Project Report

ETS-22

L. E. Eaton

Telescope B Users' Guide

28 November 1977

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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

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TELESCOPE B USERS' GUIDE

L. E. EATON
Group 94

PROJECT REPORT ETS-22

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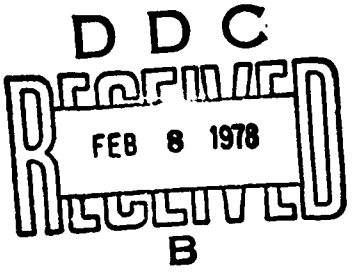
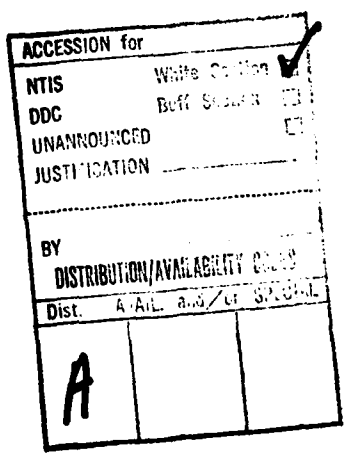


LEXINGTON MASSACHUSETTS

ABSTRACT

The second 31" telescope is operating at the GEODSS Experimental Test System, White Sands, New Mexico. The improvements over the first telescope mount include a single DC drive servo per axis, and a microprocessor control system. The report describes the operating procedures for console/telescope control.



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1. INTRODUCTION

This ETS Report describes the operational procedures required to run Telescope B at the GEODSS ETS. The telescope is a Boller & Chivens 31" optical telescope, the second of its kind installed at the GEODSS ETS. This report is written from an operator's standpoint and does not include technical descriptions of the hardware and software.

II. GENERAL DESCRIPTION

This second 31" Boller & Chivens telescope, labeled B, contains a vast number of improvements over the first telescope (A), although its physical appearance is the same.

Some of these improvements include a single DC drive servo system which is used to perform slew, sidereal, and variable track functions. This greatly simplifies the gear train mechanism drive response. Another improvement is a Motorola M6800 Micro-processor based control system which handles all handshaking between the ModComp IV computer, the external logic, the positional and status displays, and the telescope driving system.

With the use of the Micro-processor, it has become much easier to have an operator system status panel and operator diagnostic functions for ease in operational status. The Micro-processor also provides the needed flexibility to improve the system performance by changing only the software. This allows for fully meeting the system's capability with a limited amount of work.

The operator should become thoroughly familiar with the functions of the Status Panel, as it will provide all the information required to verify the proper performance of the system. Several of the Mode Switches have interacting functions, so care should be exercised at all times.

III. POWER TURN ON

There are three switches the operator must turn ON to activate the telescope. They are:

1. Telescope Logic
2. Micro-processor
3. Telescope Console Key

1. Telescope Logic Switch - this switch is found on the panel below the logic card basket. After turning this switch ON, the operator should verify that the meters on this panel show the correct voltage and current readings. They are from left to right:

    1. 0-10 volt meter = 5 volts
    2. 0-30 amp meter = ≈25 amps
    3. 0-50 volt meter = 30 volts
    4. 0-50 volt meter = ≈12 volts

2. Micro-processor - the Micro-processor is found below the Telescope Status Panel. One will find the ON switch in the back of this rack. Power ON can be verified by listening for the fan which will also come on.

3. Telescope Console Key Switch - insert the key, press in and turn the key ON. The Emergency Light will come ON. Then, press the ON button. This activates power to the telescope drives.

After all Power Switches have been turned ON, the operator presses the RESET/START Button on the Status Panel. This initializes the Micro-processor program. To use the Handpaddle, the Mode Switches on the Status Panel should

be in the following states:

1. Drives Enabled
2. Computer Inhibited
3. Thumbwheels Enabled
4. RA STOP/RA SID in RA Sid Position
5. OFF/DIRECT/VIA M-P in STOP Position
6. SIM IN and SIM OUT in Disabled Mode

The telescope will come up in an uncalibrated state. The operator should then go to the Self Calibrating Mode and does so in the following manner:

First, verify that the Sidereal Time Code Reader is displaying the correct Sidereal Time. If it isn't, fix the problem and then press RESET/START again.

