

USER HANDBOOK

SOLAR POWERED RE-CHARGING SYSTEM

FOR

NICKEL CADMIUM BATTERY PACKS

1983

FOR MODEL 1805-300

## CONTENTS

### Chapter One GENERAL DESCRIPTION

| Sections                              | Page |
|---------------------------------------|------|
| 1. Purpose and Facilities             | 1    |
| 2. System Description                 | 2    |
| 3. Technical User Data                | 4    |
| 4. General Description                | 5    |
| 5. Accessories and Operational Spares | 7    |
| 6. Technical Application Data         | 7    |

### Chapter Two OPERATION

|                            |    |
|----------------------------|----|
| 7. Setting Up Instructions | 10 |
| 8. Operating Instructions  | 11 |

### Chapter Three USER SERVICING

|            |    |
|------------|----|
| 9. General | 14 |
|------------|----|

### LIST OF ILLUSTRATIONS

1. Solar Charging System (Photo).
2. Block diagram for Solar Battery Charger.
3. Four panel array.
4. Solar cell description.
5. Charge Monitor - system interaction.
6. Charge Monitor - system configuration.
7. Charge Monitor - signal processing hybrid.
8. Charge Monitor - counters and L.C.D. driven hybrids.
9. Charge Monitor/Battery Box - electrical wiring diagram
10. Charge Monitor/Battery Box - detailed connection  
diagram.
11. Solar Array - Current voltage characteristic.
12. Battery - charge acceptance versus temperature.
13. Battery - retained capacity versus temperature.
14. Insolation rate versus time of day.
15. Complete deployed system (Photo).
16. Solar Panel.
17. Charge Monitor/battery box (Photo).
18. Charge Monitor - display detail.

## COMPLETE EQUIPMENT SCHEDULE

### 1. SOLAR ARRAY

- a. Four solar panels.
- b. Canvas carrier.
- c. Power output cable.
- d. Output connector

### 2. CHARGE MONITOR/BATTERY BOX

- a. Box assembly.
- b. Box lid.
- c. Battery contacts.
- d. Input socket.
- e. Auxiliary output socket.
- f. Cap for auxiliary socket.

### 3. STIFFENER ROD ASSEMBLY

- a. Two small diameter tubes.
- b. One large diameter tube.
- c. Internal cord.

### 4. AUXILIARY CABLE

### 5. ACCESSORY POUCH



|   |             |                        |
|---|-------------|------------------------|
| <b>TITLE</b><br><u>FOUR PANEL (24 CELL) SYSTEM WITH</u><br><u>CHARGE MONITOR (BBF1)</u> |             | <b>REFERENCE</b>       |
|   |             | <b>SHEET</b>           |
|   |             | <b>DATE</b> 11/5/83    |
| <b>AUTHOR</b> B. WILSON   | <b>DEPT</b> | <b>SUPERSEDES DATE</b> |
| <b>PHILIPS — HENDON WORKS</b> SOUTH AUSTRALIA   |             |                        |



## USER HANDBOOK

### SOLAR POWERED RE-CHARGING SYSTEM FOR NICKEL CADMIUM BATTERY PACKS

#### Chapter One

#### GENERAL DESCRIPTION

##### SECTION 1 - PURPOSE AND FACILITIES

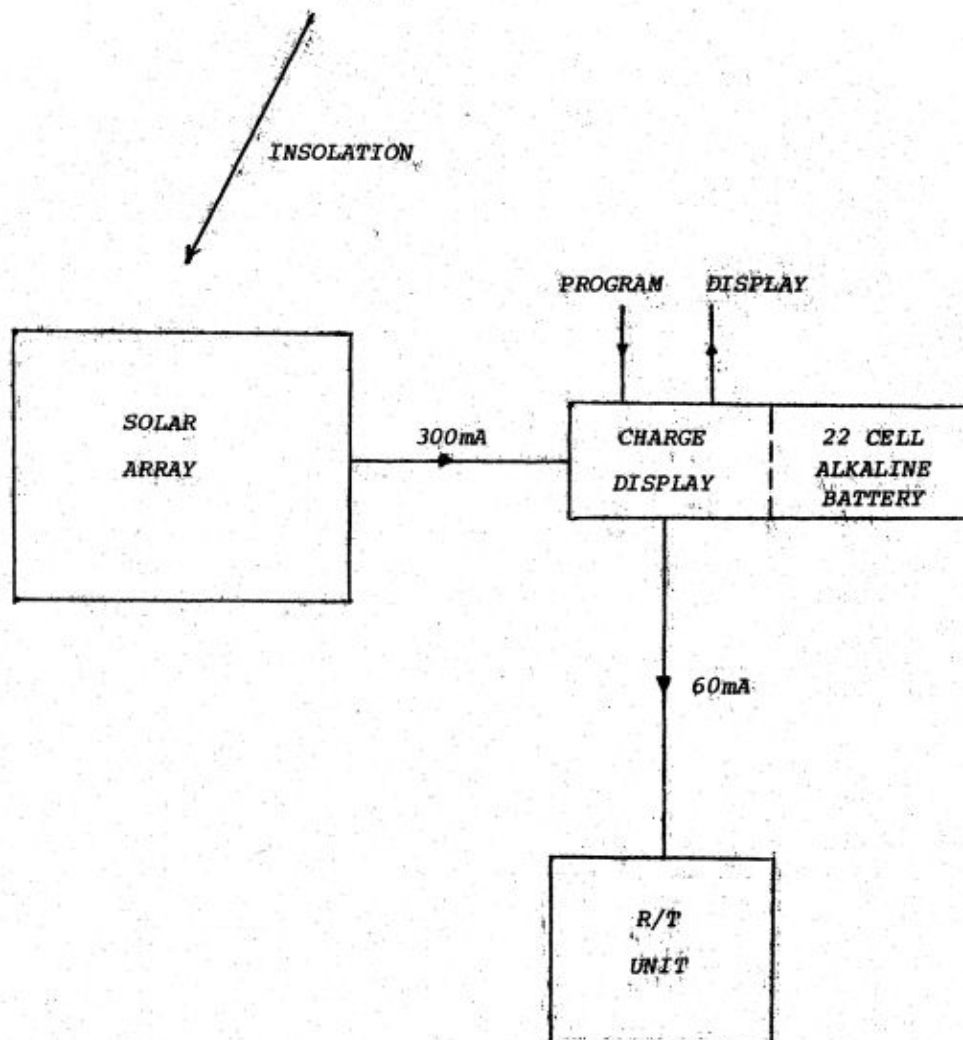
1. Nickel Cadmium battery packs which have been discharged through use or by self-discharge in storage, can be re-charged using the sun as a direct energy source. Solar photo-voltaic cells linked in a series combination generate sufficient voltage to drive current back through the battery to re-charge it. The time to re-charge the battery depends on the intensity of the sun and also on the initial state of discharge of the battery. This solar charging system is intended to be used where alternative supplies of electrical power is not available. It may not be acceptable to re-charge by other means, alternative methods of re-charging could be simply inconvenient or they may be impractical in order to remain covert. This solar re-charging system has another advantage in that the whole process once initiated is automatic requiring no direct supervision. The solar re-charger is silent and simple methods of camouflage can add to its low detectability in the field.

2. SOLAR CELLS. The solar cells are the active component of the re-charging system and should be operated in unobstructed sunlight to capture the maximum amount of the available sun energy.

3. CHARGE MONITOR. The charge monitor or charge controller does not have to be exposed to the sun and indeed is best shaded from direct sunlight to reduce heat build up. Its function is to control and manage the re-charging process.

4. FACILITIES. The solar re-charger provides the following features for charging batteries and the management of the re-charging task :

- a. Remote re-charging of batteries away from utility electricity supplies or other portable power supplies.
- b. Automatic monitoring of the amount of charge returned to the battery including compensation for re-charging losses.



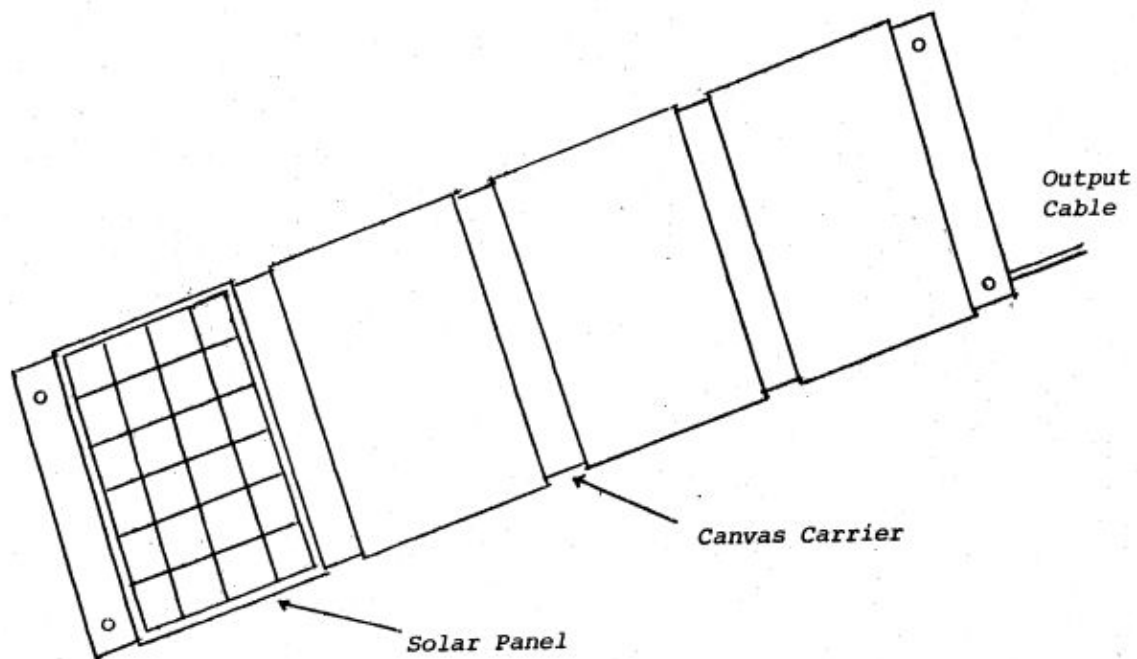
|  |           |             |                 |
|--|-----------|-------------|-----------------|
| TITLE                                  |           | REFERENCE   |                 |
| BLOCK DIAGRAM                          |           | SHEET       |                 |
| SOLAR BATTERY CHARGER                  |           | DATE 6/5/83 |                 |
| AUTHOR                                 | B. WILSON | DEPT        | SUPERSEDES DATE |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |           |             |                 |

- c. Automatic initiation of a trickle charge mode after a pre-determined quantity of charge has been returned to the battery.
- d. Non light emitting type display to indicate the returned charge.
- e. The capability to pre-select the amount of charge required to be returned to the battery.
- f. While charging a battery a secondary output enables the supply of current to a second battery which may be operating a transceiver.

