

# WHERE THERE IS NO TELEPHONE

by  
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**Republique du Zaire**

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A handbook on short wave radio and LEO satellite communication for missions and aid agencies in developing countries. The book describes how to plan, select, install, operate and maintain a radio telephone network in these countries. It deals with the peculiar and special considerations necessary for reliable operations and will assist both technical and non-technical personnel.

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*This www copy does not include the 34 diagrams.*

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## FOREWORD

It is often difficult for the uninitiated to imagine life in the jungles of Zaire, Africa. Oh, certainly the imagination soars to think of the great rain forests, pygmy natives, river boats etc. But it is easy to take many things for granted concerning the many conveniences most of us have experienced in the developed countries of the western world. The one aspect I believe we take for granted the most is good, or at least adequate communications. Six years of living in Zaire, where virtually no telephone link exists outside the capital city of Kinshasa, has made me appreciate what a precious commodity this is. The HF radio fills the crucial gap left by no telephone availability. This HF radio is no recent

marvel of the modern electronics revolution, having been in use since before World War II. Yet its sophistication can not be taken lightly. In order for one to enjoy the benefits of good communication via HF radio in Zaire, or in any other tropical environment, for that matter, careful attention must be paid to its installation and operation. For most of us without formal electronics education, the successful of an HF unit seems more shrouded in mystery...something more akin to art than science. Fortunately, John Corbett has come to our rescue with this excellent guide book to HF radio operation. Everything is here that is necessary to knowing how to install and operate this type of equipment. The book is written so that readers from many levels of electronic can benefit from it. Those who want merely to install a new unit can read those applicable sections. Whereas someone wanting more technical information to maximise their units efficiency will find that as well. Although it is written from the perspective of operations in Zaire, it is basically applicable to operations in any underdeveloped, third world country. John is uniquely qualified to author this manual. His formal electronics background coupled with his hands on experience of radio maintenance here in Zaire has given him the knowledge and insight necessary to the task. Those of us in MAF, where our flight operations depend so heavily on radio, have deeply appreciated his aid and assistance. And now, we will benefit even more from his final contribution of his worthwhile ministry here in Zaire.

Jon Lewis  
Area Director, Central Africa  
MISSION AVIATION FELLOWSHIP  
Kinshasa, Zaire  
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## INTRODUCTION

Where is your nearest telephone? If you are in a rural area of central Africa this could reasonably be 300 kms away and involve a journey of 20 to 30 hours by four wheel drive vehicle on tracks through the forest. Having reached the telephone the next question will be "Is the telephone working?"

Churches, missions, aid agencies and commercial organisations have overcome the lack of communications by installing their own private radio telephone networks. There are many reasons for having radio contact with people in remote locations. Some reasons are financial and can be shown to be cost-effective, for example it can result in a reduction in the number of times people have to undertake long and difficult journeys not knowing whether or not the person they wish to meet will be there to greet them or if the boat or plane they wish to travel on goes next day or next week!

Another important reason is that of human well-being. The ability to talk with your fellow workers and friends some distance away makes you feel part of the whole community and reduces the feeling of isolation. It is also invaluable in times of urgent medical need, providing both a means of obtaining expert advice and of requesting supplies. In addition should a need for evacuation arise, either for medical or other reasons, instructions can be quickly passed on the radio.

The aim of this book is to help present users of radio networks to make the best use of their existing facilities by improving their effectiveness and reducing the probability of failure as well as to give advice to future users before they plan and purchase a radio system.

The book covers basic theory of short wave radio communication very briefly. For further study there are many books available on this subject, a good general description can be found in amateur radio handbooks. It is the information not generally contained in textbooks that form the majority of this book. The special needs, safeguards and peculiar conditions that arise when a radio network is

operated in a developing country are dealt with. An indication of these conditions is given by the following extract, freely translated from a magazine article in French:

"There is, in general, in the population no conception of maintenance of equipment. What is broken and no longer works is repaired moreover often repaired with ingenuity but it is rare that they take care of equipment and so avoid breakdown. In these conditions the length of life of equipment is seriously reduced."

In writing this book the author wishes to share the knowledge and experience that he has gained after twenty years association with a missionary society's network from the home base in Britain. After two short visits in 1980 and in 1983 he has spent two years from October 1986 working on the network in Zaire. He has been looking at ways of increasing reliability of equipment and improving operating efficiency as well as studying the reasons for failure. These investigations have been carried out while doing the routine maintenance and repair work and while installing new equipment so that the observations are based on Sactual experience. He has also gathered information from the experiences of others visiting both Tanzania and Kenya to learn from users there as well as obtaining information from a questionnaire sent to seventeen different groups in six African countries operating between them over two hundred radio transmitters.

The person scrutinising the book from the technical standpoint may consider some aspects of radio communications have been over-simplified whilst in other cases he may think that the obvious has been stated. However experience has shown that it is very necessary to establish a few simple facts on the subject into peoples minds. It is hoped that this book will be of help to a radio technician trying to work in a situation very different from the well-equipped workshop he has been used to and also that it will be of help to those who have no prior knowledge of radio so that they can efficiently plan and maintain their network. It is not a sophisticated textbook, it is simply a means of communicating lessons learnt here in Africa. Had it not been produced now in this form it is unlikely that it would ever have been produced.

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### 1.1 Basic theory of short-wave radio.

Short-wave bands are to be found on many broadcast radio receivers. There are various broadcast bands and to tune into them you are given the wavelength, for example 25, 31 or 41 metres. In radio communications the tuning information is given in kHz (kiloHertz) or MHz (MegaHertz), formerly Kc/s or Mc/s. Radio waves travel at the speed of light i.e. 300,000 km per second and because wavelength and frequency are related you can easily translate from wavelength to frequency by the relationship:

$$\text{Frequency in MHz} = \frac{300}{\text{Wavelength in metres.}}$$

For example, a wavelength of 25 metres gives:

$$\text{Frequency} = \frac{300}{25} = 12 \text{ MHz}$$

The short-wave band is referred to as the HIGH FREQUENCY (HF) band. The HF band covers frequencies in the range 2 to 30 MHz. To communicate between two different places it is necessary to transmit radio waves to the distant receiver, but radio waves travel in straight lines and the earth is round, so how do we communicate over hundreds and thousands of miles? Such communication is possible because the earth is surrounded by the ionosphere. The ionosphere is made up of several ionised layers which are continually combining and then separating. They occupy a region between

100 and 300 kilometres above the surface of the earth. At certain times the layers will reflect radio waves back to earth, see Wave A in Fig.1. The ability of the ionosphere to reflect radio waves depends upon the electron density of the layer. The higher the electron density the more effective the ionosphere is as a reflector. The sun, shining on the ionosphere, causes the electron density to increase. Hence the density increases from dawn, being a maximum around midday and gradually decreasing towards night. In addition to this daily variation in density, there is also an annual cycle and a 11 year sunspot cycle. It is possible for radio waves to pass straight through the ionosphere without being reflected as shown by Wave B in Fig.1. To be of use for radio communications the radio waves must be reflected back to earth.

Three of the factors which determine whether radio communication is possible are the time, the frequency in use and the distance between the radio stations.

### **1.1.1. Frequency and Time**

The higher the frequency the more likely the wave will pass through the ionosphere and not be reflected back to earth. Therefore the highest frequency that will be reflected and can be used for communication between two places is called the MAXIMUM USABLE FREQUENCY ( MUF ). The MUF varies throughout each 24 hour period and also throughout the year. An example of the daily change for January and July is shown graphically in Fig 1.2. Because Kinshasa and Kisangani are near the Equator the seasonal change in MUF is not very pronounced. The graphs are drawn for a Sunspot Number of 0 which is its lowest value. The values of MUF will also change with sunspot number, in general the higher the sunspot number the higher the MUF. If possible the time around dawn and dusk should be avoided for radio communications because the ionosphere is in a state of change. The ionosphere is reasonably stable during daylight hours.

### **1.1.2. Distance**

The shorter the distance between two radio stations the lower will be the MUF. In Fig 1.3. this can be seen where the distance from Kinshasa to Tondo is 500 kms and the daytime MUF is 8 MHz whereas the distance from Kinshasa to Kisangani is 1,300 kms and the MUF is 12 MHz. With a sunspot number of 10 the MUF for stations up to 100 kms apart would be 7 to 8 Mhz in July in Equatorial Africa. Therefore at higher frequencies no contact is likely. However there will be a ground wave (see Fig 1.1. Wave C) which may extend some 20 kms or more depending upon the surface of the earth. Ranges between 50 to 100 kms can be difficult for HF communications unless a suitable frequency is used and for reliable communication up to a few hundred kms frequencies around 2 MHz may be necessary.

### **1.1.3. Sunspot Cycle**

The electron density in the ionosphere varies according to the 11 year sunspot cycle. The ionosphere is most dense when the sunspot number is high. A sunspot maximum occurred in 1979/80 so the next maximum can be expected in 1990/91 with minimum occurring in 1985 and 1996. An example of the effect of the change of sunspot number was seen in Great Britain. The use of Citizen Band ( CB ) radio for communication became very popular around 1980. The radios operated at 27 Mhz and were illegal at the time. People were able to make CB contacts into Europe and were thrilled with this long distance communication with transmitter power output often of only 4 watts. Gradually over the next few years these contacts became more difficult and few overseas CB stations were heard. The lack of propagation was simply due to the fact that the ionosphere was no longer reflecting the 27 Mhz waves back to earth. This change in propagation would have been expected by anyone aware of the sunspot cycle and its effect on the ionosphere.

## 1.2. Propagation Prediction

One frequently reads that the prediction for HF communication is as much an art as a science. There are nevertheless patterns which can be predicted and are valid guidelines on which to plan the times for your radio contacts. The ionosphere and its effect on radio wave propagation is a vast subject into which research continues and many books are written. A simple treatment of ionospheric propagation can be found in the amateur radio handbooks such as RADIO COMMUNICATION HANDBOOK from RSGB, Potters Bar, EN6 3JW, England. There are various ways to determine at what time the ionosphere will permit communication.

### 1.2.1. Computer Prediction

Programs which give the MUF between any two geographical locations are available to run on many different computers. To use such programs it is necessary to give the computer the latitude and longitude of each location, the month of the year and the sunspot number. The computer will then calculate the MUF at hourly intervals for a 24 hour period. It should be noted that with some programs the calculated MUF may be up to 2MHz above or below the actual value. Also some programs are not very accurate at ranges below a few hundred miles, though the accuracy increases at longer ranges. The name of one prediction program is MINIMUF. Enquiries about these programs should be made through the supplier of your radio, also the programs are available through amateur radio sources.

### 1.2.2. Calculation by hand

It is possible to calculate by hand the frequency that can be used for communication between any two stations. This method requires information regarding great circle distances and the zenith angle of the sun amongst other factors. However all the necessary information including step by step instructions for calculation is given in a very useful book PLANNING AND ENGINEERING OF SHORTWAVE LINKS by Gerhard Braun from Heyden and Son, London and Philadelphia.

### 1.2.3. Experience and Experiment

It is always worth listening to the experiences of other people who claim to have done what you intend to do, but enquire in detail what frequency, time and area they operated their radios in and with what success. Then proceed to verify any information by trial transmissions yourself. If you have no such prior information regarding propagation, then arrange a timetable between your stations to attempt to make contact. The contacts could be every 2 hours from 0600 to 1800 hours, trying each frequency you have for say 5 minutes. After several days you would obtain a general pattern of the best time for contacts. During such experiments if no contact is made your frequency may be too high. Also you may never make contact at frequencies of 11 mhz and above when the sunspot number is low, but when the sunspot number rises towards a maximum such contacts would be possible. It is therefore sensible to obtain some theoretical predictions of MUF before the radios are purchased. Here is an example of lack of information regarding propagation:

A group obtained radios with a frequency around 10 MHz and proceeded to try to use them for contacts at ranges of 70 kms at 1800 hours. When they found it was impossible they assumed that their radios were at fault and wanted them to be repaired. They were advised to try for the same contacts at 1300 hours instead of 1800 hours and were successful.

### 1.2.4. Rule of Thumb

A "Rule of thumb" method is used in East Africa and is also suitable for Central Africa. This method

calculates the best frequency for various radio links operating between 6 am and 6 pm.:

For ranges up to 800 kms use 7MHz. For every 160 kms of range above 800 kms add 1 MHz to the frequency. e.g.

<b>Kms</b>	<b>Frequency in MHz</b>
800	7
1120	9
1600	12

Note that frequencies below the best frequency may also be usable. For example, 7.5 MHz is used by a group based in Nairobi for links with the rest of Kenya.

### **1.2.5. Unpredicted Effects**

The general pattern of propagation is further varied by disturbances of the ionosphere caused by solar flares. The result can be very poor or no HF radio communication for a few hours or a few days. Expect such events and do not immediately assume your radio is at fault, though it is wise to perform the checks suggested in para. 7.2.3.

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The purpose of an aerial is to launch the power from a radio transmitter into space in the form of radio waves. These waves then proceed, either by reflection from the ionosphere or along the surface of the earth, to the receiving location. Here the waves are captured by another aerial and steered to the receiver. So the aerial is a very important part of your radio system and it is essential that you use an aerial which is suitable for the particular frequency you intend to transmit. You may be told that all you require is a long piece of wire, the longer the better. Whilst such a wire could be suitable for reception an additional unit would be necessary to tune the wire before it was suitable for transmission.

### **2.1. Standing Wave Ratio**

VSWR stands for Voltage Standing Wave Ratio and is often abbreviated to SWR. SWR is a measure of how suitable an aerial is for a particular transmitter at a particular frequency i.e. how well it is matched to the transmitter. The theoretical ideal value for SWR is 1. Some radio manufacturers specify that an aerial with a SWR of 1.5 or less should be used with their radios whilst others permit a maximum SWR of 2. The SWR of an aerial can be measured by connecting a SWR Meter between

the transceiver and the aerial. The operating instructions for these meters varies according to the manufacturer. You must make sure you have the instructions and keep them with the meter and always follow them correctly, otherwise you may get inaccurate readings.

Although aerials are normally made to a length suitable for your specified frequency the SWR should be measured after the aerial has been erected. It is desirable to tune the aerial for a minimum SWR but it is essential to do it if the SWR exceeds the manufacturers permitted maximum e.g. 1.5 or 2.0. For instructions on tuning aerials see para. 6.2.4.6.

## 2.2. Dipole Aerials

The horizontal half-wave dipole aerial (see Fig 2.1) is the most commonly used HF aerial. Of the 188 aerials reported on the Questionnaire 91% were dipoles. The dipole is electrically simple, cheap, requires no earth system or additional circuits and it is easy to erect. However it is normally only suitable for use with one frequency.

### 2.2.1. Dimensions

The total length of a dipole aerial is half a wavelength at the frequency of use. However it is permissible to use the aerial at frequencies up to 2% above and below this frequency. e.g. a 10 MHz dipole could be used for frequencies from 9.8 MHz to 10.2 MHz. The length of the aerial can be calculated from the following formulae:

$$\text{Total length in feet} = \frac{468}{\text{Frequency in MHz}}$$

$$\text{or Total length in metres} = \frac{142.6}{\text{Frequency in MHz}}$$

For example a frequency of 6 MHz would require an aerial of :

$$\frac{468}{6} = 78 \text{ feet} \quad \text{or} \quad \frac{142.6}{6} = 23.77 \text{ metres.}$$

### 2.2.2. Construction

The dipole consists of 2 pieces of wire each piece a quarter of a wavelength long: i.e. half of the total length. One piece of wire is connected to the centre conductor and the other piece of wire is connected to the outer conductor of a coaxial cable. The other end of each piece of wire is connected to its own insulator see Fig 2.1. Pre-stressed aerial wire is used to prevent stretching of the aerial. The resulting assembly is suspended horizontally at a certain height above the ground. The connections between the coaxial cable and the aerial wires must be both mechanically strong and waterproof. Ready-made small units can be bought for this purpose. These units can include a BALUN which it is claimed improves the aerial performance. However dipoles are usually purchased ready-made and cut for the specified frequency by your radio manufacturer.

### 2.2.3. Horizontal Directivity

A horizontal dipole transmits and receives most energy in a direction at 90 degrees; i.e. at right angles

to the wire itself as shown in Fig 2.2. For example a dipole erected in a north-south line would be suitable for communicating with stations to the east and west but would be less effective for stations to the north and south.

### **2.2.4. Height**

The height of a dipole above the ground will determine the vertical directivity i.e. the direction in which power is both transmitted and received. An indication of the vertical angles at which power is transmitted is shown in Figs 2.3. and 2.4. The height of the aerial is given in units of wavelength of the frequency for which the dipole is designed to operate. For short ranges e.g. up to 150 kms, power needs to be transmitted at a steep angle up to the ionosphere see Fig 2.3. So a dipole suspended  $1/4$  wavelength above the ground should be used. For distances of 1000 or 1500 kms a height of  $1/2$  wavelength would be more suitable see Fig 2.4. The ideal condition would be to have two dipoles one for short, one for long ranges but in practise this is not always possible. Take a frequency of 7 MHz :  $1/4$  wavelength is 10.7 metres and  $1/2$  wavelength is 21.4 metres. Erecting an aerial 21.4 metres above the ground would demand the construction of special supporting towers which would be a costly exercise even if the materials were available. Therefore in practise aerials are often suspended as high as possible between trees and poles or between a tree and the top of a building. The result is therefore a compromise between the theoretical ideal and that practically achievable but remember that for better communication at long distance your dipole should be as high as possible.

### **2.3. Inverted Vee Aerial**

This is simply a dipole supported in the middle and having each side of the aerial sloping down to some 2 metres above the ground. It thus forms an inverted V, see Fig 2.5. This aerial transmits energy in most directions hence it is suitable for more all round coverage. Some of the transmitted power is vertically polarised and some is horizontally polarised making it suitable for communicating with fixed stations with horizontal dipoles as well as vehicles using vertical aerials.

### **2.4. Vertical Aerial**

Another simple HF aerial is the  $1/4$  wavelength vertical. The name describes the aerial, a vertical conductor  $1/4$  wavelength high insulated from the ground at its base and connected to the inner conductor of a coaxial cable see Fig. 2.6.

#### **2.4.1. Earthing of vertical aerials**

It is necessary to provide a good earth for this aerial. This can be achieved by connecting 3 or more  $1/4$  wavelength long pieces of wire to the outer braid of the coaxial cable at the base of the aerial. These wires should be laid out radially and spaced an equal distance apart as in the plan view of Fig.2.7. and then buried some 25 cms underground.

#### **2.4.2. Directivity**

A vertical aerial will transmit power equally in all horizontal directions and at low vertical angles (below 45 degrees). It is therefore a good choice for a central station with a network which is spread out at various angles and long distances.

### **2.5. Mobile Aerials**

Practical considerations dictate that most mobile HF aerials are vertical but not physically a full  $1/4$  wavelength long e.g.  $1/4$  wavelength at 5 MHz is 15 metres! So you will find vertical mobile aerials

some 2 or 3 metres long. These can either be tuned to any frequency with an Aerial Tuning Unit (ATU) see para 2.6.3. or they will have been pre-tuned to a single frequency with a coil. The coil forms part of the aerial and will either be at the base of it or halfway up. The further the coil is away from the base the more efficient is the aerial. The tuning should be checked and adjusted after installation on the vehicle see para.6.4.3. Another form of mobile aerial is the helical whip. Here the aerial wire is twisted around and sealed into a fibreglass rod. If this is tuned to a specific frequency it may

also be used at other frequencies by using a ATU.

## **2.6. Multi-frequency aerials**

It has been stated that an individual dipole is only suitable for one frequency. However most transmitters will be operated at several frequencies hence requiring an aerial system suitable for all the frequencies. There are several aerial configurations that will satisfy this requirement.

### **2.6.1. Multi-dipoles**

This aerial consists of several individual dipoles, each ones length being appropriate to its particular frequency. They are A-A', B-B' and C-C' and are all connected to one piece of coaxial cable as shown in Fig 2.8. The advantages of this type of aerial is that only one coaxial cable feeder is required and that the aerials can be accommodated in a smaller space than required by several individual ones. However the frequency of each dipole should differ from the others by at least 15%. A maximum of 4 dipoles can be connected to one piece of coaxial cable. The tuning of the dipoles can sometimes be difficult because of interaction between each other.

### **2.6.2. Broadband aerials**

A single broadband aerial can cover all the frequencies in the range stated by its manufacturer for their particular aerial e.g. 3 to 30 MHz. They use special frequency compensating networks and matching circuits therefore need to be bought ready-made. One broadband aerial is some 30 metres long and has a single coaxial cable connecting it to the radio. It can be erected horizontally or in the inverted vee form. Its height above the ground should be at least 5 metres but 10 metres if possible. The SWR of these aerials can be less than 2.0 over a high percentage e.g. 90% to 95%, of their frequency range. However some manufacturers specify that an aerial with a SWR of 1.5 or less should be used with their transceivers. A broadband aerial will receive all transmissions i.e. wanted and unwanted, equally well. Hence strong transmissions, including SW broadcasts, can cause interference when the station you are listening to is weak.

### **2.6.3. Long wire aerials and Aerial Tuning Units**

A long piece of wire e.g. longer than 10 metres, can be used as an aerial but it has to be tuned for each frequency with an Aerial Tuning Unit ( ATU ). The SWR of a long piece of wire could be high so the purpose of the ATU is to match the wire to the transmitter and to give a low SWR. The ATU can be an integral part of the transceiver as in the case of some CODAN models. Here the tuning procedure is to adjust the controls of the ATU for the brightest light from a lamp. Separate ATUs can be purchased, some with meters as tuning indicators. You can buy ATUs which will automatically tune a long piece of wire to any frequency from 1.5 to 30 MHz. The most modern ATUs will reduce the SWR of the long wire aerial to 1.5 and also handle a transmitter output power of up to 1KW. Long wire aerials are often used for temporary or portable situations when it is easy to hang up a piece of wire. However the wire must be insulated from anything that supports it.

## 2.6.4. Single Dipole for Two Frequencies

It is possible to design a single dipole and its coaxial feeder cable to operate at two frequencies. The main reason for using this design is economy, that is to obtain "two aerials for the price of one". However, to understand the design you may require the aid of a radio communications engineer. The method is nevertheless a very useful one to use with aerials which do not have a balun transformer. The dipole is designed for use normally at one frequency, but at the second frequency there will be standing waves on the coaxial cable. So the length of cable has to be cut to present a low impedance at the transceiver. This is done by measuring the SWR at the transceiver output socket and by reducing or increasing the length of the coaxial cable until an acceptable SWR is achieved e.g. less than 2.

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### **3.1. Transceivers**

The word transceiver is an abbreviation of transmitter-receiver and indicates that these two facilities are combined into one unit. Normally the transceiver can either transmit or receive at any one time. The transceiver will only use one aerial which is switched automatically to the transmitter or receiver portion within the transceiver. Many different types of HF Single Sideband (SSB) transceivers are manufactured. Some sets appear to be rather complex being fully synthesised and capable of being tuned to any frequency e.g. from 2 to 30 MHz, simply by typing in the frequency on a keypad. In fact the front of these sets are often covered with press buttons and indicator lights enabling a wide range of facilities to be selected. Such sets should only be selected for use if competent operators are available who would fully understand the use of all the controls and if an adequate repair facility was available for the sophisticated circuitry. There are more simple HF SSB sets available such as those with only 4 or 10 pre-selected frequencies. The number of front panel controls on these sets is usually less and their circuitry often is more easy to repair.

### **3.1.1. Transmitter output power**

The power output of SSB transceivers is defined by its Peak Envelope Power ( PEP ) which is about 3 times the average power output. Sets are available which provide PEP in the range 25 to 150 watts. Of the 155 transceivers reported in the Questionnaire, 26% had a PEP of 60 watts and below, 52% had 100 watts PEP and 22% were between 100 and 150 watts PEP. Almost all transceivers, with power outputs up to 150 watts PEP, manufactured after 1988 were completely transistorised i.e. not containing any thermionic valves. Also many of these transceivers will operate direct from a 12 volts DC power source e.g. a car battery. It is possible to calculate the theoretical transmitter power necessary to achieve highly reliable radio communications over a specified link. However there are many other incalculable factors which determine whether you will be heard and understood by the distant station. At the present time some developing countries have a very limited telecommunications infrastructure hence Government departments, commercial companies, missions etc. all have their own HF radio communication networks with the resultant crowding of the radio channels. You may experience any of the following situations:

- a) One radio channel may be allocated for the use of several different groups, each group being given a time when they can use the channel e.g. 09.00 - 10.30. In an ordered society this system can work well but you may find that the groups do not adhere to their allocated time and chaos results.
- b) Even if you have your own radio channel you can experience interference from stations operating on adjacent channels or on the other sideband e.g. you are using USB (Upper Sideband), they are using LSB (Lower Sideband).
- c) In a town the transceivers of several different groups may be located close to each other e.g. within 1Km. Although the groups are using completely different frequencies the transceivers can cause interference with each other simply because of their proximity.

In an ideal interference free situation you might expect to use a 25 watt PEP transmitter for ranges up to 300 kms. with power rising up to 100 watts for 1,000 Kms. What is happening in practice is that many groups are using higher power transmitters in an effort to make themselves heard, even resorting to the illegal use of amplifiers producing 1,000 watts. This produces an increase in the level of interference for other users and the "law of the jungle" results.

The Questionnaire showed that 74% of the transceivers were 100 watts and above. The only realistic conclusion that can be drawn is that unless you are sure you can operate satisfactorily with a power less than 100 watts then you should select a transceiver capable of producing this power. You may be able to reduce the power output of your 100 watt transceiver to a lower level if required but you

cannot increase the power output of a 40 watt one without buying more equipment.

### **3.1.2. Transceiver power requirements**

A rough guide of the average input power required by a transceiver, during transmission, is 2/3 of the PEP watts. For example, a 150 watt PEP transceiver would require an average power of  $2/3 \times 150 = 100$  watts. The relation between power, voltage and current is:

Power in watts = voltage in volts x current in amps.

or Current = Power/Voltage.

Hence the current required from a 12 volt battery for a 150 watts PEP transmitter:

Current =  $(150 \times 2/3) \text{watts} / 12 \text{ volts} = 8.3 \text{ amps average.}$

The transceiver will in fact be demanding a peak current for short periods and then no current. The value of this peak current can be a little above twice the average current, in this case about 18 to 20 amps. Whilst receiving the transceiver will take very little power. Typical 150 watt PEP HF SSB transceivers require 0.2 to 0.5 amps during reception.

### **3.1.3. Transceiver controls**

The number of controls on the front of a transceiver can vary from some 5 to 25. The more common and essential are described here:

**VOLUME or AUDIO.**

As found on all radios, cassette players etc. it simply adjusts the loudness of sound from the loudspeaker and earphones.

