‘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 Burnaby 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.

Detectors and Discriminators

Introduction

The intent of this ‘Short’ is not to deliver a treatise on detection or demodulation, but rather briefly outline the various forms of detector used in valve receivers, when and why they are used, discuss typical detector circuits used in Eddystone valve receivers of the post-WWII era, and provide some commentary on their performance and faults that may develop in them. Detector circuits are closely integrated with automatic gain control (AGC) circuits in many receivers (though not Eddystone) and the ‘Short’ on AGC could usefully be read in conjunction with this article. This article also describes frequency modulation (FM) detector circuits and their adjustment in some detail, which will be of interest to folks using sets with FM capability, such as the S.770/R and S.770/U series.

What is a ‘Detector’?

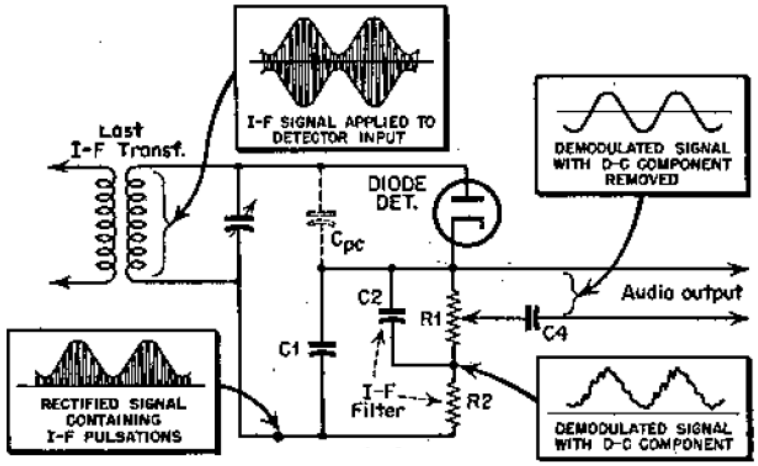
In essence, ‘detection’, or more correctly, ‘demodulation’ in the radio world is the process of obtaining intelligence from a received signal - though whether or not the original modulation was actually intelligent may, in many cases, be debatable: in this process, the desired signal is first selected and amplified by the radio frequency (RF) and intermediate frequency (IF) stages of a receiver, the next step is to derive the waveform that the RF signal was modulated with prior to transmission.

The method of demodulation depends on the original method of modulation of the signal, though the actual demodulation technique used may differ for any particular modulation type. The device used for demodulation in a receiver is commonly referred to as a ‘detector’. In superheterodyne (superhet) receivers, the signal detector is often referred to as the ‘second detector’, the term ‘first detector’ being used for the mixer stage.

Demodulation is accomplished by the following process (see diagram below):

- Rectification of the modulated RF/IF signal;
- Removal of the RF/IF component of the rectified signal (filtering); and
- Development of an audio frequency (AF) voltage that varies faithfully in relation to the modulating component.

By the mid-1920's, the use of valves (diodes or triodes) as amplitude modulation (AM) detectors was very well established, though others were also in use. The simple two-element diode is well suited to the AM demodulation process in superhet receivers as its dynamic-conduction characteristics can be made linear over a wide range of input voltage. However, whilst the diode can handle signals of high amplitude with low levels of distortion, it is not that great for low signal levels. However, this is generally not a problem in superhets, where there is ample gain ahead of the detector.



Above: one of the earliest types of detector – a galena crystal and 'cats whisker' - not found in Eddystones and therefore not described in this article… even the 1925 Eddystone crystal set used the more stable 'perikon' detector, where two crystals, zincite and bornite (or chalcopyrite) are in firm contact.

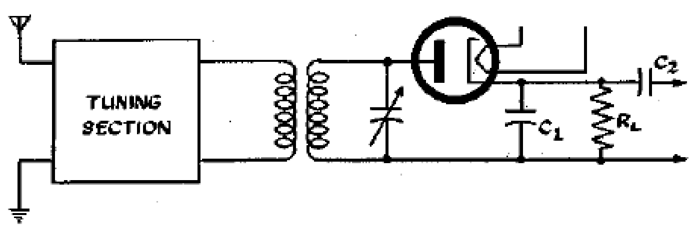
Types of Detector

The main types of detector techniques used in valve receivers over the years for AM and continuous wave (CW) signals are diode, regenerative leaky-grid, anode bend and infinite impedance detectors. However, only the diode detector has really been in widespread use for AM reception since WWII. The advent of SSB saw the introduction of the product or heterodyne detector, a form of mixer for IF and beat frequency oscillator (BFO) signals. Details of the other techniques may be found in the references given at the end of this article.

The types of modulation that post-WWII Eddystone valve receivers were designed for varied across the years and the purpose/market the sets were targeted at: in the early post-war years, CW and AM were the dominant modes in use, with radio teletype (RTTY) used in many commercial applications, the latter using a form of FM ('frequency-shift keying' or 'FSK'). The Eddystone sets of this period were therefore designed for CW and AM detection only, using single diode detectors for this purpose. By the mid-1950's, suppressed carrier or single sideband (SSB) - incidentally invented way back in the 1920's - was becoming popular in both commercial and amateur markets. Although SSB signals can be resolved on sets designed for CW and AM by careful adjustment of receiver RF/AF gains, tuning, and BFO pitch controls, it is not ideal, and so detector circuits designed specifically for SSB reception, the 'product detector', began to be introduced in medium and higher priced receiver designs. The reception of FM, both narrow and wideband, required yet other types of detector, in this case designed to demodulate the change in frequency with the imparted modulation.

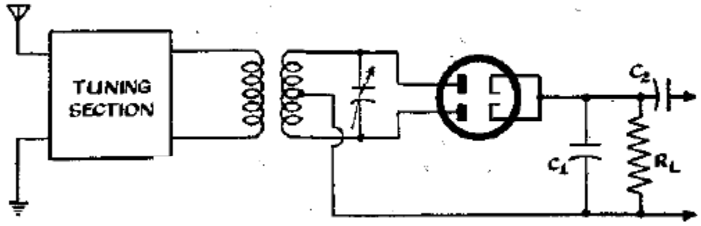
AM and CW Detectors

The basic half-wave, single-diode circuit used for both CW and AM detection is shown below: the IF signal appearing across the IF transformer secondary is rectified by the diode and this develops a voltage across the load resistor (R_L). A capacitor placed in parallel with the load resistor (C_1) by-passes all IF current to ground, leaving only the AF modulated signal to be fed to the AF stages of the receiver via C_2. The values of the load resistor and capacitor are important in designing a detector circuit that produces an output waveform that closely resembles the original modulation: appropriate values for an AM detector will typically have a time constant in the order of 100us. Also, the value of capacitor C_2 must be chosen so that its reactance will not shunt the load resistor at the highest modulation frequencies but still be sufficient to shunt the IF frequency. Also, the load resistor value should be as high as possible to encourage a high voltage to be developed without impeding current flow in the cathode circuit of the diode, such that the AF output voltage reduces. Typical values of these components for an IF of 455kHz would be 500k ohms and 0.0001uf.



The circuitof the diode detector.

