The Great Melbourne TELESCOPE

PHOENIX

Astronomical Society of Victoria (A.I.N. A0002118S)

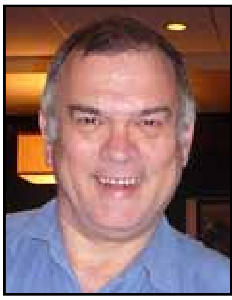
Issue 4 – May 2010

Editorial

Strewth! The previous issue of *Phoenix*, which described our activities up to workshop number 12, was done six months ago - I have excuses, of course. Now we are at workshop 46, but the early work was more spectacular and now there is less, per workshop, to show and report. For example, the Cube (isolated in workshop 8) and the Declination Axis (removed in workshop 5 as two stuck-together parts which still need to be separated) - are both still standing on their respective pallets today.

But instead, we have been pursuing the development of CAD drawings; listing, weighing and photographing the hundreds of parts of the GMT; developing the Parts Database; and removing paint and rust from the largest parts. These tasks all take time, and must be done carefully to avoid errors.

Weekly workshops have been running since mid 2009 with usually 8-10 volunteers attending; there have also been Sundays with 2-8 people, plus the MV staff presence.



All volunteers are welcome to take part - we think that we are having fun!

Steve Roberts
Editor

GMT WEB SITE IS READY

The GMT project now has its own web site www.greatmelbournetelescope.org.au and its own logo, which is featured on top of this page. After admiring this, you should visit the site, from which you can download or read a lot more material, including concise Fact Sheets on different aspects of the telescope and its history, prepared by Steve Bentley. You can also download this and all previous issues of *Phoenix*.

Drawing the GMT Parts

In parallel with the more visible task of dismantling and then cleaning the pieces, several volunteers have attended nearly every workshop to develop the paperwork. At the Museum storage premises, the GMT parts are kept and worked on in a sort of barn which is bloody cold in winter, and, as we feared, in the summer it was much too hot - see picture at right. But for desk work we have now been given our own room, which is nicely air-conditioned and heated.

Here's a close-up of Steve Bentley trying to draw a highly complex part - although he hasn't noticed that it is in two pieces. At least three specific documents must be developed for every part:

- A description of the part, on the proper MV form, recording its size, weight, appearance, condition, plus any and all markings which might give a clue as to where and how the part was used.

- A technical drawing, preferably to scale if not at the exact size, showing all possible measurements of the part, including the size of all holes in it.

- A Computer Aided Design (CAD) file, reproducing the technical drawing with even more detail if possible, sufficient to allow a replacement part to be made, now or far into the future.

Each of these takes some hours to produce, and there are hundreds of parts ranging from simple nuts & bolts to feats of engineering like the Cube, which has 6 machined faces with dozens of accurate holes drilled in each face. Enough detail must be written down to allow an exact replacement to be made. The description ends with a formal proposal for what to do next with the subject part, which will be signed off by Museum management before work can proceed. As listed in *Phoenix* 1, this proposal must be one of "conserve, restore, replace, adapt".

