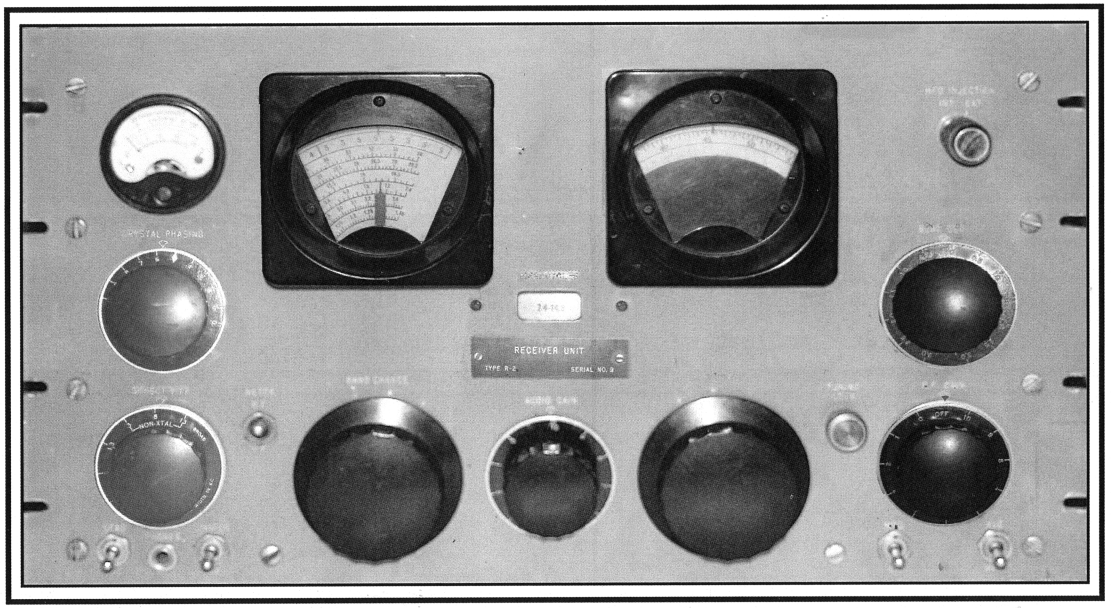
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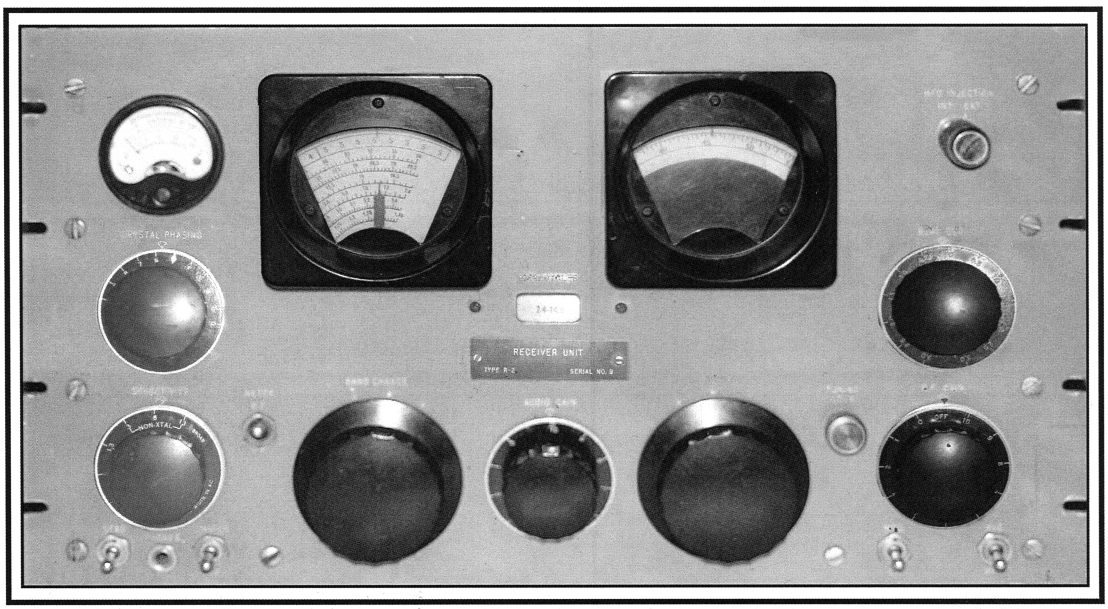


