‘Technical Shorts’

by Gerry O’Hara, G8GUH

‘Technical Shorts’ is a series of (fairly) short articles prepared for the Eddystone User Group (EUG) website, each focussing on a technical issue of relevance in repairing, restoring or using Eddystone valve radios. However, much of the content is also applicable to non-Eddystone valve receivers. The articles are the author’s personal opinion, based on his experience and are meant to be of interest or help to the novice or hobbyist – they are not meant to be a definitive or exhaustive treatise on the topic under discussion…. References are provided for those wishing to explore the subjects discussed in more depth. The author encourages feedback and discussion on any topic covered through the EUG forum.

Operating Your Eddystone

Introduction

From my earliest days of being interested in radio, I have been a keen constructor and ‘tinkerer’ – always trying to squeeze another drop of performance from my receivers or transmitters. Over the years this resulted in me building a variety of add-on devices and undertaking many modifications to existing equipment. Some of these experiments were successful, some less so, but I came to realize that other factors came into play that were external to the receiver, eg. aerials, earths, atmospheric conditions and, importantly, the skill of the user in being able to operate the receiver. Many novice shortwave listeners do not even give operating the receiver any thought beyond locating the primary controls and starting to ‘twiddle’. Being able to operate a receiver to provide its maximum performance benefits from an understanding of the receiver circuit and what each of the controls actually does within the circuit and, sometimes, any interaction between them.

This article discusses the typical controls found on Eddystone sets (and as found on most other quality communications receivers from the same era) and then describes how the controls may be used for optimum performance under a variety of receive modes and band conditions. It is recognized that each operator will develop some favourite operational techniques and this article is really only ‘food for thought’ – aimed mainly at the novice listener.

Receiver Circuits and Control Functions

The 'Short' dealing with Eddystone Circuits is a useful reference for understanding the basics of how an Eddystone is 'put together' and will not be repeated here, however, the reader should ensure that they are familiar with the various circuit elements that make up a receiver and what effect each of the controls has on the receiver operation. A brief summary of the typical controls found on an Eddystone valve receiver is presented below:

RF Gain: varies the gain of the RF stage(s) of the receiver (usually) by varying the DC bias conditions, sometimes combined with a similar function for one or more IF stages and, sometimes, the mixer stage. The control is typically a 10k ohm linear-taper wire-wound potentiometer in the cathode of the variable-mu valve(s) effecting the control. Sometimes a high positive DC voltage, derived from the HT line, is applied at the minimum settings to allow a greater range of control. The RF gain control is very useful in preventing overload of subsequent receiver stages, especially the mixer(s) and the detector – particularly when receiving SSB signals without a product detector (see below).

IF Gain: varies the gain of the IF stage(s) of the receiver by varying the DC bias conditions, sometimes combined with a similar function for one or more RF stages as noted above. The control is typically a 10k ohm linear-taper wire-wound potentiometer in the cathode of the variable-mu valve(s) effecting the control. As for the RF gain control, a high positive DC voltage, derived from the HT line, may be applied at the minimum settings to allow a greater range of control. The IF gain control is also useful in preventing overload of subsequent receiver stages – except, of course, the mixer stage(s).

AF Gain: here a potentiometer is placed in the signal line, usually between the detector(s) and the 1^{st} AF amplifier stage.

Tone: not present on many sets, but when it is (eg. S.740), usually acts as a variable high audio frequency roll-off control. It can be useful for reducing annoying high frequency whistles and heterodynes.

Band Switch: this is a multi-pole, multi-way switch, normally comprising several switch wafers, each mounted in a section of the diecast coilbox assembly. The switch connects the appropriate RF, mixer and oscillator coils into the circuit for each band selected and usually simultaneously shorts the unused coil units to earth, thus preventing unwanted parasitic resonances from absorbing RF energy from the tuned circuit actually in use.

Tuning: operates the main tuning capacitor gang through a flywheel-loaded friction drive and gearbox assembly, which also operates the tuning dial via a pulley and cord arrangement to indicate the received frequency. Eddystones are normally fitted with a high-ratio gearbox, eg. with a 1:140 ratio, and a logging scale to allow precise repeat positioning of the dial. The silky-smooth operation of the tuning control and the absence of backlash on the Eddystone sets of this era is renowned and (when working correctly) invariably makes a favourable impression with operators.

