

Vintage Radio

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Those troublesome capacitors, Pt.1

Capacitors – especially paper capacitors – have long claimed the crown for being the most troublesome components in vintage radios. They are even more troublesome than valves, which are often made the scapegoat for other faults in a set.

Confronted with a faulty vintage radio, the first thing many restorers look for is a faulty valve. Perhaps it's because they look more fragile than other components or perhaps it's because they're easier to replace than a "wired-in" component like a paper capacitor.

Often however, the problem lies elsewhere and paper capacitors are notorious for causing problems in vintage radios. As a result, many vintage radio enthusiasts spend a great deal of time checking and replacing

capacitors when restoring a set.

In fact, some take a blanket approach and replace most, if not all, capacitors in a set. However, that's not always the best approach – some will almost certainly need replacement but generally not all.

Radio servicing

Many years ago, when I was a radio serviceman, paper capacitors were just as troublesome in valve radios as they are now. Typically, the set's sound would gradually distort over a period

of approximately an hour, or the sound would become intermittent, fading out over a minute or so and then suddenly blaring out at full volume again.

Although it was possible to painstakingly check each stage and eventually locate the offending component, this usually wasn't the best approach. In those days, we didn't have the range of quality test instruments that we have today. Of course, it was always pleasing to find the offending component, if at all possible (Sherlock Holmes had just successfully solved another mystery). However, this approach was usually very labour intensive and time consuming.

I also reasoned that if one paper capacitor was faulty, then others were likely to become defective within a short time. And that could mean that the set would be back with the "same fault" after just a few weeks or months and my reputation would suffer.

As a result, I quickly came to the conclusion that it was more economic to replace all the paper capacitors in one fell swoop. The fault would be fixed (but I wouldn't know which component was faulty) and a batch of new capacitors would give years of trouble-free service.

Or would they? Unfortunately, at that time, the replacements were the Ducons and UCC capacitors of the 1950s and early 60s. These proved to be quite troublesome in service.

Capacitor faults

So what faults did paper capacitors have? Basically, there were three different types of fault that occurred.

The most common fault was leakage resistance which varied with voltage and temperature. This could vary from a few thousand ohms up to hundreds of megohms, depending on the capacitor and its manufacturer. As a result,



Capacitors that are deformed should be replaced. However, if a capacitor appears OK, it may still be used in many circuit locations even if it is leaky.



These old paper capacitors have obviously seen better days and have been replaced. If you want to maintain authenticity, you can often use the “shell” of an old capacitor to hide a modern replacement.

the capacitor looked like a capacitor with a parallel resistance.

The second type of fault involved poor contact between the end plate in the capacitor (attached to the pigtail) and the coiled ends of the capacitor plates. In that case, the capacitor would intermittently go open circuit but just touching a test prod almost anywhere in the set would cause the capacitor to temporarily “come good”. This type of fault was difficult to track down to a single unit.

The third type of fault was somewhat more common in early paper capacitors. A paper capacitor is made of sheets of specially treated paper, with two foils in between the sheets. These are wound rather like sticky tape on a roll and the foils may only be attached to the pigtail at one end of the wound layers.

A capacitor made this way (or heading this way in service) can be quite inductive and will not do a good job in RF circuits. It may test perfectly for capacitance and leakage but it won't work in the circuit. Again, this can be a tricky fault to find.

It will be quite obvious to those who read the “Serviceman’s Log” that bulk replacement of some components is done today, even though most will be quite OK. The fact is, it's far more economical to replace many small components that could cause a particular fault rather than spend time tracking down an individual culprit.

Of course, it will be obvious which component is at fault in many cases. However, it pays to replace “innocent” components that could be intermittent

and which may have caused the other parts to fail.

Restoring old radios

To ensure high reliability in vintage sets, all the paper capacitors can be replaced with modern (and much more reliable) polyester or styrofoam capacitors. In fact, this is often done as a matter of course by many vintage radio buffs. It's also a technique that's often employed by less experienced restorers to fix a problem they are not familiar with.

I was initially guilty of this approach too, probably as a result of my servicing experiences. However, sometimes I didn't have enough capacitors to do the complete job and I eventually began to wonder if it really was necessary to replace all paper capacitors.

The answer to this is “no, it isn't” and the reason is quite simple – many are not in positions where they can cause trouble, despite having measurable leakage. Of course, the exact amount of leakage that is tolerable in any location is an elastic figure – it all depends where the capacitor is located in the circuit. In short, “if it ain't broke don't fix it”!

In addition, needlessly replacing all the original paper capacitors detracts from the set's authenticity – at least when it comes to appearance. There is an alternative though and that is to remove the innards of the paper capacitors and hide polyester capacitors inside the vacated cases. That way, the capacitors look authentic but now work reliably.

