



**EISCAT
TECHNICAL
NOTES**

EISCAT UHF Antenna Acceptance Tests

EISCAT Kiruna

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**KIRUNA
Sweden**

EISCAT UHF Antenna Acceptance Tests

EISCAT UHF Antenna Acceptance Test

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PREFACE

The contract for the 32 m EISCAT UHF antennas was signed in February 1977 with TIW Systems Ltd, Toronto, Canada. The feed-systems were designed by Euratronix, Bonn, Western Germany as subcontractor to TIW. The foundations were designed by Allmänna Ingenjörbyrå, Umeå, Sweden, and in Finland built by Pohjansepot Oy, Lapua, Finland, and in Norway and Sweden by Svenska Väg AB, Piteå, Sweden. The total price for the three 32 m antennas is 26.5 MSkr.

The antenna erection work on site started in April 1978 and acceptance testing started on 24 October and was finished on 4 December 1978.

This volume contains mainly documents for the RF tests. Materiel for the other tests is contained in a report provided by TIW Systems.

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REPORT ON RF ACCEPTANCE TESTS OF THE EISCAT UHF ANTENNA AT
RAMFJORDMOEN SITE.

RF acceptance tests were conducted at the Ramfjordmoen site between Tuesday, November 7 and Wednesday November 15. Dr. Schäfer represented TIW and EISCAT was represented by Mr. Kildal, Dr. Olsson (part time), Dr. Westerlund (part time) and the data obtained were examined and discussed with the test team by Mr. Meadows and Dr. Hagfors.

1. Feed System VSWR.

The matching of the horizontal and the vertical ports were done as shown in Figure 1:

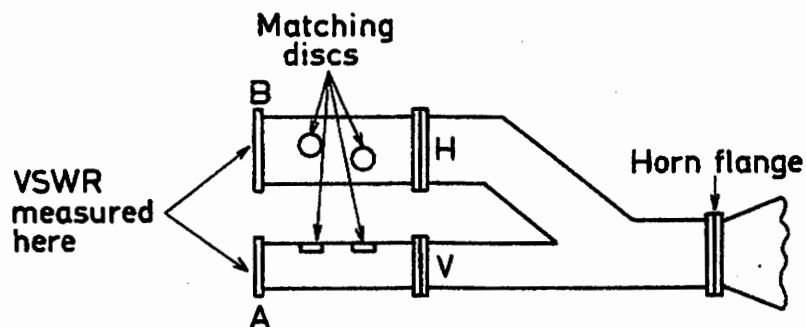


Figure 1. Horn and OMT.

The matching discs were placed so as to provide the best possible match near 933.5 MHz without making the VSWR in the remainder of the band unacceptably high.

The reflection coefficient was measured as shown in Figure 2.

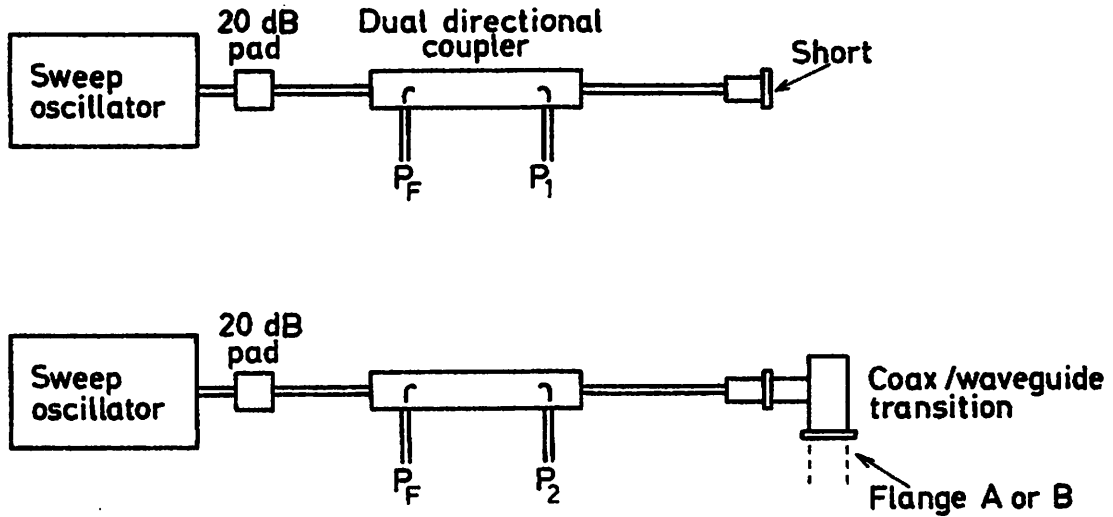


Figure 2. Setup for the measurement of reflected power P_1 or P_2 .

The reflection coefficient R is given by:

$$R = \frac{P_2}{P_1}$$

Both the forward (P_F) and the reflected powers (P_1 and P_2) were measured with a vector voltmeter. The assumption is that the coax/waveguide transition insertion loss is negligible. This was checked by the setup in Figure 3:

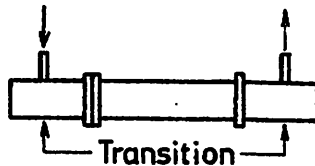


Figure 3. Measurement of insertion loss of transitions.

Insertion loss in each transition was found to vary between 0.05 and 0.09 dB of which 0.04 dB could be ascribed to reflection.

The VSWR versus frequency for vertical (flange A in Fig. 1) and

horizontal (flange B in Fig. 1) are given in attached tables 1.2 and 1.3.

Figure 4 shows frequency sweeps of reflected power for the two cases (decibel scales!)

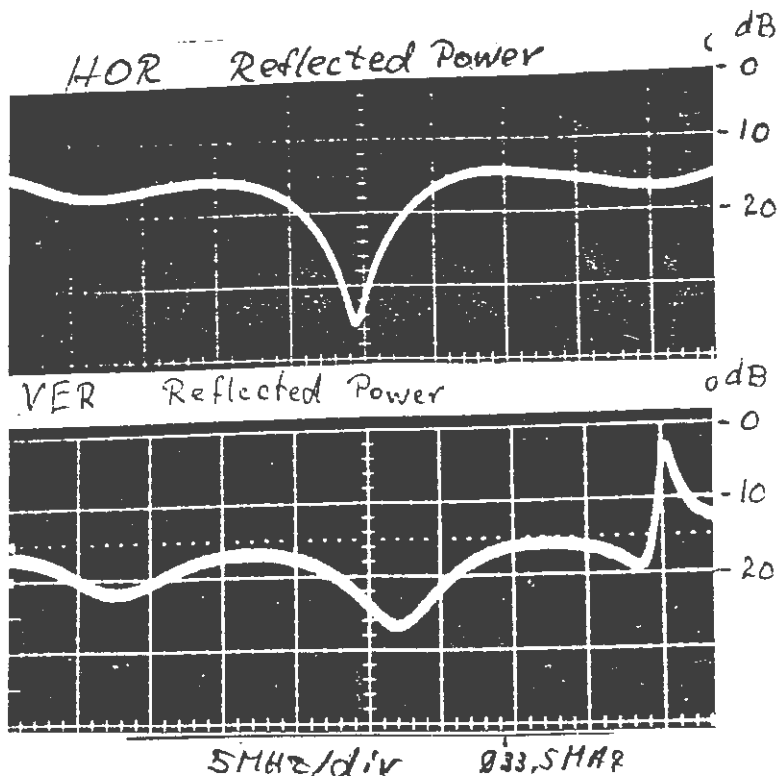


Figure 4. Reflected power versus frequency.

The cross coupling between flanges A and B was measured and the results shown in table 1.4.

2. Antenna Noise Contribution.

The antenna noise at 15° elevation angle is measured by first determining the effective receiver noise temperature referred to the flanges A and B (see Fig. 1). Then the total noise temperature is measured from the antenna at 15° elevation and from this temperature the effective receiver noise temperature is subtracted. From the difference the background sky noise is subtracted and the remainder is the antenna noise contribution.

The effective receiver noise temperature was determined as shown in Figure 5.

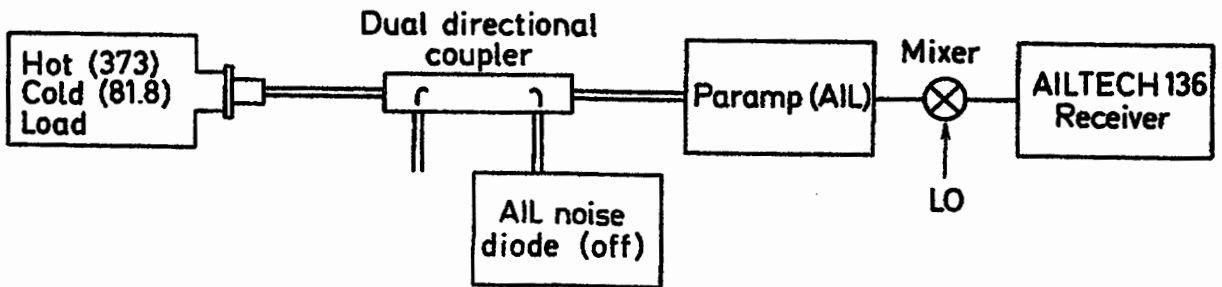


Figure 5. Measurement of receiver temperature.

Measurement as shown gave the result that the paramp plus connections have a noise temperature of 75°K . This does not include the waveguide to coaxial transition which, on the basis of the measurements quoted in the previous section will add another 3°K to the receiver noise.

The AIL noise diode is inserted via a 20.7 dB coupler and, since it has a noise 15.7 dB above room temperature will add 92°K to the noise at the point of insertion and the equivalent of 103°K at the point where the hot/cold load is attached (attenuation through cable and dual directional coupler measured to 0.5 dB) [see case α below].

The equivalent added noise was also measured by measuring the system temperature by means of the hot/cold load with the AIL diode on. The system noise was then found to be 183° , and the equivalent noise added at the input would be equivalent to 108°K , somewhat at variance with the previous result. [see case β below].

Note that this result was obtained by a local oscillator 30 MHz below the center frequency. With the oscillator 30 MHz above the center frequency the equivalent noise was determined to be 116°K . We believe that the discrepancy may be due to foldover of upper and lower sidebands of the LO frequency and that reliable results pertaining to the frequency range of interest can only be obtained if a bandpass filter, less than 60 MHz in width is inserted after the paramp. [see case γ below],

Examination of the measurement shown in diagram 7 then shows that three values are obtained for the antenna + sky noise:

- α): 29 (relying on AIL noise diode calibration)
- β): 35 (hot-cold load, upper sideband)
- γ): 43 (hot-cold load, lower sideband)

A correction of 5° at most can be made for the sky noise, so that only α) is within specs but β) and γ) not. We nevertheless believe the antenna is within spec but plan to repeat the measurements with proper filtering.

3. Antenna Gain.

The antenna gain was measured by the setup shown in Figure 6.

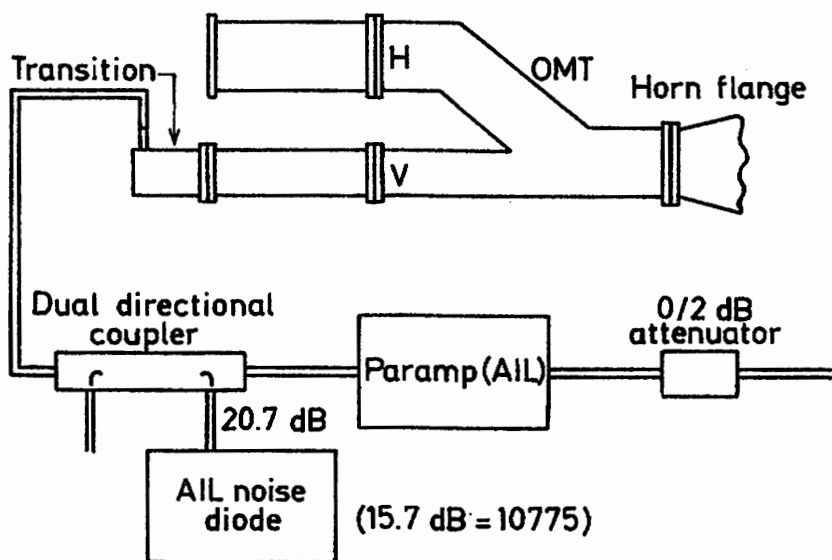


Figure 6. Measurement of source flux.

The antenna temperature with the source was determined from scans such as shown in appended graph 1 in two ways:

Method 1. From the 2 dB increase (a mm) and the temperature increase (assessed to 103°K at transition input) (b mm) the antenna temperature is determined at the minimum between the main lobe and the first sidelobe by the formula:

$$T_0 = \frac{103}{10^{b/5a} - 1}$$

From the calibration at the peak of the drift scan the temperature is determined by the similar formula and is denoted by T_m . Source temperature is $T_m - T_0 = \Delta T$.

Method 2. In this method T_0 is determined as in method 1. The rise of the peak above the baseline is now scaled as c (mm) and T_m is determined as:

$$T_m = T_0 \cdot 10^{c/5b}$$

This method depends on the decibel scale being linear.

The results of scaling graphs 1-6, all Cassiopeia A, graph 9 (Taurus) graph 10 (Cygnus A) and graph 12 (Cas A), all in horizontal polarization are shown in the following table:

Table 1. Measured antenna noise temperatures.

	Method 1			Method 2			
	(Scaled by Kildal)			(Scaled by Hagfors)			
	T_0	ΔT	T_m	T_0	ΔT	T_m	
1	102	541	643	105	474	579	Hor
2	106	639	745	107	466	573	Hor
3	106	474	580	106	419	525	Hor CAS A
4	107	420	527	103	342	445	Hor
5	107	535	632	105	467	572	Hor
6	105	515	620	103	424	527	Hor
7							
8							
9	106	186	292	103	155	258	Hor TAURUS
10	100	453	553	103	402	505	Hor CYG.A
11	108						
12	108	535	643	104	434	538	Hor CAS A

There is no indication of difference between horizontal and vertical polarizations. We note that method 2 gives consistently lower temperatures than method 1 for reasons not yet examined.

The flux of CasA at 933.5 MHz has been taken from

CCIR report, study group 4 (in publication)

which is an amendment to

CCIR report 390-2

to be:

2963 flux units (f.u.)

The temperature rise corresponding to 48.0 dB should therefore be:

$$\Delta T_{48} = 555^{\circ} \quad (\text{CasA})$$

For Taurus A and Cygnus A the fluxes are taken from Allen, Astrophysical Quantities, p. 271, respectively:

Taurus A: 955 f.u.

Cygnus A: 2340 f.u.

We then obtain

$$\Delta T_{48} = 179^{\circ} \quad (\text{Tau A})$$

$$\Delta T_{48} = 439^{\circ} \quad (\text{Cyg A})$$

Comparing these with method 1 of the table there is every indication that the specifications are met within the uncertainty of the experiments.

4. Polarization.

The polarization control was checked against the boresight tower, see graphs 36 and 37. The rotation of a linearly polarized wave was accomplished by varying the power ratio. When set for circular rotation of the boresight dipole gave 0.8 dB variation. Hence, satisfactory performance.

5. Antenna Pattern.

The antenna pattern was measured against the boresight tower and

the results shown in graphs 13 to 35. The graphs are self-explanatory and show that the requirements are met - except for the three "tripod lobes" in graph 35 which we consider unavoidable.

6. Receiver Protector.

The insertion loss of the receiver protection was measured to be close to 0.6 dB, see the signed data sheet.

We feel that this insertion loss is unacceptably high.

Tromsø, 1978-11-15

Tor Hagfors
Tor Hagfors

TEST DATA SHEETS (RF-PERFORMANCE) REV A

FINAL ACCEPTANCE TESTING

DATE _____ TESTED BY Schäfer WITNESSED BY Kildal

The Tests are conducted according to the Acceptance Test Procedure ATP 7857 REV A.

1. Feed System VSWR

1.1 Power outputs in dbm

Freq. in MHz	923.5	928.5	933.5	938.5	943.5
SWEEP OSCILLATOR					
CPLR FWD PORT					
CPLR REV PORT					
INSERTION LOSS IL					
CF=IL+REV-FWD					

1.2 VSWR for vertical polarization

Freq. in MHz	FWD power in dbm	REV power in dbm	Difference REV - FWD R'_{db}	$R=R'+CF$	VSWR
923.5	10			17.8	1.30
928.5	10			18.6	1.27
933.5	10			24.8	1.12
938.5	10			21.2	1.19
943.5	10			16.2	1.37

calibrated with a shorted N-connector

1.3 VSWR for horizontal polarization

Freq. in MHz	FWD power in dbm	REV power in dbm	Difference REV - FWD R'_{db}	$R=R'+CF$	VSWR
923.5	10			14.9	1.44
928.5	10			18.9	1.26
933.5	10			35.1	1.04
938.5	10			16.9	1.33
943.5	10			13.4	1.54

1.4 Freq. in MHz	923.5	928.5	933.5	938.5	943.5
Cross Couplg.	53	53	49	49	50

7-8 Kildal

St. Sch

2. Antenna Noise contribution

2.1 Antenna Noise contribution for vertical polarization

Antenna Noise Temperature _____ degrees
 minus sky noise, cable noise ~ _____ degrees
 noise contribution _____ degrees

2.2 Antenna Noise contribution for horizontal polarization

Antenna Noise Temperature 102 degrees
 minus sky noise, cable noise ^{paramp} ~ 82 degrees
 noise contribution ~ 20 degrees

3. Antenna Gain

3.1 Vertical polarization

Time						
Calculated Azimuth						
Antenna Azimuth						
Azimuth Difference						
Calculated Elevation						
Antenna Elevation						
Elevation Difference						
Antenna Noise						
G _{db}						
Antenna Gain						

F. S. Kida

M. White

3.2 Horizontal Polarization

13. NOV. 78

Time	1:50	2:29			
Calculated Azimuth	312.18	318.91			
Antenna Azimuth	313.25	319.98			
Azimuth Difference					
Calculated Elevation	48.16	45.72			
Antenna Elevation	47.16	44.81			
Elevation Difference					
Antenna Noise	581	552			
G _{db}					
Antenna Gain	47.95	47.75			
FREQ.	935.5	935.5			

4. Polarization

4.1 SWEEP OSCILLATOR power output _____ dbm

4.2

Set Values		Measures Values (Boresight Tower)		
Ampl. Ratio in 1/4 db	-Phase in degrees	Angle of major axis	Angle of minor axis	Axial Ratio in db
- 120	0	0	90	20
- 100	0			
- 80	0			
- 60	0			
- 40	0			
- 20	0			
0	0			O.K
20	0			
40	0			
60	0			
80	0			
100	0			
120	0	90	0	90

HOR

VER

P--S Kida

A. K. K.

Set Values		Measured Values (Boresight Tower)			
Ampl. Ratio in 1/4 db	-Phase in degrees	Angle of major axis	Angle of minor axis	Axial Ratio in db	
0	0			0.K	45°
0	30				
0	60				
0	90			0.8	Circular
0	120				
0	150				
0	180			0.K	135°
0	210				
0	240				
0	270			0.7	Circular
0	300				
0	330				
0	360				

5. Antenna Pattern (Tromsö Site only)

5.1 SWEEPER OSCILLATOR output power _____ dbm

5.2 360° patterns

Frequency	Highest Sidelobe			Attached Pattern Sheet	POLAR. No.	SCAN
	<10°	10° - 60°	>60°			
923.5 MHz	17.8	42.4	52.5	1	VER	AZ
928.5	15	41.9	52.5	2	VER	AZ
933.5	17.7	41	50	3	HOR	AZ
938.5						
943.5	15.8	41.9	50	4	HOR	AZ
933.5				21	VER	EL
933.5	13.9	37	46.1	22	VER	EL
933.5			46.6	23	VER	AZ

P-8 Kida

M. Lutz

Patterns for $\pm 10^\circ$ azimuth

Polarization	Frequency	Elevation offset	Attached Pattern Sheet No.
Vertical	933.5	0	5
"	"	0.2	6
"	"	0.4	7
"	"	0.6	8
"	"	0.8	9
"	"	1.0	10
"	"	1.2	11
"	923.5	0	12 -
"	928.5	0	-
"	938.5	0	-
Vertical	943.5	0	12
Horizontal	933.5	0	13
"	"	0.2	14
"	"	0.4	15
"	"	0.6	16
"	"	0.8	17
"	"	1.0	18
"	"	1.2	19
"	923.5	0	-
"	928.5	0	-
"	938.5	0	-
Horizontal	943.5	0	20

P. J. Kida

M. M. M.

Mechanical inspection of 32 m EISCAT antenna in Tromsø

Inspection date: 2 Dec. 1978

Inspection carried out by Lars Bolin and Jan-Erik Rowa.

1. Anchor bolts: Torques could not be checked since the nuts were locked with glue. Some jam nuts were missing.
2. Azimuth track anchor bolts: Checked torques were 60-70 kpm. Specified torque is 100 kpm.
3. Track: The clearance between rail segments is specified to 0.76 mm. Measured clearances vary between 0-2 mm. In two rail splices the segments are not aligned in the vertical plane. In one they are not properly aligned in the horizontal plane and three splices have a V-shaped clearance.

The surface seemed untreated and the splices are worn.

4. Azimuth drive: Torques of six wheel bearing mounting bolts were found greater than 130 kpm (maximum measurable). Nominal torque is 187 kpm.

Eight assembly mounting bolts were tightened to greater than 130 kpm (maximum measurable). Specified is 1245 kpm.

Clearances between wheel and bearings was approximately 15 mm. Nominal clearance is 11.7-14.3 mm.

Clearance between rail and safety grips was 2.5 mm or more. Specified minimum is 3 mm. Checked torques on 14 bolts were greater than 100 kpm in two cases, equal to 70 kpm in four cases and less than 50 kpm in eight cases.

5. Cable wrap: No remarks
6. Pintle bearing: Clearance between inner and outer teflon surfaces varied between 0-3 mm. Permissible variation is 0.13-0.38 mm. The radii do not match.
7. Alidade: 40 bolts were checked. 27 bolts had torques greater than 100 kpm (maximum measurable), 13 bolts had torques 50-70 kpm. Nominal torque is 100 kpm.
8. Elevation bearing: Four bolts were tightened to 100, 70, 60 and 50 kpm respectively. One jam nut for a jack bolt was loose.
9. Elevation gear: Lateral movement of gear was 11 mm. Should be maximum 3 mm. Radial movement was 1.5 mm and the roots of the teeth made contact in several places. Maximum of radial movement is specified to 0.76 mm.

Ten gear segment mounting bolts, with nominal torque 44 kpm, were checked. Torques indicated were: one bolt 40 kpm and 9 bolts 10-30 kpm.

Six splice bolts were checked and found OK.

10. Elevation drive: Six base mounting bolts had torques: three greater than 100 kpm and three less than 70 kpm.

All eight bearing bolts had a torque less than 20 kpm. Specified is 44 kpm.

11. Shock absorber: Measured torques were 10-40 kpm on the four bolts checked. Should be 100 kpm.

12. Reflector backup subassembly: Four bolts tested. Torques 5-20 kpm. Nominal torque 24 kpm.

Eleven bolts tested. Torques 60-70 kpm. Nominal 100 kpm.

General

The tightness torques of bolts is unsatisfactory.

The pintle bearing has too large a play and is not perfectly circular.

Several splice imperfections on track.

Elevation bearing had all tested bolts too loose.

Elevation gear lateral and radial movement too large.

Shock absorber almost loose.

Elevation drive bearing bolts not tightened enough.

**EISCAT ANTENNA SYSTEM ACCEPTANCE
TROMSØ, NORWAY**

The signatures of EISCAT and TIW SYSTEMS designated representatives for each of the antenna system categories listed, indicate completion of the antenna testing and signify acceptance of the antenna system by EISCAT. This signatory sheet, along with the completed acceptance test procedure, TIW-AT-001-1 dated June 1, 1978 and revised as required during the testing, signifies the completion of TIW SYSTEM effort at the Tromsø installation to EISCAT's satisfaction, except from matters arising which may need attention during the warranty period. All items outstanding along with the agreed-upon methods of dealing with them are indicated under the appropriate category listed and/or in the acceptance test documents.

The following are the four categories of acceptance:

1. Structural and mechanical

Outstanding items:

- a) Items which may be revealed by the EISCAT inspection team.
b) Stow pin hand crank assembly

EISCAT representative:

Kristin Føllesdal

TIW SYSTEMS representative:

Frode H. Krumher
Reginald T. Wella

8/17/78
11/11

2. Control Systems

Outstanding items:

EISCAT representative:

Kristin Føllesdal

TIW SYSTEMS representative:

Frode H. Krumher

8/17/78
11/11

3. RF performance

Outstanding items:

- a) High power tests, including rotary joints
b) Reduction of receiver protector insertion loss to specified value
c) EISCAT reservation as indicated in RF test report

EISCAT representative:

Kristin Føllesdal

TIW SYSTEMS representative:

Frode H. Krumher

8/17/78
11/11

4. De-ising system

Outstanding items:

- a) 5 V power supply with documentation
- b) One 60 A 3 ϕ circuit breaker

EISCAT representative:

Kristin Folkestad

TIW SYSTEMS representative:

Fred H. Kricher

84/11/11

EISCAT

S-981 01 KIRUNA, SWEDEN

Telephone: 0980/290 10; 122 40

Telex: 8754 GEOFYSK S

Kiruna 1978-10-28

TEST REPORT ON RF ACCEPTANCE TESTS
OF THE EISCAT UHF-ANTENNA AT THE
KIRUNA SITE

The RF acceptance tests were conducted at the Kiruna site from October 24 to October 28, 1978, according to the Acceptance Test Procedure agreed upon between TIW and EISCAT. The test results are recorded in the attached Test Data Sheets and Pattern Sheets.

Some comments are made on the measurement set-ups, which were different from the originally planned test procedures:

Para 2: Antenna Noise Contribution and
Para 3: Antenna Gain

As a Radiometer was not available, the noise measurement was done with the paramp and the EISCAT 1st Mixer (no prefiltering in addition to the paramp was possible as ordered filters had not yet arrived) at 120 MHz IF, evaluated with a TEKTRONIX SPECTRUM ANALYZER 7L13 at a 3 MHz bandwidth. The built in noise injection circuit of the paramp was influenced by the antenna matching and did not allow accurate measurements. An AIL calibrated noise source 7615 was used instead and coupled through a HP Directional Coupler 778D to the paramp input. This measuring set-up gave quite reliable values which were repeatable under different conditions. A value of 3.138×10^{-23} Watts/m²/Hz for the CAS A flux density at 933.5 MHz was used.

Para 4: Polarization

The Polarizer was set up by calibrating the input signal components at the two horn flanges. A qualitative check was made with a test-transmitter at a boresight tower.

Para 5: Antenna Pattern

The Antenna Patterns were made with a provisional boresight testtransmitter mounted on a tower at a distance of about 8 km. A waveguide to coax transition was used as the transmitting antenna.

Results:

The measured values gave no indication of the system not meeting the specs. To be certain, however, the following two things remain:

- To measure the coupler losses
- Match the horizontal polarization in the high end of the band.

EISCAT reserves the right to investigate these problems in more detail.

For EISCAT

For TIW

[Signature]

[Signature]

EISCAT 32m-UHF-ANTENNA Kiruna SITE

TEST DATA SHEETS (RF-PERFORMANCE) REV A

FINAL ACCEPTANCE TESTING

DATE 24/25 Oct. 78 TESTED BY H. S. Linder WITNESSED BY S. Westberg

The Tests are conducted according to the Acceptance Test Procedure ATP 7857 REV A.

1. Feed System VSWR

1.1 Power outputs in dbm

Handwritten notes: Cable loss between coupler and antenna input L = 0.5 dB

Freq. in MHz	923.5	928.5	933.5	938.5	943.5
SWEEP OSCILLATOR	-0.4	-0.1	0	0.1	0
CPLR FWD PORT	21.4	21.3	21.1	21.1	21
CPLR REV PORT	21.4	21.3	21.2	21.1	21
INSERTION LOSS IL	0.3	0.3	0.25	0.2	0.2
CF=IL+REV-FWD+2L	1.5	1.6	1.55	1.3	1.3

1.2 VSWR for vertical polarization

Freq. in MHz	FWD power in dbm	REV power in dbm	Difference R'_{db} REV - FWD - REV	R=R'+CF	VSWR
923.5	-21.5	-41.5	20	18.5	1.27
928.5	-21.3	-45.8	24.5	22.9	1.15
933.5	-21	-43.2	22.5	20.95	1.2
938.5	-21	-40.7	19.7	18.4	1.27
943.5	-21	-40.3	19.3	18.0	1.29

1.3 VSWR for horizontal polarization

Freq. in MHz	FWD power in dbm	REV power in dbm	Difference R'_{db} REV - FWD - REV	R=R'+CF	VSWR
923.5	-21.6	-44.7	23.1	21.6	1.18
928.5	-21.3	-48.4	27.1	25.5	1.11
933.5	-21.1	-41.7	20.6	19.05	1.25
938.5	-20.9	-40.9	20	18.7	1.26
943.5	-21.2	-36.7	15.5	14.2	1.48

Freq. in MHz	923.5	928.5	933.5	938.5	943.5
Cross Couplg.	49.1	50.5	51.5	53.2	53.7

Handwritten signature: Sam Westberg

Handwritten signature: H. S. Linder

28. OCT 1978

2. Antenna Noise contribution $933.5 \pm 1.5 \text{ MHz}$
- 2.1 Antenna Noise contribution for vertical polarization
 Antenna Noise Temperature 105 degrees
 minus sky noise, cable noise \sim 85 degrees
 noise contribution \sim 20 degrees
- 2.2 Antenna Noise contribution for horizontal polarization
 Antenna Noise Temperature 106 degrees
 minus sky noise, cable noise \sim 85 degrees
 noise contribution \sim 21 degrees

3. Antenna Gain

3.1 Vertical polarization 27 Oct 1978 CASA

Time	20:25	21:40	28.OCT 14:30			
Calculated Azimuth	215.74	250.92	67.74			
Antenna Azimuth						
Azimuth Difference	4.51					
Calculated Elevation	79.43	73.70	56.98			
Antenna Elevation	-0.05					
Elevation Difference	-0.05					
Antenna Noise	536	437	570			
G _{db}	47.6	46.7	47.9			
Antenna Gain	48.1	47.2	48.4			
Frequency	933.5	943.5	913.5			

Don F. ...

M. ...

3.2 Horizontal Polarization

28 OCT 1978

Time	11:20	13:20	13:40		
Calculated Azimuth	36.25	55.77	59.12		
Antenna Azimuth					
Azimuth Difference	4.44	4.44	4.44		
Calculated Elevation	42.08	51.17	52.76		
Antenna Elevation					
Elevation Difference	-0.09	-0.1	-0.1		
Antenna Noise	491	582	550		
G _{db}	47.2	47.9	47.7		
Antenna Gain	47.7	48.5	48.2		
Frequency	943.5	933.5	923.5		

4. Polarization

4.1 SWEEP OSCILLATOR power output _____ dbm

4.2

Set Values		Measures Values (Boresight Tower)			
Ampl. Ratio in 1/4 db	Phase in degrees	Angle of major axis	Angle of minor axis	Axial Ratio in db	
- 120	0			O.K.	HOR
- 100	0				
- 80	0				
- 60	0				
- 40	0				
- 20	0				
0	0				
20	0				
40	0				
60	0				
80	0				
100	0				
120	0			O.K.	

[Handwritten signature]

[Handwritten signature]

Set Values		Measured Values (Boresight Tower)		
Ampl. Ratio in 1/4 db	Phase in degrees	Angle of major axis	Angle of minor axis	Axial Ratio in db
0	0			C. K.
0	30			
0	60			
0	90			
0	120			
0	150			
0	180			C. K.
0	210			
0	240			
0	270			
0	300			
0	330			
0	360			

45°

135°

5. Antenna Pattern (Tromsø Site only)

5.1 SWEEPER OSCILLATOR output power _____ dbm

5.2 360° patterns

Frequency	Highest Sidelobe			Attached Pattern Sheet No.
	<10°	10° - 60°	>60°	
923.5 MHz				
928.5				
933.5	14			
938.5				
943.5				

[Handwritten signature]

M. L. Hill

5.3 Patterns for + 10° azimuth

Polarization	Frequency	Elevation offset	Attached Pattern Sheet No.
Vertical	933.5	0	KIR NO. 1
"	"	0.2	
"	"	0.4	
"	"	0.6	
"	"	0.8	
"	"	1.0	
"	"	1.2	
"	923.5	0	
"	928.5	0	
"	938.5	0	
Vertical	943.5	0	
Horizontal	933.5	0	KIR NO. 2
"	"	0.2	
"	"	0.4	
"	"	0.6	
"	"	0.8	
"	"	1.0	
"	"	1.2	
"	923.5	0	
"	928.5	0	
"	938.5	0	
Horizontal	943.5	0	

[Handwritten signatures]

6. Receiver Protector (Tromsö Site only)

6.1 RX-Mode power output _____ dbm
TX-Mode power output _____ dbm
attenuation _____ db

6.2 Freq.in MHz	923.5	928.5	933.5	938.5	943.5
Insertion loss in db					

7. Duplexer (Tromsö Site only)

7.1 RX-Mode
Power input to ANT-port _____ dbm
Power output at TX-port _____ dbm
Power output at RX-port _____ dbm
RX-TX isolation _____ db

8. Power Handling (Tromsö Site only)

Frequency	Pulse length	prf	FWD Power	REV Power	Prot # 1	Prot # 2

[Handwritten signatures]

Mechanical inspection of the 32 m EISCAT antenna in Kiruna

Inspection dates: 17 Nov. and 9 Dec. 1978,

Inspection carried out by Lars Bolin and Jan-Erik Rowa.

1. Anchor bolts: Torques could not be checked since the nuts are locked with glue.
2. Azimuth track anchor bolts: Checked torques were 20 to 60 kpm while specified torque is 100 kpm.
3. Track: The clearance between rail segments is specified to 0.76 mm. Measured clearances vary between 0 and 3 mm. In two rail splices the segments are not lined up properly in the vertical plane and four splices have a V-shaped clearance.

The surface seems untreated and is somewhat rusty.

4. Azimuth drive: Torque values indicated on eight wheel bearing mounting bolts were greater than 130 kpm (maximum measurable) in seven cases and equal to 90 kpm in one case. Specified torque is 187 kpm.

Four assembly mounting bolts were tested. Torques were greater than 130 kpm in two cases, equal to 100 kpm in one case and equal to 30 kpm in one case. Nominal torque is 1245 kpm. The two bolts with the lowest torque were found on the broken gear box.

The clearances between the wheel and the bearings varied between 5 and 25 mm. Nominal clearance is 14.3-11.7 mm. The largest deviations from nominal were measured on the wheel driven by the broken gear box.

The clearance between the safety grips and the rail was measured 3-15 mm. Nominal minimum is 3 mm. Five bolts were checked. Torques greater than 100 kpm were measured on four bolts and equal to 70 kpm on the fifth bolt.

5. Azimuth cable wrap: Some bolts are missing on the roof.
6. Pintle bearing: The clearance between the outer and inner teflon surfaces varied between 0-3 mm. Permissible variation is 0.13-0.38 mm. The radii do not match.
7. Alidade: 40 bolts were torque tested. 26 bolts were tightened to greater than 100 kpm and 14 bolts to 20-70 kpm. Nominal

torque is 100 kpm.

The galvanization was extensively damaged in two places. The repair was barely adequate.

8. Elevation bearing: Four bolts were torque tested. Two torques were greater than 130 kpm and two were equal to 40 kpm. Specified torque is 600 kpm. Four of the jam nuts for the jack bolts could be turned by hand.
9. Elevation gear: Lateral movement of gear was about 9 mm. Should be maximum 3 mm. Radial movement was about 1 mm. Should be maximum 0.76 mm.

Gear segment mounting bolts should be tightened to 44 kpm. Seven bolts were checked. Torques indicated were: one bolt 40 kpm, two bolts 30 kpm and four bolts 20 kpm.

Six splice bolts with specified torque 100 kpm were tested. Measured torques were for two bolts 60 kpm, for two bolts 40 kpm and for two bolts 20 kpm.

The gear was only partly coated with oil.

10. Elevation drive: Three base mounting bolts had tightness torques of 100, 60 and 10 kpm respectively.

Out of four bearing bolts, three were tightened to 20 kpm and one was loose. Specified is 44 kpm.

Six shaft bearing mounting bolts were checked. For three the torque was 15 kpm and for three it was 10 kpm. Specified torque is 44 kpm.

