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A Visit to Las Campanas in 1998 January

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1998 April 2

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Abstract

A trip to Las Campanas was made between 1998 January 21 and February 2. The dome-motor mounting plate was tightened, the software was upgraded, the water cooling loop was reconfigured, the temperature readout system was changed, a sun monitor was installed, a new UPS was installed, and the clutch was modified.

1 Introduction

We have come through a bad time for the Las Campanas station. It all started with a lightning strike on 1997 July 6. A visit in August [1] was needed to fix everything, though repairs at this time were hampered by a large snowstorm. A second lightning strike on September 25 wiped out our step-down transformer. It was replaced on November 11 and Richard Lines visited the site [2] later in November.

The equipment worked for a short time after Richard's visit, but eventually things began to fail again. January and February are the best months for collecting data in Las Campanas, so I decided to make my visit in at the beginning of 1998. There were many things that needed attention.

2 Dome Motor

The azimuth-motor mounting plate had come loose allowing the motor to move and the dome to slip. I removed the motor, tightened the nuts holding the lower plate, and then remounted the motor.

The motor is bolted to the top plate. These two plates are connected together at a hinge. The top plate always has moved somewhat with respect to the lower plate. I have measured the diameters of the hinge bar and the holes in the plates. This information is shown in Table 1 along with the corresponding numbers for the mounting plates in the Birmingham dome.

The holes in the top plate are significantly larger than the holes in the bottom plate. This causes the top plate to swing sideways each time the dome motor starts up. After some time, this pounding loosened the bottom plate. However, it appears that there is no more free play in Las Campanas than there is in Birmingham.

Table 1: Motor Mounting Plate Diameters

	Las Campanas (in)	*Las Campanas* (mm)	*Birmingham* (in)	*Birmingham* (mm)
Bar	0.502	12.75	0.501	12.73
Bottom Plate	0.505	12.82	0.508	12.90
Top Plate	0.520	13.24	0.521*	13.23

*This hole is actually oval shaped: 0.521×0.614 in, 13.23×15.60 mm.

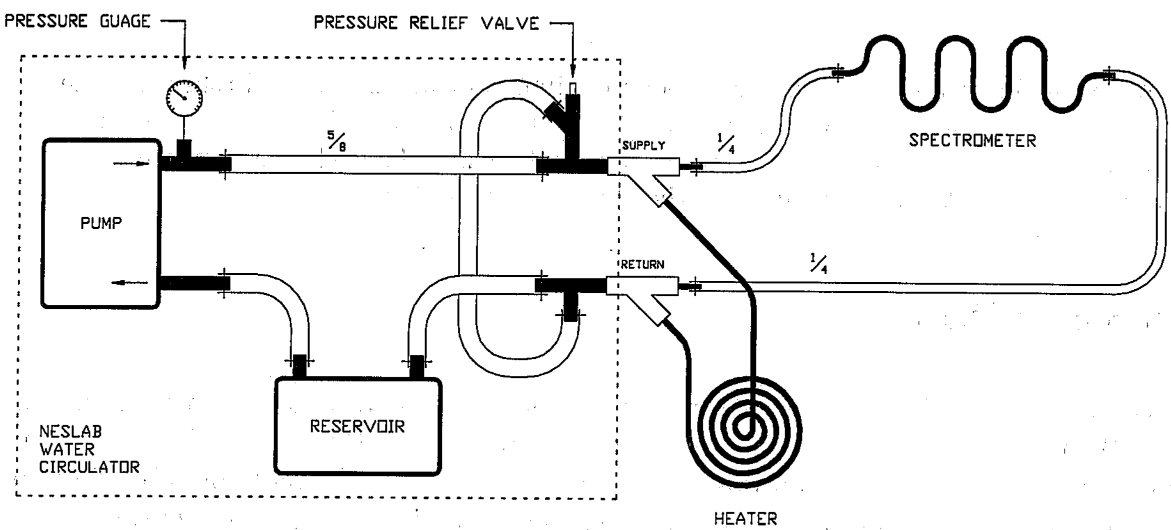

Figure 1: The original configuration of the Neslab water circulator. The sizes of the hoses are shown in inches and are the measure of the inner diameters.

3 Scavenged Junk

Richard Lines scavenged some things from the Canadian Telescope when they closed it down [2]. We now have two IBM PS/2 computers that we do not use. And we only have one working monitor to use with them. I have, therefore, told Patricio that he may have one of the PS/2s.

4 Water Loop

Bit by bit, our Neslab water recirculator has slowly been dying. The compressor failed first and was disconnected from the control electronics (unreported trip). The control electronics later failed in a way that kept the heating element powered all of the time. I disconnected the heating element and returned the control electronics to Birmingham [1]. The control electronics were never repaired, however Richard Lines instead added a forty-four-gallon oil drum filled with water to the system [2]. On this trip I found the system all clogged up. After cleaning

