



# '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.**

## Receiver Test Gear

### Introduction

I believe that there are three 'schools' of thought when considering what the test gear is needed to maintain, service and restore valve radio equipment:

- Minimalist: comprising a wet finger (signal injector/substitute resistor), a dry finger (voltage checker), light bulb/socket and, for the more esoteric and technically inclined, a cheap analogue multimeter (total cost ~\$20)
- Practical: the above plus a 'service grade' RF signal generator ('genny') and output meter (total cost ~\$300 new, ~\$100 used), and optionally a Variac, VTVM (vacuum tube voltmeter), crystal calibrator, digital frequency meter (DFM), higher-quality analogue multimeter, moderately-priced digital multimeter (DMM), capacitance/inductance meter, noise generator, valve tester, 'service grade' oscilloscope ('scope') and wobulator (total extra cost ~\$2,000 new – except for the VTVM and valve tester, which I doubt if any are available as new units since the sixties - or about \$600 used/part homebrew)
- Specialist: replace the service grade genny and scope with 'professional' units that have better calibration, are synthesized, have digital frequency readout etc, noise bridge, and the like, to allow more accurate receiver performance measurements, function genny and precision DMM (extra cost? – the sky's the limit...)

Other 'nice-to-have' gadgets in the 'practical' armoury include capacitance and resistance substitution decade boxes, digital receiver/scanner and grid-dip-oscillator (GDO).

I am firmly in the 'Practical' school, as I am in the market for repairing broken radios and making them work to a standard acceptable to me or the person I am repairing it for, not necessarily the as-new specification. The items in the 'Practical' list were the 'tools of the trade' that I was raised on in my teens in a small radio/TV repair shop in Carlisle,

Cumbria – except, of course the DMM and DFM, and the capacitance meter we used back then was an old bridge type with a ‘magic-eye’ null, and the valve tester was a huge Mullard unit with a punched card for each valve type. This selection of ‘traditional’ test equipment was also the type of kit also used by Gordon, G3MNL, my ‘thermionic mentor’, who fixed radio kit for government for a living (14MU near Carlisle).

Tales abound of service engineers making do with the ‘Minimalist’ set of equipment,

#### No Substitute for Experience

One fortunate aspect of valve radio equipment is that, unlike many modern testing procedures, measurements are relatively straightforward and simple. It has been said too, that the quantity of testing facilities required is in inverse proportion to the experience of the repairman. This is a bit of an exaggeration of course, but I well remember seeing it demonstrated some years ago by a technician with many years of fixing domestic receivers behind him. It took him less than a minute to diagnose a receiver with no sound without using any instruments at all.

First he used what he called his “calibrated screwdriver” to check the H.T by shorting the output filter capacitor to the chassis. The size of the resulting “splat” indicated that there was plenty of voltage available.

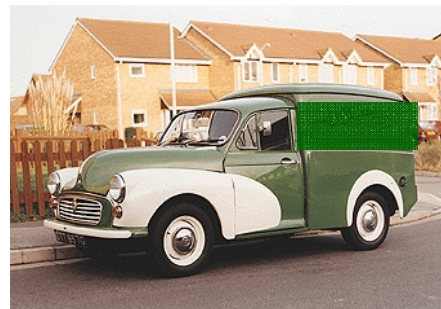
He then touched the grid pin of the output valve and the resulting “burp” confirmed that the output stage was working. Next he set the volume control to mid range and touched his screwdriver on the grid cap of the first audio stage. There was no response and as this valve was glowing and therefore likely to be operating, he suspected that the problem could be its anode resistor.

He confirmed that the fault was indeed the case, by the simple process of licking the tips of his thumb and index finger and then, with his other hand in his pocket, using his fingers to bridge the suspect resistor! The set burst into life confirming his suspicions.

usually just using the wet finger and/or ‘calibrated screwdriver’. To quote from Peter Lankshear in ‘Lighthouse’ Issue 70, pp44, *Eddystone Receiver Repairs For Beginners – Part 3, Test Equipment – ‘No Substitute for Experience’*, see inset, left.

