

# ***SOUE News***

Issue 10

Summer 2011

## ***Society of Oxford University Engineers***

### **Welcome to the tenth edition of SOUE News**

Small companies have been very much in favour recently, being hailed as just what our economy needs. And if they actually generate engineering products, so much the better. Various Oxford engineers have run or founded these in the past, so we would like some of those who have to recount their experiences in these pages. First to do so is Jim Hall, who read Eng Sci at Worcester 1964–7, and then did a DPhil. After various jobs he founded Microtrol in 1983, with the aim of “offering design engineering services to businesses not having their own electronics department”. Read his story, and some of the lessons he has learnt, on pp 12–15.

We have also last year’s Jenkin lecture, by Peter Raynes on the history of liquid crystal displays, with which he was much involved, and summaries of the other two talks given on that occasion, by Rod Smith and Vilnis Vesma. And the recent Lubbock Lecture, by Thomas Hofmann of Google, is summarised too, along with the two “mini-lectures” from that day.

Gordon Lewis (Pembroke 1942–4 and SOUE President 1993–2002) was surely one of our most distinguished alumni. He worked on the development of jet engines, first for the Bristol Engine Company and then with Rolls-Royce after the firms amalgamated. The Pegasus engine for the Harrier, with its tilting nozzles for vertical take-off, was his most famous masterpiece, but that was only part of it. He died in October 2010. Michael Neale, who knew him well over several decades, has written for us a very comprehensive account of his life, work and character.

There is no “Head of Department’s Report” in this issue. The Department is planning its own newsletter, to be sent to all alumni for whom the University has addresses, and the HOD’s report will go in that. What relationship, if any, will develop between SOUE News and future issues of this newsletter, remains to be decided.

This year’s Jenkin Lecture (17 September) will be given by Andrew Garrad, founder and Managing Director of Garrad Hassan, world-wide consultants on wind power, based in Bristol.

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## The 23rd Jenkin Lecture, 25 September 2010: Liquid Crystal Displays – Some Surprising Contributions From the UK

Lecture by Peter Raynes

Peter Raynes started by reflecting that when, 40 years ago, he told people that he was working on liquid crystals, he usually got the reply “What are they?” The answer now was more likely to be “Is there any research left to do in them?”

He went on to see if the audience had any idea of the history of the subject. Not very much apparently, but the questions, and the answers to them, were:

1. When was the first liquid crystal display sold? A single numerical digit in 1970, and an LCD calculator by Sharp in 1973.
2. When was the first one made in a laboratory? 1918 (a paper by Bjornstahl).
3. When was the first patent? 1934, by Levin & Levin of GEC.
4. When was the first liquid crystal material sold? 1907, by Merck, of Darmstadt.
5. When was the first such material identified? 1888, by a botanist, Friederich Reinitzer.

A liquid crystal is in fact a state of matter intermediate between a solid and a liquid. In a crystalline solid, the molecules (assumed to be long and thin) are in definite positions and all oriented, for example they could be exactly parallel. In a liquid the positions and orientation are random. In a liquid crystal the molecules are randomly positioned, but are partially, but not completely, lined up, and the liquid becomes anisotropic. We were shown, as analogies, first a photograph of logs floating in a Canadian river, which had collected in several parallel groups; and second, a demonstration of rice grains shaken in a dish, which behaved in much the same way. There are liquid crystals in our bodies, for instance in cell walls. DNA in solution forms a liquid crystal, and the high-strength material Kevlar goes through a liquid crystal stage in its manufacture, aligning the molecules. Liquid crystal molecules can line up in various ways,

as indicated by the names “cholesteric”, “nematic” and “smectic”.

Liquid crystal molecules are usually organic, and of modest size. Those used in displays typically contain a couple of benzene rings, with attachments, e.g. as in Figure 1.

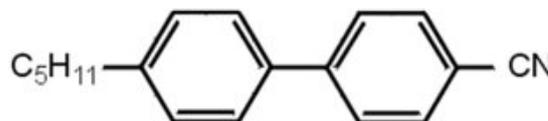


Figure 1

They show a liquid crystal phase over only a fairly narrow range of temperature, and the lecturer showed us a bottle containing a substance of milk-like appearance, which was in fact a liquid crystal. But when warmed a little it became completely clear, showing its change to normal liquid form.

Why are liquid crystals so useful? They have three properties, all derived from their anisotropy:

1. They alter polarised light, because their refractive index is different in the two directions parallel and perpendicular to the long axis of the molecules.
2. The molecules tend to align with a particular direction if close to a specially treated surface. One such treatment is simply to rub the surface along the required direction, which can be done by hand, or in a machine designed for that purpose.
3. The molecules re-orient in response to an electric field, since their dielectric constants differ parallel and perpendicular to the molecules.

If the applied electric field is perpendicular to the surface, effects 2 and 3 can act in opposition, and it takes only a small electric field to dominate. With no field, the molecules lie parallel to the surface and along the preferred direction given to it by rubbing. But

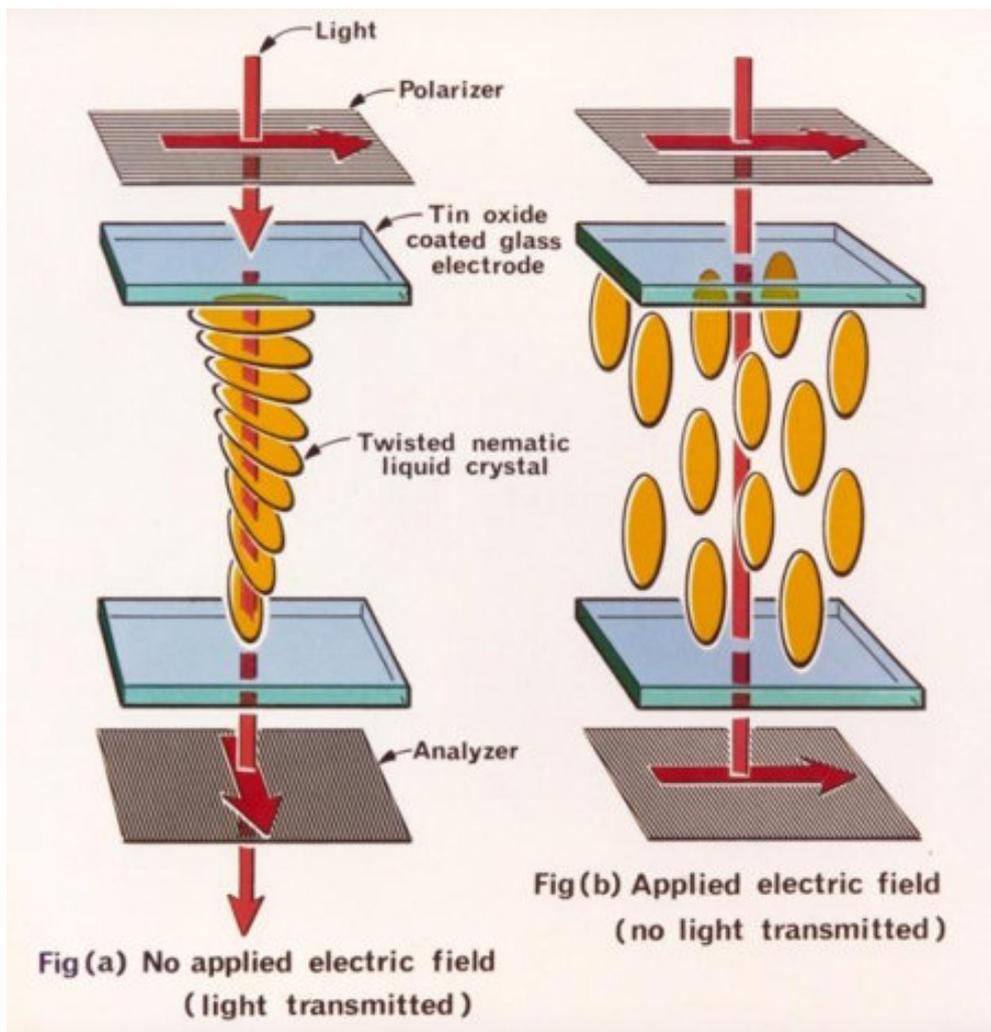


Figure 2

when an electric field is applied, they rotate so as to be parallel to the field and perpendicular to the surface. This effect was first discovered in 1932 by Freedericksz (who regrettably died a few years later in one of Stalin's Siberian forced-labour camps).

The "Twisted Nematic" LCD, based on this effect, was invented by Schadt and Helfrich in 1971 (Figure 2).

The lecturer made a simple display for us in the lecture room. He took two glass plates, coated in indium-tin oxide to make them electrically conducting, and rubbed them to impart the directional property. He put them one above the other, with a small gap between, and their preferred directions oriented at  $90^\circ$  to each other. A small amount of liquid crystal was then injected between them. The result was that the molecules lined up parallel to the

preferred directions at top and bottom, but changed gradually from one to the other, i.e. by  $90^\circ$ , as one went from top to bottom (the "twisted nematic"). This had the effect of rotating by  $90^\circ$  the plane of any wavelength polarised light passing through it.

Polarising sheets were then placed above and below, each with its polarising direction parallel to the rubbed direction of the neighbouring glass. The whole assembly was set up on an overhead projector, and thus illuminated from above. Over most of the area, the crossed polarisers prevented any light transmission, but some did get through where the liquid crystal was, since it rotated the plane of polarisation.