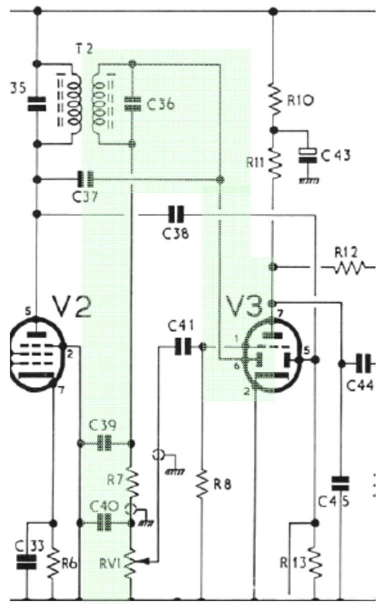
Several refinements to the basic circuit are often incorporated (refer to diagram on previous page). The inter-electrode capacitance of the diode itself causes some of the IF signal to appear across the load resistor. This can be significant, and to counteract this, it is common practice to provide additional IF filtering in the diode cathode circuit, often by splitting the load resistor (using two resistors in series), with a second filter capacitor from between the two resistors to the diode cathode. One of these load resistors is often a potentiometer, which acts as the AF gain control. A further refinement may incorporate a second diode in a push-pull arrangement (left), providing full-wave rectification of the IF signal. This arrangement has the advantage of producing a rectified current of twice the IF frequency, hence making the filtering easier, however, the

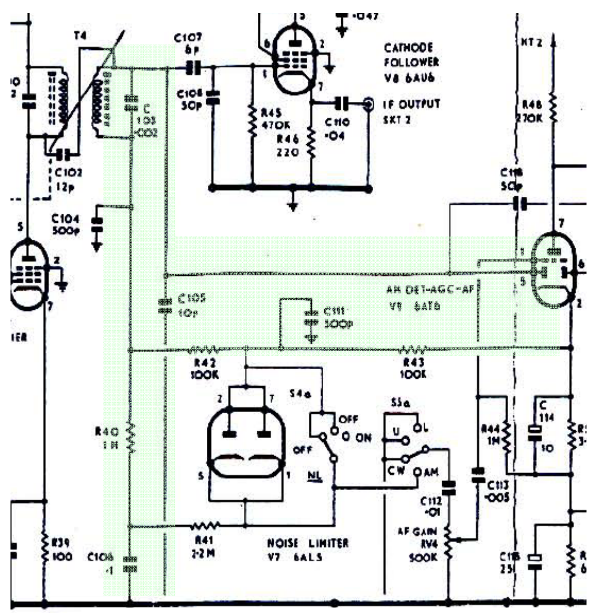


Full-wave diode detector circuit.

output from the circuit is only around half that of the half-wave circuit that is more commonly used.

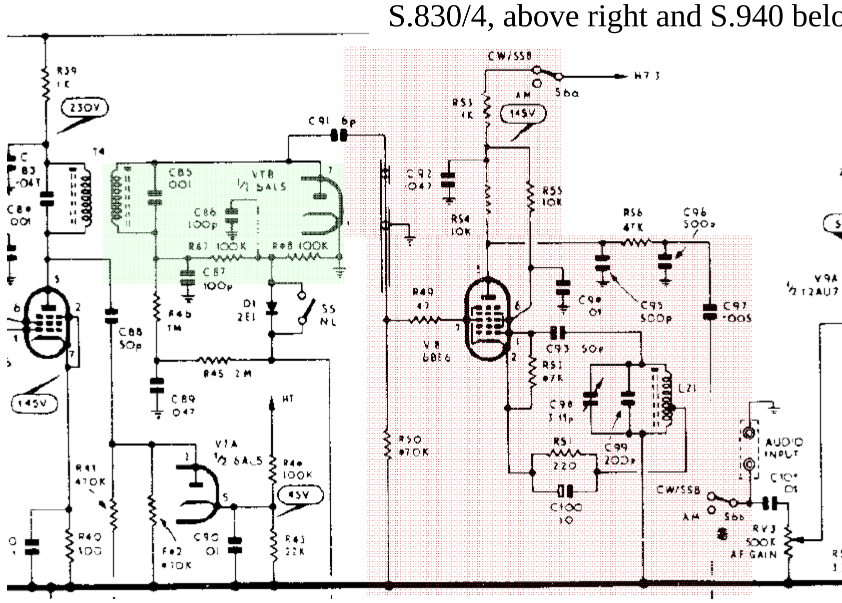
The AM detector diode in valve Eddystone receivers is usually one half of a dual diode, eg. 6AL5, as in the S.940, a diode contained in a duo-diode triode, eg, 6AT6, as in the S.830 series, or even a diode-pentode, eg. EAF42, as used in the S.740.





Although the detector diode is used in many broadcast receivers to provide the AGC voltage, Eddystones use a second diode for this specific purpose, thus allowing both circuits to be optimized. Typical AM detector circuits used in Eddystone receivers are shown above and right, shaded green.

Typical CW/AM/SSB detector circuits in Eddystone sets: S.870A, above left, S.830/4, above right and S.940 below



Product Detectors

As noted above, the detection of an SSB signal using a diode detector is not ideal. Detection of an SSB signal where the carrier signal is suppressed requires the carrier to be re-inserted and thus an SSB detector is really a form of mixer, where the SSB signal is heterodyned with the locally-generated carrier frequency (ie. the BFO signal) – a process often termed 'carrier re-insertion'. The SSB detector operating in this way performs the reverse of the modulation process at the transmitter: the side-band signal is actually the sum/difference frequencies of the carrier and the modulating frequencies. Thus by heterodyning it with the re-inserted carrier (BFO), the difference frequency produced corresponds with the original modulation.

There are many circuits suitable for SSB detection, including cathode-coupled triode mixers, balanced mixers and pentagrid converter circuits. Eddystone used a pentagrid circuit in many of their receiver designs, which combined both the carrier re-insertion oscillator and mixer in a single stage. An example of this circuit is shown at the base of previous page, shaded red.

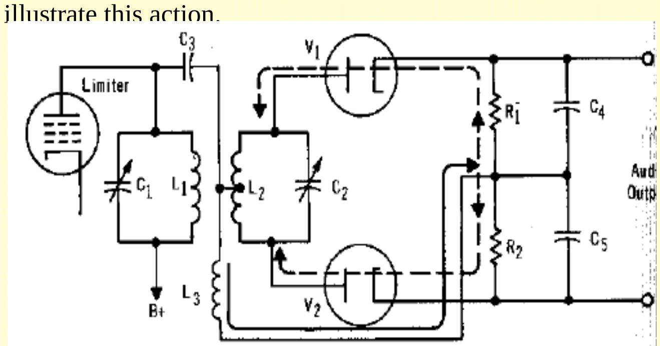
FM Detectors

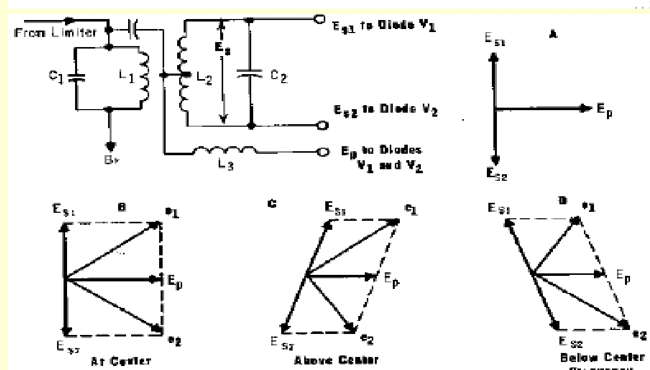
FM detection requires yet another class of detector. The function of the FM detector is to change the rate of frequency variation into voltage variation at the modulated AF frequency. As for CW/AM/SSB detectors, there are several circuits that can perform this function, although only the Foster-Seeley or 'Phase' discriminator and Ratio Detector are in common use. Other designs include the 'slope detector', which relies on the slope of the IF response curve and slight detuning of the signal to produce amplitude variations as the frequency changes, the 'off-tune' or 'triple-tuned' discriminator, where two circuits tuned to two slightly differing frequencies are used, the 'lock-in oscillator detector' where a free-running oscillator is allowed to be pulled by the frequency modulated signal, the 'Fremodyne' detector, which is a form of

The Foster-Seeley or 'Phase' Discriminator

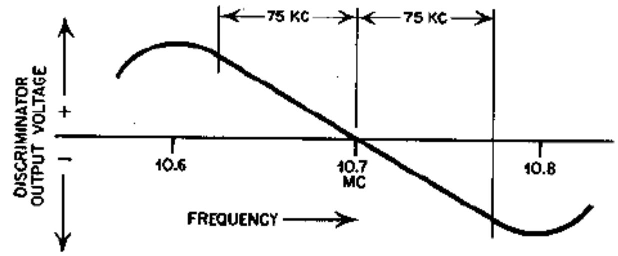
The Foster-Seeley discriminator is popular because it is simple and less critical in its operation than other types. However, as it is sensitive to amplitude variations on the input signal, it requires a limiter stage preceding it which adds to the overall cost and complexity of the circuit.

