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AUTHORITY

usae ltr 3 mar 1972

LONG RANGE SEISMIC MEASUREMENTS

PAR

9 OCTOBER 1964

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER

Washington, D. C.

9 FEBRUARY 1966

By

UED EARTH SCIENCES DIVISION

TELEDYNE, INC.

Under

Project VELA UNIFORM

Sponsored By

ADVANCED RESEARCH PROJECTS AGENCY

Nuclear Test Detection Office

ARPA Order No. 624

LONG RANGE SEISMIC MEASUREMENTS

PAR

9 October 1964

SEISMIC DATA LABORATORY REPORT NO. 135

AFTAC Project No.:	VELA T/2037
Project Title:	Seismic Data Laboratory
ARPA Order No.:	624
ARPA Program Code No.:	5810
Name of Contractor:	UED EARTH SCIENCES DIVISION TELEDYNE, INC.
Contract No.:	AF 33(657)-12447
Date of Contract:	17 August 1963
Amount of Contract:	$ 5,382,624
Contract Expiration Date:	17 February 1966
Project Manager:	Robert Van Noscrand (703) 836-7644

P. O. Box 334, Alexandria, Virginia

AVAILABILITY

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This research was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center under Contract AF 33(657)-12447.

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PAR

EVENT DESCRIPTION

DATE: 09 October 1964

TIME OF ORIGIN: 14:00:00.1Z

YIELD:

MAGNITUDE: 4.78 ± 0.29

LOCATION:

SITE: Nevada Test Site, Area U2p

GEOGRAPHIC COORDINATES:

LAT: 37°09'05" N

LONG: 116°04'37" W

ENVIRONMENT:

GEOLOGIC MEDIUM: Tuff

SURFACE ELEVATION: 4368 feet

SHOT ELEVATION: 1341 feet

SHOT DEPTH: 3027 feet

COMPUTER EPICENTER: ALL STATIONS

GEOGRAPHIC COORDINATES:

LAT: 37°39'36" N

LONG: 116°11'49" W

TIME OF ORIGIN: 14:00:04.9Z

DEPTH: 46.1 km

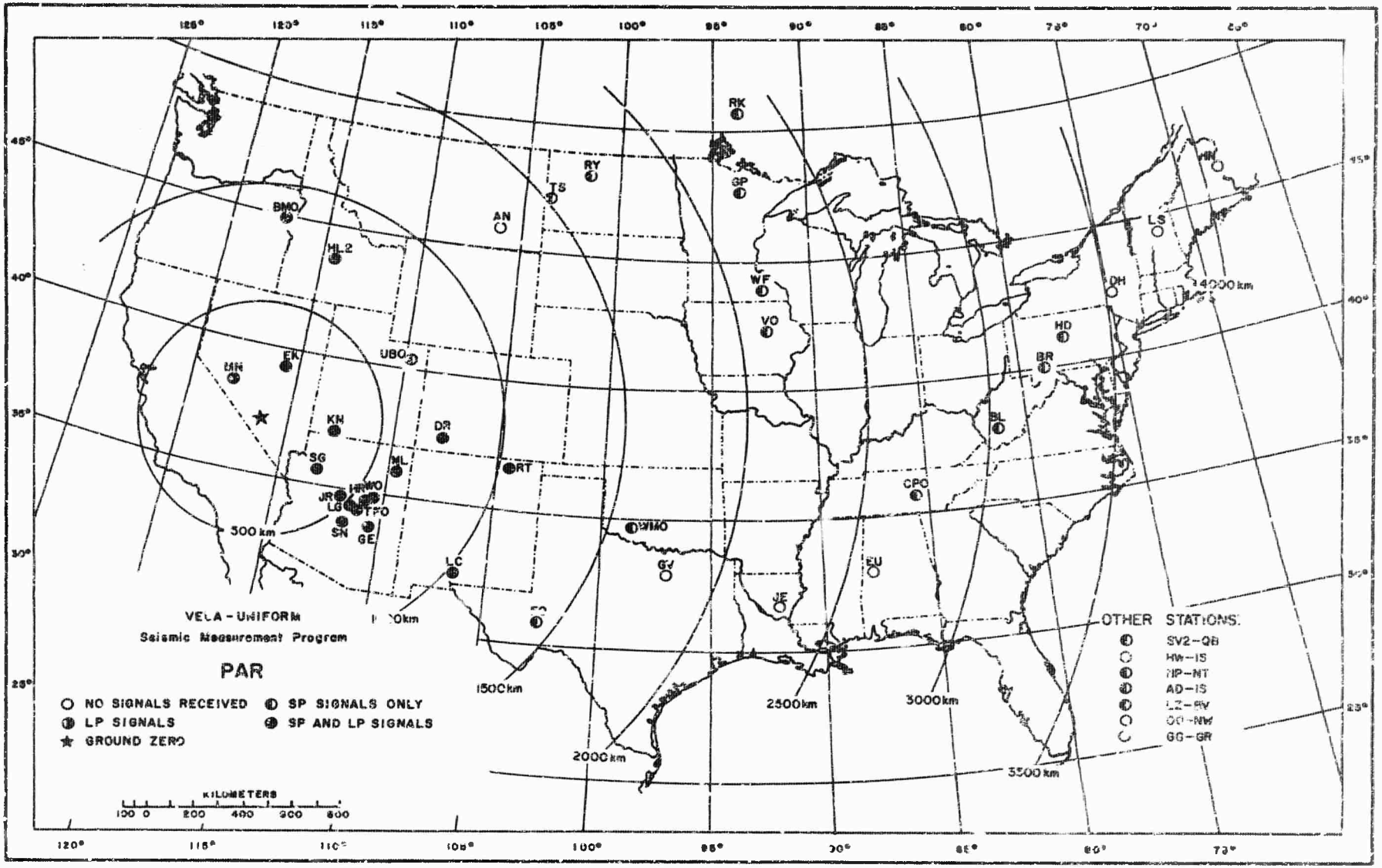
EPICENTER SHIFT: 13.1 km, S 54° W

Code	Station	Final							
		SPE	SPR	SPT	LPE	LPR	LPT	Tape	Timing
EK-NV	Eureka, Nevada	+	+	+	+	+	+	•	P
MW-NV	Mina, Nevada	+	+	+	+	+	+	•	P
KA-UT	Kanab, Utah	+	+	+	+	+	-	•	P
SG-AZ	Seligman, Arizona	+	+	+	+	+	-	•	P
JR-AZ	Jerome, Arizona	+	+	+	+	+	-	•	P
LG-AZ	Long Valley, Arizona	+	+	+	+	+	-	•	P
TFSO	Tonto Forest Observatory Arizona	+	+	+	+	+	-	•	P
SN-AZ	Sunflower, Arizona	+	+	+	-	+	-	•	P
WO-AZ	Winslow, Arizona	+	+	+	+	-	-	•	P
HB-AZ	Heber, Arizona	+	+	+	+	+	+	•	P
HL-AZ	Hoolini, Arizona	+	+	+	+	+	+	•	P
GE-AZ	Globe, Arizona	+	+	+	+	I	-	•	P
UBSO	Uinta Basin Observatory Utah	+	+	+	-	-	-	•	P
HL2ID	Hailey, Idaho	+	+	+	+	+	-	•	P
DR-CO	Durango, Colorado	+	+	+	+	+	+	•	P
BMSO	Blue Mountain Observatory, Oregon	+	+	+	+	+	-	•	P
LC-NM	Las Cruces, New Mexico	+	+	+	+	+	-	•	P
RT-NM	Raton, New Mexico	+	+	+	+	-	-	•	P
AH-MA	Angela, Montana	I	I	I	I	I	I	I	I
FO-TX	Fort Stockton, Texas	+	+	+	+	M	M	•	P
TS-ND	Trettere, North Dakota	+	+	+	M	M	M	•	P
WHSO	Wichita Mountain Observatory, Oklahoma	+	+	+	-	-	-	•	P
RY-ND	Ryder, North Dakota	+	-	-	-	-	-	•	P
GV-TX	Grapevine, Texas	+	-	-	-	M	M	•	P
VO-IO	Vinton, Iowa	+	-	-	-	-	-	•	P
WF-MN	Wykoff, Minnesota	+	-	-	-	-	-	•	P
GP-MN	Grand Rapids, Minnesota	+	-	-	-	-	-	•	P
JE-LA	Jena, Louisiana	-	-	-	-	-	-	•	P
RF-ON	Red Lake, Ontario, Canada	+	+	+	-	-	-	•	P
EU-AL	Eutaw, Alabama	-	-	-	-	-	-	•	P
CPSO	Cumberland Plateau Observatory, Tennessee	+	+	+	-	-	-	•	P
BL-WV	Beckley, West Virginia	+	+	+	-	-	-	•	P
BR-PA	Berlin, Pennsylvania	+	-	-	-	-	-	•	P
HD-PA	Howard, Pennsylvania	+	M	M	M	M	M	•	P
DH-NY	Delhi, New York	-	-	-	-	-	-	•	P
LS-NH	Lisbon, New Hampshire	-	-	-	-	-	-	•	P
HM-ME	Houlton, Maine	-	-	-	-	-	-	•	P
S72QB	Schefferville, Quebec, Canada	+	M	M	-	M	M	•	P
KW-HI	Kaauela, Hawaii	-	-	-	-	-	-	•	P
MP-NT	Mould Bay, Northwest Territories, Canada	+	-	-	-	-	-	•	P
AD-AK	Adak Island	+	-	-	-	-	-	•	P
LX-BV	La Paz, Bolivia	+	-	-	-	-	-		P
OO-NW	Oslo, Norway	-	-	-	-	-	-	•	P
GG-GR	Grafenberg, Germany	-	-	-	-	-	-	•	P

I Inoperative + Signal
M No Instruments ○ No Signal
P Primary Timing • Magnetic Tape Available

Station Status Report - PAR

Table 1



Recording Stations and Signals Received

Figure 1

Introduction

A long range seismic measurements (LRSM) program was established under VELA-UNIFORM to record and analyze short-period and long-period data from a planned series of U. S. underground nuclear tests. These, and other data, will be used by VELA-UNIFORM participants for studying and developing methods for distinguishing between explosive and earthquake sources.

The purpose of this report is to provide an analysis of data resulting from the PAR event from the LRSM film seismograms from operating mobile field teams; Wichita Mountain Observatory, Oklahoma (WMSO), Uinta Basin Observatory, Utah (UBSO), Blue Mountain Observatory, Oregon (BMSO), Cumberland Plateau Observatory, Tennessee (CPSO), and Tonto Forest Observatory, Arizona (TFSO); and from several experimental or temporary stations operated in connection with other research programs.

Instrumentation and Procedure

Instrumentation at each of the mobile stations consists of three-component short-period Benioff and three-component Sprengnether long-period seismographs. Data are recorded on 35 millimeter film and on one-inch 14-channel

magnetic tape. All of these stations are equipped to record WWV continuously in order to provide accurate time control. Calibration is accomplished once each day and just prior to each shot at operating settings. Specific details of the instrumentation and operating procedures for these stations are given in Field Manual, Long Range Seismic Measurement Program, Technical Report No. 63-17, which can be obtained from the Geotech Division of Teledyne Industries, Inc., Dallas, Texas. All the observatories have both long-period and short-period, three-component instrumentation in addition to their other specialized facilities.

Station site information is presented in Appendix I(A). This includes the station name and code; the geographic coordinates, distances and azimuths involved; the station elevations; and the type of instruments in use at each location.

A status report for PAR is included in Table 1, placed opposite the operations map, Figure 1. This report gives the names of 44 stations and indicates which instruments were operational and which recorded signals.

An explanation of the procedure for amplitude measurements used in this report is illustrated in Appendix II(A). The unified magnitude (m) computations for distances less than

16° are based on AFTAC/VSC extensions of Gutenberg's Tables*. For this purpose, points from 10° to 16° were read from a curve in the Gutenberg-Richter paper and an inverse cube relationship was used to extrapolate from two to ten degrees. A table of the distance factors (B) is provided in Appendix I(B).

A standard hypocenter location program for a digital computer has been used to determine the location using data from all stations analyzed. Best-fit values of latitude, longitude, depth of focus, and time of origin are determined statistically by a least squares technique. This utilizes a Jeffreys-Bullen travel-time curve as modified by Herrin in 1961 on the basis of Pacific surface-focus recordings. Precision of the computation is limited primarily by the accuracy of arrival times, the validity of the standard travel-time curve, and by local velocity deviations. Since the method is based on P wave arrivals, this particular program does not make use of later phases such as pP and S in the determination of depth or location. Results are shown on the Event Description page.

*Gutenberg, B. and Richter, C. F., Magnitude and Energy of Earthquakes, Ann. Geofis., 9 (1956), pp. 1-15.

Data and Results

Table 2 summarizes the measurements made of the principal phases from the PAR event. Included are the Pn and P arrival times, the maximum amplitudes (A/T) of Pn or P and Pg motion as seen on the short-period vertical instruments, and the maximum amplitudes (A/m) of the Lg phase as measured on the short-period horizontal tangential component. Long-period Rayleigh wave motion is also tabulated in (A/T) form. Thirty-four stations recorded short-period signals. Long-period signals from this event were recorded by seventeen stations.

In addition, Table 2 and Figure 2 show the unified magnitudes (m) where measurable. The average magnitude for PAR is 4.78 .

The travel-time residuals from the Pn and P phase are within the usual limits (see Figure 3). The amplitudes of Pn and P, Pg and Lg are shown in Figures 4, 5 and 6. Lines proportional to the inverse cube of the distance visually fitted through the observed points are shown on these graphs. Rayleigh wave amplitudes are shown in Figure 7.

Attached to the report are illustrative seismograms showing the signals recorded at a number of locations. The most distant station analyzed that recorded PAR was LZ-BV at a distance of 7729 kilometers.

Principal Phases
PAR
9 October 1964
19:03:00 1Z

Code	Station	Distance (km)	Inst.	Magnification (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	Magnitude (m)
EK-NV	Ekaka, Nevada	231	SPZ	3.2	Pn	00	36.0	0.6	640	5.05
			SPZ	3.2	e	00	38.6	0.8	1838	
			SPZ	3.2	Pg	00	42.5	0.6	3201	
			SPT	3.3	Lg			0.4	5607	
			LPZ	14.0*	LR			16.0	191	
MN-NV	Mina, Nevada	232	SPZ	2.2	Pn	00	36.2	0.8	479	4.92
			SPZ	2.3	e	00	38.6	0.6	2301	
			SPZ	2.3	Pg	00	42.5	0.6	3044	
			SPZ	2.3	s	00	48.0	0.7	1604	
			SPZ	2.3	s	00	50.4	0.6	2153	
			SPT	2.7	Lg			0.6	4617	
			LPZ	28.1	LR			(13.0)	(45.6)	
KN-UT	Kanab, Utah	289	SPZ	6.81	Pn	00	43.5	0.7	264	4.92
			SPZ	6.81	e	00	45.6	0.7	340	
			SPZ	6.81	Pg	00	49.1	0.7	1801	
			SPT	6.82	Lg			0.6	2654	
			LPZ	28.0	LR			15.0	20.0	
SG-AZ	Seligman, Arizona	303	SPZ	64.9*	Pn	00	43.7	(0.6)	(84.2)	(4.49)
			SPZ	4.99*	Pg	00	50.9	0.8	1326	
			SPT	6.32	Lg			0.6	2188	
			LPZ	13.58	LR			16.0	13 9	
JR-AZ	Jerome, Arizona	450	SPZ	16.1	Pn	01	04.3	0.7	117	5.19
			SPZ	16.1	Pg	01	17.0	0.6	1644	
			SPT	15.2	Lg			0.6	1022	
			LPZ	19.0	LR			15.0	18.4	
LC-AZ	Long Valley, Arizona	510	SPZ	25.6	Pn	01	11.7	0.7	26.8	4.71
			LPZ	25.6	e	01	13.6	0.7	46.9	
			SPZ	25.6	Pg	01	24.7	0.7	456	
			SPT	33.8	Lg			1.2	966	
			LPZ	13.4	LR			15.0	14.6	
TFSO	Tonto Forest Seismological Observatory, Arizona	539	SPZ-31	50.8	Pn	01	15.4	0.5	25.1	
			SPZ-31	60.8	Pg	01	31.1	0.6	108	
			SPT-75	66.2	Lg			1.2	247	
			LPZ	28.5	LR			13.0	33.7	
SK-AZ	Sunflower, Arizona	540	SPZ	23.8	Pn	01	15.1	0.7	32.4	4.87
			SPZ	23.8	s	01	18.8	0.7	32.4	
			SPZ	23.8	Pg	01	33.9	0.7	288	
			SPT	25.4	Lg			0.6	399	
			LPZ	12.4	LR			14.0	25.9	
WJ-AZ	Winslow, Arizona	552	SPZ	29.7	Pn	01	17.7	0.5	24.4	4.78
			SPZ	29.7	e	01	25.6	0.7	46.2	
			SPZ	29.7	Pg	01	37.0	0.8	369	
			SPZ	29.7	s	01	55.5	0.8	173	
			SPT	30.6	Lg			0.6	508	
			LPZ	21.6	LR			14.0	23.7	
HR-AZ	Heber, Arizona	553	SPZ	41.0	Pn	01	17.5	0.5	22.1	4.73
			SPZ	41.0	e	01	22.3	0.5	35.3	
			SPZ	41.0	Pg	01	33.3	0.7	418	
			SPT	41.0	Lg			0.6	375	
			LPZ	19.7	LR			11.0	31.6	
WL-AZ	Wallini, Arizona	599	SPZ	37.8	Pn	01	22.4	0.8	34.0	5.01
			SPZ	37.8	e	01	25.0	0.9	36.5	
			SPZ	37.8	s	01	26.7	0.6	56.3	
			SPZ	37.8	Pg	01	40.5	0.8	447	
			SPT	39.2	Lg			0.8	849	
			LPZ	8.51	LR			(12.0)	(25.6)	
GE-AZ	Globe, Arizona	627	SPZ	42.4	Pn	01	26.4	0.7	20.2	4.95
			SPZ	42.4	e	01	35.0	0.6	16.1	
			SPZ	42.4	s	01	43.7	0.9	288	
			SPZ	42.4	Pg	01	44.5	0.7	311	
			SPT	42.1	Lg			0.8	166	
			LPZ	15.65	LR			15.0	17.9	
UBSO	Uinta Seismological Observatory, Utah	666	SPZ-10	19.3	Pn	01	34.1	0.8	112	5.65
			SPZ-10	19.3	Pg	01	52.	0.8	162	
			SPE	20.0	Lg			1.0	275	
HL2ID	Hailey, Idaho	726	SPZ	95.0	Pn	01	38.4	0.6	8.1	4.61
			SPZ	95.0	s	01	41.2	0.6	44.0	
			SPZ	95.0	e	01	45.1	0.5	38.1	
			SPZ	95.0	s	01	48.9	0.5	35.2	
			SPZ	95.0	Pg	02	04.4	0.8	193	
			SPT	94.6	Lg			0.6	157	
			LPZ	40.6	LR			13.0	15.8	