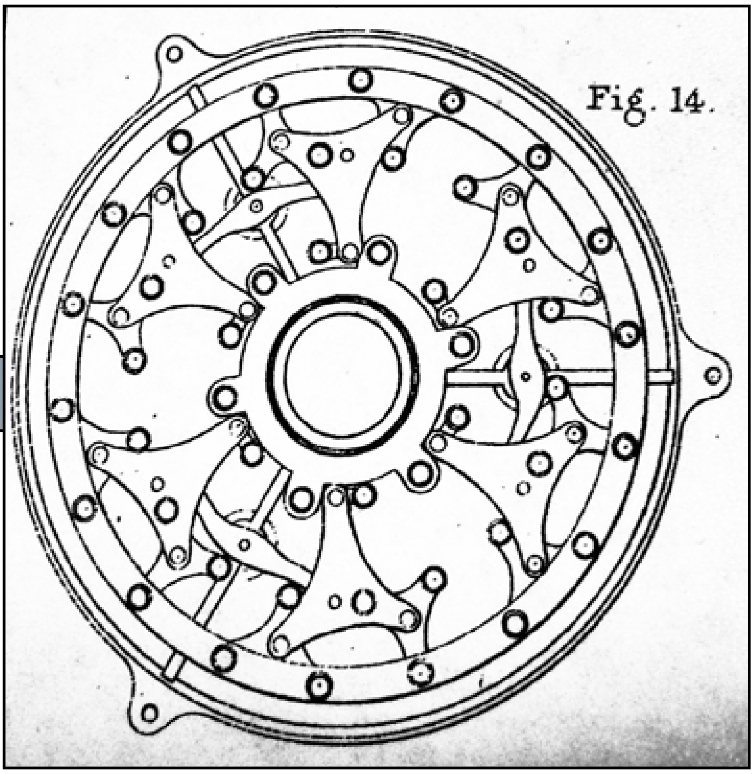
This is essential if unglamorous work; but the dedicated team of volunteers who are doing it have so far described, drawn and produced the basic CAD for about half of the major parts. Ideally, we should have inherited engineering drawings for all the parts, and these did once exist but all were destroyed in another bushfire in Canberra in 1952. But here we are now; and our intention is to leave a legacy such that engineers in a hundred years' time will be able to access our drawings (presumably, using a computer also stored in the Museum) and refer to them when repairing or modifying the telescope.

Here's a photograph of some of the volunteers … yakking away or wondering what to do next, while two are talking on their mobile phones. Woops, so here's a better picture *now that they know they are being photographed* - note the suddenly posed attitudes of studious dedication.

Initial Dismantling of the Mirror Cell

When the GMT was tragically destroyed by the 2003 bushfires, it was equipped with a modern Pyrex(*) mirror, mounted in a metal mirror cell which was fixed to the end of the telescope tube. Pyrex is a borosilicate glass, well known for its low thermal expansion and its strength - the best laboratory glassware is made of it, despite its much higher cost over ordinary glass. But although mirrors are still being made of Pyrex - the University of Arizona is busily churning out seven blanks, each *eight meters across*, for the Giant Magellan Telescope (another GMT!) - Pyrex is no longer made or worked in Australia.

And even with its low coefficient of thermal expansion, the picture on the right shows what an Australian bushfire can do to Pyrex glass - our mirror is shattered into a thousand fragments. The pieces of cullet (broken glass) are much smaller at the front surface, which was directly exposed to the radiant heat - here they are 5-20 mm across, whereas at the back, which was protected from rapid heating and cooling by the mirror cell, pieces of up to 400 mm in size are found. Anyway, if anyone knows someone who wants 400 kg of Pyrex cullet … one day the pieces may be suitable as souvenirs, if they can be rolled in a ball mill or some such treatment, because every edge of every piece is exquisitely sharp! Handling the cullet is quite hazardous and requires serious hand, face and eye protection; a terrible sort of micro-spray of tiny glass shards comes up if you even touch the shattered glass body.



Moving on to the mirror cell - the metal tray that held the Pyrex glass disk - we knew that the outer part of the tray was not original, but original internal components were believed to be present, under the glass. In particular, the GMT's original (and far heavier) speculum mirror was known to have rested on an ingenious 48-point suspension arrangement, as shown, which we were anxious to recover.

For some days we pondered on how to remove the Pyrex cullet from the mirror cell - for example, maybe several people with extensive protective clothing could pick it over with tongs, placing the cullet one piece at a time into a strong box for keeping. But MV's indefatigable Manager of Storage, Neville Quick, realised that it would be much quicker and easier to attach such a box upside-down to the pallet carrying the mirror cell, and "simply" invert the whole thing so that the cullet would fall into the box (I write "simply" in inverted commas because all sorts of safety aspects would have to be addressed).

*The brand name "Pyrex" is NOT derived from the Greek "pyr" (fire) and the Latin "rex" (king) - a Harvard graduate would never mix classical roots in that way. No sir, it had a much more mundane origin: Corning Glass Works brand names ended in "-ex" and the new glass was intended for pie dishes; and "pie-ex" became pronounceable as "pie-rex".

