Modern communication receivers.

By L Foreman

PART 1

As the name more or less suggest this is a receiver which uses the invention of Dr. T.L. Wadley, the threefold mixer system, which published before in Radio Bulletin, of November 1974, at the publication of the Racal receivers. It looks plausible, that since the Racal factories became disloyal to the Wadley-principle, hereby at the same time the base is laid for manufacturing of a significant cheaper version. Racal receivers cost 15,000.- to 25,000.- Dutch guilders.

De Barlow-Wadley XCR-30Mk2
The factory for these Wadley-receiver-for-amateurs is founded in South Africa. It is the only, but really the only factory that put on the market an amateur receiver with a continuos frequency range from about 500 kHz to 31 MHz, without coil drums or switches, with equal stability on the 11, 13 or 19 meter band (to mention something) as in the medium wave band. To come to a for almost everyone affordable construction they have to limit themselves. So there is no attention given to the medium wave band and the long wave band below the 500 kHz, although there is receiving possible till for example 100 kHz. There is no FM range, because this should not fit in this design. To keep the weight low and the inset of the receiver as large as possible it has no build-in power supply, the receiver is working on batteries. To keep the power consumption low there is used a small power stage, (class B-balance) there is a small loudspeaker and there is no scale illumination. The dial has anyway clear reflecting digits.

There are only a minimal amount of knobs, so that a not technical skilled listener becomes familiar in a short time. Irrespective the actual tuning there are: volume control, also on/off switch, fine-tuning (the so called 'Clarifier'), a switch with three positions for AM speech, upper side band (USB) and lower side band (LSB) single side band speech, whereby the last position also is used for CW (telegraph reception).
In the end there is a fourth knob, for which the antenna tuning must match with the receipted MHz band. In a course way indicated by the concerning knob and if needed exactly tuneable on maximum indication of the signal strength meter (S-meter). And that is all.

After has been tested on different ways, this receiver has made its self almost indispensable: the oldest son listened to favourite music on Radio Luxembourg, where you can hear the toppers of the Dutch hit-parades many months before (medium wave band and 50 meter band, frequencies 1439 kHz and 6090 kHz), without this music it looks impossible for a grammar school pupil to do his homework. The youngest one practice Saturday morning the Morse key training of the VRZA on frequency 3600 kHz, from 10:00 to 11:00, listen SSB amateurs on the 80 and 20 meter band and searches - after the recent send in articles in the newspaper – and the 27 MHz citizens band. And also this remark may possible budge a number of readers against the direction of their hair: with the XCR30 becomes the working area of the most cheaply 27 MHz walkie-talkie some kilometres wider.

This receiver is very well useable for keying reception: a build-in oscillator (the actual CIO, carrier insertion oscillator for single side band reception) makes reception of keying stations possible. Receiving of all sorts of ships stations and coastal stations is even so no problem. It

is recommended to make use of a not to long type of outside antenna included earth connection. Because of the full metal cabinet (where do you find this in this time of synthetic material) it is not possible to make use of a build in ferrite antenna. Directly on the upper side aside the rod antenna there has been made a connection for an external antenna. On the opposite side there has been made a connection for the earth.
One of the elementarily requirements for a short wave receiver, is the readability of the received frequency and the repeatability of the tuning at every desired moment. This readability is realised on surprising easy manor in the Barlow-wadley!

The concept of the Racal receivers and also the Barlow-Wadley XCR-30 (MK2) is unique. Without switches, without extreme expensive mechanical constructions, bands pread, where ever one may like over the total area from 300 MHz – 500 kHz (!) and everywhere steady and just as accurate. The reading of the frequency, digital-in-line, is modern and simple like a digital clock. There are two dials, one for reading 0 to 30 MHz, the other one for reading the amount of kHz (0 to 1000 kHz). And if you should think, that MHz tuning should be very critical, than you got it wrong: for each MHz area is a piece of 6 mm available. There is almost no influence on the strength of the received signal, the maximum is tuneable with the signal strength indicator. Because every piece of the electronic switch covers 1 MHz, is the bandspread also 1MHz or 1000 kHz. The drum-scale (a very fine choice for maximum scale length and minimum use of space) is easily readable and allows reading better than 5 kHz. There is a small pointer that indicates the centreline of both dial drums. The stripes on the kHz scale are separated every 10 kHz. The reproducibility of the tuning is absolutely better than 1 kHz at all frequencies.
Every receiver is supplied with a clear manual and extensive service instructions in the English language. The numbers of the parts used on the printed circuit board correspond to the drawing and the schematic diagram in the service instructions. This schematic diagram is very non-transparent to our European perspective. Because we expect that this receiver also should be discovered in The Netherlands and in Belgium, the drawing office has made a new diagram, which can give a more clear view to the used circuit. Also for finding possible faults and repair, the diagram can be usefully.
The block diagram of the XCR-30 is sketched in figure 1.