Selectivity: being able to vary the selectivity of a receiver is extremely useful – this feature can be used to reduce adjacent channel interference or select a wider bandwidth for better audio fidelity. Eddystones used two main methods of allowing variable selectivity: a mechanical arrangement that moves the IF transformers primary and secondary windings relative to each other, eg. as used in the S.750 and S.830, the other involved the switching of a tertiary coil(s) in/out of circuit in one or more of the IF transformers, as in the S.940. Some sets, eg. the S.680X, automatically adjust the receiver IF gain with selectivity in order to help equalise receiver output when varying the selectivity. Both of the variable selectivity methods used by Eddystone result in very effective and useful controls. See the Tech Short on Crystal Filters and Receiver Selectivity for more discussion on this subject.

BFO Switch and BFO Pitch: allows the beat frequency oscillator (BFO), needed for CW and SSB reception, to be switched on/off, and the pitch control adjusts the frequency of the BFO relative to the IF frequency, thus allowing the pitch of the heterodyned frequency to be varied. The control usually adjusts the value of the capacitance element of the BFO tuned circuit. In most receivers this is via a small variable capacitor, however, some, eg. the S.830/4, use a potentiometer to adjust the DC bias applied to a varicap diode. This control may be combined with the AGC on/off switching function.

Crystal Switch and Crystal Phasing: found on many Eddystone communications receivers, this control switches a single quartz crystal into the signal path within the first IF stage, resonant at the nominal IF frequency. The crystal has an inherent very sharp resonance, the behaviour of which may be adjusted using the 'phasing' control to provide either a peak in the received signal or a null ('trough' or 'slot') at a slightly offset frequency – these facilities are very useful for CW reception (see below). Again, the interested reader should refer to the Tech Short on Crystal Filters and Receiver Selectivity for more discussion on this subject.

Slot Filter (usually with a slot-depth control): as found on the EA12 amateur bands only receiver. This provides the facility to introduce a variable-depth tuneable null ('slot') within the IF passband of the receiver – very useful to reduce the effect of that annoying heterodyne caused by an adjacent station.

Noise Limiter/Noise Blanker: a *noise limiter* switches a diode(s) into/out of the low-level audio circuit of the receiver. When switched into the circuit, the diode clips excessive amplitude peaks (usually resulting from impulse noise, such as 'static') off the signal - this can be very effective in making impulse-type noise become relatively inaudible, though is pretty-well useless for the 'mushy' sort of noise generated by fluorescent lamps and the like. A *noise blanker* may provide more effective masking of all noise types by actually cancelling out the unwanted noise electronically (similar to noise cancelling headphones), but the terms 'limiter' and 'blanker' are often interchanged without consideration of what the actual circuit is doing. Valved Eddystones were fitted with *noise limiters*.

AGC (or AVC) Switch: this switches the automatic gain control in or out of the circuit, usually be shorting the AGC bus to earth when in the off position. This action is often performed automatically be switching the BFO on/off, the AGC being disabled when the BFO is operating, as this is the usual requirement (see below), as in the S.750 for example.

Mute: usually only found on sets designed for FM reception, this control activates a circuit that silences the receiver when the received signal is below a pre-determined threshold level. Sometimes the threshold is adjustable by the operator.

Mode Switch: found on the more sophisticated sets that switch in different detectors for each mode, eg. diode detector for AM, discriminator for FM and product detector for SSB. This switch may also be combined with other, related, functions, eg. switching the AGC or BFO on/off.

Ergonomics

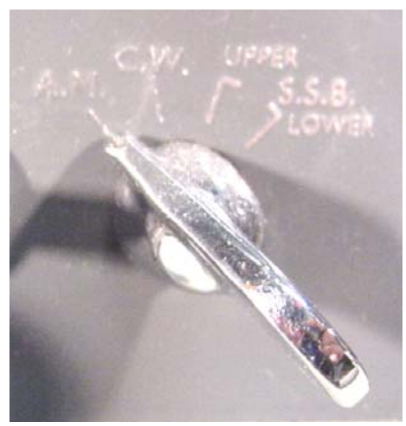
Many studies have been undertaken over the years on ergonomics as applied to many human/machine interfaces, some specific to electronic equipment. I am not sure what, if any, of such research went into the layout of controls on a typical Eddystone finger plate, but in general, I would say they 'got it right', the main controls being uncluttered and easily operated without interfering with the controls not in use. Perhaps it was not too important an issue when the number of controls were barely out of the single digit range (compared to over 130 for a typical modern transceiver) and when of these, only a few were in active use during careful adjustments to winkle out a weak signal. An interesting article on this subject was published recently in RadCom (Technical Topics, March, 2007).