**Combined ON/OFF and AUDIO.**

These are frequently found on ordinary radio receivers as well as transceivers. Because the action of switching off requires the knob to be turned down to zero volume each time and also up again to normal level each time you switch on there is excessive wear on this component and it is often the first item to wear out. If a separate ON/OFF switch were available then the volume control could be left in its usual position.

**POWER light.**

This indicates that power is being supplied to the set. It is usually a red bulb or Light Emitting Diode (LED).

**TRANSMIT light.**

This may be a red or orange light which flashes when you speak into the microphone of a SSB transceiver and shows that the transmitter is generating power. The light may be labelled TRANSMIT or XMT.

**R.F. GAIN and ATTENUATION.**

The purpose of these controls is to adjust the amount of amplification of the incoming signal in the receiver portion of the transceiver. The RF GAIN control is operated in a similar fashion to the volume control. Alternatively there may be one or two switches labelled ATTENUATOR, with values of 5, 10 or 20 dB, which enable you to reduce the RF amplification by the number of dB switched in.

**CLARIFIER or CLARIFY.**

There can be a difference of several hundred cycles in the frequency of the transmitters you are listening to. So when you listen to one person speaking they may appear to have a deep bass voice whilst the next one has a high pitched and perhaps unintelligible voice. The CLARIFIER will enable



you to adjust the pitch of the voice coming from the loudspeaker to your particular preference.

### SQUELCH.

On some Australian transceivers this is labelled MUTE. The control can either be a variable one like the AUDIO one or an ON/OFF switch. The purpose of the SQUELCH is to prevent any noise coming from the loudspeaker unless speech is being received. Hence you could have your transceiver left switched on receive, on your office desk, without it producing continuous hisses, crackles and bangs. The effectiveness of squelch circuits varies depending on their design. Some manufacturers offer what is called SYLLABIC squelch. This looks for the syllabic rate in speech and so it is able to differentiate between speech and other noises.

### CHANNEL selector.

This control selects the particular radio frequency which has been allocated to each channel. A rotary multi-position switch may be used for fixed frequency sets e.g. crystal controlled ones. Each switch position can have the full radio frequency beside it e.g. A 7305 KHz, B 5782 KHz, or the positions may simply be labelled A, B, C, etc. Synthesised transceivers are more versatile, by selecting a channel and typing in the frequency the transceiver will store this frequency so that whenever that particular channel is selected in the future it will automatically be set up to the stored frequency.

### USB/LSB.

A single channel frequency can produce two usable channels. One channel is the UPPER SIDEBAND (USB) which occupies 3 KHz above the channel frequency while the LOWER SIDEBAND (LSB) occupies 3 KHz below the channel.

### AM.

This stands for Amplitude Modulation and is used by broadcast transmitters on the short-wave bands. An AM facility is not found on all transceivers. AM is not used or indeed not usually permitted for speech communications as it requires twice the amount of frequency space that USB or LSB does i.e. 3 KHz above and 3 KHz below the channel frequency.

### CW.

This stands for Continuous Wave and only the channel frequency is transmitted and is switched on and off to form the Morse Code or any other kind of code.

## **3.2. Power Supplies**

Basically there are two types of power sources. One source which can be considered to be "interruptable" e.g. a 110 or 220 volt AC mains supplied by the local electricity authority. A failure anywhere in the generation or supply system can mean that, often without notice, you will be without power. A similar loss of power can occur when your own generator fails. So you must consider the reliability of the electricity supply which you intend to use for your radio and the effect of not always being able to transmit when you wish. Such shortcomings can be overcome by using a "uninterruptable" supply, that is to store the electricity in your own storage battery which is automatically connected to the transceiver when the mains fail. The battery will require charging and you will have to put into the battery a little more energy than you expect to get out of it.

### **3.2.1. Mains supplies**

The availability of the mains electricity supply in some towns of the developing countries can be unreliable. The supply can disappear for hours or days with no information being available regarding when it will go off or come on. So it is as well to discover as much information about the mains supply which you intend to use before you complete the plans for your network. This information

should be obtained from existing users rather than the electricity supply authority. Sometimes the authority will give you an over optimistic picture of the supply, it may well be what they hope to supply you with but not what you actually get. Some towns may have electricity for certain hours only e.g 6 pm to 10 pm.

### **3.2.1.1. Constant voltage transformers**

Apart from interruptions your mains supply may fluctuate considerably about its nominal value e.g. 240 volts. One European standard for national voltage supply is that it shall be within +/- 6% of 240 volts. You may obtain your electricity from a locally generated supply e.g. a plantation or a hospital, which also may be unreliable and unstable. In all such situations a fast-acting constant voltage transformer i.e. one which will respond to changes within 1/50 of a second could be used to advantage. Such a constant voltage transformer may accept input voltages in the range 204 to 276 volts and provide an output in the range 236 to 254 volts.

### **3.2.1.2. Fail to battery**

This facility is as its name describes. When the mains fail the transceiver is automatically connected to a standby battery. A mains operated relay can be used as shown in Fig.3.8. The relay contacts must be capable of carrying the maximum current required by the transceiver. Provision must be made to always keep the standby battery fully charged.

### **3.2.2. Generators**

You may encounter a wide range of generators from 50,000 watt ones driven from 6 cylinder noisy diesel engines to 150 watt ones driven from small quiet petrol engines. If you intend to use power from an existing generator you should check the reliability of supply for both times when power is available and the constancy of the voltage. For example, does the voltage rise by 10 or 20 volts when a load is switched off or does a 230 volt supply fall to 190 on occasion? Is there a reliable fuel supply and is the generator well maintained or are there periods of days or weeks when the generator is not working? Is there a standby generator available? You may wish to provide your own generator. This could either provide 110 or 230 volts AC direct to your radio or 12 volt DC for charging your radio battery. Some small generators provide both 110/230 volts AC and 12 volts DC.

### **3.2.3. Batteries**

Batteries can be divided into two groups. Primary batteries are ones which cannot be recharged and which are thrown away after use e.g. some torch batteries. Secondary batteries are ones which can be used and recharged many times. It is only secondary ones we shall deal with here. The value of secondary batteries is that they can be charged when electrical power is available i.e. when a generator is running, the energy is then stored and can be used when required. The classic example in daily use is the sun on the solar panels during the day charging the battery which will provide energy for lighting at night. The importance of battery use can be seen from the Questionnaire which showed that 74% of the 176 transceivers at fixed locations in Africa used batteries recharged by various means.

#### **3.2.3.1. Types**

There are many different types of secondary or rechargeable batteries. Small capacity nickel cadmium ones are used in torches and in small transistor radios. The battery most commonly used for radio transceivers is the vented lead acid type i.e. the car battery. Now increasing use is being made of sealed lead acid batteries both for cars and radios. The sealed types are sealed for life and require no maintenance whereas the vented ones need checks on their acid level and filling up with distilled

water as necessary. Note that it is important to keep the charging voltage within the manufacturers limits especially for sealed types. Care should be taken when purchasing sealed for life batteries because special PHOTOVOLTAIC batteries are now available. These are sealed for life batteries specifically designed for use in solar systems where the charge and discharge currents are usually lower than in a car. Therefore they must not be used in any vehicle for any reason not even to start one. It is suggested that their currents are calculated from the 100 hour rate in paras. 3.2.3.4. and 5. In practice the calculated values can be exceeded during peak solar charge and peak transmitter load. When one cell of a normal 12 volt battery fails the battery is of little use. It is now possible to buy a battery made up of 6 individual 2 volt cells. The advantage is when one cell fails you need only buy one new cell to restore the 12 volt supply. The cost of this arrangement is more than for a normal 12 volt battery.

### 3.2.3.2. Capacity

The amount of energy that can be stored in a battery is expressed in AMP HOURS (AH or Ah) i.e. Amps x hours. The working of a battery can be understood by considering a typical car battery with a capacity of 60 Ah. A fully charged 60 Ah battery will give 1 amp for 60 hours or 10 amps for 6 hours. This is an over-simplification because the efficiency of a battery decreases with higher discharge current. Efficiency is the Ah obtained from a fully charged battery during discharge compared with the Ah used to fully recharge it. Misunderstandings have occurred concerning the relationship between battery voltage and the state of charge of the battery. It has been assumed that the voltage of a fully charged battery was 12 volts and that this voltage would fall to 6 volts when the battery was half discharged. There is in fact only a small change in battery voltage. When a battery is delivering current its voltage will be about 12.6 volts when it is fully charged. When the voltage has fallen to about 11 volts some 90% of the stored energy will have been used up and the voltage will soon fall to 10.6 volts when it is fully discharged. These figures will vary slightly according to the type of battery and its condition. To calculate the Ah capacity of the battery you require see para 3.2.3.5.

### 3.2.3.3. Life Expectancy

The most commonly used battery for transceivers in the mid 1980s was the rechargeable lead acid type e.g. the conventional car battery. Only a few sealed types were in use. A conventional type car battery should not be stored in a discharged condition because this can drastically reduce their life expectancy. When you buy a new battery how do you know when it was manufactured and in what condition it has been stored? A good quality British made battery was purchased as new in Mbandaka in Zaire in September 1986. After 8 months in use one cell failed and the battery was no longer usable. Enquiries made to the British manufacturer showed that it was at least 5 years old when it was bought in Mbandaka. The normal storage life for that type of battery without deterioration is considered to be 1 year. You may not be able to obtain any information regarding the true age of batteries which are not manufactured in the country so if you wish to buy locally it would be best to obtain them from large trading establishments e.g. in the capital city, where there may be a rapid turnover of goods. Alternatively you could import a battery yourself preferably by air if you are able to do so. Once you have a good battery its life expectancy will be further determined by how it is used. If a battery is kept fully charged and only a 1/3 or 1/2 of the energy stored in it is used before it is recharged again a reasonably long life can be expected. The following figures indicate how many times a lead acid battery can be charged and discharged. They are for guidance only and details for any particular make of battery must be obtained from the manufacturer:

Percentage of energy used before recharge.	Number of times battery can be charged and discharged.	
	Vented	Sealed

30	1,000	850 - 1,200
50	700	280 - 450
100	350	100 - 180

These figures suggest that a vented lead acid battery used each day powering a transceiver will last for 3 years if only 30% of its energy is used and it is recharged daily. However if the battery is fully discharged each day it is used then its life expectancy is less than 1 year.

### 3.2.3.4. Charging

The voltage of a battery will vary whilst it is being charged. The actual voltage will depend upon its type and condition and its state of charge. To ensure that charging current flows into the battery the voltage of the charger should exceed that of the battery by at least 1 volt. Regulators on many vehicles limits the maximum battery charging voltage to 13.6 volts. When solar panels were first used for battery charging the voltage of the panels was often some 14 to 15 volts but this voltage did not really require regulating. Now higher voltage panels are in use and will need regulators see para 3.2.6. When a fully discharged battery is put on charge its actual voltage may be only 11 volts so a high charging current will flow. As the battery voltage gradually rises to its maximum e.g. 14 volts the charging current will reduce.

$$\text{One recommended maximum charging rate} = \frac{\text{Battery capacity in Ah}}{10 \text{ hours}}$$

$$\text{For example: } \frac{60 \text{ Ah battery}}{10 \text{ hours.}} = 6 \text{ amps.}$$

The approximate state of charge of a battery can be deduced from its voltage.

Battery state	Battery Voltage when:		
	On charge	In use i.e. Not connected	on load
Fully Charged	Maximum set by charger e.g. 15V	13.2 V.	12.6 V.
Requires Charging	—	—	11.1 V.
Fully Discharged	11 to 12 V.	—	10.6 V.

Another method of determining the state of charge of a battery is with the aid of an inexpensive HYDROMETER. This sucks a small quantity of the acid from the battery into its transparent bulb and a calibrated float gives a reading of the SPECIFIC GRAVITY (S.G.) of the acid. The acid is then returned to the battery. The following table gives the relation between the S.G. and the state of charge of the battery:

Battery state	S.G.
Fully charged	1.28

3/4 charged	1.25
1/2 charged	1.22
1/4 charged	1.19
Fully discharged	1.11

### 3.2.3.5. Discharging

The current demanded by the transceiver will determine the Ah battery capacity required. There are two figures to consider. First the total energy in Ah required from the battery before it is recharged each day. Take for example a transmitter requiring an average current of 8 amps. For a total transmit time of 1/2 hour  $Ah = 8 \times 1/2 = 4$  Ah. Transceiver when operated in the receive mode requires 1/2 amp. For a total receive time of 4 hours  $Ah = 1/2 \times 4 = 2$  Ah. Therefore total energy required from battery is 6 Ah. Second figure to consider is the maximum discharge rate in this case 8 amps. For continuous use the recommended rate is :

$$\text{Discharge amps} = \frac{\text{Battery Ah capacity}}{10 \text{ hours}}$$

Or this can be written: Ah capacity = 10 hours x Discharge amps. However for intermittent demands of current, such as speech transmission, the 10 hour rate can be reduced to 5 hours. Thus: Ah capacity = 5 hours x 8 amps = 40 Ah. Of the two figures calculated for Ah, 6 and 40 in this example, the highest Ah is the one required. If the battery cannot be recharged when necessary, perhaps because a solar battery charger is used and the amount of sunshine is irregular in certain seasons or if a generator is not run at regular intervals, then a battery of higher capacity than the calculated value will be necessary. The battery will need to store enough energy to operate the radio until the next charge is available.

### 3.2.3.6. Low Voltage Disconnect

The information in para. 3.2.3.4. showed that the life expectancy of a battery was increased if it was not fully discharged before recharging. Units are available which automatically disconnect the radio from the battery when its voltage has fallen to a preset value e.g. 11.1 volts. Note that the unit must be capable of switching the maximum current demand of the radio.

### 3.2.3.7. New Battery for Old

When a battery fails it is frequently only one of its 6 cells that has in fact failed, hence the 12 volt battery becomes a 10 volt battery. From the 12 cells of two old batteries 6 good cells can usually be found. These cells can be connected in series to give 12 volts. One method of finding the good cells is described briefly.

1. Fully charge up the battery, then discharge it through a car headlight bulb.
2. After discharging for 30 minutes measure the voltage of each cell. It may be necessary to make small holes in the top of the plastic battery case to enable contact with each cell.
3. Empty the acid from the battery. Connect the 6 good cells in series i.e. negative of one cell to positive of the next. Make these connections in the old cells adjacent to the good cells being used.
4. Refill only the 6 good cells with acid and then recharge the battery.

### 3.2.4. Solar Battery Chargers

A solar battery charger is simply a flat panel containing photo voltaic material e.g. slices of silicon. When the sunlight reaches the photovoltaic material a voltage is produced which provides a charging current to the battery. In bright sunlight each silicon slice in a panel will generate just under 0.5 volts. The number of slices in a panel can vary from 30 which will produce 15 volts to 40 which produces 20 volts. The amount of current which a panel produces is proportional to the surface area of the silicon slice. To estimate the approximate size of solar panel one can assume that 150 square centimetres of total panel surface area is required to generate 1.0 Amps at 0.5 volts. Therefore the size of a solar panel to produce 18 volts at 2 amps can be calculated, assuming 150 sq.cms. required to produce 1 amp at 0.5 volts.

$$\begin{aligned} \text{Area in sq.cms.} &= (\text{voltage} \times 2) \quad \times (\text{Current in amps}) \quad \times (150) \\ &= (18 \times 2) \quad \times (2) \quad \times (150) \\ &= 10,800 \text{ sq. cms.} \end{aligned}$$

That is a panel area of about 1 sq. metre.

#### 3.2.4.1. Available Solar Energy

The amount of solar energy available can be obtained from ISOHEL maps which show the Average Annual Solar Energy in units of kilowatt hours (kWh). The figure for Western Europe is 1,000 kWh, the Sahara is 2,000 to 2,500 kWh and most of Zaire is 1,700 kWh. Obtain details of the solar radiation for your area of work. An example of how the daily quantity of solar energy varies throughout the year is shown for Kinshasa, which is 4 degrees south of the equator, in Fig.3.1. How the total intensity of solar radiation varies through the day during June is shown for Kinshasa, the capital of Zaire, in Fig.3.2. The total solar intensity comprises both direct sunlight and that diffused by cloud. In Kinshasa the diffused energy reaches its maximum after midday, as the cloud becomes less dense, hence the total intensity peaks at 1300 hours. About 10% of the solar energy which arrives on a silicon solar cell is converted to electrical energy. An example follows showing how to calculate available electrical power. First you must know the following relationships:

$$\begin{aligned} \text{Watt hours (Wh)} &= \text{Watts} \times \text{hours} \\ \text{Watts} &= \text{Voltage (V)} \times \text{Current (A)} \end{aligned}$$

Therefore:  $\text{Wh} = \text{Voltage (V)} \times \text{Current (A)} \times \text{hours}$

A solar panel with cells covering 1 square meter will receive 4KWh per day in June in Kinshasa. Of this 10% (0.4 KWh) will become electrical energy.

$$0.4 \text{ KWh} = 400 \text{ Wh}$$

Charging a 12 volt battery from the solar panel.

$$\text{Wh} = \text{Voltage} \times \text{Current} \times \text{hours}$$

$$400 = 12 \times \text{A} \times \text{h}$$

$$\text{That is: } \frac{400}{12} = \text{Ah} = 33 \text{ Ah}$$

In theory the 400 Wh of energy will put a charge of 33 Ah into the battery. In practice the battery will receive a somewhat less charge because the voltage of the solar panel has to exceed the battery voltage before charging commences. The calculations are based on the actual area of solar cells which can be considerably less than that of the solar panel. However the calculations will give an idea of the

necessary area of solar panel required. Solar panels are classified according to their voltage and maximum power output.

### **3.2.4.2. Electrical Connection**

Solar panels can be connected together either "in series" or "in parallel". In series" means that the negative of one is connected to the positive of the next see Fig 3.3. The combined voltage of such panels is the sum of the voltage of each panel. So if you connect two 9 volt panels in series you will have an output of 18 volts. The value of the output current will be set by the panel having the lowest current output so this is normally used for connecting panels that produce similar current levels. "In parallel" means that the positive of each panel is connected to the positive of the next and negative to negative of each. It is usually used for panels of the same voltage and the total voltage for all the panels will be only the same as for one of them but the total current output will be the sum of the current of each panel. So if you connect two 9 volt panels in parallel you will get 9 volts out. It is important to get these connections right as shown in the following example. We found in one place two 9 volts panels installed and connected to a 12 volt battery. The disappointed user was certain solar power was no good because the battery was not being charged by the panels. However we discovered that the panels were connected in parallel so giving only 9 volts to the battery. Now you must have a charger that gives at least one volt more than the battery see para 3.2.3.5. so we connected the panels in series and they produced 18 volts which was more than enough to keep the 12 volt battery fully charged.

### **3.2.5. Diodes in Solar Chargers**

Originally only one diode was used with each solar panel as this has always been necessary in a solar charger circuit to prevent the battery from discharging through the panel. Now you may well find several diodes built into a panel. The manufacturers do not always explain either the presence of the diodes or their purpose. For example: there is a label on the back of your panel saying "By-pass Diodes fitted" but you would still require a Main Diode. There will probably be a small plastic box mounted on the back of your solar panel. If you remove the lid of this box you should find the + and - terminals. There may also be diodes in this box and in the absence of any information from the manufacturer you should attempt to identify the purpose of the diodes. A description of a diode and its several uses in solar panels follows.

#### **3.2.5.1. What is a diode?**

A diode is a device which permits electric current to flow through it in one direction only. It is, therefore, very important that the diode is correctly connected. One place you should always find a diode is connected between a solar panel and the battery it is charging. A diode is shown in circuit diagrams by the theoretical symbol of an arrow on a line. -->|--, see Fig.3.3. The arrow shows the direction in which the current flows. The current flows from the one end which is called the anode to the other which is called the cathode. The anode is positive and the cathode is negative. When current is flowing through a diode there will be a loss of 0.5 to 1 volt across the diode. The cathode of a diode may be identified by one of the several markings found on diodes e.g. by a light coloured ring on the dark body of the diode or by an arrow printed on the diode which points to the cathode. If the marking has come off the diode the cathode can be identified using a multimeter.(see para 8.6.2.3.) This method should also be used to test all diodes, including new ones, before they are connected as it is difficult to test them once they are in a circuit.

#### **3.2.5.2. Main diode**

When a solar panel is used for charging a battery it is always necessary for a diode to be connected

between the solar panel and the battery. The purpose of this main diode is to permit the solar panel to send charging current into the battery whilst preventing the battery discharging current through the panel during the night or when there is no sunshine. The diode may be connected in the + or the - wire provided the diodes direction is correct, see Fig 3 3. Main diodes are sometimes built into solar regulators, see 3.2.6.

### 3.2.5.3. Blocking diode

When more than one solar panel is connected in parallel it may happen that one panel becomes shaded. The output voltage of the shaded panel will fall and it will absorb current from the other unshaded panel. This waste of current can be prevented by connecting a "blocking diode " between each panel and the battery as shown in Fig 3.4. The fitting of blocking diodes is optional but if fitted to all panels then a "main diode" is not necessary.

### 3.2.5.4. By-pass diodes

These are used to minimise loss of voltage across sections of a panel or across individual panels, which are connected in series, when a part of the panels becomes shaded. The diodes limit any reverse voltage which may be produced by shading to 0.6 volts see Fig.3.5. If by-pass diodes are fitted to your new solar panel you can discover if they will in fact be of any use. That is , if a section of the panel is shaded so that a by-pass diode is conducting, will the remaining voltage from the panel be sufficient to charge the battery. For example, when two diodes are fitted to a panel which has an open circuit voltage of 18 volts, i.e. 9 volts plus 9 volts, then with one by-pass diode conducting the output voltage would be 9 volts minus 0.6 volts which is clearly not enough to charge a 12 volt battery. If four diodes were fitted i.e. 4.5 + 4.5 + 4.5 + 4.5 volts and one section was shaded causing one diode to conduct then the output is  $4.5 + 4.5 + 4.5 - 0.6 = 12.9$  volts which is sufficient to put some charge into a battery. By-pass diodes which are serving no purpose could be removed because problems may arise if they failed e.g. due to lightning damage. They can be used as blocking diodes or kept as spares.

### 3.2.5.5. Diodes for multiple loads

Where there is a solar panel which has been installed to charge a battery e.g. to power your radio, the question may soon arise "Can we charge other batteries from the panel as well?" The answer is "perhaps" and "providing priority is given to the radio battery". First it must be established that the existing panel is capable of providing adequate charge to the battery it was intended to charge. Then if there is surplus current the extra load should be so connected that there is priority to the premier battery. Such an arrangement can be achieved by using a somewhat complex and expensive electronic management system which itself will require power. Alternatively a simpler and cheaper system of diodes can be used see Fig 3.6. However this configuration of diodes does not guarantee that the principal battery will get sufficient charge but it will ensure that the additional load receives at slightly lower voltage and that it will not discharge the principal battery.

### 3.2.6. Solar Regulator

Current practice is to use solar panels producing up to 18 volts to ensure a high battery charging current throughout the period of charge. With such panels it is necessary to use a regulator to reduce the 18 volts supplied by the panels at peak performance times to the maximum permitted at the battery e.g. 14.5 volts, to prevent the battery from being overcharged. Some solar regulators contain the Main diode. Only use a regulator that can handle the maximum power output of your panel. There are several different types of solar regulators. One has a current controlling device between the panel and the battery which controls the amount of current going into the battery. Another type has resistors which "dumps" some of the current from the panel when the battery voltage exceeds the



predetermined limit. Both of these types can provide proportional control that is the charging current is gradually reduced as the battery voltage rises. There are also "on-off" regulators where the full charging current flows for a time then is reduced sometimes to zero for a period of time. Proportional types are preferable.

### **3.2.7. Pedal Generators**

Generators pedalled by people have been used to produce electricity for radio communication purposes since the 1930s. Their use was pioneered by Traeger in Australia for the Flying Doctor Service. Pedal generators were still in use in the British Army in the mid 1980s though by this time production had ceased in Australia. A network of several Traeger pedal powered transceiver, giving a power output of 25 watts PEP each, was established around Dodoma in Tanzania in 1980 and this equipment was still serviceable in 1987. These generators produced power directly but only while they were being pedalled and usually did not incorporate a storage battery. When there is no storage battery it is necessary to pedal all the time whilst you are receiving and waiting for your turn to speak, in practice this can be 10 to 20 minutes. Therefore it is helpful to have a timetable with specific times for contacts which is strictly adhered to. Since production of these ceased many individuals and groups have designed their own generators.

These designs have frequently been based on a bicycle, one incorporated a 3 speed drive, to drive dynamos or alternators from cars. A disadvantage of using a normal car alternator is that it requires a battery to provide current to start it generating and also to stabilise the output voltage. However a battery gives an operational advantage in that it can be used to power the transceiver during what may be long periods of receiving only. Then pedalling commences for transmission and also to charge the battery.

The cost of car batteries in some countries can be very high. Also the life of these batteries can be only 1 or 2 years and they can easily be stolen or borrowed for other purposes. So it is sometimes beyond the financial resources of small groups to provide themselves with a battery. When using a low power transmitter e.g. 25 or 40 watts, these groups could use a new design of pedal power generator which requires no battery although it uses a car alternator. In this design the existing control unit in a LUCAS 17ACR car alternator was replaced by the circuit shown in Fig.3.7. This maintained the output voltage of the alternator between 13.0 and 13.6 volts for a load varying from 0 to 40 watts. The pedal generator has been used to power a 40 watt PEP SSB transceiver.

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# WHERE THERE IS NO TELEPHONE

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## *Chapter 4. HOW TO PLAN YOUR RADIO NETWORK*

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When it is decided that your group needs some form of communication and could benefit from a radio communication network you should consider what this implies in some detail. Before you get down to choosing a transceiver from the glossy brochures there are some general aspects to be considered. What are the facilities you would like and what facilities you can actually afford to buy, licence, operate and maintain? What form of radio communication between which places will the Government of the country permit? You may plan several different systems on paper before you arrive at the one which is acceptable in all its aspects. Keep all your various plans because you could find that after going through various planning and costing stages and through government departments etc. you need to go back to an earlier plan!

### **4.1. Who do you want to talk to?**

The first stage of your planning should be to take a good look at the present method of communication between your locations and to make an assessment of their needs. Look at how long it takes to get urgent and routine information passed on, how much it costs, how far away from good roads each location is and from towns that might possibly have a telephone link or from other groups with a radio link. Then decide which locations have the highest priority for a radio link. You will probably give priority to the most isolated and distant places but there may be others which could be usefully linked by radio even though they are more accessible.

You may think that a place with a good road link does not need a radio even though it has no

telephone, that in an emergency a journey by vehicle could be made. However where the costs of running a vehicle are high, where there can be risks of fuel shortages and the availability of vehicles are often in doubt, then a radio link may prove invaluable in an emergency situation as well as cost effective in routine matters. You must think carefully about the advantages and possible disadvantages. For instance, while radio messages will certainly speed up your communications, it is possible that they can also put understaffed headquarters under a lot more pressure as outlying stations may come to expect instant responses to their demands. You do not want the introduction of a radio link to become "more nuisance than it's worth!"