11. Elevation shock absorber: Four mounting bolts loose. Specified torque 100 kpm.
12. Reflector backup: Three out of fifteen bolts tested showed significantly lower tightness torques than specified.

General

The tightness torques of bolts is unsatisfactory. The method used has given too low torques and a too large spread in torque values.

The pintle bearing, which will carry the horizontal loads, is far from complying with specified bearing tolerances.

Instructions for mounting the azimuth drive assembly should be more closely followed in order to avoid breakdowns, like in the case of the gear box.

In the elevation bearings, which are important in taking up wind

loads, two bolts out of four bolts checked were almost loose. Totally, there are only eight bolts! In addition, four jam nuts could be turned by hand.

Alarming was also that the bolts that hold the elevation shock absorber were loose.

The appearances of the rail splices may indicate that the specified radius of 30 ft has not been kept. The rail surface should be observed for excessive wear.

4 DEC 1978

EISCAT ANTENNA SYSTEM ACCEPTANCE
KIRUNA, SWEDEN

The signatures of EISCAT and TIW SYSTEMS designated representatives for each of the antenna system categories listed, indicate completion of the antenna testing and signify acceptance of the antenna system by EISCAT. This signatory sheet, along with the completed acceptance test procedure, TIW-AT-001-1 dated June 1, 1978 and revised as required during the testing, signifies the completion of TIW SYSTEM effort at the Kiruna installation to EISCAT's satisfaction, except from matters arising which may need attention during the warranty period. All items outstanding along with the agreed-upon methods of dealing with them are indicated under the appropriate category listed and/or in the acceptance test documents.

The following are the four categories of acceptance:

1. Structural and mechanical

Outstanding items:

- a. *Items which may be revealed by the EISCAT inspection team*
- b. *One assembly further defective and will be replaced by 7116 systems*

EISCAT representative:

TIW SYSTEMS representative:

Sören Olsson

Kjell-Erik Mellin

Fred H. Krencher

2. Control Systems

Outstanding items:

EISCAT representative:

TIW SYSTEMS representative:

Sören Olsson

Fred H. Krencher

3. RF performance

Outstanding items:

EISCAT reservation as indicated in RF test report

EISCAT representative:

TIW SYSTEMS representative:

Sören Olsson

Fred H. Krencher

4. De-icing system

Outstanding items:

TIW will replace all thermos-delay relays with delay times not exceeding 20 sec

EISCAT representative:

TIW SYSTEMS representative:

Robert Wilson
Fred H. Krencher

TEST REPORT ON RF-TESTING OF THE EISCAT-UHF-ANTENNA
AT THE SODANKYLÄ SITE

The RF-acceptance tests were conducted at the Sodankylä Site from 1 to 4 November, 1978. The same test procedures were applied as for the RF-testing of the Kiruna Site, with the exception, that the boresight tower measurement didn't give any usable results, due to the scattering caused by the trees in the vicinity of the antenna.

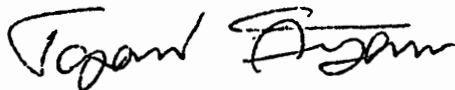
The test results are recorded in the attached Test Data Sheets. The noise measurements were done directly at the original UHF-frequencies with the Tektronix Spectrum Analyzer.

The measured results were similar to the results obtained with the Kiruna Site. There was no evidence that the RF-performance of the antenna would not meet the specifications. To be certain, however, Eiscat wants to do the following things:

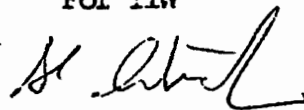
- Measure the loss of the waveguide to N-connector transition in front of the paramp
- Improve the matching between the antenna and the paramp

Sodankylä, November 4, 1978

For EISCAT



For TIW



Attachments:

1. Test data sheets
2. Antenna pattern with boresight tower

TEST DATA SHEETS (RF-PERFORMANCE) REV A

FINAL ACCEPTANCE TESTING

DATE NOV 3, 78 TESTED BY Schäfer WITNESSED BY Aijänen, Westerlund

The Tests are conducted according to the Acceptance Test Procedure ATP 7857 REV A.

1. Feed System VSWR

	Cable Loss	0.55	0.55	0.6	0.6	0.6	
1.1 Power outputs in dbm							
Factor Voltmeter (V=A·B)	0.4	0.4	0.4	0.4	0.4		
Freq. in MHz	923.5	928.5	933.5	938.5	943.5		
SWEEP OSCILLATOR	9.6	9.8	10	10.1	10		dbm
CPLR FWD PORT	21.25	21.2	21.1	21	20.9		db
CPLR REV PORT	21.3	21.25	21.15	20.9	20.9		db
INSERTION LOSS IL	0.25	0.25	0.2	0.2	0.2		db
CF=IL+REV-FWD+2L+V	1.5	1.8	1.85	1.7	1.8		db

1.2 VSWR for vertical polarization

Freq. in MHz	FWD power in dbm	REV power in dbm	Difference REV - FWD	R=R'+CF	VSWR
923.5	-10	-27	17	15.5	1.4
928.5	-10	-26	16	14.2	1.48
933.5	-10	-30.6	20.6	18.75	1.26
938.5	-10	-39.5	29.5	27.8	1.08
943.5	-10	-25	15	13.2	1.56

1.3 VSWR for horizontal polarization

Freq. in MHz	FWD power in dbm	REV power in dbm	Difference REV - FWD	R=R'+CF	VSWR
923.5	-10	-31	21	19.5	1.25
928.5	-10	-28	18	16.2	1.37
933.5	-10	-31.5	21.5	19.65	1.23
938.5	-10	-28	18	16.3	1.36
943.5	-10	-29.5	19.5	17.7	1.3

1.4 Freq. in MHz	923.5	928.5	933.5	938.5	943.5
Cross Couplg.	49.5	48.5	48.5	50	56

Tapani Aijanen

Se. Westerlund

2. Antenna Noise contribution

2.1 Antenna Noise contribution for vertical polarization

Antenna Noise Temperature 95 degrees
minus sky noise, cable noise ~ 75 degrees
noise contribution ~ 20 degrees

2.2 Antenna Noise contribution for horizontal polarization

Antenna Noise Temperature 93 degrees
minus sky noise, cable noise ~ 73 degrees
noise contribution ~ 20 degrees

3. Antenna Gain

3.1 Vertical polarization NOV 3, 78

Time UT	13:00	13:40	14:15			
Calculated Azimuth	59.54	66.73	72.96			
Antenna Azimuth	62.79	69.59	75.81			
Azimuth Difference	-2.85	-2.85	-2.85			
Calculated Elevation	53.21	56.65	59.82			
Antenna Elevation	52.31	55.75	58.92			
Elevation Difference	-0.9	-0.9	-0.9			
Antenna Noise	525°	531°	551°			
G _{db}	47.5	47.6	47.7			
Antenna Gain	48.0	48.1	48.2			
Frequ. (MHz)	923.5	940	933.5			

Tozan Arzum

H. Lital

3.2 Horizontal Polarization

Time	16:00	16:30	17:00		
Calculated Azimuth	95.08	103.39	113.54		
Antenna Azimuth	97.98	106.29	116.44		
Azimuth Difference	-2.9	-2.9	-2.9		
Calculated Elevation	69.82	72.67	74.41		
Antenna Elevation	68.83	71.67	75.41		
Elevation Difference	1.0	1.0	1.0		
Antenna Noise	574°	565°	563°		
G _{db}	47.9	47.9	47.9		
Antenna Gain	48.4	48.4	48.4		
Freq. (MHz)	933.5	923.5	940		

4. Polarization

4.1 ~~SWEEP OSCILLATOR~~ power output _____ dbm

The polarization components were set up with a 120 deg phase lag of the waveguide input for a equal phase condition at the horn output. The control was checked for different settings.

4.2

Set Values		Measures Values (Boresight Tower)		
Ampl. Ratio in 1/4 db	Phase in degrees	Angle of major axis	Angle of minor axis	Axial Ratio in db
- 120	0			
- 100	0			
- 80	0			
- 60	0			
- 40	0			
- 20	0			
0	0			
20	0			
40	0			
60	0			
80	0			
100	0			
120	0			

Toward Azimuth

M. K. K.

Set Values		Measured Values (Boresight Tower)		
Ampl. Ratio in 1/4 db	Phase in degrees	Angle of major axis	Angle of minor axis	Axial Ratio in db
0	0			
0	30			
0	60			
0	90			
0	120			
0	150			
0	180			
0	210			
0	240			
0	270			
0	300			
0	330			
0	360			

5. Antenna Pattern (Tromsö Site only)

5.1 SWEEPER OSCILLATOR output power _____ dbm

5.2 360° patterns

Frequency	Highest Sidelobe			Attached Pattern Sheet No.
	<10°	10° - 60°	>60°	
923.5 MHz				
928.5				
933.5				
938.5				
943.5				

Tojant Azam

M. White

5.3 Patterns for $\pm 10^\circ$ azimuth

Polarization	Frequency	Elevation offset	Attached Pattern Sheet No.
Vertical	933.5	0	
"	"	0.2	
"	"	0.4	
"	"	0.6	
"	"	0.8	
"	"	1.0	
"	"	1.2	
"	923.5	0	
"	928.5	0	
"	938.5	0	
Vertical	943.5	0	
Horizontal	933.5	0	
"	"	0.2	
"	"	0.4	
"	"	0.6	
"	"	0.8	
"	"	1.0	
"	"	1.2	
"	923.5	0	
"	928.5	0	
"	938.5	0	
Horizontal	943.5	0	

Tajamal D. Jern

M. Smith

6. Receiver Protector (Tromsö Site only)

6.1 RX-Mode power output _____ dbm
TX-Mode power output _____ dbm
attenuation _____ db

6.2	Freq.in MHz	923.5	928.5	933.5	938.5	943.5
	Insertion loss in db					

7. Duplexer (Tromsö Site only)

7.1 RX-Mode
Power input to ANT-port _____ dbm
Power output at TX-port _____ dbm
Power output at RX-port _____ dbm
RX-TX isolation _____ db

8. Power Handling (Tromsö Site only)

Frequency	Pulse length	prf	FWD Power	REV Power	Prot # 1	Prot # 2

Torgny Arzon

H. Lund

Mechanical inspection of the 32 m EISCAT antenna in Sodankylä

Inspection date: 26 Nov. 1978

Inspection carried out by Lars Bolin and Jan-Erik Rowa.

1. Anchor bolts: Torques could not be checked since the nuts are locked with glue. Some jam nuts are missing.
2. Azimuth track anchor bolts: Checked torques were 20 to 50 kpm while specified torque is 100 kpm.
3. Track: The clearance between rail segments is specified to be 0.76 mm. Measured clearances vary between 0 and 2 mm. In three rail splices the segments were not aligned properly in the vertical plane and two splices have a V shaped clearance.

The surface seems untreated and is somewhat rusty.

4. Azimuth drive: Torque values indicated on eight wheel bearing mounting bolts were greater than 70 kpm (maximum measurable) in seven cases and equal to 60 kpm in one case. Specified torque is 187 kpm.

Four assembly mounting bolts were tested. Torques were greater than 130 kpm (maximum measurable) in two cases, equal to 52 kpm in one case and equal to 30 kpm in one case. Specified torque is 1245 kpm.

The clearances between wheels and bearings varied between 10 and 20 mm. Nominal clearance is 11.7-14.3 mm.

The clearance between the safety grips and the rail was 3 mm as is specified as minimum. Out of nine bolts, seven had torques greater than 100 kpm and two had torques of 60 kpm.

5. Azimuth cable wrap: No remark.
6. Pintle bearing: The clearance between the inner and outer teflon surfaces varied between 0-3 mm. Specified variation is 0.13-0.38 mm. The radii do not match.
7. Alidade: 40 bolts were checked. 27 bolts had torques greater than 70 kpm (maximum measurable) and 13 varied between 10-70 kmp. Specified torque is 100 kpm.
8. Elevation bearing: One jam nut for jack bolt was loose.
9. Elevation gear: Lateral movement of gear was 1 mm. Specified maximum is 3 mm. Radial movement was 0.5 mm. Specified maximum is 0.76 mm.

Gear Segment mounting bolts should be tightened to 44 kpm. Ten bolts were checked. Five were OK, and five had torques of 10-40 kpm.

Six splice bolts with specified torque 100 kpm were tested. Measured torques were greater than 70 kpm (maximum measurable).

There was practically no oil coating at all on the gear.

10. Elevation drive: Out of four base mounting bolts three had torques greater than 70 kpm (maximum measurable) and one less than 70 kpm.

Eight bearing bolts were lightened to less than 20 kpm. Specified is 44 kpm.

11. Shock absorber: One bolt tested. Torque greater than 70 kpm.
12. Reflector backup subassembly: Torques on ten bolts was 10-20 kpm. Specified torque is 24 kpm.

General

Tightness torques of bolts are unsatisfactory.

Too large clearance in pintle bearing.

Bolts for azimuth gear boxes not tightened enough.

Several splice imperfections on azimuth track.

Of the elevation gear bolts 50% had too low torques.

All elevation drive gear bolts had too low torques.

EISCAT ANTENNA SYSTEM ACCEPTANCE
SODANKYLÄ, FINLAND

The signatures of EISCAT and TIW SYSTEMS designated representatives for each of the antenna system categories listed, indicate completion of the antenna testing and signify acceptance of the antenna system by EISCAT. This signatory sheet, along with the completed acceptance test procedure, TIW-AT-001-1 dated June 1, 1978 and revised as required during the testing, signifies the completion of TIW SYSTEM effort at the Sodankylä installation to EISCAT's satisfaction, except from matters arising which may need attention during the warranty period. All items outstanding along with the agreed-upon methods of dealing with them are indicated under the appropriate category listed and/or in the acceptance test documents.

The following are the four categories of acceptance:

1. Structural and mechanical

Outstanding items:

1) Items which may be revealed by the EISCAT inspection team

EISCAT representative:

Torvald Irgen

TIW SYSTEMS representative:

Reginald T. Wallis

6/23/78

2. Control Systems

Outstanding items:

EISCAT representative:

Torvald Irgen

TIW SYSTEMS representative:

Reginald T. Wallis

6/23/78

3. RF performance

Outstanding items:

2) EISCAT maintenance as well cited in
TII next report

EISCAT representative:

Torsten Aronson

TIW SYSTEMS representative:

Thomas H. Kuecher

11/23/76

4. De-icing system

Outstanding items:

2) TIW will replace all thermal delay relays
with delay times not exceeding 20 sec

EISCAT representative:

Torsten Aronson

TIW SYSTEMS representative:

Thomas H. Kuecher

11/23/76

MEASURED: AE = 313.25
EL = 47.16
COMPUTED: AZ = 312.18
1975-11-19. 0150 EL = 46.16

AE = 313.25
EL = 0.75

T = 736

T_S = 110

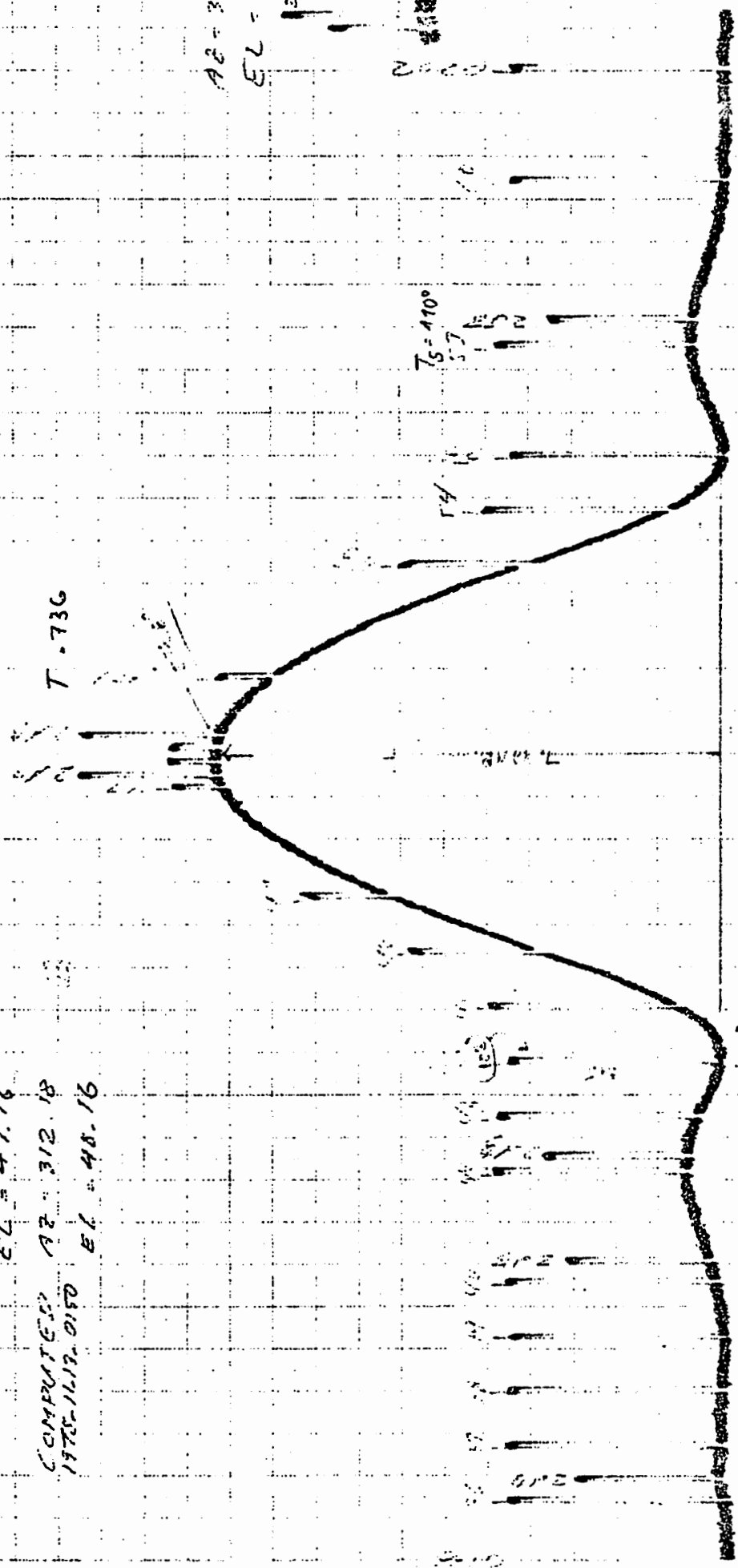
Assume horizontal distance = 1050'

100' FUL
435.5' MHz

295 A
TR01950

13 NOV 1978

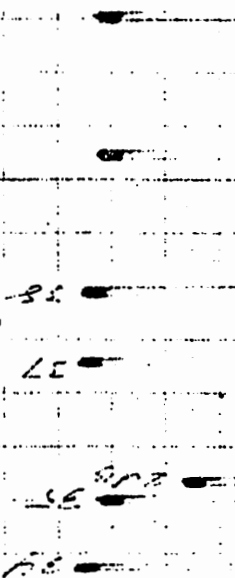
0195 - 0203 UT



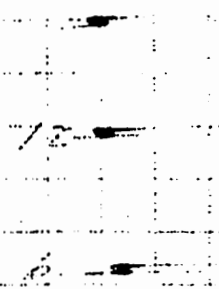
INDICATED ME = 317.96
 EL = 44.81
 COMPUTED ME = 318.91
 02 NOV 13 NOV 78
 EL = 45.72

HOLE = 1
 49 2-0636
 613

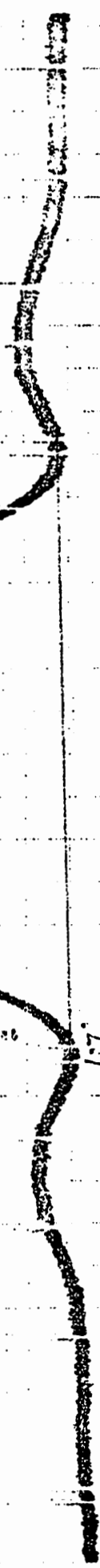
Ts=106



17. 57.2 3.86
 15. 14. 13.



57.2



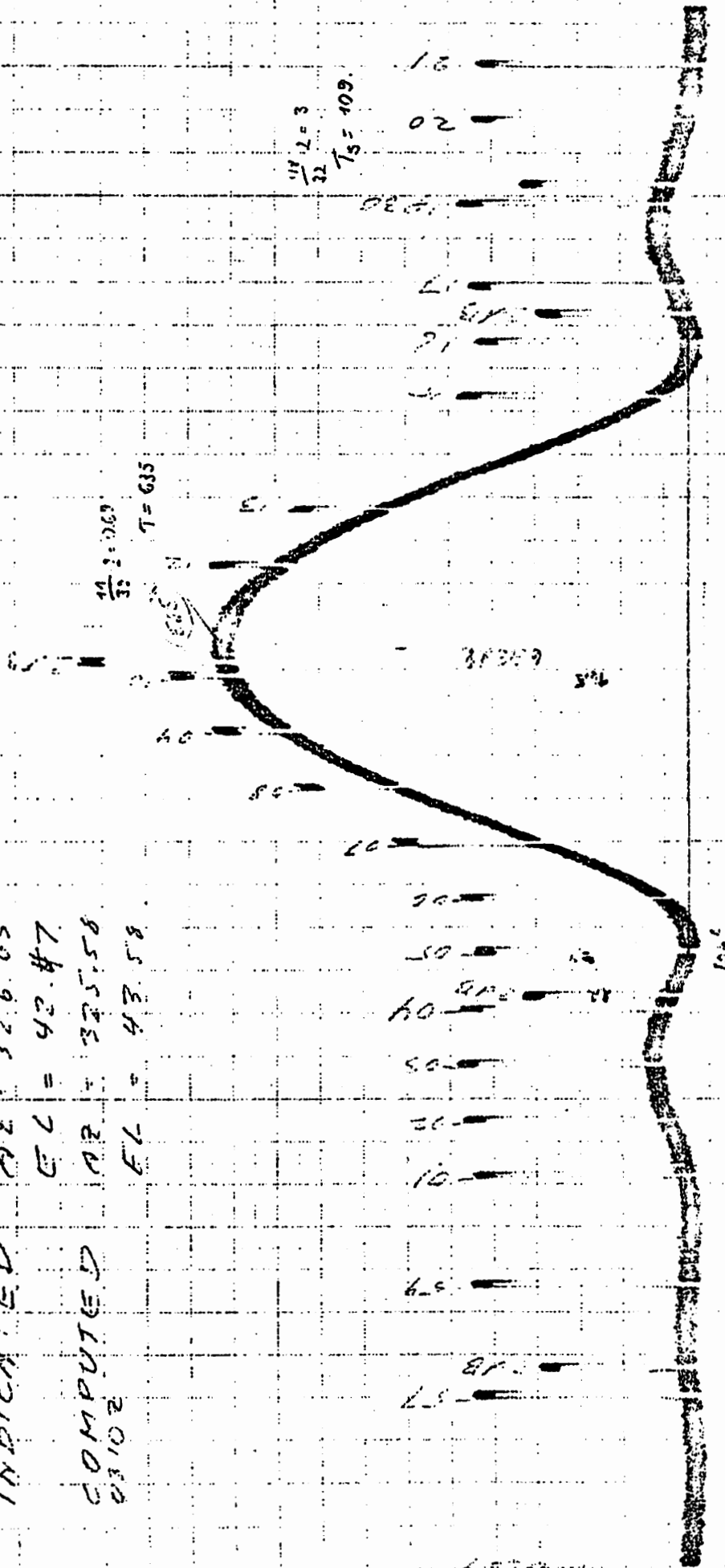
CAS A
 TRONSO
 935.5 MHz
 13 NOV 1978
 0215-0343Z
 NOR POL

12.550 ST

3

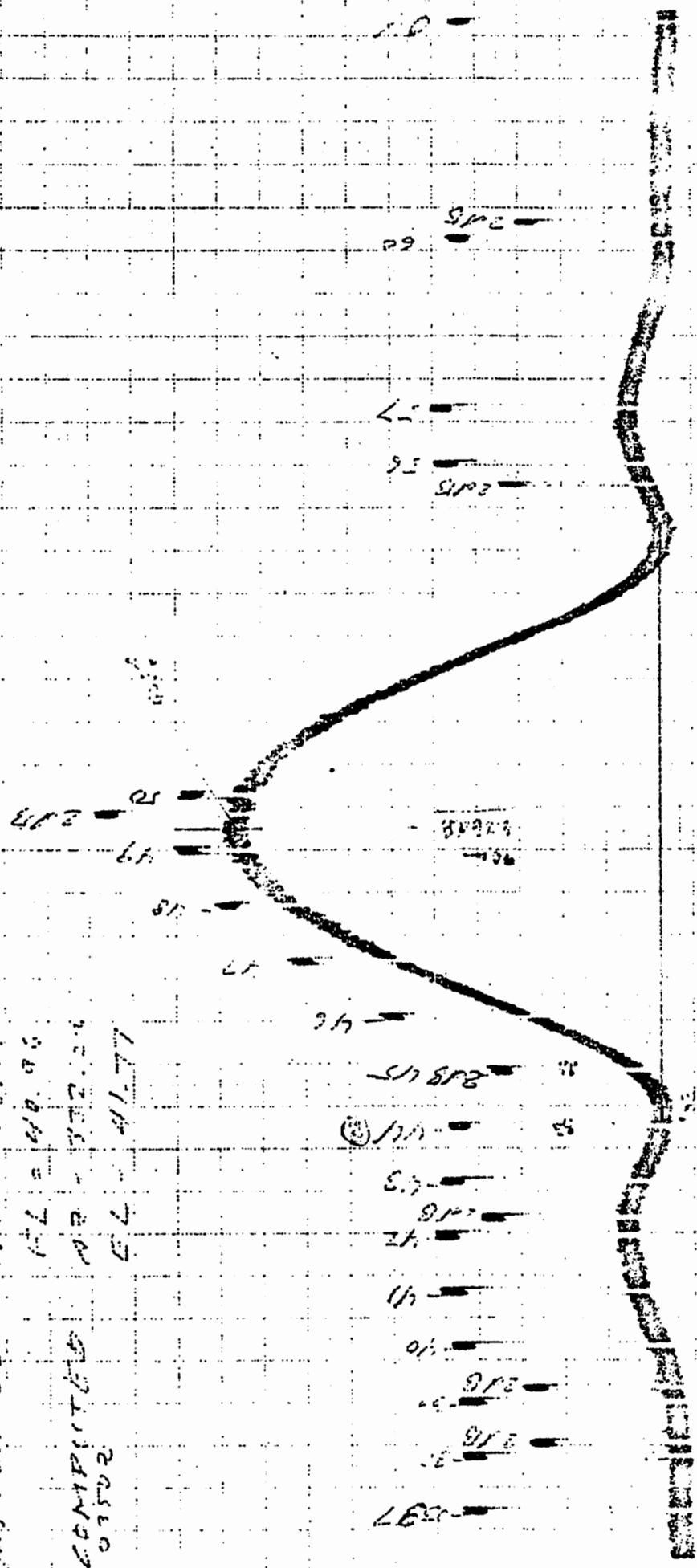
INDICATED AR = 326.65
 EL = 42.47
 COMPUTED AR = 325.58
 EL = 43.58

$\frac{14}{32} \times 12 = 3$
 $T_s = 109.$



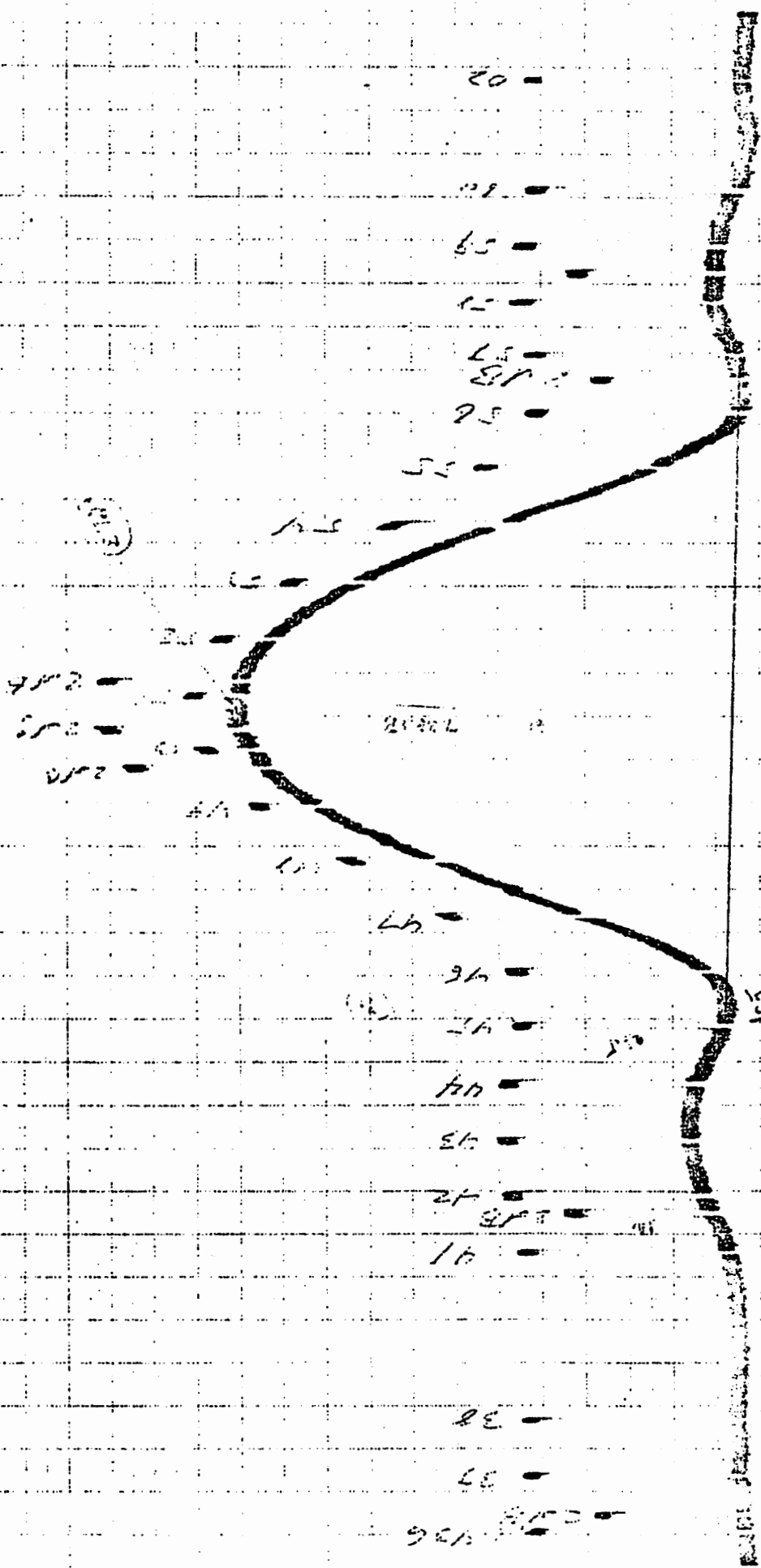
140R POL
 935.5 MHZ
 CHS A
 TRM50
 17 NOV 1978
 0254 - 0322

INDICATED
 07502
 COMPUTED
 07502
 02 = 333.04
 01 = 400.00
 02 = 332.20
 01 = 411.77



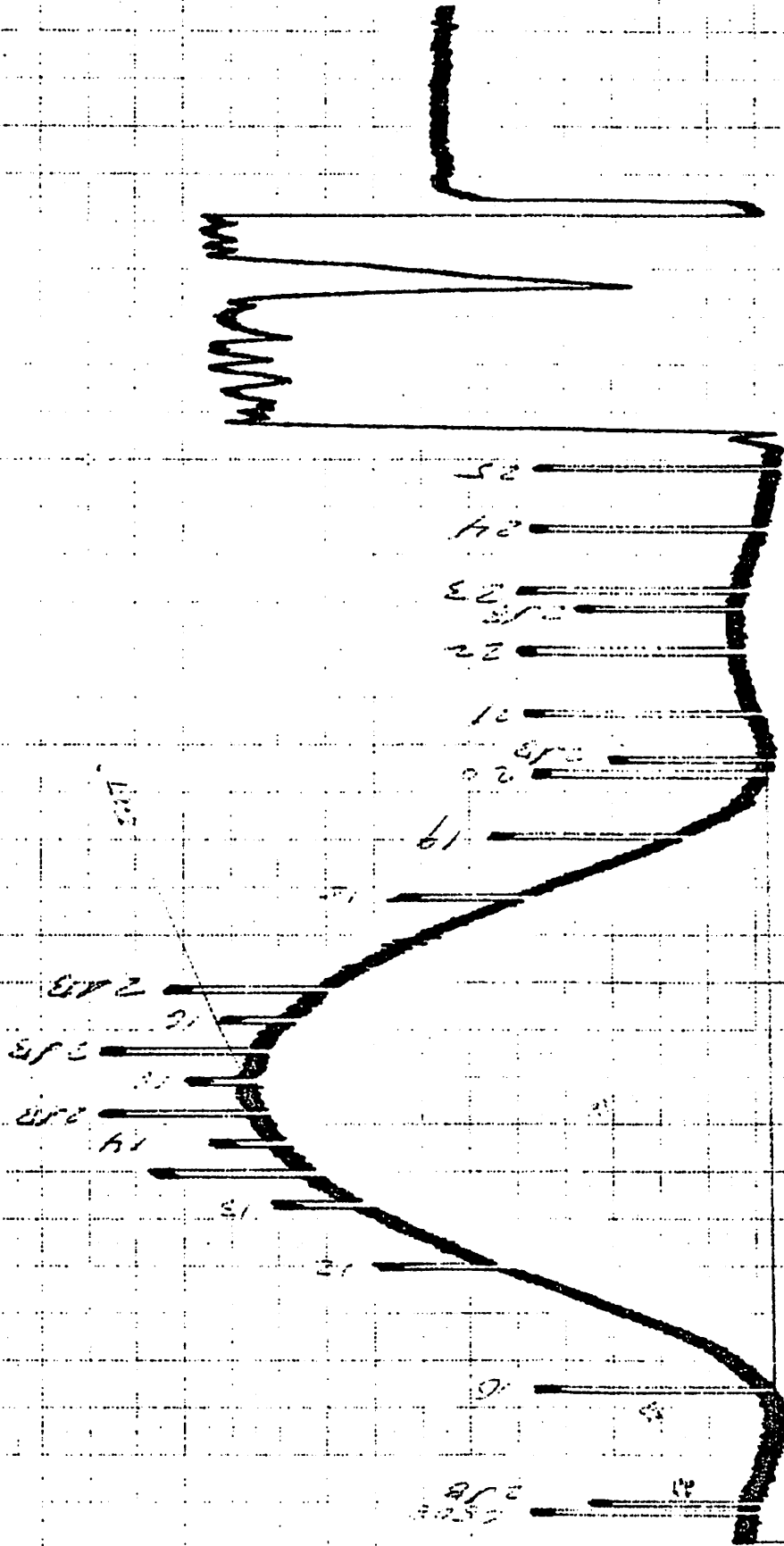
WEST MINE
 015 A
 INCOMED
 13 NOV 1971
 ONE PAGE
 HOK POL

