The Bulletin

ol. 38 no. 4 Winter 2013

The BVWS Spares Dept

DeoxIT D5 contact cleaner / lubricant £15.00 aerosol can. Not cheap – just the BEST. Available at all BVWS events or by post for an additional £3.50

New manufacture high quality metallised polyester film capacitors to replace all old paper types in vintage equipment. Ideally sized for re-stuffing

All capacitors are 630 Volt working
All prices are for packs of 50 components and includes postage and packing

0.001µF	Price band A	0.022µF	Price band B
0.003µF	Price band A	0.047µF	Price band B
0.0047µF	Price band A	0.1µF	Price band B
0.01µF	Price band A	0.22µF	Price band B

Price band A is £25.50 (inc postage)
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Electrolytic smoothing capacitors, standard 'old-fashioned' size, 500 Volt DC working

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16/32µF for DAC90A £9.00 each
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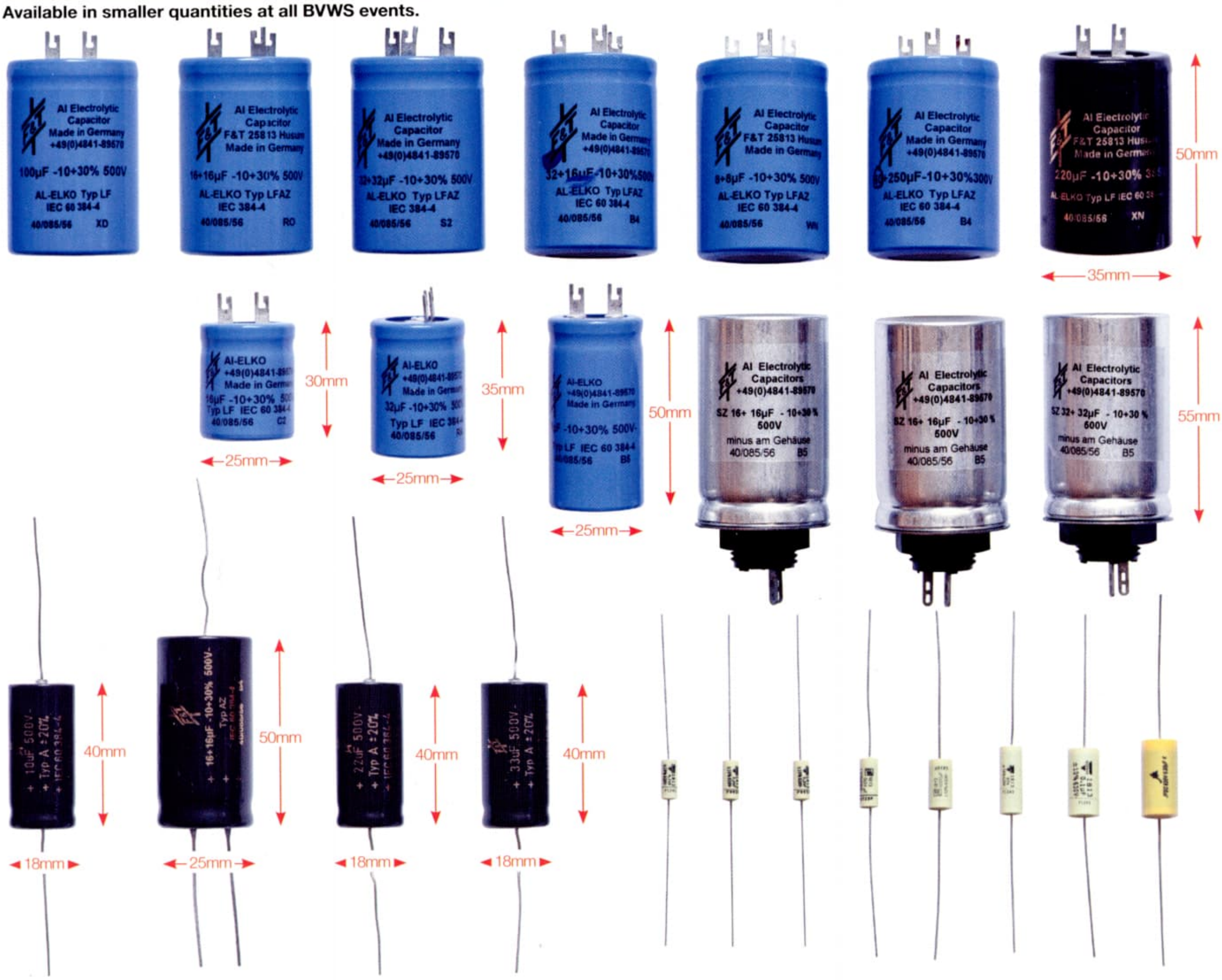
NEW smaller 25mm can types for re-stuffing original Single electrolytic capacitors

8µF, 16µF, 32µF, 500Volt DC working £5.00 each

Postage and Packing 1 – 4 caps £3.00 5 – 8 caps £4.50

All prices quoted are for BVWS members



For non UK addresses, please contact Mike Barker for prices, (see below). All orders should be sent (with payment made out to BVWS) to: Mike Barker, Pound Cottage, Coate, Devizes, Wiltshire, SN10 3LG. Cheques payable to British Vintage Wireless Society. Please allow 14 days for processing, but usually quicker! The above capacitors are supplied as a BVWS member benefit. Anyone found to be reselling these items for profit will be expelled from the Society

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Front and rear cover: A selection of the Carl Glover wireless collection.

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Edited by Carl Glover. Sub–Edited by Ian Higginbottom
Proof-reading by Mike Barker and Steve Sidaway

Contents

From the Chair

No DVD this year!

That's right; you have not been missed out. There is no DVD this year!

At the last Committee meeting it was decided that we would not include the usual DVD with the Winter Bulletin in an effort to reduce our overall costs this year. We are mindful that we have been depleting a cash reserve in order to keep membership subscriptions and event entry costs as low as possible. This has now reduced to a level we feel we should not go below to maintain a healthy reserve to operate from. The DVD costs us about £3,200 per year to produce, manufacture and post out, so this was a large sum to be able to save. This does not mean we will not have any more DVDs in the future, but just not this year. The good news is that the BVWS Calendar for 2014 is still affordable and you will find yours enclosed with this Bulletin.

Changes to The Bulletin

Another saving we have made is to reduce the Winter Bulletin to 64 pages which means we do not have the extra expense of the 'perfect binding' process which adds considerable cost. However in doing this we are able to increase (when content allows) the other three Bulletins up to 64 pages at only a tiny cost which is spread throughout the year. So in fact each year you will actually get more Bulletin pages, but at a smaller total cost to the Society.

The biggest cost to the Society after the actual Bulletin production and printing is postage. Amazingly the Society postage runs at just over £12,000 per year. So we have been looking at ways we can reduce this cost. The Bulletin changes already mentioned will reduce the Winter Bulletin weight and so to the postage, but we will be changing the way we send out the Bulletins next year which is estimated by the printers to save us at least another £1500.

No changes to Harpenden

At the last Harpenden meeting I announced that we would be actively looking for another venue due to the high costs of the Harpenden hall and the service, or lack of it, we have been receiving for our money. We have been out and about to several other venues in the general area, but none of them have proved to be either big enough, in a suitably close location for road and rail etc., been available on Sundays or have just not been a significant enough saving. We will continue to look in a wider area, but until further notice here in the Bulletin the Harpenden event will remain as it always has done. All dates for next year are booked and confirmed and we will seek a better service from the hall management.

New committee member

At the last Committee meeting Mr. Greg Hewitt was co-opted onto the Committee of the BVWS as an ordinary member. Greg has been helping out at the Harpenden and Wootton Bassett Auctions for some time and is a keen radio and TV collector, so you will probably have seen him, but not known his name. He was caught on camera in the Bletchley Park display pictures later in the Bulletin.

We would formally like to welcome Greg to the Committee where we are sure he will be a very great asset to the Society with his business and financial background and we are very lucky to have him join us.

It has been a very busy year for myself and the Committee, getting out to all of the events, and participating in displays. Then there are the auction activities which continue to keep us rushing all over the country. I cannot say just how many tons of equipment that we have moved, but it is certainly many van loads. We have clambered through peoples lofts, in sheds, down cellars and emptied garages. Where does it all come from? However it is the commissions from these sales that make it possible to give you, the membership all the other extras over the many years gone by. So remember, when you want to sell that radio, TV or even an entire collection think of the BVWS first.

And Finally I would like to thank all our Auction Helpers and events helpers for their dedicated work throughout the year. We could not do it without you!

I wish you all a very Merry Christmas and a prosperous New Year. Mike

Restoring an Integra, model 36, from 1935 by Gary Tempest

I won this inexpensive radio at auction, years ago in my early days into 'ole radio' and of going to Harpenden. It's more than a decade since and 'oldies' will remember Jim Taylor always having a stall by the door. He looked at me quizzically when I told him I had won something with odd valves and it was French. For all this time it has been in a cupboard. Over the years I thought about selling it on or doing something with it. The something was going to be a lengthy restoration as mechanically it was poor. In the end I decided it was really a very nice radio and worth my effort. It has an attractive cabinet that had no chips or cracks, which is one of the reasons I bought it. It's surprising that the cabinet is undamaged as the Bakelite is very thin being only 3-4mm thick in places.

It's a 5 valve superhet from 1935 that has some unusual features. All the control knobs are on the side and that for the 3 wavebands (LW,MW and SW) turns the switch and another turns an internally illuminated celluloid drum with the station details. This has been printed on the inside and so there is no letter loss although there is a little UV degradation on the MW scale.

An internet search didn't come up with a circuit diagram which was going to make it more difficult. Adding to this it had been 'got at' by someone who had done strange and incompetent things to it many years ago. One French website has a picture of another and their forum led me to a member, Pierre, who was kind enough to remove the chassis from his and take some pictures. It's quite different underneath with the components laid out on tag panels whereas in mine they are just strung between valve pins, earth points and a few pieces of tag strip. What was useful was the chassis topside view showing the layout of the stranded dial wire used for the dial pointer.

My chassis had been daubed over with now aged silver paint. This looked like it had been applied with a toothbrush, and went over the sides of valve holders, screws, and even partially over input and output sockets. This would have been understandable if there were obvious signs of rust but initially I couldn't see any evidence of that. Later it got even more mysterious as when I removed the IF transformers there was the same brush stroked paint. It must have been the previous would be repairer who had gone further than I would have thought likely.

But now for some more good points: it seemed to be all there but the shadow meter, again daubed with the silver paint, was held to the top of an IF can with a piece of Meccano and wire straps. The speaker looked and was good and all the valves tested well on the AVO tester. As usual the metalizing, on the RF valves, was poor and I re-sprayed these with Electrolube Screening Compound, with a resistance of less than 1 Ohm, as described in the Bulletin 2011, Winter. The metalizing is a grey colour so this was spray-painted the appropriate gold before applying computer generated transfers with the valve type.

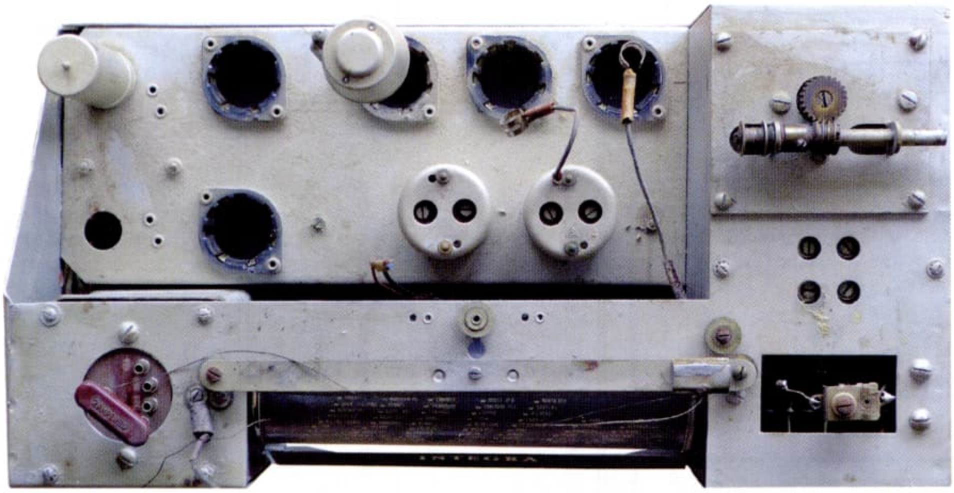
The strip down

It was obviously going to be a major strip and I intended to flat the chassis and re-spray with silver Smoothrite.

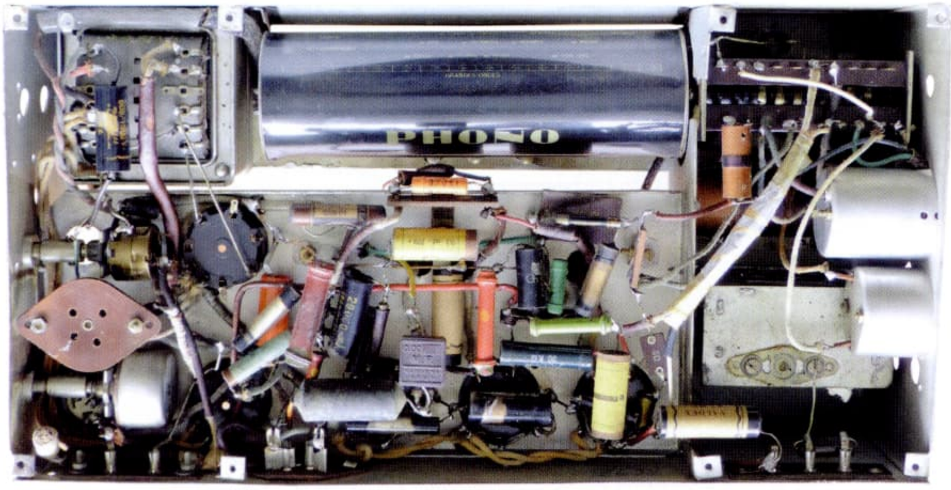
As usual I took lots of photographs before and during this operation although to me this is never enough. Images always hide things and so I make drawings in a notebook. Occasionally I break out and make diagrams on loose pieces of paper but this I've found dangerous as they can get mislaid: far better to use the notebook, although I occasionally stick loose work into it. Sometimes A3 size is needed for doing a layout diagram but fortunately this size is harder to lose.

A great tip when removing wiring is to mark the often faded and dirty wires with a small (around 3mm) ring of coloured heat-shrink sleeving. This is of course added to the layout diagrams. My notation is X/Y/Z where X is the basic wire colour, Y is a stripe if there is one (I omit this character if there isn't a stripe) and Z is the heat-shrink colour. So an example would be YL/RD/BL and only two letters are needed to describe normally used colours. Sometimes BN won't be enough and I would write out BEI for beige.

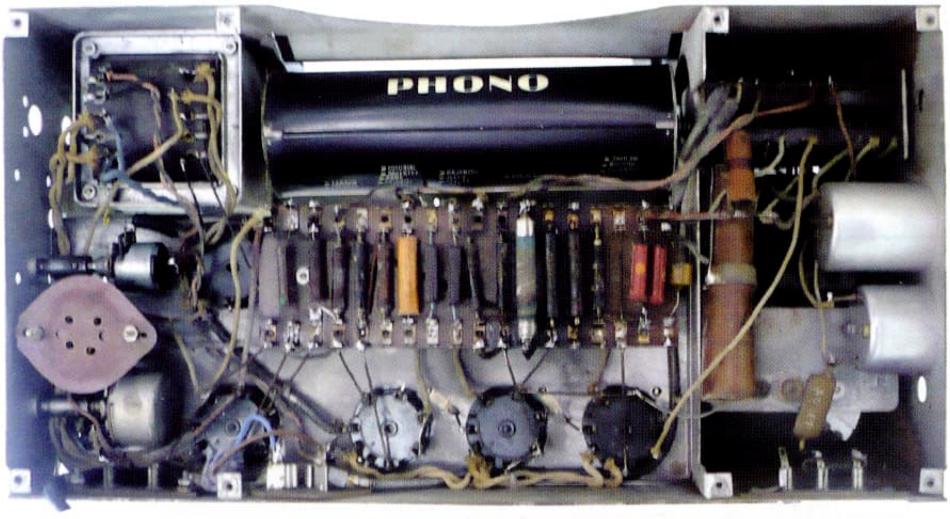
Occasionally the wiring can be tight and it's not possible to be clear where a wire goes at an early stage. Rather than unsolder it from a tag, whilst being unsure and progressing cautiously,



The original unrestored chassis



Underneath the original unrestored chassis



Underneath Pierre's Integra 36 chassis

it's better to 'chop' the wire and mark both pieces unambiguously with heat-shrink rings. The wire can easily be replaced whereas it can be difficult to get out of a bad case of confusion.

For the Integra the mechanical construction is quite complex but breaks down to an RF and oscillator front end with the rest of the electronics being built up on a shallow tray bolted between side-pieces of the main chassis. Nothing is new and this is a very early example of making things as sub-assemblies. I now found the likely reason for the unrestrained silver painting: at some time one of the electrolytic power supply capacitors, probably of the wet variety, had sprung a leak and eaten off the plating around it and across the chassis tray. This had been replaced with a single can containing two capacitors.

After I had removed the tray I drew a pencil layout and circuit diagram and it seemed conventional with just a few things I didn't understand. However, at this stage, I was much more interested in the RF and oscillator parts.

The first thing to be removed was the tuning gang and its worm gear drive. It was all in good condition needing only a strip and clean before re-assembly with a lot less grease than had been previously applied,

The RF and oscillator coils, with tracking and trimmer capacitors, and switching looked complex and did indeed take a lot of time fathoming and getting down on paper. As usual I started with hand drawing but soon got tired of the difficulty of editing and committed myself to CorelDRAW. The cam operated switching is of a leaf design but with separate pointed and flat contacts fixed into both parts and is well made. It can be described as 4 position, 14 pole, although at first glance you might think it was 20 pole being as the wipers and contacts are in banks of 10. However, on one side only 4 wipers are fitted and the other positions are just tag points. Soon I needed to separate the trimmers and trackers and the MW and LW oscillator coil tube from the switch. Once this was done, and with yet another diagram, I could remove the coils and start to understand them. This was actually easier than in many cases and with the help of a pen torch and a dentist's mirror, to look inside the tube, I was able to work out the coil connections.

Once I had a really clear layout diagram it was not difficult to convert it into a circuit diagram. I started with a hypothetical case of no switches being closed and then created specific diagrams for LW, MW and SW in order to understand it. There was no need to make one for the Phono position as here only Cs1 and Cs2 are closed with Cs3 open.

The RF and oscillator circuit

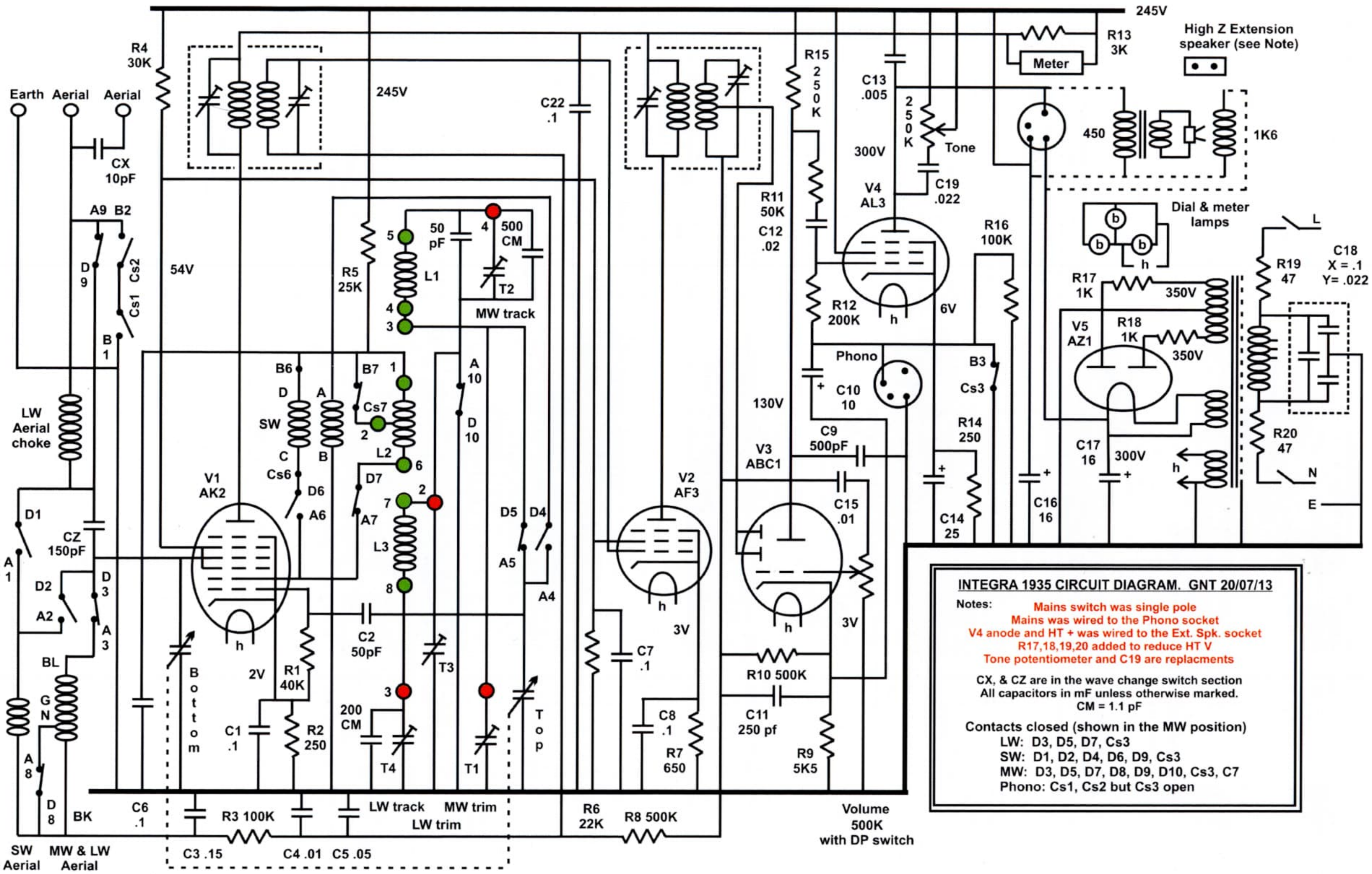
The chassis was wired with the RF tuning gang connected to switch contact A3 such that it wouldn't have worked on SW. Also a variable trimmer capacitor had replaced CZ shown on the circuit diagram.

V1 uses its first two grids in a feedback oscillator configuration with grid 2 acting as an anode. It was easy to understand SW and MW but the LW seemed strange with effectively the MW tracking components in series with its own. I wired a 'lash up' of this part of the circuit, using bench power supplies, and both wavebands tracked in an approximately correct manner. This was assuming an IF of around 470 kHz. Obviously the MW alignment is done first and then not touched when the LW is tackled.

The rest of the circuit diagram

This is conventional with a few differences (well it is French). A thing I hadn't seen before, but spotted by my friend and BVWS member Peter Lankshear, were several capacitors marked as "CM" (for centimetres). This relates to an earlier measurement system than the SI one in use today. In a text book (Morecroft, "Principles of Radio Communication") it said to convert to pF divide by 0.9 or roughly add on 10%.

The shadow meter (tune for the least shadow) is in the anode current feed to V1 and V2. When the AVC has throttled both valves back to the maximum the current must be at a



INTEGRA 1935 CIRCUIT DIAGRAM. GNT 20/07/13

Notes:

Mains switch was single pole
Mains was wired to the Phono socket
V4 anode and HT + was wired to the Ext. Spk. socket
R17,18,19,20 added to reduce HT V
Tone potentiometer and C19 are replacments

CX, & CZ are in the wave change switch section
All capacitors in mF unless otherwise marked.
CM = 1.1 pF

Contacts closed (shown in the MW position)
LW: D3, D5, D7, Cs3
SW: D1, D2, D4, D6, D9, Cs3
MW: D3, D5, D7, D8, D9, D10, Cs3, C7
Phono: Cs1, Cs2 but Cs3 open

minimum and the radio is on tune.

A diode detector and AF pre-amplifier follows the IF stage, with some fancy decoupling for the AVC line.

The line up is completed with a new, at the time, high gm pentode (9.5mA/V) output stage and full wave rectifier.

The rebuild

Before the sub-chassis could be treated and re-sprayed all the components had to be removed. The wiring was extremely crude, with horrible twisted connections and blobbed cold solder joints that fell apart when items were moved. Many items were not suitable for reuse including the crude tag strips. I used new and additional ones for these and spent time doing full size layouts on paper first. My aim was to simply achieve a period look.

As always it was re-stuff the wax paper capacitors which needed new, PC created, paper labels. Whilst doing this I found something else I had not come across before. The tubes that I had taken to be some sort of early clear plastic, were in fact glass. I saved any good micas and resistors but many of these had to be replaced (more on this later).

The tone control was unusual, being a switch that connected sections of an internally wound wax paper capacitor in parallel as it was rotated. It was disconnected and not fit for further use. I investigated the possibility of putting tiny ceramic components inside the original housing but this wasn't possible. It was replaced with a potentiometer and a capacitor in a standard top cut configuration.

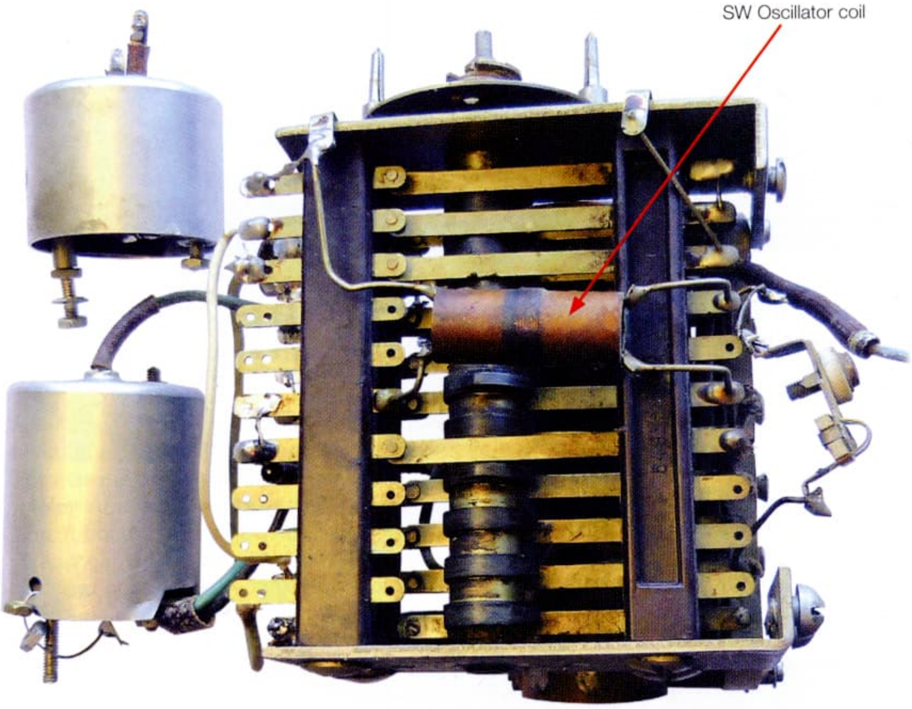
The IF transformers and the MW / LW aerial coil are the earliest example of iron dust 'pot core' construction that I have seen. They probably used these to get the highest possible Q. The coils also had old solder joints to PVC covered fly wires, presumably replacements by the erstwhile repairer.

The LW aerial choke was another surprise being sectionalised with electrostatic shields along its length. Most makers would have used a machine wound pie type coil. The partitioning disks and labour intensive winding would have made this relatively expensive. And what does it actually do? More on this later.

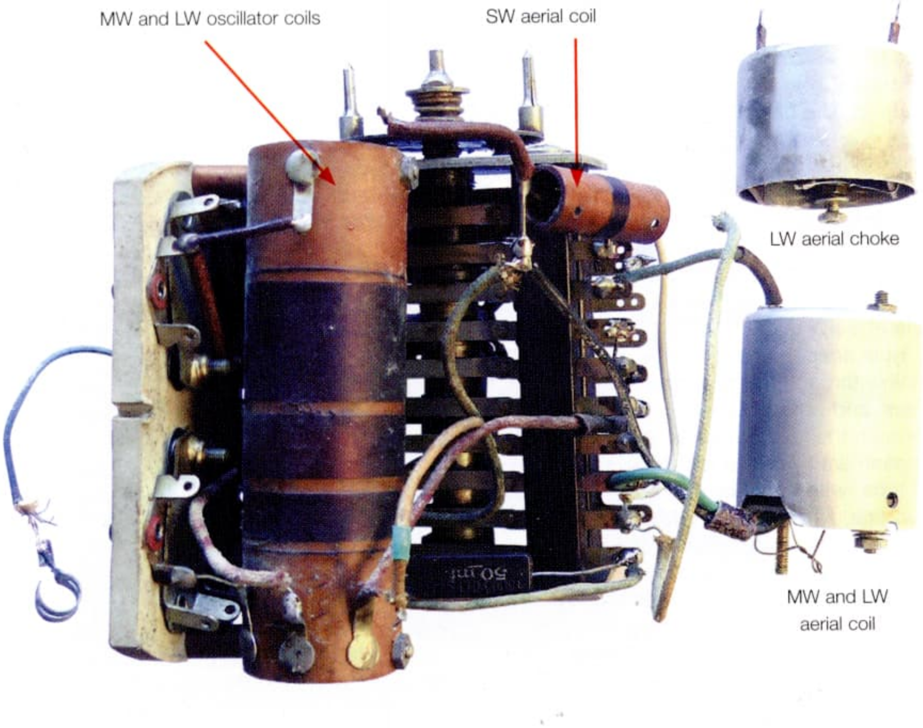
Another thing that I didn't come up with an answer for was why CZ was shorted on SW. The Ct8 side contact valve bases, which when I started I had hoped not to remove, were really filthy and initially were given a soak in cellulose thinners, as much as anything to remove the old silver paint. But they still didn't come up clean, with lots of mud coloured dirt in the interstices, so they all went in the ultrasonic cleaner, with a dilute proprietary solution called Micro-90. This really worked and they came out spotless. After a through rinse I left them on the central heating boiler to fully dry out. Along with all the previously riveted items they were replaced with nuts, bolts and shake-proof washes. An interesting thing, to me anyway, was that each had a different moulding number ranging from 16 to 21. I can imagine all the moulds in use as they made production runs of thousands in the days of mass production of radios.

The wave-change switch just fitted in my ultrasonic cleaner which removed a lot of grease and dirt. Finally I used switch cleaner and small brushes.

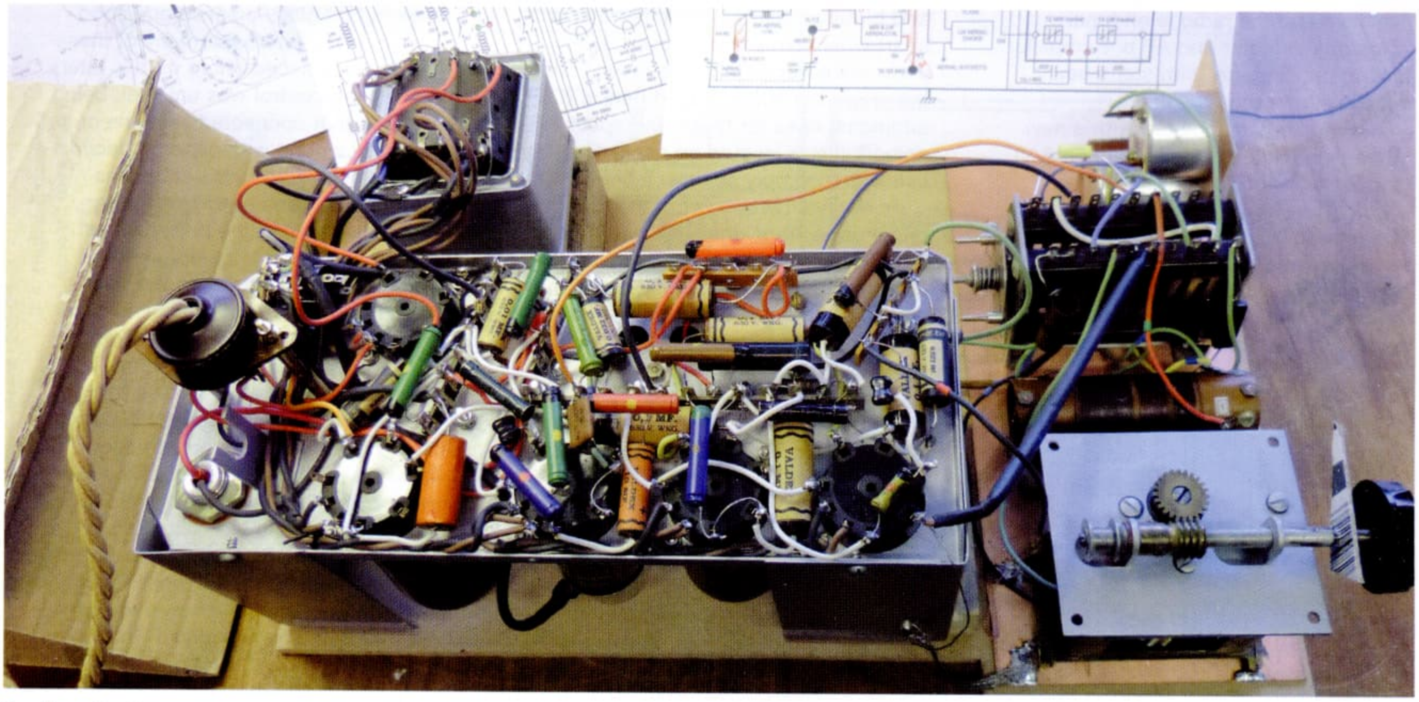
The shadow meter was clearly a non-original replacement but after taking it apart and cleaning and adjusting the moving vane it worked well. After repainting all I needed to do was to devise a method of mounting it. This was actually quite tricky as the carriage, for the dial pointer, has to run over a securing screw for the bar that it tracks along. It also has to clear the meter bracket fixings. Then of course the meter has to end up in the right position relative to the cut out in the cabinet. So the chassis was in and out of the cabinet many times and I actually made two brackets before I was successful.



Bandswitch and Shortwave oscillator coil



Bandswitch and coils


Breadboard testing

A new way, to me, to re-stuff the electrolytics.
This isn't original; I remembered seeing it years ago on a web site but had not tried it.

It would have been easier with a lathe as it requires cutting the can, near the end, and in one case another cut to shorten the can to make them look the same. Of course if using a lathe it would be best not to quite penetrate the can but gently complete the cut with a small hacksaw.

Not having this luxury a few rings of masking tape were used as a support for a sharp junior hacksaw blade. The idea is to cut very close to the end of the can to effectively make a replaceable lid.

Having done this, it then needed heat and a large woodscrew, held in a vice, to corkscrew out the original insides. In one case the can had been pitch filled and it needed soaking a couple of times in cellulose thinners to clean this up.

Cutting the can in this way doesn't ensure really square ends and so needed careful use of a fine file and a set-square. The 'lids' were simply flatted on a file and then emery paper. I couldn't remember, in the web site description, how the lids were attached but decided to drill a 3mm centre hole for a bifurcated rivet. When this was inserted the legs were bent outwards.

New caps were made up with fly wires to go through the holes in the can bushes. Once inside the gaps around them were packed with tissue before back filling with hot melt glue. The cans were filled to the top (about 15mm) and then the lids carefully put in place ensuring that the rivets were pressed down into the glue. Note: I didn't block the bottom bushes as it seems prudent to allow for pressure build up if ever the capacitors start to expire.

Hot melt glue was chosen rather than say epoxy, as with the glue, disassembly later would simply need a heat gun. Hot melt glue is about 100 deg. C and with capacitors rated for use at higher than this I didn't think they would be harmed. Capacity and leakage were unchanged afterwards before a prolonged HT soak test.

It makes for a neat result and with experience (and ideally a lathe) the join between the lid and body could probably be made even less visible.

The capacitors were cleaned and polished with #0000 wire wool before spraying with shellac, decals and a final spray of satin lacquer.

Making period looking resistors
As the restoration was being done during the winter months I had plenty of time on hand. So I thought I would try to disguise modern miniature items rather than taking the temptingly easy route of just soldering them in place.

My local model shop had Styrene tubing of various sizes and one in which the end caps from 20mm glass fuses were a snug fit. The best way to remove these was to soak them in cellulose thinners overnight and then use stout gloves to twist them free. Of course I was going to use the highest rating component (1W), that would fit inside the tube only for those resistors where the power dissipation was very low (but there was one at 5mW and another at 30mW

How does the heat escape? I suppose mainly through the tube and the end caps, and possibly a little via conduction through the lead out wires. As an experiment I put one resistor in a piece of tube, with the ends stuffed with cotton bud tips, and powered it from a bench supply to dissipate 100mW. It was left 24/7 for many weeks and when removed was warm but with no sign of excess heating. Its value was unchanged.

For a few resistors the dissipation would be too high and these were soldered in place sans tube but where possible partially hidden.

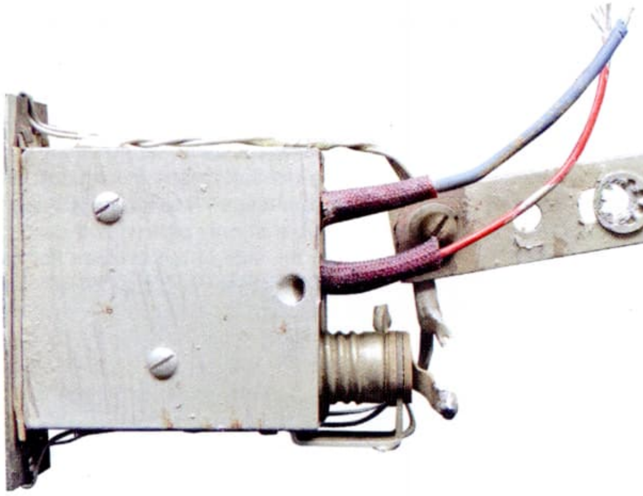
As I was making several resistors I came up with a simple cutting jig making it easy to get square ends on the tubes. These then had 3mm long slots cut at each end to fold out the wires from the resistors. I didn't want to use glue for the end caps: it could be a disaster if one came free in years to come. So I soldered a couple of turns of 22 SWG tinned copper wire around them. The inner end of this, once the cap was in place, was pinched around the resistor wire and quickly soldered with a small bit.

All that remained to be done was painting the tubes with model paints to the standard body, tip and dot colour code.