Principal Phases
PAR
9 October 1964
14:00:00.1Z

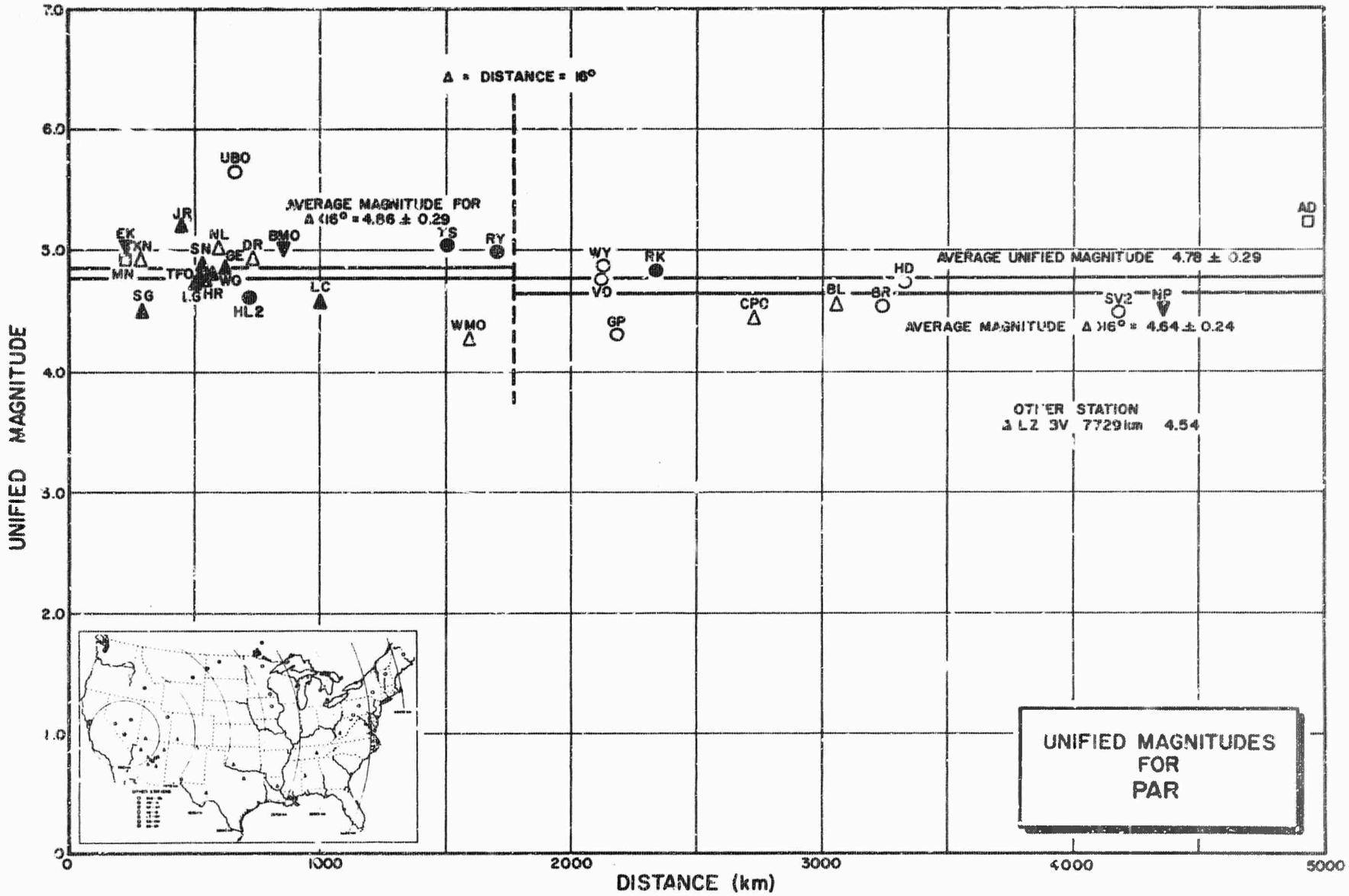
Code	Station	Distance (km)	Inst.	Magnification (x) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	Magnitude (m)
DR-CO	Durango, Colorado	735	SPZ	64.2	Pn	01	42.0	0.9	16.4	4.93
			SPZ	64.2	e	01	59.4	0.6	46.5	
			SPZ	64.2	Pg	02	03.2	0.6	157	
			SPZ	64.2	e	02	34.7	0.8	51.5	
			SPT	70.2	Lg			0.7	181	
			LPZ	57.6	LR			14.0	9.3	
BMSO	Blue Mountain Seismological Observatory, Oregon	861	SPZ-3	60.0	Pn	01	57.5	0.8	12.0	5.03
			SPZ-3	60.0	Pg	02	23.1	0.8	48.1	
			SPE	60.0	Lg			0.8	96.1	
			LPZ	40.0	LR			16.0	11.1	
LC-NM	Las Cruces, New Mexico	1014	SPZ	160	P	02	17.9	0.8	2.3	4.57
			SPZ	160	Pg	02	51.9	0.9	49.9	
			SPT	163	Lg			1.4	107	
			LPZ	72.0	(LR)			16.0	8.0	
RT-NM	Raton, New Mexico	1044	SPZ	245	(PP)	02	(26.3)	1.0	4.1	
			SPZ	245	e	02	41.4	0.9	8.6	
			SPZ	245	Pg	02	54.7	0.8	49.8	
			SPZ	245	e	03	20.1	1.0	49.0	
			SPT	256	Lg			1.4	96.4	
			LPZ	13.8	LR			15.0	8.1	
FO-TX	Fort Stockton, Texas	1414	SPT	345	Lg			1.0	37.7	
TS-ND	Trotters, North Dakota	1505	SPZ	51.5	P	03	17.6	0.7	18.3	5.05
			SPZ	51.5	Pg	03	59.0	0.6	35.2	
			SPT	48.9	Lg			0.8	24.4	
WMSO	Wichita Mountain Seismological Observatory, Oklahoma	1599	SPZ-6	190	P	03	30.0	1.2	5.9	4.26
			SPZ-6	190	PP	03	44.4	1.0	7.9	
			SPZ-6	190	Pg	04	31.3	1.0	10.5	
			SPZ-6	190	e	04	03.4	1.1	6.9	
			SPN	200	Lg			1.4	37.5	
RY-ND	Rydar, North Dakota	1701	SPZ	32.0	P	03	44.7	0.7	64.3	4.99
VO-IO	Vinton, Iowa	2123	SPZ	105.8	P	04	(25.9)	0.8	57.3	4.76
			SPZ	105.8	e	04	32.3	1.0	42.6	
WF-MN	Wykoff, Minnesota	2133	SPZ	126	P	04	26.6	0.7	72.1	4.86
			SPZ	126	e	04	47.2	1.0	33.7	
GP-MN	Grand Rapids, Minnesota	2134	SPZ	167	P	04	31.1	0.8	19.8	4.30
			SPZ	167	e	04	51.7	0.9	13.9	
			SPZ	167	e	05	00.7	0.6	10.5	
RK-ON	Red Lake, Ontario, Canada	2335	SPZ	198	P	04	45.5	0.8	48.3	4.81
			SPZ	198	e	04	51.4	0.8	25.1	
			SPZ	198	e	04	59.9	0.7	11.3	
CPSO	Cumberland Plateau Seismological Observatory, Tenn.	2732	SPZ-8	310.0	P	05	22.6	0.7	10.1	4.43
			SPZ-8	310.0	e	05	34.7	0.7	7.0	
			SPN	310.0	(Lg)			1.5	29.6	
BL-WV	Beckley, West Virginia	3059	SPZ	55.8	(P)	05	50.8	(0.8)	(9.9)	(1.54)
BR-PA	Berlin, Pennsylvania	3138	SPZ	131	(P)	06	00.9	0.6	8.5	4.53
HD-PA	Howard, Pennsylvania	3331	SPZ	176	P	06	(10.7)	(0.4)	(14.3)	(4.75)
			SPZ	176	e	06	16.0	0.5	13.4	
			SPZ	176	e	06	19.1	0.5	12.3	
			SPZ	176	(PcP)	09	00.9	0.4	27.5	
SV2QB	Schaffarville, Quabec, Canada	4186	SPZ-1	96.4	P	07	16.8	0.8	9.5	4.48
MP-MT	Mould Bay, Northwest Territories, Canada	4362	SPZ	120.5	P	07	(29.3)	0.8	13.0	4.52
AD-IS	Adak Island, Alaska	4933	SPZ	39.5	P	08	10.9	0.7	42.4	5.21
LZ-BV	Laz Par, Bolivia	7729	SPZ	219	P	11	12.3	0.6	3.9	4.54

A/T mu/sec

( ) Doubtful Values or Phases

• Measurements Made from Playouts

e Emergent Phase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DISTANCE (km)
Δ = DISTANCE = 16°
AVERAGE MAGNITUDE FOR Δ <16° = 4.86 ± 0.29
AVERAGE UNIFIED MAGNITUDE 4.78 ± 0.29
AVERAGE MAGNITUDE Δ >16° = 4.64 ± 0.24
OTHER STATION
Δ LZ 3V 7729km 4.54
UNIFIED MAGNITUDES FOR PAR
UBO
JR
EK
KN
NL
SN
GE
DR
BMO
YS
RY
WY
RK
HD
MN
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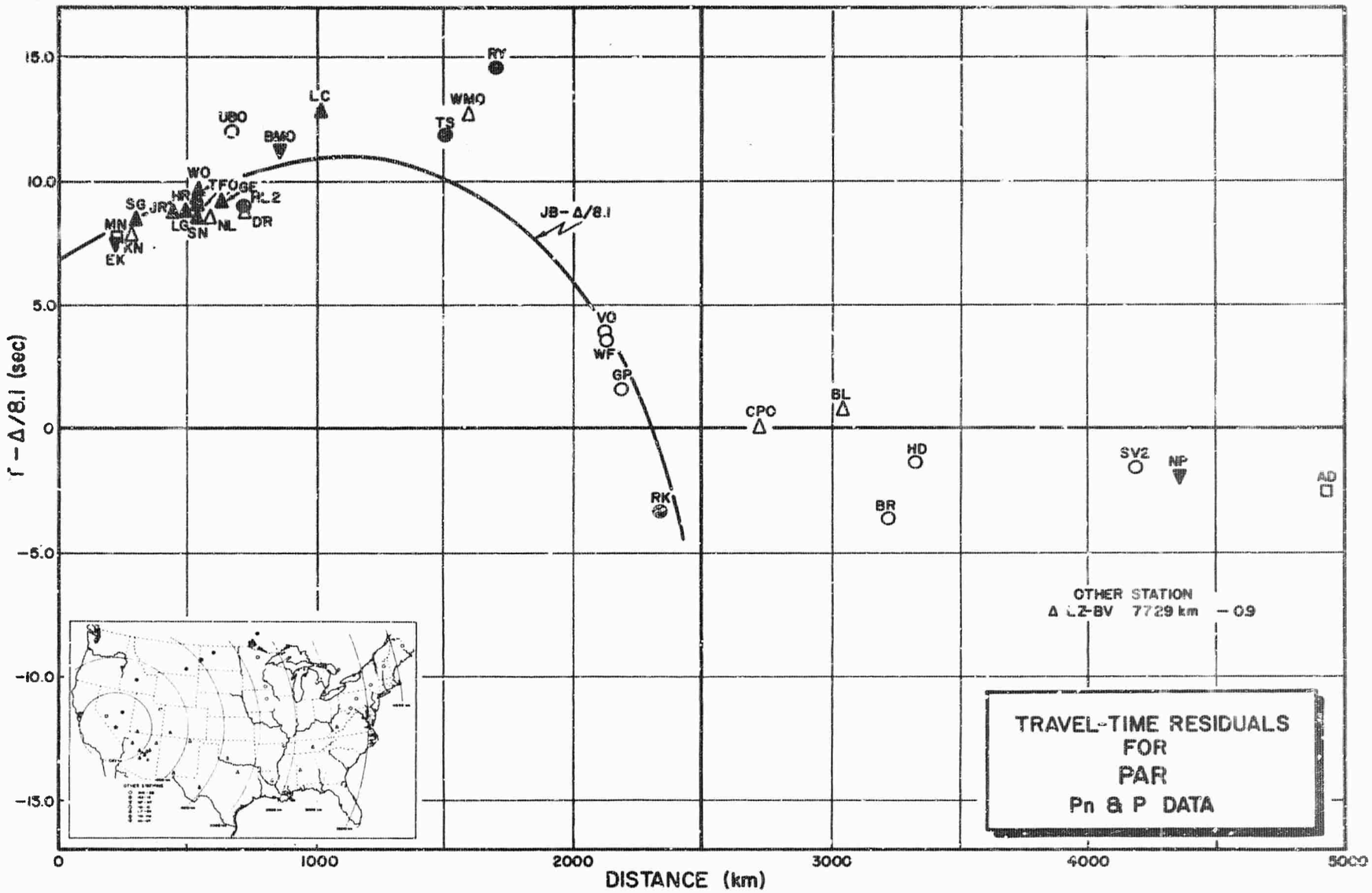
WMO
GP
CPC