## SECTION 2 - SYSTEM DESCRIPTION

- 5. THE SYSTEM. The system consists of an array of solar panels, an inter-connecting cable and a charge monitor. A canvas panel carrier and a canvas pouch are provided to house the equipment.
- 6. SOLAR ARRAY. The solar array consists of a set of four solar panels electrically connected in series and mounted on a canvas carrier. The carrier serves as a flexible support allowing convenient folding so that the entire assembly can be stored in a canvas pouch.
  - a. The solar cell collects the light energy and directly transforms it into electrical energy.
  - b. Solar cells are series connected in four chains of six cells to form a solar panel.
  - c. Shunt diodes are mounted across these chains of cells to allow alternative paths for electricity to flow in the advent of partial shading of a cell or an internal malfunction.
  - d. With the panels mounted on the canvas carrier the individual panels are electrically joined together using miniature gold plated connectors. The connectors are sealed in plastic sleeving and held captive in cable pockets in the canvas carrier.
  - e. The solar array is provided with a cable and is terminated with a connector to attach it to the charge monitor.





|  |                 |             |
|--|-----------------|-------------|
| TITLE                                  |                 | REFERENCE   |
| <u>FOUR PANEL SOLAR ARRAY</u>          |                 | SHEET       |
| AUTHOR B. WILSON                       |                 | DATE 6/5/83 |
| DEPT                                   | SUPERSEDES DATE |             |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |                 |             |

5. CHARGE MONITOR. The charge monitor is housed in a metal box which doubles to hold and make electrical contact to the battery being charged. The charge monitor consists of two main elements :

- a. An electronic section including charge measuring and signal processing.
- b. A second electronic section which includes both the liquid crystal display module and its display driver module.

When current flows from the solar array through the charge monitor to the battery the charge monitor continually adds all the current passing and digitally displays the amount of returned charge in 10% increments of a full charge dosage.

- a. A liquid crystal display indicates the returned charge as described above and also indicates the relative charge rate and displays whether in a full charge or trickle charge mode of operation.
- b. Connectors :
  - Input - this connector accepts the socket from the solar array.
  - Output - this connector accepts the cable to the R/T unit, to supply a second battery.
- c. Programming switch - the button is pressed to allow the liquid crystal display to step progressively from 0 to 9 and also to select full charge or trickle charge mode.

### SECTION 3 - TECHNICAL USER DATA

6. SOLAR PANEL. Electrical output of a solar photovoltaic system is specified at 25°C with insolation conditions of 1Kw/m<sup>2</sup> with spectral conditions of AM1 (air mass one). This in general terms corresponds to intensity levels encountered in summer time with the sun directly overhead. Twenty four solar cells are connected in series within each panel.

|                          |                     |            |
|--------------------------|---------------------|------------|
| Open circuit voltage     | (typ)               | 13.5 Volts |
| Short circuit current    | (typ)               | 315 mA     |
| Voltage at maximum power | (typ)               | 10.8 Volts |
| Current at maximum power | (typ)               | 300 mA     |
| Maximum power            | (typ)               | 3240 mW    |
| Weight                   | 300 gm              |            |
| Dimensions               | 226mm x 156mm x 9mm |            |

7. SOLAR ARRAY. To charge a standard 28 Volt BBF1 battery pack four panels are connected in series so that their respective voltages are accumulative :

|                          |       |          |
|--------------------------|-------|----------|
| Open circuit voltage     | (typ) | 54 Volts |
| Short circuit current    | (typ) | 315 mA   |
| Voltage at maximum power | (typ) | 43 Volts |
| Current at maximum power | (typ) | 300 mA   |
| Maximum power            | (typ) | 13 Watts |

8. CHARGE MONITOR. It is difficult to determine the state of charge of a nickel cadmium battery and the usual technique to re-charge such a battery is to allow a given current to flow for a pre-determined time. When the sun is used as an energy source, the output of a solar system will not be constant therefore if the total current flowing into the battery can be measured, charging can be stopped once sufficient current, in terms of ampere hours, has flowed. The charge monitor can detect this point and full charge is achieved when 120% of the rated capacity has been returned to the battery.

For 28 volt 1 ampere hour BBF1 battery pack the charge monitor has the following typical parameters :

|                                       |                 |
|---------------------------------------|-----------------|
| Maximum charge current                | 400 mA          |
| Trickle charge current                | 30 mA           |
| Voltage drop across monitor           | 1 volt at 300mA |
| Supply current with no charge current | (typ) 8mA       |
| Supply voltage                        | ± 50 Volts      |
| Regulated auxiliary output current    | 60 mA           |

#### SECTION 4 - GENERAL DESCRIPTION

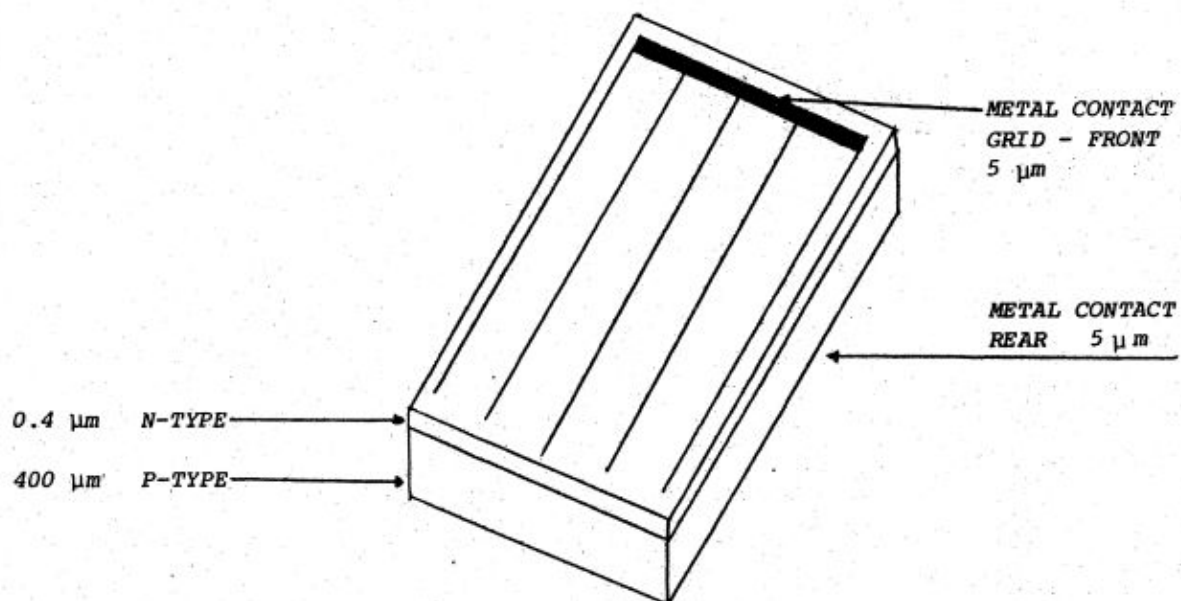
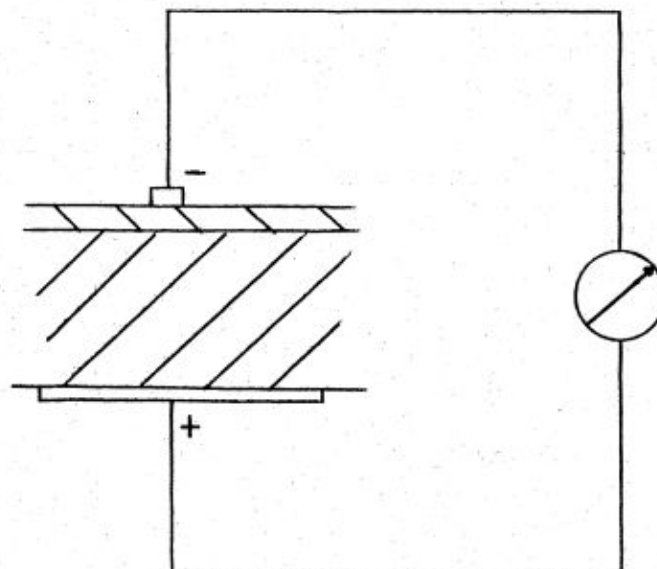
9. SOLAR CELLS. An ingot of hyperpure silicon is doped with Boron to form a p-type semiconductor material. The ingot is cut into thin slices, then Phosphorus is diffused into only one side to form a p-n junction which lies a few tenths of a micro-meter below the surface. Electrical contact with the top surface of the slice is made through a metal grid and then the top surface is entirely covered with a  $\text{TiO}_2$  (titanium dioxide) anti-reflection coating. The underside of the slice is completely covered with metal to form a second contact. Each solar cell develops about 0.5 volts and the current delivered depends not only on the conversion efficiency but also on the cell area and the insolation. The intensity of the sun will in turn be a function of the earth's latitude, the season, the time of the day, cloud conditions, atmospheric conditions including ozone content and turbidity and the presence of ground obstructions.

10. SOLAR PANELS. Round silicon solar cells are sawn into squares and arranged into rows of closely spaced chains. Operational reliability is enhanced by the use of twin electrical connections between each solar cell. The chains of cells are encased in a lamination of plastic and anodised aluminium. The encapsulant, Poly Vinyl Butyral (PVB), provides a durable moisture resistant cover for the cells. The encapsulation process involves high temperature and pressure conditions and intimate contact with the cell surface is achieved. PVB has been used for many years in the automobile industry for laminating car windscreens. Polymethylmethacrylate sheet is used for the front cover plate and surface roughening reduces unwanted reflection. For the rear side of the panel aluminium sheet, 1mm thickness, is used. It is light, durable and a good heat conductor. Rigidity is achieved by pre-forming the plate into a shallow box. Anodising gives the necessary surface hardness and chemical stability. The colour and sheen are controlled to achieve a less conspicuous assembly. A rubber belt surrounds the panel to add mechanical protection to the edges.

