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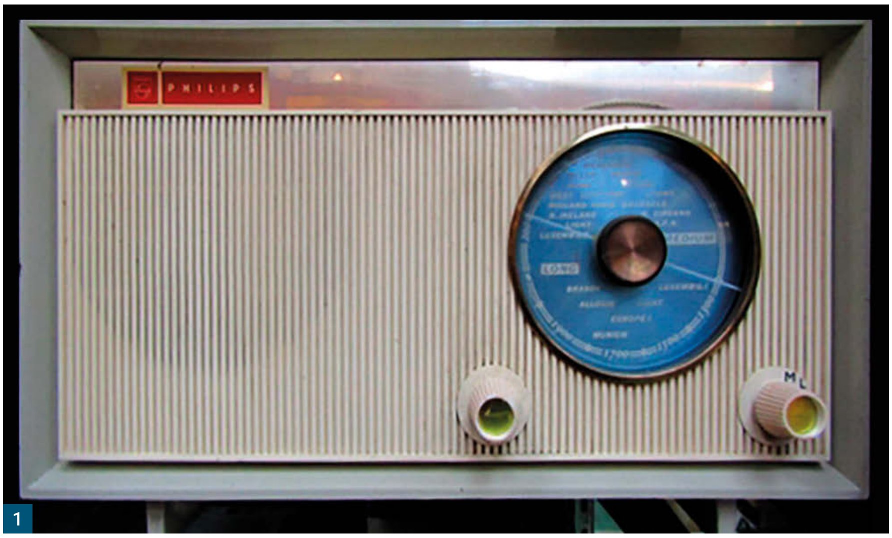

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AC/DC Radios: Eddystone 840A

Michael Jones GW7BBY/GB2MOP discusses the issues involved in working with AC/DC sets, using the Eddystone 840A as an example.

I'm sure that at some point in our radio careers most of us will have come across an AC/DC radio, also referred to as a universal set. As the term suggests, an AC/DC radio will run happily from either an AC or a DC mains supply.

History

DC mains power is unheard of these days, but when electricity started to be supplied to Industry in the late 19th century and subsequently to our homes at the start of the 20th century the supply could be AC or DC and a variety of voltages from 100 to 240. The reasons for choosing AC over DC vary. The battle of the currents raged in America with **Thomas Edison** supporting DC distribution while **Nicola Tesla** and Westinghouse supported an AC system. In the UK, **Dr John Hopkinson** and **Sir William Thomson** (later **Lord Kelvin**) supported DC while **Sebastian de Ferranti** and **Professor Sylvanus Thompson** supported AC. In both countries AC won principally because AC could easily be transformed to different voltages and was thus much more flexible than DC which, in those days, could only be changed by wasteful potential dividers or voltage dropper resistors.

Standardisation

Between the 1880s and 1920s some 600 local electricity generating companies had been established in the UK as well as many other smaller suppliers. In an attempt to standardise supplies, the Electricity Supply Act was passed in 1925. This resulted in the establishment of the Central Electricity Board, which bought the output from selected generating companies and distributed electricity through what was to become the National Grid. From this time the standard voltage for domestic use became 240V AC at 50Hz. This still left some smaller suppliers generating DC supplies as well as other larger companies who had perpetual contracts to supply DC such as the Bankside Power Station on the River Thames in London as late as 1981. Although part of the Central Electricity Generating Board, it supplied DC printing presses in Fleet Street. It was not decommissioned until 1981 when the newspaper industry moved to the Docklands area and adopted AC powered presses. Other DC supplies continued into the 1970s for things such as trams, major welding supplies and pit head mining equipment.

Domestic DC supplies persisted in some areas at least until the mid-1950s. There is even some anecdotal evidence of DC being available until the 1960s.

