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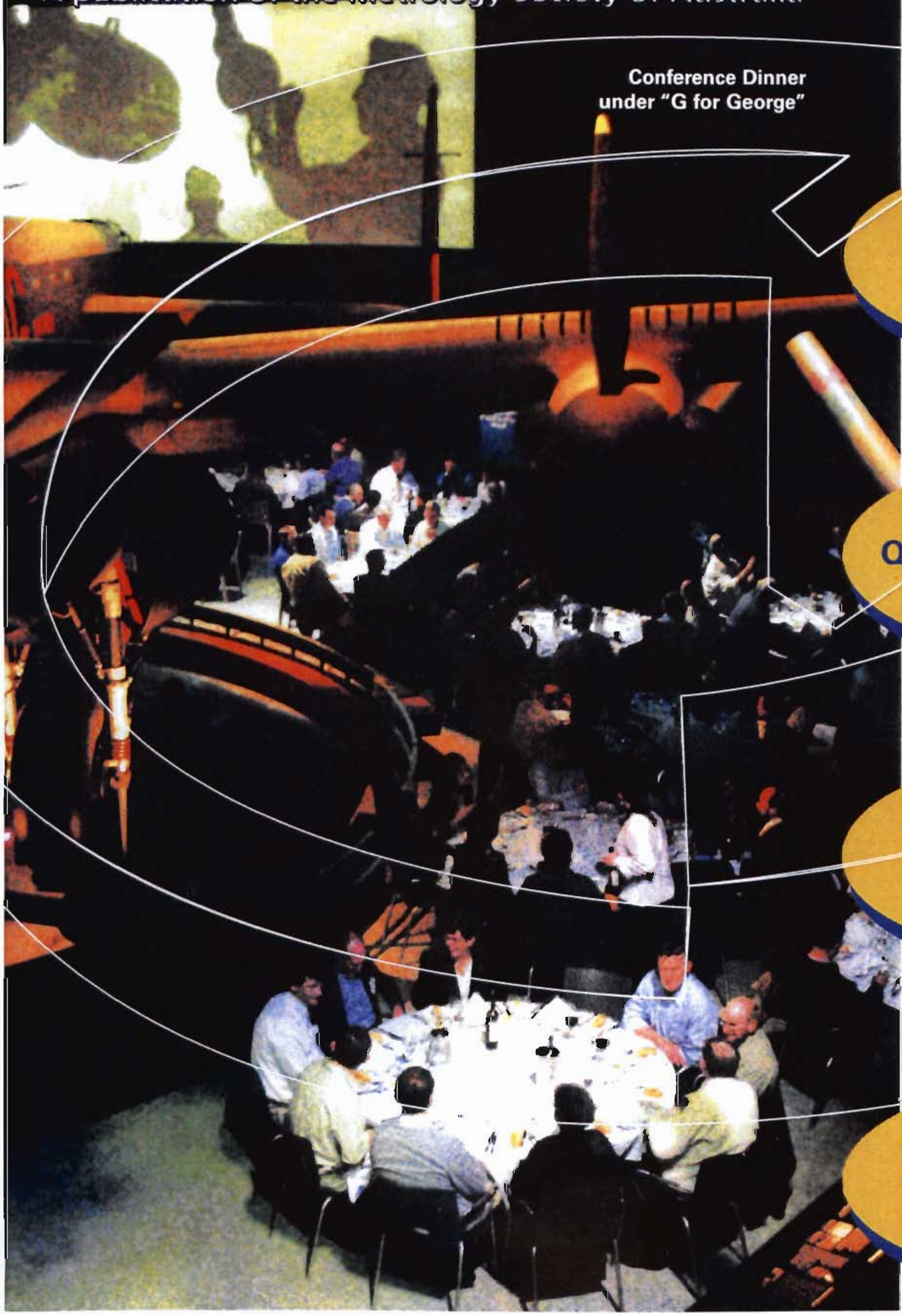

Conference Dinner under "G for George"

An Update on the Kilogram

Quantification 7

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2005 Financial Report

THE AUSTRALIAN METROLOGIST

From the Editor

In this issue we continue our popular series - Jeff Tapping's *Quantification* and Ron Cook's - *Riverbank Reflections*. Both are entertaining and thought provoking. In addition there is a reprint from *Chemistry International* of an excellent article by Ian Mills on the definition of the kilogram. The MSA financial report as presented to the AGM is provided for your information. Some photo-spreads from the Convention and a South Australian group meeting round off the issue.

I must stress my concern over the difficulty in getting articles to print in TAM. I thank those who do provide regular items, and hope they continue! Submissions may be technical articles, book reviews, state group activity notes, reprints from other journals, etc, limited only by your imagination.

- Maurie Hooper

Cover: Conference Dinner - Australian War Memorial, Canberra under *"G for George"*

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.

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President's Report - March 2006

Here we are again, a new year and a great many things on all our plates I am sure. I know that I am finding each year the speed and complexity of life is increasing. Juggling work, home, hobbies and all the other interactions of life makes me at least think that I either need a clone of myself or an extra few hours in the day! This is not a whinge but an observation of where we as individuals and as a society are at present, with time and energy rationed and the world racing past at a furious rate.

Last year ended on a huge high for the society, as I hope you will see from this edition of TAM; MSA05 was a great success and achieved a great deal. One of the big reasons for having the conference in Canberra was to promote the causes of the Society and metrology in general to government. I believe this was achieved quite well. The opening address by the Hon. Warren Entsch, Parliamentary Secretary to the Department of Industry, Tourism and Resources, and the plenary session by Alan Lawrenson, Executive Director, Science Industry Australia Inc, lead to a great number of exchanges over coffee and some very useful linkages for the Society. In particular there is strong interest from Alan to work with us on the training issues and raising the profile of the metrology and the skills shortage. A major win!