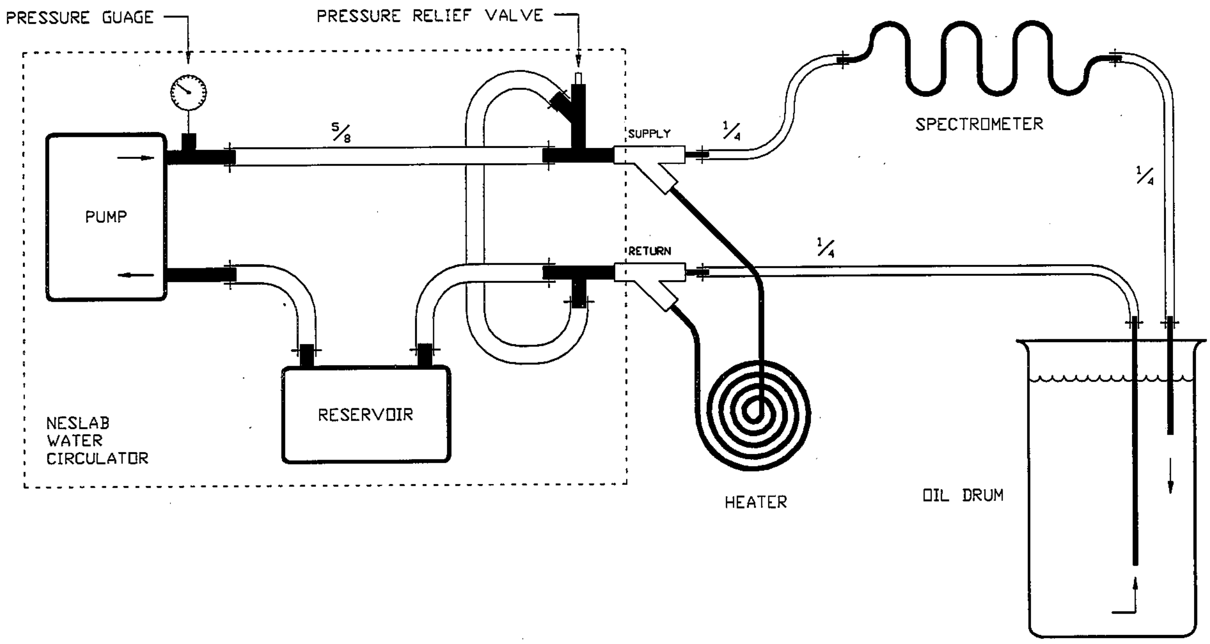

Figure 2: The Las Campanas water cooling loop after Richard Lines added a forty-four-gallon oil drum. Note that the drum is sealed. The sizes of the hoses are shown in inches and are the measure of the inner diameters.

out the filter, I rearranged the hoses to make it so that the system could start up without being manually primed.

The original configuration of the Neslab water circulator is shown in Figure 1 on the facing page. Richard added the oil drum to the return part of the loop as shown in Figure 2 on the next page. The internal reservoir had to be sealed in this configuration so that the pump could draw water from the oil drum. Richard also sealed the oil drum.

The one feature of this configuration that I dislike is that it is necessary to manually prime the system. If the internal reservoir and all of the hoses are empty, the pump cannot draw water out of the oil drum. Two things are responsible for this: First, the internal reservoir contains too much air. Second, the heater loop acts as a short circuit.

I removed the heater loop from the back of the water circulator. Remember that the heater was not being used because the control electronics failed some time ago. I have carried all of the pieces, including the mechanical and solid-state relays, back to Birmingham so that Joe Litherland can modify another Neslab water circulator, if we should ever buy another one. The workshop people here were kind enough to weld some fittings to replace the wye junctions that Joe put on the back of the circulator.

I also removed the internal reservoir from the circuit.

These two steps comprised my first attempt at fixing the water system. The configuration is shown schematically in Figure 3 on the following page. Had the system been completely sealed, it may have worked. However air entered the system at some point near to the pressure-relief valve.

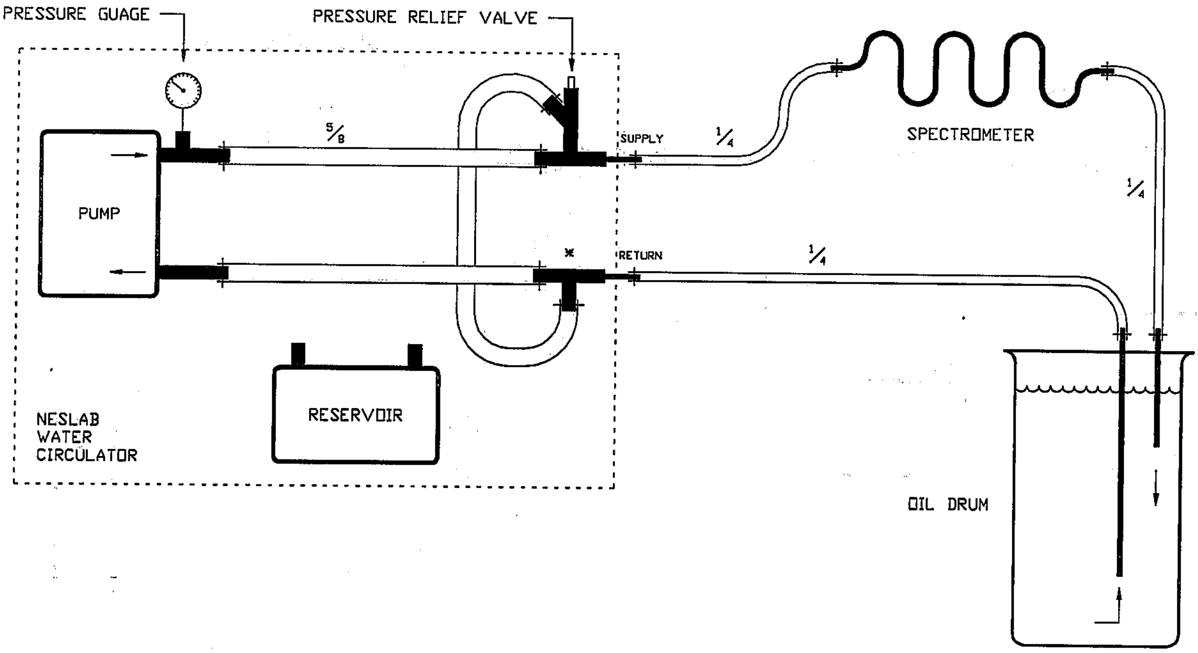

Figure 3: The Las Campanas water cooling loop after I removed the heating coil and the internal reservoir from the loop. The star marks the point at which air was leaking into the system. The sizes of the hoses are shown in inches and are the measure of the inner diameters.

Under no circumstances can the pressure-relief system be bypassed. The positive-displacement pump is capable of generating pressures high enough to rupture the flexible tubing near the spectrometer.

In the old system, the heater loop provided a convenient short-circuit and absorbed most of the flow. This kept the pressure in the spectrometer part of the circuit at a reasonable level. Without the heater loop, the pressure relief system takes most of the water. A positive-displacement pump pumps water at a fixed rate. The more resistance that the circuit applies, the higher the pressure at the output of the pump. The pump acts the same way that a constant-current source does in electronics.

Our spectrometer cooling plates are made with long sections of small-bore pipe and offer a very large resistance to the flow of water. In order to pump water at the rate that the pump works at, the pressure would have to exceed 80 psi. Because the pressure-relief valve is set at approximately 20 psi, most of the water flows around the pressure-relief loop, only a small part of it flows up to the spectrometer.

In the configuration in Figure 3, a large amount of air was going around in this loop. Small amounts of the air we deflected off, passed through the spectrometer, and then were removed from the loop in the oil drum. One would expect that all of the air in the system would eventually end up in the oil drum. However this did not happen. Air was leaking into the system somewhere.

The pump complained noisily about having air bubbles passing through it. The sealed nature of the oil drum only made matters worse. The tank became pressurized. As the pressure in the system increased, the pump complained more and more loudly.