FRONT CONTACT  
N-TYPE SILICON

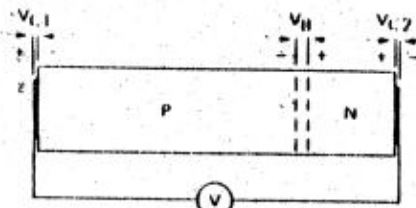
P-TYPE SILICON

REAR CONTACT

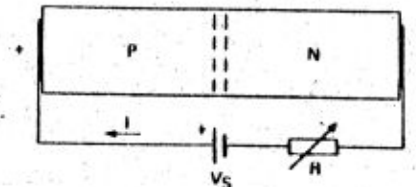


|  |  |                 |
|--|--|-----------------|
| TITLE                                  |  | REFERENCE       |
| <u>SOLAR CELL DESCRIPTION</u>          |  | SHEET           |
| AUTHOR B. WILSON                       |  | DATE 6/5/83     |
| DEPT                                   |  | SUPERSEDES DATE |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |  |                 |

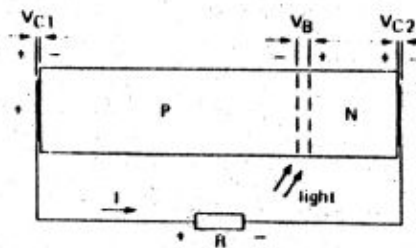




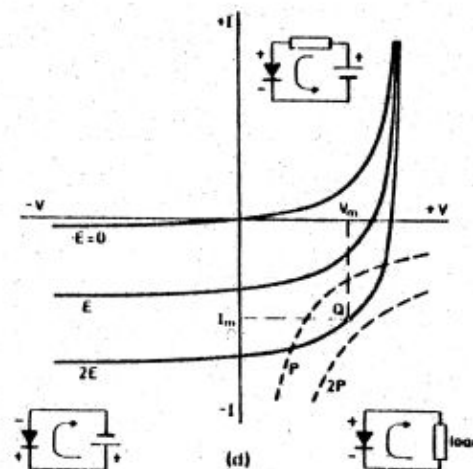
(a)



(b)



(c)



(d)

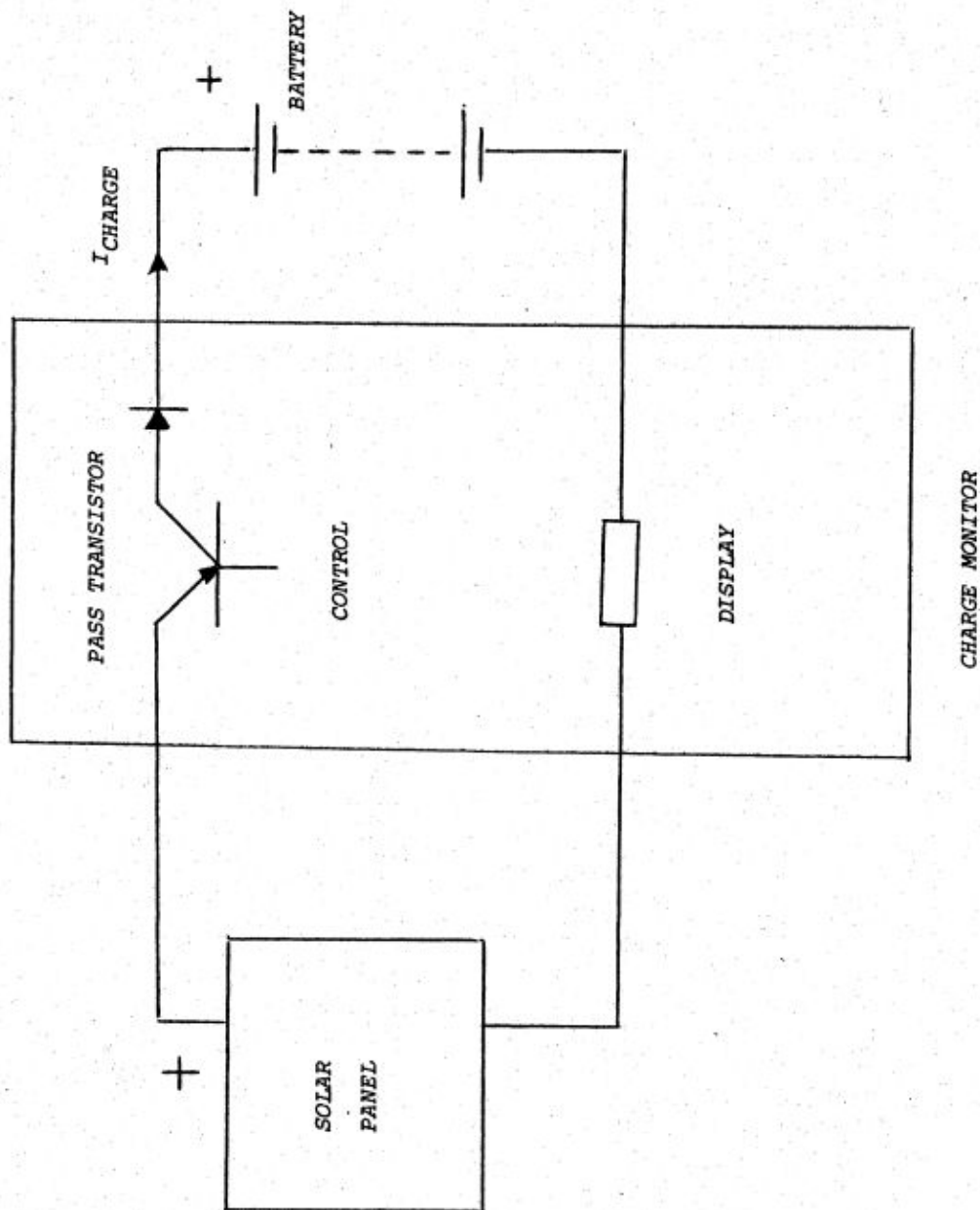
Fig. 1 Operation of solar cell:  
 (a) barrier potential and contact potentials in non-irradiated solar cell  
 (b) normal diode conduction  
 (c) production of photovoltaic current in an irradiated solar cell  
 (d) diode characteristics

|  |      |                 |
|--|------|-----------------|
| TITLE                                  |      | REFERENCE       |
| OPERATION OF SOLAR CELL                |      | SHEET           |
| TECHNICAL DESCRIPTION                  |      | DATE 6/5/83     |
| AUTHOR B. WILSON                       | DEPT | SUPERSEDES DATE |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |      |                 |

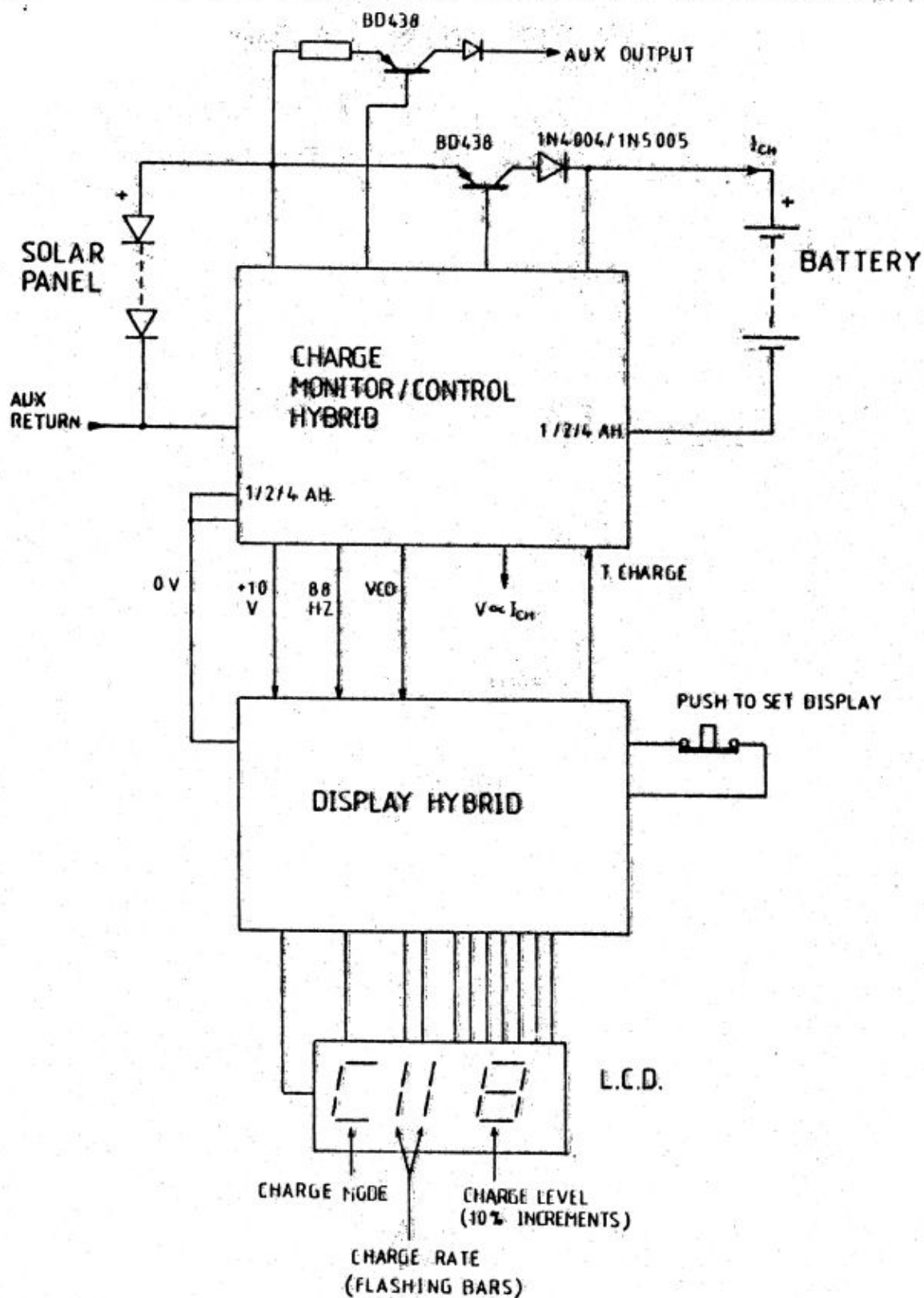
11. SOLAR ARRAY. The panels are mounted on a canvas carrier which folds, not unlike a road map, into a compact unit less than 50mm thick. Deployment is a matter of simply unfolding the array and aligning it so that its surface is approximately perpendicular to the sun. All panels remain electrically connected when stowed either in a man pack or in a belt pouch. Pockets in the canvas carrier hold and protect the electrical connections between the panels. A tubular assembly of light weight aluminium rods can be slipped into loops on the back of the canvas carrier to make the unit semi-rigid for convenient manipulation during use.

12. CHARGE MONITOR. The solar charging system does not depend on the charge monitor module for basic operation, however field trials have shown it is essential for personnel to have some indication that the current is actually flowing to the battery. To increase confidence in the equipment it is helpful for personnel to have a means to readily check that it is working. A simple moving coil instrument could have been used but it would be relatively insensitive, possibly bulky and somewhat fragile. Electronic circuitry improves the sensitivity and indication can be provided using a liquid crystal display.

