‘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.

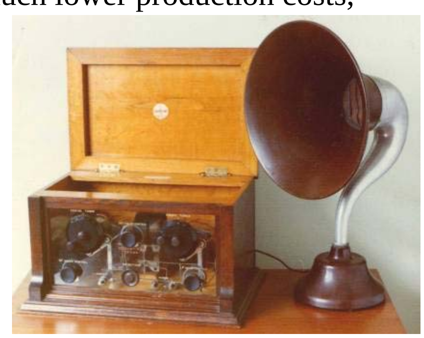
Radio Receiver Fault Finding

Introduction

Much has been written on the subject of radio receiver fault finding – I own a small personal library on the subject – so heaven knows how much has actually been written on it over the years: even today, with the renewed interest in ‘antique’ radios, newly-written books on valve radio servicing, repair and restoration occasionally appear, reprints of ‘classic’ texts are produced and there are new posts on the web each day. Many useful articles appeared within the pages of ‘Lighthouse’ over the years, such as those by Graeme Wormald (eg. ‘*Duffers’ Guide To Valve Set Fault Finding’*), Peter Lankshear (eg. ‘*Electronic Repairs To Eddystone Receivers’*), Ted Moore (many, many tidbits, tips and tricks), Tor Marthinsen and several other authors and contributors. This article is my attempt at distilling all this down into a fairly succinct and logical approach to fault finding in radios, based on my own experiences over the years, plus some sage advice garnered from various referenced texts, illustrated by some Eddystone and non-Eddystone examples. I have assumed a basic level of understanding of how a valve radio works, how it should perform, how to operate it and what its components and controls do (or should do) – if not, the reader should first read an introduction to these subjects, eg. the receiver sections of pre-1970 RSGB and ARRL handbooks and Graeme’s ‘*Duffers’ Guide*’.

I would note that ‘fault finding’ is a sub-set of ‘repairing’: fault finding is limited to the electronics of the set and, maybe the closely associated mechanical mechanisms (eg. tuning or band changing), whereas repairing could extend to woodwork/re-finishing and metal cabinet repairs, and that both these are subsets of 'restoring'. It is one thing to find a fault, yet another to undertake a satisfactory repair, but *restoration* implies that the set being worked on is in a delapidated condition and it is desired to bring not only the electrical performance of the set up to par, but also its physical condition. However, restoration does not necessarily mean restoring the set back to *original* condition – at least not in my book – but to a condition that the owner finds acceptable, ie. a balance of level of effort, cost and desired result. In this article I concentrate primarily on the electronic fault finding component, and separate Tech Short articles deal with actually effecting the repairs and restoration techniques and tips.

Finding electronic faults in radios, in particular valve radios, is not 'rocket science': it is a mixture of the application of technical knowledge, logical problem solving/deduction and experience. I cut my teeth on the subject at a time when I was very eager to learn (I took radio books to bed), soaked up information like a sponge, had mentors close at hand and was able to work on valve, hybrid and solid state equipment, both domestic and amateur. The basic techniques of fault-finding and repairing were, by necessity, developed very soon after the first radio sets were produced – this was seen as a 'boom' area for technically-inclined individuals to make a respectable living from the late-1920's through to at least the 1960's. Soon after this, domestic electronic equipment started to become 'disposable', ie. when the economic reality tended towards replacing a piece of equipment in its entirety rather than to attempt a repair: a condition that came about because of significantly reduced cost of new equipment, usually originating in the far east with much lower production costs, increasing labour costs in the west (eg. UK, Canada and US), changing expectations of 'consumers' (the instant gratification, 'I want it now' syndrome), as well as the increasing complexity of the circuitry, prevalence of integrated circuits, the digital revolution, non-availability of spare parts, poor physical circuit design and flimsiness of construction (ie. not intended for servicing). So much for sustainability… oh, well, enough of my ranting.



Before You Start…

Remember - Safety is paramount: valve radios contain lethal voltages and must at all times be treated with respect and caution. Therefore always double-check whether power is being applied to the set, on any temporary connections made for testing purposes, and never hold on to/touch the receiver chassis with one hand when probing around with the other (put your 'spare' hand in your pocket). Even after power is removed, electrolytic capacitors can hold a charge for long periods that can shock you when your guard is down. Safety is paramount.

Basic Fault finding Techniques

So what are the basic fault finding techniques? and are some better than others? – the short answer is that a combination of techniques is usually the best approach to most fault finding in electronic circuits. The basic techniques are:

- Hunches
- Educated guesses
- Diagnostic methods, including:
  - Voltage measurements
  - Current measurements
  - Resistance measurements
  - Signal tracing

Sidney has a hunch about an S.940…

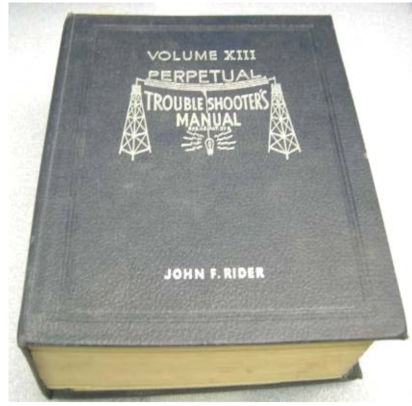
Hunches and educated guesses can actually work very well for experienced service technicians: they have seen the same set in their workshop many times with similar 'symptoms' and recall what was wrong, or apply knowledge of one set type to similar symptoms exhibited by another. This level of experience can pay dividends in terms of saving time in a commercial repair business ('Johnnies World', where 8 to 10 successful service calls were made each day). The average amateur set repairer, however, will only work on a radio once every few weeks or even much less frequently, and such a 'second-nature' or 'sixth-sense' is not formed. Also, the time element is probably not such a pressing issue (and the frustration of making non-educated guesses and bad hunches is depressing – so don't go there!): diagnostic techniques are really the only way for most mere mortals to go.

Homework

Like most processes of investigation, the more general background knowledge you can acquire the better. However, once you have a set to repair, it is time to 'get specific': try your best to obtain at least the circuit diagram for the set, preferably a manual, with alignment instructions and published specifications – this information is invaluable in assisting in understanding how the radio should work. Sources of such information are many (see Reference section at the end of this article), and include:

- '*Radio and Television Servicing'* manuals (Malloy & Poole) – useful for post-war UK domestic sets (including Eddystones): single volumes and full sets of these are often sold on EBay and extracts dealing with Eddystones can be downloaded from the EUG web site

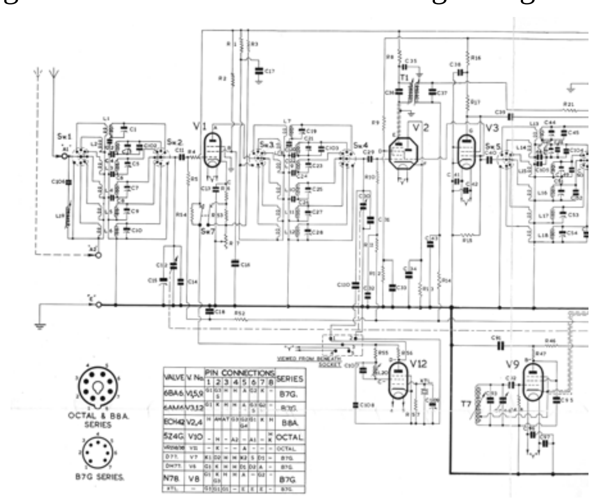
- Riders '*Perpetual Troubleshooters*' – for US Domestic Sets
- Beitman '*Most Often Needed Circuit Diagrams and Servicing Information*' series – for US Domestic Sets
- Marconi Service Manuals – for US and Canadian Domestic Sets
- RCA Service Manuals – for US and Canadian Domestic Sets
- Radio College of Canada publications – for Canadian Domestic Sets



- Canadian Radio Circuits Database Vol. 1 and 2 – CD ROMs (Whirlwind software)
- Just Radios (http://wwwjustradios.com) for Canadian, US and some UK domestic sets (also stock a supply of components, in particular good quality capacitors at reasonable prices)
- Mauritron Technical Services (http://www.mauritron.co.uk) for a huge selection of UK, US and European sets
- Boatanchor Manual Archive website (http://bama.edebris.com/manuals/) – free downloads of a wide variety of UK and US circuits for communications receivers

Many of the above can be sourced on CD ROMs or as original paper volumes on EBay, see Reference section of this article for more details.

Once obtained, spend some time studying the circuit diagram, carefully 'thinking it through' as to how the set works – especially with more complex sets, reading any circuit description (some Eddystone manuals do a good job of this, eg. S.830 series, others do not) and any alignment information provided. If a 'voltage table' is included, use a pencil to jot these directly onto the appropriate points on the circuit diagram – this saves time when doing voltage checks later. The IF frequency(s) should be specified in the manual, as should the various recommended 'spot' frequencies on which alignment is carried out for that particular set.



If the set's manual and/or the circuit cannot be obtained from any source, then the 'last resort' is to either 'trace' the circuit, ie. based on your background knowledge of radio circuitry and component types and layout, identify the main circuit elements and then painstakingly draw-out the circuit by identifying components and the connections between them – a form of 'reverse engineering'. My first experience of undertaking an exercise in 'circuit tracing' was in my youth with a '19-Set', donated to me by my uncle George – this was a military HF/VHF transceiver used in tanks and other army vehicles in WWII. It was an interesting, if a bit frustrating, intellectual experience that I have repeated many times since then (though not on 19-Sets, for which I eventually tracked down a manual and circuit – albeit some time after I had the set working): my nose was poked for so long into that set that I can still smell the fusty old wax-coated wiring when I think about it. My last such exercise was on my Supreme signal genny: quite a bit easier than the 19-Set, but hey, I am not 15 any more. If you are faced with this somewhat daunting exercise – use logic and the following process – with a bit of practice it can actually be a bit of 'fun' for the more masochistically inclined, with a smug smile appearing once you have 'sussed it':

Identify the main circuit stages and layout of circuit elements in:

- RF stages: eg. tuning gang, bandswitch and small RF transformers
- IF stages: eg. IF transformer cans, selectivity/crystal phasing controls
- AF stages: eg. AF gain control, output transformer
- Power Supply: eg. mains transformer, choke, smoothing capacitors in cans
- The valves associated with each of these stages can be identified by their type and/or by tracing the wiring back to the valve sockets. If the valves are still present, and assuming they are in their correct sockets (in sets of uncertain provenance they may not be, as the former owner has perhaps tried swapping them around to try to get the set working…), identify the socket connections using valve information from one of the resources noted in the 'Valve Lore' Tech Short an/or by using your knowledge of basic circuit principles, eg:
    - the output transformer primary winding will be connected to the output valve(s) anode, its secondary winding(s) to the speaker connections/headphones socket;
    - the AF gain control will be connected between the detector(s) and the first AF stage;
    - the IF transformers will be connected between the mixer/IF amplifier anodes and grid of the following stage;
    - cathode resistors will generally have relatively low values (75 - 500 ohm) and connected to ground, usually bypassed with a capacitor. RF/IF gain controls will usually connect into the cathode circuits of RF and/or IF stages;
    - screen resistors are generally 47k – 270k ohms, connected to an HT line at one end and the other end usually decoupled to ground with a capacitor (0.01 to 0.1uf);
    - AGC is applied via high-value resistors (250k – 500k ohms) onto the grids of the RF and/or IF stage valves (sometimes also to the mixer stage);