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The Hammarlund SP-600 Receiver

by Tom Harrison, GM3NHQ

My interest in the Hammarlund SP 600 receiver was sparked some years ago during a visit to Valle Air Museum in Arizona, USA where, among the exhibits, was a complete Lockheed 'Constellation' aircraft, which was listed as having been, at one time, the personal aircraft of General Douglas MacArthur, the American Army 'supremo' in the Pacific area during World War II, and the *de-facto* 'Shogun' of Japan for a few years afterwards.... the point being that, fitted in the radio cabin of this immaculate aircraft, was an example of the SP-600! When, some years later, I came across one of these receivers for sale, my thought was.... 'If it was good enough for MacArthur, it will be good enough for me!' and I bought it!

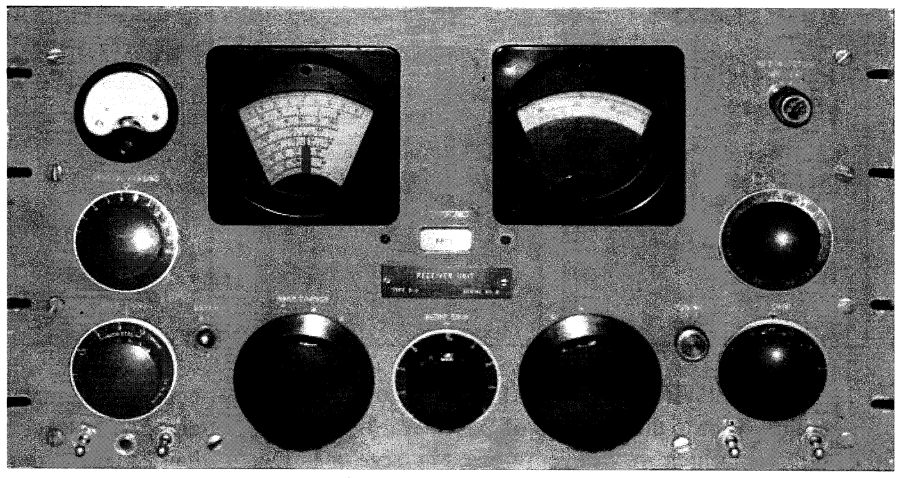


Fig.1. Front panel of the Hammarlund SP-600

The one I got was a rack-mounted unit, nameplated as 'Receiver Unit Type R-2, Serial Number 9', but inside, on the turret cover, was an instruction that, when referring to this receiver, one should quote the model number...SP-600-JX and the serial number 165, also stamped on the plate. So the identity of the beast was established. Manufacture of these sets dates back to 1951 and seems to have continued until 1972...a fair period of production.

The unit has a most impressive appearance, as shown in **Figure 1**, and is the standard 19ins wide for rack mounting, 10½ins high and 16½ins deep.... and is even more impressive when lifting for servicing, weighing in at 66lbs for the rack-mounted model. It has a complement of 20 (mostly miniature, seven-pin) valves and covers from 0.54MHz to 54MHz in six bands, receiving AM and CW (and, of course SSB, with a little effort on the operators part). It will run off a wide range of AC voltages from 95V to 260V, and consumes 150 watts.

A feature of the construction is the extensive screening of the circuitry and components, above and below chassis, an attempt to keep radiation from the receiver to a minimum.

Front Panel

The front panel is dominated by two dials and two large knobs, each associated, at first sight, with one of the dials. This, however, is misleading, as only the right-hand knob does any 'Tuning', the left-hand one being the six-way 'Bandswitch'. The left-hand dial is the 'Main Tuning' indication, with a pointer indicating both frequency and band, the right-hand dial being a logging scale, mechanically coupled to the main tuning gear-drive chain. The actual range in use is indicated in a small window located between the main tuning dials. The 'Audio Gain' control is located between the 'Tuning' and 'Bandswitch' knobs.

On the left, at the top corner, is a two-scale tuning meter which indicates RF signal strength and AF output; below that is the IF 'Crystal Phasing' control with, below that, the six-way IF 'Bandwidth' selector (three crystal and three non-crystal possibilities). On the right we have the 'BFO Tuning' control, frequency variable – and calibrated +/-5kHz around the 455kHz centre frequency; then the 'RF Gain' (with combined power On/Off switch) control.

