Soft Technology

Alternative Technology in Australia No 31 Apr 1989 $2.50

GUITAR AMP

RESOURCES CATALOGUE

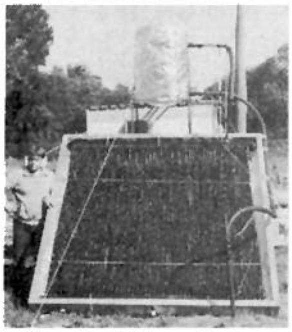
SEGNER TURBINE

CHEAP GENERATORS

A.T. FOR ABORIGINAL COMMUN-ITIES

BUYING A SOLAR HOT WATER SYSTEM

SOFT TECHNOLOGY



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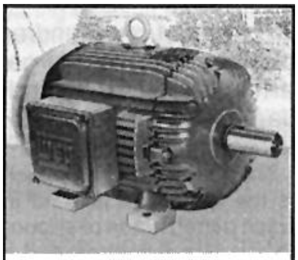

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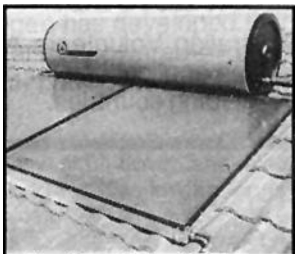

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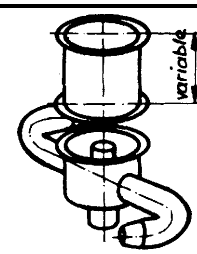

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This issue of Soft Technology was edited by Ian Scales with the help of Alan Hutchinson, Mick Harris, Noel Jeffrey and others.

If you are interested in being involved in the production of this magazine, please leave a message on (03) 650 7883.

Comments, contributions and criticisms are welcome and should be sent to the

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Worlds's biggest PV array

An array of one hundred solar-cell panels put up at a large site in the artificial Rokko Island in Kobe, Japan, generates a total of 200 kilowatts of electricity.

The 1.3 billion Yen experimental site is the largest of its kind in the world. Each panel, made of silicon semiconductors is 3 x 6 metres and generates a maximum of 2 kilowatts of electricity. Each panel can provide enough electricity during the day for normal home use if the weather is fine.

Work abroad?

Australian Volunteers Abroad are inviting applications for positions in developing countries.

The Overseas Service Bureau, an independent community organisation which administers the AVA program, regularly receives requests for people with skills in appropriate technology.

To be considered for a place in the AVA program applicants must have a recognised trade or professional qualification and a minimum of two years working experience in their field.

Their assignments are usually for a period of two years. The scheme provides an opportunity to work with local people in any one of more than 25 countries in Africa, Asia or the Pacific, sharing their lifestyle and conditions, and earning the equivalent of a local salary.

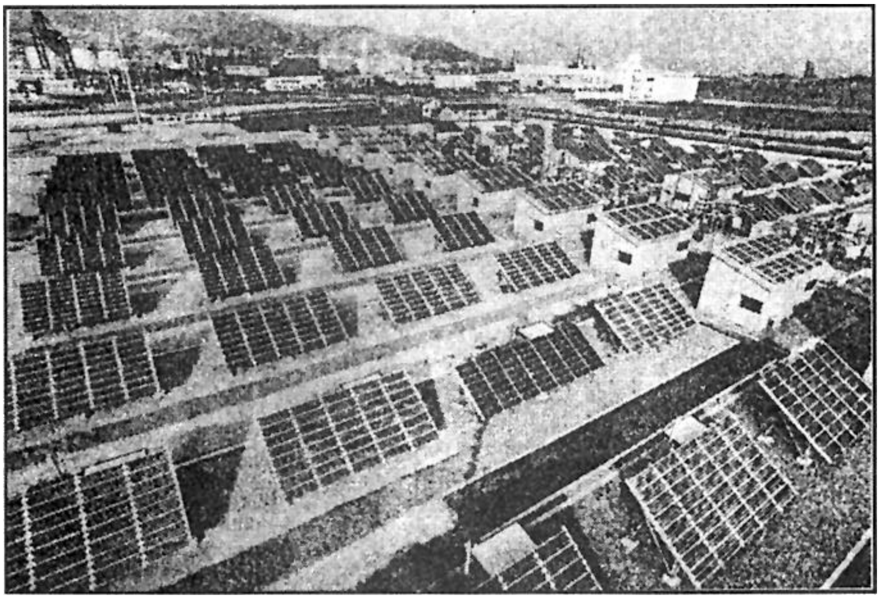
Contact the Overseas Service Bureau, P.O. Box 350, Fitzroy 3065 (phone (03) 419 1788).

Alcohol fuels for Australia?

In the early 1990's Australians could be driving cars powered by alcohol fuels. Studies by the Victorian Solar Energy Council show that Victoria has the land, water and climate for the production of substantial quantities of organic matter suitable for alcohol production.

VSEC estimates that processing this organic matter could provide sufficient neat alcohol to replace up to half of Victoria's annual petrol requirements.

Modern passenger car engines require no adaption to run on low alcohol blends. In a blend of 10% alcohol with petrol, alcohol acts as an octane booster!



The 200 kW solar cell installation in Japan

Wind news from down South

Victoria's new experimental grid-connected wind generator at Breamlea has had impressive results. During a period of unusually strong winds, the machine's output proved considerably higher than the original estimates.

The machine continued operating normally even during the gale-force wind conditions which buffeted the coastal site during that period. The machine was built by the Westwind company of West Australia.

In South Australia a detailed cost study is now being completed to fund a demonstration wind turbine to be connected to the Coober Pedy town supply.

The South Australian Wind Energy Program has also been evaluating other likely sites for wind generators.

Rainbow Power

The Rainbow Power Company of Nimbin, NSW, recently bought out the well-known "Alternatives" alternative energy shop in Brisbane.

Adrian Hogg, the previous owner needed a break but is still working at Alternatives part-time.

Putting a price on the priceless.

West German researcher Olav Hohmeyer has tried to price the costs to society and the environment of solar electricity compared with fossil and nuclear fuels.

By comparing costs in environmental damage, loss of working hours due to radiation-related diseases from past and possible future nuclear accidents, depletion of renewable energy sources and economic benefits, he found that solar power was between five and 13 cents a kilowatt-hour cheaper.

Although relating specifically to West Germany, he said there was a similar difference in most countries.

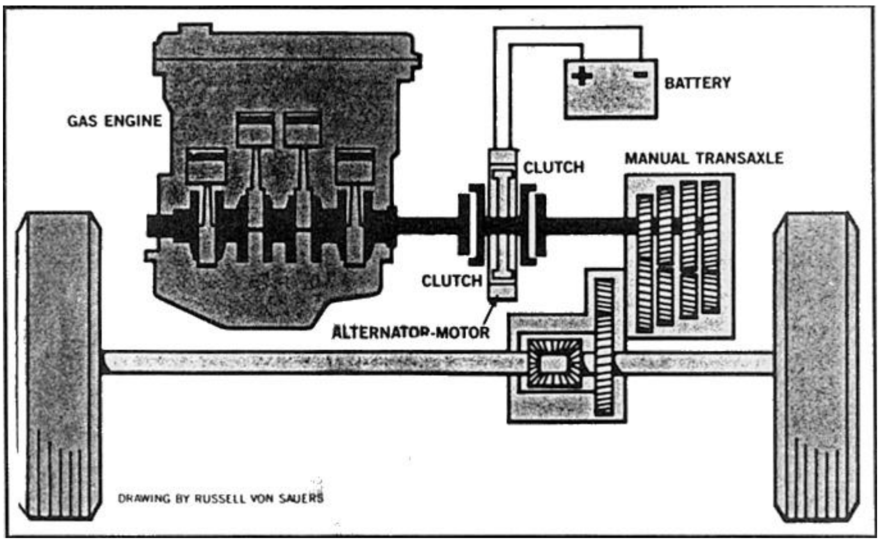
Petrol/electric drive car

Volkswagen has developed an experimental car powered by a combination of petrol engine or electric drive.

For city driving the petrol engine is automatically shut down and electric power takes over, allowing cruising speeds up to 50 km/h.

For acceleration and highway cruising the petrol engine restarts. The car uses a combination alternator-motor.

VW claim overall efficiency improvements of about 35% compared to their 'Golf' model, and a 55% improvement in city traffic.



VW's combined electric- and petrol-drive car

Hioki 3242 Solar Charged Digital Multimeter.

Now that you've got used to solar powered calculators here's a new toy for you... the solar powered digital multimeter.

Built into the case is a small amorphous silicon photovoltaic array which is used to charge a 2.5 volt NiCad battery. The meter then runs off the battery. A few hours are required to charge the battery (depending on light level). They claim 16hrs operation after 8hrs charging from clear sky.

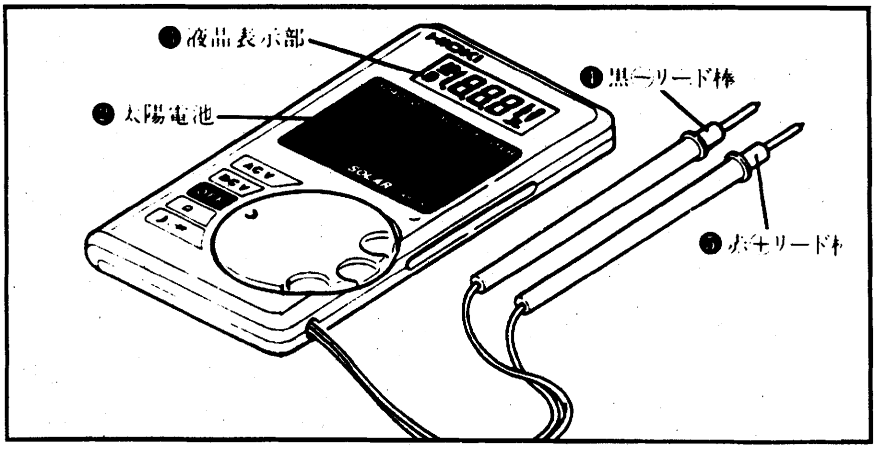
As a multimeter it's not too bad.

A switch selects ac volts, dc volts, resistance and continuity/buzzer modes. It autoranges within the modes.

Ranges.

DC volts 0.2, 2, 20, 200, 500
AC volts 2, 20, 200, 500
Ohms 200, 2K, 20K, 200K, 2M, 20M

The accuracy is not quite as good as comparable meters (probably due to the lower operating voltage).



Solar-powered multimeter

It comes in a nice compact little plastic case with a fold out back which holds the leads. Inside it's a very neat design using a custom IC and surface mounted components.

Overall it makes a good little general purpose multimeter with the nice twist that you don't need to buy new batteries for it. (a real advantage if its a half hour drive to the nearest shops).

Price $79 Distributed by Neilsen Instruments.

Weather data-logger

The Digitar company are marketing a range of low-cost small weather stations utilising microprocessor control packaged in small dedicated units.

The units monitor wind speed and direction, rainfall, temperature and pressure and apparently have data-logging capacity.

Certain models interface with personal computers. Such units are useful to those planning windpower installations. Initially three models of weather computer and one model of micro-thermometer will be available, ranging in size and capabilities.

Marketed by Solar Flair; Emerald, Victoria.

BP solar panels.

BP Solar Australia's range of Suntamer solar panels released a year ago have received an upgraded power rating.

This has been achieved by using an anti-reflective coating. The extra power is achieved by increased light absorption and hence a boost in solar cell convers on efficiency. Previous ratings of 52 and 44 Watts have now been increased to 55 and 46 watts.

A Solar Water Heater for Remote Aboriginal Communities

Martin Anda, Goen-Eng Ho, Kuruvilla Mathew

In numerous past issues (#'s, 11, 17, 19, 22, 25) we've looked at various examples of low cost and alternative solar water heaters. In this issue we look at the work in this field by the Remote Area Developments Group (Institute For Environmental Science, Murdoch University, W.A. 6150).

The group in conjunction with the Appropriate Technology Unit at Newman Campus - Hedland College has been developing a new, low-cost solar water heater for remote area Aboriginal communities.

"(The) aim is to contribute to the establishment of remote Aboriginal communities so they become a sustainable lifestyle option in modern times."

A regular and plentiful supply of hot water is necessary in the communities for showering and laundering to alleviate the immense health problems of trachoma and skin diseases. These are generally caused by dust and unhygenic conditions.

In recent years many small family groups of Aboriginal people have been moving away from larger settlements back to their traditional lands to estab-

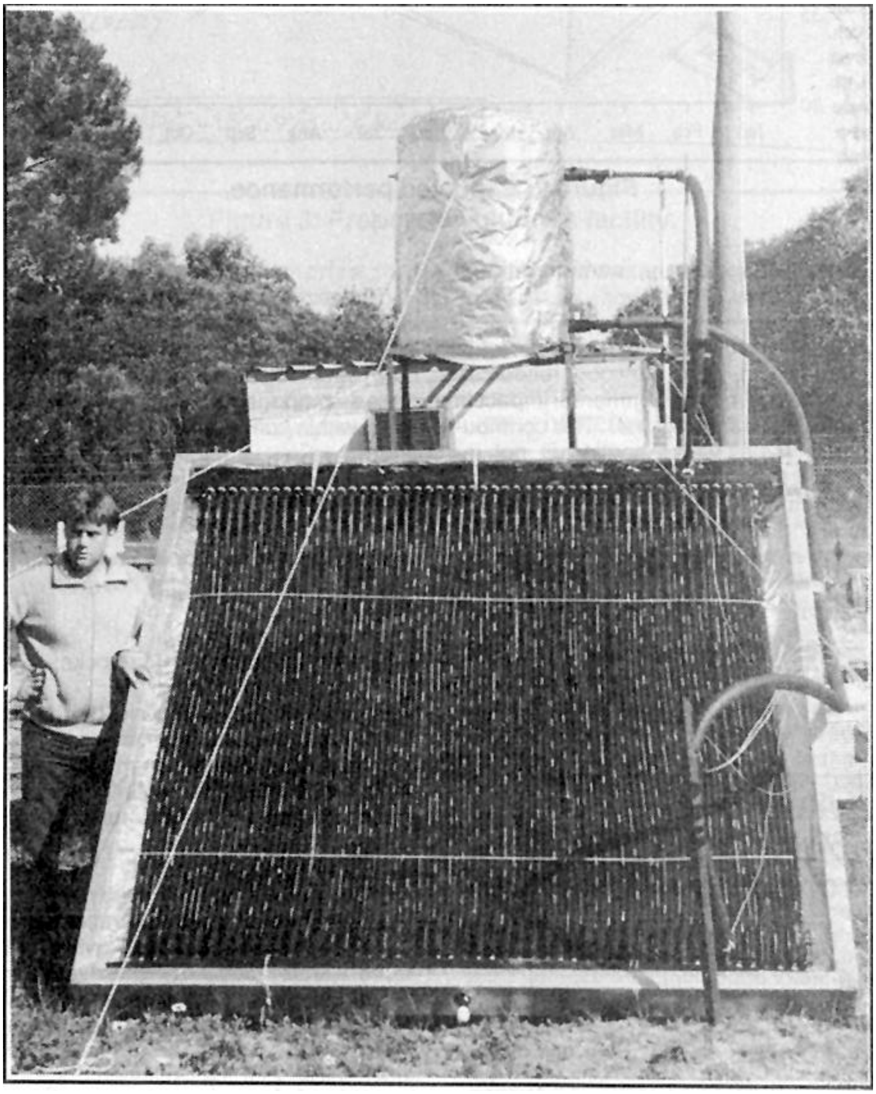


Figure 1: Tubing-type collector.

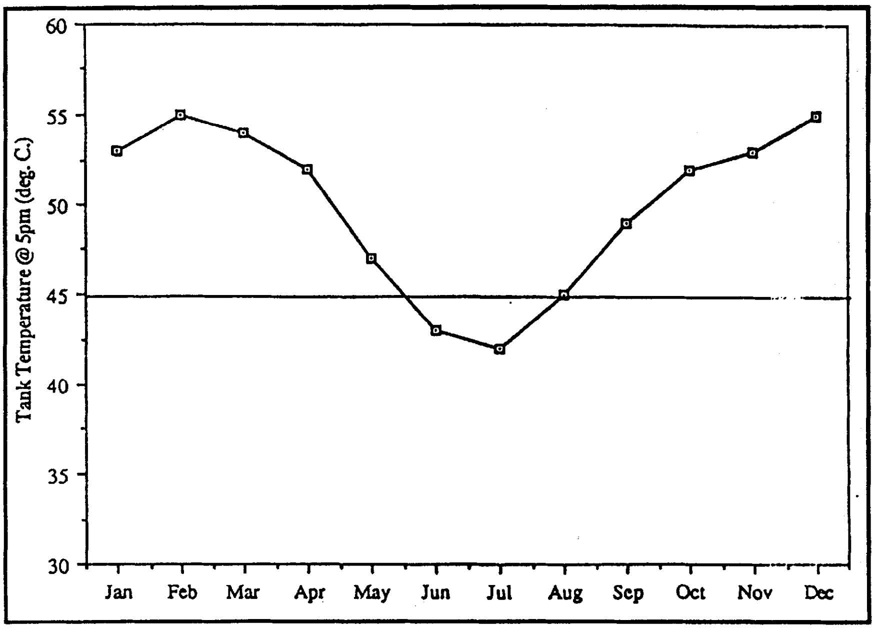


Figure 2: Expected performance.

lish semi-sedentary, semi-traditional communities.

