The Bulletin

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The BVWS Spares Dept

DeoxIT D5 contact cleaner / lubricant £16.50 aerosol can. Not cheap – just the BEST. Available at all BVWS events or by post for an additional £4.00

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
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0.001µF	Price band A	0.022µF	Price band B
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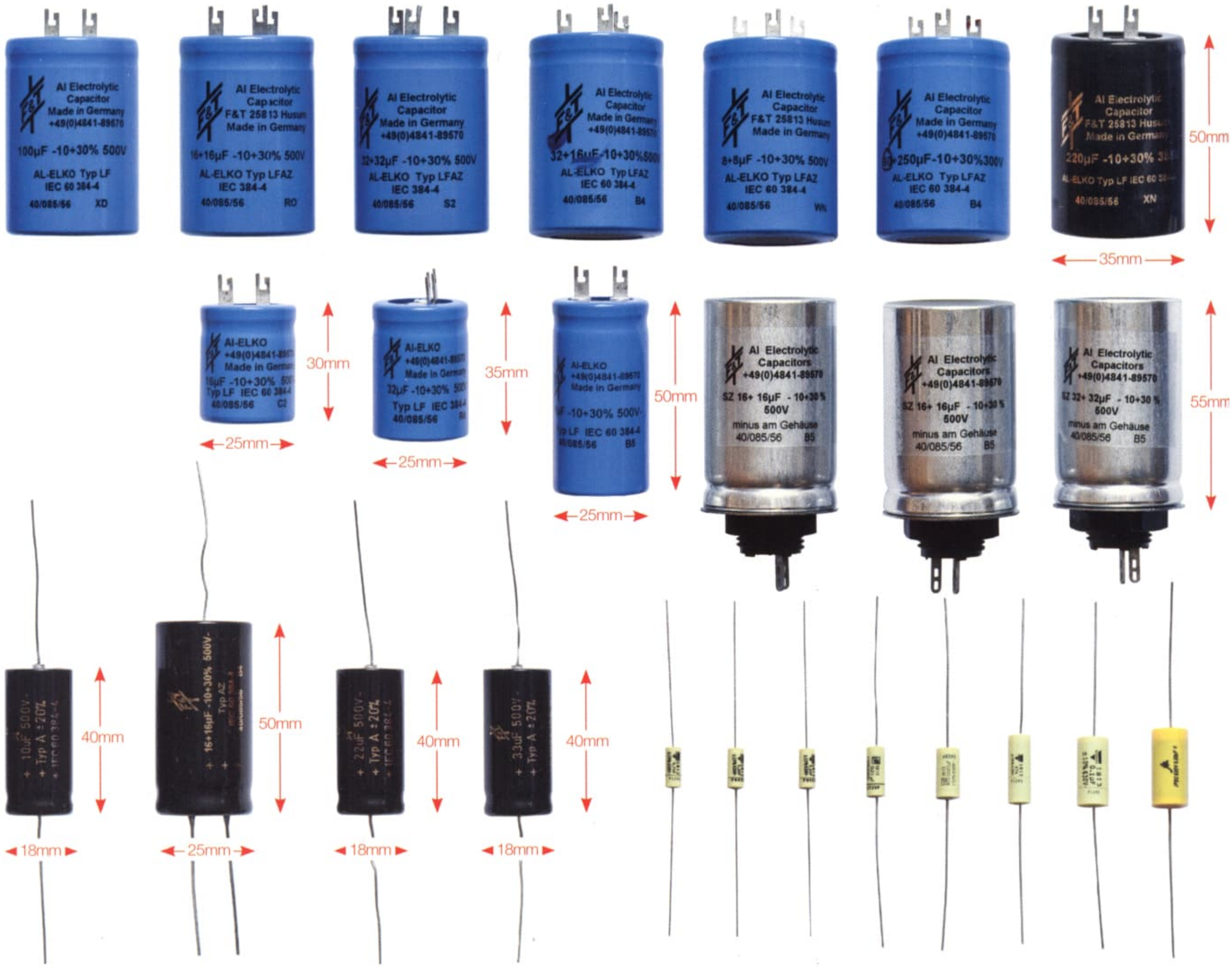
All prices quoted are for BVWS members



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

Bulletin of the British Vintage Wireless Society
Incorporating 405 Alive
Volume 40 No.4 Winter 2015

www.bvws.org.uk

Separations and printing by Hastings Print

Front and rear cover: Various reproduction wirelesses manufactured by Gerry Wells and friends at The British Vintage Wireless and Television Museum, West Dulwich, London.

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Graphic design by Carl Glover and Christine Bone
Edited by Carl Glover. Sub-Edited by Ian Higginbottom
Proof-reading by Jeremy Day, Steve Sidaway, and Mike Barker

Contents

From the Chair

Another year is drawing to a close. Where does the time go? It has been a splendid year for the BVWS and its members. The events have been very well attended and the constant flow of items coming in for auction grows with every year that passes. We have a very full store, now overflowing into my own space here. I have two very large collections still to go out and fetch back as well as several other smaller enquires on the back burner. I am seriously thinking of holding a 'Special Auction' event in late January/ early February 2016 to 'clear the decks' so to speak. There is far more than we can accommodate in the regular meetings.

With this Bulletin you will find your 2016 calendar and also the Winter DVD both of which we are very pleased with.
The subject of the DVD is a celebration of the life of Gerry Wells with a selection of pieces from the vast video archive held at the British Vintage Wireless & television Museum.
All of those on this disc are shown with the permission of the Museum.
The original material in many old formats and of varying quality was converted over to a digital format by Terry Martini-Yates a few years ago and the DVD compilation has been compiled by Jon Evans with many hours of work spent cleaning up and improving the image and sound quality. My Thanks go to both Terry and John for all the effort spent making these wonderful films available to us all. I hope you enjoy them.

You may have seen the BRIMAR Valve stall at various events over the last year.
A small group of enthusiastic fellows are on an epic journey to re-establish the manufacture of valves in the UK. Not any easy task if you have hundreds of thousands of pounds behind you, but without any equipment as well...
Please read the appeal for help in the centre pages as they have been given a once in a life time chance to achieve this goal.

What's in a name?
The Committee are very seriously looking at the future direction of the Society.
Particularly we are thinking of how the next 40 years of the Society will look.
At the recent Golborne meeting a conversation about the Societies future was in progress when it was suggested that our name no longer reflected our Society and its activities in today's world. The word Wireless is no longer associated with radio and more a term used for mobile communications devices and computer networks. I would very much like to hear from members on this subject.
Any correspondence will be published in the letters page of the next Bulletin.

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'll close by wishing you all a Merry Christmas and very happy and prosperous New Year. Mike...

An HMV model 570 radiogram and how one thing leads to another

Ken Brooks

Radiograms are intriguing products and the HMV model 570 is no exception. When casually looking for another quality radiogram this very handsome example turned up at a Royal Wootton Bassett sale. As is often the way with radiograms, the restoration work needed was considerable and continued as motivation and enthusiasm waxed and waned over a number of years.

During 1980 I had the good fortune to become the custodian of an enormous HMV model 800 radiogram, a highly advanced flagship product upon which it seems the designers expressed their wildest engineering and artistic fantasies, apparently without regard to cost. After many years of enjoyment the model 800 was acquired by the British Vintage Wireless and Television Museum where it can still be seen, and is pictured Gerry Wells' book 'Obsession'. I often thought it would be good to obtain something similar to the Model 800, but preferably smaller. An opportunity presented itself in 2008 when a very pretty and compact HMV model 570 radiogram became available. An immediate attraction was the styling, but this example gained more than my casual attention because the cabinet was in very good condition indeed having apparently been stored for many years indoors under soft covers. These admirable good points were unfortunately offset by deficiencies pointed out, the obvious ones being the absence of a PX4 output valve and a badly dished turntable. These snags resulted in it being offered at modest cost. With no other takers, that should have been a warning.

The HMV model 570 dates from 1934 and cost 33 Guineas, or £34.65. It represents a fine example of the breed and in many ways it looks like a miniature version of the contemporary model 800. The cabinet is exquisitely designed, incorporating a classic lipped lid much favoured by HMV, a wooden slatted speaker grille and fine piano finish veneers set over an ebony lower section. Unlike the model 800 with its large and heavy two section chassis, the Model 570 uses a single chassis typically used in a mid 1930's wireless. The radiogram is no lightweight however and the manual states that it weighs 129 lbs, some 58 kg. Advertising copy from the 1936 HMV catalogue uses disarmingly honest wording to describe target purchasers as "the listener of modest purse" whilst a 1934 Wireless World review states that "the most outstanding feature is the exceptionally wide specification having regard to the price." In addition to a "cabinet of outstanding design and finish" it adds that "it has always been a point of HMV policy to fit the gramophone volume control outside the cabinet so that the lid may remain closed throughout the playing of a record." This additional volume control is concentric with a record reject button.

SUPERHET FLUID LIGHT AUTORADIOGRAM

Model 570 for AC Electric Mains

WHILST retaining many of the features of the higher-priced instruments, this "His Master's Voice" 5-valve Autoradiogram enables the listener of moderate purse to have the added attraction of an electrical gramophone which changes its own records, combined with a radio receiver of high-grade tone and performance.

With station names marked on the wavelength scales, with automatic volume control—combating fading of distant stations—and with a special static suppressor switch and fluid light tuning you have here refinements which make for full enjoyment in radio listening.

The beautiful figured walnut and macassar ebony cabinet is carried out in restrained modern design.

Model 570 AC. Cash Price **33 Gns.**

Or : 12 monthly payments of £2 . 17 . 0 and £3 . 10 . 0 deposit.
Or : 18 monthly payments of £2 . 0 . 0 and £3 . 10 . 0 deposit.

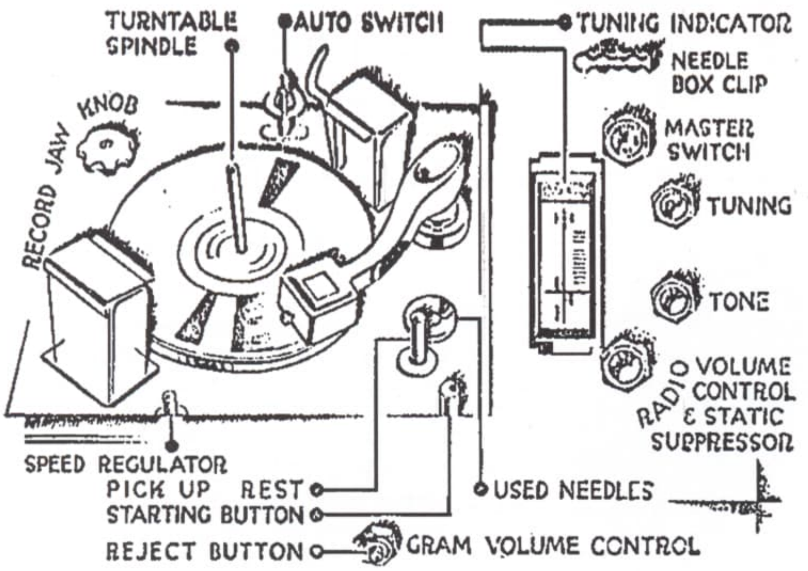
7

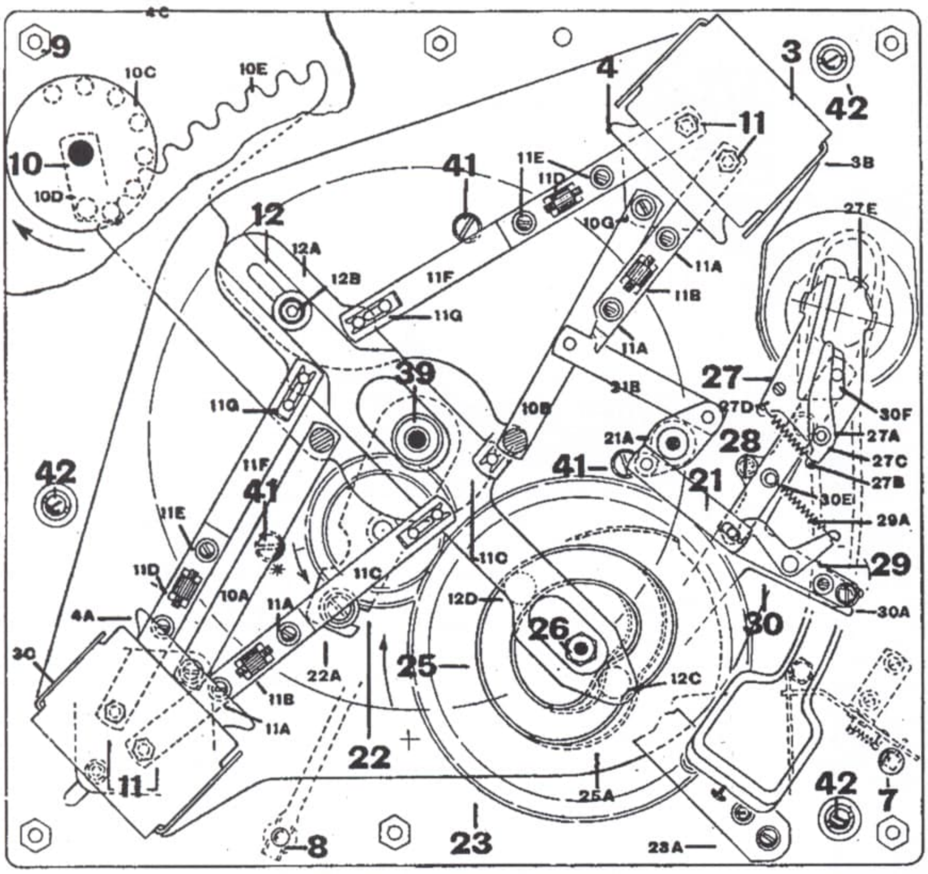
The record changer

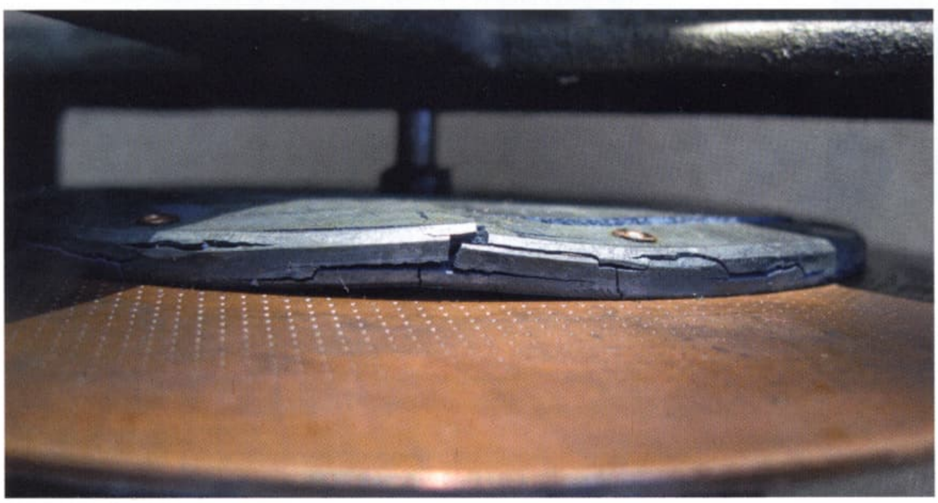
The model 570 uses a HMV K3 automatic record changing mechanism. These had been encountered in 1976 within my first old radiogram, an HMV model 490. The K3 deck is massively built and mechanically complex with many adjustments. My service manual dates from 1934 and the spare parts list covers around 200 separate items. The deck is powered by an eddy current motor comprising a copper disc held closely between AC energised coils, and looks rather like the motors seen in electricity meters. They often suffer from slowing down during record changing as if the power is being sapped by friction. The intuitive reaction is to lubricate the mechanism, but the problem is more likely to be inadequate motor torque. When first seen it had me puzzled as the motors appear to have so very little to go wrong. However, I later learned that this can be caused by a failed phase shift capacitor feeding the coils.

On close inspection, this deck had more worrying problems than first thought. I already knew that the turntable was so severely distorted that it looked like a dinner plate. Looking inside the cabinet at the motor brought more bad news. The centre bush supporting the copper disc had fractured and distorted to the extent that it caused the copper disc to foul the pole pieces and would not rotate freely. The turntable and bush are made of Mazak, or a similar casting alloy which has a tendency to distort and fracture. Clearly these parts were beyond recovery and replacements would be needed, either new manufacture or by finding spares that had better survived the many decades since being made. The entire restoration depended upon getting the deck working and patience was going to be needed whilst attempting to find replacement parts.

Over a period of months a better turntable was found but this came without a suitable motor. A complete K3 deck was missed at a subsequent radio auction and I regretted what could have been a quick transplant solution. However, Mike Barker offered a slightly scruffy incomplete motor with an undamaged induction disc. As it came without any electrical parts my







The motor disc and fractured casing

intention was to remove the motor disc and spindle from this new motor and transplant it to the existing one. Removing the old damaged disc appeared to need specialist engineering techniques so I consulted an engineering model maker to see if he could offer any advice. He demonstrated the power of lateral thinking by suggesting that I simply transplanted the electrical parts to the newly acquired motor frame. A working motor with some surface rust on the frame was better than no motor, so I followed his recommendation and transferred the parts easily as they were only attached by long BA set screws. Job done.

I refilled the motor capacitor which had failed, and tested the composite motor on mains. It seemed to work, but this was an off load test and not representative of working conditions. A better test would be driving the changer mechanism so the old congealed lubricants were first removed with solvent and a brush, then the entire deck was taken outside and cleaned with a high pressure paraffin spray powered by an air compressor. It all looked very dramatic and the messy residue remaining on some newspaper beneath justified the process. When the paraffin had evaporated, all the moving parts were lightly lubricated with machine oil.

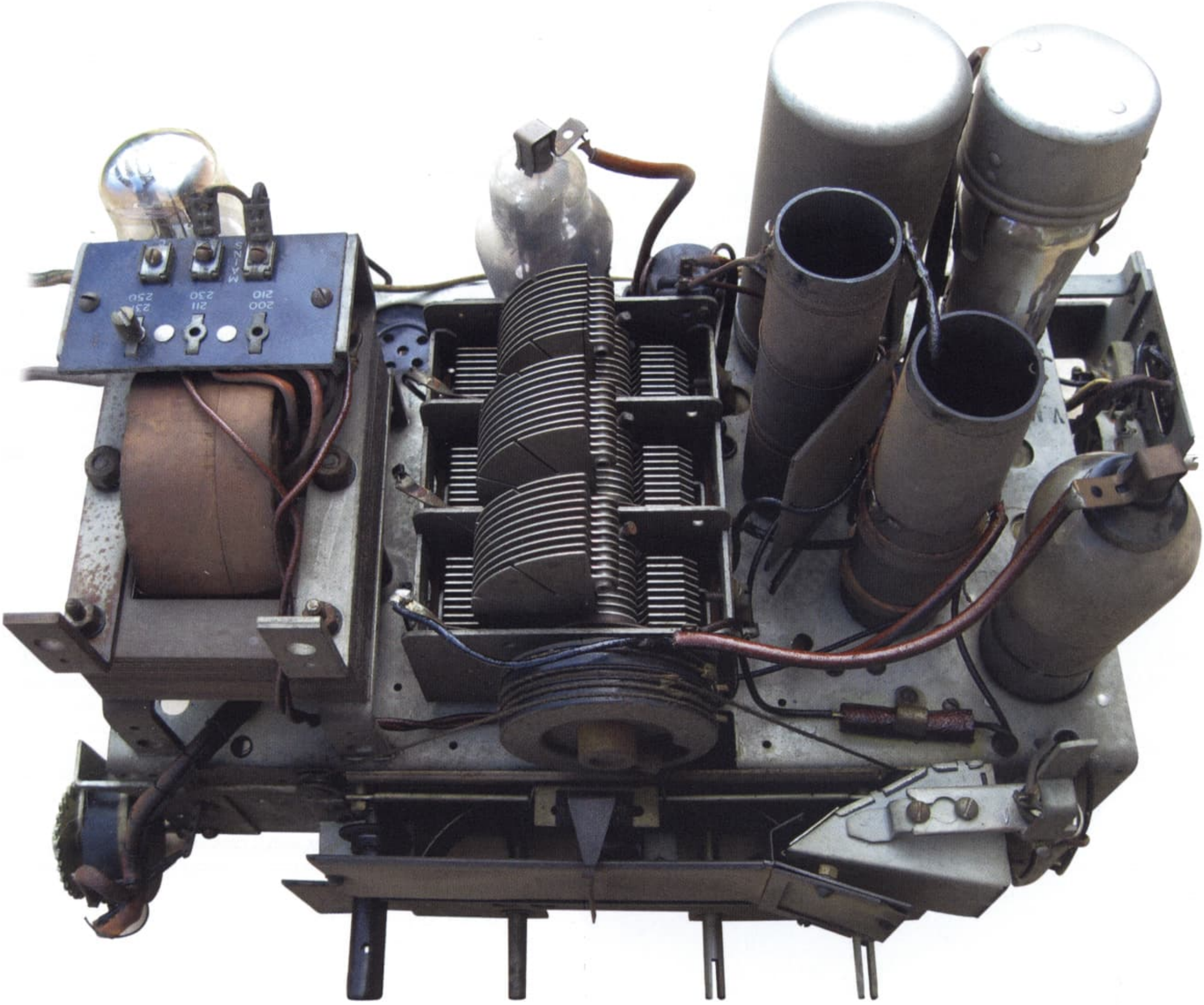
With the motor refitted, a tricky task as some fixing attachments are concealed by the changer mechanism, the deck was lowered in to the cabinet and the motor tested again. This work had paid off as the changer would complete an autochange cycle while maintaining the turntable speed. Now that I had the mechanical basis of a working radiogram, attention turned to the radio chassis.

Radio

The radio chassis is a five valve, two band superhet with a fluid light tuning indicator. It uses the 440 series chassis mentioned in "Obsession", a common steel chassis which could be customised to suit a range of products. A variant is used in the well known HMV 442 and Marconiphone 296 table radios. It uses a couple of metallised valves but on my example the metallising had all fallen away leaving just a short connecting wire on each valve base.

The radio chassis is mounted vertically on the right hand side of the cabinet. For service access two screws release a cabinet side panel which reveals the chassis underside. Chassis removal is more involved as the additional volume control in the centre of the cabinet is mechanically linked to a chassis mounted potentiometer by a chain and sprocket arrangement that looks like it came from a Meccano set. In typical, thoughtful HMV style, connections to the energised loudspeaker, motor and pick up are by spade connectors secured with 6BA screws.

When extracting the chassis I noticed that the two main filter capacitors and their bracket under the chassis were missing but otherwise it might have not been taken out of the cabinet since manufacture. A good coating of fine dust suggested it had not received attention for many years which in my view was a good omen



with the prospect, perhaps privilege, of working on an unadulterated chassis. That opinion was reinforced by the condition of the chassis attachment screws which still retained a light protective coating.

The condenser block

The Trader Sheet for this receiver illustrates the internal build of the condenser block containing twelve condensers, and this could now be seen where it forms the centre piece of the chassis. It is fairly inaccessible with numerous connections to the rest of the set and many resistors mounted above it on a paxolin tag board. The condenser block would almost certainly need internal attention due to age related failures but just to make sure that I was not embarking on unnecessary work I did a few voltage checks with an external high voltage supply. These checks confirmed that some of the condensers had indeed failed so the block would need to be removed. In the past I had refilled many smaller devices but this one looked quite complex, almost daunting. With so many connections photographs were taken to assist with reassembly. Removal took about an hour of careful unsoldering and disassembly, leaving a large vacant space in the chassis. The next challenge was extracting the pitch embedded contents from the metal can. I had given this some thought, and decided that instead of attempting heating the container from cold with a hot air gun, less stress might result by preheating the can in hot water. Although this softened the pitch, extra heat from a hot air gun was still needed for removal of the contents. The residual pitch was more or less cleaned out with a putty knife.

A new tag strip was made up with replacement capacitors, carefully marking off each against the layout drawing and using coloured wire to minimise errors on reassembly. All this was carefully checked as the rebuild proceeded and on completion the capacitor connections were electrically checked against the Trader circuit diagram. When commencing these checks I used an original HMV circuit and was puzzled that I could not reconcile the capacitor block connections with the Trader circuit used for the rebuild. I decided to return to this later while attention turned to the pick up.

Examining the pick up head

The pick up used on this radiogram utilises a moving armature to induce current in a fixed coil of fine wire. Before commencing the fiddly job of examining the pick up, the resistance of the coil was checked to ensure that it had not become open circuit. It measured 7kΩ so was clearly intact.

I had earlier cut off the cotton covered pick up lead because the internal rubber insulation had hardened. In a previous radiogram project the rubber bushes supporting the armature flaked off as it was removed for examination. I confidently expected this one of broadly similar construction to do the same but it seemed to have endured the years as the top bush, a rectangle of red colour rubber was very pliable. The rubber sleeves on the armature were also soft, so the restoration of the pick up extended to simply reversing the top bush to overcome some compression that resulted from decades of being clamped, and making up new connections. These comprised fine twisted equipment wire soldered to the coils connections with strain relief provided by heat shrink sleeving. I find this product very useful in restorations and keep a stock of various diameters. Finally, the coil resistance was checked once again, and with that reassurance the pick up was stored away until ready for installation.

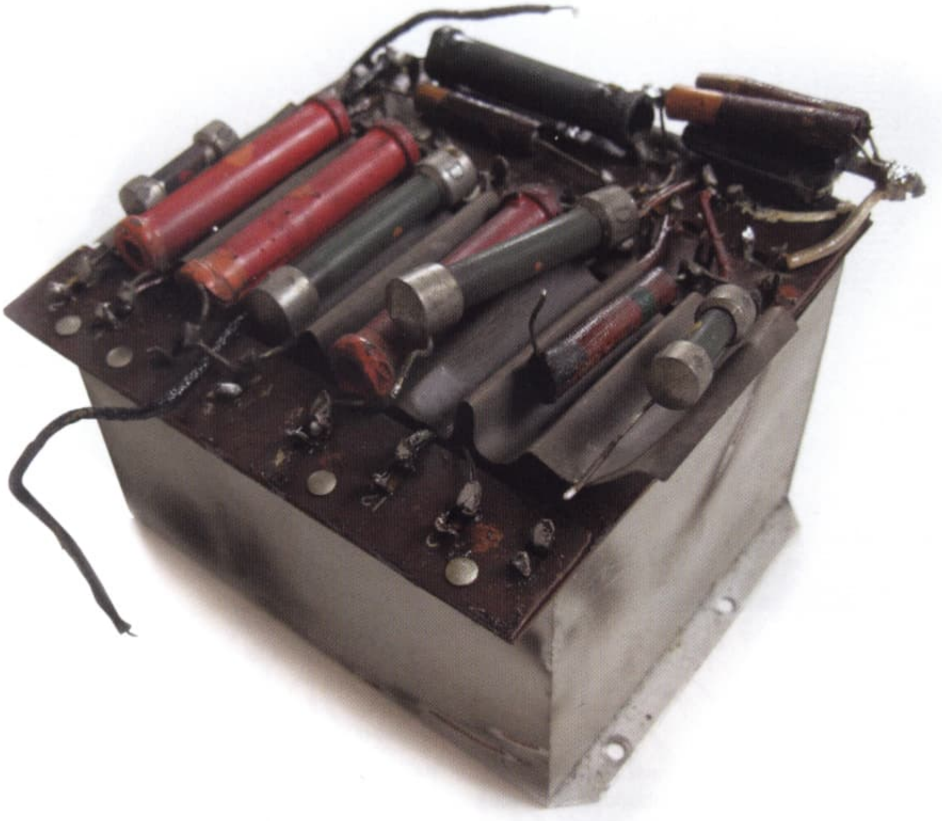
Recommissioning

Numerous major distractions including a house move resulted in the radiogram being neglected for some years. In the interim period Mike Barker had come to the rescue with a used PX4 output valve which was very carefully stored under the cabinet lid.

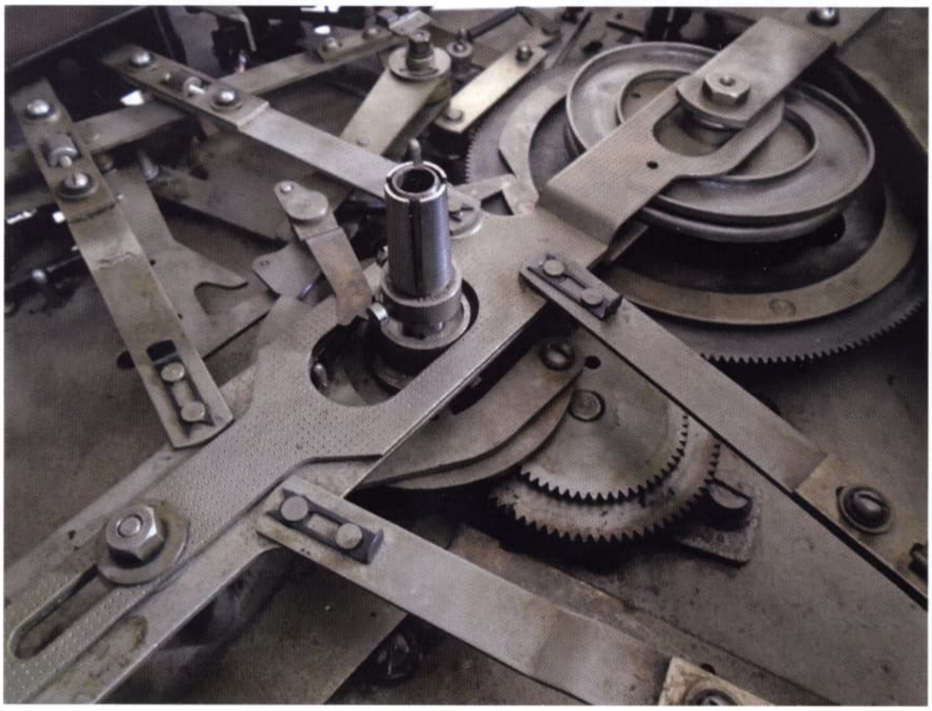
The model 570 occupies a prominent position in the house and the only attention it received was regular dusting. Having it as a silent curiosity no longer seemed acceptable and thoughts turned to completing the work started a few years earlier. When refitting the chassis in the cabinet I remembered not being completely confident that the capacitor block had been correctly wired. The opportunity of a rainy afternoon and uninterrupted concentration allowed the rebuilt capacitor block connections to be examined in depth and quickly showed the cause of my earlier doubts. Examination of the HMV and Trader diagrams revealed that some capacitors and resistors were identified by differing notations on the two circuit diagrams. This was very confusing and I am probably the last person to be aware of the inconsistency. To be absolutely sure, all the connections to the terminals and the flying leads leaving the block were checked again and found to be correct. What I failed to do was check that all the wires coming to the block were present as we shall see later.

Now satisfied that the chassis was apparently as it should be, the audio valves and rectifier were fitted. The heavy energised speaker was connected up and mains brought up which produced a slight but reassuring hum. With the record pick up fitted the audio stages allowed a test record to be played. So far, so good. The radio side was next to test and I had prepared myself for some trouble because the two metallised valves had shed their screening. It was not entirely unexpected that when the radio did provide signals, they were accompanied by loud tuning whistles. I was disappointed that wrapping the valves with aluminium foil had no effect especially as a possible source of instability from failed decoupling capacitors now seemed unlikely. After a great deal of testing and checking a detached wire close to the capacitor box was found among other wires in the dark recesses of the chassis. This had been overlooked but nevertheless I was pleased to have found it and confident the receiver would now spring into life. During the course of testing an IF transformer screening cover had been removed to more easily access various test points, but when powering up, near silence reigned. This was easily traced to sticky, failed insulation on wires entering the cover which had adhered to it on removal. Although aware that the insulation could be punctured on reassembly, marks on the cover indicated that the chassis had originally been put together with it crushing some exit wires. As some chassis wiring was very close to the IF transformer there were numerous fault possibilities. There was also a mark from a trimmer tag that was just scraping along the inside of the cover. This type of screening cover is fine provided that the wiring is very carefully routed on assembly but on this set it was not. Only good fortune allowed the set to work for years with a dormant fault until it was disturbed.

The last item on the chassis to be examined was the fluid light tuning indicator. This moving vane indicator casts a shadow from a lamp in response to the anode current of the IF amplifier valve. I could not see any light coming from it although the illuminating lamp was working. One face of the housing was undone by prising open the fixing tags which separated a small mirror used to reflect light toward the tuning scale. This was covered in a film of fine dust so was cleaned up, in the hope that the translucent scale would transmit enough light for the indicator to become visible. Looking inside the moving vane could be seen to be free and while the indicator was apart it was connected to a DC power supply for test. The vane moved smoothly as the voltage was varied, and with that reassurance it was reassembled and refitted. All that now remained was to install parts in the chassis with new mains connections and connect up the ancillary items. Describing this on paper makes it sound trivial but there was a remote control drive chain, pick up and muting wiring plus the deck and loudspeaker. Testing was performed incrementally



Capacitor box with busy tag board



The amazing complexity of the record deck

November 1934 The GRAMOPHONE

THE SUPREME INSTRUMENT FOR HOME ENTERTAINMENT

The supreme instrument for home entertainment—the "His Master's Voice" all-electric Radiogram — is brought within reach of every music lover in the country by the two splendid instruments described below. No instruments are more worthy of the great name they bear than these. Their success has been overwhelming To realise all they offer in performance, appearance and value, you must see and hear them. Ask your dealer for a demonstration to-night. Then listen to the tone — the *faultless* reproduction that is characteristic of "His Master's Voice."

"HIS MASTER'S VOICE"

Model 540 has been supplied with an ornamented fret for those who prefer it

"HIS MASTER'S VOICE"
FLUID-LIGHT AUTORADIOGRAM

MODEL 570 A.C. *Raises the whole level of moderate-priced radiogram design. Combines a magnificent superhet "His Master's Voice" radio receiver and an automatic record-changing "His Master's Voice" gramophone, in a richly figured walnut cabinet that is a masterpiece of furniture design. Features incorporated for the first time in a radiogram at this price: "Fluid-Light" Tuning; delayed automatic volume control; static suppressor; automatic record change; inclined moving coil loudspeaker.*

33 GNS *or by hire purchase*

FIVE-VALVE SUPERHET RADIOGRAM

MODEL FIVE-FORTY. *Radio and records rendered true to life! What else can you buy at the rate of 5/- a week that will give you so much pleasure as this delightful "His Master's Voice" all-electric Superhet Radiogram? Marvellous selectivity and sensitivity. Beautiful cabinet work. A.C. Model 20 gns. D.C. Model 21 gns. Model 540A with QAVC (for districts where fading is particularly prevalent) 22 gns. A.C. only. Any model small deposit and £1 a month. Model FIVE-FOUR-TWO, same as the 20 gn. 540 but with Automatic Record Change, 27 gns. or small deposit and 27/6 a month. A.C. only.*

YOURS FOR 5/- A WEEK

To The Gramophone Co. Ltd., 108D, Clerkenwell Road, London, E.C.1.
Please send me complete illustrated catalogue of the full range of "His Master's Voice" models.

NAME ……………………

ADDRESS ……………………

Please write clearly in ink in BLOCK LETTERS and post in an unsealed envelope using ½d. stamp

See pages viii and ix for details of "His Master's Voice" November Records and hear them on one of these Radiograms.

"HIS MASTER'S VOICE" RADIO

(Prices do not apply in I.F.S.)

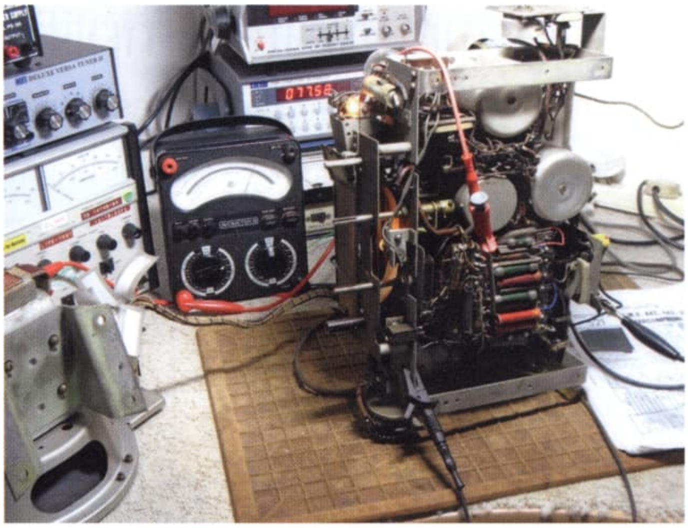
starting with the radio, and the previously dust contaminated fluid light tuning indicator was now very clear and responding to signals. A little more work had the deck playing records and the remaining loose parts were fitted to complete the job. This long running project is fully working although there are a couple of minor items that would benefit from attention when parts are sourced.

One thing leads to another

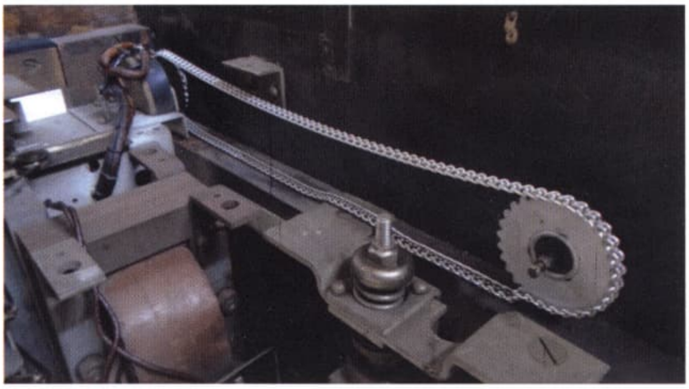
Before moving house the radio collection was reduced to retain the better pieces and those of sentimental value. My large collection of BVWS Bulletins doubled as packing and during the following months as items became unpacked they were reassembled in sequence. This was too good an opportunity (and distraction) to miss and most were re-read, while appreciating a journal of exceptional quality that we all enjoy as BVWS members. I did not recall seeing anything about the model 570 radiogram but found an article about the delights of dealing with the capacitor box on a similar Marconiphone 296, and a feature on restoring an HMV model 800 radiogram that was read with interest.

At the excellent British Vintage Wireless and Television Museum 2015 summer event celebrating the life of Gerry Wells, A Memorial to The Man in The White Coat, I looked nostalgically at what was once my model 800 radiogram. 1930's dance band music filled the air and I began to wonder – what would be the chance of finding another? Because of their high cost they would have only been made in small numbers but after some enquiries I was surprised to be offered a fine example. Back in 1980 three of us lifted a partially dismantled model 800 into the back of a hatchback car but this was not an option with the current vehicle, nor was I keen to test my lifting capability or dismantle the instrument. A call to our house removal company (who, when quoting for our move remembered my televisions from 17 years earlier) resulted in an acceptable quotation which although more expensive than hiring a van, was offset by avoiding the risk of dismantling and personal injury. In due course a model 800 was delivered and is regularly used together with the model 570.