At the centre (IF) frequency, the discriminator transformer secondary circuit is at resonance and the inductive and capacitive reactances therefore cancel each other, making the circuit purely resistive, with zero phase change, and the voltage applied to the two diodes is thus equal. In this condition, the two diodes conduct the same amount causing equal-amplitude but opposite polarity voltages to be generated across the diode cathode load resistors. When the FM signal varies above and below the centre frequency, a phase-shift occurs in the input tuned circuit. When this phase-shifted signal is added to the signal taken directly from the preceding (limiter) stage (via C_3 in the circuit below), the vector sum of the two frequencies is applied to the diodes. When the FM input signal is above the centre frequency, the voltage applied to one diode is greater than that applied to the other. As a result, one diode conducts more than the other and the voltage drop across its cathode load resistor increases relative to the other diode's load resistor, thus producing a positive output voltage. When the FM input signal is below the centre frequency, the reverse is true and a negative output voltage is produced: the audio output voltage therefore varies above and below zero as the FM signal varies about its centre frequency. The figures below illustrate this action.

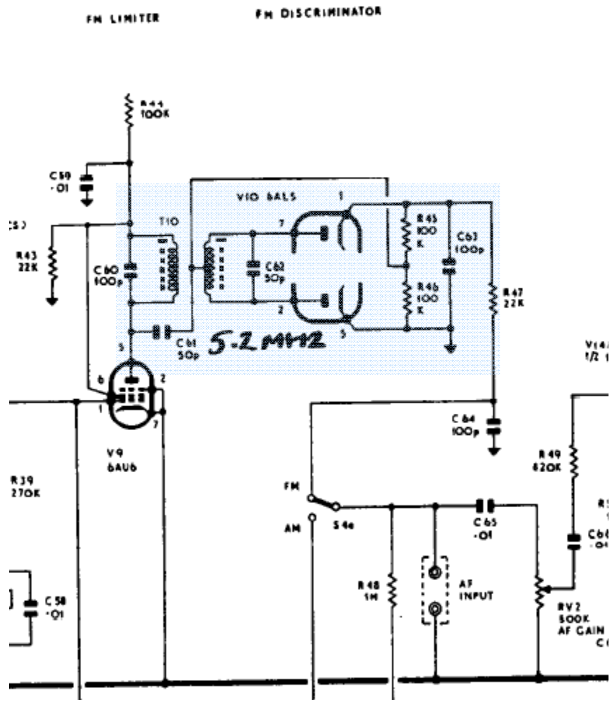




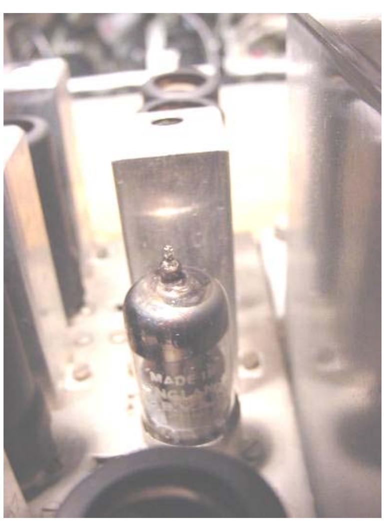
The centertapped secondary coil divides voltage E_s into two equal voltages that are both 90° out of phase with E_p at the center frequency. These voltages add vectorially with E_p to produce the total voltages, e_1 and e_2, that are applied to the diodes super-regenerative detector, and the 'gated-beam valve detector', using a specially-designed valve, the 6BN6, which acts as a type of mixer that is fed with both the modulated FM signal and the same signal shifted 90 degrees in phase to a separate grid in the valve.



A typical discriminator "S" curve in which the output voltage is plotted against instantaneous intermediate signal frequency as shown. The linearity (approach to a straight-line appearance) of the characteristic within the deviation range is a measure of the quality of a-f output of the discriminator.



The Foster-Seeley and Ratio Detector circuits look similar at first glance although more careful inspection shows that the diodes in the Ratio Detector are reverse connected in a 'series-siding' arrangement, the two cathode load resistors are replaced by a single resistor and a large value (electrolytic) shunt capacitor. The Foster-Seeley circuit (see sidebar on previous page) is somewhat sensitive to amplitude variations in the input signal and to eliminate this undesirable effect, must be preceded by a limiter stage. The Ratio Detector is effectively self-limiting as amplitude variations in the input signal are smoothed out by the large value capacitor across the load resistor.



Eddystone used the Foster-Seeley circuit in their VHF and UHF sets, preceded by a limiter stage. The circuit from the S.770U is shown above, shaded blue (the same circuit is used in the S.770R) and the operation of the circuit is described in the sidebar.

Detector Problems

Detector circuits are generally very simple, do not overly stress the components used and are therefore reliable. The primary cause of problems in the most common detector circuits are listed below, along with some troubleshooting tips. Ageing passive components are a concern in sets that are more than three decades old and faults attributable to these should certainly be considered when servicing Eddystone valve receivers:

AM Detectors

The most common cause of problems in an AM detector circuit is the diode itself. A defective diode valve may cause hum, no signal, weak signal or distortion of the AF signal. The best test is to substitute a known good valve for the suspect one. Another common cause of a problem is a fault – usually an open circuit - in the last IF transformer secondary. Thereafter the issues are most likely to be age-related component failure or drifting in value to a point where the operation of the detector function of the circuit is impaired.

A 'fault' that manifests itself in some sets fitted with a 6AT6 duo-diode triode, where one diode is the AM detector, the other is the AGC rectifier and the triode is the first AF amplifier stage, is that of signals still being audible when the AF gain is turned fully down (see my S.830/4 restoration article). This is actually not a fault but is due to stray internal capacitances (a few pf) between the diode and triode elements in the 6AT6. I have tried several different manufacturers 6AT6 valves in the circuit but with very little difference. A partial cure can be effected by increasing the value of the cathode bypass capacitor on the triode (1st AF amplifier) stage. I recently came across another suggestion that I thought may be worth a try for those that find this a problem (Technical Topics, RadCom, 1999), that being to replace the 6AT6 with an EF91 pentode – no changes are required to the circuit. The elements of the pentode structure mimic the actions of the duo-diode triode – the pentode's anode and suppressor grids act as the two diode anodes and the screen acts as the triode anode, with the cathode common to all. So I tried the swap in my S.830/4 and it certainly works: it detects the signal, produces AGC voltage and the EF91 even has more gain than the triode section of the 6AT6, but, unfortunately it suffers from even more unwanted AF breakthrough than the 6AT6 when the AF gain is turned right down… oh well, it was worth a try and certainly a useful kludge if you don't have a 6AT6 handy.

Product Detectors

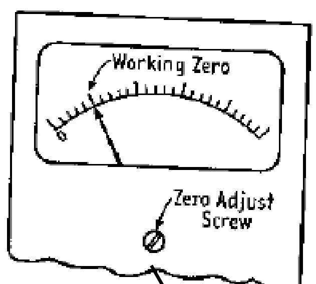
Being a more complex circuit, there are more components present to develop faults. First check that the BFO portion of the circuit is functioning – if not, first suspect the valve, its anode feed resistor(s) and the switches present in the circuit. Thereafter, age-related component failure, an open-circuit BFO tuned circuit coil or passive components drifting out of acceptable tolerance are the suspects.

