UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
National Center for Earthquake Research

TILT CHANGES OF SHORT DURATION

1) A Classification Scheme for Short Period Tilt Events,
2) Some Coseismic Tilt Data from Four Central California Tiltmeters During 1974–1975, and
3) Documentation of Some Programs Used in the Analysis of Short Period Tilt Data

OPEN–FILE REPORT 76-750

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature

Menlo Park, California
1976

ABSTRACT

Section I of this report contains a classification scheme for short period tilt data. For convenience, all fluctuations in the local tilt field of less than 24 hours duration will be designated SP (i.e., short period) tilt events. Three basic categories of waveshape appearance are defined, and the rules for naming the waveforms are outlined. Examples from tilt observations at four central California sites are provided.

Section II contains some coseismic tilt data. Fourteen earthquakes in central California, ranging in magnitude from 2.9 to 5.2, were chosen for study on four tiltmeters within 10 source dimensions of the epicenters. The raw records from each of the four tiltmeters at the times of the earthquakes were photographed and are presented in this section.

Section III contains documentation of computer programs used in the analysis of the short period tilt data. Program VECTOR computes the difference vector of a tilt event and displays the sequence of events as a head-to-tail vector plot. Program ONSTSP 1)requires two component digitized tilt data as input, 2)scales and plots the data, and 3)computes and displays the amplitude, azimuth, and normalized derivative of the tilt amplitude. Program SHARPS computes the onset sharpness, (i.e., the normalized derivative of the tilt amplitude at the onset of the tilt event) as a function of source-station distance from a model of creep-related tilt changes. Program DSPLAY plots the digitized data.

CONTENTS

I

CLASSIFICATION SCHEME FOR SHORT PERIOD TILT EVENTS

INTRODUCTION

The U.S.Geological Survey maintains an array of approximately 40 biaxial borehole tiltmeters in central California. The data from four of these tiltmeters (Libby, LIB; Sage South, SAS, Melendy, MEL; and Bear Valley, BVY - see Figure I-1) was selected for this investigation. The station-to-fault and interstation distances are recorded in Table I-1. The instrument resolution is about 10^{-8} rad., although under ideal noise-free condidtions somewhat smaller changes can be detected if they occur within a few minutes. The data, passed through a 20 second output filter, is sampled at 10 second intervals. A description of tiltmeter installation and operation is contained in Johnston and Mortensen (1974) and Mortensen and Johnston (1975).

For convenience, all fluctuations in the local tilt field of less than 24 hours duration will be designated short period (ie,SP) tilt events. Visual examination of the raw records discloses that many of the perturbations in the tilt field may be classed as SP events. Preliminary analysis of the data indicates 1) that there are many different physical processes capable of affecting the local tilt field, and 2) that there may be a large variety of waveshapes associated with a particular physical process.

Often the source of the event is unknown or only tentatively identified, so that reference to the SP event must be made without implying a physical mechanism. Although the SP event waveshapes are quite variable, there are some waveforms that repeatedly occur. Thus it would be useful to refer to a particular event type without reference to the event source.

Classification of Short Period Events

The following notation is proposed for SP tilt events based upon their appearance in the raw records (ie, monitoring tilt component amplitude versus time and sampled at 10 second intervals with a chart speed of 0.5 inch/hour; the tilt data in figures I-2 through I-5 were taken from enlarged copies of the Rustrak records that were digitized and computer processed to a common scale - see Section III-D; Program DSPLAY):

SPI: Impulsive events. These events are characterized by a very rapid onset and decay, typically appearing as "spikes" in the tilt amplitude (figure I-2a).

SPS: Step-like events. These events are characterized by a very rapid onset resulting in a permanent (or apparently permanent) offset in tilt amplitude. (figure I-2b).

SPO: Oscillatory tilt signatures. These events are quasi-sinusoidal in appearance, and may have one or many zero crossings after the onset of the event (figures I-2c, d,e). In some cases it may be convenient to distinguish between events with different numbers of zero crossings, in which case "O" followed by the number of zero crossings, or "m" (ie,"many") can be used. (e.g., the waveshape in figure I-2c can be designated SPO1; figure I-2d, SPO2; and figure I-2e, SPOm).

Waveshapes combining the above features can be designated by combining the appropriate symbols, using the convention that I will be placed before S and O, and S before O (the number of "zero crossings" in the case of a combined event can be taken as the number of half-periods existing in the "O" part of the event). For example, waveshapes can be designated SPIS (figure I-3a), SPII (figure I-3b), SPSO (figure I-3c), SPISO1 (figure I-3d), SPSO2 (figure I-3e), SPSS (figure I-3f), and SPSOm (figure I-3g).

Subsets of this classification scheme may be defined when the physical origin of the SP tilt event is known, eg., creep-related, coseismic. The following scheme establishes the basic categories and is capable of further extension:

I) SR events - These events are produced by episodic, nonseismic slip on a fault or fracture (ie., slip-related tilt events). The actual waveshapes may be quite variable depending upon the source-station geometry and the type of slip occuring. Two subgroups have been identified:

a) SRN events - These are SP tilt events with residual offsets that are suspected to have been produced by a slip process - either at depth on the San Andreas fault or on a fracture subsidiary to the San Andreas fault, but that could not be related to events on nearby creepmeters. (This category would include the SR events discussed in McHugh and Johnston (1976).)

b) SRC events - These are SP tilt events associated with, or caused by, surface creep episodes. Included in this category, are the creep-related tilt events discussed in Mortensen et al. (1975), Johnston et al, (1976), and McHugh and Johnston, (1976).

II) CS events - These are coseismic tilt signatures, ie., SP tilt events produced by a slip process that radiates seismic energy.

a) CS_L events - Coseismic signatures produced by local earthquakes (figure I-2a.2, I-4a, magnitude and source-station distance indicated by M_L and D respectively).

b) CS_T events - Tilt signatures produced by teleseisms (figures I-2e, I-4b: body wave and surface wave magnitude indicated by M_b and M_s respectively, earthquake occurrence time in hours GMT is in parentheses).

III) R- tilt signature produced by rainfall. Figure I-5 shows examples of R events at MEL for the amounts of precipitation indicated in parentheses.

IV) P - tilt signature produced by barometric pressure flucuations, such as may occur with the passage of a major storm front. The tilt amplitude change expected for a major storm can be estimated from Savino and Rynn (1972):

$$w = \frac{LP}{4\pi\mu}\left[\frac{\lambda+2\mu}{\lambda+\mu} + \frac{2\pi Z}{L}\right] e^{(-2\pi Z/L)}$$

where w is the vertical deflection at depth Z, L is the wavelength of the pressure wave, and P is the pressure. Estimating the tilt, Θ, at the surface to be $w/(L/2)$, the change in tilt caused by a change in pressure becomes:

$$\Delta\Theta = 3\Delta P/(4\pi\mu) \quad \text{with } \lambda \sim \mu.$$

Pressure changes of up to 0.1 to 0.2 in .-Hg occurring within 3 hours have been recorded at the San Francisco International Airport (National Climatic Center, NOAA), thus reversible tilt changes of up to 5.4×10^{-9} rad within 3 hours (SPP events) may be associated with major storm fronts. A visual examination of tilt records from the stations shown in Figure I-1 at times of major barometric pressure changes (and excluding times of rainfall - figure I-6) failed to reveal any perturbations above the instrument resolution (10^{-8} rad). It is expected, therefore, that P events will not be seen above the 10^{-8} rad level; they may be significant on instruments with greater resolution.

In addition to cultural noise and solid earth tides, tiltmeters may be influenced at the 10^{-8} rad level, or greater, by ground water fluctations and thermal changes; however, these would generally have a duration greater than 24 hours and so would not be properly classed as SP events.

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Johnston, M. J. S., and C. E. Mortensen, Tilt precursors before earthquakes on the San Andreas fault, California, Science, 186, 1031-1034, 1974.

Johnston, M. J. S., S. McHugh, and R. O. Burford, On simultaneous tilt and creep observations on the San Andreas fault, Nature, 260, 691-693, 1976.

McHugh, Stuart, and M. J. S. Johnston, Some short period non-seismic tilt perturbations and their relation to episodic slip on the San Andreas fault in central California, J. Geophys. Res., (in press), 1976.

Mortensen, C. E., and M. J. S. Johnston, The nature of surface tilt along 85 km of the San Andreas fault - Preliminary results from a 14-instrument array, Pure and Appl. Geophys., 113, 237-249, 1975.

Mortensen, C. E., R. C. Lee, and R. O. Burford, Simultaneous tilt, strain, creep, and water level observations at the Cienega Winery south of Hollister, California, EOS Trans., AGU, 56, 1059, 1975.

Savino, J. M., and J. M. W. Rynn, Quasi-static loading of the earth by propagating air waves, J. Geophys. Res., 77, 5033-5041, 1972.

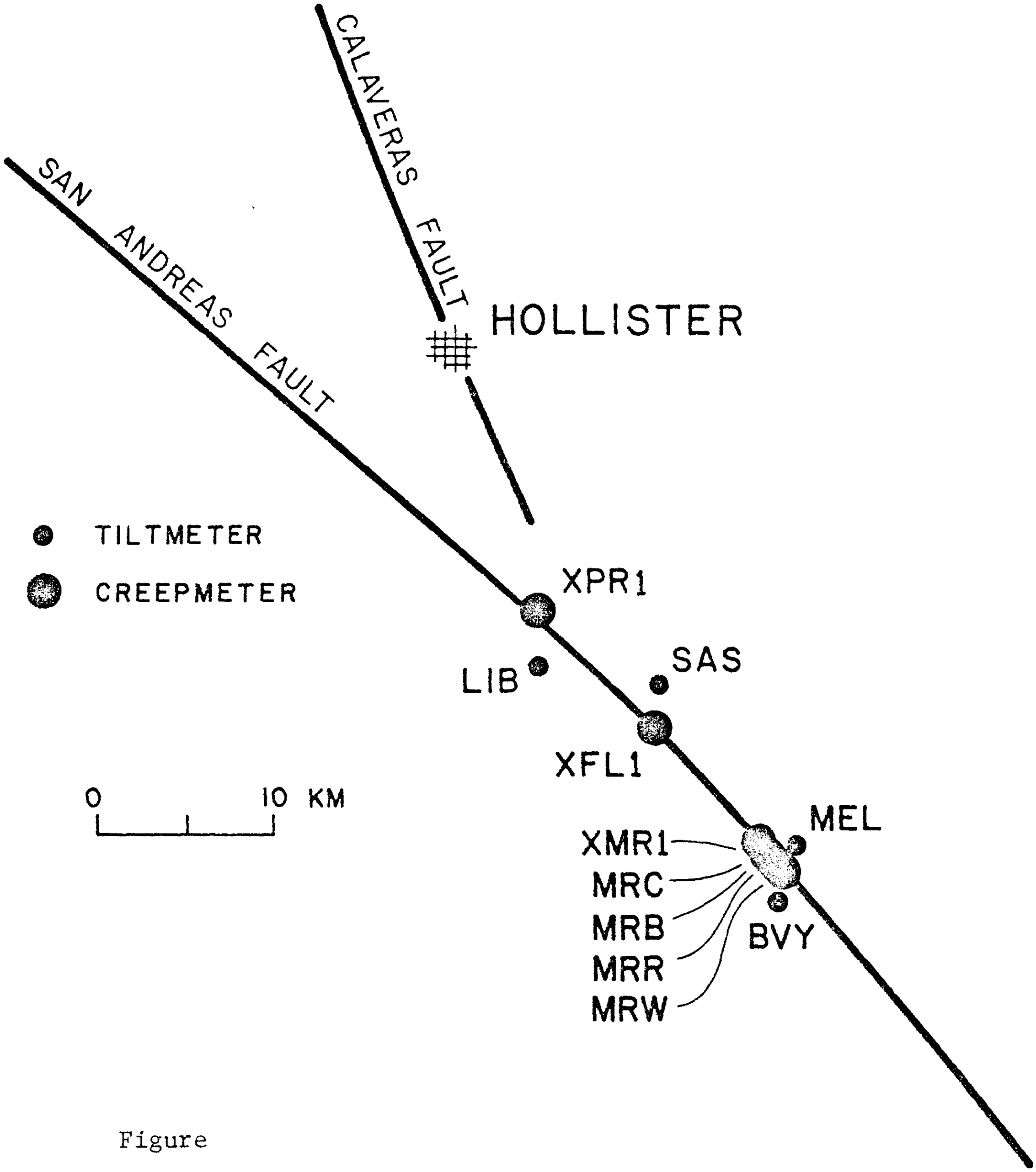
TABLE I-1

Interstation and Station-to-Fault Distances

	Distance (km)
LIB - SAS	7.0
BVY - MEL	2.2
SAS - fault	1.3
LIB - fault	2.0
MEL - fault	0.37
BVY - fault	1.6

Instrument Locations

LIB:	36°41.67'N, 121°20.60'W
SAS:	36°41.00'N, 121°16.08'W
MEL:	36°35.38'N, 121°10.63'W
BVY:	36°34.27'N, 121°11.23'W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SAN ANDREAS FAULT
HOLLISTER
TILTMETER
CREEPMETER
XPR1
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SAS
XFL1
0
10 KM
MEL
XMR1
MRC
MRB
MRR
MRW
BVY

Figure

I - 1

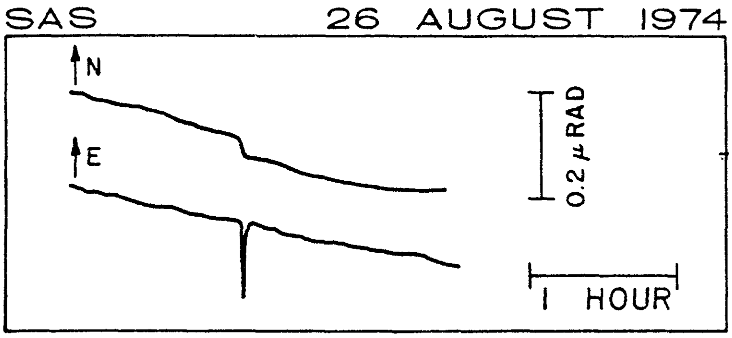


Figure I-2A.1

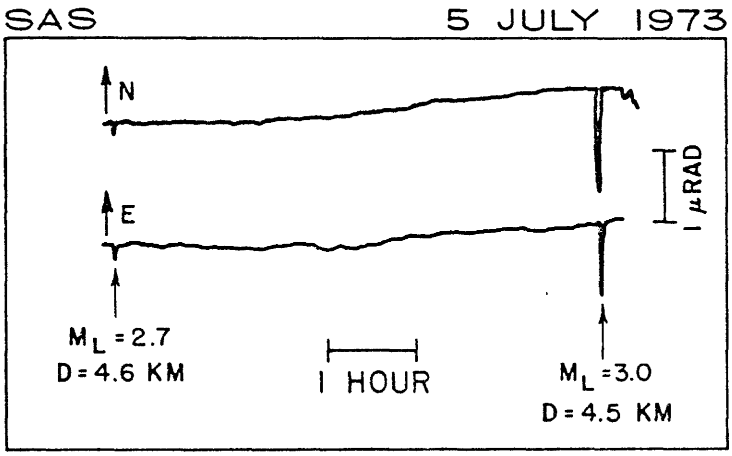


Figure I-2A.2

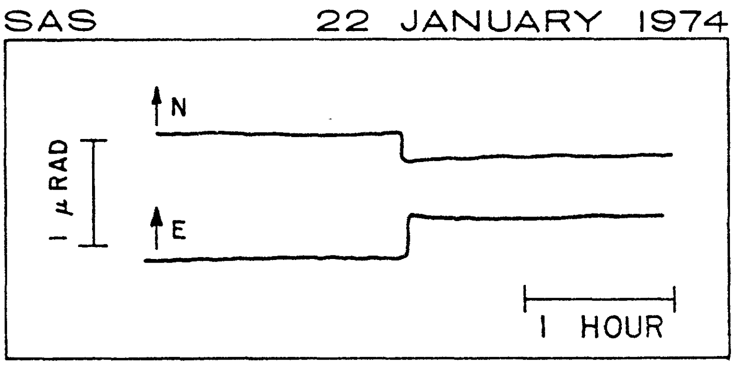


Figure I-2B

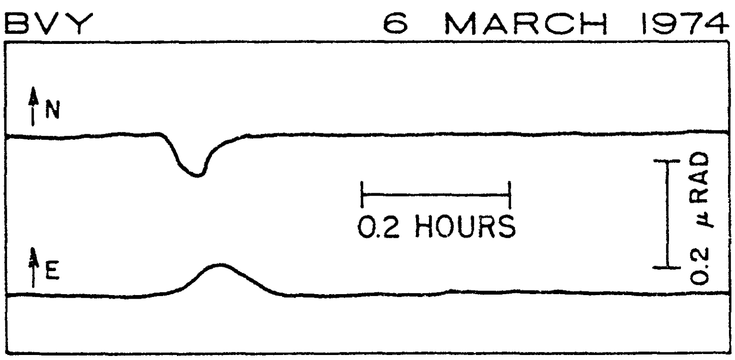


Figure I-2C

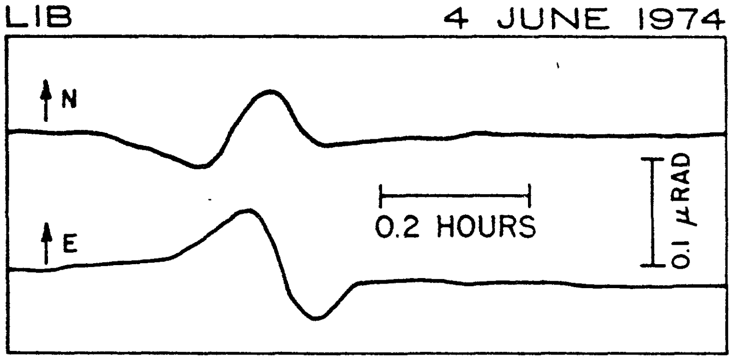
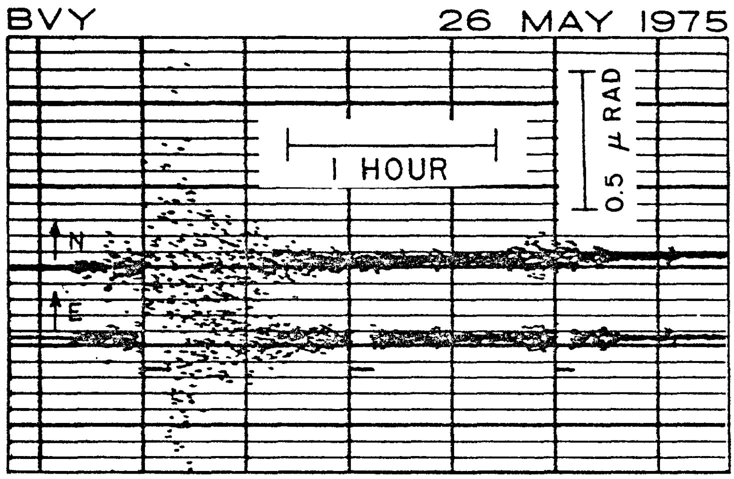


Figure I-2D



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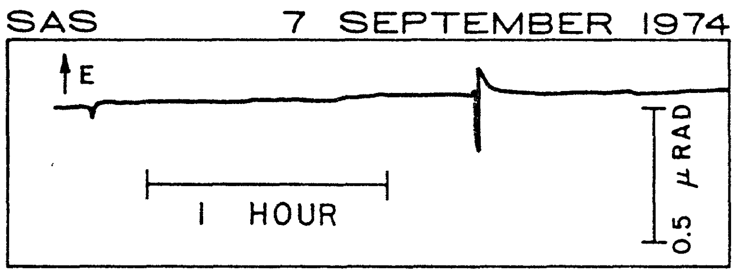

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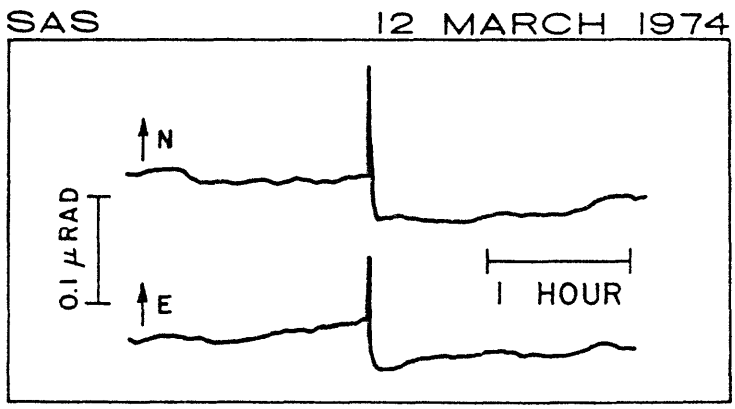

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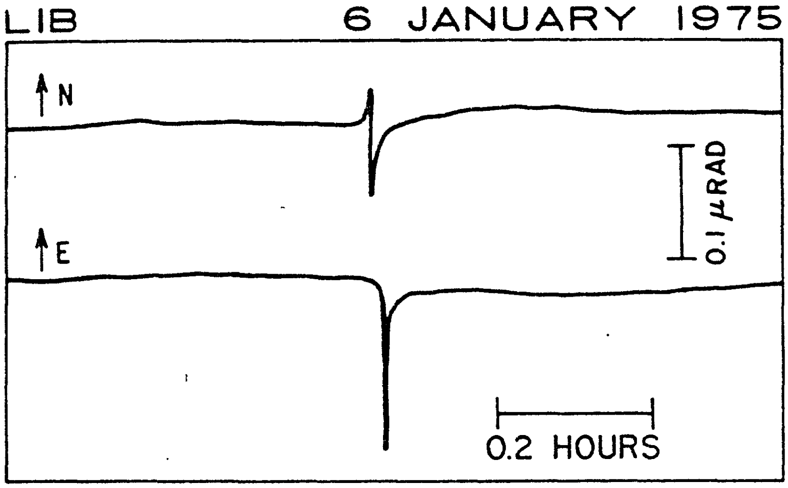


Figure I-3B

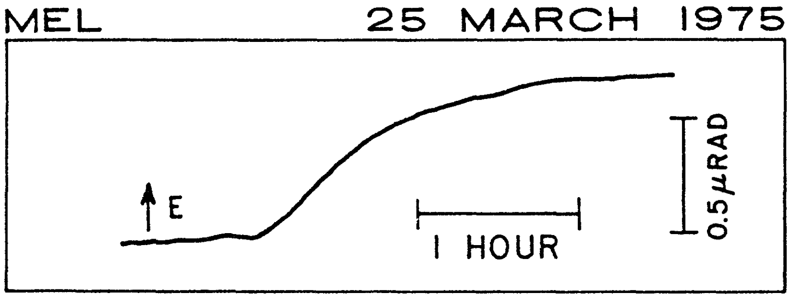
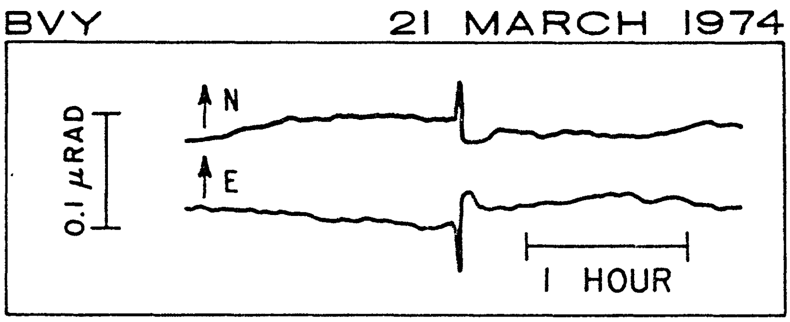


Figure I-3C



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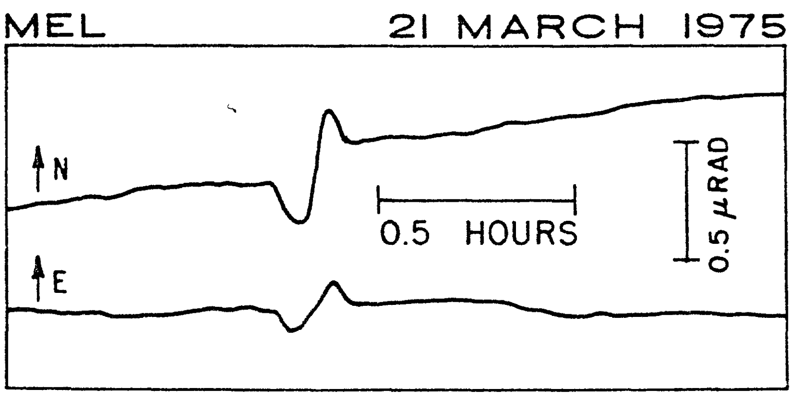

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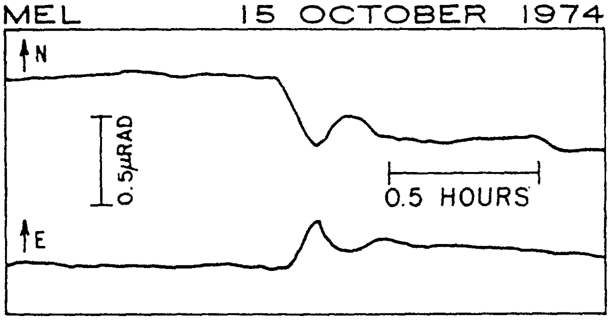

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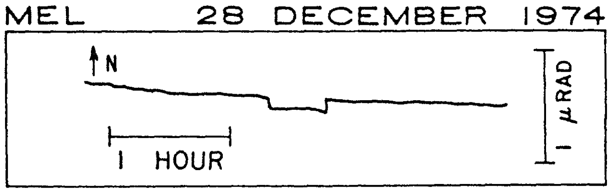

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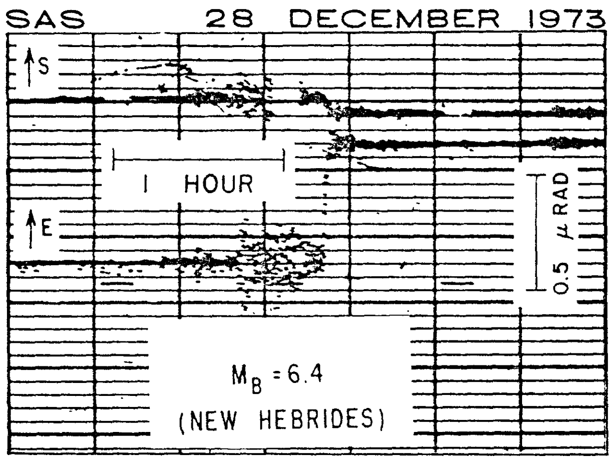


Figure I-3G

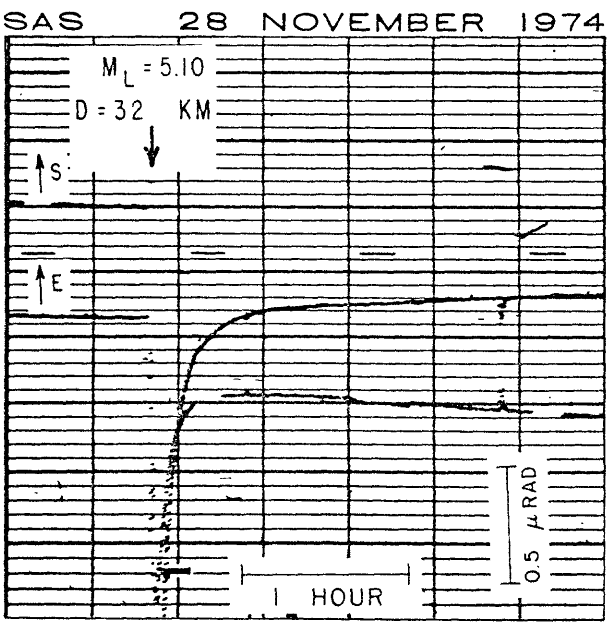


Figure I-4A.1

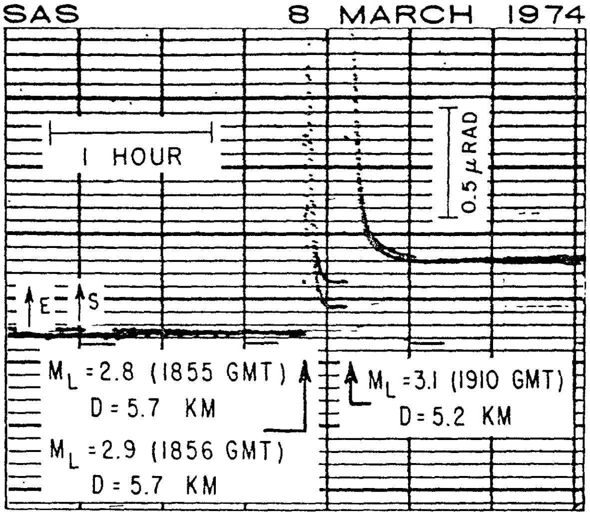


Figure I-4A.2

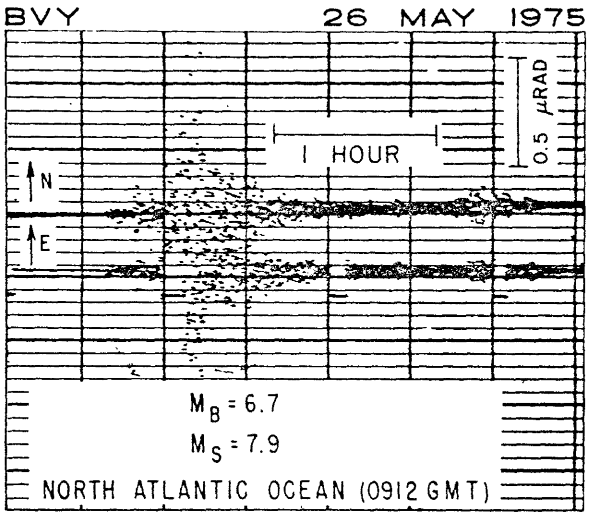


Figure I-4B

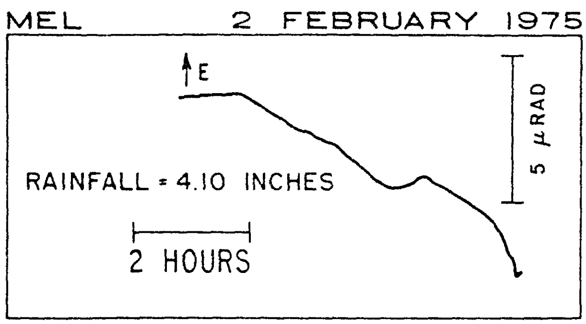


Figure I-5.1

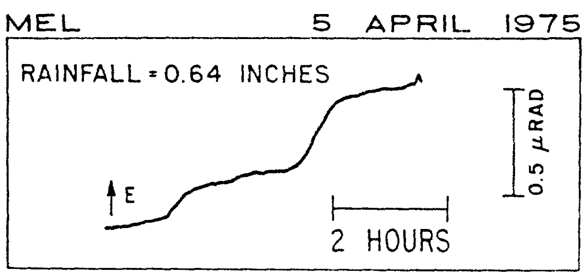


Figure I-5.2

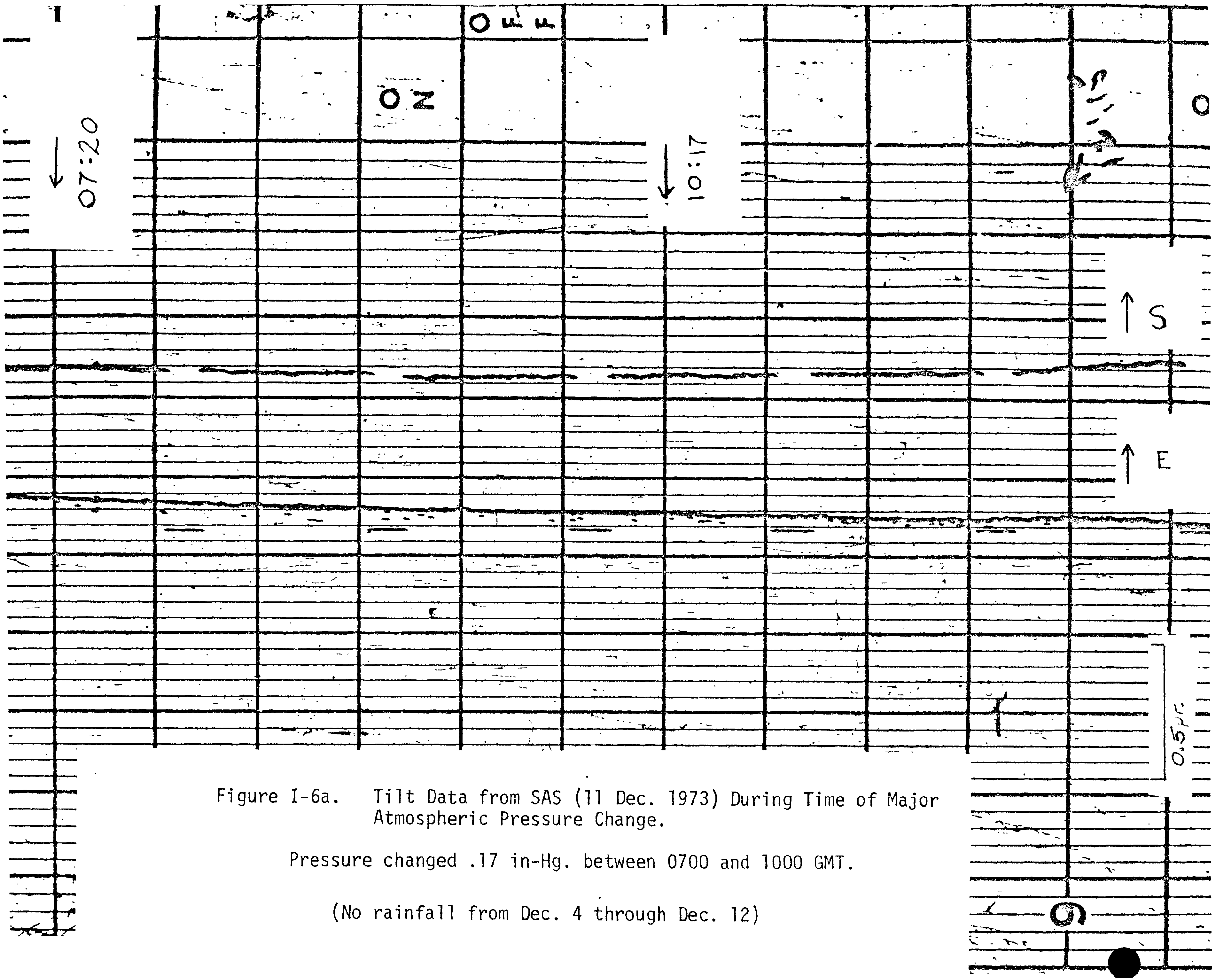


Figure I-6a. Tilt Data from SAS (11 Dec. 1973) During Time of Major Atmospheric Pressure Change.

Pressure changed .17 in-Hg. between 0700 and 1000 GMT.

(No rainfall from Dec. 4 through Dec. 12)

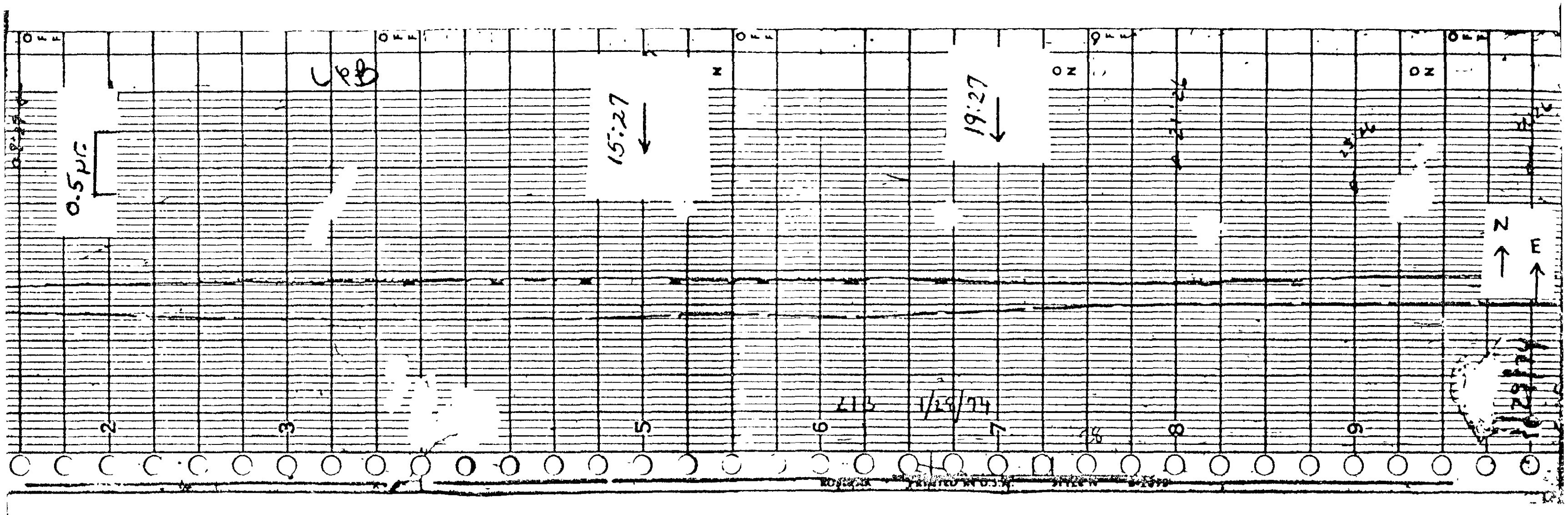


Figure I-6b. Tilt Data from LIB (28 Jan. 1974) During Time of Major Atmospheric Pressure Change.

Pressure changed .19 in-Hg. between 1600 and 1900 GMT.

Pressure changed .18 in-Hg. between 1900 and 2200 GMT.

(No rainfall was recorded between 22 Jan. and 31 Jan. 1974 in this area.)

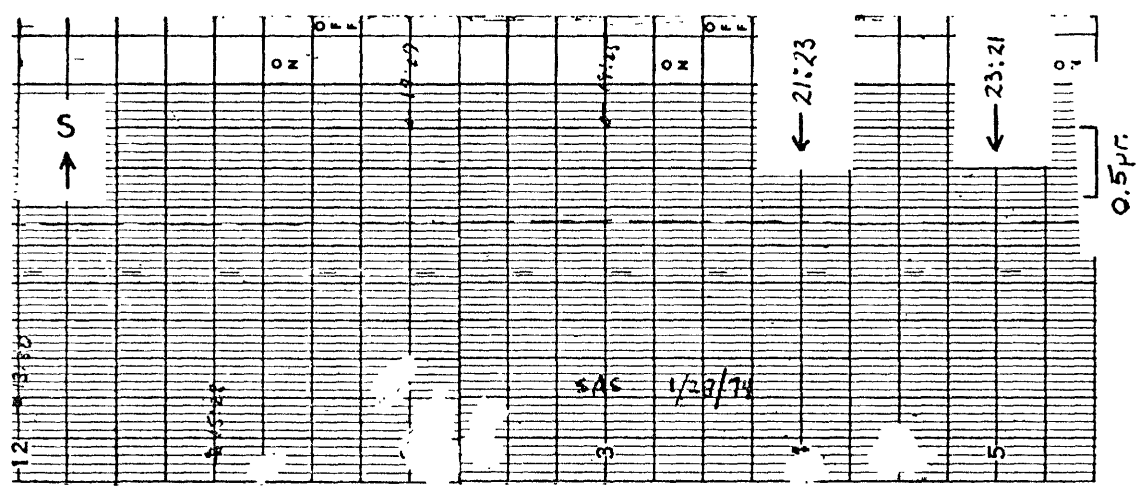


Figure I-6c. Tilt Data from SAS (28 Jan. 1974) During Time of Major Atmospheric Pressure Change.

Pressure changed .19 in-Hg between 1600 and 1900 GMT.

Pressure Changed .18 in-Hg between 1900 and 2200 GMT.

(No rainfall between 22 Jan. and 31 Jan. 1974)

II

SOME COSEISMIC TILT DATA FROM FOUR CENTRAL CALIFORNIA TILTMETERS DURING 1974-1975

INTRODUCTION

Fourteen earthquakes in central California, ranging in magnitude from 2.9 to 5.2, were chosen for study on four tiltmeters (Figure 2-1) within 10 source dimensions of the epicenters. Routine location of the epicenters places the events west of the San Andreas fault (Group I events, Figure 2-1). Therefore, 6 of the epicenters were relocated by inspection onto the fault (Group II events, Figure 2-1). Four of the remaining events were relocated using a computer routine developed for this purpose (Group III events, Figure 2-1). Tables 2-1 and 2-2 list the source data for the 14 events, and tables 2-3 and 2-4 list the source-station distances and directions.

Figure 2-2 is composite sketch of a typical coseismic tilt change. The impulse is designated 'I' and the residual offset 'S'. Table 2-4 lists the observed amplitudes, subscript a, and directions, subscript z, of the coseismic impulses and residual offsets. Photographs of the tiltmeter records from each of the four sites, shown in Figure 2-1, at the time of the earthquake occurrence are shown in Figures 2-3a through 2-3n.

Table 2-1

Earthquake Data for Group I Events

No.	Date	Time (GMT)	Latitude	Longitude	Ho (Depth) (km)	M_L	ERH (km)	ERZ (km)
1	10 Jan 1974	1122	36-57.08	121-35.86	7.84	4.20	.4	.6
2	8 Mar 1974	1910	36-38.26	121-17.51	4.33	3.14	.5	.6
3	12 Jun 1974	1921	36-44.24	121-23.41	6.43	3.70	.4	.5
4	15 Jun 1974	1749	36-43.78	121-23.64	6.54	3.28	.5	.7
5	6 Jul 1974	0403	36-32.96	121-11.18	5.33	3.07	.5	1.1
6	4 Aug 1974	1503	36-36.19	121-15.13	5.61	3.17	.4	.6
7	7 Sep 1974	2045	36-33.58	121-12.24	8.32	3.22	.4	.7
8	8 Sep 1974	1116	36-35.16	121-14.20	7.77	2.86	.4	.7
9	28 Nov 1974	2301	36-54.95	121-28.63	5.51	5.20	.3	.9
10	31 Dec 1974	2022	36-55.90	121-28.20	10.20	4.40	.4	.5
11	23 Feb 1975	1724	36-33.60	121-11.44	5.00	3.27	.4	.5
12	3 Mar 1975	1134	36-55.96	121-28.38	7.98	4.30	.5	.7
13	26 Mar 1975	2013	36-38.27	121-16.93	3.86	3.16	.5	.4
14	14 Jun 1975	1256	36-40.11	121-20.03	5.61	3.22	.4	.6

M_L: local magnitude.

ERH, ERZ: one standard deviation in the horizontal and vertical locations respectively.

Table 2-2

Data for Group II and III Events

No.	Date	Latitude	Longitude	Ho (Depth) (km)	M_L	ERH (km)	ERZ (km)	
1.	10 Jan 1974							
2	8 Mar 1974	36°39.5'	121°15.9'					
3	12 Jun 1974	36°44.9'	121°22.6'					
4	15 Jun 1974	36°44.6'	121°22.2'					
5	6 Jul 1974	36°34.08'	121°09.36'	2.9	3.1	1.0*	1.0*	+ RMS = .11
6	4 Aug 1974	36°37.10'	121°12.83'	6.30	3.17	.2	.2	+
7	7 Sep 1974	36°34.72'	121°10.11'	6.63	3.21	.2	.4	+
8	8 Sep 1974	36°36.35'	121°12.04'	6.95	2.86	.2	.2	+
9	28 Nov 1974							
10	31 Dec 1974							
11	23 Feb 1975	36°34.8'	121°10.0'					
12	3 Mar 1975							
13	26 Mar 1975	36°39.3'	121°15.7'					
14	14 Jun 1975	36°41.5'	121°18.4'					

* ERH, ERZ estimated from RMS value (Engdahl and Lee (1976)).

+ ERH, ERZ are 2 standard deviations in the earthquake position.

Columns left blank indicate values are the same as in Table

Group III Events: 6 July, 4 Aug, 7 Sep, 8 Sep, 1974.

TABLE 2-3

Station-Epicenter Distance and Azimuth
for Group I Events

DATE	LIB		SAS		MEL		BVY	
	D_o(km)	Az(°)	D_o(km)	Az(°)	D_o(km)	Az(°)	D_o(km)	Az(°)
10 Jan 1974	36.4	321	41.8	315	55.0	317	55.9	319
8 Mar 1974	7.8	144	5.5	203	11.6	297	11.9	308
12 Jun 1974	6.3	319	12.5	299	25.1	311	25.9	315
15 Jun 1974	6.0	311	12.4	295	24.8	309	25.5	314
6 Jul 1974	21.4	139	16.6	154	4.6	190	2.4	178
4 Aug 1974	13.0	141	9.0	171	6.9	283	6.8	301
7 Sep 1974	19.5	140	14.9	157	4.1	216	2.0	230
8 Sep 1974	15.4	142	11.2	165	5.3	266	4.7	290
28 Nov 1974	27.3	334	31.8	324	45.0	323	46.2	326
31 Dec 1974	28.6	337	32.9	327	46.1	325	47.3	328
23 Feb 1975	20.2	138	15.3	153	3.5	200	1.3	194
3 Mar 1975	28.9	336	33.2	327	46.3	325	47.5	328
26 Mar 1975	8.3	139	5.2	194	10.8	300	11.3	311
14 Jun 1975	3.0	164	6.1	254	16.5	302	17.0	310

Azimuth computed clockwise from north at station

TABLE 2-3

Station-Epicenter Distance and Azimuth
for Group I Events

DATE	LIB		SAS		MEL		BVY	
	D_o(km)	Az(°)	D_o(km)	Az(°)	D_o(km)	Az(°)	D_o(km)	Az(°)
10 Jan 1974	36.4	321	41.8	315	55.0	317	55.9	319
8 Mar 1974	7.8	144	5.5	203	11.6	297	11.9	308
12 Jun 1974	6.3	319	12.5	299	25.1	311	25.9	315
15 Jun 1974	6.0	311	12.4	295	24.8	309	25.5	314
6 Jul 1974	21.4	139	16.6	154	4.6	190	2.4	178
4 Aug 1974	13.0	141	9.0	171	6.9	283	6.8	301
7 Sep 1974	19.5	140	14.9	157	4.1	216	2.0	230
8 Sep 1974	15.4	142	11.2	165	5.3	266	4.7	290
28 Nov 1974	27.3	334	31.8	324	45.0	323	46.2	326
31 Dec 1974	28.6	337	32.9	327	46.1	325	47.3	328
23 Feb 1975	20.2	138	15.3	153	3.5	200	1.3	194
3 Mar 1975	28.9	336	33.2	327	46.3	325	47.5	328
26 Mar 1975	8.3	139	5.2	194	10.8	300	11.3	311
14 Jun 1975	3.0	164	6.1	254	16.5	302	17.0	310

Azimuth computed clockwise from north at station

Table 2-4

Station-Epicenter Distance and Azimuth
for Group II and III Events

DATE	LIB		SAS		MEL		BVY	
	D_o(km)	Az(°)	D_o(km)	Az(°)	D_o(km)	Az(°)	D_o(km)	Az(°)
10 Jan 1974								
8 Mar 1974	8.1	120	2.9	175	10.9	314	11.8	324
12 Jun 1974	6.7	334	12.1	307	25.1	315	26.0	319
15 Jun 1974	5.8	336	11.2	306	24.2	315	25.1	319
6 Jul 1974	21.9	130	16.3	142	3.1	142	2.8	97
4 Aug 1974	14.3	126	8.7	146	4.6	314	5.8	336
7 Sep 1974	20.2	129	14.6	143	1.4	148	1.9	64
8 Sep 1974	16.1	128	10.5	145	2.8	311	4.0	343
28 Nov 1974								
31 Dec 1974								
23 Feb 1975	20.3	129	14.7	142	1.5	141	2.0	64
3 Mar 1975								
26 Mar 1975	8.5	121	3.2	170	10.5	314	11.4	324
14 Jun 1975	3.4	97	3.5	284	16.1	314	17.0	321

Table 2-4

Station-Epicenter Distance and Azimuth
for Group II and III Events

DATE	LIB		SAS		MEL		BVY	
	D_o(km)	Az(°)	D_o(km)	Az(°)	D_o(km)	Az(°)	D_o(km)	Az(°)
10 Jan 1974								
8 Mar 1974	8.1	120	2.9	175	10.9	314	11.8	324
12 Jun 1974	6.7	334	12.1	307	25.1	315	26.0	319
15 Jun 1974	5.8	336	11.2	306	24.2	315	25.1	319
6 Jul 1974	21.9	130	16.3	142	3.1	142	2.8	97
4 Aug 1974	14.3	126	8.7	146	4.6	314	5.8	336
7 Sep 1974	20.2	129	14.6	143	1.4	148	1.9	64
8 Sep 1974	16.1	128	10.5	145	2.8	311	4.0	343
28 Nov 1974								
31 Dec 1974								
23 Feb 1975	20.3	129	14.7	142	1.5	141	2.0	64
3 Mar 1975								
26 Mar 1975	8.5	121	3.2	170	10.5	314	11.4	324
14 Jun 1975	3.4	97	3.5	284	16.1	314	17.0	321

TABLE 2-5

Observed Coseismic Tilt Data

	DATE	LIB				SAS				MEL				BVY			
		I_A	I_Z	S_A	S_Z	I_A	I_Z	S_A	S_Z	I_A	I_Z	S_A	S_Z	I_A	I_Z	S_A	S_Z
		(μr)	(°)	(μr)	(°)	(μr)	(°)	(μr)	(°)	(μr)	(°)	(μr)	(°)	(μr)	(°)	(μr)	(°)
1	10 Jan 1974	.43	241	0.0	-	.88	339.	.07	34.	*	*	*	*	*	*	*	*
2	8 Mar 1974	0.0	-	0.0	-	1.62	135.	≥.26	SE	*	*	*	*	.07	-	0.0	-
3	12 Jun 1974	.32	266	.01	243.	.10	-	≥0.0	-	≥0.0	--	≥0.0	--	.04	45.	0.0	-
4	15 Jun 1974	.47	270	.01	90	*	*	*	*	*	*	*	*	≥.02	0.0	0.0	-
5	6 Jul 1974	0.0	-	0.0	-	.61	325.	0.0	-	≥7.07	315+	.93	288.	≥0.80	-	≥.06	-
6	4 Aug 1974	*	*	*	*	≥1.18	-	≥.12	-	≥0.0	-	≥0.0	-	.08	21.0	≥0.0	-
7	7 Sep 1974	0.0	-	0.0	-	≥.21	-	≥0.0	-	≥.54	214+	.63	29.	1.25	289.	.06	351.
8	8 Sep 1974	.04	180.	.01	45.	≥.09	-	≥0.0	-	.25	281.	.07	135.	.29	0.0	0.0	-
9	28 Nov 1974	1.61	249	.11	326.	≥2.12	-	.85	4.0	7.92	-	.29	31.	≥1.70	135+	0.0	-
10	31 Dec 1974	.18	227.	.01	0.0	*	*	*	*	≥.15	-	≥.45	-	≥.09	-	0.0	-
11	23 Feb 1975	*	*	*	*	.47	187.	0.0	-	*	*	≥*	*	≥1.67	98.+	.07	74.
12	3 Mar 1975	.13	243.	0.0	-	.34	-	.01	270.	*	*	*	*	.13	207.	0.0	-
13	26 Mar 1975	*	*	*	*	*	*	*	*	0.0	-	0.0	-	.06	261.	0.0	-
14	14 Jun 1975	.62	115.	.07	207.	*	*	*	*	.28	270.	.25	349.	0.0	-	0.0	-

0.0 : Deflection less than 0.01 μrad.
* : No data available
\- : No azimuth computed -one tilt component offscale, zero, or initial sense of deflection uncertain.
\+ : Estimated
I : Impulse, S: Residual Offset
Subscripts: amplitude, A; azimuth (clockwise from north), Z

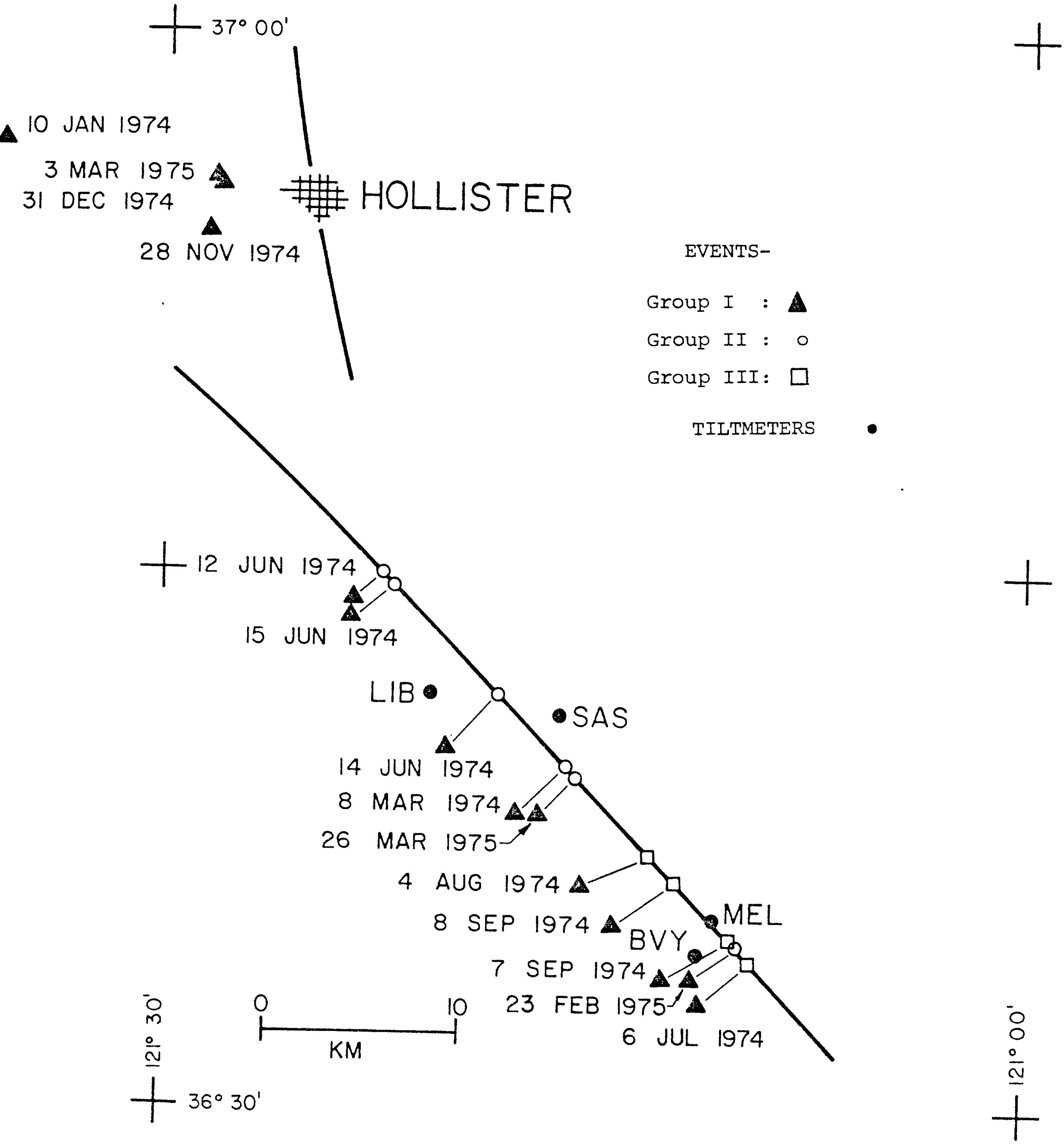

37° 00'
10 JAN 1974
3 MAR 1975
31 DEC 1974
HOLLISTER
28 NOV 1974
EVENTS-
Group I :
Group II :
Group III:
TILTMETERS
12 JUN 1974
15 JUN 1974
LIB
SAS
14 JUN 1974
8 MAR 1974
26 MAR 1975
4 AUG 1974
8 SEP 1974
MEL
BVY
7 SEP 1974
23 FEB 1975
6 JUL 1974
0
10
KM
121° 30'
36° 30'
121° 00'

Figure 2-1

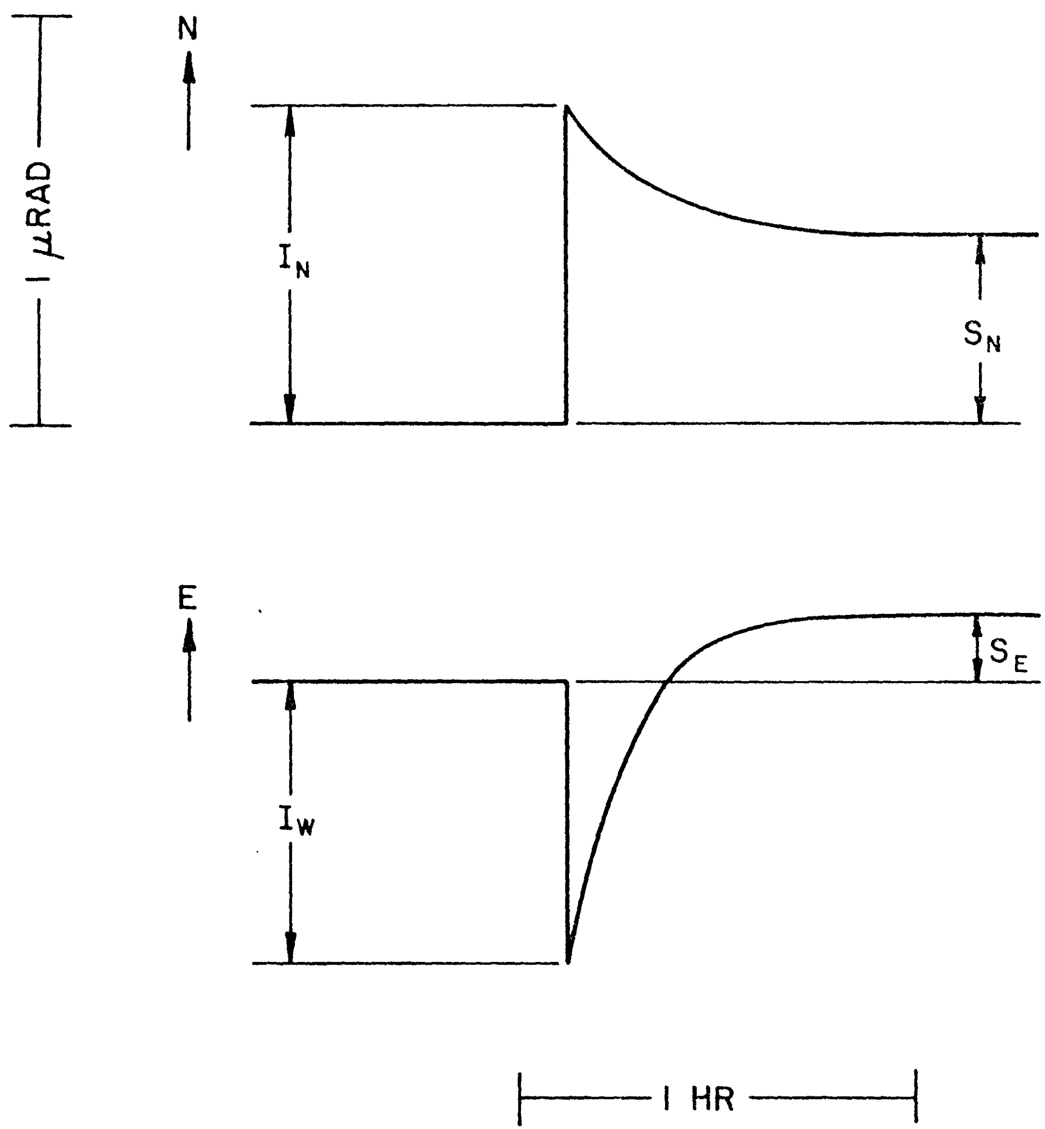


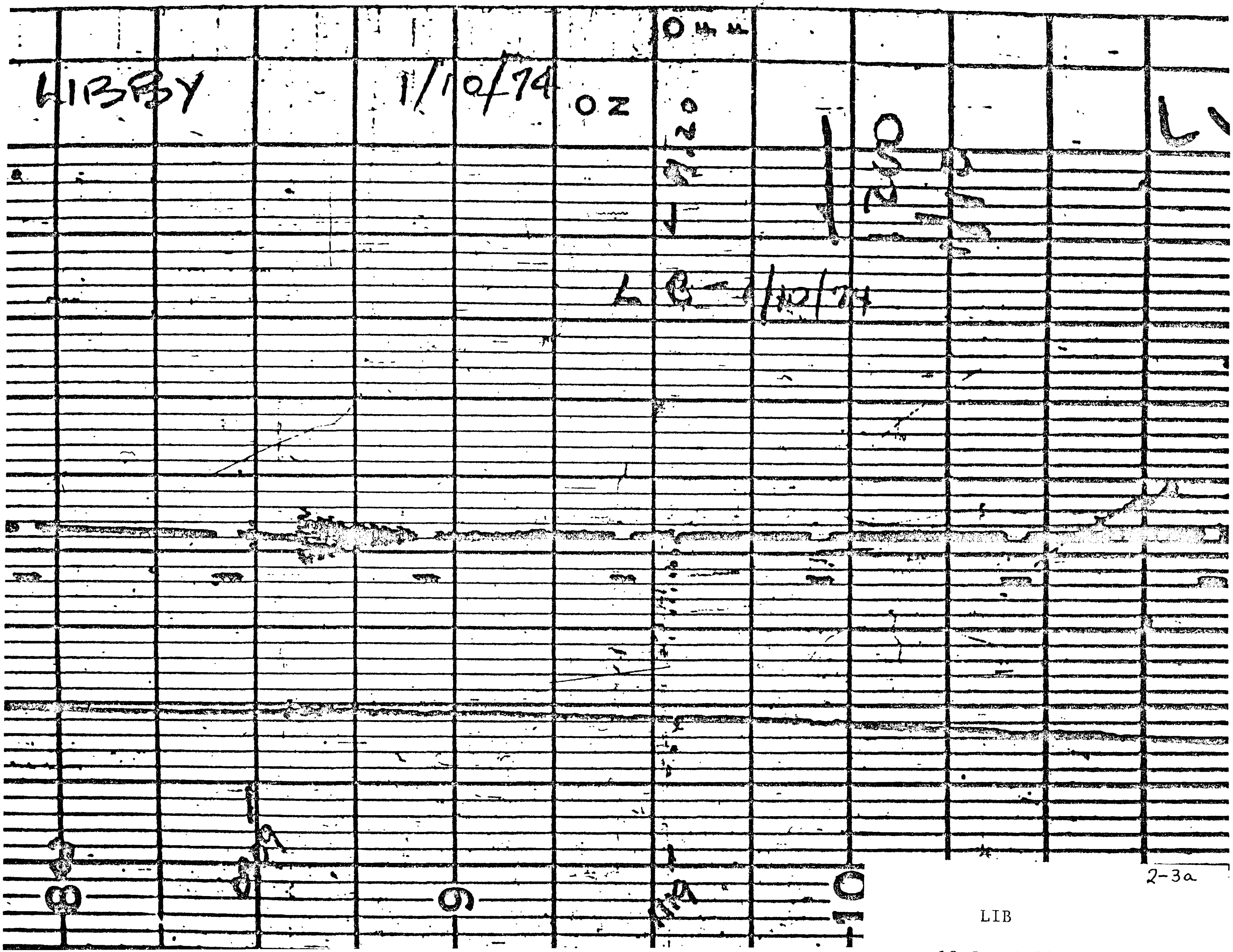
Figure 2-2

NOTE -

All events were retimed for this investigation. Some of the times shown in the photographs may not necessarily correct. In sections where confusion may arise, the earthquake occurrence time is marked by the arrow superimposed on the photograph.

The dashed trace is east-west (+X=east), the continuous trace is north-south (+y=north). The only exception to this orientation is SAS prior to 19 Dec. 1974 (when +x=south, +y=east).

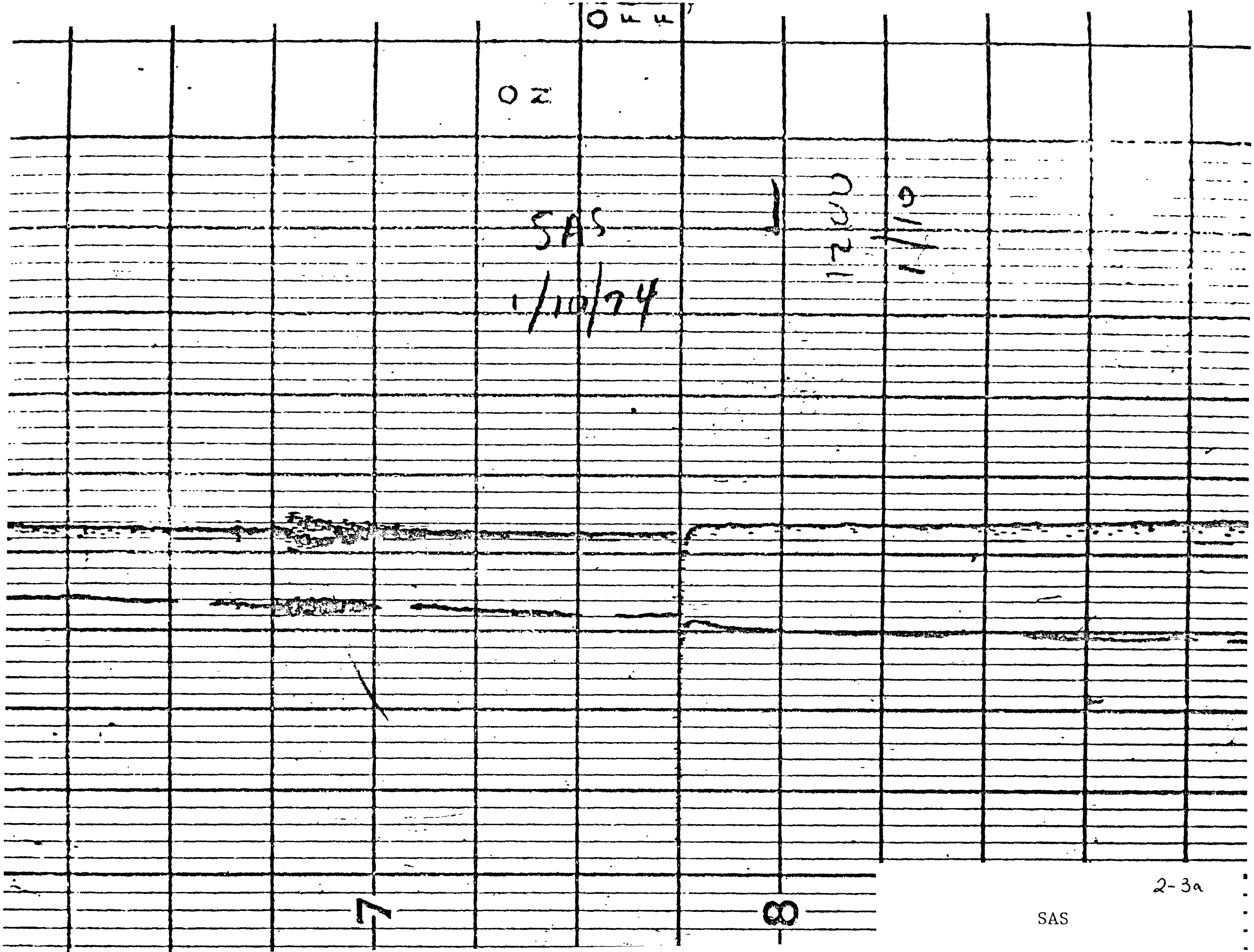
Amplitude scale at LIB, SAS, and BVY: 1 microrad. = 17 small divisions; at MEL: 1 microrad. = 3.4 small divisions. Time scale is 1 hour between the time marks (the short horizontal bars in the middle of the record).



