then temporarily mount the binding post terminals and connect them. The red (positive) terminal should connect to the underside of the last cell in the series string while the black terminal should connect to the grid connection of the cell at the other end.

Now you are ready to test the array before it is sealed.

Take the array outdoors, and expose it to sunlight and measure the voltage across the output terminals. It should be close to 8.4 volts in bright sunlight. If not, check that you have 0.6 volts across each cell and that the series connections have been correctly made so that individual cell voltages all add.

Now immerse the pump and connect it to the solar array. With bright sunlight the pump should start immediately and pump at a reasonably high rate. With no outlet pipe attached to the pump it will place maximum loading on the array which should deliver 5.5 volts or more in bright sunlight. Under these conditions each cell should deliver about 0.4 volts.

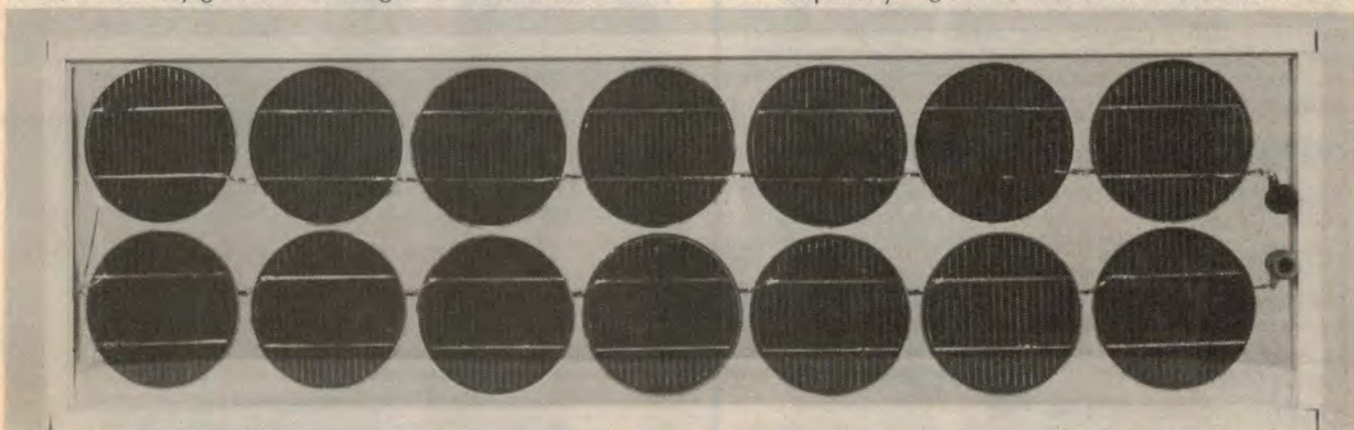
If the pump does not run it is probably because you have a bad connection to one of the cells or one of them has become partially open circuit. The voltage checks above should reveal any defect of this sort.

If one of the cells is defective, try bridging it out with a jumper lead. The pump should now run. However, if you have been reasonably careful in assembling the array you should not have any problems.

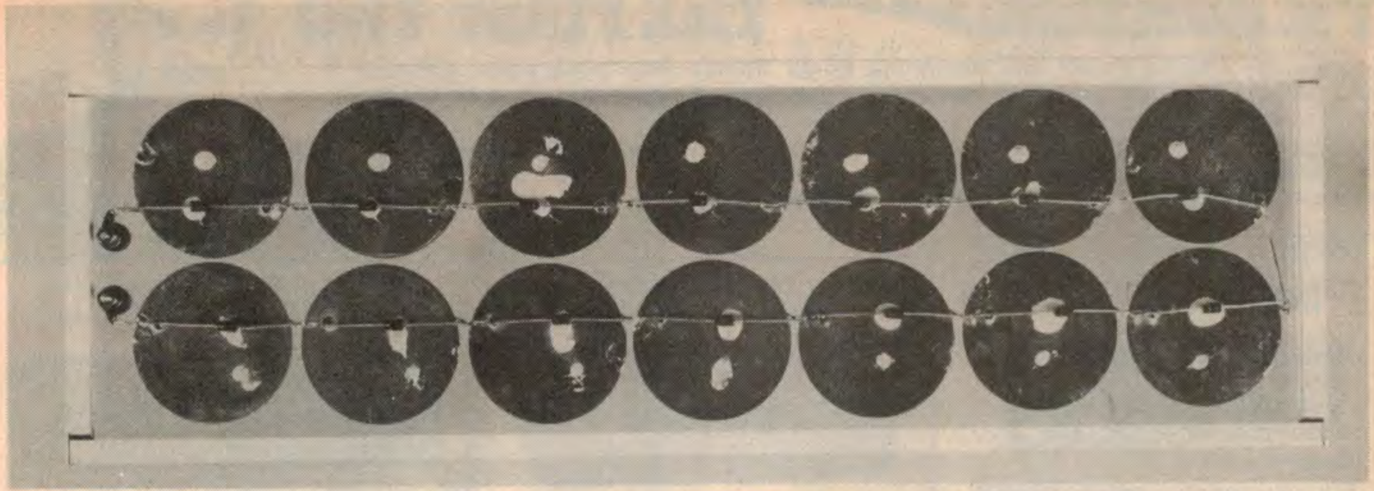
With these checks complete, we suggest the addition of a diode across each cell, connected so that it is normally reverse-biased. We recommend a diode type with a rating in excess of one amp. In practice, this means that most people will use the 1N5404 (14 required) which has a three-amp rating and is readily available.

