The very amateur telescope maker - by Trevor Gould (Originally published in Canopus)

Part 1, Summer 1991

This is Part 1 of an article. At this stage, the telescope is not yet finished, some parts are not to hand and the mirror is still under construction.

There was a lot of thought around the project – my cheap Korean binoculars were poorly suited to looking at the sky and there was no budget to purchase one of those superb fancy telescope things or even a plastic replica. No doubt about it, I had to build one.

Not of course that anyone would, even in jest, refer to me in the same breath as a handyman, but I could tell the difference between a hammer and a saw if it came to that.

Brian Fraser was, unbeknown to me, planning to run a telescope making course up at the observatory. Little did he realise, just how amateur some of the Centre's members were.

The course began, easily enough, with the collection and painting of a number of 200 litre drums. Ah, I thought, those must be for the beer. I rolled the first one across the rocky veldt, making considerable noise that echoed across the valley causing a Reaction Unit to appear in seconds.

Having calmed the Unit down and explained that the barrels were to house enough beer to make a telescope with, we stood them upside down on the veranda of the Sir Herbert Baker building. Sir Herbert probably wouldn't have approved, but after all, it is an observatory.

Brian then cut out pieces of wood that fitted the barrel ends perfectly. They had little holes in them. Later I was to become well acquainted with this equipment. The class was run on Tuesday evenings until such time as one fell over from lack of sleep. It began in March and is still underway at the time of writing – October. Each student had a different idea of the telescope he wanted to build. I had no idea, not having been exposed to many telescopes and certainly not to homemade telescopes. I had a mental picture of the sky I would see through the scope, but no picture of the equipment itself. Brian raised a few generic designs and the simplest for a beginner was the Dobsonian.

The Dobsonian was designed by John Dobson of the San Francisco Sidewalk Astronomers fame. See the diagram in the Library. While my PC is good at word processing (it made this article up, see), it is no good at art and I discarded the drawing of my Dobbie.

I got some glass, enough to build an 8" mirror, and began, with much instruction, to grind it to the appropriate depth for an f/6.3. It's not as easy as it sounds – you can't get your collection of old beer dumpies and melt them into shape (why not?). The glass is imported, because we don't cast glass in the appropriate thickness. I used plate glass, others used Pyrex and Borosilicate glass types. You also need two pieces of glass – one becomes the mirror and the other, called the "tool" is used to grind away those parts of the future mirror that you don't want. Grit is placed between the two pieces (carborundum grit – see box for details) and is wetted (with what do you wet it, dear Lisa, dear Lisa?). You grind away until the grit is reduced in size and is no longer effective. The first grit size takes about an hour. Following sizes can take about 40 minutes.

The piece of glass or mirror blank is placed on the wood surface on the drum and is kept in place by little wooden keys that fit into the holes Brian cut. Very clever... You then use the tool and rub it on the mirror blank using a particular random stroke, walking around the drum in a direction opposite to the direction you turn the mirror blank. Various strokes can be used to achieve various shapes, which is useful if you aim for one shape and succeed in achieving another.

Grit	Hours
80	7
120	1,5
220	1,5
320	1,5
400	1,5
500	2
600	1,5
800	1,5
1000	1
Figuring total 19 hours	

Carborundum Grits (box 1)

How do you know when the mirror is the right shape?

Brian has a set of graphs for 150 and 200mm mirrors. The graph shows the depth at the centre (the sagitta), the focal ratio and the focal length of the finished mirror. In addition, there is a column that shows the depth you need to get to on 80 grit.

How do you measure the depth of sagitta?

There is a measuring device, consisting of three metal bars that are joined at one end, in the middle, and radiate out. You place the device over the centre of the mirror. In the centre, Mr. Venter, there is a little gauge that looks like the rev counter in your car but it has a tiny pin that drops down until it makes contact at the surface and the rev counter reads off the difference in height from the high edge to the low centre.

One of the things they don't mention – at least they don't mention it loudly – is that as you progress the mirror to the finer grits, there is a danger that the mirror will stick to the tool. The class members who are experienced in these things waited until the first little sticking event occurred.

