Phoenix

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

Issue 3 – November 2009

The Great Melbourne Telescope Restoration Project

Editorial

Hello everyone, especially new readers! This sheet you have here - or, the pattern formed by these particular illuminated pixels on your screen - is *Phoenix*, the sporadic newsletter of the ASV team that is helping to restore the **Great Melbourne Telescope**. *Phoenix* is distributed, electronically, free to all interested parties; the content is By permission of ASV Council, this and all previous issues are placed on the ASV website from where they can be downloaded in various resolutions. (But you probably know that, having just downloaded it, or you would not be reading this...)

The mighty Great Melbourne Telescope was built using the very latest technology - in the 1860s - and for about two decades it was the biggest operational telescope in the world, incorporating many engineering novelties and advancements. It performed useful work in Melbourne and major advances at Mt Stromlo, after various modifications, until the ACT bushfires of 18 January 2003 further modified it in a wholly undesirable way. Now, using remnants that survived the fire plus many other parts discarded earlier but stored by Museum Victoria, our project is to restore it to its original appearance and as far as possible working in its original building at the Melbourne Observatory site of the Royal Botanic Gardens, for public and educational use. Full state-of-the-art 48-inch optics, and all-new data and control systems, will be designed and integrated with minimal compromise to the vast heritage value of the instrument, making it a major tourist draw and once again a jewel of Marvellous Melbourne. **It will be again be one of the world's largest telescopes … that is available for public and educational use.**

Of course an enterprise of this size is not lightly undertaken, and there has already been much careful planning and several years of liaison work between the three major parties involved, which are: Museum Victoria, the Royal Botanic Gardens, and the ASV. These three bodies have worked together cordially in other ventures, and a full collaboration is now underway at various levels. At the highest level, a communication strategy and the visitor experience policy are being developed, and a web site is being prepared. But right now, the major practical activity is the dismantling, inspection and documentation of the GMT parts, which is part of what ASV is contributing to this ambitious undertaking. This work is being done in weekly sessions by a dozen ASV volunteers and several MV staff, working within the Museum's premises using MV equipment.

Phoenix issue #2 reported the achievements of the first four of these weekly workshops; now in this third issue I will report on workshops 5 through 12. This period included MV's induction of the first batch of a dozen ASV volunteers, who are now helping with mechanical and drawing work. Those volunteers not yet inducted will be needed later, and depending on how the work pans out, another batch will be inducted in 2010 by which time the electronic and optical work will be starting up. Thus, the articles in this issue will cover some of the more interesting and spectacular feats of dismantling, as well as some more general topics.

Steve Roberts
Editor

PAPERWORK NEWS

Drawings, descriptions and photography of GMT parts has begun but has not yet come up to the required speed. MV have provided four new desks in the warm part of the premises where people can work in relative comfort. Our ambition is to have proper engineering drawings made for every part! Now, for some components such drawings exist, for others there are drawings but they are of inferior quality and they should be replaced. Yet others have no drawing at all, and in the worst case, neither the drawing *nor the component* exist.

So how can we draw something that no longer exists? Well, we have some 1868-vintage photographs of the original telescope and other historical documents that give us many clues, but in the last resort we'll have to use our imagination, constrained by scientific reality and by the shapes of the components around the one we are dreaming of.

MORE ARCHIVAL MATERIAL

Jim Pollock has come across some more historical photographs, showing the newly-made GMT standing in Grubb's Dublin factory in 1868, attended by Irish workers clad in hats, waistcoats and beards. Torn and faded depictions of a scruffy old industrial yard may be dull to most people, but these dog-eared daguerrotypes sent Barry Clark into excursions of ecstasy. Some hitherto baffling technical questions can now be answered by scrutiny of these photos. I'll trace the current owner of the photos and see if I can get permission to reproduce them.