As a part of the conference we made a press release to the local and national press. You will find a copy of it later in this edition of TAM. This is I believe one of the big things the Society needs to focus on. If we hope to make a difference at a policy or broad scale industrial level the MSA needs to be recognised as a real credible voice for the Metrology industry in Australia. A billion dollar industry! This is my personal goal for remainder of my Presidency.

In all aspects the conference was a great success, from the NATA starter with "The Five Degrees of Freedom" and their great entertainment to the closing BBQ. My observation was that it was a success at all levels with great social activities, high quality and varied papers, a really effective Trade Exhibit and solid linkages for both the Society and individuals formed. I personally, and the National Committee in general, cannot thank Ilya Budovsky and Marian Haire highly enough for there leadship, vision and implementation of this conference. We would also like to thank Jamie Hall, Ian Bentley, Stephen Grady, Adrian Caster, Thomas Hagen, and Leigh McKinnon for his amazing marketing of the conference.

The energy of the conference I am pleased to say overflowed into the AGM with three new people joining the National Committee. I would like to officially welcome Les Felix and Maurie Hooper from SA, and Gary Want as the first representative from NT on the committee.

Les became so enthusiastic that he even put up his hand to organise the next conference which is to be held in 2007 in SA. He has pulled a great team of people around him and they are already well on the way.

The other great thing to come out of the conference was that while having stepped down from the National Committee, John Widdowson has put his hand up to be the State Representative for Victoria. This was wonderful news to me as Victoria has effectively been without a representative since Mark Jenkins left for Saudi Arabia nearly four years ago. Thank you John for your great work on the National Committee and for taking courage of getting Victoria going again. John is building a small team around him and I am sure would welcome any assistance you might like to offer. To all Victorian members, I would ask you to really get behind John and build our metrology community back up.

- Dr Jane Warne

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An Update on the Kilogram

Ian Mills

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UK

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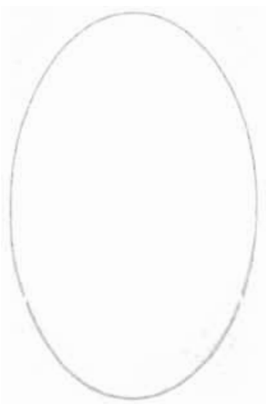


We need a new definition for the kilogram! The present definition (see the following box) was sanctioned by the first General Conference on Weights and Measures (CGPM, Conférence Général des Poids et Mesures) in 1889, with a minor revision to the words in 1901, and remains unchanged after 116 years. It is the only base unit of the International System of Units (the SI) that is still defined in terms of a prototype artefact, the International Prototype of the Kilogram (IPK) kept in a safe at the International Bureau of Weights and Measures (the BIPM, Bureau International des Poids et Mesures) in Sèvres, near Paris.

The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

The definitions of the base units play a key role in modern metrology, a subject of ever greater importance in our society. International trade, macro-engineering such as the construction of aircraft wings made in Britain to fit a hull made in France, micro engineering such as the manufacture of integrated electronic chips with many thousands of elements, the measurement of drug concentrations in medicine, the measurement of pollutants in the environment – all these, and many more, demand reliable measurements, to an appropriate level of accuracy for the purpose concerned, and with a known and appropriate uncertainty. In defining the units of the SI upon which this subject is built we endeavour today to choose definitions that are referenced to quantum properties of atoms or to fundamental constants, a subject known as quantum metrology. Thus our unit of length (the metre) is defined in terms of the speed of light, and our unit of time (the second) in terms of the period of the hyperfine frequency of a caesium atom. These are believed to be "invariants of nature", available to anyone, anywhere, at any time, and thus are appropriate references for the internationally agreed units of our system.

The present definition of the kilogram in terms of the IPK does not fulfil this requirement, and moreover there are good reasons for believing that the mass of the IPK, along with all its official copies, may be "drifting" in relation to a true invariant such as the mass of a carbon atom, by perhaps as much as 100 μg (0.1 ppm, or a part in 10^7) over periods of time of the order 50 years. The IPK, a cylinder of platinum-iridium alloy measuring 39 mm high by 39 mm diameter, has been weighed against its various copies three times since it was made: in the 1890s, in the late 1940s, and most recently in the late 1980s. The conclusion from these periodic reviews is that the various kilogram artefacts may well be changing in mass as described above. This is believed to be due to surface contamination (they are stored and weighed in air), wear and tear from handling, and the possible leaching out of gases occluded in the artefact when it was manufactured.

We would like a new definition, and we would like one that would fix the kilogram in terms of what we believe to be an invariant of nature, such as the mass of an atom, or a fundamental constant. Draft words for two possible new definitions of the kilogram that have been discussed for the past fifteen years or more are shown in the following box.

A draft definition of the kilogram to fix the Planck constant h :

The kilogram is the mass of a body at rest such that the value of the Planck constant h is exactly 6.626 069 311 x10^{-34} joule second.

A draft definition of the kilogram to fix the mass of the carbon 12 atom $m(^{12}C)$, and also to fix the atomic mass constant m_u and the value of the Avogadro constant N_A:

The kilogram is the mass of exactly (6.022 141 527 x10^{23} / 0.012) unbound carbon 12 atoms at rest and in their ground state.

It may not be obvious that fixing the value of the Planck constant defines the kilogram: it does so, because h = 6.626... J s = 6.626... kg m^2 s^{-1}, and since the metre and the second are already defined in terms of invariants, the value of the kilogram is fixed once the numerical value in this expression is fixed. Similarly $m(^{12}C) = (0.012 / 6.022...\times10^{23})$ kg , and fixing the numerical value in this expression has the effect of determining the value of the kilogram in the second alternative definition.