- Note that Eddystone sets have a wiring colour code that is really useful:

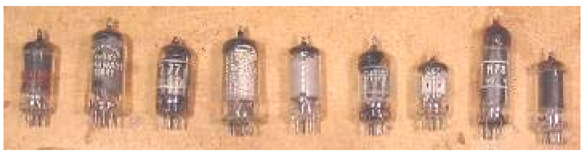
AC Mains	Grey
HT	Red
Anodes	Light Blue
Grids	Green
AGC	Pink
Heaters	Yellow
Negative to Chassis	Brown
Chassis Potential	Black
Other	White

Tips for successful circuit tracing: drink plenty of tea, do not drink plenty of alcohol (no matter how tempting when things are not making sense), use plenty of light, including a small flashlight and dentist's inspection mirror to access awkward spaces, use graph paper and a pencil to draw out the circuit, do not get distracted, eg. by keeping an eye on the TV or talking to a friend and, above all, be patient (and drink more tea). Your first attempt may look a bit like a spider's web, but it can be re-drawn later in a neater and more logical layout once the circuit is understood. Interestingly, undertaking this level of inspection of a set can often identify fault, or potential fault, issues such as dry joints, shorts/open circuits, frayed connections, dirty switches, poor insulation, roasted resistors, leaky capacitors etc. that would otherwise go un-noticed and can thus pay dividends. Also by the time you are finished you will certainly be familiar with the circuit!

The next piece of 'homework' is to assemble the necessary tools and test equipment to undertake the actual fault-finding and repairs (see Tech Short on Test Equipment for tips on what is/is not needed). For the purposes of this article I have assumed that at least the minimum of 'practical' level of test equipment is available, including a good-quality multimeter, a service quality RF/AF genny(s) and a VTVM. The use of an oscilloscope in radio fault finding is covered by a separate Tech Short.

Hand tools are really a matter of personal preference – we all have our favourites (or leftovers), but the minimum should include a set of screwdrivers of varying sizes/lengths and tip styles, at least one with an insulated shaft to avoid shorting (this can be added to any by applying heat-shrink insulation), a good set of wire snips (don't skimp here), a couple of pairs of pliers (one pair of 'needle-nose' type), tweezers, a 35w soldering iron (or similar, or better, one with a temperature-controlled tip) plus a high-wattage solder 'gun', a set of alignment tools (see the Tech Short on receiver alignment for these), a de-soldering tool, a selection of different coloured wires with insulated 'croc' clips on either end, etc.

It is also useful to have a small selection of spare 'generic' passive components available, not necessarily so that they can be used to effect the actual repair, but as temporary substitutes during the fault finding process. Start off with the following: a high-voltage, high(ish)-value electrolytic, say 16uf @ 500vw, a low-voltage, high(ish)-value electrolytic, say 50uf @ 50vw, one of each of 0.1uf, 0.05uf, 0.01uf, 0.005uf, 0.001uf, 500pf, 50pf, 5pf capacitors (or similar values, all at 630vw), 100 ohm and 500 ohm, 10w resistors, a selection of 1w resistors from 10 ohm through 750kohm, selection of 0.5w resistors from 1mohm to 20mohm. Regarding valves, it would be uneconomic to retain a spare for every possible receiver that could end up on your workbench, however, if you have a limited range of interest, eg. only post WWII Eddystones, then it is possible to keep a dozen or so of the more common ones in stock (eg. I would suggest one each of a 12AU7, 6AT6, 6BA6, 5Z4G, 6AJ8, 6AQ5, 6AK5, 6BE6, 6C4, 6AL5, VR150, 6AM5 and



6ES8 for later models, and a set of the 'U' series if you have an AC/DC receiver: see the Tech Short on Valve Lore for further discussion). I would also suggest keeping a few 1N4007 rectifiers and maybe an OA91 or GEX34 signal diode in the spares box. I have over 20 valve radios in my collection (alas, not all Eddystones by any means) and I certainly do not have a full set of spare valves for each one – however, I did invest in a valve tester to assist in identifying faulty valves, and I know that I can source and receive a replacement valve within a week or so if needed, either from local sources, web stores or on EBay.

First Things First - Safety Checks

<u>Valve radios contain voltages that can shock, hurt and kill: always treat them with due respect and caution.</u>

When you have a valve receiver on your bench, always give it a check-over for safety-related issues, especially if the set is new to you. Such checks, <u>made with the set unplugged from the mains</u>, should include:

- Mains lead and plug: check for poor/decayed or damaged insulation, frayed or loose wires, correct wires connected to each pin, etc;
- Fuses: check that the correct amperage fuse(s) and type (slow or fast blow) is installed in the plug (if applicable), or in fuseholder(s) in the set;
- With the cabinet removed, take a look under the chassis and trace the route of the mains wires. If the cable enters via a plug/socket arrangement, check that the insulating is ok and that no shorts or frayed wires exist. If it is an Eddystone set, make sure you are happy with the safety standard of the 'kettle plug' connector, if fitted – if you are not sure, remove it and replace it with a modern 'Euro-connector' type (see the sidebar in my S.830/4 restoration article for details of

how to do this). If the cable enters the set via a rubber grommet, make sure that this is in good, supple condition – if not, replace it;

- Check the cable-anchoring system: if this comprises a knot in the wire, make sure that the cable is in good condition around the knot (consider replacing the knot method with a proper cable anchor, or even a plastic cable tie, tightened around the cable – cheap, simple and it works well);
- Trace the mains leads to the on/off switch and/or fuseholder(s), making sure that the connections to the switch are good and no loose/frayed wires or shorts exist. With an ohmmeter connected to the live and neutral pins of the mains plug, check operation of the on/off switch by observing the response on the meter when the switch is operated;
- With the ohmmeter connected between the ground pin of the mains plug, check the resistance between it and the live and neutral pins (mains switch in the 'off' position): in sets with a double-pole mains switch, there should not be any continuity measured. In sets with a single pole mains switch, depending on the radios specific circuit, continuity may be present between neutral and the ground pin, but not between live and ground (**Note: some sets would not be considered 'safe' by present-day standards, even when working perfectly as designed, so be wary of this and take adequate precautions**). AC/DC sets should be considered a 'special case' and I would recommend reading the Tech Short on AC/DC sets for further information – if you have an isolation transformer available, use it to connect an AC/DC set to the mains supply when the case is removed from the chassis. If anomalies to the expected results exist when the circuit details are considered, perform further checks against what the circuit diagram would indicate should occur until you are certain that it is safe to apply power;
- Finally, give the underside of the chassis a 'once-over' for any obvious shorts, loose wires or components etc., and correct as necessary.

Fault Finding Methodologies

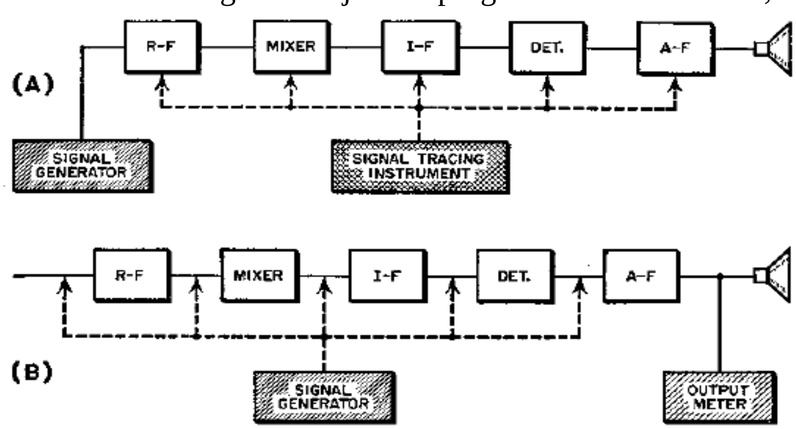
In the early days of radio there were several different schools of thought as to how to go about finding faults in radios in a logical manner. The basic methodologies developed were:

- **Symptomatic diagnosis:** a radio can be thought of a 'patient' and you are the 'physician' (general practitioner) attempting to diagnose an illness by observing symptoms and applying your knowledge and experience with the minimum of tests. Sometimes this works really well and has quick results, eg. you note that the output valve is cold when the set is switched on, so you pop in a new valve and the set springs to life. Even if things are not that straightforward (they seldom are), heeding the type of fault and how it developed, either by your own or the sets owners

observations, can help significantly in expediting identification of the fault.

- **Substitution:** simply replacing suspect faulty components with known good ones. Valve and fuse substituting is one of the easier forms of this method, although a similar philosophy can be applied to all other components, though with much more effort. It is really a very inefficient (and costly!) method if used on its own.
- **Resistance measurements using an ohmmeter:** undertaken with the set switched off - primarily checking the static condition of passive components eg. transformers, chokes, coils, resistors, solid-state diodes and metal rectifiers, switches, potentiometers and, to some extent, capacitors. Valves can only be tested for internal dead-shorts and blown heater elements using an ohmmeter. The actual operation of the receiver cannot be tested by this technique and it therefore has limited value by itself. In any case, be mindful of parallel resistance paths through the circuit, some of which may not be too obvious, as these can be very misleading unless one end of the component being tested is disconnected from the rest of the circuit.
- **Voltage measurements using a voltmeter:** undertaken with the set switched on - this technique provides some general indication of whether circuits are operating in accordance with their design, but it is only the DC conditions that are normally being tested by this technique, which is therefore of limited use by itself. Some manufacturers, eg, Eddystone, helpfully provide a table of typical voltage values taken at key points in the circuit – be careful to use the correct sensitivity of voltmeter however, as failure to so can mean that the voltages you read are significantly higher or lower than those cited. Also be careful to set up the receiver exactly as described when taking such measurements, eg. this may specify RF gain fully on, AGC off, BFO on, Range 1, aerial shorted to ground etc.

- **Signal tracing:** undertaken with the set switched on - this technique is the most logical and useful either for identifying the faulty stage in a completely 'dead' set, or for isolating the faulty stage in a partly-working receiver. In this technique, a suitable signal is first 'injected' into the radio circuits, working backwards from the AF stages towards the first RF stage. As injection progresses in this manner, the set will eventually stop responding to the injected signal, the faulty stage thus being the one between the last one working and the first one not working.

