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METROLOGIST

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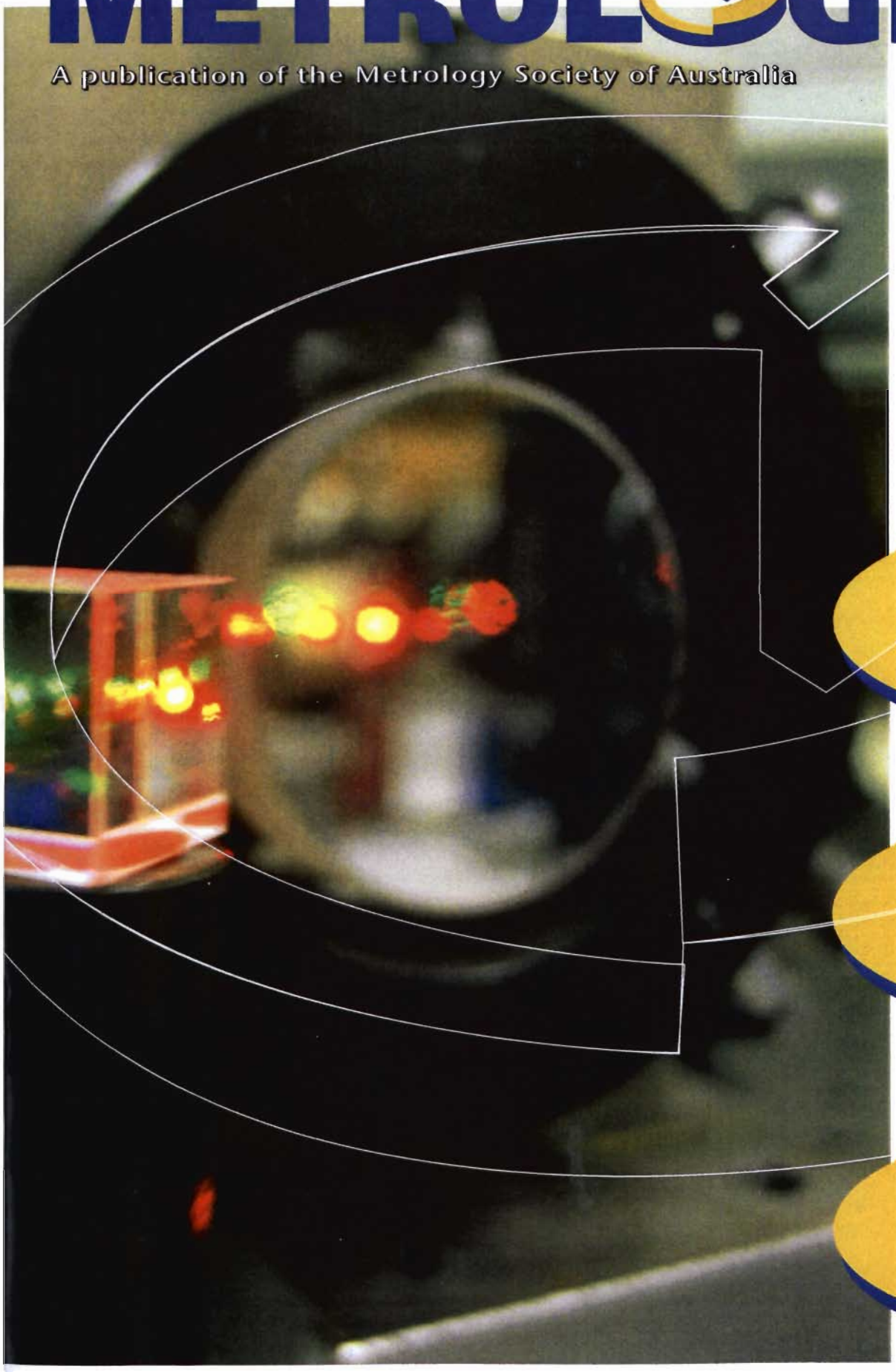

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Book Reviews

THE AUSTRALIAN METROLOGIST

From the Editor

The Adelaide Conference of the MSA has been very successful, and a number of the items in this issue relate to it. And a couple of advertorials from sponsors are provided here - better late than never.

The National Committee with its new blood will be considering the best way of communicating with members, and to this end the future of *The Australian Metrologist* - as we know it - is under review.

I assumed the role of Editor with issue 16 in 1999 and wonder whether it is now time for some *new blood* to take the baton. It has always been my view that TAM is the one thing that all members see, apart from their annual subscription bill!

The main problem for any editor, and I've seen it get worse over the years, is obtaining material to print which is likely to be acceptable to the varied membership of such an organisation. We are all too busy - perhaps because we do have work commitments and families to satisfy - and our membership is not large. I hope that TAM can continue in the future in some form.

As always, my grateful thanks to Ron Cook and Jeff Tapping for their untiring help in providing thought provoking articles on many subjects over the last few years.

On behalf of the National Committee I wish all our members the Compliments of the Season.

- *Maurie Hooper*

Cover photo - "Three colours lasers" (courtesy NMI)

The Australian Metrologist

The Australian Metrologist is published four times per year by the Metrology Society of Australia Inc., an Association representing the interests of metrologists of all disciplines throughout Australia. Membership is available to all appropriately qualified and experienced individuals. Associate membership is also available.

Contributions

Articles, news, papers and letters, either via e-mail, disk or hard copy, should be sent to:

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If you have a position vacant, write or e-mail the Editor with the details. A charge of $20 for up to 10 lines applies. (The circulation may be small but it is well targeted.)

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Letters should normally be limited to about 300 words. Writers will be contacted if significant editorial changes are considered necessary.

