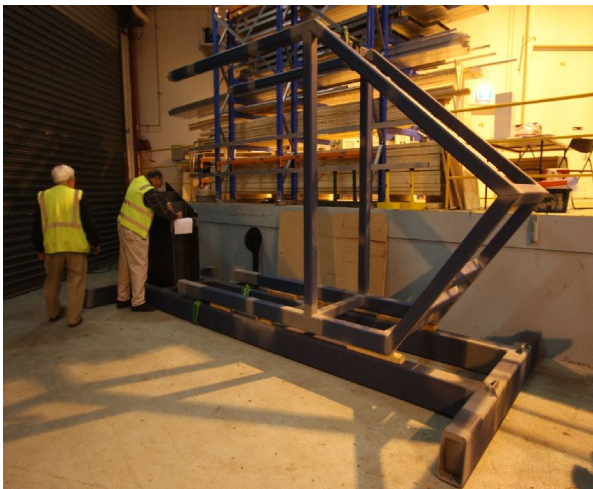


## Engineering Work Begins


Having achieved an adequate degree of documentation of the GMT parts, we have developed more than 40 written proposals for engineering work on some of the parts, and on a frame to hold the entire telescope.



Indeed, Beca, the large engineering consultancy, did all the stress calculations *gratis*, and this splendid telescope-bearing frame has now actually been CONSTRUCTED! - and it is below depicted, delivered in two pieces to the Museum's goods bay. The pointy-end piece will hold the southern bearing (after being rotated to the left and bolted to the base members), and the square black pillar will take the northern bearing. Now all we need to do is make a telescope to put on it.



In other news, the restoration team **visited the GMT house** to measure and admire the foundations; as the soil and underlying strata must be able to take the significant weight (once more - it was OK there, 100 years ago) of the telescope *plus* its mounting piers and static machinery. We also had samples of the metalwork of the Lattice Tube analysed. Articles about these appear in this issue.

The Museum has **formalised the layout of the project workshop area**, by painting walkways, defining “Keep Clear” areas around the polar axis assembly, and providing a lathe, milling machine and benches for small jobs to be done on the spot. 



# Picture Gallery - 1



*The machined, newly cast Declination Clamp Disk - the original cast-iron broke into five (easy?) pieces long ago*



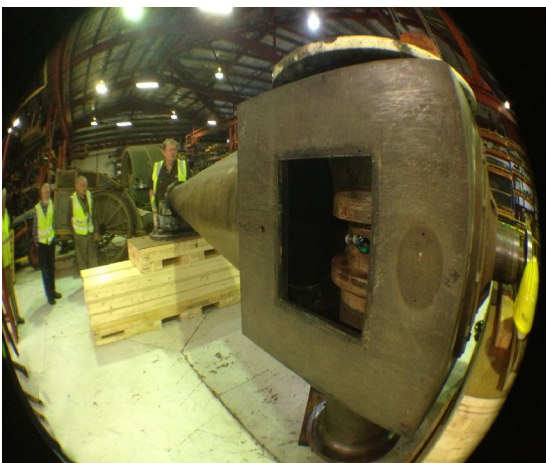
*Workshop area, with milling machine and lathe; more painted walkways surround the polar axis assembly*



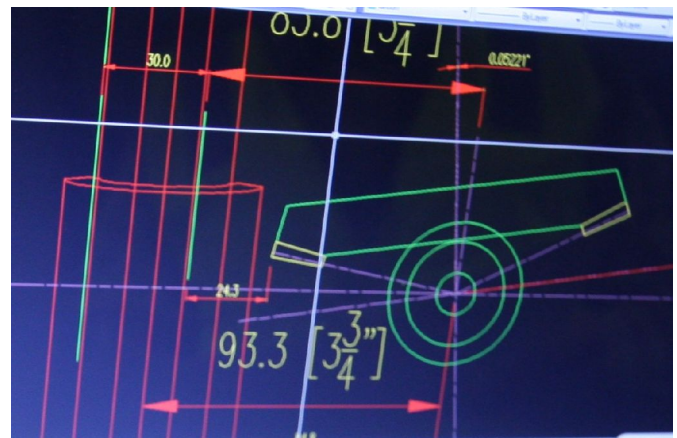
*Mirror Man*



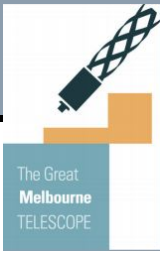
*Original Mirror Support Mechanism, now neatly stored*



