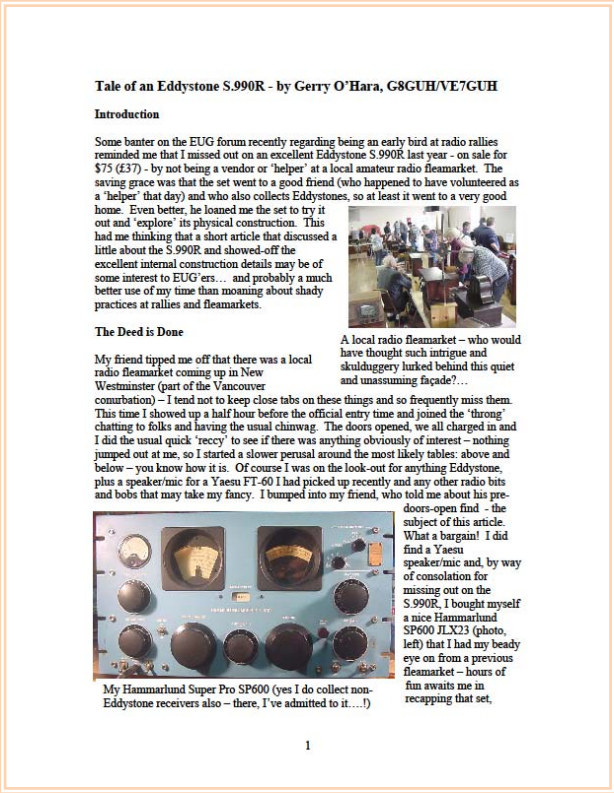
Portrait of an Eddystone S.990S: a Simple, yet a bit Complex and (Perhaps) just a little Lacking mid-1960's UHF Receiver - by Gerry O'Hara, G8GUH/VE7GUH



Tale of an Eddystone S.990R - by Gerry O'Hara, G8GUH/VE7GUH

Introduction

Some banter on the EUG forum recently regarding being an early bird at radio rallies reminded me that I missed out on an excellent Eddystone S.990R last year - on sale for $75 (£37) - by not being a vendor or 'helper' at a local amateur radio fleamarket. The saving grace was that the set went to a good friend (who happened to have volunteered as a 'helper' that day) and who also collects Eddystones, so at least it went to a very good home. Even better, he loaned me the set to try it out and 'explore' its physical construction. This had me thinking that a short article that discussed a little about the S.990R and showed-off the excellent internal construction details may be of some interest to EUG'ers… and probably a much better use of my time than moaning about shady practices at rallies and fleamarkets.

A local radio fleamarket – who would have thought such intrigue and skulduggery lurked behind this quiet and unassuming façade?…

The Deed is Done

My friend tipped me off that there was a local radio fleamarket coming up in New Westminster (part of the Vancouver conurbation) – I tend not to keep close tabs on these things and so frequently miss them. This time I showed up a half hour before the official entry time and joined the 'throng' chatting to folks and having the usual chinwag. The doors opened, we all charged in and I did the usual quick 'reccy' to see if there was anything obviously of interest – nothing jumped out at me, so I started a slower perusal around the most likely tables: above and below – you know how it is. Of course I was on the look-out for anything Eddystone, plus a speaker/mic for a Yaesu FT-60 I had picked up recently and any other radio bits and bobs that may take my fancy. I bumped into my friend, who told me about his pre-doors-open find - the subject of this article. What a bargain! I did find a Yaesu speaker/mic and, by way of consolation for missing out on the S.990R, I bought myself a nice Hammarlund SP600 JLX23 (photo, left) that I had my beady eye on from a previous fleamarket – hours of fun awaits me in recapping that set,

My Hammarlund Super Pro SP600 (yes I do collect non-Eddystone receivers also – there, I've admitted to it….!)

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Introduction

A couple of years ago I had the very good fortune to borrow a friend's newly-acquired S.990R VHF receiver for a few weeks and I took the opportunity to prepare a short article on my observations – '*Tale of an Eddystone S.990R*' – not a restoration project, just a 'show and tell'. That S.990R was definitely a very nice VHF receiver and one that I have coveted ever-since.

Fast-forward to present-day and I am now the proud possessor of the S.990R's UHF stable-mate, the S.990S. This set was recently shipped to me by Chris Pettitt in exchange for a donation to the EUG – surprisingly the shipping was very reasonable, but even more surprising was that the set arrived on my doorstep in Vancouver less than 36 hours from being collected in Birmingham. Quite amazing. So, I thought, why not write a complementary article on this receiver? – and here it is. Again, no restoration undertaken (apart from a general clean-up), just some background and description of the set along with brief observations on its performance.

Eddystone and UHF

The history behind the S.990S is of course closely-related to that of the S.990R. Thus some of the background that follows is identical to that of the S.990R – so please forgive the repetition needed to make this a stand-alone article.

Eddystone's experience of designing and building VHF radios (transmitters and receivers) dates back to pre-WWII with the S.214 receiver, used as part of a duplex police VHF radio network. Development work continued through WWII, with the production of the S.440 VHF transmitter and S.450 receiver (WS57)[1]. Post-WWII, Eddystone started to develop VHF surveillance receivers for the British Ministry of Defense at the time of the Korean War. The

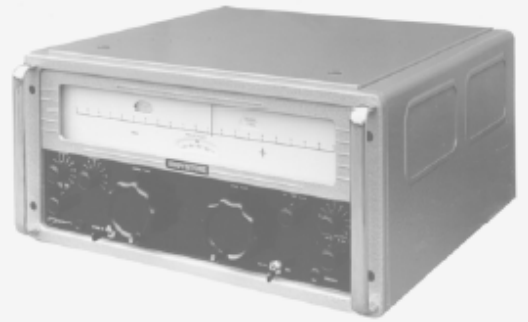
[1] The Cooke Report, Bill Cooke, 1998/9.

original specification for this was for a receiver covering 20 to 250MHz for aeronautical monitoring. Eddystone proposed this as the S.770M, which appeared at the 1951 Radiolympia show, where it was billed as a double-conversion superhet. However, this design failed to work satisfactorily as the tuning gang developed self-resonance around 200MHz[2] and the S.770M therefore never entered production. Subsequent development work at the Bath Tub culminated in the S.770R, a single-conversion superhet (5.2MHz IF) covering 19 to 165MHz, being brought to the market in 1953, while work continued on a separate receiver specification to cover the higher-VHF and lower-UHF bands. This later specification would become the S.770U (photo, below), launched in 1955, covering 150MHz to 500MHz. Although superficially similar in appearance to the S.770R, the S770U represented a fairly radical rethink of the earlier S.770R design, the S.770U being dual-conversion (IF's at 50MHz and 5.2MHz) and with a completely re-designed 'miniature' turret tuner mechanism.

