BISON Birmingham Solar-Oscillations Network

TECHNICAL REPORT NO. 5

Update on My Report on the Trip to Mount Wilson (Hale) Observatory

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This is an update on my report on the trip to Mount Wilson (Hale) Observatory

Latitude=34°.13 N

Longitude=-118°3′40″ -118.0611

Height=1742m

YE 8/17/92

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COELOSTAT

The coelostat on the 60 foot tower has 2 mirrors; a primary of diameter 546 mm (21.5 inches) whose normal faces the solar equator and and a secondary of diameter 425 mm (16.75 inches) which reflects the light vertically downwards to the observing room below. The primary mirror is offset from the secondary so that there is no need for a winter mount, but there is always some time lost for about 8 months of the year as the primary is moved from the East to the West position in the middle of the day.The original description of the tower is given in Astrophysical journal vol 27 (1908) pp204-212 in an article by George Ellery Hale. The current mirrors are not the original ones which were considerably thicker. The current coelostat mirror arrangement is shown in the pictures as is a drawing of the originals. The other optical component of the tower which is relevant to us is the so-called Ellerman lens. Ferdinand Ellerman was one of the assistant astronomers in February 1905 (Ap J **21** pp124-172 (1905)). His lens is put in at the top of the tower to take pictures (known locally as the 'direct') of the Sun. Its diameter is 305 mm (12 inches) and its focal length is 60 foot(18288 mm). I believe that in normal running the secondary is tilted towards the East so that Ed's lens can be in the centre of the beam but still not require moving when the 'direct' is taken every morning. Thus the system is aligned for the Ellerman lens and then realigned for Ed's lens. The working diameter of Ed's lens is 60 mm (2.4 inches) its focal length is 3222mm (127 inches) (diameter of solar image=29mm and solar diameter is 0.01 radians)and it is placed about 2972 mm (117 inches) above the focus of the Ellerman lens (Natasha said that there was about 10.5 inches between the focus of the 60 foot lens and the focus of their lens).In order to determine whether we can share the tower with Ed Rhodes's equipment and to determine where our pick off mirrors should be, we need to know the projected area of the secondary at the foot of the tower and then how much of the 'spare mirror area' sees the full sun. We can get a feeling for the projected areas by initially ignoring the offset between the primary and the secondary mirrors (See figure 3). In that case the angle calculation is as follows: The projection of the mirror is an ellipse with major axis equal to the full diameter of the secondary = 425mm. The minor axis, in this configuration always points due south.

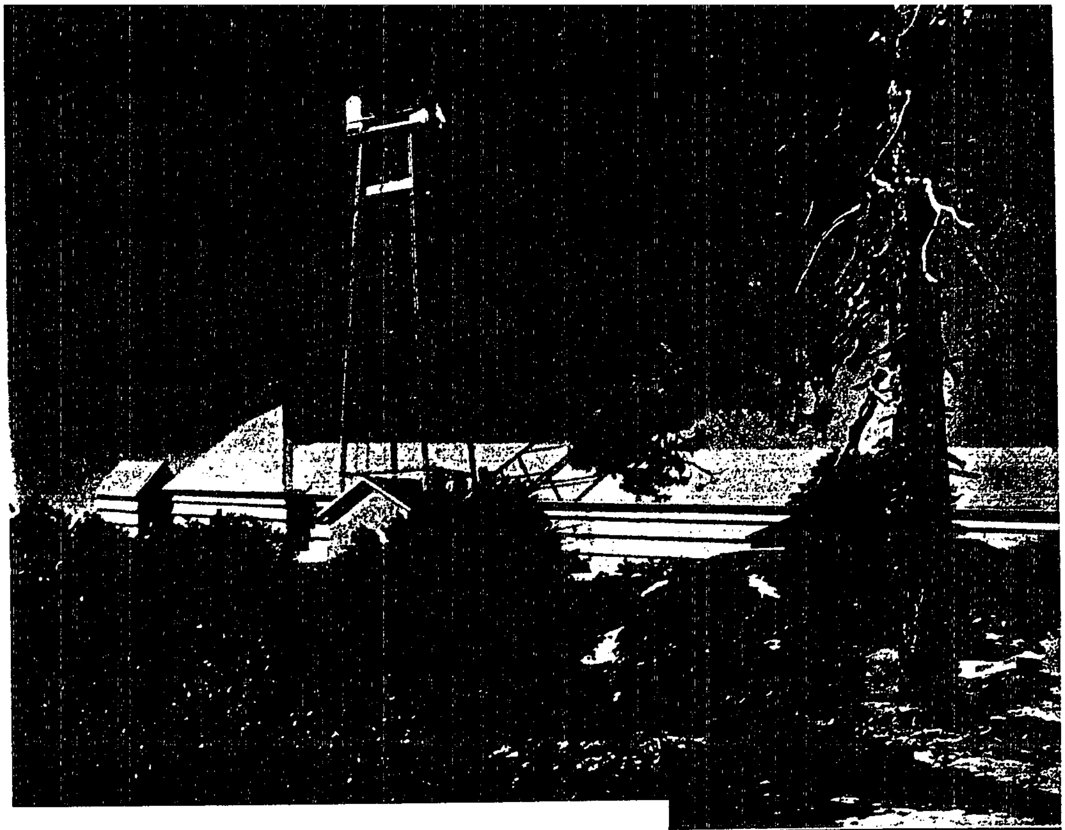
Declination	-23	0	23	degrees
Projected area	420	404	374	mm

Given that the primary is offset from the secondary, then 3 dimensional analysis is required. The first stage is to calculate which direction the output beam from the primary goes in. In the diagram, the Sun is shown at noon at (hence it is on the meridian). The primary mirror is tilted away from the meridian by an amount which depends on the physical placing of the mirrors. I have used rough estimates of the positions to give a value for p (sort of hour angle) which I call the pitch of the primary as 11 degrees. This value is reversed to -11 degrees when the primary is translated at noon assuming that the mirror is moved to the symmetric position on the other side of the secondary. When I was there, there were no stops to ensure that this happened but they are promised for the future. The normal to the mirror and the incoming and outgoing rays all lie in one plane and as the mirror is considered to be the centre of this celestial sphere, Sun, M1 and S2 must all lie on a great circle. Furthermore M1 is symmetrically placed between Sun and S2. This is enough information to allow one to work out the position of S2. A ray going in the opposite direction to S2 (ie at 180 degrees) is the input ray to the secondary,whose normal points roughly away from M1 and the output ray is directly downwards. Hence all these points on the celestial sphere are on the opposite side of the sphere from those of the primary. To calculate where the normal to the secondary(M2) points it is useful to consider the points diametrically opposite to those described above so that they are in the same region of the celestial sphere as Sun and M1. The fact that all the directions have been reversed does not changes the relationships between the angles. In the next diagram the normals to the two mirrors are shown together with S2 and the Zenith (which is opposite to 'straight down'). By the same arguments that were used for the primary mirror, the pitch of the secondary is the same as the primary and M2 lie on the great circle through the zenith and S2. M2 is no longer on the celestial equator but is tilted by an angle t2. These two angles, t2 and p, define the position of the secondary. to know the appearance of the secondary from the bottom of the tower we have to work out the altitude and azimuth in terrestrial co-ordinates. The foreshortening of the secondary is given by cos(latitude-t2) and the direction of the minor axis of the ellipse depends on the azimuth, B and no longer points due south.The spherical trigonometry is given separately and its results are.

Declination	-23	0	23	degrees to celestial equator
projected diameter	424	407	374	mm
Dir^{n} of minor axis	50	36	23	degrees to N/S




