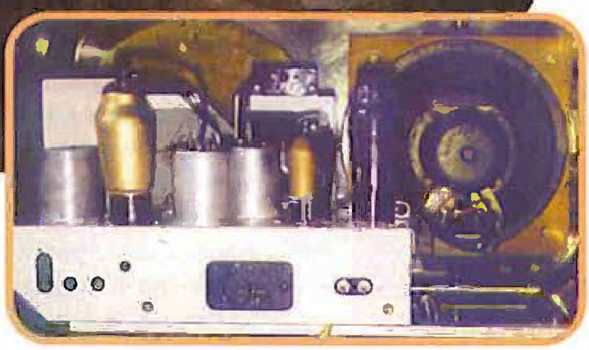
WIRELESS of Yesteryear

by Mike Holmes



MIKE HOLMES REBUILDS A VINTAGE AM RADIO SET AND DISCOVERS THAT 1930'S TECHNOLOGY WAS RATHER MORE SOPHISTICATED THAN WE GIVE CREDIT FOR TODAY

PART 2

The circuit diagram of the receiver section is shown in Figure 1, and some other notable features can be described as we go through it. It shows that the superheterodyne principle was already quite advanced by 1934, including some sophisticated features such as AGC. So much so that the basic superhet has not essentially changed at all to the present day, with the exception of the introduction of solid state devices. This circuit is, of course, designed around the characteristics of the three valves used, which again have been well developed for their respective roles.

For example V1, the octode frequency changer, is exclusively a superhet front-end device, and at first sight is quite confusing to look at until one realises it is actually two valves in one, a triode and a pentode, operating in cascode. The triode is at the bottom, where the grid at pin 1 is its anode, and pin 2 its signal grid. This, together with T1, forms the local oscillator of the reaction coil type.

Above the triode are the normal three grids of a pentode, the first separated from the triode part by a duplication of the screen grid. The pentode's signal grid receives its input via the valve's top connector from the secondary of a double-tuned RF transformer, T2. No ferrite rods here, ferrites were either unknown or virtually impossible to make at this time; instead the coils are wound onto a wooden dowel, encased in a metal screen and buried deep in the interior of the chassis. The RF input is introduced via socket 'AE' from a long-wire aerial.

Along with the local oscillator, tuning is accomplished by VC1, a 3-gang, air-dielectric variable capacitor of titanic proportions ('A' in Photo 3b). It has a thick steel frame for absolute rigidity and is attached to the chassis top with vibration-proof mountings. An epicyclic reduction drive is attached to the front, concentric with the main shaft. This includes the dial pointer, comprising a metal arm carrying an MES bulb with a 'shadow mask' ('B' in Photo 3b). This projects a strip of light onto the back of the translucent tuning scale and includes a narrow bar through the centre of the aperture, which appears on the scale as a thin shadow by way of a fine cursor.

The RF Stage

In the pentode of V1, the RF is combined with the local oscillator waveform due to its cathode current being modulated by the wire mesh anode of the lower triode section. It should be well understood by now that in the superheterodyne principle, four signals are actually present at the anode (pin 7). These are the tuned RF frequency, the local oscillator frequency, the sum of the two, and the difference between the two. It is the difference, or intermediate, frequency that is isolated and passed on by the first double-tuned IF transformer T3. Changing to a lower IF allows more gain with greater stability in subsequent stages than if the RF were amplified alone.

S1 is the band selector switch for LW or MW, and its construction is quite unusual. It consists of a bank of eight reed type switches (S1a to S1h), actuated by Bakelite cams mounted on a common shaft. Mainly it shorts out the LW coils when MW is required, or not for the other case, but it also has a third position.

S1	a	b	c	d	e	f	g	h
LW								•
MW		•	•	•	•		•	
GRAM.	•					•		

Table 1.

Where direct audio input to the amplifier is required, it will be noted that the receiver is not disconnected from the volume control. Instead S1a shorts out the IF at source, so that the receiver is effectively 'silenced'. Understanding how this and other contacts functioned was crucial from the outset and the permutations were mapped as shown in Table 1.