The S.770U was designed for wideband FM and AM reception only (no BFO present – not a lot of CW at UHF), whereas the S770R also provided for CW and NBFM reception. At the time of their initial production, it is claimed that the S.770R and S.770U represented the only commercially-available fully-tunable VHF/UHF coverage receivers, and therefore ended up in some unusual and prestigious places world-wide, such as university research labs, various arms of the military, GCHQ, the G8GUH/VE7GUH shack (ok, after a 50 year hiatus) and even NASA.

The S.770R and S.770U models were revamped in 1963 along with other product lines into the MkII versions (photo, left), sporting the new grey-painted cabinet and front panel plus the updated knob style. However, the circuitry and mechanical features were subject only to fairly minor changes, especially in the case of the S.770R, though which now included a crystal calibrator, a linear dial bar and a few other small improvements, with the basic receiver circuit remaining essentially unchanged. Further details of the S.770R can be found in my S.770R restoration article and for the S.770U in Ian Batty's article in 'Radio Waves', as well as my S.770U restoration article (all of these can be downloaded from the EUG website).

[2] The Ultimate Quick Reference Guide (QRG), 2nd Ed., Graeme Wormald, 2002.



The frequency range 500 MHz to 1Ghz was eventually covered in the early 1960's by the very rare S.770S receiver (photo, right). This behemoth weighed in at 99lbs, used 30 valves, 18 semiconductor diodes/rectifiers and used cavity tuning in its double-conversion design: a tunable 150MHz to 170MHz first IF and a fixed second IF at 46.5MHz.

Eddystone produced several other valve VHF sets in the 1950's including the S.820 FM tuner, the S.890 microphone receiver (used by the BBC), and the S.930 'bugging' receivers.

By the mid-1960's the S.770R and S.770U, even in the MkII guise, were getting rather 'old-fashioned' and, in line with sets covering other parts of the radio spectrum, Eddystone developed a solid-state replacements. For VHF, this was the S.990R (photo, left), introduced, according to the QRG, in 1967. It was a very successful receiver and was used in many applications such as Air Traffic Control and the Coastguard service. The S.990S (photo, right) was introduced in 1968[3], extending coverage well into the UHF spectrum (230MHz to 870MHz).

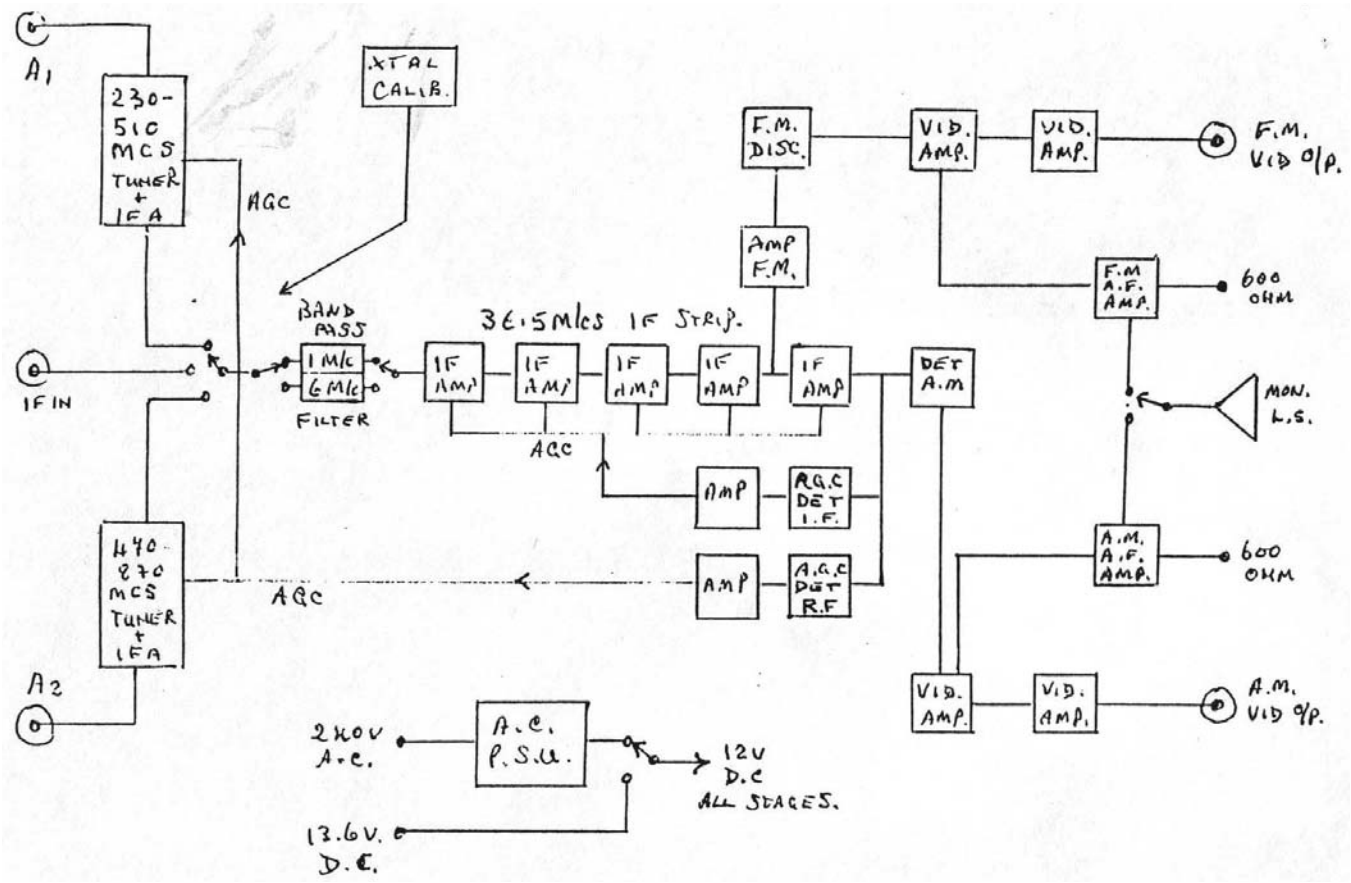
After very long production runs for a solid state professional radios, the S.990R and S.990S were superseded in the mid-1970's by the 1990-series (photo, right) covering 25MHz to 235MHz, 25MHz to 500MHz or 440MHz to 1000MHz, depending on the variant. This series were themselves superseded by the 1995/1 and 1995/2 receivers in the mid-1980's (photo, left) , these covering the frequency ranges 20MHz to 470MHz and 20MHz to 1100MHz respectively.

[3] The Ultimate Quick Reference Guide (QRG) states that the S.990S was introduced in 1968. However, my S.990S arrived with an (original) Eddystone data sheet dated 'Nov. 1965', indicating a much earlier date of introduction to the market – or maybe this was just optimistic advertising? Although the QRG shows the set was made through to 1978, EUG Newsletter Issue 54 notes that the last sets were made in March, 1975 with a total production run of 680 sets, including 3 prototypes. The serial number on my set (EW0496) is from May, 1971.