In the early days there was a demand for AC/DC sets, but despite the demise of DC supplies in the 1950s, AC/DC sets continued to be sold well into the 1970s. Radios such as the Philips, **Fig. 1**, would have adorned many a mid-20th Century sideboard. There was one big advantage as far as manufacturers were concerned: AC/DC sets were cheaper to make than AC only ones.

So What's the Difference?

Remember we are talking about valve radios, which required 200 – 250V DC High Tension (HT) for their anode supplies and a lower voltage for the valve heaters or filaments. The traditional power supply for a valve radio would require a transformer running off the AC mains to produce an HT voltage of the order of 250V AC and a heater supply of usually 6.3V AC. A rectifier valve, choke and smoothing capacitor(s) would be needed to change the AC HT voltage to DC. Importantly the transformer also provides isolation between the chassis and the mains supply. An AC/DC set would employ a dropper resistor in place of the mains transformer. This is essentially a voltage divider connected across the incoming mains to produce the required voltages. If the set is used on an AC supply, then the resulting voltages from the dropper resistor will still be AC so the choke and smoothing capacitors will still be needed. However, a dropper resistor is substantially cheaper than a mains transformer with its high steel and copper content. For DC operation, the rectifier valve behaves as a passive conductor and effectively the DC output from the dropper resistor is used.

For AC operation one simply plugs the set into the mains supply. Hopefully live and neutral wires are correctly connected in the plug. If they are reversed, the set will still work and as the chassis and all the metalwork is mounted in the plastic case, while the control knobs are plastic so the user is insulated from the risk of electric shock. For DC operation the supply wires need to be connected the right way round for the set to work. If they are reversed, the dial lights will still come on, the set will not work, but will come to no harm. Simply change the connections in the plug and it will work.

Fig. 2 Shows the inside of the Philips radio illustrated in Fig. 1. You can see that the chassis is attached to the plastic case, effectively isolating the user from contact with the metalwork. Notice the brown two-core mains cable. There is no coding to identify live or neutral, so the chassis could equally be at live or neutral potential. There is also no provision for earth, understandable in this instance as there would be no viable point to connect it to.

What's the Problem?

As many a service technician and unwary amateur can testify (hopefully!), the issue lies with that potentially live chassis. Live and Neutral may be incorrectly connected in the plug, or past repair work may have been incorrectly executed (as with the Eddystone 840A later). Even if you are familiar with working on high voltage valve equipment, a moment's inattention can result in at best a nasty belt from the chassis, at worst one we try not to think about!

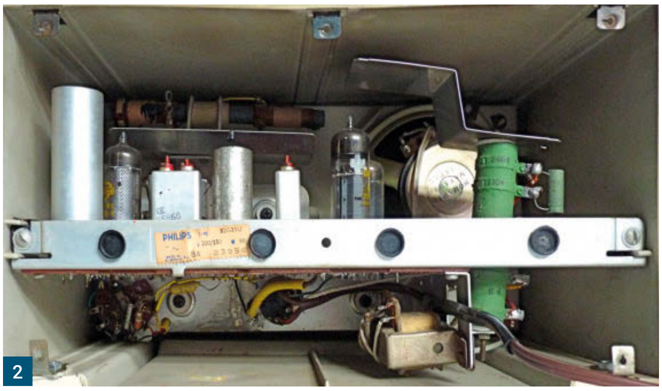

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Fig. 1: Typical Philips AC/DC Radio of late 50s/ early 60s. Fig. 2: Inside the back of the Philips AC/DC Radio. Fig. 3: Eddystone dropper resistor in parlous condition. Fig. 4: Eddystone 840A Power supply. Fig. 5: Barretter.

Other issues with the dropper resistor are mainly down to heat. Because they are lossy devices, they generate heat. The heat affects adjacent components, thermal cycling causes cracking of the ceramic insulation on the dropper resistor itself. Poor storage often in unheated garages or lofts allows damp into the cracks. If it's cold enough, the insulation will crack further and pieces fall off. Next time the set is plugged in, the dropper resistor will be in a dangerous state. Earth leakage issues at least may be a problem.