*Distorted by the fish-eye lens, or by its gravitational field?*

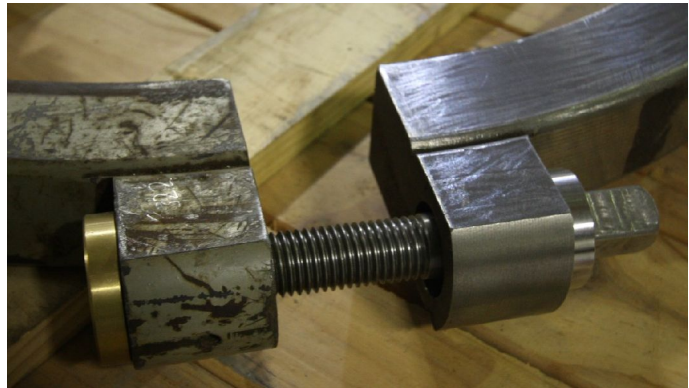


*Measurements are also being recorded in Imperial, as being more accurate and guarding against errors*



## Picture Gallery - 2

*These new parts for the polar axis clamp - closing bolt, specialised nut, and C-piece - were made gratis by LaTrobe University*



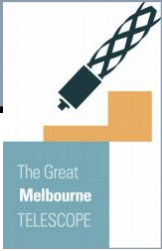
*Dr Barry Clark at a recent workshop - but what's he reading on the laptop?*

TABLE II  
PHYSICAL PROPERTIES OF VARIOUS MIRROR MATERIALS

Substance	Density ( $\delta$ )	Specific Heat 25°C, cal/gm°C (c)	Thermal Conductivity cal cm/cm <sup>2</sup> sec°C 25°C (m)	Expan. Coeff. $\alpha \times 10^7$	$\frac{\alpha \delta c}{m} \times 10^7$
Speculum Metal	8.6	0.079	0.20	186	630
Steel	7.8	0.109	0.20	110	468
Plate Glass	2.5	0.20	0.0018	75	21,000
Duran 50®	2.2	0.18	0.0028	32	4,500
Pyrex® (80% SiO <sub>2</sub> )	2.3	0.20	0.0027	33	5,600
Fused Silica	2.2	0.17	0.0032	5.6	650
ULE™ Titanium Silica	2.2	0.17	0.0031	0.2	24
Cervit®/Zerodur®					
Crystallized Glass-Ceramics	2.5	0.22	0.004	0.2	27

*A table of physical properties of mirror materials, where a low overall score in the right column is to be desired. Despite its density and expansion, speculum metal scores well due to its rapid conductivity and low thermal mass. In 1868 most of the other materials were not available, and steel could not be machined to the required quality.*

# Investigating the Original Foundations for the GMT, in the GMT House



*By Jim Pollock*

In late August 2013, the ASV and Museum Victoria investigated the state of the foundations of the Great Melbourne Telescope (GMT) at the GMT House in Melbourne Observatory.

The GMT was built in Dublin, Ireland and completed in 1868. It was then shipped to Melbourne for installation at Melbourne Observatory. In preparation for its erection, a solid rectangular plinth of bluestone (basalt) blocks was constructed at Melbourne Observatory on which the taller southern pillar and the shorter northern pillar were built.

Estimating the dimensions of the southern and northern piers which supported the polar axle and the basalt plinth on which the piers stood, the stone structure would have weighed **35 to 40 tonnes**. The moving parts of the telescope and mounting are known to weigh about nine tonnes, so the total mass bearing on the foundations was **45 to 50 tonnes**.

When the telescope was completed in late 1869, it was set in place first, and then the four walls of the GMT House were built around it, with the novel roll-off roof - itself a historic artefact - being added last. When the telescope was moved to Mount Stromlo, near Canberra at the end of World War II, the two piers were demolished down to floor level. To return the telescope to the GMT House will therefore involve rebuilding the two piers before the mounting and the telescope itself are replaced.