A minor point that should be noted is that the controls on an Eddystone benefit from being lifted up slightly above the table/bench on which the set is mounted. This was recognized by Eddystone, who sold accessories such as the Type 774 mounting blocks (photo below) for the models manufactured up to the early-1960's and the plinth speakers (photo above) for later models. If you don't have these, then try improvising – I use a pair of rubber doorstops for my S.830 and my S.750 sits atop a slimline DVD player on my desk. Also, make sure that the receiver is placed on a sturdy desk that provides an appropriate distance between the controls and the operator, suitable for supporting your arms and resting a logbook or other documents on, and so that adequate ventilation of the receiver is afforded – please don't be tempted to stack other equipment on top of the receiver or such that the side/rear vents become inoperative.

Operating Your Eddystone

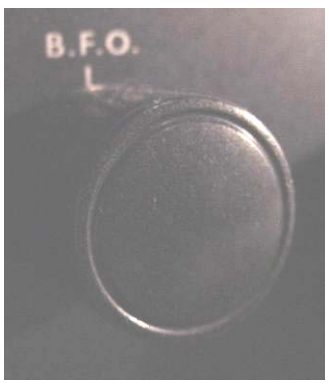
So, now you are familiar with the controls and what they do within the receiver circuit, this knowledge can be applied to actually operating the receiver….. what, but isn't that easy? – switch it on, select a band that covers the frequency of interest, tune in a signal, adjust the volume control and that's it, oh, and if it's a CW or SSB signal, switch the BFO on and fiddle with the pitch control and with a bit of luck…….. yes, it can be that simple, but not always, and certainly not if you want to obtain the best results possible.

Below you will find a few 'pointers' on how to adjust the various controls to provide the optimum receiver performance under a range of signal and band conditions. This is a summary of many years of personal experience of serious and not-so-serious listening on amateur and broadcast bands using a variety of receivers. A summary table is provided at the end of this article for ease of reference:



- **AM reception:** the bandwidth of a typical broadcast AM station is around 8kHz, that for radio amateurs using AM (few and far between these days, though they are there if you know when and where to look) somewhat less. For broadcast AM or radio amateur AM stations, select the appropriate band and tune in the desired signal, set the receiver 'mode' switch (if present) to 'AM', AGC to 'on', RF and IF gains to 'full', selectivity to 'minimum' (widest), AF gain to a comfortable volume, tone (if fitted) to suite your preference and switch the noise limiter to 'off'. If the received signal is distorted or if there is adjacent channel interference, try backing off the RF and/or IF gain control(s). If the signal remains distorted check that the AGC is functioning ok, or try using an external attenuator ahead of the aerial input to the receiver. If adjacent channel interference is a problem, try increasing the selectivity (reducing the bandwidth) at the expense of audio fidelity (reduction in the higher audio frequency content). If pulse-type interference is present (eg. 'static), try switching the noise limiter to 'on', again at the expense of some audio fidelity, this time you will probably notice an increase in the level of distortion, but the noise should be less intrusive.