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Fellow	$45 Annual Subscription
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President's Report - December 2007

MSA Ethos

When we have belonged to an organisation for some time the culture that pervades its existence becomes second nature to us and is then almost invisible. We become used to the way that things are done, where the coffee is and when our friends break for lunch. We use the language that everybody understands especially acronyms!

So the organisational culture is often more readily visible to the new arrival than to those who are experienced in how things are done. The first MSA conference I went to was in Canberra in 2005. I wasn't yet a member and I admit I was intending to be an observer; just to deliver my presentation and be off. As a scientist of the chemical persuasion I was accustomed to the Royal Australian Chemical Institute way of conferences which are very large and inevitably a little impersonal. I might add, just quietly, that there is a definite pecking order at RACI shows and it depends on academic status.

So I was pleasantly surprised to find that the MSA conference had a much friendlier feel. I thought people were down to earth and interested in the work for interest's sake. Even though people had to concentrate on their own specialities, no-one seemed to try to put one area of metrology at a higher station than any other. Everyone's contribution was equally valid and worthwhile. This freed me to enjoy many speakers that I may normally have felt I shouldn't have given my productive time to. I especially remember a presentation by a magnet manufacturer that was fascinating. I even found out what many of the other people at the National Measurement Institute were doing!

These are the things that I see as the most worthwhile things to foster in the MSA: friendliness, interest, acceptance and enjoyment. Have a look at the MSA overview and statement of purpose on our website and you will see that most of the points relate to sharing and helping each other. I think that's what make's it possible to relax and enjoy our work.

I am honoured to be elected as the President of our organisation and I will sincerely try to encourage the worthwhile ethos I have found among our members. I look forward to meeting as many people as possible during my time as your President and to listening to your concerns and sharing your interests.

- *Daniel Burke*

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Ron Cook

I commenced composing this reflection during a walk along the Adelaide seafront between Glenelg and Brighton. I was slow to make my booking for the recent MSA Conference and consequently was billeted in a motel in Glenelg so the seaside stroll was easier to do than looking for a stream with a path alongside. No fishing as a scaling knife and a packet of hooks in ones personal luggage can cause one to be ejected from the boarding queue.

At the traditional NATA starter on the eve of the conference I discussed the issue of river bank strolls in South Australia with a couple of locals and an expat Adelaidian. There is for example a pleasant walk alongside the Torrens Lake in the city area. This path actually is quite long going all the way from the sea to the other side of the city. The Port River was mentioned but really this to my mind is an estuary as there is no stream that runs from the mountains into the top of the waters. The Little Para River does flow into the northern part but I can't find any other notable stream that finishes up in the Port River. There are many rivers in South Australia mostly small with unreliable flows as might be expected of a dry State in a dry continent. At one time over sixty South Australian streams had had trout introduced but there are only a handful that would be worth trying today. The mighty Murray still offers the best river fishing in the State.

The NATA starter always gets the MSA Conference off to a good start. The Five Degrees of Freedom certainly provided a very professional musical background. It was a bit louder, OK a lot louder, and certainly livelier than the old Muzak background that was once popular. This was Tony Russell's last NATA Starter as the CEO of NATA. When he joined there were fifteen staff. Although this number has grown considerably there is still a strong team philosophy. During his watch in the CEO role NATA has become a more professional and more codified accreditation organisation, mainly in response to the growing internationalisation of accreditation. NATA is no longer the prototype and the sole ground-breaker in accreditation; it has become absorbed into an international family. We live in an era of internationalisation so we should be pleased we still have NATA as an entity and it has not been absorbed by some bigger and more cashed-up overseas group.

This conference was very well organised (Les, you and your team should take a bow) with three parallel streams and an excellent partners program. The attendance of over one hundred and forty exceeded expectations and required some reorganisation of the venue, which was done seamlessly. The bussing for those unable to be accommodated at the venue worked smoothly as indeed did the whole conference. Even when a number of attendees decided to change their minds at the last moment and attend the dinner, Les and Dennis Leaney managed to get an additional table set up in 10 minutes. One of the good points about the dinner was the choice of dishes. Indeed all the food supplied was of high quality. Those South Australians not only take pride in their wines, they are justly proud of their culinary offerings.

Talking of wine, the option of a wine tasting and educational presentation was a popular event. It was a matter of choosing between two very good industrial visits or the wine tasting. On the basis that I have seen a number of power stations and I had seen the submarine factory before and that one can never have too much good wine I chose the wine option. I fared worse in the blind tasting that someone of my years of experience should have, so I have determined to make fresh efforts to study the subject harder.

The presentations were the usual mix, from tutorials to presentations of current research. The development of the new NMI voltage divider with an uncertainty of 1 x 10E-10 was fascinating. From the 1950s onward Mel Thompson was the guru on measurement transformer design. Greig Small joined the Thompson group many years ago and it was Greig's knowledge that allowed Ilya Budovsky's team to build this ratio transformer which is 100 times better than any earlier device made by anyone anywhere. Greig has passed the nominal retirement age and is working on the design and construction of a calculable capacitor for the BIPM so he is at the NMI regularly. It was fortunate that he was available to help Ilya and not basking in the sun in some quiet part of the world. The retirement fellowship scheme is an excellent way to keep senior scientists accessible to the younger generation and to avoid the loss of corporate knowledge that retirement might otherwise bring.

Back to the Conference. All of the presentations this year had a strong practical flavour, whether it was an analysis on the performance of a mass comparator, a quantum AC voltage standard, calibration and use of thermocouple simulators or chemical profiling of cocaine. I could not attend half of the presentations I would have liked to, so the CD and book with the proceedings were carefully guarded. I had a late night after the NATA starter reading the proceedings and revising my pre-conference lecture selection list.