There are two experiments that are relevant to these two alternative definitions. The first is the watt balance experiment, in which a weight is measured against the electrical force generated by a coil carrying a current suspended in a magnetic field, the electrical measurements being made using the Josephson and quantum Hall effects. The second is the X-ray crystal density experiment, in which a perfectly spherical single crystal of silicon is weighed against a kilogram standard, and its lattice spacing is measured by X-ray diffraction, allowing a calculation of the number of atoms in the crystal from its diameter. The watt balance leads to a measurement of the Planck constant h in terms of the kilogram, and the X-ray crystal density experiment leads to a measurement of the Avogadro constant N_A in terms of the kilogram. However if we were to fix the value of h, it would define the kilogram, and the watt balance could then be used to realize the definition. Similarly if we were to fix the value of N_A it would define the kilogram, and the silicon crystal density experiment could be used to realize the definition. Both experiments are complex, and both are expensive and difficult to perform with high accuracy. The present relative uncertainty of measurement in these experiments is about 0.08 ppm for the watt balance experiment, and about 0.4 ppm for the X-ray crystal density experiment .

Either of the two alternatives would therefore give us a definition referenced to an invariant of nature, in place of the somewhat uncertain platinum-iridium prototype used in the present definition. Either could be realized by the experiments described in the previous paragraph, and would also give us a reference available to anyone, anywhere, at anytime, unlike the prototype reference that remains locked in a safe in Sèvres. However, a recent paper by Mills, Mohr, Quinn, Taylor and Williams, *Metrologia* 2005, **42**, 71-80, has drawn attention to the fact that there are further important considerations involved in changing the definition.

All mass measurements are relative. We measure the mass of one object against another. Our ability to make such measurements has improved dramatically in the last hundred years, and even during the last ten years. To discuss the uncertainties in such experiments we have to consider two distinctly different kinds of mass measurement. On the one hand we may be concerned with measuring the mass of macroscopic objects, measured in grams or kilograms, usually using a balance of some kind. This, to most of us, is the kind of mass measurement that immediately springs to mind; we might call it "macroscopic mass metrology". The reference standard for such measurements is (at present) the prototype kilogram, the IPK, used in the current definition of the kilogram. The IPK has proved a convenient reference for making macroscopic mass measurements, and even if we change the definition to one of the alternatives, it is likely to remain an important intermediate step in relating mass standards around the world for macroscopic mass measurements.

On the other hand, physicists and chemists are concerned with the masses of atoms and fundamental particles, which may be compared with each other by mass spectrometry, for example. The reference standard for these measurements is the unified atomic mass unit, symbol u, defined as one twelfth of the mass of a carbon 12 atom, $m(^{12}C)/12$, also known as the atomic mass constant m_u.[1] We might call such measurements "microscopic mass metrology". It is also a fact that the best estimates of the values of many of the fundamental constants of physics, such as the Planck constant h and the elementary charge e are strongly correlated with the atomic masses, so that whenever we discuss the masses of the atoms we have also to consider the values of the fundamental constants.

Some of the fundamental constants whose values depend on the kilogram:

unified atomic mass constant m_u	**Josephson constant K_J**
electron mass m_e	**proton gyromagnetic ratio γ**
Planck constant h	**Faraday constant F**
Avogadro constant N_A	**Bohr magneton μ_B**
elementary charge e	**Nuclear magneton μ_N**

1. This unit is also known as the dalton, symbol Da. The latter name and symbol is widely used by biochemists and others concerned with the mass of large molecules that may be measured in kilodaltons, kDa, or megadaltons, MDa. Thus 1 Da = 1 u = m_u = $m(^{12}C)$ / 12.

The present situation is that relative mass measurements within either the field of macroscopic or microscopic masses can be made with very much higher precision than that with which we are able to compare masses between the two fields.

For example, it is possible to compare the mass of two kilogram artefacts using the best modern balances to better than a part in 10^9, a relative uncertainty of less than 0.001 ppm, or less than a microgram in a kilogram. Similarly the mass of an electron m_e can be determined relative to the unified atomic mass constant m_u with a relative uncertainty of 4.4 parts in 10^{10}, 0.000 44 ppm. However, when it comes to measuring the mass of any of the fundamental particles in terms of the present SI kilogram, the uncertainty is about two parts in 10^7, 0.2 ppm, a relative uncertainty more than two orders of magnitude greater. Such measurements are dependent on either the watt balance or the silicon crystal density experiment. The present uncertainty in our best measurement of m_e/kg, for example, is 0.17 ppm, and there is a similar uncertainty in all atomic and particle masses when they are expressed in the present SI kilogram. Moreover, most of the fundamental constants of physics depend on the kilogram (see previous box). The best estimates of these constants are revised at intervals by the CODATA (Committee on Data for Science and Technology) Task Group established for this purpose, and the most recent 2002 revision was published earlier this year (Mohr and Taylor, *Rev. Mod. Phys.* 2005, **77**, 1-107). This review shows that the present relative uncertainties in the fundamental constants, when expressed in SI units, are mostly around 0.2 ppm. In every case the dominant contribution to this uncertainty is simply the uncertainty in relating atomic or particle masses to the macroscopic reference kilogram, the IPK.

The present situation regarding redefining the kilogram is, therefore, as follows. If we were to change to a new definition using an atomic mass or a fundamental constant as a reference, it would follow immediately that all particle masses and fundamental constants would be known with an uncertainty reduced by two orders of magnitude – because their values expressed in SI units would no longer involve a knowledge of the bridge between macroscopic and microscopic masses. Both the elementary charge e and the Josephson constant K_J would also be more accurately known by a similar factor, so that all electrical measurements made using these constants would be similarly improved. These are important advantages. The effect on the values of the fundamental constants is illustrated in the following box.

