

An Electrical Manufacturing Lecture was presented to a joint meeting of IET (the Institution of Engineering and Technology, successor to the IEE), and the Engineers Australia Electrical Branch, it was the ninth in the annual Electrical Manufacturing series initiated by the IEE in Queensland.

It was held in the Hawken Auditorium, Engineering House, 447 Upper Edward Street, Brisbane on Wednesday 19 September 2007 at 6.15 p.m.

"Industry and Academe - which one holds the cutting edge?"

John Billingsley, University of Southern Queensland.

In years gone by, universities have been the fountainhead of new ideas. Entrepreneurs have gathered closely round to harvest their gems of wisdom and put them to practical use.

In contrast, much of today's engineering intellectual property has been generated within industries that are jealous of their secrets. The academics must prise out information on which to base any broad research that is sufficiently novel to warrant a doctorate. Alternatively, university research must be based on narrow niches, of particular interest to smaller companies, while the major breakthroughs are announced by industries that are large enough for their R&D departments justifiably to claim university status.

It is certainly true that there are many academics who cherish the concept that their work is pure and unsullied by materialistic concepts. William Hazlitt was prompted to write,

“Learning is the knowledge of that which none but the learned know. He is the most learned man who knows the most of what is farthest removed from common life and actual observation, that is of the least practical utility, and least liable to be brought to the test of experience, and that, having been handed down through the greatest number of intermediate stages, is the most full of uncertainty, difficulties and contradictions.”

On the other hand, there are industries that have survived unchanged in principle for decades or centuries, supplying a perceived need of society in a safe and steadfast way.

But when it comes to research, the gulf between industry and academe might be more imagined than real. Once a firm has realised that it needs new ideas to survive, it is easy to find a throng of academics greedy for a practical problem on which to pin their research. But the firms should take care, since progress is a two-edged sword.

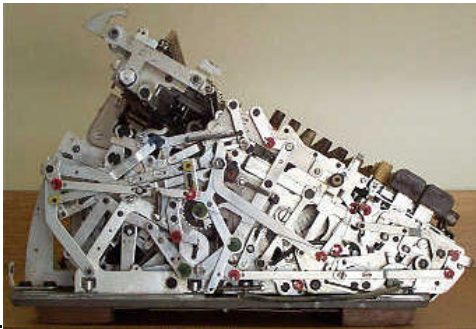
In Cambridge University, some forty years ago, I struck up a relationship with the Monotype Corporation. They made elegant machines for projecting images onto photographic film, outperforming the hot metal and mechanical typesetting systems that had gone before. But they had chosen to use stepper motors in their design and that threatened to limit the precision. The ‘step multiplier’ concept for interpolating the steps led to a battle over patents, in which I got involved.

Then on one of my consultancy visits to the Redhill headquarters, the question was asked, “Couldn’t we use a computer to generate the images of the letters?” and a collaborative project was born.

I had a young researcher who threw himself into the task, and a few years later he was able to typeset his own dissertation on his prototype machine. From an academic and collaboration point of view, the project was an outstanding success.

But of course that machine was second cousin to the laser printers that shortly burst onto the market. Within a decade or so, typesetting had become part and parcel of desktop ‘word processing.’ Elegant electromechanical technology was obsolete and Monotype no longer had an edge over its competitors, other than the ownership of a huge library of typefaces.

The microcircuit changed the world of companies such as the Monroe Calculator Company (though they have still retained a small market niche). The Friden Flexwriter is no longer the ‘interface of choice’ for any computer!



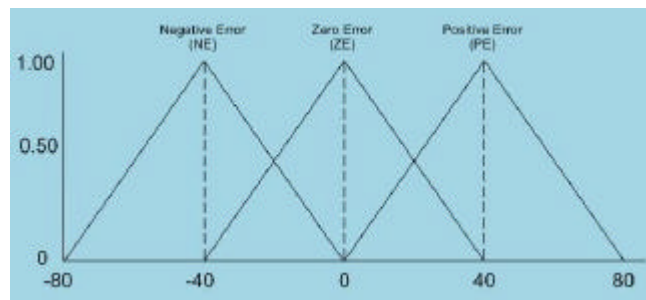
Many companies prefer to keep their research in-house, despite the cost. Indeed many have set up virtual universities of their own, such as Bell Labs and the software hothouses of California. My first taste of industry was with Smiths Aviation Division, where I had to sign the Official Secrets Act before I was even allowed through the security gates. The research and design labs of CH3, 4 and 5 were affectionately known as the ‘University of Smiths’.