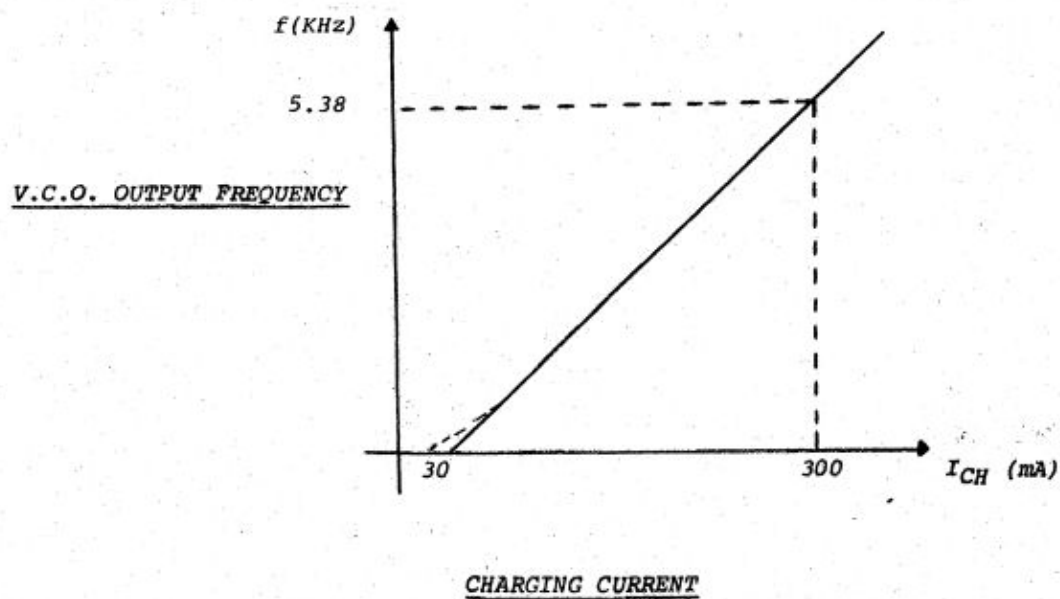
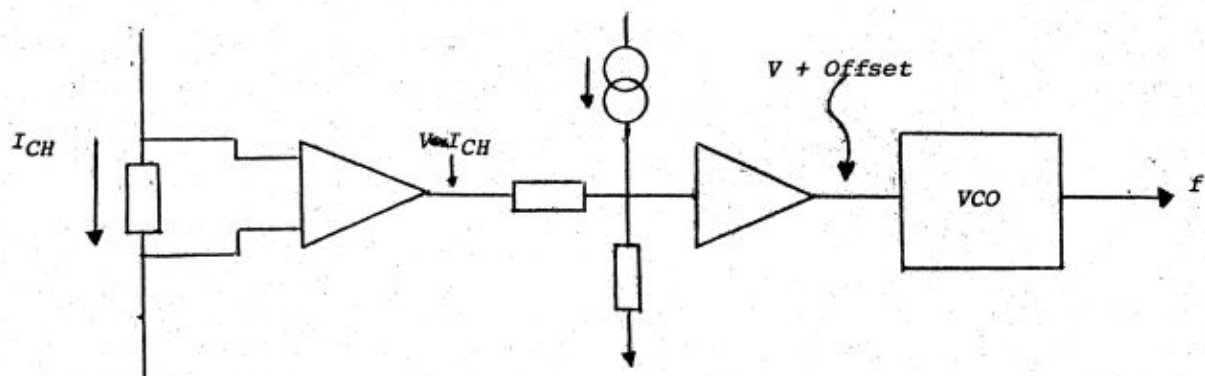
Two electronic module packages have been custom designed and by using integrated circuitry and thick film technologies miniaturisation and high reliability can be realised. The electronic configuration makes the re-charging process automatic and personnel are free for other tasks. The first hybrid OM896 contains the signal processing and measuring circuitry which calculates the amount of returned charge. The second hybrid OM897 contains a counter and display logic suitable for driving the LCD. The LCD and the two hybrids are mounted on a printed circuit board. A small push button switch allows for the programming of the charge monitor unit.



|   |  |                 |        |
|---|--|-----------------|--------|
| <b>TITLE</b><br><u>CHARGE MONITOR</u><br><u>COMPLETE SYSTEM INTERACTION</u> |  | REFERENCE       | RAVEN  |
|   |  | SHEET           |        |
| <b>AUTHOR</b> B. WILSON <b>DEPT</b>   |  | DATE            | 6/5/83 |
|   |  | SUPERSEDES DATE |        |
| <b>PHILIPS — HENDON WORKS</b> SOUTH AUSTRALIA                               |  |                 |        |

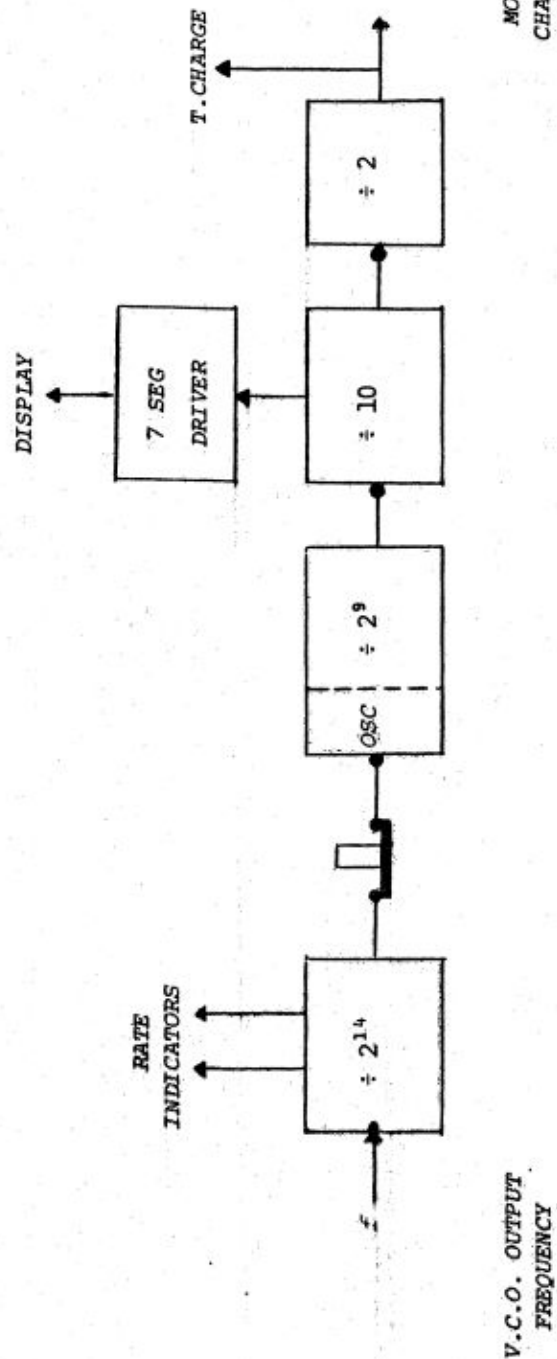


|  |           |           |                 |
|--|-----------|-----------|-----------------|
| TITLE                                    |           | REFERENCE | RAVEN           |
| CHARGE MONITOR                           |           | SHEET     |                 |
| SYSTEM CONFIGURATION                     |           | DATE      | 6/5/83          |
| AUTHOR                                   | B. WILSON | DEPT      | SUPERSEDES DATE |
| PHILIPS — HENDON WORKS · SOUTH AUSTRALIA |           |           |                 |

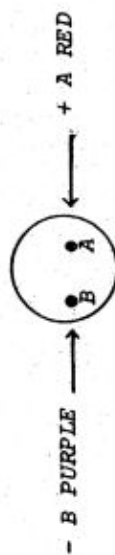


|  |      |                       |
|--|------|-----------------------|
| TITLE                                  |      | REFERENCE OM896/OM898 |
| CHARGE MONITOR                         |      | SHEET                 |
| SIGNAL PROCESSING HYBRID               |      | DATE 6/5/83           |
| AUTHOR B. WILSON                       | DEPT | SUPERSEDES DATE       |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |      |                       |





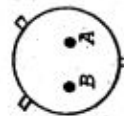
|  |      |                       |
|--|------|-----------------------|
| TITLE                                  |      | REFERENCE OM897/OM899 |
| CHARGE MONITOR                         |      | SHEET                 |
| L.C.D. DRIVER HYBRID                   |      | DATE 6/5/83           |
| AUTHOR B. WILSON                       | DEPT | SUPERSEDES DATE       |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |      |                       |



KPT06F 8-2S  
CABLE FROM SOLAR PANEL



MC11E-8-3SN  
CABLE TO R/T UNIT



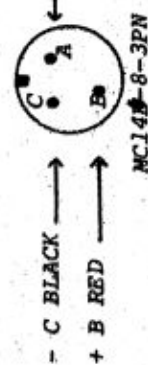
KPT07A 8-2P



MC14E-8-3PN



KPT07A 8-2P  
RECEPTACLE



MC14E-8-3PN  
RECEPTACLE

TITLE  
**ELECTRICAL WIRING DIAGRAM**  
SOLAR PANEL TO CHARGE MONITOR/R/T UNIT

AUTHOR B. WILSON

DEPT

REFERENCE

SHEET

DATE 10/5/83

SUPERSEDES DATE

**PHILIPS — HENDON WORKS** SOUTH AUSTRALIA



## SECTION 5 - ACCESSORIES AND OPERATIONAL SPARES

13. The following accessories are provided with each set of equipment :

| ITEM                       | QUANTITY |
|----------------------------|----------|
| 1. Accessory pouch         | 1        |
| 2. Stiffening rod assembly | 1        |
| 3. Auxiliary cable         | 1        |

No spares are provided with the equipment as no maintenance or repair is required in the field.

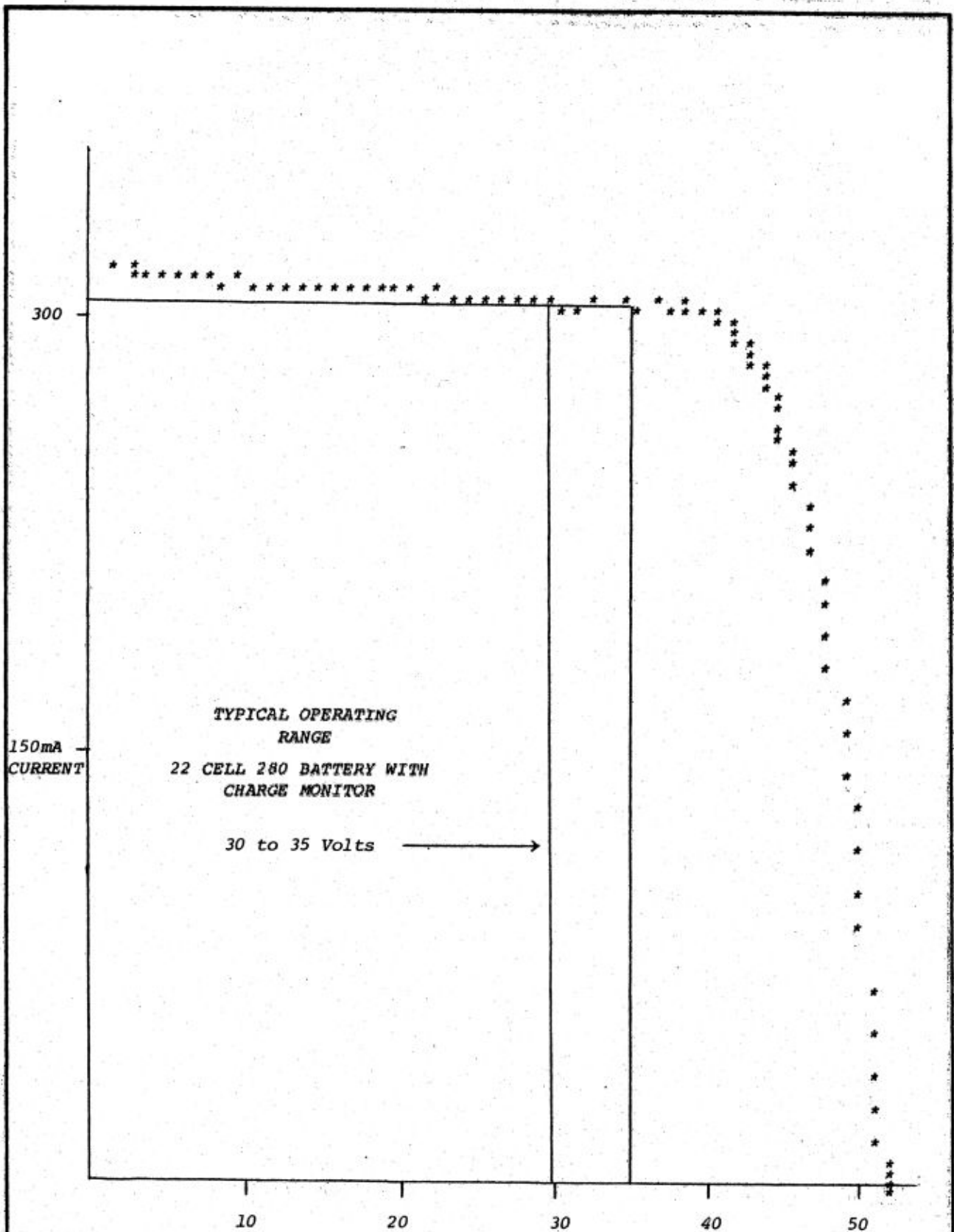
14. ACCESSORY POUCH. A canvas pouch specifically supplied to house the folded solar array and its cable. Accessory items (2) and (3) can also be stored within the bag when not in use.