The shortest title was Noel Bignell's "Redefining the Kilogram". A short title but a massively important proposal. While there is acceptance that the kilogram as it is presently defined is not drift free and cannot be replicated in any well equipped laboratory as can the other SI units there is no obvious alternative. There are at present two competing techniques, the silicon sphere and the watt balance. Adoption of either now would give an unacceptable increase in the uncertainty of the kilogram, but in the near future an acceptably low uncertainty may be achieved. Some very senior metrologists believe that an electrical measuring system will be the winner, rather than an atom counting scheme which is really what the silicon sphere standard is based on. I plead the Rumsfeld excuse – there are things I know I don't know.

Frequency and length standards are becoming more closely integrated, with exceptional uncertainties possible. Will we see some new development pave the way to defining mass in terms of electromagnetic radiation? Bignell referred to one such proposal based on $E = mc^2 = hn$. Unfortunately it requires a frequency of 1.356×10^{50} Hz which is a bit beyond the 10^{15} Hz we can generate in an accessible and stable form today

The most intriguing title was John Miles' "Chinese Leftovers, Number Theory and Gauge Block Interferometry". There is a nice illustration of Cherry Blossoms on the River Banks at Koganei in the published paper. None of the erstwhile citizens in this picture seemed to be enjoying Chinese take-aways on the river bank so I had to read the article to find out if chop suey or shark fin soup were helpful in measuring gauge block fringes. You will have to read Miles' article yourself to find out; it is quite scruitable.

The two days of the Conference were over quickly. For many the final social occasion was the BBQ. Some of us felt we could not get enough of the SA hospitality, so on Saturday an intrepid group with spouses headed for the Barossa Valley with none other than the erstwhile Les Felix in the driver's seat of a large bus. We visited Lehman's winery for a tasting and lunch with another tasting followed by afternoon tea or coffee with scones. Credit cards were waved around and some of us have already consumed the contents of the boxes delivered to our homes.

So, looking back, what else stands out? Jeffrey Tapping's Forward to the Proceedings is worth a careful read. His last sentence in particular should be heeded. In essence he says that working as a metrologist is fun but we should

make time to enjoy the company of our fellow metrologists. I certainly enjoyed meeting with both old and new friends.

The theme of the conference was Global Measurement, The Metrology Jigsaw. Well, the papers seemed to integrate together very well, leaving only a few missing pieces. However, outside of the NMI papers most of the others were more nationally than globally focussed.

The Session Chairmen kept close to the scheduled times making transfer between sessions a workable option. Well done, ladies and gentlemen.

The use of colour in the printing of the Proceedings was a positive enhancement, making many of the illustrations much clearer.

This last Conference Committee raised the bar again so the new committee will need a long run-up to equal this last effort. Well done Les and all 2007 MSA Conference Committee members.

I had earlier this year walked along Brownhill Creek and as the bus took me back to the motel for the last time I was surprised to see a sign stating that we were in the Brownhill Creek catchment area. The creek was nowhere to be seen. A later study of a map showed that the creek spends much of its journey in this part of the city underground. This happens in all of our cities but at least here the creek emerged near the airport and joined the river on its journey to the sea. I can't say if there are fish in the lower reaches of the creek but the canal along the airport perimeter is not an area where I would cast a line with confidence. There might be more chance of hooking a Boeing than a brim. I wonder how many of the sixty plus streams that had trout introduced would, after the recent long dry years, now have fish of any kind in evidence above their estuaries. One day I should do a personal and practical survey.

BOOK REVIEW

Jeffrey Tapping

Smoot's Ear and Other Units, a Book Review by Jeffrey Tapping.

If you are going to publish a successful book it helps to have an eye-catching title, preferably linked to an intriguing theme. Robert Tavernor may be an academic in his day-job but he clearly illustrates an understanding of this principle by his book **Smoot's Ear: the Measure of Humanity**. The title refers to a prank by students at Harvard University in 1958 to measure the length of a local bridge using a student, Oliver Smoot, as a measuring stick. They measured the bridge to be 364.4 Smoots ± one ear. Tavernor is an architect, and he uses this incident to open up a discussion on the relationship between measurement and the humanity.

When I began this book I had considerable misgiving when I found this passage in the Introduction:

"The metre length and associated weights and volumes are based on the assumption that measurement can be reduced to quantities, and these quantities are applicable to any discipline within the arts and sciences, and to any nation. Yet as the Smoot standard suggests, measures are much more than quantities. They have symbolic as well as practical value."

I had visions of arguments that I would find a bit wacky, rather like volumes measured in swimming pools and load capacities in elephants (or to mention two I have heard recently, the Sydharb which is the volume of Sydney Harbour, and the Iraq-day which is the quantity of money spent per day by the U.S. on the Iraq war). Indeed in the first part there is considerable discussion on beliefs in magic numbers and mystical proportions and ratios in ancient times, but a large part of the book is a meticulously detailed and referenced history of the emergence of uniform systems of measurement, well-written with some fascinating facts I had not come across before.

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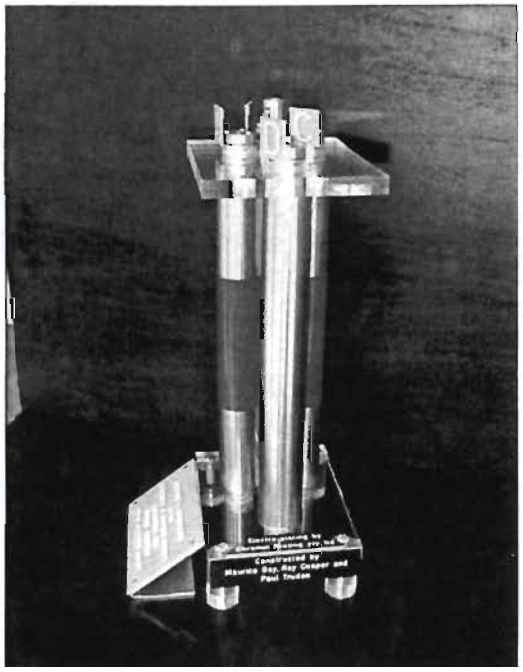
Ben goes to NMI

Ben Parkin won the prize for best Student Paper submitted to the recent MSA conference in Adelaide. As part of his prize Ben made a short visit to NMI Lindfield. Here is an account of that visit.

