The UK PRC 316 / A-16

by John Teague, G3GTJ

INTRODUCTION

This paper describes the PRC 316 and is an expanded version of an earlier contribution to the Centre for the History of Defence Electronics (CHiDE) colloquium on *Military Communications,* held in September 1999.

The radio was designed and developed for the British Army in the mid-sixties by the Signals Research & Development Establishment (SRDE) at Christchurch. Designated X3145 in the experimental phase it became “Station Radio A-16”; later it was given the Clansman style designation of “UK/PRC 316”, which is how it was generally known in service.

To quote from the November 1968 edition of the User Handbook: "*The lightweight HF patrol radio PRC 316 is a compact, simple to operate transmitter-receiver developed primarily for use at the halt. It provides 45 crystal controlled communication channels in the band 2 - 7MHz . . . . (It) is intended to operate at ranges up to about 800 km using CW*."

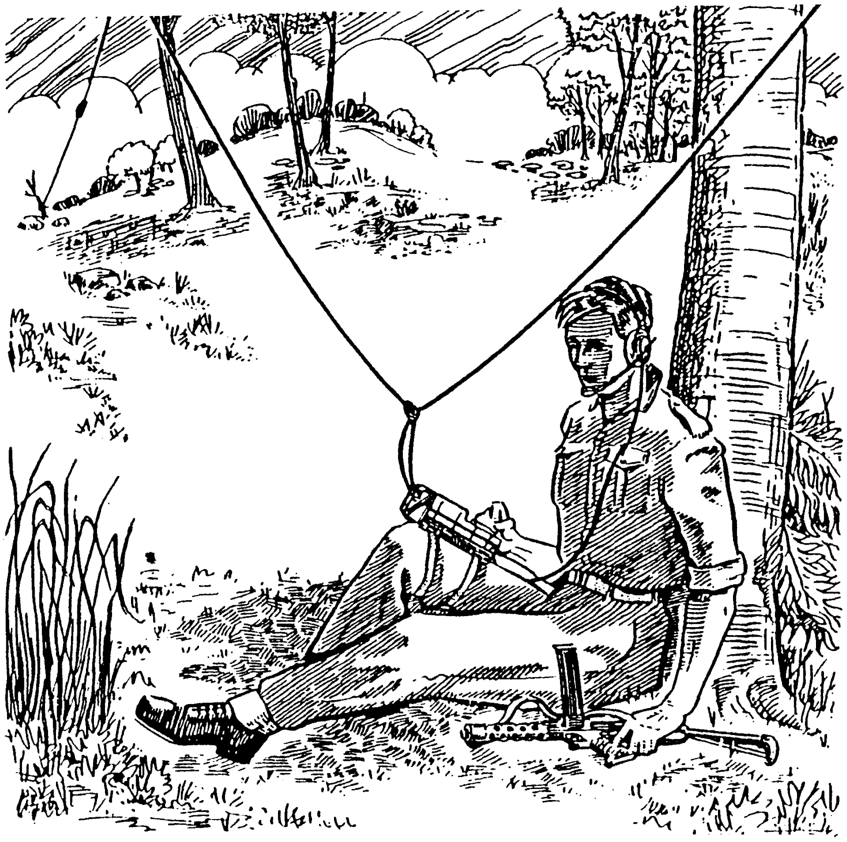


Figure 1: Light-weight HF patrol radio X3145 in use

The MoD artist's impression, Figure 1, shows a rather unhappy looking operator using a PRC 316 in the field; the leg straps, later abandoned, can be seen.