Value, and relative standard uncertainty, for the mass of the IPK, m(K), and for a small selection of fundamental constants, for three different definitions of the kilogram (abstracted from Mills et al., Metrologia 2005)

1. m(K) fixed (current definition, Box 1)
2. h fixed (first definition in Box 2)
3. N_A fixed (second definition in Box 2)

value	relative uncertainty
mass of international prototype m($\mathcal{K}$)	
1. 1.000 000 00 kg	(exact)
2. 1.000 000 00	0.17 ppm
3. 1.000 000 00	0.17 ppm
Planck constant h	
1. 6.626 069 3 $\times 10^{-34}$ J s	0.17 ppm
2. 6.626 069 311	(exact)
3. 6.626 069 311	0.0067 ppm
Avogadro constant N_A	
1. 6.022 141 5 $\times 10^{23}$ mol^{-1}	0.17 ppm
2. 6.022 141 527	0.0067 ppm
3. 6.022 141 527	(exact)
electron mass m_e	
1. 9.109 382 6 $\times 10^{-31}$ kg	0.17 ppm
2. 9.109 382 551	0.0067 ppm
3. 9.109 382 551	0.00044 ppm
elementary charge e	
1. 1.602 176 53 $\times 10^{-19}$ C	0.085 ppm
2. 1.602 176 532	0.0017 ppm
3. 1.602 176 532	0.0050 ppm

However, the mass of the IPK would no longer be 1 kg by definition, but would have to be determined by experiment. Although the constant appearing in the new definition would be chosen so that the mass of the prototype would initially still be exactly 1 kg, it would be subject to the uncertainty of about 0.2 ppm that applies to all atomic masses under the present definition, and it is also possible that future measurements would lead us to revise the mass of the IPK so that it might be slightly different from 1 kg. Although it is unlikely that this change would ever be greater than 0.2 ppm, this is seen as a disadvantage of changing the definition by those concerned with macroscopic mass metrology. Mills et al. suggest that, after changing the definition, macroscopic mass measurements could continue to be made in terms of the mass of the IPK, with a correction factor being applied in those rare occasions when it is really necessary.

If, however, we retain the present definition, then the values of the fundamental constants expressed in SI units will remain uncertain to about 0.2 ppm, just as they are at present. The mass of the IPK will remain equal to 1 kg by definition – although this would not dispel doubts arising from the uncertainty of the mass of the IPK compared to an invariant of nature. The magnitude of this uncertainty is not known, but it is believed to be of the order 0.05 ppm, or possibly as much as 0.1 ppm.

In this brief review it is not possible to cover all the problems of redefining the kilogram, and readers are referred to the paper by Mills et al. for further details. However there is one further point to note here, which concerns the timing of any possible change. Changes to the base units of the SI are made by the CGPM, on the advice of the CIPM (International Committee of Weights and Measures) and its various Consultative Committees. The CGPM meets at four year intervals, and the next two meetings will be in October 2007 and in October 2011. There is little doubt that the definition of the kilogram will eventually be changed to one of the two alternatives given here, but there are different opinions about when to make the change.

The argument for making the change as soon as possible is that once we change to one of the definitions in Box 2, we shall know the values of the fundamental constants with much reduced uncertainty, and, moreover, future CODATA reviews can only lead to zero or very small changes in their values. We shall also be using a kilogram defined by reference to an invariant of nature. This has to be set against the fact that improved watt balance results in a few years time might perhaps lead to small changes in our estimate of the mass of the IPK, which will almost certainly continue to be used as an intermediate reference standard in macroscopic mass measurements. But such changes are unlikely to be greater than the believed uncertainty arising from the drift in the mass of the IPK compared to a true invariant.

On the other hand, the possible advantage in postponing the change is that new watt balance results in the next few years *cannot* lead to any change in the mass of the IPK, which will always be 1 kg by definition, although, of course, doubts about the drift of its true mass will remain. However, we would lack the advantage of lower uncertainties in the fundamental constants, and new watt balance measurements might lead to significant changes in the fundamental constants in future CODATA reviews. This would be an inconvenience to atomic and molecular physicists, and to electrical metrologists who make use of the Josephson constant and the elementary charge.

The choice is between redefining the kilogram now, so that it is referenced to an invariant of nature, and the fundamental constants are more exactly known and will not be subject to significant future changes, or postponing the decision until new experiments have reduced the uncertainty in the relation between the atomic masses and the IPK to some chosen value, perhaps 2 or 3 parts in 10^8, and putting up with the disadvantages in the meantime.

In writing this short article, I have tried to present the various arguments objectively, without taking sides. However I must conclude by saying that I personally find the arguments for making the change as soon as possible to be compelling. I would also prefer the new definition chosen to fix h rather than N_A, although the difference is small, because of the central place that the Planck constant has as the fundamental constant of quantum physics. ■

- Ian Mills, May 2005

Quantification - Number 7

Jeffrey Tapping

More On The Fahrenheit Temperature Scale

In the last issue I left unexplained how Fahrenheit came to use the numbers that he did when he invented his temperature scale. There were two factors at work here. Firstly it should be appreciated that the temperatures of greatest interest in Fahrenheit's time were those of the environment and how these affected people. So his zero, obtained from a mixture of ice and salt, was about the lowest temperature he could imagine occurring in nature. And a particular temperature of interest was that of the human body, to which he assigned the temperature of 96 °F. Which brings us to the second factor. Fahrenheit liked the idea of a scale based on multiples and fractions of two, so the freezing point of water was defined to be 32 °F (two to the power five), and the interval from there to the body temperature was 64 °F (two to the power six).

One source of information says that Fahrenheit did not immediately arrive at this scale, that in fact it evolved over time. His original thermometers had more ill-defined markings, with a span of 26 degrees each divided into four parts. Some of these degrees had descriptions, for example the second was labelled "greatest cold", the fourth "very cold", the eighth "cold", and so on up to "unbearable heat" on the twenty-fourth. Fahrenheit was later influenced by the astronomer Röemer who also made thermometers. For calibration points Röemer used an ice-water mixture, and water at blood temperature, and he then used a complicated dividing system that made the ice point 7½ degrees, and blood temperature 22½ degrees. Fahrenheit adopted this system for a time but with each degree further divided into four parts. Later he tidied up the scale to eliminate the untidy fractions and arrived at the scale described in the paragraph above. At this stage he was still using alcohol as his liquid, but the alcohol was not very pure, which distorted his scale. With purer liquid and the same values for the ice and steam points, the body temperature was found to actually be 98 degrees.