I had arrived with a shiny new degree and was convinced that I knew all that was needed about control theory and the design of servomechanisms. When I had put together a controller that gave the ‘classic second-order response’ I was told in no uncertain terms how inadequate it was. For industry, a servo system must stop without overshoot as though hitting a brick wall and must fight to the death to get within a whisker of the target position. Nonlinear methods are needed that do not feature in any ‘Linear Systems’ course.

Industry certainly held the cutting edge there.

To this day, I see paper after paper on servos that display an elegant graphical response, but which would clearly be weak as a jelly if subjected to a disturbing force. William Hazlitt would relish the abundance of neural, genetic and fuzzy embellishments that try to make papers look trendy. The “fuzzifier” and “defuzzifier”

are merely the stuff of the diode-function-generator that formed part of an analogue computer that I met all those years ago, yet they leer with their shark's-tooth grin from so many papers today.



Not many years ago, the manager of software development for the Boeing 777 gave a presentation at Savoy Place. He was asked how the “new control theory” had helped his designs. He replied, “Not in the slightest.”

Nevertheless the symbiosis of industry and academe has resulted in some fabulous advances. Liquid crystal displays were once an academic oddity. Now they underpin almost all computer displays. Other academic oddities have not fared so well – I recall a host of papers proposing the “banana tube” as the answer to early colour television.

The attempt to play industry off against academe falters in the face of the habit of successful academics to jump across the divide and set up industries of their own. It was predictable that the nerds who dropped out of college to set up computer firms were onto a good thing, but who could have foreseen that something like the ‘Google’ search engine could become such an economic goliath?

What see there is the capture of a traditional market by a novel technology, similar in principle to the takeover of the calculator market. For centuries, advertisers have paid for their announcements to appear on the printed page, for half a century they have paid to slot material in amongst television entertainment and now their money supports web archives of home videos, maps, satellite views, newsflashes and goodness knows what else.

So far, the conventional media have stood up to the new onslaught, but what will befall television advertising in the face of the PVR?

It can be argued that business success depends much less on technological development than the perception of a new 'angle'. An army of computer companies developed wonderful technology and continued to struggle or fell by the wayside. IBM bought an operating system from Bill Gates that he in turn hastily bought from a colleague for some \$45,000 and an empire was born. In those early days I had already made the observation that you could judge the quality of a software team by the games they wrote. Sony and Nintendo realised that the games computer was a market in itself.

It took the perception of Steve Jobs to realise that a 'friendly' interface would open up the computer market to hundreds of times as many users as there were 'computer

professionals'. It took Bill Gates to exploit the ideas to the extreme, selling the 'sizzle not the sausage', in the form of an operating system divorced from any particular brand of machine.

But how could the market for operating systems be kept alive? One copy could be duplicated indefinitely by pirates. Enter the virus. With enough vulnerabilities, the system can play on the user's sense of insecurity to make him download a 'Genuine Advantage' update package that will ensure that it has been paid for. So is susceptibility to viruses a bug - or a feature? Was it an oversight in the design of Outlook that allowed an '.SCR' screensaver attachment to install malicious software as soon as an email was opened?

In the battles between competing products, it seems that the better technology is often the loser. Betamax lost out to VHS. Seizing the market is what matters most. And now we have the 'Nike' factor. Among a host of MP3 players, youngsters are prepared to pay several times as much for the one labelled iPod as they are for Chipods that are virtually indistinguishable - apart from the label.

The PVR 'personal video recorder' enables you to fast-forward over the commercials during near-real-time viewing. So far its impact is small, but when coupled with the name 'Tivo' it could take off and change the face of television commercials.



So perhaps neither industry nor academe holds the cutting edge. It is held by the media that they try to influence. While Engineers Australia struggles to enhance the image of engineering and innovation in programmes such as "The Elegant Solution", the whole creative process is trivialised in popular shows such as "The New Inventors".

The water crisis is an undoubted fact. The solution proposed on the show was to capture the cold water that preceded a flow of hot water and to force it back into the system. This won acclaim as 'marvellously inventive'. The simplest solution, of course, would be to place an electric heater directly beneath the tap, which would switch out as soon as the hot water reached it.

But we see ungainly engineering in everyday use. A company offers solar water heating - an excellent idea - but at a price of many thousand dollars. It involves balancing a tank of hot water on the roof, at supply pressure. (I bought a house that had one - the tank burst.) My quarterly bill for off-peak electric heating of my water is under a hundred dollars. That would surely set the sensible price for solar heating at no more than a couple of thousand dollars.