Next, put the telescope a little bit EAST and NORTH of the Zenith. Select a 04 on the ID Thumbwheels at the Console. Press the ENTER button, and a Variable Track Status should come up on the RA and DEC Status Bits on the Status Panel. The operator will not have control of the system until both the RA and DEC Zenith Bits are sensed by the Micro-processor.

By going to this Self-calibration Mode, the telescope will be driven SOUTH and WEST until the Zenith Bits are set. When this routine is finished, the telescope will be calibrated and the RA and DEC Status Bits will come up in a code of RA Sidereal and DEC Stop.

The operator may now enable the computer and let RTS take over control. A bright star will be easily found in full FOV on the camera, and probably re-calibration should be done with RTS on the boresight that is selected.

If something goes wrong and it is necessary to get out of the Self-calibrated Mode, simply press RESET/START again. This should give control in a normal fashion.

The only thing left is the Dome Control Rack. There are two Turn-ON switches. A pushbutton for the Logic and a Switch for the Power Amplifiers. The Dome Control Rack will come up in a state of STOP and AUTO. For Computer Mode, leave in the AUTO Mode and press the START Button. After a 15 second delay, the ON Light will come on and the computer will have control of the Dome.

For manual Dome Control, simply go to the MAN Mode, and the Dome Control Buttons on the Handpaddle will turn the Dome left and right.

There are interacting functions on the Status Panel to allow the operator variables in using the system. All operators should read and thoroughly understand the Status Panel Section of this report so that "cockpit" error does not cause the operator to mistakenly think the system is not working.

IV. DESCRIPTION OF VARIOUS COMPONENTS OF THE SYSTEM.

The various components of the system are:

A. Telescope B Status Panel

B. Handpaddle and Dome Control

C. Console Positional Displays

D. Console Thumbwheels

E. Sidereal Time Code Reader

F. Limits

A. Telescope B Status Panel;

The Telescope Status Panel is shown in Figure 1. It is used in three main ways,

1. System Status
2. Operator interaction to system
3. Diagnostic Panel

Care should be exercised when using it as some of the switches have interacting functions.

Handpaddle Leds. The Handpaddle Leds give the operator indication that the Micro-processor is reading the Handpaddle properly. The Leds are driven by the Micro-processor upon reading the appropriate switches on the Handpaddle. The Leds have the following meaning,

ON - This Led will come ON when the operator presses any of the NORTH/SOUTH/EAST/WEST Buttons on the Handpaddle.

SLEW/SET/GUIDE - These Leds will be ON when the Slew,Set,Guide switch on the Handpaddle is in the appropriate position.

NORTH/SOUTH/EAST/WEST - These Leds will come ON in conjunction with the ON Led when the corresponding Handpaddle button is pushed.

Limit Leds. The Limit Leds will come ON when the corresponding telescope Limit has been reached. The ON Led will be lit if any of these Limits come on.

Zenith Leds. There are two mechanical switches mounted on each axis of the telescope (RA & DEC). These correspond to the telescope being at its ZENITH. When the appropriate axis goes through these points, the RA or DEC ZENITH Led will flash. This is used in the self-calibration or manual calibration of the telescope.

Status Leds. There is a 2-Bit Code (for each axis) that the MICRO-processor sends to the telescope drive system (along with a voltage) to tell the telescope what mode it should be in. This Code is displayed in the Status Leds for both Declination and Right Ascension.

A "1" = Led being lit. The codes are:

RA 2(DEC 2)	RA 1(DEC 1)	
0	0	Drives are Stopped
0	1	Drives are in SLEW Mode (I.e., 5^{o}/sec)
1	0	Drives are running at Sidereal Rate(RA only)
1	1	Drives are running in VARIABLE TRACK Mode (i.e., 0^{o}/sec-2^{o}/sec in 3.5 arc sec/sec increments)

Mode Switches. There are 8 Mode Switches with some having interacting functions. The operator should be aware of all these functions. Table 1 is a chart that shows the interacting function of the Mode Switches. The 8 are,

	Led ON	Led OFF
1. Drives	Disabled	Enabled
2. Computer	Inhibited	Enabled
3. Thumbwheels	Disabled	Enabled
4. RA Drives Defaulted to:	RA STOP	RA in Sid. Mode
5. Unused		
6. Direct Voltage to Drives	OFF	(Refer to 7 & 8)
7. Direct Voltage to Drives	Direct Mode	(Refer to 6 & 8)
8. Direct Voltage to Drives	Via M-Processor	(Refer to 6 & 7)

DRIVES DISABLED. With the switch UP, the drives cannot be driven, regardless of Micro-processor/Handpaddle functions, other Mode Switch settings or ModComp computer commands. This switch physically disables the drives and is used as a safety feature. It bypasses all other switches and computers. For example, the telescope cannot be driven even when you are in DIRECT or VIA M-P.