2-3a

LIB

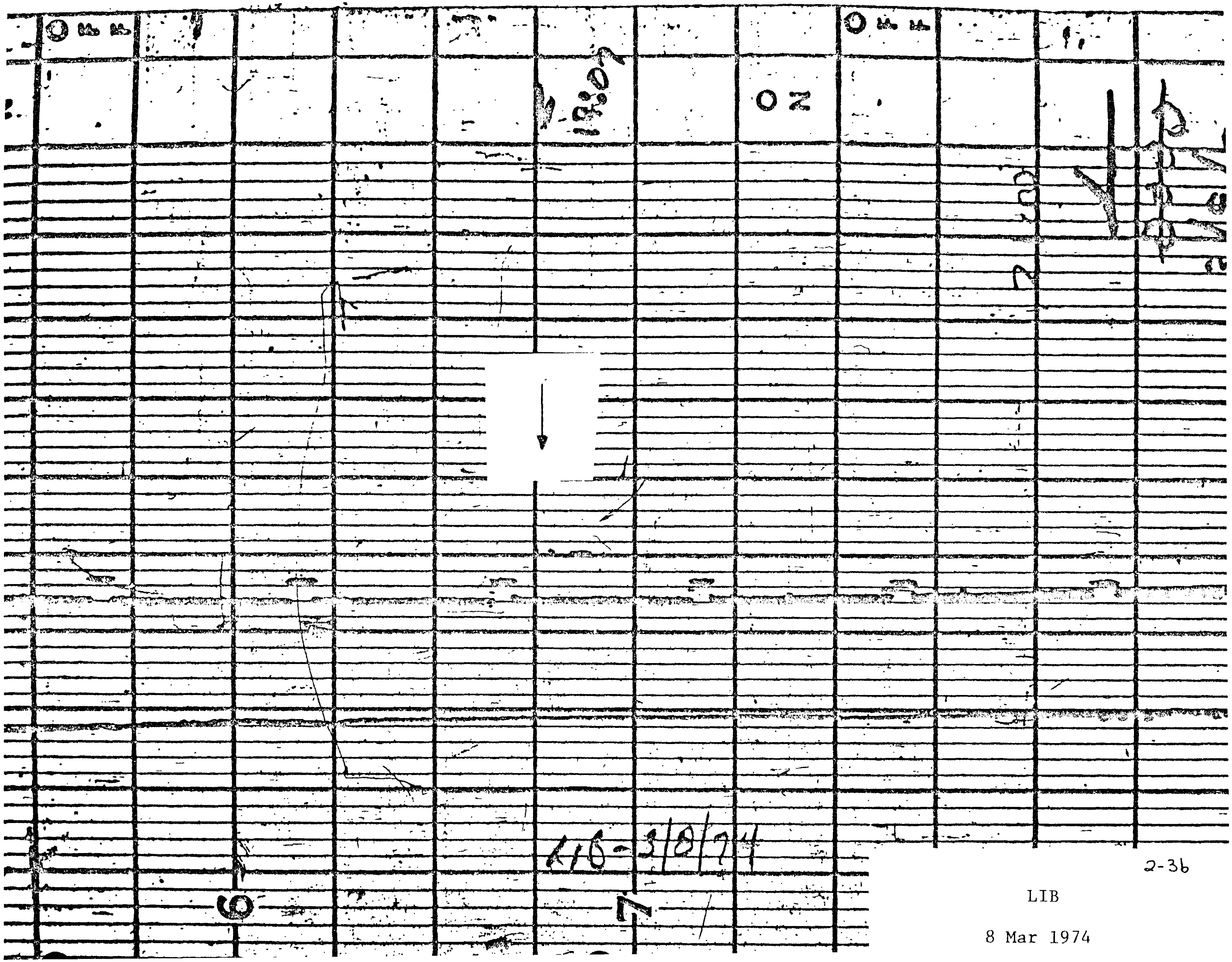
10 Jan 1974



2-3a

SAS

10 Jan 1974



2-36

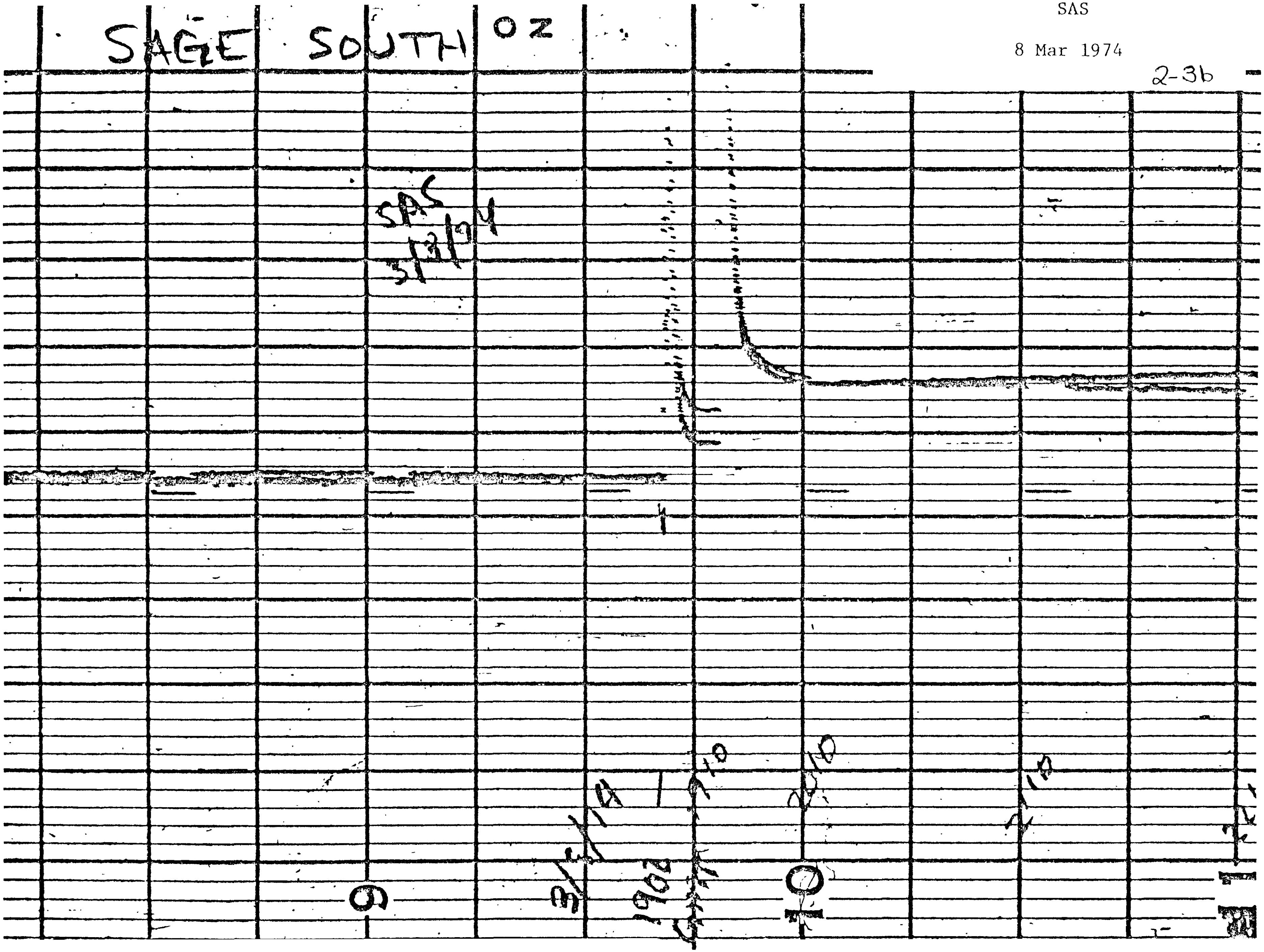
LIB

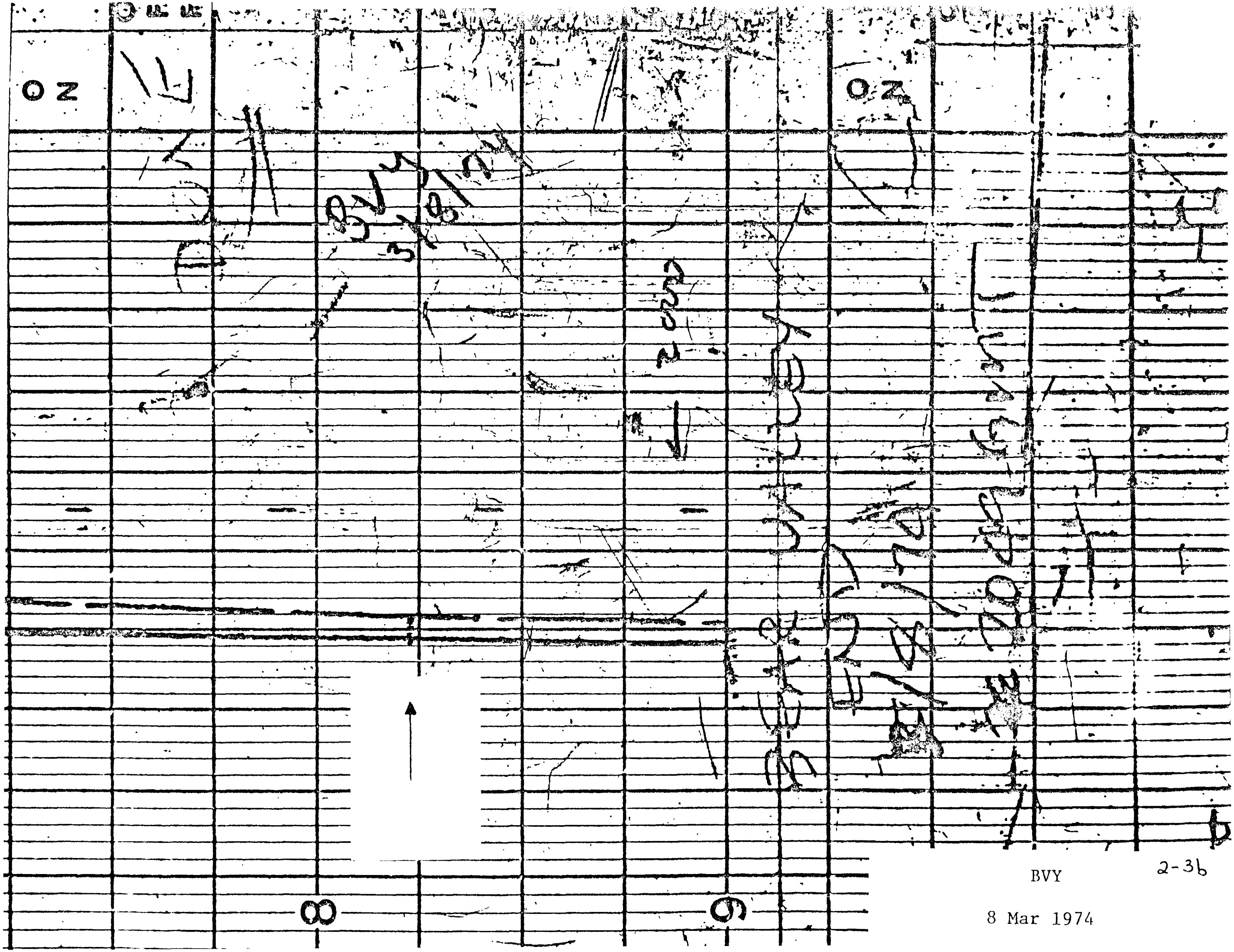
8 Mar 1974

SAS

8 Mar 1974

2-3b

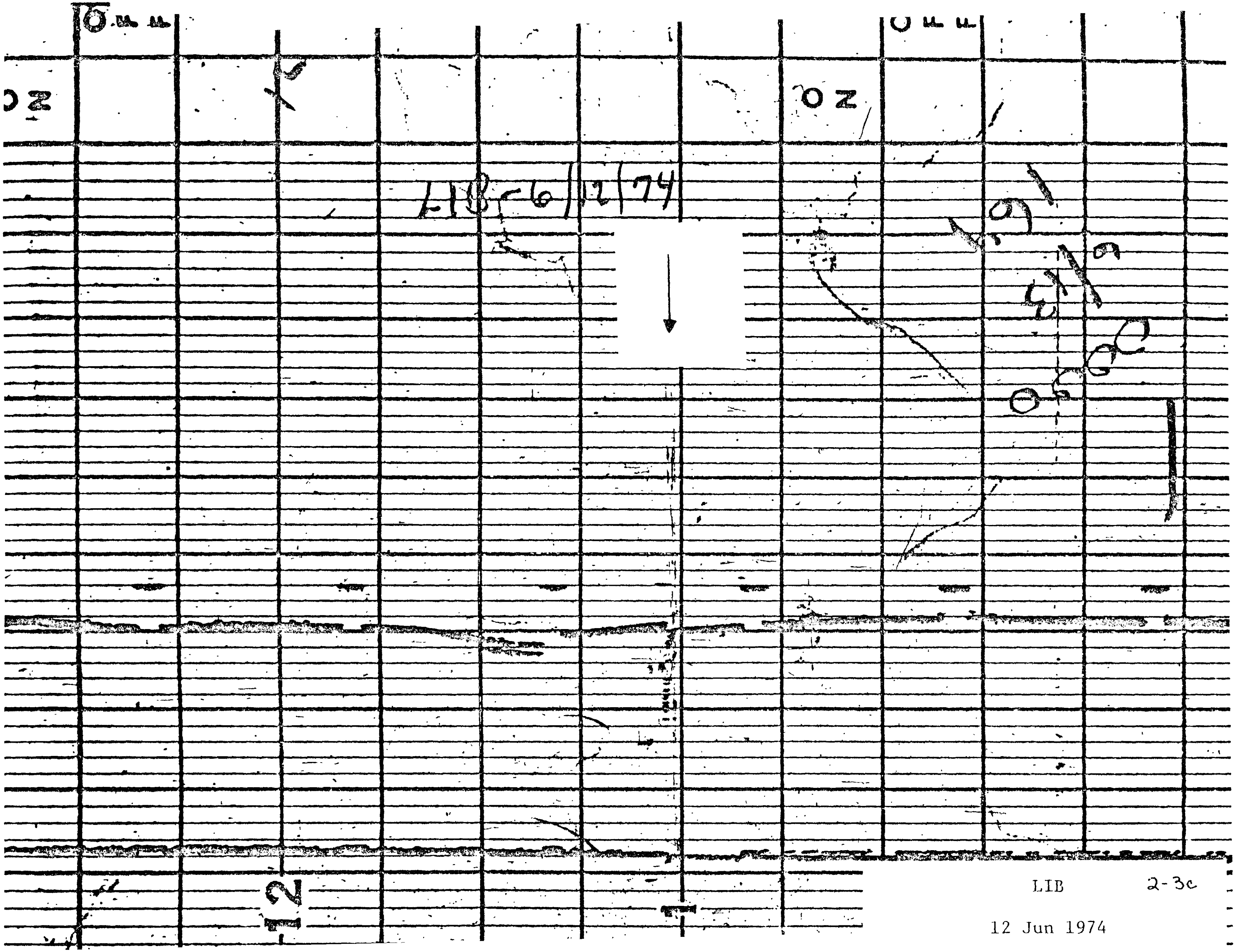




BVY

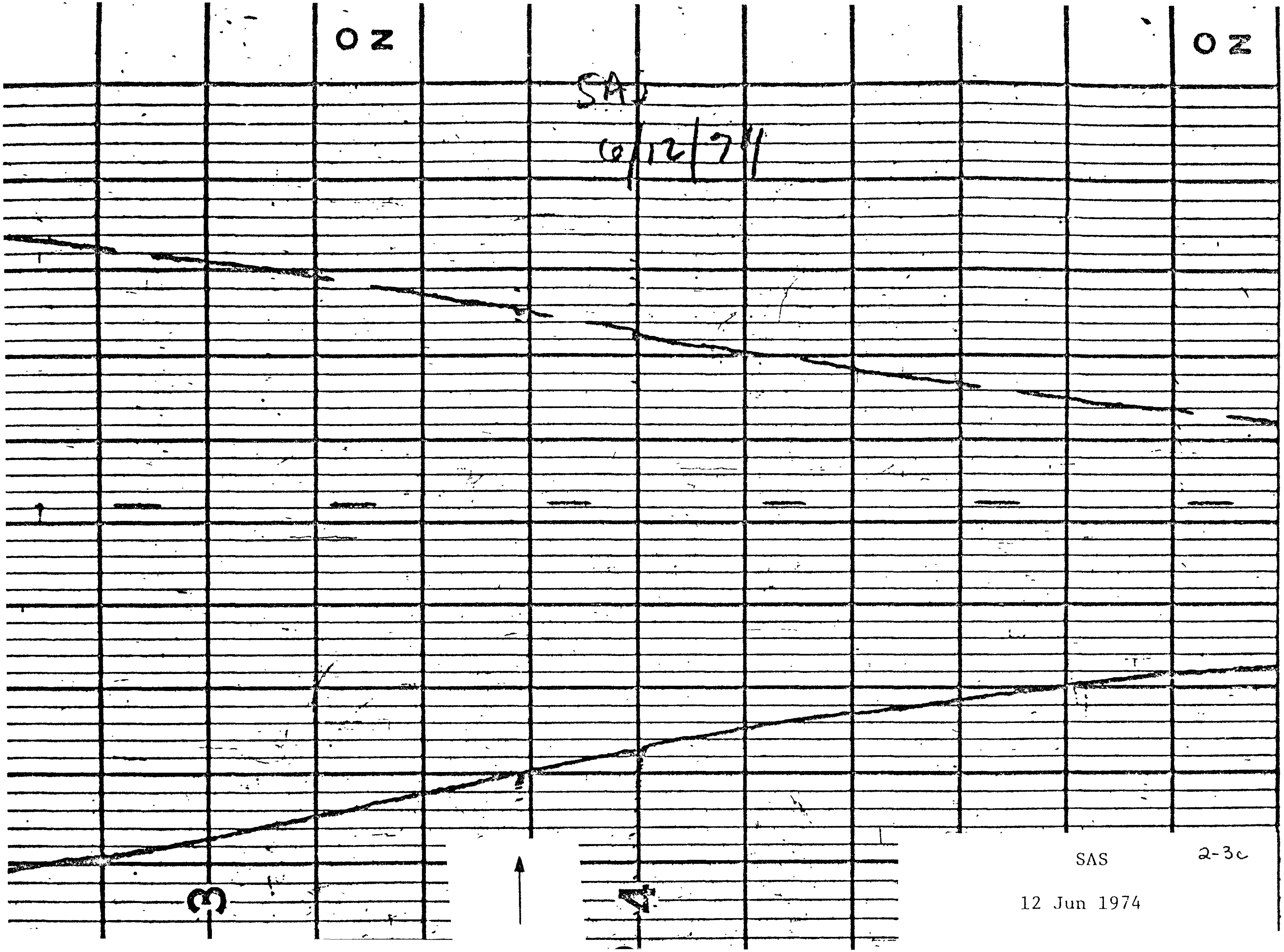
8 Mar 1974

2-3b



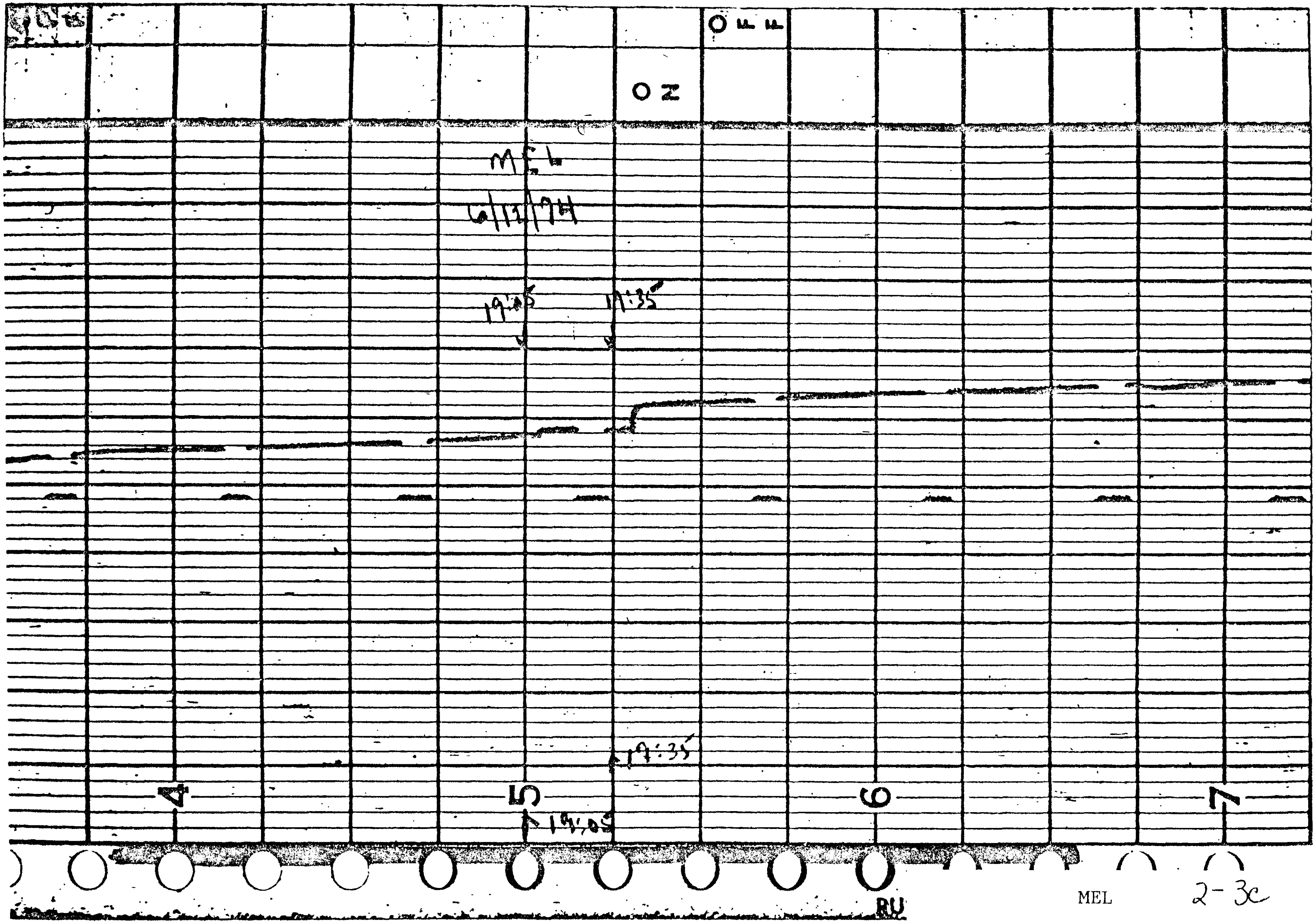
LIB 2-3c

12 Jun 1974



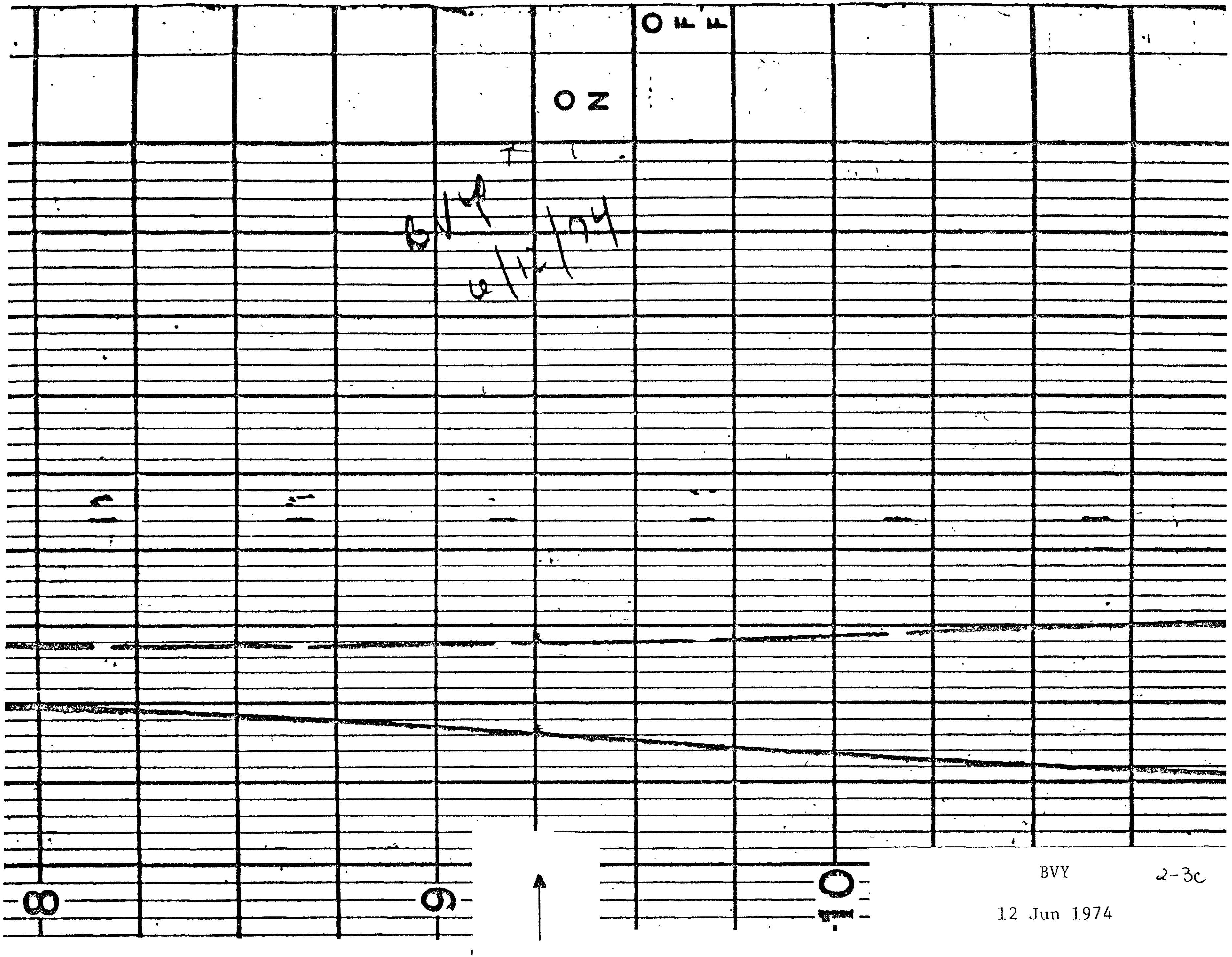
SAS 2-3c

12 Jun 1974



MEL 2-3c

12 Jun 1974



BVY

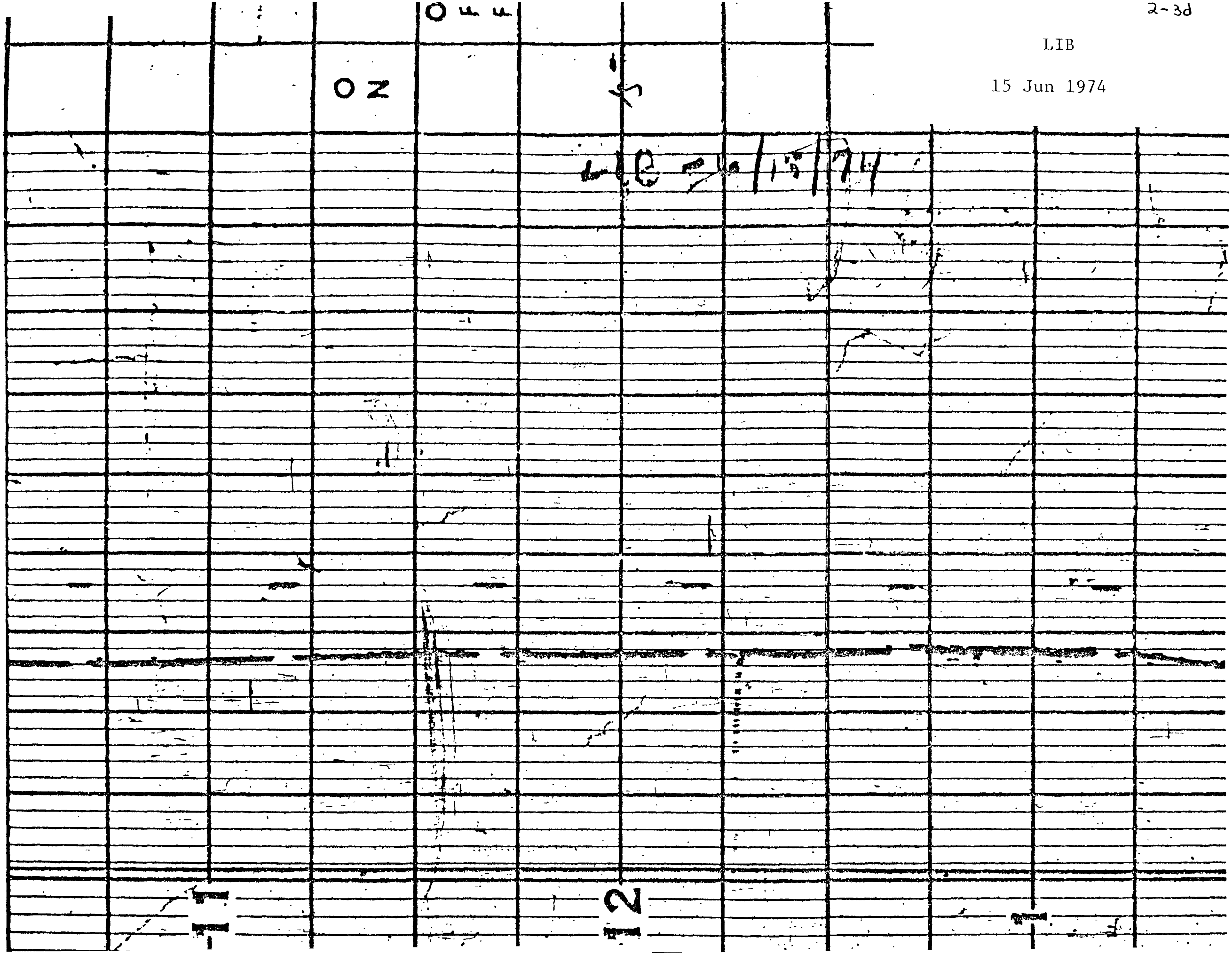
2-3c

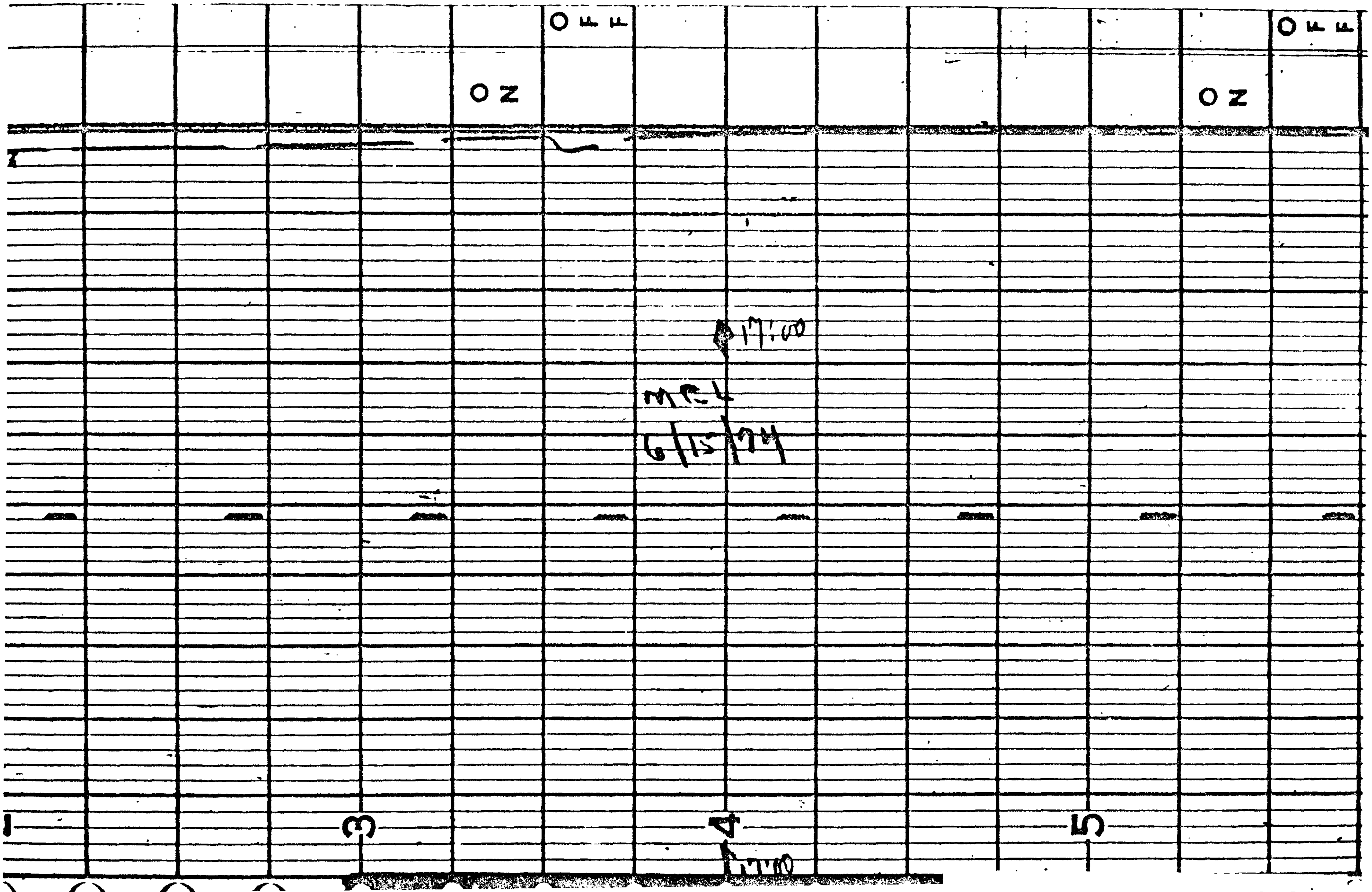
12 Jun 1974

2-3d

LIB

15 Jun 1974

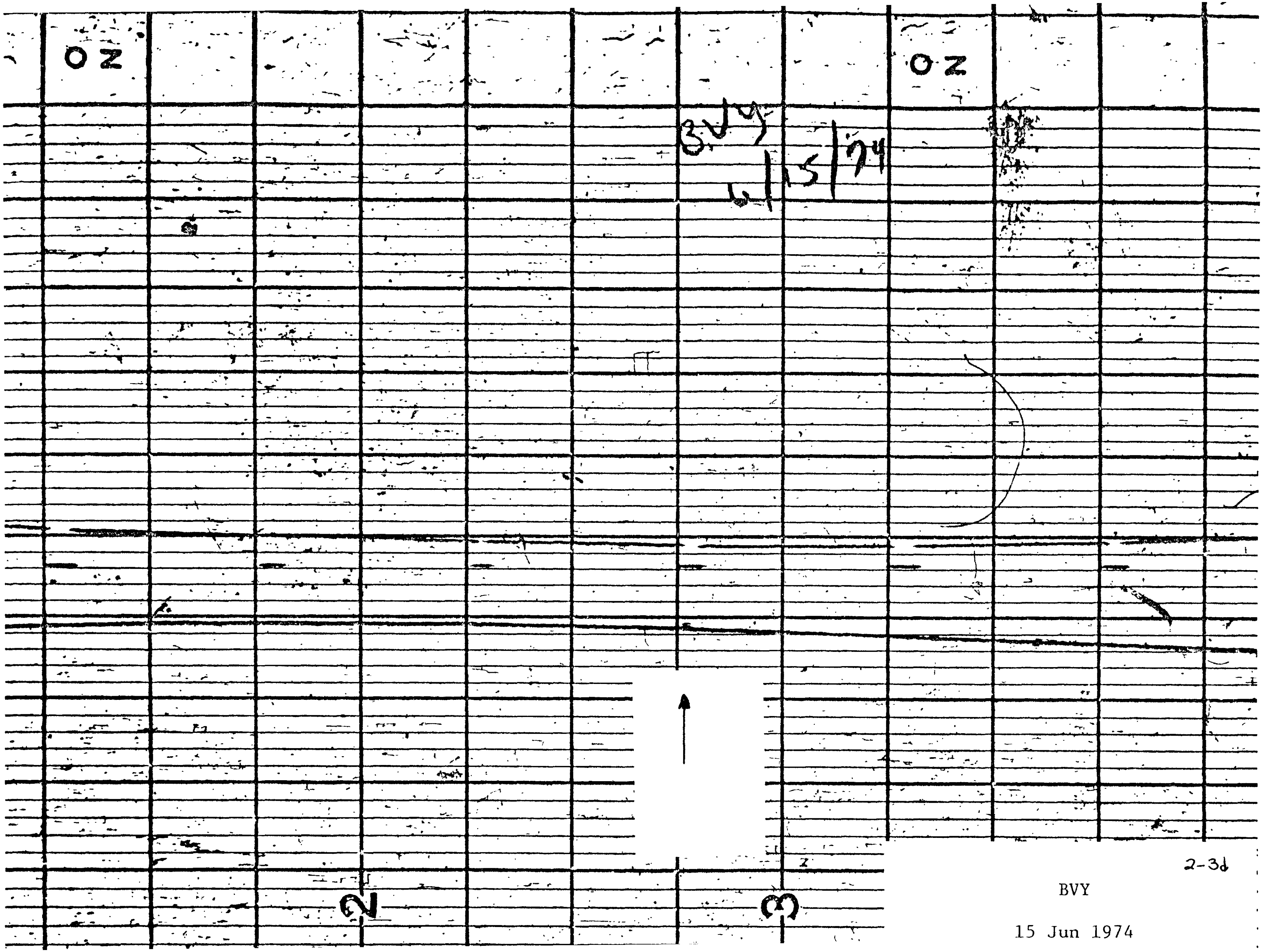




2-3d

MEL

15 Jun 1974



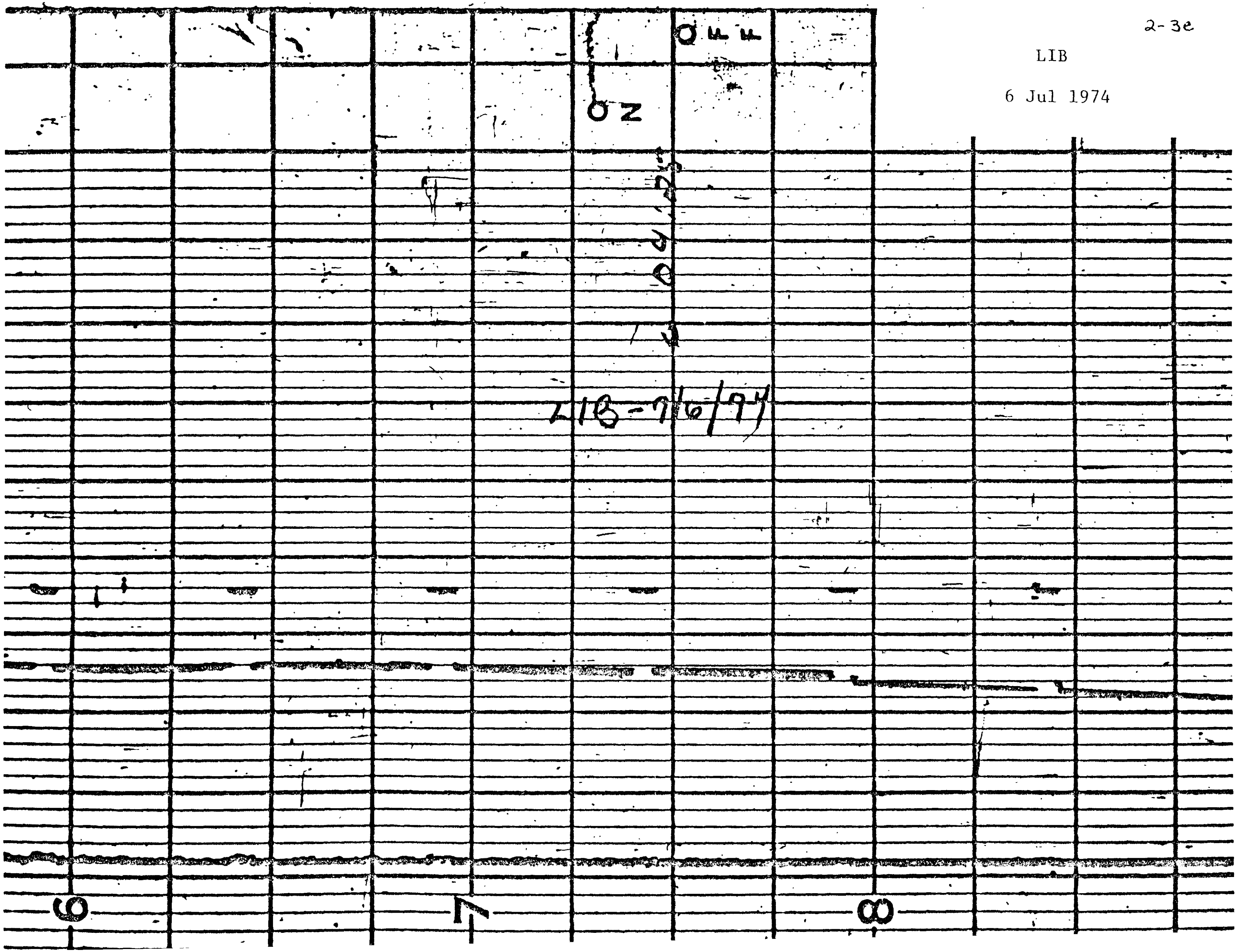
2-3d

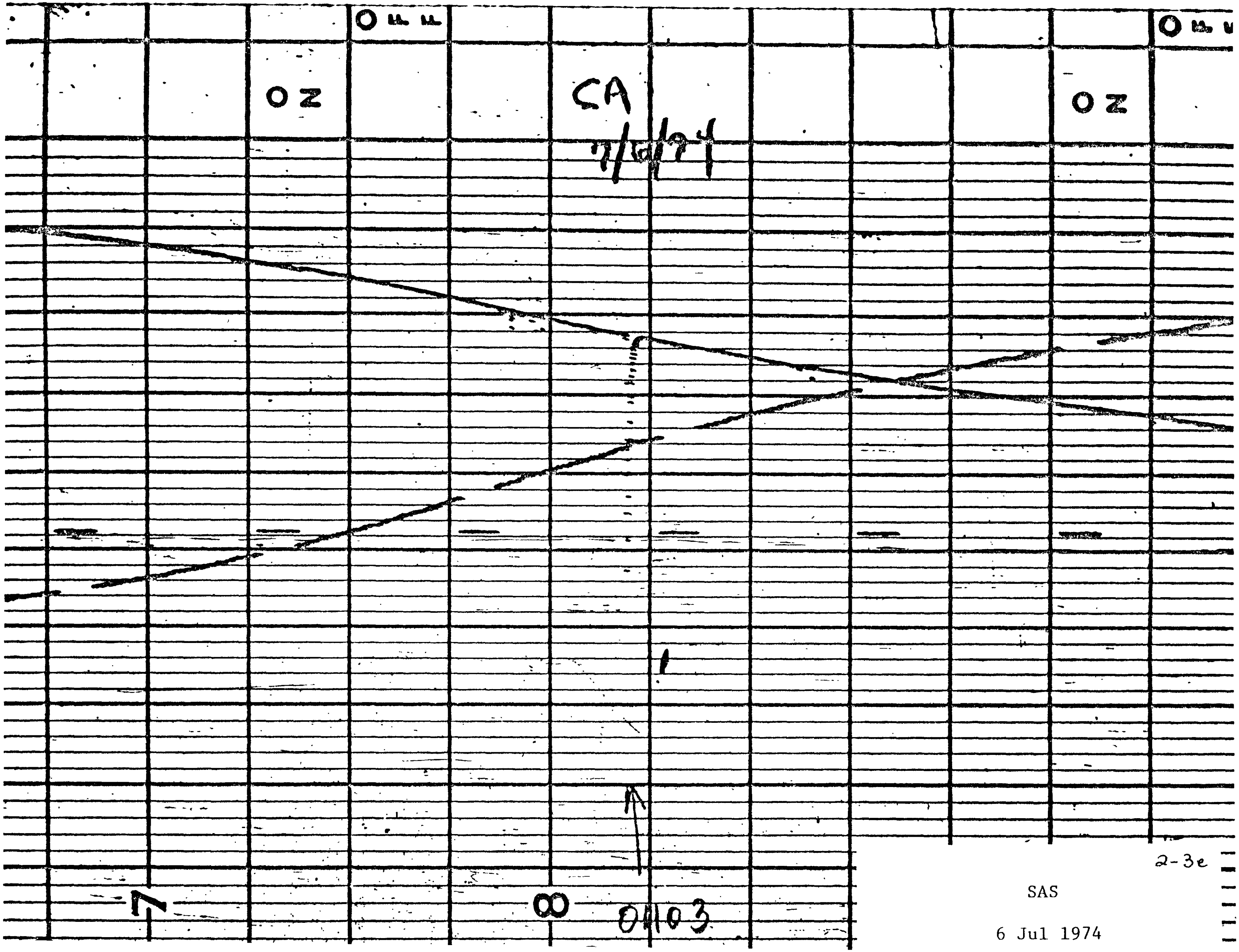
BVY

15 Jun 1974

LIB

6 Jul 1974

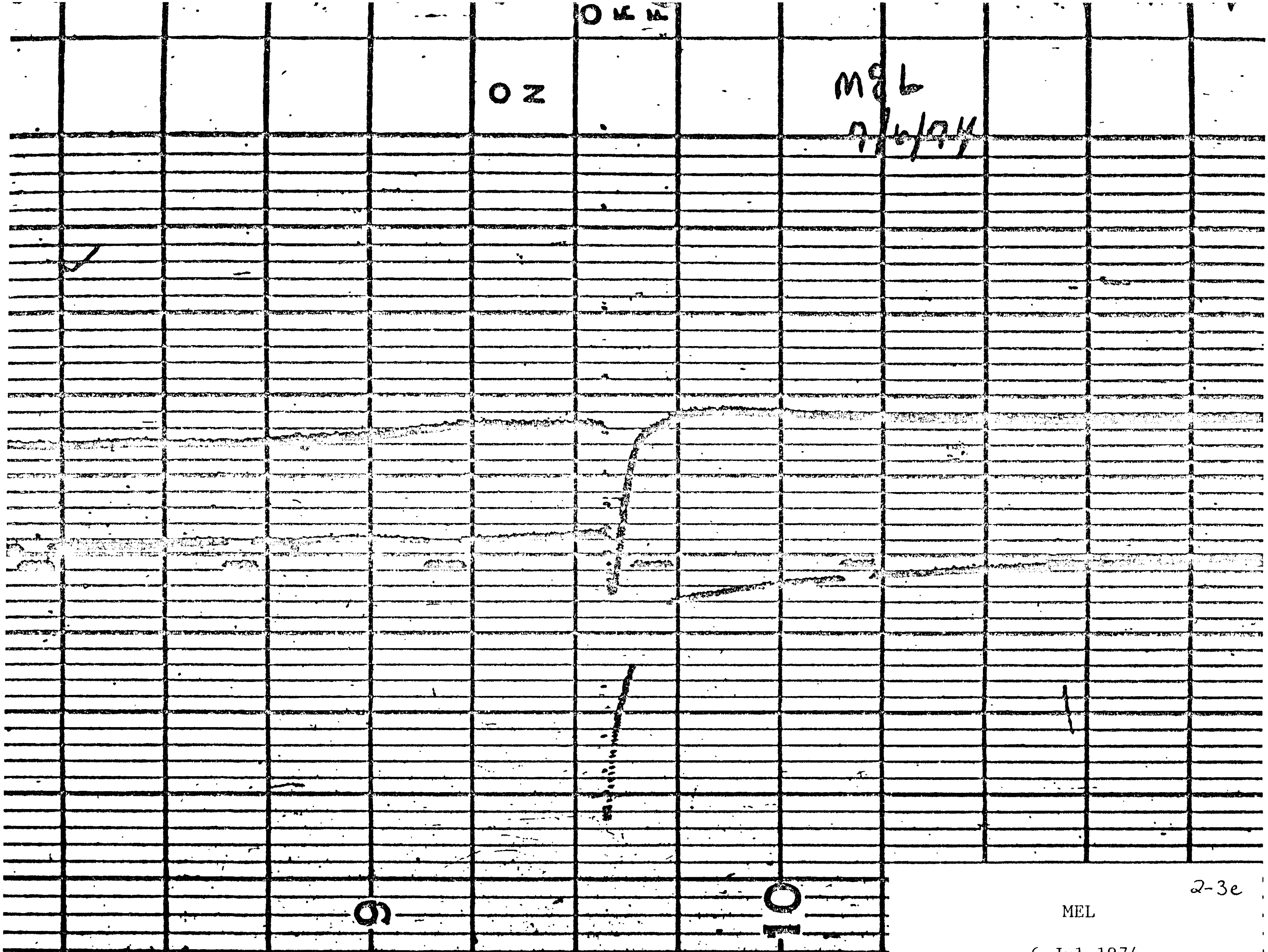




2-3e

SAS

6 Jul 1974

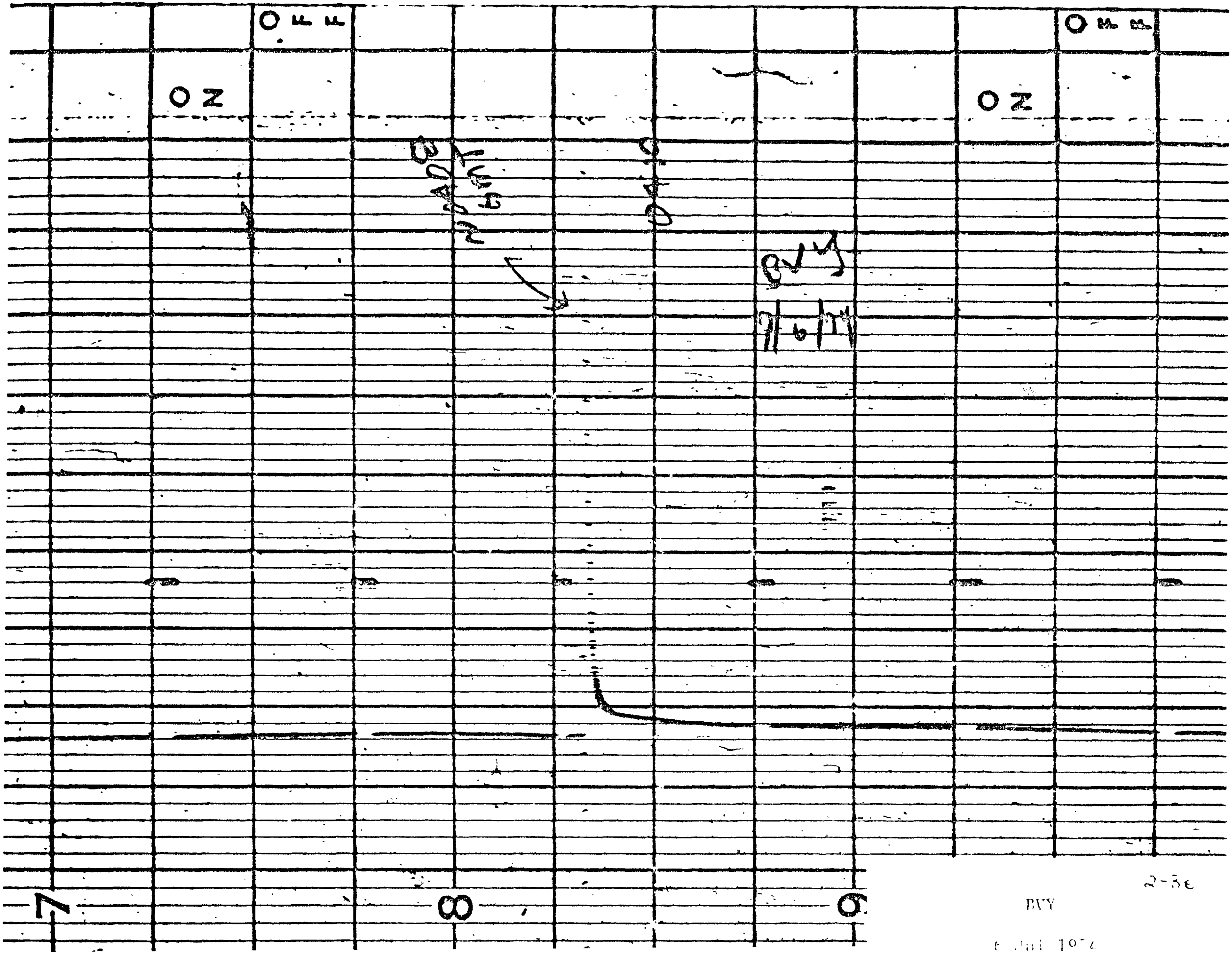


2-3e

MEL

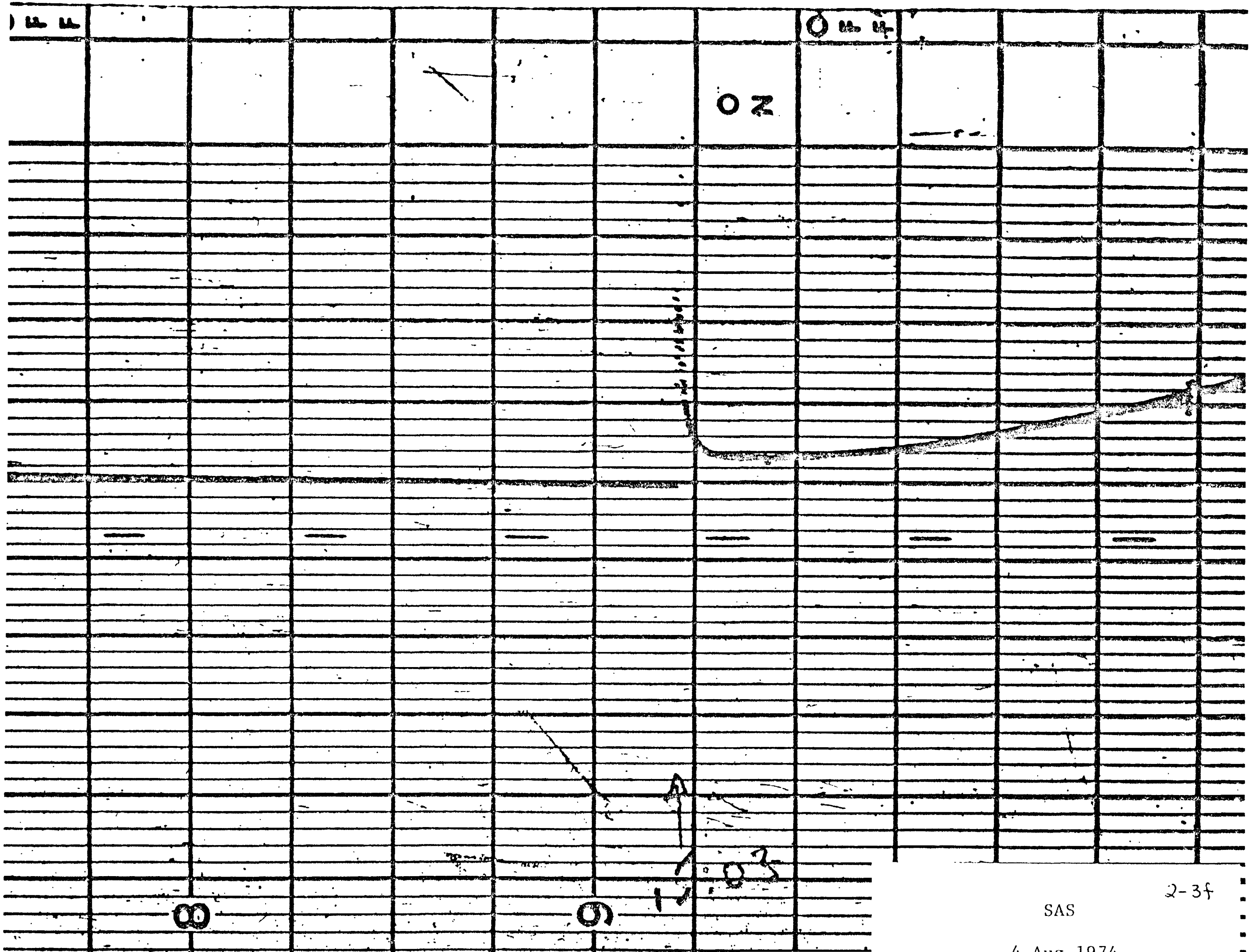
6 Jul 1974

2-3e



BVY

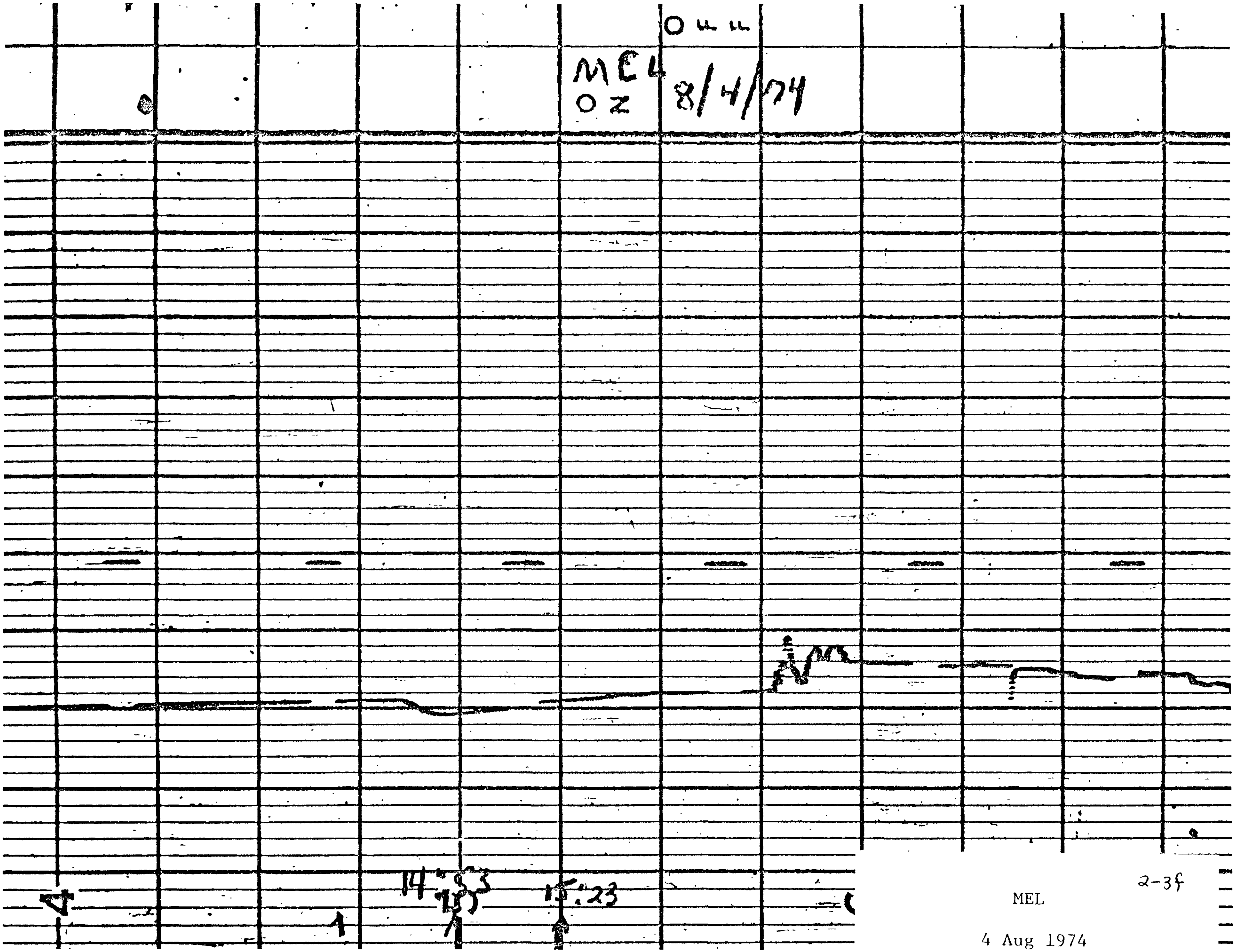
