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LONG-RANGE SEISMIC MEASUREMENTS

GASBUGGY

10 DECEMBER 1967

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER

Washington D. C.

25 JANUARY 1968

By

GEOTECH

A TELEDYNE CO.

Under

Project VELA UNIFORM

Sponsored By

ADVANCED RESEARCH PROJECTS AGENCY

Nuclear Test Detection Office
ARPA Order No. 624

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TECHNICAL REPORT NO. 68-7

LONG-RANGE SEISMIC MEASUREMENTS

GASBUGGY

10 December 1967

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ARPA Order No:	624
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GASBUGGY
EVENT DESCRIPTION

DATE:	10 December 1967
TIME OF ORIGIN:	19:30:00.1 Z
YIELD:	26 kt
MAGNITUDE:	4.53 ± 0.27
LOCATION:	
SITE:	GB-E San Juan Basin, N. W. New Mexico Geographic Coordinates: Lat: 36°40'40.4"N Long: 107°12'30.3"W
ENVIRONMENT:	Geologic Medium: Shale Surface Evelation: 7203 ft Shot Elevation: 2963 ft Shot Depth: 4240 ft
COMPUTED EPICENTER: ALL STATIONS	Geographic Coordinates: Lat: 36°39'36"N Long: 107°09'00"W Time of Origin: 19:30:01.6Z Depth Constrained to: 0 km Epicenter Shift: 5.8 km along a line 112°27'36" from true North

Code	Station	Final							
		SPZ	SPR	SPT	LPZ	LPR	LPT	Tape	Timing
TFSO	Tonto Forest Seismological Observatory, Arizona	+	+	+	I	I	I	*	P
UBSO	Uinta Basin Seismological Observatory, Utah	+	+	+	+	+	+	*	P
LC-NM	Las Cruces, N. M.	+	+	+	+	+	+	*	P
KN-UT	Kanab, Utah	+	+	+	+	+	+	*	P
CQ-NV	Caliente, Nevada	+	+	+	+	+	+	*	P
PQ-ID	Preston, Idaho	+	+	+	+	+	+	*	P
TL-WY	Thermopolis, Wyoming	+	+	+	+	+	+	*	P
WMSO	Wichita Mountains Seismological Observatory, Oklahoma	+	+	+	+	+	+	-	P
WZ-NV	Warm Springs, Nevada	+	+	+	+	+	+	*	P
WN-SD	Winner, South Dakota	+	+	+	+	+	+	*	P
HL2ID	Hailey, Idaho	+	+	+	+	+	+	*	P
MN-NV	Mina, Nevada	+	+	+	+	+	+	*	P
BS-MA	Billings, Montana	+	+	+	+	+	+	*	P
GV-TX	Grapevine, Texas	+	N	N	N	N	N	N	P
LAO	Subarray AO, Montana	+	N	N	+	N	N	*	P
LN-MA	Lewistown, Montana	+	+	+	+	+	+	*	P
BMSO	Blue Mountains Seismological Observatory, Oregon	+	+	+	#	#	#	-	P
HV-MA	Havre, Montana	+	+	+	+	+	+	*	P
PH-WA	Pomeroy. Washington	+	+	+	+	+	+	*	P
CC-WA	Cascade Tunnel, Washington	+	+	+	+	+	+	*	P
LY-WA	Lynden, Washington	+	+	+	+	+	+	*	P
RK-ON	Red Lake, Ontario, Canada	+	+	+	+	+	+	*	P
CPSO	Cumberland Plateau Seismological Observatory, Tennessee	+	+	+	#	#	#	-	P
PG-BC	Prince George, B. C. Canada	+	+	+	+	+	+	*	P
WH2YK	Whitehorse, Yukon T., Canada	+	+	+	-	-	-	I	P
HN-ME	Houlton, Maine	-	-	-	+	+	+	*	P
SV3QB	Schefferville, Quebec, Canada	+	-	-	+	+	+	*	P
NP-NT	Mould Bay, N. W. T., Canada	+	+	+	I	-	-	*	P

Symbols -

+ Received signal
- No signal received
P Primary time
S Secondary time
N No instrument
I Inoperative
Instruments assumed operational, no verification
* Magnetic tape available

Station Status Report - GASBUGGY

Table 1

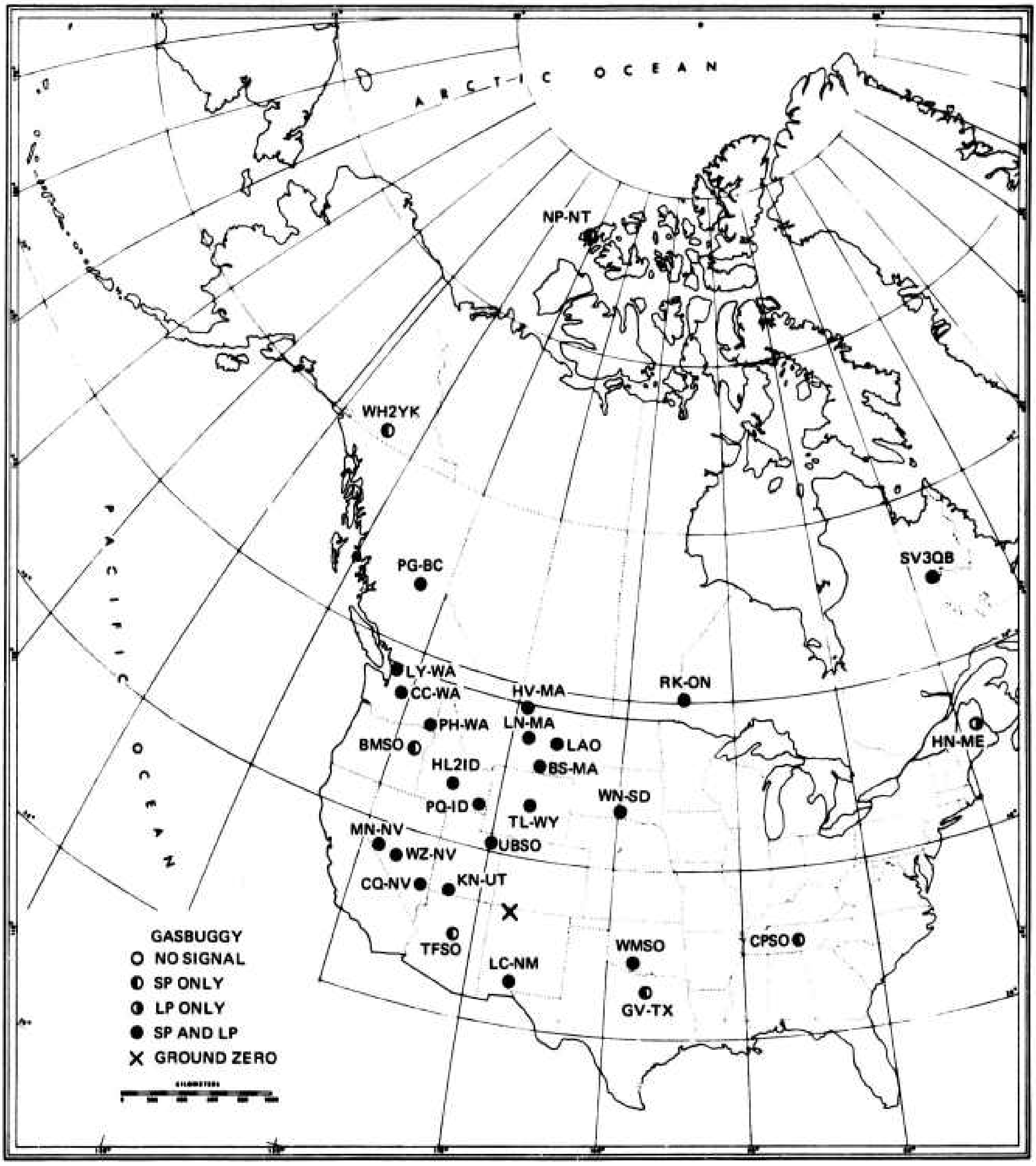

Figure 1. Recording stations and signals received

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INTRODUCTION

A long-range seismic measurements (LRSM) program and several larger seismographic observatories were established under VELA-UNIFORM to record seismological data resulting from natural seismic activity and a planned series of U. S. underground nuclear tests. The LRSM teams are mobile and occupy locations selected to provide optimum data from events of special interest; the observatories are permanent installations as follows:

Blue Mountains Seismological Observatory (BMSO)
Baker, Oregon

Cumberland Plateau Seismological Observatory (CPSO)
McMinnville, Tennessee

Tonto Forest Seismological Observatory (TFSO)
Payson, Arizona

Uinta Basin Seismological Observatory (UBSO)
Vernal, Utah

Wichita Mountains Seismological Observatory (WMSO)
Lawton, Oklahoma

Large Aperture Seismic Array (LASA)
Billings, Montana

The purpose of this report is to provide an analysis of data resulting from the GASBUGGY event recorded by the LRSM teams and the VELA observatories and a preliminary summary of the data reported by other permanent and temporary seismographic stations.

INSTRUMENTATION AND PROCEDURE

The instrumentation at each of the LRSM locations consists of three-component short-period and three-component long-period seismographs. In general, data are recorded on 35-millimeter film and on 1-inch 14-channel magnetic tape, although recently more portable instrumentation has been incorporated which records only on magnetic tape. The stations are all equipped to record WWV continuously to provide accurate time control. Calibration is accomplished once each day and just prior to each shot at the operational settings. Pertinent information useful for analysis of LRSM data is available to qualified users of this data and is contained in Technical Report 65-43, "Interpretation and Usage of Seismic Data, LRSM Program." General information on LRSM van and portable system equipment and operation is given in Technical Reports 66-27, "The LRSM Mobile Seismographical Laboratory," and 65-74, "A Portable Seismograph." Copies of these reports may be obtained from DDC. The AD control number of Technical Report 66-27 is 480343. All the observatories have both long-period and short-period, three-component instrumentation, in addition to their other specialized facilities.

Station information is presented in Appendix I(A). This includes the station name and code; the geographic coordinates; the distances and azimuths involved; the station elevations; and the type of instruments in use at each location. Representative instrumental response curves are shown in Appendices II(B), II(C), and II(D).

The procedures used in measuring amplitudes reported herein are illustrated in Appendix II(A) and the unified magnitude is calculated as shown in Appendix I(B). The distance factors (B) beyond 16 degrees are from Gutenberg and Richter.[1] For distances less than 16 degrees, values were read from a curve in the Gutenberg and Richter paper back to 10 degrees and then extrapolated to 2 degrees, using an inverse cube relationship. An additional magnitude for less than 16 degrees was computed using a method described by Evernden[2] (Figure 3).

A standard hypocenter location program for a digital computer was used to determine the location using data from all stations analyzed. Best-fit values of latitude, longitude and time of origin are determined statistically by a least squares technique utilizing the Herrin[3] travel-time curve. 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. This method is based on P-wave arrivals with depth constrained to zero.

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

[2]Evernden, J. F., Magnitude Determination at Regional and Near Regional Distances in the United States, AFTAC/VELA Seismological Center Technical Report VU-65-4A, (1965), p. 6, 13.

[3]Herrin, E., and others, 1968, Travel Times of Longitudinal Waves: BSSA, Travel Time Issue (in press).

DATA AND RESULTS (LRSM AND VELA OBSERVATORIES)

The parameters of the GASBUGGY event and a summary of the seismic evaluation are shown on the Event Description page. The operational status of the 28 LRSM stations and observatories is given in Table 1, and illustrated in Figure 1.

Table 2 summarizes the measurements made of the principal phases from the GASBUGGY event at the LRSM and VELA stations. Included are the Pn and P arrival times, the maximum amplitudes (A/T) of Pn or P motion and other phases as seen on the short-period instruments. Long-period Love and Rayleigh motion are also tabulated in (A/T)form. In addition, individual station Rayleigh wave area (mm^2) is indicated as measured on the LPZ only. Although reduced to 1K magnification and a recording speed of 60 mm/min, they have not been normalized to any magnitude. Twenty-eight stations recorded short-period and/or long-period signals.

The magnitudes determined from the LRSM and VELA observatories are shown in Figure 2. The magnitude averaged over all distances is 5.20 ± 0.57. The average unified magnitude ($\Delta > 16°$) is 4.45 ± 0.34. The average magnitude adjusted for regional propagational characteristics is 4.53 ± 0.27 and the data are plotted in Figure 3.

The travel-time residuals from the Pn and P phases are shown in Figure 4. Figures 5 through 9 illustrate plots of the amplitudes of P, Pg, Lg, LQ and LR.

Attached to the report are illustrative seismograms showing the signals recorded at four stations. The most distant station analyzed that recorded GASBUGGY was NP-NT at a distance of 4453 kilometers.

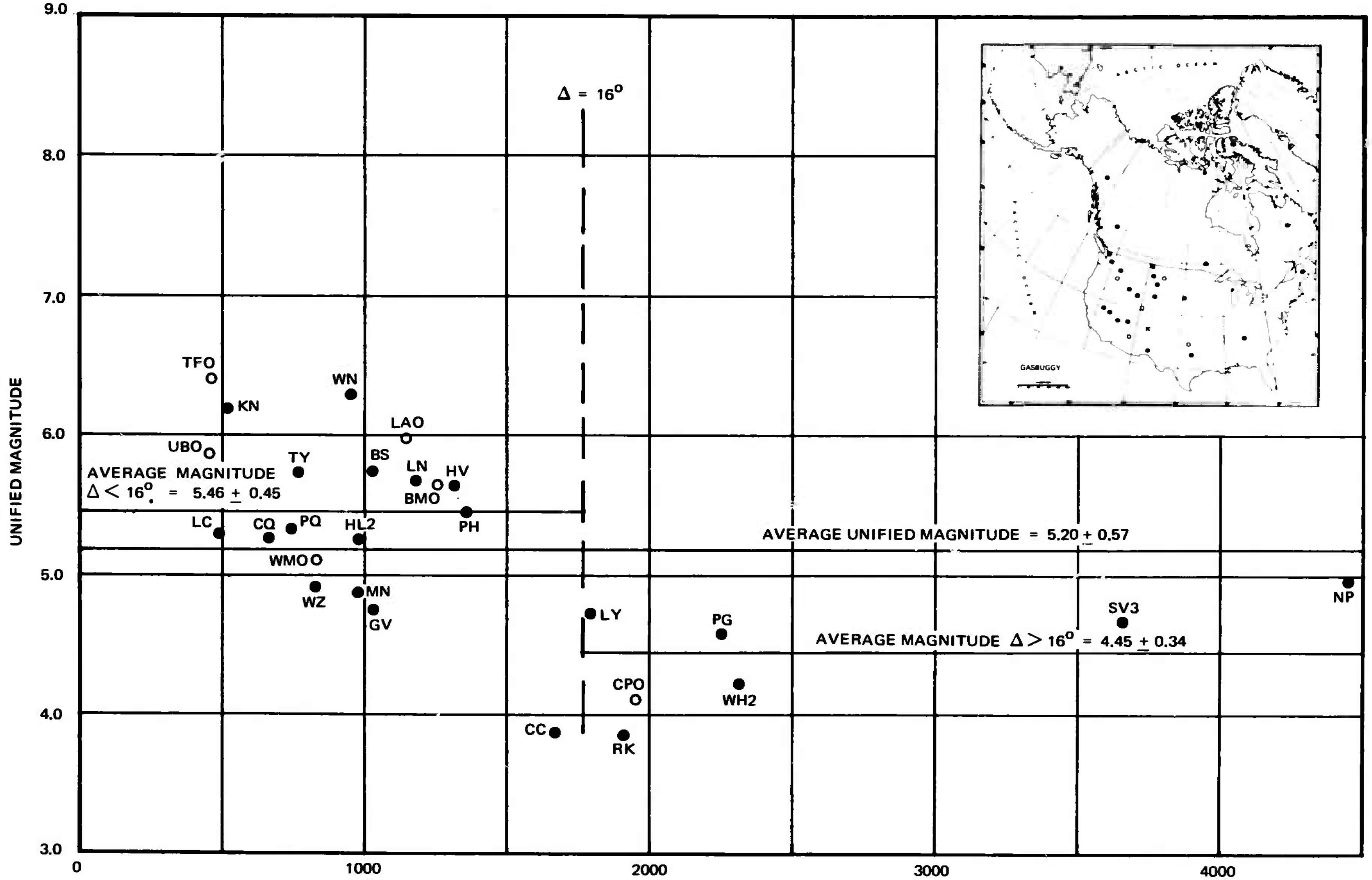
Principal Phases
GASBUGGY
10 December 1967
19:30:00.1Z

Code	Station	Distance (km)	Inst.	Magnification (K) filmX10	Phase	Observed travel time (min)	Observed travel time (sec)	Per. T (sec)	Maximum amplitude A/T	Magnitude (m) m_b	Magnitude (m) m_e	Area (mm^2) LPZ
TFSO	Tonto Forest Seismological Observatory, Arizona	454	Z60LL	6.0	Pn	01	05.6	0.4	1951.8	6.42	5.33	
			Z60LL	6.0	Pg	01	15.3	0.4	3411.0			
			E99LL	5.2	Lg	02	03	0.4	3170.5			
UBSO	Uinta Basin Seismological Observatory, Utah	454	SZ1	10.0	Pn	01	06.1	0.4	483.2	5.83	4.75	42.19
			SZ1	10.0	e	01	08.8	0.4	596.9			
			SZ10L	2.0	Pg	01	16.1	0.5	2272.5			
			NSPLL	5.0	Lg	02	04	0.4	795.9			
			ELP1	26.4	LQ	02	17	14	319.87			
			ZLP1	9.0	LR	02	29	16	485.37			
LC-NM	Las Cruces, New Mexico	478	SPZ	13.9	Pn	01	07.5	0.2	128.42	5.30	4.86	27.89
			SPZ	13.9	Pg	01	19.2	0.6	676.94			
			SPR	18.1	Lg	02	14	0.5	562.38			
			LPT	13.9	LQ	02	22	13.0	78.03			
			LPZ	14.7	LR	02	37	13.0	136.83			
KN-UT	Kanab, Utah	503	SPZ-Lo	10.4*	Pn	01	11.8	0.4	858.18	6.19	5.07	58.61
			SPZ	10.4*	e	01	21.3	0.6	2278.96			
			SPZ	10.4*	Pg	01	27.0	---	---			
			SPR	7.48*	e	02	11	0.5	1866.07			
			SPT	7.52*	Lg	02	23	---	---			
			LPT	23.2	LQ	02	24	13.5	99.88			
			LPZ	26.7	LR	02	38	13.0	256.66			
CQ-NV	Caliente, Nev.	658	SPZ	30.2	Pn	01	29.0	0.5	28.41	5.24	4.58	72.67
			SPZ	30.2	e	01	31.4	0.4	118.21			
			SPZ	30.2	e	01	38.2	0.5	165.73			
			SPZ-Lo	6.10	Pg	01	52.6	0.5	632.95			
			SPT	23.8	Lg	03	05	0.6	487.50			
			LPT	8.99	LQ	03	16	11.0	144.44			
			LPZ	8.03	LR	03	34	14.0	208.47			
PQ-ID	Preston, Idaho	728	SPZ	52.5	Pn	01	38.6	0.5	43.58	5.35	4.96	83.93
			SPZ	52.5	Pg	02	01.4	---	---			
			SPR	47.5	Lg	03	19	0.6	300.63			
			LPT	4.44	LQ	03	39	16.0	50.96			
			LPZ	4.17	LR	03	58	15.0	158.44			
TL-WY	Thermopolis, Wyoming	764	SPZ	85.7	Pn	01	42.5	0.4	90.53	5.73	4.45	45.20
			SPZ	85.7	e	01	56.5	0.6	115.49			
			SPZ	85.7	Pg	02	03.5	1.0	536.76			
			SPT	100.9	e	02	54.7	1.0	269.57			
			SPT	100.9	Lg	03	27	1.0	279.48			
			LPT	8.00	LQ	03	45	16.5	63.90			
			LPZ	12.5	LR	04	16	16.3	57.92			
WM-SO	Wichita Mountains Seismological Observatory Oklahoma	810	U6	490.0	Pn	01	48.7	0.3	17.88	5.11	3.80	51.55
			U6	490.0	e	01	51.7	0.5	26.66			
			V	5.00	e	01	58.0	0.5	45.24			
			V	5.00	Pg	02	12.7	0.5	603.20			
			ELH	50.5	LQ	03	49	28.0	5.80			
			ZLL	9.7	LR	03	57	12.0	350.13			
WZ-NV	Warm Springs, Nevada	832	SPZ	43.3	Pn	01	52.0	0.5	9.91	4.90	4.40	63.28
			SPZ	43.3	Pg	02	18.4	0.7	302.86			
			SPT	49.2	Lg	03	52	0.7	182.20			
			LPT	19.9	LQ	04	05	12.0	97.93			
			LPZ	12.8	LR	04	35	14.0	226.69			