My own experience of a variation on the minimalist level of test gear being used was ‘in the field’ with ‘Johnny-one-arm’, the ‘field’ service engineer based in the shop where I started work around 1970 (‘Little John’ was my other mentor there, he being the ‘shop’ service engineer). The story of how Johnny lost his (left) arm ranged from being run over by a tank in WWII, mauled by a lion in Africa to a car accident in London, depending on his mood or who you asked - I never found the definitive answer. He was a cockney, lived with a woman at least twenty years his junior, had a wicked, cutting, though somewhat sexist wit and he maintained a rapport with female clients that ranged from a sickly-false-polite to bordering on extremely-embarrassing, suggestive risqué. Notwithstanding, he certainly knew his stuff when it came to fixing TV’s and radios - I have seen us do 8 to 10 service calls in a day and fix all but one TV, radio or Hi-Fi in the field armed with only screwdrivers, a soldering iron, pliers, a multimeter and a few

substitute parts. Although I do not remember many of the actual repairs, I will always remember his driving technique - the service van was a green ‘Moggy Thou’ and he used a steel cup attachment on his false arm to change the gears: he’d set off in ‘bottom’ (first), accelerate to over four thousand revs and then yank the stick straight through the box into ‘top’ (fourth), the (1000cc) engine then labouring like mad and the cup attachment rattling loudly on the gear knob the whole time – it had the same effect on me as



scratching fingernails down a blackboard (so I would offer to move the gearstick for him but he never took me up on it). I found out that the poor old guy had died in tragic circumstances in the early-nineties: RIP Johnny and thanks for your experience...

The 'Specialist' gear is really only necessary if you are interested in squeezing the last ounce of performance from your receivers or in accurately quantifying their performance against published specifications. Even so, the specifications published for the range of valve Eddystones is usually limited, so the need to go to the expense of acquiring this standard of gear is questionable for valve technology radios (unless it is available at your place of work or an opportunity comes up to buy it at a good second-hand price). It should be noted that using it correctly and to its full capability needs some training and practice. I therefore will not attempt to cover this type of equipment in this article.

### What Gear is Needed?

Well, it depends on what you are trying/wanting to do, as noted above. There are three main uses for test equipment:

- Locating faults in sets that are dead or do not function correctly;
- Assist in making adjustments to improve performance (eg. re-alignment); and
- Measuring performance accurately and against published specifications.

I will be concentrating on the first two bullets in this list, describing typical basic equipment needed for these tasks as found in my basement workshop (photo, below).

### My Test Equipment

As you may have noted from other articles, I have had a bit of an 'on-and-off radio career' and by 'career', I really mean in the hobby sense – by profession I am a Chartered Engineer and Chartered Geologist working in the environmental remediation field! – my time in the radio and TV shop was mainly on weekends and during vacations while still at school and university.





As a keen young radio amateur in the 1970's and early-1980's I acquired or built a reasonable collection of test gear. Some of my acquisitions were from 'AH Supplies' in Sheffield, which was close to where I worked for a few years immediately after graduating from Sheffield University. I picked up a great Telequipment scope there as well as a signal genny, BC-221 wavemeter, attenuators, noise generator and the like. Sadly, I either disposed of that kit or left it in the UK when I came over to Canada in 1997, seeing little use for it as I had been out of the hobby since returning from a year or so 'stint' in the Falkland Islands in the mid-1980's. So, when I became interested in radio again a couple of years ago, I almost had to start from scratch – I think I still had a couple of analogue multimeters and a homebrew crystal calibrator. So, I checked out eBay for a month or so and became familiar with what price different items of test gear were fetching and eventually 'took the plunge' and purchased several items from there (a BK Precision DFM, Heathkit VTVM, Heathkit valve tester, Heathkit AF signal genny, Triplet RF signal genny, Triplet analogue multimeter, resistance/capacitance substitution decade boxes and Hitachi scope). I also checked out the local fleamarkets and second-hand stores and picked up a nice EICO VTVM, Supreme RF signal genny, Millen GDO, another Heathkit VTVM and a Precision valve tester. I also bought a new Variac, DMM and digital capacitance/inductance meter. I estimate the total cost of all this lot, bought over a year or so, to be <\$1,000, including shipping.