15. STIFFENER ROD ASSEMBLY. A three piece aluminium tube assembly is used to support the solar array during operation. The aluminium tubes slide into each other to form an extended shaft. The various pieces are kept together with a green cord, the assembly is extended by pulling on one end of the cord while holding the closest rod.

16. AUXILIARY CABLE. A cable that can be used to supply current to a transceiver unit while a battery is being charged in the charge monitor/battery box. The cable can be used either way round as identical connectors are used on each end.

## SECTION 6 - TECHNICAL APPLICATIONS DATA.

17. GENERAL. The solar charger concept uses panels of series connected solar cells. Higher voltages are obtained by connecting together the appropriate number of panels. The current capability of the system is limited mainly by the area of the solar cell and is essentially independant of voltage (see next page ). From these graphs, it can be seen that, if a battery of sufficiently high voltage were connected across the solar panels, the current may be very much reduced from its maximum value.



|  |      |                 |
|--|------|-----------------|
| TITLE                                  |      | REFERENCE       |
| CURRENT - VOLTAGE CHARACTERISTIC       |      | SHEET           |
| SOLAR ARRAY                            |      | DATE 6/5/83     |
| AUTHOR B. WILSON                       | DEPT | SUPERSEDES DATE |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |      |                 |



In this application the battery is a 22 cell, 28 volt NiCd pack powered by a four panel solar array and a charge monitor. The nominal output current is 300mA. These items are believed to offer the best trade off in regard to size weight and cost and still provide the user with sufficient capacity to meet his daily power requirements.

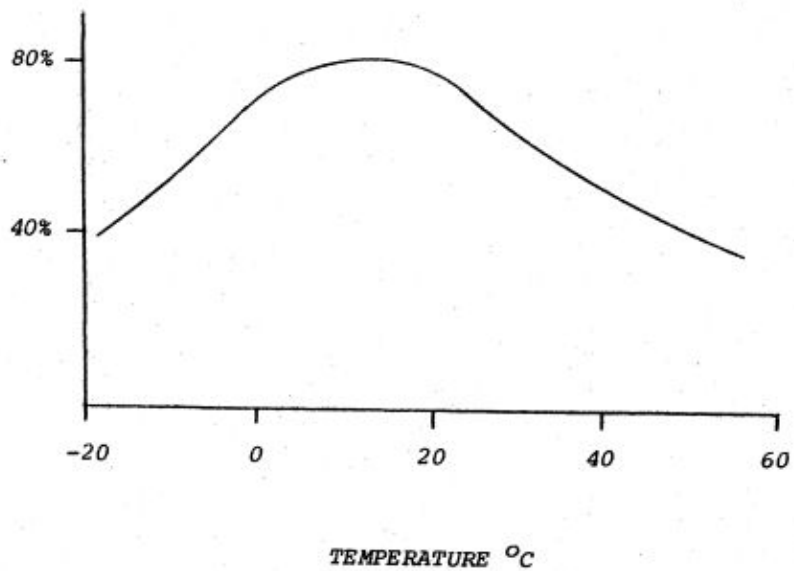
18. LIMITATIONS AND UNKNOWNNS OF SYSTEM. Many variables are discovered when a scientific study of this system is under taken.

- a. The output voltage of solar panels reduces as their temperature increases. This may lead to a reduced charging rate.
- b. The battery voltage reduces as the temperature of the battery increases.
- c. The battery voltage will be higher if the recharging rate is increased making it impossible to measure the state of charge of the battery.
- d. As the battery temperature increases then so the charge that the battery retains is reduced.
- e. The charging efficiency of the battery is reduced by both lower and higher temperatures, the optimum for re-charging is between 0°C and 30°C.

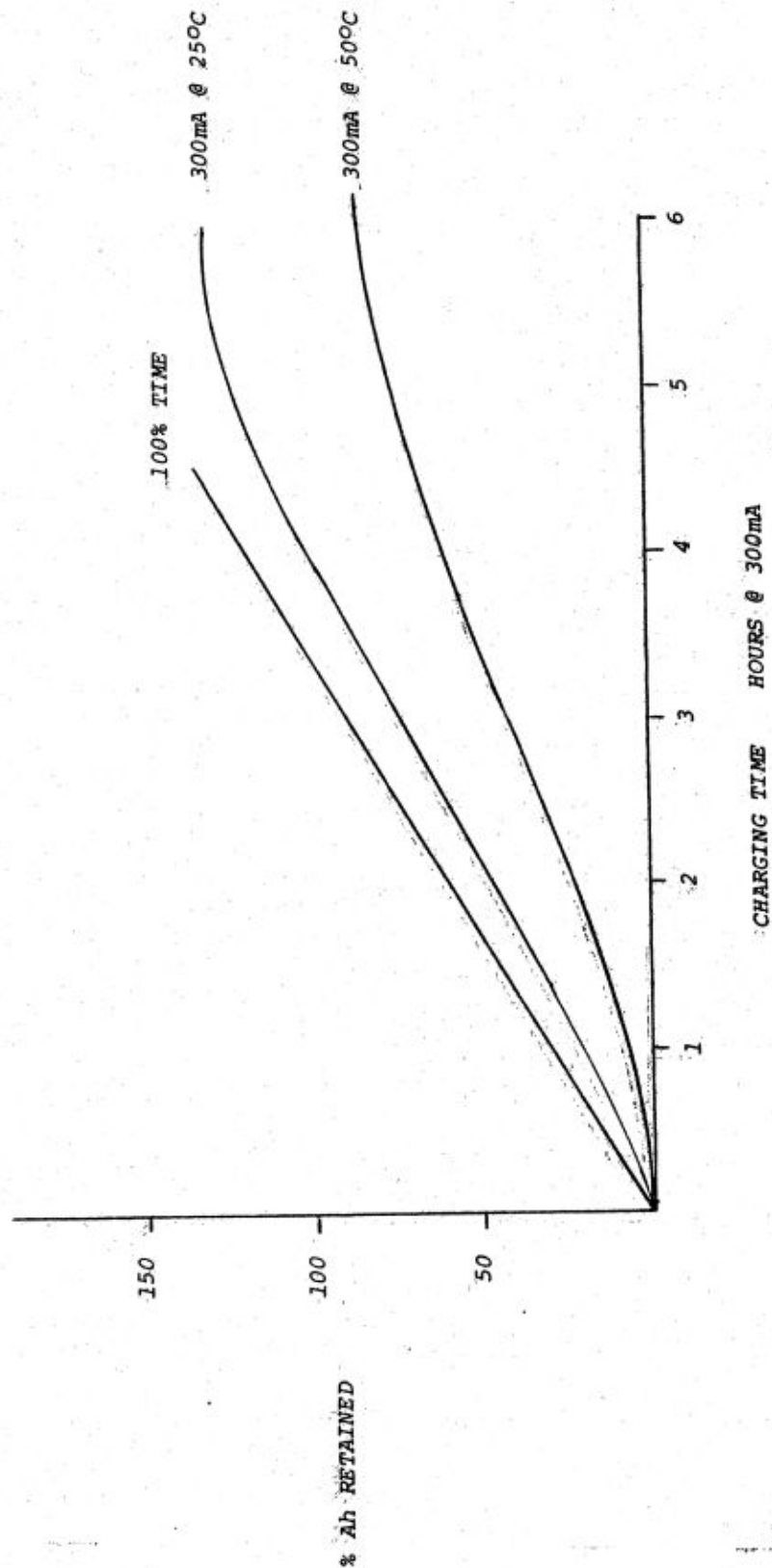
Any system that measures and controls the re-charging process can only be approximate. To improve the accuracy of monitoring the following should be sought :

- a. Keep the solar panels as cool as possible by choosing a position elevated above the ground for operation to allow for good air circulation around the panels. Select backgrounds that do not get too hot and avoid laying panels directly onto the ground.
- b. Keep the battery cool by either placing it in shade beneath the panels or some other cool spot. The charging efficiency and charge retention will be greater if the battery is kept cool and this will inturn improve the measuring accuracy of the charge monitor.