The calculable capacitor. I hadn't heard of it before and my ears pricked up as Brian Ricketts showed me its simple construction. I held the model of the capacitor in my hand and turned it over. Its construction is very basic. There were four fixed steel cylinders around a central cylinder which is moved to adjust the capacitance. Five steel cylinders being used at NMI to create an absolute electrical standard for capacitance. I was amazed. Only half way through my visit and already I had seen one of the six wonders of Australian metrology.



Calculable Capacitor – photo courtesy of Monash University

Before I tell you more about this device I will explain what brought me to be standing next to a scientist and an engineer at NMI Lindfield in northern Sydney.

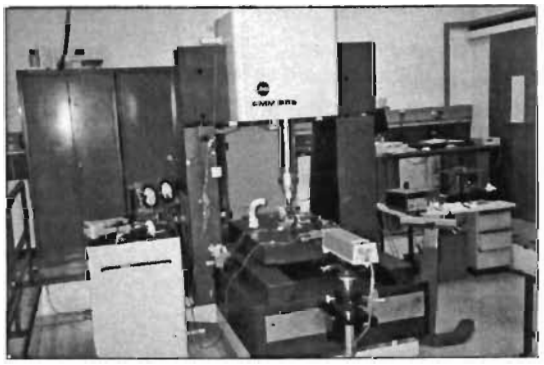
At the beginning of this year I was undertaking work experience at ITACS Pty Ltd, an electrical testing lab located near Adelaide's CBD. One of the magazines in the lunchroom was TAM. I noticed an article regarding the Horwitz function. As electrical engineers know the Hurwitz criterion is used to determine the stability of a system. But what is the Horwitz function? I read further and was intrigued to find it described measurement uncertainty in measuring chemical concentrations. Dr Horwitz was a chemist working for the FDA in the United States. He retired in 2000 but before he did he discovered an interesting mathematical function. When he sent chemical samples to other labs for testing the difference between their measurements showed an interesting relationship to the concentration of the chemical sample sent. As the concentration decreased to down to parts-per-million the relative standard deviation of the measurements increased according to a power function. The situation is reminiscent of the Rydberg formula of 1888. Johannes Rydberg discovered from looking at the sun's light spectrum a mathematical relationship between the light bands. Because the light bands followed one simple formula it was thought there was an underlying physical reason. Then, 25 years later, Niels Bohr discovered that underlying physical reason – the energy levels in hydrogen atoms which cause the sun's light emission. Could I similarly discover what was causing the behaviour Dr Horwitz had discovered? I did some research and wrote a paper on this topic. I also wrote a paper on photogrammetry which was a topic I discovered during my investigations. I had also read about the upcoming Adelaide metrology conference and I decided to submit both papers. After re-reading my Horwitz paper I realised I did not have the resources to carry out experiments and so I put my effort into the photogrammetry paper. After much help and encouragement from Les Felix, Maurie Hooper and Stephen Grady I had the paper "up to scratch" – I did not like giving up my Horwitz investigations, but I certainly felt better when Les informed me I had won the student best paper prize. At the conference Les suggested to me that a visit to NMI Lindfield would be a fantastic experience. As it would be sponsored – as part of the prize – by the Metrology Society of Australia I could not turn it down. So on Thursday the 11th of October I packed my bags and left Adelaide on a 4:20 pm flight to Sydney.

Leaving Adelaide – A View of North Glenelg from Virgin Flight DJ413

Arriving in Sydney at night I caught a bus to the Sydney Harbour Bridge – which was surprisingly easy given that it was my first time there. In the planning in Adelaide I had read that my hotel was adjacent to the bridge itself but it wasn't until I walked under the bridge (from the Opera house side) and out the other side that I saw how close it was. Teeing off from my second storey window with a golf ball and driver I could have hit the bridge easily. I unpacked my things and walked down George St. Here I have to clear up some misunderstandings between Adelaidians and Sydneysiders. Firstly, prices are not higher in Sydney – I used Woolworths on George St. Secondly, Sydneysiders are very friendly – I had to get directions several times and I always received it. And thirdly it is very clean. In fact it looks like a frame from 'An Affair to Remember' – the many grey shades in the landscape actually give it strength. The only problems were the lack of churches and the over-liveliness of the city – I'm just joking.