original view →



original coelostat

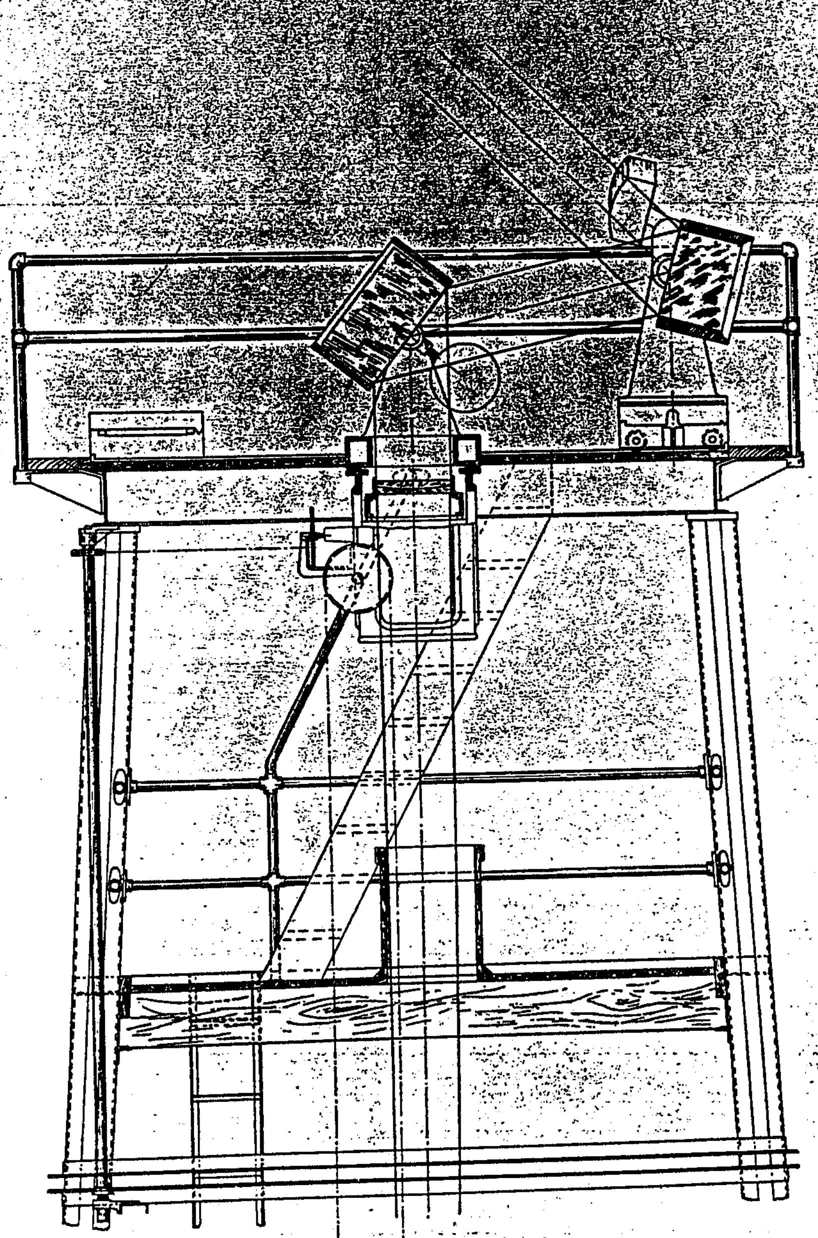
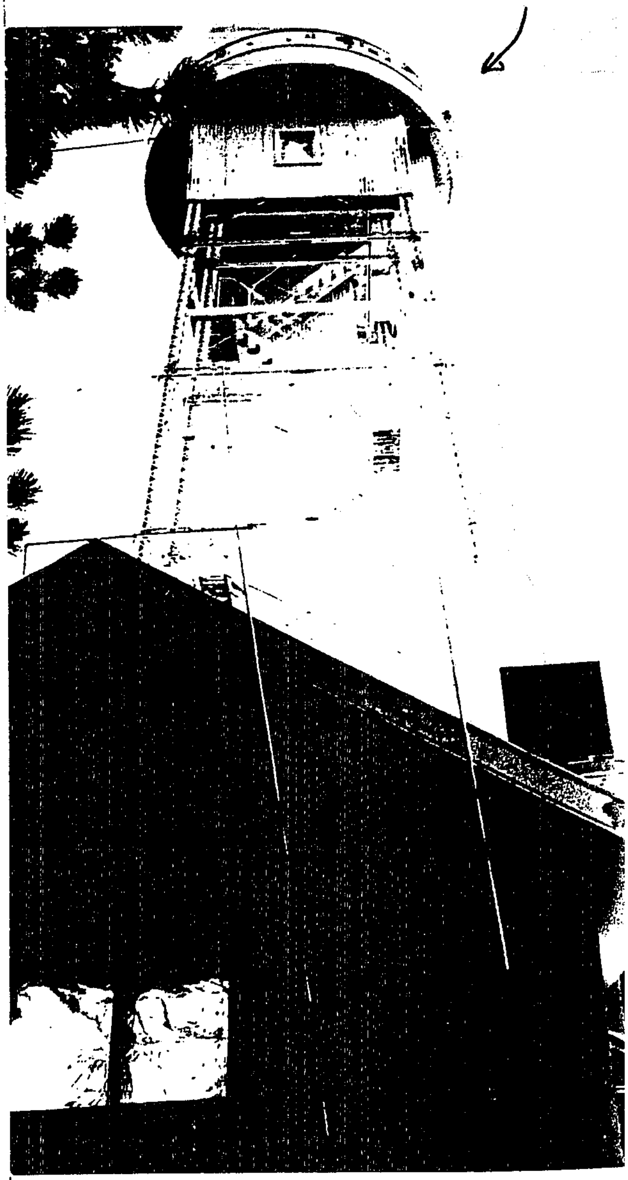


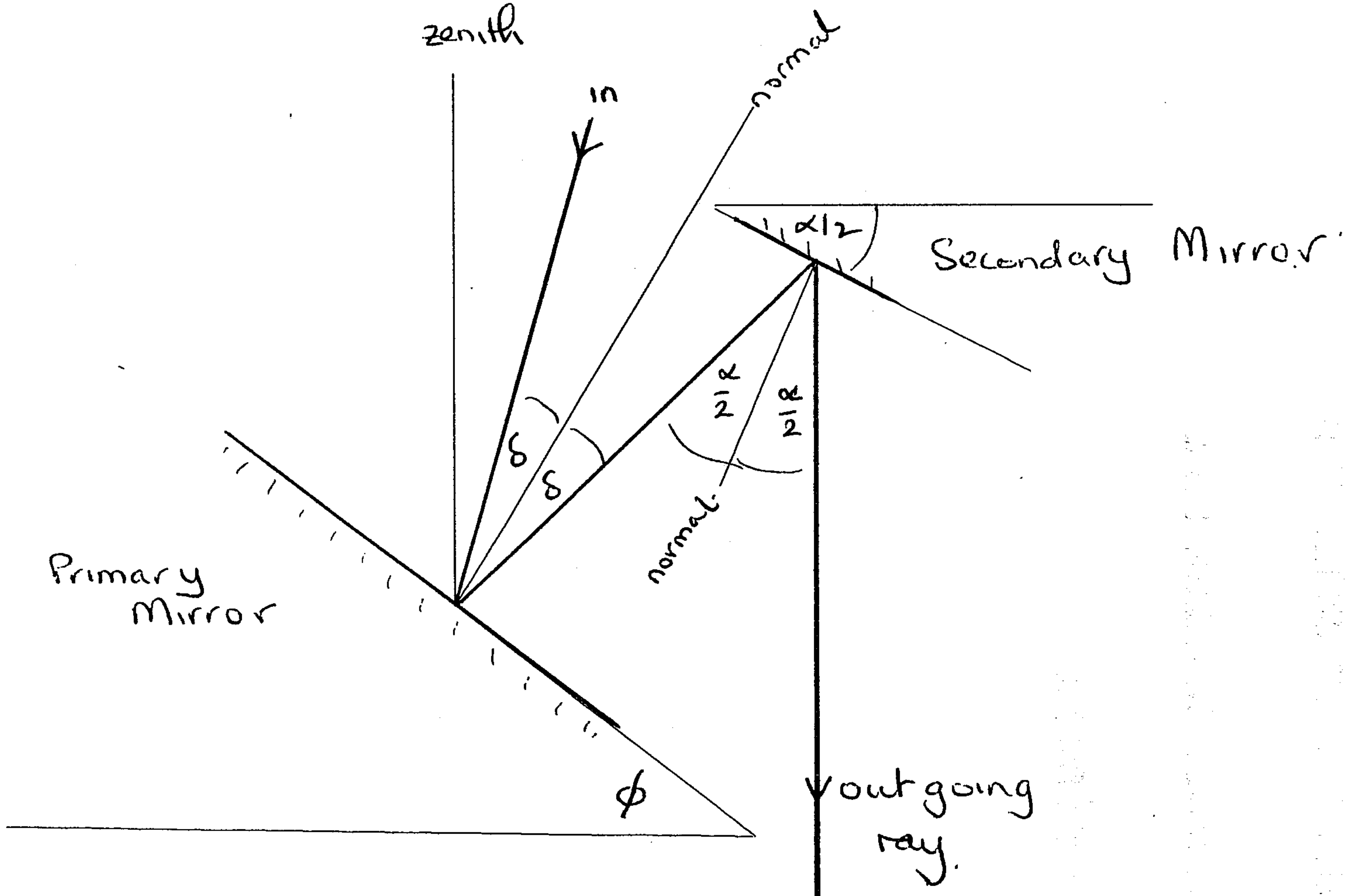
FIG. 1.—Section through upper end of Tower

ackground

1991 view ↙



Notation and Calculations for Coelostat position as a function of season



$\alpha = \phi + \delta$

ϕ = latitude

δ = declination.

Projected diameter = $D_p \cos(\alpha/2)$

D_p = true diameter = 425 mm

PROJECTED DIAMETER OF SECONDARY

Figure 3

Calculation of the projection angles of the Secondary of the Mount Wilson Coelostat

B is related to the azimuth of the secondary and $\varphi - t_2$ is the projection angle. The calculations using the optical raytrace programme, BEAM3, give celestial co-ordinates because it was easier to set the problem up in that manner but to calcuate the projected area of the secondary as a function of season requires the terrestrial co-ordinates given above.