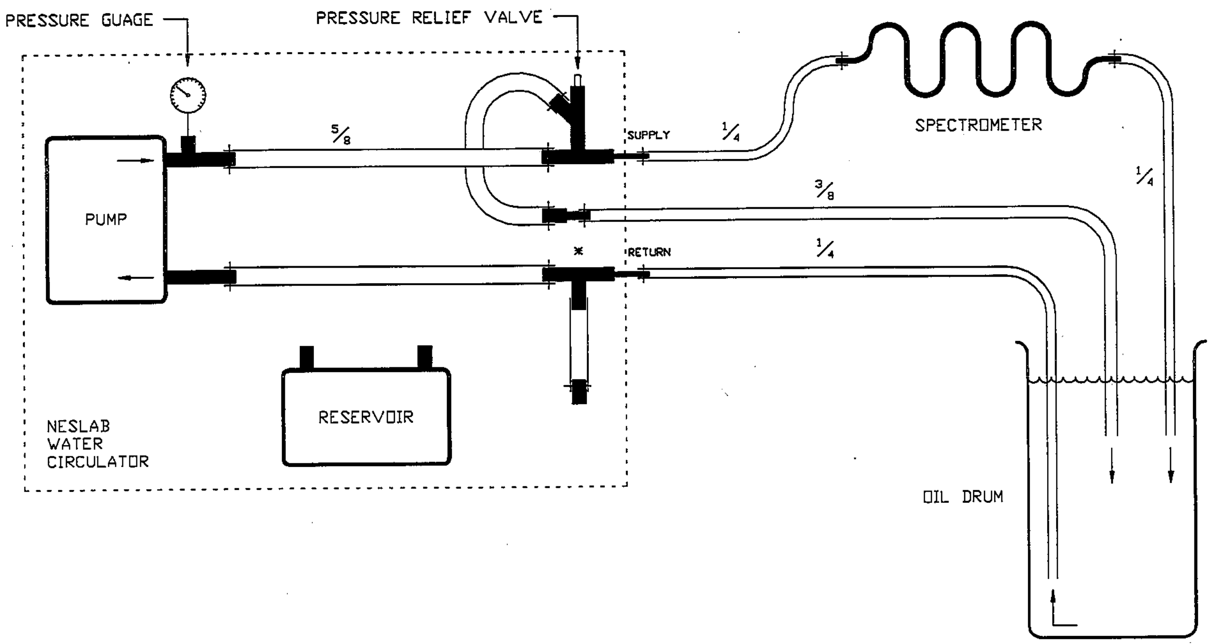

Figure 4: The Las Campanas water cooling loop after I redirected the over-pressure water directly to the oil drum. Air was still leaking into the system at the return connection (marked with a star) on the back of the Neslab circulator. The system is now unsealed.

I suspected that the leak was in the pressure-relief system and decided to break the loop and divert the over-pressure water directly to the tank. This is how the water loop is setup in Narrabri. The configuration is shown in Figure 4. The workshop people were kind enough to make for me the 5/8-inch plug and the 5/8-inch-to-3/8-inch adaptor that I needed to accomplish this. I also unsealed the oil drum at this point.

Air still entered the system. Now it was clear that there was a leak at the return connector on the back of the Neslab circulator. I decided to bypass this connector entirely. The workshop gladly made me one more 5/8-inch-to-3/8-inch adaptor and I moved the hoses to the configuration shown in Figure 5 on the following page.

The third try was lucky. There were no more air leaks and the system performed well. An additional advantage to this configuration is that the hose from the oil drum to the pump is 3/8-inch in diameter as opposed to the 1/4-inch diameter hose originally used.

I started running with this system at 1998 January $22^{d}\,17^{h}\,35^{m}$. The spectrometer temperature had been as high as 38.9°C, but dropped to 28.4°C within an hour and to 26.4°C by the end of the day. The effect on the data was quite pronounced. The sum, which had been declining, increased.

There are now only two things missing from this setup that are present in Narrabri: a radiator and a float switch. With an ambient temperature of 24°C, January 22 was probably one of the hottest days in Las Campanas. A radiator may not be necessary. It will be interesting to see if the heat being deposited in the oil drum can be dissipated quickly enough. The water in the tank may slowly increase in temperature over several days to an unacceptable level.

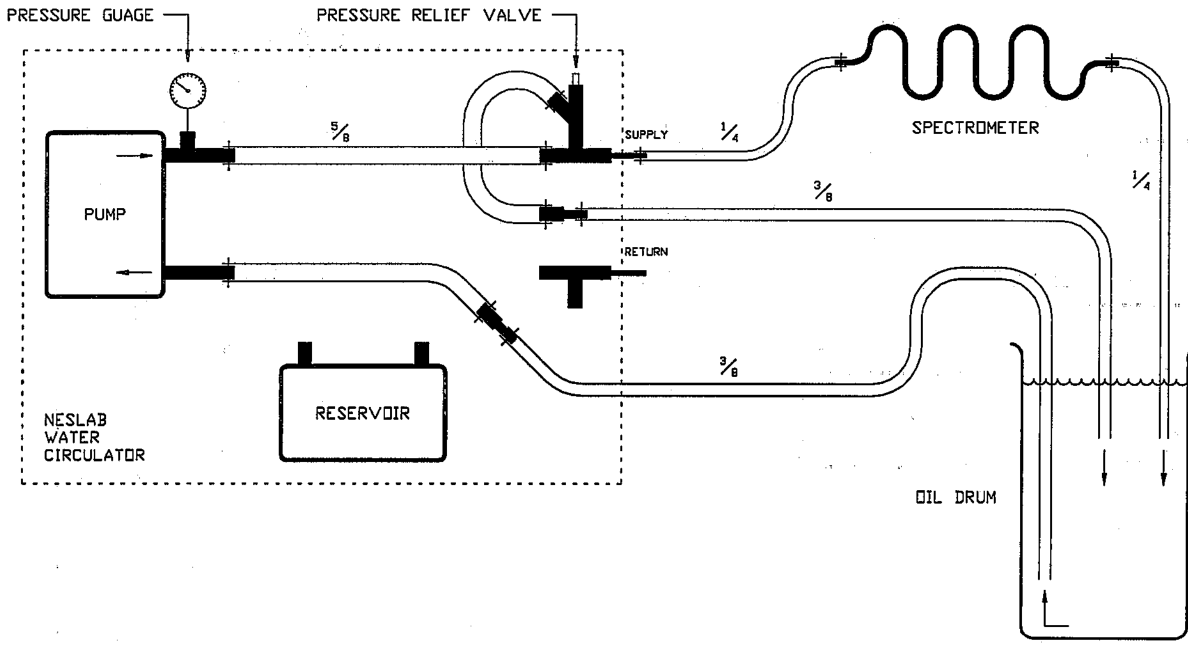

Figure 5: The final configuration of the Las Campanas water cooling loop. Here the return connector on the back of the Neslab recirculator has been bypassed. Also, the hose from the tank is now 3/8-inch in diameter rather than the original 1/4-inch in diameter.

