NIWA Library
- 5 MAY 1998
PO Box 14-901
Wellington, NZ

NIWA

Taihoro Nukurangi

Telemetry Manual

K McFarlane

NIWA Science and Technology Series No 7

ISSN 1173-0382

NIWA Science and Technology Series No 7

Telemetry Manual

K McFarlane

NIWA

Christchurch

August 1994

Cataloguing-in-publication

McFarlane, K.
Telemetry Manual / K. McFarlane -- Christchurch, NZ : National Institute of Water and Atmospheric Research Ltd., 1994. (NIWA science and technology series ; 7)

ISSN 1173-0382
ISBN 0-478-08338-6

I National Institute of Water and Atmospheric Research Ltd. II Title. III Series

© Crown Copyright 1994

No part of this publication may be reproduced in any form without the permission of NIWA, except for the purpose of private research or study.

The *NIWA Science and Technology Series* is published by NIWA (the National Institute of Water and Atmospheric Research Ltd.), New Zealand. It supercedes *NIWA Ecosystems Publications* (Issn 1172-3726; published by NIWA Ecosystems, Hamilton, *New Zealand Freshwater Research Reports* (ISSN 1171-9842; published by NIWA Freshwater, Christchurch) and *Miscellaneous Publications, New Zealand Oceanographic Institute* (ISSN 0510-0054).

Available from:

Publications	or:	Publications	or:	Publications
NIWA		NIWA		NIWA
P O Box 8602		P O Box 11-115		Private Bag 14-901
Christchurch		Hamilton		Kilbirnie, Wellington
New Zealand		New Zealand		New Zealand
Ph 03 348 8987		Ph. 07 856 7026		Ph. 04 386 1189
Fax 03 348 5548		Fax 07 856 0151		Fax 04 386 2153

NIWA specialises in meeting information needs for the sustainable development of water and atmospheric resources. It was established on 1 July 1992.

PREFACE

The introduction of FLOSYS (replacing TELSYS) as the telemetry operating system into NIWA - Climate in 1994 has required the revision of the exisiting operational procedures. This revision has also documented the new technology being introduced to telemetry networks operated by NIWA and regional councils throughout New Zealand using the FLOSYS system.

This manual supersedes the Water Resources Survey Telemetry User's Manual (Thomas and Butler, 1989).

K McFarlane

NIWA - Climate

Dunedin

April 1994.

DOCUMENT APPROVAL

The approval for distribution and use of this document has been delegated by the General Manager, NIWA - Climate, to the representative Quality Manager.

DOCUMENT APPROVAL	Date:	By: *(Quality Manager)*
Issue of original document:	27-10-93	
Issue of revision: *Pages replaced:* i, ii	20-4-94	
Issue of revision: *Pages replaced:*		
Issue of revision: *Pages replaced:*		
Issue of revision: *Pages replaced:*		
Issue of revision: *Pages replaced:*		

CONTENTS

	Page	Revision
1 INTRODUCTION	1	
2 TELEMETRY EQUIPMENT	3	
2.1 General	3	
2.2 AQUITEL equipment	4	
2.2.1 The remote unit	4	
2.2.2 The support unit	5	
2.2.3 The mobile unit	5	
2.2.4 The microbase	5	
2.3 CAMPBELL equipment	5	
2.4 Station installation	6	
2.4.1 Radio network	6	
2.4.2 Poles	7	
2.4.3 Radio/battery housing	10	
2.4.4 Recorder housing setup	15	
2.5 AQUITEL remote operation and power up	20	
2.5.1 Water menu	22	
2.5.2 Rainfall menu	24	
2.5.3 Voltage menu	25	
2.5.4 Test menu	26	
2.5.5 Remote power up	27	
2.6 AQUITEL support operation	28	
2.6.1 Remote configuration	28	
2.6.2 Transferring data	32	
2.7 AQUITEL mobile unit	36	

		Page	Revision
	2.8 Base set-up	41	
	2.8.1 AQUITEL equipment	41	
	2.8.2 Layout	42	
	2.8.3 AQUITEL microbase installation	43	
	2.8.4 Autodialler operation	44	
3	FLOSYS OPERATIONS	46	
	3.1 Initial set-up of a new system	46	
	3.1.1 Microbase	46	
	3.1.2 FLOSYS software	46	
	3.1.3 Installing FLOSYS	46	
	3.2 Initial set-up of a remote site	49	
	3.2.1 AQUITEL remote	49	
	3.2.2 FLOSYS	49	
	3.3 Day to day telemetry	50	
	3.3.1 Requirements	50	
	3.3.2 Site groups	51	
	3.3.3 Automatic data retrieval	52	
	3.3.4 Semi-automatic data recovery	53	
	3.3.5 Routine telemetry system management	53	
	3.3.6 Radio transmission	57	
	3.4 FLOSYS commands	57	
	3.5 Alarms	59	
4	EXTERNAL CONTROL BY TELEMETRY	60	
5	USING RTALK WITH AQUITEL	61	
	5.1 RTALK language	61	

		Page	Revision
	5.1.1 Setting/changing the microbase's identification and time parameters	61	
	5.1.2 Setting/changing a remote's site number	62	
	5.2 Microbase log printer messages	64	
	5.2.1 Remote parameter codes	66	
6	**TROUBLE SHOOTING**	68	
	6.1 Equipment	68	
	6.1.1 Battery\voltage problems	68	
	6.1.2 Solar panels	69	
	6.1.3 Regulator	70	
	6.1.4 Lines/radio interface problems	71	
	6.1.5 Base problems	73	
	6.1.6 Recorder/remote problems	74	
7	**GLOSSARY OF TERMS**	76	
8	**ACKNOWLEDGEMENTS**	82	
9	**REFERENCES**	83	
10	**APPENDICES**	84	
Appendix i	Responses to test communications	84	
Appendix ii	Messages for an interrogation	85	
Appendix iii	Mobile status displays during interrogations	87	
Appendix iv	Ageing Portalac and Superlac batteries	88	
Appendix v	Solar panels	90	
Appendix vi	Assembly instructions for wooden pole mount	98	

Figures

1	Telemetry system flow diagram	2
2	Functional pole equipment, and lightweight prefabricated mast	8
3	Pole installation	9
4	Lightning protection and pole support	11
5	Solar panel mounting	11
6	Radio housing	12
7	DIN plug - radio end	14
8	Radio box wiring	14
9	Alkathene pipe termination	17
10	Standard remote site cabling (part 1)	18
11	Standard remote site cabling (part 2)	18
12	Standard remote site cabling (part 3)	19
13	Standard remote site cabling (part 4)	19
14	The remote	20
15	The support	30
16	General wiring for communication line to microbase	43
17	Communication line to microbase with channel 1 as hard wire	44
18	Line between the remote/microbase and the radio	71

1. INTRODUCTION

The introduction in 1983 of AQUITEL 2, the telemetry data acquisition and flood prediction system, has proven to be a significant event in New Zealand hydrometric data collection. This system, jointly developed by Harding Signals Ltd and the Ministry of Works and Development, allows for retrieval of data from isolated sites using a radio-telemetry network. Remote dataloggers can be accessed by radio-telemetry which requires no physical connection from the computer to the datalogger. It is also not necessary to make regular visits to isolated sites for data collection.

The AQUITEL 2 telemetry system is extensively used by NIWA which has some 120 hydrometric stations linked to 15 base stations. Additionally, 8 Regional Councils operate their own systems and increasing interest is being displayed by Pacific Basin countries, with the Solomon Islands and Fiji having operating networks.

The application was conceived at the NIWA - Freshwater Division in Christchurch which developed the necessary software to operate the system. FLOSYS which combines features from an earlier telemetric system TELSYS, sets up and runs the telemetry network. It files data in an acceptable format for TIDEDA, a comprehensive software package for Time Dependent Data. Development and manufacture of the AQUITEL 2 hardware has been carried out by Harding Signals Ltd. A major design consideration was to ensure that the system could automatically collect and file data, as well as activate alarms.

This manual provides an operational guide, to both existing and potential users of the system. It follows on from its predecessor, the "Telemetry User's Manual" compiled by M B Thomas and M J Butler,1989 . When using this manual reference will need to be made to the software manuals used with the telemetry system i.e.. "FLOSYS User's Manual" by G A Halliburton and T A Hill 1993, and "TIDEDA User's Manual" by M W Rogers and S M Thompson 1992.

Increasing use of new technology, e.g. Campbell dataloggers, Unidata and new versions of software, will mean that new sections will be added to some parts of this manual. Continual reviews of new and more efficient ways of operating a telemetry system will also need to be made.

In preparing this document, extensive reference has been made to "Telemetry Operating System Users Manual" (Soutter, 1986), "AQUITEL 2, User and Systems Manuals" (Harding Signals Ltd), "Telemetry Remote Site Installation Requirement" (unpublished memo, NIWA - Kainga) and "FLOSYS User's Manual" (Halliburton and Hill).

Significant contributions were made by NIWA - Kainga, and NIWA - Climate team members throughout New Zealand.

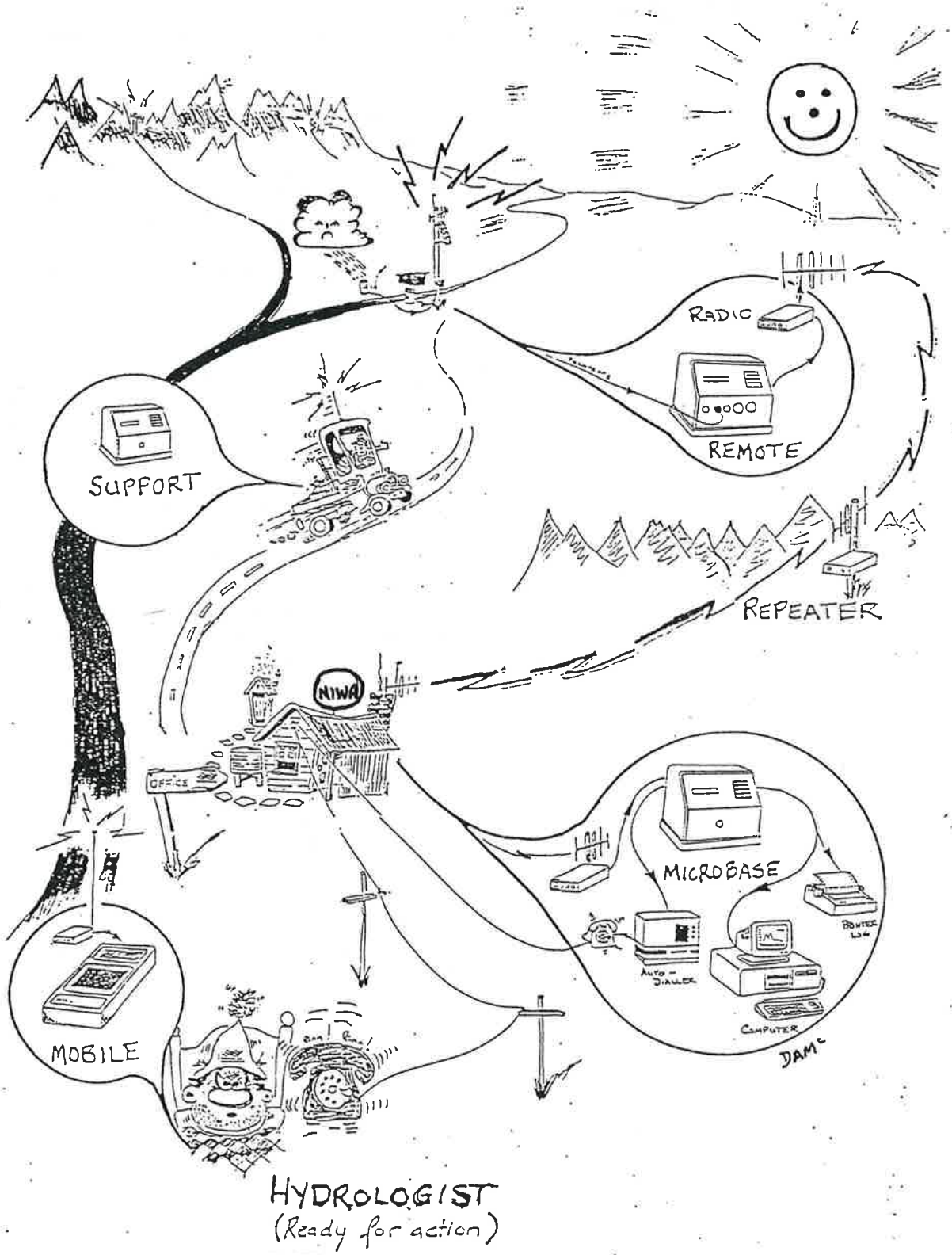


Figure 1 Telemetry system flow diagram

2. TELEMETRY EQUIPMENT

2.1. General

Methods and equipment used are generally based on NIWA - Climate practices and standard equipment supplied by NIWA - Kainga.

A telemetry network basically consists of a central base communicating with a number of remote recording stations via a radio circuit. A single base datalogger and microbase can store data and handle communications protocol for a maximum of 250 remote stations. The remote stations normally record water-level and rainfall but may be adapted to record other parameters or activate control functions. The radio circuit is configured to best suit local conditions and may be shared with other users.

The prospective telemetry user should carefully consider the benefits of a network to their operations. Station installation should not be a random, erratic affair. A rational plan should guide installation to ensure costs are minimised and benefits maximised. Some factors worth consideration are:

- telemetry of a complete field servicing circuit;
- telemetry of those stations requiring extended travel from the base;
- stations with the most frequent rating changes;
- stations which have a high servicing cost factor, e.g. helicopter,jet boat, to ensure each field measurement is warranted and cost effective;
- telemetry of upper catchment stations for flood warning;
- telemetry of stations subject to silting or damage.

Economic planning must budget for:

- radio network establishment cost;
- installation costs of station telemetry equipment;
- maintenance/servicing of remote equipment;
- radio network maintenance;
- some station equipment is relatively exposed (solar panels, radio aerials), and easily damaged by vandals.

The AQUITEL 2 Telemetry Data acquisition system provides the following features and benefits:

- excepting the radio network, all installations can be easily done with own resources;
- the system can share a voice radio channel so that network radios can be used for normal communication - a valuable asset in emergencies;

- radio network linking between agencies can assist in cost reduction and enable outside organisations to access any station, without ffecting the data;
- New Zealand designed equipment in hermetically sealed housings, to withstand extreme temperature and humidity conditions;
- certain periods of data are stored on-site and can be retrieved should the radio link fail;
- the remote units can accept various sensor inputs including pressure transducers for water-level recording;
- the software is easily used and has had a significant input from hydrologists so that it meets their needs;
- real time data is immediately available;
- there is significant reduction in data translation and processing;
- missing record is reduced - a daily check on the telemetry data will reveal station recorder malfunctions;
- it can be used to programme field servicing;
- additional skill development and dimension for staff;
- control function capabilities can be developed;
- flood forecasting is an integral component of the system. FLOSYS runs routine telemetry operations and also gives access to flood forecasting programmes;
- it allows for water management requirements, e.g. irrigation, abstractions, groundwater levels etc.

2.2. AQUITEL EQUIPMENT

The system is based on four custom built units: i.e. three field units, (the remote, the support and the mobile), and a microbase. Communication links, a dedicated printer for the microbase, an autodialler, a computer and another printer are also employed. A brief description of each type of AQUITEL unit follows.

2.2.1 The Remote Unit

The remote unit is sited at the point of measurement and normally records water level and/or rainfall at regular preset intervals. The operating voltage is automatically recorded at midday and midnight. As the newest recorded data value is stored in the memory the oldest recorded value drops out of the memory. The storage available within the memory is dependent upon the sensing interval and the type and number of sensors. With a 15 minute sampling interval and both water level and rainfall sensors operational, a minimum of 10 days storage can be expected. This increases to 15 days for water level only, and over 31 days of storage is available if rainfall only is sampled. Data stored at a remote may be either examined or copied.

The remote will not transmit data to the microbase unless it is in response to a specific request. It will however, transmit alarms, i.e. high/low water, low voltage and rainfall intensity.

2.2.2 The Support Unit

The support unit is portable and is used to set up remotes. It carries the microbase time for transfer to remotes and is also capable of taking a copy of the data from up to five remotes. This feature enables data to be retrieved by visiting remotes, for example when the communication link fails. On return to the office the data can be transferred via a microbase, to a TIDEDA file.

2.2.3 The Mobile Unit

The mobile unit enables field personnel to examine a remotes most recent data. The unit is used in conjunction with a radio telephone and may be operated from a vehicle or a home. Communications between the mobile and a selected remote would normally be via the microbase but may, under certain circumstances, be direct.

2.2.4 The Microbase

The microbase communicates with remotes. It can, via FLOSYS, retrieve data, change or report the remotes parameters, unload data from a support and display the current time and microbase number. The microbase will independently of FLOSYS, respond to an alarm from a remote. If an alarm is received, the microbase will first route the alarm to a computer. If the computer is off-line, or the operator fails to respond, the microbase will sound an audible alarm and, if that is also unacknowledged, it will send the alarm to an autodialler. A preprogrammed autodialling sequence will then begin.

The microbase is connected to a dedicated printer which logs all communications between the computer and the microbase, and the microbase and its remotes.

2.3. CAMPBELL EQUIPMENT

The CR10 is a programmable datalogger in a sealed module (not hermatic). It has 6 differential analogue inputs, 2 pulse inputs, 8 digital input/output ports and 3 switched excitation outputs. A serial input/output port provides for communication to an external device such as a PC or a modem. The onboard storage is 64 KB which translates to about 4100 sensor readings stored in a format suitable for FLOSYS.

CR10's communicate directly or via a modem to a computer. They do not go via a microbase. Campbells require programming to make them operate, unlike AQUITELs, which are preprogrammed with on-board hardware. Programs may be written with a text editor or using Campbell's "EDLOG" program. The hardware and programs used by the Campbell are fully described in the CR10 Operator's Manual.

2.4. STATION INSTALLATION

The construction of a telemetered field station or the upgrade of a field station for telemetry access usually requires the installation of a pole in a location where continuous radio reception and adequate sunlight is available. The pole has lightning protection and accommodates radio aerials, solar panel and a housing for both radio and battery equipment. Data and power cables are run from the radio box to the remote unit in the recorder housing. Installations can be changed to suit local requirements but must be guided by the need for continuous radio reception and adequate power supplies.

2.4.1 Radio network

This is the preserve of a communications technician but it is most important that users of the network be fully involved in all decisions. Much initial investigation can be undertaken using your own resources. Some of the things you can do to assist and reduce costs are:

- Locate all repeaters and their users in your area of interest. Linking to their equipment may be feasible. They can advise of dead spots and bad reception areas.
- Examine topo. maps for likely signal paths from existing or potential repeater sites.
- If there will be future expansion of the network, allow for this in the initial planning and installation. The additional cost may be relatively small in comparison to a later major upgrade.
- An indication of signal strengths can be gained by using your vehicle or a packset radio, at potential sites. This should be done in different positions and weather conditions and if communication is good in all circumstances, it can be assumed to be acceptable with a directional aerial mounted 5-7 metres up a pole. If adding to an existing network, the mobile can be used to interrogate other stations via the base from the intended site.
- In marginal locations, a directional aerial on a lightweight pole with a signal strength meter will be necessary, to pinpoint the most favourable spot.

Other factors to consider:

- Channel allocation will be organised by your communications technician with the issuing authority. Bench testing using a radio crystalled to your allocated frequency and the remote units is essential. If the units cause

interference to the radio, another frequency will be required. Suppression devices are available but are expensive. NIWA - Kainga can supply information about remote unit "noise" effects on various frequencies.

- All radios in the system should be a standard type and have a common installation. Radios should be installed in cradles with uniform plugs, including vehicle radios. A faulty site radio can then easily be exchanged for a vehicle radio and the site kept on air.
- Radio boxes can be outfitted and wired at the base. This may save the cost of a communications technician on site.
- On all radios connected with telemetry, the mute switch must be down at all times (i.e., the radio must be muted). This is because the remote uses the mute circuit when sensing for "channel busy". A radio with its mute open will stop a remote from sending.

Problems may occur if the internal setting of the mute circuit is such that the busy light flickers on and off when the radio is muted. A communication to a particular remote may not be answered because the channel is perceived by the remote to be fluctuating between "channel free" and "channel busy". The remote cannot get onto the channel. The real problems may occur when a remote, in an attempt to answer a communication, gets so tied up watching the channel free/busy oscillations that data loss occurs because it stops sampling altogether!

Sampling may not resume until after the remote has successful communicated (which may be some hours in the future). This data loss cannot occur if the channel is perceived as permanently "busy". It is the reason a radio with a flickering receive light must be replaced. Ensure your radio technicians are aware of this requirement and mute circuits are correctly set.

2.4.2 Poles

(i) Selection

Softwood types, treated to the appropriate standard are recommended. Hardwoods have similar durability but require more effort to drill holes etc. Poles with, or indications of, major splitting should be avoided. A total length of 6-8 m is generally necessary with a minimum top diameter of 150 mm. Special requirements for difficult access may be necessary, such as the prefabricated metal pole used by the Westland Regional Council, where helicopter servicing is routine. For standard installations, wood is preferable due to availability, cost effectiveness and environmental acceptability.

Before installation of the pole, some rigging is required:

(ii) Steps

Pole steps are installed in predrilled holes, positioned 600mm apart per side and displaced 300 mm on opposite sides. Two steps directly opposite, at a height adequate to service the solar panel, aerial, etc. is useful. The steps should be screwed fully home and commence at stepladder height above the ground. Some sources of supply:

- Electricorp Stock No. L163001
- Telecom Stock No. N298
- E C Gough Stock No. 390450

(iii) Lightning protection

Lightning protection, if supplied by NIWA - Kainga, is a heavy copper earth wire, with a connector wire for the radio earth and four "tails" for charge dispersion (Refer to Figure 4). Sufficient length should be allowed for a 1.5 m extension above the pole and 3m tail lengths. Fix the earth wire using staples, on the shaded side of the pole - this assists fitting of later hardware. The upper section of the wire should be threaded through a 12 mm galvanised pipe, 2.5 m long. The pipe is fixed using galvanised saddles so that it protrudes 1.5 m above the pole. The approximately 150 mm length of wire protruding from the pipe should be unstranded and formed into a ball or a spiky crown and permanently set, using silfos or copper welding rod. The tails are buried at the tower base in 0.5m deep trenches in a cross shape. Some rocky situations may require the tails clamped to driven earth rods - if so, notices should be in place, warning of the danger during lightening conditions. Metal poles are self-earthing but require a top 1.5 m "pointer" for protection.

Fit an opposum band if required.

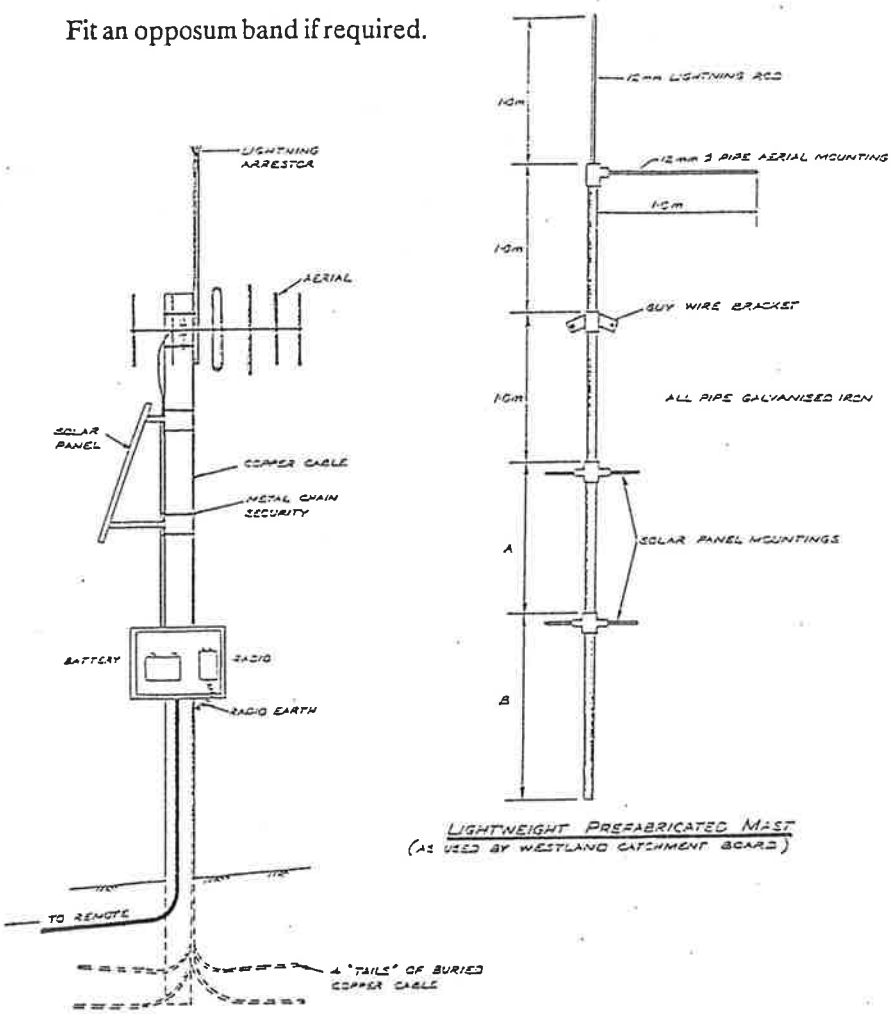


Figure 2 Functional pole equipment, and lightweight prefabricated mast.