DESIGN BACKGROUND - JUNGLE OPERATIONS

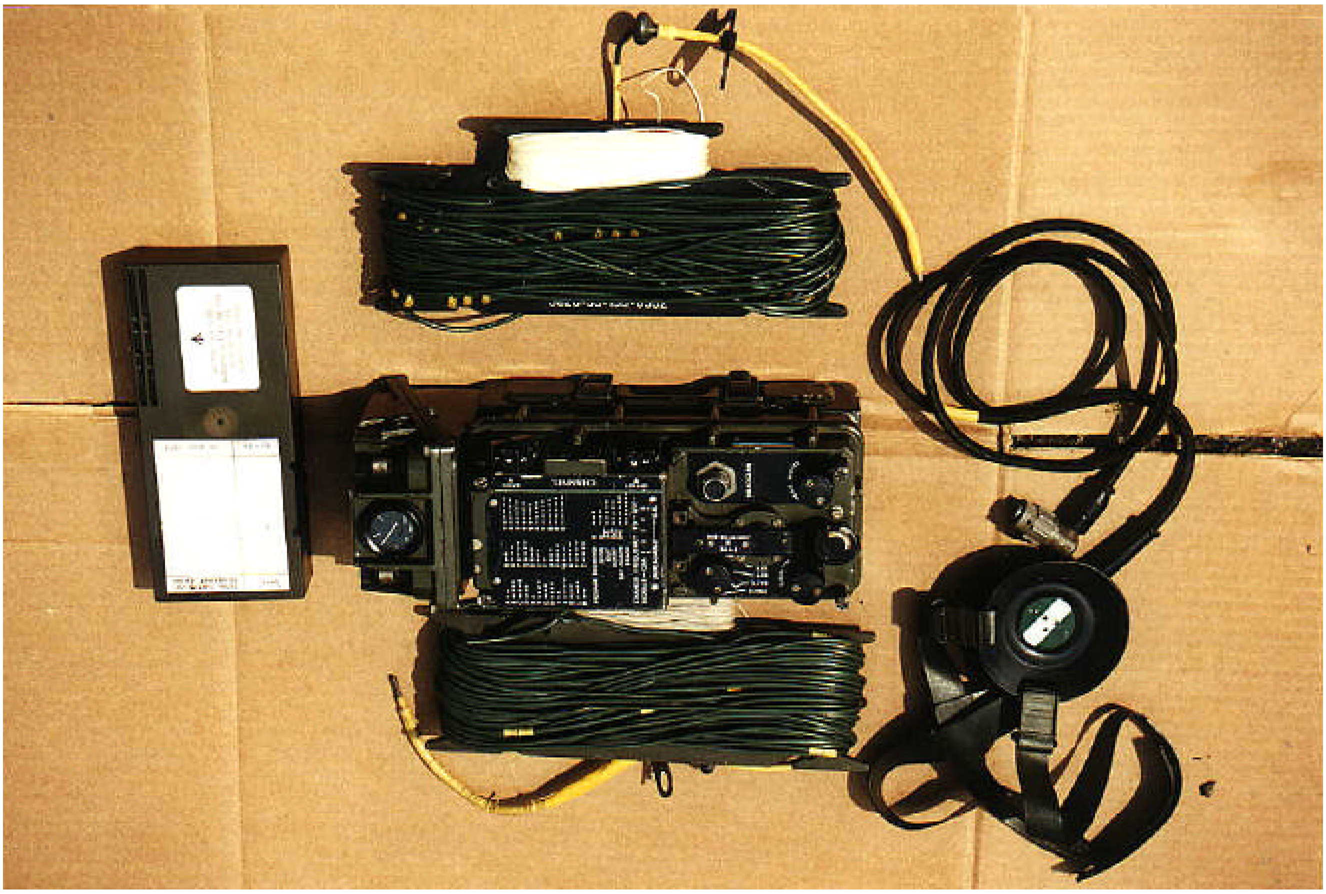
Anti-terrorist operations in the Far East typified the environment for which the set was designed. Known colloquially within SRDE as the "Jungle Set", the PRC 316 was conceived as a “soldier proof” military radio to avoid the problems which had bedevilled operations in Borneo and Malaya. It did not originate as a clandestine radio and it was not aimed at this application.

Strategy in Malaya was based on self-sufficient independent patrols, inserted by helicopter for one month without re-supply. Prior to the introduction of the PRC 316 patrols were dependent on typical army radios of the time - the A-13 and A-14. By comparison these were heavy, bulky and ineffective: patrols could become incommunicado once on the ground in their operational area.

Typical jungle for which the PRC 316 was designed consists of a wet tree canopy about 100 feet above ground level; the trees are dense but other ground vegetation is sparse. Temperature ranges in the jungle are not extreme but humidity is high. A very high level of wide band electrical noise, a consequence of the continuous tropical thunderstorms, is present at all times over the HF band. In these conditions attenuation and masking of ground wave HF radio signals is severe. Even with 50 watts of RF power a ground wave range of only two miles or so was obtained using conventional military whip aerials.

Tests had shown that Near Vertical Incidence Skywave (NVIS) propagation was not impeded by the canopy and would provide the required range coverage from zero to 300km and more. The prevailing propagation conditions favoured frequencies at the low end of the HF band and NVIS could be readily achieved using low dipole aerials.

Figure 2: The PRC 316 and accessories



THE OPERATIONAL REQUIREMENT

The set had to provide:

- As a first requirement, reliable communication from ground level jungle sites over distances from zero to 500 km. (In practice ranges of 2000 km were obtained using elevated aerials in the clear.)
- Simplicity of operation was essential, so that the set could be used by Ghurka and other infantry with morse, but little technical training - see front panel view, Figure 3. The morse code table on the front panel, provided for emergency use by completely untrained users ("the officers" according to one of my informants), is not shown on this diagram.
- A compact lightweight package sealed against jungle moisture. The set had to be reliable and insensitive to abuse; low power consumption was essential to minimise battery size and weight. Experience had shown that hand and power operated generators were not viable for routine use.
- Since the enemy was considered unsophisticated, measures against interception and jamming of transmissions were not required. Later, however, an interface unit was designed to enable the US GRA-71 burst transmission device to be used.

