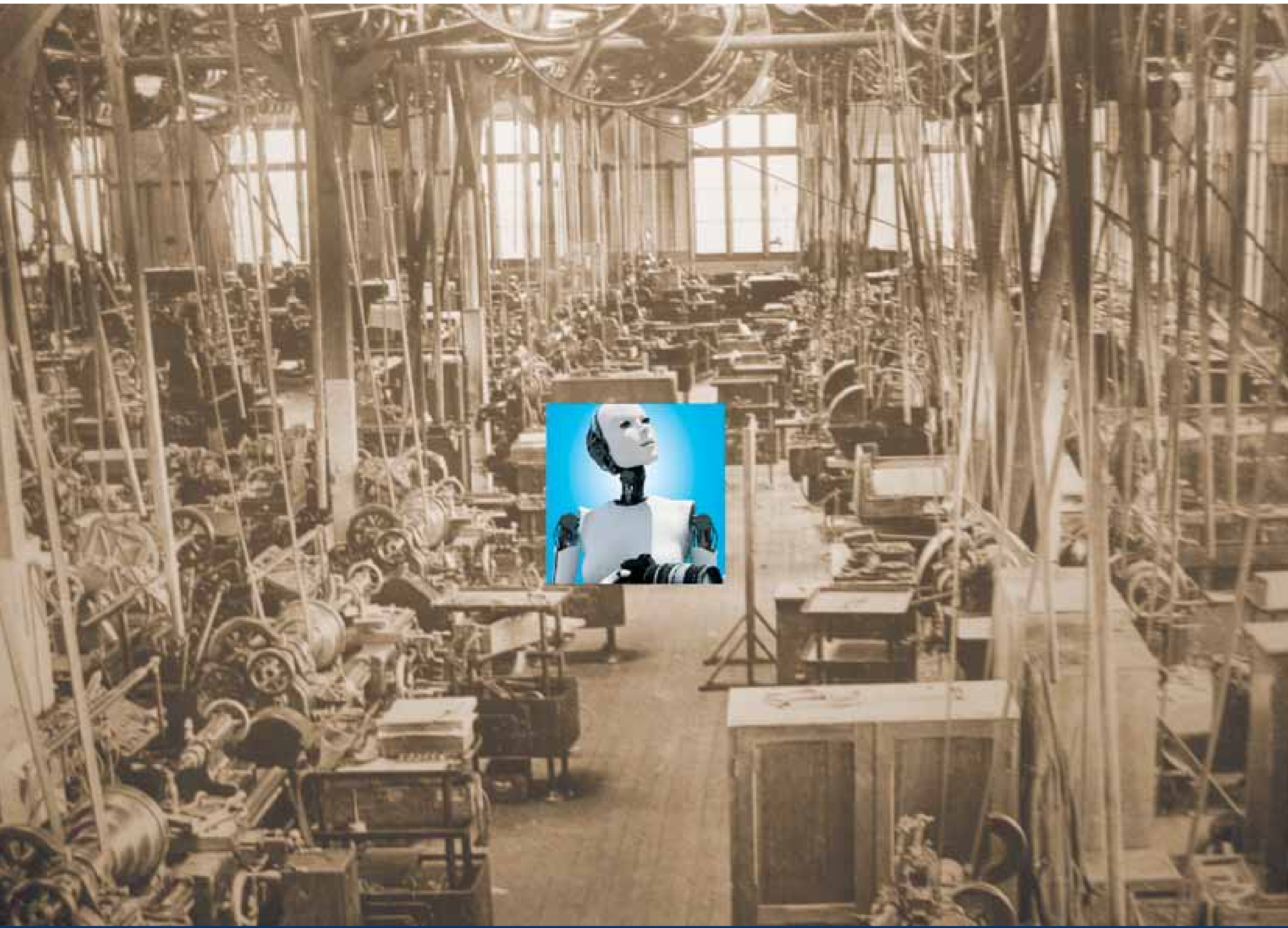
No 46 May 2011

The Australian Metrologist

The official journal of the Metrology Society of Australia



Front cover image Archival photo from Lithgow Small Arms Factory Museum and robot image from http://www.dynamicexport.com.au/export/growing/advanced-manufacturing-australia/

See page 19 for further information about the Lithgow Small Arms Factory and Museum.

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***The Australian Metrologist* is the journal of the Metrology Society of Australia, an association representing the interests of metrologists of all disciplines throughout Australia.**

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Contents

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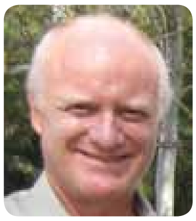
Editorial



WALTER GIARDINI

Several items this month from our members on technology (a potted history of optic fibre technologies) and remotely controlled planes for weather sensing, metrology work being done by Australians around the world, consultancy/project programs for graduates in industry, proposals to think hard about who metrologists are and what they do (see our President's column), reviews of great books on the development of measurement science, developing our MSA members' database, free thermocouple calculator software from member Jeff Tapping, and more ... see for yourself. I hope you enjoy this issue's reading. A big thank you to our members and the editorial team who contributed articles. Last month I visited the offices of our publisher (Cambridge Media) in Perth and met again with Greg Paul and the Cambridge team to talk about how to make *TAM* the best journal we can. I got lots of good ideas to discuss with the editorial team. In the meantime, remember this is your journal. If you have something to say, let your fellow members know. The copy deadline for the next issue of *TAM* (#47) is 17 August 2011, which will be mailed out to members on 19 September. To submit an item, just go to www.cambridgemedia.com.au, click on publishing, then go to manuscript system, create an account (a name and a password) and you are ready to go! Articles, pictures, letters to the editor ... we are waiting!

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The Australian Metrologist *welcomes authors to submit all articles, whether a letter to the editor, conference report or an original article to be peer reviewed, via our web-based Manuscript Management System.*

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- Go to either the publisher's website, www.cambridgemedia.com.au, or to *The Australian Metrologist* (TAM) section of the MSA website.
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Peer review

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President's column

DANIEL BURKE

Why do most people in the scientific and regulatory communities glaze over when metrology is mentioned and quickly change the topic? This is a serious question for us and is most likely very complex to answer. When I explain the concepts of traceability and fit-for-purpose accuracy to non-technical people, I am always surprised at how important they seem to accept that our work is. They usually very quickly see the practical outcome of our work, whether it be international trade, manufacturing or trade measurement.

Then if our work is so crucial, why is there such gross ignorance of metrology? Could this be a public relations failure or does it go deeper?

I think the truth is a little complex. I think the public is telling us that they don't want to know about metrology, but we keep trying to 'educate' them. Metrology is complex and it's all relative, there are no simple rights and wrongs – it's all in the definitions. The normal way of dealing with complex issues in our community is by relegating the complexity to an elite group of experts, for example, lawyers or engineers, who regulate themselves through professional associations.

The professional association for metrology in Australia is the MSA, it's us. Apart from membership rules, we don't really have any system of regulation about the quality of metrologists or their work. It is not easy for anyone to assess whether the measurements they are performing are fit-for-purpose or whether the metrologist who is advising them has adequate credentials. The regulatory system for metrology needs improvement.

The improvement may come through professional recognition as a Chartered Metrologist. I understand the idea has been investigated by previous MSA administrations so I would like to outline briefly the chartering system I am proposing.

A Chartered Metrologist will have been evaluated by a panel of senior, experienced professionals in the field as possessing the qualifications, experience and capacity to review measuring systems referred to them as satisfying the standards of traceability and uncertainty needed for their application. The system of evaluation, including written standards, methods of assessment, composition of expert panels and costs needs to be developed and we are engaging the services of an expert in metrology training and education, Ian Bentley, to provide models of how we might implement such systems.

I hope by developing this easily understandable system for ensuring the quality of metrologists our professional standing in the community generally will be improved and that it will be easier for any individual or organisation to examine their measuring systems simply by engaging a Chartered Metrologist.