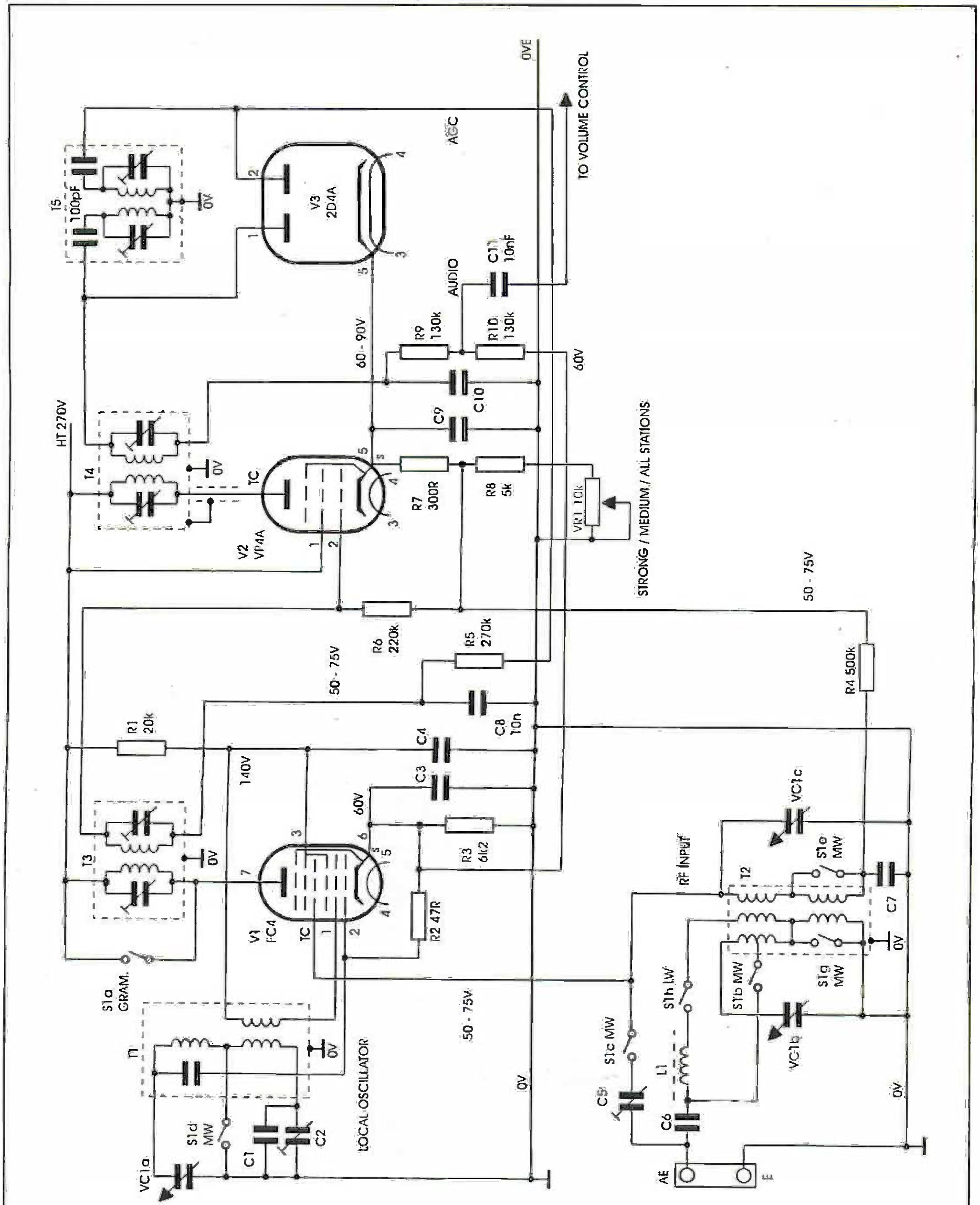


Figure 1. Circuit diagram of receiver section.