Code	Station	Distance (km)	Inst	Magnification (K) filmX10	Phase	Observed travel time (min)	Observed travel time (sec)	Per. T (sec)	Maximum amplitude A/T	Magnitude (m) m_b	Magnitude (m) m_e	Area (mm^2) LPZ
WN-SD	Winner, South Dakota	944	SPZ	116.8	Pn	02	05.4	0.6	156.35	6.29	4.87	24.77
			SPZ	9.60*	e	02	15.0	0.5	471.30			
			SPZ	9.60*	Pg	02	37.4	0.5	864.05			
			SPT	9.58*	Lg	04	36	0.6	581.84			
			LPR	28.8	LQ	04	27	12.0	95.20			
			LPZ	33.3	LR	05	13	12.0	151.35			
HL21D	Hailey, Idaho	980	SPZ	146.4	Pn	02	10.8	0.5	12.62	5.26	4.79	72.21
			SPZ	146.4	e	02	22.9	0.9	33.54			
			SPZ	146.4	Pg	02	39.7	0.7	36.37			
			SPT	166.4	Lg	04	31	1.0	24.04			
			LPR	27.7	LQ	04	50	14.0	28.18			
			LPZ	25.5	LR	04	57	13.0	227.87			
MN-NV	Mina, Nevada	986	SPZ	498.4	Pn	02	09.8	0.5	4.88	4.86	4.30	59.72
			SPZ	498.4	e	02	11.9	0.4	33.21			
			SPZ	498.4	Pg	02	41.2	0.8	56.34			
			SPR	514.3	Lg	04	45	0.8	58.48			
			LPT	20.7	LQ	04	47	12.5	64.16			
			LPZ	19.8	LR	05	05	13.0	242.02			
BS-MA	Billings, Mont.	1016	SPZ	157.8	Pn	02	14.7	0.4	35.51	5.76	4.29	54.37
			SPZ	157.8	Pg	02	51.0	1.0	155.26			
			SPR	141.7	Lg	04	49	1.0	84.69			
			LPZ	38.9	LR	05	19	15.0	79.01			
GV-TX	Grapevine, Tex.	1024	Σ2	156.0	Pn	02	14.5	0.5	3.24	4.73	4.14	
			Σ2	156.0	e	02	22.6	0.6	15.46			
			Σ2-Lo	15.6	Pg	02	50.6	0.5	161.86			
			Σ2	156.0	Lg	04	45	1.0	64.10			
LAO	Subarray, AO-10, Montana	1115	AO-10Lo	403.3	Pn	02	25.6	0.5	46.58	5.97	4.49	50.12
			AO-10Lo	403.3	Pg	03	12.4	0.7	72.87			
			D3-EHi	225.8	LQ	05	33	12.0	(5.15)			
			D3-ZHi	42.9	LR	05	52	16.0	32.72			
LN-MA	Lewistown, Montana	1181	SPZ	200.0	Pn	02	34.2	0.6	23.26	5.69	4.33	33.05
			SPZ	200.0	Pg	03	34.3	0.9	46.31			
			SPT	231.2	Lg	05	29	0.9	29.13			
			LPT	12.9	LQ	05	50	17.0	31.72			
			LPZ	11.8	LR	06	24	15.0	58.42			
BMSO	Blue Mountains Seismological Observatory, Oregon	1244	V	25.0	Pn	02	43.8	0.9	28.35	5.64	4.37	
			V	25.0	e	02	54.7	0.8	17.74			
			V	25.0	Pg	03	24.9	0.8	22.17			
			E	780.0	Lg	05	49	1.5	20.10			
HV-MA	Havre, Montana	1323	SPZ	218.7	Pn	02	51.0	0.6	33.28	5.63	4.49	31.28
			SPZ	218.7	e	03	00.4	0.6	23.90			
			SPZ	218.7	Pg	03	37.5	1.1	50.02			
			SPR	214.7	Lg	06	24	1.1	44.42			
			LPR	15.2	LQ	06	07	22.0	26.65			
			LPZ	19.6	LR	07	16	15.0	60.09			
PH-WA	Pomeroy, Washington	1363	SPZ	239.1	Pn	02	58.5	0.8	23.95	5.45	4.38	71.02
			SPZ	239.1	e	03	17.7	1.0	55.42			
			SPZ	239.1	Pg	03	35.3	0.9	23.00			
			SPZ	239.1	e	05	23.0	1.0	19.87			
			SPT	232.8	Lg	06	43	1.2	20.65			
			LPT	20.2	LQ	06	44	14.0	58.93			
			LPZ	18.2	LR	07	26	15.0	123.11			

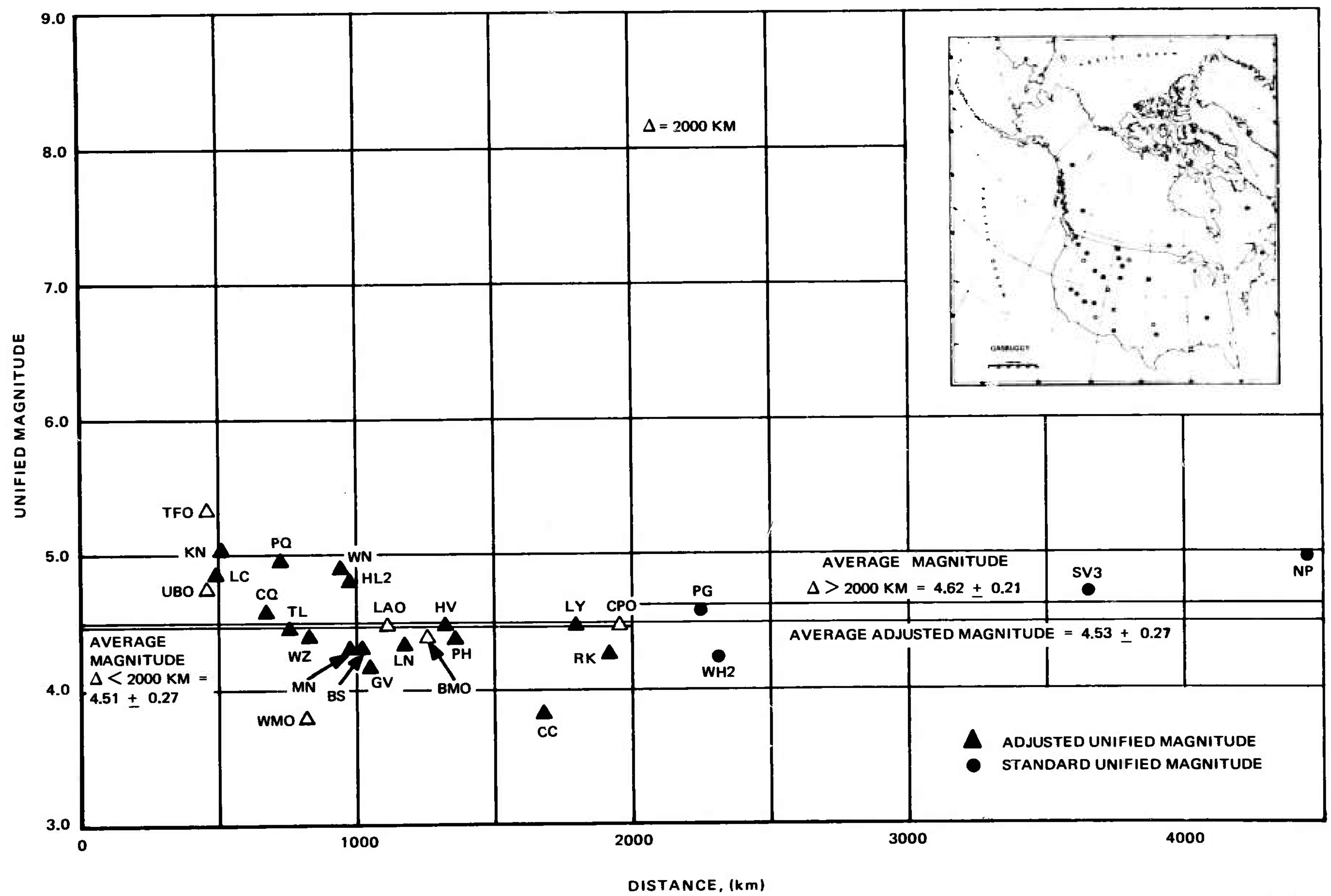
Code	Station	Distance (km)	Inst.	Magnification (K) filmX10	Phase	Observed travel time (min)	(sec)	Period T (sec)	Maximum amplitude A/T	Magnitude (m) m_b	m_e	Area(mm^2) LPZ
CC-WA	Cascade Tunnel,	1678	SPZ	235.1	Pn	03	36.6	1.0	4.25	3.89	3.81	30.57
	Washington		SPZ	235.1	e	03	41.5	0.9	20.59			
			SPZ	235.1	e	03	59.6	1.0	29.77			
			LPZ	9.65	LR	09	20	16.0	42.20			
LY-WA	Lynden, Washington	1805	SPZ	19.0	P	03	51.6	0.9	66.47	4.72	4.50	62.34
			LPZ	4.01	LR	09	43	17.0	83.49			
RK-ON	Red Lake,	1908	SPZ	153.6	P	03	58.6	0.6	9.08	3.86	4.25	17.99
	Ontario, Canada		SPZ	153.6	e	04	02.5	0.7	30.05			
			SPT	152.2	Lg	08	13	1.1	64.50			
			LPT	51.2	LQ	09	08	12.0	32.55			
			LPZ	47.8	LR	10	03	15.0	29.32			
CPSO	Cumberland Plat.	1947	ΣT	720.0	P	04	05.6	1.0	15.97	4.10	4.51	
	Seismological		Z10L	50.0	e	04	09.3	0.7	52.09			
	Observatory,		ESP	410.0	Lg	08	53	1.2	42.33			
	Tennessee											
PG-BC	Prince George,	2259	SPZ	104.2	P	04	39.6	0.6	38.46	4.62		21.91
	British Columbia,		SPZ	104.2	e	04	41.7	0.8	39.01			
	Canada		SPZ	104.2	e	04	54.1	0.8	15.96			
			LPZ	17.8	LR	12	43	13.0	69.24			
WH2YK	Whitehorse,	3314	SPZ	217.7	P	06	(09.7)	0.7	4.08	4.21		
	Yukon Territory,											
	Canada											
HN-ME	Houlton, Maine	3406	LPT	41.1	LQ	16	15	15.0	33.55			18.80
			LPZ	45.1	LR	17	09	13.0	45.90			
SV3Q8	Schefferville,	3665	SPZ	108.0	P	06	36.0	0.7	9.86	4.69		13.01
	Quebec, Canada		LPR	57.2	LQ	17	14	20.0	6.00			
			LPZ	39.4	LR	19	34	12.0	56.28			
NP-NT	Mould Bay, North-	4453	SPZ	192.4	P	07	37.9	0.7	35.69	4.95		
	west Territories,		SPZ	192.4	PcP	09	42	0.6	3.76			
	Canada											

A/T mμ/sec
( ) Doubtful values or phases
* Measurements made from playouts
--- Maximum amplitude clipped on film and tape
** Magnification questionable



G 3764

Figure 2.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DISTANCE, (km)
Δ = 2000 KM
TFO
KN
UBO
LC
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CQ
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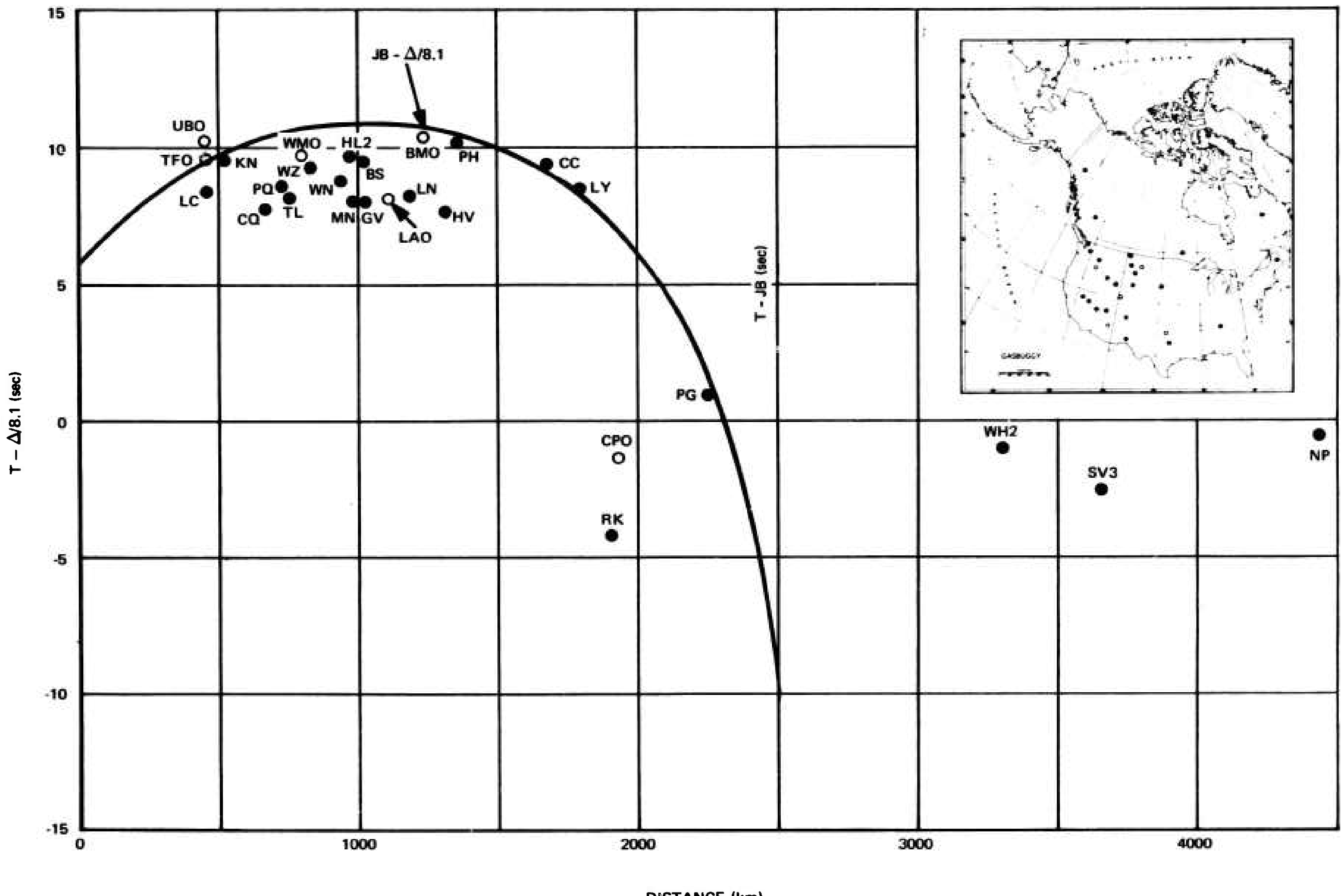
BS
WMO
WN
HL2
LAO
GV
LN
HV
PH
BMO
CC
LY
CPO
RK
PG
WH2
SV3
NP
AVERAGE MAGNITUDE
Δ > 2000 KM = 4.62 ± 0.21
AVERAGE ADJUSTED MAGNITUDE = 4.53 ± 0.27
AVERAGE
MAGNITUDE
Δ < 2000 KM =
4.51 ± 0.27
ADJUSTED UNIFIED MAGNITUDE
STANDARD UNIFIED MAGNITUDE
G 3765

Figure 3.



G 3766

Figure 4.

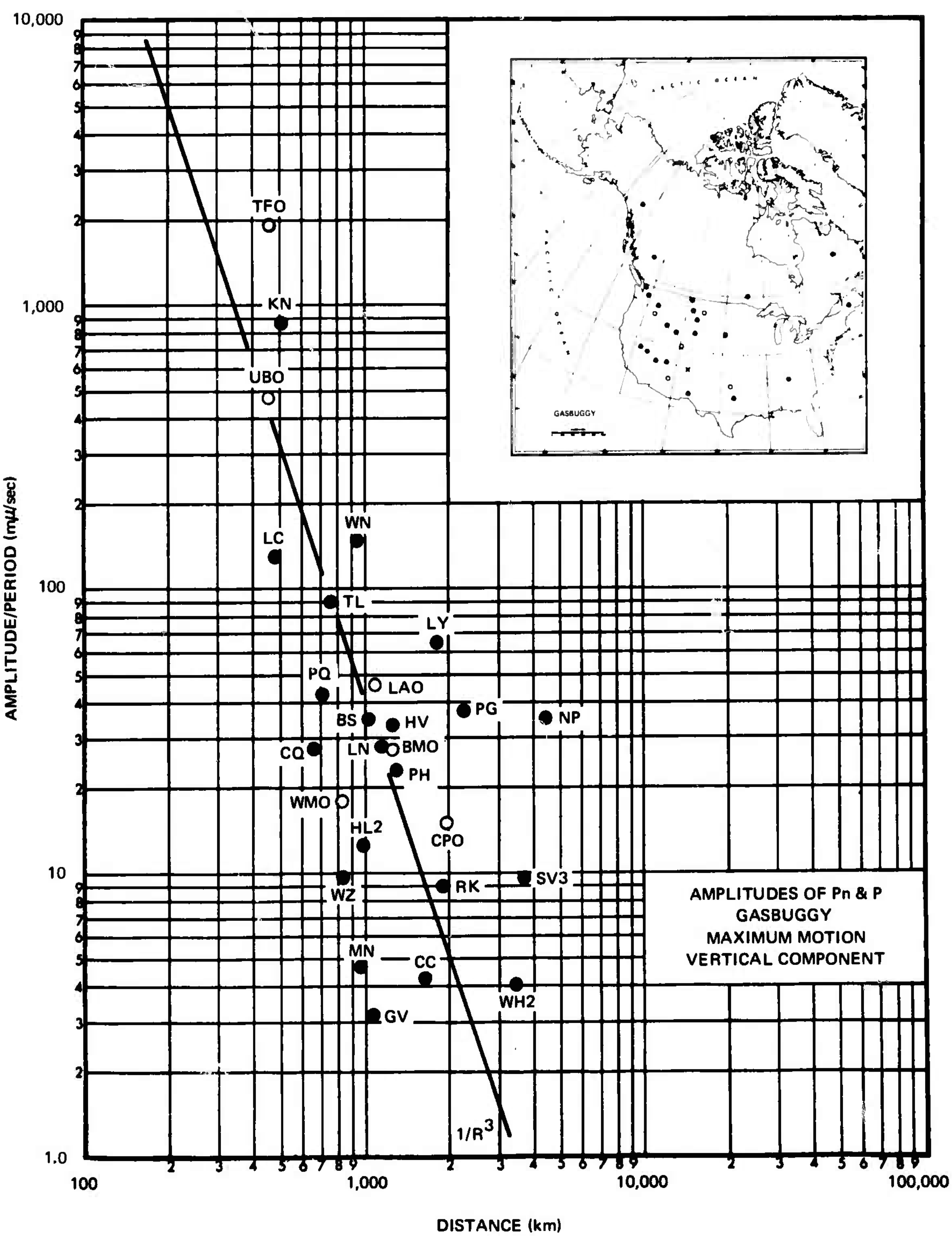


Figure 5.