Fahrenheit seems to have been the first to try to investigate the rise in body temperature resulting from infection. In one of his publications he wrote: "If, however, the temperature of a person suffering from fever, or some other disease, is to be taken, then another thermometer must be used having a scale lengthened to 128° or 132°. Whether these degrees are high enough for the hottest fevers I have not yet examined; I do not think, however, that the degrees named will ever be exceeded in any fever." I presume that he found in due course that a person with a body temperature of 132° F would be well past being sick, they would be cooked!

An interesting fact which comes out of reading this history, is the mobility of scientists at this time when travel was difficult and often hazardous. Fahrenheit was born in Danzig in Germany, was sent to Amsterdam for an apprenticeship, had his glass tubes made in Berlin and Dresden, and visited England and Denmark to show off his thermometers. It looks as if there was a great deal of unrecorded exchange of experience and views with only occasional records such as letters to attest to it. So it is difficult to be absolutely sure who was really the originator of some new ideas. One thing is clear though - Fahrenheit was the first to make thermometers which had consistent calibrations, and he set the standard (pun intended), for all who followed him.

* * *

Now let us consider the obscure units from last issue.

Tonelada

It will not surprise you to find that the tonelada was an Iberian version of the ton. The name seems to be "ton" with a suffix added. The value differed a bit between Spain and Portugal:

1 Spanish tonelada = 0.905 Imperial ton = 919.9 kg

1 Portugese tonelada = 0.781 Imperial ton = 793.2 kg

Picul

The *picul* is related to the *kati* discussed in Quantification 5. Again it was a weight artificially devised by European countries for use in the Far East colonies in relation to trade and customs duty. And again the system varied from place to place.

In Malaya, 1 picul = 100 kati = 60.5 kg

In Japan, 1 picul = 100 kin = 60.0 kg

Ephah

This was a unit of dry capacity used in ancient Israel, and is mentioned in the Old Testament. Of interest to us is that it was part of a complicated series of units that illustrate that the ancient traders must have had a good grasp of mental arithmetic.

1 ephah = 3 seah, 10 omers, 18 kab, 72 logs, = 40,320 cubic centimetres

5 ephas = 1 lethech

10 ephas = 1 kor

Oitavo

This is a unit you will not have stumbled across, but if you said that it sounds Spanish you would be close. In fact it is an old Portuguese measure of liquid capacity equal to 1.73 litres. It is an interesting case of a measurement archaeological conundrum, because the name means an eighth, and two *oitavos* make one *quarto*, but there is no known unit making the whole 13.8 litres.

Bath

All those who said this is a large container for washing things in can go to the bottom of the class. As a measurement unit it ***is*** associated with liquids, but that's as close as you got to the correct answer. It is actually a volumetric measure used in ancient Israel, equal to 40.32 litres, used mainly for measuring quantities of oil. And if you are sharp you will have noticed that the volume of one *bath* is exactly the same as one *ephah*, its just that one term was used for liquid and the other for dry goods.

Tog

If you wondered if this had anything to do with "getting your togs on", you were correct. It is a measure of the thermal resistance of clothing and other items that we use to keep us warm, such as bed-spreads. Specifically, one tog is equal to ten times the temperature difference across the item when the heat flow through it is one watt per square metre. The name is taken directly from old London slang for clothing. It is speculated (and it makes a good story so it must be true), that the path began with *tegere* which is Latin for " to cover or clothe", to the Dutch *doek* and/or German *tuch*, meaning cloth, to *duck*, a kind of cotton canvas. Also it is probably related to the expression "to be decked out" meaning finely dressed.

This unit is defined in terms of SI units, and a similar unit was also defined in Imperial units called the *clo*. You can figure out for yourself where the name came from. And to once more illustrate the convenience of the SI system, one *clo* is defined as 0.875 foot-hour-°F per British Thermal Unit.

* * *

And now the ponder-fodder.

Why is it that as the diameter of a wire becomes smaller, the wire gauge goes up, not down?

The reason is that the numbers originally represented the number of dies used as the wire was drawn down in stages to the desired diameter. An exception was the Paris Gauge, in which a gauge of 1 represented 0.6 mm, and 30 represented 10 mm. In the SI system these old units have been replaced with simple diameters.

What is the origin of the DL envelope size?

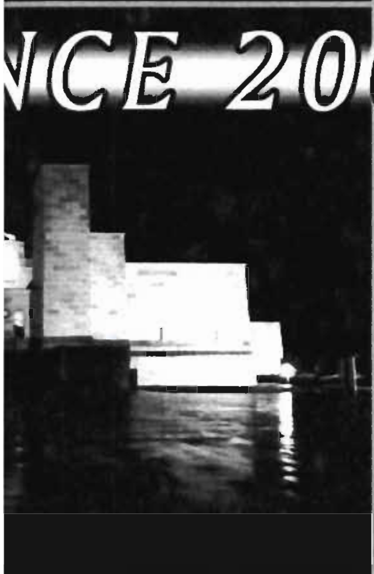
The DL envelope is part of the ISO paper size specifications, so let us look first at the general subject of paper sizing. In ancient times when I was at school, writing paper came mostly in two sizes that were called *quarto* and *foolscap*. These were respectively a bit smaller and a bit bigger than A4. I now find that these basic icons of my school years were misnamed. Official *foolscap* was 17 inches x 13½ inches, and our *foolscap* looks like it was this size cut in half across the middle. I suspect that this came about because our *foolscap* exercise books were formed by folded *foolscap* sheets. And I find that that *quarto* is not a size at all, but refers to the size of any sheet folded twice (into quarters). It looks like our *quarto* was just official *foolscap* cut twice, across the middle and down the centre.