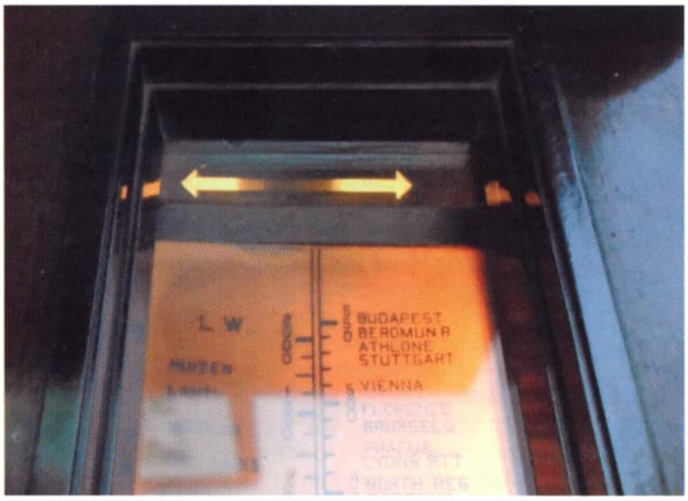
This extended restoration has taken far longer than it should and thrown up a few challenges, some self inflicted. Nothing has been done that is ground breaking or unusual, and other than the motor problems the work has followed the normal sequence of



On test



The chain drive remote control



The fluid light in operation

checking, repair and replacement. Comparing this instrument with my former McMichael model 365 radiogram previously described in these pages, the model 570 is a much more substantial and better engineered product. The chassis is self supporting on the work bench, connections between sub–assemblies are easily made, and it is not afflicted by impractical wobbly Queen Anne style legs. Although the model 570 is perhaps outshone by my more glamorous model 800, this example is no longer a lifeless curiosity but an attractive fully functioning and practical instrument doing just what it was made to do some eighty years ago.

Acknowledgements

I would like to record my gratitude for help provided by others with the restoration and preparation of this article, especially Mike Barker for his enthusiasm, encouragement, advice and the supply of parts, Ian Blackbourne for review material from Wireless World; Mike Izycky for the advertisement from The Gramophone and Steve Harris of On The Air Ltd. for the extract from the 1936 HMV catalogue.

The Loftin White amplifiers by Peter Lankshear

I have noticed on the Internet an increasing interest shown by audio enthusiasts in some early valve amplifier designs. One of these is the unusual Loftin White amplifier from 1929. It occurred to me that Bulletin readers might find this until now largely forgotten design interesting.

Figure 1: His Master's Voice. Surely one of the best known trade marks of all time, the HMV/RCA-Victor trade mark of Nipper listening to a Berliner phonograph reminds us that horns were used to reinforce sound long before the advent of radio.

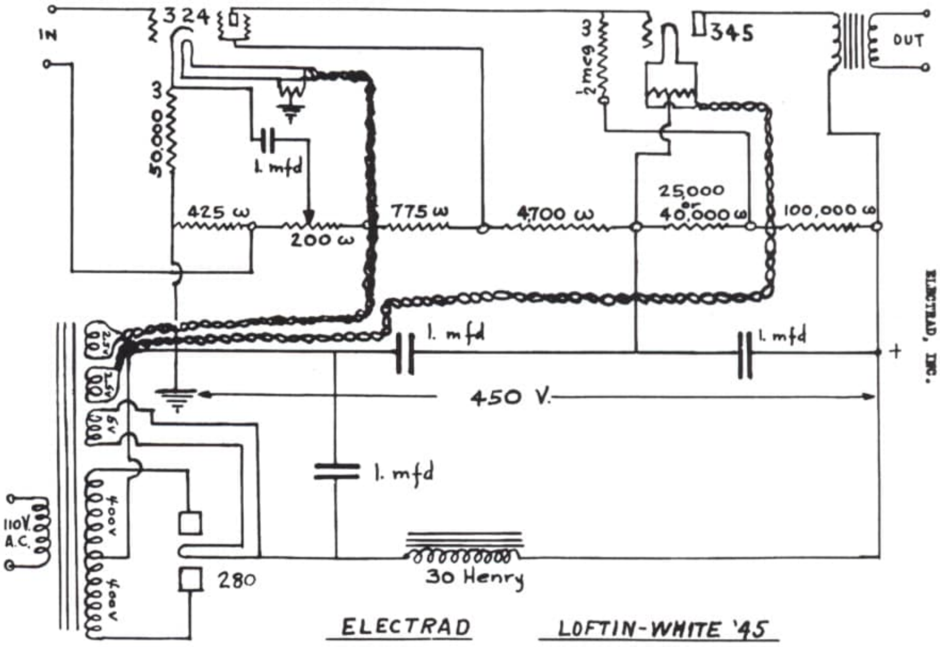


Figure 2: The original form of the Loftin-White amplifier as marketed by the Electrad Company. It's chief weaknesses were the small size (1.0 mfd) of the filter capacitors and the need for the critical setting of the 200 Ohm "hum bucking" control, and the unearthed input terminal. The high powered version required a 1250 volt high tension supply!

Communication only

Until the early 1920's, the sole function of radio was communication, practically all by Morse code, with the chief concern that received signals were as clear and interference free as possible. Headphones were universal and desirable receiver characteristics were sensitivity and selectivity. Audio quality was of no significance and often, to improve code clarity, audio transformers were tuned to peak response in the region of 1kHz. a preferred note for copying Morse signals.

The advent of broadcasting brought a new requirement. Intelligibility of signals became important with sharing received programmes increasingly popular in many households. Whilst additional headphones could be used to facilitate sharing, listeners were tethered to the radio and any conversation was difficult. A logical development was an enlarged headphone receiver fitted with a horn to concentrate sound from the modest amount of audio power available. The use of horns to boost sound was already well established and megaphones and musical instruments used them from antiquity. Predating radio, horns were used for early phonographs as depicted in the well–known HMV 'Little Nipper' badge. Although many horns were straight sided, a more efficient shape was the exponential "Morning Glory" flared type. An exponential horn can be likened to an acoustic transformer, converting the high pressure low velocity sound energy from a driver diaphragm to low pressure and high velocity in the surrounding air. It has been calculated that the efficiency of a well-designed exponential horn and driver can be as high as 50%, 10 times that of a conventional cone speaker.

Audio quality limitations

As radio programmes evolved, listeners became increasingly aware of their entertainment value, but the frequency limitations of the domestic horn speaker soon became all too obvious. Within its operating range, the exponential horn is unexcelled for efficiency and smooth response, but it has practical limitations domestically. To be of a manageable and acceptable size, most horn speakers were limited to an opening diameter of about 1ft., creating typically a low frequency roll off point of about 400 Hz. This was satisfactory for speech but quite deficient in bass musical frequencies. By now, Western Electric were using folded horns for the recently introduced "Talkies", but suitable horns needed to be about 4ft in diameter, far too large to be acceptable in the average living room. By the mid 1920's the magnetic speaker, with an armature connected to a paper cone was becoming popular. Reproduction from these was a considerable improvement over the little horns, but with their lightweight armature and small magnet were still incapable of generating real bass notes, for even with a large baffle, the generation of low frequencies with a paper cone requires large cone excursions, well beyond the capability of an armature type speaker.

In 1925, a landmark development appeared and which ninety years later is still very much in use. Chester Rice and Edward Kellog of America's GEC laboratories had since about 1922 been developing a revolutionary loud speaker, based on a moving coil situated in an annular gap in a powerful magnetic field, and connected to a paper cone. This was the original electro-dynamic loudspeaker and it set a new standard of reproduction. But it also brought with it problems. Existing radios were battery powered with the low anode currents producing small audio outputs that could be measured in milliwatts. They had neither the power nor the audio quality to make full use of the new speaker.

Transformer coupling

Meanwhile, GEC laboratories had developed a mains powered amplifier that produced a useful 1.00 watt of audio frequency power. The way was now clear to make some real progress in improving sound reproduction. Transformer coupling of audio amplifier stages was general and for good reasons. Most general purpose triodes of the mid 1920's had an amplification factor (mu) no greater than 10. Resistance coupling these valves provides a stage gain of only about 7, whereas conventional transformer coupling enables gains of treble that. Furthermore, audio designers contended that resistance coupled grid drive of output valves was unsatisfactory because they were prone to "grid blocking", caused by negative charges building up on coupling capacitors. This blocking was caused by residual gas in the valves and overdriving in attempting to extract more audio power. The best cure was to provide a low resistance path to earth to enable the charge to leak away. A suitable path was readily provided by the secondary winding of a transformer. These problems were eventually overcome by improved vacuum pumping and most importantly increasing the power handling ability of output valves so that they were not over driven to provide useful outputs.

Transformers brought their own problems. They were expensive to make and unreliable from electrolysis causing corrosion spots in the fine wire when conventionally layer wound with interleaving paper.

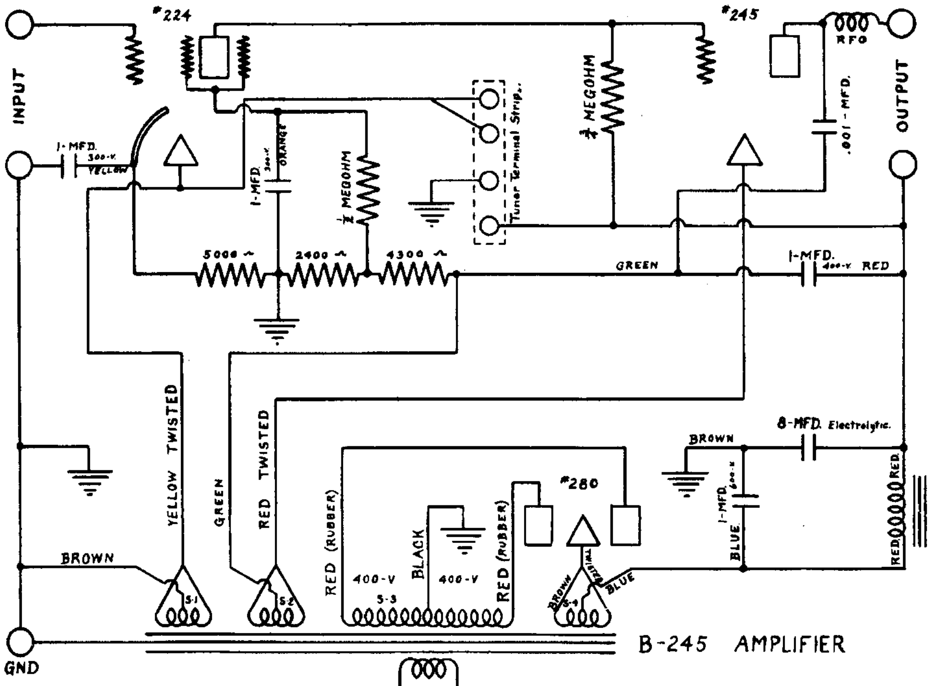


Figure 3: Electrad soon produced an improved Loftin-White amplifier. This overcame the shortcomings of the original by increasing the main filter capacitor with one of the newly developed 8mfd electrolytic filter capacitors thereby removing the need for the tricky hum bucking adjustment, and allowing earthing of one of the input terminals. In some applications, the 4000 ohm voltage divider resistor was replaced by a speaker field. One example is shown in Figure 4.

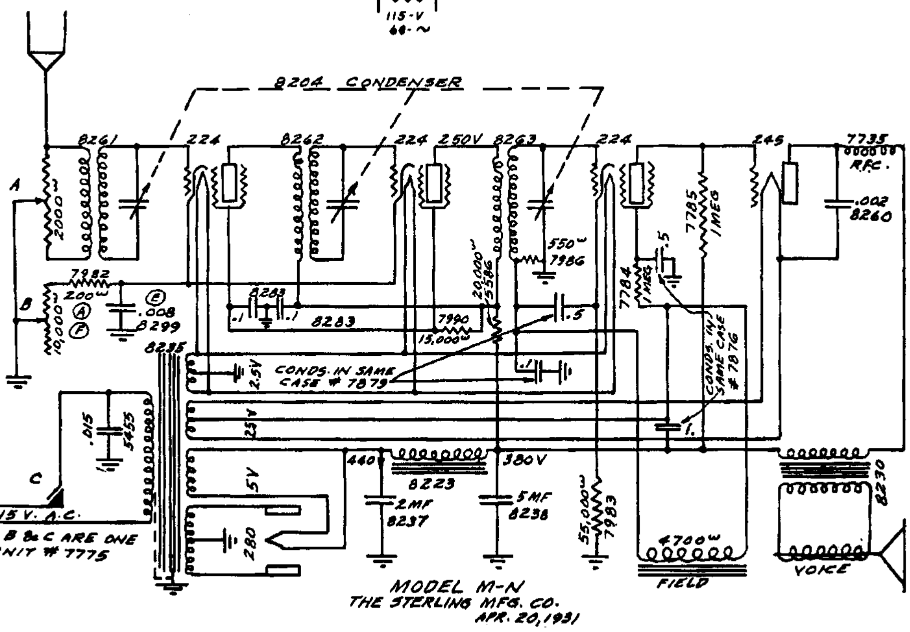


Figure 4 (below, left): Stirling took advantage of the simplified component count of the Loftin-White system to create a neat configuration for their 1931 range of compact receivers. The 224 tetrode audio valve doubles as a detector.

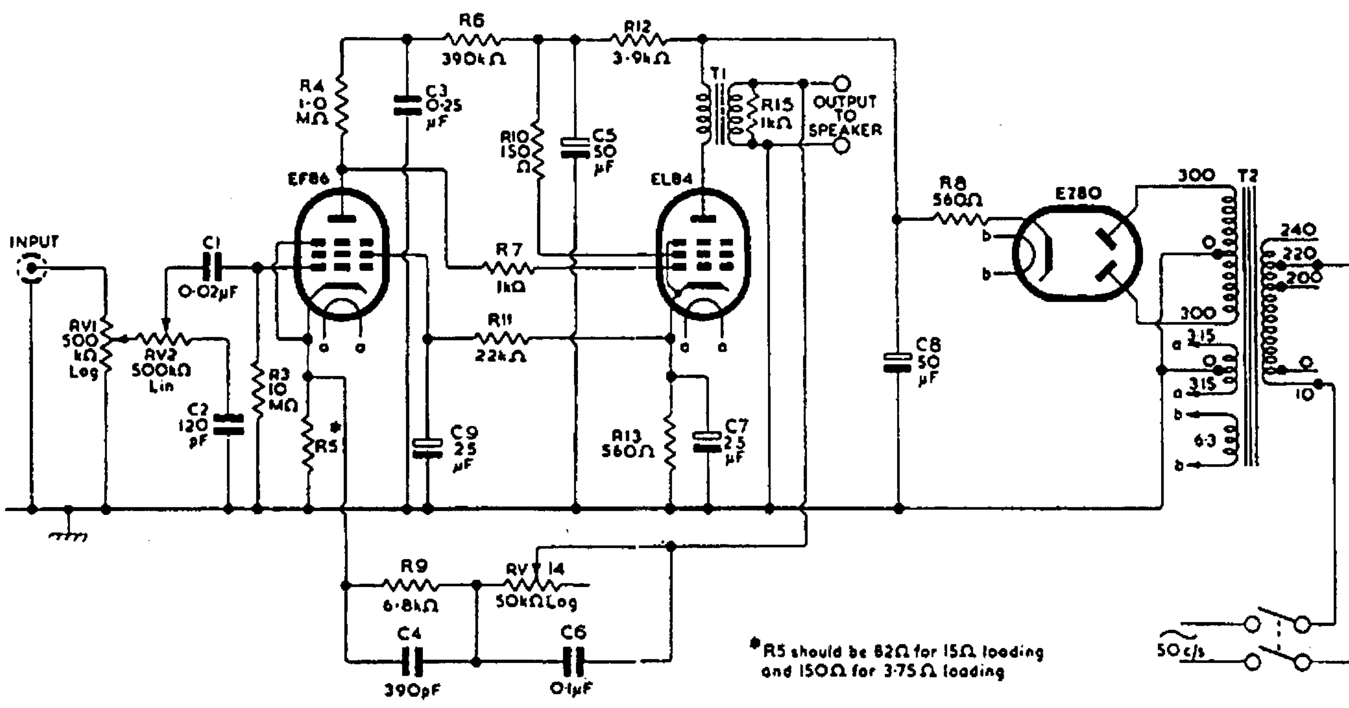


Figure 5 (bottom): After the Loftin-White circuit had laid dormant for a quarter of a century, Mullard resurrected it in the 1950's for their 3/3 amplifier. Note the absence of a coupling capacitor between the EF86 and the EL84. Bias for the EF86 is provided by R3, the 10 megohm grid leak. R5 is part of the negative feedback line.

Design 'Trade Offs'

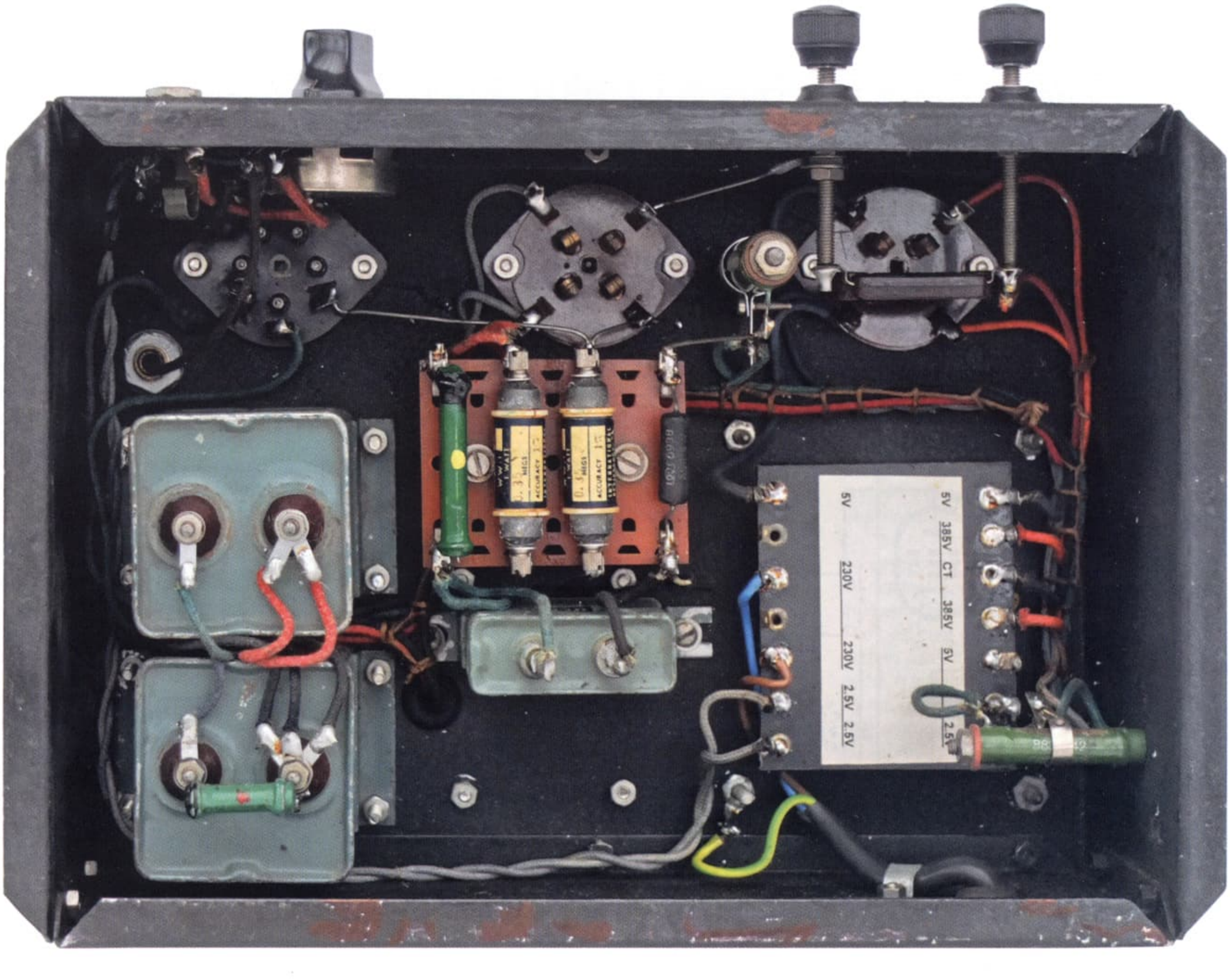
Audio transformer design is a classic example of expensive "trade-offs". To cope with low frequencies when coupled to a general purpose triode, the primary must have an inductance of several hundred henrys. With a conventional silicon steel core this means a primary of several thousand turns of wire and for many transformers, with triple that for the secondary, total turns could be as much as 20,000. Even with the finest wire, this quantity has a considerable bulk which leads to excessive spacing between windings, and creating high internal capacitance, both detrimental to the high frequency response of the transformer. Conventional transformers were therefore a limiting factor in constructing wide range amplifiers. The remedy was to sectionalise the windings and interleave them. It is not always appreciated that Britain's Ferranti company were pioneers in this method, and their AF5 audio transformers were popular for many years. But large windings are expensive to make.

Figure 6: The Loftin-White amplifier shown in Figure 3 as built by the writer. It is very compact when compared with its contemporaries. This example is in frequent use as his workshop amplifier.

What was needed was an economical coupling method that minimised resistance to earth, together with a higher voltage gain valve driving adequately sized output valves. One solution was directly coupling the driver anode to the grid of the output valve. But with valves, this creates serious problems. Direct coupling of semiconductors, which are forward biased, is, of course, common and easy. Valves, on the other hand require negative bias for their control grids. Coupling a valve anode operating at 100 volts or more positive to a control grid operating with negative voltages ideally requires two separate power supplies. Not a very economical solution. Another difficulty with direct coupling is "drift" whereby small anode current variations in the driver valve are amplified to become major variations in the output stage current.

Meanwhile, in 1928 in the U.S. two new "landmark" mains powered valves were introduced. First was the type UX245 power triode, capable of producing more than a watt of audio with only 250 volts. This was a scaled down version of the type UX250, a 25 watt anode dissipation medium to high powered triode. The other was the UY224 screen grid tetrode. Although the latter was developed as a high frequency amplifier, it was found to be an excellent high gain audio amplifier suitable for resistance coupling. In England, similar valves were introduced by several manufacturers.

Figure 7: The underside of the amplifier. There are more small under chassis components than in most pre 1930 audio amplifiers .



State of the art in 1926

The Western Electric 46A amplifier

Moving pictures with sound brought about major developments in audio equipment. Not only was a lot of volume required to fill theatres, but equipment had to be capable of a wide frequency range and low distortion. Among the pioneers and leaders in this venture were Bell Research Laboratories and their commercial arm Western Electric .Their Vitaphone system for cinemas was introduced in 1926.

Whilst major theatres used rack mounted amplifiers and power supplies, for smaller theatres, Western Electric soon developed a self contained wall mounted adaptation, the 46A amplifier, with sufficient gain to be fed from disk pickup heads. An additional projector mounted two stage amplifier provided the extra gain required for photo electric sound heads when sound on film arrived.

Many older readers would have experienced hearing 46A amplifiers in operation when visiting suburban movie theatres in their younger days. So good was the performance, it was not uncommon for this same equipment to have remained in service until recent times.

Referring to the circuit diagram, it will be seen that the 46A is basically a three stage amplifier with two resistance coupled voltage amplifiers stages. These were transformer coupled to a pair of push pull output valves, the standard configuration for audio amplifiers in 1926. By later standards, the Western Electric valves had quite modest performance characteristics as can be seen from the table. A distinguishing feature of this class of equipment would have been the good quality of the audio transformers.

It will be noticed that all the valves are directly heated. Before 1927, indirectly heated cathodes were insufficiently developed but this was soon to change, eliminating the need for storage batteries and the need for spring mounted valve sockets to reduce valve microphony in early stages.

At this stage, WE had no rectifier valves as such, so diode connected 205D output valves were used in the power supply. These collectors' favourites had globular "tennis ball" envelopes although later versions were made with the standard ST stepped envelope. The 205D could trace its origins back to 1917 when WE was asked by the U.S. Signal Corps to develop a small transmitting valve. WE had a philosophy that if an item was doing a good job, and there was still a demand, there was no point in changing it. Their valves were also distinguished by reliability and long lives. Astoundingly manufacture of the later version of the 205, the 205F was not discontinued until 1979, 62 years after the introduction of the original type! Surely this was a record for production longevity.

The rated output power of the 46A amplifier was only 1.9 watts, but with the efficiency of WE 555 drivers with exponential horn enclosures, this modest power was sufficient for small theatres.

The Loftin White amplifier was comparable in performance and would have cost but a fraction of the price of the 46A.

Characteristics of W.E.Valves used in type 46A Cinema Amplifier

	205D	239A
Filament Voltage	4.5 V	1.1 V
Filament Current	1.6 A	0.27A
Plate Voltage	350 V	100 V
Plate Current	30 Ma	2.2 Ma
Plate Resistance	3,900 Ohms	15 k Ohms
Mutual Conductance	1.870ma/v	0.4ma/v
Grid Bias	-22.5 V	-------------
Amplification Factor	7.3	6

Figure 2A WE Type 205D valve. Revealing their pioneering ancestry, dating from 1917, the early members of the 205 family had globular envelopes. Later valves had conventional stepped envelopes. The 205F, which eventually replaced the 205D was made until 1979!

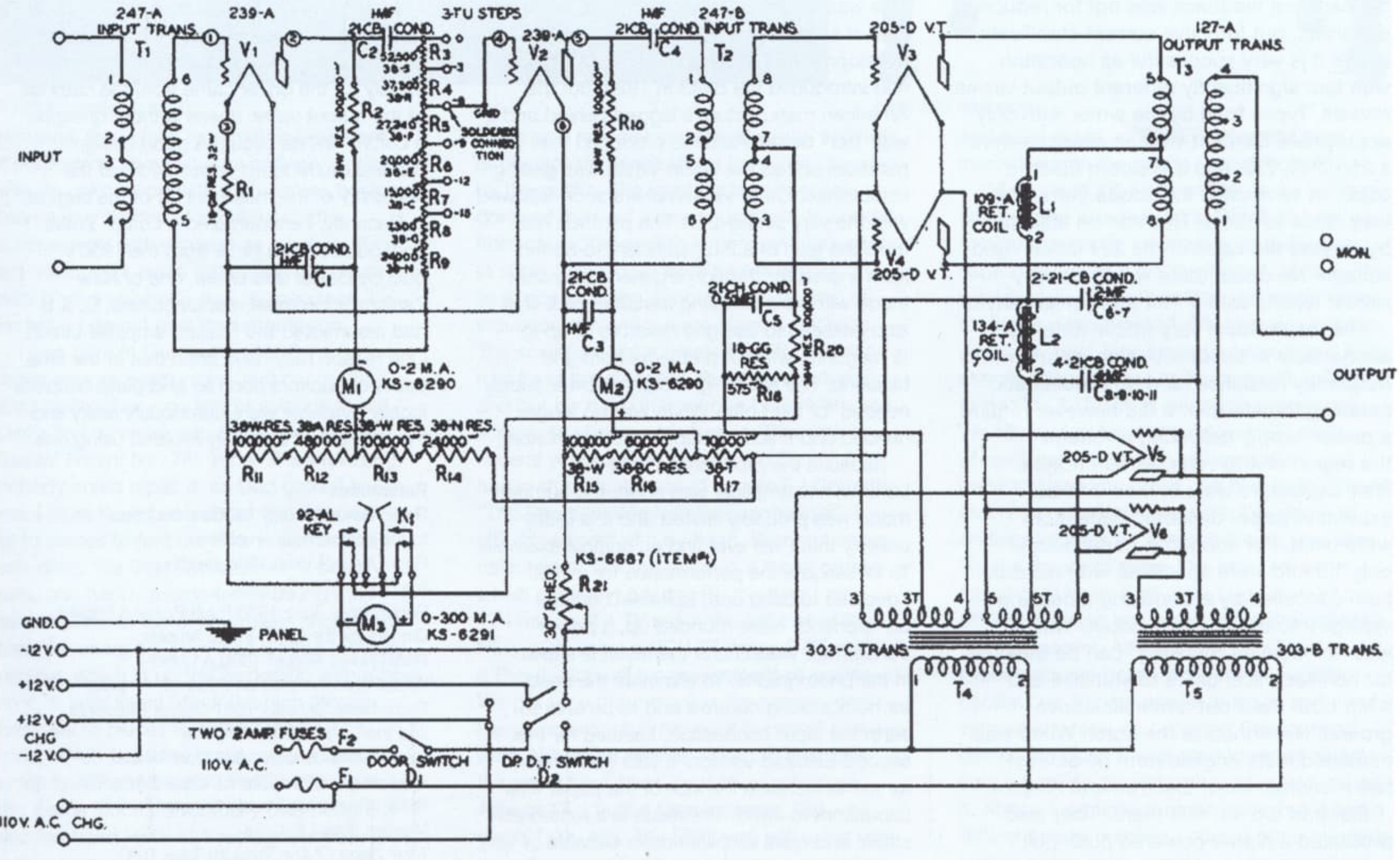


Figure 1A Circuit of Western Electric 46A Cinema Amplifier.

This class of equipment set new standards in design. As indirectly heated cathodes were still in their infancy in 1926, directly heated valves are used in all stages. The filaments of the two 239A voltage amplifier valves are lit from a 12 volt accumulator with grid bias for V1 being provided by the voltage drop across R1. Bias for V2 has additionally the voltage drop for the filament for V1. At that time W.E. made no rectifier valves so they used instead diode connected output valves.

Given their long history of telephone equipment design, it is not surprising that WE used their own nomenclature for some components. For example chokes were called 'Retardation Coils'. Loudspeakers were called 'Telephone'!

Published Characteristics of Output Valves Tested in L-W Amplifier

Valve Type	Filament Voltage	Grid Bias	Amplification Factor	Mutual Conductance ma/v	Anode Current at H.T. 250v	Power Output Watts 4 kohm Load
RCA 250	7.5	-40	3.8	1.9	32ma	1.5
RCA 245	2.5	-50	3.5	2.175	34ma	1.6
2A3	2.5	-45	4.2	5.28	60ma	2.5
WE 300B	5.0	5.5	3.8	5.5	50ma	3.2

Note: When operating in a L-W amplifier, the anode current of all valves is close to 32ma

Solutions to problems

Two American research engineers, Edwin H. Loftin and S. Young White tackled the two chief problems of resistance coupling, those of low driver stage gain and the possibility of grid current. A good starting point would be using a (UV224) tetrode directly coupled to a large triode such as the new (UX245) or the older (UX)250. They succeeded with what became the Loftin White family of amplifiers with various power ratings, from something over a watt to a monster employing a transmitting triode with a potentially lethal 1250 volts H.T!

The need for separate H.T. supplies was avoided by routing the anode current of the output valve from its cathode (filament) through resistors to the negative rail of the supply. The voltage drop through these resistors became the H.T. supply for the driver stage. The anode current drift problem was very neatly solved with D.C. negative feedback stabilisation provided by deriving the screen voltage of the 224 from the cathode of the output valve. Note that the negative feedback was not for reducing distortion, but for valve current stabilisation. In this it is very successful as operation with four significantly different output valves reveals. Types tried by the writer with only appropriate filament voltage changes were a 250, 245, 2A3 and a Western Electric 300B. In each case the anode current is very close to 32ma. This can be adjusted by varying the value of the 224 screen grid voltage. No doubt there would be very similar results with a PX4 and similar valves.

The result was a very stable amplifier, economical to build, with high gain, a wide frequency response, and no problematic coupling transformer. It did however require a power supply delivering a voltage in the region of 400 volts. As electrolytic filter capacitors were in their infancy, expensive paper dielectric capacitors were used. For economy, capacitors of only 1.0 mfd were specified, with residual hum cancelled by introducing a bucking voltage into the 224 grid circuit. This was not ideal as "bucking" can be tricky for non-technical users to stabilise and it left both the input terminals above ground. Nevertheless the Loftin White was marketed in its original form by at least two manufacturers, Electrad and Amplex.

Electrad did not rest there. They also produced a higher powered push pull version and during 1931 a modified design eliminated the need for hum bucking by increasing the amount of power supply filtering. This also permitted the earthing of one of the input terminals.

Detector

One useful bonus characteristic of the Loftin White configuration is that the tetrode stage can be used as a good quality A.M. detector. This was put to use by several manufacturers for the 1931 model year. Figure 4 shows the circuit of a typical T.R.F. made by Stirling, incorporating a Loftin-White audio system whose advent quite fortuitously coincided with the onset of the Depression and the consequent demand for economically priced receivers. Cheaply made "midget" cabinets needed compact chassis and obviously the simplicity of the Loftin-White was a valuable bonus. Incidentally, the term 'midget' is only relative. Most sets were substantial by later standards, with cabinets about 18" high and fitted with 8 inch speakers, but were significantly smaller than the previously popular floor models. Later they would be known as mantel or table top sets and from them soon emerged the well-known 'Arch top', 'Gothic' or 'Cathedral' cabinets so popular with collectors.

Rapid developments

This was a period of rapid technical advances. One of significance was the European development of the output pentode. Philips had introduced the B443 in 1929, but the American manufacturers lagged behind and it was 1931 before Arcturus produced their PZ pentode, just as the Loftin-White was getting established. Other valve makers soon followed with the very similar 247. The pentode had triple the gain of a 245, sufficient to be fed from a detector through a general purpose triode without a coupling transformer. It was also possible to use grid resistors of up to ½ megohm, without problems from grid blocking. The extra high voltage power supply needed for the Loftin-White was no longer needed and it soon disappeared into history.

Because the production life of the Loftin-White amplifier was short, the number made was probably limited and it is today unlikely that I will ever find an original example. To investigate the performance for myself I decided to build one. Suitable 'heritage components' were rounded up, a power transformer wound and the result is shown in the photographs. To eliminate the need for humbucking controls and to be able to earth the input connection, I settled for the second Electrad version. It was convenient for me to increase the size of the paper filter capacitors to 4mfd. The result is a remarkably stable and quiet amplifier quite capable of very acceptable results even today. Connected to a good quality tuner and wide range speaker through a suitable output transformer, it serves me well as part of my workshop radio, having performed flawlessly for 25 years.

It is most enlightening to evaluate this amplifier. Although there is no humbucking, any hum is practically inaudible. Due to the governing effect in the screen grid, it is remarkably stable and tolerant of varying output valve characteristics. The attached table lists results with some different valves, ranging from a 245, through its big brother the industrial sized 250 to the younger 2A3 and the legendary Western Electric 300B. The only adjustments were changing the filament voltages.

Resurrection.

Advances in technology soon overtook the Loftin –White and it became history. It was however revived in the 1950's in an unexpected way. Various English valve makers at that time published constructional details of high quality amplifiers for the home builder. Mullard Laboratories published details of three monaural amplifiers. One was an impressive 20 watt unit using EL34 pentodes. Next came a poplar 5 valve 10 watt model. There was a third - a less well known 3 valve 3 watt model using a EF86 pentode driving a single EL84 pentode output valve. Nothing unusual there, except that the valves were direct coupled. And furthermore the screen supply for the driver came from the cathode of the output valve. It was without question a Loftin – White circuit. A good design can live on. Modern valves avoided the necessity of the massive H.T. of the original.

Recently, I encountered a Loftin- White configuration in a radio from the 1950's built by Collier and Beale, one of New Zealand's foremost manufacturers. C. & B. had resurrected the Mullard amplifier circuit. One reason may have been that at the time, paper capacitors such as grid/plate couplers locally available were notoriously leaky and the L-W direct coupling avoided using one.

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My wireless hobby – the first 85 years

by Harry Woodhouse G3MFW

I joined the British Vintage Wireless Society in August 1984, and still have the welcoming letter from the Membership Secretary, Mike Kemp. I particularly enjoyed the Bulletin article about the valve with the rotating anode to speed up the electrons, and spaghetti resistors (written on April fool's day!). I think our magazine is wonderful – as well as having superb technical articles, it is a most professional production.

A junior scientist in action

HMV 521 radiogram

However, this article is something different. It purports to show how an ordinary person with no connection with the wireless business can have a lifetime of excitement and achievement with wireless as a hobby. If I am not careful, every paragraph will begin with "I", the universal sign of arrogance. I do hope I do not give that impression.

I was born in Cornwall in 1930; my father was an accountant, and my mother a schoolteacher – no hint of science there! Dad's first wireless was a Marconi 3 valver (Radio! Radio! fig 178). When it went wrong, nobody could repair it, so Dad gave it to me. I must have been about five. I took it all to pieces to find out how it worked, as one does. We then had a series of battery sets, and happy memories of taking the accumulator to the only wireless shop in the town for charging. They had a large mercury rectifier, which lit up the workshop with a blue light. In later years I took the high tension batteries to pieces to extract the carbon rods, which I used to make arc furnaces to smelt tin, in series with an electric fire across the mains (ouch!). Eventually Dad bought a second-hand HMV 521 radiogram (from1932) with automatic record changer. When that in turn went wrong, I took that to pieces too. Now, 76 years later, I still have the sexy MS4s and a priceless PT625 output valve!

At school we had a brilliant physics master. There was no science budget, so he built lots of physics demonstrations from junk donated by the public. The local cottage hospital donated their old X-ray equipment. It worked from car batteries with a mercury interrupter (a spray, picking up from a pool of mercury, all exposed to the atmosphere), feeding an induction coil and a huge glass X-ray tube. The science master erected the tube in the middle of the class (no shielding of course), and put his hand in front of a barium titanate screen, to show us his bones. This was several years before Health and Safety. My home-study bible was of course F.J.Camm's "The Practical Wireless Encyclopaedia". I still know most of it by heart. Remember his useful tip of holding metal in a moist potato whilst soldering nearby. By the time I was 17 I had built a TV set in the cabinet of the HMV 521, using a VCR 97 green CRT, and a Pye IF strip, all ex-government of course. We put up a huge mast in the garden, and (very occasionally!) received bursts of pictures from Alexandra Palace. I learned later that this must have been by meteor reflection. Also at 17, I built a tape recorder. "So what?" you say. The BBC was still using wire recorders, and there were no tape recorders for sale. I wound my own head, and made the deck from a piece of wood, and the remains of a gramophone motor. It worked, and I still have recordings of my parents and aged aunts on PAPER magnetic tape (recorded with the wrong tape direction!).

When I was 18, I was called up for military service, and was put in the REME to train as a radar mechanic. I learned a lot in the army, especially "Always do the easiest job first. You may get killed in action, then you never have to do the difficult ones". After primary training (when my best friend dropped dead on a route march), they sent me to Portsmouth college to do City & Guilds in electrical engineering. We climbed poles and soldered VIR cable, phased generators in a power station, and generally had lots of fun. We had quite difficult exams in practical metalwork. We also had endless lectures on wireless theory, and later on, the theory of radar. The lecturers soon found out I knew it all already, so they let me off lectures, and put me to repair the college's test equipment. All went well until I had a Cossor double-beam 'scope with parasitic oscillations. I spent weeks trying to sort it out, without success, so I phoned Cossor head office. They said it was easy to repair, and if I sent it back to them they would quickly repair it. After a long time, it came back, but it had a different serial number. I copied other people's lecture notes, then one day a very important REME officer arrived to inspect us. He asked who had the highest marks in the exams (me with 100%), and I had to stand in front of the class with my notebook. Unfortunately, I had written all my notes in mirror-writing just for fun. The look on the officer's face was a picture. But what could he say?

About this time my mother became very ill, and very kindly REME gave me a compassionate posting to Truro, where I looked after the Territorial Army radar set. I had trained on the Mk7, 584 and 3B radars. This one was a 3B. I conscientiously ran it every day, but never wore my uniform. One day an officer came to inspect me, but I was sitting in the radar set swatting for an exam. He was very understanding, and did not send me to jail. Another day, in a strong wind, I locked myself out of the radar set, with the key inside. I phoned REME HQ to get permission to break a window, but this was easier said than done. The windows were bullet-proof glass, and I needed a sledge hammer. I replaced the glass with ordinary window glass. Thank goodness we never had another war. I saw a UFO on this radar (?). There was a very strong signal up in the air about 10 miles away. After being stationary for about 10 minutes, it flashed away out of sight at an unbelievable speed. I do not believe in UFOs, but I wonder what it was?