(iv) Pole Installation

Position of the pole is governed by the radio and sunlight requirement but close proximity to the recorder housing is also important. If feasible, attempt to blend in with the surroundings or conceal the pole behind natural features.

Use of specialist auger truck, which normally have a "hiab" type crane, will simplify the operation. The pole should be buried 1/6 of its length into the ground. Backfill using free draining material with regular firm tamping. All safety precautions should be observed, particularly the use of guy ropes for anchoring during erection. (Refer to sections 7.4 and 13 of the Hydrologists Safety Manual 1993)

Some situations may require manual installation which is more labour intensive and has a higher danger factor. Guy ropes are essential and these must be operated through a backstay. A sloping trench can be dug to the hole and the pole base placed in it. A vehicle with a suitable rope fastened to the pole top can pull on the opposite of the hole from the trench. As the vehicle moves away, the pole slides down the trench into the hole and is subsequently pulled upright by the continued movement of the vehicle. All ropes used should be of sufficient length for people to be well clear of the pole fall zone.(Refer to Figure 3)

Unstable ground situations, particularly where narrow metal poles are used, will require the pole base to be concreted. Pole footings should be used to ensure a firm grip in the concrete mix. Permanent stay wires may also be required. These must be properly shackled and have adjustable rigging screws to maintain the correct tension. All adjustable fittings should be wired and taped to discourage interference.

(v) Rigging

Pole rigging can commence once the pole has been stabilised. Safety must be a prime consideration with ladders tied, safety belts used and hard hats worn. The following rigging is required:

- aerial mounting;
- solar panel fitting;
- radio/battery box placement;
- fitting and protection of cabling from pole equipment to the radio box; radio box wiring and equipment;

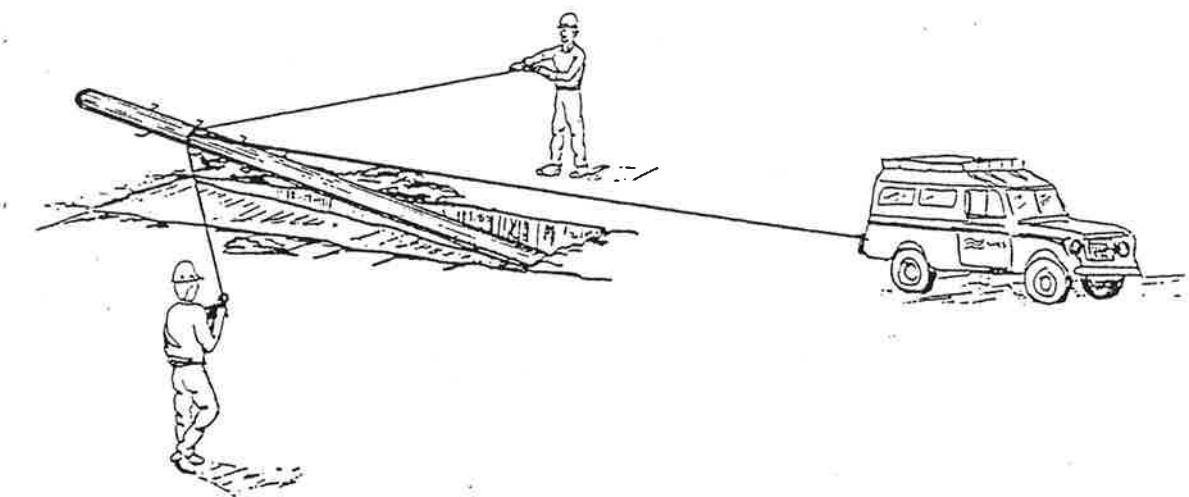


Figure 3 Pole installation

(vi) Radio aerial

The aerial should be firmly mounted as close to the pole top as feasible. It is essential that the aerial maintains its correct alignment and not be shifted by wind. Yagi type and dipole aerials must be correctly aligned to the appropriate repeater. The aerial type will be decided by your communications technician. In areas where icing may be a problem, go for the plastic coated models.

A standard chain locking system for wooden poles is supplied by NIWA - Kainga. Many other standard and local variations are available and can probably be best referenced by the communications technician (Refer to Appendix ix).

An aerial balun provides the wiring link between the aerial and the coaxial cable for the radio.

(vii) Solar panel

Panel placement must allow for maximum sunlight, be secure and clear of possible bird fouling. The panel should be northerly facing, i.e. facing geographic north and facing approximately 55 degrees off the vertical. NIWA - Kainga supply a fitting kit with their standard 30 watt panels. A blocking diode is required to prevent battery discharge through the panel in darkness. As diodes are susceptible to nearby lightning strikes and degeneration caused by panel heat, they need periodic checking.

Possible bird perching sites (including the aerial) must be minimised. Trees and overhanging foliage removed. The upper edge of the panel can be protected by stringing piano wire or greasing. Protection may also be needed against vandals as panels are easy targets and replacement expensive. Rotorua ED has overcome this by fitting polycarbonate shields on the top and plastic covers on the back. (NB. This will reduce charging efficiency.)

For lesser sunlight locations, dual panels in parallel may be necessary. A further option is to locate the panel separately to optimise available light. Investiga tion of available sunlight hours and its path of travel during mid-winter can be used as a siting criteria. Better utilisation of available sunlight may be gained by facing the panel to a gap in the surrounding hills rather than the northerly aspect. (NB. Use of two panels will necessitate the use of the higher power version solar regulator.)

Technical information (courtesy of BP solar Australia) is attached in Appendix viii, and may assist in a sensible size selection. A typical NZ requirement would be a 12 V, 33 watt panel delivering 2.0 amps.

Refer also to Figure 5 and Appendix vi for instructions on mounting solar panel onto pole.

2.4.3 Radio/battery housing setup

Refer to Figure 6.

The radio/battery box must have ample room for all equipment, good ventilation and be secure against insects, theft and weather. It should be situated to give maxi-

mum protection from the predominant weather direction and be able to obtain maximum sunlight. Interior insulation will be useful in very cold situations, to reduce condensation and keep the radio and battery within a reasonable temperature range.

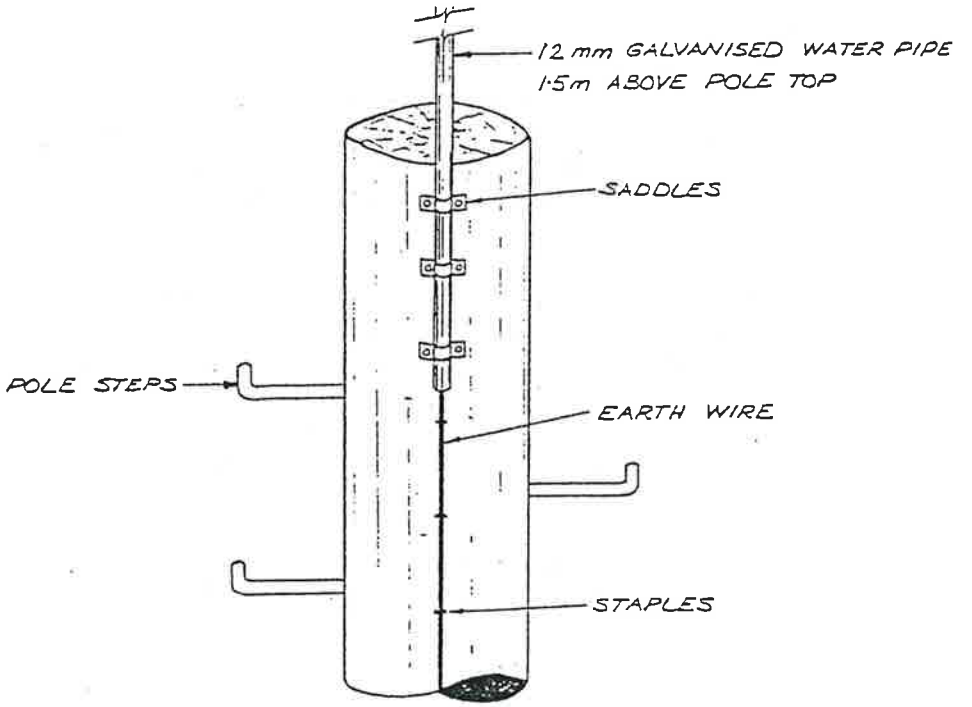


Figure 4 Lightning protection and pole support

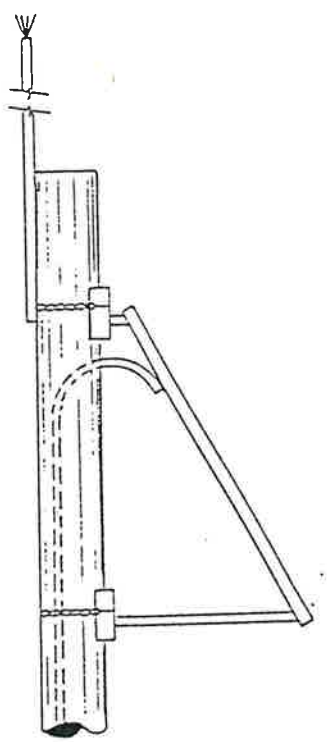


Figure 5 Solar panel mounting

Provision will need to be made for an entry port (panel/aerial cables) and an exit port (cables to remote). A shelf in the upper part of the box is required for radio mounting plus adequate space for cabling, battery regulator and possibly two batteries. A floor drain is useful, should there be a battery spill.

(i) Radio cabling

Refer to Figure 6.

Radio and aerial cables will need protection from both vandals and the elements. PVC waste pipe (32 mm) fixed with galvanised saddles are normally adequate. For the solar panel to battery power supply, twin power cable is sufficient. This should have soldered female shrouded Utilux connectors to push onto the panel connectors.

Terminate the top of the waste pipe in a 180 degree bend to prevent rain access and seal with RTV or similar - use the shelter of the panel if possible. All loose, exposed cabling should be secured with cable ties or insulation tape.

The bottom of the pipe can be curved into the box using combination terrain pipe connections, terminating with a threaded section through the housing wall to which the appropriate size brass nut is screwed. The sections must be glued together and should not exceed a radius of 12.5 cm if heavy aerial cable is being used. A small drain hole drilled in the bottom of the curve stops moisture entering the box. Long run power feeds require special treatment - refer to (iv).

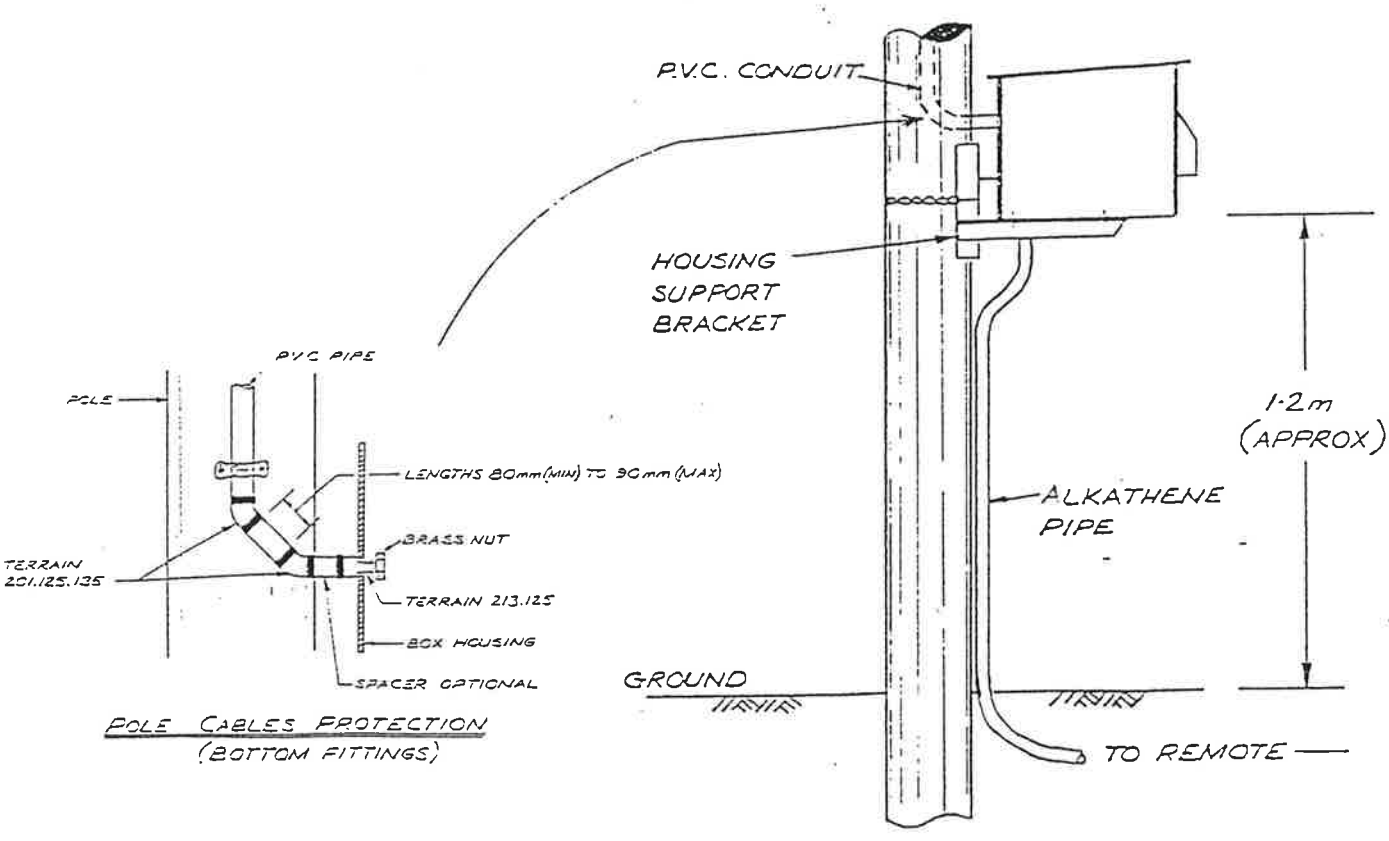


Figure 6 Radio housing

(ii) Mains power supply

Access to a 230V power supply provides the ultimate luxury for the field installation. This will usually be in a building, on the roof of which the aerial can be mounted. The radio, battery etc. can be housed in a secure environment with little temperature variation. Problems associated with solar panel charging are eliminated.

The wiring arrangement at the radio/battery end is basically the same as that of a solar powered site but the battery is powered by a charge (Pertronic or similar). A battery regulator is still required. Battery life should be relatively long in this situation. Little variation will occur between the midday and midnight voltage readings.

(iii) Radio housing wiring

Refer to Figures 7 - 13.

Radio housing wiring provides the linkage between the pole equipment and the remote. All connections, lugs, etc. should be soldered. Standard wire colour codings should be adhered to, for every installation.

All wiring should be clear of the floor in case of battery fluid leaks. The minimum of wires should terminate directly at the battery, use terminal or fuse blocks mounted vertically on the side walls for power feeds and radio connections.

The radio should be in a slide-in cradle. The cradle will be hard wired for power (to the terminal block) and for aerial and speaker connectors. A DIN plug is soldered to the data cable (see Figure 7) for connection to the radio interface.

The terminal block provides connection points for all the wiring which comes into the housing except for the aerial cable.

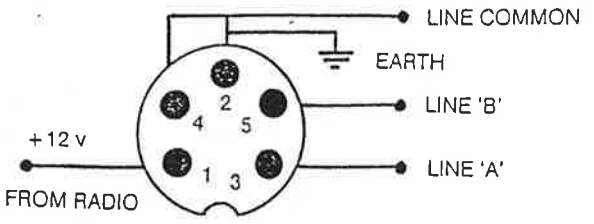
It provides connections for the data cable and is also hard wired to the battery and looping wires used on the block to supply power outlets for radio and remote. Provision for the temporary use of a 12 V, 6 AH battery while the main battery is being replaced enables continuous power to the remote. Solar panel and voltage regulator can also be directly wired into the block or onto the battery.

Fuses are designed to protect the system in case of shorting. Only one fuse is needed between the main power supply and the equipment. (see Figure 8) A 6-10 A is suitable. A second fuse is recommended immediately before the remote power supply, rated at a level less than the remotes internal fuse. (see Figure 12) This will protect the internal fuse in the remote .

The wiring arrangements can be varied to suit local requirements but should be standard within all agencies stations and understood by all staff. One lead should always be disconnected at the solar panel when wiring it into the power supply. NIWA - Kainga can supply 18 pin terminal blocks and standard fuse blocks. Ensure all connectors are shrouded with positive and negative terminals well separated.

A voltage regulator is essential to limit over-charging of the battery. As the regulator operates as a heat sink to dissipate excess charge, mount it on the coolest side of the box particularly in warmer climates. Recommended maximum voltage for AQUITEL equipment is 14.7 volts, damage may occur if 15.0 volts is exceeded (Refer to section 6.1.3 for checking and adjusting regulators).

Battery size must be matched to the station location and the expected sunlight exposure (Refer Appendix v). For normal well exposed situations, 65 AH batteries are adequate. The sealed type require minimal maintenance with little danger of acid spillage. Terminals must be kept tight and clean; use petroleum jelly or any patented battery anticorrosion agent. Vent any fume outlets, particularly from wet cell batteries, outside the box using drilled corks with inserted plastic tubes.



View into front of (female) socket

1 Red - power + 12 volts
4 Black *(or often shorted to green)* - power supply ground
2 Green - Line common
5 Yellow *(or blue)* - one leg of the line
3 Blue *(or yellow)* - other leg of the line

Figure 7 DIN plug - radio end

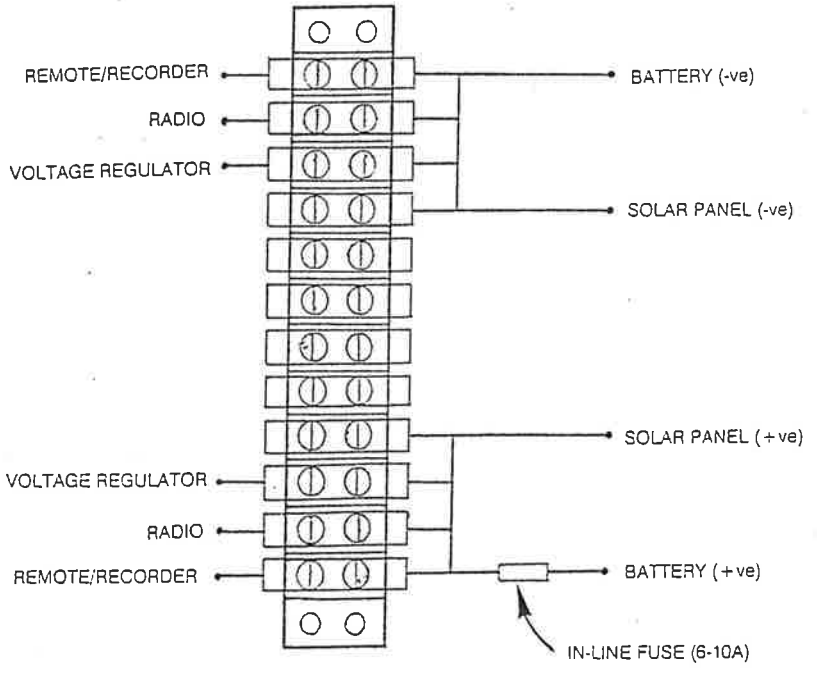


Figure 8 Radio box wiring

Allow adequate cable to terminals, so that the battery can be partially slid out of the box for maintenance. Care should be exercised when using metal tools near the battery terminals - remove metal watch straps. All safety precautions must be observed when handling batteries - an acid burn at an isolated field station is potentially serious.

Beware of power surges damaging equipment when battery reconnecting, always switch the radio off.

An information notice at field stations stressing their local importance may prevent vandalism. A "Warning - high voltage" notice attached to the pole may also stop vandals.

(iv) "Long run" power supply

"Long runs" (100-400m) may be necessary between pole and the remote to satisfy radio signal or adequate sunlight requirements. An additional battery is required in these situations, at the remote housing to compensate for cable losses and voltage drop when the recorder is sensing. A 24 AH battery is adequate with a diode in the wiring arrangement as shown in Figure 12 . This wiring arrangement gives the following benefits:

- the remote senses the main battery voltage only (after the diode):
- backfeeding fromthe small to the large battery will not occur when the large battery voltage falls at night or on sunless days;
- when the remote and recorder operate, they do so off the small battery voltage supply. This battery is then recharged by the larger. If the equipment drew power directly from the main battery, the voltage drop is likely to trigger the voltage alarm or shut the system down.

Other points to note for cabling between pole and recorder on long runs which will make the job easier:

- ensure the power cable is an adequate size for the distance required;
- use larger diameter polythene pipe, e.g. 40 mm, to protect the cables. This makes the pulling through of long length cables significantly easier;
- for cable joining - use the correct encapsulated cable connectors. These are expensive but absolutely essential;
- if future expansion is possible, e.g. rain gauge at the pole, ensure the data cable has sufficient wires for this. Whangarei ED have used 7- pair signal cable offcuts available from Telecom for this purpose.

2.4.4 Recorder housing setup

Some adjustments and linking are required in the sensor housing. These will fall into the following categories:

i) installation of data/power cables from the pole;

ii) remote installation and cabling;

(i) Data/power Cables

The power data cable between the radio box and the remote will need to meet the following specifications:

Cable size	Maximum distance - radio to remote
1.5 mm2	20 m
2.5 mm2	75 m
4.0 mm2	150 m (preferred cable)
6.0 mm2	400 m (absolute maximum)

Can be any of:

- twin power cable
- 3 core power cable
- twin and earth power cable

Data cable can be purchased from AWA (NZ) Ltd

Miniature multicore cable type 4E

"4/7/.15 5.0 mm OD" in 100 m lengths

or

Australstandardcables

Specification No. 71TH 4/53

"4 core screened flexible cable" in 100 and 500 m lengths

NIWA - Kainga also hold data cable in stock.

These cables should be protected by buried alkathene pipe (25 mm gold stripe) or similar. If a pipe joining is necessary, use Philmac or similar screw couplings in the appropriate size. (Refer to Figure 9) Cables will need to be pulled through the pipe before burying. Use of high tensile wire on a "spinning jenny" assists. Allow a generous length of cable and trim back to size.

Trenches must be an adequate depth with a plastic warning strip. Where the pipe is exposed on anks and rock faces, it should be pinned securely. If in the vicinity of other services, permission must be sought from the local authority. Buried wire notices may be necessary in this situation.

Use of a specialist trenching machine could be more economic than hand labour for trench digging and back filling. The pipe can be fastened to the radio and recorder boxes using the Philmac couplers. A male coupler is fastened to the end of the pipe with the threaded end pushed through the box and a cut down female section screwed securely on the inside. If the hole is oversized use a drilled metal plate under the base of the female coupler. (Refer to Figure 9)

(ii) AQUITEL Remote installation and cabling

Installation of all the equipment in a recorder housing should be done to allow for ease of access and visibility.

(Refer to Figures 10-13 and note the numbers on the diagrams)

Specialist cables are supplied by NIWA - Kainga for:

- power cable from block to remote;
- radio data cable from block to remote;
- water-level recorder to remote;
- rainfall cable from remote to block.

Ensure remote cables are secured and tidy to eliminate possible catching on recorder pulley wheels. The remote cables must be handled with caution, avoid undue kinking. Extreme care must be exercised when plugging into the remote, the plug must be "felt" into position and not forced, as the male pins are delicate and easily bent. The large raised lug on the male plug should be at the 12 o'clock position. The port caps should be replaced to stop moisture effecting the contact pins.

NOTE: It is important when installing the power cable to the remote, that the terminal plug ends are plugged into the power supply first. The 2 positive lines provide the power and the 2 negative lines provide the voltage sensors. If the power lines are plugged into the terminal first without the sensors, and the remote plug is already in place, the remote can be severly damaged.

