

Isaac Newton Group of Telescopes ***Aluminising the***



4.2 Primary Mirror of the William Herschel Telescope.

Introduction

The primary mirror of the William Herschel Telescope is a 16 tonne piece of glass, 4.2 metres in diameter. It is occasionally removed from the telescope for the re-coating of its optical surface. The surface is covered with a layer of aluminium no thicker than 0.0001 milli-metres.

Over a period of time (1-2 years) the optical reflectiveness of aluminium surface can reduce to a level which ultimately reduces the performance of the telescope. When this point is reached the old aluminium is washed off and a new coating is vaporised on.

This operation requires skilled engineers working to an engineering plan following detailed procedures. This document outlines the engineering step procedures to follow in order to carry out the aluminising process in a professional and safe manner.

This document is comprehensive, but there must be no under estimation of the knowledge, and professional / technical ability of all the staff involved. The five persons from the mechanical engineering group whom currently carryout the aluminising operation, have to date a total of 46 staff years with the observatory.

Responsibility

The Head of Mechanical Engineering is responsible for the WHT primary mirror aluminising operation. If absent the Head of Mechanical Operations will supervise the aluminising process and a senior engineer e.g. Head of Engineering will provide any necessary professional support or advice. The Head of Engineering and ultimately the director of the ING have the responsibility to ensure suitably qualified and/or knowledgeable personnel carry out the aluminising.

General Safety

- Hard hats to be worn at all times on ground floor level. (Except when the mirror is exposed and all staff have been cleared from higher levels e.g. when cleaning and positioning the mirror)
- To minimise risk to the mirror the following will apply.
 - Only the crane driver will be allowed directly above the exposed mirror.
 - The crane driver and all staff working on or close to the mirror must empty pockets above waist height and check that no they have no items on them that could fall.
 - The mechanical group will control access to the dome and floor levels one and two will be locked of when the mirror is exposed.
 - No metallic objects or tools must be used above the mirror surface.

- All lifting equipment and overhead cranes must be fully certified and have been checked within the last six months.

Preparation Work

Request for aluminising stand-down

The aluminising start date and duration will appear on the telescope schedule. The telescope schedules are planned 2-4 months before a new semester.

Aluminising Plan. (See appendix A)

The person responsible for the aluminising in collaboration must produce an aluminising project plan detailing the aluminising and maintenance work over the period of the stand down with group & section heads and specialists.

Locate and check Equipment (See appendix B)

- In the week preceding aluminising locate and check lifting slings and equipment, e.g. slings, trolley rails, cable wrap stands (if the cable wrap is to be lowered), mirror stands, plastic tube and any other equipment that is required.
- Coating specialist prepare aluminium foil for the vacuum tank.
- Electrical section checks and run the vacuum aluminising vessel.

Revision

Several days before aluminising watch the aluminising video and read through this change document.

1) Mirror Trolley to the observing Floor.

This process is usually carried out before the day of the actual aluminising.

- a) Check logbook and make an entry detailing work and the restrictions in force i.e. “*moving mirror trolley do not move telescope or dome*”. Set telescope and dome for engineering use. Control both telescope and dome locally.

Safety Note: Use hard hats on ground floor.

- b) Use the 2.5 tonne crane to remove the floor sections that are stored on top of the mirror trolley. Place the floor sections in front of the aluminising door. See photo 1. Tip~ Place the floor sections so they can be later lifted in order i.e. back section first followed by the two side sections and finally the front section.

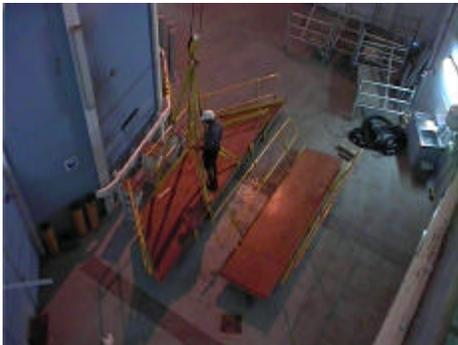


Photo 1.