Overview of the S.990S Circuit

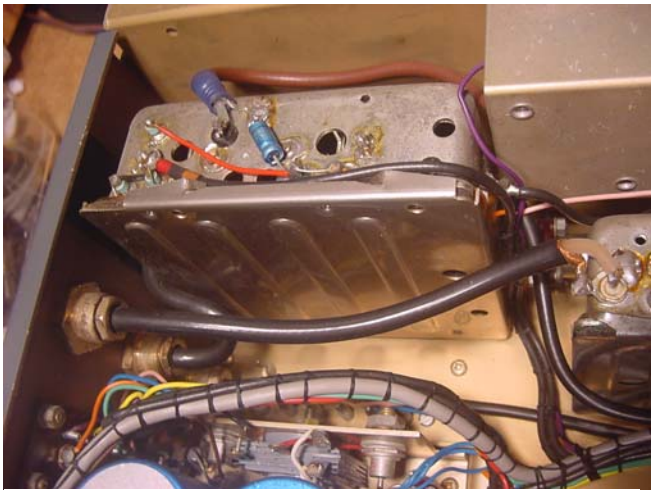
The S.990S circuit is comprised entirely of discrete devices: 33 bipolar transistors, 9 diodes, including, rather surprisingly for the mid-1960s through to the mid-1970s, one selenium bridge rectifier in the power supply (D8). The basic design concept is a very straightforward single-conversion design that could hardly be considered 'state-of-the-art' in the mid-1960's (the mid-1950's S.770U was dual conversion with 50MHz and 5.2MHz IFs), although the claimed minimum image rejection of 50dB is fairly respectable (if a little vague) and is testament to both the quality of the RF heads and effectiveness of the IF bandpass filters. The S.990S also uses predominantly germanium PNP transistors, some of which were really quite long-in-the-tooth by the mid-1960's (eg. OC72). The detailed circuit design is solid if not too sophisticated - rather 'brute force' (eg. six stages of IF amplification at 36.5MHz) - and the comprehensive output facilities were designed for a range of professional applications rather than casual band-cruising, stand-alone listening applications. A strange omission is the lack of any form of muting circuit – perhaps this reflects the particular market the set was aimed at, but very odd in my book for a UHF receiver that could be expected to be receiving FM most of the time (even the mid-1950's S.770U had a muting circuit).

The simplified block diagram provided in EUG Newsletter Issue 8 (where the S.990S is the 'Featured Model') is shown below for ease of reference and a full-scale block diagram and the full circuit description/fold-out schematic are provided in the manual, downloadable from the EUG website.



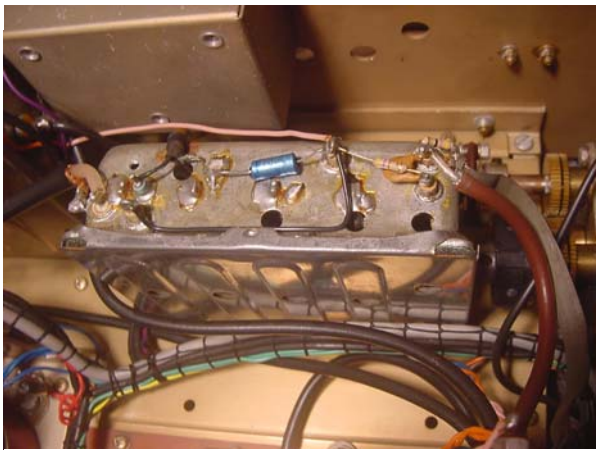
The circuit[4] consists essentially of two RF modules (one covering Range 1, the other Range 2). The receiver tunes across two ranges from 230MHz to 870MHz thus:

Range 1: 230MHz to 510MHz
Range 2: 470MHz to 870MHz



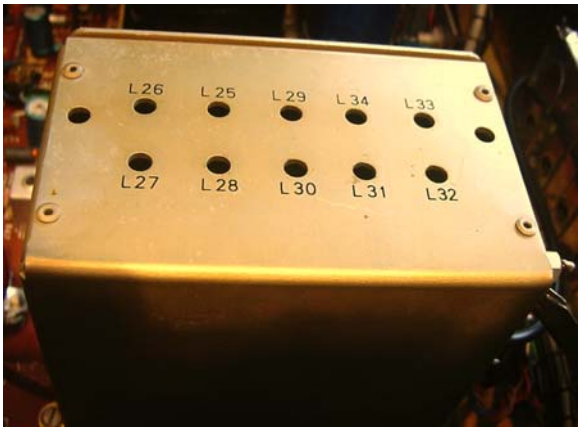
Range 1 RF Head

Tuned circuits in both of these units are capacity-tuned quarter-wave trough-lines and the robust, well-screened construction promotes good stability and simplicity of design. Both RF modules employ a tuned RF amplifier followed by a self-oscillating mixer with bandpass coupling between. The switching arrangement for the two bands is simplicity itself – applying power to and selecting the output from the appropriate unit to feed into the IF strip – I think that the designers learned much from the complex turret system of its predecessor, ie. at all costs keep it simple and avoid switching contacts at UHF…