In fact that price is easily achievable. The 'Saxon' water heater, unlike a 'Rheem', contains a heated tank of water that is not pressurised. The heat is removed from it through a coil of copper pipe acting as a heat exchanger. Now the tank water can be circulated through plastic hose on the roof to gather heat, just as in the solar heating of a swimming pool. A second 'Saxon' can be connected in series, to contain the off-peak heater that will top up the temperature.

But we see whole industries nipped in the bud by media-generated superstitions.

A terror of all things nuclear has been instilled into Australians, so that politicians mention nuclear power at their peril and even have to struggle to justify permitting the mining of the ore. Any mention of nuclear waste draws the protestors onto the streets in droves.

Imagine now a nation that embraces the technology. Not only is the ore mined, it is processed on Australian soil. It is enriched to fuel-grade standards and fuel rods are manufactured here. These are leased, not sold, to the many countries that desire nuclear energy but who are viewed with some suspicion, and used in power stations that are also leased to them.

The spent fuel rods are sent back here for replacement, where the majority of their contents can be converted into new fuel rods. Other by-products are recovered and stored - thorium and a host of isotopes. Many of these are marketable in one form or another, perhaps for food irradiation or medical uses. For safe storage, the rest simply need a dry environment and a safe distance - a kilometre or two will do - from any intruder.

An acceptance of nuclear power might be one benefit arising from the new religion that is blighting the world.

Some decades ago, a news story about storms in Jamaica cleared sugar from the British supermarket shelves - although British sugar comes from sugar-beet grown in East Anglia. A year later a fictitious story about a strike in the Siberian salt mines saw shoppers buying up ten years or more supply of salt. Hoaxes such as these could mean big business.

Then as the century neared its end, a quirk in the storage of computer dates was flaunted as the 'Millennium Bug'. Some seven billion dollars were creamed off in Australia alone. Computers sprouted stickers with little ticks and data-processing managers were happy to leverage the server upgrades they had long wanted.

Now we see another movement that threatens to reshape the whole world economy, making the brokers of carbon credits immensely rich and driving whole nations into a new dark age.

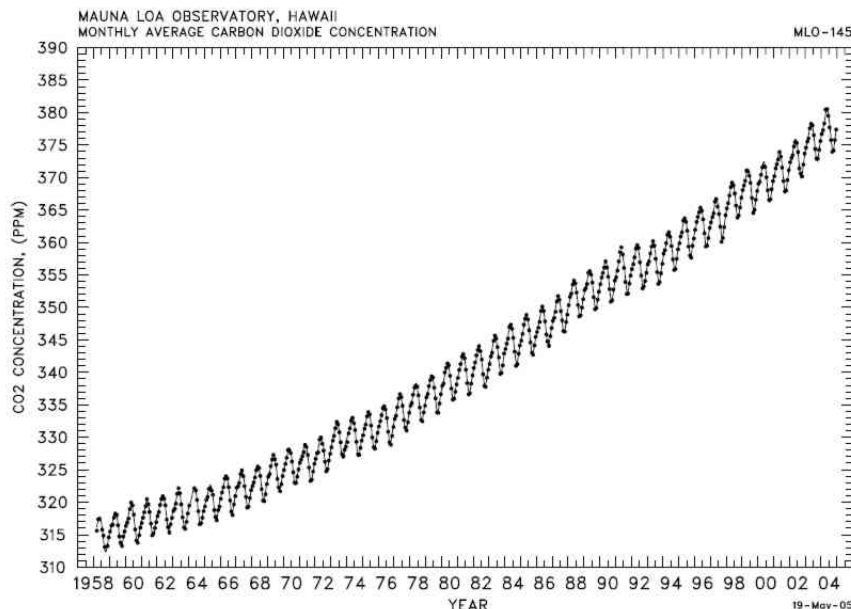
The climate is changing, that is without doubt. It has always changed and it always will. But there is danger in committing to a blind belief that the change is substantially due to the consumption of fossil fuel, with its release in the form of carbon dioxide. There is a religious fervour in those who seek to persuade us that by

taxing carbon we can change the amount we use, that this in turn will change the amount of carbon dioxide that will be in the atmosphere, that this will change the equilibrium temperature of the Earth and will thereby bring about a future that is to our majority advantage.

Al Gore has set up Billy Graham style training camps for the disciples who are to go out and spread the doctrine.