Trolley floor sections being placed outside aluminising door

- c) Remove floor section at observing level. Using 2.5 tonne crane. See photos 2 & 3.

Safety. When floor section is to be removed access to that level must be controlled and restricted. Lock off the doors.



Photo 2

Observing floor section slinging arrangement.



Photo 3

Observing floor section removed, to enable trolley to be lifted up to the observing floor.

- d) Park the 2.5 tonne crane and start to lower the 25 tonne crane in preparation to lift the WHT mirror cell-handling trolley. The trolley weighs 7.5 tonnes.

- e) Move telescope in azimuth using engineer buttons. Bring down the 25 tonne crane above the mirror trolley.

- f) Use 4 strops each with a S.W.L. of 3 tonnes & 6 metres in length. These are shackled to a single wire strop. This arrangement is necessary to cater for the plastic drip guard that is mounted on the crane.



Photo 4

The four slings shackled to the wire strop.

- g) Set the dome speed rotation to number 2. Start to take the weight of the 7.5 tonne trolley. Double check lifting shackles.



Photo 5

Telescope rotated in azimuth to enable the trolley to be lifted. As the trolley moves to the observing floor the telescope must also be moved using the local engineering buttons

- h) Lift the trolley on to the observing level through the gap created by removing the floor. See Photo 6.



Photo 6

- i) Remove the covers from the observing floor to expose the rail track. Lower the trolley onto the rails. Plug in power lead so the trolley can be moved.

- j) Fit three of the trolley floor sections i.e. back and two sides. The front section is parked in the middle of the frame and is not fitted until the day of aluminising. This allows full movement of the telescope.



Photo 7

A floor section being fitted to the trolley.

- k) Replace observing floor section. Refer to photos 2&3.

- l) Check dome rotation and telescope movements are clear. Sign off logbook.

Day of the aluminising Stand-down.

2) Cassegrain instrumentation removal and trolley positioning.

- a) Check logbook and make an entry detailing work and the restrictions in force i.e. “*Aluminising mirror do not move telescope or dome*”. Set telescope and dome for engineering use. Control both telescope and dome locally.

Safety Note: Use hard hats on ground floor.

- b) Use engineering panel at AP3 -see photo 8- and Zenith Park the Telescope. This places the telescope in the correct altitude and azimuth positions. Leave the oil system on.



Photo 8

AP3 engineering panel.

- c) Fit the two telescope ties on the drive side i.e. the UES side. Tighten the turnbuckle then back it off half a revolution. This later allows the mirror cell to horizontally align with the mirror trolley support rams.



Photo 9

Telescope tie with pin inserted.

- d) Lift up instrument handling trolley. Un-cable instrument and remove it from the A&G box flange. Photo 10 shows TAURUS being removed it could be any one of a suite of instruments.



Photo 10

Removing the cassegrain instrument.

- e) Lower the cassegrain instrument to the ground floor then lift up the A&G box handling trolley. Photo 11.



Photo 11

A&G box lifting frame.

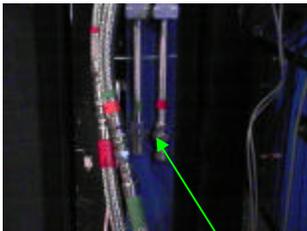
- f) Un-cable and remove the electronic racks and the A&G box. Ref. photo 12. Ensure all bolts from the A&G box flange have been removed i.e. remove the TV camera to remove the bolt in this hidden pocket.



Photo 12

A&G box being removed using the rising floor.

- g) Lift the A&G box to the ground floor.
- h) Remove the flexible helium pipes fitted from the cable wrap to the instrument. Also check and if necessary disconnect the pipes in ghril that feed cassegrain helium circuit. Ref. photo 13



Fixed pipe-work is the cassegrain helium supply in the GHRIL room.

