CAPACITOR REFORMING – or: *How to avoid the Big Bang!*

When a new bit of gear arrives in your workshop – what do you do? After a quick check to see the voltage selection (if any) is set correctly, do you apply power without further ado, just to see what happens?

Most of us – if we are honest – have done this at some time. And most of us have "got away with it". Often enough the equipment powers up OK, with evident signs of life, and no ill effects.

The problem

The trouble is that most of us have also had the ***other*** experience! After switching on – and you are in luck – there is only a nasty smell, maybe with some smoke – and you switch off in a hurry. Examination shows that one of more electrolytic capacitors is warm/hot, and possibly even bulging with evident internal pressure. The capacitor then has to be replaced – but no great harm is done.

If you are not so lucky – there is a large bang – followed by you switching off in an even greater hurry! Examination this time, shows a horrible, gungy mess inside the equipment, where an electrolytic has passed away, leaving its contents scattered into every inaccessible corner.

How to avoid a gamble

So are we faced with this gamble every time we power up new equipment? Well, no – the alternative is to carefully reform the capacitors before fully applying power. Discussing this with Mike Hazell, G1EDP, revealed a piece of equipment that he made up for this task. This handy bit of gear also tells him whether the capacitor is OK or not – if not, he can replace it before any damage is done.

Reforming the capacitors can take some time, hours typically for those that have not seen any power for many years – and in some cases, days. Naturally, this does require some patience – particularly difficult for those desperate to get that new widget up and running – but you only need one experience of the "big bang", to teach you that patience is definitely the best policy!

A memorable 'big bang'

While at school in the Cadet Force Signals section, I was one day repairing a WS19 power supply. After fixing it, I took it up to the physics labs for a test.

I put the psu (not in its case) on the bench and applied 12 volts. Everything seemed OK, so I left it running, and went to chat to the lab technician.

Suddenly, there was an almighty bang, and the physics master came rushing out of a lesson to find out what was going on. He was not pleased to find a trail of gunge scattered across the bench and floor. A glance at the PSU showed the electrolytic was now no more than an empty can. Following the trail, I was astonished to find most of the solid contents of the WS19 smoothing capacitor sitting neatly in a waste bin, some 3 yards away from the PSU.

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So what goes wrong with electrolytics?

Electrolytics use a very thin film of oxide on the positive electrode as the "insulator" between the plates. They need a small leakage current to keep this oxide layer in place. If left unpowered for long periods the oxide layer can break down, making the capacitor into more or less a dead short.

When power is applied to a capacitor in this condition, it *may* quickly re-oxidise, and limit the current flow. In some cases, lots of current flows, the capacitor gets hot, starts to gas, and may also explode.

Exactly what is 'reforming'?

Reforming applies voltage to the capacitor – but in a controlled manner so if it is a short, the current is limited to a safe value. This allows the oxide layer to slowly reform, without producing excessive heat and gases – although this may take several hours to complete.

A simple capacitor reforming unit

When I asked Mike, G1EDP about his capacitor reforming unit, he gave me a photocopy of an article from the May 1969 issue of *Radio Constructor* magazine (now long defunct – see Acknowledgements).

The basic principle of the unit is illustrated by the outline circuit in Fig.1. C_T is the capacitor being reformed or tested. A DC supply is required, with a voltage equal to the voltage rating of the capacitor under test. C_T is connected to the DC supply through R_L, which limits the maximum current flow to a safe value, typically a few milliamps. A visual indicator consisting of the neon lamp, R_N and C_N shows the progress of the reforming and state of the capacitor.

The way this circuit works is as follows. Initially at switch on, the voltage across BE is at zero (since C_T is presumably discharged) and the voltage AB is equal to that of the DC supply, and the neon lights. If C_T is at all healthy it will slowly (maybe very slowly) start to reform and charge up – the voltage across BE will start to rise, and that across AB – and the neon circuit - correspondingly falls.