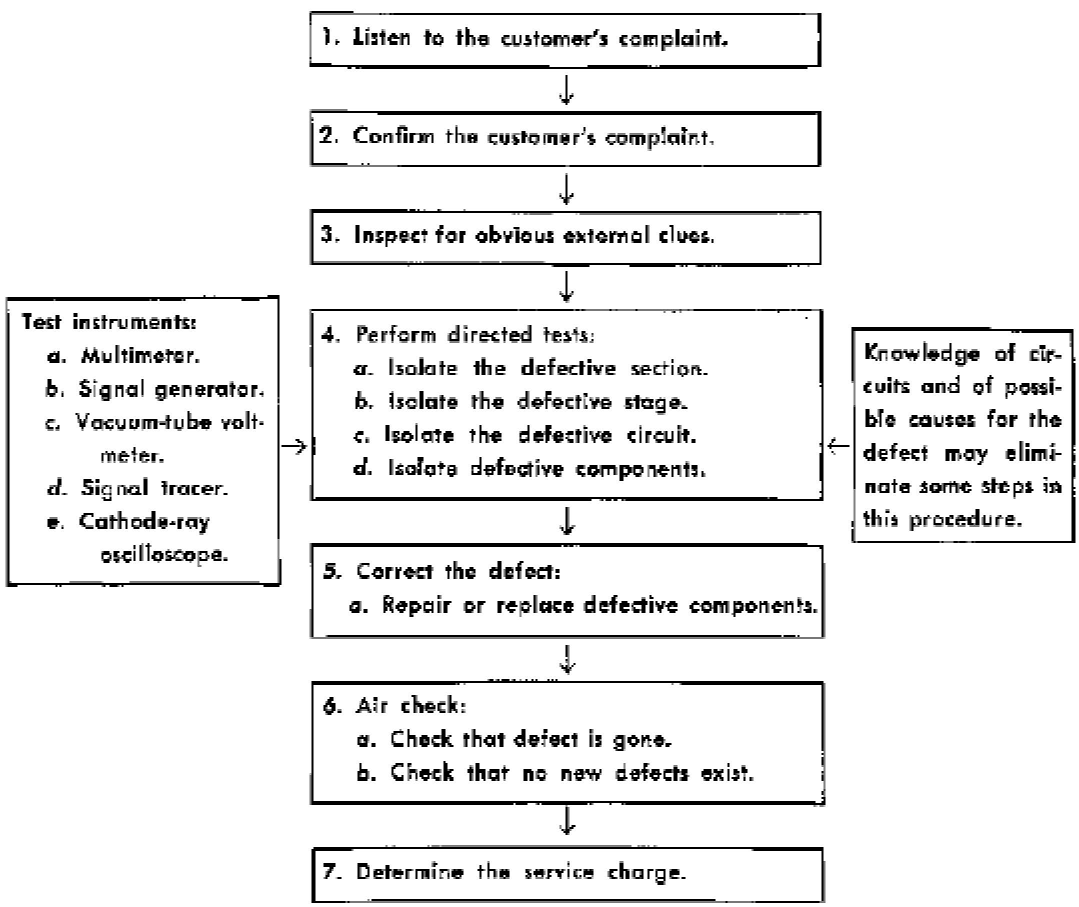


Dynamic troubleshooting analysis may be divided into signal-tracing and signal-injection methods. (A) illustrates the signal-tracing system and (B) shows the signal-injection system.

In practice, a combination of all the above techniques is the best: eg. voltage and/or resistance checks for the power supply stage, followed by signal tracing to isolate the faulty stage(s), followed by voltage and/or resistance checks to isolate the faulty component(s) in that stage. Sometimes, multiple faults may exist, especially in sets that have not been used for many years and where component ageing has become a factor – unfortunately the case in many Eddystone valve receivers, even if they have been little used over the years.

The 'professional' service procedure as used in most radio service shops is summarized in the diagram below (from '*Profitable Radio Troubleshooting'*) – with the exception of the 'customer' and 'service charge', it is just as applicable to fault finding in your own sets:

Combined Fault Finding Procedure



. Summary of the professional service procedure

The general combined fault finding procedure that I use is as follows:

1. First ascertain that the 'fault' is actually a problem with the receiver, ie. not related to the mains supply, aerial, feeder, connectors, atmospheric interference, man-made interference (at RF or mains-born), local to where/when the receiver

was being used, or even a defective or incorrect impedance speaker/open or shorted speaker connection(s);

2. Carry out the basic safety checks as described above, modifying as necessary to suit the circuit and receiver model;
3. If the set appears to be completely 'dead', refer to the appropriate 'Specific Faults' section below;
4. If the set is 'alive', ie. is operational, but has a problem, eg. hum, hiss, 'putt-putt' sounds, crackles, frequency drifting/jumping, low output, distortion, incorrect frequency displayed, go to the appropriate 'Specific Fault' section below, and if the development of the fault from onset is known, take heed of what the set owner reports/you are aware of, eg. did it develop suddenly/over time, occur only at certain times, after a period of being switched on etc?
5. If the set is apparently non-operational, but the valve heaters are glowing, then first check for appropriate mains transformer secondary AC voltages; if these are present and correct, check that a suitable HT (DC) voltage is present on the smoothing capacitors – if it is not, check that the rectifier(s), HT choke and the smoothing capacitors are ok. Once the correct LT and HT voltages to the set have been confirmed, set up your signal genny and;
6. Inject an AF signal (eg. modulation tone) into the first AF stage, usually at the AF gain control slider: if a strong signal is heard from the speaker, this would indicate that all is well from the AF gain control onwards through the audio stages, including the speaker. If no audio or only weak and/or distorted audio is heard, then there is a fault in the AF amplifier stages or the speaker. To simply test that the AF stages are working (not for distortion or poor frequency response), try placing a finger on the slider with the AF gain control turned fully up – a loud hum or buzz should be heard from the speaker if the AF stages are functioning (though not necessarily correctly). Check the speaker on a known good set;
7. If no response or only a faint and/or distorted response is heard and the speaker checks out ok, then a fault most likely exists in the AF stages: refer to the 'Specific Faults' section below;
8. Next check that the IF stages are working ok. Short out the LO section of the tuning gang capacitor to stop the LO working (use a short wire with croc clips on either end) and connect the RF signal genny (internal AF modulation on at ~30%) to the anode of the mixer valve via a 0.1uf capacitor, or as specified in the set manual. With the AF and IF (if fitted) gains turned fully up, swing the signal genny slowly through the specified IF frequency for the receiver. If the set is dual conversion, start with the second IF frequency and the second mixer stage – once this is confirmed working by hearing a response in the speaker, re-set the genny and move on to the first IF and mixer stages. A 'short cut' often used in busy service shops in days of yore was to connect the signal genny to the aerial input and inject the IF signal into the mixer or RF stage, there being enough stray coupling through these stages in many domestic radios to still leave sufficient of the injected IF signal at the input of the IF stage to confirm if those stages were working – if so, following an IF alignment check, the signal genny was then adjusted for the RF stage checks/alignment without changing the connections to the set (must have saved at least 30 seconds!). This technique has a second, and

perhaps more useful, benefit in that no temporary (minor) de-tuning of the first IF transformer occurs due to loading by the signal genny, however, in sets with high-Q RF transformers, one or more stages of RF amplification and good inter-stage screening (ie. as in many Eddystone sets), it can be difficult to push sufficient IF signal through the RF stages unless 'brute-force' signal levels are applied, which can result in undesirable non-linearities in these stages that detracts significantly from any perceived advantages;

9. If no response, or only a faint and/or distorted response is heard at this point, then a fault most likely exists in the IF or detector stages, or in AGC function: refer to the 'Specific Faults' section below;
10. In receivers with a beat frequency oscillator (BFO), its operation should be checked once the IF stages are confirmed to be working: switch off the signal genny modulation and a heterodyne beat should be heard when the BFO is switched on. If it isn't, check that the BFO valve heater is glowing and that HT is reaching the stage (a faulty BFO on/off switch can be the culprit). If these look good, check the valve by substitution, if a spare is available, and try tweaking the BFO coil. If this still does not effect a cure, check the BFO circuit passive components: refer to the 'Specific Faults' section below;
11. Next check the LO(s), in the case of double conversion sets, starting with the second LO. An easy way to check this is working is to use a second receiver, if one is available, coupling its aerial into the LO circuitry by either 'stray' coupling or by a very small capacitor (a few pf) onto the anode of the mixer or LO valve. The second receiver is then tuned across the nominal LO frequency, which should be the RF frequency being tuned, offset by the IF frequency of the set (in dual conversion sets, the second LO frequency may be above or below the first IF, offset by the value of the second IF – check the receiver manual for details). In the case of most broadcast band and shortwave sets, the LO will be running high of the dial frequency of the set, eg, for a tuned frequency of 2.65MHz on the receiver dial and for an IF of 450kHz, the LO (in a single conversion set) will be running at 3.1MHz. This is not always the case, however, and if possible check with the receiver manual. If the LO signal cannot be found where it should be, then first suspect the LO valve and try a substitute if one is available. If the LO is still not working, check the voltages in and around the LO/mixer stages – if they are outside tolerance, suspect a passive component: refer to the 'Specific Faults' section below. One method of performing a quick check on whether an oscillator is working is to check the cathode or anode current by measuring the voltage across the relevant resistor and seeing if it varies when the LO section of the tuning gang capacitor is shorted out – if it does, it is likely that the stage is oscillating. If the LO is working, but at the incorrect frequency, refer to the Tech Short on receiver alignment for the necessary procedure;
12. The final check on basic receiver operation is to check the mixer and RF stage(s) are functioning. By this time there should be some discernable noise from the speaker with the receiver gain controls turned fully on - a mixture of faint hum and hiss, and maybe a few of the stronger local broadcast stations - even if the RF stage(s) are faulty. Connect the signal genny to the signal grid of the mixer stage with a small capacitor (0.01uf or less) and tune it and the receiver to the same

frequency, away from any known strong local stations. If the genny signal cannot be heard, try tuning the receiver above and below where the signal should appear (or vice-verse). If a weak signal can be heard, then refer to 'Low Output' section below. If no signal can be discerned at all, check the mixer valve by substitution, if a spare is available. If this still does not effect a cure, check the mixer circuit passive components: refer to the 'Specific Faults' section below. If the mixer appears to be working ok, connect the signal genny to the aerial socket with a small capacitor (0.01uf or less) and tune it and the receiver to the same frequency, away from any known strong local stations. If the genny signal cannot be heard, try tuning the receiver above and below where the signal should appear (or vice-verse). If a weak signal can be heard, then refer to 'Low Output' section below. If no signal can be discerned at all check the valve(s) by substitution, if a spare is available. If this still does not effect a cure, check the RF circuit passive components: refer to the 'Specific Faults' section below.

It is interesting to note the order of frequency of component failure in valve receivers (after '*Profitable Radio Troubleshooting*') – this serves as a guide in priority of checking components in the 'Specific Faults' section below.