Photo 13

The self-sealing couplings of the fixed pipe-work should be disconnected as this photo indicates

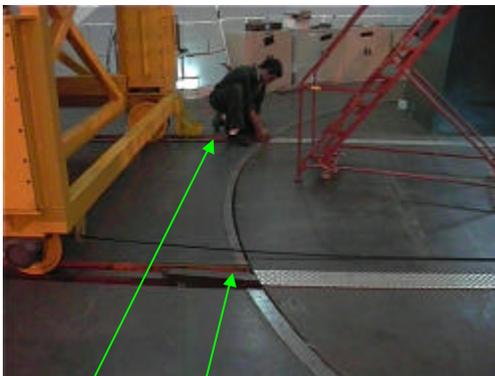


Photo 14

The small sections of track that have to be inserted.

- i) Fit the rail sections to join the floor track to the telescope track. Use the local engineering control to move the telescope in azimuth to fit and align the tracks. Ref. photo 14.
- j) Next the floor latches have to be engaged. The floor latches are pneumatics rams below the trolley rail track. These rams provide the extra support necessary to safely with stand the combined weight of the mirror trolley (7.5t), mirror cell (21t) and the mirror (16t). The use of the cassegrain rising floor is interlocked when engaging latches. On the local panel switch over to mirror trolley and floor latches. See photo 15.

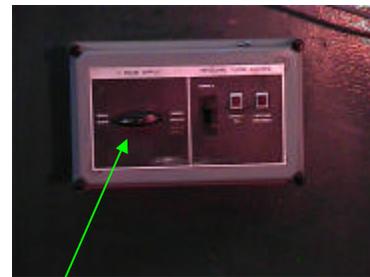
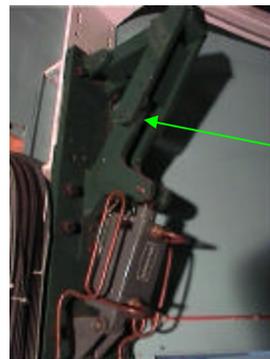


Photo 15

Switch from rising floor to mirror trolley on this panel.

- k) It is very important that the floor latches have engaged. You should hear two loud bangs as each floor latch locks in place. Check under the floor that both supports have been fully deployed. Ref. Photo 16.



This shows one of the two floor latches engaged and supporting the rail

Photo 16

- l) Visually check the floor latches. When you have confirmed that both supports are fully engaged, turn of the oil support system. Place a permit lock on the power-isolating switch in the control room.
- m) Plug the power supply for the trolley into the observer floor supply. See photo 17.



Photo 17

Remove the aluminium cover in the observing floor and plug in the power supply to the mirror trolley.

- n) Safety Note: The mirror trolley has a SWL of 37.5 tonnes. This is sufficient to support the mirror in its cell. If pocket weights are fitted to the mirror cell they must be removed. The brackets can stay on.



Photo 18

Pocket weights being lifted of the mirror cell to reduce the overall weight.

- o) Fit the front floor section to the mirror cell trolley. Ref. photo 19.



Photo 19

Front floor section being craned into position on the mirror trolley.

- p) Move the handling trolley under the mirror. Ref. photo 20 Watch out for hanging cables and ensure that the cassegrain turntable is rotated to the position indicated in figure 1

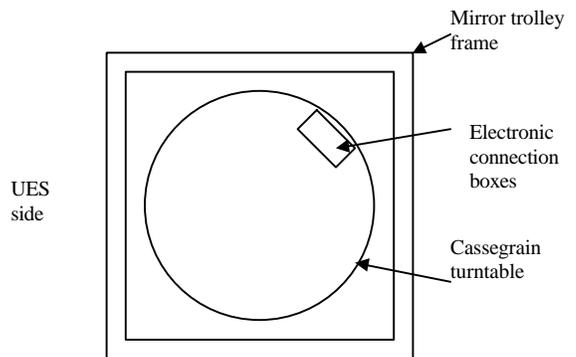


Figure 1

Plan view looking at mirror trolley frame and cassegrain TT position.