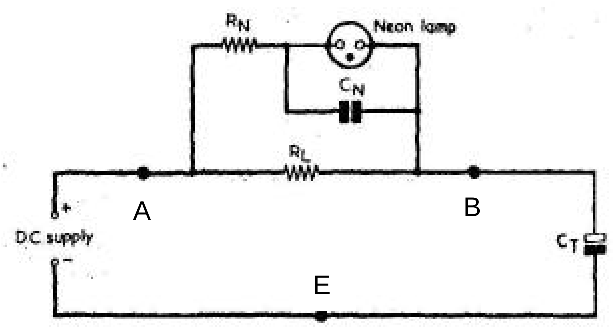

Fig.1: outline circuit of capacitor reformer

As this process continues – and it may take hours – the voltage across AB falls to the point where it is insufficient to keep the neon continuously alight. The neon then goes into a flashing mode due to R_N and C_N. Once the neon stops flashing, the voltage across AB is then at a low value (approximately 75 volts) and C_T is virtually fully charged, and can be assumed to have reformed successfully.

Design of a practical capacitor reformer

The full circuit for a capacitor reformer is shown in Fig.2 – which has been adapted from the *Radio Constructor* article already mentioned.

A simple DC supply using a voltage doubler rectifier arrangement turns a 250V AC output of the transformer into approximately 520 volts DC across C_1 and C_2. The resistor chain R_1 to R_{10} , R_{16} to R_{18} sets the actual voltage to be used in the reforming, and can be selected by the 12-position switch S1b. The resistor values have been chosen to provide the voltages shown in Table 1, and have approximately 25 mA flowing through them. When setting up the unit, the value of R_{16} should be chosen to that point 'M' has 500 volts with respect to the negative rail (chassis or ground).

Acceptable leakage current

All electrolytics leak to some degree – the question is whether the leakage is at a reasonable level or not. What is "reasonable" varies with the quality of the capacitor, and also its voltage rating. The circuit in Fig.2 detects leakage currents typical of older capacitor types – it will not necessarily work well with modern capacitors, particularly some of the very high capacitance values now available that can have