Daniel

2011 subscriptions and database – new system

This year we are developing a new system allowing members to update their own contact information on the MSA website. It will also be possible to subscribe to MSA publications as well as joining MSA interest groups. We are hopeful the changes will improve the integrity of the membership database and improve our communication systems.

Through this system invoices for annual subscriptions will be payable online using a Paypal account or credit card. It will still be possible to use less preferred payment methods. Members without email addresses or incorrect email addresses, will receive an invoice by mail. Efficiency in our administration system is important when collecting a relatively small payment and members are encouraged to use the web payment system and email communication if possible.

As the system is implemented in the next few weeks you may expect to receive an email indicating that you have been added to the online database and asking you to choose a password for access. Another email will be sent indicating the subscription invoice is ready for payment.

Letters to the editor

I understand that the MSA is investigating the possibility of Chartered Metrology qualifications, a move that I support in principle. While this is still in the early discussion stages, I would like to offer the following comments.

There are people like myself who are not university-trained, have a trade background and many years of experience in various industries. We are at the coalface of industry, carrying out calibration and verification of instrumentation on-site, and so on. I was recently asked for my qualifications and the customer was more than pleased with my foundation membership status of the MSA.

I would like to see a category of a licensed calibrator/adjuster for use in industry and trade use, similar to a licensed plumber/electrician. A Chartered Metrologist sound great, but we need to fill in the details about where it would fit into the metrology system. How would it relate to NATA? What would be the costs?

As a long-standing member of the MSA and a winner of the Metrology award, I have felt for some time that the MSA may be running the risk of focusing too much on the 'high end' of metrology, such as the research, state-of-the-art developments and laboratory environments, and not enough on industry. For the MSA, catering to the needs of its very diverse membership base was always going to be a tough job, but as the Society now evolves further into the future, it is very important that the right balance be struck, and in my view that any new 'Chartered Metrologist' category it may develop be used to support the practice and delivery of metrology across the entire spectrum of metrology activities, but particularly in the delivery of metrology products and services to industry and end-users.

Kindest regards,
Len Kerwood

Thermocouple calculator

Many 'Free gifts' in fact come at some kind of price, but here is an offer that is genuinely free. I have written a comprehensive thermocouple calculation program for the Windows operating systems which I will email or post to MSA members upon request. It was written using Visual Basic Version 5 for 32 bit systems, but will work under 64 bit systems if a particular DLL file found in the 32 bit systems is added.

The program calculates temperatures using the full ISO equations, not the approximate polynomials. It has a number of options within it that can be preserved from one session to the next (for example, thermocouple type and resolution). It has the capacity to export results so they can be inserted into other programs such as word processors or spreadsheets. There is introductory information and detailed help within the program. I have carried out extensive verification and will supply records of this if desired. And it is freeware, so you can use it however you like without restriction.

If you would like to have a copy, or have any questions, send me an email. If you want it emailed you must have a service that accepts an .exe file or zip file as an attachment.

Jeffrey Tapping
jeffrey.tapping@gmail.com

MSA members around Australia

ROBERT CRAWFORD
Les Cooke Instruments Co Pty Ltd

MSA member Robert Crawford of Les Cooke Instruments is based in Perth, and occasionally travels to the eastern states for business. He reports below on his recent visit to the NMI laboratory in Lindfield (Sydney). Being a member of the MSA means you have colleagues all around Australia, so if you are travelling for any reason, consider the opportunity to catch up with other members.

Finding myself planning a business trip to Sydney with a few hours spare in my schedule, I thought I'd see if NMI was open to a visit from an interested metrologist. A few emails later, I had finalised a time for the visit. The staff were very accommodating and my tour through the pressure labs with Dr John Man to the temperature calibration facilities with Dr Ferdouse Jahan and electrical calibration with Louis Marais were particularly engaging and informative. While I always knew that NMI was the organisation charged with keeping Australia's standards of measurement, my visit really helped me to understand so much more about the specifics of how they are developed and maintained and especially how they come to be transferred to my level in the industry

For those who haven't been there I would recommend you put it on your to-do list. Keep in mind that NMI in Melbourne has facilities in different fields of measurement and is probably also worth seeing. Get in touch with the business development and customer services person to make arrangements before you go and they will help you to catch up with your particular area(s) of interest.

In the pressure lab, a Bell + Howell absolute pressure deadweight tester. It has a specially made manual mechanism (the aluminium assembly on the top) that allows masses to be lifted individually from the pneumatic piston without breaking the vacuum in the glass chamber.

Postgrads looking for industry internships

TOM MONTAGUE
AMSI – Industry Internship Program

Just over the three years ago the Australian Mathematical Sciences Institute (AMSI) launched its industry internship program to promote links between university maths and stats departments and end-users in business, industry and government.

Since then, and much to our pleasure, we've placed more than 30 interns at all sorts of businesses from Ceramic Fuel Cells Ltd, a business that makes the BlueGen fuel cell, to Marshall Day Acoustics, a business that helps design concert halls for those with discerning ears.

Despite the claims in the media that there is a shortage of people with analytical skills, we still have more people wanting an internship than businesses to host them. It was for this reason, I thought it was high time I wrote a short note for *The Australian Metrologist* to draw members' attention to our industry internship program.

So how does our internship program work or, more importantly, why would your business want to participate and, because there is no such thing as a free lunch, how much does it cost?

Our internships are project-based and seek to address a problem identified by an industry partner over a 4- or 5-month period. Early on we mainly focus on placing maths and stats students but these days we offer placements to postgraduates (master and PhD students) from pretty much all the technical disciplines (science, engineering, IT, business and finance). Each intern comes with an academic mentor to ensure scientific rigour and keep an eye on progress so our industry partners get a two-for-one deal.

Before signing up and starting, the industry partner, the intern and the academic mentor scope the problem, to ensure it's a sensible question for the intern to be working on and develop clear milestones and deliverables. With this and the paperwork out of the way, the intern can start the placement. Interns generally spend half of their time on-site with the industry partner and the other half at the university working on the problem. It is possible to vary this by mutual consent.

Why take on an intern? Businesses usually host an intern when they are keen to solve a problem and don't have the in-house expertise to solve it nor the time and resources to spend finding someone who just might. Businesses sometimes use the internship as a way of finding and trying out new talent or as a first step in building a strategic alliance with a university. As you might expect there is a cost but at $3,000/month for some highly skilled talent and an academic mentor it's less than half the cost of recruiting and employing someone on a salary and you get the mentor for free.

Having piqued your interest, the only question that remains to be answered is how to apply. To get the ball rolling, just visit our website: www.amsi.org.au/index.php/industry/internship/apply and we'll send you a two-page expression of interest. Names are on the first page and a project/problem description on the second. Otherwise, call me on (03) 8344 1778. We're keen to help introduce some bright young minds to metrology or indeed any organisation that needs and uses high-end technical expertise.

Left to right: Dr Tom Montague (AMSI), Dr Laura Villanova (Intern), Prof Kate Smith-Miles (Monash University), BlueGen fuel cell, Dr Michael Kah (Ceramic Fuel Cells Ltd) and John Rajoo (Ceramic Fuel Cells Ltd).

The truncation problem

RR COOK
Metrology Training International

Abstract
The ISO GUM (Guide to the expression of uncertainty in measurement) recommends a particular process for dealing with digital displays. This is sound provided that the measuring instrument rounds the measured value, either up or down as per the established rules. Many instruments truncate the reading and this gives rise to a different problem. This article makes a suggestion for dealing with that issue, whilst still remaining GUM-compliant.

Introduction
The ISO GUM (Guide to the expression of uncertainty in measurement) recommendation for dealing with the resolution of digital displays is to take the uncertainty as having a semi-range of half a digit and to assign a rectangular distribution. This simple process is adequate providing the measuring instrument measures to one more digit than is displayed and rounds up or down according to the established rules. Some digital meters do this. Usually the extra digit can be found by interrogating the instrument over its digital interface. But some instruments truncate the reading. This is the case for speed measuring instruments used for road traffic speed infringement detection.