Astronomy has always interested me, and I used to count meteors, even in the daytime. I built a huge H aerial and an FM band receiver, and tuned them to the frequency of Gdansk in Poland, a frequency not used in Britain (104 MHz). Of course most of the time I received nothing, but whenever a meteor passed overhead, there was a loud blast of music. I recorded the results with an ex-government chart recorder, and reported them to the RSGB. I also listened to storms on Jupiter on AM on 21 MHz, and monitored solar flares between 25 and 80 KHz.. All this was described in Sickels' wonderful book "The Radio Astronomy Handbook" (1989).

I strongly recommend a book by Renato Romero, "Radio Nature" published by RSGB in 2008. It is full of exciting ideas for hearing and seeing strange signals from nature.

I joined the Wildlife Sound Recording Society, and recorded lots of underwater sounds in Britain and abroad. Finally I made a hydrophone in a stainless steel cage, and placed it under a rock on Duporth Beach at very low tide. My house was on the cliffs above, so I laid an armoured screened cable to a pre-amplifier half-way up the 200 feet cliff (I was also a rock climber!), then another cable under the coast path and through my neighbours' gardens into the HI-FI in my house. I recorded hundreds of hours of underwater noises, including those of limpets, shrimps, crabs and dolphins (and of course every ship and speedboat within 10 miles!). I wrote up all the results in the Society's journal. I also put hydrophones in the sailing boat I built. "Is this wireless?" I hear you say. Well, it is detecting signals from afar without wires.

I buried earths north, south, east and west of my house, in neighbours' gardens, and measured earth currents NS and EW by detecting the induced voltages using FET op-amps. Simultaneously I measured the direction of the earth's magnetic field using a magnet suspended over 2 Hall effect transistors in a jam jar buried in the ground. The 3 signals were recorded on a 3 pen recorder (ex-government of course). There was an excellent correlation, and also correlation with reports of the sun's activity from Boulder Colorado. This work was done in co-operation with the Aurora Section Magnetometry Group of the British Astronomical Association. I still have in my office a centre zero meter connected to a differential magnetometer which I made for my archaeological studies, and I watch the huge variations in the earth's magnetic field, which are always damped out in a practical compass. Again they correlate with sunspot activity.

I built a Yagi aerial to receive the NOAA weather satellites – this was before they were ever seen on television. I first displayed them on an ex-govt. Muirhead facsimile receiver, but later used my home computer. Measuring the voltage gradient in the atmosphere is great fun, and quite easy to do. Place 2 stainless steel meshes a centimetre apart one above the other, and connect them to a 7611 op-amp, feeding the output to a chart recorder. You can detect thunderstorms from many miles away. When I lived in Singapore for a while, it was quite frightening – we often had 3 or 4 thunderstorms a day. I also made a portable electrometer, using a 7611 feeding a 759, driving a loud speaker. It was sobering to discover there was no-where in Cornwall where you could not receive 50 Hz mains hum (except down a mine!). Within a mile of the National Grid the hum was deafening.

The study of vibrations through the ground is very interesting. I made a copy of an old mechanical seismograph in the Science Museum. Basically it is a very heavy weight on a beam, hinged at one end. and suspended from a pillar on the other. The suspension is arranged so that the beam is on the verge of instability. The beam is damped by a blade in an oil bath, and the movement detected by a moving magnet in a home-made 4000 turn coil, followed by a solid state pre-amp and a chart recorder. Using this Heath Robinson arrangement I could pick up a green woodpecker at the bottom of the garden, and recorded earthquakes from all over the world, including Albania, Alaska, Turkey and Vanuatu. They were checked against the real time earthquake recordings on the internet. I was approached by the head of the Cornish Astronomical Society to ask if I would do an experiment. He asked all the Cornish school children to jump into the air at exactly 11am one morning, to see if I could record the resulting "earthquake". To everyone's amazement, I recorded a distinct peak at the exact time. We shall never know if it was a lucky fluke, but the schools were given copies of my chart, which hopefully inspired an interest in earthquakes. I also had a couple of geophones in the garden to look at higher frequency vibrations. All this was amplified with home-made solid state equipment. Is this "wireless"? There were miles of wire in the equipment, but again it was receiving signals which came through the ground without wires.

My next crazy idea was to study the many longstones and menhirs in Cornwall, by investigating their resonances. I am a Cornish Bard. I bought a vintage 17 valve Sonograph from the USA, and attached microphones to the stones. When no-one was looking I gently tapped the stones and recorded the resonances. I was able to deduce how much was underground, but I am afraid the mathematics involved gave me a severe headache, and I gave up.

Returning to "real" wireless, the china clay industry carries out preliminary surveys by measuring ground conductivity from the surface. This is fine in open spaces when you own the land, but is not much good at investigating what is under the local park. I developed a system using a cheap portable radio (sorry, wireless) with a ferrite rod aerial and an S-meter, tuned to Droitwich on 1500 metres. As it was moved over the ground it very effectively measured the ground resistance, to a depth of about half of 1500 metres. It correlated very well with earth conductivity measurements. Everybody thought I was listening to the wireless.

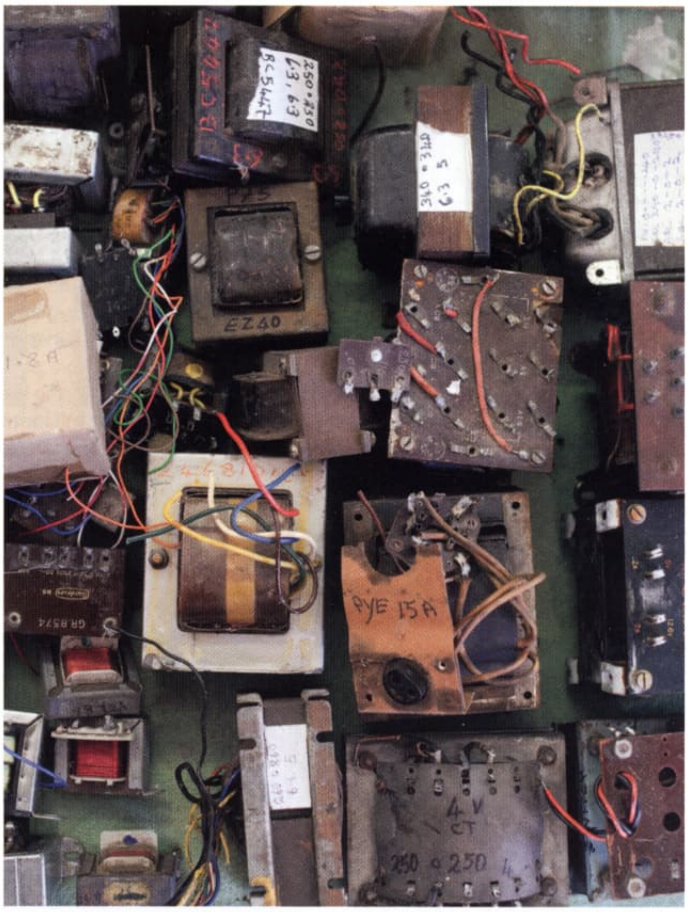
After I retired I set up a scheme for Age Concern, giving CB radios to elderly invalids living alone. My wife and I called them all every morning at 9 am to have a chat. For some this was the only conversation they had for the day. If they did not reply we knew something was wrong. We had details of their next of kin (if any) or friendly neighbours, and arranged for them to call, or went ourselves. In severe cases we called the police who broke in. We must have saved several lives, as people had fallen to the floor and were unable to get up, but they knew they would be rescued next morning. All this was before the introduction of the wonderful "red button" system for calling for help. Anyway, our customers could not afford a telephone, and of course there were no mobile phones. This is REAL wireless!

I built my first computer (a Nascom 1) from a kit, at a time when my company's IBM computer filled several rooms. The kit contained hundreds of resistors, capacitors (sorry, condensers) and ICs, and involved making thousands of soldered connections to the PCB. Nowadays people say they have "built" their computer, but all they have done is slide a few ready-built PCBs into a case. My Nascom only had 8KB of RAM, but a clever programmer could do wonders with this (in BASIC).

I ran the talking book service in central Cornwall for the RNIB for many years, teaching the blind to use the machines, and repairing them (the original model using special tape cassettes) when they went wrong, which was pretty often.

No, these last two are not really wireless, but they did need my wireless skills, and used all my wireless test equipment.

I took my exam and passed my compulsory Morse test, to become a radio amateur in March 1958 (G3MFW). I had a Marconi CR100 receiver which I bought from a scrap dealer in Plymouth and rebuilt myself, and made myself a 6L6 crystal controlled receiver for the 80 metre band. I copied the circuit on page 91 of the RSGB Amateur Radio Handbook, second edition,1946, price 3/6d (but of course I did not pay 3/6 for it, I bought it from a second-hand bookshop). The circuit wisely had a torch bulb in series with the crystal to warn you just before the crystal burned out. My first contact was with my friend



Archie Morcom, G2FZZ. He was very patient. Although by then I knew quite a bit about wireless, I found it very stressful, and it took an age to exchange the very minimum of a QSO. I still have his QSL card giving me a 5 and 9 report. I felt very pleased with myself. I spent the next few weeks doing TVI tests with the (mainly friendly) neighbours. My next-door neighbour often chatted to me over the fence, then one day there was pandemonium. His wife had a baby. She did not know she was pregnant. We had a Murphy console TV with 2 doors in the front, which I was given. I repaired it and had the tube re-gunned (as one did).

My aerial (not antenna!) was a wire dipole from the house chimney to a willow tree at the bottom of the garden. I made an ATU with home-made plug-in coils and variable condenser, both from a T1154 transmitter which I bought from Lisle street for a few pounds, and took to pieces for the parts. I made a VFO to drive the 6L6, and spent the next month vainly calling CQ. Finally I made a contact with G2RF from Cumberland, who complained of the chirp and drift. It seems daft now, but my hand was shaking with excitement at the end. Next came phone, with a home-made modulator based on the modulation transformer from an SCR 522 VHF air force transmitter (Lisle street of course). On 16th July I spoke to Michelle, F2GM, in Rouen, France. An overseas contact at last. I took some time to recover from the excitement!

I rebuilt the transmitter to cover five amateur bands (all AM of course) with an output of 40 watts, but it was a bit of a hotch-potch, so I built an "Elizabethan", I think it was a Short Wave Magazine design, with an output of 100 watts. I bought an enormous ex-government mains power supply from a scrap dealer. It weighed over a cwt (112 pounds, as I am sure you know). The set-up worked very well, and I managed to have QSOs all over Europe, USA and Australia.

I had my first station inspection. The GPO officer was very thorough, and I had to demonstrate my skill in operating the transmitter, and checking the frequency with my (ex-government) BC 221 frequency standard. They would also help you solve TVI problems. Somebody complained about my transmitter even when it was switched off. The GPO dismissed the complaint. They always supported the amateur. Those were the days.

Although my house was 250 feet above sea level, I thought it would be fun to operate from the highest point in the clay district, so I got permission to transmit from the top of a china clay sand tip 1000 feet up. I made some (comparatively) portable gear for 21 MHz, and struggled up to the top with it, together with a car battery. No road of course. I put up a home-made 3 element beam aerial in a howling gale and pointed it hopefully to America. To my horror, absolutely nothing could be heard except a roar of static interference from the National Grid system, which was all around me. I did put out a CQ, and in the lulls of interference I heard hundreds of American amateurs trying to call me. I heard one say I was the strongest signal on the band, but no good did it do me.

My father had a junk box in a cupboard under the stairs. It was full of bits and pieces which might come in useful one day. He never threw anything away. I must have inherited his genes. Ever since I was in the army, I bought loads of wireless gear from scrap dealers, and every time I was in London on business I went to Lisle Street (trying to avoid the young ladies) and brought home a lot of junk. I always tried to buy stuff which was absolutely useless as it was, but contained lots of goodies, for example the wonderful IFF aircraft transmitters. However, I did buy a few expensive things, like an R1155 receiver and a T1154 receiver for a few pounds each. There were wonderful scrap dealers in Portsmouth, when I was in the army, and I found a fantastic dealer near Devonport docks, with a pile of ex-navy gear nearly as high as a house. The manager was always pleased to let amateurs climb all over it, and sell the stuff for about £2 a cwt. Every time I was in Plymouth on business I filled the car with stuff. Amongst other things I had loads of test equipment, yards of 3cm waveguide, a CR100, a CR150, and several B29 receivers from submarines. Unfortunately the local MP heard about it, and said some of the amateurs might really be Russian spies, so ordered all the wireless equipment to be destroyed so no amateur could get it. There were also rumours that Cornish military establishments were throwing all their wartime gear down the local mineshafts. I heard of several amateurs rescuing it, but it must have been quite a challenge. I was also told the RAF employed a bulldozer to smash thousands of valves and bury them at a local airport, this at the request of the British Valve Association. I did find a few 6SN7s.

Later on, as Lisle Street dried up, I went every year to the local rallies, and the marvellous national rally at Longleat. I bought a lot of fine equipment there, but eventually even that gave up. The owner of Longleat accused the amateurs of vandalism and bad behaviour, and closed the rally. I don't believe it.

Another source of wireless equipment was industry generally – not only the wireless industry. Most industries have some electronic gear, and when it becomes obsolete they are delighted for someone to take it away. For example I bought two AVO valve testers – a CT 160 for £25, and a Valve Characteristic Meter 163 for £15.

I used to buy any receiver I saw at a low price, do it up, have fun with it, then sell it. This way I had fun with a 19 set, AR 88, National HRO, Yaesu FRG 7700, FRG 100 and FR101, an R107 (A huge heavy army receiver with terrible frequency drift), Eddystone 770R, 680, 730/4, 880/2, EA 12 and EC 10, a Marconi CR 100, CR 150, B29, Atalanta, and Electra, a colossal GEC BRT 400, several RACAL RA 17s, an R1132A, a Siemens Level Meter D2008 and a 7 foot high rack H11 Marconi double diversity receiver I bought from a school in Hertfordshire. When I was on holiday in the Isle of Man, I saw an old cargo boat in the harbour with a Marconi crossed coil aerial on the mast, and a DF receiver (a "Lodestone", I think) on the bridge. There was a crew member on board, who said the captain was in the local pub. I found him, and offered him £25 for the lot. He agreed, provided I dismantled it all myself, which of course I did.

Over the years I changed from AM to SSB, and upgraded my transmitter with modern second-hand equipment. I never bought anything new. I first had a KW 2000, which worked very well, but was not very well made. Then I read somewhere that it was based on an American Collins set, so changed to Collins (even some of that was ex-government!). I bought their 75A4 receiver, which I still think is the best amateur receiver ever made, and their matched pair of 75S-1 receiver and 32S-1 transmitter. Finally I bought a Collins KWM 2A transceiver. I had a Collins KWT6 linear amplifier, then bought a huge army ZA 55661 amplifier, and rebuilt it with two 813s and 2600 volts on the plates (sorry, anodes). I managed to get DXCC (confirmed contacts with 100 countries), WAC (worked all continents), and various minor awards, and enjoyed thousands of contacts with amateurs all over the world. I especially enjoyed a weekly "sked" with a friend in Nepal. A lovely country full of lovely people. I have been there once or twice, trekking in the Himalayas. This was before their Royal Family were shot. It was a splendid opportunity to practise other languages, I improved my French and Russian. My firm had sent me to Birmingham University on a 2-week intensive course, only one of the students had a nervous breakdown. Towards the end I felt amateur radio had changed since I started. Many conversations were not about wireless, but about tomatoes and girlfriends; most people seemed to have Japanese equipment, with a new model each year, and even wire aerials were bought rather than made. So I abandoned the short waves.

I bought an old Pye Westminster mobile radio, converted it to the 70MHz phone band and joined the regular network in central Cornwall. Then I used an RAF SCR 522 on the 2 metre band, graduating eventually to a proper Japanese hand-held. I operated from the Isles of Scilly, and was mystified by a huge slow pulsation in the signals. It stopped when the wind stopped. It was one of the first experimental windmills erected in Britain, right in the line of sight. The next step was 10,000 MHz. I had loads of 3 cm radar waveguides, switches, test meters (CT118) and receivers, so built myself a transmitter and receiver, using 723A/B and CV 129 klystrons. Finally I bought an ex-government Tellurometer (an obsolete surveying instrument), and converted it to a portable transmitter and receiver. I was the best amateur expert on 10,000 MHz in Cornwall. (You guessed it, I was the only one). However, I did take it to Bristol and used it for several QSOs with local amateurs. Finally I sold all my gear to Salisbury University at a nominal price.

Having reached the highest band available at that time, I decided to go down market. The government released a 72KHz band, available with a variation order from the RSGB for experimental work. Only a handful of people worldwide had this permission. This is very nearly audio, and a great technical challenge. The wavelength is 2.6 miles. so a half-wave dipole is 1.3 miles long. I made a multi-crystal oscillator with a mechanical disc keyer (cut with G3MFW), driving a succession of old valve audio amplifiers. I had a "long wire" aerial (actually hopelessly short) in series with a coil wound on a dust bin wound with hundreds of turns of wire. At first the range was several miles downhill with a following wind. Eventually I did many studies of propagation over the sea, from my house on the cliff. I put the transmitter on a time switch, and used a frame aerial on my car, feeding a Datong LW converter feeding my FR 101 receiver. Of course speech is impossible, so only slow Morse can be transmitted. The farthest I got was Hope Cove in Devon 40 miles away. When I was setting up all my gear, a holiday maker came up, and watched me intently. It turned out he was from Israel. He asked what I was doing, and I explained. There was a long pause, then he said "Why don't you use your mobile phone?"

I re-built my rack mounted Marconi receiver as a 72MHz transmitter, with two 813s running red hot with 3500 volts on their anodes. I used the old receiver tuning system as a VFO. I even had my T1154 going on the band! When the 72KHz band was closed, I converted everything to the new 138KHz band. For receiving at home I had the choice of my B29, 850/4, D2008 and my RA17 with an RA 137 LF converter. The transmitter was driven by computer with the wonderful QRS software, and the receiver used a home-made pre-amplifier, and my laptop running GRAM 412, ARGO, SPECTRAN, and finally the superb SPECTRUM LAB. It was quite an experience to see (in colour) a whole amateur band at once!

My friends kept saying it was not a good idea to have 3500 volts in the garage with a wet concrete floor, even though I said I always wore my Wellingtons. Indeed if I had a long fluorescent tube in my hand it would light up brightly. The answer came unexpectedly. The DECCA station in the Isles of Scilly closed down, with frequencies around 100KHz. I obtained permission to have 2 of the solid state transmitters, and 4 of the beautiful Litz wound coils. Dismantling them, taking them on a wheelbarrow to St. Mary's Harbour, and getting them back on the "Scillonian" was quite a challenge! I then sold my Marconi H11, and had a maximum DC voltage of 36 in the garage, but an RF output of a kilowatt. Don't be fooled – the RF actually radiated was about 0.001 watts!)

I changed my aerial to an enormous 80 turn vertical loop hung up from the house chimney, and managed to circulate 13 amps of RF through it. I resonated it with a home-made air-spaced capacitor. I also had a double end-fed wire running from the loft to the bottom of the garden. There was often 20,000 RF volts at the end. I'm afraid fires were quite common, and I was always renewing insulators and supports. I also ran a 387 yard Beverage receiving aerial in a field across the road. (Don't ask me how it crossed the road!).

With all this lot, I made many contacts with amateurs up in England, and even reached France and Carlesruhe in Germany. Then I became interested in the "Dreamer's Band" around 8.97 KHz. This really is audio, with a wavelength of 21 miles. For receiving I had an "active aerial" on a pole, a (very) long wire with an ATU, and a portable loop on the car roof. These fed a home-made solid state pre-amp. and my laptop using Spectrum Lab. Noise was a huge problem, although greatly mitigated by Spectrum Lab. The secret was reducing the bandwidth, and with help from my friend Eddie, G3ZJO, I used 45 millihertz bandwidth, with 60 second dots. What would Marconi have said! For transmitting I had a crystal controlled oscillator feeding an audio amplifier, keyed by QRS. The best was a commercial TOA 100 watt amp., with a high powered air blower to keep it cool. Cleverer people than I achieved ranges of hundreds of miles using kite aerials and very clever software. All results were "published" on the internet using the RSGB and Yahoo LF websites. It's no use publishing a book – it would be out of date before it came out. I never made a contact, but spent many years experimenting with propagation.

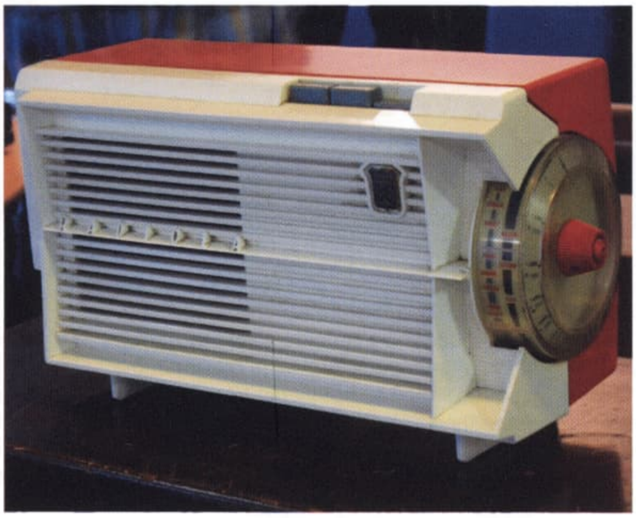
Then I became interested in wireless waves underground. There is a vast literature about this, and propagation with submarines under water. Using the house earth and 11 massive earths in parallel at the bottom of the garden for transmission, and a horizontal loop on the car roof-rack for reception, I managed a range of 11 Miles from Truro to St. Austell. It was almost certainly "utilities assisted" by pipes and cables under the road. After a couple of years, I had produced much data about propagation, which my friend Eddie put "in the clouds" on his website for the use of other amateurs He is much cleverer than I am!

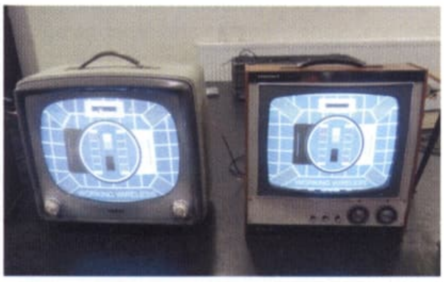
[I have 6 other hobbies besides wireless. I'm sure you don't want to hear about these. In my spare time I had a full time management career in industry, retiring in 1988 as Director and General Manager of all Far East operations for English China Clays.]

Pictures from Golborne

by Greg Hewitt and Mike Barker

The BVWS tables





The Pye Q8 reflex & related models by Henry Irwin

This radio is based on the circuit of the Ekco PT378 and is a result of the merger between Pye and Ekco in 1961 to form B.E.I., British Electrical Industries. There were several modifications during its production run. The last of these was to reflex the final IF stage to provide extra gain. The implementation of this can cause some problems which this article looks at.

A late model Pye Q8

The idea of reflexing in a superhet, using the same stage to amplify at both IF and then AF, goes right back to when the valve superhet became popular in the early 1930's. In fact Ekco were then one of the proponents of this. The technique of course saved on the number of valves at a time when these were expensive items. Forward to the transistor era and with the substantial cost of semiconductors reflexing again appeared in some early designs. Sony tried it in an earphone only radio, the TR33, and Perdio used it in the PR4 and the first version of the PR5.

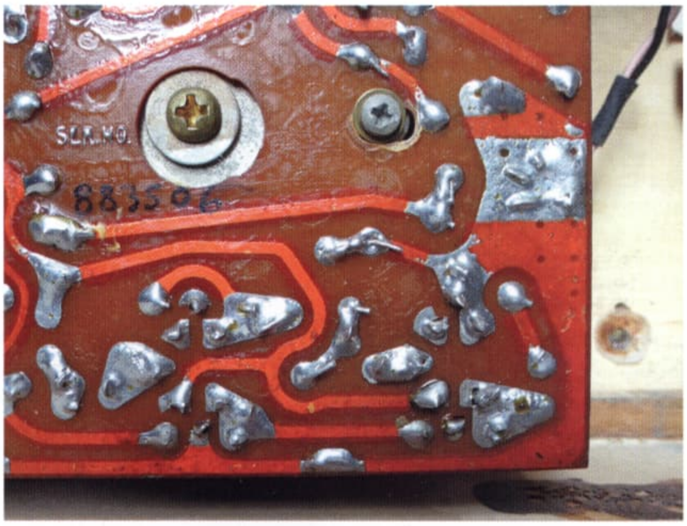
I have owned an Ekco PT378 for some time but had also been looking out for the Q8 variant as I liked its styling. The basic circuit of the PT378 is a standard six transistor superhet with transformer coupled output. Originally designed around Mullard OC series transistors it appeared with Newmarket devices shortly after the merger between the two companies. The circuit with the Newmarket devices gave reasonable selectivity but only average sensitivity however, with its good quality Elac speaker, the audio was impressive if a little muffled. Subsequently when I acquired a Q8 I felt that there was something not quite right about its sound compared with the Ekco. It wasn't just that the sound was brighter there was something peculiar as the volume control was set to minimum. On strong stations it was never possible to reduce the volume to a very low level. While turning the control to minimum the sound would suddenly dip to a minimum and then rise again and at this point there was perceptible distortion. I did some checks including the coupling capacitor from the volume control but remained baffled until I remembered something in an article by Paul Stenning back in 2003 issue No 4 of the Bulletin. Here he identified a variant of the basic circuit where the last IF stage was reflexed. When I checked I found that I had this variant of the Q8.

A closer look at reflexing

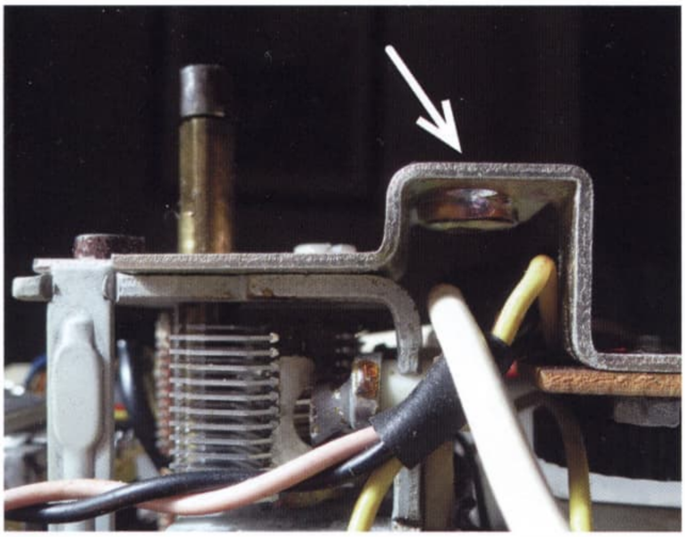
Instead of taking the demodulated audio from the wiper of the volume control via a capacitor to the first AF stage, in a reflexed radio it is taken back through a low value electrolytic to the coupling winding of the second IF transformer where the signal is again applied to the base of the second IF transistor. For the reflexing to work several additional components are added. A low value resistor of 82 ohms in the collector of Tr3 which the audio is now developed across and a large value electrolytic across the emitter resistor which prevents negative feedback at audio frequencies. More on this later. I have redrawn this part of the circuit to show the modified signal path.

After a bit of head scratching I realized that this would be OK in an ideal world but components are rarely ideal. It assumes that demodulation only occurs in the diode D1 and that Tr3 amplifies perfectly. Transistors, compared to triode valves, are not particularly linear and to be useable at audio require careful biasing and often the application of negative feedback, whereas to amplify at RF and IF the requirement is maximum stable gain. But remember demodulation itself relies on nonlinearity and with strong signals substantial audio components can be generated in the collector of the last IF transistor. Usually this is not a problem as any demodulated audio will not be developed across the final IF transformer which has low impedance at these frequencies. However place a resistive load in the collector of Tr3 and it will develop a demodulated audio component across it in addition to that produced by D1. What I believe happens is that there are now two audio signals across this resistor at low settings of the volume control and that they become out of phase causing cancellation and distortion. At higher volume control settings the amplified audio fed back from diode D1 predominates

Manufacturer's additional components for reflexing



Non reflexed circuit board



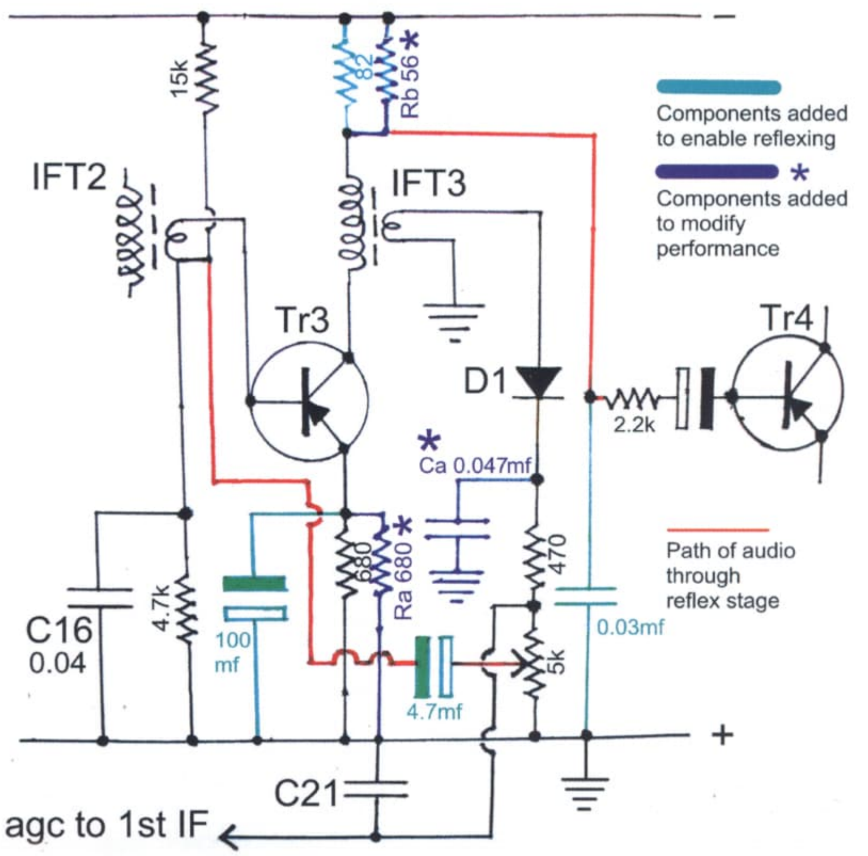
This bracket fixing-point governs how parallell the tuning knob is to the case front

Reflexed board showing break in strip and modification components

while at minimum the residual signal demodulated in the transistor remains.

Having thought about possible solutions I tried a few experiments to see if I could linearize Tr3 sufficiently to reduce unwanted demodulation. Reducing the value of the emitter resistor has the effect of altering the bias and increasing current through the device. I tried the effect of placing 680Ω across the existing resistor which gives a composite value of 340Ω and also reducing the value of the 82Ω collector resistor by bridging it with 56Ω. This increases the current through the transistor to about 3.5mA rather than the usual 1mA although care is now needed to avoid approaching the maximum safe collector current for a small signal transistor. I have soak tested the stage for many hours and the transistor appears to run cool. The modification was carried out on two Q8's and it did reduce the effect considerably on one and removed it entirely on the other. This presumably reflects variations in gain between the IF transistors of different radios. As the audio was still a bit on the bright side, due to the extra stage, I also added an additional capacitor of 0.047μf between the top of R12 and earth.

Apart from the above audio problems how do you know if you have one of



Reflexed IF stage showing manufacturer's alterations and suggested modifications. Neutralizing capacitor not shown these Pye, Ekco, Pam, Ferranti or Invicta reflex variants? Well, the evidence is on the circuit board and I have included pictures of both non reflexed and reflexed boards also showing the position of components that I added. Because of the difficulty of unsoldering from these printed circuits (the component wires are long and bent over) I have soldered the extra resistors and capacitor to the printed track side which is easier.

Other problems

I mentioned earlier that the emitter bypass capacitor for the reflexed stage has been changed by the designer to a 100µf electrolytic. In theory this will bypass at both AF and RF but of course it is a known fact that some old electrolytics develop a high impedance at RF and can thus in time reduce the RF gain. Mine were satisfactory but this is worth keeping an eye on. Unusually in this circuit the emitter RF bypass capacitor for the 1st IF stage is earthed via the electrolytic that bypasses audio off the AGC line and this has also been known to develop a high impedance. On one of my Q8's I have had to replace it but it could also be bridged with a 0.4µf ceramic on the print side of the board if the gain is down.

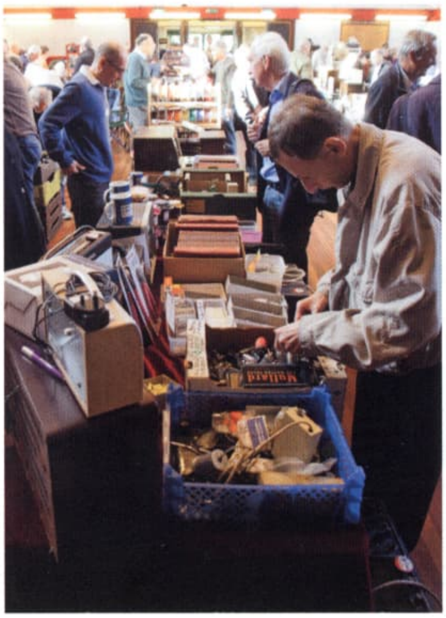
The epicyclic slow motion drives on all these sets can give trouble with slippage. This is exacerbated by a felt friction pad behind the tuning dial, as a slightly worn drive cannot cope with the extra drag. I tend to remove the felt pad and put up with the looser tuning. There is also a spacing washer deep in the outer tuning control which you mustn't lose or the two halves will rub together. In fact there can be difficulty getting the tuning control to sit reasonably flat against the case. This is governed by an angled bracket bolted to the internal tuning capacitor into which the frontal case fixing screw taps and it may be necessary to bend this slightly but firmly and very carefully with pliers.

Summary

It is questionable if reflexing the circuit in this particular manner towards the end of its production run was an effective way to improve its performance and also whether the pitfalls were fully recognized and the best circuit values were chosen. Although it is now possible to listen to weak stations that were previously inaudible at maximum volume these are noisy so it doesn't improve the basic signal to noise ratio. However with the modifications suggested my two Q8's are now much more pleasant and full sounding and closer to the sound, at low volume, of the original Ekco PT378. This is not a guaranteed remedy for the woes of all reflexed radios in this series, since the 2nd IF stage may still overload in very strong signal areas, however for anyone who has experienced similar problems, short of returning the circuit to its original form, it is a modification worth trying.

September Harpenden

Photographs by Carl Glover



Various televisions at giveaway prices

The Brimar valve stall

Pegasus receiver

Marconi V2A

Restoration of a Philips Aachen Super, D57 AU, MonoKnob from 1938/39 by Gary Tempest

The name Aachen comes from a German town, apparently it was common for a while for Philips to name radios after towns. It's a spa town about 60 km from Cologne. And then Super: well perhaps this is amongst the best of these models as it has a tuned RF stage and a high IF frequency.

This radio was won on Ebay and as usual my wife and I went to collect it. I can't exactly remember where it was now but it was off the north side of the M25.

The quite modest amount of cash was in an envelope and I had a 'print out' of the winning bid which maybe was just as well. We found a lane with the right postcode with the Sat Nav. From there it got a little more mysterious. We couldn't find any house that matched up. Fortunately, we came across a native and he said "go right down to the bottom mate, you will see a fence and high gates and you have to phone". Fortunately, as not really being mobile phone people we did have one with us. So down the lane we went which was single track with no room to turn around. I had that slightly queasy feeling of would I be able to back out of it as it seemed to go on for ages. Then we got to the wire mesh fence and the gates. Both were at least 10 foot high and the latter had a massive chain and padlock. As had been said, there was a notice with a phone number but first I took a look at the scene. It was obviously some sort of reclamation yard and all sorts of stuff could be spotted but mainly cars and parts and then the dogs. Great big Alsatians, we used to call them, although now they have been given the euphemistic title of German Shepherds. Most seemed to be on long chains and seeing me teeth were bared with the odd snarl.

Um! Let's make the phone call, get the radio and be out of here. So a lady, who turned out to be young and slim, took the call and said she would come to the gates. My paperwork and the money were pushed through the wire, examined and judged good. Then a bad idea from me, "Shall I come in and get it". The reply was "If you come in here one of the dogs will tear your arm off: I'll get it". Choke! "Yes that's fine". About 10 minutes later, out she tripped with it on her shoulder which I thought an achievement as it's heavy and she looked in need of a good steak but perhaps the dogs had had that.

The padlock and chain were taken off,

and the gates opened about 18", and the radio passed through. We very happily went on our way. If it hadn't have been as described I wasn't going back in person to complain. Let the auction house sort it out.

Fortunately, on closer examination, it looked excellent being complete with a rust free chassis and with an initially thought good dial. The cabinet had no worm or missing veneer with just the usual scratches and gouges. There was even a bonus as it seemed, looking in the removable bottom that it had only a little work done on it over the years.

MonoKnob radios
This is a repeat from the article on the new dial for this radio that appeared in the Autumn 2015 issue. But some may have missed it, or just joined, so I have included it here. Just pass on if it's 'old hat' to you.

There are a bewildering number of Philips Monoknob radios as they made them, in variants, in many of the countries of Europe. To some, now, they seem a typical Philips complicated gimmick but back in the 30's they sold well and every report I've read says they all worked and sounded amongst the best of the equivalent radios of the time. For those that haven't seen one, they have a large knob at the front of the set controlling several functions depending upon the model. It integrates tuning and fine tuning by rotation, and by up and down and side to side movement, volume and tone (in joystick style but usually not too much joy to would be repairers). But it's a little bit of a cheat saying it's all controlled by a single knob. Depending upon the model there will be other controls around it such as a rotating ring or levers. These are used for switching wavebands and IF bandwidth for example.

The chassis stand
For me, it's always an exciting moment when removing the electronics from the cabinet and the MonoKnob's aura of expected difficulty made it even more so. I can't say why this is exactly but it's about what's going to be found and hopefully the pleasure of the restoration ahead. The fact that it was also a rare set here added extra anticipation.

With the knobs off, and the four chassis screws removed, then for this radio the Cap, this is Philips name for the Bakelite housing containing the dial and other indicators, is removed. It comes out of the cabinet as the chassis (with a block of wood under the rear edge) is withdrawn. To free the Cap entails removing side screws, attaching the swivel brackets that are screwed to the cabinet. It was easier to drop the loudspeaker to the bottom of the cabinet giving more access. Reassembly was going to be fun!

Once the parts were removed then the friction devices that hold the Cap at an angle were extracted from the cabinet. These are cunningly simple devices being a flanged Bakelite housing with a plug of block felt over a fairly strong spring. They are retained by a cord that is knotted at both ends passing through the plug and through a hole in the end of the housing. The cord still seemed strong so all that was needed was a quick clean particularly of the end of the felt.

Then, being me, I spent some time with the Cap resting on top of the chassis protected by a couple of rags. Working on the 'way back' principle, I studied the tuning gang (cord) drive and the Bowden cable arrangements for the dial pointer and wave-change indicator making drawings of each (included in the article for interest) as well as taking photographs.