Solar energy can help to reduce the demand on local firewood resources and reduce the environmental impact in these semi-arid regions. The contribution of solar water heating is not intended to completely replace fire which is an integral aspect of Aboriginal culture and a technology with which they are greatly skilled.

"One or two communities in the Pilbara are interested in having the solar water heater operating there as a pilot study."

Failure of conventional technology

Conventional solar water heaters are plagued with the following problems in remote communities:

(1) the quality of water in remote areas leads to a rapid build- up of deposits in the coppertubes, resisting flow or causing complete blockage;

(2) freezing causes fracture of the copper tubes;

(3) servicing of cracked tubes or other failed components is not readily available within communities;

(4) contractors have sometimes installed the equipment incorrectly;

(5) Aboriginal people find difficulty relating to that technology in a meaningful way;

(6) glazing is smashed by rocks;

(7) absence of electricity to boost supply on overcast days; and

(8) the volume of hot water generated is sometimes insufficient for a given usage pattern.

With the high amount of solar radiation in north and central Australia there should be motivation to provide hot water with a reliable and passive solar system. Freezing has been overcome in some commercial units through the use of glycol heat exchange. Tempered glass will reduce the likelihood of rocks smashing the cover. Each of these add expense and complexity to the device. It is not necessarily appropriate to use second-hand components in this application because the prototype should reflect a unit that can in the future be made in quantity from readily available materials.

A new approach

Two different collector prototypes are being developed. One uses black polyethylene reticulation tubing as shown in Figure 1 and the other uses swimming pool heating batts (thanks to Solar Batt International P/L). Each of these materials are cheap and readily available. The collectors were $4m^2$ in area and unglazed.

An unglazed collector will lose a large amount of heat through long-wave radiation and wind. However, the reduction in performance needs to be evaluated against the costs and problems of glazing. Moreover, a fully glazed collector will bring the polyethylene close to its maximum continuous operating temperature of 80°C at stagnation.

The storage tank used was a plastic drum to avoid corrosion. This was insulated with fibreglass and the water was found to lose only several degrees Celsius overnight. The 200 litre volume was found to be sufficient for showering and washing clothes of 4-5 people. Hot water flowed from the collector to the storage tank by thermosyphon natural circulation.

"Ultimately, a design will be developed that can be manufactured by a small, Aboriginal enterprise that supplies equipment to establishing communities."

Without glazing the collector's overall heat loss coefficient was found to be 25-60 W/m^2C mainly influenced by wind, while a conventional glazed collector is typically 6 W/m C. The time taken in September to reach the acceptable tank temperature of 45°C was 2.5 hours for the batts and 3.5 hours for the tubing. By substituting the 19mm tubing with 13mm the collector will have a faster response time. 50 litre draw-offs at 10am and 3pm had minimal impact on the tank temperatures. Final tank temperatures in September in Perth were typically 40°C while in Newman they were 50°C. Figure 2 gives an estimate of how the unit might perform throughout the year in the north of W.A.

Refinements

The experimental prototype needed modifications based on tests so far. An improved, semi-glazed prototype of smaller modules will be made in 1989 with a close-coupled, plastic tank for connection to mains via a pressure reducing or float valve. It is still hoped that an unglazed collector connected to a woodheater will provide sufficient hot water to a small, remote community throughout the year. One or two communities in the Pilbara are interested in having the solar water heater operating there as a pilot study.

New directions

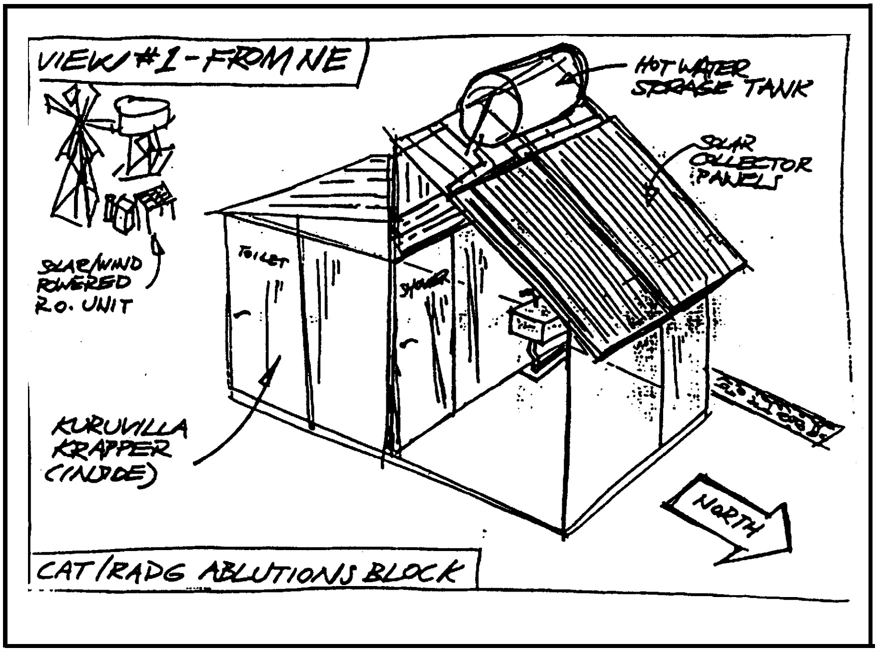


Figure 3: Proposed ablutions facility.

Ultimately, a design will be developed that can be manufactured by a small Aboriginal enterprise that supplies equipment to establishing communities. This might be similar to the Centre for Appropriate Technology in Alice Springs. An aim is to produce a solar water heater that might retail at around $600 which could then be attractive to the wider community. The group is working on a number of projects including an appropriate technology data base accessible by agencies, organisations and communities by modem or mailed-out discs; a low water demand, water-seal pit toilet; and evapotranspiration trench for the disposal of grey water and a wind or solar-powered, reverse-osmosis desalination unit.

By May this year it is intended that an ablutions block will be built at Murdoch University (and later at Newman Campus - Hedland College). The facility will be used for display and incorporate the C.A.T. basic design and chipheater plus the solar water heater, the evapotranspiration trench and the low water demand, water seal pit toilet as shown in Figure 3.

> **"An aim is to produce a solar water heater that might retail at around $600 which could then be attractive to the wider community."**

The Remote Area Developments Group looks forward to the same level of consultation and acceptance amongst Aboriginal communities as the Centre for Appropriate Technology has achieved with the VIP (ventilated improved pit) toilet and the Murdoch University Energy research Institute with the solar-powered coolroom. Their aim is to contribute to the establishment of remote Aboriginal communities so they become a sustainable lifestyle option in modern times.

THE ATA REPORT

The Alternative Technology Association has moved to the first floor of Ross House (The Environment Centre) Flinders Lane, Melbourne (for our new phone number and address, look up the 'Contents' page of this issue).

Off ice

We have moved off ice in order to take advantage of the greater range of facilities available - like the Fax machine and enlarging/reducing photocopier. There are also a larger number of organisations with philosophies similar to our own in the building. We now have an answering machine connected to the phone so feel free to leave us a message. Noel Jeffrey has taken on the office work, he is coming late most afternoons to deal with correspondence and newsletters.

Solar Workshop

We now have a metal-cutting lathe at the Solar Workshop which is available for ATA members to use (ring for further details). The lathe is a full screw-cutting lathe with 3 foot bed and 12 inch swing, complete with milling attachments and three and four jaw chucks. We will be holding workshops on its use in the near future. Members should keep their eye on the newsletter.

We have run another two welding workshops already this year - but now our supplies of scrap steel are getting low so if you know of any supplies of any size scrap let us know. We will be running two interesting mid-year workshops - one on powering a house without SEC power, and the other on metal fabrication which we will advertise through the Council of Adult Education.

Display Trailer

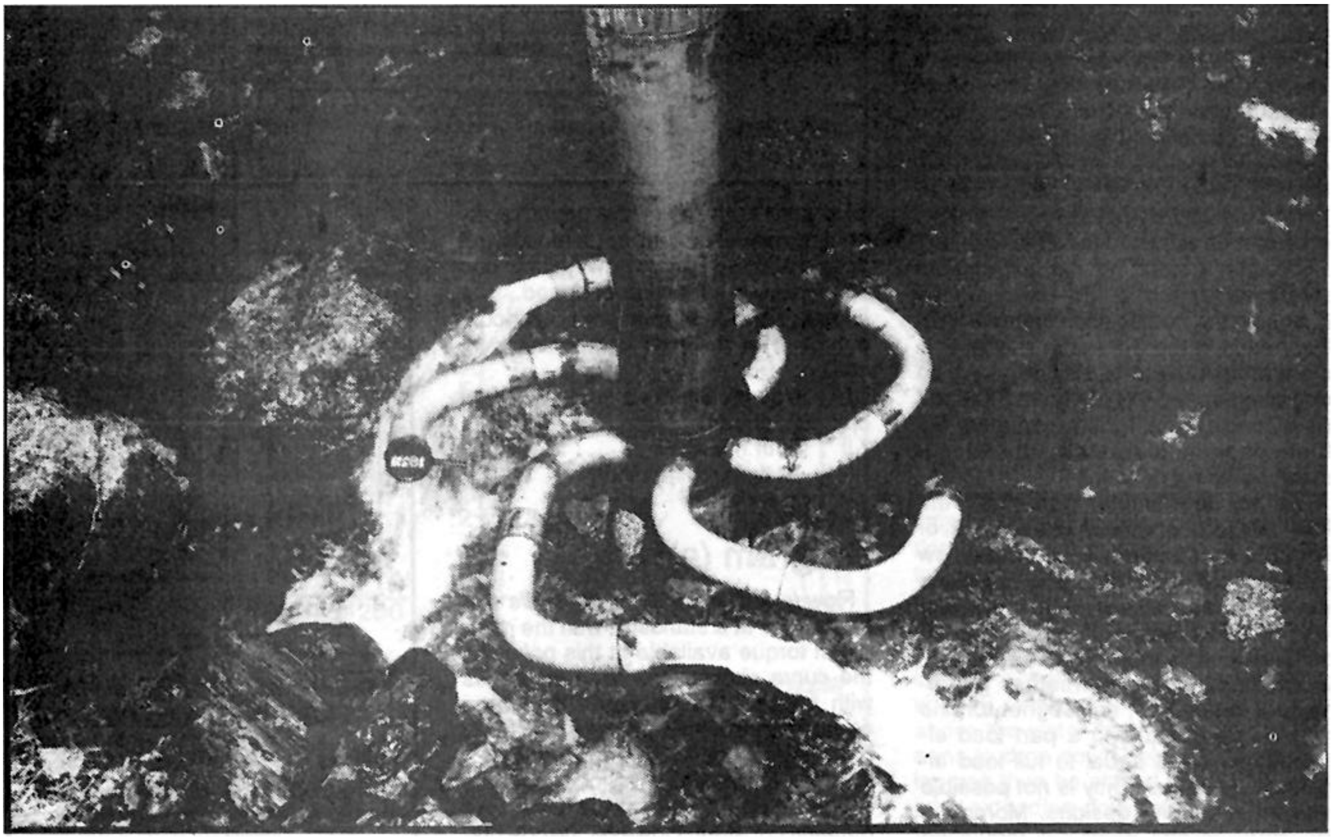
The trailer has had several outings recently, including the Down to Earth Confest over New Year, Moora Moora coop (near Healsville), Tallaroop Field Day and as part of the Palm Sunday Rally. At the Confest we ran Christmas lights up the wind generator tower and powered these off the trailer's own batteries and photovoltaic cells. The effect of multi-coloured Christmas lights flashing on and off was charming.

Policy Work

Work is continuing on energy policy in relation to the greenhouse effect. The ATA is having input to a Victorian Government interdepartmental committee on the greenhouse effect.

Our President in a Confest mood.

The Segner Turbine.



An easily constructed low head water turbine.

by Alan Hutchinson (from a publication by SKAT)

Many different designs of water turbine have been developed since humans first harnessed water power to their energy needs. Varying head, flow and power requirements will make one design more preferable than another in a given situation. Here we present details of a design which, although not as efficent as some others, is a lot easier and cheaper to construct with limited facilities and can be more readily adjusted for variations in flow.

The Segner turbine was invented in 1750 by J.A. von Segner probably on the basis of Bernoulli's work in 1738 on the water jet reaction effect. It uses the reaction effect : if you squirt a jet of water out of a nozzle, the nozzle tries to move in the opposite direction to the water. Its the exact opposite of the Pelton wheel which is a pure -turbine. It was used to power some mills in Germany and America until it was forgotten as other ideas came along. Its still used today in things such as garden sprinklers (the type with bent arms which rotate) and helicopter blades (with compressed air).

Basic Design

The Segner turbine consists of an inlet channel(1) [see Fig 1] with a cylindrical funnel through which water enters a vertical pipe (2). At the bottom of this pipe, two (or more) radial pipes (3) are provided with bends, to which nozzles (4) are fixed. This arrangement is done in such a way, that a water jet through these nozzles has an exactly tangential direction. The vertical pipe is held in place by a shaft (5) with spokes (6) which is supported by an upper and lower bearing (7), so that the vertical pipe with the radial arms at the bottom is free to rotate around its axis. A pulley (8) serves as the power take-off element.

The water consumption (Q) of the Segner Turbine depends on the head (H) under which the unit works, the total nozzle cross sectional area and the circumfrential speed of the nozzles. For a determined working condition, outflow through the nozzles is thus given. Inflow is then adjusted with the help of a simple sliding gate (9) in the inlet channel in such a way that the vertical pipe remains completely filled. The operator can easily find this out by watching the top of the inlet funnel: optimally the funnel should very slightly overflow and the gate can be adjusted to achieve this.

You can determine the appropriate rotational speed of the machine by choosing the nozzle pitch diameter (D). For heads in the 3-5 metre range, D is standardised at about 1.5m giving an operating speed (N) of about 100 RPM (at a head of 3m). Pulley diameters are then chosen to match this to the machine being driven.

The nozzle diameter (d) defines the flow rate (Q) and is made smaller or larger to correspond to the actual flow available at the inlet. The machine works just as well with only one water jet. For a flow of 50% of the design flow rate, one nozzle may simply be capped, which enhances dry weather performance. In this way, the Segner turbine may be operated with a part load efficiency which is equal to full load efficiency. This, incidently is not possible with other turbine designs. Moreover, the machine has good self-regulating characteristics.

Operating characteristics.

Fig 2 shows the relevant characteristics of the Segner Turbine in operation. For better understanding, a grain milling situation is used as an example.

Performance characteristics at full design flow and at reduced flow may easily be found for optimal loading at the highest efficiency point, maximum power output, overloading of the machine and runaway conditions at no load. The operating points found for all these situations confirm that the Segner Turbine indeed gives excellent performance in mill applications.

For each of the two operating conditions, Q = 300 l/s and Q = 150 l/s, two diagrams are shown, the upper representing power output as a function of speed and the lower showing flow and efficiency as a function of speed. The lines I, II and I+II represent power consumption of the milling machinery installed:

I : A rice huller consuming 3 kW (at optimum speed)
II : Flour mill 4kW
I+II: Both machines 7kW

Diagram (a):

Flow (curve Q) amounts to 170 l/s with the turbine at a standstill, with the maximum torque available at this point. As the curve shows, flow then increases with speed (N) and nozzle discharge equals inflow at a speed of 163 RPM. At this point, power output (curve P) reaches its maximum. Since inflow is limited, Q does not increase further but remains constant. However, nozzle discharge under the full head increases due to centrifugal forces if the speed is increased further. This results in a drop in the water level in the vertical pipe until equilibrium is reached at the maximum (runaway) speed (191 RPM). This drop in head results in a steep drop in power output between maximum output speed and runaway speed. This is very useful for turbine speed regulation without flow adjustment.

Efficiency (curve n) of the turbine is at a speed of 128 RPM. This point is chosen for design considerations for obvious reasons. (Shown as Nopt line in diagram) With speed increasing further, efficiency at first decreases gradually up to the point of maximum power output and then drops steeply to zero at runaway speed.