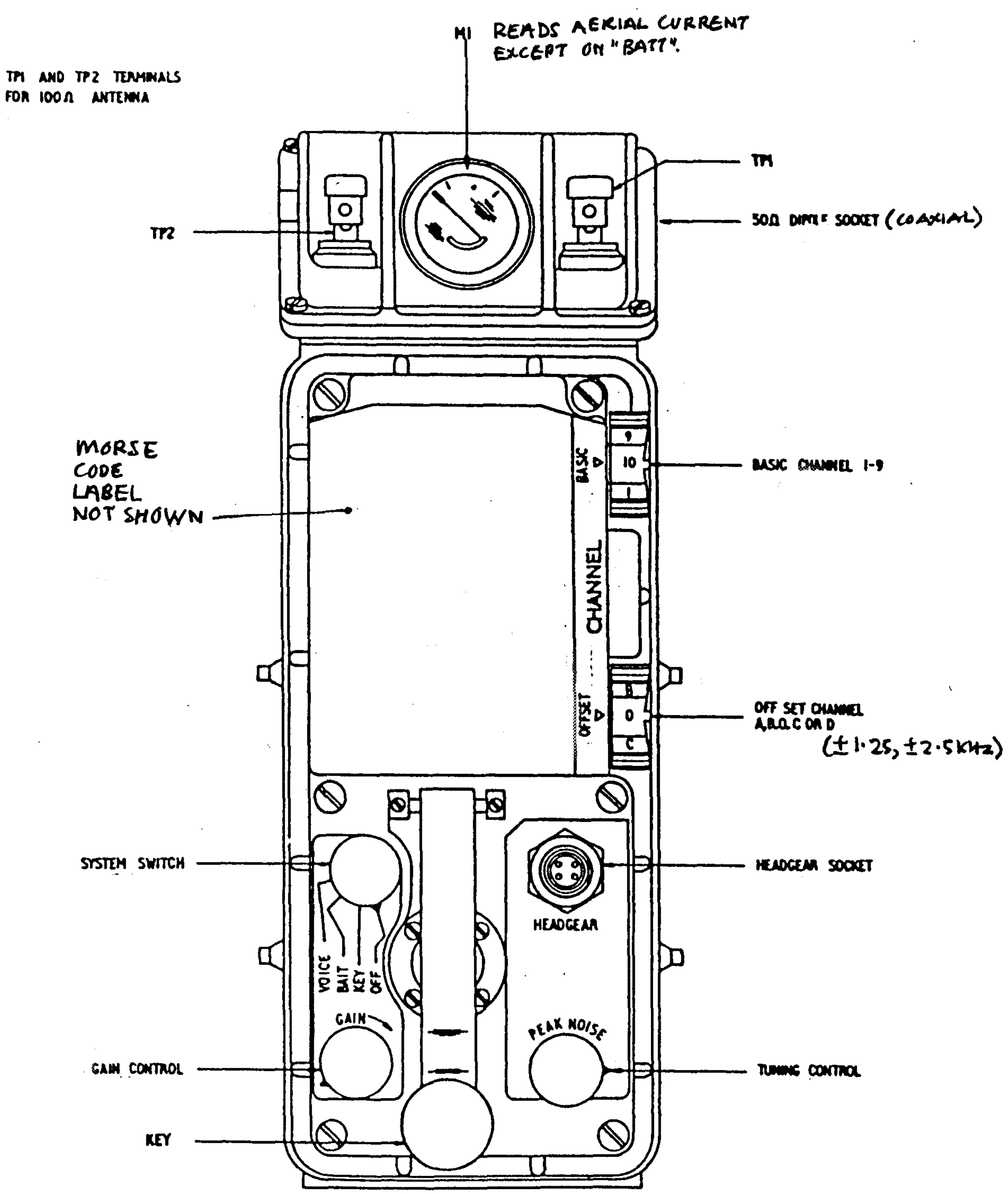
SOLUTION

Light weight and small size were achieved by using an all solid state design centred on a low power (4 watts) CW transmitter allied to a narrow band (300 Hz) receiver. Nine channels in the band 2–7MHz provided day and night propagation. Incremental tuning, crystal controlled - but not in whole numbers of kHz - enabled the majority of interfering signals, including all those generated by synthesisers, to be avoided.

The low dipole aerial, adjustable in length and connected directly to the set, provided the high angle radiation for NVIS propagation. A conventional double sideband amplitude modulation capability was incorporated for short range use, principally for air to ground communication. Then new Fairchild NPN transistors were rugged, while under-run RF power transistors gave immunity from misuse in the field - short or open circuited aerials, for example.

Despite the small size of the set and the low power, the specified performance was readily obtained and successful demonstrations to a sceptical military were carried out in typical conditions in Borneo and elsewhere. Basic performance had already been demonstrated by consistently good results over a 1250 km South Coast to Cape Wrath circuit in UK.

Figure 3: PRC 316 front panel controls and connections



The target reliability (MTBF of 1500 hours) was easily achieved. What proved far from easy was mass production of the metallised plastic case – but ultimately this problem was solved; prototype and pre-production cases were metallised at SRDE without serious difficulty. Batteries incorporating indium-bismuth cells were tried initially to give the highest performance per pound weight but these contained corrosive electrolyte, were difficult to seal and vulnerable to battle damage. They were abandoned in favour of conventional alkaline cells.