Figure 2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LG
SN
NL
DR
KN
EK
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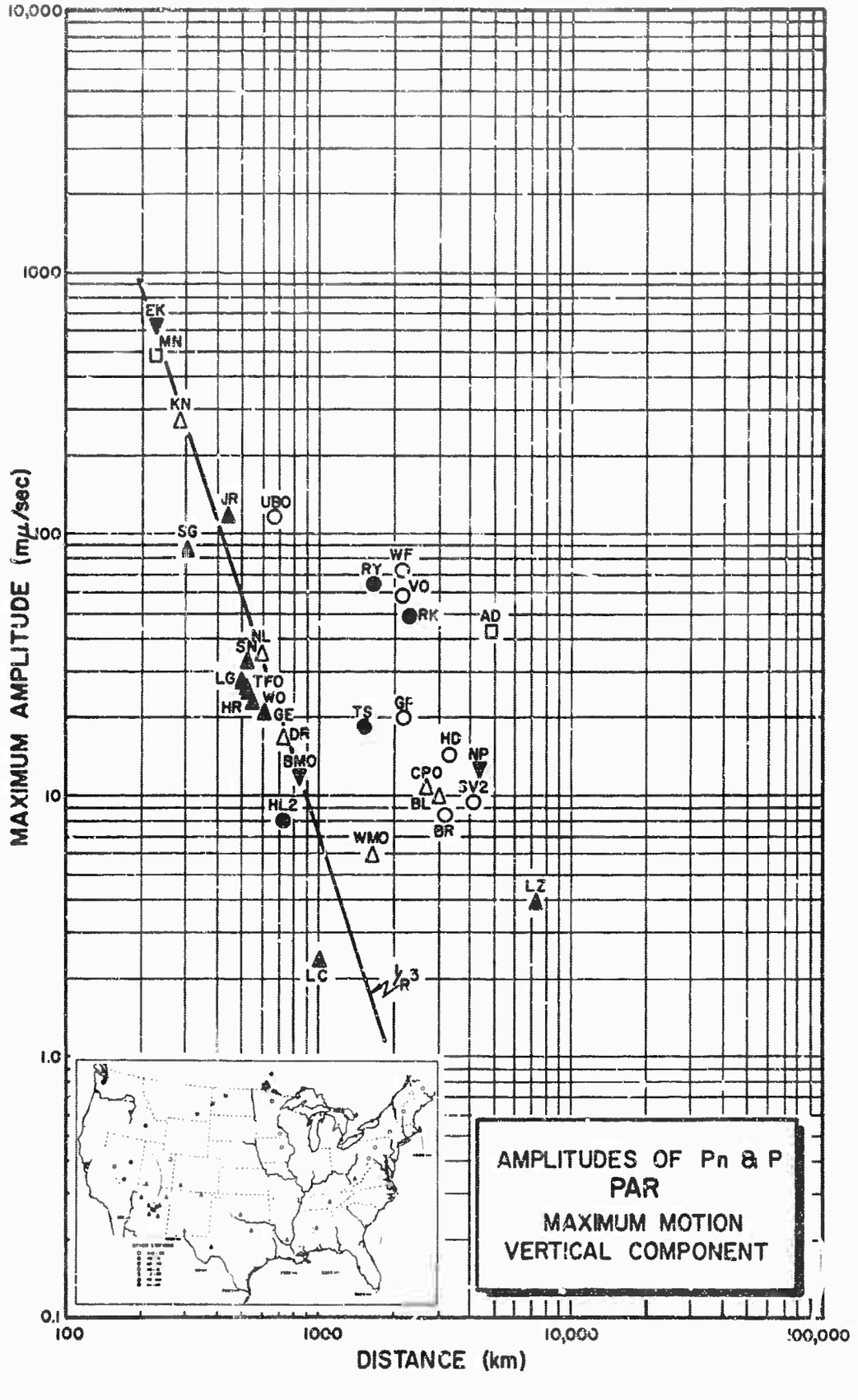
VO
WF
GP
CPC
BL
HD
BR
RK
SV2
NP
AD
OTHER STATION
Δ LZ-BV 7729 km — 09
TRAVEL-TIME RESIDUALS
FOR
PAR
Pn & P DATA

Figure 3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MN
KN
JR
UBO
SG
WF
RY
VO
RK
AD
NL
SN
LG
TFO
HR
WO
GE
TS
GF
DR
HD
NP
BMO
CPO
SV2
BL
HL2
BR
WMO
LZ
LC
R³
100
1000
10,000
100,000
DISTANCE (km)
AMPLITUDES OF Pn & P
PAR
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 4

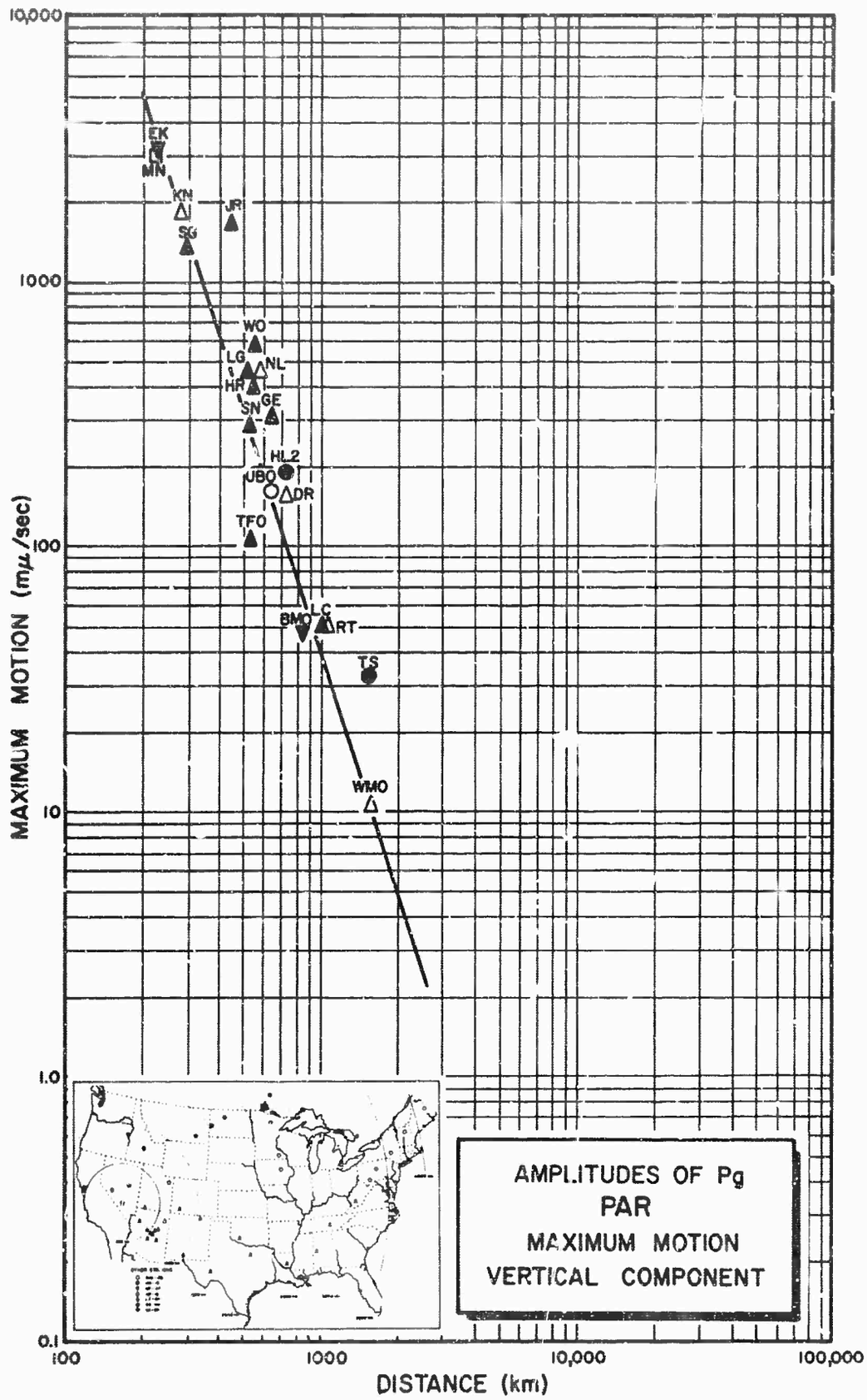

10,000
1000
100
10
1.0
0.1
MAXIMUM MOTION (mμ/sec)
EK
MN
KN
JR
SG
WO
LG
NL
HR
SN
GE
HL2
UBO
DR
TFO
BMO
LC
RT
TS
WMO
100
1000
10,000
100,000
DISTANCE (km)
AMPLITUDES OF Pg
PAR
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 5

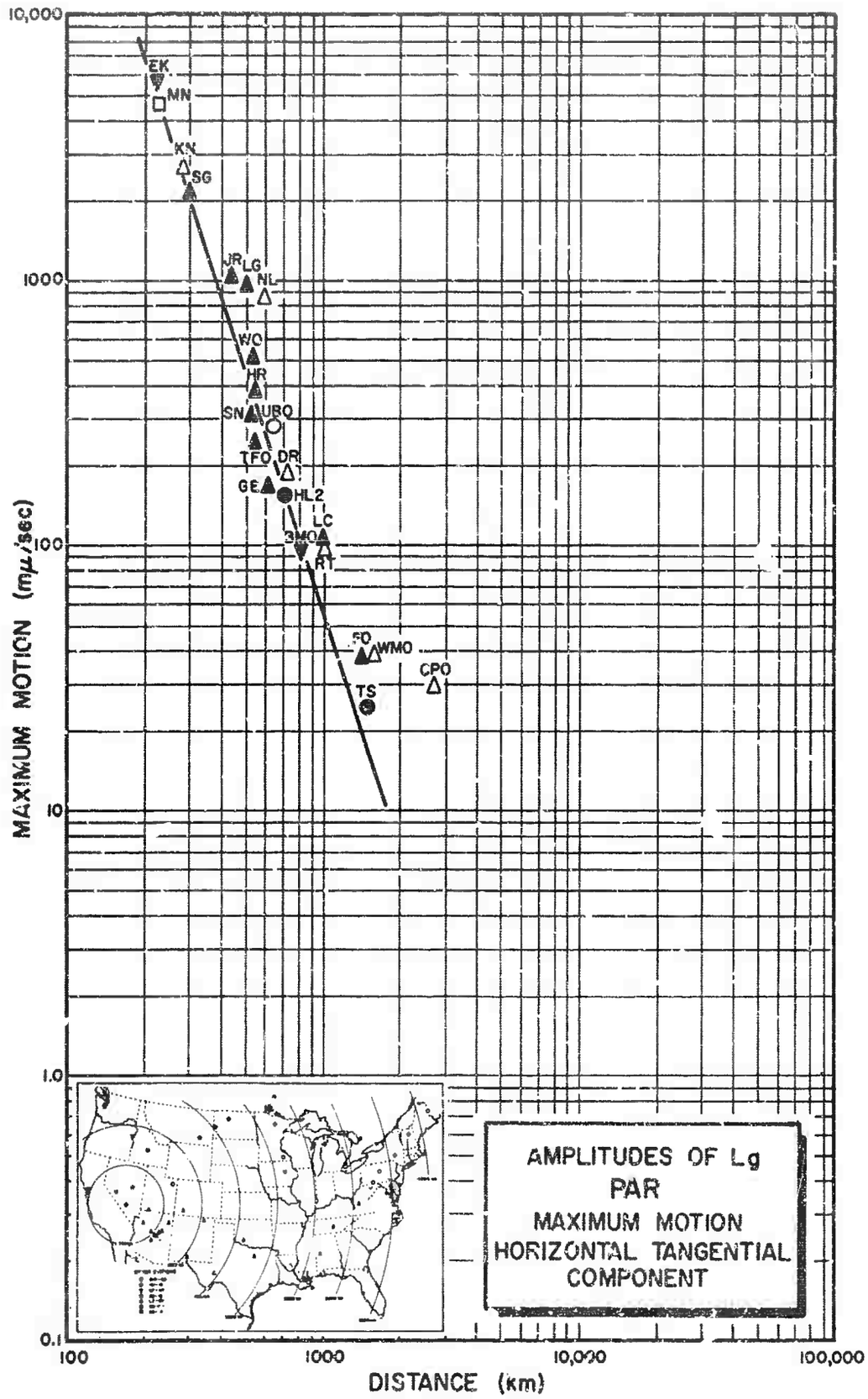

10,000
1000
100
10
1.0
0.1
MAXIMUM MOTION (mμ/sec)
EK
MN
KN
SG
JR
LG
NL
WC
HR
SN
UBQ
TFO
DR
GE
HL2
LC
3MO
RT
FO
WMO
CPO
TS
100
1000
10,000
100,000
DISTANCE (km)
AMPLITUDES OF Lg
PAR
MAXIMUM MOTION
HORIZONTAL TANGENTIAL
COMPONENT

Figure 6

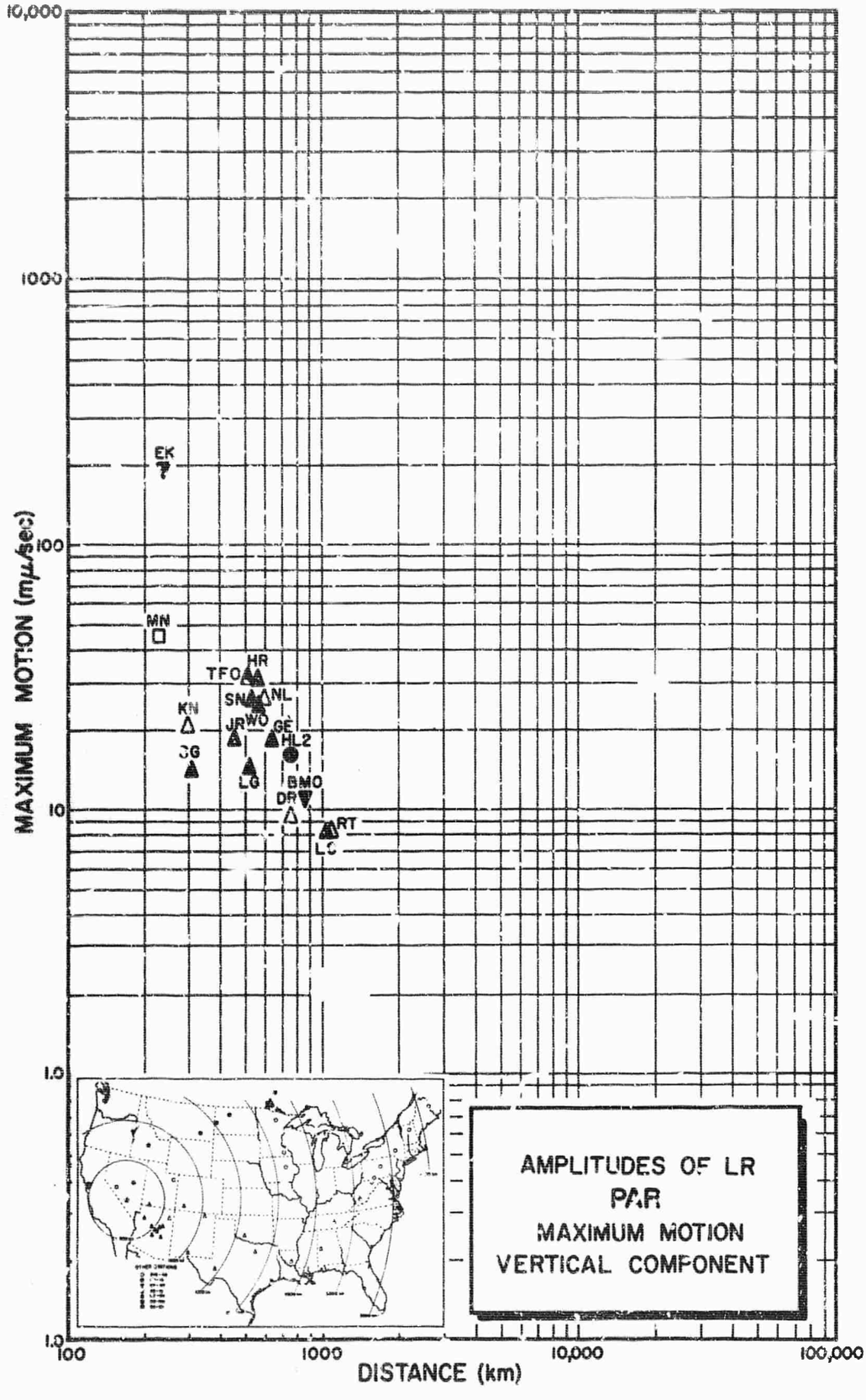

10,000
1000
100
10
1.0
1.0
MAXIMUM MOTION (mμ/sec)
EK
MN
HR
TFO
SN
NL
KN
JR
WO
GE
HL2
CG
LG
BMO
DR
RT
LC
100
1000
10,000
100,000
DISTANCE (km)
AMPLITUDES OF LR
PAR
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 7