At the top right-hand corner, we find the 'HFO/Crystal' selector switch, allowing choice of continuous variable tuning or pre-set frequency operation from a selection of six crystal-controlled channels.

A number of toggle switches are arranged around the panel, covering 'Meter Range', 'Noise Limiter', 'Mod/CW' and 'AVC On/Off'. There is also a 'Send/Receive' which desensitizes the receiver by removing the HT supply from the 1st and 2nd RF stages. (This is in parallel with a socket on the rear apron, which allows T/R operation with an external transmitter relay.)

In addition to the T/R relay connection, the rear apron has terminals for an audio input for 'Phono' which allows audio from the receiver to be played into an external audio system or sound from an external record player to be fed into the receiver (it's simply connected across the 'AF Gain' control); an SO239 socket for a buffered 455kHz output (a separate

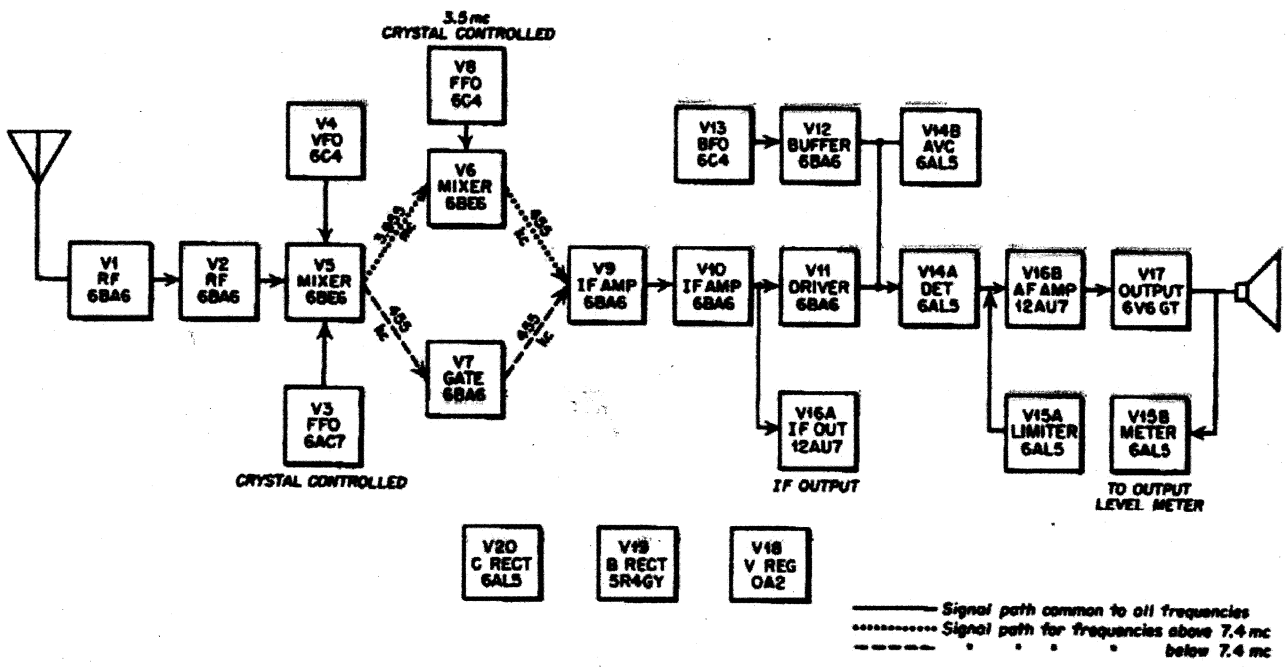


Fig.2. Block diagram for the Hammarlund SP-600 receiver

SSB adaptor was available); preset potentiometers for zero-adjustment of the AF and RF meter indications; and preset potentiometer for BFO Injection level – not something found on many communications receivers!

Audio output terminals provide for a 600 ohm line output (requiring a matching transformer for the usual 3.5 ohm loudspeaker). A further SO239 socket provides an unbuffered 455kHz output from the BFO, to feed peripheral accessories. The mains input and HT line fuses and two-pin auxiliary mains output socket complete the fittings on the rear apron. A further jack socket gives access to the AVC line, no doubt used for diversity reception.

