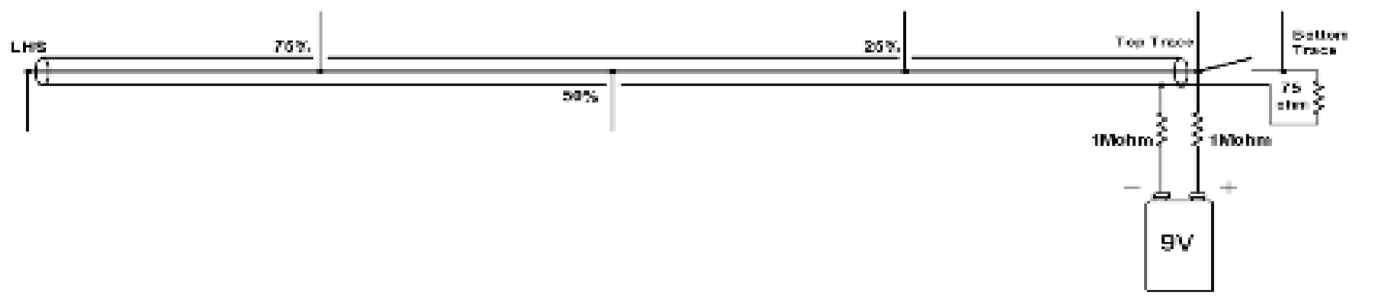
THE END OF THE ROAD

DO EXPERIMENTAL RESULTS MEAN THE END OF THE ROAD FOR WHAT HAS BEEN TAUGHT TO 14-YEAR-OLDS THROUGHOUT THE WORLD FOR 150 YEARS? THEY ARE TAUGHT THAT A "STEADY CHARGED CAPACITOR" HAS STATIC ELECTRIC FIELD BETWEEN THE TWO PLATES. BY **IVOR CATT**



A capacitor, made of 50 ohm coaxial cable, is slowly charged up to 8V from a voltage supply via a large resistor. It is then suddenly discharged by closure of a reed relay into a long 50 ohm cable. According to the Instruction Manual for the Type 109 pulse generator (GR) from Tektronix, the result is a double length, half amplitude pulse.

On page 2, the manual states: "The output pulse duration is equal to twice the transit time of the charge line used, plus a small built-in charge time due to the lead length from the GR panel connectors to the mercury [reed relay] switch contact point."

"The transit time of the cable is defined as the time required for a signal to pass from one end of the line to the other. For a 10ns charge line then the duration of the output pulse would be 20ns. The pulse amplitude obtained will be approximately one-half the power source voltage..."

It seems that since when I used it 48 years ago in 1964, nobody else has pondered the significance of the half size double length pulse. The final part of the energy must have waited for twice the delay time from end to end of the capacitor before exiting. In 1980 this led to me propounding: "This paradox, that when the switches are closed, energy current promptly rushes away from the path made available, is understandable if one postulates that a steady charged