And in the event, that was exactly how it was done. Because the body of cullet was tightly strapped around its circumference to keep it together, and the central boss of the mirror cell was loose in the hole of the glass blank, the glass body slid off in one piece - well, in thousands of pieces, actually, but they did not move relative to each other. Now the inverted Pyrex body is sitting in its new box, where, for the foreseeable future, it can darn well stay!

Regrettably, when the now empty mirror cell was revealed to us, we found ourselves gazing upon a Stromlo-built nine-point mirror suspension system, which had twelve complex components around the edge of the mirror; the original 48-point system has been lost. However, we have reasonable sketches and drawings of it in publications contemporaneous with the original manufacture, as well as two later photos, and it would be great fun to re-establish the design and build it anew.

A replacement mirror can be lighter; a modern 48-inch mirror should weigh 200-300 kg and the Pyrex was 400 kg, whereas the original speculum mirror is about 1,400 kg. However, the support system required for a thin mirror is usually more complex than for a thick mirror.

The Stromlo mirror cell was furnished with several ingenious devices for holding the mirror in place and correcting for gravity when the telescope was moved; it had a unified design of 3-, 4-, 9-, and 12- point systems, with increasing degrees of subtlety. The picture at bottom right shows one of the twelve assemblies that pressed on the side of the mirror.

Paint Removal

It's all the rage these days! At every workshop we are trying to remove the paint from the telescope parts. But this is no ordinary paint - for a start there is a mixture of primer, undercoat and a sort of gray colour that must have been popular in 1869; then there's a light blue Stromlo paint from the 1950s and later. Some of the parts are painted with a toxic red lead undercoat which we are serious about removing. Plus, on all the parts that were in the bushfire the paint has been stoved on, forming a sort of enamelled finish that resists all chemicals and is slippery under the wire brush.

After admiring the various types of paint and different finishes exhibited, even by a single part (see first picture) we have found it best to begin by chiselling off the enamelled paint with a scraper. The technique is demonstrated here by the President of the ASV, Mr Barry Adcock who, among others, can be seen at every workshop toiling away on this thankless task. A close up shows how the paint spalls off in flakes 1-5 mm in size when the 'chisel' is lightly struck; it also shows the beautiful machined finish of a typical face of the Cube, which was hidden under the paint.

Having removed all paint possible by this technique, we resort to the wire brush. Paint stripper seems not to have much effect on its own, but when used in conjunction with the wire brush we have found that it (a) removes paint a little bit better, and (b) throws up a terrible, stinging, filthy spray of solvent, dust and paint particles against which we have to wear protective gloves and shields, which makes the work less fun. But eventually - for a large part, after maybe 6-8 workshops each of 3-5 hours work - the part is free of paint and shows its beautiful, gleaming metallic surface. We have now cleaned all the large parts, notably the Bell Housing, the Quadrant, Southern Cone and every face of the Cube, as the pictures show.

Having exposed the metal surface, which on a large part is all nicely machine-finished, it immediately starts to rust, so that if we brush it again a week later, a different-coloured patch will appear, and the whole piece might then need to be brushed again. So we apply a thin coating of light oil, which itself will have to be removed chemically. A decision has not yet been made on what the surface finish should finally be, but it is quite possible that the parts will be painted again :-(

Chat with Mt. Stromlo Engineers

Jim Pollock, the team leader for the ASV's GMT restoration effort, happened to be in Canberra recently and while there, he met engineers of Stromlo's Mechanical Engineering Section and Optical Workshop. Also present was the Project Manager from a publicly-listed company that has made some of the large telescopes for major observatories around the world. Jim briefed them on our work on the GMT so far and explained that once a forthcoming professional consultant's report was completed, we would be able to set about lobbying and raising funds. All were very much in favour of our efforts, and offered to help and advise in whatever way they could.

They suggested that a particular retired engineer, already familiar and delighted with our project, should come to Melbourne to inspect and review our restoration work on the GMT, at least for the mechanical aspects. This man was the project manager when the AAT was installed at Siding Springs, and had worked at Mt Stromlo for many years, thereby supervising the work on the GMT as it underwent numerous modifications.

