BRITISH ANTARCTIC SURVEY

Dobson Ozone Spectrophotometer Operating Manual

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Contents

1. Introduction

Measurements of total column ozone have been made using the Dobson Ozone Spectrophotometer at the Argentine Islands and at Halley Bay since the beginning of the International Geophysical Year in 1957. The British Antarctic Survey operated Faraday Station from 1957 to 1995, and took over the Halley Station in 1959. The Ukrainian Antarctic Research Centre runs the former Faraday Station, now known as Vernadsky.

At Halley, BAS has the longest continuous running ozone measurement programme in the Antarctic. In addition it has used the same techniques since the programme began in the IGY. This makes it particularly valuable in the measurement of long term trends associated with the formation of the Antarctic ozone hole, and hopefully its recovery in the 21st century. Supporting measurements at Vernadsky and Rothera are important for understanding ozone depletion processes at the edge of the polar vortex. Ozone measurement is one of the 'flagship' BAS observing programmes.

The purpose of the instrument is to measure the amount of ozone contained in a vertical column of air extending from the ground to the top of the atmosphere. This is normally expressed in Dobson units (DU). An average pre-ozone hole measurement was around 300 DU corresponding to a layer 3 mm thick if the ozone were brought down to sea level.

Since the mid 1980s, depletion of Antarctic ozone has taken place each spring of up to 60-70% (minimum readings < 100 DU), before being replenished in the summer. Observations during this period are especially important.

Ozone measurements are made using the Spectrophotometer to compare the intensities of pairs of wavelengths of ultra violet between 300 and 340 nm. At this point in the ozone absorption spectra, there are large variations in absorption and it is possible to choose pairs of wavelengths, close to each other, which have greatly different absorption coefficients. By comparing a wavelength 'unaffected' by ozone with one greatly absorped it is possible to calculate the amount of ozone in the atmosphere.

Measurements are made from direct sunlight, scattered light from the zenith sky and in the winter months from the reflected light of the moon.

This manual provides some background on the theory of the instrument but is mostly concerned with practical instructions on making observations and carrying out calibrations. It should be read in conjunction with the ozone section of the BAS Meteorological Station Instructions.

1.1 Health and safety

Due caution should be exercised when carrying out work on the instrument electronics or motor. The PSU should be switched off before carrying out any work on the instrument. The internal 1000V EHT power supply should be treated with respect. EHT can kill. Live working is discouraged, but if this is essential always have an observer present and connect to the mains via an RCD.

The standard and twin lamps are very bright and generate considerable heat.

The mercury lamps give out uv light and should not be looked at directly without protection for your eyes. The uv light from the lamp generates ozone, and it must not be allowed to run for long periods in an enclosed room. The body of the lamp can become quite warm.

The Nickel Sulphate filter contains a solution of Nickel Sulphate in water and methanol. As individual chemicals Nickel Sulphate is classed as ‘harmful’ and methanol is classed as ‘toxic’ and ‘highly flammable’. The COSHH assessment shows that in normal operation the residual risk is minimal.

Guidance material on lowering the Dobson from its cradle is available at Halley.

2. The Instrument

Light enters the instrument through the small entrance window. When making measurements on direct sunlight, an external prism is used to direct sunlight into the window and a ground quartz plate is placed over the window to diffuse the beam and reduce the intensity to a level similar to that observed from the zenith sky.

The light is refracted through 90 degrees by a right angled prism and passed through a slit to select a 7 degree wedge of light from the zenith. The beam can be refracted slightly by a flat quartz plate (on the Q lever) to vary the wavelengths of interest (termed A, C and D) and also provide temperature compensation of the instrument.
See Appendix A for optics diagram

Note that the wavelengths, for example ‘A’ is infact a pair of wavelengths, in this case 305.5nm and 325.4 nm, the first being highly absorbed by ozone and the latter relatively unaffected.

The beam is made parallel by a lens and split into a spectra by a 60 degree prism. This is reflected back towards the centre of the instrument by a mirror. The beam is further split as it passes back through the prism and lens. Slits are used to isolate the wavelength pair of interest.

The beams are recombined at the other end of the instrument by an identical set of lens, prism, mirror and flat quartz plate into the photomultiplier tube (PM tube). Each of the two wavelengths is selected in turn by a rotating sector wheel which is belt driven from the electric motor, which blocks first one beam, and then the other. There is a spare belt in place for easy replacement if required.
See section 5.5 for diagram

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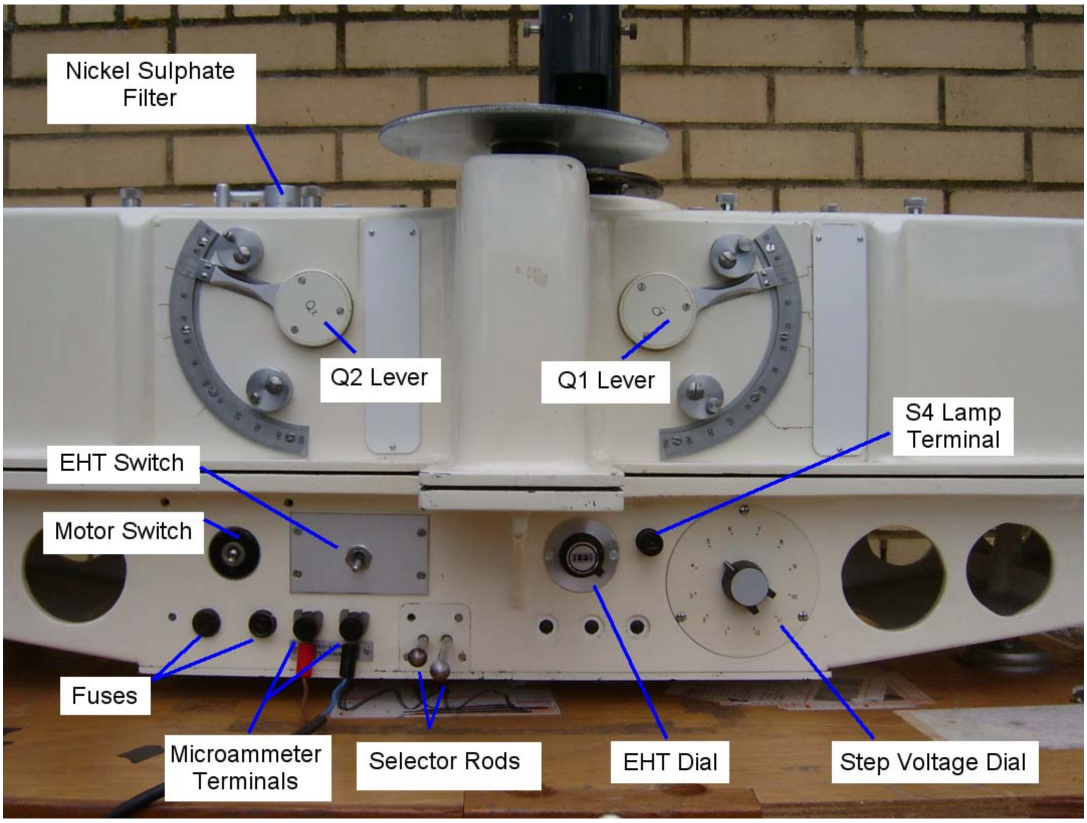
The motor runs very quietly and it can sometimes be difficult to tell if it is on. An internal EHT supply provides up to 1000 V for the PM tube through a digital potentiometer; for normal use this should be set between 700 and 900 V.

The sensitivity of the PM tube is varied by altering the EHT potential on it and the output is then amplified. The alternating signal caused by the switching of the two beams is then rectified and the output current from the amplifier which reaches the PM tube is then measured on a microammeter.

Never put a current of more than 20 microamps on the PM tube. Do not simply reduce the sensitivity of the microammeter as the current will still exist at the PM tube you must reduce the *Instrument sensitivity* dial (also known as the Step Voltage dial).

A calibrated optical wedge is moved in the path of the stronger intensity beam until the intensities of the two are equal and hence the microammeter current is zero. The dial reading gives us the measure of the difference between the two intensities.

A thermometer is inserted in a tube to measure the temperature of the instrument and dishes of silica gel are placed inside to keep the air dry.



3. OBSERVATIONS

3.1 Schedule

The normal daily observing schedule is to try and make at least five observations in a day. For convenience these can be made close in time to the 3-hourly synoptic observation. See appendix D for details. A variety of different types of observation are possible according to the height of the sun (or moon) and sky conditions.

The height of the sun (or moon) is usually expressed in terms of the value of mu. Mu is the ratio of the actual path length of light through the ozone layer compared to the vertical path length. As the sun becomes lower, the actual path length increases and mu increases, up to a maximum of 12.7 when the sun is on the horizon. There is a computer program (Mutimes or equivalent) to calculate mu for each day.

On days where there have been some direct sun observations it is very useful to make calibration zenith observations from LAN to high mu values. To be valid, the ozone has to remain fairly constant through the day. The days should be chosen to represent a variety of ozone values and it is often convenient to combine them with Lo runs, or to simply make hourly observations.

3.2 Types of Observation

The table below shows the different types of observations possible according to the value of mu. Although not desirable, an observation done outside these ranges may still be useable and should not be rejected straight away:

Mu / Obtype	ADDS	ADZB/C	CDDS	CDZB/C	CDFFS
1.0 - 2.0	*	*	*	*	
2.0 - 2.6	*	*	*	*	
2.6 - 3.0	*[2]		*	*	
3.0 - 3.5			*	*	*
3.5 - 4.4				*	*
4.4 - 5.8				*	*
5.8 - 6.5				*	*
6.5 - 10				*[1]	

1 - This range is for observations at the start and end of season when other observations are not possible. Usually observations cease above mu = 9.2
2 – Measurements are possible up to mu = 3 when ozone amounts are below 280 DU.

