NATIONAL RADIO ASTRONOMY OBSERVATORY

Green Bank, West Virginia

TELESCOPE OPERATIONS DIVISION REPORT NO. 7

OPERATIONS MANUAL

FOR

TRAVELLING FEED AND STERLING MOUNT

ON THE 300-FOOT TELESCOPE

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INTRODUCTION

This operations manual is intended as an aid to the telescope operator and or other user of the travelling feed and sterling mount on the 300-foot telescope. Additional operating information may be found in Computer Division Internal Report No. 9. Most technical data needed for maintenance and service work will be found in related reports No. 110 and No. 111 from the Electronic Division. This report does contain a system calibration procedure. When time permits, the readout calibration section should be followed on telescope maintenance day. Also to be found with this report is a simplified block diagram, a digital system block diagram, a specification table, rate and scale tables for hour angle, and tables related to computer observing card data.

SECTION 1.0

DESCRIPTION

1.1 TRAVELING FEED (TF)

The travelling feed consists of a set of rails and a feed carriage which is driven at various rates along the rails. The rails are 51 feet long, permitting 559 inches of carriage travel between limits. The carriage assembly is fastened to the rails by a series of rollers and is driven along the rails by a stepping motor.

The drive for the travelling feed is a stepping motor, gear assembly, sprocket gear, and a sprocket chain so arranged that one revolution of the motor equals about one inch of travel along the rails. The motor is pulse driven and will respond to pulses from 1 to 400 pulses/second.

1.2 STERLING MOUNT (SM)

The sterling mount located inside the telescope feed house is mounted on guide rails that allow for east-west box movement. The hour angle part of the mount carries all necessary hardware for rotation and focus drives. The sterling mount is compatible with the NRAO standard front-end box. When working inside the feed house exercise CAUTION. Open floor space is necessary to give clearance for hour angle travel of the mount.

1.2.1 STERLING MOUNT HOUR ANGLE

The sterling mount hour angle drive consists of a stepping motor, a lead screw, and guide rails. For each motor step the hour angle is moved 0.0025 inches. With 200 pulses/second to the motor, the maximum rate of 0.50 inches/second is obtained in hour angle travel. The hour angle travel is limited to $\pm$15 inches off-axis by the structural limits of the feed house.

1.2.2 STERLING MOUNT ROTATION

Feed positions through 400 degrees of rotation are provided by the sterling mount rotation assembly. The drive system uses a stepping motor, a spline gear and a ring gear to allow for fast settings in rotation position. A maximum rotation

rate of 12 degrees/second is obtained at 720 motor pulses/second. Rotation is limited to ± 200 degrees with a zero rotation axis north-south. Plus rotation is north to east beam on sky.

1.2.3 STERLING MOUNT FOCUS

Focus travel has range of 1270 millimeters; however, the up-limit position is dependent on the particular front-end box to be used. The focus drive consists of a stepping motor, a gear assembly, four lead screws and a movable platform that holds the rotation ring gear as well as the mounting ring for front-end boxes. The maximum drive rate for focus is 407 millimeters/MINUTE at a pulse rate of 400 pulses/second. Plus focus is up-focus and is movement away from the dish. Zero readout is indicated when the focus drive is at the center of travel.

SECTION 2.0

SPECIFICATION TABLE

FOR

TRAVELLING FEED AND STERLING MOUNT

FUNCTION	TRAVELLING FEED HA	STERLING MOUNT HA	S. MOUNT ROTATION	S. MOUNT FOCUS
TOTAL TRAVEL	559 INCHES 1090' = 18.2°	30 INCHES 58.5' = 0.975°	400°	50 INCHES 1270 MM
TRAVEL LIMITS FROM CENTER	± 280 INCHES ± 545' = ± 9.1°	± 15.0 INCHES ± 29.2' = ± 0.49°	± 200°	± 25 INCHES ± 635 MM
MAX. SYSTEM POSITION ERROR (with loop closed by computer)	± 0.5 INCHES ± 1'	± 0.086 INCHES ± 10''	± 0.58°	± 0.06 INCHES ± 1.5 MM
MAX. ANALOG POSITION READOUT ERROR	± 0.25 INCHES ± 0.5' ARC	± 0.05 INCHES ± 6" ARC	± 0.3°	± 0.03 INCHES ± 0.76 MM
READOUT ZERO	FEED CENTERED ON FOCAL AXIS	BOX CENTERED ON FOCAL AXIS	CENTER WITH DOWEL PIN N-S	CENTER NOMINAL
READOUT POLARITY FOR DIRECTION	+ IS WEST ON SKY	+ IS WEST ON SKY	+ IS FROM NORTH TO EAST ON SKY	+ IS UP AWAY FROM DISH
READOUT VOLTAGE RANGE	± 8.5 V	± 9.9 V	± 9.9 V	± 9.9 V
COMPUTER DISPLAY RANGE, DIGITS, AND UNITS. DEC = 87°	± 10^h XX^m XX^s	± 0^h 37^m XX^s	± 200.0°	± 640 MM
DEC = 0°	± 0^h 36^m XX^s	± 0^h 02^m XX^s		

FUNCTION	TRAVELLING FEED HA	STERLING MOUNT HA	S. MOUNT ROTATION	S. MOUNT FOCUS
READOUT VOLTAGE SCALE	33.000 INCH/VOLT	1.5152 INCH/VOLT	20.202 DEGREE/VOLT	64.646 MM/VOLT
A/D BINARY READOUT + 9.000V TEST _ 9.000V TEST	0 111 001 100 110 01 1 000 110 011 001 10	SAME	SAME	SAME
ANALOG BUFFER CHANNEL	0	1	2	3
CONSOLE DIGITAL PANEL METER (DPM) VOLTAGE RANGE AND DIGITS	± 9.999 V	± 9.999 V	± 9.999 V	± 9.999 V
VOLTAGE MAXIMUM ERROR	± 0.003 V	± 0.003 V	± 0.003 V	± 0.003 V
WHEN COMPUTER CONTROLLED: DPM RANGE, DIGITS AND UNITS	± 280.0 INCHES	± 15.00 INCHES	± 200.0°	± 640.0 MM
DPM MAXIMUM ERROR	± 000.3 INCHES	± 00.03 INCHES	± 000.3°	± 00.3 MM
VOLTAGE DIVIDER RATIO	X0.3300	X0.15152	X0.20202	X0.64646
DPM READING WITH 9.0V TEST	2.970 V= 297.0 IN.	1.364V = 13.64 IN.	1.818 V = 181.8°	5.818 V = 581.8°
WHEN MANUALLY CONTROLLED: DEC= 87° DPM RANGE, DIGITS AND UNITS DPM MAXIMUM ERROR VOLTAGE DIVIDER RATIO	± 720.0 MIN. ± 000.3 MIN. X0.850	± 37.00 MIN. ± 00.03 MIN. X0.374	± 200.0° ± 000.3° X0.2020	± 640.0 MM ± 00.3 MM X0.6465
WHEN MANUALLY CONTROLLED: DEC=0° DPM RANGE, DIGITS, AND UNITS DPM MAXIMUM ERROR VOLTAGE DIVIDER RATIO	± 036.0 MIN. ± 000.3 MIN. X0. 0424	± 02.00 MIN. ± 00.03 MIN. X0.0202	± 200.0° ± 000.3° X0.2020	± 640.0 MM ± 00.3 MM X0.6465
MOVEMENT/STEP OF MOTOR	0.005 INCH/STEP	0.0025 INCH/STEP	1.0' = 0.0166 °/STEP	0.00067 INCH/STEP