In order to facilitate the removal of heat from the oil drum, I applied some adhesive-backed aluminum foil that I found in our dome to the sides of the drum.

It would have been nice to be able to monitor the water temperature. Richard Lines provided a temperature-sensor amplifier in the sun-monitor box, but no LM35 temperature-sensing ICs were available in Birmingham before my trip and there are no spare ones in Las Campanas.

The second item missing, the float switch, may be important and probably should be installed on a future visit. Although a float switch was originally incorporated into the Carnarvon system to prevent the pump from running dry, it serves a much more useful purpose in Narrabri. If in Las Campanas one of the hoses upstairs near the spectrometer breaks, the Neslab circulator will quite happily pump forty-four gallons of water up to the top only to have it all rain back down onto the computer and electronics.

5 Temperatures

On this trip I made some changes to the Keithley System 570 analog input channels that were used to read the temperatures. The sun monitor provides two more signals that need to be digitized: the intensity of the sun and another LM35 temperature signal. It is hoped that this new LM35 temperature signal will one day be used to monitor the temperature of the water in the tank. However, it was not possible to implement this on this visit because no LM35 temperature-sensing ICs were available.

Table 2: Temperature Read-Out System Before 1998 January 22

Channel	*QSOOSY.BI Symbol*	*Chris's New* Symbol*	*Keithley Channel*	*Display Abbrev.*	*Wire Color†*
0	AMBTEMP		1	Am	
1	IFTEMP		0	IF	
2	OVENTEMP		2	OB	
3	SPECTEMP		12	Sp	
4	TOPTEMP		15	OT	
5	STARTEMP		16	SD	
6	PORTTEMP		17	PD	
7	AMB2TEMP		18	A2	
8	DECDLIM	NAIFTEMP	22	IF2	Yellow
9	DECULIM	NAOVENTEMP	21	OT2	Green
10	HALLIM	NASTARTEMP	19	SD2	Blue
11	HARLIM	NAPORTTEMP	20	PD2	Red
12	AZLOCK	PHDETTEMP	26	PHD	Red
13	ALTLOCK	PHBRIDGE	27	PHB	White
14	ALLIM	H2OTEMP	28	H2O	Blue
15	AZRLIM	TBA	29	TBA	Yellow

*These new symbols were added to QSOOSY.BI by Chris Underhill to describe the temperature-monitoring channels. The names that Chris chose are pretty good descriptions of what the channels actually monitor. Symbols beginning with NA- refer to Ivan, which used to contain a sodium cell; symbols beginning with PH- refer to the ASP.

†Ivan does not make a ground connection to the Keithley System 570, but the ASP does. That connection is made by a green wire.

The Automated Stellar Photometer (ASP) was connected to four analog input lines, though only three of them we actually in use. Because the ASP is no longer working, and because I now have software that examines and logs changes on many of the analog input lines, I decided to remove the ASP connections and restore their original functions.

Ivan's temperature controllers present four temperature signals to the Keithley System 570. However, the lines Chris chose to use for these signals are now read by the new software. I decided to reallocate the channels used by Ivan.

These changes will mean that the columns in the temperature files will change. Before 1998 January 22, the read-out system was configured as shown in Table 2. The order in which the temperatures appear in the table are the order in which they appear in temperature files. After 1998 January 22, the system was configured as shown in Table 3 on the following page.

AMB2TEMP (second ambient temperature) is not used. But I connected it to the temperature output of the sun monitor. Hopefully this will one day be the water-tank temperature.

PHDETTEMP (ASP detector temperature), PHBRIDGE (ASP bridge temperature), H2OTEMP (ASP body temperature), and TBA (unused) were removed. The four lines they

Table 3: Temperature Read-Out System After 1998 January 22

Channel	*QSOOSY.BI Symbol*	*New Symbol*	*Keithley Channel*	*Display Abbrev.*	*Wire Color**
0	AMBTEMP		1	Am	
1	IFTEMP		0	IF	
2	OVENTEMP		2	OB	
3	SPECTEMP		12	Sp	
4	TOPTEMP		15	OT	
5	STARTEMP		16	SD	
6	PORTTEMP		17	PD	
7	AMB2TEMP		18	A2	Brown
8	UNUSED4	NAIFTEMP	4	IF2	Yellow
9	UNUSED5	NAOVENTEMP	5	OT2	Green
10	AZVALUE	NASTARTEMP	6	SD2	Blue
11	ALTVALUE	NAPORTTEMP	7	PD2	Red
12	MODAMP	SUNMON	8	SUN	Red

*Ivan does not make a ground connection to the Keithley System 570, but the sun monitor does. That connection is made by a black wire.

replaced are all read by the new software: AZLOCK (azimuth lock), ALTLOCK (altitude lock), AZLLIM (azimuth left limit), and AZRLIM (azimuth right limit).

NAIFTEMP (Ivan interference filter), NAOVENTEMP (Ivan oven), NASTARTEMP (Ivan starboard detector), and NAPORTTEMP (Ivan port detector) have all been moved. The lines they used were all interesting: DECDLIM (declination down limit), DECULIM (declination up limit), HALLIM (hour-angle left limit), and HARLIM (hour-angle right limit). Ivan's temperatures are now read on lines UNUSED4, UNUSED5, AZVALUE, and ALTVALUE. UNUSED4 and UNUSED5 were naturally unused before this. I do not know why Chris did not use these channels first.

AZVALUE and ALTVALUE were used to read the position of the dome. However they were only a poor approximation to the actual position of the dome and were not normally used. The dome calibration software tried to use these values, but often with poor results. It has long been recommended [3] that the software *not* be used to calibrate the dome encoders. The appropriate way to calibrate the encoders is described elsewhere.

The sun monitor (SUNMON) has been connected to MODAMP — a channel that was supposed to monitor the output of the Pockels-cell driver. This channel has never been used.

6 Electrical Wiring

An electricity meter has been installed in our dome. Now that the observatory is connected to the national grid, people in Las Campanas are more conscious of the amount of electricity being used. In fact, they have been surprised by just how much is being used. In an effort to find our where it is all going, they have installed meters in all of the buildings.

So far the people here have indicated that there is no intention to begin billing us for our electricity usage.