CDFM - Moon observations may be carried out 7 days either side of full moon with mu from 1.2 to 3.5.

The first two letters show which wavelengths are used in the observation i.e. A and D or C and D. The other letters indicate what type of observation:

DS - Direct Sun, using the sun director.
ZB - Zenith blue, on a clear zenith sky.
ZC - Zenith cloud, on a cloudy zenith sky.
FFS - Filter Focused Sun, using the low sun filter and a focussed image of the sun.
FS - Focused Sun, an observation as for FFS but no filter.
FM - Focused Moon.
For DS, ZB and ZC observations, there is a hybrid observation when both CD and AD wavelengths may be used in a single observation producing CDADS, CDAZB and CDAZC observations.

For example:
CDADS ob would give both ADDS and CDDS results
CDAZC could give both ADZC and CDZC results

Each of these types of observation is explained in more detail in the procedures of observation (section 3.5).

3.3 Priority of observations

Every attempt should be made to obtain at least one reading on every possible observing day. The priority of the types of observation are as follows:

1. If there is just a brief gap in the clouds try and make an ADDS as these are the observations against which others are all compared. This is usually combined with a CDDS observation by doing a CDADS ob.

2. If conditions are good a series of these observations constitute an Lo observation. The mutimes program prints out when such observations should be made, however there is no need to do them at exactly the indicated time. As guidance, any time between the exact time and half way to / from the next observation is acceptable.

3. Zenith observations made at nearly the same time as the direct sun observation.

4. Routine observations; that nearest Local Apparent Noon (LAN) is the most important. See appendix D.

5. Umkehr observations. The mutimes program prints out when such observations should be made, however there is no need to do them at exactly the indicated time.

6. Moon observations.

3.4 Coding of Observations

Each type of observation has a numerical code associated with it. This is derived from the wavelengths used and whether it was performed on sun or sky light and the condition of the sky. The table below shows the codes:

L	Wavelengths	S	Sun or Sky
0	AD	0	Direct Sun
2	CD	1	Direct Moon
6	CD Focused	2	Zenith Blue
9	CDA	3	Zenith High Cloud
16	CD Filter focused	4	Zenith Middle Cloud
		5	Zenith Low Cloud
		7	Zenith Fog

Hence the various permutations are:

ADDS	00	CDDS	20
CDFS	60	CDADS	90
CDFFS	160	CDFM	61
ADZB	02	ADZC	03, 04, 05, 07
CDZB	22	CDZC	23, 24, 25, 27
CDAZB	92	CDAZC	93, 94, 95, 97

3.5 Procedures of observation

3.5.1 General

The basic method of observation is the same for nearly all measurements.

First steps for any observation

a) For all ozone measurements in addition to any computer entry there should also be a hard print out or handwritten copy of the results. Each entry should include the location, machine number, date and type of observation.

b) Next the instrument should be moved so that the right hand end points towards the sun (or moon). If the sun is obscured estimate the correct position.

c) Check that the S4 shutter rod (left hand rod) is pushed all the way in and that the wavelength selector rod (right hand rod) is set to the short position (all the way out). On instrument number 031 ensure that the rod is pulled all the way out as there is another stop just before the correct position.

d) Before switching the machine on the observer should ensure that the sensitivity on the step voltage is turned down**. Note that even when the sensitivity on the micro ammeter is turned down the full signal is still on the photomultiplier and this may cause damage. It is therefore essential to turn down the sensitivity on the Step Voltage switch rather than the microammeter during observations.** The cover for the window on the Dobson should then be removed and the power can be switched on.

Making the measurement

1) Switch on the Motor and EHT switches. Adjust the EHT dial to between 700 and 900 V, depending on the solar elevation and ozone amount.]

2) Check that the stops for the Q2 lever are set for 15°C and 1000mb? (use tables or the qset program)

3) Read the temperature from the thermometer. This should be done to the nearest 0.1°C.

4) Set the Q1 stops according to the temperature of the instrument and the air pressure. There should be a table or a computer program to calculate these settings for each wavelength.

5) Position both Q levers for the first wavelength to be measured (either A or C).

6) If the microammeter has sensitivity adjustment, this should be left at maximum. Slowly increase the Step Voltage switch and at the same time adjust the dial on the top of the instrument so that microammeter needle remains around the zero point If the voltage it is increased too far, the needle will become too erratic to make a measurement. Too little and it will not deflect at all.

7) Once you have found a good position at or averaging around zero you should take a reading from the dial on top of the instrument and note it down.

8) Decrease the sensitivity using the step voltage, (do not simply turn down the microammeter sensitivity) and set up Q1 and Q2 for the next reading. The readings will typically run in a pattern for example C – D – A – time – A – D- C, where the time (to the nearest half minute) is noted at the middle reading.

Ending an observation

1) Turn the step voltage down and switch off the EHT and Motor switches.

2) Make a note of the clouds, weather and any other relevant information. Initial your reading.

3) Check the Dobson amounts given are reasonable. You can now edit your data for mistakes or take another reading if necessary.

4) Make sure that if covers are used for the instrument that they are replaced.

Note: At Halley, measurements are usually entered directly into a PC. A hard copy should be produced after each observation or test to avoid the loss of data.

3.5.2 Direct Sun observations

```
 CDADS          mu <= 2.8       C - D - A - time - A - D - C
 CDDS    2.8 < mu <= 3.5       C - D - C - time - D - C

(ADDS           mu <= 2.8       A - D - A - time - D - A)
```

A direct sun observation requires the sun to be cloud free or with very thin cloud cover. Any cloud cover over the sun must be noted as these observations are not valid for Lo calibrations. ADDS and CDADS observations can be extended to mu = 3.0 if the ozone amount is below 280 DU.

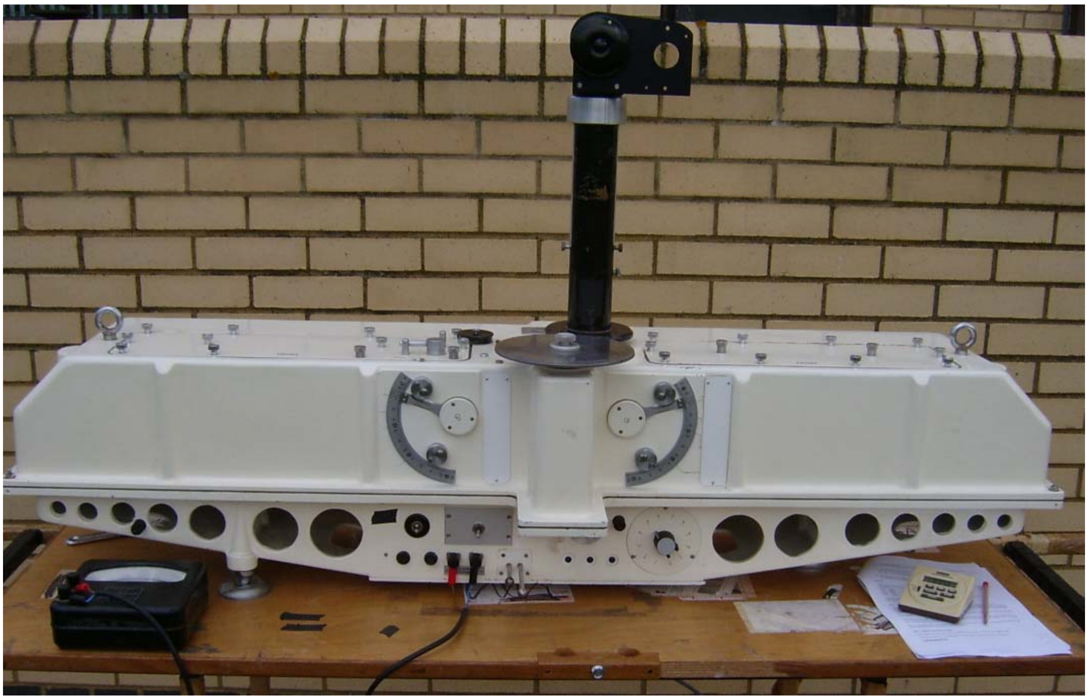
Procedure

1) Follow the standard set-up procedure as in 3.5.1 parts 1 – 5.

2) Place the ground Quartz plate (GQP) over the inlet window and mount the sun director. If the sun director has a lens inside check that the lens is at the defocussed position. When the Dobson is correctly aligned, the shadow of the sun director will fall along the left hand side of the Dobson.

3) Adjust the prism of the sun director so that the patch of sunlight falls centrally on the ground quartz plate. This can be viewed through a window at the bottom of the sun director.

The photo below shows the sun director in place:



4) For a CDADS observation, make measurements of C, D and then A wavelengths. For a CDDS observation make measurements of C, D and C again.

5) Make a note of the time at the middle reading, rounding the seconds to the nearest half minute.

6) Check that the beam from the sun director is still aligned over the GQP and adjust if necessary.

7) For a CDADS observation, repeat measurements of A, D and finally C. Obtain a true rebalance for this second A reading by first moving the dial away from the balance point obtained for the first reading before taking the second reading.

For a CDDS observation, finish with readings for D and then C.

8) Carry out the standard procedure for ending an observation.