FUNCTION	TRAVELLING FEED HA	STERLING MOUNT HA	S. MOUNT ROTATION	S. MOUNT FOCUS
DRIVE PULSES/MOTOR STEP	1 PULSE/STEP	1 PULSE/STEP	1 PULSE/STEP	1 PULSE/STEP
MAXIMUM RATE (SLEW)	2.0 INCH/SECOND 400 PULSES/SECOND	0.50 INCH/SECOND 200 PULSES/SECOND	2 RPM = 12 °/SECOND 720 PULSES/SECOND	16 INCH/MIN =407MM/MIN 400 PULSES/SECOND
MAXIMUM TRACK RATE	0.25 INCH/SECOND 50 PULSES/SECOND	0.25 INCH/SECOND 100 PULSES/SECOND	1.5 °/MINUTE 1.5 PULSES/SECOND	——— ———
NUMBER OF COMPUTER RATE-BITS	7 BITS = 128 k PULSES/SECOND + SIGN	SAME	SAME	SAME
RATE INCREMENT	0.016 INCH/SECOND = 3.1 PULSES/SECOND	0.0039 INCH/SECOND = 1.6 PULSES/SECOND	0.094 °/SECOND = 56 PULSES/SECOND	0.071 INCH/SECOND = 1.8 MM/SECOND = 2.4 PULSES/SECOND
SLOW MANUAL RATE = 1/16 SLEW	0.12 INCH/SECOND = 25 PULSES/SECOND	0.031 INCH/SECOND = 12 PULSES/SECOND	0.75 °/SECOND = 45 PULSES/SECOND	25 MM/SECOND = 25 PULSES/SECOND
LEAD SCREW	(CHAIN)	0.20 IN/REVOLUTION	27:1 SPLINE:RING-GEAR	0.20 IN/REVOLUTION
MOTOR/SCREW RATIO	------	1:2.5	4:1	1.5:1

FUNCTION	TRAVELLING FEED HA	STERLING MOUNT HA	S. MOUNT ROTATION	S. MOUNT FOCUS
STEPPING MOTOR TYPE	HS 50 L	HS 400 B	HS 1500	HS 1500
TRANSLATOR (MOTOR DRIVER TYPE)	ST 1800 BV	HTR 400 S	HTR 1500 S	HTR 1500 S

SECTION 3.0

OPERATION

OPERATION

An important point in the operation of the travelling feed and sterling mount hour angle is the difference between beam position on the sky and rail position of the feed. Whatever the feed does on the rails is a mirror image of what the beam does on the sky. When the feed is actually west the beam is east on the sky. To facilitate operations the control panel and position display are marked in terms of beam on the sky. Negative readout is beam east.

Due to convergence of the hour angle circles at the pole it is necessary that the scan rate be changed as a function of declination. Also, since the carriage rails are not curved it is necessary to change indicated declination many times during a scan. Declination changes are particularly important for a scan at high declination.

Since scan rate changes as a function of declination, the hour angle readout scale must change in the same manner. Thus, for each declination setting of the telescope, both the scan rate generator and the readout scale must be reset on the control panel; however, when operating under computer control the signals are generated from the computer.

3.1 CONTROL PANEL

3.1.1 HOUR ANGLE PANEL

3.1.1.1 CONTROL SWITCHES

1. POWER ON/OFF	+24 volts via TF/SM switch to N.O. relay contact at feed house for translator A.C. power on.
2. COMPUTER/MANUAL	contacts to TF/SM rate generator. contacts to POSITION READOUT. contacts to COMPUTER INPUT.
3. T. FEED/S. MOUNT	contacts to TF/SM rate generator. contacts to POSITION READOUT. contacts to COMPUTER INPUT. power on/off routing to COMPUTER INPUT. decimal point shift on DIGITAL PANEL METER.(DPM)
4. HI EAST	contacts to TF/SM rate generator.
5. LO EAST	" " " " " .
6. TRACK EAST	" " " " " .
7. STOP	" " " " " .
8. LO WEST	" " " " " .
9. HI WEST	" " " " " .
10. TRACK WEST	" " " " " .
11. HOUR ANGLE SCALE	4-decade thumbwheel sets DPM readout scale to inches or minutes when in manual operation.
12. TRACK RATE	6-decade thumbwheel sets pulse rate generator.

3.1.1.2 LIGHTS

1. TRAVELLING FEED STOW	pin-out/pin-in	stow position -120"
2. STERLING MOUNT EAST-LIMIT	-15°.20	
3. STERLING MOUNT ZERO		
4. STERLING MOUNT WEST-LIMIT	+15°.12	
5. TRAVELLING FEED E-2 LIMIT	-275°.4	
6. TRAVELLING FEED E-1 LIMIT	-70°.2	
7. TRAVELLING FEED ZERO		
8. TRAVELLING FEED W-1 LIMIT	+67°.2	
9. TRAVELLING FEED W-2 LIMIT	+283°.4	

3.1.2 ROTATION AND FOCUS PANEL

3.1.2.1 CONTROL SWITCHES-ROTATION

1. POWER ON/OFF	+24volts to N.C. relay contact at feed house for translator AC power on.
2. COMPUTER/MANUAL	contacts to rotation rate generator. contacts to COMPUTER INPUT.
3. HI CLOCK-WISE	contacts to rate generator.
4. LO CLOCK-WISE	" " " "
5. STOP	" " " "
6. LO COUNTER CLOCK-WISE	" " " "
7. HI COUNTER CLOCK-WISE	" " " "

3.1.2.2 LIGHTS ROTATION

1. CW LIMIT (+)	+200°.3
2. ZERO	zero axis north-south.
3. CCW LIMIT (-)	-200°.2

3.1.2.3. CONTROL SWITCHES-FOCUS

1. POWER ON/OFF	+24 volts to N.O. relay at feed house for translator.
2. COMPUTER/MANUAL	contacts to focus rate generator. contacts to COMPUTER INPUT.
3. HI UP	contacts to rate generator.
4. LO UP	" " " " .
5. STOP	" " " " .
6. LO DOWN	" " " " .
7. HI DOWN	" " " " .

3.1.2.4. LIGHTS-FOCUS

1. UP LIMIT	variable up to +640mm.
2. ZERO/RFD LIMIT	Restrictive Focus Drive Limit- prevents the focus from driving into the up-limit at rotation angles other than zero. Also prevents rotation or H A drive when in the RFD limit.
3. DOWN LIMIT	-628.6mm

3.1.2.5 FOCUS POSITIONS

		Date
1. -353.0 mm	21 cm 4-feed box.	
2. -235.0 mm	21 cm 4-feed box (ZEEMAN FEED).	20 Dec 71
3. -376.0 mm	11 cm 3-feed box.	27 Nov 71
4. -290.0 mm	18 cm box with 11 inch extension.	1 Aug 72
5. -440.0 mm	6 cm dual horn.	17 Mar 72
6. -390.0 mm	40/21 cm receiver.	10 Jun 72
7. -590.0 mm	21 cm cooled receiver.	20 Oct 72
8.		

3.2.0 MANUAL OPERATION

3.2.1 STERLING MOUNT ROTATION

1. Depress rotation POWER ON switch.
2. Select MANUAL control.
3. Depress selected direction and speed of rotation. Clockwise (CW) rotation is north to east beam on the sky and is indicated as positive (+) readout. High speed is 12 degrees/second and low speed is 0.75 degrees/second. CAUTION: ROTATION LIMITS SHOULD BE ENTERED AT LOW SPEED AND MUST BE CLEARED AT LOW SPEED.
4. To stop depress the STOP switch. The stop switch releases the holding coil of the direction/speed switch. The back-light for the stop switch will light only after the switch has been depressed for the first time under manual control.
5. The rotation limit light should light at + 200 and - 200 degrees.
6. The zero light signals that the center of rotation is north-south. The zero switch (the zero light) must be on before the focus can be moved above the RFD limit.

3.2.2 STERLING MOUNT FOCUS

1. Depress the focus POWER ON switch.
2. Select MANUAL control.
3. Depress direction/speed for desired focus position. UP-focus movement is away from the dish and is indicated as positive (+) readout. High speed is 407 millimeters/minute and low speed is 25 millimeters/second.
4. To stop depress the STOP switch.
5. The focus limit light should light at -628 and +628 millimeters. NOTE: There are two up-limit switches. There is an absolute up-limit mounted on the sterling mount frame and a movable up-limit wired in series with

3.2.2.5 cont.

the absolute limit. Thus, the up-limit light also depends on the position of the movable switch. CAUTION: WHEN FOCUS IS IN THE UP LIMIT, THE TRAVELLING FEED IS FREE TO DRIVE. THE MOVABLE UP LIMIT SWITCH SHOULD BE SET SO THAT THE CENTER BOX WILL BE CLEAR OF THE TRAVELLING FEED CARRIAGE.