4 Jul 1972



2-3f

SAS

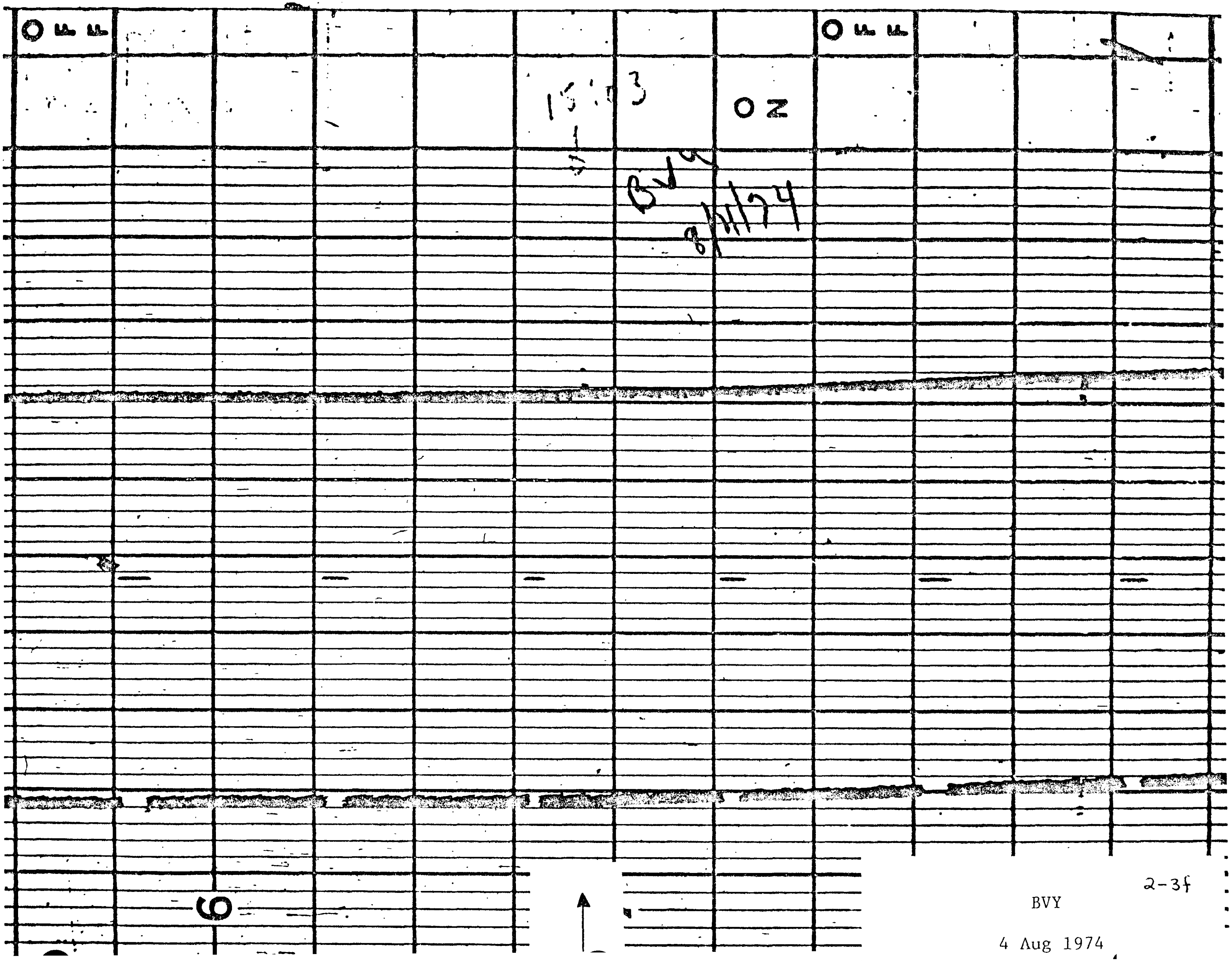
4 Aug 1974



2-3f

MEL

4 Aug 1974



2-3f

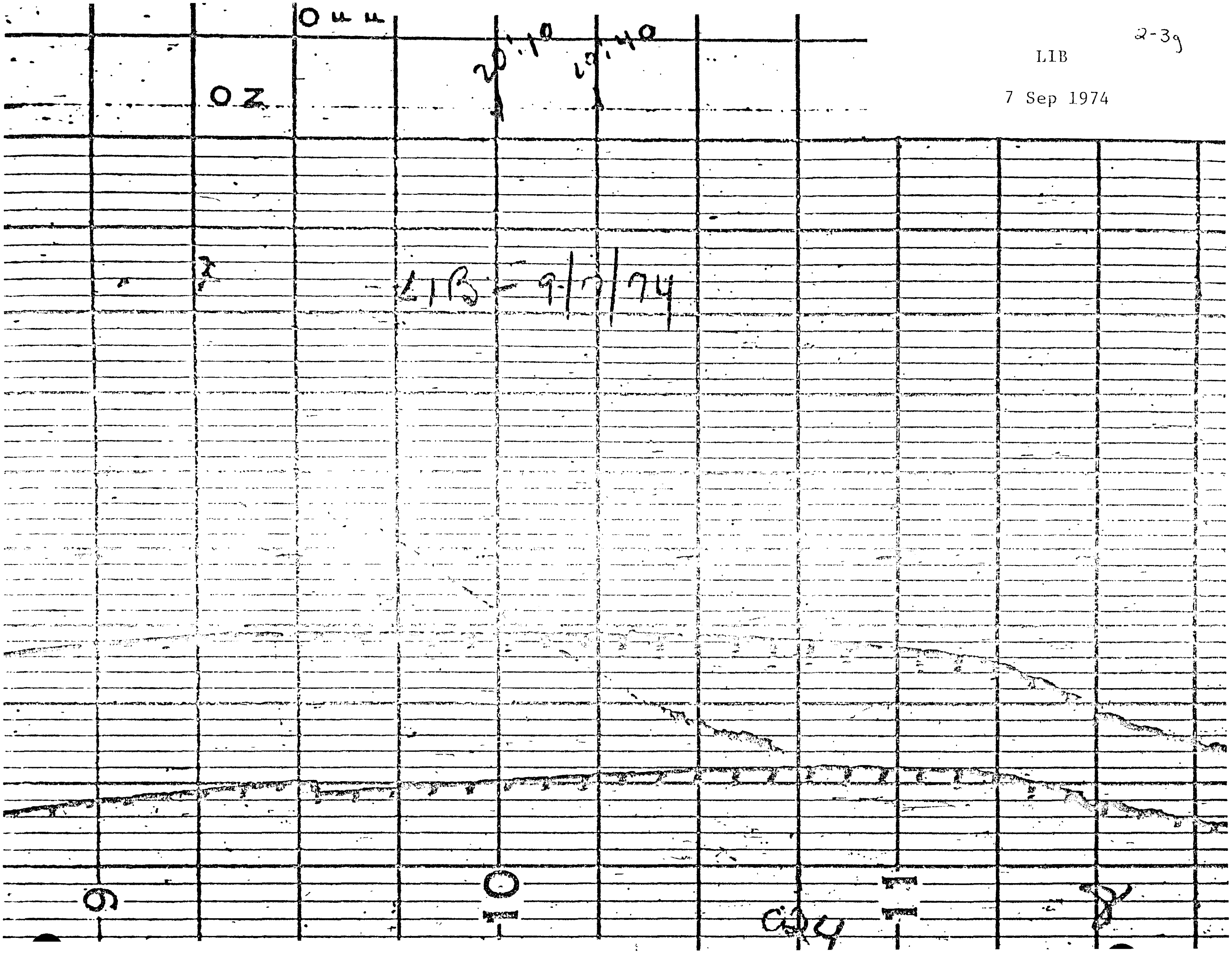
BVY

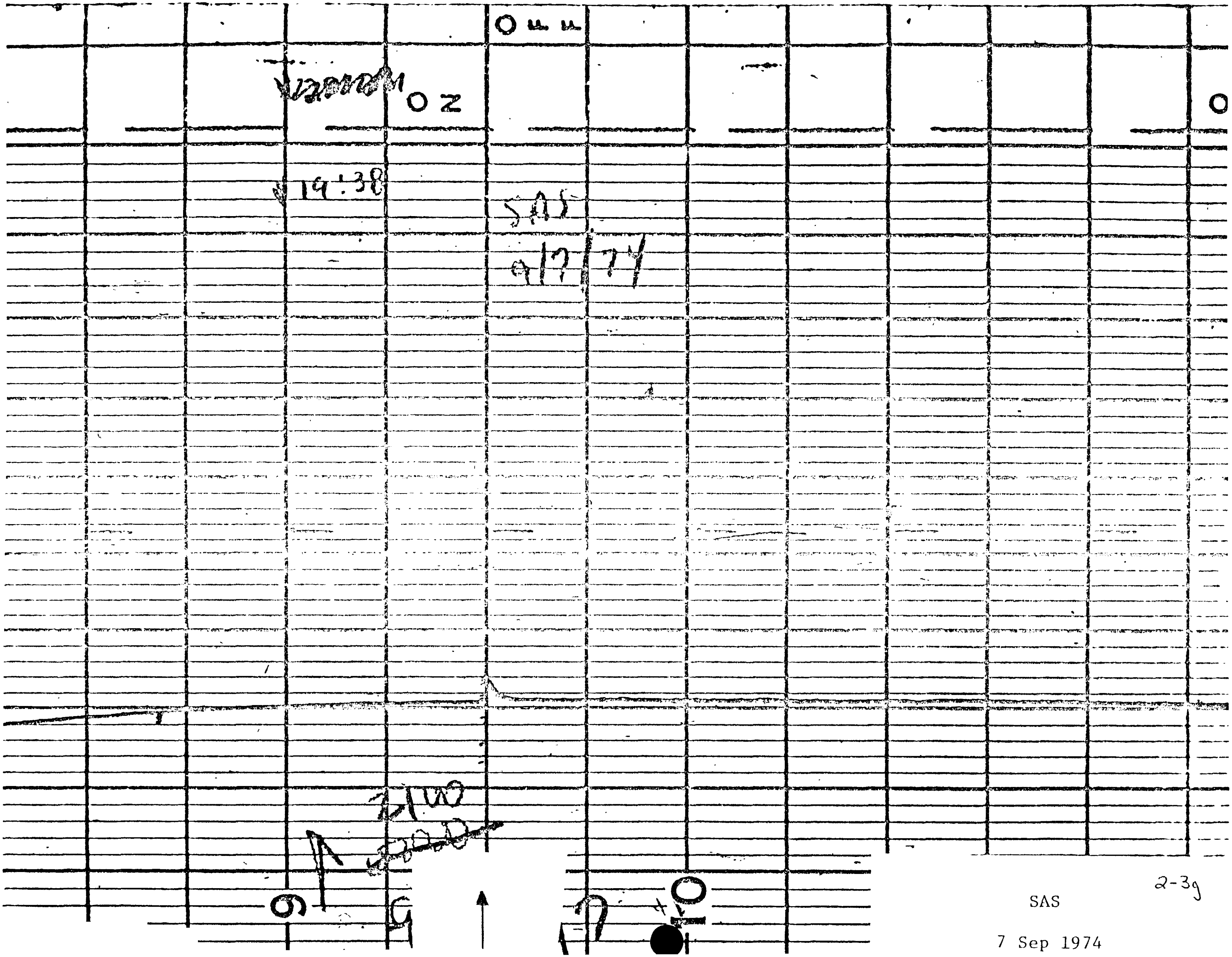
4 Aug 1974

2-39

LIB

7 Sep 1974

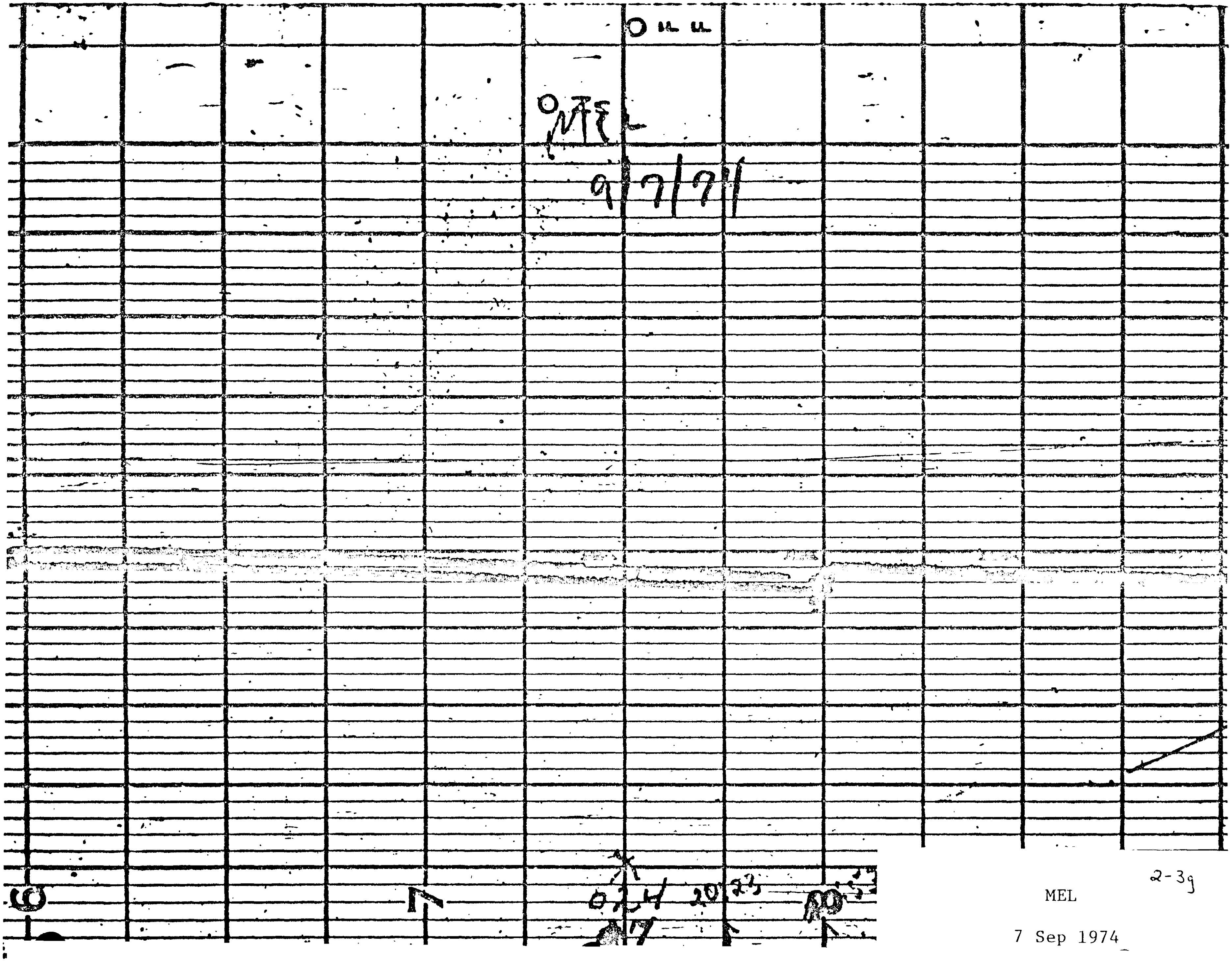




SAS

7 Sep 1974

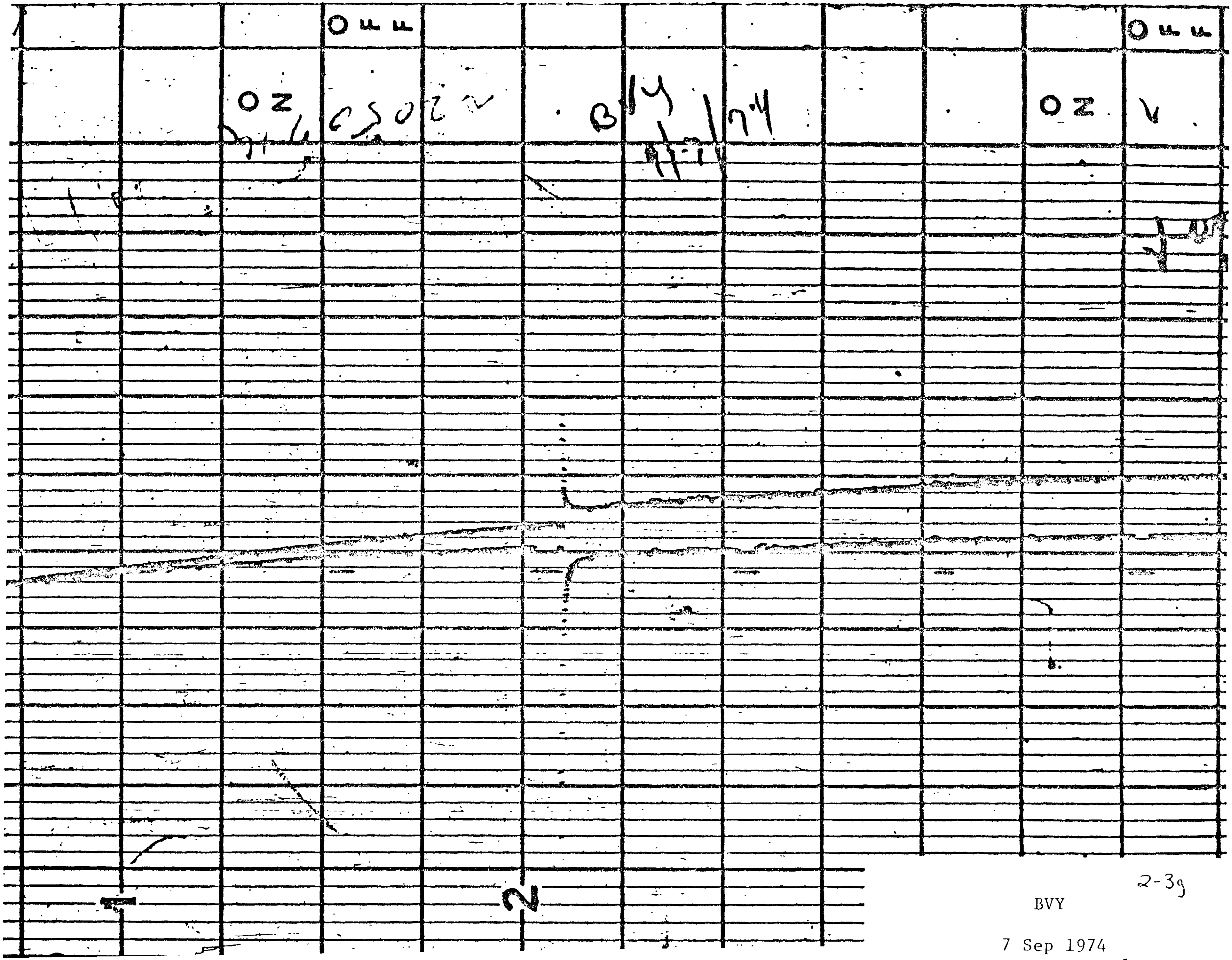
2-39



MEL

7 Sep 1974

2-39



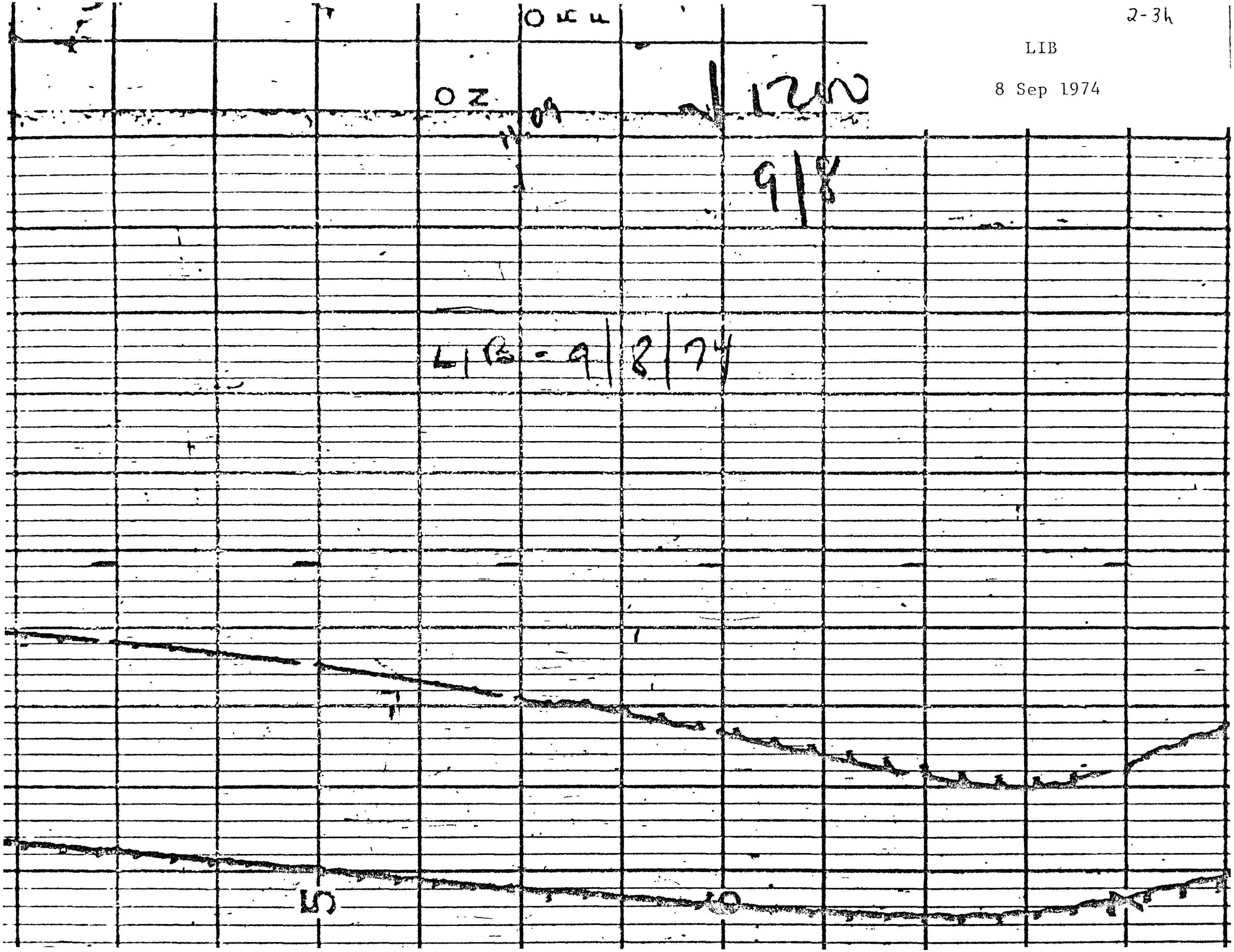
2-39

BVY

7 Sep 1974

LIB

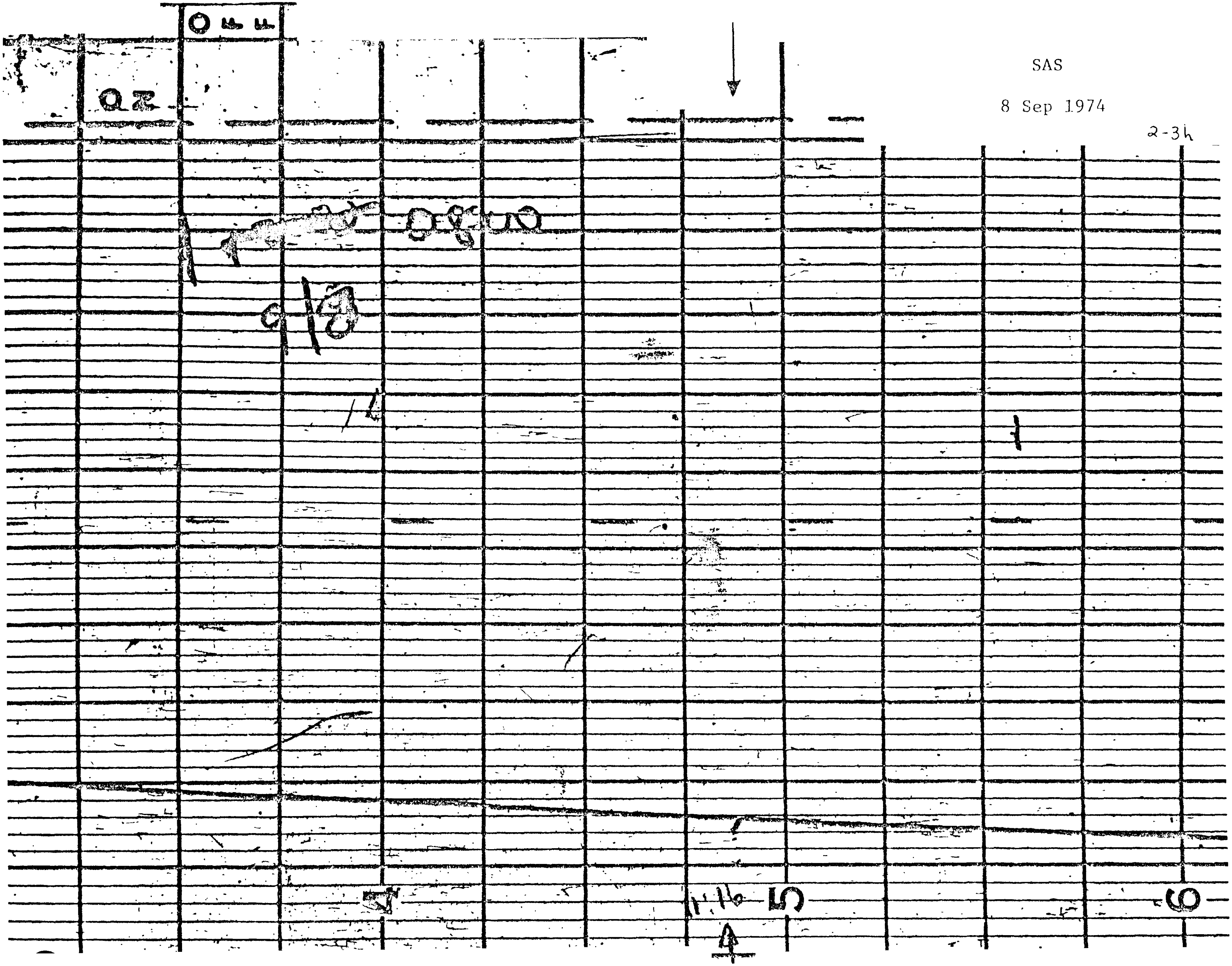
8 Sep 1974

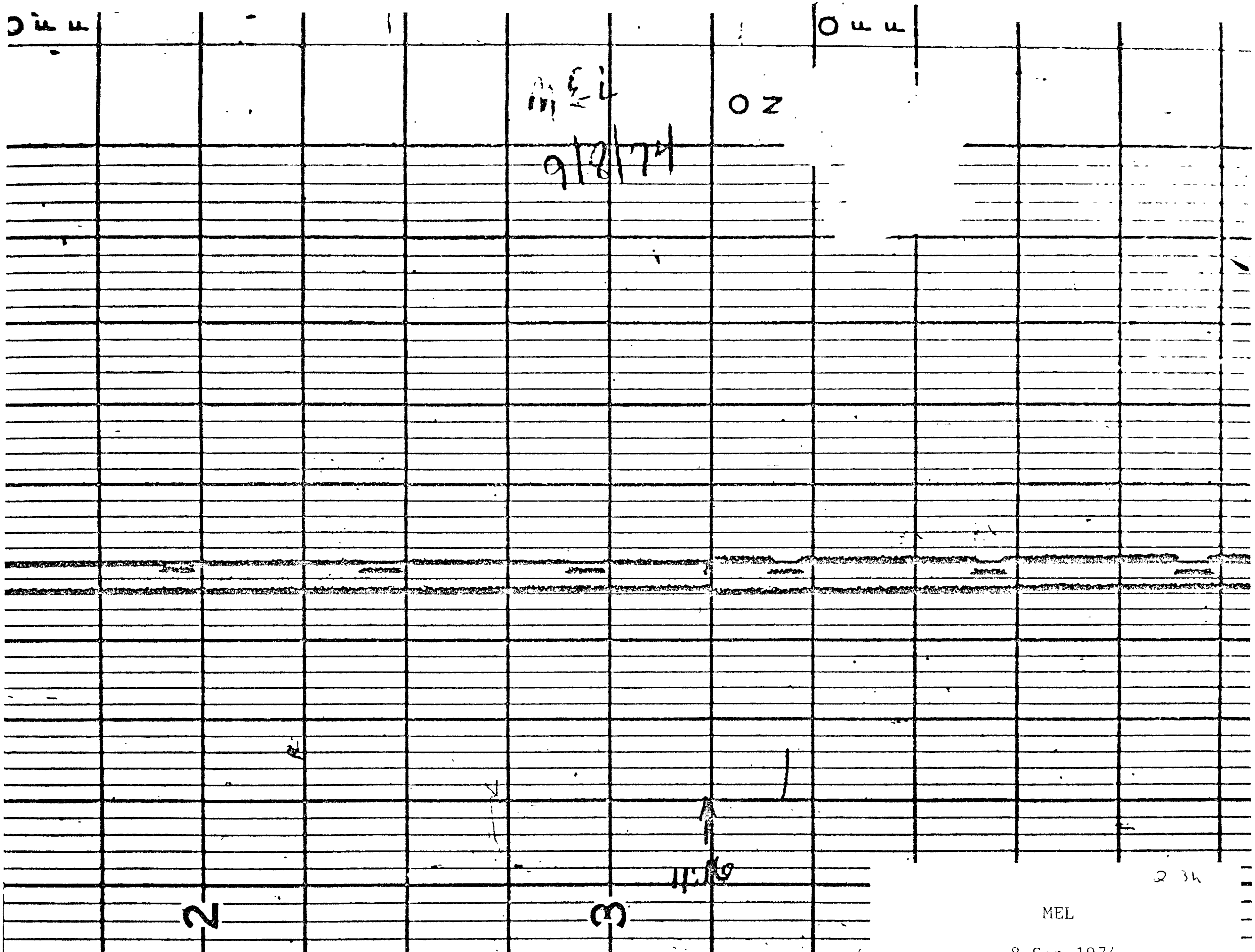


SAS

8 Sep 1974

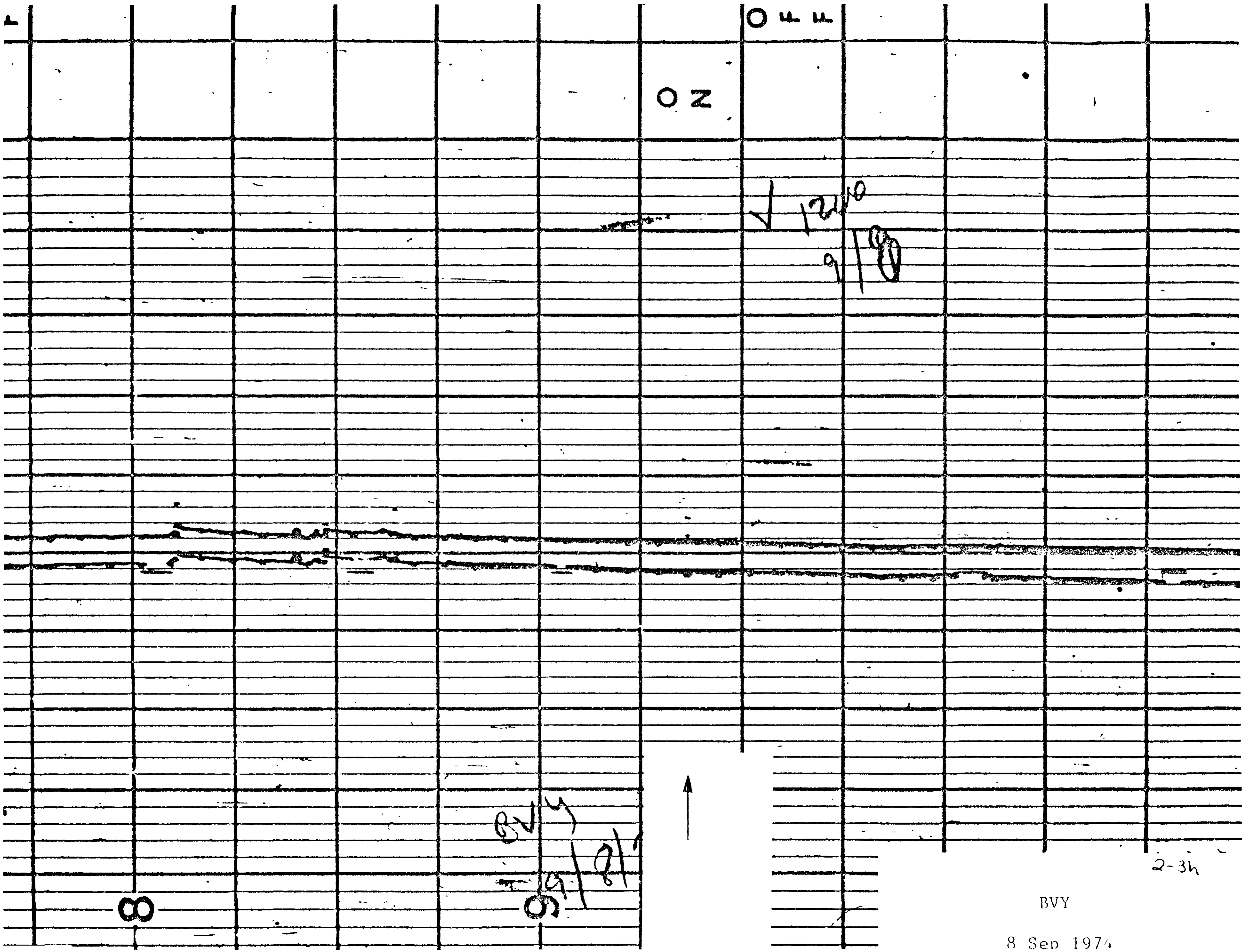
2-3h





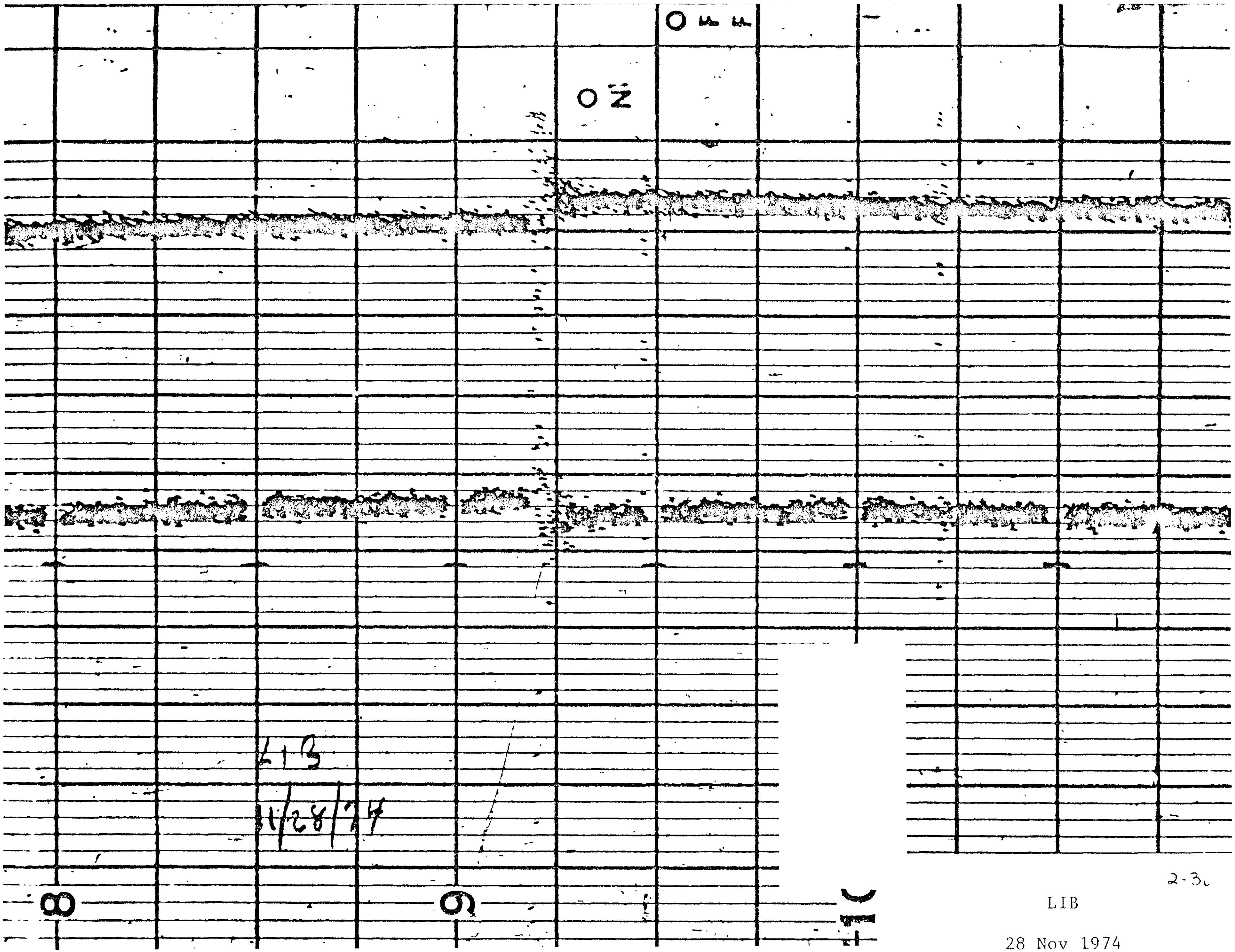
MEL

8 Sep 1974



BVY

8 Sep 1974



2-3

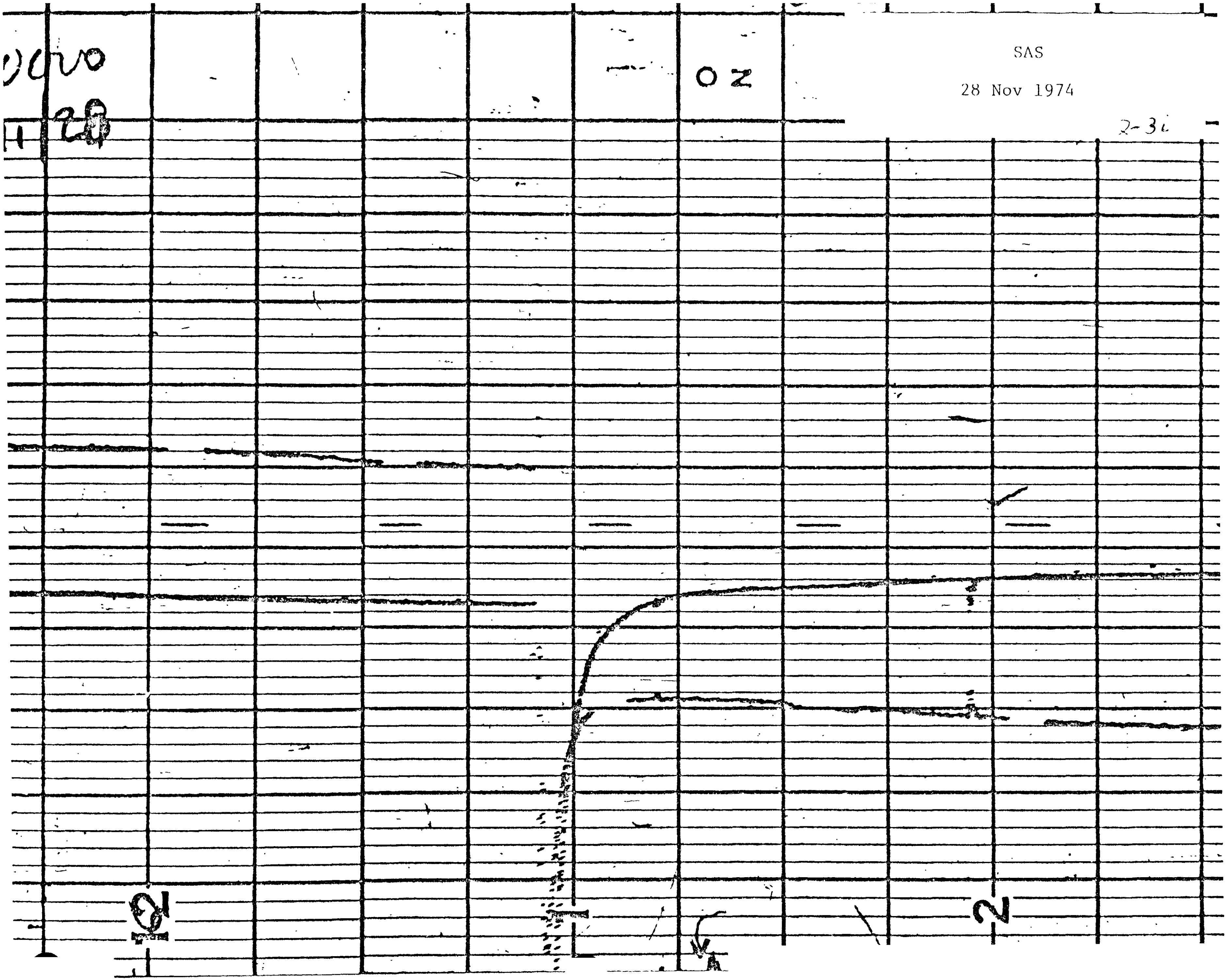
LIB

28 Nov 1974

SAS

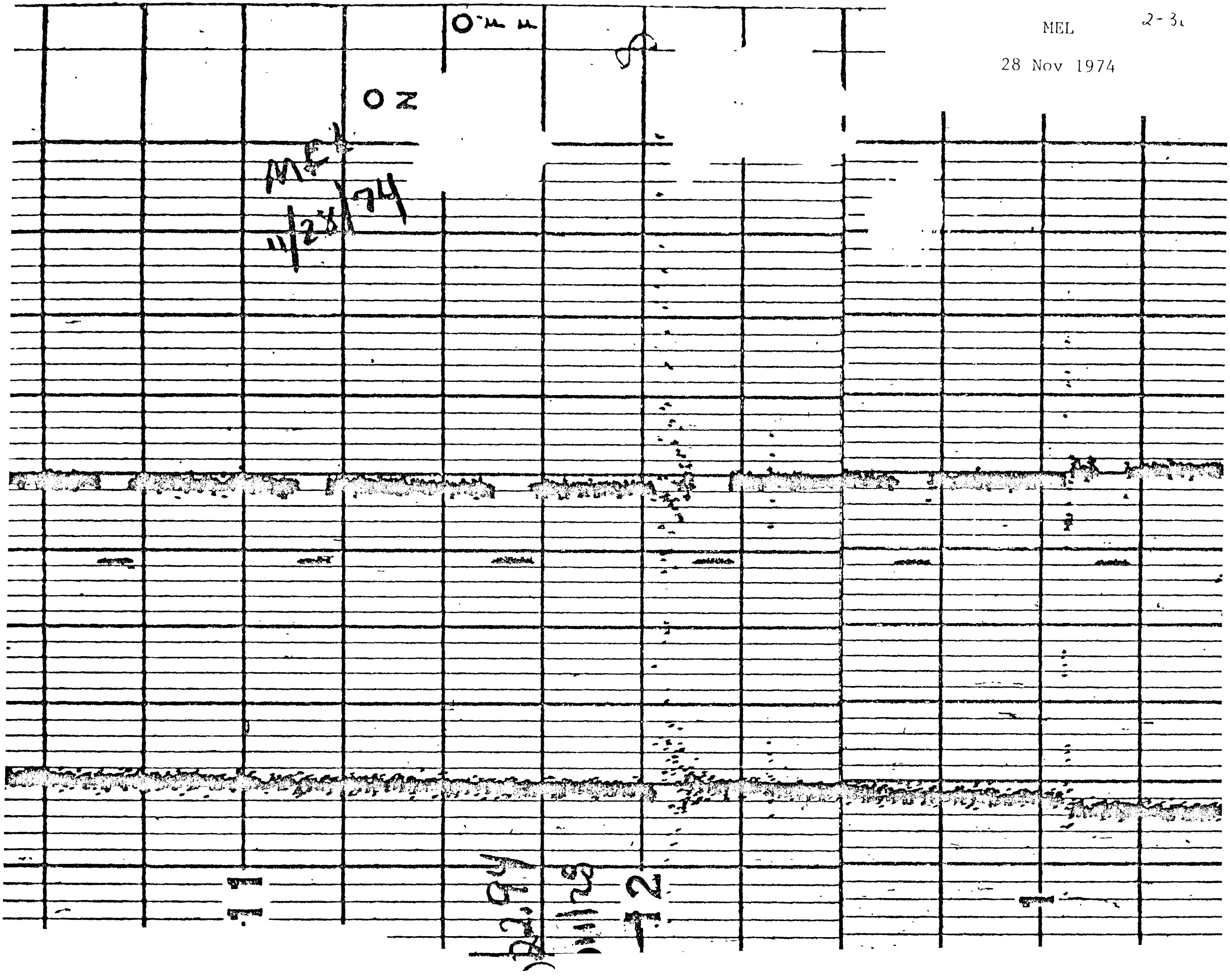
28 Nov 1974

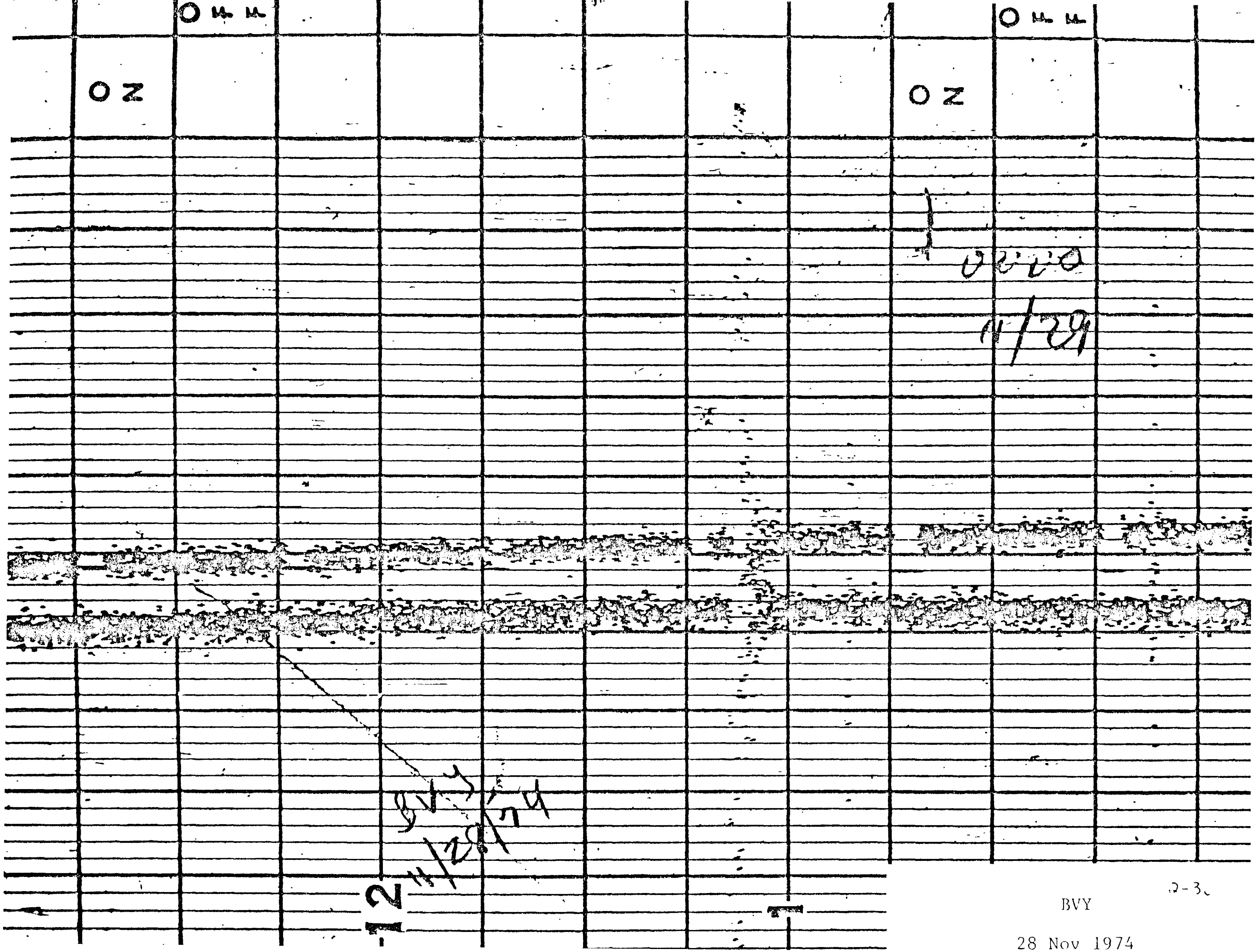
2-3i



MEL

28 Nov 1974

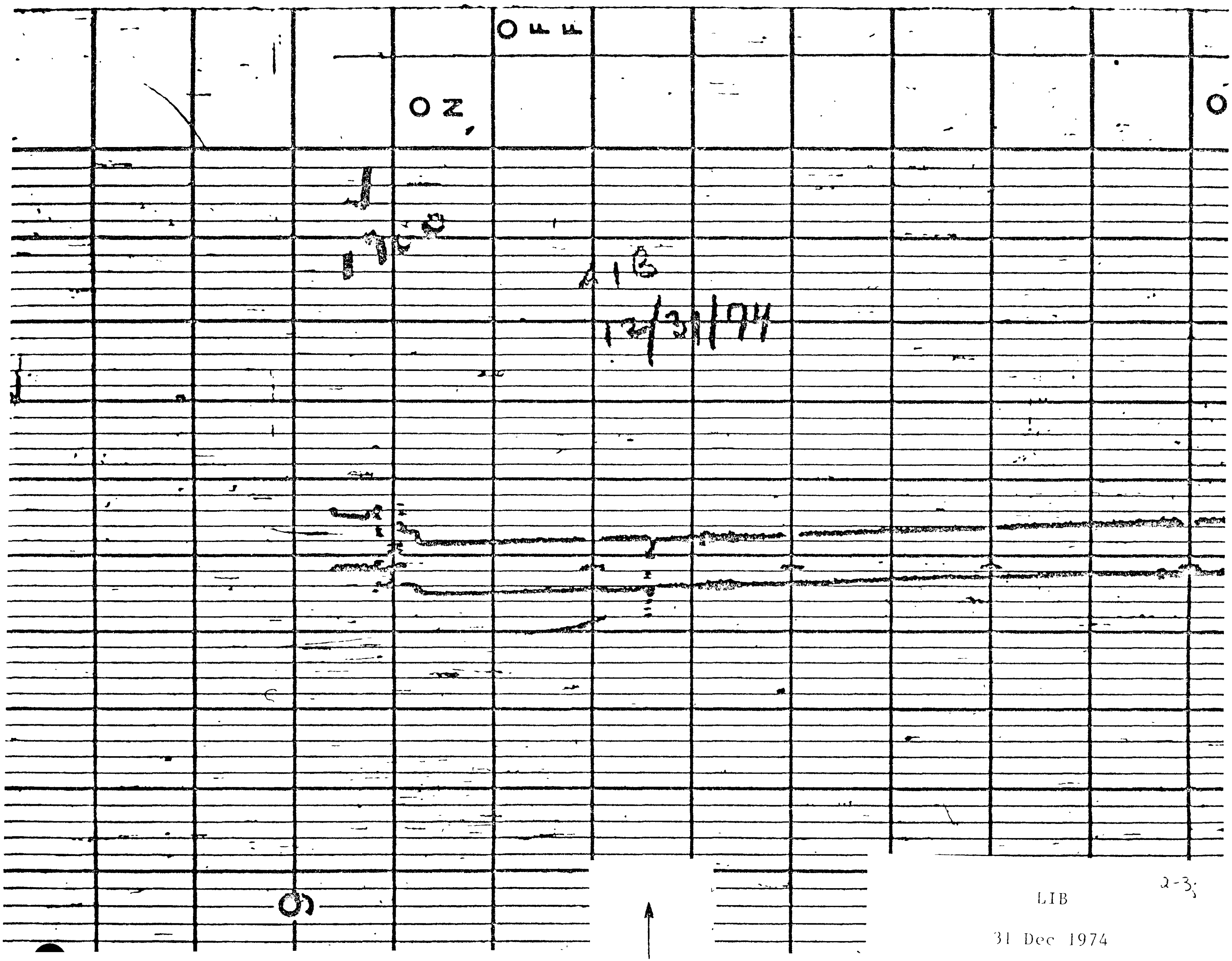




D-3

BVY

28 Nov 1974



LIB

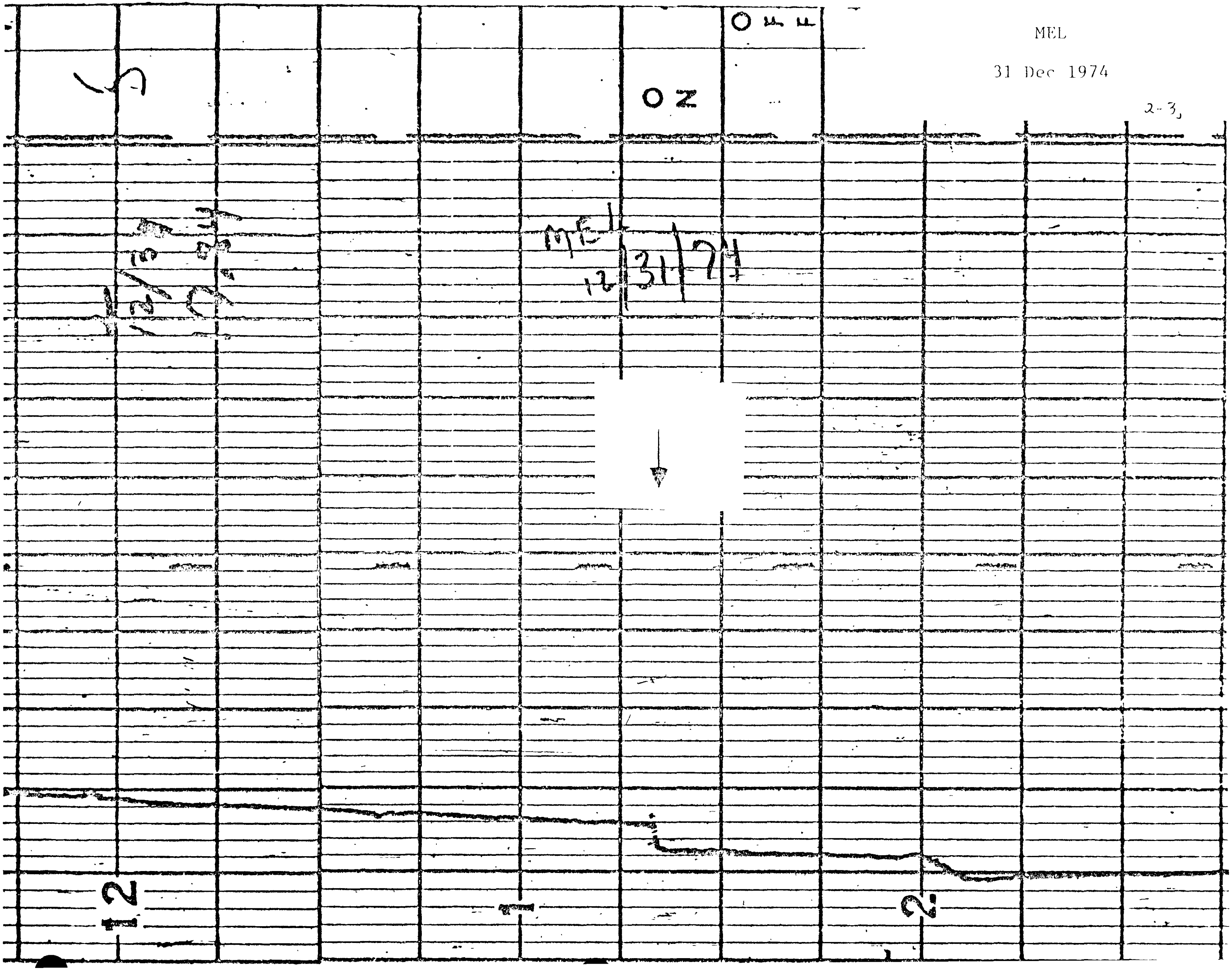
31 Dec 1974

2-3;