Chassis Layout

Internally, the 'above-chassis' layout is dominated by the RF unit in the centre, which comprises a sub-assembly with the two RF Amplifier stage valves, Mixer and Oscillator Stages, mounted on the side of a massive four-gang (eight-section) tuning capacitor, with, below all this, the turret assembly with all the RF, Mixer and Oscillator coils and capacitors. (This means all the RF wiring circuits have very short leads, with resultant benefits in frequency stability and drift.) To the left of this is the IF strip, effectively four stages at 455kHz, with a crystal filter incorporated. The actual selectivity bandwidth is chosen by a multi-section switch below the chassis, running the length of the IF strip.

The right side of the topside is dominated by the crystal oscillator for the fixed frequency function, on its own sub-assembly. The BFO coils and valve are tucked in between this and the front panel. The power supply and audio stages are at the rear of the chassis.

Block Diagram

The block diagram for all this is shown in **Figure 2**. This shows a single conversion superhet with 455kHz IF on frequencies up to 7.4MHz, becoming double conversion, with 3.955kHz first IF, on frequencies above this – more on this later. There are two RF stages and four 455kHz IF stages. Sensitivity is quoted as 2.3 microvolts (or better!) over the whole range for a S/N ratio of 10 to 1; selectivity can be varied from 13kHz at the widest setting to 0.2kHz at the narrowest, with a crystal phasing control available at the narrow settings.

Among other features that will appeal to *Radio Bygones* afficionados are the calibrated BFO, with variable injection level; the possibility of fixed channel operation (via a six-crystal oscillator, selectable from the front panel); a fully gear-driven main tuning drive with a ratio of 50:1 coupled mechanically to a separate logging dial with a further 6:1 gear drive to the main scale; a buffered 455kHz output on the rear panel, to name but a few.

Circuit Diagram

The electrical details are shown in the schematic, **Figure 3**. The antenna input is via an SO239 socket mounted on the RF assembly, and is link coupled to the first tuned circuit on the turret, amplified by two RF, 6BA6 stages before feeding into the first, 6BE6, mixer stage. The oscillator injection to the mixer can be from either the fully tuneable VFO or the crystal-controlled unit, with six possible pre-set, and highly stable, options, to suit operational requirements. The variable HF Oscillator is of surprisingly simple design for a set of this pedigree, being a simple 6C4 triode with the grid directly connected to the mixer grid. The oscillator uses the most basic 'tickler' feedback circuit (pardon the 'Americanism'), which demonstrates the old adage that it is the construction of an oscillator that determines its stability and purity, not the actual design of the