5



CAS A -
 TROMSO
 22.5.57
 11. NOV 78
 HOK VOL

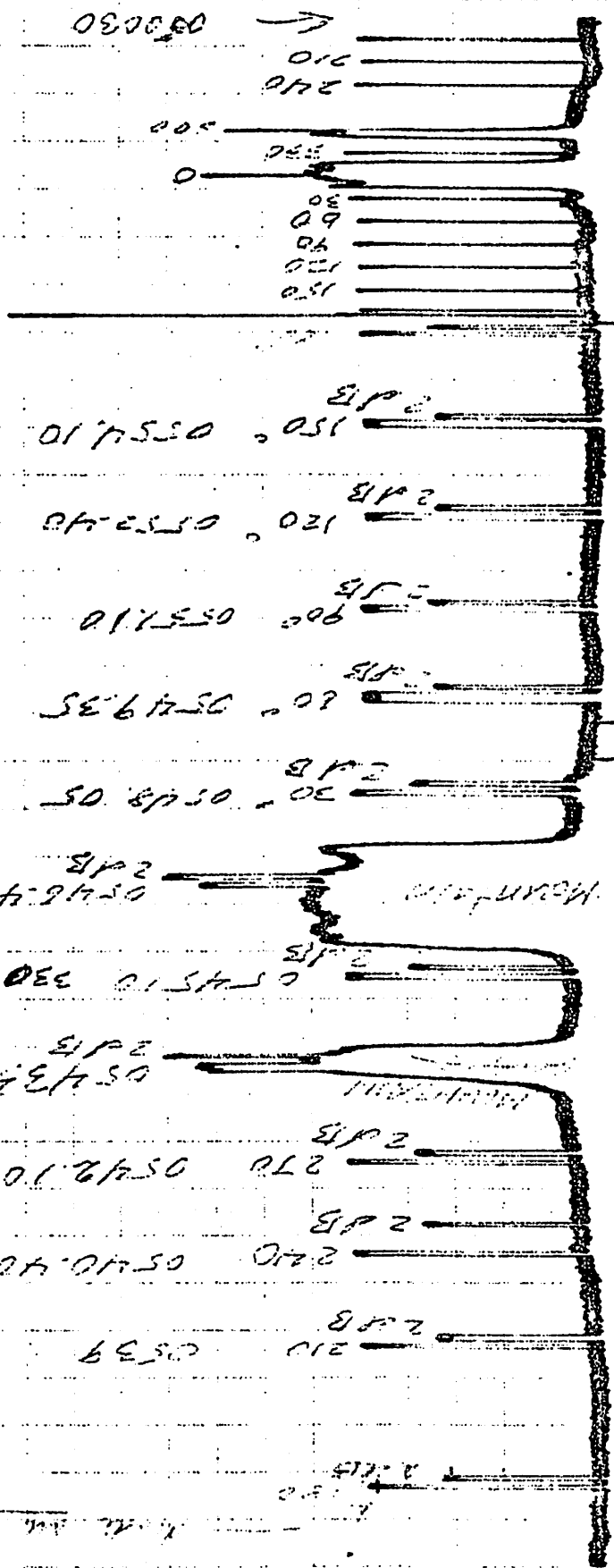
9



$\Delta A_2 = -1.01$
 $\Delta E_L = 0.99$
 HOR. POL

①

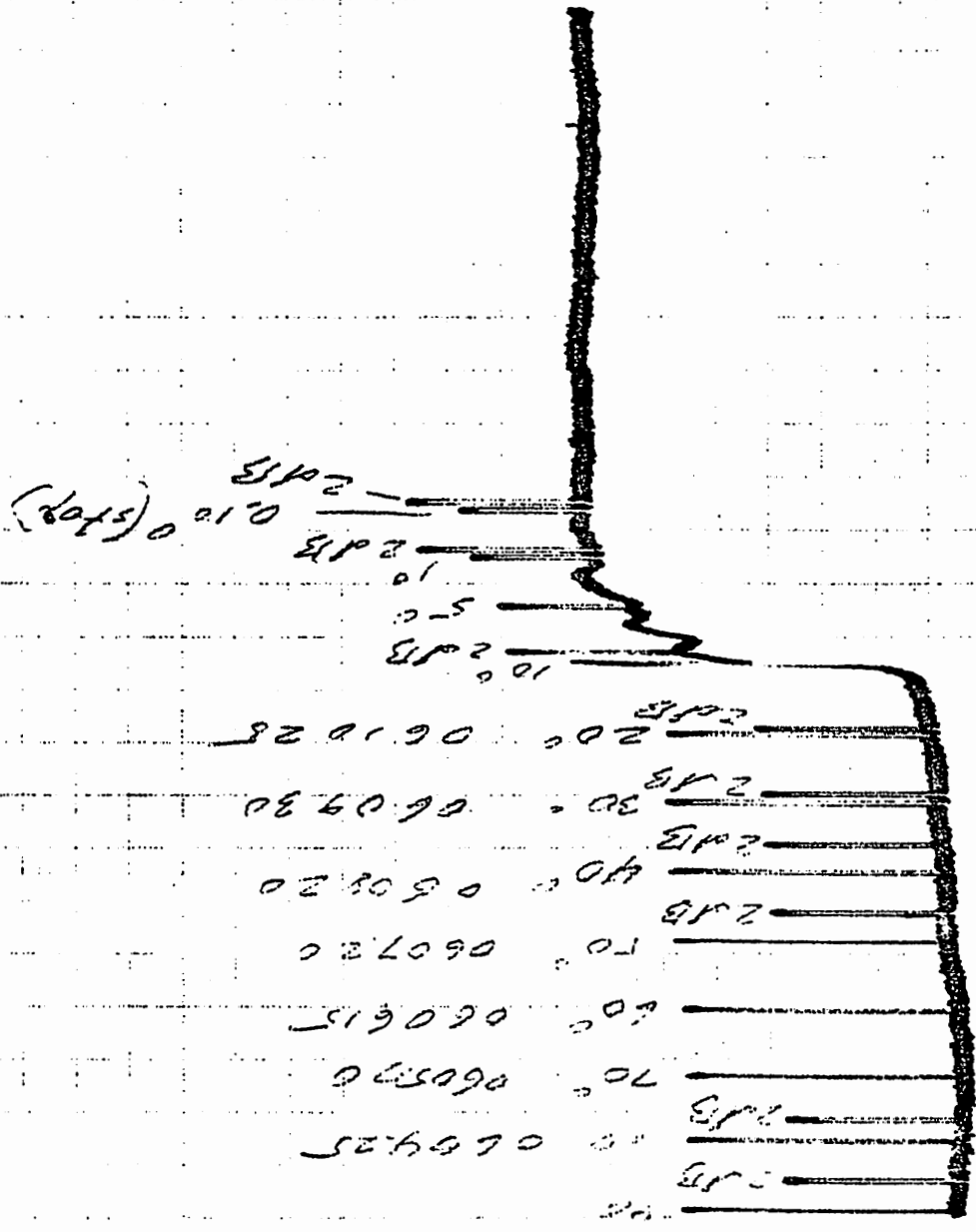
WIND
REPORT



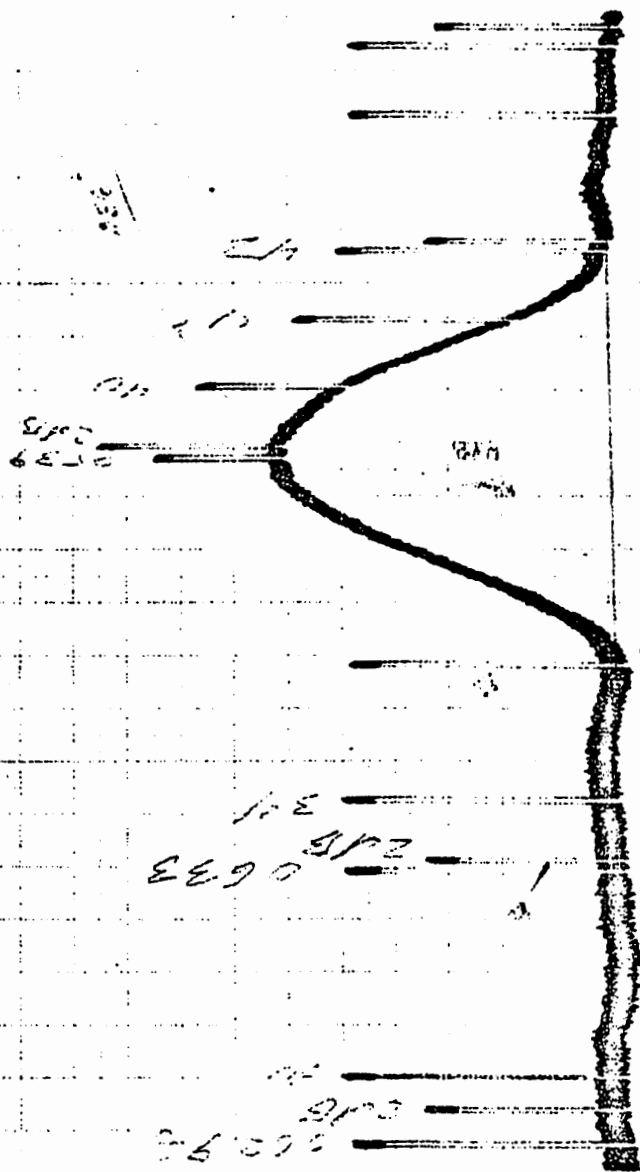
AZIMUTH SCAN
ELEV 15°
13 NOV 1978
1100:40Z

(00)

2511 3361



elevation scarp
 B2 = 1700
 13 NOV 1970
 HOR. PCL
 TRC 454



TAU A
TROMSØ
13 NOV -78
435.5 MHz
110K- FIDL
Tromsø

9)



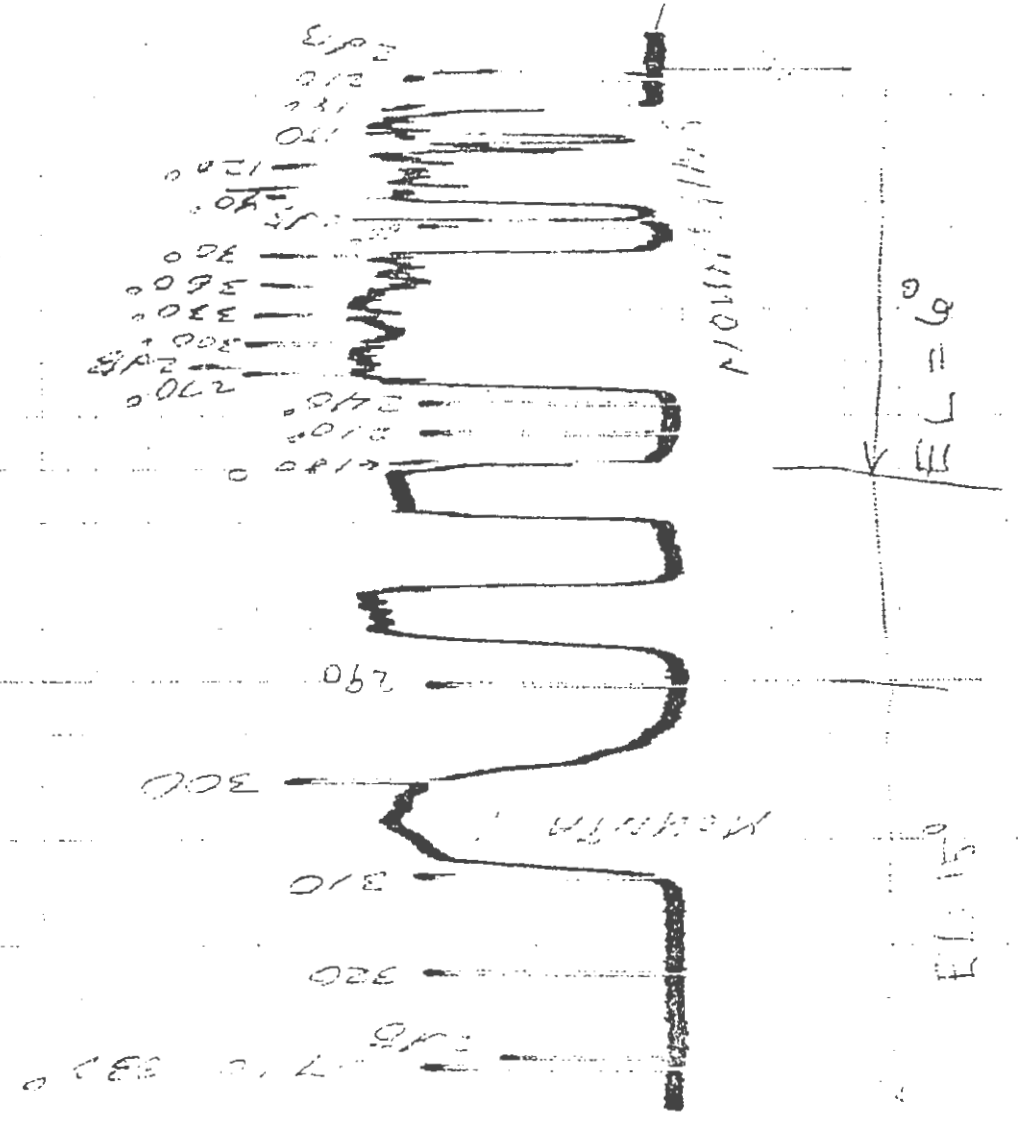
CYB A
 TRACKING
 435.5 MHz
 HOR. POL.
 13 NOV 1978

(11)

123 NOV 1978

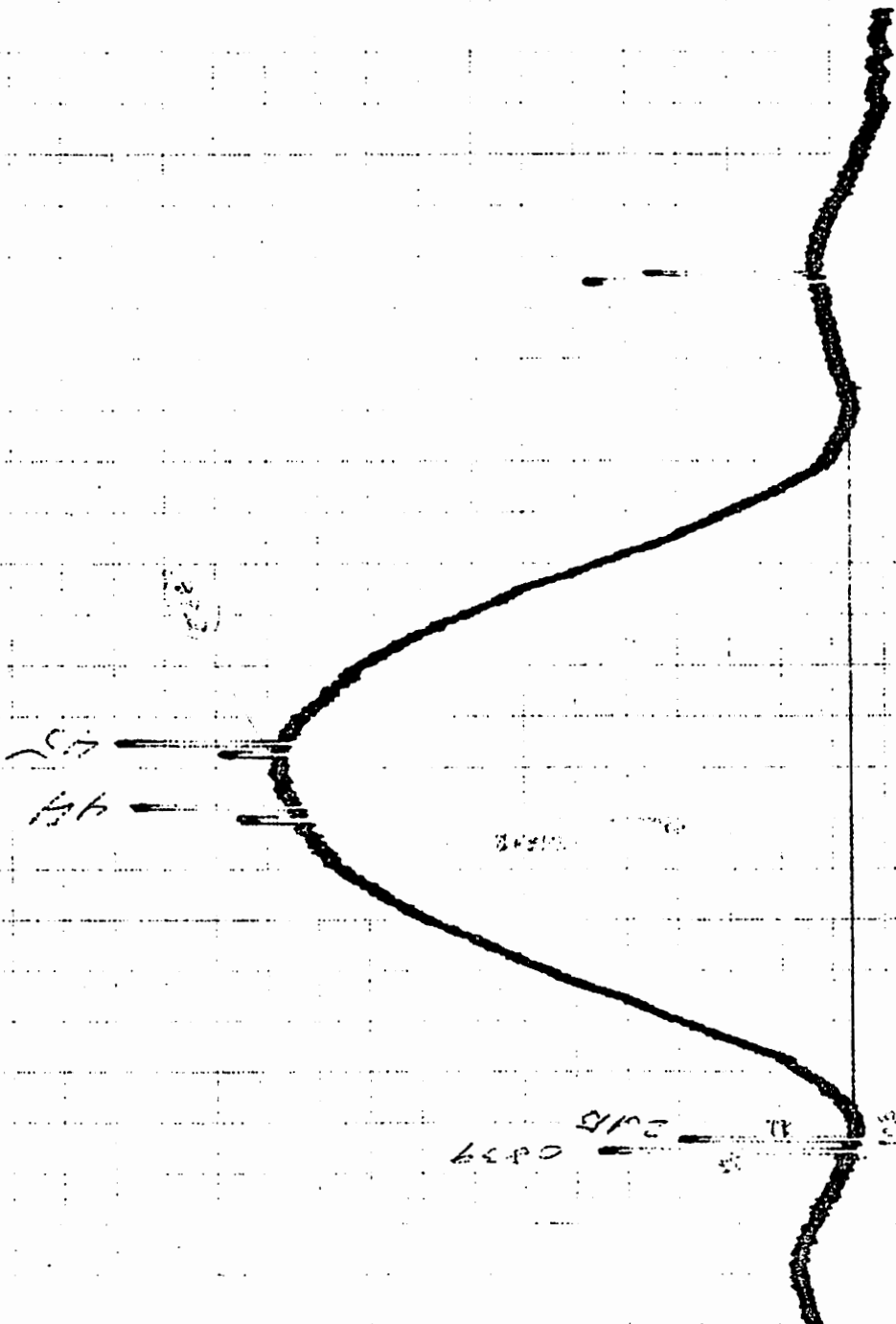
0733Z

17-8-77



12

CAS. A
HOR POL
973.5
TKOMSO
13 NOV 1978



13

SHEET 1

SC 1454

VER.

933.5 MHz

EL = 7.61 deg

EL. OFFSET = 0.0 deg

Diagram 13.

dB

0

-10

-20

-30

-40

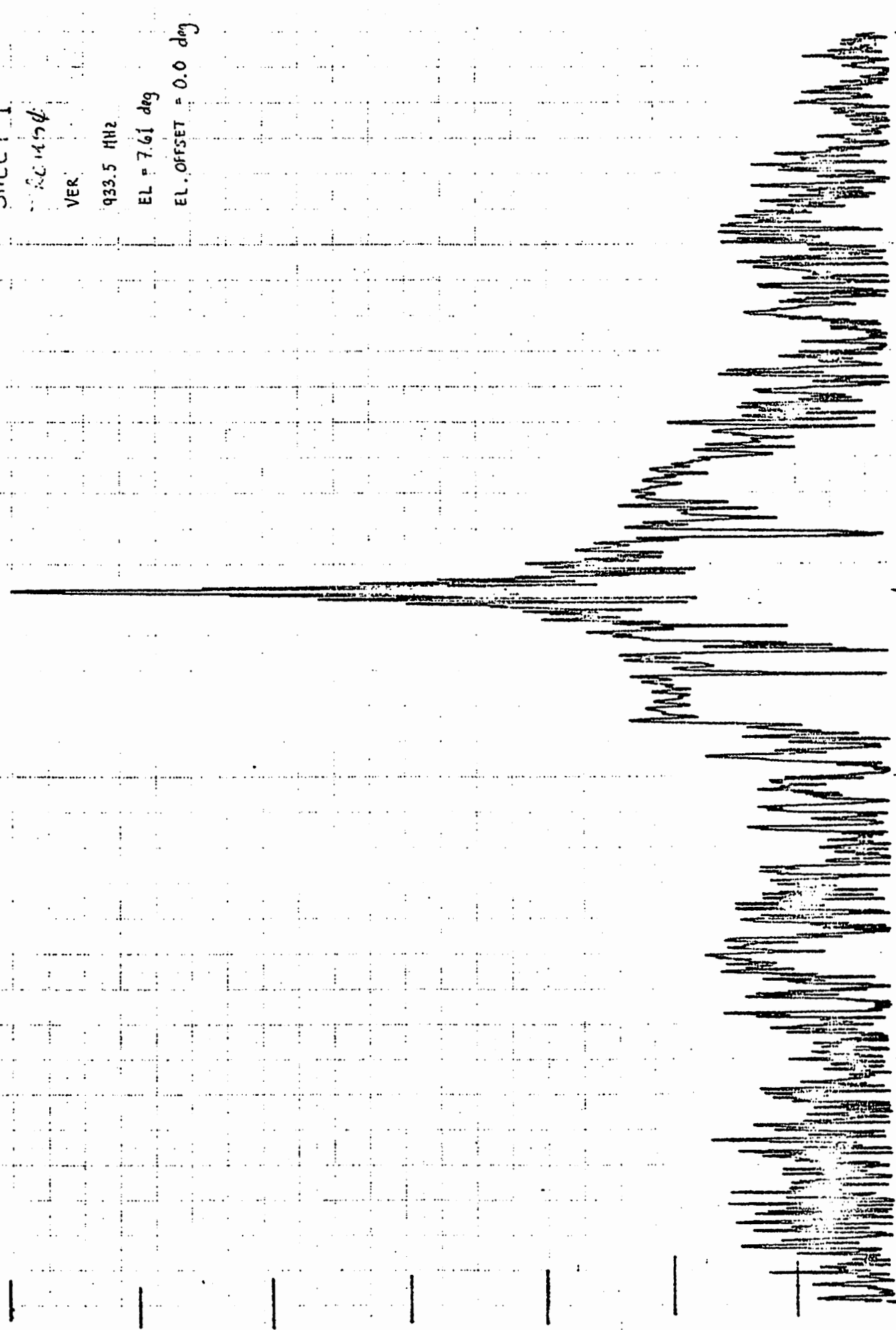
-50

-60

AZ 250 deg

97.2 deg

270 deg



(14)

SHEET 2

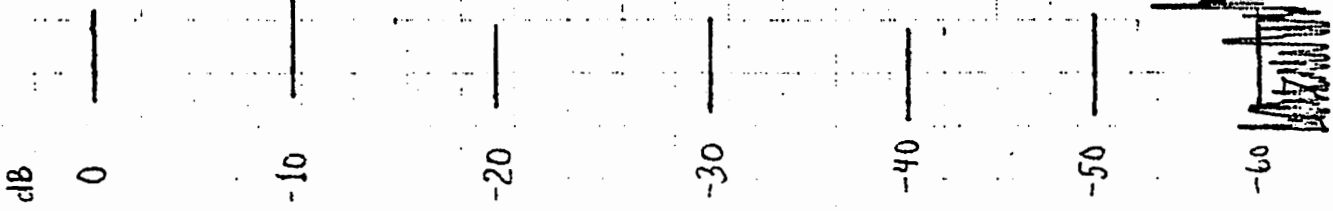
VER

943.5 MHz

EL = 7.61 deg

EL. OFFSET = 0.0 deg

Diagram 14.



15

SHEET 3

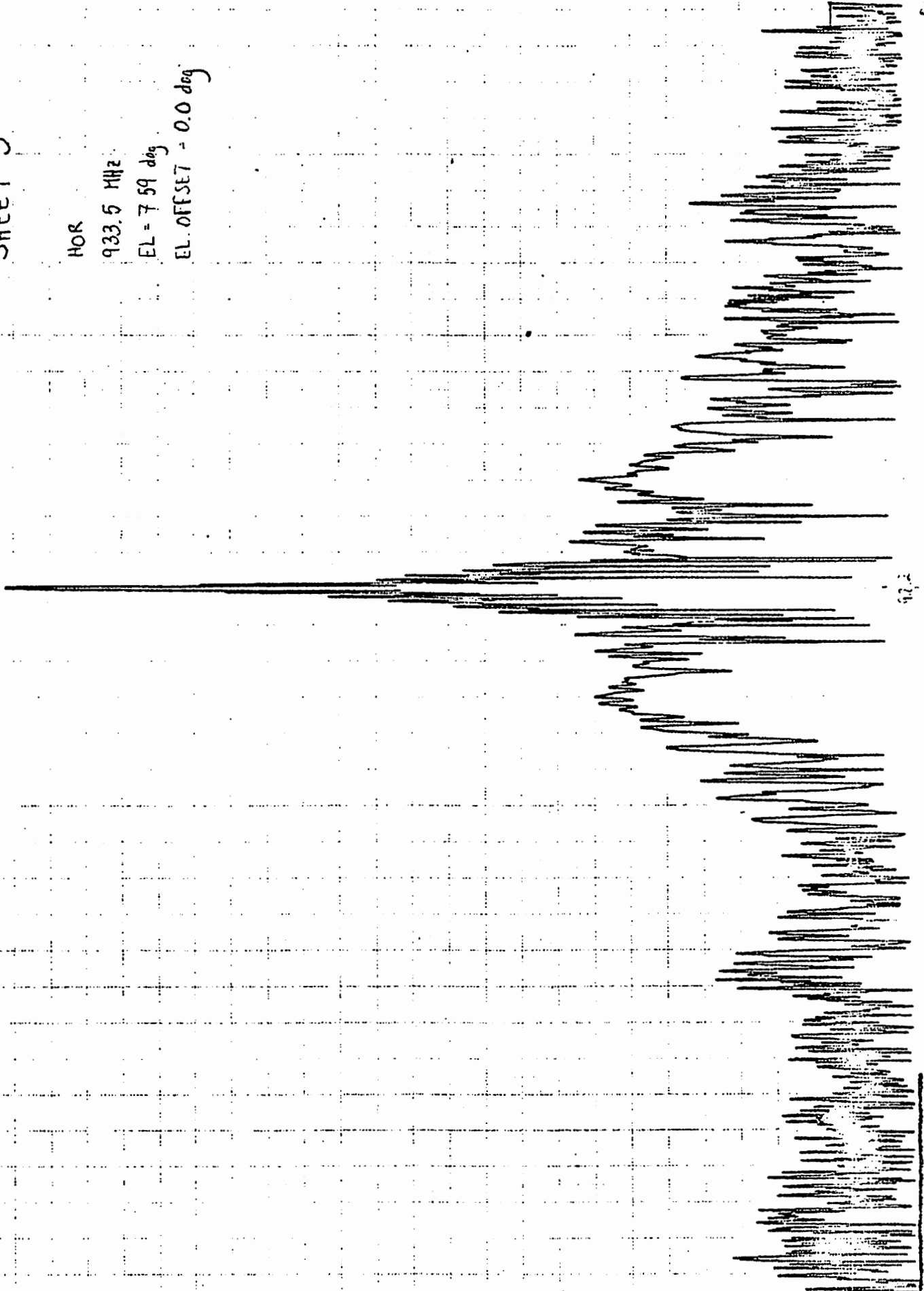
HOR

933.5 MHz

EL = 7.59 deg

EL OFFSET = 0.0 deg

dB
0
-10
-20
-30
-40
-50
-60
-70



16

SHEET 4

HOR

943.5 MHz

EL = 7.61 deg

EL OFFSET 0.0 deg

dB

0

-10

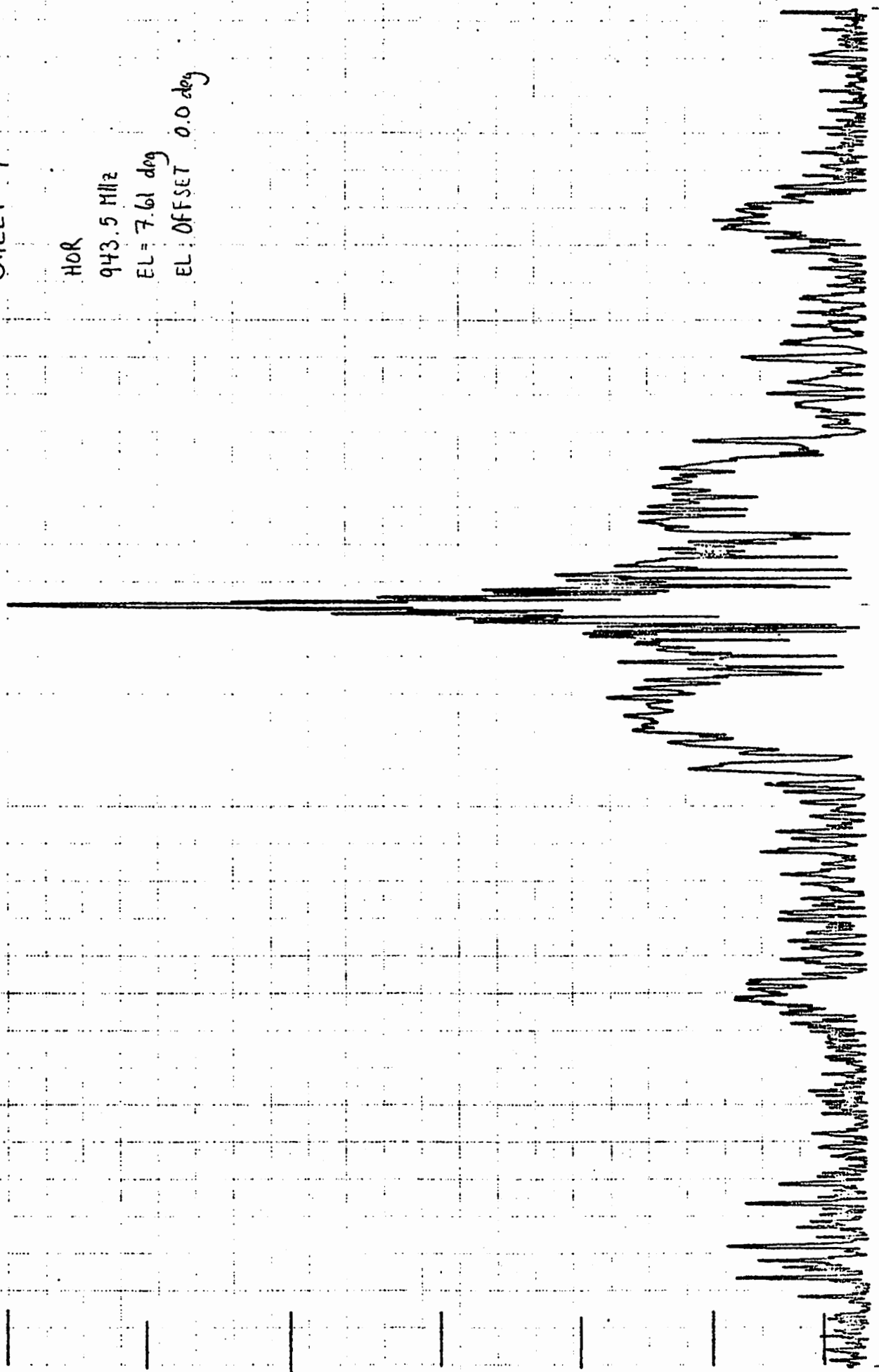
-20

-30

-40

-50

-60



A2 250

16.2

750 deg

(17)

SHEET 5

VER

933.5 MHz

EL = 7.62 deg

EL OFFSET = 0.0 deg

dB

0

-10

-20

-30

-40

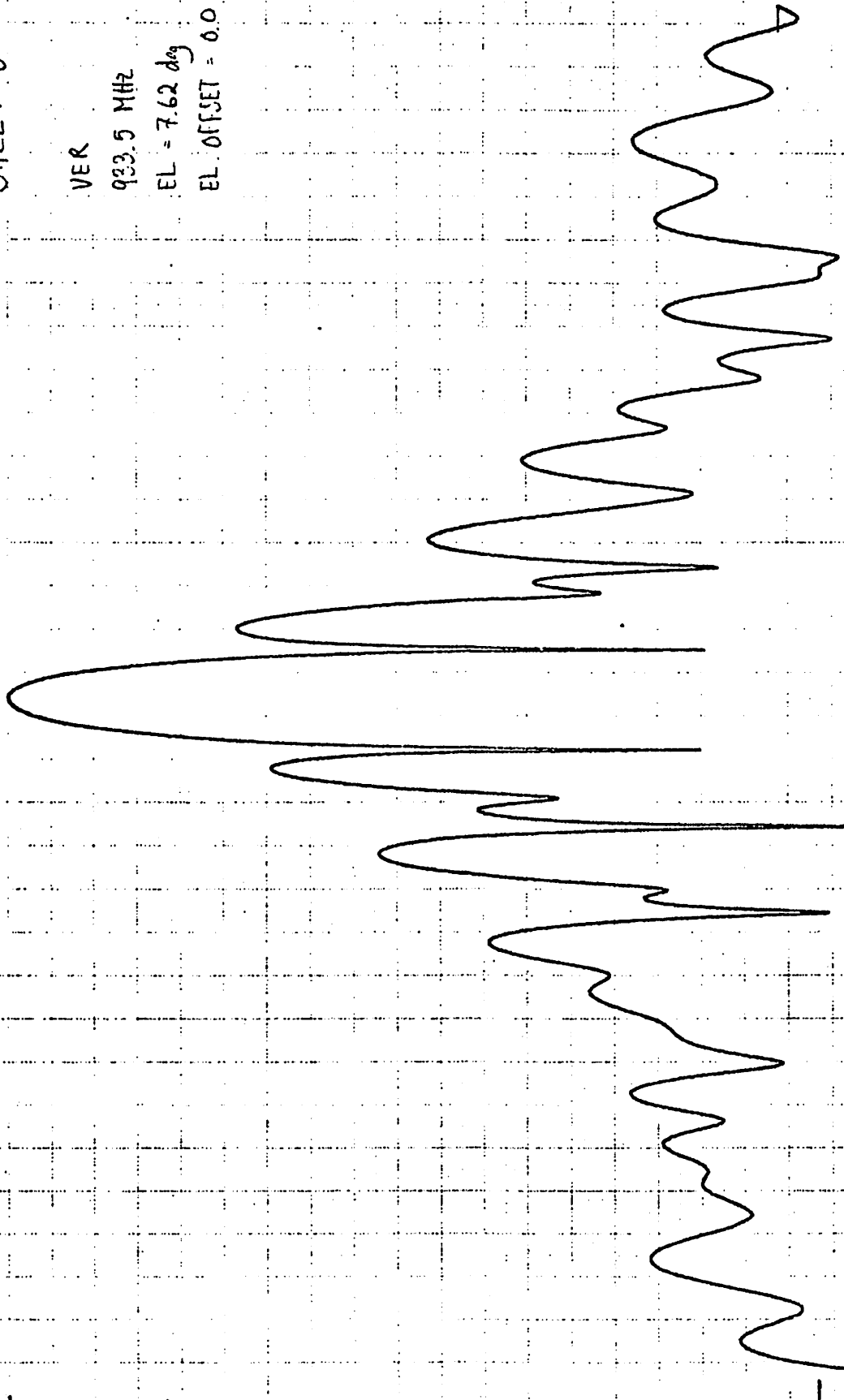
-50

-60

A7 82

92 2

102 deg



A7 82

92 2

102 deg

(18)

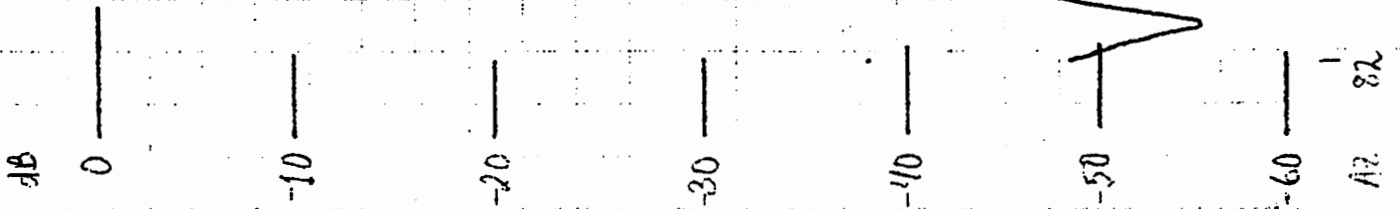
SHEET 6

VER.