As the rounding or truncating instruments operate differently a different interpretation of the resolution is required.

What does your instrument do?
An experiment can be performed to see if the instrument rounds or truncates the readings. A good-quality calibrator or similar reference can be used to increment the applied voltage (or whatever parameter is appropriate) and a recording of the instrument readings versus reference input compiled. If the result is a good approximation to proper rounding then the basic GUM recommendations can continue to be used. Truncation should also be easily detected, but the procedure for uncertainty estimation for this is less clear.

The truncating instrument
What happens if the instrument truncates the readings? A simple thought experiment can be carried out to get some guidance. Imagine we have an instrument with a 2-digit display with a full-scale reading of 19 units. Then imagine applying a million readings randomly distributed between say 1.000 0 units and 1.999 9 units and recording the readings. As the instrument truncates it will show ‘1’ for every reading. The instrument will not show ‘2’ until the input reaches or perhaps exceeds 2 by at least a ‘smidgeon’ (undocumented VIM definition of a very small amount).

Now as every one of these inputs fall randomly with equal probability between 1.000 0 and 1.999 9, the instrument has an average applied value of close to 1.5. Yet it shows only 1.0 for all values. Thus there is a bias of 0.5 units or half a digit.

Table 1 shows the differences in reading for an average reading meter and a truncating meter with a 1-unit display.

Input	Rounding meter	Truncating meter
0.90	1	0
1.00	1	1
1.10	1	1
1.20	1	1
1.30	1	1
1.40	1	1
1.50	1	1
1.51	2	1
1.6	2	1
1.7	2	1
1.8	2	1
1.9	2	1
2.0	2	2
2.1	2	2

Table 1. Comparison of readings of rounding and truncating instruments. It is assumed that the instrument has a 1-unit resolution. It is also assumed that for rounding up to occur the reading must just exceed 0.5.

A revised uncertainty analysis
Most laboratories and NATA assessors usually ignore the truncation issue either because the GUM does not specifically address it or because it had been standard practice in particular fields to ignore the effect. The author thinks it is time to at least discuss the issue amongst MSA members.

What are the options?
For truncating instruments we can still use the basic GUM recommendations but have four options.

Firstly, we could do nothing. That is ignore the truncation and calculate and report the uncertainty as if the instrument rounded instead of truncated. This is to the advantage of the defendant in speed infringement cases.

Or we could report the uncertainty as before and apply a half-unit correction to all measured values. Most laboratories would not feel comfortable with this approach although it is defendable.

The third option, which the author favours, is to report the measured value but make the uncertainty asymmetric. A simple method is described below.

Suppose for the above instrument the expanded uncertainty excluding the display resolution is ±1 unit. The uncertainty associated with truncation has a range of 1 unit or a standard uncertainty of 0.5/√(3) or 0.289 units, say 0.3 units. Combining these by the RSS method and using a coverage factor of 2 gives an uncertainty of ± 1.2 units. The uncertainty would then be modified by a 0.5 unit offset to give an asymmetric result, namely (–0.9, +1.7) units.

This approach is easy, requires no change to current calculation procedures and, as indicated below, is essentially the same result as obtained from a more sophisticated approach.

Fourthly, a Monte Carlo simulation following the guidelines in Supplement 1 of the GUM can be run. It will yield an asymmetric uncertainty if the model includes truncation. The results for the above example agree well with those obtained by the simplified method. That is the simple offset method is GUM-compliant.

It should be noted that one of the justifications for publishing the GUM Supplement 1 was to deal with such problems. However, it requires specialised software or the ability to write suitable macros for Excel. The offset method requires no new software.

Conclusion

The issue of truncated measurements cannot be ignored indefinitely. A resolution of the matter is better done now than later. A simple but adequate solution is to apply a 0.5-digit adjustment to give an asymmetric uncertainty. While real instruments may show small deviations from the assumed operation the differences are likely to be insignificant. Members are invited to comment.

Bibliography

1. ISO/IEC Guide 98-3:2008 Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement.
2. ISO/IEC Guide 98-3:2008/Suppl 1:2008 Propagation of distributions using a Monte Carlo method.

Use of the Aerosonde unmanned aircraft system in support of atmospheric and sea ice research in the Antarctic

Nick Logan from Aerosonde Pty Ltd has been talking with MSA Victorian State Coordinator Neville Owen about giving a talk in June to Victorian (and visiting interstate) members, about his company's work with unmanned aircraft systems. The synopsis below, from Daniel Fowler of Aerosonde (USA), gives a taste of what's to be presented. Please also see the notice of meeting under the Victorian News section of this issue.

In August 2009, a four-person operations team from Aerosonde Pty Ltd in Melbourne, Australia, together with Principal Investigator Dr John Cassano and Co-Principal Investigator Dr James Maslanik from the University of Colorado at Boulder, travelled to Antarctica to embark on a field campaign using the Aerosonde Mk 4 Unmanned Aircraft System (UAS) as a remote sensing and in situ observation platform.

The primary goal of the fieldwork was to study coastal polynya formation and atmosphere–ocean–ice interactions in the vicinity of Terra Nova Bay. This campaign marked one of the first practical applications of UAS in support of research on the continent, as well as being a novel example of cooperation between robotic air and ground assets, with airborne data fused with in situ data from an uninhabited sensor suite moored in Terra Nova Bay.

One-hundred and thirty flight hours were logged, covering almost 7000 miles over the course of the six-week deployment, with mission endurance of up to 17 hours in temperatures as low as –38˚C. A number of different payloads were flown in support of the research, including laser profilers, colour digital cameras, infrared pyranometers, net radiation sensors, and a dropsonde payload, with the aircraft designed for rapid reconfiguration of the sensor package according to mission requirements. As well as being a successful demonstration of the utility of UAS in the Antarctic context, the fieldwork yielded a one-of-a-kind data set capturing the atmospheric processes at work around an Antarctic coastal polynya during late austral winter, with implications for global-scale processes such as the ocean thermohaline circulation.

Photo from http://www.aerosonde.com/

***The Australian Metrologist* welcomes contributions to the letters page, comments, opinions, questions and so on.**

Fibre optics

BRIAN PHILLIPS

In the early 1960s, MSA member Brian Phillips worked for a UK company called Ellis Optical. Amongst other things, Ellis Optical produced a machine to measure the peripheral view of a patient's eye called an optician's arc and this instrument used a light source through a fibre-optic cable to trace the vision. The company also became involved with the production of signage using fibre-optic lighting. Brian migrated to Australia in 1964 and was employed as a survey instrument technician by Instrument Engineering and later by Watson Victor in Brisbane, who sent him to America to be trained by American Cystoscope Manufacturers Inc on the maintenance and repair of medical optical instruments. Brian worked on rigid optical telescopes and flexible fibre-optic equipment while employed by Watson Victor and was also trained on laboratory balances by Mettler (now Mettler-Toledo) as well as servicing surveying instruments. He started his own business when Watson Victor was sold, repairing, servicing and calibrating laboratory balances, surveying equipment and medical optics, being NATA-accredited for balances and surveying equipment. Following consulting work for a Brisbane company for their range of fibre-optic medical instruments he again travelled to Japan to train on a range of instruments produced by Machida, as part of an agency requirement. He continued his interest in fibre optics because during his time with American Cystoscope Manufacturers Inc they were involved in the production of pulsed light transmission, although at the time he was unaware of this as it was top secret.

This is only a part of Brian's wide-ranging career, but he first presented an early version of the paper which was the basis for his article below at the Fifth National Conference of the Australian Institute for Non-Destructive Testing held in Brisbane in August 1975. This was a few months after his return from American Cystoscope Makers Inc. He gives here a potted history of the development of fibre optics with an update to the present.