Jim mentioned that we had discovered cracks in the cube (see page 7) running through the holes for the bolts that attached the cube to the polar axis cones. It was pointed out that since we plan to go back to the original Grubb arrangement, without the north polar axis cone, then the stresses on the cube's bolt holes will be very much reduced; and that since it had survived what Mt Stromlo had already done to it, there may be no problem.

The optical engineer said that full thickness (1:6) boro-silicate blanks of the size we want are a rarity these days, and he thought it might be difficult to source a full thickness mirror. Thin mirrors are cheaper but usually require a more costly support system. For the GMT we would have to see if we would require a more complex flotation support system than the original Grubb design and if so, the cost of that would have to be traded off against the savings on the mirror.

The GMT at Mt Stromlo, 18 months after the fire
Taken by Mr Enoch Lau, 30 Sept 2004. Source: Wikimedia Commons

The telescope-construction company has been using Russian mirrors for the last 10 years, and has found them to be of excellent quality; the cost partly depends on the wave front accuracy that is required. Making the f/4 mirror that we want for the GMT would be no problem, and the delivery time might be shorter, as the Russians are more used to making deeper mirrors with focal ratios around f/1 to f/2.

There is a workshop for the GMT (that is, the Giant *Magellan* Telescope - www.gmto.org) in Melbourne on 15-16 June 2010. Australia is contributing $88M towards the funding of this behemoth, which will have the equivalent of an 80-foot primary and 10-foot secondary mirror, our GMT's primary being 4-foot. Some of the engineers who met with Jim will attend this workshop, and may be able to visit our project in their spare time.

Cube Crack Test

Having isolated the Cube and cleaned off all the paint, we noticed a couple of small cracks on three faces, each going from the big central hole into a nearby threaded stud hole. At some of these points, an earlier threaded hole has been made and filled so that this is the weakest path where a crack might form.

In operation, heavy metal parts such as the Southern Cone, the Cradle, and the Bell Housing would be firmly bolted to the Cube, providing a bolstering effect and reducing stress at the cracks, but we thought it advisable to diagnose the presence of any further cracks and assess the risks associated with all of them. The Museum therefore brought engineers and equipment from their Spotswood site, who tested all holes in the Cube and estimated that the existing cracks were not very serious - an opinion willingly endorsed by the Stromlo engineers that Jim spoke with (see previous page).

The crack testing technique is interesting. The relevant area, already cleaned, is sprayed with a white paint to increase the visibility of what will happen next, then a fluid containing fine iron particles is sprayed on, and a two-pronged fork is immediately applied across the area. A heavy electric current is passed from one prong to the other, that is, through the metal workpiece, creating a magnetic field which is discontinuous at the location of any cracks. At such locations the iron particles gather together, forming a visible fine black line. The fluid remains present for a few seconds, enabling more iron particles from the homogeneous areas to flow towards the crack and add to the visible line. This is then photographed and/or examined on the spot.

The existing cracks were confirmed, but they do not go as far as the edge of the Cube and do not propagate any further than we could already see. One or two new cracks, of minor extent, were also detected. Thus we can say, to a first approximation, that the original Cube cast in Dublin in 1868 can be used safely in the restored telescope.

If a replacement Cube were required to be made now, it would not be of cast-iron as was the original - a minor miracle of engineering in its own right, for 1868 - but six flat steel sheets, about 25 mm thick, would be pre-drilled and bolted and/or welded together.

