Everyone makes mistakes

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Here we present definitive evidence of the many mistakes, disasters and just plain bad luck present in every research institution. There are probably many more embarrassing mistakes that we will never admit to, but fortunately, there are no photographic records, so clearly they did not happen. Definitely.

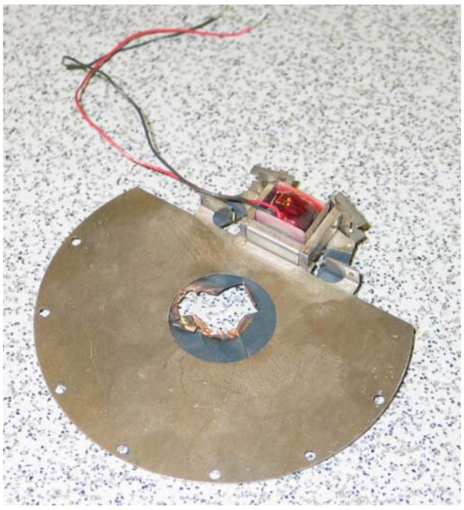
1. Drilling through power cables

When an additional Van de Graaff accelerator beam line, intended for particle micro-irradiation work, was to be installed, it was necessary to drill the floor of the physics laboratory through to the ceiling of one of the radiation/experimental areas.

But the building plans were mislaid….or were lost….The result was an amazing coincidence, shown in the figure. We 'hit' some control and power cables, putting the accelerator out of action for some time. We do not care to remember for how long. Needless to say, the contractors drilling the hole were not too pleased either. They would not allow us to photograph the damage to their drill. We could not understand why…

But, hey, neat edges……….and the hole was in the right place.

2. Using optical shutters for radiation work



Some years ago we were involved in radiation experiments requiring the generation of short pulses of protons. Our Van de Graaff accelerator was designed to produce beam continuous (DC) beam currents of the order of a few hundred milliamps at energies of up to 4 MV, i.e. beam powers could be of the order of a few kilowatts. Existing electrostatic deflection systems were put to good use by applying high voltage pulses to allow the beam to 'pass through', for a few tens of microseconds. But the 'off' state was not perfect, resulting in a 'dark current' of a few nanoamps; not much, but excessive for the particular application. So we needed to find a simple way to eliminate this low background current.

Easy: protons are easily absorbed in even thin materials so a fast acting optical shutter could be arranged to be opened for a few milliseconds 'around' the main pulse determined by the electrostatic deflector. It worked very well, until one day we forgot to turn on the shutter power

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supply. It did not open. The kilowatt beam did know this. So it simply burnt its way through the shutter leaves…….This is why it is a good idea to have feedback sensors and interlocks….

3. Why employee insurance in the workplace is a good idea

You've purchased an expensive high current power supply intended to supply a radiation beam-bending magnet with a few hundred amperes and almost no ripple. You would expect it to be full of high value electrolytic capacitors to smooth the output. It works fine for many years. Then one day, you suspect the stability is becoming worse. Naturally, you try to find out what is wrong; all the connections are OK so there's only one thing to do: take the lid off, clip meters and oscilloscopes in the right places (yes, we did actually read the manual…) and power it up.

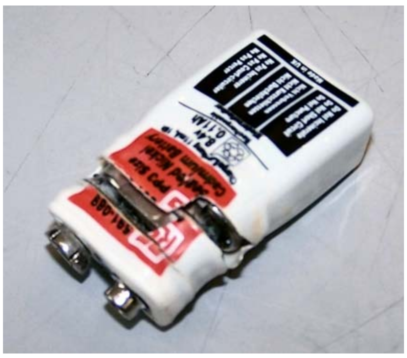
As soon as you apply power, you can't fail to be impressed by the result. Or the noise.

Faultfinding is rarely as quick and satisfying as this. Now all that's left to do is to find a replacement capacitor. Straight away……

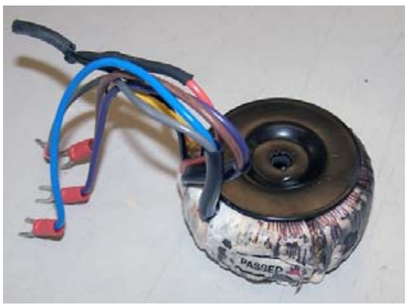
And just in case you may think the above is a unique occurrence, the image on right shows a couple more examples…..this time failure is not due to low voltage, high current operation, but high voltage low current…

But the noise is similar, as are the sparks.

4. More power…..



And here are the results when a terminal block is not tightened, when a battery has been recharged just that bit too quickly…..



Below is what happens when relay contacts have not been specified correctly and when a really good short circuit is placed across the secondary windings of a toroidal mains transformer.

Why waste good money on fuses? That is what we used to think; now we know…..