In conform with the description of the Racal receivers (Radio Bulletin Oct '74), they can see the MHz oscillator tuneable between 45,4 and 74,5 MHz. All the incoming signal are so good as possible pre-selected by a tuneable HF-stage and get through a low-pass filter, that only let pass frequencies below 30 MHz, the mixer-stage M1 where mixing takes place with the MHz oscillator. The following first IF-filter only let through frequencies between 44,35 and 45,65 MHz (45MHz + or – 650 kHz), see also figure 4a.

At the same time the signal of the MHz oscillator is also fed to the mixer-stage M2, where it become mixed with one of the harmonics (between 3 and 32 MHz) coming from the 1 MHz crystal oscillator. A very narrow filter (42,5 MHz + or – 150 kHz) (see fig. 4b), let pass through only the combination VFO – harmonic, which is about 42,5 MHz. After mixing stage M3 originates e second IF signal, that always lies between 2 and 3 MHz and on a 'classical ' way, like in a normal super heterodyne, that is tuneable with the with the second VFO, an oscillator with a frequency range from 2,5 to 3,5 MHz, the so called kHz tuning! The result is then the third IF signal now at 455 kHz (about). Every changing of frequency of the first VFO, the MHz oscillator, caused by drift, microphonic effect, or insecure tuning, is be compensated by an equal, but opposite change of the signal nominal 42,5 MHz. The signal after the mixer-stage M3 does not change at all.

For maximum sensitivity is favourable that the first VFO do not changes too much. It is easy to find the right tuning on the maximum reading of the signal strength meter (S-meter).
The combination of a crystal oscillator at 1 MHz with all his harmonics (1 to 32 MHz), with two variable oscillators is a potential source of unwanted mixing products en strange whistle tones. Even so the Racal factories had to handle this problem at that time. There is a story that after several failed experimental models, in desperate attempt someone cut the chassis in with a hacksaw at a well-defined spot. And look what happened it was the end of the unwanted currents through the chassis and the annoying source of unwanted whistle tones was disappeared. This test model – with hacksaw cut – is still exposed in the hall of the Racal factory in Bracknell/ England.

Even so in this simple implementation there are still left a couple of unwanted signals. For as far as it takes the direct harmonics of the 1 MHz crystal, these are useful: they can be used as (non switch-off-able) calibration points at the beginning and end of the kHz scale. What concerning the rest of the spurious signals, there are MHz areas where non what so ever combination of unwanted combinations occurs. In other areas there are some variating in strength, but they are not inconvenient. This kind of signals is only to identify in a screened chamber or… in a safe.

A test that is often done is supplying of two signals of two signal generators at the same time. For instance a weak signal of 5 microvolt at 14.250 kHz acting as wanted receiver signal and a searching the range from 10 to 22 MHz with a second signal generator with a signal strength of 50 millivolt (!). Or as second test at 4050 kHz a weak signal of 10 microvolt and a second signal generator at 50 millivolt between 2 and 10 MHz. During experiments with a number of popular SSB receivers, which cost a multiple of this Barlow-Wadley, there are noticed by tests on all of the devices, between 10 and 18 spurious signals, varying in strength from S1 to S6. By making use of a low oscillator frequency at the usual low first IF, it is very difficult to suppress the harmonics of the (not completely sinewave) oscillator signal.