In Triangle CP Z S_2

$\cos(2b) = \cos(90-\varphi)\cos(90+\delta) + \sin(90-\varphi)\sin(90+\delta)\cos(2p)$

this gives 'b' as a function of 'δ'

δ	-23	0	23
b	11.1	20.0	30.5

In Triangle M_1 CS Sun

$\cos(i) = \cos(\delta)\cos(p)$

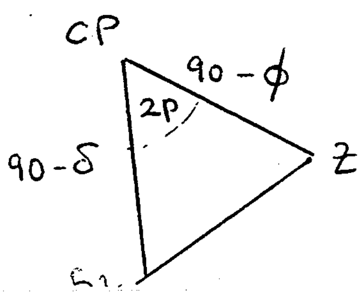
In Triangle S_2 Z Sun

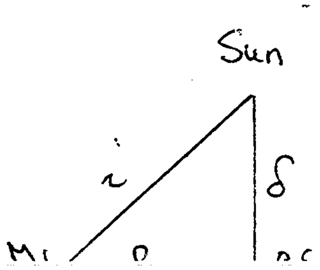
$\cos(2i) = \cos(2b)\cos(\varphi-\delta) + \sin(2b)\sin(\varphi-\delta)\cos B$

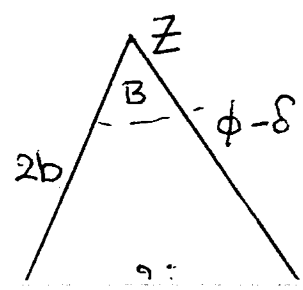
δ	-23	0	23
i	25.4	11	25.4
B	**50.3**	**35.6**	**23.1**

$\cos(\varphi-\delta) = \cos(2p)\cos(2i) + \sin(2b)\sin(2i)\cos(\beta)$

δ	-23	0	23
β	98.0	61.0	5.7







In Triangle $M_1M_2S_2$

co s(α)=cos(b)cos(i)+sin(b)sin(i)cos(β)

δ	-23	0	23
α	29.0	17.4	5.7

In Triangle W M_2M_1

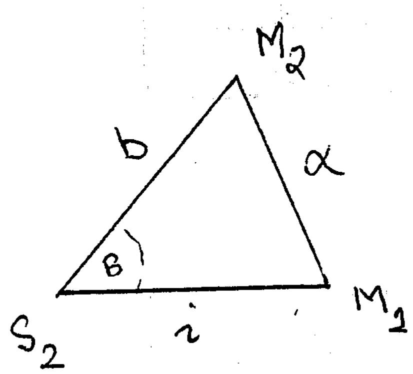
cos(A)=cos(α)cos(90-p)

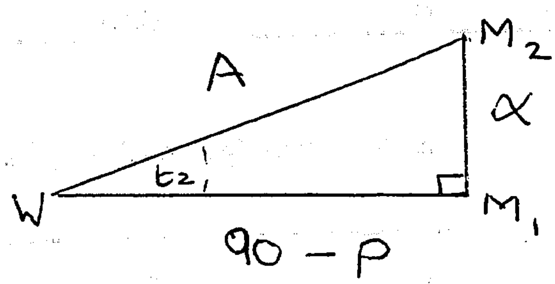
sin(t_2)=sin(α)/sin(A)

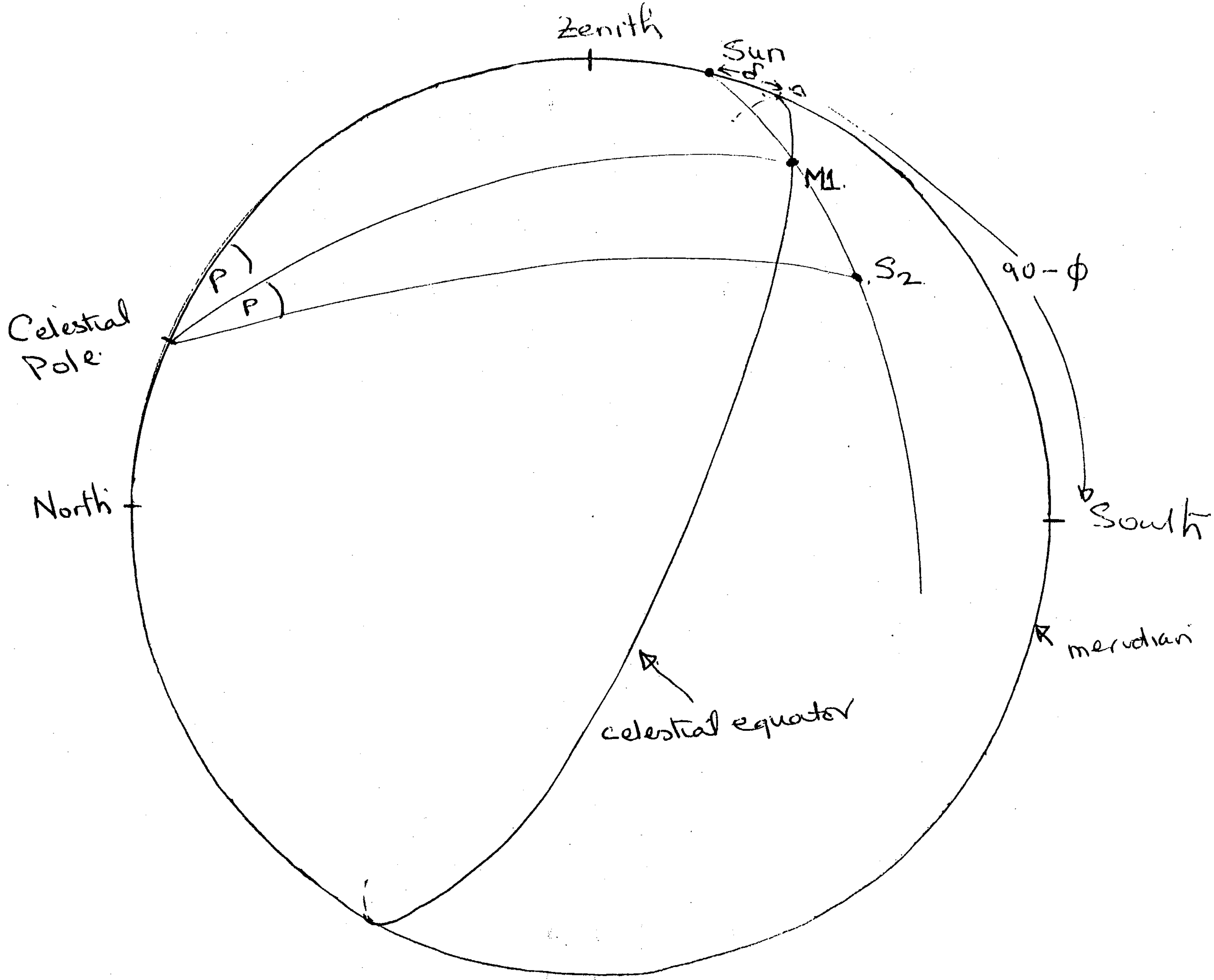
δ	-23	0	23
A	80.4	79.5	79
t_2	29.5	17.7	5.9