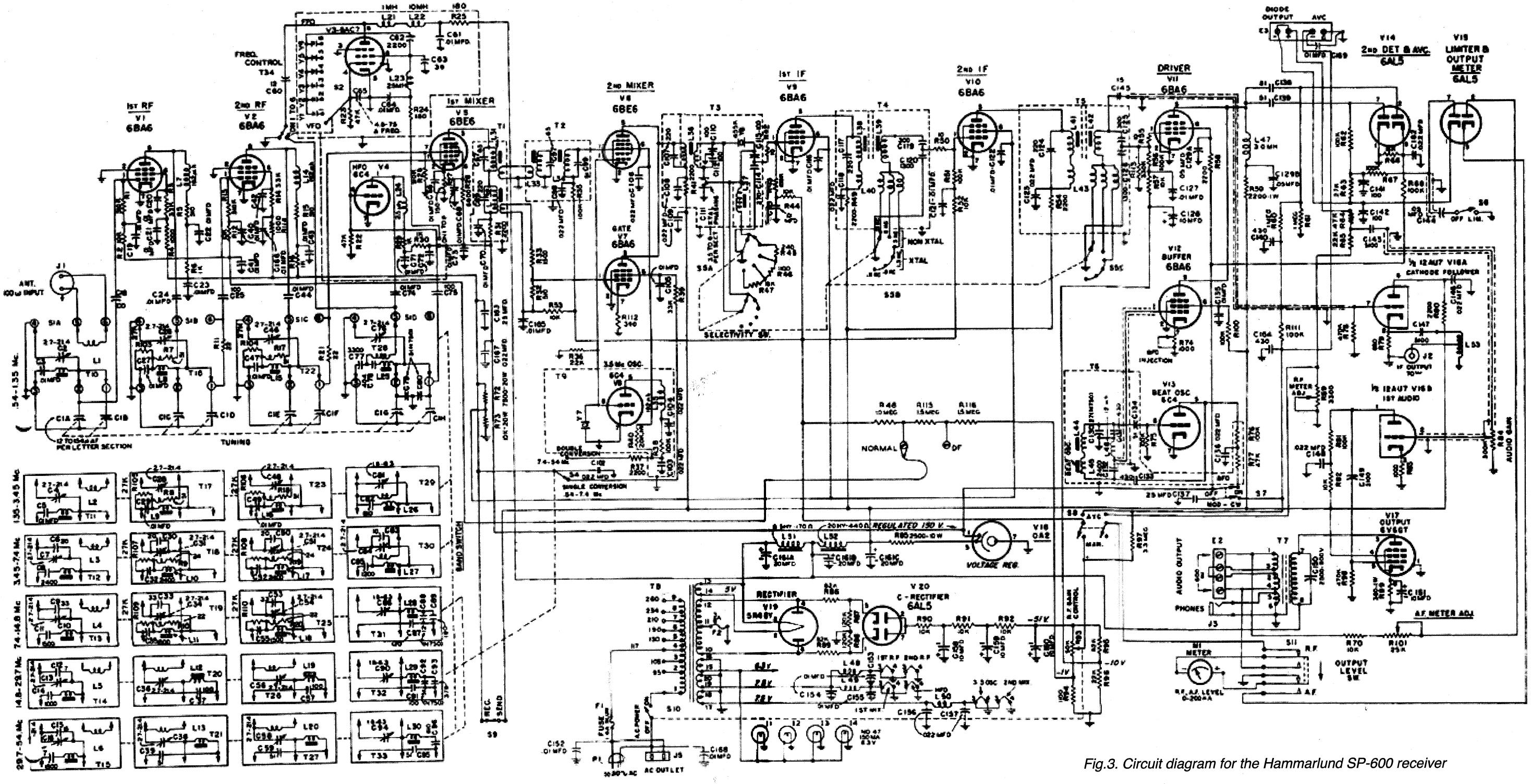


Fig.3. Circuit diagram for the Hammarlund SP-600 receiver

circuit used! Following the first mixer stage, things get a little complicated (at least for 1951!).

The receiver is muted when transmitting by opening the HT supply line to the two RF stages, V1 and V2 (and the screen grid of the IF 'Gate', V7) via the 'Send/Receive' switch on the front panel or the external 'T/R Relay' connections on the chassis rear apron.

For frequencies below 7.4MHz (Bands 1, 2 and 3) the Oscillator and RF stages are tuned to give a mixer IF output of 455kHz, for a conventional IF strip for selectivity and amplification. However, for frequencies above this (Bands 4, 5 and 6) the tuned circuits for these stages are arranged to give an output of 3.955MHz, this being fed to a second mixer, fed with a crystal-controlled 3.5MHz oscillator (brought into service by a switch on the turret assembly), to give the required 455kHz output for the main IF selectivity and amplification strip. The choice of 'normal' 455kHz IF or 3.5MHz 'double conversion' route is decided without any switching by having a 3.5MHz IF transformer in series with a 455kHz IF transformer, a technique commonly used years later in domestic AM/FM receivers! (A useful by-product of this circuit, in the case of the amateur user of the SP-600, is that it is simple to provide markers at the harmonic frequencies of 3.5MHz on the 14, 21 and 28MHz amateur bands for calibration purposes – instructions for this 'addition' are given in the manual!) On bands 4, 5 and 6, the supply to the second conversion oscillator, V8, is included in the T/R switching circuit together with the RF stages.

The 455kHz IF signal, from whichever path, next passes to the first genuine IF Amplifier via the main filter circuit, which may be crystal or non-crystal as determined by the selectivity setting. The gain of this stage is controlled by varying the negative bias on the control grid via the deceptively labelled 'RF Gain' control on the front panel. A further IF Amplifier, again gain controlled by the same variation of bias as the previous stage, follows before the signal passes on to a further amplifier, the 'Driver' on the schematic, which 'drives' the twin diode 'Detector'.

The Beat Frequency Oscillator, a simple 'Pierce' type this time, has its output buffered, to prevent strong-signal 'pulling' before combining with the Driver stage output into the Detector. The BFO Buffer stage has adjustable gain, controlled by a potentiometer on the rear chassis skirt. The combined output is also made available to external units via a 'Cathode-Follower' to give a low-impedance output at a rear panel SO239 socket.