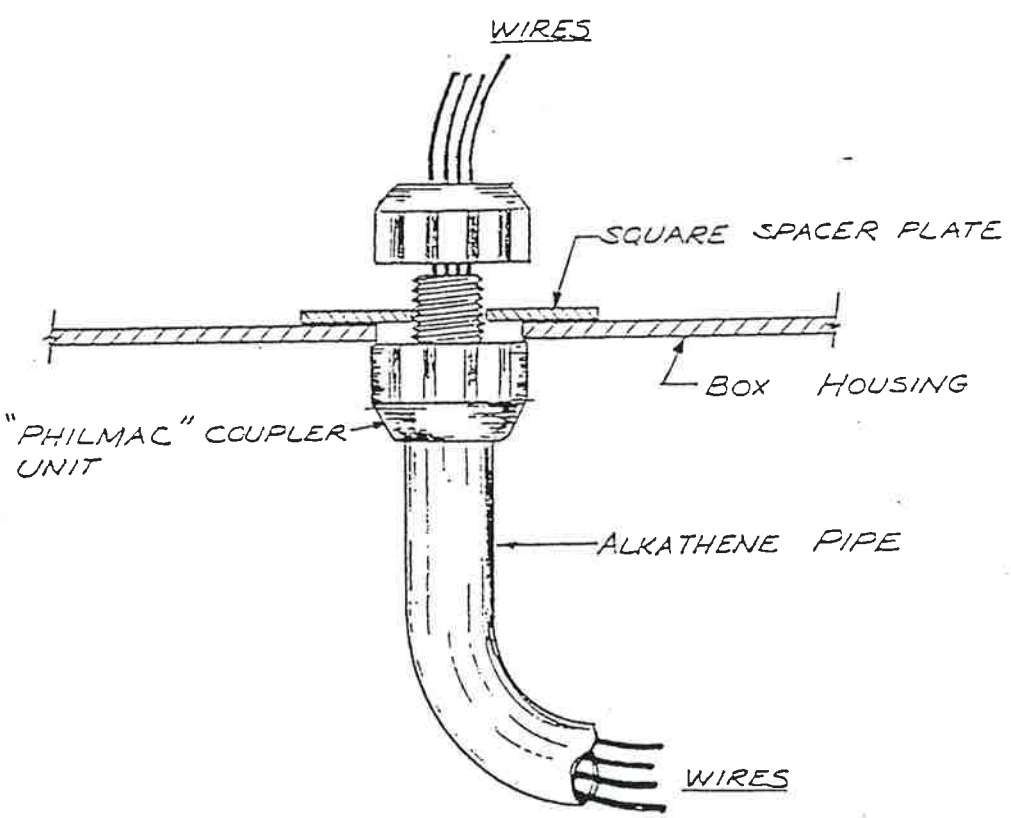


Figure 9 Alkathene pipe termination

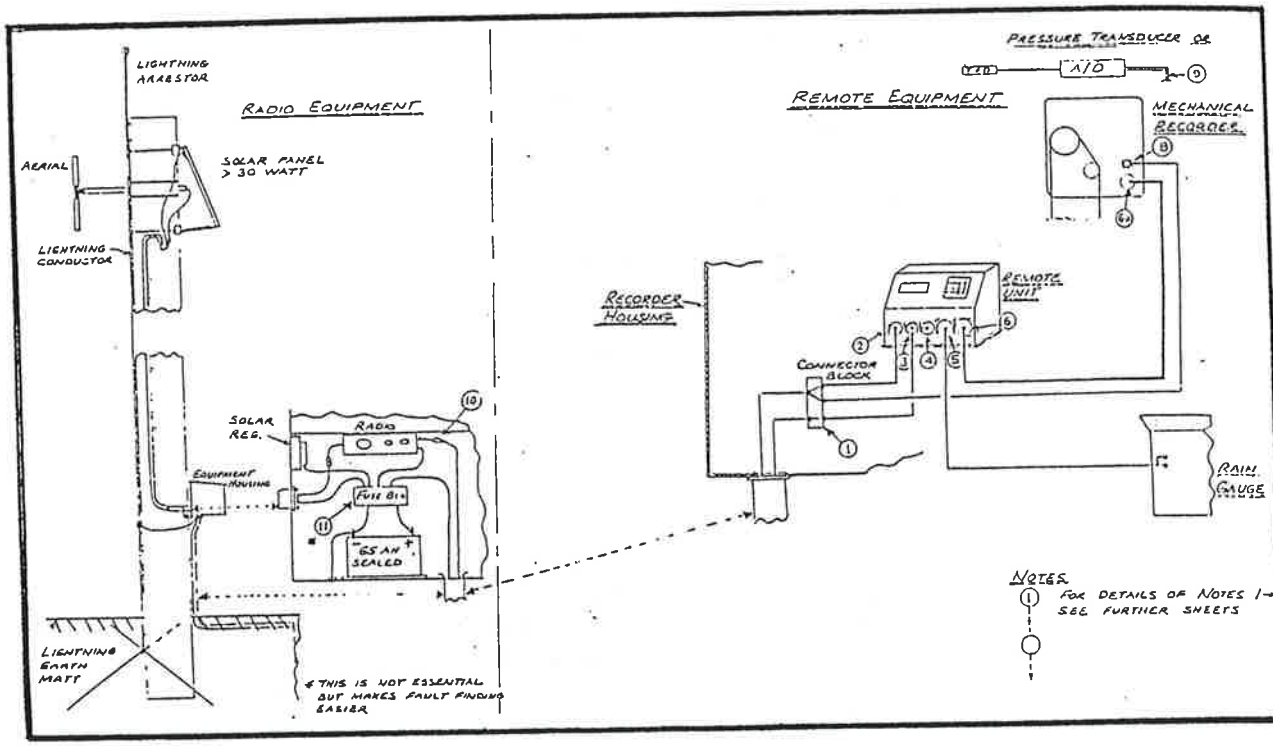


Figure 10 Standard remote site cabling (part 1)

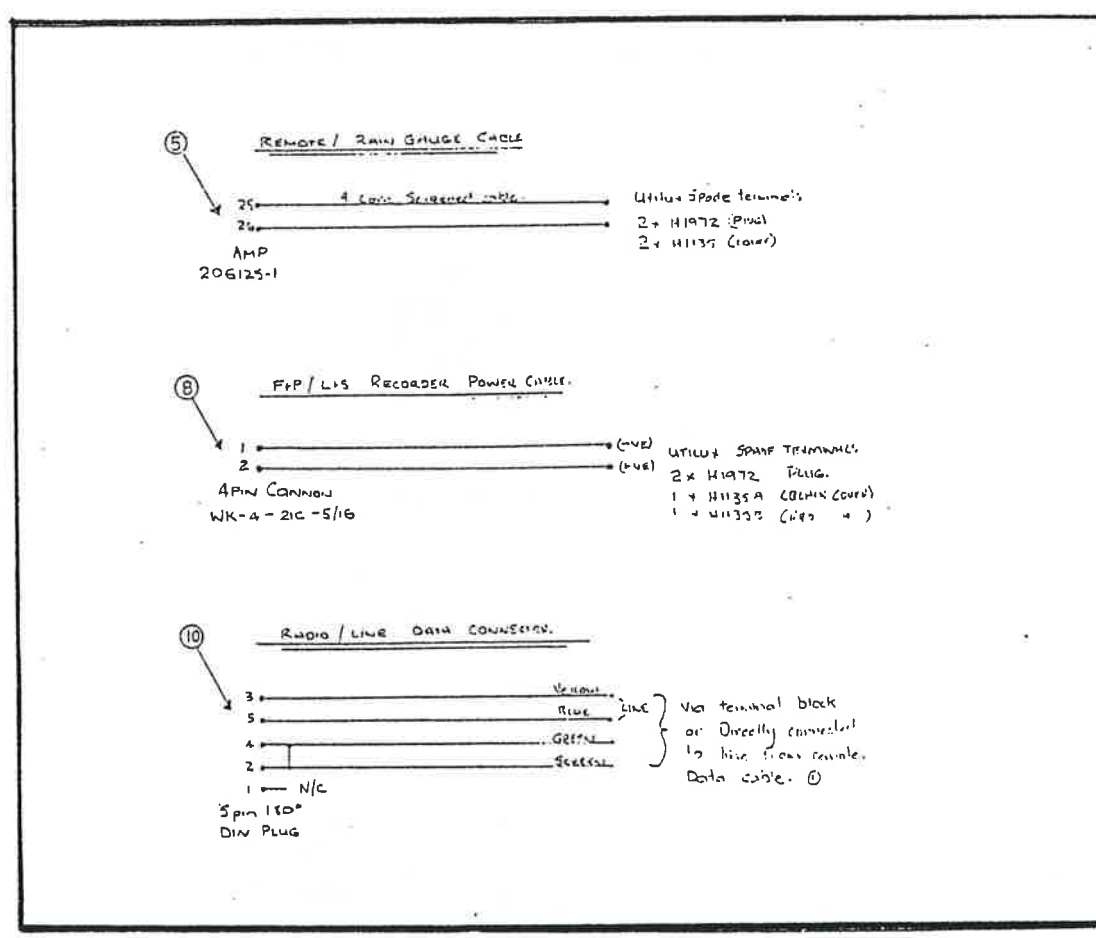


Figure 11 Standard remote site cabling (part 2)

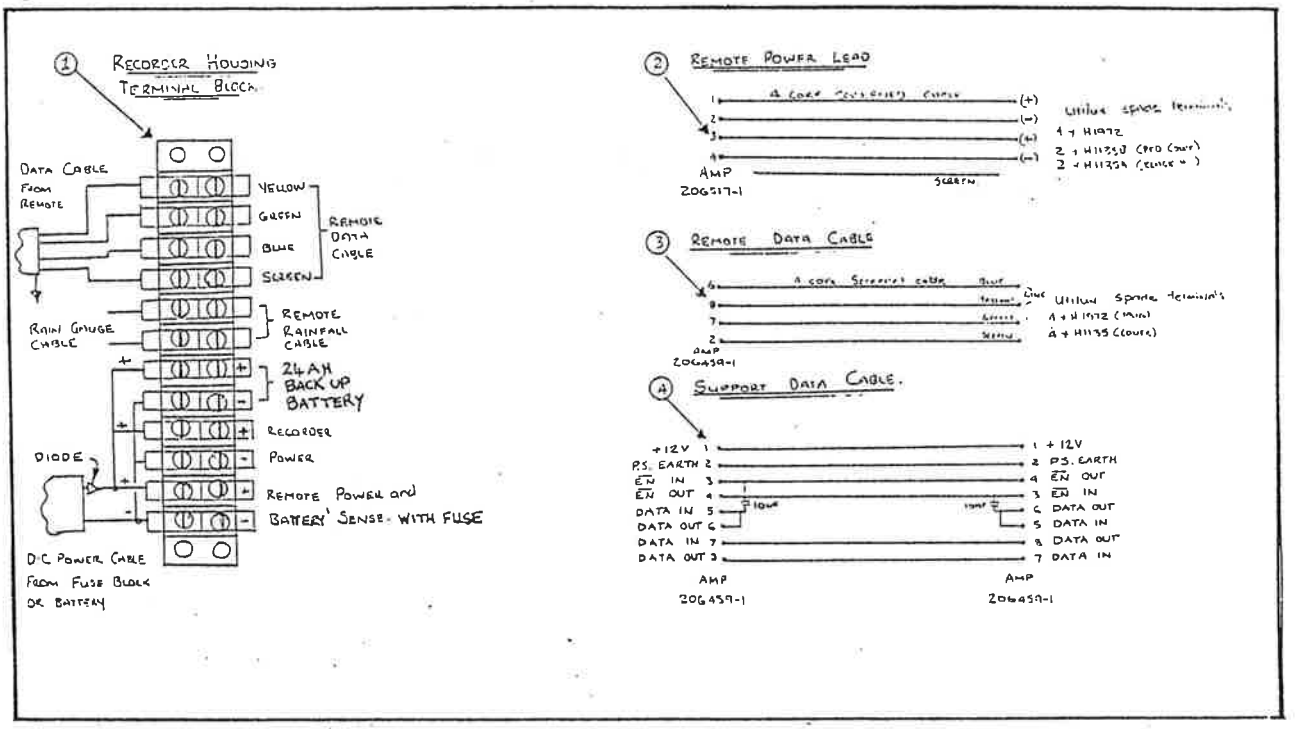


Figure 12 Standard remote site cabling (part 3)

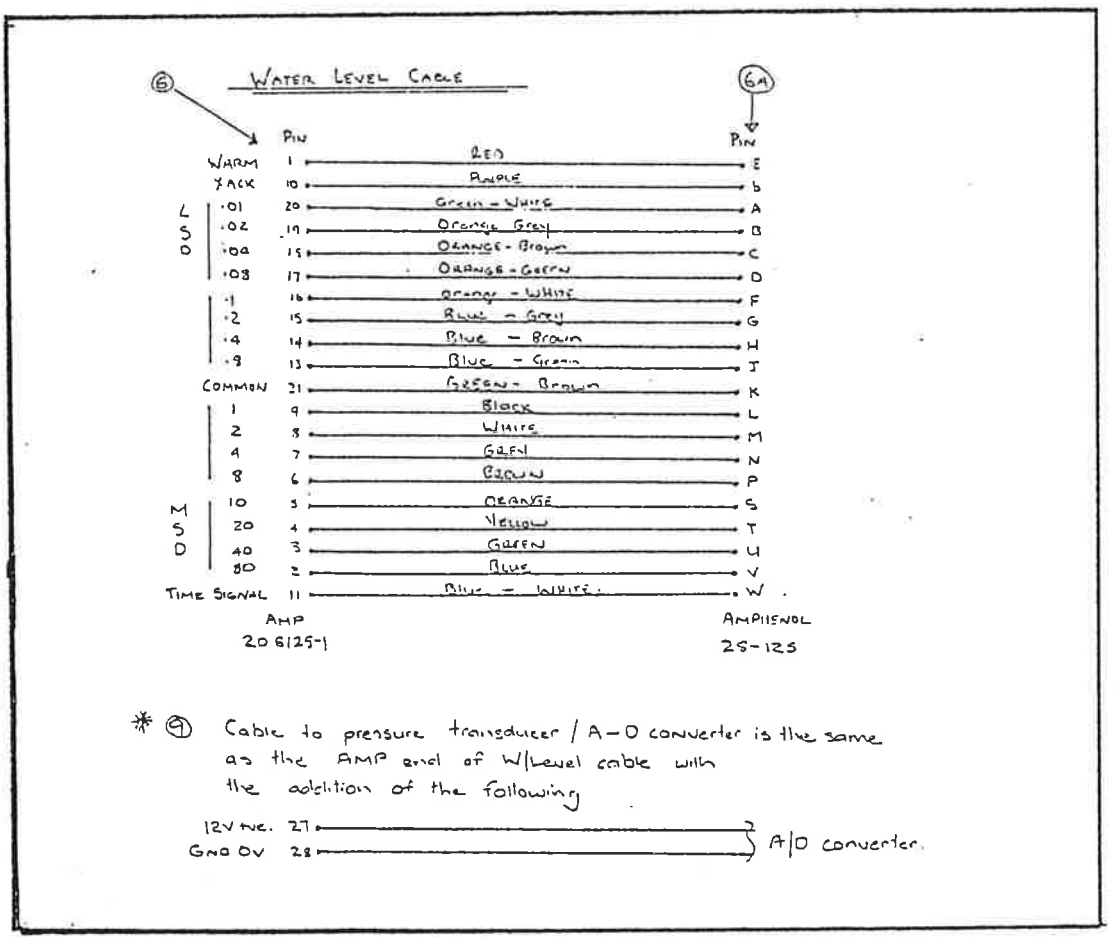


Figure 13 Standard remote site cabling (part 4)

2.5. AQUITEL Remote Operation and Power Up

The remote unit is the "intelligence" at the point of field measurement. It responds to messages from the microbase and controls the operating criteria of the measuring device. It has two input data channels, normally water-level and rainfall. Low and high alarms can be preset for both inputs. Recording intervals can be varied to suit local needs, e.g. 5, 7.5, 15, 30, 60, 120 or 240 minutes.

The on-site storage capacity of the remote is approximately 10 days of 15 minute interval data. When storage capacity is exhausted, the latest incoming data will overwrite the oldest.

Extraction of data can be carried out by the microbase via the communications link or on-site by the support unit. Remote parameters and data can be examined on-site using the keypad and LCD display. (Input of these parameters is done by the support, refer to section 2.6) An additional display facility is available via the comms. link using the mobile unit. When preset alarm conditions are exceeded, the remote unit will initiate a warning transmission to the microbase.

The unit is configured into a series of menus which are in turn subdivided into tasks, e.g.

MENU (Water)

- task 1 Water High Alarm
- task 2 Water Low Alarm
- task 3 Water Sensor, etc

MENU (Rain)

- task 1 Rain Stored
- task 2 Rain Reset
- task 3 Rain Alarm, etc

Use of the menu and task keys enables each of these parameters to be displayed. The * key initiates action on the AQUITEL units.

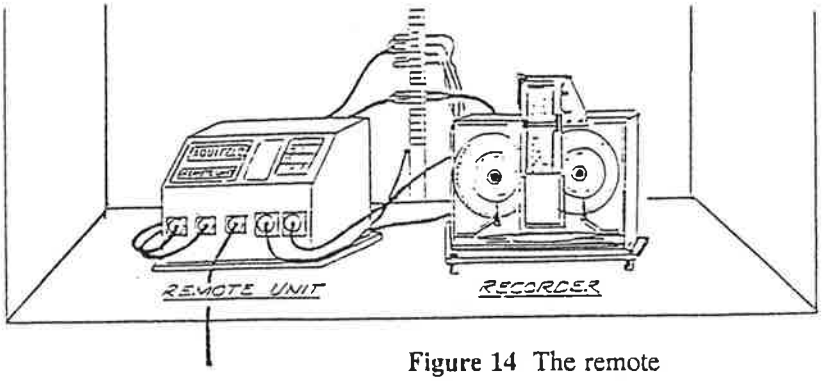
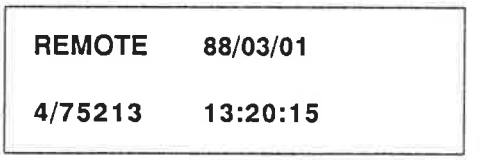


Figure 14 The remote

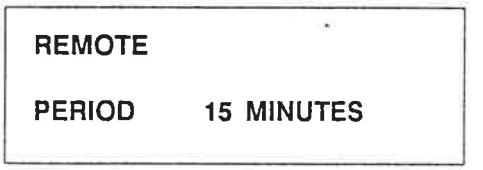
Firmly push any key to initiate the display



Current date (top) and time (bottom) are shown on the right of the display.

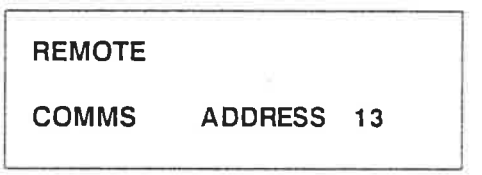
Base number (4) and site number (75213) are displayed on the left.

(TASK)



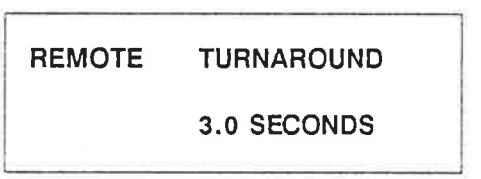
Recording interval is displayed.

(TASK)



This address is unique to this remote. Every unit on the same channel must have a different comms. number.

(TASK)



Relates to the turnaround time for all the communications equipment. Should be the same for all the units.

2.5.1 Water Menu

WATER DATA	88/03/01
NEXT	13:30:00

Current date is displayed and the next recording time. If water-level monitoring is inoperable, NEXT will be replaced by INACTIVE. In the INACTIVE mode, no further water tasks can be accessed.

SCANNING WATER DATA: previously recorded data may be scanned and viewed on the display by pressing the following keys or combination of keys:

(-) and (*) in quick succession displays the last water-level with date and time

(-) will initiate a scroll back through the record

(-) twice, every second value is displayed

(-) three times, every third value is displayed etc.

(+) a forward scan of every value

(+) twice, forward scan of every second value, etc.

(*) halts any further scanning.

If the time at a remote is ever updated or changed (no matter whether it is done via support or RTALK) the time for the "next" data collection will be cancelled and replaced with the "start time". Provided you update the start time, all will be well. If you forget to update the start time the value used will be the last entered start time which may have been some months ago. This can easily lead to data loss. (Because it is only the time that defaults then the new start time must occur sometime within the next 24 hours. Therefore the maximum data loss is one sampling interval less than 24 hours).

An example may help:

Consider being at a remote at 141730 hrs NZST on 860207. The remote is found to be running some 2 minutes slow so the support is used to update the time to 141930 NZST. The expectation is (given a 15 minute sampling interval) that the next data sample will be taken at 143000 hrs NZST on 860207.

Now imagine that the remote's start time was last set some 5 or 6 months ago when the remote was coldstarted. Assume that the start time had been set for some time in the morning - let's say 091500 hrs.

Coming back to the present; your expected punchout or sample will not occur at 143000 hrs because having reset the time the "next" time will have been reset to the old start time then the start time of 091500 hrs is the one that will be used. As

091500 hrs today has already passed, the remote will cease all sampling until 091500 hrs tomorrow. You can see this by looking at the WATER DATA NEXT display within the remote.

The moral of the story is that the remote's software expects a new start time each time the remote time is changed. You must provide it. (You can do this either by the support, section 2.6, by RTALK, section 5.0, or by CHANGE REMOTES PARAMETERS, section 7 FLOSYS User's Manual)

(TASK)

WATER HI-ALARM		1300
	RESET	1220

The alarm level is set for 1300 mm (or recorder units) and the remote unit will send a warning to the base when this level is equalled or exceeded. The alarm level will then be inactive until the reset level is reached. So if you respond to a high water alarm in the middle of the night and find the 1300 mm level exceeded, with the river continuing to rise but yet to reach a level of concern - the current water-level 1340 mm. You change the high alarm to 1500 and return to bed, confident all is under control - an unpleasant suprise awaits. An alarm will not be initiated at the 1500 level because the reset level has not been retriggered. If the reset has been changed to a value greater than 1340 prior to departure from the office, the Hi alarm level would have been reactivated.

Similarly, a multi-peak flood can deceive the user. In the previous scenario, when the river level status appears to be falling, i.e. peaked above the 1300 mm alarm level and has fallen to 1250, it is assumed that the downward trend will continue and the office abandoned. However, if the river begins to rise again before reaching the 1220 reset level, no further alarms will be initiated. The sensible solution would have been to change the reset value to greater than 1250 but less than the alarm level.

Users should be very aware of the reset criteria and its importance in relation to high water alarms.

IMPORTANT The use of a recorder fitted with a 300 mm pulley will complicate the setting of your alarm levels. Such a recorder will record only 1/3rd of the true water level - therefore alarms must be set to only 1/3rd of the required level.

You can reset the reset values either by the support, section 2.6, by RTALK, section 5.0, or by CHANGE REMOTES PARAMETERS, section 7 FLOSYS User's Manual.

(TASK)

WATER	LO-ALARM	150
	RESET	250

The layout is similar to the Hi-Alarm but note that the reset will be higher than the alarm level.

(TASK)

```
WATER SENSOR

WARM-UP    0    SECONDS
```

Use of (*) for this task gives an instantaneous sensor reading which is not stored nor will it activate an alarm.

NOTE: Some sensors require a warmup period before giving the reading. If the warmup period needs to be changed it can be done by using the support.(see section 2.6)

2.5.2 Rainfall Menu

The rainfall data is displayed and scanned using the key commands as for the WATER Menu (see section 2.5.1).

(MENU)

```
RAIN DATA        88/03/01

NEXT             13:30:00
```

When scanning through the data the accumulated rainfall total back from the latest value will be displayed on the top line. The stored value is the rainfall accumulated in the sampling interval. Units are 0.5 mm. e.g.

```
RAIN  614        88/02/23

STORED 13        09:45:00
```

(TASK)

```
RAIN HI ALARM   1200

      RESET     1150 |
```

This is the rainfall alarm level and is an accummulated count of tips in a given period of time.

(TASK)

RAIN	
ALARM TIME	60 MIN

This is the period of time which is used in determining the rainfall alarm.

(TASK)

RAIN	
TIP SIZE	0.5 MM

This displays the tip size. All readings are in multiples of 0.5 mm tip units. If a 1 mm tipping bucket is being used, the reading is automatically doubled before storage in the remote memory. As the rainfall data is processed by FLOSYS it is converted to micrometres. e.g.. 4 x 0.5 mm "tips" equals 2000 micrometres of rain.

(TASK)

RAIN SENSOR		
WARM-UP	0	SECONDS

As for the WATER sensor, this displays the rainfall at that time but does not store it in memory. It is remembered and added onto the next preset reading.

2.5.3 Voltage Menu

VOLTS DATA	88/03/01
STORED 12.3	12:00:00

Voltage is recorded at midday and midnight.

(TASK)

VOLTS LO-ALARM	11.0
RESET	11.8

Same format as other alarms. Generally good practice to leave at these default values, to ensure adequate warning of low voltage.