Code	Station	Distance (km)	Geographic Latitude	Geographic Longitude	Elev. (km)	Computed Azimuth		Installed Azimuth		Large or Small SP	LP Inst.
						Epi. Sta.	Sta. Epi.	Radial	Tang.		
EK-NV	Eureka, Nevada	231	39°12'32" N	115°43'37" W	1.95	8°	188°	11°	101°	L	X
MN-NV	Mina, Nevada	232	38°26'10" N	118°08'33" W	1.52	309°	127°	308°	38°	L	X
KN-UT	Kanab, Utah	289	37°01'22" N	112°49'39" W	1.74	92°	274°	95°	183°	L	X
SG-AZ	Seligman, Arizona	303	35°36'27" N	113°15'39" W	1.64	123°	304°	131°	221°	L	X
JR-AZ	Jarome, Arizona	450	34°45'32" N	111°59'25" W	1.31	124°	306°	131°	221°	L	X
LG-AZ	Long Valley, Arizona	510	34°24'28" N	111°32'45" W	1.77	125°	308°	131°	221°	S	X
TFSO-Z1	Tonto Forest Observatory, Arizona	539	34°17'12" N	111°16'03" W	1.49	125°	308°	90°	0°	JM	X
SN-AZ	Sunflower, Arizona	540	33°51'49" N	111°41'34" W	.98	131°	314°	131°	221°	L	X
WO-AZ	Winslow, Arizona	552	34°52'53" N	110°37'15" W	1.59	115°	299°	131°	221°	L	X
HB-AZ	Heber, Arizona	553	34°40'11" N	110°35'59" W	1.88	118°	301°	131°	221°	L	X
NL-AZ	Nazlini, Arizona	599	35°54'05" N	109°34'10" W	1.77	101°	285°	131°	221°	L	X
GE-AZ	Globe, Arizona	627	33°46'32" N	110°31'41" W	1.48	125°	308°	131°	221°	L	X
UBSO-Z10	Uinta Basin Observatory, Utah	666	40°19'18" N	109°34'07" W	1.60	56°	240°	90°	0°	JM	X
HL2ID	Hailey, Idaho	726	43°33'40" W	114°25'08" W	1.83	11°	192°	13°	103°	L	X
DR-CO	Durango, Colorado	735	37°27'53" N	107°47'00" W	2.23	85°	270°	90°	180°	S	X
BMSO-Z3	Blue Mountain Observatory, Oregon	861	44°50'56" W	117°18'20" W	1.19	354°	173°	0°	90°	JM	X
LC-NM	Las Cruces, New Mexico	1014	32°24'08" N	106°35'58" W	1.59	119°	304°	124°	214°	I	X
RT-NM	Raton, New Mexico	1044	36°43'46" N	104°21'37" W	1.95	89°	276°	96°	186°	L	X
AN-MA	Angela, Montana	1348	46°45'08" N	106°05'33" W	.91	35°	221°				
FO-TX	Fort Stockton, Texas	1414	30°54'06" N	102°41'52" W	.88	115°	303°	123°	213°	S	-
TS-ND	Trottars, North Dakota	1505	47°06'25" N	103°40'23" W	.82	59°	227°	90°	180°	L	-
WMSO-Z6	Wichita Mountain Observatory, Oklahoma	1599	34°43'05" N	98°35'21" W	.51	94°	285°	90°	0°	JM	X
RY-ND	Ryder, North Dakota	1701	48°05'50" N	101°29'40" W	.64	40°	230°	50°	140°	S	X
GV-TX	Grapevine, Texas	1801	32°53'08" N	96°59'54" W	.15	100°	291°	111°	201°	L	LPZ
VO-IO	Viator, Iowa	2123	42°13'30" W	92°07'37" W	.27	67°	263°	83°	173°	S	X
WF-MN	Wykoff, Minnesota	2133	43°48'05" N	92°22'23" W	.38	62°	250°	70°	168°	S	X
GJ-MN	Grand Rapids, Minnesota	2184	47°39'52" W	93°25'22" W	.43	51°	246°	66°	156°	S	X
JE-LA	Jena, Louisiana	2282	31°47'05" N	92°00'55" W	.05	98°	282°	112°	202°	L	X
RK-ON	Red Lake, Ontario, Canada	2339	50°50'20" N	93°40'20" W	.37	42°	238°	58°	148°	S	X
EU-AL	Eutaw, Alabama	2610	32°47'10" N	87°52'00" W	.03	92°	289°	109°	199°	S	X
CPSO-Z8	Cumberland Plateau Observatory, Tennessee	2732	35°35'41" N	85°34'13" W	.57	84°	283°	90°	0°	JM	X
BL-WV	Beckley, West Virginia	3059	37°47'56" N	81°18'36" W	.61	78°	279°	100°	190°	S	X
BR-PA	Berlin, Pennsylvania	3238	39°55'27" N	78°50'41" W	.66	73°	277°	97°	187°	L	X
HO-PA	Howard, Pennsylvania	3331	40°59'44" N	77°35'44" W	.37	71°	275°			S	
DE-NY	Delhi, New York	3544	42°14'39" N	74°53'18" W	.65	68°	275°	85°	185°	S	X
LS-NH	Lisbon, New Hampshire	3768	44°14'18" W	71°55'21" W	.29	64°	273°	94°	184°	S	X
HM-ME	Houlton, Maine	4065	46°09'43" N	67°59'09" W	.21	60°	273°	93°	183°	S	X
SV2QM	Schefferville, Quebec, Canada	4186	54°48'54" N	66°45'31" W	.58	46°	263°	131°	221°	S	LPZ
HM-IS	Kamuela, Hawaii	4277	19°58'49" N	155°42'20" W	.71	255°	55°	235°	325°	L	X
MF-MT	Mould Bay, Northwest Territories, Canada	4362	76°15'08" N	119°22'18" W	.06	359°	176°	356°	86°	JMZ S	X
AD-IS	Adak Islands	4933	51°52'30" N	176°40'45" W	.06	309°	89°	0°	90°	L	X
LC-BV	La Paz, Bolivia	7129	16°15'31" S	68°28'47" W	3.99	131°	321°	141°	231°	L	X
OO-NW	Oslo, Norway	8206	61°03'17" N	10°51'58" E	.56	25°	318°	130°	228°	L	X
GG-GR	Grefanberg, Germany	9094	49°41'32" N	11°12'55" E	.53	31°	320°	140°	230°	L	X

Recording Site Information - PAR

Appendix I(A)

Unified Magnitude: $m = \log_{10} (A/T), + B$

where

A = zero to peak ground motion in millimicrons
$= \frac{(mm)\ (1000)}{K}$

T = signal period in seconds

B = distance factor (see Table below)

mm = record amplitude in millimeters zero to peak

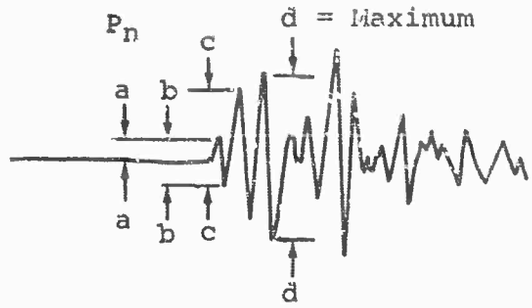
K = magnification in thousands at signal frequency

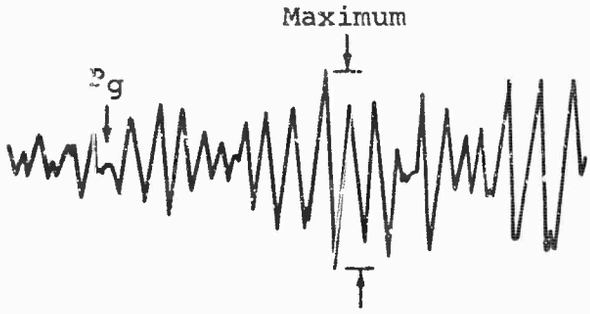
Table of Distance Factors (B) for Zero Depth

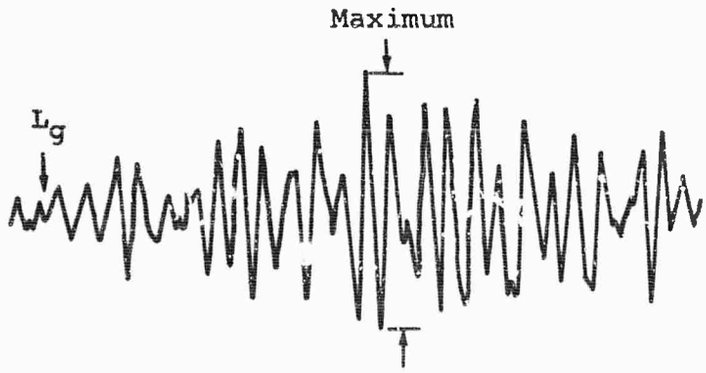
Dist (deg)	B	Dist (deg)	B	Dist (deg)	B	Dist (deg)	B
0°	-	27°	3.5	54°	3.8	80°	3.7
1	-	28	3.6	55	3.8	81	3.8
2	2.2	29	3.6	56	3.8	82	3.9
3	2.7	30	3.6	57	3.8	83	4.0
4	3.1	31	3.7	58	3.8	84	4.0
5	3.4	32	3.7	59	3.8	85	4.0
6	3.6	33	3.7	60	3.8	86	3.9
7	3.8	34	3.7	61	3.9	87	4.0
8	4.0	35	3.7	62	4.0	88	4.1
9	4.2	36	3.6	63	3.9	89	4.0
10	4.3	37	3.5	64	4.0	90	4.0
11	4.2	38	3.5	65	4.0	91	4.1
12	4.1	39	3.4	66	4.0	92	4.1
13	4.0	40	3.4	67	4.0	93	4.2
14	3.6	41	3.5	68	4.0	94	4.1
15	3.3	42	3.5	69	4.0	95	4.2
16	2.9	43	3.5	70	3.9	96	4.3
17	2.9	44	3.5	71	3.9	97	4.4
18	2.9	45	3.7	72	3.9	98	4.5
19	3.0	46	3.8	73	3.9	99	4.5
20	3.0	47	3.9	74	3.8	100	4.4
21	3.1	48	3.9	75	3.8	101	4.3
22	3.2	49	3.8	76	3.9	102	4.4
23	3.3	50	3.7	77	3.9	103	4.5
24	3.3	51	3.7	78	3.9	104	4.6
25	3.5	52	3.7	79	3.8	105	4.7
26	3.4	53	3.7				

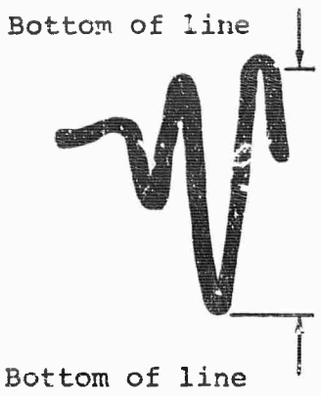
Unified Magnitudes From P_n or P Waves

Appendix I(B)









Detail Showing Allowance For Line Width

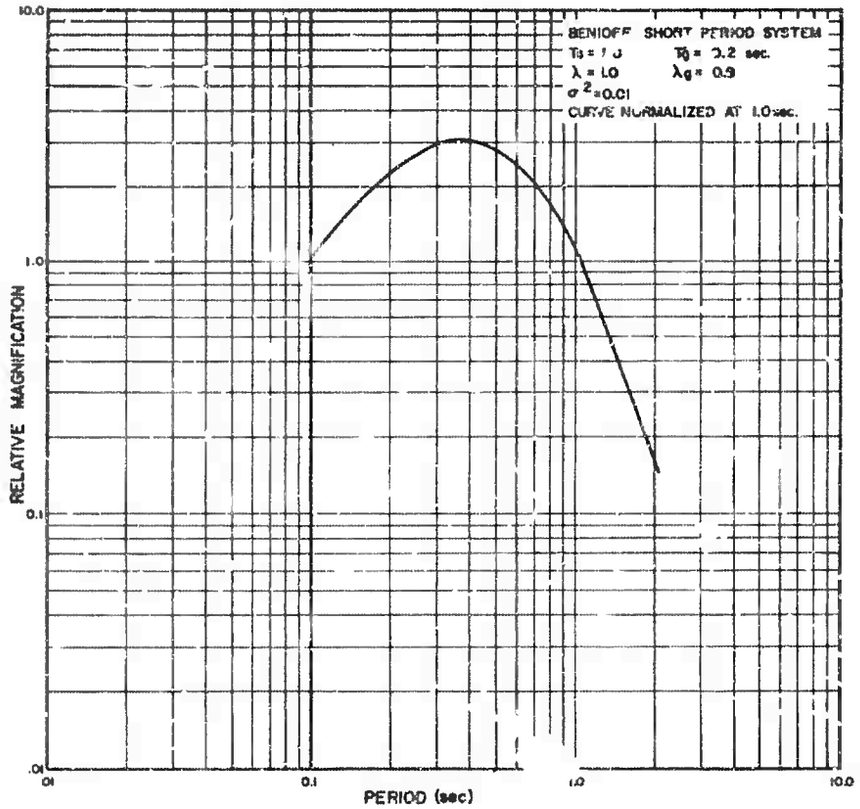
Pick <u>time</u> of <u>Pn</u> at beginning of "a" half cycle.

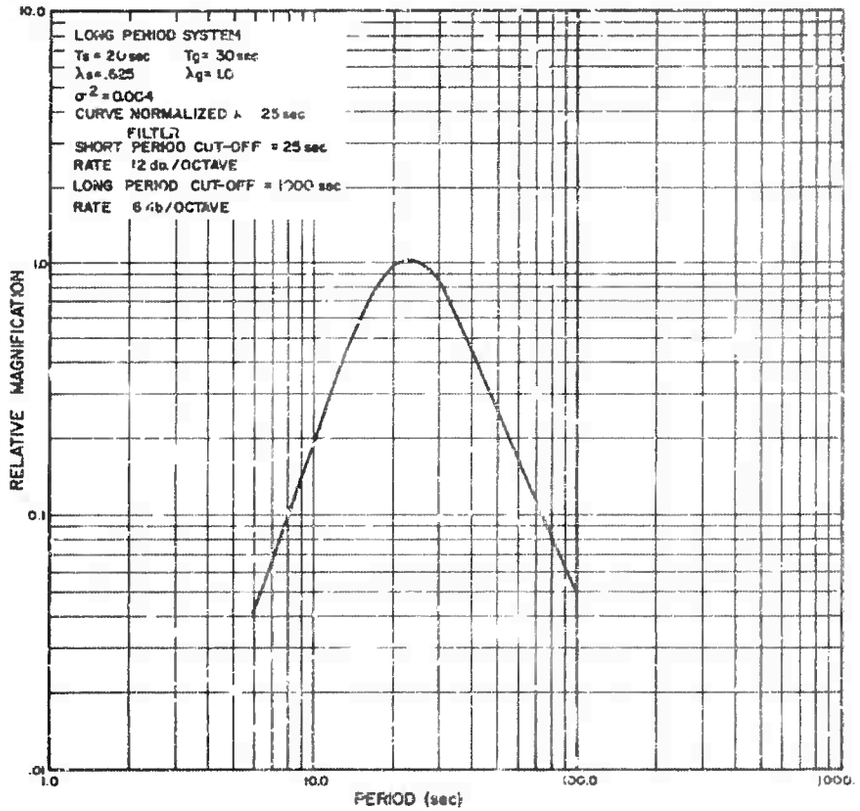
Pick <u>amplitude</u> of <u>Pn</u> as maximum "$d/2$" within 2 or 3 cycles of "c".

Pick <u>amplitudes</u> of <u>Pg</u> and <u>Lg</u> at maximum of corresponding motion.

Seismic Analysis Diagram

APPENDIX II(A)