6. The zero light indicates that focus drive is at the the center of travel.
7. Restrictive Focus Drive (RFD) is a limit switch that restricts up focus drive unless rotation is at zero position. Also, sterling mount hour angle and rotation cannot be moved when in the RFD limit.

3.2.3 STERLING MOUNT HOUR ANGLE

1. Depress hour angle POWER ON switch.
2. Select MANUAL control.
3. Select STERLING MOUNT control.
4. Set the SCALE SELECTOR as listed by declination.
5. Set the RATE SELECTOR as listed by declination.
6. Move the sterling mount to the start hour angle. H A limits at declination zero are $\pm$ 2 minutes. Limits for hour angle in minutes of time will vary as a function of declination.
7. To start tracking a source depress the TRACK switch at the required (LST) local sidereal time. (For most observations track west).
8. Hour angle zero light indicates center of east-west travel.

3.2.4 STERLING MOUNT RATE AND SCALE TABLE

DEC	SCALE	RATE	IN/MIN
0 degrees	0.0199	50.693	7.604
5 "	0.0200	50.500	7.575
10 "	0.0202	49.922	7.488
15 "	0.0206	48.966	7.345
20 "	0.0212	47.636	7.145
25 "	0.0220	45.943	6.892
30 "	0.0230	43.902	6.585
35 "	0.0243	41.525	6.229
40 "	0.0260	38.833	5.825
45 "	0.0282	35.845	5.377
50 "	0.0310	32.585	4.888
52 "	0.0324	31.210	4.681
54 "	0.0339	29.797	4.470
56 "	0.0356	28.347	4.252
58 "	0.0376	26.863	4.029
60 "	0.0399	25.346	3.802
62 "	0.0424	23.800	3.570
64 "	0.0455	22.222	3.333
66 "	0.0490	20.619	3.093
68 "	0.0532	18.990	2.848
70 "	0.0583	17.338	2.601
72 "	0.0645	15.665	2.350
74 "	0.0723	13.973	2.096
76 "	0.0824	12.637	1.840
78 "	0.0958	10.539	1.581
80 "	0.1147	8.803	1.320
82 "	0.1432	7.055	1.058
84 "	0.1906	5.299	0.795
86 "	0.2856	3.536	0.530

SCALE: READOUT IN MINUTES OF TIME.

RATE: SETS MANUAL TRACK RATE TO INCH/MINUTE.

B.D.F.=0.875

SCALE=0.02277 x Beam Deviation Factor (BDF)/COS (DEC)

RATE= 44.3564 COS DEC/BDF

READOUT IN INCHES= 0.1515

3.2.5 TRAVELLING FEED

1. Depress hour angle POWER ON switch.
2. Select MANUAL control.
3. Select TRAVELLING FEED control.
4. Set the SCALE SELECTOR as listed by declination.
5. Set the RATE SELECTOR as listed by declination.
6. Move the travelling feed to the calculated start hour angle. The H A limits at declination zero are $\pm$ 34 minutes. Limits for hour angle in minutes of time will vary as a function of declination.
7. To start tracking a source depress the TRACK switch at required LST.
8. TO FIND THE HOUR ANGLE OF A SOURCE:

LST = RA + HA RA = Right Ascension of Source.

HA = $\pm$ carriage offset for the RA.

LST = Local Sidereal Time.

EXAMPLE: Find HA for CP0834.

For $08^h\ 00^m\ 00^s$ LST at start of track.

$08^h\ 34^m\ 27^s$ RA for CP0834.

$06^\circ\ 19'\ 13''$ DEC for CP0834.

HA = LST - RA

HA = (08 00 00) - (08 34 27)

HA = $-\ 34^m\ 27^s$ or $-\ 34.45^m$ (- HA is east)

For $09^h\ 00^m\ 00^s$ LST at start of track.

HA = LST - RA

HA = (09 00 00) - (08 34 27)

HA = $25^m\ 33^s$ or 25.58^m (+HA is west)

3.2.6 TABLE OF SECONDS TO DECIMAL PARTS OF MINUTES

SECONDS	MINUTES
01	0.0166
02	0.0333
03	0.0500
04	0.0666
05	0.0833
06	0.1000
07	0.1166
08	0.1333
09	0.1500
10	0.1666
11	0.1833
12	0.2000
13	0.2166
14	0.2333
15	0.2500
16	0.2666
17	0.2833
18	0.3000
19	0.3166
20	0.3333
21	0.3500
22	0.3666
23	0.3833
24	0.4000
25	0.4166
26	0.4333
27	0.4500
28	0.4666
29	0.4833
30	0.5000
31	0.5166
32	0.5333
33	0.5500
34	0.5666
35	0.5833
36	0.6000
37	0.6166
38	0.6333
39	0.6500
40	0.6666
41	0.6833
42	0.7000
43	0.7166
44	0.7333
45	0.7500
46	0.7666
47	0.7833
48	0.8000
49	0.8166
50	0.8333
51	0.8500
52	0.8666
53	0.8833
54	0.9000
55	0.9166
56	0.9333
57	0.9500
58	0.9666
59	0.9833
60	1.0000

3.2.7 TRAVELLING FEED RATE AND SCALE TABLE

DEC	SCALE	RATE	IN/MIN
0 degrees	0.0421	27.465	7.828
5 "	0.0423	27.360	7.798
10 "	0.0428	27.048	7.709
15 "	0.0436	26.529	7.561
20 "	0.0449	25.809	7.356
25 "	0.0465	24.892	7.095
30 "	0.0487	23.786	6.779
35 "	0.0515	22.498	6.412
40 "	0.0550	21.039	5.997
45 "	0.0596	19.421	5.535
50 "	0.0656	17.654	5.032
52 "	0.0685	16.909	4.819
54 "	0.0717	16.144	4.601
56 "	0.0754	15.358	4.377
58 "	0.0795	14.554	4.148
60 "	0.0843	13.733	3.914
62 "	0.0898	12.894	3.675
64 "	0.0962	12.040	3.432
66 "	0.1036	11.171	3.184
68 "	0.1125	10.289	2.932
70 "	0.1232	09.394	2.677
72 "	0.1364	08.487	2.419
74 "	0.1529	07.570	2.158
76 "	0.1742	06.644	1.894
78 "	0.2027	05.710	1.628
80 "	0.2427	04.769	1.359
82 "	0.3029	03.822	1.089
84 "	0.4032	02.871	0.818
86 "	0.6043	01.916	0.546

SCALE: READOUT IN MINUTES OF TIME.

RATE: SETS MANUAL TRACK RATE TO INCH/MINUTE.

B.D.F. = 0.850

SCALE=0.04959x BDF/COS DECLINATION.

RATE=23.3455x COS DEC/BDF.

READOUT IN INCHES= 0.3300

3.3.0 COMPUTER CONTROLLED OPERATION

All control information for computer operation of the travelling feed and sterling mount is entered via IBM punch cards. The on-line programs incorporate positioner routines that act on the information provided by the observing card. For observing card format see figure 1, table for card and positioner parameters. For added information on computer controlled operation see the Computer Division Internal report no. 9 .

3.3.1 TRAVELLING FEED UNDER COMPUTER CONTROL

1. Depress POWER ON for hour angle, rotation and focus.
2. Set focus to the up-limit. Remember that STERLING MOUNT ROTATION must show a zero light before the RFD limit can be cleared.
3. Select TRAVELLING FEED operation. Stow pin-out light should light. If the pin-out doesn't light use MANUAL control and LOW speed to free stow pin.
4. Select COMPUTER control. If no observing cards have been loaded the feed should move to zero hour angle.
5. Load up to 10 observing cards.