He then applied a voltage between the electrodes on the top and bottom plates. Typically only 2 V is needed, and this rotated

*(Continued on page 4)*

## The 23rd Jenkin Lecture, 25 September 2010: Liquid Crystal Displays – Some Surprising Contributions From the UK cont.

(Continued from page 3)

the molecules to lie normal to the surfaces, so their ability to rotate the plane of polarisation disappeared. Thus the electrified area became opaque, showing the text 'Jenkin Lecture 2010', while the rest remained transparent (Figure 3).

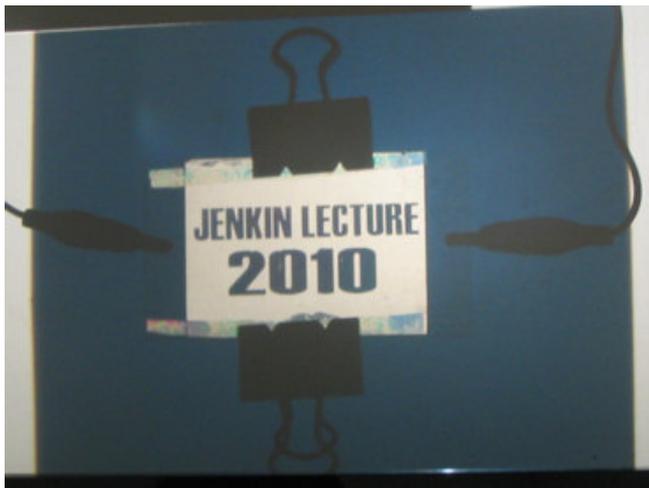


Figure 3

There is an interesting story about how the UK got involved in LCD development. The Royal Radar Establishment (RRE) in Malvern had in the 1960s been transferred from the Ministry of Defence to the Ministry of Technology. They were visited in 1967 by the then Minister of Technology, who boasted about the sums his Department was spending on the development of Concorde. The Director pointed out to him that even larger sums were being paid as royalties for the use of overseas patents relating to colour cathode-ray tubes for television receivers. The Minister's response was to direct RRE to institute research on alternative displays, and in 1970 a group was set up to do this; the lecturer joined this group in 1971. Who was the Minister who had authorised this? It was in fact John Stonehouse, who later became notorious for faking his own death by drowning so that he could go and live with his mistress in Australia under another name.

In 1970, all known liquid crystals were most unsuitable for displays. They were chemically

unstable and decomposed; they were coloured; and they had poor switching characteristics. George Gray and Ken Harrison in the Department of Chemistry at Hull University were given a research contract by RRE to see if they could make something better, and they did. They realised the faults were attributable to chemical groups *between* the benzene rings, disappearing in compounds without them, and came up with the cyanobiphenyl compounds, one of which is shown in Figure 1. However this one on its own works over too narrow a temperature range (22–35 °C). An alternative with  $C_8H_{17}O$  at the left-hand side works over 54–80 °C, but a eutectic mixture of the two covers 5–50 °C. By combining four different compounds in quite precise proportions, the lecturer formulated a mixture, given the name E7, which was usable over –10 to 60 °C, and was perfectly satisfactory for most applications. The performance and stability shown by E7 allowed the LCD market to grow rapidly and to dominate quickly the small portable display market; E7 dominated the liquid crystal market for more than 10 years.

At this point we had a display very suitable for small scale applications such as watches and calculators, where only a modest amount of information was to be displayed. The difficulty in displaying more information, for a computer or TV, is that the number of electrical connections between the display and the drive electronics becomes unmanageable. Each element in e.g. a seven-bar number display plus an associated decimal point needs its own lead, and the back-plane needs another; total nine. A ten-digit calculator display (with a common back-plane) thus needs 81 leads. By dividing the back-plane into two sections, and feeding the digit elements in pairs (Figure 4), we can get down to six connections per digit. But this relies on the bars being OFF with say 1 V between the electrodes, and ON with 2 V (which the twisted nematic display can just do). This "multiplexing" technique was quickly adopted for products such as calculators to reduce the number of connections between the display and the drive electronics. It was

realised that it could, in principle, be extended further, but only if the voltage ratio between the ON and OFF segments could be reduced significantly below 2.0 and as close to 1.0 as possible.

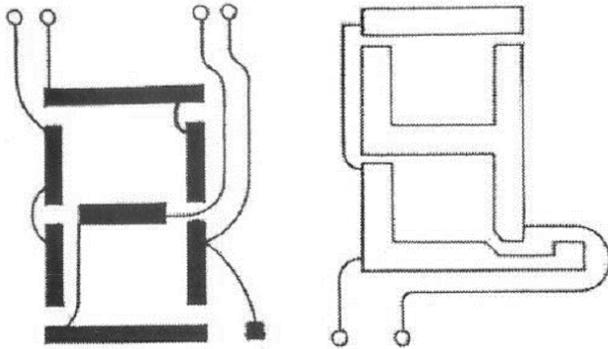


Figure 4

A computer or TV display has around  $10^6$  elements, and has a matrix of electrodes of around 1000 rows and 1000 columns and it was realised that for these displays, a breakthrough was needed.

There followed two independent breakthroughs involving the RSRE (as the RRE had now become). The first was the development around 1980 of amorphous silicon thin-film transistors (TFTs) by RSRE and Walter Spear

and Peter LeComber of the Department of Physics at Dundee University. These immediately removed any restrictions imposed by the LCD switching, but only worked on a laboratory scale. The prospect of very high development costs, and no certain market, discouraged industry from taking up the technology. Fortunately, in 1982 the lecturer, working with Colin Waters, discovered that increasing the “twist” in the twisted nematic, from the  $90^\circ$  as described above, to  $180^\circ$  or  $270^\circ$ , made the ON/OFF transition much steeper (Figure 5) and considerably improved the ability to “multiplex” an LCD. This effect became known as the Supertwist display and was used in early laptops and mobile phones, and is still found in card readers, car radios and a host of domestic and office equipment.

The availability of an LCD display suitable for laptops and mobile phones developed the market for these products and encouraged the display industry to invest in the development of thin-film transistors and their incorporation into displays at an acceptable price. After some 10 years of development TFT/Twisted Nematic LCD displays became a practical reality and gradually replaced Supertwist displays in laptops and mobile phones.

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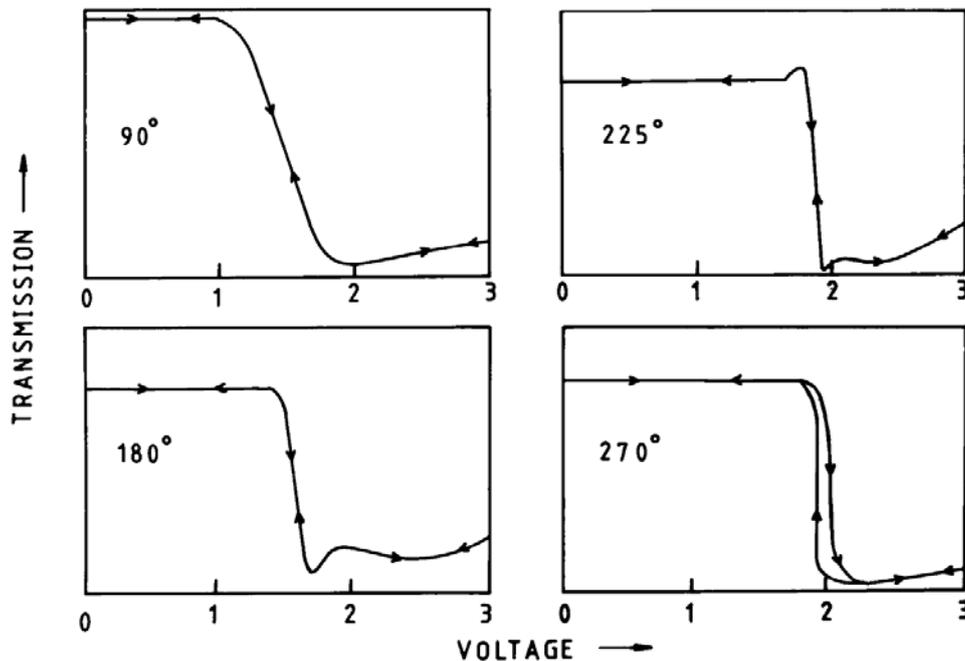


Figure 5

## The 23rd Jenkin Lecture, 25 September 2010: Liquid Crystal Displays – Some Surprising Contributions From the UK cont.

(Continued from page 5)

In contrast to a laptop display, a TV display also needs: high contrast; fast switching; and a wide viewing angle, which Twisted Nematic technology was unable to achieve. Two alternative LCD modes, both using TFT arrays, have been more successful:

1. Vertically-aligned nematic (VAN), (vertical when the display screen is horizontal!)
2. In-plane switching (IPS)

In the latter the electric field is parallel to the screen, and switched on and off by the thin-film transistors. A colour picture is achieved by having three pixels for each picture element, passing white light through red, green and blue filters respectively. Numerous additional layers are required to make a satisfactory display, e.g. to generate a uniform back light behind, and to enhance contrast, improve viewing angle, suppress reflections and protect from damage.