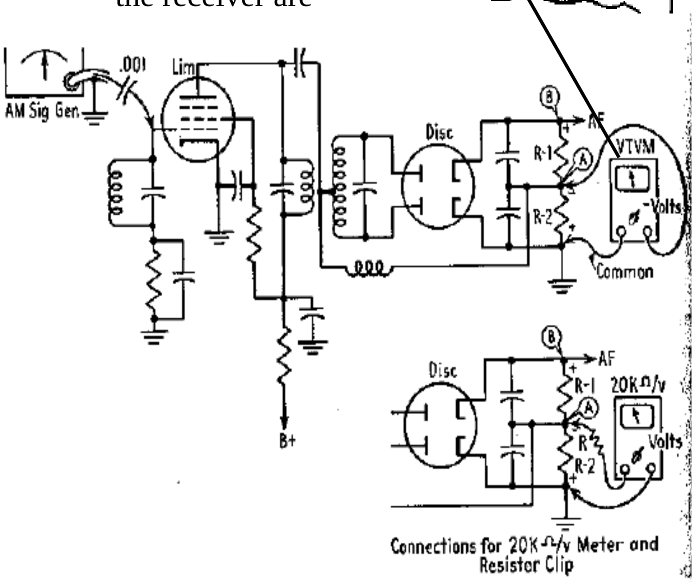
FM Detectors

Once again, the diode valves are the most likely cause of trouble in either a Foster-Seeley or Ratio Detector circuit. Loss of emission in one or both diodes will result in a weak and/or distorted signal. If replacing the diode(s) does not cure the problem, then suspect a fault in or misalignment of the input transformer, and/or age-related failure or out-of tolerance drifting of the passive components. In particular, look out for a short or leakage of the decoupling capacitor(s) on the diode cathodes in Foster-Seeley circuits and of the large capacity shunt capacitor in a Ratio Detector. The limiter stage should also be checked as a fault here would not show up under AM/CW/SSB reception but would only appear on FM. The prime suspects would be the valve and the screen decoupling capacitor.

Aligning FM Detectors in Eddystone Receivers

Whether or not to align an FM receiver detector needs to be decided on the basis of the symptoms being exhibited by the receiver and whether a reasonable level of component checking has been undertaken as indicated above. If following these checks, the RF and IF stages of the receiver are





Alignment of a Foster-Seeley discriminator.

Generic Alignment Method for a Foster-Seeley Discriminator

A VTVM is a useful piece of kit for aligning a discriminator, however, a 20kohm/volt analogue voltmeter with a 47kohm series resistor fitted in one of the test leads can be used at a pinch. Also, an oscilloscope and wobbulator may be used (Postscripts 1 and 3), however, the simple procedure outlined below works quite well in practice.

When the primary winding of the discriminator transformer is properly aligned, the voltage across either diode cathode load resistors will be maximum when an un-modulated IF signal is applied to the limiter. When the secondary winding of the discriminator transformer is properly aligned, the voltage drop across the two diode cathode load resistors is equal and opposite when an un-modulated IF signal is applied. Measurement of these voltage conditions form the basis of aligning a Foster-Seeley discriminator. Refer to the figure in the main text, below left.

Step 1: apply un-modulated IF to the limiter stage and connect a VTVM across one of the diode cathode load resistors and tune the iron dust core (slug) or trimmer of the transformer primary winding for maximum reading.

Step 2: still applying the un-modulated IF signal to the limiter stage, connect the VTVM across both diode cathode load resistors (ie. the test leads are each connected to one of the diode cathodes). Adjust the iron dust core (slug) or trimmer of the transformer secondary winding until the voltmeter reads zero, rocking the adjuster until the null is obtained. A centre-reading meter is ideal for this purpose, but a simple 'kludge' is to temporarily offset the meter zero using the zero-adjust control on the VTVM or the meter movement zero adjust screw on an analogue meter (sketch, left).

Step 3: align the limiter and preceding IF stages. For this, the un-modulated IF signal is fed to the grid of the last IF stage before the limiter and is reduced in level. The VTVM is connected as in Step 1 and the limiter input tuned circuit adjusted for maximum reading. If the response seems very broad, this is likely due to the limiting action of the circuit and the level if the input signal should be reduced further so that the actual peak can be tuned accurately. Alignment of the remaining IF stages should then proceed as normal (see 'Tech Short' on receiver alignment and relevant receiver manual).

The method outlined in the Eddystone receiver manual is similar to the above, though a centre-zero 50mA meter and series resistor is specified rather than a VTVM (see procedure extracted from an S.770R manual in main text and Postscript 2).

known to be functioning correctly (see the 'Shorts' on receiver alignment and fault-finding), and the limiter stage is working (in sets fitted with Foster-Seeley discriminators), but the AF signal is distorted, then a check of the discriminator alignment is certainly warranted.

The overall procedure for aligning a Foster-Seeley discriminator of the type found in Eddystone receivers is to align the discriminator transformer primary coil, then its secondary coil, then the limiter, then each IF stage working back towards the mixer stage, finally repeating the entire procedure. The sidebar on the previous page details the procedure generically and the excerpt from the S.770R manual below provides the specific procedure for the detector circuit in this set (see also Postscript 2).

DISCRIMINATOR ALIGNMENT.

Controls set as for I.F. Alignment, but selectivity switch to F.M.

Signal generator 5·2 Mc/s unmodulated.

Signal generator output at maximum (1 volt).

Connect generator lead to grid of limiter V8.

Connect a centre zero 0–50 microamps movement across the output of the discriminator double diode with a 100K resistor in series (i.e. from the cathode of the double diode V9 to earth). Should the discriminator be in perfect alignment at 5·2 Mc/s, the centre zero meter will read zero, and if this is so, a check can be made by moving the signal generator frequency either side of 5·2 Mc/s. This should result in equal meter readings on either side. If they are unequal, adjustment of the primary core (lower core) should be made for balanced readings.

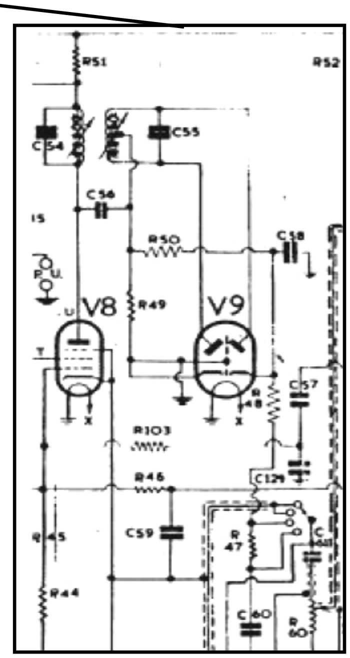
Should complete alignment of the discriminator be required, set the secondary core (upper), so that the top of the core is flush with the top of discriminator can, adjust primary core (lower) for maximum deflection on meter—and then adjust secondary core (upper) for zero reading on meter. Move generator frequency either side of 5·2 Mc/s and check balance, if unbalanced adjust primary core.

NOTE : Peak deflection should approximate 25 microamps.

Conclusion

Eddystone used standard-form CW, AM, SSB and FM detector circuits that are very reliable in use, even after many decades. The main issues arising are defective valves and aging components, though the infamous 'mad-twiddler' may have had a go at the discriminator transformer in FM sets (as in my S770R). Correcting the latter should not present too much difficulty providing homework is done so that the operation of the circuits being adjusted is understood, the correct manual/procedure is obtained and care is taken to follow the alignment instructions.

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

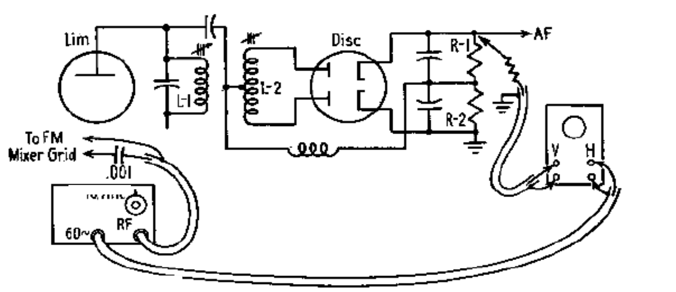


Some Useful References

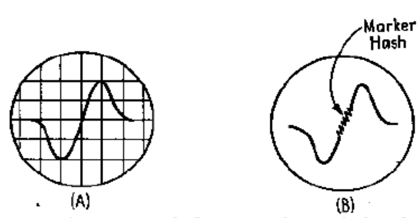
- Electronics One-Seven, H. Mileaf, 1967, Ch. 6
- Radio Communications Handbook, RSGB (eg. 4th Ed, Ch.s 2 & 4)
- Elements of Radio Servicing, W Markus and A Levy, 1955 (2nd Ed. Ch.s 24 & 26). Note: 1st Ed. Of this book is downloadable from
- Radio Engineering, F. Terman, 1947, (3rd Ed. Ch. 10)
- Radio Servicing: Theory and Practice, A. Markus, 1948 (Ch. 5)
- Radio and Television Receiver Circuitry and Operation, Ghirardi & Johnson, 1951 (Ch. 6)
- Amplifiers, Oscillators and Detectors, A. Hodges, W. Hodge and F Gager, 1941
- For a brief description/history of some of the earliest detector types visit http://www.earlyradiohistory.us/1917de.htm
- Various sections of Eddystone manuals downloaded from the EUG web site and specific articles in Lighthouse including:

Subject	***Issue***	***Page***
product detector, fitting	29	19
product detector mod	18	18
	19	12
	48	4
product detector, problems with	44	13
crystal set, 1925	94	37

Postscript 1: Aligning a Foster-Seeley Discriminator Using a Wobbulator/Oscilloscope



Aligning the Foster-Seeley discriminator.