The IF Stage

The IF amplifier uses V2 as a variable-mu pentode type VP4A, where mu denotes gain. This is achieved by winding the signal grid with a varying pitch, so that where the DC bias becomes increasingly negative, electron flow through the narrowest gaps is cut off completely, progressing to the next narrowest and so on, eventually leaving just a short portion of the total grid area to produce a small variation of the electron flow, and hence the gain of the valve is at minimum.

The variable DC comes about, of course, from an Automatic Gain Control (AGC) system and is derived directly from IF amplitude.

The VP4A is, or was, available with two base style options, either B7 or B5. The original was B7, where each electrode had its

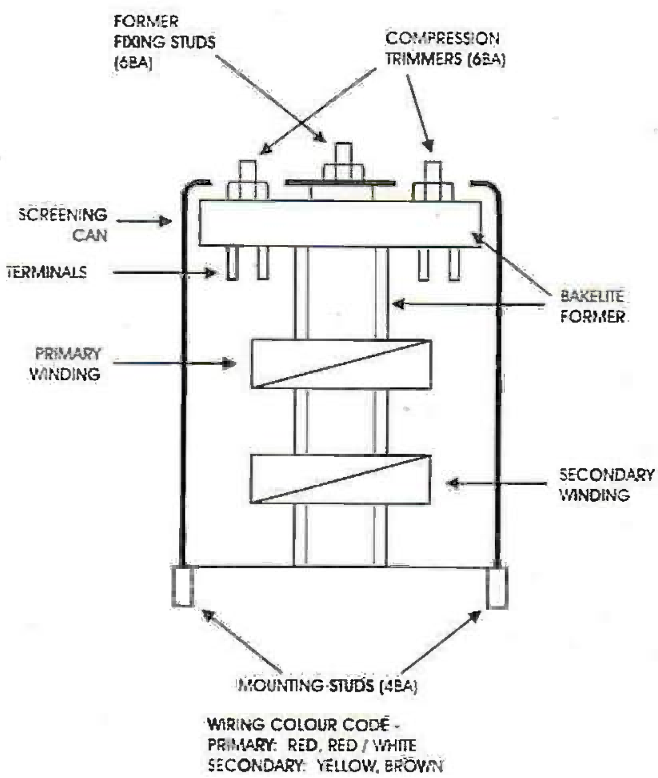
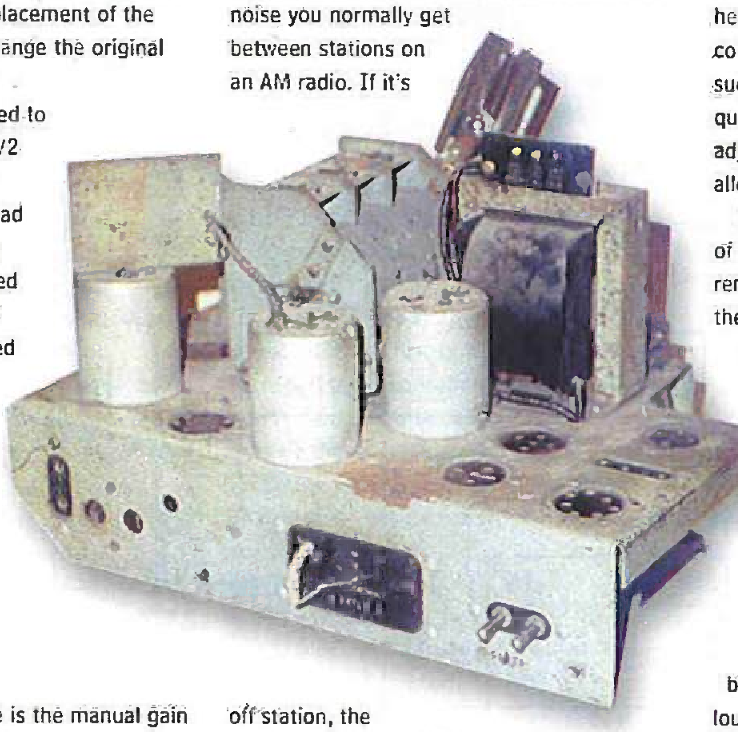


Figure 2. IF transformer construction.

own pin. The replacement, however, was the B5 option, where cathode, suppressor grid and outer shield are all commoned internally on pin 5. This required replacement of the socket also, but did not change the original circuit.