MEL

31 Dec 1974

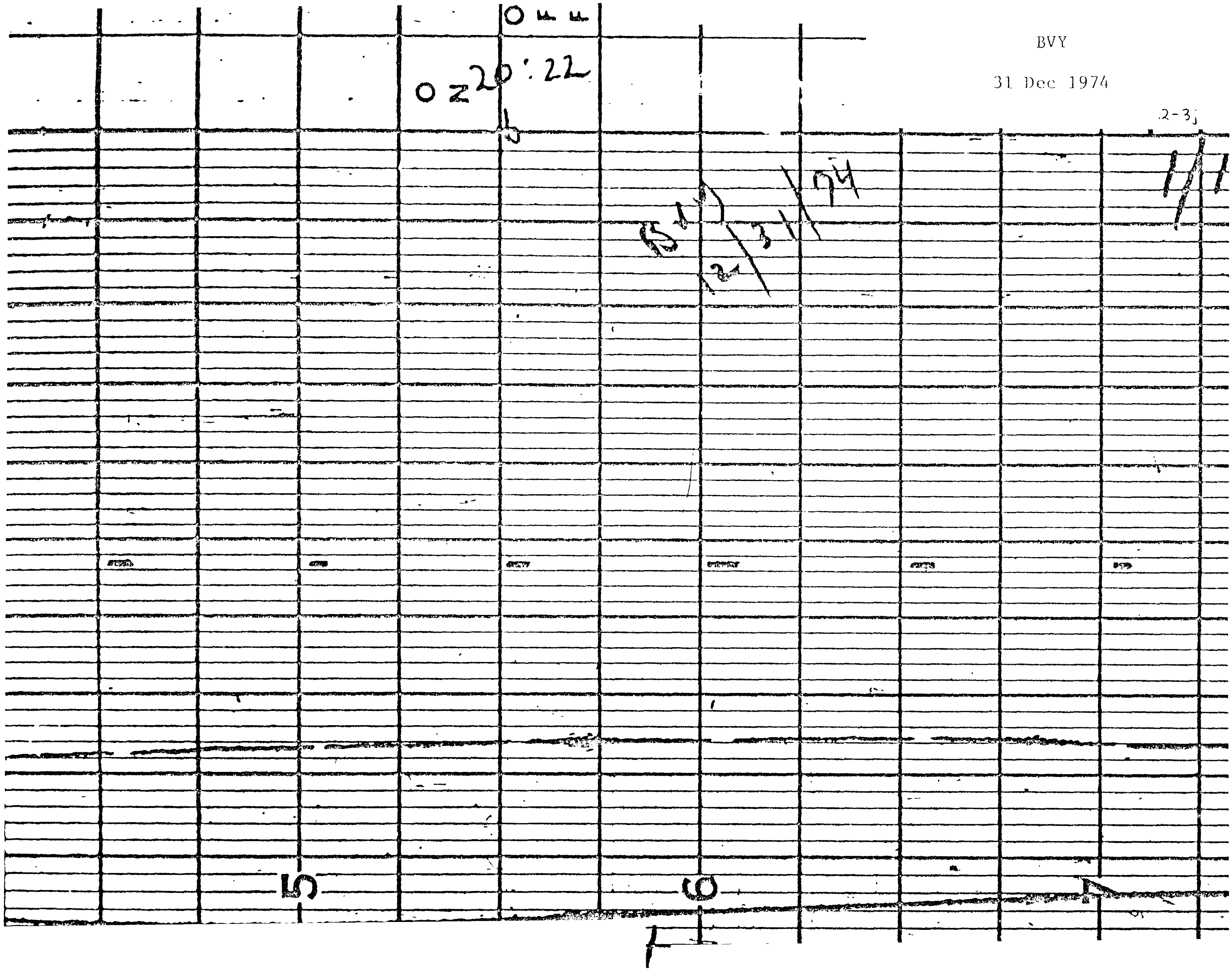
2-3

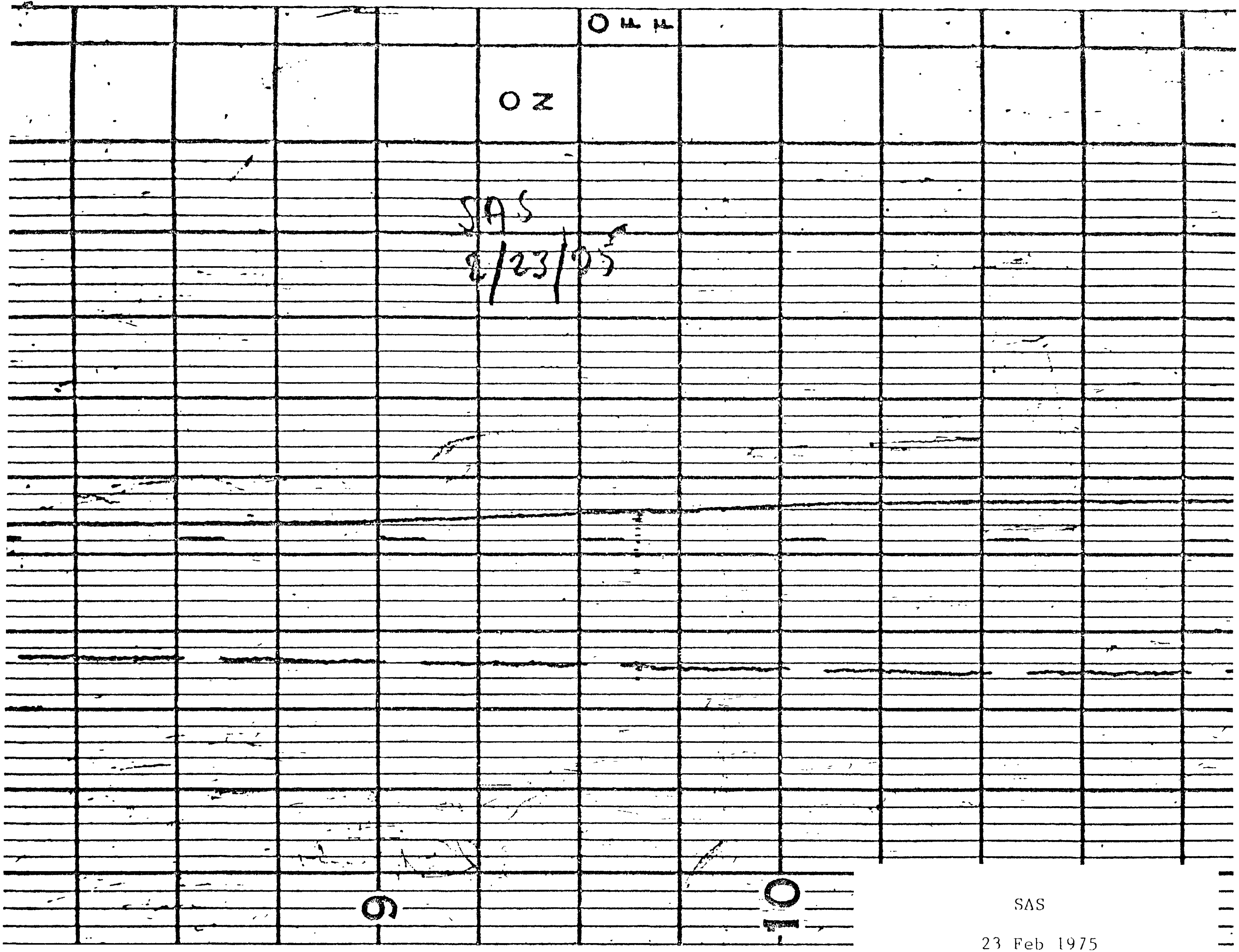


BVY

31 Dec 1974

2-3

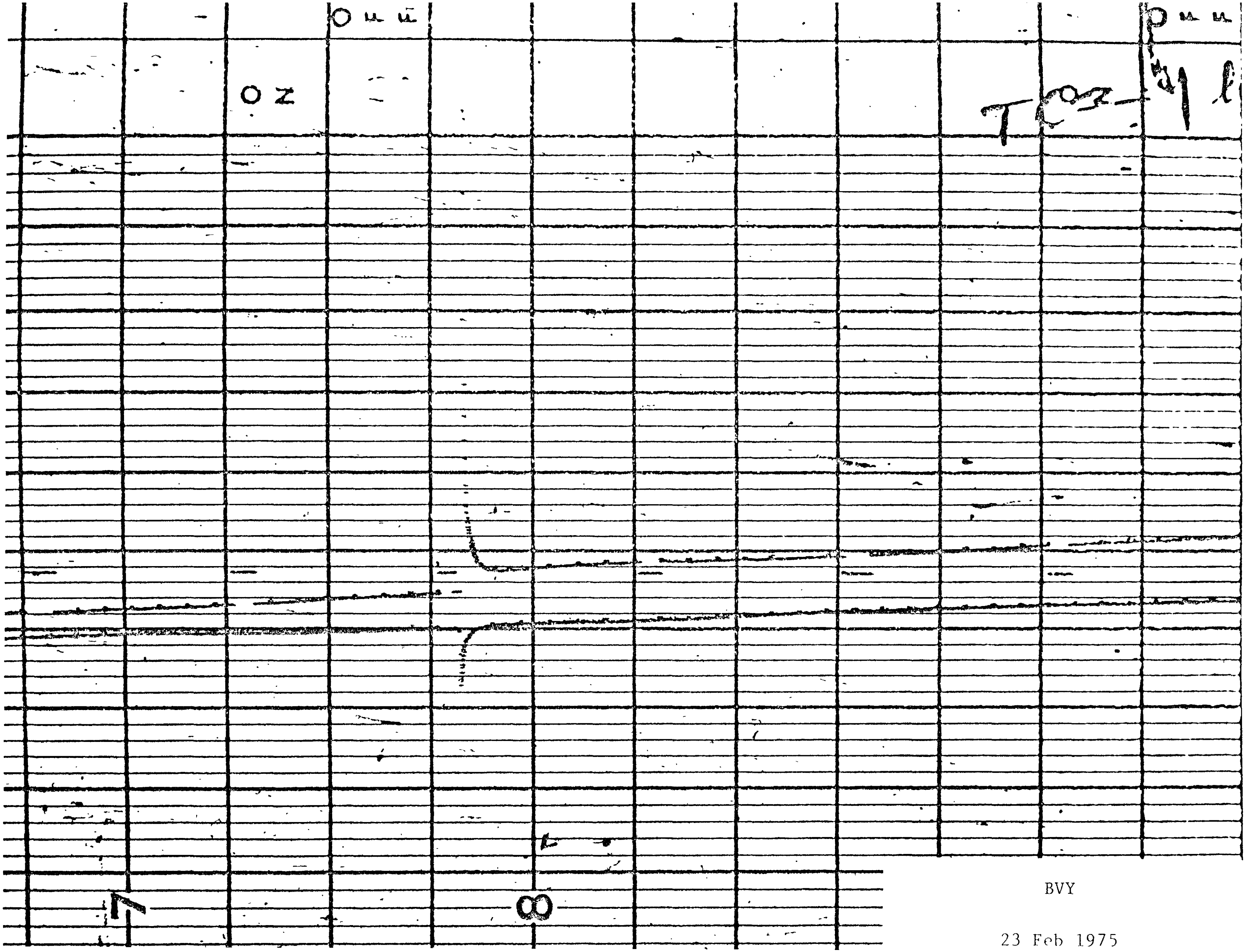




SAS

23 Feb 1975

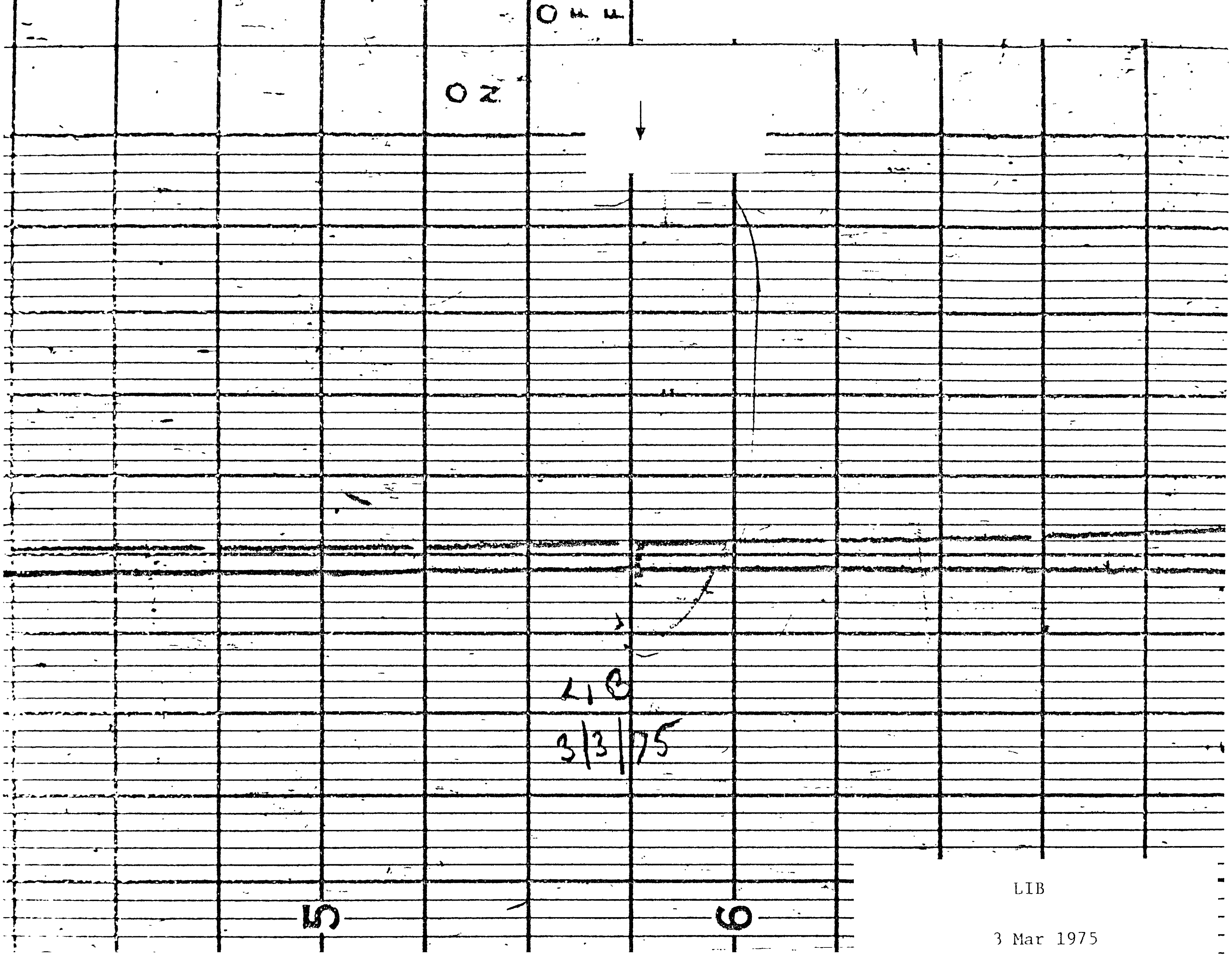
2-3K



BVY

23 Feb 1975

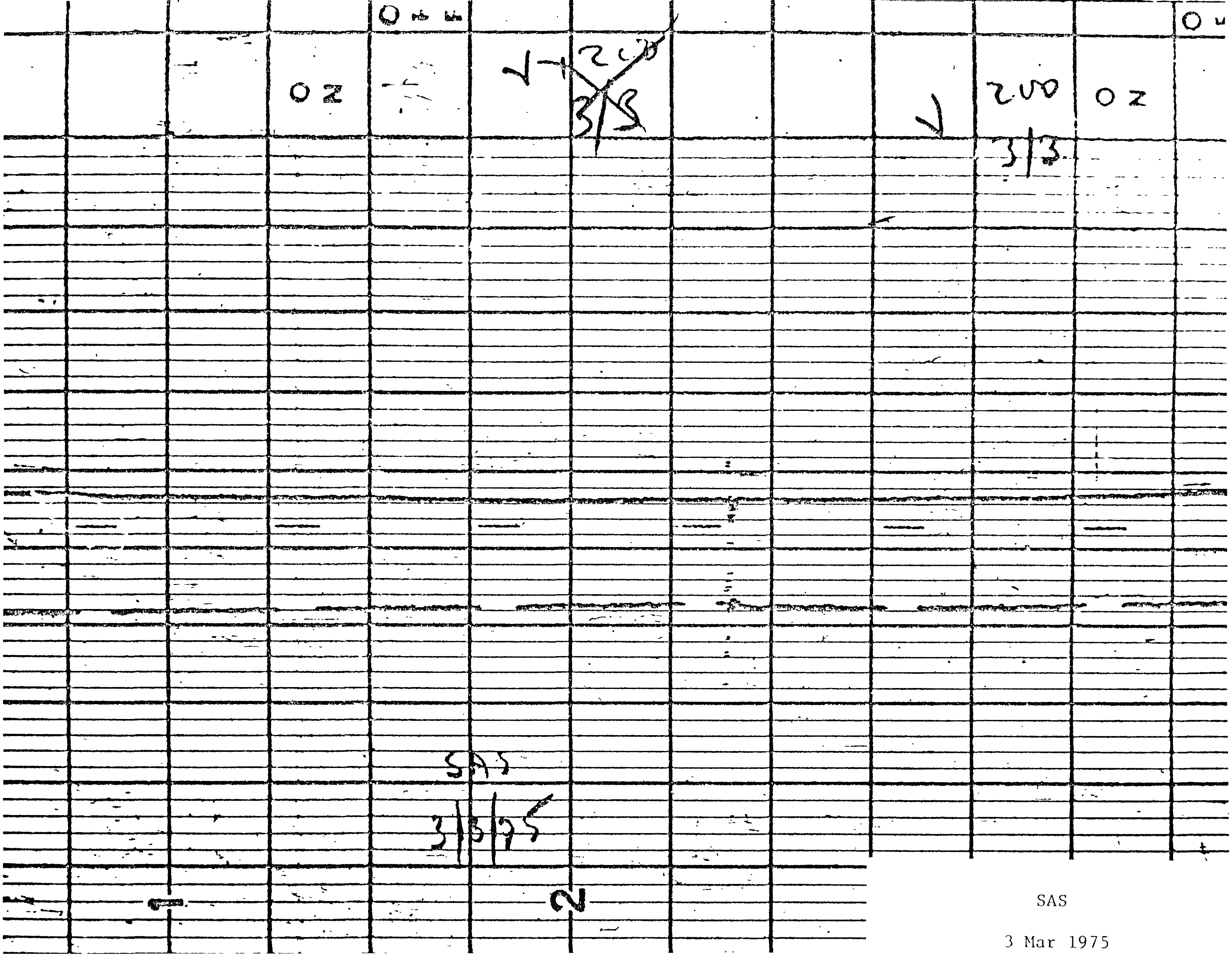
.2-3K



LIB

3 Mar 1975

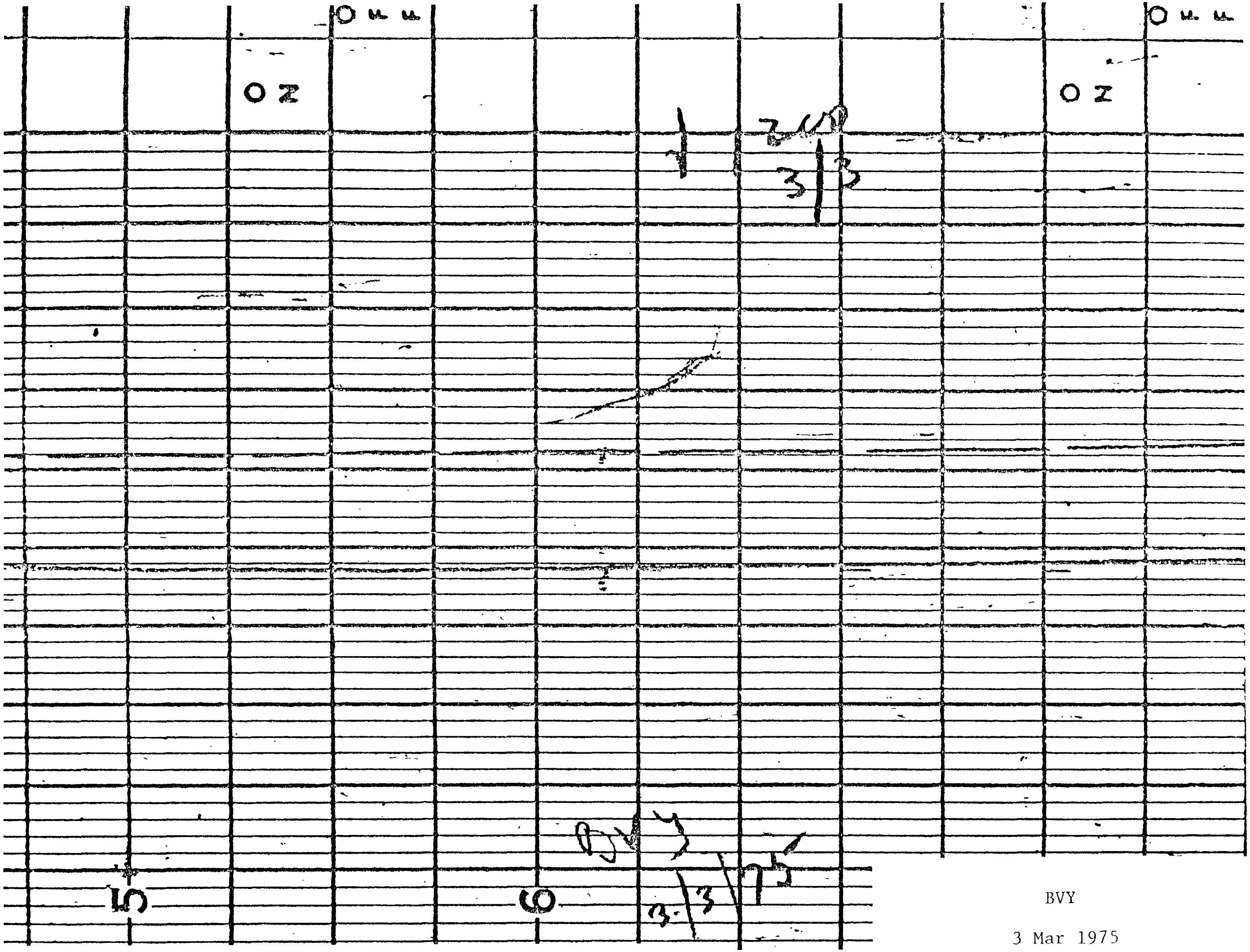
2-3L



SAS

3 Mar 1975

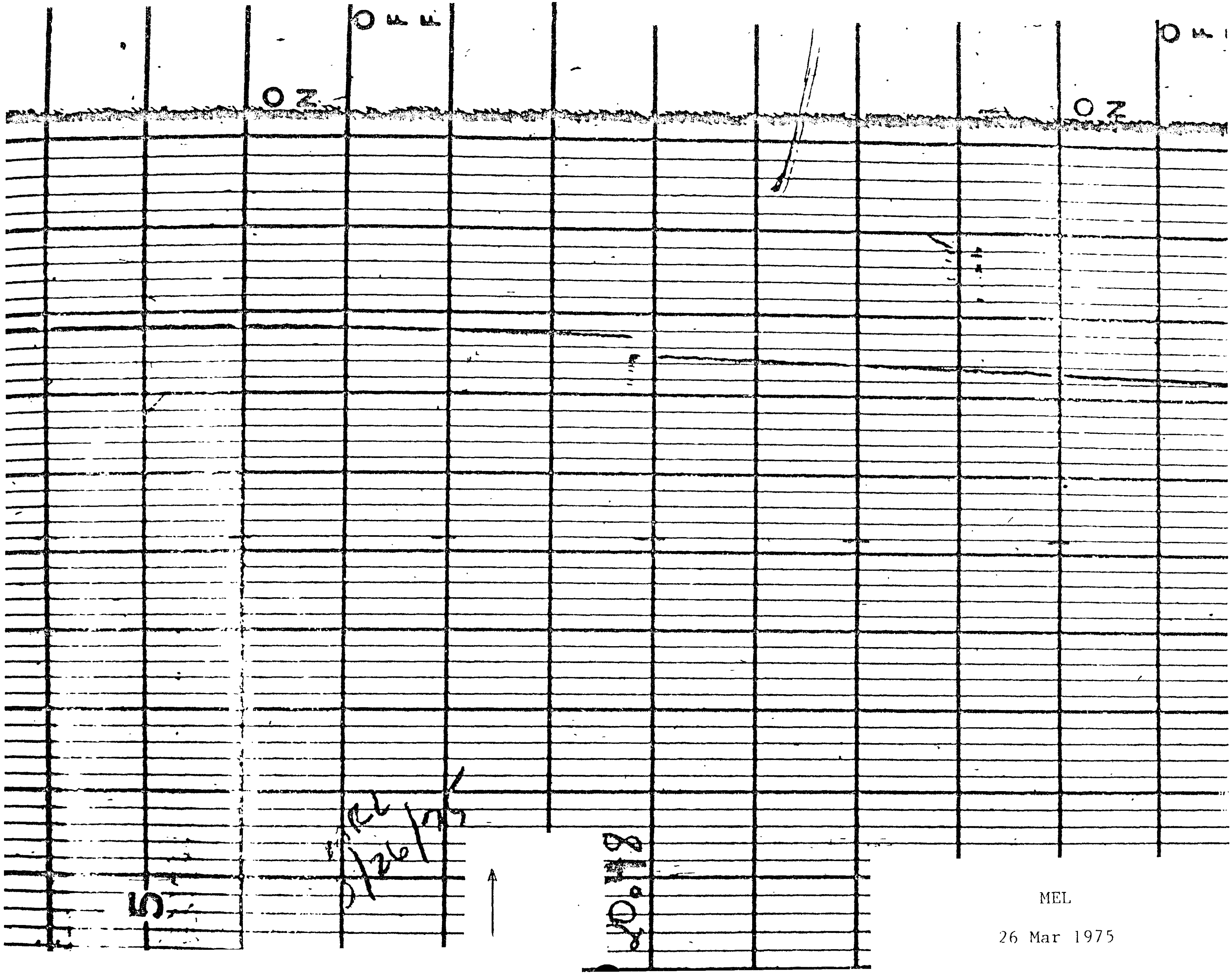
2-3L



BVY

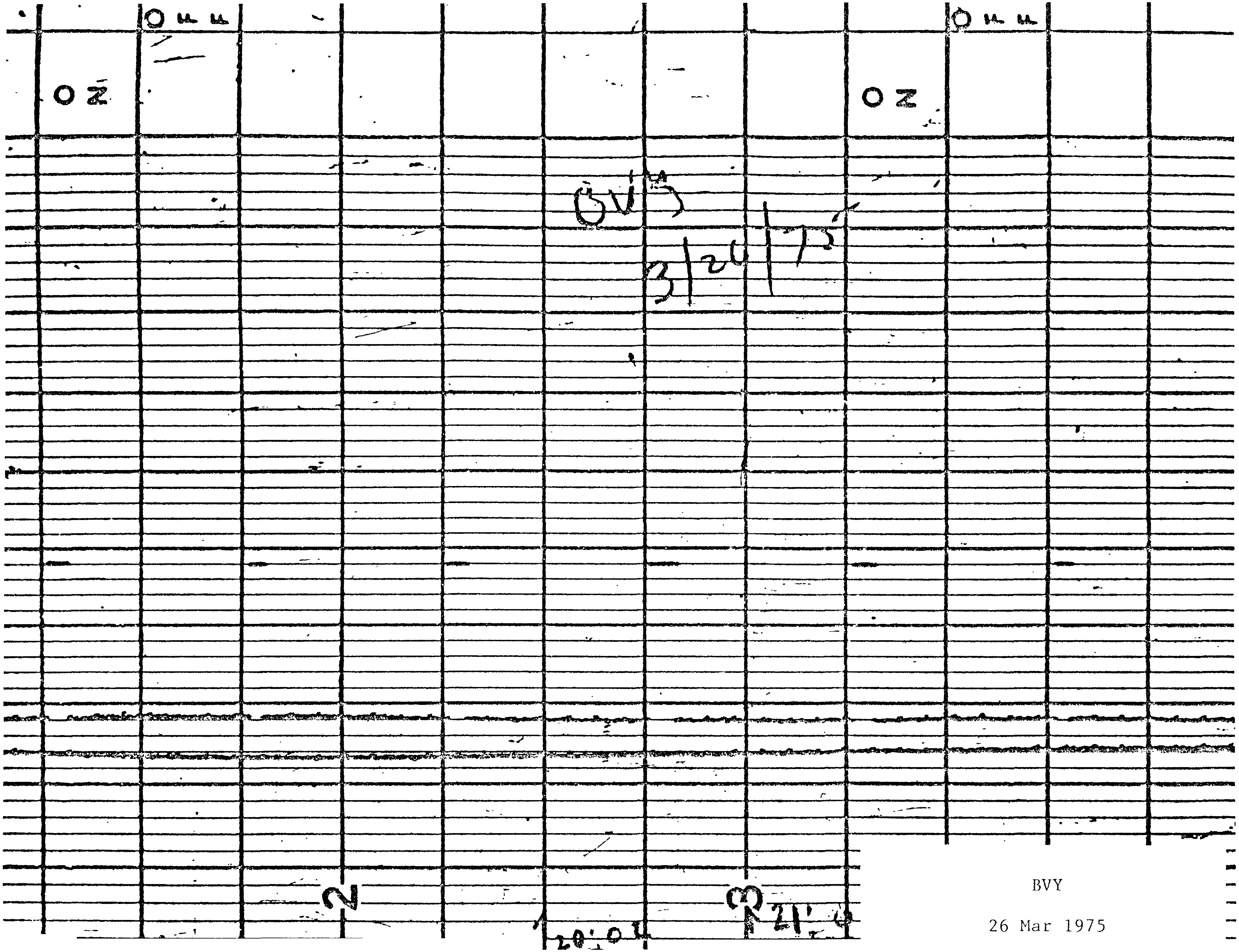
3 Mar 1975

2-3L



MEL

26 Mar 1975



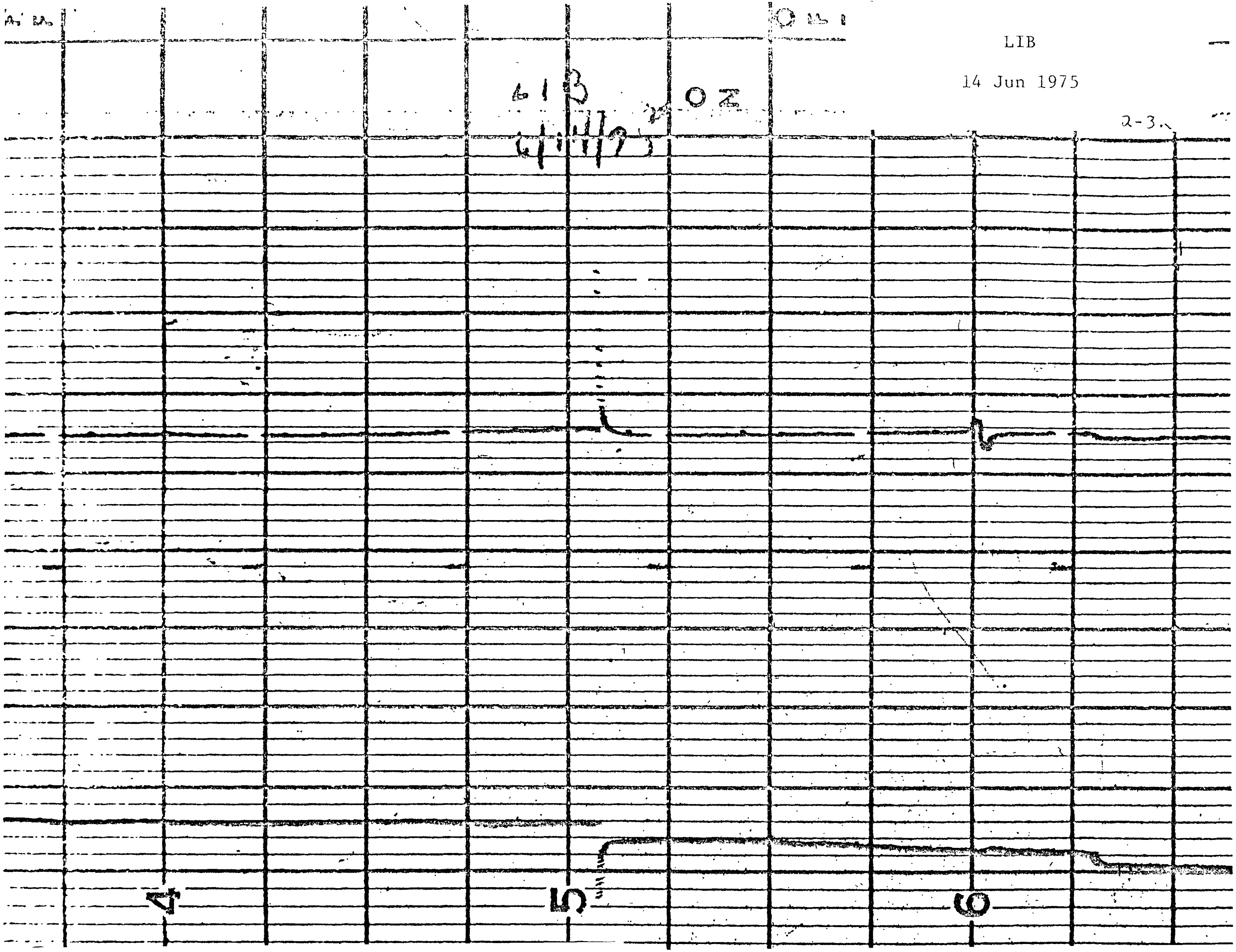
BVY

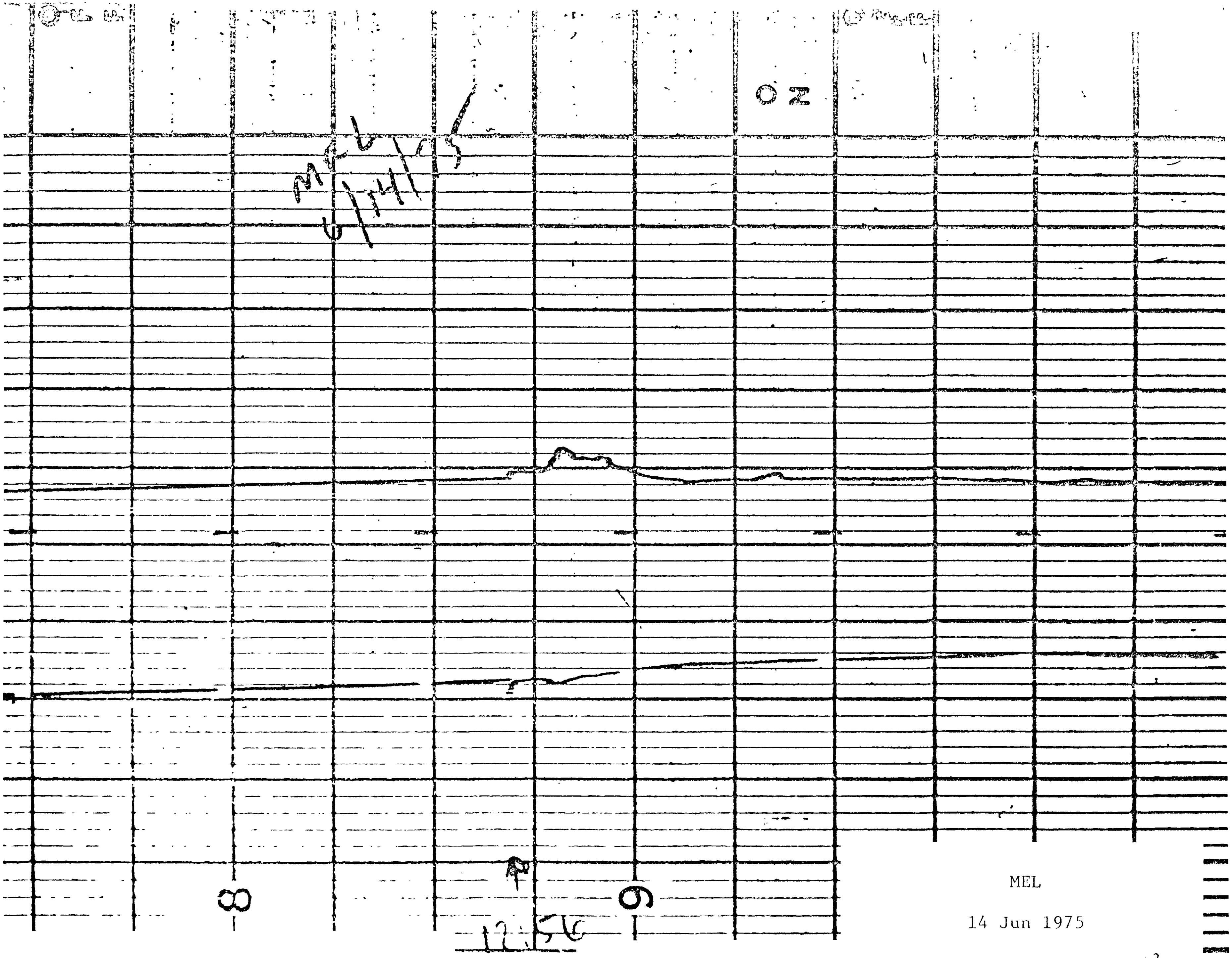
26 Mar 1975

R-3m

LIB

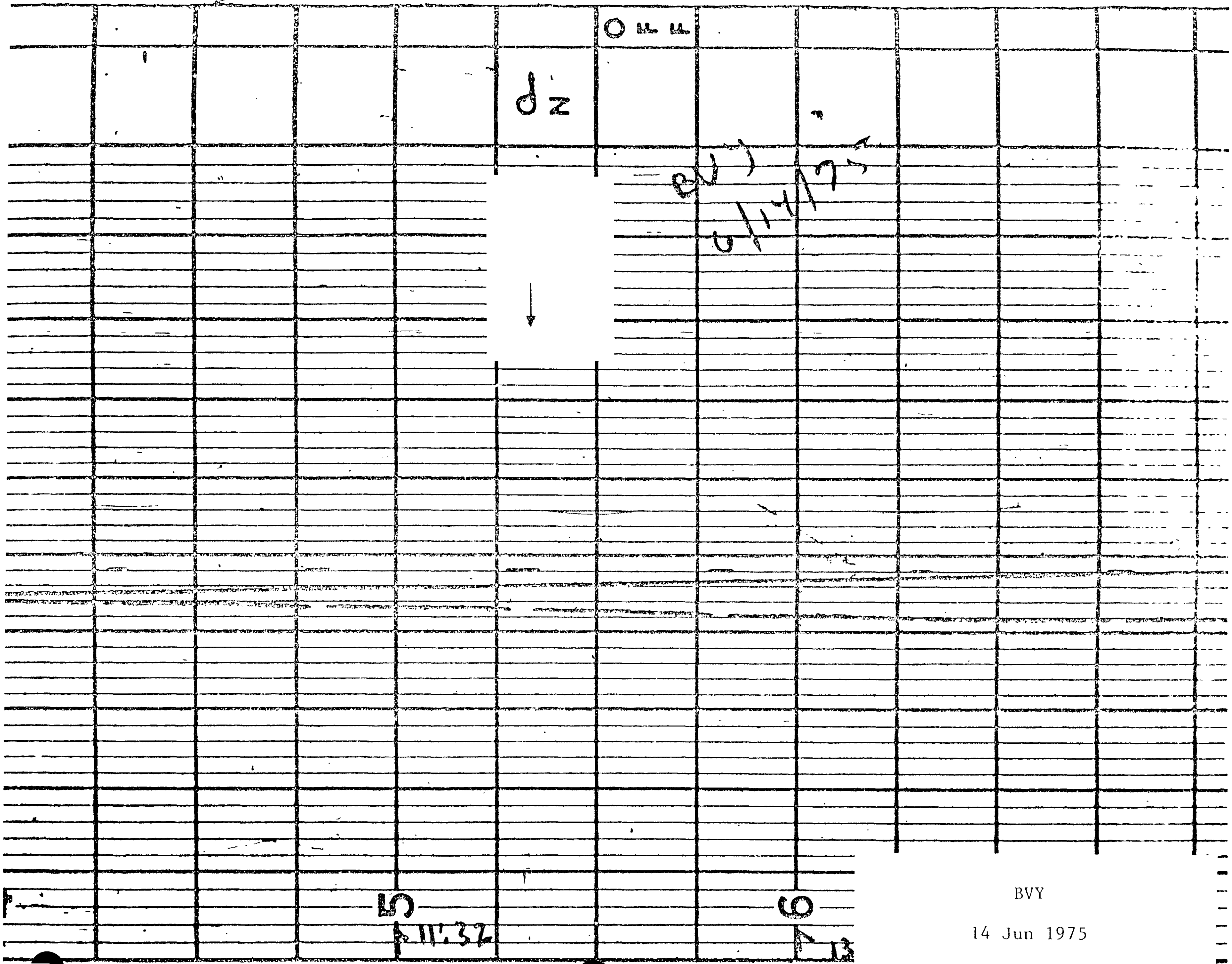
14 Jun 1975





MEL

14 Jun 1975



BVY

14 Jun 1975

p2-3n

III

DOCUMENTATION OF SOME PROGRAMS USED IN THE ANALYSIS OF SHORT PERIOD TILT DATA

A: PROGRAM VECTOR

Introduction

VECTOR takes tilt component data in (x, y) form and displays it as a series of head-to-tail vectors. Although any vector component data may be used as input (with the appropriate modifications made in the main program), this program has been specifically designed to compute the vector difference between initial and final (x, y) values. The output consists of 1) a listing of the input data and the amplitude and azimuth of the difference vector and 2) a plot of the input data in head-to-tail vector form. With VECTOR, the user may examine the temporal variation of a vector quantity and determine, for example, 1) trends in the difference vector's amplitude or direction, 2) the cumulative change in the vector's position, and 3) the rate of change of the vector's amplitude or azimuth.

Access and Use

This program is intended for use on the LBL 6600B or C computer and the Tektronix (4010-1) terminal. VECTOR may be accessed using the command:

‸LOAD, VECTOR, MCHUGH

The program operation requires approximately 50K of core. VECTOR will automatically link to the appropriate plotting routines. Consequently, the ‸LOAD command may be followed by ‸RUN.

Unless line 6 in the program listing is changed, the input data will be read from TLTEVN in library MCHUGH. No input from the operator is required until the program is ready to start plotting the data.

Input

It is assumed that the data stored on TLTEVN is in the form:

1) N = number of data blocks (e.g., from individual stations), I2 format
2) Header card with station name, A10 format
3) Data block:

   Each line (card image) must consist of the date and time of the event, the initial and final (x, y) coordinates, and the scale factor. It is assumed that + x = EAST and + y = NORTH. The Sage South data prior to 19 December 1974 (when + x = SOUTH and + y = EAST) is automatically corrected.

   The variable sequence and format is:

   NMONTH, NDAY, NYEAR, TIME, XIN, YIN, XFN, YFN, FACTOR

   (e.g., 04/12/74-2230 22.3 -3.7 21.8 -4.3 17.)

   I2, 1X, I2, 1X, I2, 1X, A4, 1X, 4(F7.21X), F10.3

   The month, day, and the last two digits of the year are in integer form. XIN and YIN are the initial (x,y) position of the vector, and XFN and YFN are the final (x,y) position. It is assumed that the x,y data must be changed from their input scale to microadians by dividing by FACTOR.

4) End card:

The end of the data block is a card with XIN, YIN, XFN, and YFN set equal to +999.99.

5) The number of "header card and data block" sequences must equal N. That is, the data is arranged as follows:

```
                    N
                  ┌ Header Card
                  │ Data Block
                  │ End Card
                  │   .
N sequences      <    .
                  │   .
                  │ Header Card
                  │ Data Block
                  └ End Card
                    EOR
```

If a different input format is desired, lines 32, 35, and 38 may be changed. The Sage South (SAS) data prior to 19 December 1974 is affected by lines 54 through 59. The month in integer form is changed to an alphabetic code by lines 42 through 53.

Output

The output for each station consists of 1) a listing of the input data and the amplitude and azimuth of the difference vector and 2) a head-to-tail vector plot of all the data in each data block.

The list is written out in the form:

DAY, MONTH, YEAR, TIME, XIN, YIN, XFN, YFN, AMP, AZM

If one or more of the (x, y) data points is unknown (i.e., equal to +999.99), the azimuth is set equal to +999.99 and that vector is not plotted. The Tektronix screen is automatically cleared prior to the data list and after every 25 lines of data have been displayed. A hard copy is automatically made of the screen after 25 lines of data have been printed. The program sums the x and y coordinates of each vector (with an azimuth not equal to +999.99), and computes the amplitude and azimuth of this cumulative vector. This information is displayed and hard copied after the data listing is terminated.

Immediately prior to the vector plot, the computer will list the total amplitude of the vectors (that is, the sum of the individual amplitudes), and ask if any scaling is required for the plot. If an N (no) is entered, the distance from the center of the screen to the margins is set equal to the total amplitude of the vectors. If scaling is desired, enter Y (yes); the computer will respond:

Enter right- and left-hand margin coordinates,
Then lower and upper margin coordinates.

The four numbers corresponding to the margin positions must be entered. The vector plot is displayed once the scaling information is entered (the start and end times of the plot are also listed). After the plotting is finished, the computer responds:

0 - Return to main program, 1 - new plot.

If a 1 is entered, the computer asks for new scaling information; and the plot is re-drawn. If a 0 is entered, a hard copy of the plot is automatically made, and data from the next data block is written.

Results and Discussion

Pages 3-A.9 through 3-A.30 show the short period tilt event data from four central California sites (Libby - LIB, Sage South - SAS, Melendy - MEL, and Bear Valley - BVY; Figure 3-A1). Each vector represents the change in tilt produced by an SR event (Figures 3-A2a and 3-A2b). Each SR event and the associated (x,y) data from June 1973 through June 1975 at LIB and SAS and April 1974 through May 1975 at MEL and BVY were read from the Rustrak records, and are listed and plotted by VECTOR. The cumulative change in tilt represented by the SR events is 2.6 μrads and 219^{o} from north at LIB, 2.9 μrads and 76^{o} at SAS, 7.0 μrads and 342^{o} at MEL, and 0.3 μrads and 6.8^{o} at BVY. In general, these trends are fairly well established at each station. Although the vectors appear to change in random directions at MEL initially, the trend for the last half of the data is north by northwest.

The SR event data indicate that there is a systematic, long-term trend to the short-period changes at each station. Although the trend at each station is different, it is clear that the SR events do not represent random changes in the tilt field. The systematic trends may indicate the SR event source is slip-related. Models for SR events have been discussed in McHugh and Johnston (1976) and McHugh (1976a and 1976b). Further discussion of SR events follows in the next section.

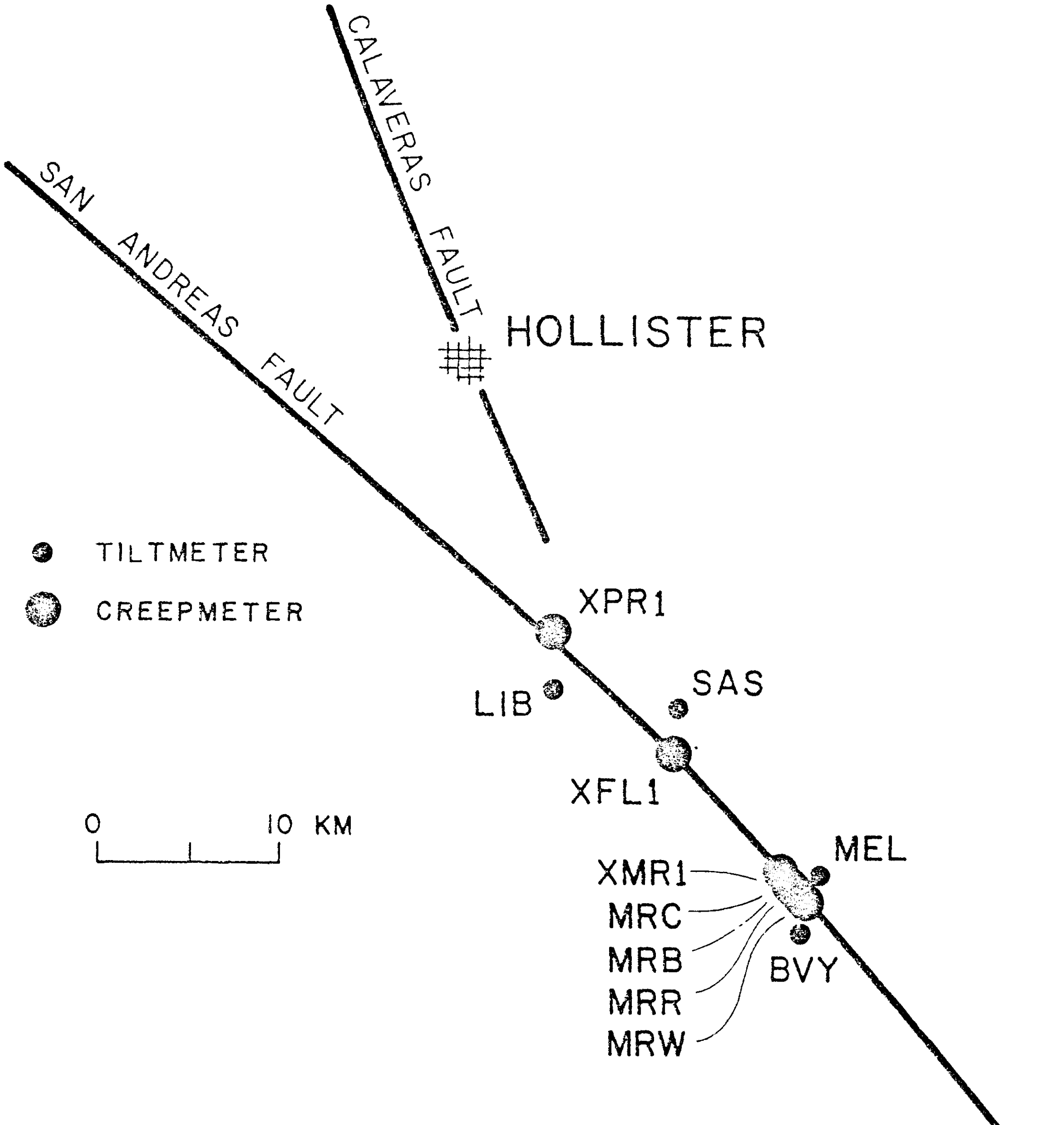

CALAVERAS FAULT
SAN ANDREAS FAULT
HOLLISTER
TILTMETER
CREEPMETER
XPR1
LIB
SAS
XFL1
0
10 KM
MEL
XMR1
MRC
MRB
MRR
MRW
BVY

Figure 3-A1

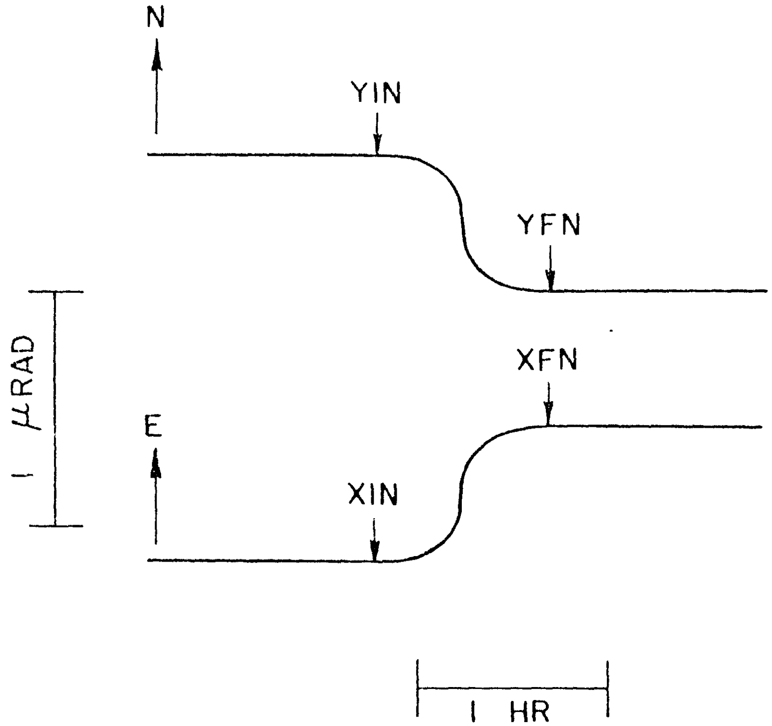


Figure 3-A2a

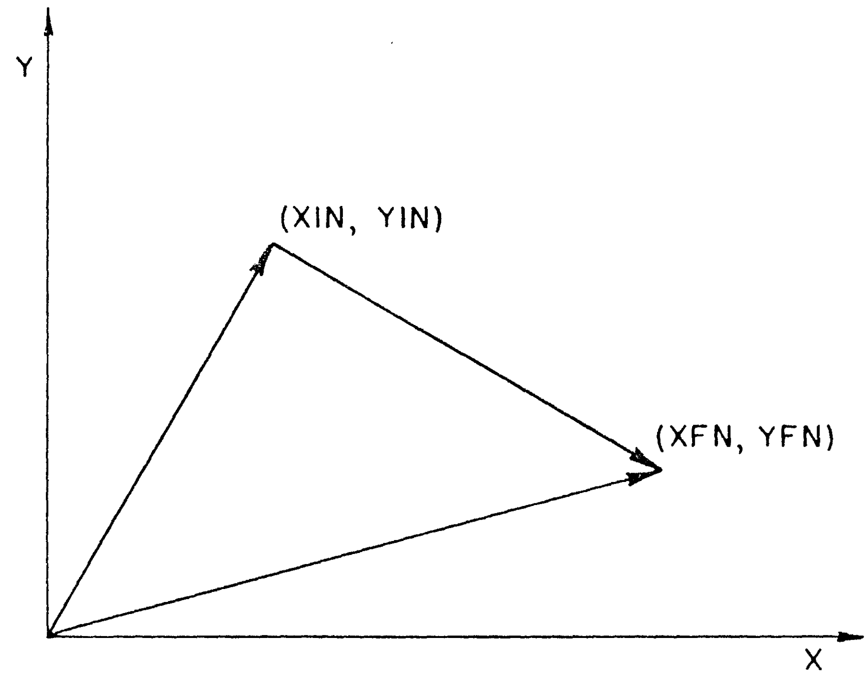


Figure 3-A2b

EXAMPLE OF VECTOR OPERATION

LIBBY

16	JUN	1973-2030	13.00	-9.80	12.50	-9.80	.147	270.00
18	JUN	1973-0330	13.00	-11.80	13.50	-11.80	.147	90.00
18	JUN	1973-2030	13.80	-12.90	13.50	-12.90	.088	270.00
19	JUN	1973-0430	14.00	-13.00	14.30	-13.10	.093	108.43
25	JUN	1973-1855	-.80	-5.60	-1.00	-6.20	.186	198.43
5	JUL	1973-1130	.10	-16.50	.10	-16.70	.059	180.00
5	JUL	1973-1645	-.30	-16.70	-.20	-16.90	.066	153.43
14	JUL	1973-0330	-1.00	2.00	-.80	1.50	.158	158.20
15	JUL	1973-0630	-1.10	.20	-1.20	0.	.066	206.57
21	JUL	1973-0915	-2.00	-4.50	-1.90	-5.10	.179	170.54
23	JUL	1973-0630	-2.00	-3.50	-1.80	-5.40	.066	63.43
26	JUL	1973-0145	-7.10	-10.30	-7.10	-11.00	.041	180.00
31	JUL	1973-0230	2.00	-1.00	2.00	-1.00	.047	180.00
2	AUG	1973-1630	2.10	-6.90	2.90	-7.90	.075	141.34
6	AUG	1973-2300	.20	-12.80	.20	-13.00	.012	180.00
7	AUG	1973-0400	.20	-14.00	.20	-14.50	.053	180.00
10	AUG	1973-1130	2.80	-20.00	2.70	-20.50	.030	191.31
12	AUG	1973-2130	-.50	-20.50	-2.10	-20.30	.095	277.13
21	AUG	1973-0930	6.00	-3.50	6.50	-6.50	.066	153.43
23	AUG	1973-0400	5.80	-6.20				
	4.50	-8.20	.140	213.02				
26	AUG	1973-0700	4.00	-12.30	3.80	-13.00	.043	195.95
6	SEP	1973-1800	2.80	-.10	2.70	-.20	.008	225.00
19	SEP	1973-0730	2.00	-4.00	1.60	-4.20	.026	243.43
22	SEP	1973-0630	1.00	-3.00	1.10	-4.00	.013	153.43
12	OCT	1973-1930	-4.20	4.50	-4.30	4.50	.018	270.00

LIBBY

16	OCT	1973-0145	-3.00	9.60	-3.10	9.50	.008	225.00
17	OCT	1973-0230	-3.50	11.00	-3.00	11.00	.029	90.00
17	OCT	1973-2130	-4.00	13.20	-3.80	14.00	.049	14.04
19	OCT	1973-2000	-5.00	16.00	-5.10	16.80	.047	352.87
27	OCT	1973-1330	-8.50	26.50	-9.50	25.00	.106	213.69
2	NOV	1973-1600	-6.80	3.00	-7.50	2.50	.051	234.46
4	NOV	1973-2100	-10.00	7.50	-10.00	7.80	.018	0.
12	NOV	1973-1900	-15.50	23.00	-15.60	23.50	.030	348.69
7	FEB	1974-0130	.50	8.50	-.50	8.50	.059	270.00
7	FEB	1974-0530	-2.10	8.50	-2.60	8.50	.029	270.00
2	MAR	1974-0400	12.00	25.00	11.50	26.80	.066	333.43
13	APR	1974-1015	16.50	-8.00	13.50	-11.00	.250	225.00
3	MAY	1974-0630	7.30	2.50	7.50	3.00	.032	21.80
9	MAY	1974-2130	13.00	7.00	12.00	8.00	.083	315.00
28	MAY	1974-1500	26.20	5.00	25.20	5.00	.059	270.00
3	JUN	1974-1045	-6.10	-11.00	-6.50	-11.00	.024	270.00
13	JUN	1974-0200	-2.80	-17.00	-4.50	-17.80	.111	244.80
3	JUL	1974-1600	-4.50	-15.80	-5.00	-15.80	.029	270.00
4	JUL	1974-1830	-5.00	-16.20	-4.00	-16.20	.059	90.00
7	JUL	1974-0000	-4.80	-17.00	-8.00	-1		
7.20		.189	266.42					
10	JUL	1974-1530	-9.80	-17.20	-9.40	-17.20	.024	90.00
14	JUL	1974-1045	-8.50	-17.50	-9.00	-17.50	.029	270.00
19	JUL	1974-0900	2.00	-2.00	0.	-4.50	.188	218.66
22	JUL	1974-0400	-2.00	-6.50	-1.00	-8.00	.106	146.31
26	JUL	1974-0300	-1.00	-10.00	-1.00	-9.20	.047	0.

LIBBY

26	JUL	1974-1100	-1.50	-11.50	-1.00	-12.00	.042	135.00
27	JUL	1974-0700	-1.50	-12.00	-1.20	-13.10	.067	164.74
30	JUL	1974-0100	-2.00	-15.80	-2.20	-16.00	.017	225.00
9	AUG	1974-1830	-1.00	-9.60	-.50	-9.00	.046	39.81
14	AUG	1974-0800	-5.00	-16.00	-5.50	-17.00	.066	206.57
18	AUG	1974-0230	-1.50	-9.80	-2.00	-10.40	.046	219.81
19	AUG	1974-1300	-2.00	-15.10	-.50	-18.00	.192	152.65
26	AUG	1974-0245	-4.00	-20.70	-4.20	-20.00	.043	344.05
18	SEP	1974-1845	4.50	7.00	4.00	7.00	.029	270.00
26	SEP	1974-1530	-5.00	-1.00	-6.00	-2.00	.083	225.00
11	OCT	1974-1500	-8.80	2.30	-8.50	2.00	.025	135.00
13	OCT	1974-2000	-11.00	6.80	-14.00	4.30	.230	230.19
25	OCT	1974-2345	-18.00	20.00	-18.00	20.50	.029	0.
27	OCT	1974-2200	-19.20	22.00	-26.00	14.50	.596	222.20
29	OCT	1974-1100	-26.00	14.80	-26.00	15.00	.012	0.
11	NOV	1974-0230	-3.50	21.00	-4.00	22.00	.066	333.43
14	DEC	1974-0145	4.50	13.00	5.30	13.30	.050	69.44
14	DEC	1974-1130	3.50	14.00	3.00	13.70	.034	239.04
23	DEC	1974-1250	21.50	7.50	20.50	7.50	.059	270.00
3	JAN	1975-0000	3.50	3.50	3.80	4.00	.0	
34	30.96							
21	JAN	1975-1300	-4.00	1.80	-3.80	2.00	.017	45.00
23	JAN	1975-0430	5.30	3.50	5.30	4.00	.029	0.
11	FEB	1975-0345	11.00	5.00	10.00	4.30	.072	235.01
11	FEB	1975-1230	11.00	5.20	10.40	5.00	.037	251.57
17	FEB	1975-0455	22.00	8.30	21.70	7.30	.061	196.70

LIBBY

1 MAR 1975-1155	2.00	-1.50	2.80	0.	.100	28.07
29 MAR 1975-2300	-12.50	3.00	-13.00	4.00	.066	333.43
30 MAR 1975-0630	-14.80	3.50	-15.00	6.00	.148	355.43
1 APR 1975-1430	999.99	22.00	999.99	21.00	.059	999.99
13 APR 1975-0730	999.99	-8.00	999.99	-9.80	.059	999.99
28 APR 1975-2300	-7.50	999.99	-9.00	999.99	.088	999.99
2 MAY 1975-0200	-7.10	5.80	-7.00	6.10	.019	18.43
2 MAY 1975-0445	-8.50	4.90	-8.50	5.20	.018	0.
2 MAY 1975-0630	-7.80	4.00	-7.60	4.20	.012	0.
2 MAY 1975-1300	-8.80	2.00	-8.80	2.20	.012	0.
3 MAY 1975-0545	-10.80	-2.80	-10.80	-2.20	.035	0.
3 MAY 1975-1645	-11.50	-5.60	-11.50	-5.20	.035	0.
4 MAY 1975-1450	-13.80	-9.10	-13.00	-8.80	.018	0.
. 21 JUL 08.42	ALL SYSTEMS UP AND RUNNING					
7 MAY 1975-0330	3.80	5.30	3.60	5.80	.021	213.69
13 MAY 1975-2345	9.00	-.50	8.70	-.80	.025	225.00
14 MAY 1975-1000	7.00	-2.50	7.30	-2.00	.034	30.96
15 MAY 1975-2300	9.00	7.50	9.60	7.80	.029	100.00
15 MAY 1975-2330	9.00	7.80	9.00	7.30	.029	100.00
16 MAY 1975-0130	9.00	8.80	9.00	8.50	.018	100.00
18 MAY 1975-1400	0.	999.99	.50	999.99	.029	999.99
24 MAY 1975-1545	2					
.00 -10.00 1.80 -10.30 .021 213.69						
1 JUN 1975-0900	2.50	999.99	3.00	999.99	.029	999.99

STATION = LIBBY

X,Y COORDINATES OF VECTOR SUM = -1.618E+00   -1.971E+00

AMPLITUDE OF VECTOR SUM   = 2.550E+00 MICRORADIANS

AZIMUTH OF VECTOR SUM   = 2.194E+02 DEGREES

```
LIBBY
TOTAL AMPLITUDE OF VECTORS =  6.264E+00
SET MARGINS?  YES(Y) OR NO (N)
N!
START TIME   JUN/16/73-2030
END   TIME   JUN/ 1/75-0900

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
1
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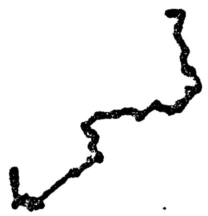

```
LIBBY
TOTAL AMPLITUDE OF VECTORS =  6.264E+00
SET MARGINS?  YES(Y) OR NO (N)
Y!
ENTER RIGHT- AND LEFT-HAND MARGIN COORDINATES,
THEN LOWER AND UPPER MARGIN COORDINATES
3 -3 -3 3!
START TIME   JUN/16/73-2030
END   TIME   JUN/ 1/75-0900

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
0!
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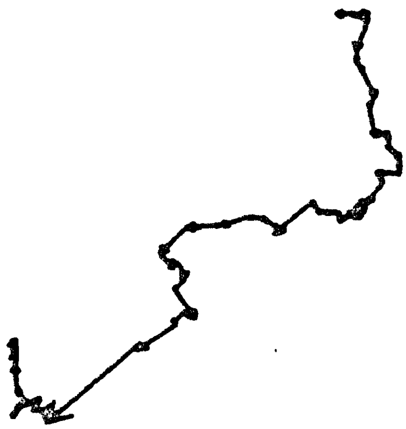


SAGE SOUTH

6 JUN 1973-0200	-28.00	18.00	-28.00	19.00	.294	90.00
22 JUN 1973-0200	7.00	-4.80	6.00	-3.50	.482	52.43
10 SEP 1973-1330	18.50	-9.00	17.20	-2.00	.419	79.48
26 NOV 1973-1500	2.00	-5.00	4.00	-4.00	.132	153.43
28 DEC 1973-1345	13.70	1.50	12.10	10.50	.538	79.92
22 JAN 1974-1945	-6.00	16.20	-1.80	22.20	.431	124.99
7 FEB 1974-1030	14.50	999.99	14.70	999.99	.012	999.99
10 FEB 1974-1745	13.00	999.99	13.80	999.99	.047	999.99
11 MAR 1974-1330	2.50	9.20	2.50	9.50	.018	90.00
12 MAR 1974-0550	2.50	10.50	2.00	19.50	.530	86.82
12 MAR 1974-1830	-.50	21.50	0.	20.00	.093	251.57
18 MAR 1974-1930	-12.00	.50	-11.50	0.	.042	225.00
28 MAY 1974-1645	5.00	999.99	5.50	999.99	.029	999.99
28 MAY 1974-1645	4.00	999.99	4.50	999.9	.029	999.99
12 JUN 1974-1530	18.00	-27.00	17.00	-22.50	.271	77.47
30 AUG 1974-2130	999.99	7.00	999.99	4.50	.147	999.99
9 NOV 1974-1830	3.20	6.50	3.30	6.00	.030	258.69
15 NOV 1974-0015	2.80	999.99	-2.60	999.99	.318	999.99
30 DEC 1974-0300	-12.50	21.50	-10.00	24.50	.230	39.81
4 APR 1975-1945	-2					
.50	3.50	-1.30	11.00	.447	9.09	
22 APR 1975-2100	-3.80	-4.80	-5.00	-3.70	.008	233.13
11 MAY 1975-1930	999.99	-6.50	999.99	-7.50	.059	999.99

STATION = SAGE SOUTH

X,Y COORDINATES OF VECTOR SUM = 2.841E+00 6.882E-01

AMPLITUDE OF VECTOR SUM = 2.923E+00 MICRORADIANS

AZIMUTH OF VECTOR SUM = 7.638E+01 DEGREES

```
SAGE SOUTH
TOTAL AMPLITUDE OF VECTORS =  4.044E+00
SET MARGINS?  YES(Y) OR NO (N)
N!
START TIME   JUN/ 6/73-0200
END   TIME   MAY/11/75-1930

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
0!
```

MELENDY

31	MAY	1974-0323	21.50	999.99	22.00	999.99	.147	999.99
12	JUN	1974-1321	2.00	999.99	1.50	999.99	.147	999.99
12	JUN	1974-1907	4.80	999.99	4.90	999.99	.029	999.99
12	JUN	1974-1938	5.10	999.99	6.10	999.99	.294	999.99
14	JUN	1974-0309	14.50	999.99	14.80	999.99	.008	999.99
15	JUN	1974-1612	25.80	999.99	25.00	999.99	.235	999.99
4	JUL	1974-2042	.50	5.80	1.50	7.00	.459	39.81
7	JUL	1974-1316	2.30	13.80	1.20	14.70	.596	327.09
10	JUL	1974-1936	2.00	15.70	1.50	16.00	.355	335.56
10	JUL	1974-2029	1.00	15.50	.50	16.00	.200	315.00
11	JUL	1974-1743	-2.50	16.30	-3.80	15.30	.482	232.43
22	JUL	1974-0430	-11.70	17.30	-11.90	18.30	.300	348.69
4	AUG	1974-1448	-9.00	999.99	-10.00	999.99	.294	999.99
3	SEP	1974-2159	-.10	-.10	-1.20	-1.20	.458	225.00
13	SEP	1974-0559	-1.80	-1.80	-1.30	-2.10	.171	120.96
21	SEP	1974-2148	4.00	2.80	3.80	3.00	.300	348.69
25	SEP	1974-0708	6.00	4.20	5.30	6.50	.707	343.07
28	SEP	1974-1716	9.00	8.80	9.20	8.30	.158	158.20
3	OCT	1974-0804	13.80	8.80	12.20	8.50	.479	239.38
18	OCT	1974-2243	10.50	2.80				
	10.50	3.10	.008					
19	OCT	1974-2307	14.80	-10.00	15.00	-8.80	.658	26.57
22	OCT	1974-1500	999.99	-19.80	999.99	-20.30	.147	999.99
2	NOV	1974-1700	-2.00	-1.50	-1.80	-3.00	.445	172.41
3	NOV	1974-1725	-3.50	-6.30	-3.30	-7.30	.300	168.69
4	NOV	1974-0142	-4.00	-10.30	-4.50	-10.50	.158	248.20

MELENDY

6	NOV	1974-1822	-5.20	-17.80	-4.90	-19.50	.508	169.99
7	NOV	1974-1058	-5.50	-19.70	-5.50	-19	.206	0.
8	NOV	1974-0415	-5.00	-20.30	-4.00	-22.70	.765	157.38
14	NOV	1974-2257	3.00	-1.00	2.50	-.80	.158	291.80
18	NOV	1974-0122	8.00	-3.00	7.80	-2.20	.243	345.96
22	NOV	1974-0016	3.00	-4.00	2.00	-7.00	.930	198.43
23	NOV	1974-0243	-.50	-11.00	-.50	-10.50	.147	0.
24	NOV	1974-0122	-1.20	-13.00	-1.20	-13.50	.147	180.00
25	NOV	1974-0249	-.80	-14.50	-1.00	-14.00	.158	338.20
28	NOV	1974-0129	3.00	-16.00	3.00	-14.00	.500	0.
29	NOV	1974-1737	8.30	-15.00	9.00	-16.00	.359	145.01
30	NOV	1974-1710	9.00	-16.00	10.00	-18.00	.658	153.43
1	DEC	1974-0040	9.00	-18.00	8.00	-17.50	.329	296.57
4	DEC	1974-2252	8.00	-6.00	10.00	-3.50	.942	38.66
5	DEC	1974-1750	6.00	4.50	6.50	6.00	.465	18.43
5	DEC	1974-1850	6.30	5.00	6.80	6.30	.410	21.04
6	DEC	1974-0007	3.00	4.00	-1.50	6.00	1.448	293.96
16	DEC	1974-0213	-17.00	-22.30	-17.50	-22.80	.208	225.00
17	DEC	1974-0100	-20.50	999.99	-20.00	999.99	.147	999.99
29	DEC	1974-0614	999.99	14.50	999.99	14.20	.000	999.99
31	DEC	1974-1956	999.99	-16.00	999.99	-17.80	.529	999.99
31	DEC	1974-2138	999.99	-18.00	999.99	-19.30	.382	999.99
13	JAN	1975-1543	-2.80	-15.40	-3.00	-15.70	.106	213.69
15	JAN	1975-0343	-7.20	999.99	-7.00	999.99	.059	999.99
25	JAN	1975-0900	-3.00	-10.30	-3.20	-10.50	.083	225.00

MELENDY

6 FEB 1975-1611	-8.20	999.99	-8.60	999.99	.118	999.99
21 FEB 1975-0856	-9.50	-8.50	-9.30	-8.30	.083	45.00
20 MAR 1975-1155	-3.00	8.10	-4.00	10.10	.658	333.43
24 MAR 1975-1115	7.70	999.99	8.00	999.99	.088	999.99
26 MAR 1975-2047	12.80	999.99	11.30	999.99	.441	999.99
4 APR 1975-0308	-8.80	13.20	-9.00	13.80	.186	341.57
11 APR 1975-0614	16.50	999.99	17.50	999.99	.294	999.99
14 APR 1975-0803	12.20	999.99	11.20	999.99	.294	999.99
16 APR 1975-1453	15.20	999.99	19.30	999.99	1.206	999.99
17 APR 1975-1121	-6.00	1.20	-5.70	3.20	.595	8.53
17 APR 1975-2026	-4.20	5.00	-3.80	10.60	1.651	4.09
19 APR 1975-0112	-6.00	16.50	-4.00	16.00	.606	104.04
23 APR 1975-1311	-6.40	999.99	-5.90	999.99	.147	999.99
24 APR 1975-0522	-6.00	999.99	-6.40	999.99	.118	999.99
24 APR 1975-1339	-6.30	999.99	-6.00	999.99	.088	999.99
27 APR 1975-0830	-2.00	999.99	-2.80	999.99	.235	999.99
29 APR 1975-2249	-3.20	3.40	-4.00	6.30	.885	344.58
7 MAY 1975-0220	-17.00	23.30	-19.00	999.99	6.878	999.99
14 MAY 1975-1406	-9.70	4.30	-13.20	7.60	1.415	313.32
15 MAY 1975-0105	-19.80	5.20	-17.30	5.10	.736	92.29
16 MAY 1975-0606	999.99	9.00	999.99	9.50	.147	999.99
16 MAY 1975-2255	999.99	9.00	999.99	8.20	.235	999.99
17 MAY 1975-2159	999.99	11.10	999.99	10.50	.176	999.99
21 MAY 1975-2125	999.99	18.30	999.99	18.40	.829	999.99
21 MAY 1975-2255	999.99	18.20	999.99	18.30	.829	999.99

MELENDY

22 MAY 1975-1248	999.99	23.00	999.99	24.80	.529	999.99
22 MAY 1975-1442	999.99	24.50	999.99	25.00	.147	999.99
23 MAY 1975-0516	999.99	23.80	999.99	25.00	.353	999.99
28 MAY 1975-1528	-3.80	6.00	-3.70	5.20	.237	172.87
31 MAY 1975-0621	999.99	3.50	999.99	4.80	.382	999.99
31 MAY 1975-2225	999.99	0.	999.99	-.80	.235	999.99
13 JUN 1975-0525	-5.80	1.20	-6.20	2.50	.400	342.90

STATION = MELENDY

X,Y COORDINATES OF VECTOR SUM = -2.147E+00   6.647E+00

AMPLITUDE OF VECTOR SUM   = 6.965E+00 MICRORADIANS

AZIMUTH OF VECTOR SUM   = 3.421E+02 DEGREES

```
MELENDY
TOTAL AMPLITUDE OF VECTORS =  2.263E+01
SET MARGINS?  YES(Y) OR NO (N)
N!
START TIME   MAY/31/74-0323
END   TIME   JUN/13/75-0525

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
1
```

```
MELENDY
TOTAL AMPLITUDE OF VECTORS =  2.263E+01
SET MARGINS?  YES(Y) OR NO (N)
Y!
ENTER RIGHT- AND LEFT-HAND MARGIN COORDINATES,
THEN LOWER AND UPPER MARGIN COORDINATES
10 -10 -10 10!
START TIME   MAY/31/74-0323
END   TIME   JUN/13/75-0525

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
1
```

```
MELENDY
TOTAL AMPLITUDE OF VECTORS =  2.263E+01
SET MARGINS?  YES(Y) OR NO (N)
Y!
ENTER RIGHT- AND LEFT-HAND MARGIN COORDINATES,
THEN LOWER AND UPPER MARGIN COORDINATES
5 -5 -5 5
```

```
0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
0!
```

BEARVALLEY

11	APR	1974-0115	-10.50	6.50	-10.40	6.40	.008	135.00
11	APR	1974-1700	-10.80	8.00	-10.80	7.50	.029	180.00
13	APR	1974-0100	-16.50	5.00	-16.30	4.80	.017	135.00
19	APR	1974-1930	999.99	6.30	999.99	6.10	.012	999.99
24	MAY	1974-2000	-22.00	-21.30	-23.00	-21.30	.059	270.00
7	SEP	1974-0930	-1.00	-4.50	-2.00	-5.00	.066	243.43
19	DEC	1974-2315	9.00	-7.30	9.80	-5.00	.143	19.18
8	JAN	1975-1145	-11.00	-24.00	-12.00	-23.00	.083	315.00
28	FEB	1975-1930	8.00	-.20	9.00	1.50	.116	30.47
10	MAY	1975-0130	1.00	13.00	1.50	12.50	.042	135.00
24	MAY	1975-0630	2.50	3.50	3.50	5.30	.121	29.05

STATION = BEARVALLEY

X,Y COORDINATES OF VECTOR SUM = 3.529E-02 2.941E-01

AMPLITUDE OF VECTOR SUM = 2.962E-01 MICRORADIANS

AZIMUTH OF VECTOR SUM = 6.843E+00 DEGREES

```
BEARVALLEY
TOTAL AMPLITUDE OF VECTORS =  6.841E-01
SET MARGINS?  YES(Y) OR NO (N)
N!
START TIME   APR/11/74-0115
END   TIME   MAY/24/75-0630

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
0!
```

PROGRAM LISTING

```
DELETE(LGO,LGOB,VECTOR)
VECTOR.
CXIT.
LIBCOPY(GRAPHIC,TXLGO/RR,TXLGO)
LIBCOPY(JORAT,NPLGO/RR,NPLGO)
LIBCOPY(MCHUGH,TLTEVN/RR,TLTEVN)
RUN76(S)
LINK(F=LGO,F=TXLGO,F=NPLGO,B=VECTOR)
VECTOR(TLTEVN)
VECTOR.
FIN.
EOR
      PROGRAM VECTOR(TAPE5,TAPETTY=201,FILM=TAPETTY,TAPE7=TAPETTY)
      COMMON/TVPOOL/TVPUL(8)
      COMMON/TVTUNE/ITUNE(30)
      COMMON/JPLCT/XLT,XRT,YLO,YUP,MAJX,MAJY,KX(2),KY(2),LTITL(8),LU,
     1 LTF,LNLGX,LNLGY,NCLX,NCLY,LTITL2(8)
      DIMENSION IFET(8)
      DIMENSION STA(10),NYEAR(1000),NDAY(1000)
      DIMENSION NMONTH(1000),TIME(1000),XIN(1000),XFN(1000),YIN(1000)
      DIMENSION YFN(1000),A(30),AMP(1000),AZM(1000)
      CALL FET(5LTAPE7,IFET,8)
      IFET(2)=IFET(2).OR.0000 0010 0000 0000 0000B
      IFET(8)=IFET(8).OR.4000 0000 0000 0000 0000B
      CALL FET(5LTAPE7,IFET,-8)
      TVPUL(5)=-.32 $TVPUL(6)=1. $TVPUL(7)=0. $TVPUL(8)=1.
      DO 10 I=1,1000
      NMONTH(I)=NDAY(I)=TIME(I)=XIN(I)=XFN(I)=YIN(I)=0.
      YFN(I)=NYEAR(I)=0.
   10 CONTINUE
      PI=3.1415926 $READ(5,1)N
    1 FORMAT(I2)
      DO 2 IJ=1,N
      READ(5,3)STA(IJ) $K=1 $SUM1=SUM2=0.
    3 FORMAT(A10)
    4 READ(5,5)NMONTH(K),NDAY(K),NYEAR(K),TIME(K),XIN(K),YIN(K),XFN(K),
     1  YFN(K),FACTOR
    5 FORMAT(I2,1X,I2,1X,I2,1X,A4,1X,4(F7.2,1X),F10.3)
      IF(XIN(K).EQ.999.99.AND.YIN(K).EQ.999.99.AND.XFN(K).EQ.999.99.AND.
     1 YFN(K).EQ.999.99)GOTO6
      A=XIN(K) $B=YIN(K) $C=XFN(K) $D=YFN(K) $LMONTH=NMONTH(K)
      IF(NMONTH(K).EQ. 1)NMONTH(K)=3HJAN
      IF(NMONTH(K).EQ. 2)NMONTH(K)=3HFEB
      IF(NMONTH(K).EQ. 3)NMONTH(K)=3HMAR
      IF(NMONTH(K).EQ. 4)NMONTH(K)=3HAPR
      IF(NMONTH(K).EQ. 5)NMONTH(K)=3HMAY
      IF(NMONTH(K).EQ. 6)NMONTH(K)=3HJUN
      IF(NMONTH(K).EQ. 7)NMONTH(K)=3HJUL
      IF(NMONTH(K).EQ. 8)NMONTH(K)=3HAUG
      IF(NMONTH(K).EQ. 9)NMONTH(K)=3HSEP
      IF(NMONTH(K).EQ.10)NMONTH(K)=3HOCT
      IF(NMONTH(K).EQ.11)NMONTH(K)=3HNOV
      IF(NMONTH(K).EQ.12)NMONTH(K)=3HDEC
      IF(STA(IJ).EQ.10HSAGE SOUTH  .AND.NYEAR(K).LE.74)GOTO20
      GOTO12
   20 IF(NYEAR(K).LT.74)GOTO11
      IF(LMONTH.LT.12)GOTO11
      IF(LMONTH.EQ.12.AND.NDAY(K).LE.19)GOTO11
```

```
      GOTO12
   11 A=YIN(K)   $B=-XIN(K)   $C=YFN(K)  $D=-XFN(K)
12    IF(A.EQ.999.99)A=0. $IF(B.EQ.999.99)B=0.
      IF(C.EQ.999.99)C=0.  $IF(D.EQ.999.99)D=0.
      AMP(K)=(SQRT(((C-A)**2)+((D-B)**2)))/FACTOR
      IF(XIN(K).EQ.999.99.OR.YIN(K).EQ.999.99.OR.XFN(K).EQ.999.99.OR.YFN
     1( K).EQ.999.99)GOTO7
      SUM1=SUM1+((C-A)/FACTOR)  $SUM2=SUM2+((D-B)/FACTOR)
      DELTAY=D-B $IF(DELTAY.EQ.0.)DELTAY=1.E-20
      AZM(K)=(ATAN((C-A)/DELTAY))*(180./PI)
      IF(DELTAY.LT.0.)AZM(K)=AZM(K)+180.
      IF(AZM(K).GT.360.)AZM(K)=AZM(K)-360.
      IF(AZM(K).LT.0.)AZM(K)=AZM(K)+360.
      K=K+1 $GOTO4
7     AZM(K)=999.99
      K=K+1 $GOTO4
6     NEND=K-1
      CALL TVNEXT
      DO 8 J=1,NEND,25
      M=J+24  $IF(M.GT.NEND)M=NEND
      WRITE(7,3)STA(IJ)
      WRITE(7,9)(NDAY(I),NMONTH(I),NYEAR(I),TIME(I),XIN(I),YIN(I),XFN(I)
     1 ,YFN(I),AMP(I),AZM(I),I=J,M)
9     FORMAT(I2,1X,A3,3H 19,I2,1H-,A4,1X,4(F6.2,1X),F7.3,1X,F7.2)
      CALL REPRO $CALL TVNEXT
8     CONTINUE
      TAMP=SQRT((SUM1**2)+(SUM2**2))
      IF(SUM2.EQ.0.)SUM2=1.E-20
      TAZM=(ATAN(SUM1/SUM2))*(180./PI)
      IF(SUM2.LT.0.)TAZM=TAZM+180. $IF(TAZM.LT.0.)TAZM=TAZM+360.
      IF(TAZM.GT.360.)TAZM=TAZM-360.
      WRITE(7,13)STA(IJ),SUM1,SUM2,TAMP,TAZM
   13 FORMAT(/,/,*STATION = *,A10,/,/,
     1/,/,/,       *X,Y COORDINATES OF VECTOR SUM = *,E10.3,5X,E10.3,/,/,
     1 /,/,        *AMPLITUDE OF VECTOR SUM       = *,E10.3,* MICRORADIANS
     1 *,/,/,
     1/,/,/,       *AZIMUTH OF VECTOR SUM         = *,E10.3,* DEGREES*)
      CALL REPRO
      CALL VCTORS(STA,IJ,SUM1,SUM2,NMONTH,NDAY,NYEAR,TIME,AMP,AZM,NEND)
      CALL REPRO
2     CONTINUE
      STOP
      END
      SUBROUTINE REPRO
      A=00000001000000000000B $CALL ENDREC(7)    $CALL FET(7,A, 2*64)
      B=00330027000000000000B $WRITE(7)B         $CALL FET(7,A,-2*64)
      CALL ENDREC(7)          $WRITE(7,1)        $RETURN
1     FORMAT(100(/))
      END
      SUBROUTINE VCTORS(STA,IJ,SUM1,SUM2,NMONTH,NDAY,NYEAR,TIME,AMP
     1 ,AZM,NEND)
      DIMENSION NDAY(50),NMONTH(50),NYEAR(50),TIME(50),AMP(50),AZM(50)
      DIMENSION A(30),STA(10)
      COMMON/TVPCOL/TVPUL(8)
40    CONTINUE
      SUM=0.
      DO 30 J=1,NEND
      IF(AMP(J).EQ.999.99.OR.AZM(J).EQ.999.99)GOTO30
```

```
          SUM=AMP(J)+SUM
       30 CONTINUE
          CALL TVNEXT $WRITE(7,99)STA(IJ)
      99  FORMAT(A10)
          WRITE(7,31)SUM
       31 FORMAT(*TOTAL AMPLITUDE OF VECTORS = *,E10.3)
          TVPUL(1)=-SUM $TVPUL(2)=SUM $TVPUL(3)=-SUM $TVPUL(4)=SUM
          WRITE(7,34) $READ(7,35)CHECK $IF(CHECK.EQ.1HY)GOTO36
       34 FORMAT(*SET MARGINS?  YES(Y) OR NO (N)*)
      35  FORMAT(A1)
          GOTO37
      36  WRITE(7,33) $CALL GETNUM(A)  $TVPUL(2)=A(1) $TVPUL(1)=A(2)
      33  FORMAT(*ENTER RIGHT- AND LEFT-HAND MARGIN COORDINATES,*,/,
        1        *THEN LOWER AND UPPER MARGIN COORDINATES*)
          TVPUL(3)=A(3) $TVPUL(4)=A(4)
     37   PI=3.1415926 $WRITE(7,1)NMONTH(1),NDAY(1),NYEAR(1),TIME(1),NMONTH(
        1NEND),NDAY(NEND),NYEAR(NEND),TIME(NEND)
   1      FORMAT(*START TIME   *,A3,*/*,I2,*/*,I2,*-*,A4,/,
        1        *END   TIME   *,A3,*/*,I2,*/*,I2,*-*,A4,/)
          BEGIN1=BEGIN2=0.
          DO 2 I=1,NEND
          IF(AMP(I).EQ.999.99.OR.AZM(I).EQ.999.99)GOTO2
          X=BEGIN1 $Y=BEGIN2
          DY=AMP(I)*COS(AZM(I)*(PI/180.))
          DX=AMP(I)*SIN(AZM(I)*(PI/180.))
          CALL ARROW(X,Y,DX,DY)
          BEGIN1=X+DX $BEGIN2=Y+DY
       2  CONTINUE
          CALL TVSEND
          WRITE(7,39) $CALL GETNUM(A) $IF(A(1).EQ.1.)GOTO40
     39   FORMAT(*0=RETURN TO MAIN PROGRAM, 1=NEW PLOT*)
          RETURN $END
$--ARROW----------------------------------------------------------
$PARAMS -- ABSOLUTE X,Y AND DELTA X,Y
          SUBROUTINE ARROW(X,Y,DX,DY)
          REAL A(6),B(6)
          A(1)=A(3)=A(5)=X             $ B(1)=B(3)=B(5)=Y
          A(2)=A(4)=A(6)=X+DX          $ B(2)=B(4)=B(6)=Y+DY
          ARWLEN=SQRT(DX*DX+DY*DY) $ HDLEN=ARWLEN/5
          IF(ARWLEN.EQ.0)GOTO 20    $ ARWANG=ACOS(DX/ARWLEN)
          IF(DY.LT.0)ARWANG=6.2832-ARWANG  $ ARWANG=ARWANG+3.1416
          DO 10 I=1,2 $ ANG=ARWANG+(I-1.5) $ J=I*2+1
               A(J)=X+DX+HDLEN*COS(ANG)
       10      B(J)=Y+DY+HDLEN*SIN(ANG)
       20 CALL TVPLOT(A,B,6,7HSEGMENT)   $ RETURN
          END
          SUBROUTINE GETNUM(R)
          DIMENSION R(1),L(80)
          READ(7,9)L $ I=J=0
        6 J=J+1 $ N=P=S=0 $ M=F=1
        5 I=I+1 $ IF(I.GT.80)RETURN $ D=L(I) $ K=4
          IF(D.EQ.38)K=2 $ IF(D.GE.27.A.D.LE.36)K=1
          IF(D.EQ.47)K=3 $ K=K+S $ GOTO(1,2,3,5,1,4,3,4)K
        1 N=N*10+D-27                  $ S=4          $ GOTO 5
        2 M=-1                         $ S=4          $ GOTO 5
        3 P=I                          $ S=4          $ GOTO 5
        4 IF(P.NE.0)F=10.**(I-P-1) $ R(J)=N/F*M $ GOTO 6
        9 FORMAT(80R1)
```

```
      END
```


44444444.444444444.444444444.444444444.444444444.444444444.444444444.444444444
44444444.444444444.444444444.444444444.444444444.444444444.444444444.444444444

B: PROGRAM ONSTSP

Introduction

ONSTSP displays 1) the amplitude and azimuth of short period tilt events computed from digitized, two-component data and 2) the "sharpness" (i.e., the normalized derivative) of the amplitude versus time graph. The input consists of digitized x, y versus time data. The sample interval of the x trace need not be the same as the y trace, nor is it necessary that their start and end times be the same. The program automatically converts the x and y traces to a common time base and sample interval, and then computes the amplitude and azimuth change from the x, y data. The "sharpness" quantity is computed from the amplitude data as follows:

$$[S] = \left(\frac{d\Theta}{dt}\right) \Big/ \left[(\Theta_f - \Theta_i) \; / \; (t_f - t_i)\right]$$

where [S] is the sharpness, Θ is the tilt amplitude, t is the time, and the subscripts i and f represent the initial and final quantities respectively.

Access and Use

ONSTSP is intended for use on the LBL 6600B or C computer and the Tektronix (4010-1) terminal. It requires 55K of core and is accessed using:

^LOAD, ONSTSP, MCHUGH

The program links automatically to the plotting routines, so that the ^LOAD command may be followed by ^RUN. The data are assumed (line 6 in the program) to be stored on EVENTS in library MCHUGH.

Input

The data, stored on EVENTS, must be arranged with the y trace (north-south component) leading the x trace. Each data block must have its own header card. The arrangement is as follows:

Event #1	Header card for north-south data Data block (x1, y1) Header card for east-west data Data block (x2, y2)
	. . . .
Event N	Header card for north-south data Data block (x1, y1) Header card for east-west data Data block (x2, y2)

There is no limit to the number of events (N) that may be operated on with this program. The number of points in each data block is limited to 1000.

The header card's information is in the form:

LTITL (1), LTITL (2),..., LTITL (7), RA, B, C

(e.g., LIBNO4-01-74 .163 .821 .172)

A3, A1, A2, A1, A2, A1, A2, 8x, 3F10.3

LTITL (1) is the 3-letter code of the station and LTITL (2) must be either N (for the north-south component) or E (for the east-west data). The remainder of the title is the date of the event (LTITL(3) must be the month, LTITL(5) the day, and LTITL(7) the year). RA is the scale factor to change the digitized time scale to hours, B sets the absolute time, and C scales the amplitude. That is, if u is the digitized time base (in thousandths of an inch) and v the digitized amplitude (in thousandths of an inch), and if T is the absolute time (in hours GMT) and S is the amplitude (in microradians), the relation between these quantities is assumed to be (lines 63 through 66 in the listing):

$$S_n = (C * v_n) + D$$
$$T_n = (RA * u_n) + B$$

where D is the first value of v ($D = C * v_1$) and <u>n</u> is the number of the data point in the data block. If B is not included in the header card (B = 0), the first point in the time series is zero (i.e., $T_1 = 0$).

The data following the header card must be in the format 12F6.3, i.e.,

$$u_1 \ v_1 \ u_2 \ v_2 \ \cdots \ u_6 \ v_6$$

If u or v equals 999.999, the data block is ended. To change formats, line 37 (for the header card) or line 50 (for the data block) may be altered. All Sage South data prior to 19 December 1974 (with +x = south, +y = east) will be automatically converted to +x = east, +y = north.

Program Operation

Both tilt components of each event (x versus time, y versus time, and the two header cards) are displayed in the form (S, T) prior to the computations that reduce the components to a common time base.

The program uses a linear interpolation scheme to convert the digitized data to a common sample interval. If (S^x, T^x) is the x (east-west) trace versus time and (S^y, T^y) is the y (north-south) trace versus time, it may happen that $T_1^x \neq T_1^y$ and $T_{end}^x \neq T_{end}^y$. That is, the time of the first x data point may not be equal to the time of the first y data point, and similarly for the final x and y data points. In addition, it may happen that $\Delta T^x \neq \Delta T^y$ or that $(T_{k+1} - T_k) \neq (T_k - T_{k-1})$; i.e., that the sample intervals of the x and y traces are not the same or that the sample interval within a particular trace is not constant (equivalent to missing data points). The program will determine a beginning and end time common to both traces and use a linear interpolation scheme (lines 135-138) to ensure a common sample interval (Figure 3-B1). This corrected x, y data $(\hat{S}^x, \hat{T}^x)$, $(\hat{S}^y, \hat{T}^y)$ is also displayed by the program.

After computing $(\hat{S}, \hat{T})$, the amplitude and azimuth (from north) of the tilt vector is determined. This data is also displayed. The final step in the program is the computation of the sharpness quantity, [S]. The sharpness is the time rate of change of the tilt amplitude normalized by the duration of the event and the total change in event amplitude. Unless otherwise specified, the initial and final times and amplitudes of the digitized data are used by the program. [S] is also displayed.

Output

After reading in the event data (two data blocks, north-south and east-west), the computer writes the contents of the header card and "0 = Re-start." If a zero is entered, the next two data blocks are read, and the new header card information and re-start statement is written. If any non-zero number is entered, the data is converted to the (S, T) form, and the minimum and maximum amplitudes are determined. The information is then written as follows:

min/max values of NS component = (numerical values)
min/max values of EW component = (numerical values)
min/max values of time (NS) = (numerical values)
min/max values of time (EW) = (numerical values)

The min/max time values should be the same for both the north-south (NS) and east-west (EW) components. This provides a check on the accuracy of the computer's selection of an initial and final time for the two components. The input data in (S, T) form is then displayed (north-south component versus time first).

The computer next converts the (S, T) data to ($\hat{S}$, $\hat{T}$) form and writes:

min/max values of NS data = (numerical values)
min/max values of EW data = (numerical values)
min/max values of time = (numerical values)

These values should be essentially the same as written previously. The computer then displays the ($\hat{S}$, $\hat{T}$) data, north-south (NS) component first.

The component data is next converted to amplitude and azimuth (from north) versus time. The computer writes:

min/max values of amplitude = (numerical values)

min/max values of azimuth = (numerical values)

min/max values of time = (numerical values)

The amplitude data is displayed first, followed by the azimuth data.

Because the sharpness quantity is scaled by the event duration it is necessary to set the initial and final event times. The computer writes:

Set initial and final times for sharpness plot?

Yes (Y) or No (N)

If an N is entered, the initial and final event times are set equal to the start and end times of the digitized data. If a Y is entered, the computer writes:

Enter initial and final times

The initial and final times of the event must be entered. These times must be in the same units (e.g., hours and fractions of an hour) as the times written by the computer. If the initial and final values of the event are equal, the quantity $\left[(\Theta_f - \Theta_i) \Big/ (t_f - t_i)\right]$ is zero, and the computer will use an "average sharpness" quantity computed using

$$\left[\left(((\Theta_f - \Theta_i)/2.) + \Theta_i \right) / \left(((t_f - t_i)/2.) + t_i \right) \right]$$

If this is also zero, indicating that $\Theta_f = \Theta_i = 0$, the computer will write:

Average sharpness is zero

Enter value for use in sharpness plot

A value for the "average sharpness" should be entered. The sharpness, [S], is then determined, and the computer writes:

min/max values of sharpness = (numerical values)

min/max values of time = (numerical values)

The sharpness quantity versus time is displayed next. After displaying the sharpness, the computer will write:

Re-compute sharpness? Yes (Y) or no (N).

If an N is entered, a new data set will be read, and the procedure is repeated. If a Y is entered, the sharpness will be re-computed.

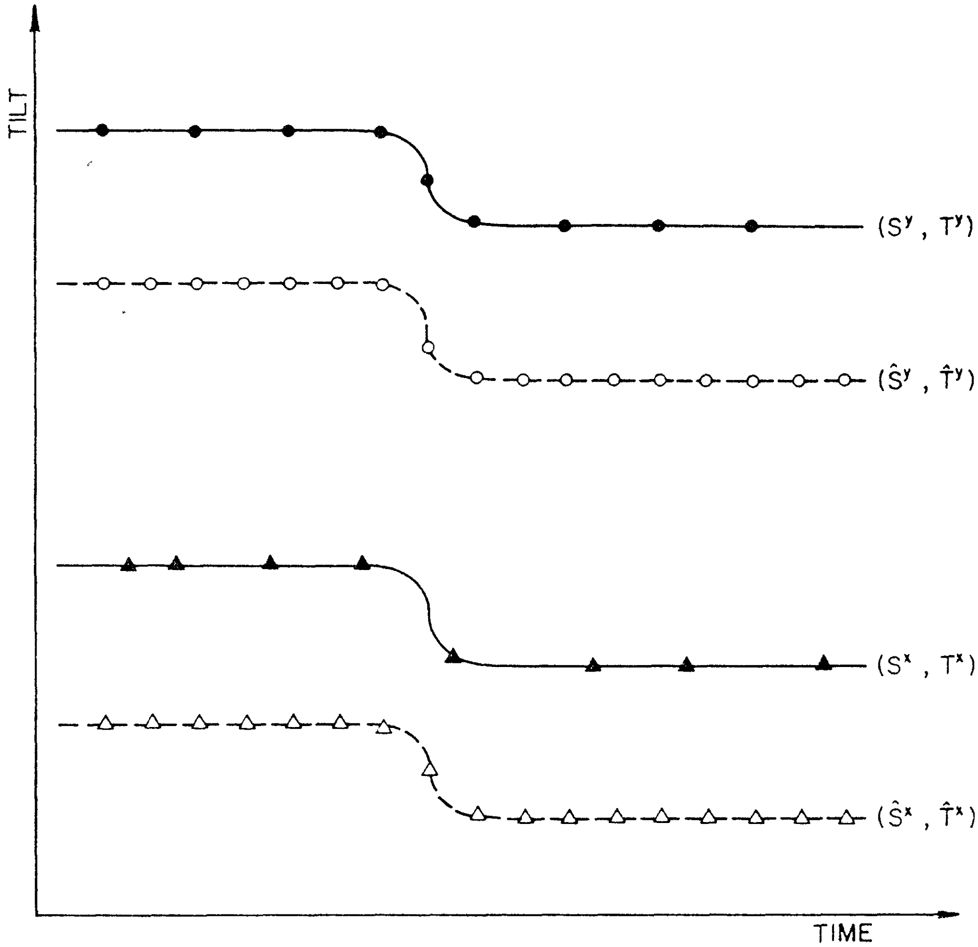
Results and Discussion

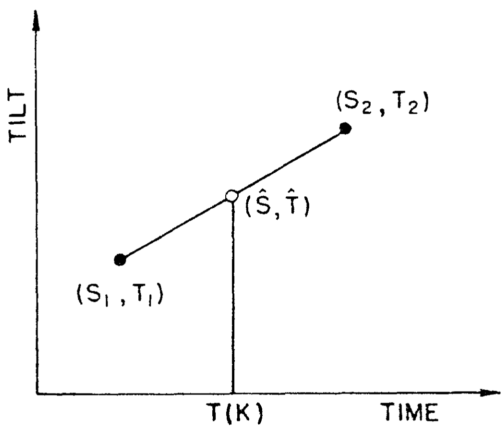
Examples of the program operation are given on pages 3-B.10 through 3-B.37 . The fluctuations in azimuth prior to the beginning of the event are caused by numerical errors. The values of tilt component amplitude are zero or near zero before the event, causing division by zero,or numbers near zero,to occur when the azimuth is computed. The fluctuations are due to noise in the original digitized data. Discontinuities in the azimuth represent a rotation through 180° or 360°. Notice, too, that for the step-like event, the sharpness is a maximum near the event onset.