COMPUTER INHIBIT. When this switch is UP, the Micro-processor gives control to the operator and ignores all commands from the ModComp. This means the operator has Handpaddle Control (unless the Drives are Disabled or the operator is in Direct Mode or Via M-Processor Mode) and can load Thumbwheel data (unless in Thumbwheel Disable Mode).

THUMBWHEELS DISABLED. When this switch is UP, the operator cannot load data via the Thumbwheels. This is a safety feature that protects the operator from using the Thumbwheels which, as an example, could cause the positional displays to be changed arbitrarily. Note that the Thumbwheels are also disabled when the Computer is enabled.

RA STOP/RA SID. This switch tells the Micro-processor what state to default to when the operator is not using the Handpaddle. The RA STOP state simply puts the RA axis in a Stop Mode. The RA SID state puts the drive into running at a sidereal rate when the Handpaddle is not in use.

OFF/DIRECT/VIA M-P. These three switch positions are included as Mode Switches and are interrelated to each other. The OFF position is the quiescent state. The DIRECT Mode and VIA M-P Mode are used in what is called Manual Tracking Mode.

DIRECT Mode, When in the DIRECT Mode, the telescope drives are controlled by the two POTS (RA POT & DEC POT), which send the voltage off these POTS directly to the drive system, bypassing the Micro-processor. The RA & DEC Status are automatically put in Variable Track(unless DRIVE DISABLE switch is ON). This feature allows the operator to bypass the Micro-processor and Handpaddle, and give a simple path to the telescope without elaborate software and hardware.

With the Micro-processor operating properly, the HEX RATE Leds will display the digitized analog voltage going

to the drives. This may be useful in setting up a fixed rate before switching to the DIRECT Mode. These displays are updated even when the switch is in the OFF position.

VIA M-P. The VIA M-P (Micro-processor) Mode is used in the same manner as the DIRECT Mode, except the analog voltage from the POTS is not sent to the drives until the corresponding RA or DEC button is pushed on the Handpaddle.

For example, the operator can set up the appropriate rates on the HEX Leds. Then (s)he may go to VIA M-P Mode and those rates will be sent to the drives upon actuation of the Handpaddle.

The Micro-processor only senses a button push on the Handpaddle for the given axis. Thus, pressing NORTH or SOUTH will simply drive the DEC axis with the given rates.

Remember, also, that the Leds display in HEX with an 800 being 0 volts.

Simulator INPUT/OUTPUT Control. Two of the lower right hand switches are presently used as hardware diagnostic switches. The Simulator INPUT ENABLE and OUTPUT ENABLE switches take control of the logic bus away from the Micro-processor and give it to the Simulator. This is used for diagnostic purposes, and they should always be in the Disable Mode.

Push Button Switches. There are four push buttons in the lower right hand corner, three of which are used.

1) Clear Simulator Counter (CLR_SIM_CTR), This push button is used for hardware diagnostics with the system Simulator.

2) Test_Load_Counters (TST_LD CTRS), This push button is used to test the Binary Counters and should not be pushed except for diagnostics.

3) RESET/START, This push button is used to Reset and Start the Micro-processor upon bringing the system up. Whenever the operator doesn't think things are running properly, (s)he may use this switch to re-initialize the system.