NOTE: IN MOST CASES USING COMPUTER CONTROLLED OPERATION OF THE STERLING MOUNT OR TRAVELLING FEED, THE TELESCOPE DECLINATION MUST ALSO BE IN COMPUTER CONTROL.

3.3.2 STERLING MOUNT HOUR ANGLE UNDER COMPUTER CONTROL

1. Hour angle POWER on.
2. Make sure that RFD limit is clear (light out). Hour angle will not drive when focus is in the RFD limit.
3. Select STERLING MOUNT operation.
4. Select computer control.
5. Load up to 10 observing cards.

3.3.3 STERLING MOUNT ROTATION UNDER COMPUTER CONTROL

1. Depress rotation POWER ON.
2. Make sure that RFD limit is clear (light out). Rotation will not drive when focus is in the RFD limit.
3. Select COMPUTER control.
4. Load up to 10 observing cards.

3.3.4 STERLING MOUNT FOCUS UNDER COMPUTER CONTROL

1. There is no fucus control in the on-line programs at the time of this report. However, when focus control is incorporated into the programs:
2. Depress focus POWER ON.
3. Select COMPUTER control.
4. Load up to 10 observing cards.

NOTE: The console stop switch for focus, rotation and hour angle will not interrupt computer control as does the declination drive stop switch. **To stop computer drive for any of the three movements, select MANUAL control for that particular drive system.**

COLUMN	1	2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19	20 21	22	23 24 25 26 27 28 29 30	31 32	33	34 35 36 37 38 39 40 41	42 43	44 45 46 47 48	49 50 51 52 53	54 55 56 57	58 59 60 61	62 63 64 65 66 67 68 69 70 71	72 73 74 75 76 77 78 79 80
DESCRIPTION		START TIME H H M M S S	STOP TIME H H M M S S	POS. CODE		PARAMETER 1			PARAMETER 2		PARAMETER 3 I5	PARAMETER 4 I5	PARMS. 5 6 7 8 I1 Form.	OBSER-VER CODE I4	SOURCE NAME 10A1	
DUMMY	BLANK IN EVERY CASE	Time computer leaves dummy card & goes to next one	BLANKS	0	+ or -	Indicated Dec. D D M M S S	BLANK IN EVERY CASE	+ or -	BLANKS	BLANK IN EVERY CASE	BLANKS	BLANKS	SEE OBSERVING PROGRAM DESCRIPTIONS FOR USAGE	N N N	MAY BE ANYTHING WITH ANY COMBINATIONS OF ALPHA, NUMERIC, OR SPECIAL CHARACTERS FOR ALL PROGRAMS	NOT READ BY PROGRAM DOES NOT INITIATE ANYTHING
INDICATED DECLINATION		LST start for data taking	LST stop for data taking	1	+ or -	Indicated Dec. D D M M S S			BLANKS		Dec. Rate '/min ± R R R	Rotation Angle ± D D D		N N N		
TRUE DECLINATION		LST start for data taking	LST stop for data taking	2	+ or -	True Declination D D M M S S			BLANKS		Dec. Rate '/min ± R R R	Rotation Angle ± D D D		N N N		
1950 DECLINATION		LST start for data taking	LST stop for data taking	3	+ or -	1950 Declination D D M M S S			BLANKS		Dec. Rate '/min ± R R R	Rotation Angle ± D D D		N N N		
CONSTANT GALACTIC LATITUDE		LST start for data taking	LST stop for data taking	4	+ or -	B II D D D . D D D			BLANKS		BLANKS	Galactic Rotation ± D D D		N N N		
CONSTANT GALACTIC LONGITUDE		LST start for data taking	LST stop for data taking	5	+ or -	L II D D D . D D D			BLANKS		BLANKS	BLANKS		N N N		
WOBBLES		LST start for data taking	LST stop for data taking	6	+ or -	South Indicated Dec. D D M M S S		+ or -	North Indicated Dec. D D M M S S		Dec. Rate '/min ± R R R	BLANKS		N N N		
CELESTIAL COORDINATES (Time control of data)		LST start for data taking	LST stop for data taking	8		1950 R. A. H H M M S S		+ or -	1950 Dec. D D M M S S		R.A. Rate '/min ± R R R	Dec. Rate '/min ± R R R		N N N		
CELESTIAL COORDINATES (Position control of data)		BLANKS	BLANKS	9		1950 R. A. H H M M S S		+ or -	1950 Dec. D D M M S S		R.A. Rate '/min ± R R R	Dec. Rate '/min ± R R R		N N N		

LEGEND: D-Degrees
M-Minutes of arc or time
S-Seconds of arc or time
R-Rate
N-Number

NOTE: Where + is indicated, a blank will suffice.

Figure 1 300' OBSERVING CARD FORMAT

SECTION 4.0

CALIBRATION

4.1.0 MECHANICAL CALIBRATION

The readouts of all motions are set by the measured movement between a precisely defined "zero" and the negative limit switch. It is assumed that this measured movement will never change significantly until either the zero indicator or negative limit switches are moved or replaced. At that time the movement will have to be measured again. All readout scales are adjusted to read zero at zero position defined by the zero indicator switch and to read the measured movement at the negative limit.

4.1.1 TRAVELLING FEED HOUR ANGLE

The console zero light defines hour angle zero when the feed is positioned on the telescope axis. The movement between zero and extreme negative (east) limit sets the readout scale.

1. Zero adjustment.

   Adjust the zero switch to actuate when the TF carriage center pointer is on the zero center scribe mark. The zero switch must de-actuate with the carriage no further than 3/8 inches either side of zero.

2. Negative limit measurement.

   Until the limit switch or carriage actuator is moved or replaced, the measured movement to the extreme east limit is -275.4 inches.

4.1.2 STERLING MOUNT HOUR ANGLE

The console zero light defines hour angle zero when the sterling mount is centered on telescope axis. The distance moved between zero and negative (east) limit when entered at low speed sets the readout scale.

1. Zero adjustment.

   With the sterling mount positioned on focal axis ($\pm$ 1/64 inch) as originally defined by theodolite measurements, position the zero switch at the center of its actuation range. Adjust the zero switch to remain actuated during movement of less than 0.04 (1/32) inch.

4.1.2 cont.

2. Negative limit measurement.

Select two reference points, one on the mount and one on the fixed structure. With the mount at zero position measure the distance d_o between the two reference points with micrometer bars to $\pm$ 0.010 inch. Under console manual control at low speed move east until stopped by the east limit switch. Measure the distance d_1 between the two reference points to $\pm$ 0.010 inch. The difference d between these distances (d_o-d_1) is the actual movement between zero and east limit. Repeat these measurements several times and record. The average is used to define the readout scale.

Trial 1: (d_o-d_1) = 18.594 in. - 3.406 = 15.188 $\pm$ 0.01 in.

Trial 2: (d_o-d_1) = 28.000 in. - 12.781 in. = 15.219 $\pm$ 0.01 in.

Trial 3: (d_o-d_1) = 36.531 in. - 21.344 in. = 15.188 $\pm$ 0.01 in.

Average East Limit = - 15.20 $\pm$ 0.02 inch.

Date Measured: 30 April 1971

4.1.3 STERLING MOUNT ROTATION

The console light defines rotation zero when a line defining the center of rotation movement is aligned to the north-south telescope axis. The center line for rotation is precisely established by using an alignment bar and theodolite measurements. Normally feed E-planes are oriented north-south or east-west at zero position. Front-end boxes should be marked with a north-pointing arrow on the flange which will actually point north when installed at zero rotation. The angle rotated between zero and negative (CCW from above) limit when entered at low speed defines the readout scale.

1. Zero Adjustment.

Adjust the zero switch to actuate when the alignment bar is oriented exactly ($\pm$ 10 arc min.) north-south as defined by theodolite measurements.

4.1.3 cont.

Adjust the zero switch to remain actuated during platform rotation of less than 20 arc minutes.