The onset sharpness (assumed to be the maximum value of [S]) of the 27 October 1974 LIB SRN event is 115 (page 3-B.21). However, this value was computed using an event duration equal to the difference between the initial and final times of the digitized record. A more realistic estimate of the event duration is the time during which the derivative of the amplitude is non-zero (approximately 0.2 hours). Re-computing [S] using this duration (page 3-B.22), the onset sharpness is reduced to 9.2.

The onset sharpness was assumed to be the maximum sharpness because of the small decrease in tilt amplitude at approximately 22.1 hours (page 3-B.18), just prior to the large increase in amplitude after 22.2 hours. This small decrease in amplitude is most likely produced by small timing errors on the original record that cause the event on the two components to start at slightly different times.

In principle, the greater the time rate of change of the amplitude at the event onset, the closer the source of the event is to the station. A method for estimating the source-station distance from the onset sharpness is discussed in the next section.





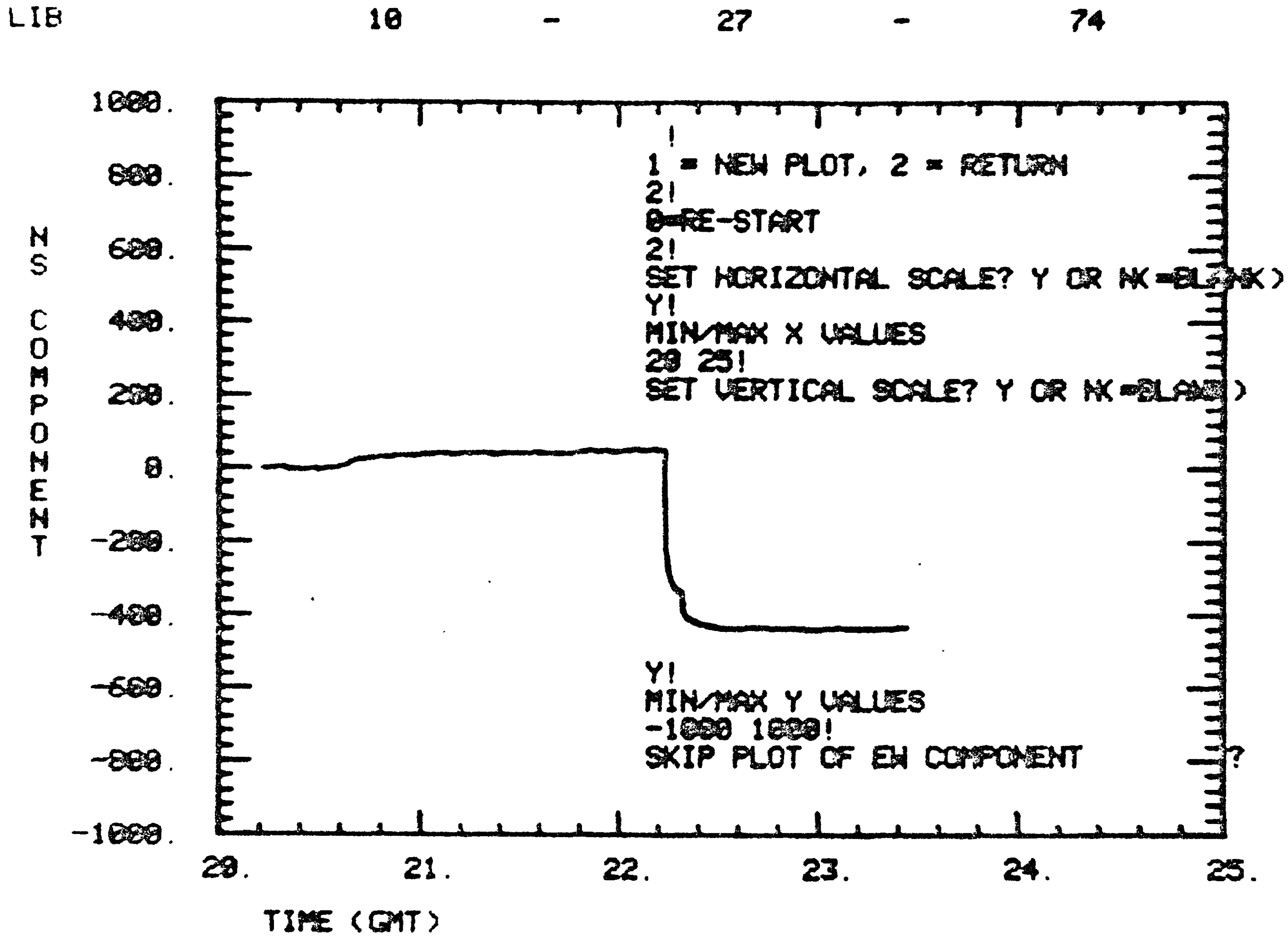
$$\hat{S} = \left(\frac{S_2 - S_1}{T_2 - T_1}\right)\left[T(K) - T_1\right] + S_1$$

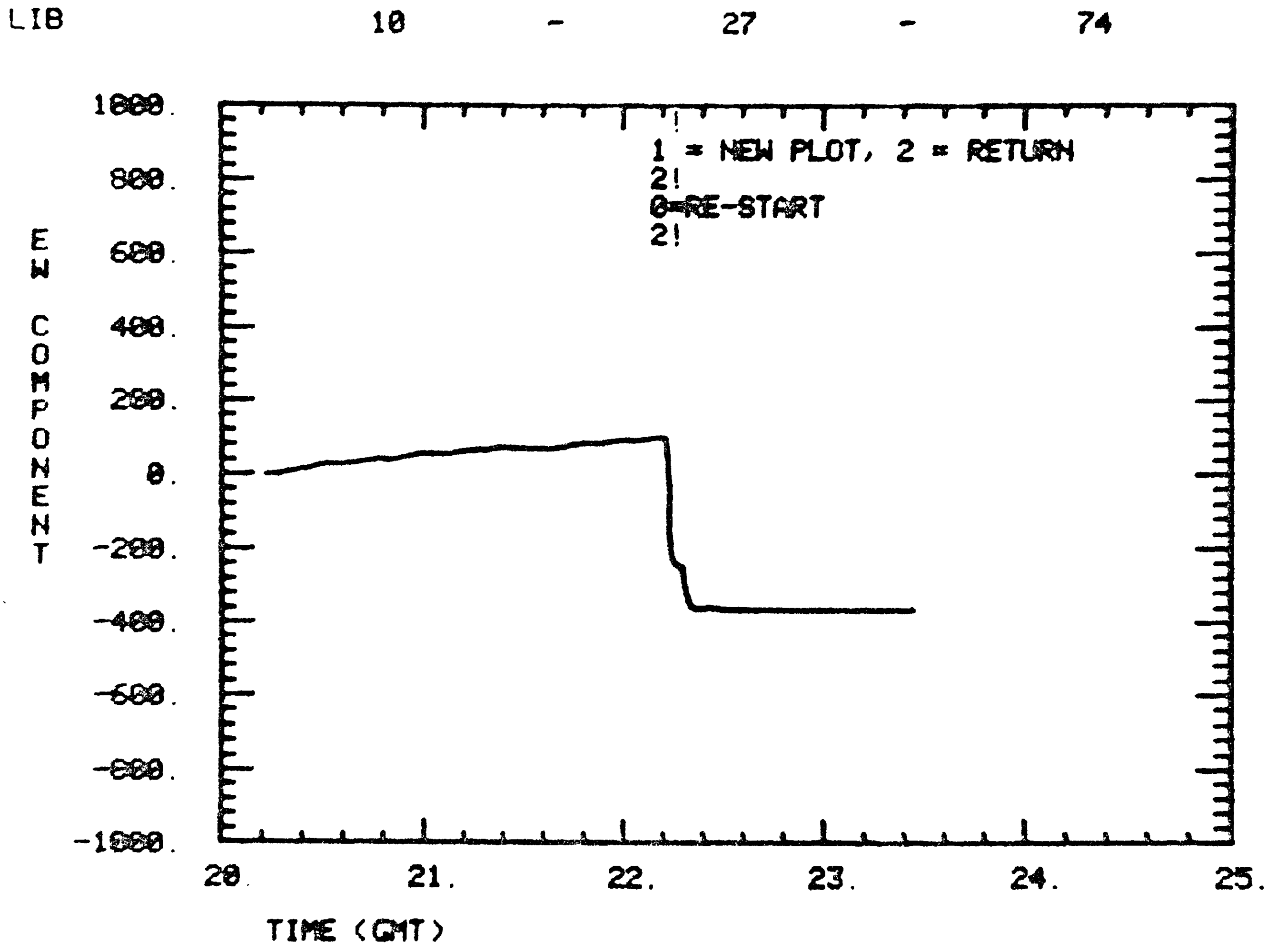
$$\hat{T} = T(K)$$

Figure 3-B1

EXAMPLE OF ONSTSP OPERATION

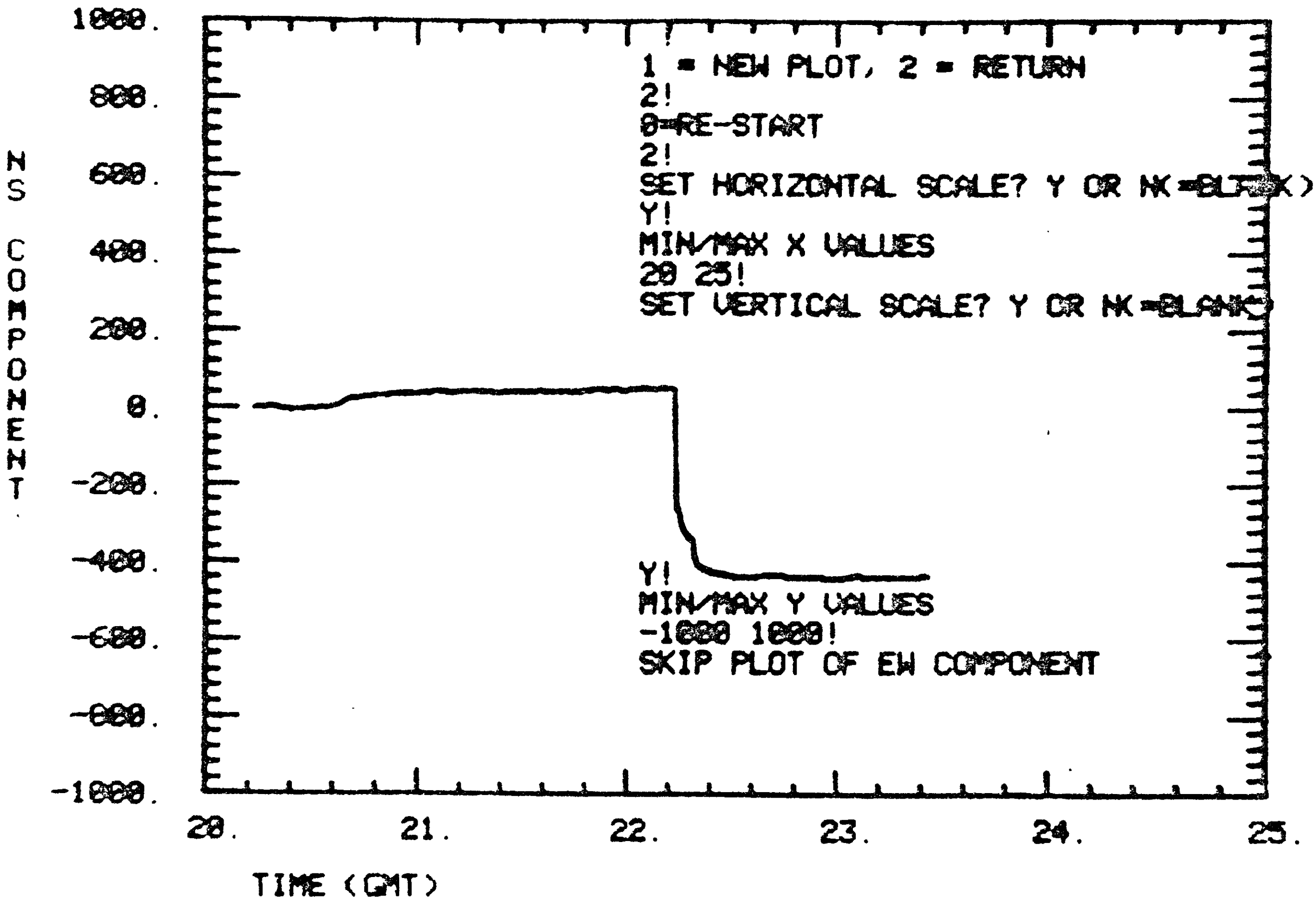
```
^LOAD,ONSTSP,MCHUGH!
LOAD COMPLETE, ENTERING ^EDIT
OK- ^EDIT
^RUN!
LIB 10-27-74                  .147    21.000      .113
0=RE-START
1!
MIN/MAX VALUES OF NS COMPONENT = -4.375E+02      5.164E+01
MIN/MAX VALUES OF EW COMPONENT = -3.663E+02      9.955E+01
MIN/MAX VALUES OF TIME (NS)    =  2.022E+01      2.345E+01
MIN/MAX VALUES OF TIME (EW)    =  2.022E+01      2.345E+01
SET HORIZONTAL SCALE? Y OB N(=BLANK)
Y!
MIN/MAP X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1000!
SKIP PLOT OF NS COMPONENT        ?
```


LIB 10 - 27 - 74
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2!
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1000!
SKIP PLOT OF EW COMPONENT ?
NS COMPONENT
TIME (GMT)
1000.
800.
600.
400.
200.
0.
-200.
-400.
-600.
-800.
-1000.
20.
21.
22.
23.
24.
25.

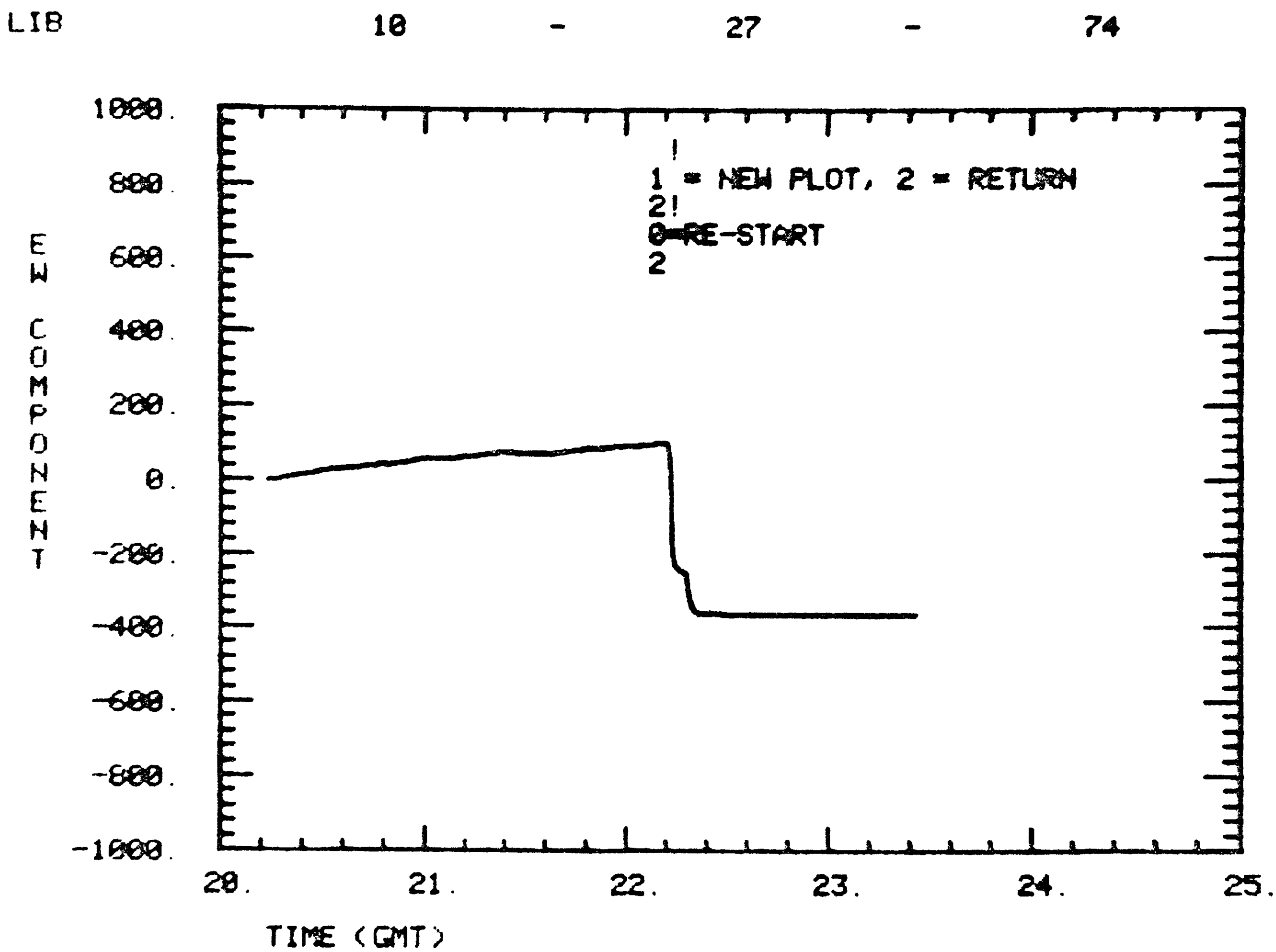

LIB 10 - 27 - 74
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2!
EW COMPONENT
1000.
800.
600.
400.
200.
0.
-200.
-400.
-600.
-800.
-1000.
20.
21.
22.
23.
24.
25.
TIME (GMT)

```
MIN/MAX VALUES OF NS DATA = -4.379E+02        5.147E+01
MIN/MAX VALUES OF EW DATA = -3.663E+02        9.949E+01
MIN/MAX VALUES OF TIME    =  2.023E+01        2.344E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1000!
SKIP PLOT OF NS COMPONENT          ?
```

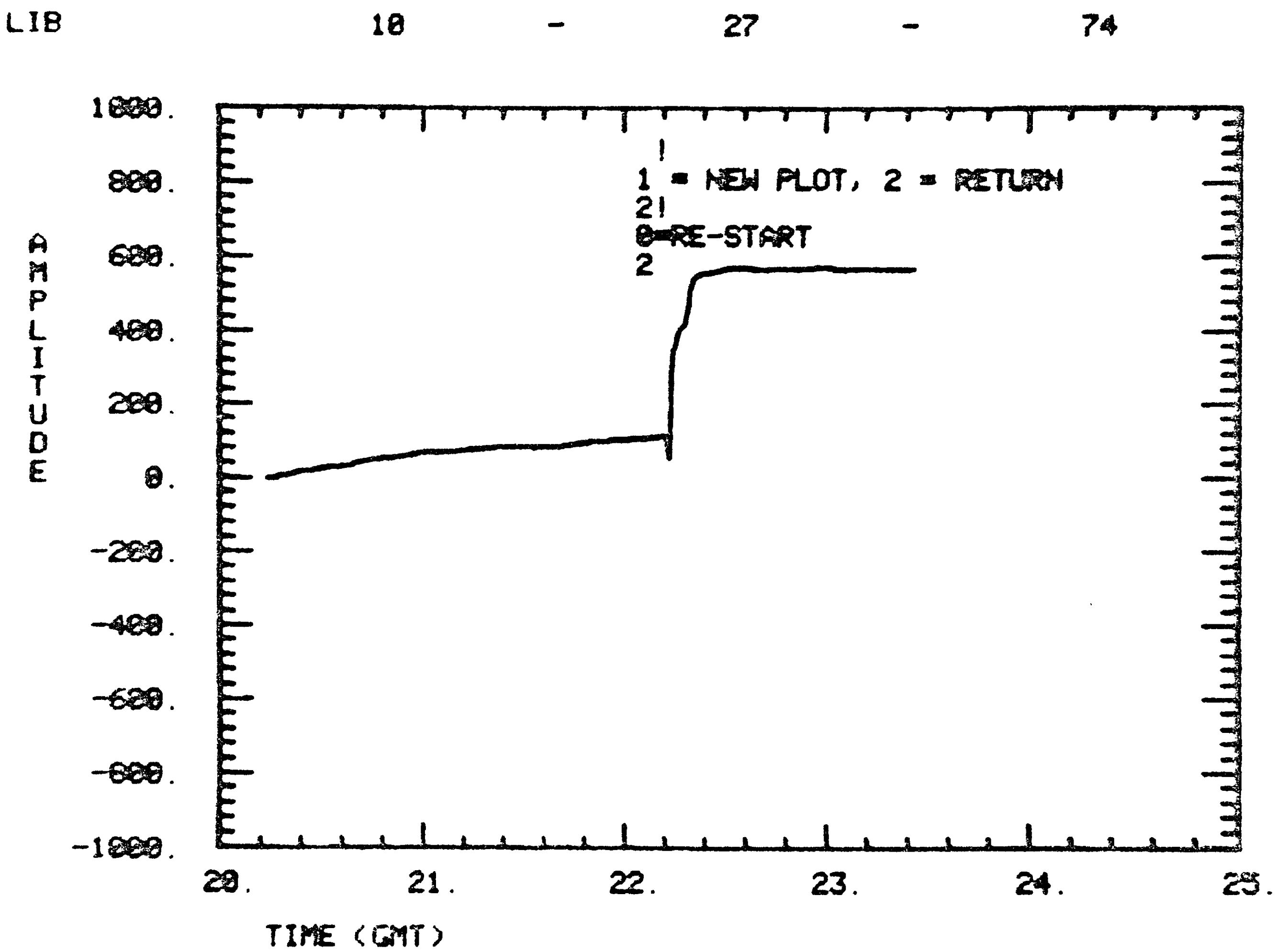
LIB 10 - 27 - 74



1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2!
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1000!
SKIP PLOT OF EW COMPONENT
NS COMPONENT
1000.
800.
600.
400.
200.
0.
-200.
-400.
-600.
-800.
-1000.
20.
21.
22.
23.
24.
25.
TIME (GMT)

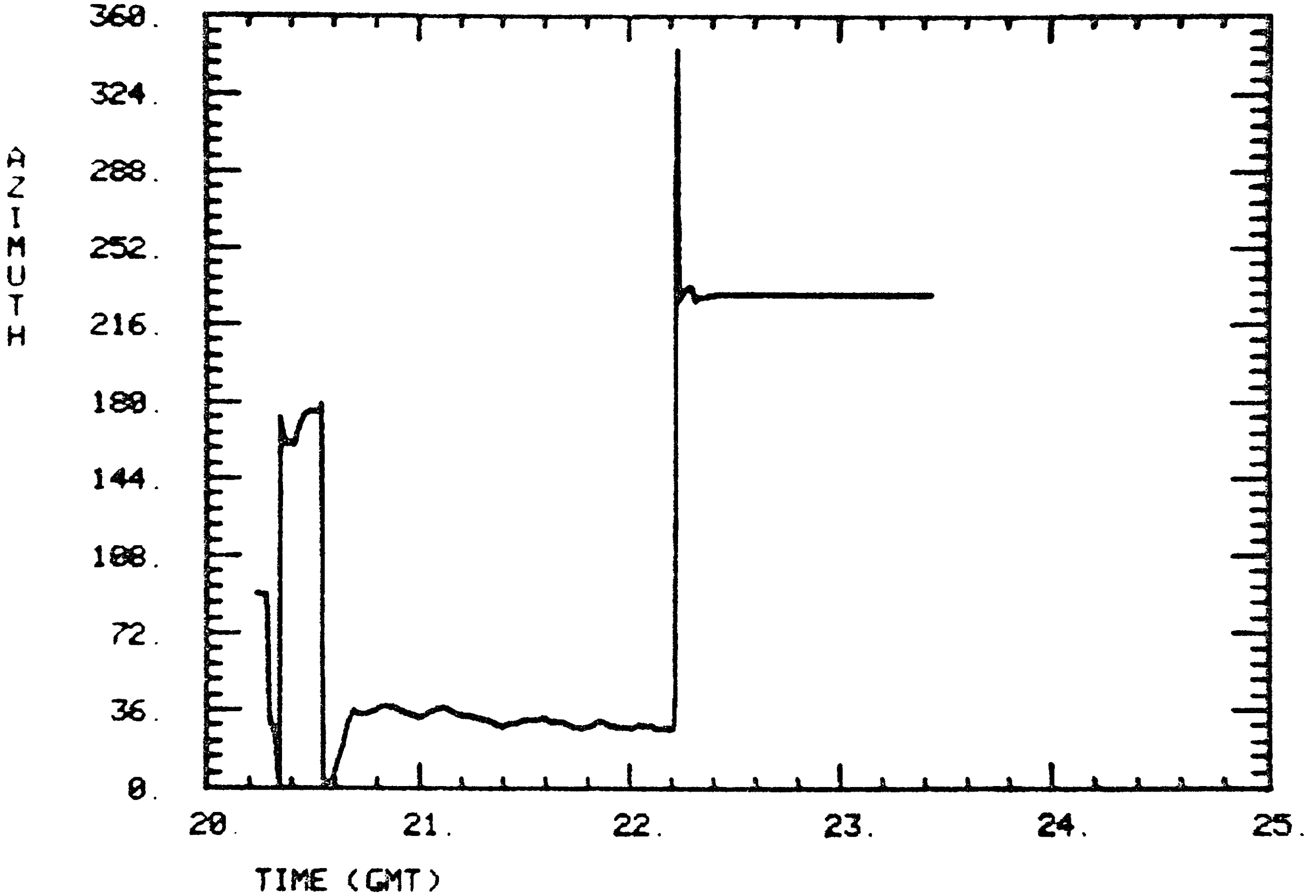

LIB 10 - 27 - 74
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2
EW COMPONENT
1000.
800.
600.
400.
200.
0.
-200.
-400.
-600.
-800.
-1000.
20.
21.
22.
23.
24.
25.
TIME (GMT)

```
MIN/MAX VALUES OF AMPLITUDE =  1.969E-02      5.705E+02
MIN/MAX VALUES OF AZIMUTH   =  1.844E-01      3.447E+02
MIN/MAX VALUES OF TIME      =  2.023E+01      2.344E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1000!
SKIP PLOT OF AMPLITUDE            ?
```



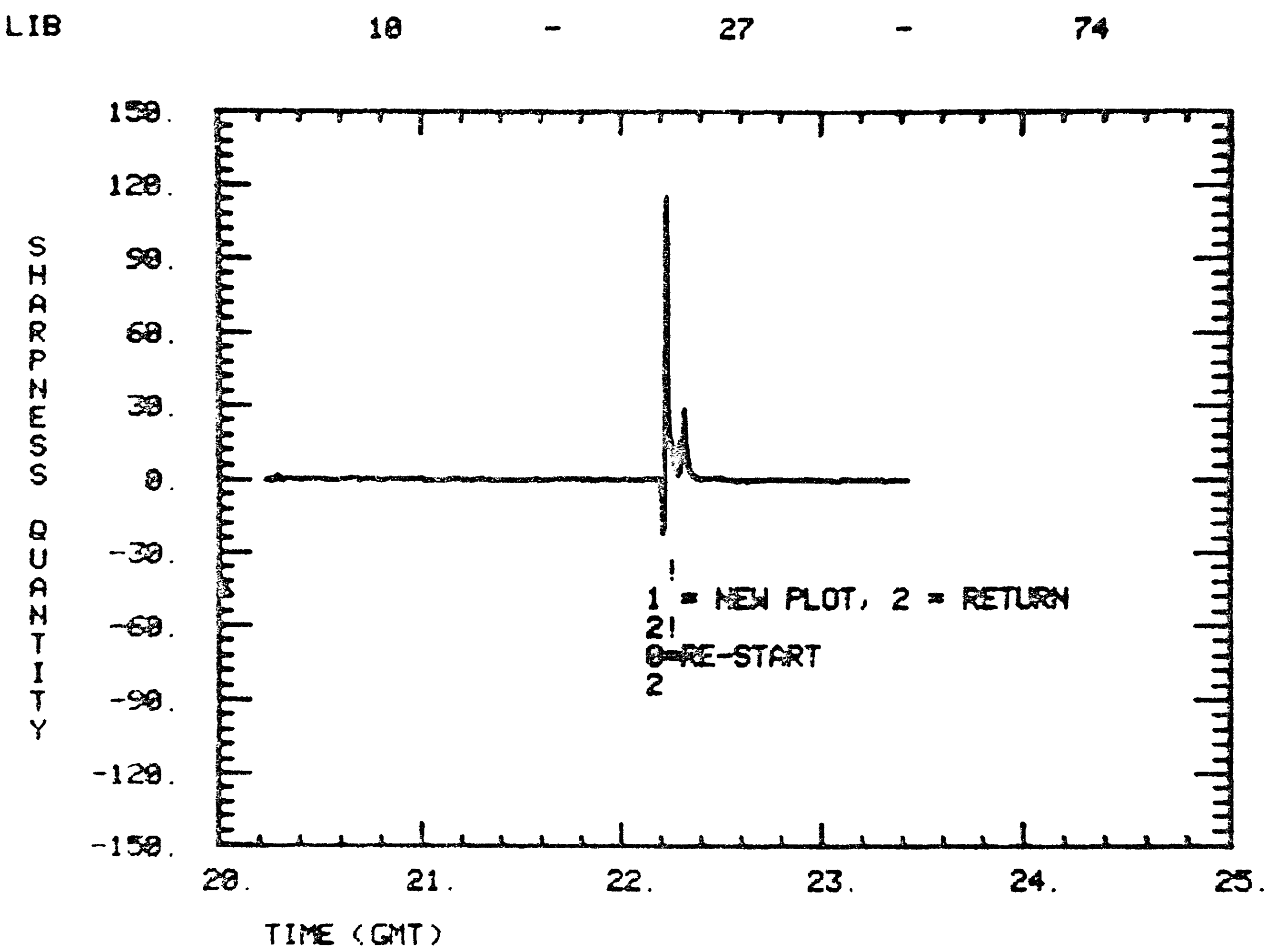
LIB 10 - 27 - 74
1000.
800.
600.
400.
200.
0.
-200.
-400.
-600.
-800.
-1000.
AMPLITUDE
20.
21.
22.
23.
24.
25.
TIME (GMT)
!
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2

LIB 10 - 27 - 74



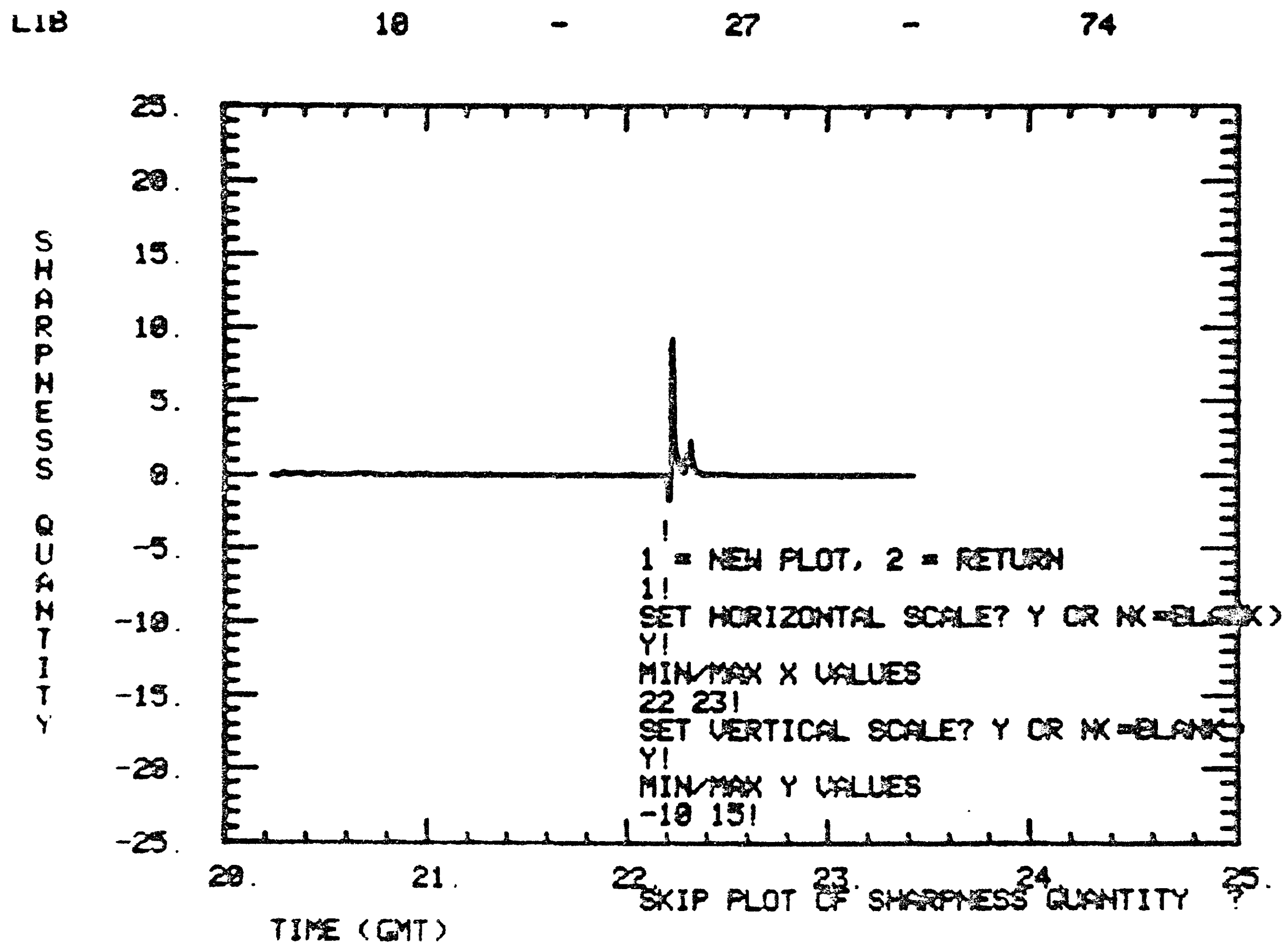
360.
324.
288.
252.
216.
180.
144.
108.
72.
36.
0.
AZIMUTH
20.
21.
22.
23.
24.
25.
TIME (GMT)

```
 '
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2!
SET INITIAL AND FINAL TIMES FOR SHARPNESS PLOT?
YES (Y) OR NO (N)
N!
MIN/MAX VALUES OF SHARPNESS       = -2.233E+01       1.152E+02
MIN/MAX VALUES OF TIME            =  2.023E+01       2.343E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
~1\
Y!
MIN/MAX Y VALUES
-150 150!
SKIP PLOT OF SHARPNESS QUANTITY  ?
```

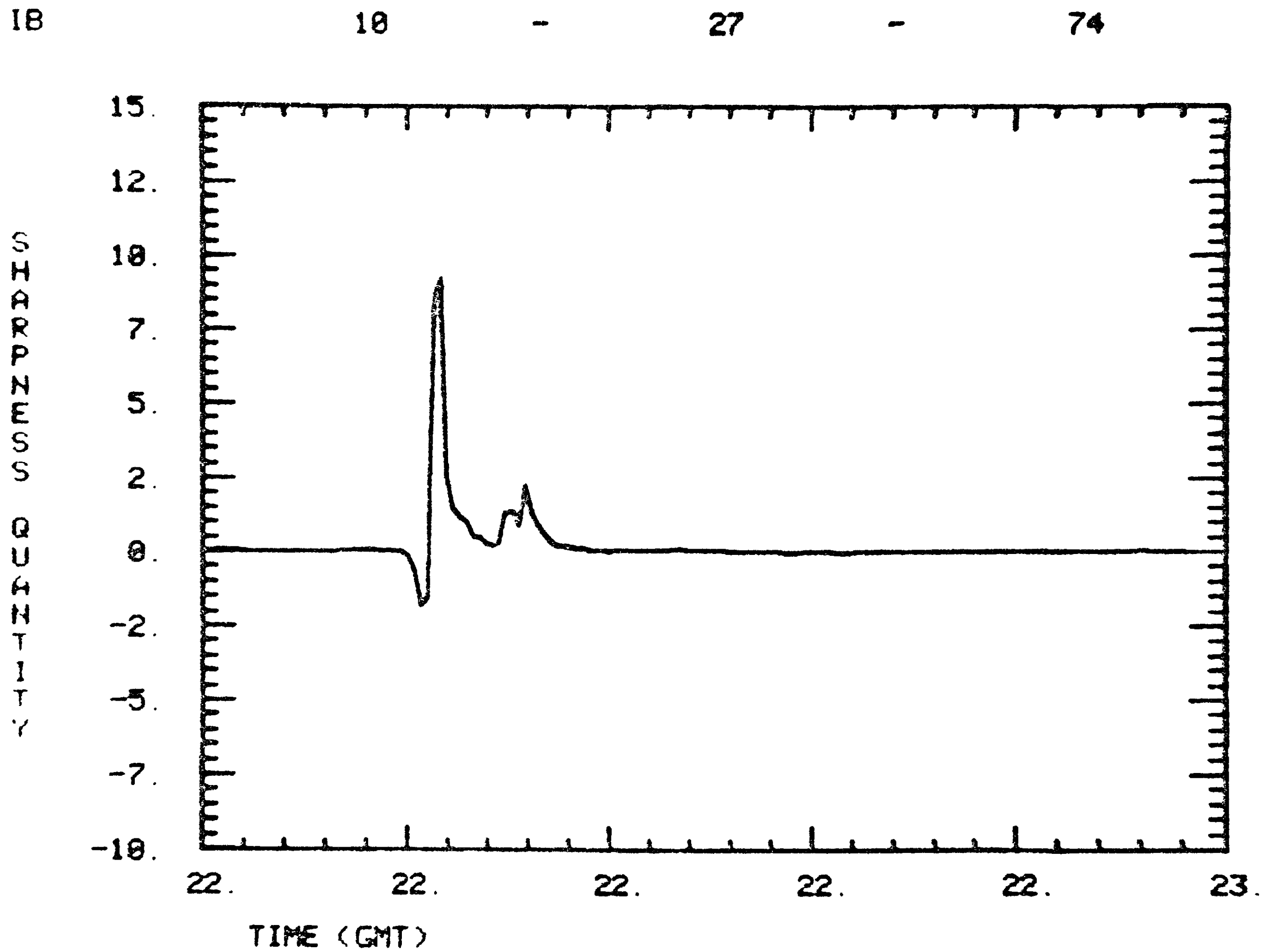


LIB 10 - 27 - 74
SHARPNESS QUANTITY
150.
120.
90.
60.
30.
0.
-30.
-60.
-90.
-120.
-150.
20.
21.
22.
23.
24.
25.
TIME (GMT)
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2

```
!
RE-COMPUTE SHARPNESS? YES(Y) OR NO (N)
Y!
SET INITIAL AND FINAL TIMES FOR SHARPNESS PLOT?
YES (Y) OR NO (N)
Y!
ENTER INITIAL AND FINAL TIMES
22.2  22.4!
MIN/MAX VALUES OF SHARPNESS        = -1.783E+00      9.185E+00
MIN/MAX VALUES OF TIME             =  2.823E+01      2.343E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-25 25!
SKIP PLOT OF SHARPNESS QUANTITY  ?
```

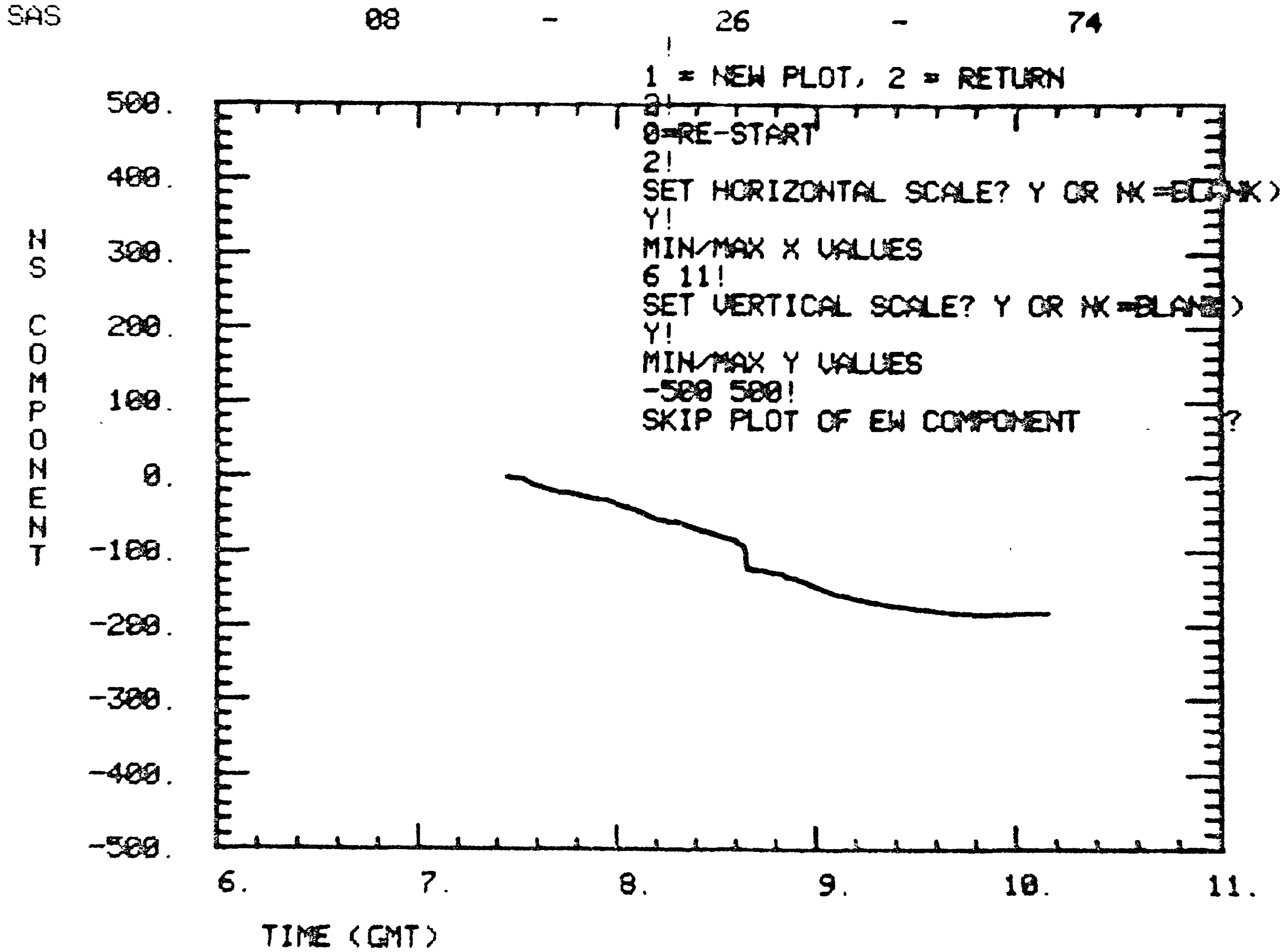


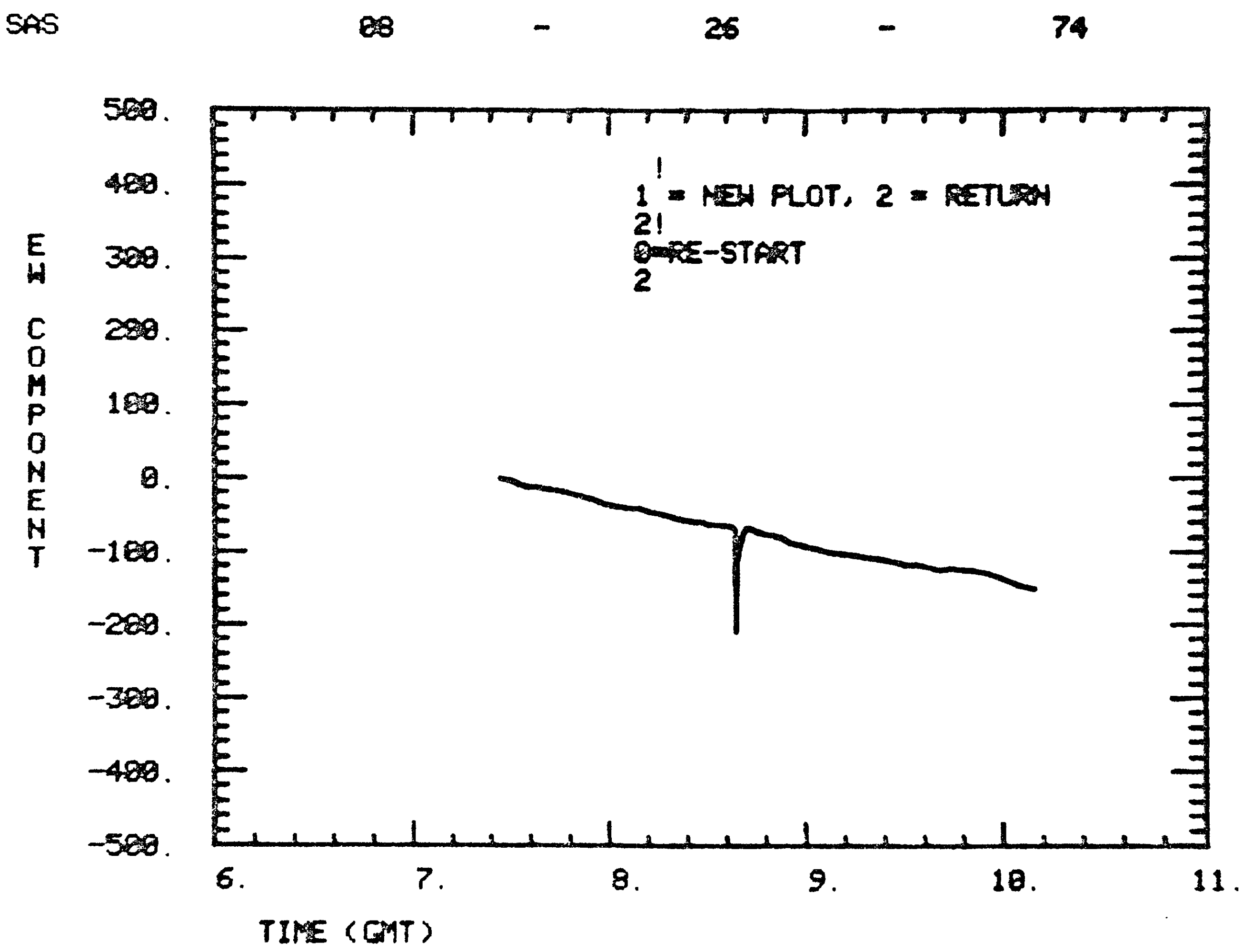
LIB 10 - 27 - 74
SHARPNESS QUANTITY
25.
20.
15.
10.
5.
0.
-5.
-10.
-15.
-20.
-25.
20.
21.
22.
23.
24.
25.
TIME (GMT)
1 = NEW PLOT, 2 = RETURN
1!
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
22 23!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-10 15!
SKIP PLOT OF SHARPNESS QUANTITY ?



IB
10 - 27 - 74
15.
12.
10.
7.
5.
2.
0.
-2.
-5.
-7.
-10.
SHARPNESS QUANTITY
22.
22.
22.
22.
22.
23.
TIME (GMT)

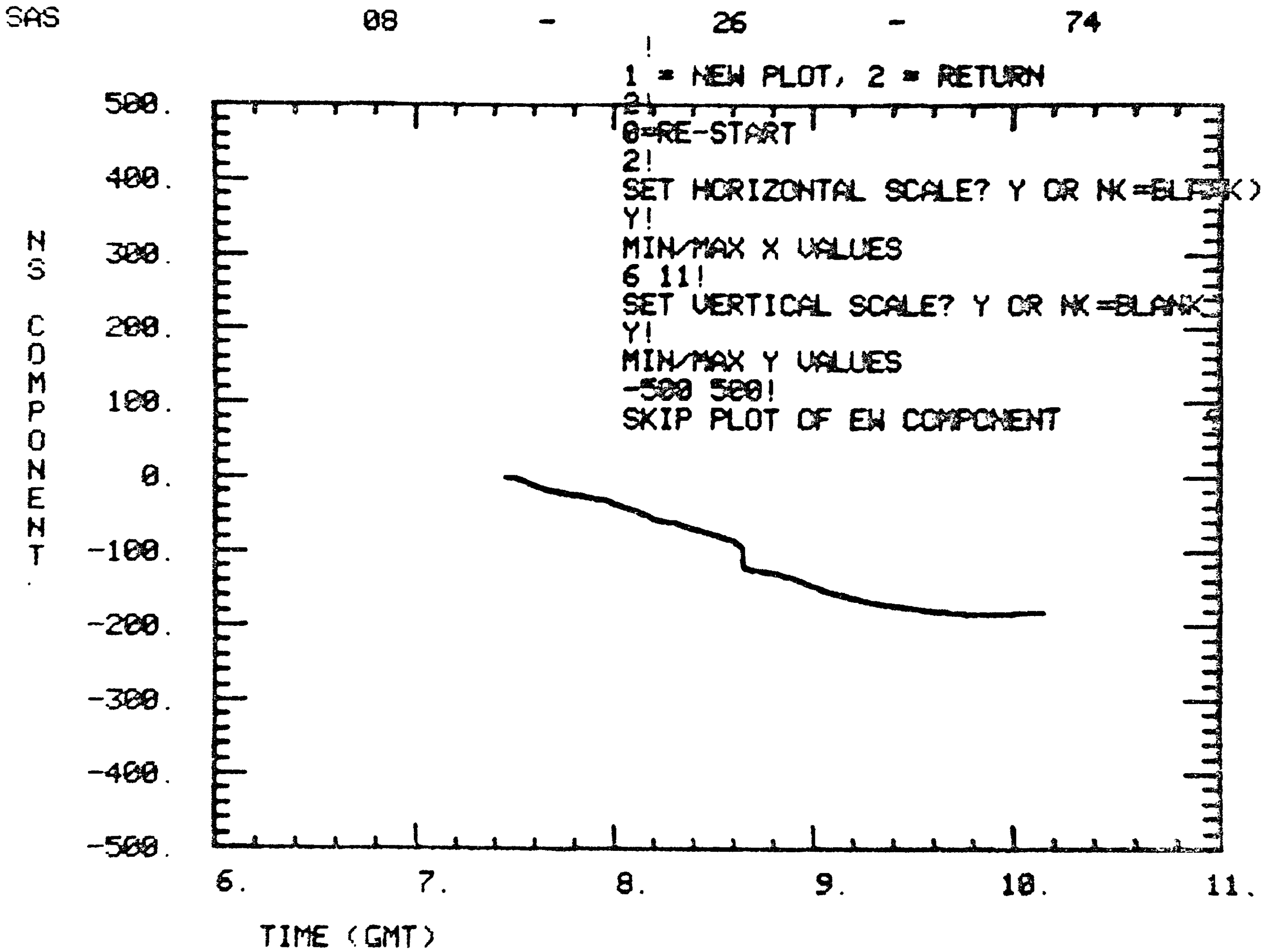
```
I
SAS 08-26-74                    152     8.000      -.109
0=RE-START
1!
MIN/MAX VALUES OF NS COMPONENT = -1.840E+02      7 276E-12
MIN/MAX VALUES OF EW COMPONENT = -2.086E+02      0
MIN/MAX VALUES OF TIME (NS)    =  7.450E+00      1 016E+01
MIN/MAX VALUES OF TIME (EW)    =  7.450E+00      1 016E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-500 500!
SKIP PLOT OF NS COMPONENT          ?
```


SAS 08 - 26 - 74
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2!
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-500 500!
SKIP PLOT OF EW COMPONENT ?
NS COMPONENT
500.
400.
300.
200.
100.
0.
-100.
-200.
-300.
-400.
-500.
6.
7.
8.
9.
10.
11.
TIME (GMT)

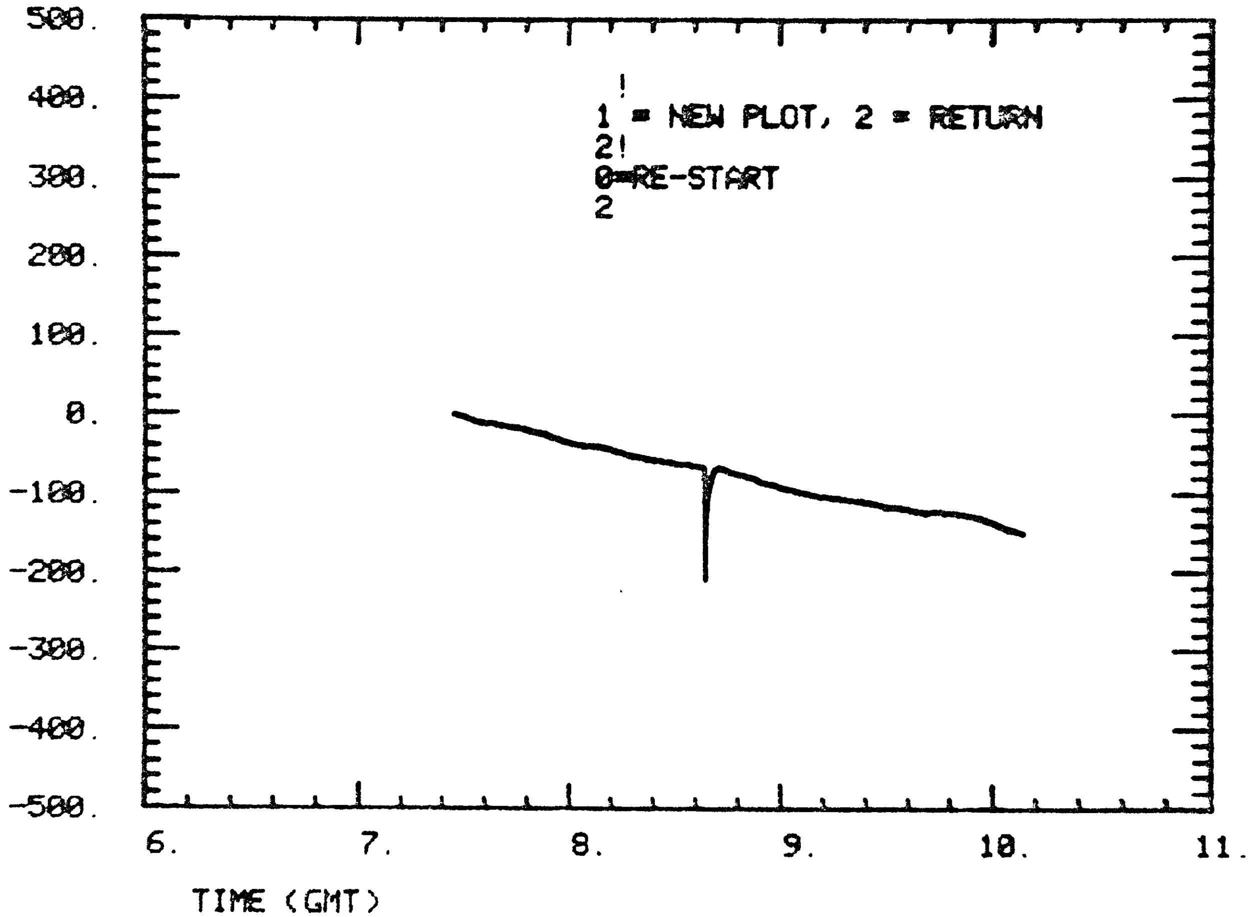


SAS 08 - 26 - 74
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2
EW COMPONENT
500.
400.
300.
200.
100.
0.
-100.
-200.
-300.
-400.
-500.
6.
7.
8.
9.
10.
11.
TIME (GMT)

```
!
MIN/MAX VALUES OF NS DATA = -7.276E-12       1.840E+02
MIN/MAX VALUES OF EW DATA = -2.086E+02      -2.914E-01
MIN/MAX VALUES OF TIME    =  7.455E+00       1.015E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-500 500!
SKIP PLOT OF NS COMPONENT          ?
```


SAS 08 - 26 - 74
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2!
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-500 500!
SKIP PLOT OF EW COMPONENT
NS COMPONENT.
500.
400.
300.
200.
100.
0.
-100.
-200.
-300.
-400.
-500.
6.
7.
8.
9.
10.
11.
TIME (GMT)

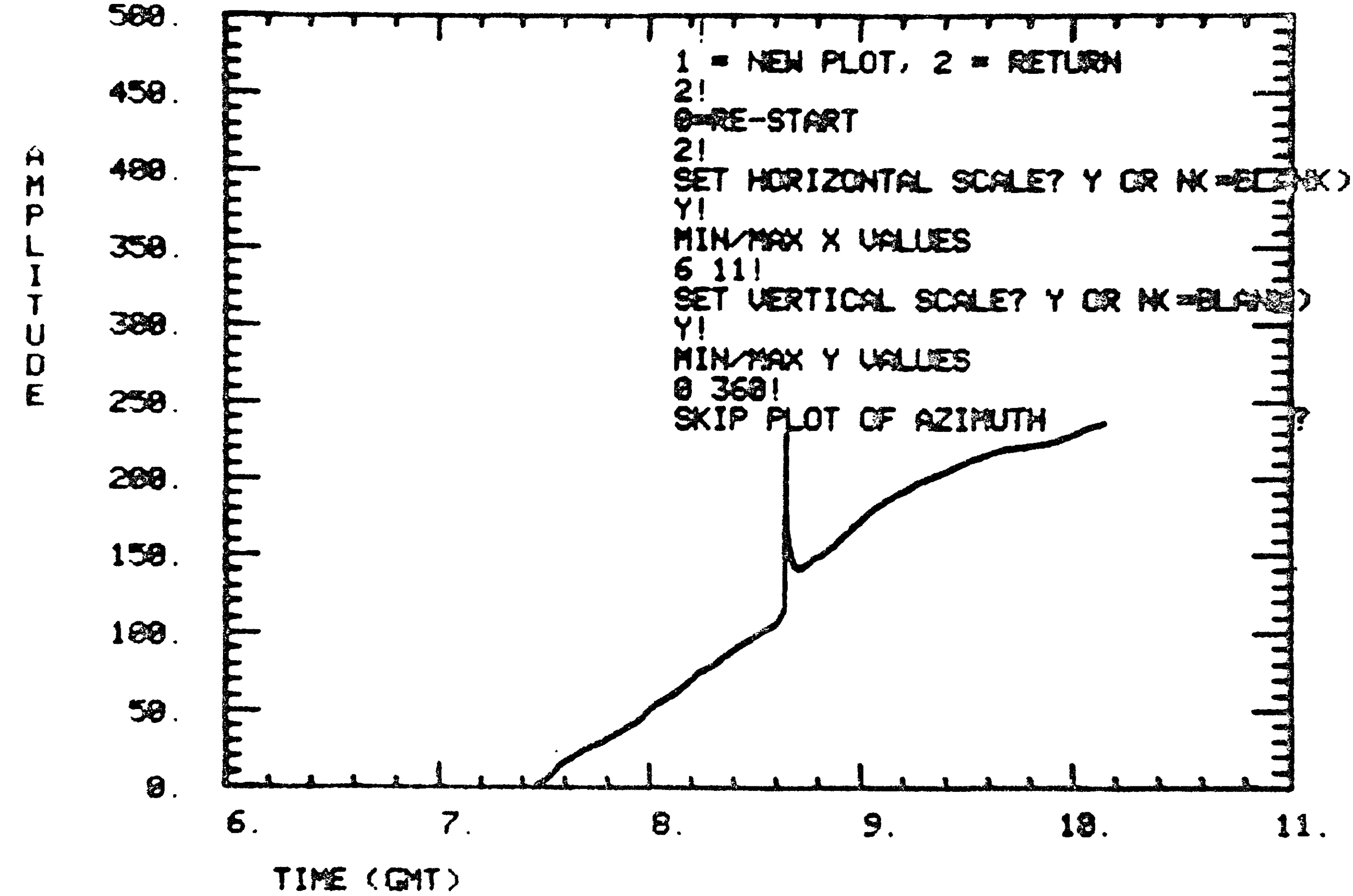
SAS 08 - 26 - 74



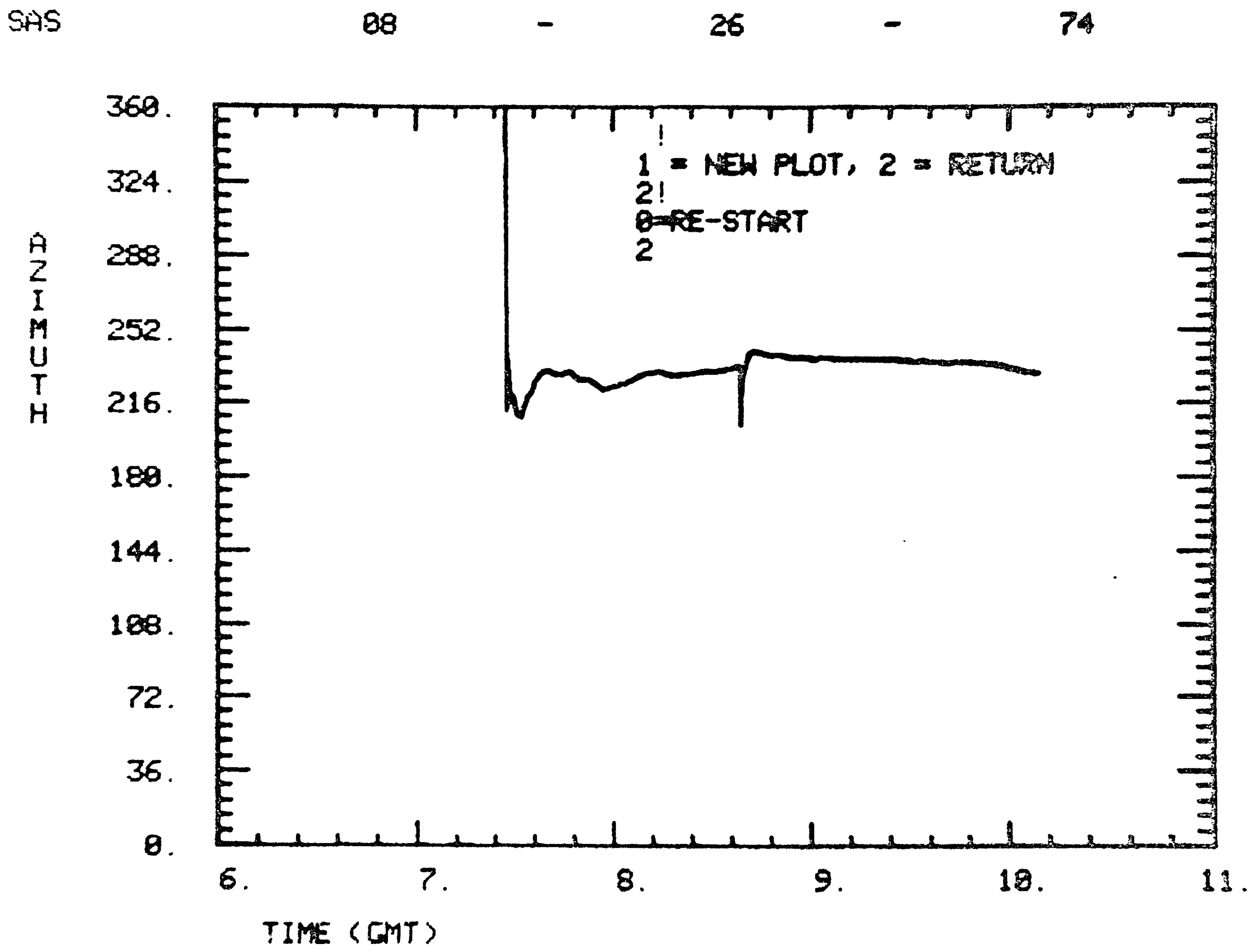
!
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2
EW COMPONENT
500.
400.
300.
200.
100.
0.
-100.
-200.
-300.
-400.
-500.
6.
7.
8.
9.
10.
11.
TIME (GMT)

```
!
MIN/MAX VALUES OF AMPLITUDE =  2.914E-01       2.365E+02
MIN/MAX VALUES OF AZIMUTH   =  1.808E+02       3.350E+02
MIN/MAX VALUES OF TIME      =  7.455E+00       1.015E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
0 500!
SKIP PLOT OF AMPLITUDE           ?
```

SAS 08 - 26 - 74

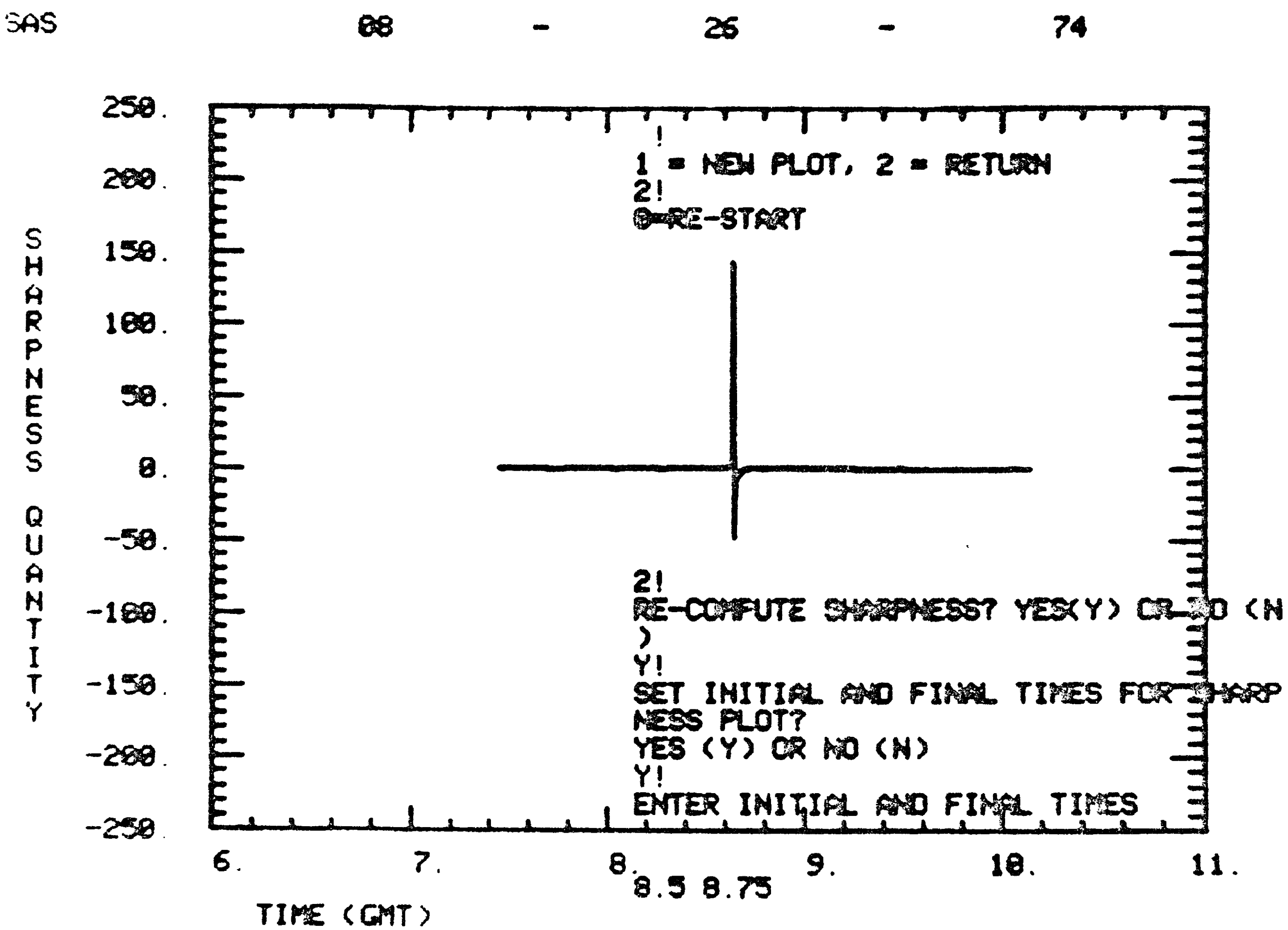


500.
450.
400.
350.
300.
250.
200.
150.
100.
50.
0.
AMPLITUDE
6.
7.
8.
9.
10.
11.
TIME (GMT)
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2!
SET HORIZONTAL SCALE? Y OR N
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N
Y!
MIN/MAX Y VALUES
0 360!
SKIP PLOT OF AZIMUTH

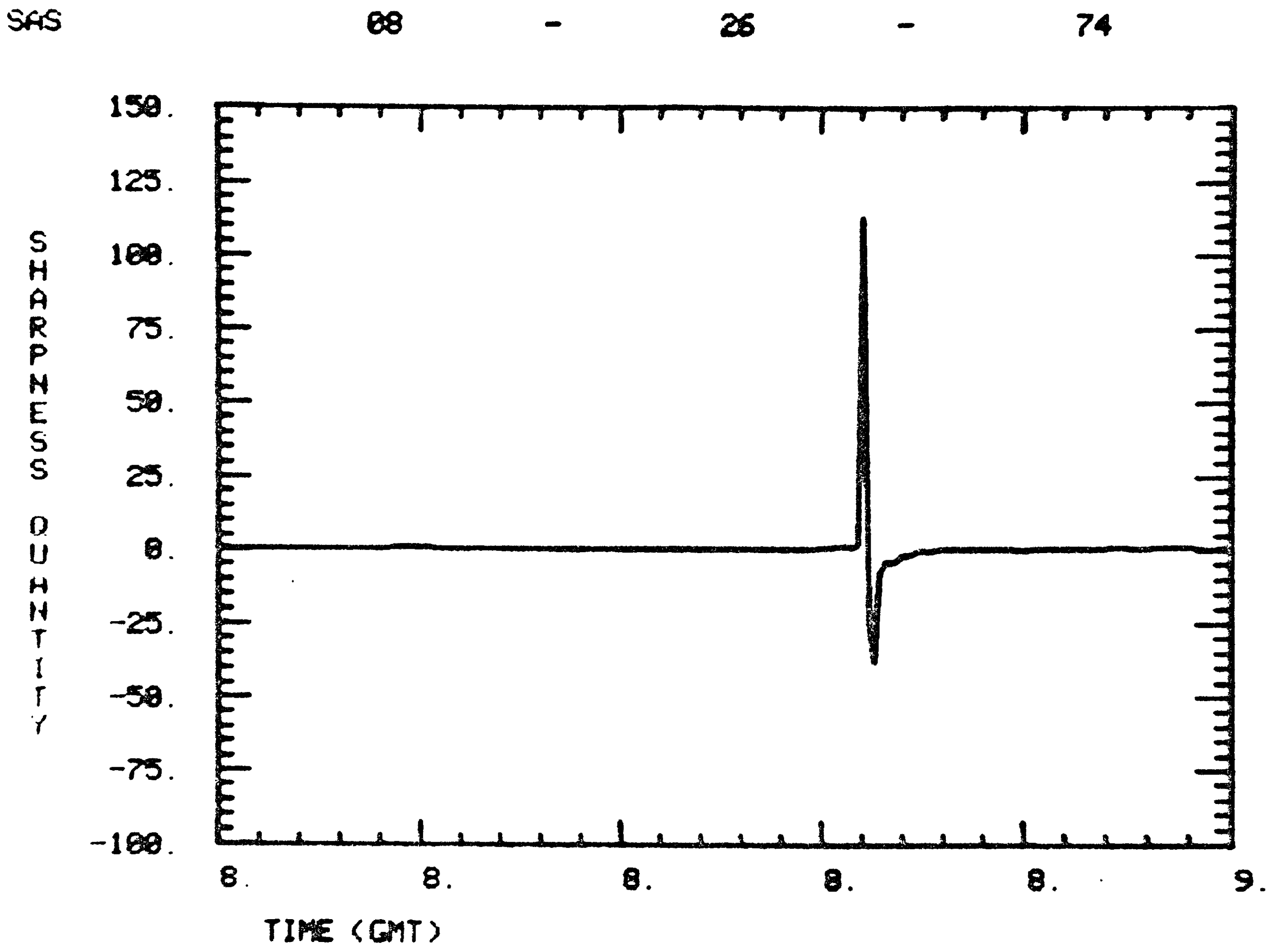

SAS
08 - 26 - 74
360.
324.
288.
252.
216.
180.
144.
108.
72.
36.
0.
AZIMUTH
6.
7.
8.
9.
10.
11.
TIME (GMT)
!
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2

```
!
SET INITIAL AND FINAL TIMES FOR SHARPNESS PLOT?
YES (Y) OR NO (N)
Y!
ENTER INITIAL AND FINAL TIMES
8.5  9!
MIN/MAX VALUES OF SHARPNESS        = -4.754E+01        1.433E+02
MIN/MAX VALUES OF TIME             =  7.455E+00        1.014E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)

Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-250 250!
SKIP PLOT OF SHARPNESS QUANTITY  ?
```