ENGINEERING

Design started in 1964 and was completed 12 months later, and Rank Bush Murphy (later Rank Precision Industries) was selected as the manufacturer. However, the introduction of stringent new quality assurance criteria and some manufacturing difficulties meant that this momentum was not maintained in the pre-production and production phases. Many of the features of the PRC 316 design, although later commonplace, were new if not revolutionary in the 1960s:

- All solid state.
- Widespread use of NPN transistors and diode switching.
- Varactor tuning of the RF circuits.
- Wide band design of transmitter.
- Metallised plastic case.
- Double conversion receiver.
- Modules - a rudimentary form of integrated circuit.

As can be seen (Figure 4), discrete components are used throughout the set – the design pre-dated integrated circuits – but some components are grouped into “cordwood” modules. These are small assemblies of vertically mounted components to reduce plan area. The only difficulty is that circuit diagrams for the modules are not given in the servicing data, although I have some information on these.

The transmitter-receiver with battery and aerial equipment fits into the small sack, and the lot weighs less than five kilograms. If required a second kitbag was provided, which contained the US-made high speed morse attachment with its British made interface unit, which plugs into the battery compartment. This enables a burst transmission to be made at about 300 words per minute. I have been unable to discover what base equipment was used by British forces in the high speed mode and if anyone can tell me more about this I should be glad to hear it.

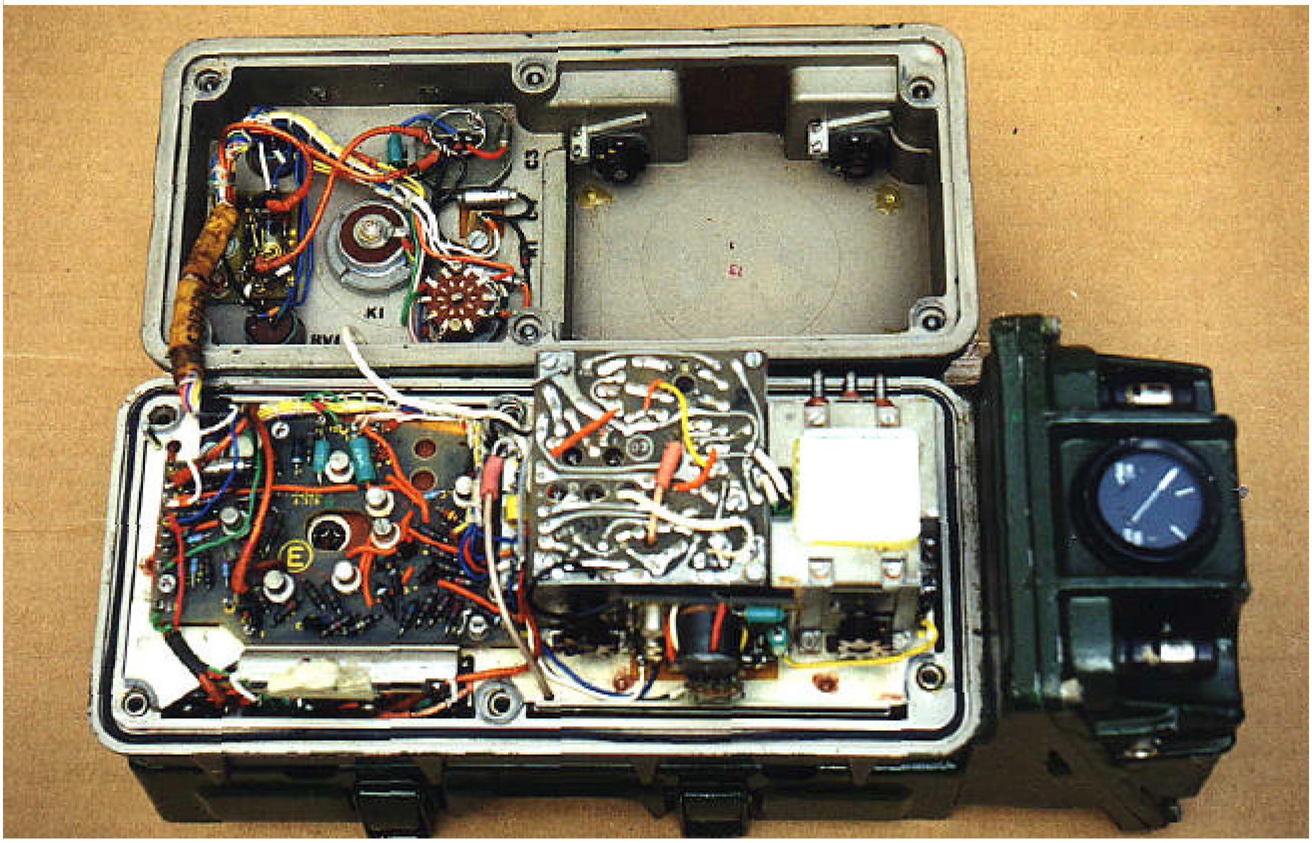
In addition to the two aerial winders, the radio is provided with an earpiece, which doubles as a microphone, or a conventional headset/boom mic assembly. An internally stowed, 16 volt, alkaline battery provides about 20 hours use. Considering the size of the set, the performance specified and obtained is remarkable in view of the transmitter output of only four watts. This was achieved through the use of crystal control to give transmitter stability allied with a narrow band receiver to provide a good signal to noise ratio.