LCDs are now in their tenth generation, and are made in enormous sheets greater than 3 m by 3 m, to be divided up as required. The total thickness is 1 mm, of which the LC layer is only 5  $\mu\text{m}$  thick, with a tolerance of 0.1  $\mu\text{m}$ . That this tolerance can be maintained over 3 m x 3 m is truly remarkable.

There is still room for further progress. For instance instead of passing white light through

colour filters, one could generate it with coloured LEDs shining alternately through the same pixel, thus saving two-thirds of the energy. Or displays could go back to using reflected light. They could be made reflective and bistable, so that they would emit the same text etc. continuously after being set up, thus using no back-light energy and very little for the drive.

There are of course other forms of flat display. Electrophoretics, used in e-books, display only black and white images. Plasma displays seem to have life problems. Organic LEDs are on their way, and are now in mobile phones at least. The lecturer was not convinced they would be used for larger area displays, but did think they had useful prospects for room lighting.

After the lecture, a lively question-and-answer session ensued. It transpired that the surface modification of glass by rubbing it was not in fact a change in the glass, but in a thin plastic coating on it, which seems more plausible. A number of questions were asked about the failure of European and American companies to commercialise LCDs when they looked like an obvious winner. Some questions were asked about the royalty stream into the UK as a result of the UK's LCD activities: the answer was that these were considerable, but not quite Concorde-sized sums!

## Finals and Prelims Prizes Awarded 2011

The Examiners recommended the following awards in respect of Final Honour Schools in 2011:

### Engineering Science Part 2

Maurice Lubbock Prize for best performance:  
Ian Ashcroft, Lady Margaret Hall

Edgell Sheppee Prize for excellent performance:

**Scott McLaughlan, St Edmund Hall**

Head of Department's Prizes for excellent performance in examinations:

**Jack Andrews, Christ Church; Andrew Pitayanuku, Magdalen; Julian Lip Yi Tan, Jesus; Joshua McFarlane, St John's**

ICE Prize for best performance in Civil Engineering:

**Jeremy Evans, St John's**

IMechE nomination to the Frederic Barnes Waldron "Best Student" Prize:

**Edward Sorby, Pembroke**

IMechE Best Student Certificate:

**Malcolm Begg, St John's**

IET Prize for outstanding academic achievement:

**Jennifer Owen, Jesus**

IET Manufacturing Engineering Prize:

**Paul Baggott, Trinity**

IChemE Prize, and Lonza Biologics Prize for the best final-year performance in chemical engineering:

**Jack Gilbert, Balliol**

### **Project Prizes**

IMechE Prize for the best project in mechanical engineering:

**Matthew Betney, Lady Margaret Hall**

IMechE Certificate for an outstanding project in mechanical engineering:

**Mark Baker, St Edmund Hall**

Motz Prize for best project in electrical engineering:

**Aleksander Chmielewski, Wadham**

Ronald Victor Janson Prize for best project in electronic communications:

**Megan Duffy, Wadham**

BP Prize for best project in chemical engineering:

**Sarah Patterson, Pembroke**

HMGCC Project Prize in Information Engineering:

**Kirsty McNaught, Lady Margaret Hall**

Von Engel/Franklin Prize to include the David Witt Premium for the best overall project:

**Matthew Betney, Lady Margaret Hall; Sarah Patterson, Pembroke**

### **Engineering Economics and Management, Part 2**

Maurice Lubbock Prize for best performance:

**Tsun Wong, Wadham**

Pilkington Prize for best performance in a management project:

*To be confirmed*

### **Engineering Science and EEM Part 1**

Edgell Sheppee Prize for laboratory or drawing office work:

**Yangshi Yu, Exeter**

Gibbs Prize for best Part 1 project, jointly to:

**Sean Brassill, St Edmund Hall; Jonathan Daly, St John's; Robert Gledhill, Hertford; Victoria Lawson, Keble**

BP Prize for best Part 1 chemical engineering project, jointly to:

**Wahbi El-Bouri; Zheng An Lo; Yan Bin Man; James Peet; Qi Nan; all of Keble**

### **The Moderators recommended the following awards in respect of the Preliminary Examination**

Shell Prizes for outstanding performance:

**Alexander Wood, Keble; Edward Birkett, Trinity; Nicholas Booth, Worcester**

## Volcanic Ash and Aero Engines

*A synopsis of a 2010 Jenkin Day talk given by Rod Smith*

In 1982 a British Airways jumbo jet flew through an ash cloud from an Indonesian volcano, lost power on all four engines, and dropped from 11,000 to 4,000 m before recovering. This incident led to an assumption that aircraft should not attempt to fly at all when volcanic ash was around, and hence to the stopping of all flights over Britain and much of Europe when the Icelandic volcano Eyjafjallajökull was erupting in April 2010. The cost of this disruption has been estimated at €1.5–2.5 billion.

Rod had felt that this original reaction had perhaps been overdone, as had the initial published views of his own Institution, the IMechE, so he collected and chaired a small working party to look into it further. The temperature in the hottest parts of a jet engine (combustion chamber and first-stage turbine rotor) is in the range 1500–1600 °C. What seems to happen is that any ash ingested melts at this temperature, and then solidifies on cooler parts downstream, thus blocking the very narrow cooling ducts. It also erodes compressor and turbine blades. The engine therefore overheats and shuts itself down. As it cools subsequently, differential contraction breaks the deposits off, so it may be possible to restart the engines (as happened in 1982).

But how much ash in the ingested air can be tolerated? The original view had been “none at all”. The protests at the resulting chaos, both for travellers and the air transport industry, led to the limit being raised first to 2 mg of ash per cubic metre of air, and then to 4 mg/m<sup>3</sup>, with accompanying time limits. But there seems to be as yet no experimental justification for any of these values, and in any case the density can probably not be predicted within an order of magnitude.

He went on to explain the difficulties that meteorologists had in predicting what the ash density would be. The “ash” particles are usually silicates, hard, sharp and angular, of size in the range 1 µm to 1 mm. The larger

particles drop to earth quite soon, but the smaller ones can be carried great distances. Volcanologists have generated some existing data about densities and distributions, but the variation is very wide.

Air travel is already very safe, and no one has yet been killed or injured as a result of aircraft flying through ash. The reduced risk to life from the flight ban seemed to be quite negligible compared with the inconvenience caused.

### Footnotes by editor

1. The working party’s report, “Volcanic ash: to fly or not to fly” was published by the IMechE, and can be downloaded from their website. It recommends experimental research into how engine damage is related to ash density.
2. In May of this year another Icelandic volcano, Grimsvötn, erupted, leading to slightly more modest disruption but very similar controversy. There seemed to be acceptance in most quarters that last year’s revised limit of 4 mg of ash per cubic metre of air was about right, but in The Times of 23 May this got converted to four grams of ash in ten cubic metres! It seems that their science correspondent and transport correspondent between them had difficulty distinguishing between ten cubic metres and a ten-metre cube. Willie Walsh on behalf of British Airways went into print comparing 4 mg/m<sup>3</sup> to “a level tablespoon of salt in an Olympic swimming pool”. He conveniently ignores that the salt would dissolve in the water and so never be noticed, but volcanic ash is not known to dissolve in air. Also, the swimming pool does indeed hold a large volume of water, but the same volume of air sweeps through an aircraft jet engine every few seconds. The question remains controversial.

## The 37th Maurice Lubbock Memorial Lecture, 7 June 2011: Google – 1 Billion Searches a Day and Counting

Lecture by Professor Thomas Hofmann

The speaker was currently Director of Engineering, Commerce and Research at Google Switzerland in Zurich, but until five years ago he had been an academic researcher into machine learning, and then an entrepreneur founding his own company. He saw this lecture as a “talk about Google”, and thought there were seven aspects to this:

1. Google as in “to Google”
2. as in “Google-scale”
3. as a mindset and engineering principle
4. as a paradise for computer scientists
5. as an economic force
6. as a research power house
7. for the Fine(r) Arts

The lecture covered all of these, but with most emphasis on the first two.

### “To Google”

Google’s mission is to organise the world’s information and make it universally accessible and useful. Currently there are some two billion Internet users, 30% of the world’s population. They are of course unevenly spread, with the highest penetration in North America, Europe and Australia, but the rest of the world is catching up fast. In fact c. 44% of all users are in Asia.

In the past, an information search would often need the assistance of a skilled librarian, but this is rapidly being replaced by the Web, and if you ask people how they have found websites they have visited, the commonest answer is “via a search engine”.

There are currently around a trillion URLs (web addresses); Google handles about a billion searches a day; but spammers generate around a million pages per hour, which a search engine has to be able to reject. This task is not trivial. A key to solving it is the “Page Rank Algorithm”, which exploits the

linked structure of the Web to assess the *authority* of each page, based on how long people look at any item. Also, although Google accepts advertisements to generate an income, it never accepts payment to bias its selection or prioritising of pages in any search.

### How it is done

It is not possible to do a search in real time – it has already been done off-line. For each search term, a file index has already been made, an ordered list of all the documents in which the term occurs. This index is stored over numerous computers, with several identical replicas of it, to guard against faults. The documents themselves, to which the index refers, are stored in a separate set of computers, again with replicas. The first response to any search request is to see if the same thing has been asked for recently. If so, use the results again. With 1000 computers doing the work in parallel, a typical search time is 200 ms.