3.5.3 Zenith Blue observations

```
 CDAZB          mu <= 2.6       C - D - A - time - A - D - C
 CDZB    2.6 < mu <= 6.5       C - D - C - time - D - C
 CDZB    6.5 < mu <= 10.0      for start and end of season
(ADZB           mu <= 2.6       A - D - A - time - D - A)
```

Zenith blue observations require that a 10 degree cone above the instrument is cloud free. If there is any cloud, then the observation should be classed as zenith cloudy.

Procedure

1) Follow the standard set-up procedure as in 3.5.1 parts 1 – 5.

2) Remove the Ground Quartz plate if present.

3) For a CDAZB observation, make measurements of C, D and then A wavelengths. For a CDZB observation make measurements of C, D and C again.

4) Make a note of the time, rounding the seconds to the nearest half minute.

5) For a CDAZB observation, repeat measurements of A, D and finally C. Obtain a true rebalance for this second A reading by first moving the dial away from the balance point obtained for the first reading.
For a CDZB observation, finish with readings for D and then C.

8) Carry out the standard procedure for ending an observation.

3.5.4 Zenith Cloud observations

```
 CDAZC         mu <= 2.6       C - D - A - time - A - D - C
 CDZC    2.6 < mu <= 6.5       C - D - C - time - D - C
 CDZC    6.5 < mu <= 10.0      for start and end of season
(ADZC          mu <= 2.6       A - D - A - time - D - A)
```

The procedure is as for Zenith Blue observations, but the cloud characteristics of the zenith sky should be noted at the end of the observation as follows:

Height of Cloud	Thickness of Cloud	Cloud Variability
L - Low	Tn - Thin	U - Uniform
M - Medium	M - Medium	V - Variable
H - High	Tk - Thick	P - Patchy

Notes:
1) Low cloud includes Nimbostratus.
2) Variable indicates clouds of differing thickness over the period of the observation.
3) Patchy indicates broken cloud cover with patches of blue sky during the observation.
4) The cloud indicator is usually shortened to a three or four letter code i.e. LTnU.

3.5.5 Focused Sun or Moon observations

```
 CDFM    1.2 < mu (moon) <= 3.5     C - D - C - time - D - C

(CDFS    3.0 < mu (sun)  <= 3.5     C - D - C - time - D - C)
```

CDFM observations are possible with a cloud free moon, 7 days either side of full moon. They are important during the winter months when sun based observations are not possible.

CDFS observations are only performed to calibrate the ground quartz plate. It is very important to have the step voltage is turned down low to avoid damage to the photomultiplier.

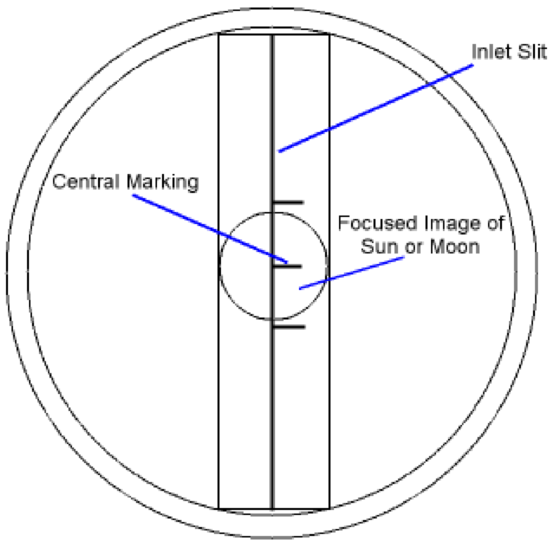
Procedure

1) Follow the standard set-up procedure.

2) Remove the Ground Quartz plate if present and mount the sun director. Set the lens in the sun director to the UV focus position.

3) If performing a CDFS observation, make sure that the Step voltage (sensitivity) dial is at position 1 and also turn down the EHT on the power supply.

4) Turn the sun director prism to align the image of the sun or moon on the inlet slit as shown in the diagram below:



For Moon obs, any other light sources will have to be turned off for you to be able to see the weak image of the moon and the EHT will need to be high and the Step voltage switch will have to be turned up a long way.

5) Make measurements of C, D and C again.

6) Make a note of the time, rounding the seconds to the nearest half minute and realign the position of the sun or moon's image if necessary. (This may need to be done after each reading if the position is changing quickly).

7) Finish with readings for D and then C.

If necessary, CDFM observations may be carried out using the smoked plate. Set up the smoked plate on the dial and the clock recorder on the mountings on top of the dobson. For each wavelength once you have found the balance point, lower the needle of the clock recorder on to the smoked plate and carry out a thirty second reading moving the dial as necessary. When the observation has finished, take the average of each of the arcs. Remember to lift the needle off of the smoked plate when moving to a different wavelength.

3.5.6 Filter Focused Sun observations

```
CDFFS       3.0 < mu <= 6.5     C - D - C - time - D - C
```

These observations are especially important in the spring, during the ozone hole before other types of observation are possible.

Do not attempt the observation at mu < 3.0 as the strong light may damage the photomultiplier - perform direct sun observations instead, using the GQP to cut down the light.
A solution of Nickel Sulphate is used as a filter at low sun angles to reduce the intensity of longer wavelengths which would otherwise become significant when trying to measure the very weak shorter wavelengths, whose intensity has been reduced by the long path length through the atmosphere.

Procedure

1) Follow the standard set-up procedure.

2) Place the sun director on the Dobson without the ground quartz plate. The lens of the sun director should be set at the UV focus position.

3) The nickel sulphate filter on the top of the Dobson should be turned to the IN position.

4) Ensure that the sensitivity switch is kept low (around 1 to 3) and if the needle is still very lively, then decrease the EHT at the power supply also.

5) Ensure that the sunlight spot is on the central marking, as for Focused observations.

6) Take measurements in the normal way for wavelengths C-D-C.

7) Make a note of the time, rounding the seconds to the nearest half minute and realign the position of the sun's image if necessary.

8) Finish with readings for D and then C.

9) Remember to set the nickel sulphate filter to the OUT position.

3.5.7 Lo observations

The factor Lo is called the 'extra-terrestrial constant', but it is also affected by transmission factors within the machine and these vary; For example, due to dust accumulating on the optical surfaces. Therefore Lo has to be frequently and accurately determined.

The minimum requirement to determine Lo is two direct sun observations: one at local apparent noon (LAN) where mu < 2.0 and one at mu = 2.5 +\- 0.1. However, to improve the accuracy, readings should also be made at increments in 1/mu of 0.05 (or less) between these two values.

The sun needs to be completely cloud free during the observations and the appropriate zenith observations should also be carried out at the same time for comparison. If possible, the range can be extended by the addition of CDDS observations at 1/mu values down to 0.27. The mu calculation program should compute these.

A minimum of around 20 half-days are needed each season for the determination. Whole days from mu=2.5 through noon and back again are especially useful, but rarely sufficient.

3.5.8 Umkehr observations

Umkehr observations are a series of CDAZB observations to provide the only ground based measurements of the vertical distribution of ozone. They should be carried out whenever time and conditions permit. Obviously, a clear zenith sky is required for the measurements, but it does not matter if cloud passes between readings.

Readings should be taken around solar zenith angles of 60, 65, 70, 74, 75, 77, 80, 83, (84), 85, 86.5, 88, 89, 90 and 91 degrees. Only the non-bracketed values between 80 and 89 are essential, but all can be included for completeness.

Observing at the exact solar zenith angles is not essential. What is required is to take sufficient readings to accurately plot N values for the 3 wavelengths against zenith angle.

4 Tests and Calibrations

The tests and calibrations provide essential measurements of the state of the machine, highlighting possible faults and to work up final ozone values.

It is important that a log book is maintained which accompanies each Dobson, containing dates of tests and details of all work carried out. All paper copies of test results (copies on disk also if applicable) should be returned each year to Cambridge regardless of whether their results have already been emailed. Complete details of work carried out should also appear in the annual report.

Any 'how-to-do-it' guides written on base should be sent back to Cambridge each year so changes in procedure can be noted.

Calendar of Tests

Monthly
- Standard Lamp
- Mercury Lamp

Quarterly
- Second standard lamp used in monthly tests
- Symmetry test

Trimester (spring, December, Autumn)

- Zenith Sky

Biannually

- GQP and filter correction tests (and combined), usually done in spring and autumn.

Yearly

- Single lamp test (best done around Mid May)
- Photomultiplier test

4.1 Monthly Tests

The monthly tests provide a regular check on the state of the machine and can be used to make minor adjustments to the constants used to determine the column ozone.

As the name suggests, these tests should normally be performed at around the same date each month, often around the middle of the month when there is less pressure from other tasks. They should also be performed before and after the lid is removed or other work carried out on the Dobson.

The two main tests are Standard Lamp and Mercury Lamp. Results should be sent to Cambridge soon after they have been worked up.

All tests should be handwritten on the test sheets, in addition to any direct computer entry.

If necessary, the silica gel can be replaced after the tests have been performed. The Ground Quartz Plate and inlet window should be gently cleaned with a mixture of soap and water, using medicinal cotton wool.