Unfortunately, it happened one night at home. As I was grinding away diligently, the mirror and the tool suddenly – and I do mean suddenly – stuck together and I was not able to get them apart. I paced up and down and tried this and that, but after so many hours the last thing you need is to break the mirror. My good wife, Glynnis, seeing my distress (no doubt with some glee) suggested we take the single piece of fused glass up to Brian.

Now Brian is one of those people, who, blessed with enormous technical knowhow, can look at your problem silently for five minutes of unbelievable tension and then say Hmm. The thought goes through your head that whatever the problem may be, it must be very serious at the very least, and most probably irreparable.

Brian did get the pieces back into their original components and suggested I use washing up detergent to prevent further mishaps. I watched the process of getting the glass apart carefully and was duly rewarded when my good friend Carlos got his mirror stuck. I am not sufficiently sadistic to look at the problem for five minutes and then utter Hmm. I used the Method and it worked – it's great trying out something on someone else's mirror. This is how you do it.

Immerse the offending set in cold water. Allow as much of the water to seep into the interstices as possible – usually not very much, because it is such a good fit that it stuck in the first place. Slowly add a little warmer water, well away from the mirror, and stir the water to circulate the warmth. Over a period of minutes, warm the water, trying to separate the mirror and tool all the time. It works eventually.

As time wore on and the sessions of weekly mirror grinding became more serious – "wash your drum and don't let little gritty pieces fall on my mirror!" – it occurred to me that there has to be a start to building the mount, and that is the subject of Part 2.

Part 2, Autumn 1992 - Polishing the mirror

I mentioned to a friend that I was doing a mirror from scratch and he suggested that if my mirror was as poor as my choice of words, he didn't want to look through my optics anyway. I told him he'd be famous long after he died – a palaeontologist would dig up his bones and reconstruct a dinosaur. It is amazing how sensitive you get about building a telescope.

In Part 1, I described the grinding of the mirror. The time went quickly and I reached the point that Brian Fraser said that it was time to build a lap. A lap? I thought I already had one – my mother in law keeps one handy, just in case. Now a lap is a neat thing. Brian cooked up some resin in a pot on the gas braai until it melted. I could see the recipe – bring to a boil and simmer for 10 minutes. He taped around the tool edge, with the tape protruding about 10mm above it, thus making an effective container for the liquid resin to be poured into.

An old rubber car mat was cut into the exact diameter of the tool. He poured the resin in and placed the rubber mat on top so that the raised pattern cut little channels into the resin. The resin set and the old car mat was removed.

I had a lap! A mixture of Cerium Oxide, water and (dishwashing) detergent was poured onto the lap, the mirror placed on top while it was still warm, and pressure was applied until the lap conformed exactly to the shape of the mirror it was to polish.

This process took about an hour. As most of the class was ready to polish at about the same time, Brian was kept quite busy. The polishing began. At this stage, November 1991, my mirror is polished, but the final figuring has still to take place. Brian is pragmatic in this regard – you can get your mirror to be perfect, but on how many nights of the year will you be able to realise that perfection? However, there is still no substitute for perfection, and I expect the mirror to last for the rest of my life at least, so it may as well be well made.

Polishing has taken a good 25 hours. It is very therapeutic and highly recommended. One thing to strive for is a random approach to the mirror, and here I achieved highly. Can you imagine polishing the mirror, with tiny back and forth strokes, but ensuring they have an uneven length and vary in direction? All you have to do is polish while watching the Grand Prix on television.

As you follow the cars around the corner, you automatically compensate while leaning into the curve by varying direction and speed. Monaco is very good for the experienced mirror polisher.

Polishing the mirror gives you a lot of time to reflect on things and I got to wondering what this little beauty was going to cost me. Here's the budget.