Despite the low power the specified performance was readily obtained, and successful demonstrations to a sceptical military were carried out in typical conditions in Borneo and elsewhere.

TECHNICAL DESCRIPTION

It will be seen from the block diagram (Figure 5) that a plethora of crystal oscillators and mixers is used to generate the various frequencies used in the set. A total of 45 channels is provided, nine spaced over the range, each variable up or down by two steps, each step being just over one kilohertz. The tuneable RF amplifier is used for both transmit and receive and the tuning voltage for the varactor diodes is produced by a low frequency RF oscillator plus rectifier.

Figure 4: Internal view of the PRC 316



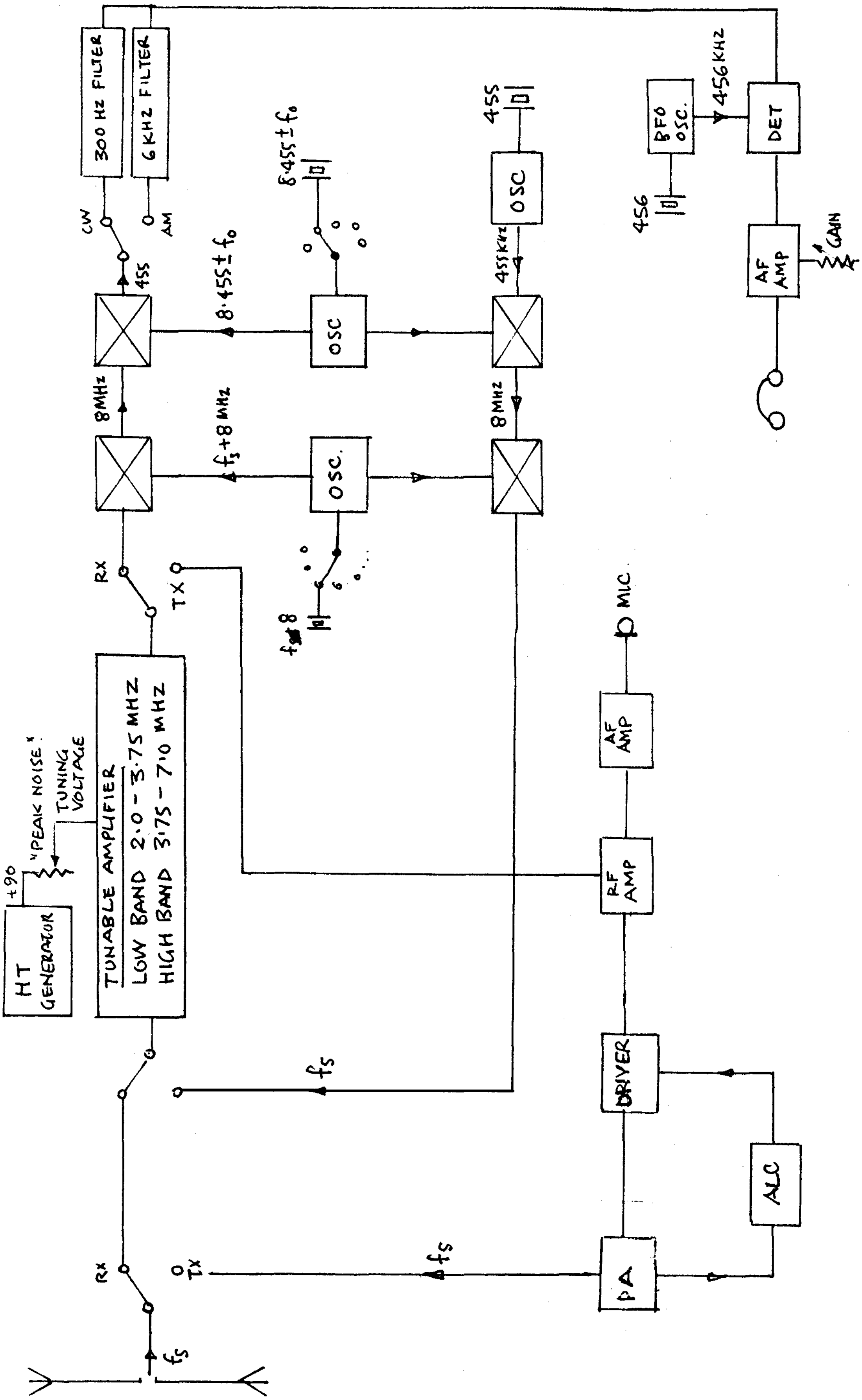


Figure 3: PRC 316 Block Diagram

Table 1: PRC UK A16/ PRC 316 crystal channels (kHz)

Chan No ∨	1	2	3	4	5	6	7	8	9
Set type ⇐									
A	2215	2520	3170	3710	4590	4875	5130	5270	5895
B	2280	2700	3280	3710	4510	4875	5305	6350	6940
C	3710	4040	4490	4574	4950	5090	5905	6770	6955
D	3205	3710	3970	4040	4595	5090	5925	6776	6955
E	2133	3170	3901	4659	4870	5202	6608	6770	6955