Introduction

The oldest, probably the most basic and certainly the most useful form of non-destructive testing (NDT) is visual inspection. Size, shape, surface irregularities and finish can be evaluated. Corrosion and surface cracks can be located swiftly without protracted delays due to calibration, interpretation and processing. With the advent of high-speed production methods and increased design demands, the scope for visual inspection appeared to diminish but in fact this turned out to be not the case. Rather it was the impetus for the development of scientific, non-destructive testing techniques to meet the new demands for quality and reliability. Radiography, magnetic field, ultrasonic, eddy-current and a number of other tests emerged to meet industrial needs. Such processes continue to develop in terms of sophistication of equipment and defect detention sensitivities.

While the 'scientific' methods of NDT developed, visual inspection was also on the move. From the naked eyeball to the mirror on a stick, through complex mirror and prism combinations in steel tubes, until finally we saw the emergence of fibre optics and its application as a powerful inspection tool.

Background to fibre optics

Fibre optics can be defined in a very general manner as the science of radiation transmission through fibres. In NDT we are predominantly, although not exclusively, concerned with the transmission of visible light.

As long ago as 1880 instruments were being developed for the internal examination of the human body, usually through a natural body opening. From the rude and clumsy efforts of that time, the miniature telescope or endoscope as it was known, gradually developed. Refinements of the instruments followed and in the medical field today internal inspection of the body without major surgery is a common and almost routine procedure.

Because of their medical origins the early (and many current) endoscopes developed for industry were similar in design and appearance to their medical counterparts. This proved to be a boon because many of the demands made by the medical profession were similar to those made by industry. Both areas wanted to be able to view the interior of cavities inaccessible to conventional visual inspection procedures. Doctors and inspectors both wanted to know what it was like inside.

Miniaturisation became the largest development theme. The problem of optical miniaturisation is tremendously complex, but an intense research and development program mounted by many companies overcame the major stumbling blocks. It is now possible to consistently mass-produce lenses of 0.8 mm diameter. The big problem was to get sufficient light to the inspection point. The early boroscopes utilised small filament lamps located at the end of a rigid tube fitted with an array of lenses, mirrors and/or prisms. This system provided the maximum light possible at the time but it was still well below the demands of the inspection engineer. In addition, heat was generated at the area under inspection and this may often be undesirable. Electrical contact down the length of the tube often around 1.8 metres or more represented a seriously weak point for breakdown problems. The electrical contacts also introduced a hazard where spark risks had to be considered. Nevertheless, rigid boroscopes with standard incandescent lighting became useful instruments which still find widespread application.

The development of light-transmitting fibres overcame the problems produced by the placement of incandescent light sources at the inspection site.

With fibre optics, an intense external light source can be transmitted to the area to be inspected. The use of an optic pipe ensured a cold light in the inspection area, and elimination of the

spark hazard and the fragility of the electrical contacts required with the incandescent lamps. This represented the first important step. Next came the capability of image transmission through a flexible optic path, which opened a field of visual inspection bounded only by ingenuity in matching a flexible optic system to inspection demands.
Examination through flexible optics probably had more than one origin but in the period between 1954 and 1958 work on forming bundles of glass fibres for image transmission made a number of advances. Research work was carried out at the University of Michigan, with the objective of constructing a fully flexible instrument for the examination of the stomach. Those associated with the project, Curtis, Peters and Hirschowitz, took up work from earlier developments but the performance of the first bundles was poor. In fact, the light transmission was little better than that achieved in 1930 by H Lamm, when he worked with quartz fibres. The cause of loss of light was demonstrated to be due to contamination of the surface of the fibres by dirt and oils, these having refractive indices comparable to that of the fibre. One method used to avoid this deterioration of the interface by contaminants was to use fibres of substantially higher refractive index than the index of the contaminants expected to be encountered. A bundle of this nature was constructed and, as predicted, gave substantially improved transmittance; up to one-third of the incident light was found to be possible in the early instruments. But light transmittance was not the only requirement in the quest for image clarity; it was also necessary to prevent light leakage from one fibre to another. This was not a problem in a short bundle, but it became critical as soon as a long bundle was packaged to form a compact unit. It was a major problem, because although the bundle could transmit a brilliant image when the fibres were lying loose, it became unrecognisably washed out when packaged into a latex tube. In the latter part of 1956 a method of coating the high refractive index glass fibres with a low-index lacquer achieved the desired isolation of the individual fibres. When this type of bundle was packaged to form a compact bundle, image contrast was retained. Even with this partial success, when a bundle was produced of any significant length, the scattering of light from interface surfaces where a number of irregularities occurred was greater than had been anticipated, seriously degrading the quality of the image.

In 1956, Curtis drew glass-coated fibres from an assembly of high-index glass rod inserted within a low-index glass tube. This formed the first glass in glass fibre and overcame the transmission loss. The technique was subsequently refined and greatly improved so that the cross-sectional geometry of this assembly was retained down to extremely small fibre diameters, yielding a controlled, uniform, non-scattering, low-index coating on a high-index core. Glass in glass. This composite fibre was mechanically far stronger than previous fibre produced with plastic coatings and the simultaneous drawing of both core and coating, orientated and lengthened any inhomogenities and tended to render them fairly insignificant. It had suddenly become possible to pass light through more than 9 metres of 0.3 mm diameter fibre. Losses due to internal reflection in these fibres can be reduced to 0.00004%. A 1 metre long image bundle constructed from these fibres became the basis of the first clinically useful flexible instrument.

In the steps which led towards image transmission, another problem had to be overcome, that of orientation. It was clear that a fibre must occupy a similar position at both ends of the bundle or although full transmittance is achieved, what is seen is a scrambled version of the true image. This was resolved in the design of the fibre drawing equipment.

Further developments

In 1957 Hirschowitz used the first flexible instrument on a patient at the University of Michigan hospital and a few months later another instrument was constructed, which included many of the features of the subsequent commercially successful models. It was obvious even at that time, that flexible fibre-optic instruments had a great deal to offer industry, and the development of fibre-optic boroscopes was soon to follow the achievements made for the medical profession.

Development of fibre-optic instruments is still of prime importance and after the first breakthrough when images were first seen, improvement has centred mainly on the quality and type of image. Naturally, great importance has been placed on achieving greater flexibility, with greater strength. The answer to both these requirements was virtually the same, reducing the diameter of the individual fibres. Fibres are now readily drawn to less than 0.01 mm diameter. Bundles with an overall diameter of only 1.25 mm can be made, which gives good reproduction of the viewed object. Flexibility is certainly improved by reducing the diameter of a fibre, so too is the strength of the complete bundle; but it is the image itself that gains the most benefit by a reduction in size. By reducing the size of the instrument and requiring more magnification to inspect areas for faults, the power of the auxiliary optics has to increase. When the magnification of the eyepiece reaches a certain level, each small space formed between the fibres becomes a black spot. This produces a “pepper” effect on the image, which is certainly not desirable. By reducing the diameter of the fibres we also reduce the size of the spaces between them and this improves the clarity of the viewed image.

For almost a decade glass was the only material used in the fabrication of optical fibres. In 1966 plastics entered the field. Initially they competed for all applications as there was much confusion as to the applications in which plastic should be used and the application in which glass should be used. Later this competition eased off as people realised that each material has its own set of properties that make it desirable in certain environments.

Glass, because of its rheological properties, can be drawn into extremely small fibres. The small diameter of the glass fibres also helps to reduce the brittleness of the fibres. Therefore, glass is seldom manufactured as individual fibres in diameters larger than 0.06 mm. It is almost always used as a bundle, either a light or image guide.

Plastics, while not having the tensile strength of glass, are considerably tougher. For this reason plastic optical fibres are much larger in size than glass fibres. The smallest practical commercial plastic fibre is about the same size as the largest practical commercial glass fibre (0.06 mm). The largest commercial plastic fibre is about 1.4 mm diameter. Some plastic fibres are so big in comparison to glass they may be handled as monofilaments as well as light guides. Unlike glass, plastic fibres are seldom fabricated into image transmission bundles as the fibre size is too large to obtain good image resolution.