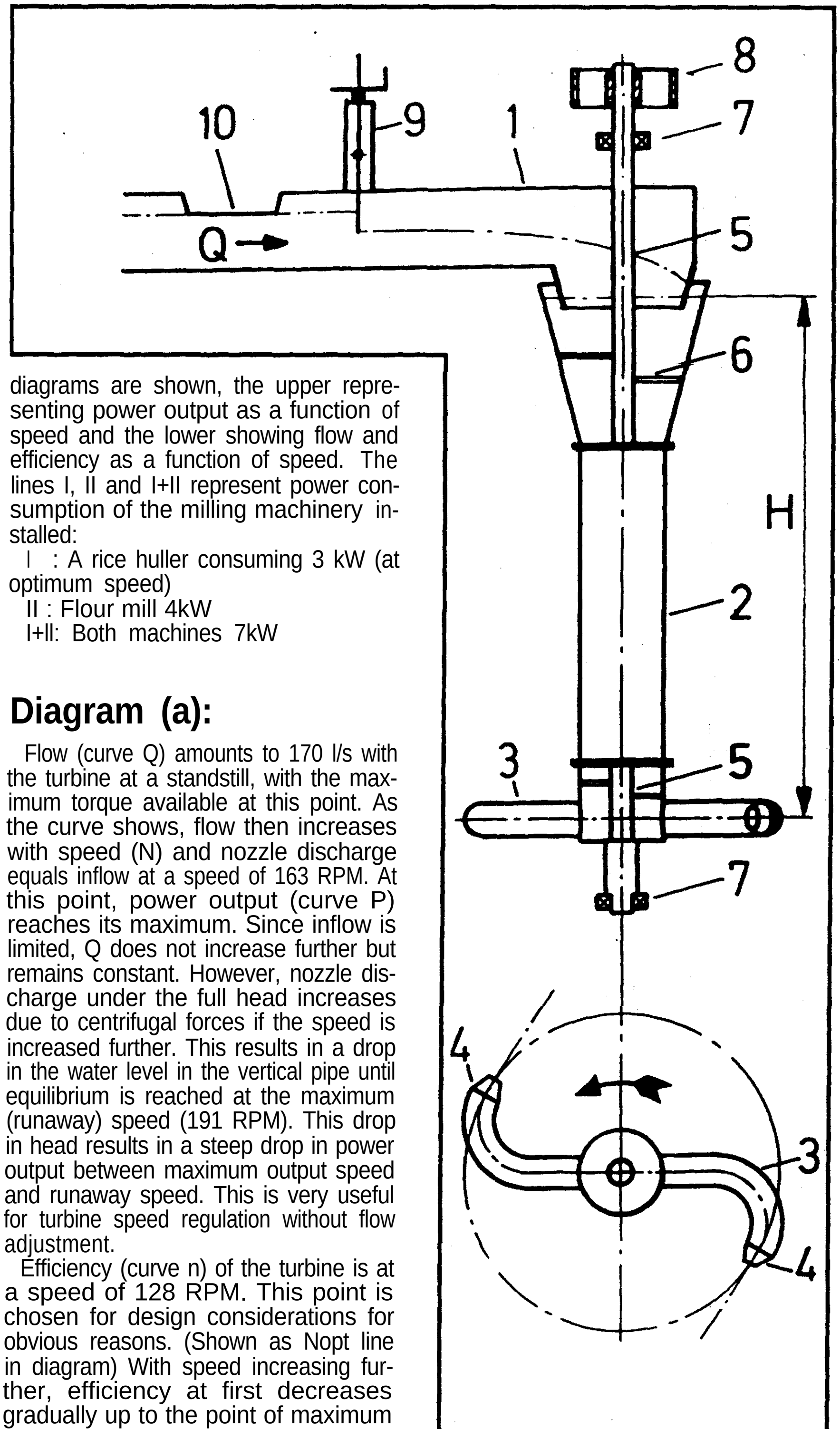


fig. 1 Basic design of a Segner Turbine

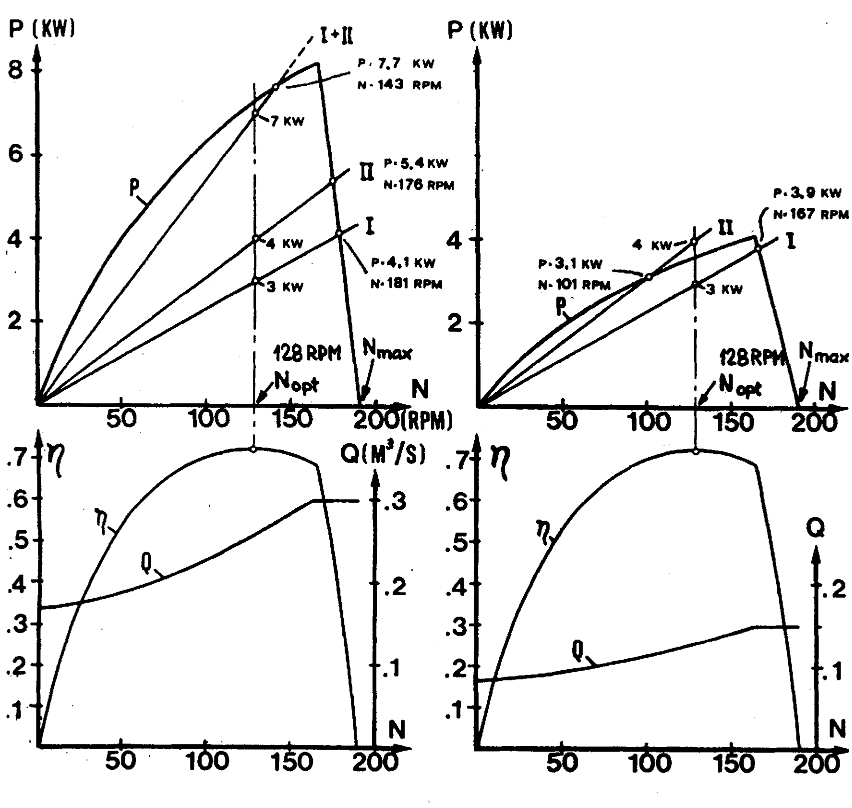


Fig 2. Performance A: 2 nozzles B: 1 nozzle

Complete Technical Data:

net head	**Hn**	**4 m**	**nozzle pitch diameter**	**D**	**1.5m**
nozzle diameter	**d**	**11.3 cm**	**nozzle coefficient**	**cf**	**0.96**
flow available	**a: 300 l/s**		**b: 150 l/s**		

Diagram (b):

Here the turbine is adapted to an inflow of 50% of full flow and nozzle discharge is cut to half simply by putting a cap on one of the nozzles. (Note that no imbalance is caused by this since the capped arm remains full of water.)

The efficiency curve remains the same as with full flow. So do optimum speed and runaway speed, while flow and power curves reach exactly 50%.

Installation components.

The components of a typical Nepalese milling installation are shown in fig 4.

If two sizes of nozzle are used, the smaller being 60% of the cross-sectional area of the larger, then the flow rate variations shown the table in fig 3 are possible.

The application diagram in fig 3 shows power output curves as a function of operating head and flow rate.

Construction.

The shaft is supported at the top by an ordinary flange mounting radial ball bearing and at the bottom by a specially sealed taper roller bearing (to take the trust due to the weight of the column).

A lower power version could be made with somewhat narrower pipe. The main requirement is that the head lost due to flow down the central column is small (ie the velocity head is small relative to the static head).

In 1983, 3kW machines were available in Nepal for less than $800 complete.

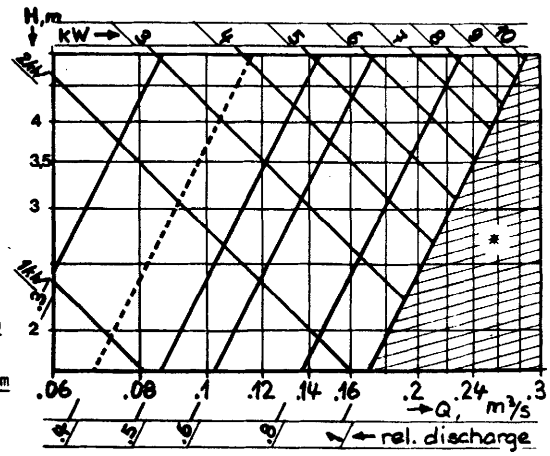
Why publish an article about this sort of turbine in Australia?

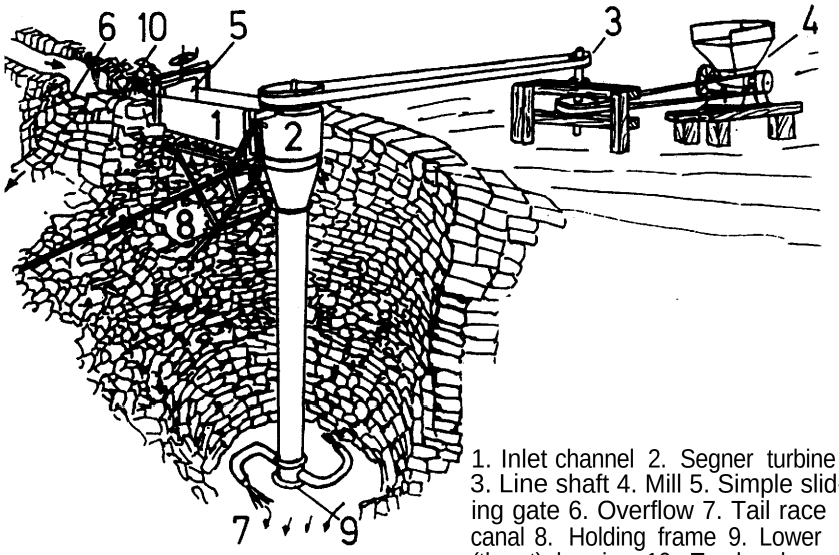
I think that smaller units built could be built very cheaply from plastic plumbing fittings without sophisticated construction equipment. It would be interesting to see the results of local experiments with low head versions. With this design there are no tight tolerances to be met and the only real problem, that of sealing the bottom bearing, can be dealt with by raising the bearing 30-40 cm above the water level and allowing the arms to drop down below it. The bearing can then be placed inside a plastic tube extending downward to keep the water off it. As an aid to would be ex-

fig 3. Application Diagram

Size of nozzles: radial arm 1	radial arm 2	Relative discharge
large	large	1
large	small	0,8
small	small	0,6
large	blind fl.	0,5
small	blind fl.	0,3

size of large nozzles: d=113 mm
→ cross section: A=2x0.01 m²
size of small nozzles: d=87.5 mm
→ cross section: A=2x0.006 m²





1. Inlet channel 2. Segner turbine 3. Line shaft 4. Mill 5. Simple sliding gate 6. Overflow 7. Tail race canal 8. Holding frame 9. Lower (thrust) bearing 10. Trashrack

perimenters, we have included the basic design formulae (see box). One interesting advantage of the Segner Turbine is that its a particularly open design which is less likely to jam on obstructions which swim into it like eels or frogs!

The material in this article is culled from a publication called The Segner Turbine : a low cost solution for harnessing water power on a very small scale by Ueli Meier, Markus Eisenring and Alex Arter. It was published by SKAT (Swiss Centre for Appropriate Technology at the University of St. Gall) about 1984. The ATA has a copy if you want to have a look at it.

PERFORMANCE CALCULATIONS

Symbols used

H	[m]	available head
Q	[m^3/s]	available water flow
D	[m]	nozzle pitch circle diameter
d	[m]	nozzle diameter
z		number of nozzles
cf		nozzle coefficent
n		efficiency
N	[rpm]	rotary speed
P	[kW]	shaft power
T	[Nm]	shaft torque
A	[m^2]	nozzle cross sectional area
u	[m/s]	circumferential velocity
w	[m/s]	relative velocity
g	[m/s^2]	gravitational constant
r	[kg/m^3]	density (of water)

BASIC FORMULAE:

$P = Q.H.r.g.n.10^{-3}$ = hydraulic power

$A = z.d^2.pi/4$ = nozzle cross section

$P = T.pi.N/30$ = rotary power

$N = u.60/(D.pi)$ = rotary speed

$u = D.pi.N/60$ = circumferential velocity

SEGNER FORMULAE:

$Q = z.d^2.(pi/4).cf\sqrt{2gh+u^2}$ = discharge

$P = A.w.u.(w-u).r.10^{-3}$ = power output

$T = A.w.(D/2)(w-u).r$ = shaft torque

With given inflow, the working head (water level in vertical pipe) remains constant up to a certain speed (N_{limit}). In the case of higher speed, working head will be decreasing. This is reflected by formulae for N_{limit} and N_{max}.

$n = [u/(g.H)](cf\sqrt{2gh+u^2} - u)$ = efficiency

$n_{max} = 1 - \sqrt{1 - cf^2}$ = max. efficiency

$w = cf\sqrt{2gH + u^2}$ = relative velocity

$N_{limit} = (60/[D.pi])\sqrt{(Q/[cf.A])^2 - 2gh}$ = speed limit for full head

$N_{max} = 60.Q/(D.pi.A)$ = runaway speed

$N_{opt} = (60/[D.pi])\sqrt{gH([1/1-cf^2]-1)}$ = speed at max. efficiency

CALCULATION EXAMPLE

Given parameters:
$H = 4.0m$, $Q = 0.15m^3/s$, $cf = 0.96$
hence:

$n_{max} = 1 - \sqrt{1 - cf^2} = 0.72$

$P = Q.H.r.g.n_{max}.10^{-3} = 4.24$ kW

(the turbine is to operate a 4kW oil expeller with a turbine speed in the range of 100 to 150 rpm.)
Nopt = 120 rpm (selected)

so $D = (60/[N_{opt}.pi])\sqrt{gH([1/1-cf^2]-1)} = 1.6m$

$u_{opt} = D.pi.N_{opt}/60 = 10.05$ m/sec

$A = Q/(cf\sqrt{2gH + u_{opt}^2}) = 0.0117\ m^2$

so

$d = \sqrt{A.4/(z.pi)} = 0.086$ m ($z = 2$ selected)

Check for the acceptability of runaway speed:
N = 60.Q/(D.pi.A) = 154 rpm
Available torque at operating speed:
T = (D/2) . A.w.(w-u).r = 336.75 Nm

BUYING A

Solar Hot Water System

Part One

In most parts of of Australia, between 65 and 80 percent of domestic hot water can be supplied by a solar water heater.

There is now a proliferation of different brands, types and sizes of solar water heating systems on the market. This issue we give some clues to help reduce your bewilderment when shopping for a system.

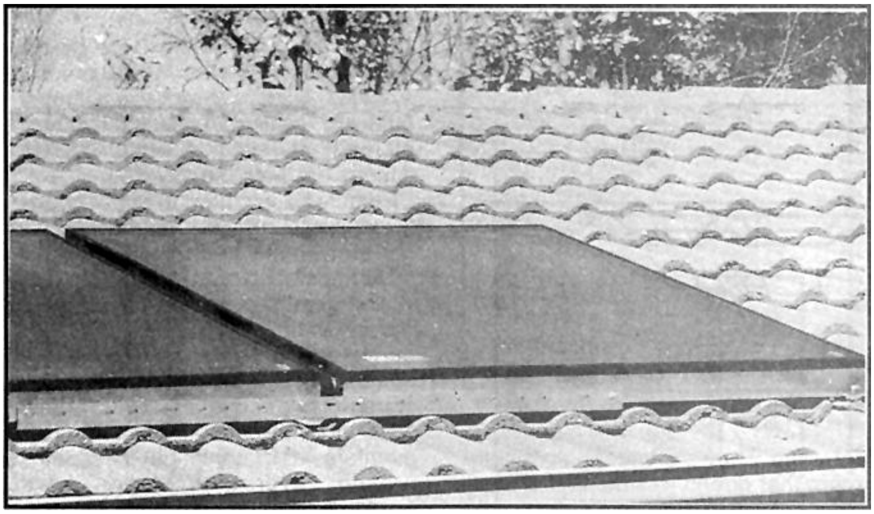
Soft Technology has contacted all the manufacturers of domestic solar hot water systems in Australia that we could find. In Part Two we will present the results of our survey, along with tips on sizing and siting your system.

Introduction

Right throughout Australia, the contribution of a solar water heating system justifies the initial capital outlay. Here are figures for the average annual solar contribution using a typical (flat-plate collector) system:

Darwin	90-95%
Cairns	80-85%
Brisbane	75-80%
Perth	75-80%
Sydney	65-70%
Adelaide	65-70%
Canberra	60-65%
Melbourne	55-65%
Hobart	50-55%

Several designs of solar water-heating systems are available. Each comprises collector, storage tank and interconnecting piping. Briefly, the three major types are the flat-plate collector system, the heat-pipe system and the heat-pump system. We'll explain these later. Right now, we will go through the various options.