*Inspecting under the floor in the GMT Chamber: Matthew Churchward of Museum Victoria is kneeling on the concreted top of the bluestone plinth. Dr Barry Clark is standing on the true ground, next to a deep test hole. Barry Cleland and George Littlewood are in the background.*



*Under the GMT Chamber floor, looking south. The floor is supported by the bluestone wall at the left and by the bricks on and alongside the plinth on the right. The soil is remarkably dry.*

If you visit the GMT House today you can see the position originally occupied by the northern and southern piers. The top of the bluestone plinth is now covered by a thin veneer of concrete to make it flush with the existing floor. Visitors will also notice the peeling paint and plaster on the inside of the GMT House. This indicates the presence of rising damp and that scourge of late 20th-century renovators of Victorian buildings - *Kalsomine*, a cheap water-based powder paint.

The telescope's foundations will have to carry the mass of new piers, the mounting and the re-built telescope itself. It is therefore vital that the foundation below the floor of the GMT House is in good shape and is not affected by rising damp.

*Continued....*

(continued from page 4)

Our inspection of the under-floor section of the foundations indicated it was in excellent condition. Unlike the walls of the GMT house, which are made of brick and lime mortar, the foundation of the GMT itself is composed of bluestone blocks bound together with a mixture of Portland cement and sand. Some of the bluestone blocks are huge and span the full 5-foot (150cm) east-west dimension of the telescope foundation. The use of Portland cement at this time (1869) is most interesting in that it was not commonly used in buildings much before 1900.

**Our investigation of the bluestone blocks showed no signs of deterioration or cracking. The cement between the bluestone courses appears to be as good as the day the blocks were laid, 144 years ago.**

Foundation engineers contracted by the Royal Botanic Gardens have investigated the soil characteristics below the GMT plinth. They found the soil to be unstable in the presence of moisture and thought that linear movement of the plinth could be excessive, requiring a new plinth anchored to the bedrock. But we have found historical records of the actual angular movement of four heritage telescope plinths on this site, all acceptably stable under natural ground water conditions. So we think that the GMT plinth is re-usable as is, if the soil is kept dry.

Had the foundation been composed of bricks and mortar, rising damp could have made the foundation both unstable and unusable. Rising damp can slowly dissolve the lime binding the mortar leaving only loose sand grains to hold the bricks together. If this had been the case, it may have been necessary to remove much of the original floor, demolish the existing foundation and rebuild the whole structure. This would have involved considerable time and expense.




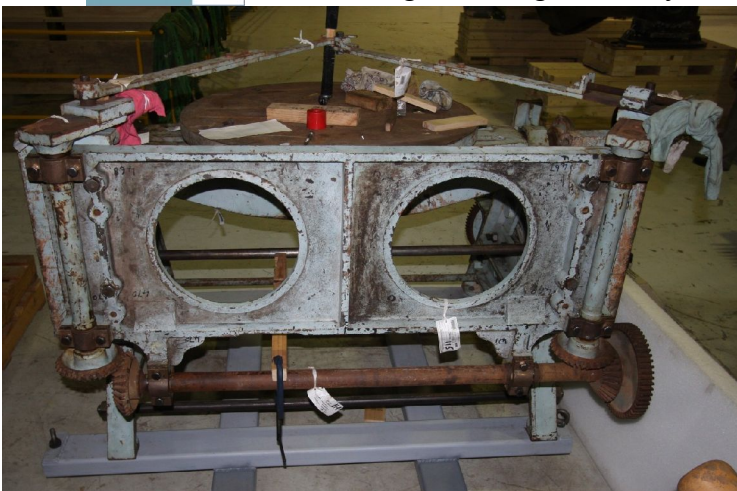
*Intrepid Jim Pollock sits on the edge of the test hole, in order to admire the historical bluestone plinth*

## The Mirror Grinding and Polishing Machine



The Great  
Melbourne  
TELESCOPE

David Linke has made further progress with assembly of this historic beast, including mounting the heavy backplate. Voila: 



## Workshop Assembly of Cube and Axes




Over recent months the best-fit relative angular positions for the South Cone, the Stub Axle and the Bell Housing on the Cube have been determined and marked permanently so that future reassembly can be straightforward. The Stub Axle, Cube and South Cone together form the polar axle.