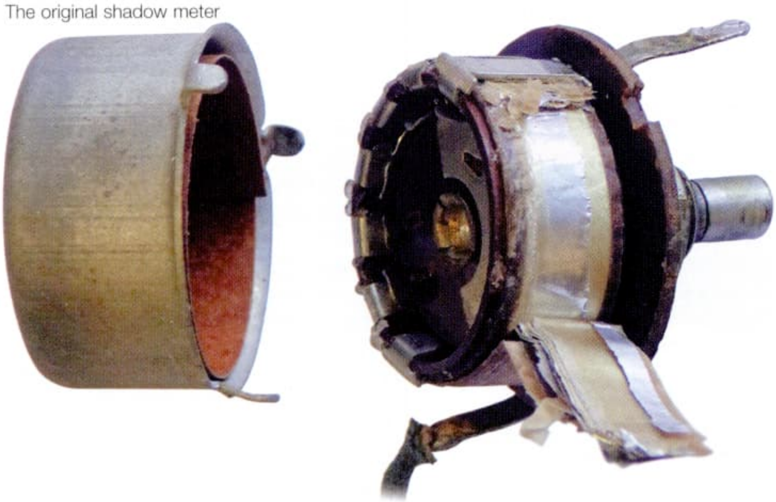
The first powe-up, IFs and oscillator
I didn't want to rebuild into the main chassis, which is quite difficult to do, until I knew that the sub-chassis and RF, switch and coils (RF end) made a functional and reasonably performing radio. So the items were connected in bread-board fashion with the RF end being built up on a piece of copper clad circuit board acting as a ground plane. Actually, I started without the RF end at all as I wanted to set the IF's and with it in place I couldn't tilt the sub-chassis on end to get at the trimmers.

So, after carefully measuring that there weren't any HT shorts, power was applied and thankfully voltages seemed reasonable for now. To set the IFs I terminated V1 grids, 2 (oscillator) and 4 (aerial), and injected the signal generator into grid 4. The lowest frequency I could set them to was around 480k c/s and that was with some of the trimmers screwed hard down. Setting them somewhere near mid range gave close to 500k c/s which was suspicious.

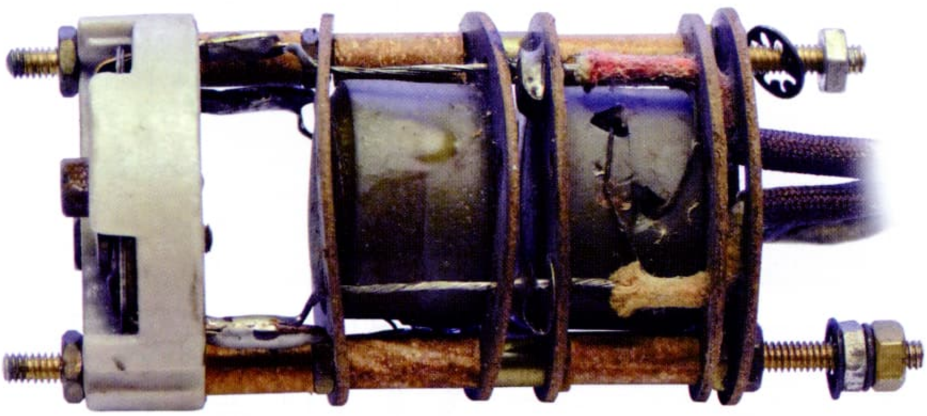
Anyway, pressing on, the RF end was connected and signals were received, albeit with signs of instability. Clipping the oscilloscope X10 probe on the insulation of V1 grid 1 wire, for minimal loading, showed the oscillator going into



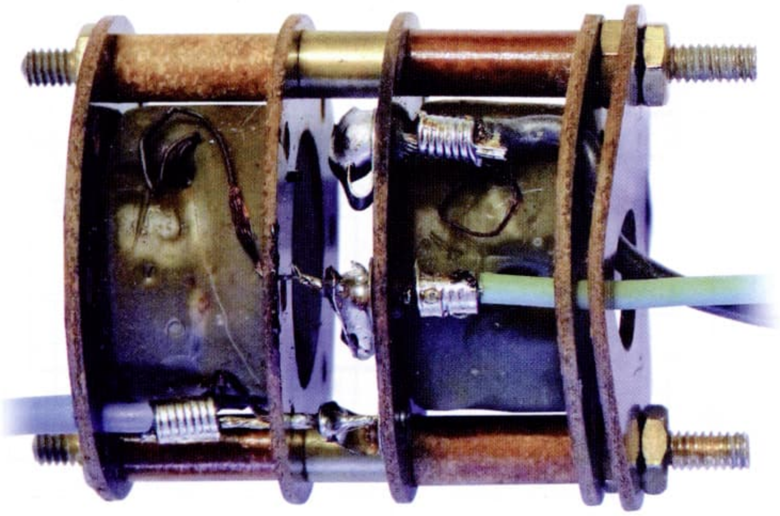
The original shadow meter



Tone switch with integral capacitors



Inside an IF transformer



LW and MW aerial coil

a frequency doubling mode, with plops from the loudspeaker, as the gang was opened. The leads in this setup are longer than when the components would be in the chassis. A cure at this stage was to screen the connection to grid 2. There's a little déjà vue here as the chassis picture of the set, as worked on before me, shows this lead wrapped in silver foil.

I wasn't bothered with SW yet (although this band was working) or too much concerned with aerial coil tuning. There isn't much of this with the chassis having only one trimmer on the tuning gang. Also, I hadn't come up with a value for CZ yet and so was feeding the signal generator, via a 120K resistor (so as not to load the aerial coil) and a 100pF capacitor to grid 4 of V1.

I was mostly interested in the tuning and tracking for MW and LW. These weren't correct and the top end of the band was at too low a frequency at minimum trimmer settings. The obvious thing to do was to lower the IF frequency.

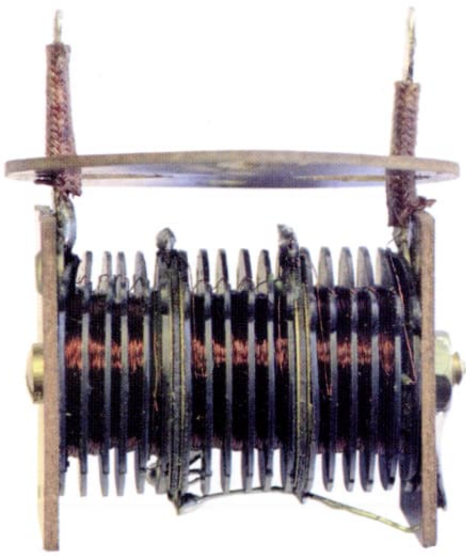
So having decided to concentrate on the MW band I made a pointer for the slow-motion drive of the tuning capacitor such that I could measure the aerial and oscillator tuning at an arbitrary 7 points of the gangs from fully open to near closed.

To measure the aerial tuning I used the signal generator and a counter with the frequency changer V1 converted to an un-tuned RF amplifier. A resistor of 22K was used instead of the IF transformer primary and as the 'scope monitoring point. The oscillator was stopped.

To measure the oscillator frequencies, at the same pointer positions, I clipped a X10 'scope probe to the insulated wire of V1 grid 2. With only a pF or two of loading the counter was still able to read the frequencies reliably.

Looking at the results an IF of 465k c/s seemed to be a reasonable choice. I was lead a little towards this anyway from some information on a French Clarville set, from 1937, that used the same valve line up and had that IF. So I went ahead and added some extra mica caps inside the IF transformers (see note below).

Fortunately, the IF screening cans



LW aerial choke

could be removed simply by undoing the pair of top nuts to fit the extra mica capacitors inside. Once this was done and the transformers aligned, using the same method as I started with, then I could recheck tracking. This was nearer to what I expected from reading the wavelengths on the tuning drum. Of course I had no idea at this stage whether the tuning gang, dial cord and pointer covered all of the range shown on the drum that was larger than the now accepted MW and LW bands.

Whilst I had things set up I tried plate bending, of the slotted sections of the outer gangs, of the tuning capacitors to optimise the MW tracking between aerial and oscillator tuning. I found this a tedious business but did make improvements so the effort was worthwhile. Once the gang is back in the main chassis this isn't possible.

So the radio was now working on all bands with good sensitivity and very selective tuning. What the IF bandwidth was I didn't know at this stage but thought it must be narrow as the IF trimmers tuned with knife edge sharpness. It would have been really pleasing if it hadn't been for so many whistles across the MW and LW bands. This was most marked on weak stations and could be improved with careful tuning but not eliminated.

I had another e-mail chat with Peter, who has years more experience of all things radio than me and he made some suggestions, none of which improved things but were stored away for later. My feeling was that I had taken the breadboard to its limit. Hopefully, when all the parts were back in the main chassis, with shorter leads and more screening, then it might behave better.

Note: I was primed that the IF transformers might need added capacitors as I remembered an article by deceased but not forgotten, member J.D. Nuttall where he had done this and concluded that it was necessary due to a fall off of permeability and hence inductance with age. In his case the transformers in question were tuned by ferrite slugs and didn't use the pot core construction of the Integra.

The dial drum

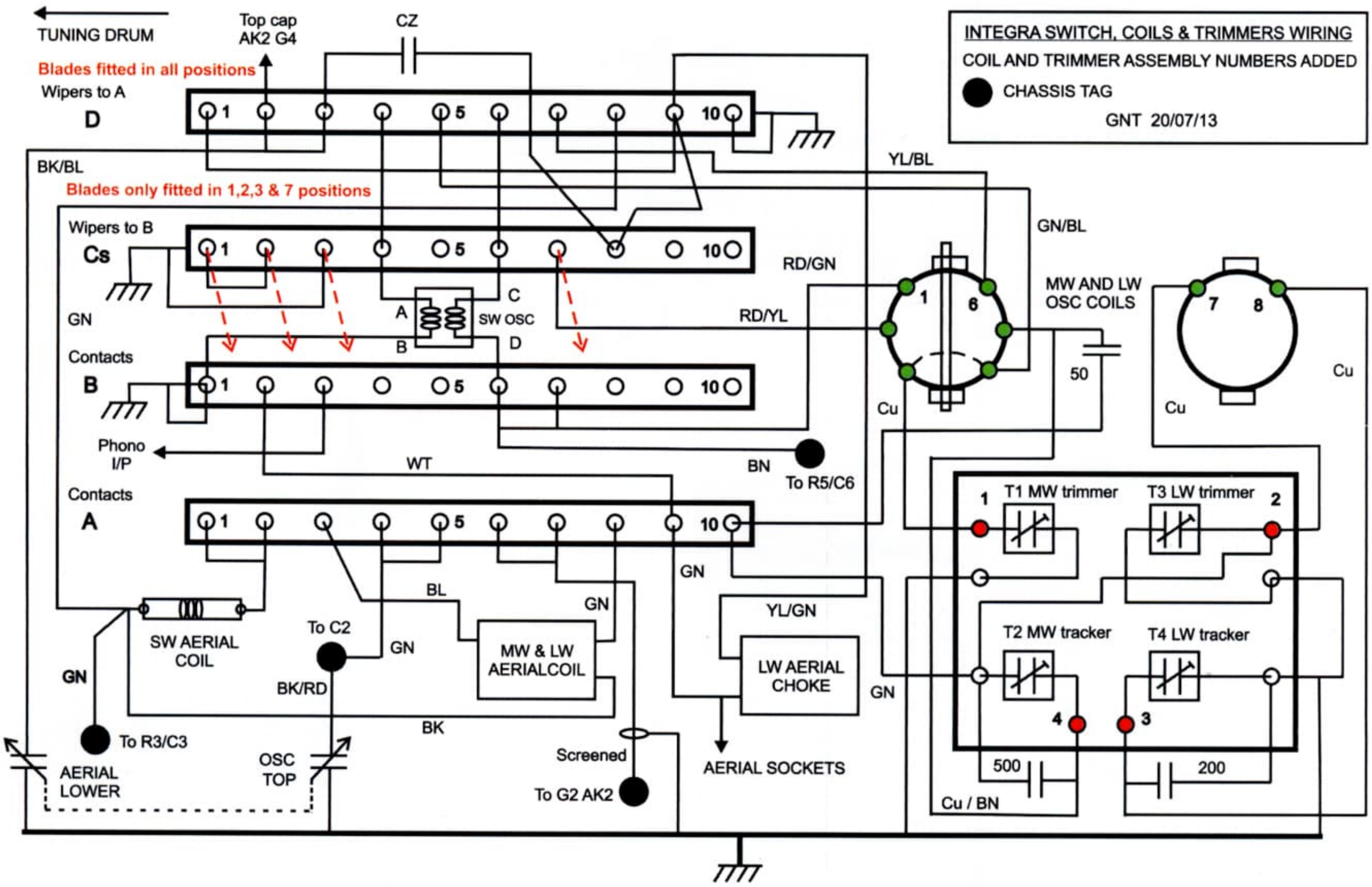
This needed sorting as it had been got at and the internal wiring and one of the bulb holders needed replacing. The method of putting the live side of the heaters to the end plate was also an old bodge and so I made a new brass bush soldered by a flange into the end plate. Turning inside this I used a shouldered brass pin that mounts to a spring steel bracket carrying the power. This, originally wrapped in insulating tape but now heat shrink tubing, is insulated from the chassis by Tufnell bushes. Earth gets to the other end plate by being turned by two tapered pins on the switch assembly. The existing bulbs, possibly changed to 6.3V types later, were well under run, and still good, so were left to continue on.

I expect it was hoped that the power bracket could be sprung back, with just enough room between it and the mains transformer, to remove the drum for changing bulbs. I tried this and to me it was impossible. So not wanting to remove the mains transformer, at some time in the distant future, because of a bulb working loose I put a dab of nail varnish on the threads before screwing them back in.

I was disappointed with my drum mounting method as too much effort was needed to change wavebands with the small knob that only protrudes a short way from the side of the cabinet. For this reason and another, I was going to take the mains transformer out again. So I took the opportunity to shorten the bush in the end plate (and the corresponding pin) to reduce the loading by the spring steel bracket.

At the same time I refitted the "INTEGRA" name plate and the logging scale strip which should have gone in before the dial drum. These strips, made from thin brass with embossed detail, have turned over ends and were additionally secured with adhesive to the chassis. How were they made? They appeared to be etched and black anodised rather than stamped as the back of the strips were completely flat.

They were both bent and dented as the edges overlap the chassis parts they are attached to. They are easy to bend and damage unless a lot of care is taken when working on the chassis. They were not good enough to go back as they were. I then spent a ridiculous amount of time and not thinking them salvageable went to CorelDRAW. New ones were created and printed on best quality photo paper, with Epson inks and sprayed with clear lacquer. The idea was to attach them with 3M Photo Mount (ph



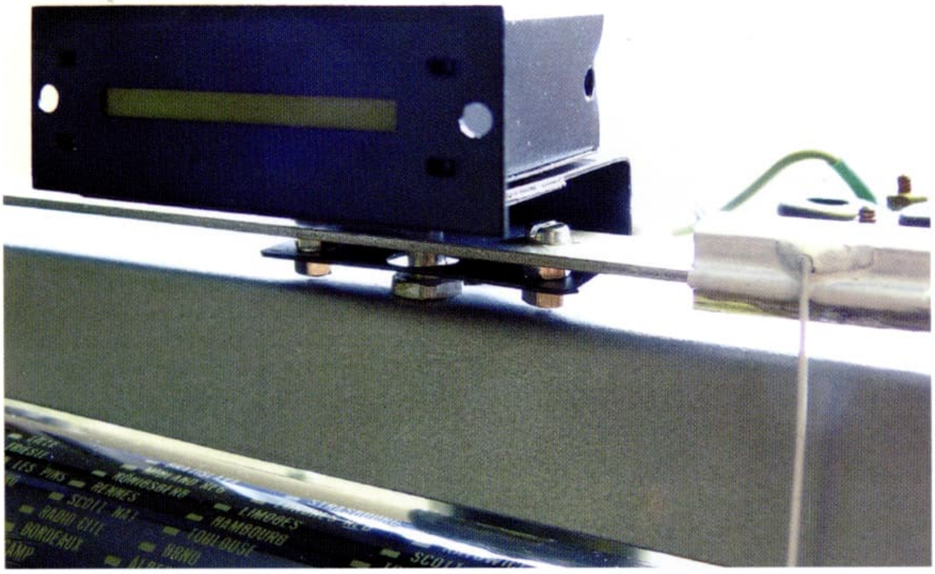
Integra switch layout

Neutral for no yellowing). But in parallel, I addressed the originals straightening the edges and filling the wounds with car body filler before spray painting satin black. Once the paint was well hardened the raised detailing was exposed with #0000 wire wool and beeswax before a final lacquer coat. Although not perfect, and they could have been better had I not started flatting them down to fit the photo-paper version (annoying!), I judged them to be good enough.

All parts back in the chassis

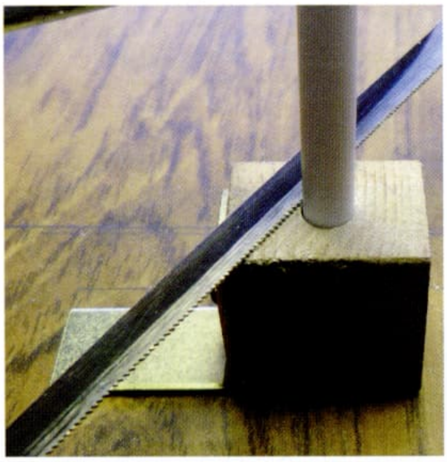
Initially results were little more impressive than when the radio had been built as a breadboard. As then, the oscillator was going into spurious modes including doubling so I decided to reinstate the screening of V1 G2 wire which I had done away with. On this fairly long piece of wire were peak to peak voltages of between 30 to 70V.

But alas the whistles and the ultra sharp



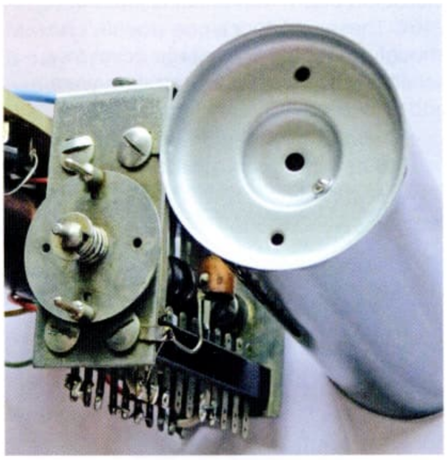
Shadow meter mounting

Restuffed electrolytics

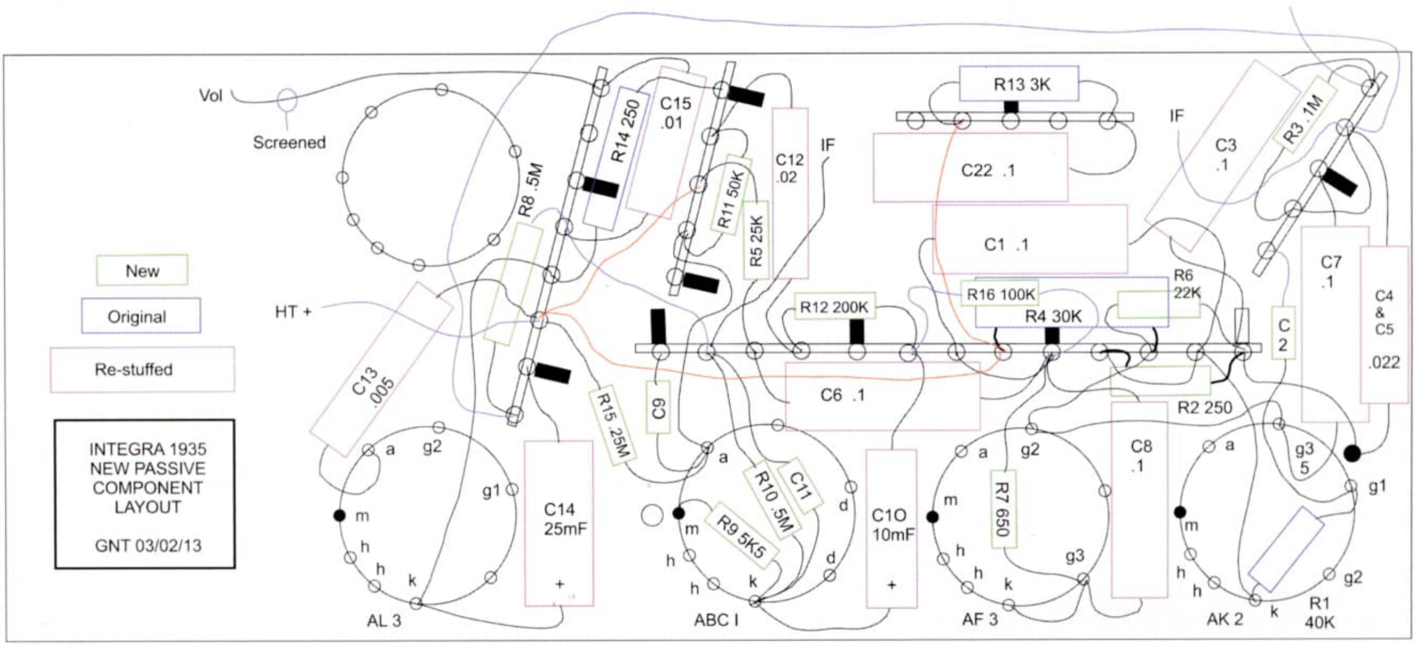


Cutting jig for resistor tube

Making a period looking resistor



Dial drum, Earth side



Under chassis layout

tuning were still there. Back for Peter's views again and the first thing he spotted was the high HT voltage of 350V, compared to a similar period radio, my Beethoven 77. The HT for this was 230V. True it used an 8mF reservoir capacitor compared to the 16mF I had fitted in the Integra but that didn't make much difference. These days, in my location, the mains voltage gets up into the high 240's and that wasn't helping. The real culprit though was the 350–0–350 HT winding of the transformer. This seemed a completely original part and looked the same as that on Pierre's chassis. The speaker, with its HT dropping field coil, of 1K6, also looked original and untouched as well. Why the designer would have used a transformer with such high HT windings is a mystery but many things about this radio are unusual.

I modified the chassis to include a 47 ohm metal clad, chassis mounted resistor, in each leg of the mains supply after the switch (new mains cable with earth fitted). By taking out the mains transformer they could be hidden behind it. They didn't have to be metal clad types for the wattage but not needing tag strip, for connections, makes them an attractive choice.
Of course I didn't want to add too much resistance otherwise the heater voltages would be too low. With the resistors they measured 3.95V with a mains input of 246V. These resistors alone wouldn't be enough to get the HT voltage down to a sensible value and so 1K resistors were added in each AZI rectifier anode lead.

Looking at the data for this valve the curves showed that the HT, with these conditions, should be about 260V and I measured 245V. The voltage / current curve was still reasonably flat so I didn't expect regulation problems with the small variation from the AGC controlled valves.

The set seemed better in two ways: first the mains transformer was a lot cooler to the touch and reducing the HT would lower the oscillator output and reduce feedback drive leading to increased stability. It was best on LW R4 as MW still had too many whistles either side of very sharp tuning. It was best on strong stations from the short aerial I was using.

After trying other ideas I decided to get out the wobbulator and see what the IF bandwidth looked like. It was easy for this to be as narrow as a couple of kHz which might be the case with just peaking with a signal generator. But with careful tuning it could be improved to be a more reasonable 5 kHz or so at half height (see picture). This was at a signal level creating an AGC voltage to V1 of about that of a strong station on the short aerial. Increasing the level the shape stayed gratifyingly much the same. Reducing the level the shape smoothly changed to a single triangular peak.

The radio now sounded much more promising. Far fewer whistles, the odd plop but not too bad. I felt that it was now worth stringing (or in this case wiring) the dial pointer and seeing if the tracking had any chance of working out.

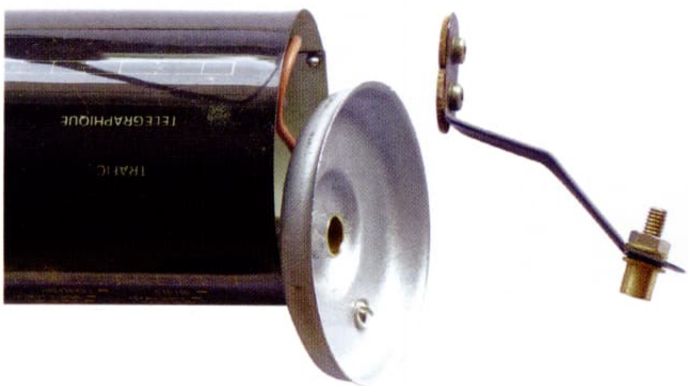
The dial pointer and wire

On the face of it this is quite simple with the wire winding off one end of the drum and winding back on at the other. But it still took me several goes to get it right including the classic of the pointer moving the wrong way with rotation of the knob and tuning gang.

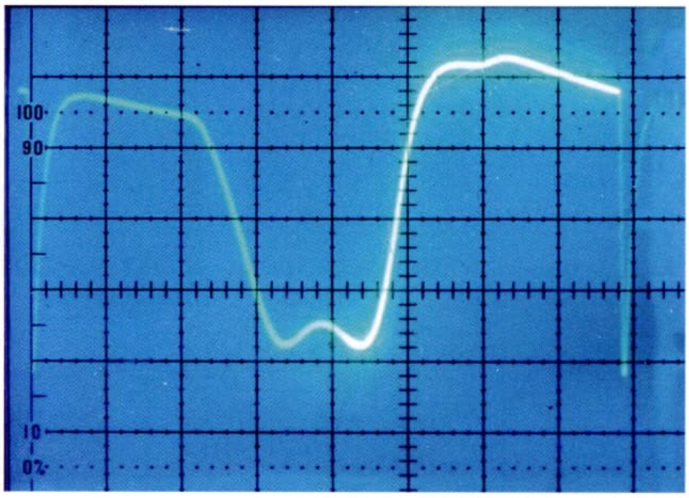
It's obviously vital that the gang opens and closes fully without running out of wire. Using 9 turns left about a turn at each end spare.

I used braided stainless steel, 15lbs breaking strain, fishing line. How to secure the ends was solved by using beading crimps. These are a metal crushable bead and should be applied with the correct pliers having cups that squash the bead symmetrically. I didn't have these but cosmetics weren't important so I just used ordinary pliers and flattened them. To be on the safe side I put on two, one behind the other. Later I was told by a 'beader' that they fit them by passing the wire back through, forming a loop, before crushing. For me, with fumbling hands it was hard enough getting the wire through once so maybe it was best that I didn't know that.

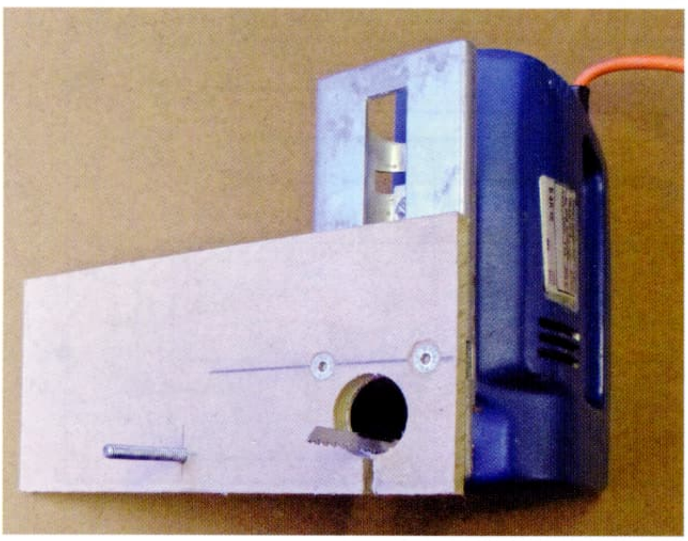
The wire is tensioned by the centre jockey wheel being sprung to the back of the chassis. To fit the wire I tied this in place, for no tension, right up against the bracket of the shadow meter. Once the wire was in place and with an even amount of turns, at each end of the drum, I cut the securing string.



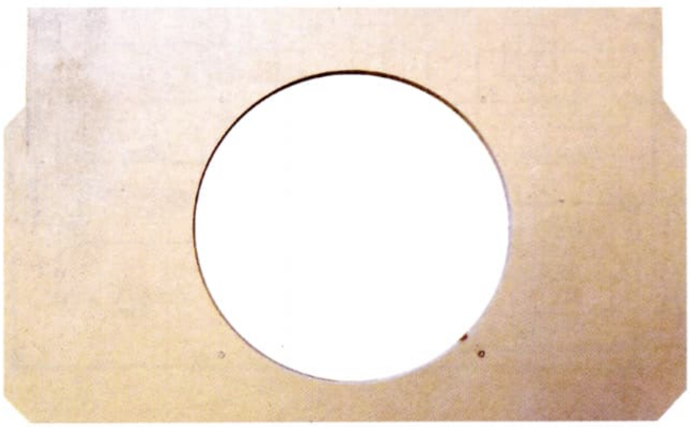
Dial drum, power side



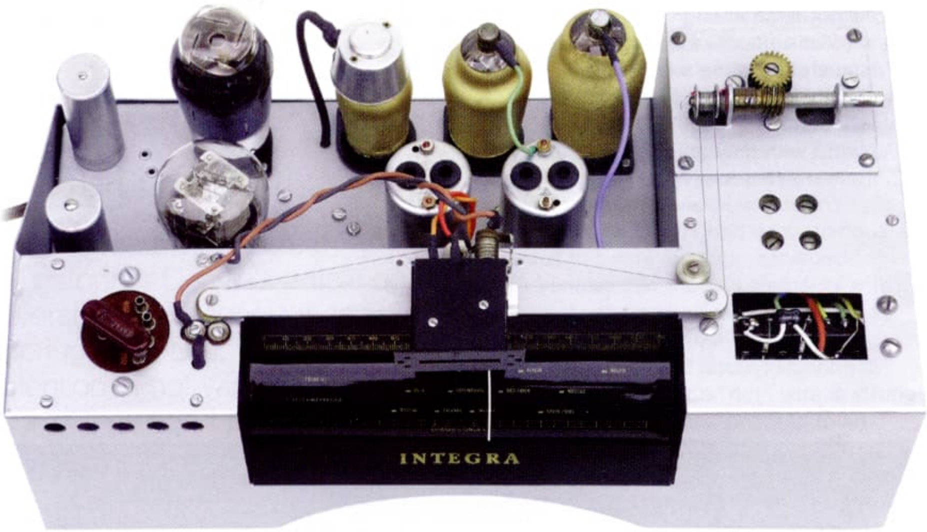
IF bandwidths 5kHz



The jig for cutting the baffle board

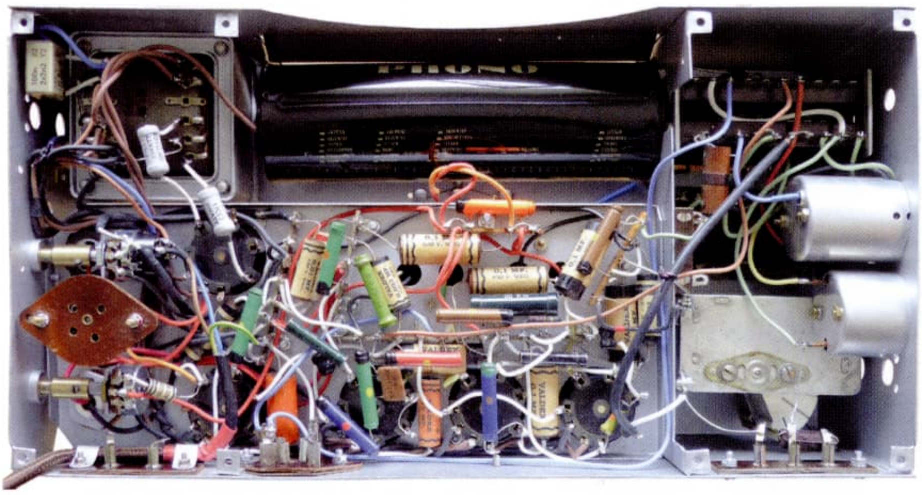


The new bafflle board



The finished chassis


The finished chassis (rear)


The finished chassis (underneath)

Final alignment and testing

I was pleased to find that I could get the radio to track on two stations chosen at each end of the MW band. Of course the shadow meter (and magic eye on, radios that have them) does make this quick and easy as there is no need to connect up a meter to the audio.

For starters I had soldered in a capacitor for CZ of 150pF and found that I could set R4 LW to be in the right place on the dial, (it is necessary to align the MW on this radio first as the tracker components are effectively in series).

The LW choke is 33mH and I tried values for CZ in steps from 15pF to over a 1000pF with minimal change in signal strength as indicated on the shadow meter. The value seemed non-critical and so I settled on the starter 150pF (resonant frequency 72 kHz). My only guess as to why the choke is there, is possibly as a loading coil for long wire aerials.

This was certainly progress and the radio sounded good and reasonably sensitive. A final tweak with the signal generator didn't make much improvement.

A new speaker baffle board

This was needed as the old one, made from 6mm hardboard, was disintegrating. It was replaced with one cut from MDF. I could have cut the large hole freehand using the jig saw but it wouldn't have given a really neat hole. As the saw had screw fixings I made up a jig, such that it would rotate around a centre spindle; a 6mm bolt. Feeding the saw very slowly gave a perfect result.

Making a speaker bag

A piece of black muslin was stretched out, and taped in place, over a smooth board. It was easy to mark through the speaker fixing holes and by marking diagonal lines between them find the speaker centre. A crude compass, made from a strip of wood and a panel pin, allowed marking out a circle of a size such that the finished bag, complete with a half inch turnover for a drawstring, would cover the holes in the speaker frame. The speaker fixing holes, edged on the machine, had their centres cut out with a blunt red hot punch.

Making a back panel

It may have originally had a back panel over the lower half covering the loudspeaker and its high tension connections. From the lack of fixings the top was probably open but with the exposed items, including the stranded wire for the dial pointer, I thought it better to cover this too if I could devise a method which required no changes to the cabinet. The pictures show how this was achieved.

The back panels, using a plasic H section joining strip, were cut and drilled from 3mm hardboard. The patterns of holes were drilled through an accurately made jig loaned by a friend.

As the cabinet is so thin it has very few internal fixings and the chassis is wedged in place by two spring wires. The front pushes against the speaker baffle board at the top holding this in place. The baffle, at the bottom, is pressed against the front of the cabinet by a bracket, with a rubber buffer, and the bracket is secured with counter sunk screws through the cabinet base.

Conclusions

This was an enjoyable but often frustrating radio to bring back to life, so thank you to Peter for his ideas and encouragement along the way. To restore it took a lot of patience, time and effort as the chassis is very awkward to work on. But this could be the way forward of not acquiring too many radios (unless you already have like me): just find ones that are interesting, challenging and need a lot of time.

To me, it's now an attractive radio that works as good as any 5 valve superhet of the time and I suppose the main thing is I really like it.

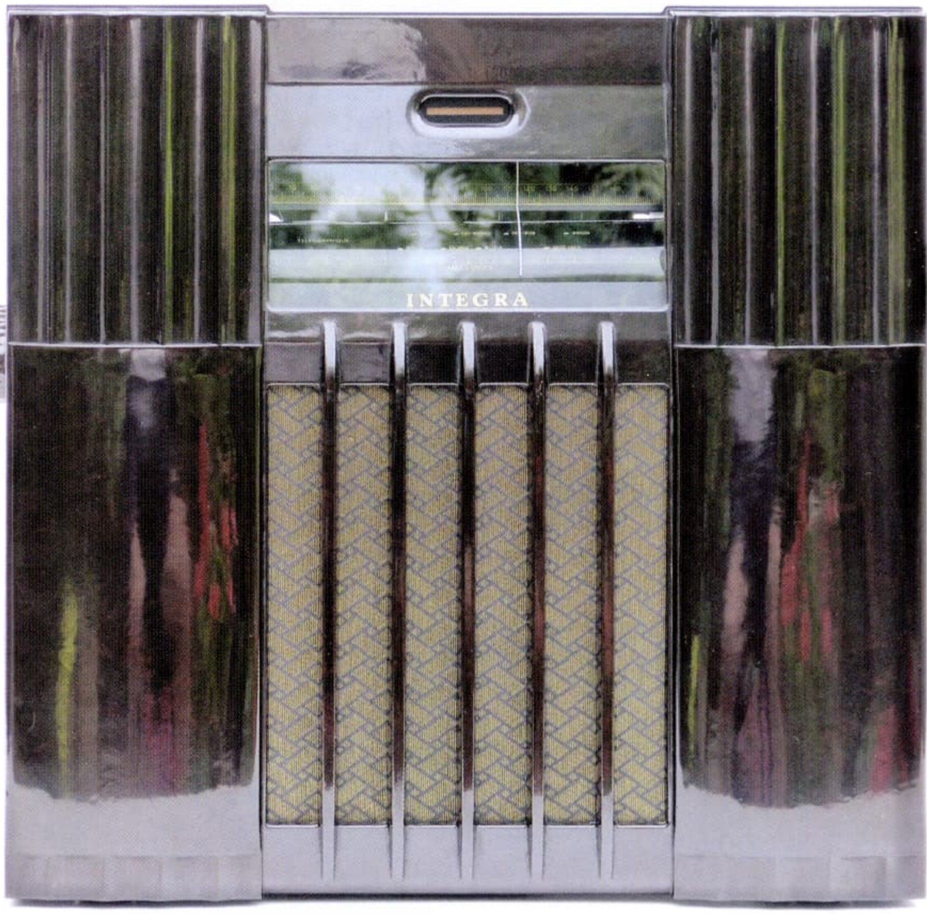
It's a set with unusual design features and some clearly advanced. Many items are particularly well made such as the coils, the wave-change switch and the drum dial. However, the mechanics and metal work do let it down with a lot of screws under tension to tighten fully. I eased these where I could. The chassis has a steel bottom panel that was particularly bad and I decided to slot many of the holes. The cabinet has plenty of free space and yet at the sides the chassis is a very tight fit. It was as if the chassis had been drawn up without taking into account that there are screw and nut heads on both sides.

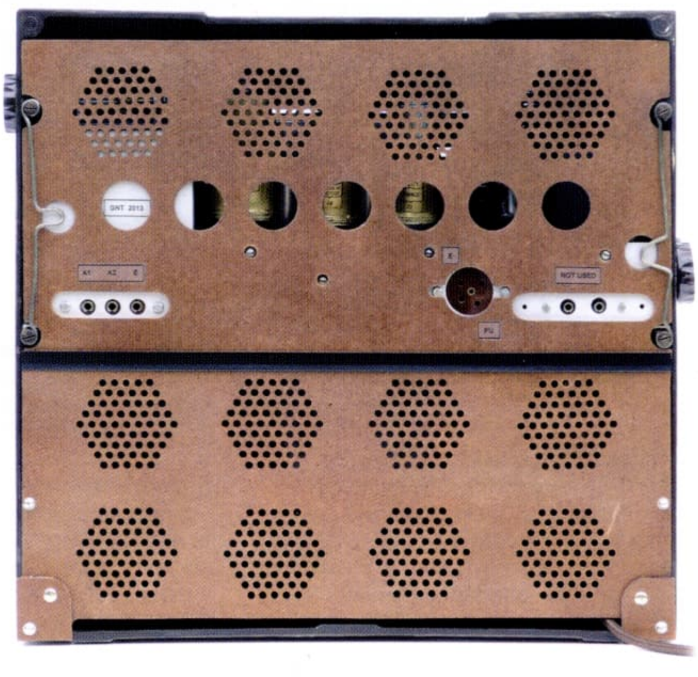
A lesson for the future is that I should have made an early decision to completely strip the chassis and then had all the metal work re-plated in old nickel. But by the time I had decided the valve holders had to come off, by drilling out the rivets, I had already repainted the main chassis. I recommend re-plating, for similar situations, it's tougher when rebuilding and there are no issues with earth bonding of parts.

The cabinet deserves a special mention as the Bakelite, whilst thin (and my thanks to all those who have kept it unbroken for nearly 80 years) is of a very high quality and beautifully detailed on all surfaces. The filler used must have been especially fine giving it more shine, than is seen on the majority of British radios.

The side knobs are unusual having a 3mm brass split shaft moulded into them. They engage into mating bushes. Those for the volume and tone controls are a separate bush with grub screws that mount onto the conventional 6mm spindle (these can be seen in the under-chassis picture).