On receive the input signal is mixed with the output of the channel oscillator with its nine crystals, to generate a first IF of 8MHz. This 8MHz signal is mixed again with the offset oscillator output to produce the final IF of 455 kHz. The offset oscillator has five crystals, one at 8.455kHz and the others at plus and minus 1.3 or 2.5kHz. This arrangement allows the output frequency to be varied +/- 1.3 or 2.5kHz, the objective being to move the carrier away from integral numbers of kilohertz generated by synthesised interfering signals. Finally the IF is passed through the narrow (CW) or wide (AM or drifting signals) filters to the detector and audio amplifier. A crystal controlled BFO displaced by one kilohertz feeds the detector on CW. The receiver has a manual gain control, but no AGC, and consequently a restricted dynamic range.

For transmit an additional crystal oscillator at 455kHz “sidesteps” the 8.455MHz +/- offset frequency back to 8MHz where it is mixed with the channel oscillator output to generate the signal frequency. This is filtered in the tuneable amplifier and feeds the linear driver and PA via a further amplifier, which is amplitude modulated on “voice.” The PA output is sampled to feed an ALC loop. The PA output can be short or open circuited without damage. A meter is fitted which reads battery voltage or aerial current. I have used my set over distances from 50 to 500 miles and it performs admirably in both modes.

Altogether five variants of the PRC 316 entered service with the British army, each having a different selection of channel crystals - see Table 1. The sets are identified by the letters A to E and kits were provided containing the crystal channel oscillator unit with the corresponding type label and aerial length table. In addition each variant of the set demands a different pair of aerial winders. Changing the frequency range was not practicable in the field.

The channels available from each of the five variants are shown in Table.1 above.

AERIALS

Each dipole element is normally connected directly to the set terminals; for long distance skywave propagation the dipole can be elevated and coupled to the set by a coaxial feeder to the alternative low impedance aerial output. The aerial winders carry about 100ft of non-kinking insulated conductor and a similar length of thin throwing cord. A table of element length according to transmitter channel is provided in the battery compartment of the set. The aerial conductors carry sleeves in groups corresponding with the channel numbers (Figure 6) For this reason each variant of the radio required a corresponding pair of aerial winders. The aerial length table also gave lengths of plain wire elements – i.e. not from a winder. These lengths are

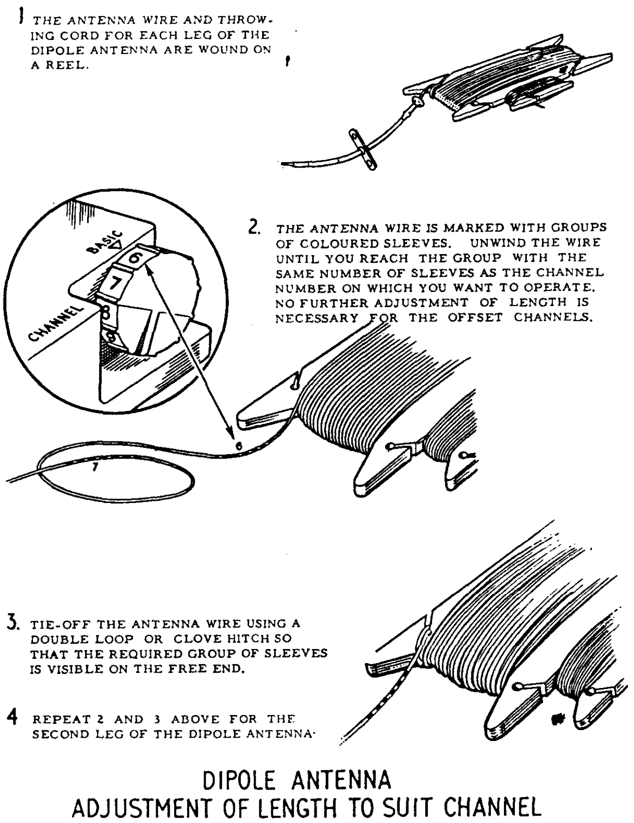
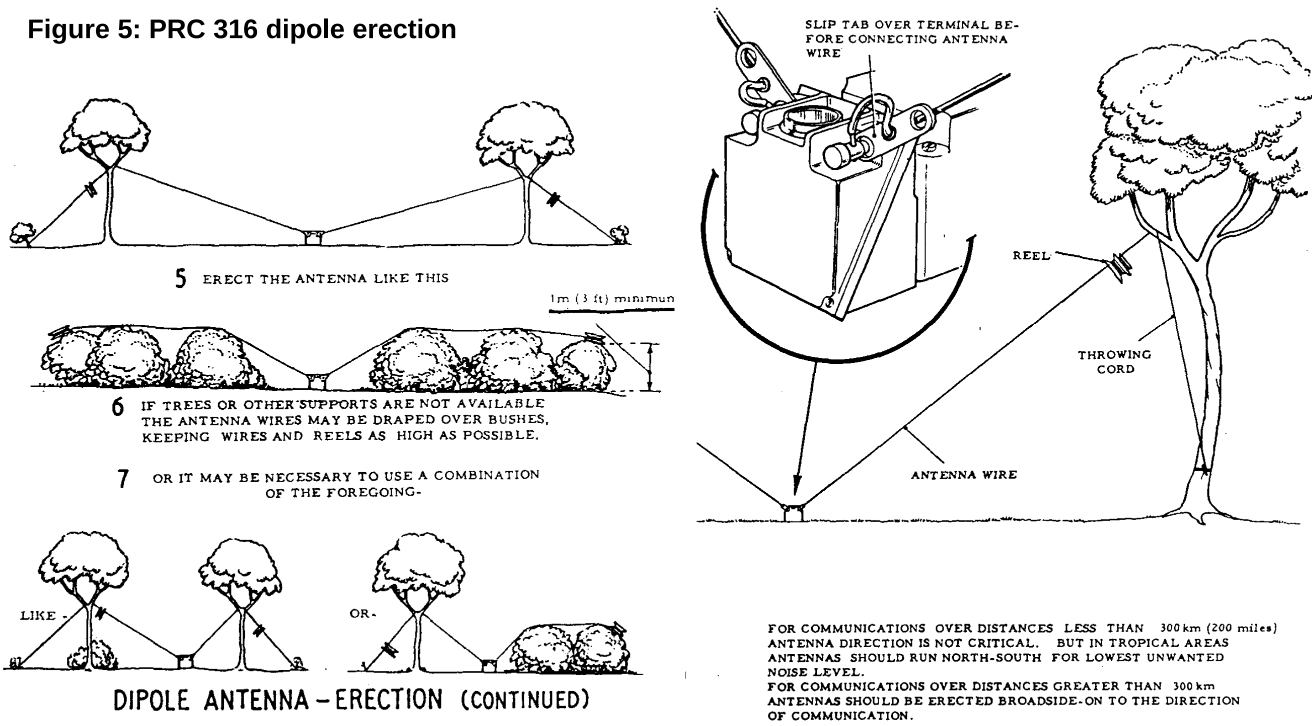