Also, we are reading the 1868-74 diary of J.E.Gilbert, a junior assistant at the Melbourne Observatory, which records minor but useful details on the GMT's installation; and another contemporaneous diary will soon be followed up.

REMOVAL OF DECLINATION AXIS FROM CUBE

Introduction

An article in *Phoenix* issue #2 described the disassembly of the northern end of the combined axis assembly. The next big job was to remove the declination axis from the cube - an undertaking of similar magnitude, which similarly occupied several Wednesdays. The declination axis is a flanged tapered cylindrical casting that passes through the middle of the cube and through the 'bell housing' extension of the cube that once held the large squarish Mt Stromlo counterweight. The casting rotates in a pair of large 'turntable' roller bearings on one side of the cube. Mt Stromlo installed these bearings in place of the original plain bearing, which failed in the 1970s. Another replacement roller bearing is at the narrower end of the axis casting. The housing of this bearing is missing but this is of little account as substantial changes will be necessary in order to reproduce the original outer end of the declination axis and to attach its fittings. A modern sleeve on the thick end of the casting has a large flange that held the aluminium centre section of the modern truss tube installed at Mt Stromlo. The two flanges were bolted together. The original flange was rectangular and fitted inside the tube saddle casting, but the corners of the flange were machined off at Mt Stromlo, leaving circular ends with two chords between them. **Picture 1** shows the end faces of both parts, held together by 14 machine screws.

Picture 1

For the work of removing the hour angle drive gear, the whole cube/cones assembly had been positioned with the declination axis horizontal, but now it was moved to make the declination axis vertical. This also allowed us to access the inside of the cube, through the rectangular hatches on both sides. **Picture 2** shows Barry Clark admiring the re-positioned assembly, while others idly chatter; note the interesting northern end*. Also of interest, in the background, are the two surviving pieces of the original GMT telescope tube – part of the original lattice structure is intact within the right-hand piece. This thing is BIG!!

Picture 2

* Of the assembly.

Step 1

Removal of Wiring Harness

Electrical movement control was introduced in one of the early Mt Stromlo modernisations of the GMT. Power and guidance cables were fed into the lower end of the four conduit tubes inside the northern cone (the new lower extension of the polar axis) and passed up to the cube, into the centre of the declination axis, and then through the saddle and into the tube. Several spare turns of the cables were wrapped around a large reel that had been fitted to the declination axis within the cube. This arrangement allowed the telescope to move in hour angle and declination without the cables breaking or getting tangled or trapped. The spare lengths of cable on the reel could be paid out if a cable did break, for example through repeated flexing.

With some difficulty, we unbolted the cylindrical cover on the outside of the reel but fire damage prevented removal of the remainder of the reel. We eventually had to use a sabre hacksaw - a very effective but nasty tool - to slice through the entire thing, which then came out in several pieces, as in **picture 3**. The reel is not an original component and there is no plan to re-use it, so it will be discarded. Of course all cables were wrecked by the fire, which left only a jumble of copper strands protruding from melted and charred insulation.

Picture 3

With the cable reel system now removed from within the cube, it was possible to see inside the cube with less hindrance. For the first time, the nuts and bolts that attach the northern and southern polar-axis cones to the cube could all be seen. We sprayed these with WD-40, to help with future removal; after that, anyone putting his head inside the cube got a considerable blast of the oily smell, which some of us enjoyed less than others.

Step 2

Removal of Declination Axis from Cube (Failed Method)

The assembly was turned over under the gantry crane; this was done by fitting a second, very slack sling to a pulley/chain lifter suspended from the crane hook; the respective slings were then lowered and lifted so that the assembly's weight was gradually transferred from one sling to the other, while it turned through 90 degrees. It was then set down, re-slung and the process repeated to achieve a 180-degree turnover. We now had access to the main declination bearing at the top of the assembly, as shown in **picture 4**, where the cube is sitting on a robust frame made by MV, so as to keep the smaller declination bearing off the floor.