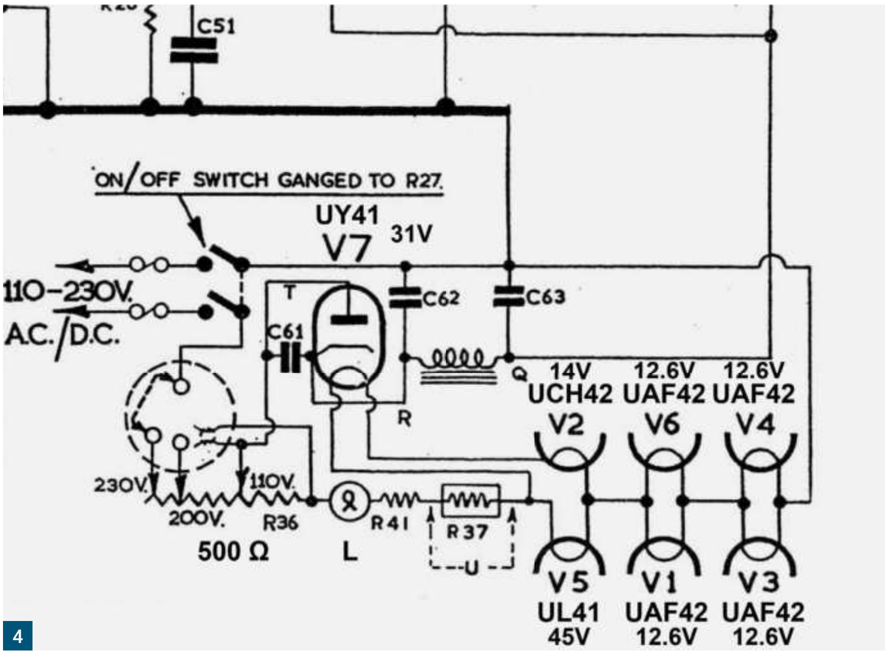
See **Fig. 3**: If this was my personal radio with this dropper resistor, I would disconnect the dropper resistor and associated components and build a transformer-based power supply in a separate enclosure. If originality was not an issue, I might even remove the dropper resistor and build the power supply on the vacated real estate.

In addition to the primary health concerns, care needs to be taken when testing an AC/DC radio to avoid grounding problems when mains-powered test equipment such as signal generators, oscilloscopes etc are being used. An isolating transformer should be used to protect your test equipment and for your own safety. Incidentally, a Variac is not an isolating transformer.

When first turning on a valve radio a simple preliminary check to see if all the heaters are alight can often save a lot of time. You need to be aware that with an AC/DC set the heaters are connected in series or series /parallel chains (**Fig. 4**: Eddystone 840A) so that if one fails all the others in that chain stop working.

Resistive Power Cords

Instead of a dropper resistor some sets, notably American, had a resistive mains lead, which was all very well. As **Harry Leeming G3LLL** warned in his *In the Shop* series in *PW,* more than one person has fallen foul of these by either replacing the mains lead with a conventional copper-cored lead, or shortening the lead. Either way the performance is compromised and the set suffers the consequences. Resistive mains cable is specified as so much resistance per foot, commonly 60Ω per foot. It can be expected to get quite warm in use. Such cable is probably hard to find now, but probably best substituted with a suitable dropper resistor in the set itself, or perhaps an external enclosure. Herein lies another danger signal: if the cord is in good condition and working, leave it alone. If it is at all damaged, beware, it probably contains asbestos insulation.