The knobs are not a design success as they have to be thin so as not to protrude too far. But for the wave-change, with the strong switch indent and the pressure exerted by the sprung dial drum, the knob is not large enough to grasp and turn without considerable effort. The little old dames of the time might have had a struggle with that but I expect after a while it got left on the "PETITES ONDES" (MW) band with only an occasional foray into the "GRANDES ONDES" (LW).





A closer look at a hot wire Instrument

By Roger Grant

Having read with interest Christopher Deavin's article on Evershed and Vignols in the Spring 2013 Bulletin, he makes mention of hot wire instruments, some time ago I purchased a hot wire type instrument from a boot fair for my collection of pocket test meters, a 1.5 Amp ammeter, (its about 2.5 inches in diameter) Christopher's article on test equipment prompted me to re-visit this simple but interesting device and see if it still works as I didn't get around to testing it at the time.

On test it was found to be open circuit and on dismantling it I found the "hot wire" had blown like a fuse, the fused wire had blobbed at the ends of the break, but there was still enough left for me to measure its diameter, 22swg, guessing that it was probably Eureka or Nichrome wire (nickel copper or nickel chrome alloy) I had some various sizes of this wire in stock, salvaged from various new heating elements with broken insulators and kept for resistor winding, (I knew it would come in handy some day) I then set about repairing it.

Inside the meter the "hot" wire is strung between the terminals, one end to an anchor point on the left and the other end to a zero adjustment return spring on the right. In the middle is a ceramic bead thermally isolating the hot wire from the pointer actuating thread, this is a piece of sewing thread connected to the hot wire above the pointer shaft and the tension spring below. This is via two turns around the pointer shaft. When a current passes through this resistance wire it expands as it heats up and the slack is taken up by the tension spring rotating the pointer shaft indicating the current, the movement is proportional to the temperature of the wire due to the current passing through it, the hotter the wire gets the greater its resistance, making the indication non-linear, hence the log scale, the give away.

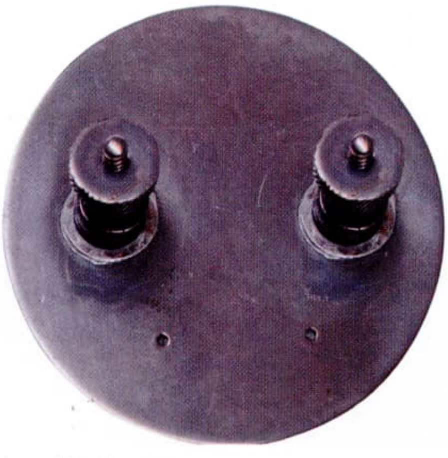
Cutting off and straightening a length of 22swg Eureka wire, with the adjusting screw set about amidships, it was threaded through the insulating ceramic bead and soldered onto the anchor points, its length adjusted to set the actuator tension spring to about its mid point of travel.

The current reading is read from a plotted log scale printed onto paper stuck onto the brass front plate.
On test with an AVO 8 in series, the readings were surprisingly close, in the mid scale of 1 amp it was about right with only about a 10 percent error at both ends of the scale, not bad for such a cheaply contrived device.
I tried to find some information on its manufacturer, W.R. Morris of Birmingham, but no trace of this company appears to exist, even the internet came up with nothing and I can only guess that it was probably made sometime in the 1920's.

Full face


Inside the Ammeter

General view


Rear of the Ammeter


The Ammeter adjusting screw

Pictures from Wootton Bassett, July 2013 by Carl Glover

A busy morning!

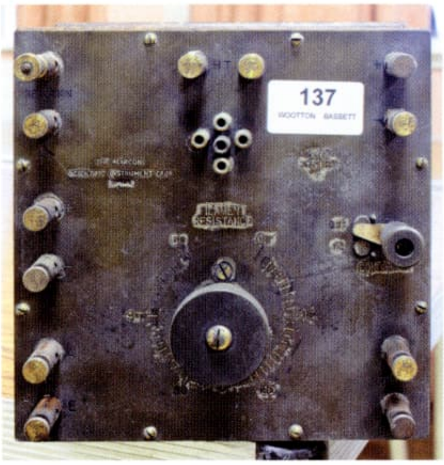
The cake celebrating 20 years of Wootton Bassett

Auction lots ready for being moved onto the stage

Auction lots 'vacuum packed' into the van with little room to spare!

The catering crew: Jill, Jim and Edna

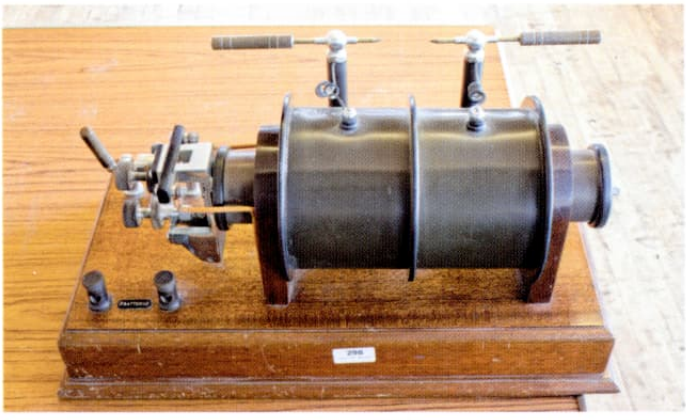
Ekco AD75



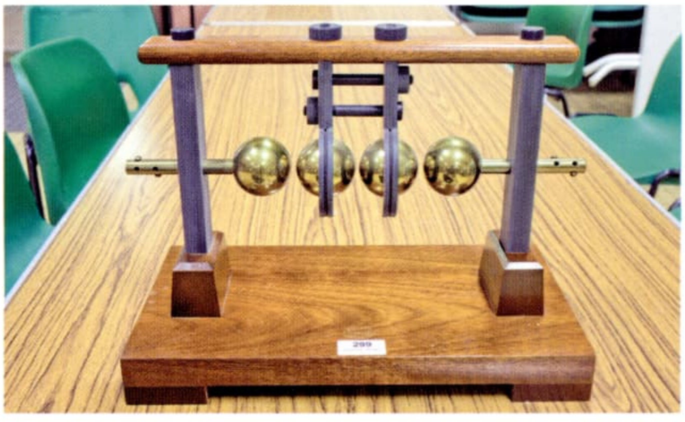
Marconi 1920's set

Ekco AD65

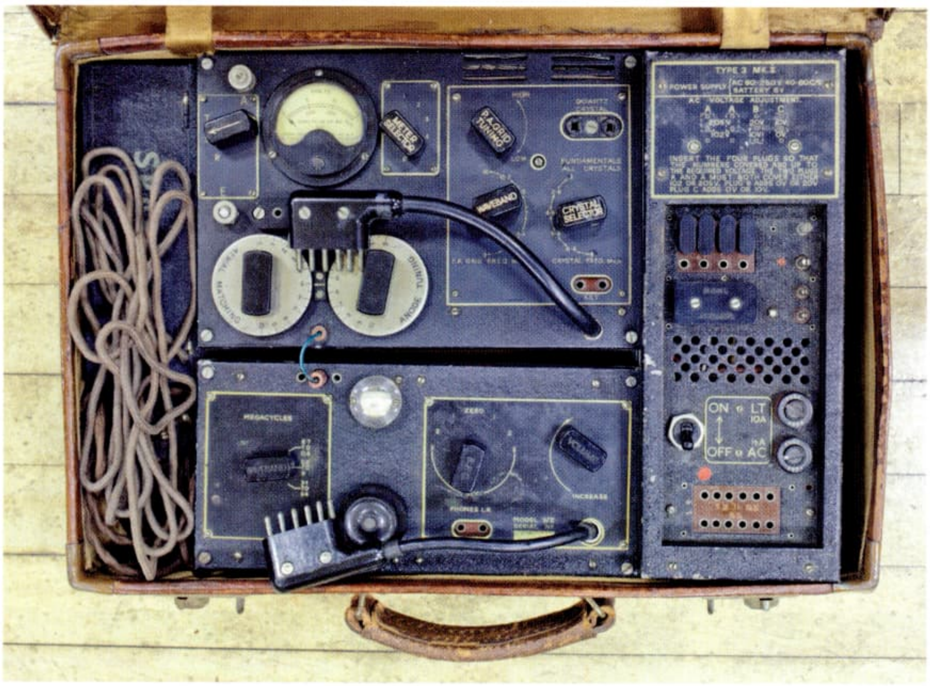
Swapping and browsing



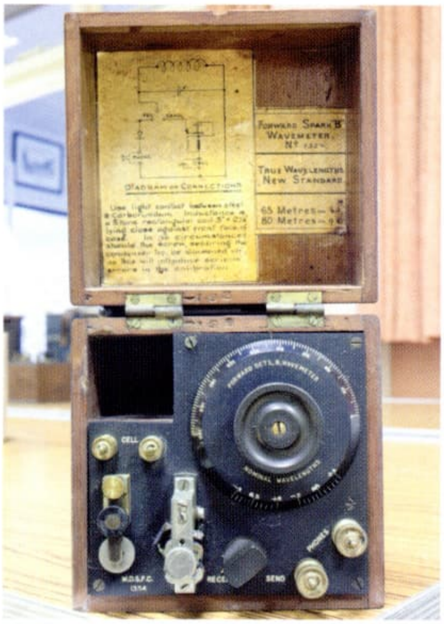
Large induction coil

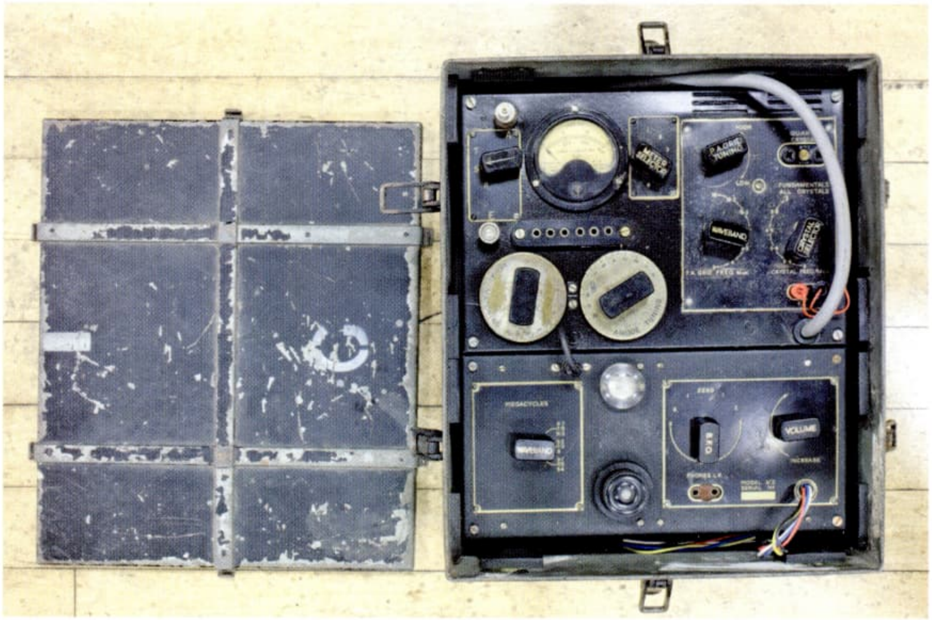


Replica Righi oscillator

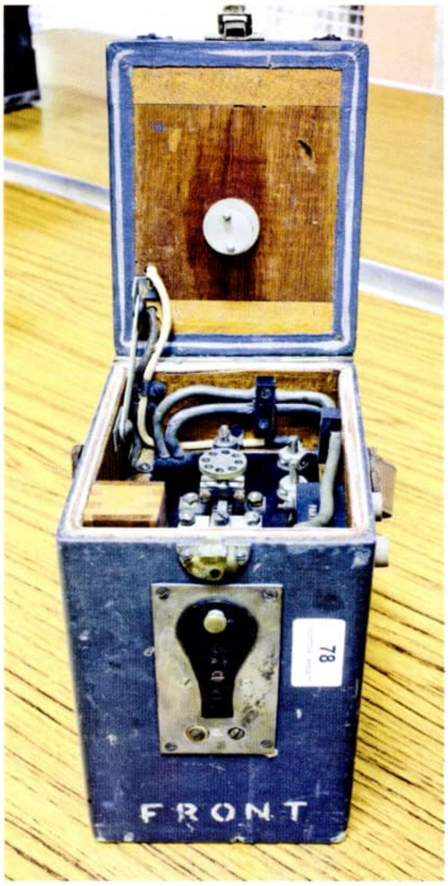


B2 set in leather suitcase

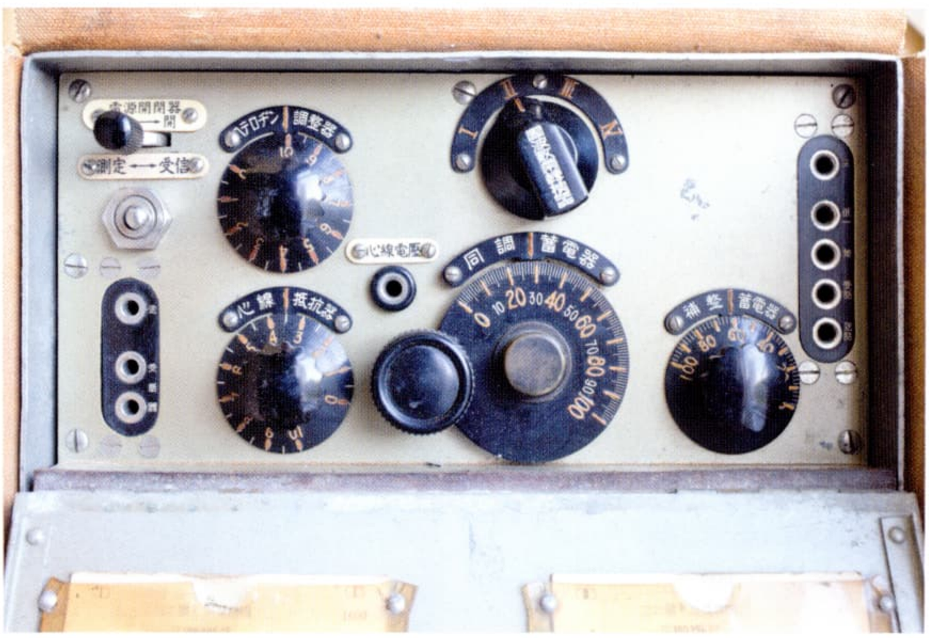




B2 set in parachute drop-case

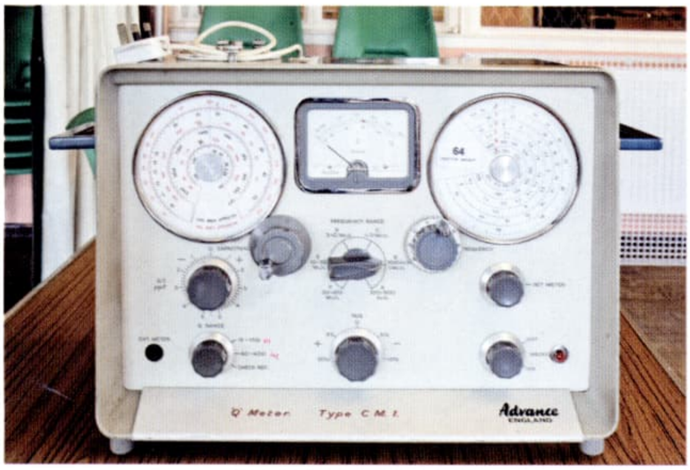

78
FRONT


296


同調蓄電器
補整蓄電器

Pye M78F

Philips 830A

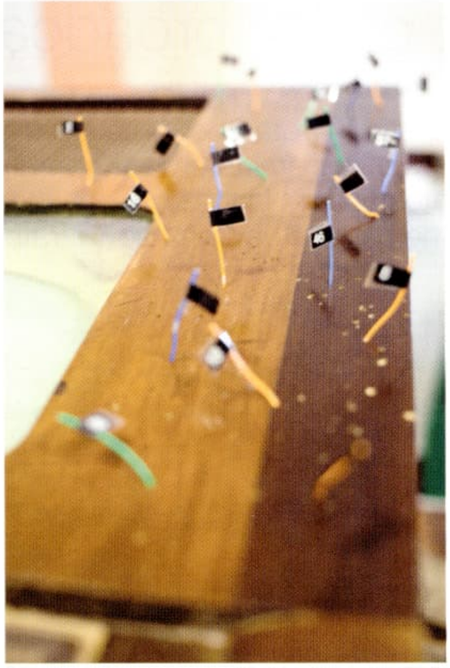


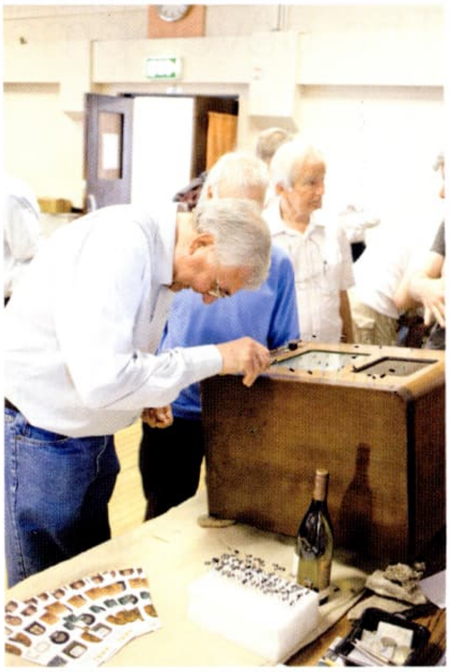
Philco and Ferranti sets

Pye Model G

Mike with his Cat!

Ekco M23





The British Vintage Wireless and Television Museum had a 'Spot the Worm' stall where punters would place a numbered flag in the wormholes in a delapidated TV cabinet

An Radio Rentals set

Philips 930A

Pye All-in-One Test Bench

Burndept Universal Screened Five

Sunrise at Wooton Bassett

The development of FM broadcasting in the UK

by Stef Niewiadomski

In the spring 2012 issue of The Bulletin I wrote about the state of VHF-FM broadcasting in the US in 1948. By this time many hundreds of transmitters were operating and the service was expanding rapidly. This article contrasts the state of affairs in the US with what was happening (or not happening) in the UK from the end of WWII to the present day, and how it rather belatedly became the broadcast service we know today.

European E.H.F. Broadcasting Stations

The transmitters listed are frequency modulated unless marked with an asterisk.

Mc/s	Metres	kW	Station	Country
41.62	7.206	0.75	Stockholm	*Sweden*
42.00	7.143	0.8	Copenhagen	*Denmark*
46.50	6.452	—	Moscow, Russia	*U.S.S.R.*
56.50	5.310	0.25	Lyons	*France*
56.50	5.310	0.25	Paris	*France*
69.00	4.348	5	Paris	*France*
89.10	3.367	0.1	Hamburg, Br. Zone	*Germany*
90.10	3.330	0.25	Munich, U.S. Zone	*Germany*
90.30	3.322	0.5	London	*G. Britain*
93.10	3.222	0.8	Copenhagen	*Denmark*
93.90*	3.195	0.5	London	*G. Britain*

Figure 1: Table from the 'The Wireless World Guide to Broadcasting Stations, 5th Edition', published by Iliffe in 1949, showing 'European EHF Broadcasting Stations' in the range 41.62MHz-93.90MHz.

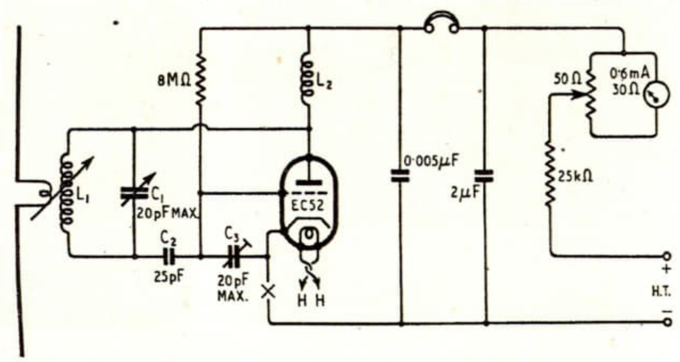


Fig. 1. Circuit diagram of the receiver shown above.

Figure 2: Schematic of the EC52 triode VHF super-regenerative receiver published in Wireless World for January 1947.

The inventor Edwin Howard Armstrong was highly influential in the early development of FM broadcasting and personally bankrolled its pre-war roll-out in the frequency range of 42MHz-50MHz (sometimes referred to as the 'Armstrong band') in the US before the war. By 1948 FM broadcasting in the US was in a buoyant state, by then transmitting in the internationally agreed 88MHz-108MHz frequency range, having migrated there from the lower frequency band on 1 October 1947.

FM broadcasting at VHF was developing in some parts of Europe at the time, but the UK was an obvious exception where the introduction of any FM radio services seemed to have a low priority with the BBC and the government. Germany was an early adopter of VHF broadcasting (initially using AM and then FM) soon after the war because it was not allowed any high power medium wave allocations. Initially I wondered why this was, and I suspected at first that this was a way of punishing the nation for the war. However I soon discovered that the vast majority of medium wave channels in post-war Germany were occupied by British and American Forces Networks, and Voice of America broadcasts – beaming towards the Iron Curtain countries – and hence the shortage of channels for German civilian broadcasting. Germany had used VHF and UHF links during the war for military purposes (see for example Reference 1) and so had considerable practical experience in the art of communicating at VHF.

AM or FM?

Immediately post-war it was generally accepted that the future of radio lay in what today we call the VHF bands, either in the region of 40MHz-50MHz or round about 100MHz, but to the BBC the modulation scheme to be employed was unclear, despite practical evidence from experience in other countries.

The US had already settled the AM versus FM question. In 1948 there were 463 FM broadcasting stations actually in operation in the US; 564 authorised by the FCC but not quite yet in operation; and 88 broadcasting applications still pending, giving a total number of potential FM stations of just over 1,000. By 1948 Armstrong had proved that FM broadcasting was possible and that it gave the benefits he had predicted. All the changes needed in the move from AM had been made, at considerable financial and personal cost to Armstrong himself. Transmissions were on VHF, giving the necessary bandwidth, and the infrastructure of transmitters was building at a considerable pace.

US experience had shown that the theoretical advantages of FM over AM could be realised in practice. Specifically it gave freedom from interference and improved bandwidth so that the quality of the transmitted audio could be greatly improved over that achievable with AM broadcasts. The freedom from interference aspect showed itself in two ways: firstly FM broadcasts were relatively immune to impulse type noise generated by motors and car ignition (as long as the FM discriminator in the receiver was designed correctly); and secondly, freedom from superimposed distant signals which propagated much further on the medium wave band at night than in the day. This second point was partly due to the use of VHF frequencies for the transmissions, and partly because FM discriminators tend to lock onto and demodulate strong signals, and reject weaker ones. Simple AM detectors do not possess this property to reject interference from signals at (or close to) the same frequency, and weaker AM signals appear as lower level audio interference on top of the desired signal. The price you pay for this is that the bandwidth of an FM transmission has to be several times wider than the bandwidth of the modulating audio.

How aware was the BBC of what was happening in the US? I'm sure they must have known of Armstrong's work, and the fact that in 1948 something like 1,000 radio stations in the US were betting their future on FM at around 100MHz. However the BBC was, and still is, a meticulous organisation and it felt obliged to carry out its own experiments, including the testing of the relative merits of FM versus AM.

Perhaps it was thought that the problems associated with AM, especially its susceptibility to impulse-type interference, would be reduced by simply moving up in frequency. Certainly the problem with broadcasts travelling further at night and therefore interfering with each other would largely be solved by the move to VHF. The 405-line TV system operating in the UK since 1936 (apart from a break during the war years) used AM for the sound and this was found to be susceptible to interference despite its higher transmission frequency. The conclusion was that the use of Band I (between 45MHz and 66.75MHz) alone would not fully solve the problems associated with AM. Band I only permitted five TV channels, all BBC of course, and therefore was in itself restrictive to the expansion of TV services: when independent TV broadcasting started in 1955, this was in Band III, in the range 174MHz-230MHz.

Early trials in the UK

Starting in 1945 trials were carried out by the BBC in the 45MHz band using both AM and FM to determine the relative merits of the two modulation methods.

PLAN FOR NATIONAL VHF COVERAGE (1954)

Station	Frequencies (MHz) Light	Third	Home	erp (kW)	Site Height (ft AMSL)	Aerial Height (ft AGL)
Stage I						
Wrotham	89·1	91·3	93·5	120	720	406
Pontop Pike	88·5	90·7	92·9	60	1000	296
Divis	90·1	92·3	94·5	60	1200	262
Meldrum	88·7	90·9	93·1	60	800	290
Wenvoe	88·9	—	92·1 West 94·3 Welsh	120	420	647
Norwich	89·7	91·9	94·1	120	230	332
North Hessary Tor	88·1	90·3	92·5	60	1675	538
Sutton Coldfield	88·3	90·5	92·7	120	555	647
Holme Moss	89·3	91·5	93·7	120	1720	647
Blaen Plwyf	88·7	90·9	93·1	60	565	332
Stage II						
Rowridge	88·5	90·7	92·9	60	450	296
Kirk o'Shotts	89·9	92·1	94·3	120	910	647
Sandale	88·1	90·3	92·5 Scot. 94·7 North	120	1220	332
Anglesey	89·6	91·8	94·0	60	500	500
Corwen	—	—	94·9	1	1840	250
Rosemarkie	89·3	91·5	93·7	6	680	302
Stage III (tentative)						
Les Platons				2		
Dover				1		
Isle of Man				1		
S.W. Scotland (Ayr)				2		
Galashiels				5		
Londonderry				1		
Central Berks.				5		
Hayle (Cornwall)				2		
Brechin (E. Central Scotland)				1		
E. Lincs.				5		
Mendips				120		

Figure 3: The planned three-stage introduction schedule of the BBC network, as conceived in 1954. As you can see stages I and II were definite but stage III was tentative.

OCTOBER

2 TUESDAY

EVENING FROM 5.0 P.M.

In Other Home Services

MIDLAND (276 m.; 1,088 kc/s)
6.15-6.35 News, sport.
6.35-7.0 As West.
9.45-10.15 Intimate Music Group.*

NORTH (434 m.; 692 kc/s; 92.9 Mc/s VHF)
6.15-6.30 News, sport.
6.30-7.0 C.W.S. (Manchester) Band.
9.45-11.0 BBC Northern Orchestra; Kabi Laretei (piano): Overture The Thieving Magpie (*Rossini*); Eine kleine Nachtmusik (K.525) (*Mozart*); Piano Concerto No. 2 in B flat (*Brahms*).

N. IRELAND (261 m.; 1,151 kc/s)
6.15-6.30 News, sport.
6.30-7.0 As North.
7.30-8.0 Twenty-five Years Back: impression of Northern Ireland in the year 1931, compiled by Duncan R. Hearle.*
8.0-8.30 Malcolm McKeown (tenor); Ormiston Choir; Sean Maguire (traditional fiddler); BBC Northern Ireland Light Orchestra.
9.45-11.0 As North.

SCOTTISH (371 m.; 809 kc/s; 93.1 Mc/s VHF)
5.0-5.55 Children's Hour. Story. 'Tullyvore Castle': feature about The Lyalls of Tullyvore.*
6.15-6.35 News, sport.
6.35-7.0 Songs from the Cinema: BBC Scottish Variety Orchestra.*
7.0-7.30 Visit to '17, Sauchie Street': Variety.*
7.30-7.45 The Paisley British Legion Pipe Band.*
7.45-8.15 Joan Dickson (cello); Hester Dickson (piano): Brahms.
8.15-8.30 I Went North. 4—Robin Fletcher of Ardlussa, Jura.*
9.45-10.15 Orchards of Scotland: talks on famous orchards compiled by Scott Kennedy.*
10.15-10.45 The National Mod: Junior Concert.*
10.45-11.0 Gaelic talk on the Highland Association.
11.8-11.12 Ere I Sleep: Prayers.

WELSH (341 m.; 881 kc/s; 94.3 and 94.0 Mc/s VHF)
5.0-5.55 Children's Hour in Welsh.
6.15-6.45 News, sport. News in Welsh.
6.45-7.15 Y Cwydryn Llawen: Welsh programme (recordings).
7.15-7.30 Welsh talk by Lyn Howell.*

WEST (285 m.; 1,052 kc/s and 206 m.; 1,457 kc/s)
6.15-6.30 News, sport.
6.30-7.0 Nocturne: BBC West of England Light Orchestra.
7.0-7.30 Wilfred Pickles in 'Have a Go!'*
8.15-8.30 Teaching in a French School: talk by Eric Dehn.*
9.45-10.15 All Kinds of Musick. Colin Sauer (violin); Kathleen Frazier (piano): Handel; Delius; Bartok.*

* *Recorded programme*

5.0 CHILDREN'S HOUR
For Younger Listeners
'A Nursery Sing-Song' with Doris and Trevor and Mabel Hardy at the piano
'The Three Blackbirds' Story written by Margaret Turner and told by Joan Bailey

5.25 *For Listeners of All Ages*
Children's Newsreel
October Edition
'Here and There' General news by Alan Dixon
'London News' by Nan Macdonald
'Sports News' by Kenneth Wolstenholme
'This Month in Your Garden' by Fred Loads
'Countrywide Reports' from Children's Newsreel Observers
Edited and introduced by John Musgrave

5.55 The Weather
Forecast for land areas, followed by a detailed forecast for the South-East region

6.0 Greenwich Time Signal **NEWS**

6.15 TOWN AND COUNTRY
A programme for listeners in the South-East of England
6.15 Local news
6.25 Today's sport
6.30 Reports and comments

6.45 NOCTURNE
A programme of continuous music played by the BBC West of England Light Orchestra
(Leader, Frederick Lunnon)
Conductor, Frank Cantell
Polonaise, Arietta, and Passacaglia — *Handel, trans. Hamilton Harty*
O lovely night — *Landon Ronald, arr. Jack Byfield*

The Home Service
330 m. (908 kc/s) 93.5 Mc/s VHF

Dr. Maude Royden
C.H.
A PERSONAL TRIBUTE from *Dame Kathleen Courtney* who was her friend for many years
Dr. Maude Royden, who died in July, was one of the first women Pastors in England. For some years an assistant preacher at the City Temple, she was joint founder of the 'Fellowship Services' and of the Guildhouse.
at 8.15

7.0 Northern Variety Parade presents
KEEP 'EM LAUGHING
An all-in comedy match between Richard Murdoch Ken Dodd, Bob Andrews
Inter-round notes by The Smith Brothers and the BBC Northern Dance Band
Promoted by James Casey
(BBC recording)
(Ken Dodd is appearing in 'Let's Have Fun' at the Central Pier, Blackpool; The Smith Brothers in Variety at the Alhambra, Bradford)

7.30 THE NEWCOMERS
A story of child adoption
Written and narrated by Stephen Grenfell
Produced by Tom Waldron
(BBC recording)
Alan and Jane Burnham lost their only child Carol when she was five years old. They longed for another child but Jane Burnham was not able to bear one. So they decided to adopt a child through the National Children Adoption Association. This programme—in telling the story of Alan and Jane Burnham—describes the carefully safeguarded methods by which a child may be adopted in this country.

9.15 AT HOME AND ABROAD
A twice-weekly survey of current affairs
Speakers in the studio in London and from regional and overseas centres contribute news and views on the issues of today and tomorrow

9.45 RECITAL
Anton Dermota (tenor)
Hilde Dermota (piano)
Song Cycle: An die ferne Geliebte — *Beethoven*
Slovene Folk Songs, arr. *Janko Ravnik*

10.15 WRITING FOR SOUND
A series of specially chosen programmes
4—'How Many Miles to Babylon?'
Mary Wimbush and Hugh Burden in a sentimental dream of London by James McFarlan
'How many miles to Babylon? Three score miles and ten. Can I get there by candlelight? Yes, and back again.'
He....Hugh Burden
She....Mary Wimbush
Mother....Olwen Brookes
Father....Hamilton Dyce

Figure 4: The Home Service programme schedule for Tuesday 2 October 1956, from that week's Radio Times.

The 45MHz upwards region was occupied by BBC TV broadcasts, and so perhaps there was a theory that sound broadcasts could be 'shoe horned' between the TV transmissions. As early as 1947 BREMA (the British Radio Equipment Manufacturers' Association) included a statement in their recent report that 'the ultimate employment of FM transmissions is inevitable'. Maybe this was a lucky guess, but the organisation put its money where its mouth was and authorised the expenditure of £2,000 on an FM-AM investigation. It also recommended to its members that 'development of the FM system should be supported'.

By 1949 the experiments at 45MHz had stopped as it became obvious that the final resting place of VHF sound broadcasting would be in the 88MHz-95MHz (or above) band – the so-called Band II. It had also been noticed that the 45MHz band was not quite local enough and interference was experienced from stations over considerable distance: for example the powerful FM station WGTR Boston, on 44.3MHz, could sometimes be heard in London.

A table in the the Wireless World Guide to Broadcasting Stations, 5th Edition, published by Iliffe in 1949, shows European EHF Broadcasting Stations in the range 41.62MHz-93.90MHz, as shown in Figure 1. These are hardly extremely high frequencies by today's standards (now formally defined as the band from 30GHz to 300GHz), but nevertheless were challenging to broadcasters at the time. Note the two stations located in London (at Alexandra Palace) on 90.30MHz and 93.90MHz, which transmitted from 6pm to midnight. Clearly the 90.30MHz transmission used FM, and the asterisked broadcast on 93.90MHz was not – in fact it was an AM signal. Note that old habits die hard in that the wavelengths of the transmissions were given as well as their frequencies.

Tests were also carried out from Bagley Croft (near Oxford, where the BBC had a research department) and Moorside Edge (near Huddersfield) for propagation tests in hilly countryside. The transmitter site at Wrotham (on the North Downs in Kent, which was already transmitting TV signals) enters the FM story at this point with the first test transmissions starting in 1950. The BBC was still hedging its bets with FM on 91.4MHz and AM on 93.5MHz.

Horizontal polarization of the transmitted signal was found to be less susceptible to ignition interference and to distortion caused by multi-path propagation than vertical polarization. It also made the design of high-gain transmitting aerials easier. Horizontal polarization was therefore adopted for the BBC's roll-out of the VHF-FM service. More recently there has been a move towards vertical or slant polarization to provide improved reception on car radios and portable sets.

In 1951 the BBC submitted a plan to the government for the national adoption of the broadcasting of the Home, Light and Third programmes on VHF. The government accepted the findings but because of national restrictions on capital expenditure

Figure 5: The Eddystone S.820 VHF tuner, introduced in 1955 and staying in production until 1958, covering 85MHz-100MHz.

Figure 6: An advert for RCA's 'Orthophonic High Fidelity' VHF receiver from the March 1957 issue of Wireless World.

and the investment needed by industry in developing the transmitter infrastructure and mass-produced receivers, approval was given to start the service no earlier than 1953. In fact it was not until 1954 that the AM versus FM question was finally settled when the government ratified the findings of the Television Advisory Committee, and work began on the first production, rather than experimental, VHF-FM stations.

Negative feedback from the US

A worrying report (see Reference 2) was circulating in the UK during 1952, written by two Pye Ltd executives who had recently visited the US and investigated the state of FM broadcasting over there. They said: 'It is paradoxical that while Britain is apparently about to embark on VHF broadcasting, in America where FM VHF broadcasting has been in existence for fifteen years many people are wondering if it can survive much longer'. They went on to say that production of FM radios was disappointingly low, and they were expensive. The number of FM stations had reduced to about 600 from its peak of about 800, and was expected to decline further. They estimated that less than 1% of listeners tuned to FM stations.

They came away from the US with the impression that AM would have been a more successful modulation scheme for the VHF broadcasts, though I don't know how this might have improved audience numbers. Perhaps it would have made suitable radios cheaper and hence more accessible to the masses. Maybe Pye had some axe to grind with the choice of modulation method? Thankfully for the future of FM broadcasting in the UK the report seems to have been digested, but not taken as being conclusive by the BBC. In the end Pye had to accept the BBC's decision to go with FM, and the company produced many fine AM/FM radios over the years.

Early radios

On which radio sets were listeners meant to listen to these experimental BBC broadcasts? Andrew Denton recently pointed out to me that HMV made the model 1250 14-valve radio, introduced in September 1948, which was fixed tuned to 90.3MHz, and clearly aimed at the Alexandra Palace broadcasts. An example of this set exists in the British Vintage Wireless and Television Museum, in West Dulwich.

R N Fitton Ltd of Brighouse, Yorkshire, also made a similar set, under the Ambassador brand. At the time Fitton had a good reputation for producing domestic radios with several short wave bands covering up to the 11-13m band (round about 22MHz). Which set they adapted for reception at 90-odd MHz is not clear to me at the moment. It may even have been one of their late-1940s TV sets. Certainly a TV set would have had an IF more suitable for receiving at this frequency resulting in a more reasonable local oscillator frequency, though the sound channel for any 405-line TV set was designed for AM. Exactly how listeners got hold of these special VHF radios, and how much they had to pay for the privilege, is unknown.

Perhaps readers have recollections of listening to these early VHF broadcasts?

Decca produced a tuner to fit into their top of the range Decola radiograms and TV sets in 1948/49. For these tests it makes sense to add a tuner to a radiogram as the audio section would have been of better quality and capable of reproducing a broader frequency range than an average radio, and therefore better suited for testing the wider audio range modulating the VHF broadcast.

For keen constructors, in 1947 Wireless World published a single-valve super-regenerative receiver (Reference 3) using an EC52 triode (designed for VHF transmitting use). One advantage of a super-regenerative design is that it is capable of receiving AM and FM signals, so it was ideal for this period of AM/FM experimentation by the BBC. Coil winding details were given covering four ranges from 37MHz to 170MHz, so these included the original Alexandra Palace TV sound AM transmissions on 41.5MHz (which was used as a sound-only service out of TV broadcasting hours, which weren't very long in those days) and later FM and AM broadcasts round about 90MHz. The article's author noted that the tuning range also covered police transmitters 'which, on identifying, one will, in accordance with the terms of one's license, immediately tune out!'. The schematic of the receiver is shown in Figure 2.

As early as November 1952 Practical Wireless reported from the 1952 National Radio Show (at Earls Court) that of the many new TV sets on offer, some incorporated built-in FM receivers, though what frequency range these covered was not stated. No doubt sets were sold as being 'FM ready'. I presume that other manufacturers built experimental sets, and VHF radios from continental Europe and the US (such as the Pilotuner T-601) must have drifted into the UK. I would also guess that avid constructors would have adapted ex-service AM and FM receivers to cover the BBC's experimental broadcasts.