Picture 4

Our first hope was that the inner part of the declination axis would simply come out of the outer part, once the 14 machine screws were removed (these are the inner set of screws in **picture 1**, page 2, of two types: ten with hex recesses and four blind). But we were unable to budge these screws; we huffed and puffed, we slid a pipe over the end of the socket wrench,

we tapped their heads sharply with a hammer and chisel, we made a cup of tea and came back and tried again, we stamped and screamed, we prayed, we cursed - all to no avail. Escalating to a still higher level of desperation, we used a blowtorch to heat the heads of the screws quickly (**picture 5**) and then, with the application of as much as 500 Nm of torque*, we finally heard that welcome "crack" sound as the screws were freed. **Picture 6** shows Neville Quick heaving away; note that the handle of the socket wrench is bending. Later examination of one of the offending screws (**picture 7**) showed that the WD-40 had not penetrated to the threads, but the threads were in good condition anyway; our problem had been to start sliding the metal-to-metal surfaces against static friction, the original lubricant having gone or been baked by the bushfire.

Picture 5

Picture 6

Picture 7

With the screws finally removed, we gently set the assembly down (without MV's wooden frame) with the lower bearing resting on the concrete, to press the declination axis out. Our triumph was short-lived - well, non-existent actually - the two axis parts were evidently still stuck together at the mating surfaces, even without the screws. Leaving it standing so that the full weight of the assembly acted to separate the axis parts did not work - nor did trying to drop it from a great height onto the concrete, because the overhead crane can't do that, it can only let its load down at a strictly controlled speed. Time for a coffee.

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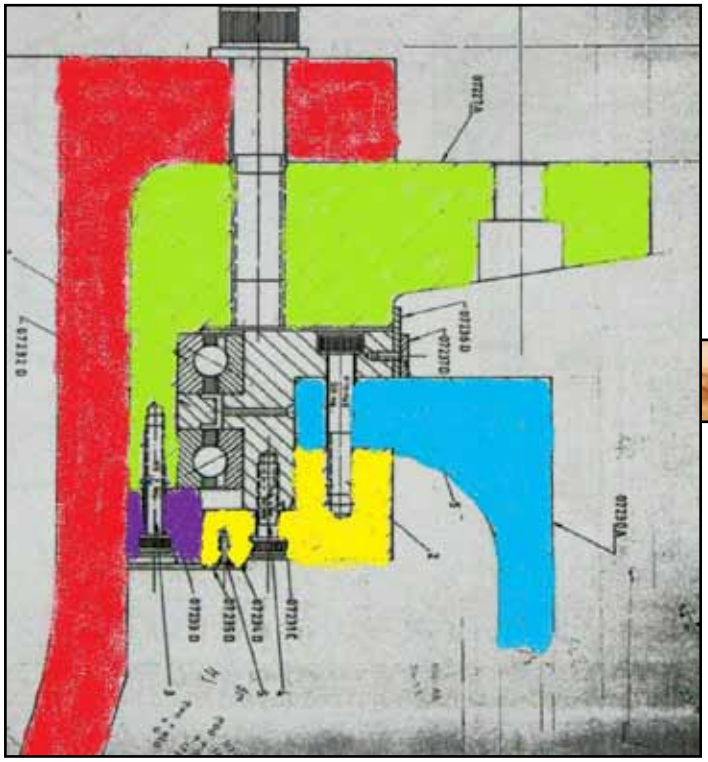
* Like the GMT, I was born into a world of feet, pounds and poundals, so I mentally converted this large figure of 500 Nm to 370 ft-lbs, which I could then recognise as being about 5 times the torque typically applied to cylinder head bolts of car engines. This seemed much too much! But to bring these new-fangled metric units into the real world, I have learnt something rather beautiful: that **one Newton is approximately the force exerted by a small apple hanging from an apple tree** (or hanging from anything else; but only at the Earth's surface). So I considered a bag of 500 apples hanging out at 1 metre; this again seemed rather a lot. Converting to kilograms of force (or weighing 500 apples) we divide Newtons by *g*, so it'd be about 51 kg of force at 1 metre (depending, strictly, on where you live), or 102 kg of force applied at half a metre - which was about the length of the handle of our socket driver. So 500 Nm does seem about right, after all, for two men pulling as hard as they could. Therefore, you can ignore this footnote.