933.5 MHz

EL = 7.82 deg

EL. OFFSET = 0.2 deg



102 deg

98.2

Az 82

(14)

SHEET 7

VER

933.5 MHz

EL = 8.02 deg

EL. OFFSET = 0.4 deg

dB

0

-10

-20

-30

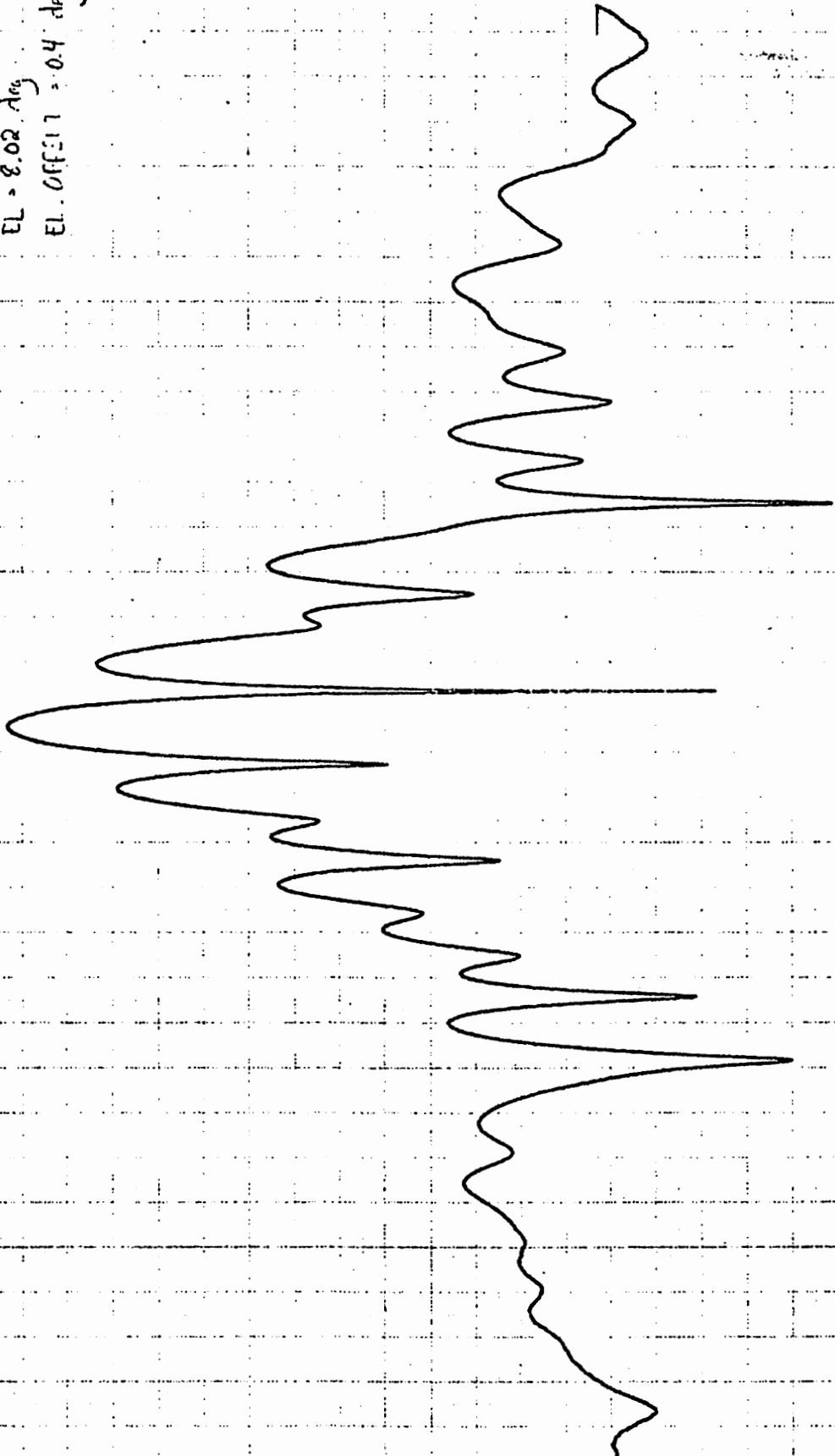
-40

-50

-60

02

EL



102.2

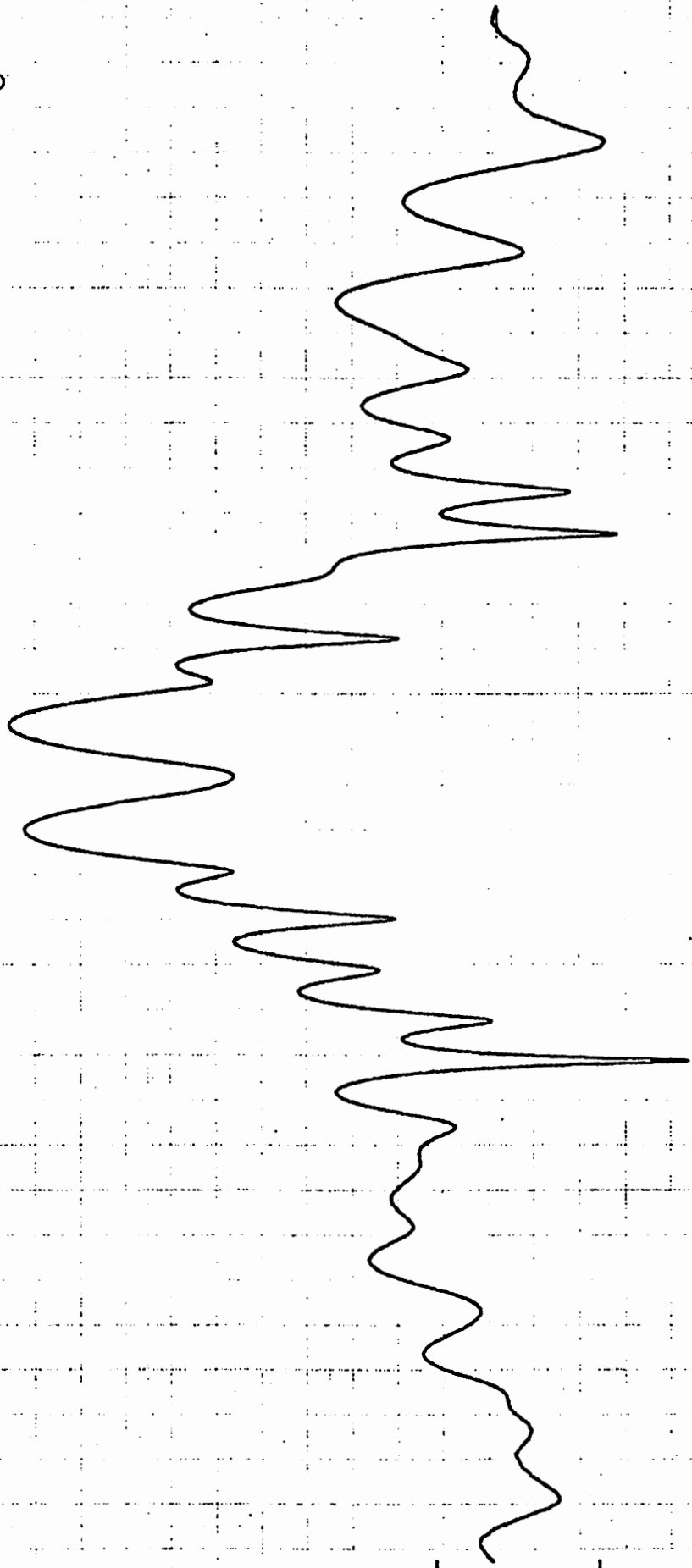
102 MHz

(12)

SHEET 8

VER
933.5 MHZ
EL: 8 22 deg
EL OFFSET = 0.6 deg

dB
0
-10
-20
-30
-40
-50
-60



AZ 22

(21)

SHEET 9

VER

933.5 MHz

EL = 8.4 deg

EL. OFFSET = 0.8 deg

dB

0

-10

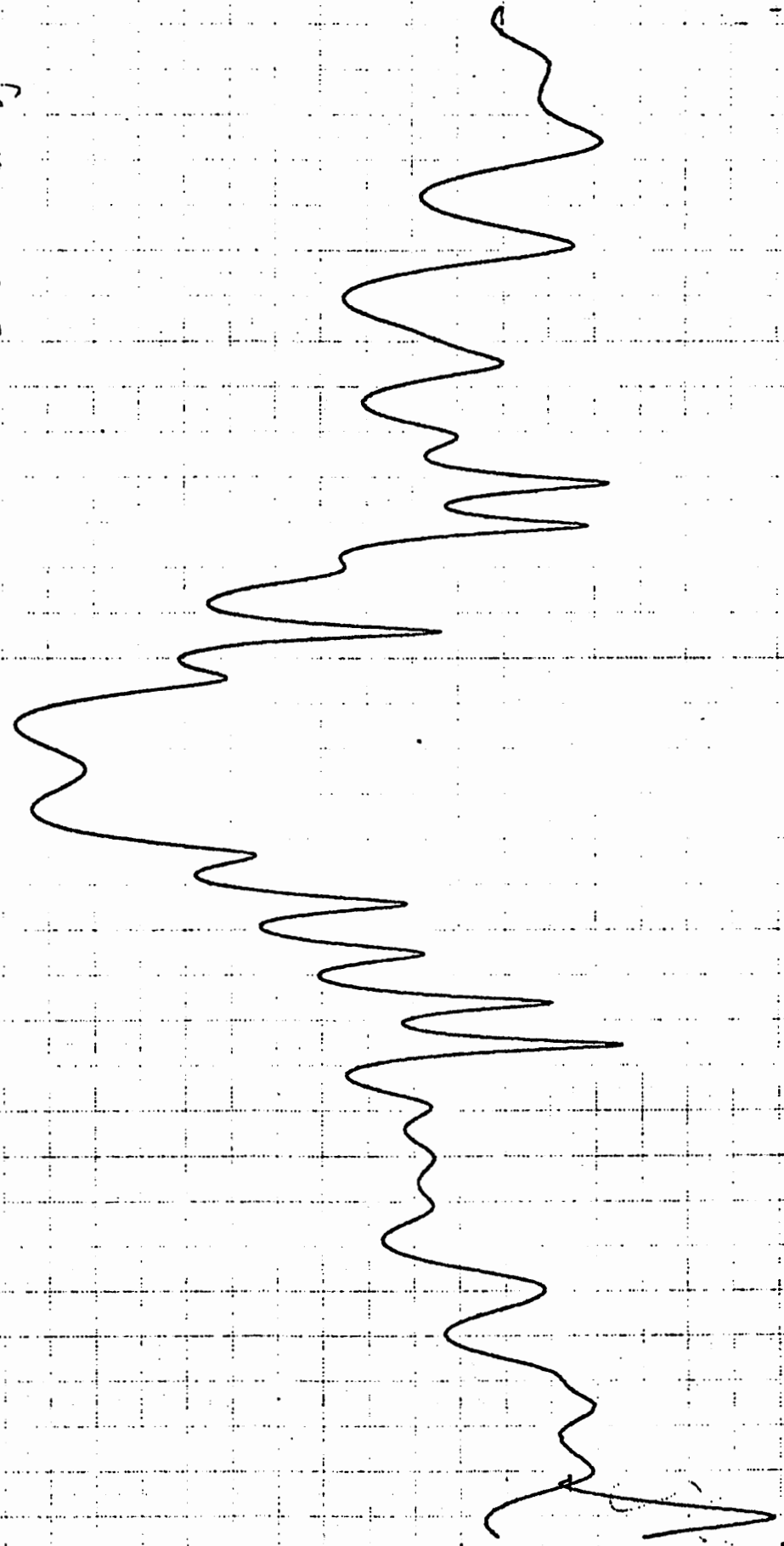
-20

-30

-40

-50

-60



102 deg

(11)

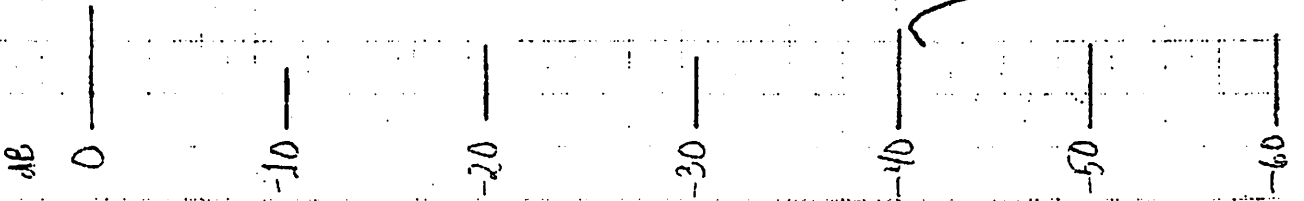
SHEET 10

VER

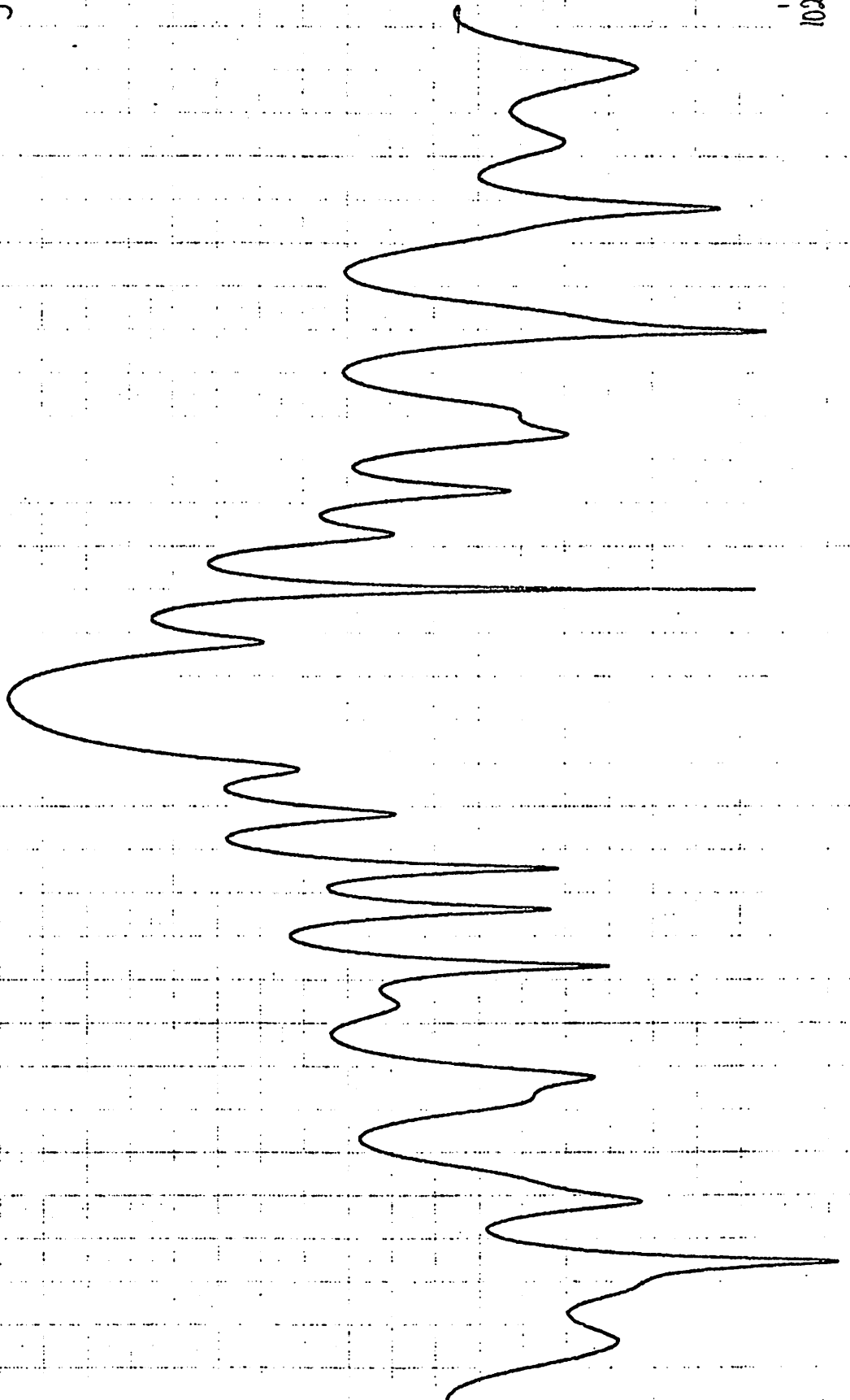
933.5 MHz

LI = 8.62 deg

EL. OFFSET = 1.0 deg



112 82



102 deg

SHEET 11

(13)

VER

933.5 MHz

EL. - 8.82 deg

EL. OFFSET - 1.2 deg

dB

0

-10

-20

-30

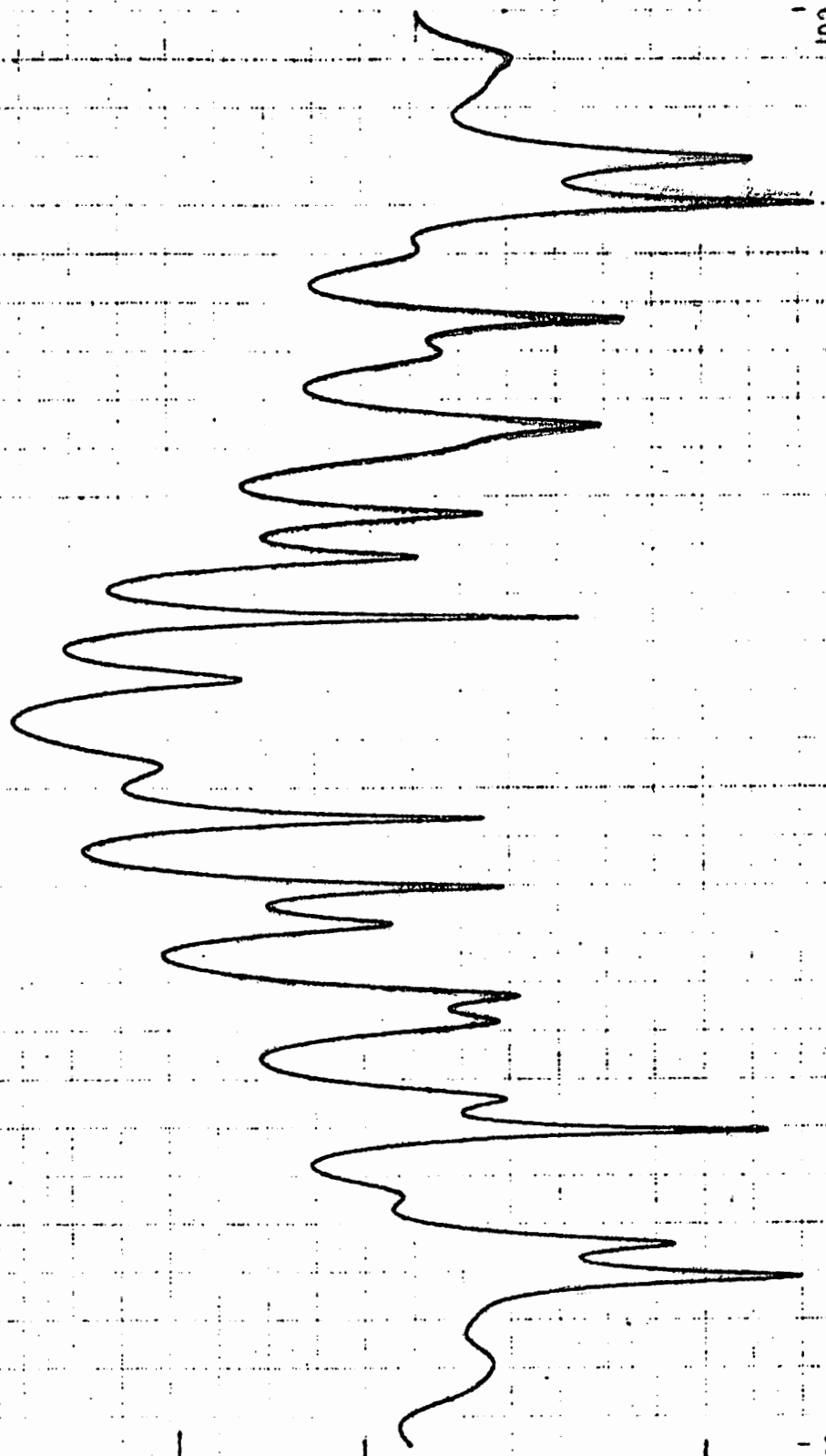
-40

-50

-60

AZ 82

102 deg



dB

0

-10

-20

-30

-40

-50

-60

A2

82

SHEET 12

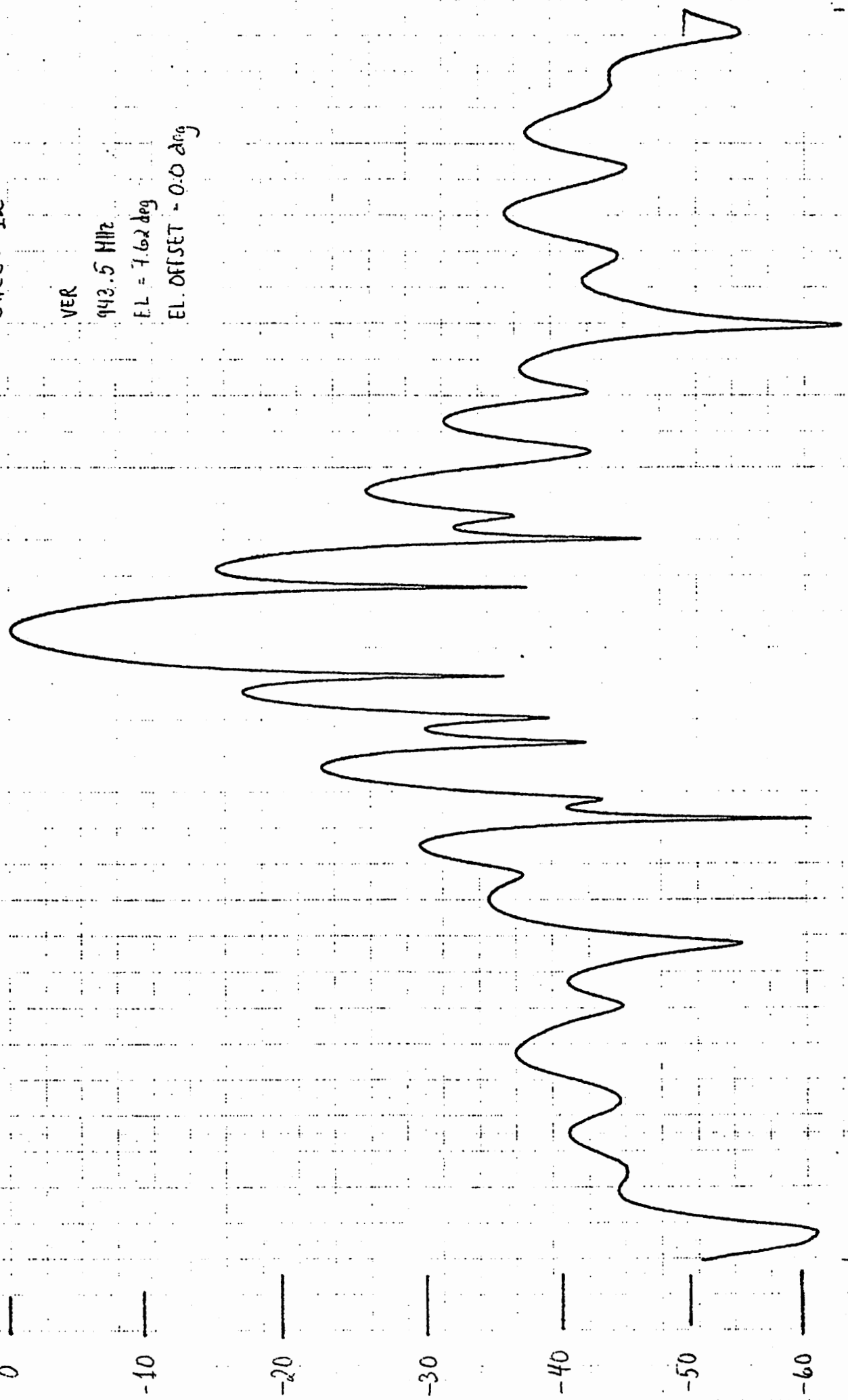
VER

942.5 MHz

FL = 7.62 deg

EL. OFFSET = 0.0 deg

Diagram 24. 102



SHEET 13

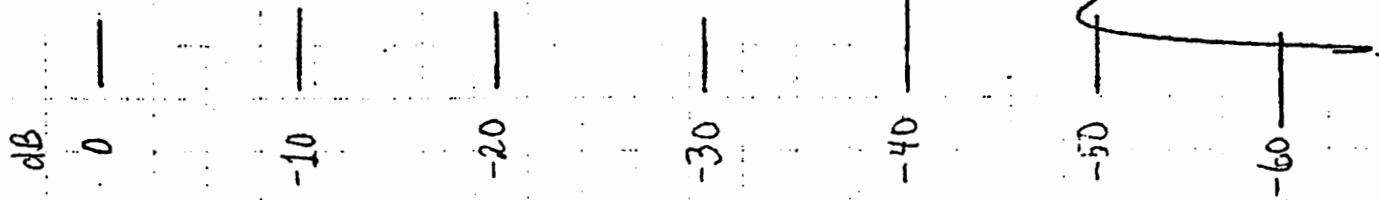
(25)

HOR

933.5 MHz

EL = 7.62 deg

EL OFFSET = 0.0 deg



SHEET 14

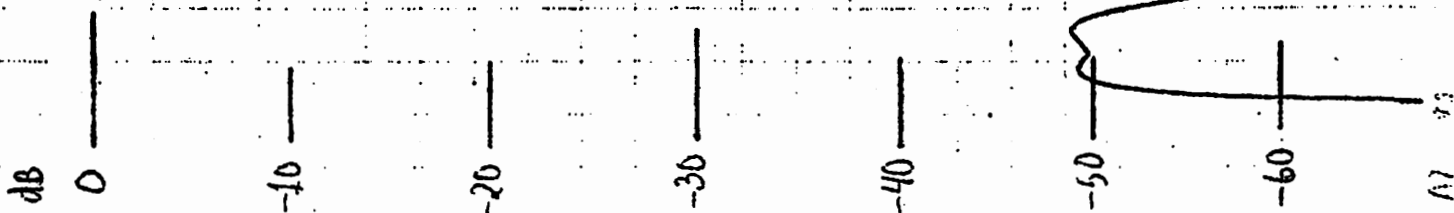
26

HOR

922.5 MHz

EL = 7.82 deg

EL OFFSET = 0.2 deg



MHz

dB

(17)

SHEET 15

HOR

933.5 MHz

EL = 8.02 deg

EL OFFSET = 0.4 deg

dB

0 —

-10 —

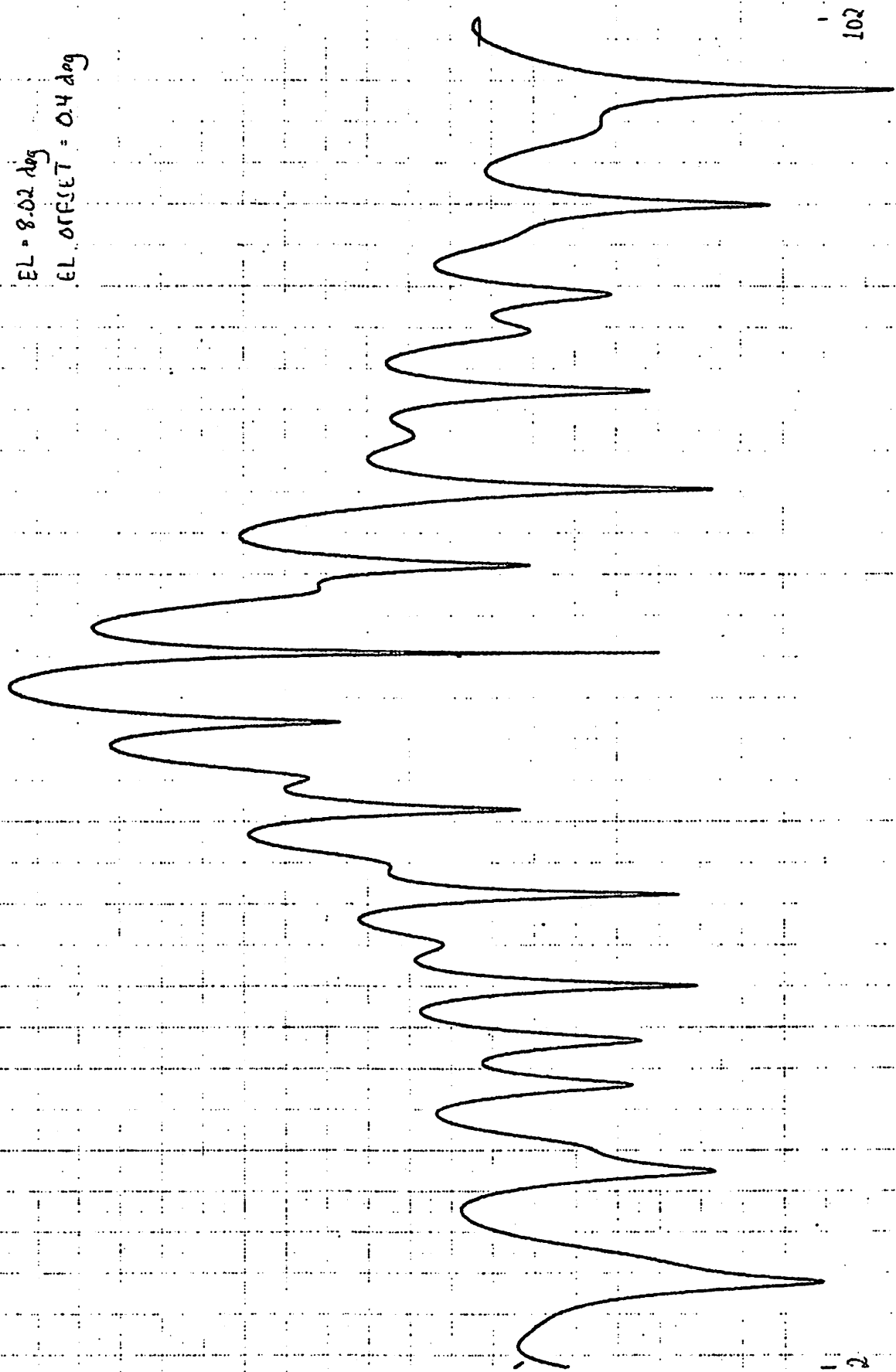
-20 —

-30 —

-40 —

-50 —

-60 —



AZ 82

102 deg

26

SHEET 16

HOR

933.5 MHz

EL = 8.20 deg

EL OFFSET = 0.6 deg

dB

0 —

-10 —

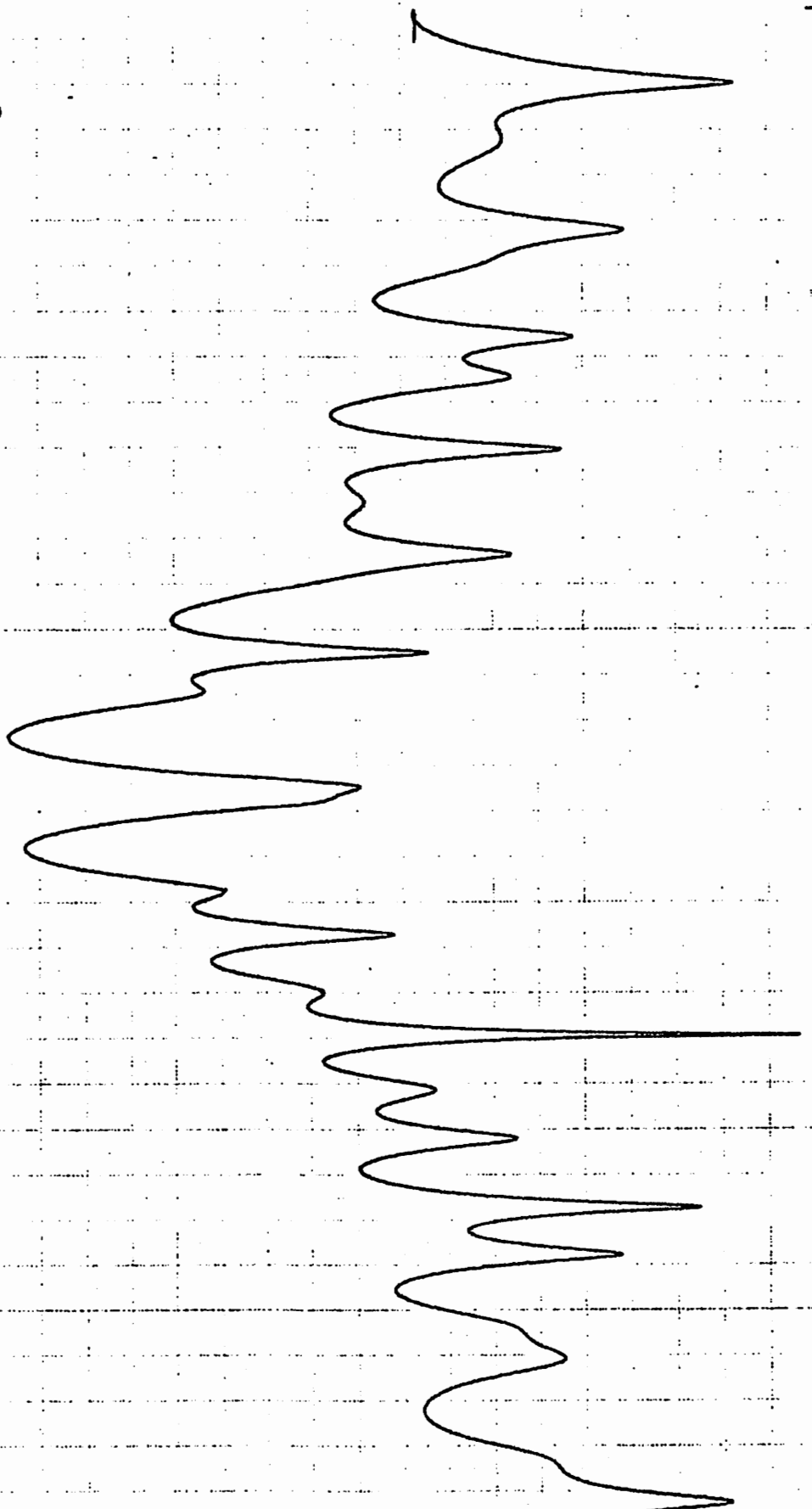
-20 —

-30 —

-40 —

-50 —

-60 —



102 deg

17 22

(29)