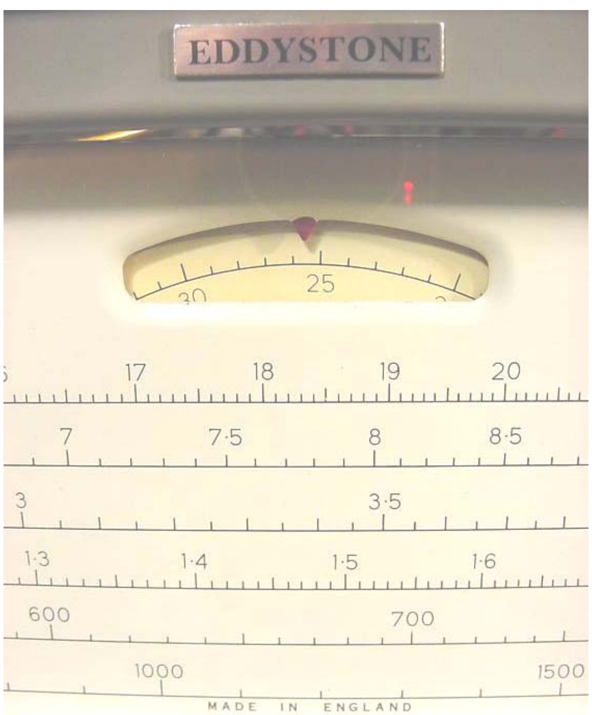
- **CW reception:** In theory, the bandwidth of a CW signal is a single frequency – that of the carrier wave itself, with no sidebands. This means that the selectivity of the receiver can be increased significantly, allowing reception of a CW signal through much adjacent channel interference – much more so than for AM and even SSB signals. Select the appropriate band and tune in the desired signal, set the receiver 'mode' switch (if present) to 'CW', AGC off, BFO on and offset the BFO to the IF centre-frequency by the nominal desired CW tone pitch (say between 400Hz and 1kHz), reduce the RF and IF gains to less than 'half', selectivity to 'maximum' (narrowest) setting, or, if present 'crystal', set the AF gain to a comfortable volume, tone (if fitted) to suite your preference and switch the noise limiter to 'off'. If present, adjust the crystal 'phasing' control to either further peak the desired signal or reduce an adjacent channel signal (null). If pulse-type interference is present (eg. 'static), try switching the noise limiter to 'on'.



  The optimum positions of the RF/AF gain controls, crystal 'phasing'/selectivity, tuning and BFO pitch may then be 'fine-tuned' for optimal reception under the particular circumstances and band conditions: note, if a single crystal filter is being used, only very small adjustments of the tuning and BFO pitch controls are needed. You will usually find that the AF gain will be almost full-on and that volume adjustment of the received signal should be made with the RF/IF gains under most circumstances.

- **SSB reception:** The bandwidth of an SSB signal is in the order of 2.3kHz, meaning that the selectivity of the receiver can be reduced from that used for AM reception, but not by as much as for CW reception – the use of a single crystal filter (as fitted to many Eddystone sets) is not recommended, as this has too narrow a bandwidth, resulting in poor intelligibility of the SSB signal (sounding very muffled, with significant frequency distortion). However, a double crystal filter, using slightly offset crystal frequencies to form a bandpass filter with a wider 'nose' and sharp 'skirts' on the bandpass response curve, is the best option for SSB reception if available. Many Eddystones offer variable selectivity (eg. the S.750) and on these models a position somewhere between minimum and maximum should be selected that provides optimum rejection of interference without affecting the intelligibility of the speech too much.

The optimum control settings for SSB reception depend to a certain extent on the receiver design, in particular whether the receiver is fitted with a product detector or not (several Eddystone models, eg. the S.830 series and S.940, are fitted with this form of detector) and the type of selectivity provisions as noted above. For a set without a product detector, the main problem facing the operator is that the level of BFO injection to the detector stage is generally low compared to the applied signal strength when the receiver RF/IF gains are set high (as for AM reception). The best receiving technique for SSB for a set without a product detector is therefore to switch off the AGC, switch on the BFO, advance the audio gain almost full-on and back-off the RF and IF gain controls to obtain a signal at a comfortable listening level. With the BFO pitch control set as for receiving a CW signal, tune through an SSB signal very slowly with the tuning control until maximum intelligibility of the signal is obtained and the speech sounds 'normal' pitch (this tends to be a fairly critical point). If the speech cannot be resolved, then the signal is likely the opposite sideband to where the BFO pitch control is set – if this is so, rotate the BFO pitch control to oscillate on the opposite side of the IF frequency by the same offset and try again. Note: 'traditionally' in amateur applications, lower sideband (LSB) is used mostly on frequencies below 10MHz and upper sideband (USB) on frequencies above 10MHz – this is an artefact of the early days of amateur SSB use, when early SSB transmitters did not include a sideband selector switch (ie. had a single-frequency carrier oscillator) and the heterodyne oscillator frequency was selected to provide the best image rejection for the transmitter filter circuitry – this resulted in LSB signals on the 160m, 80m and 40m amateur bands and USB on the higher bands). Some receivers, eg. the S.830 series, include pre-set BFO offsets for LSB and USB, allowing only minor adjustment using the BFO pitch control when the set is in the SSB mode.