Items Becoming Defective	*Frequency of Defect*
Tubes	60%
Filter condensers	10%
Bypass condensers	9%
Resistors	5%
Voice coils	4%
Bad connections	3%
Volume controls	3%
Output transformers	2%
Coils	1%
Bad contacts	1%
Power transformers	1%
Others	1%

Table showing per cent of times various defects occur in radio sets

Specific Faults

Once the faulty stage has been isolated, the next step is to track down the faulty component(s). This is usually down to a dozen components or less. There are a number of specific faults that are evident by distinct 'symptoms'. These are:

Set Completely 'Dead'

Meaning no signs of 'life' at all, ie. dial lights unlit, valve heaters not glowing/heating, no noise or hum from speaker. First check the fuse(s), if present and on some Eddystone sets (eg. S.740, S.750, S.770R, S.830), check that a correctly-wired Octal/Jones plug is inserted in the appropriate socket on the rear panel of the set (this has even caught me out after a long day…). Next, check that the AC power is being fed into the set: use an AC voltmeter to check voltage on either side of the fuseholder(s), then on either side of the mains switch, then the transformer primary. If the appropriate AC voltage is not present on any of these locations, identify the cause and correct (suspects are a blown fuse, broken wire, poor/corroded connection, bad switch or corroded fuseholder).

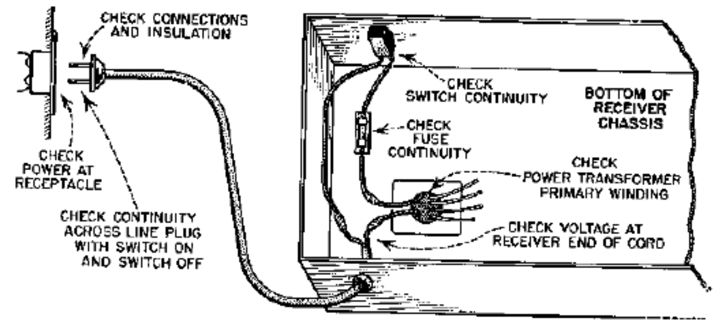


Diagram illustrating the checks which can be made for trouble in the primary a-c circuit of a receiver.

If voltage is getting to the mains transformer primary, check the AC voltages on the transformer secondary: the HT windings should be in the 250v-0-250v AC range in most Eddystone valve receivers and the LT voltages should be 6.3v AC and 5v AC (rectifier). If neither of these are present, this could be bad news, indicating that there is probably a problem in the mains transformer (likely an open circuit primary winding – very bad news). If the LT voltages only are present, the HT secondary may be open circuit and vice-verse – this is still bad news, but may be recoverable, depending on the transformer design: some Eddystone sets are fitted with an oversize mains transformer that has unused heater windings and extra

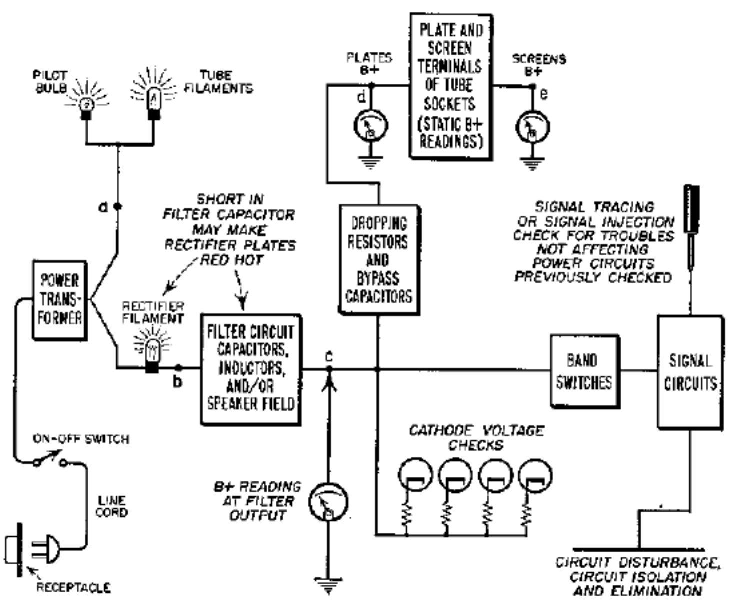
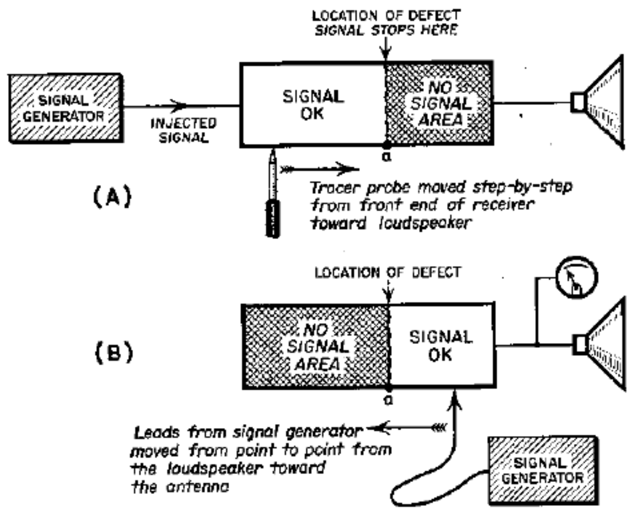


FIG. 0-2 Diagram illustrating the logical checking procedure in a dead receiver. The sequence of steps starts with the power receptacle at the lower left and proceeds toward the right as explained in the text.

taps on the HT winding. If your set has these, and they are functional, it may be possible to re-wire the transformer to get the set working, though maybe with slightly reduced HT voltage. If the LT windings are not working, and there is not a spare winding available on the transformer, a small low-voltage transformer can be purchased and fitted (6v transformers are widely available from many suppliers). Alternatively, a replacement power transformer can be sourced either from the EUG site, or from suppliers of 'antique' radio spares, eg. http://www.tubesandmore.com, or direct from manufacturers (eg. Hammond).

'Dead' Stage

In many ways this is the easiest fault condition to diagnose and repair: first check the voltages around the valve(s) in the faulty stage identified by the signal tracing methodology described above (Eddystone manuals usually have a voltage table for key nodes in the circuit, or as noted on the circuit diagram. None-Eddystone sets servicing data also frequently includes this information). However, if this information is not available for the particular set you are working on, the following table provides some 'typical' voltages for a range of circuit nodes in Eddystone AC-only supply valve receivers (note: measured voltages depend on the sensitivity of the voltmeter being used and on control settings, especially AGC and RF/IF gain settings, as well as the band selected and mode switch settings – ensure that the correct meter sensitivity and settings are used as specified in the model manual). All voltages are DC, positive with respect to chassis, unless otherwise indicated:



Comparison between the signal-tracing and signal-injection methods. (A) In the signal-tracing method, the signal is injected into the front end of the receiver, and the tracer is applied at various points, moving from the antenna circuit toward the loudspeaker, until the signal disappears. (B) For signal-injection method, the lead from the signal generator is touched to various points from the loudspeaker back toward the antenna connections until no signal is heard or indicated at the loudspeaker or loudspeaker circuit.

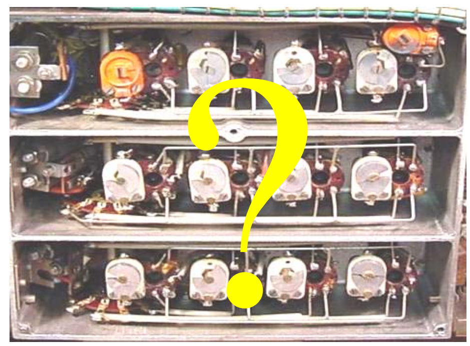
Node	Typical Voltage	Comments
Mains transformer HT secondary	250-0-250	AC
Standard HT line	250	May be higher in many non-Eddystone sets, up to 350
Stabilized HT line (eg. to LO)	150	Check type of stabilizer valve for specified voltage
AF Output stage cathode	12	

Node	**Typical Voltage**	**Comments**
AF Output stage screen	225	
AF Output stage anode	230	
First AF stage cathode	12	May change with mode setting on some sets, eg. S.830
First AF stage anode	100	50 for 12AU7
IF stage anode	230	
IF stage screen	95	
IF stage cathode	1.5	May depend on IF (or IF/RF) gain control setting – up to 45
LO anode	120	As low as 50, as high as 200
LO cathode	0	Depends on LO design
Mixer anode	200	
Mixer cathode	3	May depend on IF (or IF/RF) gain control setting
Pentode RF stage anode	230	
Pentode RF stage screen	100	
Pentode RF stage cathode	1.5	May depend on IF (or IF/RF) gain control setting – up to 45
Cascode RF stage 2nd anode	170	
Cascode RF stage 1st anode/2nd cathode	90	
Cascode RF stage 1st cathode	1.5	May depend on IF (or IF/RF) gain control setting – up to 45
BFO anode	140	
AGC bus	0 to -10v	AGC on, depends on strength of applied signal. Measure with VTVM or DVM only
Heater supply	6.3	AC
Noise limiter heater supply centre tap bias	5	Models using this circuit only, eg. S.830, S.770R
Rectifier heater supply	5.0	AC

If the voltages are within tolerance of those shown in the manual, or similar to those shown in the above table, then it is likely that the DC conditions in that stage are ok and that the valve(s) is working ok too. If the stage is the LO or 'frequency changer' (combined LO/mixer) stage, the valve may be drawing current but not oscillating - suspect the valve, as some sets can be temperamental once the valves characteristics have changed (aged) beyond a narrow tolerance range. Then suspect decoupling capacitors on the screen and cathode, followed by inter-stage coupling or tuning devices (capacitors or transformers). Transformers in LO, RF or IF stages can suffer from the dreaded 'green spot' syndrome: open circuit or high resistance winding resulting from corrosion of a connection or tap on the fine-gauge enamelled copper or Litz wire winding.

If the voltages are outside the specified tolerances, use logic and/or perseverance to locate the faulty part(s) – and also investigate and identify possible causes as to why the part became faulty, eg. a low valve screen voltage may be due to the screen resistor becoming high in value, or open circuit after failure, due to its associated decoupling capacitor failing (shorting to ground) – in this case there being no point in replacing the resistor without also changing the capacitor.

Low Output



There are many reasons why a set can have an output lower than expected or as specified – albeit this may be a subjective observation. At least in this condition a signal is being received and heard, thus providing 'something to work on' and indicative that the major components of the set are at least functional. First check the obvious: is there a decent signal being applied to the set and is a speaker of the correct (or close) impedance and sensitivity being used? - be careful of modern speakers – many are very insensitive and of a higher impedance than valve radios were designed for, eg. Eddystones generally had a 3ohm output impedance, and although an 8 ohm or 16 ohm speaker will work, the volume level will be significantly lower.

Once it has been confirmed that the low output is due to a fault condition within the set, work through the signal tracing procedure noted above, referencing the following sections as necessary. Check that the specified output level (usually a standard 50mW), as measured with an output meter across the speaker, can be attained with the specified input level to the AF, IF and RF stages. A 'weak' valve or poor alignment of the IF and/or RF stages are obvious suspects, however, before randomly trying new valves or undertaking re-alignment, I would recommend doing some fundamental checks on operation of all stages first: sets don't suddenly 'go out of alignment', but tend to do so over prolonged periods (years) unless a valve or other component has been changed in the RF stages. If the set is new to you however, a 'mad twiddler' may have 'had a go' and it is worth taking a look inside the coilbox and inspecting the IF transformers to look for any obvious signs of this activity, eg. broken seals, burred trimmer slots and broken iron dust cores. Also in such circumstances, check that the valves are in their correct sockets. If, following signal tracing and various diagnostic checks on circuit operation, eg. voltage checks, poor alignment is still suspected, refer to the receiver manual and the Tech Short on alignment to undertake this operation correctly.