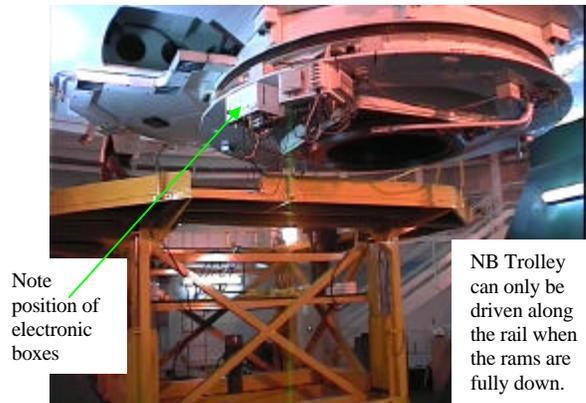


Photo 20

Trolley being traversed under mirror cell.

- q) As the trolley is driven in fit the 3rd telescope tie. When the trolley reaches the other side fit the 4th telescope tie. See photo 21. Remember to back of the turnbuckle by half a revolution



Photo 21

3rd telescope tie being fitted using the mirror trolley platform.

Safety note: the next operation involves removing a section of the observing floor. Lock of the door to that level and restrict access.

- r) Now that the trolley is underneath the mirror cell remove the observing floor section. Ref. photos 22, 2 & 3.



Photo 22

Observing floor section being removed.

- s) Lower it down to the ground floor in front of the aluminising tank door. Place it on pallet trucks and move it away from the aluminising door. Ref. Photo 22.



Photo 23.

Observing floor section being moved on pallet trucks toward the WHT entrance door

- t) Fit barrier in front of removed area of the observing floor.
- u) Fit the 3 mirror support stands on the metal pads in front of the aluminising tank door. Place the locating bolts into the holes but do not tighten them. This allows the rubber pads on the stands to find their own level when the mirror sits on it. See photo 24



Photo 24

Mirror support stands being fitted.

The mirror trolley is now in position and all other preparation work is complete. The next stage is to lower the mirror cell and position it for mirror removal.

3) Preperation for Cell removal

- a) Take DTI readings of the mirror axial position at 3 of the four cardinal points. Mirror support ON and Off. It is very important to record the position of the mirror with respect to the mirror cell. This record enables the mirror to be placed in the same position in the event of anything being adjusted or moved etc. Photo 25 shows one of the axial DTI's. The absolute reading DTI is set to 0.00 mm when the mirror support is inflated.



Photo 25

One of the axial DTI's. There are also holes at the three axial definers to take depth micrometer readings

- b) Turn the mirror support off.
- c) Disconnect mirror cell cables and the helium pipe-work. Visually check to see that nothing bridges the gap between the mirror cell and the telescope structure. See photo 26.
- d) Remove any temperature sensors that are connected to the mirror surface.

Tip~ When raising the rams check horizontal alignment with respect to the cell. Watch and adjust if necessary the telescope ties as the cell may level when subjected to hydraulic support.



Photo 26

Power cables being disconnected from the telescope connector panel.

- e) Using the trolley handset drive the four rams up towards the base of the mirror cell. On top of each ram sits a hydraulic jack. Ref. Photo 27. The four hydraulic jacks must not (at this stage) be pressurised. This is because the rams raise until they reach a limit switch and if a jack is extended and pessurised it will hit the bottom of the cell before the limit switch is made. Therefore make sure the four valves on the manifold and the one valve on the hydraulic pump are open (see photo 28).



Photo 27

Ram raising towards the mirror cell

- f) Now that the four rams have reached the extension limit. The weight of the mirror cell and mirror has to be supported on the hydraulic rams. Close the valve on the pump and pressurise the system (see photo 28) until a pressure of 4500 PSI is reached. Keep the four isolating valves open so the each jack is on equal load. Watch the pressure gauge for 30 seconds to see if the system is leak tight. If the pressure remains constant proceed.

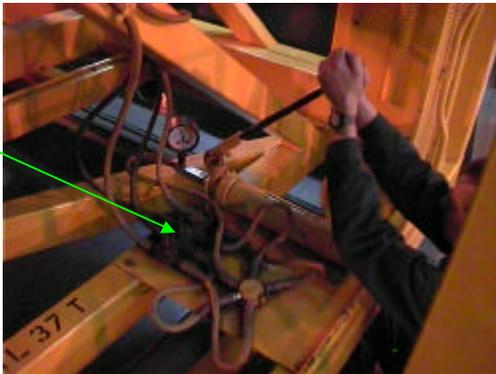


Photo 28

Hydraulic pump for mirror cell support system.