The main items needed for basic, practical but unsophisticated AM/SSB/CW/FM receiver servicing procedures are as follows. Some of this kit is also described in the 'Tech Short' on receiver alignment, so bear with me if you detect some repetition:

- **Signal Generator(s):** A signal generator (genny) covering the IF and RF range of frequencies of interest is really a 'must have' for anything other than 'casual' repairs. This instrument is useful for a variety of radio repairs using the standard 'signal tracing' techniques, as well as being essential for re-alignment. Standard 'service-quality' signal generators can be bought for a few tens of dollars on eBay or new ones for not much more. I use a typical valve-based 1950's service-grade 'genny' manufactured by Triplet, Model 3432-A, bought on eBay for around



- \$80. It covers 160kHz through 220MHz (plus more on harmonics), has variable-level AM modulation, a fairly basic output attenuator and is remarkably stable after 30 minutes or so. I also have a Superior Inst. Model 660-A that is not as nice to use (or as stable), but extends down to just below 100kHz. For lower frequencies (eg the 85kHz second IF found in the Eddystone S.750), I use a Heathkit 'audio' generator (Model IG-5218) that covers all frequencies up to 100kHz, switchable in 1Hz increments. Also needed is an appropriate cable(s), with croc clips at the receiver end, and a few isolating capacitors - 0.1uF for IF stages and 0.01uF (or lower) for RF stage injection.
- **Analogue Multimeter:** This is the single-most used piece of equipment – I use them far more frequently than DVM's as they provide a quicker, more 'intuitive' response, especially when trying to find a peak or null voltage. There are many different types on the market. The most useful type is a 20,000 ohms/volt type (50uA meter movement) as this level of sensitivity is often specified by voltage tables in Eddystone manuals (sometimes 1000 ohms/volt is specified, ie. 1mA meter movement – however, this can be reproduced using suitable shunt resistors with a 20,000 ohm/volt unit as described in the sidebar, right). I own one very good analogue multimeter (a Triplet model 630-NA picked up from EBay for \$70) and several 'cheap' multimeters, including one made by Eagle purchased at 'cost price' from the radio shop when I started work there when I was 15 (it still works albeit with many a 'battle scar' and has itself been repaired dozens of times!). This allows more than one parameter to be measured at once, eg, leave one meter connected into the HT line whilst reforming electrolytic capacitors measuring mA current draw, while simultaneously

### 1000 ohms/volt Meter Switchbox

In my S.770R restoration article, I described a simple gadget to convert a 'modern' 20kohms/volt meter into a 1000ohms/volt unit as specified in many Eddystone manual voltage tables.



This has been improved to allow rapid switching between ranges – took about an hour to construct and works really well – every bench should have one!



All you need is a box, two banana plugs and sockets, a multi-pole switch and some resistors to suit your voltmeter ranges (eg. for my Triplet meter, I needed 600ohm, 3kohm, 12kohm, 60kohm, 300kohm and 1.2mohm resistors for its 0.6, 3, 12, 60, 300 and 1200 volt ranges). Arrange the switch to have the correct resistor shunt the voltmeter on each range. I also added a switch to allow the unit to be quickly switched out of circuit for all other measurements ranges.

observing applied voltage on another. If you can only afford one, buy the very best you can, ensuring it has a mirrored scale to avoid parallax errors when reading and also buy/make a few different test leads: some with insulated slender point probes, some with croc clips etc.

- **Output Meter:** Many novices think that they can tune a signal peak by 'ear', well yes, you can, but it is surprising what an improvement can be made using a visual aid. My Triplet multimeter conveniently has an 'output meter' input installed – circled on the photo, right - (it simply has an internal 0.1uF capacitor that is connected in series with the AC voltage ranges): if your multimeter does not have this facility, just connect a capacitor externally. While the receiver S-meter (if fitted) can be used for peaking receiver tuned circuits, it has the disadvantage that it is not sensitive to signal level changes at very low levels and it may be connected into the circuit ahead of the final IF transformer (many Eddystones are like this: eg. the S-meter is often located in a bridge circuit connected to the screen grid of the final IF stage, thus adjusting the cores of the final IF transformer will have little or no effect on the S-meter reading). A simple output meter can be made using a milliammeter and a couple of passive components (see various Lighthouse articles and textbooks referenced below).