It would have been nice if the dial assembly could be removed from the Cap to be mounted on the chassis stand separately but this simply isn't possible. Very soon I had a lot of parts and a dial pointer wire that wanted to coil itself and easily kink. The outer sheaths, for the cables, could be removed from their clamps by just opening them slightly. Once I had the whole cable extracted, I laid it out straight, and secured it to a length of board with a panel pin, through the cable loops, at each end. I removed the cable for the wave-change indicator completely; an easy task, and then undid the two screws holding the indicator to the Cap and bagged it up to be cleaned later.

Then it was start on a chassis stand design such that the Cap could be mounted upon it, with access for me to put everything back, and working correctly, before it was all removed and eased into the cabinet along with the electronically restored chassis

As shown (see picture) I made MDF extensions to hold the Cap which are secured using captive bolts and wing nuts behind.

When I had everything mounted up it was apparent that the stand was deeper than it need be. But I left it as it was; maybe with the front studding pieces farther away the better access would be an advantage.

Inside the Cap, the dial and the eye valve
There is not a lot inside this really: mountings for the dial, the pointer, the eye valve, the waveband indicator and a single scale bulb reflected by a long mirror. All this was covered in the article "A new dial for a Philips D57" in the Autumn 2015 Bulletin. However, one thing that did change was finding a NOS AM2 eye valve which I had judged to be impossible but 'valve man' Phil Taylor had one. It was preferable to use rather than an EM1 with an under run heater and having to change circuit values.

The AM1 was the first German eye valve in 1936/7 but it was soon superseded by the AM2. Apart from the tuning indicator it also includes a triode that could be used as an audio amplifier but this is not done in this circuit.

Research
For me it's always a good idea to do this before starting pulling a radio apart: it's rather like the old adage of "measure twice and cut once".

Of course with the Internet this is relatively easy, just taking up a few hours of enjoyable time. Being a member of the Antique Radio Museum (ARM) was the place to start and it turned up the best information. Here I found pictures, a circuit diagram and a chassis underside layout. Understandably, the original pull-out layout had been scanned in two jpg halves making a difficult spider's web even harder to read. Also it would have been much more helpful if the item numbers (Cs, Rs, etc.) on it had been marked on the schematic.

ARM has aforum that is sensible to pose questions as 'stickies' to the model in question. From this it was easy to contact a member directly, who had posted. He, very kindly, sent a scan of the complete service manual which helped enormously.

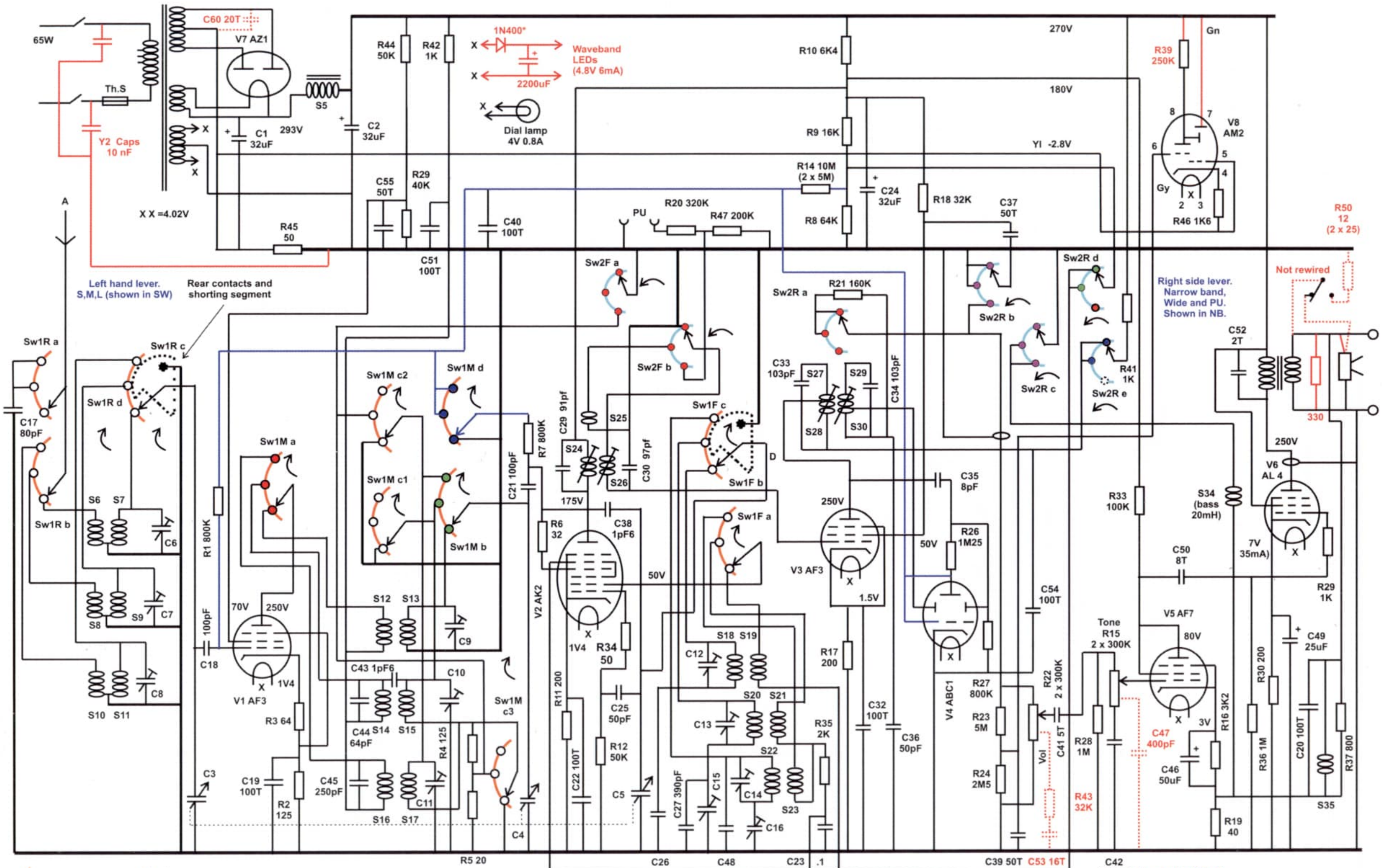
A little about the radio
It was made only in the German Philips factory in 1938/39 and along with the D58 is the last and the best of the Monoknobs as it has a higher IF frequency of 468 kHz. This is of course preferred for image reduction particularly on SW. The D58 has the addition of a row of push buttons, for preset station selection, and uses two valves with 6.3V heaters (RF amplifier and Frequency Changer) and the rest at 4V.

The D57, designed for a range of AC (110 to 245V) and DC (110 to 275V) supplies, has an 8 valve chassis including rectifier and magic eye using valves all with 4V heaters. These are side contact types (Ct8) starting with a tuned RF stage followed by an octode frequency changer and local oscillator. The first IF transformer has switched bandwidth by means of a tertiary winding. This differs from other earlier models (for example the D53) where the bandwidth is changed mechanically, by a cable, altering the spacing of the primary and secondary windings.

The model designation is explained as D for Germany, A for AC and U for Universal. The Universal is referring to DC operation by an additional vibrator (Wechselrichter). This is mounted in the cabinet roof and is connected by rearrangement of the complex multi-pin power plug and an additional component panel. See "Work on the electronics" and "Eye socket and Mains transformer".

I have heard the Ct8 base maligned but I have never had problems in all the radios I have restored that used them. The springs in the contact are very strong and better they never break off on the solder side unlike, for example, EMI octal ones. Of course they need cleaning and a way of doing this on the valve is to rub the contacts with the side of a draughtsman's soft rubber.

IF bandwidth control
I came across the tertiary winding method back in 2003 on an RGD 925 restoration. The selectivity is altered by switching in an extra winding, in series with the secondary of the first IF transformer. This so called tertiary winding provides coupling back to the primary winding. It is the increase in mutual inductance that is required to give the desired increase in bandwidth. In *the Radio Designers Handbook*, by F. Langford Smith, he compares increasing bandwidth by pure mutual inductance (moving the coils apart) and by the tertiary winding. For this the shift in centre frequency can be made small enough to be acceptable. The winding may only have 5% of the turns of the secondary and only 0.5% of its inductance. When the winding is switched in, then the increase in coupling makes Q fall slightly



Waveband = Sw1 Bandwidth & PU = Sw2

F = Front wafer, M = Middle wafer, R = Rear wafer

a,b,c (1,2,3) and d are poles

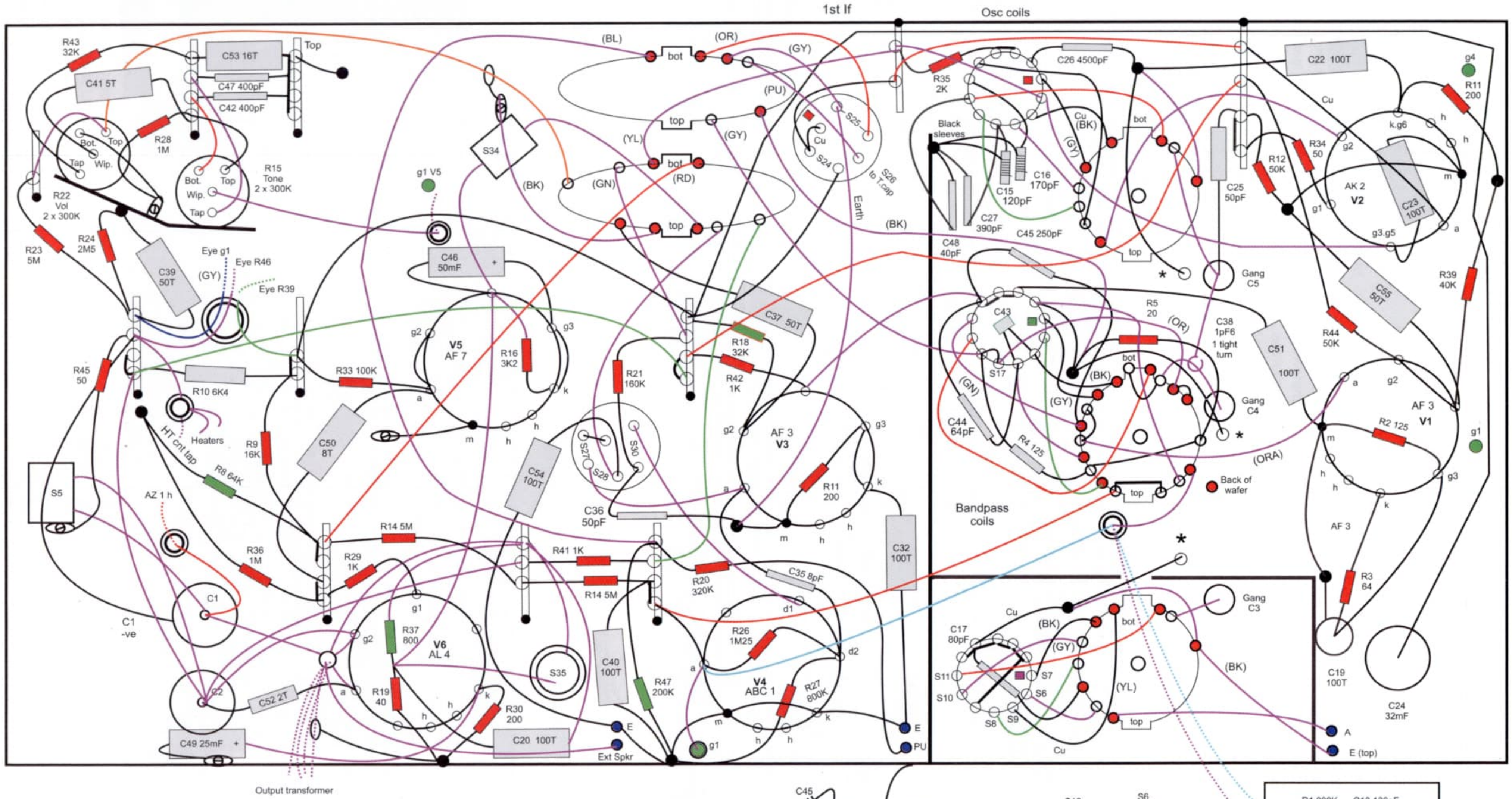
T = nF — AVC Screened lead

Modification ———

Omited ··········

C12, 13, 14 are 30pF in the coil can
C15 & C16 are 'wire' adjust
C15 = 120pF & C16 = 170pF

Philips D57 GNT 07/10/2015 09:15



Heaters, a series chain: Transformer to V6, V5, V4, V3, V2 and V1.
The Eye tube comes off of V5.

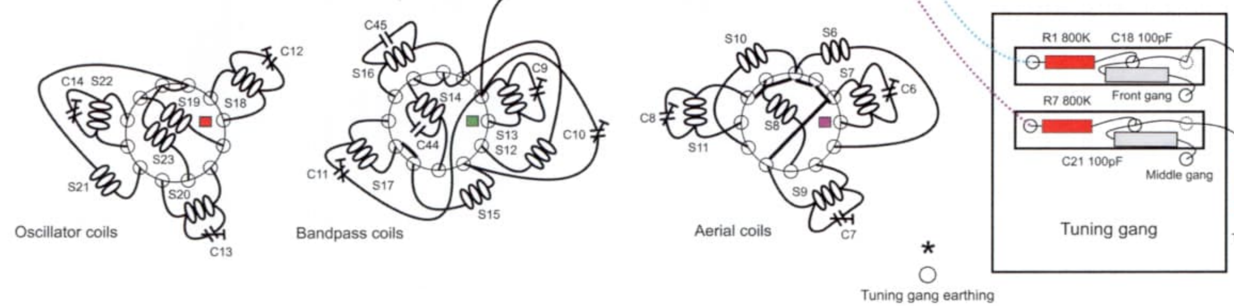
= Yellow (yellow does not print well)

= Own marker sleeve

(XX) = Replacement colour

Switches drawn looking down into chassis (birds eye)

Philips D57 Layout GNT 14/06/2015 08:27



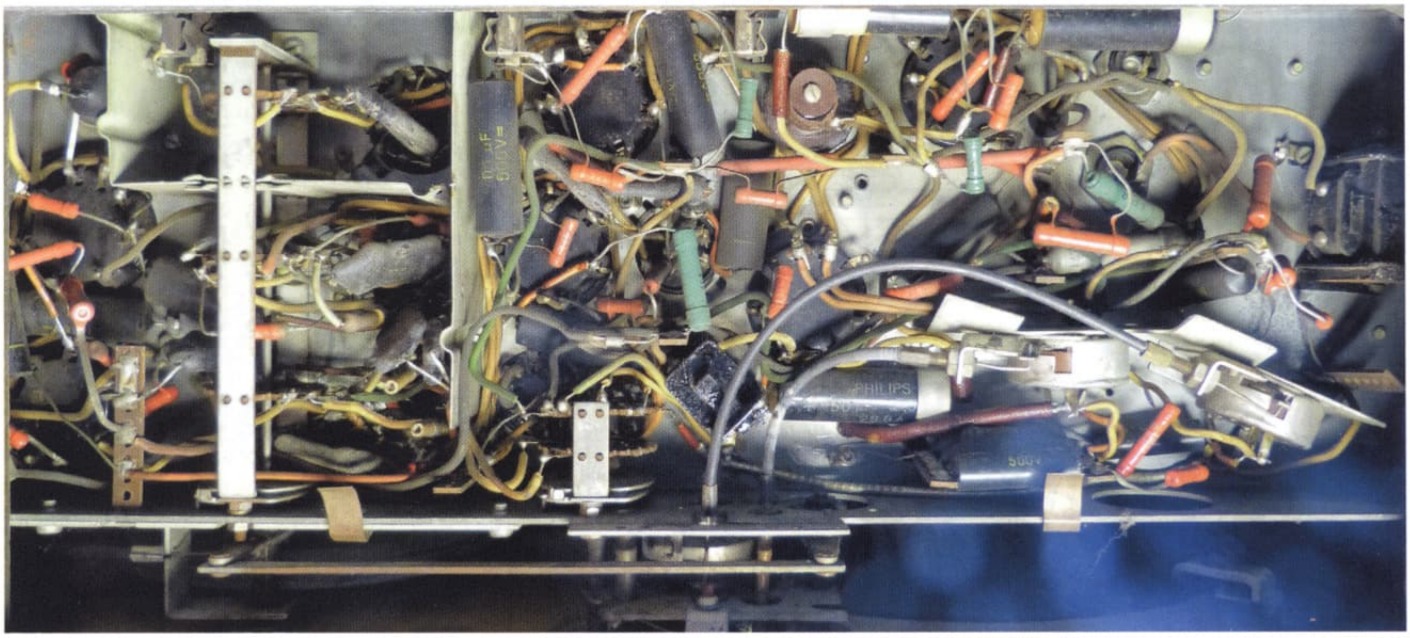
and the response peak broadens. For the RGD the IF bandwidth, at 50%, was 6 kHz without the coil and 10 KHz with it. The response curve still looked good with no noticeable shift in centre frequency. It will be interesting to see if the D57 is similar.

The IF frequency and the rest of the circuit
In the service data the IF frequency is given as 468 or 472 kHz and of course I wondered why and which to use. A forum member explained this to me. *"The reason for using different IF frequencies was the interference produced by the powerful Luxemburg MW station, working on 232 kHz, later on 234 kHz. Non linearity's of the mixer then produced the frequency of 464 kHz. However, this lies inside the bandwidth of a 468 kHz IF filter and a 4 kHz whistle will result behind the demodulator. This problem existed in the western part of Germany. Therefore, in this region an IF frequency of 472 kHz was used. If you want to align your set, simply look for the maximum from the IF filters which maybe 468 kHz or 472 kHz."*

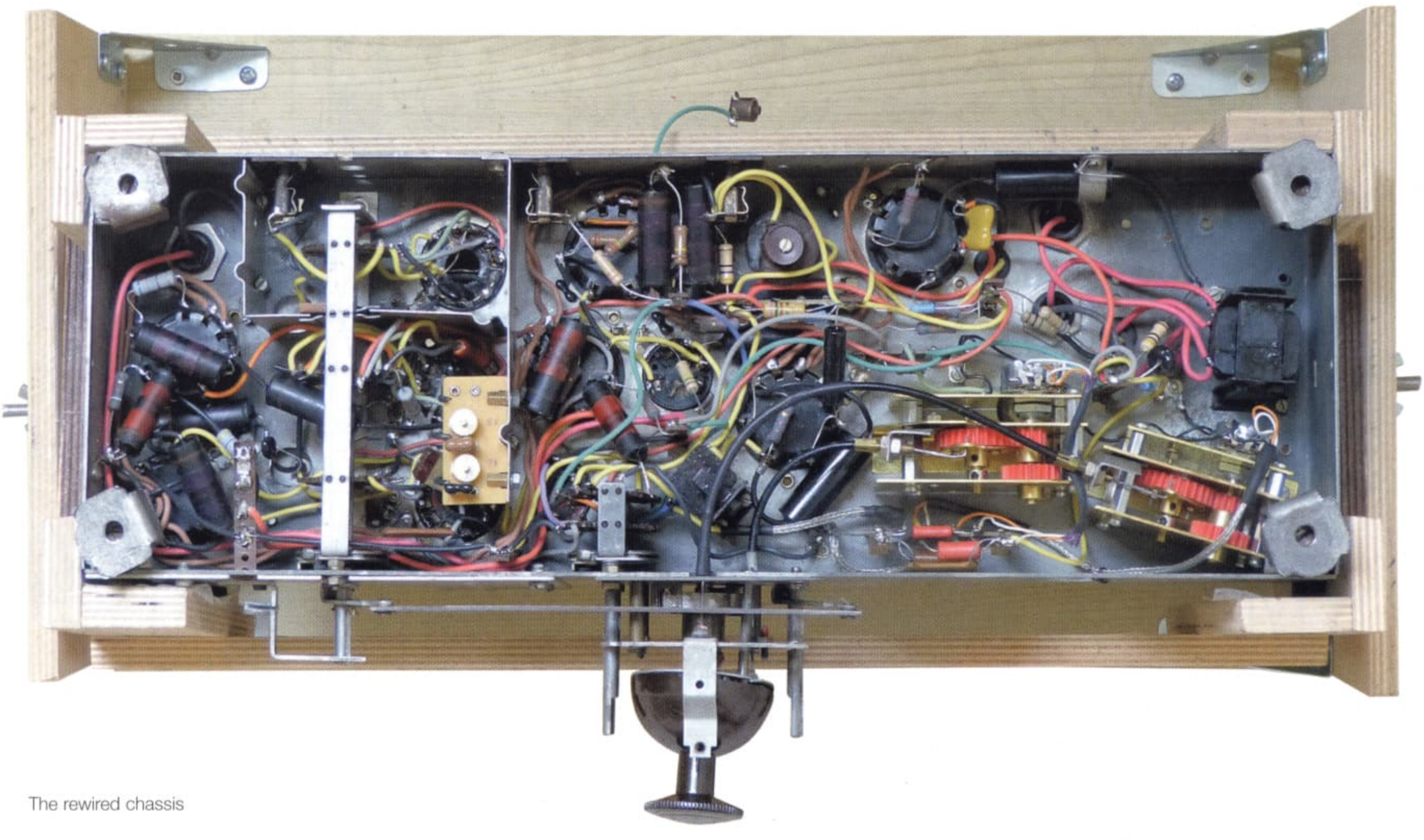
But I digress, there follows an IF amplifier, with a conventional transformer, preceding a diode detector and separate diodes for sophisticated delayed AVC. Audio amplification is two stage with overall negative feedback, via a frequency tailored network, from the secondary of the speaker output transformer.

Work on the electronics.
Eye socket and mains transformer
The first items removed were the eye tube socket and the mains transformer. Both, and all other items topside, would need rewiring as the rubber insulation was crumbling away.

The wiring around the transformer was puzzling with its attached double pole mains switch (interesting to see that Philips had safety in mind all those years ago), voltage selector and multi-pin mains lead connector. I made a drawing of this and the transformer has a 27V bottom tap that connects to unused pins of the multi-connector. This is possibly used with one of the two additional vibrator packs in DC operation. There are apparently two types: 110 to 145V and 200

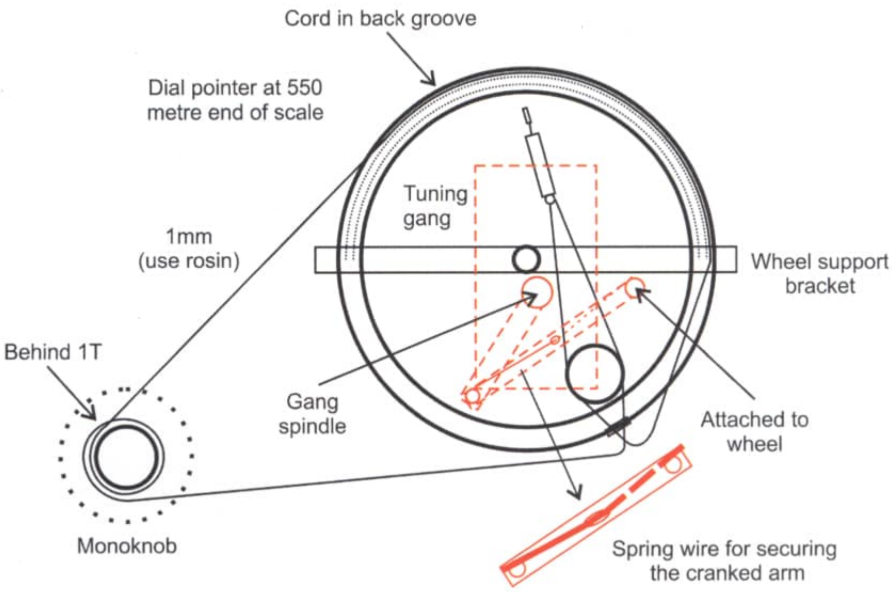


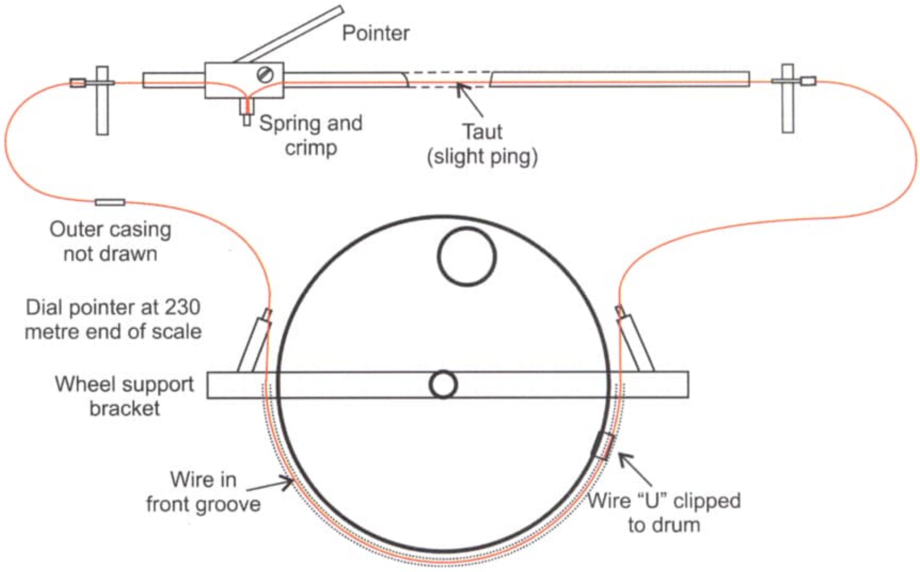
The underside of the chassis before restoration



The rewired chassis

Cap friction pads





Total wire length loop to loop 1250 mm. One side 759 mm through 467 mm outer cable. Other 495 mm through 217 mm outer cable. Wire lengths are from the loop ends to the pointer spring and crimp.

Tuning gang and pointer drives for Philips D57 monoknob

to 275V. Perhaps I am not alone, in the past, wondering what the two brackets were for in the top of many Philips radios and they are to mount the vibrator unit. This is a ventilated tube 60mm diameter by 335mm long so quite large. It contains, along with the switching contacts, extensive choke and capacitor filtering. An additional panel, containing a fuse and a couple of capacitors, is mounted on the extended legs of the voltage selector panel.

There is also an over temperature cut out, mounted on the transformer, the contacts looking as if they are held together with a ring of solder. It's so remote from the surface of the transformer I think the set would have to catch fire before it did its stuff. After cleaning it measured satisfactorily so I left it in service.

The mains switch was open on both poles but with some cleaning and DeOxit it seemed reliable. Later I resisted the urge to wire the poles in parallel and use them to switch a hidden double pole mains relay for actual on / off.

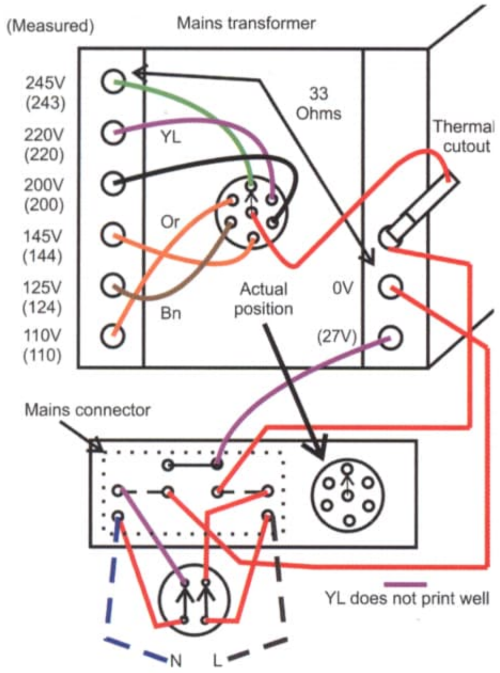
Mains filter capacitor

There is a mains filter capacitor, mounted on the rear of the bracket for the rectifier. It is from one anode to earth, (why did some manufacturers put them on this side of the transformer and others on the mains input?) that had failed spectacularly despite being rated at 3Kv. Most other Monoknobs, that I have circuit diagrams for, have them here, either on one anode or both. Philips didn't always do it this way and some earlier 30's sets have nothing or primary side capacitors or chokes. I decided to use a Y Cap on each leg of the mains supply to chassis. A compelling reason for choosing this option was that I could mount them on the rear of the voltage selector panel. These items, although normally rated for 'spikes' to 2.5Kv, are known to fail and I wanted them in a position where they could be changed without removing the chassis from the cabinet.

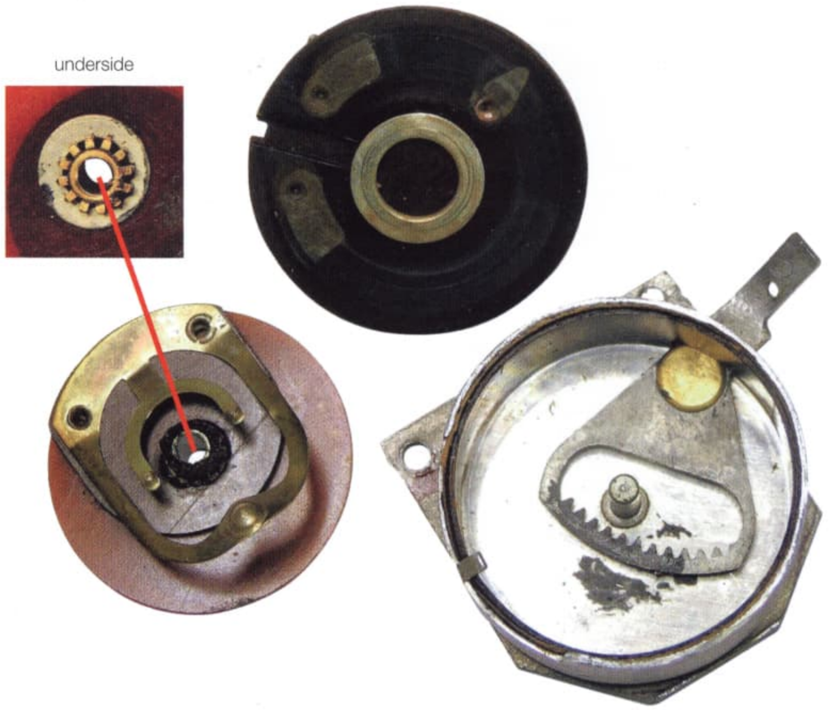
Electrolytics and filter choke

Slowly I removed items; the electrolytics for re-stuffing and the filter choke which was open circuit. I was able to get a good replacement later so it saved a strip and rewind. The electrolytics were of the wet type, which are really easy to do. The top, outer lids, were removed by using a blunt piece of plastic and pulling upwards around the lip. Note that this is best done whilst the capacitors are still on the chassis. Once the capacitors were removed the inner tops were cut off so that the internal electrode structure could be taken out. This just needed drilling out the rivet in the centre of the Bakelite mounting bush. After cleaning everything, new electrolytics, with suitable packing, were made up, with fly wires, to exit the hole in the bush. The outer top lids were then replaced on the can. A final touch was to put on some new labels using decals.

I picked up this snippet, on a forum recently by member Alan Douglas, about



Philips D57 Monoknob mains wiring



Pot inside

the original electrolytics, which to me was interesting. "The original … wet electrolytics, would purposely leak above their rated voltage and hold the voltage down. They could absorb tens of milliamps without harm, being "liquid-cooled" so to speak". It's the reason we fit 450 to 500V dry replacements as with the directly heated rectifier the HT, on switch on, will rise to well over 400V until the other slower heating indirect valves load the supply.

Wax paper capacitors

A lot of the wax paper capacitors had strangely high voltage ratings of 1Kv, 1.4Kv and even 2.5Kv and were accordingly large. Perhaps as it was 1938 and building up for WW2 they were using what they had. Some were a standard 500V and had leakages of 10MΩ at 100V but others were down to 150KΩ at 25V. Depending upon where they were in the circuit some were acceptable but as I removed items, it became clear that re-assembly would be a lot easier with a smaller case size. Having some smaller period items they were quickly re-stuffed for the purpose.

Under chassis wiring

The under chassis wiring was also bad and mainly the most common yellow colour. This included the heaters, which had the rubber falling away and couldn't safely be left. I find the decision on what to do difficult; start replacing some of it and it's going to mean removing lots of items. There is the old dodge of crumbling away the insulation and unsoldering one end and slipping on some sleeving. But here some of the runs were long and disappeared under many other components. What was I doing here? Was I making it work again or doing a restoration as I understand it. Would the vintage car people pull out a few dodgy wires from the loom and leave the rest? The best of them wouldn't and I decided I couldn't either on the chassis.

But I didn't replicate the yellow everywhere changing this to appropriate and different colours making checking after re-wiring much easier.

Monoknob removal, another chassis stand and resistors

It was time to remove the Monoknob and later the tuning capacitor so that I could clean the chassis and the RF coil cans. The chassis would now be at the minimum height and could be mounted in a shallow chassis stand, and one going up market for me, that actually was made to swivel. This would allow work on the underside sitting down rather than standing up as had to be the case with the big stand needed when the dial mechanism was mounted.

I pressed on from the RF end, measuring components and disconnecting where I could and at this time it seemed worth the effort. I found one open circuit resistor and a solder tag that had a screw that wasn't really tight down to chassis. Was it slightly cross-threaded? Philips liked tapped holes and it had obviously been like that from new. I wondered how many crackles and pops had been put down to atmospherics because of it.

It's worth mentioning another Philips dodge regarding the component tag strips that are mounted vertically with no screws used. What they did was to punch slots in the chassis, for the ends of the stepped strips, with other cut outs punched adjacent to the slot. Then a strip was staked in position using material from the edge of the second cut out to hold the strip. It's cunning but not ideal (well 70+ years later) as some strips are loose and don't always stand vertical.

Switches

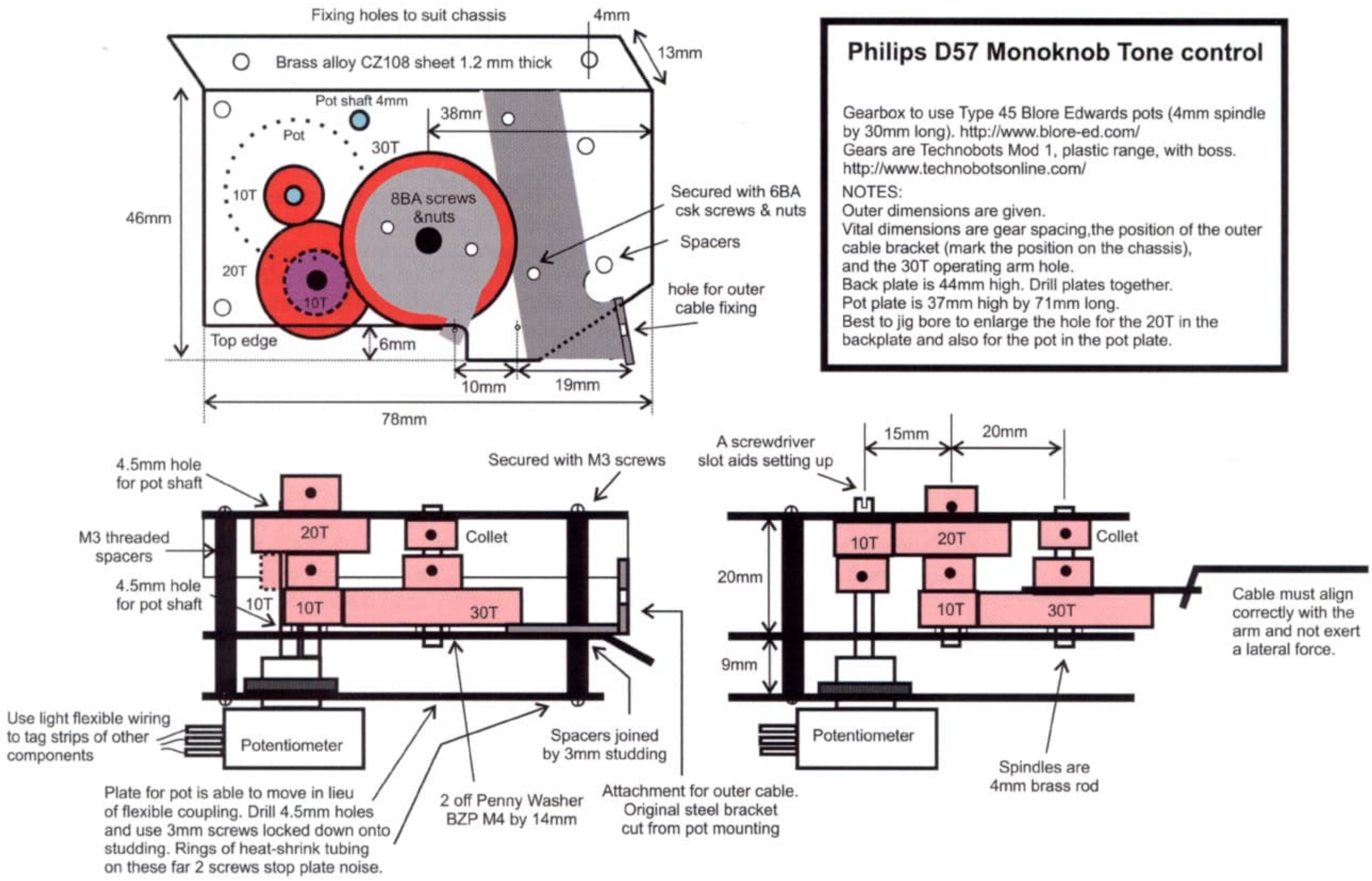
I felt disgruntled with the way things were going as I didn't understand the switches as they were drawn on the best schematic I had. Does anybody? I would have to take a break from practical work and get to grips with what the draughtsman had drawn. This took a little while for the bandpass filter (the middle wafer of the waveband switch) but the hardest of all was the switch for bandwidth and pickup. The former wasn't too bad as once understood it was close to normal practice. However, that for the latter was very Philips and needed a deeper knowledge of its associated circuitry. Chassis work would have to stop until I had redrawn the circuit whilst trying to solve its mysteries. Not that I'm knocking Philips switches, they are very cleverly thought out. As you will notice I have drawn them, on my schematic, in Plessey switch kit fashion and I know I would have used more wafers building them with those.