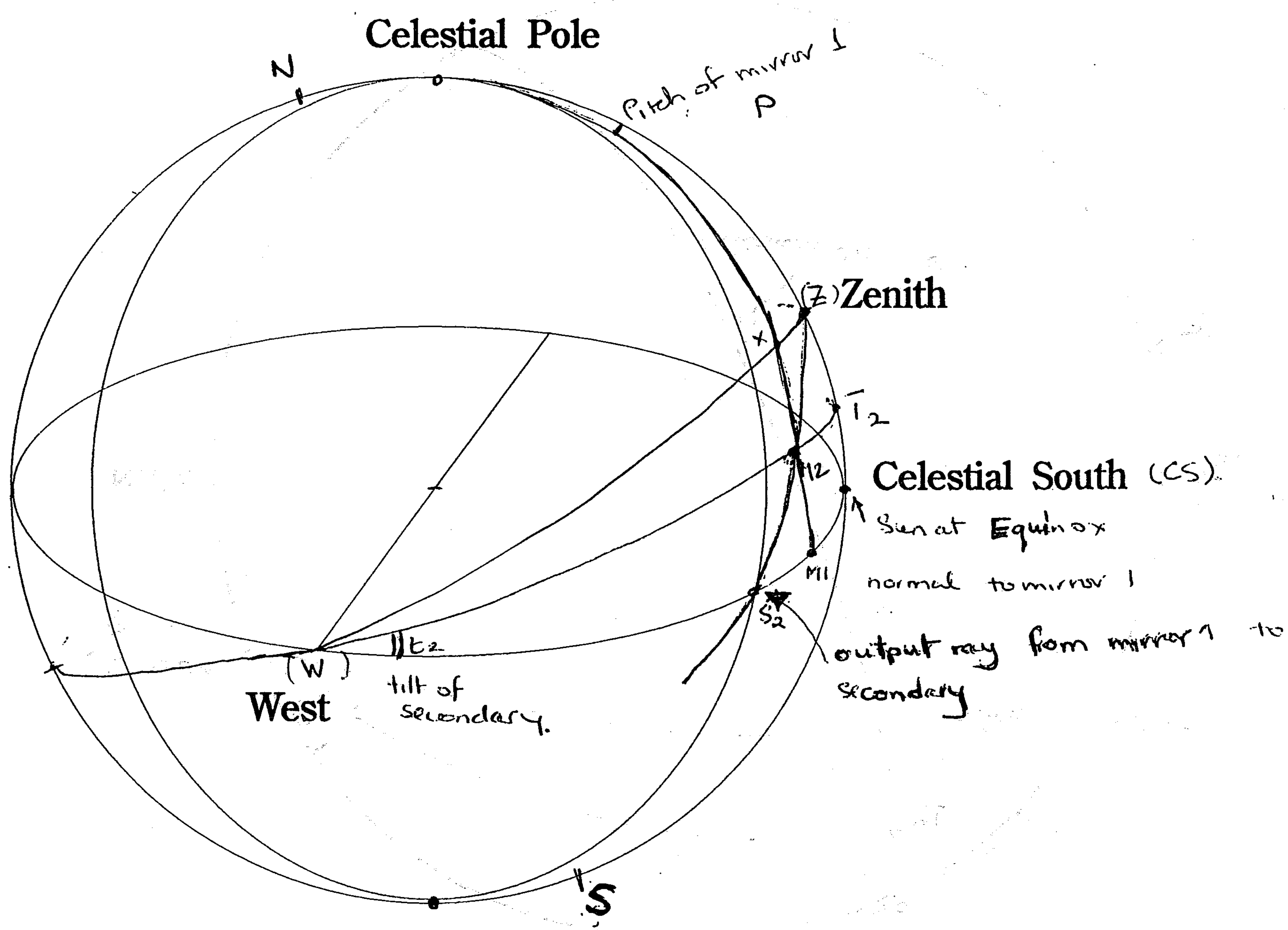
from BEAM3

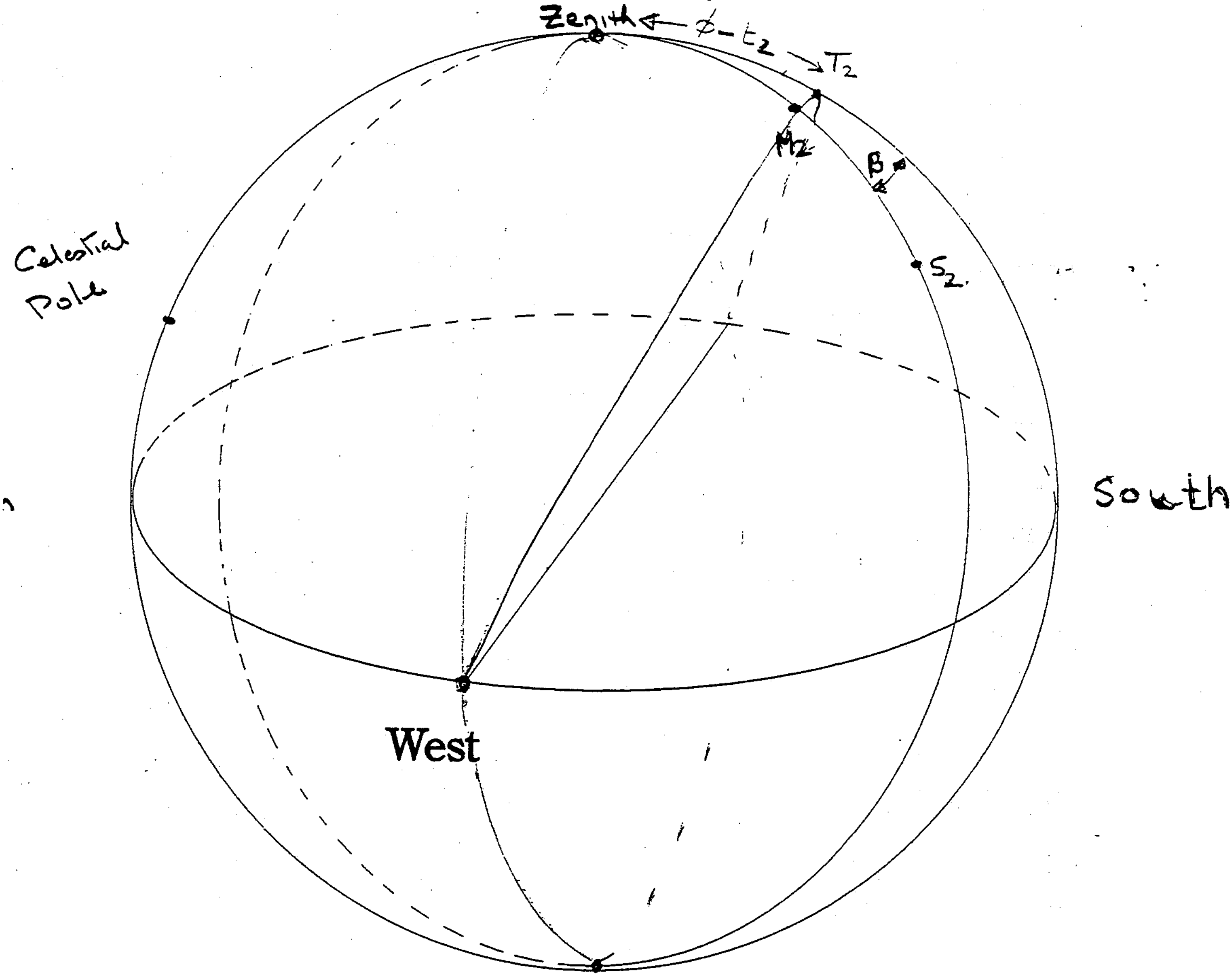
t_2	**29.8**	**17.8**	**5.6**
φ-t_2	**4.7**	**16.5**	**28.7**






Zenith
Sun
δ
90 - φ
South
meridian
S2
M1
celestial equator
P
P
Celestial Pole
North


Celestial Pole
N
Pitch of mirror 1
P
(Z) Zenith
X
T2
M2
Celestial South (CS).
Sun at Equinox
M1
normal to mirror 1
S2
output ray from mirror 1 to secondary
t2
tilt of secondary.
(W)
West
S



Zenith
$\phi - t_2$
T_2
M_2
β
S_2
Celestial Pole
South
West

Recommendation for periscope position

Having calculated the angles involved one can now determine the optimum place to put the pick off mirrors (or periscope). But first a description of the periscope itself. The mirrors as mounted on the optical bench are shown in the photograph. When they are in place in the tower then the optical pins holding the mirrors are horizontal. There are no micrometer adjustments available. The mirrors are positioned correctly and then the fixing screws are tightened. There are several problems with this at the moment. Firstly, for various reasons the bracket which supports the assembly is not correctly positioned in the shaft. It should be central but it is in fact off to one side. This just makes the adjustment difficult and requires that not all the fixing screws are used. New holes should drilled to place the assembly centrally in the tower. There is also no adjustment in the 'up-down' angle of the mirror. We require that the light bean leaving the periscope is not parallel to the incoming ray, but is tilted to the west. I relied on gravity to help me, but Joe has made some shims and wedges for Brek so that everything can be left secure. A third mirror is placed near the entrance to the spectrometer to reflect the sunlight along the optic axis of the spectrometer.

The previous calculations have shown that the worst time for our system is in summer when the projected area is at a minimum. We need to work out what space is available at this time.

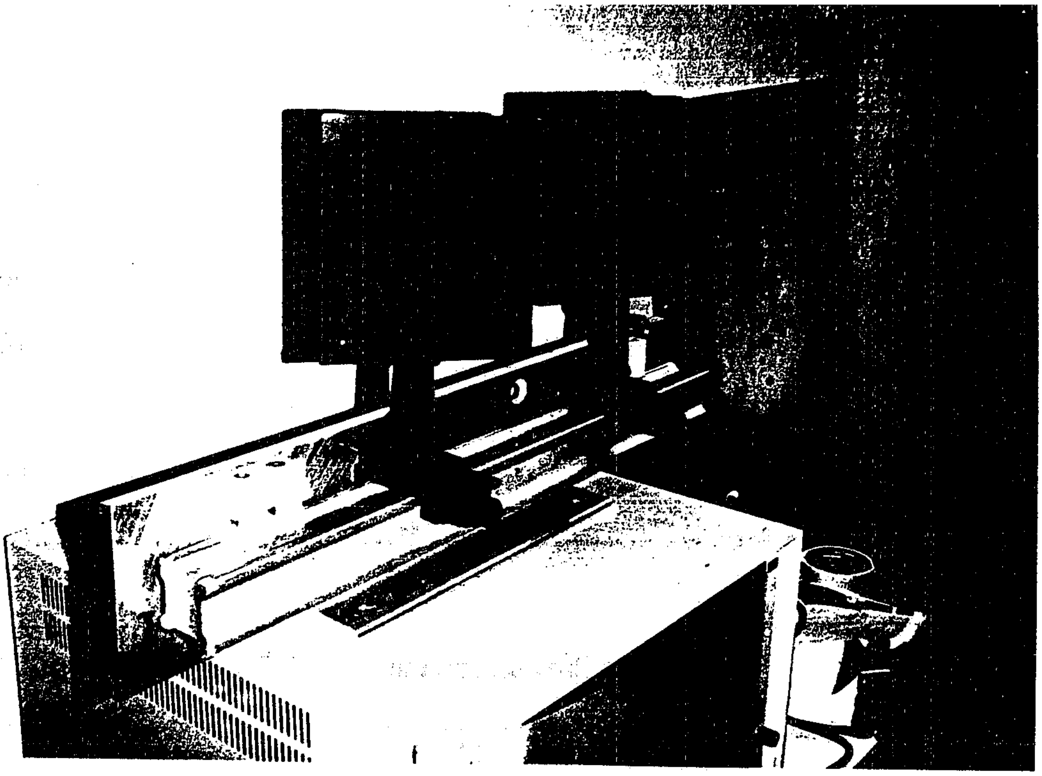
Ed's lens is 6cm in diameter and is about 63 feet from the secondary Assume that the solar diameter is 0.01 radians. Thus the diameter that is being used is 6+19.2=25.2 cm. Our limiting aperture is the spectrometer input lens which is just over 13 feet from the first mirror of the periscope. We have to be able to accommodate the solar deviation over this distance which is 4cm on the diameter. Ed is in the centre of the field of view and we are on the side therefore the amount of spare space for us in summer is (37.4-25.2)/2=6.1 cm. This gives a maximum entrance aperture for us of 6.1-4.0=2.1