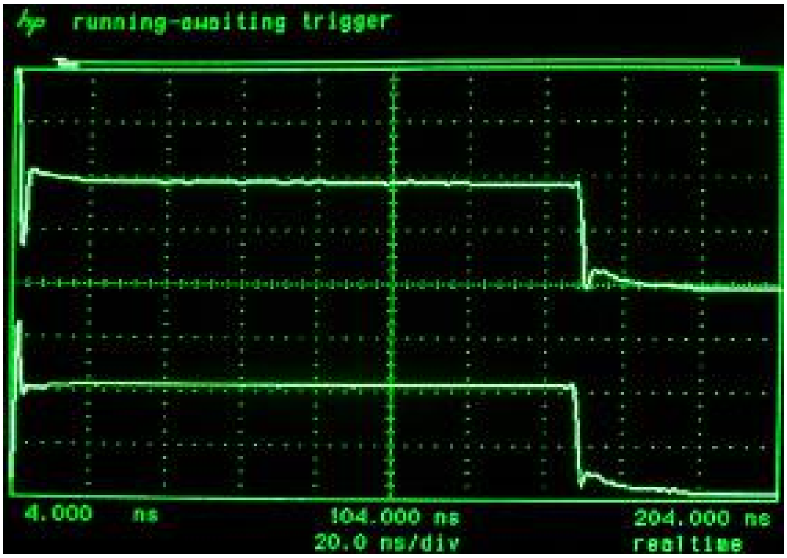


Figure 1: Bottom Trace: The bottom trace probe is across the 75Ω terminator used as a trigger. It shows a pulse of ½ of the battery's 9V (actually 8V after the 2 x 1MΩ resistors and the probe loading)
Top trace: Left-hand side of the reed switch. The trace immediately drops from 8V to 4V

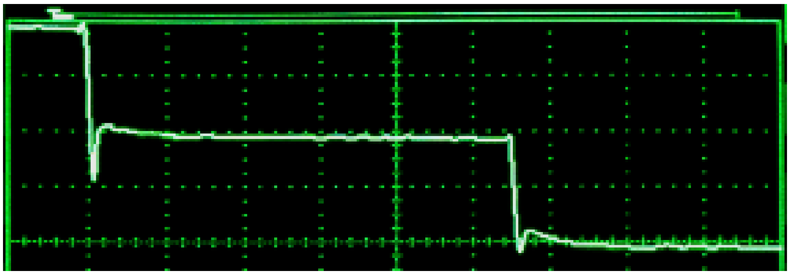


Figure 2: 25% to the left of the reed switch (4.5m)

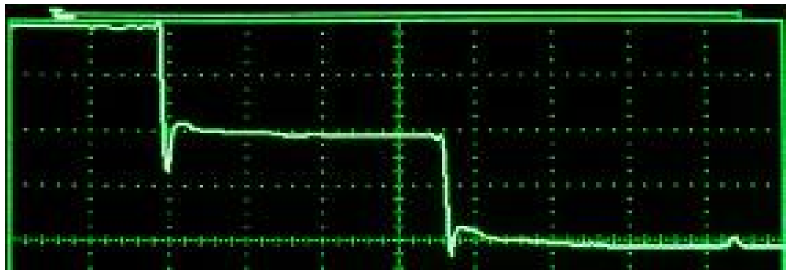


Figure 3: 50% to the left of the read switch

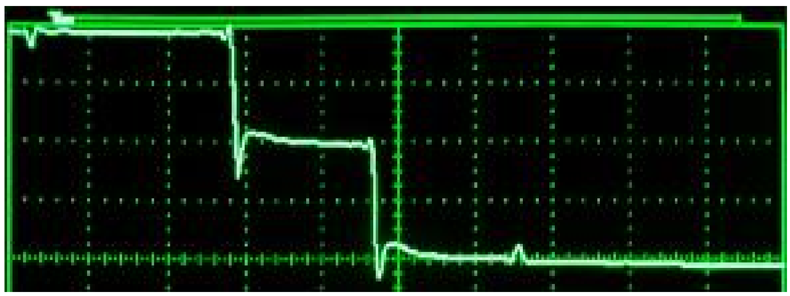


Figure 4: 75% to the left of the read switch

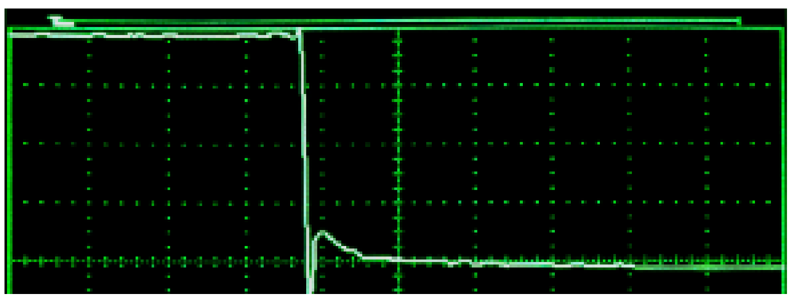


Figure 5: At extreme left at the unterminated end of the coax

capacitor is not steady at all; it contains energy current, half of it travelling to the right at the speed of light, and the other half travelling to the left at the speed of light.