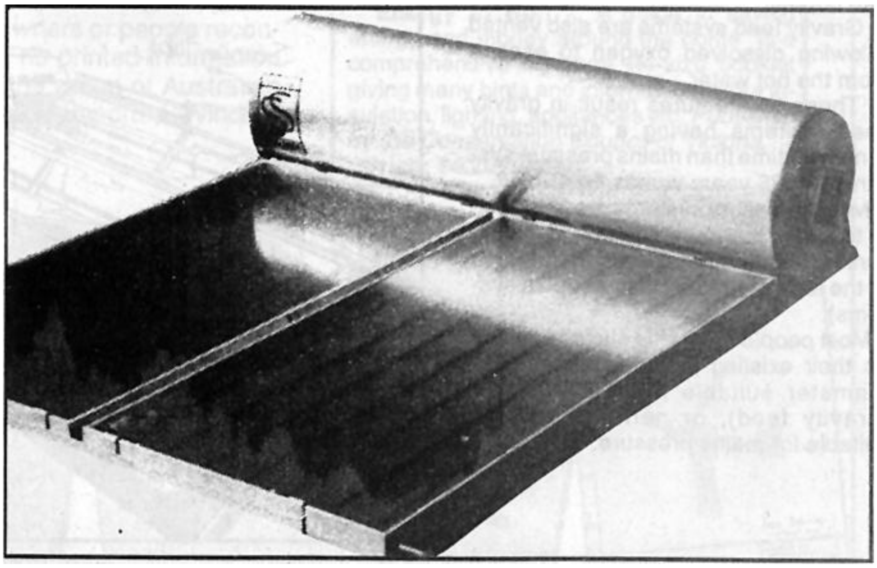


Remote-coupled flat plate collector

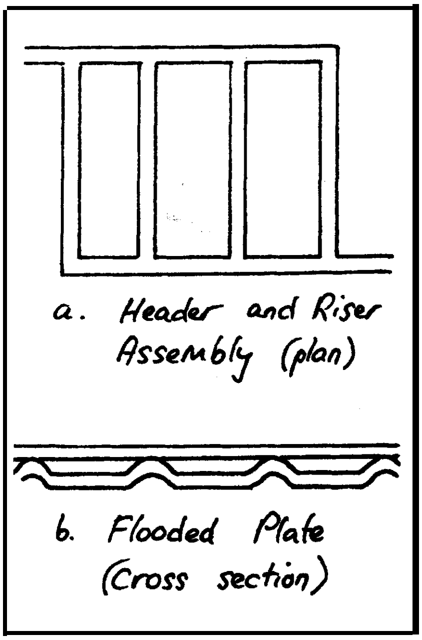
Gravity feed or mains pressure?

The difference between a mains pressure and a gravity feed hot water system is the pressure at which each operates. A mains pressure system operates at the same pressure as that provided by the water mains, This is never less than 200 kPa and can be higher than 700 kPa.

On the other hand, gravity feed systerns are isolated from the mains by a



Close-coupled flat plate collector



Flat plate waterway types

float valve. They are under no pressure except that due to gravity. Water pressure at the point of use is determined by the height of the storage tank above the point of use. In a single storey house this is about 20 kPa and in a two storey house about 40 kPa. Some people find these pressures too low for ordinary use.

However, such low pressures allow gravity feed systems to be made out of structurally weak but durable materials like copper.

Gravity feed systems are also vented allowing dissolved oxygen to escape from the hot water.

These two features result in gravity feed systems having a significantly longer lifetime than mains pressure systerns (20-25 years versus 10-15).

Mains pressure systems are less costly to install but more space consuming (unless located outside as in the case of the roof-mounted close-coupled systems).

Most people have little choice anyway as their existing piping is either wide diameter suitable for low-pressure (gravity feed), or narrow diameter suitable for mains pressure.

Close-coupled or remote-coupled?

Close-coupled systems are those which have the storage tank sitting on the floor right beside the collector. Remote-coupled systems have the tank located either within the ceiling space or down at floor level.

Close-coupled systems may be supplied as either low- or mains- pressure systems. Usually they have a thermostatically controlled electrical booster element installed to ensure a continuous hot water supply.

Remote coupled systems are normally low-pressure units. Both upright and horizontal tanks are available.

Thermosiphon or forced-circulation?

Most domestic installations use thermosiphon flow. This is where water in the collector is heated by solar radiation and then flows to the upper part of the storage tank and is replaced by cooler water from the bottom of the tank. To maintain thermosiphon flow and to prevent reverse circulation, which would result in heat loss, the top of the collector must be lower than the bottom of the storage tank.

It may, however, be impracticable to mount the storage tank above the collectors and pumped circulation must be considered. This is usually not an economic proposition in a domestic situation because of the additional cost of the pump and the thermostatic control necessary for it.

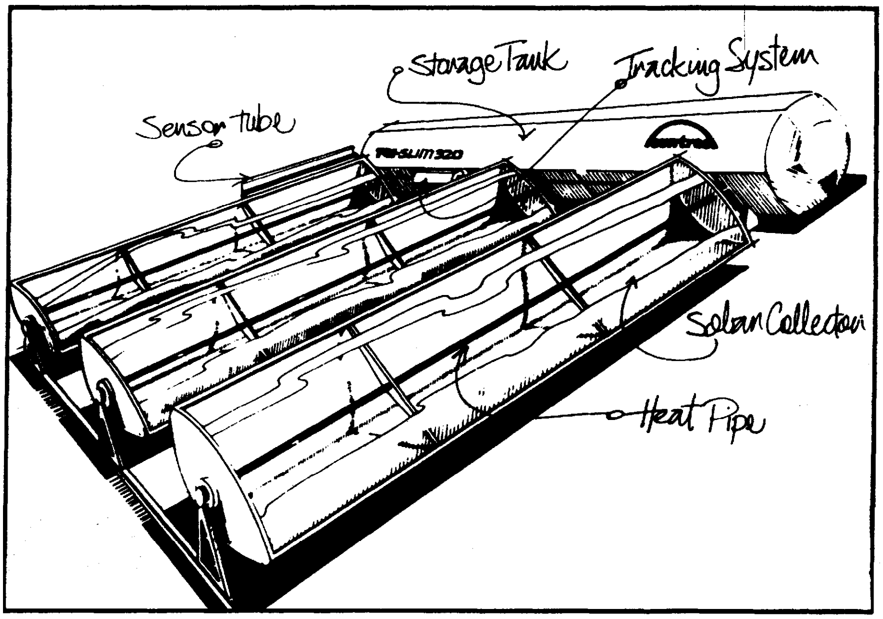
Auxiliary heating

In most places boosting is essential. Most commonly the booster is electric, but this depends on the availability of a suitable tariff.

A slow-combustion stove can be effectively used in conjunction with the system. You effectively create a thermosiphon "branch line" pipe to a coil in the stove. This line is joined by T- intersections to the inlet and outlet lines of the main collector panel.

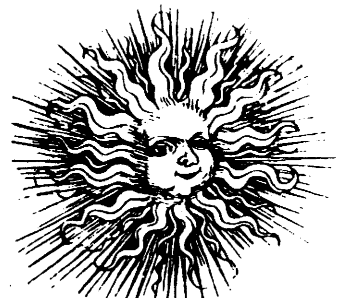
Any existing instantaneous water heater can be used as a booster. During cold weather the instantaneous heater can be used to raise the temperature of the solar pre-heated water to a desirable level.

Solar preheaters are manufactured for connection into existing hot-water systems in which the storage tank is so situated that it is impracticable or inconvenient to attach absorbers directly. Solar preheaters consist of a collector and a small storage tank (up to 100 litres) which is mounted on or in the roof and connected to the cold water line to the existing storage tank.



Heat pipe collector

Solar Energy Resources Catalogue



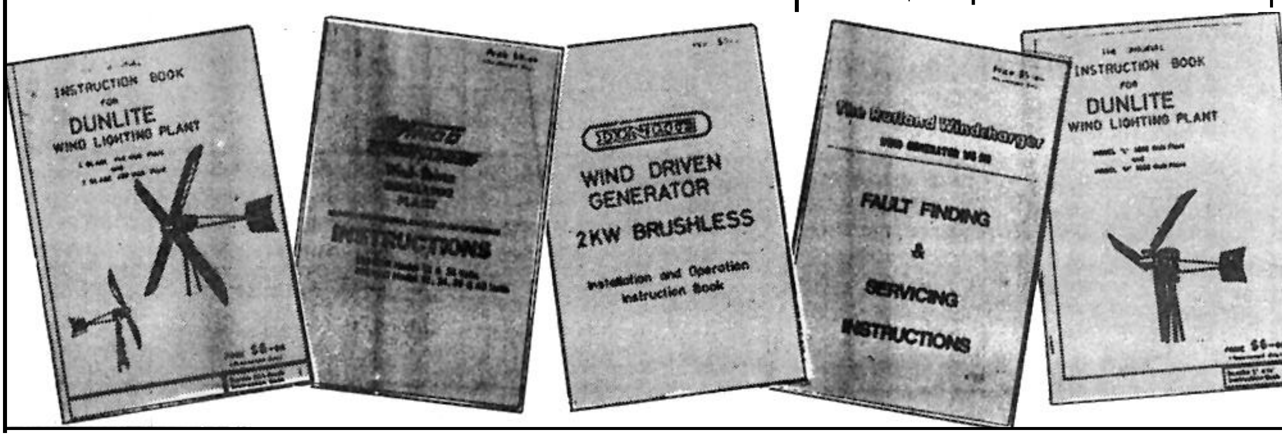
This catalogue has been produced by the *Alternative Technology Association.*
The ATA is a community based organisation involved in the promotion of technology which works in harmony with the environment. The group runs a wide range of activities including meetings, film nights, field trips and practical workshops.
The ATA also produces a quarterly magazine Soft Technology and a bi-monthly newsletter. It built and manages the Solar Workshop and maintains the Alternative Technology Resource Library.
If you wish to contact the group write to the ATA at the address on the back of this catalogue.

Energy Conservation

"Energy to Burn?: A guide to saving energy and money around the home" is a comprehensive *48* page A4-size booklet giving many hints and information about insulation, lighting, appliances etc. *Published by the Conservation Council of Victoria.*
Price: $4.20 posted.

Windpower Information

These booklets give technical details of individual windgenerators. They give information on installation, maintenance and basic repairs. A must for owners or people reconditioning old generators but who have no printed information on the machines. The booklets cover the range of Australian made Dunlite windgenerators as well as the imported "Windco" and "Rutland" machines.



Soft Technology:

Back Issues

Soft Technology magazine contains current Australian information on the whole range of renewable energy sources and alternative technologies.
It includes a balance of practical construction articles and reports of Alternative Technology developments both in Australia and overseas. A limited number of back issues are still available.

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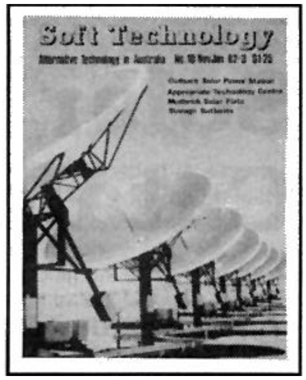

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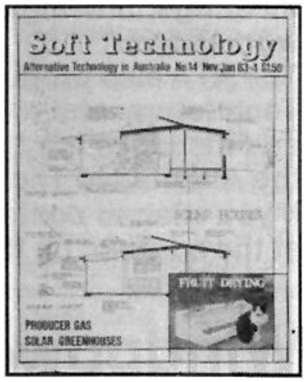

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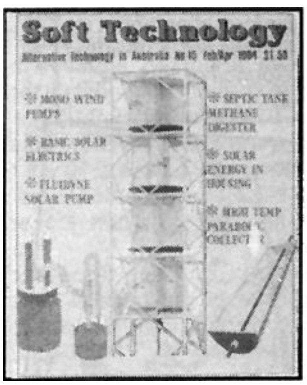

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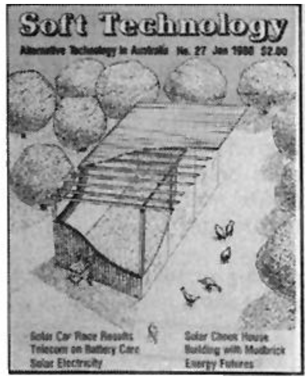

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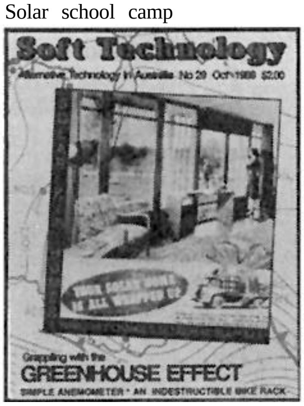

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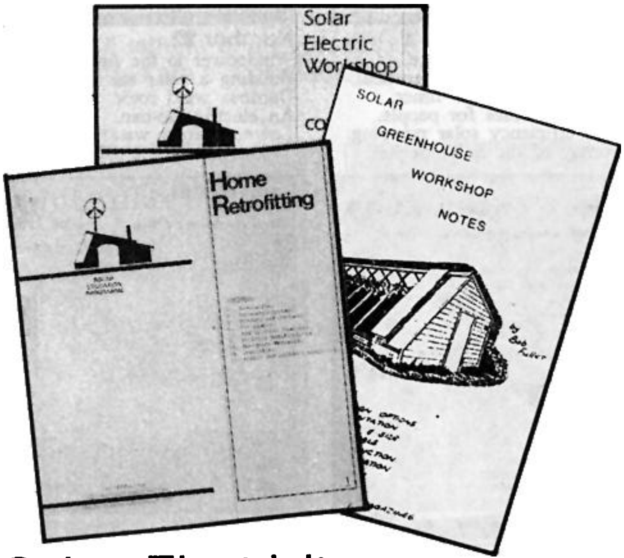
The Solar Workshop

A detailed description of the Solar Workshop including information on the wind generator, solar electric system, water turbines, solar water heating and the building's passive solar design.

The booklet includes diagrams with detailed explanations of the various features of the workshop. It also contains details on materials used, their costs and sources.

Price $2.00 **posted.**

Information Kits



Solar Electricity

Everything you could ever want to know about setting up your own solar electric system. Solar cells, batteries, wiring, inverters and appliances are all covered. How to design and size your own system - and once it's put together how to maintain it with minimal effort.

Home Retrofitting

How to make your existing home save energy by adding features which will improve its thermal performance. includes information on insulation, weatherstripping, building modifications, landscaping, energy use of appliances and emergency measures to save energy.

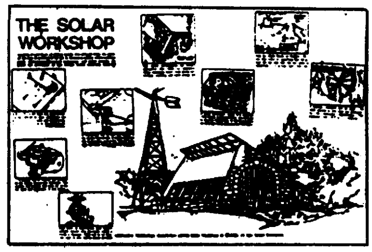
Solar Greenhouses

Standard greenhouses overheat in summer and are too cold in winter. A correctlydesigned solar greenhouse gives the plants the best conditions all year round. The kit describes in simple terms how to design a solar greenhouse, materials to use and where to get them. It also gives a recipe for a small Solar Greenhouse and information on a simple greenhouse you can build into your home.

Price: All $4.50 each, POSTED.

The Workshop Poster

An attractive poster showing the Solar Workshop and its features. Includes illustrations and basic explanations of the solar cells, wind generator, waterwheel, back-up generator, wood heater, water supply system & solar water heater.



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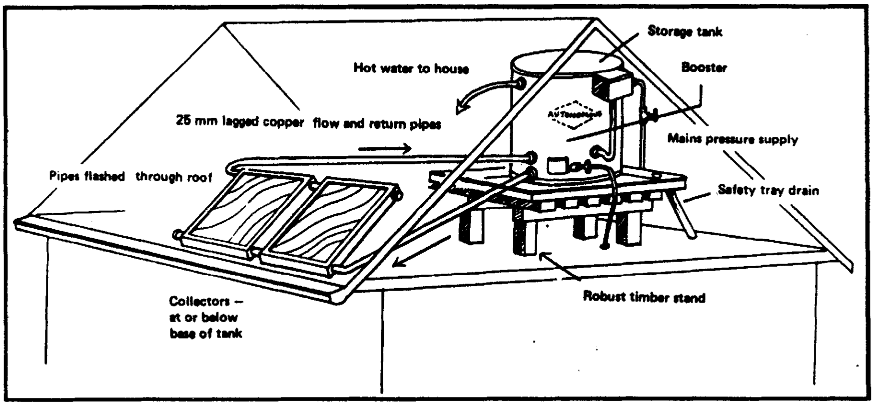


Thermosyphon principle

New or retrofitted system?

If you're buying a new system, choose a thermosiphon system rather than one requiring forced circulation if possible. Basically a thermosiphon system is cheaper and usually more efficient. With the thermosiphon system the bottom of the storage tank must be above the top of the collector; with some house designs this is not possible.

In theory, solar equipment can be fitted to pre-existing electric, gas and slow-combustion systems. If you're considering connection to a gas heated system, consult your local gas supplier first.

Where an existing water heater needs replacing, it is best to replace it altogether with a a new solar water heater. If, however, the existing system is new or less than five years old, it may be incorporated into a solar system.

Mains pressure storage water heaters are most easily converted by using a "5 way connector".

An existing system converted in this manner can be just as efficient as a new solar system.

A gravity-feed water heater can only be converted into a solar system if an outlet and inlet are already provided for connection of the flow and return lines to solar collectors.

If these are not provided it is usually not financially worthwhile to have the heater modified.

A quick recovery water heater will probably require the connection of an extra storage tank because of its small capacity. The new tank then acts as a solar preheater tank.

The two-tank system is less efficient than a single tank system.

Freeze protection.

Where night-time or winter temperatures drop to 0 degrees Celsius or below, water can freeze in the collector and damage the piping. A selective surface will generally reduce the risk of damage. However in locations like Alice Springs and Canberra other precautions must be taken.

