The SSB Manpack And Its Pioneers in Southern Africa – Part 1

by Brian Austin, G0GSF (ex ZS6BKW)

The account by Pat Hawker in *RB45* on the evolution of the solid-state manpack radio provided valuable background information about this important piece of military communications hardware. What it really brought home was how the manpack, or packset, had developed in the twenty years since the end of the Second World War. Then, the cumbersome and hopelessly underpowered WS68, as used at Arnhem, fulfilled this role in the British Army but seldom with great success. It was replaced in the 1960s by the A13, A14 and A16 with higher power and improved performance in every respect. All were much more rugged in their construction though some still required considerable muscle-power to hump them around.

In addition, phase modulation (PM) was adopted, at least in some of the types, instead of the amplitude modulation (AM) capability of their predecessors. Of course, CW still played a significant part in military communications at that time and all equipments provided for it though it was hardly the mode to use when on the move.

What was also obvious from the article was the dominance exerted by the Signals Research and Development Establishment (SRDE) over the whole design and procurement process in England. This proved to be a double-edged sword as electronics surged ahead in the era of the transistor. In addition, as the article also made clear, single-sideband or SSB had already been seen in other quarters as the way to go. This article deals with the development of the SSB manpack, not in England but in South Africa, and the influence it had on military communications well beyond its own shores.

Some SSB Background

Single Sideband (SSB) modulation completely changed the face of HF communications when it first appeared as a viable alternative to amplitude modulation (AM) in the 1950s. Its history, though, is far older than that and one has to go back to 1923 to see the original patent granted to John R. Carson of the American Telephone and Telegraph Company for "A Method and Means for Signaling with High Frequency Waves". Even more intriguing is the fact that the patent was originally filed on 1 December 1915, the year after Carson had proved mathematically that sidebands existed above and below the carrier signal.

The eight-year hiatus between those two dates was caused by a heated debate as to whether Carson's calculations were just mathematical fiction! His patent shows a transmitter with balanced modulator and bandpass filter remarkably similar in concept to the circuits used today and a receiver with, what we might call today, its carrier insertion oscillator.

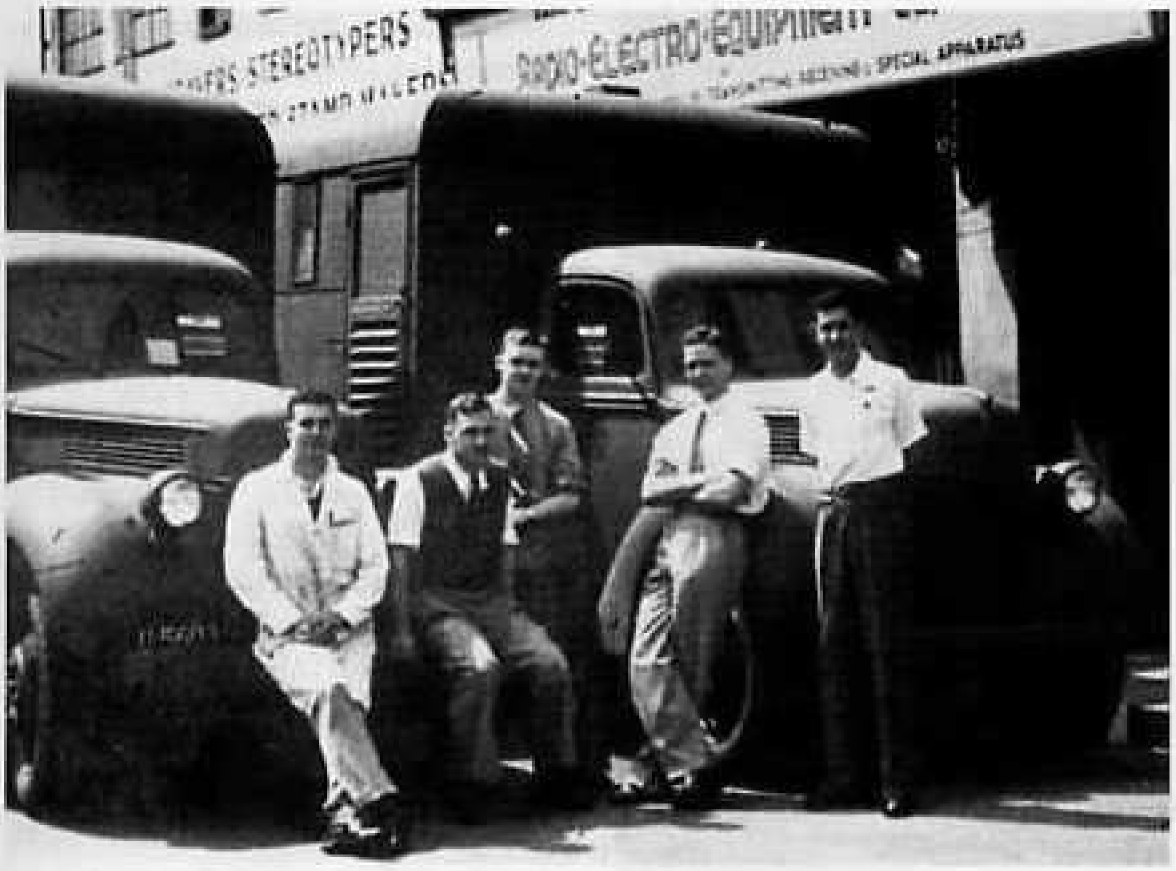
By 1927, fixed channel trans-Atlantic SSB was a reality. Progress, however, was slow with SSB playing no part during WWII. However, by the mid-fifties, both RCA and the Collins Radio Company in the USA and RACAL in the UK had developed commercial-grade equipment that operated on a number of pre-set crystal-controlled channels. Oscillator stability, especially when continuous tuning was required, proved to be the major hurdle but it was O.G.Villard (W6QYT), a professor at Stanford University, who showed that the immediate post-war technology was up to the task.

In 1947, 'Mike' Villard put the University's amateur radio station, W6YX, on the air on SSB and this started a surge of interest in this new mode of communications. But other radio amateurs had been there before. According to the American Radio Relay League (ARRL) publication *Single Sideband for the Radio Amateur* (1965) there were perhaps as many as half a dozen amateur SSB stations on the air as early as 1934 following some pioneering work done by one Robert Moore, W6DEI. But the ARRL's own views at the time were that SSB would require a level of technical expertise beyond that of radio amateurs and so further work was shelved. Such timidity, however, is the very gauntlet that inspires a reaction and so it was elsewhere too, as we will see.