I have read the meter on several days just to see how much electricity we are using (see Table 4).

Table 4: Electricity Meter

Time	*Reading* (kW hr)
1998 January $25^{d}\,17^{h}\,50^{m}$	0160
$26^{d}\,11^{h}\,10^{m}$	0162
$31^{d}\,00^{h}\,17^{m}$	0171
1998 February $2^{d}\,14^{h}\,15^{m}$	0175

With the addition of the meter, the wiring in the circuit-breaker box is getting quite complicated. In case anyone needs to make sense of it in the future, the connections are shown in Figure 6 on the following page. It is my opinion that the meter is connected incorrectly and is only measuring half of our actual power usage. I made no effort to correct this or to point it out to anyone on site.

7 UPS

Our original UPS is not working and cannot be repaired. While it was working, Las Campanas Observatory was powered by three diesel generators and very rarely experienced any interruption in service. Now that the UPS has failed, the Observatory has been connected to the Chilean national grid. The service at first was, perhaps understandably, very poor. But now, almost a year later, the service is still very poor. I saw seven outages in the first six days of this visit.

The first four of these were harmless. However, the fifth caused lots of trouble. The computer did not come back up in a good state. Turning it off and on did not help. The problems happened during the BIOS self-test routines before DOS is loaded, so the software can not be blamed for this one. I opened the computer and found that the Keithley Interface Card was not fully pressed into its socket. A connector on the mother board near the end of the card gets in the way.

Eventually I got the computer working again. After a few minutes I noticed that the sums were astronomical. However, the ratios were normal. Turning the scaler crate off and on fixed this problem.

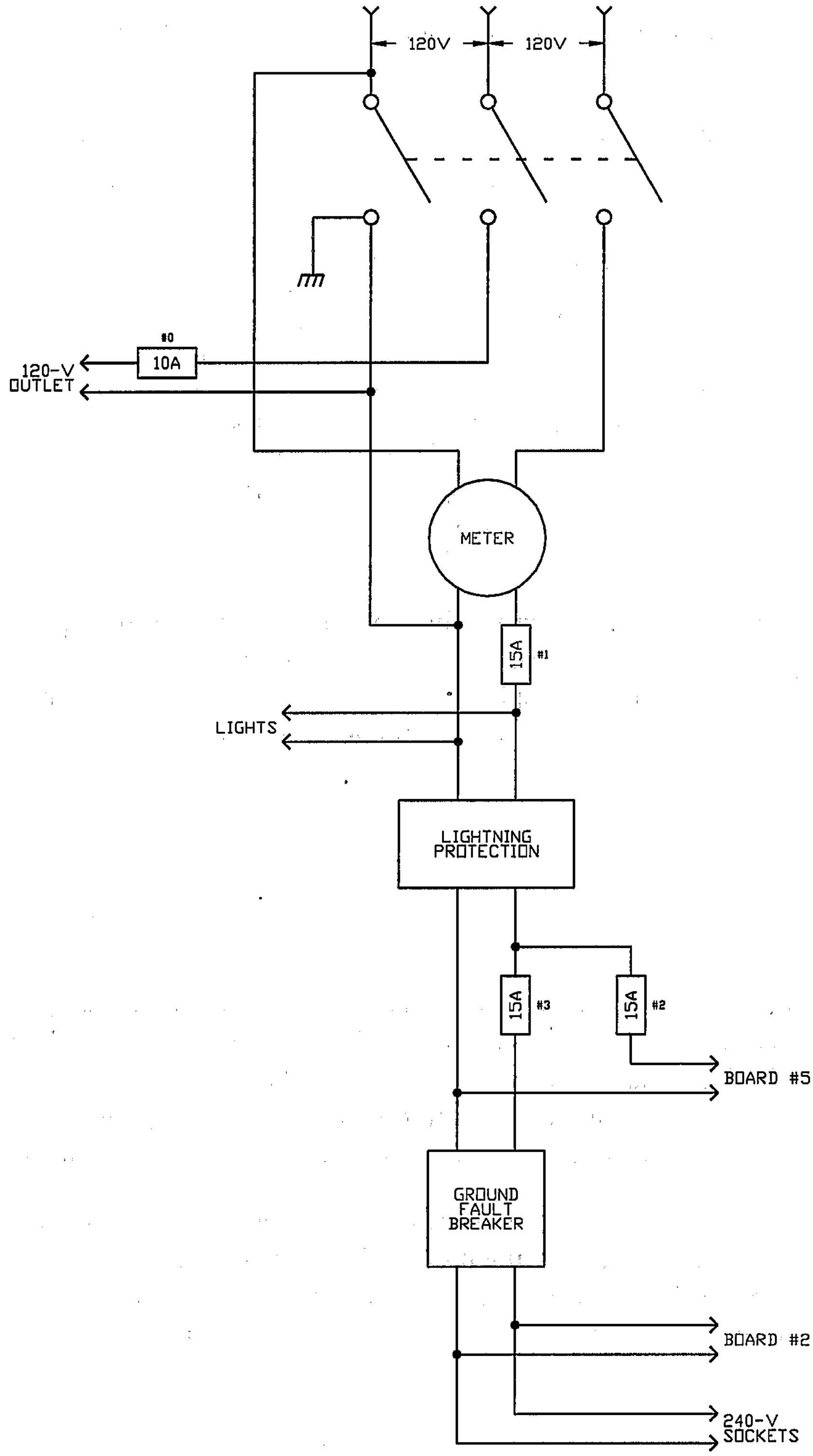

Figure 6: The circuit-breaker box in Las Campanas.