With the modern self-aligning rolling bearings in place at each end and supported at a suitable height on solid timber piers, the polar axle can now be rotated by hand to allow measurements of concentricity and eccentricity of various parts.

Because the north and south faces of the Cube are slightly out of parallel, it is impossible for both the Stub Axle and the South Cone to run true.



Originally the Stub Axle position on the Cube was determined precisely by turned surfaces but the centering hole in the Cube was enlarged during the rebuilds at Mt Stromlo and the holes for the bolts are now oversized. We made special fittings to allow precise adjustment of the Stub Axle position on the Cube face. Run-out of the Stub Axle is measured with a dial indicator; it varies with the centration setting. The goal is to find the position that gives minimal runout for the Stub Axle because it is important that the drive sector, polar setting circles and the still-to-be-designed new worm wheel all run true. When that position is found (by trial and error), the Stub Axle position will be set permanently by steel pins. 





# Analysis of Iron and Steel from the Great Melbourne Telescope

*By Jim Pollock*

In August 2013, some preliminary analytical work was carried out on samples of iron and steel from the Great Melbourne Telescope. The samples were taken by Helen Privett, Manager, Conservation at Museum Victoria. The purpose was to determine which parts of the telescope were original and which were more modern, for example dating from its time at Mount Stromlo. A number of samples were submitted for analysis, from various parts of the telescope and mounting.

The detection and measurement of elements in a sample used to be carried out chemically, using 'wet' analytical methods which were slow, cumbersome and expensive. But from the early 1950s, scientists at the CSIRO developed Atomic Absorption Spectroscopy (AAS) which allowed samples to be analysed far more quickly, for a greater number of elements and above all, far more cheaply.

Besides AAS, other methods are based on optical emission spectroscopy (OES) where the atoms of the element to be analysed are excited, often by an electrical spark, and the intensity of the light produced is measured at certain wavelengths. Further advances have been made for getting the sample into a gaseous state using an ionised gas or plasma (Inductively Coupled Plasma or ICP) so that it is now possible to detect the presence of certain elements to around one part in 10 billion.

The GMT samples were analysed using ICP-OES. Some of the samples were similar in composition and averaged 2%-3% carbon, 1.0%-1.2% silicon and 1.0%-1.3% phosphorus. Apart from minute percentages of other elements, the remainder was iron. This composition is characteristic of **high phosphorus cast iron**. Another group of samples averaged 0.20%-0.24% carbon, 0.80%-0.87% manganese, around 0.2% silicon, very low values for nickel, molybdenum and vanadium, with the remainder being iron. These had the composition of **low-carbon steel**.

The final set of four samples was taken from the lattice tube and one of the circular bands that help to stiffen the tube. The results of these analyses, tabulated below, are quite interesting:

Element	Sample 1	Sample 2	Sample 3	Sample 4
Carbon (C)	0.03	0.45	0.38	0.17
Manganese (Mn)	0.05	0.07	<b>0.53</b>	0.12
Silicon (Si)	0.19	0.15	<b>0.07</b>	0.13
Sulphur (S)	0.02	<i>Trace</i>	0.01	0.02
Phosphorus (P)	0.33	0.14	<b>0.02</b>	0.15
Nickel (Ni)	0.02	0.02	<b>0.06</b>	0.02
Chromium (Cr)	<i>Trace</i>	<i>Trace</i>	<b>0.26</b>	0.01
Molybdenum (Mo)	<i>Trace</i>	<i>Trace</i>	<b>0.45</b>	0.01
Copper (Cu)	0.02	0.01	0.03	0.01
Vanadium (V)	<i>Trace</i>	<i>Trace</i>	<b>0.07</b>	<i>Trace</i>
Niobium (Nb)	<i>Trace</i>	<i>Trace</i>	<i>Trace</i>	<i>Trace</i>
Titanium (Ti)	0.01	0.01	<i>Trace</i>	0.01
Aluminium (Al)	0.03	0.02	0.02	0.03
Iron (Fe)	<i>Balance</i>	<i>Balance</i>	<i>Balance</i>	<i>Balance</i>

*Continued....*

(continued from page 7)

As can be seen, samples 1, 2 and 4 were similar but sample 3 is decidedly anomalous, particularly when it comes to Mn, Ni, Cr, Mo and V, which are all higher than for the other three samples, and for Si and P, which are lower.