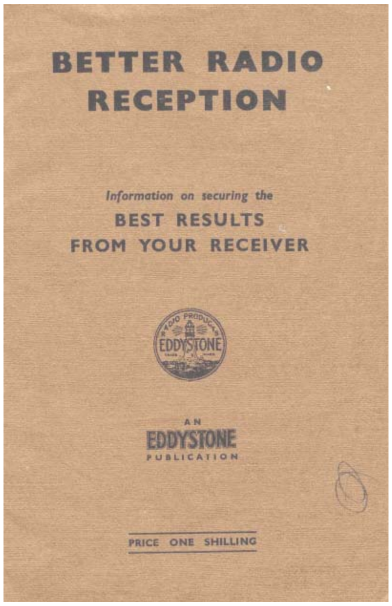


The optimum positions of the RF/AF gain controls, selectivity, tuning and BFO pitch may then be 'fine-tuned' for optimal reception under the particular circumstances and band conditions. You will usually find that the AF gain will be almost fully advanced and the volume of the received signal will best be adjusted with the RF/IF gains under most circumstances. When the receiver is fitted with a product detector, a similar technique can be used, although the RF/IF gains can be advanced further and the AGC left in circuit as the mixing level of the BFO and signal is much less critical and the BFO does not influence the operation of the AGC circuit. This is particularly advantageous for receiving strong SSB signals, when the AGC action can reduce the noise level between pauses in speech. If the set has provision for adjusting the AGC time constant, set this to a longer constant for SSB than for AM reception – this is sometimes undertaken automatically by the set's controls, eg. as on the S.830 series. If pulse-type interference is present (eg. 'static), try switching the noise limiter to 'on'.

- **FM reception:** Broadcast FM stations have a much wider bandwidth than AM broadcast stations (several 10's of kHz), whereas many amateur FM stations (on VHF and above) usually use narrow band FM (NBFM) with a bandwidth suitable for communications speech quality only, say 5kHz. The bandwidth setting should be selected to suit the signal type being received. Most sets designed for FM reception are fitted with an FM detector, usually a Foster-Seeley discriminator or a ratio detector (valve Eddystones are fitted with discriminators). For these sets (eg. S.770/R and S.770/U), the RF/IF gains are normally fully advanced and the AF gain used to set a comfortable listening level. With the set tuned to a position on the band of interest where there is no signal present, the mute (or 'squelch') control should be backed-off until the set is just silenced – tuning through a signal will then cause the mute circuit to allow the signal to be heard and the noise between signals to be muted. The mute control may be adjusted to allow only signals above a preferred threshold strength level to be heard if so desired (this is a pre-set control on many sets, eg, the S.770/R), with the front panel control being limited to an on/off function. Most FM sets are fitted with a signal strength (S-meter) and tuning meter (photo, right): if fitted, tune through the signal for the position that corresponds with the centre position on the tuning meter and maximum signal strength on the 'S-meter'.

NBFM can be received (after a fashion) on sets without a discriminator, using the 'slope detection' technique. To do this, the receiver is set up as for AM reception and the tuning slightly offset (by around half the bandwidth of the NBFM signal) to one side or other of the signal. At this point, variations in frequency of the received signal caused by the original modulation will result in amplitude variations as the signal frequency moves across the slope ('skirt') of the receiver passband. Experiment with the receiver selectivity and gain controls to provide optimum intelligibility and lowest distortion.

Other Considerations for Better Reception



Knowing how to operate the controls on your receiver is only part of the story, as the radio itself is only one component in a larger system from the aerial through to the human ear. Recognizing this, Eddystone produced a pamphlet that was included with sets from the early 1950's through the late-1960's. The various versions of this may be downloaded from the EUG web site. They are quite interesting, useful and practical documents, dealing with a variety of simple aerial types, feeders, connections to the receiver and types of interference and mitigation of same. The novice reader is advised to download and study these. There are also a variety of publications that provide advice on operating radios, including those listed in the References section of this article. In addition, the difference a suitable aerial tuning unit (ATU) can make cannot be stressed enough (refer to the Technical Short on Matching). Knowledge of the performance of the various broadcast and amateur bands at different times of the day/night and with the seasons, and even sunspot cycles is also imperative and the various RSGB and ARRL handbooks and other publications provide some very useful information on this topic.