Both glass and plastic fibres have basically the same ability to transmit visible light. With plastic optical fibres, most line loss is due to scatter from contamination. With glass fibres, more losses are caused by molecular absorption. Due to packing and end losses, percentage transmission varies with fibre length. Typical figures are:

	Plastic	Glass
Transmission over 0.3 m	80–85%	70–75%
Transmission over 1.2 m	60%	60%
Transmission over 1.8 m	50%	50%
Transmission over 7.5 m	10%	15%

Fibres made from special glass can greatly reduce these transmission losses but they are very expensive and used only in specialised applications.

Glass is more suitable for many industrial applications because of its ability to be used over a wide temperature range. Glass may be used to withstand exposure to temperatures from –40°C to in excess of 200°C when fitted with glass outer sheaths. Plastic fibres are usually limited to about 100°C maximum. The other major difference between glass and plastic fibres is the mode of manufacture. Glass fibres require very sophisticated end-finishing techniques to reduce end losses to an acceptable level. This consists of epoxying the fibres in place, rough cutting, grinding and final polishing. Plastics, on the other hand, require only a razor cut to provide transmission the equal of well-finished glass. The plastics used for fibres are polystyrene, acrylics or a combination of the two.

The use of fibre-optic bundles to transmit cold light to the inspection point and the flexible transmission of images allowed the development of two powerful inspection techniques: photography and television monitoring. With normal incandescent lamp illumination there was not sufficient light to allow photography through the instrument and some additional form of lighting was required. With the advent of fibre-optic bundles, an intense light source could be passed to the distal end of the instrument. Because of its brilliance, no additional light was needed as illumination for the camera, whether photographic or television. With the aid of beam-splitting devices, the boroscopes could be used and viewed in the conventional manner while simultaneously a second image of the same field of view could be transmitted and displayed on a television screen or recorded on film. In this form fibre optics represents an invaluable asset for training purposes and provides a permanent record of inspection.

Fields of application

With knowledge of the basic principles of fibre-optic equipment the question of where it can be used is raised. The fields of application are very broad and are continuing to expand as the physics of fibre optics is developed. Several areas of application with one or two specific cases in each area are described to provide an appreciation of the scope offered by fibre optics.

An inspection tool

When used as an inspection tool to provide visual access to internal or remote surfaces, both illumination and image transmission properties of fibre optics are utilised. Light is needed to illuminate the object so that the image may be observed. Common application is found in inspection of:

Internal surfaces of heat exchange, boiler and condenser tubes.
Aircraft wing spars.
Aircraft engines, particularly gas turbines.
Hydraulic cylinders.
Turbine blades and propeller blades.
Engine blocks and castings.
Internal surfaces of aircraft fuel tanks.
Transmissions and differentials.
Small pumps, motors and electrical assemblies.
Small pressure vessels.
Rifle bores.
On nuclear reactors in areas of high radiation hazard.

Units for these applications may be used for direct viewing or camera coupled as previously described. The rigid units may vary in dimension from about 2.25 mm diameter with lengths of 250 mm up to 45 mm diameter and lengths of 12 m. Diameter and length are dictated by the application but the final criterion is strength. With flexible boroscopes, standard diameters usually range from 6.5 mm to 15 mm with lengths from 375 mm to 3 m. These units are usually battery-operated and the last 40–50 mm may be flexed by control from the eyepiece. The normal field of view is 60° and the depth of field ranges from around 5 mm to 30 mm.

A specific application where fibre optics has been married to television scanning is in the remote inspection of aero engines in the UK. This work was originally done with the direct use of boroscopes inserted through points in the engine housing or by dismantling the engine. With remote television scanning and video recording, the inspection can now be done remotely and efficiently. The cameras are used with 4.5 mm, 8 mm and 11 mm boroscopes. Such inspection can reveal cracks, corrosion erosion, oil leaks, weld defects and the presence of foreign matter. The depth of corrosion pits and so on, however, can not be measured.

The use of fibres to transmit images had some problems, already mentioned above, the ‘pepper’ effect could make interpretation of inspected areas difficult. The circular presentation of a fibre end also could distort the image of a straight line, making it appear waved. These shortcomings, although not critical in medical inspection, could cause misinterpretation in engineering applications. Development in the manufacture of CCD chips overcame the problem and the modern boroscope uses a camera at the distal tip to produce an image, which is either produced on a small screen as part of the instrument or on a large screen accessory.

Monitoring

Remote light monitoring is an area that uses large quantities of optical fibre each year and holds a large potential for future development. Monitoring is used in the motor industry, plywood manufacture, computer terminals, welding and photography. In the motor industry, a simple application is the use of light guides to detect whether bulbs are working or not. A small fibre bundle is pointed at the bulb in question and the other end is presented to the driver. When the end of the bundle glows you know that your lights are working. Fibre-optic systems are superior to electronic sensing systems as they eliminate the expensive and sensitive detection devices and increase reliability by reducing complex electronic circuitry.

An interesting monitoring technique is the use of fibre optics and infrared radiation detection in resistance weld quality. Sensors are placed at the weld and, from these, thermal information in the form of infrared radiation is conveyed through a fibre-optic path to a detection unit. The system compares the output signal from the weld against two set points, high and low. The result of the comparison determines whether the weld is of acceptable quality. It is possible to incorporate some feedback, which will adjust the welding equipment to correct deviations in quality that occur.

A similar system is used in the manufacture of some transistors where a sensor is located at the junction and the signal again transmitted through the fibre-optic path to a detector. Rapid determination of junction bond is achieved.

Displays

Fibre optics are very suitable for visual displays. Fibre-optic bundles are produced in the form of a harness, with one input and up to 250 tails. The output tails are arranged in a pegboard to provide a fixed message in the form of an array of dots of light. With an etched plastic diffuser in front of the pegboard the dots of light from the ends of the fibres tend to enlarge and merge until they appear to be a solid bar of light. When the light is switched off, no sign of the message is visible. Composite multicolour displays are available by using different harnesses for each colour and simply installing colour filters at the source. Displays of this nature are being used for highway signs and airport runway signs, where it is claimed they are more vivid and uniformly brighter than conventional signs.

Image intensification

The term fibre optics tends to conjure up the idea of only long slender instruments but this is not necessarily the case. Small fibre-optic plates and discs are manufactured for image inverter lenses and face plates for image enhancement. These items are used in image enhancement for military night vision equipment in the infrared range and in space photography.

Communication

In the field of message transmission through fibres, the advances have exceeded the expectations of early workers associated with communications. These are mainly due to the removal of impurities in glass and the fusing of elements to enhance the property of clarity. Alongside this development came the use of semiconductor laser light sources, the first practical one being gallium arsenide (GaAs). These early semiconductor lasers had short life spans and only fired intermittent pulses but further improvements have made message transmission a reality.

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The metrologist as a tourist: Part 1

RON COOK

In 2010 I signed up as a member of a NATA Consortium bidding for a contract to provide technical assistance to the Abu Dhabi government. NATA subsequently won the contract and it was all hands on deck from then on for two months. My role was as lead metrology expert with the main task of developing a metrology centre from scratch.

I spent two spells of three weeks in Abu Dhabi and found it a pleasant place to work. The only hazards and annoyances were drivers who ignore speed limits (well you would, wouldn't you, if you owned a Maserati, a Bentley and a BMW or two and had three-lane highways to drive on) and taxi drivers whose meter is "broken" or who know the "quickest way". The high quality of the food in the restaurants and hotels and the cold beer available in these was definitely a mass hazard.