Far from the SSB front line, in South Africa, two radio amateurs were experimenting with home-built sideband equipment in the 1950s. They were Bill Meyer, ZS6DW, and 'Empty' Wessels (*pr. vessels!*), ZS6KD, and they were almost certainly the SSB pioneers on the African continent. Their signals attracted much local attention and soon others joined them in popularising this new mode of transmission.

SSB, Radio Amateurs And The Military

Radio amateurs in the earlier days of the hobby were, by and large, inveterate builders of their own equipment. Amongst them, too, were those who rose to every new challenge and one of those was the



Horace Dainty (second from left) and some of his staff outside his Radio Electro-Equipment Co. (Pty) Ltd in 1939 with Union Defence Force vehicles ready for fitting with radio equipment

exciting subject of 'single sideband suppressed carrier', SSSC, soon to be known by the more euphonious SSB. By contrast, and despite some popular misconceptions, military communicators were seldom the trailblazers when it came to pioneering the latest techniques, though there were exceptions, as we will see. And so it was with SSB.

The first SSB equipment to see service with the British Army was the Clansman series introduced after interminable delays during the 1970s. By then the pioneering radio amateurs had a head start of many years. The Army's decision to change from the AM equipment of the wartime era and the more recent adaptation Phase Modulation (PM) to SSB was taken in 1966. However, the wheels of military specification and procurement turn slowly and, as Pat Hawker pointed out, it took some major restructuring of the Signals Research and Development Establishment (SRDE) at Christchurch before things really started to happen. Intriguingly, the real inspiration behind the decision to ditch a technology no longer suited to the highly congested HF spectrum in favour of one that was may well have come from an unexpected quarter – South Africa.

In the early months of the Second World War, the South African forces were not overly endowed with modern signals equipment but there was an embryonic radio industry in the country that soon rose to the challenge. In Durban, Horace Dainty (ZS5HT later ZS5C) had established The Radio Electro-Equipment Company (soon to become the S.M.D Manufacturing Company) in 1937 selling electronic components and manufacturing radio receivers and transmitters. On 7 September 1939, the day after South Africa declared war on Germany, he sent a terse telegram to the Postmaster General: "Can make transmitters", it said. Almost immediately he was requested to make a 150W HF transmitter for use in Port Elizabeth for communication with the Royal Navy's vessels in the Indian Ocean. It was duly delivered within a month and commissioned by Dainty himself. A number of orders soon followed for various items of equipment that rapidly caused S.M.D to turn its facilities over to full-scale wartime production.

Both the South African Air Force and Army were soon using S.M.D's 150 watt AM transmitters in their ground stations and at headquarters. That equipment saw service both in the East African campaign to drive the Italians from Abyssinia and, later, in the Middle East with the 8th Army. The largest order from the South African Army was for 400 30W HF transmitter/receivers to be installed in armoured cars. The prototype appeared in just four weeks and became the M17. As often happens, however, its reputation was marred by the Army's insistence on using just an 8 foot (2·4m) rod antenna without any inductive loading. A considerable reduction in working range was the obvious result.

Peacetime

S.M.D had established its reputation in the field of military communications equipment during the war. When peace eventually returned the Company was therefore in a unique position in the early 1950s when the South African Council for Scientific and Industrial Research (CSIR) was seeking an industrial partner to build six pre-production versions of the famous Wadley drift-cancelling, continuously tuneable, HF receiver.

Trevor Wadley, the Durban-born designer of this remarkable receiver had originally conceived the idea when developing a novel ionosonde – a radar-type device for measuring the characteristics of the ionosphere – immediately after the war. He was then working in the Telecommunications Research Laboratory (TRL) of the CSIR in Johannesburg following his own wartime service in the S.A. Corps of Signals. Then, in its Special Signals Service, Wadley had made significant contributions towards improving the performance of the South African-designed radars that ringed the country's very long coastline.

Those six prototype receivers that S.M.D built soon lived up to all Wadley's expectations and the CSIR duly patented the design and its underlying principles. It was now time to move into commercial production and the seventh receiver was the prototype of a commercial model with the serial number 007. It was made at S.M.D by David Larsen, (ZS5DN later ZS6DN), who was soon to become a highly innovative designer of solid-state SSB equipment and a leading figure in the South African electronics industry.

And so began the long and very successful partnership between Horace Dainty and David Larsen, that

Horace Dainty and David Larsen who produced the first commercial SSB equipment in Africa

propelled South Africa into the world of modern electronics. It started with the Wadley receiver but it was SSB that really turned a small Durban company into a pioneer in the field of military radio communications.

Enter RACAL And The SSB Manpack

In 1954, the struggling RACAL Company in England turned Larsen's prototype of the Wadley receiver into one of the most famous radio receivers ever manufactured – the RA17. It entered service with the Royal Navy and soon established itself as a most remarkable piece of equipment in terms of stability and ease of operation. In keeping with the technology of the time its modes were AM and CW; SSB had not yet become part of the British military communications armoury. Technology advances quickly; the logistics of equipment procurement do not.

The RA17 was undoubtedly the making of RACAL. But there was even more to come and much of it, too, came from South Africa. In March 1963, RACAL UK became a major shareholder in a new company formed in partnership with S.M.D. Known as RACAL-SMD it was situated in Pretoria, close to the industrial and military heart of South Africa. This relocation of S.M.D from Durban actually saw it split two ways with one part going north to Pretoria, while the other shuffled just a short way to its new home, still in Natal, where it became part of the large Barlows industrial group and was soon to be the main supplier of all VHF equipment to the South African Defence Force. In 1969 RACAL-SMD was renamed RACAL Electronics South Africa Ltd (RESA).

In the early 1960s, by which time SSB transmitters and receivers using valve technology were already well established in the radio amateur literature (and in some shacks too), the British Army introduced its Larkspur series of radios into service. Short-range tactical nets made use of the VHF spectrum for the first time with FM being the modulation mode. However, the Larkspur HF equipment for the longer-range circuits was still based on AM or PM and, of course, CW. The underlying design philosophy, which was essentially conservative, was both determined and carefully controlled by the Signals Research and Development Establishment (SRDE), as we have seen.