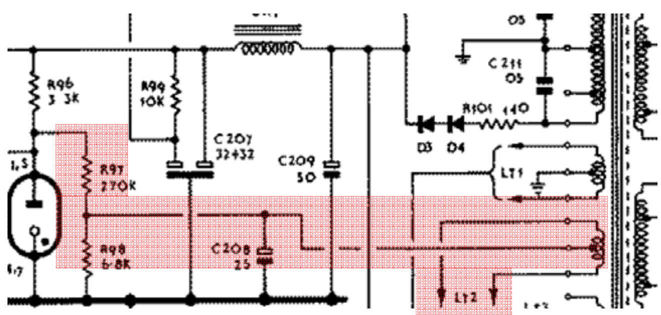
Hum

There are three forms of hum:

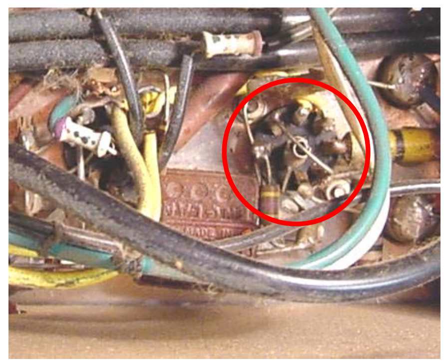
- who’s volume stays constant when the AF gain control is moved;
- who’s volume varies when the AF gain control is moved;
- which appears only when a station is being tuned in (termed ‘modulation hum’).

Constant hum is often a result of a power supply problem, most likely one or more smoothing capacitors on the HT line becoming low in value or even open circuit. Other causes of such hum, unaffected by the AF gain control, include a low value or open circuit anode bypass capacitor in the first audio stage anode circuit, or a heater to cathode short/leakage in one of the audio stage valves. Check suspect smoothing or decoupling capacitors by placing a suitable substitute in parallel with the original components (use a couple of wires with insulated croc clips on either end to do this, observing correct polarity of electrolytics), replacing the faulty component once identified. Do not be tempted to leave the original part connected, though it may be left in place to preserve appearances, eg. in the case of a can-type smoothing capacitor if a modern replacement is fitted below the chassis. Other suspects include poor grounding (check for corroded grounding points), feedback capacitors in the first AF and output stages, faulty valve sockets/wiring, tarnished valve pins (try removing each valve and clean the pins with ‘Servisol’ or De-Oxit and re-insert/remove a few times to clean the socket contacts).

Hum that varies with the setting of the AF gain control is obviously entering the circuit ahead of this control. One of the frequent causes of this in sets with a valve noise limiter stage is via the noise limiter diode (often a 6AL5 in Eddystone sets). Eddystone took precautions to minimize this in some set designs, eg. the S.830 and S770R, where the 6AL5 heater was supplied from a separate secondary winding on the mains transformer, centre-tapped and biased a few volts positive with respect to ground (red shade on circuit above, right). This heater bias circuit often fails with one or more resistors going out of tolerance and/or the associated low voltage electrolytic going open-circuit, or low in value, after many years – test these and replace as necessary. Other causes include a heater to cathode short/leakage in a valve ahead of the AF gain control, or even mains or heater wire-born hum entering the detector circuitry by mis-dressed wiring following an earlier repair, poor/frayed or corroded grounding connections (on earlier Eddystone sets, eg. the S.740, check front panel and AF gain control grounding), or even via connections to the phono socket, if fitted.



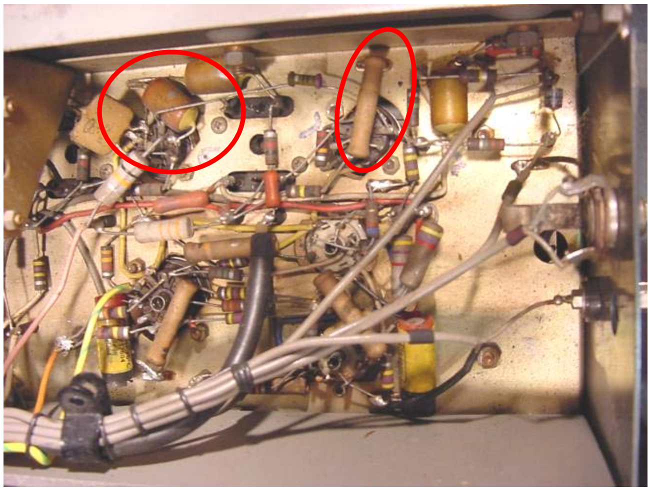
Modulation hum, which appears only when a station is being tuned in may result from cathode-heater leakage in an RF, LO or mixer valve, or by open-circuit or low value screen and/or cathode bypass capacitors in the RF, LO or mixer stages of the set, as well as poor grounding, or poor soldered or mechanical connections in these stages. Check suspects by placing a suitable substitute in parallel with the original components (use a couple of wires with insulated croc clips on either end to do this), replacing the faulty component once identified. Another cause of this form of hum is a failed suppression capacitor(s) in the power supply circuit (normally these components are in the range 0.01uf to 0.05uf, see photo, above). When testing/replacing these, select replacement components with adequate voltage rating, remembering that they are in an AC application where transient spikes present on voltage peaks may be two or three times the RMS value – so use 1600vw parts for 240vAC and 1000vw parts for 120vAC mains.



Another cause of hum may result from electrical ‘tracking’ across a valve base which produces a high-resistance connection between the heater pins and one or more of the other valve pins.

Distortion

Audible distortion usually originates in the detector and/or audio stages of a receiver. Distortion can also occur in RF and IF stages, but the result often tend to be inaudible in the normal sense, but can result in other effects such as ‘frequency distortion’, caused by an uneven IF response across the receiver passband, ‘lop-sided’ tuning, with one sideband becoming distorted due to the steepness of the ‘skirt’, or ‘inter-modulation distortion’, caused by non-linearity in the RF and/or mixer stages due to overloading or improper bias conditions in these stages. The latter condition can result from defective AGC operation, usually resulting from a leaky AGC by-pass capacitor. This is a high-impedance circuit and even a very small leakage in this capacitor can cause problems – check with a VTVM, or simply replace it as a precaution.



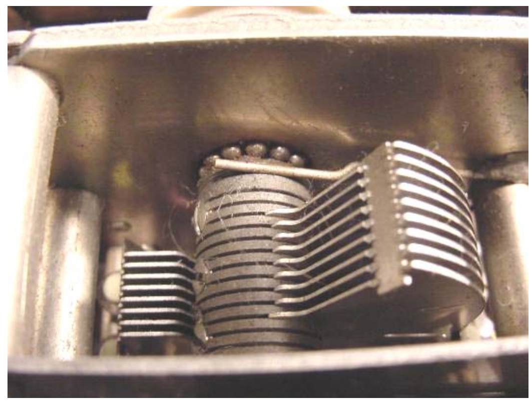
Distortion in the audio stages of a receiver can result from several causes: inter-stage coupling capacitors, cathode by-pass capacitors, grid leak, anode and cathode resistors are also likely culprits, as are the audio valves themselves, especially if the distortion commences some time after the set was switched on – this possibly being attributable to secondary emission from the grid of a valve. The inter-stage coupling capacitors should be the first suspect(s) as these have to maintain a voltage separation between the negative grid voltage on one stage and the high positive voltage on the preceding stage: even a high DC resistance within the capacitor will cause the grid of the second stage to become positive and thus severely affect the bias conditions of that stage, causing distortion, and in extreme cases, the anode of that valve to glow red hot/valve to fail. The paper dielectric capacitors often used in this application frequently become leaky with age and many folks replace them as a matter of course - use a high-quality ceramic or Mylar dielectric part with an adequate voltage rating.

Frequency Drifting or Jumping

This can be a very annoying fault condition. Drifting, to a certain extent, is 'normal' for valve receiver until the set attains a stable state after switch on (see Terry Parker's article on the behaviour of an S.750 receiver and Graeme Wormald's article on the S.940 in Lighthouse Issue's 94 and 78 respectively).

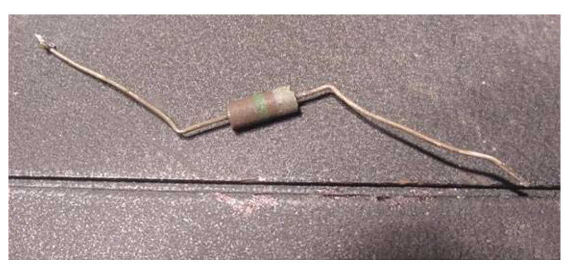
Manufacturers often designed the layout/ventilation of their sets to promote rapid thermal stabilisation, as well as including temperature compensating components in the sensitive circuits, normally by inclusion of a negative temperature coefficient capacitor(s) in the local oscillator(s) (LO) tuned circuit. If your set continues to drift significantly after the first hour or so - to the point that stations have to be re-tuned to maintain comfortable listening - then it is probably worth checking out. First check that adequate ventilation is provided to the set and it is not in an overly-drafty location. Also check that any internal protective screens are in place around LO components, including the tuning gang, if applicable. Also check that there is nothing affecting the tension of the dial cord (I once had a set that drifted due to a binding tension spring slowly releasing tension and the dial cord then incrementally turning the tuning gang by enough to cause the station to go 'off-tune' – an effect that occurred for several minutes after release of the tuning knob). After any ventilation and/or mechanical issues have been checked and eliminated as potential causes, the primary suspects are any capacitors in the LO tuned circuits, the LO and mixer valves, the LO and mixer valve sockets (check for discoloured areas on the sockets that may indicate that 'tracking' has occurred), condition of the iron dust cores in the LO coils and the coil windings themselves. The bias conditions of the LO and mixer valves can also affect stability, eg, try switching off the AGC and/or turning the RF/IF gains down to see if that affects the stability – if it does, check bias resistors and the AGC decoupling components. Even aged coax cable, eg. connecting the LO or mixer to another stage, can induce frequency drifting as the internal or external insulation and/or the outer braid can change capacitance or other physical property with varying temperature, humidity or applied voltage.

Sudden jumps in frequency are often attributable to mechanical effects, eg. poor grounding of the tuning gang rotor (check, clean and lubricate as necessary and also check the condition of any insulating grommets or spacers). Other causes are faulty capacitors or inductors that have developed intermittent internal partial shorts in the LO section. The LO valve may also cause this effect and a substitute should be tried.