2. Negative limit measurement.

Using the theodolite and the alignment bar as reference, measure the rotation angle (± 10 arc min.) from zero (defined by actuated zero switch) to the CCW (from above) limit switch when driven at low speed under manual control. Rotation should be 200 degrees nominal. Repeat this measurement several times and record. The average defines the readout scale.

Trial 1: -200.25 degrees

Trial 2: -200.22 degrees

Trial 3: -200.25 degrees

Average negative limit = -200.24 degrees ± 0.02 degrees

Date measured: 30 April 1971

4.1.4 STERLING MOUNT FOCUS

The console zero light defines focus zero when the focus movement is located at the center of travel. The distance between the bottom of the box mounting surface and the top surface of the floor has been measured with the mount at zero focus and is 26.125 inches. From this measurement the distance between the mounting surface and the focal point can be calculated.

1. Zero adjustment.

The zero switch is set to actuate near the center or travel. Adjust the switch to remain actuated during focus movement of less than 0.04 inch (1/32 inch).

2. Negative limit measurement.

Find a reference surface on the platform and a reference surface on

4.1.4 cont.

the upper frame between which the micrometer bars can measure both at zero and at down limit. With the mount at zero focus, measure the distance d_o between reference surfaces to $\pm$ 0.01 inch and record. Then drive into the down limit (negative) at low speed under manual control from the console. Measure distance d_1 between reference surfaces to $\pm$ 0.01 inch and record. The average is used to define the readout scale.

Trial 1: d_1-d_o = 26.719 - 1.969 = 24.750 in.

Trial 2; d_1-d_o = 51.219 - 26.469 = 24.750 in.

Trial 3: d_1-d_o = 52.094 - 27.344 = 24.750 in.

Average down limit = (24.75 $\pm$ 0.03 inch) x 25.400 mm/inch

= 628.6 $\pm$ 0.8 mm.

4.2.0 READOUT CALIBRATION

Whenever any part of the readout system is calibrated for any reason, the entire procedure for the particular mount or feed movement should be followed in the sequence given below.

The readout calibration consists of three basic steps. First, the Digital Panel Meters (DPM) and analog -to- digital buffers are set to absolute zero and to absolute scale as defined by an internal 9.0000 volt standard. Second voltage adjustments set the readout to zero when a particular motion is set at the zero indicator switches. Third, other voltage adjustments set the readout scale as defined by the known positions at the negative limits.

MOTION	READOUT VOLTAGE SCALE
Travelling feed	33.000 inch/volt
Sterling Mount HA	1.5152 inch/volt
Sterling Mount Rotation	20.202 degree/volt
Sterling Mount Focus	64.646 mm/volt

4.2.1 ABSOLUTE ADJUSTMENTS

1. Digital panel meter absolute adjustments.

The absolute scale is defined by the internal 9.0000 volt standard.

First: Internal absolute calibration adjustments of the DPM's are enabled individually by means of push-buttons on the rear of the position readout chassis .

Zero: Hold this button down and adjust the "Z" pot on the DPM front panel until its minus sign flicks on and off while reading all zeros.

The zero button shorts the DPM input.

+9.0 V: Hold the +9.0 volt test button down and adjust the "FS" pot on the DPM front panel until it reads 9000 steadily. This button connects the 9.0000 volt standard to the DPM.

-9.0 V: Hold the -9.0 volt test button down and check that the DPM

4.2.1 cont.

reads -9000 ± 1. If not, the DPM requires internal adjustments. The -9.0 volt button connects the 9.0000 volt standard in reverse polarity to the DPM.

Second: External absolute calibration adjustments of the DPM displays are enabled individually by means of push-buttons on the front panel of the position readout chassis.

Zero test: Push the zero button to check that DPM reads 0000.

-9.0 V test: With the console in manual control and the HA SCALE set as listed below, hold this button and adjust the -9.0 V ADJ until the DPM reads as listed below.

MOTION	HA SCALE	-9.0 V ADJ READING
Travelling Feed	.3300	-297.0 inches
Sterling Mount HA	.1515	-13.64 inches
Sterling Mount Rotation	-----	-181.8 degrees
Sterling Mount Focus	-----	-581.8 mm

This button applies the 9.0 V standard to the input of the voltage divider which scales the DPM to read in inches, degrees or millimeters as required. The -9.0 V ADJ adjusts the HA SCALE voltage divider.

2. Computer input absolute adjustments.

Internal absolute calibration adjustments of the digital buffer cards are enabled by means of the push-buttons on the front of the position read-out chassis.

MOTION	DIGITAL BUFFER CHANNEL
Travelling Feed	0
Sterling Mount HA	1
Sterling Mount Rotation	2
Sterling Mount Focus	3

4.2.1 cont.

Zero test: Hold the zero test button (on the front panel of the position readout chassis) down and adjust the zero pot on the appropriate channel buffer card until the A/D converter reads either all zeros or all ones. This pot is located on top of the buffer card socket.

+9.0 V test: Hold down the + 9.0 volt front panel button and adjust the gain pot, located on the bottom edge of the buffer card, until the analog-to-digital converter reads as listed below.

-9.0 V test: Hold down the - 9.0 volt front panel button and check that the A/D converter reads within the lowest four bits of the value as listed below.

Test	S	1	2	3	4	5	6	7	8	9	10	11	12	13	14
+9.0 V	0	1	1	1	0	0	1	1	0	0	1	1	0	0	1
-9.0 V	1	0	0	0	1	1	0	0	1	1	0	0	1	1	0

NOTE: Use manual digitize and channel advance switches on the Redcor A/D Converter/Multiplexer.

4.2.2 READOUT ZERO ADJUSTMENTS

Under manual control, move the particular motion to be calibrated to zero position as indicated by the zero light. Try to position at the center of the zero light "on" condition by noting the DPM readout at light on and off when passing through. Then adjust the ZERO LIGHT ADJ for DPM reading of 0000.

4.2.3 READOUT SCALE ADJUSTMENT

Under manual control, move the motion being calibrated into the negative limit at low speed. Then set the console HA SCALE as listed below if either Hour Angle adjustment is being made. Now adjust the - LIMIT LIGHT ADJ for a DPM readout as shown in the table. The negative limit position is equal to the average negative limit position as measured in the Mechanical Calibration sections 4.1.1 thru 4.1.4 above.

4.2.3 cont.

Motion	Scale	Negative Limit Position	
Travelling Feed HA	.3300	-275.4	inches
Sterling Mount HA	.1515	-15.20	inches
S. Mount Rotation	-----	-200.2	degrees
S. Mount Focus	-----	-628.6	mm

4.3.0 CONTROL SYSTEM CALIBRATION

4.3.1 COMPUTER CONTROL CALIBRATION

No calibration is necessary. Only the clock frequency and the computer-rate-bits to frequency conversion must be correct.

4.3.2 MANUAL CONTROL CALIBRATION

1. Rate generator.

No calibration is necessary. It is only occasionally necessary to check that the computer-rate-bits to frequency conversion is correct.

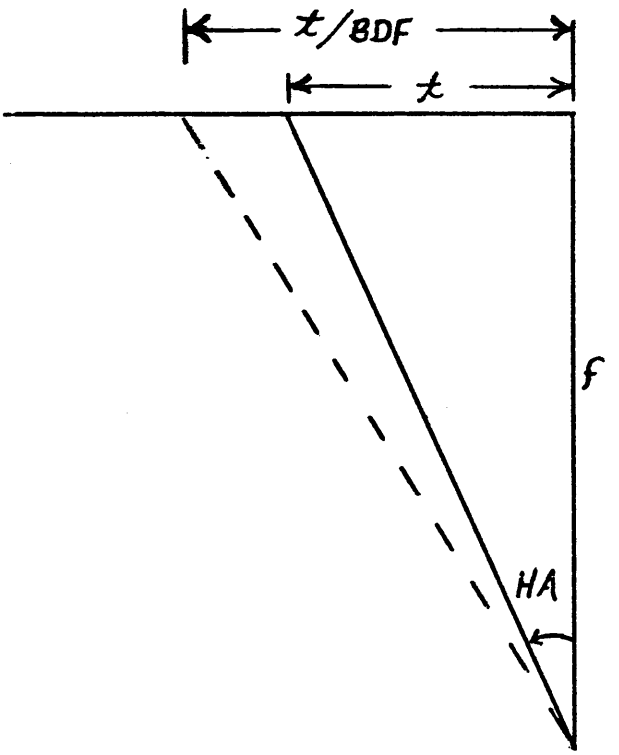
2. Movement per pulse.