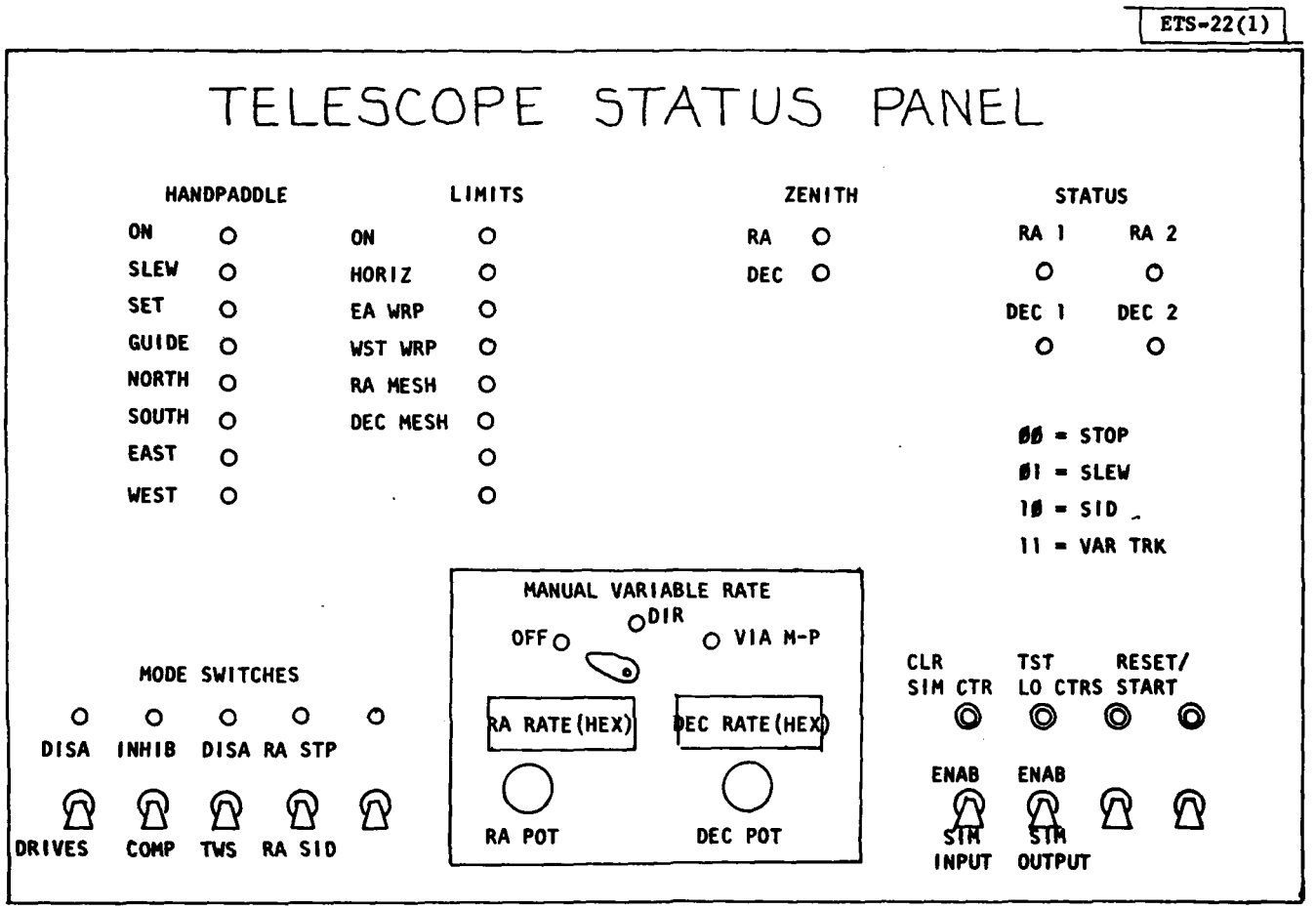

Fig. 1. Status panel layout.

B. Handpaddle and Dome Control;

The Handpaddle gives the operator manual control of the telescope. If the Mode Switches are set up in the proper fashion (refer to section IV-A), the operator may move the telescope at 3 speeds. A Three-position Switch is located on the Handpaddle with the following speed associated with each setting -

HP Switch	Speed	RA/DEC Status
Slew	$\approx 5^{\circ}$/sec	Slew (01)
Set	$\approx 200\pi$/sec	Var Trk (11)
Guide	$\approx 30\pi$/sec	Var Trk (11)

The telescope will go in the NORTH/SOUTH/EAST/WEST direction, depending on which switch is pressed on the Handpaddle.

There are two other sets of switches on the Handpaddle. AUX 1 and 2 and Dome LEFT and RIGHT. AUX 1 and 2 are presently not used. Dome LEFT and Dome RIGHT will turn the dome under the following conditions -

1. Dome Rack Power ON and in MANUAL
2. Micro-processor system running

If the operator wishes to turn the dome without the Micro-processor system, then there are two (Left and Right) switches in the back of the Dome Rack.