Item Description	Budget(R)
8 inch glass mirror blank	65
8 inch glass tool	20
Course and materials	25
Plastic tube	100
Wood for Dobsonian mount	40
Eyepiece holder	80
Eyepiece	200
Spider and diagonal holder	50
Secondary mirror	175
Paint, varnish, etc.	40
Teflon bearings	50
Finder scope parts	105
Other	50
Total Budget	**1000**

This would be a basic telescope and the slightly optimistic budget, which you could easily spread over a period of time, involves a certain amount of scrounging, which will become apparent when, in Part 3, I discuss building the mount. In essence there are a lot of things about, that no one wants, which are ideal for a telescope.

How do you test the shape of your mirror? There is this little piece of equipment that the connoisseurs build for themselves, but I didn't. It is also called the Knife Edge Test. A cunning little piece, it operates fiendishly well. You set your potential mirror on a stand, about double the focal length away from this gadget, which consists of a little globe that issues a ray through a tiny hole and onto the mirror, which reflects the ray back again. The ray comes to a focus at the Foucault Tester, where it is split by a knife edge. The pattern seen by looking immediately past the knife edge will tell you how good the figure on your mirror is. Mine wasn't very good at all. In fact the pattern did not even appear in the famous textbook. Actually, a lot of people came and hummed and harr'd at the image. You know how you feel when the doctor looks down your throat and says hmm. Well I felt like that, only worse, because if there is a problem with the doctor, HE has to fix it, whereas with the mirror YOU have to fix it.

The pinpoint of light illuminates the whole surface of the mirror and when the knife edge cuts the beam the pattern forms. It's all very well knowing your mirror is imperfect, but what can you do about it? If you have the book (Texereau) you can look up the problem and the correction from the pattern diagram. If you don't have the book, and your pattern wouldn't have appeared in it anyway, you ask Brian Fraser. He will suggest corrective strokes and the amount of time to apply them.

One thing impressed me when we set up to perform the test on the veranda of the Baker building. I washed my mirror and left it to dry and then took it outside for testing. The test results were dreadful, but over a period of half an hour, improved dramatically, simply because the mirror had adjusted to the change in air temperature between the kitchen and the veranda. I had considered that this waiting period, to adjust to the air temperature, was mainly a theoretical notion and of little practical consequence. One learns...

You get closer and closer, until one day, Brian pronounces your mirror "polished". Great, now to get into all the other things. However, polishing the mirror is not the end of the process. You still have to parabolise it.

What is parabolisation? It seems that polishing a mirror gets you a spherical surface. This means that light coming from a nearby (less than infinity) source, i.e. radiating from the source, will be brought to a point at a distance equal to the focal length of the mirror. Unfortunately, from the point of view of optics, most things you want to look at in the sky are a long way off – to all intents and purposes, infinitely far away, which means that light rays arrive parallel to each other. Now to bring these to a point requires a paraboloidal surface. If you go for a long focal length mirror, this process amounts, give or take a little, to rubbing Cerium Oxide on the middle of the mirror for a minute or two. As the focal length gets progressively shorter, so the process of parabolising your mirror gets longer. Brian says that it is not more to parabolise the mirror than to polish it. For my f/6 it could amount to 10 minutes using a longer stroke. Again, you need to decide exactly how accurate you would like the mirror surface to be. You could parabolise it to less than a fraction of a wavelength of light. This seems to be OK in terms of matching commercial mirrors. You might want to get it accurate to less than, say, 1/20 of a wavelength of light and then you would be looking at maybe another 10 hours of work. You would set this off against the fact that the sky is seldom clear enough to use the additional accuracy – maybe once or twice a year. The other argument is that once you put the polishing set away, your mirror is good to last a lifetime and you may well get to see a lot of clear skies in that time.

From my personal point of view, I was keen to have and use a telescope and the objective was to get it to acceptable accuracy as quickly as possible, as I don't have too much spare time. Some of the other guys on the course already had telescopes and were therefore in no rush to complete the mirror – their objective was to improve on what they already enjoyed, even if it took a while to do so. Quality was the watchword and it was amazing to see it in progress. Can you imagine the dedication involved in polishing for a minute, then washing, cleaning, drying, waiting for the mirror to resume ambient temperatures, testing, analysing the change in patterns, then polishing for another minute? While watching from the sidelines, I can well imagine doing much the same on future telescope projects.