The above essential instruments can be supplemented with:

- **A crystal-controlled 'marker' oscillator:** this instrument is very useful when the receiver local oscillator alignment is 'way out'. I use a homebrew unit I made when I was 16 (I think it was in 'Practical Wireless') that has switchable 1MHz, 100kHz, 12.5kHz and 10kHz output markers set up using one of the standard frequency transmissions on 10MHz or 15MHz (see photo above). I also used to use to use a 'Class-D' Wavemeter and a BC221, but these still reside in my mother-in-law's garage in Burton (I don't miss them, though the BC 221 was beautifully made and nice to use).
- **Digital frequency meter:** modern signal generators have these as standard, but I use a stand-alone BK Precision Model 1803 that I picked up on EBay for a few dollars – checked against my crystal calibrator it is 'spot on' right up to 100MHz, even though it is 20 years old. It gives a bit more confidence than using just the signal genny scale. The





capacitance/inductance meter I own (see below) also has a 15MHz frequency meter built in that I occasionally use;

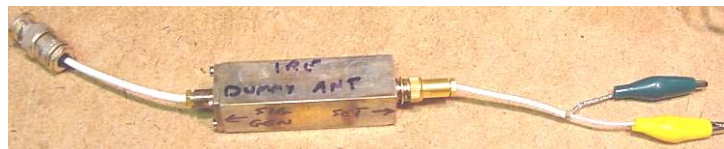
- Digital Multimeter: I desperately wanted one of these back in the early-1980's when they first became 'affordable' as they seemed to offer such great accuracy – I saved up and bought a rather expensive Fluke unit: however, I soon came to realize its limitations for the sort of work I needed it for, though for accurate measurements of a fairly static nature it was great... until I accidentally connected 240vAC across the mA range and the internal protection circuit did not work – I sobbed for weeks. I think it is still in my junk box somewhere, as is its replacement, a much cheaper Maplin one, that suffered a similar fate (the fuse was the only re-usable part recovered!). I now own a medium-priced DMM and two cheap DMMs – they all get occasional use only, and who cares if they blow up?
- VTVM: I own several VTVM's – two Heathkit ones, a V-7A dating from the 1950's and an IM11 from the early 1960's, and a homebrew one (actually an FET version), but my favourite is a traditionally-wired, early-1950's EICO Model 221 (photo, right) which uses a 6SN7GT valve. Their very high input impedance is of great value in many applications,



eg. they can be used to check AGC action in a receiver, and their ability to measure very high resistances is useful for capacitance leakage tests. My EICO unit cost \$15 from a local 'antique' store, one Heathkit unit was free as it was faulty (and still is – the printed circuit plays up on the highest resistance range as it had a battery leak at some time in its life and the

electrolyte has soaked into the Paxolin), the other cost \$20 on EBay;

- A dummy aerial: not essential but can make a difference in aligning the RF input circuits – see figure at the end of this article that shows a typical equipment setup for a



receiver re-alignment and the circuit of a broadcast-band dummy aerial (this circuit is installed in the small box in the photo above). For the SW bands I use a resistor of the specified input impedance connected across the aerial connections, applying the signal genny signal through a 220pf, or smaller, capacitor;

- Another receiver of known accuracy: a modern digital-readout receiver (eg. I have a Radio Shack DX-394) and/or scanner can be very useful in checking local oscillator operation and frequency – though not for the ‘purist’ I guess...
- Signal injector/tracer: a small oscillator working in the AF and/or RF spectrum can be installed in a suitable pen-like case and used to inject a signal into each stage of the radio being checked, working towards the RF stages from the AF stages – I have never owned one of these as I use RF and AF signal gennys.
- Oscilloscope: on its own, an oscilloscope can be used as a visual form of VTVM for alignment work, however it really comes into its own when used with an IF sweep-generator or ‘wobbulator’ for both AM and FM receiver IF alignment operations. Scopes suitable for normal servicing work can be bought new for \$700 or so, or for less than \$150 on EBay (I bought a 1990’s dual trace Hitachi 20MHz unit, shown below, for about \$100 that does all I need), having left my trusty ‘Telequipment’ 1960’s scope back in the UK years ago;



- Wobbulator: by providing a swept range of frequencies (say 50kHz) centred on the desired IF frequency, and the sweep frequency used to trigger the ‘scope, the IF response curve can be viewed. This allows for more accurate and symmetrical alignment of multiple-stage IF’s and filters in all sets, and also discriminators in FM receivers. Wobbulators can be bought (often called ‘Sweep Generators’ or similar), but simple ones can be constructed from a handful of components - see Lighthouse articles and References;
- Calibrated attenuator: whereas the non-calibrated attenuator in my Triplet signal genny is useful for ‘backing-off’ signals as the receiver alignment improves during the calibration process, an accurately calibrated attenuator can be used to make quantitative measurements of performance improvements;
- Grid-dip oscillator (GDO): useful for checking the resonant frequency of tuned circuits (eg. to





ascertain the IF in a set where no service information can be obtained) – eg. the ‘Edometer’ (nice but pricey), Heathkit or Millen types (I have a Millen Model 90651-A of late-1960’s vintage, picked up on a local fleamarket – like new, in its case and with all coils all for just \$15 - photo, above).