Trace in alignment of the secondary of the discriminator transformer.

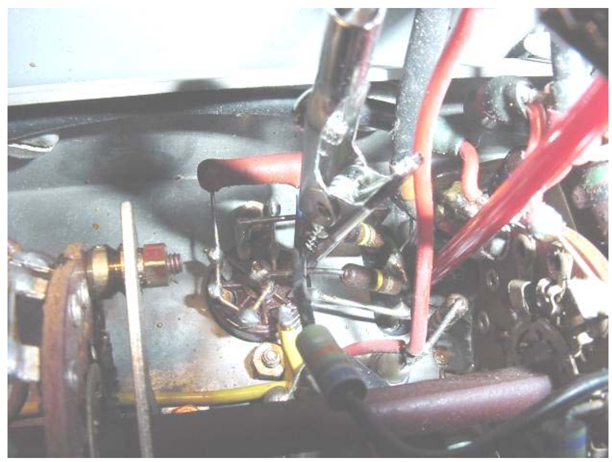
For those folks that have access to a wobbulator and oscilloscope, the method of alignining a Foster-Seeley discriminator using these tools is provided below.

The set-up is shown in the diagram to the left: connect the signal (5.2MHz IF for an S.770R or S.770/U receiver) lead from the wobbulator to the input of the limiter stage (or earlier in the IF strip) and the vertical-input of the scope across the AF output of the discriminator. The horizontal input of the scope is connected to the sweep trigger of the wobbulator. Adjust the discriminator secondary winding core until a trace as shown in

(A) in the figure, left, is seen. Then adjust the primary winding core to peak the amplitude. Re-tweak both cores for best symmetry of the curve: the centre slant (diagonal) of the trace should be straight and the upper and lower peaks should be the same shape and equal in height. The wobbulator centre-frequency marker should then be switched in and a check made that the marker appears in the centre of the trace as shown in (B) – if it does not, readjust the cores until it does and then re-peak as necessary to obtain the best amplitude and symmetry. See traces in Postscript 3.

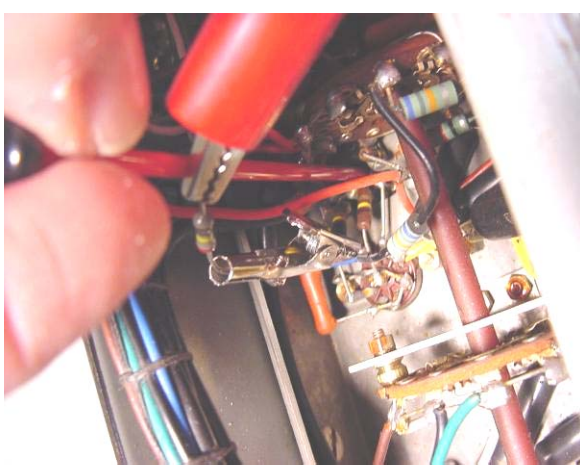
Postscript 2: Discriminator Alignment in an S.770R MkI using the Meter Method

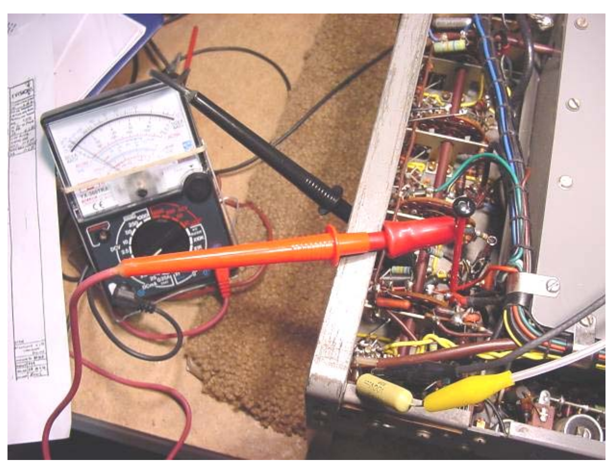
Left: my S.770/R on the workbench getting ready for re-alignment of its discriminator. All you really need is a sensitive multimetre, a series resistor, a signal genny… and the instructions from the manual (see excerpt in the main text above).



Right: connecting a multimeter set to 50uA range to the discriminator output as per the instructions in the S.770/R manual, with the 100k ohm series resistor held between two croc clips (below).

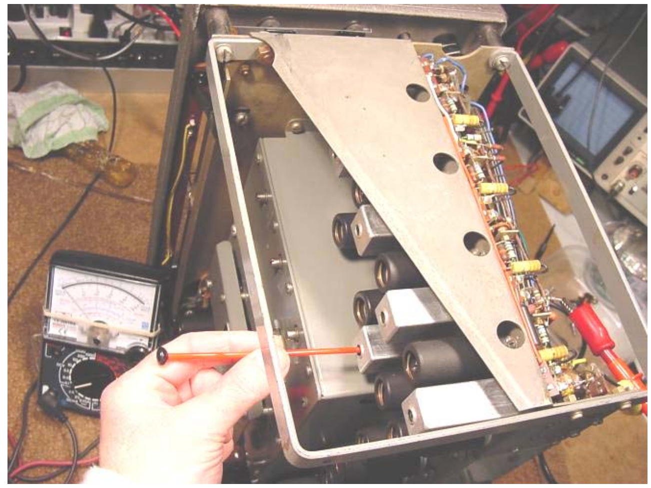
Below: tweaking the primary (lower) core of the discriminator transformer for maximum output.





Right: tweaking the secondary (upper) core of the discriminator transformer for zero meter reading. Note the plastic knitting needle tool…

Repeat the process once or twice and your done.



Postscript 3: Aligning a Foster-Seeley Discriminator Using an Eddystone Panoramic Display Unit

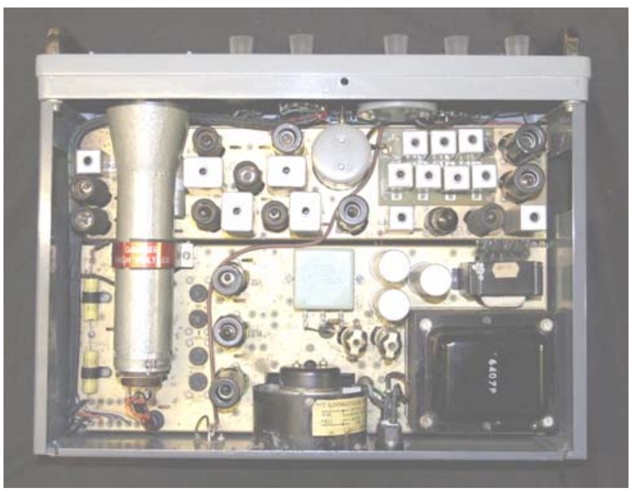
Eddystone manufactured a range of panoramic display units (PDU's) – basically dedicated oscilloscopes intended to be used with the more professional range of Eddystone receivers. The main purpose of these units was to examine the range of signals present within the bandwidth of the set's IF and thus be able to provide a visual indication of sideband content. These units are described briefly in the EUG Ultimate Quick Reference Guide (p53) and the manuals for them can be downloaded from the EUG website.