SHEET 17

NOR

933.5 MHz

EL = 8.41 deg

EL. OFFSET = 0.8 deg

dB

0

-10

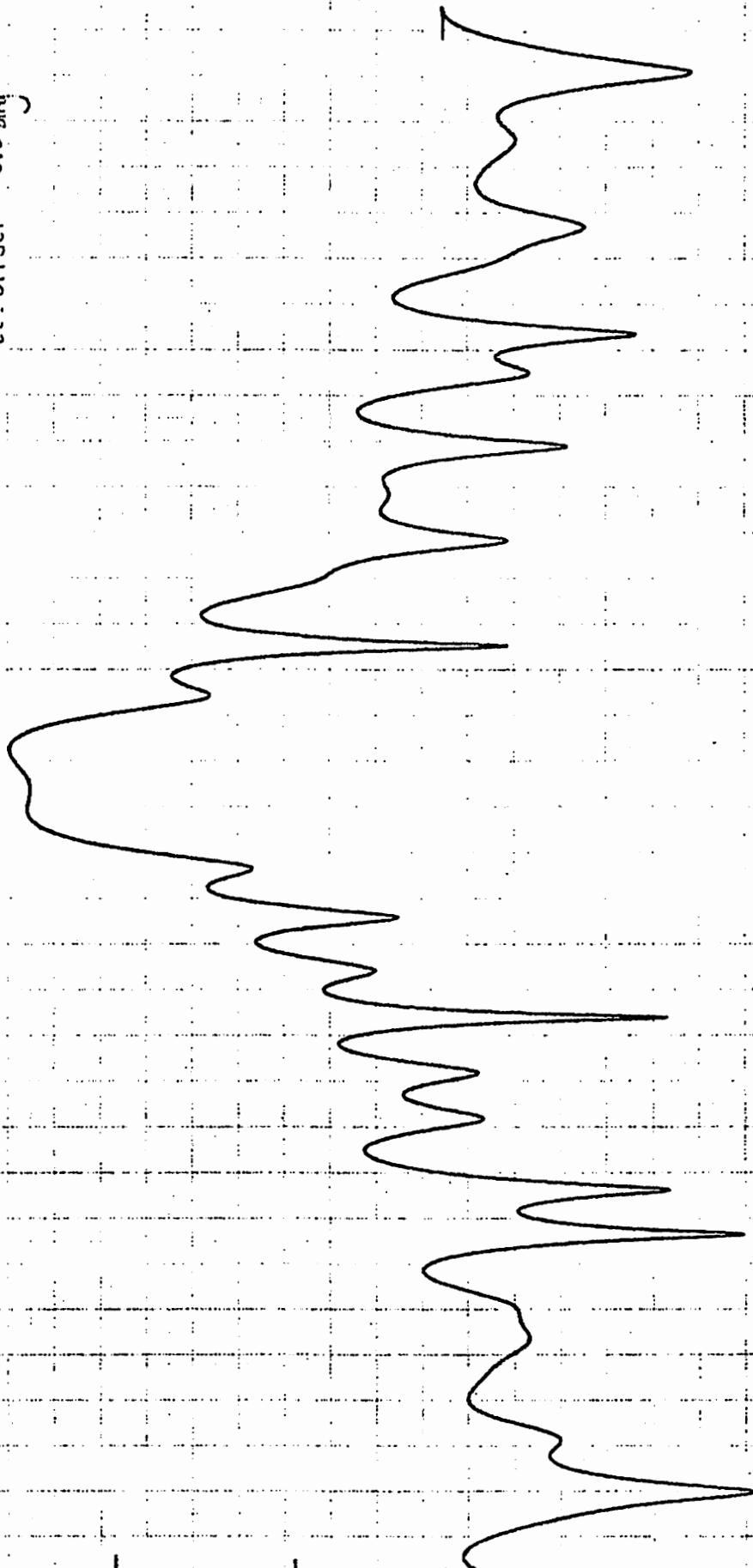
-20

-30

-40

-50

-60



102 deg

211 82

dB
0
-10
-20
-30
-40
-50
-60

SHEET 18

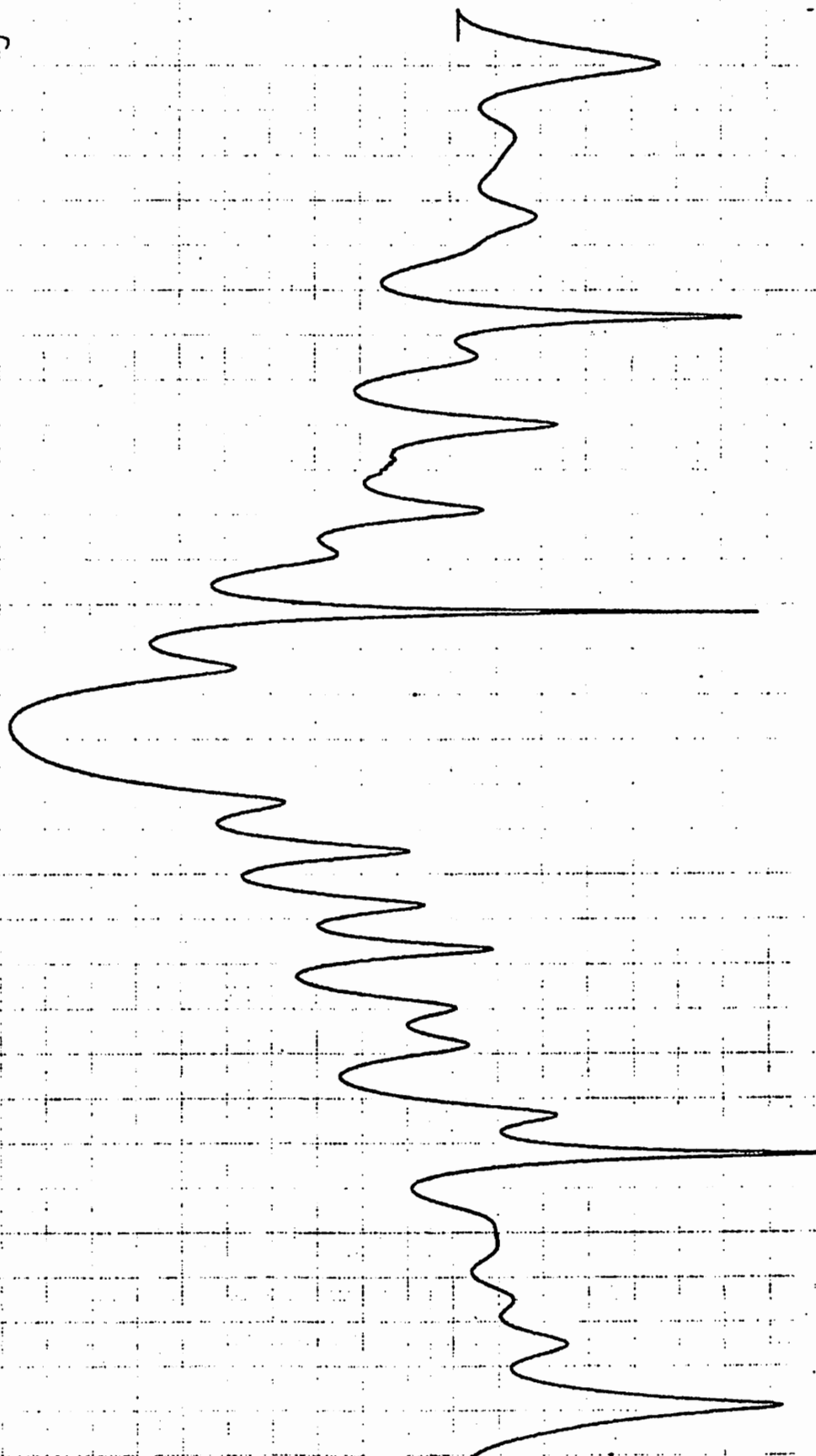
50

HOK

422.5 MHz

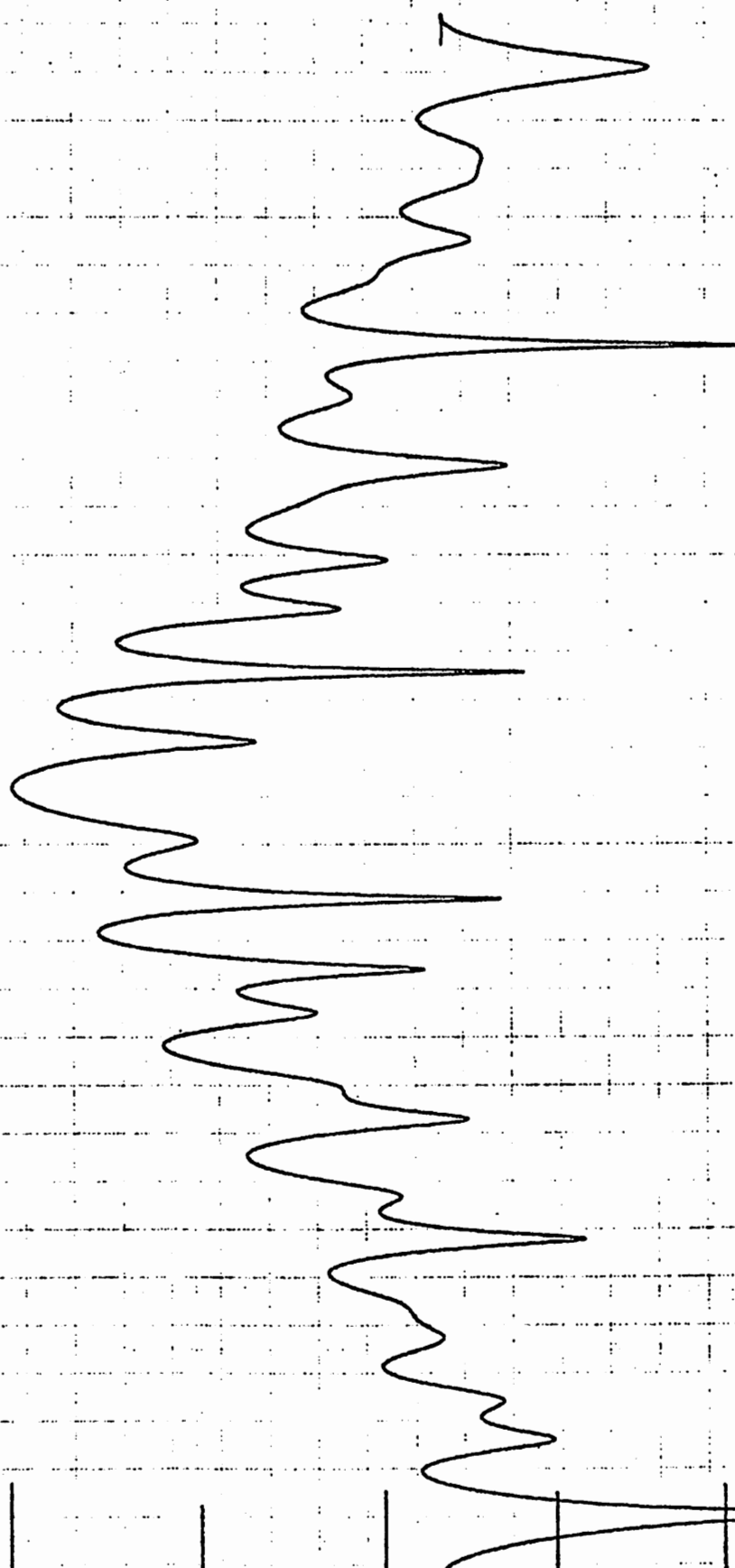
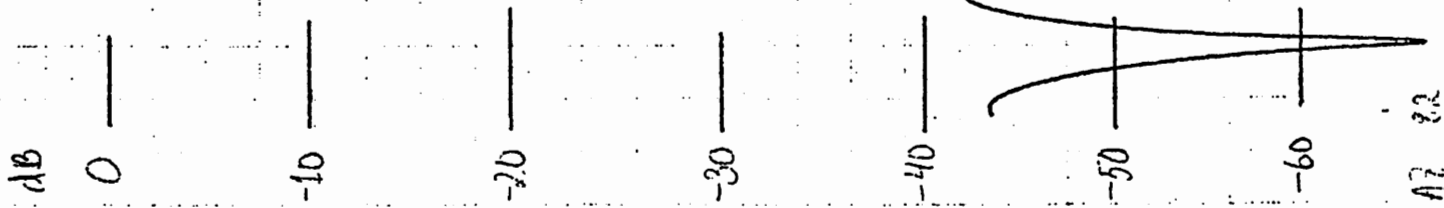
EL = 8.62 deg

EL. OFFSET = 1.0 deg



SHEET 19 (31)

HOR
939.5 MHz
EL = 7.81 deg
EL. OFFSET = 1.2 deg



100 deg

A7 22

100 deg

32

SHEET 20

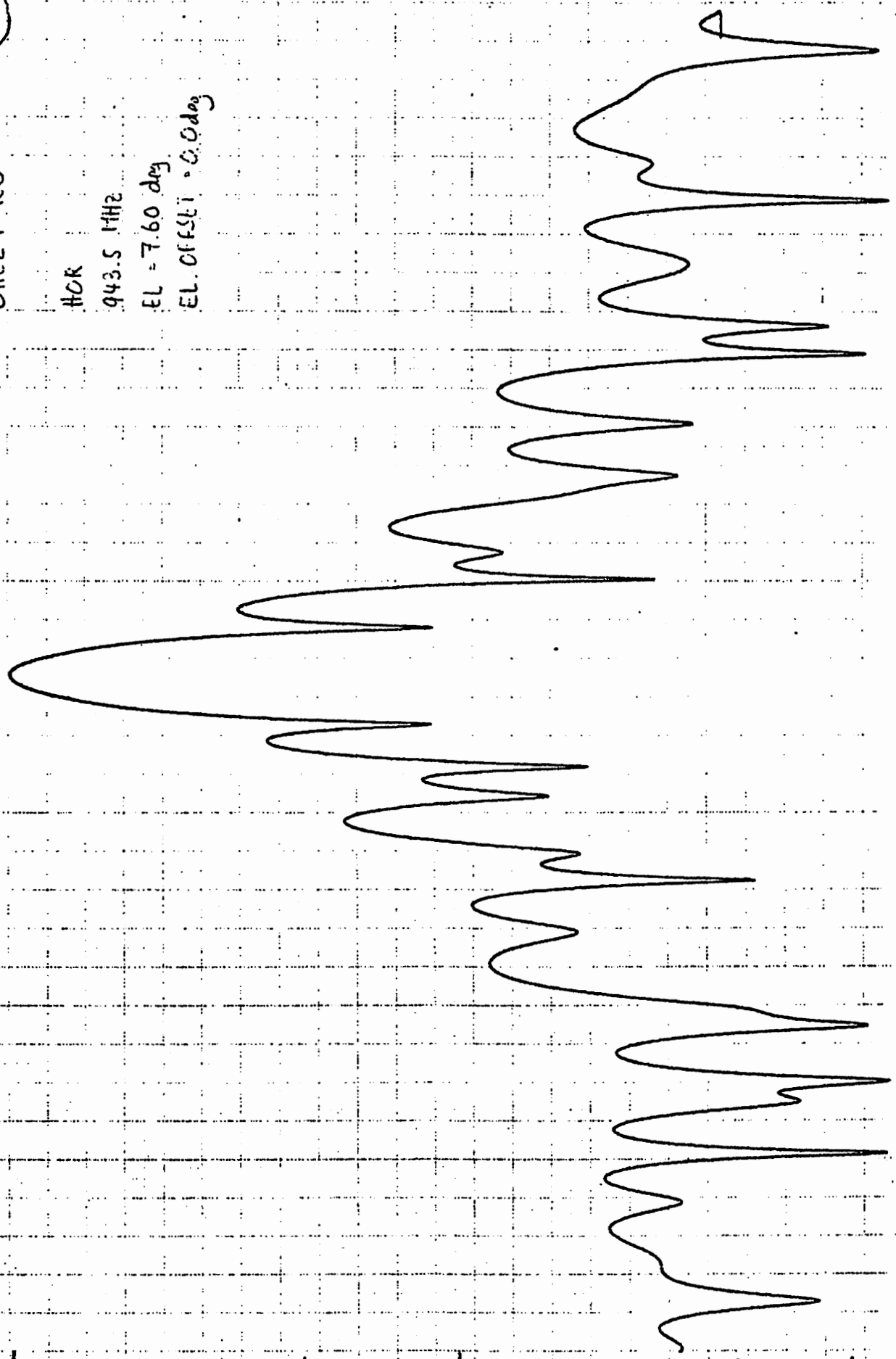
HOK

943.5 MHz

EL = 7.60 deg

EL. OFFSET = 0.0 deg

dB 0 -10 -20 -30 -40 -50 -60 A7 82



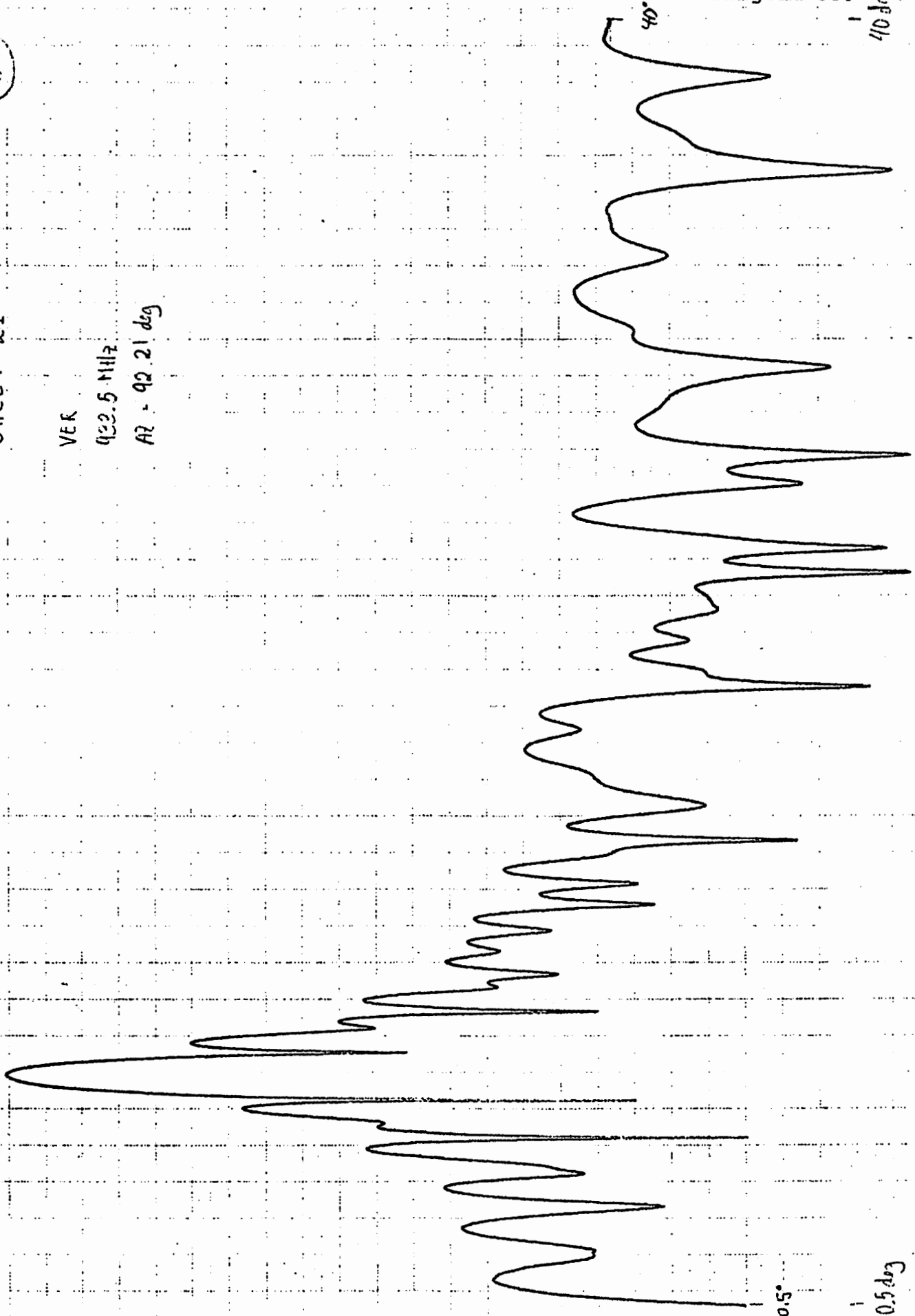
33

SHEET 21

VER
122.5 MHz
AZ - 92.21 deg

Diagram 33.
40 dB

dB
0
-10
-20
-30
-40
-50
-60



EL 0.5 deg

SHEET 22

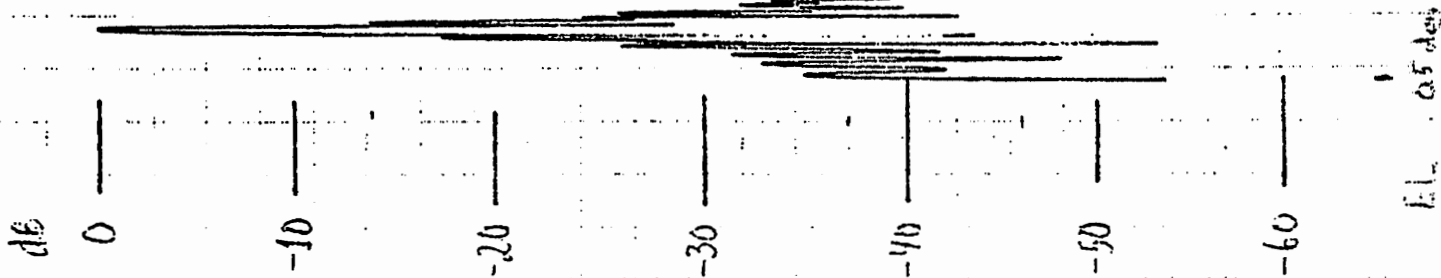
(39)

VER

933.5 MHz

AZ = 272.21 deg

AZ = 92.21 deg



EL = 0.5 deg

deg

deg

deg

SHEET 23

35

VER

922.5 MHz

EL = 29.65 deg

EL OFFSET = 22.02 deg

Max. of lobe for EL = 90.24 deg and
polarization parallel to leg, e.g.

$R = -2.5 \text{ dB}$

PHASE = 0.0 deg

Max. of lobe for EL = 90.66 deg and

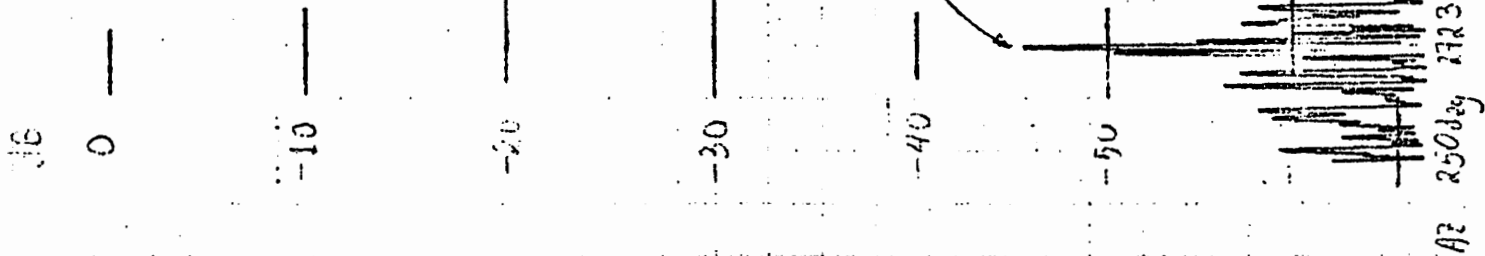
polarization parallel to leg, e.g.
 $R = -2.5 \text{ dB}$ to -10 dB ($R = \frac{\text{VER}}{\text{HORIZ}}$)

PHASE = 12.0 deg

Lobe from leg unit
in-line

Lobe from leg
of tip

Lobe from
vertical leg
of tripod



AZ 250deg 272.3deg

154deg

250deg

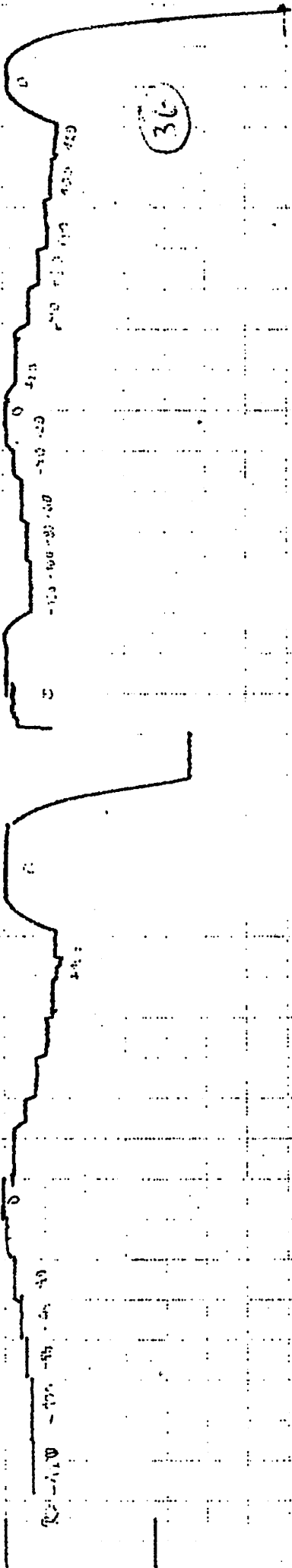
933.5 MHz Polarization

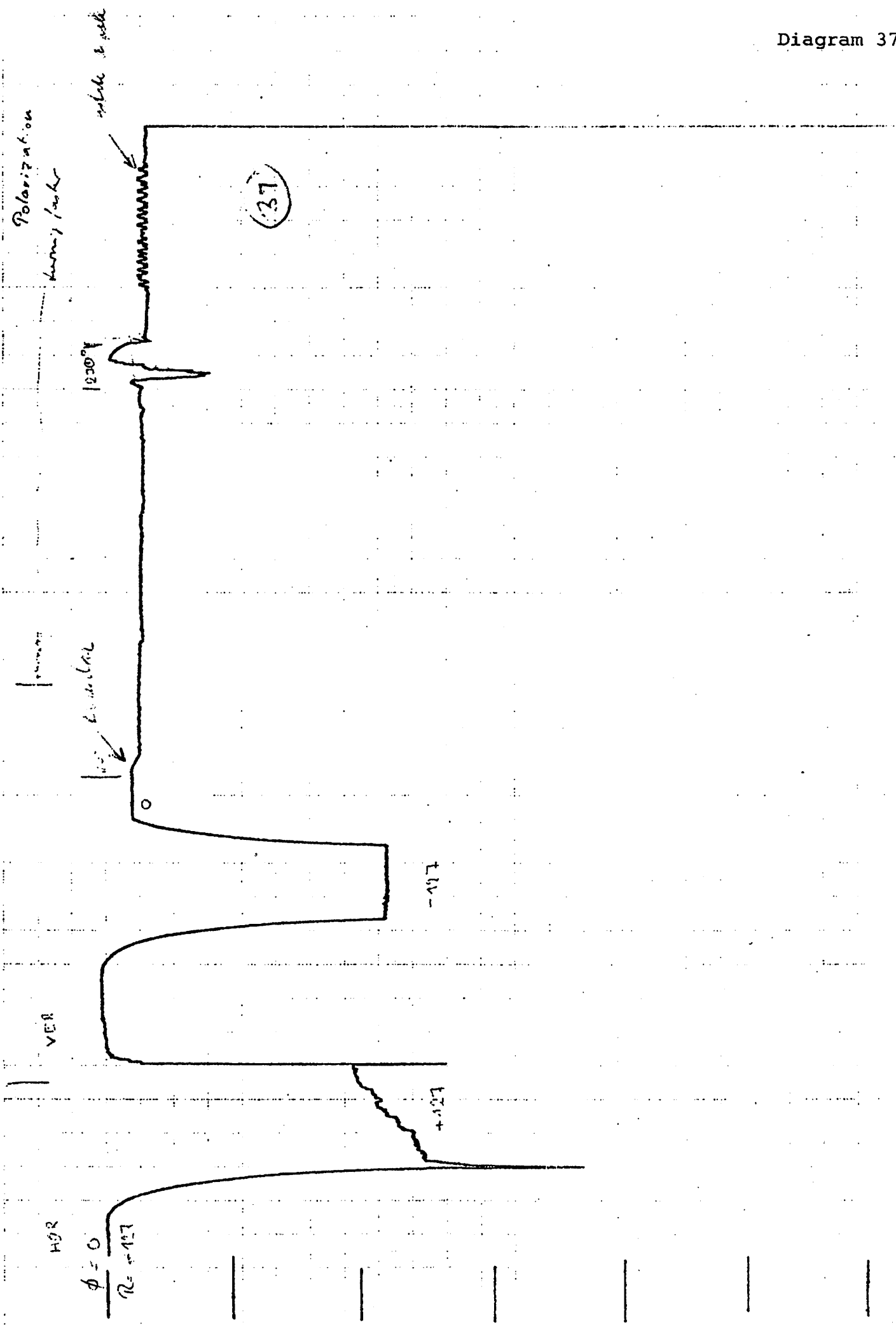
-45°

180°

$+45^\circ$

$\phi = 0$





TRM=0
11-29-79

$$\frac{1.4 \times 10^{-4} \times 0.5 \text{ m}^2}{2 \times 30 \text{ days}} = 3.75 \times 10^{-6} \text{ g/g}$$

$$\frac{1}{2} \text{ score} = \frac{1}{2} \times 100 = 50 \text{ sec}$$

$$\frac{1}{2} \text{ score} = \frac{1}{2} \times 100 = 50 \text{ sec}$$

FLIGHTING REGISTRATION

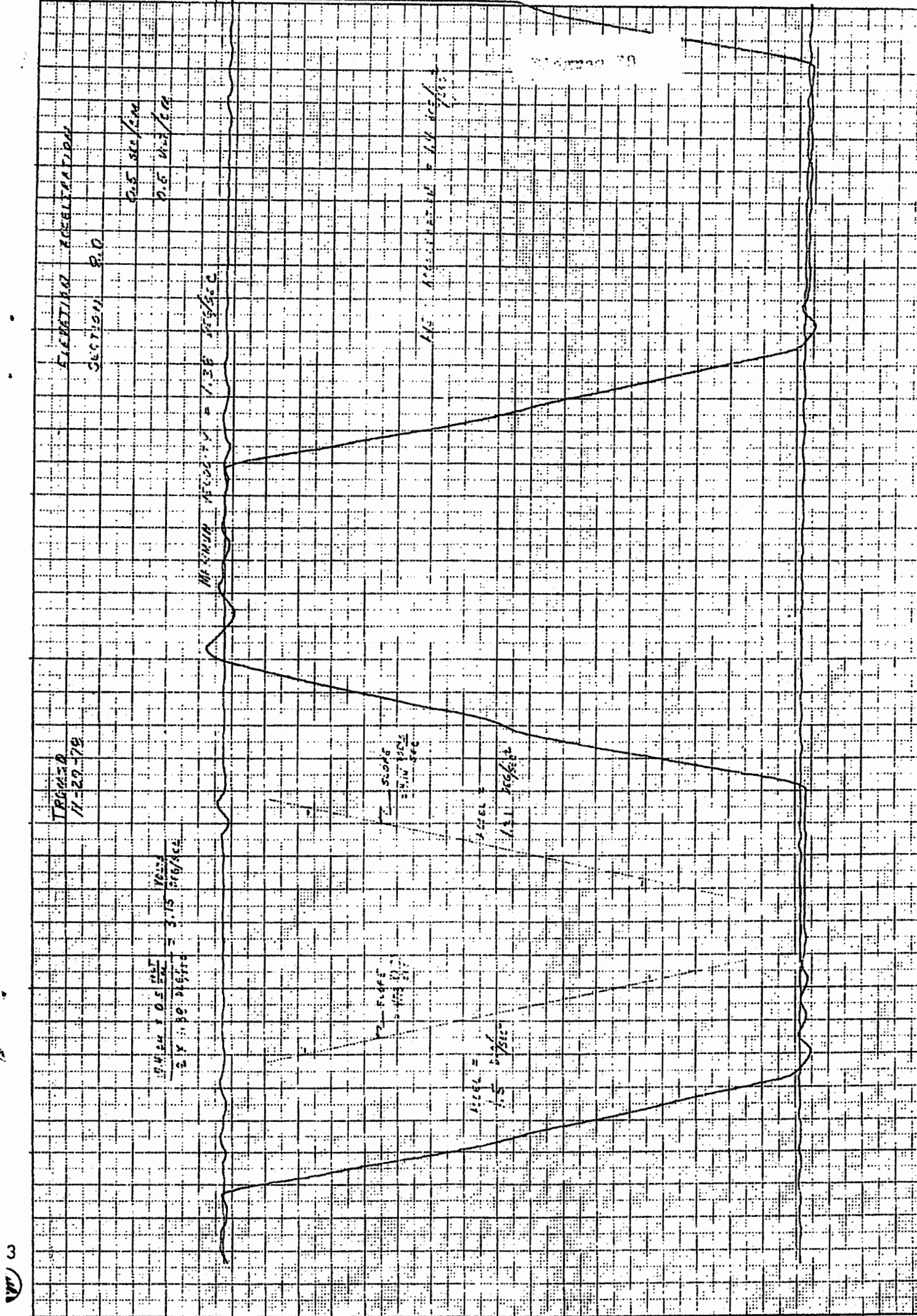
SECTION 8.0

$$0.5 \text{ sec/cm}$$

$$0.5 \text{ sec/cm}$$

MINIMUM RESOLUTION = 1.35 sec

$$\frac{1}{2} \text{ score} = \frac{1}{2} \times 100 = 50 \text{ sec}$$



LENGTH ACCELERATION
SECTION 5.0

0.5 552 / 100
0.5 10.7 / 100

ADVISOR
11-27-78

MAX VELOCITY = 124
174 50 X 0.5 0.1
2 X 1.34 350
3.000 200/100

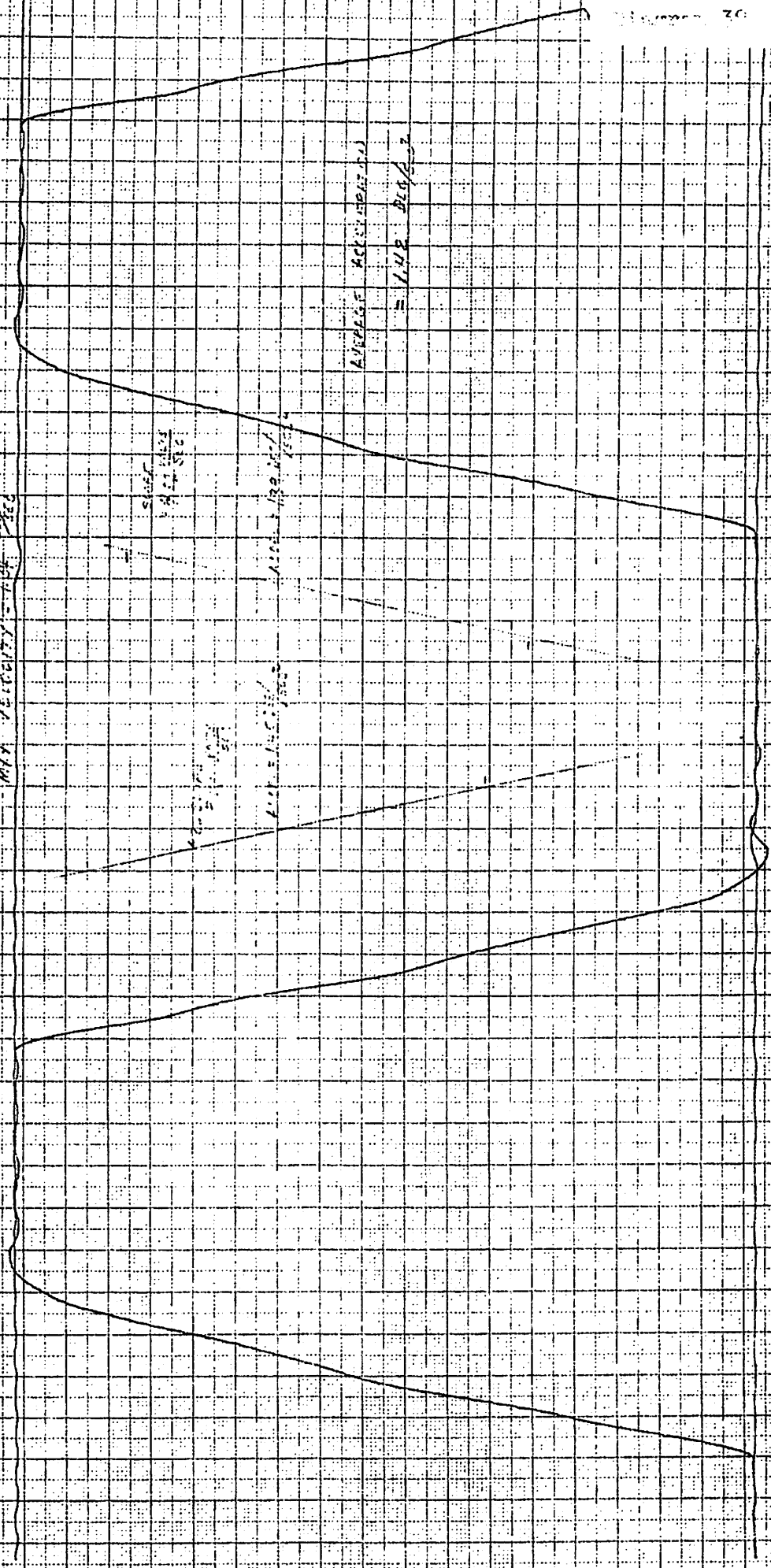
MAX VELOCITY = 124

SECTOR
10.7 10.7

MAX VELOCITY = 124

SECTOR
10.7 10.7

AVERAGE ACCELERATION
= 1.08 0.002



11-27-73

ELEVATION POSITION RESPONSE
SECTION 9.5

2.5 1/2 in

0.5 1/2 in

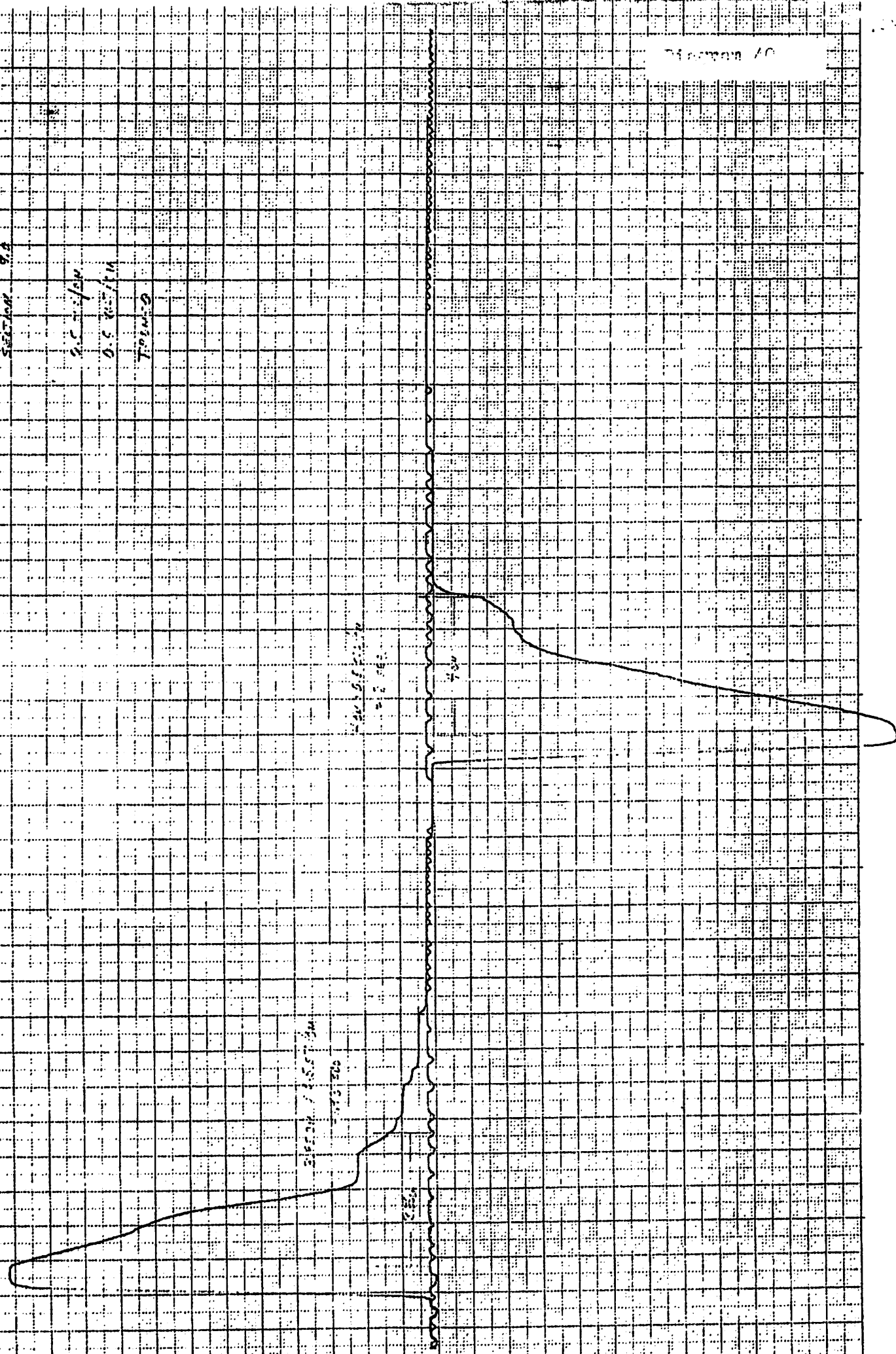
Point 9

SECTION 7 1/2 in

0.5 1/2 in

SECTION 5 1/2 in

0.5 1/2 in



1-27-78

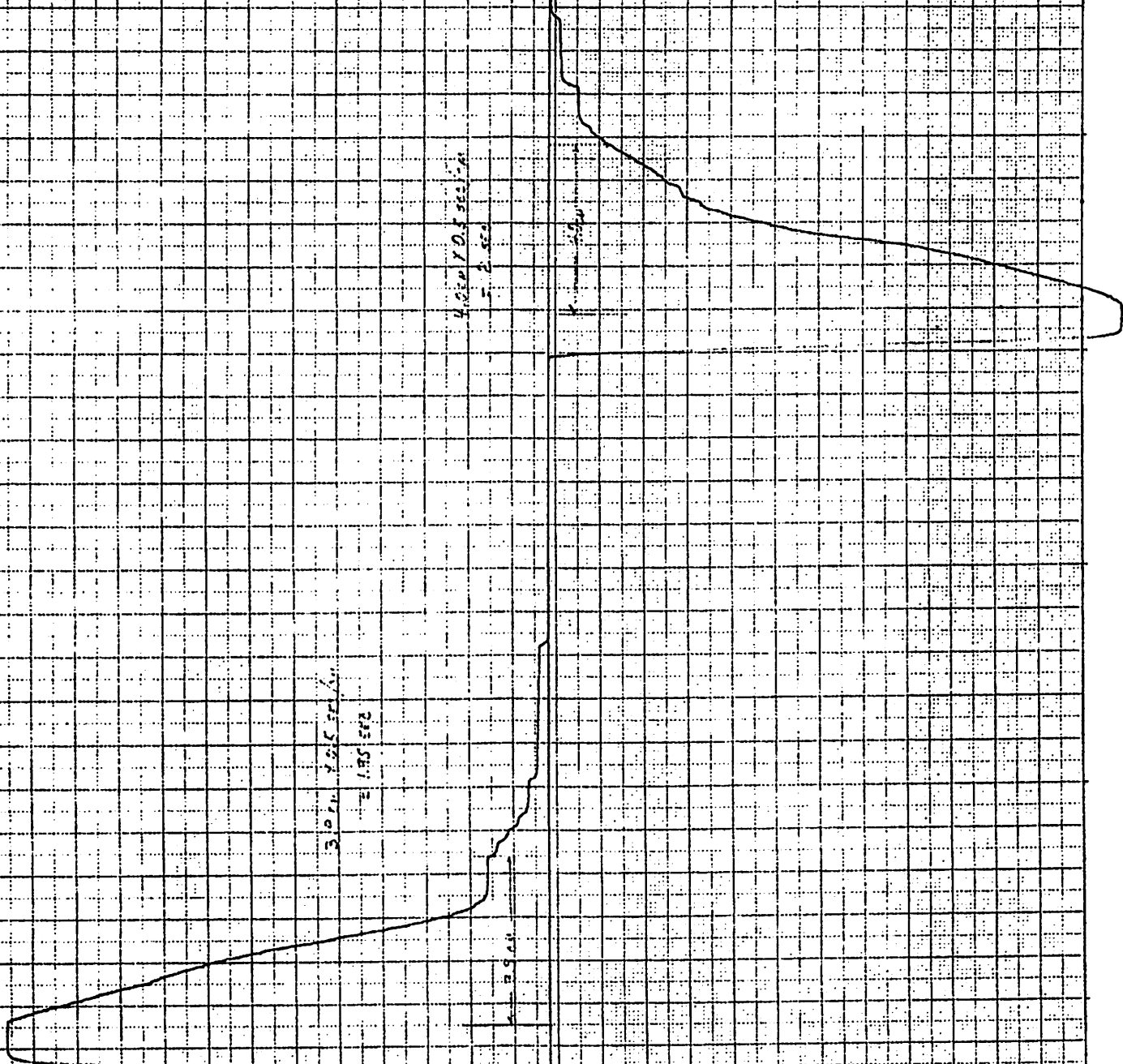
ALPHAS: POGONIPAL PR. SP. 100
SECTION: S.D.