Audio from the detector passes to a triode '1st Audio' stage then to the

final 6V6 'Output' stage, all very conventional, except that the audio output is set for a line impedance of 600 ohms, not the conventional 'speaker' impedance of 3.5 or 8 ohms.

The 'S' meter circuit is switchable between an RF indication, where the AVC voltage is measured to give an indication of signal strength when 'AVC' is selected, and AF output, where the 600 ohm output voltage from the output transformer is rectified and displayed. The selector switch is biased to lie in the 'RF' position.

Modifications

Sets of this vintage have almost always been subject to repairs and 'modifications' (both official and unofficial) and mine was no exception.

'Official' differences from the manual were: a) the addition of a 'Phono' input on the rear panel; b) a jack output for the AVC and 'Diode' output instead of the prescribed terminal strip; and c) the absence on the front panel of a control for the crystal unit frequency 'trimming' – even though the actual capacitor was fitted on the unit! A bit of a puzzle this, since the absence of the trimming control and associated frequency chart from the front panel obviously dated from original manufacture! And, in any case, the set was working perfectly on all bands – so what did it matter!

There were a few capacitor and resistor replacements due to past failures but no signs of 'amateur' improvements. However, I decided to restore the set to 'as built' operation, with the high stability crystal option available for PSK31 and SSTV modes so a detailed investigation of the 'crystal-controlled' facility was carried out.

The output capacitor from the frequency control unit to the RF assembly was found to be disconnected, as well as the feed-in connection to the first mixer. The switch 'S3', which controls the HFO/Crystal selection was missing, as well as its linkage to the crystal selector switch, S2. Restoring all this required a fair bit of investigation as the set had been modified to work without it. The reason for all this modification was eventually revealed as a damaged crystal change switch in the crystal unit. (At least it all made sense!) However, rather than immediately undertaking the mechanical engineering involved in linking the two switches as designed, I adopted the stopgap measure of independently-operated switches – after all, I had easy access – my set not being in a cabinet!