C. Console Displays;

There are three Positional Displays in the telescope console. They are Right Ascension, Hour Angle and Delcination. The RA and HRA Displays give the telescopes position to sec's of time (15 arc sec of angle)

and DEC displays to tenths of minute of angle.

The HRA and DEC positions have quadrant information associated with them, although this is not displayed. Figures 2 and 3 show the quadrant information associated with HRA and DEC.

The logic has positional information stored to .2 arc sec of accuracy internally.

D. Sidereal Time Code Reader;

There is a Time Code Reader above the Status Panel, which the Microprocessor reads upon initialization (i.e., pressing RESET/START). The program uses this number to load an internal Binary Sidereal Counter. This Counter is used to calculate the telescope's RA. It, thus, becomes important that the operator makes sure the Time Code Reader is displaying the correct sidereal time.

E. Limits;

There are five (5) mechanical Limits the telescope can reach. They are displayed on the Status Panel and are listed here -

1. HORIZON
2. EAST WRAP
3. WEST WRAP
4. RA MESH
5. DEC MESH

If any of these limits are reached, an audible alarm will sound and the telescope cannot be driven.

HORIZON Limit - This Limit is reached whenever the telescope reaches

an elevation of 10^{o}. To get the telescope out of this limit, simply press the HORIZON LIMIT OVERRIDE button and use the Handpaddle to raise the elevation of the telescope until the audible alarm goes off and you are at a safe elevation. Be careful, as pressing the OVERRIDE button will also allow the telescope to be driven to a lower elevation, and this can cause severe damage to the mirror.

RA MESH and DEC MESH - These limits come on whenever the associated axis gears are taken out of MESH for balancing the telescope. The telescope cannot be driven at this time.

EAST WRAP - Whenever the telescope is driven to the EAST by more than 420^{o}, a cable wrap problem is encountered, and the drives to the EAST will be disabled. The telescope can only be driven WEST and should be done to a safe position.

WEST WRAP - This shows the same problem as EAST WRAP, only the telescope has been driven too far WEST ($>420^{o}$). The telescope can only be driven EAST and should be taken out of this limit to a safe position.

F. Console Thumbwheels;

On the telescope console there are 10-BCD Thumbwheels with a button labeled, ENTER. The Micro-processor will read the Thumbwheels upon the operator pressing the ENTER button (that is, provided the computer is inhibited and Thumbwheels are enabled). The Thumbwheels have two main functions -

1. Operator Functions
2. Activate Diagnostic Routines

At the present, the Operator Functions include -

1. Calibrate RA Register
2. Calibrate DEC Register
3. Calibrate SID Register
4. Go to Telescope Self-calibration
5. Go to Fixed Point in RA
6. Go to Fixed Point in DEC

The Diagnostic Routines are described in Section V of this report.

Of the 10 Thumbwheels, the first two on the left are designated as ID Thumbwheels. The last 8 are used for Data. That is, the ID Thumbwheels will alert the Micro-processor to the appropriate meaning of the 8 Data Thumbwheels.

ID Thumbwheel Settings of 01-09 are reserved for Operator Functions and ID Codes of 10-99 are reserved for Diagnostic Routines.

1. Calibrate RA Displays

   ID = Ø1

   Press: ENTER

   Data Thumbwheel Pattern -

Thumbwheel #	9 8	7	6	5	4	3	2	1	0
	/0 1/ ID	RA HR	RA HR	RA MIN	RA MIN	RA SEC	RA SEC	RA 1/10 SEC	RA 1/100 SEC

The Hour Angle is calculated by the Micro-processor and will automatically be set upon entering the data. The quadrant information

For Hour Angle is shown in Figure 2.

2. Calibrate DEC Displays

ID = Ø2

Press: ENTER

Data Thumbwheel Pattern -

Thumbwheel #	9	8	7	6	5	4	3	2	1	0
	/Ø	2/	QUAD	DEC	DEC	DEC	DEC	DEC	DEC	DEC 1/10
	ID		(1-4)	DEG	DEG	MIN	MIN	SEC	SEC	SEC

The DEC Quadrant information is given in Figure 3. Notice that DEC position can be loaded to an accuracy of 1/10th sec with the displays only showing the position to 1/10 min.