0.5 sec/cm

0.5 sec/cm

TRON 30

Diagram 41



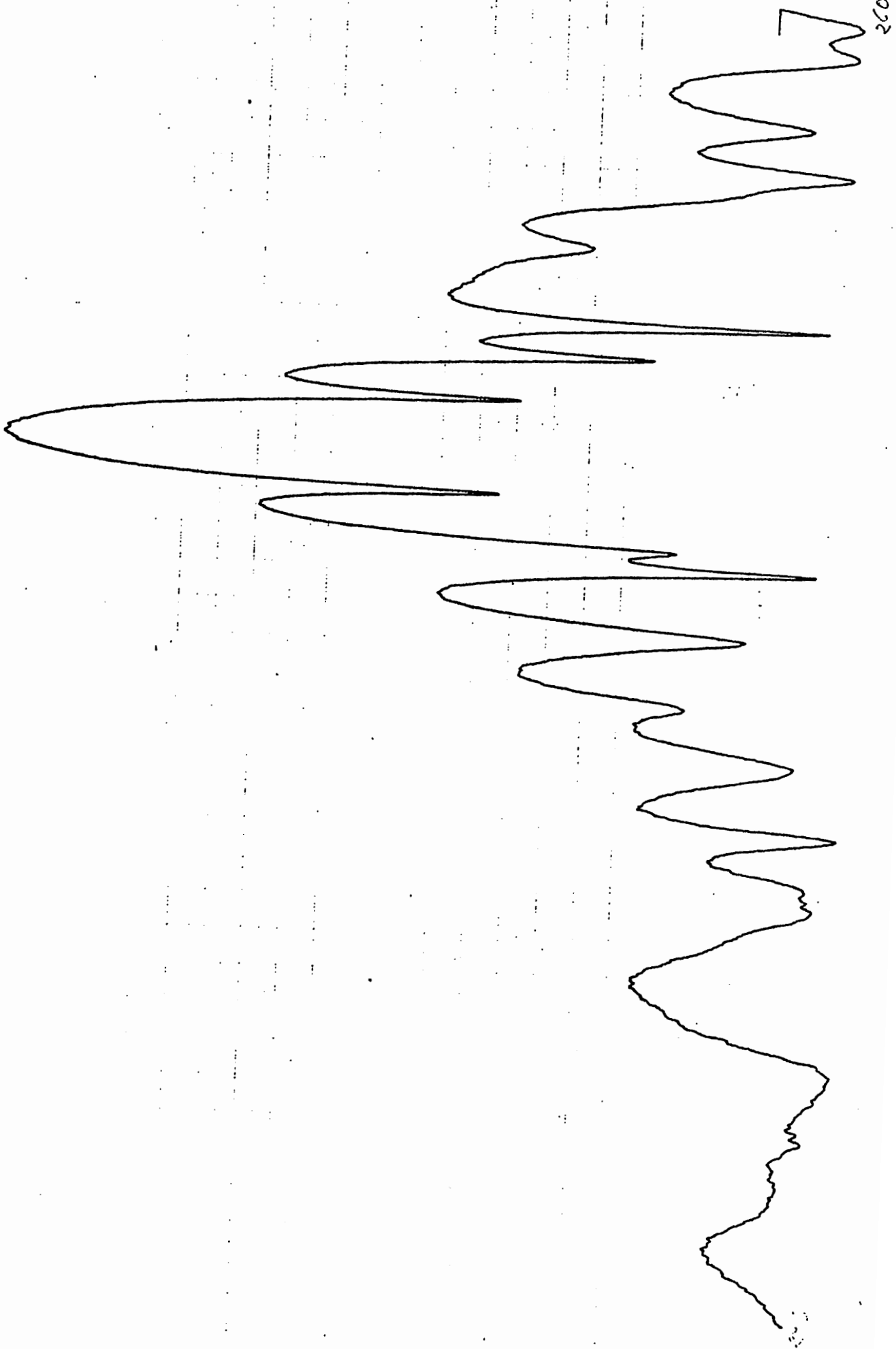
3.0 sec 1.05 sec
= 1.05 sec

1.0 sec 1.05 sec
= 1.05 sec

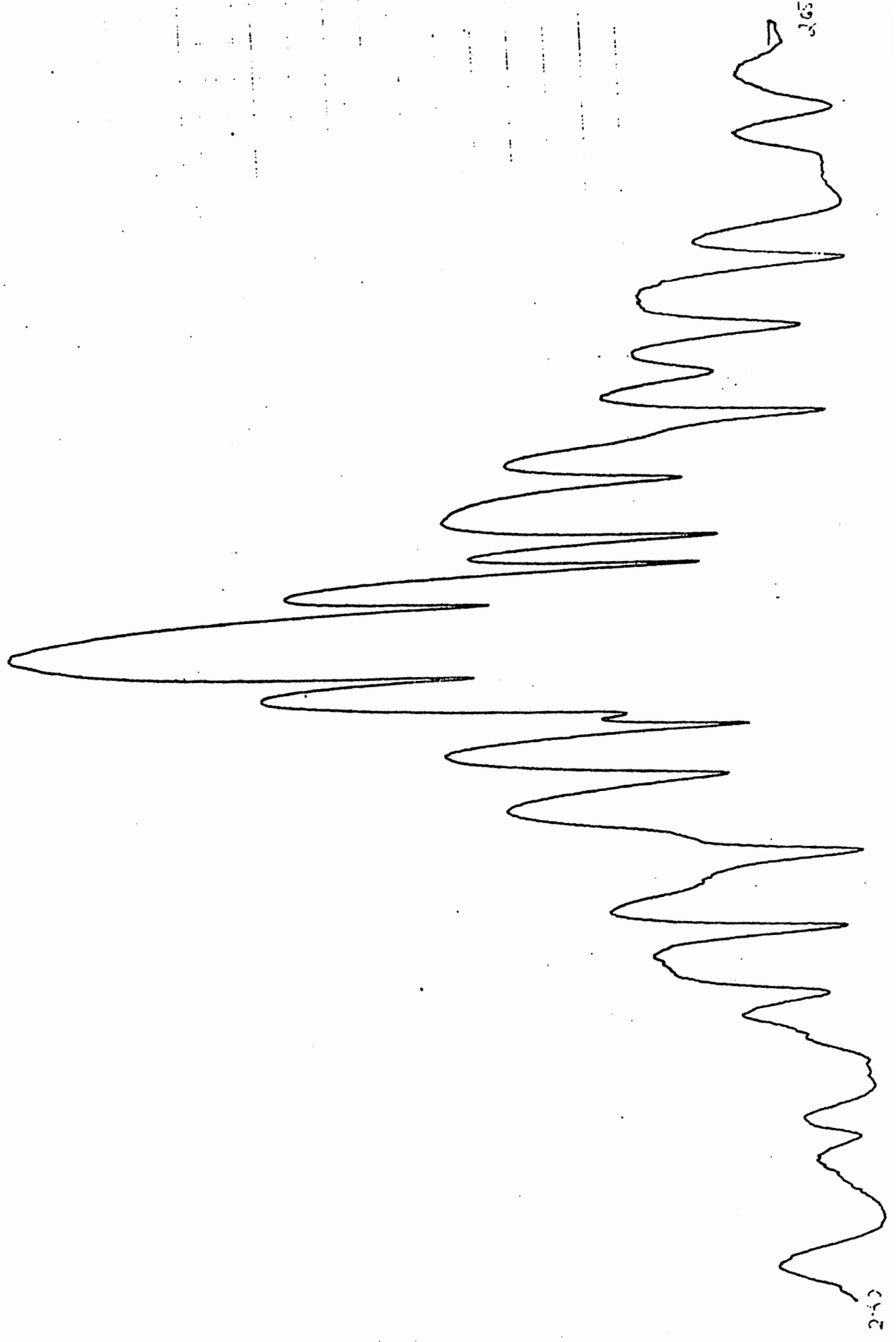
1.0 sec 1.05 sec
= 1.05 sec

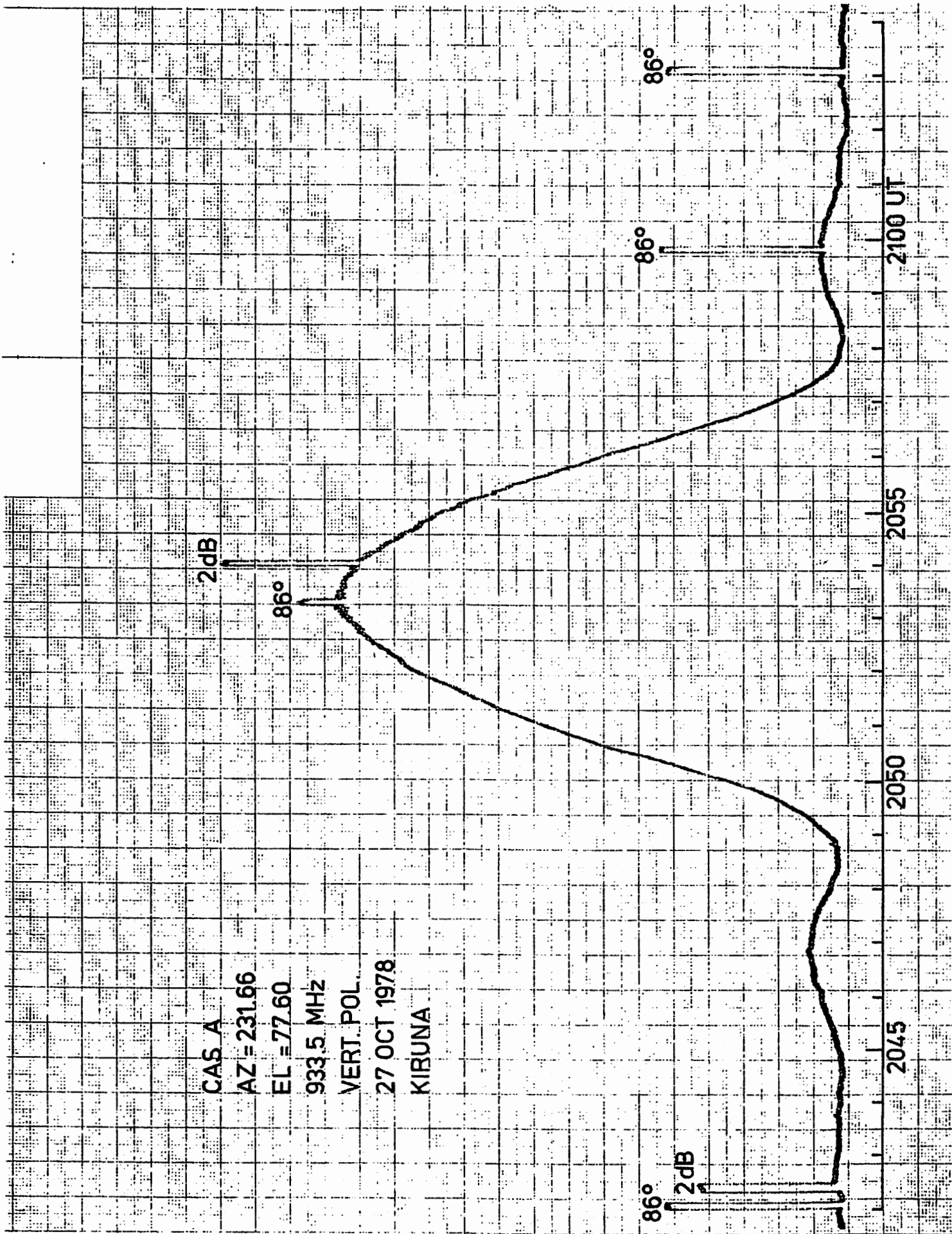
1.0 sec

VER 935.5.1.142



2014 5:55:56 AM
HOR 5:55:56 AM





CAS A
AZ = 231.66
EL = 77.60
933.5 MHz
VERT. POL.
27 OCT 1978
KIBUNA

86°
2dB

2dB

86°

86°

86°

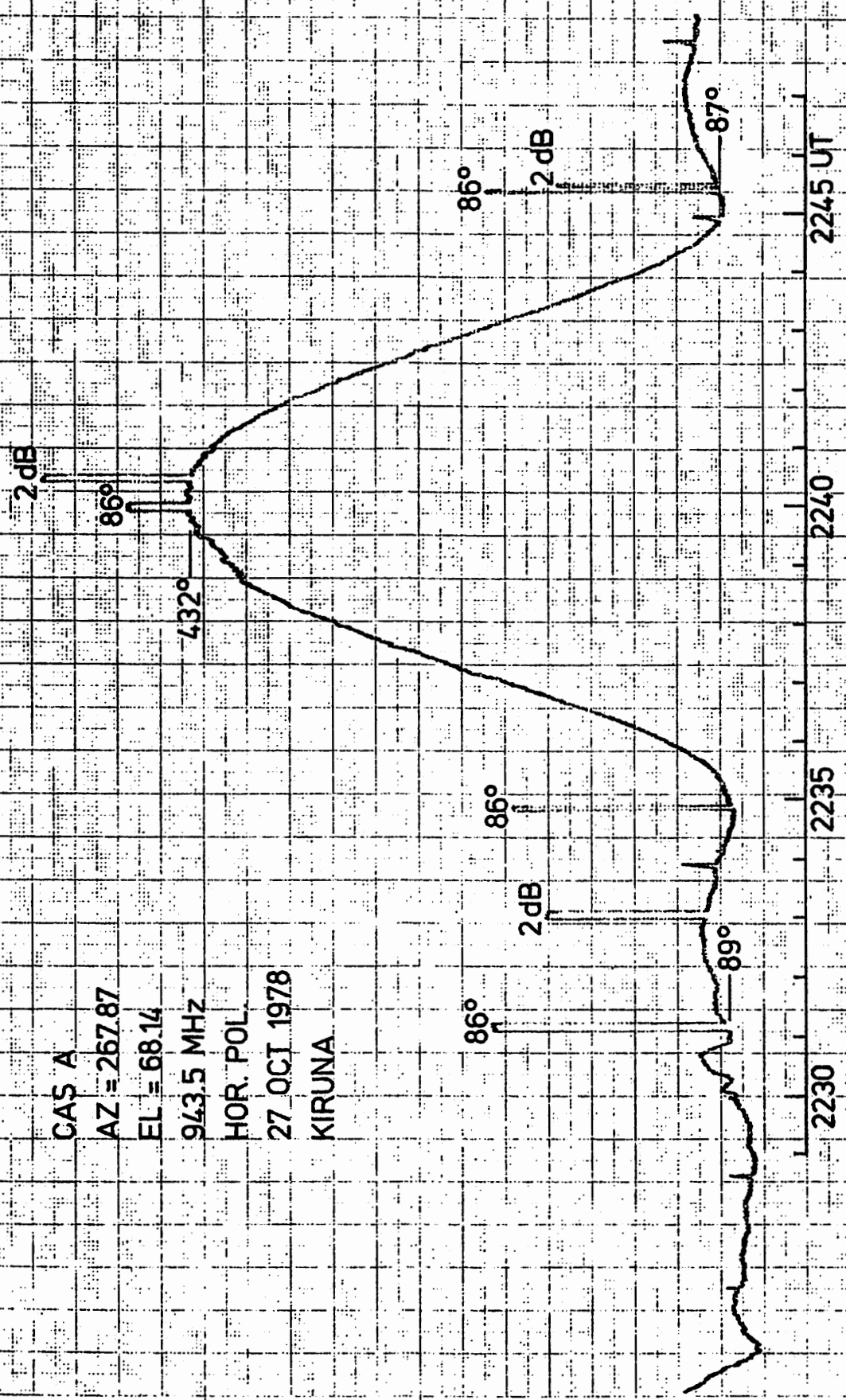
2045

2050

2055

2100 UT

CAS A
AZ = 267.87
EL = 68.14
943.5 MHZ
HOR. POL
27 OCT 1978
KIRUNA



CAS A
AZ = 215.74
EL = 79.43
933.5 MHz
VERT. POL.
27 OCT 1978
KIRUNA

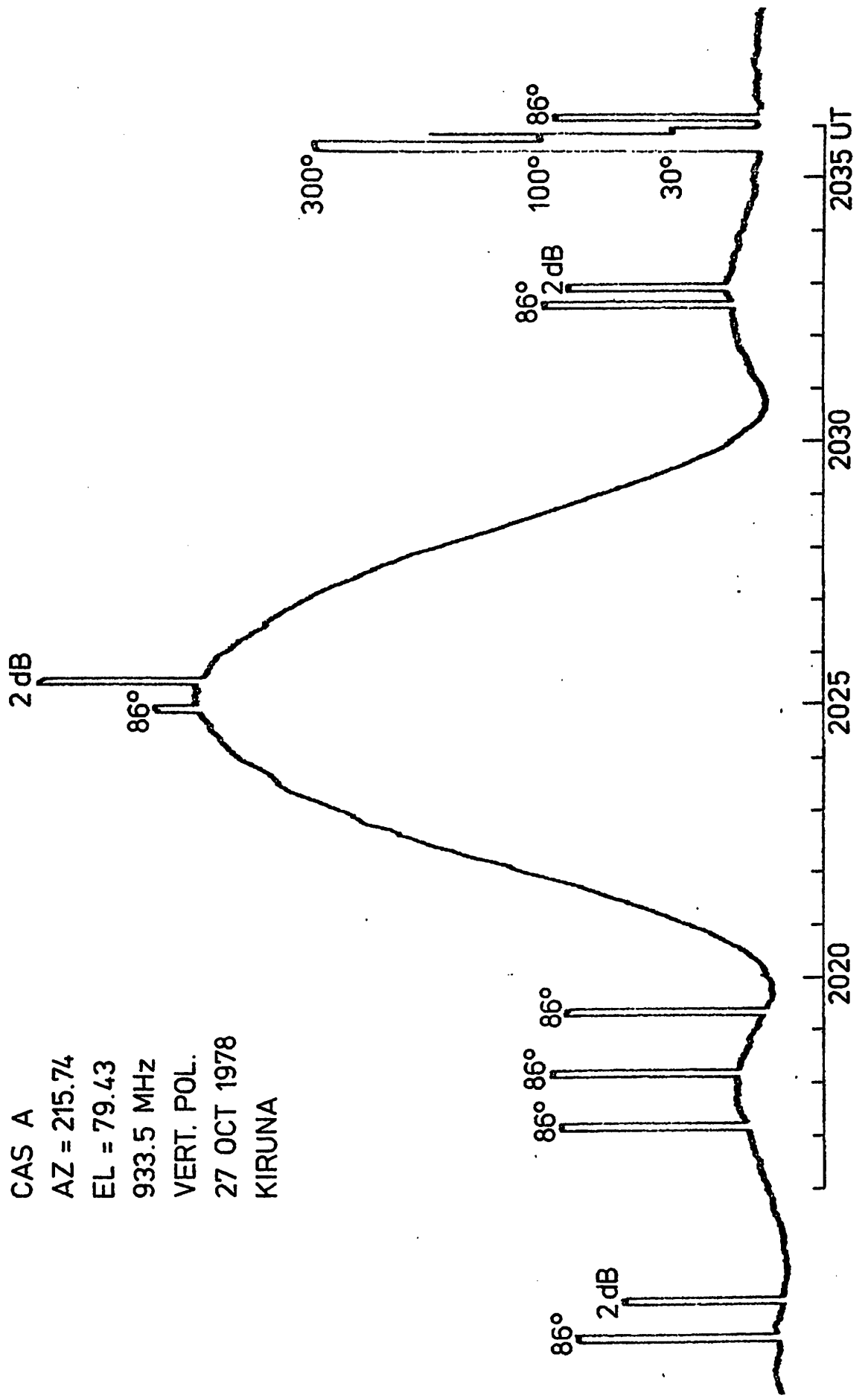
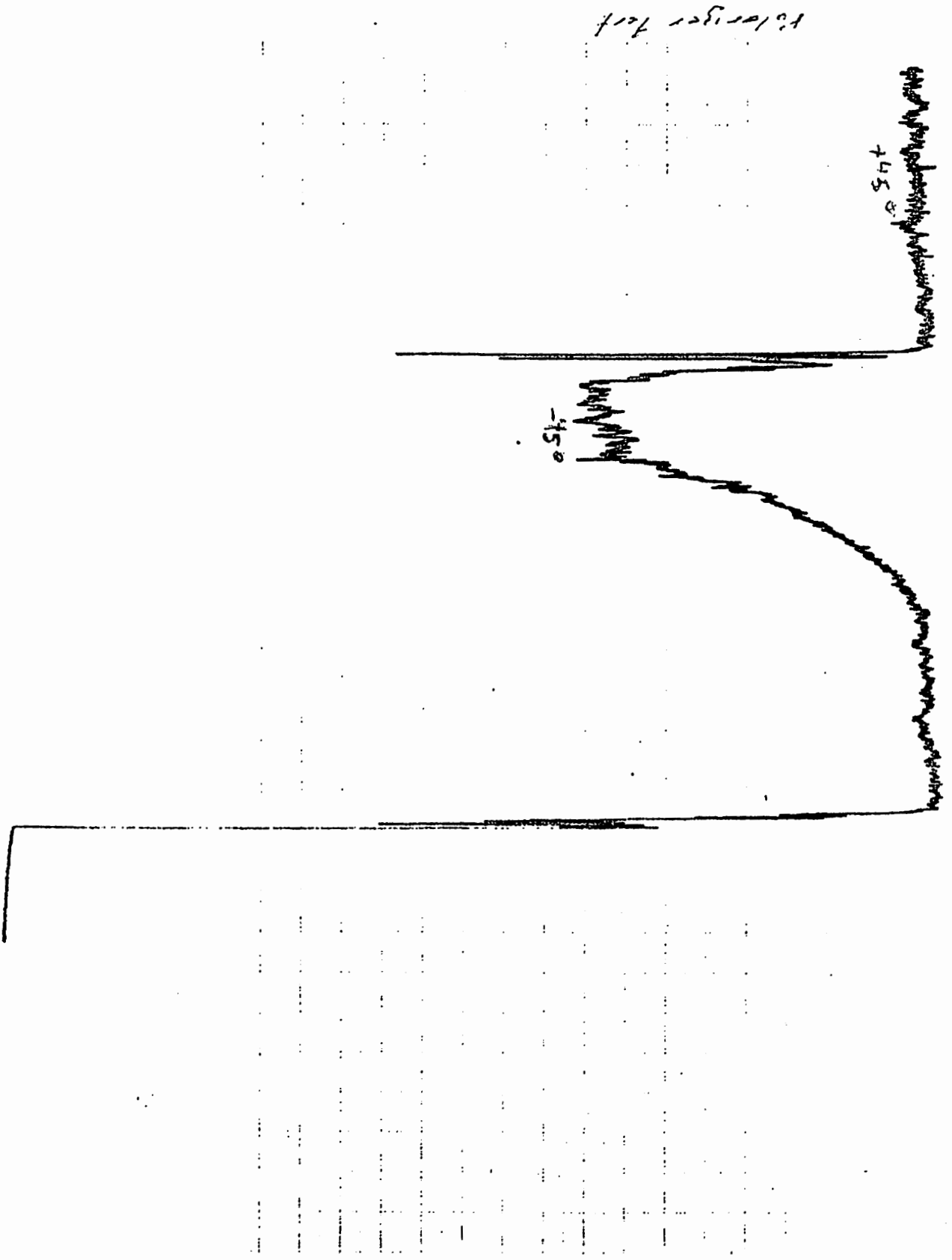
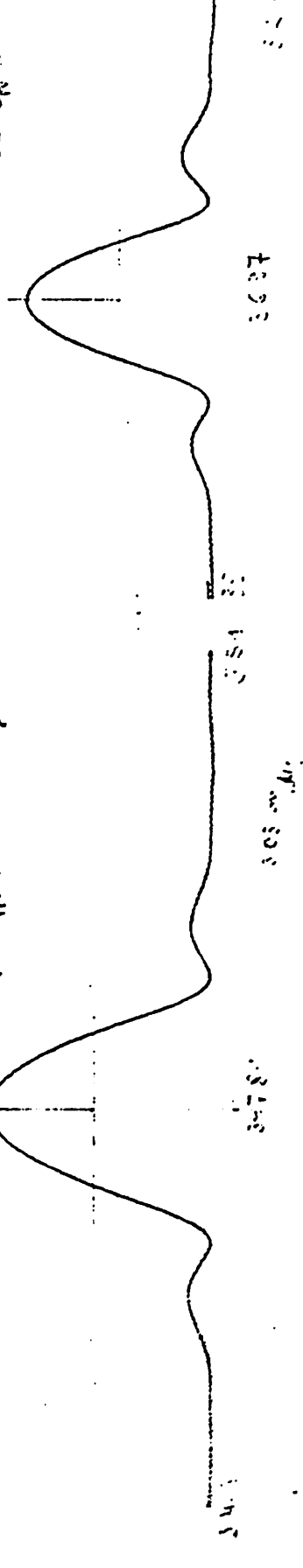
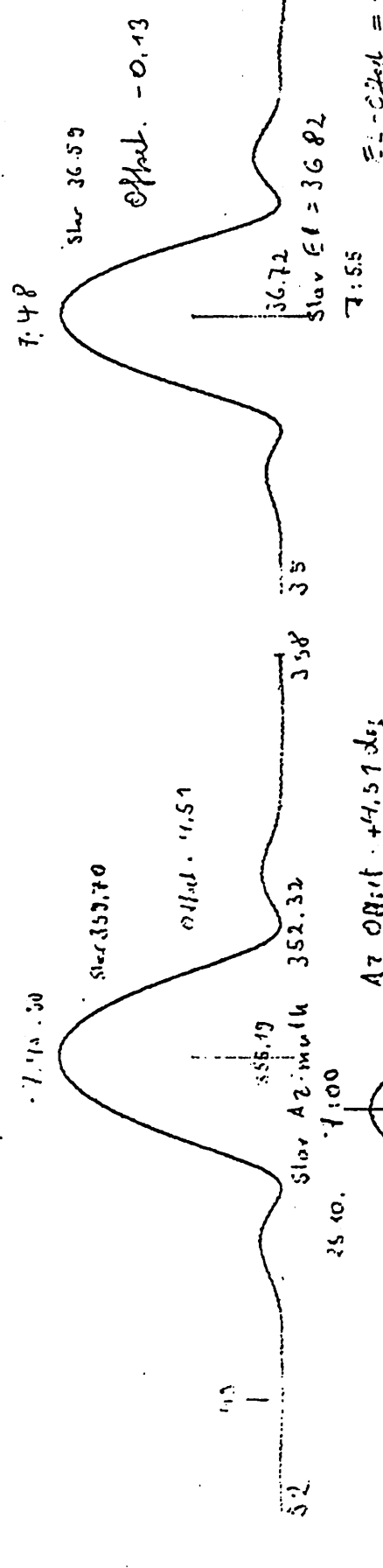
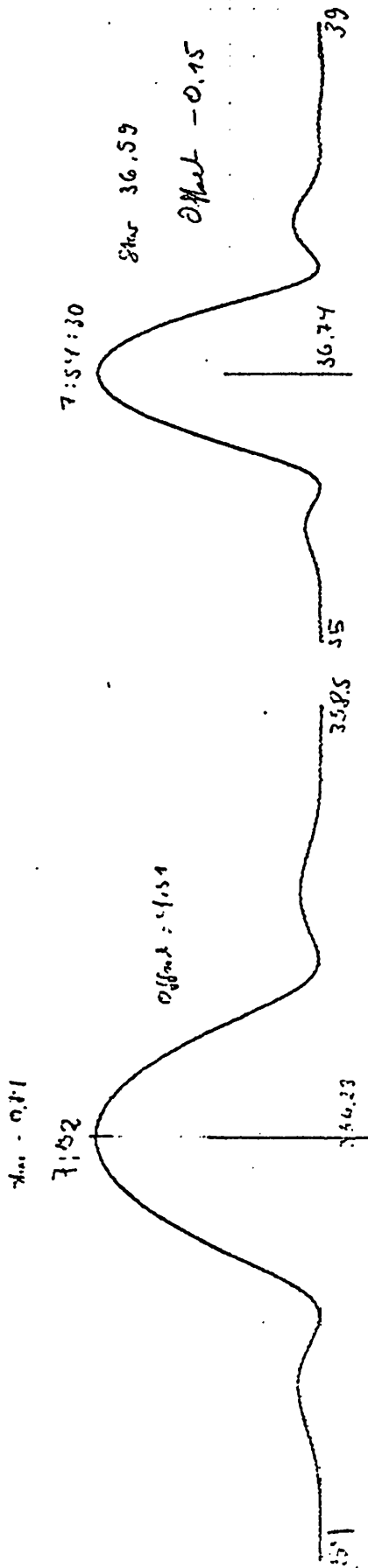


Diagram 46





35.85
 35
 39
 36.87
 35.85
 35
 39

Diagram 49

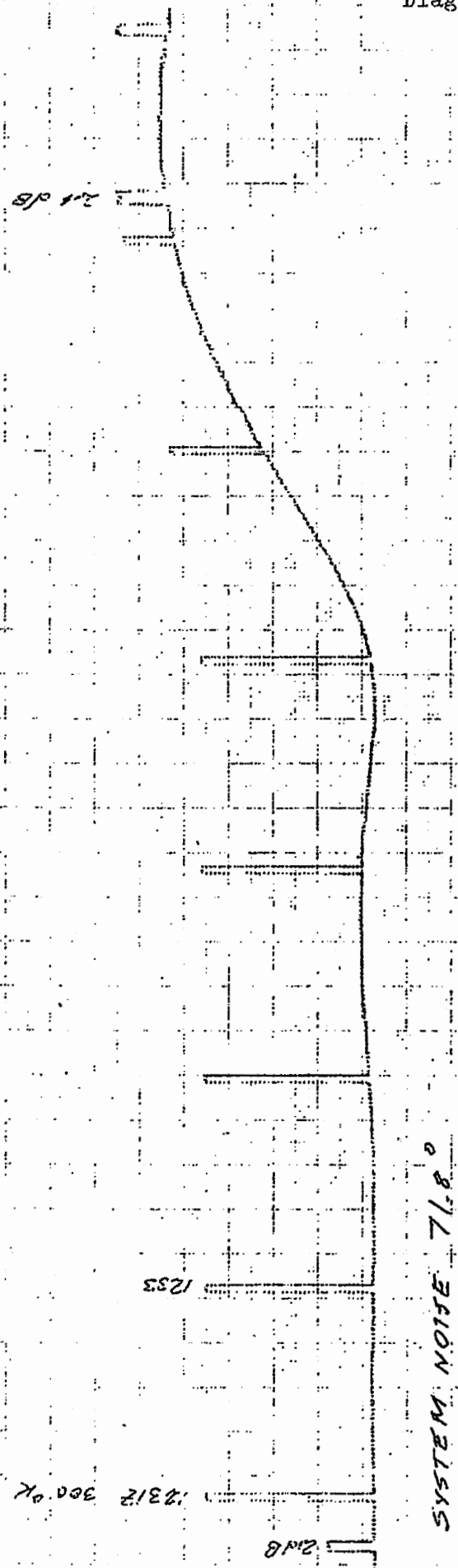
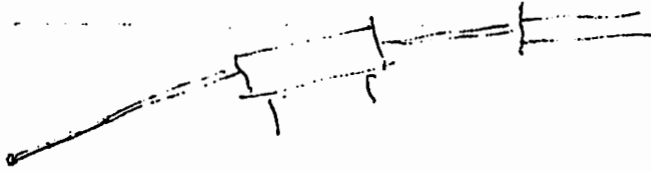