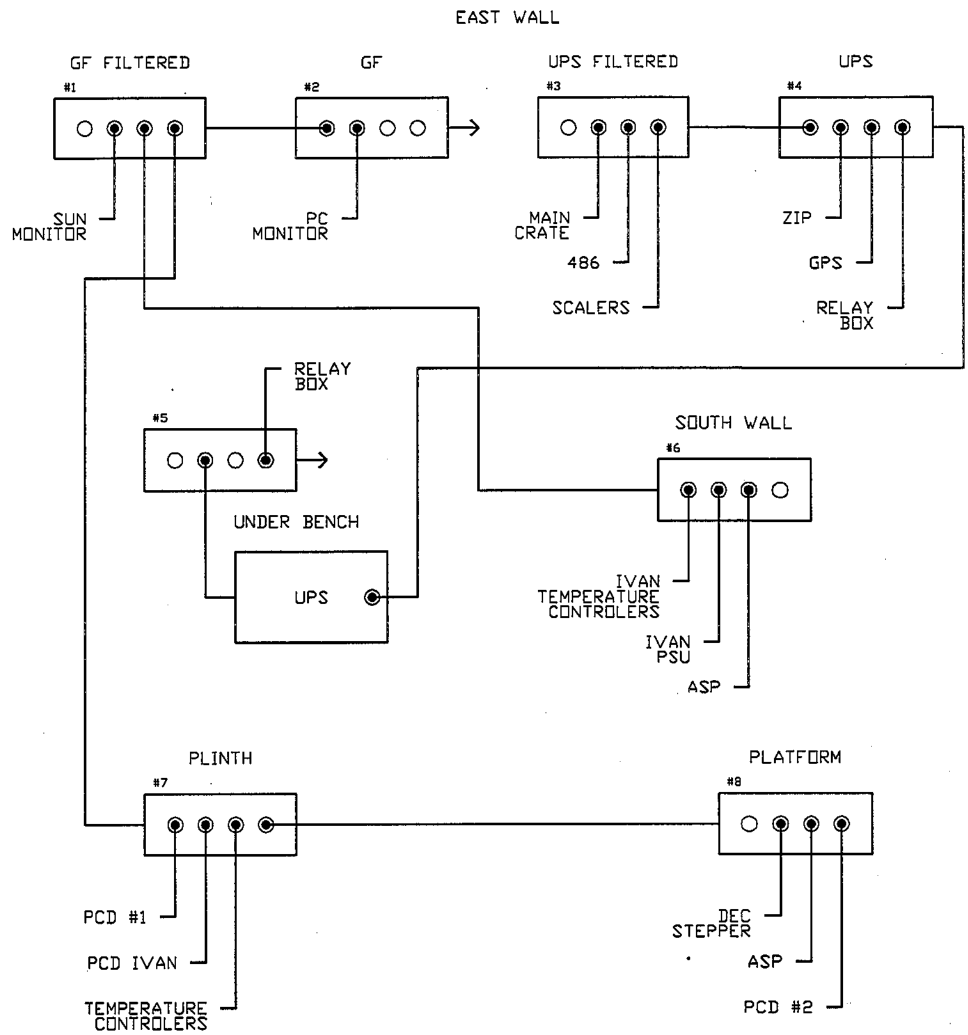

Figure 7: The arrangement of the mains cables in Las Campanas. Boards #2 and #5 are hardwired to the circuit-breaker box (see Figure 6 on the preceding page). Board #2 is connected to the ground-fault (earth-leakage) circuit breaker, Board #5 is not. Boards #1 and #3 are filtered.

I am beginning to believe that many of our problems in Las Campanas are a direct result of the unreliable electricity supply. Because of this, I ordered a new UPS. It was delivered the next day.

There has been several devices installed in the time since the last UPS failed and things were plugged in without regard for what needs UPS power and what does not. I rearranged all of the mains cabling, the new layout is shown in Figure 7.

8 Clutch

I discovered many problems with the dome when I arrived. One of them was that the clutch was not working. Patricio Pinto said it had been that way for some time.

Clutch problems are not uncommon across our network. Las Camapans suffered badly when it was first commissioned. But eventually the problems were dealt with and things have worked well, ... until now.

Richard Lines had noticed [2] some damage to the teeth on the clutch dogs. He saw that the two dogs were not fully engaging and removed some metal to allow the dogs to mate properly. Unfortunately, this seems to have caused the problems to appear.

In Narrabri, similar problems with the clutch were fixed by Roger New by adding a stop to prevent the dogs from fully engaging. It was noted that the solenoid met with much less resistance when this was done. With this in mind, I added a stop to the mechanism in Las Campanas to prevent the dogs from fully engaging; in effect, undoing what Richard had done. And it worked, ... for the first night.

I have always acknowledged that this solution was a bit of a fudge. Now I had to look into the situation more carefully to find out exactly what the problem really was.

Though I suspected that the solenoid was just not big enough, I found instead that the two dogs were not aligned properly. The fixed dog applied sideways pressure on the teeth of the moving dog. The moving dog could slide very easily along its axle, however, when there was a slight torque applied to it, it tended to bind against the axle.

The misalignment was not due to any errors in assembly. Instead I found that the aluminum block on which the 10:1 Muffett gearbox was mounted was too large. You may recall that this gearbox connects to the drive motor and is not the original gearbox sent out with the mount. A change was required to adapt to the 60-Hz power supply here on the mountain.

I estimated that the axles were misaligned by about 0.035 inches (everything is done in inches here) so I asked Frank Perez to machine 0.040 inches off one side of the mounting block. Before you ask, I did this because I wanted to err on the large side. If not enough material was taken off, I would have to ask for another favor. If too much was taken off, I could fix it with shim plates. There is a large range of shim material in the 100-inch dome. Also, I preferred to have a little room for adjustment, so shims did not seem like such a bad idea to me.

I installed the new block and estimated that it was about 0.005 inches too small. Perhaps I should have had more faith in my ability to measure things. I reassembled the mechanism anyway, without shims, and found that it worked well.

9 Sun Monitor

The first BiSON sun monitor was added to the system on this trip. This should not be confused with the cloud detector. The latter contains a photoresistor mounted at the bottom of the shutter on the moving part of the dome. It is monitored by the weather module which will close the dome if clouds are detected.

The sun monitor, on the other hand, is mounted some distance from the dome and does not move. A photoresistor is mounted flat and a plastic cover keeps it clear. This is monitored by a separate box of electronics that provides a voltage signal to the Keithley System 570. The software reads this signal along with the temperature signals and logs the forty-second averages to the temperatures file.

The idea behind this new invention is to determine whether or not clouds are responsible for bad data. While the cloud detector output is monitored by the computer and logged to the station log file, it suffers from two problems. First, only *tripped* or *not tripped* status is logged. And second, dome-pointing problems cause the cloud detector to become shadowed and trip. The sun monitor will hopefully provide a completely independent assessment of the sky conditions.

I bolted the sun monitor to a metal sawhorse and placed it on top of the hill ten meters to the North of our dome. The electronics box was placed next to the computer and connected to the Keithley System 570 as described in Section 5 on page 6. The operation of the unit is described in detail elsewhere [4].

10 Software

I reinstalled the newer QSOOSY code, again replacing Chris Underhill's old program. I found a couple of small bugs in the code I had written for Las Campanas on my previous visit, but I am not sure if they could explain the behavior we have been experiencing. Chris's code was restored by Hernan Solis after my last visit, but things did not return to normal. While I was present at the station, there were no anomalies in the computer's performance, except those caused by the power flickers.