The oscillator frequency 45.5 to 74.5 MHz of the Barlow-Wadley is higher than the highest received frequency (to 31 MHz) and even so the first intermediate frequent stage, at 45 MHz. The result is according: in the first mentioned area where only two extremely weak spurious signals observable (namely with the signal generator at 15.25 MHz and at 13.25 MHz) and in the second area only one (with the signal generator at 5 MHz). In both cases they where completely disappeared at a signal generator strength of 10 millivolts of less. Not one short wave broadcast station can introduce disturbing signals, unless they find them self directly under the transmitting antenna.
Mirror frequencies (from the UHF area!) are at least suppressed by 60 dB.
The number of stations here is less, even so the strength and reach: we have identified all so no one.
The diagram figure 2 gives the detailed configuration of the high frequency part. Ones see that the MHz oscillator uses a double tuning capacitor, with one section of 150 pF for the actual oscillator. It is a Colpitts oscillator circuit, with a coil of 6 windings, diam. 8 mm, and length 18 mm. The second section of 320 pF is used for coarse tuning of the pre-selection (aerial tuning). Fine-tuning in the selected area is done by a little iron core, which can be moved by a cable through all three in each other's length mounted coils. Tuning take place by

the knob ‘Antenna trim’ on the front. All to the position of this knob, become microswitches switched in with the corresponding inductance.

After the high frequency stage with transistor V5 comes in the collector circuit the low pass filter. This filter exists of four coils on a rod of 6 mm diameter, 13+28+20+28 windings, and 0,25 mm. Also the crystal oscillator becomes followed by such a filter, which suppresses strongly frequencies above 32 MHz, so that only antenna signals respectively the harmonics onto 32 MHz can be given through the mixing stage M2.
At the output of the high frequency part come into existence the signals 42.5 MHz (+ or – 150 kHz) and 45 MHz (+ or – 650 kHz). Both signals are fed to mixing stage M3, Where the second IF signal is coming to existence, that is tuneable from 2 to 3 MHz, see figure 3. This part, after mixing stage M3, is consequently a normal super. With the help of an oscillator frequency of between 2.5 and 3.5 MHz exists than the third intermediate frequency, now at 455 kHz.
The oscillator is the kHz tuning of the receiver, with a large overlap covering 1000 kHz and with a precise calibrated scale. The tested apparatus with serial number 2943 displayed just at an only point an inaccuracy to 6 kHz. All other dial divisions where within 5 kHz accurate.

It is possible to correct the tuning frequency scale by a small trimmer (knob under S-meter) with the use of the calibrating points (0 and 1000 kHz) or if desired any other known frequency can be used to exactly correspond the scale to. For example a broadcast transmitter in the medium wave band. A nice thing of the receiver is that the calibration stays also applicable for all of the short wave ranges! Ones one has for example the exact tuning set for Hilversum 3, at a frequency of 1250 kHz and if necessary corrected the scale with the trimmer ‘zero set’, than one can easily find short wave stations with the frequency of 2250 kHz, or 3250 kHz, 4250 kHz etc. by simply put the MHz scale to 2, 3 or 4. Because there is for every 10 kHz a mark on the dial (distance 2 mm), one can unbelievable fast tune at a certain frequency.
The 1 MHz crystal did not differ more than 6.5 Hz from the nominal frequency, an insignificant difference. Eventually bigger differences can be compensated with trimmer C6. One can be make use calibration signals of American station WWV at 5, 10 or 15 MHz or one of the stations MSF (Rugby) or HBN (Neufchatel) at 5 MHz, or a reliable signal generator or synthesiser.

Because of the tolerances of the used crystal filters, the intermediate frequency can be differing a little from 455 kHz. It is possible to widen the bandwidth of these crystal filters with switching-in extra capacitors. That is why in the selection AM the bandwidth is about 6 kHz, measured at the –3 dB points. For both SSB selections only narrow throughput is used (about 3 kHz), but even so the carrier insertion oscillator is switched in. To get a higher selectivity, in the AM selection, it is also possible by turning the switch just a little bit in the direction of LSB, just before the point ’switching on the CIO’.
Figure 4c, visualises the effect of bandwidth selection.
The narrow curve becomes used for reception of single side band and keying stations. Of course it is also possible by putting in an extra switch to disconnect the CIO. This switch contact can be put in series with R64 (100 ohm), after opening the back cover located in the nearby of the mode switch.
After the mode selection switch AM or SSB and detection, follows a simple low frequency part, with a little buildin loudspeaker, with 8-ohm impedance. An output socket for use of headset or amplifier is present, whereby the buildin speaker is gonna be switched off.