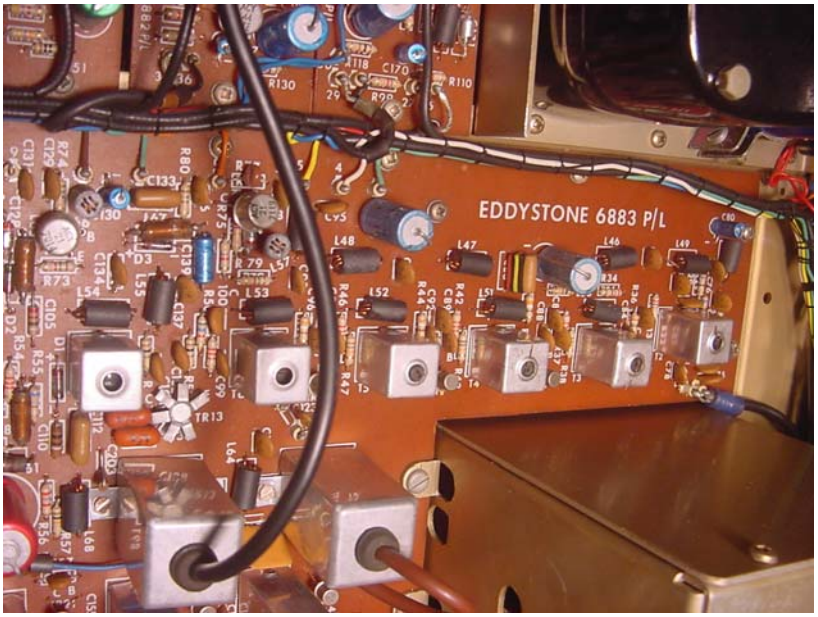


Range 2 RF Head

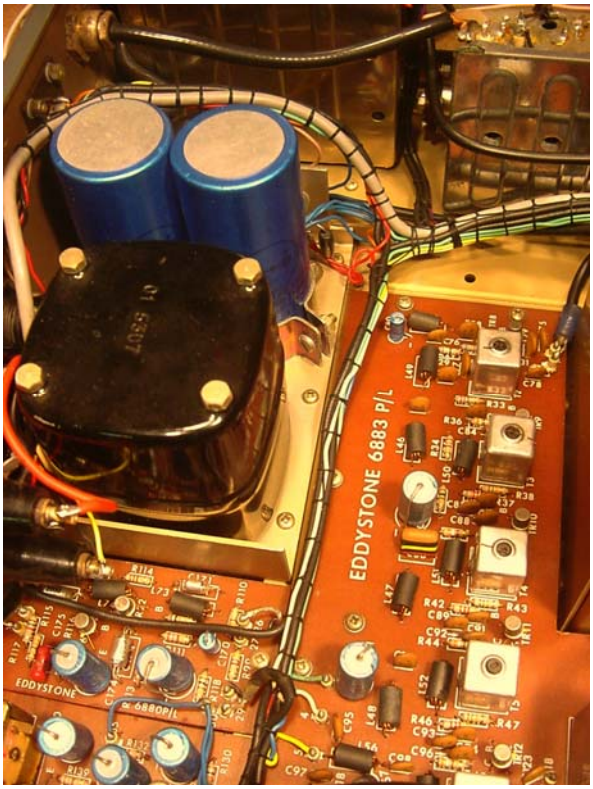
Each front-end module is followed by an IF pre-amp, then common switched (1MHz or 6MHz) bandpass filters (photo, left) feeding a fairly simple multi-stage 36.5MHz IF strip (photo, top of next page) for both AM and FM, a three-stage limiter for FM, separate AGC circuits controlling the RF and IF stages, AM/AGC detectors, a Foster-Seeley discriminator for FM,



[4] This is very much an overview of the circuit only - the S.990S manual (downloadable from the EUG website) provides a very detailed description of the circuit and features of the set. I was lucky in that my set arrived complete with its original manual, including the large fold-out circuit diagram, which is most helpful (beats sticking bits of paper together!)



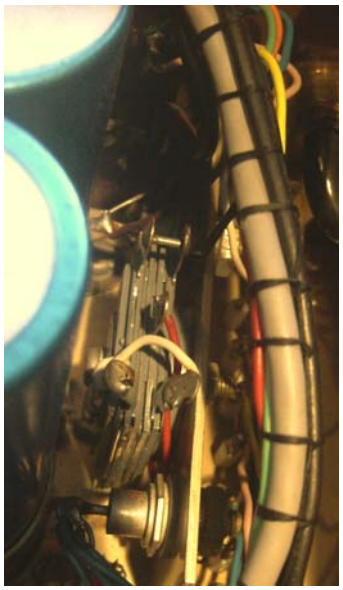
AGC (DC) amplifiers, low-level video/audio and speaker output circuits, and a zener-stabilized power supply. A tone-modulated 50MHz crystal calibrator is provided and a front panel meter is switchable to read either signal strength (logarithmic or linear response) or centre-set FM tuning. Unusually, switched (stepped) resistor strings are used for manual control of RF and IF gain - possibly providing better reliability than using potentiometers, but perhaps more importantly, allowing more precise-reproduction of a gain settings for laboratory instrument use.



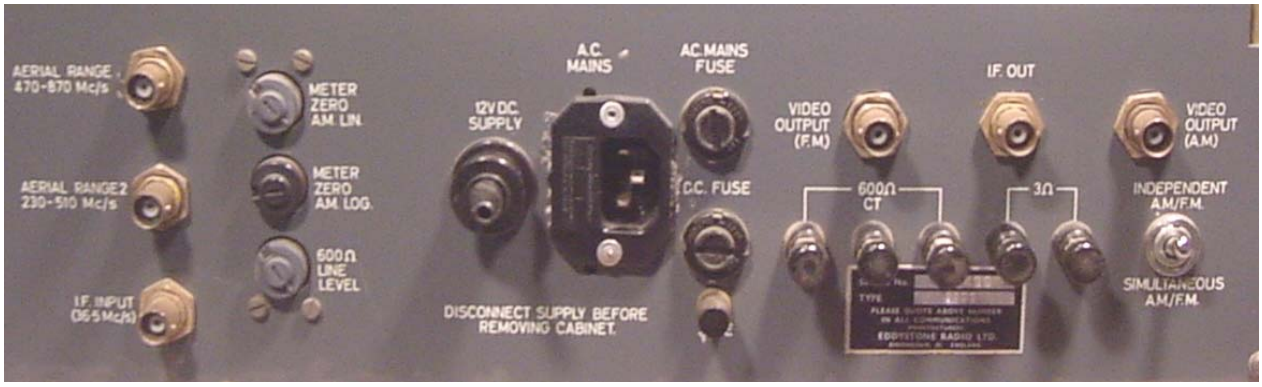
Above: The neat power supply sub-chassis. Left: Selenium rectifier tucked away behind the power supply filter capacitors

Facilities

The S.990S can be used on a nominal 110v or 250v AC supply or from a 12v DC supply. The dual RF head setup means the user has to change antenna connections when changing bands – in practice probably not such a big deal as it would first appear as different antennas would likely be used anyway (and there is some overlap between the two ranges), but can be annoying. A buffered IF output is available at 36.5MHz. Video output is available in both AM and FM modes (photo of rear panel below). A buffered 36.5MHz IF input is also provided.



Audio facilities are comprehensive, driving the internal/external speaker, phones and remote lines, however, in practice I found the lack of a muting circuit to be annoying and almost inexplicable. The crystal calibrator is useful (supplying tone-modulated 50MHz markers across the receivers tunable range) and a small mechanical 'cal-adjust' control on the front panel can be used to tweak the dial curser to the nearest marker.



Strangely, to use an Eddystone panoramic display with this set (actually the old valve-based EP17R dating from the mid-1950's and designed for use with the S.770U), an external IF converter must be used (Eddystone Type 939), this having 36.5MHz signal in and 5.2MHz signal out. When the S.990S is coupled with the Type 939 converter and EP17R panoramic display the set-up is referred to as the 'EPR29'.