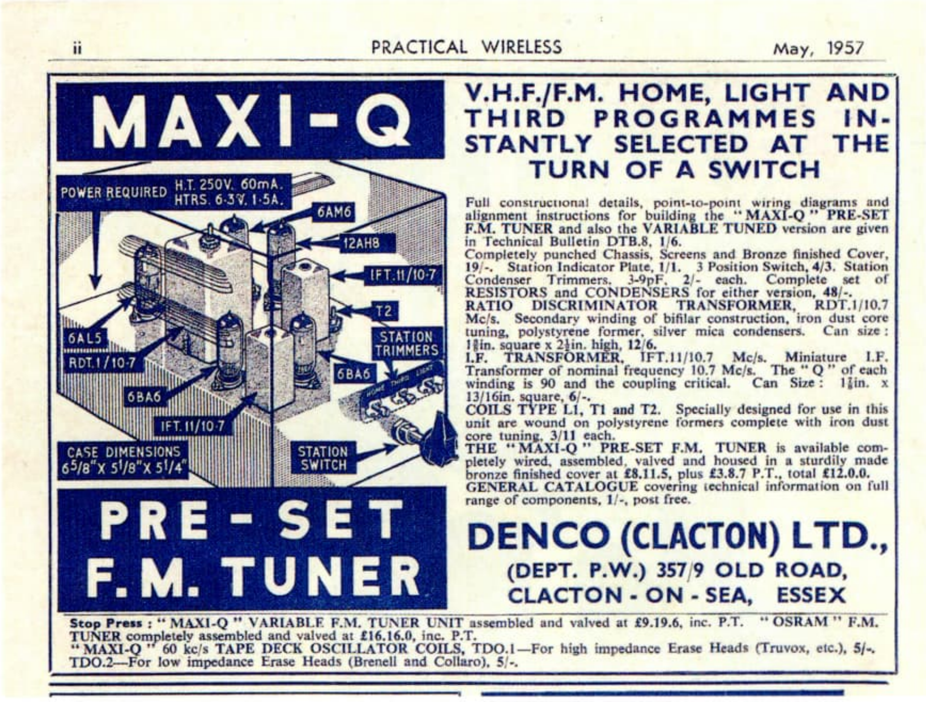


Figure 7: The Maxi-Q pre-set FM tuner kit from the well known coil manufacturer Denco.

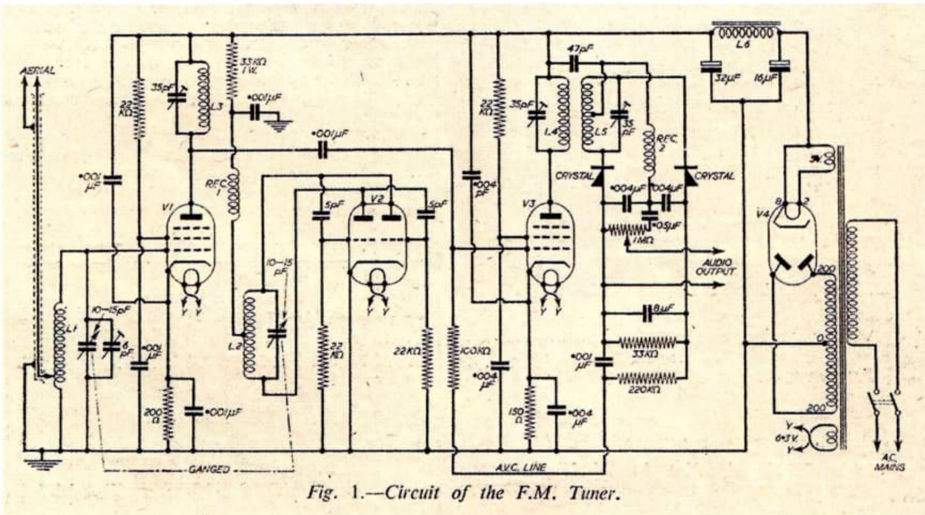


Figure 8: A simple valve-based FM tuner design from the August 1956 issue of Practical Wireless. There is some doubt as to how this design worked, if indeed it did!

Compatibility and pre-emphasis

FM receivers from different parts of the world are not necessarily compatible with all FM transmissions, even if they cover the correct VHF frequency range. One of the problems with high quality VHF-FM transmissions is that the increased audio bandwidth available means that background noise can often be perceived at the treble end of the audio spectrum, as hiss. Since the broadcast medium is intended to provide high quality audio transmissions any background noise needs to be reduced as far as possible. One method of reducing the background noise is to use a scheme called pre-emphasis.

At the transmitter the level of the treble frequencies is increased and at the receiver they are correspondingly attenuated after demodulation to restore the audio back to its original frequency balance. The process of increasing the treble signals is called pre-emphasis, and reducing them in the receiver is called de-emphasis. The rate of pre-emphasis and de-emphasis is expressed as a time constant. It is the time constant of the capacitor-resistor network used to give the required level of change. In the UK, Europe and Australia the time constant is 50μS whereas in the US it is 75μS. Why the US is different from the rest of the world is unknown to me.

VHF-FM receivers contain the de-emphasis circuitry, consisting of a simple CR network, incorporated immediately after the FM demodulator. In this way it is not incorporated into an amplifier that may be used for other audio sources that would not require the de-emphasis needed for VHF-FM transmissions.

The big switch on

Official VHF radio broadcasts in the UK began on 2 May 1955 when the BBC started an FM service of the Light Programme, Third Programme and Home Service from Wrotham to its audience in the south east of England. As originally conceived the FM network in the UK consisted of 100% BBC stations. Independent (of the BBC) commercial radio stations in the UK at this date were not considered, other than allowing non-BBC spectrum in the upper bounds (that is, above 100MHz) of Band II if and when services already operating there were moved out. I presume that potential commercial radio operators had their hands full at the time with the roll-out of independent TV from 1955 onwards. As well as facing the technical challenges these operators also had to prove themselves of being trustworthy with the morals of the nation and capable of maintaining the standard of the programmes they produced, 'BBC standard' being of course the minimum acceptable. It's probably true to say that even today the jury is still out on these contentious questions.

Figure 3 shows the planned three-stage introduction plan of the BBC network on Band II, as predicted in 1954. Hopefully you will recognise most of the names of the stations: Les Platons may be a mystery to you (as it was to me). It was - and still

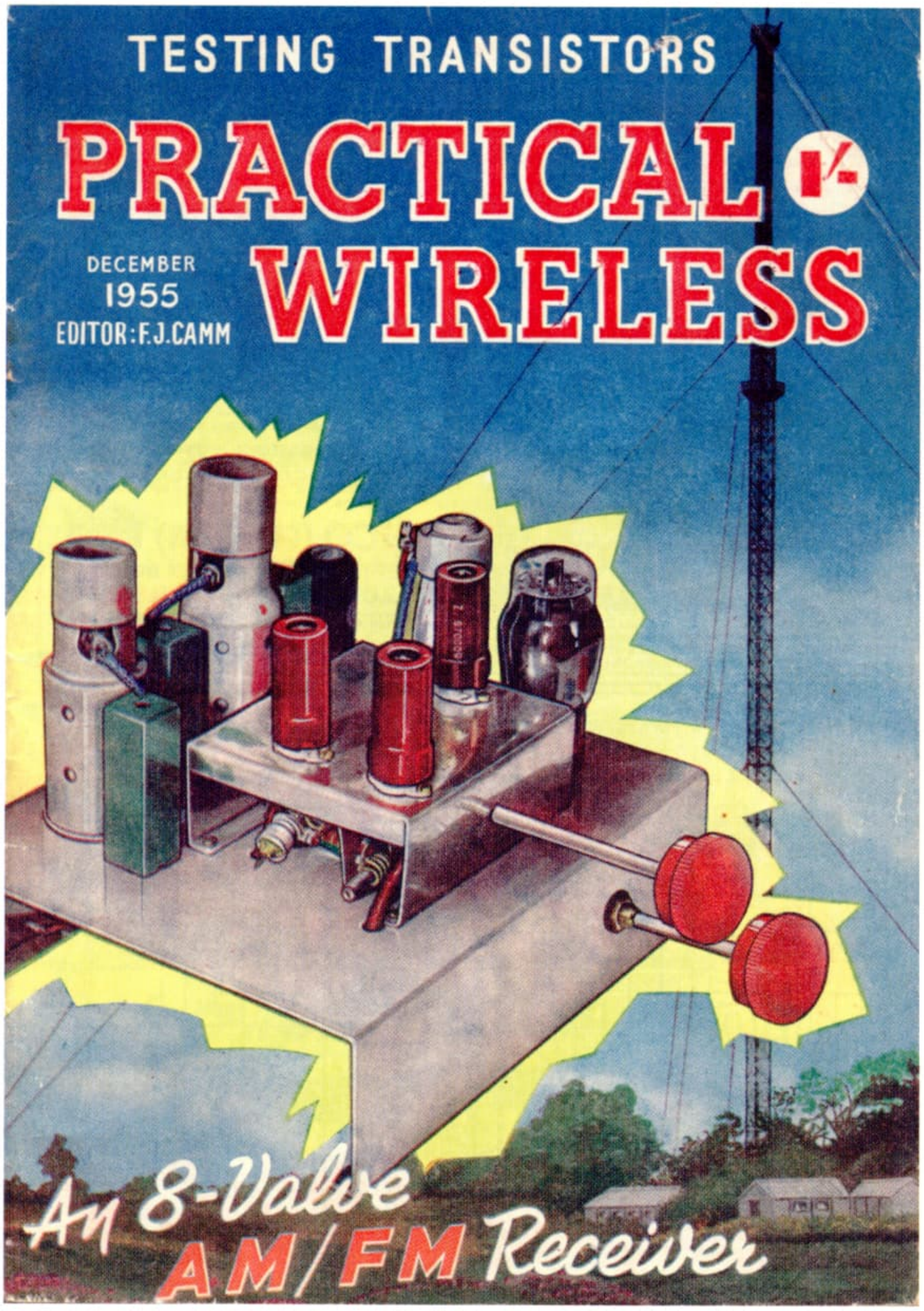


Figure 9: The cover art of Practical Wireless for December 1955 showing an 8-valve AM/FM receiver.

is - the highest point on the island of Jersey, and of course an ideal spot for the erection of a broadcasting station. As you can see stages I and II were definite but stage III was tentative. Note that the powers quoted are Effective Radiated Power (ERP) which takes into account the directional gain of the aerials. The policy was to co-site the new FM transmitters alongside existing TV transmitters and to make use of existing masts wherever possible, to give economies in capital costs, reduce maintenance costs and permit unattended operation.

The FM system transmitted was identical to that used in the US, except for the pre-emphasis applied to the modulating audio, as mentioned above. Because of the wide separation of adjacent channels the wider bandwidth enables the FM broadcaster to send more than one signal over a given FM channel using a process known as multiplexing: specifically it held the promise of stereo broadcasting. See later for how and when this was introduced.

Practical Wireless regularly reported on progress with the roll-out of the service. For example in December 1956 it reported that the South Devon station at North Hessary Tor had been brought into service. North Devon, Somerset and parts of Dorset, Wiltshire and Gloucestershire were to be covered from Wenvoe (near Cardiff) when new transmitters, in addition to those already dedicated to the Welsh service, were switched on. In May 1958 it reported that the FM station at Douglas, Isle of Man (a stage III station in the 1954 plan) had been brought into full service on Sunday 9 March, having operated an experimental service since December 1957. Even the building of an extension onto the Wenvoe TV station in 1955, in preparation for the FM transmitters, was newsworthy. In 1960 it reported that 97.3% of the population was then covered by FM services.

Figure 4 shows the Home Service programme schedule for Tuesday 2 October 1956, from that week's Radio Times. The main listing shows the service from Wrotham, as indicated by its VHF

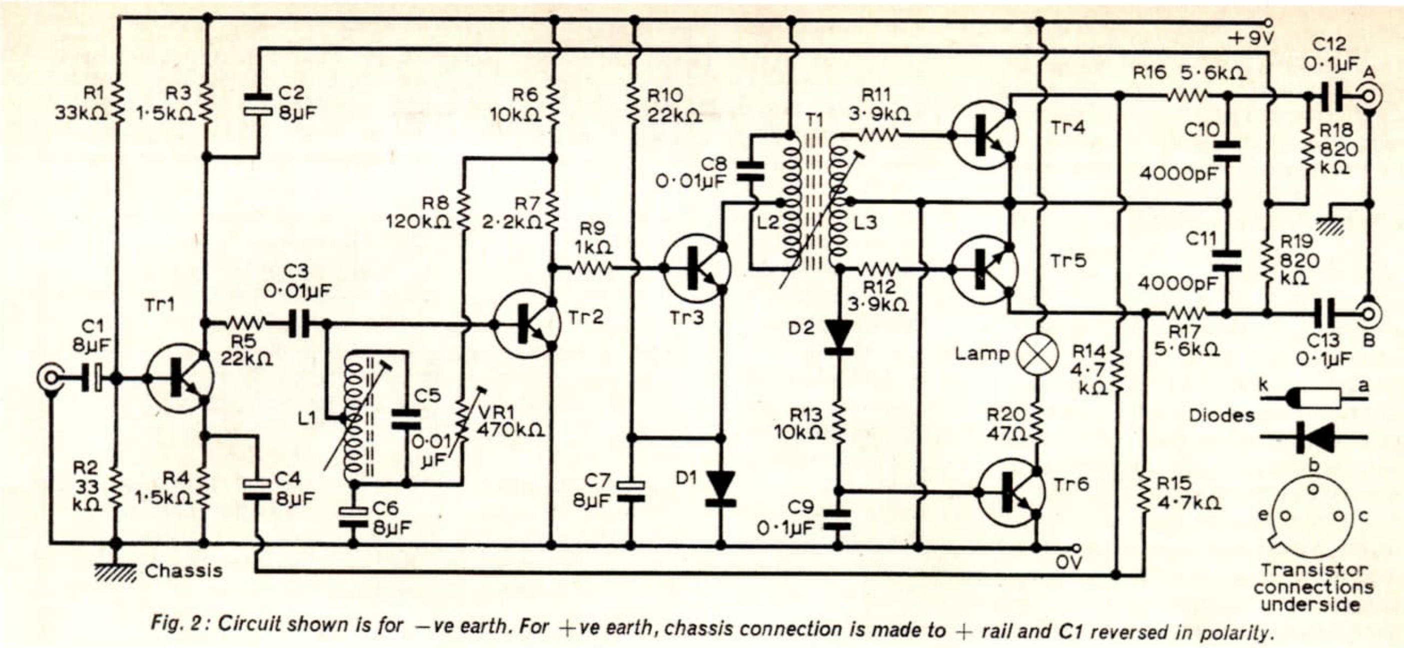


Figure 10: A transistor-based stereo decoder from the May 1970 issue of Practical Wireless.

frequency of 93.5MHz. On the left hand side of the page the differences for the regional services are shown. You can see that some of these services are transmitting on VHF, as well as on medium wave AM of course. For example Welsh (from Anglesey on 94.0MHz, and Wenvoe on 94.3MHz) and Scottish (from Meldrum on 93.1MHz) are transmitting on VHF-FM, whereas some services are still not on AM.

Radios in mass production

Once the BBC had decided on the modulation system and the exact frequency coverage of the band to be used manufacturers could design and start to mass produce suitable radios. It must have been tricky for manufacturers to choose the coverage of their radios, and no doubt some used 'full coverage' to 108MHz as a selling point. As it turned out broadcasting above 100MHz didn't really start in the UK until 1973.

By the mid-1950s Fitton were producing AM/FM sets (for example the 1287 radiogram) covering the full VHF-FM band of 88MHz-108MHz. Decca decided to cover the range 87MHz-101MHz with its 1955 model 1225 AM/FM table radio, and most manufacturers adopted what had by then become the standard IF of 10.7MHz for the FM signal path.

Although individual AM/FM sets varied in design, Mullard and others provided a complete set of modern 100mA heater B9A-based valves and a fairly standard AC/DC radio's valve line-up looked as follows. A double-triode (typically a UCC85) tended to be used in the VHF front end: one triode was connected as a grounded-grid RF amplifier and the other triode as a self-oscillating frequency changer. A UCH81 was used as the AM frequency changer and clever arrangements of IF amplifiers having AM (at round about 465kHz) and FM (at 10.7MHz) IF transformers in their anodes, each feeding the appropriate detectors, and switched by the bandswitch, were devised. A UABC80 provided the three diodes needed for the FM discriminator and the AM detector, and a triode for audio pre-amplification. The up-rated UL84 or UL85 audio output stage replaced the old UL41, giving more power and lower distortion, which was, after all, the whole idea of using FM. The good old UY41 mains rectifier was superseded by the higher current UY85, and often a UM80, or similar, magic eye indicator helped the user to get the tuning spot on for best audio reproduction from the FM signal. For manufacturers who were happy to use a mains transformer there were 6.3V versions of all these valves.

FM tuners

The concept of the add-on (to a Hi-Fi amplifier system, or feeding the gram input on an existing radio) tuner was born at this time. The Eddystone S.820 VHF tuner (see Figure 5), introduced in 1955 and staying in production until 1958 covered 85MHz-100MHz, and had the advantage that it incorporated its own power supply. I've seen several of these tuners at recent Society meetings, so they seem to have survived well.

Figure 6 shows the advert for RCA's 'Orthophonic High Fidelity' VHF receiver from the March 1957 issue of Wireless World. The tuner needed external HT and heater supplies which could be provided by the matching RCA power amplifier. Orthophonic was the brand name of RCA's comprehensive range of Hi-Fi gear, including the FM tuner, record turntables, amplifiers and speakers. Presumably this US-designed tuner was fitted with the correct de-emphasis components for the UK FM system.

The Jason Motor & Electronic Co offered FM tuners ready-built or in kit form, with pre-set or continuous tuning, which often appeared as constructional articles in The Radio Constructor. There were versions for listeners close to transmitters and ones for fringe area reception. The well known coil manufacturer Denco offered the Maxi-Q pre-set FM tuner kit (see Figure 7) for which constructors could also buy a companion power supply and audio amplifier. The likes of Osmor, Weyrad and Repanco also sold kits. An interesting coil pack design, and unique as far as I can see, was the Weyrad B60 AM/FM coil pack, which appeared in 1955. The pack covered long, medium, short and 'the FM band' (the pack restricted tuning to 87.5MHz-100MHz). All the wiring to the valve holders and their associated components was complete, and ready for installation into the radio chassis. There was a set of contacts on the wavechange switch for selecting the output of the AM or FM detector, appropriate for the band in use.

Having released its first high quality valve mono amplifiers in 1948 the Acoustical Manufacturing Co Ltd (the company we now know as 'Quad' - the company name was changed to this acronym for 'Quality Unit Amplifier Domestic' in 1983) developed separate high quality AM and FM tuners in 1959. Armstrong (no connection to the pioneer of FM in the US) offered various AM/FM tuner chassis which you could build into your stereo cabinet, along with their amplifiers. Other recognisable, and some not-so-recognisable, names building FM tuners were Rogers of Catford and Dulci of Willesden, both in London, and C T Chapman (Reproducers) Ltd with their sales office in Chelsea. Dynatron of Maidenhead also offered the public a four-station pre-set FM tuner which they also supplied to the BBC for use as a monitor receiver.

Leak's owner Harold Leak managed a team of designers, including two who were BBC engineers, and after a year of work the first FM tuner, the Trough-Line, was launched onto the UK market. The name was derived from an aspect of the design, specifically the tuning element. It was difficult to design a local oscillator for a VHF receiver that was stable (especially in the hot environment inside a valved-based tuner) and the Leak designers' solution was a shortened quarter wavelength transmission line in place of a conventional coil. This transmission line was made in the form of an open trough which was square in section, and made of copper. Early models had the trough made of solid copper, which made them heavy and expensive, and later versions used copper-plated mild steel troughs which did the job just as well. In the centre of the trough, a conductor ran along the length, with various taps that connected into the circuit of the oscillator valve and tuning capacitor. This transmission line was almost impervious to the effects of heat and so the oscillator frequency remained much more stable than is possible with a conventional coil. The trough-line based design technique went through several models and these tuners are still sought after today.

What exciting times these must have been as the design departments and factories of the British radio industry responded to the needs of the new broadcast medium – quite a contrast to what typically happens today!

Amateur FM receivers

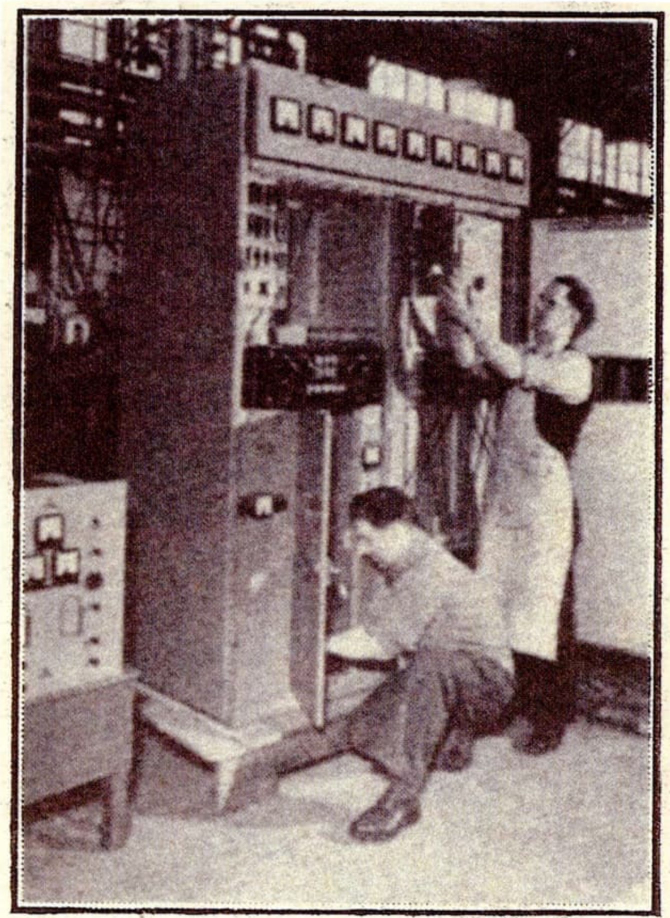
UK radio amateurs were authorised to operate in the 2m (144MHz-146MHz) amateur band from 1 September 1948 and so experience was building in the design and constructional techniques needed at these frequencies, albeit mainly for AM receivers and transmitters. By the mid-1950s the amateur radio press was keen to publish

S.T.C. Crystal Type	Transmitter	Triple Crystal Frequencies (Mc/s) (5th Overtone)		
		Light	*Third*	*Home*
4434/A	Wrotham	78.4	80.6	82.8
4434/B	Peterborough, Divis & Thrumster	79.4	81.6	83.8
4434/C	Rosemarkie & Llanddona	78.9	81.1	83.3
4434/D	North Hessary Tor	77.4	79.6	81.8
4434/E	Sutton Coldfield	77.6	79.8	82.0
4434/F	Pontop Pike and Rowridge	77.8	80.0	82.2
4434/G	Meldrum and Blaen Plwyf	78.0	80.2	82.4
4434/H	Holme Moss and Orkney	78.6	80.8	83.0
4434/J	Douglas	77.7	79.9	82.1
4434/K	Kirk o' Shotts	79.2	81.4	83.6
4434/L	Llangollen	78.2	80.4	82.6
4434/M	Norwich	79.0	81.2	83.4
4434/P	Les Platons	80.4	83.75	86.4
4434/Q	Oxford	78.8	84.7	83.2
4434/R	Dover	79.3	81.7	83.7
4434/S	Wenvoe	79.25	86.1	81.425 (West)

Base Connections:—Pins 1 & 5 Light Programme
Pins 3 & 7 Third Programme
Pins 2 & 6 Home Service

S.T.C. crystal type numbers and frequencies.
(Add 10.7 Mc/s to obtain transmitted frequencies.)

Figure 11: The range of sixteen triple crystal units introduced by STC in the 1960s, covering the main FM transmitters in service.



Assembly work in progress on a Marconi 4½ kW F.M. transmitter for the BBC.

V.H.F. Coverage

BY the opening of three more v.h.f. broadcasting stations (Wenvoe, replacing the temporary low-power transmitter, Sutton Coldfield and Norwich) a day or two before Christmas, the B.B.C. made good its promise to complete the first batch of ten stations by the end of 1956. To say "complete" is perhaps a slight exaggeration, for the Cardiganshire station at Blaen Plwy at present has only one of its three transmitters (Home Service) working. An eleventh station, at Penmon, was subsequently added to the original chain, but so far only one transmitter has been installed and this is radiating the Home Service with an e.r.p. of 1 kW.

The service now reaches 84% of the population.

	Light (Mc/s)	Third (Mc/s)	Home (Mc/s)	e.r.p. (kW)
N. Hessary Tor (S. Devon) ...	88.1	90.3	92.5	60
Sutton Coldfield (Warwicks.)	88.3	90.5	92.7	120
Pontop Pike (Co. Durham) ...	88.5	90.7	92.9	60
Meldrum (Aberdeenshire) ...	88.7	90.9	93.1	60
Blaen Plwy (Cardigan.) ...	88.7	90.9	93.1	60
Wrotham (Kent)	89.1	91.3	93.5	120
Holme Moss (Yorks.) ...	89.3	91.5	93.7	120
Penmon (Anglesey)	89.6	91.8	94.0	60
Norwich	89.7	91.9	94.1	120
Wenvoe (Glam.)	89.9	92.1	94.3	120
Divis (N. Ireland)	90.1	92.3	94.5	60

Figure 12 (left): One of the Marconi 4½kW FM transmitters being assembled in 1955.

Figure 13 (above): Wireless World for February 1957 reported that all ten of the stage I transmitters and one stage II (Penmon on the island of Anglesey) had been brought into service by the end of 1956.

constructional articles featuring FM radios, which readers could construct without buying kits. Figure 8 shows a simple valve-based tuner design from the August 1956 issue of Practical Wireless. The design is interesting in that it uses a push-pull oscillator running at 7.5MHz below the frequency of the received signal, and a single stage of IF amplification, driving a pair of 'crystal' diodes in the ratio discriminator circuit.

Peter Vaughan has sent me a few comments on this design which I thought would be useful to include here: 'First, the oscillator is indeed push-pull, with the anode circuit tuned. The tuning capacitor has both plates with RF on them, both are also at significant DC potential, yet this capacitor is ganged with the RF aerial tuning capacitor! This must have been a challenge.

Next, there's no obvious coupling of the oscillator into anything else. Is it coupled by mutual inductance between the oscillator tank circuit and the RF amplifier anode circuit – or by stray capacitance into the IF amplifier (which therefore does the frequency changing)? Or maybe it's into the first valve which does the frequency changing and the anode circuit of this is tuned to the IF. Whichever way, layout will be critical to make it work.

Next, although the discriminator is described as a ratio detector, the diodes are pointing the same way as for a Foster-Seeley discriminator. However, the AF take-off point is from the mid-point – as for a ratio detector. Moreover, there's a biggish capacitor across the total diode output, so one presumes that it really is a ratio jobbie and one of the diodes is drawn with wrong polarity.

Next, there is an AVC line shown feeding a voltage back to the IF / frequency changer. Fine – but the detector diode circuit is isolated from chassis, DC-wise, so it hasn't got a hope of working or even of biasing V3 correctly! Finally, the heater line is also shown as isolated from chassis. I've found this is a no-no unless you like hum. Hopefully nobody will try to build this design as it is (hopefully they didn't in 1956 either, unless there was a correction listed in a subsequent month)!'

The tuner was reported as being very suitable for local transmissions from Pontop Pike (in County Durham), but when Wrotham was being received amplitude pulse interference was sometimes audible, so it sounds like the designer did actually build his own design. As you can see the temptation to try to receive distant stations was still there, even though VHF-FM broadcasts were intended to cover relatively short distances.

FM tuners and receivers continued to appear in the radio magazines of the second half of the 1950s. I thought I'd show the cover art of Practical Wireless for December 1955 (Figure 9) featuring an 8-valve AM/FM receiver. You can see the VHF tuner section, using miniature B7G valves, perched on top of the main chassis. The rest of the design used good old fashioned octal-based valves. As a sign of things to come, notice the 'Testing Transistors' strap line at the top of the cover.

Valves, Transistors and Integrated Circuits

Throughout the 1960s, 1970s and 1980s FM tuners were popular articles in the radio press. Designs evolved through valves, transistors and eventually integrated circuits as these became affordable to amateurs. Recognising that most listeners would only listen to the three BBC services from their local transmitter many designs had three-position switched tuning which also helped with frequency stability. High class designs used crystals to control the local oscillator for ultimate stability. When stereo broadcasting started in 1966 many stereo decoder designs were published. A transistor-based stereo decoder is shown in Figure 10, from the May 1970 issue of Practical Wireless.

Mullard introduced a range of VHF/FM tuner and IF amplifier modules and these made the construction of a high quality FM tuner much simpler for the amateur. These modules were also used in commercial tuners and radios: for example Roberts used the LP1164, which was fitted with Mullard germanium transistors, in the R600 radio. Later Roberts radios were fitted with silicon transistor versions of the modules, such as the LP1179.

To solve the problem of local oscillator stability the Quartz Crystal Division of STC offered 'Triple crystal units for frequency control of FM tuners'. These consisted of three crystals encapsulated in a single B7G glass envelope, whose frequencies were determined by the BBC transmitter you wanted to receive. The crystal frequencies were set to be 10.7MHz below the Light, Third and Home broadcasts for that particular transmitter. In 1961 STC produced eleven units covering the fifteen main transmitters in service at the time, and eventually expanded the range to sixteen, as shown in Figure 11 taken from a constructional article in The Radio Constructor for March 1968.

FM transmitters

Practical Wireless for June 1955 reported on the BBC placing orders with Marconi's Wireless Telegraph Co Ltd for the construction of 26 VHF-FM transmitters 'for sound broadcasting'. Delivery was scheduled to begin within 14 months. The transmitters comprised 24 with powers of 4½kW, and two of 10kW. The 4½kW transmitters would be operated in parallel-pairs, each pair handling one programme. Therefore six transmitters were needed for each BBC three-programme station. The two 10kW transmitters were to be operated in parallel at the existing VHF station at Wrotham, where there were already two 25kW Marconi transmitters. Air-cooled valves were used (in contrast to liquid cooled in many high power AM transmitters), resulting in reduced installation and running costs. Note that these are the 'raw' power outputs of the transmitters, and the directional nature of the aerials raises the effective power to the ERP levels shown in Figure 3.

Frequency modulation used the so-called 'FMQ' system, consisting of a frequency-modulated quartz crystal which supplied an output at the carrier frequency. The signal was then amplified to the required output level, the number of amplification stages used depending on the rated output power of that particular type of transmitter. The amplification stages used a combination of tetrode and triode valves. Of course FM has the advantage that it doesn't need high power modulation of the power amplifier stage, as does an AM transmitter. Figure 12 shows a picture of one of the Marconi 4½kW FM transmitters being assembled.

Marconi had previously been given the order for six 10kW FM transmitters to serve the north of England, located at Holme Moss. At this site the FM aerials were a slotted array forming an integral part of the existing 750ft TV mast. The ERP of each signal transmitted from this site was 120kW.

The other UK supplier of transmitters was Standard Telephone and Cables (STC) who used a different method for generating FM. They made use of balanced reactance-valve modulation of a free-running oscillator whose centre frequency was controlled by a reference signal, locked, after frequency division, to a low-frequency crystal standard. Wireless World documented the standards (see Reference 4) of quality achieved by 1957 by these two forms of transmitter. Because the way the performances were reported were expressed in different ways and were therefore not directly comparable, they

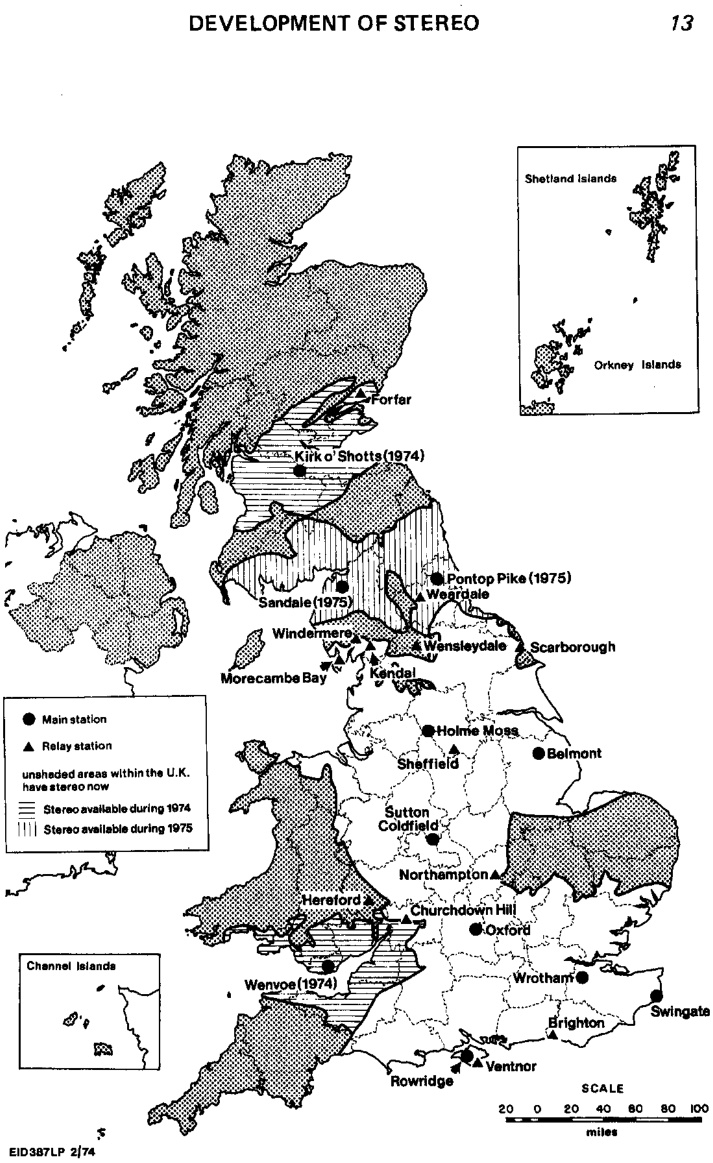


Figure 14: The state of stereo coverage in the UK in 1974.

indicated 'the high standards achieved in the frequency-modulated VHF service'.

In February 1957 Wireless World reported that by the end of 1956 all ten of the stage I transmitters, and one stage II (Penmon on Anglesey) had been brought into service, although not all stations were transmitting all BBC services, see Figure 13. The policy seemed to be to 'bring up' the regional Home Service first.

FM DX

Although transmissions at 100MHz were generally regarded as being line-of-sight, examples were seen where transmissions reached much further afield, just as similar phenomena had been seen in the US. Wireless World for August 1957 reported a listener located in Bolton, in Lancashire, having no trouble receiving Wrotham, more than 200 miles away. His aerial was 'an improvised single dipole consisting of lengths of brass wire fixed to a thin board with paper clips'. There were other examples of long range reception of VHF-FM signals but Wrotham seems to have been pushing out the most far flung of the Band II transmissions. Mike Barker seems to have experienced something similar recently (see The Bulletin for autumn 2013) with his reception of Italian and French stations around 100MHz.

Just to indicate what might have happened if the BBC's FM service had been allocated to the spectrum around 45MHz, a Wireless World reader in New South Wales, Australia, reported that he had regularly received the Alexandra Palace (or had the transmitters moved to Crystal Palace by then?) TV transmission sound on 41.5MHz 'on peaks as strong as the local TV station' from October 1956 throughout 1957, on his Hallicrafters SX28 receiver. The listener had recorded what he had received and had it verified by the BBC. Another listener in South Africa reported similar results. This period was not too removed from the peak of solar cycle 19, lasting officially from April 1954 until October 1964, which produced the highest number of sunspots (both peak and averaged counts) since records began in 1755, and since. This may have been responsible for these examples of exceptionally long range reception. See Reference 5 for more details of this solar cycle.

The state of play in 1966

How had the FM network developed in the ten years or so up to 1966? The 15th edition of the 'Guide to Broadcasting Stations' booklet, published by Wireless World in 1966, described the European VHF sound networks, including that of the BBC. The UK network includes 146 'stations' (all BBC of course), by which I mean distinct broadcast services from a given location: for example, Wrotham counts as three 'stations'. From the powers given for some (for example, Kinlocheven, a small town in a narrow valley in the Highlands of Scotland, which was transmitting with an ERP of just 2W) there were many 'in-fill' transmitters to cover relatively small audiences in difficult locations. There was a total of about 3,500 FM transmitters throughout Europe, which I think is an impressive number. Hundreds of these were relatively low power stations in Italy, where many low power transmitters were needed to cover the numerous small valley communities in mountainous terrain.

All UK transmitters were still using channel numbers of 34 (that is 97.2MHz) and below. If you'd invested in an Eddystone S.820 tuner in 1955, with its upper limit of 100MHz, it would have still been perfectly usable. These channel numbers are in steps of 200kHz and I believe that the UK kept to this channel spacing at this time. If you look at a complete list of European stations in 1966 many of them are 'off' these channels, though they are still mostly on integers of 100kHz. However some stations are on '50kHz' frequencies: for example Aachen in West Germany was transmitting on 98.45MHz.

In a rebranding of the BBC's radio services in 1967 the Third and Home services became Radio 3 and Radio 4 respectively. The Light programme split into two parts: the more adult Radio 2, and Radio 1 which was intended as the young person's radio station (remembering that the BBC had been effectively forced into the creation of Radio 1 to compete with the pirate radio stations and Radio Luxembourg). Radio 1 broadcast initially on 1214kHz on the medium wave band - or 247m as it was referred to at the time - and eventually on VHF-FM in the newly vacated range of 97-99MHz.

It was not until 1973 that the first independent (of the BBC) national commercial stations appeared and these gradually occupied the spectrum above 100MHz. With the gradual clearance of other users (notably Public Services such as police, fire and ambulance) they were joined in this frequency space by independent local and BBC local stations, and stations can now be found stretching pretty much up to the upper limit of the band at 108MHz.

The NTSC experience

The caution that the BBC exercised in the choice of modulation method and transmission frequency (although it must be said that this was heavily bound by international agreements) of the new radio service seems like ultra-conservatism to us now. However it might be relevant to point out that in the rush to roll-out colour TV in the US (driven mainly by NBC and RCA, after an aborted attempt to introduce a service based on a CBS standard) starting in 1953, the choice of NTSC as the video standard turned out to be a disaster which viewers are only finally free of now, as analogue TV finally shuts down in the US.

Maybe the BBC was already hearing rumblings about the US experience with colour TV, which was being driven more by commercial concerns than picture quality, and was worried that a non-ideal radio system could be imposed on the UK.

In 1954-1955 experimental broadcasts of a 405-line NTSC colour system were carried out in the UK by Marconi. Money permitting this could have led to the relatively quick introduction of a full colour TV service: as it turned out the standard was not adopted, and the UK had a lucky escape. It was not until the introduction of PAL 625-line colour TV (using FM for its sound) in 1967 that regular colour TV broadcasting started in the UK, on BBC2.

Stereo broadcasting

The FM signals being broadcast in 1955 were of course in mono. There were some fairly esoteric experiments with stereo broadcasts in the UK, including test transmissions where one channel was transmitted from Wrotham (on VHF-FM) and the second channel was transmitted on medium wave AM from Brookmans Park. The listener needed two radios and placed them a few feet apart to give the stereo effect. Surprisingly the results were impressive and sounds could be located between the speakers, which is what true stereo should give you. Exactly what the point of the experiment was has gone unrecorded, as I can't believe it was ever considered as a feasible scheme.

F J Camm, the editor of Practical Wireless, considered the tests as 'interesting, regarded as an experiment, but in our view it failed to demonstrate that it was worth the trouble and expense of having two perfectly matched loudspeakers which are necessary'. He continued 'the need therefore, for stereophonic sound with the extra expense involved is almost non-existent. In our view the BBC transmissions are so good that this refinement in any case is unnecessary'. Hardly the view of a visionary!