There were in fact at least ten basic official sheet sizes varying from *atlas* at 26 x 34 inches, to *pot*

continued on page 12

CONFERE

UNIVER



NCE 2005

continued from page 9

at 12½ x 15½ inches, the names coming from the watermarks applied to the paper. To add to the confusion, *foolscap* could be up to 10% less than the sizes given above. So it was to tidy up this mess that ISO developed new international standard paper sizes. There are two series of sizes, with each having sides in the ratio of $1:\sqrt{2}$, and smaller sizes formed by cutting a larger sheet across the middle, which maintains the ratio of the sides. The A-series begins with A0 of 841 mm x 1189 mm (which gives an area of 1 m^2), and the B-series begins with 1000 mm x 1414 mm (which gives an area root-two bigger than A0). The C-series is of envelope-sizes suitable for holding sheets of the A-series, either flat or folded across the middle. Finally we come to the question of the DL envelope. It seems that users refused to desist in their old habit of folding their A4 sheets twice across at 1/3 and 2/3 the height, and this did not fit neatly into the C-series envelopes. So the DL envelope was introduced to take an A4 sheet folded twice. It is an anomaly and has no companions in a D-series. Another victory of common sense over dogma.

What other unit is represented by the symbol °R, in addition to the Rankine scale of temperature?

The answer is, surprisingly, another temperature unit, in this case the Réaumer temperature scale. Réaumer worked on thermometers in France at the same time as Fahrenheit was working in Holland. He used the melting temperature of ice as his sole reference point, which was designated as zero. He then derived the rest of his scale using a complicated system based on the volumetric expansion of the fluid, which was an alcohol-water mixture of specified purity. It so happened that the steam point came out very close to 80 degrees on his scale, and in time the scale came to be defined using 80°R as the steam point.

What is epagomenal time?

This term refers to an extra day inserted into a calendar to adjust it to solar time. The one we use is the extra day inserted into February in leap years, but past cultures had complicated calendars that required more epagomenal days. For example the ancient Egyptians, who had a year of twelve months each of thirty days, had to insert five extra days each year, plus another one each four years.

If you were looking at a shock of objects, what would you be looking at?

You would be looking at sixty of the objects. Well, perhaps sixty. It began as a word like "dozen", referring to the number of items in a group, but the quantity has varied in different applications. For example a shock of corn was twelve sheaves standing close together. The term evolved into a reference to a pile or bundle of items, and survives in the term "a shock of hair".

What quantity is represented by the unit, the *pond*?

As you all know, the metric system preceded the SI system, and many metric units arose in different places. The unit the *pond* seems to have been used for two different purposes, both of them for mass (or weight), and both in Europe. In Holland a pond represented 500 grams, and arose from an earlier local version of the pound. Generally in Europe the term *kilopond* was used for a kilogram-force, but I can find no reference to the use of *pon*d alone in this context. The mystery is, what confusion was there was in Holland between a weight of 500 kg and a kilogram-force?

And now the questions for the next issue.

1. If you look at old maps you will see areas referred to as *hundreds*. What is the origin of the term *hundred* in this context, and how does it relate to the *wapentake* and the *virgate*?

2. You are up to scratch with the *bath* and the *pond*. How about the *tub*, the *tank* and the *shower unit*?

3. What sort of measuring instrument is a *clepsydra*?

4. What is the *denier* system of measurement?

5. What unit is the *typp*?

6. We know that atmospheric pressure changes, so what exactly is a pressure of one *atmosphere*?

7. What was a *Tower Pound*?

8. What quantity is referred to as *ullage*? And how does it relate to the *tret* allowance?

9. What is the essential difference between an *acre* and a *jugerum*?

10. What is the difference between a French *arpent* and a Canadian *arpent*?

■

Riverbank Reflections 4

Ron Cook

I can clearly see a fish big enough for a satisfying feed, lazily waving its fins and waiting for some delicious morsel to plop into the water. Unfortunately I am without any fishing tackle, and besides, it's a golden carp in the feature pool outside the Common Room of the University House of the ANU, Canberra. Being caught molesting the wildlife here would get me frog-marched out of the territory. Yes, I'm at the 6th Biennial Conference of the MSA. No doubt there will be a review of the Conference elsewhere in this journal, but I'm going to give some of my thoughts on it anyway.

The NATA Starter is always an excellent way to commence proceedings. Those who have flown in no doubt need a little something to settle down after bumping their way over the Brindabella ranges and landing on a tarmac shared with gung-ho RAAF types. Perhaps not as much as those from the NMI who travelled in buses driven by colleagues. Not than any land speed records were set but having been both driver and passenger in similar situations, something a little stronger than chlorinated water is called for at journey's end. NATA's generosity certainly set the atmosphere for what was a Conference with a good sense of fellowship.

Canberra is an interesting place for the tourist. A large country town, it boasts modern museums, galleries, a couple of lakes, two parliament houses, and the best memorial in the whole country - the War Memorial. This has grown and developed remarkably in the last 4 years and would require great stamina and several days to adequately see all that is now on display. The National Museum and the Botanical Gardens were also rewarding places to see. The countryside was emerald green with new grass growth covering thousands of square kilometres where sterile pine forests once stood – resinous sentinels guarding against attack from the West.

Looking at how Mt Stromlo now sits in stark relief against the background of similarly nude hills with the burnt remains of old buildings on the skyline, it is difficult to recall that it was once invisible until the last few metres of the drive up the winding road through the silent forest of pinus radiata. The great fire that two and a half years ago swept the area could so easily have caused much more destruction. Much of the forest was completely burnt to the ground, no trunks or stumps remaining, so intense was the heat. Little rows of burnt trunks can be seen in many places and, although tens or even hundreds of thousands of native trees have been planted, it may be for a decade or two that the landscape will continue to be more like the pastures of Gippsland than the forests of the ACT. As I write, another report on the fire that was allowed to get away is being discussed. Another case of a group of people not properly using their collective knowledge and skill anywhere near their potential and the result being great economic loss.