- Noise generator: tuned circuit peaking can be undertaken (after a fashion) using a noise source, including background ‘atmospheric’ noise, however, a specially-designed noise source and accurate attenuator can be used along with other instruments mentioned here to determine actual receiver sensitivity. I used to use one of these when I was ‘into’ constructing and operating microwave kit many years ago, but no longer have one (see RadCom Volume 82, No.11);



indicate whether it *should* work or not. There is a range of levels of sophistication of testers however, ranging from the simplest ‘emission’ testers, which connect all the grids to the anode during ‘testing’ (eg. a pentode is connected as a diode) to provide a qualitative indication of valve condition (usually having a ‘Replace-Weak-Good’



range on the meter), to the more sophisticated types that apply pre-set DC and/or AC voltages to appropriate grids during testing (these are the ‘dynamic’ testers, though again often with only a ‘Replace-Weak-Good’ range on the meter), to the most sophisticated mutual conductance testers and ‘curve tracers’ that better simulate actual circuit conditions to the point that the valve characteristics may be quantified and compared to published

specifications. For more information on valve testers, check out [http://www.tone-lizard.com/Tube\\_Testers.html](http://www.tone-lizard.com/Tube_Testers.html). I originally bought a Heathkit emission tester on EBay for \$60 that did not do a bad job (photo, above), but then came across a very

- Valve Tester: Certainly not essential, but if you like gadgets with many knobs and levers you must have one(!). Valve testers cannot determine categorically whether a valve will work in the circuit you need it for, but can usually identify really bad valves, eg. they can almost all identify valves with inter-electrode ‘shorts’ (which may not actually be a short, but a high-resistance connection), and whether the heater is working, as well as whether the valve has a reasonable level of emission - sufficient to



nice Precision Instruments Model 10-12 for only \$50 at a radio fleamarket sale at the American Museum of radio and Electricity in Seattle

(<http://www.amre.us/site/>).

This unit provides me with



just the right level of sophistication for my purposes.

- Resistance and capacitance ‘Decade Boxes’: Although these have a limited use in repairing valve circuits and are of more value in ‘experimenting’, it is occasionally handy to be able to quickly select a resistor or capacitor value as a substitute part (though be mindful of the voltage rating of the capacitors and the wattage rating of the resistors contained in the boxes).
- Capacitance/Inductance meter: a ‘nice to have’ instrument that once seemed a bit esoteric (what is wrong with substitution?), but now are relatively inexpensive and are often combined with some limited DFM/DMM functions, temperature probe etc all for around \$100 or so. I purchased such a unit from Knight (Model K-240C, shown right) that has given great service to date (<http://www.knightonline.com/>). Its abridged specs are:

- 3½ Digit, 2000 Count
- DC Volt: 0-20V ±2%
- Resistance: 0-20/200 ohm/2/20/200/ 2000K ohm/20/200/2000M ohm ±0.3%
- Capacitance: 0-200P/2/20/200nF/2/20µF ±2%/200µF to 200mF ±3%
- Inductance: 0-200µH/2m/20m/200mH/2H/20H±5%
- Temperature: -20-500C ±2% 500C-750C ±3%
- Capacitance: 0-200P/2/20/200nF/2/20µF±2.0%
- Frequency: autoranging up to 15MHz ±0.1%
- Continuity
- Diode test function
- Signal output function
- 24VDC/24VAC overload protection
- Continuity



## Conclusion

I honestly believe that anything more than the above 'practical' list is really overkill for repairing or maintaining the Eddystone range of valve receivers unless accurate, quantitative measures of performance are desired. If you are just starting out, first invest in a good quality 20,000 ohm/volt analogue multimeter (and maybe a cheap second one), then a reasonable quality RF signal genny, which will usually come with an audio (modulation) tone output that can be useful, then add the rest as you have opportunity or feel the need, starting with a VTVM.