So-called private-venture designs by companies not working closely with the SRDE were not much favoured. This meant that in 1966 a piece of equipment that fell into that category, the RACAL solid-state SSB manpack known as the TRA 906 or 'Squadcal', was never acquired by the British Army even though more than 25,000 were sold abroad to approximately 50 countries. For this important information I am indebted to Geoff Bennett, G3CYL, who was RACAL's Marketing Manager for South East Asia at the time and then ultimately Managing Director of RACAL Radio Ltd.

A New Era

Of particular interest is the fact that the Squadcal was actually based

The RT14B SSB manpack developed by S.M.D. in Pretoria in 1965 on a solid-state manpack designed in South Africa by David Larsen and known there initially as the RT14 and then the RT14B. As subsequent events were to show, it was the beginnings of a new era in military hardware that shot the SSB manpack into the international arena.

In 1972, Mr E.T. (later Sir Ernest) Harrison, Chairman of the RACAL Group, paid tribute in a press release to both Horace Dainty and David Larsen. "It was Mr Larsen", he said, "who had been responsible for the development of equipment which had enabled RACAL International to reach its dominating position, particularly in the world of military mobile communications. RACAL UK was exporting more manpacks than any other company in the world and they had been developed from designs which originated through Mr Larsen in South Africa".

Keith Thrower, until recently Research Director of the RACAL Radio Group, provided some of the background surrounding the story of the RT14/Squadcal in his June 2003 article in *Transmission Lines*, the newsletter of the Defence Electronics History Society. It will be expanded upon here.

The genesis of the RT14 can actually be traced to the late 1950s when David Larsen designed S.M.D.'s first SSB exciter using transistors when these devices were little more than electronic curiosities. Naturally enough, the transmitter was put through its paces on the amateur bands where it soon came to the attention of the Americans, most notably Don Stoner, W6TNS. Stoner, well-known as a pioneer in the field of single sideband and solid-state circuits, had published his *New Sideband Handbook* in 1958, just a year after the appearance of the very first book to deal with the subject in any depth, the Collins Radio Company's *Fundamentals of SSB*

Larsen and Stoner subsequently collaborated closely. The American was full of ideas, particularly on crystal filters, and was also a ready source of components that were hard to come by in South Africa. His attempts, though, to persuade Larsen to join him in the USA were unsuccessful after the South African had astutely weighed up all his options.

By the early '60s *QST*, the ARRL's

The RT422B: the first commercial SSB transmitter/receiver designed and manufactured in Durban by S.M.D in 1960

monthly magazine, had already featured many articles on the theory and practice of single sideband and a selection of the best formed the basis of the ARRL book, *Single Sideband for the Radio Amateur*, first published in 1958. Except for two in the 1965 edition, all the circuits were based on valve (or tube) technology. Those exceptions were a remarkable 14MHz transistorised transceiver, described as being the 'ultra-ultra in compactness', designed by Benjamin J.Vester, W3TLN, and the 'Imp-TR' a solid-state transmitter of Joseph S. Galeski, W4IMP, first published in *QST* in December 1961. Some of the circuitry Galeski used, and the assistance he needed in getting started, came from Dave Larsen and Joe Galeski made full acknowledgement to ZS5DN for that.

The RT14 Manpack

Not only was the Larsen SSB exciter the model for that 'Imp -TR' but, far more importantly, it also formed the basis of S.M.D.'s first SSB transceiver, the transistor-valve hybrid known as the RT422 and its later model the RT422B. This transportable combination that included a separate linear amplifier may well have been the world's first commercial, transistor-valve, 'filter-type' SSB transceiver. It started life as an amateur radio venture and was built by David Larsen over the two week Christmas holiday period of 1959/60. Like all his home-brew designs it soon found its way into the S.M.D design register, many of which later became commercial products. Its possible competitors for this title might include the Redifon