'Hissing' Noises

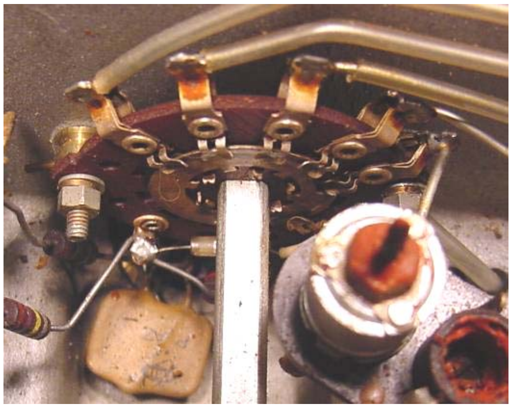
The presence of a slight hiss is normal with valve receivers – it is caused by random electron movements in components such as resistors and valves. With the aerial shorted to ground, any hiss due to 'cosmic', 'atmospheric' and 'anthropogenic' sources is eliminated (apart from slight stray pickup in the exposed receiver circuits) and ideally, any remaining hiss, from the receiver's circuits, should be negligible. In practice, however, in a multi-stage receiver the hiss level with all gain controls fully advanced may be substantial and may indicate a fault condition in the set: what is important though is the signal to noise ratio of the radio – if the desired signal cannot be heard for the noise (and it should be) you have a problem. Excessive hiss can result from several sources – primary suspects are failing (or simply noisy) resistors, capacitors, or a failing valve. Use the signal tracing method to isolate the stage generating the hiss and then identify the faulty component by the techniques described in this article. Suspect anode resistors should simply be replaced as these can check out as being ok with an ohmmeter.



'Crackles' and 'Scratching' Noises, Abrupt Volume Changes

The stage where the noise occurs can be isolated using a form of the signal injection procedure, the crackle acting as the injected signal. Crackles and scratching noises and/or sudden volume changes are usually attributable to one of the following:

- Dirty switch contacts: signal switches that have no DC component often develop poor contacts with time (placement of a small DC current through the switch can help prevent this). The condition can usually be cured by spraying the switch contacts with 'Servisol' or DeOxit' contact cleaner. Multi-pole/sectional 'wafer' switches are notorious for such faults as they are often carrying very low signal levels and their contacts are exposed to all manner of potential contaminants/oxidants – oil residues from lubrication attempts, inappropriate contact cleaner residues etc. These should be cleaned using a cotton-bud (Q-Tip) soaked in Servisol or DeOxit, and then sprayed lightly with similar; a dry cotton bud then being used to remove any excess contact cleaner and the switch 'worked' a few times;



- Dirty potentiometers; this condition can usually be identified readily by rotating the offending control and listening to see if the crackling noise changes in response. If it does, the problem can usually be cured by spraying inside the control with 'Servisol' or DeOxit' contact cleaner and rapidly 'working' the control several times: if it does not, replace the control. If it is an RF or IF gain control however, be sure to use a wirewound replacement part. If it is the AF gain control, use a log-law carbon track part.
- A 'dry' soldered joint: these can often be identified visually (dull grey, rough appearance), but not always. If this condition is suspect, start by using the signal tracing method to isolate the suspect stage, and then try tapping the joints in the suspect stage(s) with an insulated tool (eg. a wood pencil, plastic alignment tool or piece of wooden dowel) – the problem

joint can usually be found this way, but sometimes not. If still elusive, re-solder all the joints in that stage to eliminate the possibility and then look for other causes if the problem persists;

- Loose or oxidised mechanical connection (including crimped connections), eg. in a capacitor or resistor, valve socket, transformer winding or aerial connectors. Remove each valve and clean the pins with 'Servisol' or De-Oxit and re-insert/remove a few times to clean the socket contacts. Valve sockets can also develop 'tracking' across the insulation material, whereby intermittent arcing can occur, producing a hard-to-find source of crackles in receivers – inspect carefully and clean (sometimes replacement is the only cure); and

- Faulty resistor or capacitor – try tapping with an insulated tool, heating or cooling the suspect to see if a change can be induced. My favourite suspects if the noise cannot be controlled with the AF gain control are the anode decoupling or load resistor in the first audio stage, screen resistor or associated decoupling capacitors.

'Put-Put' Noises ('Motorboating')

This is a form of low-frequency positive feedback, usually attributable to poor bypassing or decoupling in the audio or detector stages of the receiver. Check the power supply smoothing capacitors, any additional HT bypass/decoupling capacitors that may be present (eg. local to the AF stages, in particular the HT feed to the first AF stage), valve screen and cathode bypass capacitors and resistors, as well as any feedback circuit components, lead dress and the integrity of grounding points.

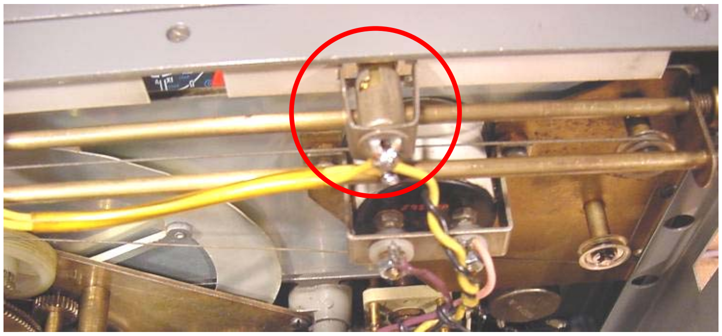
Squeal's, 'Rushing' or Whistling Noises

Another form of positive feedback and may be present with or without a station being tuned. If 'tuneable' these effects are likely caused by instability in the RF, mixer or LO stages, usually through faulty decoupling of an anode, cathode or screen resistor. If the fault is present throughout the tuning range and the AF gain control can control its volume, suspect similar components in the IF stage. Also check that valve screens are in place where they should be, that all grounding connections to valve bases and decoupling capacitors are sound and leads are dressed as close as possible to the original layout. If the AF gain control does not affect the noise volume, suspect instability in the AF stages – again through a faulty decoupling capacitor, incorrect bias conditions, eg. through out of tolerance resistors, and also a possible fault in a negative feedback loop.

'Intermittents'

Intermittent faults can be the most frustrating to identify and cure with certainty – they are often very elusive, appearing when you are not in a position to fault-find, or they suddenly cease once you start to check what is going on… an application of 'Murphy's Law'. The nature of intermittents are varied, as are their causes: these range from the set going completely dead, through any of the above specific faults occurring for a while and then reverting to normal operation.

First try to induce the fault condition: with the set operating, try 'wiggling' or tapping valves, grid caps, the tuning gang and various other passive components (resistors, capacitors, coils, transformers) and soldered joints with a wood pencil or other insulated object – this can sometimes induce the fault condition - if it does, change the component that seemed to have the effect or re-make the suspect soldered joint. Another technique is to temporarily apply heat or cold to suspect passive components, either by applying the tip of a soldering iron or heat gun for a short period (seconds), or using one of the 'cold spray' products available in electronic stores. Remove each valve and clean the pins with 'Servisol' or De-Oxit and re-insert/remove a few times to clean the socket contacts. In Eddystone sets, check the dial light bulb holders – these little blighters tend to short out to the case (a good example of an intermittent fault condition that may be hard to find when the case is off in your workshop), and sometimes when tuning the receiver (the slider momentarily catches the connections when passing), causing crackles and dimming of the bulbs.



If none of the above induce the fault condition, try leaving the offending set switched on near your workbench when you are around so you can start working on it as soon as the fault appears - from the symptoms (when the set misbehaves), take an educated guess at the cause from the information in this article and rig the set with one or two meters, recording voltage(s) in the suspect stage and recording the normal voltage(s): when the set exhibits the fault, immediately glance at the meters to see if any change has occurred – if it does, then you have located the faulty stage at least and can track down the offending component(s) from there. In the case of 'fading' sets (sets that progressively get 'weaker' with time since switch-on), connect a VTVM across the AGC line (AGC switched on), and tune in the signal genny – if the meter reading changes when the set 'acts up', the defect is in the RF or IF stages of the set: if it does not, then suspect the AF stages.

The table at the end of this article provides a fairly comprehensive summary of common valve receiver faults, their causes and cures. Reference to this and the above discussion should prove helpful in diagnosing and fixing such faults. There will, however, always be the odd, hard-to-find and/or fault that is specific to a particular sets circuit, component layout, component type/manufacturer or mechanical construction. In such circumstances the applied logic of signal tracing, application of your knowledge of the receiver circuit and your experience should stand you in good stead to make some educated guesses as to what the issue is and get to the heart of it without too much frustration….

Good luck and have fun: if/when you stop having fun, my advice is to leave the set well alone for a day or two and then re-visit it – it is amazing what the subconscious mind can process, the fresh pair of eyes can see and rested hands can apply with positive results after such a break. If this still fails to sort things out, tap into others combined knowledge, either by your local amateur radio club or via various forums on the web (eg. the EUG forum or others listed in the Reference section of this article) – folks are usually only too willing to help and there is a wealth or experience out there to share.

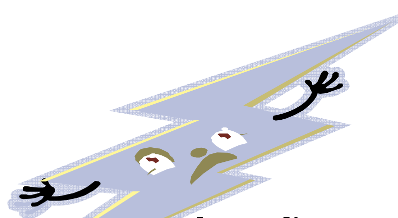
Conclusions

Fault finding in valve radios is usually a straightforward exercise in the logical application of knowledge, which is helped and expedited by hands-on experience. Whilst more 'exotic' faults are encountered occasionally, there are a multitude of 'old chestnuts' that appear time and time again – often specific to a particular make or model of receiver, perhaps due to a type/make of component, eg. capacitor, employed in that set, the design of the circuit, or the set layout tended to stress certain components. The savvy radio repair tech learned these over the years and thus became more efficient and thus profitable (many trade journals, and even some books, concentrated entirely on reporting known 'stock' problems with particular sets, eg. '*Radio Field Service Data'* and a large section of '*Radio Troubleshooting Handbook'* by Ghirardi in the 1930's for US sets). This type of issue is exemplified by the component-age related problems (bias resistors) that beset cascode RF stages in some Eddystone sets (S.830, S.940 and EA12), or premature heater failures in 6AL5 duo-diodes in other Eddystone sets as this valve's heater is run off its own LT secondary tap on the mains transformer, which therefore tends to apply a higher voltage to this valve's heater. The more exotic faults can be extremely frustrating and can these days often result from age-related issues that are poorly (or not) documented in period textbooks on valve radio servicing techniques – for

example, one of the most frustrating faults I have encountered in recent times was an 'intermittent' in my 1940 Zenith AC/DC set, finally tracked down to a rubber mounting grommet on the tuning gang stator that could not normally be seen. This caused anything from crackles, to intermittent complete silences (the LO had stopped working) to frequency jumping and slow drifting – this particular grommet had hardened with age (preferentially by heat from a nearby valve) and was sometimes shorting to chassis and sometimes acting as a small capacitor with properties that varied with temperature and ambient humidity. All the visible grommets looked reasonably ok as they weren't near a valve. Other hard-to-find faults include those resulting from complete or partial shorts/open circuits in coils or transformers (oft' reported in 'Lighthouse' as the 'dreaded green spot' issue), shorts in usually non-suspect silver mica and plastic film capacitors, and the ubiquitous dry joint.