### Guessing what the searcher is about to type

When the searcher has typed the first few letters of his search term, the system starts to guess, and offer, various ways in which he might continue. For example, typing “Oxf..” could lead to offerings of Oxford, Oxfam, Oxford dictionary, Oxford Brookes, Oxford Mail. This takes around 20–30 ms. The searcher can then opt for one of these, or continue typing. This facility speeds up the process, especially for someone typing on a mobile phone, but it has to be designed to filter out guesses that might be offensive to some users.

### Broadening the sources of information

Initially searchers could be directed only to websites. More recently a “real-time search” has been incorporated enabling one to find current news items. For example, by typing “Federer” on 5 June, one could get the current score in the Wimbledon final. Ideally it should be possible to implement a “universal search”

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## **The 37th Maurice Lubbock Memorial Lecture, 7 June 2011: Google – 1 Billion Searches a Day and Counting cont.**

*(Continued from page 9)*

of images, books, news and video, as well as the Web, but this will require an enormous expansion of storage capacity.

### **Web search as an arms race**

The activities of spammers, often very clever people if with rather dubitable economic motives, could, if successful, render any search engine ineffective. An example quoted was the money that could be made by influencing Stock Exchange prices, even for only a few hours. Google is perpetually improving its anti-spam algorithms, but these are naturally secret.

### **Experiment-driven engineering**

Google employees are encouraged to develop their own ideas, trying them initially on particular cases in what Hofmann called a “sandbox”. The changes in system performance that they generated were evaluated by an external panel, and if they showed promise, a small sample of the real traffic was exposed to them. Depending on how this worked, the idea might be adopted for the whole system, or “sent back to the drawing board”. In 2010, of about 23,000 ideas, 516 were finally adopted!

### **Google-scale computing**

As already stated, Google handles about one billion searches a day, or approximately 10,000/s, each dealt with in about 200 ms. The computing power needed to handle this is enormous. The amount of data stored is around 70 PB ( $70 \times 10^{15}$  bytes), in numerous data centres around the world, and about 10 million operations are carried out per second.

The hardware is made up basically of PC-class motherboards, each with its own CPU, DRAM and disk. 40–80 of these server boards are stacked in a “rack”, and 30 racks form a “cluster”. A cluster thus has 30 TB of DRAM and 48 PB of disk storage, both of which can be accessed at 10 MB/s. Failures obviously occur in the hardware, but everything is stored in multiple places, so software can cope with

any likely failure. Storage spread around the world helps to compensate for the finite speed of light, which as the lecturer said “is not fast enough for Google!”

All this computing clearly consumes lots of energy, around half of which goes on cooling, but this is being improved by the use of evaporative cooling, on the same lines as power-station cooling towers. The energy used per search is modest, around one joule, about that needed to propel a car for two metres.

### **Working at Google Zurich – a paradise for computer scientists**

There are plenty of relaxation opportunities. And 20% of one’s time can be spent on ideas of one’s own, to which end there are white-boards everywhere! Groups of around ten people are empowered to make their own suggestions.

### **The economics of it**

Google gets its income from the advertisements which appear on the top and right-hand side of the search page. Other adverts can be shown alongside any web page displayed to the searcher. The world-wide income is currently of the order of \$20 billion per annum. Part of the computation task is to work out which adverts are most appropriate for any particular search query, and advertisers are allowed to bid in an auction to have their adverts associated with particular key-words. It has been estimated that the economic activity generated by Google in the United States in 2009 amounted to \$54 billion.

### **Other activities**

Google’s “Product Search” can look for where any product can be bought most cheaply, and an extension of this now being developed will allow one to inspect the stock inventory of any particular store, to see if they have what is wanted.

They have built a very large machine-translation system, with 60 languages (and growing) and a much better quality standard of translation.

And finally, their Art Project is bringing some of the world's pictorial art on-line. Pictures are being scanned from 17 of the world's principal museums, some of them to unusually fine detail, several giga-pixels. The lecturer showed as an example *The Ambassadors* painted by Hans Holbein the Younger in 1533, now in the National Gallery.

Down on a shelf and rather unnoticeable in the full picture is a world globe. By successively zooming in on this it eventually showed a (rather inexact) map of England and Scotland, with the cracks in the paintwork clearly visible.

The lecture was followed by a question-and-answer session. The lecture, and the lecturers slides, may be viewed on the Department's website, [www.eng.ox.ac.uk](http://www.eng.ox.ac.uk).

## Resource-Constrained Digital Health Care

*A synopsis of a 2011 Open Day talk given by Dr Gari Clifford*

Dr Clifford started his talk by observing that data analysis in health care has currently not moved far beyond simply digitising a paper process. Technology can sometimes interfere with the data recording, producing a system that is slower than the pen: meanwhile, time delays in analysis can lead to "clinically significant" errors. An example was given of nurses sampling blood pressure at regular times, with intervals that might be up to 120 minutes, tending to over-estimate the readings and sampling at a very low rate (below Nyquist), which can lead to hypotensive (low B.P.) episodes being missed altogether, with serious diagnostic consequences. It is impractical to sample more frequently, so *irregular* sampling is needed; additionally, using direct personal monitoring avoids human transcription errors.

World Health Organisation figures make it clear that quality of health care is not a function of per-capita spending: the USA comes 37th on the quality list, just below Costa Rica, despite spending more per capita on public health care than the UK. The UK is 18th on the list, which is topped by France.

But while money is not so important for quality as might be expected, lack of trained health care workers in resource-poor regions means poor infrastructure: but Coca-Cola still gets there — as do mobile phones. The Chinese access the Internet largely through mobile phones: it is estimated that 950 million people will be using mobile phones for Internet access

by 2020. (The figure rose by 18% in six months recently.)

The mobile phone infrastructure can be used to capture and transmit medical notes, images, videos etc. The phone itself is a physical object with a password, giving automatic security; and modern phones are also often equipped with accelerometers, cameras etc. that can provide rich diagnostic capture, and can automatically monitor patient activity; they can also play a vital role in prompting patients to carry out necessary tasks, e.g. checking blood sugar levels.

Using mobile phones in this way is known as "mHealth". Dr Clifford gave an example of an Oxford trial monitoring COPD (chronic obstructive pulmonary disease), which combines monitoring of sleep, ECG, heart sounds, pulse oximetry, respiration and blood pressure. Heart monitoring can be performed using a hands-free kit mounted in an egg cup to provide a cheap mobile stethoscope; and a mobile phone blood pressure monitor can be produced for just £5, using a cheap cuff with a manual inflation ball, a £3 silicon chip to measure pressure, and a USB connection to the phone — an app running on an Android phone gives exact instructions to the patient on what to do, and measures the pressure fluctuations directly. Heart rate can be determined by Fourier analysis of the pressure variations during the measurement.

Dr Clifford made a convincing case for the ability of the mobile phone to transform health care, particularly in resource-poor regions.

## Running Your Own Business (An Insider's View)

*Jim Hall (Worcester 1964–71)*

March 1985 found me at a low ebb. Two years earlier a colleague and I had started Microtrol and we had just reached the parting of the ways.

The company had been launched with the objective of offering design engineering services to businesses who were not in possession of their own electronics department, placing strong emphasis on working with the customers, understanding their needs and pooling our engineering skills with theirs. Initially we targeted data logging to complement the then new range of instruments appearing with serial communications. However as initial enthusiasm became tarnished with commercial reality it began to look as though it perhaps hadn't been such a great idea after all.

As I had been responsible for the technical direction of the business, the marketing and administration were unfamiliar territory for me but needed to be taken in hand if the business were to survive. A few weeks later my wife, heavily pregnant with our fourth child, was seeking out a new accountant whose advice was that I should continue to run the business whilst looking for a new job. The running of the business left little time for job seeking but, one year on, together with two loyal employees we were still at work and had moreover posted a first profit. Fifteen years later I was able to invite the same accountant to the company's newly acquired business premises in the Worcestershire countryside and today the company is turning over just short of one million, providing a good living for its small number of employees and having a portfolio of customers who, almost without exception, we are pleased to class as good friends.

### Change over time

In the early days some business was generated through advertising but the majority came from contacts already known through our previous positions as sales engineers for temperature control manufacturer Eurotherm Ltd (now part

of the Invensys group).



The first products were designed around the emerging range of personal computers, adapting their operating systems to fulfil our needs. Hard to believe how advanced this seemed at the time, perhaps demonstrated by the picture showing one of our early data logging systems which conceals (not very well) a Commodore PET, a BBC model B, a 'Tangerine' and a specialist 64 colour graphics card. However, it rapidly became apparent that we could not be competitive and flexible without our own processor cards and we therefore set about the design of these, painstakingly tracking the boards using rubber tape. Three years later and by then in possession of our first PC with a massive 10 MB hard drive (who could need more!) we purchased our first PCB CAD software, putting us in a position to generate new boards customised to project requirements. This package served us well for a number of years with business comprising a selection of large projects underpinned with a steady demand for our original printing logger and a range of signal and protocol converters to smooth the flow of funds.