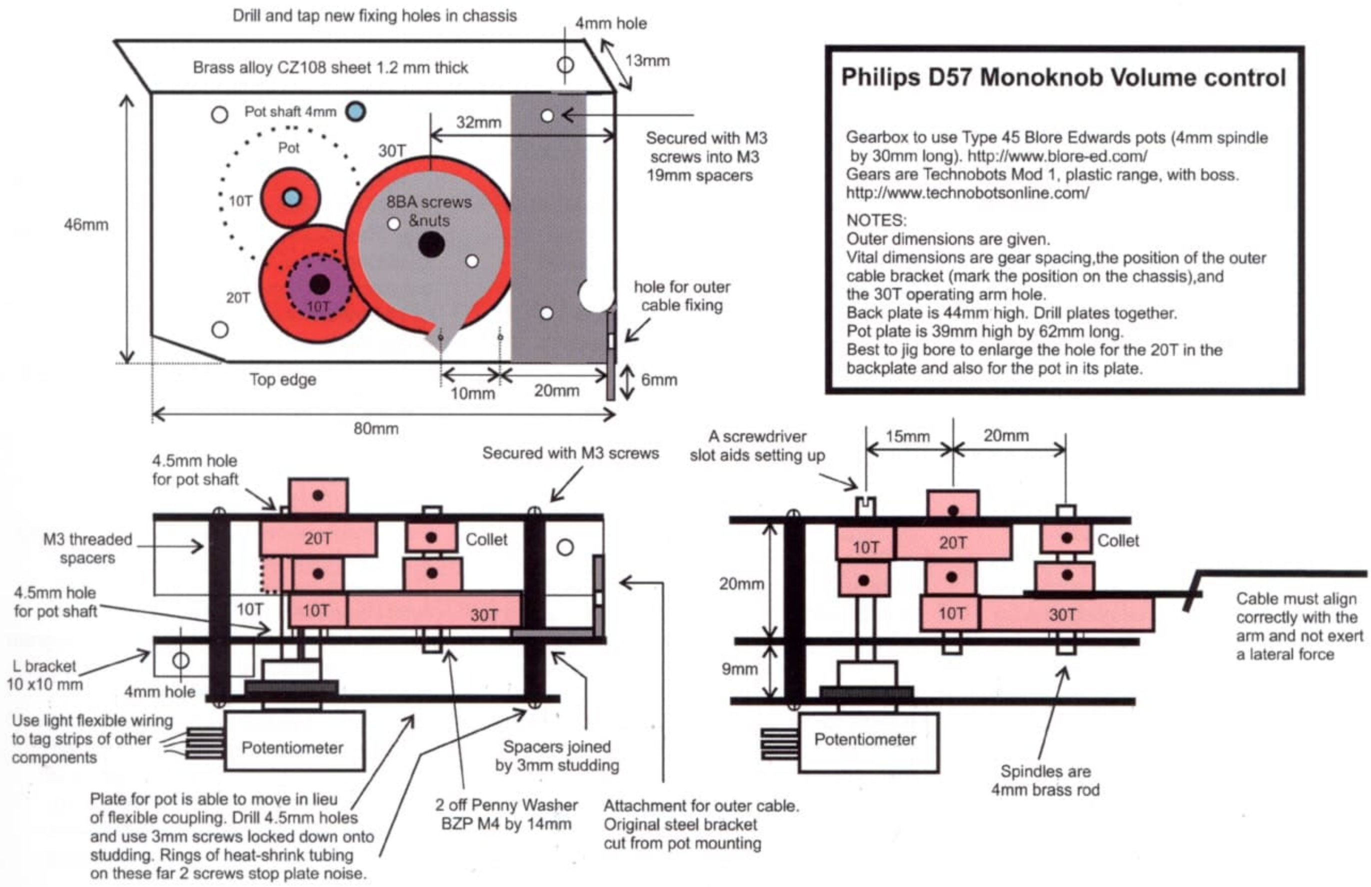
Plessey switch kits

For those that have never come across a Plessey switch kit, and amazingly for me it's more than 5 decades since I saw one, a description, as I remember it, would be in order. It came in a nicely made wooden box with compartments for front plates and spindles, studding and spacers, resin bonded wafers, rotors, contacts, wipers, shorting rings and other parts but importantly eyelets and riveting pliers. To make a switch the basic mechanical parts were selected and stops added for the number of positions needed, the maximum being 12 (continuous rotation). Then the wafers were built up by riveting on contacts of the Yaxley design (imagine first finger and thumb pressed together). It was possible to over crank the pliers which would result in a cracked wafer and a restart. But conversely not tight enough made a contact that moved particularly when wiring. But with practice I got the hang of getting it just right usually with a couple of squeezes of the pliers. Then the wipers (break before make or make before break) were selected, up to a maximum of 3 for a 3 position switch: 3 contacts for the poles and one longer wiper contact for the rotor, bearing in mind that there were only 12 riveting positions on the wafer. What we often did though was to rivet a contact on each side of the wafer and on the rear add a shorting ring. This could be notched out to allow an open contact on the front face but short others to the typically earthed ring (by its own wiper contact). I have used this feature on my circuit diagram. It was possible to add complexity by having contacts on the rear of the wafer insulated from those on the front but I don't remember ever using them. Apart from getting the design right was the problem of using insulating pads, between the front and back contacts, using longer rivets and getting the pressure just right to hold everything in place.

Later and the re-drawn circuit diagram

Eventually the circuit diagram got re-drawn at A3 size (CorelDraw as usual) to be more understandable to me (and hopefully others) but still with lots of Philips complexity that at first I didn't. The new schematic is actually not too bad to read at A4 although





even easier at the bigger size. The local library will enlarge it for those that need it and are interested in the fine detail.

The circuit in more detail.
The aerial switch Sw1R
This is straightforward but whilst on SW, a lightning strike on a long wire aerial would have certainly destroyed the coil S6.

The bandpass filter switch
Much more complex and I first redrew the switch wafers to understand it.
Sw1M a and b are 'standard'.
On SW both S15 (MW) and S17 (LW) are earthed out by Sw1 c3, c1 and c2.
On MW, Sw1M c2 and c3 short out S17 (LW) and Sw1M c3 also shorts out R5.
The selected, MW coil (S15) has 20 Ohms returning it to earth. Sw1M b is selecting the appropriate band coil for V2.

On LW the coil S17 (LW) and S15 (MW) are returned to earth via R4 and R5 (a total of 145 Ohms). Possibly these resistors are for gain balancing or for stability reasons.

SwM d is an AVC switch such that none is applied to V2 on SW.

The oscillator coil switching Sw1f
This is 'standard'.

The bandwidth and PU input switch SW2
Lots of interest here and Philips certainly went to town with this one.

Sw2F a, well I'll leave this one until last.

Sw2F b, connects the tertiary winding in series with the secondary of the first IF transformer in the broadband position (called "Wide" on the schematic). In the PU position this input is connected to V3 grid via the same IF transformer secondary.

Sw2R a, normally connects the detected audio to the top of the volume control except in the PU position. Here Sw2R b, connects the decoupling capacitor, from the screen of V3 to the top of the volume control. The screen has now become a triode anode and HT is removed from V3 anode by Sw2R e.

Never having come across this configuration before I asked my friend Peter Lankshear about it and he had this to say. *"Using the screen as a triode anode gives about the same gain as when tying together the screen and anode. In both cases the screen sets the parameters".* (Yes! obvious when you think about it or know). *"With a normal RF pentode I would expect a mu in the vicinity of about 20. The anode resistance of the screen wont be high but even so a gain of 10 could be likely from the stage".* Philips were obviously catering for some low output pickups; possibly they may have been already developing moving coil pickups. As there is an AF pre-amp prior to the output valve there should be plenty of gain for an EMI playing deck and moving iron pickup which I intended to try.

Sw2R c, connects S34 bass enhancement except when switched to narrow band.

And so to Sw2F a, which ensures an earth to the top of R5 in the PU position irrespective of the waveband. It seems unnecessary but is deliberate; maybe it was part of development and finally not needed but just got forgotten. I know from experience that this happens.

The switches deserve special mention. They are compact, pack in a lot of functions per wafer and are amongst the very best for mechanical design. The contacts are a sprung leaf with wiping action by studs or a shorting bar. Whilst in the chassis I had given the wafers a squirt with a little DeOxit, and 'worked them'. But I was surprised later when I had the switches out on the bench how much oxide remained. Obviously the contacts are silver plated and some of the shorting bars were still very black where they were out of sight in the chassis. A little more cleaner, and a short and stiff right angled dental brush, was used to clean the bars and after a lot more rotations I had readings of less than .05Ω for all contacts. I doubt that I would have got such a good result with the switch in the chassis not that I'm recommending removal as standard procedure.

The AVC and the magic eye
Philips on this radio used a delayed AVC system that is not so often encountered. Apparently other firms used it many being in the USA.

The common way of providing delayed AVC is of course by biasing its diode with the cathode voltage (the delay) of the associated triode amplifier. The diode for small signal levels, from weak stations, is reversed biased and no AVC action takes place. When the signal amplitude increases, from more powerful stations, the bias is exceeded and the AVC rail goes negative and gain control happens. A disadvantage was said to be that for large delay voltages and low signal levels that just exceed it then distortion occurs due to the characteristic curve of the diode used in this manner. F.W. Langford Smith calls this differential distortion in the Radio Designers Handbook.

For this radio the I.F. voltage at the anode of V3 is coupled via C35 to the diode (D1) formed by the anode / grid of V4.

With no input signal the consequent AVC controlling voltage across R26 is small, and positive, as a result of bias supplied from R14 (10MΩ). The resistance of D1 is low compared to R26 and clamps the AVC line at earth potential. AVC action is delayed until the positive bias is overcome.

With a weak signal the anode voltage of D1 decreases across R26 to become partly negative and the resistance of D1 rises. R26 and the diode resistance effectively form a potentiometer and the AVC line starts to go negative as the signal level increases.

For increasing signal amplitude the anode voltage of D1 becomes even more negative and its resistance larger so that eventually it is no longer in circuit. Control is handed over to the right hand diode, on the schematic, as almost the full IF voltage from V3 anode passes to it and across R27. The consequent negative voltage from this now exercises full control of the AVC line with increasing bias for V1 and V2 (excepting on SW).

Differential distortion does not occur as detection of the audio output is separate using the left hand diode which has no delay voltage as the cathode of V4 is returned to earth.

Note that the grid of magic eye V8 is controlled by the negative voltage from the same audio detector diode 'potted' down by R23 and R24 and filtered by C39. It responds to weak signals which would not be the case if it were connected to the AVC line because of the delay.

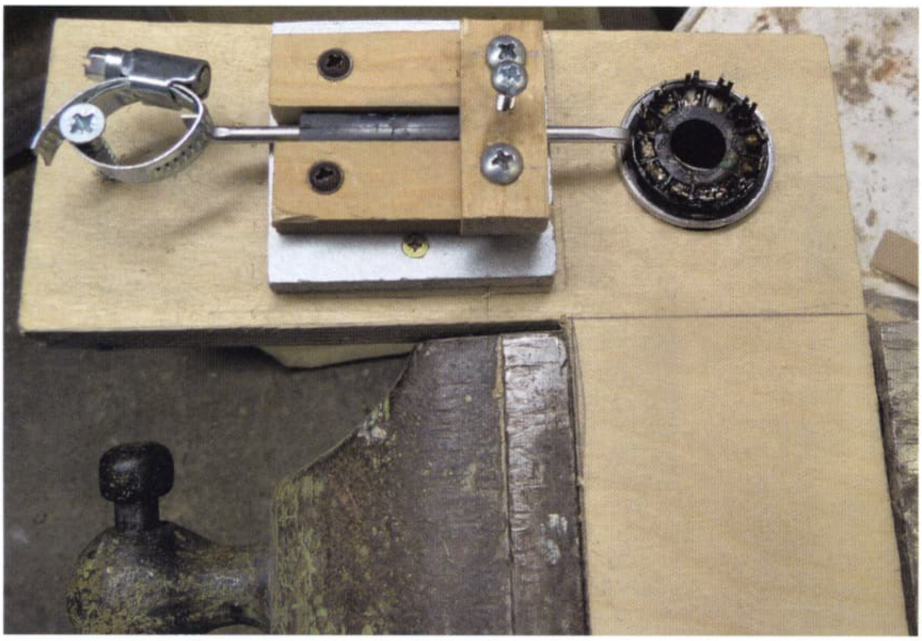
The magic eye feed resistors are deliberately high in value so as not to appreciably shunt the audio detector. This has a near optimum load (again Langford Smith) of R21 and the value of the volume control (a total of 760KΩ). Some AC loading and distortion will occur due to coupling to the tone control but with a high gain audio stage the volume control for strong signals will be set quite low. Below one fifth of the maximum then the effect is said to be negligible. For low level signals then increased distortion, with a higher volume control setting, is usually of no consequence as the signal to noise ratio will be low anyway.

The audio amplifier
Philips liked tapped potentiometers and so did Philco for another. The tone control is basically top cut with a little smoothing by C47. The volume control with tap I have seen before and is what today would be called a loudness feature. As the wiper of the control approaches the tap then treble is shunted away such that conversely the lower bass frequencies are emphasized.

The choke S34, excepting on narrow bandwidth, is in shunt with the un-decoupled part of V5 cathode resistance. For the lower tones its reactance will fall, shunting R19, and so the pre-amp will have a rising gain characteristic providing some bass boost. To understand the amplifier fully then a detailed analysis using for example Spice (Reference 1) is needed. This is not something I have ever tried to get to grips with but somebody else did but you have to be a member of ARM to read it. It is in German and the interesting details are the frequency response curves.

There is a switch to disconnect the internal speaker and sockets to connect an external one. The sockets are useful to connect a test loudspeaker but the switch is unlikely to be used again, if it ever was. It now is a source of intermittency in a low impedance circuit, and it made re-installing the chassis easier without it, so the bracket was de-rusted and the switch left in place for appearance.

Back on the electronics.
Layout diagram
Eventually, and with less trepidation now that I mainly understood the circuit I decided that I would remove the waveband switch. There were just too many bad wires and even components soldered to earth that couldn't be got at. I did have a layout diagram but it was manic and just too confusing to take a complicated set apart with. So I drew my own, at first a daunting task but I imagine it to be a little like knitting (which I have never tried) and quite a pleasure as it grew. As I went along I checked it to my own circuit diagram which is an excellent way for finding any mistakes or omissions.



Opening the bandpass coil base

Coil with trimmers exposed

Defective coil

Tone and volume controls

And so to the tone and volume potentiometers which had obviously been 'got at' as the cases had been bent open and then crudely knocked back with a blunt instrument. These have a lever that is pushed and pulled by a Bowden cable having a stiff steel inner wire of 1.5 mm diameter. Those on earlier Monoknob models have more finesse as they use a fine inner cable to pull the lever and a spring for the return function. The difference is noticeable when operating the D57 Monoknob, particularly for tone, with its very small radius cable drive, resulting in not such a light feel. Philips had obviously simplified the mechanics around the D57 which was a bonus for me.

Returning to the early attempt to repair the 'pots'; it was obviously done years ago as the solder looked original. I tested them first with a meter and just to confirm with an audio generator and headphones. Alas, they were useless. No further harm could be done by opening one up again and to see how Philips had used gearing. This has a ratio of 5:1 (the ratio of the diameters) multiplied by the position of the operating lever fulcrum to give an effective ratio of about 8:1. This translates about 10mm of linear cable movement into a used rotation of say 220 degrees; they have longer lead in and finish areas than on normal pots. The track length is compressed as with the gearing used and the amount of cable travel that is about all that could be covered. A higher gearing would have needed a larger case diameter and possibly given resolution problems.

Sometimes what to do about dud 'pots' in these radios comes up on forums and I have seen a reply of "... take the track out of a similar value conventional control and mount this in its place". Obviously the poster had never taken a Monoknob one apart as the photos show that this is impossible being as the differences in construction are so great. Of course I stand to be corrected if someone writes an article, complete with photographs of how to do it.

I started to look around for any model 'scrapper' Monoknob radios, that I might extract useable, with modification, pots and found one. Alas, it was of no use as someone had been there and botched the pots, including putting one back together with a hose clip. And then later Andrew Denton, who has a stall at many swap meets, kindly, gave me a falling apart and much mildewed scrap D57. One pot was untouched but the other, as usual, had been tampered with.

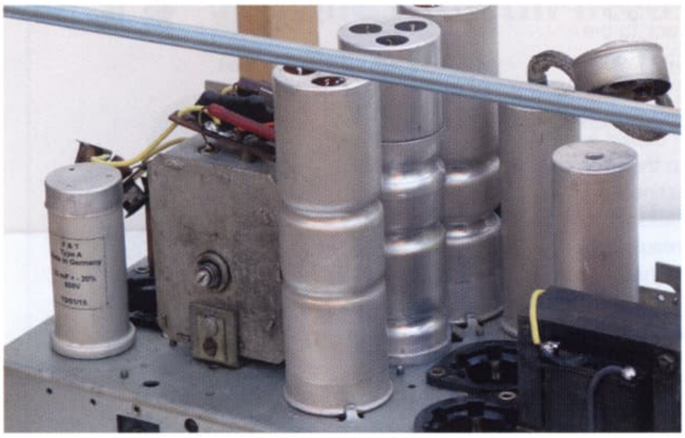
These like other pots of the same type, measured by me, are always miles high in value being typically three times that specified (for example a 600KΩ that measures 1.6MΩ. This comes from poor conductivity of the track to the rivets used for the connection tags.

Although the pots on Andrew's chassis were no good to me I never look a gift horse in the mouth. The Bowden cables were in much better condition than those on my chassis looking almost pristine. So I swapped this part of the Monoknob assembly. I'm sure it helped getting my result to work smoothly. Also, it was from this chassis that I took the HT filter choke to replace the open circuit one of mine. Finally, it's always a real help having another chassis to look at to reassemble your own no matter how many photos and drawings you've made. I looked under it countless times for details that weren't showing on photos, or forgotten to be taken, or I had not included on diagrams.

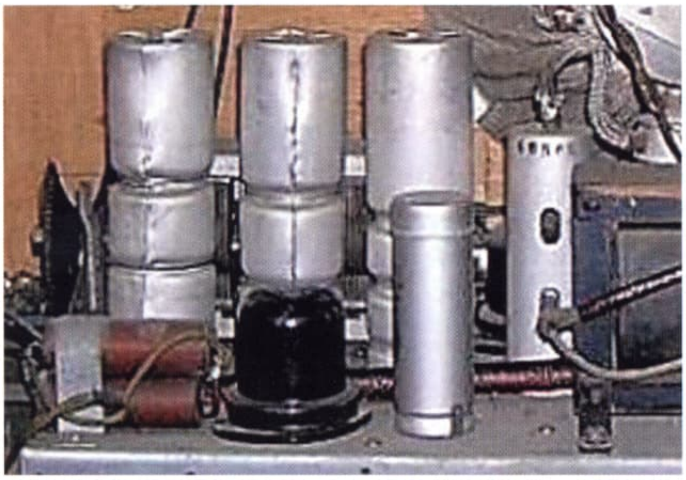
Band-pass filter coils

And now a major disappointment: two of the coils in the bandpass filter, S14 MW and S16 LW, measured open circuit. Well, I did want to look inside one of these coils with the indented sides but I would have preferred to have done it on one from a scrap chassis. I had heard that the indents were from a machine that swaged the sides adjacent to the windings, to adjust the coarse frequency (the beehive trimmer capacitors, for fine tuning, are in the can and in circuit), with automatic cut off when the correct values were reached. This seemed barely believable and what

Coil rewound with parts for reassembly



Bandpass coil back on the chassis



Frankenstein coil surgery on an internet D58

would happen to Q? But I measured the depths of the indents and they varied from 1.6 to 4.4mm so something was going on.

I asked Peter what he thought and he sent me a couple of pages from the book *The Technique of Radio Design* by Zepler which I don't have. The key part was this:
"The damping factor of the screening box increases with decreasing frequency. As a rough guide it may be said that for frequencies above 0.5 Mc/s a reduction of 10% in L increases the circuit damping by not more than 10%. On long waves above 4000m the effect may easily be several times as large".
Of course we are only going down to 2000m and it wouldn't matter as the cans would just be swaged less adjacent to the LW coils.

So it would seem Philips, in their wonderful way, wound the inductance to be always high and then reduced it by this unique technique. If Q was high to start with then a minor reduction wouldn't be serious.

I don't think that they were just trying to be different but it was a technique that suited the beehive trimmers they favoured. These have air as the dielectric and only have a range of about 3 to 30 pF which is about half of that for a typical mica dielectric, compression trimmer, used in similar circuit positions. An example is the Ekco AD65, the values for which I have in my notes. So the coils would have been wound and then the coarse resonant frequency adjusted by swaging the can knowing the trimmers would cope with the fine tuning when in the chassis. It's certain that beehive trimmers are very stable and that is why most Philips sets need little adjustment even decades later.

The RF beehive trimmers
This is a little out of chronological order but seems a good place to include it in the text. In Philips Service data they say to remove the wax for trimmer adjustment by use of a hot soldering iron. After a rebuild the chassis was pretty certain to need realignment and so I tried this. But it is messy and hopeless: the wax used was almost certainly sealing wax and even with the chassis upside down I couldn't make it drip and come reasonably clean.

The best way was to use a Dremel type tool and a small burr, plus a scalpel and abrade and pick it away. To make an adjustment tool I used the body of a ball point pen, cut off square, and then pushed a 4 BA nut into the end with a hot soldering iron. When cooled and the nut removed it was a useable fit for the trimmers.

I wanted to be sure that all trimmers worked so I hooked up a signal generator, with a resistive feed, and an oscilloscope to each coil in turn and checked for resonance and adjustment.

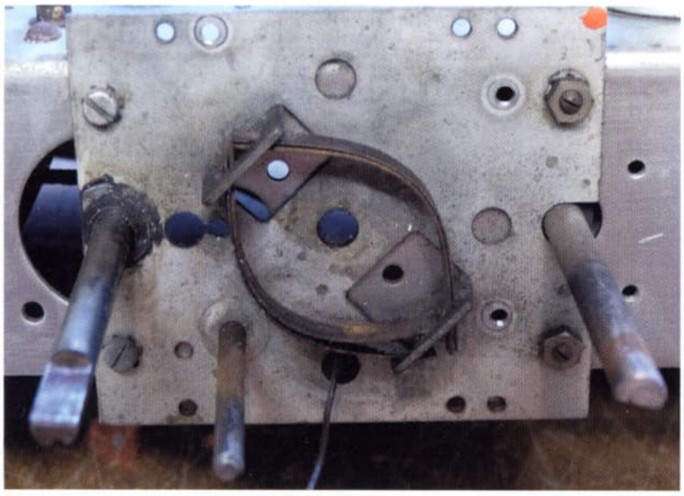
The IF ferrite core trimmers
These are in the side of the coil can and were sealed with a softer wax that was easy to pick out. I was surprised to find that there are ferrite cores: was it Philips being ahead of everyone else again? I haven't come across any other radios that used them at that time. My EMI sets still have mica compression trimmers.

How the radio had been made to work on MW
This fooled me for a while as extra components had neatly been added. Whilst not exactly in keeping with the rest of the radio they were old style with ancient solder joints. What had been done was to remove the connection from coil S14 to the switch Sw1M a, and replace it with a 100 pF capacitor to the top of S15 to bypass the filter. But of course V1 would not have had the anode current path, via S14, and so a 16KΩ resistor had been added from HT feed R42. Possibly with a war going on it provided a performance that was better than nothing.

Taking the bandpass filter coil apart
I developed a neat way of pealing back the crimp on the bottom of the coil can. This used a right angled screwdriver, mounted as shown in the picture, to apply progressive pressure by tightening the jubilee clip, as the coil was rotated from underneath. If you have a lathe then rigging something similar could be even easier.

What I hadn't at first appreciated was that the three trimmers are mounted on a Paxolin panel that is a snug fit inside the can. Of course it won't pass the swaged in areas that were done after assembly. So there was nothing for it but to cut the can as shown, then remove the trimmer assembly such that finally the coils could be removed. But there was no "hooray!" moment as there were no visible broken wires.

There is another way of opening these coils, as shown



Slow motion tuning friction bands (before cleaning)

Wire strip trimmers

in a picture of a model D58 'grabbed' from the Internet that wouldn't have occurred to me. A friend humorously dubbed it "from the Frankenstein school of restoration"

Looking at the coils it seemed it might be impossible to rewind, particularly as I only knew resistance. For both, this was very high at 260 and 450 ohms, on coils measuring less than 30mm in diameter, and later when I measured it the wire gauge was around 46 or 47 SWG. After I first removed the wax that was supporting lead out wires, by gentle heat, and then the pitch by soaking in White Spirit it began to look possible. The coils in question are not the tuned coils so hopefully would be less critical. But the coils do have a capacitor across them that I surmised was to tune them to a frequency below that of the lowest waveband frequency. Peter agreed with this and said: *"It's a very complex business but if primaries are tightly coupled to the tuned windings, gain varies considerably over the tuning range. By using a loosely coupled primary, resonant at a low frequency, and a bit of top coupling (e.g.C43) the gain overall is evened out. High inductance primaries are loosely coupled and are wound out of phase with the tuned winding".*

"Unfortunately pitch and wax don't always guarantee there won't be corrosion or "green spotting" of fine wire (40 SWG or finer). In my experience, open fine wire coils are one of the most common problems encountered in receivers. A lot of this problem has been analysed as the result of electrolysis. This to me is confirmed by the fact that grid windings rarely have the problem because of negative bias. At one time Philips and some others connected output transformer cores to H.T. Generally it prevented the problem. The connection was made via a high value resistor often about 250KΩ. Rola put their "Isocore" output transformers with the cores directly connected to the H.T. supply in pitch filled cans)."

But it was now time to wait for collection of the scrap D57 with hopefully a good coil pack. Alas, this wasn't the case and I could hardly believe it that the high resistance feedback coil was good but the 260Ω MW one was open circuit. Without a lot of hope, I removed the coil can as before, but the winding was definitely open. Now I needed help as wave winding of such coils is beyond me: I have neither the experience nor the equipment. Fortunately our Chairman came to the rescue and rewound the one with the pitch removed. Apparently, to actually do the rewind, because of mechanical limitations of the coil winder, all three of the top coils needed to be removed and rewound. This is because the "button" on the wave winder which oscillates from side to side will not have enough room to do so with the middle coil in place. Mike said *"... its normal to work from one direction only when using a wave winder so that you can get the coil spacing correct".* At the NVCF I received the coil back and a beautiful job had been made of it. Apparently, it was really tricky due to the fineness of the wire and the winding needing support by applying quick drying lacquer every few layers. But it did mean the coil was effectively impregnated as it was wound with the lead out wires secured with wax. No 'dip' was applied and I didn't bother either as no risks could be taken.

The coil was put back in the bottom part of the can, lined with a new piece of insulating cambric. Now for the confessional: I was advised to anneal the can, pressing a piece of soap on the metal, which is hot enough when the soap turns black. Alas, being a modern household we only use liquid soap so I guessed the temperature. But first, because of this, I did try heating a similar, but not the same, scrap can with a blowlamp and it didn't have enough heat to show any ill effects. But on the real thing, using the same blowlamp, a small distortion occurred: perhaps the can was of thinner metal. But it turned out alright after the can bottom was peened over helped with a little Araldite steel in places. It actually looks fine and mounted in the chassis no one would know but next time I will go out and buy a bar of soap! Finally, the beehive trimmer panel was remounted with new wires to the trimmers. To rejoin the top part I used a ring, cut from a scrap can, with a similar depth of swaging, glued with gap filling Super-Glue for the lower part and Araldite Steel for the top.

And what to do about the pots?

I had hoped to get the tracks of a pair of pots 're-treaded' with new carbon and Brett at Blore Edwards (BE) (Reference 2) did not immediately dismiss the idea. However, he wanted whole undamaged items and I didn't have any.

So my thoughts turned to a suggestion, and a sketch, by Erwin Scholle of the Vintage Radio Museum website to use standard pots and external gears. Initially I dismissed this as I don't have a lathe. But it's surprising all the tricks I have developed over the years in just using a drill press and hand tools to get around this. And it certainly started to look possible once I started to see what gears and other parts were available (Reference 3). Also, it might be useful to others, as I had discovered how many more of these radios are present in Germany. Whilst working on mine several came up on German Ebay beside those listed on the Museum.

The first attempt was a mock up, using Mod (Module or Modulus) 0.5 gears, but I soon found that it was too crude and the gears too small. So a better build was made using Mod 1 gears with a 6:1 ratio. My rotation was slightly less than the original setup but as the tone pot is basically a linear top cut where most of the 'action' is low down it was likely to be fine. For the volume that's 600KΩ too but of course has a logarithmic law. How many radios that we use do we ever get near the top of the pot? So I reasoned that as long as I could cover to near zero, for minimum sound, it should be fine. If not I could always remove the cover and use silver conductive paint to short out the unused part of the track. Just in case I needed to do this 700KΩ pots were ordered so that the 600KΩ value would be preserved. In practice the pot covered from 0 to 686KΩ.

BE agreed to make pots with 4mm spindles to suit the plastic gears. It would have been icing on the cake if resistive taps had been available. The one on the tone possibly makes the top cut a little smoother and that on the volume automatically cuts the top (giving a mellower sound) as the volume is reduced. It's not essential and there is a cheat around it with a C and R combo from the wiper that I didn't bother to add.

Pot gearboxes

It was going to be easier for me to make separate gearboxes for the tone and volume controls and I started with a prototype for the tone that worked. For this I used a linear BE pot that I had, with the 6mm end cut off and drilled for a 4mm piece of brass rod. Then whilst waiting for new controls I made more refined items, assuming that with minor modification they would be the same. I was a little taken aback that this wasn't the case and so I had to start again for the rear volume control. (see diagrams). For this it does mean drilling and tapping new fixing holes in the chassis plus losing one chassis solder contact and a vertical tag strip. I also broke one of these during my prolonged endeavours so a little redesign of the layout was needed in this area. As you can imagine, making and getting the gearboxes set up correctly took a lot of experimentation and time (I actually made four in all; one because I bent the bracket the wrong way). I wasn't able to find, or devise, a small enough flexible coupler to the potentiometer so my solution was to leave the plate mounting it some freedom of movement. The fixing holes were made larger than needed and rattle was prevented by small rings of heat shrink sleeving on the screws. These were done up tight, leaving the plate free to move, by using the right length of studding between the spacers. To aid movement I also used a very light and flexible gauge of wire.

The first IF transformer with top cap connection to V3 grid

The makers did me a favour here as the screened lead comprises a braid lined inside with ceramic beads. Through this runs a very fine wire from the grid cap to the transformer. Had it been rubber insulation it might have needed changing as did the audio screened leads. This of course would have meant getting the coil out of the can with it's rolled over base. The coax is presumably designed to have low capacitance and worked out at around 28 pF / ft which is similar to that used by EMI at 23 pF / ft.

Rewiring

The chassis was cleaned and some rust specks treated before spraying with shellac and a matt lacquer to dull the shine.

Most components had to be removed along with the wax paper capacitors. I had made the decision that I couldn't cope with the pitch dipped, large silver mica types apart from possibly the oscillator 'trackers'. Some were already battle scarred and I just hated trying to get into confined spaces and catching them with the iron and getting a nose full of 'petro-chem'. Most resistors measured within reasonable tolerance (apart from the one that was open circuit) but after being pulled about during the strip, they looked very tatty and some were mechanically unsound with ends where the wire broke off. As I never wanted to take this chassis out of the cabinet again I replaced them all with new mainly 3W metal film types as the size looks about right. I just resisted the urge to paint them in Philips red and green though!

The Monoknob mechanics

This is simplified from earlier UK models that I have looked at. Basically the rotating knob has a universal joint that allows for the joystick movement of the Bowden cables for the tone and volume potentiometers. The tuning gang is 'string driven' by pulleys and the pointer is moved by two cables from the same pulley but in a separate groove. I used 20lbs breaking strain, braided steel, fishing line to renew the inner of the cables but for the waveband indicator I used a 50lbs type because it had a similar diameter to the original. These can be bought for a few pounds along with appropriate crimps and pliers which make a neat job. A point of interest with the tuning gang drive is the neat way that slow motion is incorporated using an epicyclic 3:1 gearbox that is stopped short of a full 360 degree movement, in both directions by a tag. The perimeter of the gearbox is gripped by two sprung cardboard friction pads that hold the outside for slow motion until it comes to the tag and a stop. Then further rotation allows the outer case to slip within the friction bands for fast tuning.

The 'wire strip' trimmers and alignment

These trimmers are a metal stud inside a ceramic tube around which a springy wire, covered in soft solder, is wound. This forms a one way trimmer in that wire can be unwound, for tuning, and the spare wire can then be cut off. Of course the disadvantage is it's not easy to reverse the process for re-alignment. On the D57, two are used for tracking, which were replaced with 6 -65pF modern types and additional mica capacitors mounted on a small panel. It is important when using components really intended for solid state circuitry to check that they have sufficient voltage rating. For the fixed mica it is easy to buy items specified for 500V but for the trimmers these were only 150V. However, they are in the grid circuit of the oscillator and coupled to it by a fixed capacitor so only minimal voltage stress occurs.

The first power up

After the usual resistance checks of the HT and heater lines I applied power by the Variac and nothing untoward occurred and the volt drop across the output transformer was consistent with the valve passing the correct current. This was without the Cap and eye valve connected, more on that later.

Then an emotional moment, my wife said she saw me 'well up' but don't be silly that was just catarrh. This was when I connected an aerial and tuned across the MW band, with lots of stations present and one playing a favourite 80's song. It might have been partly the music but I do admit to a great surge of joy: it had been a long time getting this far and the fact that it played and sounded so good was a real bonus and shows that checking and more checking is worth the effort. The radio actually had reception on all wavebands and seemingly had plenty of RF gain and this before alignment.

The chassis was turned over and valve cathode (and screen where appropriate) voltages measured and all were close to specification.

Philips designed the mains transformer well with its 245V top tap that suits modern supply voltages. The HT and the heater supply were almost spot on and the transformer runs barely warm even after hours of use.

The cabinet

This was not in bad condition without worm and all the veneer present. It had some dings in the side that could be filled and touched in. The worst parts were the front corners. It is often the way with heavy sets that these get bashed when the radio is being moved. I hoped I could fill and flat them out and touch up before new lacquer. It was obvious that the radio had had a high gloss when new so my aim was to replicate that.

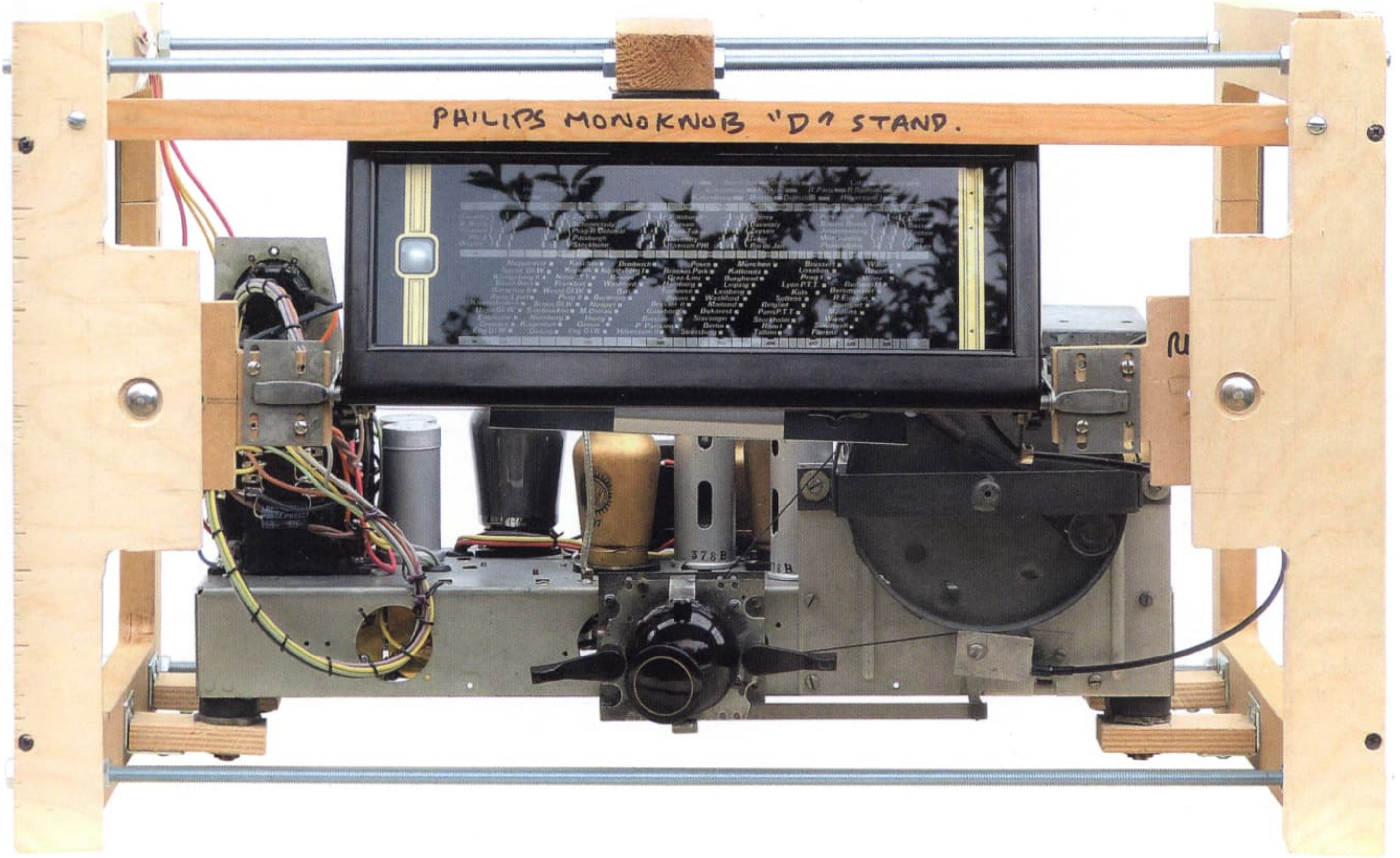
The duration was long, spent in short working spells and then leaving it to let whatever I had done harden properly. The top which I had expected to be easy wasn't as that too had several dents and scratches. These filled, with car body filler, and flatted well and in Halfords grey primer looked fine but once sprayed Halfords satin black, flaws in the finish grinned at me. So more filling and levelling was needed until eventually I got a satisfactory result.

The moulded foot now not removable, as the glue is still rock solid, was a small problem. It has a semi-circular part that was dented and knocked about, easy to fill but how to sand to a proper shape? My answer was a piece of styrene tube, of the right diameter, sliced along its length and half used to pinch a strip of wet and dry around it. Slid back and forth the result was perfect.