G 3767

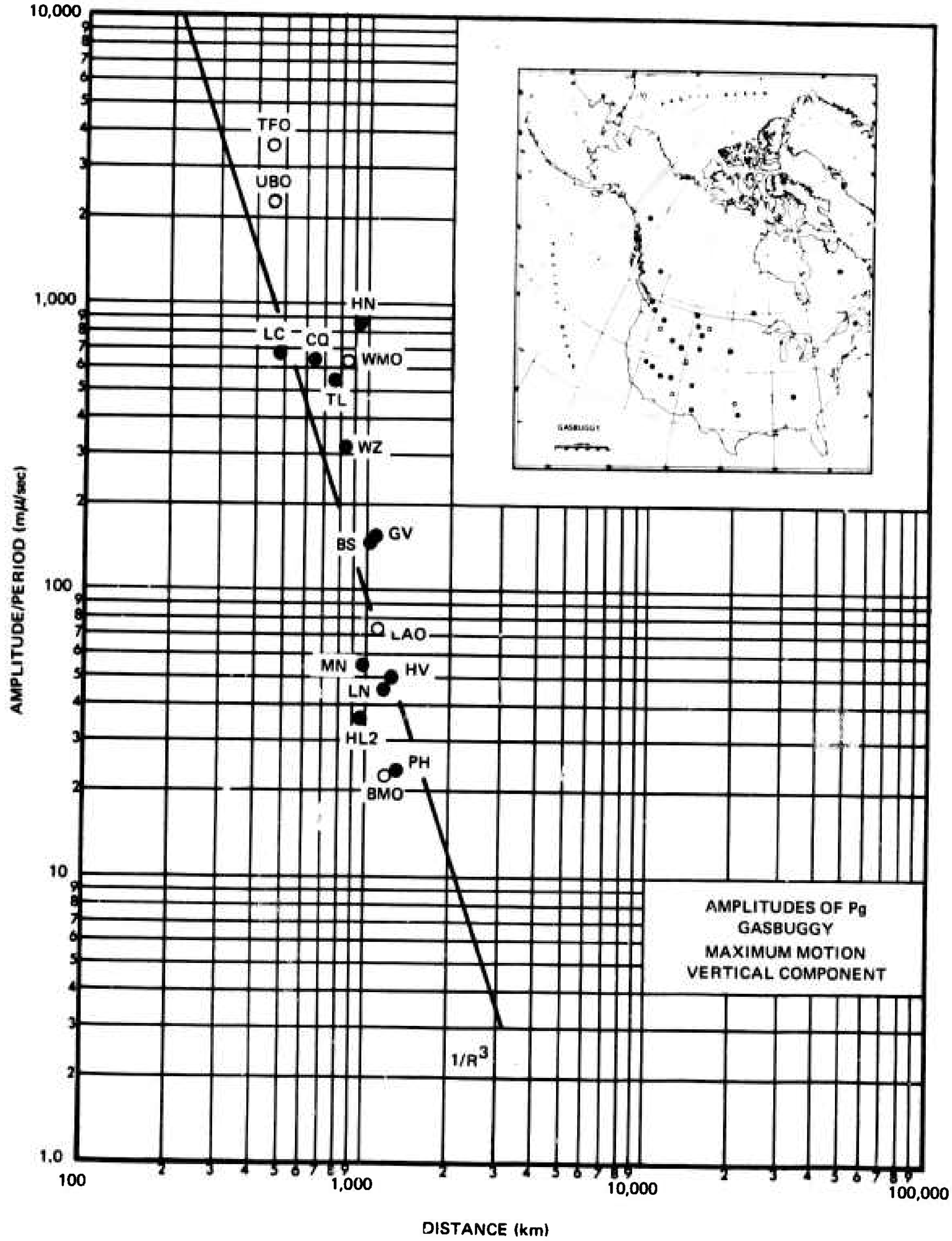


Figure 6.

G 3768

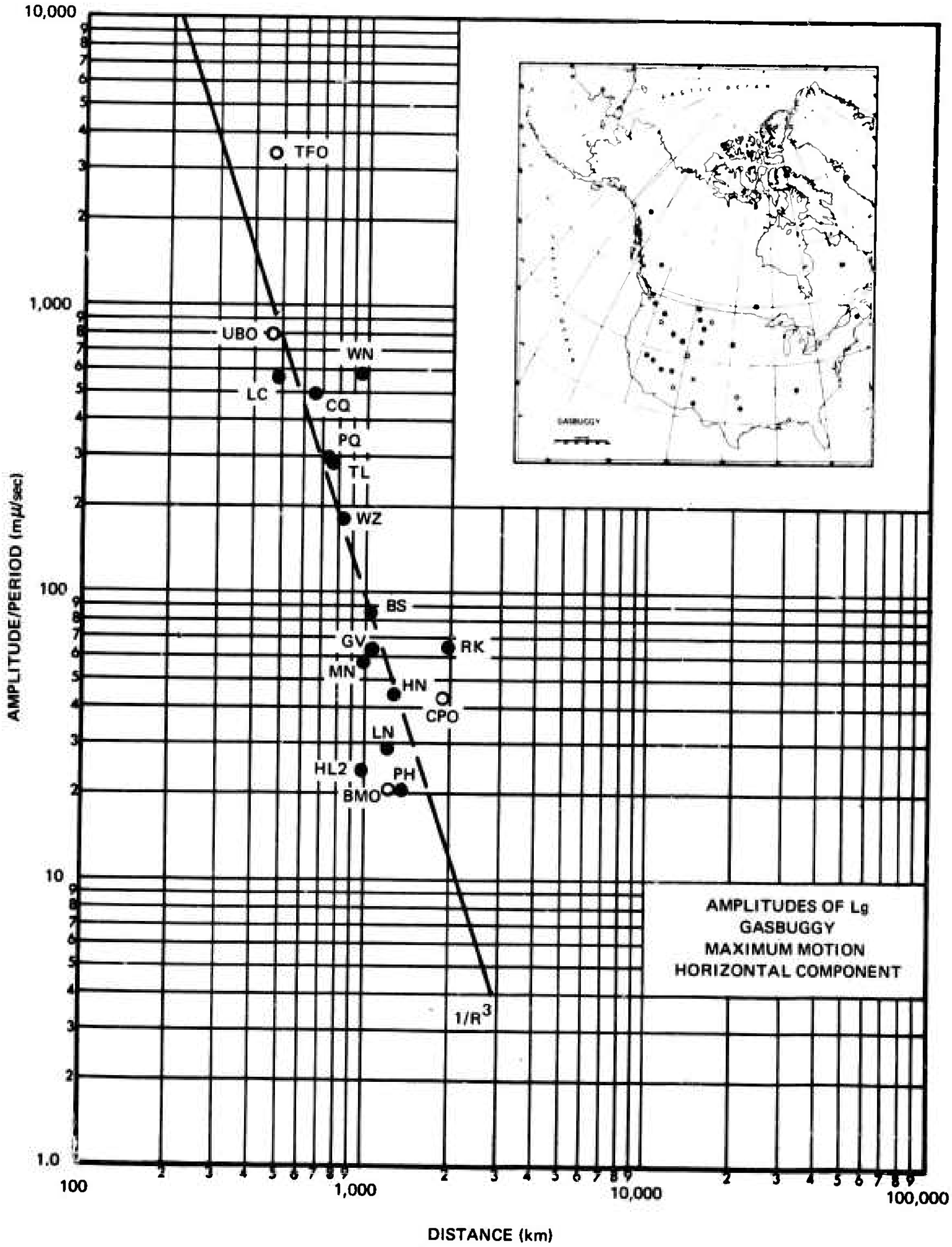


Figure 7.

G 3769

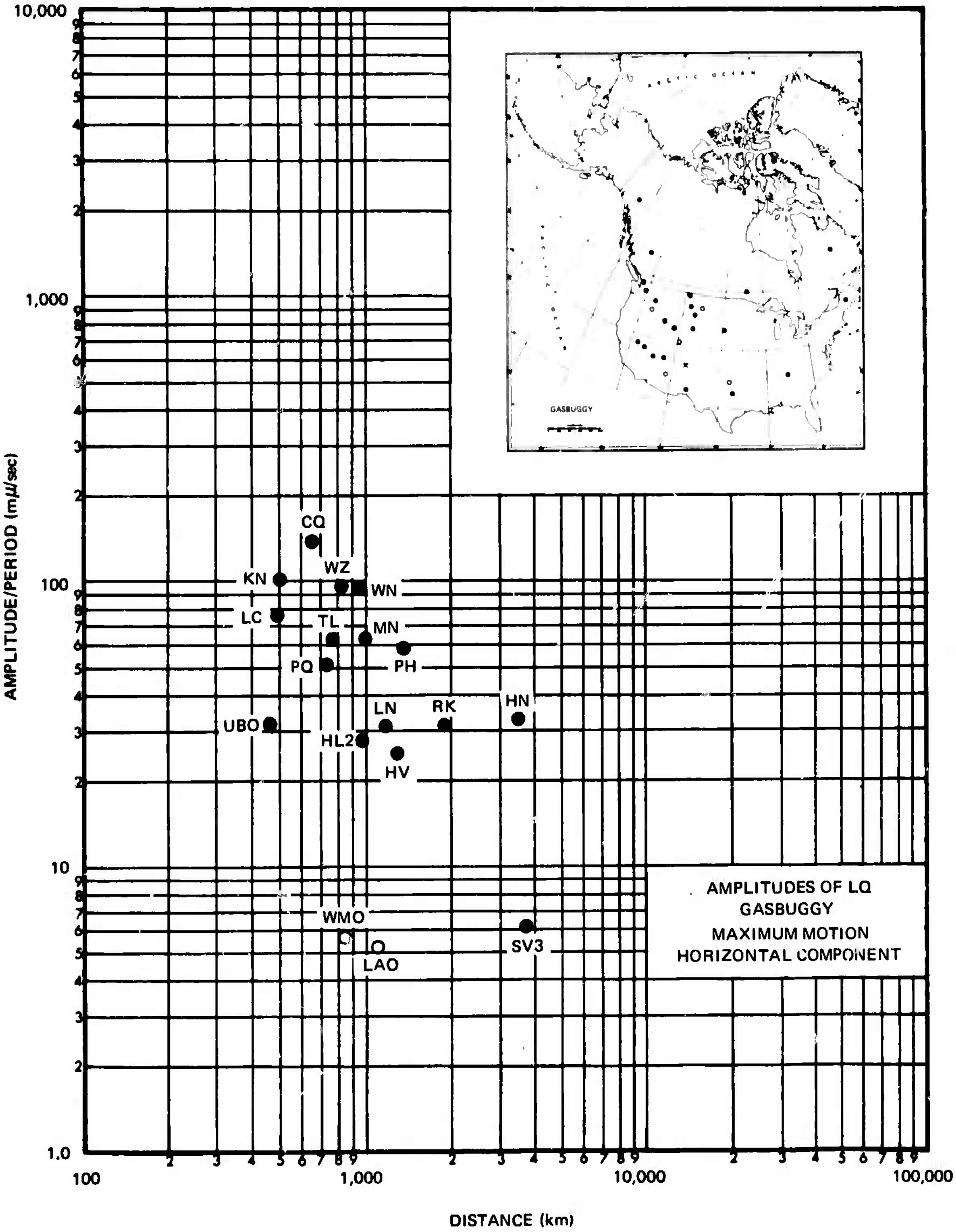


Figure 8.

G 3770

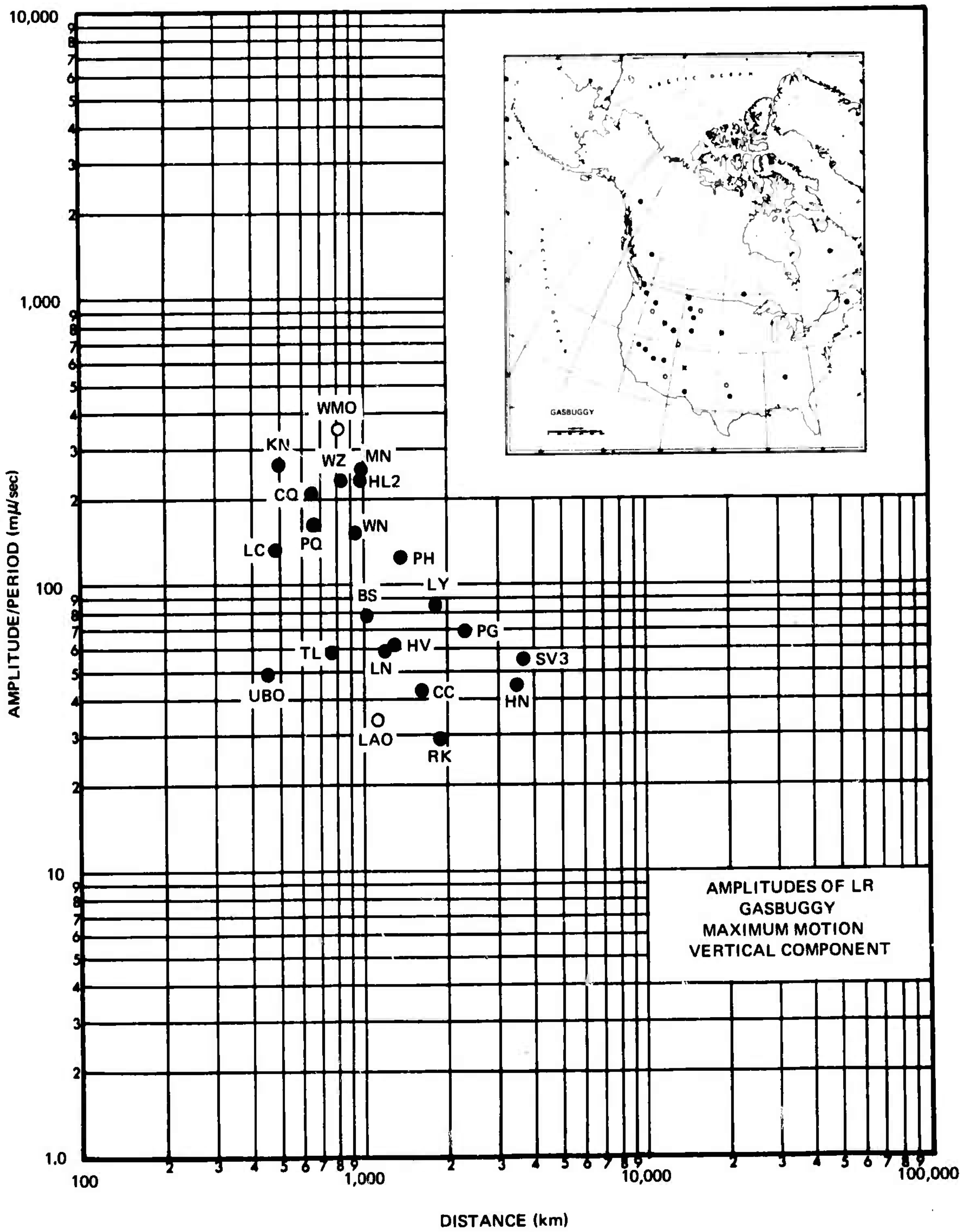


Figure 9.

G 3771

Code	Station	Distance (km)	Geographic latitude	Geographic longitude	Elev (km)	Computed azimuth Epi sta	Computed azimuth Sta epi	Installed azimuth Radial	Installed azimuth Tang	Type of SP seismometer	LP inst
TFSO-Z1	Tonto Forest Observatory, Arizona	454	34°17'12"N	111°16'03"W	1.50	2[illegible]5	053	090°	000°	Johnson-Matheson	X
UB50-Z10	Uinta Basin Observatory, Utah	454	40°19'18"N	109°34'07"W	1.60	334	152	090°	000°	Johnson-Matheson	X
LC-NM	Las Cruces, New Mexico	478	32°24'08"N	106°35'58"W	1.59	173	354	133°	223°	Small Benioff	X
* KN-UT	Kanab, Utah	503	37°01'22"N	112°49'39"W	1.74	276	93	095°	185°	Large Benioff	X
[illegible]-NV	Caliente, Nevada	658	37°54'15"N	114°28'15"W	1.80	284	100	280°	010°	Geotech Portable	X
PQ-IO	Preston, Idaho	728	42°13'41"N	111°42'57"W	1.55	329	146	326°	056°	Geotech Portable	X
TL-WY	Thermopolis, Wyoming	764	43°31'30"N	108°05'17"W	1.62	355	174	354°	084°	Large Benioff	X
WM50-Z6	Wichita Mountains Observatory, Okla.	810	34°43'05"N	098°35'21"W	0.50	103	288	090°	000°	Johnson-Matheson	X
WZ-NV	Warm Springs, Nevada	832	38°03'46"N	116°26'23"W	2.07	283	098	278°	008°	Geotech Portable	X
WN-SD	Winner, South Dakota	944	43°15'08"N	100°11'46"W	0.79	037	222	129°	219°	Large Benioff	X
HL2IO	Hailey, Idaho	980	43°33'40"N	114°25'08"W	1.83	324	139	124°	214°	Small Benioff	X
* MN-NV	Mina, Nevada	986	38°26'10"N	118°08'53"W	1.52	285	098	308°	038°	Large Benioff	X
BS-MA	Billings, Montana	1016	45°43'56"N	108°53'32"W	1.22	353	171	351°	081°	Small Benioff	X
GV-TX	Grapevine, Texas	1024	32°53'09"N	096°59'54"W	0.15	111	297	-	-	Geotech Triaxial	-
LAO	Subarray AO, Montana	1115	46°41'19"N	106°13'20"W	0.90	004	185	000°	090°	Hall-Sears	X
LN-MA	Lewistown, Montana	1181	47°12'43"N	109°08'56"W	1.45	353	172	351°	081°	Geotech Portable	X
BM50-Z3	Blue Mountains Observatory, Oregon	1244	44°50'56"N	117°18'20"W	1.19	320	133	000°	090°	Johnson-Matheson	X
HV-MA	Havre, Montana	1323	48°25'20"N	109°49'20"W	0.88	352	170	122°	212°	Large Benioff	X
PH-WA	Pomeroy, Washington	1363	46°19'25"N	117°19'41"W	0.95	325	138	318°	048°	Large Benioff	X
CC-WA	Cascade Tunnel, Washington	1678	47°46'09"N	121°05'01"W	1.04	322	132	312°	042°	Geotech Portable	X
LY-WA	Lynden, Washington	1305	48°38'51"N	122°12'10"W	0.12	322	132	312°	042°	Geotech Portable	X
* RK-ON	Red Lake, Ontario	1908	50°50'20"N	093°40'20"W	0.37	030	220	058°	148°	Small Benioff	X
CP50-Z8	Cumberland Plateau Obs., Tenn.	1947	35°35'41"N	085°34'13"W	0.57	087	280	090°	000°	Johnson-Matheson	X
PG-BC	Prince George, British Columbia	2259	53°59'50"N	122°31'23"W	0.71	333	142	110°	200°	Large Benioff	X
* WH2YK	Whitehorse, Yukon Territory	3314	60°41'41"N	134°58'02"W	0.85	333	131	325°	055°	Large Benioff	X
* HN-ME	Houlton, Maine	3406	46°09'43"N	067°59'09"W	0.21	060	266	093°	183°	Small Benioff	X
SV3QB	Schefferville, Quebec	3665	54°48'39"N	066°45'00"W	0.58	044	254	139°	229°	Small Benioff	X
* NP-NT	Mould Bay, Northwest Territories	4453	76°14'36"N	119°22'06"W	0.02	356	165	356°	086°	Johnson-Matheson & Small Benioff	X

Recording Site Information - GASBUGGY
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

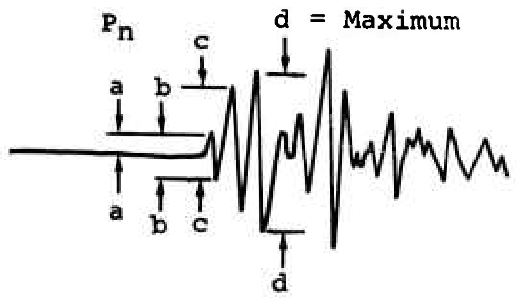
B = distance factor (see Table below)