A metal screen is screwed to the top of T1 to separate V2 from V1 and prevent feedback, and the flying lead to V2 top connector had a length of bare wire wrapped around it as an attempt at screening. (Proper screened leads either did not exist in 1934 or were thought too expensive.) This was replaced with a piece of modern screened cable as it needed to be longer anyway.



The Detector

An especially novel feature is the manual gain control, VR1. In practice this not only varies the gain of V2 by changing its anode current, but also works as a squelch control through changing the threshold of the AM detector valve, V3. With VR1 at minimum resistance (maximum sensitivity), the cathode voltages of both V1 and V2 are practically equal at 60 Volts. That of V1 is communicated to the resistor chain R9 and R10, and thence to the anode of diode V3a via T4 secondary.

Meanwhile V3 cathode is directly connected to V2 cathode, and at this setting the diode is on the point of forward conduction so that very little IF amplitude is required to complete the process. As VR1 is increased, however, the detector will only conduct on successively higher and higher levels, and everything below this fails to reach the threshold and is muted.

This muting facility is an especially nice bit of extra sophistication and even works on the maximum sensitivity setting, because in use there is none of that nerve-jangling, rushing noise you normally get between stations on an AM radio. If it's off station, the loudspeaker is completely silent, and it's just one feature that makes the AC85 particularly pleasant to use.

It might seem that rectifying the output of T4 to derive the audio is all that is required, but this is not what happens. Instead it is used to excite a slightly modified T5, configured as a double-tuned, passive resonator, and it is to this that the diodes respond. Working like a DC restorer, positive peaks are 'clamped' to create a negative going offset that is communicated back through T4 secondary to appear on C10. IF is filtered out by R9 and C14, leaving the audio at the volume control. T5 secondary operates in exactly the same way with V3b to produce the AGC bias.

All the IF transformers are basically identical and their construction is illustrated in Figure 2. Because of the lack of ferrites, the former is wholly air-cored which means tuning adjustment must be done by making the capacitors variable. These are compression type trimmers actuated by nuts recessed into the top of the screening can. Holes are provided in the top of the can allowing wires to be drawn through the top if required (as is the case for T4 primary to the top connector of V2). The IF is surprisingly low by modern standards, at about 105 kHz.

Power Supply And Loudspeaker

Figure 3 shows the power supply and audio amplifier sections of the AC85. The sizeable mains transformer, T6, includes the input voltage selector on top (see also Photo 3b). This consists of a 3-way patch board and the required contact is made with a beautiful little brass screw with a knurled Bakelite head, the tip of which presses against a common bus bar behind. There are three such screws throughout the receiver and it quickly becomes apparent that these indicate adjustments or settings that the user is allowed to 'fiddle with'.

Note that the primary is shielded by a layer of foil called an Electrostatic Screen (ES); this removes the large potential difference across the respective ends of primary and HT secondary windings which might otherwise overstress insulation between layers. This was common in the days before the modern, split-bobbin type of former. The double-wound HT secondary of T6 is full-wave rectified by V6, the DC appearing on one half of the dual capacitor C12.

From here on the power supply becomes slightly confusing since the loudspeaker is obviously an inseparable part of it. The loudspeaker itself is recognisably modern enough in principle, having a 6 inches diameter, stiff paper cone complete with a corrugated surround suspension glued into an open steel frame or 'basket' (see Photo 6). Similarly, the voice coil is wound onto a paper tube and inserted into the ring gap of a magnet as you might expect, but it is at this point that the design deviates from