So there you have it, a short lesson on radio fault finding: I have tried to pack in enough to get the novice way beyond the 'tinkering' stage, but it really only scratches the surface and there are many books devoted entirely to this subject. The next step in the learning process is up to you - gain some more knowledge by reading one or two of these books and a few of the recommended articles (see References below) – for starters, I would certainly recommend downloading and reading a copy of Elements of Radio Servicing by Marcus and Levy from the web (http://www.archive.org/details/Elements_Of_Radio_Servicing), Chris Parry's book on restoration of valved HF radios (http://www.vk2bv.org/radio/parry1.htm), Graeme Wormald's 7-part '*Duffers Guide*' (in 'Lighthouse' Issues 86 to 92), and Peter Lankshear's electronic repairs article (in 'Lighthouse' Issues 70 to 75). Then apply this knowledge to a faulty set, working through the process described above: in the 'old days' of receiver servicing, a receiver would sometimes be 'rigged' with faults that the trainee technician had to identify and repair – if you have a suitable spare receiver, a handful of failed components, and a knowledgeable friend who can introduce the 'faults' into that set for you, try this method for practice. Alternatively, try introducing such faults yourself and observe the resulting symptoms first-hand, taking notes for future reference.

A final tip: start a 'service record' for each receiver you work on: I keep a loose-leaf binder for each of my Eddystones that includes the service manual, reviews, Lighthouse articles and references, several copies of the circuit diagram – at least one enlarged version with voltages pencilled on it and a few notes (both published voltages and others at non-published circuit nodes, measured by myself when the receiver was functioning well), photographs (some prints, others on CD) and several pages for notes, eg. what tests were undertaken and when, what faults were identified, components replaced, valve test results etc. – its amazing what you forget if you don't do this, so get into the habit.



A Final Word…

In all the above, safety is paramount: valve radios contain lethal voltages and must at all times be treated with respect and caution. Even when a shock is not lethal, it can cause unpleasant 'collateral damage', eg. when you withdraw your hand rapidly it can be gashed on a sharp piece of metal, your head could bump on something, or you could accidentally short something out and cause damage to the radio. Therefore always double-check whether power is being applied to the set, on the status of any temporary connections made for testing purposes, and never hold on to/touch the receiver chassis with one hand when probing around with the other (keep your 'spare' hand in your pocket). Remember, even a very small current passing directly through the chest resulting from a momentary contact with a voltage not much higher than 100v or so can kill. Also bear in mind that even after power is removed, electrolytic capacitors can hold a charge for long periods that can shock you when your guard is down…

Good luck with your fault finding – and may the combined forces of the 'Wise Old Men', the 'Genie of the Soldering Iron' and the 'Tetley Tea Folk' all be with you…

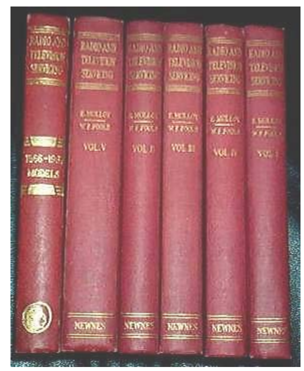
Gerry O'Hara, G8GUH, Vancouver, BC, Canada, December, 2006

Some Useful References

- Elements of Radio Servicing, W. Markus and A. Levy, 1955 (2nd Ed., Esp. Ch. 27) - the 1st Ed. is downloadable (free) from the web in pdf format – see below
- Radio Receiver Servicing and Maintenance, E. Lewis, 1944 3rd. Ed. (UK text) – a concise text often found for sale on EBay
- Wireless Servicing Manual, W. Cocking, 1945, 7th Ed. (UK text) – more 'how it works' than fault finding
- Teach Yourself Radio Servicing, l. Butterworth, 1964 (UK text) – a concise and practical text (includes some theory) often found for sale on EBay
- Radio Servicing Made Easy, L. Lane, 1962, Vols. 1 & 2, Revised Ed.
- Radio Receiver Servicing, J. Frye, 1955 – another concise and very practical text often found for sale on EBay
- Profitable Radio Troubleshooting, W. Markus and A. Levy, 1956. This 330 page tome provides an insight into how radios were serviced in a commercial environment (several figures from this text are in this article) – it includes some interesting variations on the signal tracing theme, including a 'shock therapy' technique, ie. introducing a known transient stimulus into the radio and observing

the effect, eg. shorting something out, pulling a valve out of its socket/removing its top cap connection, discharging or connecting a capacitor into the circuit etc. - great fun, if you know what you are doing… this is sometimes found on EBay

- Practical Radio Servicing, W. Marcus and A. Levy, 1955 – good text for AC/DC sets, occasionally found on EBay
- Radio Servicing: Theory and Practice, A. Markus, 1948 – good standard text, often found on EBay
- Radio and Television Receiver Troubleshooting and Repair, Ghirardi & Johnson, 1952 (Esp. Ch. 6, '*Practical Direct-Approach Troubleshooting*') – excellent text, though rarely found on EBay
- Radio and Television Receiver Circuitry and Operation, Ghirardi & Johnson, 1951 – another excellent text, though rarely found on EBay
- Radio and Audio Servicing Handbook, King, 1970, 2nd Ed. – fairly useful UK text, often found on EBay



- Modern Radio Servicing, Ghirardi, 1935 – a very old, but 'classic' and interesting 1300 page tome, frequently found on EBay (be careful of the binding condition though, some pressings tend to come apart easily)
- Radio and Television Servicing volumes, E. Molloy and W.F. Poole, 1950's/1960's – often found on EBay (at least try to obtain Vol. 1)
- Principles and Practice of Radio Servicing, H. Hicks, 1943 – reasonable text sometimes available on EBay
- Radio Servicing Manual, New York Electronics Inst.
- Basic Radio Course, J. Frye 1961, 2nd. Ed.
- Rider's *Perpetual Radio Troubleshooters*, Beitman's *Most Often Needed*, and other trade journals and reference publications (many available on indexed CD ROM, but be wary of poor scans)
- Various sections of Eddystone manuals downloaded from the EUG web site and specific articles/tidbits in Lighthouse (see 'Super Index' on the EUG web site), including:

Subject	***Issue***	***Page***
S.940 Frequency Stability	78	27
Hum, curing	73	10
	4	4
	19	6
drifting, cure	44	15
mechanical problems	40	18
motorboating	7	5
	10	14
	25	16
avc fault	10	14
drifting	58	34
curing	40	5
mains switch problem	95	20
audio output		
distorted	17	6
	52	2
lack of	6	9

- Some web-based articles/resources on subjects covered in this article include:
  - http://www.archive.org/details/Elements_Of_Radio_Servicing
  - http://www.justradios.com
  - http://www.mauritron.co.uk
  - http://bama.edebris.com/manuals/
  - http://www.tubesandmore.com
  - http://www.vk2bv.org/radio/parry1.htm
  - http://vintagevalveradio.mysite.wanadoo-members.co.uk/
  - http://www.milliron.net/al7kt/boatanchors.htm
  - http://www.radioattic.com/links.htm
  - http://vintageradio.me.uk/novice/novice.htm
  - http://www.antiqueradios.com/
  - http://www.oldradiosrus.com/
  - http://www.antiqueradioschematics.com/
  - http://www.stevenjohnson.com/manuals/radio.htm
  - http://www.nostalgiaair.org/references/articles/rn/tfsm/tfsm.asp?DSP=00
  - http://www.nostalgiaair.org/references/articles/nri/index.htm
  - http://www.manualman.com
  - http://www.radioera.com/l-manuals.htm
  - http://radioswapmeet.com/
  - http://www.antiqueradios.com/
  - http://www.agtannenbaum.com/
  - http://web.ukonline.co.uk/p.foden/

Finally, although radio fault finding and servicing is not 'rocket science', remember…

Table 10. Auto-radio Power-supply Defects (Continued)

Component	Defective Condition	Accompanying Effects
C-1	1. Shorted buffer condenser.	1. Dead receiver. No or low B voltage. Heavy battery drain.
V-1	1. Internal short or open heater. 2. Low emission.	1. Dead receiver. Heavy battery drain. 2. Weak reception.
C-2	1. Open. 2. Short. 3. Leaky.	1. Hum. 2. Dead receiver. Heavy battery drain. 3. Weak reception. Hum. Low B voltage.
C-3	1. Open. 2. Short. 3. Leaky.	1. Hum. Oscillation. 2. Dead receiver. 3. Hum. Low B voltage.
C-6	1. Open. 2. Short.	1. High hash level. 2. Dead receiver.

Three-way Portable Radio Power Supply. Figure 14-4 shows a typical power supply for a three-way portable receiver, and Table 11 gives its component defects.

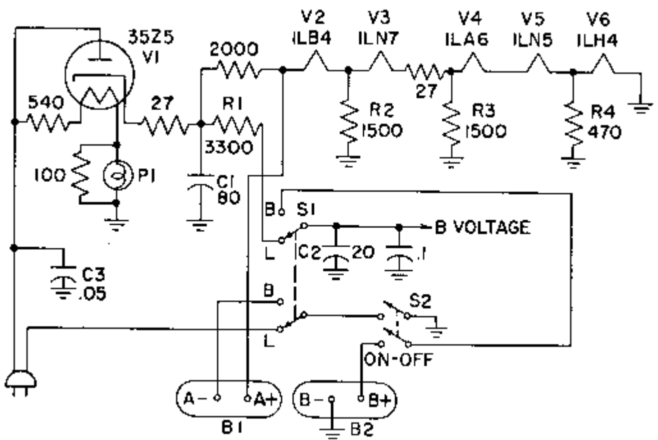


Fig. 14-4. A typical power supply for a three-way portable

Table 11. Three-way Portable Power-supply Defects

Component	Defective Condition	Accompanying Effects
R-2, R-3, R-4	1. Open.	1. Tube heaters burn out. Dead receiver.
V-2, V-3, V-4, V-5, V-6	1. Open heater.	1. Receiver dead.

Table 11. Three-way Portable Power-supply Defects (Continued)

Component	Defective Condition	Accompanying Effects
B-1, B-2	1. Batteries weak. 2. Dead batteries. 3. Poor battery plugs.	1. Weak reception. Distortion. Oscillation. 2. Dead receiver on battery operation. 3. Noise. Intermittent operation.
S-2	1. Open switch. 2. Dirty corroded contact.	1. Dead receiver. 2. Noise. Intermittent operation.
S-1	1. Poor contacts.	1. Intermittent operation. Failure to switch from battery to line operation.
C-3	1. Open. 2. Short.	1. Modulation hum on line operation. 2. Dead receiver.
V-1	1. Open heater. 2. Low emission.	1. Dead receiver on line operation. Tubes do not light. 2. Weak reception on line operation. Distortion.
C-1	1. Open. 2. Dried out, low capacitance. 3. Short.	1. Audio howl. 2. Audio howl. Weak reception. Distortion. 3. Dead receiver. Ruined V-1.
R-1	1. Open.	1. Dead receiver on line operation; no B voltage.
C-2	1. Open or lowered capacitance. 2. Short. 3. Leaky.	1. Hum, oscillation, or motorboating. 2. Dead receiver. 3. Hum on line operation.
P-1	1. Pilot lamp poorly seated.	1. Noise.

Table Referenced in Article Text Below

Defective-receiver-operation Analysis. Still another system for arranging a servicing glossary is that of listing the main reasons for defective receiver operation. These will now be listed below.