Common commercial methods used in flat-plate collectors include fitting a thermostatically controlled valve to discharge water from the collectors when the temperature falls below a safe level. The discharged water is replaced by warmer water from the storage tank. Another method is to fit a thermostatically controlled electric heating element into the bottom header of the solar collector. In a pumped system, water can be reticulated through the collector. Where a heat exchanger is used, an anti- freeze chemical can be added to the heat transfer fluid in the collector. Finally it is possible to drain the collectors manually overnight. The drawback of this system is that you forget to drain the system.

Mechanical and electrical anti-freeze systems waste hot water or require extra energy - which can be considerable in a frost-prone area. The only reliable energy efficient method is to use anti-freeze in conjunction with a heat-exchanger type ("jacketed") storage tank.

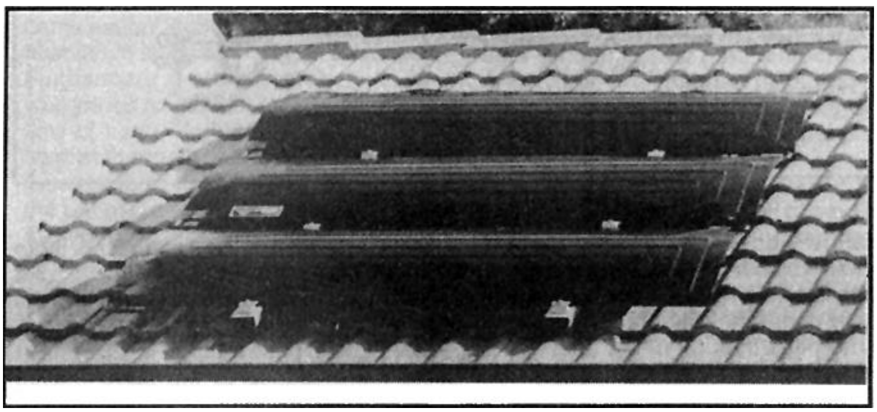
Both the heat pipe collector system and the heat pump system are innately protected against freezing.

Storage tanks

A typical storage tank holds between one-and-one-half and two days' supply of hot water. Gravity feed systems use solid copper for the hot water storage tank. Copper has excellent resistance to corrosion and tanks made of it usually last about 20-25 years.

Mains pressure tanks are manufactured from either stainless steel or a low carbon steel lined with vitreous enamel (sometimes called "glass"). It is not yet known how long mains pressure stainless steel storage tanks will last since the current method of manufacture has only been used for about 15 years. The manufacturers claim that they should last about 20-25 years. Vitreous enamel tanks last about 10-15 years.

"Jacketed" tanks, i.e. one tank within another, are now available. The outer jacket is not under pressure allowing connection to a low pressure collector



Heat pump collector panels

to which anti-freeze and corrosion inhibitor have been added. The collected heat is transferred to the inner mains pressure cylinder by conduction. Such systems are often called "heat exchanger" systems.

Some manufacturers are now offering external solar water heaters in a range of colours as well as the basic silver.

Note that when filled with water, a close-coupled solar water heater can weigh in excess of 400 kg. Traditional roof framing is generally able to carry this load, or can easily be reinforced.

You may have problems with trussed, flat and skillion rooves, so check it out with the local council.

Collectors

There are three major types of collector to choose from. The most common is the flat plate collector. Also on the market is a heat-pump type collector and a concentrating (heat pipe) collector.

FLAT PLATE COLLECTORS

This is a flat blackened plate to which a number of (usually copper) tubes are thermally bonded to ensure good heat conduction between plates and tubes. The plate is backed by mineral wool or equivalent insulation and is enclosed in a case (usually of sheet metal) with a clear glass cover.

The Absorber Surface

The sun radiates energy and the purpose of the collector absorber plate is to capture as much of this as possible. It is well known that black painted surfaces will absorb this energy. Many collectors with metal absorber plates on the market today have been painted with a high quality matt black paint. A paint of this type will give the plate an absorbance of about 95%. Another property, however, of such a coating is that as it gets hot it will also start radiating or emitting heat at the same rate. However this re-radiated energy will be of a different type (infra red wavelength) from the incoming solar energy. The less heat that radiates out from the plate the more that is available for heating the water.

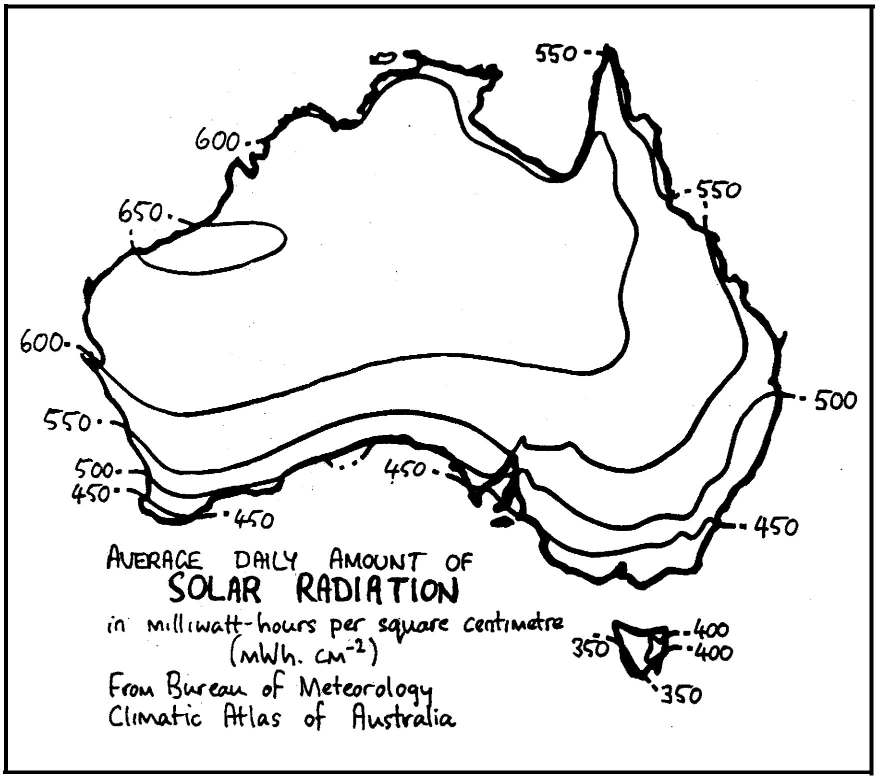
Selective surfaces have been developed to overcome this problem. As their name suggests, they are a thin coating put onto the plate which selectively absorbs most of the incoming sunlight; but re-radiates out only a small amount of the heat. These surfaces therefore have a high absorbance value and a low emittance rate. Copper Oxide, the Amcro Surface and Chromium Black are examples of such surfaces. They are all achieved by chemical process and tend to increase the cost of the unit.

The Collector Cover

The purpose of the cover, often glass, on a solar collector is to help reduce the losses from the absorber plate. The plate will do this firstly by radiating to other objects at lower temperatures than itself. Fortunately glass allows virtually none of this infrared radiant energy to pass through it, but heat will be passed to the air next to the absorber plate. This heated air will rise and be replaced by cooler air which in turn is then heated. The effect of placing a cover over an absorber plate is to greatly reduce this mechanism.

The cover, no matter what material it is made of, will absorb and reflect some of the sun's incoming radiation. The values for 3mm thick Australian window glass are about 9% for absorbance and 7% for reflectance. An improved type of glass, usually called LOW IRON GLASS, is now offered on some units. This has a lower iron content than the standard window glass. As a result it has virtually no absorbance and will transmit approximately 91% of the incoming radiation.

Acrylic covers are also found nowadays on domestic solar collectors. They offer some advantages over glass. For the same thickness, an acrylic cover will be lighter and more resistant to impact than glass. Like glass, acrylic allows virtually none of the radiant energy coming from the absorber plate to pass through it. In terms of its transmittance to the sun's radiant energy, i.e. its solar transmittance, it is



How much sun do you get?

also very comparable with standard window glass.

In areas where the likelihood of damage due to hail is high (such as in northern Queensland), solar water heaters can be supplied and installed with hail resistant toughened glass.

Insulation

The heat losses out of the collector, which we are seeking to reduce to a minimum, are the result of a number of heat transfer mechanisms. One of these, conduction out through the sides and back of the collector, is reduced if adequate insulation is placed around the edges and the rear of the absorber plate. Most collectors designed for domestic hot water have some sort of insulation behind the panel, but insulation at the sides and between the absorber heaters and the case is not always included. Insulation materials themselves, of course, can vary, some offering a greater resistance to heat flow than others.

The Absorber Panel Material

The first solar panels which appeared on the market had absorber panels of an all copper construction. Copper had, and still has many advantages: conductivity, resistance to corrosion, forming and joining. However, copper over recent years became more and more expensive. Alternative materials have been sought and different options are available.

A combination of an aluminium plate and copper waterways is now commonly available. A disadvantage of this combination is that the conductivity of aluminium is lower than that of copper. Furthermore the two metals must be well joined to provide for a satisfactory flow of heat. To obtain an acceptable level of thermal contact a thermal paste is usually placed between the tubes and the panel sheet. Also, no water can be allowed to come into contact with the two metals together because electrolytic corrosion will take place. These disadvantages seem to have been overcome by the manufacturers who use this combination of materials and tests show quite satisfactory performance for domestic solar water heating.

Other materials used are stainless steel and plastic. Steel has an even lower thermal conductivity than aluminium and copper. This disadvantage is compensated for in some panels by producing what is called a FULLY FLOODED plate. In this design, the maximum possible area of the absorber plate is in direct contact with the waterways so that the requirement for good conduction of absorbed heat along the fins to the water 'riser' tubes is virtually eliminated.

Tests conducted by the CSIRO indicate that there is no appreciable difference in performance between designs using copper sheets and tubes, aluminium sheet and copper tubes, and steel sheet and tubes, providing the entire collector is well constructed.

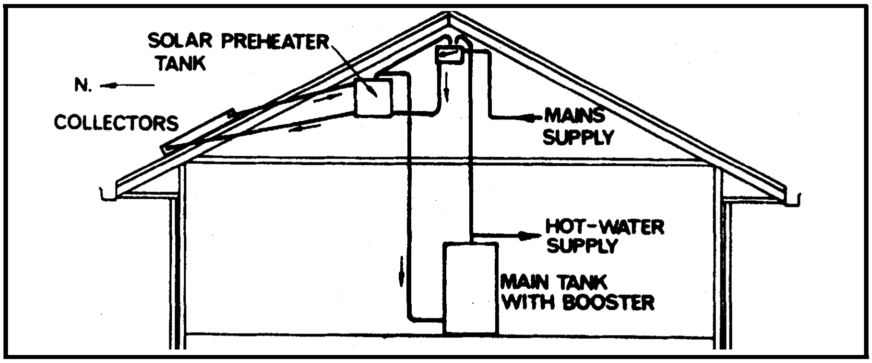
Plastics have normally been associated with unglazed swimming pool collectors. The lower temperature requirement of heating a swimming pool was well suited to plastics, but for the higher temperatures demanded for domestic hot water, the disadvantages such as the very low thermal conductivity, inability to withstand high stagnation temperatures (the temperature reached by the absorber plate with no water/fluid passing through it) and also the aging characteristics of some plastics rendered them unsuitable.

Solar collectors made of materials like EPDM rubber are now being offered for domestic hot water. They offer some advantages like lower cost, ease of installation, etc., but in general, PVC and EPDM collectors are incapable of supplying hot water in the temperature range 55-60°C which is the minimum range required for domestic hot water.

Size and Price

When determining the number of panels you require on any given system, take care to ascertain the actual size of each panel in square metres. This not only assists in determining the number of any particular panel that you require for your system (see Table I), but enables you to compare different manufacturers products on a dollar per square metre basis ($/m²).

Simply divide the cost of panel X by its area. This will give you a $/m² figure, which can then by compared directly with panel Y, provided you have carried out the same calculation on that product. This will avoid the confusion of having panels of different prices and areas. Once the units are expressed in the same terms, one can begin to took for the reasons, if any, why Panel X is, say, more expensive than Panel Y.



Solar preheater connections

Waterway Type

The two most common waterway types are tube and plate collectors, and flooded-plate, or envelope, collectors. Tube and plate collectors consist of a number of riser tubes connected to horizontal flow and return headers. Over these is fastened an absorber plate. Tube and plate collectors are suitable for mains pressure installation. Flooded-plate collectors consist of two sheets of metal (usually stainless steel or mild steel) pressed together in such a way that waterways are formed between the sheets. They are only suitable for low pressure applications.

The following generalisation may be made about the spacing between riser tubes. If in all other respects, two collectors were identical except that one had one extra riser tube and therefore smaller spacings between tubes, then this collector should be superior, albeit marginally, than the one with the lesser number of tubes.

The limit of increasing the number of tubes is, of course, a collector similar to a flooded plate. It is only in cheaper materials with a low thermal conductivity that one is likely to encounter such a design, since what the manufacturer is doing is offsetting the poorer thermal qualities of the material with the advantages gained from many waterways. Flooded plates are unsuitable for thermosiphon systems.

HEAT PIPE COLLECTORS

These are also called concentrating collectors. The principle of this system is the concentration of solar radiation at a single point by using a parabolic reflector as a focussing device. A pipe containing the water to be heated is then situated at this point. Because the collector will only be efficient if the sun's rays strike the parabolic reflector face-on, the collector is coupled to a tracking device.

One of the important advantages of flat-plate solar collectors is that they still operate, admittedly at a reduced level, even when the sun is obscured by cloud. On the other hand, concentrating collectors do not operate under these conditions. This, with their complexity and cost, makes them less suitable for domestic systems.

SOLAR BOOSTED HEAT PUMPS

A new Australian designed type of domestic hot water system combines a heat-pump with solar evaporators (collectors). The system works on the principle of a refrigeration circuit, drawing heat out of one space and discharging it into another. The solar boosted heat pump consists basically of three components - two heat exchangers (an evaporator plate and a condenser) and a compressor.

In operation, the evaporator, usually on a roof, absorbs whatever heat energy is available to it - sunshine, wind, rain or ambient air - to vaporise the refrigerant. The vapour is then compressed raising its pressure and temperature. This high temperature vapour is passed through pipes bonded around the outside of the water storage tank. That is the condenser.

As the refrigerant (R12 - a fluorocarbon gas - like freon - now notorious for its effect on the ozone layer) vapour condenses back to its liquid form, it gives off its heat to the stored water. As this happens, the condensed refrigerant liquid passes back to the evaporator plates and the cycle is then repeated.

The heat pump operates even without sunshine utilising sun, wind and rain. For example, Siddons claim their standard unit will provide a peak day (72 MJ) of Class A hot water (57°C or over) on Melbourne's coldest July day without a booster heating element.

Other advantages are 24 hour a day operation, water heating in all weathers, lightweight aluminium evaporator plate, no freezing of collectors possible, no water overheating problems and high efficiency. Against this are the environmental dangers of the Freon-type refrigerant and the added complexity of the a compressor pump - unnecessary with passive thermosiphon flat plate collectors.

Further information.

Apart from manufacturers' information, we used the following sources which should be easy enough to get hold of. Also try the Energy Information Centre in your state.

CSIRO Division of Mechanical Engineerlng, 1977. *Guidelines for prospective purchasers of domestic solar water heaters. 12/A/2 Sept. 1977.*

Energy Authority of N.S.W., 1985. 20 *Questions and answers on domestic solar water heaters.* PS25 Oct. 1985.

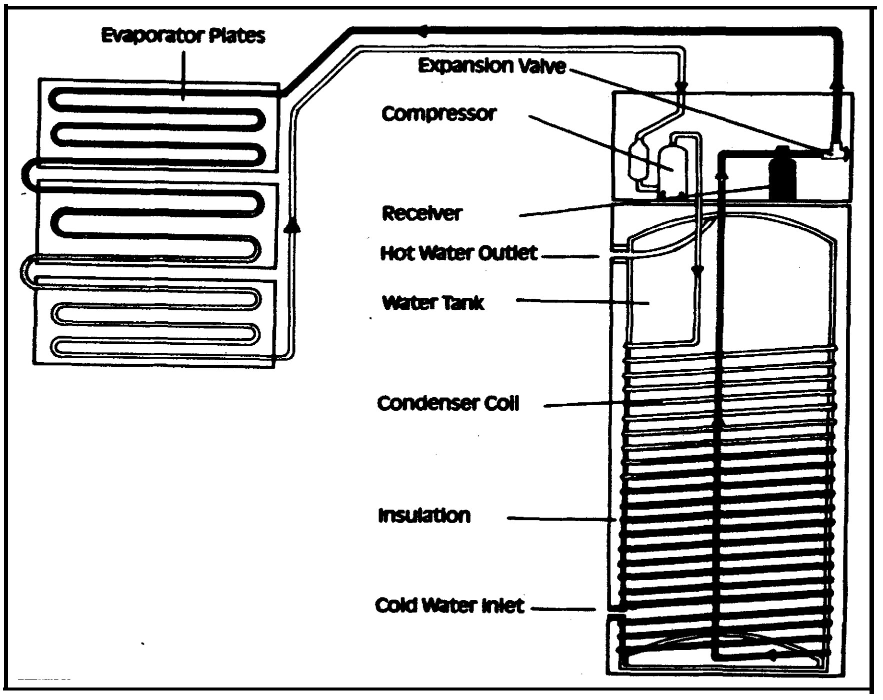
Experimental Building Station *1976. Domestic solar water heating. NSB 143. Department of Housing and Construction, Canberra*

Fuller, Bob, 1981. *Buying a solar collector* Soft Technology No.4.