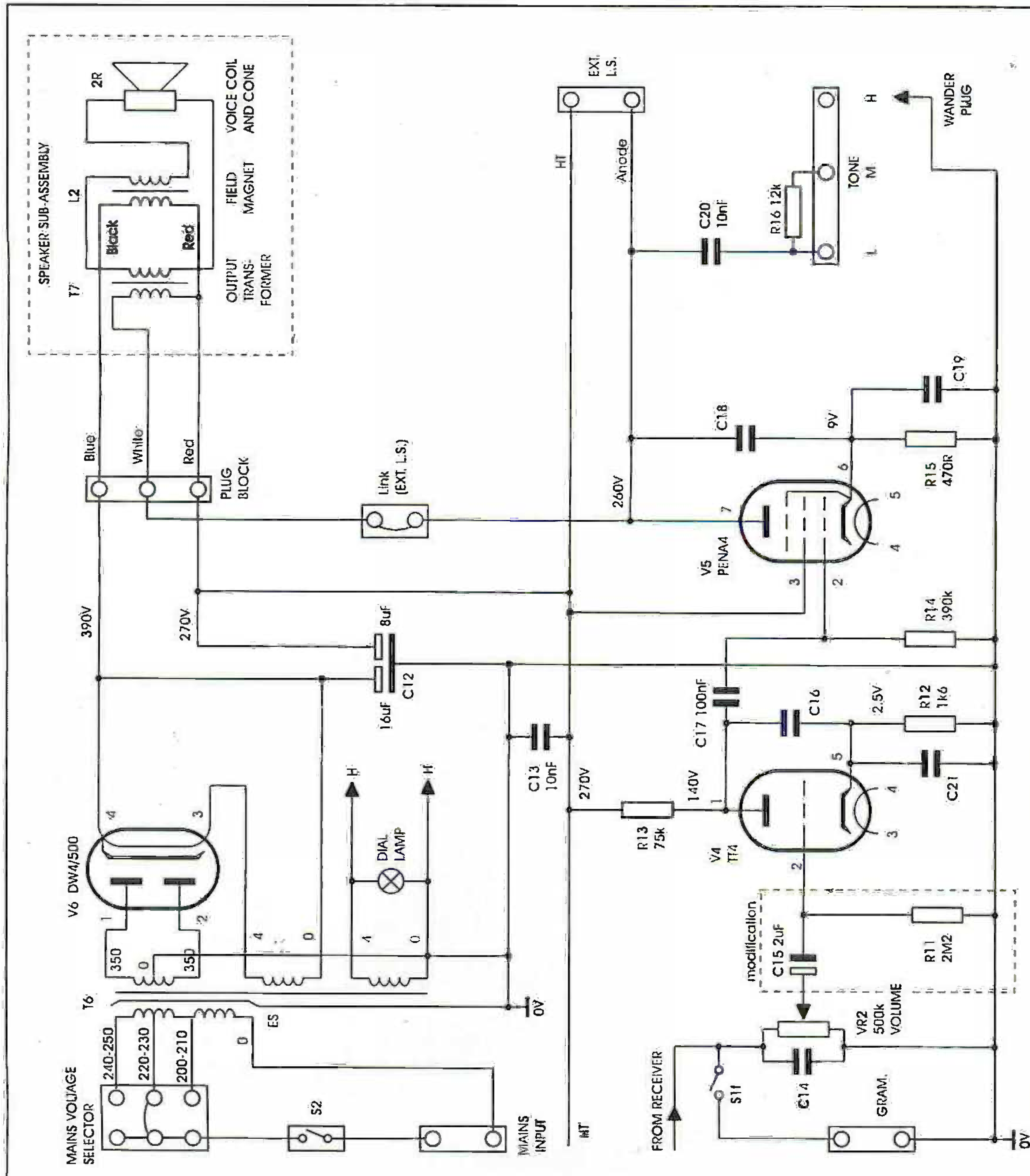


Figure 3. Circuit diagram of power supply and amplifier section and separate speaker assembly.

any modern counterpart, because this magnet is electric.

This has much to do with the fact that it has only been possible to make genuinely powerful, permanent magnets during the latter decades of the twentieth century. Prior to this electric magnets for moving coil speakers were the norm, powered, as here, by the HT supply. Moreover, in this design it doubles as an HT smoothing, low frequency choke, the resultant LC filtered output side being from the second half of C12.