The diodes are a protective measure. First, if one cell does become defective over the life of the array, the parallel diode will automatically shunt it out of circuit and only a small loss of performance will result, rather than complete failure. Secondly, if a leaf or other object lodges over one of the cells it will not be reverse-biased and possibly burn out.

Deep shadows falling over part of the array will also be protected against. This is important if the array cannot be posi-



The prototype solar array with extruded aluminium frame. Note the two binding posts. The cells to be supplied will have a different grid pattern.



The rear of the cell array showing the dabs of caulking compound on each cell and the protective diodes wired in place.

Optimum inclination for solar arrays

Darwin	17°
Cairns, Broome	22°
Rockhampton, Alice Springs	28°
Brisbane, Geraldton, Broken Hill, Perth	37°
Sydney	39°
Canberra, Adelaide	40°
Melbourne	43°
Hobart	48°

tioned high enough to avoid shadows falling over it at some time of the day. We wired the diodes directly across the back of each cell, as shown in the accompanying photographs.

With the wiring complete, there still remains the task of making a suitable frame for the Lexan sheeting so that the array is a rigid assembly. We made our prototype from white-enamelled aluminium extrusion which is normally intended for making flyscreens. This extrusion is made by Alcan and has two channels, one of which will hold the two sheets tightly together. A similar rolled and folded aluminium strip, also intended for flyscreen use, is available from most hardware stores and can be used for this purpose.

Individual constructors can make their own decision as to whether the aluminium frame should be mitred, lapped or butted. We used lap joints. Before slipping the frame work over the Lexan sheets, run a bead of silicone caulking compound into the channels to provide a good weather seal.

Wipe off any excess caulking compound after the frame has been assembled. Now set up the array in the sun and leave it to run the pump for several hours. This will make it quite hot and any moisture lodged between the sheets should be exhausted via the wiring holes in the bottom sheet of Lexan. Finally, seal each of these holes with a dab of caulking compound. The assembly should be completely sealed against any ingress of moisture

Constructors may also wish to provide a protective panel over the rear of the array, to avoid any possibility of damage to the wiring of the diodes. We did not do this.

When finally installing the array, it should be firmly mounted and positioned as high as possible so that it will be unaffected by trees, shadows, mischievous children and other hazards. Ideally, it should face due north and be inclined as shown in the accompanying table, to obtain maximum solar input, all year round. In this application, this is probably not really important.

Wiring from the solar array to the pump can be ordinary figure-8 mains cable but the overall resistance should be less than 0.3 ohms to avoid undue voltage losses. The wiring can be buried so that it is out of sight.

This posed picture shows the solar array with a set of three small cascading pools at Ferguson's Garden Centre, Narrabeen, NSW.

Where to buy the bits

Amtex Electronics, of PO Box 285 Chatswood, NSW 2067 will supply the pump, 14 cells and two sheets of Lexan or equivalent polycarbonate glazing cut to size. The price for the package is $150. See details in the advertisement elsewhere in these pages. Aluminium flyscreen framing can be obtained from hardware stores or Alcan aluminium centres. Selley Dow-Corning silicone caulking compound is available from hardware stores in tubes or cartridges. The cartridges cost about $6.60. 1N5404 diodes can be obtained from almost any electronic parts retailer, as can figure-8 cable. Fountains and recirculating pools can be obtained from landscapers, nurseries or home handyman centres. Have a nice day! Good gardening!