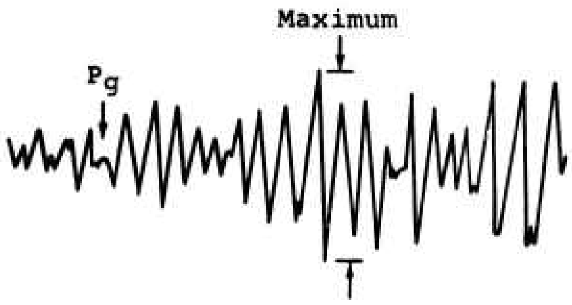
mm = record amplitude in millimeters zero to peak

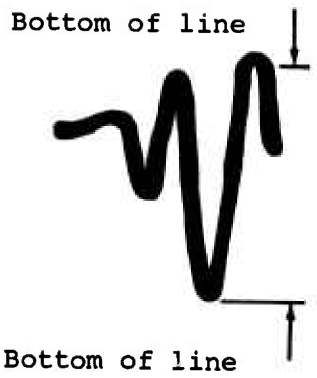
K = magnification in thousands at signal frequency

Table of Distance Factors (B) for Zero Depth

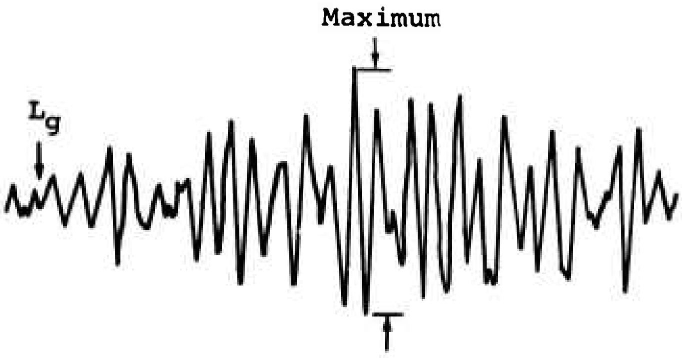
Dist (deg)	B	Dist (deg)	B	Dist (deg)	B	Dist (deg)	B
0°	-	27°	3.5	54°	3.8	80°	3.7
1	-	28	3.6	55	3.8	81	3.8
2	2.2	29	3.6	56	3.8	82	3.9
3	2.7	30	3.6	57	3.8	83	4.0
4	3.1	31	3.7	58	3.8	84	4.0
5	3.4	32	3.7	59	3.8	85	4.0
6	3.6	33	3.7	60	3.8	86	3.9
7	3.8	34	3.7	61	3.9	87	4.0
8	4.0	35	3.7	62	4.0	88	4.1
9	4.2	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				







Detail Showing Allowance For Line Width



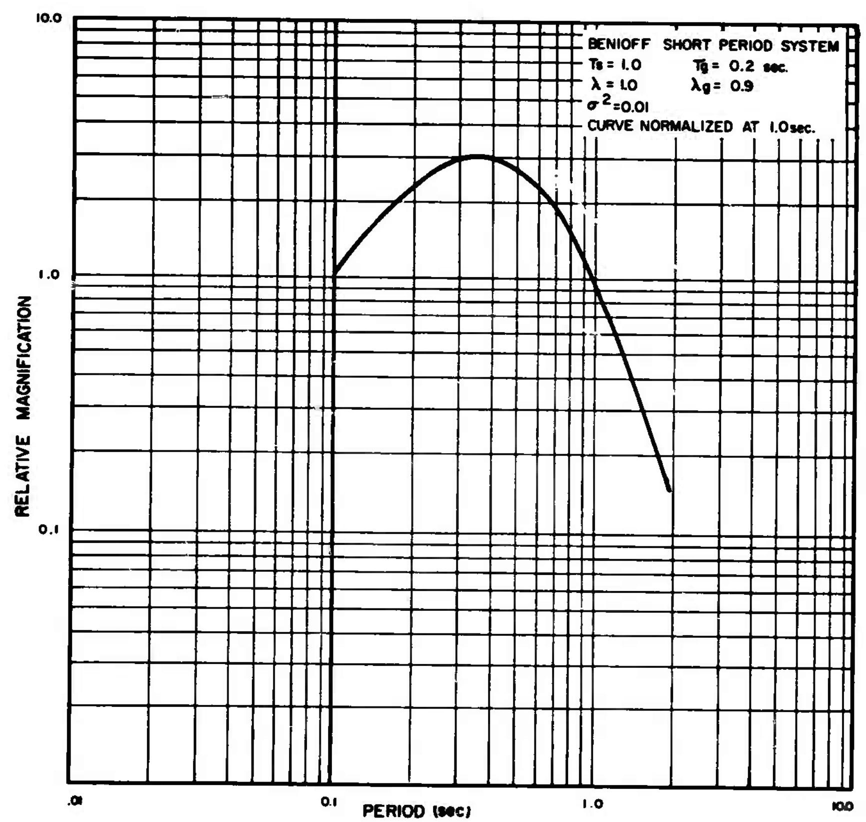
Pick time of Pn at beginning of "a" half cycle.

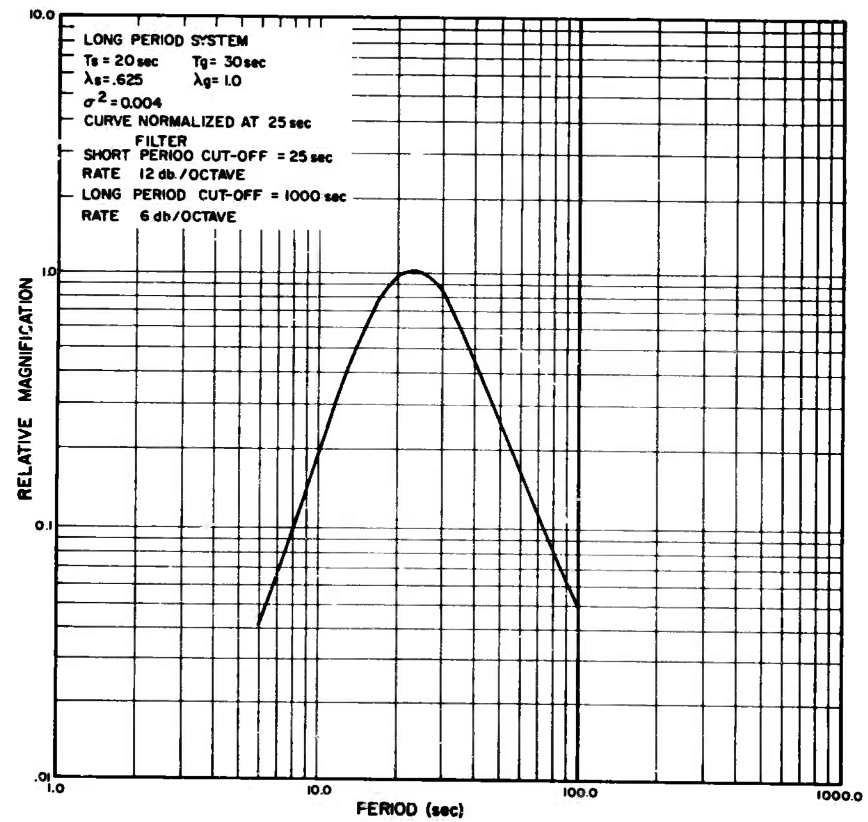
Pick amplitude of Pn as maximum "$d/2$" within 2 or 3 cycles of "c".

Pick amplitudes of Pg and Lg at maximum of corresponding motion.

Seismic Analysis Diagram
Appendix II(A)

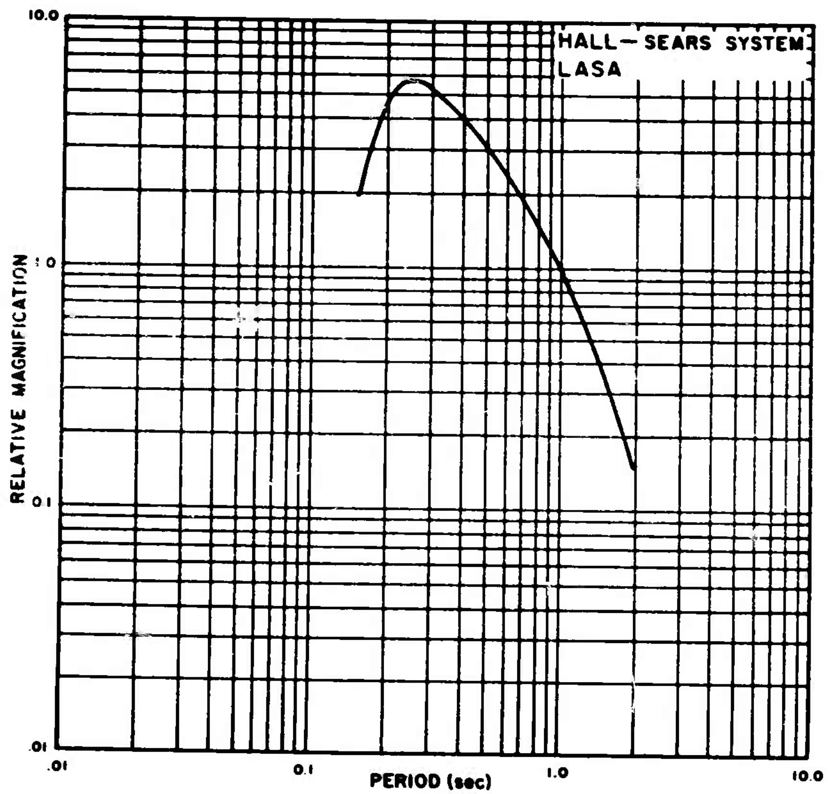
G 3777

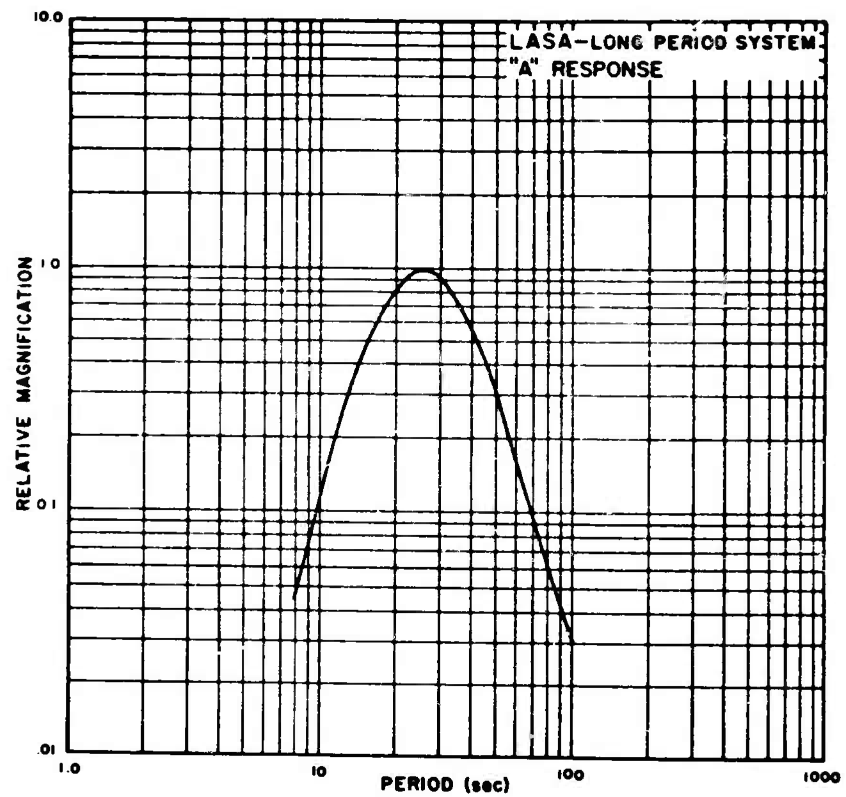




Instrument Response Curves - LRSM
Appendix II(B)

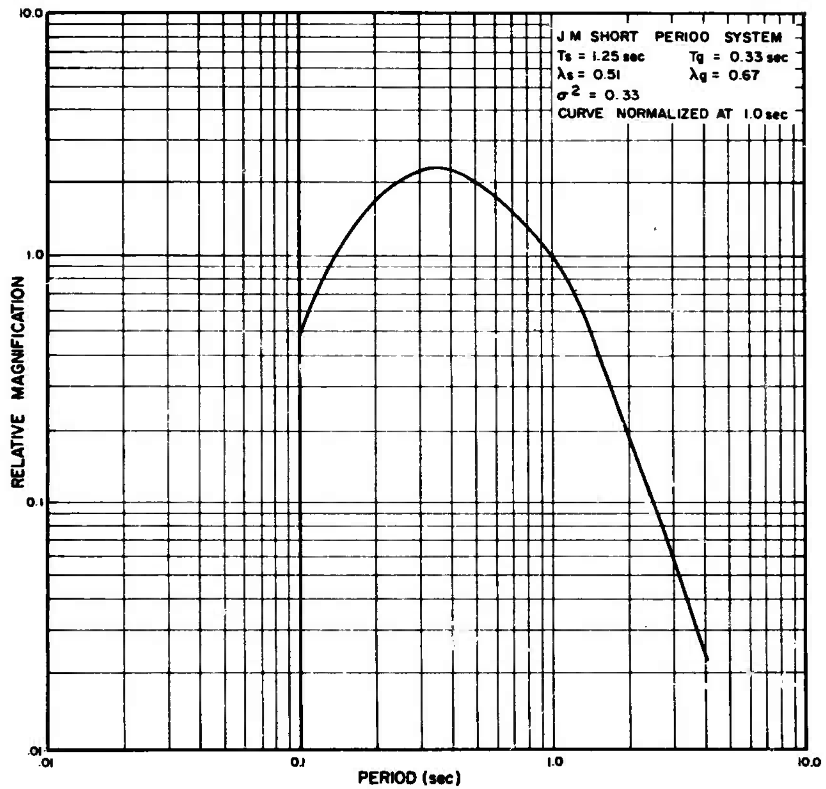
G 3778

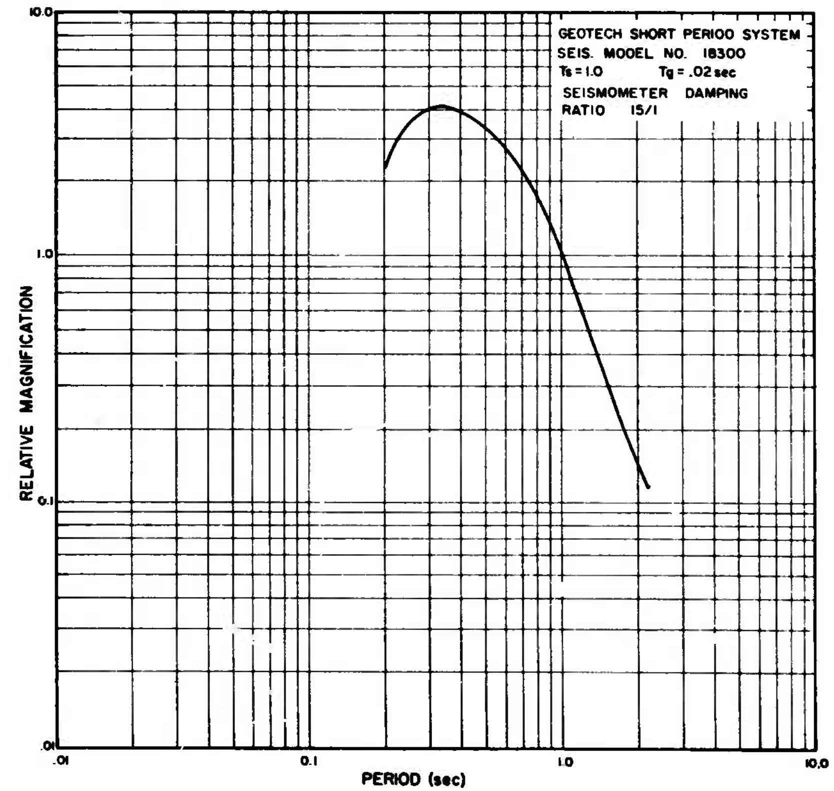




Instrument Response Curves - LASA
Appendix II(C)

G 3779





Instrument Response Curves - Other Short-Period
Appendix II(D)