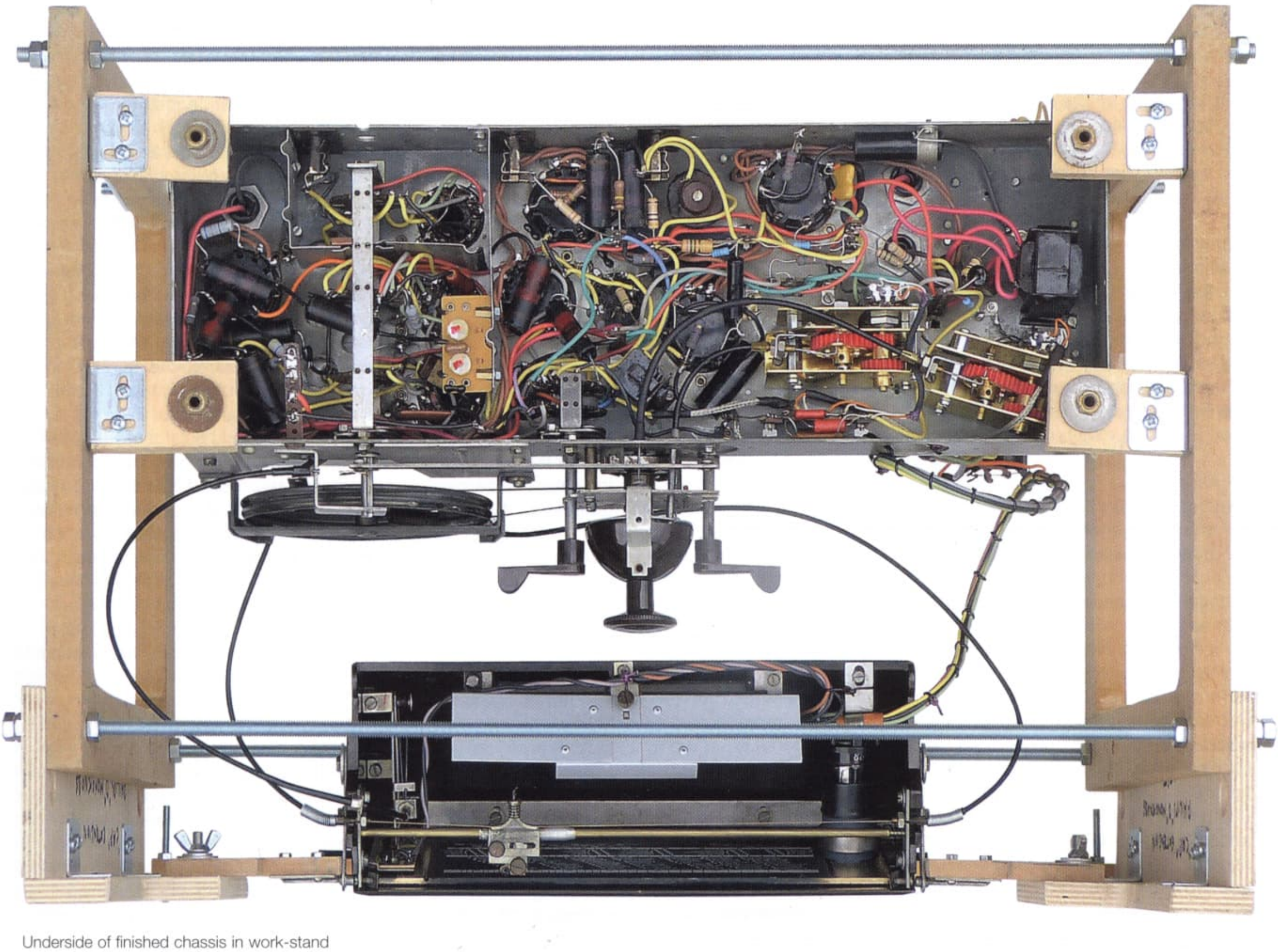
All the wood veneered parts filled and touched in excellently and finally the whole cabinet was given several coats of Mohawk lacquer before leaving a week or so and then 'rubbing out'.

And then a setback as some tiny cracks appeared in the bottom black trim and the Monoknob control panel. Nothing for it but to wet sand all the way back and into the primer to get rid of them. It couldn't have been due to over-spraying Halfords acrylic with cellulose lacquer as I have done this many times before with no problems and the cracking was below the cellulose. It's been a bad year for cabinet refinishing with a lot of damp cold weather which doesn't help. On the remedial work I re-primed, in a heated garage, it now being early September, and put the cabinet in the boiler cupboard for several days before continuing. My hope was that I could just spray with satin black, rubbed out and polished to the right gloss and not to have to over-lacquer.

Of course I started worrying about the top surface, large, black and beautiful, which I had rubbed out to almost the famous piano standard. It was perfect apart from two tiny marks against the light. They almost looked like black hairs and not the same as those on the foot. I could live with them but would more appear? Of course they did, and they went from black to grey, and so nothing for it but to wet sand off all the lacquer and quite a lot of the primer. This



Finished chassis in work-stand



Underside of finished chassis in work-stand

is called gaining experience. Once again it was left to settle, this time choosing a warm shelf in the airing cupboard before back to the primer and many days in the warm before attempting the satin black. I choose satin black as it's easy to polish this to any shine required and easier than dulling gloss. But it was all to no avail as the refinished black parts looked patchy without any hope of polishing out. It was put away for a while as cabinet work, without a properly heated workshop, was over for 2015. With some warm time in the New Year I would gently strip it of all finish and start from scratch which, with hindsight, is what I should have done in the first place.

A few weeks went by and then I decided to put the chassis back in the cabinet, take some pictures and finish off this article. Perhaps next year I will write another of how I re-refinished the cabinet.

Another tricky thing, not normally encountered, will be refitting the material dust seals, around the Cap. These had been fixed with hide glue and staples. They had been soaked off and then washed, which I left to my wife as she knows much more about this sort of thing than me. Imagining lacquer falling off from the impact I don't fancy banging in staples so will probably use adhesive and some small woodscrews and washers, first drilling pilot holes for these. Of course for this temporary fit this will be left until the next and hopefully last time.

Alignment.

IF Alignment

The IF alignment was straight forward if a little awkward, needing detuning 80pF capacitors placed across the transformer winding not being peaked. Checking afterwards with a Wobbulator showed narrow and wide bandwidths of around 5.5 and 9.5 kHz. As seen before on an RGD, and mentioned earlier, this tertiary winding method achieves good results with little change in the tuning point when switching bandwidths.

RF Alignment

Trimmer capacitors (high frequency end) and tracker capacitors (low frequency end).

For the RF alignment, the Philips service manual details their usual complexity, not aided of course by being in German, although the manuals and Trader sheets for British models help as the process is similar (but sometimes even more complicated). It calls for the use of a not shown 15 degrees tuning jig and a proprietary tuneable auxiliary receiver.

The jig, used at the high end just sets the gang at a defined position allowing the dial pointer to be adjusted to the corresponding wavelength. Then a modulated 1442 kHz signal (MW band) is injected, via a dummy aerial, and the trimmers adjusted for maximum voltmeter output into a dummy load at the loudspeaker terminals.

After this, for the low end, the auxiliary receiver is connected to the anode of V2, via a 25pF capacitor, and the local oscillator stopped by short circuiting its tuning gang. A 550 kHz modulated signal is now injected and tuned (D57) for maximum output on the auxiliary receiver. Ideally the dial pointer will be at the corresponding wavelength (545m) otherwise some compromise in the previous dial pointer adjustment can be made. Now the auxiliary receiver is disconnected and the short on the oscillator tuning gang removed. The tracker capacitor is now adjusted for maximum loudspeaker output.

As usual it is necessary to repeat the process at the high and low ends for the best overall performance before doing a similar procedure for LW. The makers let us off on the SW and only trimmers are adjusted at the high end (15 degree jig) for maximum loudspeaker output at 17 mHz.

For MW, details are given of how to shift the position of the tuning gang wheel in 4 directions to aid pointer tracking. This is done by having large holes in its mounting bracket, and using small diameter screws, with the holes covered by 15mm washers. There is a diagram of which way to move the wheel to correct for misalignment of the tuning at two further dial points. Of course the wheel still moves in a circle but the tuning gang, with its pivoted coupling arms, can be made to move in slightly different paths to correct for pointer inaccuracy. Another Philips set, a Super Inductance (638A, French or 472A, British) has a similar arrangement. Astonishing tuning accuracy was achieved by me on a 638A; what other manufacturer of domestic radios went to such trouble?

For my alignment of the D57 I took the obvious first step of putting the tuning gang wheel bracket back in its original position using chassis witness marks. I had also made notes of the scale pointer positions at each end of the dial and did the same here.

It was good to understand the service manual method of alignment but I was going to just set the same positions on the dial and use the generic method starting with the MW band. For LW it would hopefully be even easier as I would just peak for R4 at 1515m and wouldn't be too concerned about tracking.

The MW band set up beautifully and was so easy that it surprised me. I checked the tracking at many points on the dial and it was within a few percent. For LW I had to reduce the fixed tracker capacitor but after that adjustment for R4 was straight forward as it was for SW but of course the trimmer points for this were razor sharp.

Would the makers have achieved more performance from the radio with their complex procedure? It would certainly have had the effect of deterring many from touching the alignment and apparently owners were always encouraged to take a faulty set to their local Philips Service Centre.

The AF amplifier, the pick up input and the loudspeaker

The response of the output amplifier, from the gramophone pick up input, into a dummy load was plentiful for the era, being fairly flat and falling away to 3dB down at 6 kHz. At the bass end it was flat being 3dB down at 100 Hz but with a slight hump at 50 Hz. This is not a problem as hum is very low with this radio. Note that in this operation the bass enhancement choke (S34) is in circuit.

I connected an EMI playing deck (Model 122) to it and was pleasantly surprised at the quality: the two could have been made for each other. The gain, via the convoluted path to the output amplifier, was perfect for the pickup and the usual hum and buzzes that one gets, that have to be cleared, were simply not there.

Listening was on my test loudspeaker (an old 60's bookcase 'hi-fi' unit) and I wondered what it would be like with its own loudspeaker in the cabinet. The speaker, apart from a paper cone, has a rigid Bakelite trumpet for the higher notes. How effective would this be? I had read that the D57 was a radio known for its excellent audio quality. In the picture of the speaker it can be seen that the cone edge has been painted with a 50:50 mix of PVA glue and water. I'm hoping that the PVA mix will stay flexible although latex material glue would have been better but I didn't have any. These cones are now very fragile particularly at this flexible junction so some strengthening is needed.

The magic eye

This was initially disappointing being dim and without a large change in shadow angle as stations were tuned. This I had expected as it is written about on the Radio Museum. Other experimenters there had changed the anode resistor and increased the target voltage. I decided to do the same as it made the indicator much more acceptable. Perhaps Philips were trying to prolong the target phosphor by use of a lower voltage. Returning the triode amplifier grid and cathode to a negative voltage didn't make sense either. It could be just returned to 0V, with just a change in sensitivity, but I left it as it was.

That cableform needs re-routing

Getting it back in the cabinet
I must admit to worrying about this and scratching the finish but now for what was effectively a dummy run I could relax. It is almost a three handed task but I didn't have an experienced other one handy so preferred to persevere on my own.

Looking at Philips Service Data for UK Monoknob radios, one said to remove the chassis, disconnect the tuning pointer drive from the tuning gang drum and the waveband indicator inner cable. This was done by pulling the chassis back, as far as it would go onto wooden blocks, and disconnecting the inner cables through the removable cabinet bottom. How would you actually do this? Imagine a bench with a hole that aligned with the removed bottom and then lying on your back with a torch and tools. Reinstatement was the reverse of this procedure which I certainly wouldn't want to attempt. Perhaps the makers really did it this way with a special high bench so that working from underneath was not too difficult. The method given on Trader Sheets is more practical, for the repairer or restorer, where the chassis and dial are removed and replaced using the 'three handed method' that I followed.

Basically most of the valves were removed and the Cap laid on a thick folded towel on top of the chassis. Then the assembly was raised up so that the chassis was level with the cabinet and offered up. But it is difficult and time consuming. Next time should be easier as I have taken lots of photographs and written up the method that I could include in the cabinet refinish article.

Conclusions
The chassis was extensively rebuilt and I aimed for the highest reliability with all new passive components. My excuse is that I didn't want to remove it ever again but with the cabinet setback this isn't going to be the case. However, I feel fairly confident that I can do this and now put it back in a well finished cabinet without marking it.

Philips presumably expected a lot of RF gain from this radio or experienced instability during development.
The gain of V1 is reduced by the un-decoupled R3 and included a grid stopper R6 in the top cap of V2.

There are also quite a number of screening items, those visible underneath but also one over the tuning gang that goes between the grid components of V1 and V2 and also between the valves themselves even though they are metallised types. The tuning gang is almost fully screened being only open on one side but the movable plates never come outside of this even at minimum capacity.

Unusually they also screened the lead from the output valve anode V6 to the output transformer. Possibly this was for stability reasons in the audio amplifier.

The RF performance of the radio is on par with the best EMI sets (561 and 650) but where it really excels is on audio quality. At low level, the care taken with the detector and the AVC method contributes to this. At high volume the sound punches out and is distortion free but on some 'pop music' stations there is too much bass. Unfortunately there is no bass control and the grill cloth moves in and out in sympathy with the music. But the bass can be reduced by switching to narrow band, where the bass enhancement choke (S34) is not in circuit.

To hear the radio playing and sounding so good was thrilling and offsets my disappointment with the cabinet. The new dial, actually in the radio, is very beautiful and the Monoknob volume and tone controls work smoothly and feel like the originals did.

It was a long and at times frustrating restoration, but overall such a lot of interest and enjoyment. It's doubtful that I will ever work again on a domestic radio that got me through a whole winter, and almost to the next, with so many challenges. But of course it isn't over yet, as apart from the cabinet I want to change the waveband indicator. At the moment it looks too LED modern. Hopefully with the use of some green film I can make it appear more original.

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Gears from Technobots: www.technobotsonline.com/

October Audiojumble

Photographs by Carl Glover


Nakamichi
Studio Reference Quality Transcription
Cassette Recorder


OFF SOURCE MON
MODEL 510
BALANCE
VOLUME
TUNER DISC TAPE
Crimson Elektrik


HIGH FIDELITY
AMPLIFIER
TYPE HF25
POWER
SUPPLY
OFF
ON
2 AMP
FUSE
100-150V
200-250V
A B C
LS
MOTOR

A home-built TRF using three EF50s

by Stef Niewidomski

I picked up this radio for a mere £3 from the Bring and Buy stall at Royal Wootton Bassett in December 2014. The radio attracted me because it was obviously amateur-built – from a kit as I later discovered – and looked complete with its three knobs and a varnished wooden cabinet. Looking into the back of the radio I could see three red-cased EF50 equivalents and this re-enforced my view that this was an amateur design, rather than one produced by a professional manufacturer. The radio had at some time been the pride and joy of its constructor, and I love to bring such radios back to life and allow them a further period of activity. See Figure 1 for the restored condition of the radio.

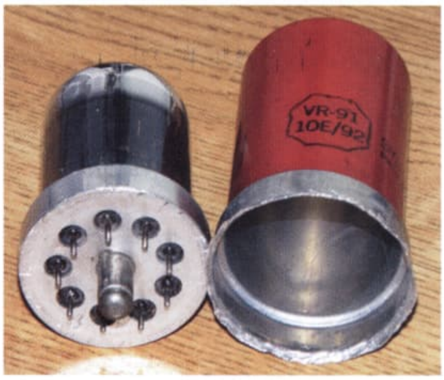


Figure 1 (left): Front view of the restored radio. Hopefully the attractive vintage bronzed edging to the dial can be seen. Left to right the controls are: Tuning, Volume and Wavechange.

Figure 2 (above): A Sylvania VR91 with its aluminium can removed so that the glass envelope can be viewed. After restoration of the radio, I tried this valve in the audio output stage position, and it worked perfectly well without its aluminium casing.

Figure 3 (below): A robust ceramic EF50 socket, with a locking ring which holds the valve in the socket even under high vibration and shock conditions, typical of what could be encountered in military and airborne applications.

Cabinet

There were many kits offered in the amateur radio magazines of the 1950s. Most used surplus stocks of wooden and Bakelite cabinets from established manufacturers, so this radio was unusual in that it seemed to use a purpose-built cabinet.

The 11-inch wide by 6-inch deep by 7-inch high cabinet was built from 3/8-inch thick plywood and its varnished finish was still in very good condition, as were all the joints. A couple of simple wooden strips on the base act as feet. A 3-inch diameter hole lets the sound out, and a rectangular 4-inch by 3-inch cut-out, edged by vintage bronzed-finish edging, surrounds the dial. The cabinet simply needed a wipe over with a damp cloth to clean off some accumulated dirt and dust.

The EF50, A very brief history

The EF50 'single-ended short wave HF pentode' was designed in 1938 by Philips of Eindhoven for use in Band 1 TVs and was released to production in 1939. Just before war broke out, the strategic value of the valve was recognised by the UK government, and with the outbreak of war it was realised that the supply of EF50s would dry up, and Mullard UK was not capable of manufacturing the special glass base with sealed-in pins. As the legend goes, just before Germany invaded Holland, a truck arrived in England from Holland with one million of these glass bases for use while Mullard and others mastered the technology. Later, huge numbers of the valves were manufactured by Sylvania in the US and shipped across the Atlantic, which is the source of the valves coded VR91 in my radio. UK versions of the valve tend to be the natural colour of their aluminium cans, whereas Sylvania versions tend to be red, though this doesn't seem to be a hard and fast rule.

To take a look at what goes on inside the valve, I eased open the circular crimped joint between the metal base and the aluminium casing of a Sylvania VR91: the internals can be seen in Figure 2. You can see that the valve has a standard all-glass envelope, with the nine pins sticking out of its glass base and through holes in an aluminium bottom plate. The spigot cast into the bottom plate in the centre of the pins cleverly serves three purposes: firstly it houses the tail of glass from where the envelope is evacuated (the top of the envelope is smooth); secondly it gives a locating and locking action in the valve's socket; and finally it forms a grounding pin for the perforated base and the aluminium can around the valve.

Military-coded versions of the EF50 were used extensively in radios and radar equipment during the war, and were produced in vast numbers. They had a reputation for being relatively unreliable and over-production to compensate for this may partly account for the huge numbers left over after the war. The valve has a 6.3V 300mA heater, and is rated for a maximum anode voltage of 250V: this sounds a little low and it may be that in many applications it was run with a higher HT voltage, with a detrimental effect on its lifetime.

Sockets for the B9G base (sometimes referred to as 'loctal' in the Philips data) of the valve include a self-locking clip arrangement that is meant to engage with the centre spigot and, together with the pressure on each of the nine pins, hold the valve firmly in place. Figure 3 shows a more robust B9G socket intended for use in military equipment, made from a ceramic material for better high frequency performance, and with a locking ring which positively grounds the case and holds the valve in its socket even under high vibration and shock conditions.

The Philips/Mullard EF50 carried several service numbers: the original Air Force type number was VR91; the Army used the designation ARP35 (and ZA3058); and after 1941 the common valve designation of CV1091 (and later CV1578) was used. Cossor produced an equivalent as the 63SPT, as did Marconi-Osram with the Z90, and these companies supplied the valves into government and commercial equipment. The GPO also used the valve, and gave it the part number VT-207. See Reference 1 for more information on the EF50.

Basis of my radio design

There have been several all-EF50 TRF receiver designs published in amateur radio magazines over the years, and I wondered whether one of these had formed the basis of my radio. I was familiar with 'The Versatile EF50' by J B Willmott, published in Practical Wireless for September 1965, so my first move was to dig out this article. This was rather late in the lifetime of the EF50, but as the author wrote in the mid-1960s: 'EF50 valves are obtainable at almost give-away prices, frequently as little as 1s 6d each' and so the valve was still a low cost candidate for inclusion into a radio. The article describes the use of the EF50 in many circuits, including detectors (with and without reaction); audio amplifiers; phase splitters; and audio output stages, but does not show a complete aerial-to-speaker radio design, though of course the constructor may have joined the stages together himself.

A search on the internet brought up a few links to TRF receivers based on the EF50. The best candidate was 'Midget Three-Valve AC Mains Receiver' by S W Amos, published in Wireless World for February 1950 (Reference 2). The design was described in detail and covered the long and medium wave bands using Denco type 'C' dual-band coils. I have this issue of the magazine and so I made a copy to refer to as I examined my radio in detail. Figure 4 is the schematic of this radio, taken from the article.

References to other EF50-based TRFs can be found at the end of this article.

The chassis

I removed the three knobs and the two woodscrews that were holding the chassis in the cabinet. The chassis, made from thin steel, painted grey and still generally in good condition with just a few spots of rust, slid out backwards complete with its tuning dial and the 4-inch diameter loudspeaker. The tuning cord had broken and so I removed the dial to get behind it to carry out the re-stringing, which was an easy job. The dial, which looks like a commercially-produced standard item, had suffered some rubbing by the pointer over the years, and when I touched the printed writing, more rubbed off. So I very carefully cleaned the areas around the writing and left the rest alone. I'll keep an eye open for a replacement dial, perhaps from a scrap domestic radio.

On top of the chassis, a neat Stern type 653M mains transformer was present. Often on radios of this vintage, the mains transformer only provides the 6.3V supply for the valve heaters, and the HT supply is derived directly from the mains, resulting in a live chassis arrangement. However in this case, the chassis is isolated from the mains, the HT being generated from the transformer's secondary winding via

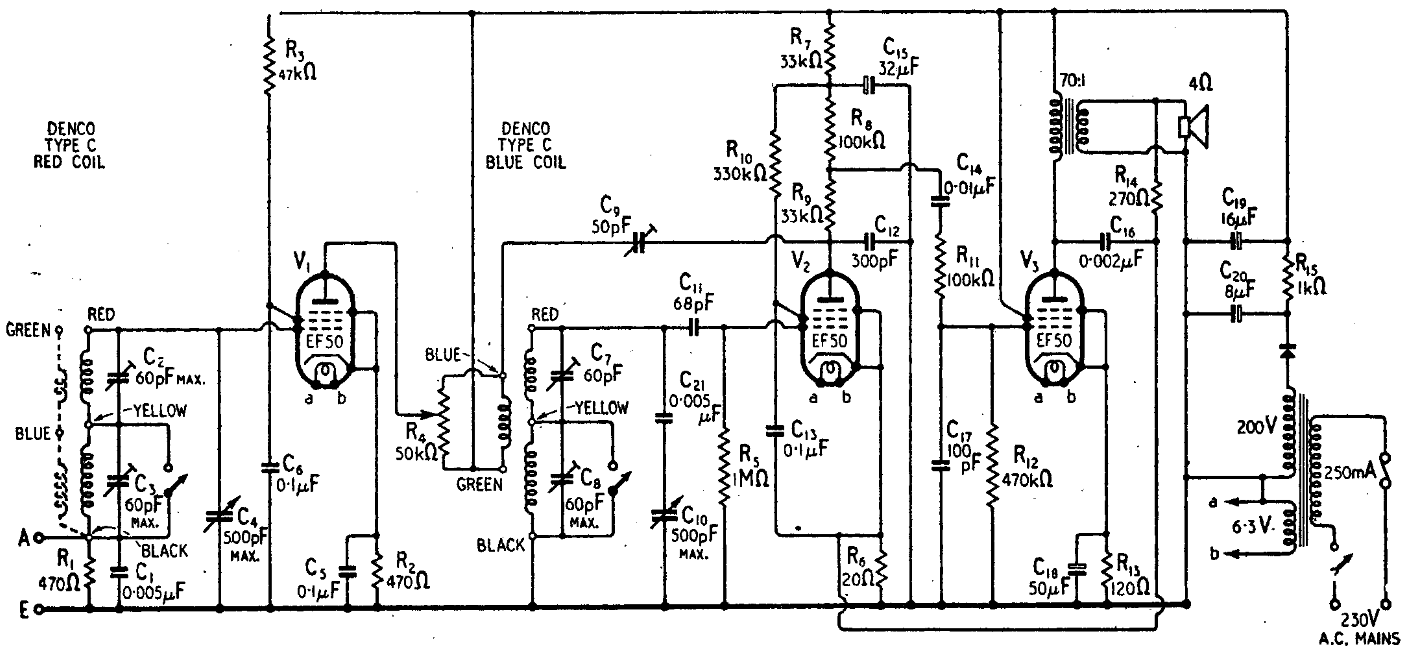


Fig. 1. Complete circuit diagram with component values. All resistors can be of ¼-watt rating.

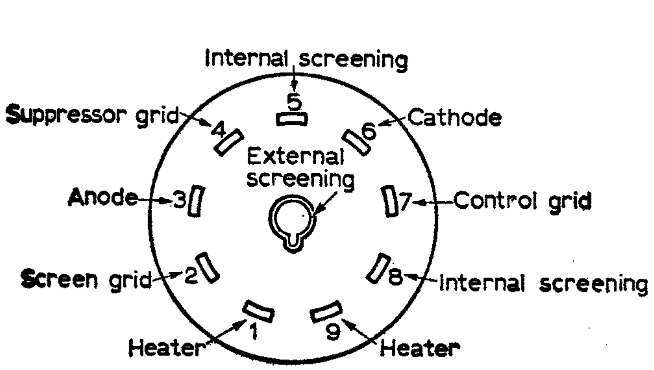


Figure 4 (above): Schematic of the 'Midget Three-Valve AC Mains Receiver' from Wireless World for February 1950. The design used Denco type 'C' coils, and turned out to be the design followed by the constructor of my radio.

Figure 5 (left): Base connections of the EF50. Note that pins 5 and 8 are connected to internal screens, and the centre spigot is connected to the external aluminium casing of the valve.

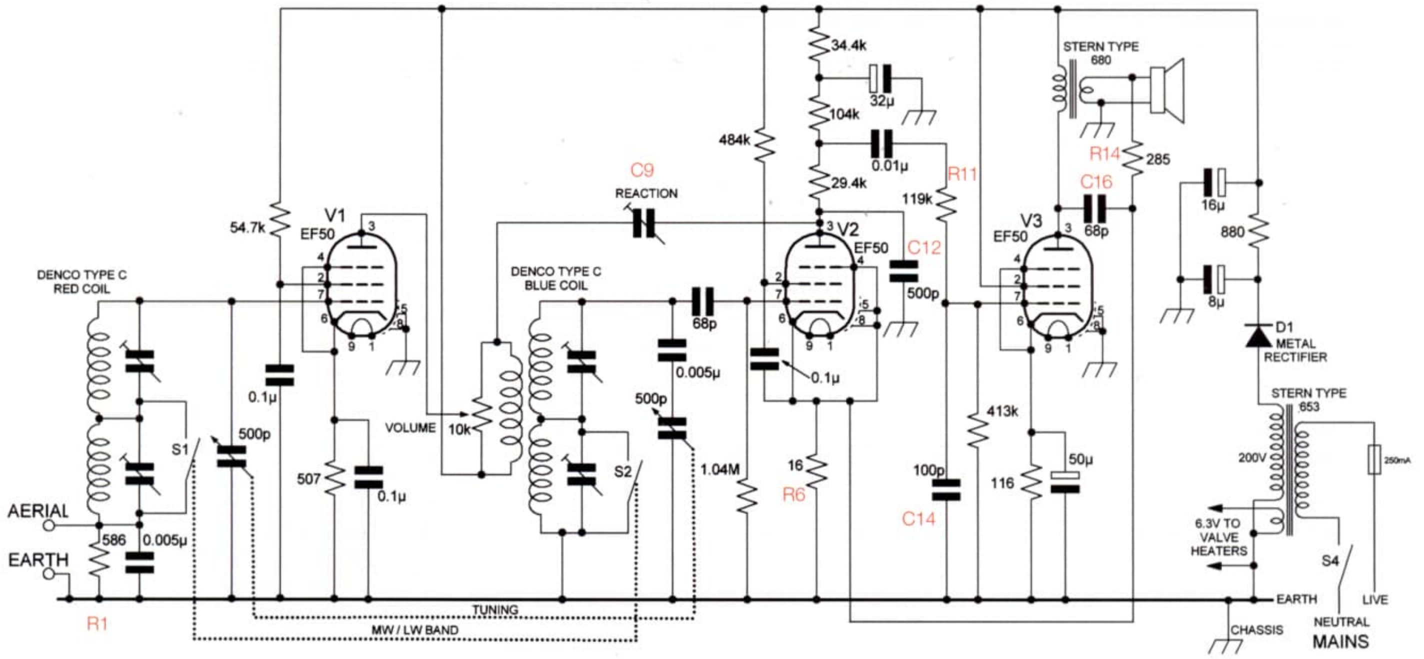


Figure 6: Schematic of my EF50 radio. The resistor values shown are as measured on the components fitted, and hopefully their nominal values can be deduced.

the selenium metal rectifier, and the 6.3V LT comes from another winding on the transformer. Although the wiring under the chassis was rather untidy, it looked safe. The mains lead was in reasonable condition and was equipped with a modern plug fitted with a 5A fuse. As there was also a 250mA mains fuse mounted under the chassis, I decided to plug the radio in and give it a try.

I fitted some temporary knobs and gingerly switched the radio on, and it immediately tripped my mains RCD. Neither of the mains fuses on the chassis or in the plug had blown, and so it looked like a leakage to mains earth had caused the trip, rather than an overload. I verified that the earth pin on the mains plug was connected to the radio's chassis, and measured the insulation resistance between the live and neutral pins of the mains plug to the radio's chassis. This indicated about 0.3MΩ at 500V, which looked pretty poor, and I concluded that this leakage was the reason for the RCD trip.

I probably could have disconnected the mains earth from the chassis and got away with it, but I wanted a better and safer fix. I decided to disconnect all the leads from the mains transformer, remove it from the chassis and repeat the resistance measurements with the transformer standing on its own. This would also give me the chance to tidy up the mains and power supply wiring, which was a dire mess. The transformer still showed leakage from the primary winding to its case, but worse – the secondary HT winding was open circuit. I couldn't see any obvious and repairable reason for the open circuit, and so it was into the bin with that transformer. Luckily I had a very similar Stern transformer which I picked up at a radio meeting a few years ago: it still has its price written on it – a bargain at £1. Tests of this transformer went well, and I knew it was suitable for when I reconstructed the chassis.

Schematic

I wanted to draw the schematic of the radio, so I started at the audio output stage and traced the circuit back towards the front end, carefully checking the connections to all the components, and measuring the values of the resistors as I came across them. I used the EF50's base connections shown in Figure 5 as a reference to the pin numbering. The resistors were a mix of colours, sizes, manufacturers and power ratings, and all but one were sufficiently close to their nominal values to be left alone. Assuming an HT current of say 20mA (to be measured later), R15, the 1kΩ HT smoothing resistor (which measured at 880Ω), seemed to be under-rated as a ¼W component was fitted, and so I replaced it with a 1W resistor.

As I proceeded, the similarities to the February 1950 Wireless World design became obvious, especially in the way feedback is applied from the secondary of the audio output transformer to V2, and in the circuitry around the anode of V2. The chassis-mounted 250mA fuse holder in the mains connection was another give-away. In the end I concluded that this was indeed the radio that had been built. Figure 6 shows the schematic of my radio, and the close similarities to the Wireless World design can be seen.

The first EF50 is a conventional RF amplifier whose grid is coupled to the input tuned circuit which uses an off-the-shelf Denco type C red coil. The type C coils are air-cored and chassis mounted, rather than Denco's more familiar plug-in octal or B9A-based coils. Because the EF50 has a high gain, an unconventional method of attaching the aerial – shunt capacitance coupling, which has a low voltage gain – could be used. According to the author of the original article, this coupling method gives high selectivity and minimises the effects of different lengths of aerial. R1, at 470Ω, preserves the DC continuity to ground for the grid of V1.

The EF50 is not a variable-µ valve and whatever method is used to control the gain of the RF stage, it must not overload V2, the second EF50, which forms the leaky-grid detector. The anode of V1 drives the wiper of a 50kΩ potentiometer which is connected across the primary of the inter-stage transformer - a Denco type C blue coil. By adjusting the potentiometer, the amount of RF signal at the anode which appears across the coil is varied, and hence the signal level into the detector stage is controlled. Reaction is also applied to this coil from the anode of V2 via the pre-set capacitor C9. You can tell that the radio was intended for domestic use as the reaction control was not mounted on the front panel, where it would have been useful to vary the sensitivity and selectivity of the radio, but would have needed an 'expert' to use it correctly.

The two Denco type C coils have medium and long wave windings: the long wave coil is shorted out by the wave change switch when medium wave coverage is selected.

When an RF pentode is used in the audio output stage of a radio, care must be taken with post-detector filtering to ensure that no RF reaches this final stage. In this design, C12 shunts RF from the detector stage to ground, and further attenuation is provided by R11 and C14. Finally C16, connected from the anode of V3 to the cathode of V2 gives considerable negative feedback at radio frequencies without affecting the performance at audio frequencies. A fixed amount of voltage negative feedback, provided by R6 and R14, is used in the audio amplifier stage. According to the original article, this helps eliminate mains hum and allows smaller values of HT smoothing capacitance to be used.

HT is generated from the secondary winding on the mains transformer by a conventional half wave metal rectifier and capacitor-resistor smoothing.

Restoring the chassis

The Bakelite B9G sockets used in my radio looked to be of rather low quality, especially the connection to the centre spigot of the valve. I was thinking that maybe I'd have to change at least one of the sockets, but in the end, this was not necessary.

I changed the three Hunts 0.1µF and 0.01µF capacitors as I had no faith in them

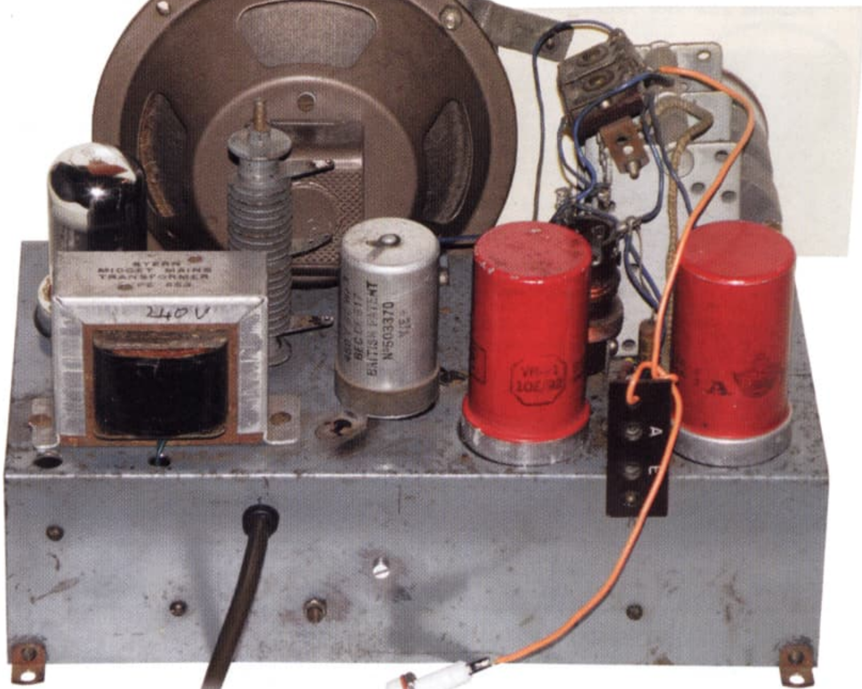


Figure 7 (top right): Rear view of the EF50 radio chassis after restoration. The three Sylvania VR91s are prominent, along with the replacement mains transformer and a vertically-mounted metal rectifier, which is no longer in circuit, its place having been taken by a modern 1N4007 diode. Two of the VR91s have their standard bright red cases, but I've left the case off the third valve, which works perfectly well in this state. The orange wire is an aerial connection, I think added sometime after the original building of the radio.

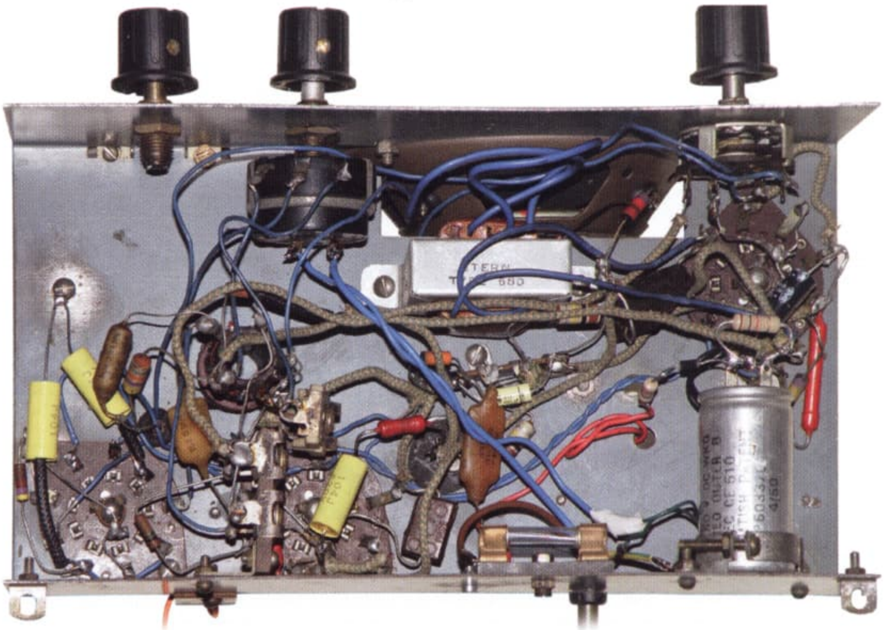


Figure 8 (centre right): Under chassis view of the restored radio. The Stern audio output transformer can be seen centre-chassis towards the top of the view, to the right of the volume potentiometer. The wiring is still rather untidy, but safer than it was originally.

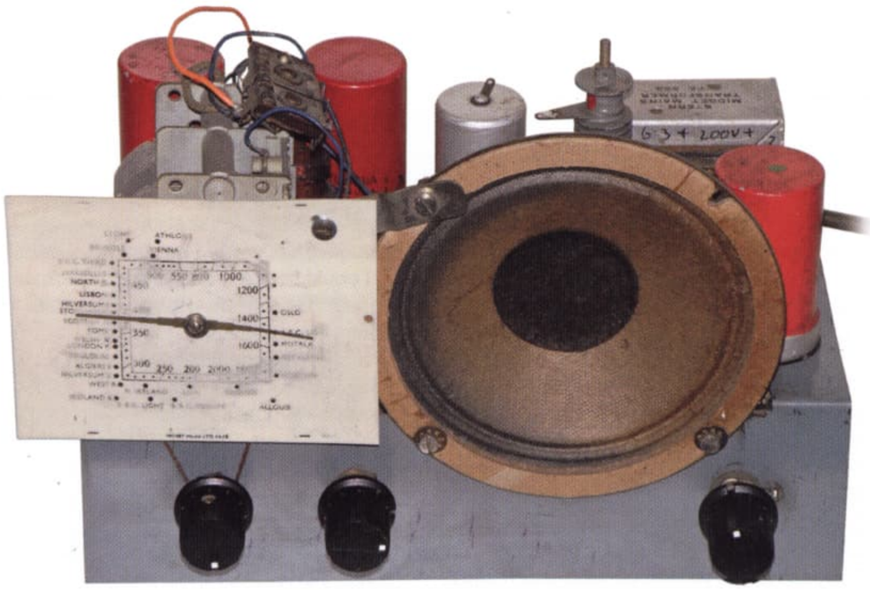


Figure 9 (lower right): Front view of the radio's chassis after restoration. Eagle-eyed readers may have spotted that in this view, all three VR91s still have their red cases. The rubbing of the dial markings can be seen: I'll keep a look out for a replacement dial from a domestic radio with the same format.

still being leak-free. I discarded V3's cathode resistor bypass electrolytic and fitted a modern low voltage 47µF equivalent. I removed the 8µF + 16µF HT smoothing electrolytic can (a BEC component dated 4/50) from underneath the chassis and tried the two capacitors on my capacitor reformer. To my delight both sections were good, with very little leakage current at 250V. The positive connection to the 32µF HT decoupling electrolytic in V2's anode supply was difficult to get to but I eventually managed to remove the component leads connected to it and connect it to my reformer. Again, this capacitor turned out to be good, with very little leakage current, and so was connected back into circuit.

I fitted the replacement Stern mains transformer, which only needed a slight adjustment of its mounting holes to fit onto the chassis. I also took the opportunity to drill a couple more holes in the chassis to better accommodate the wires to and from the transformer, which previously had all been stuffed through a single, rather small, hole. Leaving the original component in place, I replaced the function of the metal rectifier with a 1N4007 1000PIV 1A diode, and included a 220Ω resistor in series to limit the initial surge current into the 8µF section of the smoothing electrolytic. I replaced the mains lead and opened up the hole where it passed through the rear of the chassis so that I could fit a rubber grommet, which wasn't fitted originally.

The resistance of the output transformer's primary winding was 395Ω, and its secondary measured at about 0.5Ω, and so the component looked good. The speaker had a DC resistance of about 3Ω, indicating that electrically at least, it was also good, and probably of 4Ω impedance. The volume control potentiometer measured at 66kΩ, but this was close enough to its nominal 50kΩ value to give it a try.