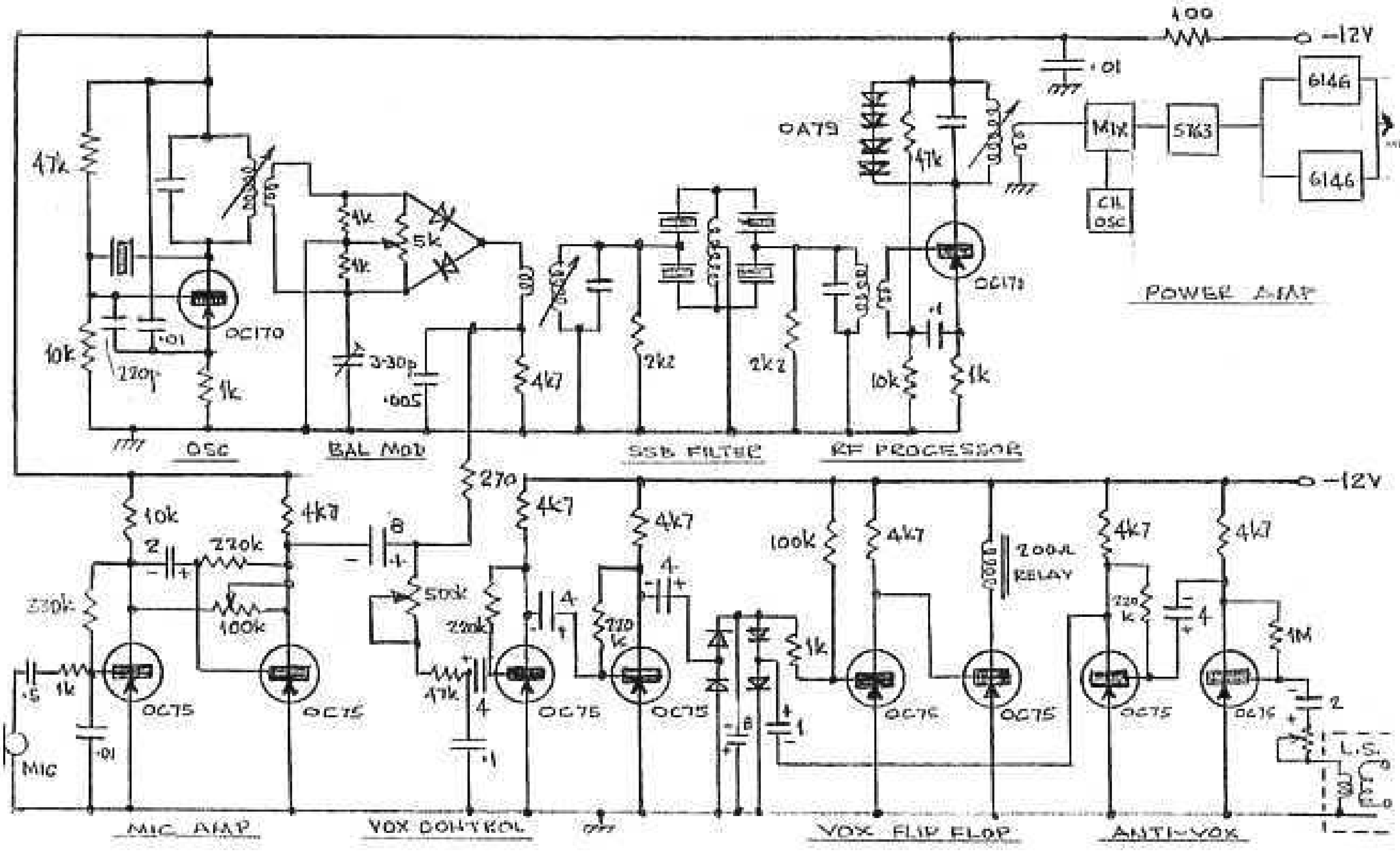


Fig.1. Circuit diagram of the RT422B/RT14 solid-state SSB exciter

GR.410, based on the so-called 'third method' of SSB generation, which was first marketed in 1962.

Shortly thereafter, the SSB exciter reappeared in the RT14, the all transistorised manpack soon to become the Squadcal in England and the TR28 in South Africa. As indicated above, this crucial circuit, and the broadband solid-state power amplifier that followed it, could probably lay claim to having launched the SSB manpack on the world stage. Its only apparent challenger was the American-manufactured Hughes HC-162, described by Pat Hawker in his *Radio Bygones* article, which made its appearance in England in 1963. A remarkable design for its time, the HC-162 included a 10,000 channel frequency synthesizer compared with the 29 crystal-controlled channels of the Squadcal or the 12, 24 or 36 channels of the TR28, shortly to appear. However, it was very much more expensive than its British and South African competitors and yet, other than its synthesizer, it offered nothing more by way of performance.

Circuitry

The circuit diagram of the SSB exciter section of both the RT14 and the RT422B is shown in **Fig.1**. It has been re-drawn from David Larsen's original diagram of 1959 but retains its authenticity by using the symbol for the *PNP* bipolar transistor in use at that time. Its similarity with that of a triode valve will be obvious.

There are a number of noteworthy features in this circuit that merit some comment. First, is the use throughout of *germanium* transistors in the famous OC70 and OC170 series from Mullard; next is the remarkable simplicity of the circuit itself: two stages of audio amplification following the microphone; the simplest of diode balanced modulator driven by an unbuffered crystal oscillator; a full lattice filter using four, carefully selected, war surplus FT-243 crystals that had been carefully 'doctored' by the merest pencil mark or a wipe with a piece of solder to shift their frequencies ever so slightly to produce the desired passband.

Then came the *piece de resistance* – an amplifier, tuned tô the centre frequency of the crystal filter, which incorporated a logarithmic compression network of four diodes shunting a high-Q tuned circuit. Since this element of the RT14 proved so controversial when first examined in England – yet so effective when tested in the field – more will be said about it later.

Following the microphone amplifier is a diode rectifier network plus four common emitter amplifiers and switches. This is the VOX and anti-VOX circuitry providing the voice-operated switching from receive to transmit. It will be noted, too, that the drawing includes, in block diagram form, the channel oscillator and mixer plus valve driver (type 5763) and the push-pull, linear, output stage consisting of two 6146s, so typical of the transmitters then available on the radio amateur market that featured these ubiquitous beam power tubes.

The receiver was a conventional superhet whose IF bandwidth was determined by that same crystal filter after suitable switching into the receive path. The photograph opposite shows the original RT14 in its sheet metal box with a centre-loaded and base-matched whip antenna during field trials in South African in 1964. Just evident, as well, is the shroud over the top panel-mounted loudspeaker that also doubled as the microphone. This novel approach would not go down too well with soldiers attempting, by all means

The prototype RT14 undergoing field trials near Pretoria in 1964

possible, to operate in a clandestine fashion! The next model, the RT14B, used the more conventional telephone handset.

A Sceptical Response

Early in 1963 Horace Dainty, Managing Director of RACAL-SMD, took the RT14 to England in order to demonstrate it to his major shareholder at the RACAL headquarters in Bracknell. The reaction he got was mixed. Viewed superficially the simple and inexpensive construction and the rather primitive case in which it was housed (looking like a biscuit tin, some said), may have contributed to this. However, the 5W PEP broadband linear power amplifier did intrigue RACAL's engineers who had not come across the particular circuit configuration before. It bore a marked similarity to the push-pull audio amplifiers then in common use in the transistor portable radio market. And so it should, since that was exactly the technology upon which it was based, but the clever use of ferrite-cored transformers and low impedance inter-stage coupling allowed it to operate at much higher frequencies.

For all that, there were those who had serious misgivings about the RT14's ability to meet the SRDE's requirements based, as they were, on a strict interpretation of CCITT specifications, especially those related to stability and out-of-band emissions. In Bracknell particular criticism was levelled at the RF speech processing circuit with its propensity, so some believed, to generate quite unacceptable distortion products when subjected to a conventional 'two-tone test'. When this pessimistic view was confirmed by the SRDE itself, after the RT14 was shown to them, Horace Dainty returned to South Africa feeling somewhat perplexed.

Before he left, though, he impressed upon Ray Brown and Ernie Harrison who, with Calder Cunningham, were instrumental in founding and fostering the RACAL company, the absolute need to 'get into the lower cost market' if they wished to remain competitive. By then, more than 600 of the RT422B transceivers were in service in various parts of southern Africa where they were used, often under the most demanding conditions, in both fixed localities and in vehicles, and frequently by very inexperienced operators. Despite this, and without having complied with any 'mil-spec' in their design, their performance and serviceability were reported to be excellent.