The reason for recording these notes is to tell you armchair astronomers that if a klutz like me can build a telescope, so can you. Think about it. To begin from a zero base, learn new skills, use borrowed tools, make new friends and wind up with a telescope that will last (God willing, a long time), gives one a lot more satisfaction than watching other people doing their thing on TV or reading a book. Don't read about it, get on the phone to Brian and anyone else in the Centre who will listen to you, and get another class going. You can make a difference – you can make it happen.

Long ago I fell into the trap of reading about others' achievement until it dawned upon me that maybe it would be better to do something myself, even if others chuckled at my efforts, than to do nothing but be a spectator in life. OK, if you read this far, wait for the next instalment on building a mount.

Part 3, Winter 1992 – Building a Finder Scope

Brian Fraser suggested it because the field of view of the telescope was quite small – even with a 20mm eyepiece, the field is only about 1 degree. "You will find", he said, "That you can't even locate the Moon without the aid of a finder scope." In fact, if you don't have a finder scope you won't use the telescope, because of the frustration in finding things. So there it was: I had to get a finder scope. What with things not being cheap, and also in the true spirit of an amateur telescope maker, it had to be made. Here I was fortunate in being able to acquire three indispensible items which made the building of the finder scope a lot easier: 1. An old objective lens from a photocopier, 2. A right-angle finder to fit a 0.965" eyepiece, and 3. A 20mm 0.965" eyepiece.

I looked through the photocopier lens and it focused about 20mm beyond the end of the lens. The eyepiece did something similar, but combined they focused at a reasonable distance and even magnified the image. My good wife, Glynnis, who come to think of it has been most sympathetic and helpful, helped to measure the length of the system. On a cloudy night in summer, we found a faint Sirius through the clouds, pointed the components at it, and moved them back and forth until a) Sirius could be seen and b) it was roughly in focus. While I held onto the loose components for dear life, Glynnis held up a tape measure to determine the length, then rushed inside to read off the distance on the scale in the light.

Using a piece of plastic wrapped around the objective lens "to get the diameter right" and glued together to form a cylinder the objective lens was pressed inside to a predetermined point. A piece of wood was cut to size and a 0.965" hole drilled roughly in the middle. It was inserted into the other end of the tube and varnished in place, while we moved it back and forth (the varnish was not yet dry) until a focus was achieved. Note that focusing on a tree and focusing on a star produce very different lengths.

I took the final product outside and looked at the sky. Apart from experiencing difficulty in finding the thing aimed at (because of the right angle) the resulting image looked good. With practice finding things in the sky became easier. The image was upside down, but then so is the image in the telescope. It helps you to orient yourself. The final touch was to cover the tube with black contact adhesive plastic kitchen cupboard sheet. Here Glynnis, who is experienced at these things, was of enormous help – do you know how easy it is to get crinkles and folds permanently installed on a surface you are trying to improve on. I looked for red sheets but they only had white sheets with red lines that looked more appropriate for kitchen cupboard work than a finder scope, so I settled on black.

The objective lens from the dead photocopier is a Schneider-Kreuznach and with the eyepiece gives me about 3,5 degree field of view, much the same as my binoculars. I shall try to get a 30 or 40mm eyepiece, which will increase the field of view and, possibly, brighten the image. Good, one more part completed, but how do you attach a finder scope to a telescope? You need a set of two rings, through which you pass the tube. The rings should be fitted with three bolts, set at 120-degree angles, which hold the scope and allow one to collimate it with the main scope. Barry Dunman showed me the one he had built. It looked like a lot of hard work. I didn't have the necessary metalworking equipment, so requested a friendly workshop to build two rings to my drawing. They couldn't understand my drawing, because I also don't draw very well. Nevertheless, they produced a magnificent set of rings, designed, as Barry had suggested, to take plastic number plate bolts, in order not to damage the plastic tube of the finder scope.