SAS 08 - 26 - 74
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START
2!
RE-COMPUTE SHARPNESS? YES(Y) OR NO (N
)
Y!
SET INITIAL AND FINAL TIMES FOR SHARP
NESS PLOT?
YES (Y) OR NO (N)
Y!
ENTER INITIAL AND FINAL TIMES
8.5 8.75
SHARPNESS QUANTITY
250.
200.
150.
100.
50.
0.
-50.
-100.
-150.
-200.
-250.
6.
7.
8.
9.
10.
11.
TIME (GMT)

```
!
MIN/MAX VALUES OF SHARPNESS       = -3.759E+01       1.133E+02
MIN/MAX VALUES OF TIME            =  7.455E+00       1.014E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
6\\
8 9!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-100 150!
SKIP PLOT OF SHARPNESS QUANTITY  ?
```


SAS
08 - 26 - 74
SHARPNESS QUANTITY
150.
125.
100.
75.
50.
25.
0.
-25.
-50.
-75.
-100.
8.
8.
8.
8.
8.
9.
TIME (GMT)

PROGRAM LISTING

```
DELETE(LGO,LGOB,ONSTSP)
ONSTSP.
EXIT.
LIBCOPY(GRAPHIC,TXLGO/RR,TXLGO)
LIBCOPY(JDRAT,NPLGO/RR,NPLGO)
LIBCOPY(MCHUGH,EVENTS/RR,EVENTS)
DELETE(LGO,LGOB,ONSTSP)
RUN76(S)
LINK(F=LGO,F=TXLGO,F=NPLGO,B=ONSTSP)
ONSTSP(EVENTS)
ONSTSP.
FIN.
EOR
      PROGRAM ONSTSP(TAPE5,TAPETTY=201,FILM=TAPETTY,TAPE7=TAPETTY)
      COMMON/TVPOOL/TVPUL(8)
      COMMON/TVTUNE/ITUNE(30)
      COMMON/JPLOT/XLT,XRT,YLO,YUP,MAJX,MAJY,KX(2),KY(2),LTITL(8),LU,
     1 LTF,LNLGX,LNLGY,NCLX,NCLY,LTITL2(8)
      DIMENSION IFET(8)
      DIMENSION T(1000),AMP(1000),AZM(1000),A(30)
      DIMENSION DELTX1(1000),DELTX2(1000)
      DIMENSION X1(1000),X2(1000),Y1(1000),Y2(1000)
      CALL FET(5LTAPE7,IFET,8)
      IFET(2)=IFET(2).OR.0000 0010 0000 0000 0000B
      IFET(8)=IFET(8).OR.4000 0000 0000 0000 0000B
      CALL FET(5LTAPE7,IFET,-8)
  100 CONTINUE
      PI=3.1415926   $NTOTAL=500  $MTOTAL=NTOTAL-1
      DO 30 I=1,1000
      AMP(I)=AZM(I)=T(I)=X1(I)=X2(I)=Y1(I)=Y2(I)=0.
 30   CONTINUE
      DO 310 I=1,8
 310  LTITL2(I)=10H
      LU=7 $LNLGX=LNLGY=1 $NCLX=NCLY=2 $MAJX=5 $MAJY=10
      DO 200  MR=1,2
      READ(5,45)(LTITL(I),I=1,7),RA,B,C
   45 FORMAT(A3,A1,A2,A1,A2,A1,A2,8X,3F10.3)
      LTITL(8)=10H
      IF(LTITL(1).EQ.3HEOR.OR.LTITL(1).EQ.3HEOF)GOTO110
      IF(LTITL(1).EQ.3HSAS)GOTO1000
      GOTO91
 1000 IF(LTITL(7).GT.74.)GOTO91
      IF(LTITL(7).EQ.74..AND.LTITL(3).EQ.12..AND.LTITL(5).GT.19.)GOTO91
      IF(LTITL(2).EQ.1HN)KARD=1HE $IF(LTITL(2).EQ.1HE)KARD=1HN
      LTITL(2)=KARD
  91  CONTINUE
      DO 170 I=2,1000,6
      J=I+5
      READ(5,31)(X2(K),Y2(K),K=I,J)
   31 FORMAT(6(2F6.3))
      DO 180 M=I,J
      IF(X2(M) .EQ. 999.999 .OR. Y2(M) .EQ. 999.999)KK=M
      IF(X2(M) .EQ. 999.999 .OR. Y2(M) .EQ. 999.999)GO TO 190
  180 CONTINUE
  170 CONTINUE
  190 NEND=KK-1
      IF(MR.EQ.1)NN1=NEND $IF(MR.EQ.2)NN2=NEND
      IF(LTITL(1).EQ.3HSAS)GOTO102
```

```
          GOTO101
      102 IF(LTITL(7).GT.74)GOTO101
          IF(LTITL(7).EQ.74.AND.LTITL(3).EQ.12.AND.LTITL(5).GT.19)GOTO101
          IF(LTITL(2).EQ.1HN)C=-C
     101  IF(B.EQ.0.)B=-RA*X2(2)
          D=Y2(2)*C*1000.
          DO 20 I=2,NEND
          X2(I)=(RA*X2(I))+B $Y2(I)=(1000.*Y2(I)*C)-D
          IF(MR.EQ.1)X1(I)=X2(I) $IF(MR.EQ.1)Y1(I)=Y2(I)
       20 CONTINUE
     200  CONTINUE
          LTITL(2)=10H
          WRITE(7,45)(LTITL(I),I=1,7),RA,B,C
          WRITE(7,450) $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO100
      450 FORMAT(*0=RE-START*)
          IF(LTITL(1).EQ.3HSAS)GOTO233  $GOTO300
    233   IF(LTITL(7).GT.74)GOTO300
          IF(LTITL(7).EQ.74.AND.LTITL(3).EQ.12.AND.LTITL(5).GT.19)GOTO300
          DO 235 I=1,1000
          AMP(I)=X1(I) $AZM(I)=Y1(I) $X1(I)=X2(I) $Y1(I)=Y2(I)
          X2(I)=AMP(I) $Y2(I)=AZM(I)
    235   CONTINUE
          ABC=NN1 $NN1=NN2 $NN2=ABC
      300 CONTINUE
          IF(X1(2).LT.X2(2))GOTO3
          IF(X2(2).LE.X1(2))TINITL=X2(2)+((X2(NN2)-X2(2))/NTOTAL)
          Y1(1)=Y1(2) $X1(1)=X2(2) $N1=NN1 $N2=NN2-1
          DO 2 I=1,N2
          Y2(I)=Y2(I+1) $X2(I)=X2(I+1)
        2 CONTINUE
          GO TO4
        3 TINITL=X1(2)+((X1(NN1)-X1(2))/NTOTAL) $Y2(1)=Y2(2) $X2(1)=X1(2)
          N2=NN2 $N1=NN1-1
          DO 5 I=1,N1
          Y1(I)=Y1(I+1) $X1(I)=X1(I+1)
        5 CONTINUE
        4 IF(X1(N1).LT.X2(N2))GOTO6
          IF(X2(N2).LE.X1(N1))TFINAL=X1(N1)-((X1(N1)-X1(1))/NTOTAL)
          Y2(N2+1)=Y2(N2) $X2(N2+1)=X1(N1) $M2=N2+1 $M1=N1 $GOTO7
        6 TFINAL=X2(N2)-((X2(N2)-X2(1))/NTOTAL) $Y1(N1+1)=Y1(N1)
          X1(N1+1)=X2(N2) $M1=N1+1 $M2=N2
        7 DELTAT=(TFINAL-TINITL)/NTOTAL
          CALL AMINMX(X1,M1,B1,B2)
          CALL AMINMX(Y1,M1,B3,B4)
          CALL AMINMX(X2,M2,B5,B6)
          CALL AMINMX(Y2,M2,B7,B8)
          WRITE(7,32)B3,B4,B7,B8,B1,B2,B5,B6
       32 FORMAT(*MIN/MAX VALUES OF NS COMPONENT = *,E10.3,5X,E10.3,/,
         1        *MIN/MAX VALUES OF EW COMPONENT = *,E10.3,5X,E10.3,/,
         1        *MIN/MAX VALUES OF TIME (NS)    = *,E10.3,5X,E10.3,/,
         1        *MIN/MAX VALUES OF TIME (EW)    = *,E10.3,5X,E10.3)
          KTER1=10HNS COMPONE $KTER2=10HNT
          CALL AGRAPH(Y1,X1,B3,B4,M1,KTER1,KTER2)
          WRITE(7,55) $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO100
       55 FORMAT(*0=RE-START*)
          KTER1=10HEW COMPONE
          CALL AGRAPH(Y2,X2,B7,B8,M2,KTER1,KTER2)
          WRITE(7,55) $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO100
```

```
      DO 8 I=1,NTOTAL
      T(I)=TINITL+(DELTAT*(I-1))
      DO 9 J=1,M1
      DELTX1(J)=X1(J)-T(I)
    9 CONTINUE
      DO 10 J=1,M2
      DELTX2(J)=X2(J)-T(I)
   10 CONTINUE
      DO 11 J=1,M1
      JK=J+1 $IF(JK.GT.M1)JK=M1
      IF(DELTX1(J).LT.0..AND.DELTX1(JK).GE.0.)IX1UP=JK
      IF(DELTX1(J).LT.0..AND.DELTX1(JK).GE.0.)IX1DN=J
   11 CONTINUE
      DO 12 J=1,M2
      JK=J+1 $IF(JK.GT.M2)JK=M2
      IF(DELTX2(J).LT.0..AND.DELTX2(JK).GE.0.)IX2UP=JK
      IF(DELTX2(J).LT.0..AND.DELTX2(JK).GE.0.)IX2DN=J
   12 CONTINUE
      AMP(I)=(((Y1(IX1UP)-Y1(IX1DN))/(X1(IX1UP)-X1(IX1DN)))*(T(I)
     1 -X1(IX1DN)))+Y1(IX1DN)
      AZM(I)=(((Y2(IX2UP)-Y2(IX2DN))/(X2(IX2UP)-X2(IX2DN)))*(T(I)
     1  -X2(IX2DN)))+Y2(IX2DN)
    8 CONTINUE
      CALL AMINMX(AMP,NTOTAL,B1,B2)
      CALL AMINMX(AZM,NTOTAL,B3,B4)
      WRITE(7,13)B1,B2,B3,B4,TINITL,TFINAL
   13 FORMAT(*MIN/MAX VALUES OF NS DATA = *,E10.3,5X,E10.3,/,
     1        *MIN/MAX VALUES OF EW DATA = *,E10.3,5X,E10.3,/,
     1        *MIN/MAX VALUES OF TIME    = *,E10.3,5X,E10.3)
      KTER1=10HNS COMPONE $KTER2=10HNT
      CALL AGRAPH(AMP,T,B1,B2,NTOTAL,KTER1,KTER2)
      WRITE(7,55) $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO100
      KTER1=10HEW COMPONE
      CALL AGRAPH(AZM,T,B3,B4,NTOTAL,KTER1,KTER2)
      WRITE(7,55) $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO100
      DO 14 I=1,NTOTAL
      Z1=AMP(I) $Z2=AZM(I)
      AMP(I)=SQRT((Z1**2)+(Z2**2))
      IF(Z2.EQ.0.)Z2=1.E-20
      AZM(I)=(ATAN(Z1/Z2))*(180./PI)
      IF(Z1.LT.0.)AZM(I)=AZM(I)+180.
      IF(AZM(I).LT.0.)AZM(I)=AZM(I)+360.
      IF(AZM(I).GT.360.)AZM(I)=AZM(I)-360.
   14 CONTINUE
      CALL AMINMX(AMP,NTOTAL,B1,B2)
      CALL AMINMX(AZM,NTOTAL,B3,B4)
      WRITE(7,15)B1,B2,B3,B4,TINITL,TFINAL
   15 FORMAT(*MIN/MAX VALUES OF AMPLITUDE = *,E10.3,5X,E10.3,/,
     1        *MIN/MAX VALUES OF AZIMUTH   = *,E10.3,5X,E10.3,/,
     1        *MIN/MAX VALUES OF TIME      = *,E10.3,5X,E10.3)
      KTER1=10HAMPLITUDE    $KTER2=10H
      CALL AGRAPH(AMP,T,B1,B2,NTOTAL,KTER1,KTER2)
      WRITE(7,55) $CALL GETNUM(A)  $IF(A(1).EQ.0.)GOTO100
      KTER1=10HAZIMUTH
      CALL AGRAPH(AZM,T,B3,B4,NTOTAL,KTER1,KTER2)
      WRITE(7,55) $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO100
   22 CONTINUE
      WRITE(7,16) $READ(7,17)CHECK $IF(CHECK.EQ.1HY)GOTO18
```

```
 16   FORMAT(*SET INITIAL AND FINAL TIMES FOR SHARPNESS PLOT?*,/,
     1        *YES (Y) OR NO (N)*)
 17   FORMAT(A1)
      KLM1=1 $KLM2=MTOTAL $GOTO19
 18   WRITE(7,123) $CALL GETNUM(A) $TON=A(1) $TUP=A(2)
123   FORMAT(*ENTER INITIAL AND FINAL TIMES*)
      IF(TON.LT.TINITL)TON=TINITL $IF(TUP.GT.TFINAL)TUP=TFINAL
      IF(TON.GT.TFINAL.OR.TUP.LT.TINITL)WRITE(7,21)
      IF(TON.GT.TFINAL.OR.TUP.LT.TINITL)GOTO22
 21   FORMAT(*INITIAL AND/OR FINAL TIME ERROR, TRY AGAIN*)
      DO 23 I=1,NTOTAL
      X1(I)=T(I)-TON   $X2(I)=T(I)-TUP
  23  CONTINUE
      KLM1=1 $KLM2=NTOTAL
      DO 24 I=1,MTOTAL
      J=I+1 $IF(X1(I).LE.0..AND.X1(J).GT.0.)KLM1=I
      IF(X2(I).LE.0..AND.X2(J).GT.0.)KLM2=I
  24  CONTINUE
 19   CONTINUE
      BETA=(AMP(KLM2)-AMP(KLM1))/(T(KLM2)-T(KLM1))
      IF(BETA.EQ.0.)BETA=(((AMP(KLM2)-AMP(KLM1))/2.)+AMP(KLM1))/
     1 (((T(KLM2)-T(KLM1))/2.)+T(KLM1))
      IF(BETA.EQ.0.)WRITE(7,25)  $IF(BETA.EQ.0.)CALL GETNUM(A)
      IF(BETA.EQ.0.)BETA=A(1)
 25   FORMAT(*AVERAGE SHARPNESS IS ZERO*,/,
     1        *ENTER VALUE FOR USE IN SHARPNESS PLOT*)
      DO 26 I=1,MTOTAL
      AZM(I)=((AMP(I+1)-AMP(I))/(T(I+1)-T(I)))/BETA
 26   CONTINUE
      CALL AMINMX(AZM,MTOTAL,B1,B2) $B3=T(1) $B4=T(MTOTAL)
      WRITE(7,27)B1,B2,B3,B4
  27  FORMAT(*MIN/MAX VALUES OF SHARPNESS       = *,E10.3,5X,E10.3,/,
     1        *MIN/MAX VALUES OF TIME            = *,E10.3,5X,E10.3)
      KTER1=10HSHARPNESS  $KTER2=10HQUANTITY
      CALL AGRAPH(AZM,T,B1,B2,MTOTAL,KTER1,KTER2)
      WRITE(7,55) $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO100
      WRITE(7,56) $READ(7,17)CHECK$IF(CHECK.EQ.1HY)GOTO22
  56  FORMAT(*RE-COMPUTE SHARPNESS? YES(Y) OR NO (N)*)
      GOTO100
110   WRITE(7,900) $READ(7,17)CHECK $IF(CHECK.EQ.1HY)REWIND 5
900   FORMAT(*END OF DATA.  RE-START?*)
      IF(CHECK.EQ.1HY)GOTO100
      STOP
      END
      SUBROUTINE GETNUM(R)
      DIMENSION R(1),L(80)
      READ(7,9)L $ I=J=0
    6 J=J+1 $ N=P=S=0 $ M=F=1
    5 I=I+1 $ IF(I.GT.80)RETURN $ D=L(I) $ K=4
      IF(J.EQ.36)K=2 $ IF(D.GE.27.A.D.LE.36)K=1
      IF(D.EQ.-7)K=3 $ K=K+S $ GOTO(1,2,3,5,1,4,3,4)K
    1 N=N*10+D-27                    $ S=4          $ GOTO 5
    2 M=-1                           $ S=4          $ GOTO 5
    3 P=I                            $ S=4          $ GOTO 5
    4 IF(P.NE.0)F=10.**(I-P-1) $ R(J)=N/F*M $ GOTO 6
    9 FORMAT(80R1)
      END
      SUBROUTINE AGRAPH(R,T,A1,B,NRECPT,K1,K2)
```

```
      COMMON/JPLOT/XLT,XRT,YLO,YUP,MAJX,MAJY,KX(2),KY(2),
     1 LTITL(8),LU,LTF,LNLGX,LNLGY,NCLX,NCLY,LTITL2(8)
      DIMENSION R(50),T(50),A(20)
      KX(1)=10HTIME (GMT)  $KX(2)=10H
      XLT=T(1)  $XRT=T(NRECPT)  $KY(1)=K1  $KY(2)=K2
      YLO=A1  $YUP=B
   13 WRITE(7,3)  $READ(7,4)CH  $IF(CH.EQ.1HN.OR.CH.EQ.1H )GOTO5
    3 FORMAT(*SET HORIZONTAL SCALE? Y OR N(=BLANK)*)
    4 FORMAT(A1)
      WRITE(7,6)  $CALL GETNUM(A)  $XLT=A(1)  $XRT=A(2)
    6 FORMAT(*MIN/MAX X VALUES*)
    5 WRITE(7,7)  $READ(7,4)CH  $IF(CH.EQ.1HN.OR.CH.EQ.1H )GOTO8
      WRITE(7,9)  $CALL GETNUM(A)  $YLO=A(1)  $YUP=A(2)
    7 FORMAT(*SET VERTICAL SCALE? Y OR N(=BLANK)*)
    9 FORMAT(*MIN/MAX Y VALUES*)
    8 AA=YUP $IF(YLO.EQ.AA)YUP=YUP+1.  $IF(YLO.EQ.AA)YLO=YLO-1.
      WRITE(7,10)KY(1),KY(2)
   10 FORMAT(*SKIP PLOT OF *,2A10,*?*)
      READ(7,4)IJVAR
      IF(IJVAR.EQ.1HN.OR.IJVAR.EQ.1H )CALL PLOTS(R,T,1,NRECPT)
      WRITE(7,12) $CALL GETNUM(A)  $IRS=A(1)  $IF(IRS.EQ.1)GOTO13
   12 FORMAT(*1 = NEW PLOT, 2 = RETURN*)
      RETURN $END
      SUBROUTINE AMINMX(R,NRECPT,B,A)
      DIMENSION R(50)
      AMIDPT=((R(NRECPT)-R(1))/2.) + R(1)
      A = B =AMIDPT
      DO 1 I=1,NRECPT
      IF(R(I).GT.A)A=R(I)
      IF(R(I).LT.B)B=R(I)
    1 CONTINUE
      RETURN $END
```

C. PROGRAM SHARPS

INTRODUCTION

A model for slip-related tilt events has been discussed in McHugh (1976b). Briefly, the model assumes a rectangular, vertically oriented, dislocation loop expanding quasi-statically in a homogeneous elastic medium with a spatially and temporally variable displacement distribution across the slipping region (Model II). This model demonstrates that a slip zone very close to the station will produce a more rapid change in tilt amplitude than a distant slip zone. Model II allows the source-station distance to be estimated from the onset sharpness (i.e., the time rate of change of the tilt amplitude). The program input consists of the slip zone geometry, and the output is a graph of onset sharpness versus source-station distance.

Access and Use

The program requires approximately 70K of core and is intended for use on the LBL 6600B or C computer and the Tektronix (4010-1) terminal. To access and operate the program, enter an ‸LOAD, SHARPS, MCHUGH followed by ‸RUN. The program links automatically to the appropriate plotting routines.

Input

The input, source-station configuration, and program options are identical to those described for Model II (McHugh, 1976b) and will not be repeated here. Program SHARPS computes the gradient of the tilt amplitude change as a function of source-station distance. Consequently, in addition to the source configuration, the X1 position of the station (X1), the initial

X2 position (X2IN), and the increment in the X2 position (DELTAX) must be entered (Figure 3-C1). These three parameters are entered after the slip zone coordinates when the computer writes:

Enter X1, X2IN, and DELTAX

Program Operation

The program computes the quasi-static tilt amplitude as a function of time at a station in position(X1, X2)as the slip zone expands from its initial to final positions. The sharpness quantity, $\left[S\right]$, is computed by numerically differentiating the tilt amplitude and normalizing by the event duration and residual offset. The maximum sharpness at the onset of the event (the onset sharpness, $\hat{0}$) is computed for the station position, X2. The X2 coordinate of the station is normalized by the final length of the dip-slip zone (unless the length of the dip-slip zone is zero, in which case the length of the strike-slip zone is used - Figure 3-C1). The program then increments X2 (using DELTAX) and computes the onset sharpness produced by the slip zone at the new station position.

By definition, the sharpness quantity is:

$$\left[S\right] = \frac{d\Theta}{dt} \Big/ \left[(\Theta_f - \Theta_i) \Big/ (t_f - t_i)\right]$$

where Θ is the tilt amplitude, t is the time (determined by the position of the zone, as discussed in McHugh, 1976a, b), and i and f refer to the initial and final quantities. The derivative is normalized by the residual offset $(\Theta_f - \Theta_i)$ because the tilt amplitude is proportional to the slip, which in general cannot be determined from the records of a single station.

The duration of the event is also used to normalize the derivative because the correspondence between time as a model parameter and time on the station's record cannot be precisely determined.

The onset sharpness ($\hat{O}$) is the maximum sharpness of the event within the first few time units (defined by N1, = (.075*NRECPT)+1 in line 73, and NRECPT (line 190)) to avoid the possibility of a global maximum, not coincident with the onset, contaminating the results. The onset sharpness is determined for 20 station positions (i.e. X1 constant, X2 = X2IN + (DELTAX * K), K = 1 to 20, line 194 in the program listing) and plotted as a function of D/L (D is the perpendicular source-station distance - the absolute value of X2, L is the length (in the X1 direction) of the dip-slip or strike-slip zone - Figure 3-C1).

Output

After the computations of $\hat{O}$ versus D/L are completed the program writes:

Min/Max values of sharpness = (numerical values)

Min/Max values of (D/L) = (numerical values)

These statements are followed by requests for scaling information pertaining to the graph of $\hat{O}$ versus D/L. The scales are set in the same fashion as in programs discussed elsewhere (McHugh, 1976a) and will not be described here. After the plot of $\hat{O}$ versus D/L has been displayed, the graph can be re-scaled and displayed (option 1), or the computer will move to the next section of the program (option 2). If option 2 is selected, the computer will write:

0 = Re-start, 1 = Specify new DELTAX and continue.

Entering a zero causes the program to be re-started, and 1 causes the computer to write:

Enter new DELTAX

The new value of DELTAX must be entered; the computer will respond:

0 = Re-start with all new values

1 = Re-start with previous values and new DELTAX

Entering a zero causes the program to be re-started (i.e., new input values must be specified), a 1 causes the program to be re-started with the new DELTAX and the previous slip zone geometry.

Results and Discussion

As an example of how this technique and program may be used to interpret a tilt event, consider the 27 October 1974 LIB event (Figure 3-C2) with onset sharpness equal to 9.2 (using program ONSTSP - page 3-B.22). The observed tilt component amplitudes and the sharpness, [S], computed from the observed tilt (using ONSTSP) as functions of time are shown in Figure 3-C2a. If it is assumed that the observed tilts are produced by an expanding dip-slip zone (which is known to be capable of producing a step-like tilt event), the source-station configuration may be estimated from the tilt amplitude versus time waveshape; and the onset sharpness may be used as a constraint on the source-station distance.

The assumed source-station configuration shown in Figure 3-C.1 will produce a waveshape and deflection similar to the event observed at LIB, but in general the displacement and source-station distance (D) will not be known. The amplitude of the offset is affected by the amount of dislacement across the slip zone as well as D. However, the source-station distance may be estimated using the onset sharpness, which allows the dislacement to be determined directly from the event amplitude. Figure 3-C2c is a plot of onset sharpness ($\hat{O}$) versus D/L computed using program SHARPS for the model in Figure 3-C1. An onset sharpness of 9.2 (determined for the observation at LIB on 27 October 1974 using ONSTSP) implies that D/L = .85

(page 3-C.9) for the configuration in Figure 3-C1. If L = 100m, then the X2 coordinate of the station is 85 m. The observed deflection at LIB is 0.6 μrad to the southwest, consequently the displacement must be .36mm (determined by using the source-station configuration in Figure 3-C1 as input to program SLPPRP and adjusting U3IN and U3FN until the theoretical residual tilt offset equals the observed residual tilt offset).

Program SLPPRP was used to generate the tilt component amplitudes and sharpness versus time plots in Figure 3-C2b (with the time scale adjusted so that the theoretical event duration was similar to the observed duration). Although it was assumed that the source of the LIB event was a bilaterally propagating dip-slip zone (because this type of source will produce a step-like tilt waveform), 100m in length, the source-station distance and amount of displacement (85m and .36mm respectively) were estimated directly from the observations.

Comparing Figure 3-C2b to 3-C2a, it is seen that the model in Figure 3-C1 reproduces: 1) the observed sense of deflection (i.e.southwest), 2) the general, step-like, appearance of the waveform, 3) the amplitude of the deflection (about 0.6 μrad), 4) the correct onset sharpness (about 9.), and 5) the basic features of the sharpness, [S], versus time curve. Although the theoretical solutions are not in complete agreement with the observations, the basic features of the data can be interpreted with the model and techniques presented.

NOTE: The observed tilt component amplitudes versus time profiles (Figure 3-C2a) were processed using program ONSTSP; the sharpness versus time (Figure 3-C2a) was computed by ONSTSP. The theoretical tilt component amplitude (Figure 3-C2b) were generated by program SLPPRP (McHugh, 1976b), the theoretical tilt sharpness (Figure 3-C2b) by a modification of SLPPRP. The onset sharpness versus D/L (Figure 3-C2c) was determined using program SHARPS. The theoretical curves (Figures 3-C2b,c) were generated for the model in Figure 3-C1.

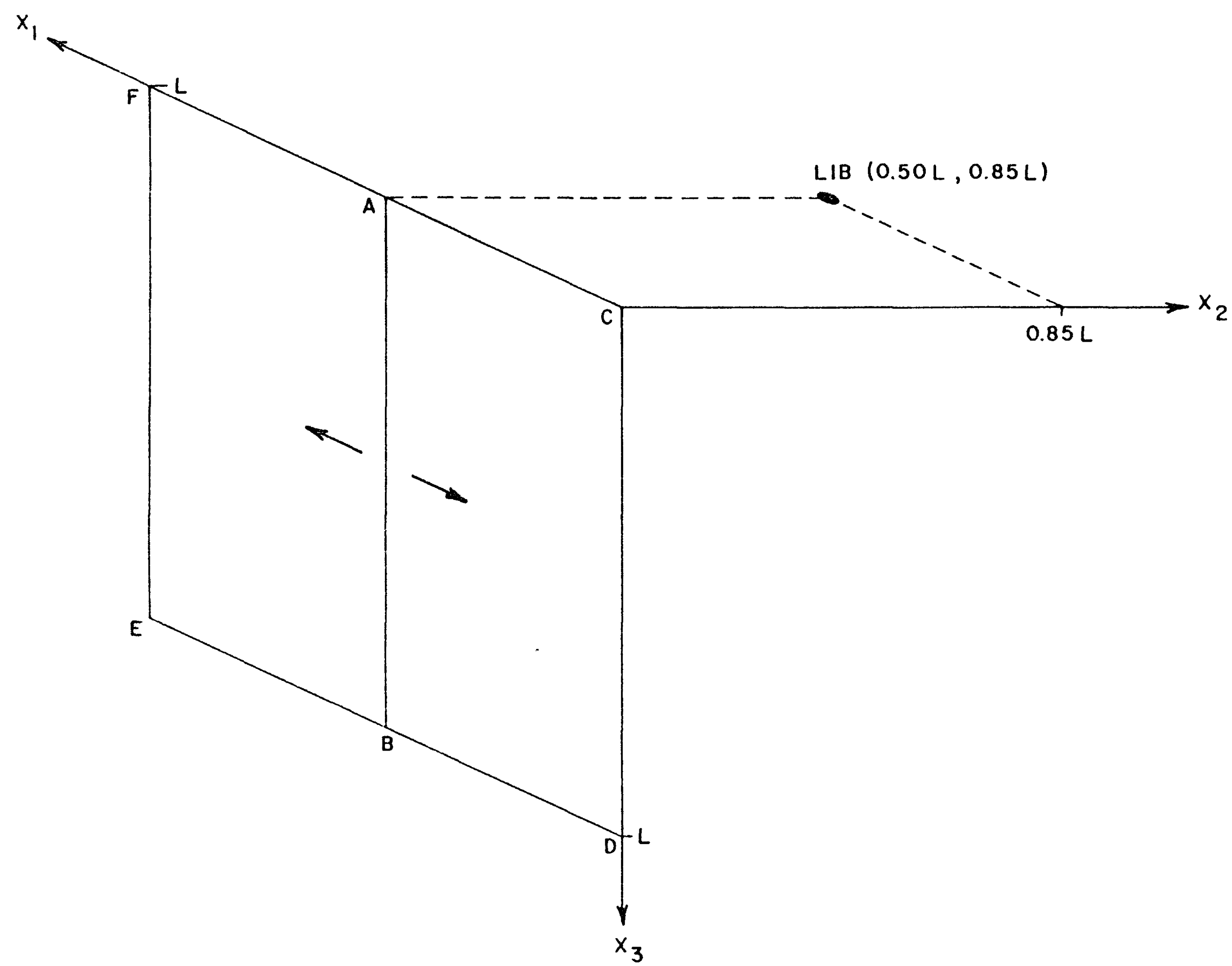


Figure 3-C1

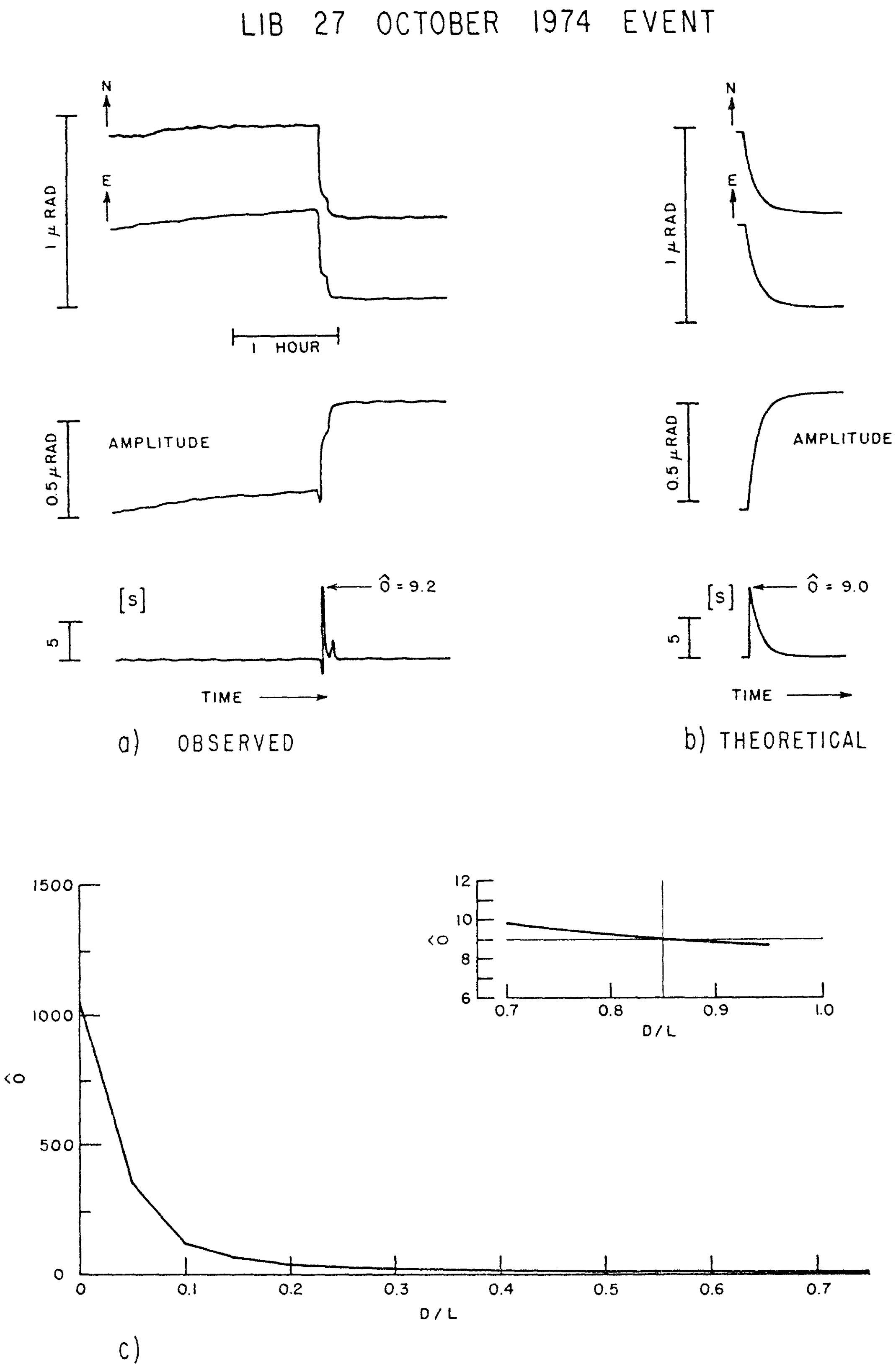
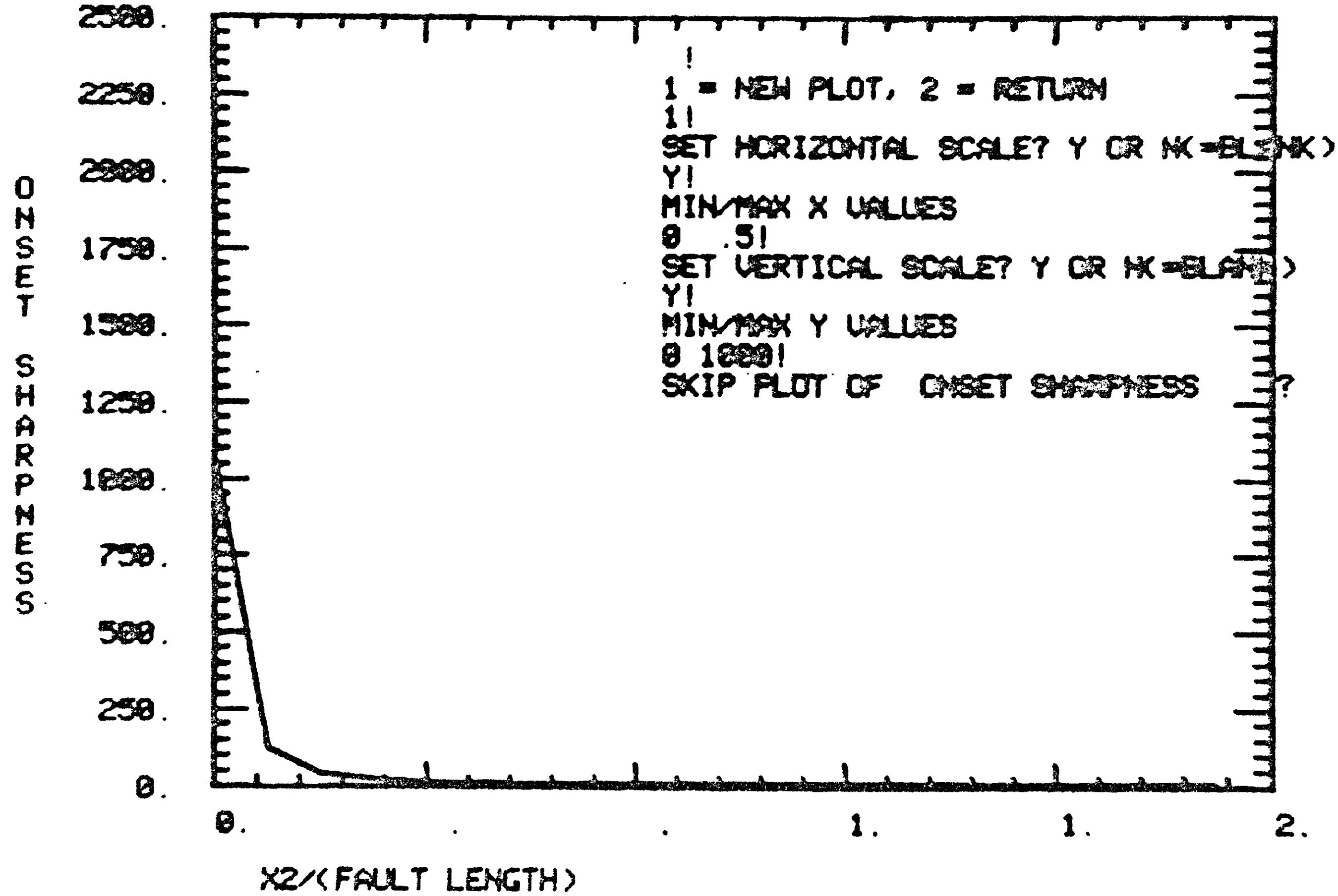

LIB 27 OCTOBER 1974 EVENT
N
E
1 μ RAD
1 HOUR
AMPLITUDE
0.5 μ RAD
[s]
Ô = 9.2
5
TIME
a) OBSERVED
N
E
1 μ RAD
AMPLITUDE
0.5 μ RAD
[s]
Ô = 9.0
5
TIME
b) THEORETICAL
1500
1000
500
0
Ô
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
D/L
12
10
8
6
Ô
0.7
0.8
0.9
1.0
D/L
c)

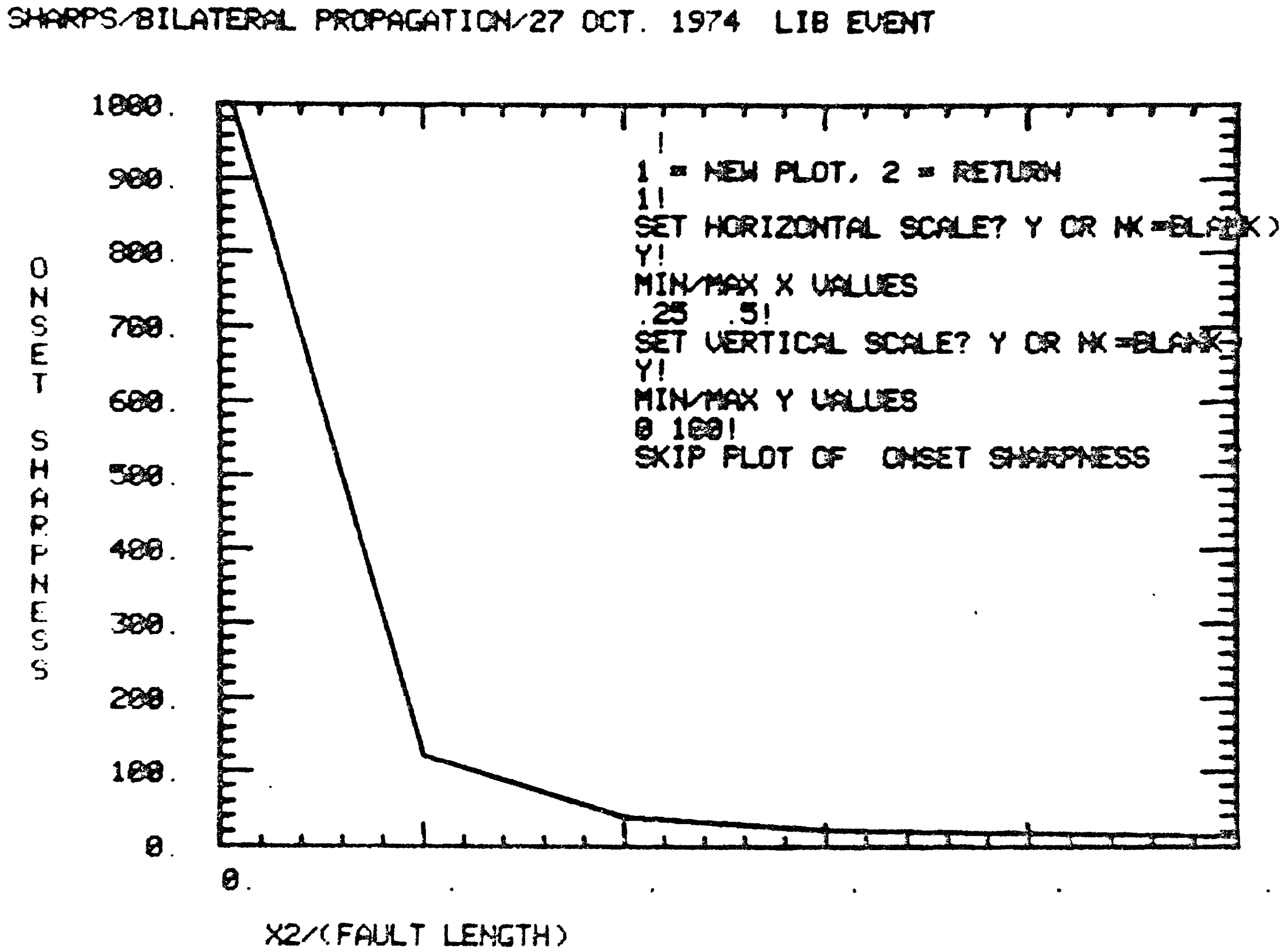
Figure 3-c2

EXAMPLES OF SHARPS OPERATION

```
^LOAD,SHARPS,MCHUGH!                    SKIP PLOT OF  ONSET SHARPNESS     ?
LOAD COMPLETE, ENTERING ^EDIT
OK - ^EDIT
^RUN!
1=ZONE EXPANDS, 2=ZONE CONTRACTS
1!
1/2=SLIP INCREMENTED EXPONENTIALLY/LINEARLY
STRIKE-SLIP/DIP-SLIP
1 1!
0  =INCREMENT CORNERS SEPARATELY
1/2=INCREMENT ALL CORNERS EXPONENTIALLY/LINEARLY
STRIKE-SLIP/DIP-SLIP
1 1!
'U1>0' = LEFT-LATERAL STRIKE-SLIP
'U3>0' = 'X2>0' SIDE DOWN
U1IN, U1FN, U3IN, U3FN
0 0 1 1!
'TRIGGER' OPTION DESIRED?
N!
D1X1IN,D1X3IN,D2X3IN,D3X1IN,D1X1FN,D1X3FN,D2X3FN,D3X1FN
 .05  0  .1  .05  .1  0  .1 0!
ENTER X1, X2IN, AND DELTAX
 .05  .000001  .01!
MIN/MAX VALUES OF SHARPNESS =  7.426E+00       1.060E+03
MIN/MAX VALUES OF (D/L)     =  1.000E-05       1.900E+00
WRITE PLOT TITLE, 80 CHARACTERS
SHARPS/BILATERAL PROPAGATION/27 OCT. 1974  LIB EVENT!
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
0 2!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
0 2500!
```

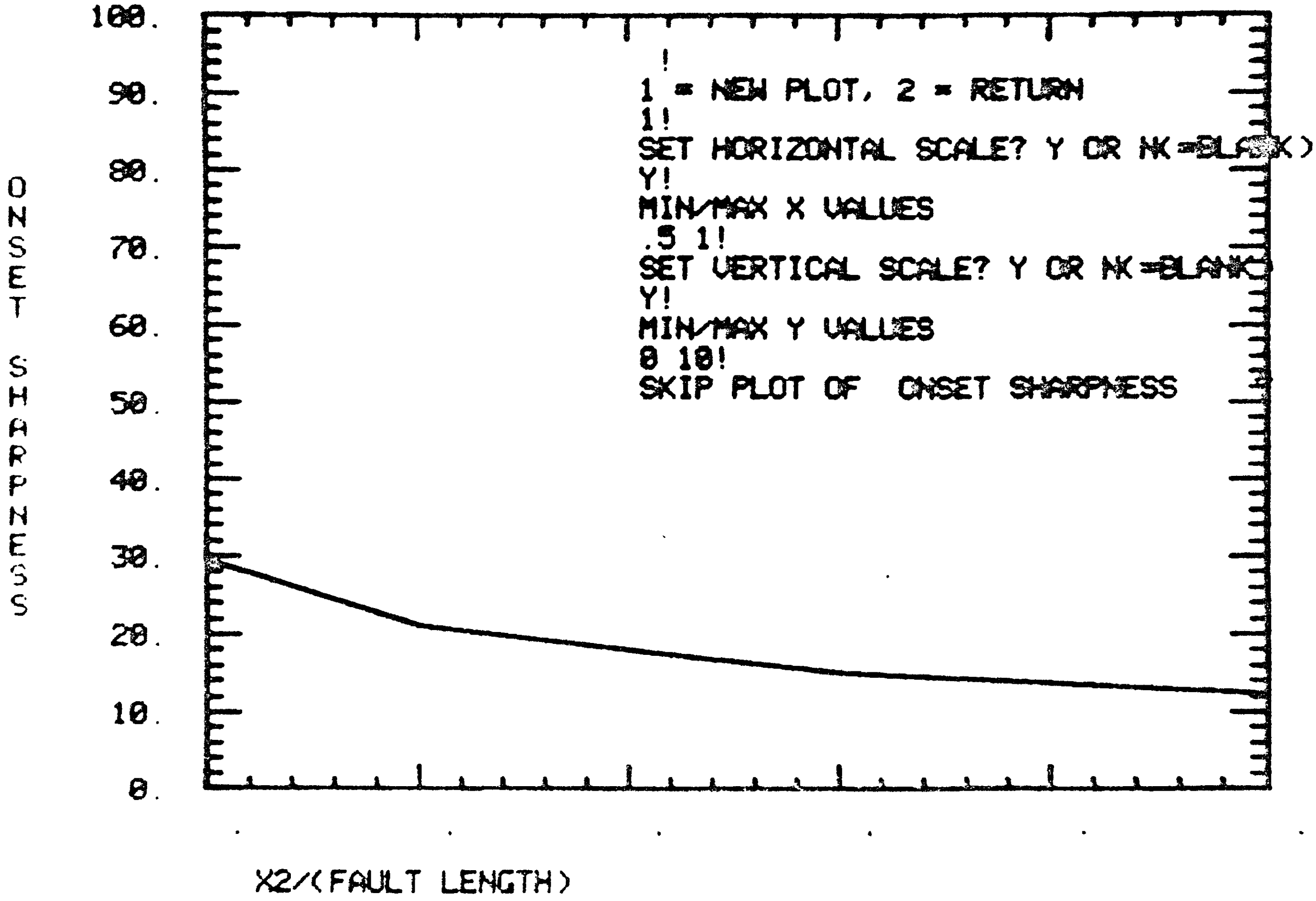
SHARPS/BILATERAL PROPAGATION/27 OCT. 1974 LIB EVENT

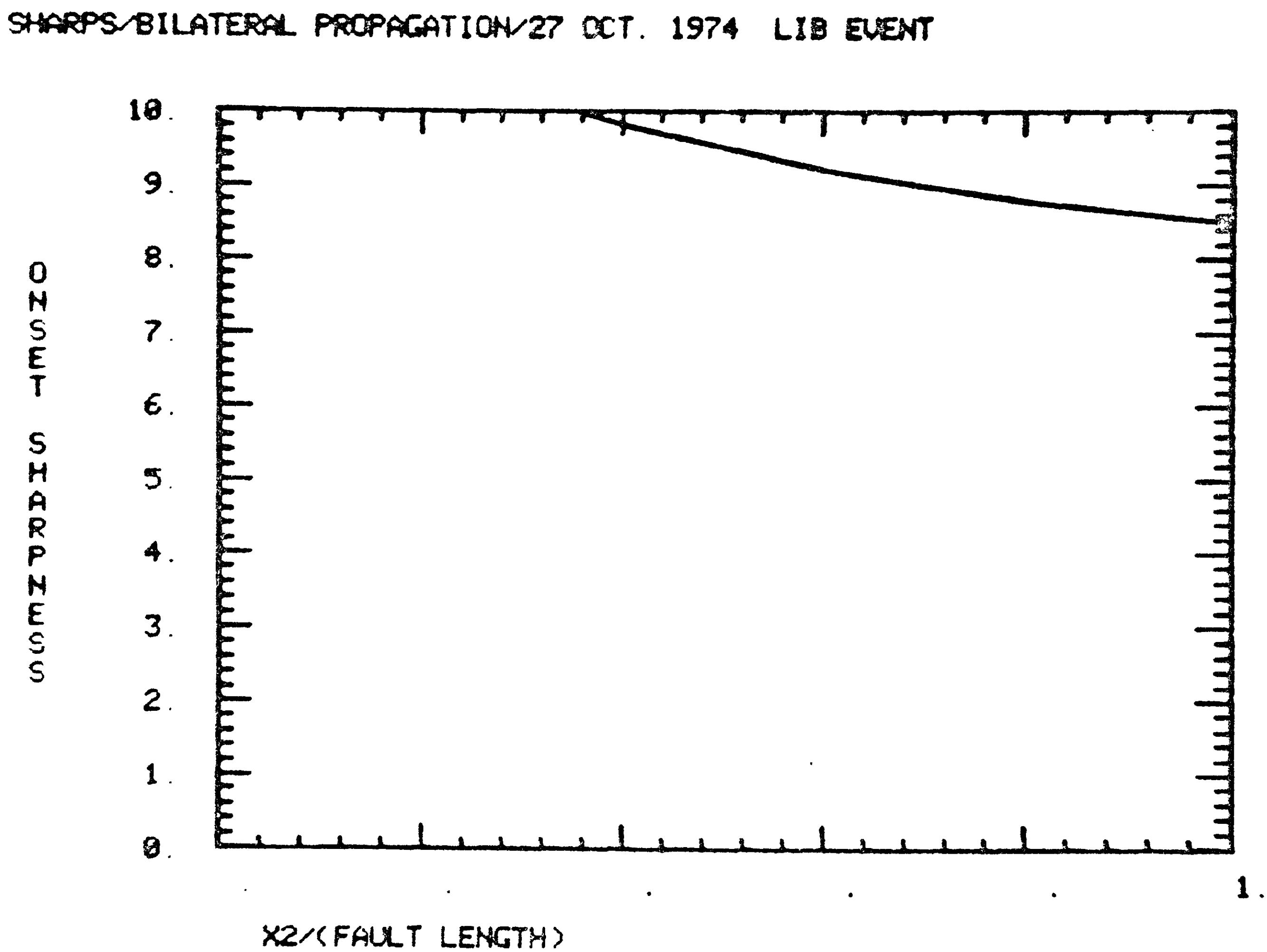




SHARPS/BILATERAL PROPAGATION/27 OCT. 1974 LIB EVENT
1000.
900.
800.
700.
600.
500.
400.
300.
200.
100.
0.
ONSET SHARPNESS
0.
X2/(FAULT LENGTH)
1 = NEW PLOT, 2 = RETURN
1!
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
.25 .5!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
0 100!
SKIP PLOT OF ONSET SHARPNESS

SHARPS/BILATERAL PROPAGATION/27 OCT. 1974 LIB EVENT




SHARPS/BILATERAL PROPAGATION/27 OCT. 1974 LIB EVENT
ONSET SHARPNESS
10.
9.
8.
7.
6.
5.
4.
3.
2.
1.
0.
1.
X2/(FAULT LENGTH)

```
 !
1 = NEW PLOT, 2 = RETURN
2!
0=RE-START, 1=SPECIFY NEW DELTAX AND CONTINUE
2!
OK - ^EDIT
```

PROGRAM LISTING

```
DELETE(LGO,OUTPUT,SHARPS)
SHARPS.
EXIT.
LIBCOPY(GRAPHIC,TXLGO/RR,TXLGO)
LIBCOPY(JDRAT,NPLGO/RR,NPLGO)
DELETE(LGO,OUTPUT,SHARPS)
RUN76(S)
LINK(F=LGO,F=TXLGO,F=NPLGO,B=SHARPS)
SHARPS.
FIN.
FOR
      PROGRAM SHARPS(TAPETTY=201,FILM=TAPETTY,TAPE7=TAPETTY)
      COMMON/TVPCOL/TVPUL(8)
      COMMON/TVTUNE/ITUNE(30)
      COMMON/JPLOT/XLT,XRT,YLO,YUP,MAJX,MAJY,KX(2),KY(2),
     1LTITL(8),LL,LTF,LNLGX,LNLGY,NCLX,NCLY,LTITL2(8)
      DIMENSION IFET(8)
      DIMENSION TX(100),TY(100),T(100)
      DIMENSION D(20),C(40),A(30),IT(4),ICRNR(16)
      DIMENSION TAMP(100),SHARP(20),DOL(20)
      CALL FET(5LTAPE7,IFET,8)
      IFET(2)=IFET(2).OR.0000 0010 0000 0000 0000B
      IFET(8)=IFET(8).OR.4000 0000 0000 0000 0000B
      CALL FET(5LTAPE7,IFET,-8)
      KTEST=1
   67 DO 101 J=1,18
      D(J)=0.  $C(J+18)=0.  $C(J)=0.
  101 CONTINUE
      WRITE(7,1)
    1 FORMAT(*1=ZONE EXPANDS, 2=ZONE CONTRACTS*)
      CALL GETNUM(A) $IFLAG=A(1) $WRITE(7,2)
    2 FORMAT(*1/2=SLIP INCREMENTED EXPONENTIALLY/LINEARLY*,/,
     1       *STRIKE-SLIP/DIP-SLIP*)
      CALL GETNUM(A) $KFLAGS=A(1) $KFLAGD=A(2) $WRITE(7,3)
    3 FORMAT(*0  =INCREMENT CORNERS SEPARATELY*,/,
     1       *1/2=INCREMENT ALL CORNERS EXPONENTIALLY/LINEARLY*,/,
     1       *STRIKE-SLIP/DIP-SLIP*)
      CALL GETNUM(A) $LFLAG=A(1) $MFLAG=A(2)
      DO 110 I=1,4
      IT(I)=5
  110 CONTINUE
      DO 4 I=1,16
    4 ICRNR(I)=1
      IF(LFLAG.EQ.0.OR.MFLAG.EQ.0)CALL SLPCRN(LFLAG,MFLAG,ICRNR)
      IF(LFLAG.EQ.2)GOTO 5 $GOTO6
    5 DO 7 I=9,16
    7 ICRNR(I)=2
    6 IF(MFLAG.EQ.2)GOTO8 $GOTO9
    8 DO 10 I=1,8
   10 ICRNR(I)=2
    9 WRITE(7,11) $CALL GETNUM(A) $C(33)=A(1) $C(34)=A(2)
   11 FORMAT(*'U1>0' = LEFT-LATERAL STRIKE-SLIP*,/,
     1       *'U3>0' = 'X2>0' SIDE DOWN*,/,
     1       *U1IN, U1FN, U3IN, U3FN*)
      C(35)=A(3) $C(36)=A(4) $WRITE(7,12)
   12 FORMAT(*'TRIGGER' OPTION DESIRED?*)
      READ(7,13)TRIG $IF(TRIG.EQ.1HY)CALL TRIGGR(IT)
   13 FORMAT(A1)
```

```
      IF(C(33).EG.0..AND.C(34).EQ.0.)GCTO14
      WRITE(7,15) $CALL GETNUM(A) $C(17)=C(19)=A(1)
   15 FORMAT(*C1X1IN,C1X3IN,C2X3IN,C3X1IN,C1X1FN,C1X3FN,C2X3FN,C3X1FN*
      C(18)=C(24)=A(2) $C(20)=C(22)=A(3) $C(21)=C(23)=A(4)
      C(25)=C(27)=A(5) $C(26)=C(32)=A(6) $C(28)=C(30)=A(7)
      C(29)=C(31)=A(8)
   14 IF(C(35).EG.0..AND.C(36).EQ.0.)GCTO16
      WRITE(7,17) $CALL GETNUM(A) $C(1)=C(3)=A(1) $C(2)=C(8)=A(2)
   17 FORMAT(*D1X1IN,D1X3IN,D2X3IN,D3X1IN,D1X1FN,D1X3FN,D2X3FN,D3X1FN*
      C(4)=C(6)=A(3) $C(5)=C(7)=A(4) $C(9)=C(11)=A(5)
      C(10)=C(16)=A(6) $C(12)=C(14)=A(7) $C(13)=C(15)=A(8)
   16 WRITE(7,18) $CALL GETNUM(A) $X1=A(1) $X2IN=A(2) $DELTAX=A(3)
   18 FORMAT(*ENTER X1, X2IN, AND DELTAX*)
      X3=0. $NRECPT=100 $N=(.075*NRECPT) $X2=X2IN
      N1=N+1 $N2=NRECPT-(.075*NRECPT)-1
      N3=N2+1 $PI=3.1415926 $RN1=N1 $RN2=N2 $ITIME=99999
   75 CONTINUE
      DO  21 J=1,8
      D(J)=C(J)  $D(J+8)=C(J+16)
   21 CONTINUE
      D(17)=C(33)  $D(18)=C(35)
      DO 19 I=1,N
      CALL CMPTLT(D,X1,X2,X3,T1,T2)
      T(I)=I $TX(I)=T2 $TY(I)=T1
   19 CONTINUE
      DO 24 J=1,8
      D(J)=C(J+8)  $D(J+8)=C(J+24)
   24 CONTINUE
      D(17)=C(34)  $D(18)=C(36)
      DO 23 I=N3,NRECPT
      CALL CMPTLT(D,X1,X2,X3,T1,T2)
      T(I)=I $TX(I)=T2 $TY(I)=T1
   23 CONTINUE
      IFGREC=0
      DO 25 I=N1,N2
      T(I)=I  $RI=I
      IF(TRIG.EQ.1HY)GOTO26
      DO 27 J=1,8
      J8=J+8 $A1=C(J) $B=C(J8) $E=C(J8+8) $F=C(J+24)
      CALL XPNSHL(A1,B,RN1,RN2,RI,Y1)
      CALL XPNSHL(E,F,RN1,RN2,RI,Y2)
      IF(ICRNR(J).EQ.2)CALL ALINAR(A1,B,RN1,RN2,RI,Y1)
      IF(ICRNR(J8).EQ.2)CALL ALINAR(E,F,RN1,RN2,RI,Y2)
      D(J)=Y1 $D(J8)=Y2
   27 CONTINUE
      CALL XPNSHL(C(33),C(34),RN1,RN2,RI,Y1)
      CALL XPNSHL(C(35),C(36),RN1,RN2,RI,Y2)
      IF(KFLAGS.NE.1)CALL ALINAR(C(33),C(34),RN1,RN2,RI,Y1)
      IF(KFLAGD.NE.1)CALL ALINAR(C(35),C(36),RN1,RN2,RI,Y2)
      D(17)=Y1 $D(18)=Y2 $GOTO28
   26 IF(IT(2).EG.1.AND.KFLAGS.EQ.1)CALL XPNSHL(C(33),C(34),RN1,
     1 RN2,RI,Y)
      IF(IT(2).EG.1.AND.KFLAGS.NE.1)CALL ALINAR(C(33),C(34), RN1,
     1 RN2,RI,Y)
      IF(IT(2).EG.0.AND.KFLAGD.EQ.1)CALL XPNSHL(C(35),C(36),RN1,
     1 RN2,RI,Y)
      IF(IT(2).EG.0.AND.KFLAGD.NE.1)CALL ALINAR(C(35),C(36),RN1,
     1 RN2,RI,Y)
```

```
      IF(IT(2).EQ.0)D(18)=Y $IF(IT(2).EQ.1)D(17)=Y
      DO 32 J=1,8
      J8=J+8 $A1=C(J) $B=C(J8) $E=C(J8+8) $F=C(J+24)
      CALL XPNSHL(A1,B,RN1,RN2,RI,Y1)
      CALL XPNSHL(E,F,RN1,RN2,RI,Y2)
      IF(ICRNR(J).EQ.2)CALL ALINAR(A1,B,RN1,RN2,RI,Y1)
      IF(ICRNR(J8).EQ.2)CALL ALINAR(E,F,RN1,RN2,RI,Y2)
      D(J)=Y1 $D(J8)=Y2
   32 CONTINUE
      MIT3=IT(3)  $MIT4=IT(4) $IF(IT(1).EQ.1)GOTO29
      IF(D(MIT3).LT.C(MIT4).AND.IT(2).EQ.0)D(17)=C(33)
      IF(D(MIT3).LT.C(MIT4).AND.IT(2).EQ.1)D(18)=C(35)
      IF(D(MIT3).LT.C(MIT4).AND.IT(2).EQ.1)GOTO33
      IF(D(MIT3).GE.C(MIT4))GOTO35
      DO 40 J=9,16
  40  D(J)=C(J+8)
      GOTO28
  29  IF(D(MIT3).GT.C(MIT4).AND.IT(2).EQ.0)D(17)=C(33)
      IF(D(MIT3).GT.C(MIT4).AND.IT(2).EQ.1)D(18)=C(35)
      IF(D(MIT3).GT.C(MIT4).AND.IT(2).EQ.1)GOTO33
      IF(D(MIT3).LE.C(MIT4))GOTO35
      DO 34 J=9,16
  34  D(J)=C(J+8)
      GOTO28
   33 DO 36 J=1,8
  36  D(J)=C(J)
      GOTO28
   35 IFGREC=IFGREC+1
      IF(IFGREC.EQ.1)ITIME=I
      IF(IFGREC.EQ.1)RITIME=ITIME
      IF(IT(2).EQ.0.AND.KFLAGS.EQ.1)CALL XPNSHL(C(33),C(34),RTIME,
     1 RN2,RI,Y)
      IF(IT(2).EQ.0.AND.KFLAGS.NE.1)CALL ALINAR(C(33),C(34),RITME,
     1 RN2,RI,Y)
      IF(IT(2).EQ.1.AND.KFLAGC.EQ.1)CALL XPNSHL(C(35),C(36),RITME,
     1 RN2,RI,Y)
      IF(IT(2).EQ.1.AND.KFLAGC.NE.1)CALL ALINAR(C(35),C(36),RITME,
     1 RN2,RI,Y)
      IF(IT(2).EQ.1)D(18)=Y $IF(IT(2).EQ.0)D(17)=Y
      IF(IT(2).EQ.1)GOTO37
      DO 38 J=9,16
      A1=C(J+8)  $B=C(J+16) $CALL XPNSHL(A1,B,RITIME,RN2,RI,Y)
      IF(ICRNR(J).EQ.2)CALL ALINAR(A1,B,RITIME,RN2,RI,Y)
  38  D(J)=Y
      GOTO28
  37  DO 39 J=1,8
      E=C(J) $F=C(J+8) $CALL XPNSHL(E,F,RITIME,RN2,RI,Y)
      IF(ICRNR(J).EQ.2)CALL ALINAR(E,F,RITIME,RN2,RI,Y)
  39  D(J)=Y
  28  CALL CMPTLT(D,X1,X2,X3,T1,T2)
      TX(I)=T2 $TY(I)=T1
   25 CONTINUE
      IF(IFLAG.EQ.2)GOTO46
      AR=TX(1) $B=TY(1)
      DO 47 I=1,NRECPT
      TX(I)=TX(I)-AR
  47  TY(I)=TY(I)-B
      GOTO48
```

```
   46 DO 49 I=1,NRECPT
      TX(I)=TX(NRECPT)-TX(I)
   49 TY(I)=TY(NRECPT)-TY(I)
   48 DO 50 I=1,NRECPT
      TAMP(I)=SQRT((TX(I)**2)+(TY(I)**2))
   50 CONTINUE
      NEND=NRECPT-1
      BETA=TAMP(NRECPT)-TAMP(1) $IF(BETA.EQ.0.)BETA=((TAMP(NRECPT)
     1  -TAMP(1))/2.)+TAMP(1)
      AIOTA=T(NRECPT)-T(1) $IF(AIOTA.EQ.0.)AIOTA=1.E-20
      ZETA=BETA/AIOTA $IF(ZETA.EQ.0.)ZETA=1.E-20
      DO 51 I=1,NEND
      ALPHA=T(I+1)-T(I)  $IF(ALPHA.EQ.0.)ALPHA=1.E-20
      TAMP(I)=((TAMP(I+1)-TAMP(I))/ALPHA)/ZETA
   51 CONTINUE
      NNEND=N1+(.1*NRECPT)  $CALL AMINMX(TAMP,NNEND,AMIN,AMAX)
      SHARP(KTEST)=AMAX $ALNGTH=C(13)-C(9) $BLNGTH=C(29)-C(17)
      RLNGTH=ALNGTH $IF(ALNGTH.EQ.0.)RLNGTH=BLNGTH
      DOL(KTEST)=ABS(X2/RLNGTH)
      X2=X2IN+(DELTAX*KTEST) $KTEST=KTEST+1 $IF(KTEST.LE.20)GOTO75
      KTEST=20 $CALL AMINMX(SHARP,KTEST,A1,A2)
      CALL AMINMX(DOL,KTEST,B1,B2) $WRITE(7,57)A1,A2,B1,B2
   57 FORMAT(*MIN/MAX VALUES OF SHARPNESS = *,E10.3,5X,E10.3,/,
     1        *MIN/MAX VALUES OF (D/L)      = *,E10.3,5X,E10.3)
      LU=7 $LNLGX=1 $LNLGY=1 $NCLX=2 $NCLY=2
      DO 200 KM=1,8
  200 LTITL2(KM)=10H
      WRITE(7,53) $READ(7,54)(LTITL(I),I=1,8)
   53 FORMAT(*WRITE PLOT TITLE, 80 CHARACTERS*)
   54 FORMAT(8A10)
      MAJX=5 $MAJY=10 $KTER1=10H ONSET SHA   $KTER2=10HRPNESS
      CALL AGRAPH(SHARP,DOL,A1,A2,KTEST,KTER1,KTER2)
      WRITE(7,1234)  $CALL GETNUM(A) $IF(A(1).EQ.1.)WRITE(7,1235)
 1234 FORMAT(*0=RE-START, 1=SPECIFY NEW DELTAX AND CONTINUE*)
 1235 FORMAT(*ENTER NEW DELTAX*)
      KTEST=1 $IF(A(1).EQ.0.)GOTO67 $IF(A(1).EQ.1.)GOTO1236
      GOTO73
 1236 CALL GETNUM(A) $DELTAX=A(1) $KTEST=1 $WRITE(7,1237)
      X2=X2IN $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO67 $GOTO75
 1237 FORMAT(*0=RE-START WITH ALL NEW VALUES*,/,
     1 *1=RE-START WITH PREVIOUS VALUES AND NEW DELTAX*)
   73 STOP  $END
      SUBROUTINE XPNSHL(P,Q,R1,S1,T,Y)
      S=(T-R1)*6.  $R=S1-R1  $IF(R.EQ.0.)R=1.E-20 $ALPHA=-S/R
      Y=((Q-P)*(1.-EXP(ALPHA)))+P
      RETURN $END
      SUBROUTINE ALINAR(P,Q,R,S,T,Y)
      Y=(((Q-P)*(T-R))/(S-R)) + P
      RETURN  $END
      SUBROUTINE SLPCRN(LFLAG,MFLAG,ICRNR)
      DIMENSION A(20),ICRNR(16)
      WRITE(7,1)
    1 FORMAT(*1=VARIABLE INCREMENTED EXPONENTIALLY*,/,
     1 *2=VARIABLE INCREMENTED LINEARLY*)
      IF(MFLAG.NE.0)GOTO2
      WRITE(7,3) $CALL GETNUM(A) $ICRNR(1)=ICRNR(3)=A(1)
    3 FORMAT(*D1X1, D1X3, D2X3, D3X1*)
      ICRNR(2)=ICRNR(8)=A(2)  $ICRNR(4)=ICRNR(6)=A(3)
```

```
      ICRNR(5)=ICRNR(7)=A(4)
 2    IF(LFLAG.NE.0)RETURN
      WRITE(7,4)  $CALL GETNUM(A)  $ICRNR(9)=ICRNR(11)=A(1)
 4    FORMAT(*C1X1, C1X3, C2X3, C3X1*)
      ICRNR(10)=ICRNR(16)=A(2)  $ICRNR(12)=ICRNR(14)=A(3)
      ICRNR(13)=ICRNR(15)=A(4)  $RETURN  $END
      SUBROUTINE TRIGGR(IT)
      DIMENSION A(20),IT(4)
      WRITE(7,1)  $CALL GETNUM(A)  $IT(1)=A(1)  $WRITE(7,2)
 1    FORMAT(*0 = D(I1) > C(I2),  1 = D(I1) < C(I2)*)
 2    FORMAT(*0 = STRIKE-SLIP/1 = DIP-SLIP ZONE TRIGGERED*)
      CALL GETNUM(A) $IT(2)=A(1)  $WRITE(7,3)
 3    FORMAT(*SPECIFY I1 AND I2*)
      CALL GETNUM(A)  $IT(3)=A(1)  $IT(4)=A(2)
      RETURN  $END
      SUBROUTINE AGRAPH(R,T,A1,B,NRECPT,K1,K2)
      COMMON/JPLCT/XLT,XRT,YLO,YUP,MAJX,MAJY,KX(2),KY(2),
     1 LTITL(8),LU,LTF,LNLGX,LNLGY,NCLX,NCLY,LTITL2(8)
      DIMENSION R(50),T(50),A(20),KX(2),KY(2)
      KX(1)=10HX2/(FAULT  $KX(2)=10HLENGTH)
      XLT=T(1)  $XRT=T(NRECPT)  $KY(1)=K1  $KY(2)=K2
      YLO=A1  $YUP=B
 13   WRITE(7,3)  $READ(7,4)CH  $IF(CH.EQ.1HN.OR.CH.EQ.1H )GOTO5
 3    FORMAT(*SET HORIZONTAL SCALE? Y OR N(=BLANK)*)
 4    FORMAT(A1)
      WRITE(7,6)  $CALL GETNUM(A)  $XLT=A(1)  $XRT=A(2)
 6    FORMAT(*MIN/MAX X VALUES*)
 5    WRITE(7,7)  $READ(7,4)CH  $IF(CH.EQ.1HN.OR.CH.EQ.1H )GOTO8
      WRITE(7,9)  $CALL GETNUM(A)  $YLO=A(1)  $YUP=A(2)
 7    FORMAT(*SET VERTICAL SCALE? Y OR N(=BLANK)*)
 9    FORMAT(*MIN/MAX Y VALUES*)
 8    AA=YUP $IF(YLO.EQ.AA)YUP=YUP+1.  $IF(YLO.EQ.AA)YLO=YLO-1.
      WRITE(7,10)KY(1),KY(2)
 10   FORMAT(*SKIP PLOT OF *,2A10,*?*)
      READ(7,4)IJVAR
      IF(IJVAR.EQ.1HN.OR.IJVAR.EQ.1H )CALL PLOTS(R,T,1,NRECPT)
      WRITE(7,12) $CALL GETNUM(A)  $IRS=A(1)  $IF(IRS.EQ.1)GOTO13
 12   FORMAT(*1 = NEW PLOT, 2 = RETURN*)
      RETURN $END
      SUBROUTINE AMINMX(R,NRECPT,B,A)
      DIMENSION R(50)
      AMIDPT=((R(NRECPT)-R(1))/2.) + R(1)
      A = B =AMIDPT
      DO 1 I=1,NRECPT
      IF(R(I).GT.A)A=R(I)
      IF(R(I).LT.B)B=R(I)
 1    CONTINUE
      RETURN $END
      SUBROUTINE CMPTLT(D,X1,X2,X3,T1,T2)
      DIMENSION D(20)
      A1=A2=A3=A4=B1=B2=B3=B4=0.
      DA1=DA2=DA3=DA4=DB1=DB2=DB3=DB4=0.
      U1=D(17) $U3=D(18)
      IF(U1.EQ.0.)GO TO 1
      CALL TILT(D(17),X1,X2,X3,D(11),D(12),A1,B1)
      CALL TILT(D(17),X1,X2,X3,D(9),D(10),A2,B2)
      CALL TILT(D(17),X1,X2,X3,D(13),D(14),A3,B3)
      CALL TILT(D(17),X1,X2,X3,D(15),D(16),A4,B4)
```

```
    1 IF(U3.EQ.0.)GO TO 2
      CALL DPSFTL(D(18),X1,X2,X3,D(3),D(4),DA1,DE1)
      CALL DPSPTL(D(18),X1,X2,X3,D(1),D(2),DA2,DE2)
      CALL DPSFTL(D(18),X1,X2,X3,D(5),D(6),DA3,DE3)
      CALL DPSFTL(D(18),X1,X2,X3,D(7),D(8),DA4,DE4)
    2 T1=A1-A2-A3+A4+DA1-DA2-DA3+DA4
      T2=B1-B2-B3+B4+DB1-DB2-DB3+DB4
      RETURN $END
      SUBROUTINE TILT(U1,X1,X2,X3,P1,P3,T1,T2)
      R=SQRT((X1-P1)**2+X2**2+(X3-P3)**2)
      RP=R+P3
      T1=(U1/12.5664)*(X2*(X1-P1)*(R*RP-(R+2.*P3)*(2.*R+P3)))/
     1 (R**3*RP**2)
      T2=(U1/12.5664)*(X2**2*(R*RP-(R+2.*P3)*(2.*R+P3))/(R**3*RP**2)
     1 +(R+2.*P3)/(R*RP))
      RETURN $END
      SUBROUTINE DPSPTL(U3,X1,X2,X3,P1,P3,DT1,DT2)
      R=SQRT(((X1-P1)**2)+(X2**2)+((X3-P3)**2))
      DT1=(U3/6.28318)*((X2*P3)/R)*((1./(R**2))-(1./(((X1-P1)
     1 **2)+(X2**2))))
      DT2=(U3/6.28318)*(((X1-P1)*P3)/((X2**2)+(P3**2)))*(((P3**2)
     1 -(X2**2))/(R*((X2**2)+(P3**2)))+((((X1-P1)**2)+(P3**2))
     1 /(R**3))+((X2**2)+(P3**2))/(R*(((X1-P1)**2)+(X2**2))))
      RETURN $END
      SUBROUTINE GETNUM(R)
      DIMENSION R(1),L(80)
      READ(7,9)L $ I=J=0
    6 J=J+1 $ N=P=S=0 $ M=F=1
    5 I=I+1 $ IF(I.GT.80)RETURN $ D=L(I) $ K=4
      IF(D.EQ.38)K=2 $ IF(D.GE.27.A.D.LE.36)K=1
      IF(D.EQ.47)K=3 $ K=K+S $ GOTO(1,2,3,5,1,4,3,4)K
    1 N=N*10+D-27                 $ S=4          $ GOTO 5
    2 M=-1                        $ S=4          $ GOTO 5
    3 P=I                         $ S=4          $ GOTO 5
    4 IF(P.NE.0)F=10.**(I-P-1)    $ R(J)=N/F*M   $ GOTO 6
    9 FORMAT(80F1)
      END
```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D. PROGRAM DSPLAY

Introduction

It has often been necessary to display digitized tiltmeter and creepmeter data, particularly when enlarged copies of short period events made from the raw records have been digitized. The method used to display the data must be sufficiently flexible that scale changes can be made easily and that portions of the data set can be enlarged or compressed. Program DSPLAY was developed to meet these requirements.