More detailed and technical information can be found in:

DUFFIE, J.A. and BECKMAN, W.A., 1974. *Solar Energy Thermal Processes.* Wiley, New York.

CLOSE, D.A., 1980. *An Introduction to Solar Energy Systems and System Design* CSIRO, Division of Mechanical Engineering, Technical Report No. TR 26.



HOw a heat pump works

Build a simple 12 Volt 10W

Practice Amplifier

by Craig Burnett

Here is a small, neat unit that allows you to practice your guitar playing using a small speaker and any 12 volt DC power source. It is also handy for any other low-power amplifier application.

Introduction

The guitar practice amp uses a prebuilt audio module using a TA7205 AP audio device. In this application the device is run 'bridged' to produce a larger output. Selecting a suitable input resistor adjusts the sensitivity of the module. In this case a variable resistor determines the sensitivity.

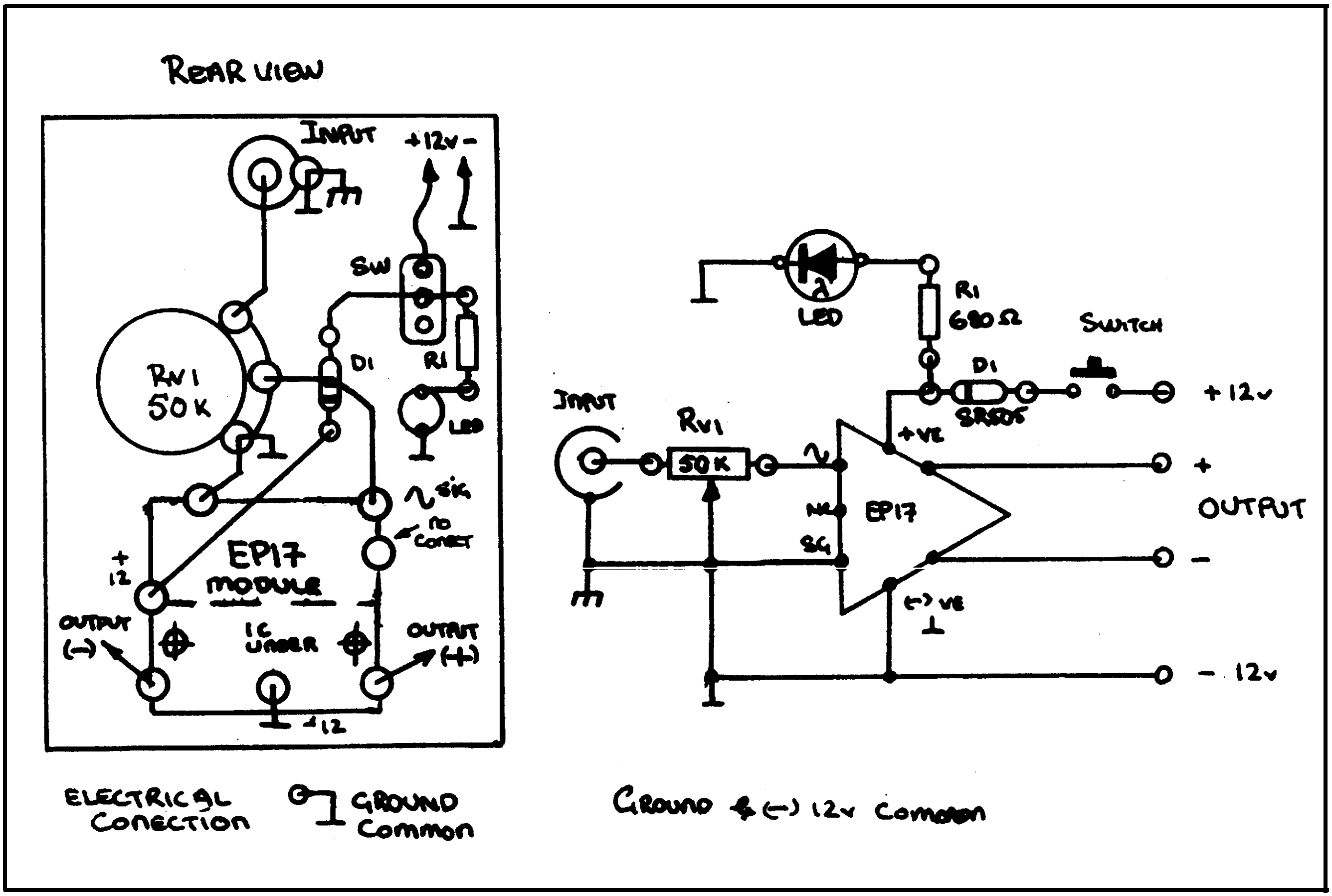
Specifications

Consumption: @12 volt approx 300 mA, Max 1.8 A
Frequency response: 10 Hz to 20 kHz
Input sensitivity: around 8 mV
Output performance:
Output power: 10 W average
17 W max.

Construction

Tools needed: basic hand tools and a soldering iron.

1. If heatsink is not predrilled, drill and countersink the dimensioned hosed referring to drill diagram.
2. Dress any rough edges on heat-sink with a fine file. Suitable finish can be achieved by sanding the heatsink in running water with fine wet and dry paper
3. If desired the heatsink may be painted with lacquer.
4. Fit the EP17 module with two counter-sunk head nuts and bolts. Don't forget a smear of thermal compound between the IC surface and the heatsink.
5. Install the RCA socket, switch, pot, the led - I found it a good move to drill the led hole slightly undersize and ream from the inside out to give a neat fit to the led.
6. Using tinned copper wire, wire the switch, pot and input socket noting that all connections marked 1 are common and must find their eventual return to the ground on the input socket.

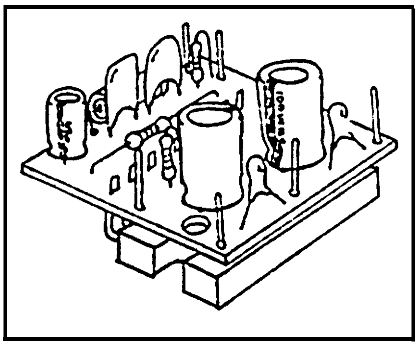


Circuit Diagram for the Unit.

7. The led and its current limiting resistor can be easily 'hard wired' between the switch and this pot.
8. If the led is reversed in its connection it will not light.
9. Fit the polarity protection diode between the EP17 & VE terminal and the switch ensuring the stripe on the diode is closer to module than the switch.
10. Connect the speaker wire to the terminals market 'output' (+) and 'output' (-).
11. Connect the power input cable with the positive to the switch and the negative to the - VE terminal marked on the EP17.
12. Check all wiring carefully against the diagrams and if satisfied its time for the 'smoke test'.
13. Apply 12 volts to the power cable and note that the led lights in the 'on' position.
14. Switch the unit 'off' and connect the speaker to the speaker lead. Switch the unit 'on' and set the level control to minimum.

At this stage a low hiss should be apparent in the speaker.

15. Switch the unit 'off' and connect the signal i.e. guitar, keyboard or oscillator.



The EP17 Amplifier Module

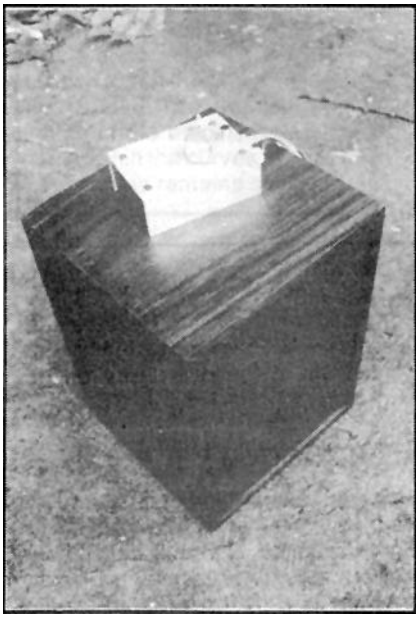
16. Switch back on and play checking out the subjective performance, if satisfied disconnect and fit the cover and thread the 2 'figure 8' cables through the cord grips and install the plastic cover box and knurled cord grip nuts.
17. The amplifier should be able to drive low-impedance headphones to an ear splitting volume as well as drive speakers (4) from 4" to 8".
18. Note that power and speaker plugs are not provided.
19. Do not short the speaker line to this power supply nor (-) common (1) ground.
20. Ensure power supply does not exceed 15 volts DC.
21. Enjoy your new mini practice amp.

Kit supplier

A complete kit of parts will be available from Rainbow Power Com-

Parts List

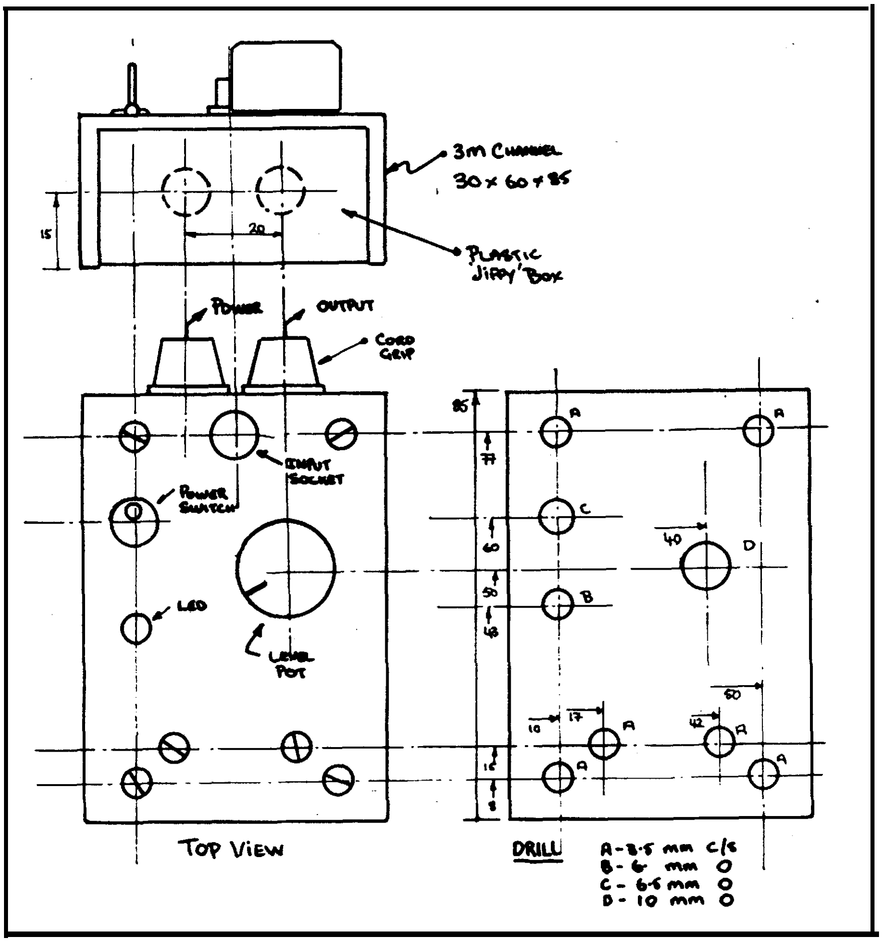
Heatsink 30x60x3mm U-channel
Plastic Box - jiffy box - lid not used.
Cord grips - 2 x knurled nut type - plastic
4 x self tapping screws - from jiffy box
2 x 1/8 BSW x 1/2 c/s head and 2 nuts
Tinned copper wire - for hook up
Knob - to suit
50 K Lin pot (variable resistor) VCU type
Mini toggle switch SPST type
Yellow led 5mm type
680 1/4 w resistor
SR505 Diode
EP17 amplifier module
RCA socket, panel mount
1m .75mm twin flex
1m speaker flex
60/40 resin cored solder



The Unit with Speaker Box as supplied by RPC.

pany, P.O. Box 217, Nimbin NSW 2460. Including an optional speaker box (kit form), the kit will retail for around $60 including freight. Rechargeable cell batteries are available ex stock Rainbow Power Co. Gell cell chargers available ex stock 12 and 240 V from RPC. All units and modules available 'built and tested' from the same supplier.

Next - gain lift and tone control kit available soon.



External Layout and Dimensions of the Unit.

INDUCTION GENERATORS FOR CHEAP ENERGY PROJECTS

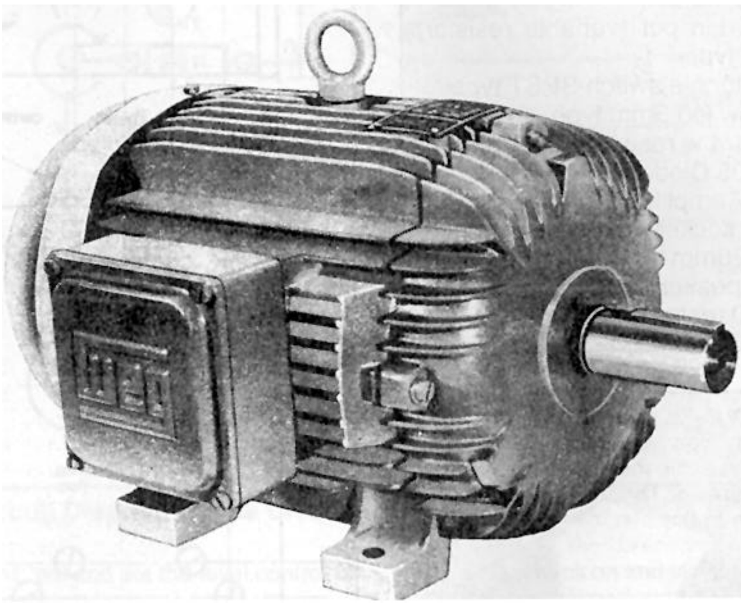
by Karl McLaughlin

That door-stop in the garage is Tesla's wonder' invention! The humble induction, or squirrel cage, motor is a remarkable machine. It is very simple; superficially it has no magnets, there are no brushes to wear out, and has only one moving part. As a result of its simplicity it is highly reliable. Moreover, it can function either as a motor or a generator without any modifications.

Introduction

The relevance of induction motors to soft technology is that they are the most plentiful and cheap electrical machine in the world, and in operation are flexible, efficient and very robust. So for your special energy project be it a windmill, water wheel, or engine driven battery charger, the lowly and modest induction motor could be the best solution.

This article explores the application of the induction machine to the simplest of cases - powered by a petrol-driven motor for battery charging. However induction generators are deserving of much more elegant applications than being driven by noisy, smelly petrol engines. This discussion lays the foundations for contemplating applications to hydro and wind powered systems as well. We will be following up these other applications in the next issue of Soft Technology.



An Induction Generator

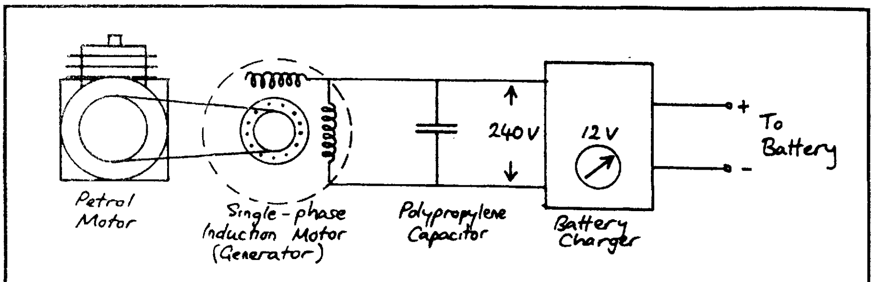


fig. 1 Induction Generator: Single Phase

Advantages

So, you ask, why not just use an automotive alternator? The efficiency is about the same. The main advantage the induction generator has over a car alternator is a better matched loading curve (see figure 1). What you need in a generator is an ability to run at a speed high enough for sufficient power to be developed, and an ability to ensure the whole set-up remains stable and doesn't speed up out of control. The

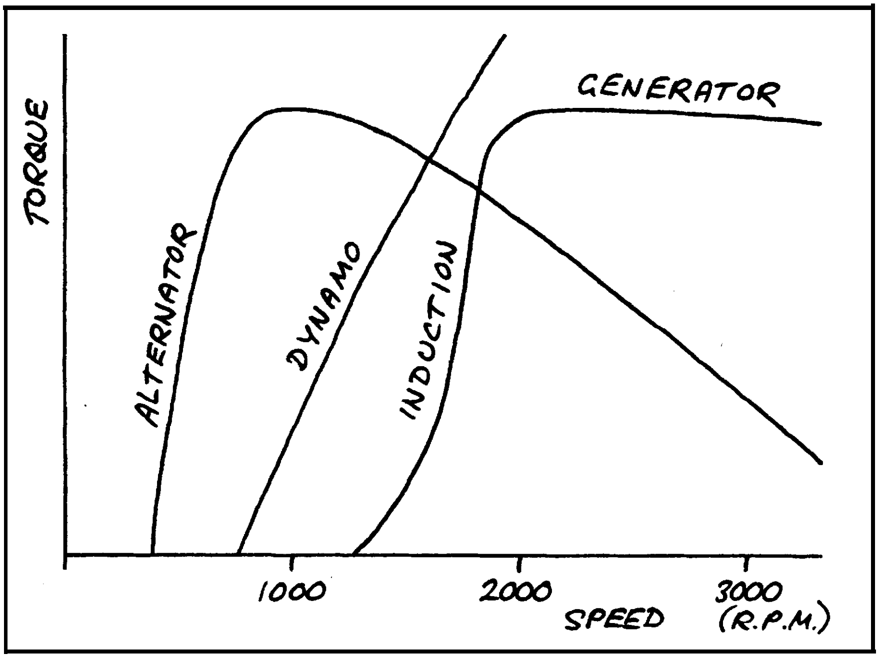


Fig 2. Torque curves for various generators.

main advantage of the induction generator is that it has a very suitable loading curve so that the petrol motor can be set up at a good operating point - about 2000 rpm at half throttle.