Now it becomes obvious that when the switches are closed, the right-wards travelling energy current will exit down BC first, immediately followed by the leftwards travelling energy current after it has bounced off the open circuit at A.

We are driving towards the principle that Energy (current) E x H cannot stand still; it can only travel at the speed of light. Any apparently steady field is a combination of two energy currents travelling in opposite directions at the speed of light. E and H always travel together in fixed proportion Zo." – "Death of Electric Current", Wireless World, December 1980, page 79.

An Historic Experiment

On 5 June 2009 I belatedly realised that we could do a historic experiment.

The new experiment was to set up a Tek109 pulse generator with a 40ns charging line, but introduce monitor points every 10ns along the line into a sampling scope. We would then see the clean way in which the charged voltage, say 8V, drops to 4V at the appropriate moment when the first part of the output pulse has outputted to the right but the second part, travelling in the opposite direction, is still present. That is, first of all we would see 8V and then for a period we would see 4V, then 0V.

The 'establishment' would have to resist the obvious conclusion, that before the reed relay was closed, half of the energy in the cable was already travelling to the right and the other half to the left. Nothing was ever stationary.

My colleague Forrest Bishop and I had bought four Tektronix 109 pulse generators, which more or less all turned out to be faulty. Matters had drifted for three years.

There were considerable problems in getting the necessary equipment together. Finally, after three frustrating years, Tony Wakefield of Melbourne succeeded, and we here present the results. Wakefield happened to have a newer type of oscilloscope with could register a one shot with a response of 2ns, and as such he did not need the Tektronix pulse generator. Within a few days he had done the experiment and delivered his results.

> It seems that nobody else has pondered the significance of the half size double length pulse

We now have experimental proof that the so-called steady charged capacitor is not steady at all. Half the energy in a charged capacitor is always travelling from right to left at the speed of light, and the other half from left to right.

T109 experiment uses 75-ohm coax. Length = 18 meters

The left-hand end is open circuit. The right-hand end of coax is connected to a small 1cm long, normally open reed switch. On the far side of the reed switch is a 75-ohm termination resistor simulating an infinitely long coaxial cable. A hand-held magnet is used to operate the switch.

The coax is charged up from a 9V battery via 2 x 1 megaohm resistors, close-coupled at the switch to center and ground. Two resistors are used to isolate the relatively long battery wires from the coax. High value resistors are used as to minimize any trickle charge after the switch is closed.