The field magnet is 2,400 Ohms and carries the entire current consumption of the receiver, about 50 mA, thus dropping 120 Volts and consuming 6 Watts. Consequently the initial HT at C12a is high at around 400 Volts, coming out as a more typical 270 Volts at the receiver's main HT line.

Of special interest is the small secondary winding connected in series with the voice coil. Because there will be a certain amount of 100 Hz ripple current in the main winding due to its additional role as a smoothing filter, this will motivate the voice coil, producing audible hum. The secondary compensates by passing a proportional, reversed current through the coil, induced by the main winding and core. This seems really naff but is actually very effective; audible hum is extremely low and I suspect most of that is generated in the output stage.

The speaker unit had obviously not been

manufactured in-house, but bought in from an outside contractor whose quality control leaves much to be desired, as most mistakes and 'bodges' were found here. The magnet clamp bolts were nearly loose and — much more seriously — the voice coil was off-centre and rubbing on the magnet. Some copper was exposed but fortunately not cut through and no turns seemed to be shorted. This was recovered and after de-rusting and repainting, the speaker was reassembled properly with thread locking compound for all screws.

Correct alignment of the voice coil is achieved by a ring-shaped device glued into the centre of the cone, apparently made of black nylon and incorporating three flexible legs (virtually identical to the Isle Of Man emblem), consequently called a 'spider' (and now you know where the term 'spider' comes from in connection with loudspeaker cone suspension). Its central hole is anchored to a spigot extending from the centre pole piece by a screw, and there was an over-sized nut under the head of this screw because somebody couldn't find a suitable washer.

Audio Amplifier

Notice that the speaker assembly includes the output transformer bolted onto it (Photo 6). This is obviously a standard format of the time as external or 'stand alone' speakers were expected to be similarly equipped. Hence, if it is desired to connect an external loudspeaker this is taken directly from the anode of the output valve (with HT!), which then has to be isolated from its internal circuit by removing another Bakelite headed screw ('Link' in Figure 3). This subject is mentioned in The Handy Man And Home Mechanic, which recommends a permanent wiring installation buried in floors and walls (see Figure 4), presumably to negate long trailing leads carrying HT. (It omits to mention though whether such external speakers also need a power supply for their own field magnets.)

The audio amplifier is a modest but archetypal triode-pentode combination that, much later, would be combined into a single and much smaller glass envelope (for example Mullard ECL82); but at this stage valves were still largely separate. The output stage is single-ended class A. In addition to the permanent connection to the receiver output, an external audio source can be input via S1f from the 'GRAM.' socket (meaning gramophone). A compatible 78 r.p.m. record player would include a magnetic transducer in the pick-up arm, and the input impedance — actually R9 in parallel with R10, and not that of VR2 alone — is comparable.

Initially the volume control, VR2, was quite noisy, making 'scratchy' noises whenever moved. It turned out that C11 in Figure 1 was leaky, dropping about 12 Volts across VR2 and biasing on V4. This was cured by replacement with an axial polyester type, and just to make sure the input to V4 was decoupled from VR2 completely and given a new grid leak resistor, R11.

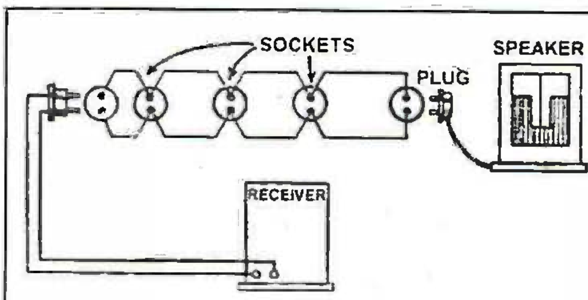


Figure 4. Recommended wiring diagram for connecting to an external speaker in one of a number of separate rooms in the house using under-floor wiring and wall sockets (from The Handy Man and Home Mechanic).