The emus and kangaroos who have been able to move into the area must think that they are in grass-eaters heaven. I've never seen such a high proportion of kangaroos with joeys and two of the emus would have been more than enough for the end of conference BBQ.

Perhaps we should all reflect on whether we are making the most of the human resources around us. Have we recently summarily rejected out of hand an idea a colleague has put forward? Many metrologists today face the equivalent of a dangerous fire coming out of the hills and consuming the business. Is there any smoke out there? Large laboratories that stuck with traditional methods and failed to make management understand the productivity that could be obtained from a laboratory if changes were made, have closed. The calibration work has been taken up by smaller more agile commercial laboratories. Regrettably the research activities associated with these larger laboratories has ceased.

It would have been untenable for things not to change for these largely government owned laboratories. One example where some lateral thinking and a lot of hard co-operative work has produced a new and vital laboratory activity from several groups under threat is the NMI. We have just seen some more redundancies in CSIRO and there is no doubt that the old NML would have been cut further had it stayed there. The AGAL was up for a review with the pending retirement of its eminent head Dr Sandra Hart and the NSC, although ably lead by Dr Judith Bennett, was feeling the pinch in several areas. With leadership from Dr Barry Inglis and huge amounts of effort from the other organizations, political support was obtained for a radical move - take the NML out of CSIRO and merge it within a new NMI along with the AGAL and NSC. A bold move undertaken after wide consultation and much planning, it required the combined talents of the leaders in these three organizations plus the good will and guidance of senior staff in the DITR to make it happen.

Judging by the papers presented at the Conference the NMI has consolidated and is moving into productive areas of research while still providing a wide range of scientific services and support to the community. Funding for capital expenditure has improved and the various training programs have been welded into a solid structure covering many areas of metrology.

So, for these achievements alone, Barry Inglis richly deserved his election at the AGM as a Fellow of the MSA. His prior work as a scientist, manager and founding vice president of the MSA would have been more that enough.

The conference dinner was held literally under the wing of the famous Lancaster bomber, *G for George*. Full marks to the organizing committee for a memorable evening. The formal entertainment was, not surprisingly, based on the activities of our politicians. I'm grateful my job never exposed me to the scrutiny of journalists, comedians and the general public as are politicians. While I have a pretty cynical view of many of our politicians, Warren Entsch, the Parliamentary Secretary to the Minister for Industry, Tourism and Resources, presented very well and showed a genuine interest in matters metrological while opening the conference. He has been a staunch supporter of the establishment of the NMI and as an indication of his ability to deal with a diverse range of activities is deeply involved with the indigenous members of his electorate.

With more than 40 technical papers presented in three parallel streams, I found myself having to make some hard decisions about which one to attend. I think the mark of a good conference is one where this happens several times each day. Even though the proceedings has a copy of the paper, the presentation is always, for me at least, more enjoyable and educational. The workshops on training, pressure measurement, and CMMs were by all accounts a great success. The session chairmen did a splendid job in keeping the speakers to time, thus allowing many attendees to switch streams.

Dr Ilya Budovsky and his committee did a sterling job with this Conference. Hearty congratulations are in order for all involved. The trade displays were of a high standard. Whilst I am now unlikely to be directly involved in purchasing any of the goodies on display it was interesting to see the technology and a good exercise to think about the differences in uncertainty achieved by different systems. I use the word system deliberately as today there are few measuring instruments that aren't a system. What sort of instrument isn't a system? Well yesterday I saw a Liquid-in-Glass thermometer in a cut-price shop. Brand new and with a scale length of 300 mm that allowed me to read the ambient temperature adequately without my glasses. Even more impressive was that the three units I inspected all read the same within my ability to read them. Cost for this very useful instrument? $2.00. Now all I need is to get someone to calibrate it for a fee not exceeding 50% of the purchase price.

I enjoyed catching up with many old friends, but quickly it was all over and the BBQ and closing ceremony was upon us. Dr Jane Warne, our intrepid President, announced that the next Conference, in 2007, would be held in Adelaide. This city has long been a centre for advanced electronics and defence systems, based around the old Weapons Research Establishment and the Woomera rocket range. Today BAE Systems and several Department of Defence facilities carry on the tradition. Perhaps there will be scope for delegates to have an industry visit preceding or following the Conference? No doubt, during the Conference, there will also be some scope to experimentally determine if McLaren Vale or the Barossa or Clare Valley produces the better wines.

Alert readers will have noticed no technical content whatsoever in this piece, nor any river. Well a long reflecting pool alongside a well manicured lawn is the best I can offer in place of a river and the column is meant to be reflective rather than particularly technical; much easier to digest. And that brings me to a conclusion. The sustenance supplied at the Conference was first class, so the fish in the pool was never in any real danger. I'm told the only way to eat these carp is to bleed them immediately after capture and grind up the flesh to make fish patties strongly flavoured with thyme. Lots of flour and egg are apparently also recommended and having none of these at hand I stuck to the open sandwiches and scones with strawberry jam and thick cream.
Ah, now its time to stop and go for a walk to see if I can get rid of that extra Conference kilogram I picked up.

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Metrology Society of Australia

ABN 802 123 257 48

Annual Financial Report 2004/05

Treasurer's Report:
This financial situation of the society is strong with the $97,364 cash and an operating surplus for the 12 months of $8,214. As the reports are prepared on a cash basis, the underlying operating profit/loss can hidden by large variability in the subscriptions collected in the period and the costs that just happen to occur between 1 July 2004 and June 30 2005.

No conference occurred during this year although a late expense for MSA2004 is included and some early income for MSA2005.

Which Bank:
We have changed banks this year from the Commonwealth to Westpac enabling improved efficiency in internet banking and greater return on cash investments. At June 30 all cash was in the cheque account on the way to the new cash management account allowing flexible transactions and an interest rate currently at 5.2%.