The mirror cell is now properly supported and you can see from photo 29 that the four rams are extended and the jacks are placed on the mirror cell support pads.



Photo 29

Shows one persons using the hydraulic pump while the other persons check the jacks, support in the right place on the cell. Also check for hydraulic leaks.

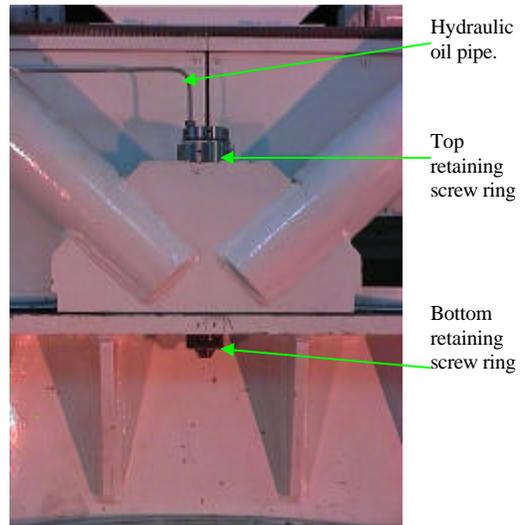


Photo 30

One of four "PILGRIM" bolts that hold the mirror cell on.

- g) Release the pilgrims bolts by using the hydraulic pump. The hydraulic pump is accessed by entering GHRIL and removing the panel behind the electronics rack. See photo 31



Photo 31

The hydraulic hand pump mounted on the side of the telescope. Access is gained via the ghril room.

Pilgrim bolt release procedure.

1. Pump pressure to 27000 psi.
2. Losen top screw retaining ring.
3. Release hydraulic pressure.
4. Remove bottom screw retaining ring.
5. Close the valve on the hydraulic pump

The Mirror cell is now ready to be lowered.

4) Lowering the mirror cell and lifting the mirror.

Safety Note: The mirror will shortly be exposed. Lock of doors to levels one and two. Make an intercom announcement stating that access to the dome will be strictly controlled until further notice.

Remember.

1. Only the crane driver should be above the mirror.
2. No metal objects or tools should be handled directly above the mirror.
3. Check that there are no loose objects on any persons involved in the mirror work.
4. Always have enough people to watch all the surfaces of the mirror i.e. top, bottom and cardinal points when moving the mirror.

- a) Use the trolley handset to lower the mirror cell. At least four people should watch as the mirror cell is separated from the telescope. Continually check that everything is disconnected. Photo 32 shows the cell as it is being lowered. Continue to lower until the rams cut out on the micro switch. NB the trolley will not traverse unless it is fully lowered.



Photo 32

Mirror cell being lowered.

- b) Use the handset and traverse the mirror trolley out from under the telescope. See photo 33.



Photo 33

Trolley being traversed from under telescope

Safety Note: Ensure nothing can touch the surface of the mirror as it is traversed out.

- c) Drive the trolley until the cell is completely clear of the telescope structure. Ref. Photo 34.



Photo 34

Trolley nearly out from underneath the telescope structure.

- d) Drive the trolley to the position at which the mirror can be safely lifted.
- e) Inspect all pads that are glued to the mirror.
- f) Take four radial depth micrometer readings of the mirror in respect to the mirror cell. Use the cardinal points

- g) If any temperature sensors have been fitted to the mirror, remove them or ensure that their cables are securely reeled up.
- h) Remove the quick release pins from the mirror side of the counter balance arms. See photo 35. Lift back the arm and place the pin back in.