For further information on how to



A high-voltage insulation tester is useful for checking capacitors out of circuit.

do this, the Historical Radio Society of Australia magazine “Radio Waves” had an article in its January 2004 issue on this very subject.

The decision to replace a paper capacitor will depend on its leakage resistance, its location in the circuit and the component values around it. However, there are some capacitors that must have negligible or unmeasurable leakage resistance. These are the audio coupler between the plate of the first audio stage and the output valve grid and the AGC/AVC bypass capacitors. I routinely replace these capacitors without even bothering to test them, particularly the audio coupler.

Cathode bypass capacitors can be extremely leaky and still be “satisfactory” as far as the circuit is concerned. However, if their leakage resistance is below around a megohm or two, I would still replace them as the leakage may be due to another fault which then needs to be tracked down.

Example sets

It has always been my philosophy to place the least strain possible on components within a receiver. This sometimes involves making slight alterations to circuits to achieve this aim, as detailed for the two example circuits presented below and in Pt.2 next month. The less strain on a part, the more reliable it is likely to be.



Electrolytic capacitors can also be unreliable and need to be carefully checked, both for leakage and for capacitance value. Again, you can hide modern units inside the “shells” of the originals to keep the appearance authentic.

My first example is the Healing R401E/S401E, a simple 4-valve superhet receiver. This set places relatively little stress on its capacitors and is also quite tolerant of leakage resistance.

Pt.2 next month covers the Healing 505E, a 5-valve superhet. By contrast with the 401E, this set has a number of capacitors that are either under significant stress or are in places where very little leakage can be tolerated.

The Healing R401E/S401E

The R401E has no AGC and only one audio stage, so that greatly simplifies matters. Generally, bypass capacitors (such as a screen bypass) can have a leakage resistance of 10 times the value of the screen dropping resistor and the performance of the set will be little affected (if noticeable at all).

In practice, I prefer to limit the leakage resistance to something like

20 times, with a minimum of around 2MΩ. In this case, screen bypass capacitor C8 could have a leakage of 20 times the value of R5 (20kΩ) which is 0.4MΩ but as just stated, I would replace it if it were below 2MΩ just to be on the safe side.

Note that C8’s voltage rating is 400V, although the operating voltage is around 116V. However, the voltage across this capacitor could be as high as 330V just after switch-on, as the 5Y3GT is operating and supplying peak DC voltage well before the other valves start drawing any current.

C3 is used as an RF bypass and is connected to potentiometer R1 which has a resistance of 50kΩ. Even with R1’s moving arm at the centre of its travel, the maximum resistance to earth is around 14kΩ and so the maximum voltage across C3 is only about 35V. As a result, C3 isn’t highly

stressed and it can be quite leaky at perhaps 300kΩ and still cause no problems in the set.

C9 is the cathode bypass for both of the radio frequency (RF) valves (6A8G & EBF35). This capacitor is in parallel with R3 which in turn is in series with R4 and R1 in parallel. As a result, the resistance from the cathodes of these two valves to earth is around 3kΩ and so the leakage across C9 could be as low as 60kΩ without causing problems.

By contrast, C10 is a mica capacitor and it must have very low leakage – ie, greater than 20MΩ internal resistance. In practice, mica capacitors generally have extremely low leakage (high resistance) and rarely need replacing.

Next, we come to the critical audio coupler – capacitor C11. Resistor R7 has a value of 1MΩ, so as a rule of thumb, I would expect C11 to have greater than 20MΩ of resistance or I would replace it. There’s not much voltage across this capacitor though, so it’s quite unstressed in this circuit.

The voltage across C10 will vary from around +35V to perhaps +20V, depending on the setting of the volume control and the strength of the received station. Assuming that C11 has a resistance of 20MΩ, this means that the voltage at the junction of R7 and C11 will be just under +2V. This voltage is applied to the grid of the 6V6G and will cause it to draw more current, so the voltage across R8 rises by almost 2V to almost bring the stage back to its correct bias.

In greater detail, the normal bias on a 6V6G running from a 250V HT supply is around 12.5V. If it has +2V on the grid, the cathode voltage has to rise to 14.5V to cancel the effect of the positive grid voltage. As a result, the valve will draw 14.5/12.5 times its intended current, or about 16% more (of course, this increase would be much greater with a valve that requires just 5V of bias).

In this set, a 20MΩ leakage across C11 is probably acceptable as the valve is not being pushed hard. However, I would still replace it if it were below 50MΩ leakage resistance. Note that although the maximum voltage across this capacitor is only 35V, it is rated at 600V!