Note: Battery voltage drops very quickly after 11.0 is reached. Higher LO-ALARM levels will provide more warning.

If the supply voltage to a remote drops below 10.6 volts the remote will shut down. It will not collect data, send alarms or answer requests whilst the voltage remains so low. The remote will only recommence recording after a key has been pushed, and the voltage has risen above 10.6, but the next reading will have reverted to start time.

NOTE: Where a sensor is linked to a remote but has no communications link, the voltage and other alarms should be set to extreme levels. This is because an alarm is activated in this situation cannot be acknowledged, but the remote will attempt to send an alarm for up to 21 hours at which point it acknowledges the alarm itself. However your power supply may be so depleted by the additional transmit attempts that the remote shuts down, and stops collecting data. In this situation, set the alarm levels unrealistically low to prevent this occurring.

(TASK)

VOLTS SENSOR	03/01
12.8	13:16:00

(*) gives instantaneous voltage reading. The value is not stored.

2.5.4 Test Menu

TEST COMMUNICATIONS

(*) will initiate a test transmission to the base to check the integrity of the comms link. Should always be completed after any station work on the telemetry equipment.

For a list of likely replies refer to Appendix i.

(TASK)

TEST DISPLAY

Of interest only to your supplier.

(TASK)

TEST VERSION 15-DEC-86

The version date of the remote software - supplier interest.

(TASK)

TEST SHUT DOWN

(*) forces the remote to be immediately shut down rather than waiting 5 minutes for the automatic shut down.

2.5.5 Remote powerup

With the power lead plugged in, any key push will initiate start up - the display will be activated. Some units are occasionally reluctant to power-up and several firm key pushes may be necessary or even several reconnections of the power supply. Use of the menu and task keys will display the default parameters.

A remote is "awake" when you can see the display and is "asleep" when the display is blank and the dark background colour of the display has disappeared. Disconnecting a remote from its power supply while it is still "awake" will cause the remote to "coldstart". All its memory will be lost and its parameters will revert to the default values. It will retain its memory and the set parameters if you wait until it is "asleep", or you make it go to sleep, before disconnecting it. However there is always some risk associated with disconnecting the remote from its power

supply so it should not be done without good reason. The following can occur when power disconnections/ reconnections are made:

- You may forget to ensure that the remote is asleep. Result? Instant "coldstart" as just described.
- You may jiggle the lug too much as you power the remote back up. Result? Instant "coldstart".
- The remote may lose the "next" data time. Result? "Warmstart". The loss of the expected "next" data time and some data loss.
- The power disconnection and subsequent reconnection may work without any problems. Result? "Hotstart" and happiness.

Any one of the above may happen when you disconnect the power. You should therefore ensure that you always have a support unit with you so that you can reconfigure the remote if necessary or that you have somebody back in the office who is capable of "RTALKing" a "coldstarted" remote back up. This process is described in section 5.0. It is essential also to obtain a copy of the latest stored remote data either via the support or by interrogation from the office before tampering with the power supply. Because of the above you should ensure that you check the time of the "next" data collection before leaving the remote and you should stay and watch it occur.

To conserve power, the remote automatically goes to sleep five minutes after the last key push. However this shutdown is inhibited during some parts of the COMMS. TEST, therefore the remote should not be left until this is completed. Again you should not leave the field station until at least one data recording has been observed.

2.6. AQUITEL Support Operation

The support is a portable unit designed to be carried from station to station. It will only function when connected to a remote or microbase as it requires power from these units to operate. A rechargeable battery within the unit maintains the integrity of its memories and time clock. Battery power can be maintained by trickle charging. The support has a dual function of setting or changing parameters in a remote (also possible using RTALK and FLOSYS) and transfer of data to the microbase. The remote must be awake before the support is plugged in. Any attempt to interrogate the remote will fail while the two units are linked or "handshaking". The support must have the latest microbase date and time to ensure no disparity in times between remotes and the microbase (the microbase transfers its date/time each time the support is connected).

2.6.1 Remote configuration

With the support connected all actions are initiated from its keypad. The arrangement of MENU and TASK is virtually identical to that described for the remote. The parameters shown on the support display can either be overwritten by use of

the key pad or the (CLR) key used for removal and new values inserted. No changes are made to the remote parameters until (*) is pushed, e.g.:

CHANGING REMOTES BASE NUMBER

REMOTE WAS	99
BASE # NOW	99

These are the default values, we want to change the base number to 5.

Either

Push the (0) key - gives

REMOTE WAS	99
BASE # NOW	90

Push the (5) key

REMOTE WAS	99
BASE # NOW	5

The original number has been "pushed" out.

Push the (*) to transfer the new base number to the remote

or

REMOTE WAS	99
BASE # NOW	90

Push the (CLR)

REMOTE WAS	99
BASE # NOW	

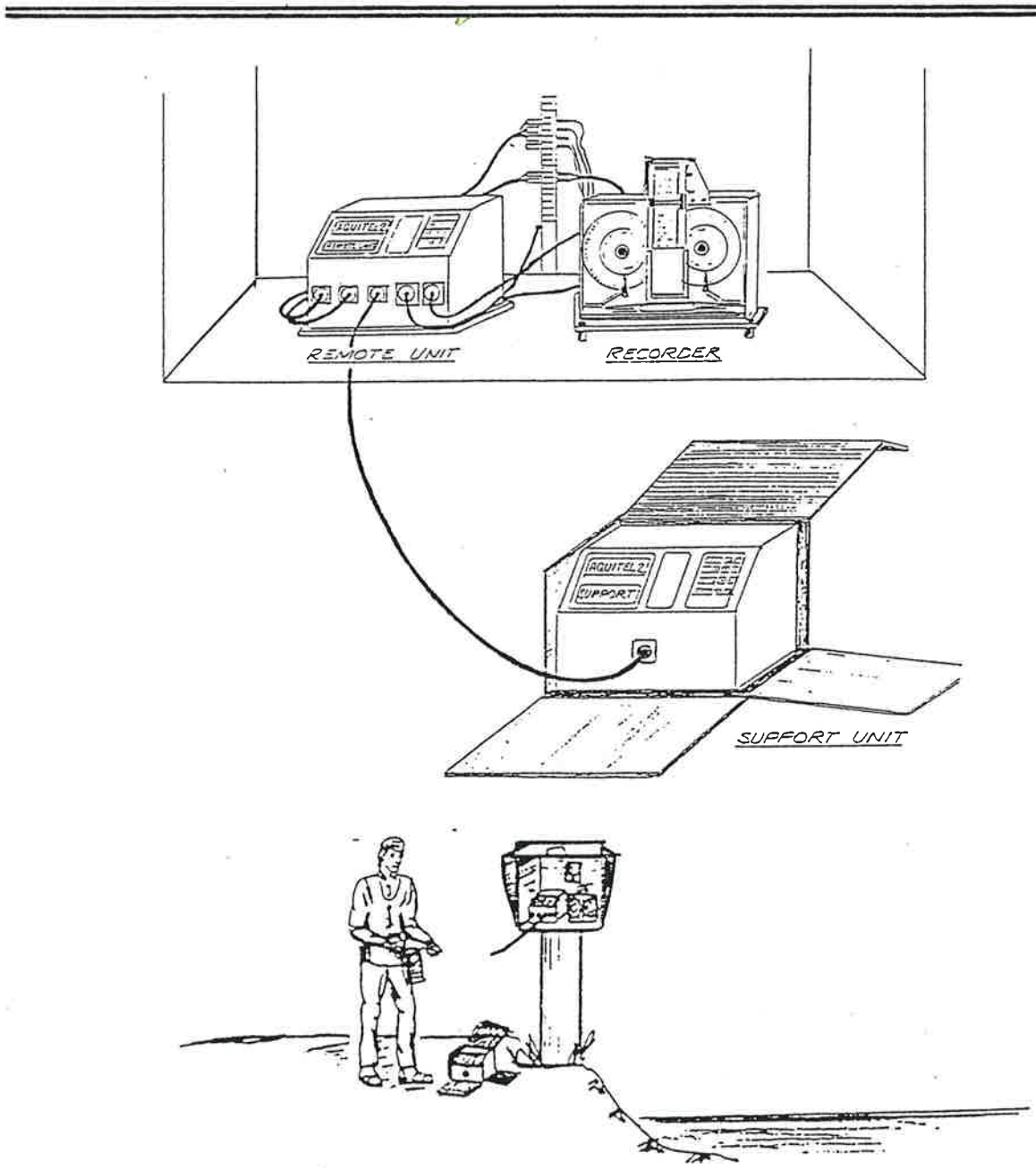


Figure 15 The support

Push the (5) key

REMOTE WAS	99
BASE # NOW	5

Use the (*) to send the base number to the remote.

The next time the support is used, this panel will display as

REMOTE WAS	5
BASE # NOW	5

The "was" value is that transferred in the last handshake.

Note: in all cases (*) must be used to initiate the change of parameters from support to remote.

Particular care is needed with:

Setting start time

REMOTE WAS	12:00:00
START T NOW	00:00:00

The start time of recording should always be later than the current remote time. The consequences are discussed earlier of setting start time earlier than current time. As when any other parameter changes are made, the remote values should be checked. If you have made a mistake updating the start time the WATER DATA NEXT date in the remote, will be the following day. The absolute check is to wait until the first data collection happens.

Activating data collection

WATER WAS ACTIVE
NOW INACTIVE

Use of (*) changes the display to

WATER WAS ACTIVE
NOW ACTIVE

and water recording is actuated. A further push of (*) changes status to Inactive etc.

VoltageAlarm

VOLTS WAS	11.0
L-ALARM NOW	11.0

The low alarm is the only voltage parameter than can be changed. It should not be lower than 10.6 V - the remote shut-down value.

When (*) is actioned to change any parameter, a series of numbers will flicker briefly in the lower right of the support screen - this indicates that data transfer is occurring.

2.6.2 Transferring data

(i) From the Remote

The support is capable of transferring data from remote to microbase, should the radio link fail. The standard support (extended memory version available) has five memories, each of which accepts the contents of one remote. No discrimination can be made to the quantity of data copied from a remote - the total record is collected on every occasion.

To examine the memories

(MENU)

MEMORY
CAN TAKE 5 REMOTES

(TASK)

```
SELECT MEMORY AREA
```

Each memory can then be selected using the appropriate numeric key, i.e. (1)

```
MEM # 1 USED   86/06/15
4/75213        15:00:00
```

Indicates that memory 1 has data from site 75213 which has a base number 4, the last data value at 860615 150000.

Key (2)

```
MEM #2 USED    86/06/16
4/75272        10:15:00
```

Memories are notated as FREE, USED or UNDF.

FREE indicates that the memory is available to accept data.

USED indicates that data has been copied from a remote into it but has not been transferred to the microbase. The designation protects the data in the memory and no further data input can occur until the label is changed.

UNDF indicates the memory is undefined and data transfer can occur, only inwards.

The remote data is copied into a FREE memory which becomes USED at the completion of the transfer.

Support data from a USED memory is copied into the microbase, at the completion of which, the memory reverts to FREE.

Use of (*) can change memory status from FREE to USED and vice versa.

```
MEM # 1 USED   86/06/15
4/75213        15:00:00
```

(*) causes

```
MEM # 1 FREE   86/06/15
4/75213        15:00:00
```

(-) changes a FREE or USED memory to UNDF and vice versa.

```
MEM # 1 UNDF   86/06/15
4/75213        15:00:00
```

Memory contents are not lost with changes of status but when a

FREE memory has new data from a remote the original data is overwritten. The usefulness of manipulating the status of memory areas will be explained shortly.

With the remote "awake", the support is plugged into the appropriate port (ensure your connector cable is long enough for comfortable operation at all the sites) causing the support panel to activate and display.

```
WAITING FOR MESSAGE
FROM CONNECTED UNIT
```

Followed by

```
MEMORY HANDSHAKE
STARTED
```

and a succession of numbers in the right lower corner as the data is transferred

```
MEMORY HANDSHAKE
COMPLETED
```

Means all is well and the memories can be scanned to confirm the data has transferred.

However the following message may appear:

```
MEMORY HANDSHAKE

ABORTED - NO MEMORY
```

There is no FREE memory in your support. se (TASK) and (*) to free a memory. It is not necessary to disconnect and reconnect the units to initiate the memory handshake again but use (TASK) until

```
TO ATTEMPT ANOTHER

HANDSHAKE  = PRESS *
```

(*) will complete the job.

Note:

- Each time you connect to the remote, data will be copied into the support provided there are FREE memories. This can be a nuisance having to wait for a data transfer, when a minor change in parameter is all that is required. Changing to status of all the memories to USED will ensure this does not occur.
- Care should be taken to make the support plug connections and disconnections as " clean" as possible. Hold the plug in while operating the locking ring to ensure unnecessary "jiggling" does not occur. If when disconnecting the plug a brief message appears on the support display

```
SPURIOUS MESSAGE

RECONNECT
```

you will need to recopy the data. This is deceptive as a support memory scan confirms the data is there but it will not successfully transfer to the microbase.

(ii) Transferring Data to the Microbase

Data transfer from support to microbase is relatively simple. The support is connected to the microbase.

MICROBASE	88/04/02
CONNECTED	14:30:12

The date and time shown is that of the microbase which is copied to the support each time the connection is made. Memory transfer does not begin until the "GET SUPPORTS DATA" in FLOSYS is given. Data from all FREE and USED memories is copied, so any memories not required should be made UNDF.

Upon command from FLOSYS

MICROBASE TRANSFER
STARTED

The key pad will not respond once the transfer begins

MICROBASE TRANSFER
COMPLETED

The appropriate memory now becomes FREE.

2.7. AQUITEL Mobile Unit

The mobile is a portable, hand held unit which can be used to get current data status from the remote. The unit operates in conjunction with any of the network radios and may be used from a vehicle. It is especially useful for field staff operating away from the base or for site status checks from home, particularly during flood events. The unit may be set to interrogate the remote directly or via the microbase.

The mobile derives its operating power from the radio to which it is temporarily linked. The MENU, TASK configuration is similar to the other units, as are the key operations. The unit has its own unique comms number. It should not be disconnected from the radio while a task is still running. Unlike the remote unit, parameters can be set directly into the mobile with (*).

Refer also to Appendix ii. and iii.

When first plugged into the radio, the following display may be shown:

COLDSTARTING

(*) will be necessary to start the unit. This indicates that the battery backed RAM has failed which could be the result of disconnecting the mobile from its power source while a task is still running.

All the parameters will need to be reset - this can be avoided by ensuring all tasks are completed before disconnection.

The alternative and more usual display when the unit is first connected would be:

LAST ALARM

Use of (*) gives detail of the last alarm reported to the microbase.

75272	88/06/01
WH	172 07/30/00

This indicates a water high alarm was reported from site 75272 on 1.6.88 at 7.30 am on channel 1, COMMS. number 72 (172).

The alarm abbreviations are:

WH - water high

WL - water low

R - rainfall

V - low battery alarm

B - f\microbase alarm (microbase goes into alarm mode when no data from any site has been unloaded for a specified time, normally 120 hours).

or

NO ALARMS

Have been no alarms since the microbase was last started.

To use active data interrogation

(MENU)

SET TARGET REMOTE	
COMMS ADDRESS	13

If this is the remote required, no further action is needed on this panel. If you wish to change the target remote, use (CLR) either the number and action it with (*).

(TASK)

SET BASE TO REMOTE	
CHANNEL NUMBER	1

The appropriate port must be used for each remote.

(TASK)

SET BASE NUMBER 4

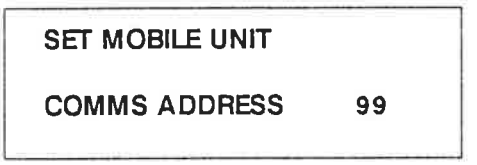
The base number of your microbase

(TASK)

SET MINUTES FOR	
TOTAL RAINFALL	0

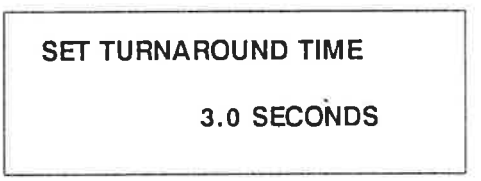
Will give total rainfall back from now. The number of minutes gives the accumulated total for that period. Maximum of 4 figures can be entered (9999 minutes = 7 days approximately).

(TASK)



The unique number for the mobile communications address

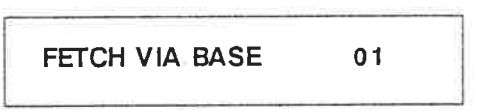
(TASK)



Remember it must be the same for all units in the network.

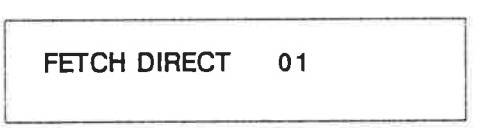
Setting up of the mobile is now complete - there are two options for the communications path

(MENU)



(*) will initiate a message from the mobile through the microbase to the appropriate remote. The return travel path is reversed. This interrogation would be the normal one used. However

(TASK)



(*) will initiate a direct message to the remote if you are in close enough proximity to have direct radio communications.

Once (*) initiates the transmission, a series of messages will be displayed and the distinctive telemetry tone will be heard on the radio.

FETCH DIRECT	36
TRANSMITTING	

followed by

FETCH DIRECT	13
WAITING TO RECEIVE	

and

FETCH DIRECT	15
GOOD DATA RECEIVED	

The keyboard will not respond until the task is complete. If information has not been supplied, e.g. base number, channel number, then you will be requested to do so. If a COMMS problem has occurred, the unit may ask you to "RETRY".

The numbers in the upper right part of the display indicates the status during the interrogation. Information on these and possible interrogation responses from the mobile are contained in appendix ii as they are useful diagnostic tools.

Data appears to have been received but now needs to be displayed.

(MENU)

TOTAL RAIN	15:00:00
2 TIPS	1440 MIN

Total rainfall recorded in 1440 minutes (24 hours) is 2 tips (i.e. 1 mm if using 0.5 mm buckets) with the last recording at 1500 hours (i.e. indicator of the time you interrogated - not when the last rainfall was recorded. If rainfall is not recorded at the remote, the display will show 0 tips.

(MENU)

REMOTE WATER DATA	
4/75276	0076

Data is for site 75276 which has a comms. address of 76 and base number of 4. To examine the data (-) is used as previously explained in the remote section. The data quantity is limited to sixteen readings.

2.8. BASE SET-UP

The base station is the central point of the telemetry system and its primary purpose is to access information collected by individual remotes at one common point. Normally, all communication to the field stations originate at the base station. Data retrieval, remote programming, and system analysis can all be done from the base station.

2.8.1 AQUITEL Equipment

Equipment dedicated to the telemetry system will be:

- The Microbase - it is the controller of the telemetry system handling radio transmission protocol, checking and correcting errors, extracting data from the support, talking to the datalogger or microcomputer and the other AQUITEL units. It interfaces to the communications network, an automatic telephone dialler and a dedicated printer to give a hard copy of all its transactions. It can activate a local audible alarm or light to warn of an alarm status before the autodialler is finally prompted. It can operate independently of the datalogger;
- The Radio and Aerial or an LDC line. One radio per channel is normally required;
- A dedicated Log Printer - which logs all microbase communications;
- A Data Logger or Computer to run the necessary software and provide the ultimate storage medium for the collected data;
- A 12 volt DC battery to supply microbase radio and auto dialler power. The battery is continuously charged by a 230 V charger which ensures power is available to the essential units at all times;
- An Autodialler which will on command from the microbase initiate a pre-programmed telephone diallingsequence.

Other equipment associated with your base will be a plotter, additional printer and possibly a digital tape reader and/or digitiser.

2.8.2 Layout

Base layout is important for efficient operations, maximum space utilisation and the final effect should look professional and tidy. Equipment linking and power supply cables should be as concealed as possible but still easily accessible. A wide variety of custom built units are available for housing computer and anciallary equipment. These should be the adjustable type which enable future expansion.

The microbase has connecting cables to the communications network (3 sockets - 2 ports on each), the data logger, log printer and the auto dialler. It is wired to the 12V power supply with a 1A rated fuse in the circuit. The only regular access requirement to the unit is the support port on the front but the equipment plugs at the rear should be easily reachable if changing the unit.

The 230V supply should be from a dedicated outlet which cannot be accidently switched off. A multibox with switches for each outlet is ideal, enabling a single unit to be removed from the system without depowering all the units. Additional outlets should be available for peripheral tasks such as trickle charging the support etc. If it is not possible to operate a dedicated outlet then warning signs should be placed clearly and visibly to prevent any possible accidental power failures.

The battery charger maintains the battery voltage - similar battery to that used at the field stations. A protective tray beneath the battery is essential to protect against acid leakage. A recommended charger is the Pertronic Telecom 420 as supplied by NIWA-Kainga, which displays voltage and amperage. Power is taken from the battery for radios, microbase and autodialler. If these are all hard wired to the battery, an unsightly "birds nest" of wiring can result, as well as the problem of having to disccnnect all units when only one is required. A recommendation is made to use a DC "splitter" box for power outlets. This is hard wired to the battery (means only two sets of wires including the battery charger) and the box mounted on the most convenient wall. Standard removable plugs then provide the necessary DC power. An extra outlet on the box is useful for checking remotes in the office.

A similar system can be used to link from the microbase comms. ports to the communications system. The comms. tech. should be able to construct a small hard wired box to accept jack plugs or similar - one plug per channel. Channels can then be easily changed for trouble shooting purposes. The radio should be situated as close as possible to the work station but ensuring there is no interference from thecomputer.

NOTE: High frequency interference from the PC can affect the microbase especially if the PC has a 486 board. Locating the two items in close proximity can cause the microbase to crash.

The autodialler can be attached to a convenient wall with access necessary to the front programme wing keys. This will be linked to a telephone which ideally can be switched from autodialler dedicated to general use. The switch should be clearly marked as to the appropriate position for the dialler. If telephone access to your building is through a central switchboard ensure that telecom have a record of your dialling equipment. Many of the computerised switchboards need to be programmed to accept the decadic dialling used by many autodiallers.

Provision will be necessary for continuous paper feeds for printers. It is useful for later diagnostics, to retain the log printer output. This can be allowed to accumulate in a rack or similar beneath the printer and need only be removed to check entries for previous days, weeks or months. A copy of the "microbase printer message codes" should be displayed nearby to enable quick translation of messages.

Adequate and secure storage for discs is essential. (refer to Office Practise Manual) Reference manuals, plotter paper etc. should be close at hand. Pinboards and a message board are useful for status updates and general information.

2.8.3 AQUITEL Microbase Installation

1. Set up power supply (see above) Do not attempt to power up.

2. Install communication system i.e.. the radio or hardwire telephone. Refer to Figures 16 and 17.

3. Connect communication system to microbase.

4. Connect log printer to microbase. (If available) When the log printer is disconnected it must be at the microbase end. If the cable is disconnected at the printer end only, the microbase is likely to crash.

5. Connect the microbase to the PC. i.e. connect the datalogger plug on the microbase to the comms. port on the PC.

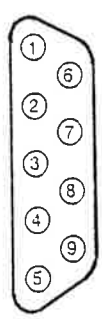
6. Plug into power supply. When connecting the microbase to the power a short sharp beep should be heard. If not check the power connections and fuses. Refer to section 4, FLOSYS User's Manual for accessing the telemetry system.

NOTE:

- A microbase crash is accompanied by a high-pitched whistle.
- Disconnect the microbase from the power for 15-20 seconds to reset.
- The microbase number and time (if set) will have to be reset.

Microbase DB9/F

View from back of microbase



1 Green - common channel 2
2 Red - power supply + 12v
3 Black - power supply earth
4 Green - common channel 1
5 Yellow *(or blue)* - one leg of line channel 1
6 Yellow *(or blue)* - one leg of line channel 2
7 Blue *(or yellow)* - the other leg of line channel 2
8 Not connected
9 Blue *(or yellow)* - the other leg of line channel 1

Figure 16 General wiring for Communication Line to Microbase.