When I visited the local number plate makers, the owner gave me a set of plastic bolts and nuts and they fitted the tapped holes on the rings exactly, but didn't quite connect to the surface of the finder scope. I used some longer brass bolts and these did the trick. In order not to damage the fine plastic surface of the finder scope tube, the plastic number plate nuts were attached to the end of the bolts. Bolts were again used to attach the rings to a box built around the main telescope tube – see part 4 for that saga. The finder scope was installed in the rings and collimated with the rest of the telescope optics. In order to produce something reasonably user friendly, the finder scope rings were attached to the right hand side of the box as I prefer to use my left eye for observing (we all have our preferences).

By this stage, the neighbours were getting used to equipment being carted around in the dead of night with the lights out. Being quite polite, they avoided direct mention of the subject, but looked surreptitiously around when invited to dinner parties. I mean, when I began the project I had no idea that ad 8" scope would be so large – it looks like a howitzer. In fact, a gun carriage could come in useful in moving the thing about. I wondered why my chiropractor was keen to take out shares.

Part 4, Spring 1992 – Building the Mount

The wooden mount

I spent some time at work, drawing little diagrams on scraps of paper, trying to crystallise a picture of the mount. Much theoretical measuring was undertaken, the measurements being transformed into a scale drawing of the mount. Then the individual pieces of wood were separated from the design and measured again. Eventually, a design came together. It consisted of a single piece of wood, to be cut at strategic places, the pieces of which could be connected together. John Dobson's design is the simplest for a first time Amateur Telescope Maker and that sounded right for me.

I went to Timber City and they cut the wood for me. I have the tools, it's just that I can't cut straight. The pieces were glued and screwed together and I had a basic mount, which took around a Saturday morning to put together.

Chris Stewart looked at my version of a Dobsonian mount without actually laughing, and said that it should have a saddle in which the tube rides so that the tube could be rotated, otherwise situations could arise where the eyepiece becomes inaccessible. In addition, having a saddle would spare my having to drill unnecessary holes in the tube for attaching the trunnions [large wheels that provide a bearing surface for vertical movement].

It would be nice to be able to use the tube in future projects on other mounts, especially a driven mount, so that was it. A saddle would now be built. A piece of flexible plastic was employed and cut to the right size. Spare pieces of the wood used for the mount were manufactured into trunnions. This was done by inscribing a circle on the wood with my son's compass from his school maths set and cutting on the line with a jigsaw that was passing by. The result looked almost, but not quite, totally unlike a circular disk. Not only did the jigsaw cut not follow the line perfectly, but the angle left something to be desired. Chris noted that for a Dobsonian to work well, it had to glide smoothly over the bearing surfaces.

No amount of sanding smoothed out the surface adequately. The people at work offered to do some smoothing in the workshop, but when the trunnions came back, the originals were returned, together with professionally turned ones. It does take skill...

If the wooden trunnions were screwed through the flexible plastic, the plastic would tear as it had to support the mass of the tube and optics, so to strengthen the plastic edge, the little metal edges from hanging files were used and cut to length. Holes were drilled through the metal hanging file bits and screws were driven into the wooden trunnions.

As a result of careful measuring, the saddle fitted both the tube and the mount. In order to prevent the tube slipping out of the saddle when angled vertically, old belts were buckled around the tube/saddle assembly. I mean, they didn't fit me anymore.

Chris looked at this. Others looked at this. Eventually it was suggested that two old mainframe tape reels would do a much better and smoother job than wooden trunnions. The edge of the tape reel that holds the tape in could prevent the saddle from slipping off the mount. Also it might be much better to replace the saddle with a box through which the tube could pass and be permanently secured. The old mainframe tape reels could be screwed to the box.

The wooden box

Old mainframe tape reels were duly obtained [do you know a big pile the old tape makes on the floor?], more wood was obtained from Timber City and a box was begun.

It was suggested that for the mount to rotate horizontally [left and right], it would be better to get an old mainframe disk drive and use that as a bearing surface.

The time spent doing things on the project amounts to less than an hour a week, but a lot more time was spent thinking and discussing the telescope.

An interesting aspect of the project was the looking about for suitable cast off pieces of other things which might be useful. This is known as scrounging, a skill at which I have now become adept.