5. How not to wire up a UK mains plug

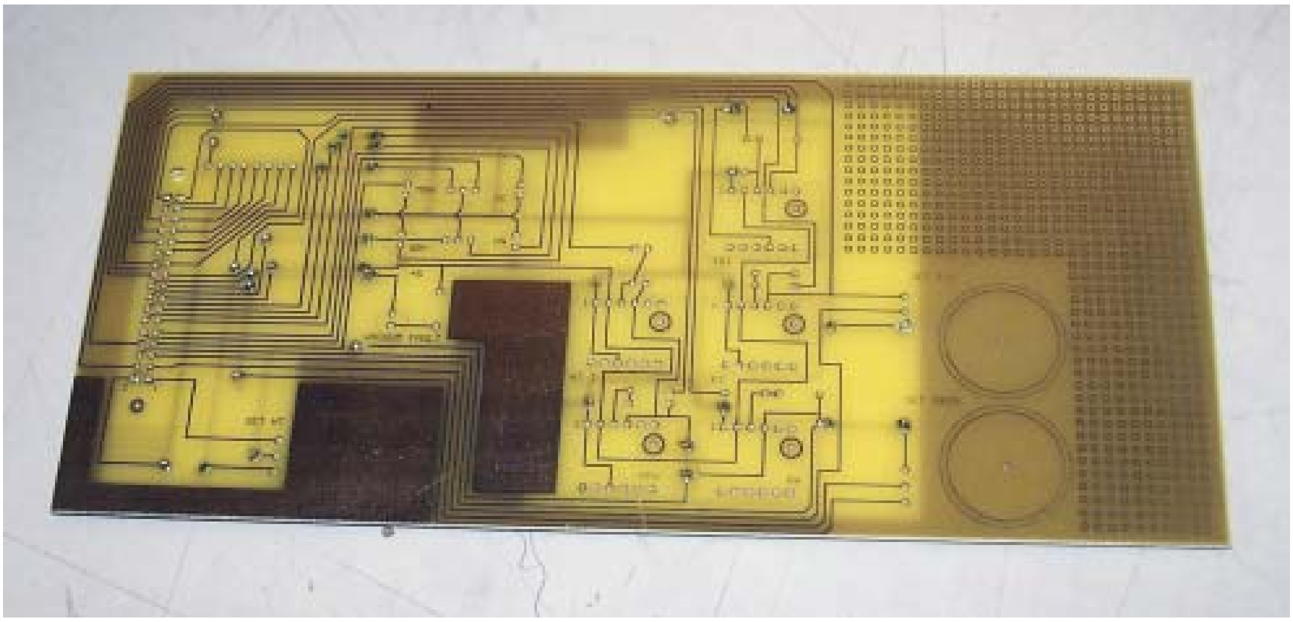
Colour blindness is reasonably common, but can it really be an excuse for the wiring example on the right? I guess there was an additional problem: three terminals, two wires…Mmm…the big pin must be the important one!…

What was even more amazing was that the instrument this was fitted to was not only sold in that condition but worked! Until another fault blew up a poorly soldered regulator chip (right).

6. Printed circuit board fun

Having the ability to make one's own printed circuit boards is very useful, particularly during the summer months when vacation students are all too eager to drill the holes and start assembling, as in the example below. Beautifully made, double sided, all the holes line up…..only one problem: it's a mirror image of what it ought to be! No, the pub is never frequented at lunchtime…..

But at least the mistake was spotted before all the other components were fitted. And we should not blame the students too much; after all, some of us can still remember 35 mm slides… now how many ways were there to insert them incorrectly into the projector? Printed circuit board masks don't have a 'dot' to show you the right orientation. Well, they do now!