Dead A-C Receiver. For an a-c receiver, no program is heard. The tubes may or may not light, and hum may or may not be present. Causes are as follows:

1. Defective rectifier tube.
2. Shorted filter condensers.
3. Open heater in any tube.
4. Shorted B supply in the receiver.
5. Open power-transformer primary or secondary.
6. Defective wall outlet.
7. Open filter choke (speaker field).
8. Filter choke shorted to chassis.

9. Open connections in the receiver.
10. Open coupling condensers.
11. Open voltage divider resistors.
12. Open voice coil.
13. Open winding in the output transformer.
14. Break in the receiver line cord.
15. Internal short in tubes.
16. Open line fuse.
17. Open self-bias resistors.
18. Defective receiver line switch.
19. Open audio transformers.
20. Open plate loads (resistors or transformers).
21. Shorted line filter condenser.
22. Open volume control.
23. Shorted signal paths.
24. Open air-core coils.
25. Shorted trimmer condensers.
26. Shorted tuning condensers.
27. Great misalignment of i-f transformers.
28. Critical oscillator stage.
29. Grounded antenna.
30. Break in antenna, leadin, or window strip.
31. Short in lightning arrester.
32. Defective band switch.
33. Open plate decoupling resistor.
34. Disconnected grid caps.
35. Reversed antenna and ground leads to the receiver.

Dead A-C/D-C Receiver. For an a-c/d-c receiver, the same conditions as those listed above may cause a dead receiver, with a few exceptions related to the power supply and a few additional factors. Of course, item 5 above is not applicable. Additional factors are:

1. Open line-cord resistor.
2. Defective ballast tube.
3. Open heater voltage-dropping resistor.
4. Open filter resistor in the power supply.
5. Shorted selenium rectifier in the power supply.
6. Reversed line plug in a d-c wall outlet.

Dead Portable Receiver. For the three-way portable receiver, you have the same defects as for the a-c/d-c receiver with these additional causes:

1. Dead A or B batteries.
2. Defective battery plugs.
3. Open or overheated heater equalizing resistors.
4. Open mode-of-operation switches.

Dead Auto Radio. There are many causes for a dead auto receiver. For the most part, they are the same as those for an a-c receiver, except for the power supply. These additional causes are listed below:

1. Grounded auto antenna.
2. Defective vibrator unit.
3. Open battery fuse.
4. Open line switch.
5. Shorted buffer condenser.
6. Open or shorted power transformer.
7. Wrong polarity of synchronous vibrator.

Weak Receiver. Weak response from a receiver may be caused by factors listed below:

1. Low tube emission.
2. Receiver misalignment.
3. Weak field excitation of loudspeaker.
4. Open or leaky input filter condenser (plus hum).
5. Open cathode bypass condenser in a-f section.
6. Short in filament winding of a-c receiver.
7. Open coupling condensers (for strong locals only).
8. Open grid circuit in output stage (plus hum and distortion).
9. Poorly seated tubes (plus noise).
10. Gassy tubes (plus distortion).
11. Leaky coupling condenser (plus distortion) in a-f section.
12. Jammed or rubbing voice coil of loudspeaker.
13. Open antenna-coil primary.
14. Poor tuning condenser wiper contacts.
15. Open avc bypass condenser.
16. Shorted secondary of antenna, r-f, and i-f transformers.
17. Shorted turns in output transformer.
18. Shorted turns in a power-transformer secondary winding.
19. Corrosion in tuned circuits (plus noise).

20. Damp tuned circuits.
21. Open secondary of antenna, r-f, and i-f transformers.
22. Leaky screen bypass condensers.
23. Open plate bypass condenser in output stage.
24. Dirty tuning or trimmer condensers.
25. Open plate bypass condenser in a-f section.
26. Low line voltage.
27. Break in antenna.
28. Altered resistance of cathode self-bias resistor.
29. Weak batteries (plus distortion or oscillation).
30. Worn vibrator in auto-radio power supply.
31. Open or leaky buffer condenser in auto-radio power supply.
32. Defective volume control.

Receiver Hum. Humming in a receiver may be caused by these conditions:

1. Open power-supply filter condensers.
2. Lowered capacity or leaky output filter condenser.
3. Cathode-heater leakage in tubes (usually the audio section).
4. Open grid circuit (plus distortion).
5. Poor lead dress.
6. Poor grounding of shields.
7. Defective volume control.
8. Open line filter condenser (tunable hum).
9. Leakage between condensers in a filter condenser block.
10. Shorted turns in the power-supply filter choke.
11. Gassy rectifier tube.
12. Weak tubes.
13. Open cathode bypass condenser.
14. Unbalanced tubes in a push-pull stage.
15. Open decoupling filter condenser.
16. Overbiased tube.
17. Leaky screen bypass condenser.
18. Antenna pickup from nearby power lines.
19. Mechanical vibration of transformer or choke plates.
20. Poor grounding of a receiver.
21. Reversed loudspeaker hum-bucking coil.
22. Shorted turns of a hum-bucking coil.
23. Open half of high-voltage secondary winding in a full-wave rectifier.

24. Reversed plug in outlet receptacle.
25. Corroded contacts.
26. Misalignment.
27. An oscillating stage.
28. Shorted secondary winding turns of power transformer.
29. Open filament center-tap resistor.

Receivers that Squeal and Motorboat. Common causes for squeals and motorboating in a receiver are:

1. Open or low-capacitance output filter condenser.
2. Poor shielding.
3. Open screen bypass condenser.
4. Open cathode bypass condenser.
5. Open plate decoupling condenser.
6. Open or shorted grid decoupling condenser.
7. Open screen voltage-dropping resistor.
8. Misalignment.
9. Poor lead dress.
10. Poor grounding.
11. Corroded or poor connections.
12. Open grid circuit.
13. Low tube bias.
14. Open secondary of antenna, r-f, or i-f transformer.
15. Poor grid-cap connection.
16. Improperly grounded tuning condensers.
17. Poor wiper contact in tuning condensers.
18. Gassy tubes.
19. A microphonic tube (loose internal elements).
20. Poor rubber mounts.
21. High line voltage.
22. Weak batteries.

Noisy Receiver. The defects listed below may account for a noisy receiver:

1. Pickup from power lines.
2. Pickup by the antenna and ground.
3. Poor shield grounding.
4. Poor seating of the line plug in the wall outlet.
5. Corroded soldered connections within the receiver.

6. Intermittent shorting of leads within the receiver.
7. Worn volume and tone controls.
8. Intermittent shorts within a tube.
9. Corroded windings in r-f, i-f, and a-f coils.
10. Conductive dust on tuning condensers.
11. Intermittent shorting of stators and rotors of tuning condensers.
12. Poor seating of tubes in their sockets.
13. Poor tube grid-cap connections.
14. Conductance around a tube base.
15. Dirty wiper contacts of tuning condensers.
16. Loose hardware or parts in the receiver.
17. Poor internal tube contacts.
18. Intermittently open condenser.
19. Loose fuses in the fuse box.
20. Defective switches.
21. Intermittently grounding antenna or leadin.
22. Break in antenna leadin.
23. Cracked carbon resistors.
24. Intermittently shorted turns of wire-wound resistors.
25. Rubbing loudspeaker voice coil.
26. Dirt between voice coil and center pole piece.
27. Torn loudspeaker cone.
28. Loose loudspeaker spider.
29. Loose voice-coil wires (broken cement).
30. Corroded battery connectors.
31. Weak batteries.
32. Weak gassy tubes.
33. Loose pilot light.
34. Leaky condensers.
35. Dirty lightning arrester.
36. Dirty contacts in auto vibrator.
37. Poor grounding bonds in auto receiver.
38. Missing auto static-collector springs.
39. Open hash filter in an auto radio.
40. Defective buffer condenser in an auto radio.
41. Open line filter condenser.

Receiver That Distorts. The causes for distortion in a receiver are listed below. The defect is usually found in the a-f section of the receiver.

1. Leaky coupling condensers.
2. Open output filter condenser (plus hum).
3. Weak tubes.
4. Misalignment.
5. Grid emission.
6. Cathode-heater leakage (plus hum).
7. Lowered capacitance of output filter condenser (plus hum).
8. Shorted cathode bypass condenser.
9. Cathode bias resistors whose resistance has changed.
10. Incorrect tube bias.
11. Shorted turns in the primary of the output transformer.
12. Open grid circuit (plus hum and weak output).
13. An oscillating stage.
14. Rubbing voice coil.
15. Leaky avc filter condenser.
16. Warped loudspeaker cone.
17. Unbalanced push-pull tubes.
18. Defective tone control.
19. Weak field excitation for loudspeaker.
20. Weak batteries.
21. Location too close to a powerful station.

Intermittent Receiver. Conditions within the receiver that may cause intermittent operation are listed below. Fading of station signals is included in this defect. Remember that any form of defective operation may be intermittent.

1. Intermittently open fixed condenser (rarely shorts).
2. Defective tubes:
   a. Intermittently open heater.
   b. Intermittent internal shorts.
   c. Intermittently open electrodes to their leads.
   d. Gassy tubes.
   e. Grid emission.
3. Intermittent open coils.
4. Defective volume controls.
5. Internal cracks in fixed resistors.
6. Dirty wiper contacts in tuning condensers.
7. Intermittent shorts in tuning condensers.
8. Poorly soldered joints.

9. Poor antenna-ground joints.
10. Intermittently grounding antenna and leadin.
11. Broken window strips.
12. Poor seating of tubes in their sockets.
13. Poor seating of line plug in wall outlets.
14. Loose shields.
15. Intermittent shorts within the receiver.
16. Leaky filter condensers.
17. Poor tube grid-cap connections.
18. Defective switches.
19. Iron-core coils shorting to chassis.
20. Fixed resistors that change in value.
21. Extreme line-voltage variations.
22. Leaky coupling condensers.
23. Weak batteries.
24. Worn-out vibrators in car radios.
25. Critical oscillator stage.
26. Intermittent shorts in trimmer condensers.
27. Faulty taps in wire-wound resistors.
28. Poor seating of pilot lights.
29. Poor fuse contact in car radio.
30. Swinging antenna flat-top.

Receiver Exhibiting Station Interference. Some station interference effects are inherent in a low-cost receiver. Those listed below are interference effects in receivers where service adjustment may improve the condition.

1. Wave trap out of adjustment.
2. Wrong i-f alignment.
3. Wrong antenna orientation.
4. Too long antenna.

Receiver with Broad Tuning. A receiver that exhibits broad tuning is said to have poor selectivity. The possible causes are listed below:

1. Improper r-f and i-f alignment.
2. Tubes with weak emission.
3. High resistance and corroded contacts in tuned circuits.
4. Dirty wiper contacts in tuning condensers.
5. Poor seating of tubes in sockets.

6. High-resistance contacts in grid circuits.
7. Corroded tube-grid clips.
8. Weak batteries.
9. Low line voltage.
10. Disconnected ground connection.
11. Too long an antenna.
12. Poor shielding.
13. Inexpensive receiver.
14. Too close to a strong station.