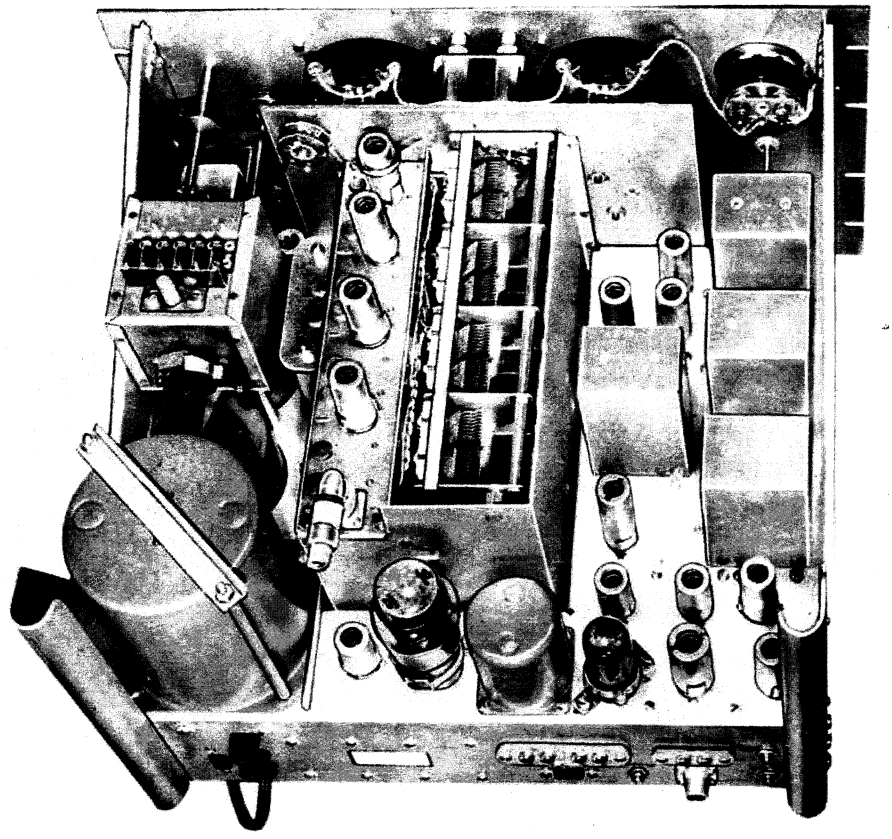


Fig.4. Top view of the SP-600 chassis

The operation of the 'Crystal/VFO' selection is actually quite elegant. The 'Crystal' unit features a seven-way selector switch, S2, which connects the oscillator control grid of V3, a 6AC7 pentode, to any one of six crystals, the first switch position being open-circuit for 'HFO' operation. This multi-way switch also transfers the stabilised 150V plate supply from the HFO plate circuit to become the V3 screen-grid supply. An external mechanical linkage connects to a two-pole two-way switch transferring the oscillator input to the first mixer from the HFO to the Crystal Unit output, the cunning part about this arrangement being that the changeover takes place when switching the 'Crystal Select' switch from position 1 to position 2 of its seven possible positions (and back again, of course, when changing back from 'Crystal' control to 'HFO').

Inside The Set

So, what does the set look like on the inside? The internal layout, above chassis, is shown in **Figure 4**. Centrally located is the RF strip mounted on the tuning capacitor assembly (the cover for the four-gang, eight-section tuning capacitor has been removed for the photograph). The IF strip runs from front to rear on the right, with the mammoth power transformer dominating the left. The crystal-control unit is the box on the left with the BFO hidden in front of it. The corresponding underside view is shown in **Figure 5**.

In the centre, is the turret assembly (again, cover removed) showing the coil strips for each band. The IF Selectivity switching is on the left, the power supply on the right, with the HT smoothing capacitor prominent. This view shows the gap between the main chassis and the front panel to accommodate the tuning drive and bandswitch gearing. The box between the IF switch and the coil turret shields the wiring associated with the second mixer, 3.5MHz oscillator and 'Gate' stages. When fully assembled, the whole underside is fitted with a screening cover and this, combined with all the screening cans on the valves and on the units above chassis, gives very little unwanted radiation from the set.