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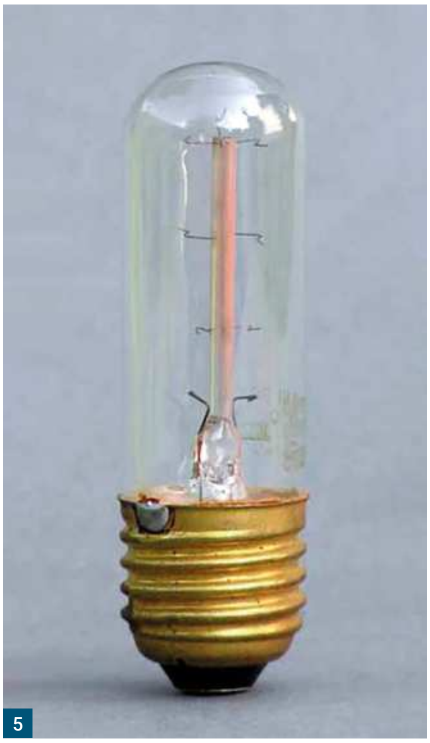
Precautions

If you're not sure, don't do it! Otherwise before working on an AC/DC set, leave it unplugged, but turn the power switch to the on position. Get your multimeter and check for continuity from the neutral pin on the plug to chassis, it should be close to 0Ω. There should be no continuity from live to chassis (Open Circuit). Even so, take great care not to touch the chassis while poking around looking for faults. It's easy to get too engrossed in checking a voltage and absently brush against the chassis or some other live component.

If you have the chassis removed from the cabinet,



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make sure that all the control knobs are replaced on their spindles. It's all too easy while engrossed in the innards of the set to just get hold of a bare spindle to see a switch operate, for instance.

While the AC/DC set carries its own set of safety risks, I must emphasise that working on any mains powered valve radio, AC/DC, AC/Battery or AC only, requires constant attention to the risk of electric shock.

A Typical AC/DC Circuit

The circuit shown on Fig. 4 is the power supply section of the Eddystone 840A. The layout is not as intuitive as might be desired.

Power enters from the left via fuses in each line to the two-pole switch incorporated in the tone control. From here the neutral, or negative line goes to the chassis. The live, or positive side goes to the top of the 500Ω dropper resistor, which offers 230V, 200V or 110V operation. The 110V tapping goes to the anode of the rectifier valve. You can see then that the HT voltage is an unusually low 110V DC. Indeed, on the 110V tapping the dropper resistor is effectively out of circuit and the 110V mains is rectified directly. The rest of the HT circuit is quite normal, with the half-wave rectified output taken from the cathode of V7 via a pi-section smoothing circuit comprising a choke, C62 and C63.

Heaters (Filaments)

If you are used to AC-only radios, you will know that the valves, aside from the rectifier, have 6.3V heaters. They are connected in parallel to a suitably rated 6.3V tapping on the mains transformer. With this arrangement each valve has the same heater voltage and can draw the current it needs from the transformer.

The arrangement for AC/DC sets may seem to be quite simply one of connecting all the valves in series. The problem is that their current requirements will vary, causing unequal voltage drops along the series chain. This could be mitigated to an extent by using shunt resistors across some of the filaments Furthermore, it would need a lot of 6.3V valves (17) to add up to 110V.

Valve manufacturers addressed this problem by developing a range of valves with various, higher, heater voltages, but all with the same specified current. A 'U' prefix (UAF42, UL41 etc) valve consumes 100mA, but has different heater voltages, UAF42, a small signal valve, has a 12.6V heater while UL41, an output pentode, has a 45V heater. Similarly, a 'P' prefix indicates a 300mA range of valves commonly found in TV sets; a 'C' prefix denotes a 200mA heater usually in a pre-war design; an 'H' prefix is for a 150mA heater commonly in American sets.

In the Eddystone 840A circuit (Fig. 4 again) the valves are all in the 'U' series and therefore have 100mA heaters. The heaters are connected in series/parallel. You will see that V4 and V3, both UAF42s, are in parallel and they have 12.6V heaters. Similarly, V6 and V1 are also UAF42s. V5, UL41, an output pentode, has a 45V heater. The series combination of V2, UCH42 with a 14V heater and V7, UY41, with a 31V heater gives a total of 45V in parallel with V5. Adding up the parallel pairs we get 45 + 12.6 + 12.6 = 70V. The resistance of the additional dropper resistor R41, the dial light 'L' and thermistor R37 bring the total voltage requirement to 110V. Other sets will have similar arrangements, some more imaginative than others!