Pulley ratio will shift the curves, i.e. pulleys allow you to control the speed at which to run the generator for a given motor speed. The level of magnetic excitation in the electrical machine (flux) will also shift the curves, but the SHAPE of the curves remains similar.

Inefficiencies

A major problem in using a stationary motor driving ANY load is to get the speed of the motor right: not lugging at 1000 rpm with insufficient splash lubrication, and not revving out at 4000 rpm wasting petrol and rattling valves. A 2.6 kW (3.5 h.p.) motor will typically only yield 10 amp at 15 volt (150 watts!) in a home-made genset because the petrol motor is either lugging or running light.

In other words only 1/17th of the petrol motor's capability is being used. Even allowing 50% efficiency for the generator, only 1/8 of generator capacity is being used. This is because of unstable operating point: if you load the motor enough to do some work, the revs drop to lugging when there is no horsepower. Look at the torque curves (Figure 2). point A is the desirable operating point. However because any random fail in speed will lead to more alternator torque and LESS motor torque, speed will fail further. This will continue until point B, where motor power output is poor.

This strange torque curve of the alternator is a necessary result of being designed to do what it has to do in a car. it must have minimum cut-in speed, high amps at low speed, and low weight. It is not a problem when being driven by such a powerful motor as a car engine.

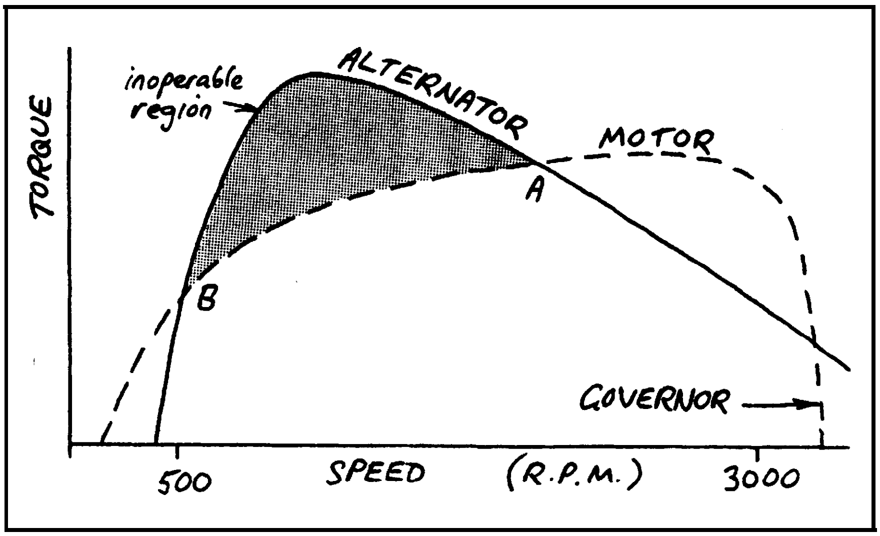


Fig 3. Matching an alternator to the petrol engine

Setting up

So, how do you turn an induction motor into a generator? Simply connect a capacitor across the wires and spin at motor speed. The bigger the capacitor the lower the running speed. The correct size for a 1/4 h.p. generator is about 12 to 20 micro farad. It is necessary to use paper foil or polypropylene capacitors, the sort used in fluorescent light fittings or capacitor run motors. Electrolytic capacitors will not work, and motor START capacitors will fail. Also note that some motors won't generate, e.g. "Betts" brand. Some always work, e.g. Crompton Parkinson, Teco, ASEA, WEG. Sometimes after disassembly a short circuit 'flashing' is necessary. A 12 volt battery can be sparked across the wires to renew the residual magnetism. Polarity of the battery does not matter.

How it works

Induction motors come in different speeds. Depending on whether they are wound 2, 4, or 6 pole they may be rated at 930, 1440 or 2480 rpm respectively. These rather strange speeds come about as follows: The mains alternating power is 50 cycles per second. if the rotor turned around once per cycle exactly then the motor would run at

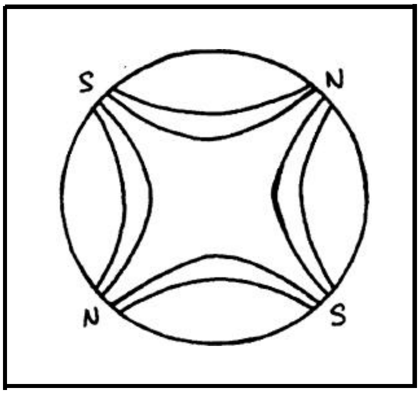


Fig 4. 4 pole machine

3000 rpm (i.e. 50 Hz x 60 sec.). If the machine were wound with twice the number of poles, i.e. 4 pole, the rotor would turn around 1/2 cycle for the sequence of north-south-north and the speed would be 1500 rpm. Likewise, if wound six-pole the speed would be 1100 rpm.

The rotor however does NOT turn around at quite the same speed as the voltage alternates. To demonstrate why, there is a little experiment I recommend to all. Get an induction motor and connect the wires to a 12 volt battery (brown and blue if single phase, any pair if 3-phase). The machine won't spin, rather the opposite - you have a magnetic brake! Wind a string around the shaft of the machine, and try spinning the shaft slowly by pulling on the string, then pull quickly. Very slow turning feels gooey and a bit notchy. Medium speed feels tough and rubbery, and at fast speed the rotor "lets go" and the shaft spins easily. Figure 3 is a graph illustrating the effect.

In the effect above the magnetic field was stationary, provided by the 12 volt battery. Now if the shaft is stationary, and the whole outside of the motor is the rotor is being spun at 50 cycles per second (for a 2-pole motor). Hence the torque curve of the machine appears as in figure 4.

Note that at 3000 rpm in figure 4 the rotor is stationary compared to the mag-

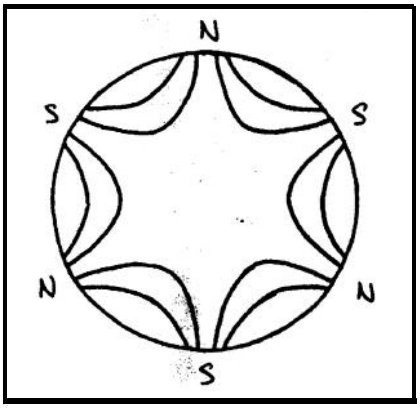


Fig 5. 6 pole machine

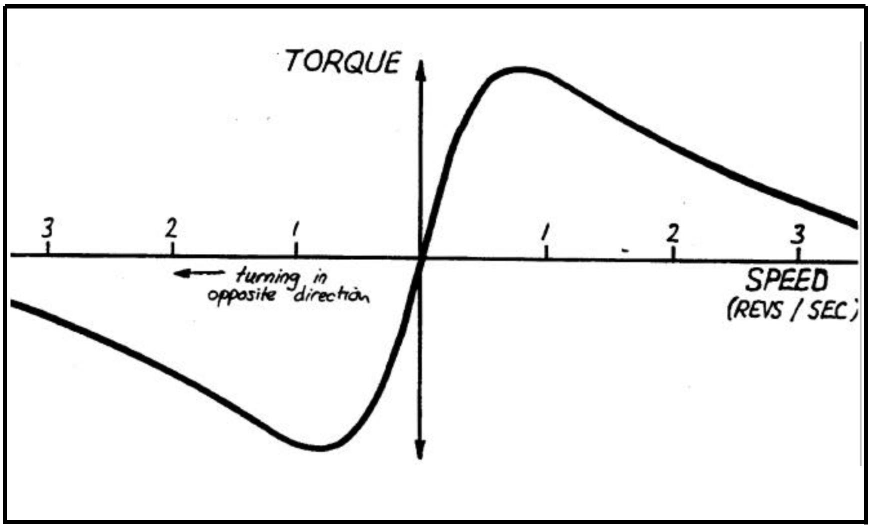


Fig 6. Spinning the shaft with a stationary field

turned, the shaft will try to follow it with the same curve as figure 3. The RELATIVE speed is what produces the torque. If instead of turning the whole netic field. At the rated power speed the shaft is experiencing the force caused by being dragged through the field at about 2 cycles per second.

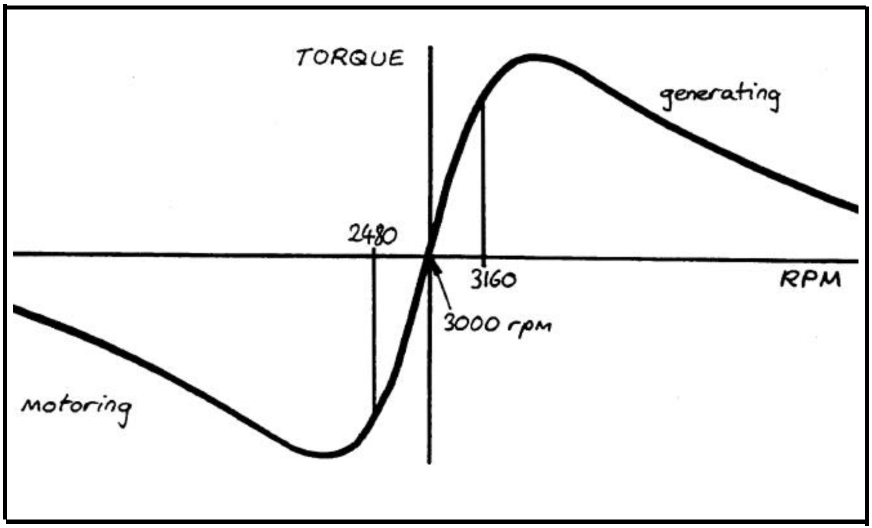


Fig 7. Torque speed relationship in an induction machine

outside of the motor we simply turn the magnetic field by applying alternating voltages, the rotor can't tell the difference and reacts as if the outside of

The induction generator is very confusing because there are three independent frames of reference which all rotate compared to each other: the

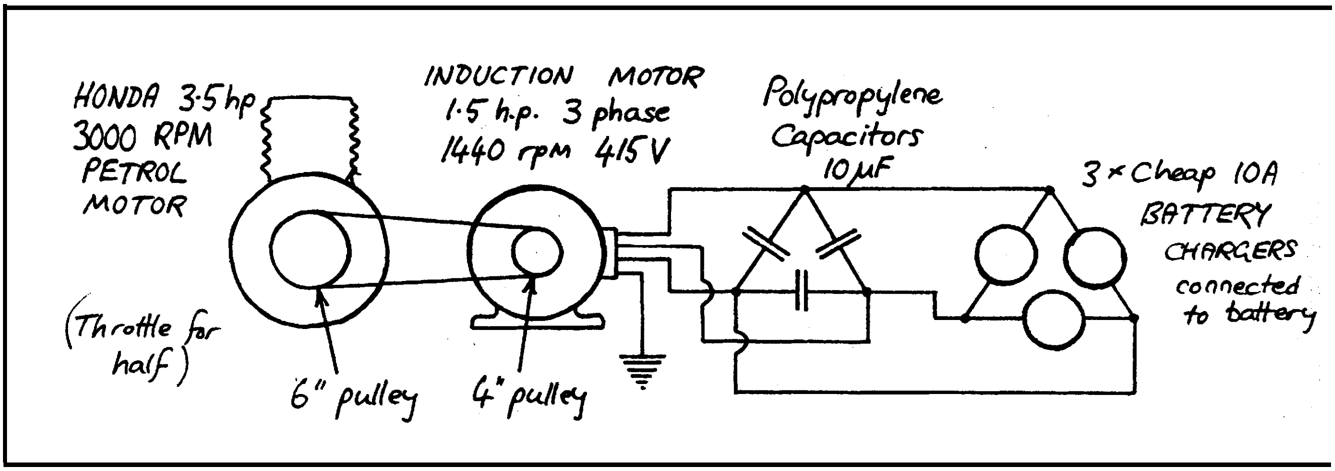


Fig 8. A practical backup generator.

rotor, the motor frame and the magnetic field. Looking from the rotors perspective in figure 4 it is obvious why the curve is symmetrical. At 3160 rpm the force is equal and opposite to rated speed and load. This corresponds to rated GENERATOR operation. The force is opposite, the rotation in the same direction, and power flows from the shaft back into the power lines, incidentally moving the kWh meter backwards!

In short

With a stationary field the shaft is stiff to rotate against the field and "wants" to remain stationary. It follows that if the whole outside of the motor is turned the shaft tries to follow it. The same effect can be achieved if the magnetic field is set spinning by application of AC. power: the shaft tries to spin so as to remain stationary with respect to the field. So the shaft only takes effort to spin faster than the magnetic field, and the petrol motor can accelerate to this speed with no load. After this speed the load increases sharply as the generator operates, holding the speed at that point.

In other words, if the shaft is spun faster than the magnetic field the machine starts generating and the energy being generated is causing the petrol motor to be loaded. A further factor is that the rotating field which builds up depends on the capacitors applied. The bigger the capacitor, the slower the field naturally rotates, and the slower the speed of generation, so the petrol motor speed can be controlled (to a limit of about 500 rpm minimum, depending on the induction motor).

An example

Figure 5 shows a Honda 3.5 hp. motor operating at 1/2 throttle, driving a 3-phase, 1.5 h.p. induction motor at 2000 rpm (its normal rated speed is 1440 rpm). The generator is connected to the essential capacitors connected in delta. The lines are then connected to. three cheap battery chargers con nected in turn to a battery. Overcharge cut-out will be necessary, as the chargers will not limit as usual on 240 volt mains. P.S. The 240 volt present across each phase can be used to power tools etc. up to about 500W as the battery chargers operate as voltage regulators.

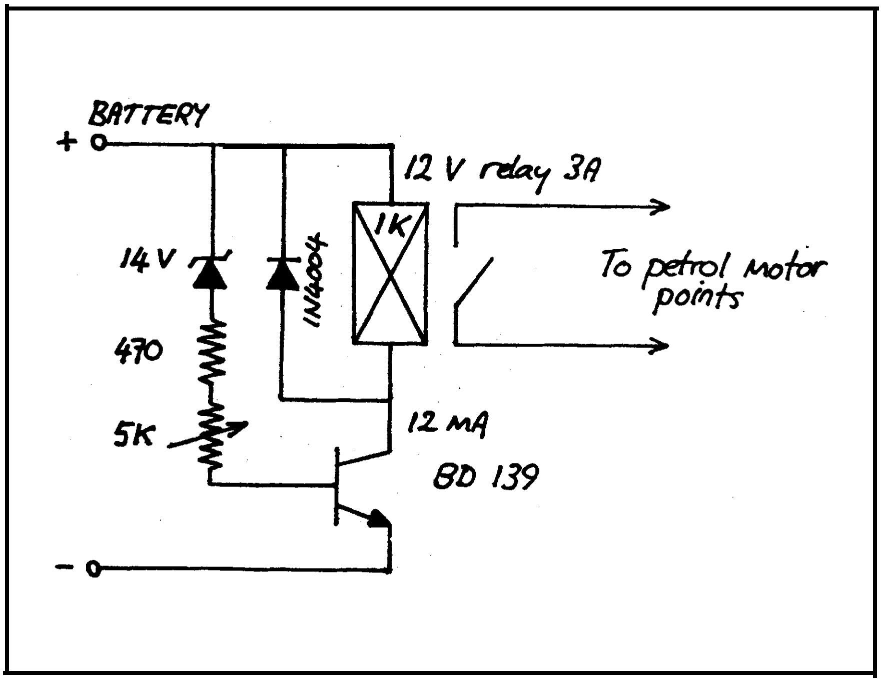


Fig 9. Cut-Out Circuit

Free Energy Not Valid....!

Government Policy based on Dollars.

by Peter Pedals

In 1988 the Department of Primary Industries and Energy published A NATIONAL ENERGY POLICY PAPER.