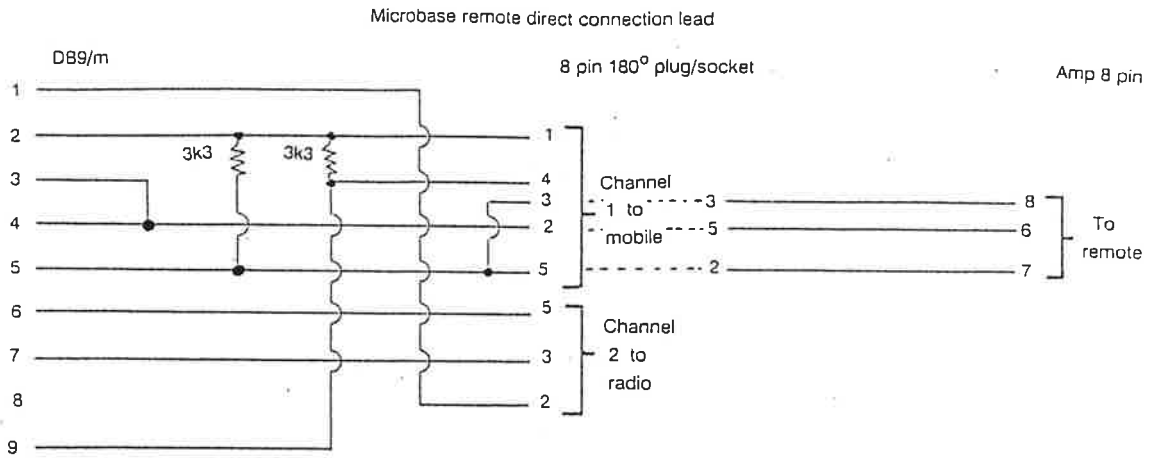


Figure 17 Communication Line to Microbase with Channel 1 as a hard wire.

2.8.4 Autodialler operation

Autodialler operation is a minor part of the telemetry system but a particularly important one which ensures an adequate response to alarms raised. NIWA field teams are equipped with BRANDT Microdials - model ATD502 to which these notes apply. The unit is powered by 12 volt DC and is linked to the microbase and a telephone line. One activated, the dialler will ring up to seven numbers from a preprogrammed repertoire for a total of sixty calls. Upon a response to its dialling, the unit will play a prerecorded message from a continuously looping cassette until cancelled by the handheld 'toner' unit. Dialling can also be stopped by depowering the unit, or entering the access code. The numbers in the permanent repertoires are held on an EPROM chip, a new version of which has to be arranged with your supplier, to change numbers. A temporary repertoire of three numbers is also available for the user to enter numbers manually.

When the unit is depowered, an access code of four numbers (your choice) between 0000 and 9999 must be entered to reactivate the unit. The sequence is:

1. apply power - orange light illuminates and beeper sounds
2. press *
3. Enter the four digits
4. Press * - green verify light should light up
5. Re-enter the four digits - green light should extinguish if OK. If not, orange light appears and beeper sounds. Start again at step 2.

If you wish to use the temporary repertoire a similar sequence is required. Numbers may be up to twelve digits and must not be to emergency services or toll operators. When the unit is depowered, these numbers will be lost:

1. Press

2. Enter the four digit access code - orange light indicates the code is acceptable

3. Press *

4. Enter 1 then then number you wish dialed, not forgetting to include the number required to get an outside line. If this was to be the second number in the repertoire,enter 2 then the number etc.

5. Press * green verify light will illuminate

6. Re-enter the number excluding the additional 1, 2 or 3 at start - orange light should come on. To enter further numbers, go back to step 3.

7. Press * twice to finish - orange light will extinguish and beeper sound.

This repertoire can be used to check the operation of the dialler by inserting an office extension number and shorting out the pins of the dialler plug into the microbase. The dialler can be heard dialling the appropriate numbers. Numbers can be changed or deleted from the temporary repertoire (refer to your dialler manual) but it is just as easy to depower the unit and start again. If the orange light is illuminated at any time - there is a problem, possibly the unit has been depowered. Play safe and start from the beginning. The sequence of alarm notification is to the microbase from the remote. The microbase sounds its own warning device which can be stopped via the button on the back. After five minutes, the autodialler is signaled by the microbase.

The canceller unit sends a programmed tone to the dialler which stops any further dialling. The unit is held over the telephone mouthpiece and sounded for about 5 seconds. Normally, the message from the dialler can be heard to stop. The battery in the unit should be charged about every six months to ensure the tone has sufficient volume to be effective.

Note:

The autodialler, as supplied at NIWA installations monitors its own power supply and will, if the supply voltage falls below 11.0 volts, initiate an autodialling sequence on the permanent repertoire. Because the autodialler and the microbase share a common power supply, a low voltage alarm initiated by the autodialler may be your first indication that the microbase may soon cease to function.

The autodialler specifically identifies a power supply low voltage alarm by inserting one second interrupts into the message. It is up to the user to interpret the interrupts as a low voltage warning.

Because the alarm is initiated by the autodialler it will not be logged by the microbase nor will it be accessible via the "last alarm" function on the mobile.

3. FLOSYS OPERATIONS

3.1. Initial set-up of a new system

3.1.1 Microbase

For installation of the microbase see section 2.8.3.

The baud rate between the microbase and logging printer is 4800.

The baud rate between the microbase and the computer is selectable but a rate of 4800 or 9600 is suggested.

Consult the appropriate AQUITEL hardware manual and DOS Manual for information on setting these.

3.1.2 FLOSYS software

The FLOSYS software package is primarily a system for the telemetric collection of data. It combines features from an earlier telemetric system, TELSYS with selected display facilities from the data processing and archiving system, TIDEDA. It may also have a flood forecasting program added so that its operation can be extended from routine telemetric collection of data to full flood forecasting. All data collected by FLOSYS is filed in a TIDEDA file and can be displayed in various formats.

TELSYS was originally written by Systems Software and Instrumentation Ltd to support the telemetered hydrological data acquisition system (AQUITEL) developed by Harding Signals Ltd, for the Ministry of Works and Development. FLOSYS has since been expanded to support Campbell dataloggers to provide multiple sensor capability.

Refer to Section 4 of the FLOSYS User's Manual for instructions on how to set up the FLOSYS software.

3.1.3 Installing FLOSYS

Back-up the FLOSYS program disk.

Create a directory called TELEM (or any relevant name). Copy all files plus RTALK.EXE onto this directory.

Edit the AUTOEXEC.BAT file on the root directory and change the following:

1. Include the telemetry directory (created above) in the PATH statement.

2. Insert or change the tiparm path to tiparm = c:\ (or your root directory).

3. Insert or change the teldat path to teldat = c:\telem\ (or your directory name)

4. Insert or change the telrem path to telrem = c:\telem\ (or your directory name)

NOTE: TELDAT is the path of the TIDEDA file to receive the received telemetry information and telrem is the path of the REMOTE.FIL (refer to section 3.2.2)

These changes enable FLOSYS, when entered from the directory, to locate, received information and store data in the appropriate files.

WARNING: Use EDIT or a non-document of WORDSTAR when editing the AUTOEXEC.BAT file.

When you have set up your FLOSYS system you should have at least the following files on your FLOSYS system directory:

FLOSYS.EXE

FLOSYS.FMS

MBASE.DAT

DEFOPT.DAT

REMOTE.FIL

FLOSYS.GRP

This does not include the files required by the flood forecasting program. If you want to be able to run this program on the FLOSYS system directory then you should refer to the user's manual for the relevant forecasting program for details on setting up the files required for this.

When you are ready to run the FLOSYS program type the word FLOSYS after the prompt i.e.:

Type FLOSYS <cr>

The VDU screen will renew and your present settings will be shown. Press <cr> and the following message will be displayed:

```
FLOOD    MANAGEMENT    SYSTEM

~~~~ version  n.nn ~~~~  dd/mm/yy

System  by  NIWA  FRESHWATER,  CHCH


setting  up  system
```

The Log printer will start printing as the microbase goes through a start-up and memory checking procedure.

The screen will renew and FLOSYS will move into the command mode.

```
FLOOD MANAGEMENT SYSTEM VERSION n.nn   dd/mm/yy


COMMAND  ?