The tube

The very first thing would be to get a telescope tube of the right diameter, length and strength. Brian Fraser said that the tube should allow air currents to get at the mirror, so to make the tube a good 2" in diameter larger than the mirror. The length could be gauged by taking the radius of curvature – calculated by measuring the Foucault length - and dividing by 2. This length could be reduced by bending it at an appropriate point where the light path reflects off the secondary mirror and is directed towards the eyepiece. To this reduced number add a number of centimetres for good measure, the good measure being used to reduce extraneous light sources that might stray into the tube from the ground.

My good friend Mark Spires organised a piece of plastic of the right size, had it glued to form a cylinder and even had it painted black inside. The plastic proved to be structurally unstable as it was only 2mm thick and the tube wobbled and dented under a little pressure. It had no hope of remaining wobble free with several kilograms of optics attached to it.

In the meanwhile Barry Dunman sold me a length of tubing [250mm Class 4 Duroflow Pressure Pipe] left over after he had built an 8" scope.

Another friend, Peter Maritz of Imperial paint kindly donated the correct sort of paint of the right colour that would stick to the inside of the tube, as well as a tiny paint roller. This proved to be just the right size to paint inside the tube, with one's arm extended – I could reach halfway down then turned the tube over to do the other half. What do people do to paint the inside of a tube that is more than twice the length of their arm and roller combination? Can you imagine the contortions?

The spider and secondary holder saga

In my innocence, I thought you just went into your local hardware store and asked for a spider and secondary mirror holder for an 8" f/6 Newtonian, and paid for it at the door. I was speedily educated in this regard, not even the Planetarium import these items of necessary equipment.

I was dumbfounded – I mean, what do you do? Here I've spent a year working on the mirror and other bits and pieces and lo and behold the country is out of stock of a basic telescope part.

At length I was forced to the conclusion that I would have to build this as well. Had I known this at the start of the project I would have stuck to mineralogy instead of reaching for the stars.

Whilst bemoaning the status quo, Barry Dunman, a Centre member in good standing, offered to assist in building the required items. Barry had built his own spider and secondary holder and his telescope was similar in design and materials [well, some of them] to the one I intended. He described a complicated set of metal parts and I had some doubt about whether I would ever, ever be able to complete the telescope.

Nevertheless, I visited Barry frequently and the parts took shape on his metal lathe before my eyes. He guided me all the way and at last the spider and secondary holder were complete. I found it hard to accept that all my life I had never built anything of consequence [even plastic model aircraft kits fell apart at my delicate touch], but here was a professional looking, precision set of parts that I had had a hand in creating.

While awaiting the secondary mirror, which I was not going to do myself, Chris Stewart lent me a piece of optically flat mirror, aluminised on the right side [not the left, ya]. He had a strip of this plane glass and after meticulous calculation, cut a line across the glass with a glass cutter, placed a metal edge along the line and hit it with a little hammer. I was impressed – a piece the exact size of the measured piece fell off the other end of the glass strip. Now here was something – for all our science, something unusual had happened – the glass having been examined for planeness etc. must have harboured a latent area of stress just far enough along to produce a piece of the exact size and shape?

Rebuilding the Wooden Mount and Box

The day arrived when the secondary holder and spider were complete and I took the mount, box and tube around to Barry to show that I could build something without supervision.

Barry noted that, while a good design, the mount was a bit rickety and the box was less of a square than it was a rhombus. In fact, the square was out by more than a centimetre.

I had more wood at home, and he took this and strengthened the mount. He also said that wood glue provides a stronger bond than the screws I had used. He was right. The bonding was stronger, smoother and he got the angles right.

The Mirror Holder

The mirror holder was made from the remains of a swing that my Dad had made for my daughter. Good wood. I cut the square seat into a circle with my trusty jigsaw. In places it was the same diameter as the mirror. What do you use to attach the mirror to the mirror holder? I saw an old hanging file in the garage, the sort with metal edges. The metal bits were cut to size and bent. This was after I spent a lot of time sawing aluminium, and then discovering it didn't bend too well. In fact, it broke. Never mind. I can always use the pieces on another project.