Switch on

I checked the heater continuity of the three valves and they were all about 3.5Ω cold, and so looked good. I inserted them into their sockets, and after a careful check around the chassis, plugged in an aerial and switched on. Tuning around, no stations could be detected on either band and only a faint presence could be heard

DESIGNS FOR THE HOME CONSTRUCTOR

THE "MINI FOUR".—A 4-valve Battery Superhet Receiver, designed by "Practical Wireless" to receive 4 Pre-Set Stations, no tuning being necessary. The complete Receiver can be built for £9/10/0 (plus case, 15/6). Send 1/6 for Assembly Instructions, Layouts and Component Price List.

THE "MINI TWO-THREE."—Complete diagrams and layouts from which either a T.R.F. 3-valve set or a 2-valve set (afterwards easily converted to the 3-valve) can be made for £5/3/0 or £4/3/6 respectively (plus case, 15/6). Full Instructions, Layouts and Component Price List, 2/-.

THE "MINI TWIN."—The ideal set for the beginner! A simple 1-valve 2 stage Battery Set covering Long and Medium Wavebands. Can be built for 37/6, plus 9/6 for attractive Plastic Case and 14/9 for suitable headphones.

Complete instructions, layouts and price list 1/3

THE "WIRELESS WORLD" 3-VALVE SET

A Midget 3-valve T.R.F. Receiver for operation on A.C. mains, covering long and medium wavebands.

We are able to supply all of the components to build this set, as designed, and specified in the Feb. 1950 issue, including the drilled chassis, valves and moving coil speaker, etc., at the following prices :—

To construct complete chassis, less dial and drive assembly, £5/5/0. Ditto, including dial and drive assembly, £6.

To construct the complete Set, including dial and drive assembly and cabinet, £7/3/6.

Overall size of cabinet is 7¼in. x 5¼in. x 11¼in.

A reprint of the designer's article, giving Circuit and Assembly Instructions (this is available separately for 9d.), together with a Practical Component Layout is included with each of above assemblies.

A QUALITY "PUSH-PULL" AMPLIFIER KIT

A Kit of Parts to build a 6-8 watt Push-Pull Amplifier for operation on A.C. mains 200-250 volts.

Incorporates a simple arrangement to enable either a magnetic, crystal, or lightweight pick-up to be used.

A 10-watt Output Transformer is designed to match from 2 to 15 ohm speakers, Tone control is incorporated. The overall size of the assembled chassis is 10in. x 8in. x 7½in. high. Price of kit complete in every detail, including drilled chassis and valves, £6/12/6. Component layout is supplied.

Price of assembled chassis, supplied ready for use, £8/2/6. Instructions, layouts and price list 1/-.

"PERSONAL SET" BATTERY ELIMINATOR

A complete kit of parts to build a Midget "Alldry" Battery Eliminator, giving approx. 69 volts and 1.4 volts.

This Eliminator is for use on A.C. mains and is suitable for any 4-valve Superhet Receiver requiring H.T. and L.T. voltage as above, or approx. to 69 volts.

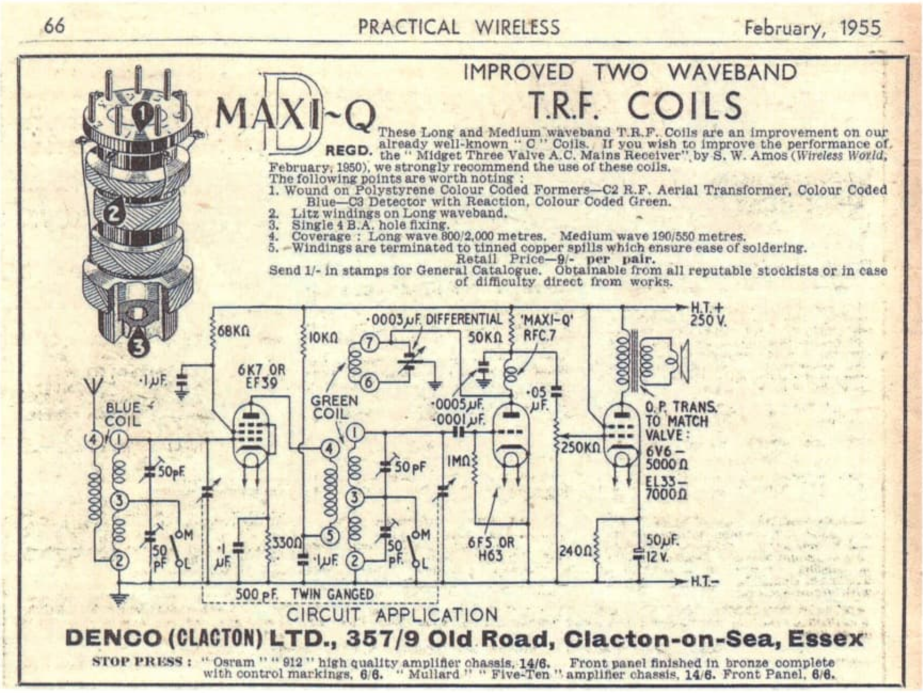
The kit is quite easily and quickly assembled and is housed in a light aluminium case, size 4⅝in. x 1⅜in. x 3⅛in. Price of complete kit, with easy to follow assembly instructions, 42/6.

In addition we can offer a similar COMPLETE KIT to provide approx. 90 volts and 1.4 volts. Size of assembled Unit 7in. x 2½in. x 1¼in. Price 47/6.

★ *Send 9d. P.O. for our STOCK LIST, showing many KITS OF PARTS for Sets and Battery Chargers and "hundreds" of Wireless Components. When ordering please include 1/6 to cover cost of postage and packing.*

STERN RADIO LTD., 109 & 115, FLEET STREET, E.C.4. Telephone : CENtral 5814 & 2280

Figure 10: Stern Radio's advert in the November 1952 issue of Practical Wireless.



IMPROVED TWO WAVEBAND

MAXI-Q REGD. **T.R.F. COILS**

These Long and Medium waveband T.R.F. Coils are an improvement on our already well-known "C" Coils. If you wish to improve the performance of the "Midget Three Valve A.C. Mains Receiver" by S. W. Amos (*Wireless World*, February, 1950), we strongly recommend the use of these coils.

The following points are worth noting :

1. Wound on Polystyrene Colour Coded Formers—C2 R.F. Aerial Transformer, Colour Coded Blue—C3 Detector with Reaction, Colour Coded Green.
2. Litz windings on Long waveband.
3. Single 4 B.A. hole fixing.
4. Coverage : Long wave 800/2,000 metres. Medium wave 190/550 metres.
5. Windings are terminated to tinned copper spills which ensure ease of soldering.

Retail Price—9/- per pair.

Send 1/- in stamps for General Catalogue. Obtainable from all reputable stockists or in case of difficulty direct from works.

CIRCUIT APPLICATION

DENCO (CLACTON) LTD., 357/9 Old Road, Clacton-on-Sea, Essex

STOP PRESS : "Osram" "912" high quality amplifier chassis, 14/6. Front panel finished in bronze complete with control markings, 6/6. "Mullard" "Five-Ten" amplifier chassis, 14/6. Front Panel, 6/6.

Figure 11: Denco's TRF design in an advert in the February 1955 issue of Practical Wireless.

from the speaker. I gave the wavechange switch a spray, but this made no difference.

Since I'd given the radio major surgery in the power supply area I monitored the HT voltage and noted that it was barely 2V! - a quick switch off before too much damage was done. After unplugging from the mains, I measured the resistance between the HT line and the chassis which was only a worryingly few ohms. The replacement mains transformer's secondary winding had been saved by the 1kΩ HT resistor. Poking around the wiring, especially on the valve sockets, I could see that there was an intermittent short circuit close to the base of V2. The original soldered joints were very 'blobby' and I think two of these joints were shorting together. Resoldering and easing the joints well apart seemed to fix this, so I was ready to try again.

This time things were much better, and a check on the HT voltage showed about 260V while the valves were warming up, settling to 190V when they were fully operating and taking anode and screen current. The voltage drop across the 1kΩ HT resistor was 14V, indicating an HT current of 14mA, a little lower than my original estimate, but very reasonable. Mr Amos had got his sums right in 1950: a ¼W resistor was suitable, though it would have run rather warm.

I could hear a French station (probably Allouis in Paris) and adjusting the volume control brought it to a good volume, though if turned up too far, a whistle was produced, indicating that the amount of reaction feedback was affected by the volume setting. Tuning higher in frequency produced Radio 4 at very good volume and quality, so I was sure that the wavechange control was set to the long wave.

Switching to the medium wave produced Radio 5 Live on 693kHz, which is always very loud in my area. The gain of the RF amplifier stage is not controlled but I never found any overloading effects in this stage, and audio quality was always very good as long as the volume potentiometer was adjusted correctly. Tuning towards the high frequency end of the medium band produced more stations, but they were not very well separated. Mains hum on the audio was undetectable, so the HT smoothing arrangements were working well, as was the hum-cancelling audio negative feedback.

As well as the aerial and earth sockets fitted onto the chassis, the radio had an orange wire dangling out of the back and so I tried connecting the aerial to this wire: the volume level improved considerably. I traced the connection to the wire and it was connected to the 'top' of the input coil. Connecting the aerial to this point negated the advantages of the original method (if you recall, to improve selectivity and to reduce the effects of using various aerial lengths) but increased sensitivity. It may be that as the valves aged, the owner decided that the radio was becoming rather 'deaf' and the added gain of top coupling was more important than any negative effects on selectivity.

From the stations I could receive and their positions on the dial, the radio was fairly accurately calibrated and aligned, and so I resisted the temptation to start fiddling with the trimmers and try to improve matters.

Figure 7 shows a rear view of the radio's chassis after restoration. The three Sylvania VR91s, with their bright red cases, are prominent, along with the replacement mains transformer and the vertically-mounted metal rectifier, which is no longer in circuit, its place having been taken by a 1N4007 diode. The restored under chassis can be seen in Figure 8. The wiring is still fairly untidy, but safe. Figure 9 is a front view of the chassis after restoration, before re-insertion back into the cabinet.

Tracking down a kit

Towards the end of this restoration, browsing through some early 1950s issues of Practical Wireless revealed an advert for a kit by Stern Radio of Fleet Street (see Figure 10), which is clearly for this radio, and the full kit could be bought for £7 3s 6d. The cabinet of the radio in the advert is definitely the rather naïve one used for my radio. The advert confirms my research that the design was published in the February 1950 of Wireless World.

Summary and conclusions

This radio, using three EF50 equivalents in its RF amplifier, detector and audio output stages, represents a state of the art domestic TRF design of the early 1950s, a time when this receiver type had fallen out of favour with most commercial manufacturers. Of course the EF50 itself was rather long in the tooth by this date, but had the advantages of being very cheap and easy to obtain.

Wireless World would never have published a standard TRF design, and the author had incorporated some clever features which made it worthy of publication in this professionally-read magazine. After making a neat job of mounting the components on the chassis, the constructor had wired the radio rather untidily. Research into some 1950s magazines showed that the radio was built from a kit, and the neatly-constructed cabinet was supplied ready-built. The resulting radio has survived something like 60 years, and after the renovation I applied to it, will hopefully last for many more.

I think I'll try to pick up some 'new old stock' EF50s and give them a try in the radio. The ones fitted could have had a long operating life and may not now be at full emission, resulting in the rather 'deaf' state of the radio when fed by an aerial in the originally intended mode.

References

Reference 1: The National Valve Museum at: http://www.r-type.org/search.php contains much information on the EF50 and its equivalents, and many other valves.

Reference 2: The 'Midget Three-Valve AC Mains Receiver' article, by S W Amos, can be seen at: http://www.vintageradio.me.uk/radconnav/ef50_3valve.htm

Other EF50 TRF Receiver Designs
'Midget AC Mains Receiver' by S W Amos, published in Wireless World for March 1949. The design used two EF50s in the detector and audio output stages. This was the design improved upon in the February 1950 article.

'TRF Ham Receiver' by J N Walker of Stratton & Co, published in Australasian Radio World for April 1949. The design used three EF50s in the RF amplifier, detector and audio output stages, and uses Eddystone type 706 ready-wound coils. The article can be found on the Eddystone User Group website at: http://www.eddystoneusergroup.org.uk/

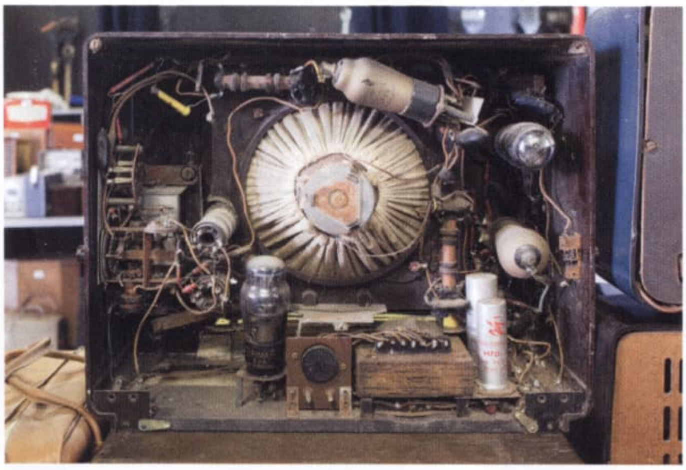
'A Tuning Unit' in Query Corner of Radio Constructor for April 1952. The design used two EF50s in the RF amplifier and detector stages, producing an audio output for feeding into an audio amplifier.

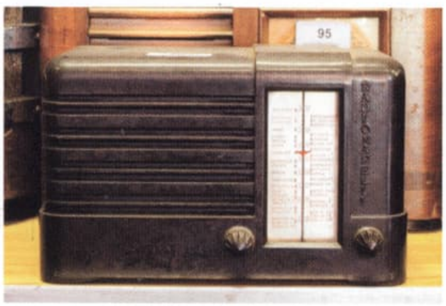
'Sensitive Two-Valve Receiver' by H E Styles, published in the May 1953 issue of Wireless World. This EF50-based design is interesting in that it runs the regenerative detector at a very low HT voltage, such that its anode could be DC-coupled to the grid of the audio output stage. The design was claimed to be so sensitive that it needed no external aerial, relying on its own wiring to pick up signals.

'Making a Sensitive Two-Valver' by R Berry, published in the August 1955 issue of Practical Wireless. The design used an EF50 regenerative detector stage in front of the EF50 audio output stage, and a metal rectifier in the power supply. A Wearite PHF2 coil was used in the front end.

Denco published its own TRF design as an advert in the February 1955 issue of Practical Wireless, see Figure 11. The coils used were coded C2 (blue - aerial) and C3 (green - detector coupling, plus reaction) and were replacements for the C coils used in the February 1950 Wireless World design.


Harpenden auction lots
A small selection of what was on offer photographed by Carl Glover





Negative reaction by Carl Glover

For many years I have been collecting slides and negatives from all eras due to an interest in how we used to live. On these pages are a sample of images which feature wireless in one way or another. It is fascinating to see the once-futuristic equipment in brand new condition.

Detail of main photograph


Richmond
Music
Home


CARTE DE FRANCE
FRANCE

Selecting HT power supply replacement capacitors

by Stef Niewiadomski

When the HT power supply electrolytics inside a piece of vintage equipment are beyond saving, there is often the need to replace them with new ones, either mounted in full view under or above the chassis, or 're-stuffed' into the original capacitors' cases. Capacitors with the correct capacitance and working voltage rating are available from the BVWS, on eBay, and I sometimes use ESR Electronic Components Ltd (see Reference 1), but another important parameter of any substitute capacitor is its ripple current rating. You often see advice saying 'be sure to use capacitors with adequate ripple current rating', but with very little (or no) advice on what ripple current rating is needed for the various power supply configurations, be they half or full-wave, and designed for UK or US mains voltages, and for various DC current values supplied by the power supply.

Figure 1: A vintage Hunts 32µF 275V electrolytic (front right) marked with its 250mA ripple current rating, alongside a few modern high voltage axial electrolytics, and an F&T (Fischer and Tausche) 16µF + 16µF 500V can electrolytic, which can be purchased from the BVWS Spares Department. This capacitor is of the 'old fashioned' size and fits directly into the mounting clamp of old capacitors.

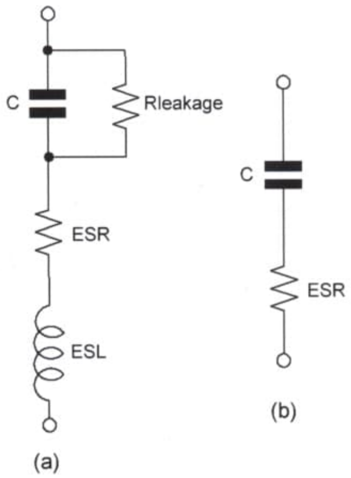


Figure 2: A generally accepted model of a capacitor (left), and the simplified model that can be used in most power supply applications (right).

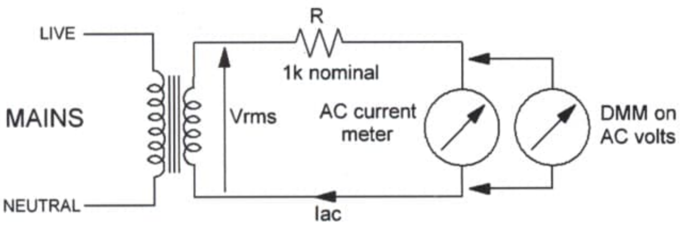


Figure 3: A simple circuit used to test my ability to measure AC current.

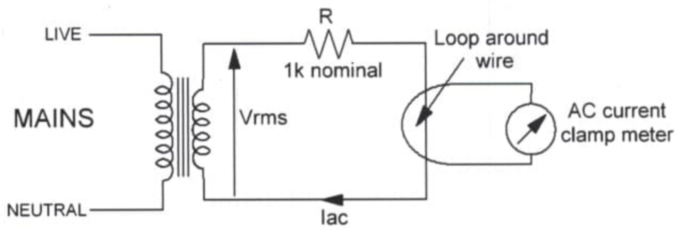


Figure 4: A less invasive method of measuring AC current, using a clamp meter.

The purpose of this article is to show some work I've done on measuring capacitor ripple current, and comparing this to what would be expected by calculation and simulation. The aim is to give some rules of thumb which allow the restorer to estimate ripple current for different power supply types and load currents, and therefore to be sure that the replacement capacitors are suitable and will give a long service life. I also want to discuss some capacitor specifications, such as operational and storage lifetimes, which can give rise to concern unless they are properly understood. If you find the going rather 'heavy', then just skip to the Recommendations section towards the end. Hopefully they will be useful to you without all the theoretical background to how I derived them.

Figure 1 shows a Hunts electrolytic capacitor salvaged from an old radio, which very helpfully has its rated ripple current printed on its case, alongside a few modern high voltage electrolytics. The Hunts capacitor is definitely from an HT smoothing application, and so you might expect that the value of 250mA gives us some idea of the value needed in this application. Sadly most capacitors do not have their maximum ripple current marked on their cases. Generally speaking, Hunts capacitors have a bad reputation and I would reform and measure the capacitance of this one before I used it in a restoration project.

Capacitor Model

A generally accepted model of a capacitor is shown in Figure 2(a). The ideal capacitance is represented by C, and the other components in the model are parasitic effects caused by the real-world construction of the capacitor. Sometimes a zener diode is added to the model - across the ideal capacitance - to represent the over-voltage and reverse voltage behaviour of the capacitor, but I have omitted this here in the interest of simplicity.

The resistor, Rleakage, across the ideal capacitor, models DC leakage current, which for a healthy electrolytic is typically less than 500µA when the capacitor is operated at its maximum rated voltage. Manufacturers often quote one minute and five minute leakage currents (see Reference 2), the five minute value being about half the one minute value, implying that the electrolytic tends to self-heal any internal microscopic breakdowns in the dielectric insulation material, rather like the reforming process that we sometimes consciously apply to old capacitors (see Reference 3). As long as the capacitor is kept relatively cool and is operated with some margin away from its maximum voltage rating, this leakage current can be ignored, and the resistor removed from the model.

The equivalent series resistance, ESR, is the result of the metallic resistance of the leads and electrodes, and losses in the dielectric of the capacitor. Although ESR is frequency-dependent, it is usually regarded as being purely resistive. On capacitor data sheets, ESR is sometimes presented in an indirect way: the quantity tan δ is specified, and δ is often referred to as the loss angle. Tan δ is related to ESR via the formula:

ESR = tan δ / 2πfC
where f is the frequency in Hz,
and C is the capacity in F.

Meters are available (for example the Peak ESR60 Atlas) that can measure ESR (and capacitance) directly. However it may not be possible to control the frequency at which the measurement is taken, and it is generally measured at the industry standard frequency of 100kHz.

Every conductor has the property of inductance, and the equivalent series inductance, ESL, is the sum of all the inductive elements used in the capacitor (including its leads). Luckily for us, the ESL of a typical electrolytic is 50nH or less (see Reference 2), and at the frequencies we are considering here, can be ignored.

For electrolytics used in mains power supplies, the model therefore simplifies to Figure 2(b), which is much more manageable for simple analysis and calculation. Any AC voltage across a real capacitor 'sees' a complex impedance consisting of a capacitive reactance at the frequency of the AC source in series with a resistor of the value of the capacitor's ESR. See Reference 4 for a useful on-line calculator of a capacitor's reactance at any chosen frequency. Let's plug in some typical values and see what current flow through the capacitor for given applied voltages.

Let's say we have a 22μF capacitor which has its ESR specified as 4.1Ω (taken from Vishay data). At 100Hz the capacitor has a 72.3Ω capacitive reactance, and therefore the total impedance of the real capacitor is 72.3Ω<-90° + 4.1Ω<0°. This works out at 72.42Ω<-86.8°. Therefore if a 1V RMS sine wave is applied across the capacitor, an AC current of 1/72.42 = 13.8mA RMS will flow through it. For each RMS volt of AC, the capacitor will have to handle 13.8mA of current. To save you having to do the maths, Reference 5 is an on-line calculator for the combined impedance and phase angle of a capacitor and resistor in series.

The example above assumes that the capacitor is connected to a pure sine wave source, and of course this is rarely true, especially in a power supply where although there is typically a strong fundamental at 50Hz, 60Hz, 100Hz or 120Hz, harmonics at multiples of these frequencies will also be present, generated by the rectification process. All of these harmonics will contribute to the current through the capacitor, and ideally they should be calculated separately, and allowed for in the rating of the capacitor.

It can be seen that with a new and 'healthy' capacitor, the ESR has relatively little effect on the AC current through the capacitor, but it should be remembered that it's the ESR that causes a capacitor to dissipate power – an ideal capacitor will dissipate no power. An old electrolytic which has a high ESR (perhaps because the electrolyte has dried up, or leaked out) will warm up rapidly and perhaps explode dramatically.

True RMS

You sometimes see the phrase 'true RMS' with reference to measuring AC waveforms, so what does this mean? The RMS value of an alternating current is also known as its heating value, as it is the DC current which would have the same heating effect as the AC signal. Most low-cost instruments (for example, cheap handheld digital multi-meters) carry out this measurement by converting the input signal into an average rectified value and applying a correction factor. The value of the correction factor is valid only if the input signal is sinusoidal, which is not true for a rectified mains supply.

The true RMS value is actually proportional to the square root of the average of the square of the curve, and not to the average of the absolute value of the curve. For any given waveform, the ratio of these two averages is constant and, as most measurements are made on (nominally) sine waves, the correction factor assumes this waveform, but any distortion away from a sine wave will lead to errors. Although in most cases this produces adequate results, a correct measurement of non-sinusoidal values requires a more complex and costly conversion process, which can be found in instruments specified as performing 'true RMS' measurements, which are generally more expensive than 'normal' meters.

Measuring AC current

That's enough about the basic theory of AC current flowing through a capacitor. What we need are some simple rules of thumb that give us confidence that the capacitors we install in a power supply are up to the job, and so some measurements in real circuits would be useful.

Since I wanted to actually measure ripple current in some typical power supply configurations, it was necessary to investigate a few methods of measuring AC current, and checking if there are any drawbacks to the methods chosen. Ideally, as with any current measurement, what you need is a meter with effectively zero-Ω series resistance so that it doesn't affect the current in the wire being measured.

On eBay, for a fiver, you can buy good old fashioned analogue AC current meters (made in China, of course) and at first sight they look like the simplest way to measure this quantity. I rigged up a simple circuit (see Figure 3), supplying an AC voltage from the secondary of a mains transformer, the current limited by a nominally 1kΩ resistor (which actually measured at 947Ω) and a 100mA AC current meter measuring the current flowing in the circuit. I used a true RMS digital multi-meter (a UNI-T model UT61E) to measure the AC voltage across the current meter. With a secondary voltage of 56.7V, the AC meter indicated about 57mA, which looks about right, but the meter had a voltage of about 2.5V across it, indicating a resistance of about 44Ω. In this example, this 44Ω doesn't make much difference because it is pretty much swamped by the 947Ω resistor. However, in a circuit where the series resistance is much lower - as I expected would be the case when I got round to making measurements on smoothing capacitor circuits - this could be significant and it would change the value of the current, which of course is not what I wanted.

I also tried measuring the AC voltages using the AC volts range on a 'normal' DMM, that is, one that doesn't claim to measure true RMS. The readings were very close to those measured with the UT61E meter: this is to be expected, as I was measuring the amplitude of sine waves and therefore both types of meter should give the same result.

AC clamp meter

A less intrusive way of measuring current seemed to be desirable, and it would be nice to have the current measured to great accuracy and displayed to the nearest μA with great resolution in digital format. Clamp digital ammeters are available which measure current by detecting the magnetic field surrounding any conductor that is carrying current. The meter has a loop which opens, allowing the wire to be surrounded by the clamp, effectively acting as a single turn transformer when the loop is closed. The great thing about this kind of meter is that it is not connected in series with the current being measured and so does not affect the value of the current (OK, I admit that there's no way of measuring a quantity without affecting its value, but the effect with this type of meter should be negligible).

Most of these meters boast the ability to be able to measure up to 1000A (this may be useful if you want to measure the supply current to a large AC motor) which is rather high for what I wanted, and which implies that it probably measures lower currents with low accuracy and resolution, but I did find the UNI-T model UT210B, which has a lowest range of 2A, a good resolution, and claims to be accurate, so it seemed to be very suitable. Also this model measures and displays the true RMS value of the current flowing in the wire.

Figure 4 shows how this clamp meter was used to measure the current in my simple circuit. The secondary voltage measured 57.3V, and the clamp meter indicated 58mA, when set to its 2A range. 57.3V/947Ω gives a theoretical current of 60.5mA, and so it looks like the measurement was within reasonable limits of its actual value.

One way of making these clamp meters more accurate for low currents is to pass the wire being monitored through the clamp several times, thereby increasing the effective magnetic field being measured. I tried this with five turns passing through the loop, and the meter indicated 296mA: dividing this by five gives an actual current of 59.2mA, which is closer to what I would have expected to measure. By the way, I found that the clamp meter was sensitive to stray magnetic fields: it would give higher or lower readings as it was brought within a few inches of the mains transformer, depending on which way round its loop was orientated with respect the transformer's laminations, so you have to be careful when making these measurements using such a meter.

To further check the sanity of what I was doing, I used LTspice, available free-of-charge from the Linear Technology website (see Reference 6) to simulate the circuit in Figure 4. The software gave me an RMS current of 60.52mA, which agreed very well with the calculated value.

At the front end, LTspice has an easy-to-use schematic editor, and a very useful results display editor and post-processor where you can, for example, display the RMS values of waveforms, compute FFTs, and so on.

Figure 5

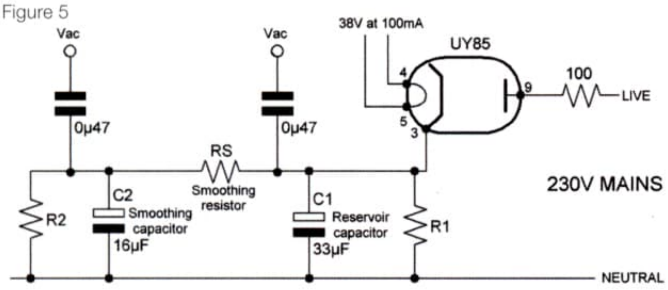


Figure 6

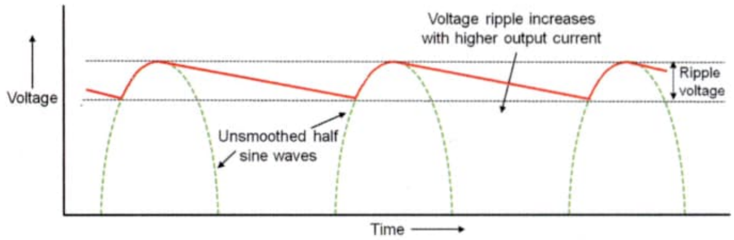


Figure 7 **Test results for UY85 half-wave rectifier on 230V UK mains**

Total DC output current	AC RMS current through C1	AC current through C1/ Output DC current	AC RMS current through C2	AC RMS voltage across C1	AC RMS voltage across C2
11.6mA	19.5mA	1.68	1.56mA	1.80V	0.36V
18.2mA	29.5mA	1.62	2.5mA	2.63V	0.50V
27.9mA	43.7mA	1.57	3.7mA	3.98V	0.75V
36.0mA	56.4mA	1.57	4.8mA	5.05V	0.95V
43.9mA	66.8mA	1.52	5.7mA	6.07V	1.14V
46.7mA	71.6mA	1.53	6.2mA	6.49V	1.22V

Notes:
All AC measurements were made using UNI-T 'true RMS' meters.
C1 is the reservoir capacitor: 33uF (measured at 33.39uF) 450V.
C2 is the smoothing capacitor: 16uF (measured at 16.19uF) 450V.
AC voltages across C1 and C2 were measured via 0.47uF DC blocking capacitors.
1kohm (nominal) smoothing resistor.

Figure 9

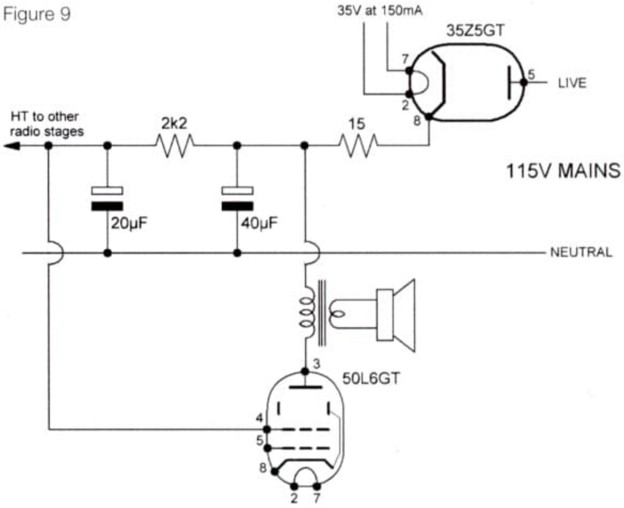


Figure 8

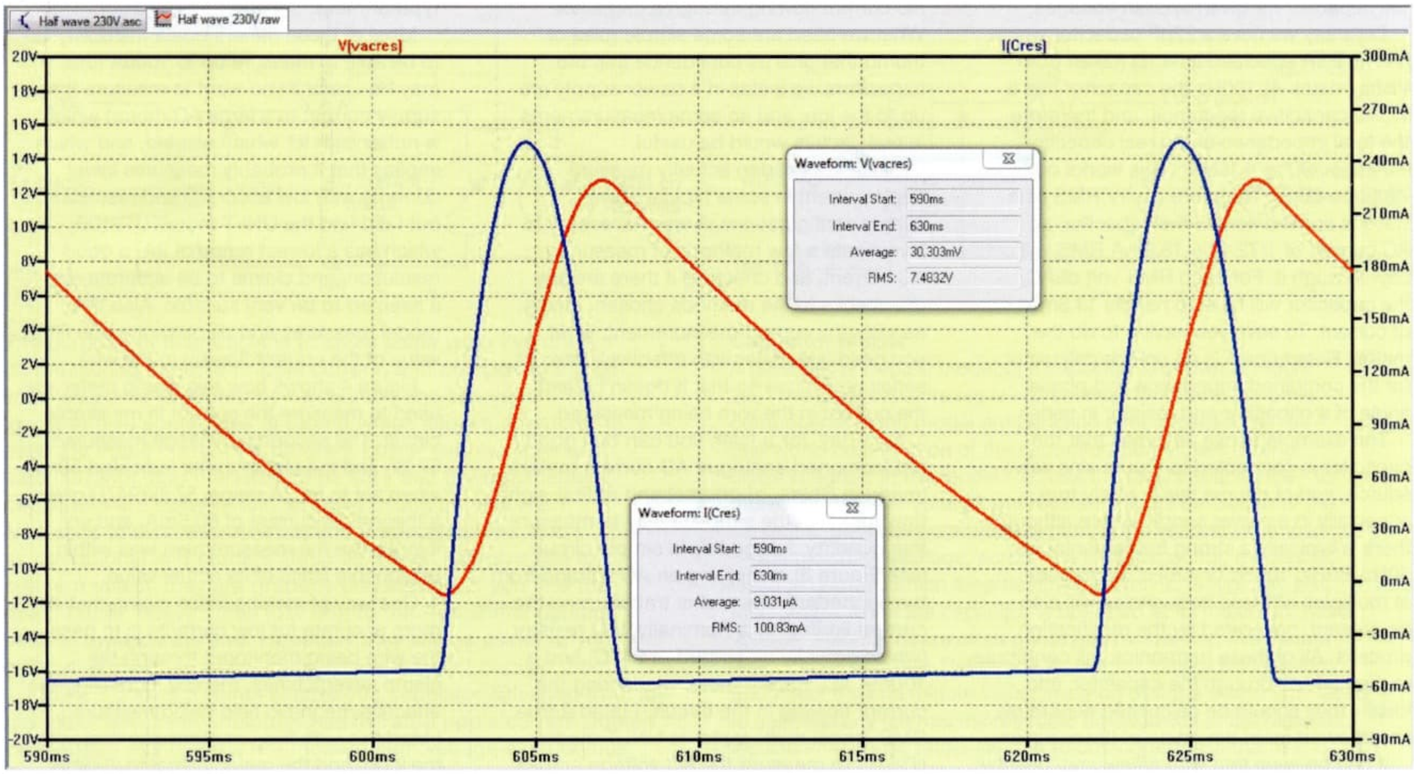


Figure 5: A typical generic UK 230V mains half wave circuit.

Figure 6: The half wave rectified waveform (in red) expected at the top of the reservoir capacitor.

Figure 7: Table of test results for the UK 230V mains half wave circuit.

Figure 8: LTspice plots of the current through (in blue), and the ripple voltage across (in red), a reservoir capacitor for the UK 230V mains half wave circuit.

Figure 9: A typical circuit of the US mains half wave power supply in the Arvin model 440T radio, using a 35Z5GT rectifier.

Series AC current DMM

Most cheap DMMs don't have AC current ranges, but I found another type of ammeter, namely the UNI-T model UT50A meter, which you connect in series with the AC current being measured. The operating manual for this meter states that the measurement voltage drop is 200mV for full range, which sounded acceptably low for the measurements I wanted to make.

So it was back to Figure 3 for the set-up for this meter, which indicated 59.8mA, when set to its 200mA range. This compares very well with the theoretical current of 60.5mA. I measured the voltage drop across the meter at 80mV RMS, which indicated that the meter is having very little effect on the current being measured.

I was happy now that I could use the UT210B AC clamp meter or the UT50A series AC current meter (or both) to make accurate measurements of the ripple current flowing through an electrolytic capacitor.

For those of you who possess analogue multi-meters, generally these do not measure the true RMS value of a non-sinusoidal waveform. For example, the AVO model 8 (which has useful looking 100mA, 1A, 2.5A and 10A AC current ranges) manual states: 'In as much as rectifier moving coil instruments give readings on AC proportional to the mean and not the RMS value of the wave form with which they are presented, they depend for their accuracy not only on their initial calibration, but also on the maintenance of a sinusoidal wave form. Since the form factor (RMS value divided by mean value) of a sine wave is 1.11, this has been taken into account in calibrating the meter which does, therefore, indicate RMS values on the assumption that the normal sine wave will be encountered'.

UK 230v mains half wave rectifier

It's commonly accepted that the toughest smoothing application (from the capacitors' point of view) is in a transformerless half wave rectifier circuit fed from the 230V UK mains. A typical generic circuit is shown in Figure 5, which I built to allow me to measure the relationship between DC load current and voltage ripple, and hence to the relationship to the capacitor's ripple current rating. Over the years many half wave valve rectifiers have been used in this application, and I used a UY85, simply because I had a couple to hand. The convention commonly used (and which I will use here) is that the capacitor connected to the cathode of the rectifier is called the 'reservoir capacitor' (C1 on Figure 5), and the capacitor connected to the other side of the smoothing resistor is the 'smoothing capacitor' (C2 on Figure 5).

The resistor RS can be thought of as a 'smoothing resistor' in that it forms a lowpass filter in partnership with C2. Many older radios have a choke of typically 5-10H fitted in place of the smoothing resistor, whose inductance gives a greater smoothing effect than a resistor, but which in itself may have a DC resistance of maybe 200Ω. Such a choke is very efficient at smoothing the HT supply, but was generally phased out of radios because of its high cost when compared to a resistor. The field winding on older loudspeakers, or part of the audio output transformer's primary may also be used instead of, or as well as, the smoothing resistor.

Many radios have the supply to the anode of the audio output valve – which is usually the highest current load from the power supply - fed from the reservoir capacitor, and therefore its current does not drop voltage (and waste power and generate heat) across the smoothing resistor. Some writers refer to this as feeding the output valve with 'raw' rectified AC, which isn't true. As you will see later, although there is often considerable voltage ripple at this point, the reservoir capacitor has a very useful smoothing effect which it carries out in association with the series resistance of the rectifier valve. All current to the other stages of the radio (including the screen grid of the output valve) is supplied by the smoothing capacitor. This allows the smoothing resistor to be higher in value (typically 10kΩ), and its filtering effect combined with C2 to be greater, and less HT hum is fed to the rest of the radio.

By adjusting the values of R1 and R2, I could vary the amount of current taken directly from C1 and C2: by omitting R1 altogether and setting RS to a lower value, I could emulate the case where all the HT current for the radio is taken from across the smoothing capacitor. The two 0.47µF capacitors are DC blockers which allowed me to measure the AC waveform at the 'tops' of C1 and C2.

I'm making the assumption that the original designers of the radio chose the correct values of reservoir and smoothing capacitors, and the smoothing resistor, and that the repairer is simply trying to restore the radio back to its original state in terms of the perceivable hum level (hopefully very low) at the audio output, as generated by mains ripple on the HT rails. Sometimes restorers try to 'improve' on the original design by increasing the value of these capacitors in an attempt to cure hum problems, and this rarely works: usually the hum is coming from somewhere else, though it's worth checking whether they have lost capacitance over the years.

The generally accepted waveform at the top of the reservoir capacitor is shown in Figure 6. The positive half cycles pump charge into the capacitor during their rising periods: during their falling periods and during the negative half cycles (when the rectifier is not conducting) charge is removed from the capacitor by any load attached to it, causing the voltage across the capacitor to fall. This rising and falling of the voltage across the capacitor represents an AC waveform (by no means a sine wave), which we know as ripple, sitting on top of the DC voltage. If the load were zero (and assuming a non-leaky capacitor) there would be no ripple, and the voltage across the capacitor would be pure DC. As the load increases, during the non-charging periods the voltage 'droops' more, and so we should expect some relationship between DC load current and voltage ripple. Since we know that voltage ripple results in AC current through the capacitor, we are on the way to determining how we should rate the capacitor for ripple current for a given value of DC current.