After experiments with various techniques the stereo system adopted in the US was a combination of those proposed by set manufacturers GE and Zenith, which were so similar that they were considered theoretically identical. This was formally approved by the FCC in April 1961 as the standard stereo FM broadcasting method in the US and later adopted by most other countries, including the UK. It is important that stereo broadcasts should be compatible with mono receivers. For this reason, the left (L) and right (R) channels were algebraically encoded into sum (L+R) and difference (L−R) signals. The (L+R) main channel signal was transmitted as baseband audio in the range of 30Hz-15kHz. The (L−R) sub-channel signal was modulated onto a 38kHz double-sideband suppressed carrier (DSBSC) signal occupying the frequency range of 23kHz-53kHz.

A 19kHz pilot tone, at exactly half the 38kHz sub-carrier frequency and with a precise phase relationship to it, was also generated. This was transmitted at 8–10% of the overall modulation level and used by the receiver to regenerate the 38kHz sub-carrier with the correct phase. The final multiplex signal from the stereo generator contains the main channel (L+R), the pilot tone, and the sub-channel (L−R). This composite signal, along with any other sub-carriers, modulated the FM transmitter.

A mono receiver used just the (L+R) signal so the listener heard both channels in the single loudspeaker. A stereo receiver added the difference signal to the sum signal to recover the left channel, and subtracted the difference signal from the sum to recover the right channel.

Regular stereo broadcasting began in the UK in 1966. Stereo FM signals are more susceptible to noise and multipath distortion than are mono signals. In addition, for a given RF level at the input of a receiver, the signal-to-noise ratio for a stereo signal will be worse than for a mono signal. For this reason many stereo FM receivers include a stereo/mono switch to allow listening in mono when reception conditions are less than ideal.

I used the past tense for the description of how FM stereo broadcasts worked in 1966: in fact it's pretty much the same today, with the addition of other low bandwidth data, such as RDS (Radio Data System).

Figure 14 (taken from Reference 6) shows how stereo broadcasts had 'rolled out' by 1974. As you can see the main areas of population in the south east, midlands and north of England were well covered, and 1974 and 1975 would see more significant areas covered. There were still large areas in Wales, East Anglia and the south west of England, Scotland and Northern Ireland still without a firm date for when their stereo service would begin.

Local radio

When BBC services opened from Holme Moss in December 1957 it was estimated that some 14 million people were covered, assuming of course that they had made the investment in a radio or tuner. In the south east Wrotham must have covered a similar number of potential listeners. Although the Home service they broadcast was different (in fact there were seven regions in total, just as there were on the medium wave) by no stretch of the imagination is this local broadcasting. In 1967 the Postmaster General, Mr Edward Short, presented a White Paper to Parliament dealing with the future of broadcasting in the UK. Much of it covered the BBC's finances (the combined TV and radio license was £5 at the time, and the BBC was now to be allowed to keep all of it) but it also mentioned new technology and services, and when they might become available. The new kid on the block was of course colour TV which was just about to start in that year on BBC2.

The paper could see no prospect of a fourth TV service (on top of BBC1, BBC2 and ITV) for at least ten years. In fact the commercial Channel 4 network didn't appear until 1982, and struggled financially for many years until it was supported by the government in 2007.

A new 'popular music programme' – Radio 1 – was also just about to launch. On the subject of local radio it was recognised that this could not be accommodated on the congested medium wave, and so 'the only possibility for such a service lies in VHF'. The possibility of financing this service via advertising on commercial stations was considered, but the conclusion was that 'it is in their view of first importance to maintain public service principles in the development of the broadcasting services' and there was 'evidence of the expertise and professional enthusiasm which the BBC could bring to local sound broadcasting' as evidenced by some trial programmes they had prepared. In the conclusion of the report the government authorised the BBC to go ahead with a nine station local service on VHF-FM.

The BBC would not accept commercial advertising on these local stations but was willing to accept financial support from local authorities, Chambers of Trade and Commerce, local Councils of Churches, arts associations and 'other representative bodies active in the social and cultural life of the community'. How many of these bodies actually contributed is unknown but certainly most local councils refused to pay and it's likely that the BBC – or more precisely the license payer – paid the vast majority of the set-up and running costs for these local broadcasts.

Legal commercial broadcasting on AM medium wave and VHF-FM finally began in the UK in 1973, with the launch of the London Broadcasting Company (now LBC Radio) and this gradually took some of the burden from the BBC of being the sole provider of radio broadcasts. Of course the BBC did not give up its obligation to local broadcasting: in most areas today there are both commercial and BBC local stations.

In conclusion

VHF-FM broadcasting in the UK took a long time to roll-out and to get to a mature state, which strongly contrasts with what happened in the US. I suppose the most significant difference between the UK and the US was that in the latter country there was a driven individual, Edwin Howard Armstrong, who was willing to put his money where his mouth was and personally fund the development of FM broadcasting. In the UK of course we had to wait for a conservative BBC and a cash-strapped government to get their acts together, which finally resulted in a public service in the mid-1950s.

Tests before and after the war didn't reach a conclusion until 1954 when FM was finally chosen as the modulation method – though those in the know could probably have guessed with some certainty in 1950 or so that this was the way it would most likely turn out. Seemingly the BBC ignored most of the knowledge built up in the US, Germany and other countries, and insisted on repeating all the tests for itself. Perhaps the government was secretly relieved by this: it meant it could postpone the decision on spending on the infrastructure during a very difficult period until finances became easier in the mid-1950s. Let's not forget that the BBC and the government had already been investing in national 'high definition' TV broadcasting for the ten years before the VHF-FM switch on. This certainly consumed much of the BBC's resources, both in terms of manpower and finances.

Initial reaction to the FM programmes was not all positive. In the May 1959 issue of Practical Wireless the editor commented on the quality (or lack thereof) of the land-lines feeding the BBC's FM transmitters. These lines had an upper frequency limit of about 8.5kHz and therefore limited the potential quality of the audio to the listener below that achievable by the FM broadcast system itself. Listeners who could receive several stations said they could hear different quality sound from each, specifically at the upper audio frequencies, with Wrotham being the best. The theory was that when Wrotham was constructed it was equipped with new, high-quality links from the BBC studios in London, whereas other stations were not. Presumably all these land lines were gradually upgraded so that the full potential of the FM system was realised. The advent of stereo with its increased overall audio bandwidth, and availability of the technology, led to an upgrade to digital Pulse Code Modulation (PCM) links being adopted in the 1970s.

After its introduction the medium of FM broadcasting stayed with a niche audience of mainly Hi-Fi enthusiasts for a long time, perhaps because for many years it offered services that could still be received on AM, albeit at lower quality. In my humble opinion the introduction of affordable car radios capable of receiving VHF-FM did a great deal to bring FM to the masses. What was probably the first car radio produced in the UK capable of receiving VHF-FM was introduced by Philips in 1957. This valve-based design cost 49 guineas, which was a significant proportion of the cost of the car itself, and therefore made it a bit of a luxury, and I'm sure it wasn't installed in too many vehicles. The development of Radio Data System (RDS) containing low data rate information such as PS (Programme Service - that is the station's name) and AF (Alternative Frequencies – that is data to allow the radio to re-tune to the same station automatically) embedded in the transmitted signal made FM reception in a car much more straightforward. It was then possible to drive from one end of the country to the other without retuning your radio, the radio itself seamlessly selecting the strongest transmitter broadcasting the programme you were listening to. See Reference 7 for more information on RDS.

As far as I can determine there doesn't seem to have been a train of thought in the UK that FM broadcasting at VHF would eventually cause the demise of AM broadcasting on the medium and long waves, as Armstrong had envisioned in the US. Both forms of modulation are still with us and both serve us very well. The threat to both today is from new digital modulation systems such as DAB and DRM+ (the VHF extension to DRM), and the will of politicians rather than the technical merits of the various modulation schemes. Another factor is the rapid growth of wireless internet whereby 'listeners' can receive their favourite radio stations on their mobile devices.

The latest view is that AM and FM will be switched off in the UK sometime between 2017 and 2022, if any government thinks this is worth the political risk. One of the technical challenges for these new broadcast systems that has yet to be solved is how to reach the millions of car drivers with a reliable radio service, which VHF-FM still does very well. As we approach the 60th anniversary of the official start of FM broadcasting from Wrotham let's celebrate that the service is still with us, and long may it continue.

The majority of this article was originally published in Radio Bygones magazine, and it is reproduced here by kind permission of the editor.

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Reference 3: 'First Steps in VHF Exploration' by 'Cathode Ray'. Wireless World January 1947.

Reference 4: 'BBC FM Transmitter Performance'. Wireless World February 1957.

Reference 5: More details of solar cycle 19 can be found at: http://en.wikipedia.org/wiki/Solar_cycle_19 and http://www.solen.info/solar/cycl19.html

Reference 6: 'BBC Television and Radio Stations' published by the BBC's Engineering Information Department in 1974.

Reference 7: Information on the RDS system as transmitted on VHF-FM can be found at: http://en.wikipedia.org/wiki/Radio_Data_System

Other Useful References

'Man of High Fidelity: Edwin Howard Armstrong' by Lawrence Lessing. Published in 1956, by J B Lippincott Company of Philadelphia and New York.

'BBC Engineering 1922-1972' by Edward Pawley. Published by BBC Publications in 1972. A comprehensive and weighty tome (569 pages) which contains nine very informative pages on the development of VHF-FM broadcasting in the UK.

A detailed description of the BBC's experimental FM transmitter at Wrotham was given in the April 1951 issue of Practical Wireless.

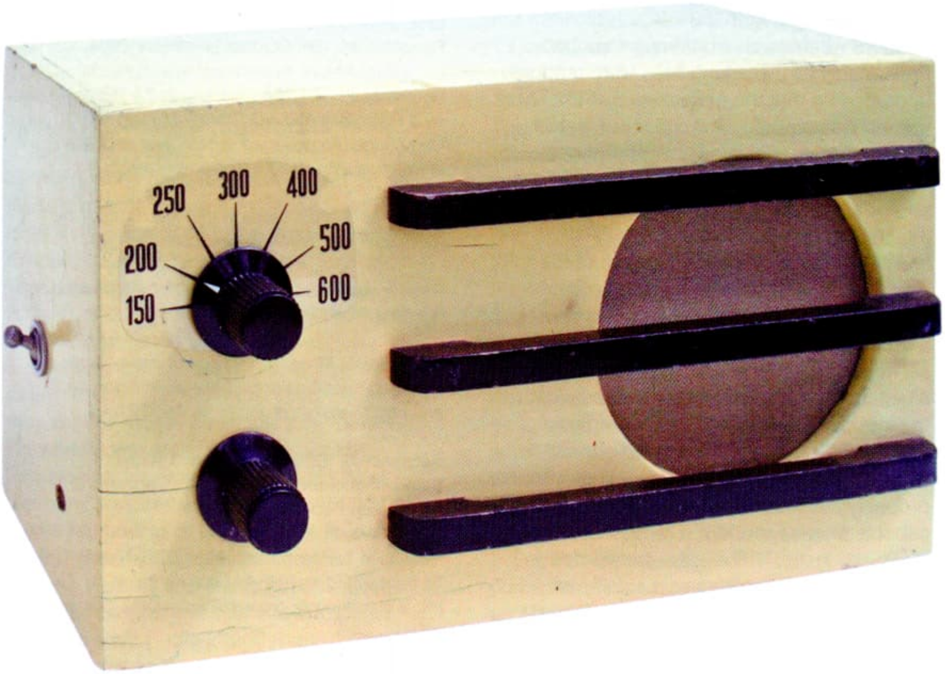
'The Wireless World Guide to Broadcasting Stations' was published by Iliffe in many editions starting in 1946, and is a very useful reference to the state of broadcasting worldwide at any particular date. In 1947 the 48-page booklet cost 1/- (one shilling) and postage was 1d (one old penny).

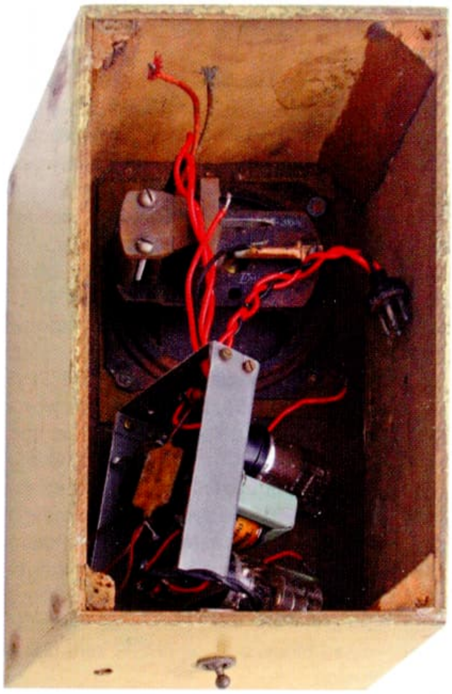
The BBC produced several very useful booklets over the years entitled 'BBC Radio Transmitting Stations', 'BBC Radio and Television Stations' and 'BBC Engineering Information' which catalogued all their broadcast stations, locations, power levels, services, etc. Modern equivalents are the 'Radio Listener's Guide' and 'Television Viewer's Guide', edited by Clive Goodyear, information on which can be found at: http://www.radioguide.co.uk/

The restoration of an Eddystone S.820 FM tuner is described by Gerry O'Hara at: http://www3.telus.net/radiomuseum/projects/LeakMk1/EddystoneS820Restoration.pdf

A junk box radio By Roger Grant

While sorting through a pile of radio odds and ends, including a couple of home made Hi-Fi amplifier chassis and a few power supplies, I discovered a small wooden box full of radio components. When the components were tipped out along with the dead spiders and sawdust, a small chassis containing two valves was found inside and this was attached to the box by three wires connected to a toggle switch on the side of this box and a solid dielectric variable capacitor in the bottom. There's also a 4" moving Iron speaker fitted to the bottom of this box. Turning the box over I discovered that it was a purpose built cabinet in an art deco style, these features were hidden while upside down and full of junk. Closer inspection of the chassis revealed several different periods of radio history all cobbled together and obviously very home made, and this reminded me of the sort of set I used to build as a schoolboy in the 50's and 60's.





Upturned junk box as found

The small chassis inside had two valves fitted, an HL2 four pin triode and a DL35 1.4v Octal output valve, first impressions were it had been turned into an amplifier or an intercom as it was found with other audio items, but on sketching out the circuit I found that there's an RFC in the anode circuit of the HL2, indicating that this is an RF stage, this would also explain the 300pf variable capacitor on the front panel, possibly a reaction control.

So far we have a moving Iron speaker and an HL2 2v triode from the late 20's or early 30's, a cabinet style from the 30's, a DL35 1.4v output valve from late 30's or early 40's and a 4 pin battery plug that fits an Eveready B114, a combination HT and LT battery definitely post war from the late 40's or early 50's and an Eveready B114 battery fits in nicely behind the speaker, the more I delved into this set the more interesting it got, there's another aspect of this stylish little set that's a bit strange but I haven't quite worked it out yet.

The speaker, a bit unusual, it's a moving Iron type with a paper cone, it's 4" diameter and reads 250 Ohms on the AVO, I haven't seen a moving Iron type this small before and it doesn't have any means of adjustment for the moving iron reed as is usual for this type of speaker, it does seem to have quite a lot of freedom of movement between the pole pieces and perhaps it doesn't need any. The moving Iron reed is cantilevered via a leaf spring and attached to the cone by a thin rod, all of the mechanical linkage from the moving iron to the cone has soldered joints and is also completely un-adjustable.

The frame is sprayed matt black and a bit rusty around the edges so needs some attention, there's a make and part number stencilled on the centre mounting plate, I don't want to loose these, so I'll mask them off and just clean and puff in the rusty bits with a touch of satin black spray paint.

The speaker grille cloth is also unusual as it's a square piece of cloth woven with fine brass wire about 36 swg, this is heavily oxidised, a good scrub with a cut down stiff brush and a drop of Brasso and its gleaming again, this followed by a good rinsing off and after fully drying in the airing cupboard, a light puff of clear lacquer to stop re-oxidation, this brought this stylish little set back to life. The main RF components, a tuning coil, tuning capacitor and a means of connecting an aerial are missing but everything else is intact, only three components but I'd like to get replacements as close as possible in keeping with the theme of this set, now that I'm hooked on getting it working.

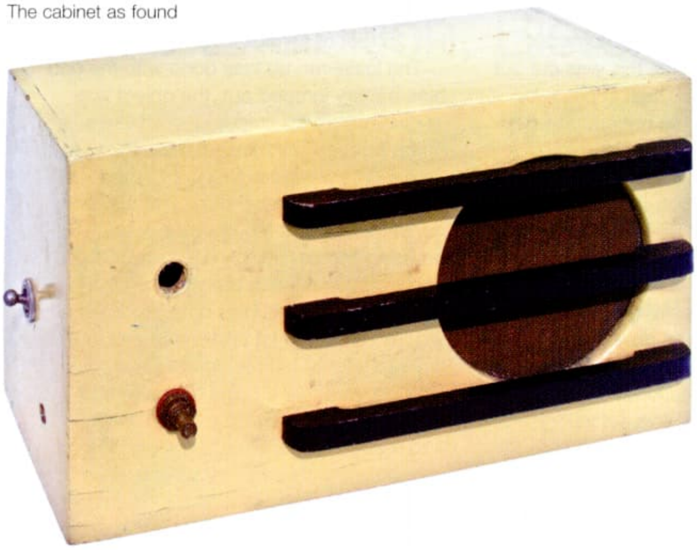
Looking through a copy of the bound version of the 1947 Radio Constructor, (this just happened to be on my desk in front of me at the time and just the right period) and browsing a few copies of Practical Wireless from the early 50's, I discovered several circuits for two valve receivers explaining the basics and aimed at beginners, there were many articles of this sort and this was an ideal source of information to refresh my memory of the finer details of this period of radio home construction.

After an hour or so of reading through these articles, I had rediscovered an aspect of these periodicals that annoyed me intensely as an amateur constructor in my youth back in the 50's and 60's, most of the circuits used commercial coils manufactured by companies like Denco, Wearite, Repanco or Weyrad, for a school boy on very limited pocket money buying expensive coils was a big no-no, all of my constructional projects were from circuits where you wound your own coils, so I'll do the same here especially as the tutorial articles were very good and contained enough details sufficient to design my own in keeping with this period.

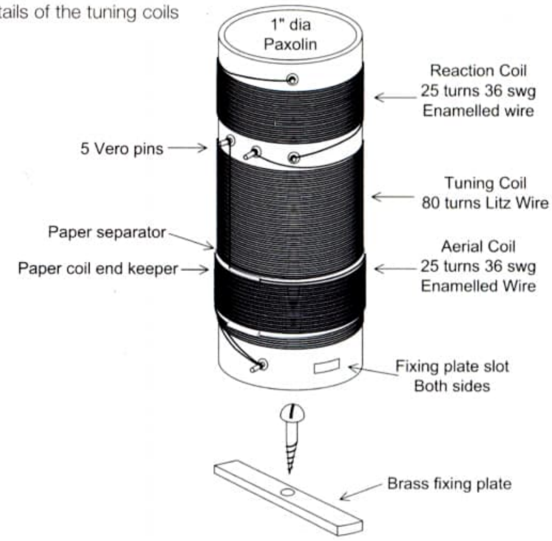
The tuning coil requires three windings, aerial tuning, aerial coupling and reaction feedback coupling.

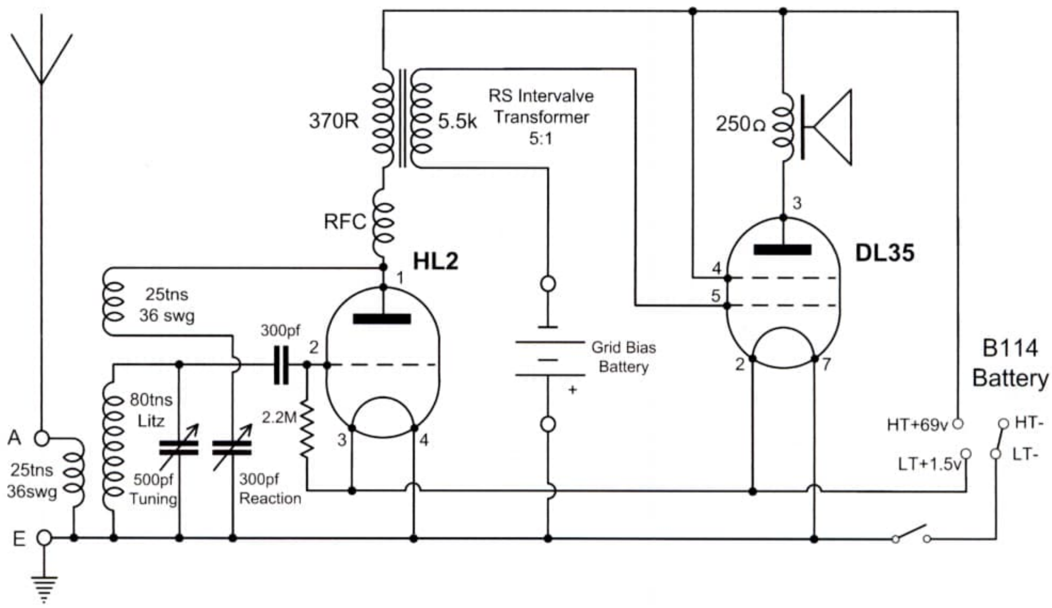
I would like this set to cover 1600kc/s

The cabinet as found



Drawing and details of the tuning coils





The tuning coil

(around 185m) on the end of the medium wave band, so taking the approximately 85 turns on a 1" former as a standard coil for this band, I have reduced mine to 80 turns to cover this frequency, I'll wind it in Litz wire to give it a higher "Q" and best chance of selectivity (and I have a large reel in stock), the Aerial coupling coil 26 turns of 36swg enamelled copper wire over the top of the tuning coil (wire gauge not critical), giving this RF transformer a ratio of around 3:1, finally the reaction winding, this will be about half the number of turns of the Aerial coupling coil and wound further up the former.

I started by sawing off a 3" length of 1" dia Paxolin tube, I then cut a couple of opposing slots at the base 1/4" x 1/8", these were cut about 1/4" up from the bottom and then inserted a piece of 1/8" brass plate 1/4" x 1 1/8", this has a hole drilled in the middle for a single screw to mount this coil, next, after working out the spacing of the coils, five 1mm holes were drilled and Vero pins inserted as terminals, the coils then wound and the end wires soldered to the Vero pins, finally the coil was mounted on the back of the front panel close to the 500pf solid dielectric tuning capacitor, this fitted in the vacant hole in the front panel and a similar type to the reaction capacitor already fitted.

Checking around the rest of the components I discovered the secondary winding of the valve inter-stage transformer was open circuit, fortunately this winding is on the outside and relatively easily replaced, I removed the outer frame and all of the "E" and "I" laminations, the winding was unwound a few hundred turns and no break found, I then continued unwinding and it was soon obvious the break was near the inner end of the winding, so the rest was cut away and replaced with the same gauge wire (44swg) about 2 thou, filling the bobbin to the previous level, the original outer cover with the RS logo re-fitted followed by the laminations and outer frame, both windings now tested ok.

One end of this secondary winding is connected to the grid of the DL35, the other end connected to a black flying lead, this is paired with a red flying lead connected to the common chassis, these fed out from under the chassis, these wires are only a few inches long with the ends stripped back ready for connection to a grid bias battery.

Both of the valves were run up on the valve tester and both were very healthy, so all it needs now is a battery.

I have two original B114 batteries in stock one an Eveready of the type number quoted and an Exide version type number DM541, both of these have had their covers unglued and have been scanned into my PC for future reference and manufacture, the Eveready is very tatty and only good for a reference, but the Exide is in nice condition, now copied, I'll re-stuff this original, the HT is 69v so it'll be 8 PP3's to give me 72v and a "C" type Duracell for the LT, with the LT battery fitting in a carrier, there's just enough room for the PP3's with their outer cover stripped off reducing the thickness, this all fits in a purpose built folded aluminium tray with a paxolin four pin socket fitted, this assembly fits inside the re-glued original battery, this has one unglued end just held closed with two small beads of Blue-Tac.

A final check round and I had forgotten to fit an aerial and earth socket, this soon remedied, a small piece of wood was glued to the inside of the top of the set, the Paxolin aerial and earth panel then screwed between this and the cabinet corner quadrant.

I connected my long garden aerial and a mains earth (the blue plastic water pipe not a lot of use), I then plugged in the battery and switched on, the set then practically jumped off the bench, I hadn't expected much out of this basic little set, certainly not the level of volume obtained, several overlapped stations uncontrollably loud, I unplugged my main aerial and plugged in my secondary workshop aerial, this is about 25 feet long strung up along the ceiling of my workshop, this improved the situation considerably, I could now separate the stations and control the level with the reaction control.

The reaction control didn't push the RF stage into oscillation so I reversed the connections to the coil to make sure it was in the right phase, and it was right the first time, I originally wound the reaction winding with 15 turns so I re-wound it with twenty five turns for a bit more feedback, this did the trick and I can now get peak performance just before oscillation at the far end of the reaction controls travel.

I checked its tuning range with the signal generator, it tunes between 550 kc/s and 2 Mc/s at its very extremes, The useful bit between 600kc/s and 1800 kc/s, (500m to 170m) and while the test gear was out I plotted out a near enough tuning scale, (I'd rather it looked right than be totally accurate) then generated some appropriate numerals and printed it onto an acetate, this was cut out and fitted to the front panel, held in place by the tuning capacitor retaining nut and washer, followed by a pair of appropriate knobs.

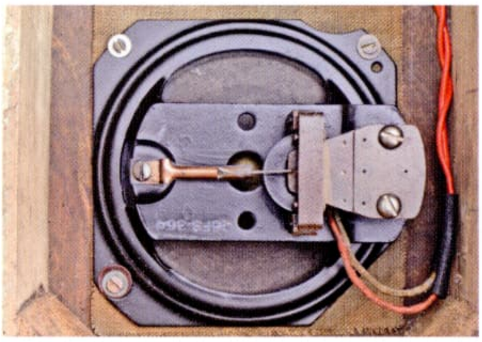
I spent the next hour or so just playing and listening to this lively little set, the listening level was very good for a two-valver with a speaker and it was possible to push the speaker into distortion if too loud, tuning was surprisingly sharp and selectivity excellent for a TRF set and a slow motion drive would be a big improvement, this would also ease the solid dielectric tuning capacitor as these tend to be a bit stiff. If I had built this set in my youth I would have been very pleased with it.

I reconnected my long garden aerial, this just seemed to swamp and over load it and selectivity was lost, back to uncontrollably loud overlapped stations, I did consider incorporating an attenuator but as the set was very happy and a lot of fun with just 25 feet of aerial, I'll settle for that.

The initial run up was done with the grid bias battery jumped out, the object was to give maximum output as I didn't expect much from this circuit, I later fitted one and tried it on several tappings, it just reduced the volume a little and of course the current consumption of the output valve, as I won't be using this set for long periods, battery consumption is not a problem so I'll leave it jumped out, as grid bias batteries often were, or they just went flat and were never replaced.

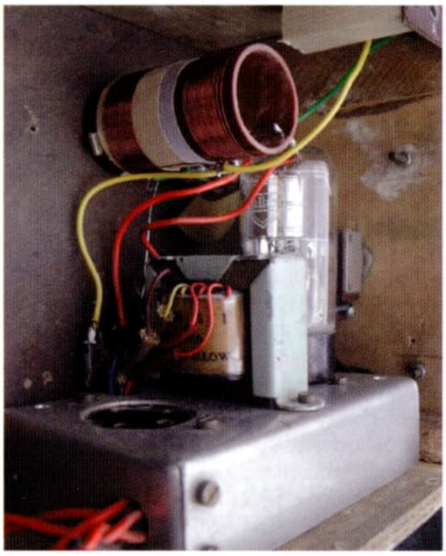
I had a lot of fun restoring this excellent little DIY radio and would recommend anyone from beginner to expert to build one just for fun, especially sourcing all the parts from a junk box and an excellent way to spend a wet winters weekend. Oh! another odd aspect of this set that has just dawned on me, it's builder must have been left handed as the controls are on the wrong side of the set.

Brass speaker mesh



Speaker plan view

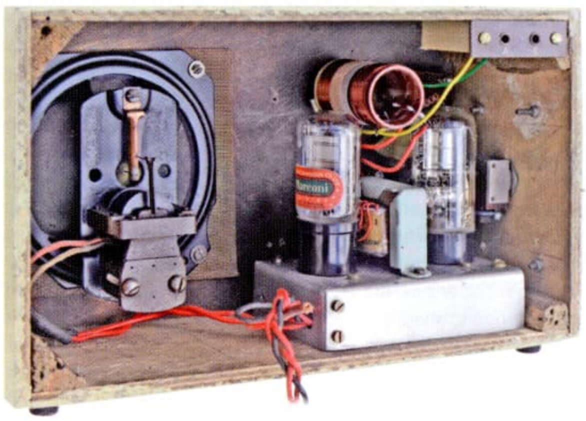
Speaker mechanism close up



Close up inside cabinet

Battery new innards

Rear cabinet battery in



Rear cabinet battery out

BVWS Exhibition, Bletchley Park 5-6th October 2013 photographed by Lorne Clark

Jeremy Day with a few of his Ekco sets


Time travellers from the 1940's pay a visit


Greg Hewitt showing 405 line black and white television to a future collector

How do they work? 2. Voltmeters

by J Patrick Wilson

Voltmeters are designed to measure electrical potential and three different physical principles have been utilised for this purpose. The first method, *electrostatic*, is the earliest and most direct one and relies on the mechanical force between charged bodies. The second, *thermal* method relies on the heating effects of electrical power either by the mechanical expansion of a wire or by the generation of a thermoelectric potential. The third and most common method relies on the *electromagnetic* effects of electric current controlled by a known resistance and depending upon Ohm's law. As described for ammeters in the previous article there are many possible configurations of magnets and coils to measure this current. Unlike an ammeter, however, an ideal voltmeter consumes as little current as possible in order not to modify the voltage being measured. For this reason the movement or magnetising coils are normally wound with many turns of fine wire in combination with series or swamp resistors for the higher ranges.

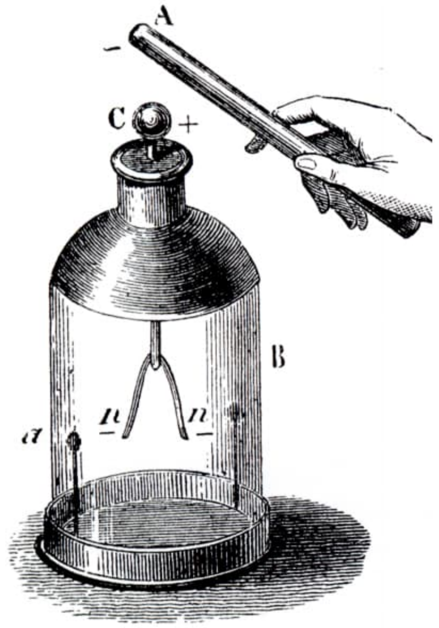


Figure 1. Gold leaf electroscope

Figure 2A. Electrometer (RW Paul)

Figure 2B. Electrometer (RW Paul)

Electrostatic instruments

The attractive effects of rubbed amber were known to the Greeks whose word for amber was *electron* from which our word *electricity* was derived. The first instrument designed to gauge this effect was the gold leaf electroscope (Fig. 1). Two strips of gold leaf hang from a central conductor suspended inside an insulating, and draught excluding, glass bottle. When a voltage is applied to them either directly or, as illustrated, induced by a nearby charged body both leaves become charged with the same polarity and repel each other. Gold leaf is used because it can be beaten much thinner than other conductors making it light and flaccid even though it is a dense metal.

Thomson Absolute Electrometer

The first instrument developed to measure this electrostatic effect rather than merely indicate it was Coulomb's torsion balance of 1785. From 1855 William Thomson (later Lord Kelvin) developed the absolute electrometer in various forms. In the attracted disc version the electrostatic force between a charged disc and an earthed one can be balanced by small weights. The force $F=-\varepsilon_0 AV^2/2x^2$ where the electric constant or permittivity of space, ε_0, is 8.85×10^{-12}, the area of discs, A, the voltage, V, and the separation of the discs, x.

An example made by Robt. W Paul is shown in Fig. 2 (the attracted disc is not visible). The aluminium balance beam can be seen in Fig. 2b suspended by a torsion wire with the earthed attracted disc attached by a rod through the hole in the brass plate. The forked far end of the beam can move vertically between stops and balance observed by a lens visible through the rectangular aperture in the case. Comparison weights can be placed on the small pan at the near end of the beam for calibration.

Fig. 2a shows the charged disc supported on a glass rod and opposing the earthed attracted disc when assembled. This can be adjusted in height by a screw with scale beneath the base plate. The absolute values of potential and charge can be calculated from the area and separation of the plates and the electrostatic force produced. The lead tank is for concentrated sulphuric acid through which air is bubbled to give a dry atmosphere within.

Figure 3. Quadrant electrometer (Dolezalek pattern)

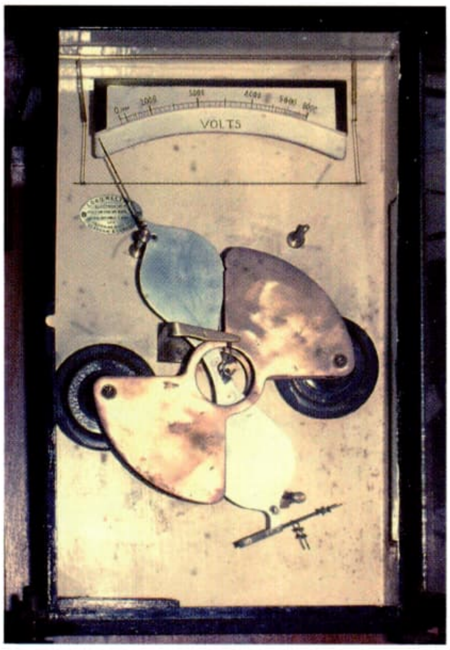


Figure 4. Thomson ES voltmeter (Crich Tram Mus)

The two vertical cylindrical plates are part of a Nicholson revolving doubler, an electrostatic machine for generating a constant potential by rotating an inner pair of cylindrical plates by a knob beneath. The absolute electrometer is limited to a range from about 200V to 5kV, and being a square law device could be used for AC.

Quadrant electrometer

Much greater sensitivity can be achieved with the quadrant electrometer devised by Thomson in 1867, covering the range from 10mV to 400V. An example of the Dolezalek version is shown in Fig. 3. A thin aluminium butterfly with small mirror above is suspended by a fine quartz fibre from a torsion head, and situated within a quartered hollow brass 'cheese' each sector mounted on a separate amber insulator. In its normal sensitive heterostatic, DC only, mode the sectors are cross connected and taken to the two terminals through insulators in the base plate. The butterfly is given a charge of a few hundred volts by a thin conducting fibre when a vertical rod is rotated from the terminal on the top plate. The potential difference between the adjacent sectors rotates the charged butterfly to an angle proportional to the product of the charge and the potential difference and is controlled by torsion.

Because it requires a constant polarising potential the quadrant electrometer is not suitable as a direct reading voltmeter although modern stable electrets would allow that possibility. The alternative less sensitive *idiostatic* mode is selected when the butterfly is connected to one of the pairs of plates when it becomes a square-law device suitable for AC or DC.

Interleaving plates voltmeters

Thomson's first direct reading electrostatic voltmeter dates from 1887 and is a rotated version of the *idiostatic* quadrant electrometer with the sectors connected to the butterfly omitted. Fig. 4 shows a 1907 example, covering 0-6kV. Thomson's instruments were made by Glasgow instrument maker, James White, in which he had a financial interest, becoming Kelvin, Bottomley & Baird in 1900. The butterfly is vertically suspended on knife edges and gravity controlled by nuts on screw threads on the lower wing (an earlier model had a pan for weights to provide the restoring force). Most electrostatic voltmeters have the moving parts connected to the case with the high potential applied to well insulated fixed plates.

To increase sensitivity in order to measure power supply voltages Thomson devised the multicellular version in 1888 (Fig. 5) with a torsion wire suspension and a horizontal circular scale. This was superseded in 1892 (when he became Lord Kelvin) by the 'engine room' version, less reverently known as the 'carriage lamp' voltmeter (Fig. 6, wall mounted with plumb line and levelling screws 15x18x38, 7cm curved reverse scale 260-0V, Pt/Ir torsion wire with worm drive zero adjustment, oil dashpot below, James White, Glasgow, No.1506).

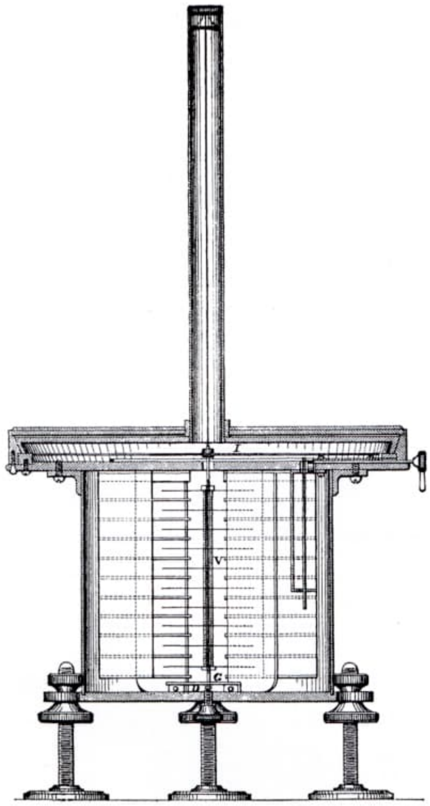


Figure 5. Thomson multicellular voltmeter

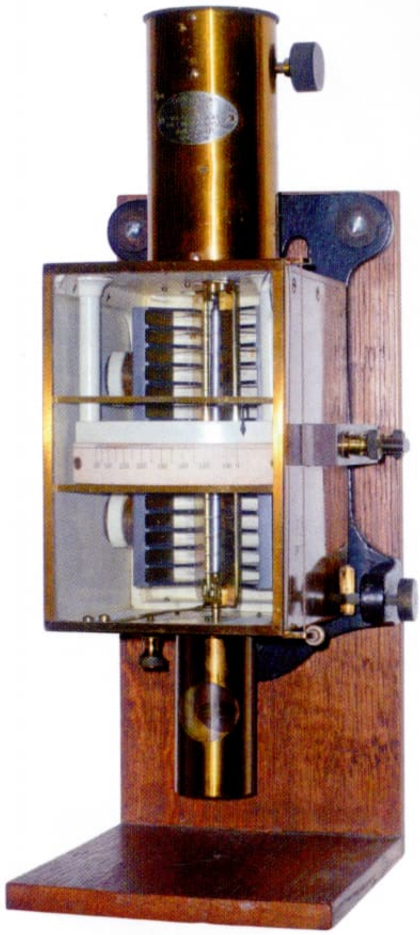


Figure 6. Kelvin engine room voltmeter

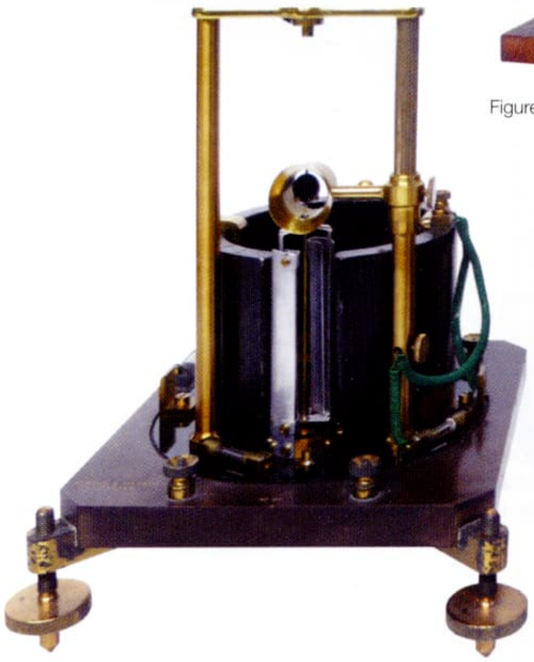


Figure 7. Ayrton & Mather ES voltmeter

There are 15 cells with a total capacitance of 11pF and an accuracy of ±0.5% of fsd. At this capacitance, current consumption is effectively zero. The movement is damped by a disc suspended in a glass vessel below which when filled with liquid paraffin gives critical damping. It is potentially hazardous because the brass case forms one terminal!