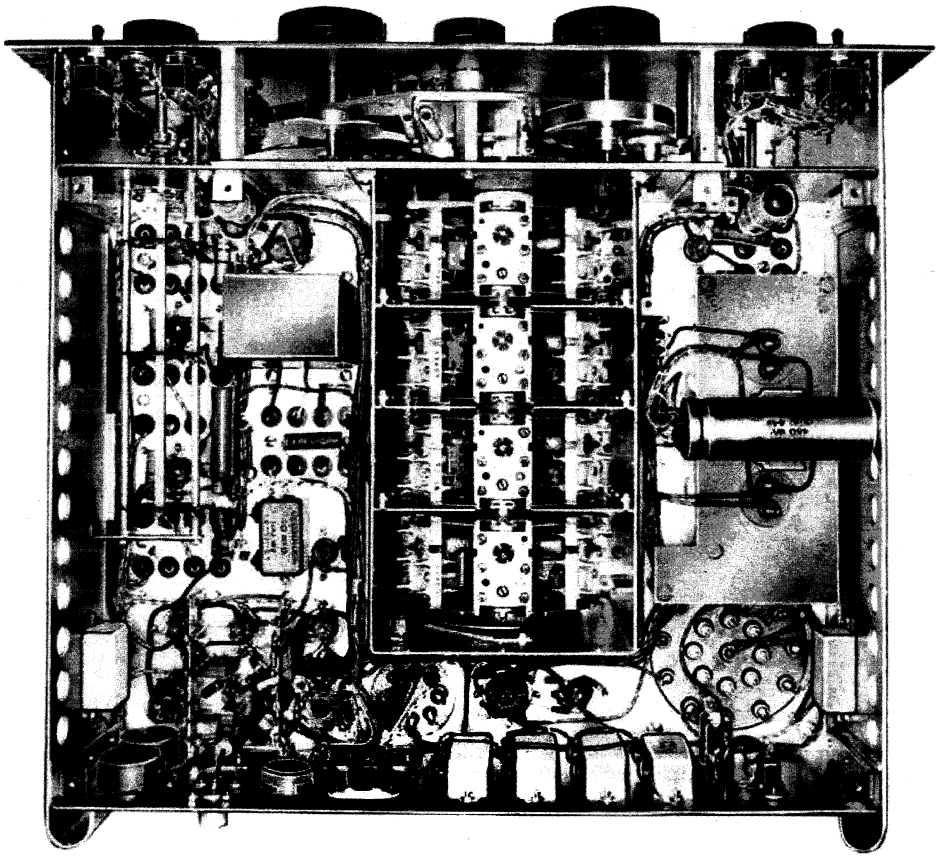


Fig.5. Underside view of the chassis of the SP-600

Operation

Operationally, the set is a pleasure to use. The gear system for the main tuning is smooth and backlash-free; the tuning rate, though not up to modern 'digital' standard, is acceptable (like all 'old' sets, you have the feeling that you are operating it, not the other way around!); after warm up, frequency stability is good (certainly for SSB and CW, although not quite good enough for PSK and SSTV on the higher-frequency bands – more on this later). The actual tuning rate is very fast compared to modern 'digitally-controlled' sets – three turns of the tuning knob for a 100kHz change at 1.8MHz, falling to 1.5 per 100kHz on 14MHz and 0.25 turns per 100kHz on 28MHz (to illustrate my point, my IC757 transceiver needs 20 turns of the tuning knob for 100kHz change on all bands!).

The designer has gone to some effort to arrange that the tuning scale is linear on all bands, employing rather complicated arrangements of coils and capacitors on each of the turret coil assemblies. Indeed, the choice of oscillator circuit changes with band, using a straightforward 'tickler' circuit on LF to something resembling a 'Pierce' on the HF bands. The selectivity, however, is good for both SSB and CW, with a nice sharp peak of 200Hz bandwidth at the most selective position.

Changing bands requires some physical effort! The coil turret mechanism has considerable spring loading to ensure proper location of the coil packs against the spring-loaded contacts on the RF Unit and the 'Bandswitch' knob requires one full turn, and a fair amount of effort, to change to the next band!

Drift

Although, as mentioned, the oscillator stability is very good, especially on lower bands, trials on the PSK31 frequency of 14.070MHz showed an unacceptable, though still slight, frequency drift, requiring very slight BFO adjustment to maintain signal intelligibility – the lower 7MHz band signals were steady enough, though. The answer to this 'nuisance' was to use the 'Crystal Control' function, with an appropriate crystal in place. The output from the mixer on the HF bands is 3.955MHz so crystals have to be above or below the operating frequency to give the eventual 455kHz IF. Thus, for PSK reception around 14.071MHz, a 10.107MHz crystal is required in Position 1 of the Crystal Unit, with 10.247MHz in Position 2 for SSTV. (The built-in crystal oscillator trimmer allows exact frequency setting for the mode). Also, the calibrations on the 'BFO' tuning (+/-3kHz) allow calibrated variable tuning over the 'narrow band mode' sections of the amateur bands.

Sensitivity

Sensitivity is given as 2.3 microvolts for a S/N of 10 to 1, well down on modern equipment performance for CW/SSB, but about the same for AM reception. This compares with 1.2 microvolts for 6dB S/N ratio for the WWII AR88 and 5 microvolts for 20dB S/N ratio for the Eddystone 750 of roughly the same vintage.

The IF bandwidth is selectable from 13kHz to 200Hz (for 6dB down), in six stages; nice for AM (and SSB) and, at its narrowest, good enough for even CW contest work!

The 'adjustability' of the BFO injection voltage is a curiosity I have not encountered before (although I recall a series of notes by Pat Hawker in the RSGB magazine a number of years ago, commenting on the injection levels in modern equipment being too high). Presumably, its function is to match the strength of the BFO into the detector to that of the received RF/IF signal, the premise being that if the two voltages are the same, the resulting audio output will have least distortion. Or perhaps it is an attempt to reduce the BFO 'hiss' to a minimum when receiving weak signals (in this respect, I found the old AR88 receiver ideal for receiving the RS10 and 12 satellites on 28MHz, as the BFO injection on that receiver is very low). Perhaps an *RB* reader can enlighten me. Whatever the reason may be, the preset control is awkwardly placed for operational purposes on the rear chassis apron! (In the absence of better guidance, I set mine to 'mid-range'!)

So there it is. Another 'boat-anchor', as our American friends call sets of this weight, and vintage. Nevertheless, a pleasure to operate and I'm sure General MacArthur would have been quite pleased with its performance, as he flew around the Pacific in his beautiful 'Constellation', listening, no doubt, to the American Forces Network! ***RB***