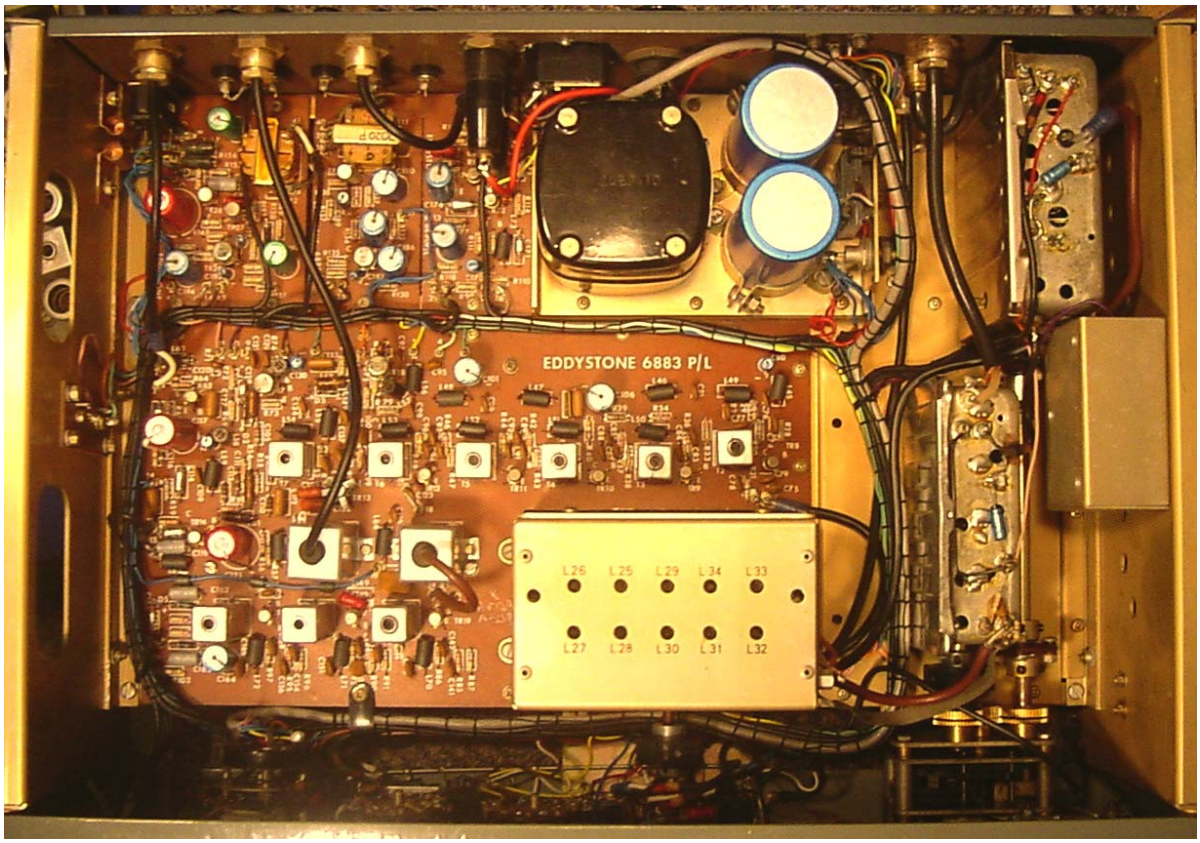
Construction Details

Externally (photo, below) most versions of the S.990S, as per the one described here, have the 'MkII' case-style look and feel of the previous generation of Eddystone (valve) receivers such as the S.770R MkII, S.770U MkII, S.940 and the S.830 series, retaining the colour scheme, the later knob style and the slide rule dial. In keeping with the 1960's 'MkII' styling, the front panel is a grey-painted aluminium casting with chrome-plated

carrying handles. The case is fabricated from light-gauge sheet steel in a grey paint finish.

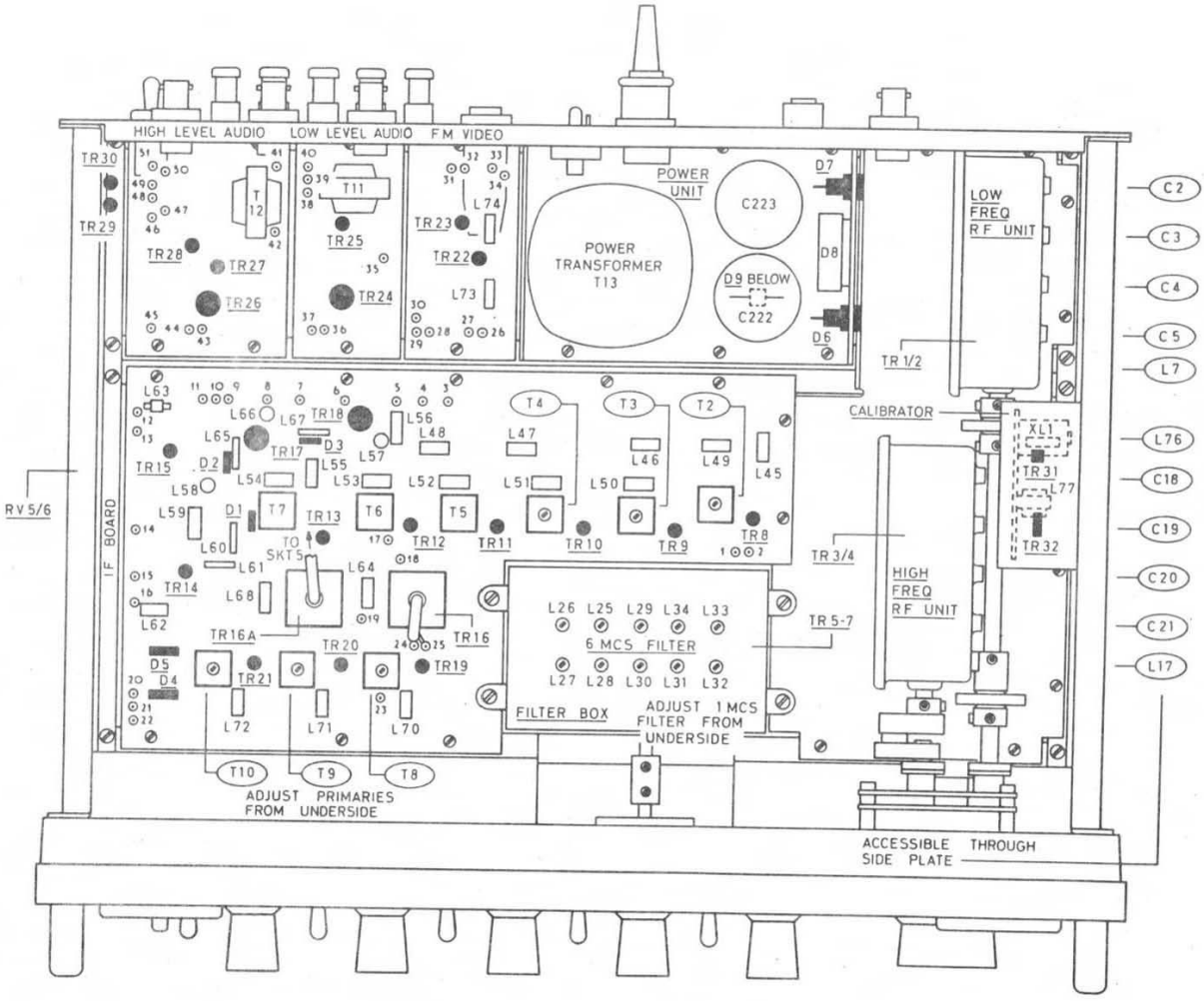
Internally, all construction, with the exception of the power supply and front panel-mounted components, is on printed circuit boards, bolted to the steel chassis, and could almost be described as modular. The separate units comprise:

- High Frequency RF Unit (located towards the front of the chassis)
- Low Frequency RF Unit (located towards the rear of the chassis)
- Crystal Calibrator (mounted at the side of the unit, in front of the Low Frequency RF Unit)
- IF Pre-Amp/Filter (mounted centrally behind the front panel)
- IF Board (main circuit board, centre-left)
- Video Amplifier (located towards the centre, rear)
- Low-level Audio Amplifier (located towards the left, rear)
- High-level Audio Amplifier (located left, rear)
- Power Supply (centre, rear)

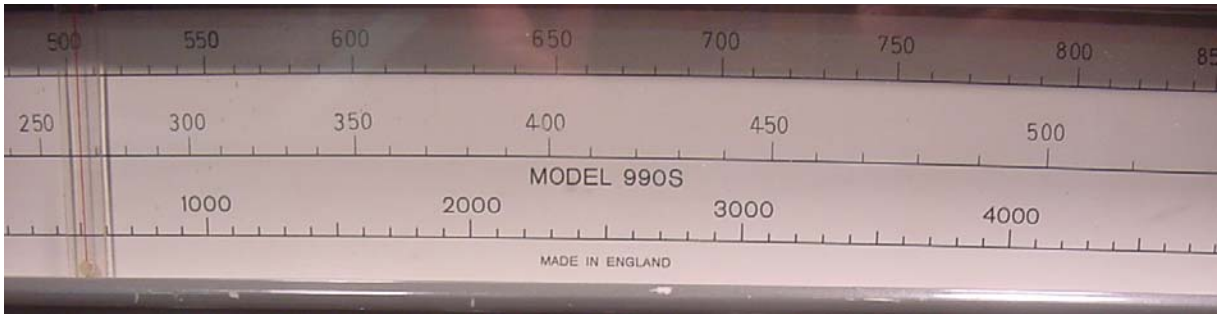


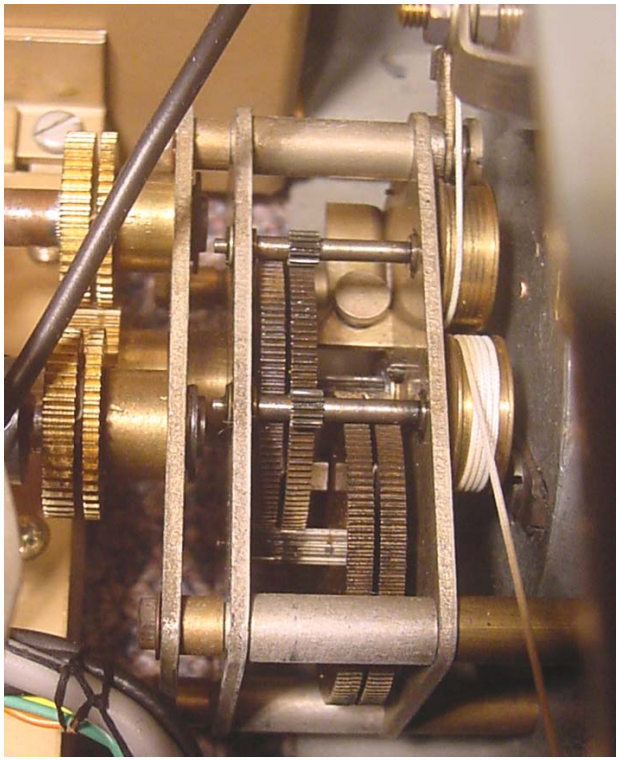
A plan view of the internal construction is shown at the next page for reference and comparison with the photographs. The internal 'above chassis' construction is shown in the photo above. The L-shaped IF board is the largest unit and is mounted in the centre of the set. This is flanked to the rear by the video and audio boards, together with the

power supply sub-chassis. The crystal oscillator unit is mounted in a small box located under a cutout in the right-hand side chassis panel, and the RF units are next to this.



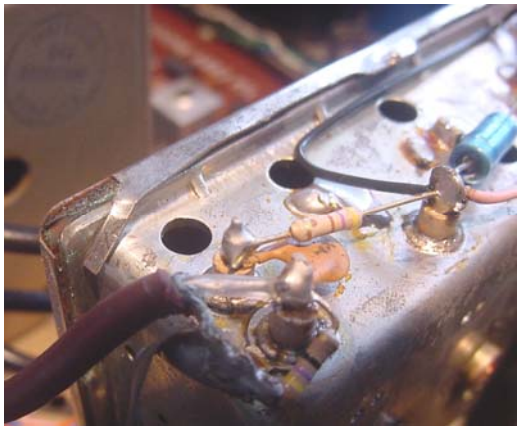
The tuning mechanism, mounted between the front panel casting and the RF tuner units (photo on next page), shows its Eddystone heritage, sporting a flywheel for that legendary smooth tuning, here with a 100:1 backlash-free reduction gearing to the tuning capacitors in the RF modules. This mechanism drives the dial pointer via cord/pulleys over a 9" scale length. The reduction section of the gearbox drives a pinion on its output shaft that engages with split-pinions on the two tuning shafts of the high and low frequency RF modules – a neat arrangement with minimal backlash. The tuning mechanism in this





particular set works very well and shows no signs of wear. The dial cord looks to have been replaced at some point as it appears almost new (photo. left).

On close inspection of the sets innards, all components looked original and there was no sign of any re-worked solder joints beneath the circuit boards. Everything else also looked to be in very good condition and almost 'Bath Tub' fresh. The fold-over sealing tags on the RF tuner unit lids (photo, below) look as though they have never been untwisted, so I did not open them up to take a look inside. The only thing detracting from this set's appearance (apart from a few scratches, paint chips and scuff marks on the case and front panel) is the way the IEC mains connector has been installed into the rear panel by a former owner – in rather a brute-force fashion to say the least, leaving a raggedy edge to the hole into which it has been inserted (looks almost as it was chiseled-in!) – no excuse for that in my book – still, it works ok, and I might get around to tidying it up one day (photo, below).



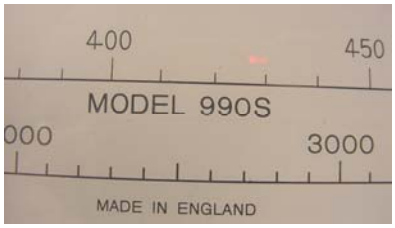
Performance

The claimed performance figures for the S.990S do not include sensitivity, instead the manual cites a noise factor on Range 1 of 10 – 16dB and 8 – 12dB for Range 2. Spurious responses (including images) are noted as being at least 50dB down. On FM, deviation up to 250kHz can be accepted and the frequency stability is quoted as better than 1 part in 10^5 per degree C change.