Figure 4: PRC 316 dipole antenna detail

Figure 5: PRC 316 dipole erection



very slightly shorter than the winder lengths to allow for the effect of the coiled unused wire.

The User Handbook gives numerous examples of field installations – see figure 7. In service it was common practice to connect the set to a convenient wire fence as aerial, if it was available. Whip aerials were also used, particularly when the set was adapted as a manpack, the whip being tuned by means of an A-13 type, tuning unit. For long distance skywave working fifty feet of small diameter coaxial cable was provided as feeder to a dipole centre so that the aerial could be raised between trees or buildings.

ACCESSORIES

In addition to the burst transmission equipment a small range of accessories was produced for the set and others were taken from earlier equipment – the A-13, for example – see Figure 8. The Adaptor Battery fits in place of the battery and enables the set to be powered from any input supply between 12 and 32 volts; it also provides reverse polarity protection.

PERFORMANCE

The set that entered service differed little from the original design. Provision for strapping the set to the operator's thigh was disliked by users and abandoned; the control knobs were changed too. The headset alternative to

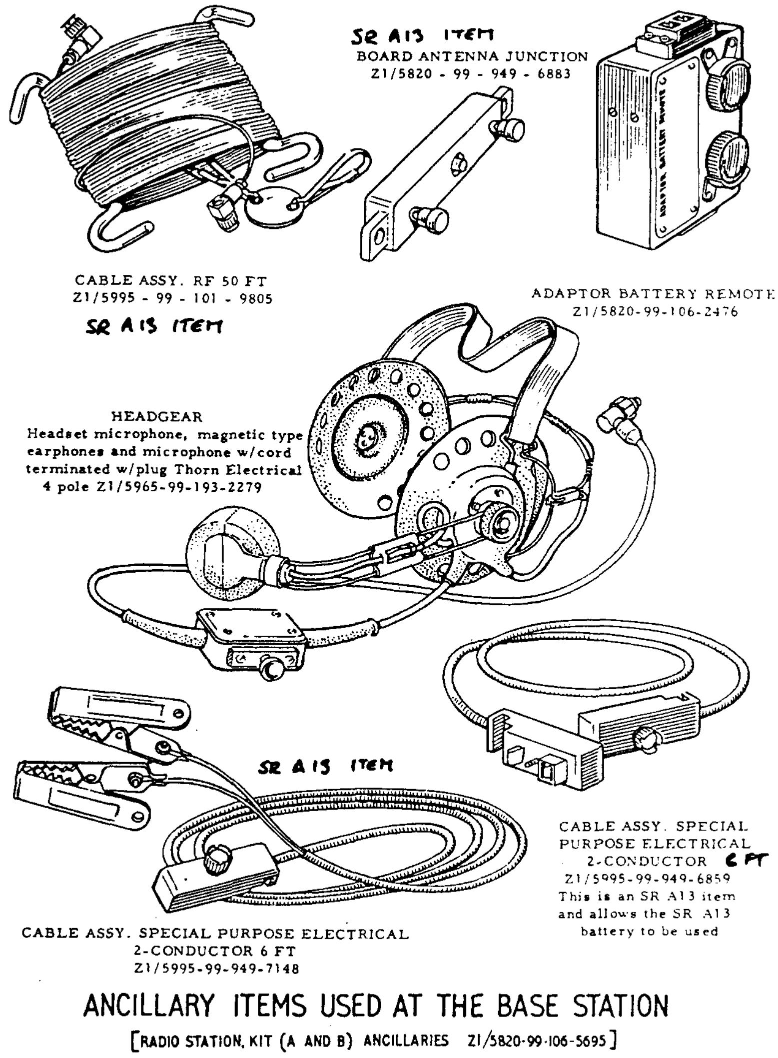


Figure 8: PRC 316 accessories

the combined mic/earphone was unpopular, rarely used in the field. While production was in progress the manufacturers offered the set to export customers for around £600 each. Reputedly used in the Falklands campaign the PRC 316 was taken out of operational service with the British Army in the early nineties - but it is believed to be still in use as an aid in the training and selection of technicians.

SOURCES

A great deal of information was kindly provided in conversation and correspondence with Dr R. Whittlestone (G3AOH) a member of the original design team at SRDE. In addition Pat Hawker G3VA, John Langan G0KKO, Hugh Kemp G4TMO and John Weston of the Electrical Inspection Directorate have also been very helpful.

Published Articles:

Harrison, Tom: "*The PRC-316 . . . an Appreciation*", Radio Bygones No 43, October/November 1996.

Hawker, Pat: "*The UK/PRC316 (A-16) and Early Solid State Manpacks*", Radio Bygones No 45, February/March 1997.

Farmer, E: "*A look at NVIS Techniques*", QST January 1995, pp 39-42 (I have seen a number of articles - this is the most comprehensive).

Official Handbooks:

User Handbook for UK/PRC-316, Army Code No 14961, November 1968.

User Handbook (Trials Edition) for Lightweight HF Patrol Radio X3145, SRDE Handbook No 1154A, October 1965.

EMER Telecommunications F 203 & F 204 "*Station Radio UK/PRC 316 Technical Handbook*" October 1971.

APPENDIX - THE PRC 316 ON THE AMATEUR BANDS

It will be seen from Table 1 that all the sets except Model E have a channel at 3710kHz. For other frequencies alternative crystals can be fitted – quite a straightforward operation but a slim soldering iron will be needed. If the frequency is above 3.75MHz, then the new crystal must be fitted in one of the "high band" positions of the channel switch. To fit the new crystal, the channel oscillator unit must be removed complete and dismantled. In my experience with two sets the available tuning range easily extends to cover all top band and most of 40m although with a slight power loss at frequencies above 7050kHz. Thus three bands are available.