You should decide which location is to be your Headquarters (HQ) station and most likely use this station to control the operation of the radio network. At this stage you should plan for locations to be able to speak directly with each other rather than have messages relayed by intermediate stations as this can be a source of introducing errors into messages. There is a party game where one person whispers a message to the next person and so on until it is relayed round the room to the last person. Invariably the message quoted at the end differs considerably from the original one. This demonstrates the hazards of relaying messages by speech. From Table 4.1. emerges the number of transceivers required, the distances that each station has to communicate over and the cost of the present method of communications.

Table 4.1.Existing methods and cost of communications.

Location	Kms to HQ	Time for message to arrive	Present Method	Present cost per message	Total cost in past year
"A"	350	2 or 3 days	URGENT. Via radio of other group if it is working then by 2 days overland.	no charge + £10.00	— £70.00
		4 days	URGENT. If radio is not working send person by air and road	£110.00	£330.00
		Variable	ROUTINE. Send with next person to travel there		
		3 months or never	ROUTINE. Letters by local post	£0.00	£2.00
"B"	250	1 day	URGENT. Via radio of other group if it is working	no charge	
		1 day	URGENT. Charter an aircraft	£300.00	
		1 week	SEMI-URGENT. send a person by boat	£20.00	£100.00

		Variable	ROUTINE. send with next person to travel		
		3 to 8 weeks	ROUTINE. letters by local post	£0.05	£2.00

Making a list similar to this for all your stations should help you decide which places really need a radio. When you have reached this decision then draw a geographical map to scale showing the locations of the proposed radio stations with respect to the HQ station. Join together with a straight line the stations which are to speak directly to each other. Write beside each line the number of kilometres it represents, see the example in Fig.4.1. Let this be your basic plan for the future network.

## 4.2. Licences

Licences for radio communication equipment are usually obtained through the national post and telecommunications office of the country concerned. e.g. in Zaire - Office National des Postes et Telecommunication du Zaire (ONPTZ). Whilst these deal with the technical aspects, approval may also be needed from the state security. So you should have a licence before you use your radio or you may be in trouble!

### 4.2.1. Applying for a licence

Attempt to discover all the information you can about licensing conditions before you purchase your radio. You may be able to get information from the authorities or from other groups who are already licensed to operate. There may be a central body which is experienced in applying for licences and may handle the applications for you. In Zaire such a body is L'Eglise de Christ du Zaire (ECZ) which is recognised by the Government as representing the Protestant Churches. Obtaining licences can sometimes take a long time and you may have to fill in many forms and supply technical specifications and circuit diagrams of the radios you intend to use together with maps and plans of your network for each proposed station. You should obtain the technical specifications and circuit diagrams from the manufacturer of the radio you hope to use but you should not purchase or import your radios until you have the licences for them, sometimes the condition of importing them is that you must have the licence first. Also it is possible that the authorities might not give you the required permission or might impose limitations on the sort of radios you can use.

Some countries may wish to study a complete technical specification of the particular type of radio in order to give "type approval" before it is imported and used there. Sometimes "type approval" may have been given previously to another group using that particular radio so this is one stage where you may experience little delay. If "type approval" is a necessary stage in your particular country, enquire which types of radio have already been approved in this way as it could be helpful for you to choose one that has been approved. Do ask people who are already licensed for advice on all the things you can, e.g. you might learn, perhaps, that it is better to apply for more licences than you need because it is the practice of the authorities to only grant five out of ten applications.

One question which appears on application forms is often "What is the distance to the nearest public telephone?" It is reasonable that if the national telephone service has provided a telephone system, both private and public, that works then it should be used where possible. The operative words being

"that works". The national telephone networks of several countries in East Africa are being extended into the rural areas, some telephones being linked by VHF radio not by telephone wires. One mission with 55 licensed radio stations in its network had the licences of 20 stations withdrawn as telephones became available as an alternative means of communication. Before spending a large sum of money on a radio telephone network it would be as well to enquire if there are plans to extend the national network to any of your areas. The plans and timetable of any proposed extension of the national system should be looked at through the eyes of experience of that particular country. To some authorities success is the provision of marvellous plans and this is an end in itself. The fact that these plans may never be implemented for years or decades is of no consequence.

#### **4.2.2. Licence Fee**

The annual licence fee for a transmitting station varies greatly from country to country. In 1987 the licence fees in some African countries varied from the equivalent of £25 to £75 per station. It is an offence to operate a transmitter without a current licence therefore it must be renewed annually.

#### **4.2.3. Frequency choice**

When applying for your radio licence you can mention the time of day you want to speak over the radio link, the distances to be covered and suggest a suitable frequency. You may then be allocated a frequency of the order you require. Alternatively you may be given a frequency and have to schedule your operating times on it for satisfactory ionospheric propagation. See the information on propagation in Chapter 1.

#### **4.2.4. Limitations**

You may wish to use a synthesised transceiver capable of operating at any frequency from 2 to 30 MHz. However the ability to transmit on all these frequencies may not be acceptable to the licensing authorities. You may only be permitted to use a transceiver containing the frequencies for which you have been licensed. Your plan may be for a network with twenty stations with whom you wish the HQ station to communicate direct as suggested in 4.1. Such an arrangement may not be agreed by the licensing authority. For instance they could suggest that your twenty stations be divided into four groups of five stations. Each group having a principal station with whom the other four communicated and only these four principal stations permitted to communicate directly with HQ. The reason for this might well be that they do not want too many high-powered stations and they could limit the power of the subsidiary stations in each group to, perhaps, only 25 or 40 watts depending on the local situation.

#### **4.2.5. Import Licence**

At the same time as you apply for the licence to operate the radios you should also enquire if a licence is needed to import them. Enquire about customs charges and if any exoneration from duty is available to churches or aid agencies. If the radios are being purchased by a mission or aid agency in another country as a gift to your organisation you may need papers giving proof of this. It is important to make sure that you have all necessary documentation with the equipment when it arrives or it could be stuck in a customs store while you obtain what you need. In such a situation there is always a danger of loss or damage as well as the risk of being charged large sums of money for storage.

### **4.3. What type of radio communications?**

There are many different types of radio communication ranging from local Citizen Band (CB) to the men who talked to earth from the moon! Within each type there are many methods of transferring information, for example by the spoken word, morse code, teletype, picture and data transmissions.

Methods of radio communication normally used by groups who have no access to a telephone are CB, VHF (Very High Frequency) and HF. The subject of CB and VHF are covered briefly but the main concern of this book is with HF radios.

### **4.3.1. CB**

The use of CB radio is authorised by the Governments of many countries. There are no international regulations for standardising the service, though the majority of countries allocate frequencies in the range 26.96 to 27.41 MHz. One country allocates 49 MHz and a further two allocate frequencies between 476 and 479 MHz. The U.K. has made an allocation just above 900 MHz as well as 27.6 to 29.9 MHz. Typical values of maximum transmitter power allowed is 5 watts of FM and AM and 12 watts of SSB, though some countries limit the power to 0.1 watt. The result is that legal CB is meant to be for local use, typically up to 8 kms range. But if one or both stations are on high ground then longer ranges are possible. Also if the transmitter power is increased to 40 or 100 watts or if beam aerials are used ranges up to 30 kms. may be achieved.

The types of modulation used in CB sets can be AM, FM and SSB. Some sets are capable of producing all three types of modulation and have a selector switch. Other sets are only for one type e.g. AM. A FM transmission cannot be understood on a AM receiver or a SSB transmission on a FM receiver. Therefore you should ensure that any CB radios you obtain all have the same modulation system.

For a few years, each time the sunspot number is around its maximum, CB can be used for long distance contacts between countries and continents. Such contacts are often not within the terms of the CB licence. CB radios are readily available and often at low cost so depending on your distance requirements CB may be an economic solution. It is a useful solution for communication within a mission or other establishment e.g. a hospital complex, where the buildings are spread over a wide area and where an internal telephone system would be impossible to install and maintain owing to its high cost and to the possible theft of overhead lines as has happened in some cases. CB has proved to be very useful within towns and cities which have no satisfactory telephone system. For it to provide a good service some form of co-ordination is necessary. In one African city a mission group took the lead and produced a list, updated twice a year, of some eighty CB users. This gave the channel on which each one listened and their individual call-sign. The CB transceivers were left switched on all day, with the squelch control set to prevent noise from the loudspeaker until a signal was received. So by using the correct channel and callsign one could call a required station as easily as using a telephone. Most CB sets have forty channels, others may have eighty.

### **4.3.2. VHF**

VHF can be a reliable form of communication as it is not dependent upon the fluctuations of the ionosphere but its range is limited. For networks using 25 watt transmitters ranges up to 80 kms. may be achieved. However the range is very dependent upon the topography of the area. A rough guide is that if there is a "line of sight" between the two VHF aerials then communication is possible. Range can be extended beyond the horizon and round intervening hills by unattended automatic VHF relay stations. These can be located on a hill or high building and can greatly increase the area served by VHF transceivers. This is because there can be line of sight from each station to the elevated repeater even though stations are not visible to each other. Therefore it may be possible for all stations within a 80 kms. radius of the repeater to communicate with each other. VHF systems often operate in the 70 and 150 MHz region. The operational requirements for a VHF radio network should be specified with the help of a radio engineer who would then produce a plan and a list of appropriate equipment to satisfy your needs.

### 4.3.3. Amateur Radio

The facilities provided by the amateur radio service should not be confused with CB or privately licensed networks. Amateur frequencies are allocated on an international basis and range from 1.8 MHz to 10,000 MHz and enables global communication including the use of satellites. All types of communication are possible including normal speech, television, teletype and computer talking to computer. However as the name suggests the facilities are intended for the amateur enthusiast and not for commercial organisations. The restrictions on what communication can be performed by amateur radio varies from country to country. Most countries expect the amateur to pass certain examinations before a licence is issued and some will only permit the licence holder himself to speak on the radio. Others will allow anyone to speak under the supervision of the licence holder. Also others e.g. USA, will allow the amateur to connect his amateur friend from another country into the telephone system via the radio so enabling him to speak to non-amateurs. Unfortunately in UK for example this is never permitted. Amateurs are also expected to co-operate with the International Red Cross and Government departments during disaster and relief operations. The facilities of the amateur service are many and varied and are also continually increasing therefore you should enquire if the amateur service is relevant to your situation and if so encourage some of your personnel to obtain an amateur licence. Many expatriates use amateur radio for a daily or weekly talk with their friends in their home country. However it should be noted that some countries put many restrictions on amateurs, others make it difficult to obtain licences while a few ban amateur radio completely.

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## *Chapter 5. COSTS AND CHOICES*

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### **5.1. Costs**



First impressions of the cost of a radio network can be deceptive. You may know that a basic transceiver can cost around £1,000 but before that transceiver and its associated equipment is installed and working the total cost can be up to £2,500. The cost of introducing a radio network can be divided into two parts. First there is the capital cost of the equipment together with the shipping, insurance, customs duty and installation which are "once only costs". Secondly there are the "recurring costs" of operating, maintaining and licensing the network.

### 5.1.1. Capital Costs

The £1,000 mentioned above is the cost of a basic transceiver. There are many additional items necessary as suggested in Table 5.1. which gives an indication of the approximate prices in 1988. Whilst not all the items listed will be necessary, you may require some of the additional facilities described in Chapter 9. The cost of the additions will need to be discovered at the time because they vary considerably with manufactures and time etc. An adequate selection of spare parts should be purchased with the transceivers. The manufacturers may have a recommended list of spares based on experience. Allow about 10% of the basic transceiver price for spares for each set you buy. Technical manuals of the transceivers must be obtained, preferably in the language of the country where they will be operated. The numbers of manuals will depend upon what provision you make for maintenance. If each station is responsible for maintaining their own sets then there should be a manual with each set. The purchase of major items of test equipment such as a signal generator or an oscilloscope will again depend upon your plans for maintenance, see para.5.2.4.

Table 5.1.

<b>Item.</b>	<b>Cost in £</b>
150 watt pep SSB HF transceiver	1,000
Each additional Channel	50
Spare parts	100
AC power supply	40
USB and LSB	80
Hand-held (fist) microphone	25
Desk microphone	80
Earphones	15
Single dipole aerial	150
Broadband aerial	300
Aerial selector switch	25
Your specified modifications(para.5.2.5.)	50
Technical manuals	10
12 volt battery	80
Solar battery charger	250
Mains battery charger	50

The list may have to be extended to cover such items as petrol or diesel generator and aerial masts. The possibility of obtaining a discount price should be investigated especially if you are buying a large quantity of radios. Some manufacturers give concessionary prices to missions and aid groups, indeed some give gifts of equipment. Discounts of 10% to 40% have been obtained. Check if there is a tax on equipment when it is purchased e.g. Value Added Tax (VAT) in Great Britain, which need not be paid or can be reclaimed when you export the equipment. It is the resulting discounted price

that must be considered e.g. a £1,000 radio with 40% discount costs £600, a £700 radio with 20% discount costs £560. You will have to make a list of your particular needs. If your set is mains operated and you wish it to switch automatically to battery operation when the mains fail, you will need a "fail to battery unit". If you employ a solar charger then you may not need a generator or a mains battery charger.

### 5.1.2. Shipping

To ship equipment from the country of manufacture to the country of use could take several days by air or several months by sea. Air freight costs more but the longer equipment is in transit the more likely is it to be damaged or lost so using the cheapest method is not always the most cost-effective in the end. It is usual for radio manufacturers to pack equipment in shock absorbent material in a cardboard box. You should instruct them or the shipping agency to further enclose the cardboard boxes in a strong wooden one. This is to give both added mechanical protection and to reduce the chances of cardboard boxes being opened and items stolen. Insurance may cover the cost of replacing any equipment stolen but the time and effort necessary to recover the cost, reorder and ship the replacements will mean a delay in the installation and availability of your radio network. Therefore any steps you take to prevent loss of equipment at any time is worthwhile. The following example gives some idea of the cost of shipping equipment by air freight from Britain to Zaire in 1986. You must, of course, make sure you have up-to-date information for your own estimates. It shows that there are other things beside the actual freight charges.

	£
To supply wooden box, pack band and mark	35.00
Delivery to the airport	8.00
Air freight charges on 147 kilos at £2.25 per kilo	330.75
Airway bill charges, documentation etc.	20.00
Insurance	10.00
Telex with flight details	6.00
<b>Total</b>	<b>£409.75</b>

If you have small amounts of equipment to come out the best and safest way is often for someone to bring it out with their personal luggage even if you have to pay excess baggage costs but you must make sure they have all the necessary documentation with them.

### 5.1.3. Customs Duty

The custom duty payable varies from country to country and can also depend on the type of organisation you are working with e.g. commercial, foreign government aid programme, church or mission. Some countries allow properly documented gifts of equipment going to non-profit making organisations to come in free of duty, others do not, while again others give this concession only to a few aid agencies. The regulations and duty payable can also be changed without much warning so make sure you get as much up-to-date information as you can. An example of what can happen is that the cost of equipment ordered in U.K. in 1986, as a gift to a church, was doubled by the imposition of customs duty just before its arrival a few months later. Previously all genuine gifts had come in free of duty for many years. In some cases customs duty is charged not only on the value of the equipment but on the total cost of equipment, freight charges and insurance. It is therefore important to obtain full details of all likely charges including any local tax and possible storage and handling costs. In some places it can be difficult to get accurate and reliable information thus making it hard to know whether or not the amount you are asked for is the true amount. If you are not familiar with the system

it would be worthwhile using an agent who is known to be reliable by other missions or groups. You would have to pay for this service but it could save you time and money as an experienced importing agent would know what was legally required to be paid.

### **5.1.4 Installation**

After you have imported the equipment into the country there will be further expenditure for transporting it, together with a technician to install it, to its final destination. The cost for this can vary depending on availability of transport and technician and the remoteness of the location. For instance, if there is no other way, it may be necessary to charter a small plane. The cost of a day's charter with Mission Aviation Fellowship (MAF) to a station one and a half hours flying time away was in 1988 in Zaire £300. A commercial charter company would charge double this. In practice however it is often possible to share costs with others or to make use of local transport. As regards the installation work it is very important to get things fixed up correctly. A properly installed station will function better and longer and be more cost effective, even if you have to pay a technician to do it, than one badly installed by someone who knows nothing about it. It is even worse still to use someone who thinks he knows what he is doing when he really does not. See chapter on Installation. There are several options open to you regarding using a technician:

Option 1. Employ your own technician. This is the best method especially if you will have a big network.

Option 2. Use one of your personnel who has a practical aptitude and an appreciation of things electrical. If he reads and understands the information in this book and can follow instructions sensibly the installation should be successful.

Option 3. Obtain the services of a local technician either from another mission or group or from a local company if there is one. Costs may vary but could be £10 to £20 per hour.

Option 4. Use a technician employed by the manufacturer of the equipment. This is an expensive option as it could involve, for example, the cost of flying out the technician from U.K. and paying a daily rate of £300 for each day he is away from U.K. Therefore to get such a person to spend several days at a remote location in Africa could cost some £3,000.

### **5.1.5. Operating**

Who will operate the radio? How long will they spend each day sending and receiving messages and getting answers to messages and passing on requests for help or information? At a small station the extra demand on people's time due to the introduction of the radio may be low so that it can be absorbed with no extra cost. At the HQ station of a large network it will be different. Here it may be necessary for someone to be available all day both to operate when required and to deal with messages. The question of employing and training a radio operator and the responsibility of who should pay his wages ought to be carefully thought out beforehand. There will also be a small cost involved in the provision of "log books" to keep a record of all messages both sent and received. This is usually a legal condition of your radio licence.

### **5.1.6. Maintenance**

You should decide how you are going to maintain your network before you buy your equipment. There are many factors which will determine the annual maintenance costs and therefore this is a difficult figure to estimate.

The need for maintenance will be minimised by certain factors which include good quality control

during manufacture, having safeguards built into equipment, by good design of installation at each station and by having good operating procedures. These are dealt with in detail in this book. If your network will have twenty five or more stations you should consider having your own radio technician and workshop unless you are in an area where good reliable repair facilities are available at reasonable cost from other sources. The initial cost of equipping a workshop with the basic test equipment can start at £1,000 depending on the technician's choice. See para. 5.2.4. for choice of test equipment. To this you may need to add the cost of providing a building and work benches and seats, lights and fans or an air conditioner.

Then there is the annual cost of employing the technician. This is one area of cost in which certainly church missions and to a lesser extent aid agencies have an advantage over commercial concerns. The annual allowance paid to an expatriate missionary radio technician working in an African country was about one quarter of that paid to a similarly qualified person by a commercial organisation. Once you have established a repair facility you will usually find that other groups will come to you requesting you to do repairs on their equipment. If your technician has time available to do this then this could be a source of income to help with your costs.

An alternative to setting up your own workshop may be to arrange for prompt and effective repair work through an existing organisation. Some individual groups have a reliable facility in their own area but a more widespread organisation is MAF who because it has to maintain the equipment in its aircraft have some workshops of their own and sometimes is able to offer repair facilities to others. In Zaire the Catholic church is spread over the whole country and has radios at some five hundred locations. It has its own organisation for the supply and repair of radios and also offers a repair service to other groups. The cost of using a repair service other than your own will consist of the transport costs of getting the equipment to and from the workshop, the cost of the technicians time e.g. £10 to £20 per hour and the cost of replacement parts.

## **5.2. Choice of equipment**

After you have decided the plan for your radio network and obtained the necessary permission you will need to make your shopping list. If you have had to give details of your chosen transceivers in order to get your permission you should have already studied the next section!

### **5.2.1. Transceivers**

There are many glossy brochures advertising radio communications equipment. Pictures show vehicles with aerials sweptback as they speed across the desert or through the forest and the equipment is claimed to be "highly reliable for all conditions". Such claims are meaningless unless data such as the "mean time between failure" (MTBF) is quoted for specific operating conditions and this data is normally not available. Organisations such as MAF make a study of transceivers suitable for use in countries in which they operate and may be able to advise you. You should aim for the simplest transceiver that will satisfy your needs. A leading manufacturer of transceivers recently introduced a new crystal controlled model by claiming: "You do not have to be a computer programmer to operate it or an electrical engineer to repair it!" There now follows a list of some of the things to look for when selecting a transceiver.

#### **5.2.1.1. Supply Voltage**

You should discover what voltages are actually available at the site where you intend to install a transceiver. For example you may be told that a 220 volt AC mains supply is available but in reality this could fall to 185 volts at certain times. The voltage requirement of a transceiver may be given as

one fixed voltage e.g. 220 volts or it may be able to be set at any one of several voltages e.g. 210, 220, 230 or 240 volts. Enquire from the manufacturer the AC voltage range over which the transceiver will really operate as this may be greater than that quoted in the specification. One British transceiver was found that would operate satisfactorily when the main voltage had fallen to 190 volts. Battery voltage. There is generally a misunderstanding about the voltage required for a battery operated transceiver. You may find a transceiver which is said to operate from a 12 volt DC supply. However the specification for such equipment is usually based on an input voltage of 13.6 volts because this is the voltage of a vehicle battery on charge i.e. with vehicle engine running. When the transceiver is operated from a battery which is not on charge at the time then the voltage supply may well be just 12 volts and the specification may be different. For example a transceiver which produces 150 watt PEP with a 13.6 volt supply may only produce 100 watt PEP at 12 volts. Be aware of the real voltage which will be available and ensure that you obtain a transceiver that will operate satisfactorily from that voltage.

#### **5.2.1.2. Ease of maintenance and modification**

Can the transceiver be easily dismantled for servicing? There are some, e.g. the TWC ones from U.S.A. and AEL from the U.K., which have plug-in circuit boards. This means that the components are built onto a board which can be simply unplugged from the chassis of the set and an identical replacement board can be plugged in, should a component on the circuit board fail. With such a system it is often possible for someone with little radio knowledge to locate and correct a fault by simply taking out and replacing each board in turn with a new board. It is then easier to send a single faulty board to be repaired at your nearest radio workshop than to send the whole transceiver. Please read para.8.6.2. on maintaining your network for further details of this procedure. Can the transceiver be easily modified e.g. to add an additional frequency? In the case of Traeger (Australia) this was done by adding a single circuit board whereas some radios will require several components to be soldered into various parts of the transceiver. Ensure that the Technical Manual for each set contains full circuit diagrams and testing procedures with numerical values. If you require more detailed information ask for this as part of the purchase arrangement, otherwise additional information may be more difficult to obtain at a later date.

#### **5.2.1.3. Ease of use**

An explanation of controls etc. was given in para 3.1.3. You do not want the front of the transceiver covered with controls and indicators that the operator may never use. The minimum controls necessary for a SSB transceiver are: ON/OFF, VOLUME, CLARIFIER and a CHANNEL SELECTOR if more than one channel is fitted. A SQUELCH control and a TRANSMIT indicator will also usually be found. The use of earphones has proved successful for hearing weak signals under noisy receiving conditions. Some transceivers have a earphone socket, others can be modified to have one. If you want this facility, check on its availability and order as necessary. see also para. 5.2.5. If you expect to use the transceiver on both the mains and DC battery operation from time to time, find out what is involved in changing from one to the other. Is it by a switch, changing plugs or soldering wires? Will a separate unit for operation on AC mains be required? Some transceivers have their AC power supply unit built into them, others do not. External power supply units require interconnecting cables, plugs and sockets, all of which can wear out or be damaged and thus be a source of failure.

#### **5.2.1.4. Future availability**

It is wise to standardise on one model of transceiver if it has proved satisfactory but unwise to buy a model that is about to go out of production. This may be difficult as manufacturers do not always give advance notice when a model is being withdrawn. After production of a particular model has ceased

spare parts are usually available for several years. Before you buy the equipment write to the manufacturer and ask for how many years are they going to supply spare parts. You may get a more realistic answer to a written question whereas an enthusiastic salesman's response to a verbal question may be: "No problem, spares will be available for the next ten years!" Two years later when that particular salesman has left the company there could be difficulty in obtaining spares. You will need to consider how easily and rapidly you will be able to communicate with the manufacturer. Do you have a common language in which to discuss technical questions? How rapidly can you obtain equipment and spares? It may be advantageous to select a manufacturer, or certainly an agent, in the country in which you are working or in your home country. With foreign manufacturers you will be subject to fluctuations in the exchange rate when performing currency transfers. It should be noted that whoever you are dealing with, you will possibly encounter delays in the postal system when enquiring or ordering from overseas.

#### **5.2.1.5. Protection**

You should enquire if there are any protective devices built into the transceiver to protect it from damage by lightening. These usually take the form of diodes which give limited protection, in practice the aerial ought always to be disconnected from the set when it is not in use. see para.7.2.2.5. Some transceivers are "reverse polarity protected" i.e. the 12 volt DC supply can be connected to the transceiver the wrong way round without damaging it. See para.5.2.5.

#### **5.2.1.6. Channel Frequencies**

Transceivers which are not synthesised only have a limited number of channels see para. 3.1 and 3.1.3. For these you will need to specify the required frequencies for each channel, including whether it is USB and/or LSB, and you will need to choose a transceiver which will provide the necessary number of channels.

First you must list the frequencies which have been authorised for use by your own group.

Secondly you may need the authorised frequency of some other groups. e.g. MAF frequency for a location with an airstrip.

Thirdly there may be certain frequencies on which you want to listen i.e. receive but not transmit. List these as channel frequencies but qualify with RECEIVE ONLY. For example, there may be members of your organisation in another nearby country with whom you are not permitted to communicate by radio. However you can listen to their transmissions on their particular frequency and similarly they could listen to you. Note if you have for personal use a short-wave broadcast receiver, preferably digital, that has a SSB facility you could use this to listen to any frequency.

Fourthly if the country in which you are operating permits amateur radio and you have or are likely to have radio amateurs in your group then you could allocate one or two channels to amateur frequencies. Such channels have been used in the past with some success in Africa for a missionary net on 14.19 MHz. The merit of this arrangement is that a limited amateur facility is provided at the cost of one or two extra channels rather than the cost of a complete amateur transceiver. The reverse has also been done when amateur transceivers have been successfully modified to provide the authorised mission frequencies.

Lastly you ought to have at least one channel, possibly two, spare for future use as you may well find at a later date that it is necessary to add a further frequency. So now you should know the number of channels you will need and you will be able to select a transceiver that satisfies your demand. There are two frequencies associated with a channel. There is the CHANNEL frequency which is the actual

frequency transmitted and there is the CRYSTAL frequency which is often 1650 KHz higher than the CHANNEL frequency. When ordering crystals for a additional channel or for replacement, either definitely state which frequency you are giving or state both the channel and crystal frequency.