Step 3

Removal of Declination Axis from Cube (Successful Method)

With our brains revitalised by caffeine and tannin, we decided to resort to engineering instead of brute force. Scrutiny of a Stromlovian engineering drawing - which I have copied and crudely coloured, in **picture 8** - showed that there was a second way. The two concentric parts of the declination axis (red & green - with the big screw now removed) are still stuck together by friction; the outer part (green) is held in the face of the cube (blue) by bearings and retaining rings. By removing a dust-cover ring and one set of the head-downwards screws, the "purple" ring would come loose and we would be able to lift out the red & green parts, *albeit still stuck to each other*. The uncoloured and yellow parts could then be unbolted from the cube.



Picture 8

So, after removing the dust cover and the screws, we gently set the assembly down again and, lo and behold, the axis assembly was now easily pressed out from the cube, with the "purple" ring being allowed to fall down inside the cube ~~with a mighty crash~~ eliciting a nice ringing sound from the bell housing. We then lifted the two-part axis assembly out with the crane (**picture 9**); then, using a fork-lift truck with a second sling to bring it nearly horizontal in mid-air (**picture 10**), we lowered it gently onto a prepared pallet.

After fixing it to the pallet, some of us found it suitable for striking the famous pose of St George, standing with one foot on the body of the slain dragon.

Picture 9

Picture 10

At the time of writing, it still remains to separate the inner cone from the outer one of the declination axis - the "red" and "green" parts in **picture 8** above. These two parts, as far as we can tell, are simply stuck together by friction and the sands of time. Later, we will devise a way of pressing one part away from the other in a controlled manner, oh yes we will, and the resulting carnage will be mercilessly depicted here, in the pages of *Phoenix*.

REMOVAL OF ALL FITTINGS FROM THE CUBE

Picture 11

Picture 12

With the Hour Angle drive dismantled, the northern cone cleared of its attachments, the declination axis removed and the cube completely empty, we now had comparatively free access to all nuts and bolts that attached the three major components to the cube (these being: the Stromlo-made north polar-axis cone, the historic original south polar-axis cone, and the bell housing for the counterweight end of the declination axis). **Pictures 11 and 12** show some of the internal bolts at this stage.

WD-40 was applied, and the following week all nuts were fairly easily removed from their studs, except for three nuts which had earlier struck us as being unusual, because they were two sizes smaller than all the other nuts! This was due to substantial removal of iron by rusting, and we had to drill and chisel through these nuts to remove them, which was quite difficult work to do, inside the cube (**picture 13**).

With a bit of tapping in the right place, the bell housing fell off the cube to the concrete floor, which was only a few millimetres below. It was then, of course, suitably mounted on a pallet and labelled. The southern cone also came off, as soon as its weight was taken by the overhead crane (**Picture 14**).

Picture 13

Picture 14

This left only the northern cone stuck to the cube. We tried to separate it by hitting the cube with club hammers (through wooden blocks, to avoid damage), but even doing that with the assembly suspended 10 mm off the ground, so that the cube's own weight acted in our favour, failed to move it. The next step was to use 8-tonne hydraulic jacks and accurately cut lengths of "two be four" wood to bear on the flange at the end of the cone and press the cube away from it. We operated the jacks to their working limit - bending the wood alarmingly with the pressure (**picture 15**, next page) - and under that pressure we hung it off the floor and again wielded our hammers with semi-frenzied desperation - but no cigar. Not for the first time, we went home defeated.