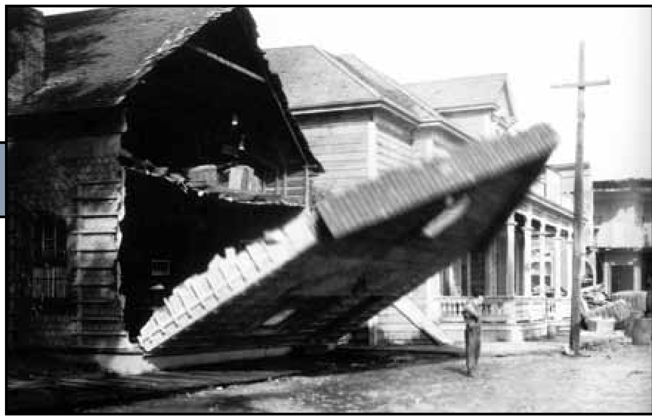
Weighing the GMT Parts

While handling the heavy parts with the overhead crane, we got the chance to weigh most of them. The original assembled telescope was known to weigh about 8 tons, and we will need to know the weight of every part so that we can ensure that the rebuilt telescope is properly balanced.

MV's weighing apparatus is like two overshoes for a fork-lift truck. These were placed on the concrete floor, within the overhead crane's operating area, and a spare empty pallet placed on top of them; the device's reading was then zeroed, making a sort of giant bathroom scale. Thereafter, any part that happened to be handled by the crane could be briefly dunked down onto it and weighed, accurate to 0.5 kg. Lesser parts were simply (ha!) lifted on and off the scales. Among the more spectacular results were:

Lowest third (boilerplate sheet) of tube	**645 kg**
Middle third (lattice of strips) of tube	**445 kg**
Cube	**822 kg**
Southern Cone of polar axis	**840 kg**
Declination axis, stuck-together pieces	**621 kg**
Cradle (joins tube to cube)	**465 kg**
Part 66 - Friction Relief (?) weight	**??? kg**
Speculum Mirror, very roughly	**1250 kg**
Mirror-polishing tool, solid disk, each	**190 kg**
Mirror Cell Back Plate	**271 kg**
Mr Barry Cleland	**86 kg**

Being Australians, we ran a book on the result of weighing some of the heavier parts, and I thought you'd like a go too -- see next page for part 66. The craning process, by the way, also allowed a rare view and brief photo-opportunity of the underside of some parts - here's the Cradle for example - and no, I am not going to stand directly underneath it, even if it does have a useful hole where it might fall on me, like the house wall that fell on Buster Keaton.



While we were doing this, it was tempting to try to weigh the Museum's stuffed whale, but as everyone knows, the right place to do this is at a **whale-weigh station**.

And we wanted to know how heavy Barry's cold lunch was, but again we suspected there might be a more appropriate place to do that. Where would be a good place to weigh a pie? Answer at bottom on the last page.

Competition

Win your own Wire Brush!

Part 66 is a solid metal weight, originally believed to be for powering the clockwork mechanism for the RA drive, but as our photo of this dismal part with the 10cm scale shows, it is much too big and heavy for that. (Or perhaps the gearing was made really badly. When I was just a lad, I made a clumsy clock in Meccano that refused to tick unless powered by an enormous weight. Now, of course, I am older - and just as clmusy;).

So we now suspect that it hung from the block-and-tackle that pulled on the top end of the southern cone, to relieve pressure on the bearings. We are having a competition: Guess the Weight of the Counterweight! Send your guesses to steve@steveroberts.com.au - *Phoenix* issue 5 (which probably won't be ready for months, so there is plenty of time) will feature a photo of THE WINNER, clutching THE PRIZE, which is a handsome WIRE BRUSH, so useful for removing stoved-on paint from telescope parts. But this is no ordinary wire brush - far from it; this one has been *signed* by the Museum's Manager of Collection & Research and by the Head, History & Technology! Imagine the amazement of your friends when you whip out this unique artefact and put it to good use.

St Patrick's Day

We never lose sight of the fact that the GMT is an *Irish* telescope - made in Dublin, quite soon after the first iron ships were invented and more than 40 years before the Titanic (in Belfast). Its cast-iron parts were poured from furnaces partially heated by peat! And much of its engineering was pioneered by Lord Rosse when making his giant speculum-mirror telescope at Birr Castle, which was (and still is, to be sure) inland from Dublin.

So when we realised that our workshop #39 would fall on March 17, a special Irish celebration was arranged! It being too early in the day to start on the Guinness, instead we had an Irish cake for morning tea.