No calibration is necessary since this is fixed by the stepping motors and gearing.

Travelling Feed	0.00475	inch/pulse
Sterling Mount HA	0.00250	inch/pulse
Sterling Mount Rotation	1.0' =	0.0166 degrees/pulse
Sterling Mount Focus	0.00067	inch/step

3. Rate equation.

The rate in pulses/second required for tracking in right ascension at any declination can be determined from a rate table. The table is generated from the equation derived below. Track rate depends on fixed telescope parameters, the true declination and a variable parameter depending on the feed in use. See Figure 2.



HA = hour angle offset in degrees

f = focal distance = 1525.00 inches

t = feed travel in inches

BDF = beam deviation factor (0.85 assumed but depends on the feed in use)

Travel for 1^m of HA at DEC zero = (tan 15 arc min) x f

Travel for 1^m with BDF applied = (tan 15 arc min) x f/BDF

-figure 2-

4.3.2 cont.

Focal length = f = 1525.00 inches.

Beam Deviation Factor = BDF = 0.85 but depends on feed in use.

Declination of telescope = DEC

Rate Scale (rate generator pulse frequency) = R pulses/sec.

Movement per drive pulse = MPP = 0.00475 in/pulse TF

= 0.0025 in/pulse SM

1^m of hour angle at DEC zero = 15 arc min = 0.25°

Travel for 1^m of hour angle at DEC zero = (tan 0.25°)*f/BDF

= 0.004363* 1525.00/BDF

= 6.6535/BDF inches

Travel for 1^m of hour angle at DEC_n = (6.6535/BDF) * cos DEC inches

Rate/Second = 6.6535 * cos DEC/(BDF * 60) in/sec

Rate Scale = (0.110891 * cos DEC/BDF in/sec)/MPP

4. Scale equation.

The hour angle SCALE setting required for DPM display in minutes of time can be determined from a scale table. The table is generated from the scale equation derived below. The scale depends on fixed parameters of the readout system, the telescope declination and beam deviation factor which varies slightly with the feed in use.

Scale setting = S = voltage divider ratio output/input.

Beam Deviation Factor = BDF = 0.85 but depends on feed in use.

Readout Voltage Scale = RVS = 33.00 inch/volt for TF

= 1.5152 inch/volt for SM

DPM input at HA = 1^m = [(6.6535*cos DEC/BDF inches)/(RVS inch/volt)]*S = K

K = 0.0100 volt for TF

K = 0.1000 volt for SM

4.3.2 cont.

Solving for Scale S:

$$S = (K * RVS * BDF)/(\cos DEC * 6.6535)$$

SM Scale = 0.1 * 1.5152 * BDF/(cos DEC * 6.6535)

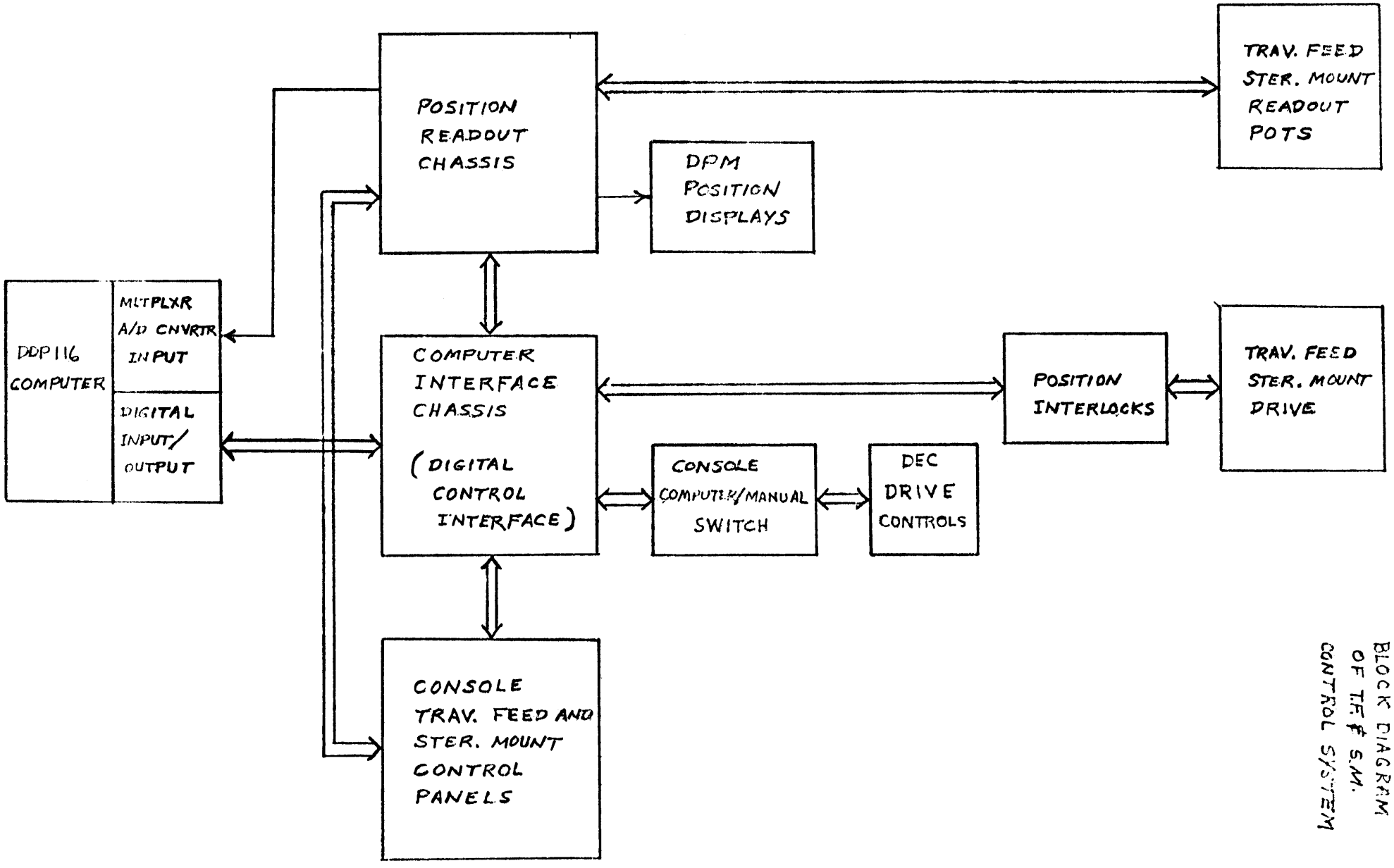
= 0.02277 * BDF/cos DEC

TF Scale = 0.01 * 33.000 * BDF/(cos DEC * 6.6535)