After a big night out it was Friday morning 11 am and Walter Giardini was on the phone. "Are you coming today?" Yes, I had not gone through two months of anticipation to miss out through over-sleeping. I hailed a cab and instructed the driver to head for Lindfield. One thing I have to mention. I have heard Sydney cabdrivers cannot be trusted. I had looked up the route beforehand just in case I was carried on a Brownian journey through the grey jungle. But this driver was very friendly and the meter rate was comparable with Adelaide. Upon driving through the leafy gates of NMI Lindfield I passed the high voltage lab on the right, the theodolite calibration posts on the left and finally arrived at the entrance. The building's architecture instantly reminded me of my 1970s style high school, Adelaide High, being solely made of yellow bricks. I hadn't slept much the night before but I was full of expectation as I opened the door. I walked up to the reception and asked for Walter. I was halfway to getting a cup of water and in bounded Walter. "Good to see you Ben, come through to the canteen and meet the staff". I had made it. Here I was inside the custom-built, environmentally buffered, gold-plated EMF protected NMI – CSIRO lab with the hospitable Walter Giardini. I eagerly followed him into the canteen. I have to mention something about the inside the building. The architects designed NMI with environmental control in mind. Obviously this is vital with high-precision science as fluctuating temperature and humidity levels are undesirable. To ensure a stable lab environment the entire building contains passageways which share a wall with the outside world. The laboratories are cocooned inside these passageways. Walter and I walked down one of these passages and entered the canteen. There I met Barry Inglis and Stephen Quigg whom I had met from the conference. I began to feel more at ease having seen two familiar faces. Walter explained that we would be interviewing many scientists throughout the day and so time was all-important. We left the cafeteria and ran to meet the first. Asa Jamting of the nanometrology group – actually she is the only scientist currently working in this area so an accurate description would be she *is* the group. Nanotechnology is quite often mentioned in articles related to nano-actuators or nano-medical devices. But I was interested to find out why the measurement of objects less than 100 nm was important. Asa explained how nanoparticle technology is important to industry. Nanoparticles? These are particles which are used for products in the cosmetic and paint industry. Manufacturers cannot inexpensively measure the size and shape of these particles and so for the growing nano-particle industry this work is vital. On the equipment side Asa explained that she collaborates with Australian Universities who possess a SEM microscope as the group does not currently own one. The instrument she uses day-to-day measures the size of particles by deflecting laser light

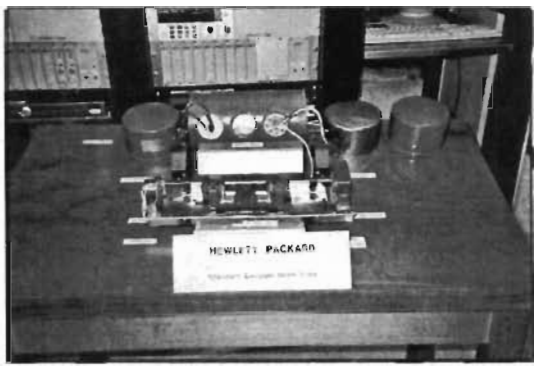
from them. Nanoparticles are placed into a liquid medium in a glass vial. This vial is then placed into the instrument. Once the lid is closed laser light passes through the liquid, scattering from its path when it encounters a nanoparticle. Photodetectors surrounding the vial pick up the light signal and calculate properties of the nanoparticles. We thanked Asa and went on to one of Walter's passions, the Coordinate Measuring Machine (CMM). This machine is at its most basic the same as an industrial CMM in that it measures the three-dimensional characteristic of an object. However, the science involved in measuring to an accuracy of 200 nanometres is vastly more advanced. A laser had been added (bottom middle of photo) to the setup when we visited the lab. This is used to better calibrate the machine.



CMM Machine

Next is was upstairs to meet Stephen Quigg and Malcolm Lawn who were running a time comparison between NMI's atomic clock and the University of Western Australia's atomic clock. This was very exciting as they had to ring up the satellite service provider and organise the uplink. After this excitement we calmed down and Stephen and Malcolm explained the technology behind atomic clocks. Long term the most accurate clocks still (although modified) follow the old Caesium clock technology. In this setup a quartz crystal's oscillations are controlled using the quantum spin-flips of Caesium atoms. These spin-flips are interrogated using a high-precision RF wave fed through a waveguide. Research to improve atomic clocks is an active area, including a current proposal to fly a new Caesium clock design on board a satellite in 2011. A near-zero gravity field improves the accuracy of the clock.

By now it was past one o'clock and I was feeling quite hungry. Fortuitously Walter stepped through the door and we raced off to lunch. Over a lunch



Caesium Atomic Clock

of hot chips I talked politics and had an interesting conversation with Stephen and NMI's patents expert concerning Henry Ford. After the quick lunch it was on to meet the person I had most been looking forward to talking to which was Ilya. He is an electrical engineer specialising in AC and DC standards. Firstly he showed me the most theoretically simple work, the AC–DC transfer measurement devices. These resemble large glass M&Ms with four wires protruding from their sides. Using two wires an AC signal is passed into the capsule. The remaining wires (which are joined inside the capsule to the AC signal wires) form a thermocouple by which temperature measurements are made. This forms an ingenious method for AC measurement because rather than trying to measure a rapidly changing AC voltage and current characteristic we can measure the heat generated in a resistor via a thermocouple attached to the resistor. The resistor is acting as an integrator of the power passing through it. Next it was upstairs to look at the Australian work on the determination an absolute standard for AC voltage. So far an absolute standard for the DC volt has been determined by using a quantum standard – the Josephson junction. A high precision clock signal from the time and frequency division (where Stephen and Malcolm work) is fed into the DC voltage lab and the Josephson junction acting as a frequency to voltage converter produces a voltage standard. Ilya explained that NMI is working to extend this method to develop an absolute AC voltage standard. Then it was time to meet Brian – which is where this article began – to discuss the calculable capacitor. Ilya, Brian and myself were all looking at a poster in the lab that was very interesting. It showed two NMI scientists, Malcolm McGregor and Hugh Bainsfather, at work with the calculable capacitor. The reason why one of the two is peering into what appears be a microscope is to calibrate the capacitance value. The movement of the central guard rod (which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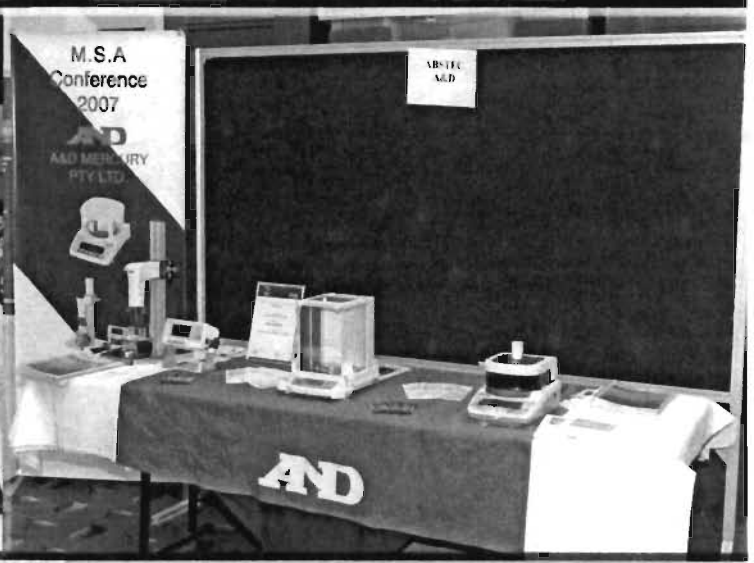
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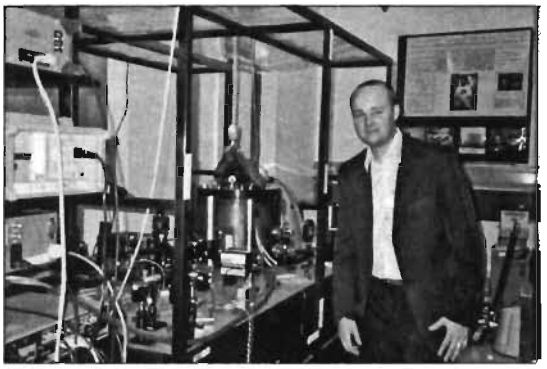
determines the capacitance value) is monitored using laser light.