When David Larsen, by now Technical Director of RACAL-SMD, heard how the RT14 had come in for what he considered to be ill-informed criticism he was incensed. "We're interested in communications, not specifications", he said when told that it was those CCITT specifications as well as the almost esoteric 'Fletcher-Munsen' audio intelligibility curves that had floored his brainchild. At Horace Dainty's invitation he duly headed for England on the next available flight to confront the sceptics.

RF Speech Processing

Amongst Larsen's many objectives on arriving at Bracknell was to convince RACAL's engineers that his method of modifying the speech waveform in the transmitter produced a marked improvement in the signal-to-noise ratio at the receiver without also causing any significant increase in distortion products, either in-band or out-of-band. There was more, too. After much experimentation RACAL-SMD had developed a technique of matching to 50Ω the impedance of a short whip antenna on an operator's back by using just a single rotary inductor. This, too, was an important and useful technique they might wish to use.

David Larsen's undoubted powers of technical persuasion (as well as Horace Dainty's commercial pep talk, one must assume) led, over the next couple of years, to a series of visits by RACAL's engineers to South Africa and to further trips by Larsen himself to England. It soon became clear that the South African company had developed an uncomplicated, yet highly effective piece of equipment that was apparently quite unique. Since RF speech processing was the key to its performance – and is now recognized almost as a *sine qua non* in SSB transmitters – the method Larsen devised will be described briefly. In addition, his simple yet effective method of feeding the short whip antenna on the RT14 will also be touched upon.

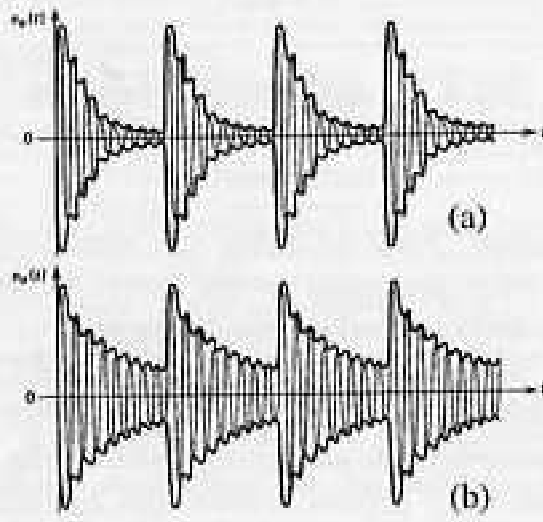


Fig.2. SSB waveforms: (a) unprocessed speech (the repeated word "three") with 16dB peak-to-average ratio; (b) the same word with 6dB of compression

Typically, unprocessed speech has a ratio of instantaneous peak to average power of about 16dB, see **Fig. 2**. In a peak power limited system, such as an SSB transmitter, this represents a considerable loss of potential output power so some means of compressing the dynamic range of the speech signal is required before transmission. It is now well known that clipping (or hard limiting) the peaks of an SSB waveform, and then filtering by a second bandpass filter similar to that in the SSB generator to remove the resulting harmonic and high-order products, can markedly improve the articulation index of the transmitted

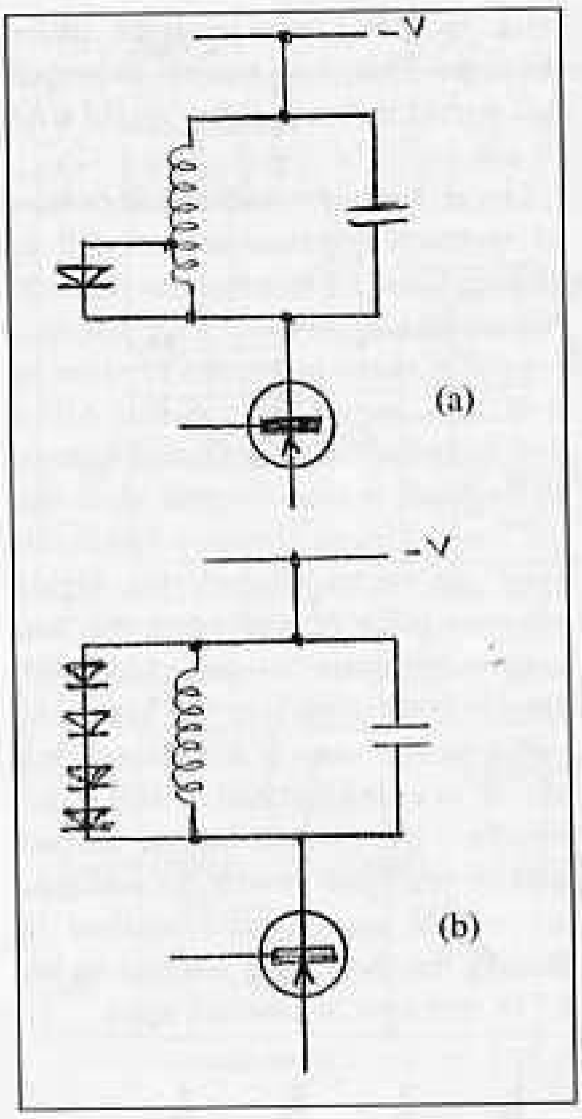


Fig.3. RF speech processing by means of logarithmic compression

signal. Ways of doing this were just being developed in the early 1960s when Larsen designed his system.

Instead of just clipping the peaks, followed by filtering, it worked on the principle of changing, dynamically, the Q of a tuned circuit that formed the load of a common emitter amplifier. **Fig. 3** shows two ways of achieving this. In (a) a diode is tapped across just a portion of the tuned circuit. On certain peaks of the signal the diode will conduct but instead of clipping ferociously it can be made to react logarithmically by appropriate choice of the tapping point for a given signal level and diode characteristic (i.e. germanium or silicon). The effect of this controlled conduction is equivalent to loading the tuned circuit by a variable resistor which, effectively, lowers its Q and hence its impedance in a variable way. Since the gain of the amplifier is proportional to its collector load, it decreases on signal peaks and so compresses the SSB signal's dynamic range.