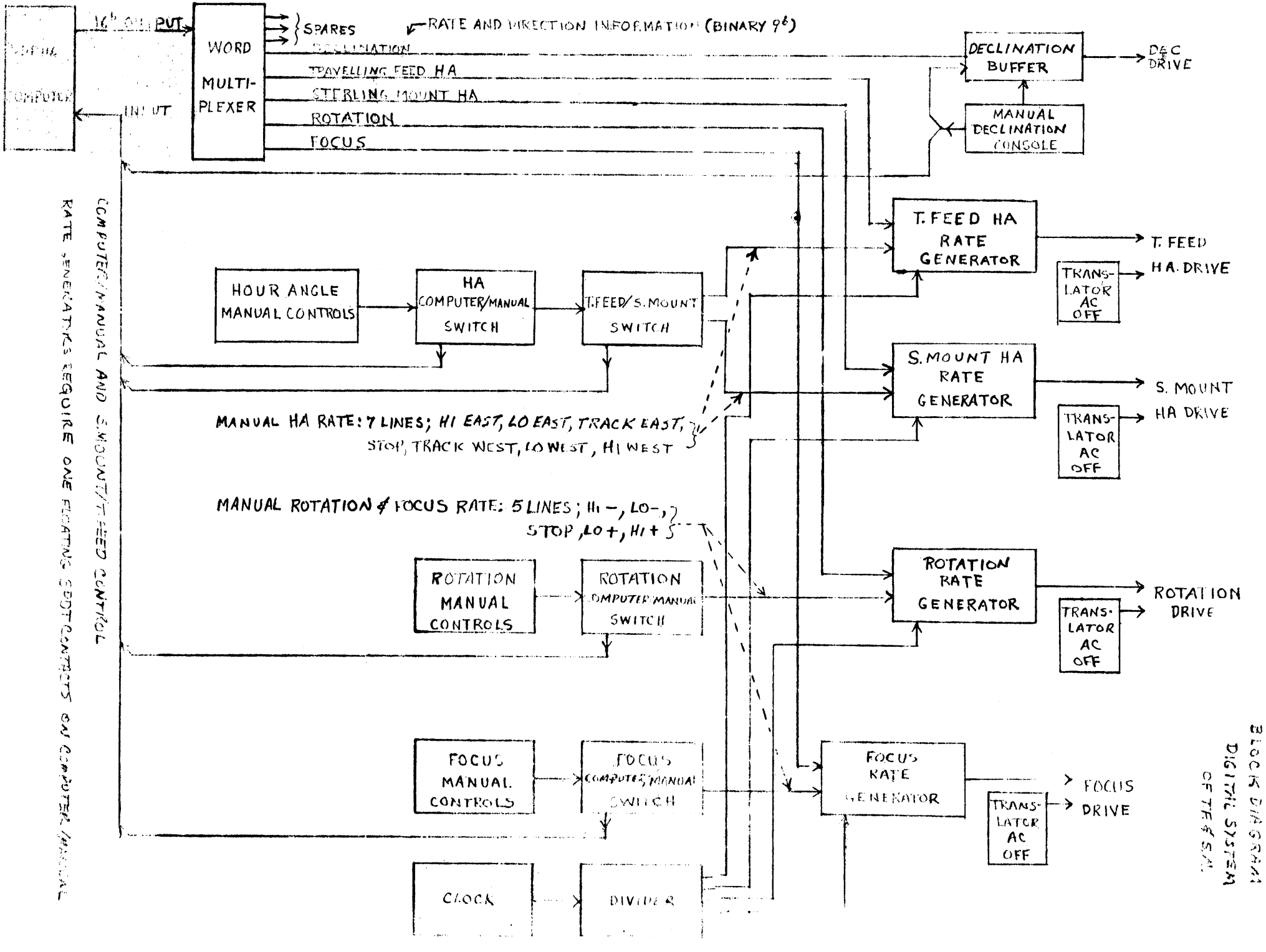
= 0.04959 * BDF/cos DEC

SECTION 5.0

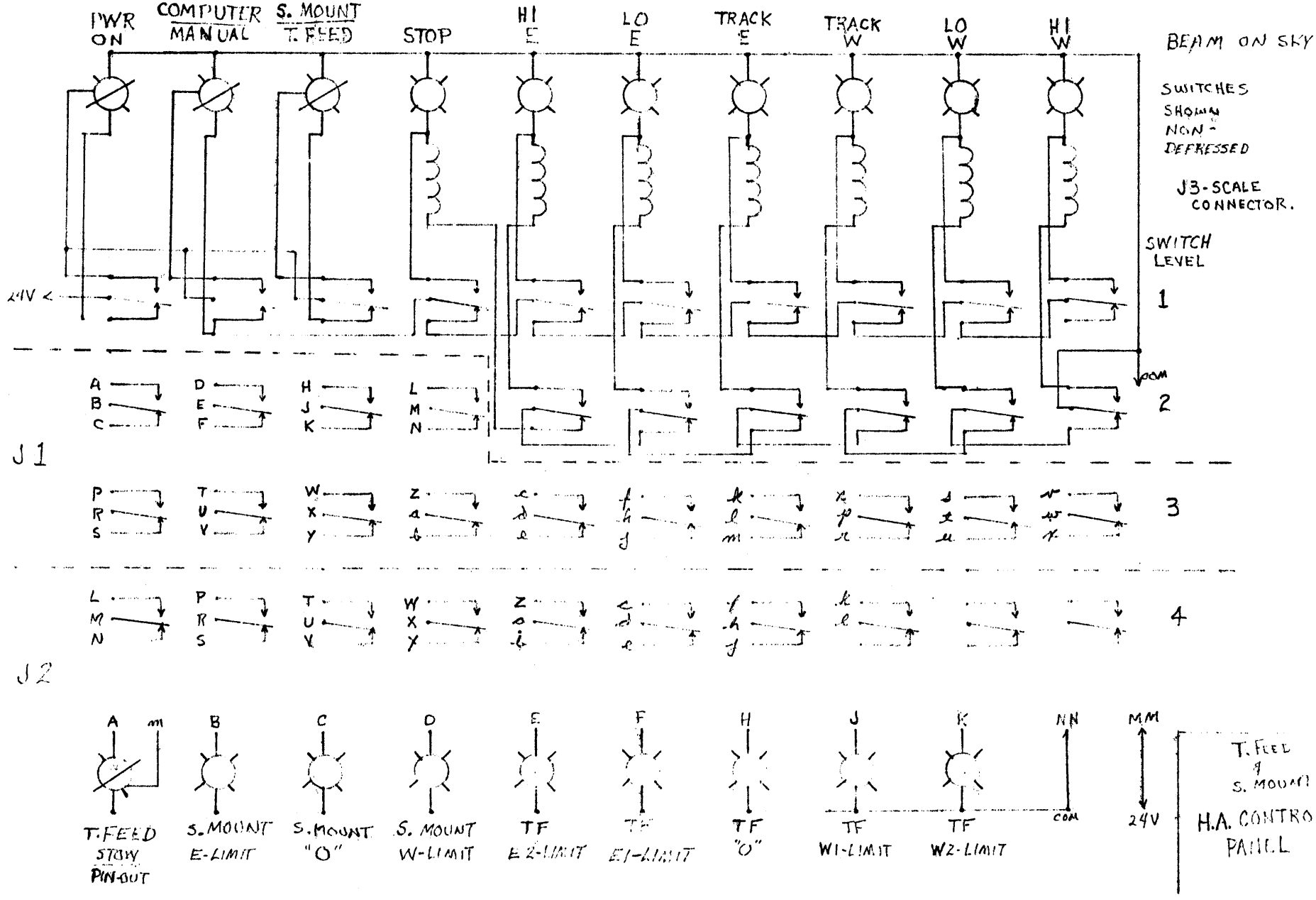
DIAGRAMS



BLOCK DIAGRAM OF T.F. & S.M. CONTROL SYSTEM



BLOCK DIAGRAM DIGITAL SYSTEM OF THE 85'