The next significant change in design occurred when we attended a Department of Trade and Industry seminar which introduced us to the new and highly versatile processors — microcontrollers. These devices with on-chip ROM and RAM opened new possibilities and have been the bedrock of our products since

then. Microcontrollers moved digital electronics into an extended range of markets not accessible to the conventional bus based processor systems of the time. Our first microcontroller product was a digital thermostat for an air conditioning system, commissioned by a distributor for one of the major Japanese air conditioning companies. Without microcontrollers this product would never have been viable but as it was we were able to hit the target price and with an acceptable margin. We were not to know at the time but this was a massive milestone for the company. We were subsequently asked to design larger and more complex systems to link complete air conditioning complexes to Building Management Systems and today we directly supply that same air conditioner company with a wide range of specialist interfaces for their equipment. The products control the environments of hotels, offices, shops, hospitals and many industrial premises. As volumes have grown we have needed to put in place structures to allow a small company to handle quantities. Our latest departure, a track-day logger for motorcycle enthusiasts, takes advantage of these as we venture into the consumer marketplace. Using a combination of rate gyroscope, accelerometer and GPS, the unit logs position, speed and, uniquely, the lean angle of the bike – a simple concept which has

proved surprisingly challenging to achieve. A picture of the unit is shown ready for action.

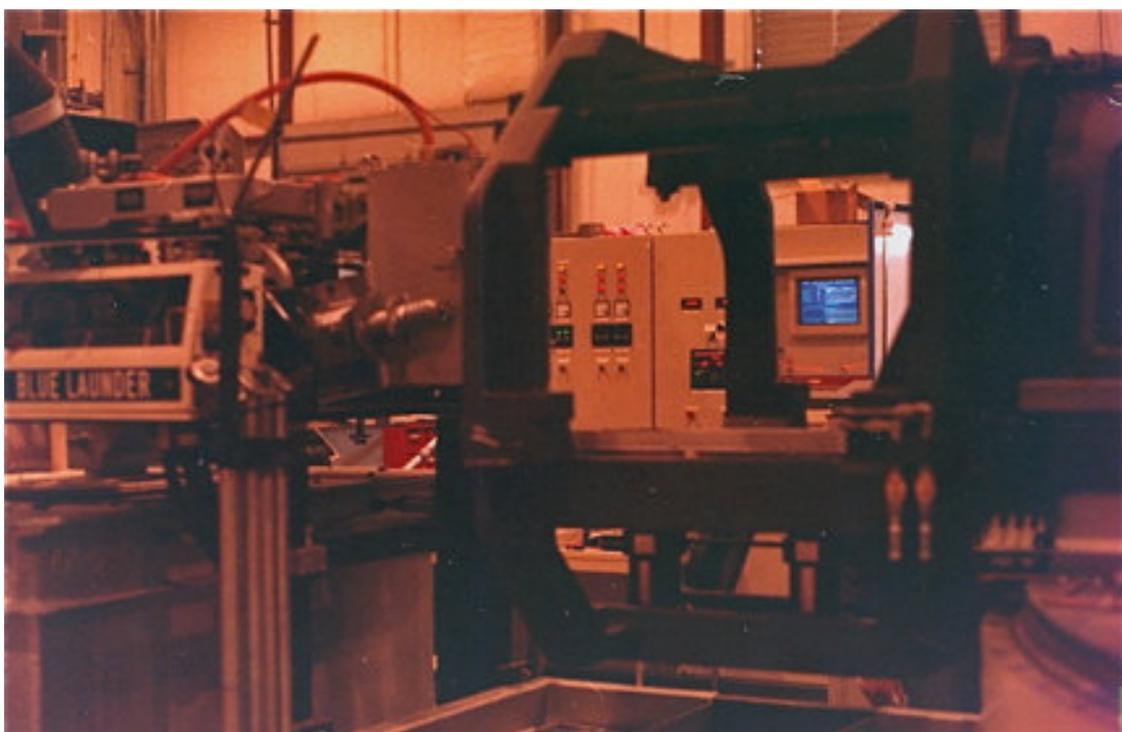


It is all a long way from the PET-BBC-Tangerine of 1985.

### Engineering the solution

At the onset the plan was to offer engineering services in response to companies' requirements and we targeted these around a configurable, printing data logger, dubbed an 'intelligent printer'. Before long we found ourselves being encouraged off piste and on to "more interesting" projects. An early coup was gaining involvement with an engine casting/motor racing company to assist them in computerising their aluminium casting process.

*(Continued on page 14)*



## Running Your Own Business (An Insider's View) cont.

*(Continued from page 13)*

The process used a ceramic eddy current pump, originally designed to pump sodium in nuclear reactors, with mould level being detected by a custom designed capacitive sensor. This project was to occupy us intermittently for several years from the original (inevitable) BBC model B to the eventual OS/2 based installation of three casting stations — each producing one engine block per minute — at one of the major motor manufacturers in Detroit. The picture overleaf shows the US pilot plant with the control panel viewed through the casting clamp and the pump launder nozzle to the left. Other stimulating projects included the control of a 150 tonne, 3 m diameter hydraulic press to a travel accuracy of 0.1 mm in 2 m; the transmission heat treatment line at a prestigious West Midlands 4x4 motor company; a winder system capable of smoothly winding 25,000 m reels of 12 micron, 2 m wide laminating film; and substantial work on ceramic cooker hobs to provide quick boil, automatic pan temperature control for frying and boil-dry detection.

These were the one-offs, very interesting but leaving a sort of post-natal depression at the end where the elation of sending the final invoice was tempered by a sadness at the sudden loss of involvement and possibly the question of where the next salary cheque might come from. The more continuous business whilst perhaps not quite so exciting presented its own challenges as we developed control packages for a variety of machines including the cold forming of coil springs using up to 28 mm diameter wire, a range of electronic systems for the testing of the properties of plastics (viscosity, friction, impact strength etc.) and even the control of crematorium furnaces.

In all of these projects, and many more, I have been grateful for the wide grounding I acquired from the Oxford Engineering first degree and my DPhil experience. The ability to discuss engineering aspects outside the electronics element has been invaluable and is a great asset in gaining customer confidence. It also removed much of the fear of the unknown

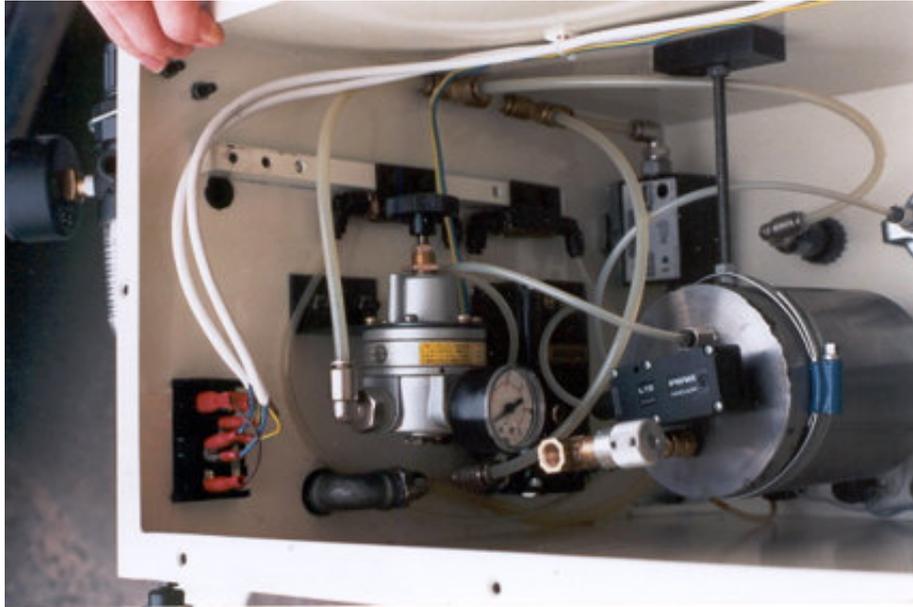
which may otherwise have accompanied a number of projects.

The cross-disciplinary capability is well demonstrated by the project shown on the facing page. Here we had been asked to produce an automatic test rig for low pressure boiler flue switches, generating both positive and negative pressures from a compressed air line using a Pitot vacuum pump. The electronics were relatively trivial but the associated pneumatics less so. Although we were able to pick some ideas from the original old and decaying rig we were unable to dismantle sealed components, in particular the large 'plenum chamber' shown in the centre. No one seemed to know exactly what was inside so we took an educated guess and tests with the aid of a large coffee tin and improvised baffle plates showed our guess to be promising. One of our customers then assisted us, manufacturing the official parts and the project moved to a successful conclusion.

### Engineering is about people

Of course a business is not just about hardware and applications. The third element in the mix is people. The right mix of capable and effective people is the difference between an enjoyable and vibrant business and one where stress and disillusion reign — and without doubt, the former has the better prospects. The requisite skill requirements need to be met but it is not necessary for everyone to be highly qualified. People bring their own skill sets, which will grow with the job, and with the right encouragement this process should be stimulating and fun rather than pressured. In our first year we advertised in a local shop for a technician. A couple of days later a mum appeared ushering in her 16 year old son fresh from school. He seemed pleasant and capable so we took him on. Paul is still with us, now a highly accomplished printed circuit board designer and a key member of the team.

The people link doesn't stop in house. Good partnerships from supplier through to final customer promote an efficient wealth generation route. A recognition that everyone



needs to make a sensible return helps to keep the relationships long term. Everybody responds well when treated fairly and requests for special performance when needed are much more likely to be met. Finding good, new suppliers and customers is time consuming and time is a very precious commodity. We have always tried to work with customers as if we were a part of their company, making sure that we fully understand the problem they have and how we may be able to help. This puts us in a position to make additional suggestions to enhance the product – on the basis that the more they sell the more we will sell. In general it seems to have worked well.