Like all of the Emirates, Abu Dhabi is mostly sandy desert. Oil, gas and condensates are the main exports. The country has an excellent road system and the main centres of Abu Dhabi, located on the coast, and Al Ain, roughly 200 km inland near the Saudi Arabia border, are clean, modern and have good infrastructure. Money (lots of) is being invested in selected industries. They have a fully integrated steel works (Australia buys over $30m worth of steel per annum from there) the world's largest aluminium refinery, an AMD integrated circuit foundry, a comprehensive aerospace industry with full airframe and engine servicing plus composites manufacturing. Of course, the construction industry is a major employer, largely of Indian labourers, and consumes vast amounts of locally produced steel and concrete.

The electrical power for industry and the large desalination plants comes from oil- and gas-powered plants. With an eye to the future, Abu Dhabi is buying two nuclear reactors from South Korea. Abu Dhabi is not as glitzy or, as yet, not as high rise as Dubai, but it is much richer and life goes on at a rapid pace. In January the weather was a pleasant 23°C and many residents could be found strolling along the Cornish (the seaside beach and walkway) enjoying the evening breeze that wafts lightly along the coast.

A basketful of novice aeronauts with Captain Atilla at dawn over the desert.

The bogged vehicle with Mark Bezzina, John Gilmour and Graham Drake sizing up the situation.

Only 15% of food consumed is produced in the Emirates, generally from small farms scattered along the coast and along the road to the oasis city of Al Ain, which is about two hours' drive south from Abu Dhabi. The country is justly famous for the quality of the dates grown there. The waiting rooms in government departments have a tray of dates and a pot of Arabic coffee for visitors, both of which I recommend. Arabic coffee is milder than others in the region and is flavoured with cardamom. A pleasant drop to start the day, although I did still obtain a strong black coffee from the kitchen every morning around 10.15 am.

Four-seater, autonomous, electric cars

In the process of gathering information, I visited a number of laboratories and factories. One interesting place was Masdar, a model green city, where to get from the visitors' car park to the university you take an autonomous vehicle. This egg-shaped electric car can hold four people comfortably and at the push of a button takes off and finds its way to the destination. There is no driver and it finds its way by sensing magnets in the roadway and a wire overhead which radiates a guidance signal. The newly opened Metro in Dubai also has no drivers for the trains. Well this is the 21st century.

It wasn't all work and we had several days on the weekends to play the tourist. On the first trip to Abu Dhabi four of us hired a driver for a trip to the Liwa oasis. The driver thought that an adventure was in order and 150 km out of town departed from the highway and took to the desert. The first couple of drifts down the steep sand dunes in the four-wheel drive were fun but the driver became more enthusiastic. The passengers were hanging on grimly as the vehicle raced up the slope, lifted off briefly and slid down the other side at an angle with the sand flowing over the bonnet. After a few of these manoeuvres it was initially something of a relief when the vehicle was bogged just below the lip of one dune.

After a few minutes it was obvious the driver had no clue as to how to extract the vehicle and had got it firmly into the sand above the axles. We suggested he use the floor mats under the wheels to gain traction but he resisted that idea and instead called his mate for backup. Where was he? Dubai. How long to get to us? Three hours. It was now close to midday. A plan was hatched whereby we would dig out the sand in front of the wheels and the driver would gently drive forward. "Gently" was not a word he understood. Consequently little progress was made. The sand from higher up the dune kept flowing into our trenches – an interesting demonstration of the angle of repose.

The plan was modified to try and turn the vehicle so it faced downhill instead of across the slope. After more than half an hour of digging, pushing and wheel-spinning, the vehicle moved a few millimetres, then 20 mm, then 100 mm and finally it dragged itself free.

The Burg Khalifa in Dubai, the tallest building in the world. The bottom quarter could not fit into the picture.

Sand dunes near Liwa.

The driver, having been told we had had enough dune surfing, then headed for Liwa using a "short cut" at considerable speed across the ridges. Reaching a sealed road with posted speed limits was a great relief.

The following morning three of the group set out on a trip over the desert in captain Atilla's hot air balloon. The landing was somewhat exciting, leapfrogging 400 kV power lines and clipping a water hydrant as we plonked down on the sand in the middle of a farm.

On the second trip the expeditions were more sedate with visits to various markets, a museum and a day trip to Dubai to see the Burg Khalifa, which at 828 metre high with 160 floors was hard to photograph properly. The viewing platform on level 124 was booked out until 9.30 pm so I was unable to ascend and was unable to go for option B, the restaurant a floor lower as it was the opening day (VVIPs only). The Dubai Mall at the base of the big tower is also on a similar scale with an aquarium of significant size. The mall claims to have the biggest aquarium viewing wall and to be the biggest shopping leisure and entertainment destination in the world. It is bigger than the Mall of the Emirates, which incorporates a 400 metre long, indoor ski run with real snow. Nothing very cheap on offer but everything seemed of good quality and a fair price as there is no GST or other tax applied.

There are no shortages of malls or supermarkets or markets (souks) in the Emirates. With a total UAE population of less than 1 million Emirates and about 4 million foreigners, many of whom are low-paid labourers, it is a surprise to see these establishments crowded day and night. The old souks (markets) have been replaced by modern shops, usually sizeable complexes in modern buildings.

Abu Dhabi CBD from the beach near the Heritage Village.

The really grand Grand Mosque. The highlight of the rest of the tourist bit on the first trip was a conducted tour of the Sheikh Zayed Mosque, a truly beautiful building and a must-see for anyone with a few hours in Abu Dhabi.

Housing is a mix of high-rise apartments and villas, usually in walled villages. Most offices and hotels have good water views due to their height and Abu Dhabi being built on an island less than 10 km wide.

I found the Emirates and the consultants from McKinsey and Mercer excellent people to work with. I was fortunate that we were there in the winter and the outdoor temperatures were quite pleasant.

The legal metrology service is now up and running with the first inspections being conducted on balances used by merchants in the Gold Souks (markets). I look forward to seeing the Metrology Centre 'hatch' and grow.

What's on in Victoria

The MSA 2011 Conference

The Victorian branch of the MSA will host the next MSA biennial conference in 2011. The venue is the Deakin Centre in Geelong and boasts a range of facilities ideally aligned with the MSA conference needs. We will occupy the entire business centre and gain access to range of good-sized rooms for our multiple presentation streams. A large foyer in the middle of the centre will allow our sponsors to set up their wares among the spacious and comfortable gathering areas. The centre includes hotel rooms attached to the business centre making this a one-stop-facility for all our conference needs.

We will also take advantage of this location by featuring the conference dinner at the Werribee Open Plains Zoo just 20 minutes away. The dinner will include a twilight tour of this spectacular zoo featuring animals from around the world.

The theme of this conference is *A Climate for Better Measurement*. We all know the importance of good quality measurement and this is what we, as metrologists, are all about: better measurement. On behalf of the MSA 2011 conference committee, we hope to see you there.

Neville Owen
Randall Anderson
Ian Dollery
Keith Fordham
Jane Warne

Up and coming events

We have secured a presentation by Nick Logan from Aerosonde on the Unmanned Aircraft System (UAS) trials conducted in Antarctica to demonstrate the agility and reliability of this new UAS. Nick is a dynamic speaker and we expect it to be a very entertaining evening. To help make this event accessible to as many people as possible we will be starting later than previous events and we will be catering, so if you'd like to come along, please register by emailing Neville Owen and Randall Anderson as noted below.

Time:	6.30 pm Tuesday 14 June
Place:	Mettler Toledo Port Melbourne 3/220 Turner Street, Port Melbourne, 3207, VIC www.mt.com
Event:	Nick Logan from Aerosonde
Catering:	Pizza, drinks and snacks provided

We are always looking for interesting events, so if you would like to open your doors to an MSA event and demonstrate your capability, then please let us know.

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William Petty and the Ambitions of Political Arithmetic

JEFF TAPPING

Ted McCormick
ISBN 9780199547890, Oxford, 2009

Firstly, I must confess that I have not read this book, only an extensive review in *The London Review of Books*, but this was sufficient to convince me that it was worth discussing. The main relevance to us is that Petty was one of the remarkable men involved in the newly formed Royal Society in the 17th century, and one of his interests was measurement. Not exactly the sort of measurement we are concerned with, but close enough. The story also helps to paint a picture of the context in which the Society began, and discusses Petty's views on why some nations were more progressive and innovative than others.