A mirror torsion wire instrument by Ayrton & Mather with interleaving cylindrical plates is shown in Fig. 7 (Laboratory bench instrument with levelling screws requiring lamp and scale, 18x18x22). The suspended vanes form part of a single shorted aluminium turn moving between the poles of a magnet to give eddy current damping. Maximum deflection is obtained with about 55V.

Although the maker's name has been erased an identical instrument is illustrated in the Elliott Bros' 1895 catalogue together with some more practical gravity-controlled pointer versions based on similar design features.

Fig. 8 illustrates a wartime design in which the high potential fixed brass plates attract an aluminium vane into the gap with the torque balanced by a hair spring. (Plug-in instrument, d=6.5, 4cm nonlinear scale 0-1500V, AM issue No.629566, 1944, period 1s under damped, 5s settling time, accuracy not assessed).

It will be noticed that many electrostatic voltmeters are similar in design to tuning capacitors and it is an amusing thought that without friction in the bearings, electrostatic

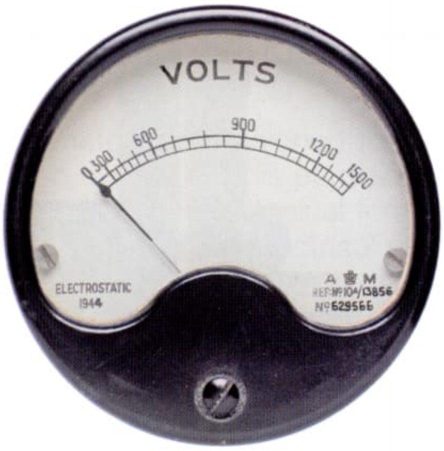
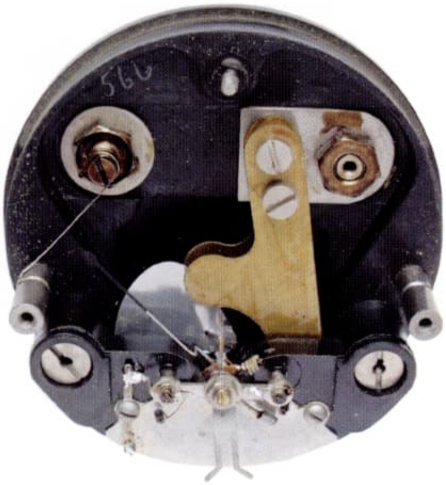


Figure 8. Bakelite ES voltmeter



forces generated when a station is tuned should in principle rotate it off tune!

Pye Scalamp 18kV voltmeter
(Bench instrument 19x28x18, 14cm nonlinear scale 0-18kV, self-contained mirror instrument requiring 4v or mains supply for lamp, WG Pye & Co. Ltd., Cambridge)

This electrostatic taut suspension instrument (Fig. 9) is designed for a maximum peak voltage of 18kV, thus being restricted to 12.7kV on AC. To avoid corona discharge or spark-over sharp edges and corners are

Figure 9. Pye Scalamp ES voltmeter

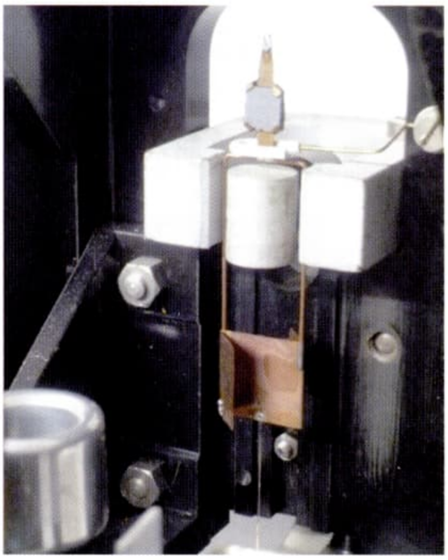


Figure 9B. Pye Scalamp ES voltmeter

avoided. The live electrode is a polished aluminium ring with rounded edges (Fig. 9b, lower left) fed by a metal rod from the heavily insulated external contact. The attracted element is a rectangle of copper sheet bent into a 'Z' shape suspended from a loop of copper wire forming a single turn in a moving coil magnet assembly to give eddy current damping. Attached above this is a small mirror with the whole movement mounted on taut suspension wires. The electrostatic attraction is greatest on the nearest part of the 'Z' and exerts torsion which is indicated on its calibrated scale by a reflected circle of light with cross hair. A Wimshurst machine set to give 2cm sparks gives fsd but the calibration accuracy has not been checked.

Cardew thermal voltmeter
(Horizontal wall mounting, l=107, 300° d=10 circular nonlinear engraved silvered brass scale 0-150V, No.367 on dial, D&G No.5457 inside cover).

Capt. Philip Cardew patented the hot wire voltmeter in 1883 and it came into widespread use in the early power industry. A range of models were produced, the earliest using vertical tubes, but the horizontal one became standard presumably because of better cooling. In the model illustrated (Fig. 10) a 4m length of 0.0025" platinum/silver wire, which expands with temperature, is attached to two insulated brass pillars (Fig.10c), and passes down the tube and round insulated pulleys (Fig.10d) and back to a central ruby pulley between the pillars where it is held in tension by a thin wire passing round a grooved disc to a coil spring taking up the tension. The remote end of the coil spring can be adjusted by an external knob to zero the instrument. On the same spindle as the grooved disc is a toothed wheel engaging with a pinion on an arbor passing through the dial to the pointer. All bearings including the pulleys are jewelled and the pointer arbor has a hairspring to take up any backlash in the magnifying gear.

The pulley table is supported, not by the tube, but by a pair of rods fastened to the movement case. One end of these is brass whilst the other is iron to give temperature compensation for ambient temperature. As the instrument consumes 55W at fsd (430Ω & 350mA) it takes a long time to stabilise and becomes quite hot. Nevertheless it responds rapidly in a dead-beat manner. Unfortunately the original wire was damaged and has been replaced with tungsten which although suitable for demonstration, has a low resistance at room temperature and would fuse if full voltage were applied rapidly. The red fibre disc seen edge-on in Fig.10c supports four radial pieces of fuse wire put into circuit by rotating the disc. In power

Figure 10. Cardew hot wire voltmeter

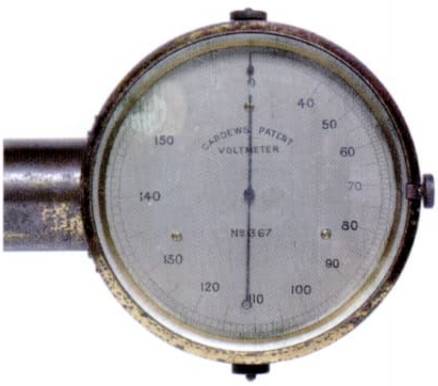


Figure 10B

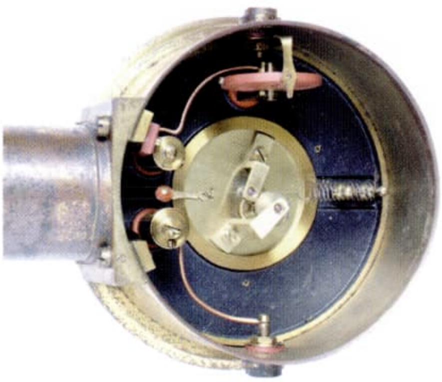


Figure 10C

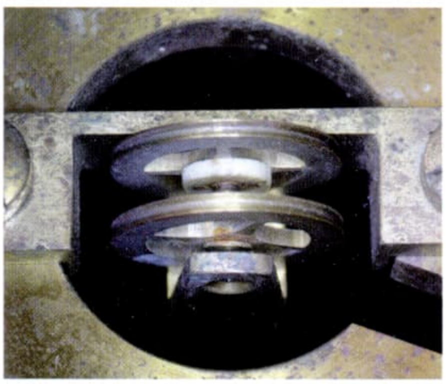


Figure 10D

Figure 11. ECC moving magnet voltmeter

Figure 11B. ECC moving magnet voltmeter

stations it was common to leave meters permanently connected, resetting them each day against a standard instrument. Its low inductance and the small skin effect with fine wire make it suitable for high frequencies.

Electromagnetic instruments: moving magnet types

Most instruments of this type employ a small needle magnetised by a permanent magnet which provides the balancing force as in the tangent galvanometer. In the ECC Voltmeter (Fig. 11, vertical bench instrument, 14x13x5, 10cm nonlinear engraved scale 2.5-0-2.5V on silvered brass dial, Electric Construction Corporation Ltd, London, No.302) its range suggests that it is intended primarily as a cell tester. Its low resistance of 8Ω (0.31A & 0.8W at fsd) would be an advantage in this application, measuring voltage under load, as it is often the increase in internal resistance rather than open circuit voltage that indicates a cell needs replacing or recharging. It clearly follows the design of the Ayrton & Perry Am-meter (described in the previous article) including their 1884 introduction of adjustable magnetic cores within the coils. Short oval iron cores are situated in the outer ends of the coils (Fig. 11b) with square headed adjustable iron screws extending about 5mm further inwards. In addition the pole pieces can be adjusted. Nevertheless, despite Ayrton & Perry's claims for linearity the scale is nonlinear. Probably owing to later tampering the instrument is +2% at ±1v, correct at ±1.5V and -10% at ±2.5V, response time is 0.2s lightly damped. It cannot be used on AC.

By rotating the magnet so that the pointer is at the left end of the scale the near-linear range is extended. Fig. 12 shows an instrument by a small unknown firm which is of simple construction but gives the impression of quality. The case back is turned from a single block of wood into which the terminals are screwed. Into this is let the cast brass movement chassis with protrusions at the rear on which the coil is wound and held in place by sealing wax. The needle is a rectangle of iron above and across the ends of a 'C' magnet which has been stuck into the wooden block. The pointer is a piece of wire wrapped round the arbor and continuing on the other side to a lead counterweight. The cover is made from brass tubing with a soldered turned bezel.

Initially the instrument over-read by about 40% but after placing it at the appropriate angle near the poles of a large powerful magnetron magnet it under read by about

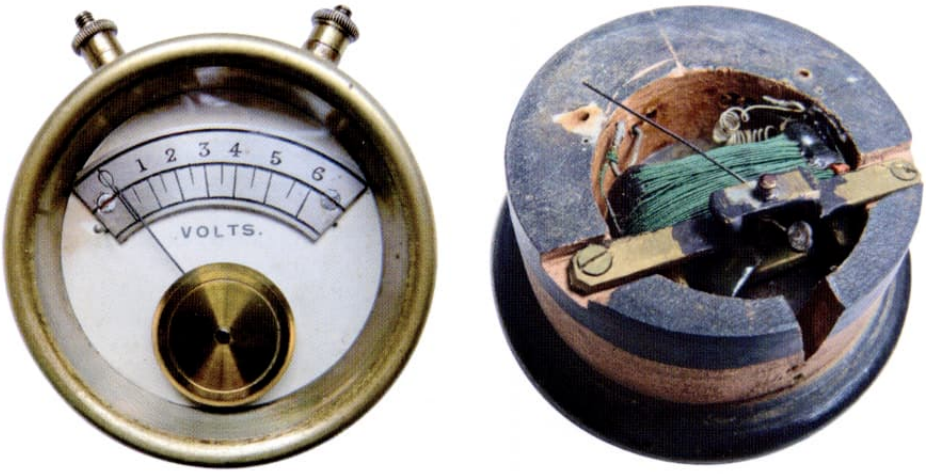


Figure 12. Moving magnet meter

Figure 13. Mass-produced moving magnet

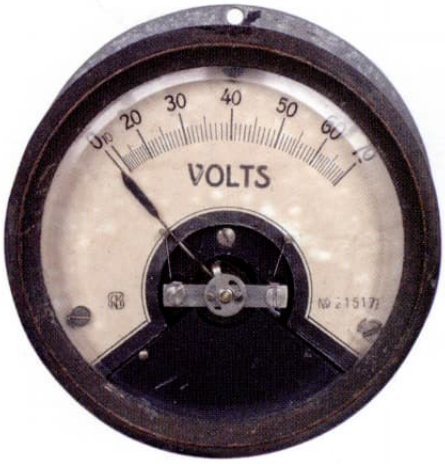


Figure 14. RK moving iron repulsion type

Figure 14b

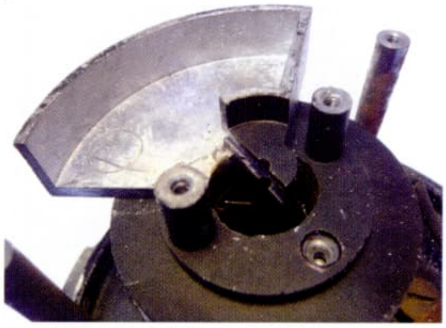


Figure 14c

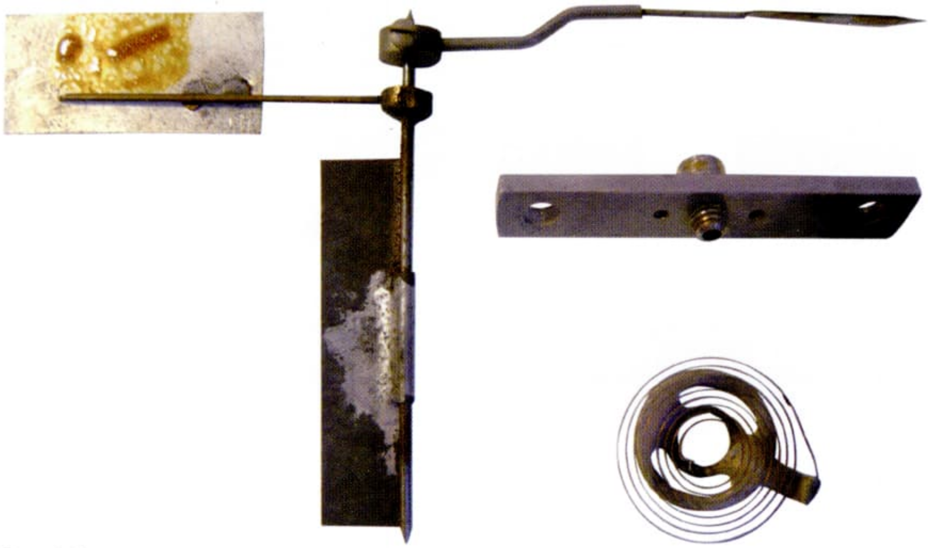


Figure 14d

10% with the pointer off zero. By judicious application of a smaller magnet it proved possible to set both the sensitivity and zero to be correct in the absence of any external magnet. (Domed wooden base 7.5cm diam, 4cm nonlinear engraved silvered brass scale 0-6V, serial no. 182 on back of scale).

Fig. 13 shows a mass-produced voltmeter working on the same principle in which it appears from the + changed to - that a previous user has reversed the polarity of the magnet. (Pocket watch type, d=5.5cm, printed card scale 0-8V & 0-120V, marked 230Ω & 3400Ω [actually 143Ω & 2270Ω], 55mA fsd, S.A.R.E., ±5% both ranges).

Moving-iron repulsion voltmeters

Although in principle both repulsion and attraction moving-iron meters should be useable on AC, the inductance of the coil and hysteresis of the iron mean that the AC and DC calibrations may be different.

Fig. 14 shows an example where the dashpot is visible through the bevelled glass (Wall mounting, d=12, spring controlled, 6.5cm nonlinear scale 0-70V, RK No.21517). The fixed repulsion plate, which becomes magnetised along the axis of the solenoid, can be seen in Fig. 14c together with its tail which holds it in place by spring fit. The moving plate which becomes magnetised along its length in the same sense is seen attached to the pointer assembly together with the aluminium dashpot vane. The instrument over reads by about 10% on AC and 20% on DC (DC resistance 1.33kΩ, 53mA fsd, 3.7W).

Fig. 15 shows a bakelite example by MV (Wall mounting, d=18, 13cm nonlinear mirror backed scale 0-20V, spring controlled, dashpot damped, 50~ moving iron, MV, military nos. on back). Part of the moving and fixed plates can be seen at the bottom of Fig. 15c. (The brownish bent metal to the left may be a piece of transformer lamination added to increase sensitivity). The meter under reads slightly (-1% on AC & DC, 0.31A and 6.2W at fsd, 1s period under damped).

A mass-produced 'watch case' example is shown in Fig. 16. In this the needle is a rod which is repelled by a plate with cylindrical tapered tail as in Fig. 14. (Hand held, d=5.5, crudely printed card scale 0-6V, 24Ω, 250mA & 1.5W fsd, ±5%).

Moving iron attraction voltmeters

Fig. 17 shows a high quality instrument by Evershed & Vignoles in which a black vane normal to the spindle rotates as it is attracted into the horizontal slot within the flattened brown solenoid (Fig. 17b). The dial plate closes off the top of the large dashpot below the pointer and scale. The resistance of the solenoid is supplemented by the four pot resistors. Zero is set by a screw head on the right of the case bearing on a brass spring and rod link to the hair spring. (Horizontal or vertical bench meter 20x21x10, engraved

Figure 15. MV moving iron repulsion type

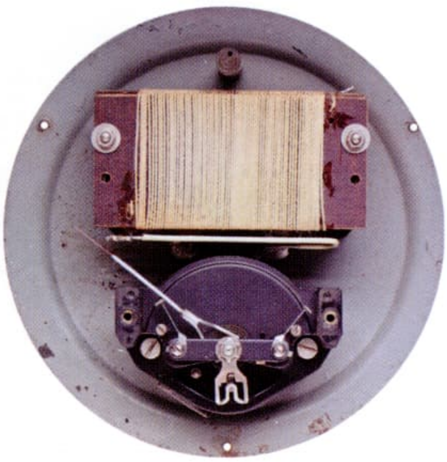


Figure 15b

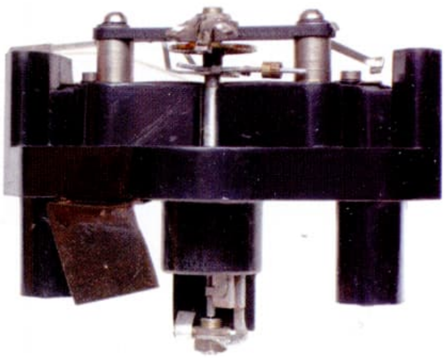


Figure 15c

Figure 16. 'Watch case' repulsion type

Figure 17. SEV moving iron attraction type

Figure 18. Fleming & Gimingham electrodynamic type

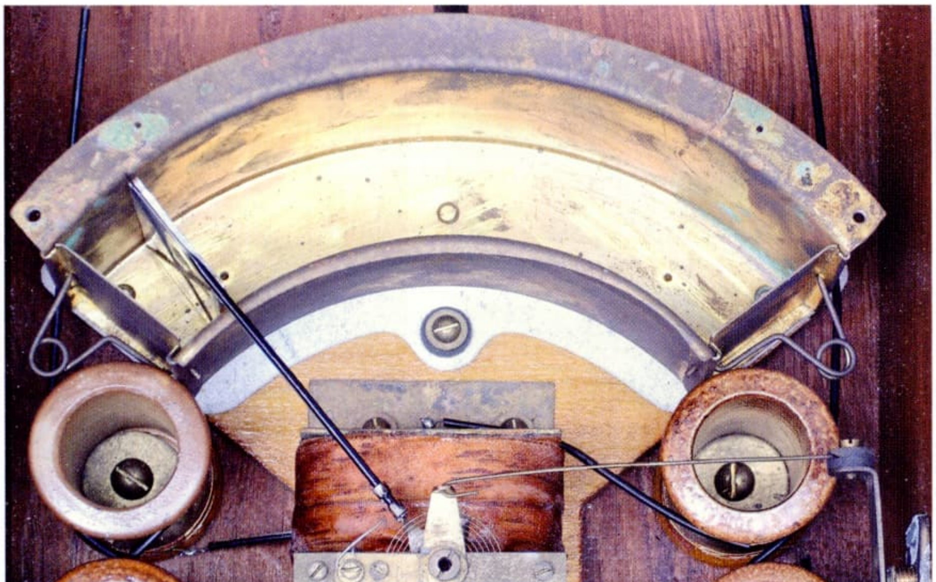


Figure 17b

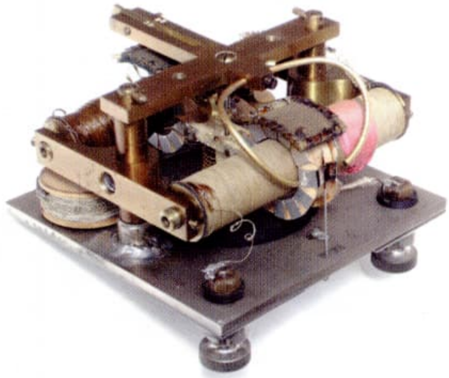


Figure 18b

Figure 18c

silvered brass 13cm nonlinear scale 0-250V, SEV No.44088). Between 150 and 250V the meter is fairly accurate (+0.5±0.5% AC & DC, 6.97kΩ, 36mA fsd).

Electrodynamic voltmeters

The electrodynamic principle can be used in ammeters, voltmeters and wattmeters and as it does not need magnetic material, is free of the problems of hyteresis and loss of magnetism. The penalty is lower sensitivity and greater possible influence of the earth's field. Nevertheless it is suitable for stable standard instruments. With improved magnetic materials these are now incorporated in some designs. In all cases, because the torque is a product of the current passing through the static and moving coils, it is a square law device for voltage or current and linear for power. The inductance of the coils does not produce significant error at power frequencies.

Fig. 18 shows a beautifully made meter by Fleming & Gimingham in a neat and compact case, which would have had no competition in terms of accuracy and portability when introduced. Fleming was a consultant for, and Gimingham works manager of, the Edison-Swan Co. and they gave a very detailed description of this meter in *J Telegraph Eng, 24th Nov. 1887* (which also includes discussion of the Cardew voltmeter). The instrument was also supplied as a wattmeter. It is in effect a Kelvin current balance turned on its side. Because the moving coils are wound oppositely, the torques exerted by the earth's field will cancel rendering the instrument astatic. (In my previous article I erroneously stated that the moving coils of the Kelvin current balance were wound in the same direction!).

The Fleming & Gimingham instrument consists of two moving coils mounted at the ends of an ivory beam supported by an inverted hardened steel cup on an iridium tipped point. When the lid is screwed down a rod and lever lifts the coils on a

Figure 19. Elliott sub-Standard electrodynamic voltmeter

Figure 20. Cambridge electrodynamic voltmeter

Figure 20c

pair of cloth-lined cradles firmly against the fixed coils (seen inverted in Fig. 18b). The balance pointer can be seen attached to the coil passing through a rectangular aperture in the nickel plated top plate. The helical controlling spring suspended from the rotating dial assembly is just visible in the centre. Although the fixed coils look like simple solenoids their two halves are wound in opposite directions. This results in the N poles being in the middle and the S poles at the four ends, giving radial fields at their centres with the

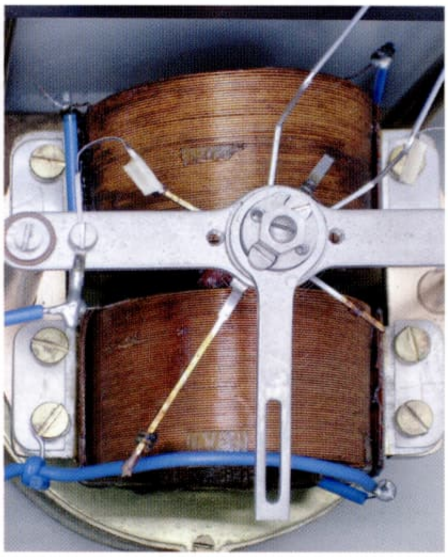


Figure 19b

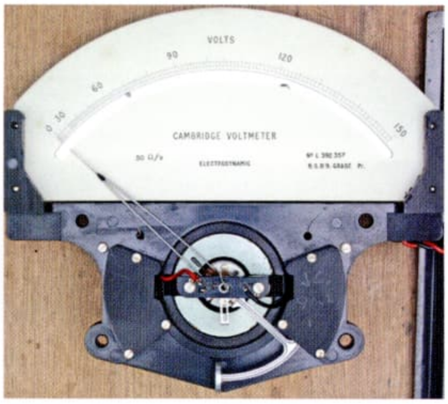


Figure 20b

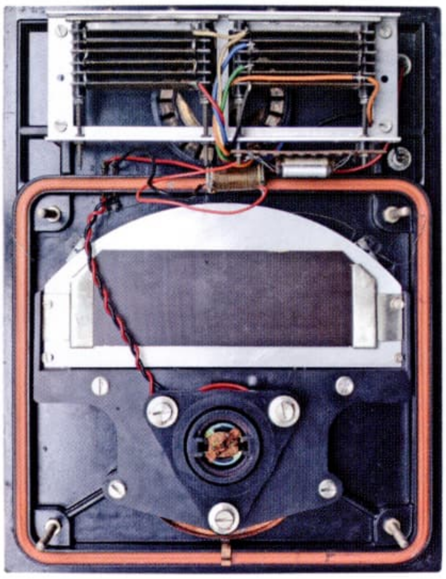


Figure 20d

flux passing through the moveable coils.

Initially the instrument has to be levelled so that the balance index moves freely within its aperture using the wooden wedge provided. The mica scale pointer is rotated until the balance index is at zero, the knob loosened, scale pointer set to zero, and tightened. When energised the moving coil assembly rotates and then balance is restored by rotating the dial, which then indicates the voltage.

The small ebonite headed plug below the scale can be removed to add an

Figure 21. Early Weston voltmeter

Figure 22. Weston microammeter

additional resistor, seen on the left of Fig. 18b between fixed coil and top plate, to double the range. All windings are of German silver giving a temperature coefficient of 0.273% per 10°C. Although the instrument has suffered attention over the years it is within 0.2% for AC or DC on the 110V range (935W, 118mA, 13W at fsd) and 0.5% low on the 220V range.

Another electrodynamometer is the Elliott Bros. Portable Precision Voltmeter (Fig. 19, bench use, 14cm mirror backed nonlinear scale, 0-75/150/300V ranges,

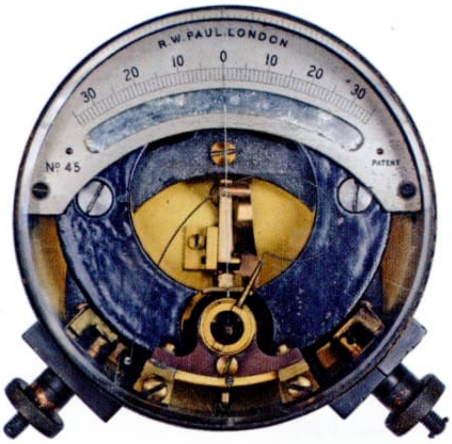


Figure 23. Unipivot moving coil

Figure 23b

Figure 23c

spirit levels and levelling screws, Elliott Bros. (London) Ltd,, No.A52673, Sub-Standard grade certificate dated 17.10.49). The spring controlled moving coil rotates between 50° and 120° from the axis of the fixed coils (Fig. 19b). The three copper coils are wired in series with resistors giving total resistances of 1.56, 3.12 and 6.24kΩ respectively for the three ranges (48mA fsd, 3.6W on 75V range). The instrument under reads by 0.1% between '25' and '75' on the scale for all ranges. No temperature coefficient is quoted. As the moving coil is quite large and unshielded by magnets the earth's field could be significant on DC. The movement is therefore enclosed in a shielding box and no influence could be detected.

A dynamometer voltmeter in which the magnetic circuit has been improved by the use of magnetic materials can be seen in Fig. 20. (Bench use, 16cm mirror backed square-law scale, 150V x 0.2, 0.5, 1, 2 & 5 (30, 75, 150, 300 & 750V), 50Ω/V, Cambridge Instrument Co. Ltd., No.L.392357, Precision grade ±0.5% of fsd, ±0.5% frequency 20-1000Hz, temperature correction -0.2%/10°). This is similar to a moving coil instrument in which the central core has been replaced by stack of circular laminations slotted and wound as an electromagnet and surrounded by a ring of laminations completing the magnetic circuit. Thus it becomes a multiplicative device in which the torque is proportional to the product of the currents flowing in the electromagnet and in the moving coil.

It appears from Fig. 20b&c that the pivots must be within the moving coil and the external laminations can be seen within the black plastic frame. The dashpot damping is split with the left end of the scale served by the right dashpot and vice versa. On test the instrument was found to over read by about 1% with no obvious way of adjusting the sensitivity. At 20mA fsd (0.6W on 30V range) it is more sensitive than the iron-free Elliott meter above.

Moving coil voltmeters

In the moving coil meter the magnetic flux flows inwards across one annular gap and outwards on the other side so that the currents in the coil, upwards on one side, downwards on the other, both exert a clockwise torque which is balanced by the hairsprings leading the current in and out.

Edward Weston, an Englishman who set up in business in Newark, New Jersey, USA, introduced many advances to accurate measurement including a standard cell as well as new alloys for resistance materials, magnets and hair springs. He found that by cyclically remagnetisation and final magnetisation to two thirds maximum, magnets remained stable. It is remarkable that the majority of his innovations remained virtually unchanged for the remainder of the pre-digital age.

In my experience some moving coil instruments do seem to lose sensitivity over the years. This may be due either to poor design and manufacture or to mistreatment by the user such as dropping or touching the magnet with a screwdriver. As the magnetic gap normally has an adjustable shunt, it is only possible to comment on stability if the instrument is certified and remains sealed. Two early Weston meters in the Science Museum were retested a century after production and found to be correct. The only moving coil instruments in my collection fulfilling these criteria are the Weston microammeter (see opposite page) and the Elliott 150/300V voltmeter (+0.3%, on the upper limit specified). Thus clearly Weston was justified in his claims for stability. Fig. 21 shows an early Weston 150/300V voltmeter from a private collection. The upper right knob is pressed for test. Although Weston had set up a subsidiary in this country their movements continued to be made in New Jersey until 1937 when Sangamo took over the company, becoming Sangamo-Weston in 1938 with local manufacture.

Into the electronics Age

Early voltmeters were mostly for the power industry and 50mA at fsd would be quite common and perfectly satisfactory. With the introduction of valve circuitry, however, more sensitive movements became desirable for voltage, current and resistance measurement. Fig. 22 shows a 1937, 150mA fsd (36.9Ω and 0.83μW) microammeter, made in the USA but calibrated at the Weston Laboratory, Surbiton. As the instrument is still sealed and correct to 0.1% there is no photograph of the movement.

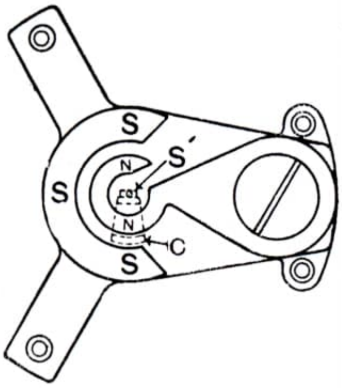
The temperature dependency of resistance of the copper moving coil is not a major problem for voltmeters because it is normally swamped by the series resistance necessary to set the range. Nevertheless there are slight changes in current sensitivity with temperature due to the magnet, elasticity of the hair springs and dimensional changes. From the certificate in the lid of this meter (Fig. 22) it amounts to +0.12% for a 10°C rise.

Swamp resistors

There are many types of resistor used in voltmeters depending on voltage range, order of accuracy required, and cost. In general traditional carbon resistors are unsuitable because they have a large negative temperature coefficient (dependent upon value), and are unstable with age, humidity and soldering. Furthermore they do not obey Ohm's law exactly. The cracked carbon resistor, however, is much more stable and used in later models of AVO and many other instruments. They have a negative temperature coefficient (-0.06 to -0.25 %/10°). In my experience these resistors do remain stable. With more sensitive movements these became a necessity because 1MΩ is about the practical limit for wirewound resistors. More recently metal oxide and metal film resistors have become available with even better characteristics and can also be used in printed circuits.

Wirewound resistors come in two types, the more familiar being power types as used in mains droppers. Alloys such as nichrome are designed to work at high temperatures and can be used as heaters but do not need or indeed have particularly low temperature coefficients. The second type are instrument grade resistors where accuracy and stability are important. These are generally produced specifically for the application, e.g., in a multirange instrument all the shunt or swamp resistors may be wound on a common former. Eureka or constantan is generally used for voltage ranges where thermoelectric potentials would not be significant. Manganin is used for high grade shunts and for standard resistors and bridges but requires hard soldering.

Figure 24. Benjamin Davis 240° moving coil



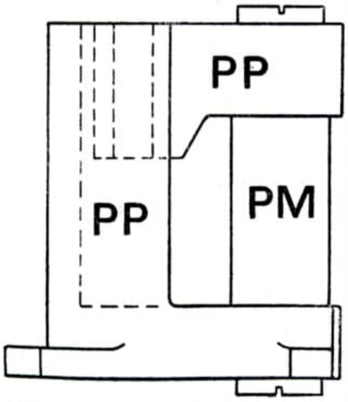


Figure 24b

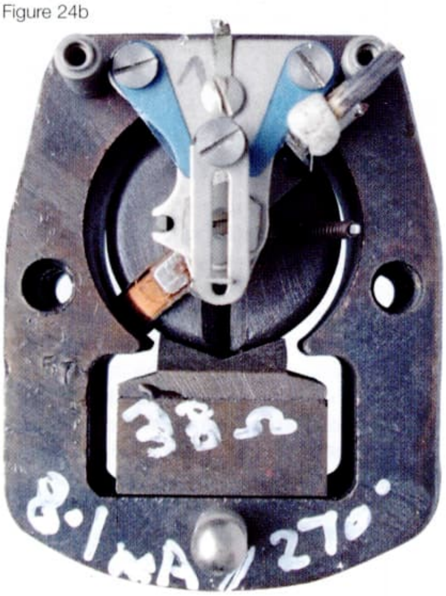


Figure 25. 270° moving coil movement

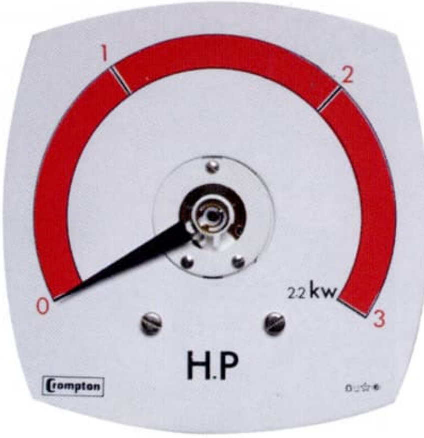


Figure 26. Crompton 240° taut suspension moving coil

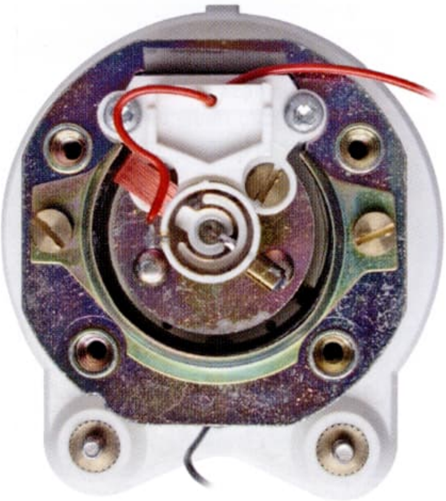


Figure 26b

Variations on the moving coil

In 1903 the Robt. W Paul Co. patented a new form of moving coil movement using a single pivot point at the centre of a spherical soft iron core which is also the centre of gravity. The advantages claimed are lower friction and self balancing, making the reading independent of levelling. This allowed the use of very light springing and consequent high sensitivity. These were continued after Paul joined with The Cambridge Scientific Instrument Co. in 1919.

Fig. 23 shows an early 35-0-35μA galvanometer (No. 45, d=10.5cm) with a mirror backed engraved silvered brass dial. Fig. 23c shows a 0-12/120mV millivoltmeter for either bench use or wall mounting (18x17x7, 14cm mirror backed scale, 50/500Ω, 240μA fsd and 2.9μW on 12mV range). Unfortunately neither movement now moves as freely as it should.

In 1895 Oliver Lodge's research assistant, Benjamin Davies, devised a long scale version of the moving coil in which the pointer covered up to 270°. Fig. 24 shows a 240° version by Muirhead. In these, the moving coil rotates on an axis along one side of the coil (Fig.24b) with the central core being a shell attached to the N pole of the vertical magnet (PM). The outer pole piece is attached to the S pole. The inner pole piece has to be slotted to allow assembly of the coil.

The Record 'Cirscale' movement is similar except that the outer S polepiece embracing the movement is replaced by two endplates above and below the coil. Thus instead of the outer limb of the coil cutting a radial flux it is the radial end limbs of the coil cutting a vertical flux and allowing 300° of rotation.

Improvements in permanent magnets allow a more compact structure (Fig. 25, where the magnet block is marked with the coil resistance '38Ω'). One pole contacts the outer polepiece, embracing the movement, and the other pole, the inner cylindrical polepiece. The stub of the missing pointer is at the upper right. This produces a full 270° deflection at 8.1mA (2.5mW).

Fig. 26 shows a Crompton power meter (0-3HP or 0-2.2kW) with a 240° scale using a taut suspension instead of pivots and hair springs. The structure is otherwise very similar to the previous instrument except that the pole pieces are laminated. This suggests that the permanent magnet, concealed by the white plastic, could be replaced by an electromagnet giving an electrodynamic version. The instrument is part of a 3-phase power meter in which a direct current proportional to the power is derived by internal electronic circuitry from three voltage and two current terminals via external transformers. There would be similar blue and yellow scaled meters for the other phases. The movement is linear with 1mA fsd and 265Ω resistance (0.265mW).

Figure 27. Sangamo Weston voltmeter

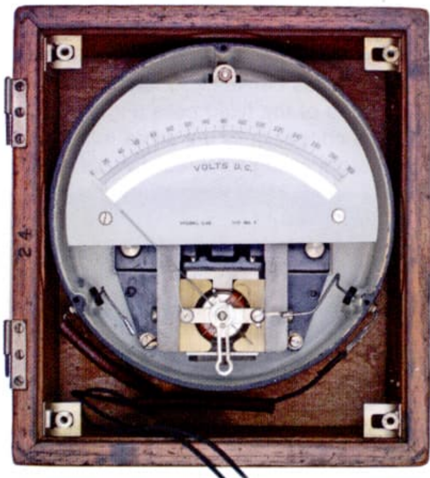


Figure 27b

Some high quality moving coil voltmeters

Fig. 27 shows a Sangamo Weston Ltd. Model E45 (No.184E, 13cm mirror backed scale 0-150/300V, 20x21.5x12, 15/30kΩ, 10mA/V). This instrument over reads by 0.2% at half scale and above.