Calculable Capacitor

After spending a pleasant time with Brian it was on to the high voltage lab. This is a huge separate building with a twenty metre ceiling. Calibration services for electricity suppliers are carried out here. Looking at the massive insulating rings it really did look like something out of a Frankenstein movie. Dangerous but very exciting.

Impulse Generator inside the HV Lab

After the excitement of seeing the HV test equipment it was on to what most people would recognise as the forefront of metrology – the redefinition of the Australian kilogram. As with all physical quantities the aim is to obtain an absolute standard – to find a definition which will not change with time because it is related to a changing quantity (a relative standard). What makes this project interesting is that it relies on very accurately determining the number atoms of a specific isotope of Si in one kilogram (hence the name Avogadro project). What it is attempting is reminiscent of Archimedes determining the value of pi by narrowing its upper and lower limits. Nearest to me in the photo below you can see the chamber used to hold the silicon sphere. Temperature-controlled water is circulating in the walls of the vacuum-sealed container.



Avogadro Project

Next it was on to see Mark Ballico, the resident expert on temperature probes. He explained how melting points for various metals are used for temperature calibration. It may seem old-fashioned to use such a method but it is highly repeatable. I was very impressed with the setup he had to calibrate infra-red temperature sensors.

The final metrologist interview for the day was with Kitty Fen. By this time I was very tired but I was not disappointed with what I discovered. Kitty explained to Walter and myself how smaller and larger weights are determined from the standard kilogram. It is much like the movie Die Hard where Bruce Willis must follow an algorithm to determine an exact weight using only two known weights.

I jumped (or rather slumped) into the back of the taxi and waved goodbye to NMI Lindfield. It had been an exciting night and day in Sydney and now it was time to reconnect with Adelaide – my home town.

from page 6

And the discussion on mysticism does provide some interesting stories as well as being a good study of quirks of human belief systems.

The book relates how the ancient Greeks were preoccupied with measurement in terms of its relationship with particular values and their ratios. They believed for example that the numbers 6 and 10 (and sometimes 16), had magical significance. They were fascinated to observe that the length of a man's foot was one sixth of his height, and saw many other ratios that they believed specified perfect human proportions. Incidentally they also believed that the circle and square were perfect shapes, and this is the reason behind that famous diagram by Leonardo da Vinci of an outstretched man circumscribed by a circle and a square.

In the system of rule by royalty that followed later in Europe the King dictated what measurements should be used in his domain. The King was seen as not just appointed by God, but was himself divine, so his measurement units were also. The book relates how part of the impetus for the French revolutionaries to establish new units derived from nature was to refute the connection between units and royalty, and to some extent the established church.

One thing that comes out in the book is the number of attempts, of varying success, to establish uniform units of weights and measures. Even kings, for all of their divine backing, had limited success at best. There were frequent agitations from many influential quarters, particularly in France where things were more chaotic than should have been acceptable. For example in 1790 The French Royal Society of Agriculture made a complaint to the National Assembly that across France "the measures differ although they are designated by the same name; that these differences are very considerable, not only from one province to another, but in the same city, the same borough, the same village." It is estimated that there were as many as 800 to 900 customary units of measure in use in France in the 18th century. In the north of the country there were 18 kinds of *aune* varying in length from 0.620 m to 0.845 m.

Although diversity of units in France was a vital factor in the acceptance of the metric system there, it was clearly not a sufficient precondition. I certainly had the impression from my earlier readings that while the French were in chaos, the more rational British and the US had no difficulties. Not so. I found that a report to House of Lords in 1823 stated that over the years 200 attempts at unification resulted in 500 different units being introduced. In the early days of independence the US set up units based on the English ones, but by the end of the eighteenth century things had gone astray. The problem was that there were ten different systems in Britain, plus some separate Irish and Scottish units. In the US they initially chose one set of these, but over time they got to a state where "there were 25 units of length: three had same length but different names, the remainder had different names and values that were unrelated to one another." In spite of this the arguments ebbed and flowed about the appropriate replacement. There were strong proponents of the metric system, but even these wavered and changed their minds. And as so often happens the conclusion was to do the minimum, which meant that they just continued with the British Imperial system.