In (b) the same effect occurs but here the chain of diodes only conducts at a higher voltage so they can be connected across the complete tuned circuit – an easier option in practice since it obviates the need for the inductor tap. This latter method was used in the RT14 with suitable pre-emphasis of the voice frequencies, provided by the type of microphone used, to ensure the appropriate balance between vowel sounds and sibilance.

This form of RF speech processing was well ahead of its time. The acid test of its effectiveness was to compare two transmitters of equal peak envelope power; one processed, the other not. If specifications mattered more than performance then a spectrum analyser would produce all the numbers but say nothing about the quality of communications. However, such instruments were rare in those days and so other simpler, yet ingenious methods, which said a lot about both, had to be used instead. Most often the test instruments consisted of an in-line RF power meter and a selective receiver.

Whistling into the microphone (by sucking not blowing) produces a very good sinewave. This signal would then drive the transmitter to its maximum PEP output. Replacing the whistle by a long "aaaah" sound, of no intelligibility but considerable utility to both man and beast, simulates well a continuous waveform containing a range of speech frequencies. When used to drive an unprocessed SSB transmitter it produces an output 10 to 15dB below the whistle, which clearly emphasises the point made above. By contrast, the same whistle and primeval "aaaah", when fed through the processed system, might differ by less than a decibel in output level.

Comparative Listening Tests

Many would argue that an 'on the air' comparison is the only meaningful arbiter of effectiveness. Such comparative listening tests, of which RACAL-SMD had conducted a good few, confirmed that the increased 'talk power' of the processed signal brought about a marked improvement in the received signal-to-noise ratio (SNR), while not introducing significant distortion products either within the audio passband or in its adjacent channels. In fact, it was so good in this respect that one of RACAL-SMD's customers used to run independent radio nets on the same frequency, one on LSB the other on USB!

The increase in SNR was equivalent to that obtained by increasing the power output of an unprocessed 5W transmitter by as much as 10dB to 50W. Since every watt on a man's back mattered – as more power always means larger batteries and heavier sets – this was not to be sneezed at. In addition, short, inefficient whip antennas are often obligatory for both practical and tactical reasons; therefore optimum transmitter performance is vital.

Short Antennas

Those whip antennas are frequently no more than 8 feet or 2·4m long. Their already poor efficiency at HF must not be compromised further by inadequate coupling both to the transmitter and to the ground which, after all, is very much part of the antenna circuit. The RACAL-SMD approach was to use a 'body capacity plate' of wire gauze ('fly screen') built into the shoulder pads, the operator's belt and the back of the carrying harness for the RT14. These capacity plates were then inter-connected and joined by a flexible lead to the earth terminal of the radio.

Their effect was to increase the capacitive coupling between the case of the radio and the operator's body and thence to the ground. By so doing the effectiveness of the antenna system improved markedly. This occurred because the losses associated with the already compromised short monopole, and the operator's body, were reduced. Of particular interest was the finding that over the range from 2 to 8MHz the resistive part of the antenna system input impedance remained remarkably constant at around 50Ω. Thus, all that was required to bring such a capacitive antenna to resonance, as well as to match it to 50Ω, was an appropriate series-connected inductor.

The RT14, in its embryonic form, had no built-in inductor for this purpose, rather it appeared as an adjustable device at the base of the whip antenna (see photo). This was cumbersome so at Bracknell the ATU from the venerable HF156 AM manpack manufactured by BCC was bolted to the side of the RT14 in order that field trials might commence.

To be continued in RB94.

The SSB Manpack And Its Pioneers in Southern Africa – Part 2

by Brian Austin, G0GSF (ex ZS6BKW)

The account of the development of the SSB Manpack continued from Part 1, featured in *RB93*

Field Trials

The RT14 was first put through its paces in England on the 40m amateur band between the homes of Geoff Bennett G3CYL and Jim Crerar G3BYV, who was then RACAL's Sales Director. The results were impressive with many other radio amateurs all around the country being 'worked' on SSB. This convinced RACAL of the need to set up a far more demanding series of trials in the jungles of Malaya where, in the 1950s, the British Army had conducted its very successful counter insurgency campaign. One of the lessons of that war was the importance of good radio communications. But the jungle is a hostile environment not only to man but also to his electronic equipment and to its radio signals.

Geoff Bennett carried out the field trials using a pair of RT14s in Malaya in April 1965. The results were an eye-opener to all who were used to the limitations of the older and heavier radio sets with which both the British and Malayan armies were then equipped. Whip-to-whip communications, using SSB, were possible over distances up to about 15km via the ground wave. This was increased to nearer 150km when a 10m end-fed horizontal antenna was used to launch a high-angle sky wave. These trials not only indicated the superiority of low-power, speech-processed SSB over AM but they also showed how the appropriate antenna (and its correct orientation) played a major part in achieving such effective long distance propagation.

RT14 undergoing field trials by RACAL in Malaya in 1965

The technique of radiating a signal almost vertically, at the appropriate frequency, in order to produce continuous coverage (thus eliminating the so-called 'skip zone') over a significant distance will be discussed later in this article. It was no accident that it was tested in Malaya as it had been the subject of much discussion between David Larsen and Jim Diggins, the RACAL engineer assigned to the RT14 project, during his visit to South Africa in 1964.

A British Venture

The field trials completed, Geoff Bennett returned to Bracknell and presented his report. The reaction was immediate when the implications of those Malayan trials became obvious. What was to have been just a few weeks before a South African-led programme in Pretoria to produce the manpack for the relatively small local market now became a British venture with a far larger market in mind. Jim Diggins was appointed to redesign the RT14 in line with current RACAL thinking. In under a year it appeared in its new guise as the Squadcal or TRA906. Housed in a waterproof Cycolac plastic case able to withstand severe environmental conditions as well as rough treatment, it operated from 2 to 7MHz on 29 channels at 5W PEP output. Both SSB and CW were provided, as well as compatible AM to ensure its inter-operability with the AM sets still in use by military services across the world.

But the Squadcal contained no RF speech processing!

And, as if to add further spice to the mix, the policy of the SRDE against private venture projects still held sway. Since the Squadcal fell into that category the British Army did not acquire it. However, many British soldiers soon became familiar with the set while serving alongside the forces of Oman, Aden, Malaya and Borneo whose governments had bought the manpack in vast numbers.