They may of course be right.

It would be stupid to make a dogmatic assertion either way, without assessing the evidence objectively. I might be warned of the consequences of a meteorite landing on my house, but I would need to make a careful examination of the probabilities before moving into a cave. And just as I would be wary of an investment adviser who was taking a commission, I might prefer to draw my own conclusions in preference to a researcher whose grant depended on alarmism. Let us try to separate facts from conjectures.



The atmospheric content of CO₂ is increasing, that is an observable fact. The data records from Mauna Loa are a sound basis on which to base any theory. But we must first put them into a form that is easy to understand. Figures of billions of tons are hard to grasp, so let us relate everything to one square metre of the Earth's surface.

For 2006, we have a figure of around 380 parts per million of CO₂ in the atmosphere by volume, that is some 520 parts per million by mass. But what is 520 parts per million of the atmosphere? As any SCUBA diver knows, one atmosphere is the equivalent of a depth of ten metres of water. The atmosphere above each square metre weighs ten tons. 520 parts per million of this is some five kilograms.

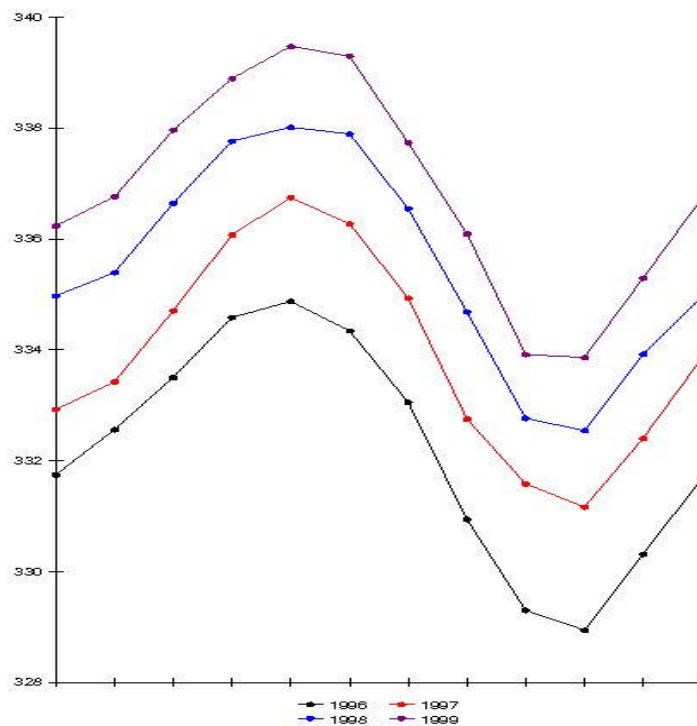
But that is for carbon dioxide. For the carbon alone we must multiply by 12 and divide by 44 (the ratio of atomic and molecular weights) to get 1.43 kilograms per square metre. The whole of the carbon in the atmosphere is equivalent to a layer a little over one millimetre thick. That is a fact, not a conjecture.

And how much is it increasing by? The recent average rate is around 2 parts per million by volume per year - that is around 7.5 grams per square metre. Again that is a measured fact.

But how much carbon are we emitting? Estimates are around 7 billion tons per year. Dividing by the area of the Earth, at $440 * 10^{12}$ square metres (easy to check) we are left with 16 grams per square metre - over twice as much as the atmospheric rate of increase.

The atmosphere certainly does not seem to act as a 'lake', integrating the output. Instead it could behave as a 'low pass filter' that might be responding as a river would to a changing inflow. That would be a conjecture, but a reasonable one.

If we could halt all carbon output for six months, we could obtain an experimental response that would predict the effect of limiting our carbon use. But we can do nearly as well. In 1997, fires in Indonesia destroyed a peat dome, estimated to have released as much carbon into the atmosphere as between 13 and 40% of the annual global fossil fuel output.