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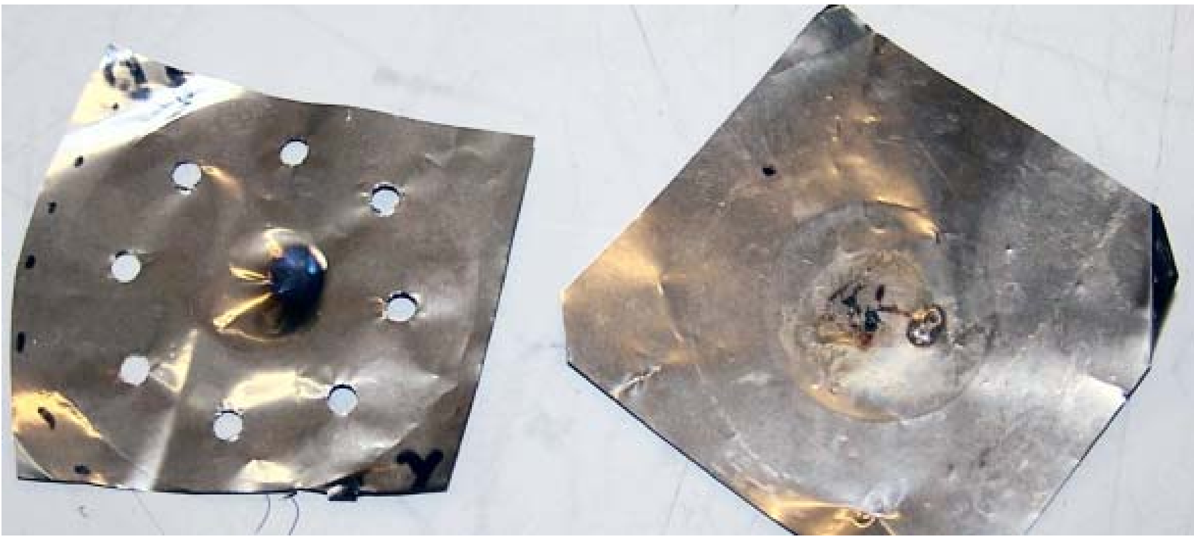
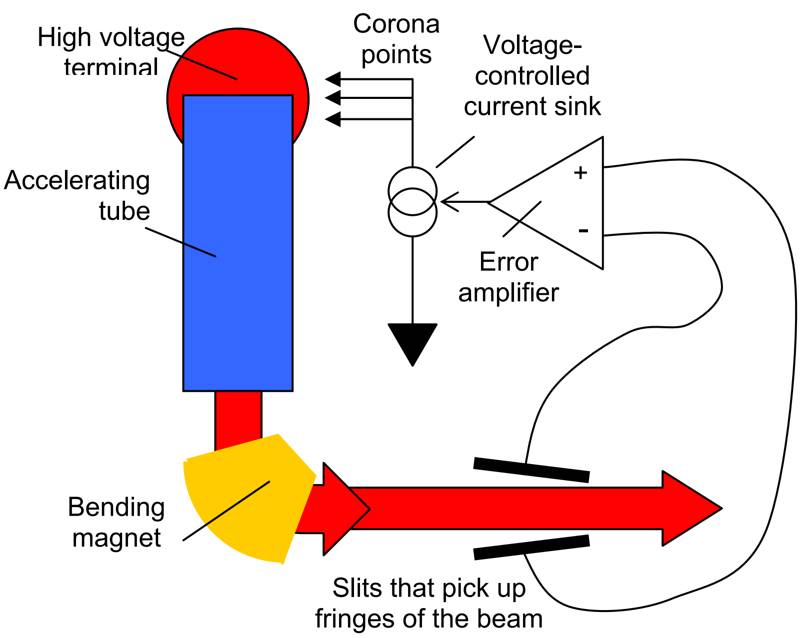
7. Radiation is dangerous, isn't it?

Yes, sometimes it is. For example, when you try to pass too great a beam current through the vacuum 'window' which allows the radiation beam from an accelerator to pass into the 'experiment'. You can see the results below: a nice 'bulge' beginning to form from the excess heat not being dissipated quickly enough (left). But did we learn from this? Clearly not, from the example on the right: no bulge, just a nice clean hole. And no vacuum….



8. What is the difference between positive and negative feedback?

The explanation can be involved, bringing in concepts like loop gain, phase shifts, delays, bandwidth and all kinds of complex bits of maths. So let's illustrate this with a practical example involving stabilising the bending of the radiation beam in our Van de Graaff accelerator. Here is the basic circuit:



The beam passes in between two slits; if the energy is too low, the upper slit picks up more current and this causes the current sink to be less effective so the corona points bleed off less charge from the terminal, the terminal voltage goes up and the beam energy is increased. This causes the beam to be 'bent' less and the beam direction returns towards the horizontal. The opposite happens when the energy is too high: the bottom slit then picks up more current and the process thus ensures constant beam position. That's negative feedback.

Good. Now what happens when the wires from the slits are reversed?

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You've guessed it….Now, you have positive feedback. Instead of the beam always hovering between the slits, it just sits happily on one of them.

And eventually burns a hole in the slit. Actually this only takes a few seconds.

It should of course be noted that the slits are cooled by flowing water through them. Water tends to have a great affinity to find holes. So it can escape into the vacuum system….and to fill it up!

The evidence for all this is shown below.

So the moral of all this is that it is a good idea to label wires. Otherwise you will have to dismantle the beam lines and pour the water out of all of them. Vacuum is a good sucker for water….and we ended up being suckers during the early days of installation of the Van de Graaff accelerator.

But we did learn all about not just feedback, but also all about weekly pumping rates of vacuum pumps; there's only so much you can do with a tissue to mop up all the water.

Finally, just to show that we are not the only ones who don't always do things properly, here is an example from the 'professionals'. On the right is shown what happens to a vacuum bellows used within a vacuum 'gate valve' when the mechanism gets stuck. We tried to sell the result on the modern art market, but nobody seemed interested. Obviously ahead of its time.