Figure 28. GEC iron clad voltmeter

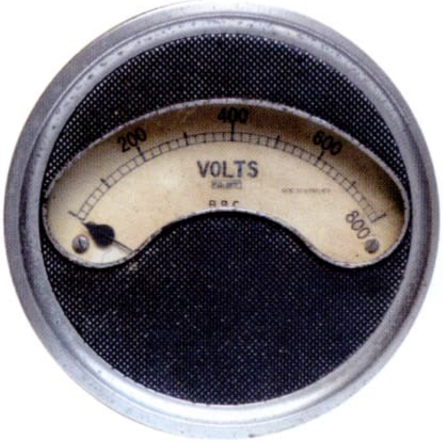


Figure 29. Elliott BBC Droitwich meter

Fig. 28 shows a GEC 120V iron clad meter for use in magnetic environments with 13cm mirror backed scale (No.11310VP, 18x20x8, 18.4kΩ, 6.52mA/V). It over reads by 1 to 1.5% across the scale.

Fig. 29 is one of a pair of meters made by Elliott Bros. for the BBC transmitter at Droitwich, this one being 0-800V (No.1104810, d=20cm, 21Ω movement) the other being 0-40A. As the internal swamp resistor has been rewound for a lower voltage it is not possible to comment on accuracy although as fsd is 8.08mA it may have lost 1% of sensitivity.

Fig. 30 shows an Elliott Bros. Portable Standard Voltmeter (No.D226301, 21x19x11, 12cm mirror backed scale 0-150/300V, 6.7mA/V). This instrument is still sealed so the inside is not shown. It is certified accurate to 0.3% of fsd for International volts. It over reads by almost this amount and may just exceed 0.3% in absolute volts (which are about 0.034% smaller).

Fig. 31 is another Sangamo Weston DC Voltmeter (Model S83, No. AH15910, 1958) suspended on sorbo-rubber blocks within a rugged military case (26x27x16). It has a 12.5cm mirror backed scale 0-400V, 1mA fsd, certified Precision Grade BS89. The temperature coefficient (-0.1%/10ΩC) is opposite to that of the 1937 Weston meter (Fig. 22). The meter was obtained, apparently unissued, on the surplus market only a few years after certification and has since remained in storage. It was found to under read by 1% but was easily corrected with the magnetic shunt.

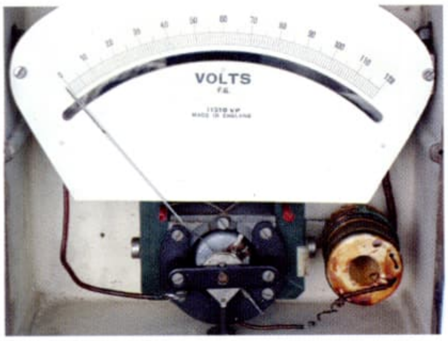


Figure 28b

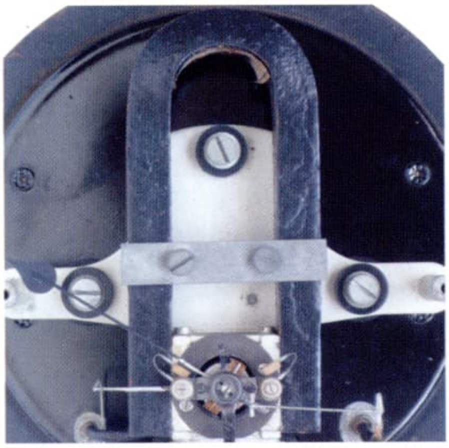


Figure 29b

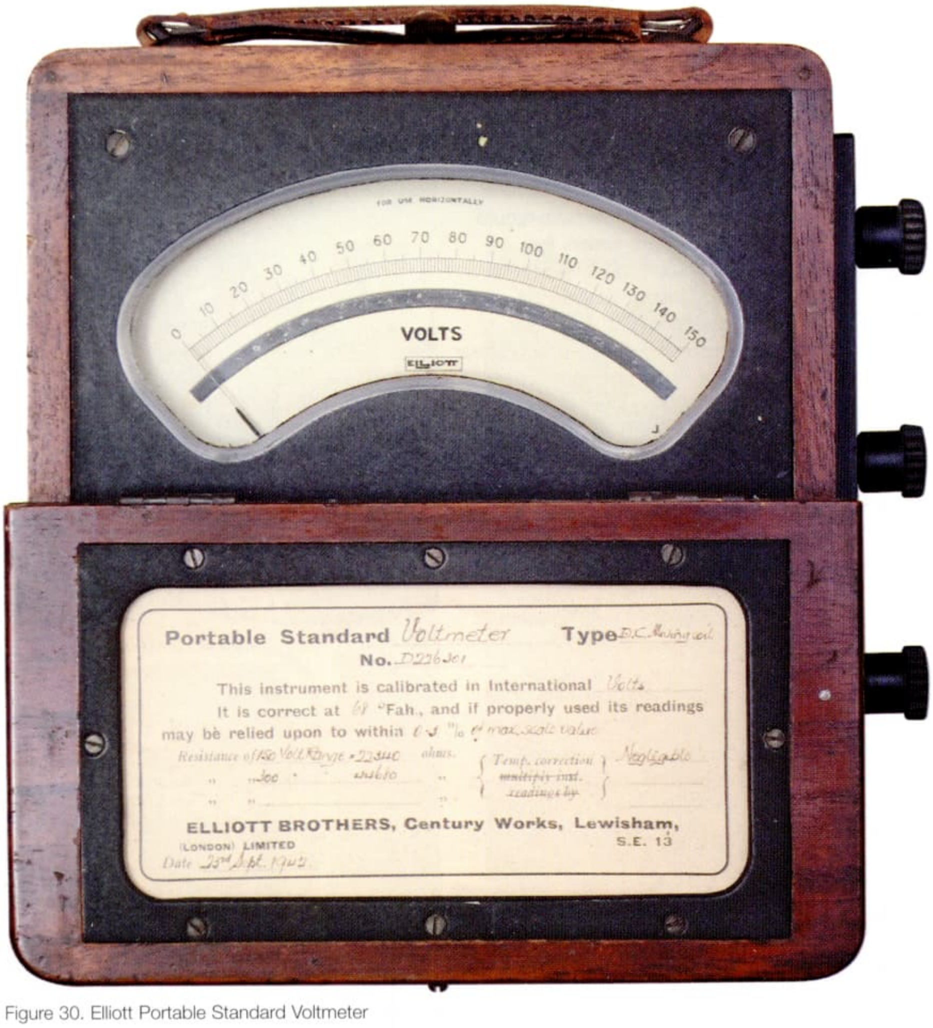


Figure 30. Elliott Portable Standard Voltmeter

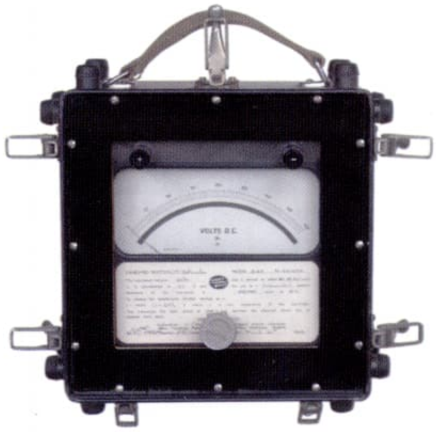


Figure 31. Sangamo Weston in rugged case

Figure 31b

Figure 32. Ernest Turner AC voltmeter

Figure 32b

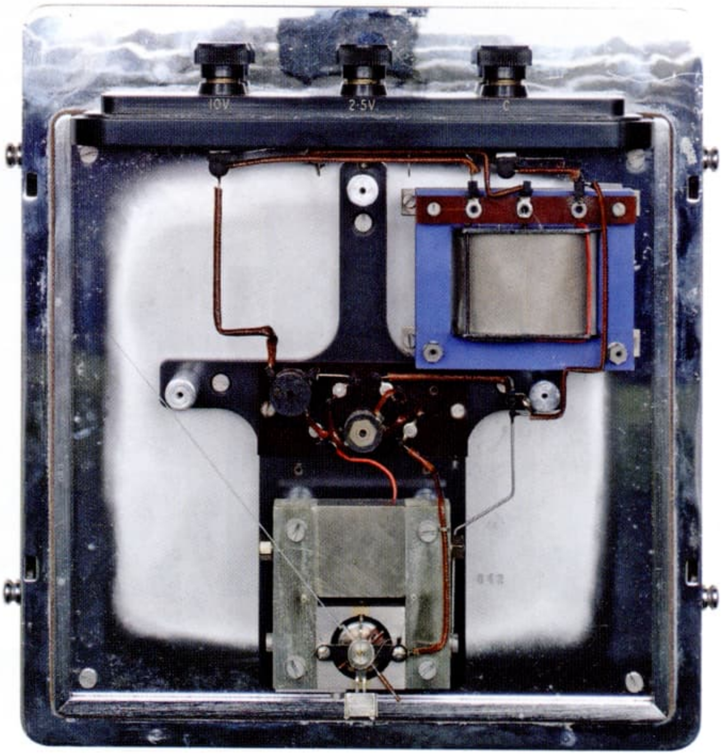


Figure 32c

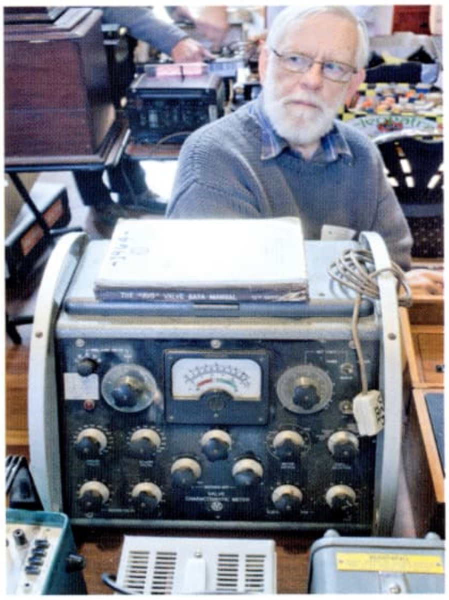
Turner AC rectifier voltmeter
(Horizontal bench meter, 26x27x16, with 20cm mirror backed scales 0-2.5V and 0-10V, 50~ AC, Ernest Turner Electrical Instruments Ltd, High Wycombe, Bucks, Model 102 Pr, No.1893149)

This is a stylish design (Fig. 32) of the period (1960s?) aiming to look modern and scientific with rounded corners, textured grey enamel, polished chrome and black perspex, and matt teak cover, the effect somewhat spoiled by the carrying handle. Perhaps the nicest feature, however, is the use of vernier scales in which the minor divisions are crossed by faint (faded?) diagonal lines so that on the inner, 10V scale, the crossing points divide the 0.2V divisions into quarters (0.05V) whilst on the 2.5V scale the 0.05V divisions into fifths (0.01V). Reading the 2.5V scale would, however, have been made easier if it had been marked 0, 0.2, 0.4, 0.6, etc, instead of 0, 0.25, 0.50, 0.75, etc. In spite of this great precision the instrument was found to under read by 2% with its magnetic shunt already at minimum. The movement itself is a very neat and compact design (Fig. 32c) with the shaped pole pieces separated by brazed inserts and machined as one block.

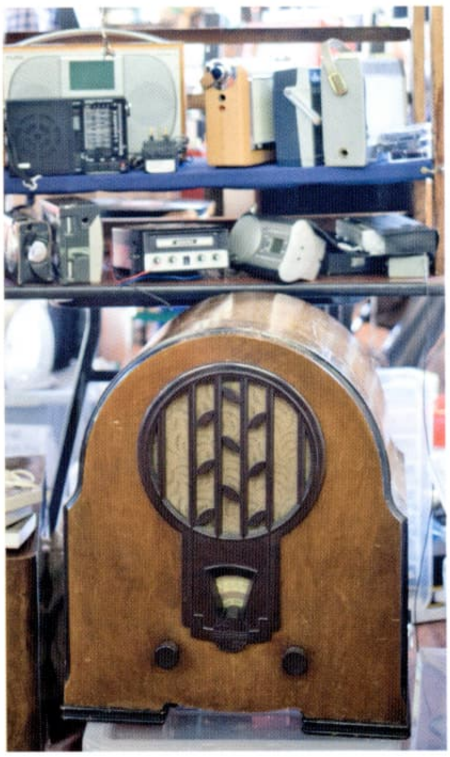
Rectifier instruments are normally designed and marked for sinusoidal rms (root mean square) although the deflection actually depends on the arithmetic average of all deviations taken as positive, which is 10% lower. For other waveforms this ratio would be different, e.g. for square waves the rms and average are identical. The other shortcoming of such instruments is the small forward voltage drop across the rectifier, resulting in the compression of markings near zero. In multimeters where the same scale is used for AC and DC this is sometimes ameliorated by tapping off a small proportion of the voltage of the battery (used in the resistance ranges) to apply an offset to the pointer. A half wave rectifier cannot be used because damaging reverse voltages would occur on higher ranges. When an instrument transformer is used, the meter can be fed from a higher voltage winding, where this offset becomes negligible, at the cost of higher current consumption.

This is done in the Turner meter (Fig. 32c) where the 10V terminals are directly connected to the single swamp, bridge rectifier and movement, and a transformer is used to step up the 2.5V range to 10V, with the secondary winding permanently in circuit.

Pictures from Harpenden, September 2013 by Carl Glover



Double Decca



Philips 630A 'Ovaltiney' set

Bush TV22

Various treats on display!

Ekco ACT96

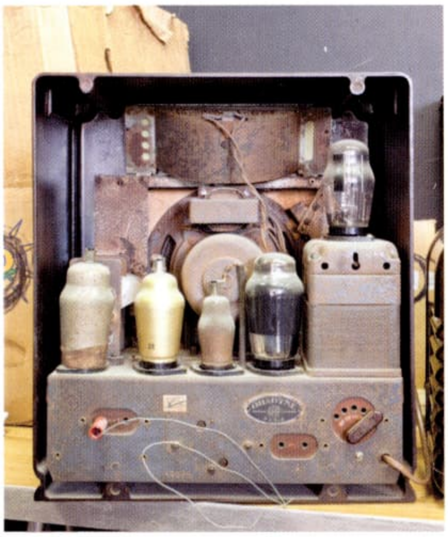
An impressive piece of 1920's furniture

Revophone crystal set

KB, Philco, Ekco, and Ultra sets ready for auction

The atmosphere at this Harpenden was quite lively!

Marconi V2A



French Oradyne 1930's bakelite receiver

Murphy SAD94L

Chris Brown's stall

An Ekco set

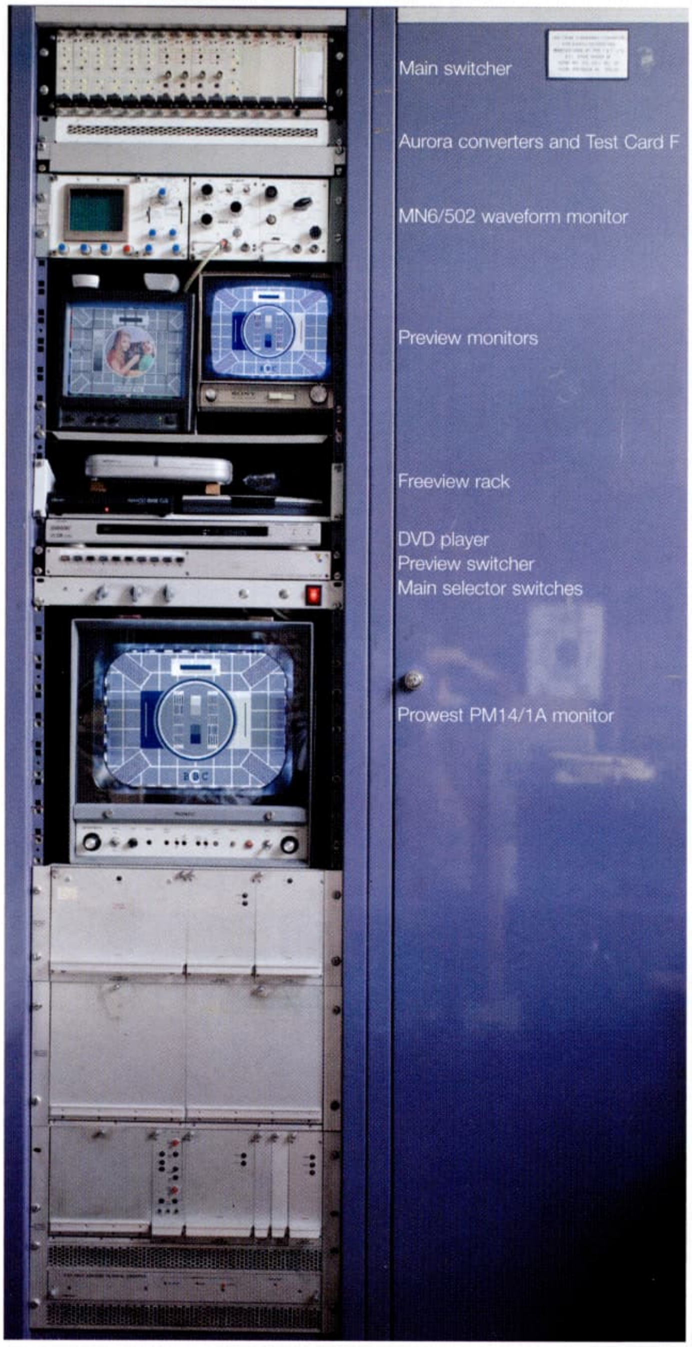
R115L complete with DF equipment

Ekco AD75 and a 1920's 'homebrew' set

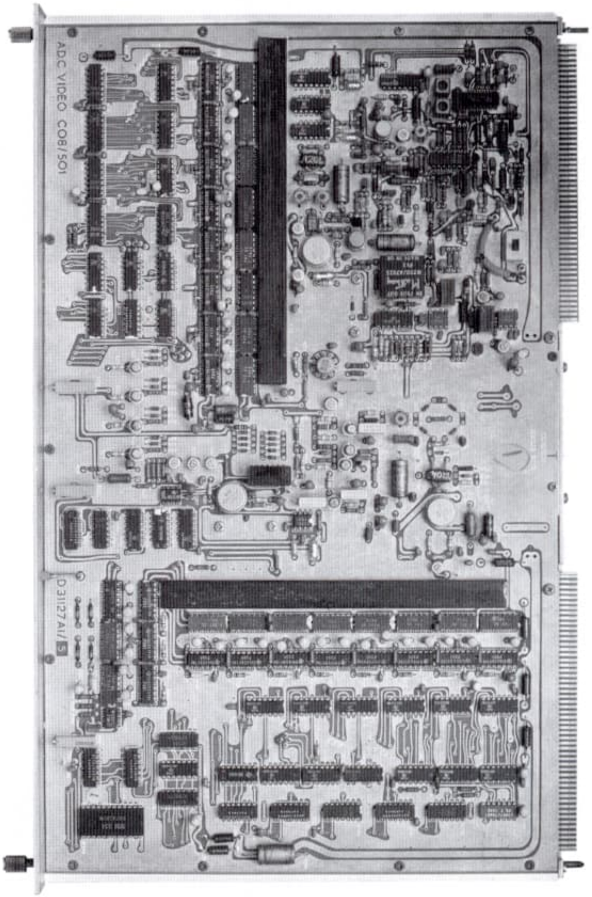
TV installation at the British Vintage Wireless and Television Museum

by Jeffrey Borinsky FIEE CEng

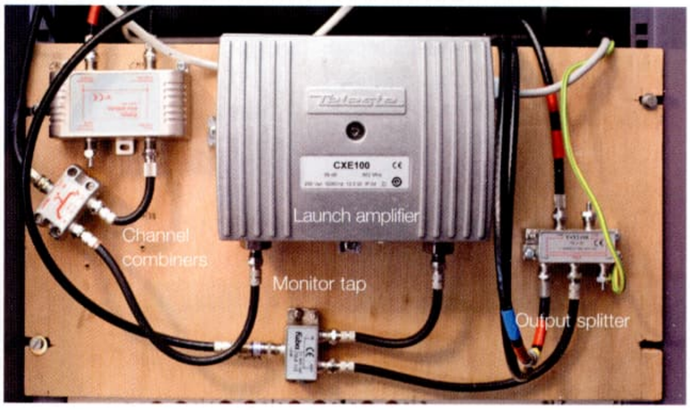
My first visit to the Vintage Wireless Museum was for the 1986 garden party. I was amazed to see a massive 625 to 405 standards converter supplying pictures to a number of 405 line TVs.



New installation



ADC from CO6/509



RF head end

This brute was a CO6/501, housed in a pair of tall 19" rack bays. It was designed by the BBC in the early 1960s but this example was built by Pye for the IBA. They were typically used in pairs at main transmitter sites. In the late 1960s the BBC recognised that it would be difficult to maintain these converters in service until 405 shutdown which eventually happened in 1985. Hence they designed a digital converter, the CO6/509. The IBA stuck it out with the CO6/501 which must have given some maintenance nightmares. Remember that this was in the days before Dinosaur, Aurora and Domino. Apart from the BBC and IBA converters the only way to get 405 pictures after the 1985 shutdown was a 405 camera pointing at a 625 monitor. A late night visit to Crystal Palace transmitter yielded a CO6/509 along with a load of spares. Lucien Nunes and I set about adding it to the installation. We cleared space at the bottom of the left bay which wasn't quite sufficient for the job. This was solved by omitting some of the vent panels and fitting a fan tray. It didn't take much work to repair the power supplies and get excellent pictures. We designed and fitted some simple switchery, I built a Ch1 modulator and loaned a BBC waveform monitor. We more or less abandoned the CO6/501 at this point and it's been a static exhibit ever since.

Dave Grant and I occasionally maintained the system but as it aged the CO6/509 suffered various niggling faults, usually fixed by traditional methods such as whacking one of the panels. The RF distribution side, while adequate in 1987, was no longer working well. This gave variable signal strength and patterning. The Museum is intended mainly to display radios and TVs. The 405 signals are meant to be provided as a service, always there and working properly when you need them. A major refit was needed. Darryl Hock had generously donated a pair of the excellent Aurora SCRF converters so the Museum committee agreed that these should be at the heart of the refit. The CO6/509 would then be left as a static exhibit alongside the CO6/501.

I proposed two schemes. One was a simple interim measure to fit an Aurora in the existing bay with minimal modification. The other was a complete new system, built in a new bay, with the existing bays relocated as static exhibits. Peter Sanders came up with the most important idea; we had 2 Auroras so why not make a 2 channel system, just like olden days in London with BBC on Ch1 and ITV on Ch9. Brilliant! We soon added BBC2 on Ch33 to the proposal to re-create conditions as they would have been in 1967 at the start of colour. John Thompson, Peter Sanders and I refined the ideas one day over the dining table at the Museum. We decided to keep the existing bays in situ and do a major refit.

All we had to do now was turn the ideas into a practical design and build it.

What did we want to do? As a minimum, each of the BBC1, ITV and BBC2 outputs needs an off-air feed of its named channel, an appropriate test card and DVD replay. We also wanted a monitoring system so that any AV source can be checked and an RF monitor to check the signals going "up the pipe". It all had to be very easy to operate.

Signal sources and test cards

Three Freeview boxes provide BBC1, ITV and BBC2 off-air. We are gradually acquiring some spare Freeview boxes – donations welcome. They are not always reliable and can be hard to fix. They will soon become rare as people buy new TVs and chuck out their Freeview boxes. At present a DVD player is installed. We hope to add a media player running from SD card or USB stick. This will be able to provide a continuous loop of vintage programmes.

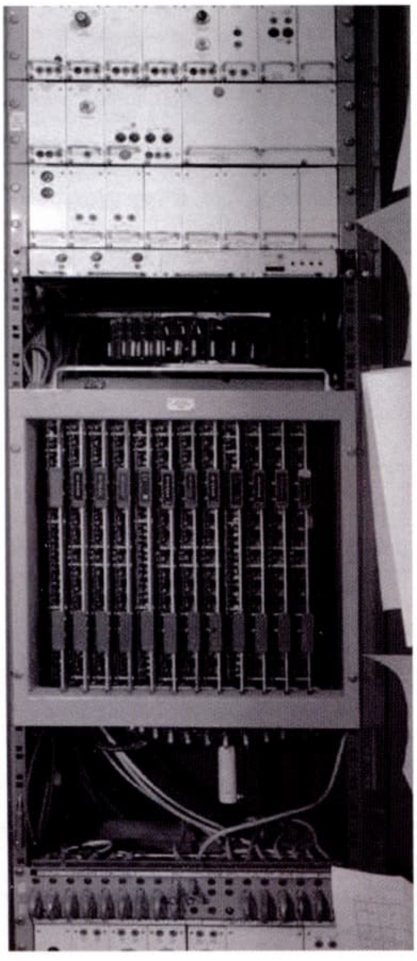
Each Aurora has a built in test card generator. Ch1 carries test card C with a customised Museum ident. Peter Sanders has programmed the Ch9 Aurora with test card D and an ITV ident. A Dinosaur generator mounted in the Aurora rack generates the famous colour test card F for Ch33. Auroras can generate tone with test card but at some point we will acquire an MP3 player, loaded with a continuous loop of test card music.

Switching and routing

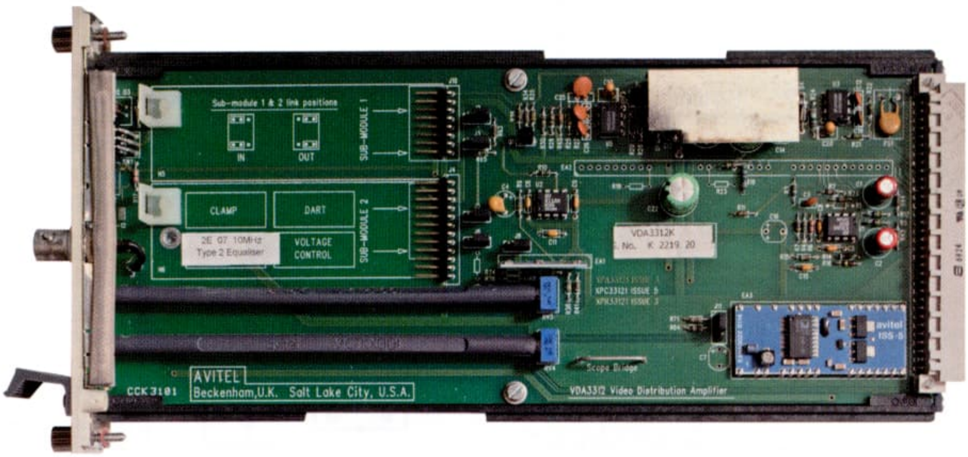
Any TV installation that's more than trivial needs audio and video switching. I put out an appeal for a suitable switcher. Brian Summers donated an 8x4 AV switcher but this has issues with its control system and we decided not to use it. The immediate answer was some kit that had been thrown out by the Croydon transmitter site at digital switchover. The versatile Avitel 3U rack system can hold many different modules. The ones that mattered to us were dual 2x1 relay switches and video distribution amplifiers (VDA). A VDA has a single video input and up to 7 independent video outputs. Each of the relay switch modules could be made into a 3 input, 1 output audio or video switch. Hence we needed 2 per channel, 6 in all. Fortunately we had 8. I made a very simple control panel with 3 rotary switches, each having 3 positions to select off-air, test card or media player. We would like to extend the switching to provide at least one more input but this is not essential.

Preview and monitoring

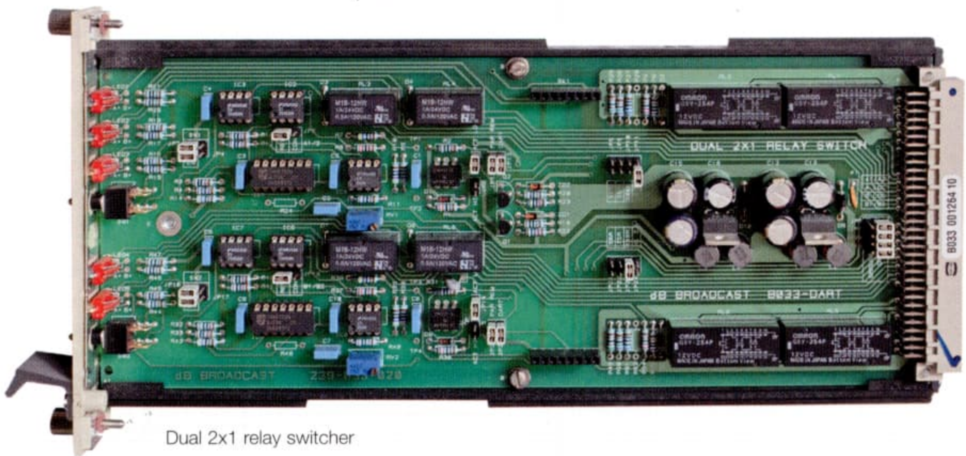
No point in having a marvellous installation if you can't check what you're sending. The old system had both 405 and 625 monitoring. 405 monitoring was essential since the CO6/509 converter couldn't be trusted to work well at all times. The preview on the new system is 625 only since the Auroras should be very reliable. Until we have a full router the preview is separate from the main switcher. I found a simple passive 10 input audio/video switcher in my loft. Each Freeview box has a second video output so we saved 3 VDAs. The DVD player and test card F generators feed VDAs so that they can feed the preview switcher as well as the channel selectors. The other test cards cannot be previewed this way as they are only present at the 405 outputs. The preview switcher's audio and video outputs are connected to a small colour monitor. The video is also looped though to the MN6/502 waveform monitor. This BBC designed unit is over 30 years old and works



Part of CO6/501 in 2002



Avitel video distribution amplifier



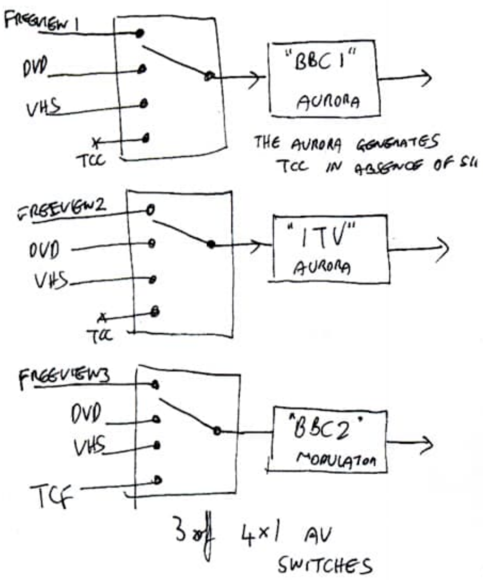
Dual 2x1 relay switcher

remarkably well, despite little maintenance. Its problem was badly intermittent switches. Some of these are difficult to reach even with a long nozzle on a can of Servisol. They are now all OK except for one which is a little dodgy. I don't even want to think about the amount of dismantling that would be needed to change it so we'll put up with it.

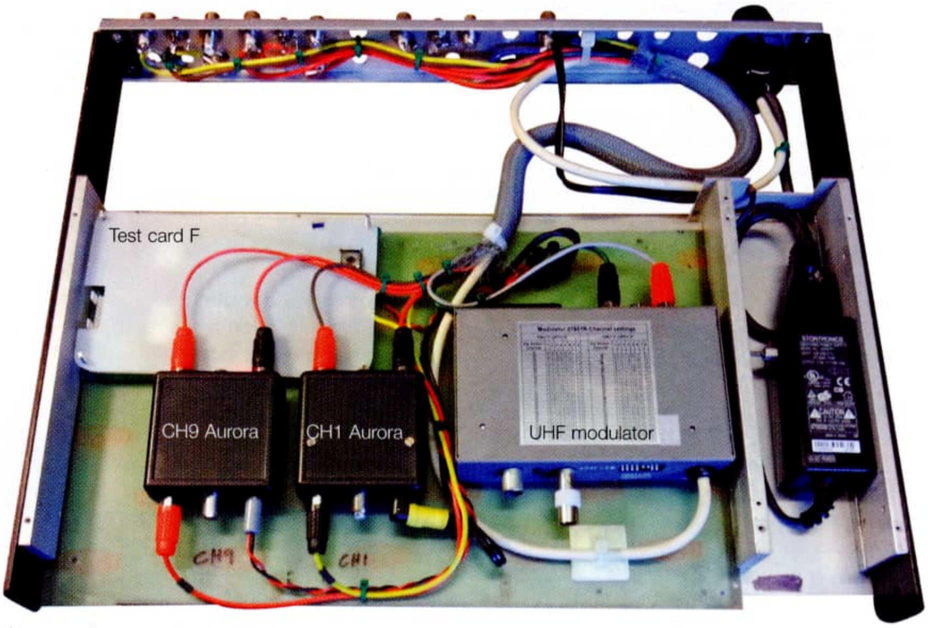
The small Sony TV9/90 portable TV may not give the highest quality pictures but serves well as an RF confidence monitor for all 3 channels. It sits neatly alongside the colour monitor. We used a 12dB tap to bleed a little signal from the output of the launch amplifier, followed by an attenuator to prevent overloading. Ideally we would have used a 20dB tap but we didn't have one to hand.

We also had the top quality Prowest PM14/1A dual standard monitor. While we didn't specifically need a 405 video monitor we felt it would be nice to display 405 at the highest possible quality. The problem was where to put it. On top of the bays? No, too awkward and far too high up to view comfortably. By the window? Don't want sun heating it up and would like to keep that area clear of TV kit. So could we squeeze it in the bays? Not easy but by finessing every last bit of space we managed. This meant that part of the CO6/501 that was in the left bay had to be removed and stored. We felt this was an acceptable compromise between keeping the old converters as static exhibits and having a good new system.

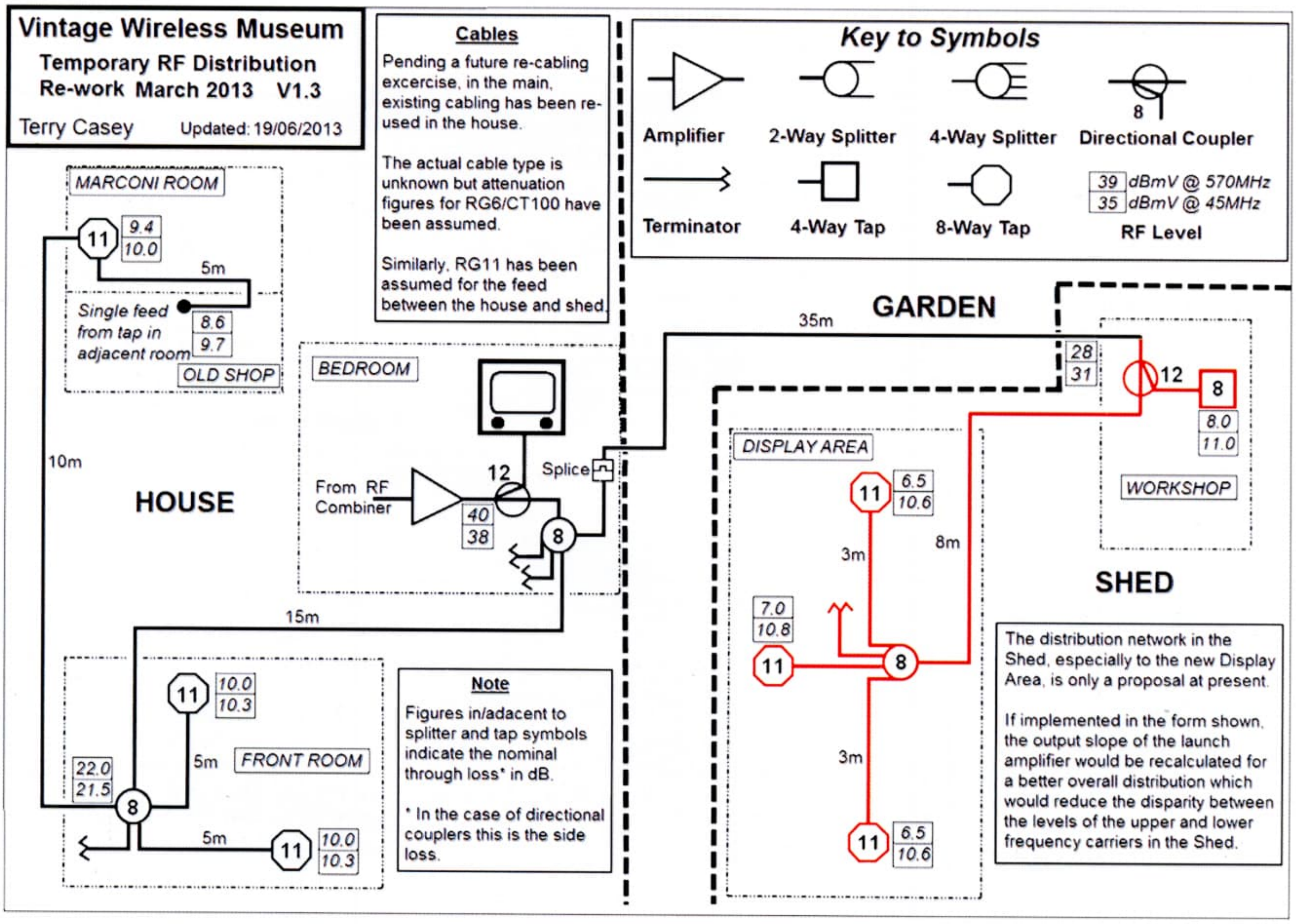
The Prowest monitor has suffered many



First design sketch



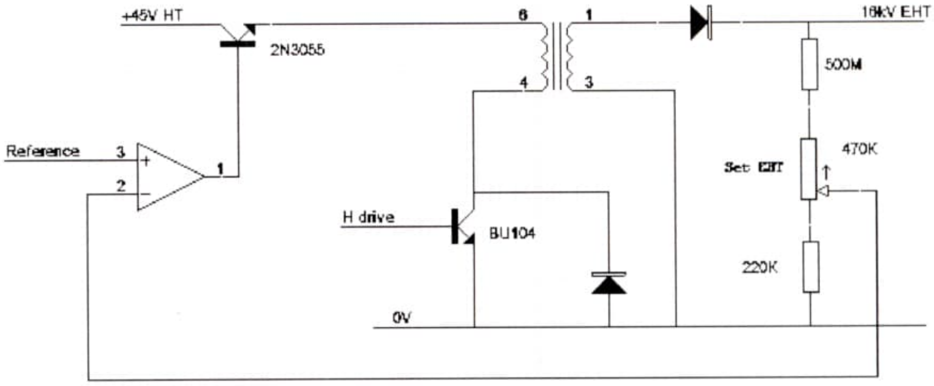
Aurora rack



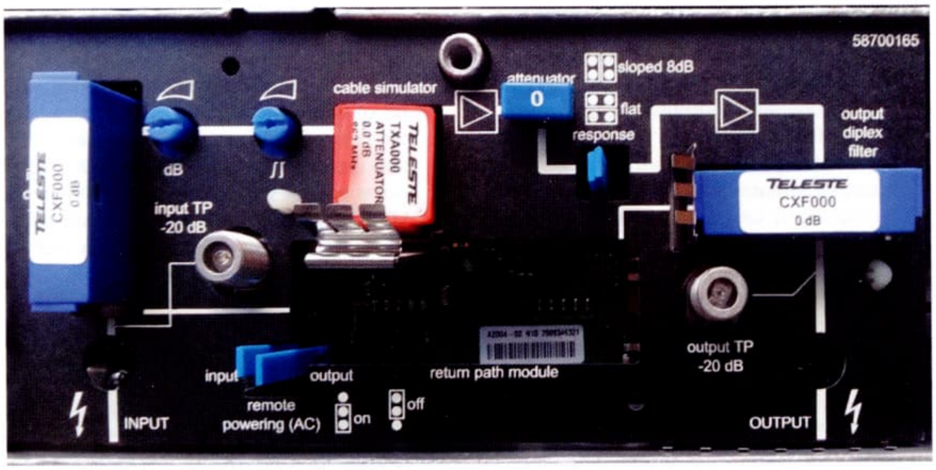
problems over its life. Despite being the best ever 405 capable monitor, the build quality isn't marvellous. A few years ago the mains transformer expired in a cloud of smoke. This was expertly rewound by Mike Barker who also generally overhauled the monitor. A short while before the refit it failed again. This time it was the EHT unit. The EHT in this monitor is entirely separate from the line output stage and is fully regulated. It's like a second line output stage, a technique also used in the Thorn 2000 colour TV. A sample of EHT is compared with a reference voltage. The result is used to control a series pass transistor in the 45V HT feed. The output transistor and the series pass transistor were both fried. The series pass is a common 2N3055 but the output transistor is a BU102 or BU104. These are rare types so I fitted a BU208 from my spares box. This worked OK on 625 but took excessive current on 405 causing the beam limiter to cut in at low brightness. Also there was a tendency for the EHT to arc over. For a quick fix I swapped the EHT board with the one from my own similar monitor. I rebuilt the offending EHT wiring with new EHT diodes and meticulous attention to insulation. The excess current problem was trickier. It didn't help that neither of the schematics I had for the EHT board conformed to the actual units. Eventually I realised that on 405 the BU208 was coming out of saturation towards the end of the scanning stroke. I saw this by carefully scoping the collector waveform. Turns out that the BU208 has a very low hFE compared to the BU104. I found a BU104 by raiding another (625 only) Prowest monitor. I'm not sure what to use to replace this transistor in future. Common line output transistors have rather low gain but it's only got to withstand less than 200V peak so I might choose a high power audio device.