### **5.2.1.7. Microphones**

The most expensive transceiver and elaborate aerial system will not permit you to speak to anyone if your microphone fails!. Although the microphone is one of the least expensive items of a radio system many people try to save money and buy cheap ones, often with disastrous results. Prices in 1988 for hand-held or "fist" microphones varied from £12 to £36. When a hand-held microphone is in use there is continual movement, both of it and of its connecting cable. There is also the temptation of passing it from one speaker to another often involving the stretching of its cable to its furthest extent! It is also easy to put it down carelessly or even to drop it on to a table or desk or to let it swing from the end of its cable. All this constant wear and the occasional bump is often the cause of failures which could be avoided if a desk microphone is used which can cost £60 to £85. They are normally left in the same position on the desk or table and apart from pressing the on/off switch at the beginning and end of your message it does not need to be handled. If considered necessary a desk microphone can be securely fastened to the desk. It is recommended that you use a desk microphone and also have a hand-held one as a spare. In any case you should always keep a spare one available as it such an essential part of your equipment. Microphone types are classified as dynamic or ceramic and their impedance as high, medium and low. You will need the microphone to be compatible with the stated needs of the transmitter, in other words the manufacturer will tell you what sort of microphone you must use with a particular transceiver. See also suggested microphone modifications in para.5.2.5.2.

### **5.2.1.8. Power Requirements**

Transceivers are available to operate from either one or more voltages e.g. 12v DC, 110 or 220 to 240v AC. If the transceiver circuits operate from 12v DC then an additional power unit is necessary for operation from 230v AC. Conversely a transceiver requiring 230v AC will need a power unit for it to operate on 12v DC. These units will either be inside the transceiver case or in a separate case connected by a cable.

### **5.2.2. Aerials**

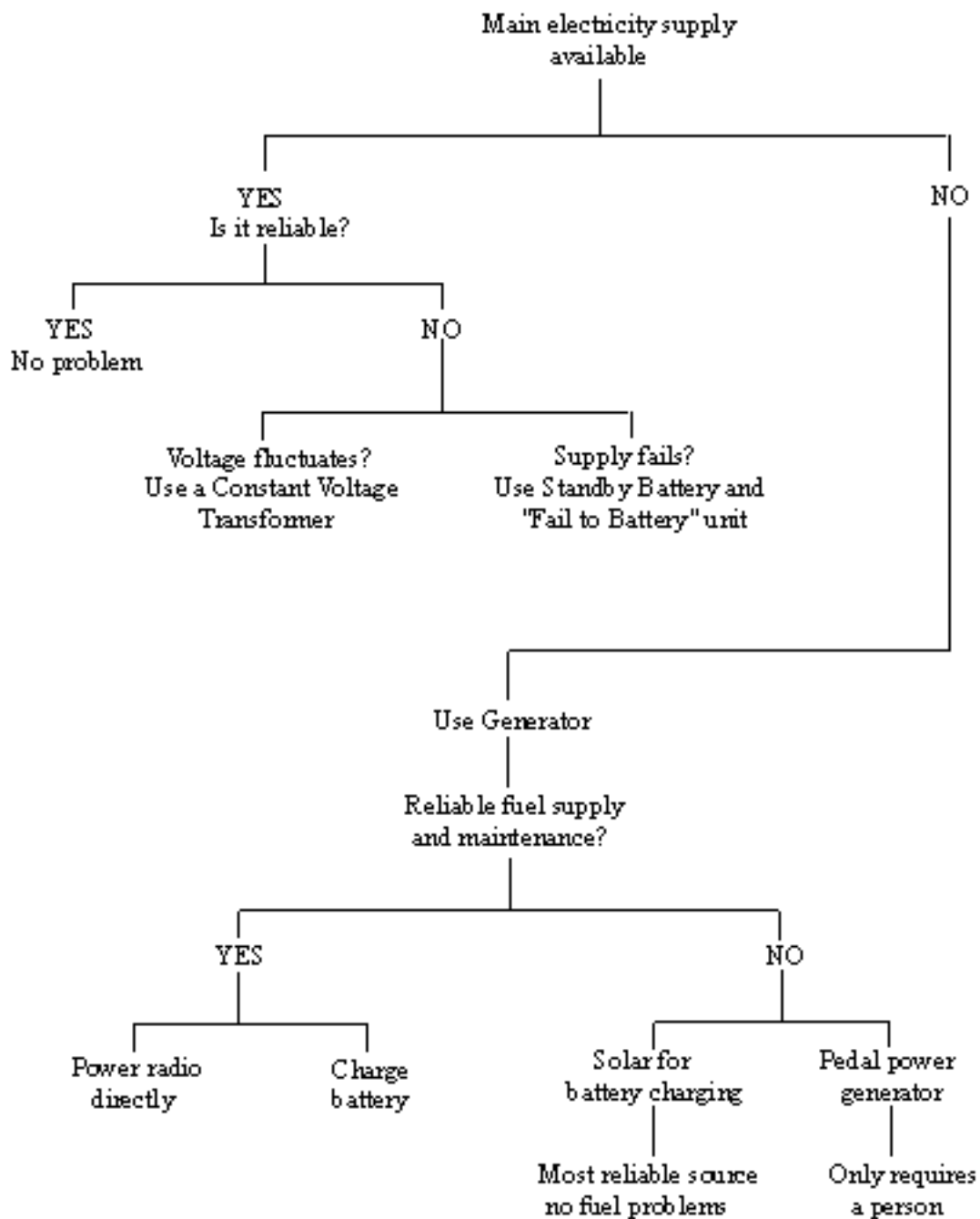
For a single channel set a single aerial will most likely satisfy your need but it will depend on your directional needs. See para.2.2.3 and 4. A single dipole can be used for all frequencies within +2% or -2% of the centre frequency for which it was cut, see para.2.2.1. Up to four dipoles can be combined with in multipurpose configuration to cover a range of frequencies see para.2.6.1. A broadband aerial, see para.2.6.2. should be considered for more than two frequencies as its cost can be competitive. Check that the all weather power rating of the aerial is sufficient for the power you will be transmitting. This is unlikely to be problem as aerial ratings of 1Kw. PEP. and above are common and your transmitted power may be a maximum of 150w. PEP.

### **5.2.3. Power Sources**

It is the externals to the transceiver that often cause the failure of a radio station e.g. microphone or power supply. Table 5.2. can be used for selecting a reliable and suitable source of electric power. For more detailed information on each source read para. 3.2. on Power Supplies. In particular note that if you choose solar power it is an advantage to have done your own calculations to obtain an estimate of your needs before you buy the panels see Para.3.2.4. One user found that the quantity of solar panels they had purchased on the advice of the supplier were insufficient for the task they had specified. It was later discovered that the supplier had intentionally underestimated the need in order to quote a

lower and more competitive price. The result was that they had to buy more panels at a later date after experiencing frustrating delays in setting up their operation.

Table 5.1. Selection of Power Source.



#### 5.2.4. Test equipment

A simple item of test equipment is the multimeter which measures voltage, current and resistance. The original multimeters consisted of a meter with a moving pointer (analogue type) and a range and function (voltage or current) selector switch. More recent versions have a numerical display (digital type) of three or four digits and automatic range selection, only requiring a function selector switch. Whilst digital displays are more robust than moving pointer types they do require a battery to power them. Examples of multimeter prices are:

Analogue type £20 to £150. Digital type £60 to £140.

Multimeters have proven useful wherever there is a radio because most people are capable of using them to measure mains or battery voltage and testing fuses. If you are equipping a radio workshop you can spend from £1,000 to £10,000. The choice of equipment should be made by the radio engineer



who will have experience and preferences. A modest workshop would contain an oscilloscope (£300 to £600), a signal generator (£100 to £200), multimeter, SWR meters, transmitter dummy load, soldering irons and various tools. The amount of test equipment necessary can be minimised by using a spare transceiver as a transmitter to provide a test signal for a receiver being repaired, then as a receiver for testing a transmitter.

### **5.2.5. Modifications**

If the modifications suggested in this section do not exist in the transceiver you select then they can usefully be added. This may be costly if performed by the radio manufacturers so you should first obtain a quotation for such work. Missions and aid agencies may have a radio engineer amongst their home base supporters who could do the modifications at low cost. However it is important to make sure a volunteer engineer is really competent to do the job before you let him touch your equipment! If you do have a radio engineer able to help you in the country where it is manufactured he could visit the manufacturer for the final testing of the equipment as this would be an excellent opportunity to check that your written specification has been interpreted as you wanted. If such a relationship with your manufacturer can be established it will give you confidence in their equipment and their ability to serve your future needs and it may be useful to them to have feedback from someone using their equipment in your particular area. Such an arrangement with one particular firm in UK has been of great help to the author. Suggested modifications will now be explained.

#### **5.2.5.1. Reverse polarity protection**

As everyone should know a 12v.DC battery (e.g. a car battery) has a positive terminal and a negative terminal. The power cable coming from your transceiver will have a positive lead which should be connected to the positive terminal and a negative lead which goes to the negative terminal. Many times these leads have been wrongly connected with disastrous results to transceivers resulting in having to replace expensive transistors. The leads on the cables should be labelled but labels can be removed and replaced incorrectly. They are also often colour-coded e.g. black negative red positive but different colours are used by different countries and by different manufacturers so causing mistakes to be made. The safest thing to do is to provide protection which will prevent the reversed voltage reaching any components should the wrong connection be made. Three methods of providing this reverse polarity protection will now be described.

##### **1. Fuse and diode.**

A diode provides a short circuit to a reverse polarity causing the fuse to blow, see Fig.5.1. In practice this configuration has not always safeguarded a transceiver because a fuse takes a fraction of a second to react and in that short time damage has been done to transistors. Also after a reverse polarity connection had been made to several transceivers the diodes were found to have been destroyed and no longer providing any protection. Without an electrical check of the diode this fact would not have been known to the user. The shortcomings of the quality control of one manufacturer was very evident because the diodes were connected directly across the supply. When a reverse polarity connection was made the diode immediately burnt out and had no effect on the fuse so giving no protection.

##### **2. Series diode.**

This is connected in series with the power supply where it enters the transceiver and will prevent current flow in the reverse direction, see Fig. 5.2. The voltage lost across a silicon diode will be about 0.6 volt, therefore only 11.4 volts will reach the transceiver from a 12 volt supply. A transceiver using an average of 8 amps on transmit will cause 4.8 watts (0.6 volts x 8 amps) to be generated as heat in the diode. Therefore this method of protection is usually found in low power transceivers e.g. up to 40 watts pep. To reduce the 0.6 volt loss which occurs across the

diode some transceivers use a series transistor with base and emitter connected which loses only 0.2 to 0.3 volt.

### 3. Relay.

The power supply has to pass through the contacts of a relay before it reaches the transceiver. The relay will only operate through D1, see Fig.5.3, when the supply polarity is correct. D2 is a suppression diode normally found across relay coils. So if you have a relay fitted in this way and you connect the transceiver to the battery the wrong way round nothing should happen as no power will go past the relay! The cost of a diode is low 1988 prices were 0.05 for 1 amp, 0.10 for 13 amps and 0.15 for 40 amps. A relay with contacts to switch 20 to 30 amps costs 0.7 but this gives good protection. Many transceiver in Zaire have had their HF power transistors wrecked because of reverse polarity and these cost 0.30 each. Another factor that makes some transceivers more vulnerable to reverse polarity damage is that their +12 volts supply goes direct to the HF power transistors as soon as the battery is connected before you switch on the set at the on/off switch, only the low current circuit goes through this switch. This problem is overcome by ensuring that the supply to all the transceiver goes through the protection diode or relay. When Low Voltage Disconnect (para.3.2.3.6) and Solar Regulator (para.3.2.6) units are used their circuitry should be protected by a series diode. It will be necessary for a radio engineer to consult the circuit diagram and possibly the manufacturer because the introduction of a protection diode will alter the voltage at which the units operate. Hence some circuit adjustment will be necessary.

#### 5.2.5.2. Microphone switches

There may be several switches on your microphone, e.g. high-low impedance and VOX, which can usually be set and left in one position. Therefore it would be safer to fix these in the required position by altering their wiring. Impedance only on the switch shown in Figs. 5.5 and 5.6, it may appear that shorting pin A to C would be sufficient but Low Impedance could still be selected. Therefore it is necessary to remove the wire from Pin C and connect it to Pin A. If a transceiver has a VOX position it means that whenever you speak into the microphone you will automatically transmit without pressing the "press to talk" control providing the microphone is switched to VOX. If you do not have a VOX facility on your transceiver or if you will not be using VOX then the microphone VOX control should be wired to the normal position.

The "press to talk" control normally operates two switches inside the microphone as shown in Fig. 5.5. One switch shorts out or disconnects the microphone during reception. This is a facility not required in most modern transistor transceivers because the power is automatically removed from the microphone amplifier during reception. This switch causes problems when it does not make good contact and often one can hear transmissions going on and off every few seconds due to an intermittent contact. When the switch is not necessary the wires should be removed from it and the microphone permanently connected as shown in Fig. 5.6. This leaves the switch free for other use. The second (transmit) switch turns the transceiver on to transmit and should be left to operate normally. However the now disconnected microphone switch can be connected in parallel with the transmit switch as shown in Fig. 5.6. to give extra reliability.

#### 5.2.5.3. Earphone socket

When earphones are plugged into their socket it is usual for the loudspeakers to be disconnected automatically. The earphones used should be of similar impedance to the loudspeaker they are replacing e.g. low impedance phones for a low impedance speaker.

#### 5.2.5.4. Squelch

The squelch control, see para. 3.1.3., can present a problem to inexperienced operators. If the squelch control is set for high level signals then weaker ones can be missed altogether. One aid agency in Kinshasa requested the help of a radio engineer because they could no longer hear any of their other stations. On turning the squelch control on the front panel the engineer was able to hear all stations without any problems. There was no fault at all in the transceiver, the operator had actually set the squelch control so high that no stations could be heard. In situations where the squelch facility will not be used the control can be wired so that it is permanently off. This can be done by removing the wire from the "variable" arm of the control and soldering it to the "squelch off" end. To indicate that this has been done the squelch control knob can be removed from the front of the transceiver.

#### **5.2.5.5. Power light**

The simple power light, see para.3.1.3., can be replaced by a two state LED (indicator light). The LED can be green when the +12 volt DC supply is in excess of say 11.6 volts and then it changes colour to a flashing red when the voltage falls below that. Supporting circuitry is necessary to operate these LEDs but this indication is particularly useful when the transceiver is operated from a battery and no voltmeter is available. A competent radio engineer should be able to design such a circuit using transistors and zener diodes. A circuit used by the author is given in Fig.5.7. The LED was Radio Spares (RS) 588-112.

#### **5.2.5.6. Internal connections**

Maintenance of a transceiver can be carried out rapidly by a technician visiting a remote location if all the main components are on plug-in circuit boards. However some transmitter HF power amplifiers have their connections made via soldered wires e.g. the high current connection to the power supply. This can be modified so that the connections to the power amplifier are routed via plugs and sockets e.g. the power supply can be via high current snap-on car electrical type connectors.

#### **5.2.5.7. Foot switch**

This is simply a foot operated version of the microphone "press to talk" switch. Pressing the foot down on it causes the radio to transmit removing the foot returns the radio to receive. The foot switch can be wired in parallel with the existing "press to talk" switch on the microphone so that either can be used.

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# WHERE THERE IS NO TELEPHONE

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Once you have obtained the radio equipment there will be an instinctive urgency to get it installed and working as soon as possible. However long term benefits should not normally be sacrificed for rapid results! The equipment should be installed by the most competent person available, see para. 5.1.4. for options regarding technician.

If you are using a technician unfamiliar with the various locations make sure you have as much information as possible about each site available for him to study before he visits them, when possible give him the opportunity of discussing a site with someone who is familiar with it. You should make sure you have all the necessary equipment ready for him to take with him and if equipment such as aerial poles need to be got locally you should advise those in charge at each location regarding the size of poles and that they are to have them ready for his arrival. Wherever possible unsuitable temporary arrangements, e.g. wiring, should not be fitted because once the transceiver is working this may never be changed. For example the limitation in performance caused by the loss of voltage in a long thin wire being used as a power lead from battery to transceiver may never be discovered. The resulting poor quality of transmissions may well become accepted as normal for that particular location whereas with more careful and proper installation things could be much improved.

You should allow adequate time for the installation by building in an allowance for delays which you, from experience, have learnt to expect. Bearing in mind the culture and traditions of the area you are in, for example, a long welcoming session before you can proceed with the work. If the equipment arrives at your HQ direct from the manufacturers in large packages it will need re-packing in suitable sizes for transporting by small aircraft, Land Rover or canoe to the various installation sites. You must ensure that any new packing is sufficiently shock-absorbent and waterproof.

Whether or not the equipment needs re-packing you should take every opportunity to check that all the items are actually there and if possible that they are working before despatching it to the various sites. Although everything is new and apparently working it is wiser for the installer to have spare parts with him to avoid delays and abortive journeys if a fault occurs during transporting or installing the equipment. Another point to consider is whether you may need documentation for the equipment you or your technician will be carrying. The need for this will vary from country to country. When you travel by air within Zaire, for instance, you have to pass through immigration and sometimes customs and you may need to prove to the authorities concerned that you are authorised to carry this equipment and that customs etc. have already been paid when it originally entered the country. So make sure that all the necessary papers are available including customs receipts, radio licences and written authority from your organisation saying who you are, where you are going and what equipment you are carrying. It is better to be prepared than to risk confiscation of the equipment.

## **6.1. Where to put the equipment**

Ideally your technician should have sufficient time at each location to supervise each step of the installation and this ought to include time for inspection of the site and time for deciding the details of where best to locate the equipment. However in practise he may have only a short time to spend on each site or you may have no technician available and so you may need to do these things yourself.

Therefore before you start any installation work look around your location and ask yourself where is the best place to put it all? Ideally you should select or build a room to house the radio equipment then clear a large area of ground of trees and any other obstructions then erect aerial poles of the required height. The solar panel would be mounted in an unshaded position and the battery would be adjacent to the transceiver. However in practice the ideal is rarely achieved. Indeed you may have little choice in locating your equipment in an existing building complex and it may not be acceptable to clear fruit trees such as mangoes which are a valuable source of food for the people. The aim should be to locate the transceiver within 25 metres of the aerial and as close as possible to the battery. It is important to locate the battery near to the radio because of the high current e.g. a peak of 20 amps, flowing in the connecting cable. However the solar panel can be further from the battery as the solar charging current may be only 1 or 2 amps.

### **6.1.1. The Radio Room**

Try to find a permanent place for the transceiver and its battery. This place will have to be secure and you may have to fit burglar bars and reliable locks. It is not a good idea to have to carry the transceiver and/or its battery from its place of use during the day to a safe storage place at night. This practice could well result in unnecessary damage being done to the equipment because of constant moving and careless handling as well as causing inconvenience to those responsible for using and moving the equipment. In one situation where only one lady was available to carry a vented battery, her tee-shirts were spoiled from acid burns which could easily have resulted in hurt to the person. There was also the problem of keeping the transceiver dry whilst carrying it through wind and heavy rain to keep a scheduled radio contact. Conversation by radio is not private in as much that anyone with a suitable receiver can listen on your frequency. You may however wish to fit the equipment in a separate room which affords some form of privacy to the operator and prevents conversations being overheard. If this is desirable but not possible then the operator can wear earphones so preventing the distant end of the conversation being overheard. Rooms in which other people are working and talking, also rooms which echo should be avoided because the sounds in the room will be picked up by the microphone and transmitted as background noise. This will not help the person receiving your transmission as they may already be listening through the crackle of static and interfering transmissions. Any form of sound absorbing screens or the "telephone hoods" as used in airports can be of help. Provision must be made for keeping the equipment dry even if this means covering it and its desk with a plastic sheet. Tropical rain can penetrate roofs, windows and doors!

#### **6.1.1.1 Radio Desk**

You should consider the ergonomics of operating the equipment and so prevent any time-wasting exercise. The transceiver should be located on a table or desk of a suitable height for the operator to sit at and where there is sufficient light for reading and writing messages. There should also be adequate space for writing and for using a desk microphone. If this is to be a busy station it is helpful to provide the operator with a foot operated switch in place of the hand operated "press to talk" switch. In Zaire desks have been made specifically to house the radio equipment. These were made of solid hard wood and with a good padlock were safe and secure. The desk was designed so that it was impossible to close it without first disconnecting aerial and power leads thus reminding the operator of the vital necessity of this action. You must not make holes in the desk for these cables to go through, see Fig. 6.1. If an aerial selector switch is used it should be within easy reach of the operator not on a distant wall. If several aeriels are used with an aerial selector switch, this switch can be fitted on the outside of the desk so that only the single cable from the switch to the transceiver needs to be disconnected. The fold-back lid of the desk can be used to display information e.g. lists of stations with their call-signs and times of operation, also the phonetic alphabet. The layout of the desk in

Fig.6.1 provides for ease of operating and hence reduces operator time. The desk microphone and foot switch give the operator two hands free for writing and referring to any documents.

### **6.1.1.2 Power supply**

Your power supply connections whether from a battery or mains should be a permanent and reliable installation from the beginning, not a temporary and unsafe mix of wires and sockets as so often has happened.

**MAINS.** A mains supply will come from a socket on the wall or perhaps a socket hanging from a cable on a wall. You should firmly fix a socket near the transceiver because long mains cables on the floor or draped round tables and chairs are a danger to people and equipment. If your transceiver has provision for an earth connection on its power lead make sure that the earth pin on the wall socket you are using is connected and actually goes to an earth point.

**BATTERY.** The battery should be located as near as possible to the transceiver. Experience has shown that the only battery in a village that is not flat is often the radio battery. Disastrous results have occurred from disconnecting the battery, taking it to a vehicle, flattening it trying to start the engine and then reconnecting it to the transceiver with the wrong polarity. Therefore the battery should be in a secure enclosure close to the transceiver. One method is to screw the wooden case in which the battery was transported to the floor, then put the battery in and secure wooden bars across the top to hold it in. If it is a vented battery there must be room between the bars for making visual inspection of the acid level and for easy topping up with distilled water.

Where for reasons of security it is impossible to keep the battery permanently in the radio room then you should install a permanently fixed cable from the battery to the radio room rather than be constantly carrying it back and forwards. If this cable is to go between buildings then for safety reasons it should go underground. The voltage drop in this cable should be as low as possible and never more than one volt and this will in fact limit the distance you can have between battery and transceiver. For guidance on this note that the thicker the metal conductor inside the cable the less will be the voltage loss. Also the lower the current flowing in a cable the less will be the voltage loss. For example a conductor with a cross-sectional area of 3.25 sq. mm. will drop one volt over a length of 15 metres when the current is 10 amps or over a length of 60 metres when the current is 2.5 amps. So if your transceiver uses 10 amps on transmit your battery must not be more than 15 metres away. The best solution is to try to have both transceiver and battery located securely in the same room.

**PEDAL GENERATOR.** A pedal generator is not very noisy and if located in a room shared with other people it will not cause any more interference than a radio operator speaking into a microphone or the sound from a loudspeaker. The generator can have the transceiver mounted on it so that one person sits on it to both pedal and operate or it can be located adjacent to the transceiver's position so that one person pedals while another does the operating. Experience has shown that if one person pedals while a second transmits then the speech transmitted is much clearer and more understandable. The generator should be in a room which is as cool and has as much ventilation as possible.

## **6.2. Installation**

A good initial installation will require much more work than a quick job of just putting the equipment on a table and erecting an aerial. But the resultant good reliability and hence availability of communications has shown that sufficient time spent on installation to be a cost-effective exercise. There can be a conflict of demands for funds in an organisation if each department is trying to keep its expenditure to a minimum. For example one department may have been responsible for funding the purchase of the equipment, another for the installation and a further for the operating. If there is no

one person with technical understanding and financial responsibility for the overall project then inefficiency can result. In one radio handbook it is written " the efficiency of communications and the long term reliability of the transceivers are critically dependent upon correct installation and the use of a suitable aerial." Your equipment should have with it both operating and installation instructions, when ordering the transceiver you should have specified a technical manual see para. 5.1.1. Always read and take note of all instructions and try to follow them but you may find that in your particular circumstances this may be a little difficult. One of the aims of this book is to help you solve problems you will not find mentioned in your technical manual.

### **6.2.1. Transceiver**

Ideally the first step in your installation should be to fit the transceiver into its chosen position as this will determine the length and routing of the connecting cables. When you have the transceiver set up with its power source ready and working then you should begin to get the aerial up because you will need the transceiver working to tune the aerial and test its effectiveness. However there are times when you may have to do it differently. For instance, if the time your radio technician can stay at a certain location is very limited it may be a good idea to get the aerial up beforehand as this can be a time-consuming exercise, always depending of course that the aerial can be sent on in advance and that there is someone at the location capable of following correctly the instructions you would need to send for erecting it. It is best to have your technician or some other competent person there to supervise all the details of the installation and this is what you should aim for. So now we will look at points concerning the installation of the transceiver.

#### **6.2.1.1. Cooling**

For security reasons the transceiver may be housed in an enclosed space e.g. the radio desk. In mains operated transceivers the regulator transistors can produce a lot of heat and require a fan to keep them cool. You should obtain the quietest fan possible e.g. axial flow type, and fix it on a sound absorbing mount if necessary. To ensure a flow of air around the transceiver it is an advantage to mount it on two pieces of wood about 2 inches square with holes drilled in the wood for any "feet" on the transceiver and the wood attached to the desk see Fig. 6.2.

#### **6.2.1.2 Microphone clip**

A hand-held or fist microphone is supplied with a clip for holding the microphone when it is not in use. The clips are intended to be fitted in a place convenient for resting the microphone e.g. dashboard of a car or the side of a desk. No provision in the form of holes, screws etc. is usually made for these clips to go on the transceiver but in practice they frequently end up attached to it. One clip was found attached by a single existing screw so that it had swivelled round and broken an indicator light on the front of the transceiver. Another example is of two holes drilled into the side of the transceiver case and self-tapping screws being used to secure the clip. Whilst this provided a firm fitting for the clip the screws protruded inside and made it very difficult to remove the case. More seriously if the screws had been put in a different place they could well have made contact with the components inside the transceiver thus causing damage to the circuits they were touching. So some thought should be given to the where and how of the apparently simple exercise of fitting a clip. When the transceiver has to be carried about it is an advantage to have the microphone clip on it because it means you do not have the microphone swinging around on the end of its cable but otherwise this should not be necessary. If you do need to fix it on the case first all remove the case from the transceiver and ensure that the screws will not touch any internal parts and that it will not make it difficult to fit the case back on. Note also the stiffness of the spring in these clips vary with the result that it is almost impossible to put some microphones in and out while it has difficulty retaining others. The spring usually takes the



form of a piece of metal the angle of which can be bent to give the required tension.