Like so many of the early Society members, Petty was interested in many things, but he was unusual in that he crossed perceived boundaries between the disciplines of science, engineering and sociology. And that was the aspect of the man that particularly captured my attention.

The first part of the book describes a major enterprise to try to develop a twin-hulled ship, what we might call a catamaran. Petty had been commissioned by the Royal Navy to improve the design of ships, motivated by the existing rivalry with Holland. He reasoned that twin-hulled ships would travel faster and would be able to navigate in shallower waters. He actually built three vessels and demonstrated in races that they did sail faster than single-hulled versions. But a mixture of vigorous opposition arising from fear of change and an unfortunate loss of the third and biggest vessel in a storm resulted in termination of the project. It is interesting that Samuel Pepys, the equally remarkable man who left us *Pepys Diary* and who was then an official in the Navy Board, was one of the few supporters.

The big story takes place in Ireland, where Petty first went to attend to the medical needs of the invading British army, then took on the job of assessing, surveying and valuing the properties in the country. If, like me, you have a fragment of Irish ancestry you will find this bit of history makes you a bit queasy. The reason for the exercise was to value properties that were to be confiscated from their Irish owners and handed to new British landlords as rewards for services to the British government. The Irish were regarded as close to savages and the objective was to Anglicise the Society, and incidentally remove the threat of Irish Catholicism to Protestant England. Petty benefited substantially, receiving 50,000 acres of land, but to his credit he opposed those who thought the simplest answer to the Irish problem was to put all the natives to the sword. It was during this time that Petty developed an interest in Political Economy, a study of the interaction between politics and the economic structure of a society.

To carry out his survey, Petty had to perform measurement in its broadest definition. He had to use knowledge of mathematics, natural history, geology, forestry and agriculture to measure areas and values, and he carried out his task with amazing efficiency. He completed his job under budget in just over one year instead of the projected seven to 10 years. He did this by understanding the intellectual limitations of his soldier workforce then giving them appropriate tasks and tools and by developing a recording system to represent the data in an intelligible form. Along the way he thought about what made societies what they were. Why were the Dutch so powerful? He concluded that environment shaped societies, including factors such as climate, diet and the physical environment. For example, the sea was on one hand a threat to Holland, but also provided economic strength from fishing and trade. Superior naval strength followed which, in turn, assisted trade and expansion into lucrative colonies. This is a plausible explanation for why science and technology forged ahead in western Europe rather than in the Middle East and China where it began centuries earlier but stalled.

Petty was most remarkable for developing ideas that did take hold for hundreds of years and still struggle in some respects. He showed the boundaries we place between disciplines are artificial and that success comes from a multidisciplinary approach. And he promoted the principle that outcomes are influence by environment, something every metrologist must be conscious of. Finally, to quote the last paragraph of the review I took all this from:

> *The double-bottomed vessel had failed, but Petty's experiments in political arithmetic were wild successes. He built the prototype of a ship of state that now sails on the sea of science.*

Call for papers

MSA Conference 2011

A Climate for Better Measurement

Deakin Management and Convention Centre, Geelong, VIC
19–21 October 2011

The Metrology Society of Australia is holding its biennial conference in Geelong at the Deakin Management and Convention Centre 19–21 October, 2011. This modern facility includes a generous gathering area, a number of presentation rooms of different sizes and on-site accommodation for over 60 delegates. The MSA has secured the entire facility for the duration of our conference, so delegates and exhibitors can conveniently interact, attend the presentations and conduct private meetings in the generous foyer or in private breakout rooms.

Please visit **www.managementcentre.com.au** for more detailed information about the venue.

The theme of the conference is:

A Climate for Better Measurement

This is the second call for papers and expressions of interest and a brief abstract of approximately 150 words should be submitted by 15 June. Submissions should be forwarded by email to:
neville.owen@measurement.gov.au

Successful applicants will be notified by 22 June. The deadline for submission of papers will be 15 August. Details on the conference venue, time line for activities and conference fees are available on the MSA website. The conference will include at least two technical forums:

The Dimensional subgroup will hold a forum on training and use of Coordinate Measuring Machines including GD&T and GPS, the language of this field. An international expert has been invited to co-chair this forum (Greg Hetland, USA).

The Pressure subgroup will hold a forum to review the application and acceptance of the MSA test methods for pressure metrologists. This group will also discuss the issues associated with the application of Dead Weight Testers outside the range of testing used to characterise the piston cylinder unit.

Other forums will be considered based on anticipated attendees.
The 2½ day conference will start on Wednesday 19 October with a welcome barbecue from about 4:00 pm followed by the two-day technical program on 20–21 October with a conference dinner at the Werribee Zoo on 20 October. The conference will conclude with the MSA AGM on Friday afternoon, followed by light snacks allowing delegates to depart at their leisure to catch flights home or return to Melbourne.

Conference fees:	MSA members	$340	Early registration	$272
	Non-member	$390	Early registration	$312
	Single day pass	$200		
	Conference dinner	$60		

Early bird registration will close on 31 August, so don’t delay.

Should you have any questions regarding the conference, the call for papers or the technical program, then please contact one of the members of the organising committee:

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The Invisible College – The secret history of how the Freemasons founded the Royal Society

JEFF TAPPING

Robert Lomas
Corgi paperback edition 2009, ISBN 9780552158374

In November 2010 the Royal Society (or to give its full title, The Royal Society for Improving Natural Knowledge) celebrated its 350th anniversary. This Society is probably the oldest scientific organisation of its kind and certainly has been a role model and inspiration for many other organisations. The first part of the title of the book comes from its precursor, a discussion group which included many names familiar to us today, such as Robert Boyle, Robert Hooke and Christopher Wren.

The book is principally a tale about a long search by the author for evidence about the formation of the Royal Society, but in the process it is a narrative about great social changes that took place in Britain in the 17th century, changes that reverberate in our present-day society. The author examines the proposition that the Society was a creation of members of The Masonic Lodge, and as an active member of The Lodge himself he is as much occupied by the history of the Masons. But to be fair to him, he makes a good case that the system of scientific societies we have today, and indeed the philosophy that we call "the scientific method", is the end result of a long evolution which began with stonemasons in Scotland in the 16th century. Briefly the tale is as follows.

In mediaeval times, stonemasons formed themselves into a sort of trade union that was also a kind of secret society. This was seen as necessary to protect against incursions by unqualified people at a time when communication was limited and few people could read or write. The craftsmen were semi-itinerant because they had to move from one construction site to another, which made it difficult to keep track of who was qualified to which level, so they developed a set of secret signs to communicate their status. And this was more than just looking after their own interests, because one piece of defective work could bring a cathedral tumbling down. Remember this was before there were architects' plans and engineers and detailed design was the responsibility of the tradesmen.

How the Masonic Lodge grew out of this was not addressed directly by Lomas, but he does relate that when the Lodge began in the 1500s, a prominent member of the Lodge was Minister of Works to the King of Scotland. At this time Protestant clergy enforced very strict rules of behaviour, and it seems most likely that open-minded members of the upper classes used the masons as a model to form a secret society where they could discuss matters between themselves that if discussed openly would have brought great wrath upon their heads.

After Queen Elizabeth I of England died without a successor, the throne passed to the son of her late sister Queen Anne of Scotland, and he was James VI of Scotland, who then became James I of England. This is the king who was beheaded by the government of Oliver Cromwell at the end of the Civil War. Incidentally, the author says that the Civil War came about in part because James, as a Scot, did not properly understand the sensitivities of the English. And James was really a Catholic like his mother, while at the same time being head of the Church of England.
Meanwhile Masonry had come to England with men who followed the King. King James found himself in financial difficulties because Parliament refused to give him the funds he needed for many projects. One of these projects was to improve the performance and efficiency of the English navy. The superior Dutch ships were making increasing incursions into English fishing grounds and were winning the trans-Atlantic trade war.