I am beginning to suspect that there is something wrong with the computer. The night-time program BLASTER began having difficulties after I left. Sending a new executable file to Hernan solved the problem. Are our files being corrupted in some way? Could it be a hardware fault or a virus? It will be difficult to diagnose a problem like this when the system exhibits no symptoms while people are on site.

During this visit I extended the changes I was making to QSOOSY to include the new code written at Sutherland [5]. This now means that many more events are logged to the `STATION.LOG` file, including limit-switch changes, weather-sensor changes, and autoguider signals.

I also connected an Iomega ZIP drive to the computer and modified the compacting code to copy the rawdata file to a ZIP disk every evening at sunset. Each 100-MB ZIP disk can hold about one month of rawdata files. I left four blank ZIP disks in the dome along with a list of the dates that they are to be changed and sent back to Birmingham by post (Table 5 on the next page). Hernan is going to arrange for new disks to be sent from Pasadena.

I have also backed-up the entire hard disk onto a ZIP disk and have left it in the dome.

Table 5: ZIP Disk Changes

Disk	*Change Date*
LC RAW #1	1998 March 1
LC RAW #2	1998 April 1
LC RAW #3	1998 May 1
LC RAW #4	1998 June 1
LC RAW #5	1998 July 1
LC RAW #6	1998 August 1
LC RAW #7	1998 September 1

I was hoping that there would be an Internet connection in the dome when I arrived, but that was not to be. The fiber-optic cable was in place and all of the hardware had been purchased, but the fiber terminators had not yet arrived.

In preparation, I tested my software by connecting one of the IBM PS/2 to our computer with a serial line and used that as an Internet link. I was not able to completely test the software, but I tried my best to eliminate as many of the bugs as possible. The important IP addresses in Las Campanas are shown in Table 6.

Table 6: IP Addresses in Las Campanas

Name	*Address*	
bison.ctio.noao.edu	139.229.9.200	
charlie.ctio.noao.edu	139.229.9.50	
router-lco.ctio.noao.edu	139.229.9.254	Gateway
ctios2.ctio.noao.edu	139.229.2.3	Nameserver

The Internet connection was eventually established after I left the mountain. Surprisingly enough, the software worked! Well, it almost worked. I entered the wrong IP address for the gateway in `BRDP.C`. This meant that QSOOSY could not send any messages off the local Ethernet.

However, the night-time program was configured correctly and did work. But there was a problem here too. I discovered that the maximum transmission unit (MTU) between here and Las Campanas is 250. That means that any Internet message carrying more than 250 bytes is fragmented by one of the gateways between here and there. My code does not implement fragment reassembly, so things do not work correctly. I have modified both BLASTER and GHETTO to send smaller messages. The new BLASTER has been sent to Las Campanas and Helen Williams is using the new GHETTO (called GHETTOC) to retrieve files from the station each day.

Las Campanas will soon be connected by a better link. Hopefully this will mean the end of the 250-byte MTU.

11 Pockels Cells

There are three Pockels cells in Las Campanas. Two of them are in Spectrometer H and one in Ivan. I checked the operation of the two velocity Pockels cells by scanning the driver output voltage from zero up to the operation level while monitoring the ratios. I tested the magnetic Pockels cell by the same method except that I first moved the cell to the velocity position inside the spectrometer and connected the velocity signal to the driver. All three cells are operating normally and the voltages are set just below the quarter-wave point. I did not increase the driver output voltages for fear of shortening the life of the cells.

12 Autoguider Alignment

I scanned the autoguider in both right ascension and declination and plotted the ratios and sums versus autoguider position. The original autoguider position was very near to the optimal position according to these scans so only a minor adjustment in the autoguider position was necessary.

13 Interference Filter

I attempted to tune the interference filter using the potassium lamp, however I was unable to get a sufficient signal at the transmission monitor and had to abandon the effort.

14 Heating Curves

I acquired a heating curve for both instruments. The results for Spectrometer H are shown in Figure 8 on the next page and the results for Ivan are shown in Figure 9 on page 17. In both cases the original temperature setting turned out to be the optimal value.

References

[1] Brek A. Miller. The trip to Las Campanas during the big snowstorm of 1997 August. *BISON Technical Report Series,* Number 62, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, November 1997.

[2] Richard Lines. A visit to Las Campanas after the lightning strike that destroyed our step-down transformer. *BISON Technical Report Series,* Number 71, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, February 1998.