This audio part is drawn in figure 5. By well-engineered design, the apparatus is extremely economical in power consumption: that is a major point in remote areas. The supply current is at 6 volts, 15 mA (quiescent) and 60 mA top (max audio signal), at 9V this is 20 mA (quiescent) and 100 mA (top).
To overcome a wrong polarity of an eventual external power supply, there is put a germanium diode in series with the power connection. With this diode shortened, the receiver can be even functioning with a battery voltage of 4.5 V
The supply current is than 10 à 20 mA. External voltages of 6V to 12 V can be connected without modifications: a series transistor plus a zener diode takes care of the stabilisation of the power supply at about 6.6 volts.
The power supply is depicted in figure 6.

Part 2

Detection circuit and automatic gain control
The circuit of the AM detector, with S-meter and the circuit for automatic gain control is clarified in figure 7. One sees that the voltage divider across the power on the test point 5, in this figure even so all other voltages are indicated in respect to the negative powerline, whereto all emitters via resistors are connected, delivers a positive voltage of 1.2 volts to?? Volts.
Fig. 7. Detail of AM-detector and automatic gain control.
Without signal is because of that a such as basis current (respectively emitter and collector current) possible, that for example at transistor V11 a voltage of 0.5 volts over the emitter resistor 560 ohm occurs.
As soon as there is received a signal of any importance, there come in to existence by the AM detector diode D8 a DC voltage across the capacitor C56 (10nF), with an in the figure depicted polarity. This DC-voltage is in opposite with respect to the voltage on the line marked as TP5. By this DC-voltage, coming from C56 should the basis-current of the controlled transistors decrease and more, in proportion as the received transmit signal increases. The gain of the controlled transistors V8, V10 and V11 decreases and the delivered audio signal stays about constant. The functioning is very effective as can be seen in Table 1.

Tabel 1

Antenna signal	Audio signal
2 µV	0 dB =1
20 µV	+ 3.5 dB = 1.5 x
200 µV	+ 5 dB = 1.8 x
1000 µV	+ 5 dB

The scale of the S-meter is divided into three parts: red – black – white, with eleven lines (position 0 to 10). Figure 8 gives the relation between reading of the S-meter and the antenna signal.
It looks maybe wise to attend to the fact that after the actual high frequency part of figure 2, supplemented with a mixer stage, like for example M3 from figure 3, or a ring-modulator (see Radio Bulletin Nov. '74), also any other receiver can be used after this HF-front-end.

Tabel 2

Coil	Number of wdg	Diameter	Coil length
L3	5	8 mm	18 mm

L4	4	8 mm	15 mm
L8	4	8 mm	15 mm
L9	4	8 mm	20 mm
L5	6	8 mm	20 mm
L7	6	8 mm	20 mm
L14	6	8 mm	20 mm
L15	6	8 mm	20 mm

Wire diameter 1 mm, free-space winding.

Because the possibility to construct an all band receiver by them self looks interesting, we also mention the data of the coils from the high frequency part in table 2. Using a modern ring-modulator with schottky diodes definitely advised for mixing stage M1, but also for M3. As soon as proper data is collected from experiments, we come back to this subject.

Page 192
With signal larger than 1000 microvolts the transistors are pinched off, because of this the receiver is blocked. This is the reason not to use a to large external antenna or one has to limit the maximum signal strength by setting the antenna tuning not to the maximum point, but leave it besides. This has no disadvantages, because there are no disturbing mirror signals or there can not occur internal modulation products.

From Mr. J. de Groot, Gein Noord 24 at Abcoude, we received a couple of details concerning this receiver. He was one of the firsts, maybe the very first owner of a Barlow-Wadley XCR-30 receiver in The Netherlands and was afterwards intermediate in the procuring for other short-wave listeners of the Benelux Dx-Club. He is also very enthusiast about the receiving performance. The receiving of Greek or Russian coastal stations is excellent, with a little outside antenna or a ferrite-coil outside the metal cabinet. The well-known American coastal station WCC (Chatham-Radio, Massachusetts) at 2036 kHz with keying signal could be received frequently. Mr. De Groot reported also frequent reception of the Brazilian broadcast station Radio Tupi at the medium wave band, without using an extra antenna!