          M/B printer flow is on
```

Note: If the Logging printer doesn't start and the setting up message stays on the screen check:-

- The connections between the Computer and the microbase.
- That the microbase is turned on .

Reboot the system and type FLOSYS <cr> again.

The following warning will also be displayed. This indicates that the microbase number and time have to be set.

To set the microbase number and time use the SET TIME command as described in the Command Descriptions, Section 6 FLOSYS User's Manual.

NOTE: The microbase number must be the same as that used or to be used to set up the remote.

The microbase is now operational but before FLOSYS can interrogate remote stations (sites), communication parameters must be entered into the REMOTE'S FILE. Read INITIAL SET-UP OF A REMOTE SITE, (section 3.2.1). The procedure is the same whether installing the first or twenty first site.

3.2. Initial set-up of a remote site

3.2.1 AQUITEL remote

Installation of remote equipment should be to the specifications given in section 2.4.4.

When installed the remote's identifying parameters will have been loaded via the support. (see section 2.6) These parameters include:-

1. the remote number. (between 2 and 254)
2. the microbase number of its controlling microbase (refer to foreign microbase for clarification in the SET REMOTE"S FILE command, section 6 FLOSYS User's Manual).
3. the Site number (TIDEDA number) of the principal (water-level) sensor.
4. the sampling interval of the water-level sensor and, if required
5. the alarm and alarm reset levels.

3.2.2 FLOSYS

The remote is the primary store for its own identification and communication parameters (they include items 1-3 above). These parameters cannot be changed via FLOSYS but can be changed using RTALK. (see section 5.0)

Other parameters which are site specific and control the operational conditions at the site are also stored at the remote (i.e. items 4 & 5 above). These can be changed via FLOSYS as well as by use of the support, section 2.6 and by CHANGE REMOTE'S PARAMETERS, section 6 FLOSYS User's Manual.

All the remote's parameters are stored also on the REMOTE'S FILE which is used by FLOSYS to control communication between the microbase and the remote. Also stored on the REMOTE'S FILE are parameters, such as multiplica-

remote. Also stored on the REMOTE'S FILE are parameters, such as multiplication, division and addition constants, which control the handling of data.

The steps to install a remote site on FLOSYS (Refer to the FLOSYS User's Manual for an explanation of the various commands) are:-

1. Initiate the remote's File using SET REMOTE'S FILE. This sets the communication/identification parameters as well as the data handling parameters.

2. Interrogate the site using UPDATE REMOTE'S FILE. All the Parameters loaded into the remote on installation will be copied onto the REMOTE'S FILE.

3. Examine the REMOTE'S FILE using DISPLAY REMOTE'S FILE.

4. Further changes can be made to the remote's operating parameters using CHANGE REMOTE'S PARAMETERS.

   The parameters will be changed at the remote and the remote's file automatically updated.

5. Add the new site or sites to any advanced programs and script files.

NOTE:

- It is possible to change a REMOTE'S communication or identification parameters via RTALK. This should only be done by experienced operators as it is an involved procedure in which it is very easy to loose contact with a remote completely. RTALK can also be used to "COLD START" a remote on installation. The use of RTALK is covered in section 5.0.
- If parameters in the remote are altered by use of the support or RTALK, they are not updated in the remote file, so the command UPDATE REMOTE'S FILE should be run at base. It is easy to forget to do this when back from a field trip so a routine running, say every 6 months, of UPDATE REMOTE'S FILE may solve any problems.

3.3. Day to day telemetry

This section describes the requirements of a typical telemetry installation and the day to day operations involved.

3.3.1 Requirements

Hardware

- Computer (IBM PC or similar)
- Microbase
- Communication network (Radio or Telephone circuit)

- RemoteStations
- Log printer } These last two are not essential
- Autodialer } for a basic system.

This equipment should all be installed to the specifications given in sections 2.4 and 2.8 of this manual.

Software

FLOSYS and associated files as listed in section 3.1.3.

General

- Formatted floppy disks. These will used to backup the telemetry data.
- It is a good idea to keep a telemetry diary or have a small whiteboard or similar alongside the logging printer. This can be used to highlight or pass problems on to the next day's operator.

The Telemetry System

In general, a standard telemetry system will include the following components:

- Automatic retrieval of data for all sites on a regular (usually daily) basis.
- Automatic archiving of retrieved data.
- Automatic retrieval of the STATUS of selected sites on a regular basis.
- Monitoring of alarms
- Manual interrogation of remote sites.
- Set-up, configeration and/or reconfigeration of remote sites.
- Maintainance and backing-up of data files.
- General telemetry housekeeping.

3.3.2 Site Groups

For automatic data or status retrieval and alarm monitoring remote sites should be sorted into groups.

The sites in each group should be related in some way.

The relationship could be flood-warning, e.g.. all sites in the same catchment or region in the same group, or client needs e.g.. Electricorp sites, Fish and Game Council Reports etc.

Other relationships could include normal servicing circuits, or water-right monitoring networks.

It is possible and even likely that a site may be included in several different groups because of its varied uses.

Common sense should prevail though and a site should only be included in one group destined for automatic recovery.

NOTE:

Groups are not set up only for automatic recovery, on a regular basis. They can be use to retrieve data on a "semi-automatic" basis. (see section 3.3.4)

Groups should be filed using SET ADVANCE PROGRAMME. (see section 7 FLOSYS User's Manual) Those that are for daily interrogation should have "**" in the description.

3.3.3 Automatic data retrieval

Automatic retrieval and archiving of data is fundamental to the operation of a telemetry system. Data is recovered and stored at fixed time intervals and is therefore available for use when required.

Daily

The most usual interval for recovery is daily. Daily recoveries are recommended for the following reasons;

- Easiest method to set up.
- Previous days data is available for use each day.
- Day to day management decisions such as sites requiring gauging can be made.
- Minimal loss of data if a remote loses power.
- Minimal drain on the remote sites power supply. This is especially important in areas of low sunshine.

A site can be automatically interrogated more than once a day by including it in groups programmed for different times of the day.

e.g:

Group 1. may have an interrogation time of 060000

Group 2. may have an interrogation time of 180000

A site included in both groups would be interrogated every 12 hours. Most sites should be included in a group to recover and archive data on a regular basis. Selected sites should also be included in daily recovery of STATUS information.

The latest water-level, rainfall and voltage information along with the current alarm status is displayed on the log printout and is useful for;

- Water right monitoring.
- Gauging scheduling.
- Voltage level monitoring especially uring winter months when low levels can be detected before alarm levels are reached.

Sites included in the daily STATUS groups should be revised as conditions or requirements change.

3.3.4 Semi-automatic data recovery

FLOSYS allows for automatic recoveries at specified dates and times. These times can be entered into the schedule long before the time of the interrogation.

Use the SET ADVANCE PROGRAMME to modify the advance schedule (section 7 FLOSYS User's Manual)

This procedure is very useful when monitoring floods. When an alarm has been received specific groups can be set up for data retrieval at specified times and the progress of the flood monitored.

3.3.5 Routine telemetry system management

Once groups have been selected and set up on the advance programme, operating the system becomes a routine daily, weekly and monthly task.

(i) **DAILY**

Morning

1. Check log printout.
   - Task errors
   - Alarm or warning messages.
   - "Bad reading" messages.
   - Any other unusual messages.
   - STATUS messages check for low power, gauging trigger levels or any other status requirements.

2. Check the computer screen for onscreen warnings. These will appear in the top left-hand corner above the COMMAND prompt.

3. The use of stage and rain reports in FLOSYS will make checking of sites easier. These reports give a summary of the most recent data. (see section 6 of the FLOSYS User's Manual)

4. An automatic PSCAN output can be run and sites checked from this. Note down any problem sites in a telemetry diary or communications log. Attempt to retrieve these later in the day.

5. To save time, automatic script files can be set up to check data. These can also be run overnight, weekly or monthly.

Depending on the problems encountered the following actions should be taken:

- TASK ERRORS (Refer to section 6.2.2)

  DON'T PANIC. Radio transmission paths can sometimes be fickle.

  The microbase will attempt to retrieve the data several (7) times before giving up.

  Follow the log messages to see if the data was retrieved on a subsequent interrogation.

  If it hasn't been retrieved chances are that the next day's interrogation may be successful.

  Note any TASK ERRORS where data was retrieved on subsequent re-interrogation of the same site.

  Check on TASK ERRORS where no data is retrieved to ensure that the interrogation was successful on the previous day.

  Report TASK ERRORS where no data was retrieved. Highlight these in the telemetry diary or on the message board.

  If possible try a GET REMOTE STATUS interrogation on the site to see if it will respond.

  A site that will not reply two days in a row may be considered "DEAD" and appropriate action taken.

  For a full explanation of TASK ERRORS refer to Section 6.2.2

- ALARMS or WARNINGS. (see section 8 FLOSYS User's Manual)

  Notify the appropriate authority for all alarms.

  If low voltage alarms occur remove the site from the automatic interrogation groups.

  Radio transmission puts a large strain on the power supply and there is a good chance that by not interrogating, the site will continue recording data until repairs can be made.

- BADREADINGS.

  Check the TIDEDA files by TIDEDA process BSCAN.

  If there is a large number of bad readings remove the site from the automatic interrogation groups. If this is not done the TIDEDA files could become prematurely full and inhibit the further interrogations.

- STATUS Messages.

  Low Voltages - if the voltage for a site appears to be getting low compare with previous voltages for the same site.

  If the trend is downwards then it may be appropriate to remove the site from automatic interrogations to give the power supply a chance to recover.

  Comparison with other sites in the area will indicate if it is a site problem or a general problem with the area. e.g.. Low sunshine hours.

  If it is a general area problem there voltages are likely to return to normal during a period of good weather.

  Check voltages after a period of good weather or after a day or so using GET

  REMOTE'S STATUS and if it has recovered sufficiently, reinstate automaticinterrogation.

  Other STATUS messages should be treated according to the local operating procedures.

- TIDEDAFILES

  Insufficient space - This can be caused by "BAD" readings in the data or too much data on the Disk.

  Release data if there is an insufficient number of free batches.

Afternoon

Set up the TELEMETRY for automatic operation overnight.

- Make sure the telemetry backup disc is inserted in "a" drive.
- Type FLOSYS or FLOSYS/A
- Answer "No" to the opening question. (FLOSYS/A will bypass this question)
- Run DISPLAY TIME to ensure that the system is operational
- Switch off any unnecessary computer peripherals (printers, plotters etc.) and remove optical disk if present.

(ii) WEEKLY

Monday (or immediately after a long break)

- Plot data for each site - check for missreadings etc. Script files can be used to plot all water level, rainfall and voltages. Over-plots are also useful.
- Change and check back-up disk. (see section below on backing up data)
- Check TIDEDA Files using (TIDEDA) BSCAN ensuring that there is enough space on all files for incoming data. Look for any "BAD" readings in the data. These checks are particularly important if a site is producing a lot of "BAD" readings, each "BAD" reading inserts a GAP in the record and initiates another 10 kbyte batch.

Any problems with sites will be highlighted using the processes just described and the appropriate action can be taken.

(iii) BACKING UP TELEMETRY DATA

Daily, data is collected via telemetry and stored on the hard drive. A backup copy of the raw telemetry data can be carried out using the following process:

NOTE: The backup period must be based around the remote's memory capacity. The following process is for an AQUITEL remote with data loss after 10 days. If the remotes memory is only 3 days (i.e.. from collecting at a 5 minute interval), then the floppy disk must be changed every 3 days.

1. A series of 5 rotating floppy disks numbered Week 1, Week 2 etc. are inserted into "a" drive each week.

2. A DOS command within an advanced program (see section 7 FLOSYS User's Manual) is used to automatically copy data onto these disks. This can be done every day, or every second day depending on the amount of data being collected.

3. At the end of the week a new disk is inserted into "a" drive. The previous weeks data (i.e..water level, rainfall and voltage) is plotted and checked for any problems. (see section 3.3.5 for checking of data) This disk is then stored in a fireproof safe.

4. At the end of the month the disk containing the month's data (i.e. Week 5) is relabelled. It becomes the permanent original record and is stored in the safe. A new Week 5 disk will have to be formatted and renamed to continue the backup sequence.

5. The remaining weekly disks can be reformatted ready for use.

6. When updates to the archive take place, the raw record for that period can also be updated. Raw data should be kept in a fireproof safe for approximately 2 years.

NOTE: The ADVPRG.TLM and REMOTE.FIL files remain on the hard disk. A back-up copy of these should be made either regularly or after changes. This will save considerable time and frustration if the original files are lost.

3.3.6 Radio transmission

It seems pertinent at this stage to make a comment on radio useage.

Most telemetry systems operating via a radio channel share that channel with voice traffic.

The smooth operation of a telemetry system operating under these conditions requires cooperation and goodwill between all users.

Irate or frustrated users (voice) can effectively sabotage telemetry transmissions causing further frustration to all.

The observance of a few simple rules can help reduce and/or avoid this frustration.

1. Avoid lengthy telemetry transmissions during normal working hours. Schedule all automatic data retrieval and status tasks outside of working hours e.g.. 5am.

2. If it is necessary to operate during working hours then;
   - try to transmit during less busy times. e.g.. morning/afternoon tea or lunch hour.
   - ensure that the channel is not only free but that any conversations have been completed.

The microbase will check for " channel free" but is liable to transmit during a break in conversation. i.e. the period between one person finishing talking and the other replying.

- Before transmitting broadcast a warning such as " This is NIWA transmitting telemetry data during the next one minute."
- At the end of the transmition let users know it is over by thanking them.

3.4. FLOSYS commands

The prompt "COMMAND ?" appears in the upper left of the screen whenever the system is waiting for a Command.

The FLOSYS Commands are:

DISPLAY TIME

DISPLAY SITE INDEX

DISPLAY REMOTE'S FILE

UPDATE REMOTE'S FILE

UPDATE GROUP

GET REMOTE'S STATUS

GET REMOTE'S DATA

GET GROUP STATUS

GET GROUP DATA

STAGE REPORT

GET SUPPORT'S DATA

DISPLAY TASK SCHEDULE

DELETE TASK FROM SCHEDULE

DISPLAY ADVANCE PROGRAMME

DISPLAY GROUP INDEX

ACKNOWLEDGE ALARM

SET ALARM LEVELS

PRINT

RUN DOS COMMAND

TIDEDA

SETUP

HELP

END

After "SETUP" has been entered, extra commands relating to the setting up of the telemetry system are available. They are:

SET ADVANCE PROGRAMME

SET TIME

SET REMOTE'S FILE

CLEAR REMOTES FILE

CHANGE REMOTE'S PARAMETERS

GATE CONTROL

SET REMOTE'S TIME

DOWNLOAD CAMPBELL PROGRAM

SET CAMPBELL LOCATION

For a full description of these commands, refer to section 6 of the FLOSYS User's Manual.

3.5. Alarms

One of the main uses of telemetry is the monitoring of alarms. This section will briefly explain alarms and warnings. A full explanation on alarms and how to interpret them can be found in Section 8 of the FLOSYS User's Manual.

An alarm reports the excedence of a preset level or condition at a remote. e.g.. water high or voltage low alarms.

A warning reports irregularities in the telemetry operation. e.g.. TIME ALARM is caused by a mismatch in the microbase and remote's times.

Alarms.

If, during a remote's reading of a sensor (eg. 15 minute punchout of a digital recorder), a preset alarm level is reached or exceeded an alarm message is transmitted to the microbase. The remote will remain in alarm status until the reset condition is met (see Glossary section). This means that no further alarms, for the condition causing the alarm, will be reported until the alarm status is removed.

If an alarm has occurred and you decide that you should reset the alarm to a different level, you must also reset the "reset" value. See section 2.5.1 for an example of when this could occur. You can reset the reset values either by the support, section 2.6, by RTALK, section 5.0, or by CHANGE REMOTES PARAMETERS, section 7 FLOSYS User's Manual.

4. EXTERNAL CONTROL BY TELEMETRY

The AQUITEL Control remote is a specialised remote capable of outputing data to external equipment.

Physically the remote has two extra plugs on the front panel, one for output and one for input.

The term Control is somewhat misleading as the remote itself is not capable of controlling equipment but passes numerical instructions to another device.

Output

Output is in the form of a 4 bit BCD encoded number in the range 0 - 9999.

The output is latched until the next output instruction is received from the microbase.

Input

Input is in the form of a 4 bit BCD encoded number in the range of 0 - 9999.

The input is alarm driven, that is, when the value presented (by an external source) to the input port is changed, the remote accepts it and transmits it to the microbase as an alarm or warning.

Input alarm priorities can be altered ia FLOSYS from "warning", which prints on the logging printer, to "alarm" which initiates the standard alarm sequence.

Other Ports

The water-level and rainfall ports operate in the same way as a standard remote.

Refer to section 7 FLOSYS User's Manual for instructions on the GATE CONTROL.

5. USING RTALK WITH AQUITEL

5.1. RTALK language

The RTALK program allows a user to communicate directly with the microbase without the aid of FLOSYS.

FLOSYS is the next level language to RTALK and converts commands into RTALK format when communicating with the telemetry system. It also converts the RTALK formatted messages received from the microbase into the FLOSYS messages seen on the screen.

Users can bypass FLOSYS to perform tasks not available to them via FLOSYS. These tasks include;

- Setting the communication protocol between the micro-base and logger printer. (See section 4 FLOSYS User's Manual for X-on and X-off)
- Setting or changing Site parameters held at the remote. (Communication, site and M/base numbers and date/time parameters).

Section 5.2 and 5.3 describes the microbase printer message and the remote parameter codes as used in the logger printer and the INMSG file. These are he codes used in RTALK essages.

5.1.1 Setting/changing the Microbase's indentification and time parameters

- EnterRTALK
- type D 1,88 2,09 3,27 4,10 5,15 6,00 7,05 <cr>

Where

D - see section 5.2

1,88 - parameter one, year

2,09 - parameter two, month

3,27 - parameter three, day

4,10 - parameter four, hour

5,15 - parameter five, minutes

6,00 - parameter six, seconds

7,05 - Microbase number

any one or all of these parameters can be set/changed a time

5.1.2 Setting/changing a remote's site number.

- From DOS type RTALK < cr >

  = = = will appear on the screen .

- To set up RTALK press back space and < E > < T > keys until

  the next " = = =" appears.

- Type B 1012 3,12345 < cr >

  B (in upper case) is the type of message to report/change a remote's parameters

  1 MicroBase port number (see section 6 FLOSYS User's Manual)

  012 Remote's communication number (see section 6 FLOSYS User'sManual)

  3 Remote parameter code for site number (see section 5.3)

  12345 New Site number of remote site.

To "**COLD START**" a remote via the Telemetry system.

Sometimes it is necessary to enter the site parameters into a newly installed remote via the microbase. This can happen if the support unit fails or if it is unavailable.

The default values for the remote's microbase number and communication number are 99 and 254 respectively. These numbers must be used when initially communicating with the remote.

- Enter RTALK
- type D 7,99 < cr >

  to change the microbase number to the remote's default.

The logging printer will print and the following message will be displayed on the screen:

D 88/06/01 12:27:04 BASE 99

- type B 1254 1,12 2,5 3,12345 4,880601123000 10,124500 < cr >

B 1254 Change remote's Parameters for remote number 254 on microbase port number 1.

(Note: Default remote number for a new remote is 254)

1,12 The new remote number is 012.

2,5 The new microbase number is 05.

3,12345 The site number is 12345.

4,880601123000 The current date is 880601 and time is 123000

10,124500 Starting time for the remote is 124500

- if you make a mistake backspace will delete the character immediately to the left. This deletion will not be apparent, ^H ^H will be displayed on the screen for each character deleted.
- Press <R>

when a reply has been received from the remote, the following message will be displayed.

B 1254 99 99999999 0A00 40/01/01 00:08:33

0012 #E 05 #E 00012345 #E 880601123000 #E 0150 #C 124500 #E

01 #C 019999 #C 019999 #C 000000 #C 000000 #C 00 #C

01 #C 0000 #C 9999 #C 9999 #C 00 #C 05 #C

0110 #C 0118 #C 0030 #C

The first line lists the site and identifying time parameters already held in the remote.

The remotes parameters are then listed in order (refer to section 5.2.1) followed by a #E or #C.

#E - means the parameter has been changed.

#C - means the parameter has not been changed.

- type D 05 <cr> (or nn, where nn is the microbase number)

TO SET THE LOGGING PRINTER PROTOCOL

This is only necessary when a "Star" printer is being used.

- Enter RTALK.
- Type F 3000,01 <cr>

If successful " F 3000, 0000 to 0100 " will be displayed and the log printer will print a series of messages.

If unsuccessful the microbase must be switched off (disconneted from the power supply) and on again before retrying.

LEAVING RTALK

- Press "CNTL-Z"

5.2. Microbase log printer messages

The log printer records information on each task performed by the microbase. The time, type, source and destination of each task along with details of the task is printed followed by details of the task.

The leftmost set of four digits split by a ":" is the time of the task in hours and minutes.

e.g.. 09:03 = 3 minutes past nine (am)

Next is a column containing a 3 letter code.

The first letter describes the type of message.

The second letter describes the messages source.

The third letter describes the message destination.

FIRST LETTER CODE

A - Get remote's historical data.

B - Report/change a remote's parameters.

C - Get a remote's historical data (requested by mobile).

D - Microbase's time and base identification number.

E - Print (message).

F - Patch/Query the remote's RAM.

G - Microbase to unload the support for the computer.

H - Onset of an alarm at the remote.

I - Microbase/support handshake.

K - Test communications between remote and microbase.

L - Remote/support handshake.

M - Last alarm reported to the base.

N - Warning alarm condition.

S - Intermediate message.

T - Task error/abort.

SECOND and THIRD LETTER CODES

B - Microbase.

D - Datalogger (Computer).

M - Mobile.

S - Support.

R - Remote.

EXAMPLE

" ADB"

"A" - Get remote's historical data.

"D" - Source of message is computer.

"B" - Destination is microbase.

This would normally be followed by an "ARB" message if the interrogation was succesful.

THE REST OF THE LOG PRINTER ENTRY

For entries other than "E" (PRINT messages) the letter code is usually followed by the remote identification in the form of a four figure number.

The first number is the microbase port number.

The remaining three figure number is the remote number (communication number).

e.g. 1045 - microbase port number 1.

- remote number 45.

The rest of the message gives details of the task. It is not necessary under normal operating conditions to be able to fully decode these.

By comparing the log message with the examples given in the command summary of the FLOSYS User's Manual, FLOSYS users should obtain an appreciation of their content. AQUITEL hardware manuals should be consulted if a fuller knowledge is required.

5.2.1 Remote parameter codes

The following codes are used to identify the different parameters in the remote. They are used when reporting or changing the parameters e.g.. CHANGE/UP-DATE REMOTES PARAMETERS or RTALK.

Parameters are identified in the INMSG file using these codes.

Code	*Parameter*	
1	Remote's (Communication) number)	(2....254)
2	Base number.	(1....99)
3	Site number.	(1..8388607)
4	Time.	(yymmddhhmmss)
5	Sampling interval.	(see section)
10	Starting time.	(hhmmss)
11	Sampling water.	(1 or 0 (y/n))
12	Water high alarm.	(0....19999mm)
13	Water high reset.	(0....19999mm)
14	Water low alarm.	(0....19999mm)
15	Water low reset.	(0....19999mm)
16	Water sensor warmup.	(not used)
17	Rain active.	(1 or 0 (y/n))
18	Rain accumulation time.	(max 999 mins)

Code	*Parameter*	
19	Rain alarm level.	(max 9999 tips)
20	Rain alarm reset.	(max 9999 tips)
21	Rainfall sensor warmup.	(not used)
22	Tip size.	(5 or 10 (.5 or 1 mm))
23	Volts alarm.	(0....200 [0....20 v))
24	Volts alarm reset.	(0....200 [0....20 v))
25	Comm's turnaround time.	(in tenths of a second)

The units given are those used in the INMSG but are not necessarily those used in the rest of FLOSYS.

Refer to the Glossary, section 7 for an explanation of the parameters.

Apart from the 10 second interval, the sampling interval used in INMSG and RTALK are those given in the Glossary multiplied by ten. e.g.. 60.0 minutes is expressed as 600.

The 10 second interval is given as 0002.

6. TROUBLE SHOOTING

6.1. Equipment

6.1.1 Battery\Voltage Problems