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Thermistor or Barretter

R37 is a thermistor: a negative temperature coefficient device. In other words it has a high resistance when cold, but as it warms up its resistance drops rapidly. Its purpose is to control the inrush current that occurs at switch-on. The valve heaters have a lower resistance when cold so the inrush current can shorten the life of the valves. In older sets, mainly pre-war, a barretter [**1**] performs this function. A barretter (**Fig. 5**, [**2**]) is a constant current device consisting of an iron filament in a hydrogen atmosphere. As well as controlling inrush, it will maintain a constant current of, say, 150mA over a moderately wide range of input voltage. This used to be more important when the mains supply voltage could vary quite considerably, especially on the remaining DC supplies. (I'm afraid I can't explain the physics involved!)

Remember the Dial Light

'L' is the dial light. In this circuit as in many others, failure of the dial light will interrupt the supply to the heaters and will thus stop the set working – remember this!

Other sets may have a shunt resistor across the dial light, this will slightly reduce the brilliance of the light, but prolong its life. Crucially, if the dial lamp does fail, current will continue to flow through the shunt resistor and keep the set working.

The Eddystone 840A

So, to the focus of this month's story: the Eddystone 840A is an AC/DC set produced from about 1955 to 1958. One wonders why a quality manufacturer like Eddystone continued with this practice. The reason is that Eddystone supplied equipment for maritime use and the voltages available on board ship were either 110V DC or 240V DC.

At *Internal Fire, Museum of Power* we have two Eddystone 840As as part of a new display depicting the BBC's Tatsfield Receiving station as it was in the early 1960s. They are both clean and visually in good condition, **Fig. 6**. I knew that they were AC/DC sets and decided that as they were expected to be working in a public area, it would be prudent to do some checks. I needed to ensure that

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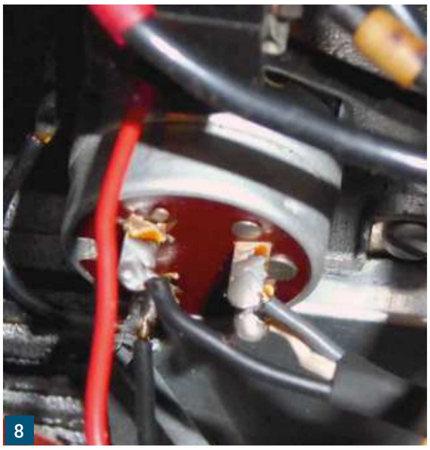
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Fig. 6: The two Eddystone 840As. Fig. 7: Non-polarised power inlet on the 840A. Figs 8 & 9: The two different power switch connections. Fig. 10: Rubber power connector. Fig. 11: IEC C6 connector fitted. Fig. 12: IEC connector offered up to rear panel.

mains neutral, not live, was connected to chassis and that all the insulation between the aluminium casework and the chassis was intact.

Mains Inlet

One of the first things to notice is that the mains inlet is a two-pin non-polarised connector, **Fig. 7**. It can plugged in either way round so irrespective of how the three-pin mains plug is wired, there is only a 50% chance of actually having a neutral chassis. I believe some Eddystone sets had one pin larger than the other, but on the 840A they are both the same size. Indeed the 840A Instruction manual states, *"On AC mains the receiver will work with the plug either way round.........On DC mains.........(if) the valve heaters and the pilot lamp glow but if after the normal 30 seconds.....the set remains lifeless, the power plug should be reversed."*

I decided to determine which of the two pins was connected to the chassis and thus should be the mains neutral. On the first 840A the top pin went to chassis, on the other one the bottom pin went to chassis. Odd! Upon following the wiring it became apparent that the tone control, which incorporates the two-pole on/off switch, had been replaced at some point in one set and the wiring had become reversed at that time, **Figs 8** & **9**. Here is a classic example of how the unwary repair man can be caught out even though the mains plug is correctly wired and the two-pin plug at the back of the radio is correctly oriented.

