# *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 select (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 of 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 or 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 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.

***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 lab 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*

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

***So what goes wrong with electrolytics?***

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

When power is applied to a capacitor in this condit may quickly re-oxidise, and limit the current flow. In cases, lots of current flows, the capacitor get hot, to gas, and may also explode.

***Exactly what is 'reforming'?***

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

***A simple capacitor reforming unit***

When I asked Mike, G1EDP about his cap reforming unit, he gave me a photocopy of an article the May 1969 issue of Radio Constructor magazine long defunct - see Acknowledgements).

The basic principle of the unit is illustrated by the o circuit in Fig.1. CT is the capacitor being reform tested. A DC supply is required, with a voltage eq the voltage rating of the capacitor under test. ( connected to the DC supply through RL, which limi maximum current flow to a safe value, typically a milliamps. A visual indicator consisting of the neon RN and CN shows the progress of the reforming state of the capacitor.

*bench and floor. A glance at the PSU showed that 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 from the PSU.*

***Richard, G7RVI***

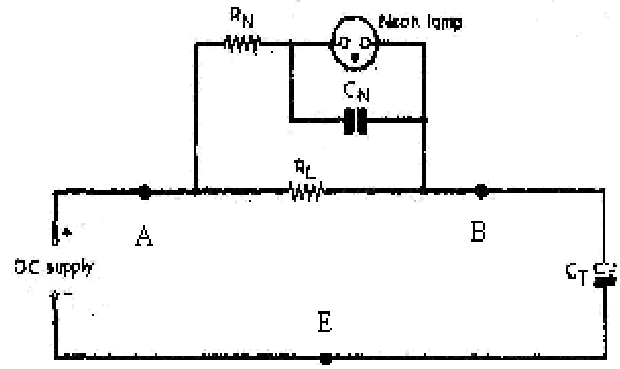


*Fig.1: outline circuit of capacitor reformer.*

1

The way this circuit works is as follows. Initially at switch on, the voltage across BE is at zero (since CT is presumably discharged) and the voltage AB is equal to that of the DC supply, and the neon lights. If CT 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.

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 RN and CN. Once the neon stops flashing, the voltage across AB is then at a low value (approximately 75 volts) and CT 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 hown in Fi which has been adapted from the Radio Const article already mentioned.

A simple DC supply using a voltage doubler re arrangement turns a 250V AC output of the transf into approximately 520 volts DC across C1 and C2 resistor chain R1 to R10, R16 to R18 sets the a voltage to be used in the reforming, and can be sel by the 12 position switch S1b. The resistor values been chosen to provide the voltages shown in Tal and have approximately 25mA flowing through t When setting up the unit, the value of R16 shou chosen to that point 'M' has 500 volts with respect t negative rail (chassis or ground).

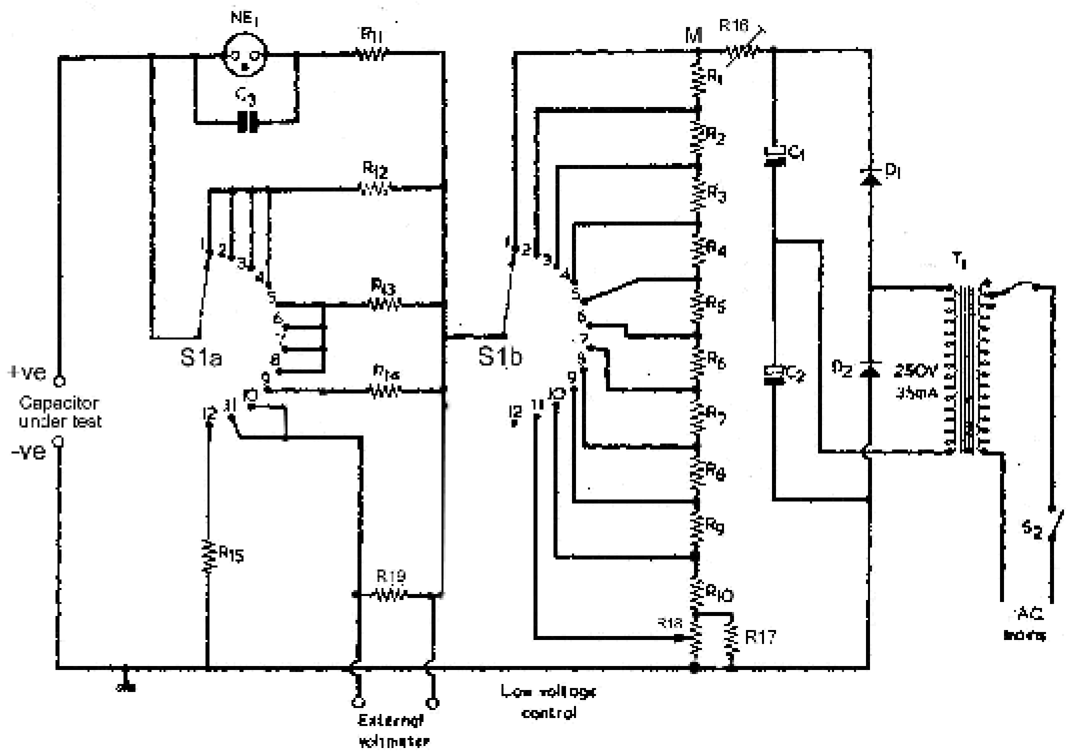


*Fig.2: Full circuit of capacitor reformer*

***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 leakage specifications up to a few milliamps.

A capacitor with acceptable leakage current is indi by the neon stopping its flashing and goinc completely. This occurs when the voltage across A Fig.1, falls to about 75 volts. The values of resistors R13, R14 and R19 (the equivalent of RL in Fig.1 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 Table 2) give the leakage currents shown in Table 1.



| Table 1: Switch S1 settings | | |
|---|---|---|
| S1 position | Approximate voltage available | Maximum capacitor leakage current (μ A) |
| | | |

| Table 2: Parts list for the capacitor reformer | |
|---|---|
| Component reference | Value and type |
| $R_1 - R_9$ | 2.2 kΩ , ± 5%, 2W |
| | |

| | | |
|---|---|---|
| 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 R19 - this should be a 20kΩ/V meter (such as an AVO) or better, a DVM.

R19 has a value of 10kΩ so each volt developed across it indicates that 100mA 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 mA, 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.

| | |
|---|---|
| $R_{10}$ | 560Ω , ± 5%, ½ W |
| $R_{11}$ | 220kΩ , ± 5%, ¼ W |
| $R_{12}$ | 68kΩ , ± 5%, ¼ W |
| $R_{13}$ | 82kΩ , ± 5%, ¼ W |
| $R_{14}$ | 100kΩ , ± 5%, ¼ W |
| $R_{15}$ | 1.5kΩ , ± 5%, 1W |
| $R_{16}$ | potentiometer or select on tes resistor to give 500V at point ‘ |
| $R_{17}$ | 18kΩ , ± 5%, ¼ W |
| $R_{18}$ | 2.5kΩ linear pot, 2W wirewou |
| $R_{19}$ | 10kΩ , ± 5%, ¼ W |
| $C_1$, $C_2$ | 16μ F, 350V wkg |
| $C_3$ | 0.22μ F, 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 wa taken from an article by T.W. Bennett, "Reforming ar Testing Electrolytic Capacitors", published in the Ma 1969 issue of Radio Constructor magazine.

***Submitted by Mike Hazell, G1EDP***

***Originally published in the VMARS Newsletter, April 2000***

***Written up by Richard Hankins, G7RVI***

***HTML conversion for website by Barbara Guy, G8IEV***

3

---