Picture 15

Returning the following week with new strength in our hearts, we again inspected the Stromlo drawings of the northern cone for clues as to how it might be attached to the cube, but the only drawing showing the end of the cone was incomplete and lacking in engineering detail. We surmised, correctly as it turned out, that the cone was a push-fit in the face of the cube and that only static friction was keeping the parts together. Whereupon we decided to place the jacks *inside* the cube and press up against the inner face of the cone.

Twelve short lengths of wood were arranged in a 4x3 array to make a sort of composite beam about 200 mm wide and 300 mm high; this was pushed through the cube, resting on the lower edges of the two rectangular windows in the cube's sides. Then two 8-tonne hydraulic jacks placed on the wood were applied to the end face of the cone, inside the cube, and the assembly. The assembly was suspended just off the floor, so that the weight of the cone did not add to the load on the jacks. On pumping the jacks so that they were exerting **their full design force** and the wood in the cube was visibly compressing and bending (**picture 16**), the two components suddenly separated by 2 mm. After much celebration, further jacking completed the separation.

Picture 16

Picture 17 below shows the bare cube with, from the left, Neville Quick (MV Collection Manager), Arthur Coombs, Steve Roberts, Barry Clark and David Crotty (MV Curator), all looking pleased with themselves. The five major pieces - cube, northern cone, southern cone, bell housing and declination axis - are now resting on their respective pallets, a joy to behold and a sight to gladden the heart of a tired telescope dismantler.

Picture 17

EXPOSURE OF THE LATTICE TUBE

Every photograph of the original GMT shows its telescope tube, the lower part being sheet metal and the longer, upper part comprised of a criss-cross lattice of metal strips. This design was intended to save weight and reduce wind drag in the upper part of the tube. The resulting lattice tube is iconic in nature, and indeed its representation will be the essential element of the ~~loggo~~ logo of our glorious project.

Scrutiny of the early photographs shows that the width of the metal strips decreases as they go up the tube, from about 45 mm at the bottom of the lattice to less than half that at the top; their thickness does not diminish.

However, a further scrutiny of our hardware shows that more than half of this lattice tube is missing!

After the telescope was moved to Mt Stromlo, the lattice tube was unbolted from the boiler plate lower part and cut into two pieces. The lower lattice part was strengthened by the addition of inner rings attached to the original metal strips, then outer rings were added to hold new sheet metal, which fully enclosed it. The upper lattice part was less fortunate - it was left outside and exposed to the flames of the 1953 bushfire at Mt Stromlo, after which it was dumped; now it exists only as silver granules in an emulsion (and as 0's and 1's in computer files). But in any case it is better to rebuild this in aluminium, because the weight of the original part helped to counterbalance the 1.5-tonne speculum-metal mirror, and it would be far too heavy now that we have decided to use a ceramic glass primary mirror.

So, deep in the darkest recesses of the MV store, we have a bit more than half of the original telescope tube (visible in **picture 2** on page 2). We estimate that we can use the original lower lattice more-or-less as-is but without the sheet metal cladding. The new, upper lattice will be designed to suit whatever secondary mirror and other apparatus it will need to hold in place. By the way, the lattice part of the tube is conveniently navigated by counting the rhombodial "diamond" shapes between the metal strips. The original lattice was 10½ diamonds in length; the surviving part has only four, thus being a bit less than 40% of the original.

On getting the tube out and clambering over and through it, we noted that the enclosing sheet metal was turned down at its edges by about 3 mm and a gap of about the same existed between most sheets, which was filled with inert fibrous material. This was easily removed thus exposing a length of the small bolts that held the sheets together. These bolts being internal were difficult to access, but were simply cut through with an angle grinder. The sheets were then strapped around for stability and removed in a controlled fashion, exposing the lattice of metal strips.