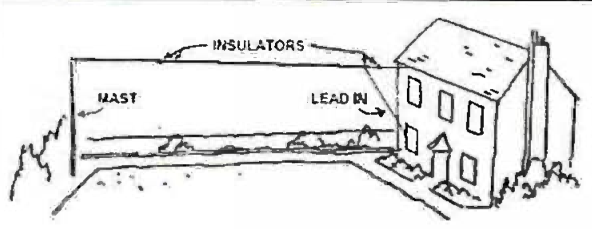


Figure 5. Recommended layout for an outdoor aerial (from The Handy Man and Home Mechanic).

C17 was also leaky, turning V5 so hard on as to 'sag' the HT by 80 Volts (and might this have contributed to the original valve's failure?). This was replaced with a modern polypropylene equivalent and immediately after this the entire receiver, not just the output stage, worked a whole lot better. A crude 'tone control' is added, almost as an afterthought, where a wander plug on the rear panel is used to select either 'Low', 'Medium' or 'High' sockets.

Arranging An Aerial

Restoration of the receiver was complete, while keeping as many of the original parts as possible, and the final stage was obtaining a signal and alignment of tuned circuits. As regards aerials, The Handy Man And Home Mechanic recommends an outdoor type as illustrated in Figure 5. The book specifies that the wire be between a high point of the house and a 25 feet high mast at the end of the garden, with insulators at each end (but fails to suggest suitable lengths). The down lead, at the junction of the aerial and the nearest insulator, '— should be ... at an angle and clear of the house, as the efficiency of the aerial will be reduced if allowed to touch the house.' Furthermore, '— a proper earthing switch or lightning arrester should be incorporated ... so that in the event of a thunderstorm, any charge induced may pass freely to earth without traversing any part of the receiver.' (!).

Figure 6 shows some of these devices, not least the earth tube, which is inserted into the soil outdoors to obtain an earth point (literally!). To ensure good connection with the ground the book advises: 'By its use the ground is kept moist in dry weather by simply pouring a bucketful of water down the tube. The water is evenly distributed in the soil by means of a series of holes in the wall of the tube.'

Needless to say I did not resort to any such lengths since about ten metres of spare wire taped to a picture rail for an indoor aerial was more than satisfactory. I did, however, discover that earthing the chassis improved reception a good deal, but which of course was most easily got direct from the mains earth.

Alignment

Trimming the IF coils was easiest, and done with the aid of an oscilloscope to obtain greatest amplitude. Correct balance of T5 was particularly important. Trimming the RF coils had to be done from scratch since the

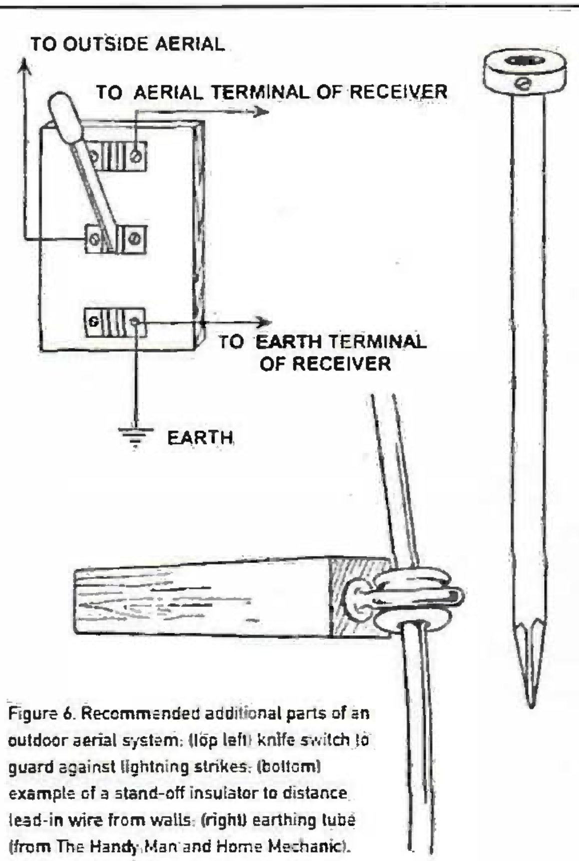


Figure 6. Recommended additional parts of an outdoor aerial system: (top left) knife switch to guard against lightning strikes; (bottom) example of a stand-off insulator to distance lead-in wire from walls; (right) earthing tube (from The Handy Man and Home Mechanic).

copper trimmers for VC1 had to be completely stripped, cleaned of verdigris and the underlying steel top panel removed of rust and repainted.