I did not have opportunity to use the receiver with a decent wideband UHF antenna, but did try it out on 70cm using both the 'rubber duck' off my hand-held and a small homebrew 2-element Yagi,

plus a random length of wire. It performed very well on 70cm, picking up a local repeater and a couple of simplex contacts (oh my poor ears with no muting!). It also pulled in TV station sound signals to full quieting and the audio quality through an external speaker was very good (the tiny internal speaker was ok for speech).

Conclusion



Like the S.990R, I quite like this receiver – it is beautifully constructed and is a testament to Eddystone workmanship. Having said this though, in use I find the lack of a muting facility and the need to access the rear of the set to change aerial connectors for the two bands (or install a separate, low-loss coaxial switch) annoying. I can (almost) understand the omission of an internal coaxial aerial switch to minimize contact problems and thus reduce maintenance requirements, but the lack of muting in a UHF set that will be used to a large extent for FM signals is, to say the least, odd. If I decide to use the set for more than casual use I may install both a mute circuit and an (external) coaxial aerial switch operated via the front-panel Range switch – I think both of these could easily be fitted in such a way as to be completely reversible. From an aesthetic standpoint, the set certainly looks 'the part' next to my S.830/4, S.940 and EC958/3. Now, back to the hunt for an S.990R…

73

References:

- 'The Ultimate Quick Reference Guide' (QRG) 2nd Ed. Graeme Wormald, G3GGL, 2002
- 'The Cooke Report', Bill Cooke, GW0ION, 1998/9
- "You must be Nuts…" – Restoration of an Ebay Left-over Eddystone S.770U MkI, Gerry O'Hara, September, 2009
- 'Tale of an Eddystone S.990R', Gerry O'Hara, VE7 GUH /G8GUH, November, 2008
- 'The Eddystone S.770U MkI/II', Ian Batty, Radio Waves April, 2008
- ' Restoration of Eddystone's One and Only HiFi Separate – Model S.820 Tuner', Gerry O'Hara, G8GUH, October, 2007 (and Postscript, November, 2007)

All the above can be downloaded from the EUG website, http://eddystoneusergroup.org.uk/)

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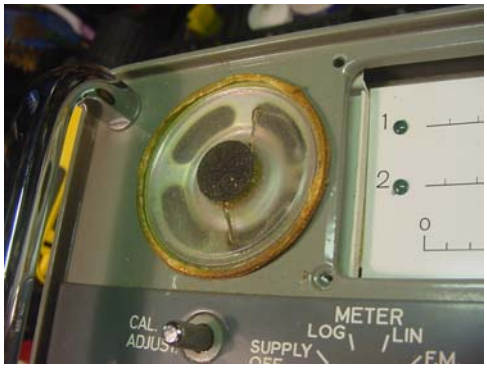
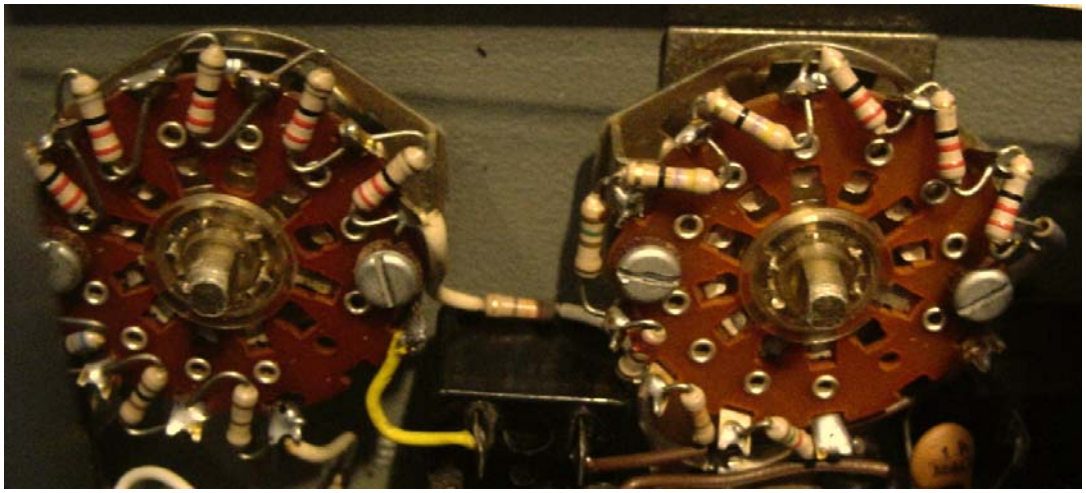


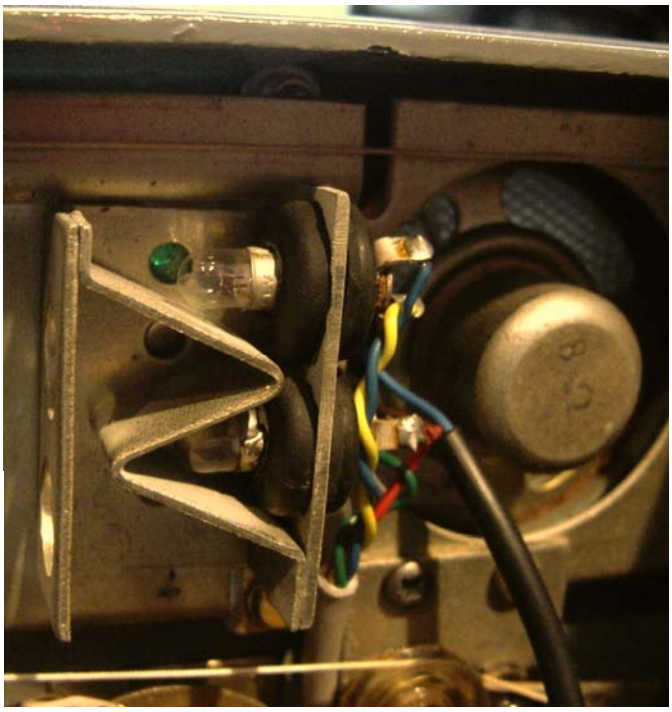
Above: The tiny speaker uncovered when taking the metal dial escutcheon off for cleaning

Left: The 50MHz crystal calibrator peeking-out through a cut out in a chassis side panel