## 6.2.2. Power Supplies

Your power supply is a most vital link in your equipment e.g. with no mains and a flat battery your transceiver is useless! So it is well worth while taking time and trouble to get it right at the beginning. Experience has shown that seemingly small things like misunderstanding the colour coding of a cable for instance can have quite an effect on vital equipment. A power supply depends both on its source of power and on its connecting cables for it to work well.

### 6.2.2.1. Connections

The power and aerial connections are usually found on the rear of the transceiver. These should be made as accessible as possible for disconnecting the cables or you can fit another plug and socket in the cables in a more convenient place. Transceivers have been and still are suffering severe and costly damage because incorrect power connections are made. Some have been destroyed because 230 volts AC mains have been connected to models designed to operate on 12 volt DC only. Some of the things you will need to check are as follows:

1. Are there internal connections or switches which change the transceiver to work from 12 volt DC, 110 volt or 220 volt AC? You should be able to make the appropriate connections by carefully following your manufacturers instructions. Some models may have switches on the rear of the transceiver which require adjustment by a screwdriver.
2. Are there two power leads provided which plug into the same power socket on the transceiver? One will be for 12 volt DC and when plugged into the transceiver will be connected to the 12 volt DC input pins in the socket. The other will be for your AC mains volts and when plugged in will be connected to the AC input pins.

For AC mains operation check that the transceiver is set to operate at the required voltage e.g. 110, 220 or 240 volts and fit a suitable mains plug i.e. of the type normally used in your area. This will avoid any confusion in the future. For DC operation there will be a positive and a negative wire which should be terminated in different connectors which are not interchangeable and which can be easily identified as positive or negative. If you are not using such connectors and have to remove the insulation from the wires to attach them to the battery terminal make sure that they are clearly labelled as positive and negative. A common fault in 12 volt DC supplies is the wrong polarity connection being made but transceivers can be safeguarded as explained in para.5.2.5.1.

### 6.2.2.2. Colour Coding

One reason for mistakes being made is due to the colour coding of the cables because no world-wide standard exists. As a result the colours of the cables in your equipment will depend on what each individual manufacturer decides or on what is demanded in the country of manufacture. Some combinations of cable colours which have been seen in use are listed below.

Table 6.1 Examples of Colour Codes Seen.

#### AC Mains.

Example.	Phase or Line.	Neutral.	Earth.
1.	Black	White	Green
2.	Brown	Blue	Grey/Yellow
3.	Brown	Blue	Green/Yellow

**Cables on 12 volt DC transceivers.**

<b>Example.</b>	<b>Positive.</b>	<b>Negative.</b>
1.	White	Black
2.	Brown	Green
3.	Red	Black

**Cables on Solar Panels.**

<b>Example.</b>	<b>Positive.</b>	<b>Negative.</b>
1.	Brown	Blue
2.	Black	Blue
3.	Red	Black

This lack of standardisation has led to mistakes being made. An example of this was when a person making a connection on a 12 volt transceiver which had black as negative and white as positive was himself familiar with the AC mains system which has black as line and white as neutral with the result that he mistakenly assumed that on this transceiver black was positive and white was negative. If different coloured wire is going to be used for the same voltage connections then the cables should be labelled to show what voltage and polarity they carry and a wiring diagram should be provided. However in practice labels can come off and diagrams be lost especially if there are changes in staff. One can always tie a knot in the positive cable to identify it. It is recommended that you decide on a colour code for your wiring which will be used for all the equipment in your network, for example the traditional colours in UK for DC wiring was red for positive and black for negative. These should be used throughout the wiring from solar panel and regulator to the battery and the transceiver. Where necessary you should change the existing cable. Whilst this will involve additional cost it could well be repaid in saving future catastrophes such as the inability of a different person to reconnect any wires which have become disconnected.

**6.2.2.3. Plugs and sockets**

Plugs and sockets which will only fit together in one orientation will have a locating lug and key-way to ensure a correct fit. If the plugs are often pulled out e.g. for the power supply, it is worth painting matching halves of the plug and socket in the same colour, but one that contrasts with the rest of the radio. This will assist the person to fit the plug correctly and should reduce attempts at forcing the plug in the wrong way.

**6.2.2.4. Solar Panel****POSITION.**

In Equatorial regions the solar panel can be mounted nearly horizontal. Rain will clean the surface of the panel but there must be sufficient slope for it to run off. e.g. 15 degrees from the horizontal. Panels installed north of the equator should slope towards the south, those south of it should slope northwards. An approximate guide is to make the angle of slope equal to the number of degrees of latitude of the geographical location. The panel should have an uninterrupted view of the sun especially from 9 a.m. to 3 p.m.

**FIXING.**

When a panel is mounted on a metal roof note the following;

- (a) it should be spaced at least 2 inches off the roof on pieces of wood to allow for cooling.
- (b) the metal roof should be electrically connected to earth.
- (c) the panel should be mounted below the highest point of the roof unless it is protected by lightning arrestors.

Solar panels have been installed on thatched roofs, this presents no problems provided the panels are mounted on a wooden frame which rests on the thatch. Wires can then be easily passed through the roof and secured inside either to the existing roof frame or to extra lengths of wood attached below the roof frame. In fact panels can be mounted on any suitable structure e.g. a wooden frame at ground level if this can be safe and secure. The extent to which it is mechanically screwed to its mounting will be determined by both the local type of storms and to the probability of it being stolen. Always use rust-proofed screws, do not use nails to secure the panel.

## DIODES.

A blocking diode may have been fitted to the solar panel during manufacture, see para. 3.2.5.1. to para. 3.2.5.5. for description of various diodes. It is recommended that the blocking diode be removed or if this is not practical then shorted out and one should be fitted instead near the battery. The reason for this is that these diodes have been destroyed by lightning and so needed replacing. It is so much easier to test and replace a diode in the radio room than when lying on your back on a hot tin roof trying to work on connections underneath a solar panel. The diode connections should be made to rigid points e.g. soldered lugs rather than just connected to flexible cables as the movement of such cables could break the diode leads.

## REGULATORS.

Where a solar regulator is used it may have a blocking diode within it. If the regulator is the "dump" type see para.3.2.6. you should mount the resistors so that they have a free circulation of air because they become very hot and should not be touched.

### **6.2.2.5. Battery**

## TRAVEL.

New batteries are available "dry-charged" i.e. there is no acid in the battery but it is partly charged. If you are travelling by air you may not be permitted to take a battery filled with acid so either a "dry-charged" one or a sealed one would be necessary. Do not forget to have sufficient battery acid available to fill the "dry-charged" one when you reach your location. The acid required will have a SG in the region of 1.240. Note that the battery will get very hot when it is filled with acid and the metal connections may be too hot to hold.

## SECURITY.

Where there is need to prevent misuse of the battery as mentioned in para. 6.1.1.2. you can further safeguard it by sawing off the battery lugs along the dotted line in Fig, 6.3. Spade terminations of the type used on vehicles can then be attached by self-tapping screws or soldered to the lug. If available use a wider spade for the positive than for the negative. You can also paint the positive red and negative black or blue and scratch + and - on the battery as a further means of identifying polarity. If a vented battery is used and it is not housed in a wooden crate then stand it on a solid piece of wood larger than its base or in a plastic tray. This will prevent on overflow of acid from reaching the floor.

## CONNECTIONS.

The cables connected to the battery should be via proper battery connectors. Crocodile or other types of clips are not suitable for permanent use. Not only do they make poor electrical connection, especially as their teeth wear away, but they also wear away the battery lugs so preventing future use of proper connectors. The position of the positive and negative lugs are not the same on all batteries. Usually the lugs are both on one side of the battery so that if you turn the battery round the position of the positive and negative terminals are reversed. So if it has had to be moved do not automatically assume that the positive is still on your right, for instance, as it was before, but always carefully check that you are reconnecting to the correct lug. When you install the power leads for the battery make them sufficiently long for connection to a different size and shape of battery for sooner or later you will need to replace it. Whatever method of connection is used on the battery all the metal parts must be covered with a good layer of an anti-corrosion grease.

### 6.2.2.6. Fail to battery

At least one make of transceiver has a 6 pin input power socket which accepts a cable and plug either from the AC mains or from a 12 volt battery. However the mains plug serves a second purpose by completing another electrical circuit because two of its pins are shorted. Therefore if you are installing your own "fail to battery" relay and circuit first check in detail what is connected to each pin of the transceiver power socket. A simple "fail to battery" circuit was described in para.3.2.1.2.

### 6.2.3. Protection against lightening

Another point to consider before commencing installation which many people are not aware of is lightening protection. When broadcast receivers first came into use in the early days of radio they used a long piece of wire for an aerial. This aerial had always to be disconnected from the receiver during storms to protect it from lightening strikes. So most people who used radios were aware of the problem. Today people are used to having portable transistor sets which have their aerials built in to the set so that the question of disconnecting aerials during thunderstorms never arises. When it comes to short wave transceivers the users must be made aware of the damage that can be caused by lightening and must be instructed in the necessary precautions. This is particularly important in countries such as Zaire where thunder and lightening are very frequent occurrences. For instance Kenya has a National Lightening Protection Committee which arranges the installation of lightening arrestors within that country. Where there is no such official advice and help available it is absolutely necessary to alert the radio communications users to the possible dangers and how to cope with them. Lightening can cause the failure of costly transistors and other components within a transceiver and can even destroy it altogether. It can also cause injury to the operator who attempts to use it during thunder or even to someone who happens to be by a radio at the moment of a lightening strike. The lightening reaches your transceiver by way of the aerial cable and in some cases by the power supply cable. We will now look at some of the ways lightening protection can be provided.

#### 6.2.3.1. Arrestors

If you are not familiar with lightening arrestors take a look at the highest point of any building in your area. You may see lightening arrestors with several spikes pointing upwards and connected to earth by a thick metal conductor. The expectation is that lightening will take the easiest path to earth via the arrestor thus safeguarding the building etc. on which it is mounted. Arrestors can be mounted near to but higher than solar panels to give them protection. The conductor to earth should be capable of carrying 50 amps. A good earth can be made by burying a 6 foot water pipe or metal rod and keeping the ground damp.

### **6.2.3.2. Aerials**

There are several methods of stopping lightning passing through the aerial and reaching the transceiver. The safest method and the most simple which has not been known to fail is to always disconnect the transceiver from the aerial after it has been used and never to use it during a thunderstorm. You must ensure that the radio operator has been given these instructions and understands their importance. Also these instructions should be displayed in a prominent position and in as many languages as may be necessary so that if someone other than the normal operator is using the transceiver they will know what to do. After disconnecting the aerial it can either be connected to earth or just left "floating" i.e. not connected to anything, but it should not be left within 30 cms. of the transceiver. Other methods of protection include gas discharge lightning arrestors which can be screwed into the coaxial cable between the aerial and its transceiver.

### **6.2.3.3. Transceiver**

A limited form of protection is often found in transceivers in the form of "back to back " diodes connected across the receiver input. Both normal rectifying diodes and zener diodes have been used in this role. Transceivers powered from solar charged batteries should be disconnected from the battery when not in use because lightning striking the solar panel could be conducted to the battery and hence to the transceiver.

### **6.2.3.4. Static**

Users of transceivers in dry desert areas across Africa have complained of getting an electrical shock when they touch the aerial or the transceiver to which the aerial is connected. The reason was because of a build up of static electricity on the aerial. In such situations it is necessary to have an aerial switch or other arrangement which earths the aerial either all the time that the transceiver is not in use or at least just before the aerial is connected to the transceiver to discharge the static. Its case should also be earthed to avoid the build-up of static.

## **6.2.4 Aerials**

An aerial properly installed can stay up and operate correctly for many years. Therefore it is worth allowing sufficient time, for example several hours, for aerial erection. Attempts at forward planning are not always successful in some cultures. The sending of messages to one village to cut two straight 12 metre poles from the forest and have them ready for a certain day resulted in no poles being available that day! However, as soon as the technician arrived in the village the men departed to the forest, returning with the necessary poles four hours later. Whenever it is possible a competent person should install the aerial. Whilst it is time consuming for a technician to spend days away from his workshop, it is nevertheless a worthwhile exercise. There are many examples of incorrectly installed aerials. For example, in Zaire an aerial has been found erected at 90 degrees to the required direction and one where the coaxial cable was tied to the top of one of the poles while the one end of the aerial was almost on the ground! In Tanzania an aerial was supplied of the correct length but during installation pieces of the aerial had been cut off to make it fit between two posts.

### **6.2.4.1 Aerial Supports**

Survey the site and decide the best location for the aerial and what sort of support you are going to use e.g. existing buildings and trees or poles.

1. Anchor points on buildings. Make sure that they are strong and secure enough to hold the weight of the aerial. Facia boards are not normally satisfactory. If metal hooks are fitted to

wooden beams be aware of the fact that some woods rot rapidly in the tropics. Ensure that the aerial or its associated wire or rope will not rub against adjacent walls or overhanging roofs whilst swinging about in strong winds.

2. Trees. Palm trees can frequently be found in convenient positions to support aerials but the fronds need to be kept cut so that they do not foul the aerial. It should be allowed to hang a little slack because of the movement of the palm tree in storms could break a tight aerial. The same considerations apply to other trees used as supports. Fix the aerial to a rigid part of the tree, not on thin branches which wave about in storms.
3. Metal masts. Where no suitably located buildings or trees are available then aerial masts can be erected. Masts can be made from metal tubing e.g. galvanised steel, aluminium etc. depending on what is available. They will require guy wires about every 4 metres, depending on the strength of the pole material used. At least 3 guy wires are necessary at each point to give all round support. Barbed wire has been successfully used for aerial guys. If it is thought that the aerial will remain in the same place for many years then the mast and the anchor points for the guy wires can be set in concrete.
4. Wooden poles. In Zaire 12 metre wooden poles set into 2 metre holes in the ground have been used as aerial supports. Although the poles were painted with used engine oil some rotted after 3 to 5 years and had to be replaced. If set firmly into the ground these should be self-supporting and not need guys.
5. Movable bases. A mission in Zaire has found that they have had to relocate aerials because the radio room has had to be changed to different buildings. Hence they are trying out a movable aerial base made from pieces of steel e.g. two 1 metre steel bars in a cross and also old vehicle wheel hubs as anchor points for guys. These bases are all buried several feet underground but can be dug up when necessary.
6. Guidelines. The following should be aimed for but may not be achieved. Do not put the aerial parallel to electric power lines or other long pieces of metal wire. Do not suspend the aerial above a tin roof. Have some 20 metres of clear ground in front of the aerial, that is in the direction the power in it is to be transmitted. A horizontal dipole can be supported at each end. If thick co-axial cable is used then an extra pole can be used to support the centre of the aerial. Do not let either of the aerial wires touch this pole, it should be attached to the central insulator. A central support is necessary for inverted-vee aerials, see Fig. 2.5.

#### **6.2.4.2. Aerial adjustment**

The aerial will have been cut either to the correct length or if you have so specified to some 10 cms. too long to allow for tuning after erection. Ideally it should be possible to raise and lower the aerial by means of halyards of nylon rope and pulleys. One disadvantage of nylon rope was that after several years of exposure to the sun in equatorial Africa the rope broke easily. Also in some places a rope halyard is an attractive item and could well be stolen. Hard-drawn wire has been used instead as it is more durable and less noticeable than white rope. An alternative is to use an aerial clamp of the type shown in Fig, 6.4. This was developed by apprentices in Britain to serve the special requirements of being able to raise and lower for initial tuning then to leave the aerial erected whilst being able to recover the ropes. The aerial can be pulled up and lowered by the rope loop A. When adjustments are complete the aerial is pulled up and the eyelet will automatically be above the hole in the base. The rope loop B is now pulled down causing the metal rod to come down through the eyelet and to lock into the hole in the base. The ropes A and B are no longer needed and the knots in them can be untied enabling both of them to be pulled down to earth.

#### **6.2.4.3. Erection**

Do not attempt to erect an aerial if lightning can be seen or thunder heard. The length of the aerial together with its required direction and height will be determined from Chapter 2. Now comes the task of putting these theoretical ideals into practice. If the aerial is not going to be lowered for tuning then it should be the calculated theoretical length before erection. See para.2.2.1.

Having decided how and where the aerial will be erected uncoil it and its coaxial cable ensuring that there are no twists or kinks in it. If possible lay it out on the ground below where it is to be raised. This will confirm that the aerial supports are sufficiently far apart. Measure the length of each piece of aerial wire as a final confirmation that the aerial length is correct. These checks are necessary as shown by the following experience. While looking at two dipole aerials which had been in use for some years in Zaire one did not "look right". Its SWR was checked and found to be 4 which was much too high. It was lowered to the ground and measured. One wire was the correct length of 12.3 metres but the other wire was 10.1 metres which happened to be the correct length of the two wires on the other aerial. A possible explanation is that there was a mix up of wires during manufacture of the two aerials.

Check the length of coaxial cable on the aerial although you know how long it should be, 25 to 30 metres are typical lengths fitted by manufacturers unless you specify a special length. Also ensure that the coaxial cable is secured to the centre insulator and not left to hang only from its coaxial plug. Wire or nylon rope can be used between the aerial insulators and the tree, pole or building on which it is suspended. See Fig. 2.1. If wire is used check that it does not touch the aerial wire. Also do not use pieces of wire whose lengths are the same as or within 1 metre of the length of any one piece of aerial wire or any multiple of aerial wire length. For example, a dipole for 7.305 Mhz will comprise two pieces of wire each 9.76 metres long. Therefore the supporting wire should not be between 8.76 to 10,76 metres, 18.52 to 20.52 metres etc. This is because such wires can be resonant parasitic elements and can have a detrimental effect on the aerial.

Having taken these necessary precautions and having securely fastened the aerial insulators to their supporting wire or rope you are ready to raise it into position. Note that your supporting wire or rope at this stage should be considerably longer than the amount you will finally need otherwise you will be unable to lift it into position especially if someone has to climb up a tree or ladder to fix it. The excess should not be cut until it is firmly and finally attached to its support. First raise and secure one end firmly to its point of suspension whilst taking care to remove any twists or kinks in wire and cable. If a pole is to be used to support the centre insulator, then erect this next, checking the aerial wires do not touch anything. Then the other end of the aerial can be raised and secured by its wire or rope to its support being careful all the time not to twist or make kinks in the wires and removing any that appear.

For aerials supported between solid buildings or rigid metal poles pull the supporting wire or rope until the aerial is reasonably straight. For aerials supported by trees let the aerial sag in the middle by up to 1 metre. If an aerial is 20 metres long and allowed to sag by 1 metre this will only permit an outward movement of 5 cms in both trees before the aerial is horizontal and tight. However it can be argued that the wind will be blowing both the trees in the same direction hence reducing any strain on the aerial. If thin wooden poles are used without guy ropes it is wiser to allow a little sag as a too tight aerial could cause the poles to break in a strong wind. Once the aerial is in position the coaxial cable can be routed to the radio room. The cable can be afforded some form of protection against damage by suspending it on poles some 3 or 4 metres above the ground. Do not use thin wire to attach the coaxial to the poles as this will cut into the cable. Either put some solid material between the wire and the cable or use cord or other broader material that has not any sharp edges.

#### **6.2.4.4. In the Radio Room**

When routing the coaxial cable to the radio room ensure that it does not rub on any rough surface or sharp edge e.g. the edge of a tin roof. Do not put too much pressure on the cable when making a bend rather let it be in a gentle curve. If there are several metres of aerial cable spare when it reaches the transceiver do not cut off the cable as it may be required if the radio is moved in the future. Do not coil up the excess cable but try to lay it out straight, in the roof space for example. Where the installation involves more than one coaxial cable label each one immediately you bring it into the room to avoid future confusion. SRoute the cables to the radio desk and then either to the aerial switch or to the transceiver. Aerial switch positions should be numbered e.g. 1 to 4. and the aerials connected so that they correspond with the channel number which they serve on the transceiver i.e. Aerial position 3 serves Channel 3.

#### **6.2.4.5. Fitting a plug to a coaxial cable**

The cable from your aerial will normally be a coaxial cable of which there are 2 common sizes. A thick one which is approximately 10 mm diameter and includes types RG 8/U, RG 213/U and URM 67. A thin one which is approximately 5 mm diameter and includes types RG 58/U and URM 43. The plug in common use is a PL-259, an additional adapter being required for fitting thin cable. If you have never soldered a plug to coaxial cable before it is recommended that you practice preparing the cable end using an extra piece of cable. Do not actually solder the plug on the practice cable. Step by step instructions for large size coaxial cable i.e. 10mm. Refer to Fig. 6.5.

1. Cut the coaxial cable (coax) to the required length.
2. Unscrew the coupling ring from the plug and put it onto the coax with the threaded end nearest to the cut end of the cable. Note. The coupling ring must be put on the cable first as it cannot be fitted after the plug has been soldered to the cable.
3. Remove 28 mm. of the outer sheath which is likely to be made of black plastic. This can be done by cutting round the sheath with a knife.
4. Using a small tip soldering iron and small diameter solder, apply solder to the braid from the point where the sheath finishes for some 15 mm along the braid.
5. Now cut the soldered braid, but not the inner insulation, with a fine saw or small tube or pipe cutter at 11 mm from the end of the sheath.
6. At a point 2 mm. from the cut in the braid now cut through the inner insulator but not the central conductor. Remove the cut piece.
7. Check that the coupling ring is still on the cable as instructed in step 2.
8. The cable is ready for fitting the plug. Gently screw the plug on to the cable ensuring that all the central conductor is inside the hollow central pin of the plug. Continue to screw the plug on to the cable, the thread on the plug will grip the black outer sheath and then the soldered braid should be seen through the solder holes of the plug.
9. With a small soldering iron with a small bit apply solder in the holes and solder the braid to the plug. Be careful not to overheat the cable in the plug.
10. Solder the central conductor where it protrudes from the central pin. Now cut off any wire protruding from the pin and remove any excess solder.
11. Screw the coupling ring on to the plug and check that the assembled plug will screw into a socket.
12. If the far end of the cable is disconnected i.e. not yet connected to an aerial balun or a transceiver etc. then electrical tests can be performed on the cable.
13. If practical check there is contact, i.e. a resistance of only a few ohms, between the central pin



of the plug and the distant centre of the coax. Also between the outer coupling ring and the braid at the distant end of the cable.

14. Provided there is nothing connected to the distant end of the coax check that there is a high resistance between the inner and outer connections to the cable. A resistance of 1M ohms or more can be expected. Note that if you are touching both the inner and outer conductors or both the metal parts of the meter probes, then you will be measuring your body resistance which could be only 200K ohms.

Fitting a plug to thin coaxial cable i.e. 5mm. e.g. RG-58A/V or URM43 or URM76. You will require the same plug PL-259 but also an adapter (Type UG-175/V) or reducer to enable the smaller diameter cable to be secured into the plug. Step by step instructions. Refer to Fig. 6.6.

1. Cut the coaxial cable (coax) to the required length.
2. Push the cable through the centre of the adapter such that the narrow end of the adapter is nearest to the cable.
3. Unscrew the coupling ring from the plug and put it onto the coax with the threaded end nearest to the cut end of the cable. Note. The coupling ring must be put on the cable first as it cannot be fitted after the plug has been soldered to the cable.
4. Remove 18 mm. of the outer sheath which is likely to be made of black plastic. This can be done by cutting round the sheath with a knife.
5. Ensure that the end of the adapter is level with the outer sheath.
6. Now cut the outer braid, but not the inner insulation, with a pair of small scissors at 10 mm from the end sheath. Remove the cut braid and fold the remaining braid back over the adapter. If necessary further trim the braid so that there is only 10mm folded over the adapter and it does not reach the tread.
7. At a point 2 mm. from the braid now cut through the inner insulator but not the central conductor. Remove the cut piece of insulation.
8. Apply solder to the central conductor.
9. Check that the coupling ring is still on the cable as instructed in step 3. and ensure that the braid is folded back over the adapter.
10. The cable is ready for fitting the plug. Gently screw the plug on to the adapter ensuring that all the central conductor is inside the hollow central pin of the plug. Continue to screw the plug on to the adapter, then the braid should be seen through the solder holes of the plug.
11. With a small soldering iron with a small bit apply solder in the holes and solder the braid to the plug. Be careful not to overheat the cable in the plug.
12. Solder the central conductor where it protrudes from the central pin. Now cut off any wire protruding from the pin and remove any excess solder.
13. Screw the coupling ring on to the plug and check that the assembled plug will screw into a socket.
14. If the far end of the cable is disconnected i.e. not yet connected to an aerial balun or a transceiver etc. then electrical tests can be performed on the cable.
15. If practical check there is contact, i.e. a resistance of only a few ohms, between the central pin of the plug and the distant centre of the coax cable. Also between the outer coupling ring and the braid at the distant end of the cable.
16. Check that there is a high resistance between the inner and outer connections to the cable. A resistance of 1M ohms or more can be expected. Note that if you are touching both the inner

and outer conductors or both the metal parts of the meter probes, then you will be measuring your body resistance which could be only 200K ohms.

#### 6.2.4.6. SWR measurement and aerial tuning

The meaning of SWR has been explained in para 2.1 To measure SWR first familiarise yourself with the particular SWR meter by reading the instructions. However in many instances these are not available having been lost or mislaid. Examples of such instructions are: For single meter units there will be a switch labelled REF/VSWR or SET/READ or similar. Put the switch in REF or SET position and connect the meter between the transmitter and the aerial taking note of the labels on the sockets of the meter e.g. "Transmit" and "Antenna". With the transmitter giving a continuous output adjust the meter's variable control for the meter pointer to be at the REF or SET level on the dial. Methods of obtaining a continuous output can be obtained from the transmitter by:

- (a) connecting a 2 tone oscillator into microphone socket
- (b) unbalance the carrier null control.
- (c) whistle or sing a continuous steady note into the microphone.

Now switch to VSWR or READ and note the meter reading which is the SWR. For two meter units: One meter reads power output to the aerial and the other the SWR. A variable control will need to be adjusted so that the power meter needle reads either full scale or at the SET position. The other meter now indicates the SWR. **SPrecaution** : never disconnect the aerial from the SWR meter when the radio is transmitting. The higher the SWR the less effective is the aerial. An indication of the percentage of power wasted i.e. reflected back from the aerial is given in Table 6.1.

Table 6.1.

<b>SWR</b>	<b>% reflected power.</b>
1.1	0.23
1.3	1.7
1.5	4.0
2.0	11.0
3.0	25.0

The SWR can be measured once the aerial has been erected. For aerials that are difficult to take down and alter their length a SWR of 1.5 or less is acceptable and the aerial can remain as erected. For aerials that can be taken down easily the SWR should be adjusted to the minimum possible. To tune a dipole aerial first note its reading when erected e.g. 1.8. Lower the aerial and reduce the length of BOTH pieces of aerial wire by 3 cms. Do not cut the wire but twist it around the wire as shown in Fig. 6.7. Re-erect the aerial and measure its SWR, this could be for example 1.5. If at one stage the SWR rises after you have shortened the aerial increase the length again using some of the extra wire you have twisted around the aerial. Do not cut off the extra wire until the aerial tuning is complete.