The Eddystone power plug, **Fig. 10**, is a rubber covered affair. Even if you have an original one, it is likely to be perished and unsafe to use.

Replacement

I decided to replace the two pin mains inlet with an IEC C6 or cloverleaf chassis connector, **Fig. 11**. This would be non-reversible thus ensuring that neutral was always in the right place. It would also allow me to connect the front panel and case to earth so that in the event of any insulation issue between chassis and case the RCB in the consumer unit will trip very rapidly.

Fig. 12 shows the Cloverleaf socket offered up to the 840A rear panel over the two-pin mains inlet. You can see that the fixing holes do not line up with the old two-pin socket holes, in fact they fall right on the edge of the existing apertures for the two-pin plug. My original plan was to make up a small plate from Perspex or stripped PCB material to carry the IEC socket and utilise the original fixing holes. In the end I simply used two large washers to spread the fixing force, **Fig. 15**.

You will have to remove the bridge, **Fig. 13**. I used a router, **Fig. 14**, as it is quick and easy and the vibration transmitted to the radio is minimal. The IEC C6 Cloverleaf socket will then drop nicely into the space created and can be fixed with 3mm countersunk screws with large washers on the inside to spread the load, **Fig. 15**.

The bar shown in **Fig. 16** will have to be removed; it will break off cleanly by bending it back and forth a few times.

I am pleased with the end result, Fig. 11 again. It works well ensuring that the chassis is at neutral potential and that the exterior metalwork is earthed.

An equally valid solution would be to install a captive mains lead. In **Fig. 17** I have just shown the cable passing through one of the two pin plug holes. You will have to incorporate a cable grip and strain relief.

If you decide to carry out this modification, do not earth the chassis. Neutral is grounded, earthed at the substation, not in your home. As a consequence there can be considerable circulating earth loop currents. At the very least an RCB will trip, if you have one.

While I have focused on the Eddystone 840A the IEC connector is a good solution for other radios, including domestic radios with plastic or Bakelite cases. For the latter, the earth connection will not in general be used, but as the connector is polarised you can ensure that neutral is always connected to chassis thus reducing the risk to future service personnel.

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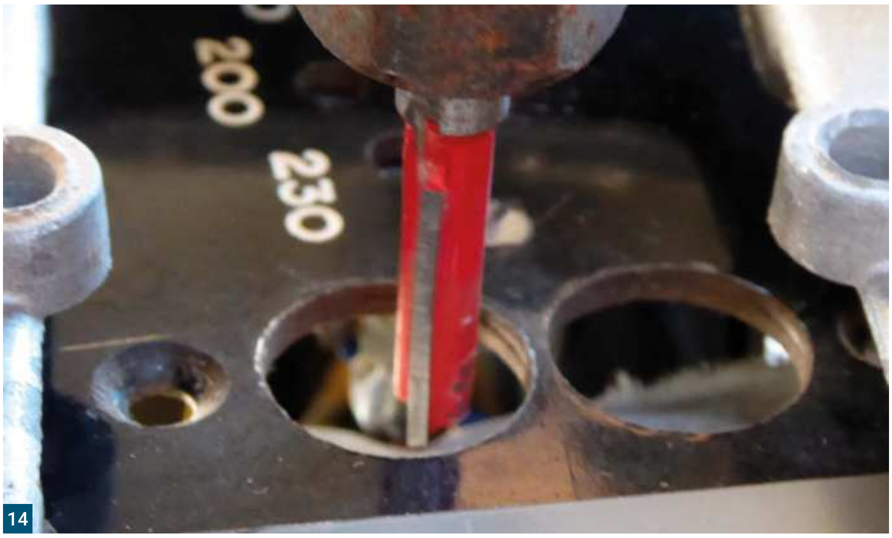

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Fig. 13: This bridge to be removed.
Fig. 14: Using router to remove material.
Fig. 15: Internal view of completed installation.
Fig. 16: This bar to be removed.
Fig. 17: Captive mains cable an option.
Fig. 18: Note C13 to be in good condition.