New Database:
A new database has been recently introduced to streamline management of subscriptions providing improved reporting and simplified administration generously provided by the National Measurement Institute under the care of Maria Mochnik. Maria has done a fantastic job in coping with the old database and bringing our systems into order. The management of member's subscriptions will be overhauled next year with a clear schedule of invoicing and reminders encouraging all members to pay promptly and cost effectively.

Fees:
We are asking for subscriptions to increase across the board this year by a small amount to keep up with costs and allow for planned improved services to members in the future. At the same time we would like to abolish the joining fee to encourage new members and those who have retired from the society to consider rejoining without penalty.

As part of this report I propose we continue with the appointment of Marianne Philips as our auditor for the next financial year.

R Anderson
Dated: 5 October 2005

Statement of Financial Performance
As at 30th June 2005

		2004-05	2003-04
Assets:			
	Westpac Cheque Account	97,364	0
	CBA Cheque Account	0	29,641
	Cash Management Accl	0	17,362
	Term Deposit 1	0	19,193
	Term Deposit 2	0	12,413
	Term Deposit 3	0	10,508
	Total Assets:	**97,364**	**89,118**
Equity:			
	Retained Earnings	89,118	76,371
	Net Surplus/(Deficit)	8,214	12,747
	Total Equity:	**97,364**	**89,118**

Metrology Society of Australia – Treasurer's Report continued.

Statement of Financial Performance
For the year ending 30th June 2005

		2004-05	2003-04
Income:			
	Fees:		
	Fees	15,990	12,140
	Conference Income:		
	Registration	2326	36,995
	Merchandise	71	265
	Sponsorship	3,000	19,477
	Total Conference Income:	**5,397**	**56,737**
	TAM subscriptions	0	0
	Interest	3,116	2,285
Total Income:		**24,503**	**71,162**
Expenses:			
	Conference:		
	Advertising	0	4,179
	Proceedings MSA2004	2400	2,498
	Satchels & Invited Speakers	0	5,515
	Conference Dinner	1,000	12,509
	Venue Hire Catering	1,500	20,627
	Transport	0	996
	Credit Card Merchant Fees	0	701
	Miscellaneous	0	1470
	Total Conference:	**4,900**	**48,494**
	Society:		
	Sponsorship CMM Standards Meetings	0	1,000
	Fair Trading	0	0
	Workshops – State Function Costs	248	262
	Bank Fees	413	310
	State Floats Reimbursements	890	984
	IMEKO	0	705
	Meetings	60	217
	Office & Miscellaneous	325	79
	Web Site	669	804
	Insurance	694	694
	Total Society:	**3,298**	**5,055**
	TAM Magazine	**8,091**	**4,866**
Total Expenses:		**16,289**	**58,415**
Net Surplus/(Deficit):		**8,214**	**12,747**

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N°1190
PATENT
EARTH
BRIDGE

Press Release from the Metrology Society of Australia

18 October 2005

Metrologists Advancing Industry

Over a hundred metrologists, (measurement scientists) from across the country will converge on Canberra from the 19th to the 21st October 2005 for the Metrology Society of Australia's 6th biennial conference. The Hon Warren Entsch MP, Parliamentary Secretary to the Minister for Industry, Tourism and Resources, will open the conference.

This conference "Smart Measurements – Metrologists Advancing Industry" will discuss state-of-the-art measurement technologies that contribute significant economic value to Australia. The conference is wide ranging and deals with real-world problems such as the need for improved blood pressure measurements or reference materials for sports drug testing.

One of the pressing issues to be discussed relates to training. Like many other industries that have depended upon on the job training, metrology is struggling to recruit and maintain skilled people. Traditionally, measurement specialists have learnt their trade working in government or utilities' laboratories. However, outsourcing, privatisation and the drive for increased productivity of the past 10 years, has resulted in smaller private laboratories struggling to provide the necessary training or recruit trained personnel.

Earlier this year the Government raised the issue of skills shortages in some industries. Metrology and calibration did not make it onto their lists. Without action to stop the haemorrhage of skills in measurement, there will be a major impact on Australia's manufacturing, infrastructure and mining industries.

Measurement contributes strongly to 50 to 60 % (GDP) of the value of Australian trade. It is also all pervasive. Whether it is in filling the car with petrol, exporting coal to Asia or firing the furnaces of industry, these transactions rely upon trustworthy measurement. The measurement industry adds 3 to 4% to the GDP. It also adds to the health and safety of the community. A significant part of the near halving of deaths on the roads over the past 40 years is a result of reliable and accurate measurements.

The government has demonstrated its commitment to the industry at high levels through the successful amalgamation of National Measurement Laboratory, AGAL and the National Standards Commission last year to form the National Measurement Institute. It greatly strengthened the measurement infrastructure. The measurement community now looks to work with Government to address the current training and retention issues.

For further information please contact Dr Jane Warne on 0409 335 967

2005 REPORT SOUTH AUSTRALIAN GROUP

The start of this year saw changes in the number of members attending meetings; leaving us to question the content and venue etc. Since no one appeared willing to take the reins, I agreed to continue to organise the meetings in their smaller format. With my employer's blessing we now hold meetings at our Laboratory and order take away dinners eg pizzas.

We are going back to basics and are calling for members to bring unusual pieces of equipment for a "show and tell". (Since Abstec Calibrations is gathering pieces for a measurement museum in our foyer we might well unearth some interesting items.)

Since we have been given the opportunity to host the 2007 bi-annual conference of MSA this should be capitalised upon to bolster interest. We have already had eager people to tend to the different sections of the conferences. With Maurie Hooper, Jeff Tapping and Richard Duncan in the membership we have high expectations of a five star convention.

So please start on the next round of papers and email me if you would like us to consider any special content in the conference.

- Les Felix