Besides things 'upstream' of the radio, the 'downstream' end also warrants some attention for optimum performance, ie. what you connect to the speaker terminals or 'phones socket. For serious communications listening you cannot beat a proper set of 'phones – not the 'HiFi' type or the sort designed for use with portable CD, MP3 players and the like, but those designed specifically to respond to the fairly narrow band of frequencies that the human ear needs to discern to make sense out of speech. 'Phones produced by companies such as SG Brown for this purpose are amongst the best, acting as an audio filter in their own right, making the speech stand out amazingly well against a noisy background. I own a pair of 'phones produced by Thomas (right in photo on previous page) and a much more comfortable pair produced by Sonetronics (left in photo on previous page). Both are high impedance types and work well when plugged into the 'phones socket on my Eddystones, which are designed to work best with 'phones having an impedance of between 600 and 3,000 ohms. For more general listening, a speaker is satisfactory, but again, choose one to suit the set and the type of listening you are interested in. Eddystone sets have a low speaker output impedance (2.5ohm) and whilst using a speaker with a higher impedance will work and will not cause damage to the set, there will be a loss of bass frequencies as well as a reduction in available volume. The speaker units manufactured by Eddystone (eg. Models 688 and 652, as well as the 'plinth' types, Models 906 and 989) work very well, look the part and should be used if available.

Conclusion

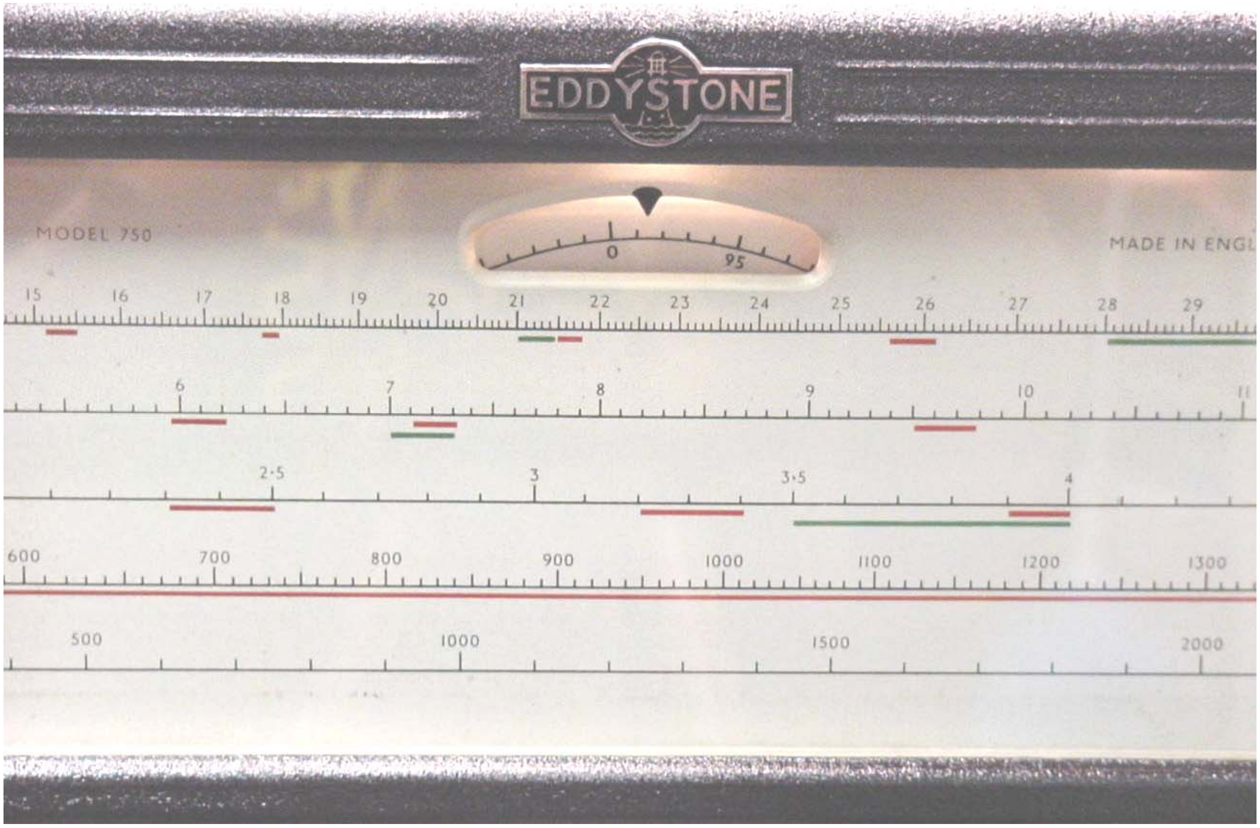
Anyone can switch on, turn up the volume, twiddle the tuning control and listen to signals on any radio, but to get the most out of your investment, a little background reading to understand how a radio works, what the controls actually do and how they may be used interactively to obtain optimal performance can pay significant dividends to your listening enjoyment and prowess in winkling out that weak signal under difficult band conditions and high levels of interference. Perseverance and 'getting to know' your receiver is the key – practice the techniques described in this article and apply them to the controls available on your set(s) and you will soon be receiving signals that you never even realised existed…