The tuning scale of the AC85 is 'back to front' compared with a modern receiver since it is calibrated by wavelength in metres, not kilohertz. Hence the left hand end begins at 200 metres on Medium Wave, or the highest frequency. The most accurate procedure was to turn VC1 to minimum, and apply a signal generator set to 1.5 MHz (equals 200 metres). The trimmers could then be adjusted to tune this in for maximum gain.

Of the three, that for VC1a, the local oscillator (T1) is the most sensitive, where degrees of movement of the screw could be measured in gnat's whiskers and had the most profound effect. The next most sensitive was that for T2 primary, and the least, T2 secondary. The latter two were best adjusted to the centre of two points where signal amplitude was discerned to drop off. The receiver's own squelch control, VR1, was extremely useful here since it was possible to set a threshold that was immediately audible through the speaker as it went off-tune. For final adjustments this was repeated against an actual weak radio station.

C5, a compression trimmer with a Bakelite headed screw, controls sensitivity, but not, as I discovered, in a way you might expect. Tightening it up actually decreases the sensitivity, almost as though some part (if not all) of T2 secondary was wired in anti-phase. Earlier on, in fact, I had noticed a short, isolated winding at one end of the T2 former that indeed appeared to be reverse connected to the remainder.

Performance

First off it must be said that the tone is quite superb — while the introduction of transistors allowed miniaturisation on a scale hitherto unimagined, resulting in the explosion of the 'portable trannie' and such like, it also meant that whole generations thereafter would be deprived of the experience of what a decent sized speaker in a decent sized box sounds like. Bass is plainly present, if somewhat limited in scope, and even the treble is reasonable. (Of course with AM you can adjust for treble by off-tuning.) Noise is zero apart from a little hum as mentioned earlier, even then it is only discernible in a dead quiet room with the sound fully off.

With the aid of its large knob, tuning control is smooth and slip-free and easily adjustable to within fractions of a millimetre if necessary. This is important since selectivity is quite sharp, and the AC85 is able to isolate and extract quite weak stations from a plethora of other, stronger ones close by, at least with enough competence to make them intelligible. The only problems were where two stations of exactly the same frequencies were received, resulting in a beating effect or a mix of both audio signals, so neatly accomplished as to sound deliberate!

There was not, however, very much in the way of whistling that results from close adjacent stations, all due no doubt to the selectivity of the double-tuned RF transformer, and what there was, was tolerable. The Handy Man And Home Mechanic mentions it, but only in this context: 'Whistling noises ... are often caused by a nearby neighbour fooling about with his old-fashioned set and allowing it to get into oscillation. If this annoyance persists and the owner can be traced, a few friendly but firm words will generally put matters right' (honestly I am not making this up). Of course the AC85 is slightly thrown by nearby sources of radio interference in the modern home, such as TV sets, computers, light switches and thermostats, but is not rendered unusable.

Choice of AM stations multiplies dramatically after dark and apart from the usual high power BBC and local ones, the AC85 was also able to get something from most of Europe. These included many from France and Germany (obviously), but also Spain and Portugal, Holland, Sweden and even Italy. Of particular interest were the Russian sounding examples, or which alternatively might have been from former Soviet Bloc countries. English examples comprised a few 'obscure' or local only transmitters in Norfolk, Suffolk and Cambridge, and also one or two low power London transmitters.

I hung on to it for as long as was decently possible but eventually the thing had to be returned to its rightful owner, which was a bit of a shame as I was quite getting into it. Now I want one.