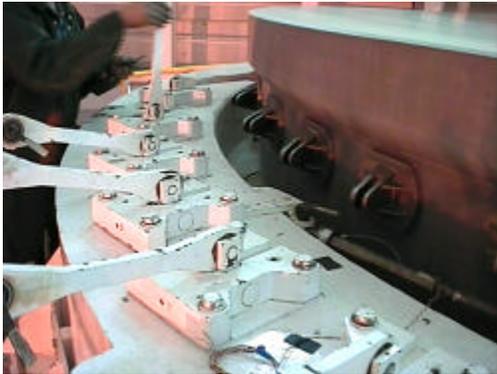


Photo 35

Counter balance arm removal

- i) Remove the quick release pin from the mirror side of the radial definers. Ensure that they are clear and will not interfere with a mirror lift. If there is any doubt remove both quick release pins and place the radial definer on the mirror cell.



Photo 36

Radial definer detached and clear of the mirror.



Photo 37

Removing top retaining screw from one of the 3 axial load definer.

- j) Using an Allen key remove the screw on the top of the axial definer. See photo 37. Place the screw and dome spacer safely on the base of the mirror cell next to the axial definer.
- k) One person now makes a final check, to ensure that all axial load cells, radial definers and counterbalance arms are detached and clear of the mirror.
- l) Using the handset raise the mirror cell on the handling trolley to the mid-point of travel.
- m) Obtain a 14mm Allen key. Crawl underneath the cell into the centre section of the mirror. Remove the four Allen bolts that secure the lifting spigot.
- n) Position the 25 tonne crane with the mirror-lifting spider. A person in the centre of the mirror should align the crane to be central with the mirror-lifting spigot. Lower the spider on the crane until the spider is a few cm from entering the spigot. See photo 38

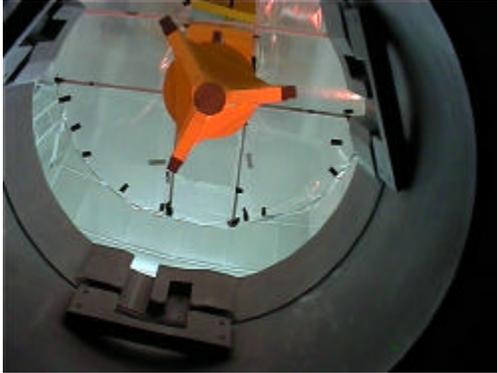


Photo 38

The lifting spider being lowered on the crane towards the mirror lifting spigot.

Safety note: Careful alignment is essential. Spend time on centring the lifting spider with the spigot. Also use the mirror trolley to raise and lower the mirror and cell with respect to the lifting spider when completing delicate manoeuvres. The mirror trolley raise and lower speed is slower than the crane.

- o) Using the mirror trolley handset raise the trolley until the spider enters the spigot continue to raise the trolley until the spider can be rotated to the lifting slot in the spigot. Once engaged lower the mirror trolley until the spider positively locates on the top of the lifting spigot. Ref Photos 39& 40.

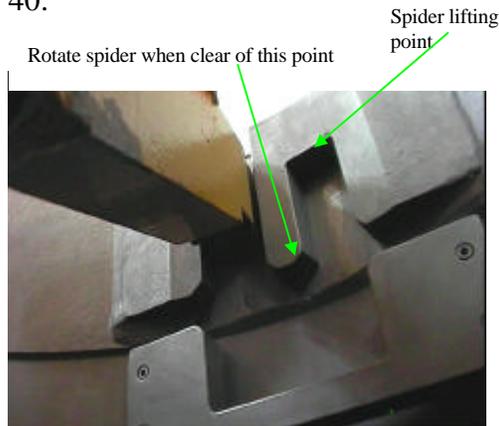


Photo 39

Spider entering lifting spigot as the trolley is raised.



Photo 40

Spider located and engaged in spigot ready to lift the mirror.

- p) One person checks again that the mirror is free to be lifted and nothing is connected to it.

Check list

1. 3 radial definers disconnected
2. 3 axial load cells disconnected
3. All counter balance arms disconnected
4. 4 Allen screws in spigot removed.
5. Temperature sensors removed or reeled up.