### 6.3. Final Checks

All the preparations and the good installation should be rewarded by a good radio contact when you test the completed system. Arrangements should be made for a test contact at a specific time so that someone is listening specially for you but a final series of checks should be performed before the test transmission.

#### 6.3.1. Power

1. Connect an ammeter in series with the solar battery charger. Record the value of charging current noting whether bright sunshine or dull and also the battery voltage.
2. Record the battery voltage with the transceiver:  
(a) switched off (b) on receive. (c) transmitting with a whistle or singing a continuous and steady note into the microphone. These measured voltages will depend on many factors, you could expect the voltage to fall by up to 0.5 volts when transceiver is switched on and by a further 1 volt during continuous transmission.
3. Connect a SWR meter in the aerial circuit next to the transmitter. Set the meter calibration control so that it reads power output at the particular frequency of transmission. Transmit by using a 2 tone Test Generator or by making a continuous loud note into the microphone. The meter should indicate a power output some 40 to 60 watts for a 100 to 150 watt pep transceiver providing the SWR is below 1.5. Higher SWR will result in a lower power output. Measure and record the SWR and power output for each channel with the transceiver connected to its appropriate aerial.

### 6.3.2. Netting

You will have specified the frequency of each channel in your transceivers when you ordered them. However the crystals in each set, although made to the same frequency, can differ by several hundreds of cycles. This difference sometimes can be heard when listening to a network of several stations. With the clarifier control set to give clear speech from one station when the next station speaks it can be necessary to adjust the clarifier and to readjust it when the original station is on again. This problem can be overcome by adjusting the frequency of all the transceivers to exactly the same frequency, a process called  
NETTING

Ideally this will have been done already if:

- you have an accurate frequency counter i.e. one which reads to 1 or 10 cycles, and have set the crystal trimmer to give the exact frequency.
- you have brought the transceiver from your HQ station where you have netted the crystal to the frequency of that station.

If it has come direct from the manufacturer or has been used on another network, then check that it is netted onto your HQ station. The method of netting of each different make should be explained in the technical manual of the transceiver and some manufacturers e.g. AEL, make provision for this to be done in the field after the transceiver has been installed. You must consider how and when you are going to net your transceiver before leaving for your installation visit. However, if you do not have the technical knowledge or ability to net the transceivers it is not a major problem but simply means that all the stations will have to make greater use of their clarifier controls. As the crystals age so their frequencies change hence further netting can be performed. In an ideal situation this would be done after 3 months and 6 months and then annually. In reality many networks function without this being done.

### 6.3.3. Operating

Remove all your test equipment and go through the procedure of switching-on connecting any cables as described in the instructions. Let the operator perform all the operations and make a radio contact with another station at a prearranged contact time. At the same time you may check the operators method of sending and receiving and recording messages. Then let the operator switch off and disconnect any cables necessary. This sounds like an organised and controlled exercise however it can

become chaotic as has been our experience of installing transceivers in remote African villages where these are to be controlled and operated by local people. You may have many interested villagers surrounding the building and blocking the light through the windows. For them to hear the voice of a known person hundreds of miles away causes great excitement and everyone in any position of authority wants to speak. So it is a good idea to try to instruct the operator in advance of the initial formal contact in as quiet a situation as possible.

#### **6.3.4. Look around**

Take a final look around and check to see if all is well with the equipment and that nothing has been moved or disturbed by all who had crowded into the room to see it working. Check that the cables on the outside have not be disturbed as well. Collect up all your tools and test equipment and make any final notes regarding the particular installation, especially the non-standard features as these are important for your central records and for future maintenance plans. Make sure that operating instructions and all other necessary information is left with the operator or person in charge in a secure and available position. Make sure they know how to top up the acid level in the battery and how long they can use the radio for each day whilst keeping the battery fully charged. After completing the installation of a system with a solar-powered supply designed for the needs of that particular station one usually gets asked questions such as: "Can we run a light off the radio battery in the evenings?" or "Can we charge another battery off the solar panel?" The answer must normally be "No, because then you will not have sufficient power for your radio and your equipment may be damaged by careless and incorrect connecting and disconnecting of the battery". Many faults have arisen from incorrect connections and radio batteries have been flattened and their lives shortened by extra or unauthorised loads. Impress on all concerned that the reliability of their radio link depends very much on how they use it and how they take care of their power source. Expatriate personnel are often very guilty of mis-use of batteries provided for radio use only. Where the radio battery may be the only fully charged one around there is a great temptation to use it for personal reasons but it must be understood that this must not happen.

### **6.4. Mobile Installations**

Many HF SSB transceivers with power outputs up to 150 watts PEP are designed so that they can be used equally as well in vehicles or as a base station. Care must be taken in the mobile installation so as to make best use of this facility.

#### **6.4.1. Transceiver**

The mobile transceiver should come with its manufacturers special mobile mount. A common place to put it is below the dashboard in front of the passengers seat. This is a good location in as much as it provides some shading of the transceiver from direct sunlight and it can be operated by the passenger. Enough legroom should be left for the passenger if long duration journeys are undertaken. The mounting should allow the transceiver to be easily fitted and removed by authorised persons but some form of lock may be necessary for security reasons. A fist or hand microphone must be used and a clip for securing it fitted on or near the transceiver.

#### **6.4.2. Power supply**

A 150 watt pep transceiver operating from a 13.6 volts vehicle supply requires an average current of some 12 amps with a peak demand of 18 amps. Because of this relatively high current demand the transceivers power cable must be connected to the vehicles electrical system at a point where sufficient current is available. The current for the transceiver must not flow through any of the

existing fuses because the fuse rating will only be sufficient for its present circuit. The cigarette lighter socket is not suitable for high powered sets though it could be used for 4 watts CB sets. The above constraints demand that the power cable for the transceiver must start from the vehicle battery and that you should install a 20 amp fuse in the cable. The nuts on the battery lugs on many vehicles were found to be worn round hence a grip rather than a spanner was necessary to release the nut. Also lugs were found loose on battery terminals as the terminals had worn thin hence some packing was necessary to ensure a reliable contact to the battery.

### **6.4.3. Aerial**

You may have observed many vehicle aerials mounted on or near the rear "bumper" or "fender". This is not a good position because of the proximity of the vehicle body effects both the tuning of the aerial and the horizontal directions in which power is transmitted. Whilst mounting on a front wing is an improvement the centre of the roof is the most suitable location. The aerial will require tuning after installation Follow any instructions which you have concerning the tuning up of your particular aerial. For example a single frequency aerial can have a coil in the middle and a top section of stainless steel rod some 2 mm diameter. This aerial will have been designed so that 2 to 5 cms of the rod can slide into a housing and be locked by a screw. This enables the length of the aerial to be adjusted by several centimetres for tuning. If the rod is too long then cut off a centimetre at a time to achieve the lowest SWR. If you intend to use the vehicle for journeys with the complete aerial mounted then ensure that the aerial base is secure on a strong part of the vehicle body. The thin metal of a wing or a roof can become distorted by the force of the aerial when travelling so the body may need reinforcing. It is recommended that the aerial be completely removed from its base and carried inside the vehicle for journeys through the jungle. Otherwise overhanging foliage, bamboo etc. could soon damage it.

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# WHERE THERE IS NO TELEPHONE

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There are two main requirements that have to be satisfied if you are to have a radio network which is useful, effective and efficient. The first is that the radio equipment satisfies the operational need, i.e. you can talk reasonably clearly with all the stations you want to. Ways of satisfying this requirement are covered in the previous chapters. The second requirement is equally important, it is that the network is so operated that it satisfactorily serves the needs of all its users. It is not just a case of finding someone to speak on the radio but serious consideration must be given to the choice of operator, the method of controlling the network of stations and the handling of outgoing and incoming messages. For instance, the advantage of having a well organised and clear speaking operator is that he will require far less time operating the radio. This not only means that he will occupy less time himself on the radio but also all the people he speaks to will >also require to spend less time on their radios. Less time operating means less power discharged from the battery where this is the power source. This will give a longer life to the battery, and a better performance from the transceiver, particularly where a solar charger is in use.

## **7.1. Choice of Operator**

Your aim should be to use a person whose ability is best suited to the demands of the operating but in reality your choice may well be limited. Despite all the properties you are looking for in an operator there may only be one person available. Did you consider making provision for an additional person to be paid as an operator, see para. 5.1.5.? If operating the radio is an extra job given to an already busy person then the result may not be good. One missionary in Zaire said " I would not want to be without the radio but the time you spend operating it detracts from your other principal work." However your system will work only as well as your operators play their parts.

### **7.1.1. A Good Operator**

The qualities to look for in a good operator should include:

1. A clear speaking voice without a too strong regional accent.
2. A good hearing ability.
3. An ability to remain calm and controlled when under pressure.
4. Enthusiasm for the job.

5. Good time-keeping. i.e. being there at the radio and prepared for the contact before it starts, also waiting until its over before switching off.
6. Patience and perseverance i.e. for repeating and confirming messages when reception is difficult.
7. Fluency in language .
8. An ability to understand the controls of the equipment.
9. A good memory. i.e. for callsigns.
10. Ability to keep accurate records.
11. A sympathetic and friendly approach to other operators while keeping the messages as concise and businesslike as possible.
12. Have good handwriting ability.

### **7.1.2. Control or HQ Station**

This is the vitally important station. A careless operator at HQ who overlooks sending messages or does not pass them on correctly will cause more frustration than if you did not have a radio network. Here there are two options open in the choice of operator. Either the person responsible for the administration and organisation of your group does the operating himself or herself, or he or she decides to employ or delegate it to someone else to act simply as a relayer of messages.

There are advantages if your admin person becomes the operator for he may be able to answer many queries and perhaps sort out any problems immediately so that the outlying station gets its answers straight away. On the other hand it may be an extra job in an already busy schedule and through lack of time it will not be done as it should. It is not only the operating time to be considered but also the proper keeping of message records and the time spent contacting the right person and passing on the message. If the operating is delegated to someone else that person must be allowed sufficient time to do the job properly. They must be able to read accurately over the air the messages for each individual station and to take down accurately the messages coming in. Therefore they must be fluent in the language used for transmission. They must not be expected to answer questions immediately but rather relied on to pass them on correctly to the right person. Do not under estimate the time they will need to do all this properly.

The actual time taken for an operating session in Zaire between the HQ station and 4 outlying stations was typically over 1 hour. The time was occupied thus:

5 minutes to obtain the keys, go to the room, unlock room and radio desk, connect cables and set the controls ready for the contact.

20 minutes to send and receive messages.

10 minutes to ensure log book was completed correctly and to make the written copies of any messages necessary for distribution.

5 minutes to switch off, disconnect cables and lock up securely.

20 minutes to contact people for whom there were messages or questions.

### **7.1.3 Outlying stations**

The observations about the qualities of a good operator apply equally here although there will obviously be less volume of messages to deal with. It may well be necessary to have several of your people acquainted with the operation of the radio so that in an emergency they could all cope but it is better to stick to one regular operator whose daily work schedule includes the radio operating. The operator here must learn to take his turn on the air with other stations and must be prepared to obey



the instructions of the controlling station.

#### **7.1.4. Stand-by operators**

Whilst it is wise to keep to one experienced and reliable operator it is also necessary to have a stand-by who has been trained to take over when necessary. The stand-by should keep familiar with the operating procedure and the controls by operating at least once a month.

#### **7.1.5. Training an operator**

Each station should have a set of operating instructions applicable to its individual needs and its particular equipment. These instructions must be read and understood before someone is allowed to operate. Training may involve instructing an operator or teaching yourself. There is often sound technical reasons why an operator is told to use a specific piece of equipment although the reason may not be known to him. For instance the use made of one radio network was far in excess of that originally expected and as a result the cables and connections on the hand held microphones developed faults. These microphones were replaced with a desk type so it and its cable remained in one place and was rarely moved. The hand held microphones were then kept as spares at each station. However it was later discovered that an operator had changed back to the hand held against instructions because he preferred that type. To prevent the moving of desk mikes some have been fixed to the radio desk. The operator should also be told never to smoke or use a candle or naked light near a battery. The reason for this is that hydrogen gas is released from a vented battery, i.e. a car type battery, when it is being charged and if connected to a solar panel the battery will be continually charged throughout the day. The operator should be shown the equipment and the instructions and each switch or knob should be explained to him, see details in para 3.1.3. It will help if he can understand why he should or should not do certain things.

1. He should be told never to operate when lightening can be seen and thunder heard and always to disconnect the aerial and power cables after use because of danger from lightening. If he understands that lightening can come through the cables to the radio and damage it or strike the operator he will take more notice of the instructions.
2. The radio should not be operated from a battery while the battery is being charged by any other means than by a solar charger. This is because excess voltage e.g. from a vehicle alternator with a faulty regulator, can damage the transceiver.
3. No books or papers should be put on top of the transceiver while it is in use. The reason for this is that most transceivers require a free air circulation to assist cooling especially in warm climates. Black cooling fins are often found on the rear of the transceiver.
4. If the radio installation has a "fail to battery" facility, see para.3.2.1.2. then the importance of switching the transceiver off as well as disconnecting the mains must be stressed. With a "fail to battery" facility when the mains plug is removed without switching off at the transceiver controls the transceiver will automatically be connected to the battery and so remain on.

Go through with him the routine of connecting up, switching on, selecting channels, adjusting gain and tone, speaking into the microphone, taking down messages and switching off again before actually trying to transmit. Continue with this practise until it can be done without hesitation then, if possible, let him watch an experienced person going through the routine and let him listen while some are contacts are being made. Explain to him the operating procedure used at the station and let him become familiar with call signs and expressions used. His first actual contact is best done with an experienced person at hand to help. The first experience of speaking into the microphone and knowing your voice is being heard many miles away can be quite a nerve testing experience for some people although others may find it easy. A nervous operator who is not sure what he is supposed to do will be

prone to make mistakes so good instruction and training is very important. The operating instructions should be provided in a simple step by step form and kept close to the transceiver for easy reference. There should be available to the operator such things as a pen and a spare pen, sufficient paper and a clock or watch that keeps correct time. Note that simple things like these are not always instantly obtainable if the station is an isolated one. The operator must know what he is expected to do to take care of the equipment, see para 7.2.2., and what his responsibilities in recording and passing on messages are, see paras 7.3 and 7.4. The operating instructions should include a check list of things he must and must not do, including what to do if there appears to be a problem with the equipment, see para 7.2.3.

## **7.2. Operating the Equipment**

There are many different controls and facilities on transceivers and these vary according to the model. Always be aware of any facility which is peculiar to your particular station whether it was put in by the manufacturers or modified by your networks engineer. However there are certain basic rules that will apply to all equipment.

### **7.2.1. Transceiver Controls**

The most common and essential controls are listed in the chapter on transceivers see para. 3.1.3. Read again the descriptions given there and then note the following operational points. The handbook for your particular transceiver may give special operating instructions e.g. if the transceiver contains thermionic valves or crystal ovens it should be switched on 5 to 10 minutes before use.

#### **7.2.1.1. Clarifier**

The operator may need to alter this control for each station he listens to so as to get the best pitch or sound for his particular hearing. The pitch that sounds clear to one person may not be so clear to another.

#### **7.2.1.2. Squelch**

This has often caused problems where its function is not understood. When the transceiver is switched on the Squelch should be OFF. That is either switched OFF if the control is a ON/OFF switch or if it is a variable control it should be fully rotated so that noises come from the loudspeaker. Then after all the other controls have been set e.g. channel selected, audio gain adjusted the Squelch can be set to inhibit the loudspeaker background noise if required. However in many instances operators have set the Squelch threshold too high and stations have not been heard. The author found that it was rarely correctly used in his network and to avoid problems removed it from most sets, see para. 5.2.5.4. on modifications.

#### **7.2.1.3. RF Gain**

This should be set for maximum to start with then gradually reduced for the best sound. If the RF gain is set too high then the signal received from a nearby or strong station can sound distorted or even appear to be going off and on. Operators listening to such strong signals have told the station transmitting to them that there is a fault in their transmitter whereas the problem was their own RF Gain control was set too high. Be careful with this control because if someone with a weak signal calls in when the RF Gain is turned down they may not be heard. The operator should get to know all the stations on his network and by experience learn which ones will need the RF turned up and which will need it turned down. Make it the rule always to commence with it at maximum and adjust as necessary.

#### **7.2.1.4. Interference**

This can be caused by nearby transmitters although they are not operating on the same frequency. In this case best reception conditions can be obtained by reducing the RF Gain as far as possible whilst still enabling the operator to hear the station with whom he is in communication, any loss of volume can be compensated by using the Audio Gain or Volume control.

#### **7.2.1.5. USB/LSB**

If the stations are equipped and permitted to operate on both upper (USB) and lower (LSB) sideband then if there is interference on one sideband it may be possible to use the other. First check the other sideband to see if it is free from interference and is not in use by someone else. Then inform the other stations and suggest they move on to it. After the contact is over return the USB/LSB switch to its normal position for the next contact.

#### **7.2.1.6. Earphones**

At stations where some of the other stations are difficult to hear then earphones may be provided. If you have more than one operator you will have to decide whether each operator should have his own earphones on grounds of hygiene. The cable on the earphones can easily become twisted and in knots so be careful and prevent this from happening.

#### **7.2.1.7. Transmit**

It is good operating practice to press the transmit button before beginning to speak in to the microphone and also to cease speaking before the button is released. The operator must always speak clearly and reasonably slowly into the microphone but must never shout. Shouting will only distort the signal especially if done close to the mike. If there is a "transmit" light which flashes as the operator speaks he should watch this light as it ought to go out during the slight pauses in his speech. It will be necessary to adjust either the loudness of the voice or the closeness to the mike to ensure that the light goes on and off in sympathy with the voice. When the distant station says they are not receiving the transmission the instinctive reaction is to speak louder. However shouting into the microphone may cause the Automatic Level Control circuits to operate in the transmitter and so make the transmission less intelligible to the distant receiver. Some improvement in communication can be made on a "trial and error" basis. For example one operator can ask the other operator "do I sound better on this first transmission or on the second transmission after I have changed my position?" The success of such tests will depend on the organising ability of the operators.

### **7.2.2. Care of the Equipment**

Operators must be made aware that the equipment they are using needs to be handled carefully. It is often expensive and sensitive but used properly most modern communication equipment should stand up to daily use for a long time. In addition the operator may be asked to do some routine maintenance, see para. 8.6.

#### **7.2.2.1. Controls**

Controls and knobs should only be adjusted when necessary, it often happens that operators waiting their turn to transmit will fiddle with the controls turning them first one way then another. Knobs and indicator lights have worked loose and been broken because of this kind of treatment. So the rule must be to touch the controls only when necessary, e.g. to hear more clearly or to change channels.

#### **7.2.2.2. Microphones**

Microphones are delicate instruments and have often been treated badly, sometimes being pulled to reach across a room for someone else to speak resulting in broken connections. So the rule must be that only the operator or the person sitting in his chair does the speaking and in the case of a desk mike it must be left on the desk or the table close to the transceiver. It may be wisest to have it fixed in position on the desk or table and it should always be left connected to the transceiver. Hand held mikes are very often passed from hand to hand or left swinging loose on the end of their cables. The cable can become worn and broken just by the continual handling. They are best kept for use with mobile equipment or as a spare microphone.

### **7.2.2.3. Cables and Aerials**

Cables and leads such as those coming from the power source and from the aerial should not be allowed to become tangled up or twisted into knots. They should be handled with care the same as the rest of the equipment. In particular watch the plugs or connections on the ends. When disconnecting an aerial cable, for instance, make sure that the coupling ring see Fig.6.5. has been fully unscrewed before pulling it from the socket. Never remove a cable by pulling it but hold on to the connector on its end while removing it. Be careful not to cross thread the connectors. If there is more than one aerial, label each aerial cable with the frequency and channel number it is used with. If there is an aerial switch in use leave the aerials connected to the switch all the time, disconnect the transceiver from the aerials by using the connecting cable between the transceiver and the switch. This cable is best connected and disconnected at the aerial switch rather than from the transceiver socket. The actual aerial should be checked visually regularly but particularly after storms and high winds. No tree branches should be allowed to obstruct it.

### **7.2.2.4. Battery**

Never switch on a transceiver when it is only connected to a solar charger i.e. when the battery has been disconnected. The acid level of a vented battery must be checked regularly at least once a week. If the level is down it must be filled up with distilled water or other substitute e.g. rain-water collected in a plastic sheet. The battery voltage should be measured regularly if there is a voltmeter available to do this. If voltage is too low the transceiver must not be used until the battery is fully charged again. It has been known for an operator whose battery was flat to get a second battery and connect it in series with the radio battery with the result that 20 volts was applied to the 12 volt transceiver causing serious damage. When transmitting, the battery voltage is low if it goes down below 11 volts. Receiving does not require so much power so if the voltage is too low to transmit it may be possible to listen and receive messages.

### **7.2.2.5. Lightning Danger**

In areas where thunder storms occur frequently it is a good practice to disconnect the aerial when the transceiver is not in use. Where thunderstorms only occur in certain seasons some operators will only remove the aerial during these seasons but this is not an entirely reliable scheme as the start and finish of a season is not always well defined. Therefore the practice of always removing the aerial at the end of every contact is the recommended practice. The HQ station of one radio network in Kenya periodically reminds the operators of the other stations to disconnect their aerials after using their radios. It is also good practice to disconnect power cables especially mains cables and battery cables where the battery is being charged by solar panels on the roof.

### **7.2.2.6. Aerial Tuning Units**

The operator should be warned that high voltages occur at the aerial terminal of transceivers which

incorporate an aerial tuning unit (ATU). RF burns can be received if the terminal is touched during transmission. With these units when the frequency in use is changed the ATU will need retuning as per instructions for that particular unit.

### 7.2.2.7. Check List

This is an example of instructions given to stations on "Looking after your radio." Always follow the operating instructions.

- Never forget to remove power and aerial cables at end of contact.
- Look after your battery. Keep acid level topped up with water as required. Check it once a week.
- Keep battery lugs free from corrosion and covered with grease.
- Keep the cabinet, desk or table clean and free of dust and pieces of unnecessary paper etc.
- Make sure nothing blocks the ventilation around the radio when it is in use.
- If the radio is covered with a dust sheet when not in use always remove it completely before commencing contact.
- Keep the radio room clean and secure.
- Do not handle the controls more than necessary, especially do not twist knobs etc. round and round when waiting by the radio.
- Do not allow unauthorised people to use the radio.
- Keep an eye on aerials and cables especially after storms.
- Keep an eye on your solar panel e.g. make sure it stays clean and trees do not grow up to shade it.
- Keep to the one operator but have someone trained as a standby.
- Keep operating instructions accessible.
- In case of breakdown of the radio get message by some means to HQ giving as much information as possible.

### 7.2.3. Fault Finding

An alert radio operator can often give advance warning of the onset of a fault in the radio system by reporting anything that is unusual. This can cover such symptoms as a station becoming persistently weak, apparently distorted or of gaps occurring in the transmission. These observations should be reported back to the station with the problem and to the person responsible for radio maintenance. However a operator should not be over enthusiastic in telling another station that they have a problem until he has ensured that the apparent problem is not being caused by his own equipment. For example, is it only one station that sounds distorted ? If all the others sound distorted as well then the problem well may be in the operators own equipment. Again if it is a strong station that sounds distorted then is the RF Gain set too high at the receiving station? see para.7.2.1.3. If an operator is told that his own transmission sounds weak or distorted then there are certain checks he can do himself. The following simple tests are given so that the operator can render "First Aid " or advise the radio maintenance person of the possible cause of the fault. Note that in the event of a possible fault in the radio network the radio technician responsible may wish to limit the operators actions to observation and certain permitted actions only. When there is a fault which the operator thinks is within the transceiver he should be told never to remove the cover to inspect the interior unless he has been given precise instructions by the technician to do so. If a component inside the transceiver is at fault there is little an unqualified person can do either to trace the fault or to fix it. Indeed such a

person has been known to cause further damage to the transceiver in his desire to help.

### **7.2.3.1. Transmitting and receiving difficulties**

1. If the operator is having difficulty hearing and making himself heard:

Check (1) That the power light or indicator comes on at its usual brightness. If it is dull then the battery voltage is low and it needs to be charged up again before using the transceiver .

Check (2) That the power light remains bright when the operator is transmitting. If it goes dull the battery voltage is too low for transmission although it may be all right on receive.

Check (3) That the TRANSMIT light or indicator flashes as the operator speaks. If it does not try using the spare microphone. If the TRANSMIT light then works the fault is in the first microphone. If it still does not work there is a fault inside the transceiver.

Check (4) Repeat Check (3) on all the channels on the transceiver. Note if the fault appears on all channels or one particular one.

Check (5) That the aerial appears to be in good order i.e. no parts are broken or hanging down and no tree branches obstructing it. If the aerial is down try to reinstate it to the original state or ask HQ for any new pieces needed.

Check (6) That the aerial cables and connections are not damaged. If there is a visible broken connection the operator may be able to do a temporary repair then inform the person responsible for maintenance and wait for his instructions.

### **7.2.3.2. Battery voltage problems**

If battery is charged by solar panels.

Check (1) That the surface of the panel is clean.

Check (2) Observe any charging indicator light or meter where fitted .

Check (3) That the duration of daily use has not exceeded the recommended time.

Check (4) Suspect lightening damage possibly to diode.

Check (5) Allow battery time to recharge see para.3.2.3.4. If battery does not recover inform maintenance person. If battery is charged by other means.

Check (1) That the generator or mains battery charger is giving the necessary charging current.

Check (2) Allow battery sufficient time on charge to recover, if it does not suspect battery is too old or damaged in some way, see para 3.2.3.3 on battery life etc.

### **7.2.3.3. Unusual Noises**

For any unusual noises coming from the loudspeaker, first of all try:

Check (1) Disconnect the aerial from the transceiver itself to see if the noise stops. If it does these are strong external signals and there is nothing wrong with the transceiver.

Check (2) If there is still a whistle or warbling tones etc. even with no aerial connected then reconnect it and try reducing RF and AF Gain controls to stop the whistle etc. so that you can receive, then inform radio maintenance of the problem.

Check (3) If there is a loud hum during receive:

(a) where radio battery is charged off the mains, ensure that the mains battery charger is switched off while operating.

(b) where there is a hum on a mains operated transceiver there is a possible fault in the transceivers own mains power unit.

### **7.2.3.4. Power failure**

There is no power at all in transceiver after it is connected and switched on. This is shown by the

power light being off and no sound coming from the loudspeaker on receive.