Measurements

Figure 7 is a table of test results for the UK 230V mains half wave circuit, with a 33µF capacitor fitted for C1 (measured at 33.4µF, remarkably close to its nominal value), and a 16µF capacitor fitted for C2 (measured at 16.2µF). I've simplified the way I've presented the results in the interest of clarity: for example, I measured and recorded separately the currents through R1 and R2 as I varied their values, whereas in the table I have summed these two currents together, shown as 'total DC output current'.

My finding was that it didn't matter whether the current was drawn by R1 or R2, it was the sum of these two currents that affected the AC current through C1, the reservoir capacitor. Column 3 of the table shows the calculated ratio between the AC current through C1 and the total DC output current, and this ratio was remarkably constant at between 1.68 (for low output currents) and 1.52 (for high output currents). I tried a couple of sets of values for C1 and C2, and this ratio remained fairly constant for these values.

Column 4 shows the AC current through C2, the smoothing capacitor: this was very low – between about 1.5mA and 6.2mA, and was always about one twelfth the AC current passing through the reservoir capacitor.

Columns 5 and 6 show the AC ripple voltage across C1 and C2 respectively. Row 3 shows an AC ripple voltage across C1 of 3.98V RMS for a current through C1 of 43.7mA – does this make sense? A 33.4µF capacitor has a capacitive reactance of 95.3Ω at 50Hz, and so ignoring the ESR of the capacitor (which I showed earlier was fairly insignificant) 3.98V RMS will result in an AC current of 41.8mA RMS through the capacitor. This calculated value is within about 5% of the measured value of 43.7mA on the UT50A current meter. The discrepancy in measured versus calculated current may be due to harmonics of 50Hz (which must be present since we do not have a pure sine wave), and of course some inaccuracy in the meter itself, contributing the extra 5% or so. It seems then that if we can't directly measure the AC ripple current through C1 or C2 (which is much less than that through C1), we can calculate the current fairly accurately by measuring the RMS value of the ripple voltage and dividing it by the capacitor's reactance at 50Hz. This probably sounds pretty obvious, but it's good to have shown the correlation between the directly measured ripple currents through the reservoir and smoothing capacitors, and their calculated values. If you are unable to measure the AC ripple voltage, measure the total DC current the power supply feeds into the radio (or check the service sheet) and multiply this value by 1.7 to give the worst case AC ripple current through the reservoir capacitor.

Simulation

Using LTspice, I simulated the circuit, using load resistors (R1 and R2) taken from a couple of the entries from the table in Figure 7. The Spice model for capacitors allows you to enter the capacitance, ESR,

Figure 10: A simplified version of the US mains half wave power supply.

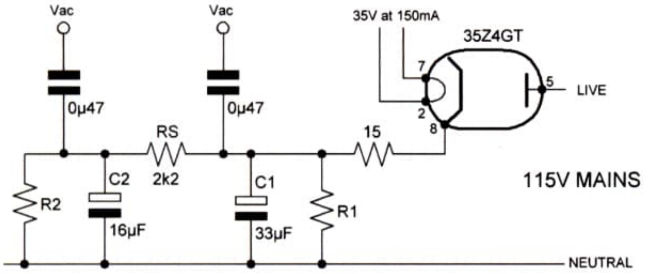


Figure 11 **Test results for 35Z4GT half-wave rectifier on 115V mains.**

Total DC output current	AC RMS current through C1	AC current through C1/ Output DC current	AC RMS current through C2	AC RMS voltage across C1	AC RMS voltage across C2
8.5mA	14.1mA	1.66	0.54mA	1.30V	0.08V
25.9mA	40.3mA	1.56	1.6mA	3.70V	0,23V
33.3mA	51.7mA	1.55	2.1mA	4.81V	0.30V
36.5mA	56.6mA	1.55	2.2mA	5.25V	0.33V
42.0mA	63.9mA	1.52	2.6mA	5.85V	0.37V
47.5mA	71.8mA	1.51	2.9mA	6.63V	0.42V

Notes:
All AC measurements were made using UNI-T 'true RMS' meters.
C1 is the reservoir capacitor: 33uF (measured at 33.39uF) 450V.
C2 is the smoothing capacitor: 16uF (measured at 16.19uF) 450V.
2k2 (nominal) smoothing resistor.
AC voltages across C1 and C2 were measured via 0.47uF DC blocking capacitors.

Figure 12: A typical full wave rectifier arrangement, with the rectified anodes driven from a centre-tapped mains transformer

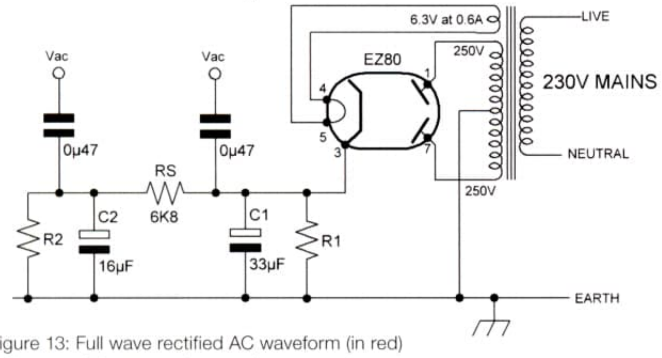


Figure 13: Full wave rectified AC waveform (in red) at the top of the reservoir capacitor.

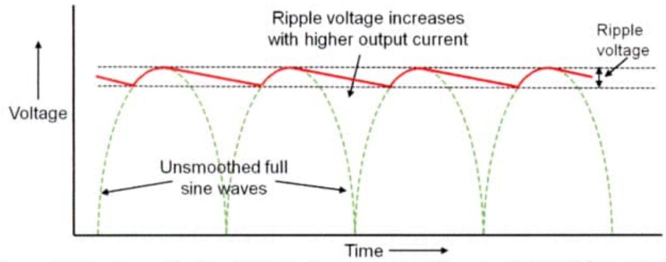


Figure 14 **Test results for EZ80 full-wave rectifier on 230V UK mains.**

Total DC output current	AC RMS current through C1	AC current through C1/ Output DC current	AC RMS current through C2	AC RMS voltage across C1	AC RMS voltage across C2
24.1mA	33.1mA	1.37	0.22mA	1.49V	0.05V
35.7mA	47.0mA	1.32	0.29mA	2.11V	0.06V
39.2mA	51.6mA	1.32	0.31mA	2.32V	0.06V
53.8mA	68.1mA	1.27	0.41mA	3.07V	0.05V

Notes:
All AC measurements were made using UNI-T 'true RMS' meters.
C1 is the reservoir capacitor: 33uF (measured at 33.40uF) 450V.
C2 is the smoothing capacitor: 16uF (measured at 16.26uF) 450V.
2k2 (nominal) smoothing resistor.
AC voltages across C1 and C2 were measured via 0.47uF DC blocking capacitors.

ESL and leakage resistance, and several other useful parameters you can use to model a real-world capacitor if you want to be very exact.

The results correlated well with the measured voltages and ripple currents, but I found that the exact values are rather sensitive to the value of the resistor in series with the ideal rectifier model. For the measurements I set this to 100Ω, but to this the hot resistance of the rectifier valve has to be added - which is difficult to estimate exactly - and is likely to depend on the age and condition of the valve, and the exact heater voltage at which it is being run. To get an idea of what this resistance might be, I measured the hot resistance for three examples of the UY85 rectifier (one each from Mazda, Mullard and Cossor: all were ex-equipment, so probably not in ex-factory condition) with anode DC currents of about 20mA and 40mA, and got values of between 125Ω and 170Ω.

For the simulations I set the resistor to 300Ω, to include an estimate of the rectifier's hot resistance in series with the 100Ω surge limiter resistor fitted to most radios in real life. The rectifier itself was represented by an ideal diode. One advantage of a simulator is that it allows you to view the current waveform through the reservoir capacitor, which is very difficult to monitor directly: using my experimental method I was only seeing its RMS value.

Figure 8 shows a plot from LTspice of the half wave rectifier circuit. The blue waveform is the current through the reservoir capacitor: the right hand axis is the scale for this waveform. The value of the current can be seen as about -55mA (that is, current out of the capacitor) for most of the time - 'drooping' as the capacitor discharges - interspaced with spikes reaching about 250mA (a positive value indicating current into the capacitor) during the short charging periods. The average and RMS values of the waveform – as calculated by the software - can be seen in the display box. The red waveform is the AC ripple across the reservoir capacitor, with its axis on the left hand side. Again, I've shown a display box with the average and RMS values.

US mains half wave rectifier

A typical circuit of a half wave rectifier supplied by the US mains voltage at about 115V is shown in Figure 9. This is taken from the Arvin model 440T midget radio and uses a 35Z5GT rectifier. The 35Z5GT, and its cousin the 35Z4GT, were used in their millions in almost all American AC/DC radios from about 1939 until the introduction of the miniature B7G 35W4 after the war. Here the HT current for the 50L6GT audio output valve is fed from the reservoir capacitor, and does not pass through the 2.2kΩ smoothing resistor, which supplies the rest of the radio, including the screen grid of the 50L6GT. The 40µF reservoir capacitor is the maximum value recommended by the valve manufacturers (see later for a discussion of this value) and the 15Ω resistor is connected between the rectifier's cathode and the reservoir capacitor to limit the charging surge current.

Figure 10 shows a simplified version of the circuit, using a 35Z4GT, which I built to allow me to make measurements similar to the 230V UK mains case. Since 40µF electrolytics are no longer available, we have the option of choosing the value of 47µF or 33 µF for the reservoir capacitor. A new 47µF capacitor would be above the maximum value recommended by the valve manufacturers, so we have to think a little about whether to use this value and possibly stress the rectifier, or go for a 33µF capacitor. When the original component was specified, electrolytics had a very wide tolerance (their specified tolerance is still rather high, but not quite as bad as 70 years ago) and so the designer probably satisfied himself that a considerably lower value would still be OK. So the answer is to use the 33µF capacitor. If you hear a little more hum than you would expect, and you've eliminated all other possible causes, add a 10µF capacitor in parallel, and you should be OK. Alternatively fit the 47µF capacitor and increase the value of the surge-limiting resistor to say 27Ω.

Figure 11 is a table of test results for the US 115V mains half wave circuit, with a 33µF capacitor fitted for C1 and a 16µF capacitor fitted for C2. Again the measured values of the capacitors were remarkably close to their nominal values. I've shown the results in the same format as for the UK 230V mains case, and the results are very similar. As before, column 3 of the table shows the ratio between the AC current through C1 and the total DC output current, and this ratio was fairly constant at between 1.66 (for low output currents) and 1.51 (for high output currents).

Taking the values from Row 2, an AC voltage across C1 of 3.70V RMS should result in a ripple current of 38.8mA RMS through the capacitor. The measured value was 40.3mA, which is within about 4% of the calculated value.

The advice is as before: if you are unable to measure the AC ripple voltage directly, measure the total DC current the power supply feeds into the radio (or check the radio's service sheet) and multiply this value by 1.7 (call it 2 for a little safety margin) to give the worst case AC ripple current through the reservoir capacitor.

As for the UK mains case, I used LTspice to simulate the circuit, using load resistors (R1 and R2) taken from a couple of the entries from the table in Figure 11. The results correlated well with the measured voltages and ripple currents, but again I found that the exact values were sensitive to the value of the resistor in series with the rectifier. For the simulations I set this to 200Ω to include the hot resistance of the rectifier valve. The simulator allowed me to set the mains frequency to 50Hz and 60Hz, and although at 60Hz I saw about 1V RMS more ripple across the reservoir capacitor than at 50Hz, the ripple current through this capacitor was very much the same at both frequencies.

250V rated electrolytics should be suitable for use as the reservoir and smoothing capacitors in this application: the maximum voltage I measured at the rectifier's cathode was 155V, with no load on the power supply, and about 120V with a current load close to that of the Arvin 440T, resulting in a ripple current of about 64mA RMS through the reservoir capacitor. The Fischer and Tausche (see Reference 7) data for their type A 250V 33µF capacitor indicates a maximum ripple current of 200mA, which is more than adequate for all reasonable load currents. The ESR Electronic Components Ltd data for their 250V 47µF capacitor indicates a maximum ripple current of 184mA, again more than adequate for all reasonable load currents.

UK 230v mains transformer-fed full wave rectifier

The safest power supply configuration uses a mains transformer which isolates the chassis of a radio from direct connection to the mains, and allows it to be connected to mains earth. Some implementations use an untapped secondary HT winding on the transformer, which results in a smoothing challenge identical to the UK mains half wave rectifier example described earlier. If the secondary winding is centre-tapped, then a full wave rectifier arrangement is possible, as shown in Figure 12, where I use an EZ80. Full wave rectified AC looks something like Figure 13, and this is easier to smooth, and perceived wisdom says this results in less ripple current in the reservoir and smoothing capacitors.

Figure 14 is a table of test results for the UK 230V mains full wave circuit, with a 33µF capacitor fitted for C1 (measured at 33.4µF), and a 16µF capacitor fitted for C2 (measured at 16.3µF).

Column 1 shows the combined DC current sourced by the power supply via R1 and R2, and column 2 is the measured AC current passing through the reservoir capacitor. Column 3 of the table shows the calculated ratio between the AC current through C1 and the total DC output current: this ratio was fairly constant at between 1.37 (for low output currents) and 1.27 (for high output currents). These ratios are about 80% of the half wave rectifier case.

Column 4 shows the AC current through C2, the smoothing capacitor: this was very low – between about 0.22mA and 0.41mA, and was always much less than one hundredth of the AC current passing through the reservoir capacitor.

Columns 5 and 6 show the AC ripple voltage across C1 and C2 respectively. If you compare the ripple voltage across C1 shown in Figure 7 (the half wave rectifier case) with an equivalent value in Figure 14, you will see that the ripple in the full-wave case is less than half the value for the half wave case. For example: the ripple value for 36.0mA of DC current from Figure 7 is 5.05V RMS, compared to 2.11V RMS for 35.7mA of DC current from Figure 14.

Therefore the rule of thumb for the full wave rectification case seems to be: measure the total DC current the power supply feeds into the radio (or check the service sheet for the radio) and multiply this value by 1.4 to give the worst case AC ripple current through the reservoir capacitor.

Simulations showed good correlation with the measured results, after I'd made a reasonable estimate of the EZ80's on resistance and the mains transformer's winding resistance, both of which affect the charging current into the reservoir capacitor.

Rectifier ratings

Data sheets for valve rectifiers typically specify a maximum value of the capacitor that can be connected directly to the cathode, which is often referred to as the 'filter input capacitor' or 'input capacitor of the smoothing filter'. For the UY41, this is specified as 50µF; for the UY85 it's 100µF; for the EZ80 it's 50µF; and the 35Z4GT and 35Z5GT have this quantity specified at 40µF. A value for series resistance is also specified, which you can see at the mains input side of the rectifier in Figure 5, and which in the case of full-wave transformer-driven rectifiers is provided by the resistance of the secondary windings in series with some reflected resistance from the primary winding.

The combination of the filter input capacitance and the series resistance determines the maximum current during the charging part of the rectified waveform. With a valve rectifier, which has to warm up, the initial surge current into the fully discharged capacitor when the circuit is first switched on shouldn't be a problem, as this build up in current should be gradual as the valve starts to conduct. Probably the only exception is when a radio is switched off and then quickly switched on again before the rectifier has cooled down. This is possibly what we do quite often when a radio is being restored, and we should be careful about doing this too often because it may have a detrimental effect on the capacitor and rectifier.

High voltage electrolytics

The brief specification for a range of modern 450V electrolytics is shown in Figure 15, taken from the Fischer and Tausche website. Note that it shows the ESR values at 100Hz and 20°C in mΩ, so don't panic at the large numbers. You can see that the maximum ripple current for a 47µF component is either 200mA or 300mA, depending on which size you choose. The company also sells 350V and 250V (and lower voltage) electrolytics, and their data shows that the lower the working voltage, then the smaller the physical size of the component, which leads to the maximum ripple current being lower.

A worrying specification quoted for electrolytics is its 'useful life', sometimes called the 'service life' or the 'operational life'. This is often quoted as 5,000 hours for 85°C rated capacitors, which is only about 6 months if switched on for 24 hours a day. Operating conditions significantly affect the life of electrolytic capacitors, and ambient temperature has the largest effect. The relationship between life and temperature follows a chemical reaction formula, and a reasonable approximation is that the life of a capacitor doubles for every 10°C decrease in temperature (within certain limits). See Reference 8 for a life calculator for various types of capacitor.

Voltage de-rating also increases the life of a capacitor, but to a far lesser extent than temperature de-rating. Internal heating caused by ripple current, also reduces the projected life of an electrolytic capacitor, and so minimising the actual ripple current versus the capacitor's maximum rating, is beneficial. Figure 16 is a useful graph, published by Fischer and Tausche, which shows the effect of ripple current and temperature on the nominal 3,000 hour lifetime of their 105°C rated type AH electrolytics.

If you take the point marked Point 1, operating at the maximum ambient temperature and at the rated maximum ripple current, the lifetime multiplier is 1.0, that is, the capacitor's predicted lifetime is 3,000 hours, as specified in the data sheet. If however you reduce the temperature and/or the ripple current, then the predicted lifetime rises dramatically. For example, one of the curves shows that halving the ambient temperature to 52.5°C while still operating at the maximum ripple current, increases the lifetime to about 100,000 hours (Point 2 on the diagram) – well worthwhile! It can also be seen that the ripple current rating is not a 'hard' limit: if the ambient temperature can be guaranteed to be less than 50°C, then 100,000 hours can still be achieved with the actual ripple current at twice the rated value (Point 3).

Shelf life

An even more worrying specification for electrolytics is their shelf life, which is often quoted at 500 hours, which is only about 21 days! Certainly most assemblers of electronic equipment buy in, assemble and power up their electrolytics as quickly as possible, and do not keep stock 'on

Figure 15: The brief specification for a range of modern 450V electrolytics, taken from the Fischer and Tausche website.

F&T 450V electrolytic specifications

Rated voltage U_R [V]	Rated cap C_R [μF]	Case Size D x L [mm[	Typ. ESR 100 Hz 20°C [mΩ]	Ripple current IR~100 Hz 85°C [A]	Order Code A...
450	10	10x30	11146	0,1	10045010030
450	15	12x30	7431	0,1	15045012030
450	22	14x30	5067	0,1	22045014030
450	33	14x37	3378	0,2	33045014037
450	39	16x30	2858	0,2	39045016030
450	47	16x39	2372	0,3	47045016039
450	47	18x30	2372	0,2	47045018030
450	56	18x39	1990	0,3	56045018039
450	100	21x36	1115	0,4	10145021036
450	150	25x38	743	0,6	15145025038
450	220	25x49	507	0,8	22145025049
450	330	30x50	338	1,0	33145030050
450	470	35x50	237	1,3	47145035050
450	560	35x66	199	1,6	56145035066

Figure 16: A useful graph, published by Fischer and Tausche, showing the effect of ripple current and temperature on the nominal 3,000 hour lifetime of their 105°C rated type AH electrolytics.

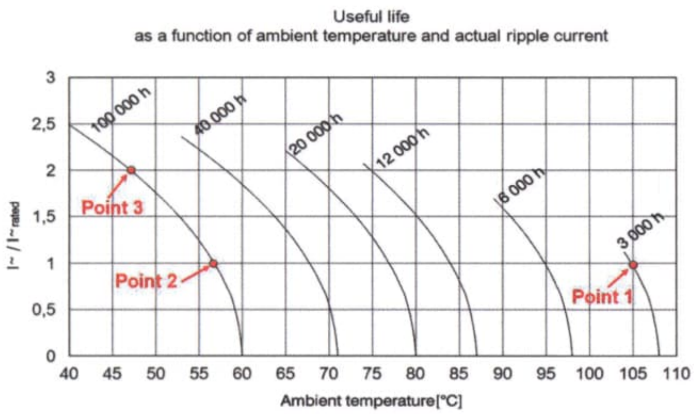


Figure 17: Line-up of the true RMS UNI-T meters I used to make the measurements. To the left is the UT210B clamp ammeter; in the centre is the UT61E; and on the right is the UT50A. The UT50A costs about £20 on eBay, and if I were to buy only one of these meters, this would be one I'd choose.

the shelf' for long periods. Shelf life is an ill-defined parameter: if the capacitor exceeds its leakage current when first switched on, it can be defined as a failure, even though it will probably quickly recover as it reforms in its application. As long as electrolytics are stored under relatively cool conditions (that is, nowhere near to their maximum working temperature) then you probably don't need to worry if the capacitor is less than five years old. After that, it may be a good idea to test its capacitance, and even to check its leakage current on a reformer. Similarly, to be kind to the electrolytics fitted into your radios, it might be best to power each one up for a few hours at least every five years or so.

There is some discussion of shelf life on the www: a Master of Science thesis entitled 'Determination of the Shelf Life of Aluminum Electrolytic Capacitors' prepared at the University of North Texas in 2002, discusses the effect, and shows test results on batches of capacitors which had been stored for several years. It reported that the significant effect on unpowered electrolytics was an increase in leakage current as their storage time increased. Reforming at regular (but long) intervals was found to be an effective way of controlling this problem. The full thesis can be read at Reference 9.

BVWS electrolytics

If you look at the BVWS Spares Department page of the Bulletin, you will see a range of high voltage electrolytics manufactured in Germany by F&T (Fischer and Tausche). If you want to look up the data for these capacitors: the 500V single axial electrolytics are F&T's type A; the 500V tubular double axial capacitors (8μF + 8μF, and so on) are type AZ; the single can capacitors are type LF; the dual can capacitors are type LFAZ; and finally the single screw-fixing capacitors are type SZ.

These capacitors are of high quality and are used in many professional valve Hi-Fi and guitar audio amplifiers, and therefore in very similar applications to how we want to use them.

Radial versus axial

For under chassis use, I usually use axial electrolytics, that is, where the leads exit the case at opposite ends. For top of chassis use, I tend to use radial components, which are often replacing the original capacitors on the chassis. Is there any difference in performance of these two different case styles? Although it's difficult to be sure that I'm comparing like-for-like, it would seem that axial capacitors have a slightly lower ESR value, and a higher ripple current rating, than a similarly voltage rated radial equivalent.

Wrong way round

Most electrolytics have the negative end of the capacitor marked, often with a negative sign and an arrow, and the outer metal case is usually this terminal. If you get mixed up (as I have done from time to time) and connect an electrolytic the wrong way and apply power to it, the best that can happen is that the capacitor is terminally damaged, and the worst is that the capacitor explodes violently (see YouTube for a few videos of this happening). Many manufacturers specify the maximum reverse voltage at only 2V: therefore almost any reverse voltage will kill your precious capacitor. So if it happens to you, swallow your pride, throw the capacitor away and move on.

Warm up period and solid state rectifiers

If the rectifier valve warms up and starts to conduct more quickly than the other valves, the voltage across the electrolytics in the power supply will rise above what they will see when everything has warmed up. This is because any voltage drops across resistors in the HT rail (for example the smoothing resistor) will be minimal until current passes through them. With solid state rectifiers, for example metal rectifiers in vintage radios, this is certain to happen.

Some manufacturers specify a 'surge voltage' of 10-15% above the rated working voltage, though I couldn't see a time specified for how long this over-voltage condition should exist. For we amateurs, probably the best way around this problem is to choose capacitors with working voltages say 100V greater than what the circuit needs when fully warmed up. Once the radio is restored, you can monitor the voltage across the reservoir and smoothing capacitors as it warms up (an analogue meter is probably best for this) and check that the applied voltage during the warm-up period doesn't exceed their working voltage.

Does current flow through a capacitor?

Whilst writing this article I was aware of a thread on the UK Vintage Radio Repair and Restoration forum with the above title. The discussion seemed to go rather beyond what the originator of the question had intended, at one stage talking about quantum effects – which capacitors don't rely on for their operation – but it was interesting in that it spoke of dielectrics, charge, displacement current, and exactly what we mean by 'current' and 'flow'. It goes to show that a simple question doesn't necessarily have a simple answer.

I must admit that it felt to me like AC current was flowing through the capacitors I tested – my meters measured it to some degree of accuracy, and at one stage, just to be sure that I wasn't going mad, I even connected a small bulb in series with the reservoir capacitor, and guess what? – it lit up! Looks like current to me.

Disclaimer

Although I found the UNI-T true RMS meters to be very suitable to make the measurements, I make no recommendations to you, and other manufacturers' instruments are available. See Figure 17 for a line-up of the UNI-T meters I used.

I used Vishay (which over the years has acquired many established active and passive component manufacturers - including Sprague, a well-known capacitor manufacturer); and Fischer and Tausche electrolytic data in the article, but data from other capacitor manufacturers would have been just as valid.

Recommendations

At the beginning of the article I suggested that by the end I might be able to suggest a few rules of thumb for when you are faced with having to replace the electrolytics in an HT supply. These suggestions also hold good if you're designing an HT power supply – perhaps for a valve-based audio amplifier – from scratch. You may have picked up on these already, but in summary:

1. Use good quality, branded electrolytic capacitors, and try to obtain ripple current and ESR data on the capacitors you intend to use.
2. Use a voltage rating of at least 100V above the HT voltage being smoothed. If in doubt, use a 450V or 500V rated component. If your HT is even higher than this, use series-connected capacitors with voltage balancing resistors.
3. Don't use higher capacitance values than those fitted in the original design. If the audio output of the radio hums even after you have fitted new capacitors, then the problem is probably elsewhere.
4. For a 230V UK mains half wave circuit, measure the total DC current that the power supply feeds into the radio (or check the service sheet) and multiply this value by 1.7 to give the worst case AC ripple current through the reservoir capacitor. To be on the safe side, simply double it, and choose a capacitor with a ripple current rating equal to or higher than this value.
5. For a 115V US mains half wave circuit, the multiplication factor is also about 1.7. Again, double the total DC current value to be on the safe side with your estimate of the ripple current.
6. For a 230V UK mains full wave circuit, the multiplication factor is about 1.4. This estimate can also be used for a 115V US mains full wave circuit.
7. The ripple current rating of a capacitor is not a 'hard' limit. Although I do not recommend doing this, it can be exceeded as long as the capacitor is operated at a cooler ambient temperature than its rating, without a detrimental effect on the capacitor's life.
8. The smoothing capacitor generally passes a much lower ripple current than the reservoir capacitor, probably by a factor of between 10 and 15 for the half wave case, and more than 100 for the full wave case.
9. For the reservoir capacitor, use as physically large a component as will fit into the space available. This will generally have a higher ripple current rating and a lower ESR than a smaller capacitor, and any internal heating will dissipate via the greater surface area, and hence extend the life of the capacitor.
10. Given the choice, use an axial case style rather than radial. This may give a marginal increase in the lifetime of the capacitor.
11. Use 105°C rated capacitors if possible, and position them away from high temperature heat sources, to extend their operational life.
12. If you connect an electrolytic the wrong way round and apply power, even for just a short time, replace the capacitor (the right way round this time) before switching on again.
13. As long as electrolytics are stored at a reasonable temperature (that is, well below their maximum working temperature) their shelf life should be much longer than the 500 hours often stated. After say five years of non-use they should be checked for leakage and capacitance, and reformed if necessary.
14. After you have fitted the new capacitors, switch on and try to measure the AC ripple voltage across the reservoir and smoothing capacitors (if possible with a true RMS AC voltmeter), calculate the ripple current through the capacitors and check that this doesn't exceed the maximum value specified.
15. If you want to delve deeper into the operation of HT power supplies, use a Spice simulator, for example the free-of-charge LTspice from Linear Technology.

Conclusions

As well as calculating and measuring the values of voltage and current at key points in the circuits typically used in the HT power supplies in the valve-based radios, TVs and amplifiers we collect and restore, the use of LTspice allowed me to simulate the circuits. All three methods produced similar results, which gives me the confidence that the recommendations I've shown, particularly those for ripple current, are valid. The use of a Spice simulator gives insight into voltages and currents, for example the exact waveform of ripple current in a capacitor, which are very difficult to monitor in practice.

The good news is that in most cases, we have probably been fitting adequately-rated electrolytics during our restorations without realising this, but it's good to put this on to a firm practical and theoretical basis.

I hope readers have found this article informative, and I'd appreciate feedback on what it says. I'm very much an amateur when it comes to analogue electronics, especially where it involves AC theory. Comments on how the circuits were analysed and simulated, and measurements were made and interpreted would be interesting, perhaps from those who have done similar work either in their amateur pursuits or in their professional life.

Despite already having a few DMMs (they are so cheap these days), I spent a few tens of pounds on a couple of new meters to enable me to accurately measure the true RMS values of AC current and voltage, and which I know will be very useful in future. Christmas isn't too far away, so maybe you can drop some strong hints, and get your hands on one of these true RMS meters, to supplement the other meters you may already have.

References

Reference1: ESR Electronic Components Ltd's range of components can be seen at: www.esr.co.uk

Reference 2: Typical leakage current and ESL values can be seen for the Vishay range of electrolytics at: http://www.vishay.com/docs/28329/041042043ash.pdf

Reference 3: 'Capacitor Tester and Reformer Unit', published in the BVWS Bulletin for Winter 2008.

Reference 4: An on-line calculator of a capacitor's reactance at any chosen frequency can be found at: http://www.sengpielaudio.com/calculator-RC.htm

Reference 5: A useful on-line calculator for a capacitor and resistor in series can be found at: http://keisan.casio.com/exec/system/1258032632

Reference 6: LTspice can be downloaded free-of-charge from the Linear Technology website at: http://www.linear.com/designtools/software/

Reference 7: Data sheets for the F&T (Fischer and Tausche) capacitors can be seen at: http://www.ftcap.de/index.php/products.html

Reference 8: A working life calculator for various types of capacitor can be seen at: http://www.illinoiscapacitor.com/tech-center/life-calculators.aspx

Reference 9: 'Determination of the Shelf Life of Aluminum Electrolytic Capacitors' prepared at the University of North Texas in 2002, discusses the effect, and test results on batches of capacitors which had been stored for several years. The full thesis can be read at: http://digital.library.unt.edu/ark:/67531/metadc3104/m2/1/high_res_d/thesis.pdf

Duncan's Amp Pages at: http://www.duncanamps.com/index.htm has a link to a page of Spice simulators, some free and some not. There is also a link to PSU Designer II, intended to help with the design and analysis of simple linear (unregulated) mains power supplies. The website also contains some useful Spice models of valve rectifiers.

Letters

Dear Editor,
I've just acquired this Sylvania 12SA7GT valve (clearly marked on the top of the glass), and I was wondering if any reader has seen an octal valve before with this narrow base? The glass envelope is the same diameter (about 28mm) as a 'normal' octal valve, but the base section is about 4mm narrower than the standard base. I guess it could allow even closer packing of valves than you see in an American midget, but any socket it plugged into would have to be designed to allow this. Or perhaps it used less materials and therefore was cheaper to produce?

Kind regards,
Stef Niewiadomski

Dear Editor,
I have just received the latest copy of The Bulletin (Autumn 2015) and found it excellent as always, both in its content and presentation. There was one item which caught my attention however, which I felt I needed to correct. Pedantic of me no doubt, but having been in the radio and television servicing trade for over 40 years and now retired, living on my own and still wishing I was still in the trade (that has now been totally erased by modern techniques), I am quite ready to comment on things that were once, an everyday experience for me.

There is an article by Henry Irvin describing a KB UP11 'Cadet' transistor portable radio. He mentions that the front escutcheon proudly proclaims that the radio employs a total of eight transistors, but that one of these devices has been wired as a diode purely as an 'artful device' intended to upgrade the radio's status among its peers! He is quite correct in this respect, for clearly an OA79, OA91 or similar germanium diode could have been used instead.

On page 55, under the heading 'Circuit', Mr Irwin states '*The circuit diagram shows how the seven transistors are utilised, that extra device providing additional amplification.*' I think not. First and foremost, a transistor that is strapped as a diode can only rectify, demodulate, or gate, depending upon the particular circuit environment it resides in.

In this case, the device (TX4) is functioning as a demodulator; in other words as the detector, an absolutely vital component in any radio or TV receiver, without which the radio would be useless, even if fitted with twenty transistors. It also has an unseen secondary function in this circuit, as the AGC rectifier, in that the AGC voltage is taken from the top end of the volume control and fed back to the AGC reservoir capacitor C6 (10µF). This ultimately controls the bias on the base of the transistor TX2 (1st IF amplifier) and thus the gain of this stage.

On a different note, I must compliment Mr Gary Tempest on his truly amazing and immaculate restoration of the glass tuning dial for the Philips Aachen Super D57 wireless set. This is, as far as I am concerned, restoration at its most critically technical, and very demanding upon one's patience. It is fairly easy to restore the innards but any part of the cosmetic detail that is damaged requires real skill (and a steady hand!). Congratulations on a magnificent job!

Yours sincerely,
Alistair S. M. Boyle

Dear Editor,
Through The Bulletin's letters page I would like to thank those members who responded to my request for assistance with repair to a Ferguson CTV. I received some very generously given time and help enabling me to return the television to regular use. In particular, I would like to thank the gentleman who took the trouble to send me the service manual and was also very willing to share his time and expertise by talking me through an unfamiliar circuit. Your help was greatly appreciated.

Secondly, I would like to offer some positive feedback regarding the venue for the swapmeet in London in June, namely the Cinema Museum near the Elephant and Castle. Although not as large a venue as Harpenden, it was a friendly meeting that was very accesible. I was there for the opening and there was plenty of parking space available (unusual for central London!) although I arrived by Tube.

The venue itself was interesting with the vintage cinema exhibits all around. I hope that this was found to be the case by others and that there will be further meetings at this location.

Yours sincerely,
Peter Nash

Dear Editor,
'Cider with Rosie' and tea with Diana
We were most surprised, when we saw the recent BBC adaptation of "Cider with Rosie", to recognise the house portrayed as Laurie Lee's home as "Trillgate" where we had visited Diana Lodge and her sons, Tom and Colin, to record memories of Sir Oliver Lodge and other members of the Lodge family. A copy of this 1995 recording is now deposited in the IET Archives.

Oliver WF Lodge was Sir Oliver's eldest son, and a writer and poet, and had lost his first wife, Wynlayne, during the birth of their first child, also Oliver. Ten years later he married Diana and they had three children, Belinda 1933-96, Tom 1936-2012, and Colin 1944-2006. Diana knew Laurie Lee well as a friend and neighbour in the Slad valley and he undoubtedly visited her at "Trillgate" although this was not the house in which he had been brought up. The photos show "Trillgate" on a card she made from one of her paintings and Tom, Diana and Colin inside it in 1995.

Tom had a particularly colourful life, persuading the family to let him have part of his inheritance early so that he could go over to Calgary to become a cowboy. He had various jobs such as used-car salesman, mining company employee, where he was asked to assay gold recovered from "Lodge dust" collected by electrostatic precipitation from flue gasses, and also as a fisherman on the Great Slave Lake. At one stage a raft of ice broke away and he and a native Canadian drifted out into the middle of the lake where tragically the Canadian died and Tom was rescued near to death by fur trappers. He later worked for CBC as an announcer and then station manager. After returning to England in 1964 he joined Ronan O'Rahilly in setting up Radio Caroline to compete with the BBC's staid choice of music. His transatlantic style proved popular and he was soon joined by others including Johnnie Walker, Simon Dee, Emperor Roscoe, Dave Lee Travis and Tony Blackburn. He was aboard Mi Amigo with Tony Blackburn when it broke away and beached at Frinton. Radio Caroline closed in 1968 when off-shore broadcasting was banned and he joined BBC Radio 1 for a short while before returning to broadcasting in Canada, where he also introduced a course for recording engineers. In the 1970s he moved to California, where he became involved with Zen Buddhism, eventually taking the name "Umi" with an ashram of his own.

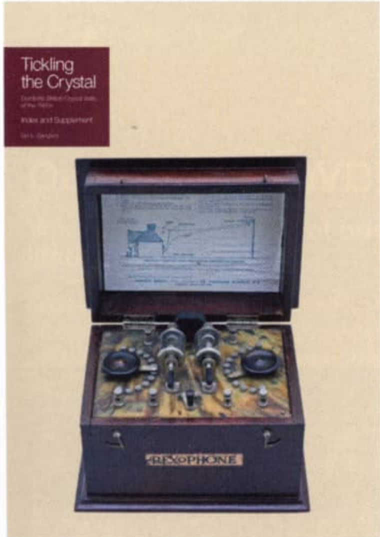
Another place in the news recently, with Lodge connections, was Adams Grammar School, Newport, Shrops, where Jeremy Corbyn went to school and where, a century earlier, Oliver Lodge, had such a miserable time as a boarder.

Yours sincerely,
J Patrick Wilson

Trillgate, illustrated by Diana Lodge

Tom, Diana, and Colin Lodge

BVWS Books



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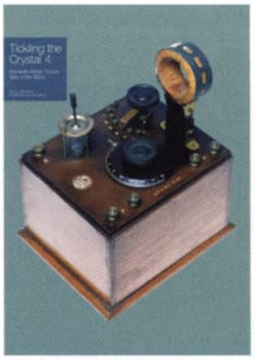

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Cheques payable to British Vintage Wireless Society

Mike Barker, Pound Cottage, Coate, Devizes, Wiltshire, SN10 3LG

BVWS Books

Events Diary

2015 Meetings

December 6th Royal Wootton Bassett

2016 Meetings

February 21st Audiojumble
February 27th An afternoon of music at the BVWATM
March 6th Harpenden (Auction & AGM)
April 10th Golborne
April 24th Table top sale at the BVWATM
May 15th NVCF
June 4th Garden Party at the BVWATM
June 5th Cinema Museum London
July 3rd Royal Wootton Bassett
August 14th Punnetts Town
August 20th An afternoon of music at the BVWATM
Sept 11th Murphy Day
Sept 18th Table top sale at the BVWATM
Sept 25th Harpenden
October 2nd Audiojumble
November 6th Golborne
November 19th An afternoon of music at the BVWATM
December 4th Royal Wootton Bassett

GPO Numbers

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.

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telephone: 01252-613660 e-mail: martyb@globalnet.co.uk

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
Royal 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
Punnetts Town: Punnetts Town Village Hall, Heathfield, East Sussex TN21 9DS (opposite school) Contact John Howes 01435 830736
Mill Green Museum: Bush Hall Lane, Mill Green, Hatfield, AL95PD
Cinema Museum: 2 Dugard Way (off Renfrew Road) London SE11 4TH Tel.: +44 (0)20 7840 2200 Email: info@cinemamuseum.org.uk **For more details with maps to locations see the BVWS Website:** www.bvws.org.uk/events/locations.htm

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Send your articles to: Carl Glover, 33 Rangers Square, London SE10 8HR
Tel: 020 8469 2904 bulletin_editor@bvws.org.uk

Sunday 15th May 2016
National Vintage Communications Fair
Warwickshire Exhibition Centre CV31 1XN

Vintage Radios and Televisions • Phonographs and Gramophones Valve and Transistor Hi-Fi equipment • 78 and Vinyl records, Record Players • Vintage telephones and equipment Vintage spares, speaker cloths, valves and components

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Any enquiries: info@nvcf.org.uk or post: NVCF 13 Warneford Road Oxford OX4 1LT UK (enclose an SAE)

The Bulletin

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