We had thought to make a Media Event out of this, where the Press and other admirers would marvel and photograph as the cladding fell away to reveal the lattice in all its original glory - well, in a bit less than 40% of its original glory - but this had proved infeasible to arrange. So, only a handful of volunteers and MV staff witnessed this event - but now you can see the exposed lattice too, in picture 18!

Picture 18

Having removed the metal sheets and the outer rings that held them in place, we noted the presence of added inner rings but we decided to leave them in place, because they usefully strengthen the lattice, without interfering with the optical path. The enclosed lowest section of the tube remains untouched by us so far; it is made of rivetted boiler plate and is rather heavy. Bear in mind that the GMT, made in Dublin in 1868, predates the *Titanic* (made in Belfast) by more than 40 years, and post-dates the *Great Eastern* and other feats of I.K.Brunel by only 10-20 years.

STEVE'S ADVENTURES IN MORELAND

At each workshop our dedicated ASV volunteers toil away, dismantling and documenting and fretting over the parts of the GMT. But we don't toil all day, for around lunchtime the old belly starts complaining and this problem gets bigger and bigger and will not go away. (As, indeed, does the belly itself, on some of us.)

We cannot bring food or drink into the working area, because MV want to avoid problems with rats and ants nibbling at their priceless collection. So the volunteers all go to the nearest cafe, which in my humble opinion is the most awful cafe in the world. They don't have half the food on their menu, what they do have is terrible, and the service is lousy. The best bet is to get the dim-sims and other junk food from the bain-marie, although there isn't much of that, so that it is every man for himself!

They once offered a chicken dish which I rashly ordered, and soon I saw a small piece of chicken being got out of the fridge and carried like a trophy right through the cafe, unwrapped and held in the waitress's bare paw; and later, it was my turn to enjoy that piece of chicken.

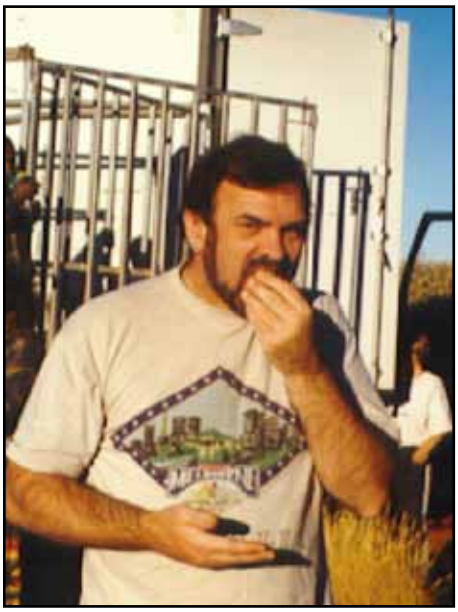
So, I usually make a big noise about going somewhere else. But where? The other day, I hiked a long way up the road in search of alternative sustenance. In one direction there were lots of dentists and bridal-wear shops - handy if you have a fiancee with toothache - but nowhere with anything edible.

However, I went some distance in the other direction and after much walking, I found a very trendy, poofy-looking cafe with nice tables and chairs and magazines to read, and European staff. I went in and chose a nice-looking foccacia which was sitting on a trendy square plate in the display cabinet. It was probably very healthy, and I can't stand healthy food, but I was desperate.

And it was then that I found out what the magazines were for! They were for reading while you waited, and waited, for your food to appear. Eventually, after three or four magazines my lunch did arrive, but it had been so compressed by the infra-red cooker that it resembled a biscuit more than a foccacia. Two bites, and it was gone! I went up to pay. "*Alors, le foccacia, errmm, eet ees eleven dolleurs fiftee*".

And so, empoverished by that amount, but still hungry, with saddened heart I slunk back to work.

On the way, I had to pass the Awful Cafe. All the other volunteers had already eaten and left, so, after making doubly sure that I was not being observed, I furtively crept in and wolfed down a second lunch, consisting of the entire contents of the bain-marie.



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