Diagram 51



A2 57139

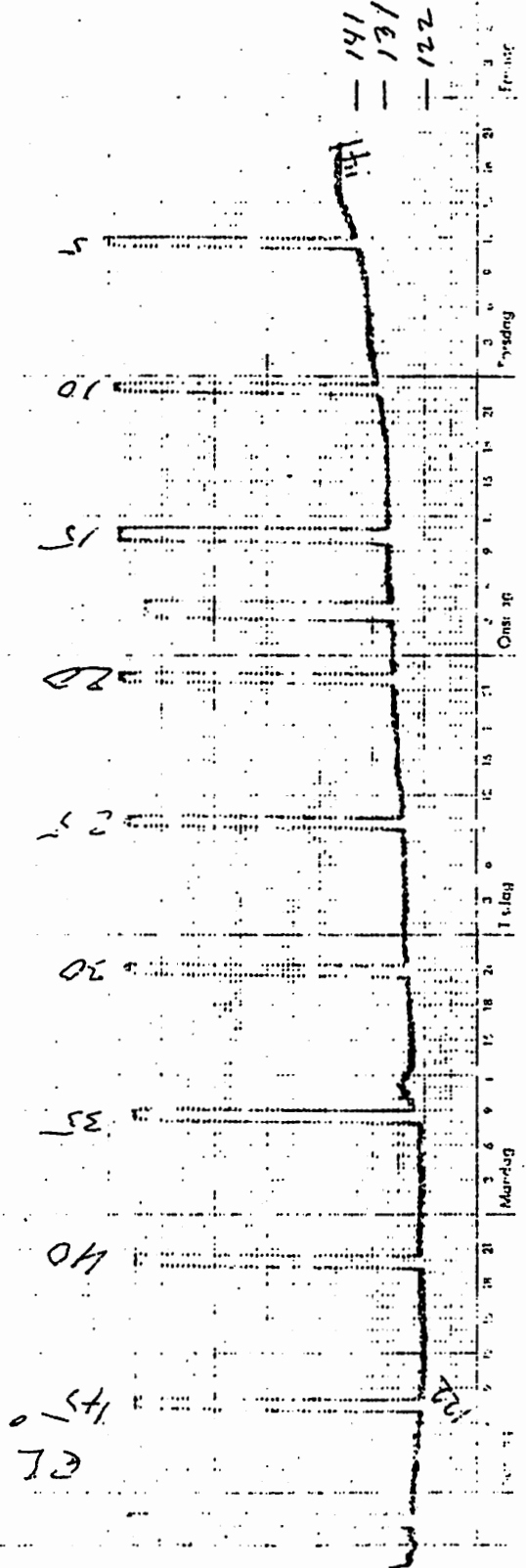
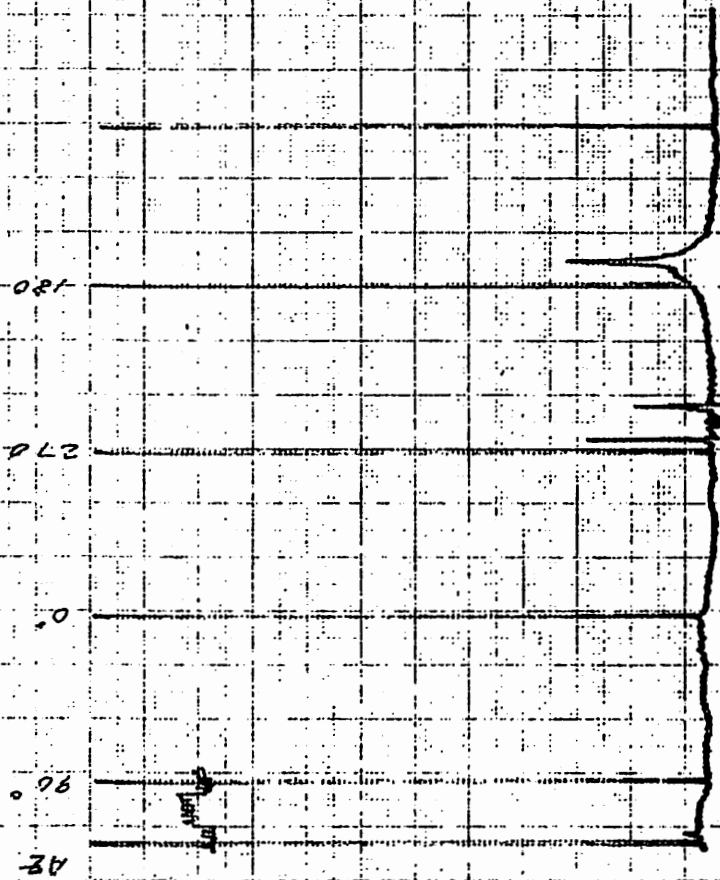


Diagram 52



51-15

bore sight
Sodan kylä

Vier
1. 101
9 1/2 30

BORR 316 HT
500
930 HT
140 V
VEP



Sodan kylä FL = 553

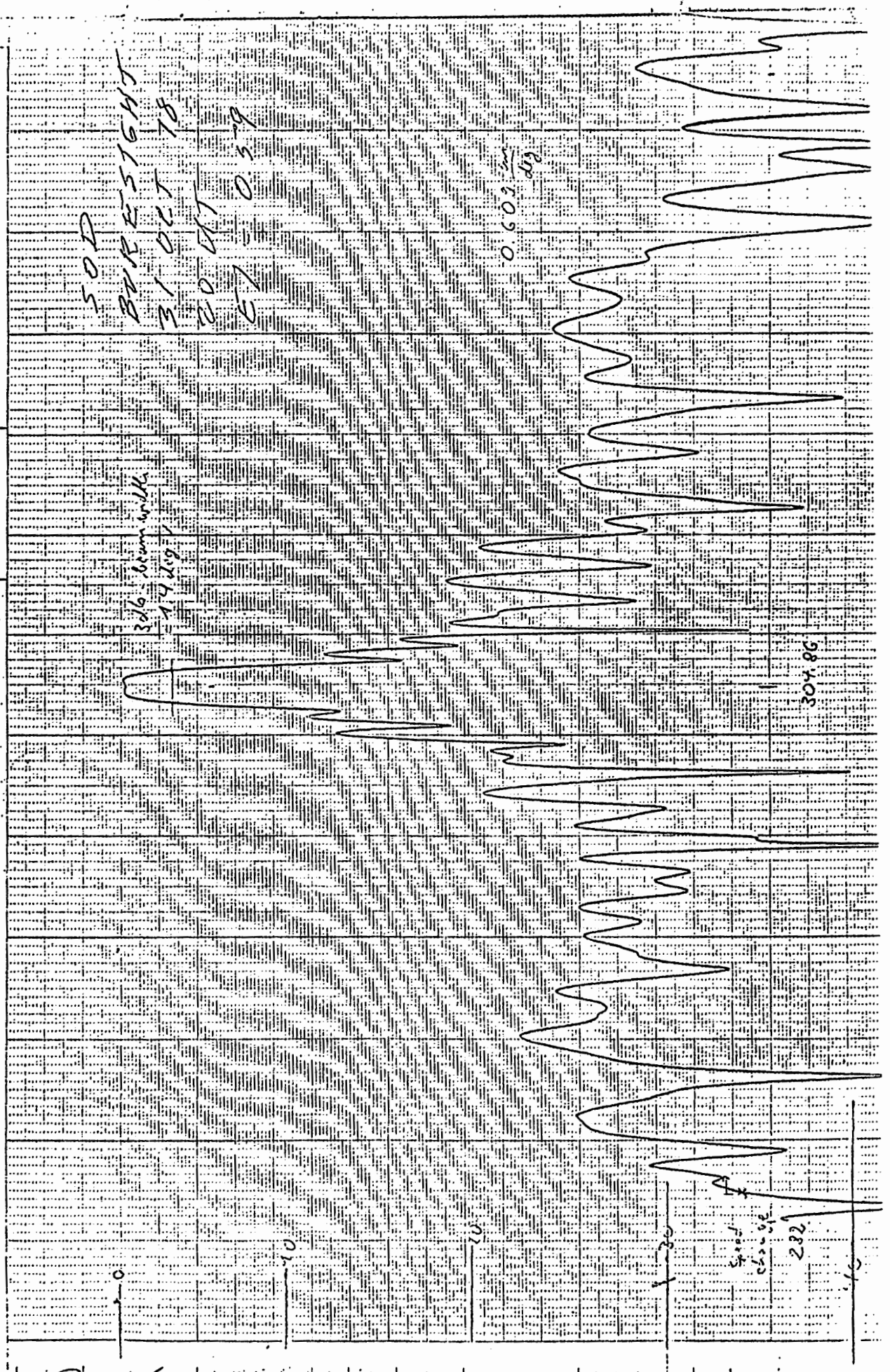
50 D
BARE-STGHJ
M1 OCT 18
20 AT
ET = 0.39

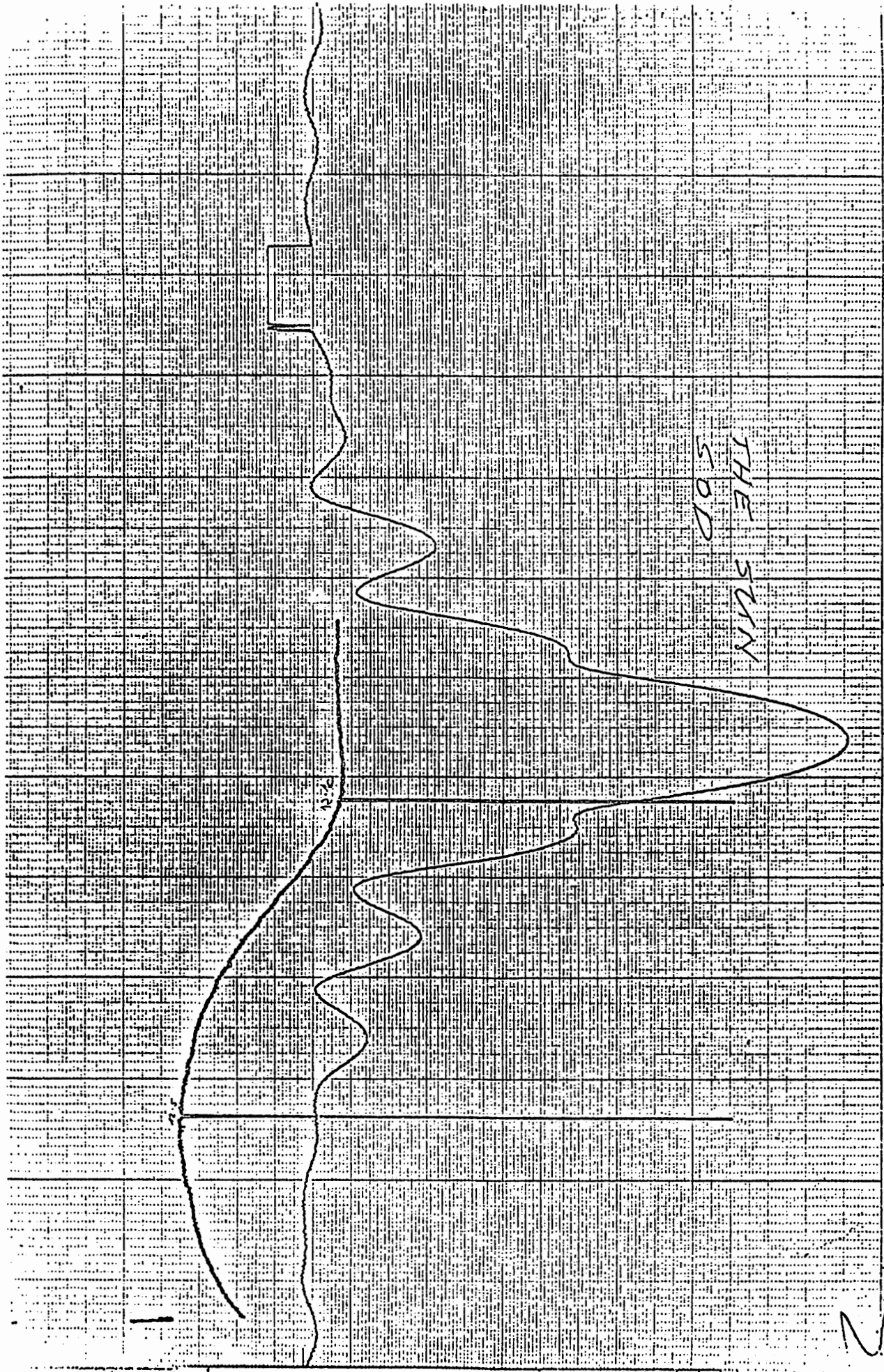
306 drum with
19 kg

0.603
kg

304.86

Speed
clock
282





THE SKIN
SOP

Handwritten signature or scribble on the right side of the page.

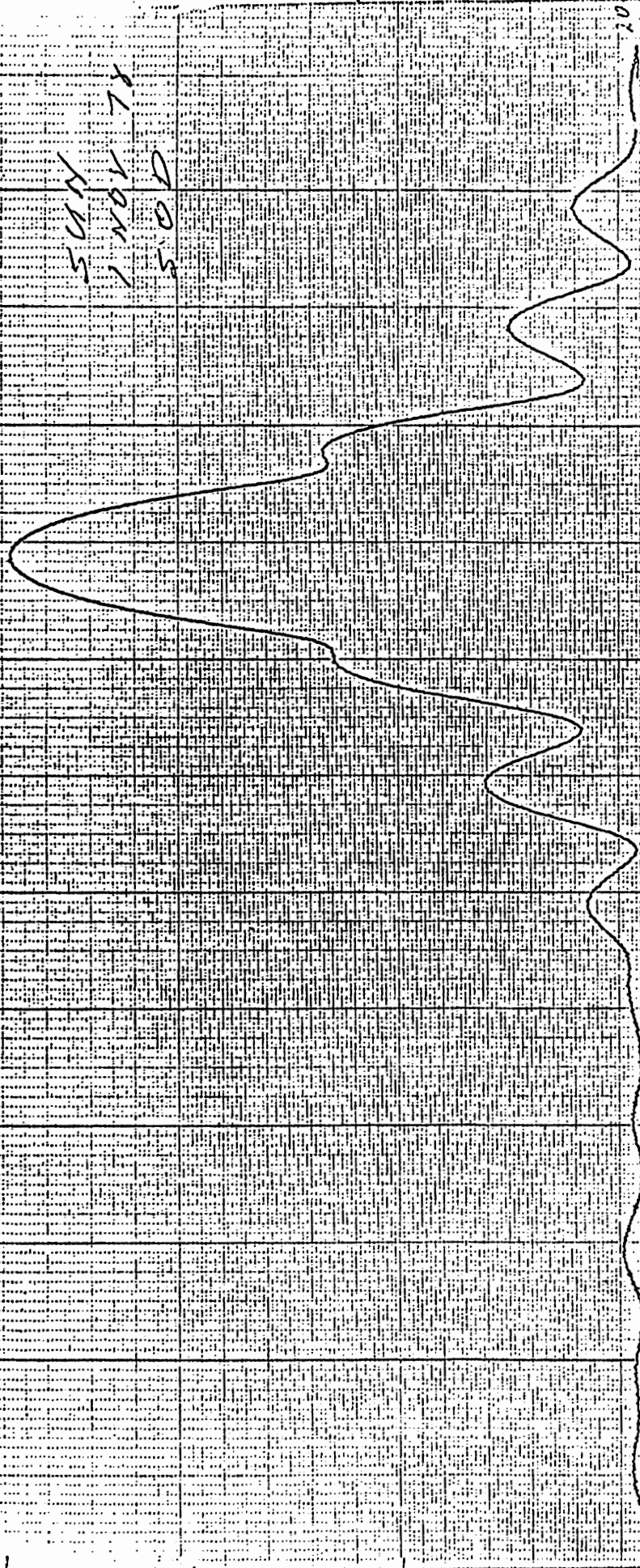
1. 11. 78

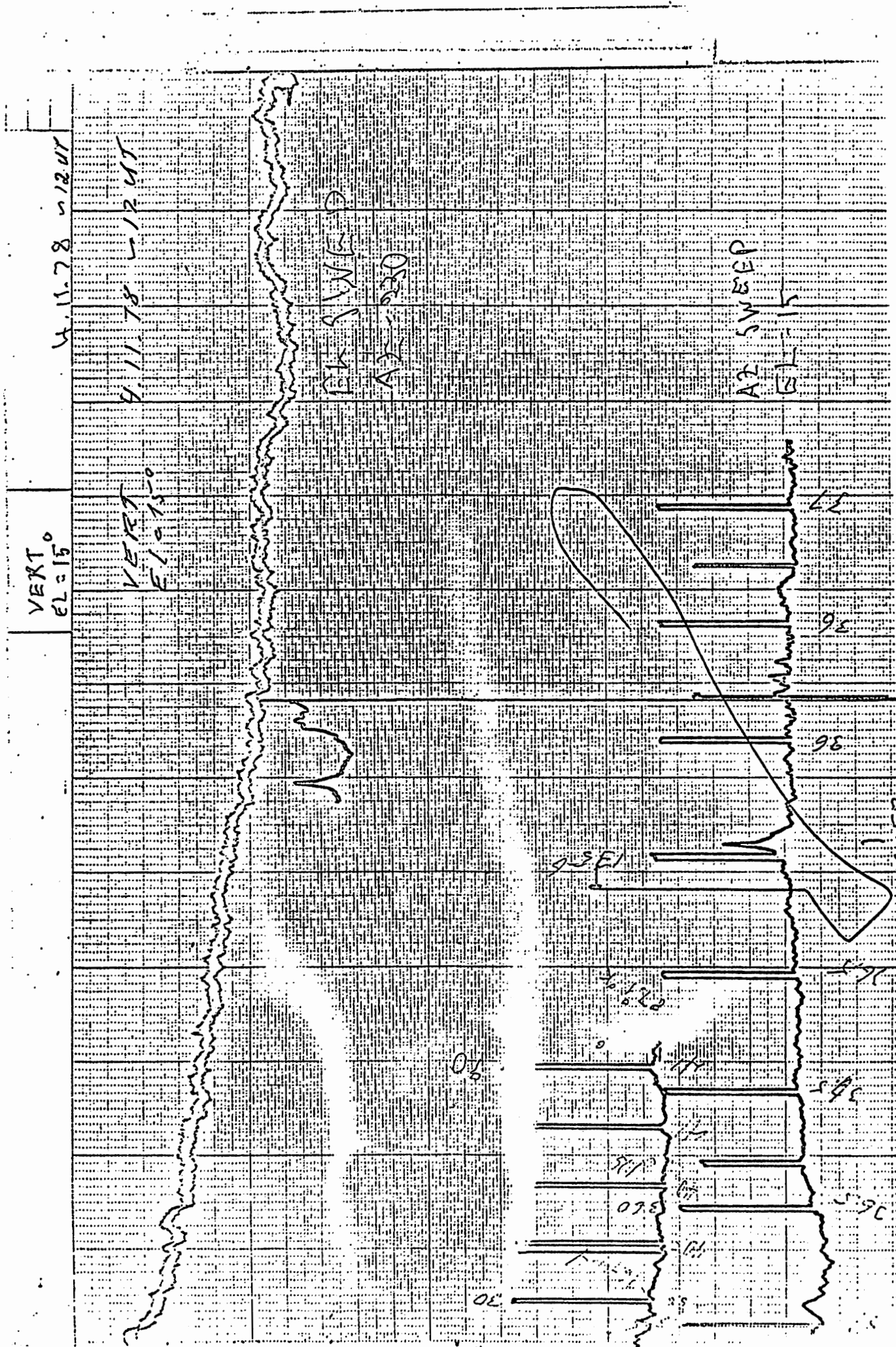
5.00

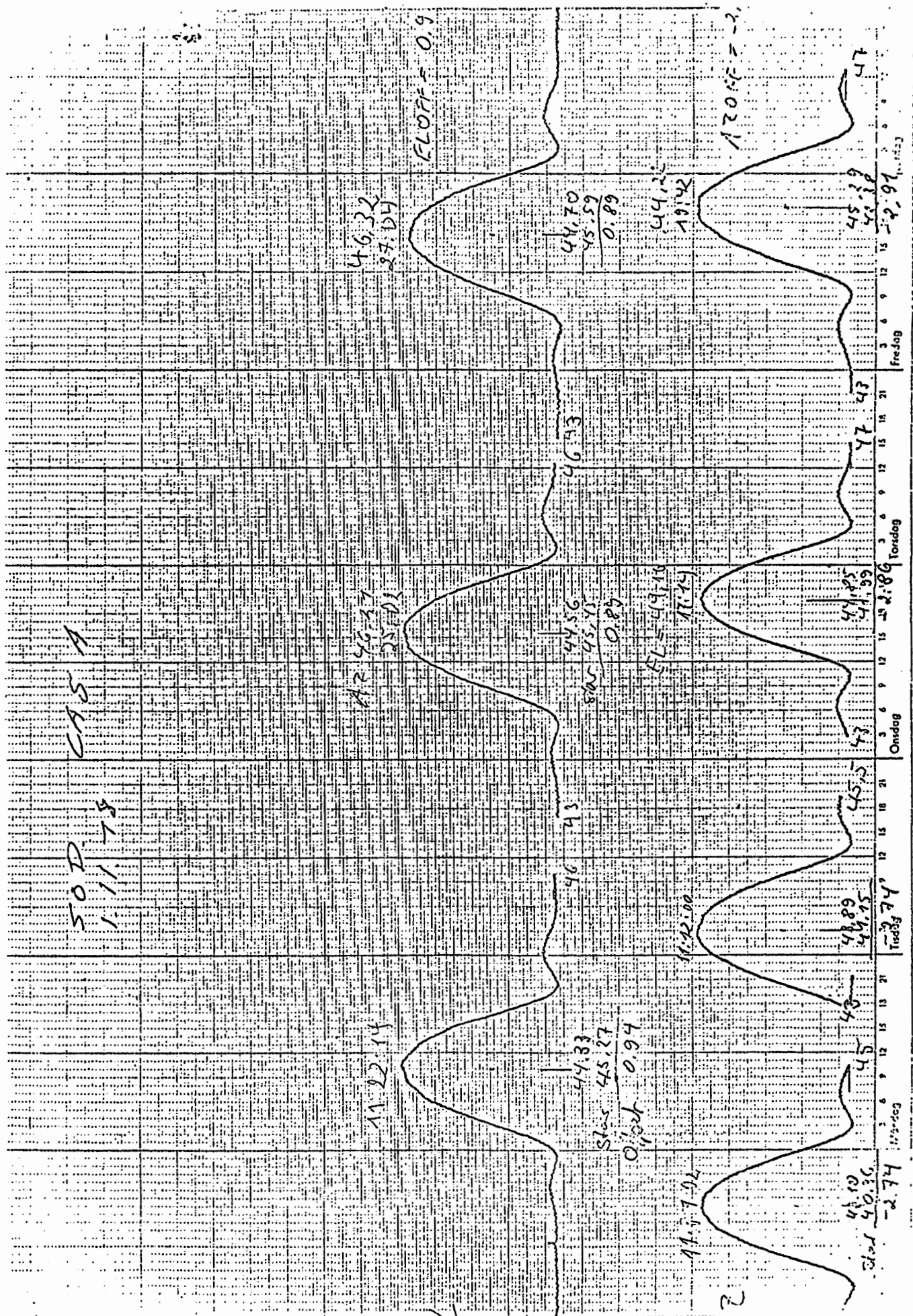
1 NOV 78

5.00

20







4.11.78 SOD (S.S.)

4.11.78

4.11.78

4.11.78



0.40
AZ = 37.93
ELEVATION
CAMERA

0.40
AZ = 37.93
ELEVATION
CAMERA

0.40
AZ = 37.93
ELEVATION
CAMERA

0.40
AZ = 37.93
ELEVATION
CAMERA

12 - 61.79
FL = 52.31

SOD
VER
923.5
A = 62.79
E = 52.31
3 NOV 78

618° 01' = 525

13.00

93°

10.50



Sobonhye

Rz. 56.550
El. 49.240
CASA

711.18

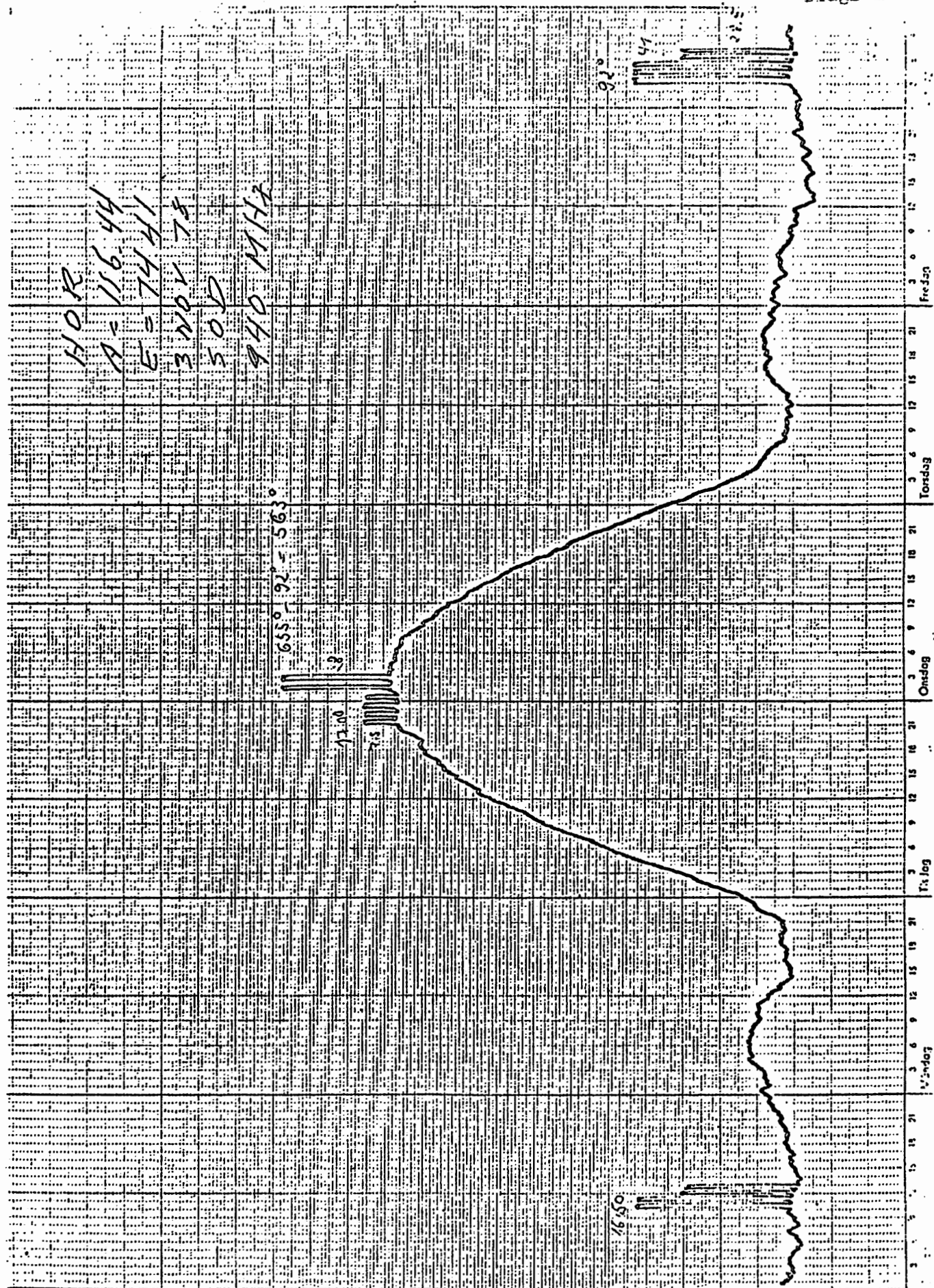
Rz. = 56.55
El. = 49.24
CASA
110V 70
500

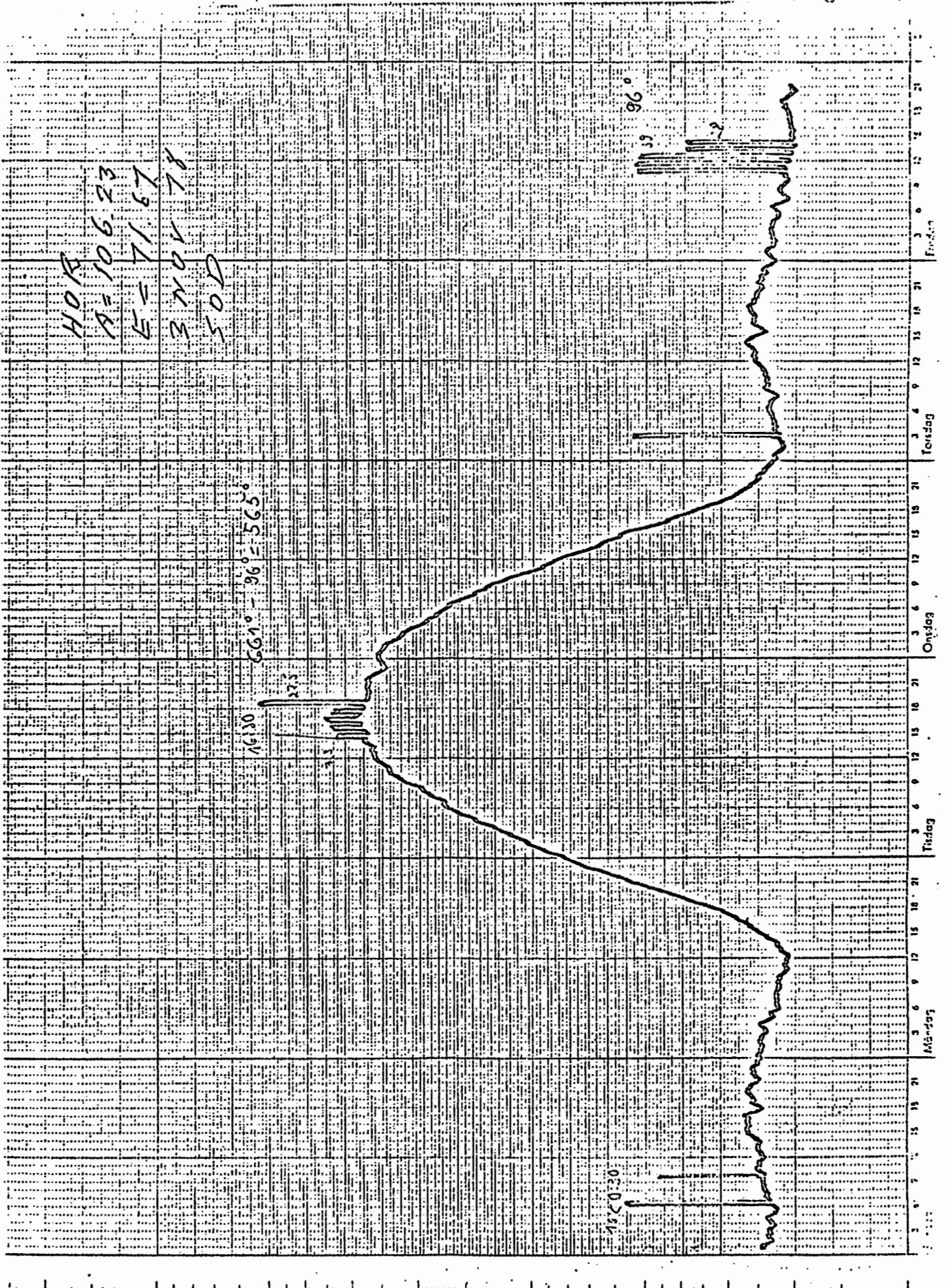
08:20

08:40

08:00







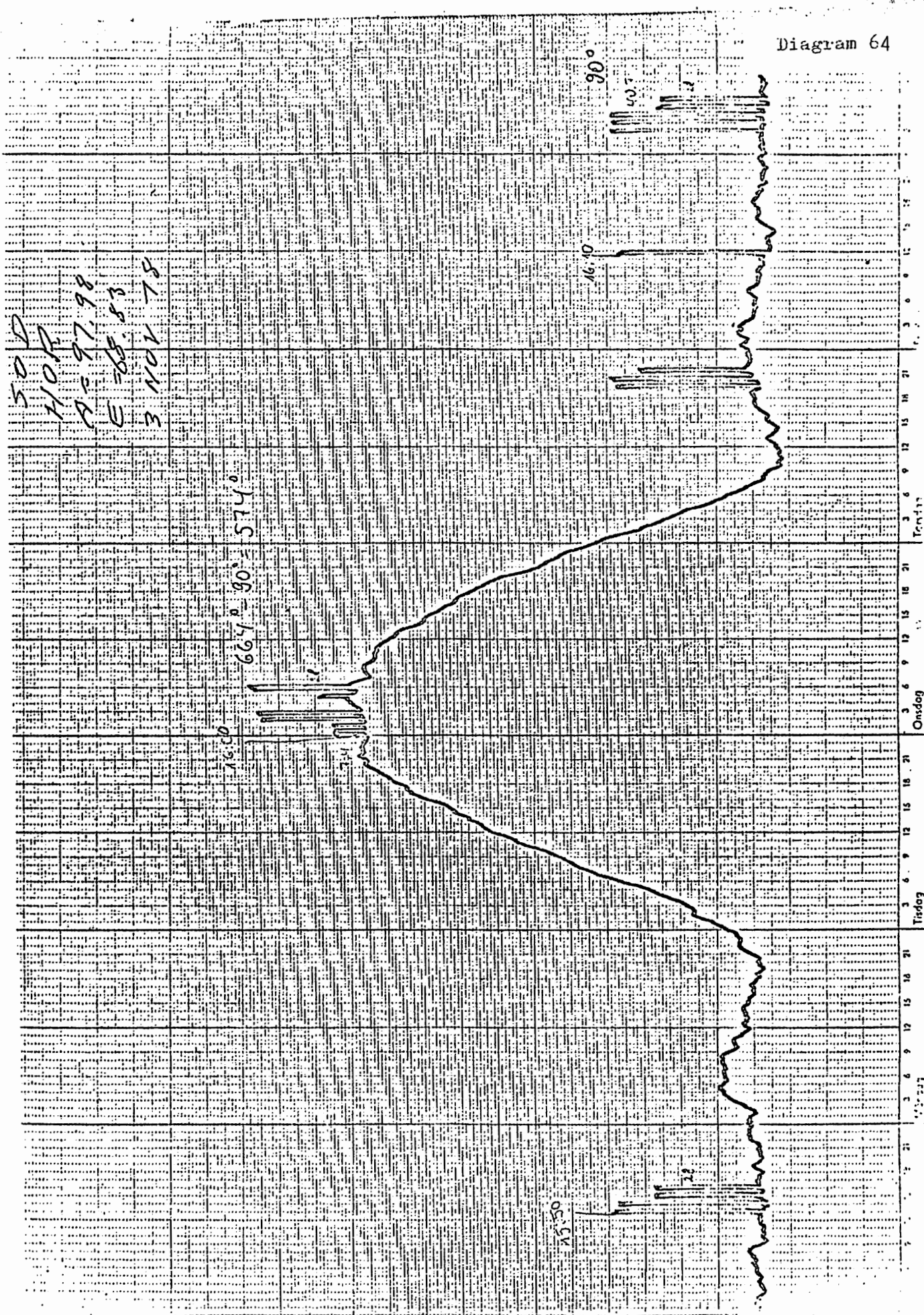
500
1100
AP 97.98
E 88.53
3 NOV 78

16.50
664° - 90° = 574°

15.50

16.40

90°



VER 333.5
AZ = 78.87
EL = 58.92

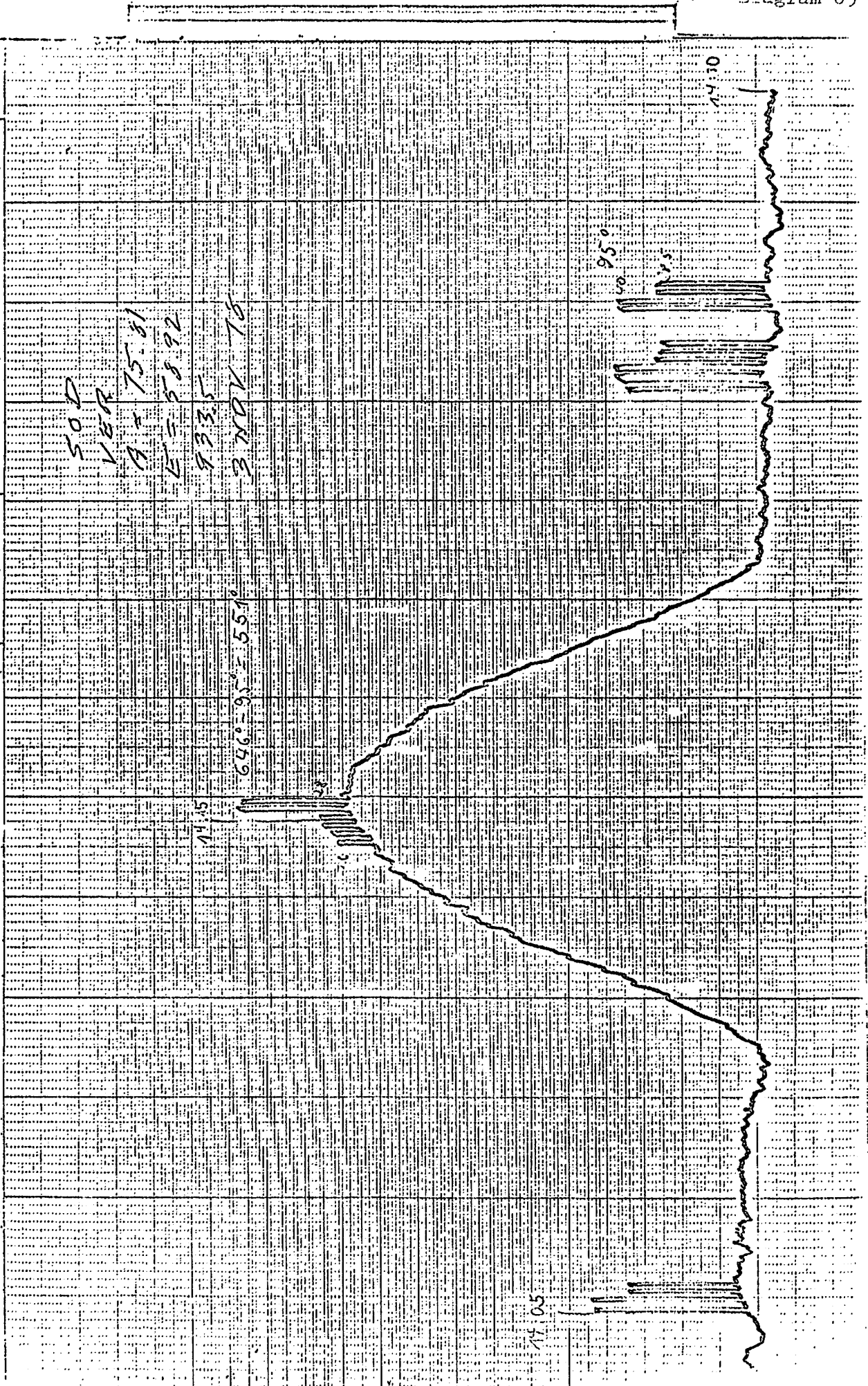
50.8
VER
A = 75.81
E = 55.92
93.35
3 NOV 75