During the Civil War, things got even worse, so when James II took over after the Restoration he was desperate for answers to his difficulties, particularly those of trade and finance. The problem was that many of the cleverest people around had supported the Parliament side of the conflict, and so were *persona non grata*. One of the King's supporters, a Mason, had the answer in respect to science: form a society to discuss "natural philosophy" modelled on the Masonic Lodge. In the meetings of the Society discussion of politics and religion was strictly forbidden, a policy necessary for it to be tolerated. The Society was to be financially self-supporting by charging members a substantial monthly fee. Membership was to be by invitation only. Some members were prominent members of society, 'movers and shakers', some were natural philosophers like Isaac Newton, Robert Hooke and Charles Boyle. Many problems were discussed and examined, but the author believes that it is no coincidence that one of the problems tackled was measurement of longitude at sea.

Lomas addresses the mystery of how the Society could come about when members of it were only a short time before on opposite sides of a brutal and bloody conflict. How could King James consent to the royal imprimatur to such a group? It was quite a new concept in science and so how were such a disparate group persuaded to join together?

The secrecy practised by the Masonic Lodge made the task of tracking events very difficult but Lomas puts together a convincing case that the motives were essentially political. It was a way for the former supporters of the rebels to work their way back into the system, and for supporters of the king to exploit their skills.

And King James got a research organisation at no cost to himself. Have you ever read about Isaac Newton indulging in alchemy and wondered how this could be? It seems that he was not the only great scientist that dabbled with ideas we laugh at today. This book explains how the Royal Society was pivotal in dragging science in general out of the era when belief in magical processes and astrology were mainstream thought. For the first time ideas were assessed by peer review of evidence rather than by dogma. For the first time ideas, questions and answers were openly discussed and shared. And for the first time these matters were published in a journal so that they were collected in an easily accessed record. This sparked a thought in my mind. There is much speculation on why the science and technology of China and the Middle East stalled after very promising beginnings, while that of the West forged ahead. Is this part of the explanation?

It is so easy for us to believe that our present wisdom is the result of a natural evolution, but this book demonstrates that sometimes historical accidents, politics and economics take more of the credit. And it supports the argument once put to me by a historian that while scientists like to think that scientific endeavour has been an independent search for truth, commercial need has always been the main driving force. Astrology morphed into astronomy because of the needs of navigation. Chemistry has been driven by the benefits of new materials. Thermodynamics was needed for steam engines. The list goes on and on.

Perhaps one of the most interesting things about the Society is that it so similar today to what it was at formation. It is still an advisory body to governments on scientific matters, it is still entered by invitation and applies a code of conduct, it still conducts meetings and publishes journals. If it was not so suitable to its environment it would either have become extinct, or evolved into something different. But it seems that the creators got the structure close to right at the beginning.

This a tedious book in many ways with its examination of myriad fine traces of evidence and frequent repetition of points. And the preoccupation with the role of early Rotary has little relevance to the main topic. But I am glad that I persisted to the end because it really opened up my mind about the history of science and technology and of how our society came to be as it is, so the effort was worthwhile.

You might ask what this has to do with metrology. Well, the Society pioneered the way in establishing the principle of critical examination of experimental results. Measurement is a vital part of this, as well of the technology that arose from the scientific progress. It was a long trek from these early days to the rigorous and comprehensive systems we now have, but the formation of the Royal Society was certainly a large stride along the journey.

The Lithgow Small Arms Factory and Museum

In 1906 the Australian Government decided that Australia could no longer rely upon Britain for her defence needs and decided to build a factory for the manufacture of arms. Opened on 8 June, 1912, the factory initially manufactured Short, Magazine, Lee-Enfield Mk III rifles (and bayonets thereof) for the Australian military during World War I. The Lithgow Small Arms Factory was Australia's first high-precision, mass-production facility and has an historic association with the inaugural Australian federal government of 1901.

In an attempt to sustain the maximum number of employees during the economic recession that followed World War I, the factory entered the commercial marketplace. Numerous commercial products were manufactured until the commencement of the hostilities of World War II. During World War II production expanded to include Vickers machine guns, Bren Guns, and, post-WW2, branched out into sporting goods (including civilian firearms and golf clubs), tools, sewing machines, (from the mid-1950s) the F1 sub-machine gun, L1A1 Self-Loading Rifle, KAL1 General Purpose Infantry Rifle prototype and similar products. The factory played a significant role in saving the floundering Australian wool growing Industry during the 1930s by manufacturing parts for shearing handsets, replacing those purchased from England at too high a price. The Lithgow Small Arms Factory became an Australian industrial and rural Icon.

The factory was first 'corporatised' as Australian Defence Industries (ADI) by the Hawke Government, then later sold in 2006. ADI Lithgow is now owned by Thales Australia and continues to manufacture the F88 Austeyr rifle and F89 Minimi currently used by the Australian military. There is a museum on site with a large collection of military and civilian firearms manufactured at the factory and elsewhere.

Metrology Society of Australia Award

Calling all Australian metrologists! Do you know of good metrology work being done in Australia?? On the factory floor, on the production line, in the analytical lab, along the pipeline ... anywhere. Here is your chance, and the metrology industry's chance to recognise work that makes all our lives better. Note that the rules for the award have been changed – we are now including not only work actually done by members of the MSA, but work done by anyone, anywhere in Australia, which deserves to be recognised. So if you can think of a potential worthy recipient, read on below, and get your proposal in ...

The Metrology Society of Australia Award recognises achievement and excellence in Australian metrology and the contribution metrologists make to the Australian community. Metrology is the science of measurement. Membership of the MSA includes scientists, engineers and technicians working in government and industry from all fields of measurement in Australia and overseas.

The MSA Award is presented biennially at the MSA conference dinner. In 2011 this will take place in Victoria on 19–21 October.

Nominations are now invited for this award. The work nominated must be substantially produced in Australia, but must be nominated by a member of the MSA. The National Committee of the MSA will decide where necessary the eligibility of the submission, and its decision will be final.

The award is for work completed, or that has gained scientific or industrial recognition, in the past five years and which has contributed to the Australian economy. The work must fall into ONE OR MORE of the following categories:

BASIC RESEARCH Original research directed towards the significant improvement of fundamental measurements, the accuracy of derived units or fundamental constants. Solutions to difficult measurement problems, work that has FUNDAMENTAL importance to the development of measurement, the application of new or existing science and mathematics to new measurement applications, including the development of new instruments, techniques or methods for reducing uncertainty.

DEVELOPMENT The development of new instruments, measuring techniques or systems for Australian industry, including the design of prototypes, testing, characterisation and product manufacturing. For example, the development of a new thermometer or an inline automatic inspection system.

APPLICATION TO INDUSTRY The use of new or improved measurement science and technology in Australian industry to increase quality, productivity and competitiveness. For example, the use of new sensors to control production processes or the application of statistics for scheduling recalibration systems.

SELECTION PROCESS The award judges will be a subcommittee of the MSA National Management Committee. The judges will use criteria such as: degree of innovation; significance of the work; potential or real cost savings; stage of development; potential for application in other fields or industries; quality of supporting material and testimonial evidence supplied.

The award judges are bound by confidentiality agreements, ensuring complete confidentiality of submitted material.

Application form opposite

MSA AWARD APPLICATION FORM

To nominate, please fill in the entry form below and send it to:

The Secretary
Metrology Society of Australia
C/- National Measurement Institute
PO Box 264
Lindfield, NSW 2070

Name of nomination:...

Address: ....

Telephone: ....

Fax:..

Email: ....

Concise description of work on which the nomination is based:

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Nominated by: ....

If self-nominated, please provide contact information below:

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Signed: ....

Printed name (if different from nomination): ....

Date: ....

Do you wish the submitted material to remain confidential? Y/N:..