Barry took the ex swing to heart and swung away at it, producing a solid, but light, mirror holder. The mirror was then connected to the holder on a bed of silicone sealant and little arms were constructed to hold it in place. To protect the edge of the mirror, a wine cork was sliced and glued to the little arms, an excellent end for some fine wine.

At this point the parts have been constructed and need only be assembled, and provided this works, my telescope will be operational and you are all invited to enjoy it with me. Part five looks at final assembly and operation. Pray hard.

Part 5, Summer 1992/1993 – Final assembly and other tales.
Final assembly. This is the nerve wracking part. Will all the assorted pieces of hardware come together? Will the tube prove long enough? Will it fit in the boot of the car? Will the kids stop seeing the mount / tube as a seesaw. Tune in ...

Barry and I preassembled the scope, prior to the mirror being aluminised and were able to focus on images, balance the tube on the mount, get rid of the kids, and generally fall down in surprise at the way things hung together. We could see atmospheric bands on Jupiter, the Galillean satellites and the most marvellous view of the Moon. For Moon minders, the view in an unaluminised mirror is much superior – try it, you can put your dark glasses away and enjoy the detail without screwing up your eyes and have your night vision return the next morning at 09:00.

The final assembly, thanks to Barry's meticulous measuring went quickly. All parts fitted. The mount worked. The tube fitted exactly over the beams, and all things were bright and beautiful.

There was a lot of viewing of objects in the scope prior to aluminising, and this was a wonderful time, except for the sad fact that before we could enjoy some dark site viewing together, Barry left to live happily in Cape Town. I actually think that he got a bit tired of the amount of time I spent enticing him into the workshop, and moving to Cape Town may have been the best solution.

I had been warned that aluminising a mirror attracts a good week of cloud cover, and while watching the process (and generally getting in the way), I peeked out the window and saw clouds rushing in from all directions. For those unlucky enough not to have witnessed this marvellous process, here is a brief and entirely accurate account. Only some details have been altered to punish the innocent, as is their just reward.

Tony Voorveld kindly arranged facilities at the Physics Department, as all efforts to get the Transvaal Centre's plant running proved short of actual vacuum. A number of us, Dave West, Dave Blane, and several other Daves arrived at 08:00 and washed our mirrors. Altogether, 8 mirrors were aluminised in the hopes of negating the El Niño effect.

The mirrors were washed in water, then washed in an ultrasonic bath, then washed in the ultrasonic bath using a mixture of isopropyl alcohol and acetone. The carefully washed mirror is kept in the bath while the vacuum plant was checked out. Now in my technological innocence, I fully expected Tony to develop a full vacuum, then attach a vacuum cleaner... I mean, what else could a vacuum cleaner be used for? OK. In fact, the mirror was placed appropriately in the vacuum chamber, before the vacuum was generated. The two electrodes were placed carefully near the centre of the mirror, a tungsten filament was bent into a "V" shape and hung between the electrodes and finally some aluminium foil was wrapped around the tungsten filament. A glass dome covered the space. A very expensive glass dome. The vacuum was initiated, and once at a suitable intensity, 1×10^{-3} atmospheres, an electric current was slowly applied using a large knob to control the rheostat. As the current increased the temperature of the tungsten filament, the aluminium foil began to rotate, then melt. This was a critical point, for if it melted and dropped off the filament onto the centre of the mirror one had spent a year or more figuring, someone would no doubt be dead. As the temperature of the melted aluminium increased and reached boiling point, the glass dome began to cloud very slowly. With consummate artistry, Tony continued to control the current until only a faint image of the glowing filament could be seen. The surface of the glass dome had been aluminised. The current was reduced, the air was allowed into the chamber, and the dome was removed to reveal a splendidly aluminised mirror.

The coating on the dome was removed by washing it in a caustic soda solution until it was clean enough to begin the process again. So the scope is complete. It comes apart and bits go into the boot of the car, and bits on the back seat, and the kids sit on the roof. Now to this point, I had invested a lot of time in building this telescope, and not once had it occurred to me that I would have to work night shift in order to use it.