3. Calibrate SID Time

ID = Ø3

Press: ENTER

Data Thumbwheel Pattern -

Thumbwheel #	9	8	7	6	5	4	3	2	1	0
	/Ø	3/	SID	SID	SID	SID	SID	SID	SID 1/10	SID 1/100
	ID		HR	HR	MIN	MIN	SEC	SEC	SEC	SEC

When the operator presses RESET/START, the Microprocessor reads the Sidereal Time Code Reader. If for some reason this is inoperable, the operator may set the sidereal time by the above procedure. Caution - If the operator presses RESET/START after setting the Sidereal Time, the bad Time Code Reader data will reset the internal registers.

HOUR ANGLE POSITION

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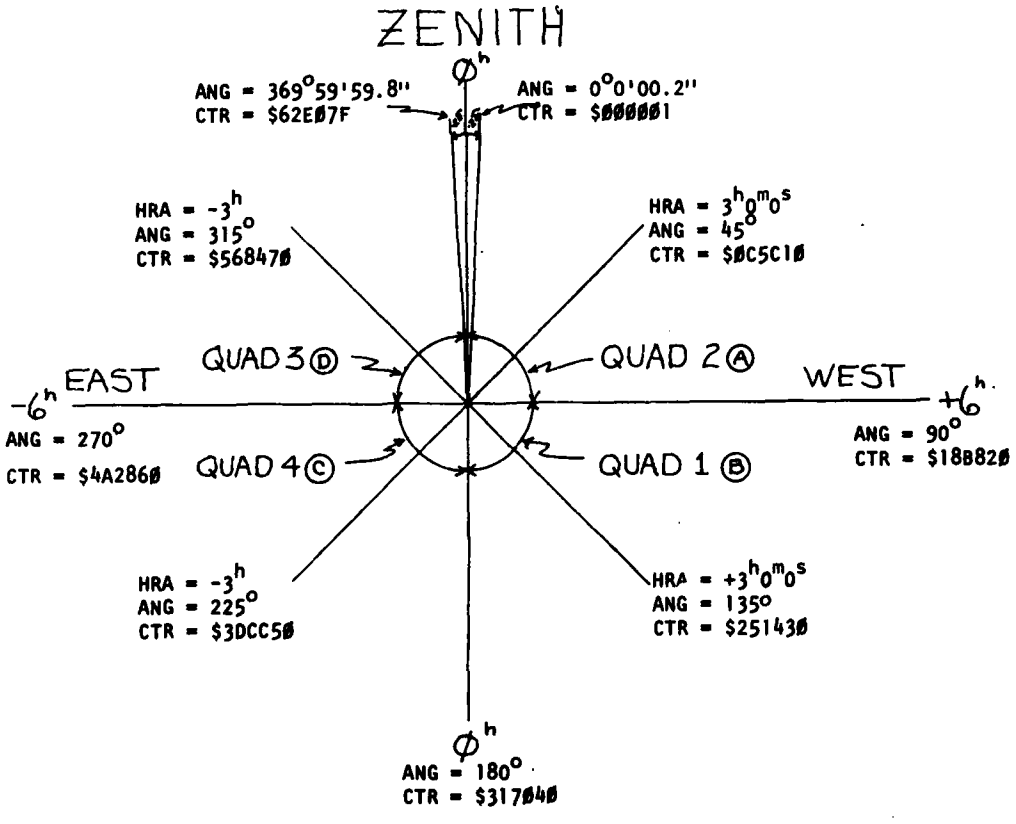

TEL TO MODCOMP	
QUAD	CODE
1 (B)	$0(0000)
2 (A)	$4(0100)
3 (D)	$C(1100)
4 (C)	$8(1000)

MODCOMP TO TEL	
QUAD	CODE
1 (B)	$0(0000)
2 (A)	$4(0100)
3 (D)	$8(1000)
4 (C)	$C(1100)

Fig. 2. Hour angle quadrant information.