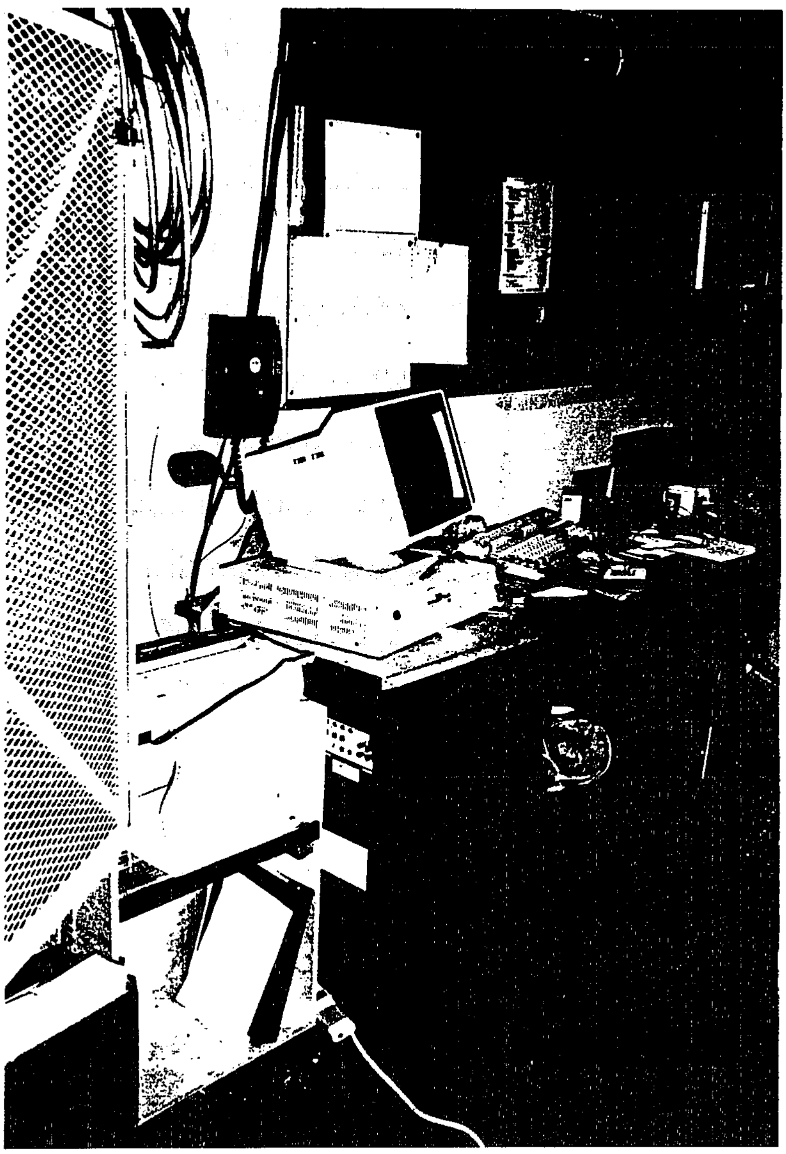
cm. My measurements suggested that about 1.5 cm was the maximum aperture in the south, which is consistant. I did try moving to the East which should have slightly more space and found that I could use a bigger aperture. Unfortunately, lack of time and a decent modulator prevented me from taking a spectrum and proving the point. The calculations here fit with the measurements that I made last September and Roger made last January.

I suggest that Brek sets up the system with the periscope to the East of Ed's lens and not to the South as was suggested to me. The projected area is improving all the time and he should not have too many problems. There is a further advantage to this position that the optical pins are shorter and the vibration should be less. Some mechanical effort will be required and Harvey Crist's services may be needed.

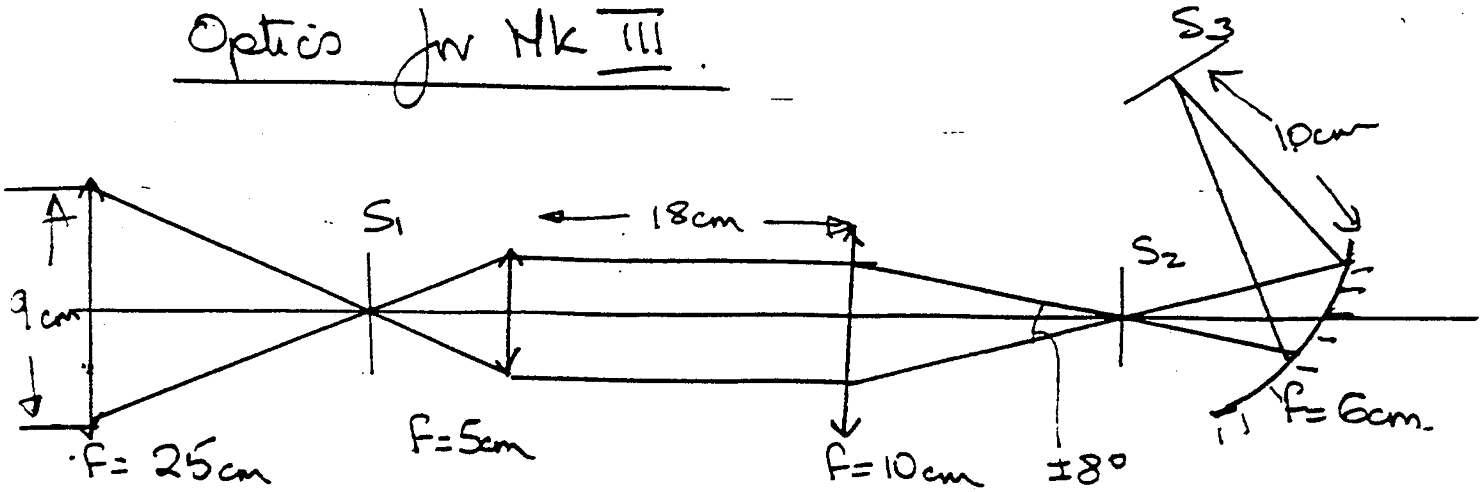
A good way of checking that one is seeing the full Sun is as follows (see diagram of our optical system). The first lens forms an image of the Sun in its focal plane. To see this image remove the other optical components including the red filter on the input. If the image is vignetted then the brightness of the image will vary form one side to the other. This can be quite difficult to see. I used a small pinhole in the entrance plane to isolate a small bundle of rays. In this case the image of the Sun will have a bite taken out of it if the full Sun cannot be seen from the position on the aperture of the pinhole. In approximately the same plane as the solar image is the image of the coelostat secondary. This is much fainter than the image of the Sun because it comes from scattered light, however it is discernible. By comparing the position of the secondary to the solar image, one can determine how marginal the solar image is. It is actually impossible to see the precise focal plane of the input lens, but with small pinholes on the input , the depth of focus is sufficient that it hardly matters where you look at the image.

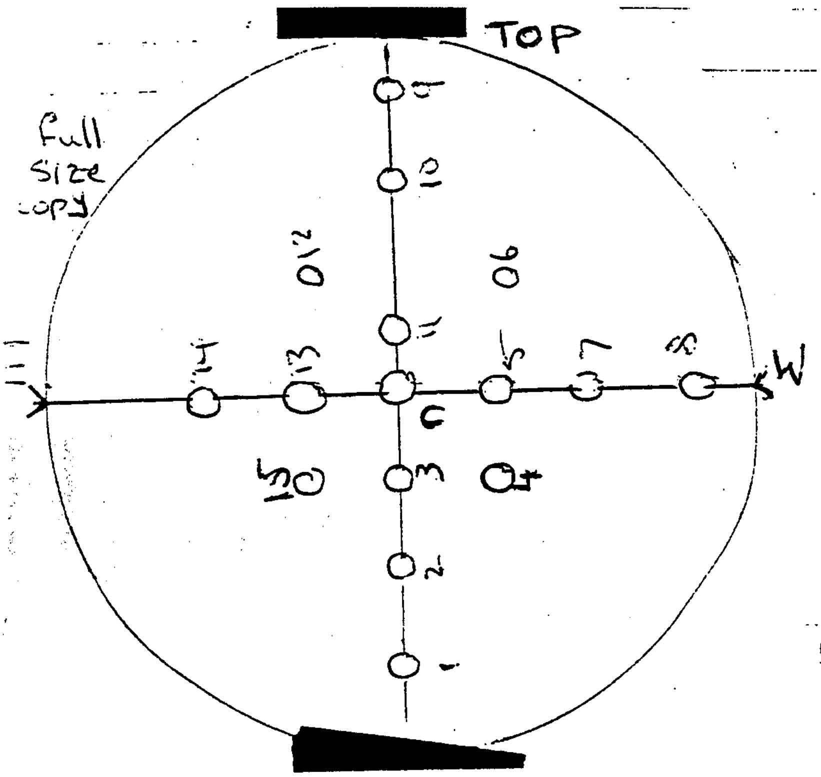
There is a drawing of the sorts of solar images which I saw.