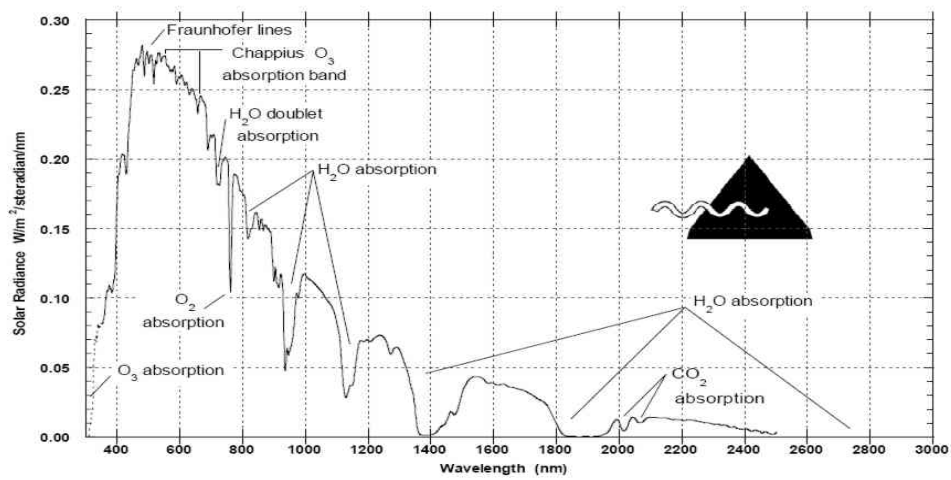
If the atmosphere were a 'lake', we would expect to see a step change that remained forever. Instead we can certainly see a large change for September, but within a very few months we can see that the atmosphere is back on its previous track. The recovery time-constant is measured in months, not years.

This is not surprising, when we realise that one season's grain harvest at up to ten tons per hectare, that is one kilogram per square metre, has the potential to strip the atmosphere of a great proportion of its entire carbon.

So changing our fuel habits would probably have little or no effect on atmospheric carbon, which appears to be dancing to an entirely different tune.

And how can carbon affect the climate anyway?

The "Greenhouse Effect" is an appalling misnomer. There is nothing corresponding to a "layer of glass" that reflects long wavelength radiation back to earth, the paradigm suggested in a lurid science fiction story and seized upon by the early proponents. Instead, CO₂ gives a slight tinge to the infrared colour of the whole atmosphere. I say slight, because it is indeed small when compared to the effect of water vapour.



Typical Solar Energy Spectrum at Earth's surface.

So does a body in space settle at a different temperature from the "black body temperature" if it is not black?

It does not need to.

An 'atmospheric blanket' paradigm can be based on the concept of the 'thermal horizon'. When you look at Earth from space, the apparent temperature averaged over all the spectrum has to appear to be -18C, if the heat flows are to be balanced. But what we see from space over such an average is not the surface of the Earth, but a view of the atmosphere like looking into a muddy pond. With an average surface temperature of 14.5C and a 'lapse rate' (the rate at which the air cools as we move upwards) of 6.5C per kilometre, we would see a temperature of -18C at an atmospheric altitude of 5 kilometres.

The discussion is transformed from a mish-mash of modelling into a question of how far increasing the CO₂ could lift this thermal horizon. Calibration data from a company selling spectrophotometers suggests that the answer is, "Not a lot."

The only thing that we can say with certainty is that there is no certainty. The enormous stake that carbon tax would cost us merely moves our bet from one uncertain future to another, which might well be identical to the first. If the justification is based on correlation alone, we are just as likely to deduce that the barking dog causes the postman to appear. We need sound and unbiased analysis of

all the data available, plus a plausible physical mechanism that could link carbon to temperature.

But let us escape from contentious conjecture back to reality.

Media pundits are predicting the demise of the polar bear, government advisors talk of carbon dioxide as a pollutant that is building up in the atmosphere - and the politicians believe them.

In consequence the markets for nuclear energy, wind generators, non-incandescent light-bulbs (and the dimmers to go with them), solar hot water systems at any price, electric vehicles, solar panels and bio-fuels are set to get the same boost that text-messaging gave the mobile phone.

Or will cold reason pop the bubble, just as 'chlorophyll' was popped by a simple rhyme? Every toothpaste and deodorant used to be green, boasting that the chlorophyll it contained was a miracle ingredient. Then someone coined the ditty, "The reeking goat on yonder hill doth browse all day on Chlorophyll."



So you have serious decisions to make about the future of your companies. Where are you going to pin your future products? Are you going to harness academics to whip up new technologies that are increasingly indistinguishable from magic, or do you employ sorcerers of your own? Are you going to hang on the coattails of Chinese and Japanese imports?

Which emotions are you going to pin your products on?

Fear, with burglar alarms and surveillance systems?

Pride and envy, the desire to be the first with the latest 'Blackberry'?

Loneliness, maybe a chat service for the solitary?

A wish for comfort, air conditioning, entertainment?

Or maybe just food appliances to pander to a love of gastronomy.