- q) One person located at each axial definer. One person operating the mirror handset and the crane driver watching the spider and lifting spigot. Lower the mirror trolley until the crane takes the weight of the mirror. Ref photo 41.



Photo 41

Mirror suspended from the crane.

- r) Once the mirror weight is taken on the crane check everything is OK and then lower mirror cell using handset.

- s) Use the overhead crane to raise the mirror fully out of its cell. Remember to watch all surfaces of the mirror as it is being handled. The mirror needs to be lifted just high enough so that the mirror cell clears the base of the mirror.



Photo 42

The mirror being raised out of its cell, exposing the mirror support system.

- t) Fit the Allen screws to the top of the axial load cells so they do not get lost.
- u) Once the mirror base clears the cell traverse the mirror trolley under the telescope. Ref. Photo 43



Photo 43

Mirror trolley being traversed back under the telescope.



Photo 44

Mirror being moved towards GHRIL over the observing floor safety rail.

- v) When the trolley is under the telescope and clear of the mirror, use the overhead crane and lower the mirror until the base of the mirror clears the observing floor safety rail by 0.5 metre. Remember to watch all mirror surfaces. Ref. Photo 44
- w) Set dome rotation on creep speed i.e. less than 2. Rotate dome and mirror towards GHRIL. Watch all mirror surfaces and the mirror drip guard. Ref. photo 44.



Photo 45

Mirror in position to be lowered down on to the mirror stands.

- x) Lower the mirror on to the mirror stands. Watch all surfaces of the mirror. Ref. Photos 45 & 46.



Photo 46

Mirror lowered onto stands. Measurements being taken to centralise the mirror on the stands.

- y) When the mirror is securely on the stands continue to lower the lifting spigot and remove it from underneath the mirror by landing it on a pallet truck. Ref. Photo 47.

Spigot removal.

1. Lower the spigot on to a pallet truck.
2. Lower the crane until the spider can be rotated.
3. Raise the crane until the spider is clear of the spigot.
4. Remove the spigot on a pallet truck.
5. Move the spigot well away from the mirror so it does not get splashed with water when cleaning.
6. Raise the spider sufficiently high enough (10 metres) not to get wet when the mirror is being cleaned.



Photo 47

Spigot landed on the pallet truck. The spider is being raised out of the spigot.

5) Mirror cleaning and placement in the aluminising tank.

Safety Note: while the mirror is on the stands and being cleaned do not allow people to work above the mirror. This means that until the mirror is safely in the aluminising tank no work may be carried out at levels one and two. Staff cleaning the mirror do not need to wear safety hats.

- a) Hose down the mirror surface with water. This removes the dust and dirt from the aluminium surface. See photo 48



Photo 48

Mirror being washed with water.

- b) Staff involved in mirror cleaning put on personal protective equipment (PPE). I.e. plastic overalls rubber gloves and boots and safety goggles.
- c) Remove the aluminium coating with caustic soda. See photo 49.



Photo 49.

Aluminium being removed from the glass.

d) When all the aluminium has been removed. Wash the mirror with water.

e) Dry the mirror.

NB This is an overview of mirror cleaning. Precise steps and quality checks are performed by the head of the telescope operators and the optics group.

f) Lift the mirror and remove the stands. Ref. Photo 47.& 50.

1. Return the spigot to underneath the mirror.
2. Lower the spider into the spigot.
3. Turn the spider and lift the spigot.
4. Raise the crane and lift the mirror.
5. Remove the stands. (Photo 50)
6. Raise the mirror enough to clear the tank.



Photo 50.

Stands being removed.

g) Clean bottom rubber seal of the aluminising door. Clean and check inside of the aluminising tank base. Place rubber support pads in tank.

h) Drive out aluminising tank base. Ref. Photo 51.

i) Carefully align and centre mirror with the aluminising tank base. Lower the mirror into the tank checking alignment with a tape measure.



Photo 51

Aluminising tank base being driven under the mirror.

j) Once the mirror is sitting firmly on its rest pads in the aluminising tank, continue to lower the crane until the spigot rests in the tank.

k) Continue to lower the crane until the spider can turn to its release position. Use a **plastic pipe** to turn the spider. See photo 52.