This was my first effort at cake-making, and it was very thoroughly baked - after all, look what happened to our telescope. Cutting through the outer layers of the cake was quite difficult, even with a serrated frozen-meat knife - heavy gloves were worn, as the knife tended to slip and the Museum don't want blood all over their floor, as it would attract vermin (unlike the cake). But once the inside of the cake was accessed, this was found to be mostly edible, and enough cake was left over to feed the Sunday workshop 4 days later.

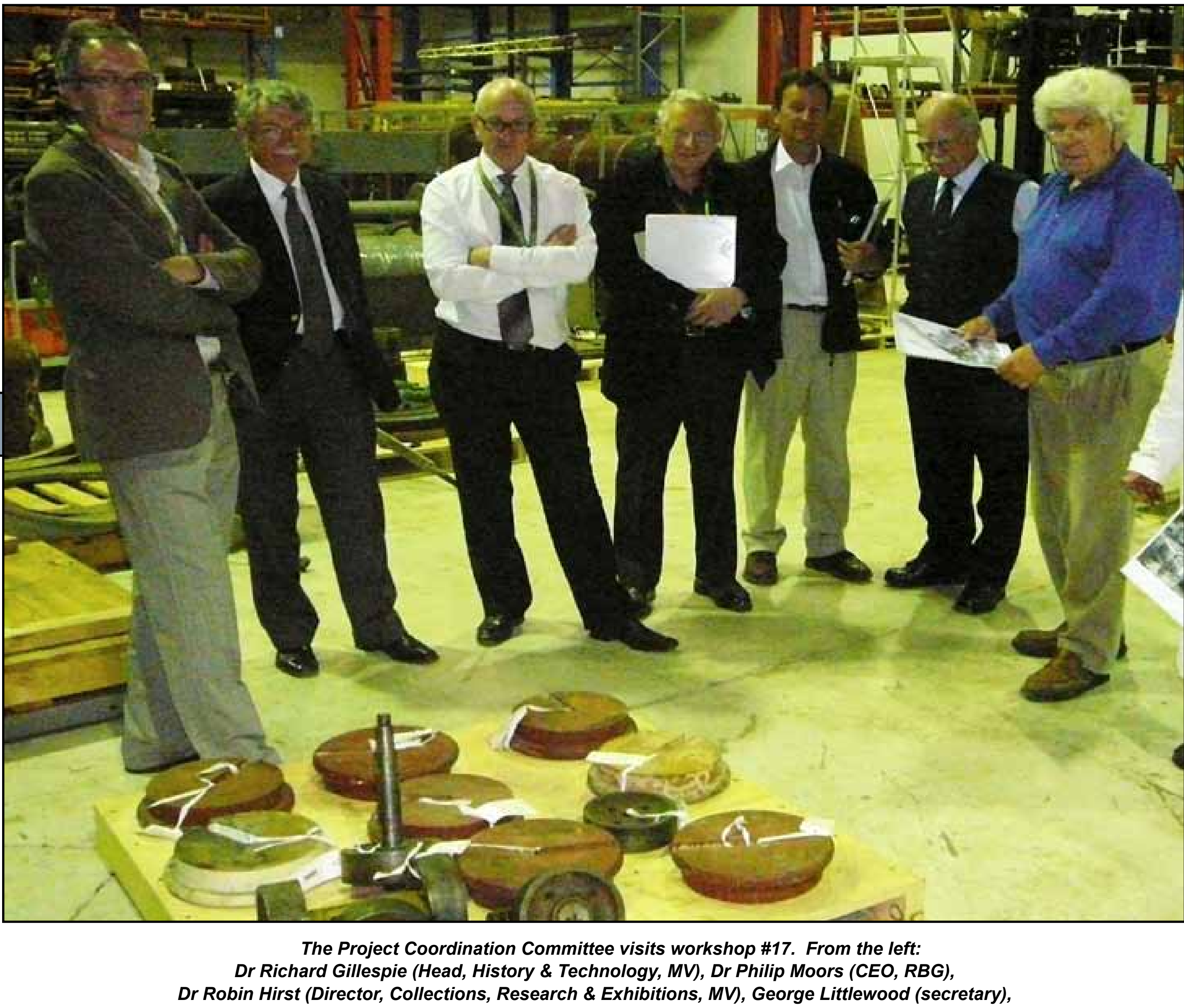
Everybody agreed that sufficient cake was provided to fulfil their requirements, which strangely turned out to be quite modest, at least in respect of cake, on this occasion.