Access and Use

The program is intended for use on the LBL 6600B or C computer and the Tektronix 4010-1 terminal and required 50K of core. The program requires a data set labelled 'EVENTS' on library MCHUGH; if the data is stored elsewhere lines 6 and 10 in the program must be altered. DSPLAY is accessed using the command ^LOAD, DSPLAY, MCHUGH; and the ^LOAD command may be followed by an ^RUN.

Input

The data is assumed to be in the form:

```
          Header Card
          Data Block
              .
              .
     N        .

          Header Card
          Data Block
          EOR
```

There is no limit to the number of events, N, that may be read, but each data block must contain no more than 1000 data points (i.e. 1000 (x,y) pairs).

The Header Card is assumed to contain the following variables with the format indicated:

LTITL(1), LTITL(2), . . ., LTITL(7), RA, B, C

(eg. SASN01/03/74 .163 12.0 .192)

A3, A1, A2, A1, A2, A1, A2, 8x, 3F10.3

LTITL(1) is the station code (3 characters); LTITL(2) is the component--north or east (1 character) in the case of tilt data; LTITL(3), LTITL(5), and LTITL(7) are the month, day, and year respectively (2 characters each); LTITL(4) and LTITL(6) are ignored in the program; RA, B, C are scale factors used in the program and will be explained below. If it is desired to structure the Header Card differently, lines 25 and 26 in the program must be altered.

Each line in the data block is assumed to have a format of (6(2F6.3)); for example:

$x_1, y_1, x_2, y_2, \ldots, x_6, y_6$

-15370+04204-15330+04200 .... -14990+04190 .

If a different format is desired, lines 39 to 42 may be altered. The data block is terminated when either x(I) or y(I) is equal to 999.999. The upper limit of the array index, I, need not be specified, the computer will automatically determine the number of data points it reads.

Unlike the input to program ONSTSP, the input to DSPLAY need not be arranged such that the north-south component of the tilt data is read prior to the east-west component data. Each component is treated independently of all others. Consequently, creepmeter data or tiltmeter data with only one component present may be displayed.

Program Operation

The data is assumed to be in x, y form (eg. north-south tilt amplitude versus time). In addition to displaying this data as a plot of 'y' versus 'x', the computer will rescale the data. If the input is digitized data, the units of x and y are typically hundredths or thousandths of an inch. The scale factors RA, B, and C are used to convert the data to microradians, millimeters, hours, or whatever other units are desired. The conversion is assumed to be of the form:

x(I) = RA* X(I) +B

y(I) = C* Y(I)* 1000. (lines 54 through 59)

If B = 0. on the Header Card, the computer sets B = -RA*x(1). If Sage South tiltmeter data prior to 19 December 1974 (when +x = south, +y = east) is submitted, the computer automatically converts the coordinate system to +x = east, +y = north (lines 29 to 35 and lines 50 to 55). The minimum and maximum amplitude (y) and initial and final x values are determined in lines 60 to 67.

Output

The contents of the Header Card are written, followed by: TO SKIP, PUT 1 IN COL 1. Entering a 1 causes the computer to skip that data block. Any other number entered will cause the data to be read. After reading and re-scaling the data, the computer writes:

min/max x values (numerical values)

min/max y values (numerical values)

The computer then requests plotting information:

Set horizontal scale ? Y or N (= blank)

If an N (no) or blank (space) is entered, the computer requests information for the vertical scale (described below). If a Y (yes)is entered, the computer responds:

min/max x values

The endpoints of the x axis must be entered. Then the computer writes:

Set vertical scale? Y or N (= blank)

If an N or blank is entered, the endpoints of the vertical axis are the minimum and maximum y values determined from the input. If a Y is entered, the endpoints of the vertical axis must be entered. The plot is displayed after the scaling information is provided. The plots are titled using the information on the Header Card. The axes are labelled with the information in lines 68 through 71.

After the plot is displayed, entering a blank (space) causes the computer to return to the main program. The computer will write:

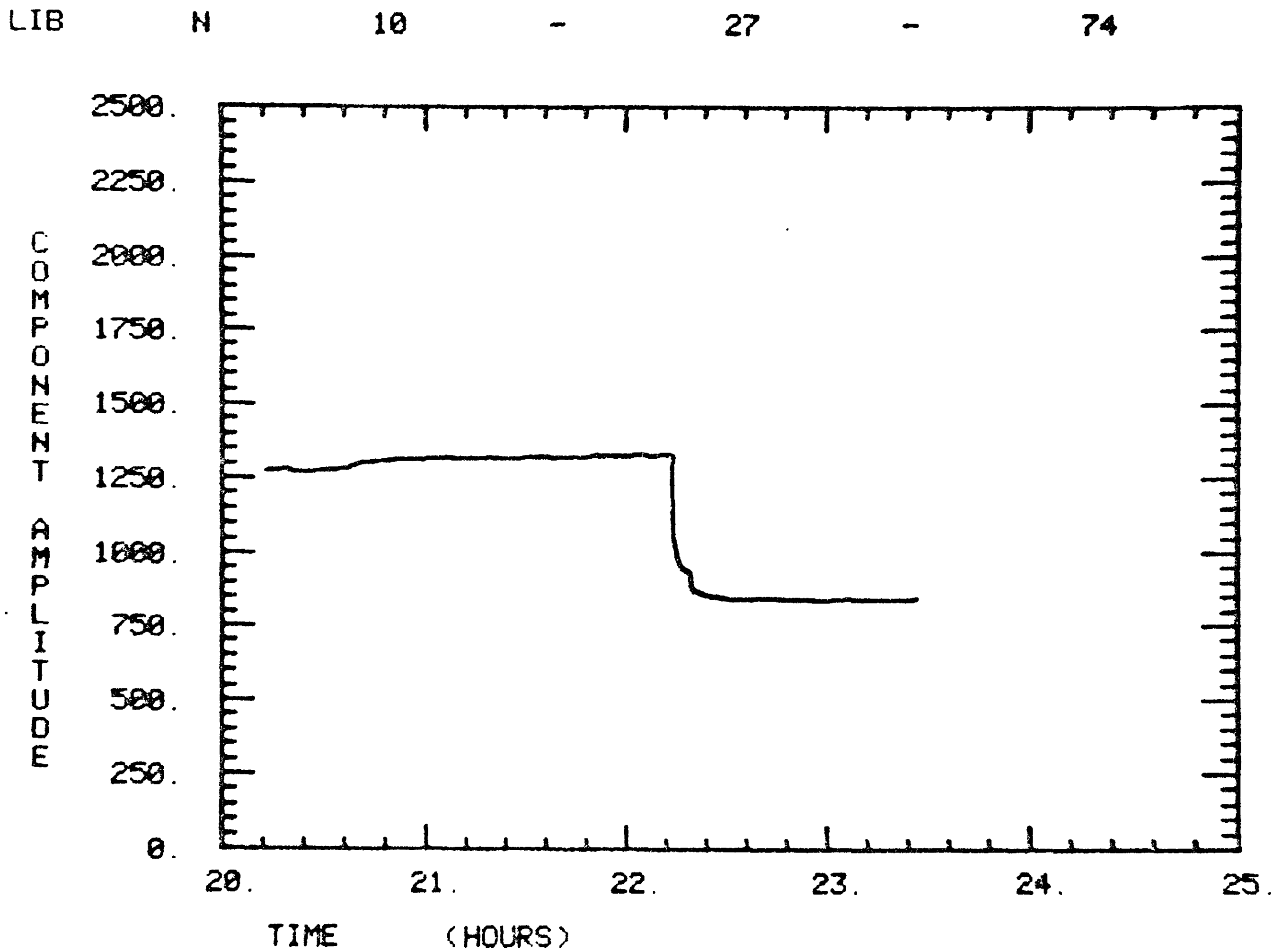
New plot = 1

Entering a 1 allows new scaling information to be provided and a new graph to be plotted. Any other number causes a new data set to be read.

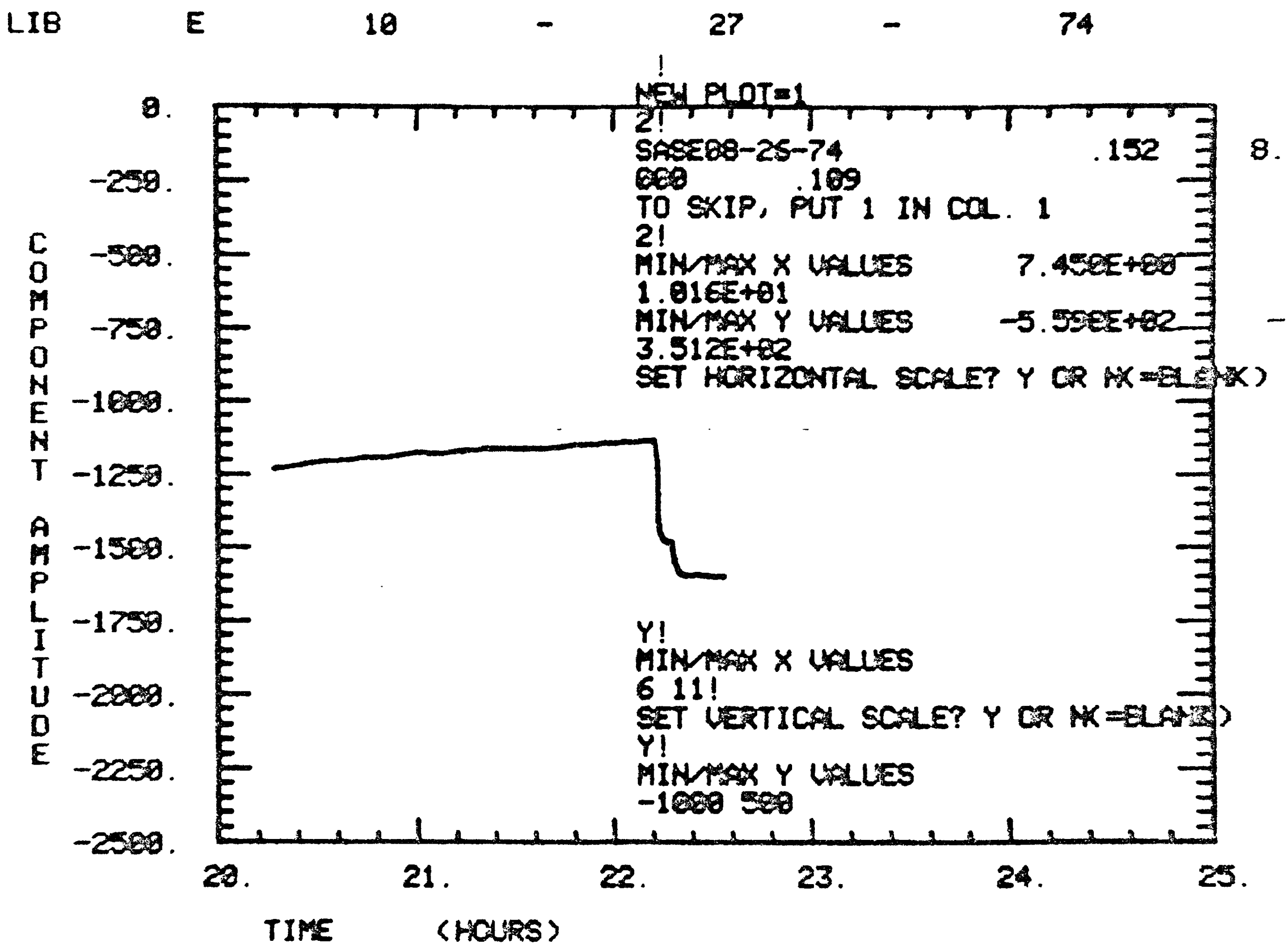
Examples of the program operation are provided on pages 3-D.6 through 3-D.40. The program listing is on pages 3-D.41 through 3-D.44.

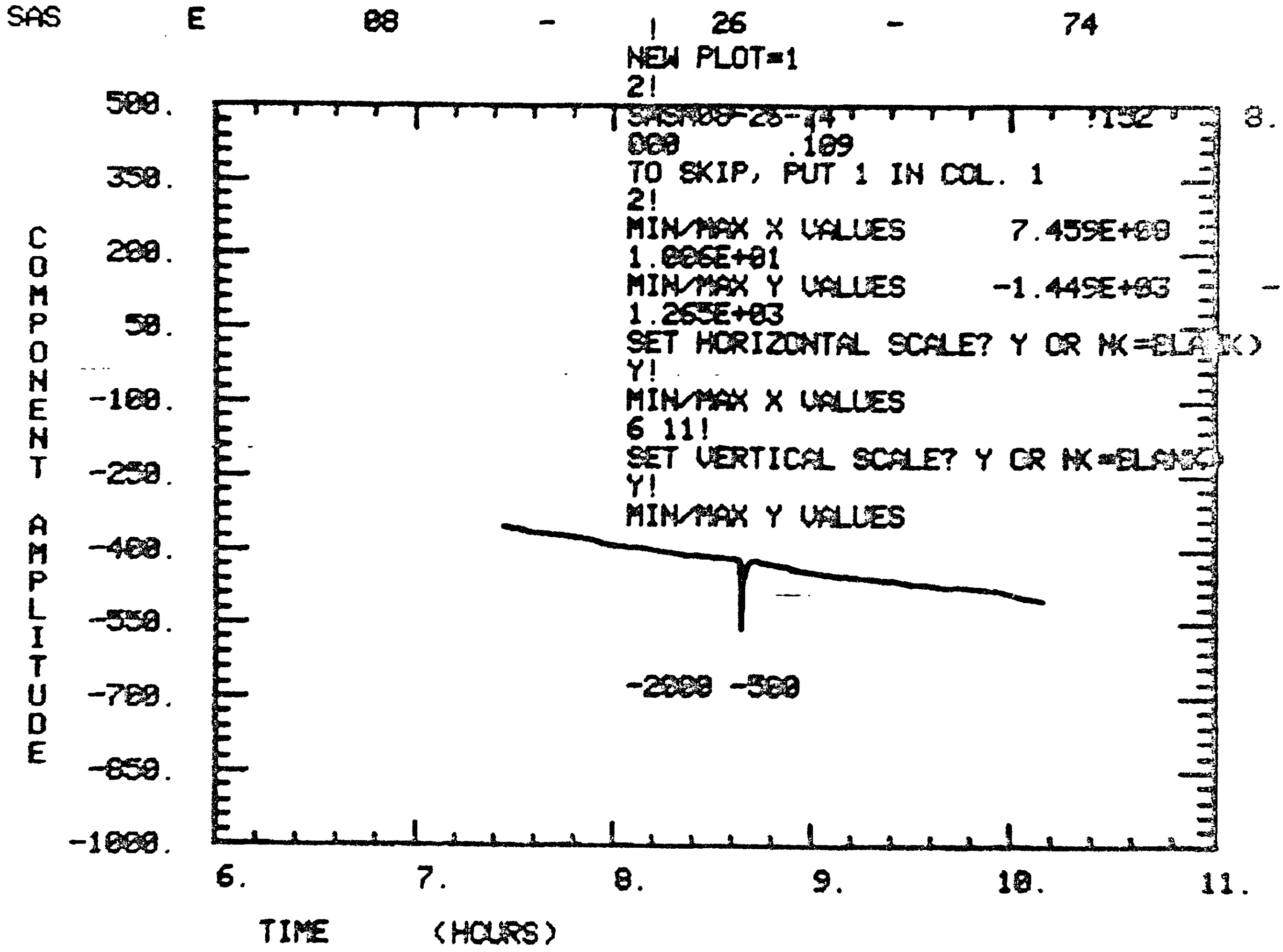
EXAMPLE OF DSPLAY OPERATION

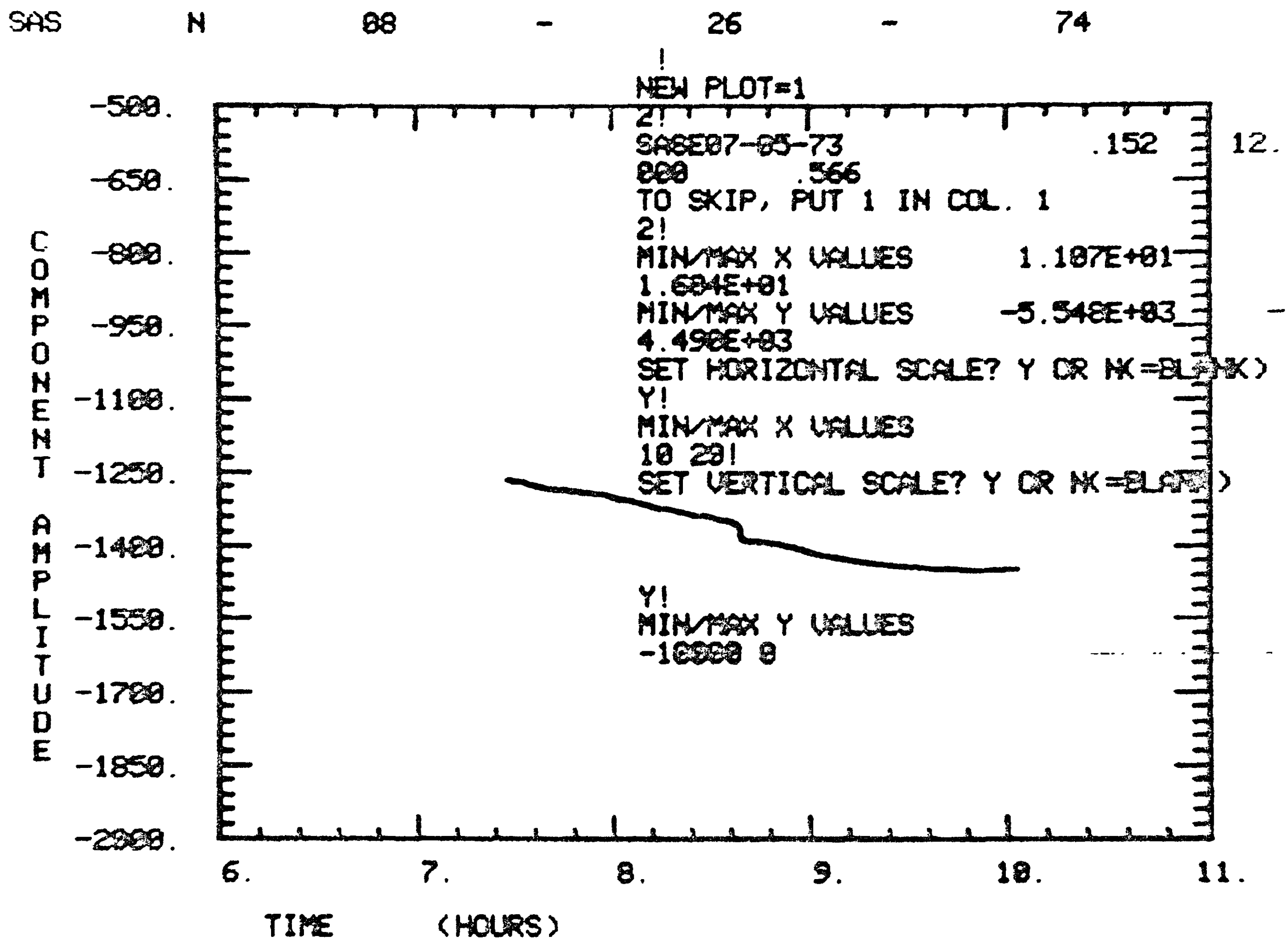
```
^LOAD,DSPLAY,MCHUGH!
LOAD COMPLETE, ENTERING ^EDIT
OK - ^EDIT
^RUN!
LIBN10-27-74                 .147    21.000      .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES      2.022E+01      2.345E+01
MIN/MAX Y VALUES      8.391E+02      1.328E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
0 2500
```


LIB N 10 - 27 - 74
COMPONENT AMPLITUDE
2500.
2250.
2000.
1750.
1500.
1250.
1000.
750.
500.
250.
0.
20.
21.
22.
23.
24.
25.
TIME (HOURS)

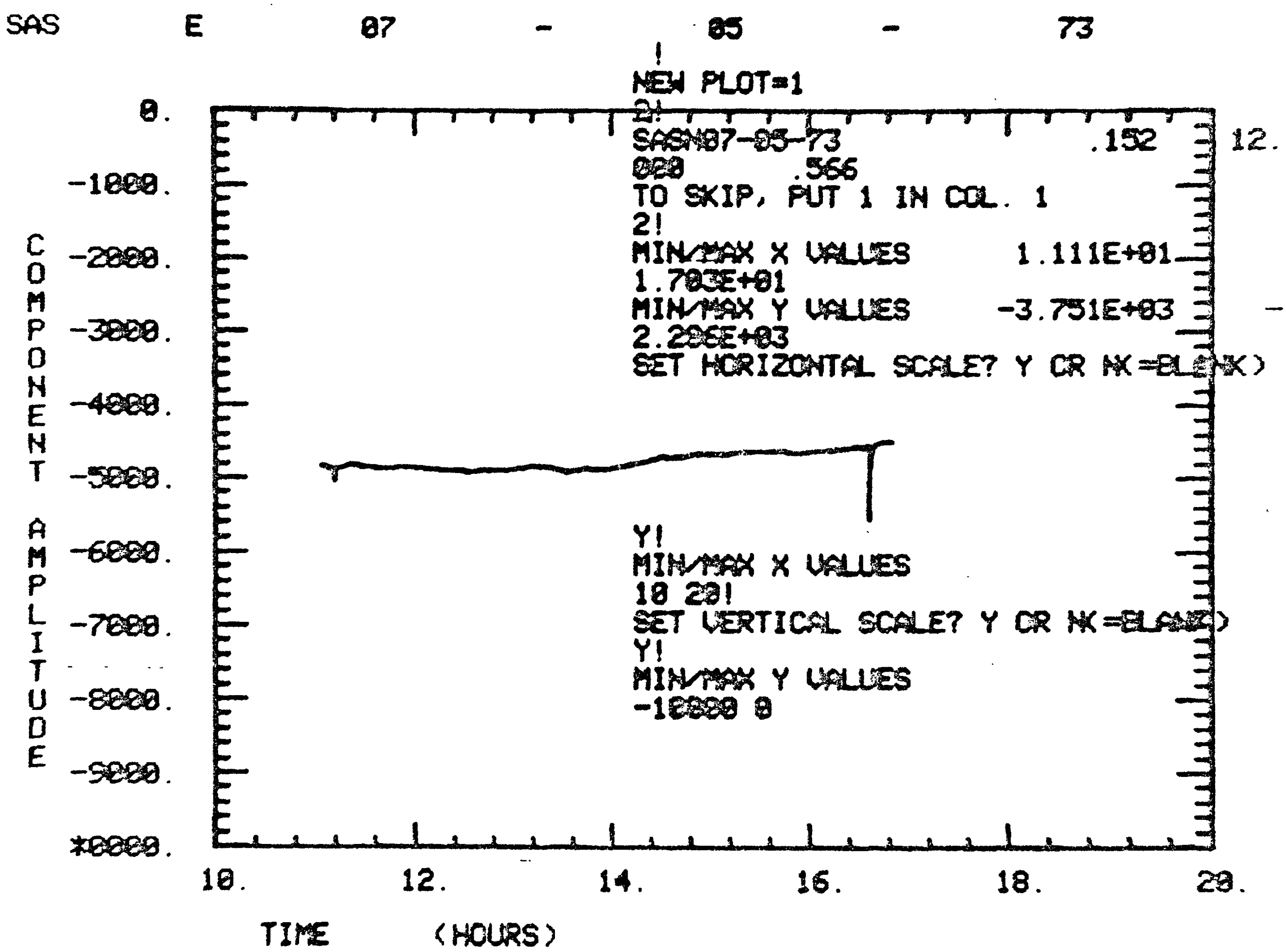
```
 !
NEW PLOT=1
2!
LIBE10-27-74                    .147     21.000      .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES       2.028E+01       2.256E+01
MIN/MAX Y VALUES      -1.600E+03      -1.135E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-2500 0
```

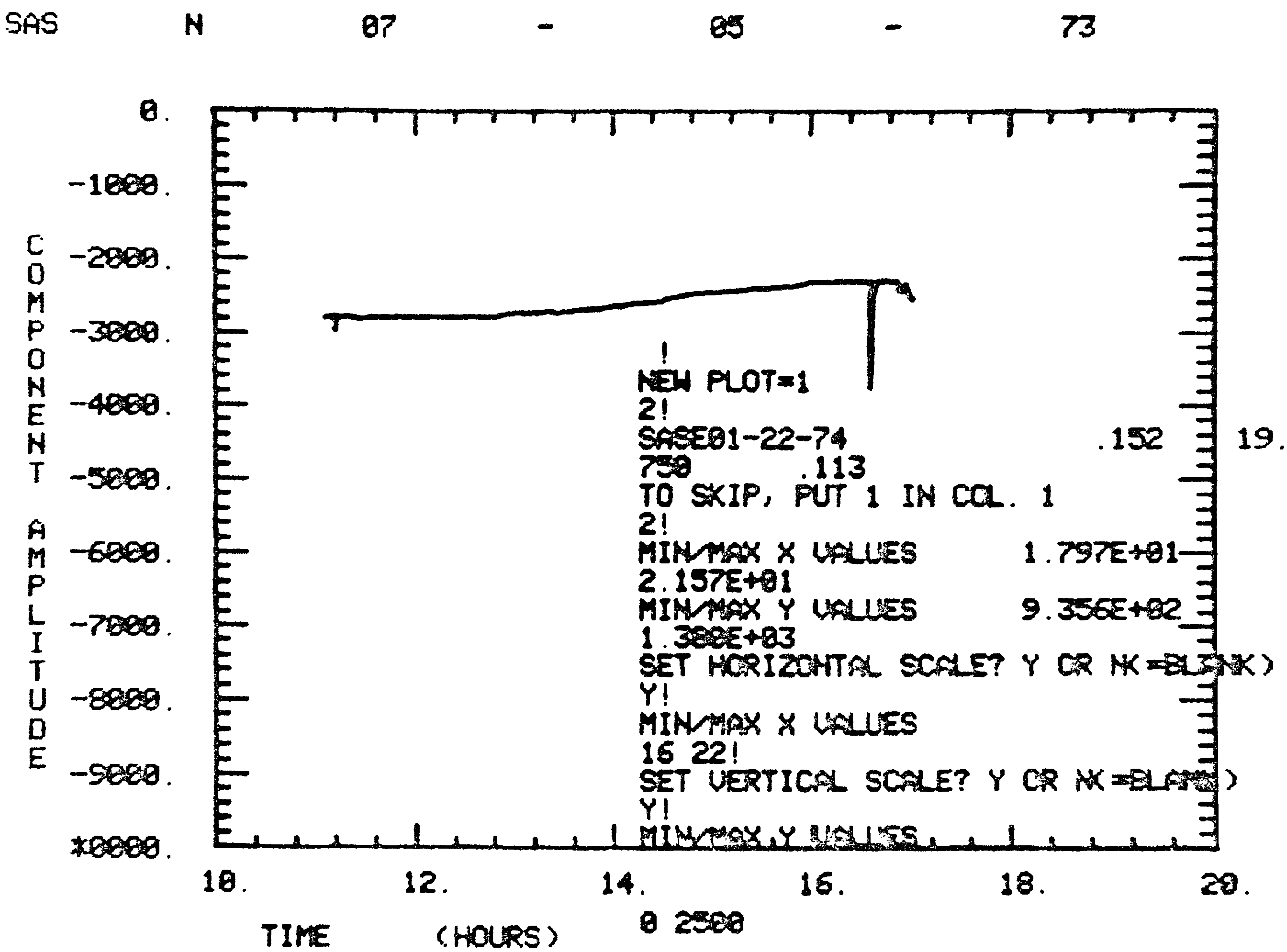

LIB E 10 - 27 - 74
NEW PLOT=1
2!
SASE08-26-74
000 .109
.152
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 7.450E+00
1.016E+01
MIN/MAX Y VALUES -5.590E+02
3.512E+02
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-1000 500
COMPONENT AMPLITUDE
0.
-250.
-500.
-750.
-1000.
-1250.
-1500.
-1750.
-2000.
-2250.
-2500.
20.
21.
22.
23.
24.
25.
TIME (HOURS)

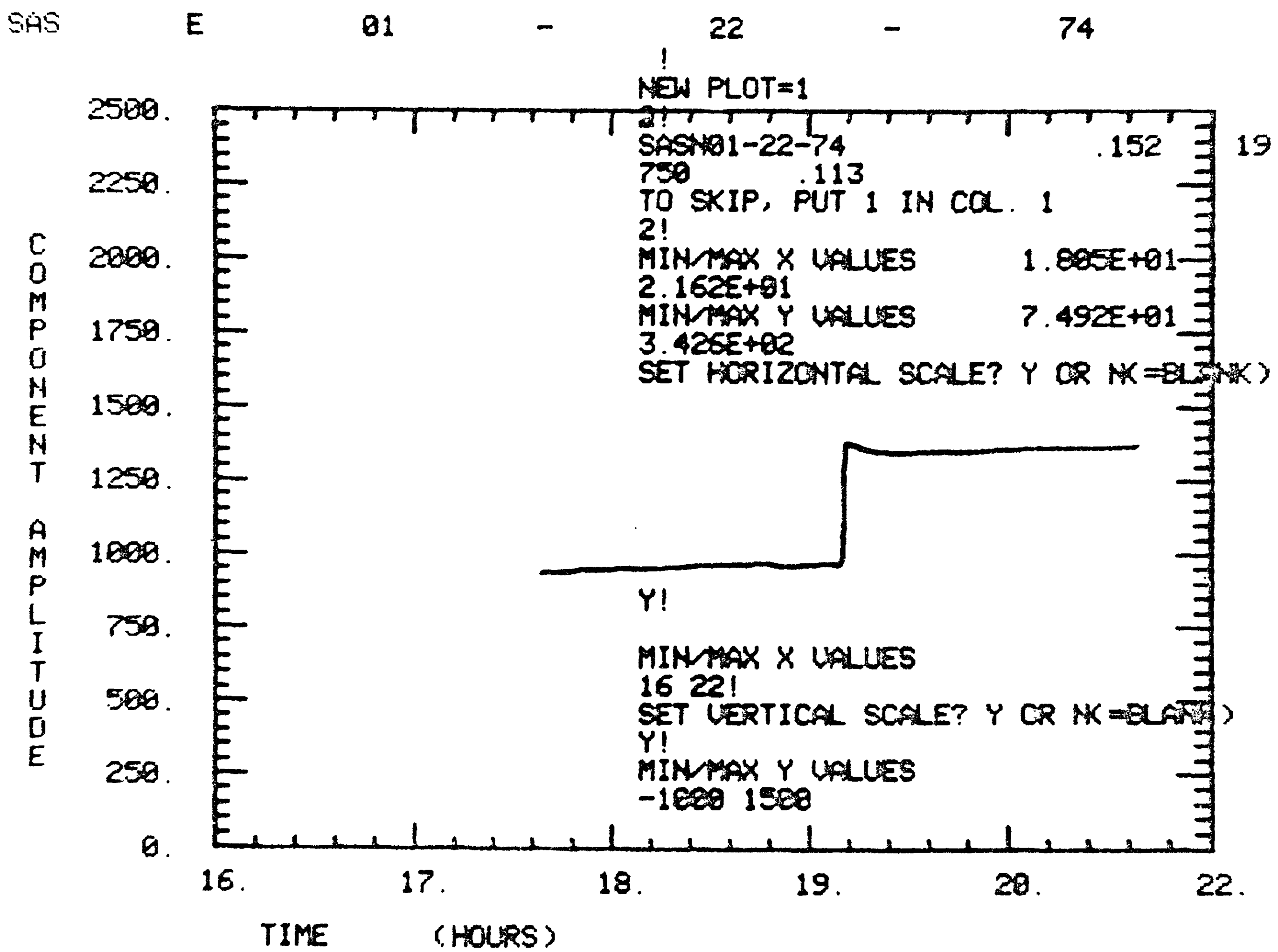

SAS E 08 - 26 - 74
NEW PLOT=1
2!
000 .109
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 7.459E+00
1.006E+01
MIN/MAX Y VALUES -1.449E+03
1.265E+03
Y!
MIN/MAX X VALUES
6 11!
Y!
MIN/MAX Y VALUES
-2000 -500
500.
350.
200.
50.
-100.
-250.
-400.
-550.
-700.
-850.
-1000.
COMPONENT AMPLITUDE
6.
7.
8.
9.
10.
11.
TIME (HOURS)

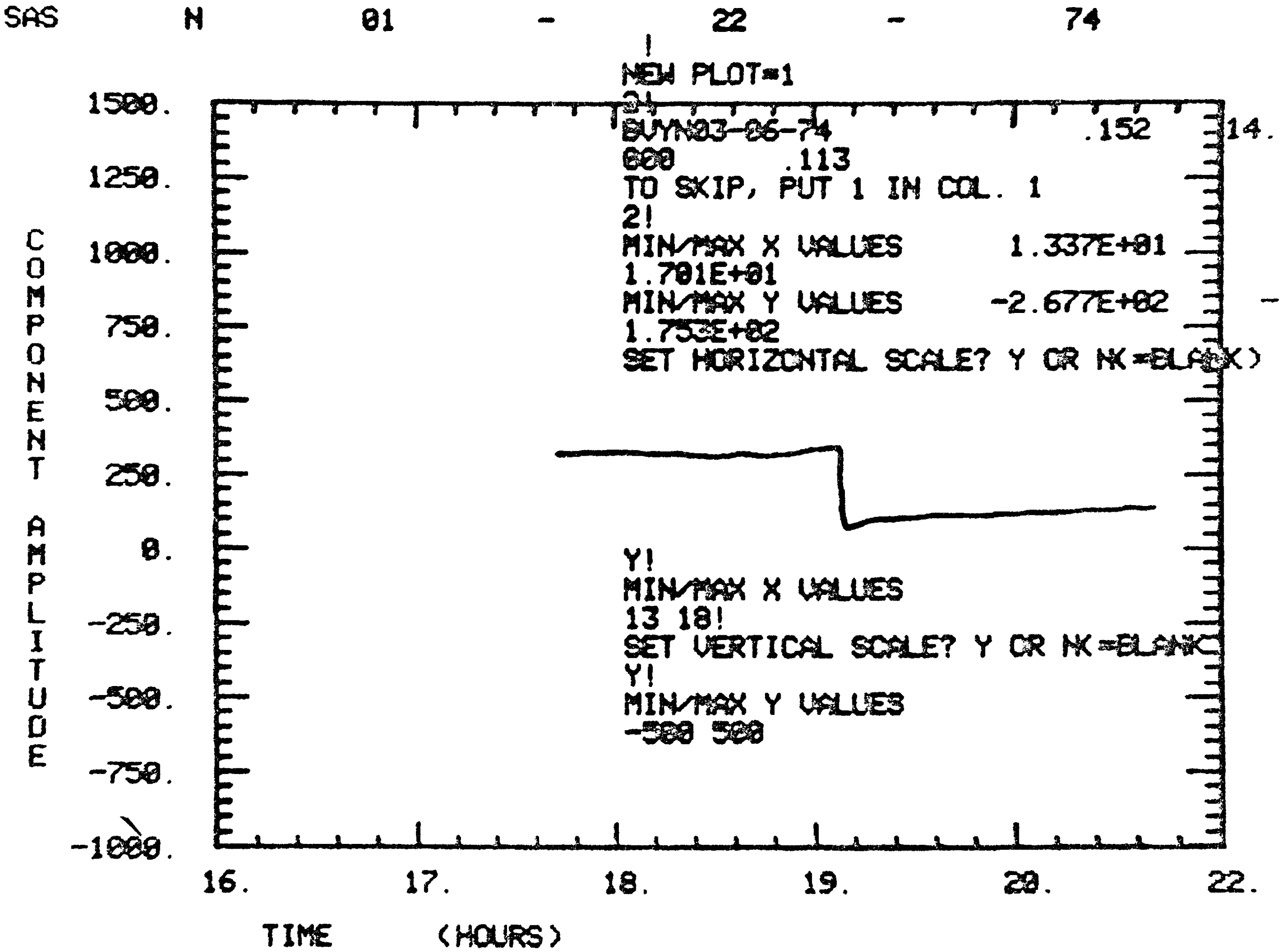


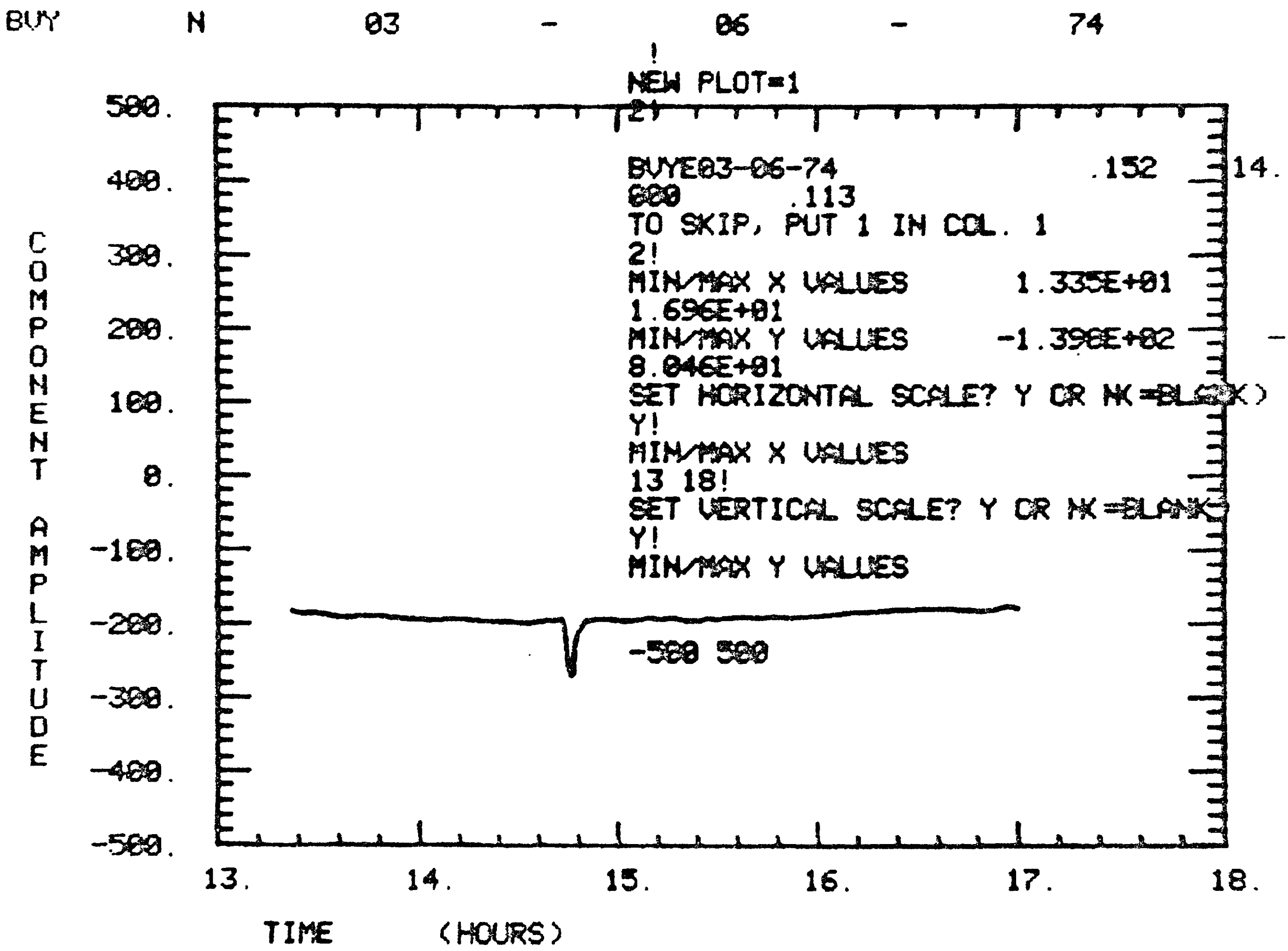
SAS N 08 - 26 - 74
NEW PLOT=1
2!
SASE07-05-73 .152
000 .566
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.107E+01
1.604E+01
MIN/MAX Y VALUES -5.548E+03
4.490E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
10 20!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-10000 0
COMPONENT AMPLITUDE
-500.
-650.
-800.
-950.
-1100.
-1250.
-1400.
-1550.
-1700.
-1850.
-2000.
12.
6.
7.
8.
9.
10.
11.
TIME (HOURS)

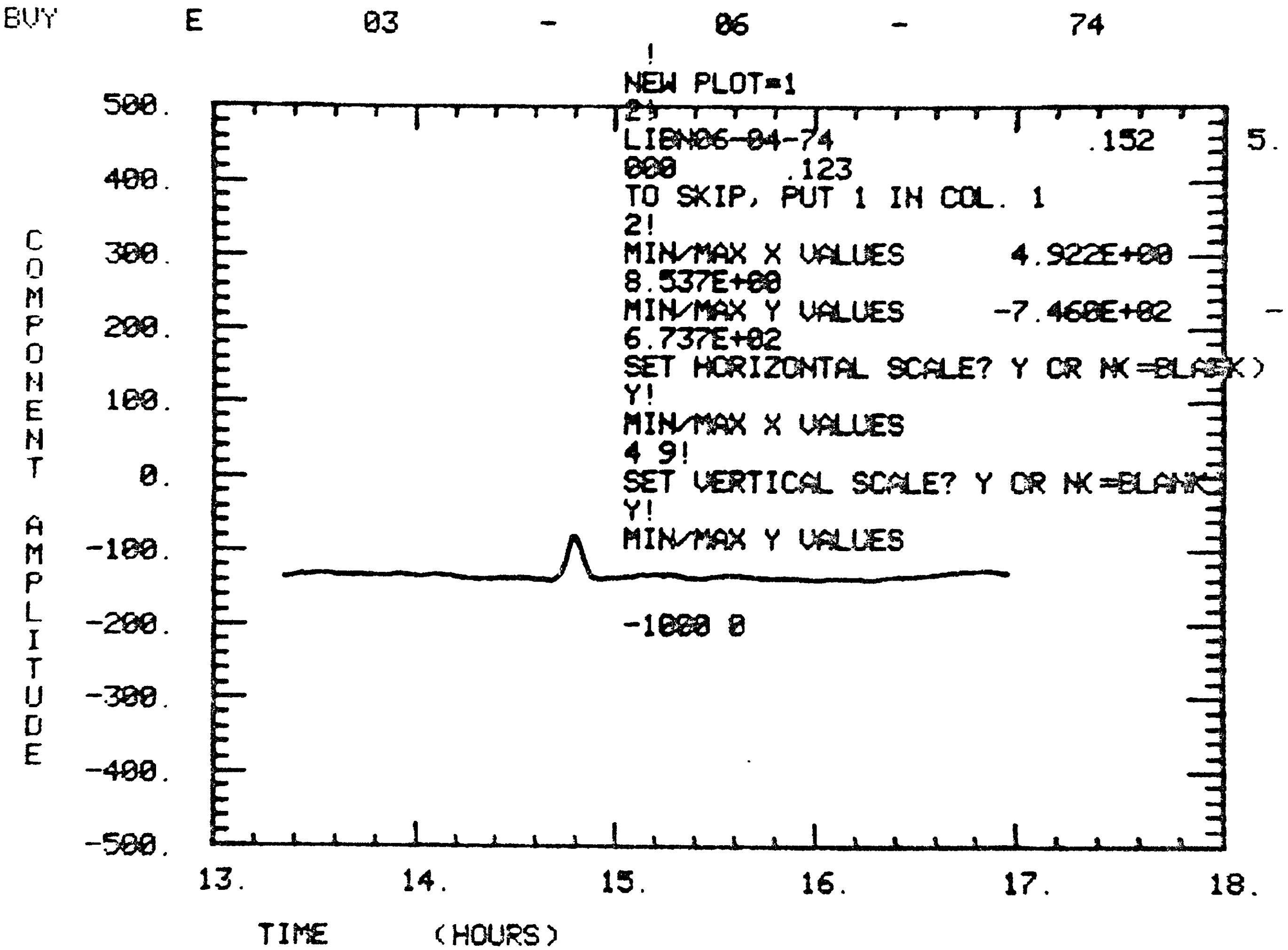

SAS E 07 - 05 - 73
NEW PLOT=1
2!
SASN07-05-73 .152
020 .566
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.111E+01
1.703E+01
MIN/MAX Y VALUES -3.751E+03
2.206E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
10 20!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-10000 0
12.
0.
-1000.
-2000.
-3000.
-4000.
-5000.
-6000.
-7000.
-8000.
-9000.
*0000.
COMPONENT AMPLITUDE
10.
12.
14.
16.
18.
20.
TIME (HOURS)

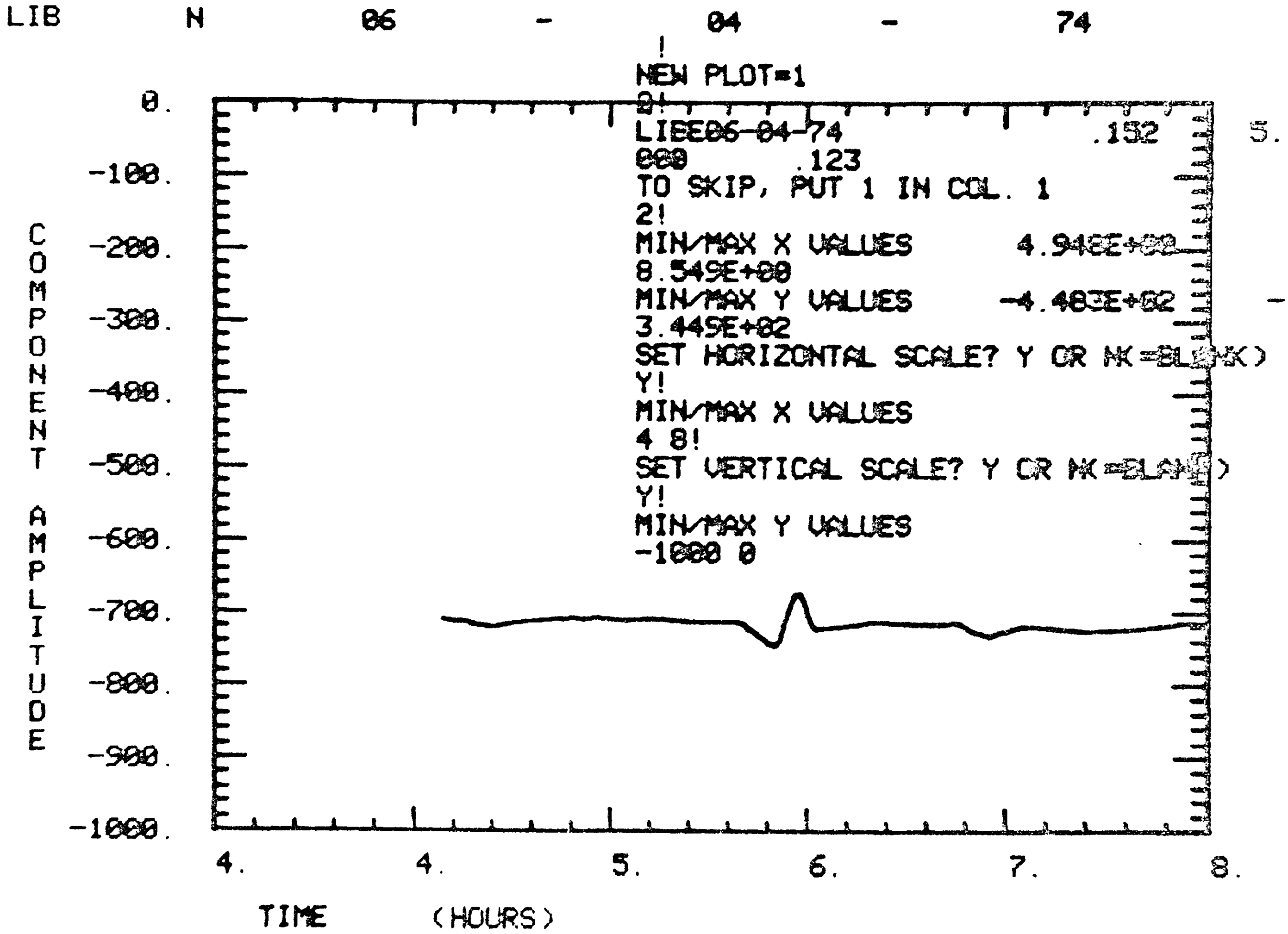

SAS N 07 - 05 - 73
0.
-1000.
-2000.
-3000.
-4000.
-5000.
-6000.
-7000.
-8000.
-9000.
*0000.
COMPONENT AMPLITUDE
10.
12.
14.
16.
18.
20.
TIME (HOURS)
!
NEW PLOT=1
2!
SASE01-22-74 .152 19.
750 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.797E+01
2.157E+01
MIN/MAX Y VALUES 9.356E+02
1.388E+03
SET HORIZONTAL SCALE? Y OR NK =BLANK)
Y!
MIN/MAX X VALUES
16 22!
SET VERTICAL SCALE? Y OR NK =BLANK)
Y!
MIN/MAX Y VALUES
0 2500

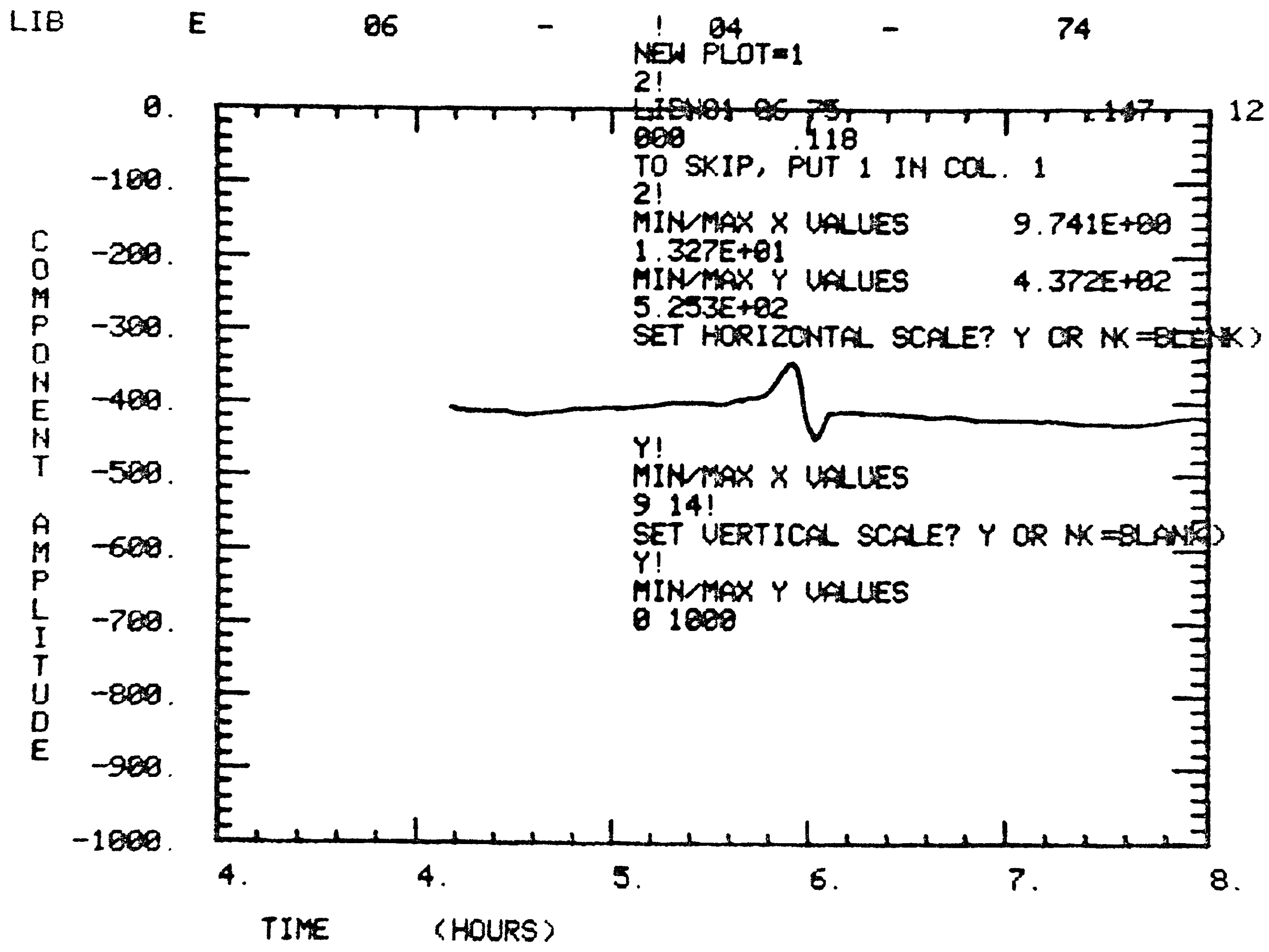

SAS E 01 - 22 - 74
NEW PLOT=1
2!
SASN01-22-74 .152 19.
750 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.805E+01
2.162E+01
MIN/MAX Y VALUES 7.492E+01
3.426E+02
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
16 22!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1500
2500. 2250. 2000. 1750. 1500. 1250. 1000. 750. 500. 250. 0.
COMPONENT AMPLITUDE
16. 17. 18. 19. 20. 22.
TIME (HOURS)

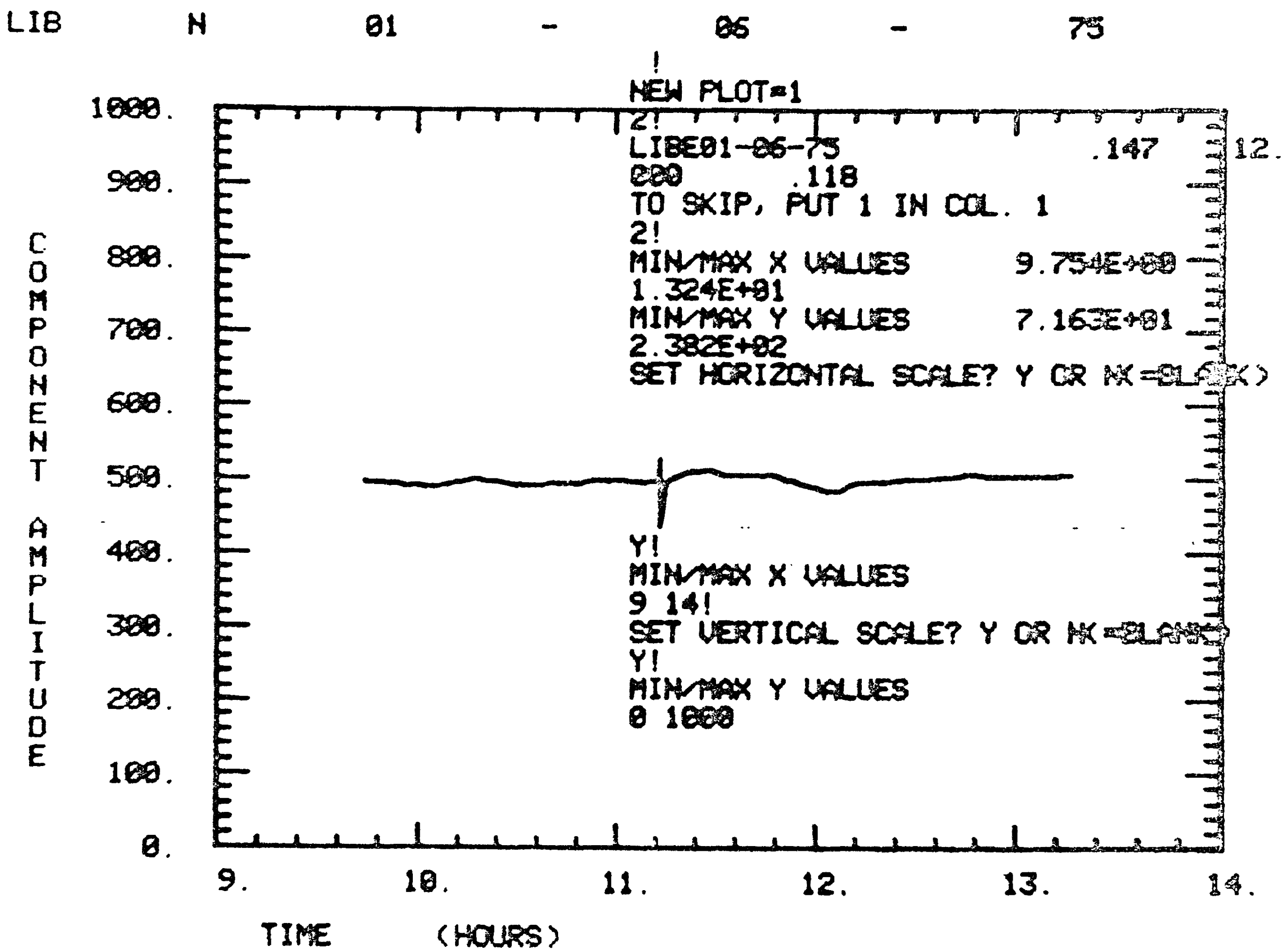

SAS N 01 - 22 - 74
NEW PLOT=1
2!
BUYN03-06-74 .152
600 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.337E+01
1.701E+01
MIN/MAX Y VALUES -2.677E+02
1.753E+02
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX X VALUES
13 18!
SET VERTICAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX Y VALUES
-500 500
COMPONENT AMPLITUDE
1500.
1250.
1000.
750.
500.
250.
0.
-250.
-500.
-750.
-1000.
16.
17.
18.
19.
20.
22.
14.
TIME (HOURS)

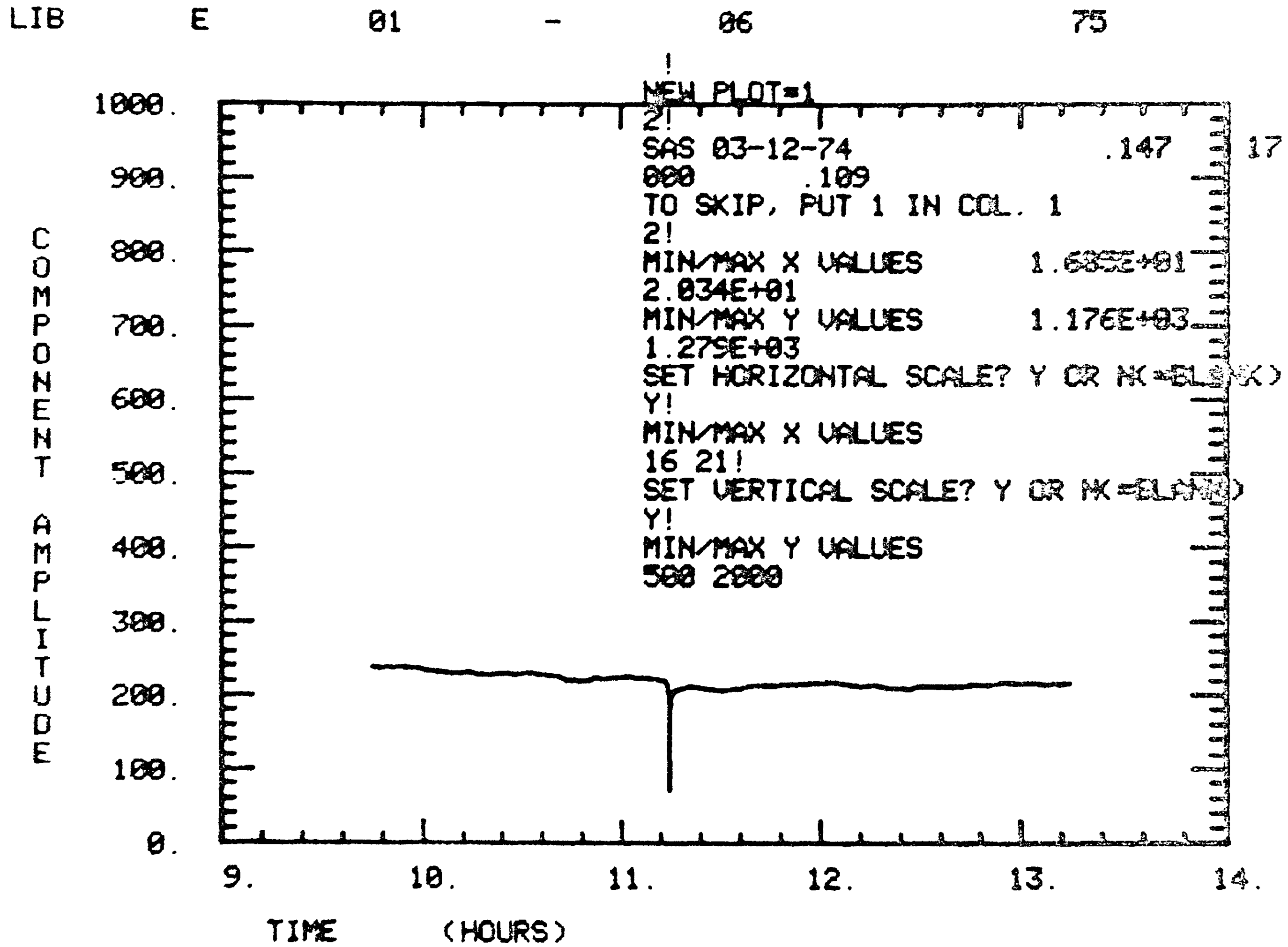

BUY N 03 - 06 - 74
NEW PLOT=1
BVYE03-06-74 .152
000 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.335E+01
1.696E+01
MIN/MAX Y VALUES -1.390E+02
8.046E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
13 18!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-500 500
COMPONENT AMPLITUDE
500.
400.
300.
200.
100.
0.
-100.
-200.
-300.
-400.
-500.
13.
14.
15.
16.
17.
18.
TIME (HOURS)

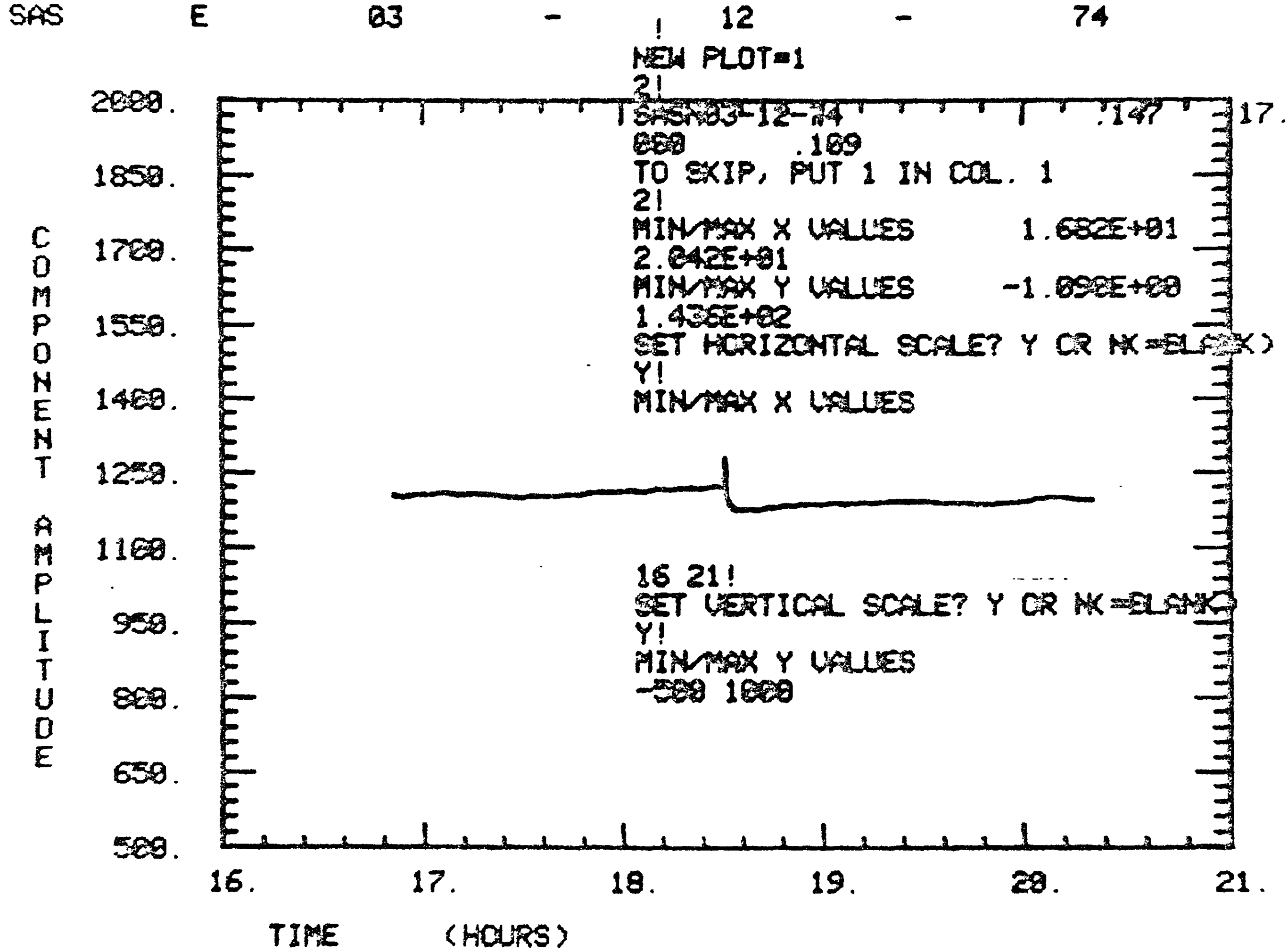

BUY E 03 - 06 - 74
!
NEW PLOT=1
2!
LIBN06-04-74 .152 5.
000 .123
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 4.922E+00
8.537E+00
MIN/MAX Y VALUES -7.460E+02
6.737E+02
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX X VALUES
4 9!
SET VERTICAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX Y VALUES
-1000 0
500.
400.
300.
200.
100.
0.
-100.
-200.
-300.
-400.
-500.
COMPONENT AMPLITUDE
13.
14.
15.
16.
17.
18.
TIME (HOURS)