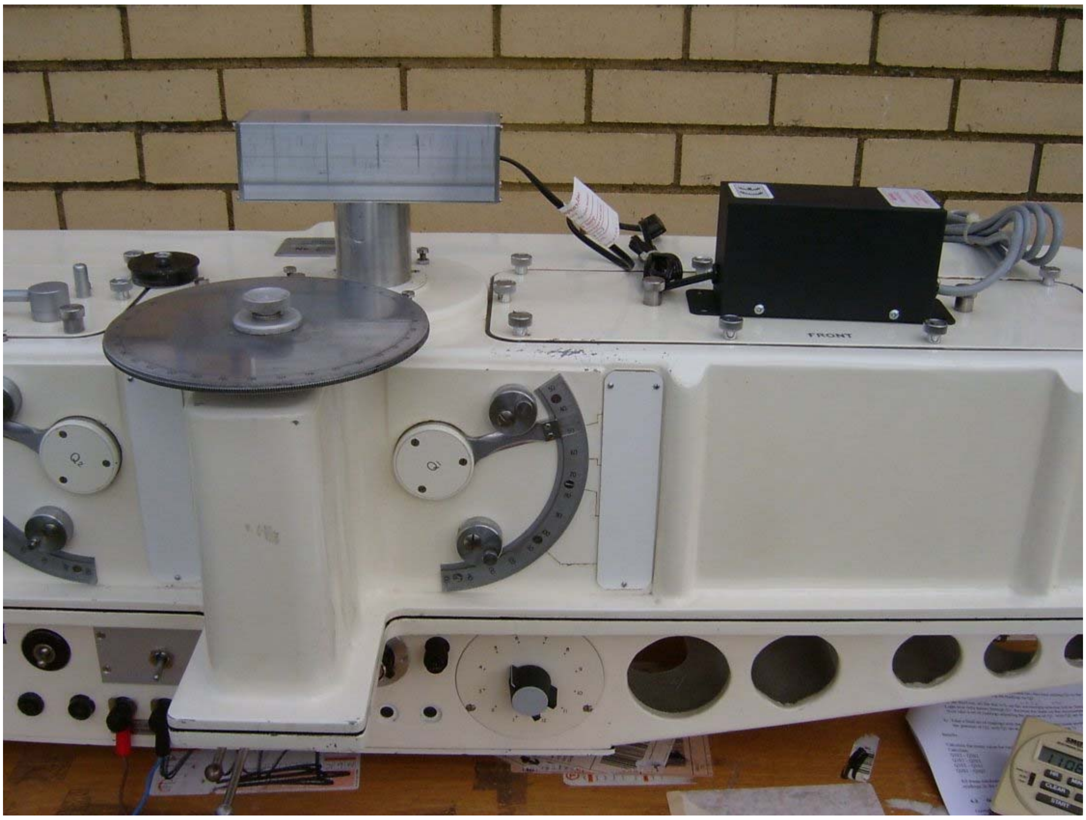
Example Monthly Tel: Monthly Tests on Dobson 103

```
---------------------------
Mercury   17/10/93  835 833 150 024
Standard  17/10/93  238 245 269 B42
```

4.1.1 Mercury Lamp Test

The wavelengths falling on the slits which select the wavelength pair may change due to small deformations in the casting of the instrument or due to a shift of some of the optical parts. This is checked by using the line spectra of a mercury lamp.

Take care not to look into the lamp barrel as the ultra violet light may damage your eyes



If you want to check that the lamp is working, it is possible to see a faint blue reflected light when the lamp is pointed at the top of the Dobson lid.

Procedure

1) All measurements should be recorded on the Mercury lamp test form. First check that the micro-ammeter needle is correctly zeroed with the Dobson turned off. Check that it also reads zero when the motor is turned on but the cover remains over the inlet window. Use the adjustment screw on the microammeter if it is not.

2) Insert the Ground Quartz Plate (GQP), make sure the low sun (nickel sulphate) filter is OUT and mount the mercury lamp as shown in the photograph.

3) Connect the Mercury Lamp to its power supply and switch on.

4) The lamp takes about 2 minutes to warm up and stabilize.

5) Set the dial to 300 and Q2 to the mercury line setting for 15°C. Q1 should be set to the mercury line setting for the current instrument temperature. (Use the qset program)

6) Make sure the Step Voltage dial (sensitivity) is set to the lowest setting, i.e. 1. and set the selector rods to ‘short’ and ‘clear’ this allows light only through the S2 and S3 slits.

7) If the microammeter has an off-centre zero point then reverse the connections on the microammeter to allow more room for the needle deflection, otherwise leave.

8) Set the EHT voltage to around 250V – 300V approximately.

9) Follow the normal start-up procedure for the Dobson i.e. turn on the motor and EHT switches.

10) Adjust the (Step voltage) sensitivity switch so that there is a full scale deflection of the microammeter needle. E.g. 16 or 20uA. This may mean turning the Step voltage quite high. This can be fine tuned with the EHT once roughly in the right place.

11) Adjust Q1 upwards until the microammeter needle reads half of the full scale deflection. E.g. 8 or 10. Record the position of Q1.

12) Move Q1 downwards, back through the peak, until the needle again reads half scale and record the position of Q1 now.

13) Move Q1 upwards, back through the peak, until the needle again reads half scale and record the position of Q1 now.

13) Repeat steps 12 and 13 until you have five pairs of readings.

14) Measure again the instrument temperature and take the station pressure.

15) Reverse the microammeter connections back to the normal position if they needed to be changed in 7).

Results

Calculate the means of the Q1 readings and calculate the table value from the mean temperature and station pressure. I.e the result given by the qset program. Subtract your averaged test value from the table value. This difference should normally be within 0.3. If a large difference is recorded, check carefully that you have performed the test correctly i.e low sun filter is out, Q2 set correctly and repeat the test.

Note the pressure on the test form.

Email back the date, measured Q value (i.e. what you have found), table calculated Q value (from q set program), average temperature (all in tenths) and station pressure to the nearest millibar, modulo 1000;
e.g. 15/10/93 835 833 150 024

4.1.2 Standard Lamp Test

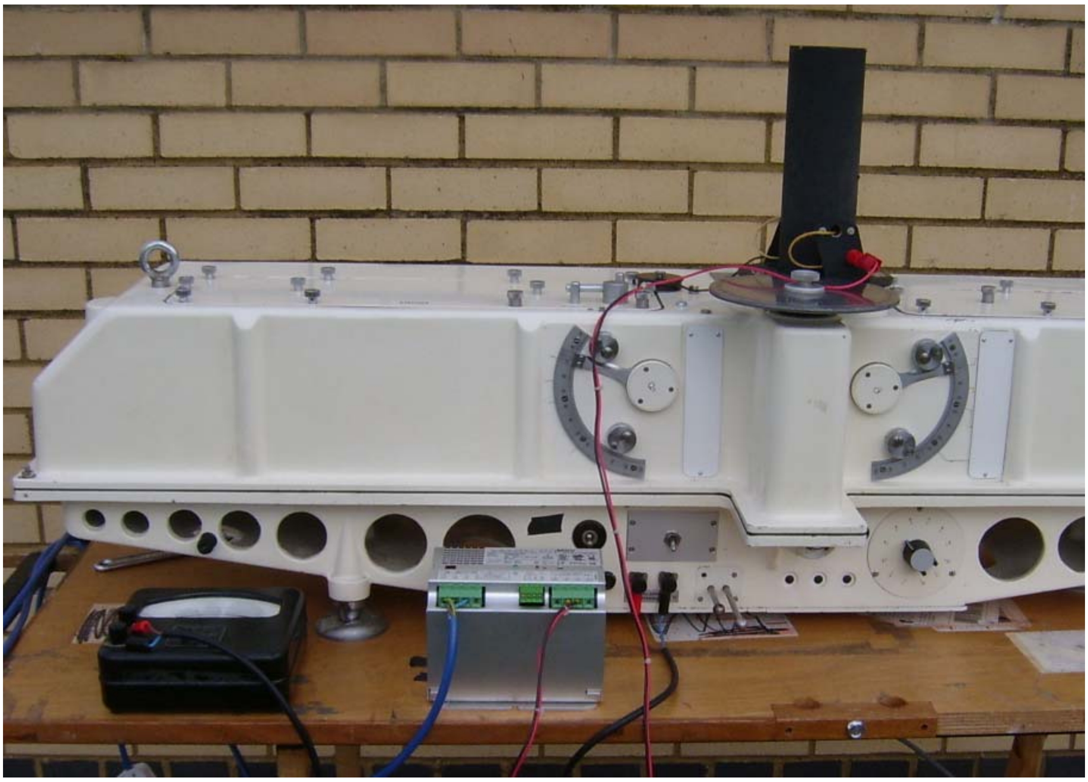
The standard lamp tests the Dobson by making a standard measurement on all three wavelengths. It can determine overall shifts in the calibration of the instrument or show if there is only a shift in one or two of the wavelength pairs.

A gradual change is expected in these tests due to the aging of the standard lamp itself. For this reason, a second lamp is kept as a check and is used in addition to the normal lamp every three months or to eliminate the lamp when a large change is recorded. This lamp is also a back-up if the main lamp were to blow.

Procedure

Note down the results on the Standard Lamp test form.

1) Place the Ground Quartz Plate (GQP) over the inlet window, make sure the low sun filter is out and mount the standard lamp as in the photograph below.



2) If the lamp's power supply has no separate on/off switch it is very important to **connect the leads to the lamp first** before turning on the mains to the power supply, there is then no chance of the leads shorting.

3) Plug the lamp into its power supply and switch on. Make sure the step voltage is at its lowest setting.

3) Check the voltage is 24V at the point the leads connect to the lamp.

4) Leave the lamp for about 10 minutes to stabilize.

5) Set the EHT voltage to about 800V and the selector rods to ‘short’ and ‘clear’. This lets light pass through slit S2 and S3.