14.15
646° 9.5' = 55.1°

14.05

95.0

14.10



EL = 55.75

500

YER

A = 69.59

E = 55.75

3 NOV 78

628 297 531

13.10

20

197

10.5

13.30



ELEVATION APP. 100 FT
SLOPE 1:1

CA 5 561 711
3. 200 1 1 1 0

11-23-73

12.3 AM 20.5 VOLT
2.7 1.37 26/ACC = 316 568/SEC

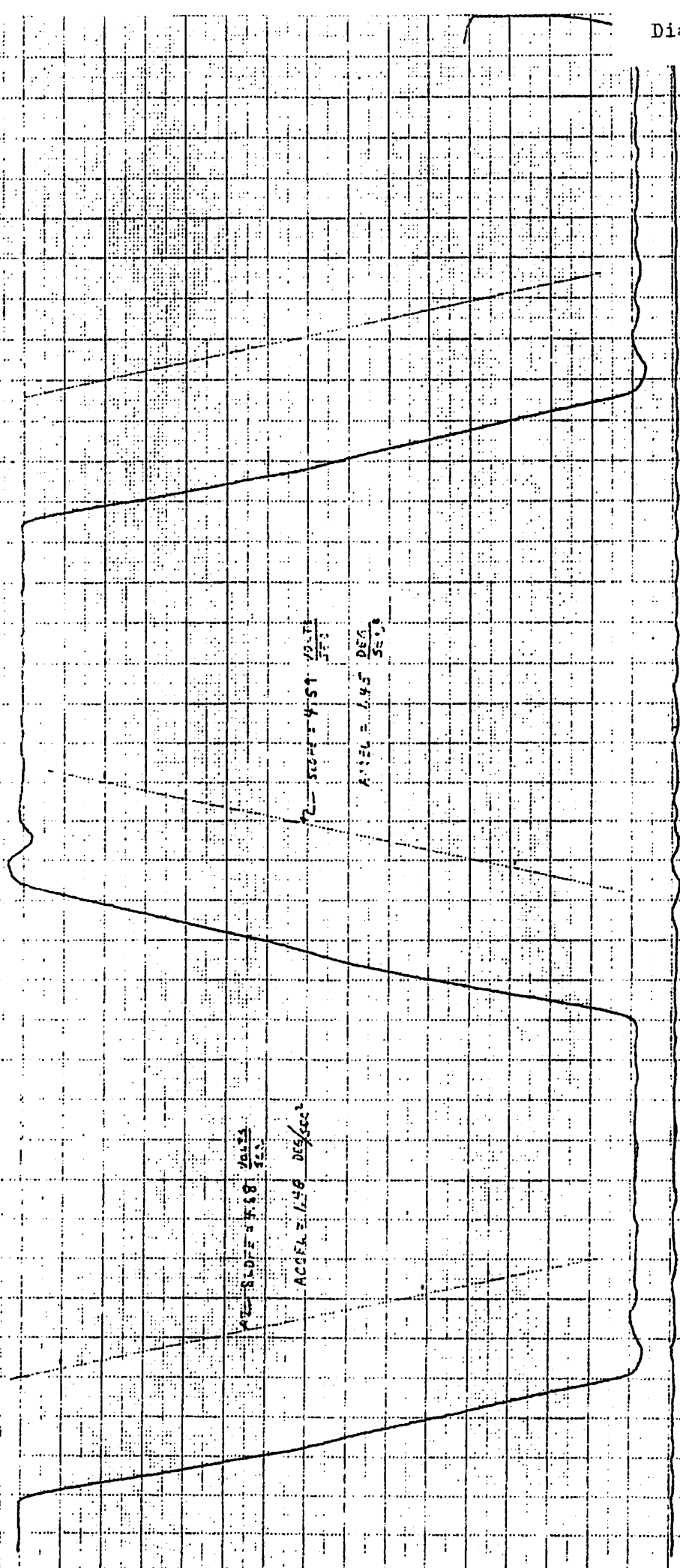
1000 1000 1000 1000 1000 1000

ACCEL = 1.88 VOLT/SEC

ACCEL = 1.46 DEG/SEC

2-STEP = 4.51 VOLT/SEC

ACCEL = 1.45 DEG/SEC



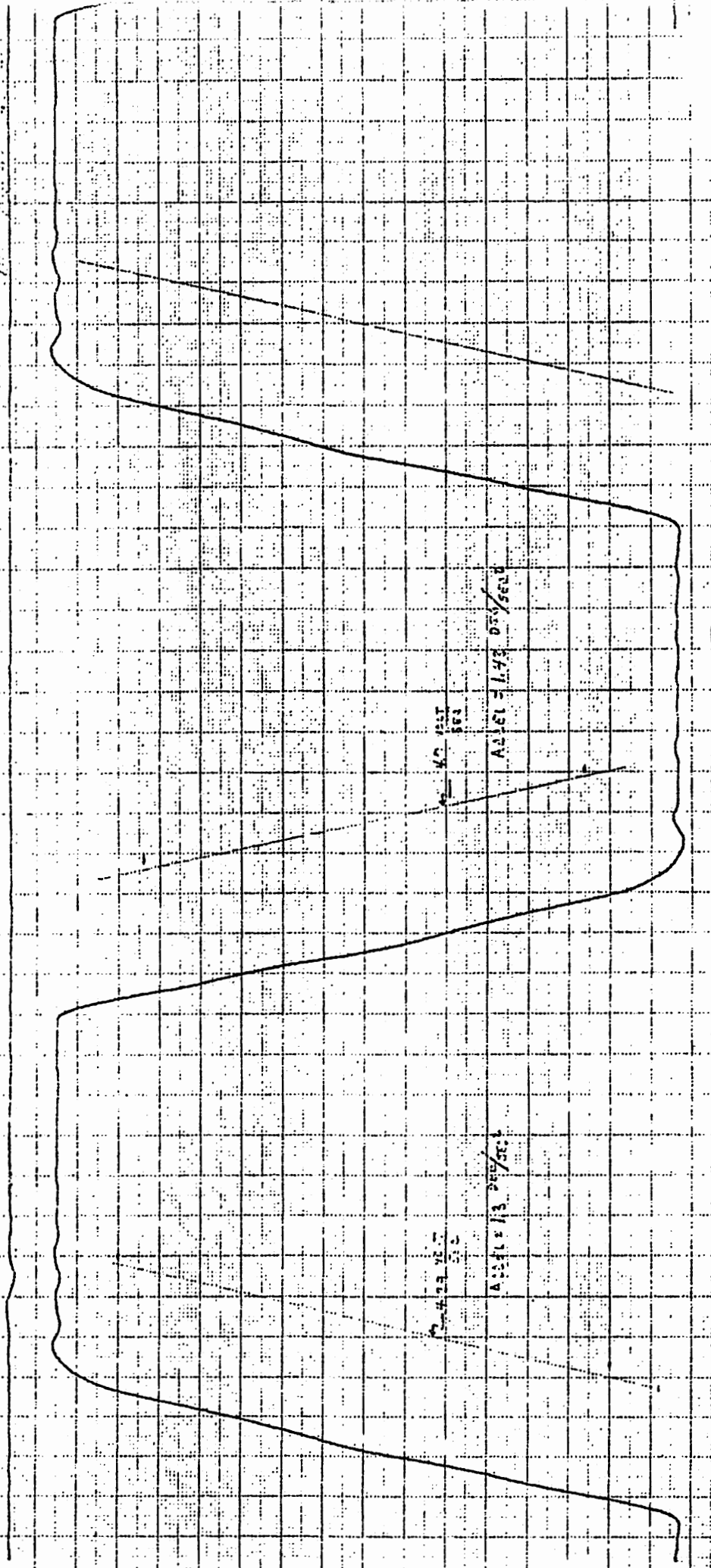
REMARKS
AS WITH DISCREPANCY
SOCIETY BAR
ONE SECTION
ON 11/1/20

SECTION A
11/21-23

SECTION A
11/22 10:00/SEC
11/23 10:00/SEC

SECTION A
11/22 10:00/SEC

SECTION A
11/23 10:00/SEC



11-23-79

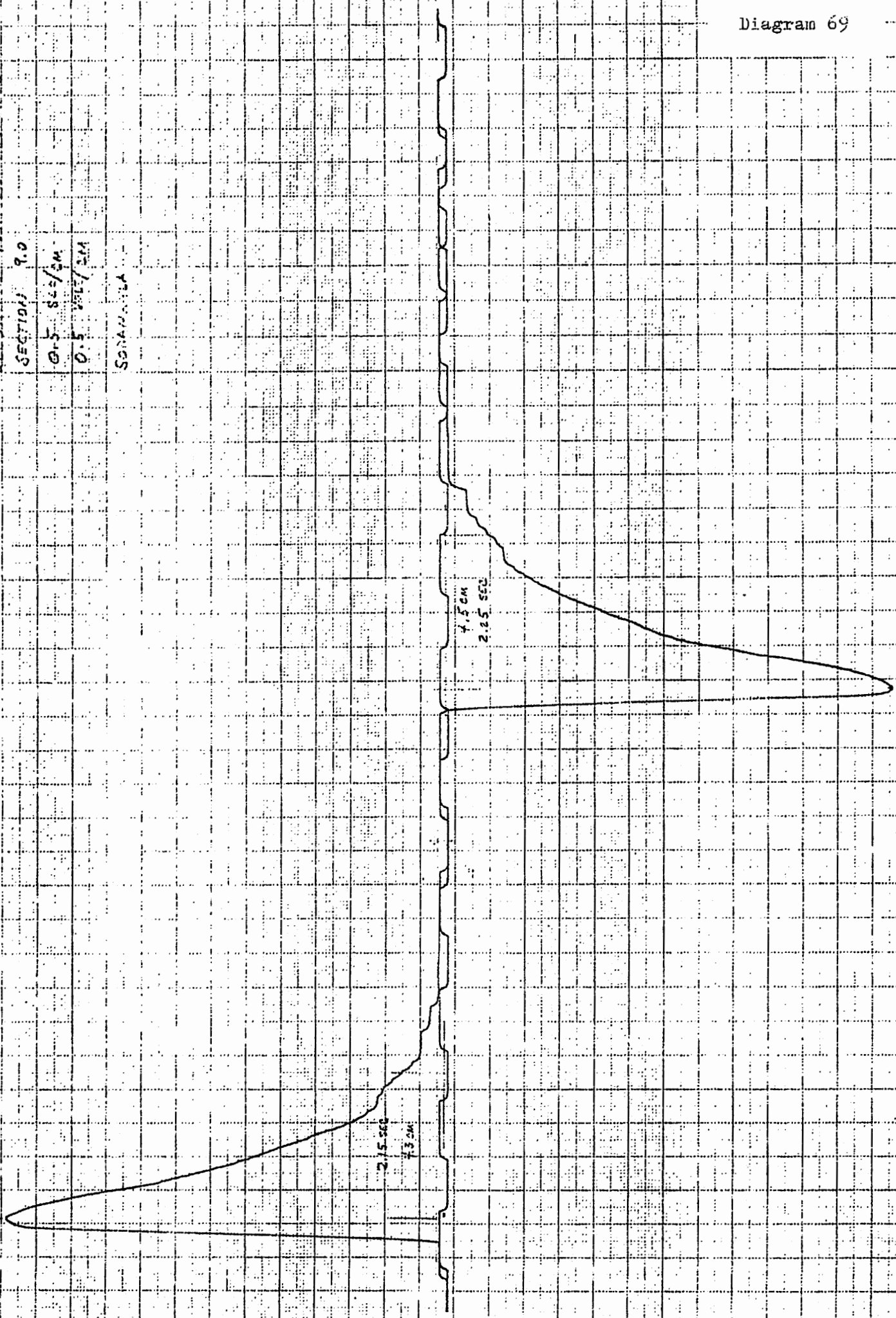
ELEVATIONAL POSITIONAL RESPONSE

SECTION 9.0

0.5 SEC/CM

0.5 VOL/CM

SORANAWA



11-23-78

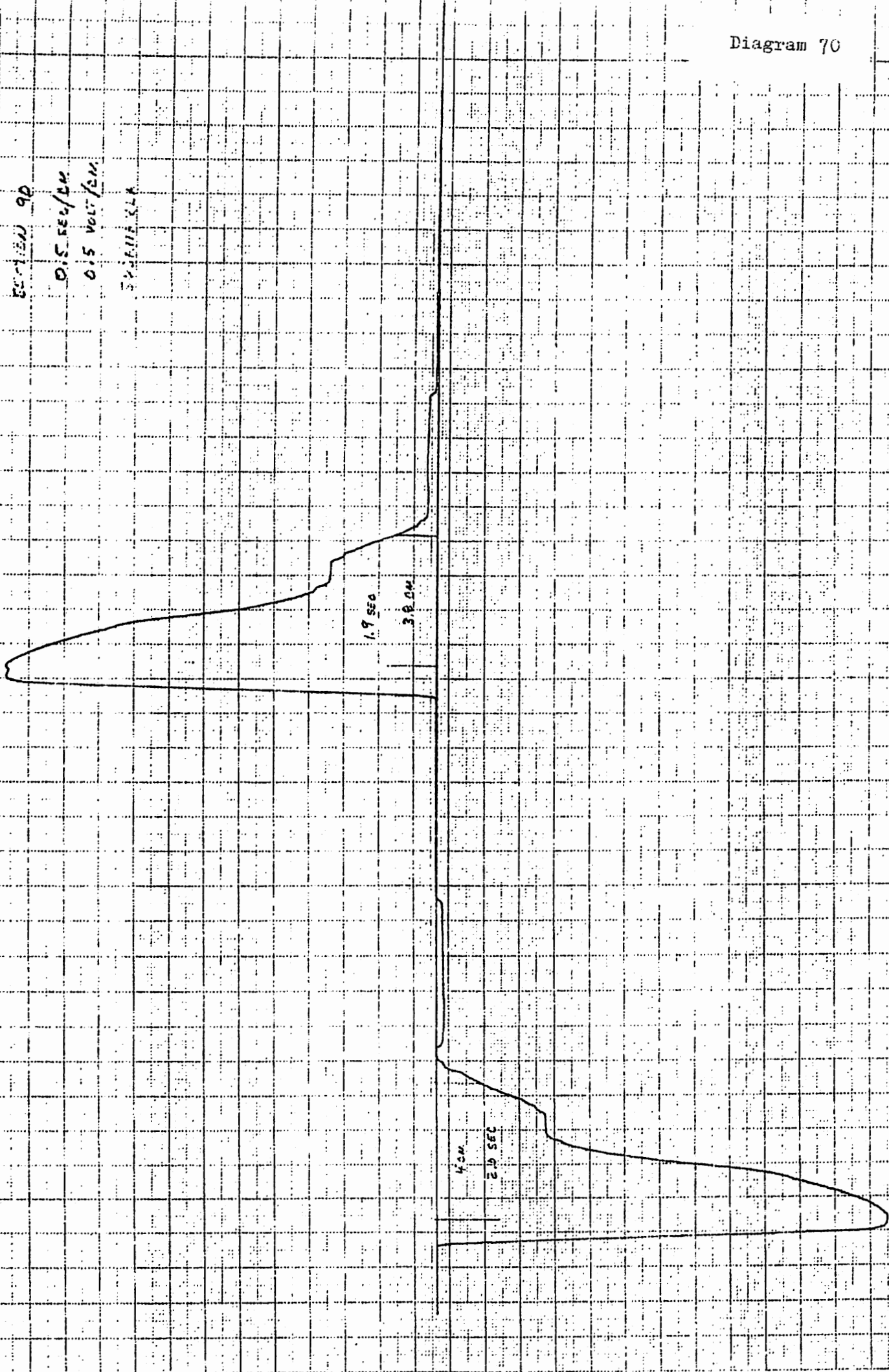
AZIMUTH POSITION RECORD

SECTION 90

0.5 SEC/CM

0.5 Volt/cm

SP-2115 KLA



1.9 SEC

3.0 CM

2.0 SEC

2.0 SEC

EISCAT 32m-UHF-ANTENNAS

Acceptance Test Procedure ATP 7857 REV A

RF-Performance

Test Equipment

2 ea WR 1150-1 5/8" Coax Transition

2 ea 1 5/8"-N Coax Transition

Dual Directional Coupler hp 778D

Sweep Oscillator hp 8620C, 86222B

Frequency Counter hp 5328A opt. 031

Power Meter hp 435A, 8481A, 8484A

50 Ω Termination

Radiometer Receiver Supplied by EISCAT

VECTOR VOLTMETER hp 8405A

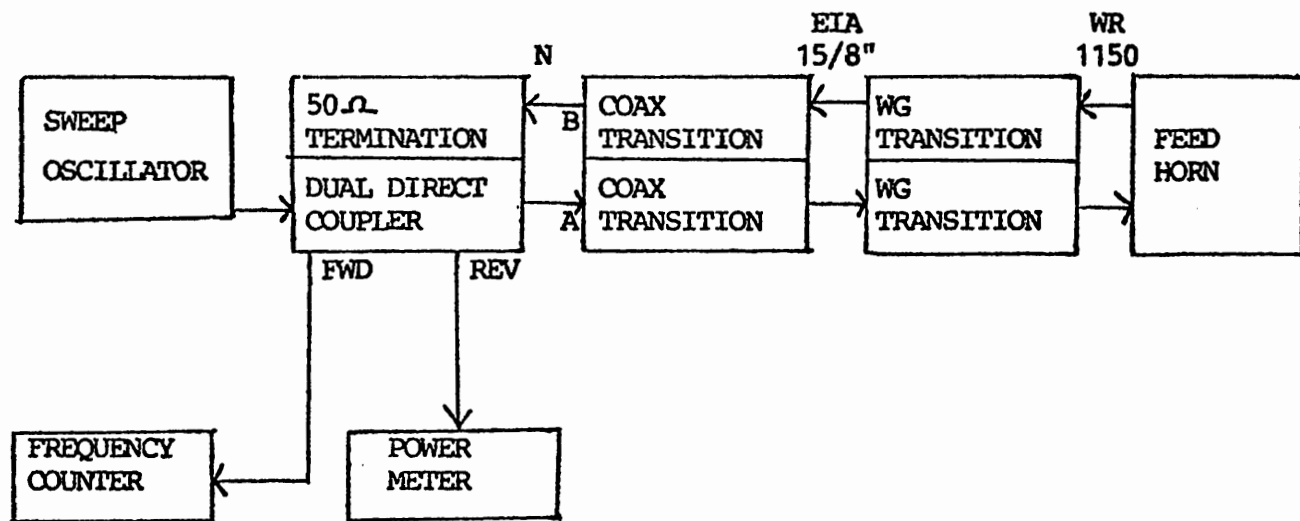
Boresight Antenna at Tromsø Site Supplied by EISCAT

Spectrum Analyzer hp 8558B

Voltage Ramp Generator

X-Y Recorder hp 7015A

1. Feed System VSWR



- 1.1 Set the output power of the SWEEP OSCILLATOR to 0 dbm. Measure power in dbm at FWD-port of DUAL DIRECTIONAL COUPLER and by turning around the coupler check the equality of the coupling ratios over the interesting frequency band 933.5 ± 10 MHz. Measure the insertion loss IL in db of the COUPLER for the different frequencies. Calculate the COUPLER correction factor CF by adding the insertion loss to the difference between reverse and forward power levels:

$$CF = IL + REV - FWD$$

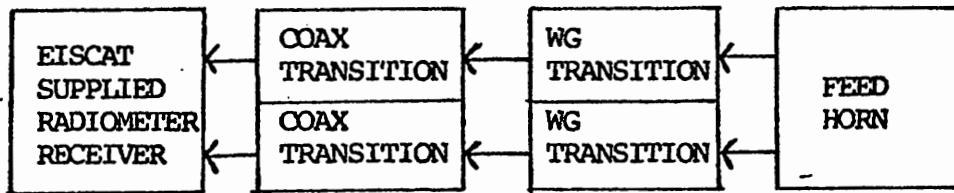
- 1.2 Measure the power ratio R' between the forward and reverse port of the Coupler in db for different frequencies and calculate the VSWR with the corrected ratio $R = R' + CF$

$$VSWR = \frac{1 + \sqrt{R}}{1 - \sqrt{R}} \quad ; \quad \sqrt{R} = 10^{(R_{db}/20)}$$

(R_{db} is a negativ number)

- 1.3 Interchange the connections to receiver ports. A and B and repeat the measurement of 1.2 for the orthogonal polarization.
- 1.4 Measure cross coupling between port A and port B over the frequency range. ✓

2. Antenna Noise contribution



- 2.1 Connect the FEED SYSTEM of the antenna to the RADIOMETER RECEIVER supplied by EISCAT and measure the antenna noise temperature. Point the antenna at 15° elevation and change the azimuth for a minimum readout.

Deduct value of the sky noise proven for the EISCAT sites at 15° elevation

measured

→ 20°K: for waveguide transition, coax transition, cable connection to RADIOMETER RECEIVER.

The resultant noise contribution due to feeder loss (to horn flange) and spillover should be less than 25°K.

- 2.2 Repeat the system noise temperature measurement for the other polarization.

3. Antenna Gain

Same measurement setup as in paragraph 2.

The gain of the antenna will be measured by using the well known radio emission of the radio star Cassiopeia A.

The flux density at $\lambda = 32.1$ cm is $P_0 = 3.5 \cdot 10^{-23}$ watt/m²/Hz.

With an effective aperture A_{eff} the antenna will collect a total power of $A_{\text{eff}} \cdot \frac{1}{2} P_0$ for one polarization. A radiometer receiver measures, this power as the noise temperature T_{CAS} , which de-

finies the power $K \cdot T_{\text{CAS}} = A_{\text{eff}} \cdot P_0 / 2 = G \cdot \frac{\lambda^2}{4\pi} \cdot P_0 / 2$.

The antenna gain G is determined with this relation as

$$G = \frac{K \cdot T_{\text{CAS}} \cdot 4\pi}{\frac{1}{2} P_0 \cdot \lambda^2} = \frac{1.38 \cdot 10^{-23} \cdot 4\pi}{1.75 \cdot 10^{-23} \cdot 0.321^2} \cdot T_{\text{CAS}}$$

$$G = 96.17 \cdot T_{\text{CAS}}$$

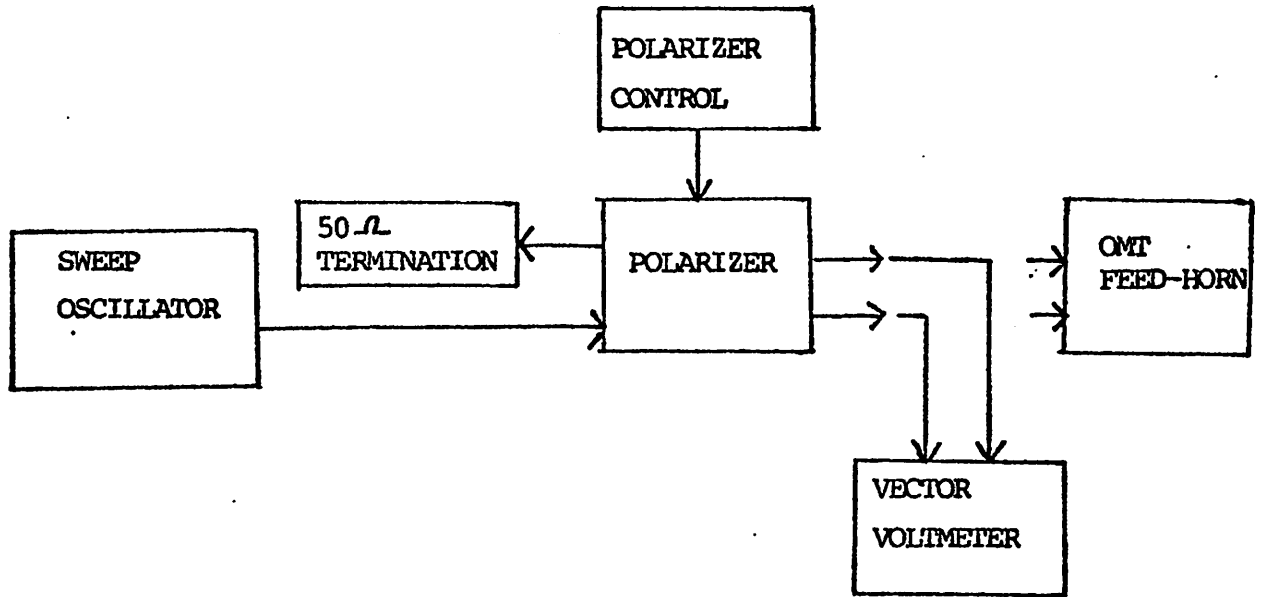
$$G_{\text{db}} = 10 \cdot \log [96.17 \cdot T_{\text{CAS}}] \quad (3)$$

For $G > 47.5$ db, $T_{\text{CAS}} > 585^\circ$ K

- 3.1 Point the antenna to the radio star Cassiopeia A (EISCAT supplies Azimuth and Elevation coordinates). Adjust the antenna position for maximum noise power measured with the RADIOMETER RECEIVER. Make sure, that the receiver evaluates only the 933.5 + 10 MHz band. Calculate antenna gain with equation (3). Add 1 db for losses in waveguide, transition, coax transition and cables.
- 3.2 Repeat measurement of 3.1 for the orthogonal polarization.
- 3.3 Repeat measurement of 3.1 with other radio stars at different elevation angles.

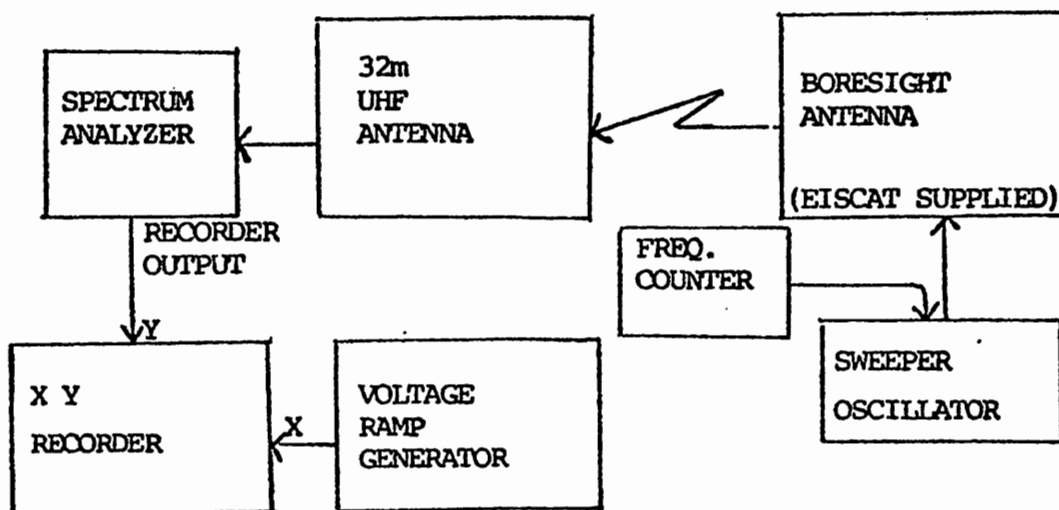
end mtl 5.12.11

4. Polarization



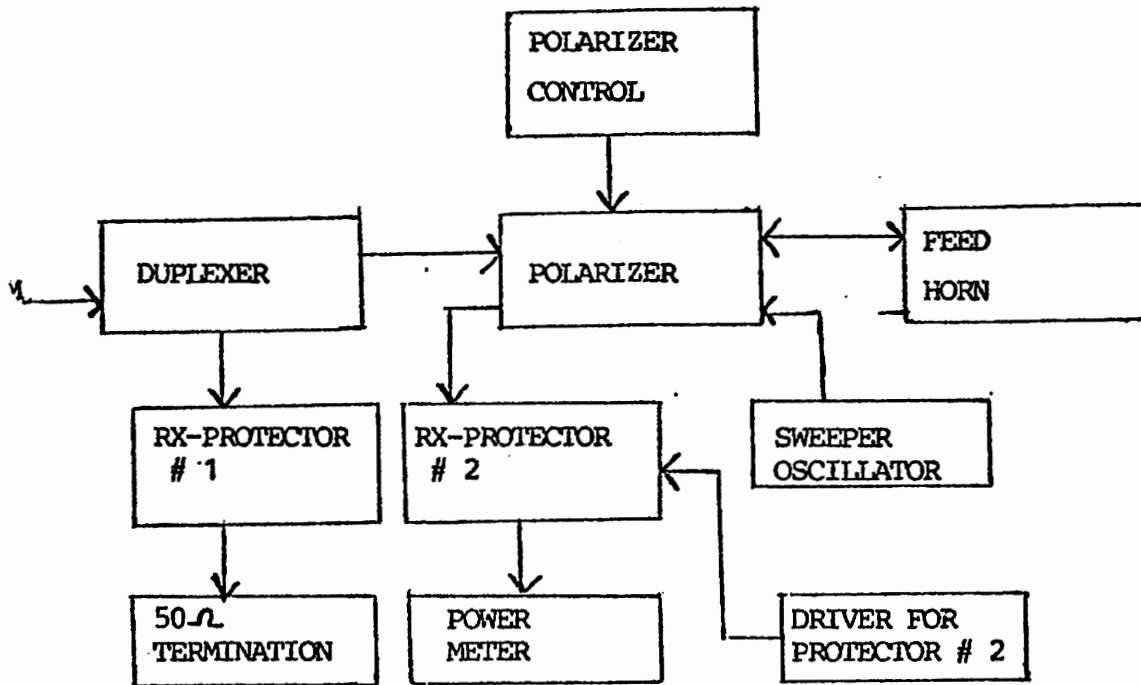
- 4.1 Set the **POLARIZER CONTROL** to 0 db amplitude ratio and 0 degree phase difference. Disconnect the inputs to the OMT and check the phase difference between the two inputs to the OMT. The vertical component should have a 120 degree phase lag to the horizontal component.
- 4.2 Reconnect **POLARIZER** to OMT and check different polarization settings with the boresight tower. Determine the angular location of the major and minor axis of the polarization ellipse and the axial ratio.

5. Antenna Pattern (Tromsø Site only)



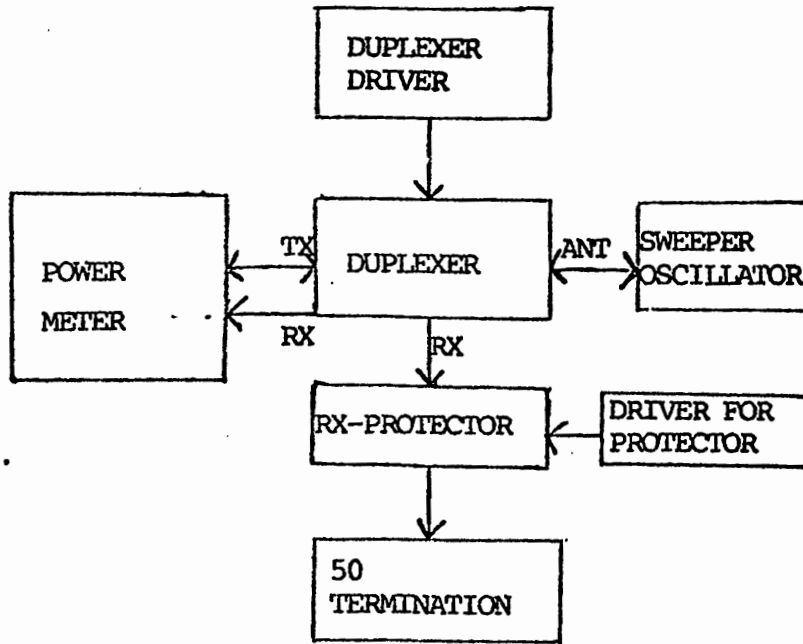
- 5.1 Feed BORESIGHT ANTENNA with a 933.5 MHz Signal of + 13 dbm and align both antennas for maximum reception. Set SPECTRUM ANALYZER in Manual Sweep Mode and adjust for maximum Recorder Output. Allow enough warmup time for good equipment stability.
- 5.2 Turn 32m-UHF-ANTENNA in a position -200° off boresight and change the azimuth angle at a constant speed from -200° to $+200^\circ$. Start the VOLTAGE RAMP GENERATOR together with the antenna movement to establish a defined relation between the X-axis of the recorder and the azimuth angle. Note the maximum sidelobe levels for sidelobes
 - closer than 10 degrees from beam axis -
 - between 10 degrees and 60 degrees from beam axis -
 - more than 60 degrees from beam axis.Repeat measurement for other frequencies.
- 5.3 Make patterns for -10° to $+10^\circ$ azimuth for different elevation settings, different frequencies and different polarizations.

6. Receiver Protector (Tromsø Site only)



- 6.1 Disconnect one of the two connections between POLARIZER and FEED HORN and apply a +10 dbm signal to the POLARIZER input. Switch the RX-PROTECTOR # 2 in the RX-mode and change POLARIZER CONTROL for maximum reading of the POWER METER. Switch the RX-PROTECTOR in the TX-mode and note the change of the power reading.
- 6.2 Disconnect the RX-PROTECTOR #2 and measure the insertion loss in the RX-mode over the frequency band.

7. Duplexer (Tromsö Site only)



7.1 Switch the DUPLEXER in the RX-Mode. Apply a + 10 dbm signal at the ANT-port and note the power outputs at the RX- and TX-ports for different frequencies.

8. Power Handling (Tromsø Site only)

Connect the waveguide run to the EISCAT supplied UHF Transmitter and increase the power slowly to a maximum of 4 MW peak and 500 KW average. Watch the reflected power reading of the transmitter. Measure the power outputs of the two RX-PROTECTORS. Turn the antenna into different azimuth and elevation positions and read the reflected power. Repeat the measurements for different frequencies over the frequency band from 929.5 to 937 MHz.