CHARGE ACCEPTANCE  
EFFICIENCY  
@ 300mA



|                                      |      |                 |
|--------------------------------------|------|-----------------|
| TITLE                                |      | REFERENCE       |
| CHARGE ACCEPTANCE VERSUS TEMPERATURE |      | RAVEN           |
| FOR ALKALINE (NiCd) BATTERY          |      | SHEET           |
| AUTHOR                               | DEPT | DATE            |
| B. WILSON                            |      | 6/5/83          |
| PHILIPS — HENDON WORKS               |      | SUPERSEDES DATE |
| SOUTH AUSTRALIA                      |      |                 |



TITLE  
RETAINED CAPACITY VERSUS CHARGE TIME  
ALKALINE (NiCd)

AUTHOR B. WILSON

DEPT

REFERENCE RAYEN

SHEET

DATE 6/5/83

SUPERSEDES DATE

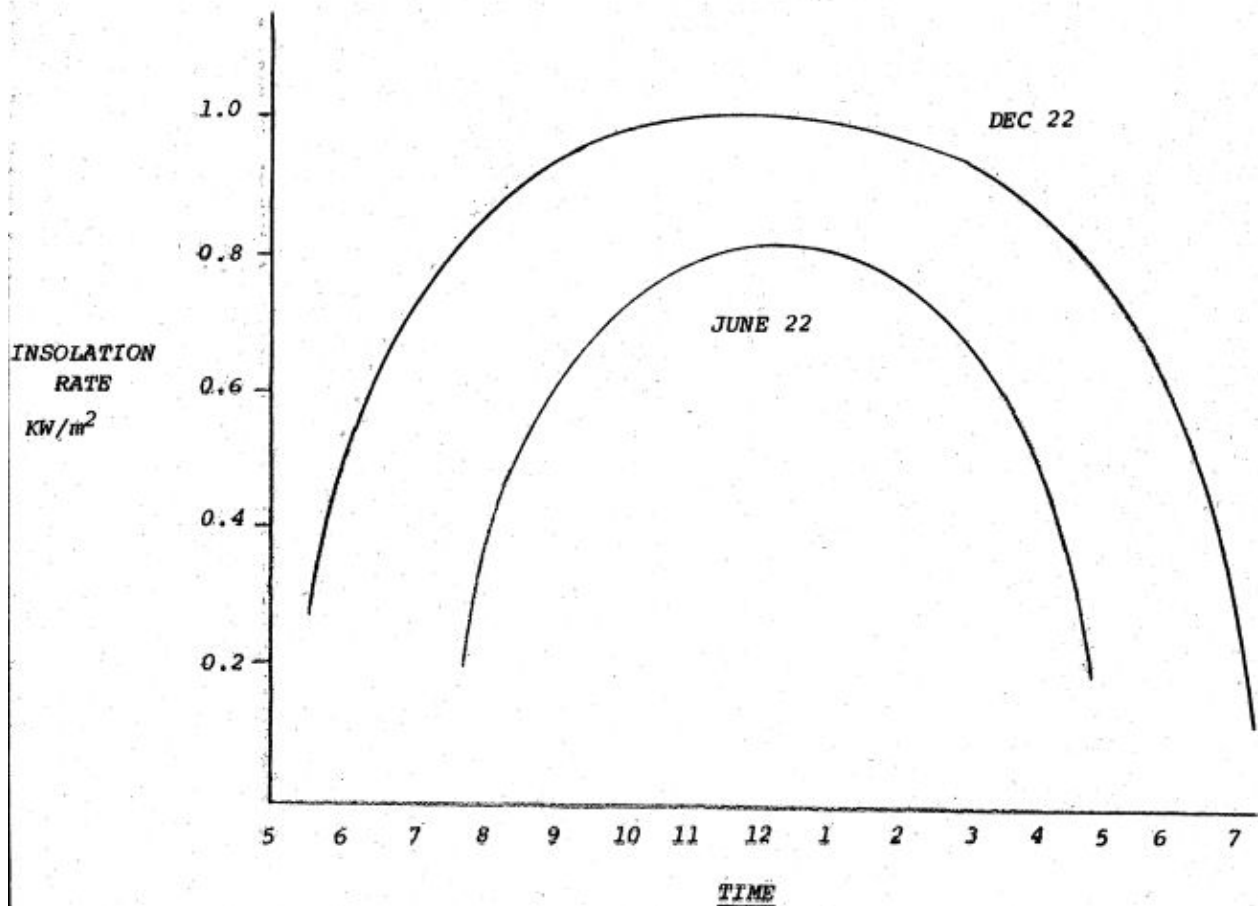
**PHILIPS — HENDON WORKS** SOUTH AUSTRALIA

19. CORRECT ALIGNMENT. In order to re-charge the battery in the minimum time the panels must be carefully aligned to the available sun. A minimum of two re-alignments per day will usually be necessary. The panels must be aligned both to account for the sun's path across the sky during the day and the elevation of the sun in the sky. Extra re-alignments will increase the output of the system and may allow for the re-charging of more than one battery in a day.

20. IRRADIANCE LEVELS. The latitude of the location that the system is operating markedly affects re-charging times. Other factors affecting operation are time of the year and geographical effects including cloud cover. The BBF1 battery pack (1ah) requires approximately  $4\frac{1}{2}$  hours of full sunlight (at 300mA charging current) to be completely re-charged. This accounts to a total solar irradiation of  $4.5 \text{ Kwh/m}^2/\text{day}$ . The following three scenarios considered are based on a location  $35^{\circ}\text{S}$  latitude and a worse case where panels are allowed to lie horizontal without any re-alignment but with an unobstructed view of the sun and no cloud conditions. Greatly improved charging is achieved with correct angular alignment especially in winter periods.

- a. Winter (June 22) Temperatures between  $0-15^{\circ}\text{C}$   
Irradiance of  $2.4 \text{ Kwh/m}^2/\text{day}$  (horizontal) at a maximum rate of  $0.42 \text{ Kw/m}^2$ .  
Irradiance of  $6.25 \text{ Kwh/m}^2/\text{day}$  (normal)
- b. Summer (Dec. 22) Temperatures between  $20-45^{\circ}\text{C}$   
Irradiance of  $8.0 \text{ Kwh/m}^2/\text{day}$  (horizontal) at a maximum rate of  $1.0 \text{ Kw/m}^2$ .  
Irradiance of  $11.6 \text{ Kwh/m}^2/\text{day}$  (normal)
- c. Spring/Autumn (March 21) Temperatures between  $10-25^{\circ}\text{C}$   
Irradiance of  $5.2 \text{ Kwh/m}^2/\text{day}$  (horizontal) at a maximum rate of  $0.75 \text{ Kw/m}^2$ .  
Irradiance of  $8.8 \text{ Kwh/m}^2/\text{day}$  (normal)

It can be seen from these figures that a large variation in re-charging potential is possible and it is essential especially in lower latitudes and in winter months to align panels for optimum output. As high temperatures are associated with long periods of high insulation and corresponding high charge rates, the charger loses little effectiveness when used in these conditions. To ensure that the user gets good results from the charger, he must be aware of the many parameters mentioned here.



TYPICAL CURVES FOR LOCATION 35°S  
 Direct solar irradiation on surface  
 normal to the solar beam.

|   |  |                 |
|---|--|-----------------|
| TITLE<br><u>INSOLATION RATE - TIME OF DAY</u><br><u>VARIOUS TIMES OF YEAR</u> |  | REFERENCE       |
|   |  | SHEET           |
| AUTHOR B. WILSON  |  | DATE 6/5/83     |
| DEPT  |  | SUPERSEDES DATE |
| <b>PHILIPS — HENDON WORKS</b> SOUTH AUSTRALIA                                 |  |                 |



Chapter Two  
OPERATION

SECTION 7 - SETTING UP EQUIPMENT

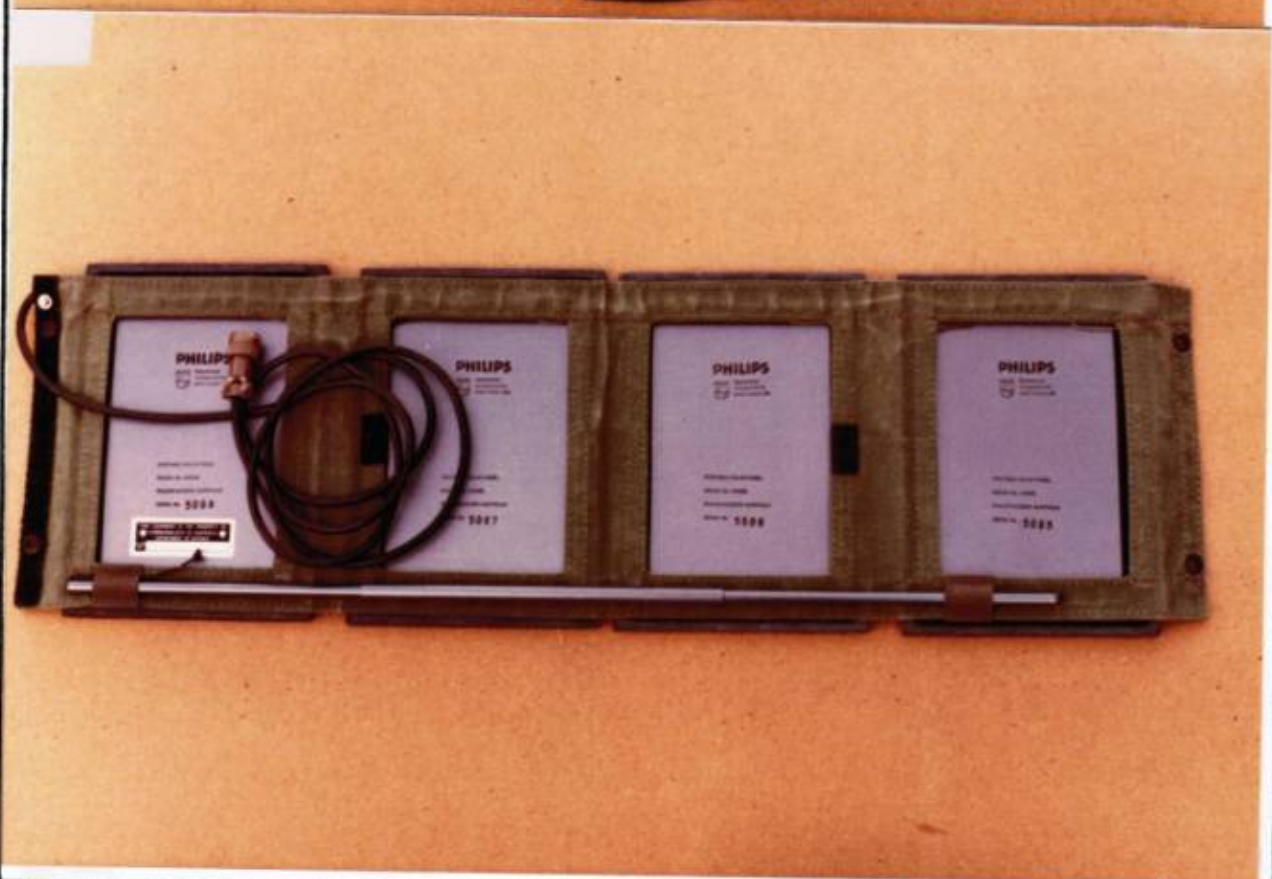
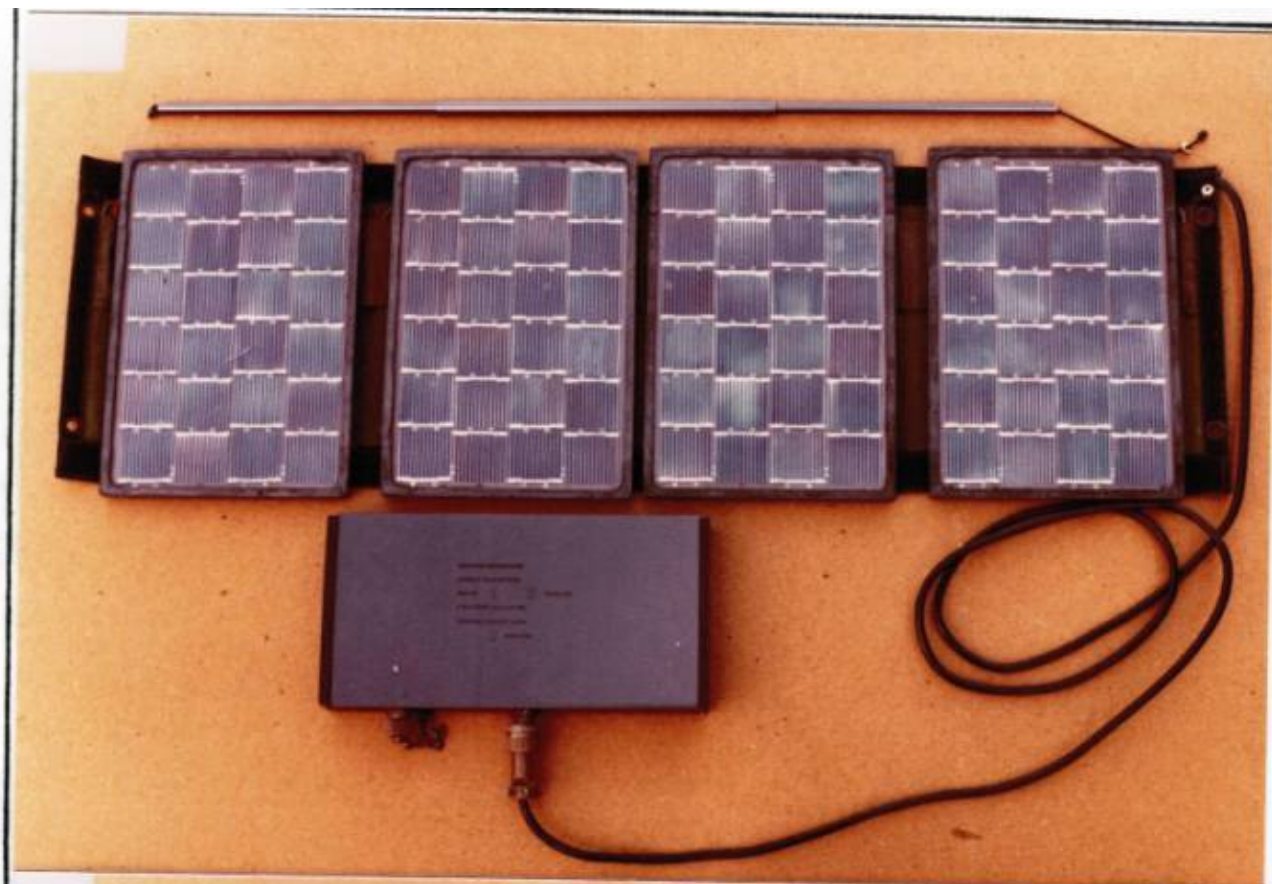
21. ACTION ON RECEIPT OF EQUIPMENT. When the equipment is received, it should be checked to ensure that it contains all items listed in the Complete Equipment Schedule.