INSTRUMENT RESPONSE CURVES - LRSM

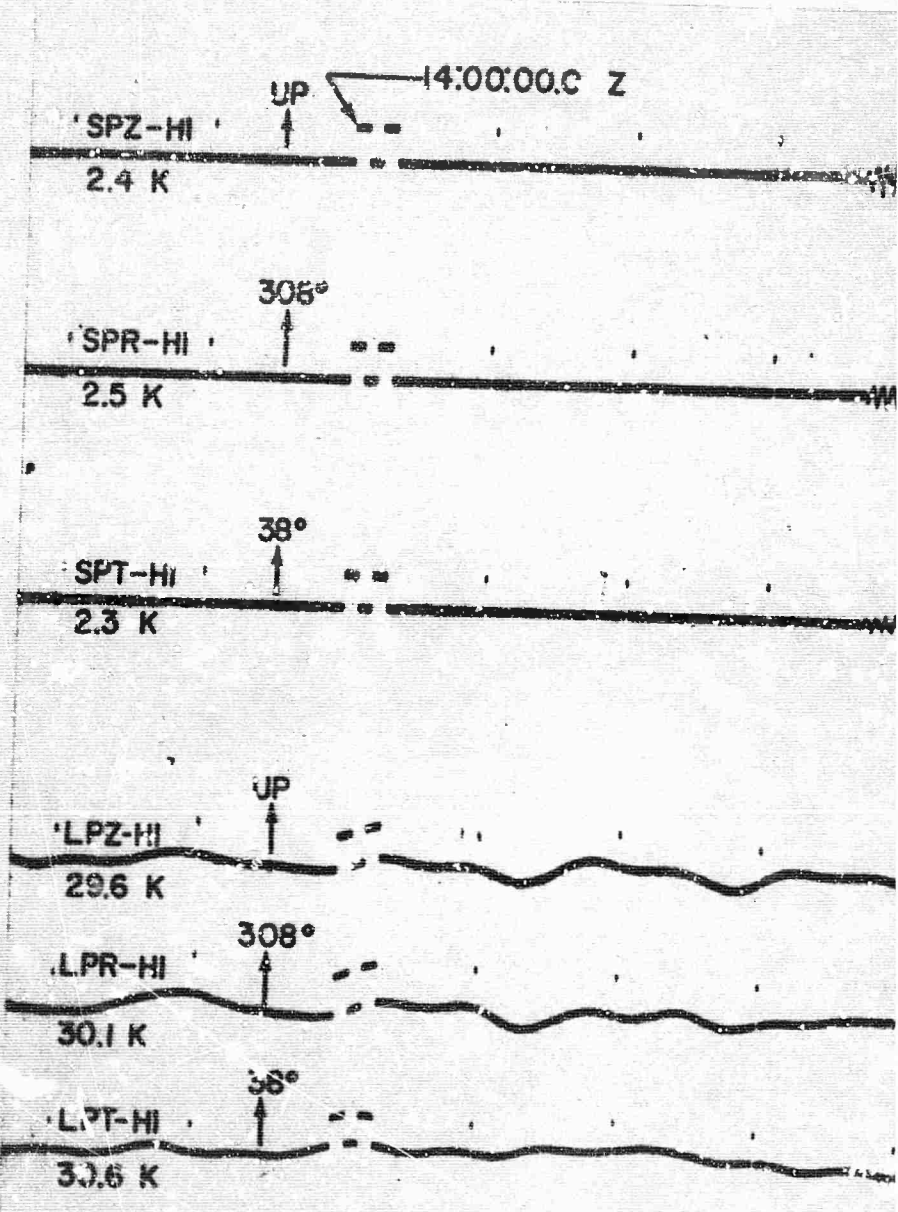
P&R

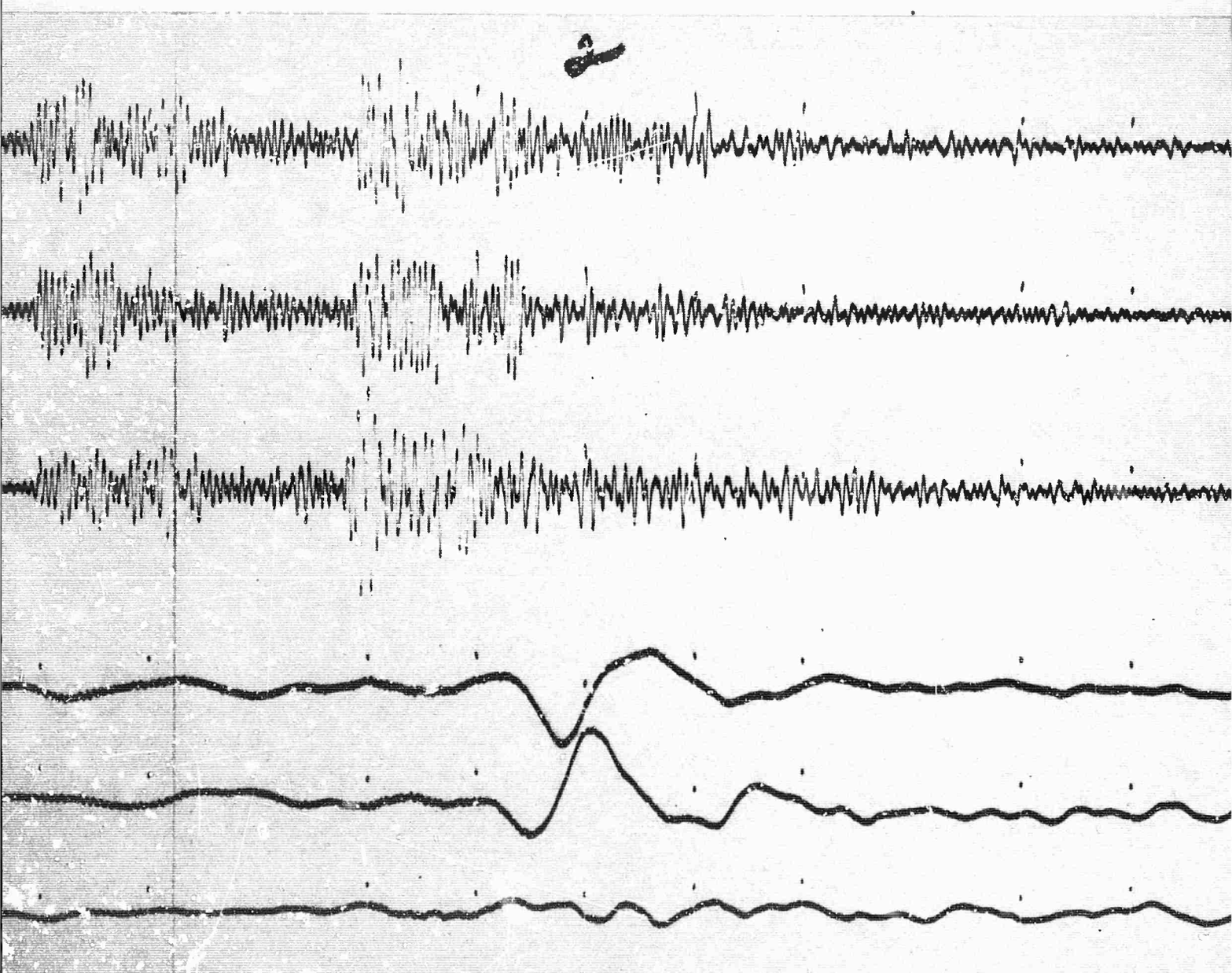
MN-NV

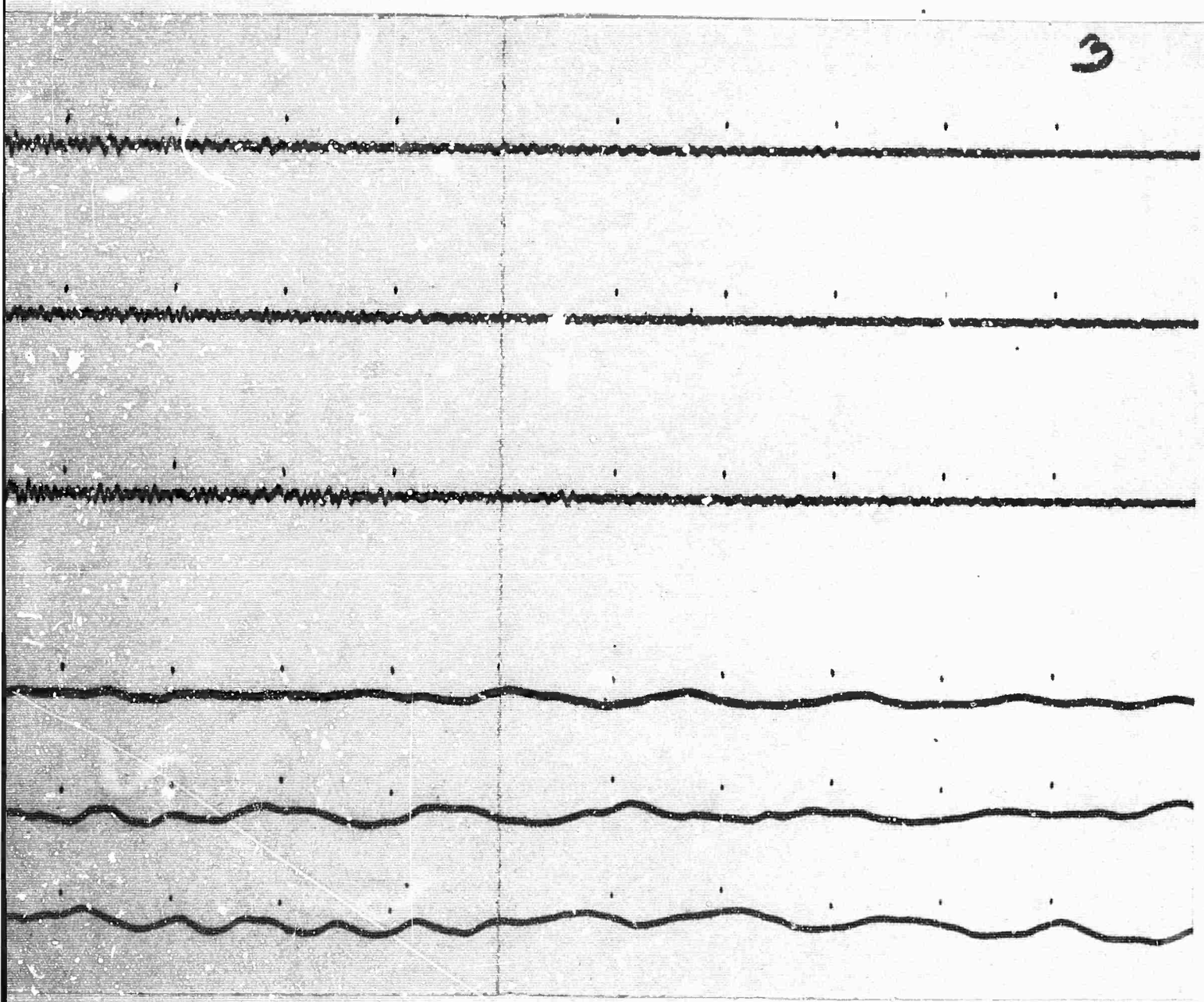
Mina, Nevada

9 October 1964

Δ = 232 km






3

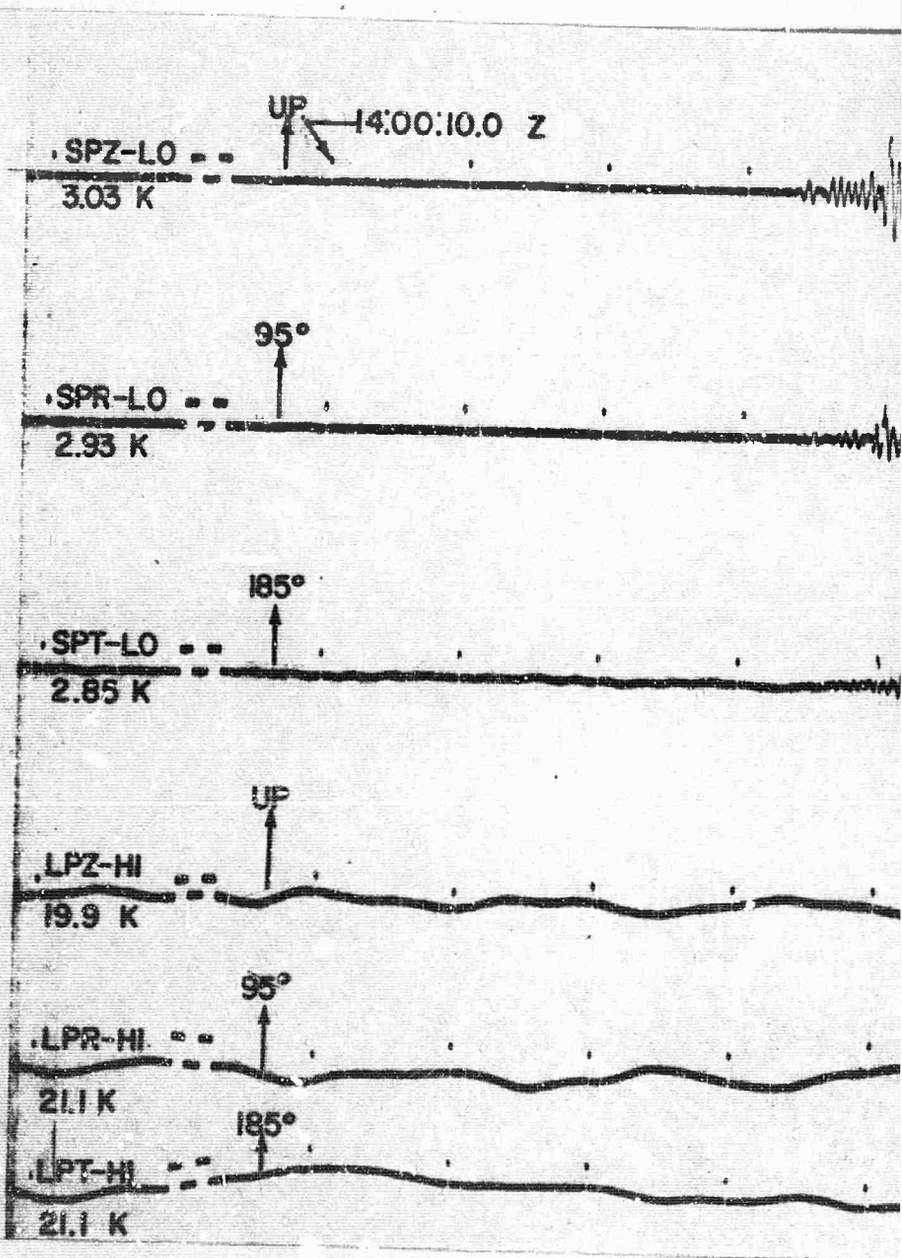
PAR

KN-UT

Kanab, Utah

9 October 1964

Δ = 289 km



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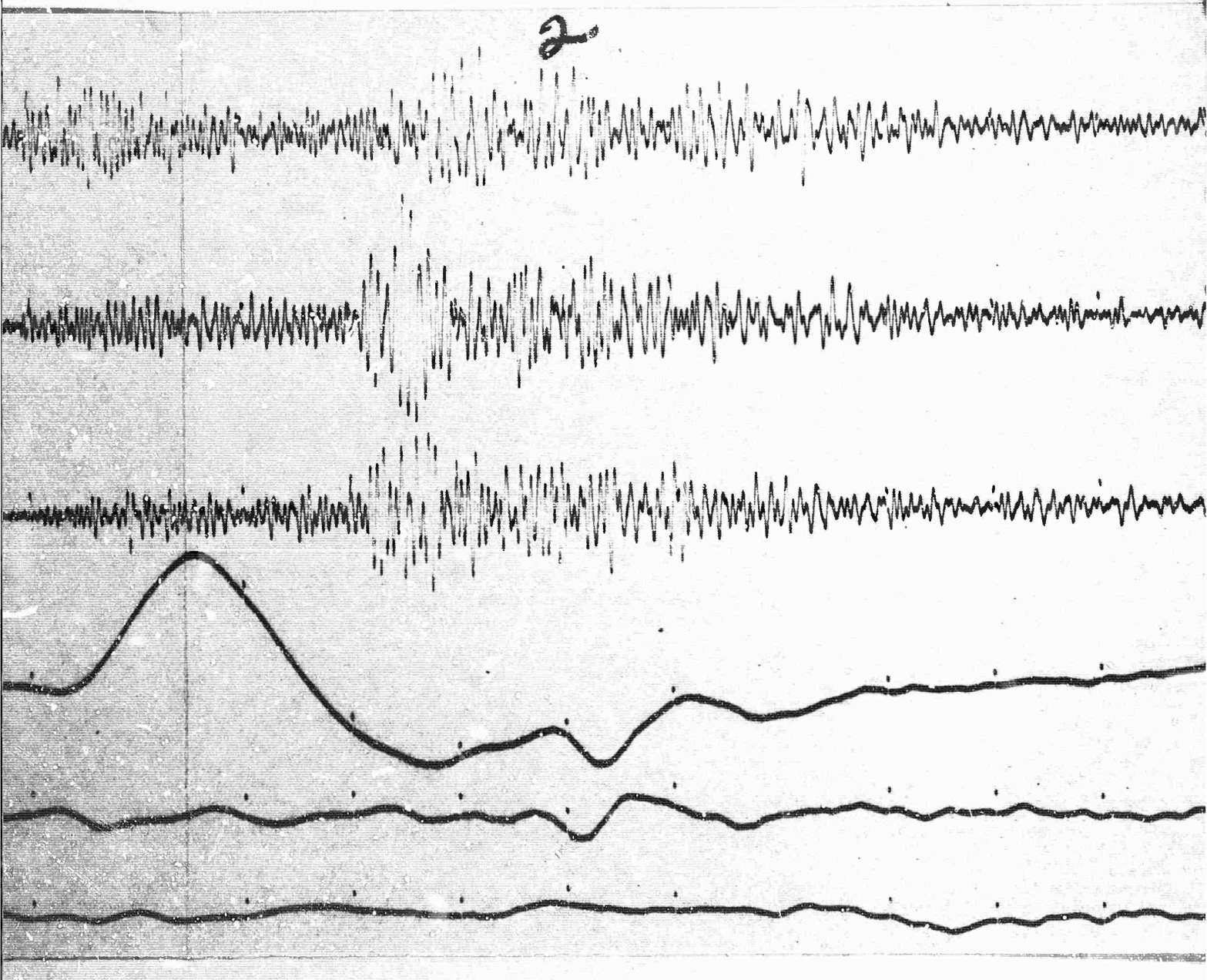