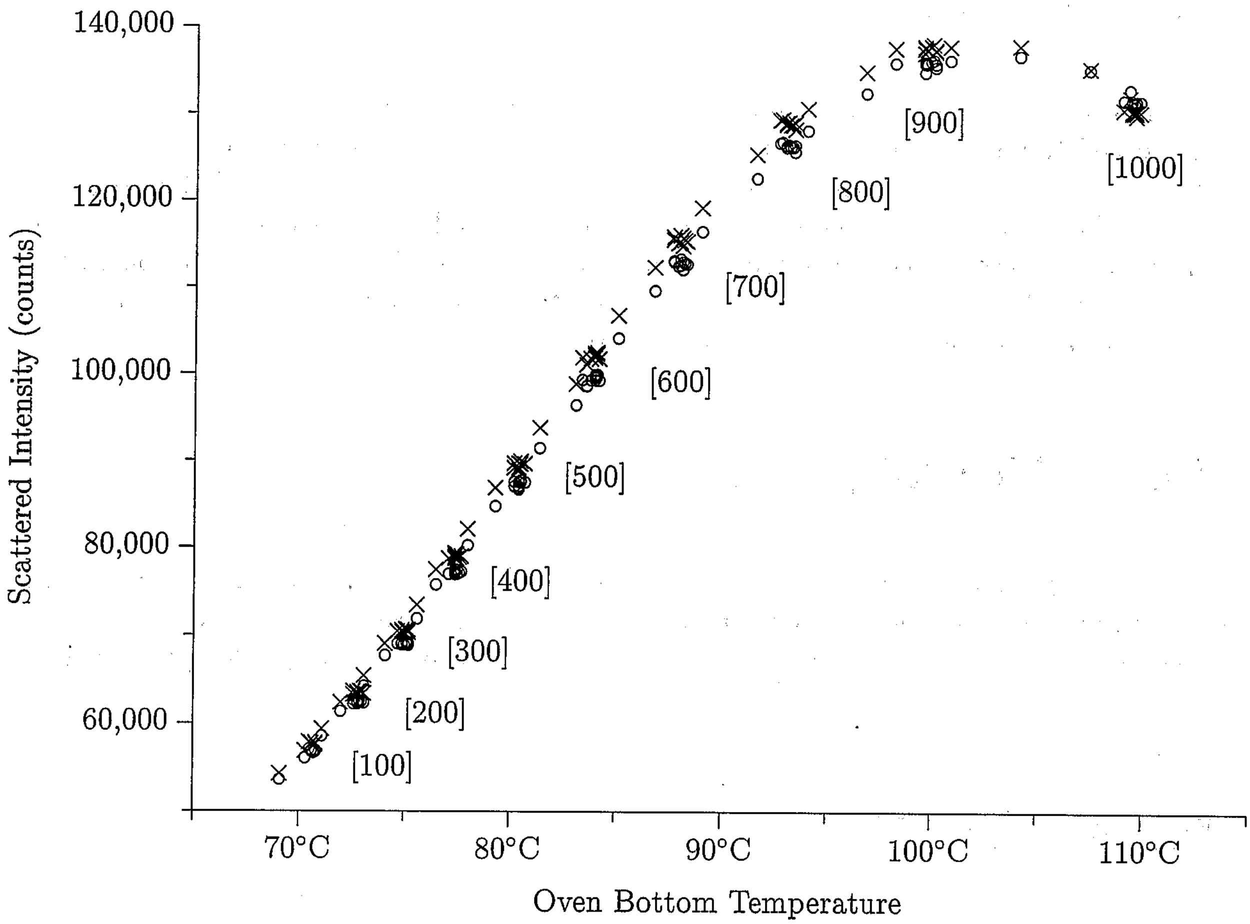

Figure 8: Heating curve for Spectrometer H. The counts from the starboard detector (○) are shown separately from those from the port detector (×). The dial on the front of the temperature controller was set at ten positions ranging from 100 to 1000. Each point shown represents the mean of 10 3.2-second readings. Twelve points were collected at each dial setting. The dial values corresponding to each clump of data points are shown.

[3] Brek A. Miller. A description of the automated solar-observatory encoder system. *BISON Technical Report Series,* Number 60, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, November 1997.

[4] Brek A. Miller. Sun monitor #1. *BISON Technical Report Series,* Number 75, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, April 1998.

[5] Brek A. Miller. Work done at Sutherland from 1997 September 23 to October 6. *BISON Technical Report Series,* Number 63, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, November 1997.

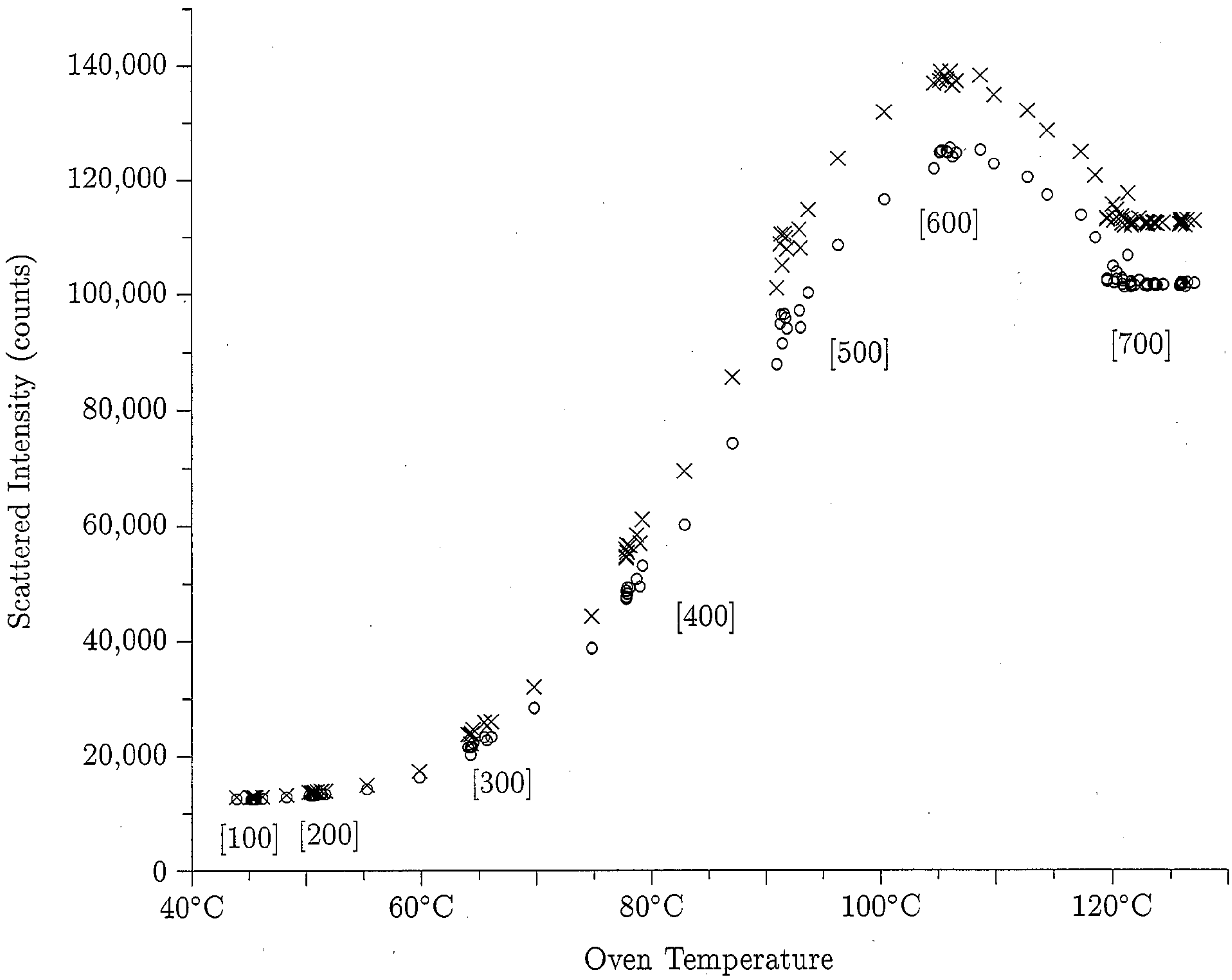

Figure 9: Heating curve for Ivan. The counts from the starboard detector (∘) are shown separately from those from the port detector (×). The dial on the front of the temperature controller was set at seven positions ranging from 100 to 700. Each point shown represents the mean of 10 3.2-second readings. Twelve points were collected at each dial setting. The dial values corresponding to each clump of data points are shown.