At a time when the Greenhouse Effect and the holes in the Ozone Layer are bringing civilisation to its biggest environmental crisis ever, the Australian Federal Government is continuing to make decisions that will contribute to the worsening of this crisis.

In the Federal Government's policy decisions, renewable energy is constantly ignored and its contribution played down. According to the policy paper "Australia has some of the lowest cost energy resources in the world, especially coal and uranium". What about sun, wind, flowing water (hydro) and wood as energy resources? And what about conservation, recycling and re-use of resources? Free and cheap energy resources have little influence on policy decisions because Gross Domestic Product (GDP) is used as a measuring stick in order to gauge the contribution made by any

energy source towards national policy making. The document defines renewables as follows: "Renewable energy sources involve conversion of energy forms which effectively and potentially have an infinite life." Sunshine, wind and hydro are obvious examples of such energy sources, the energy from which can be harnessed with little or no deleterious effect upon the environment. If an energy source can be utilised at very little cost it does not feature prominently in the GDP.

All of us who are harnessing these energy sources for our domestic (or commercial) power supply and who do not pay any bills to any energy authority do not have any effect upon the GDP (other than the capital cost of installation and replacement of components if necessary). This means that the very technology which may save civilisation from an impending doom is not of any relevance in national policy decisions. Fossil fuel products (Oil, Gas, Coal and Petroleum) and Uranium mining feature prominently in the national energy policy. Using GDP as a measure to set priorities for a National Energy Policy is therefore to give preference to the more pollutant, wasteful and non-renewable energy sources.

"The pre-occupation with large contributors to energy use, and the cor-

responding denigration of small contributors is illustrated by the figure of 1.7 PJ (Peta Joules of 1015 Joules) contributed by solar hot water installations in one year (in 5% of Australian households).

The Humble Clothes line: highly successful renewable technology.

If electric heaters were used to heat the same amount of water then the figure would be nearer to 5 PJ which would then get preferential treatment because of its increased contribution to GDP. Our aim should be to decrease the energy used for a given task, even though the GDP may decrease in the process. GDP is not an indicator of the quality of life or of environmental desirability and should not be used as an indicator for a correct energy policy."

Investment also features prominently in the policy document. The $2,762 million investment in electricity supply is to be recouped from the consumer in the long term - if necessary by increasing per unit cost. Although this figure is looked upon as an investment by the industry management, to the consumer it is a liability. As a comparison, investment in fossil fuel products comes to $1,767 million and solar water heaters is $2 million. Other renewable energy technologies didn't rate a mention as investments, the investments in these areas possibly not making the big league.

The policy paper goes on to list the benefits of renewable energy technologies which are:

- long term security of energy supply;
- expansion of the renewable energy equipment supply industry;
- reduced environmental impact.

But the paper then continues with "However, these benefits do not provide a compelling case for the artificial stimulation of the utilisation of renewable energy technologies in Australia.... Subsidies or price support for renewables would place a financial burden on the public and would not necessarily result in the optimal allocation of resources." What measuring stick is used in deciding on "optimum allocation of resources"? Would this also be dictated by impact on GDP (i.e. $$$)?

One problem with small independent power systems is that they are privately owned and have no effective lobby group to represent their interests. The largest single user of photovoltaic (solar) electric systems would be Telecom who has in excess of 500 kW (Kilowatt) of photovoltaic modules installed and is embarking on a remote and rural telecommunications program using $40 million of photovoltaic power supply systems.

When discussing coal and uranium, the document is careful to give an estimate of the size of the resource at various levels. For renewables it makes no such estimate, yet these are likely to be orders of magnitude greater than the others.

The document fails to recognise that renewables do not play a minor role in Australia's energy balance. The fact that solar, wind and hydro are making substantial contributions in lighting, passive heating, drying etc. has been ignored. Throughout the document energy is equated to fuel which completely ignores solar, wind and hydro as valuable energy resources. Passive solar design and wind turbines are referred to as new technologies.

"The humble clothes-line is a good example of a highly successful renewable technology; it is cheap, energy efficient and produces minimal pollution. Its non-renewable equivalent, the electric clothes dryer, has the opposite qualities. Despite the social and economic advantages the former compared to the latter, the latter is taken into account in energy balances but not the former!"

There is a small chapter devoted to Alternative Fuels, but with the possible exceptions of methanol and ethanol, these fuels were all forms of fossil fuels not based on crude oil that have not as yet been marketed. There is no attention paid to or mention of environmental sustainability of the various potential fuels discussed.

There is little reference in the policy paper to the dangers and harmful environmental effects of fossil fuels and nuclear fuels. Although it is considered that "Uranium has no relevance as an energy source for Australia which has adequate reserves of coal and gas" the policy paper devotes a whole chapter to Uranium. Both Uranium and Coal feature very largely in Australian exports. The policy paper makes numerous references to export/import and balance of payments. There should be a move away from an export/import economy to a self-sufficient economy. If we could move towards an environmentally harmonious self-sufficiency we would decrease our need to export fuels to other countries for them to pollute the planet with. Air pollution and acid rain know no national boundaries!

It is indeed a sad state of affairs that environmental issues are obscured by financial issues at a time when worldwide effort and attention needs to be turned towards the rapid deterioration of the atmosphere and the ozone layer. When are we going to see governments making policies that give environmental issues all the importance that they deserve?

Do we have to wait for the catastrophe before we take action?

Quotations are from the Conservation Council of South Australia reply to A NATIONAL ENERGY POLICY PAPER.

Give a rebate for solar water heating

Recent advances in solar water heating technology have resulted in extremely efficient and reliable units. There are Australian units which even in the depths of winter will not run out of hot water if they are properly sized.

The widespread use of solar water heating would have a significant effect on reducing carbon dioxide emissions to the environment. In Victoria the SEC and the Gas and Fuel Corporation compete with each other and offer ridiculously low tariffs for water heating. The SEC even pays householders up to $140 as a rebate to install an electric hot water service.

If a rebate was offered to householders installing solar water heaters this would make more sense.

This is a clear case of the Government contributing to the Greenhouse effect.

Higher prices for water heating by gas or electricity would also encourage the use of non-polluting solar systems.

As far as water heating is concerned, it is difficult to see the Victorian Solar Energy Council as other than a public relations exercise by a government committed by its electricity and gas-tariffs to ensuring that solar water heating remains an uneconomic proposition. This is a clear case of government contributing to the greenhouse effect.

Andrew Blair, Outlook Alternatives, Wangaratta

Got a query?

We would like to start an *enquiry service* for readers.

Our idea is that if we print an enquiry, another of our readers may be able to answer it.

Start Scratchin'!

Basic Errors

Dear Editor,

I am writing to you concerning the "Discussion Article" in Soft Technology, Number 29 page 30 by J. Thillaimuthu.

This article seems to have all the right terms and includes many current "buzz" words. Unfortunately, though impressive, it may also be misleading to some readers not familiar with some basic ideas of the science of heat and engines; thermodynamics. An article of this nature is probably difficult to check and edit. The workload of the team of dedicated staff producing the magazine from Melbourne is no doubt high.

One result in thermodynamics is critical to the discussion of efficiency of a heat engine. Sadi Carnot, a French engineer, showed in 1824 that no heat engine can be more efficient than that undergoing the so called "Carnot" cycle. The efficiency of this cycle is given by a simple formula and is dependent only on the input temperature T1 and output temperature T2 of the engine.

$$\text{Carnot Efficiency (\%)} = \frac{T_2 - T_1}{T_2 + 273} \times 100$$

Again, no heat engine can be more efficient than this. An ideal engine using boiling water (100 degrees C) and freezing water (0 degrees C) has an efficiency, using the formula, of 27%. Often the efficiency of a real heat engine is quoted as how close it is to achieving the Carnot efficiency. If one achieved 20% overall efficiency in the above case, it is sometimes called 74% efficient, as it achieved this fraction of the maximum possible efficiency.

It is important to note that the medium used for the engine be it water as vapour or liquid or a water ammonia mixture cannot gain an advantage over an ideal Carnot engine working between the same temperatures. The first law of thermodynamics has been phrased "you cannot win, you can only break even" or "there is no such thing as a free lunch". The achievable efficiency is limited primarily by the temperature difference, T2-Tl. When this is small, as in the Thillaimuthu proposal, the efficiency must be low.

So perhaps solar energy is indeed free. However, solar collectors, heat exchangers, plumbing, other equipment and maintenance is definitely not and thus it may be quite unreasonable to scale up a system to overcome intrinsic inefficiencies in the engine. The following overall scenario for a solar powered heat engine is probably reasonable. . Starting with water at 20 degrees C this may be heated using common solar panels to around 60 degrees C with around 50% efficiency. A real engine of modest scale may achieve half of the Carnot efficiency which is 12% from the equation. The efficiency of small electric generators does not usually exceed 60%. Thus the overall efficiency will be only 1.5%.

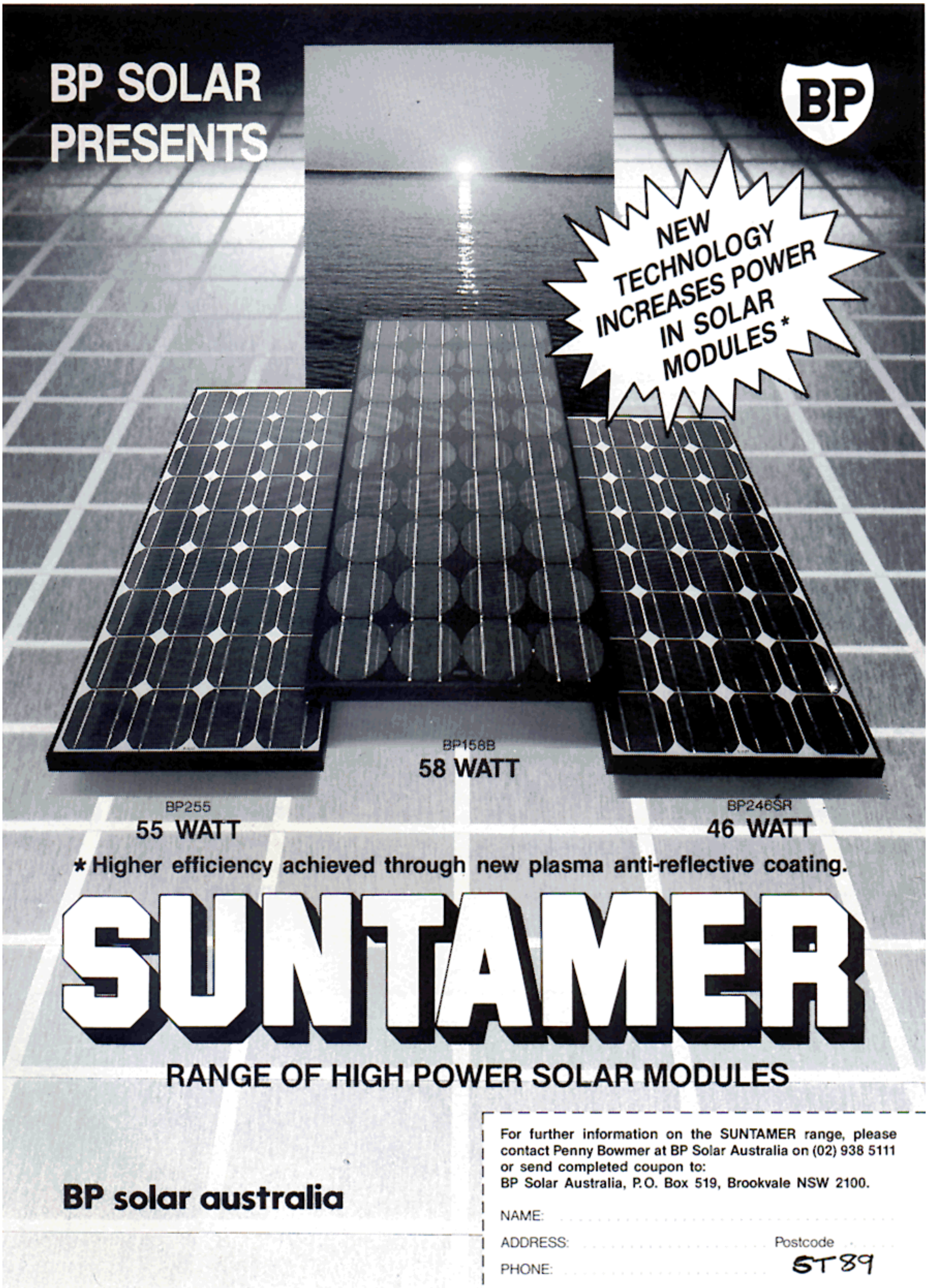
The first law of thermodynamics has been phrased as 'you can't win whatever you do' or 'there is no such thing as a free lunch' ...

This is about ten times less than that of a photovoltaic panel. These are fairly expensive, but require little maintenance, have no moving parts, used no water or chemicals and make no noise.

One reason that the photovoltaic panel is intrinsically more efficient, is that it effectively uses the 5000 degrees C temperature of the sun's light and not the 60 degrees C temperature of the hot water.

Please continue to encourage people to put forward and discuss ideas. They are perhaps old ideas that have not worked in the past, perhaps due to the lack of some suitable modern material to technique, and may now be begging to be effectively rediscovered.

Yours faithfully
Stephen Downing
Kamgah, ACT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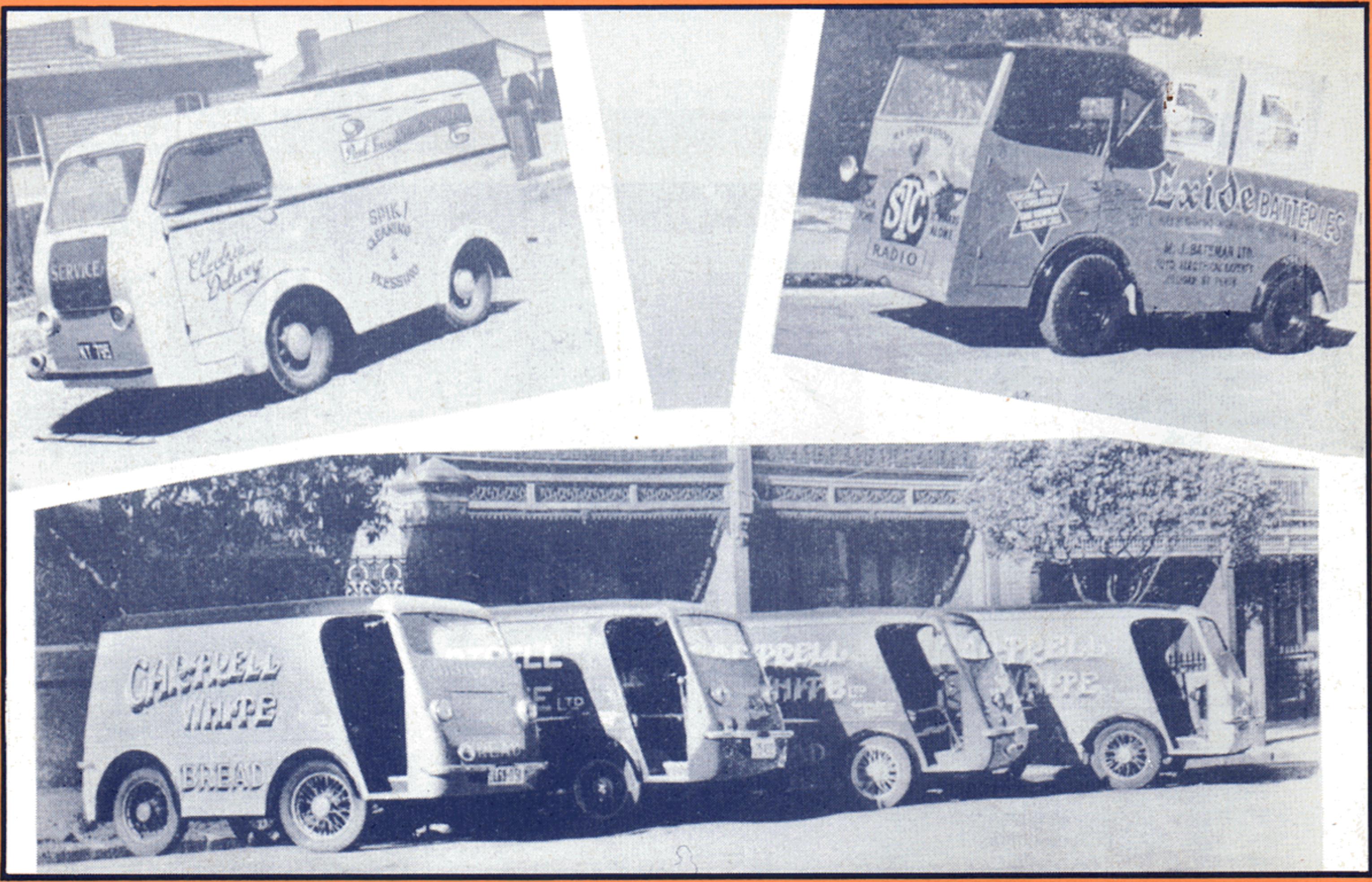

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Electric Delivery Vans from around Australia, late 1940's.