6) Note the temperature and set the Q levers and stops for a normal reading i.e. Q2 for 15°C and standard pressure and Q1 for current instrument temperature and pressure, using the qset program or tables..

7) Make a measurement at each of the A, C and D wavelengths and note the dial readings.

8) Repeat step 7 twice more and record the results on the form. The three readings for each wavelength should agree to within 0.5 of each other.

9) When disconnecting the power supply **turn off the mains first** then remove the leads to the lamp.

Results

Calculate the mean value for the three readings of each wavelength. The average should be within 0.5 of the last test on the same lamp.

If a large jump is recorded, first check that the lamp is correctly aligned and fitted on the inlet window. Check that the GQP is in place and the lamp is being run at the correct voltage. If a shunt is used, this sometimes becomes faulty. The low sun filter should be out. Repeat the test and also try the back-up lamp to check it is not the lamp that has changed.

Note the voltage at which the lamp was run at on the test form.

Email back the date, mean of each wavelength in tenths for A, C and D and the lamp identification number;
e.g. 15/10/93 238 245 268 B42.

4.1.3 Wedge Calibration Test [This test is obsolete]

Procedure

1) Mount the plate holder on the inlet window and ensure the GQP is not in place. Wire the lamp up as for the standard lamp test.

2) Place the glass X and Y plates under the lamp so that they cover the inlet window. The plates should be placed with the X plate on top and the letter markings upper most. Make sure that the plates and lamp etc are orientated exactly the same from month to month.

3) Increase the current to the lamp slowly up to 7.5 Amps and allow the lamp and plates to warm up for about half an hour.

4) Check the current and adjust it if necessary.

5) Note the temperature of the instrument and set Q1 and Q2 for D-wavelengths. Make sure the wavelength selector is set to short.

6) Make a measurement with the Rhodium Plate set to IN followed by another with the Rhodium Plate set to OUT.

7) Repeat this until you have 4 pairs of readings.

8) Carefully remove the Y plate leaving just the X plate under the lamp.

9) Repeat the four pairs of readings.

Results

Calculate the means of each of the sets of four dial readings. Using the program ('rton' or similar), calculate N values for the mean R readings. For each of the X+Y and Y plate tests calculate the difference in N between having the Rhodium plate in or out.

Note the lamp number and current at which it was run at on the test form.

Signal back the date and differences in N for first the X+Y plates then the X; e.g. 15/10/93 514 512.

If strange results are obtained, check the alignment of the lamp and wedges, lamp current, sun filter out, GQP out, Q lever settings.

4.2 Symmetry Test

The symmetry test is an extended version of the normal mercury test and is carried out four times a year (March, June, September and December). It checks the relative alignment of the slits, mirrors, lenses and Q lever settings by taking four sets of readings. The test should be carried out under stable temperature conditions and with the mercury lamp warmed up. If the difference between the start and end temperatures is more than 0.5 degrees the test will need to be repeated.

Procedure:

1) For the first reading follow exactly the same procedure as for the normal monthly mercury lamp test. Note that on the forms 'Test value' is the value from your results and 'Table value' is the value computed either from the qset program or other spreadsheets that would give the expected for that temperature and pressure.

2) Having completed the test, carry out a second run, this time setting Q1 to the value you have just measured and taking the readings on Q2.

3) For the third run, set the dial to 0, set the wavelength selector rod to 'long', (this blocks S2 and opens S4) the other rod is kept in the 'clear' position. Light now only passes through S3 and S4. Reverse the leads on the microammeter if necessary and increase the EHT (this may need a large increase). Now take a set of readings adjusting the position of Q1, with Q2 set for 15°C.

4) Take a final set of readings with the dial and rods in this same position but now adjusting the position of Q2, with Q1 set to the value found from step 3)

Results

Calculate the mean value for each of the four readings. These are Q1S2, Q2S2, Q1S3 and Q2S3.
Calculate:
Q1S2 – Q2S2
Q1S3 – Q2S3
Q1S2 – Q1S3
Q2S2 – Q2S3

All these residuals should be less than 1°. Ideally within +/- 0.5^{o}. Email back the four sets of readings in the usual format with the differences on a new line.

4.3 Ground Quartz Plate and Filter Corrections

Ozone calculations are standardized on direct sun readings. When the ground quartz plate is removed for focused readings or the low sun filter included for low sun readings, corrections have to be applied. The corrections are determined from the following tests which <u>should be performed around twice a year.</u>

If the ground quartz plate is replaced or the Nickel sulphate solution changed, then the tests should be repeated to determine the new values.

For all three tests, mu should be in the range 3.0 to 3.5 and preferably around LAN when mu is only changing slowly. Signal strengths will be high, so keep the sensitivity switch on low settings and turn down the EHT supply if necessary.

The two separate tests will suffice to determine the constants, but the combined test confirms the results and should be completed when possible.

4.3.1 Filter Correction Test

1) Set up the sun director as for a CDFFS observation. Make sure GQP is out.

2) Set Q levers for C wavelengths. Remember to keep the Step voltage low and if necessary turn down the EHT.

3) Take a reading with the low sun filter in, followed by one with the sun filter out. Continue until you have taken five readings in and four out.

4) Repeat step 3 for D wavelengths.

Results

Use the r to n program to calculate the means of the N values. The program must be run from DOS.

The correction for each wavelength is the difference in the mean N values.

Email back the mean N values for each wavelength with the filter in and out.

4.3.2 Ground Quartz Plate test

For this test we alternate between CDDS and CDFS observations. In this way, both C and D wavelength corrections are measured together as it takes too long to swap between the observations to work on each wavelength separately.

1) Perform a CDDS observation. Make sure GGP is IN

2) Perform a CDFS observation. Make sure GQP is OUT. Remember to keep the step voltage switch at a low setting.

3) Repeat until you have three DS and two FS observations.

Results

The correction is calculated as the difference of mean N values between the two type of observation. It is calculated separately for each wavelength.

The observations can be included and returned in the normal data file (zoz and ztx files). Email back test results with the date and delta N for each wavelength.

4.3.3 Combined Ground Quartz Plate and Filter Test

For this test we alternate between CDDS and CDFFS observations. In this way, both C and D wavelength corrections are measured together as it takes too long to swap between the observations to work on each wavelength separately.

1) Perform a CDDS observation.

2) Perform a CDFFS observation. Remember to keep the sensitivity switch at a low setting.

3) Repeat until you have three DS and two FFS observations.

Results

The correction is calculated as the difference of mean N values between the two type of observation. It is calculated separately for each wavelength.

The correction calculated should be equal to the sum of the two corrections determined separately.

The observations can be included and returned in the normal data files (zoz and ztx). Email back the test results with the date and delta N for each wavelength.

4.4 Zenith Sky Test

This test should be performed at or around Local Apparent Noon (LAN), early in the spring, during December and in the autumn. Together with the mercury lamp test, they can be used to update the Q lever table. They should always be performed as soon as possible after any sudden change in the mercury lamp test results.

The test should be carried out on a clear sky or if necessary a uniform cloud layer.

It is known that the readings taken during the period of ozone depletion (Sept – Oct) are offset somewhat.

Procedure

These are CDAZB observations though if necessary CDAZC (with uniform cloud)

1) Carry out the normal start-up procedure for the dobson in section 3.5.1. (i.e set the EHT to around 800V) **Remove** the GQP.

2) Q1 should be set to a position 5 degrees below the A wavelength setting given for the current instrument temperature.by the q-set program. Q2 should be set to the 15^0C setting.

3) Take a normal reading, recording the dial position.

4) Move Q1 up by one degree. (Optionally in 0.5 degree steps)

5) Repeat steps 3 and 4 until Q1 is 5 degrees higher than the value given by qset. i.e you have moved it through 10 degrees). Repeat the readings working back down to 5 degrees below the expected position.

6) Repeat for C and D wavelengths.

Results

For each wavelength, plot dial readings against Q1 position and fit a curve to the points. Determine the positions of the maximum and minimum and calculate the Q lever setting mid way between the two.

For each wavelength, email back the value determined from the graph, the current table value for that temperature and pressure, temperature in tenths of a degree and pressure modulo 1000. This is the same format as for the mercury lamp test, but for each wavelength.
The table value is the Q1 wavelength setting given in the Q-set program.

4.5 Twin Lamp Test [Note: this test is now only done during recalibration]

The calibration of the wedges is the fundamental calibration for the Dobson and the method for determining Lo is dependent on its accuracy.

The test should be carried out each year, normally during winter when the ozone season has finished, except for moon readings.

For each wavelength, readings are taken at steps of three degrees around the whole dial (along the whole of the wedges). These readings are used to compile the R (dial reading) to N (logarithmic units) conversion tables.

A pair of balanced lamps are used to provide two intensities at each measurement point, one twice that of the other.

Preparations

1) Examine the twin lamp apparatus for good electrical connections and clean the lamp holder contacts, taking care not to touch the glass of the lamps themselves.

2) Check that the shutters operate freely without sticking.

3) Check that there is a functioning S4 lamp inside the Dobson. This can be done by applying 12 volts to the S4 lamp terminal and checking that a current is drawn (but is not short-circuit). If a lamp needs to be fitted or replaced, perform monthly tests before and after the lid is removed.

If the lid is removed, then any annual maintenance can be performed. The base can be lightly brushed clear and optical surfaces dusted down using a blower brush. NEVER clean any optical surfaces with alcohol or other liquid cleaner without prior consent and guidance from Cambridge.

Procedure

1) If necessary, move the Dobson into an easily accessible position.

2) Place the Ground Quartz Plate in position.