G 3780

GASBUGGY

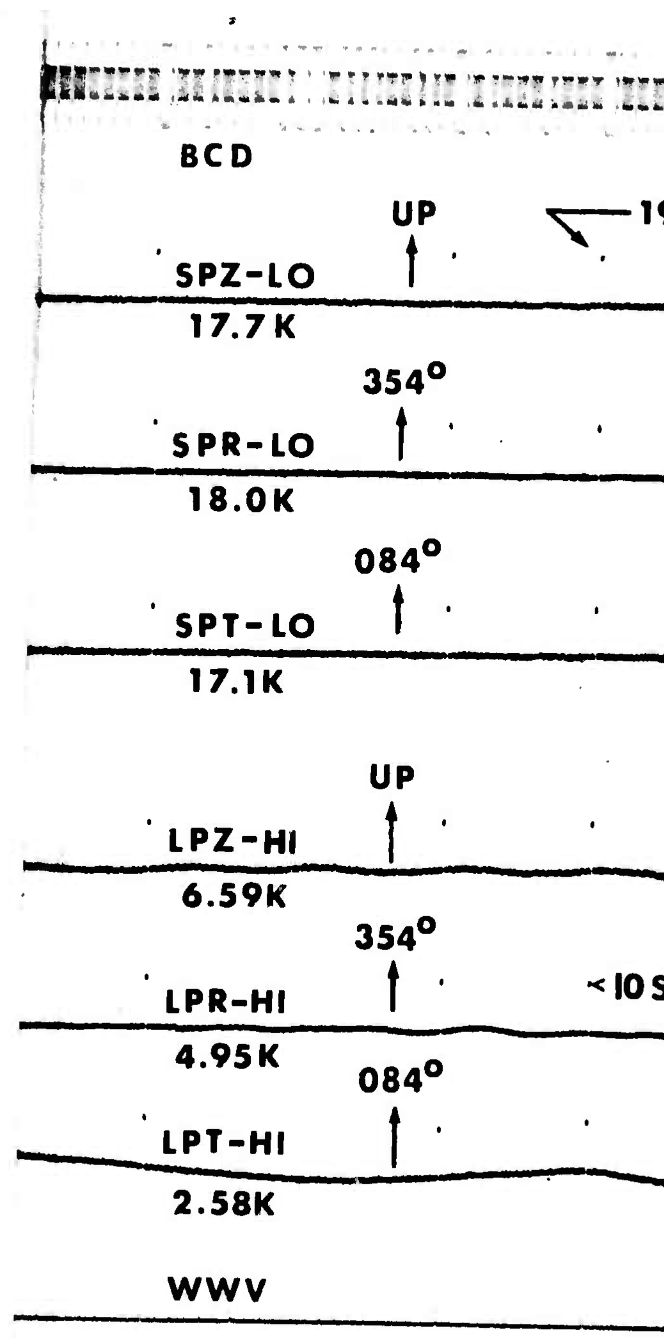
TL-WY

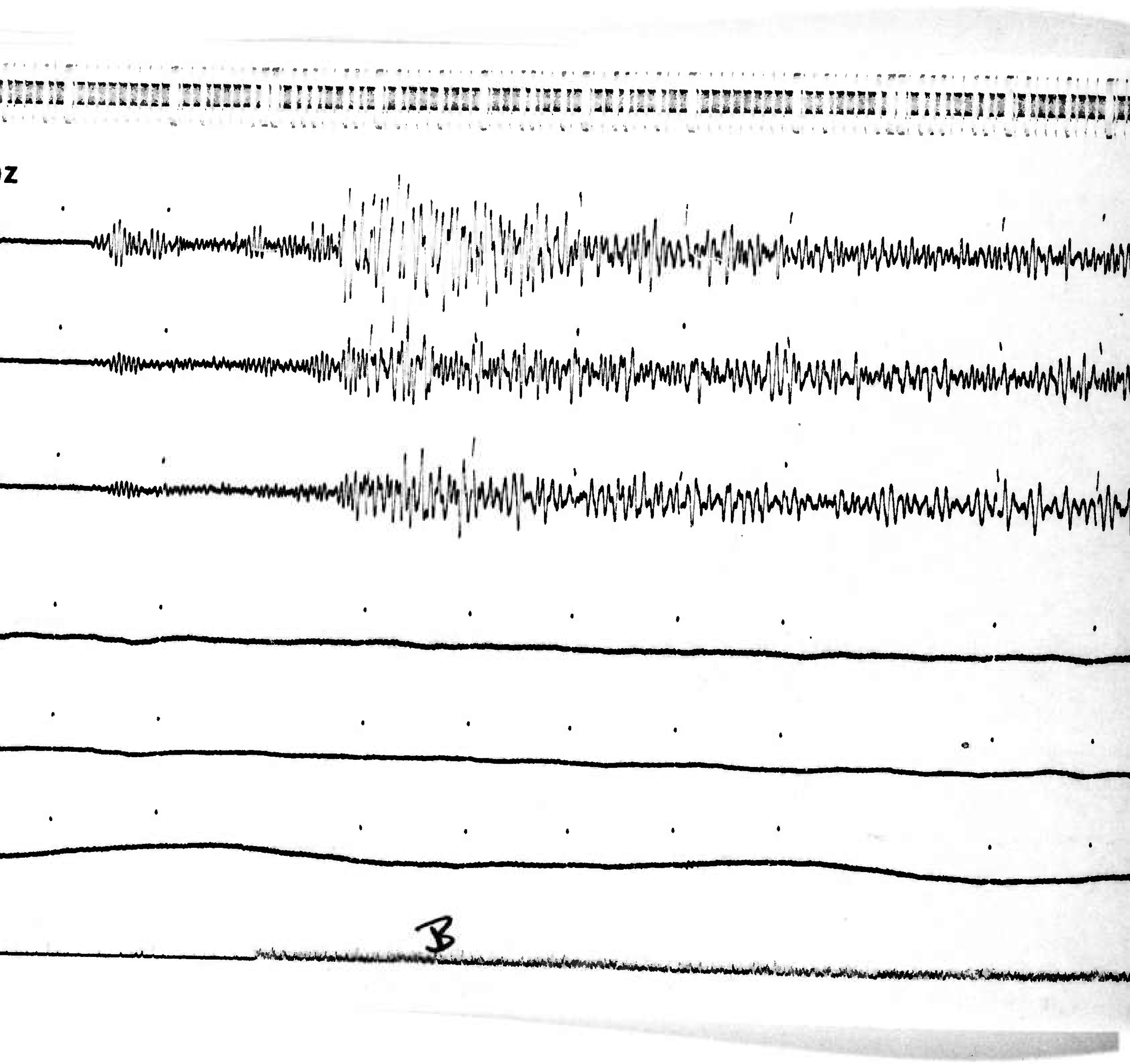
Thermopolis, Wyoming

10 December 1967

$\Delta = 764$ km

A

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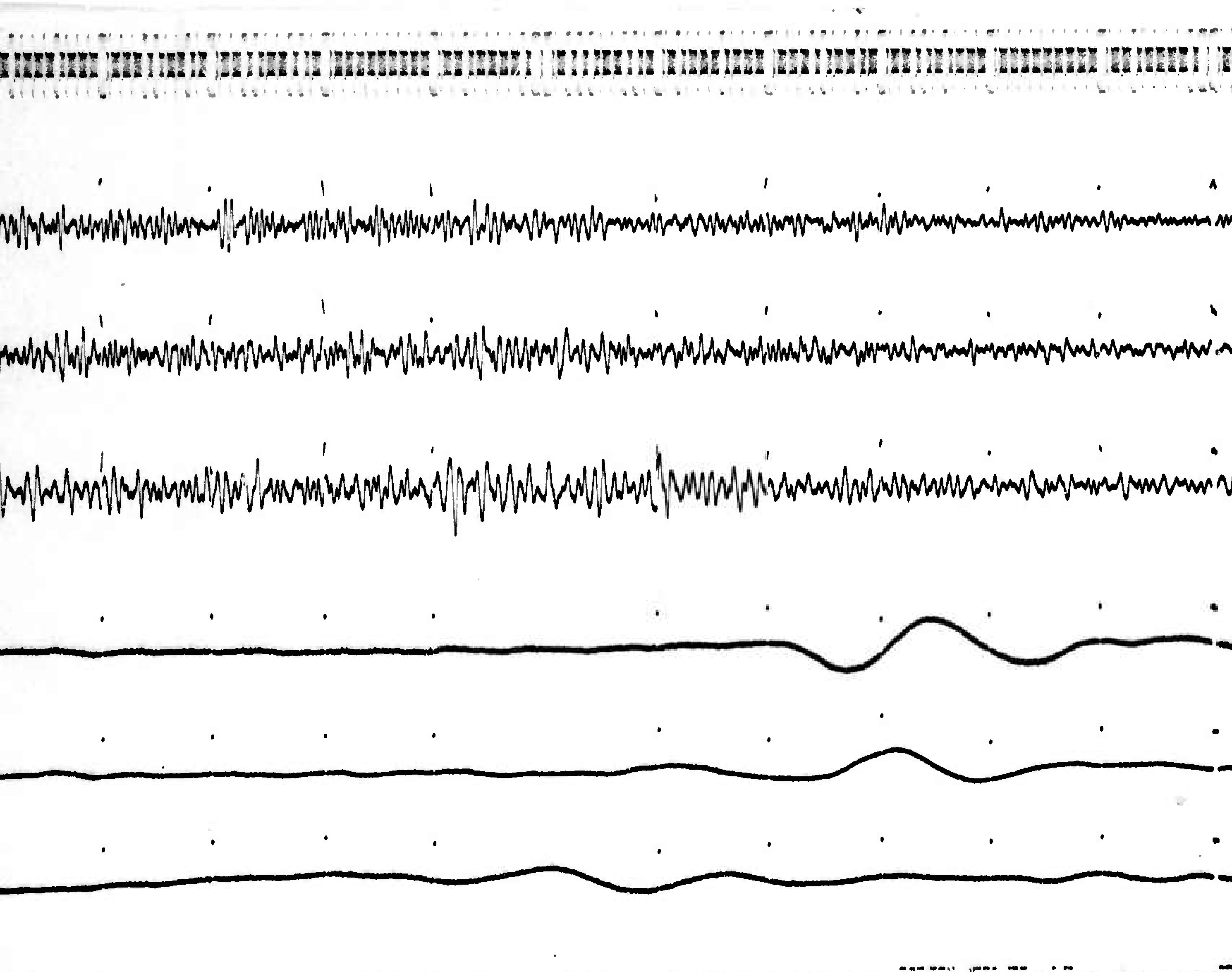
B



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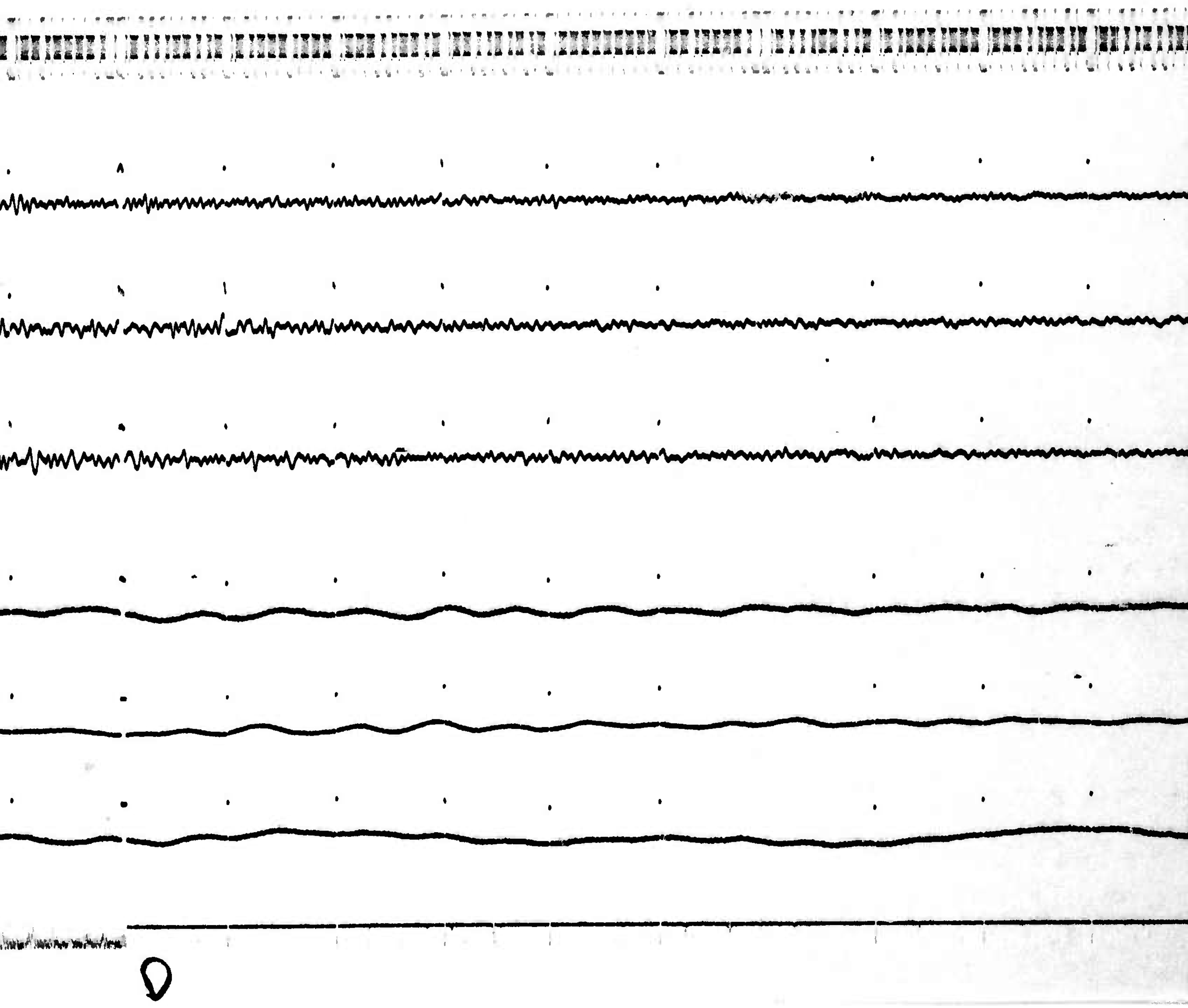
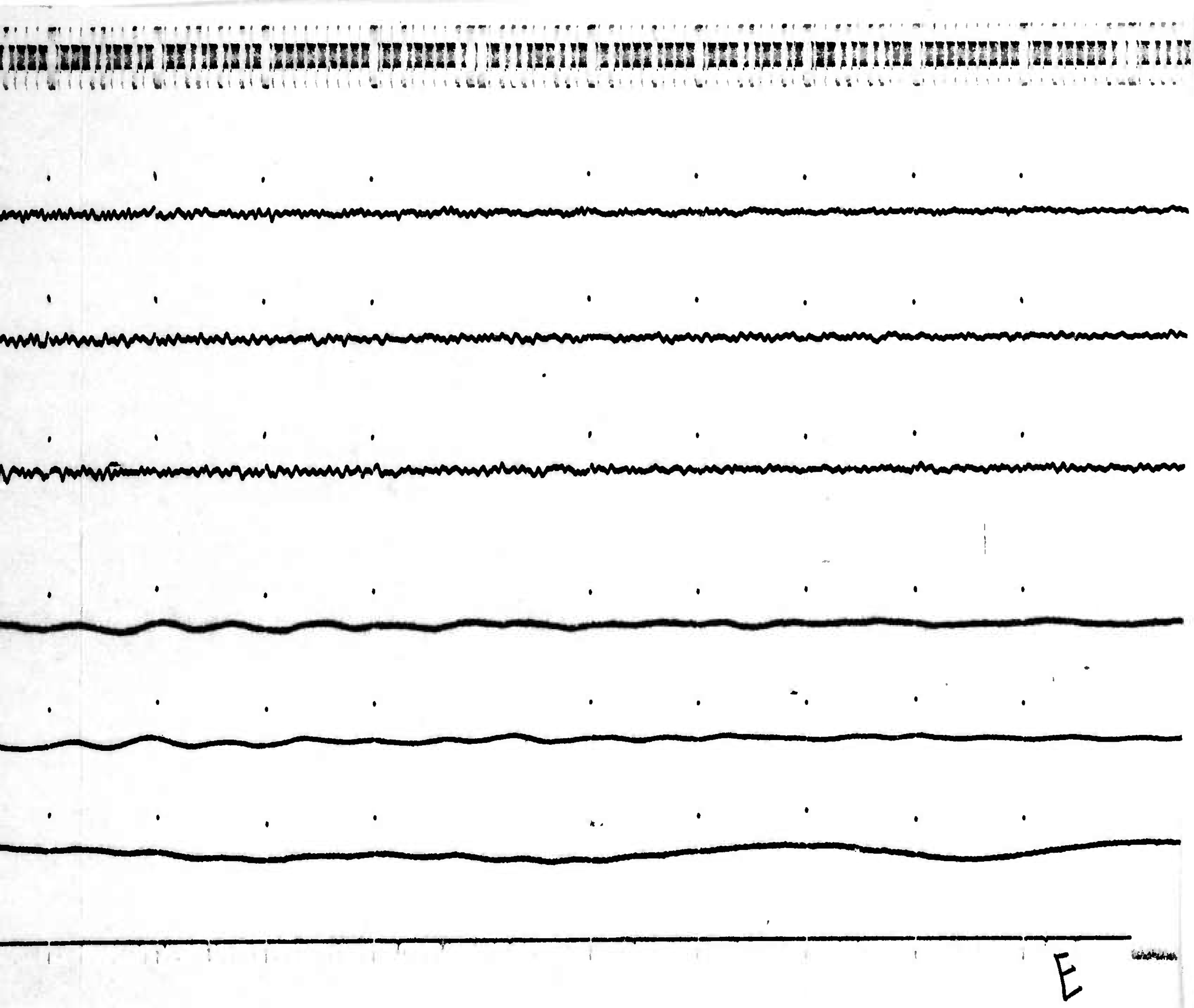



E

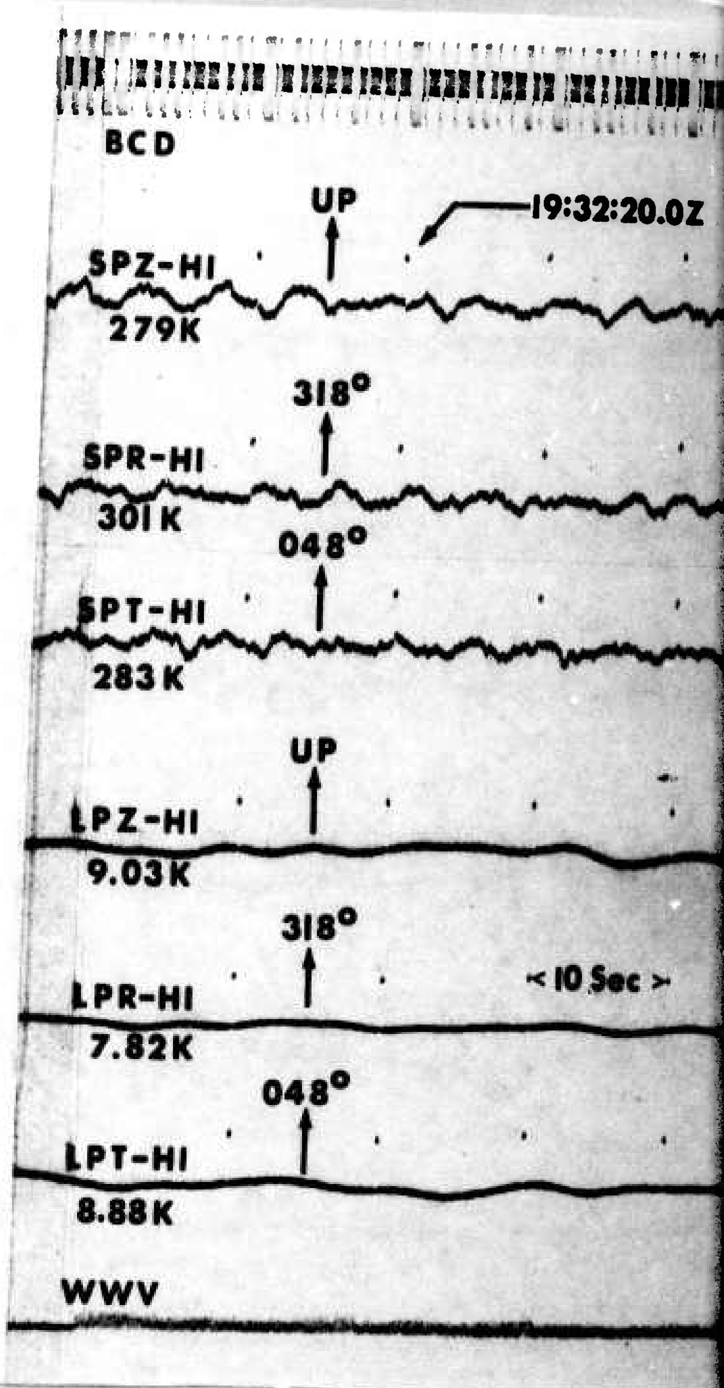
GASBUGGY

PH–WA

Pomeroy, Washington

10 December 1967

$\Delta = 1363$ km



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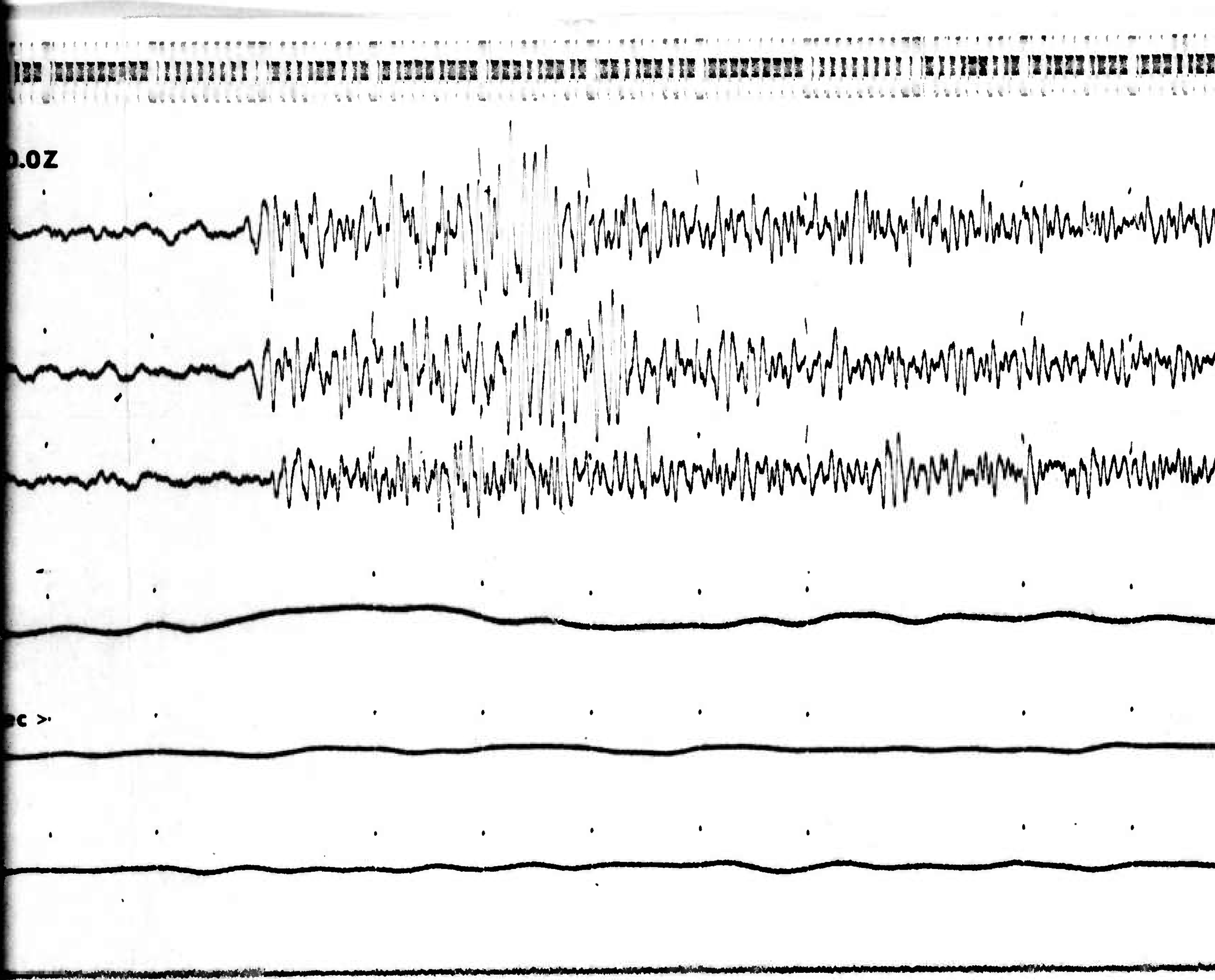