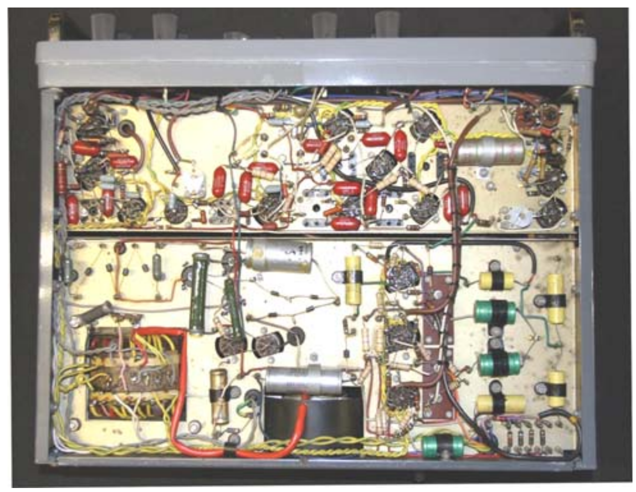
Mike Cassidy, a fellow EUG'er, has an S.770/U MkII that he has been restoring. Mike noted some time ago that he had a couple of PDU's in his possession. During some recent correspondance, Mike noted that he was thinking of using his EP17R PDU to align the Foster-Seeley discriminator in his set, as the manual describes how this can be done (the PDU effectively acting as a wobbulator/ oscilloscope combo). This seemed like a good subject to include in this 'Short', and a brief summary of Mike's efforts is provided below.

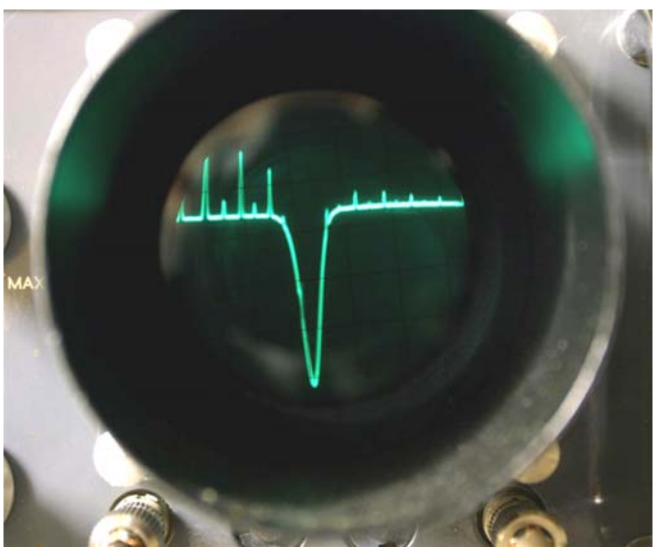
An excerpt from the EP17R manual is provided at the end of this article that describes the discriminator alignment procedure in detail. The photos are courtesy of Mike Cassidy.

The EPR26 'Panoramic Receiver' – an S.770/R or S.770/U receiver combined with an EP17R PDU

Above left: Mike Cassidy at work on aligning his S.770/U MkII - the EP17R (top right in the photo) is being used - below it is an EP20R. Note some of Mike’s other MkII style Eddystone collection in the background – here an EA12 and an S.770/R. Above right: The two PDU’s and attenuator. Below left: above-chassis view of the EP17R. Below left: under-chassis view (both very distinctly Eddystone).

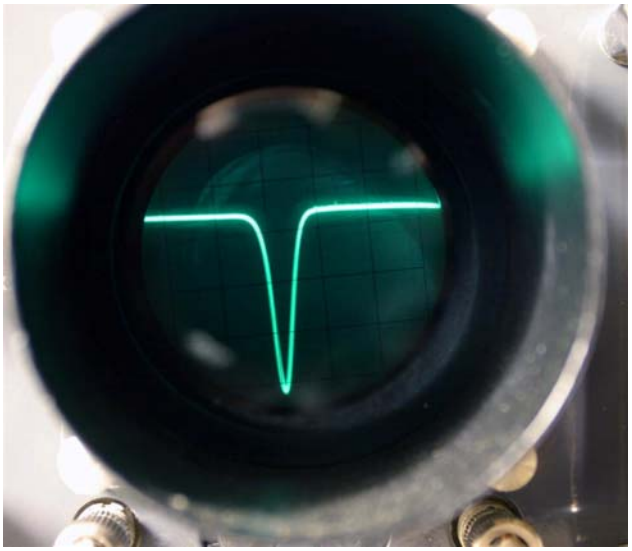






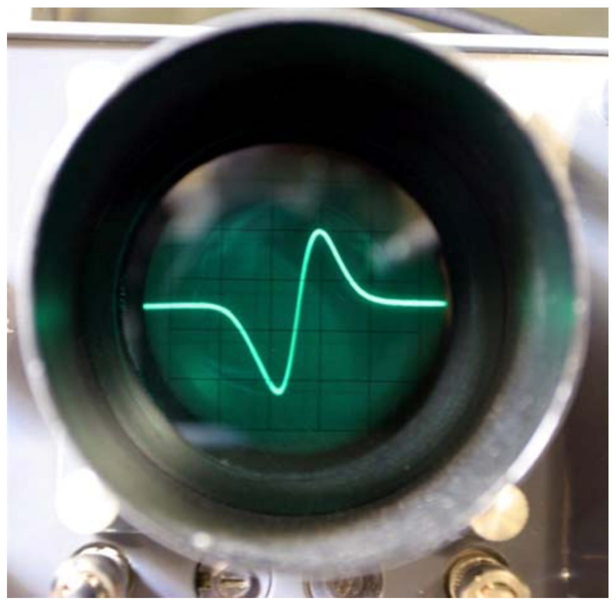
Mike reports that he had some set-up difficulties, never having used the PDU’s before (and unsure if they were actually working correctly) and at the time of writing this article it was still a bit of a ‘work-in-progress’ – good fun though and likley the first article on the use of an Eddystone PDU on the web!

Left: (inverted) IF response curve with 100kHz marker pips superimposed. These are generated internally by the EP17R circuitry as a calibration aid.

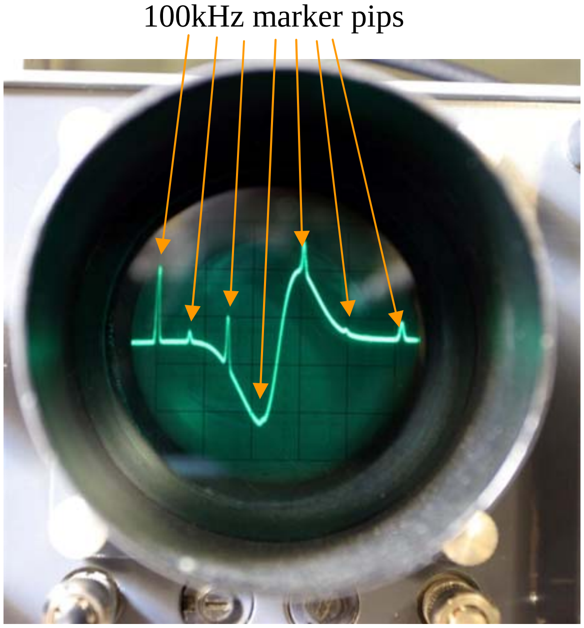


Left: IF response curve without the 100kHz marker pips.