Check the Metal Casework

The next thing to notice is that the Eddystone 840A has an aluminium front panel and steel case, rather than the plastic, wood or Bakelite case found on domestic sets. The chassis is insulated with Paxolin washers from the enclosure metalwork in numerous places. Great care is needed when reassembling these sets to ensure that all the insulation is correctly fitted and not damaged in any way. Eddystone specify that the insulation resistance chassis to case/front panel should be >100MΩ measured at 500V with a Megger.

It may be worth noting that these sets will run cooler and more efficiently on 110VAC if you have a suitable 240/110V transformer, as the dropper resistor will be largely by-passed.

One final observation on the Eddystone concerns C3, **Fig. 18**. This needs to be in good condition. If it becomes leaky, one half of a dipole antenna could become live. Alternatively, if the earth plug is fitted, the cabinet could potentially become live.

Conclusion

An AC/DC set in good working order, correctly installed in its enclosure, will give good service, but if the time comes to carry out repairs, take care. Whenever we work on mains operated equipment we must be aware of the risk of electric shock and take precautions. These precautions are largely common sense and keep us safe when working on 'conventional' AC mains powered units. Working on AC/DC universal radios requires just a bit more vigilance as there are a few non-intuitive traps to catch us out – take care!

Notes

[1] In the early days of radio a barrettter was used as a detector as the low thermal mass of the filament could respond to changes in audio frequency, but could not respond to RF frequency, thus the change in resistance demodulated the signal.
[2] Barretter © 2005 - 2012 by **Andy Cowley M1EBV**, image is licensed under a Creative Commons License. See:
https://g3ynh.info


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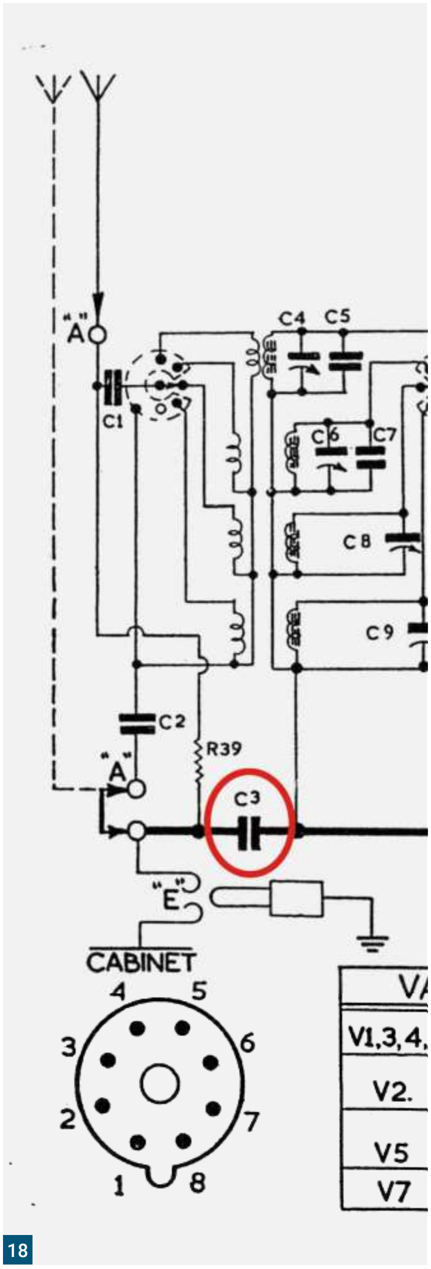

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