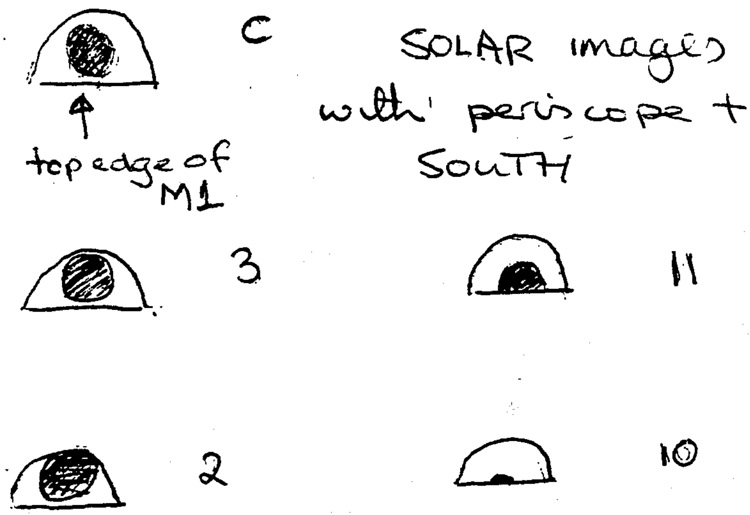




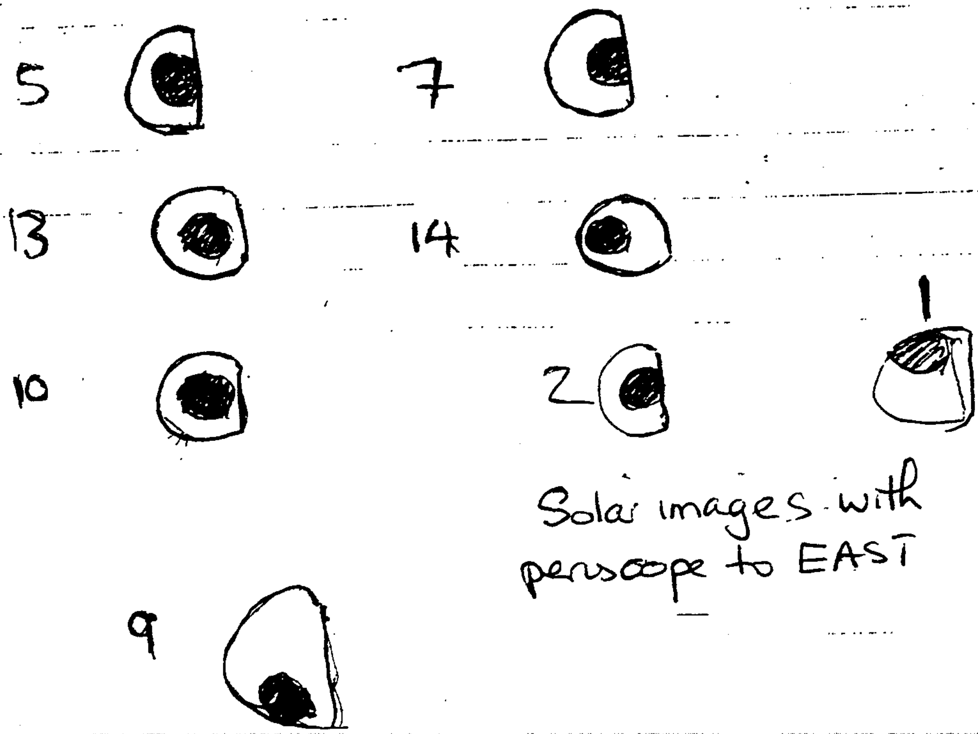
Optics for Mk III





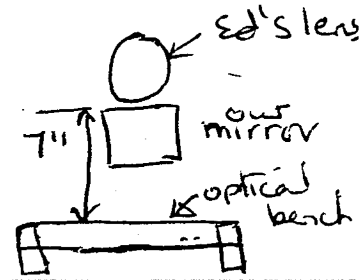


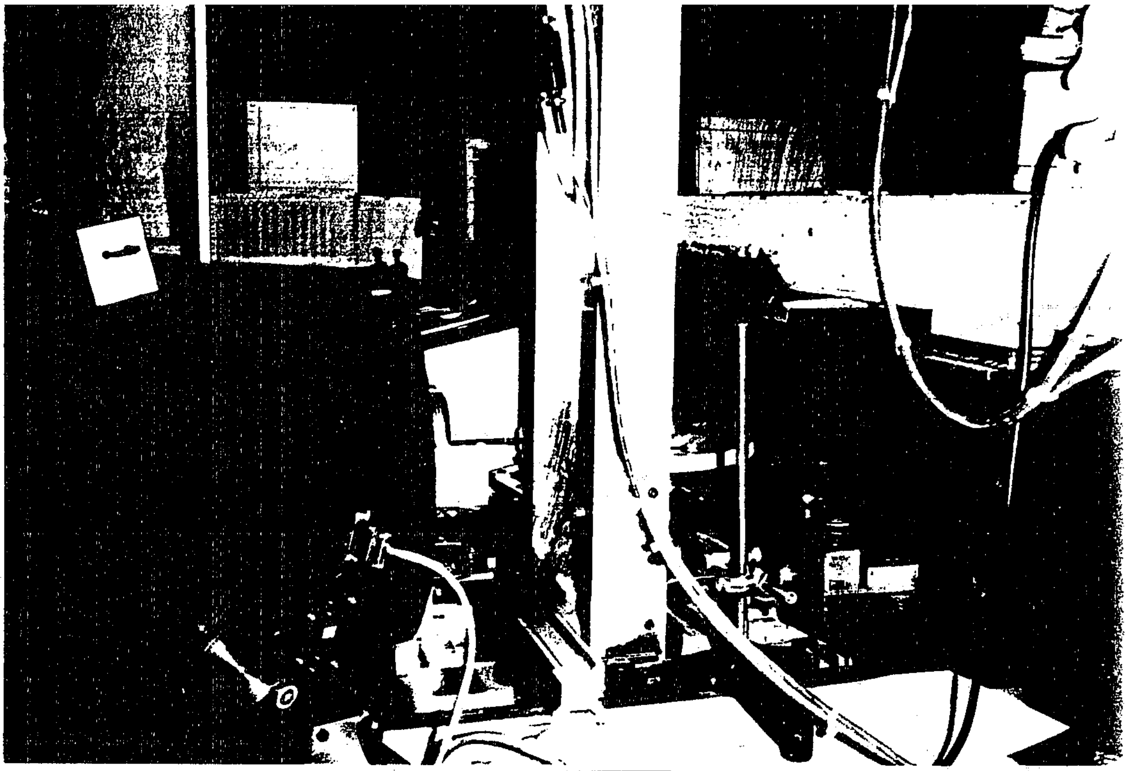
SOLAR images with periscope + SOUTH

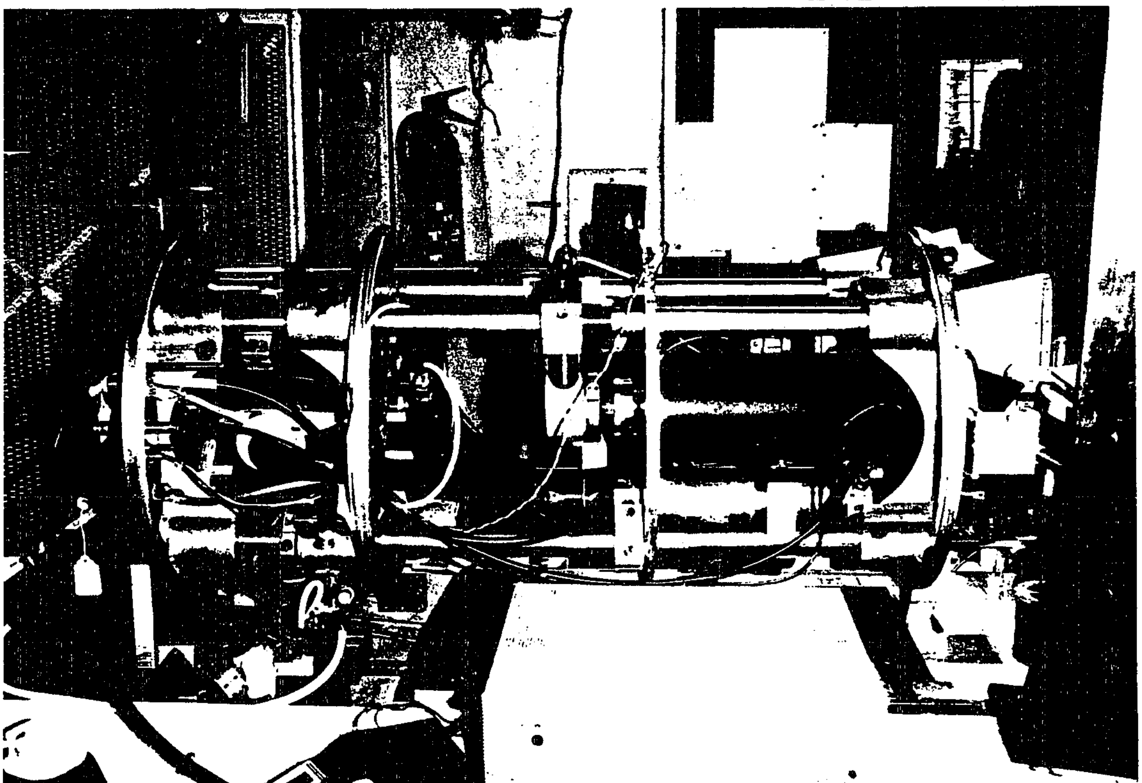


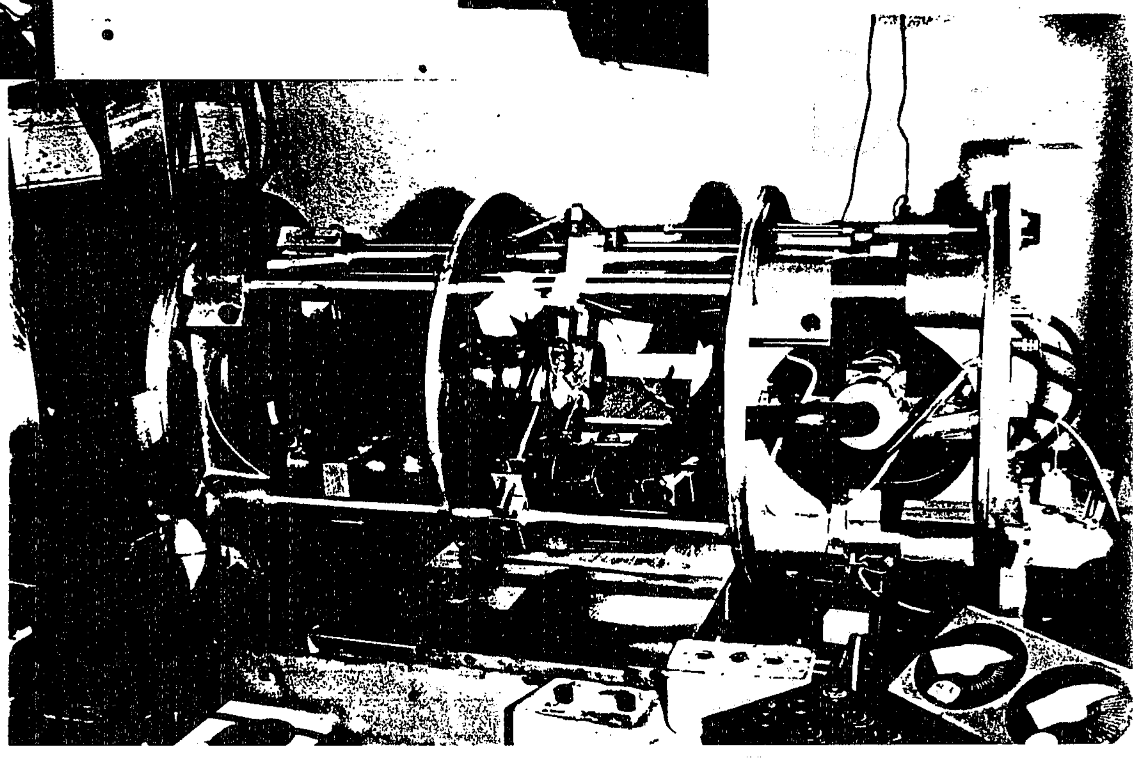
Solar images with periscope to EAST

limits are 1,9,5,14
ie not quite centra
8cm x 4cm availabl









Where our Equipment is placed

The spectrometer has been put to the South of the support for Ed's guider and South of Ed's equipment but on roughly the same centreline. There is a drawing of the room and some photogarphs of Mk III in position. The cell oven supply and the driver for the PEM are placed just next to the spectrometer. The photomultiplier power supply and amplifiers together with the temperature controller for the interference