Maintaining an adequate power supply to the remote units is a critical factor in a successful telemetry network. Use of the battery can be minimised by interrogating on a regular basis, i.e. daily.

It is important that your power supply and radios are checked regularly.

1. At most sites, a fully charged battery (65ah or greater) should operate for two weeks with no charge. Remote shutdown occurs at 10.6v so alarm levels should be set at a higher level than this.

   Plotting voltage should be carried out on a weekly basis. Any downward trends will warn you of any potential problems.

2. When visiting a site, the following should be checked:

   (a) The solar panel should be clean and clear of any debris or branches. One solar cell covered up can affect the whole panel. If birds have been sitting on top of the panel put a small strand of wire or a bit of grease across the top of the panel. At high altitude sites make sure there are no bits of wire for the keas to play with.

   (b) Wake up the remote. Check the volts sensor. A check should also be made with your multimeter. If the voltage is above 14.5 v the regulator in the radio house should be warm, due to excess voltage being converted to heat.

   (c) Check that the battery terminals are clean and all terminals are tight. If using wet batteries check the water-level.

3. Visually check the battery for any signs of excessive warmth, swelling, cracking or high fluid use. Batteries should be discharge tested annually. A modern battery will have a life of around 5 years and should be replaced after this time.

4. It is useful practice to number batteries and operate a log book to record age, maintenance, discharging etc. for each. This will be of assistance in culling suspect batteries from your network.

   To assist with aging Superlac and Portalac batteries refer to Appendix iv.

5. Fuses should be checked thoroughly. Poor contact or corrosion within the fuse holder can cause failure of the whole system.

6. For stations subject to voltage problems, try to schedule interrogations for mid or late afternoon when temperature and sunshine conditions are at their optimum.

7. Power input/output can be roughly calculated as follows:

Maximum charge received every fine day
Charge = panel max x 5 hrs
i.e. 36 x 5 = 180 Whr
but battery efficiency 50%
= maximum usable energy = 90 Whr
power comsumption during receive (Rx)
110 mA X 12V x 24 hr = 31.7 Whr
(NB Some radios are over 200 mA)
(for Tait T 198) during transmit (Tx)
5A x 12 V x 1/30 hr = 2.0 Whr
Total = 33.7 Whr

Therefore every third day must be fine. A larger battery will cope with extended bad weather but takes longer to recover. Some savings are possible by disconnecting non-essential radio circuitry, i.e.

- Power indicator on front panel - saves 8%
- Modify to turn off audio power amp when not required - saves 7% (Consult your radio techs for any such modifications.)
- Sites which lack direct sunshine can have a seperate system set up to prevent the shut down of the remote.

The radio and recorder housings contain a battery each with a diode between the two. If the volts in the radio housing drop the battery in the recorder housing will keep the remote going.

8. Pertronic chargers can be used for checking conditions of batteries at mains powered installations. The test facility on TC420-T automatically shuts down the charger for 45 minutes every 24 hours. This should be set to occur at 1130 am.(Refer to the Instruments section of the Environmental Data Operations Manual.) If the recorded 1200 voltages are lower than the 2400 voltages, your battery may be faulty.

6.1.2 Solar panels

In a standard telemetry system solar panels rated at 30 watts or greater are used.

On a sunny day the open circuit volltage measured across the panel's terminals should be 18-20v.

The short circuit current (measured by placing an ammeter across the terminals) should be 2 amps or greater. (Sites with two solar panels should be 4 amps or greater.) Readings lower than this can be expected on cloudy days.

NOTE: Disconnect the panel(s) from the battery before taking this reading.

When voltage is below what is usually expected, check the blocking diode wiring, and damage to the panels or individual cells.(NB Dirty or shaded panels will reduce the ouput.)

Checking Diodes

- Locate diode.
- Check the voltage drop across the diode. This should be approximately 0.6v. If significantly greater of less than this (0 or 1 volt) the diode is suspect. Replace it.

6.1.3 Regulator

The solar regulator is required to prevent damage to the storage battery by over-charging from the solar panel.

The regulator has a voltage sensitive switch that has a controlable turn on point. The turn on point is set between 13.8 and 14.5v at which the battery can be considered fully charged. Any further charge from the panels is consumed as heat in the regulator. A correctly operating solar regulator system, assuming favourable weather conditions, should maintain the voltage of the storage battery at this 13.8 to 14.5 level. If incorrectly set the results will be :

- Set too low: the regulator will discharge a fully charged battery down to the turn on point of the regulator and prevent the solar panel from fully charging the system;
- Set too high: the voltage level per cell of the storage battery may rise to a level whereby the cells begin to rise in temperature and gas. In a wet cell system this means a loss of important electrolyte and the exposure of plates. In a maintenance free system this excessive charge can lead to increases in internal pressure caused by gasing action which can cause distortion of internal plates and eventual failure of the battery.

Methods of Checking Regulator Operation:

1. Check the voltage sensor on the remote. If the reading is between 13.8-14.5 volts the regulator should be on and warm.

2. Check battery voltage.

   Measure the incoming current from the solar panel.

   Measure the current going to the regulator. (At the in line fuse.)

   - If both currents are the same and voltage is above 14.5 volts the regulator is working.
   - If both currents are the same and the voltage is below 13.8 volts the regulator is set too low.

- If both currents are the same and the voltage is greater than 14.5 volts the regulator is set too high.
- If the regulator current is zero and the battery range is above 14.5 volts then the regulator is either faulty or set too high.

Adjusting the Regulator

This should only be done on a fine, sunny day in which voltage readings are between 13.8-14.5 volts.

1. Remove face plate.
2. Connect regulator line to solar panel.
3. Place mulitmeter across the terminals.
4. Adjust internal potentiometer until the voltage is reading between 13.8-14.5 volts. Reconnect system up.

6.1.4 Lines/Radio Interface Problems

(Refer also to the Field Manual, "Telemetry Remote Installation and Field Checks", AppendixB:Instructionsheets)

Normal operating conditions are:

- line should be +12V with respect to line common (i.e..yellow/green or blue/green) when the squelch (mute) is closed. (refer to Figure 18)
- line should be approximately OV with respect to line common when the squelch (mute) is open.
- line should drop from +12V to approximately OV when Comms. test is done and radio should transmit for the period that the line is at OV.

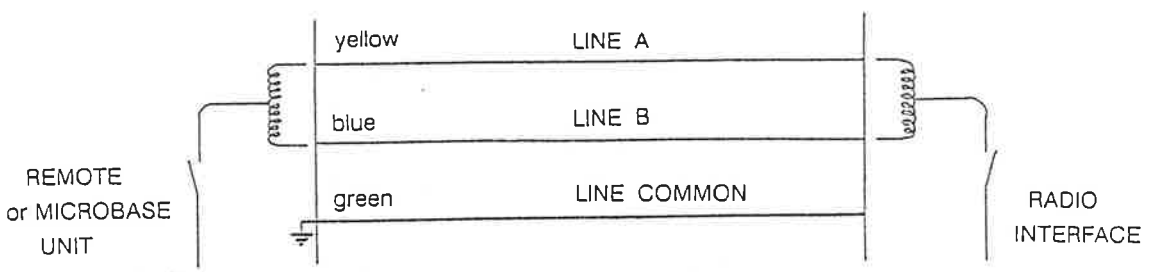


Figure 18 Line between the Remote\Microbase and the Radio

Fault Finding

Isolating faults can be carried out using the following tests (refer to Figure 18 and note that the colours of lines may change):

1. At the remote end, connect each line (yellow or blue) separately to the line common(green). This should cause the radio to go into transmit mode.

2. The yellow and blue lines from the remote carry the signal from the remote to the radio and vice versa. These form a continuous loop from the remote through the radio interface transformer back to the remote and through its transformer.

   The continuity of this loop can be tested by;

   a) disconnecting the remote from the line at the remote end.

   b) using the multimeter on the "ohms" scale measure the resistance between the two lines. This should be 35-50 ohms depending on the length of line.

   c) reconnect the remote and repeat the test at the radio end. (remember to disconnect the radio first).

   d) if there is a problem, it can be isolated by repeating the test at each junction moving towards and past the problem.

3. To check the line levels, i.e. the strength of the signal going from the remote to the microbase and radio, place the multimeter across both lines. (yellow and blue) Switch the multimeter onto AC millivolts. While the leading tone is being transmitted you should read approximately 250 mV.

   This test can also be carried out from the radio back towards the remote.

4. Line levels can also be tested by special units which have been made by communication technicians.e.g. a Line Level Testing Unit.

General Points

- Be methodical in approaching problems and eliminate each part of the system in turn.
- Contact your radio technicians when problems occur. They may be able to suggest simple checks and tests which will easily rectify the problem.
- If the field station will not respond in the morning but generally operates in the afternoon, the cold is affecting the radio. Consult your radio technician.
- If you have continuous vandalism problems, have the older style concrete towers, and a high strength radio signal - the aerial can be mounted in the tower.

Note: Various radio interfaces are available from NIWA Kainga i.e.:

- standard interface which can be used with most radio types;
- dual radio interface which will allow access to one remote unit by two radio systems and still retain the one radio - one remote features.

6.1.5 BaseProblems

- Refer to section 9, 10 and 11 of the FLOSYS User's Manual for explanation about FLOSYS error messages.
- If you are in FLOSYS and the cursor just sits at the command prompt you have probably not got the microbase connected to the PC. Check your cabling or if fitted, the rotary switch. Check your microbase - has it blown a fuse? - does it draw approximately 500 milliamps when connected to the battery?
- If either FLOSYS or the microbase appear to have "locked up" there are five things you should try:

  (a) use the DISPLAY TIME command - this may fix it;

  (b) disconnect the microbase from the PC. Wait for 20 seconds or so beforereconnecting;

  (c) Switch the log printer off then on again.

  (d) Get out of FLOSYS and re-enter;

  (e) Disconnect the microbase from its power supply. Restart it;

  (f) Power the microbase down. Turn off the PC, the VDU and the printer. Do a complete restart.

- If the system will not run or you are having difficulties with either FLOSYS or the microbase check the baud rates. (i.e. the speed at which information travels from one piece of equipment to the other, measured in bits/sec.)

General Points

- The microbase alarm may sound if the lead between the microbase and its printer is unplugged at the printer end. To avoid this ensure that you always unplug the printer at the microbase end.
- High frequency interference from the PC can affect the microbase especially if the PC has a 486 board. Locating the two items in close proximity can cause the microbase to crash.
- It is normal for the microbase alarm to sound as the microbase is first powered up. It should stop after 10 seconds. If the alarm persists, power the microbase down and remove all the plugs (comms, printer, autodialler

etc.), from the back of it. You should end up with a bare microbase that has a power cord only coming from it.

- Now power the microbase up - if the alarm still persists the microbase requires servicing. If the alarm has stopped then insert the plugs, one at a time, back into the microbase. The problem should be fixed but if the alarm sounds as you plug a particular item in you will have at least isolated the cause.
- On the water-level recorders commonly used, the recorder dials have only 4 digits and therefore read 0000 when the 10,000 m stage is reached. The remote will know th is and, if it occurs, will set a flag within the status code (called "water-level overflow"). The purpose of the flag is to alert FLOSYS to the "overflow" problem and thus a stage height of 0257 mm with the overflow flag set is interpreted by FLOSYS as 10257 mm.
- A stage height that is printed on the log printer as part of an alarm message from the microbase will, even though the overflow flag is set, be only 4 digits long. i.e. 0257 rather that 10257. However, all data that has been interpreted by FLOSYS will, if the overflow flag is set, show the full 5 digits. (This includes the last 6 water data values that may be printed on the logging printer as part of the "GET REMOTE'S STATUS" command).
- It is possible to accidently induce the water-level overflow flag when flushing the water recorder tower. Always check the values in the remote after the flush is completed. It may be necessary to DEPOWER the remote to reset the flag.
- The remote and FLOSYS were designed for a maximum water-level range of 19.999 m and if this range is exceeded, the data values may be spurious.
- Provided the tip size parameter at the remote is set correctly, all rainfall (whether from 0.5 or 1.0 mm tipping buckets), will be displayed on the logging printer in terms of 0.5 mm increments. As the rainfall data is processed by FLOSYS it is converted to micrometers. e.g. 3 x 0.5 mm "tips" equals 1500 micrometers of rain.
- The maximum number of rainfall tips that can be displayed within a particular sampling interval and printed as part of an alarm message is 99. There is no "overflow flag" facility available if 99 x 0.5 mm tips (49.5 mm) is exceeded within a particular sampling interval. On a 15 minute sampling interval this will not normally be of any concern but if you were to have a remote that was sampling a 4 hourly intervals, the rainfall during a sampling interval could exceed 99 tips and your rainfall data would be incorrect.
- Have a precise office clock with seconds display which is used as a standard time for the microbase. This will ensure minimum disparity between microbase and remote times.

6.1.6 Recorder/RemoteProblems

- If you run the remote and the recorder on separate batteries, the remote will not initiate the punchouts on a punched tape recorder. You may overcome the problem by running a wire between the negative terminals of the batteries.

- A digital recorder works on a binary code (BCD) where numbers are represented by combinations of 1,2,4 and 8 (as on the punched tape). If for some reason the remote picks up data that is an invalid combination, e.g.4, 8 it will file an "E" value. FLOSYS will find any "E" value and insert a gap element in its place.
- If "E" values are detected, FLOSYS will print a warning message on the printer. **** SITE nnnnnnn BAD READINGS IN DATA ***. Use PROCESS BSCAN to check your TIDEDA directory. Any inserted gap elements will be creating batches which may be filling your directory. This problem is commonly caused by the telemetry sensor fingers beneath the punch block, not operating correctly.
- A remote may lock into a continuous transmit mode and not respond to the microbase. While there are gaps between transmissions, the radio channel is effectively blocked to any user. You will need to define which remote is causing the problem and replace it.
- AQUITEL remotes can be adversely affected by close proximity of the radio. This may explain the remote suddenly reverting to "coldstart" but everything functions normally when you arrive to check it. It is also the common cause of "crashes". (Remote sits there doing nothing with display partially lit).
- Intermittent spikes in the record will probably be the recorder telemetry sensor fingers. Another possibility is the remote to recorder cable being twisted to such an extent that a wire has parted and a short is occuring.
- A remote will not function properly if it is interrogated when a support is plugged into it. (see Task Error 21, section 11 FLOSYS User's Manual)

7. GLOSSARY OF TERMS

AQUITEL 2

The Hydrological telemetry hardware developed by Harding Signal Ltd

COMMS. TECH

Your communications technician

COMMS. TEST

The communications test between remote and microbase to ensure the radio link is satisfactory.

MOBILE

Portable AQUITEL unit which enables the user to interrogate remote data while absent from the base

MICROBASE

The AQUITEL unit located at the base which provides the system housekeeping and link between remotes and computer

REMOTE

The AQUITEL unit located at the point of field measurement. Stores data and communicates with the microbase

TELEMETRY

Recording of readings at a distance

NIWA-KAINGA

NIWA - specialists in instrument and scientific equipment. 21 Kainga Road, Christchurch 9.

COMMAND

Individual procedures within FLOSYS are called Commands.

The prompt "COMMAND ?" appears in the upper left of the screen whenever the system is waiting for a Command.

When a Command is issued FLOSYS enters an input mode determined by the command. These input modes are described fully in section 6 FLOSYS User's Manual.

Parameters for the input modes are defined later in this section.

Some Commands interact with the Microbase while others maintain the system's operating files.

Immediate tasks (those not interacting with the microbase) are processed immediately and results displayed before the next Command can be issued. Other tasks are put in a queue for processing by the microbase. These Commands can be issued immediately one after the other before the previous results are displayed. See section 6 FLOSYS User's Manual.

TASKS

Commands sent by FLOSYS for processing by the microbase are called TASKS.

Not all TASKS are generated from the "COMMAND ?" mode by the operator.

FLOSYS generates tasks from within the system. e.g. running ADVANCEDPROGRAMS

Some "immediate" TASKS require the microbase, e.g "DISPLAY TIME" and "PRINT". These TASKS will be inhibited if attempted while the microbase is processing previous TASKS. A warning will be issued. (see section 11 FLOSYS User's Manual)

TASK SCHEDULE

The TASK SCHEDULE is the queue of tasks awaiting processing by the microbase. The TASK SCHEDULE may be viewed and Tasks deleted from it.

REMOTE'S FILE

FLOSYS maintains a file called REMOTE.FIL which holds the information required by FLOSYS for each remote site. This information is called the REMOTE'SFILE.

ADVANCE PROGRAMME

FLOSYS has the ability to automatically interrogate sites for 'STATUS' or 'DATA' information at predefined- defined times (daily) and/or pre-define dates and times. This is controlled by the ADVANCE PROGRAMME which is stored on a file called ADVPRG.TLM.

SENSORS

A SENSOR is the measuring device connected to the remote.

The usual Sensors are Water-level, Rainfall (event) and Voltage (the voltage sensor is inside the remote).

Each Sensor needs an individual site number but are accessed via the same Comms number.

PARAMETERS

Parameters are held in the microbase, remote and the datalogger files which:-

- Uniquely identify the site.
- Define the sampling regime.
- Specify site constants.

These parameters are defined below:

Communication number (Comms number)

The number used to identify each individual remote. It is unique to the remote and is assigned at installation.

Comm's numbers must be within the range of 2-254 and once assigned should not be changed.

The Comm's number is used to identify the remote in the REMOTE'S FILE.

Microbase Number

The number used to identify each individual microbase.

The microbase number is unique, assigned at installation, lies in the range 1-99 and should not be changed.

Microbase Port Number

The microbase has facilities for communicating via up to six communication channels. The port number tells the microbase which port (as distinct from radio channels) the particular site communicates through.

Ports are identified on the back of the microbase, but are confusingly labelled as COMMS CHANNELS.

Site number

TIDEDA site number. Refer to the TIDEDA users manual.

The Site number is used by TIDEDA for filing the data. It is unique nationally whereas the Comms number is unique only to the local telemetry system.

Time

Time is given as Date and Hour.

Date is the TIDEDA date in the form YYMMDD, where:-

YY = year, MM = month, DD = day

Hour is the TIDEDA hour in the form HHMMSS, where:-

HH = hour, MM = minutes, SS = seconds

Sampling Interval

The sampling interval is the time period between successive readings of the remote's sensors.

Acceptable intervals are:-

10 seconds

5 minutes

7.5 minutes

15 "

30 "

60 "

120 "

240 "

Starting Time

Time at which the remote will take it's first sample. Each successive sample will be taken at "sampling interval" time from them.

Sample Water, Sample Rain, Sample Voltage

These are used to set whether or not FLOSYS is to store the available data. Set to 'Y' or 'N' (yes or no).

Water High Alarm

The water-level at which the remote will issue a water-high alarm message to the microbase.

Water High Reset

After issuing a water-high alarm no further water-high alarms will be issued until the level has first fallen below the reset level.

Water Low Reset

After issuing a water-low alarm no further water-low alarms will be issued until the level has first risen above the reset level.

Water Low Alarm

The water-level at which the remote will issue a water-Low alarm message to the microbase.

Battery Low Alarm

The Battery level at which the remote will issue a voltage-low alarm message to the microbase.

Battery Low Reset

After issuing a battery-low alarm no further battery-low alarms will be issued until the Level has first risen above the reset level.

Rain Accum. Time, Rain Accum. Level

The combination of these two parameters set the high intensity rainfall alarm level. The intensity being the level/(time interval).

Rain Accum. Reset

After issuing a Rain-high alarm no further Rain-high alarms will be issued until the intensity has first fallen below the reset level.

DEFAULT VALUE

For some Commands FLOSYS assumes values for parameters such as site-numbers and start/finish times. The site number is the last site used while start/finish times relate to the last interrogation of the required site.

To use the default values press < cr > when he values appear.

To change from the default values overtype the required fields. In some instances it may be necessary to delete first using the backspace or left-arrow key.

DEFAULT OPTION

Where there are options (Yes/No, Correct/Reset) the most likely answer is given as the default.

e.g. OK to interrogate ? Y

To use the default press < cr > otherwise overwrite the default and press < cr >.

e.g. OK to interrogate ? Y
overwrite with N OK to interrogate ? N < cr >

GROUP

A collection of remote sites to be interrogated in the same way, at the same time usually for the same purpose.

e.g. A group of sites in the same catchment being used for flood warning purposes.

TELSYS KEYBOARD FUNCTIONS

At Command level

< backspace > - deletes characters to the left.

< left arrow >

At Input level

< up arrow >	- retains the current value and moves one field up.
< down arrow >	- retains the current value and moves one field down.
< cr >	- retains the current value and moves one filed down.
< left arrow >	- moves cursor to left within a field.
< right arrow >	- moves cursor to right within a filed.
< del >	- deletes the character to the left.
< ^Z >	- to choose an option or exit an input mode.

An on-screen prompt is given when it is required.

8. ACKNOWLEDGEMENTS

The authors wish to acknowledge the valuable assistance from Graham Elley and Ian Stevenson, NIWA-Kainga, for technical information and guidance, all the NIWA staff who responded with constructive review of the draft document and Doug McMillan for compiling the manual's sections.

9. REFERENCES

Halliburton G A and Hill T A (1993): *FLOSYS User's Manual*, NIWA - Freshwater, Christchurch, New Zealand.

Rogers M W and Thompson S M (1992): *TIDEDA User's Manual*, Publication No. 24 of the Hydrology Centre, Christchurch.

Harding Signals Ltd. (1984): *AQUITEL 2 - User Manual*, Wellington, New Zealand.

Harding Signals Ltd. (1984): *AQUITEL 2 - Sytems Manual*, Wellington, New Zealand.

Soutter W R (1986): *TELSYS User's Manual*, Hydrology Centre, DSIR, Christchurch, New Zealand, Unpublished Internal Report No. 903.

Thomas M B and Butler M J (1989): *WRS Telemetry User's Manual*, Water Resources Survey, DSIR, Dunedin, New Zealand.

10. APPENDICES

Appendix i Responses to TEST COMMUNICATIONS

TRANSMITTING:	the test message is being transmitted.
RECEIVING:	transmission completed, waiting for the base response.
COMMUNICATIONS TEST SUCCESSFUL:	alls well!
WAITING FOR RADIO AVAILABLE:	your remote is currently responding to another request (check radio busy light).
WAITING FOR CHANNEL FREE:	the radio channel is currently in use, you should be able to hear the radio traffic. If this problem persists there may be a radio problem or the remote's electronic "noise" interfearing with the radio. To check the latter, shut the remote down, if the radio busy light simultaneously goes off, the problem is obvious.
COMMS TEST FAILED - BAD REPLY:	the remote cannot understand the message. Did disruption from voice traffic occur?
COMMS TEST FAILED - NO REPLY:	no message from your microbase.
COMMS TEST FAILED - 76 REPLIED:	a response from another unit (comms address 76), but not the microbase.
COMMS TEST FAILED - 5/121 REPLIED:	a unit with the wrong base number has replied - comms address of both shown.

Appendix ii Message for an interrogation

Unless described as an intermediate message, the message signifies the end of the attempt.

Message *followed by* **Comment**

Messages Before Transmission Starts

NO MOBILE COMMS ADDR	Supply Mobile comms address.
TARGET COMMS AD REQD	Supply remote's comms address.
NO BASE NO	Supply base number.
CHANNEL NO REQUIRED	Supply channel number.
WAITING FOR FREE CHANNEL	This intermediate message shows the radio channel has other active users. May use (CLR) key to abort task.
UNABLE TO REQUEST TX	Retry. Will probably only occur if mobile has been accidently powered down.

Messages Once Transmission Has Started

TRANSMITTING	An intermediate message
BASE ACKNOWLEDGES	Intermediate - indirect request acknowledged by base
BAD RX, STILL TRYING	Intermediate
GOOD DATA RECEIVED	Successful end to an interrogation
WAITING TO RX	Intermediate message
TIMED OUT OF RX WAIT	No message received
BAD RX, RETRY	Retry if desired
T14 INACTIVE CHAN	Base channel is inactive. How you got it correct?
T31 NO REPLY EX REM	Remote did not reply to base
T21 REM/SUP LINKED	Remote has support attached

Other various error messages

QUIT, WRONG BASE RED

QUIT, INVALID MESS

OTHER T MESSAGE

UNDETECTED BAD MESS

Appendix iii Mobile status displays during interrogations

This information was displayed for development purposes, but since it conveys some indication of activity and also may assist in solving comms problems, it has been retained.

The left-hand digit displays the variable RCSTS

Value	Meaning
0	Ready to receive (transmit)
1	Receiving
2	Good received message available
3	Bad received message available
4	Transmitting or transmit request made
5	Cancel transmission request made

The right-hand digit displays the variable DETAIL

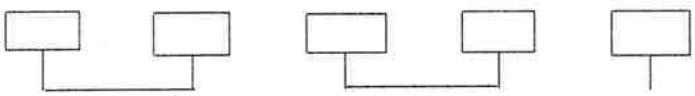
Value	Meaning
0	Holding TX on
1	Channel clear