Ironically, in South Africa, the situation was not too dissimilar. The RT14 was soon to become the TR28 with even more impressive performance than its British counterpart, yet few were purchased by the local military since RACAL-SMD was not one of their 'preferred' suppliers. In that case, considerations of a more political nature lay behind the decision even though both the TR28 and the RT422B, before it, had made considerable impact amongst the military forces of some of South Africa's immediate neighbours.

The RT14 Becomes The TR28

In South Africa the progression from the finished product of the RT14 to the X-model prototype of the TR28 occurred within the space of just one week in March 1966. This followed Larsen's visit in 1965 to the United States for discussions with Don Stoner who, very quickly, saw the potential of the South African manpack in the massive US military market. As related previously, Stoner's attempts to persuade Larsen to join him in a joint venture with Les Earnshaw, (formerly ZL1AAX), an ex-patriot New Zealander with prodigious skill as an electronic circuit designer, came to naught. But Stoner's contacts with the suppliers of electronics components in the States were most useful and Larsen returned home with all the latest silicon TV line time-base transistors he could ever use, as well 10·7MHz SSB filters manufactured to his specifications in double quick time by a firm in Phoenix, Arizona.

Once back home he and one of his colleagues, Ken Clayton (ZS5GU), took the original RT14 circuit and turned it, using Clayton's dining room as both drawing office and workshop, into the prototype TR28, all built on a tin plate ground plane. The silicon transistors and the 2·4kHz bandwidth filter with a shape factor of better than 2:1 ensured that this X model did more than meet its specification; the A model followed very shortly thereafter.

Naturally, the TR28 included its trump card – the very effective RF speech processing circuit that had so ruffled feathers in Bracknell. In addition, it also boasted considerably more output power than the 5W PEP of both its predecessor and the Squadcal. By including a DC to DC converter to step up the 12 volt battery supply, the same PA transistors were able to deliver 25W PEP over the frequency range from 1·6 to 8MHz. The receiver was conventional in design but far-sighted in concept. By using an intermediate frequency above the signal frequency, with the first local oscillator above that, meant that the image and oscillator harmonics were much higher than the highest signal frequency and so could be removed easily by a simple low-pass filter at the front end. In addition, all signal frequency circuits were broadband which made both setting-up and servicing very easy.

The TR28 (B16) in use during the Rhodesian bush war

And so the TR28 emerged in 1966 in two models: one offering 12 crystal-controlled channels, the other 24 or even 36, if required, on SSB, compatible AM and tone-modulated CW. The single-control ATU allowed a variety of antennas to be used. It tuned and matched the usual 2·4 or 3·6m whips, as well as any end-fed wire antenna from 2·4m up to a quarter-wavelength while also handling typical low impedance, centre-fed dipoles. The set, shown in the photo above, met all the prevailing environmental specifications of the time in terms of waterproofing, operating temperature range as well as shock and vibration resistance.

A Rhodesian Prediction ...

What seemed at the time like a rather long shot turned out a decade later to be remarkably prescient. It was a prediction, made in 1957, at a high-level military conference of commanding officers in the Central African Federation, comprising the three former British colonies of Nyasaland, Northern Rhodesia and Southern Rhodesia. The prediction, in answer to a question about future developments in military communications, was that an SSB manpack would be available within ten years. The officer who made it was a second lieutenant in the Rhodesia and Nyasaland Corps of Signals (RN Sigs). The occasion was the GOC's Annual CO's Conference at which the signals subaltern found himself, in rather exalted company, representing his commanding officer who happened to be in England at the time.

The reaction of the meeting is not recorded; that of the CO on his return was less than enthusiastic. When, eight years later, a senior officer from the Royal Corps of Signals was visiting Bulawayo he was asked by that same signals officer (by now a major) about the likelihood of the British Army obtaining an SSB manpack in the near future. He was told that such an event was 'a pipe dream'.

It is well worth noting that SSB had already won its spurs in Central Africa. Since 1956 a pair of RCA mains-powered SSB-1 transceivers, running 60W PEP with parallel 6146s in the PA, had been in service with RN Sigs. Their performance was excellent and this had convinced the Signals Staff of the effectiveness of this SSB mode of transmission. Given the close affiliation that existed at the time between RN Signals and all things British, the then head of the Federal Corps placed all further orders for equipment with RACAL in England. The RACAL TRA55, in almost every way equivalent to the RCA set, went into service with the Federal Army and performed very well in its intended base-station role.

In August 1967, just two years after Rhodesia's unilateral declaration of independence and a matter of just ten years and three months after that speculative prediction about an SSB manpack, the Rhodesian African Rifles used the TR28 (or B16) in military operations for the first time. It joined its SMD counterpart, the larger base/mobile station the RT422B, that had been acquired by the Rhodesian Army in September 1965 following its very successful use by the local Department of National Parks and Wild Life Management since 1961.

Intriguingly, it would be almost another decade before the Royal Corps of Signals – *the* Corps of Signals – received its first SSB manpack; so those pipe dreams in Bulawayo were probably not too wide of the mark. On the other hand, 2Lt (later Colonel) Gordon Munro's own reading of the runes in the wilds of the Southern Rhodesian bush had been shown to be remarkably accurate!