Gerry O'Hara, G8GUH, Vancouver, BC, Canada, March, 2007

EDDYSTONE

Some Useful References

- Amateur Radio Operating Manual, RSGB (the latest Ed. is #6)
- Radio Communications Handbook, RSGB (the latest Ed. published in 2006 is #8)
- Radio Amateurs Handbook, ARRL (the latest Ed. for 2007 is #84)
- Radio and Television Receiver Troubleshooting and Repair, Ghirardi & Johnson, 1952, Ch. 9
- Radio Engineering, F. Terman, 1947, (3rd Ed.)
- Radio and Television Receiver Circuitry and Operation, Ghirardi & Johnson, 1951
- 'Technical Topics', RadCom, Vol. 83, Issue 2, March, 2007
- Various sections of Eddystone manuals downloaded from the EUG web site



Above: the lovely linear 'sliderule' dial from my S.750 – the logging scale at the bottom is used in conjunction with the circular 'vernier' dial at the top to provide excellent frequency logging capability and reproducibility. Below: introduction to the Eddystone pamphlet 'Better Radio Reception' (1958 version)

HOW TO OBTAIN THE BEST RESULTS FROM YOUR RADIO RECEIVER

There are many different types of listener using Eddystone and other radio receivers and there are various types of receiver possessing different characteristics. Of necessity, therefore, the advice given in these notes is of a general character. Some users are very interested technically as well as aesthetically—others are solely interested in the actual performance obtained, and, providing the latter is good, they are not concerned how it is brought about. Those in the first category are usually in the position to know how to get the best out of the receiver, and we would ask those in the second category to appreciate the fact that, by paying attention to a few details when installing the receiver, their listening pleasure can be greatly enhanced. Some of the following suggestions, which amplify those given in the Instruction Book, can be carried out by the user with very little difficulty—other suggestions may need the assistance of a friend or of the distributor from whom the receiver was purchased.

Receiver Control Settings Summary Table

Reception Mode	RF/IF Gain	AF Gain	AGC	BFO	Selectivity	Crystal	Noise Limiter	Mute
AM	Full-on, but back off if distortion/ cross-modulation appears	Adjust to suit desired volume	On, use a short time constant	Off	Low (wide) or Medium, if adjacent-channel interference is present	Out	Off, but switch in if pulse interference is present	N/A
CW	Back right off and then advance to adjust overall gain of set	Approaching full-on, unless hum or other receiver artifact or behaviour prevents this	Off	On, adjust pitch to suit preference	High (narrowest) or switch the crystal into circuit (if fitted)	In, use the phasing control to peak the desired signal or reduce the impact of an interfering signal	Off, but switch in if pulse interference is present	N/A
SSB	Use to adjust overall gain of set, unless a product detector is in use, then increase if AGC action is desired	Full-on, or back-off to suit desired volume if product detector is in use and RF gain is advanced	Off, but may be on with a long time constant if product detector is in use	On, adjust pitch to provide maximum intelligibility and to suit preference (ensure that BFO is tuned for the correct sideband)	High (narrow)	Out (single crystal). In, if a bandpass crystal filter of suitable bandwidth is in use	Off, but switch in if pulse interference is present	N/A
FM	Full-on	Adjust to suit desired volume	On	Off	Low (widest)	Out	N/A	On
NBFM	Full-on	Adjust to suit desired volume	On	Off	Low (wide)	Out	N/A	On