filter (and its transformer) are placed on top of a 19" rack in the South East corner of the room. If the rack is moved then be careful not to pull them off. The rest of the equipment, including the computer is on or underneath a table to the South West. Space there is very tight.

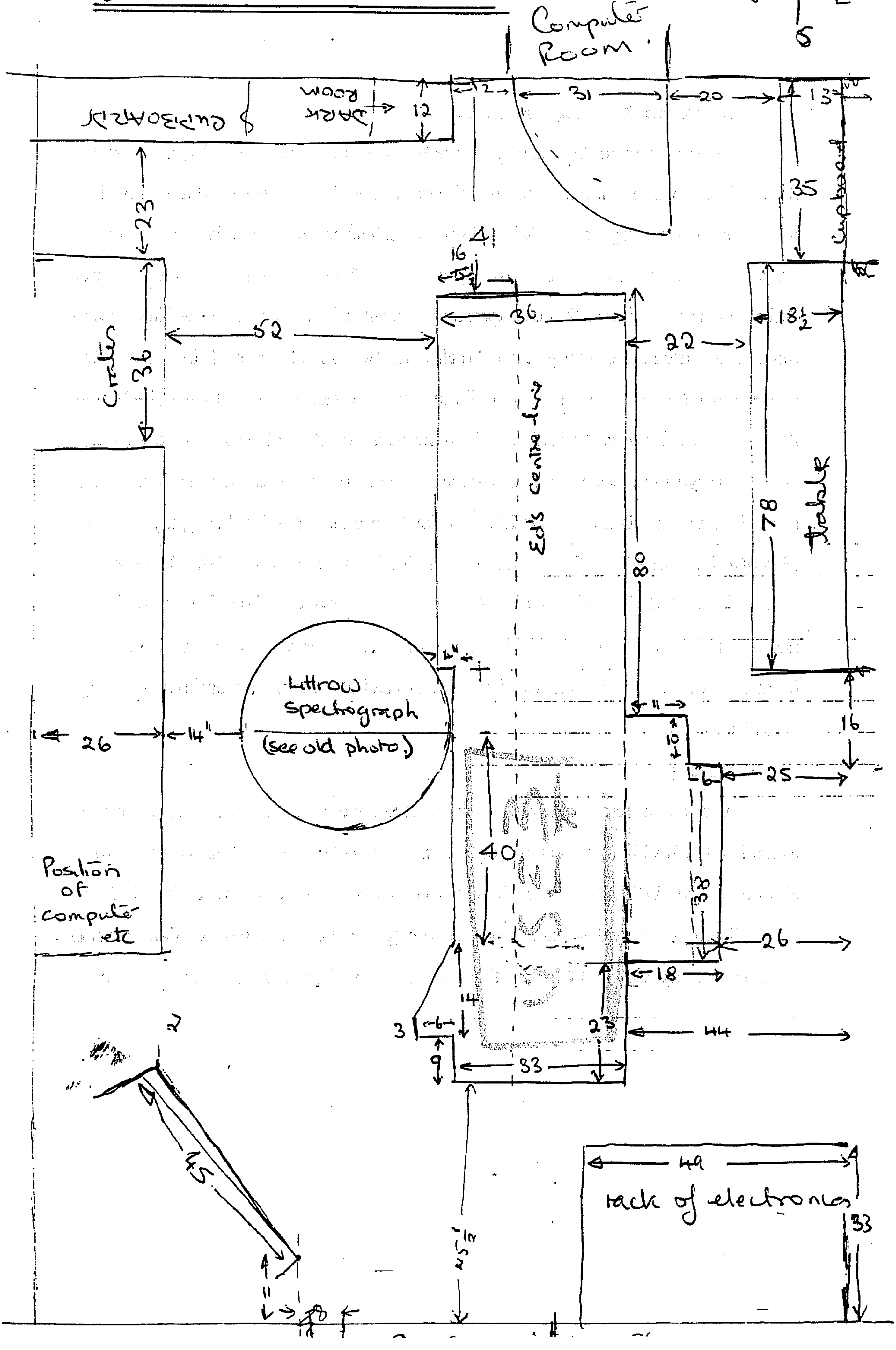
Everything exècept the interference filter controller runs off U.S. mains. There is a small mains transformer for the IF controller. The 'chocolate block' dangling from the IF controller comes from the thermistor at the IF. The temperature is OK when the reading is 2.92kΩ. The cell oven is not temperature controlled. The voltage at which it has been run for some time is 22.1V. There is a small meter which enables both these to be measured. There is a thermistor for the cell oven but it did not appear to be working when I was there.