2	Channel busy
3	Receiving DCD
4	Receiving a block
5	Good block's extra frames being received
6	Going to TX
7	Sending wakeup frame
8	Transmitting frames
9	Wait idle at end of TX
A	Going to receive

Appendix iv Ageing Portalac and Superlac Batteries

PORTALAC BATTERIES

Date Code of CS Portalac

(Order)



Month Year Plant

(Month)

01	02	03	04	05	06	.....	11	12
Jan	Feb	Mar	Apr	May	Jun	.....	Nov	Dec

(Year)

87	88	89	90	91	.....	00	01
1987	1988	1989	1990	1991		2000	2001

(Plant)

1	3	4	5
Kono	Sanshin	Degan	Others

(Place)

Next to positive terminal on top cover.

(Time of Apply)

From January 1988 production unless customer requests old data code.

(Example)

06 88 1 = June 1988 Kono

SUPERLAC BATTERIES

1 Date of production or the date of initial change, is stamped on the top cover beside the positive terminal with the following codes:

(a)	Month of Production	A = January
		B = February
		C = March
		:
		:
		L = December
(b)	Year of Production	K = 1988
		L = 1989
		M = 1990
		etc.
(c)	Plant Code	3 = Sanshin Plant

Example: DN3 = April 1991 Sanshin Plant

2 Code on the top cover beside the negative terminal showing the date of assembling.

(a)	Month of Assembling	A = Jan
		B = Feb
		C = Mar
		etc.
(b)	Date of Assembling	A = 1
		B = 2
		etc.

Example: EM = May 13

Technical information brochures follow:

Manual Sizing

To obtain an accurate and authoritative calculation of the solar system requirements for a given application, reference should be made to the BP Design Programme as detailed on Data Sheet 0013. First estimates, however, can be made to a reasonable level of accuracy by the methods shown below. Some examples using typical sunshine data are shown overleaf.

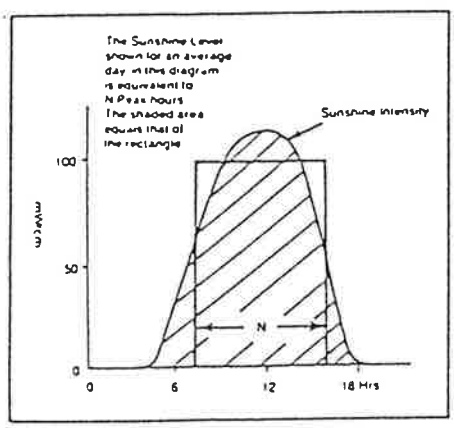
1. Input Data Required

As for the computer based sizing procedure, two basic inputs are needed. These are the sunshine figures, and the load requirements. Most sources provide Sunshine data expressed in average Langleys/day (1 Langley = 1 calorie per sq.cm). Daily averages are quoted for each month, as in the samples shown overleaf.

Load requirements are specified in terms of voltage and current draw in amp hours per day.

2. Calculation of 'Peak Sunshine Hours'

The sunshine figures given in Langleys are converted to simplify calculations into 'peak hours'. That is, the effective number of hours per day at Peak Sunshine level. Peak Sunshine is 1kW/m² (= 100mW/cm²) and this is the level of irradiation at which module data is given.



This conversion is done by multiplying the figure of Langleys/days by a factor of 0.0116 (or 1/87). For example, if the average radiation figure is 348 Langleys/day, this is equivalent to 4 'peak hours'. Thus the day's output of a solar array would amount to four hours at its rated current output = 4 x 2.58 for BP 1245 HP module.

For most estimates an average figure is sufficiently accurate. The data overleaf shows the yearly mean peak hours/day for each location, which is normally used in manual sizing.

3. Solar Array Sizing

The solar array consists of a number of modules connected in series and parallel. The more modules in series the higher the voltage; the more in parallel the higher the current. The total number of modules, of course, is the number in series multiplied by the number in parallel, as calculated in the following sections.

4. Modules in Series

Broadly speaking, the number of modules in series is calculated as the system voltage divided by nominal module output. Thus a 24 volt system requires two 12V modules in series.

The specifications of nominal 12V modules are such that their actual output voltage is sufficiently above this nominal value to allow for losses in the system.

5. Modules in Parallel

The daily module output is derived by multiplying its rated output current by the number of peak sunshine hours per day. The number of modules in parallel is then calculated by dividing the daily load in ampere hours/day by the daily module output rounding up to the next whole number. For example, if a 12 volt system needs 40 ampere hours/day in a location of 4 peak hours of sunshine, 4 x BP 1245 HP modules would be used in parallel. Each module could produce 10.32 ampere hours/day (2.58 amps x 4 hours/day) so 4 modules could give up to 41.28 ampere hours/day (and is the nearest whole number over 40/10.32 = 3.87).

A number of worked examples are shown overleaf.

6. Battery Sizing

Batteries are used to store energy from the solar array, when array output exceeds demand. During periods when array output does not meet the demand the stored energy is then available to supply the load. This situation occurs at two major times over a day

(i) At night.
(ii) During periods when the daily output does not meet daily demand.

As a general rule the battery capacity should be at least five times the daily load for locations near the equator and up to some thirty times the daily load in areas where extended bad weather prevails. This safety factor is highly dependent upon location.

7. Example 1 Communication System

A 24 volt radio repeater station near Singapore will draw 120 watts on transmit for 20 hours/day and 48 watts for 4 hours/day on standby.

(thus transmit current = 5 amps, standby = 2 amps)

Load = 5 x 20 + 2 x 4
= 108 ampere hours/day

At Singapore the recorded sunshine figures average 395 Langleys/day

Peak hours = 395 x 0.0115 = 4.54 hours/day

Using BP 1245 HP modules of nominal voltage 12V and current 2.58 amps:

No. in series = System/module voltage
= 24/12 = 2

Module Current output = 4.54 x 2.58
= 11.71 ampere hours/day

No in parallel = 108 ÷ 11.71 = 9.22
(rounded up) = 10 modules

Total number of modules = 2 x 10
= 20 BP 1245 HP modules

Thus the manual sizing recommendation is for 20 modules, 2 in series by 10 in parallel.

8. Example 2 Domestic System

A household in Kalgoorlie, W.A. requires a solar power system to run lights, T.V. and radio.

Description	Power	Voltage	Qty.	Usage
Lights	20W	12 VDC	3	2 hrs/day
TV	80W	240 VAC	1	3 hrs/day
Radio	40W	240VAC	1	3 hrs/day

Load: 20W x 3 x 2 = 120 Whrs/day
(60W x 1 x 3 + 40 x 1 x 3) 1.2* = 360 Whrs/day
TOTAL LOAD = 480 Watt hours/day

At 12 VDC Load = 480 ÷ 12 = 40 ampere hours/day

At Kalgoorlie the recorded sunshine figures average 470 Langleys/day.

Peak hours = 470 x 0.0115 = 5.4 hrs/day.

Using BP 1245 HP modules of nominal voltage 12V and current 2.58 amps:

No. in series = Systems/modules voltage
= 12/12 = 1

Module current output = 5.4 x 2.58
= 13.9 ampere hours/day

No. in parallel = 40 ÷ 13.9 = 2.87
(rounded up) = 3 modules

TOTAL number of modules = 1 x 3
= 3 BP 1245 HP modules

Thus the manual sizing recommendation is for 3 modules, 1 in series by 3 in parallel.

**To account for inverter inefficiency.*

3. Estimate Errors Though the above calculations are only approximate some of the known errors do cancel themselves out.

Using the yearly average figures, for example, does not show the worst case. On the other hand the sunshine figures used are recorded on a horizontal surface, so tilting the array towards the equator would compensate by increasing output.

The field sizing methods usually give a result accurate to within 10% of the computed value.

SAMPLE SUNSHINE FIGURES

Country	Town	Lat.	Long.	Jan	Feb	Mar	Apr	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.	Yearly Av	Av Peak Hrs/day
Australia	Adelaide	34°S	138.5°E	642	599	496	385	275	230	253	320	413	521	594	642	449	5.16
	Brisbane	27.5°S	153°E	516	535	471	420	337	303	325	382	465	516	567	566	455	5.23
	Broken Hill	29°S	143°E	619	599	496	418	306	272	294	348	459	535	616	631	467	5.36
	Cairns	17°S	146°E	504	487	475	451	385	370	380	442	521	545	566	526	471	5.42
	Darwin	12.4°S	131°E	453	484	447	492	472	484	488	536	583	587	573	477	500	5.74
	Kalgoorlie	31°S	121.5°E	652	565	511	378	316	270	296	381	496	550	612	645	470	5.41
	Longreach	23°S	144°E	611	571	549	467	389	361	362	439	545	595	664	618	517	5.95
	Melbourne	38°S	145°E	606	574	496	300	195	164	180	241	323	432	511	577	372	4.27
	Oodnadatta	27.5°S	134°E	614	538	474	422	341	307	326	387	484	521	598	569	467	5.25
	Perth	32°S	116°E	652	609	517	345	273	230	247	329	419	525	587	663	449	5.16
	Sydney	34°S	151°E	533	508	442	370	287	239	270	318	408	463	540	547	410	4.72
	Tennant Creek	19°S	134°E	532	518	467	461	385	384	403	456	556	584	594	565	490	5.63
Fiji	Suva	18°S	178°E	546	514	438	394	363	345	364	413	472	515	547	536	454	5.22
Indonesia	Jakarta	5°S	106.5°E	378	387	414	403	375	384	388	425	454	430	410	385	407	4.62
Malaysia	Penang	5°N	100°E	455	481	450	438	470	453	480	467	484	468	448	442	458	5.26
New Caledonia	Noumea	22.5°S	166.5°E	586	564	514	462	388	369	383	439	531	578	625	603	503	5.79
New Zealand	Wellington	41°S	175°E	533	464	356	245	151	127	134	194	314	413	484	524	329	3.76
Papua New Guinea	Port Moresby	9°S	147°E	483	510	484	469	416	420	429	462	507	546	562	556	490	5.64
Singapore	Singapore	1°N	104°E	406	446	443	409	382	378	386	395	400	390	354	345	395	4.54
Sri Lanka	Colombo	7°N	80°E	498	505	579	529	467	493	475	519	535	528	487	480	509	5.85
Thailand	Bangkok	14°N	101°E	415	446	467	484	435	412	399	380	387	430	427	417	425	4.88

Solar Modules
Operating Characteristics

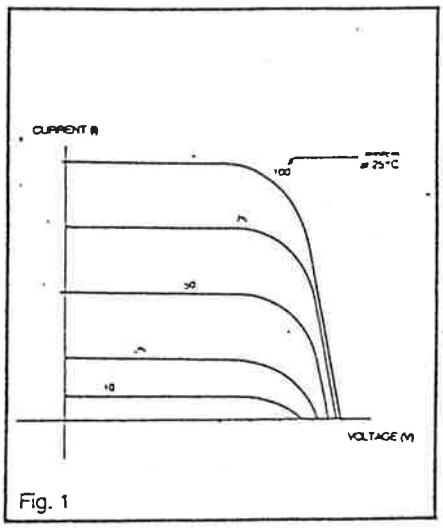


Fig. 1

I-V curves for different sunlight intensity

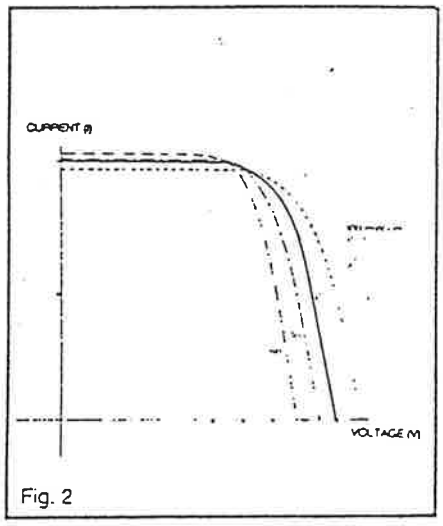


Fig. 2

I-V curves for different temperatures

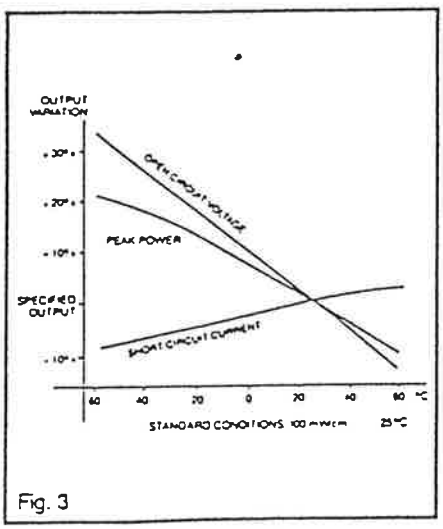


Fig. 3

Temperature effects

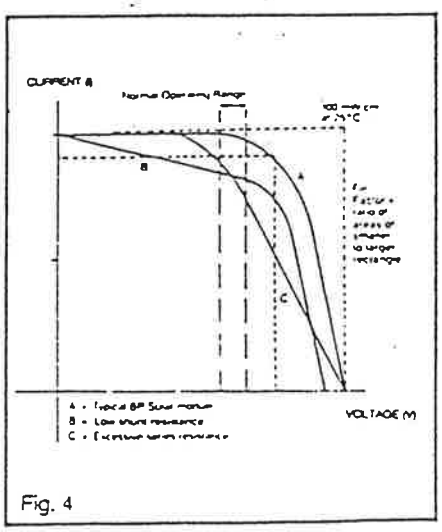


Fig. 4

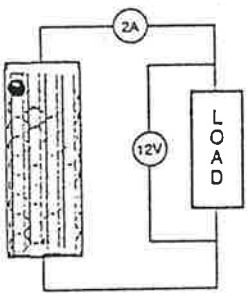
Effect of shunt leakage and series resistance on I-V curve and fill factor

I = Current (Amps)
V = Voltage (Volts)
Standard conditions = 100 mW/cm² solar intensity (AM 1.5) at 25°C cell temperature

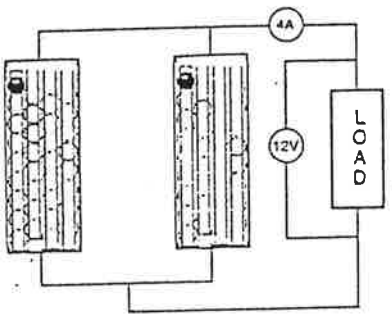
Solar Array Design

VARIOUS SCHEMATIC CONFIGURATIONS

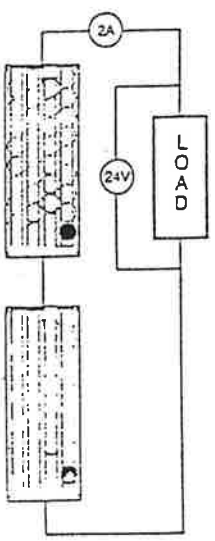
SINGLE MODULE
ARRANGEMENT
1 x MODULE
12V, 2A



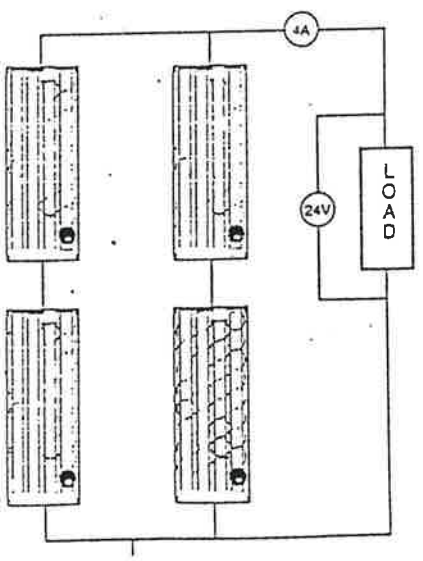
DOUBLE MODULE
ARRANGEMENT
IN PARALLEL
2 x MODULES
12V, 4A



DOUBLE MODULE
ARRANGEMENT
IN SERIES
2 x MODULES
24V, 2A



FOUR MODULE
ARRANGEMENT IN
SERIES/PARALLEL
4 x MODULES
24V, 4A



Using the principles shown above a Solar Array can be designed to any current/voltage combination.

Energy Storage Principles of Operation

Since the periods when power is required do not usually coincide exactly with the times when the sun is shining, some form of energy storage is required. This storage also has to provide for periods of low sunlight in poor weather and similar below average sunshine conditions. The overall yearly sunlight figures, however, remain fairly constant so that the solar array can be designed with sufficient precision to meet the overall load, with the storage system smoothing the output to that required. It stores the surplus energy generated on sunny days to drive the load at night and in poor weather, as well as making up any deficit that may be incurred in the less sunny months.

The present BP Solar systems incorporate rechargeable batteries as the storage medium. They serve to stabilise the system voltage and are normally of lead-acid type.

Lead-Acid Battery Systems

While the choice of batteries is often decided by the customer, lead-acid batteries are usually specified if no preference is indicated. The reason for this is that they operate at high efficiencies (i.e. the ampere hours that can be taken out are almost as much as the ampere hours put in) typically in excess of 95%. Nickel-Cadmium (NiCad) batteries with their lower efficiencies, 80% or less, require a larger solar array to supply the same load since the voltage required to charge a Nicad battery is higher than for a lead-acid battery. Of the many different types of lead-acid batteries each have advantages and disadvantages which are summarised opposite for four of the most common types. The final choice of battery depends to a large degree on environmental operating conditions, but low loss types with large electrolyte reserves should always be used.

Comparison of Lead-Acid Battery Types

Batteries of various constructions and plate types may be suitable for solar applications and some of the main features are identified in Table 1

TABLE 1

Plate Material	Pure Pb	Pb/ Ca	Pb/* low Sb	Pb/ high Sb
Monthly self discharge %	1-3	1-3	2-3	3-10
Cycle life	poor	fair	good	good
Robustness	weak	strong	strong	strong
Water loss	low	low	low	high

KEY Pb = lead, Ca = Calcium, Sb = antimony
* Best for Photovoltaic (PV) applications

The operating conditions normally define the battery chosen. The automotive cell for example, though cheap, needs a comparatively larger solar array owing to its lower efficiency, and should only be used where frequent service visits are possible.

Batteries with lead plates strengthened by calcium or small amounts of antimony are comparatively cheap and exhibit good properties for remote applications.

Sealed cells have the advantage of no maintenance requirements and also cannot spill acid, so these are particularly useful for remote, marine or transportable applications, but to date types available are not considered best for larger solar power applications.

The BP Solar P-series battery cells have been specially developed for use in remote, unattended photovoltaic applications. Excellent cycling ability, high charging efficiency, low self-discharge losses, a large electrolyte reservoir contained within a tough transparent SAN casing all combine to produce the best photovoltaic battery, i.e. one with high efficiency, long life, and limited maintenance requirements

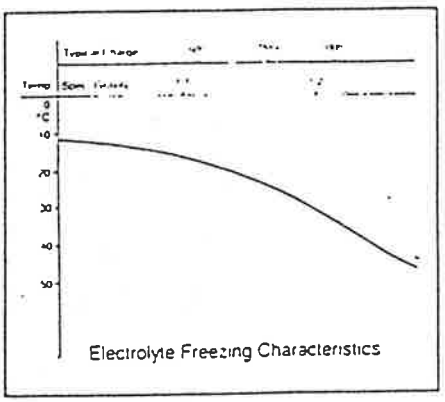
TABLE 2

Cell Construction	Automotive type	PV type	Sealed cells
Electrolyte checks/year	4-10	1	0
Life expectancy years	3-5	7-10	2-3

Low Temperature performance

Batteries are normally rated for operation at temperatures between 0° and 30° and extremes of temperature can usually be avoided by burying and insulating the batteries in the shadow of the solar array or in a shelter. In very cold climates however, special allowances must be made to prevent freezing to the electrolyte.

The freezing point of a lead-acid battery electrolyte varies with the specific gravity.



Electrolyte Freezing Characteristics

The specific gravity of the battery is related to the state of charge, such that when fully charged the S.G. is between 1.2 and 1.3 for different types and this reduces to 1.0 when the electrolyte is totally discharged. As the battery discharges the S.G. decreases and the temperature at which the electrolyte freezes is increased.

Consequently a battery can be prevented from freezing by maintaining a high state of charge. In practice this is achieved by increasing capacity by a known factor to achieve performance down to a specified temperature. If performance down to −25°C is needed for example, a battery of 1.22 initial S.G. is oversized by a factor of 2. This ensures that the maximum discharge is reduced by the same factor. Thus the batteries never lose more than 25% of their charge (50% is normally allowed for sites where the temperature stays above freezing) so the specific gravity never falls below 1.17 and the battery never freezes. A feature of lead acid batteries is that as the battery cools down the charging voltage increases; however this is offset by the silicon solar cell I-V curve moving to the right along the voltage scale as temperature decreases. Nicad cells on the other hand can recover from freezing but precautions must still be taken against low temperature operating conditions.

Battery System Design

Firstly, the battery capacity must allow for low sun storage. This is the storage required to make up any deficit during winter months or other regular periods of below average sunshine. For example the array required to drive a 4 amp hours/day load might produce that which is shown in the table below

	Daily load	Daily output	Daily difference	Monthly difference
January	4	5 2	+1 2	+37 2
February	4	4 3	+0 3	+9 0
March	4	4 1	+0 1	+3 1
April	4	4 0	0	0
May	4	3 8	−0 2	−6 0
June	4	3 7	−0 3	−9 3
July	4	3.7	−0 8	−24 8
August	4	3 7	−0 3	−8 4
September	4	4 2	+0 2	+6 2
October	4	4 8	+0 8	+24 0
November	4	5 2	+1 2	+37 2
December	4	5 5	+1 5	+45 0

To determine how much low run storage is required it is done by adding up the deficits that occur consecutively. In the example in the table above these are:

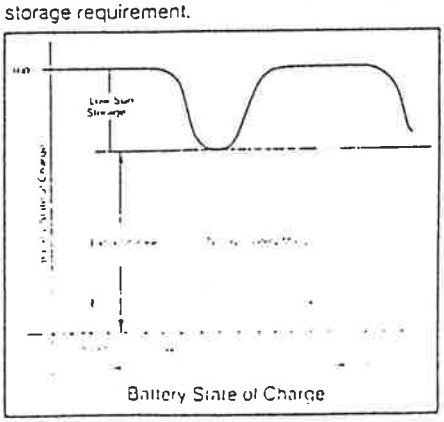
May	− 6 0
June	− 9 3
July	−24 8
August	− 8 4
	−48.5

The consecutive deficits total 48.5 ampere hours. Therefore, the minimum storage required is 48.5 ampere hours.

It is worth noting that excess power is generated from September to March, this totals 193 ampere hours which is more than enough to charge the batteries in preparation for the deficit of 48.5 ampere hours.

The second factor is the number of days extra storage build in for safety. This will vary depending on location and the expected reliability of sunshine according to the average figures quoted. Between 5 and 30 days are normally allowed in addition to the 'low sun' storage.

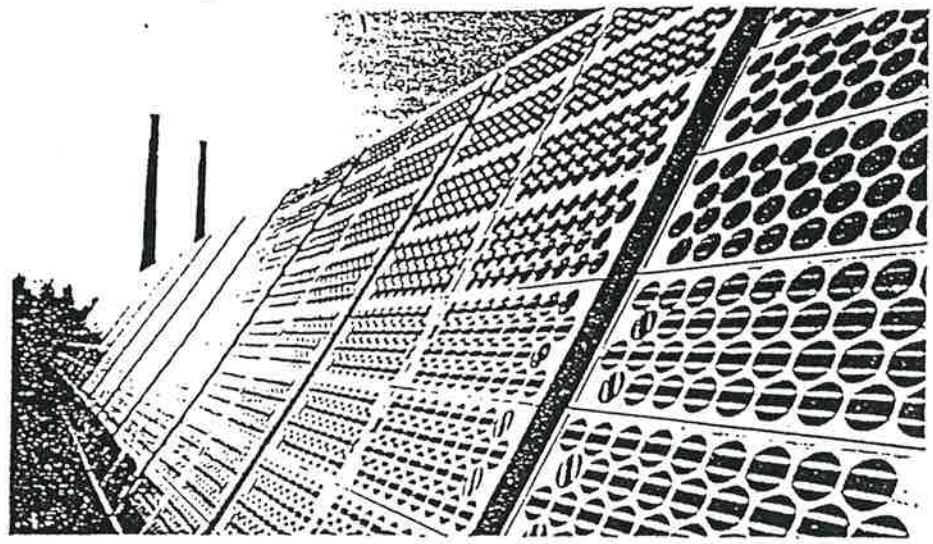
In the above example for instance. 15 days of storage would add another 60 amp hours to the storage requirement.



Battery State of Charge

Finally an increase in battery capacity may be allowed for low temperature protection as indicated previously

Solar Array Principles of Operation



A typical BP Solar generator comprising 240 modules each with 36 solar cells of 100mm diameter

Solar Cell Operation

Basically a solar photovoltaic cell is a large area semi-conductor diode made by doping high purity silicon crystals with controlled amounts of other chemical elements. The introduction of controlled impurities to pure silicon gives rise to excess negative or positive charges which can carry electric currents. When phosphorus is added the silicon develops negative (n) charge carriers (electrons), silicon doped with phosphorus is called n-type silicon. When Boron is added positive (p) charge carriers (holes) appear, silicon doped with Boron is called p-type silicon. In effect the phosphorus acts as an electron donor in a silicon crystal and boron as an electron acceptor. A p-n semi-conductor junction can be formed by high temperature diffusion of phosphorus into the surface of a boron doped silicon crystal. The p-n junction formed between the p-type silicon wafer and the n-type surface layer provides the electric fields which give rise to the diode characteristics as well as the photovoltaic effect.

As the p-n junction is the working region of the cell it is near and parallel to the front surface to ensure maximum effective light utilisation. When the cells are illuminated, units of light energy (photons) are absorbed by the electrons in the silicon wafer. This creates an excess of negative charges (electrons) and positive charges (holes); exactly one electron-hole pair for each photon absorbed. If this occurs near the p-n junction the electric fields present separate the electron hole pair, causing the positive charges (holes) to build up in the p-type material and the negative charges (electrons) in the n-type material. After connecting wires to the n and p-type regions an electric current flows; the excess charges generated by light can be made to flow through a circuit to provide power to an external load.

Since light must pass through the front surface to create this reaction; the front contact must not completely cover the surface and so a grid pattern is used. The rear contact though, can cover the whole of the cell's surface. There is no need for exposure to light on the back surface so it is fully covered to maximise charge carrier collection.

The voltage generated by each cell is a function of the material and the method of processing. A typical monocrystalline silicon cell generates maximum power at 450-500 mV. The current output is proportional to the surface area and is typically 27 mA per cm^2. A 100mm diameter single crystal cell can generate over 2 Amps under full sunlight which represents between 12% and 15% efficiency, though higher figures can be demonstrated in laboratory conditions. The characteristics for individual cells are of the same form as the module characteristics discussed in the following section. Interconnection of matched cells within a module simply multiplies the cell voltage (by a factor equal to the number of cells in series).

Solar Module Design and Characteristics

Since most load systems require voltages higher than that produced by a single cell, a multicell, modular construction is employed providing strong units of convenient power outputs.

Cells 100mm in diameter generating 2.0 Amps at 480 mV can be coupled 36 in series to give over 16 Volts (peak power for 12V system) at 2.0 Amps, or 18 in series by 2 in paralleled to give over 8 Volts at 4.0 Amps.

All modules are designed incorporating encapsulating materials which have been chosen to withstand environmental effects. See module Data Sheets for details.

The most common measure of output of a photovoltaic array is the 'peak power'. This is the maximum power that can be delivered under standard conditions of 100mW/cm² solar intensity at 25 °C. However, the shape of both current and voltage characteristics illustrated on BPSA003 is also important in practice, since they must match up with those of the battery storage system being used. The point where cell and battery curves cross is the working point for the system, and the current at this point will the charging current. This current must be generated at a sufficiently high voltage to fully charge the battery even in temperatures of +60 °C. A properly designed solar module or array will generate the system voltage at relatively low light intensity (10 mW/cm²) and then the current output will increase proportionally with light intensity.

Light Intensity Performance

As a general rule current output is directly proportional to light intensity, and the effect of varying the illumination intensity is shown in Fig. 1.

The top I-V curve gives typical performance under Standard Conditions defined as 100 mW/cm² light intensity at 25 °C. From the I-V curves shown, it can be seen that the characteristic is essentially self-regulating. The current output remains virtually constant up to the peak power point (arrowed) which is fixed by the number of series connected cells, then falls off rapidly with increasing voltage.

Thus if the battery is charged above 16 Volts the operating point moves down the I-V curve and the charging current is reduced.

Temperature Performance

The output current and voltage are also affected by cell temperature and Figs. 2 and 3 show the relationship between temperature and output voltage and current.

The voltage derating effect is roughly linear and can be approximated to −0.4% °C above 25 °C cell temperature, while the current temperature coefficient may be taken to be +0.1% °C above 25 °C cell temperature. Cell temperature can be estimated as 20-25 °C above ambient temperature. To allow the full current rating of the modules to be used for system sizing the peak power point has been chosen to provide full charge current into a lead acid battery at cell temperatures up to 60 °C. Above this temperature charging still occurs but at a reduced current and this would be taken into account when calculating the number of solar modules for a given application though fortunately it would normally occur during periods when the output is high anyway.

Performance and fill factor

Not all solar modules demonstrate characteristics as beneficial as those detailed above, and the comments on module design in this section were based specifically on the I-V curve shape shown in curve A, Fig. 4, which is typical of BP Solar modules. Other solar cells may give rise to different curve shapes which could for instance modify the calculations for the number of series connected cells to charge a 12 Volt battery.

In Fig. 4, curve A is the typical I-V curve for BP Solar modules under standard conditions. If this module had been constructed of cells having low shunt resistance the I-V curve would look something like curve B. In this case, the nominal current rating of the module would have to be specified at a lower value. If the module were constructed of cells having excessive series resistance, the I-V curve would look something like curve C. In this case, it is clear that additional series connected cells would be advantageous to reduce the very large derating which this module would exhibit at higher cell temperature. Also direct correspondence between integrated sunlight data and total ampere hours supplied by the module would no longer be independent of sunlight intensity unless the number of series connected cells were increased by about 25% for the case shown. This would seriously increase the cost. Thus, knowledge of the detailed shape of the I-V curve is essential for proper module design, and the features to look for are the squarest possible shape with highest peak power performance. This corresponds with a high fill factor, defined as the ratio peak power, divided by open circuit voltage times short circuit current.

Solar Array Design

From all the above factors it can be seen that the various BP Solar modules have been designed to meet anticipated requirements up to cell temperatures of 60 °C. Under these conditions the peak power voltage of the nominally 12 Volt modules can still charge a 12V system even allowing for the 0.3V diode drop and 0.3V maximum allowable wiring volt drop.

The current supplied by a solar cell is directly proportional to incident sunlight and because of the flat topped nature of the I-V curve a direct relationship exists between the integrated sunlight data and total ampere hour output of the cell. Use is made of this characteristic when sizing the system. In general the electrical characteristic shape displayed by a solar array is the same form for a module or single cell, so that electrical behaviour of an array may be accurately predicted regardless of the number of solar cells or modules used in that array. Thus two modules properly designed for 12 Volt operation will be equally applicable to 24V when connected in series, or may be connected in parallel to double the current output without altering the power point voltage.

The system sizing programme detailed in later Data Sheets shows how all these factors are taken into account in designing a BP Solar electric system.

Appendix vi Assembly instructions for wooden pole mount

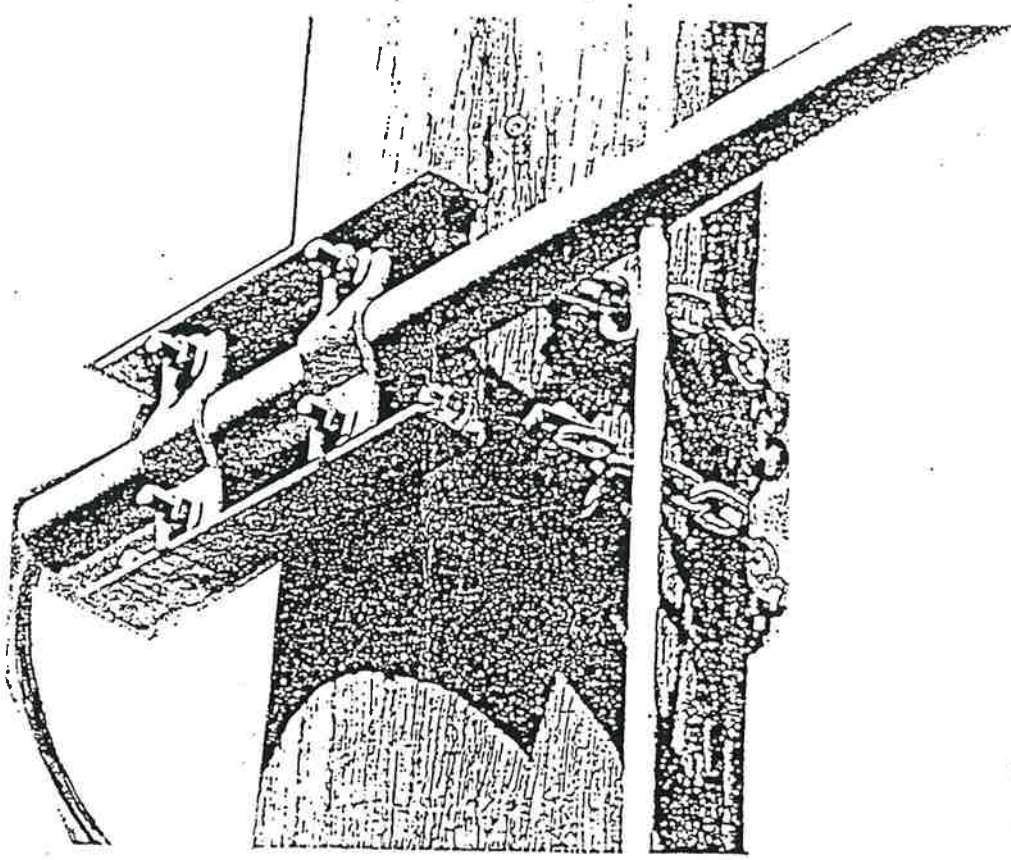
Refer to photograph and assembly drawing enclosed.

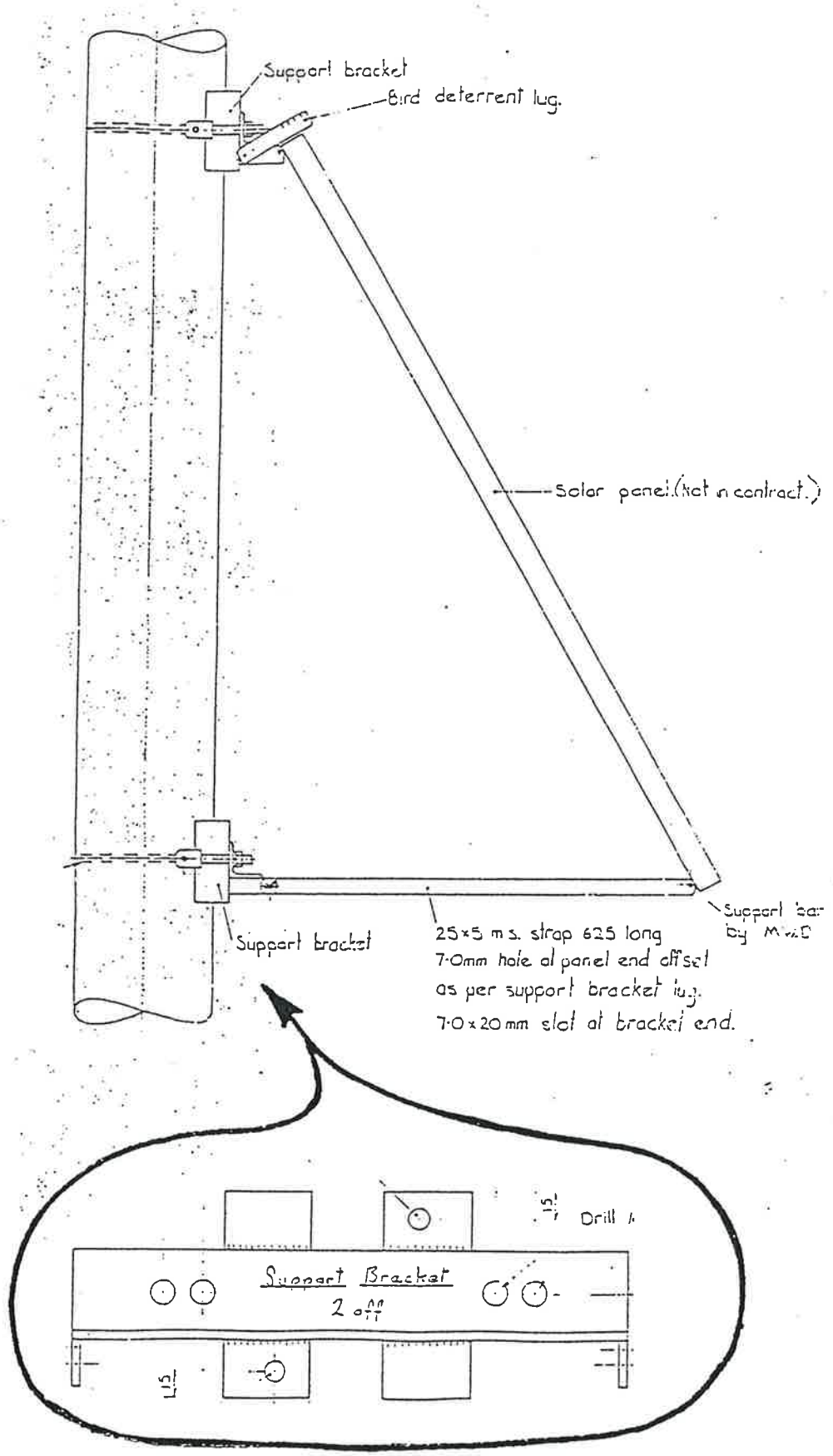
1. Bolt TIE bars (Item 1 in assembly drawing) squarely onto CLAMP bars (Item 2 in assembly drawing) using M12 x 75 bolts, washers and nuts, as shown, to make sub-assembly.

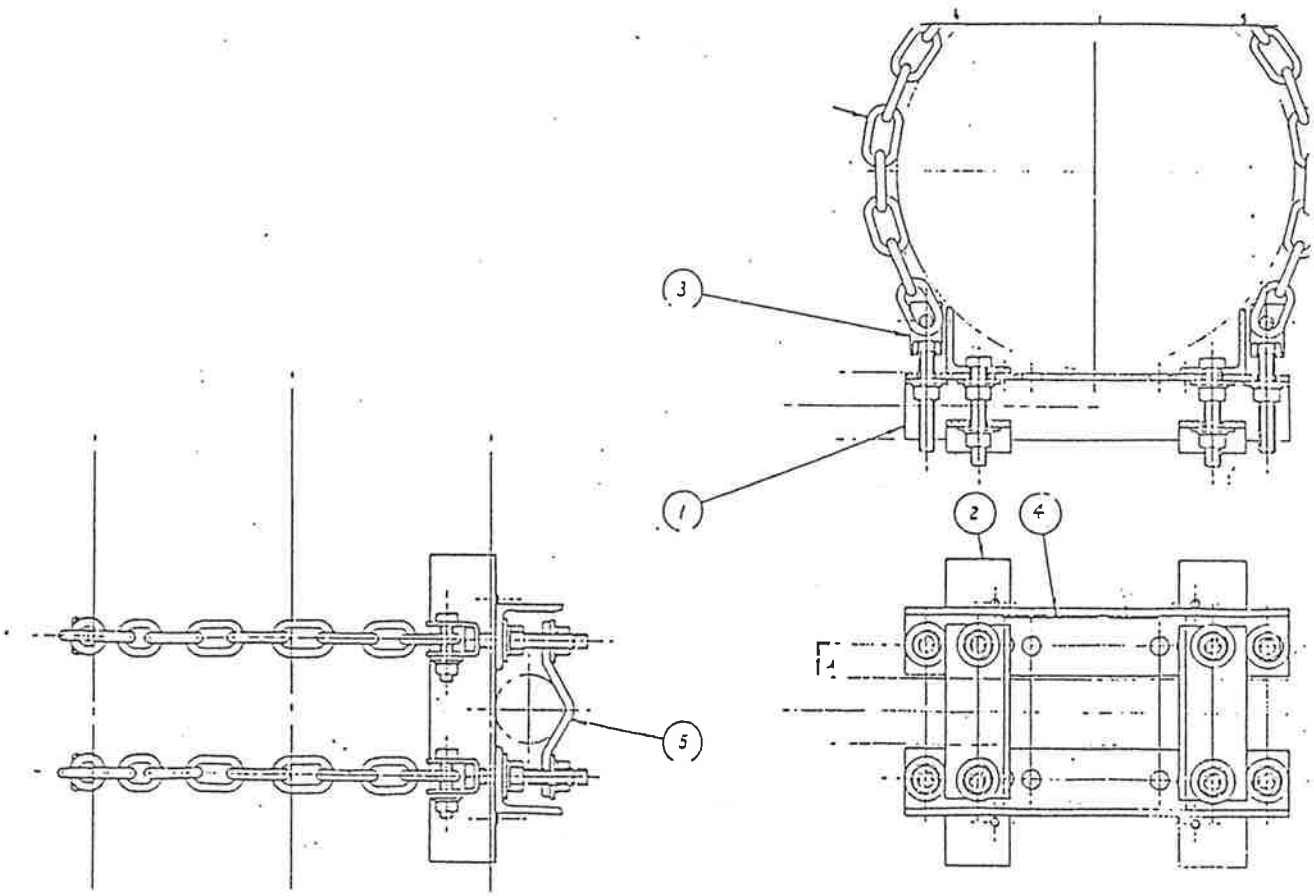
2. Fit M12 x 75 bolts into CLEVIS (Item 3 in assembly drawing) and bolt CLEVIS to chain, using M10 x 45 bolts, washers and nuts to make sub-assembly.

3. Position TIE bar sub-assembly on wooden pole, wrap CHAIN sub-assembly around pole and bolt to TIE bar sub-assembly, using washers and nuts as shown in assembly drawing. Adjust the assembly to correct position on pole before tightening nuts.

4. Position antenna boom in clamp, fit TUBE CLAMP (Item 5 in assembly drawing) over antenna boom. Fit washers and nuts and tighten the clamp.




Support bracket
Bird deterrent lug.
Solar panel (Not in contract.)
Support bracket
25×5 m.s. strap 625 long
7·0mm hole at panel end offset
as per support bracket lug.
7·0×20 mm slot at bracket end.
Support Bracket
2 off


3
1
2
4
5