DECLINATION POSITION

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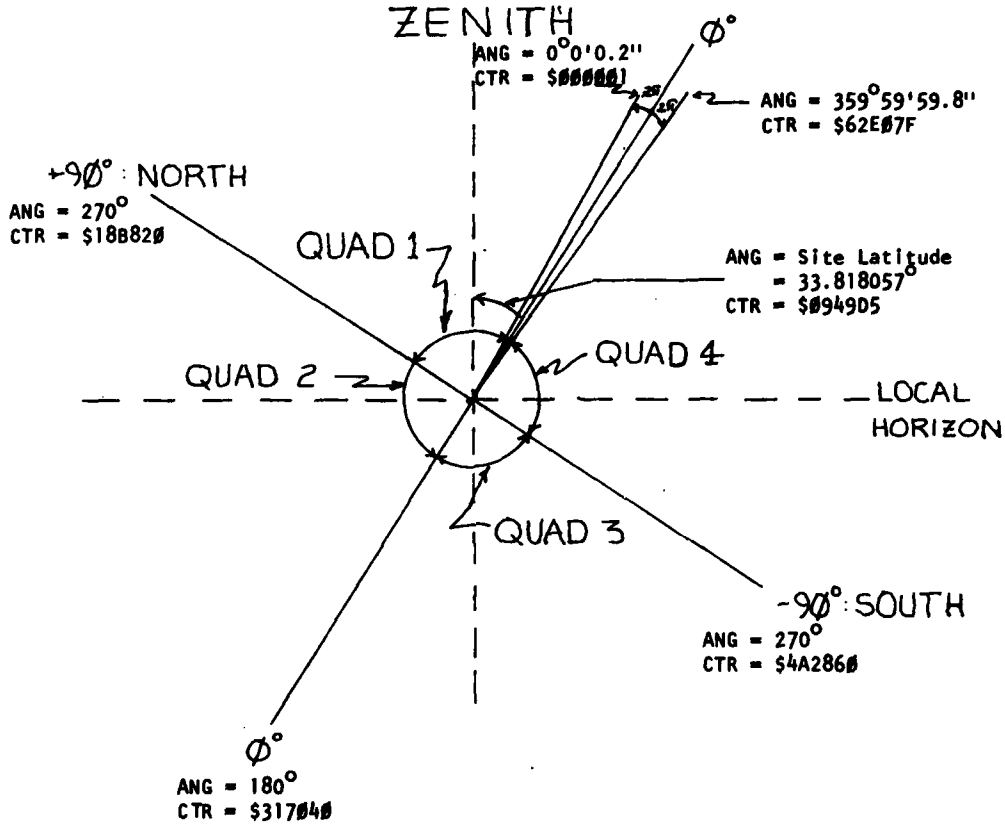

TEL TO MODCOMP	
QUAD	CODE
1	$4(Ø1ØØ)
2	$Ø(ØØØØ)
3	$8(1ØØØ)
4	$C(11ØØ)

MODCOMP TO TEL	
QUAD	CODE
1	$Ø(ØØØØ)
2	$4(Ø1ØØ)
3	$8(1ØØØ)
4	$C(11ØØ)

Fig. 3. Declination quadrant information.

4. Telescope Self-calibration

This telescope has the capability of calibrating itself. It is known that at the ZENITH the telescope's RA will equal the local sidereal time, and the DEC will equal the site's latitude. An ID code on the Thumbwheels of 04 will actuate this routine. Thus, to Self-calibrate, the operator does the following -

a) Make sure Mode Switches are:

i. Drives Enabled

ii. Computer Inhibited

iii. Thumbwheels Enabled

iv. RA STOP/SID in SID

v. OFF/DIR/VIA M-P in OFF

b) Press RESET/START

c) Put telescope (with Handpaddle) NORTH and EAST of the Meridian

d) With an ID Code of 04 on the Thumbwheels press ENTER. The other Thumbwheels are ignored.

The telescope should now go to Variable Track in both axis and drive slowly SOUTH and WEST. When each axis hits the ZENITH, the appropriate ZENITH light should flash. During the routine, all other functions will be disabled. When the telescope goes back to RA SID and DEC STOP, it will be calibrated. For a quick check the operator should observe that the RA will approximate the Sidereal Time and DEC should be approximately equal to 33°. If something appears to be wrong, the operator may regain control by pressing RESET/START.

5. & 6. RA and DEC FIXED POINT

The operator may send the telescope to a fixed RA and DEC by setting the ID code to Ø5 for RA and Ø6 for DEC. The rest of the Thumbwheels are set with the same data pattern as described in parts 1 and 2 of this section.