PWR ON
COMPUTER MANUAL
S. MOUNT T. FEED
STOP
HI E
LO E
TRACK E
TRACK W
LO W
HI W
BEAM ON SKY
SWITCHES SHOWN NON-DEPRESSED
J3-SCALE CONNECTOR.
SWITCH LEVEL
1
2
3
4
24V
COM
J1
J2
A B C
D E F
H J K
L M N
P R S
T U V
W X Y
Z a b
c d e
f h j
k l m
n p r
s t u
v w x
L M N
P R S
T U V
W X Y
Z a b
c d e
f h j
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B
C
D
E
F
H
J
K
NN
MM
T. FEED STOW PIN-OUT
S. MOUNT E-LIMIT
S. MOUNT "O"
S. MOUNT W-LIMIT
TF E2-LIMIT
TF E1-LIMIT
TF "O"
TF W1-LIMIT
TF W2-LIMIT
24V
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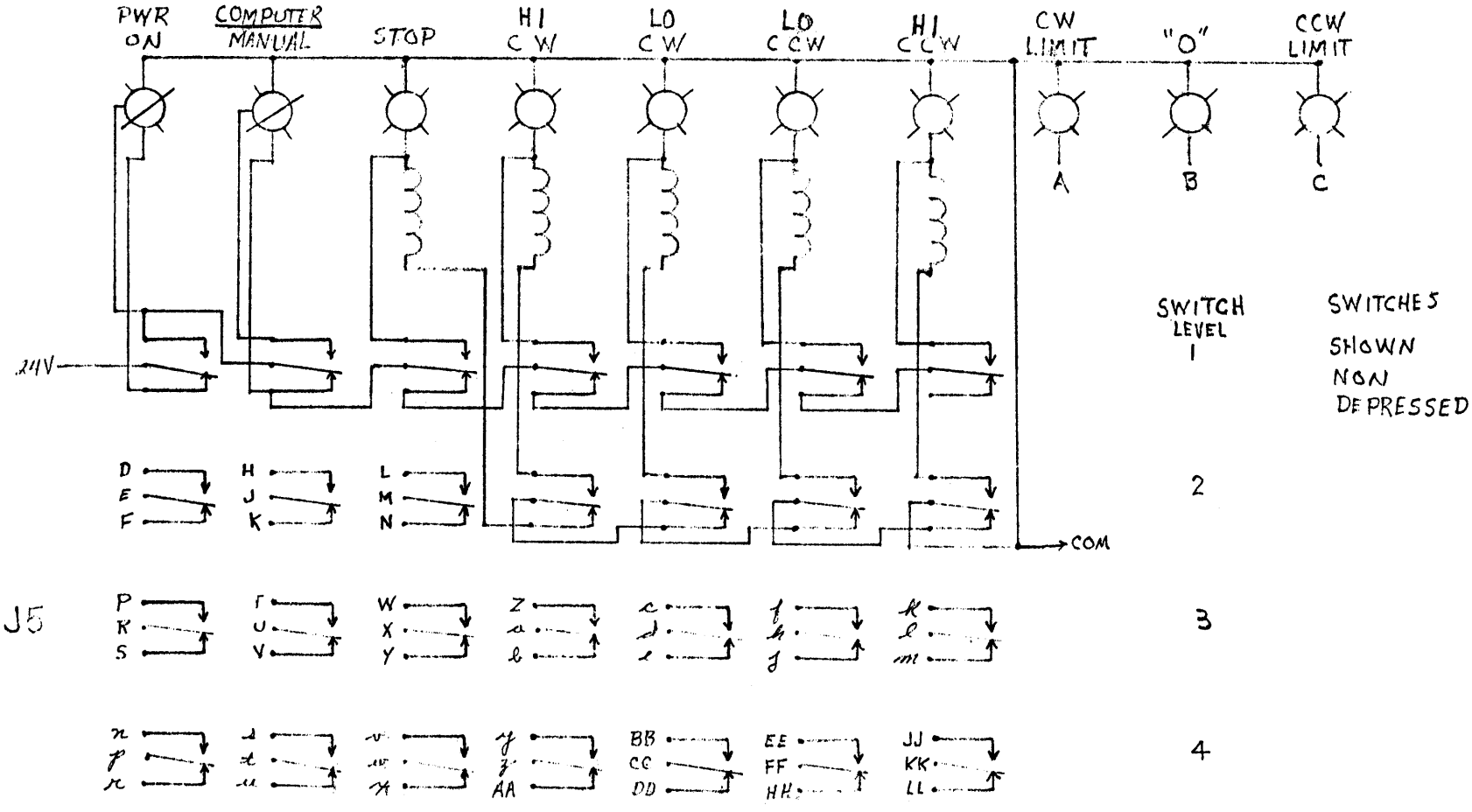
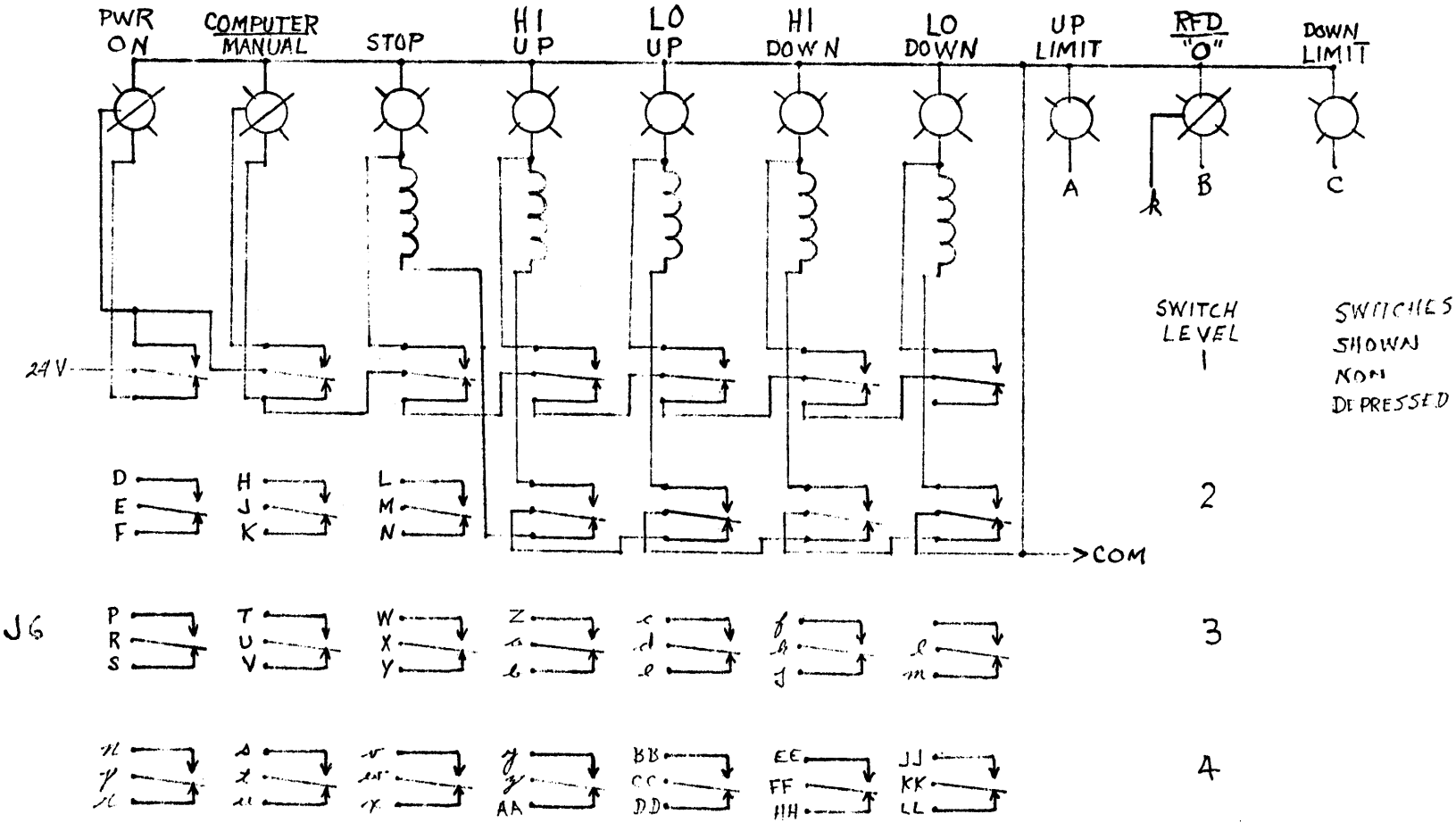
T. FEED & S. MOUNT H.A. CONTROL PANEL



S. MOUNT
ROTATION
PANEL



S. MOUNT FOR PANEL