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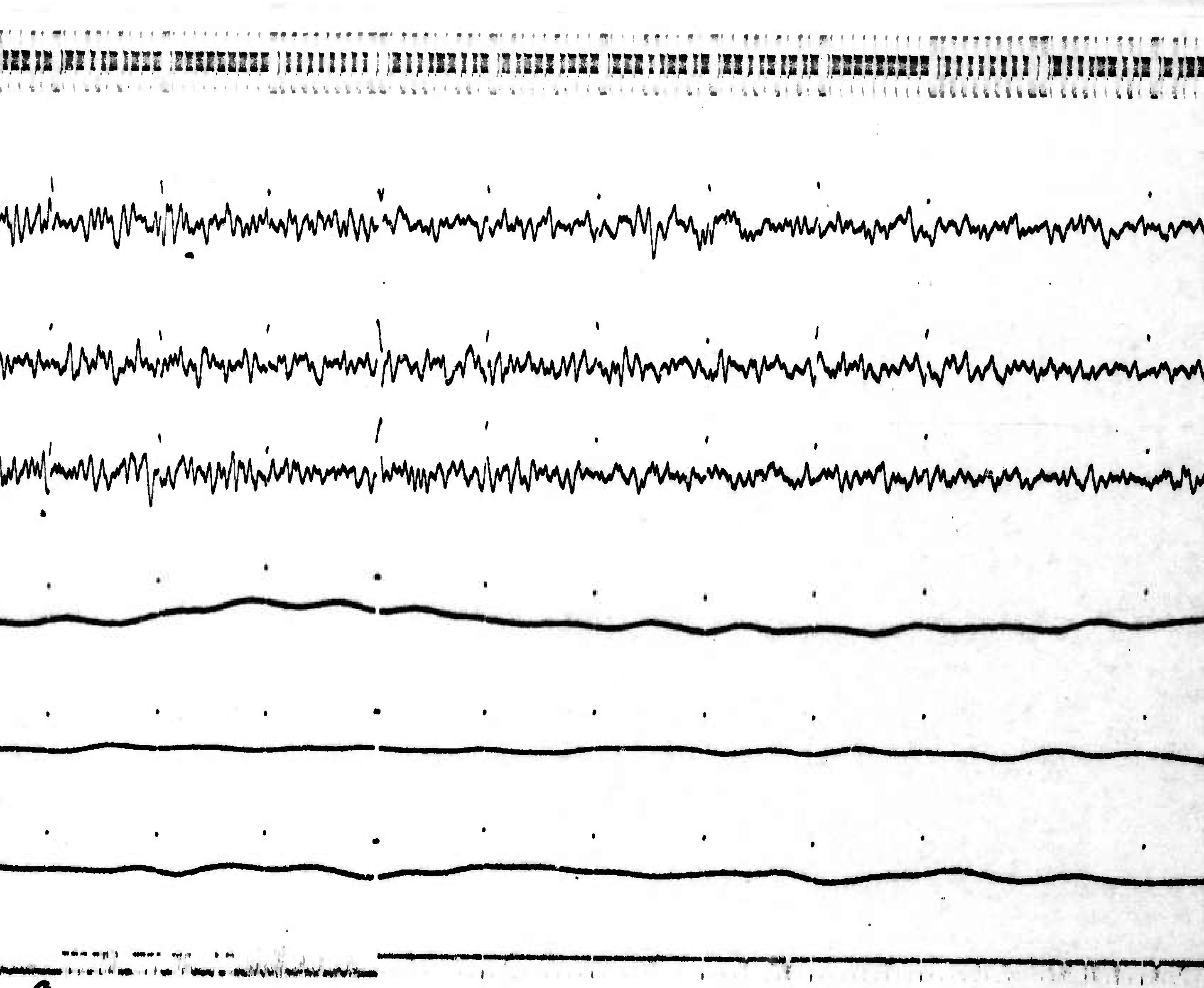

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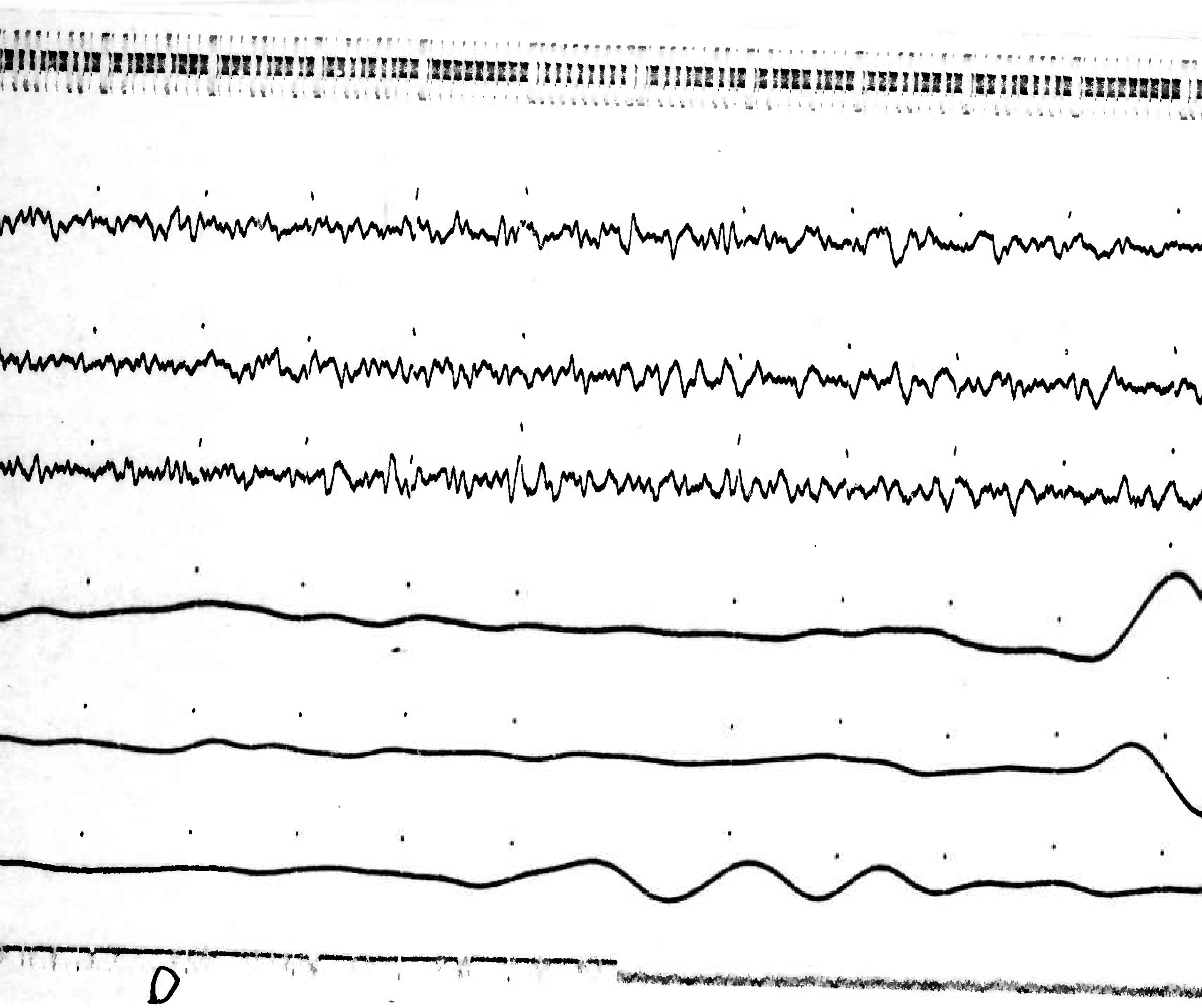
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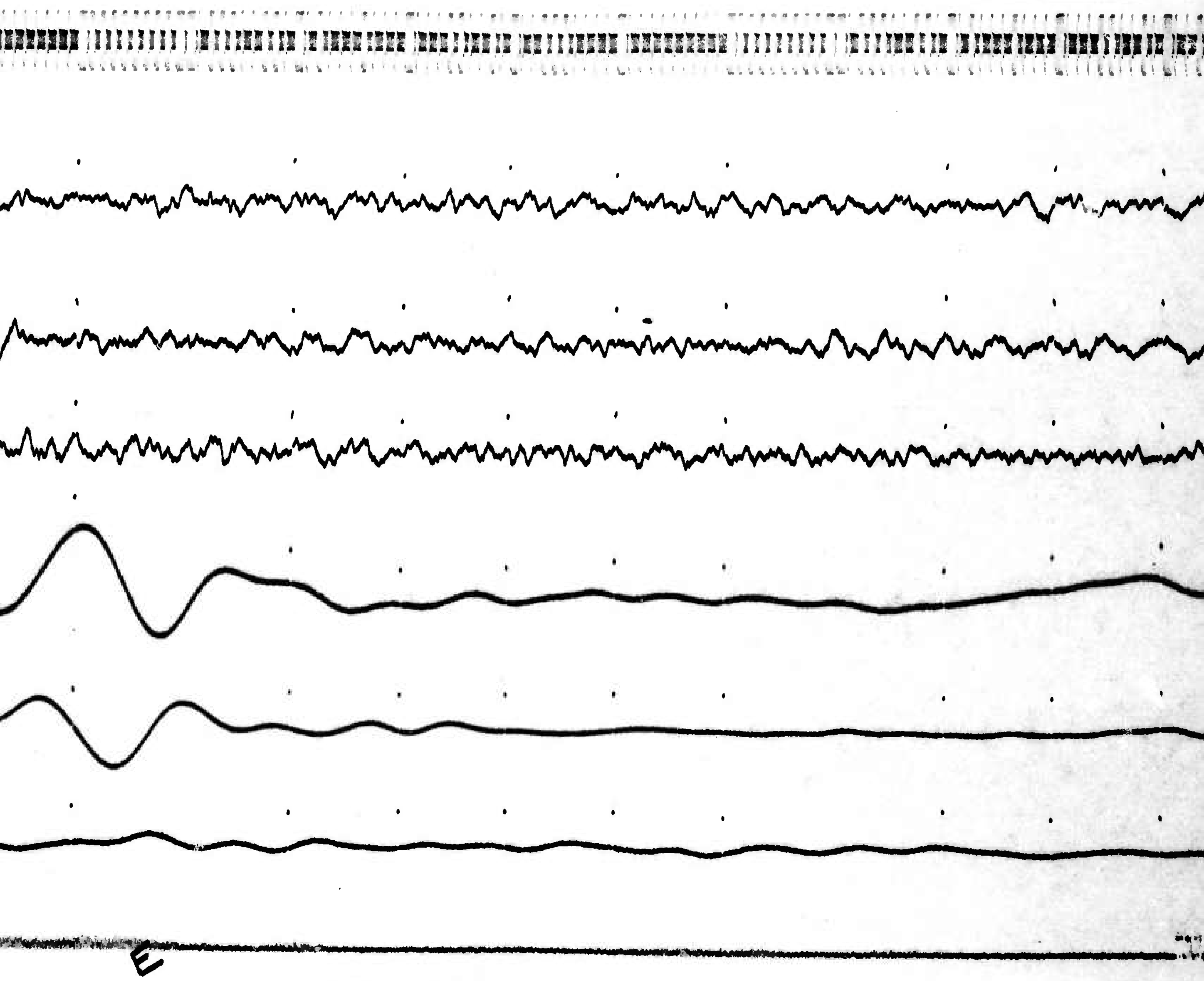
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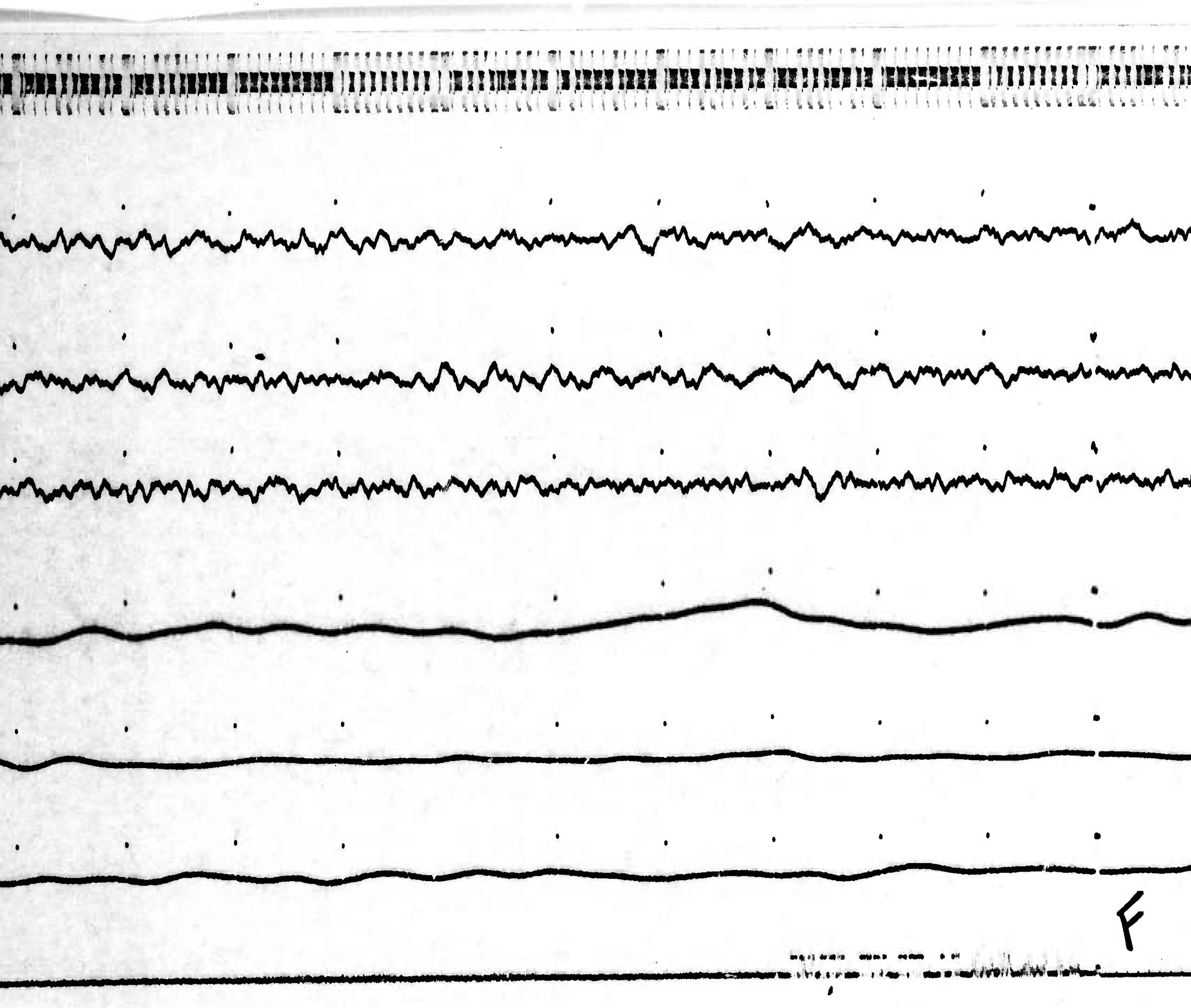