Power distribution

We abandoned the original strips of 2 amp 3 pin sockets in the bays. I mounted a couple of 6 way power strips on a bit of wood and screwed this into the back of the left bay. The idea was to leave one strip permanently powered so that a bare minimum of signals from the Freeview boxes would be available at all times. The second strip is switched from the front panel. It turns on the routing switcher, monitoring etc. The Freeview boxes get a bit warm but this was solved with some spacers. The rack with the Freeview boxes still looks a bit of a mess, one day I might rebuild it. The other problem was very unexpected. After several hours the Ch9 sound went fuzzy. Turned out to be the Aurora. These are noted for superb reliability so I swapped it for one of my own and took it home for investigation. When it was warmed with a hairdryer the sound went bad. Hotter still and the vision failed. Darryl already knew the problem, a tolerance issue with the modulator chips. He made a couple of resistor value changes to tweak the reference frequency drive level to the modulator chips. Darryl suspects that a few more of these Auroras escaped before the problem was found. If you have a version 3.0



Prowest monitor EHT - simplified outline



Teleste CXE101

SCRF Aurora with these symptoms please contact me to arrange for it to be fixed.

Not specifically a power problem but one night all the TVs in the museum went blank. The RF launch amplifier had taken up smoking. John Thompson bridged out the amplifier which restored pictures but with a very weak signal. The switchmode power chip had blown apart, probably caused by a failed electrolytic. To save re-aligning the amplifier controls we swapped the power PCB from the other amplifier which is not currently in use.

Building the racks

I resolved to pre-build and test as much as possible of the new installation. This was done in the comfort of my own workshop rather than the limited time available at the Museum.

Switcher

The switcher was simply a matter of selecting the correct mix of relay switchers and VDAs to fit in an Avitel frame. While we would like an extra input this will have to await a suitable switcher. If and when this is available it should be simple to do the swap.

The preview switcher annoyingly has 3.5mm jacks for audio. I considered changing them for phonos but decided it was easier to use adaptor cables.

Auroras

The photo shows the Aurora rack complete except for the RF wiring. A 7.5V switchmode PSU (far right) powers both Auroras (front) and the Test Card F generator (back left, under insulating cover). The UHF modulator is mains powered.

The whole assembly was mounted on a piece of fibreglass PCB material that can be slid out for maintenance.

Freeview boxes

These were awkward to mount and are just lying loose in their rack. The photo shows a partial assembly with the Sagem box sitting on top of one of the others. The third box was at the Museum providing off-air pictures for the old installation. I'm still not happy with the arrangement. We were lucky in that the 3 Freeview boxes we had available only respond to their own remotes. The Sagem box is the best of the three. It's smallest, coolest and has the best video waveform. The others have technical deficiencies which shouldn't matter for us but indicate cheapskate design.

RF head end

The photo shows my original build, since modified with better filtering and multiplexing. The 3 channels are multiplexed to the left of the amplifier. The RF monitor tap is below. The output splitter to the right feeds the front room, upstairs via the front room and the sheds.

RF distribution

The old RF system had grown in an ad-hoc way to feed an increasing number of sets. The signals to each set were neither clean nor consistent. There were intermittent problems with poor signals, patterning, vision on sound etc. I'm pretty good with video and audio but not so experienced with RF. Terry Casey is an engineer with many years of experience on CATV systems. He surveyed the Museum and designed a distribution system that can cope with almost any future requirements. As with video and audio, we had a sensible policy on connectors. (See Appendix A) Terry insisted that it's F all the way. The only place anything else was allowed was on the fly leads to feed each TV. These would adapt from F to Belling & Lee or any of the weird and wonderful connectors used on early TVs.

An appeal for parts moved Luke Kelly to donate a pair of professional RF amplifiers and assorted splitters etc. Terry produced a seemingly endless supply of splitters and other useful bits. In the world of CATV real men think in decibels. Strictly speaking decibels with respect to 1mV or dBmV. Hence 2mV is 6dBmV, 0.25mV is –12dBmV and so on. Terry is a wizard at working out the gains and losses for each path on the distribution system to get the right level for each channel at each socket. We decided on at least 2mV or +6dBmV for each output, with a maximum of 3mV or +10dBmV. This is higher than you might choose for a domestic system but justified by the likelihood of "deaf" sets. If some poor set doesn't like that much juice up its sockets then attenuators are cheap and simple.

What do we need to do at RF? Ch1, Ch9 and CH33 must be multiplexed into a single circuit and fed to the launch amplifier. Then the high level output is split to feed many destinations. We also need to take a sniff of the output to feed the local RF monitor. The Aurora output is about 6mV or +16dB (I'll drop the mV now we all know what we mean) which is ample. The problem is severe harmonics. Although the harmonics of Ch1 and Ch9 aren't very harmful to Ch33 we really don't want to be distributing them. They're bound to give trouble somewhere and can aggravate intermodulation in the amplifier. Hence we need filters and diplexers. A UHF modulator donated by John Thompson has an output of only +10dB which is a bit low for comfort. It also has evidence of unwanted low frequencies on its output which could interfere with Ch1. This is likely an IF used as part of the modulation process but we still needed to get rid of it. As a temporary measure we pressed into service an old Labgear amplifier with filtered inputs. This has (shock horror) Belling & Lee connectors but with some adaptors and attenuators we obtained +16dB of clean UHF.

The resulting multiplexed RF feeds the launch amplifier. This can give up to 40dB gain from below 40MHz to the top of Band V. It has adjustable gain and a slope control so that it can compensate for greater cable losses at high frequencies. In practice we are running it at not much over 20dB gain with a little bit of slope.

There's a lot of it about. Bad RF cable that is. The classic "low loss" co-ax is horrible stuff. The braid coverage is often minimal so it leaks like a sieve. Not only does wanted RF leak out but the Museum is only a mile from Crystal Palace transmitter so there's a lot of hostile RF trying to get in and cause patterning. You never needed an aerial there to get an off-air signal on a TV. A screwdriver or finger in the socket usually did the job. Terry rightly insisted that we use decent cable throughout. This has copper foil and braid shielding and is commonly, if incorrectly, called CT100 or satellite cable. There are many minor variants on this class of cable. The most useful has foamed dielectric and is often called PF100.

Replacing the cable runs from the converter racks to the front room wasn't feasible at this stage. They are the dreaded low-loss co-ax, partially crushed in places by overenthusiastic stapling. Fortunately they didn't measure too badly so Terry said they'd be OK for now. They will be replaced when convenient. The cable from the front room to upstairs was an abysmal bit of damp string. Due to time pressure we connected it up. You didn't want to see the bodge needed to fit F connectors, nor measure the losses, especially at UHF. It was subsequently replaced by Peter Sanders and Tony Clayden. Tony just happened to have an power drill handy at the right moment to put a new hole through the wall between the hall and lounge. We haven't yet measured the cable from the house to the sheds. All the evidence suggests it's RG11, a high quality cable about 10mm in diameter. This is ideal for the job with low losses up to UHF. Assuming it's not been damaged in the underground duct it will be fine. We're certainly getting subjectively good signals down in the sheds. Making a good RF-tight connection to RG11 posed a problem. Terry found the correct F connectors but not the special crimp tool. I speculated that some large N connectors might work but the solution was the old fashioned PL259, sometimes called UHF or F&E. Fold the foil and braid back over the outer and it just nicely screwed on to the RG11. Not the best RF connector but the effects of the mismatch would be minuscule. Standard adaptors from there to F.

Aerial isolation is important. Many TVs are live chassis and even with the best of intentions some of these will sometimes be connected to mains live. There is also a law which states that the capacitors in a TV's aerial isolator will fail occasionally. It is vital to prevent this being a hazard to humans or damaging the distribution system. One answer would be to have galvanic isolation on the fly lead to each set. This is an expensive option unless somebody has a spare pile of isolators as used by the cable TV companies. Even this isn't ideal as a fault could remain undetected for a long time. Our solution is a traditional one. The distribution system is earthed at the head end and as often as possible at individual splitters. This ensures that a fault will blow a fuse in the TV or its mains plug. RCDs in the mains supplies to TV display areas would enhance the protection. The feed to the sheds has an isolator fitted not just for safety but also to prevent earth loops.

Peter Sanders and John Wakely have been working their way through fitting 8 way F splitters and fly leads to feed sets in the various rooms where they are displayed. The results are excellent. Even first generation dual standard sets with notoriously insensitive valve UHF tuners give good pictures. We can now be confident that any picture or sound defects are due to the TV itself and not the picture source or distribution system.

The RF system can be readily expanded to carry extra TV channels and possibly also VHF radio channels. The limit is set by intermodulation in the launch amplifier but we're a long way from that.

Installation 1

One Saturday in January John Thompson and I went down to the Museum, to be joined later by Peter Sanders. John and I cleared as much space as possible round the bays, isolated the mains and gently eased out the bays. They rolled surprisingly well on their castors. We ruthlessly stripped out all the old wiring and equipment from the left bay plus a few bits from the right bay. This raised clouds of ancient dust. A lot of patient hoovering and brushing got things reasonably clean. We also stripped the old RF distribution bits that were outside the bays.

Before mounting the various items you have to fit caged nuts to the appropriate square holes in the sides of the bay. We don't have the special tool for the job so it's done with a screwdriver, the odd flying nut and a gash in your hand if you slip. John turned out to be much better than me as a caged nutter. We fitted all the kit in the bay and I started to wire it up. The Freeview box rack was awkward to wire up and could do with a rethink. The audio was a bit of a nuisance too, finding a need for leads with multiple phono plugs in parallel and too many phono to 3.5mm jack adaptors. It didn't take too long to get some pictures on the preview monitor. Sound, as ever, proved trickier but we gradually beat it into submission. At some point the bay could do with a tidy up, with all the audio and video cables being tied into neat bundles.

The RF install was very rough and ready at this stage. We fitted the pre-built RF head end to a space in the right hand bay. I had already proven that the door would still close without hitting the amplifier. We did just enough to get signals though to the various areas without worrying about quality or quantity. We knew that Terry Casey would be coming down in a few weeks to sort out the RF properly.

The whole thing looked fairly neat by now. All the wiring (mains in, aerial in and RF out) was routed via the proper cable entry at the rear of the right bay. No odds and sods outside the bays themselves. John had to get away a bit early so Peter and I tidied up, with Peter working on it long after I had gone.

Installation 2

Early in March Terry Casey, John Thompson and I went to the Museum for the second instalment. Terry was well armed with assorted splitters, a portable spectrum analyser and great expertise in RF distribution systems. I worked on tidying the wiring a bit, especially the audio. John and I plotted how to get the Prowest monitor in the bay while Terry started to get the RF side working properly. After much measurement and tweaking we had a good signal at all sockets except upstairs. This was weak on Ch33 due to a very nasty bit of co-ax between the front room and upstairs which has since been replaced.

Looking ahead

The Museum now has a good 3 channel distribution system that should serve well for many years. There's nothing that can't be improved so what would we like to do? A replacement switcher with more inputs would be nice, as would an MP3 player for testcard music and a media player. I need to get the Freeview rack looking better. There are also plans to extend the RF distribution system, especially in the sheds. This will use another amplifier to feed lots of sets.

I would like to thank all those who have contributed to this project. I hope I have mentioned all of you in text but I apologise for any omissions.

Appendix A: Analogue video and audio

The universal video standard is 1Vp-p into 75 ohms. While it is possible to loop video to several destinations you can't just parallel multiple loads. Hence to route a source to multiple destinations needs a video distribution amplifier or an electronic router. Audio doesn't have such limitations since we normally work with low impedance sources and high impedance loads.

Appendix B: Connectors

I decided that all video would be carried on BNC connectors in accordance with professional practice. I also have large quantities of high quality BNC cables. The new installation did not need a MUSA patch panel.

Audio to be mono and on phono connectors. Not professional but practical and adequate. As with video, no jackfield was needed.

All RF to use F connectors. They are universally used for CATV installations except with some larger cables. F connectors have good mechanical and RF performance, are cheap and easy to fit. They are much better than the commonplace Belling and Lee co-ax connector.

Where kit had other connectors such as SCART we used adaptors.

Appendix C: RF system frequency response

Many amplifiers, splitters etc are rated from 47MHz up to 1GHz or so. The top end is no problem but what's going to happen to Ch1 with 45MHz vision and 41.5MHz sound? It's not usually a problem in practice provided you make sure there isn't any return path filtering. Frequencies below 40MHz have been used in a return path for various purposes, none of which are relevant to the Museum installation. The launch amplifier measures flat to well below 40MHz. Out of curiosity I measured an assortment of old amplifiers found at the Museum. One was by Labgear, a semi-professional unit previously mentioned. This has filtered inputs for Bands I, II, III and UHF. It gave a consistent 30dB gain with sensible response for each input. Of 3 small domestic grade amplifiers one gave a useful 12dB or so gain from below 40MHz while the others rolled off badly below 70MHz. These last were not specified below Band II, OK for intended application but useless for Ch1.

Cyril Frank Elwell

Pioneer of American and European Wireless Communications, Talking Pictures and founder of C.F. Elwell Limited, 1921-1925 by Ian L. Sanders

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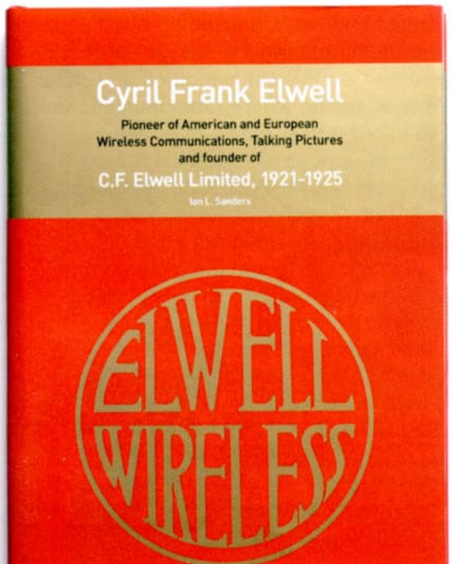

In many ways an enigma, Cyril Frank Elwell defies conventional typecasting. He was in every sense an international player. Born in Australia in 1884 to an American father and a German mother, Elwell received his engineering credentials from California's Stanford University at the turn of the twentieth century. As an early pioneer of wireless communications, he split his time between the United States, Great Britain and Continental Europe.

Elwell's professional contributions en-compassed long-distance radio transmission, domestic wireless, cinematics, radar tower design and more. But, despite a legitimate claim to world-class technical achievements, he received little recognition in his lifetime and has been largely forgotten since his death in 1963.

Drawing from primary source materials and with an emphasis on Cyril Elwell's British enterprises, this book seeks to document the man, the organisations he founded and the technologies that he touched.

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Letters

Dear Editor

I was interested to read Stef Niewiadomski's article on the Vidor company in the Winter 2012 edition of the Bulletin and in particular his comment that it was a pity that Vidor folded before they could make another transistor radio after the CN440 Gem (February 1958).

It seems that Vidor had advanced plans to do just that with two new transistor sets shown at the 1958 radio show. First of all the CN443 Viscount, described as a 6 transistor superhet with push-pull output (battery operated) 'a battery table model in a handsome polished cabinet, slow motion tuning and a 7" x 4" high sensitivity loudspeaker.'

The other set was the CN447 Stowaway described again as a 6 transistor superhet with push-pull output (battery operated) 'the most intriguingly and beautifully made pocket size receiver'. It was described as being less than 8 inches long.

It also seems that the company were still hedging its bets regarding valve technology as a new (unnamed) attaché case valve portable (CN446) was exhibited at the same time as the Viscount and the Stowaway. All were intended to go into production during 1959 but unfortunately this never happened. However it may be conceivable that one or two of the prototypes may still exist?

In view of this, it was indeed a shame that the radio side of Vidor folded when it did as these sets would have provided some home grown competition to Ever Ready in the portable radio market.

My source of information is www.radiomuseum.org but unfortunately there are no images of these sets in the picture gallery. Even so I trust this is of interest, incidentally I wondered whether the 'CN' prefix stood for 'catalogue number'.

Regards,
Del Burgess

RADIO RECEIVERS

Portables

AC/BATTERY

A.M. only

Make	Model	£	s	d
Pam	706...	15	15	0
Invicta	27	16	5	6
Defiant	PSH255	17	6	6
Stella	ST108AB	17	6	6
Pye	P131MBQ	18	7	6
Vidor	CN426	18	7	6
Berec	Fiesta	18	18	0
Marconiphone	T36AB	19	7	6
Vidor	CN430	19	8	0
Ferranti	955...	19	19	0
Vidor	CN420	13	13	0
Berec	Jester	13	17	0
Ever Ready	Sky King	13	17	0
Ferranti	855...	14	3	6
Vidor	CN432	14	3	6
Berec	Calypso	14	10	10
Ever Ready	Sky Princess	14	10	10
Philco	A3632	14	14	0
Roberts	R55	16	10	0
Bush	BAC31	18	10	0
Murphy	B229	20	14	0
Roberts	RP4	21	7	6
Cossor	Handbag ¶	27	6	0
Pam	710 ¶	31	10	0
Cossor	Personal ¶	—		

¶Employs transistors.

With F.M.

Make	Model	£	s	d
Vidor	CN436	—		

Table Models

AC

A.M. only

Make	Model	£	s	d
K-B	FB10	12	0	0
Vidor	CN433	15	15	0
G.E.C.	BC5445	16	16	0
Cossor	501...	18	15	0
Defiant	MSH555	18	18	0
Philco	A3654	19	8	6
K-B	LR10	19	19	0
Masteradio	D159	19	19	0
Sobell	515P	19	19	0
Pye	P100‡	20	9	6
Regentone	A133	20	9	6
H.M.V.	1127‡	21	0	0
Pilot	T854	21	0	0
Pam	703A	21	0	0
Pye	P75	21	0	0
Pye	P75T	21	0	0
Cossor	520...	21	10	0
Philco	A3650	22	1	0
R.G.D.	T10	22	1	0
Ekco	A244‡	23	2	0
Masteradio	D159/3	23	2	0
Philips	342A‡	24	3	0
Philco	A3656	25	4	0
R.G.D.	110...	25	4	0

‡Clock radio.

With F.M.

Make	Model	£	s	d
K-B	FB10FM*	15	0	0
Cossor	524...	22	1	0
K-B	MR10	22	1	0
Murphy	A362	23	10	0
Murphy	A362T	23	10	0
K-B	LR10FM	25	14	6
Defiant	MSH556	26	5	0
Ferguson	383A	26	5	0
Ferranti	255...	26	5	0
H.M.V.	1128	26	5	0
Philco	A3610	26	5	0
Philips	353A	26	5	0
Roberts	R66	19	19	0
Murphy	BA228	24	3	0
Roberts	RMB	25	8	6

AC/DC BATTERY

A.M. only

Make	Model	£	s	d
G.E.C.	BC4444	16	16	0
K-B	MP151	17	6	6
Ferguson	342BU	17	17	0
Ultra	Twin	18	7	6
Murphy	BU183M	18	18	0
Philco	A3782	18	18	0
R.G.D.	B55	18	18	0
Regentone	22 ...	18	18	0
Pilot	BM90	19	10	0
G.E.C	BC4448	19	19	0
Cossor	523...	27	6	0
G.E.C.	BC5645	27	6	0
Philips	G74A	27	6	0
Sobell	636WF	27	6	0
Stella	ST234A	27	6	0
Bush	VHF61	28	7	0
Ekco	A274*	28	7	0
K-B	KR20FM	28	7	0
McMichael...	FM55	28	7	0
Pam	713...	28	7	0
Marconiphone	T42A	28	15	0
Ambassador	AM/FM TM	29	0	0
Defiant	MSH556W	29	8	0
Ferguson	372A	29	8	0
Philco	A3658	29	8	0
Invicta	37 ...	29	18	6
McMichael...	M101R	30	9	0
Masteradio	D159F	30	9	0
Murphy	A262	31	0	0
Pye	FenMan I	31	10	0
Bush	VHF54	32	0	0
Invicta	38 ...	32	0	6
Ekco	A277*	32	11	0
G.E.C.	BC5842	32	11	0
Philips	G63A	32	11	0
K-B	NR30	33	12	0
Pilot	T91	33	12	0
Pilot	T92	33	12	0
Alba	3211	34	13	0
Masteradio	D157	35	3	6
H.M.V.	1251	35	14	0
Pam	714...	35	14	0
Regentone	A155	35	14	0
R.G.D.	112...	35	14	0
Ekco	A239	36	15	0
Philips	G64A	37	16	0
Defiant	MSH755	39	18	0
Pye	FenMan II	42	0	0
Decca	66 ...	43	1	0

*F.M. only.

AC DC

A.M. only

Make	Model	£	s	d
Alba	C116	9	19	6
Alba	C116LW	10	10	0
Pye	Pye Piper	11	0	6
R.G.D.	AP33	††12	12	0
Pilot	T105	12	19	6
R.G.D.	A33	12	19	6
Regentone	DW1	12	19	6
Regentone	DP2	12	19	6
Masteradio	D121	13	15	0
Murphy	U198H	14	0	0
Murphy	U198M	14	0	0
Defiant	MSH356	14	3	6
Ferranti	M55	14	3	6
Ferguson	352U	14	14	0
Marconiphone	T43DA	14	14	0
Pye	P98U LW	15	4	6
Regentone	D15	15	4	6
Ultra	Troubadour	§15	4	6
Vidor	CN431	19	19	0
McMichael...	354...	20	18	6
Ekco	MBP183	21	0	0

BATTERY

A.M. only

Make	Model	£	s	d
Cossor	543...	12	0	0
Invicta	26 ...	12	1	6
Pam	700...	12	1	6
Ekco	BP257	12	12	0
Berec	Ballerina	13	2	6
Ever Ready	Sky Baby	13	2	6
Masteradio	PB101	13	2	6
Pye	P114BQ	13	2	6
Vidor	CN434	13	2	6
Regentone	B1	13	13	0
Ekco	U245	15	15	0
Philco	A3606	15	15	0
Stella	ST105U	15	15	0
Philips	151U	15	15	0
Bush	DAC90A	†16	0	0
Masteradio	D155	16	0	0
Ferranti	555...	17	6	6
Alba	3122	17	17	0
Cossor	501(UL)	19	5	0
Philco	A3608	19	8	6
Bush	DAC10	19	10	0
Pam	955U	19	19	0
K-B	LR15	20	9	6
H.M.V.	1360	21	0	0
Philco	A3650U	22	1	0
Philco	A3656U	25	4	0
Pye	P93W/U	27	6	0

†Brown. Cream £16 10s.
††Maroon. Cream £12 19s 6d.
§Brown. Cream 10s 6d extra.

With F.M.

Make	Model	£	s	d
Ferguson	382U	21	0	0
Bush	VHF90	†23	2	0
Ultra	U930	24	3	0
Philco	A3610U	26	5	0
Ultra	U940A	26	5	0
Ultra	U940B	26	5	0
Ekco	U243	27	6	0
Philco	A3658U	29	2	0
Bush	VHF55	33	0	0

†Brown. Cream £24 3s.

BATTERY

A.M. only

Make	Model	£	s	d
Ever Ready	Sky Prince	14	14	4

With F.M.

Make	Model	£	s	d
Ever Ready	Sky Monarch FM	30	9	5

Consoles

AC

With F.M.

Make	Model	£	s	d
McMichael...	255...	34	13	0
McMichael...	255S	34	13	0
Murphy	A272C	38	15	0
Cossor	540...	39	18	0
Ekco	C273*	44	2	0

*F.M. only.

Car Receivers

A.M. only

Make	Model	£	s	d
Philips	344V	23	2	0
Ekco	CR152	27	15	0
Philco	CR3692	32	11	0
Philco	CR3696	37	16	0
Ekco	CR227	39	15	0

Dear Editor

How much is that radio in the window?

I recently acquired a few issues of Wireless and Electrical Trader magazine, which was aimed at the trade and was the source of the pull-out 'Trader' service sheets which we use today for circuit diagrams and alignment information for the radios we collect and restore. Amongst these was the issue for 1 September 1956, which contained a list of all the models (TVs, radios, radiograms and record 'reproducers') along with their prices, exhibited at the annual Radio Show, held at Earls Court, at the end of August of that year. The Trader service sheets usually contained the price of the radios they were describing but it's rather laborious to compare the prices of several models, so this list is a quick and easy way of seeing where radio manufacturers positioned their radios price-wise.

These prices included purchase tax, and Resale Price Maintenance ruled out any discounts, so that was the price you paid in the shop.

If you'd like to see the prices of the TVs, radiograms and record players, contact me at stef@altera.com and I'll send you a scan.

Regards,
Stef Niewiadomski

Dear Editor

Current Comments

Patrick Wilson's comprehensive article on current measuring instruments (BVWS Bulletin Vol 38 No 3 August 2013) was a very informative review of all those ingenious instruments that were such essential devices for electricians and telegraphists well before the days of AVOs and Valve voltmeters.

Patrick pointed out that the unit of current used to be called the webber. This is something we rarely encounter these days but it is an important part of history. The name ampere was formally introduced in September 1881 at the first international congress of electricians in Paris. Until that time, the written symbol for current was the letter 'C' but thereafter it was changed to 'I' from the phrase intensité

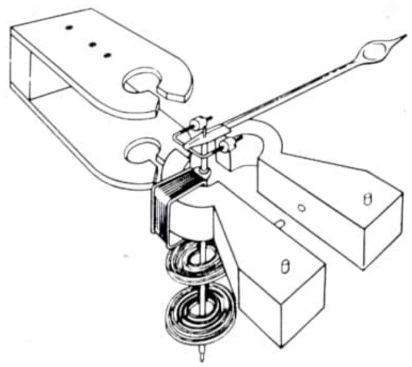


Fig. 1 The pole irons of the Cirscale movement. These instrument elements are joined and then bridged by the main meter magnet.

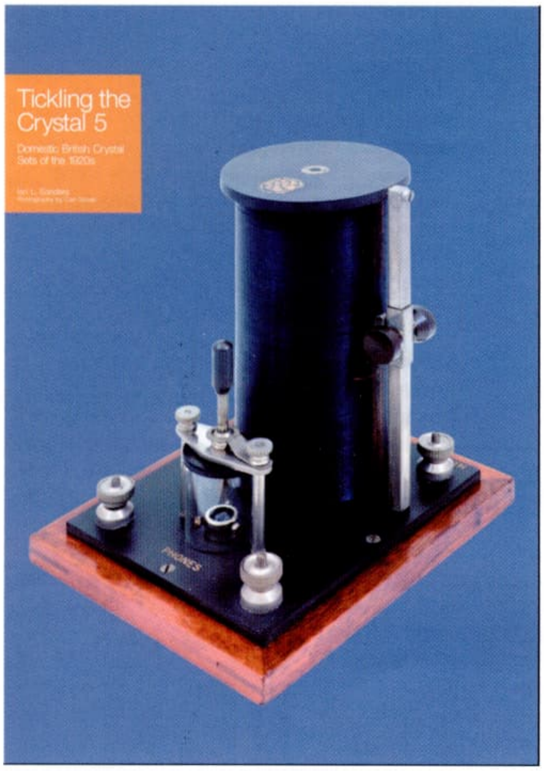
Fig. 2 A Cirscale sub standard ammeter. The overall diameter is 22 cm (8 ½") and it weighs 6 kg (13.2 lb).

de courant, although some writers continued to use 'C' for several years.

Prior to 1881 the unit of current was not only called the webber, some referred to it as the oersted and others as the farad/sec. The farad/sec may seem a bit odd but the name farad was sometimes used as a unit of charge as well as the unit of capacitance. Also, just to confuse matters further, a current of one farad/sec was sometimes abbreviated to one farad by telegraphists – so in 1881 it was high time for the introduction of an international unit of current, the ampere, which was then simply defined as the current through 1 ohm under a potential difference of 1 volt. At a subsequent congress in Chicago in 1893 the definition of the ampere became the well remembered deposit of 0.001118 g/s of silver on the cathode of a silver nitrate electrolyser. It is now defined as the current which results in a force of 2 x10-7 newtons/m between two infinitely long parallel conductors when 1 m apart in vacuo. At one point in his article, when talking about meter scales, Patrick said that, "the longer the scale the better". This is an important point and, as long ago as the early 1880s, attempts were made to extend the scale of the primitive moving coil meters from its usual 90o or so. I consider that the best example of this was achieved by Mr Jack Westmorland Record a century ago in 1912 when he patented his Cirscale moving coil instrument (Fig.1) where the coil was mounted in such a way that it was free to move in a uniform field through an angle of about 300°. This instrument was particularly useful when an ammeter was used to indicate big variations in current: eg the speedometer on trains and ships is often based on a voltage generator whose output is directly proportional to the speed of the vehicle and fed to a Cirscale meter calibrated in m.p.h.or knots. The 300° scale is an ideal instrument for this tachometer application and Cirscale meters are still in production by Record Electrical Associates Ltd in Manchester. Cirscale meters were also widely used as panel meters in power stations and as sub-standard instruments (Fig.2) in industrial research departments and scientific laboratories. Record Electrical Ltd was originally based in Broadheath, Altrincham and, although the wide range of meters they produced did not have quite the same reputation as those made by such leading companies as Evershed & Vignoles, their Cirscale instruments were first class and unique - and still are. I look forward to Patrick Wilson's further articles.

Tony Constable

BVWS Books



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Growing up in the 1930s, young Gerry Wells preferred wireless to toys. He had a postwar career as a radio and TV engineer designing and managing amplifiers, PA's and TVs. He now runs the British Vintage Wireless and Television Museum from the home where he was born. This is the story of one man's dedication to wireless £6.00 196 pages paperback (+ £2.50 p&p UK) £3.50 EEC (rest of world £5.50)

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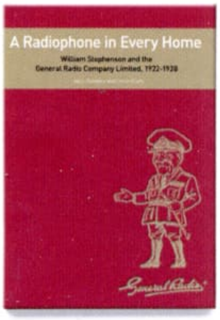
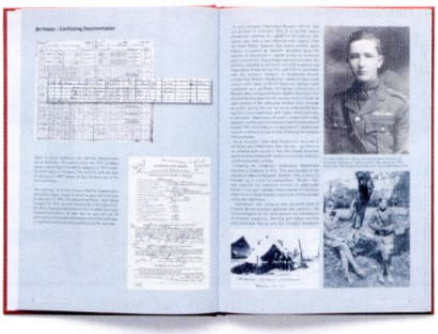
BVWS Books

Out Now!

A Radiophone in Every Home - William Stephenson and the General Radio Company Limited, 1922-1928

by Ian L. Sanders and Lorne Clark, with foreword by Jonathan Hill. Published by Loddon Valley Press. ISBN 978-0-570773-0-0.





Between 1922 and 1927, during the life of the British Broadcasting Company (forerunner of today's British Broadcasting Corporation), literally hundreds of wireless manufacturing firms sprang up to take advantage of the new craze for 'listening-in'. In the fiercely competitive market of those pioneering days, many of these businesses were to disappear within just a few years. While much has been written on the history of the larger companies during this period of attrition, names such as Marconi, British Thomson-Houston, Burndept and General Electric – very little has been published about the smaller to mid-sized enterprises.

In their superbly illustrated new book, Ian Sanders and Lorne Clark tell the fascinating story of one of these smaller firms, the General Radio Company Ltd., and its enigmatic Canadian founder, William Samuel Stephenson, WWI air ace and WWII secret agent, thought to be the model for Ian Fleming's James Bond character.

As well as producing an extensive range of radio receivers, the company also worked on the development of mechanical television.

This high quality publication is available for immediate despatch, price £19.95 (£17.95 for BVWS members) plus £4.95 P&P for UK, £7.50 P&P for EEC. BVWS members should quote their membership number in order to secure the discounted price. Payment via PayPal accepted.
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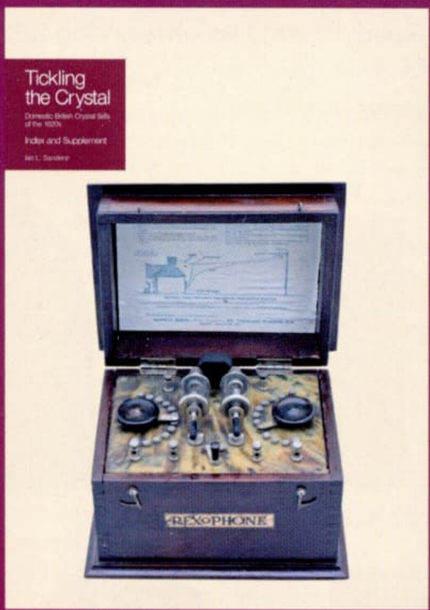
Out Now! Tickling the Crystal index and supplement



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1st December
Royal Wootton Bassett

The Memorial Hall, Station Rd. Wootton Bassett.
Nr. Swindon (J16/M4). Doors open 10:00.
Contact Mike Barker: 01380 860787

Eighth page advertisements cost £22.50, quarter page advertisements cost £45, half page: £90 and full page: £180. Cheques made payable to 'BVWS' please

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All Bulletins and supplements are priced at £2.50 each + postage.

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Marconi on the Isle of Wight

In November 1897, a twenty-three year old Italian inventor visited the Royal Needles Hotel that overlooked Alum Bay on the west coast of the Isle of Wight. The young Guglielmo Marconi's proposal to rent rooms to perform his 'experiments' over the deserted winter months was warmly welcomed by the hotels proprietors. Marconi used some of the working capital of his newly formed Wireless Telegraph & Signal Company to convert the hotel's billiard room and install his equipment and spark transmitter. Several small ships were hired and fitted with wireless aerials and receivers while moored at the pier below. A huge mast, 168 feet high, had to be hauled up the cliff face of Alum Bay and raised in the hotel grounds, a feat that required the help of most of the able bodied men in Totland. On Monday 6th December 1897 Marconi started his wireless experiments from the Royal Needles Hotel, including a month of private demonstrations for Queen Victoria and the Royal family using wireless stations he installed at Osborne House and on board the Royal Yacht. For the next two and a half years the world's first permanent wireless station would be operated from the Isle of Wight.

By 1900 Marconi realised he need more space, greater privacy and longer ranges to his new stations being built in Cornwall. He moved his equipment and aerial mast from Alum Bay across the Island to a new station built in Knowles farm in Niton. While there Marconi developed the vital science of tuning, enabling multiple wireless signals to be separated without interference. In January 1901 transmissions from Niton reached Marconi's new station at Lizard Point in Cornwall. This was 196 miles away, a world record for 'radio' waves, convincing Marconi that his system was now ready to attempt to transmit across the Atlantic ocean, over 2,100 miles.

The success of Marconi's famous "S" across the Atlantic in December 1901 gave a huge impetus to the growth of wireless (or radio as it soon become known) equipment. As the orders for ships wireless equipment started to increase, Niton soon became an active Marconi shore station (one of 40) handling passing ship wireless traffic in the Solent. Marconi's Niton station was taken over by the Post Office on 29th September 1909 and four years later, as part of a major reorganisation, land at Niton Undercliffe, about four miles from Ventnor, was leased from Lloyds at an annual rent of £5. On the new site a Lloyds signal and wireless telegraphy station using Marconi equipment was built, along with various houses which belonged to the Coastguard, and the station building that was later to become Niton Radio. There was also a Marconi station located on Culver Cliff.

The science and art of wireless communication was born on the Isle of Wight.

The story of a young Italian engineer, whose small experiments on a small Island grew to produce our modern world of instant global communication, radio broadcasting, mobile phones, television, satellite communication and even the internet is simply amazing. Marconi on the Isle of Wight changed the world forever.

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For further information please contact the author at timwander@compuserve.com or as always see 2mtwrittle.com

News and Meetings

Martyn Bennett is the custodian of the BVWS GPO Registration Numbers list. As many members know, the project of assembling this list was started in the early days of the BVWS and was carried on by the late Pat Leggatt. Members are strongly urged to help build the list, whenever they get the opportunity, particularly as it is something that will help with the identification of vintage wireless in years to come. The list is by no means complete and the GPO no longer have a record of the numbers granted to wireless manufacturers. The BVWS Handbook contains the current listings - one in numerical order and one ordered by name. Please let Martyn have any additions, or suggestions for corrections, by mail or over the phone.

Martyn Bennett, 58 Church Road, Fleet, Hampshire GU13 8LB telephone: 01252-613660 e-mail: martyb@globalnet.co.uk

2013 Meetings

23rd November An afternoon of music at The Vintage Wireless and Television Museum, West Dulwich
1st December Wootton Bassett

2014 Meetings

February 9th Audiojumble
March 2nd Harpenden
April 6th Golborne
May 11th National Vintage Communications Fair
May 31st Garden Party at The Vintage Wireless and Television Museum, West Dulwich
June 1st Harpenden
July 6th Wootton Bassett
September 14th Murphy Day
September 28th Harpenden
October 5th Audiojumble
November 2nd Golborne
7th December Wootton Bassett

The British Vintage Wireless and Television Museum: For location and phone see advert in Bulletin.
Harpenden: Harpenden Public Halls, Southdown Rd. Harpenden. Doors open at 9:30, tickets for sale from 09:00, Auction at 13:00. Contact Vic Williamson, 01582 593102
Audiojumble: The Angel Leisure Centre, Tonbridge, Kent. Enquiries, 01892 540022
NVCF: National Vintage Communications Fair See advert in Bulletin. www.nvcf.co.uk
Wootton Bassett: The Memorial Hall, Station Rd. Wootton Bassett. Nr. Swindon (J16/M4). Doors open 10:00. Contact Mike Barker, 01380 860787
Golborne: Golborne: Golborne Parkside Sports & Community Club. Rivington Avenue, Golborne, Warrington. WA3 3HG contact Mark Ryding 07861 234364
Mill Green Museum: Bush Hall Lane, Mill Green, Hatfield, AL95PD
For more details with maps to locations see the BVWS Website: www.bvws.org.uk/events/locations.htm

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