3) Clamp the Twin Lamp apparatus to the Sun Director mounting screws, as shown in the photograph.

4) Set the wavelength selector rod to 'long' and the rhodium plate rod to 'clear'.

5) Use a spirit level to set the Twin Lamp Plate level.

6) Rotate the upper plate of the Twin Lamp so that the long side of the chimney is at right angles to the axis of the Dobson.

7) Use the Kingshill power supply to power the two lamps in series. An accurate measure of the current is not necessary. The power supply meter is sufficient to keep the current below 8.33 Amps.

8) Switch on power for the Twin Lamps and slowly increase the current to around 7 to 7.5 Amps.

9) Switch on the S4 lamp. This may be powered by a separate well regulated supply if problems are experienced using the Dobson supply. However, great care is required to avoid exceeding the

12 volt working voltage as replacing the lamp involves removing the twin lamp apparatus and the lid of the Dobson.

10) Leave the lamps for half an hour to heat up. (Any new bulbs should be left running for 10 hours before being used in the test.)

11) Set Q2 for 15°C and Q1 for the temperature of the instrument. Start with the D wavelength.

12) It is now necessary to adjust the twin lamp apparatus until the same dial reading is recorded for each of the lamps, within 1 degree. Close first one shutter and take a reading. Call this X. Now open this shutter and close the other. Call this reading Y. Swivel the lamp apparatus to make the two readings converge until they are within 1 degree. It is possible to get them in agreement within 0.1 of a degree and in this case, they are likely to remain within balance for much longer. Now bolt the apparatus firmly in place.

13) Adjust the S4 voltage until the balance point for the two individual lamps is around 1 on the dial.

14) Make a set of 7 readings: X+Y X Y X+Y Y X X+Y. X+Y is with both lamps (both shutters open). Ensure that the four single lamp readings are still within 1 degree of each other. Rebalance the lamps if they are not.

15) Calculate the mean of the four single lamp readings, R1 and the mean of the three two lamp readings, R2. Calculate delta R as R2 - R1. This should be around 30.

16) Decrease the voltage to the S4 lamp until the balance point moves 3 degrees further along the dial. Repeat steps 14 and 15. When the S4 voltage approaches 6 or 7 volts, the readings will become harder to make. Increase the current to the twin lamps and start with the S4 lamp at 12 volts again. This can be repeated up to the maximum current of 8.33 Amps. For large increases, you may have to allow the lamps to settle again for a couple of minutes.

17) Repeat readings until the 300 point is reached on the dial.

18) The graph of delta R against R1 should be plotted as the test is performed - a second person can do this as the readings are taken. This should be a smooth curve and be similar to previous results for that Dobson. Repeat points where there are sudden jumps, but signal all results back to Cambridge.

19) Repeat the test for C and A wavelengths. It will be harder to reach the far end of the dial with each of these wavelengths.

Wedge calibration by Rhodium plate

If it proves impossible to reach the end of the wedge for C or A wavelengths, then the calibration can be finished using the rhodium plate. Set up the twin lamp with both shutters open and remove the GQP. R readings are taken alternatively with the Rhodium plate and without. The S4 lamp is again used to move along the dial.

Because the N value of the Rhodium plate also needs to be accurately measured, the you must commence readings to cover a part of the wedge which has already been successfully calibrated using the twin lamp.

Results

Return all the readings to Cambridge by email and also as hard copy at the end of the year.

4.6 Single lamp test

This calibration is a replacement for the twin-lamp test (see 4.5) and should be carried out every year. It is far easier to carry out than the TLT and should only take a few hours. Data is entered into an excel spreadsheet as you go, and the results are graphed. It does not give exactly the same results as the TLT, but will show up any relative changes in the wedges. If it looks as if these are significant we may ask you to carry out the full TLT.

4.6.1. General principle

Whilst the TLT uses a doubling of light intensity, this test assumes that the measured current from the photo multiplier is directly proportional to the light intensity over a range from 20 – 6 micro Amps. Computing the difference in the log of the current from that at the starting point is then a measure of the absorption of the wedge. By taking measurements in steps over the entire wedge it is possible to build up a profile of the wedge.

Procedure

1) Set the dial to zero. Set the Q levers to the D wavelength. Set the selector rods to long and opaque. This means light only passes through S3 i.e. only the through the wedges..

2) Depending on the type of micro ammeter, swap the micro ammeter leads so that you can record a current from 0 – 20 uA. It is essential that the meter reads exactly zero when no light falls on the photomultiplier, ie when the motor is on and the window covered there may be an offset for a dark current. If possible take all readings with the step voltage on the same setting. (If the microammeter has a shunt leave this at maximum sensitivity, as always.)

3) Adjust the EHT dial to set the microammeter to exactly 20 micro amps, this will be at about 330V. The step voltage will be fairly high.

4) With the settings as they are, adjust the dial to 10° and record the value on the microammeter.

5) Continue moving the dial in 10 degree steps up to 50°, recording the current on the microammeter each time. After recording the current for 50°, turn the dial back to 0° and check that it still gives 20 micro amps. If not, adjust and repeat the section up to 50 again. Enter these values in column 2(Galv reading) of the spreadsheet.

6) With the dial now at 50 increase the EHT to give a reading of 20 micro amps at 50° and move the dial in 10 degree steps up to 100^o recording the microammeter reading each time. Once at 100 check that when you move the dial back to 50 it still reads 20uA.

7) Repeat these steps in groups of 50 degrees on the dial until you reach 300..

8) Repeat the whole process for the C and A wavelengths. Remember to reduce the EHT to about 330V before starting again.

Results

The spreadsheet will already have the nominal wedge table entered. As you enter the points it will calculate a new table and display the residuals between the two on a graph. These should all be small. Once the test is complete email the spreadsheet to Cambridge.

4.7 Photomultiplier test

This test should be carried out once a year. It is a relatively quick test to check the position of the photomultiplier is ok.

The set up is very similar to the Mercury lamp test.

Procedure

1) Set up as for Mercury test : Section 4.1.1 Parts 1 – 10.
2) Adjust the EHT voltage and step voltage so the micoammeter needle has a maximum deflection (say 16 or 20uA)
3) Move Q2 to 60^o and read the microammeter output, note this down.
4) Move Q2 up in 2 degree steps up to 110^o
5) Plot a graph of Q2 reading against microammeter output.
6) Push in the long-short rod. This will allow light to pass through S3 and S4 only. Turn the dial to 0, increase the EHT to approx 500V and if necessary swap over the connections on the microammeter. Now repeat the test again.

Results

Email the results back to Cambridge.
The graphs whether using S2 or S3 should have a steep increase at around 60 on the dial, followed by a long flat portion of the graph and finally a steep decrease near 110^o.

5 Maintenance and Faults

5.1 Monthly Maintenance

Check the silica Gel and replace if necessary. This is possible through the two lids in the top of the cover. Be careful to avoid touching the optical parts.

Avoid exposing the photomultiplier to strong light when opening the hatches.

Use the blower brush on any dust on the sun-director prism, the inlet window or ground quartz plate. Every month, the GQP should be washed in soapy water using medicinal cotton wool, rinsed in clean water and left to dry. The inlet window may need to be cleaned in the same way. If the sun director prism or lenses are obviously dusty they should also be cleaned in the same way.

The Dobson log book should be updated with details of any maintenance carried out. Cambridge should be consulted before anything apart from routine maintenance is carried out.

Quarterly: Check the voltages of the Dobson power supply **-** see section 5.7 for correct readings.

5.2 Annual Maintenance

The outer surface of the case should be wiped with a cloth. The lid may be removed (see below), followed by any guard which is in place around the motor.

The silica dessicant can be replaced if necessary.

The base can be lightly brushed clear and optical surfaces dusted down carefully using a blower brush. NEVER clean any optical surfaces with alcohol or other liquid cleaner without prior consent and guidance from Cambridge.

The motor assembly can be removed (see below) and a small drop of high vacuum oil applied to each of the bearings. Wipe off any excess. It is essential to use high vacuum oil, as the vapour from normal oils may contaminate the optical components.

Carry out a set of monthly tests after the lid is replaced.

5.3 Removing the motor assembly

The motor assembly may be removed from the bottom of the Dobson, by two people. It is not normally necessary to remove the lid to do this. The small front plate that surrounds the rhodium and wavelength selectors needs to be unscrewed first.

Now, with one person supporting the motor plate (it is quite heavy), the second can remove the screws from around the plate. Lower the assembly slowly. The motor power lead will either unplug or can be removed from a terminal block to allow complete removal of the assembly.

Be very careful when replacing the unit to have it correctly aligned and avoid damage to the rhodium plate. Do not force the unit back in. Reconnect the motor power before screwing up the base plate and finally reconnect the commutator connections.

5.4 Removing the Lid

Only remove the lid of the Dobson if absolutely necessary and always ensure that the photomultiplier is switched off. You can be certain of this by removing the EHT power connector.