F

GASBUGGY

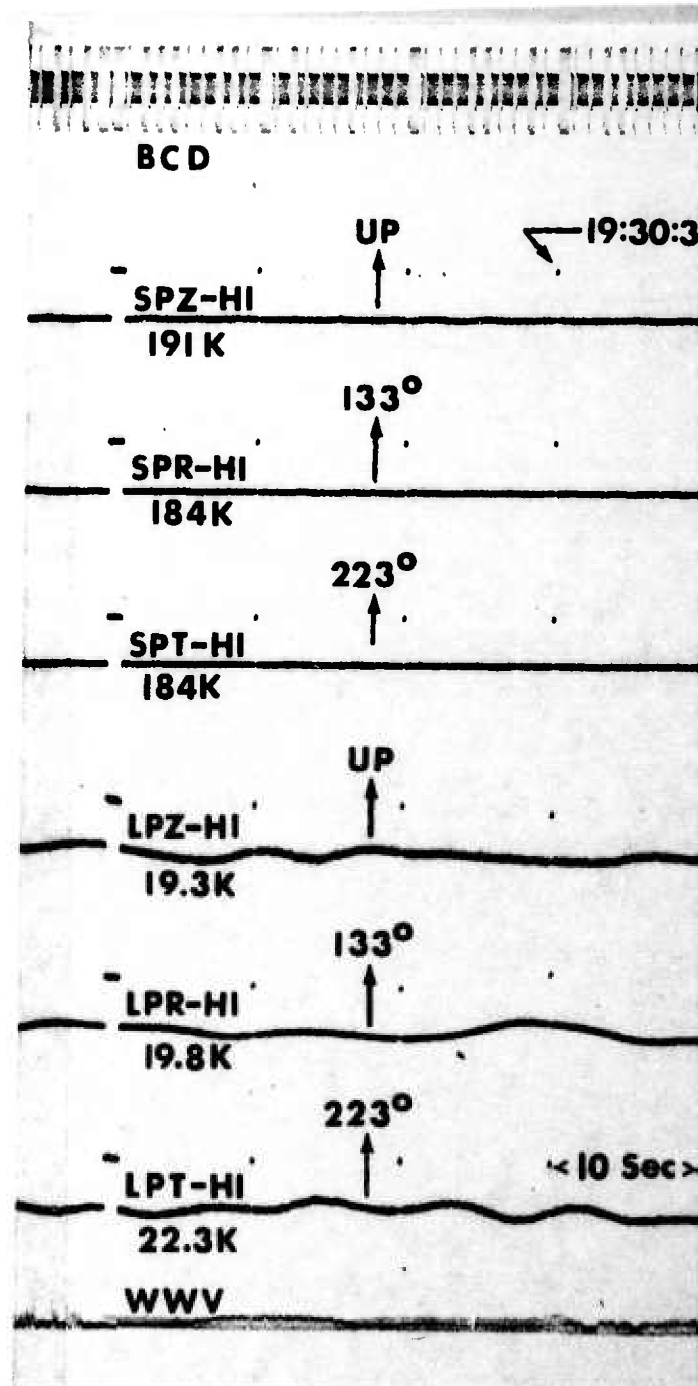
LC-NM

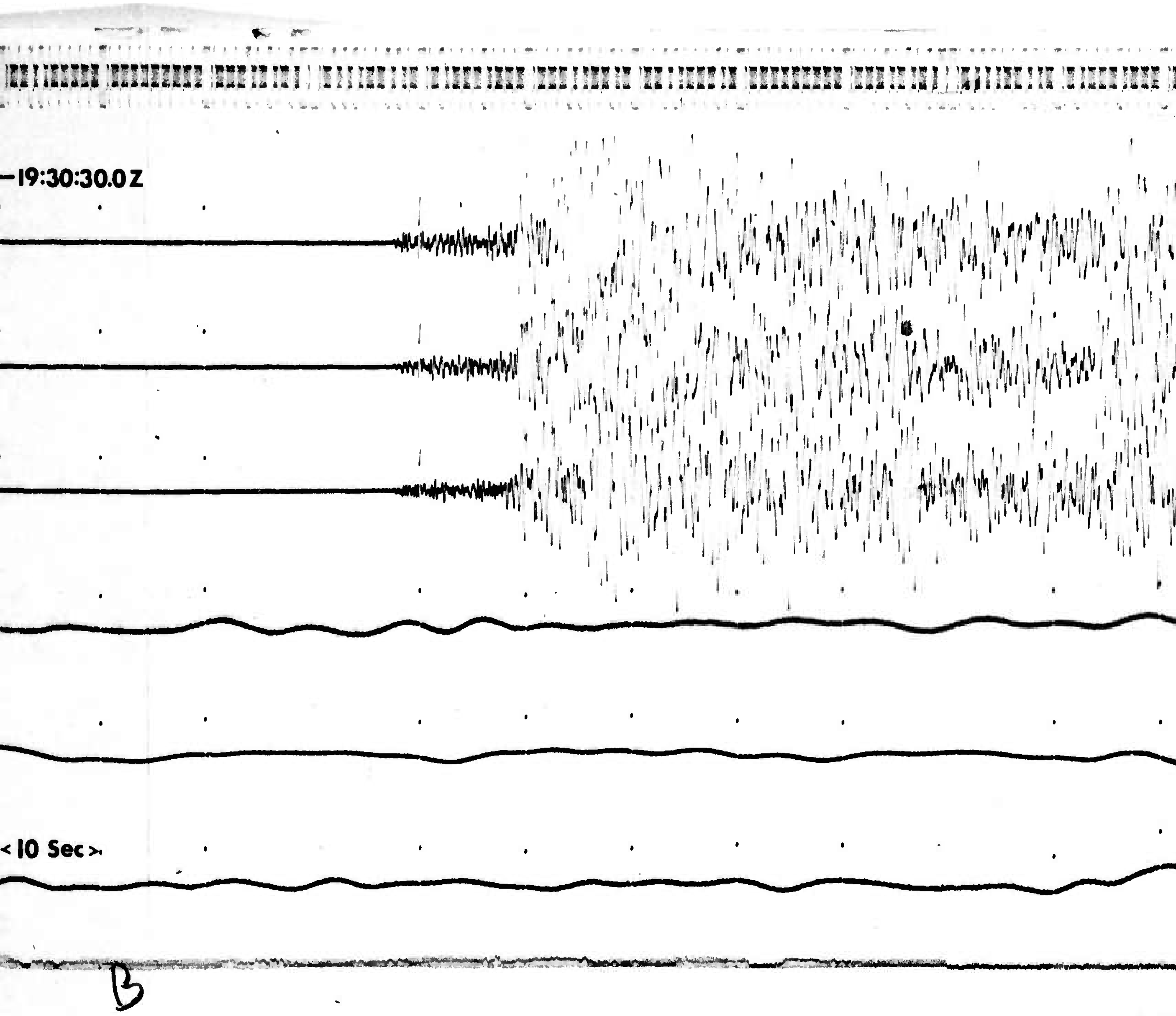
Las Cruces, New Mexico

10 December 1967

Δ= 478 km

A

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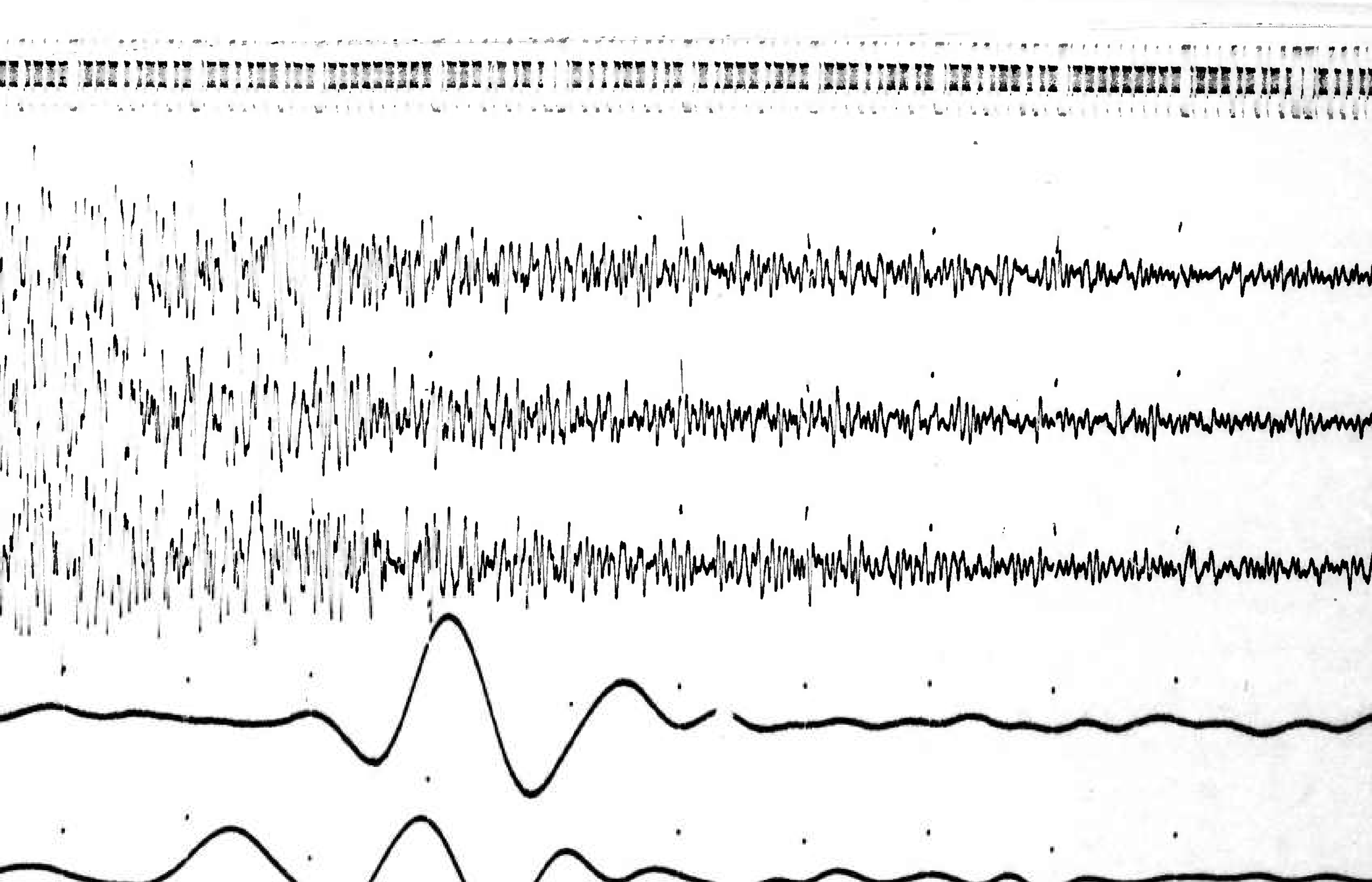

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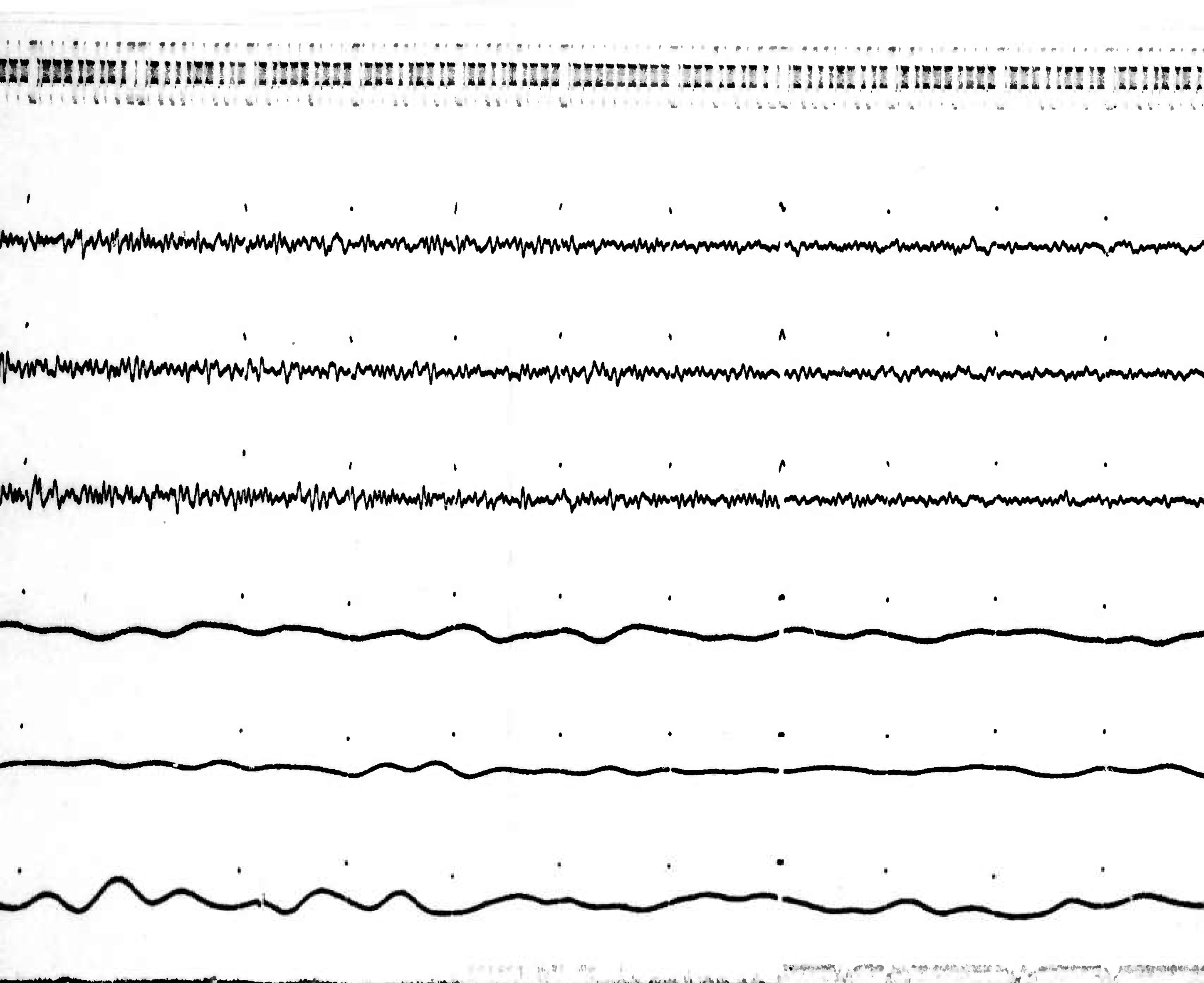

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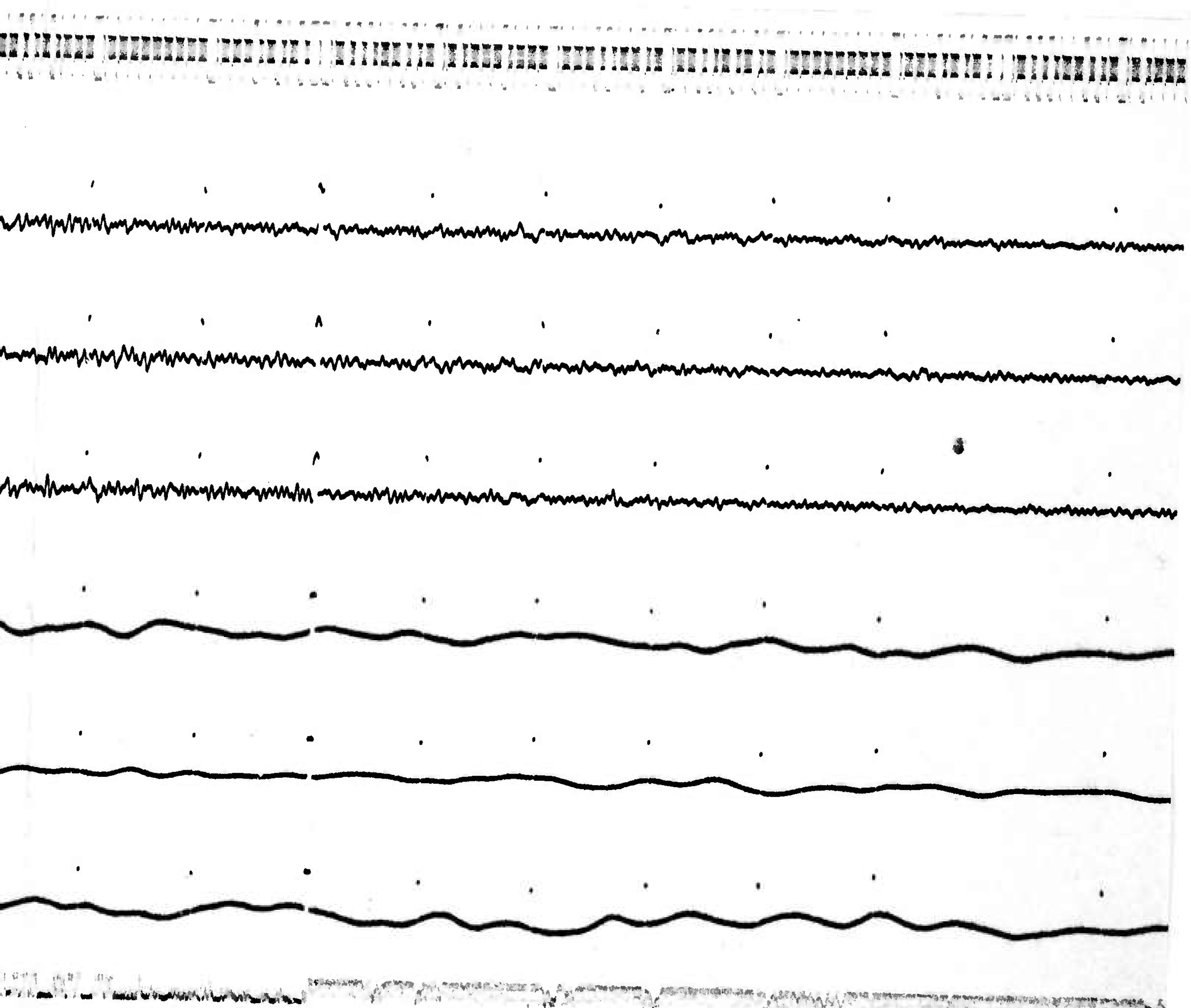