22. Set up the equipment by carrying out the procedures in the following sequence :

- a. Remove the parts from the accessory pouch
  1. Solar array
  2. Aluminium stiffening rod
  3. Auxiliary cable

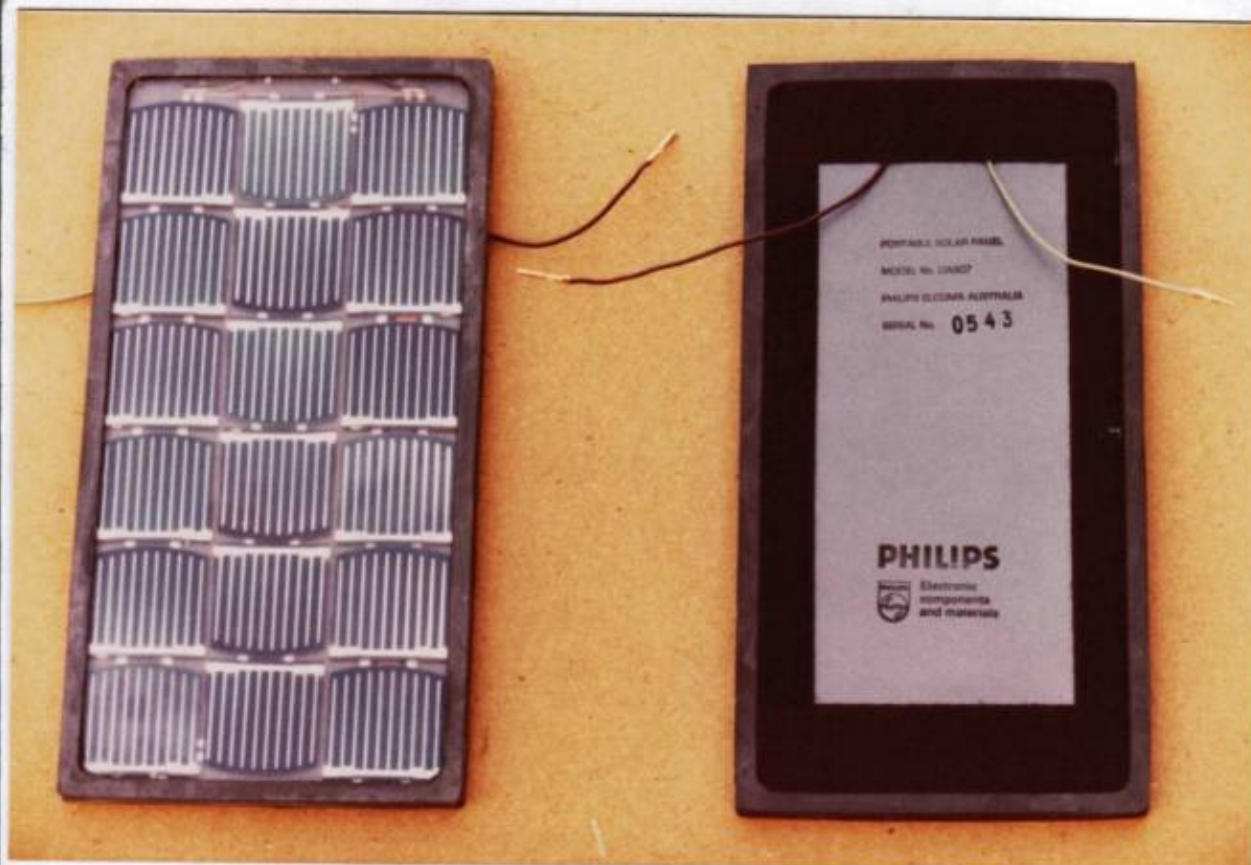
Unfold the solar array and insert the assembled stiffener rod into the loops on the back side of the canvas carrier. Lay the solar array in the required operating position with the power cable extended. Ensure that the plug on the cable extremity is kept free from sand and other contaminants.

- b. Slide the lid from the charge monitor/battery box and insert the BBF1 battery pack. Slide in the battery end with the terminals first, then snap the battery into position. Unless the battery is entirely discharged the display on the side of the box should be activated.
- c. With the battery in place and the display active connect the cable from the solar array to the charge monitor input socket.
- d. If it is required, the battery in a transceiver unit can be trickle charged (60mA) by connecting the auxiliary cable between the charge monitor/battery box and the transceiver unit.

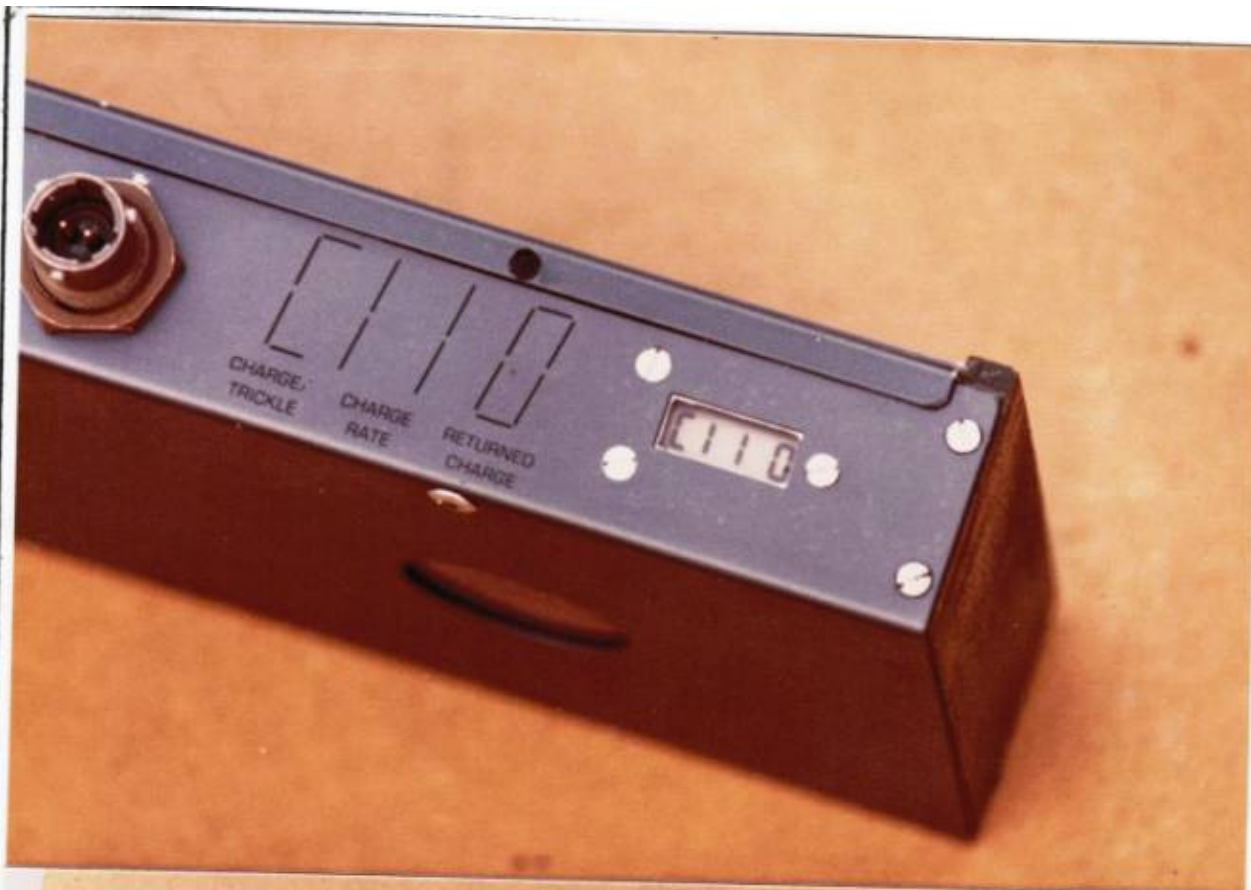


|  |      |                 |
|--|------|-----------------|
| TITLE                                  |      | REFERENCE       |
| SOLAR CHARGING SYSTEM                  |      | SHEET           |
| COMPLETE                               |      | DATE 11/5/83    |
| AUTHOR B. WILSON                       | DEPT | SUPERSEDES DATE |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |      |                 |





|  |      |                 |
|--|------|-----------------|
| TITLE                                  |      | REFERENCE       |
| <u>SOLAR PANEL - FRONT/REAR</u>        |      | SHEET           |
| AUTHOR B. WILSON                       | DEPT | DATE 11/5/83    |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |      | SUPERSEDES DATE |



|  |      |                 |
|--|------|-----------------|
| TITLE                                  |      | REFERENCE       |
| CHARGE MONITOR/BATTERY BOX             |      | SHEET           |
| AUTHOR B. WILSON                       | DEPT | DATE 11/5/83    |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |      | SUPERSEDES DATE |



23. FUNCTIONAL TEST. Having carried out the above mentioned procedures, the equipment is ready for a functional test. This test must be done outside in bright conditions (other than heavy cloud cover).