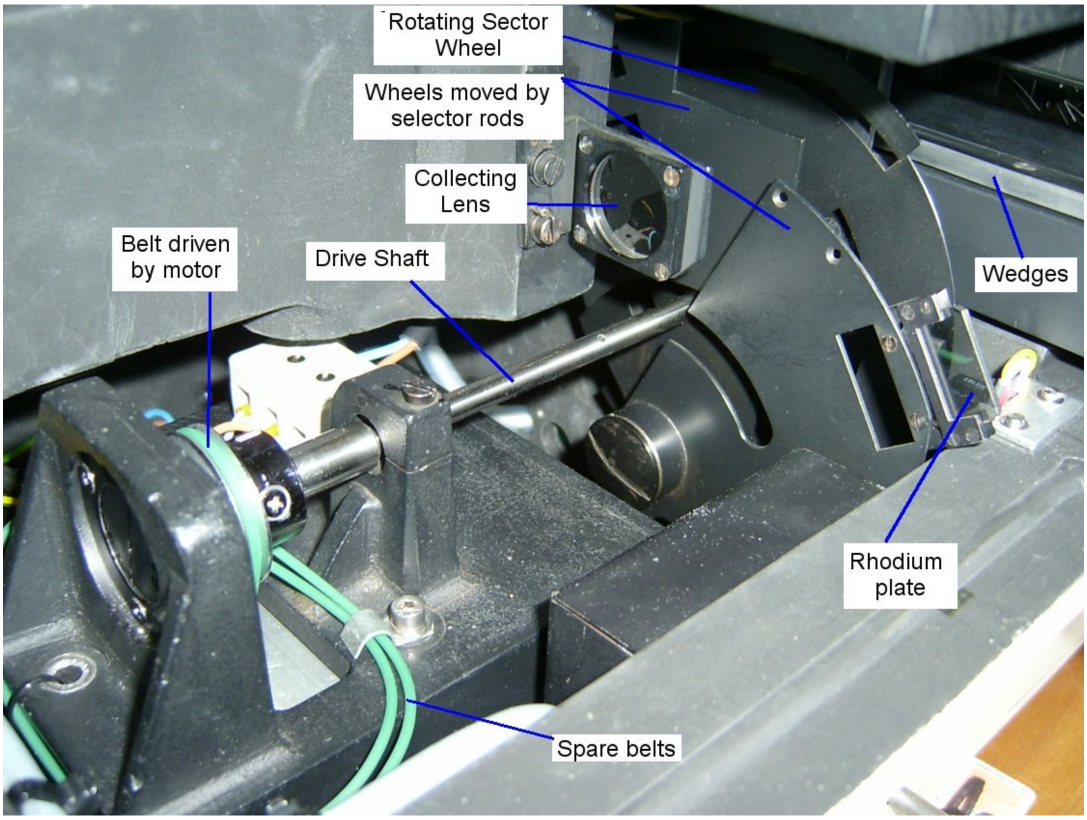
Remove any equipment from the lid, unscrew and remove the dial and the four nuts at the corners of the case.

Do not turn the lid upside down due to the bottle of nickel sulphate solution.

It takes two people to carefully lift the lid straight up by the eye bolts.

Replace in the same way ensuring that the two pegs inside the cover at the ends align with the base. The lid must be lowered horizontally to avoid jamming and carefully to avoid knocking any parts of the instrument.

5.5 Replacing the drive belt.



Spare drive belts are already in place as shown in the diagram above.

5.6 Micro-ammeter Faults

It is possible with some spade connectors to short the terminals of the microammeter out. This results in zero output. Either replace the spade connectors with more suitable ones or fasten the connectors so they are not shorting.

Needle flicker may be a common problem with the microammeter. This can be caused by radio frequency interference, poor earthing or other poor electrical contacts inside the instrument, failure of the power supply or incorrect sector wheel setting.

Earthing of the case can be checked with a multimeter. Look especially at the contact between the two halves of the case.

5.7 Power Supply Faults

The power supply unit output should be as follows:

EHT = variable up to 1000V and 200 micro-amps.

The EHT can be measured with care using an AVO. Ensure the correct insulated leads are used.

5.8 Loose/Broken solder joints

Joints can either break completely or form dry joints. Dry joints are the most difficult to detect as they are often intermittent.

The symptoms obviously depend on where the fault occurs but they usually result in intermittent or total loss of sensitivity. Common places for breaks are any spade or switch connections. Wires inside the power supplies have also been known to come loose.

Before resoldering ensure that both the contacts are cleaned.

5.9 Motor Problems

The motor can be slow to get started or not start at all, especially if it is cold. Check nothing is jamming it and it may start if it is left switched on.

Lack of oil or excess pressure on the bearings may cause the motor to run slow. Only apply high vacuum oil to the motor or shaft bearings.

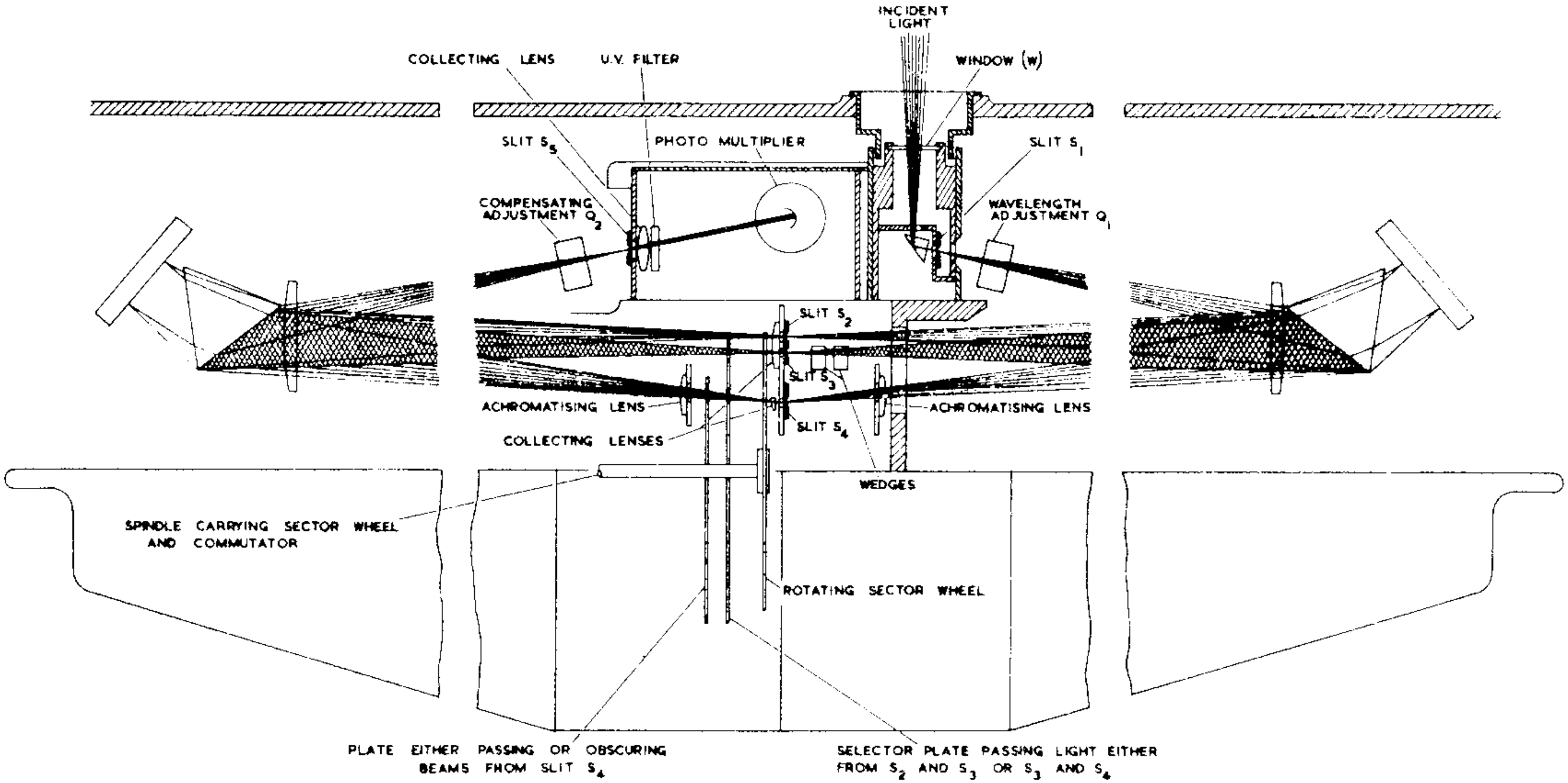
5.10 Nickel Sulphate Filter

This should be around 90 per cent full. It may be topped up from spare solution if necessary, but check with Cambridge first as this changes the filter calibration. Carry out Filter Correction Tests before and after filling.

5.11 Stiff Q levers

Should the Q levers become stiff, a little high vacuum oil on the bearings should loosen them.

APPENDIX A – Optical system of the Dobson spectrophotometer



APPENDIX B – Data input and reduction programs

B1. Programs

The sequence vercam, procam1 and dispcam2 can be run using the camoz.bat file.

B.1.1. VERCAM

Observation input program. A derivative of a program that was originally written for use at Halley, but which is designed to be run at any station. Other variants that you may encounter are *verhut* or *zhut*. The program asks you what sort of ob you want to do, tells you the q-lever settings and allows you to enter a complete ozone observation after it has been completed. The data and output corresponding to the observation form is stored in a monthly holding file.

Parameters:	none
Input Files:	pathfile.dat
	dn<nnn><v>.dat
	d<nnn><v>.dat
	q<nnn><v>.dat
Output files:	<b>oz<mon><yy>.dat
	<b>tx<mon><yy>.txt (notebook format data)

B1.2. PROCAM1

A program to compute and check ozone data using the monthly data file. It is derived from a program intended for use at HQ and produces a large number of output files, which can mostly be ignored.