Next on the list is C13 which is wired from the plate of the 6V6GT to its screen. It acts as an elementary tone control (so that the set doesn’t sound



This photo shows a couple of old Ducon paper capacitors. They were notoriously unreliable.

HEALING R401E/S401E.

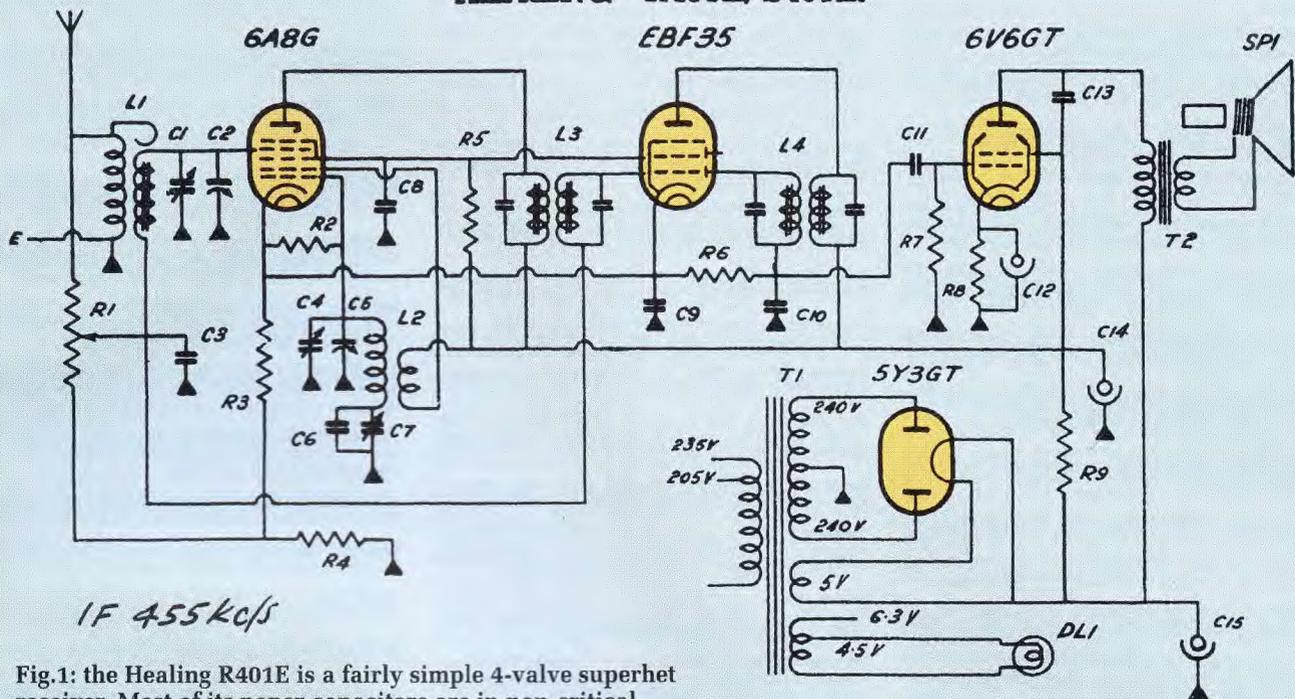


Fig.1: the Healing R401E is a fairly simple 4-valve superhet receiver. Most of its paper capacitors are in non-critical locations when it comes to leakage.

“screechy”) and as an RF bypass to filter out any residual 455kHz energy in the audio amplifier. Once again, there is only around 40V DC and about 150V of audio impressed across this capacitor which is also rated at 600V.

R9 and output transformer T2’s primary are connected in series across C13 and have a combined resistance of about 4.5kΩ. Once again, this capacitor could theoretically be quite leaky at around 20 times this value (ie, 90kΩ) without having any real affect on the set.

Only C8 is stressed

In summary, there’s only one paper capacitor in this set that’s under any real stress and that’s screen bypass capacitor C8. The others all have quite an easy life and can have quite high leakage without upsetting the operation of the receiver. This means that you may not have to replace any paper capacitors when restoring this set (except for C8), which is contrary to what many people have believed in the past.

Next month, we’ll examine the paper capacitors in the Healing 505E receiver. This set is far less tolerant of leaky capacitors than the 401E, as we shall see.

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Photo Gallery: Breville 621 Pick-Me-Up-4



Introduced in 1947 by Breville Radio, Sydney, the 621 was housed in a painted metal cabinet fitted with a carrying handle. However, the set wasn’t really a portable, being designed for mains-only operation. The valve line-up was as follows: EK2G frequency changer; 6G8-G reflexed IF/audio amplifier/AVC rectifier; 6V6-GT audio output; and 5Y3-GT rectifier. Photo: Historical Radio Society of Australia, Inc.