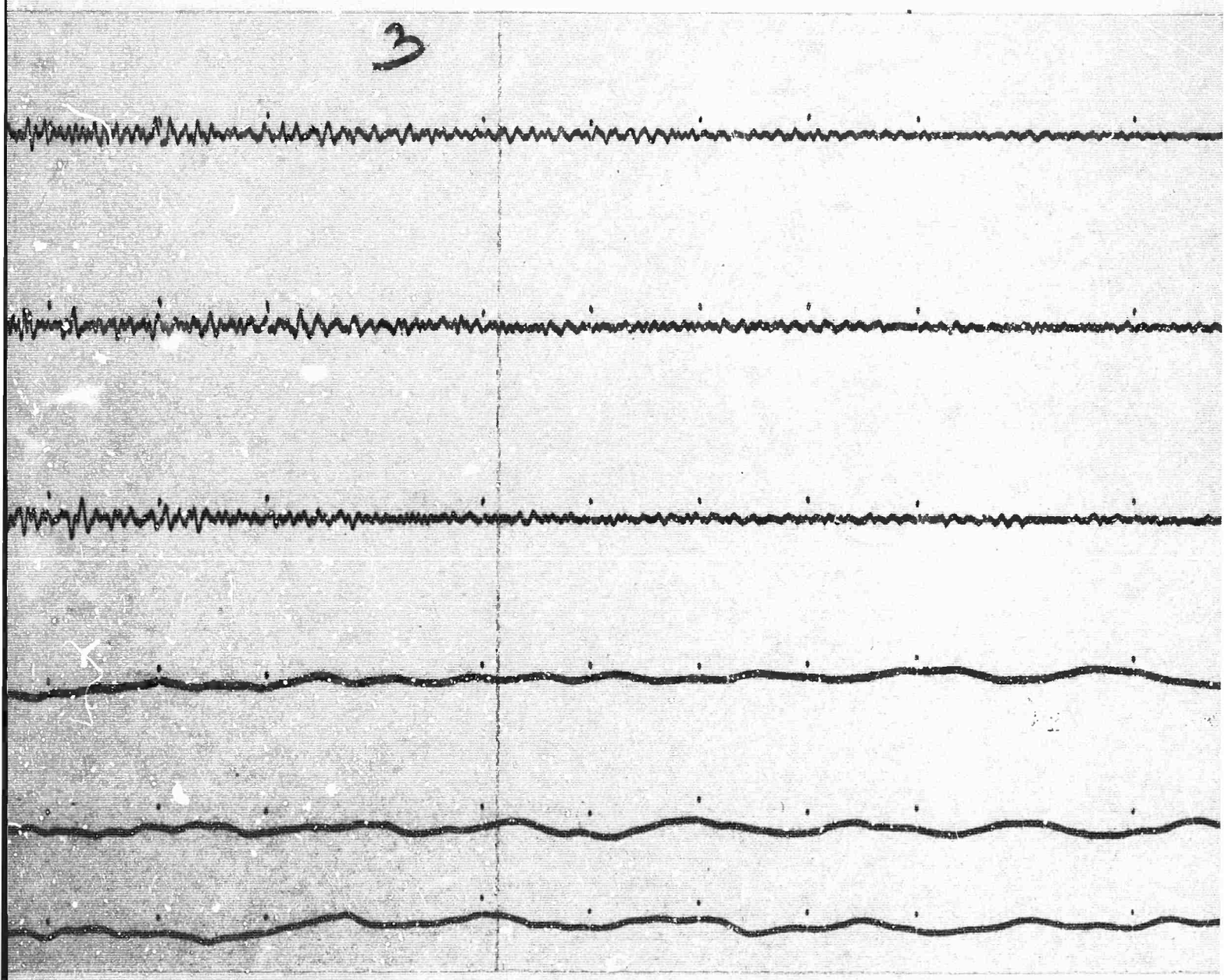
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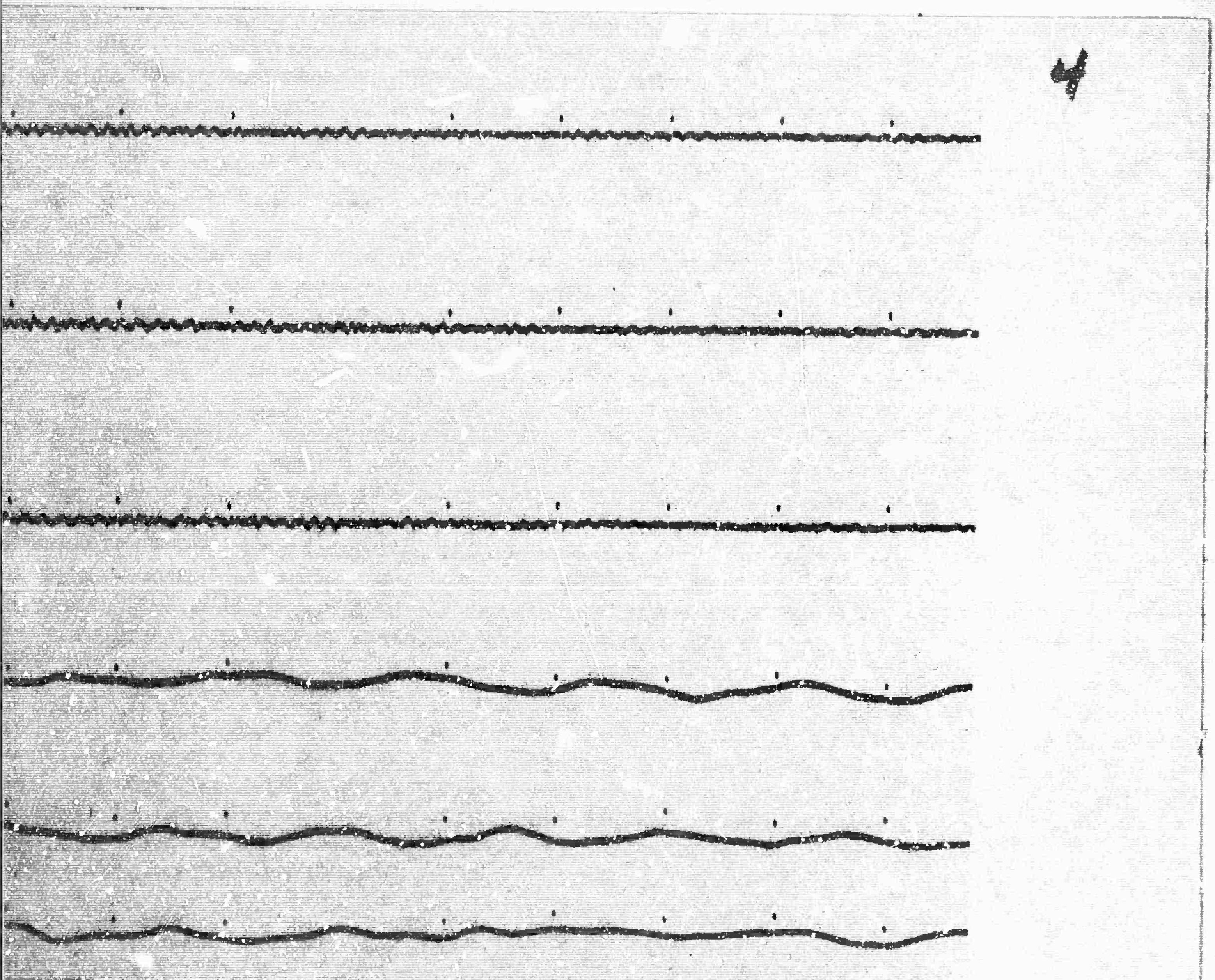
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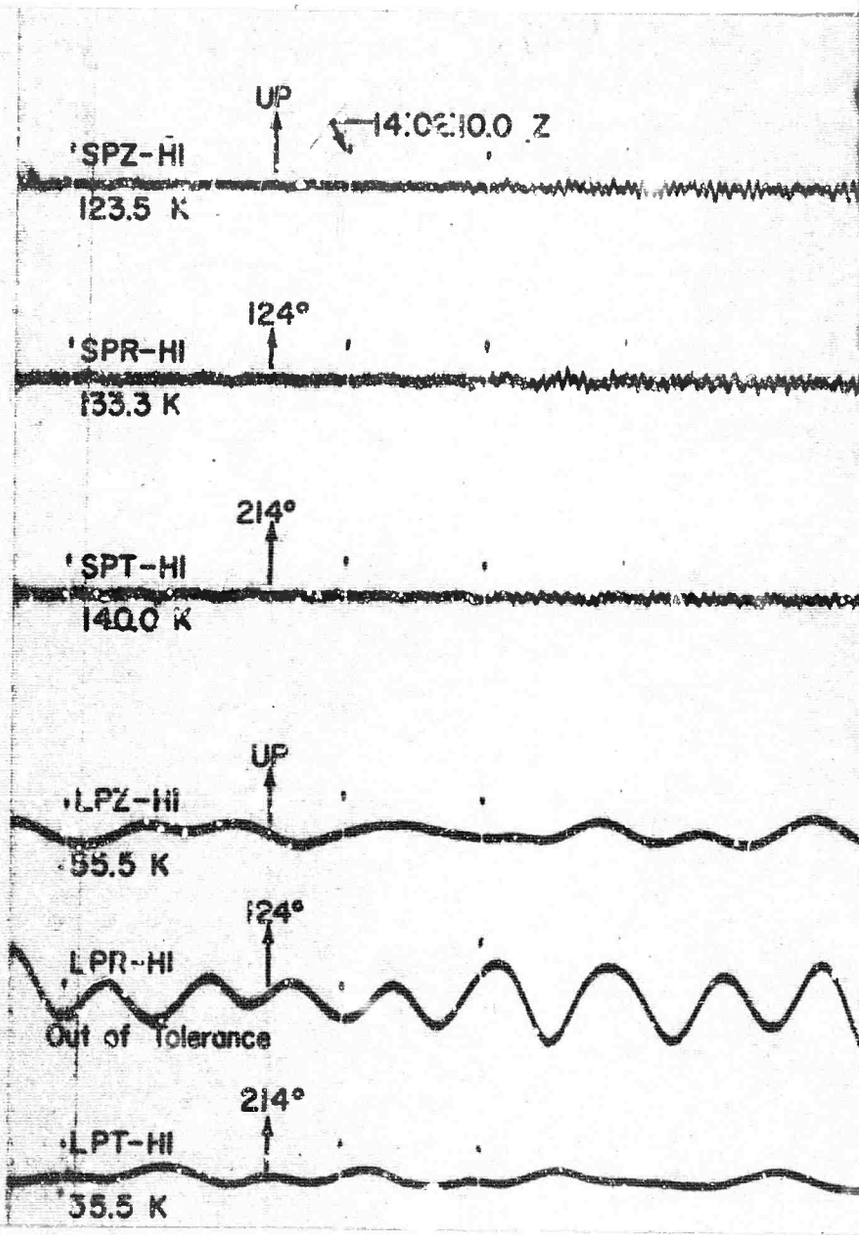
PAR