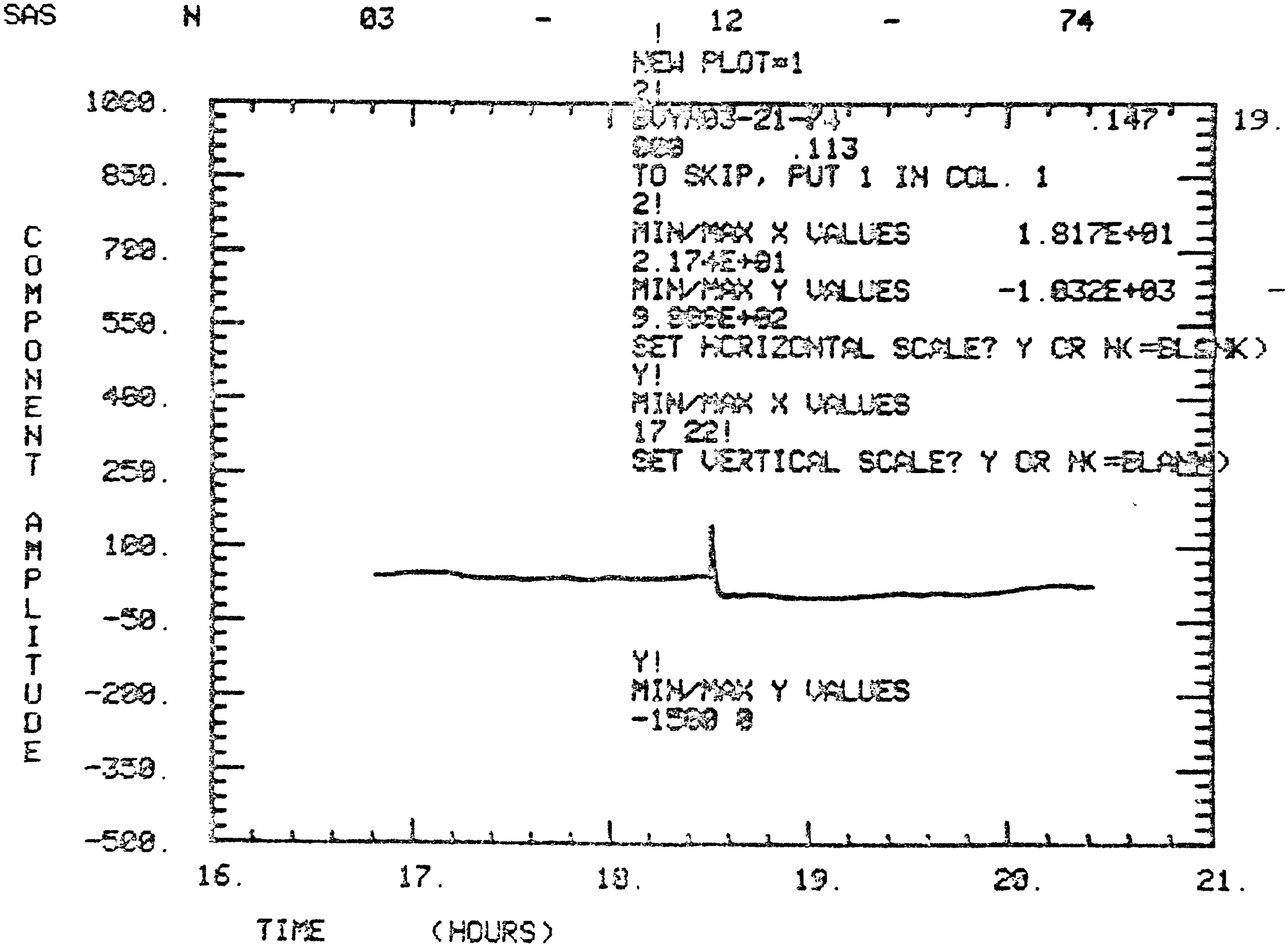

LIB N 06 - 04 - 74
NEW PLOT=1
LIBE06-04-74
.123
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 4.94
8.549E+00
MIN/MAX Y VALUES -4.48
3.449E+02
SET HORIZONTAL SCALE? Y OR N
Y!
MIN/MAX X VALUES
4 8!
SET VERTICAL SCALE? Y OR N
Y!
MIN/MAX Y VALUES
-1000 0
.152
COMPONENT AMPLITUDE
0.
-100.
-200.
-300.
-400.
-500.
-600.
-700.
-800.
-900.
-1000.
4.
4.
5.
6.
7.
8.
TIME (HOURS)

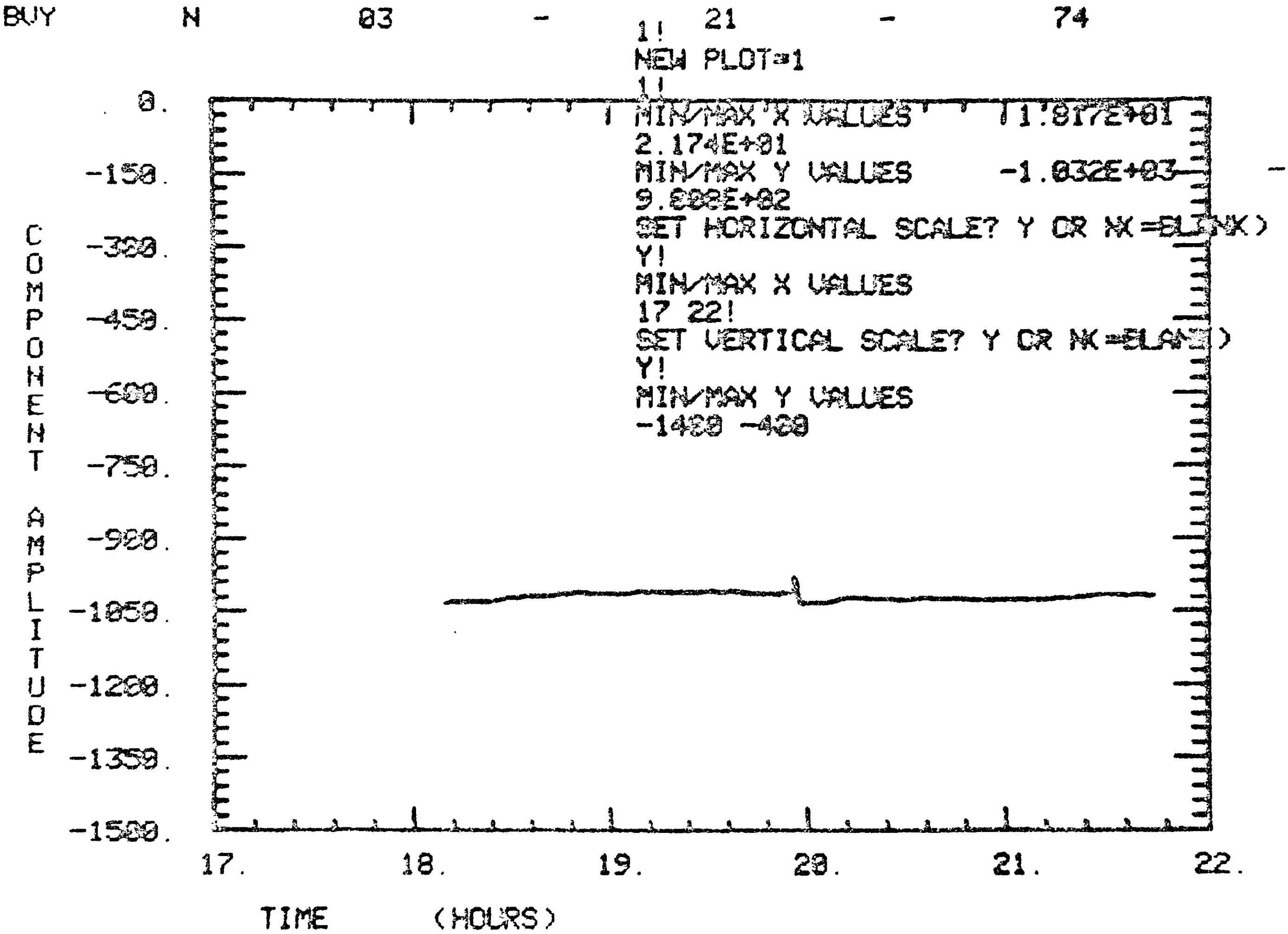

LIB E 06 - ! 04 - 74
NEW PLOT=1
2!
LIBN01 06 75,
000 .118
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 9.741E+00
1.327E+01
MIN/MAX Y VALUES 4.372E+02
5.253E+02
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
9 14!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
0 1000
COMPONENT AMPLITUDE
0.
-100.
-200.
-300.
-400.
-500.
-600.
-700.
-800.
-900.
-1000.
12.
4.
4.
5.
6.
7.
8.
TIME (HOURS)

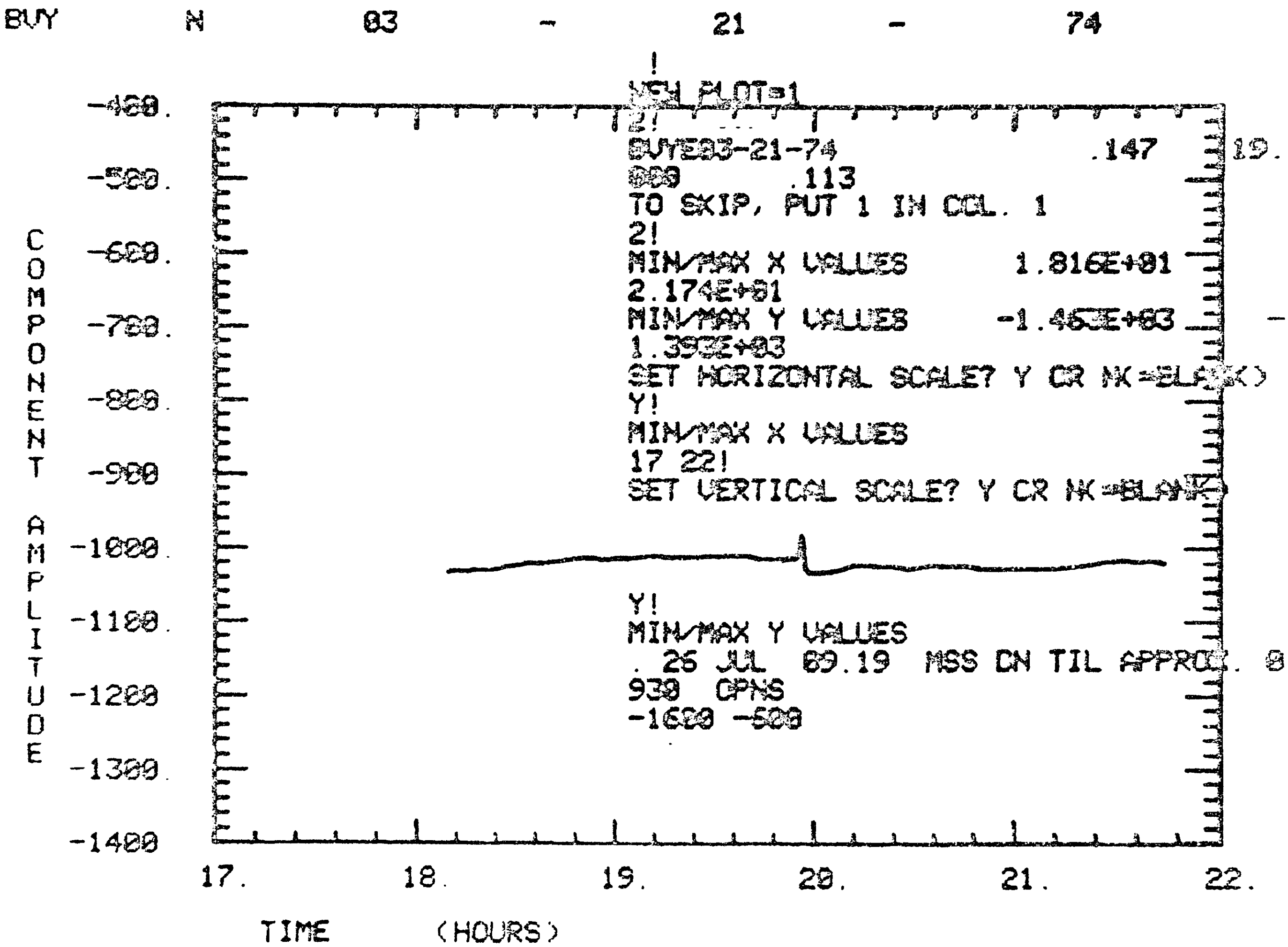

LIB N 01 - 06 - 75
NEW PLOT=1
2!
LIBE01-06-75 .147 12.
000 .118
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 9.754E+00
1.324E+01
MIN/MAX Y VALUES 7.163E+01
2.382E+02
Y!
MIN/MAX X VALUES
9 14!
MIN/MAX Y VALUES
0 1000
1000.
900.
800.
700.
600.
500.
400.
300.
200.
100.
0.
9.
10.
11.
12.
13.
14.
COMPONENT AMPLITUDE
TIME (HOURS)

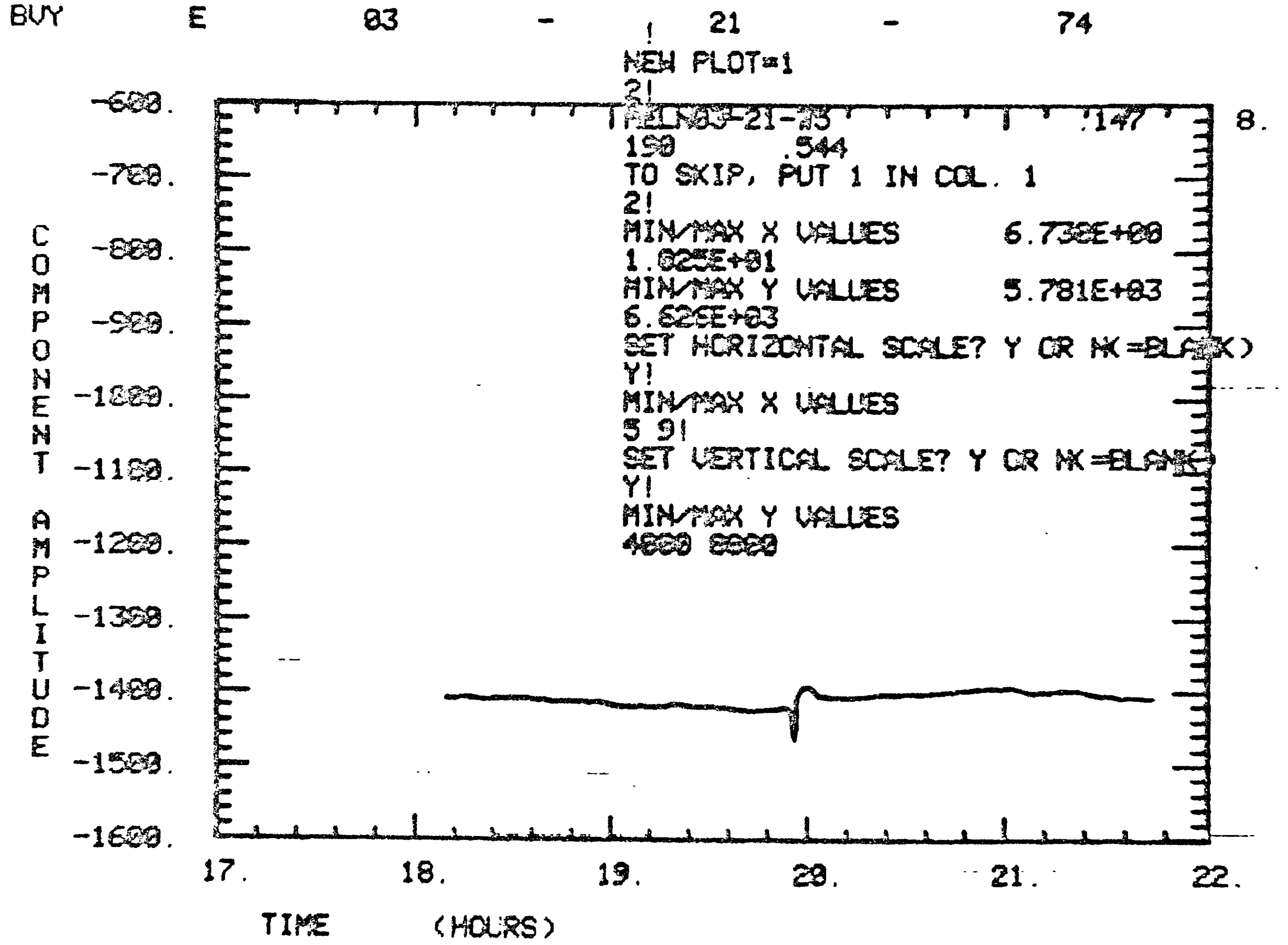

LIB E 01 - 06 75
NEW PLOT=1
2!
SAS 03-12-74 .147 17.
000 .109
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.689E+01
2.034E+01
MIN/MAX Y VALUES 1.176E+03
1.279E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
16 21!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
500 2000
COMPONENT AMPLITUDE
1000. 900. 800. 700. 600. 500. 400. 300. 200. 100. 0.
9. 10. 11. 12. 13. 14.
TIME (HOURS)

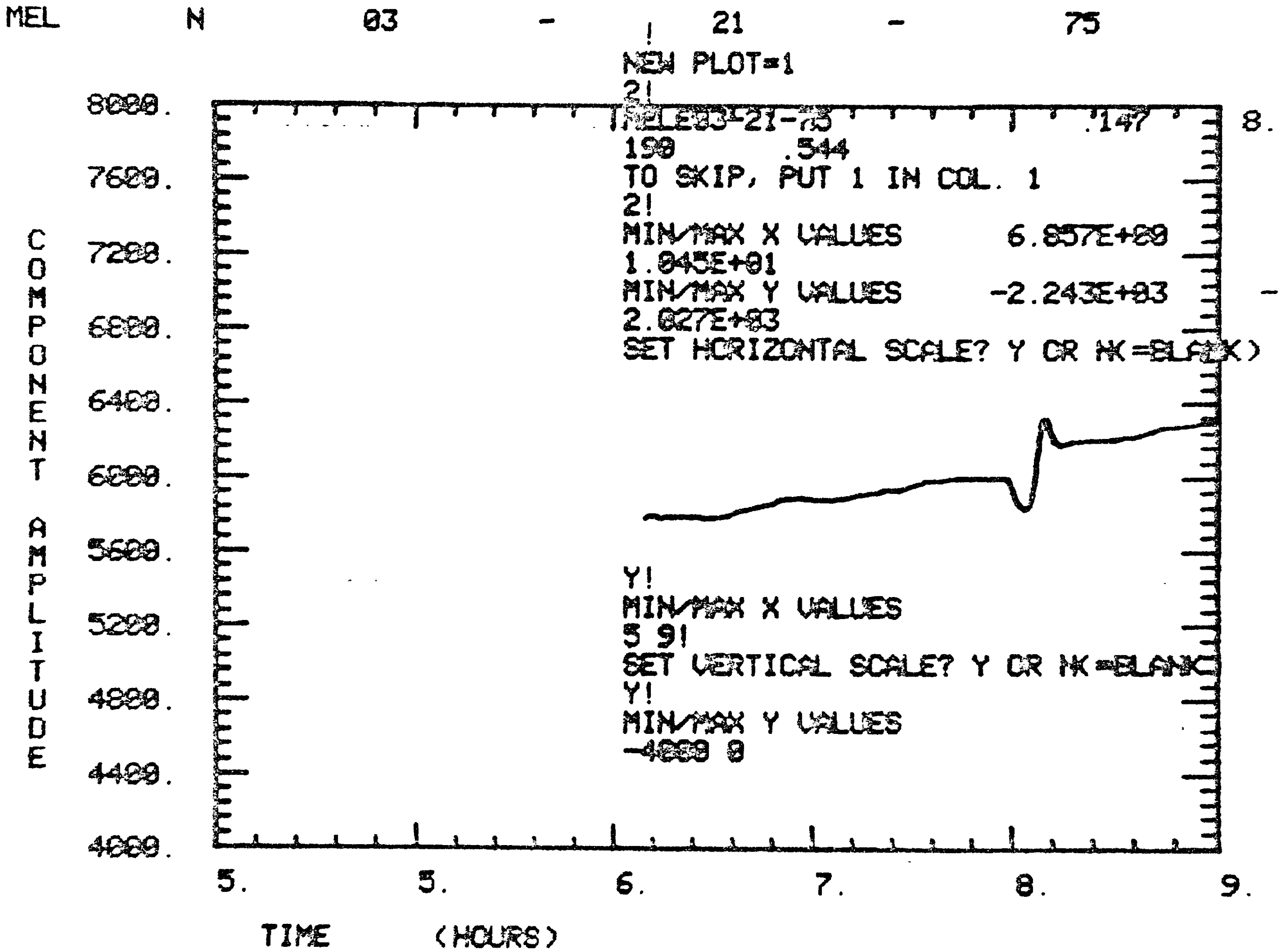

SAS E 03 - 12 - 74
NEW PLOT=1
2!
SASA03-12-74
000 .109
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.682E+01
2.042E+01
MIN/MAX Y VALUES -1.090E+00
1.436E+02
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX X VALUES
16 21!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX Y VALUES
-500 1000
COMPONENT AMPLITUDE
2000.
1850.
1700.
1550.
1400.
1250.
1100.
950.
800.
650.
500.
16.
17.
18.
19.
20.
21.
TIME (HOURS)

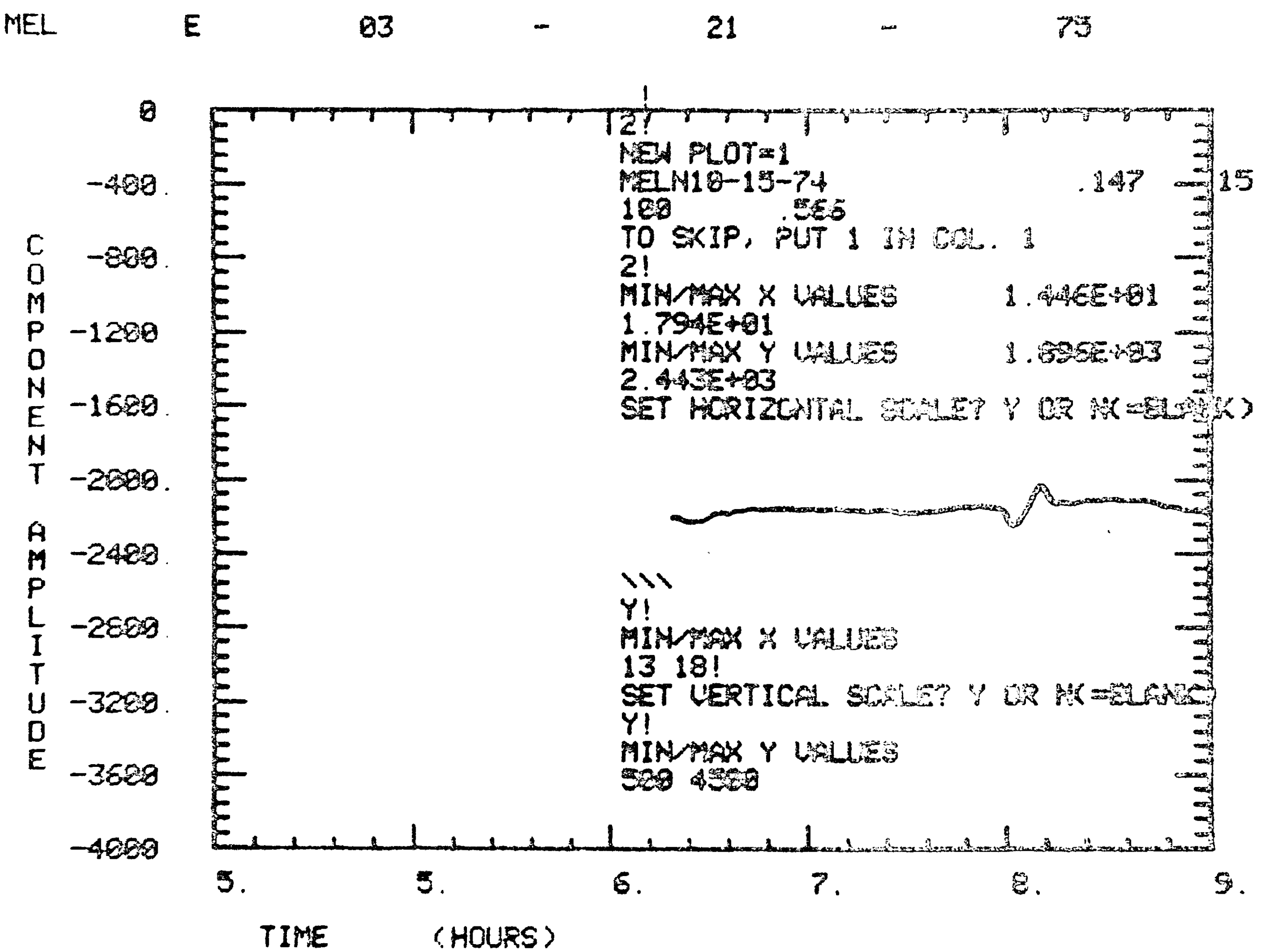

SAS N 03 - 12 - 74
NEW PLOT=1
2!
BUYA03-21-74
.147
.113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.817E+01
2.174E+01
MIN/MAX Y VALUES -1.032E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
17 22!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
COMPONENT AMPLITUDE
1000.
850.
700.
550.
400.
250.
100.
-50.
-200.
-350.
-500.
16.
17.
18.
19.
20.
21.
TIME (HOURS)


BUY N 03 - 21 - 74
1!
NEW PLOT=1
1!
MIN/MAX X VALUES 1.817E+01
2.174E+01
MIN/MAX Y VALUES -1.032E+03 -
9.800E+02
SET HORIZONTAL SCALE? Y OR NX=BLANK)
Y!
MIN/MAX X VALUES
17 22!
SET VERTICAL SCALE? Y OR NX=BLANK)
Y!
MIN/MAX Y VALUES
-1400 -400
0.
-150.
-300.
-450.
-600.
-750.
-900.
-1050.
-1200.
-1350.
-1500.
COMPONENT AMPLITUDE
17.
18.
19.
20.
21.
22.
TIME (HOURS)

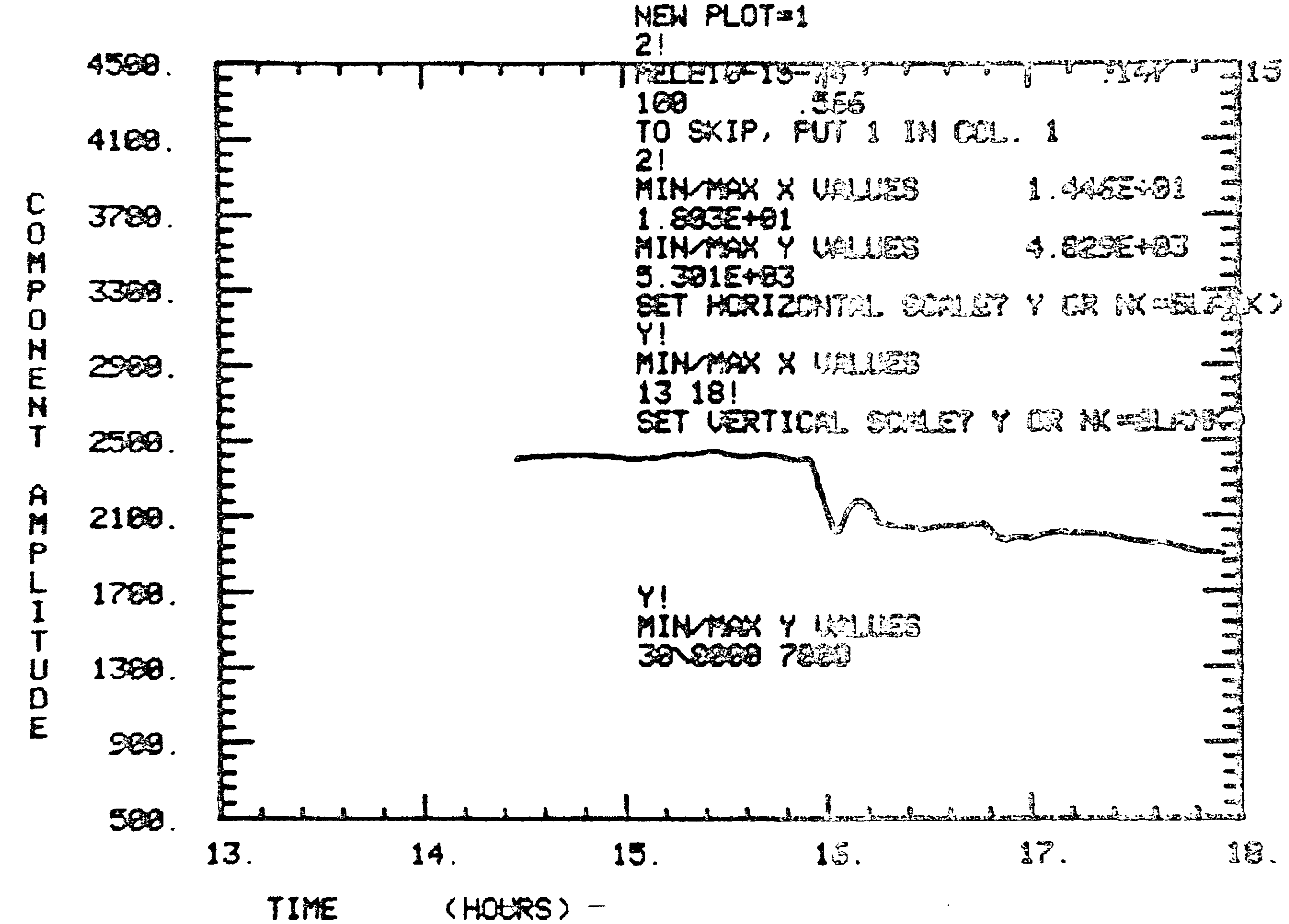

BUY N 03 - 21 - 74
-400.
-500.
-600.
-700.
-800.
-900
-1000.
-1100.
-1200
-1300.
-1400
COMPONENT AMPLITUDE
17.
18.
19.
20.
21.
22.
TIME (HOURS)
NEW PLOT=1
2!
BUYE03-21-74 .147 19.
.113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.816E+01
2.174E+01
MIN/MAX Y VALUES
1.393E+03
SET HORIZONTAL SCALE? Y OR NK
Y!
MIN/MAX X VALUES
17 22!
SET VERTICAL SCALE? Y CR NK
Y!
MIN/MAX Y VALUES
26 JUL 69.19 MSS ON TIL
930 OPNS
-1600 -500


BUY E 03 - 21 - 74
NEW PLOT=1
2!
1 ... 147
190 .544
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 6.730E+00
1.025E+01
MIN/MAX Y VALUES 5.781E+03
6.625E+03
SET HORIZONTAL SCALE? Y OR N
Y!
MIN/MAX X VALUES
5 9!
SET VERTICAL SCALE? Y OR N
Y!
MIN/MAX Y VALUES
4000 8000
8.
-600.
-700.
-800.
-900.
-1000.
-1100.
-1200.
-1300.
-1400.
-1500.
-1600.
COMPONENT AMPLITUDE
17.
18.
19.
20.
21.
22.
TIME (HOURS)

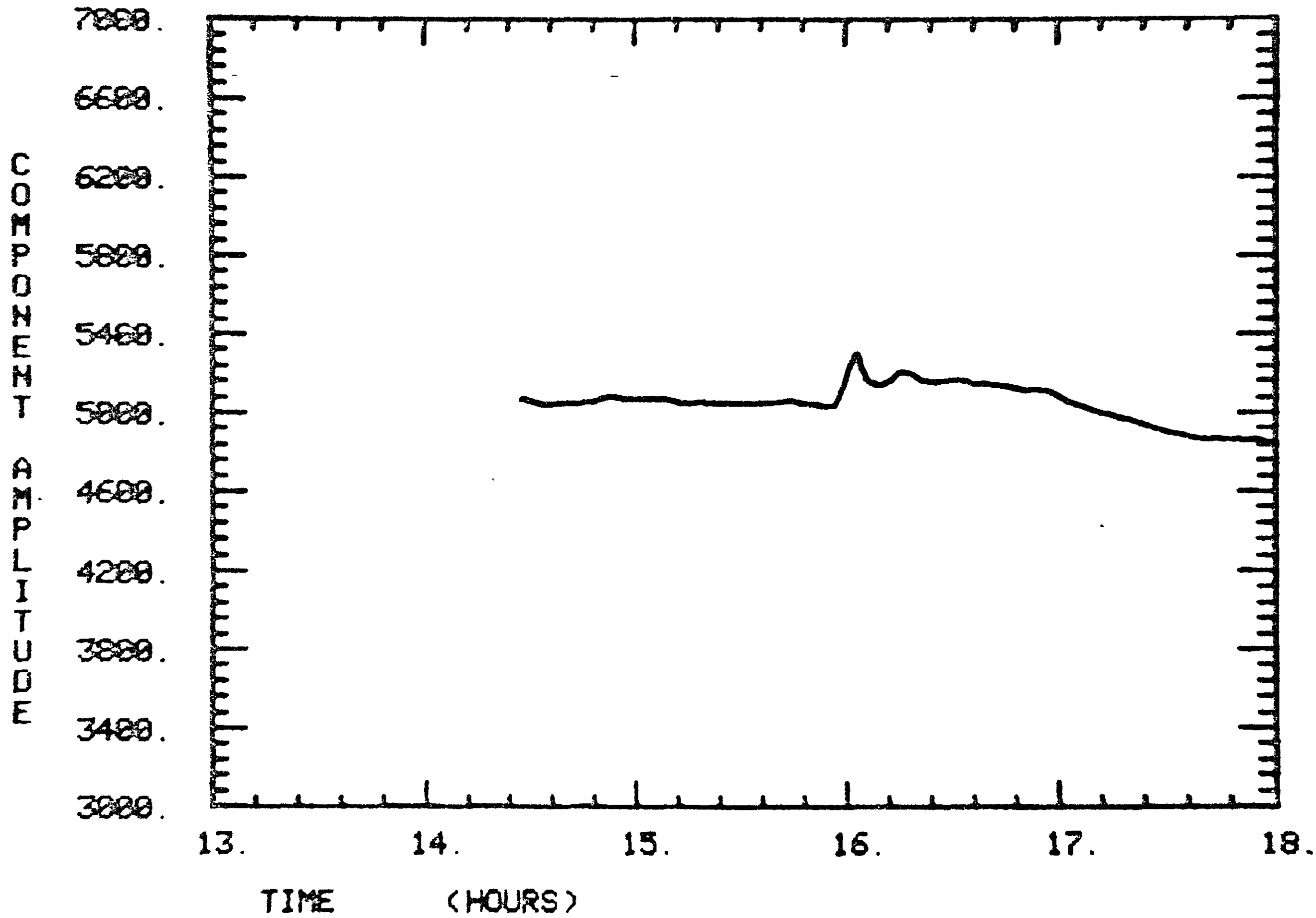

MEL N 03 - 21 - 75
NEW PLOT=1
2!
MELE03-21-75 .147
190 .544
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 6.857E+00
1.045E+01
MIN/MAX Y VALUES -2.243E+03
2.027E+03
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX X VALUES
5 9!
SET VERTICAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX Y VALUES
-4000 0
COMPONENT AMPLITUDE
8000.
7600.
7200.
6800.
6400.
6000.
5600.
5200.
4800.
4400.
4000.
8.
5.
5.
6.
7.
8.
9.
TIME (HOURS)


MEL E 03 - 21 - 75
0
-400.
-800.
-1200
-1600.
-2000.
-2400.
-2800.
-3200.
-3600
-4000
COMPONENT AMPLITUDE
2!
NEW PLOT=1
MELN10-15-74
100 .566
.147
15.
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.446E+01
1.794E+01
MIN/MAX Y VALUES 1.896E+03
2.443E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
13 18!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
500 4500
5.
5.
6.
7.
8.
9.
TIME (HOURS)

MEL N 10 - 15 - 74


NEW PLOT=1
2!
MELE10-15-74
100 .566
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.446E+01
1.803E+01
MIN/MAX Y VALUES 4.829E+03
5.301E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
13 18!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
COMPONENT AMPLITUDE
4500.
4100.
3700.
3300.
2900.
2500.
2100.
1700.
1300.
900.
500.
13.
14.
15.
16.
17.
18.
TIME (HOURS)

MEL E 10 - 15 - 74

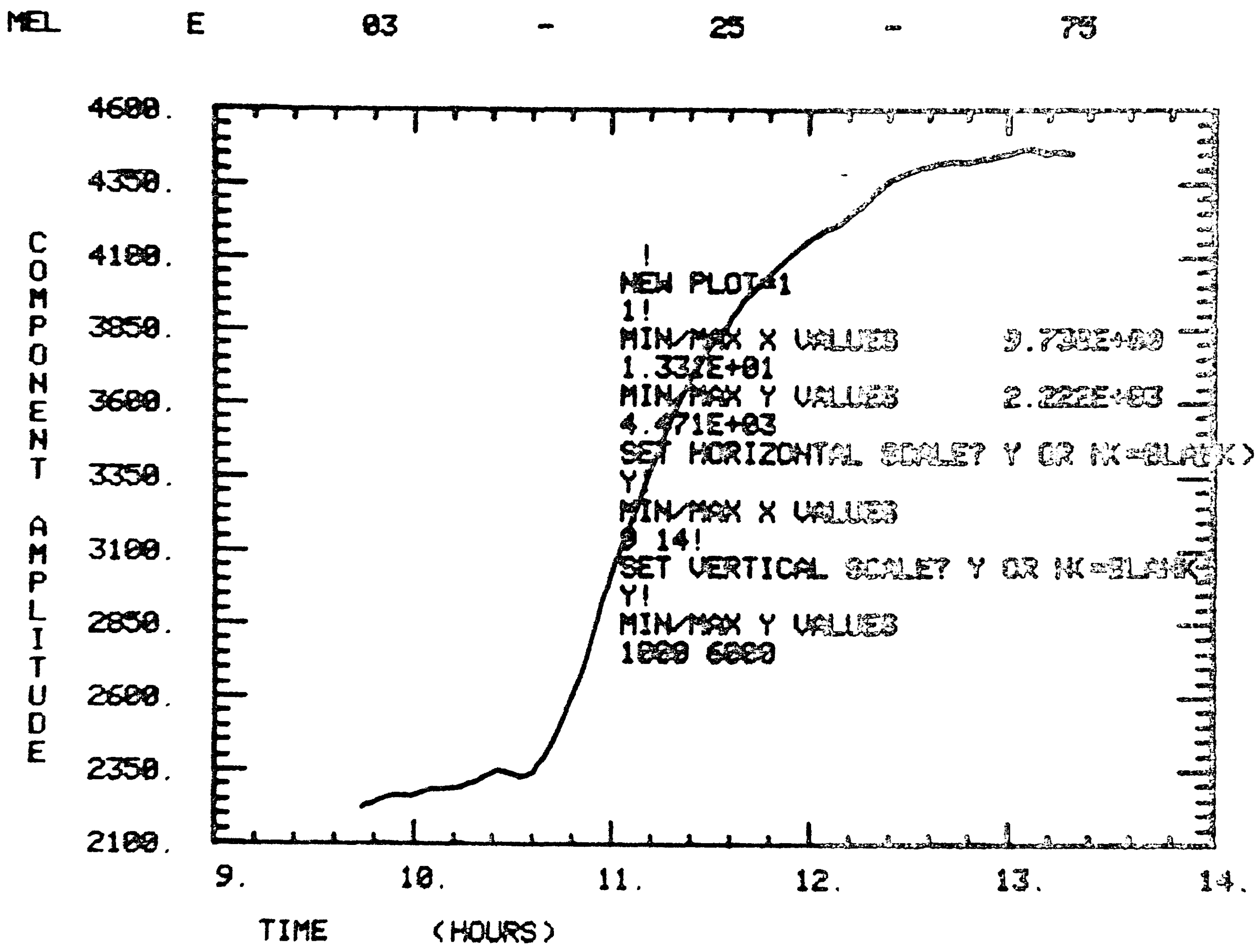

COMPONENT AMPLITUDE
7000.
6600.
6200.
5800.
5400.
5000.
4600.
4200.
3800.
3400.
3000.
13.
14.
15.
16.
17.
18.
TIME (HOURS)

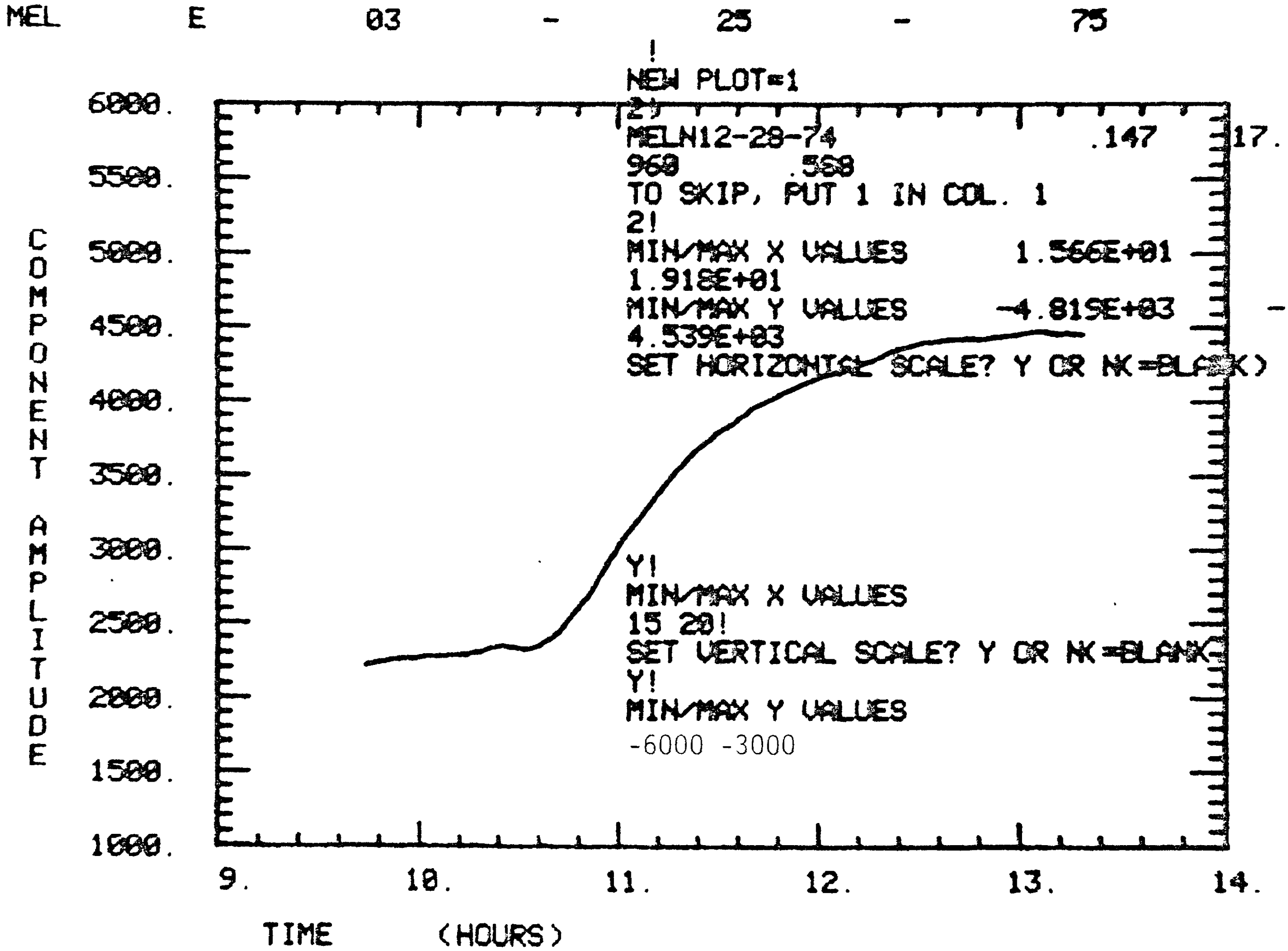
```
 !
NEW PLOT=1
2!
BUYN06/29/75                   .146    22.933       .109
TO SKIP, PUT 1 IN COL. 1
1!
BUYE06/29/75                   .146    22.933       .109
TO SKIP, PUT 1 IN COL. 1
1!
MELN10/27/75                   .147    18.783       .566
TO SKIP, PUT 1 IN COL. 1
1!
MELE10/27/75                   .147    18.783       .566
TO SKIP, PUT 1 IN COL. 1
1!
BUYN10/27/75                   .147    18.300       .109
TO SKIP, PUT 1 IN COL. 1
1!
BUYE10/27/75                   .147    18.300       .109
TO SKIP, PUT 1 IN COL. 1
1!
MELN01/25/76                   .154    12.227       .516
TO SKIP, PUT 1 IN COL. 1
1!
MELE01/25/76                   .154    12.227       .516
TO SKIP, PUT 1 IN COL. 1
1!
BUYN01/25/76                   .143    12.767       .105
TO SKIP, PUT 1 IN COL. 1
1!
BUYE01/25/76                   .143    12.767       .105
TO SKIP, PUT 1 IN COL. 1
1
```

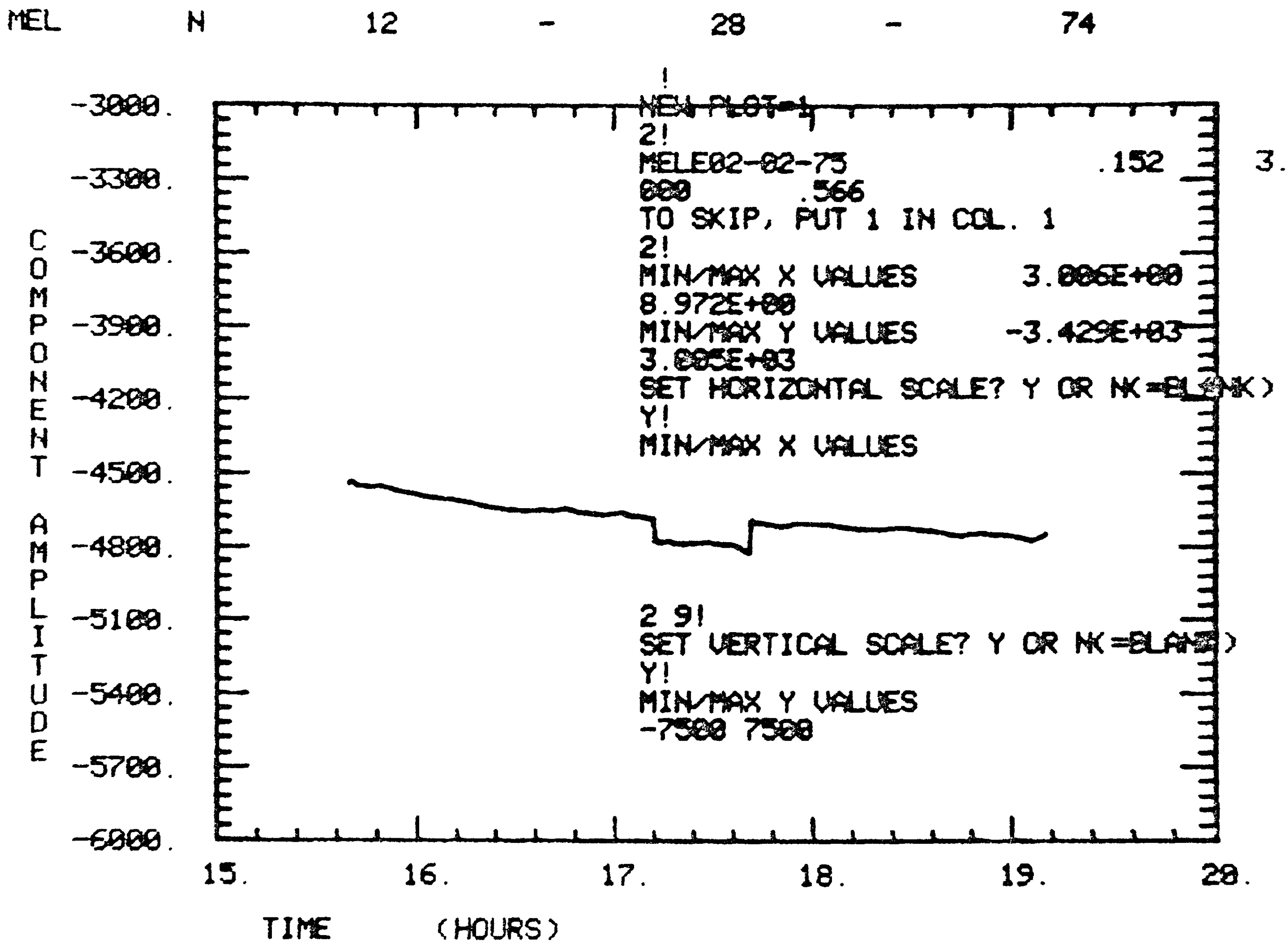
```
!
MELN04/16/76                  .148    11.267     .566
TO SKIP, PUT 1 IN COL. 1
1!
MELE04/16/76                  .148    11.267     .566
TO SKIP, PUT 1 IN COL. 1
1!
MLAN04/16/76                  .142    11.383     .525
TO SKIP, PUT 1 IN COL. 1
1!
MLAE04/16/76                  .142    11.383     .525
TO SKIP, PUT 1 IN COL. 1

1!
MLCN04/16/76                  .144    11.550     .516
TO SKIP, PUT 1 IN COL. 1
1!
MLCE04/16/76                  .144    11.550     .516
TO SKIP, PUT 1 IN COL. 1
1!
SASE09/10/73                  .160    -0.        .120
TO SKIP, PUT 1 IN COL. 1
1!
SASN09/10/73                  .160    -0.        .120
TO SKIP, PUT 1 IN COL. 1
1!
SASE01/22/74                  .182    -0.        .121
TO SKIP, PUT 1 IN COL. 1
1!
SASN01/22/74                  .182    -0.        .121
TO SKIP, PUT 1 IN COL. 1
1!
SASE03/12/74                  .165    -0.        .119
TO SKIP, PUT 1 IN COL. 1
1
```

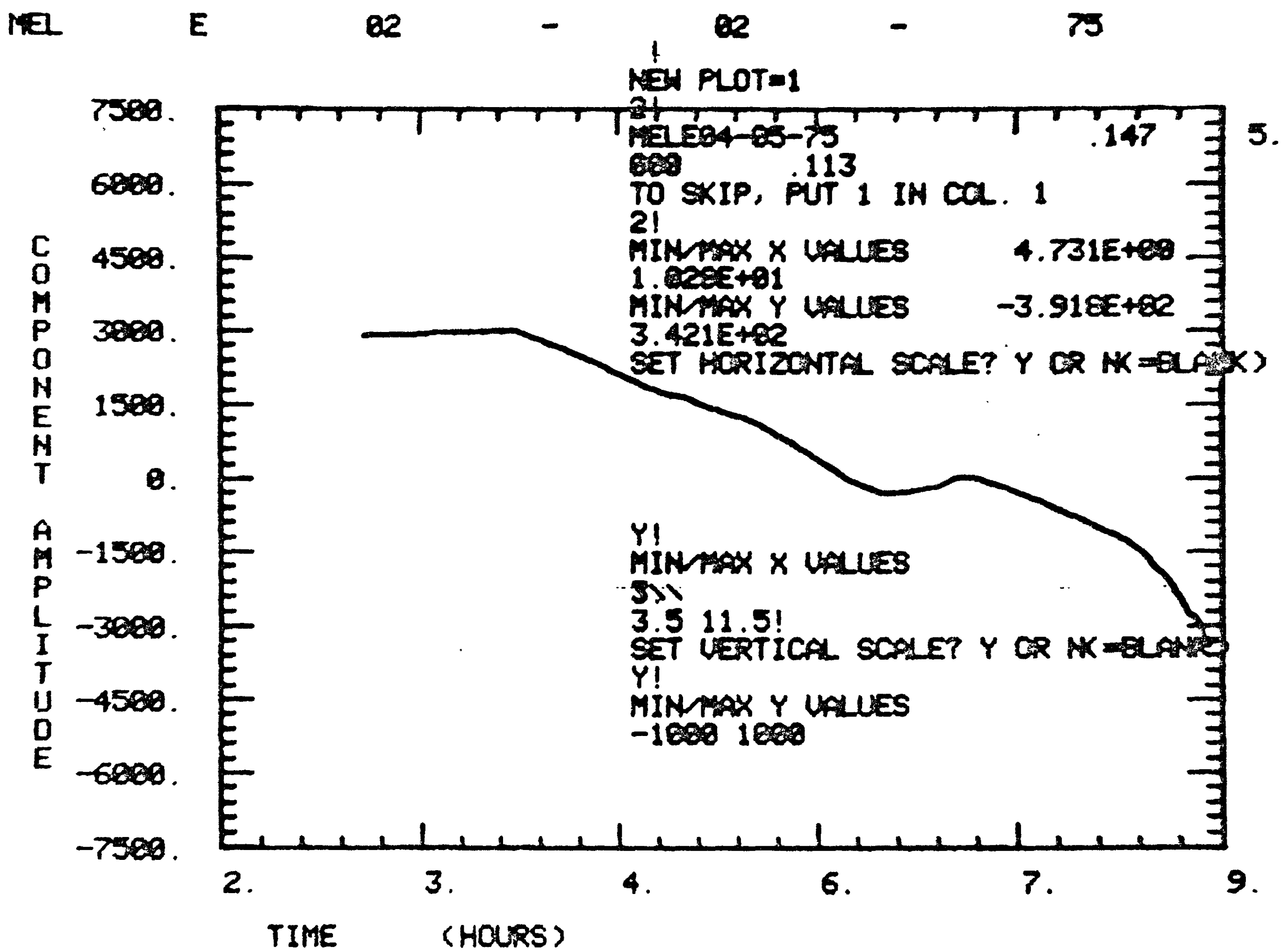
```
!
SASN03/12/74                    .165    -0.          .119
TO SKIP, PUT 1 IN COL. 1
1!
SASE03/18/74                    .165    -0.          .120
TO SKIP, PUT 1 IN COL. 1
1!
SASN03/18/74                    .165    -0.          .120
TO SKIP, PUT 1 IN COL. 1
1!
LIBN07/19/74                    .170    -0.          .127
TO SKIP, PUT 1 IN COL. 1
1!
LIBE07/19/74                    .170    -0.          .127
TO SKIP, PUT 1 IN COL. 1
1!
LIBN10/27/74                    .162    -0.          .123
TO SKIP, PUT 1 IN COL. 1
1!
LIBE10/27/74                    .162    -0.          .123
TO SKIP, PUT 1 IN COL. 1
1!
MELN09/29/74                    .164    -0.          .639
TO SKIP, PUT 1 IN COL. 1
1!
MELE09/29/74                    .164    -0.          .639
TO SKIP, PUT 1 IN COL. 1
1!
MELN10/19/74                    .166    -0.          .634
TO SKIP, PUT 1 IN COL. 1
1!
MELE10/19/74                    .166    -0.          .634
TO SKIP, PUT 1 IN COL. 1
1
```

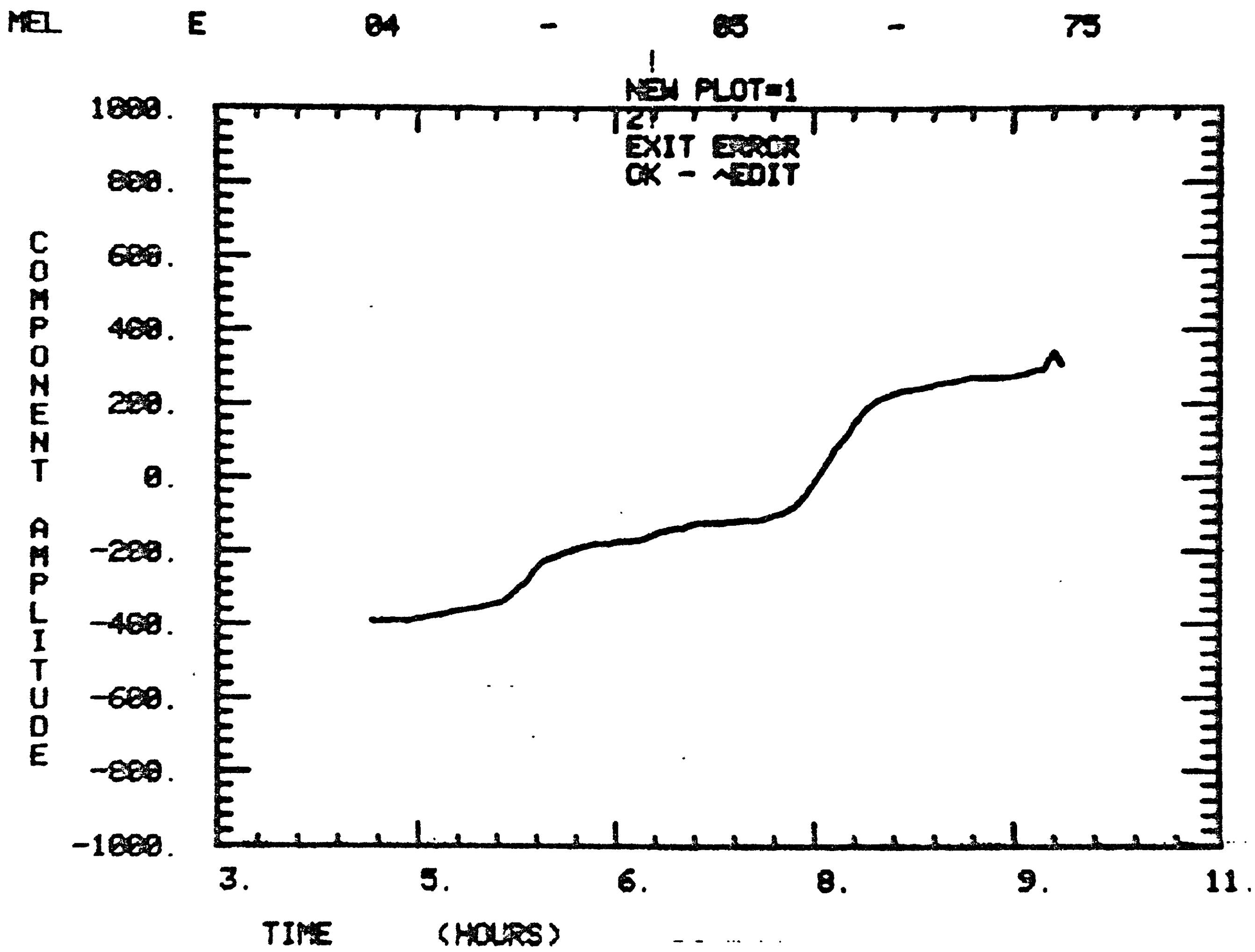
```
!
MELE11/05/74                                .163     -0.          .608
TO SKIP, PUT 1 IN COL. 1
1!
MELN11/29/74                                .162     -0.          .639
TO SKIP, PUT 1 IN COL. 1
1!
MELE11/29/74                                .162     -0.          .639
TO SKIP, PUT 1 IN COL. 1
1!
MELN07/11/74                                .343     14.895       .661
TO SKIP, PUT 1 IN COL. 1
1!
MELE07/11/74                                .343     14.895       .661
TO SKIP, PUT 1 IN COL. 1
1!
MELN10/03/74                                .348      4.657       .623
TO SKIP, PUT 1 IN COL. 1
1!
MELE10/03/74                                .348      4.657       .623
TO SKIP, PUT 1 IN COL. 1
1!
SAS 09-07-74                                .147     21.000       .113
TO SKIP, PUT 1 IN COL. 1
1!
MELE03-25-75                                .147     12.000       .566
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES       9.730E+00      1.331E+01
MIN/MAX Y VALUES       2.222E+03      4.471E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
9 14!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
2100 4600
```


MEL E 03 - 25 - 73
4600.
4350.
4100.
3850.
3600.
3350.
3100.
2850.
2600.
2350.
2100.
COMPONENT AMPLITUDE
9.
10.
11.
12.
13.
14.
TIME (HOURS)
NEW PLOT=1
1!
MIN/MAX X VALUES
1.332E+01
MIN/MAX Y VALUES 2.222E+03
4.471E+03
SET HORIZONTAL SCALE? Y OR N
Y!
MIN/MAX X VALUES
9 14!
SET VERTICAL SCALE? Y OR N
Y!
MIN/MAX Y VALUES
1000 6000


MEL E 03 - 25 - 75
NEW PLOT=1
MELN12-28-74 .147 17.
960 .568
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.566E+01
1.918E+01
MIN/MAX Y VALUES -4.819E+03
4.539E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
15 20!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-6000 -3000
COMPONENT AMPLITUDE
6000. 5500. 5000. 4500. 4000. 3500. 3000. 2500. 2000. 1500. 1000.
9. 10. 11. 12. 13. 14.
TIME (HOURS)


MEL N 12 - 28 - 74
NEW PLOT=1
2!
MELE02-02-75 .152 3.
000 .566
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 3.006E+00
8.972E+00
MIN/MAX Y VALUES -3.429E+03
3.005E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
2 9!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-7500 7500
-3000.
-3300.
-3600.
-3900.
-4200.
-4500.
-4800.
-5100.
-5400.
-5700.
-6000.
COMPONENT AMPLITUDE
15.
16.
17.
18.
19.
20.
TIME (HOURS)


MEL E 02 - 02 - 75
NEW PLOT=1
2!
MELE04-05-75 .147
600 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 4.731E+00
1.029E+01
MIN/MAX Y VALUES -3.918E+02
3.421E+02
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX X VALUES
3.5 11.5!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1000
7500.
6000.
4500.
3000.
1500.
0.
-1500.
-3000.
-4500.
-6000.
-7500.
COMPONENT AMPLITUDE
2.
3.
4.
6.
7.
9.
5.
TIME (HOURS)


MEL E 04 - 05 - 75
NEW PLOT=1
2?
EXIT ERROR
OK - ^EDIT
1000.
800.
600.
400.
200.
0.
-200.
-400.
-600.
-800.
-1000.
COMPONENT AMPLITUDE
3.
5.
6.
8.
9.
11.
TIME (HOURS)

PROGRAM LISTING

```
DELETE(LGO,LGOB,VECTOR)
VECTOR.
CXIT.
LIBCOPY(GRAPHIC,TXLGO/RR,TXLGO)
LIBCOPY(JORAT,NPLGO/RR,NPLGO)
LIBCOPY(MCHUGH,TLTEVN/RR,TLTEVN)
RUN76(S)
LINK(F=LGO,F=TXLGO,F=NPLGO,B=VECTOR)
VECTOR(TLTEVN)
VECTOR.
FIN.
EOR
         PROGRAM VECTOR(TAPE5,TAPETTY=201,FILM=TAPETTY,TAPE7=TAPETTY)
         COMMON/TVPOOL/TVPUL(8)
         COMMCN/TVTUNE/ITUNE(30)
         CCMMON/JPLCT/XLT,XRT,YLO,YUP,MAJX,MAJY,KX(2),KY(2),LTITL(8),LU,
        1 LTF,LNLGX,LNLGY,NCLX,NCLY,LTITL2(8)
         DIMENSION IFET(8)
         DIMENSION STA(10),NYEAR(1000),NDAY(1000)
         DIMENSION NMONTH(1000),TIME(1000),XIN(1000),XFN(1000),YIN(1000)
         DIMENSION YFN(1000),A(30),AMP(1000),AZM(1000)
         CALL FET(5LTAPE7,IFET,8)
         IFET(2)=IFET(2).OR.0000 0010 0000 0000 0000B
         IFET(8)=IFET(8).OR.4000 0000 0000 0000 0000B
         CALL FET(5LTAPE7,IFET,-8)
         TVPUL(5)=-.32 $TVPUL(6)=1. $TVPUL(7)=0. $TVPUL(8)=1.
         DO 10 I=1,1000
         NMONTH(I)=NDAY(I)=TIME(I)=XIN(I)=XFN(I)=YIN(I)=0.
         YFN(I)=NYEAR(I)=0.
   10    CONTINUE
         PI=3.1415926 $READ(5,1)N
    1    FORMAT(I2)
         DO 2 IJ=1,N
         READ(5,3)STA(IJ) $K=1 $SUM1=SUM2=0.
    3    FORMAT(A10)
    4    READ(5,5)NMONTH(K),NDAY(K),NYEAR(K),TIME(K),XIN(K),YIN(K),XFN(K),
        1  YFN(K),FACTOR
    5    FORMAT(I2,1X,I2,1X,I2,1X,A4,1X,4(F7.2,1X),F10.3)
         IF(XIN(K).EQ.999.99.AND.YIN(K).EQ.999.99.AND.XFN(K).EQ.999.99.AND.
        1 YFN(K).EQ.999.99)GOTO6
         A=XIN(K) $B=YIN(K) $C=XFN(K) $D=YFN(K) $LMCNTH=NMCNTH(K)
         IF(NMONTH(K).EQ. 1)NMONTH(K)=3HJAN
         IF(NMONTH(K).EQ. 2)NMONTH(K)=3HFEB
         IF(NMONTH(K).EQ. 3)NMONTH(K)=3HMAR
         IF(NMONTH(K).EQ. 4)NMONTH(K)=3HAPR
         IF(NMONTH(K).EQ. 5)NMONTH(K)=3HMAY
         IF(NMONTH(K).EQ. 6)NMONTH(K)=3HJUN
         IF(NMONTH(K).EQ. 7)NMONTH(K)=3HJUL
         IF(NMONTH(K).EQ. 8)NMONTH(K)=3HAUG
         IF(NMONTH(K).EQ. 9)NMONTH(K)=3HSEP
         IF(NMONTH(K).EQ.10)NMONTH(K)=3HOCT
         IF(NMONTH(K).EQ.11)NMONTH(K)=3HNOV
         IF(NMONTH(K).EQ.12)NMONTH(K)=3HDEC
         IF(STA(IJ).EQ.10HSAGE SOUTH  .AND.NYEAR(K).LE.74)GOTO20
         GOTO12
   20    IF(NYEAR(K).LT.74)GOTO11
         IF(LMONTH.LT.12)GOTO11
         IF(LMONTH.EQ.12.AND.NDAY(K).LE.19)GOTO11
```

```
   20 Y(I)=1000.*Y(I)
      YMID=Y(1)
      YLC=YMID  $YUP=YMIC
      DO 160 I=1,NEND
      IF(Y(I) .LT. YLO)YLO=Y(I)
  160 IF(Y(I) .GT. YUP)YUP=Y(I)
      LU=7 $LNLGX=1 $LNLGY=1 $NCLX=2 $NCLY=2
      MAJX=5 $MAJY=10 $LTITL2(1)=1 $XLT=X(1) $XRT=X(NEND)
      PR1=XLT $PR2=XRT $PR3=YLO $PR4=YUP
   85 KX(1)=10HTIME
      KX(2)=10H(HOURS)
      KY(1)=10HCOMPONENT
      KY(2)=10HAMPLITUCE
      WRITE(7,88)PR1,PR2,PR3,PR4
   88 FORMAT(*MIN/MAX X VALUES*,5X,E10.3,5X,E10.3,/,
     1        *MIN/MAX Y VALUES*,5X,E10.3,5X,E10.3)
      WRITE(7,70)
   70 FORMAT(*SET HORIZONTAL SCALE? Y OR N(=BLANK)*)
      READ(7,66)CHARAC  $IF(CHARAC .EQ. 1HN .OR. CHARAC .EQ. 1H )GOTO71
   66 FORMAT(A1)
      WRITE(7,72)
   72 FORMAT(*MIN/MAX X VALUES*)
      CALL GETNUM(A)  $XLT=A(1)  $XRT=A(2)
   71 WRITE(7,73)
   73 FORMAT(*SET VERTICAL SCALE? Y OR N(=BLANK)*)
      READ(7,66)CHARAC  $IF(CHARAC.EQ.1HN .OR.CHARAC.EQ.1H )GOTC74
      WRITE(7,75)
   75 FORMAT(*MIN/MAX Y VALUES*)
      CALL GETNUM(A) $YLC=A(1)  $YUP=A(2)
   74 IF(YLO.NE.YUP)GOTO87
      IF(YLC.EQ.YUP)RG=YLO
      IF(YLO.EQ.YUP)YLO=YUP-1.
      IF(YUP.EQ.RG)YUP=RG+1.
   87 CALL PLOTS(Y,X,1,NEND)
      WRITE(7,89)
   89 FORMAT(*NEW PLOT=1*)
      CALL GETNUM(A)  $C1=A(1)
      IF(C1.EQ.1)GOTO85
      GO TC 10
   11 WRITE(7,12)
   12 FORMAT(*ENC OF DATA*,/,
     1 *CONTINUE?, YES=1*)
      READ(7,13)LFLAG
   13 FORMAT(I1)
      IF(LFLAG .EQ. 1) REWINC 5
      IF(LFLAG .EQ. 1)GO TO 10
      STOP
      ENC
      SUBROUTINE GETNUM(R)
      DIMENSICN R(1),L(80)
      READ(7,9)L $ I=J=0
    6 J=J+1 $ N=P=S=0 $ M=F=1
    5 I=I+1 $ IF(I.GT.80)RETURN $ D=L(I) $ K=4
      IF(D.EQ.38)K=2 $ IF(D.GE.27.A.D.LE.36)K=1
      IF(D.EQ.47)K=3 $ K=K+S $ GOTO(1,2,3,5,1,4,3,4)K
    1 N=N*10+D-27                    $ S=4          $ GOTO 5
    2 M=-1                           $ S=4          $ GCTO 5
    3 P=I                            $ S=4          $ GCTO 5
```

```
    4 IF(P.NE.0)F=10.**(I-P-1) $ R(J)=N/F*M $ GOTO 6
    9 FORMAT(80R1)
      END
```

REFERENCES

McHugh, Stuart and Malcolm J. S. Johnston, Some short period non-seismic tilt perturbations and their relation to episodic slip on the San Andreas fault in central California, J.G.R., in press, 1976.

McHugh, Stuart, Documentation of programs that compute 1) quasi-static tilts produced by an expanding dislocation loop in an elastic and viscoelastic material, and 2) surface shear stresses, strains and shear displacements produced by screw dislocations in a vertical slab with modulus contrast, U.S. Geological Survey open-file report, 76-484, 1976a.

McHugh, Stuart, Documentation of programs that compute 1) Static tilts for a spatially variable slip distribution, and 2) quasi-static tilts produced by an expanding dislocation loop with a spatially variable slip distribution, U.S. Geological Survey open-file report, 76- 578, 1976b.