Check (1) For a battery operated set that battery leads have not become disconnected and that the battery is still there! For a mains operated one that there is actually power in the radio room.

Check (2) That the fuse has not gone. Replace it if necessary with a good one, if this then goes there is a fault inside the transceiver so do not replace again but inform HQ by some other means that there is something wrong with the transceiver.

Check (3) That plugs and cables have no visual damage. If a faulty cable is suspected inform maintenance and ask for replacement.

Check (4) If there is a simple explanation. For example where the power lead is normally plugged and unplugged from the wall socket and the other end is permanently connected to the transceiver. It has been known for someone to disconnect it both ends and for the next person to come in and plug into the wall socket without realising the other end is not connected to the transceiver.

Note that things like this can easily happen so always check the ordinary and the obvious when there appears to be a problem!

### **7.2.3.5. Receiver failure**

If there is power in the transceiver i.e. the power light is on at its normal brightness, but there is no sound coming from the loudspeaker.

Check (1) That all the controls have been set to correct position as in the operating instructions. If RF gain or Squelch is incorrectly set or the Channel switch is wrong for instance.

Check (2) That the aerial is correctly connected and if using an aerial switch that it is switched correctly.

Check (3) That the aerial or its cables are in good order.

Check (4) If the above are all correct and there is still nothing coming from the receiver try transmitting and see if the transmit light flashes. If it does there may be a fault in the receive side only. Try sending a message to say what has happened to your HQ station.

### **7.2.3.6. Transmit Failure**

If the receiver is working all right i.e. the power light is at its normal brightness and other stations can be heard at their normal level but it is obvious that they are not able to hear your transmission.

Check (1) That the microphone is correctly plugged in and that the transmit light flashes when speaking. If light does not flash try spare microphone. If the light still does not flash there is a fault in the transceiver or the battery voltage is too low for transmitting so:

Check (2) That the battery voltage is good. Note if it is low i.e. below 11 volts, it may be possible to receive but not to transmit.

Check (3) If the voltage and transmit light are correct check that aerial has not been damaged, one half hanging down or broken off for instance. Note that it is possible to receive on a long piece of wire but to transmit needs an aerial properly tuned and the right length for the particular frequency.

### **7.2.3.7. Physical Tests**

Faults often take the form of disconnected or broken wires. These can either occur at the point where the wire is soldered or screwed into a plug or further along a piece of cable. Providing the action is gentle the operator can move the cables about, one at a time, especially where they enter a plug or socket to see if the transceiver will start working again. If the transceiver can be made to work by holding or twisting the faulty cable then a message can be sent to request a replacement cable or the

help of a technician. Instructions will have been given to ensure the acid level of a vented battery. This is so often overlooked that it cannot be said too often. Again and again it is not till the voltage falls sufficiently to cause a problem with the radio that the battery is checked. Also the wires from the transceiver can corrode away and break the circuit where they are connected to the battery. A movement of these wires will show if there is a problem.

### **7.2.3.8. Breakdown Procedure**

All stations should have instructions as what to do in case of breakdown. This will depend on the particular situation of each network and sometimes of each station. Where there are reliable repair facilities nearby arrangements should be set up by your group or organisation when the equipment is installed and the operators should be aware of them and have available a technical manual for the technician. Where there are no such facilities operators must await instructions from HQ. HQ operators must take note of any stations who do not answer when called in and report this to the person responsible for maintenance in the network. A few contacts may be missed for reasons such as sickness or flat batteries but if a station remains off the air for longer than normal it must be assumed that it has broken down and steps must be taken to find out what has happened. The HQ operator should note that it may be possible for the missing station to receive even though it cannot transmit so the operator should continue to call them in and should send any messages or instructions required. However bearing in mind the possibility of a complete breakdown instructions should also be sent by whatever other means are available.

## **7.3. Operating the Network**

It is possible to treat a radio contact in the same way as a telephone conversation with the addition of the word OVER at the end of each portion of speech. If there are only two stations talking to each other this is no problem. However the problems arise when there are three or six or maybe twelve stations waiting their turn to speak. In these cases there must be an orderly procedure to follow and everyone must understand it and keep to it. The following notes are drawn from practical experience and work well if carried out correctly. The important thing is to have a recognised pattern to your radio contacts that all your operators can respond to and cope with.

### **7.3.1. Callsigns and Control**

Each station should have its own official call-sign e.g. 9SD67 or 9SD47, although in practice only the last part is used e.g. 67 and 47. These callsigns will be allocated by the licensing authorities of individual countries. A list of the callsigns belonging to the network should be kept at each station and all operators should know and use them rather than the place names. One station, which is normally the HQ station, should be in control of the network and all others should obey his instructions. When calling a particular station the operator should say this number first followed by his own e.g. 67 from 47.

### **7.3.2. Starting a contact**

The situation exists in one African country where the same radio frequency channel has to be shared by several different organisations. In such situations there should be a timetable which gives you the channel at specific times and days. Even if this is the case it is not always adhered to by all users. When more than one pair of stations are trying to speak at the same time the result is often that nobody can really understand what the others are saying. This "law of the jungle" usually resolves itself into some informal agreement between users so before the operator starts transmitting he should first listen on the channel. If it is in use he can remind the users that it is his time and unless they have



very urgent messages, when some immediate arrangement can be made, then he should be given the use of the channel. Assuming the channel is clear the controlling station should begin by calling in each station in turn by their callsign, asking them if they have any messages and telling them to standby to receive any messages. One station may have a message for one of the others as well as the HQ station in which case it should clearly say so then that particular one will know to wait for it.

If there are no messages incoming or outgoing for a particular station it could leave the net after all stations have been called in. In practice most stations remain to listen to all the others as this is a source of news, especially in remote locations. When all stations have responded to HQs call they should be asked by callsign one after another to pass their messages to HQ and to be ready to take down incoming messages. This should be done in an orderly fashion with each station taking its turn under the control of HQ. They must wait for their number to be called and never try to jump in on top of someone else. Never forget that only one person at a time can transmit and expect to be understood. Two stations talking at once makes for confusion! The HQ or the controlling station should make a note of any stations who do not reply to his call and inform the necessary person.

### **7.3.3. Sending and Receiving messages**

Each message should be as clear and concise as possible. It should be read clearly and not too fast into the microphone. Never shout as this can cause distortion. The operator should begin by saying the callsign of the station he wants to talk to followed by his own. Finish a message distinctly by saying the callsigns again followed by the word " Over" or "Over to you". Confusion can be caused if the operator does not finish clearly but lapses into silence so that the other is not sure that he has finished. Also long pauses and hesitations during transmission can give the impression he has finished or that there is something wrong with the transceiver. Keep all messages to essential matters. Remember others are waiting their turn. Take care that the messages have been clearly understood on both sides. If in doubt the receiver should read back the message to the sender to check for errors in reception. Where reception is difficult and noisy it is essential to do this. If there is difficulty in understanding certain words e.g. names of peoples and places or medical terms, ask the operator to spell them using a phonetic alphabet. see para.7.3.5.

### **7.3.4. End of Contact**

When each station has given and received all its messages it may want to finish and switch off. It should make this clear by using the expression "47 signing off" or "47 going clear". If the operator is finished but he wants the others to know he is still listening he can say "47 standing by". If the operator wants another station to wait for him he should say "can 46 stand by for 47". These phrases may sound like operators jargon but if used and understood by all they can be an aid to communication. See para.7.3.6. for list of words often used by radio operators. When all messages have been transmitted and received HQ, the controlling station, should pause and check for any stations that were missing at the beginning. He should allow enough time for any delayed station to call him when the others have finished and should give missing ones one more call. If these stations still do not reply then the operator should transmit the messages to them because they may be able to receive. There have been many cases of transmitter failure whilst the receiver has remained serviceable. Also when a battery is discharged there is often sufficient power to operate the receiver but not enough to transmit. Finally the controlling operator should indicate clearly that he has finished by saying "67 going clear" or "67 signing off" before switching off his equipment.

### **7.3.5. Phonetic Alphabet**

To spell out words using this alphabet use a well-known and easily recognised word beginning with

the letter that you are sending. e.g. CORBETT spelt out in this manner becomes Charlie, Oscar, Romeo, Bravo, Echo, Tango, Tango. It is possible of course to use any suitable words familiar to the operators but there are some phonetic alphabets which are well known and international and can be heard on channels used by aircraft.

Here is one alphabet in common use:

A ALPHA	BRAVO	C CHARLIE	D DELTA	E ECHO	F FOXTROT
G GOLF	H HOTEL	I INDIA	J JULIET	K KILO	L LIMA
M MIKE	N NOVEMBER	O OSCAR	P PAPA	Q QUEBEC	R ROMEO
S SIERRA	T TANGO	U UNIFORM	V VICTOR	W WHISKEY	X X-RAY
Y YANKEE	Z ZULU				

### 7.3.6. Radio Jargon

It is possible, of course, to talk on the radio as in normal conversation but it sometimes helps in communication to use certain set phrases or words. These must be understood by everyone using them and not thrown in because it is thought it sounds good. Words like "negative" for "no" help because a little word like no is easy to lose amongst the noise in poor reception conditions. "Negative copy" makes it clear that the message has not been understood and most people recognise the term "Roger" as meaning message received and understood. Here is a list of radio expressions commonly heard.

"Over" Short for "over to you" meaning the operator has finished speaking for the moment and is waiting for a reply. Always use it to indicate that the message is finished to avoid any doubt. In French "A vous" also has the same meaning and in Lingala "na yo".

"Go ahead" or "47 to 67 Go ahead" is also used with the same meaning.

"Roger" message received and understood.

"I copy" or "I read" has the same meaning. Also the French "capte" or "bien capte".

"Negative copy" Message not received or understood.

"Negative" No, that is not correct.

"Affirmative" Yes, that is correct.

"Stand by" Please wait for further messages.

## 7.4. Message Handling

The technical side of the radio network can be working well but the purpose of the network is to pass messages. Therefore the handling of messages before and after transmission over the radio is just as important as the transmission. Messages received on the radio must be passed on accurately and quickly to the person they are intended for and requests received for information or for supplies must be dealt with accurately and efficiently otherwise the network is not satisfying its purpose. In practice it is often found that once a network starts operating the type of message and requests far exceeds the original agreement.

### 7.4.1. Type of Messages

The Government of the country may place certain restrictions on the use which can be made of the radio network. In addition every effort should be made to define what types of messages your

organisation will permit to be sent over the radio network and what services can be requested. Unless there is general agreement on these subjects the advantage of a radio communications network can become a source of discontent because messages are not being passed on and requests for goods etc. are not being met. Messages could be classified as URGENT or ROUTINE. However in practice some originators of messages tend to classify all their messages as URGENT. This becomes obvious to the person receiving the messages who will then handle them as routine so defeating the aim of the classification. An analysis of the messages passed by expatriate personnel over a mission network during a three months period in 1987 is given in Table 7.1. Of these 679 messages 388 were to HQ and 291 from HQ. The network consisted of 9 stations spread along 1700 kms of the River Zaire. It was used to a much greater extent by the national church for which no figures are available.

Table 7.1.

**Message type as percentage of total messages.**

<b>Type of message.</b>	<b>To HQ.</b>	<b>From HQ.</b>
Travel Information(passengers)	16.5	21.6
General Administration	14.4	13.2
Missionary Aviation Fellowship (flight information)	7.4	11.7
<b>Messages-</b>		
Medical	8.5	8.9
Personal	7.2	11.7
For other organisations	4.4	2.4
Technical Information	3.1	3.4 S
Medical Emergency	0.5	1.4
<b>Supplies-</b>		
General Medical	6.0	3.8
Technical and Construction	3.9	2.7
Books and stationary	3.1	1.0
Urgent Medical	2.6	1.0
<b>Finance-</b>		
Personal	6.4	5.2
For others	6.2	3.4
Official	4.4	1.7
<b>Shipping-</b>		
Freight by Air	2.6	3.8
Freight by Boat	1.5	1.4
Personal Items	1.3	1.7

When a lone expatriate is working in a remote location it is helpful for them to have some time on the

air for general conversation in addition to the normal message time. This has to be when the channel is not busy, usually a Sunday afternoon. It is often people in similar situations i.e. living alone in remote places, who arrange to talk together.

### 7.4.2. Timetable

The existence or otherwise of a timetable for different organisations to use the same channel has been discussed in para.7.3.2. Your organisation may wish to further subdivide its own time between different departments. For example one mission allocated 0900 to 1000 Education, 1000 to 1100 Medical and at 1200 General Rendezvous for all other matters. If your network covers a very large area it may be necessary to subdivide it on a regional basis. For example each region could be allocated a certain time to deal with its own regional business and a certain time when it could contact the central HQ control for other matters. Never change an existing timetable that works until you are sure that the channel will be free for you to use at the new time. This can be done by simply listening on the channel for several days to see at what time it is in use.

### 7.4.3. Message Recording

A log book is necessary at each station as a written record of all messages sent and received. This may be a legal requirement by the Government of the country who may prohibit the use of a loose leaf type of book. Duplicate pads are available which provide one page to be left in the book as a record and a second carbon copy on a tear out page for passing on to the person to whom the message is addressed. Even if there is no such legal requirement the written record is essential to ensure the smooth running of the network. A verbal message is easily forgotten or mistaken! Before the contact begins the operator should write his name the date and time across the page and then the outgoing messages. There should be columns to show if the message is to or from a station, the message itself and then the action taken in response to the message. The HQ operator can give each individual outgoing and incoming message a serial number which he informs the other stations of and this can be used as a quick reference for any future associated information. The log could take the following form:

Operator John Smith 30 June 1988 0615.

To/From	Message	Action
From 45	Please send us 6 drums of diesel fuel.	Replied 8 July that 6 drums left on boat MAKASI on 7 July.
From 43	Tell Olive Brown that the box of Lingala books have arrived.	Received message 30 June signed O. Brown.
To 87	Mr and Mrs James need dental treatment. Please arrange appointment and accommodation and advise us of dates.	Reply received 3 July. Go on 10 July and return 14 July must make own travel arrangements

There should be a person on each station who is responsible for seeing that all messages are passed

on. The person need not necessarily be the operator. Where practical a person should take the log book around the personnel of the station after each contact so that recipients of messages can sign to acknowledge receipt. Also they can enter messages they wish to send in the book in their own words. Many errors occur because the operator sends his own interpretation of the message and does not faithfully read it as written. An alternative arrangement is for the log book to be available to everyone to see at a certain time and place each day. When receiving messages some operators write them down rapidly on scrap paper and then copy them into the log book afterwards. When this happens the log should be written up as soon as possible after the contact while the messages are fresh in the operators memory.

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# WHERE THERE IS NO TELEPHONE

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There are several aspects of a radio network which have to be satisfied if it is to give a continuous satisfactory service. These aspects are dealt with in each chapter, the importance of each has been stressed e.g. choice, installation and operating of the equipment. However you are unlikely to end up with a perfect system. There will be failures in the radio equipment, some of which may be due to design or manufacturing faults, others to poor installation or bad operating practices. Wherever possible the author analysed the faults which occurred in the radio systems in Zaire. This frequently showed that either the fault was not in the transceiver itself or if it was it had been caused by something external to the transceiver. The various ways to safeguard the transceivers and prevent some faults occurring are in the chapters of this book, for example see para. 5.2.5. After you have taken all reasonable precautions, there will still be the failures. It may be due to a fault within a

semiconductor which is beyond your control or it may be due to somebody in a hurry forgetting to disconnect the aerial and thus allowing lightening to damage the transceiver.

Therefore you must make some provision for the maintenance of the whole network. Within a few hours of the author arriving in many towns and villages in Zaire the fact was known that a radio engineer had arrived and requests were made to look at transceivers that were not working. Enquiries revealed every time that no spare parts were kept, no manual or circuit diagrams were available and no provision had been made for maintenance. Hence the resulting situation of unserviceable transceivers which were unlikely to work until someone got round to taking them to a repair facility within the country or often in another country. A maintenance philosophy which relies on all faulty equipment being sent to a central workshop for repair and then being returned to their stations is not always appropriate for developing countries where there are very few such workshops and transport arrangements are difficult. If the equipment was not originally installed by a competent radio technician then when one becomes available he should make an inspection and upgrade as necessary all the installations.

## **8.1. Staff**

There are often very few qualified full-time radio engineers or technicians working for missions and aid agencies in the developing countries of Central Africa. In July 1988 the author knew of no other radio technician working with any Protestant mission in the northern half of Zaire an area of about 500,000 square miles where there are many radio networks. The need for short-wave communications is decreasing in the developed countries as satellite systems take over therefore there are now not so many communication engineers available who have had experience with short-wave communication. So in countries where short-wave communications are important, nationals need to be trained in this aspect of radio engineering. This, however, is a long term solution. An interim solution could be for several co-operating organisations to provide a technician in turn, e.g. for 2 years who will service the equipment for all the organisations. Another person could also run a programme to train nationals as technicians. It will be necessary to be aware of the visa and work permit regulations of each particular country before you plan to send in expatriate personnel.

## **8.2. Cost and Payment**

The maintenance facility may be allowed an annual sum of money to perform a service to an organisation or it may have to be self-supporting financially. The financial arrangements should be well defined and estimates of the various costs made at an early stage see para. 5.1.6. It should be decided who will pay for:

1. Repair of transceivers in the workshop including time and parts.
2. Travel and accommodation costs of a technician visiting a distant station.
3. Recurring replacements e.g. batterys.

Also how the payment will be made especially in countries where bank cheques are not in common use and where bank transfers of money can take a long time. In these circumstances money is usually physically moved around the country with the attendant hazards. Examples of costs in 1987 were \$15 an hour for a missionary radio technicians time when working on equipment of other churches and missions. One commercial firm would send out a technician from Britain to work in Africa for the cost of his travel, accommodation plus o300 per day. The costs of either providing a radio maintenance facility for your own use or using someone elses facility are considerable and must not be underestimated.

### 8.3. Spare Parts

If you are providing your own maintenance facility or even if you have arranged for a visiting technician to repair your equipment you should hold a range of spare parts. Providing you hold a good stock of spares your transceiver can be repaired rapidly and returned to service. The cost of spare parts was mentioned in para. 5.1.1. It is recommended that the spares should be kept at the central maintenance facility rather than having a full set at each station. This reduces the capital cost, e.g. 1 spare item for every 10 transceivers rather than 1 item with each transceiver. Originally the author put some spares with each transceiver in Zaire, however over a period of several years many of these spares were lost. This mainly occurred when there were changes of staff and when staff were absent for long periods. There are sometimes advantages in having the spares with the transceiver, for example when you are able to call upon the services of a nearby radio technician. If there is no recommended list of spares from the manufacturers or you do not wish to use the list then a guide to the selection of spares is given in order of priority.

1. Plug-in circuit boards or modules.
2. Mechanical parts which are liable to wear out e.g. switches, press buttons, relays and variable resistors such as volume controls.
3. Hot filament devices e.g. thermionic valves and indicator lights, not LEDs.
4. Plugs and sockets which are unplugged daily, e.g. aerial and power connections.
5. High power transistors used in the transmitter.
6. Loudspeaker and microphone.
7. Non standard components which are special to the particular transceiver.
8. A selection of transistors, resistors and capacitors if possible chosen by the person responsible for maintenance.

Keep an up to date list of all the spare parts you hold. Where the parts have an identifying number always use this to aid the identification of the correct part. An additional completely spare transceiver can be worth keeping at the central workshop so that this can be used as an immediate replacement for a faulty transceiver. In real life it has been found best to await the arrival into the workshop of the faulty one before dispatching the replacement. Otherwise once the replacement transceiver has arrived at the distant station the need to send back the faulty one seems less urgent. Indeed the known existence of a spare serviceable transceiver in the workshop can present a problem in some cultures. When there is a long waiting list of places requiring radio equipment the head of the organisation may not fully appreciate the need to have a little used spare transceiver. However if it is pointed out that it will be necessary to purchase a new aerial, battery, solar charger, microphone etc. to go with the spare transceiver to make a complete station then the idea may not appear so attractive.

#### 8.3.1. Fuses

Most modern radio equipment requires replacement fuses of the non-repairable type, that is where the fuse wire is enclosed in a glass or ceramic tube. On opening many fuse holders it has been found that the fuse has blown and a piece of wire had been twisted around the fuse to keep the equipment going. The fusing value of the added wire was usually in excess of the fuse rating. Information on the fuse rating and fusing current of copper wire varies from different sources. In general one can say that a current which is twice the "fuse rating" will blow the fuse. If you have no proper fuses an indication of the size of wire to use instead is given in Table 8.1.

Table 8.1. Fuse Rating of Copper Wire.



SWG	Diameter in mm.	Fuse rating in amps.
38	.152	3
35	.213	5
29	.345	10
25	.508	15
23	.610	20
21	.813	30

## 8.4 Tools

The decision of what tools to provide for the places which have a transceiver should be based on what you expect the people to do. It may be that you do not wish anyone to attempt to do anything to the transceiver if it fails. It has been proved necessary in some places to paint in white paint the instruction "Do not open" in three languages on the cover of the transceivers and to also seal the screws which secure the cover with white paint. This instruction applied to all personnel, expatriate as well as local. No tools were supplied to these places.

### 8.4.1. Basic Tools

Providing you are confident that the provision of tools to the people will not cause damage to the equipment, that the tools will not be lost or broken through misuse and that the people are competent to use all the tools i.e. including the multimeter then the following list is recommended.

1. A selection of screwdrivers to fit the necessary screws of the particular installation only.
2. Spanners if necessary. The modification of battery terminals see para. 6.2.2.5. means spanners for battery lugs are unnecessary.
3. A multimeter to cover the voltages and current in use and to measure resistances from 0 to 10M. A digital meter with an accuracy of only 3 digits e.g. to read 12.6 volts, is suitable. An analogue meter i.e. one with a pointer moving on a scale, should have suitable ranges. For example to measure a 12 volt solar supply system which may be between 10 to 18 volts, a meter scale of 0-20 volt DC will give a much more accurate reading than a scale of 0 to 50 volt DC. A 250 volt AC range is necessary for measuring mains voltage. Also check the manufacturers quoted accuracy for the meter which should be less than plus or minus 3%.
4. Where a multimeter is not supplied then a 230 volt mains bulb of 40 watts to 100 watts, fitted in a bulb-holder with two insulated cables, can be used carefully for checking the presence of mains voltage. Similarly for 12 volt systems a 12 volt car bulb can be used. If the bulb is to be used for testing a solar panel then the current consumption of the bulb should be less than half the current producing capacity of the solar panel e.g. a 12 volt 0.3 amp bulb to test a 12 volt 1 amp solar panel.
5. One or more of the following types of soldering irons should be made available.
  - (a) Mains soldering iron to suit available voltage e.g. 110 volt or 230 volt. A small iron of about 20 watts for printed circuits and one of about 40 to 60 watts for coaxial cables.
  - (b) 12 volt DC iron for use from either a vehicle or a radio battery are available at 30 watts.
  - (c) Fire iron. These irons have no heating element and require heating by a flame e.g. charcoal fire or blow lamp.

### 8.4.2. Workshop Tools

The requirements for the workshop should be decided by the chief radio engineer of your organisation or this may be delegated to the technician who will be working in the shop. The choice of equipment should be made by a person who is knowledgeable about current electronic equipment and maintenance philosophy. The tools can consist of the basic ones mentioned in para.8.4.1. together with the more major items of para. 5.2.4. For transceivers which comprise mainly plug-in circuit boards a spare transceiver can save many items of test equipment.

## 8.5. Routine Maintenance

In the history of radio engineering there was an era when "preventative maintenance" was in vogue. A time was given for the expected service life of various components in the radio and these components were then changed well before they were expected to fail. Hence the radios were taken out of service for maintenance at arranged times and few unexpected breakdowns occurred. However this was an expensive method of maintenance and is now more usually found in areas of activity where the reliability and availability of equipment is important at any cost.

The situation likely to be found in a developing country is one in which it is often difficult to ensure that even the essential basic routine maintenance is performed. When questioning a driver if he had checked the oil level in the vehicle engine he said that it was alright because whenever the light flashed on the dashboard he put oil in the engine. The light was the oil pressure failure warning light!

In countries where the main object of the people is the need to survive and eat today, there is little thought for the needs of tomorrow so this attitude affects their ideas of maintenance. If the radio or the vehicle works today then all is well. If it does not work then it needs maintenance. An understanding of this attitude and the reason for it is necessary when instructing your staff about routine maintenance. The routine actions necessary should be included in the operating instructions given to all stations. An example of this is given in para. 7.2.2.7. and will depend to a large extent on the particular equipment at each station and on the capability of the operators. The most important points are listed below.

1. Check the acid level in a vented battery each week and refill with distilled or rain water.
2. Prevent the growth of corrosion on the battery terminals. Clean and cover with petroleum grease as necessary.
3. Clean the solar panel especially during any dry season when it should be checked every two weeks. In dry, dusty and desert areas it may be necessary to clean it more frequently.
4. Prevent the build-up of dust on the transceiver and microphone. Keep covered inside desk or with a dust cover when not in use.
5. Trees and vegetation grow rapidly in the tropics. Cut down branches before they have grown over or are touching the aerial and its cable. Stop creepers growing up aerial masts and cables.
6. If there is any means of measuring the state of charge of the battery e.g. voltage indicator or hydrometer, then record the state each day before using the transceiver. This record will give advance warning before a battery becomes too discharged due to (a) over use (b) under charging or (c) end of battery life.

## 8.6. Fault Finding

When a fault occurs some preliminary investigation should be made by the radio operator as discussed in para.7.2.3. Sometimes what the operator thinks is a possible fault can simply be that he has not followed operating instructions e.g. the RF Gain or Squelch control is in the wrong position. In any

case the checks mentioned in para.7.2.3. should be done by the operator before contacting the maintenance person. Also the tests mentioned in para.8.6.2.1. could be done by the operator if the person responsible for maintenance considered this suitable. This can be done even if you have the option of calling in a radio technician and should be done before sending the transceiver off for repair. The amount of testing you want an operator to do should be specified when the equipment is installed and the relevant tools and written instructions left.

### **8.6.1. False Indications**

Indicator lights are provided on transceivers to give confirmation that certain parts of the transceiver are working. Unless the indicators actual position in the circuit is known or its operation fully understood these lights can sometimes give a false indication.

#### **8.6.1.1. Power Light**

The DC power protection circuit of one make of 150 Watts PEP HF SSB transceiver is shown in Fig. 8.1. When the transceiver is connected to the 12 volt DC supply the 12 volts will go immediately to the power amplifier circuit via a 15 amp fuse. No voltage will be connected to the rest of the circuits until the transceiver is switched on when the Power light will be lit. If the 5 amp fuse blows this will be indicated by the Power light being out. However if only the 15 amp fuse blows the Power light will remain on so giving a false indication that the power is being supplied to all parts of the transceiver. Once the situation is understood the presence of 12 volts on the power amplifier can be verified by speaking into the microphone thus causing the Transmit light to flash provided the rest of the transmitter is working.