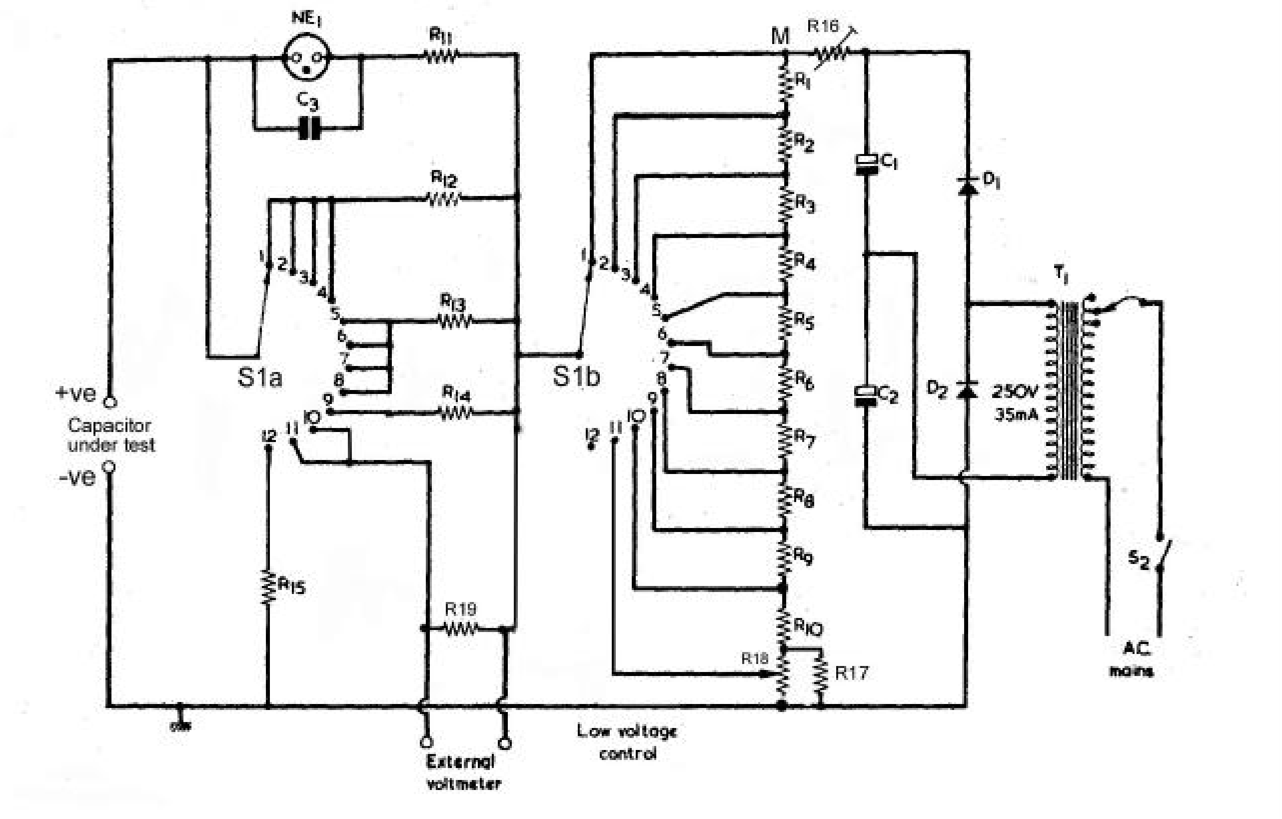

Fig.2: Full circuit of capacitor reformer

leakage specifications up to a few milliamps.

A capacitor with acceptable leakage current is indicated by the neon stopping its flashing and going out completely. This occurs when the voltage across AB, in Fig.1, falls to about 75 volts. The values of resistors R_{12}, R_{13}, R_{14} and R_{19} (the equivalent of R_L in Fig.1) are chosen by:

$$R\ (k\Omega) = \frac{\text{75 volts (i.e. voltage neon goes out at)}}{\text{max acceptable leakage current (mA)}}$$

The values for these resistors shown in the parts list (see Table 2) give the leakage currents shown in Table 1.

Table 1: Switch S1 settings

S1 position	Approximate voltage available	Maximum capacitor leakage current (μA)
1	500	1,000
2	450	
3	400	
4	350	
5	300	850
6	250	
7	200	
8	150	
9	100	700
10	63	see text
11	0 – 50	see text

Low voltage electrolytics

A slightly different arrangement is made for low voltage electrolytics, which may be tested on positions 10 and 11, of S1. Position 10 provides about 63 volts, and position 11 a variable voltage in the range 0 – 50 volts. Since the neon indicator will not work at all at these low voltages, provision is made to connect an external voltmeter across R_{19} – this should be a 20kΩ/V meter (such as an AVO) or better, a DVM.

R_{19} has a value of 10kΩ so each volt developed across it indicates that 100μA is flowing in leakage current. The acceptable limit value in this case can either be taken from the specifications, or if these are unavailable, use a value of 0.01CV μA, where C = capacitance in μF, and V = applied voltage in volts.

Position 12 of S1 is provided for safe capacitor discharge: remember a capacitor charged with up to 500 volts can give a very unpleasant belt!

Professional capacitor reformers

It is worth noting that there are ex-MOD capacitor reforming units around – although I personally have never seen one for sale, nor do I have any information on such units. You may be lucky and pick one up at a rally – well worth getting if you see one.

Table 2: Parts list for the capacitor reformer

Component reference	Value and type
R_1 – R_9	2.2 kΩ, ±5%, 2W,
R_{10}	560Ω, ±5%, ½W
R_{11}	220kΩ, ±5%, ¼W
R_{12}	68kΩ, ±5%, ¼W
R_{13}	82kΩ, ±5%, ¼W
R_{14}	100kΩ, ±5%, ¼W
R_{15}	1.5kΩ, ±5%, 1W
R_{16}	potentiometer or select on test resistor to give 500V at point 'M'
R_{17}	18kΩ, ±5%, ¼W
R_{18}	2.5kΩ linear pot, 2W wirewound
R_{19}	10kΩ, ±5%, ¼W
C_1, C_2	16μF, 350V wkg.
C_3	0.22μF, 100V plastic
D_1, D_2	1N4007 diodes or similar
T_1	Mains transformer with 250 – 300V, at 35mA (or more) secondary
S_1	2 pole, 12-way
S_2	Mains on/off toggle
NE_1	Neon indicator

Acknowledgements

The basic circuit design for the capacitor reformer was taken from an article by T.W. Bennett, "Re-forming and Testing Electrolytic Capacitors", published in the May 1969 issue of *Radio Constructor* magazine.

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