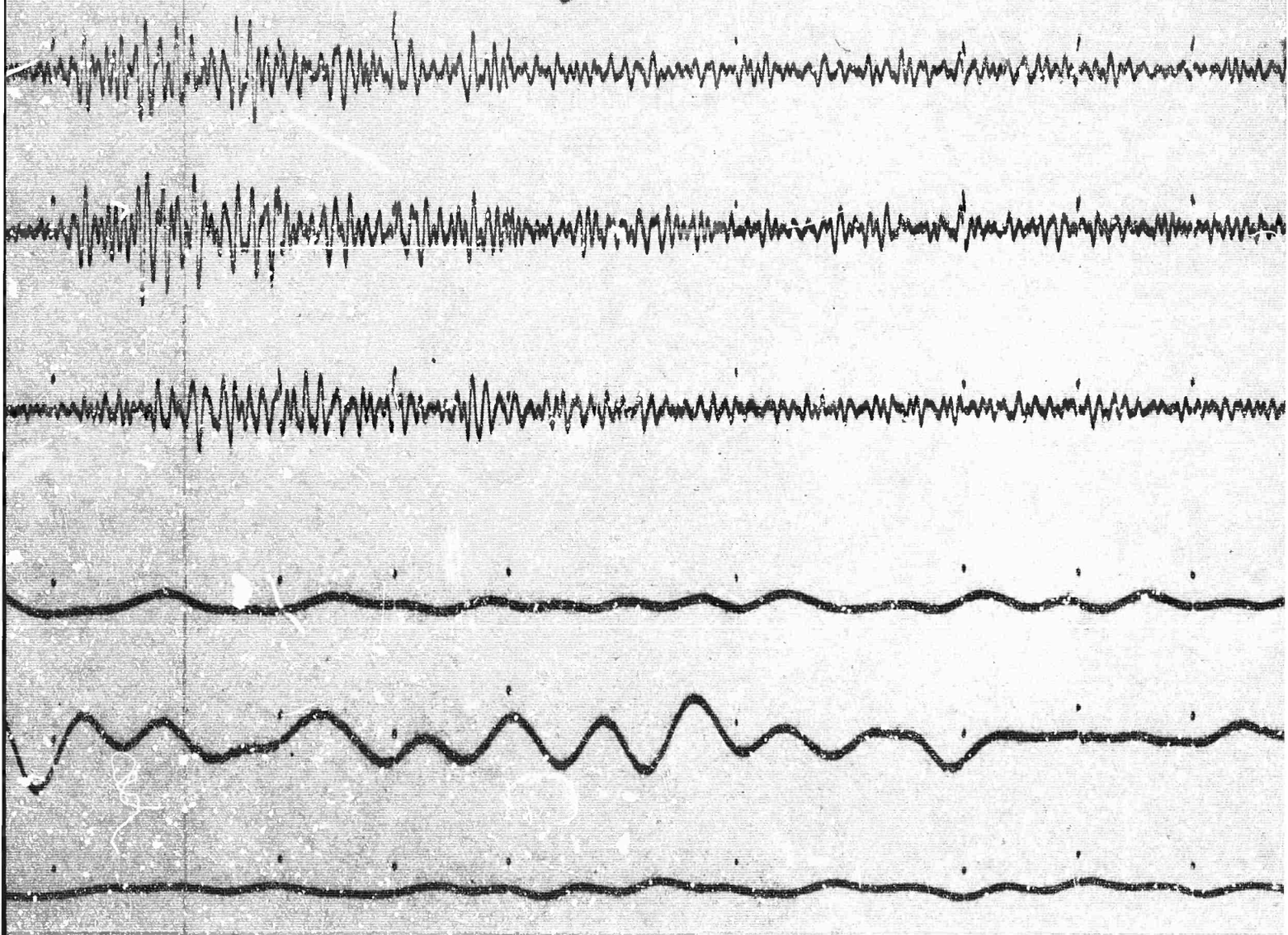
LC-NM

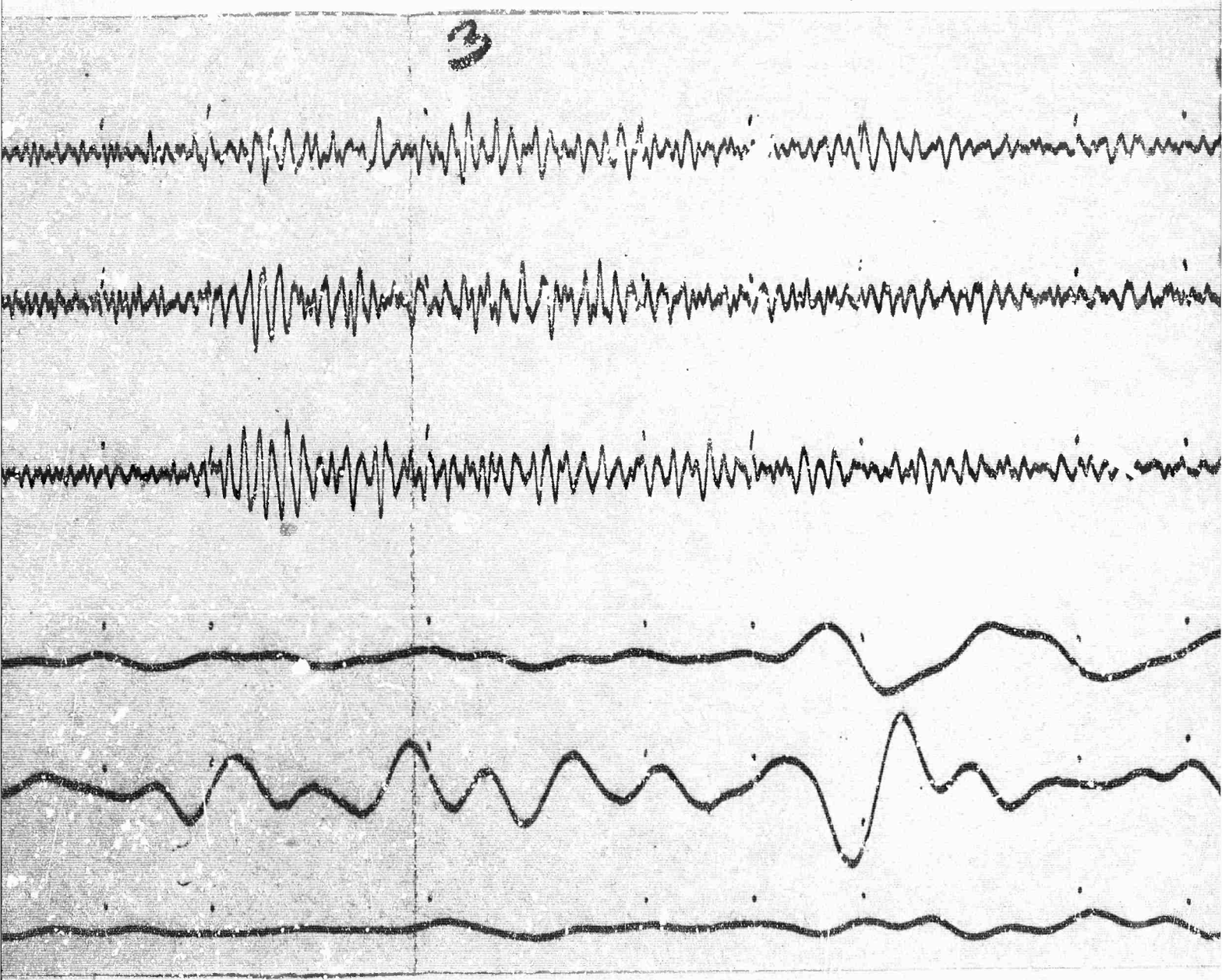
Las Cruces, New Mexico

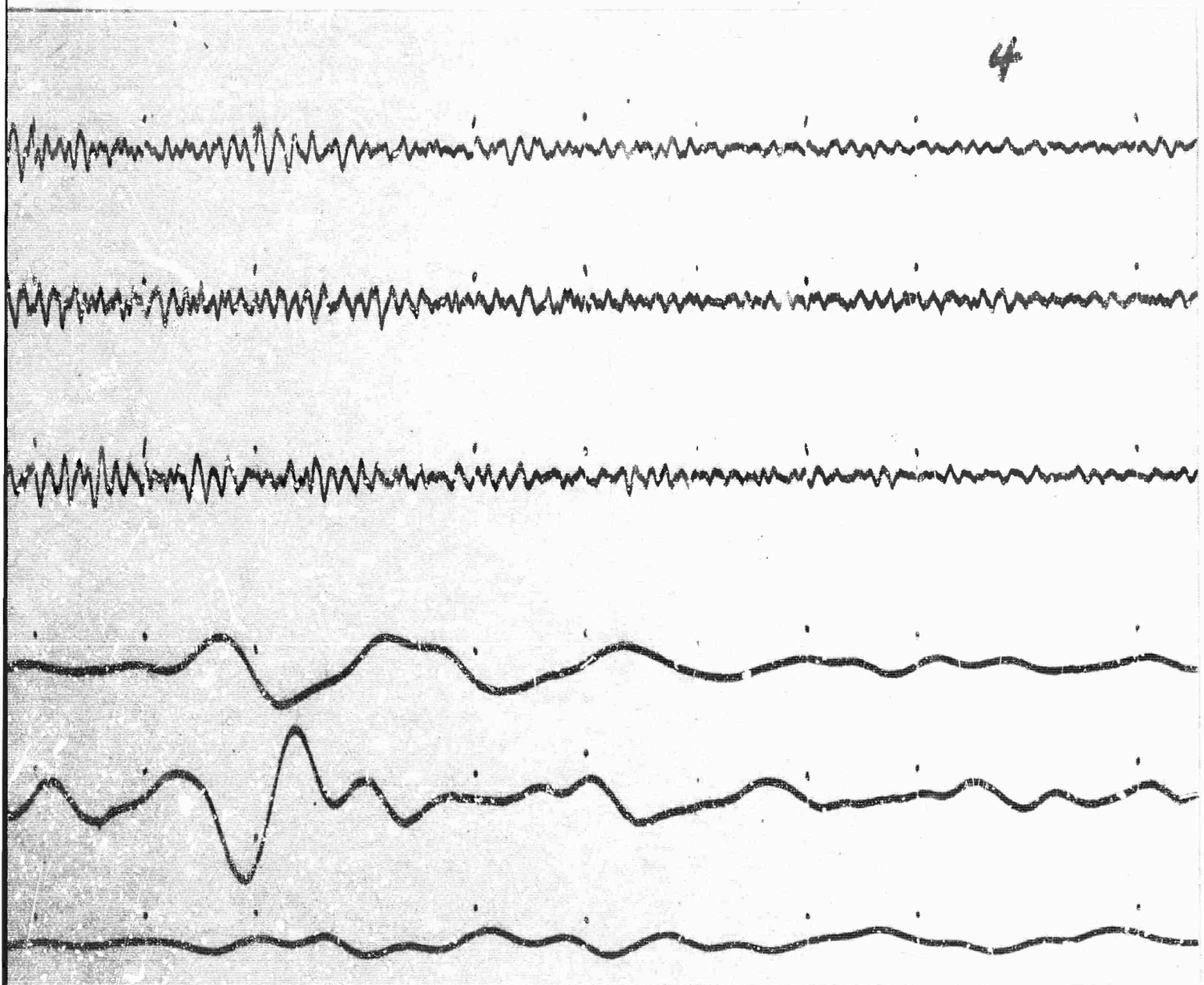
9 October 1964

Δ = 1014 km









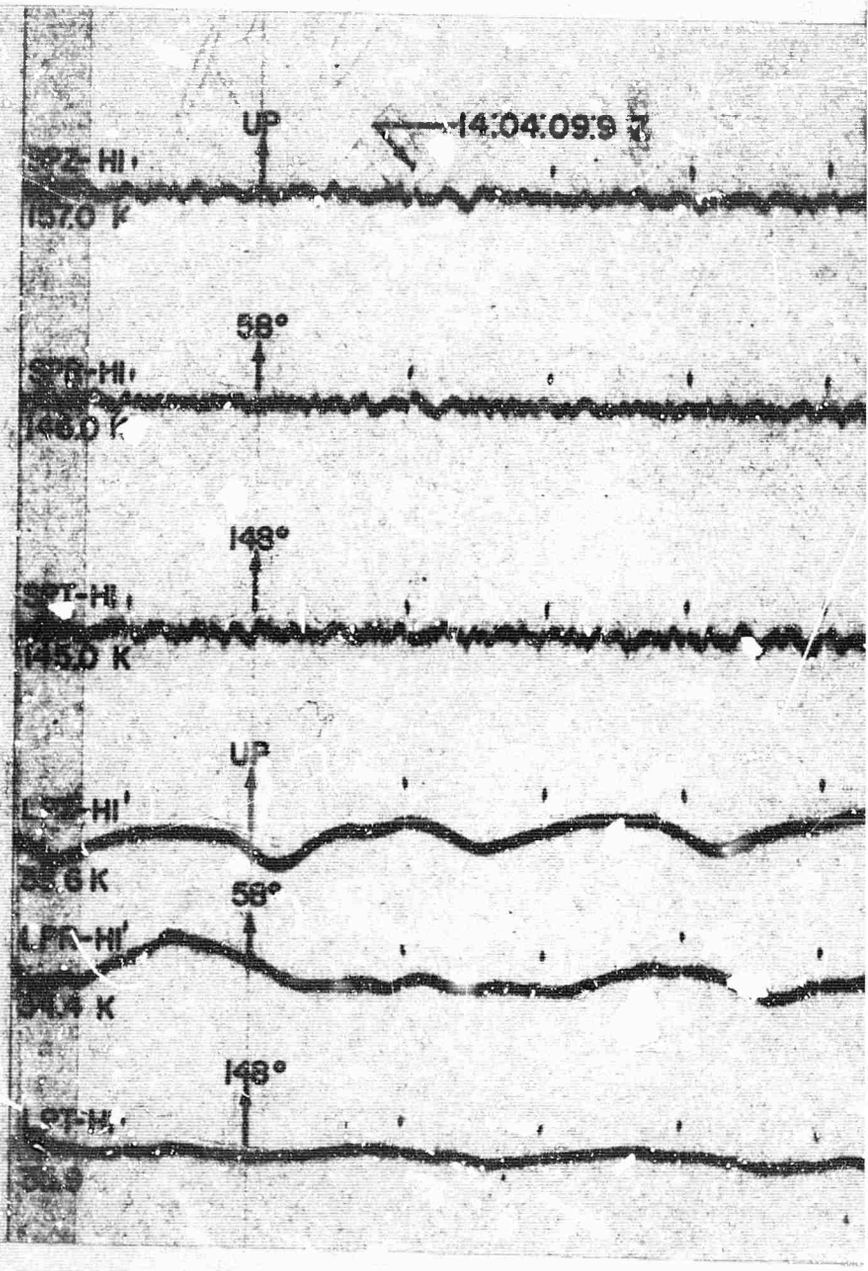
PAR

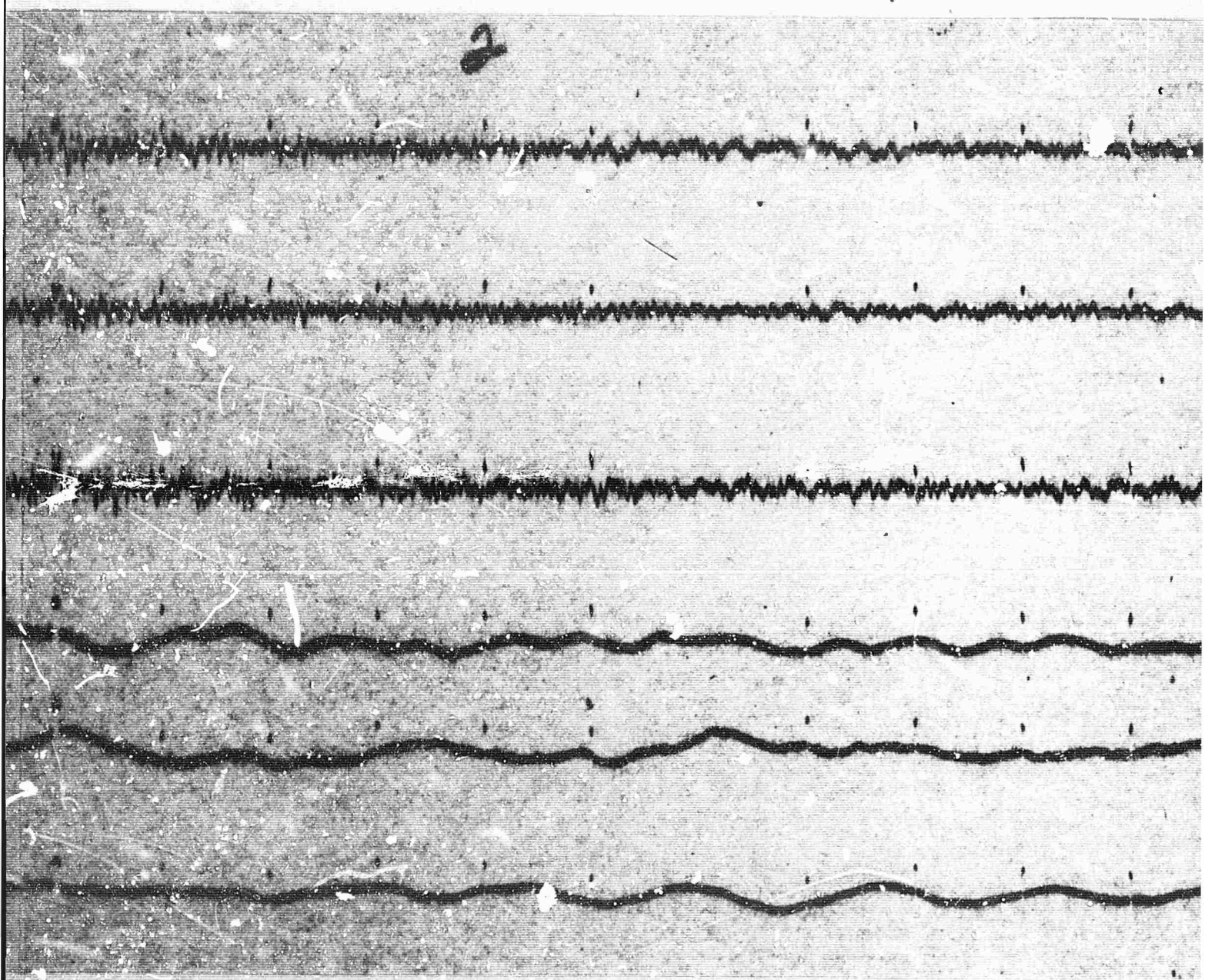
RK-ON

Red Lake, Ontario

9 October 1964

Δ = 2339 km

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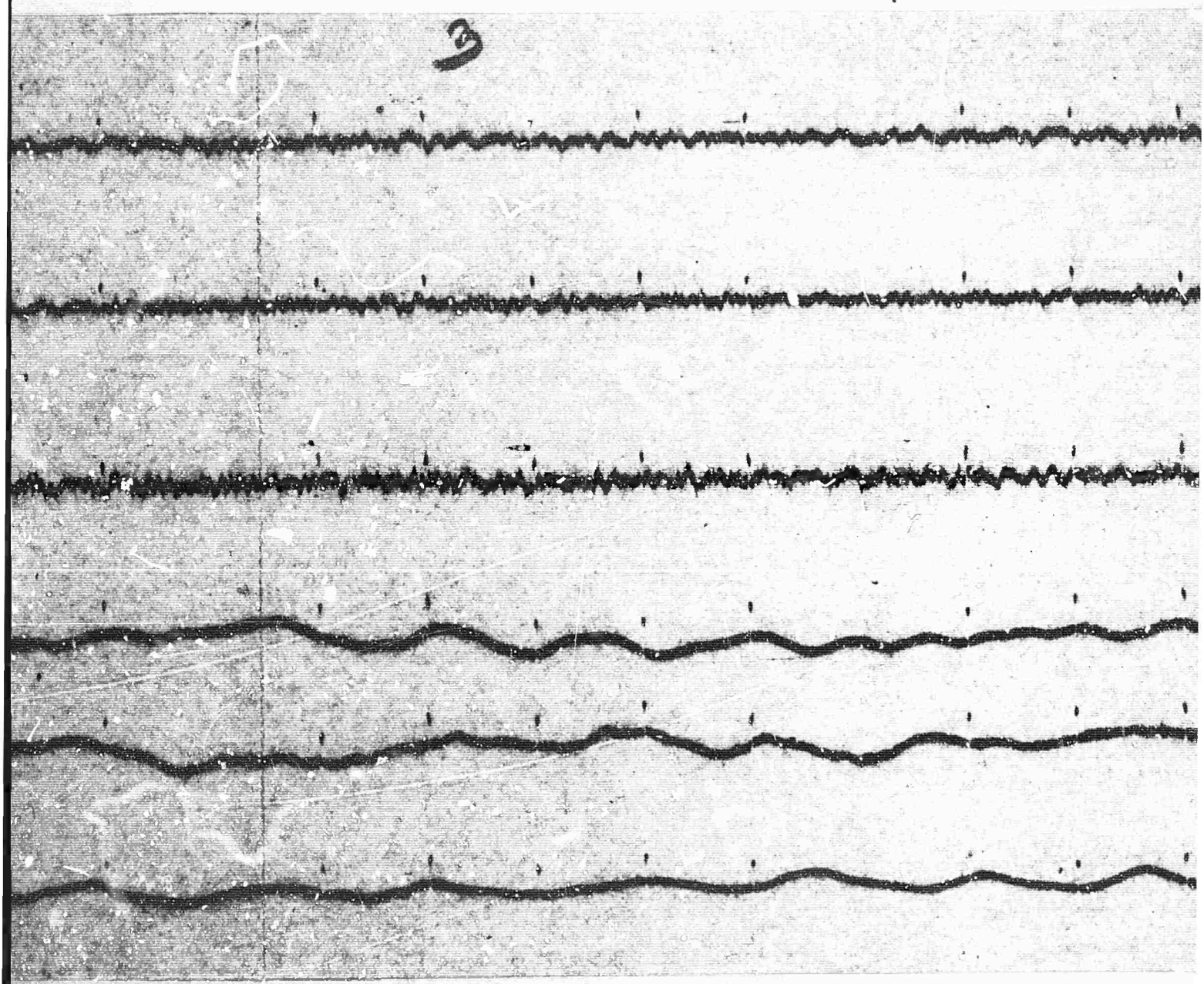
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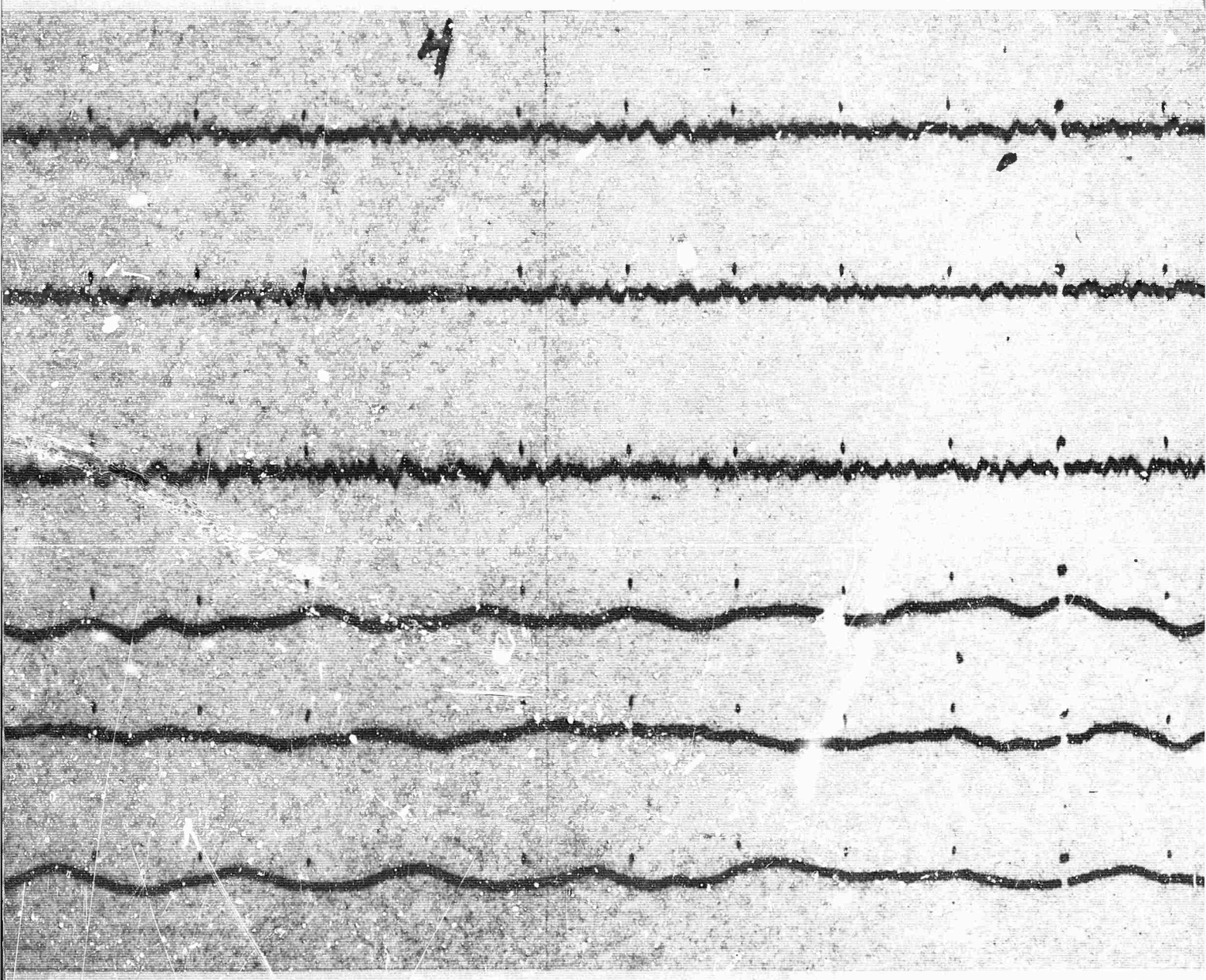