### **Reflections and a few Do's and Don'ts... with hindsight**

Running a business inevitably will have its ups and downs. When things go well it is hugely rewarding but you do need to be prepared to ride the downs. As a competent engineer your services should always be saleable. The engineering world needs logical, informed thinking and that is not always as readily available as might be assumed.

However, simply solving specific problems has limited growth potential. The aim should be to capitalise on the solutions wherever possible – think once and sell it many times.

Over the years we have mentally drawn up a list of Do's and Don'ts – this does not mean to say that we have not done any of the Don'ts or

done all the Do's first time but for what it's worth here are a few.

Firstly, don't try to be good at everything. Do what you do well and leave others to do what they do. Preferably do the things that you can do and others can't – why invite unnecessary competition?

Be flexible. Don't avoid something simply because you haven't done it before. Push yourself and follow up (at least briefly) all reasonable enquiries – you never know which box may contain the golden egg. New challenges are exciting and provided the risk factor is not too great they will ward off any threat of boredom.

When something doesn't want to work try explaining to a colleague how you have tackled the problem. It's amazing how many times you will solve the problem yourself half way through the explanation!

Present products and services professionally. The small company will tend to be the focus of attention when everything is not going quite as planned. Good presentation generates early credibility – which, one would like to think, will prove to be fully justified.

Hopefully your lucky break will come – but keep in mind Thomas Jefferson's view:

“I'm a great believer in luck and I find that the harder I work, the more I have of it.”

## Tidal Stream Energy – The Role of Efficiency

*A synopsis of a 2011 Open Day talk given by Dr Richard Willden*

The talk started with a brief summary of the potential for tidal power in the UK: EU Commission figures from the 1990s estimate that it could provide 5% (18 TWh/yr) of the UK's requirement, although Dr Willden believes it could be closer to 10% – the EU figures are quite old. Tidal power is therefore of considerable interest to the UK in particular.

Although they might at first sight appear similar, tidal power is not quite like wind power: the environment is harsher, with heavier loadings, and of course tidal power is predictable – the time, volume and direction of flow are known in advance – which enables different strategies to be employed.

There is a balance to be found between power coefficient (ratio of power obtained to power available in the stream) and efficiency when extracting energy from tidal flow: developers want maximum power coefficient, while regulators want maximally efficient use of the water resource. Predictably, these two goals cannot be met simultaneously!

The speaker's speciality is device modelling, using numerical modelling and simulation tools: as well as discussing the performance of various different device types, he also laid to rest some basic misconceptions, chief among which is that *no* device can out-perform simple momentum theory (which sounds obvious, but apparently some people claim otherwise).

During a wide-ranging overview of the field, four different types of turbine were discussed in particular:

1. Simple axial-flow rotors (the tidal equivalent of conventional wind turbines): these come quite close to “disc” theory (86% at peak), but perform more badly on efficiency.
2. Ducted turbines have converge/diverge ducting to increase flow speed, which gives more power (power is proportional to the cube of flow speed), but – despite

some extravagant manufacturer claims that this gives you something for nothing – water spills around the outside of the ducting, so not as much water is processed as might be expected.

3. Open-centre turbines use a jet to reduce pressure behind the turbine and suck more flow through, but the overall effect is poor because the hole in the middle of the rotor reduces its area.
4. Cross-flow turbines (i.e. where the turbine axis is perpendicular to the stream: see Ross McAdam's article in SOUE News issue 7) are able to block the entire channel better than circular axial-flow devices, but generate vortices which reduce efficiency, and also suffer badly from viscous effects, blade lift and drag – the blades only spend part of their cycle time “working”.

Common problems of tidal stream turbines were also discussed:

- Fatigue poses a problem for tidal turbines, especially cross-flow, due to torque variations around the cycle (for cross-flow, when the blades are at the back of the rotor; for axial-flow, when the blade passes the tower holding the turbine in place).
- Flow stream through a turbine needs to expand downstream, which causes particular problems in confined flows.
- Extracting energy from a stream reduces its free surface height (so it is potential, not kinetic, energy that is extracted); this has environmental impact downstream, a problem that turbines share with tidal barrage schemes.

Comparing the various types, Dr Willden observed that axial-flow rotors are very hard to beat (while engaging in some good-natured banter with the Head of Department, who is currently involved in an attempt to develop a commercial cross-flow turbine!)

## A Short History of the Low-Carbon Future

*A synopsis of a 2010 Jenkin Day talk given by Vilnis Vesma*

Vilnis runs a consultancy specialising in energy management. He started by entertaining us with fantastic cases of energy being wasted by ignorant or careless maintenance. For example, a flight of steps leading to a building entrance, observed to be totally dry, *all except the bottom one*, shortly after a shower of rain. The steps had been provided with electric heaters to melt any ice in winter. But somehow they had come to be left switched on all the time, summer and winter, all except the bottom one, which had failed, and hence gave the clue to what was happening. In other cases valves had either been damaged or locked permanently open by maintenance people who had no idea what they were meant to do, or very possibly couldn't care less. One valve left permanently open was estimated to be wasting £9000 per annum in energy costs. He had found wasteful design errors too, including a

set of three boilers, any one of which was over-rated for the load, all running continuously and wasting 360 kW.

His recommended approach for reducing energy consumption was to estimate how much *ought* to be used for various processes etc., possibly just by considering past consumption, and then to list actual present consumptions in descending order of over-spend. Then start at the top of the list. He described an instrument that would record external temperature in terms of "degree-days" over a period, as a guide to how much energy *ought* to have been used for space heating over that period.

Turning to the more general need to reduce fossil fuel consumption in order to minimise climate change, Vilnis thought there was no point in waiting for global agreements about what to do – we should just get on with it ourselves. He believes that, ultimately, energy will have to be rationed.

## Fourth-Year Project Exhibition 2011

This year the prizes were sponsored by civil engineers Laing O'Rourke, by IC engine experts Ricardos, (both of these for the first time), and by Glaxo Smith Kline and Sony Broadcast & Professional. There were fourteen entries, a slightly disappointing number – twenty to twenty-five would have been better, but the number does vary somewhat from year to year. And the exhibition was in the sixth week of Trinity Term, two or three weeks later than usual, which may have had some effect.

The judges were, as usual, a selection of fairly recent graduates, now engineers in the "real world", namely:

Mark Gooding, Merton 1996–2000, now with Mirada Medical

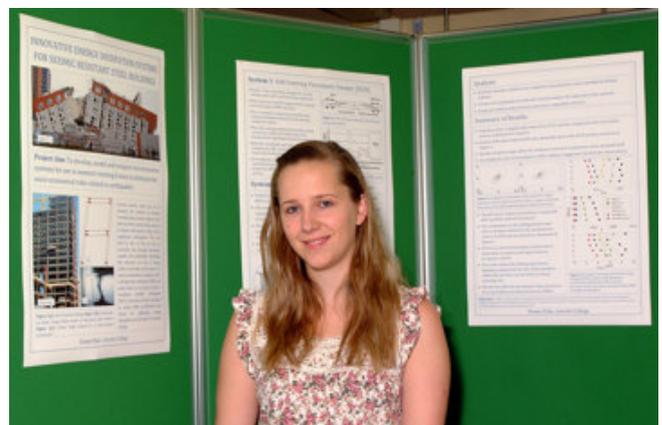
Richard Lane, Oriel 1996–2000, now working on radar with QinetiQ

Margot Mear, New College 2001–5, now a

civil engineer with Atkins

Mike Parker, Keble 1994–8, now a semiconductor engineer with STMicroelectronics.

They awarded prizes as follows:



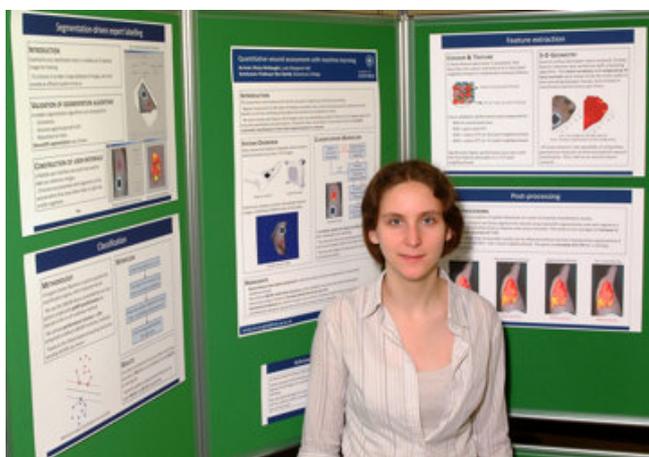
**Emma Hale** of Lincoln (above) got the £600 Laing O'Rourke prize for the best civil or

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## Fourth-Year Project Exhibition 2011 cont.