Timing

We have access to a WWV receiver, all that we need is some software and a 'box' to tap into the RS232 line. Brek has ordered a serial port card so thatwe don't have to choose between WWV and the modem. The connection requirements are given below.

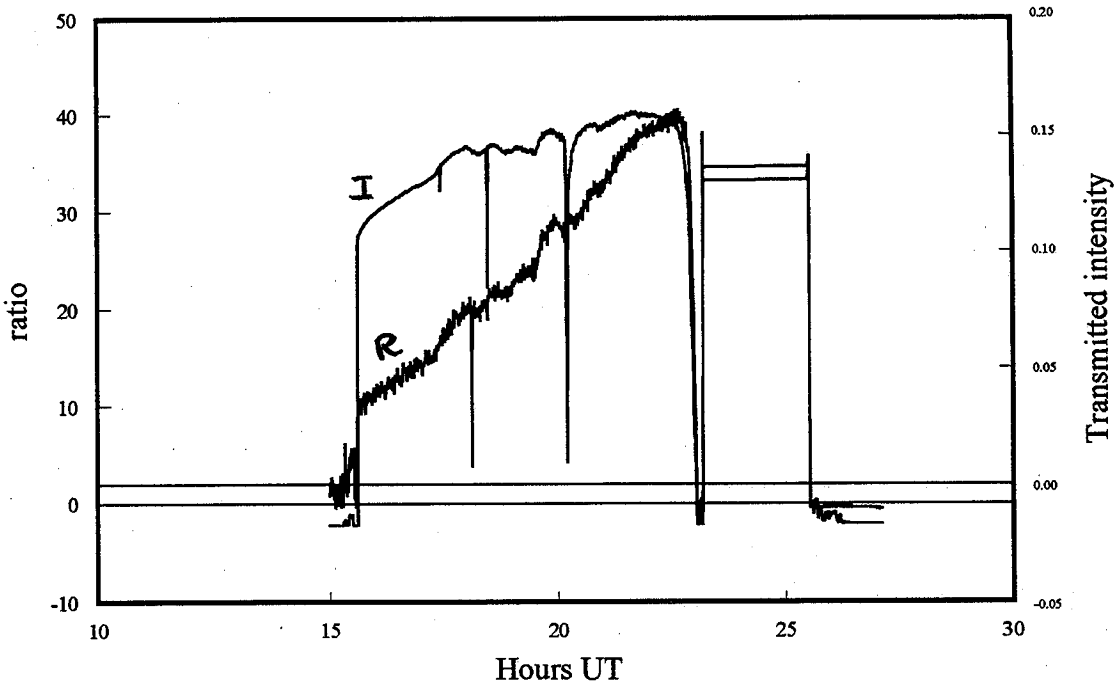
There is a very detailed manual describing how the WWV works. Various wires have been cut by Maynard Clark so that the user is not allowed to re-programme the clock.

OBSERVING ROOM.



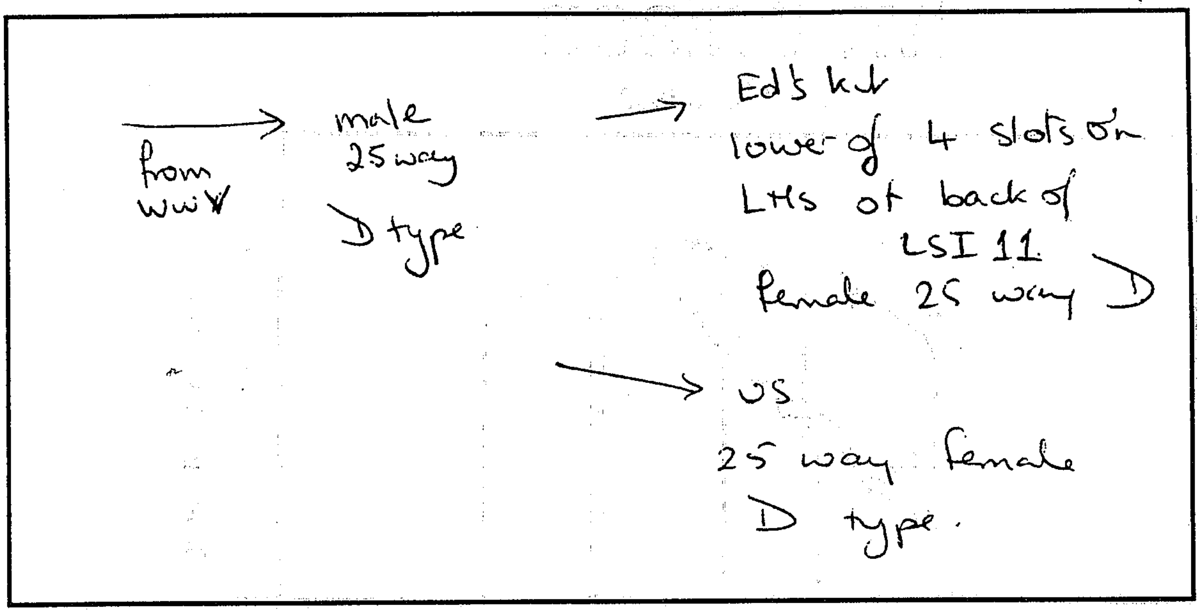
Mt Wilson

28-29th June 1992



Data taken with beam splitter over Ed's lens. About 30% of light sent our way.

I have worries about rising intensity in the morning



section 3-63 Connector and pin assignments

1 Chassis ground

2 Transmitted data to user

3 Received data from user

4 Request to send which is internally connected to 5

5 Clear to send which is internally connected to 4

6 not used

7 ~~chassis~~ ground signal ground

25 IRIG B

3-67 1 stop bit no parity 9600 Baud

3-79 (SOH)DDD:HH:MM:SS(Q)(CR)(LF)

Q is quality factor of time signal

(SOH)=ctrlA=(01)hex

(LF) (0A)

(CR) (0D)

Modem

The modem was sent away to be repaired by the manufacturers. It is due back 7 weeks after the 22 June. In case there are any problems the details are :-

RMA number 13 321

Mercedes at 800-835-3248   technical support

$195 flat fee for repair

The modem and the transformer but not the telephone cable nor the computer connector which is being used by Natasha and co. were sent back to

TELEBIT

1315 Chesapeake Terrace

Sunnyvale

Ca 95089

To use the modem you will have to fit a new socket to the wall. The telephone lines are available just next to our computer.

Modulator

The PEM was sent back to Hinds. I have been told by Natasha that it has come back. The repair estimate form them is attached to this report. Their phone number is

800-688-4463 or 503-648-1355

Ted Oakbury and Rick Rockwell are 2 of the people involved.

Oakberg

Hinds Instruments
5250 N.E. Elam Young Parkway
Hillsboro, OR 97124-6463

HINDS INSTRUMENTS

Hinds Instruments, Inc
5250 NE Elam Young Parkway
Hillsboro, OR 97124-6463
Phone: 503-648-1355
Fax. 503-640 8695 97124-6463

FAX COVER SHEET

To: Dr. Yvonne Elsworth

Company: University of Birmingham

Dept:

Date: July 14, 1992

Fax No: 44 21 414 4577

Page 1 of 1 Pages

From: Ted Oakberg

Subject: Repair of PEM-4 Photoelastic Modulator

Rick Rockwell, our optical technician, has located the trouble with your PEM-4 modulator. One of the lead wires has come loose of the transducer, taking a significant piece of the gold plating with it. The transducer needs to be replaced, which will necessitate tuning the new transducer. The cost of the repair will be:

1	Transducer	US$275.00
4 hrs.	Labor at $50 per hour	200.00
Total		US$475.00

e can proceed with the repair on receipt of a purchase order. Hinds will ay for shipping back to Mt. Wilson Observatory.

ery truly yours,
NDS Instruments, Inc.

heodore C. Oakberg

eodore C. Oakberg
plications Physicist
ical Systems Engineering

+1- 503-648-1355

Crates

I left 2 crates there. One is stored in the Snow telescope and contains just packing materials. The other should still be in the 60' computer room.

contents

numerous and various English plug boards

1 dead interference temperature controller

servo motor power supply

±15V(1A) +5V(5A) Topps 2 power supply

Spare PMT EMI 9658A

BNC and sundry other cables including telephone cable for modem

2 foot (or so) of optical pin material

Lockin amplifier Brookdeal 9503

Modulator control box Hinds PEM-FS-4

240 V soldering iron

pens and sticky tape

glue- silicon rubber RS 555-588

rapid araldite loctite evostick impact

2 US mains plugs ,1 British

tool box (falling apart)

2 water cells

1 spare vapour cell

2 polaroid sheets (HN 7)

prisms and components for servo optics

optical tissue

finder telescope

lots of manuals **but no circuit diagrams**

Useful Telephone numbers

Joe Litherland	021-476-0992
150'	818-440-1119
ask nicely for FAX	
60'	818-440-1149
Natasha	818-792-8766
Ed (home)	818-366-2166
USC	213-740-6329
secretary	5848
computer lab	6331
?	6327

the time difference in summer was such that 12 noon Mt. Wilson=8pm UK

The official address is

Mt. Wilson Observatory

Mt. Wilson

Ca 91023