- a. The display must show  $\bar{\_}$  in the first position and 0 in the last position, if this is not the case, firstly disconnect the solar array and remove the battery, then replace the battery and re-connect the solar array.
- b. Fully expose the solar panels to the sun. The space between  $\bar{\_}$  and 0 is allocated to current flow indicators which flash at a rate proportional to the amount of charging current flowing. The unit is operating correctly if these two indicators are flashing.
- c. Partially cover one or more solar panels and observe the flash rate reduce until no current flows indicated when the colons no longer flash.
- d. Fully expose the panels to the sun and press the button at one end of the battery box. Observe that while the button is pressed the R.H.S. digit will change from 0 through to 9. When the digit indicates 0 again observe that the colons are no longer flashing.

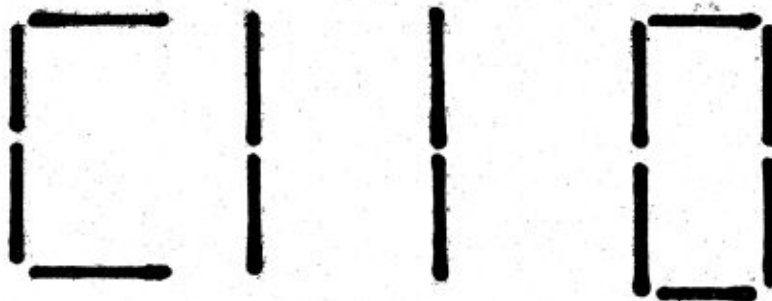
#### SECTION 8 - OPERATING INSTRUCTIONS

24. With reference to section 6 and section 7 relative to operating precautions, alignment and setting up information, the Solar Charger is relatively easy to use.

##### IMPORTANT - REMEMBER

1. CLEAR SUNLIGHT
2. KEEP COOL
3. RE-ALIGN REGULARLY
4. KEEP PANELS CLEAN

25. ACTIVATION OF MONITOR. The charge monitor is activated by inserting the partially discharged battery into the battery holder. The liquid crystal display (LCD) indicates the mode of operation, the charge rate and the level of recharge by displaying



MODE

CHARGE RATE

RETURNED CHARGE

CHARGING/TRICKLE

10% INCREMENTS

MODE

□ Indicates charging mode.

Blank indicates trickle charging mode.

CHARGE RATE

Flash rate proportional to charge rate.

RETURNED CHARGE Expressed in terms of 10% of battery capacity

|  |  |                 |  |
|--|--|-----------------|--|
| TITLE                                  |  | REFERENCE       |  |
| CHARGE MONITOR                         |  | RAVEN           |  |
| DISPLAY DETAIL                         |  | SHEET           |  |
| AUTHOR B. WILSON                       |  | DATE 6/5/83     |  |
| DEPT                                   |  | SUPERSEDES DATE |  |
| PHILIPS — HENDON WORKS SOUTH AUSTRALIA |  |                 |  |



- a. ☐ ☐ ☐ ☐ indicates the monitor is in the charging mode, no indication when monitor is in trickle charging mode.
- b. ☐ ☐ rate of flashing relates to rate of charging, faster flashing indicates higher current flow.
- c. ☐ ☐ ☐ ☐ indicates zero returned charge.
- ☐ ☐ ☐ ☐ indicates 50% returned charge.
- ☐ ☐ ☐ ☐ indicates 100% returned charge.

26. PARTIAL RECHARGING OF BATTERY PACK. Should the battery pack only require partial recharging the LCD read out can be advanced to the estimated state of charge of the battery by holding in the push button switch located at one end of the battery box. The display advances approximately once a second while the button is depressed. Should the required display be overshoot, the monitor can be reset as described in part 28.

27. RECHARGING THE BATTERY PACK. As soon as both the battery is in the holder and the illuminated panel is connected, the charge monitor will start recharging the battery, indicated by the colons in the display flashing. The colons flash in proportion to the charge rate, with the colon next to the digit visibly flashing for low charge currents. The colon on the left hand side is used for higher charge rates, when the former colon appears to be continually on. By observing the colon flash rate the solar panel can be oriented for maximum charge rate.

The LCD digit indicates the charge delivered to the battery in 10% increments. On reaching 100% charge both colons stop flashing and the display reads 0 in the far R.H. position. Trickle charge is now operating.

28. RESETTING THE CHARGE INTEGRATOR. After the battery has been fully charged, another battery can be recharged by resetting the charge integrator. This is done by removing the charged battery, disconnecting the solar panel, inserting the discharged battery and reconnecting the solar panel. The display will read

29. RADIO BATTERY TRICKLE CHARGE OUTPUT. This output is provided independent of the charge integrator, hence a failure of one section will not affect the other. Because the battery in the battery holder takes priority over charge from the solar panel, the trickle charge current is only supplied if the battery holder is empty, or the battery in the holder is in the trickle charge mode.

30. RETENTION OF BATTERY IN HOLDER. To retain information on the amount of charge delivered, the battery can be retained in the holder with the solar panel folded or disconnected. However, it is advised that in order to reduce discharge of the battery, the battery should be removed from the holder if it is anticipated that re-charging from the solar panel will not be attempted for say five to ten hours. Typically 2 - 4% of the battery charge will be lost after 10 hours in the battery holder.

## Chapter Three

### USER SERVICING

#### SECTION 9 - GENERAL

31. SOLAR PANEL. The solar panels are inter-changeable in the field but it is preferable to carry out the exchange in the work shop.


- a. Carefully remove the inter-connecting wires from their housing pockets. (Green is positive, Brown is negative). Using a sharp knife carefully slit the black plastic sleeving which encases the connectors.
- b. Disconnect the two connector pairs and remove the panel from the canvas carrier.
- c. Insert the replacement panel and re-connect the gold connectors. If available, bind the connectors with adhesive tape and re-insert in the pockets.
- d. If adhesive tape is not available then carefully return the mated connectors to the pockets and make final repairs in the work shop.

32. SOLAR PANEL FAULTS. If no current flowing in the solar array chain check the following :-

- a. Broken cell or cells - replace panel.
- b. Broken wire joining panels - replace panel or repair wire.
- c. Faulty connector between panels - remove plastic sleeve and re-join connector.
- d. Contamination on the panel surface - clean panel surface.
- e. Faulty connector on output cable - replace the connector.

33. CHARGE MONITOR/BATTERY BOX FAULTS. The electronic section of this unit is not serviceable beyond checking the condition of the connector contacts and the battery contactors. The entire electronics is encased in silicone resin.

In the advent of an unrepairable fault within this section, the entire electronic section may be bypassed by removing the connector from the solar array and connecting the wires directly to the battery contactors.

NOTE : If current is not flowing ensure that the monitor is displaying  in the left hand position, refer to the operating instructions.

### TEST RESULT SHEET

*SHEET 1 OF 1*

TEST SPECIFICATION NO. :

ITEM NAME : CHARGE MONITOR

SERIAL NO. : 13 - DIDS 0185

DATE : 23rd May 1983

| TEST REQUIREMENT   | RESULT        | CONFORMS |
|--|---------------|----------|
| Tolerance to $\pm 50$ volts applied to battery connection. | $\pm 50.15$ v |          |
|  | 0.002 mA      |          |
|  | 2.8 mA        | Yes      |
| Supply current with a) No charge current                   | <3.5mA        |          |
| b) 300mA charge current                                    | <8mA          | Yes      |
| Charge monitor voltage drop with :                         |               |          |
| a) 300mA charge current                                    | <1.5V         |          |
| b) 400mA charge current                                    | < 2V          | Yes      |
| Full Charge level at 300mA charge rate min 1.0 AH          | 1.24 AH       | Yes      |
| max 1.4 AH   | AH            |          |
| Trickle charge current min 25mA, max. 60mA                 | 39 mA         | Yes      |
| Auxiliary Output current min 50mA, max. 90mA               | 70 mA         | Yes      |
| Display Charge Level                                       |               |          |
| Display Advance  |               |          |
| Charge Mode  |               |          |
| Charge Rate  | OK            | Yes      |

**TEST ENGINEER**

Bill Forsey 25/5/83

TEST RESULT SHEET

SHEET 1 OF 1

TEST SPECIFICATION NO. :

ITEM NAME : SOLAR ARRAY

MODEL NUMBER : 1805-300

SERIAL NUMBER : DIDS 0176

DATE : 23-5-83

| TEST REQUIREMENT                                      | RESULT     | CONFORMS |
|---|------------|----------|
| Open Circuit Voltage 25°C AM1, 100mW/CM <sup>2</sup>  | 52.4 volts | YES      |
| Short Circuit Current 25°C AM1, 100mW/CM <sup>2</sup> | 291.7 mA   | YES      |
| Maximum Power 25°C AM1, 100mW/CM <sup>2</sup>         | 11.5 watt  | YES      |
| Current at 28 Volts                                   | 278.9 mA   | No       |

TEST ENGINEER

Bric Wot





Commanding Officer,  
16 Air Defence Regiment,  
Woodside Army Camp,  
WOODSIDE S.A. 5244

**PHILIPS**

111-113 Tapleys Hill Road  
Hendon, South Australia 5014

P.O. Box 1, Alberton, S.A. 5014  
Telegrams: "PHIHEN" Adelaide  
Telex: 82230 Phone: 243 0155

Your Ref.

Our Ref. **JT:IS:ME4388**

Date **23rd June, 1983**

Dear Sir,

RE : HANDBOOK FOR SOLAR BATTERY CHARGER

Enclosed please find the following documents relating to the above handbook :-

1. Amended "Contents" sheet.
2. "Amendment List" to be inserted after contents.
3. "Parts List" to replace "Complete Equipment Schedule".

Would you please insert the new sheets, destroy the old and complete the "incorporated by, and date" column.

Yours faithfully,  
PHILIPS ELECTRONIC COMPONENTS & MATERIALS  
HENDON WORKS

*Jeff Telfer*

J. TELFER

Encl.

Copy - Mr. W. McCormick - Lane Cove