Samples 1, 2 and 4 showed a high proportion of phosphorus, which is typically seen in **wrought iron**.



*The lattice section of the GMT tube, showing two small drill holes from which a steel sample was taken for analysis.*


Sample 3 showed significantly higher chromium and molybdenum, which suggests that it is a **medium-carbon low-alloy steel**. The molybdenum content is a real give-away. Although it was first isolated in 1781, the element had no industrial use for more than a century owing to its relative scarcity and the difficulty of extracting it from its ore. Molybdenum was used during World War I as a steel additive, but demand plummeted when the War ended in 1918. The world's principal source was the Climax Mine in the Rocky Mountains in Colorado, at an altitude of 11,360 feet (3,465 metres.) The mine opened in 1915, closed in 1919 but reopened in 1924 and ran almost continuously until the 1980s. For decades, it produced three-quarters of the world's molybdenum.

Therefore, it highly unlikely that Sample 3 comes from any part of the original GMT. It is more likely that the particular steel band from which Sample 3 was taken dates from the 1940s or 1950s. This is consistent with the time that the GMT was recommissioned at Mt Stromlo having left Melbourne at the end of World War II.

The methods of production of iron and steel in the mid-19<sup>th</sup> century are fascinating subjects. The development of the Bessemer process for producing steel from molten iron dates from the first half of the 1850s. This was not long before the construction of the GMT. This process relies on high pressure air blown through the liquid iron to oxidise impurities including carbon, silicon and manganese, which are removed as gases or in the slag. When these elements have been reduced to very low levels, precise amounts of these and other elements are added back in, to confer particular properties on the resulting steel. 

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## *FLANGE NEWS*

Whoa ho!! I had written that there isn't any Flange News, and the flange remains as firmly in place as ever before ... but meanwhile the paperwork has been flying and I can now report as we go to press that the flange-infested Declination Axle has just been sent off to Robinson Engineering, at Altona, for **removal of the flange!** Next issue will show pictures of the flange-free axle!! 





## Steve's Adventures in Moreland

*Another Wednesday, another workshop, another lunch at the Awful Cafe ... but wait!*

This Mecca of our erstwhile hebdomadary patronage has new Indian owners, who have instantiated a number of essential reforms, like putting some actual food in the bain-marie display.

And the good news is, it's *Indian* food - the bad news, it is only MILD stuff and I do like mine fiercely hot ... but they spiced it up specially for me.



I do declare, that this place now has the **very best Indian food** until you get to the next cafe, which is miles down Sydney Rd, and it's better than theirs too. Henceforth I shall eschew the alimentary opportunities proffered by alternative establishments, and I shall eat **ALL my Wednesday lunches** in this now Much Improved Cafe. Look, here we all are, at the trough.



Our lunches, of course, as well as being *Great* and in *Melbourne*, are *Telescopic* and indeed *restorative*. If they were Mexican, they'd conform to the Burro Charter. (groan)

I've had more adventures beyond Moreland too, which is why this issue of *Phoenix* is as late as ever - been cycling in the Netherlands, Germany, Denmark, Sweden, and Finland - my natty new Hungarian bicycle lasted 4 days before it conked out and was sent home in high dudgeon. See the carnage at my blog, whenever I have time to stop

procrastinating and write postings for it, at <http://stevethings.wordpress.com>



### GMT TWITTER FEED

On our new Twitter feed, an update (a 'tweet') will be posted every few days on how the GMT project is going. Well worth following -

<https://twitter.com/GMT21stC>

You do not have to be a subscriber of Twitter to get the updates!

### PHOENIX, issue 9

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Written/edited/layout by Steve Roberts,  
for the GMT Restoration Project

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