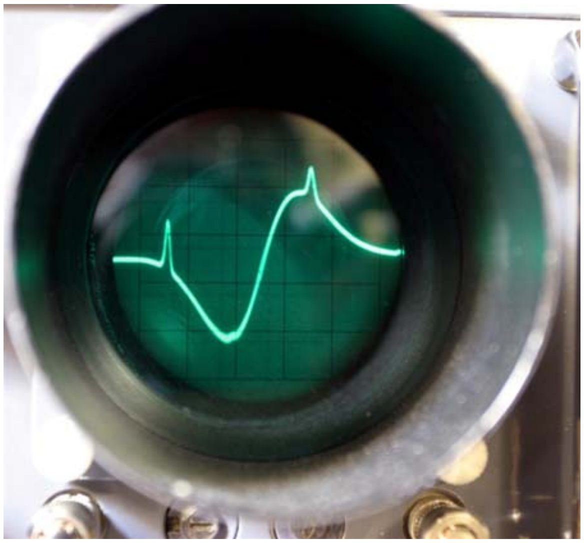
Right: discriminator response to the EP17R swept 5.2MHz signal showing good alignment – note the symmetry of the trace (equal amplitude peaks of the same shape and nice straight diagonal in between). Compare with the diagrams on page 10



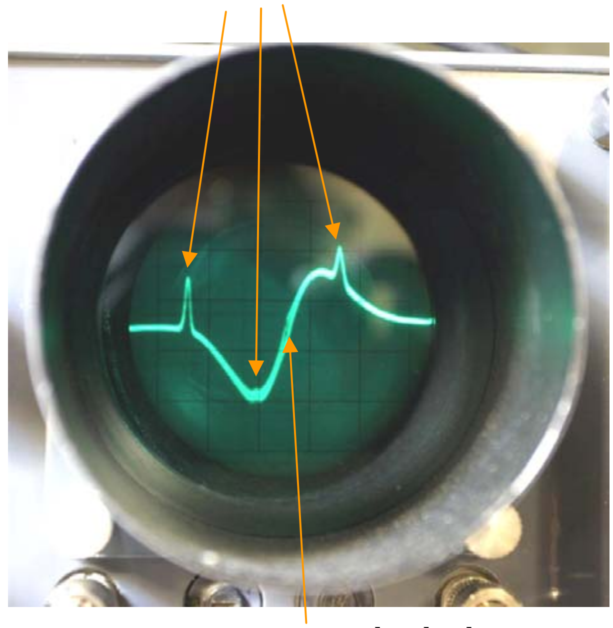
100kHz marker pips



Left: same trace as above with 100kHz marker pips superimposed. This indicates that the linear portion of the response curve (the diagonal) is around the desired ~100kHz or so width

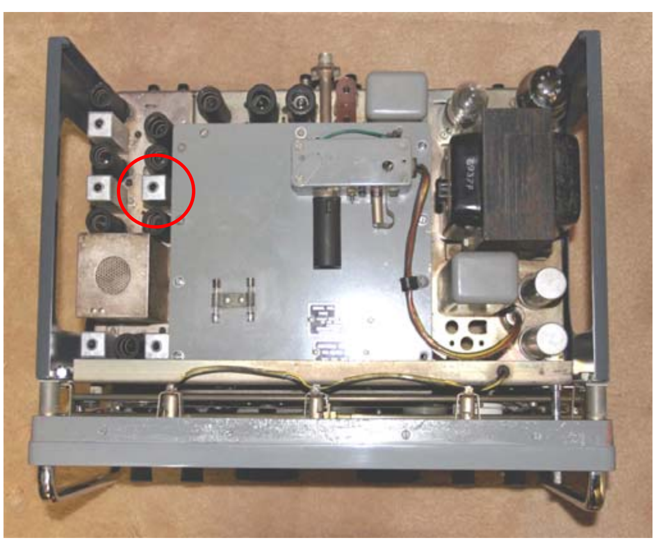


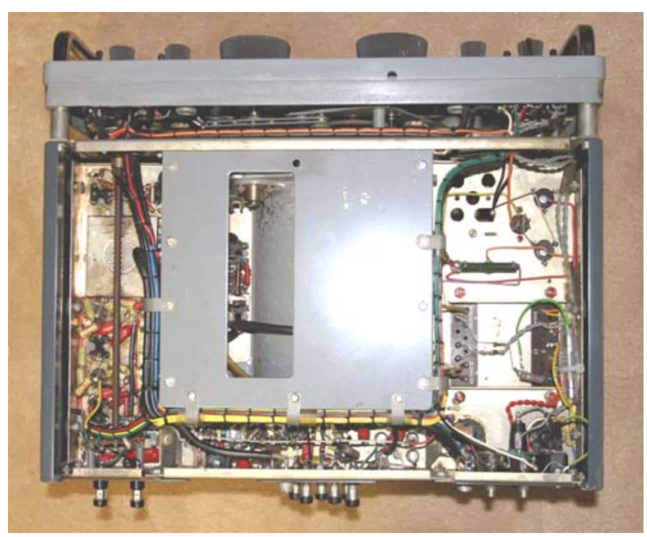
Left: same trace with 100kHz marker pips superimposed, but with the trace focused on the 'S' portion of the curve (about 175kHz sweep)



Right: same trace as above but with a 5.2 MHz (centre IF frequency) marker hash from an external signal generator superimposed. This appears (correctly) at the centre of the diagonal portion of the trace, although this cannot be easily discerned on the photo. Feeding this signal in reduced the trace height and also appeared to modulate it (giving an out-of-focus look to the display)

Below left: above-chassis view of Mike's S.770/U MkII (discriminator transformer circled red). Below right: under-chassis view





USE OF THE EP17R AS A WOBBULATOR

General.

The EP17R can be used for direct visual alignment of amplifiers operating in the following frequency bands:-

OSC FREQ switch to position '1'.		OSC FREQ switch to position '2'.	
5.42 - 6.42 Mc/s.	(x1)	4.8 - 5.6 Mc/s.	(x1)
10.84 - 12.84 Mc/s.	(x2)	9.6 - 11.2 Mc/s.	(x2)
16.26 - 19.26 Mc/s.	(x3)	14.4 - 16.8 Mc/s.	(x3)

These figures are quoted on the basis of a fundamental sweep width of one megacycle about a fixed centre frequency. Greater coverage can be obtained by using the CENTRE FREQUENCY TRIMMER to shift the nominal centre frequency. The exact limits of the actual ranges will vary slightly from unit to unit since they are dependent on the final setting of the CENTRE FREQUENCY TRIMMER obtained during initial alignment.

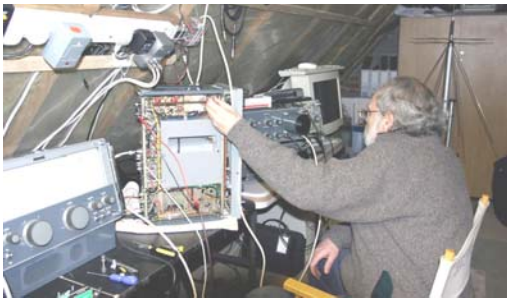
Greatest flexibility in operation will occur when the alignment frequency falls in the centre of the sweep range since this allows greater freedom in use of the WIDTH control for widening the signal display. Standard IF's of 5.2 Mc/s and 10.7 Mc/s lie in the middle of the appropriate ranges and are therefore convenient in this respect.

Alignment of IF amplifiers on frequencies which lie outside the ranges given above can be carried out provided the receivers in which they are used are capable of being tuned to one or other of the sweep ranges available.

Visual Alignment of 770R IF Stages and Discriminator.

1. Check that all IF circuits are peaked accurately to 5.2 Mc/s by carrying out normal alignment procedure using a modulated signal generator and audio output meter. The generator should be checked against a reliable frequency standard and all equipment allowed half an hour for 'warm-up' before commencing alignment. (Use 'CW' position of MODE switch as detailed in the Manual supplied with the receiver).
2. Connect the OSC OUT socket on the front of the EP17R to the IF OUT socket on the receiver using a short length of coaxial cable terminated at each end with a Belling Lee Type L.734 coaxial plug. Arrange some form of control over the level of oscillator output as described previously.
3. Connect a screened lead or coaxial cable terminated at one end with an L.734 plug to the 'Y' AMP INPUT socket on the EP17R unit. Connect the screen at the other end to the left-hand terminal of the pair of terminals labelled 'AF INPUT' at the rear of the receiver. Connect the inner of the screened lead to the right-hand terminal through a 0.1MΩ resistor. The left-hand terminal is directly earthed within the receiver and the other is connected to the AM Detector load resistor.
4. Set the receiver controls as follows:-
   - (a) Place the MODE switch in the 'CW' position to disable the AGC circuit.
   - (b) Set the IF GAIN to maximum and the AF GAIN to minimum.
   - (c) Switch off the N/L and MUTING.
   - (d) Put the STANDBY switch to 'ON' (i.e. dolly down).
5. Set the EP17R controls as follows:-
   - (a) Move the OSC FREQ switch to position '2'.