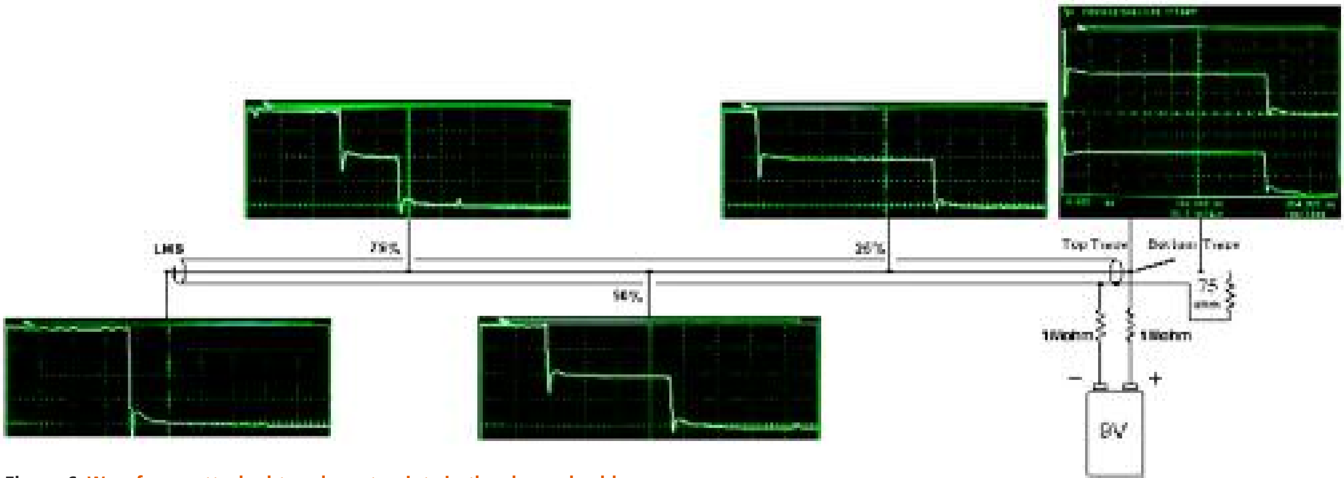


Figure 6: Waveforms attached to relevant points in the charged cable

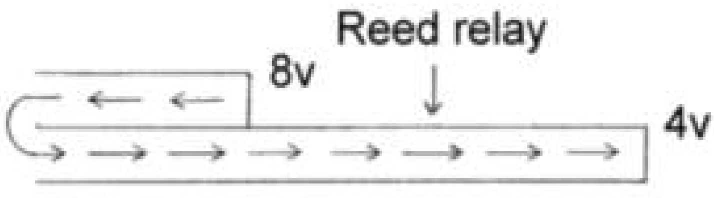


Figure 7: Snapshot of the cable when one quarter has left the charged cable

A 2-channel HP 54510B digital sampling scope set to 2V/div vertical and 20ns/div horizontal is used to capture five images:

1. The bottom trace probe is across the 75 terminator used as a trigger. It shows a pulse of ½ of the 9 battery volts (actually 8V after the 2 x 1 megaohm resistors and the probe loading).
2. Top trace. Left-hand side of the reed switch. The trace immediately drops from 8V to 4V.
3. Bottom trace. Across 75 ohms. Immediately rises to 4V.
4. 25% to the left of the reed switch (4.5m).
5. 50% to the left of the read switch (9m).

ONGOING DOUBTS

ALTHOUGH MY COLLEAGUE FORREST BISHOP ARGUES THAT SURELY SOMEONE ELSE WILL ALREADY HAVE THOUGHT OF TAPPING INTO THE CHARGED PIECE OF COAXIAL CABLE TO SEE WHAT HAPPENS DURING DISCHARGE, I DOUBT IT. After all, it was only after more than 40 years that the idea occurred to me. Also, it somewhat contradicts Forrest's other point, that long ago he realised that the level of competence among those with accreditation in electromagnetic theory – professors and text book writers – is far lower than I would have imagined until recently. They are lost in a cloud of dubious mathematics and early 20th century delusions including wave-particle dualism, also using Fourier to ignore anything other than sine waves, and so lack grasp of the physics of a TEM pulse.

A Change in Theory

In my article entitled "Displacement Current" in Wireless World in December 1978 it was pointed out that when a battery charges a capacitor, the energy is introduced into the capacitor at the speed of light. Once inside the capacitor, there is no mechanism for the energy to slow down.

The change in theory for a charged capacitor from stationary electric field to two electromagnetic fields travelling at the speed of light is an introduction to my general theory, that there is no such thing as a stationary field, electric or magnetic.

Not only in the case of a charged capacitor, but always, any apparently stationary electric or magnetic field is in fact the superposition of two ExH electromagnetic fields travelling in opposite directions. Occam's razor supports this assertion. In the case of the charged capacitor, the magnetic dimensions to the two electromagnetic fields are equal and opposite. They cancel, so an instrument cannot detect them. This gives the impression that a charged capacitor only has electric field, although the energy delivered to it when charging is a TEM wave of ExH energy current. The delivered energy is conventionally said to have half its energy in the electric field and half in its magnetic field, travelling at the speed of light.

In Electronics World, January 2011, page 20, I again proved from first principles that such a TEM wave can only travel at the speed of light for the dielectric, $\pm 1/\sqrt{\mu\varepsilon}$. It cannot travel slower. In our case the only possible velocity remains c, because it should be well known that when two pulses travel through each other in a coaxial cable they do not slow down. Rather, i2r losses disappear.