One topic I found fascinating was the amount of support there was for the main competitor for the size of the earth as a definition of the basic unit of length, the Seconds Pendulum. This device defined the unit as the length of a pendulum that had a period of exactly one second. There were many twists and turns to the debate, too many to relate here, so you will have to read it up for yourself for details. One comment I will make however is that an objection to the pendulum was that the division of a day into seconds was not a nice round number, a concern that harked back to the attitude of the ancient Greeks towards numbers. I wonder what the objectors would think of the scrambled number in current definition of the metre in terms of the velocity of light.

Another bit that grabbed me was about the people who believe still that the Imperial system of measurements was ordained by God, along with those who believe that the Egyptian pyramids have magical dimensions. I was amused to find at the end of the book that the author seemed to have a distinct sympathy for some these bizarre beliefs, and the book seems to be in part an effort to promote them. When I realized this I found a strange satisfaction, because up to that point I was wondering what the real point of the book was. And it fed my interest in trying to understand the thinking of people with mystical beliefs, particularly when they seem to be intelligent and otherwise rational.

So is this a book that I would recommend? Well, I would recommend reading it if you have an interest in history, or human behaviour (which are arguably the same topic). There were some bits about architecture and art that I intend to re-read because I did not understand them first time around, and I think they might be good when I can read the waffle without falling asleep. You will not learn much about taking measurements, but if you can manage to borrow it from somewhere it will provide some cheap amusement and a bit of education. If you are seriously interested in the history of measurement, then buy a copy to keep. Otherwise see if you can borrow one from a library.

Smoot's Ear, the Measure of Humanity, by Robert Tavernor, Yale University Press, New Haven and London.
ISBN 978-0-300-12492-7

Feedback from School at the Conference

Feedback from Anita Trenwith (High school science and electronics teacher and year level manager year 11, Salisbury North High School)

This was a fantastic opportunity for the students involved to be exposed to cutting edge information and technology in an environment aimed at adult participants. The content of the presentations though at times well above the students level of understanding was well delivered and the format of the day kept the students and adult participants engaged. The students will also benefit in the future from the content they have been exposed to in the presentations when they cover the related topics in their future study at high school or university.

The environment was completely different to anything the students had experienced before and this in itself was also a learning opportunity for them. For two of the students hoping to get into the National Youth Science Forum in Canberra in 2008 it gave them an insight into the adult learning environment as well as knowledge that they will find useful in their application process.

The conference certainly had a positive impact on the students. They have continued to talk about the content from the presentations and their experiences at the venue in a positive and enthusiastic way with not only their peers but with their various subject teachers. They have especially delighted in discussing their newly discovered complicated mathematical equations with their maths and physics teachers.

I have also taken on content from many of the presentations and will be implementing that within the science curriculum and year 11 chemistry course. I have also gained a number of contacts for people to come and talk to students back at school as well as contacts for resources through the NMI.

Thank you for providing the opportunity for myself and the students to be involved.

Feedback from Matt McFadyen (Year 11 student)

My favourite presentation was J.R Miles presentation on the Chinese Remainder Theorem and Gauge Block Interferometry. It was my favourite because it involved maths that I could understand and it was extremely interesting to learn that Chinese mathematicians from the Han Dynasty could create a Theorem that can actually be adapted for modern day use.

Another favourite would be the trip to Torrens Island Power Station. We were exposed to a different part of the Power Station then we would normally see as students. We were in a different environment and we also learnt quite a few of the stations secrets.

Another great presentation in my opinion was Benjamin Parkins (Student paper winner 2007) Introduction to Photogrammetry and although I could not understand it all it was interesting to me and I thoroughly enjoyed it.

During the two days I learnt quite a few things such as what Avogadro's Constant is and it's applications, the Chinese Remainder Theorem, what a thermocouple is and quite a few other things.

This has been a great experience for Ben, Tristan and I. I would recommend it to other students who are given the opportunity. But I would only recommend students that are planning a career in a similar field or are doing a physics, maths, chemistry combination otherwise they will not get as much out of it as they possibly could.

I would recommend that a few students are invited to the MSA meetings from now on but I would suggest that a maximum of 3 students at a time because it is an adult environment and if too many students are invited they might not see it as a privilege to attend.

But all in all, I would like to say that it was an

inspiring experience and I really have gained a lot from it.

Feedback from Ben Nitschke (Year 11 student)

My three favourite presentations were

-Physical and Documentary Standards for Nanometrology

-Torrens Island Power Station

-Chinese leftovers, Number Theory and Gauge Block Interferometry

I learnt about how nanotechnology will impact us and be used a lot in science in the coming years. I enjoyed the Chinese Remainder Theorem, it was easy for me to grasp and it was very well presented. The trip to Torrens Island was great because we were in an adult environment and we were exposed to more than what students would be, so this was great.

If the MSA are thinking about inviting students in the future maybe they could email teachers and the students in advance so they would have more information about what the conference will be like. Also there could be one seminar on the two days where it could be especially for students.

I would recommend this to other students as it is a great opportunity to learn new things and be involved with adults.

Overall it was a great experience and thank you for inviting me.

Congratulations to Benjamin Parkin on winning the MSA 2007 Student Paper.

Here we see Benjamin Parkin receiving the award from Dr Jane Warne, President of the MSA, and Dr Barry Inglis of NMI.