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

## Some Useful References

- Radio Communications Handbook, RSGB (eg. 4<sup>th</sup> Ed, Ch. 19, 6<sup>th</sup> Ed., Ch. 15)
- Radio Amateurs Handbook, ARRL (eg. 31<sup>st</sup> Ed. Chapter 21)
- Elements of Radio Servicing, W Markus and A Levy, 1955, 2<sup>nd</sup> Ed. (Esp. Ch. 4 to 7 inc.)
- Radio Servicing: Theory and Practice, A. Markus, 1948 (Esp. Ch. 13)
- Radio and Television Receiver Troubleshooting and Repair, Ghirardi & Johnson, 1952
- Radio and Television Receiver Circuitry and Operation, Ghirardi & Johnson, 1951
- Practical Radio Servicing, W Marcus and A Levy, 1955, (Esp. Ch. 6)
- Radio Servicing Instruments, EN Bradley, 1953
- Getting The Most Out Of Your VOM, T Jaski, 1960
- Latest instruments For Servicing Radio-Television, Coyne Radio School, 1956
- Amateur Tests and Measurements, LM Dezettel, 1969



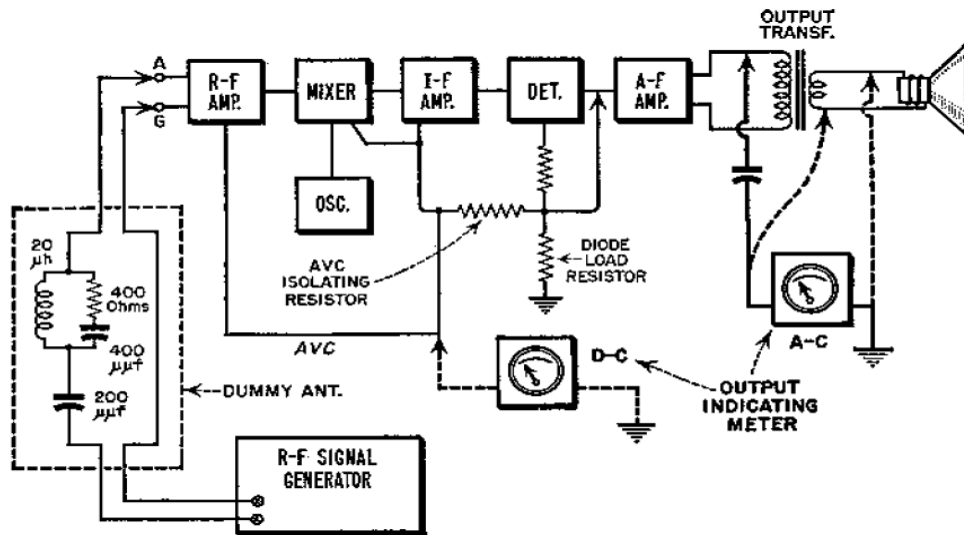
My first multimeter – battle-scarred, but still providing service after 36 years





The 'not-so-superior' *Superior Instruments* signal genny

- Some web-based articles/resources on some subjects covered in this article include:
  - <http://www.tone-lizard.com/>
  - <http://www.oscilloscope-tutorials.com>
  - <http://pcbunn.cacr.caltech.edu/jjb/Precision/TubeTesters.htm>
  - <http://users.rcn.com/fiddler.interport/EICO.HTM>
  - <http://archive.org/web/20040208014604/www.circuitarchive.fsnet.co.uk/hath.htm>
  - <http://www.isquare.com/millen/millen-page.htm>
  - <http://bkprecision.cpm>
  - <http://triplett.com>
  - <http://www.knightonline.com/>



Typical test equipment setup for re-aligning a receiver: note the circuit for a broadcast band dummy aerial to the left. The 'indicating meter' on the AVC line should be a very high-impedance type, eg. VTVM or DMM (Figure from Ghirardi & Johnson)



A museum piece of test equipment in my collection – a *Supreme Model 551 Analyzer* dating from the 1930's: it came complete with a full set of pre-WWII valve base adapters and is intended to be inserted between the valve and its base, measuring current and voltage conditions of the stage being analyzed – yours new for \$38.95 in 1935, I paid \$20 in 2005. I repaired its circuits but have never tried to use it as intended! This type of tester was very popular in the 1930's but lost favour following WWII.