In practice a VFO drive is desirable. An external VFO can be replace either the channel or incremental crystal oscillators. I have used both methods and had successful QSOs on 40m and 80m (I don't have an aerial usable on top band.)

With either method a decision has to be made on bringing in the coaxial cable feed from the VFO. Phono plugs are small and convenient and are very shallow inboard. If you don't object to drilling holes then the best place to fit it is on the left hand side of the case in the region of the Gain control. The internal cable can then be integrated with the existing wiring loom and will not impede lifting the lid. Otherwise it is possible, but room is very tight, to remove the mods label and drill 'beneath' it. The VFO input connection is made to the emitter output from the crystal oscillator in both cases. The advantages of using the incremental oscillator are that the necessary VFO frequency range is restricted to 8.455MHz +/- 500 kHz, and the VFO frequency subtracts from the channel oscillator frequency, so that all bands are immediately available. However some mental arithmetic is needed to translate the VFO frequency to the output signal frequency, and from an operating point of view substituting for the channel oscillator is easier, but the VFO will have to tune 9 – 15 MHz approximately. If anyone would like fuller details of how to carry out these modifications I will be glad to provide them.

Faults

If a clear noise peak cannot be tuned by the "Peak Noise" tuning control, then it maybe that the tuneable amplifier chain needs alignment. This can be carried out without a signal generator by merely tuning for maximum noise using the channel positions at the end of each tuning range - but the relevant EMER is necessary, to identify the tuning slugs, and a fine tuning screwdriver. I used a sharpened matchstick.

A much more likely problem is failure to start by the tuning voltage oscillator and the user handbook recommends switching on and off a few times. This oscillator output is rectified to provide the 90 volt supply for the tuning diodes. I have had no other problems with either of my sets.

Expended batteries can be emptied of their cells (with some difficulty) and new cells installed, rechargeable if required. Battery dates are sometimes surprisingly recent because the same battery was used in other, more recent applications.

Some trouble has been taken in the design of the aerial terminations to prevent disconnection of the conductor through frequent flexing – however this is not always successful. Surplus aerial elements bought at rallies, I have found, are often broken internally at the pin end. The conductors are few and thin and difficult to solder – re-crimping the end is the best solution after drilling out the original stub. The conductors have a DC resistance of about 4.5 ohms when unbroken.

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