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BOOK REVIEW

Jeffrey Tapping

The Mismeasure of Man, by Stephen Jay Gould

This is a rather unusual review because it discusses a book first published in 1981. My reason for reaching into literary history is that for me this is one of my favourites and I believe it should be read by every person taking serious measurements. Regular readers may recall that I referred to it in a discussion of intelligence quotient (IQ) in one of my Quantification articles. Since then I have been nagged with the thought that I should be conveying to you all more about the book. This review also enables me to sound off about one of my favourite topics, the fallibility of the measurement process, or perhaps more accurately, the fallibility of the people who make and interpret measurements.

My journey to this point began, I think, many years ago when I was a relatively junior experimental scientist at the National Measurement Laboratory. We had built a new high-precision measuring instrument and to test it I measured what was considered to be a well-established quantity because a number of eminent metrologists had recently measured it and they agreed quite well. To the dismay of me and my supervisor the uncertainty range of my value did not cover the accepted value. So I went back and checked everything but our value did not change. I was confident of my work, but my supervisor insisted that we must be wrong and we must find the error before we published. I kept working to try find the elusive problem, and in due course a very eminent person, one of those who had made an earlier measurement, came from the other side of the world to discuss where we might be going wrong. But still we disagreed. After two years an important conference loomed so we published our value there. Over the next few years I watched as old values were recalculated, and new measurements made and the accepted value gradually moved to correspond with ours! There were no admissions of error, no credit extended to us for being right, and somehow this has continued to annoy me. I have to keep reminding myself that this is how the world is, and this experience was actually a valuable demonstration of the fact that measurements are not objective, but are carried out by people with all of the failings of human nature. And if I find myself getting a bit pious about it, I think of what I would have done if in fact I had found some correction that brought me into line with the others. Wouldn't I have just stopped looking and published the incorrect answer?

Stephen Jay Gould's book is also about measurement and human nature, but in his case about the measurement by humans of human nature. It covers the long history of what he calls "biological determinism", the idea that the capability of each of us is set by our biology (particularly our gender, race and social class). But it is not a history lesson, rather he uses this topic as a vehicle to make a fundamental point, which he explained in the introduction:

"Even so, I do not intend to contrast evil determinists who stray from the path of scientific objectivity with enlightened antideterminists who approach data with an open mind and therefore see truth. Rather, I criticize the myth that science itself is an objective enterprise, done properly only when scientists can shuck the constraints of their culture and view the world as it really is. .... My message is not that biological determinists were bad scientists or even that they were always wrong. Rather, I believe that science must be understood as a social phenomenon, a gutsy, human enterprise, not the work of robots programmed to collect pure information."

You can now see how my views and those of Gould coincide.

So what is the book about? The main topics are titled "Measuring Heads", "Measuring Bodies", "The Hereditarian Theory of IQ", and "The Real Error of Cyril Burt".

The first of these topics is a fascinating story about a science of the nineteenth century called

Craniometry, that began with the hypothesis that intelligence is directly correlated to brain size. To the proponents it seemed almost self-evident: the (nutritionally deprived) poor had smaller overall body size and obviously were duller than the upper class, women had smaller heads than men, and clearly were less intelligent. It just remained to establish by measurements the obvious hierarchy covering the classes, genders and races. For me the most interesting and amusing part of this story is how the scientists dealt with results that conflicted with their hypothesis (and of course their prejudices). In many cases in the book Gould has gone back to recalculate results and has revealed how the apparent outcome of research has been distorted by the way in which the data have been presented. My favourite is the tale of a man who was measuring the relative sizes of frontal lobes to other lobes of brains, because it was known that the higher level brain functions occur in our frontal lobe. When he found that so-called primitive natives had larger frontal lobes than Europeans, he justified this on the basis that the frontal lobe contains the scent processing function, and primitive people rely heavily on their sense of smell, so the larger frontal lobe must be due to a much larger scent detection mechanism. In another case the results were explained as an indication that blacks had lost total brain capacity and had just lost more from the back than the front. In some, inconvenient data were left out of tables without explanation.

"Measuring Bodies" refers to two sub-topics, the first on efforts to show that black people had head-shapes more closely related to apes than to Caucasians, implying that they are in fact a different species; the second the hypothesis that criminals are born that way and have physical characteristics indicating their nature. Demonstrating that blacks are a different species had important implications for the use of slavery, so it was more than just an academic subject. The idea that criminals have distinctive features was important because it was advocated that people with these features should be imprisoned in anticipation of their inevitable criminal behaviour.

The hereditarian theory of IQ was discussed in my Quantification article in an earlier issues, and so I will expand on it only briefly here. Intelligence Quotient was developed by Alfred Binet in France as a means of identifying children who needed extra assistance at school, and was only later extended as a measure of innate capability of people in general, much to the distress of Binet who recognised that it was not really valid in this role. The book describes how IQ measurements have been used to discriminate unfairly against various groups.

Cyril Burt was an extremely well-respected and influential academic in England in the mid-twentieth century, who published extensively on the inherited component of IQ, particularly using twin studies. It was not until after his death in 1971 that it was found that researchers named as co-authors in his papers did not exist, and much of his data were fraudulent. This section of the book is relatively heavy going, but if you want to learn a bit more about correlation and the statistical process called factor analysis that is used to produce things like outcomes of medical trials, then it is worth the effort to persist.

So what can we learn from this book? I think an important lesson arises from the fact that scientific measurements are used politically and so can affect our society and wellbeing in fundamental ways, and we should recognise it in our own society today. While we should not ignore what appears to be overwhelming evidence on a particular issue we should never totally dismiss the dissidents. They might be right after all.

A second lesson is that the human fallibilities described apply to the work of calibration as much as it does to science. We may try our hardest to be honest and accurate in our work but that does not mean we necessarily succeed.

Finally, the failings in the scientists who produced flawed conclusions of the sort described by Gould are certainly universal in humans, and are within us all today, ready to break out in a new form like an evolved bird flu. We should be on our guard.