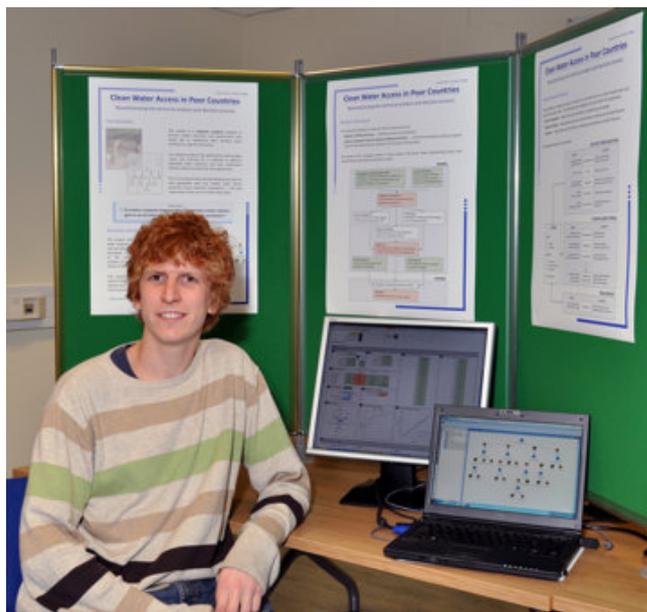
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constructional engineering exhibit. Her work was on Innovative Energy Dissipation Methods for making steel-framed buildings more resistant to earthquakes. It was a computer-based study, and concluded that the best of the techniques she studied was to incorporate short lengths of RSJ with cross-wise slits in the web. They were arranged so that if the building frame was distorted from its normal rectangular shape, the flanges of these little RSJs slid in opposite directions and the web yielded plastically, dissipating energy and thus damping oscillations. See figure opposite.



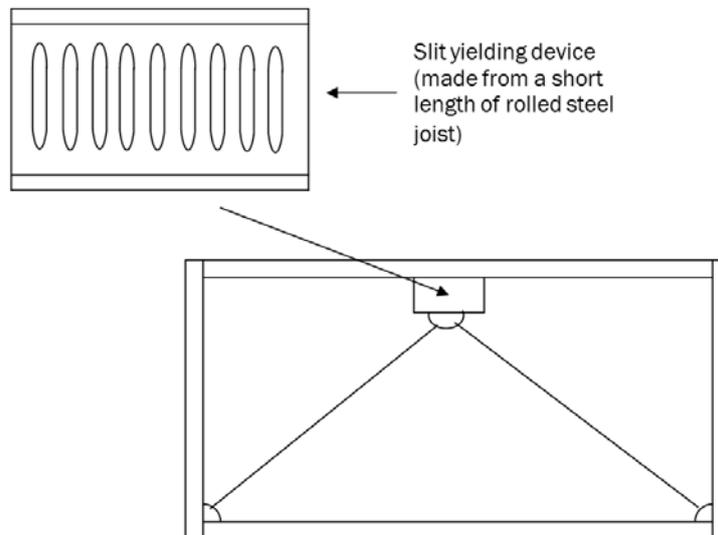
**Kirsty McNaught** of LMH (above) got the £300 Sony Image Processing prize for an exhibit about a computer program to assess the state of wounds (to the feet in the example shown) by analysing images of them. This was a project done in collaboration with Eykona Technologies. She found that she got the best results by doing Fast Fourier Transforms on the colour (RGB) signals from arrays of 7 x 7 pixels.

**Jeremy Evans** of St John's (top right) exhibited a complex computer program for finding the best way to generate a clean water supply in poor countries, taking account of numerous different factors: rainfall, proximity of the water source, pollution, population etc. Depending on circumstances, the optimum solution might vary from simply ladling it out of the river with a bucket, to much more complex pumping and piping arrangements. Jeremy treated his visitors to an extended demonstration, and the judges thought this was the best exhibit of the lot, and awarded him a £750 prize.



**Andrew Pitayanukul** of Magdalen was awarded a "best poster" prize of £200 for an exhibit concerned with the new "ballistic" way of administering drugs or vaccines, projecting them through the skin from behind a bursting diaphragm, an alternative to needle injection. He described an acoustic method for assessing how well the drug had been assimilated, by seeing how rapidly the solid particles diminish in size as they dissolve.

**Ian Ashcroft** of LMH had another water-supply exhibit, but his project was very different from that of Jeremy Evans. It described a doubling-acting hydraulic ram pump for getting water from bore-holes too deep for it to be sucked up from the top. Unlike the more familiar ram pump, it had a mechanical input, but it still used the ram effect to generate high transient pressures. Water was made to flow in alternate directions along a pipe, carrying a "shuttle" with it. When the shuttle hit its end-stops the flow was brought instantly to rest. The high pressures generated by this deceleration allowed water to flow through non-return valves into the outlet pipe, where it was stored briefly in a high-head accumulator. Following a design study, the pump had actually been built and tested, but unfortunately could not be transported to the exhibition room. Nevertheless the judges awarded him a £150 "best hardware" prize, which seemed well-



### One bay of a multi-storey steel-framed building, incorporating the slit yielding device to reduce earthquake damage

deserved. Only a small fraction of the projects exhibited had actually involved making anything!

**Mark Baker** of St Edmund Hall also got a £150 prize for “Best Commercial Awareness”. His exhibit was about “TBlocker”, a new software package for Computational Fluid Mechanics. He had been applying it to the estimation of leakage flows through the seals separating the various turbine stages in aircraft gas turbines. Reducing this leakage by good seal design can greatly improve the engine efficiency.

Three more prizes, of £50 each, were awarded to the “commended” exhibits of:

**Oliver Cohen** of LMH, Switching and sequential colour for high-speed bend-state liquid crystal displays;

**Sanaya Kerawala** of Exeter, Hysteretic model for steel energy dissipation devices (a theme similar to that of Emma Hale above);

**Joshua McFarlane** of St John’s, Automatic generation of time-lapse videos, with examples of buildings viewed over 24 hours, and of people aging.

The remaining five exhibitors, who though they did not win prizes, certainly produced some interesting displays between them, were:

**Hassan Al-Wakeel** of St Anne’s, Holographic optical nanofabrication;

**Louise Ellis** of Hertford, The static analysis of masonry vaults (with an example of a structure from ancient Rome);

**Andrew Mather** of Keble, Human-induced sway of footbridges, a topic originally raised by the London Millennium Bridge.

**Douglas Reed** of Hertford, Optimisation techniques for the design of framed structures;

**Scott McLaughlan** of St Edmund Hall, Wave loading of offshore wind turbines.

### Changes to the future organisation of the exhibition

The SOUE has been organising this exhibition annually since 2001. This has involved finding sponsors for the prize money, recruiting judges from our recent alumni, publicising the event to fourth-year undergraduates, and making sure all runs as it should. The Department is now taking over some or all of these activities, and in 2011 two young academics, Theodore Karavasilis and Cathy Ye, took part in running it, and will take over more of it in the future. One of the more powerful reasons for this is that academics in post are in a much better position to encourage undergraduates to exhibit than is a long-retired academic no longer known to them. But we hope that the SOUE and other alumni will continue to support the event as they have done in the past.

## Gordon Lewis: Pembroke College 1942–1944

*An obituary by Michael C Neale CB, sometime Director-General Engines (PE), Ministry of Defence*

Gordon Lewis will be remembered for the outstanding part he played in the evolution of the aircraft gas turbine from the pioneering era of the 1940s to the near universal aircraft powerplant of today. He is rightly included in the Rolls-Royce 'Hall of Fame'. This commemorates those key individuals whose work shaped the Company, made 'Rolls-Royce' a hallmark of engineering excellence throughout the world, and laid the foundations for continued success in the years ahead.

Lewis was born on 24 June 1924, the son of a railway clerk, and attended Pate's Grammar School, Cheltenham. In 1942 he sat an examination for the Townsend Scholarship, a closed award at Oxford for Gloucestershire schools, which he won on condition that he satisfied the examiners in Latin. This he duly did after a two month cramming course. The prestige of the Townsend award, of £90 p.a., was enough to attract other awards, notably a Kitchener scholarship offered to the children of those who had fought in the 1914–18 war and – this being the middle of the 1939–45 war – he was given a year's deferment from military service.

Thus Lewis went up to Pembroke College in the autumn of 1942. A further year's deferment in 1943 enabled him to graduate in 1944, this reflecting the shortened wartime degree course. Summoned for interview at the Directorate of Scientific Manpower (an occasion punctuated by the closely adjacent explosion of a V1 flying bomb), Lewis was offered three options for employment: the coal mines, REME training for tank recovery, or 'structural research' at Farnborough. With what in retrospect can be seen as an early example of the determination he maintained throughout his life, Lewis made clear that none of these appealed. He wanted to work on the then secret jet engine. He got his way, and duly arrived at Bristol where he was to make his career.

At that time aero-engine work at Bristol was highly focussed on the development and production of the radial air cooled piston engines that were being produced in large numbers to support the war effort. Gas turbine work took a back seat. Nevertheless by 1946, in response to a Ministry specification, and on his own initiative (he having rejected the engine layout defined by his superiors), Lewis was drawing out a scheme for a two spool engine featuring two axial compressors in tandem. In the fullness of time, after much development, this was to become the Olympus, a landmark in the evolution of the aircraft gas turbine, and to achieve fame as the powerplant for Concorde.