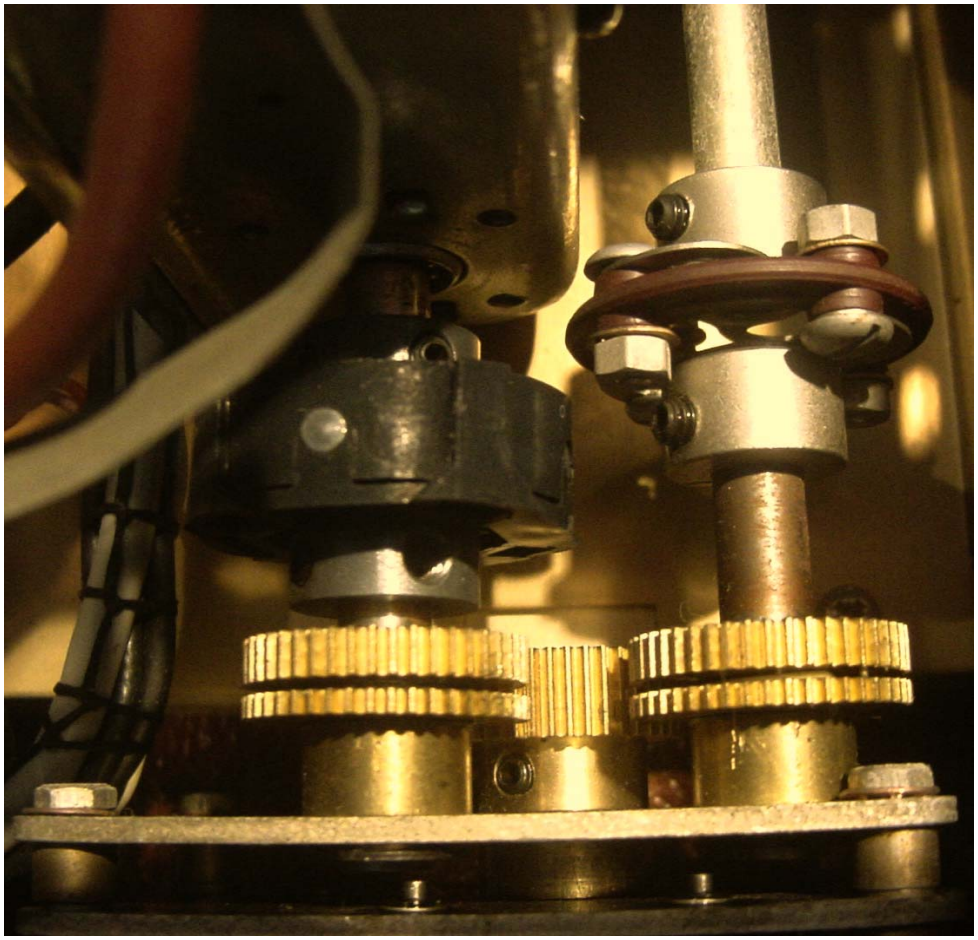
Below: RF and IF gain controls – use switched resistors rather than the more conventional rotary potentiometers

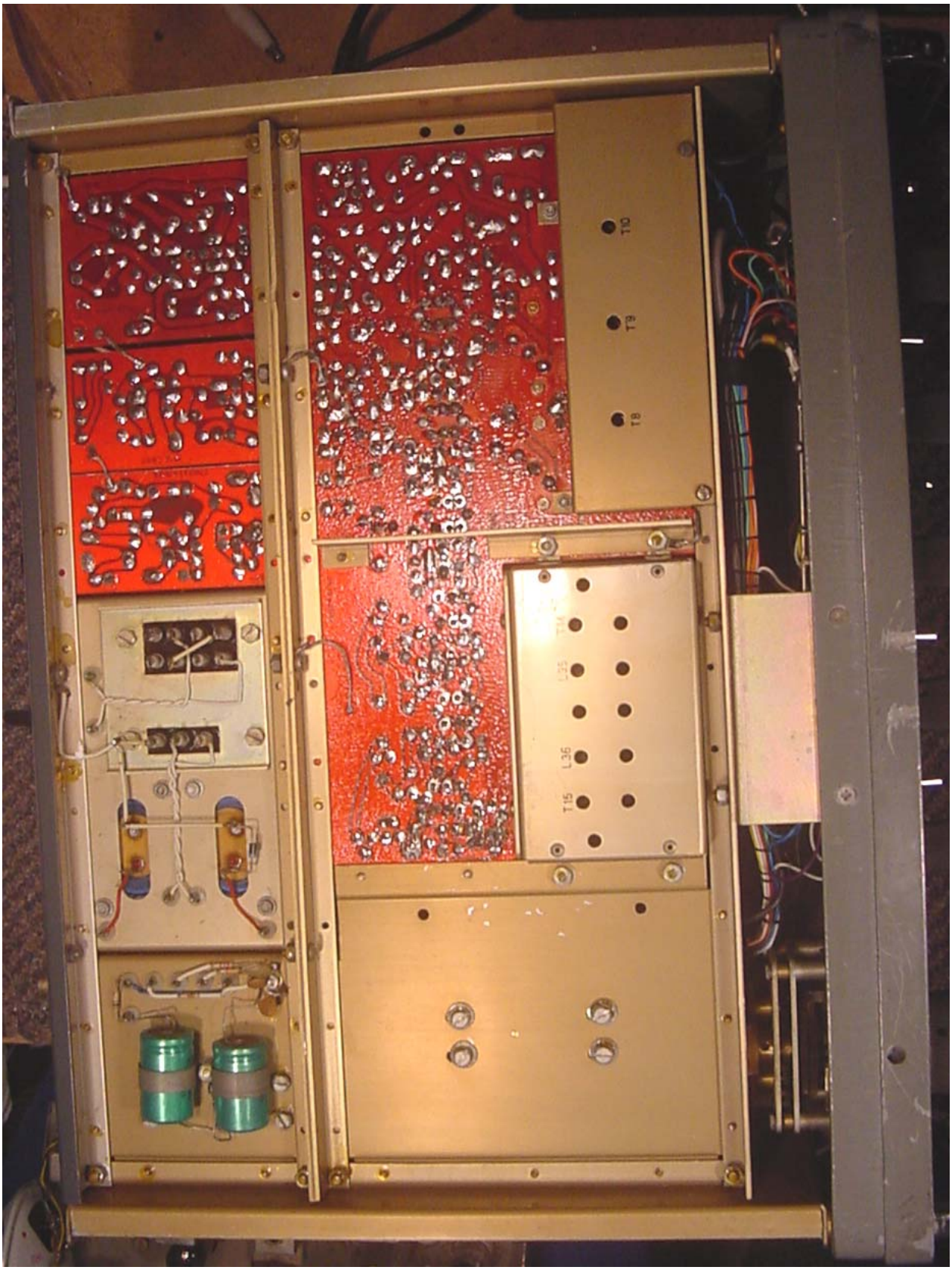


Looking good on one of my home-brew Eddystone-look-alike speaker stands



Above: Signal strength/tuning meter (note small crack in the bottom of the cover). Right: dial light arrangement (same as in the S.990R but only half-populated with bulbs). Below: Drive splitter pinions and flexible couplings to the RF head tuning shafts





Under-chassis view: note the separate small output boards (top left), large main IF board (centre top, and power-supply section (lower left).


MODEL 990S
MADE IN ENGLAND
TUNING
A.F. GAIN
I.F. GAIN
R.F. GAIN
MANUAL
SHORT
AGC. LONG
6 Mc/s
1 Mc/s
F.M.
ON
RANGE 1
RANGE 2
METER
LOG
LIN
F.M.
SUPPLY OFF
L.S.
PHONES
CAL. ADJUST.