Parameters:	None
Input Files:	pathfile.dat
	dn<nnn><v>.dat
	d<nnn><v>.dat
	c3lmh.dat
	<b>oz<mon><yy>.dat
Output files:	xdata.dat (individual ozone obs)
	ydata.dat (daily mean values
	ldata.dat (lo n values)
	udata.dat (umkehr n values)
	zbdata.dat (C' zb n values)
	results.dat (sic)
	queries.dat (sic)
	lores.dat (lo results)
	comp.dat (AD and DC zenith comparisons)
	add.dat (ADZ/DS differences)
	cdd.dat (CDZ/DS differences)
	cc.dat (CZ/DS differences)

B.1.3. DISPCAM2

A program to display the past weeks ozone data, using data from the monthly files. On a colour VGA screen each obtype is displayed in a different colour.

Parameters:	none
Input Files:	pathfile.dat
	dn<nnn><v>.dat

	d<nnn><v>.dat
	<b>oz<mon><yy>.dat
Output files:	wdata.dat (ozone values)

B.1.4. MONTH

A program to enter the results of monthly tests and produce a tel to send to Cambridge.

Parameters:	none
Input Files:	rntab.txt
	wtemp.dat)
	stemp.dat) holding files for test results
	mtemp.dat)
Output files:	wtemp.dat
	stemp.dat
	mtemp.dat
	<dd>-<mm>-<yy>.txt (tel to send to Cambridge)

B.1.5. MUTIMES

Produces 4 files which give the times of standard, Lo and Umkehr (or comparison) observations, and general information on sunrise, sunset and LAN. It needs to be compiled with compiler options 8087 and Emulation set off if it is run on a computer without coprocessor.

Parameters:	dobson
Input Files:	dn<nnn><v>.dat
Output files:	monlos.txt
	monumk.txt
	monstd.txt
	moninf.txt

B.1.6. QSET

Lists the q-lever settings when given the pressure and instrument temperature.

Parameters:	Dobson
Input files:	q<nnn><v>.dat
Output files:	None

B.1.7. RTON

Gives a Dobson n value for a given r value.

Parameters:	Dobson
Input files:	d<nnn><v>.dat
	dn<nnn><v>.dat
Output files:	None

B.2. Parameter formats

When required parameters are given on the command line following the program name. Dobson is <nnn><v> where <nnn> is the Dobson number and <v> its refurbishment letter. Mawspath is an optional parameter that gives the network path on which MAWS data can be found. The path must end with a \.

B.3. Input file formats

Note some files include constants for observation types which are no longer made.

B.3.1. Annual Dobson constants: dn<nnn><v>.dat

Latitude, Longitude, Dobson No
Lo Values for A, C and D using R-N table in d<nnn><v>.dat
GQP factors for C, D and C', NiSO4 factors for C, D and C', Rhodium plate N value
C' ZB constant, CDDS offset
ADZ, CDZ, CC'Z and CDZ high mu offsets
Year, month, day, hour, minute at which the above values change

Example:

-75.58 26.37 103
-0.250 -0.205 -0.195
-0.090 -0.105 0 0.340 0.625 0 0.505
0 0
24 -23 -65 70
2005 06 30 24 00

B.3.2. Dobson instrument constants: d<nnn><v>.dat

Description of file
Ozone absorption coefficients
C' ZB equation coefficients
ADZ equation coefficients
CDZ equation coefficients
CZ equation coefficients
CDZ high mu equation coefficients
R-N tables for A, C and D at 10 degree intervals from 0 to 300°.

Example:

```
Constant table for Dobson 103 at Halley
1.806 0.833 0.374 0.114 0.109 0.104
0 0 0 0
29 50.82 0 1911.0 -1812.0 0
-23 104.2 1662 0 0 0
-48 127.14 898.8 0 0 176.30
80 1033 393.2 -11.92 0 0
  0.000  0.098  0.195  0.300  0.407  0.512  0.624  0.737  0.848  0.961
  1.071  1.183  1.295  1.406  1.521  1.633  1.747  1.857  1.969  2.082
  2.191  2.303  2.415  2.528  2.641  2.750  2.863  2.970  3.080  3.199  3.318
  0.000  0.099  0.197  0.301  0.405  0.512  0.622  0.733  0.844  0.955
  1.065  1.175  1.284  1.395  1.506  1.616  1.728  1.837  1.944  2.054
  2.163  2.273  2.385  2.496  2.607  2.716  2.825  2.933  3.042  3.159  3.277
  0.000  0.094  0.193  0.296  0.400  0.507  0.617  0.726  0.836  0.945
  1.053  1.161  1.270  1.377  1.487  1.598  1.706  1.813  1.921  2.029
  2.137  2.246  2.356  2.466  2.577  2.683  2.789  2.896  3.004  3.117  3.234
```

Note that the initial value in each of the zenith equations is over-written by the value in the annual file and can be set to 0.

B.3.3. Q lever constants: q<nnn><v>.dat

Value at 15 degrees Celcius
Temperature coefficient for A, C, Hg and D
Default pressure for station

Example:

48.2 76.0 107.1 83.5
0.110 0.160 0.155 0.160
1000

B.3.4. Ozone datafile: <b>oz<mon><yy>.dat

Year, month, day, hour, min, sec, ls, R1, R2, R3, R4, R5, R6, (R7, R8)
for ob type 9x: R1, R2 = A, R3, R4 = C, R5, R6 = D
for ob type 8x: R7, R8 = C'
other types: R1, R2, R3 = A or C, R4, R5 = D

B.3.5. C' zenith cloud correction chart

Three 7x8 arrays of numbers representing Chart C3 for low, medium and high cloud. Not used in present day observations and all values can be set to zero.

B.3.6. Pathfile

Path for Dobson information files.
Path for ozone data files

Example:

c:\ozone\dobsons
c:\ozone\data

B.3.7. Ozone values: wdata.dat, xdata.dat

month, day, hour, min, julian date, mu, zenith distance, ob code, ls, ozone value.

APPENDIX C – Reconditioned or new instruments

1. Procedure on receiving a new instrument in Cambridge

Because the instruments are calibrated at Hoenpeissenberg, which is a high altitude station, the q lever settings are likely to be out, as are the instrument calibration constants. You will need to revise these as far as is possible before the instrument is shipped south.

1. Set up the instrument in the normal observing position and refill all the silica gel holders.
2. After allowing it 24 hours to settle, carry out a mercury lamp test. If the observed value differs from the table value by more than 0.3° adjust all the reference values in the q<nnn>.dat file.
3. If you have had to adjust the q file, perform a zenith sky test on each wavelength as soon as possible. Carry out another mercury lamp test and adjust the reference values in the q file.
4. Update the Dobson instrument constants file with the new N values determined at Hoenpeissenberg. These should be in a spreadsheet with a name like R_G_N<text>.xls.
5. Make a series of direct sun and zenith observations over a couple of days. This should provide enough values to give an initial assessment of the constant offsets for the annual file.
6. Run the processing suite using camoz.bat and assess the rough offsets compared to ADDS. Adjust the CDDS, ADZ, CDZ etc offsets in the annual file to make the observations agree with ADDS.
7. It is unlikely that you will make enough observations in Cambridge to re-evaluate the regression equations.

2. Procedure on receiving a new instrument in the Antarctic.

When a newly refurbished Dobson first arrives on station the calibration constants are likely to be poorly defined. The q lever settings may have changed and it is probable that the zenith ozone reduction algorithms will need to be revised.

1. Follow steps 1 – 3 above.
2. The instrument should now be able to make accurate <u>measurements</u>, however the computed <u>results</u> are likely to be in error. Initially assume that ADDS observations are correct.
3. At every opportunity make a direct sun and a zenith observation according to the Lo schedule, with additional zenith observations at higher mu values. It will probably take a full season before there is sufficient data to re-determine the zenith equations. It will take several years to fully confirm the Lo values set at Hoenpeissenberg.
4. Cambridge will advise the new constants as soon as possible. The zenith equations are determined by multiple linear regression against the ADDS observations made close in time to zenith observations.

APPENDIX D – Routine observing schedule

Routine observations are made close in time to the 3-hourly synoptic observations. Before LAN they should normally be made after the synoptic observation, and after LAN before the observation, particularly for the first and last ozone observation each day. You should aim to make at least five observations each day. On occasion you may need to do additional observations between synoptic observations, if so, one of these should be near LAN. Observation times in brackets are optional. The type of observation will be as indicated by the data entry program.

1. Cambridge

At the synoptic hours:

(06) April 5 – September 9
09 All year
12 All year
15 All year
18 April 2 – September 6

2. Vernadsky

a) From July 22 – July 31 and May 10 – May 20: two independent CDZ observations at 16:15 (LAN).
b) From August 1 – September 5, and April 1 – May 9: hourly CDZ observations between 15:00 UT and 18:00 UT.
c) Outside these periods, observations at the synoptic hours:

00 November 13 - February 10
(09) October 24 – February 9
12 September 5 – April 4
15 July 29 – May 15
18 July 31 – May 9
21 September 14 – March 29

3. Halley

a) From August 26 – August 31 and April 11 – April 16: two independent CDZ observations at 13:45 (LAN).
b) From September 1 – September 21, and March 15 – April 10: hourly CDZ observations between 12:00 UT and 15:00 UT.
c) Outside these periods, observations at the synoptic hours:

00 November 12 - February 3
(03) November 12 – January 28
(06) October 19 – February 18
09 September 22 – March 18
12 August 31 – April 10
15 August 28 – April 12
18 September 18 – March 25
21 October 18 – February 27

d) If additional zenith observations are required for calibration purposes they can be carried out from the 8^{th} umkehr observation of the day to the $n – 8^{th}$.