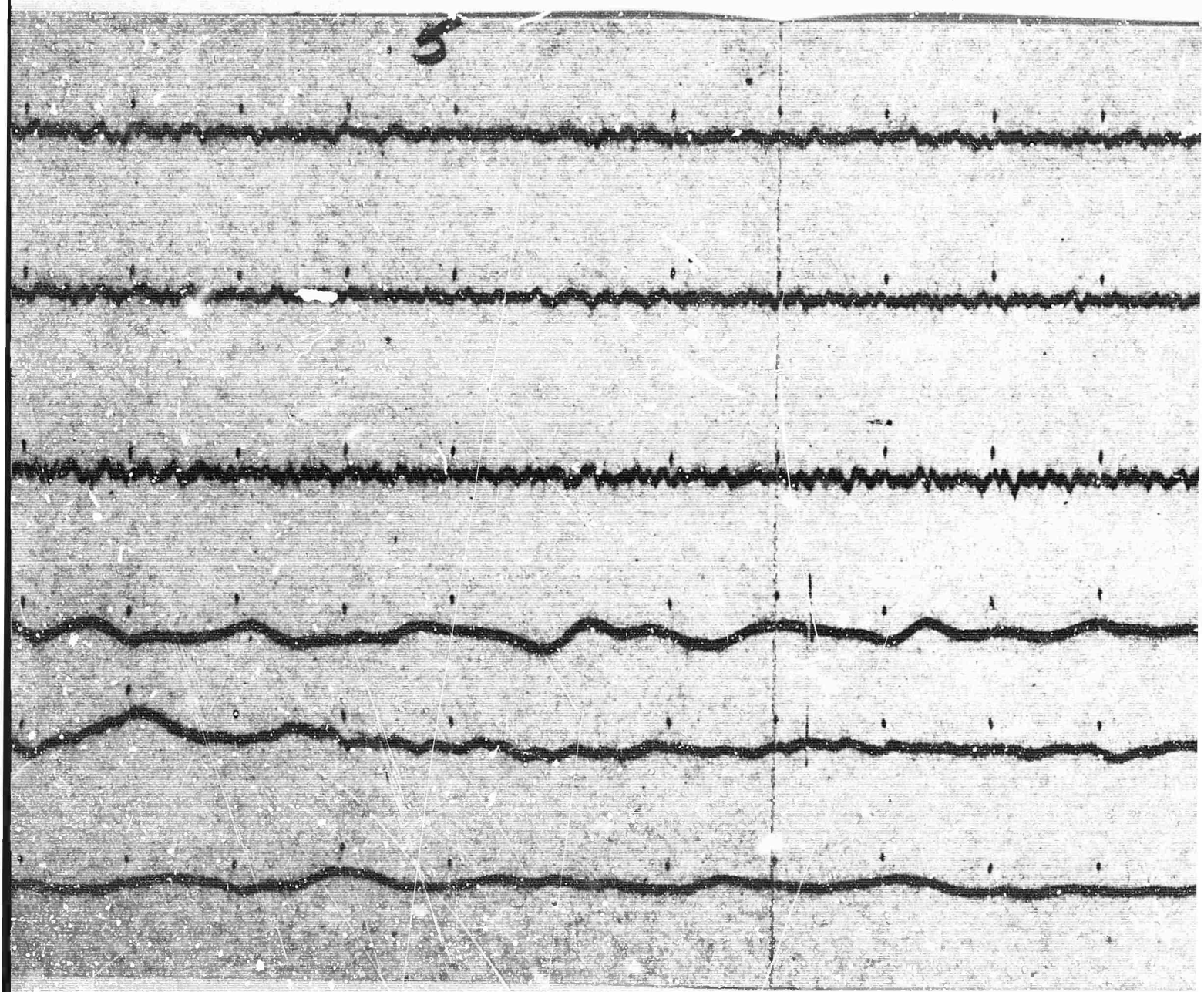
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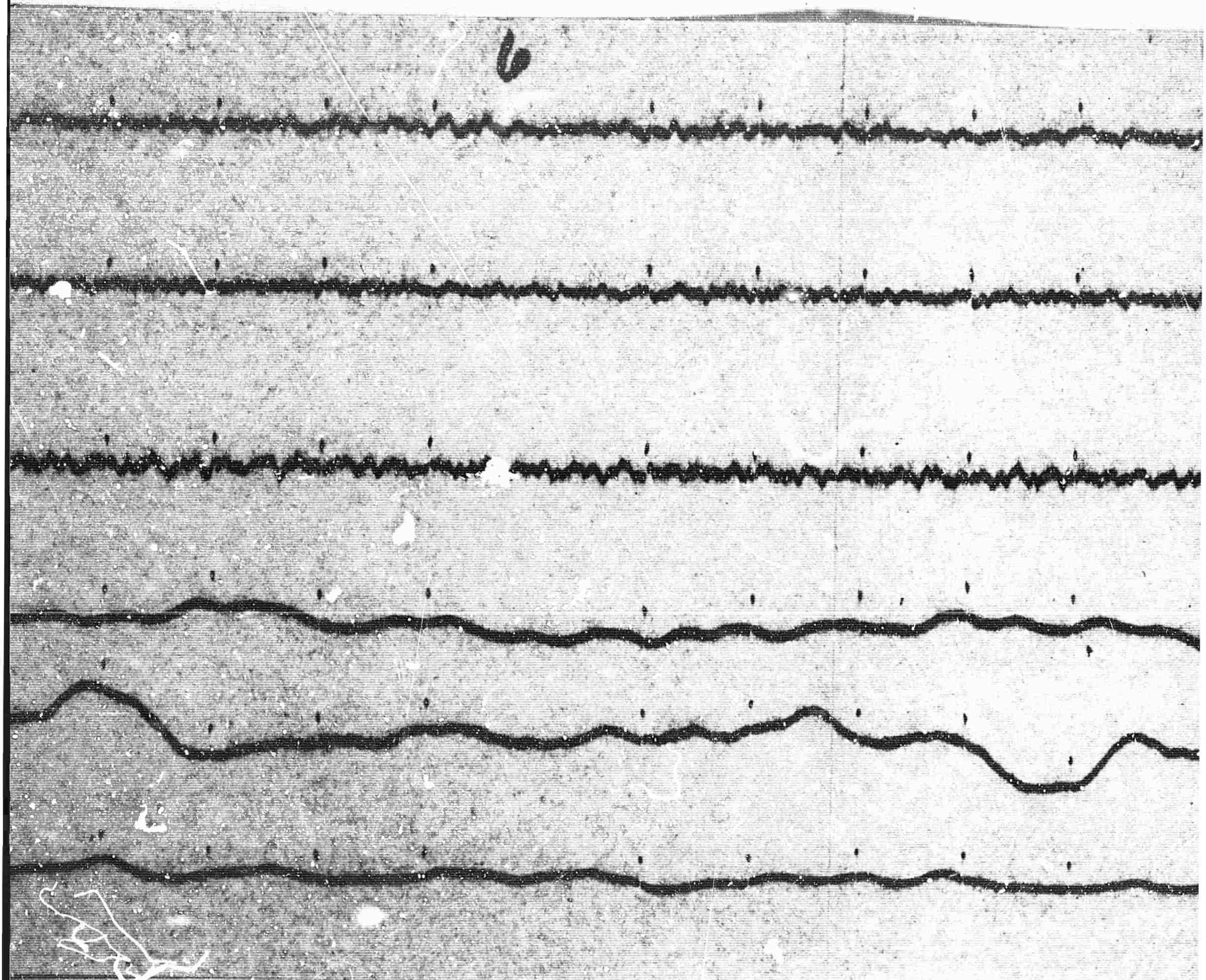

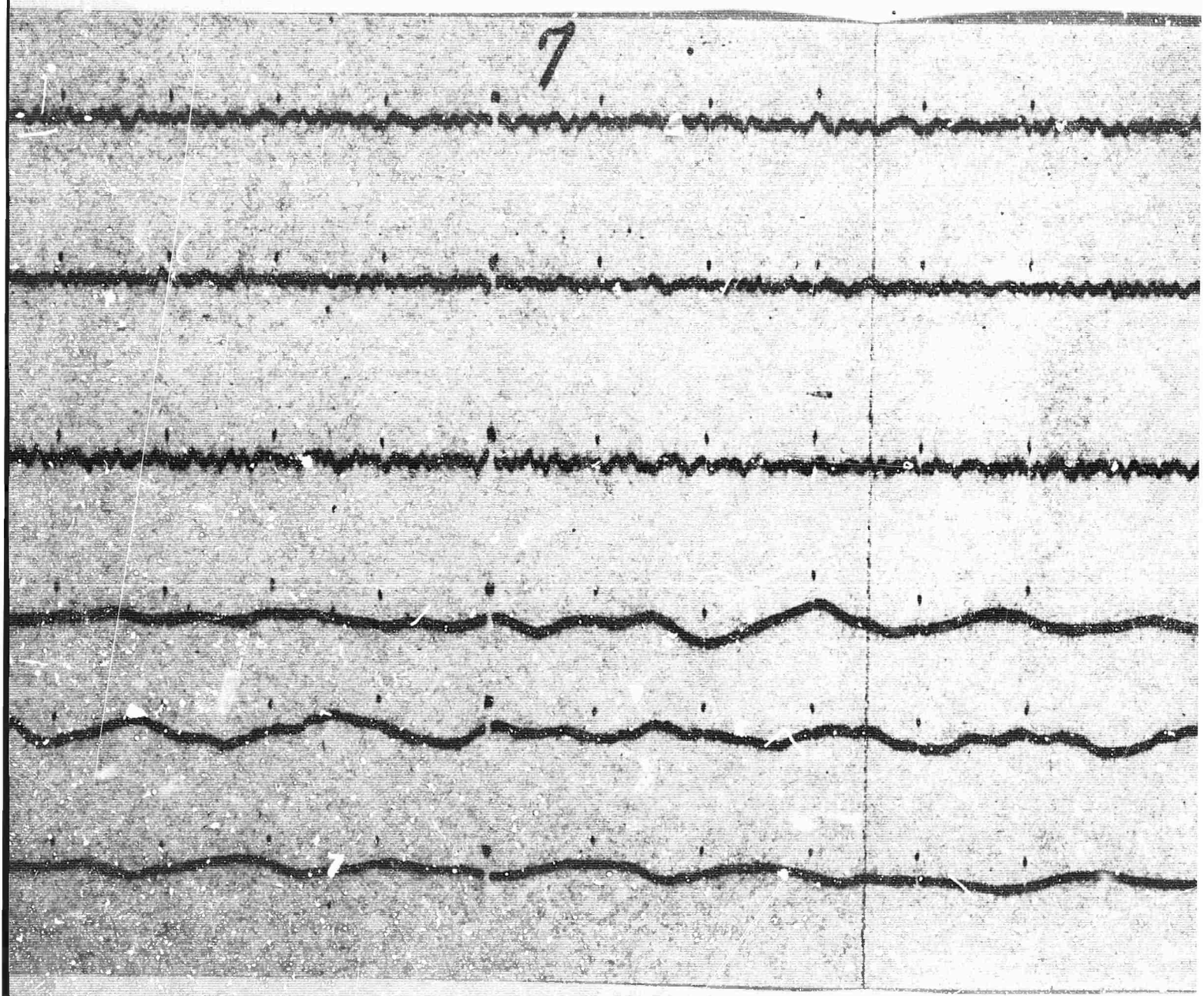
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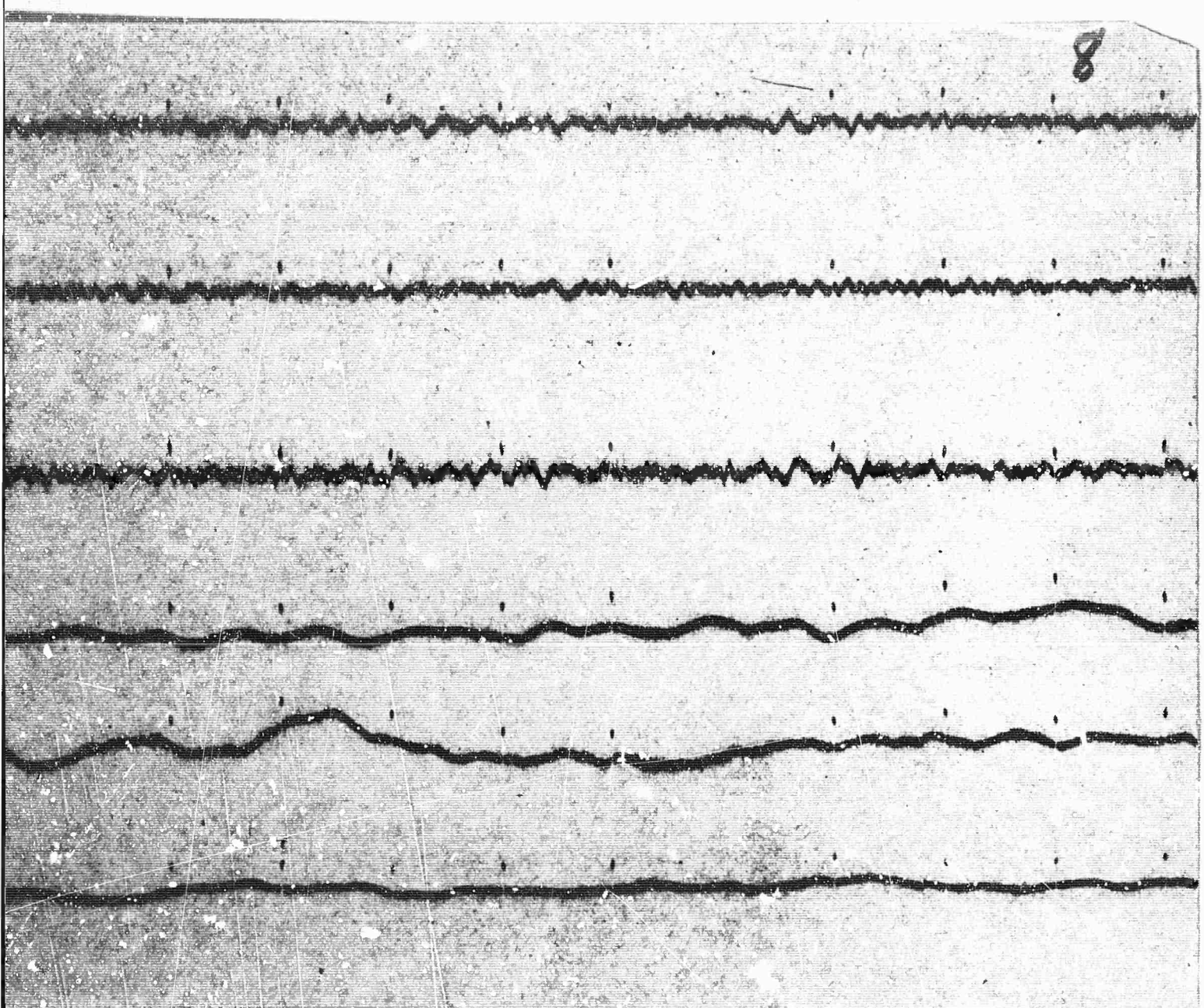
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13. ABSTRACT

An analysis of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves are included along with other unidentified phases.

DD FORM 1 JAN 64 1473

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14 KEY WORDS	LINK A		LINK B		LINK C	
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Seismic Magnitude						
Seismic Travel-Time						
Seismic Amplitude						
VELA-UNIFORM						
Nuclear Tests						

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