E

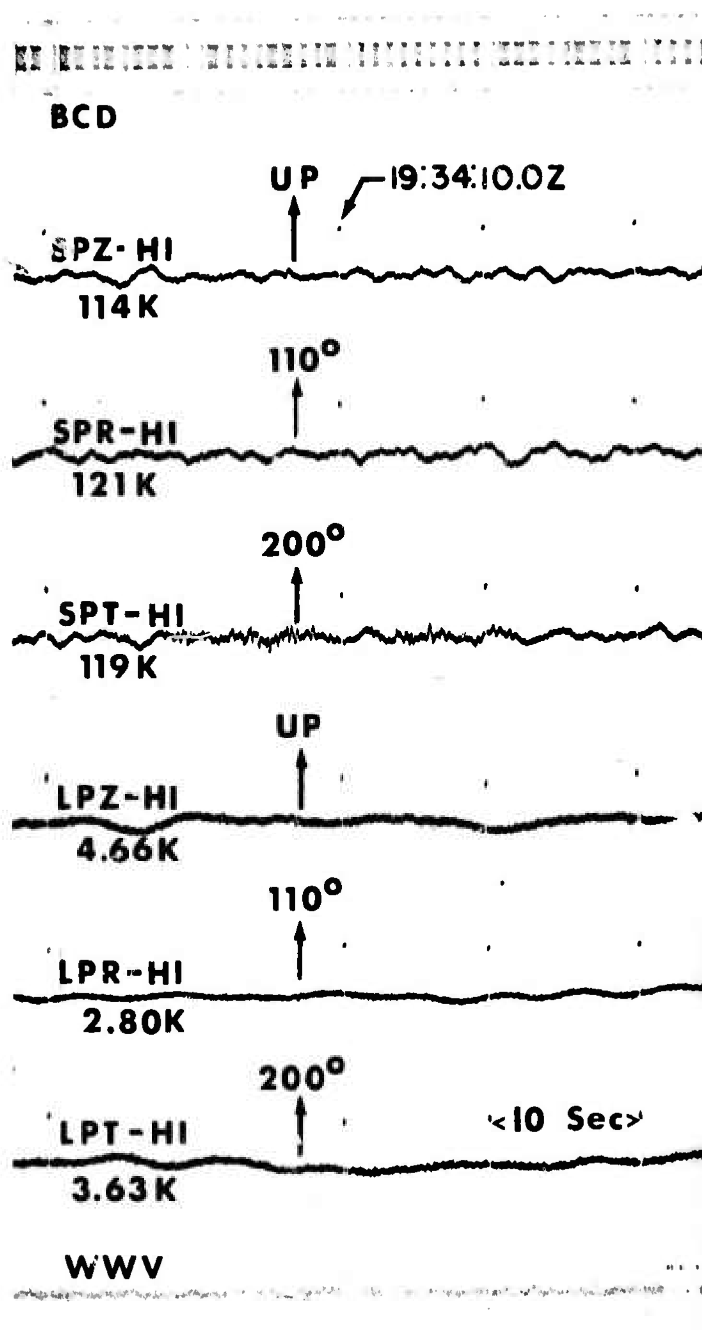
GASBUGGY

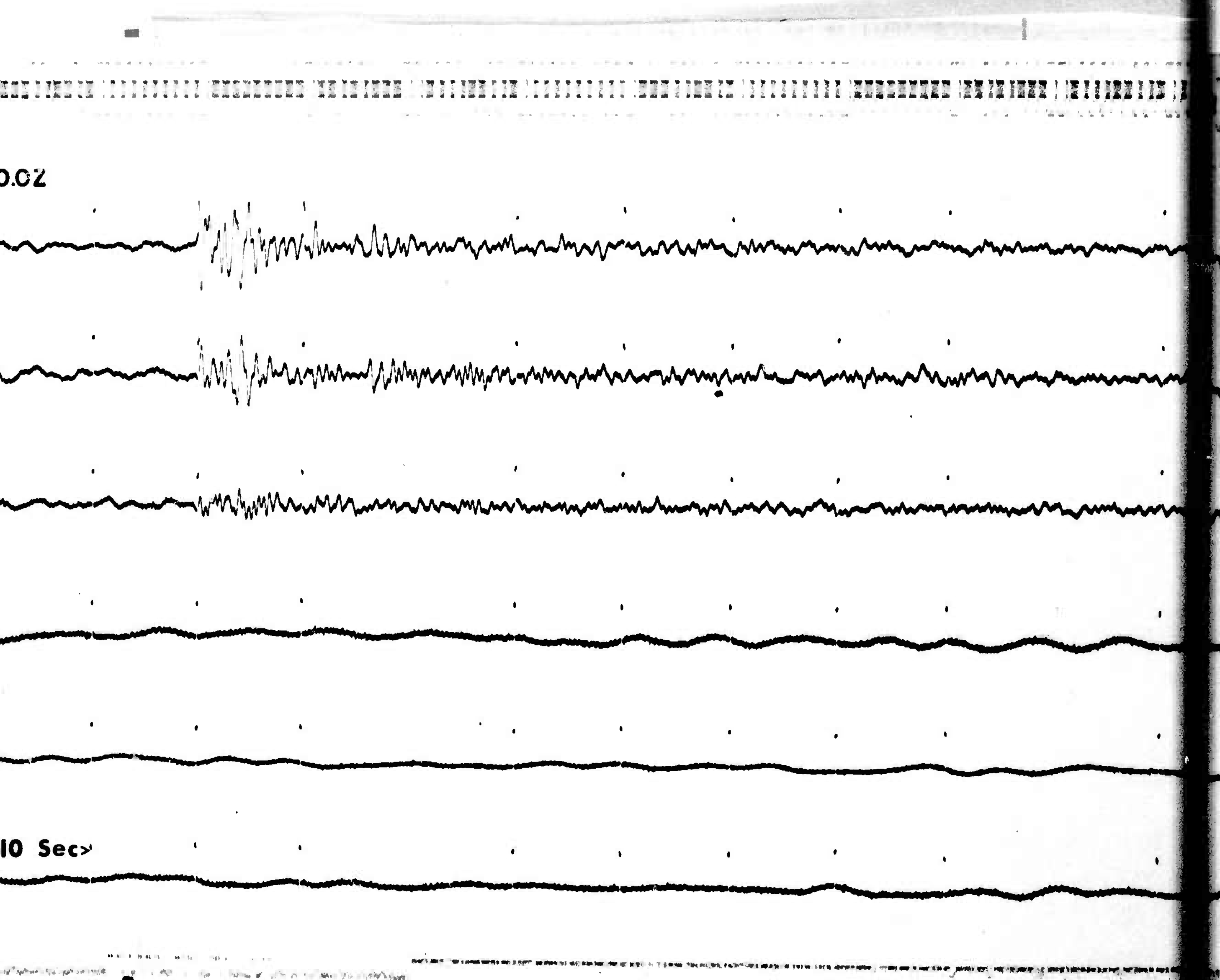
PG-BC

Prince George, B.C., Canada

10 December 1967

Δ = 2259 km





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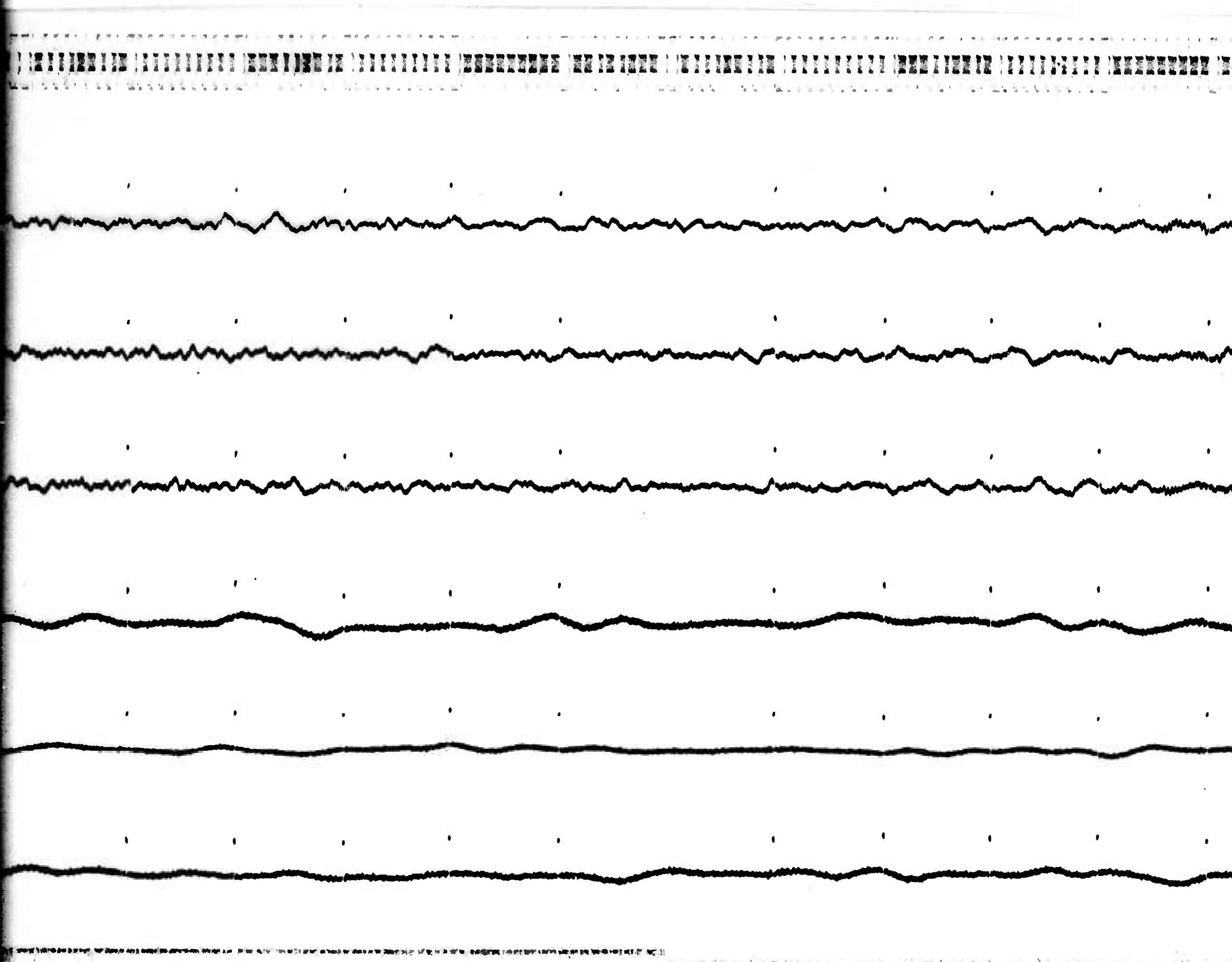

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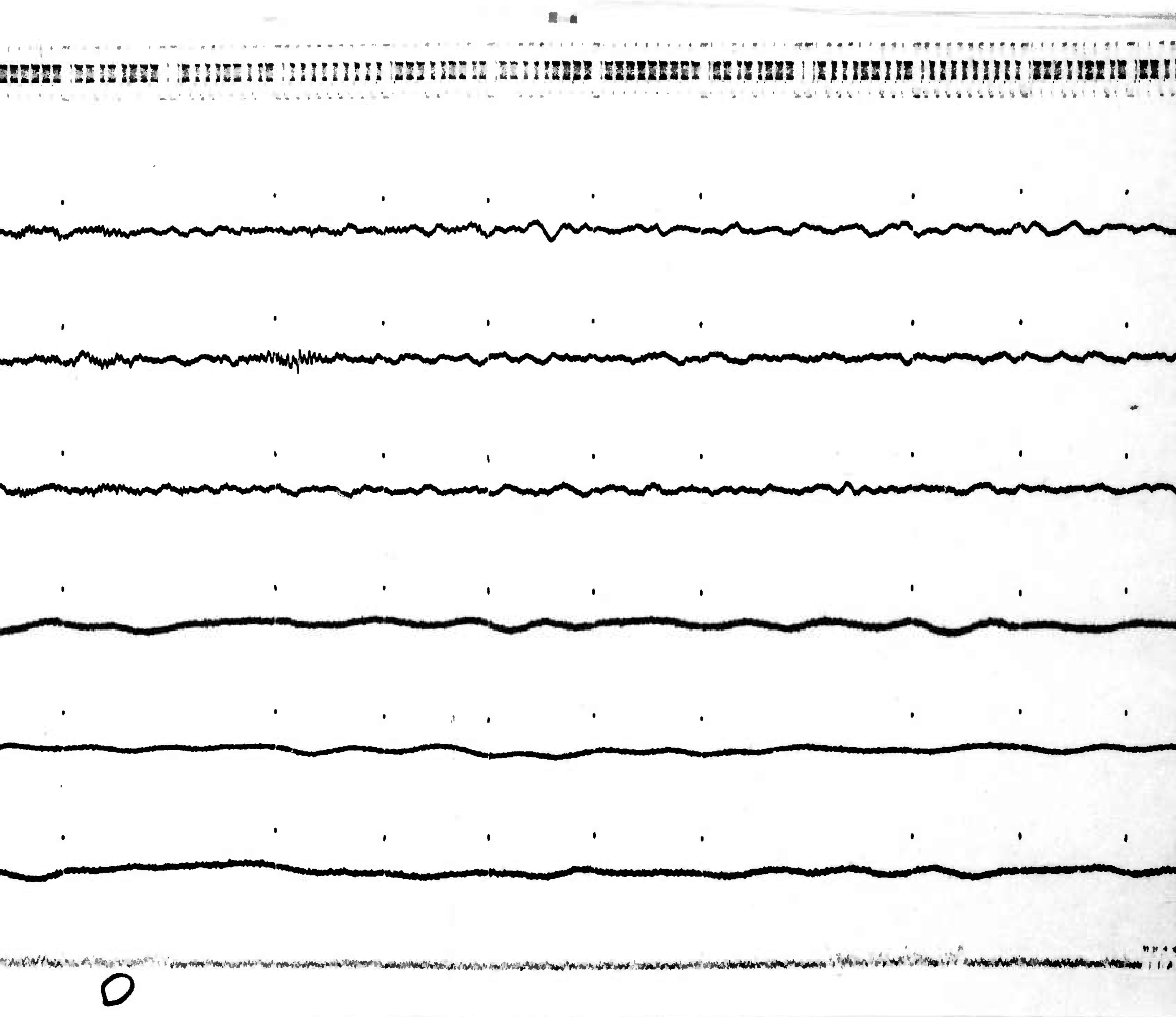

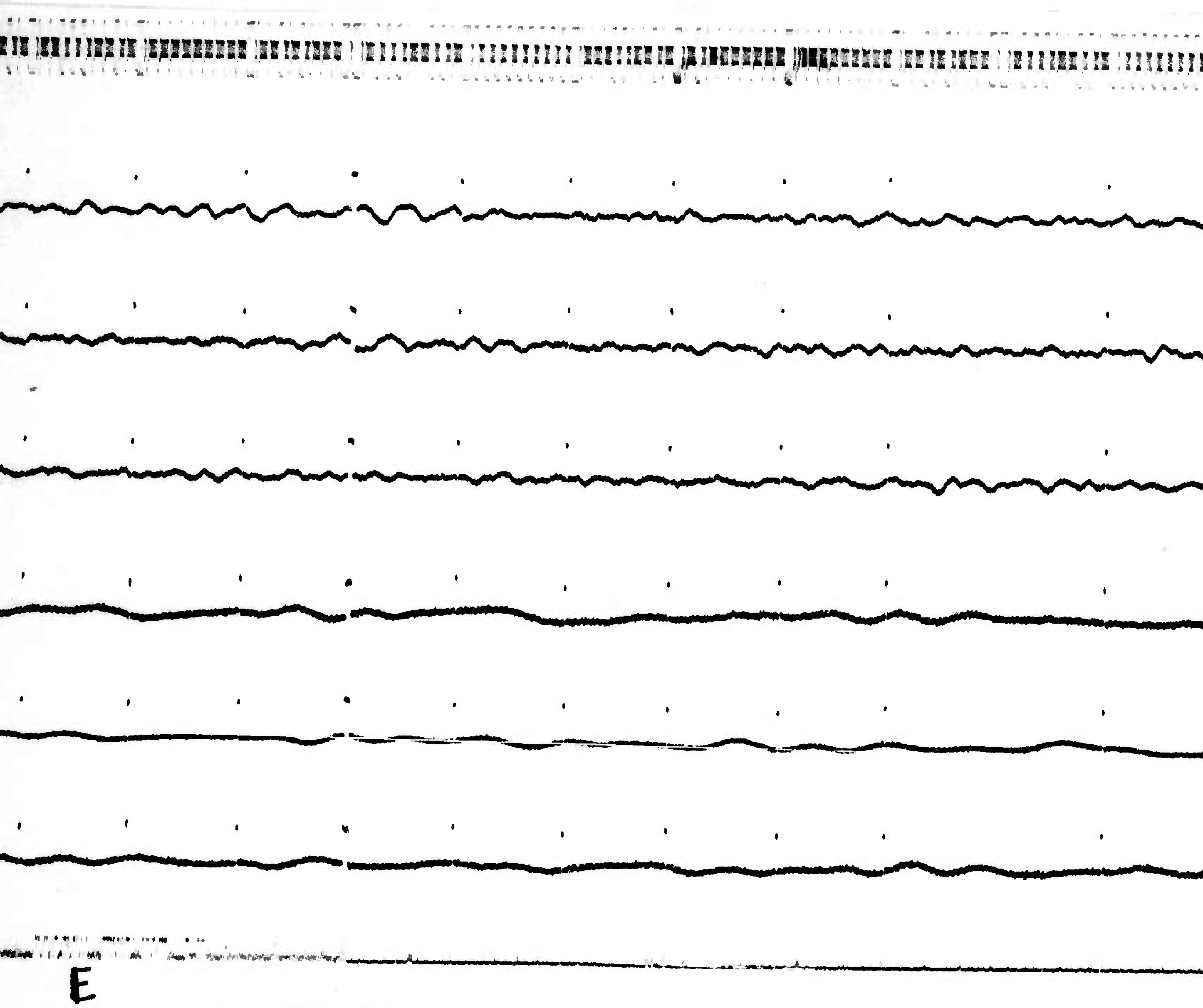

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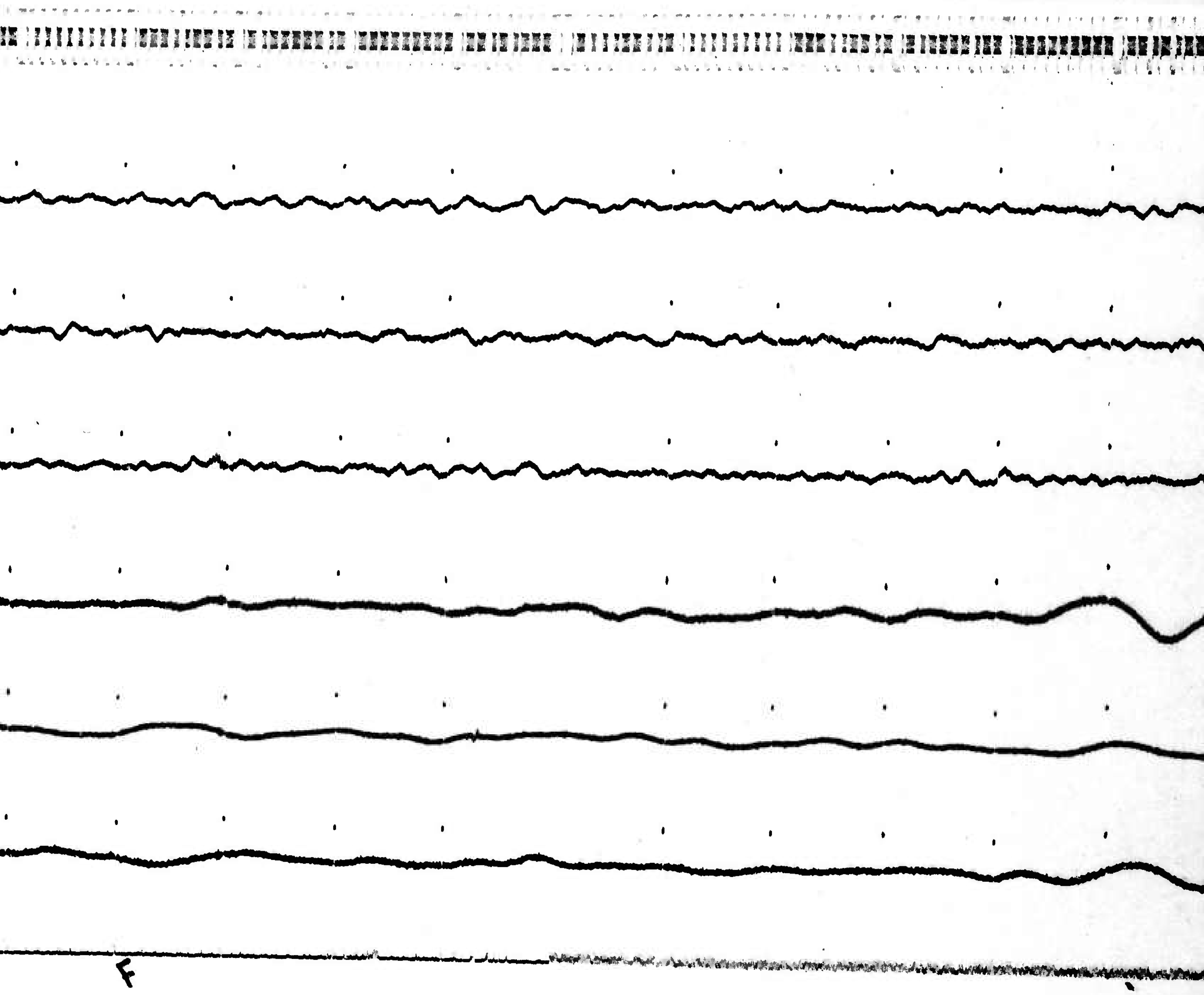
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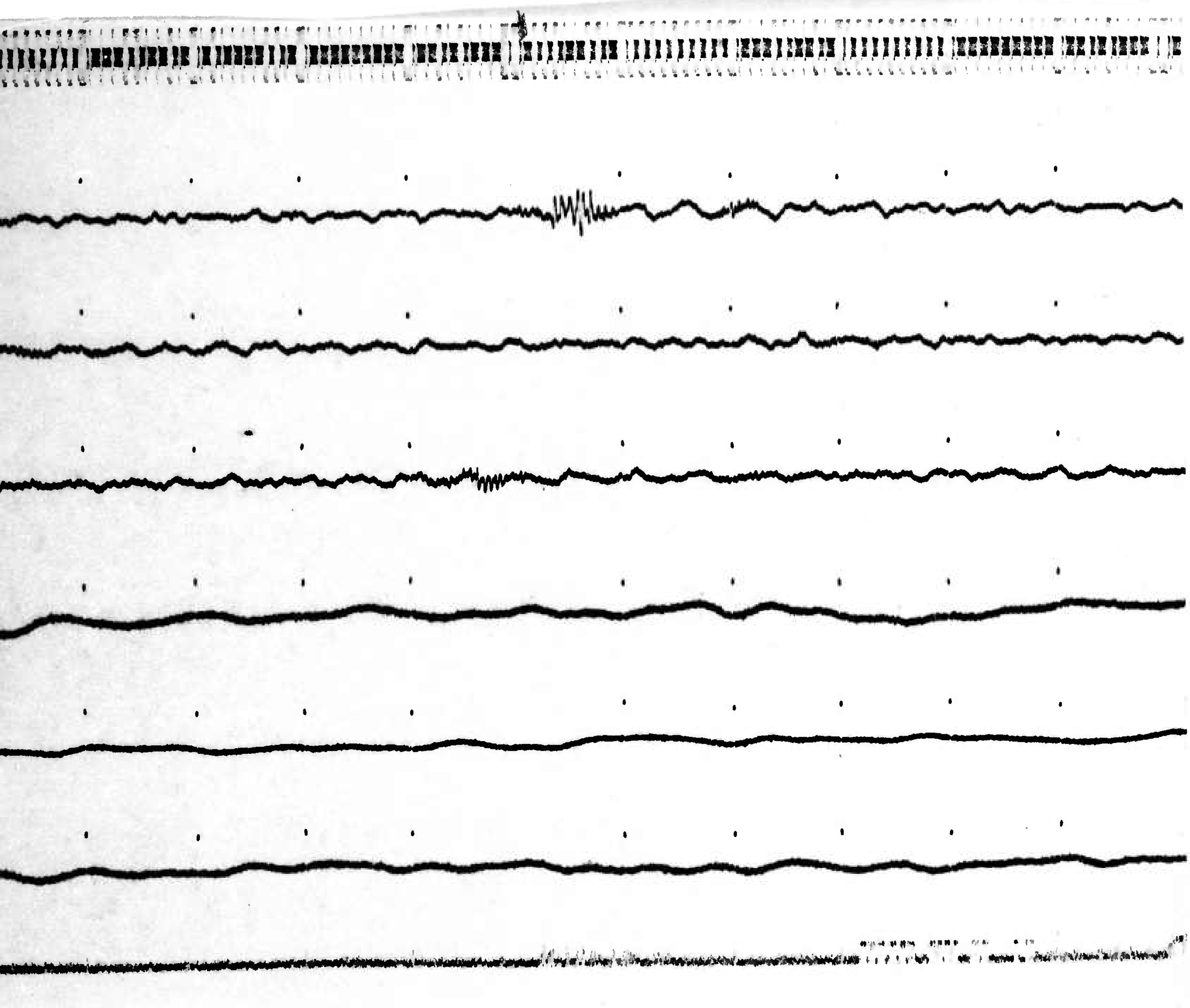

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
-----	Advanced Research Projects Agency Nuclear Test Detection Office Washington, D. C.

13. ABSTRACT

An analysis of seismological data from a Project PLOWSHARE underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions.

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Unclassified
Security Classification

Unclassified

Security Classification

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

Unclassified

Security Classification