The Project Co-ordination Committee

Our efforts to restore the Great Melbourne Telescope occupy a place in a major project that is administered by a formal Project Co-ordination Committee. This august body is comprised of two executive officers from each of the stakeholders - Museum Victoria, the Royal Botanic Gardens, and the Astronomical Society of Victoria - plus a Secretary.

Normally we volunteers do not see or hear much about the P.C.C., but clearly a lot of liaison and exploratory work was done at this level for some years before the project even got off the ground. The P.C.C. meets every few months and has developed its media and sponsor communications strategies, the formal definition of project goals, the concepts and policies for the visitor experience (what the public will actually see and do at the restored GMT), and the necessary documentation for the internal use of each of the three collaborating parties. They consult with the management of similar major public displays, to gain ideas and guidance.

Recently the P.C.C. decided to commission a professional Concept Study, which will define the overall scope and demonstrate the feasibility (if so) of the GMT restoration; this report will become the cornerstone of our fundraising effort, when that begins. Potential major sponsors will expect to see such documentation and organisational structure already in place. The cost of this study has been capped, and will be borne equally by the three partners, who will jointly own the resulting report.



The Project Coordination Committee visits workshop #17. From the left:
Dr Richard Gillespie (Head, History & Technology, MV), Dr Philip Moors (CEO, RBG),
Dr Robin Hirst (Director, Collections, Research & Exhibitions, MV), George Littlewood (secretary),
Richard Barley (Director, RBG), Barry Adcock (President, ASV), Jim Pollock (Vice-President, ASV).

Steve's Adventures in Moreland

Sometimes the GMT work may get a bit dull, but it's all happening on the streets outside. We went out for lunch one day and saw, to our surprise, that Sydney Rd was closed to traffic. Lunch of course was of much more interest to us, but when we emerged from our victuals, the road was still closed but now there was a large pall of dust, further down the street. It turns out that a nearby building had collapsed:

http://moreland-leader.whereilive.com.au/news/story/pictures-building-collapses-in-brunswick/

Fortunately the occupants of this doctor's surgery were able to leave in time … somebody must have said "I say everybody, I think that the building is about to fall down" and people believed him. The article goes on to say that "structural engineers are assessing the site" which is a very good idea, but surely a little too late?

You are reading *Phoenix*, a sporadic newsletter reporting on the activities of the ASV volunteers in the Great Melbourne Telescope project. In a full and fruitful collaboration, three stakeholder parties - Museum Victoria, the Royal Botanic Gardens, and the Astronomical Society of Victoria - are toiling to restore this mighty instrument, which was for several decades the biggest telescope in the world. Its original iron pieces were cast - welding not having been invented - in Dublin in 1868, using peat-fired furnaces, and its design featured many engineering novelties and advancements.

After performing major work for a long time in Melbourne, the telescope was moved in 1946 to Mt Stromlo, near Canberra, where it performed many more years of sterling work and survived through various modifications - but it failed to survive the disastrous bushfires of 18 January 2003. However, many original parts were unwanted and had already been returned to Melbourne, where they were being stored safely by Museum Victoria, and a restoration of the telescope to its original appearance appears to be feasible.

Our goal is also to return it to its original observatory building at the Royal Botanic Gardens, making it available for public and educational use, as well as being a major tourist draw and once again a jewel of Marvellous Melbourne. It will feature modern 48-inch optics, data and control systems, with minimal compromise to the original instrument's vast heritage value; thus becoming again one of the biggest telescopes in the world that is available for public and educational use.

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Layout: Richard Saunders

Answer to question on page 8

♫ ♪ Some-Where, Over the Rainbow - Weigh a Pie ♫
(Sorry about that. As Neville said to me, "I used to like you, Steve")