Mike tweaks it here and he tweak it there, but… I see no tea in sight!



(b) Set the TIMEBASE FREQ to 5 c/s.

(c) Move the CENTRE FREQUENCY control to its mid-travel position.

6. Adjust the CENTRE FREQUENCY TRIMMER and WIDTH control to give a sweep of the order 200 kc/s with the response at 5.2 Mc/s centred in the middle of the tube.

7. Adjust the level of oscillator drive to the IF OUT socket on the receiver to give a suitable display.

8. Examine closely the response on the face of the c.r.t. , checking carefully the overall symmetry. The oscillator drive can be increased and the WIDTH setting altered to allow inspection of the skirt response below 20dB down. Any re-alignment which may be required should if possible be restricted to T3, T4 and T5. It should be noted that the re-adjustment required will be very small indeed and should be distributed evenly between the three transformers mentioned rather than by attempting to obtain complete correction by adjusting one circuit alone.

9. Transfer the 'Y' AMP INPUT lead to the junction of R47 and R48, retaining the 0.1MΩ series resistor as before.

10. Adjust the 'Y' SHIFT on the EP17R to position the trace mid-way up the screen so that both peaks of the Discriminator characteristic can be seen clearly. Adjust the level of oscillator drive and the WIDTH setting as required to give a suitable display.

11. First observe the centering of the characteristic by feeding in a marker signal on 5.2 Mc/s. If the response lies off-centre a correction can be made by adjustment of the top (secondary) core of T6. Any tendency towards non-linearity can be eliminated with the primary core and each adjustment should be repeated as necessary until a symmetrical response is obtained.

Visual Alignment of the 770U 5.2 Mc/s IF Stages and Discriminator.

The procedure to be adopted when aligning the 5.2 Mc/s Amplifiers and the Discriminator of a 770U (Mk.II) receiver is as follows:-

1. Check that the appropriate IF circuits are peaked accurately to 5.2 Mc/s by carrying out normal alignment procedure using a modulated signal generator and audio output meter. The generator should be checked against a reliable frequency standard and all equipment should be allowed half an hour for 'warm-up' before commencing alignment. Reference should be made to the Manual supplied with the receiver for details of connections, control settings etc.

2. Connect the OSC OUT socket on the front of the EP17R to the IF(2) socket on the receiver using a short length of coaxial cable terminated at each end with a Belling Lee Type L.734 coaxial plug. Arrange some form of control over the level of oscillator output as described previously.

3. Connect a screened lead or coaxial cable terminated at one end with an L.734 Plug to the 'Y' AMP INPUT socket on the EP17R unit. Connect the screen at the other end to the left-hand terminal of the pair of terminals labelled 'AF INPUT' at the rear of the receiver. Connect the inner of the screened lead to the right-hand terminal through a 0.1MΩ resistor. The left-hand terminal is directly earthed within the receiver and the other is connected to the AM Detector load resistor.

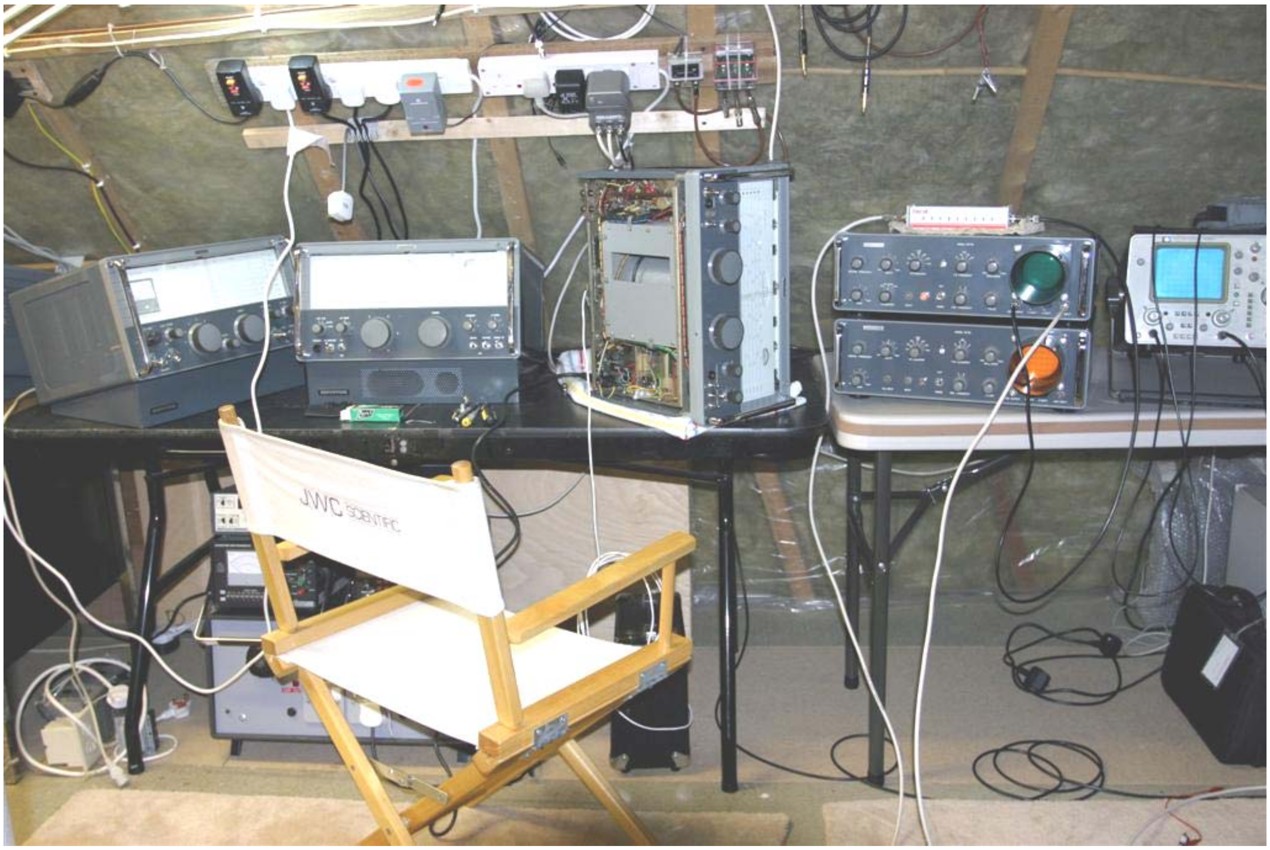
4. Set the receiver controls as follows:-

(a) Place the MODE switch in the 'AM' position.

(b) Set the IF GAIN to maximum and the AF GAIN to minimum.

(c) Switch off the N/L, MUTING and AGC. (d) Put the STANDBY switch to 'ON'.

5. Set the EP17R controls as follows:-
   (a) Move the OSC FREQ switch to position '2'.
   (b) Set the TIMEBASE FREQ to 5 c/s.
   (c) Move the CENTRE FREQUENCY control to its mid-travel position.
6. Adjust the CENTRE FREQUENCY TRIMMER and WIDTH control to give a sweep of the order 200 kc/s with the 5.2 Mc/s signal response centred in the middle of the tube.
7. Adjust the level of oscillator drive to the IF(2) socket on the receiver to give a suitable display.
8. Examine closely the response on the face of the c.r.t., checking carefully the overall symmetry. The oscillator drive can be increased and the WIDTH setting altered to allow inspection of the skirt response below 20dB down. Any re-alignment which may be required should if possible be restricted to T8 and T9.
9. Transfer the 'Y' AMP INPUT lead to the junction of R45 and R47 (retain the $0.1M\Omega$ series resistor) and proceed with alignment of the Discriminator by following the Instructions in paras 10 and 11 under 'Visual Alignment of 770R'. The Discriminator transformer is T10 in the case of the 770U.



I guess he snuck out for a cuppa while we weren't looking… oh well, many thanks Mike!