The early success on test of the engine's twin spool compressor greatly impressed Stanley (later Sir Stanley) Hooker, 17 years senior to Lewis, who had moved from Derby to Bristol in 1949, shortly to become Chief Engineer there. Earlier in his career Hooker himself had carried out postgraduate research at Oxford, and quickly realised that in Lewis he had got, as he put it, 'pure gold'. Whilst still in his twenties Lewis was put in charge of all Bristol work on compressor design and performance and, with Hooker, went on to form a formidable engineering partnership at Bristol that was to last for the best part of twenty years.

For pure, frequently hilarious theatre, allied to engineering brilliance, the barnstorming performances of Hooker can have been matched by few in the engineering profession. But those closely associated with the Company knew that behind the undoubted brilliance of Hooker there was always Lewis – quietly spoken, measured, choosing his words carefully, always in full possession of the facts whatever the issue might be, and with a capacity for marshalling and explaining them that could only be admired.

Significant though the success was that Lewis had achieved whilst barely out of his twenties, it was but a prelude to his work that led to the Pegasus engine, the powerplant of the ever to be remembered Harrier vertical take-off fighter. Probably more than any other, this is the



**The Pegasus engine**

engine with which Lewis will always be associated. Its origins go back to 1956. It was then that a French proposal for a vertical take-off aircraft was referred to Lewis who, as was his way, studied it in detail. Whilst in awe of the revolutionary flight prospects offered by the concept, he was appalled by the mechanical and aerodynamic complication envisaged.

Lewis set out to devise an alternative. Ultimately there evolved the powerplant layout which, in its simple elegance, is unlikely ever to be surpassed in an aircraft providing the capabilities of the vertical take-off Harrier: a single bypass engine with four swivelling exhaust nozzles, two each for the front cold and rear hot streams respectively. Thus was born the Pegasus, of which about 1300 examples were to be built, including many for the United States for service with the US Marine Corps. This was an outstanding military export achievement into the notoriously hard to penetrate American defence equipment market. With the British services the Harrier operated successfully in the Gulf Wars and in

Afghanistan. Most notably though, the Pegasus powered Sea Harrier (the naval variant) achieved distinction in the re-capture of the Falkland Islands: after the conflict the First Sea Lord observed that “without the Sea Harrier there could have been no task force”.

Following the Pegasus Lewis faced what was perhaps the most difficult task of his career: the development of the engine – designated RB199 – for the Tornado aircraft. This programme had an unfortunate start. For reasons outside his control Lewis found himself landed with the responsibility for developing an engine with, for the role in mind, the unnecessary complication of three shafts rather than the two shafts he rightly favoured. Further an imposed competition with other contenders for the choice of engine led to the adoption of ambitious performance targets for which there was no prior technology demonstration. A consequence was that the airframe design commenced ahead of the launch of the engine programme: the cart was

*(Continued on page 22)*

## Gordon Lewis: Pembroke College 1942-1944 cont.

*(Continued from page 21)*

now well and truly before the horse. To all this was added the task of welding together the German, Italian and British engine teams with their very different backgrounds and levels of achievement into a unified development effort. Thus Lewis, as Managing Director of Turbo Union, the tri-national company formed to develop the engine, faced a formidable challenge.

Inevitably there were cost and timescale overruns. These attracted much publicity, it tending to be forgotten by the critics that the root cause of the difficulties lay in the unpromising circumstances surrounding the launch of the engine. Lewis bore with quiet fortitude, confidence and good humour the criticisms levelled at the programme. He was never in doubt that ultimately there would emerge an engine that would give distinguished service in the Royal Air Force and the Air Forces of Germany and Italy. That events proved him right demonstrated his mastery of the whole process of complex engine development and his ability to get the best out of people in the difficult circumstances in which the tri-national team had been placed.

However Lewis was not going to be landed with the same difficulties a second time. Thus when in the early 1980s the possible development of a European Fighter Aircraft began to be discussed in earnest he was to the fore in urging the necessity of a comprehensive programme of engine technology demonstration prior to any commitment to full development of the new engine that was in mind. This was met with a long familiar reluctance or, more accurately, refusal to spend money prior to a firm commitment to the project. Lewis showed his customary determination in overcoming this. The required technology programme was initiated and went on to earn the plaudits of the National Audit Office for the huge benefit it conferred on the development of the EJ200 engine for the Typhoon aircraft. Save for the complications of multi-national working this was a model development, a world removed from the

difficulties that had dogged the development of the RB199.

An early step on the road to this successful outcome, and one of fundamental importance, was the adoption of a two shaft layout for the engine. No sophisticated PowerPoint presentation of today could surpass the clarity of the case advanced by Lewis to this end. In illuminating a complex technical argument he needed no more than four Vu-foils drawn freehand with a magic marker on the kitchen table. Those simply drawn Vu-foils defined the layout of the engines that will be in front line service with the Royal Air Force and the air forces of the other participating nations for decades to come.

But beyond the detail of his engineering designs Lewis always saw a bigger picture. He appreciated, as did his colleagues in the Ministry of Defence, that wherever in the world an aircraft or aero-engine industry is established, industry and Government are inextricably linked – whether either party likes it or not. His MoD colleagues argued constantly that the interests of the United Kingdom are best served when the two work in partnership rather than in opposition. No one saw this more clearly than Lewis. Within MoD he was seen not just as an outstanding engineer, but also as an outstanding ambassador for the great company he served. He worked tirelessly not just as an engineer, but in representing his company to the wider community and, above all, in seeking the common ground in his dealings with government.

This whole process, tortuous and time consuming though it often was, should not be thought of as unflinching solemn. Especially engaging was Lewis's sense of humour, never far beneath the surface, as Hooker had noted approvingly in his early days at Bristol. The writer recalls that a trait among Bristol engineers was to ring him up in his MoD office at about six or later in the evening. Mischievously he used to claim that they were checking up on him: they were still working and so should he be! On one such evening the

'phone rang and it was Lewis. After he had offered a few complimentary remarks on finding the writer still at his desk the latter explained wearily that he had had an awful day — continuous meetings since before 9 am — and only then, he felt, was he getting down to his proper day's work.

Lewis was not impressed. Without a second's hesitation he replied, undoubtedly with a twinkle in his eye, "Well it's all very well for you to say that Mike, but you have no idea what it has been like down here".

It was heart warming. On another occasion the difficulties and delays in the development of the RB199 were causing great concern in Whitehall. As was the custom, the chiefs there called for a report, and for Lewis in person to present it. Having prepared his report Lewis came first to see the writer, who told him to be prepared. "Gordon," he said, "I know it is not your fault but when you get down to the Main Building you're going to be told to bend over: you're going to get six of the best." "In that case Mike," rejoined Lewis, "do you think that the best thing I can do with the report is to stuff it down the seat of my trousers?"

And this was the man, this giant of the profession — all humility — who had personally made a huge contribution to the aero-engine business right from the early days of the

aircraft gas turbine. Self effacing always in the eyes of his friends and colleagues, this merely added to his stature. All in Government who ever met Gordon Lewis will remember him not merely as one of the giants of his profession — but as one of nature's gentlemen.

Lewis retired as Rolls-Royce technical director in 1986. He was the recipient of many honours and awards. These include:

Appointment as CBE; Royal Aeronautical Society Gold Medal; Membership of the team receiving the MacRobert Award for engineering innovation with the Pegasus engine; Fellowship of the Royal Academy of Engineering; Design Council Award for the Pegasus engine; Award from the American Helicopter Society; F E Newbold Award from the American Institute for Aeronautics and Astronautics; Honorary DSc from Bristol University; American Society of Mechanical Engineers designation of the Pegasus engine as an International Historic Mechanical Engineering Landmark.

Gordon Lewis died on 4 October 2010. He is survived by his wife Marjorie, whom he married in 1947, and a son and two daughters.

*Editor's note: Gordon Lewis was President of the SOUE from 1993 to 2002.*



**The Harrier hovering gracefully — a sight regrettably consigned to the past by defence cuts**

## **Richard Darton FEng, OBE**

SOUÉ News congratulates Richard Darton on the award of OBE, for “services to engineering”, in the June Birthday Honours. Richard’s earlier career had been with Shell, mainly in the Netherlands. When the Department was planning courses in chemical engineering, on the initiative particularly of the late Peter Whalley, Shell seconded him to Oxford to help

with this, in 1991. He later became a full member of the academic staff, eventually Professor, and was Head of Department from 2004 to 2009. In 2008–9 he was President of the Institution of Chemical Engineers, and is currently President of the European Federation of Chemical Engineers.

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## **The David Witt Premium Prize**

*Raoul Franklin*

This year for the first time an award was made to recognise the tireless devotion that David Witt has given to the Department through the medium of project work, which can count towards the degree classification of those involved.

Essentially it relied on the judgement of the Finals Examiners and was financed by a fund at

the disposal of the Department, the initiative coming from Raoul Franklin, a member of the Department from 1963 to 1978, and colleague of David’s for many years.

The Prize was to go to the most innovative or imaginative of all of the projects undertaken and submitted for judgement, and an appropriate mechanism was put in place.

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# ***SOUÉ News***

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Produced by David Witt (Magdalen 1959) and Simon Turner (Lincoln 1984)

Printed by Holywell Press

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Society of Oxford University Engineers  
Department of Engineering Science  
University of Oxford  
Parks Road  
Oxford  
OX1 3PJ

E-mail: [soue@soue.org.uk](mailto:soue@soue.org.uk)

**Visit our website:**  
**[www.soue.org.uk](http://www.soue.org.uk)**