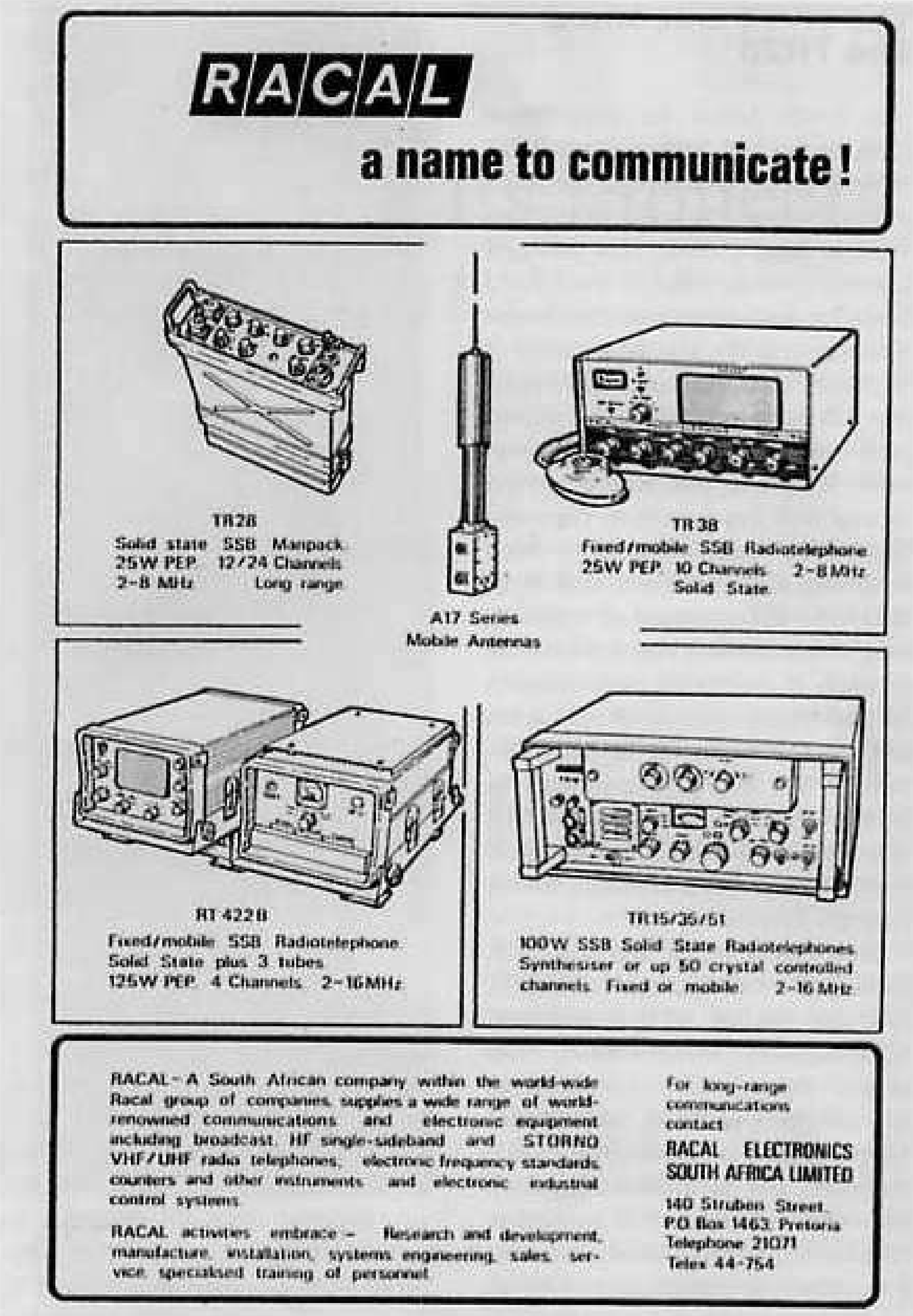


Fig.12. Some of the RACAL family of equipment developed in South Africa prior to 1970

The RT14 in Rhodesia

In terms of historical perspective the very first SSB manpack to make its appearance in what was now Rhodesia was the RT14, brought to the country by David Larsen in late1965 or early 1966. This followed an invitation from the Army's Directorate of Signals as soon as word reached them about the development in South Africa of this key piece of equipment. He duly put the 5W PEP manpack through its paces, achieving good results and generating great excitement within the Directorate. It was felt, though, that the set might be somewhat underpowered for the type of operations in which it was likely to be used. After all, Rhodesia was a sizeable country and its military forces would depend very much on HF radio for their longer-range communication needs.

That requirement, and the interest from Don Stoner in the States for a higher power version, was the spur that immediately led RACAL-S.M.D. to step up the output to 25W by the simple expedient of increasing the voltage on the PA transistors. And so the TR28 came into this world and the Rhodesians took delivery of their first sets in May 1967.

Whilst conducting trials with the prototype TR28 in places as inhospitable as the Zambezi valley, David Larsen and some of his colleagues roughed it with the soldiers and showed them how to overcome the problem of the 'skip zone', mentioned previously. This is that region between the ground wave limit and the point of return of the reflected signal from the ionosphere where communications are frequently very poor, if not non-existent. By using a horizontal wire antenna, of length usually less than a half wavelength and never more than a quarter wavelength above the ground, it is possible to launch the signal vertically such that, on reflection by the appropriate ionospheric layer, it will produce continuous coverage with no skip zone at all out to a range of some 100 to 200km.

NVIS

At about this time, the US Army was conducting similar experiments in South East Asia and soon this technique became known as NVIS, the acronym for 'near vertical incidence sky wave' which, of course, is just what the RACAL-SMD manpack was launching in Rhodesia, as it had done in Malaya the previous year.

The TR28 immediately became the HF workhorse of the Rhodesian Army in company with the RT422B already well established in its role as a fixed or mobile set at brigade and battalion level. This remarkable manpack also made its mark elsewhere in the region after entering service with the Portuguese forces operating in the two colonies of Angola and Mozambique following extensive trials in the Angolan jungles around Salazar in 1966. There, too, the emphasis was on its NVIS capability with both the short whip and a 'throw-out and wind up' wire antenna being used.

So successful was the TR28 in those equatorial theatres of counter-insurgency warfare that manufacturing facilities were eventually established in Lourenco Marques (now Maputo), and even in Lisbon itself. Hundreds of TR28s (in its various versions), along with the RT422B, were used by the troops in the field until Portugal's precipitate withdrawal from its African colonies in 1975.

Within five years of its introduction the TR28 was joined in Rhodesia, and then superseded, by its slightly bigger and more sophisticated cousin, the TR48, that was synthesized in 1kHz steps and operated from 1·6 to 30MHz. It soon became the standard HF SSB manpack of the Rhodesian Army and was used right down to platoon and troop level. Soon, too, the venerable RT422B was retired and was replaced by the TR15, a synthesized 100W PEP transceiver operating from 1·6 to 16MHz.

A frequency-hopping version, the TR15H which led the world in this revolutionary technology appeared in 1978. All these pieces of equipment were developed and produced in South Africa. The fact that they never appeared in the inventory of South Africa's own armed forces except when pressed into service when the 'preferred' equipment from other local suppliers failed to measure up – is one of those fascinating aspects of the apartheid-era government's political thinking. Such, though, is the stuff of another account entirely!

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