V. DIAGNOSTIC ROUTINES

With the advent of the Micro-processor, it becomes very useful to have diagnostic routines that enable the operator to determine proper functioning of the system. This becomes useful for both hardware diagnostic routines (internal logic tests) and visual operator diagnostics, such as display tests, etc.

Table 2 gives a quick reference to ID Codes and their function. Some of the ID codes simply activate a specific routine while others alert the Micro-processor to look at the Data Thumbwheels and use those in the test.

The computer has to be inhibited and the Thumbwheels enabled for the Micro-processor to accept the operator's press of the ENTER button. To get out of the present diagnostic routine, the operator presses RESET/START.

TABLE 2

DIAGNOSTIC ROUTINES

ID THUMBWHEELS	DESCRIPTION
11	Test Interrupts & Display nos. on Manual Tracking Leds
12	Cycle Address bus (increment PIA)
13	Cycle Address bus (by Output Commands)
14	Cycle Address bus (by Input Commands)
15	Input Test
16	Output Test
17	Display TW's 9-4 Manual Tracking Regs.
18	Display TW's 5-Ø on Manual Tracking Regs.
19	Sequentially Display all Manual Tracking Led numbers
20	Display HEX HRA Binary Counter in Manual Tracking Leds
21	Display HEX DEC Binary Counters in Manual Tracking Leds
22	Display HEX Sidereal Binary Cntr. in Manual Tracking Leds
23	Test Dome Led Tests
24	ModComp to Micro-processor Test
25	Status Panel Led Test
26	Zenith Bit Counter Check (HRA)
27	Zenith Bit Counter Check (DEC)
28	Test RA Display Leds
29	Test HRA Display Leds
30	Test DEC Display Leds
31 - 99	Unused at Present

Test 11: Test Interrupts -

This test allows the operator to manually set one of the 8 priority interrupts. The appropriate number will appear on the Manual Tracking Leds.

Test 12: Cycle Address Bus by Incrementing Address PIA -

This test cycles the address bus by sending out sequential 8 bit numbers via the address PIA.

Test 13: Cycle Address Bus by Output Commands -

This test sends out Output Commands which should cycle the Address bus.

Test 14: Cycle Address Bus by Input Commands -

This test sends out Input Commands which should cycle the Address bus.

Test 15: Input Test -

This test selects Register $ 25 and displays the contents in the HP Leds. The operator can ground various pins on the data bus and see them displayed in the HP Leds.

Test 16: Output Test -

This test selects Register $ CØ and sends sequential data to the data bus.

Test 17: Display Thumbwheel Test (9-4) -

This test reads the first 6 Thumbwheels and displays them in the Manual Tracking Leds.

Test 18: Display Thumbwheel Test (5-Ø) -

This test reads the last 6 Thumbwheels and displays them in the Manual Tracking Leds.

Test 19: Test Manual Tracking Leds -

This test sequentially changes all the Manual Tracking Leds.

Test 20: Display HRA Binary Counter -

This test reads the Hour Angle Binary Counters and displays them in the Manual Tracking Leds. The system may be operated in a normal fashion.

Test 21: Display DEC Binary Counter -

This test is the same as test 20, only the DEC Binary Counter is displayed.

Test 22: Display Sidereal Time Binary Counter -

This is the same test as 20, only the Sidereal Time Binary Counter is displayed.

Test 23: Dome Led Test -

This test reads the Dome's position Leds and writes to the commanded Leds. Thus, the Dome may be manually turned and the commanded position should equal the actual position.

Test 24: ModComp to Micro-processor Test -

This test is used in conjunction with a program called MPT on the ModComp. It tests the data path from and to the Micro-processor.

Test 25: Status Panel Led Test -

This test lights and then extinguishes all the Status Panel Leds.

Test 26: (RA ZENITH) and 27: (DEC ZENITH) -

These tests check the RA and DEC shaft encoders, making sure there are 18,000 pulses per revolution from the shaft encoders. The number is displayed in the Manual Tracking Leds. A test switch has to be thrown in the logic.

Test 28: Test RA Display Leds -

This test sequentially lights all the Leds on the RA displays.

Test 29: Test HRA Display Leds -

This test sequentially lights all the Leds on the HRA displays

Test 30: Test DEC Display Leds -

This test sequentially lights all the Leds ont he DEC displays.

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GEODSS ETS optical telescope

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

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