#### **8.6.1.2. Transmit Light**

This light indicates that RF voltage is present. The point at which the light is connected to the circuit depends on the particular design, see Fig. 8.3. If the light is connected to Point A it only means that transmitter power i.e., RF voltage, is available at that point. A fault in the filter could prevent any power reaching the aerial. A light connected to Point B simply shows that power is available at the RF filter output but it may have to pass through an aerial change-over relay before it reaches the transceiver output socket. Even if the power is reaching the output socket the aerial could be disconnected or have a fault and the Transmit light would still flash. Therefore you should be aware of the difference between what the light is labelled and what the lights actually indicate.

### **8.6.2. Do It Yourself**

In such areas as house repair and car maintenance the idea of "Do it Yourself " (DIY) has become very popular in recent years. Various guide books and aids have been produced to help the "man in the street" do the job that was previously done by a skilled craftsman. Some jobs have turned into disasters whilst others have been successful often depending upon the aptitude and ability of the person doing the work and the standard of the DIY instructions. There exists a shortage of skilled technicians in many developing countries and so DIY can have an important place. Much care must be taken when introducing DIY into the field of radio communications engineering and notice must be taken of the sayings such as "a little knowledge is a dangerous thing" and "it can do more harm than good". However providing the DIY instructions are sufficiently well defined and also rigidly adhered to then this method of maintenance can give useful results. Before reaching this stage of repair the operator should have performed the Fault Finding procedure given in the sections of 7.2.3.

#### **8.6.2.1. Trial and Error**

It is possible for a person with little or no technical knowledge to perform tests on the parts of a radio system and in some cases effect a repair. The following tests are examples and further tests could be devised to suit your particular system. It should be noted that the results of these tests are not always conclusive.

1. Symptom. Transmit light flashes but no stations heard although noise from the receiver.

Test: Where an aerial switch is in use remove the coax aerial cable from the switch and connect it direct to the radio.

Result:

- (a) Stations are now heard and normal contact is possible means a fault in either aerial switch or cable between switch and transceiver.
- (b) no different then do next test.

2. Symptom: Noise from the transceiver loudspeaker but no stations are received on any channel.

Test: Disconnect the aerial. Turn RF Gain to maximum. Adjust AF Gain or Volume to give a reasonably loud noise (or hiss) from the loudspeaker. Touch the central pin only of the coax plug of the aerial cable to the centre of the transceivers aerial socket, being careful not to let the outer ring of the plug touch the transceiver.

Result:

- (a) Noise from loudspeaker increases and possibly some stations heard. This means the receiver is working.
- (b) Noise from loudspeaker remains the same.

Possible fault in transceiver or break in central conductor of coax cable. Now remove the aerial cable and instead connect about 2 metres of wire into the centre of the transceivers aerial socket. If noise level still does not increase most likely cause is fault in receiver. If the noise does now increase then faulty aerial cable is likely.

3. Symptom: No noise from loudspeaker at maximum volume.

Test: Reduce volume control from maximum and plug in earphones.

Result:

- (a) no noise in earphones when volume at maximum means a fault in the transceiver, probably in audio amplifier circuit.
- (b) noise in earphones means either a failure of the loudspeaker or the circuit to it which may be via contacts in the earphone socket.

4. Symptom: The transmit light is on all the time that the transmit button is pressed although nobody is speaking into the microphone.

Test: Unplug the microphone from the transceiver and connect together the "press to transmit" contacts in the microphone socket.

Result:

- (a) no difference. Fault in transceiver e.g. gain of microphone amplifier too high, amplifier oscillating or carrier balance needs adjusting.
- (b) light is out means either wire open circuit on microphone or gain was too high in microphone amplifier.

If your transceiver is designed on the plug-in module or printed circuit board system then you have the opportunity of attempting to repair it by changing modules. Whilst this is an advantage, the contacts on the plugs of the modules can themselves cause problems. They can become tarnished, oxidised or corroded so the first thing to do is to unplug one module at a time. Clean the contacts with glass fibre or a piece of course material to remove any layer on their surface. Do not use sand-paper,

glass-paper or anything too abrasive. Replace the module and check if the radio works before removing the next module. If after cleaning all the modules the radio does not work then replace each module in turn with a serviceable one leaving each new module in the transceiver until it works. Then leaving the last new module in its place in the transceiver try restoring the old modules in turn to see if it continues to work. For example if the transceiver works after the third module has been replaced then restore the original module 2 and if it continues to work then restore the original module 1. If it then continues to work the fault will have been put right by the replacement of module 3 but if it does not then you will need to use the replacement module 1 or 2 as well.

There are disadvantages in this method of "trial and error" replacement. For example if there was a fault on the main part of the transceiver which had in turn caused the fault on the module then the replacement module would suffer the same fault. Therefore this method of repair should only be used when no better system is available.

### 8.6.2.2. Diagnostic Aids

One method used to test transceivers is to have a purpose designed test unit with a keyboard which is plugged into the transceiver. This unit then performs certain tests and measurements on the transceiver semi-automatically and displays the results on a screen. Such units have not been encountered amongst the missions and aid agencies in Central Africa.

A simplified and manual version of such test facilities exists in the form of three diagnostic boards designed by the author for the AEL 3030 transceiver which is produced by AEL Communications of Gatwick, UK. Whilst these particular boards can be only used in this model of transceiver, the principles of testing and indeed the circuits are suitable for other makes of transceivers, especially those from Trans World Communications Inc of the USA. The diagnostic boards are fitted, only one at a time, into the place of existing boards in the transceiver. An example of the tests which Test Board 101 can perform on the AEL 3030 is given in the following instructions which accompany the board. The circuit of Test Board 101 is shown in Fig. 8.3. This board has a row of LED lights along its top edge, numbered 1 to 7.

Test Board 101.

Switch off transceiver. Remove any mains power lead. Remove printed circuit board PC 101 and plug Test Board 101 into the same socket. Ensure aerial and microphone are connected and mains if used. Switch on the transceiver.

<b>OBSERVE LIGHT NUMBER</b>	<b>YOU OPERATE</b>	<b>CONDITION OF LIGHT</b>	<b>THIS INDICATES</b>	<b>YOUR ACTION</b>
<b>1.</b>	Press transmit button and speak into microphone.	Light flashes	Correct	No action.
<b>To test the microphone.</b>		Off	No input from microphone	Check connections to microphone. Repair as necessary. Otherwise try spare microphone.

<b>2. Tests that 12v is being switched to the Transmit circuits</b>	Transceiver on receive	Off	Correct	No action.
		On	Relay locked on Transmit	Short in microphone leads to transmit button. Repair or use spare microphone
	Press and hold on transmit	On	Correct	No action.
		Off	Relay not operating.	Break in microphone leads to transmit button. Try spare microphone. If fault remains change relay.
<b>3. Tests the 12volt supply</b>	When transceiver is on transmit and also on receive.	On	Correct	No action.
		Off	No 12 volts on PC 101.	If 12 volts present in Tests 2 or 4 then fault in the transceiver.
<b>4. Tests that 12volts is being switched to the Receive circuits</b>	Set on Receive	On	Correct	No action
		Off	Relay locked on transmit	Check for short in transmit button. Try spare microphone. Change relay.
	Press and hold on Transmit	On	Relay not operating.	Break in wires to the transmit button. Change relay.
		Off	Correct.	No action.
<b>5. Tests if the</b>	Rotate Squelch fully	On	Correct.	No action.

<b>Squelch control is worn.</b>	anti-clockwise	Off	Squelch control worn.	Replace Squelch control.
	Rotate Squelch slowly clockwise.	Slowly goes off.	Correct.	No action.
<b>6. Tests Loud-speaker.</b>	No operations	On	Correct	No action.
		Off	No circuit through loudspeaker.	Check connections to loud speaker and earphone socket.
<b>7. Tests if Audio control is worn.</b>	Rotate Audio fully clockwise.	On	Correct.	No action.
	Rotate Audio slowly anti-clockwise	Off	Audio control is worn.	Replace audio control.
		Slowly goes off.	Correct	No action.
		Goes out instantly.	Audio control is worn.	Replace Audio control.

### 8.6.2.3. Testing Diodes

Select the OHMS range on a multimeter and connect the diode between the leads. Measure its resistance and then reverse the leads and measure its resistance in the reverse direction. In one direction the resistance should be low e.g. 10 to 300 ohms, and in the other direction it should be high e.g. 1 Megohm = 1,000,000 ohms or more. If the diodes resistance is similar to these values then it is serviceable.

## 8.7. Workshop Repair

The aim of all users of radio communications equipment should be either for their own organisation to have a radio workshop, providing they have sufficient equipment to justify this, or to have definite arrangements with other workshops to repair the equipment. Workshop repairs is a subject on its own and no attempt is made to explain the methodology of repair. The cost of maintenance was mentioned in para.5.1.6. and of equipping a workshop in 5.2.4. The other aspects of staff, payments and spare parts have been mentioned in paras.8.1 to 8.3.

### **8.7.1. Requirements**

To perform satisfactory repairs in a workshop it is necessary to have:

- A qualified and capable radio technician.
- Adequate test equipment, tools and working space.
- A reliable source of sufficient electrical power.
- A secure and dust free room with adequate lighting and ventilation.
- A store of sufficient spare components and parts.
- Technical manuals for each type or model of transceiver to be repaired.

### **8.7.2. Instructions**

Radio operators should be instructed and encouraged to perform the test specified at their station before sending the equipment to the workshop. They should be instructed to send the microphone with the transceiver and any separate mains or other power unit used. Also the power cable and plug, aerial switch and its connecting cable if used. It must all be packed in a way suitable for the mode of transport.

## **8.8. Contract Maintenance**

Contract maintenance should be considered where there exists a reliable commercial radio repair facility which will usually be in a large city e.g. as in Nairobi. Also where there exists means of transporting equipment to and from this facility at reasonably frequent intervals. The actual economics of each organisation will be different and you will need to compare all the advantages and disadvantages involved.

The questions and costs to ask of a proposed provider of contract maintenance include: Retaining fee, labour cost per hour, overheads involved in obtaining and handling spares, equipment transportation arrangements, technicians travel and accommodation, and the maximum time from reporting fault to completion of repairs if this is definable.

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# WHERE THERE IS NO TELEPHONE

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## *Chapter 9. ADDITIONAL FACILITIES*

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In addition to the basic facility of transmitting and receiving speech a radio network of HF SSB transceivers can be used as the medium for transferring other forms of information. These can include teletyped messages which are typed out on a teleprinter by the operator for transmission and which are received and printed out automatically. Computers can be linked by radio and enabled to "talk to each other" and pictures can be sent over radio links. All these facilities are usually provided by additional "add on" equipment which simply plugs in to the basic transceiver. Note that SSB transmitter power rating is in watts pep, the equivalent continuous power output will be less than half that figure. So when continuous tones are being transmitted e.g. using a modem, the transmitter output must be kept within the specified limit.

### **9.1. Selective Calling**

Selective calling systems in various forms have been in use on radio networks for many years. The facility provided can be likened to that of a telephone in as much as you are able to cause a bell or buzzer to ring at a selected station by transmitting its individual calling code. For your HQ station to be able to call each station in the network individually you will require a selective calling unit with a different calling code for each station. This unit will also be capable of receiving the code and activating its own bell. All the other stations will require a unit to receive only their particular code and also to be able to transmit the code. The extent of the calling facility can be varied according to your needs e.g. the HQ station could call all stations at one time or each station could have the same ability as the HQ station etc.

Units are available which can be plugged into an auxiliary socket on the transceiver through which all

the connections are made. Other units are battery powered, give an audible output and have to be held in front of the microphone whilst the transmit button is pressed. To be able to receive a call the transceiver must of necessity be switched on and have the aerial connected. The transceiver can be left switched on all day with the loudspeaker off to await a call. Care must be taken to disconnect the aerial etc. when lightning is near. Calling units which use a series of tones are best suited to AM and FM transceivers but can be used on SSB provided that the transceiver is tuned within the limits stated e.g. + or - 500 Hz. Other units transmit a tone which is pulse width modulated and suitable for AM, FM, and SSB transceivers. The calling signal is transmitted for some 5 to 10 seconds and the units give very few false alarms.

## **9.2. Modems**

The word MODEM is derived from MODulator/DEModulator. It will produce the necessary modulation, usually 2 tones to enable data to be sent over an audio channel i.e. a telephone line or a radio channel. The unit also demodulates incoming tones and converts them into a data format. There are various pairs of tones and different durations of tones used in the many signalling systems. Therefore it is necessary to ensure that the modem at each end of the link and the transceivers are capable of handling the particular signalling system. Where a modem is used with a SSB transceiver link a tuning aid is necessary to enable the clarifier to be adjusted to set the tones at the correct pitch.

## **9.3. Facsimile**

A facsimile or fax machine converts a static black and white picture into electrical signals which can be transmitted over the audio channel of a radio link. The machine can also receive fax signals and convert them into a picture. The picture is transmitted by frequency modulating an audio sub-carrier e.g. a nominal 1900 Hz which transmits white when at 2300 Hz and varying scales of grey through to black at 1500 Hz.

## **9.4. Electrocardiographs**

Low frequency wave forms such as those from some medical sensors e.g. electrocardiographs (ECG), electronic stethoscopes etc. can also be transmitted over audio channels. The same method is used as in facsimile transmissions see para.9.3. ECG waveforms have been transmitted from Africa to America on frequencies allocated to amateur radio operators. This transmission method also enables you to have "a stethoscope a 1,000 miles long".

## **9.5. Morse Code**

The international morse code covers all the letters of the alphabet and all numbers. This code was well used in the early days of wireless communication. Today its use has greatly diminished. When a signal is weak or when there is a lot of interference you can hear and distinguish the dots and dashes of the morse code when you are unable to understand the speech. The operators at both ends of the link will have to be able to send and receive the morse code at a sensible speed. The minimum speed for a useful link would be some 8 words per minute. A morse key and possibly a tone oscillator will be necessary.

## **9.6. Linear Amplifier**

The transceivers mentioned so far have produced power outputs up to 150 watts pep. A linear amplifier can be connected between your transceiver aerial socket and the aerial itself to amplify the

150 watts pep to some 500 to 1,000 watts pep of transmitted power. A linear amplifier producing 1,000 watts pep will require from its mains or battery supply an average input power of some 500 watts. However if this power is obtained from a 12 volt source e.g. battery, then an average of 40 amps, peaking to over 100 amps would be necessary. Therefore it is best to only use such amplifiers from a 230 volts or 110 volts supply.

A linear amplifier enables you to transmit more power and to be heard more clearly by the distant station. However you could also cause interference to other users of the same or adjacent channels as well as other receivers within a few hundred metres of your aerial. Linear amplifiers can be left permanently connected in the aerial circuit and only switched on when another station is having difficulty receiving you. When the linear amplifier is switched off the transceiver output is automatically connected straight to the aerial therefore it will still be necessary to disconnect the aerial after using the equipment.

## **9.7. Aerial Tuning Units**

The use of these units have been described in para. 2.6.3. for tuning long wire aerials to a transceiver. They can also be used to tune a dipole or other aerial for use at a frequency for which it was not designed.

## **9.8. Remotely Controlled Coaxial Switches**

Where a transceiver needs to use more than one aerial either a manual or a remotely controlled selector switch can be used. A remote switch will be connected to the transceiver by a multicore cable so that when a channel is selected the appropriate aerial is automatically selected by the remote switch.

## **9.9. Telephone Handset**

A handset which looks similar to those in use on a normal telephone can be connected to the transceiver. The handset will have an additional button or lever switch to provide a "press to transmit" facility.

## **9.10. Boom Microphones**

If it is necessary for the person speaking on the radio to look around whilst speaking e.g. whilst driving a vehicle, then a boom microphone which can be fitted to a pair of earphones should be positioned in front of his mouth.

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# WHERE THERE IS NO TELEPHONE

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## *Chapter 10. Packet Radio*

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**10.1**     [HF, VHF and UHF Links](#)

**10.2**     [Satellite Links](#)

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Packet radio is a form of data communication which has several forms e.g. X25 is in professional use, AX25 is used by amateurs and there are other formats. The text message to be transmitted is broken up into packets which may contain up to 256 characters. AX25 packets take the following form: They start and end with synchronising signal thus making the data within the packet a synchronous format.

The second part of the packet is an address area which contains the destination, origin and any station through which the originator may wish the packet to be relayed.

The relay stations are called digipeaters. They simply receive a packet and automatically transmit it to the next address on the packet. In addition to the text, each packet also contains control codes and error checking information. Until the receiving station confirms to the transmitting station that it has received the packet correctly, the same packet will be transmitted again. This procedure of re-tries will continue until the maximum number of re-tries e.g. 10, is reached after which a failure will be indicated.

The packet radio operating system, packet format and other information is stored either in the Terminal Node Controller (TNC) or a computer program which interfaces between the keyboard and the radio. The TNC switches the transmitter on and off automatically. Initially the operator has to establish contact with the distant station using the keyboard. A connection will be indicated either by text on the VDU or printer, or by illumination of the appropriate LED, after which the operator sends the message using the keyboard. A further command is necessary from the operator to disconnect the link otherwise automatic disconnection may occur if no messages have been passed for a given time e.g. 1 minute.

In addition to a direct contact between two stations, packet radio is extensively used with mailboxes and bulletin boards. These facilities are similar to those which are available using modems over telephone lines. Mailboxes, as the name suggests, provide the facility for leaving mail at a distant station when the operator is not present. The mailbox may be at the distant station or some other station from where the mail can be collected, over the radio link. Bulletin Boards are again self explanatory. Messages are displayed on a bulletin board (BBS) at a station which has the necessary computer and software. These stations can be connected to and the list of bulletins observed. The full text of the required bulletin can then be down-loaded as indeed can any files or computer programs listed as being available at that particular BBS.

In addition to PACKET there are other systems for passing data such as AMTOR and PACTOR, the

latter being a combination of PACKET and amTOR.

## 10.1. HF, VHF and UHF Links

Problems can be encountered when transmitting data over HF links. Signal fading can be more serious when data is transmitted than with voice transmissions. Whereas a human operator can decide whether a missed word needs repeating, a data system cannot so decide and is required to produce an error free message. On the other hand data transmissions require a lower signal to noise ratio than speech. A voice radio link can also be used to carry packet radio. However the highest baud rate that can be used will be dependant upon the quality of the radio link. This is the case when data is passed over the telephone network where the quality of various lines vary. A baud is the number of pulses transmitted per second.

On VHF and UHF circuits baud rates of 1200 to 9600 bauds are common. Because of effects such as multipath reception on HF the baud rate is lower, 300 bauds being common. An example of incorporating packet radio into a radio network can be seen in a unit developed by Dr S.A.G. Chandler of Warwick University, U.K. The unit can be used in developing countries which have limited telecommunications infrastructure, one network was established in the Bonthe area of Sierra Leone. The AFRICOM RADIO NETWORK CONTROLLER can be used to provide many very useful facilities on a radio network which would otherwise only have conventional voice capability. In its packet mode the unit enables the exchange of text messages between any two similarly equipped stations. If the stations are too far apart for direct contact then the messages can be automatically relayed via several intermediate stations. If the distant station is switched on, even though no operator is present, the text message can be received and stored.

Amongst other parameters the unit measures the stations battery voltage and solar charging current every 15 minutes and stores this data for the previous and current day. This data can be requested by a distant station and will be automatically transmitted to that station. The unit can measure the transmitter power output and VSWR of the aerial system. Again this information can be requested by a distant station. It appears that this unit is most useful, not only in the management of the station itself, but also for remote measurements of all the stations in a network from the maintenance headquarters.

An extension of the facilities envisaged by the author is that one station will collect daily, over the radio network, the 24 hour record of each stations parameters including transmitter power, VSWR etc. This data can then be transmitted via a store and forward packet satellite (see para 10.2) to another country, which may have the overall maintenance responsibility.

## 10.2. Satellite Links

When communication facilities were first provided by satellites in the 1960's it was anticipated that this would result in the demise of short wave radio communication systems. Despite the vast number of satellites in orbit, providing many thousands of telephone and data channels, short wave radio is still in common use and is the only means of communication that many organisations can afford.

Much of the international telecommunications traffic is carried by geostationary satellites in orbit at some 33,700 kilometres above the earth. Using one or two of these satellites gives virtually instantaneous communications between any two locations on the earth, except in the polar regions. Such satellites can cost \$400,000,000. When instantaneous communications is not vital then a less costly satellite system is available using satellites in low earth orbit (LEO). These satellites can be in orbit some 800 kilometres above the earth and cost some \$1,000,000. Such satellites are only visible

to an earth station for up to 15 minutes at a time and take about one and a half hours to go around the earth. Hence messages are transmitted up to the satellite, stored and then transmitted down when the required ground station is in view. The satellite is a flying mailbox and the technique used is called STORE and FORWARD.

LEO's are a suitable and affordable solution to the problem of transferring information between two places on the earth without dependence upon the telephone systems of the countries concerned. Telecommunications to, from and within some developing countries can be difficult and in some cases impossible. By 1992 two groups, Volunteers in Technical Assistance (VITA) and SatelLife, had provided a satellite. This had a store and forward facility and enabled text messages to be sent by various groups involved in helping in developing countries. LEO's were described by some people as "the poor mans satellite", but in this application they can be described more correctly as the "appropriate satellite".

The opportunities offered by LEOs are limited, e.g. a satellite can only be contacted from a particular point on earth whilst it is passing over that particular region i.e. within a range of some 3,000 km from the ground station. Then the satellite is usable for 1 to 15 minutes during each pass and there are 2 or 3 consecutive usable passes, occurring at 100 minute intervals, every 12 hours. The method of handling the text messages is by packet radio. It may seem that a usable time of 10 minutes is rather short, but with a baud rate of 9,600 and a duplex system, the packet radio system used can in theory send and receive 700,000 characters in 10 minutes. In practice some 500,000 characters have been down-loaded in one pass.

A ground station for the VITA system consisted of a computer e.g. laptop, a packet radio terminal node controller (TNC), a transmitter for 148 to 149.9 MHz with a power output of some 30 to 40 watts, a receiver for the 420 to 430 MHz band and a modest aerial array made of thin metal tubing. The whole system could be solar powered with the aid of a storage battery. The cost of a ground station was some \$4,500 to \$6,000 in 1997. Such a VITA ground station, provided the the UK based Baptist Missionary Society, was rapidly deployed at Vanga Hospital, Zaire at the time of the ebola outbreak in May 1995. This facility provided a data link from this remote area to the international community, via satellite UO\_14. Similar additional equipment was later provided from USA for a link to the SatelLife satellite HS\_2.

At the beginning of 1997 the addresses of the organisations were:

Volunteers in Technical Assistance	Tel: 703 276 1800
Director of Informatices	Fax: 703 243 1865
1600 Wilson Boulevard. Suite 500	E-mail: vita@vit.org
ARLINGTON	
Virginia 22209	
USA	

SatelLife	Tel: 617 789 5455
Director of Operations	Fax: 617 789 4771
1360 Soldiers Field Road	E-mail: hnet@usa.healthnet.org
BOSTON	URL: <a href="http://www.healthnet.org/">http://www.healthnet.org/</a>
Mass. 02135	
USA	

The World Administrative Radio Conference (WARC92) allocated 148 to 149.9 MHz on a primary basis, for use with small LEO satellites e.g. the VITA satellite. In the UK the radio regulatory body is the Radiocommunications Agency of the Department of Trade and Industry. This agency will not permit the use of 148 to 149.9 MHz by ground stations to communicate with LEOs. This is because they allocate the frequencies to the private mobile radio systems of the gas and electricity industries, for public safety and emergency situation communications. This was the situation in September 1992 but it may change with time. Current regulations can be obtained from:

Radio Communications Agency  
Waterloo Bridge House  
Waterloo Road  
LONDON SE1 8UA

UK users are overcoming this restriction by sending their messages by e-mail to other countries e.g. Eire and USA, where there are ground stations in operation.

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# WHERE THERE IS NO TELEPHONE

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## ***Chapter 11. DISASTER AND RELIEF COMMUNICATIONS***

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### **11.1. Need**

If the urgency for a task determines the priority given to it, the communication facilities for disaster and relief come high on the agenda. The rapid progress in, and availability of, smaller and less costly portable global communication facilities means that this is a continuously changing scene. However it is necessary to stop, consolidate a requirement and provision for that need. But, wherever possible, designing in the ability for the system to be updated rather than replaced when this a cost+effective exercise for the user. Many specifications have been written for such communication facilities.

### **11.2. History**

In 1979 the World Administrative Radio Conference updated its recommendations of 1971, relating to the use of satellite telecommunications for disaster situations. The belief was that "the rapid availability of reliable communications immediately following a natural disaster would prove helpful in saving lives". Mention was made of the CCIR study of 1974+78 for a "transportable earth station" which could be shipped by air and not exceed some 7 to 10 tons.

By 1984 equipment size had been reduced and an experiment was performed in Swaziland, using a land mobile facility. This consisted of a 'ship earth station' mounted in a Land Rover, with an extended roof area at the rear. A portable generator provided the electrical power and the system could be operational 5 minutes after the vehicle had been parked. The cost of ground stations is an important consideration for relief agencies. At the Disaster Communication conference, held at Tampere, Finland in 1991, the US\$ 35,000 cost of an INMARSAT+ portable earth station was considered too high.

### **11.3. Today**

The situation in 1997 is that portable earth stations exist in the form of SATPHONES, costing from



US\$4,500 to US\$9,000. The whole system is contained in a small case with the lid housing the antennae, having an area of approximately 0.05 square metre. The weight, including the rechargeable batteries can be some 2.5 kgs. Additional charges can be incurred for import into, and for use within, some countries.

#### **11.4. Tomorrow**

By the year 2000 there should be several satellite communication systems operational which can be accessed with handsets, which resemble the mobile phones of today. The satellites will be in either low earth orbit (LEO) at a height of some 1,000 kms or medium earth orbit (MEO) at some 10,000 kms.

#### **11.5. Information**

A book has recently been published, in June 1996, which deals with the whole subject of communications for disaster and relief. The book is DISASTER COMMUNICATIONS by Mark Wood of "The Disaster Relief Communications Foundation". Ordering details can be obtained on Web page:

[http://ourworld.compuserve.com/homepages/mark\\_a\\_wood](http://ourworld.compuserve.com/homepages/mark_a_wood)

The book is obtained from:

ASSOCIATION OF PUBLIC SAFETY COMMUNICATION OFFICIALS (APCO) with USA telephone: 904.322.2500 or fax: 904.322.9766 the cost is US\$ 40 plus shipping.

Because this book covers the subject in detail, no attempt is being made in this chapter to duplicate the subject. Instead the Index of the book is given in the following Appendix so that the extent of the contents can be seen.

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