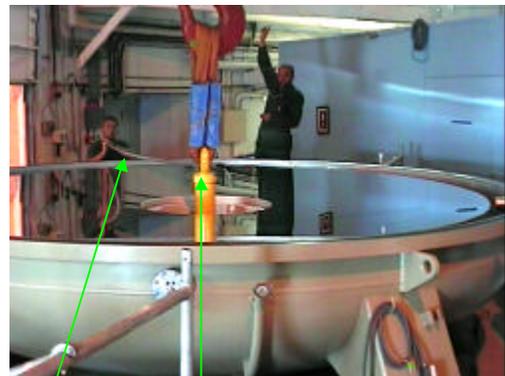


Photo 52.

Plastic pipe passed through the spider-lifting eye. This allows you to turn the spider and disengage it from the spigot.

l) Once the spider is free raise the crane and lift the spider out of the way.

m) Drive the aluminising tank base under the aluminising tank. See photo 53.



Photo 53

Aluminising tank base being driven towards the aluminising vessel. Base temporarily stopped to allow reflectivity measurements to be made.

- n) Raise the tank base and seal the tank. Turn on vacuum system.
- o) Approximately two hours later and after also flowing liquid nitrogen through the top ring. The vacuum pressure attained is now suitable to vaporise the aluminium foils in the vacuum tank.
- p) Aluminise the mirror.

6) Returning the aluminised mirror to the Telescope.

- a) Follow the steps in reverse order. Reading and checking each section before proceeding.

Additional Notes.

Take great care that nothing drips on the mirror surface. Clean the bottom edge of the aluminising door before driving the mirror under it. Ensure that the lifting spider and hook are clean. Later ensure that the PILGRIM bolts have no oil drips on them. If necessary wipe them and seal them with tape.

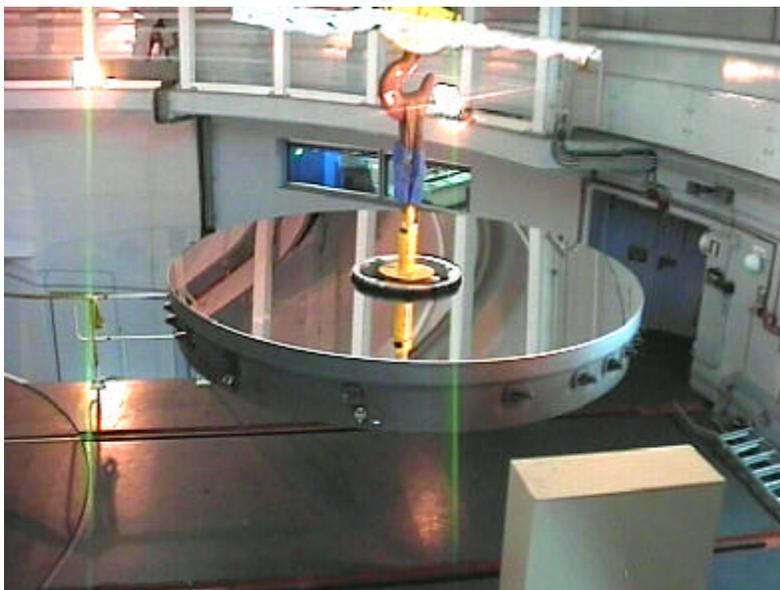
Ensure that a detailed check of the inside of the mirror cell is made and that all the tops of the *belloframs* are clean. Lower the mirror into the cell guiding the mirror onto the axial definers. Remember to use the trolley for delicate lifting operations.

When the mirror is exposed control access and do not let staff directly above the mirror.

Special note on the PILGRIM bolts.

The piston on the underside of the top head should protrude by 1 mm. The bottom screw-retaining ring sets this distance.

When the mirror cell is back on the telescope and the mirror support is on, check the mirror position. It may not settle until it has been moved in elevation a few times and the mirror support system has been exercised.



The 4.2 metre mirror re-aluminised and in the process of being returned to its cell.