To reduce the noise in some cases, it can be useful to connect a piece of 5 or 10 meters of wire or TV-twincable to the earth contact as capacity to earth. The sensitivity of the receiver is very well. AM signals from 0.5 microvolt can be heard when atmospheric noise and noise out of the surrounding area (man made static) are not too strong. The sensitivity of the receiver for several frequencies is visualised in figure 9 and 10. One sees that it is reasonably smooth, there can only be observed decay at lower frequencies. For the medium wave band there was no accurate (calibrated in absolute values) instrument available. The relative comparison looks clear enough. It must be said once again that the manufacturer does not guaranty good performance beneath the 1000 kHz. The by us tested receiver was certainly usable down to 300 kHz.
The usability for very low frequencies increases by improvement of the pre-selection, but this requires modification in the internal of the apparatus, which not every one should like to do. Apart from that is the range below 450 kHz is only interesting for an individual. The ships traffic performs mainly between 470 and 500 kHz and in this range one can reach this range exactly with the ‘antenna trim’, with a extra antenna of ferrite rod, plus earth or capacity to the surrounding area.

Single Side Band reception of amateur stations at 80 and 20-meter band does go well to the 13-year-old junior. Thereby it is easy – and for a communication receiver obviously – that the carrier insertion receiver is build in and that there are no other resources needed than the switching over a knob. LSB for 40 and 80 amateurs, USB for 20, 15 and 10 meter bands. The stability is more than sufficient. By receiving good single side band stations, the tuning has not to be adjusted. By switching on the receiver for instance the next day, the frequency is only shifted a few hundred Hz. By the minimal heat dissipation in the receiver, the frequency shift is also minimal after switching on, see figure 11. A well-known precision calibrator like the BC 221 drifts also a few hundred Hz, if one measures accurate.

Page 193
The knob 'Clarifier' does the accurate setting of the 'tuning' during receiving SSB stations. This one is moving a little ferrite core that is put in series with the oscillator coil (L6). The span is to our opinion rather large. Besides this is the adjustment A-symmetrical: the left half covers 5.5 kHz and the right side 1.5 kHz, total span ca. 7 kHz.
It is advisable to tune SSB stations with the kHz scale so that fine tuning can be take place at the right half of the clarifier.

Common data and remarks
The weight of the receiver is some what more than 4 kg. The dimensions are 29.2 x 19 x 9.8 cm. It is also a really portable receiver to take with you when you are travelling.
After removing the back panel (by loosen two screws and take out the back panel, so it can be removed completely) and after removing the front panel (pull-off the knobs and loosen the screws on the printed circuit board) the metal frame of the cabinet is left over with the attached printed circuit board and all of his parts. Everything is accessible for eventual repair or adjustment. The uncomplicated mechanical construction makes that it should not be a problem.
Due to the low price for this receiver, one can not expect 'everything'. Possible supplements or modification in the future should certainly raise the price. It is imaginable that, one can build in a better (more expensive!) Mechanical- or crystal intermediate filter for a higher selectivity. It is also possible to improve the pre-selection and adapt it for lower frequencies and/or to make a connection for an external ferrite antenna (direction finder for water sports!)

Refinement of the clarifier, together with a some what larger fine-tuning for the kHz scale and maybe an extra bearing tube, are improvements that will cost a little. A tone control and an on / off switch for the carrier insertion oscillator shouldn't also.
This are the only remarks about this receiver, regardless a decrease of the number of whistle-tones, which does not mean anything compares the range of 30,000,000 Hz.
Other wishes that may come from other users, for instance more output power are not attractive for common use. Besides that it is always possible to connect an extra amplifier, when it is essential to have more soundlevel.
As common conclusion we may say: a fantastic, really universal and portable communication receiver for a very low price.

Figure 1. Block diagram of the XCR-30
Figure 2. Schematic diagram of the HF-part
Figure 3. Schematic diagram of the IF-part with detection
Figure 4. Bandwidth curves of 1st IF 45 MHz, the filter at 42.5 MHz and the 455 kHz IF-part
Figure 5. Schematic diagram of the audio part
Figure 6. Schematic diagram of the power supply part
Figure 7. Detail of the AM-detector and automatic gain control
Figure 8. Relation between reading of the S-meter and the antenna signal
Figure 9 and 10. The sensitivity for different frequencies
Figure 11. The frequency stability after switching-on