LONG RANGE SEISMIC MEASUREMENTS

KLICKITAT

20 FEBRUARY 1964

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER

Washington, D. C.

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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

KLICKITAT

20 February 1964

SEISMIC DATA LABORATORY REPORT NO. 131

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Project Title:	Seismic Data Laboratory
ARPA Order No.:	624
ARPA Program Code No.:	5810
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KLICKITAT

EVENT DESCRIPTION

DATE: 20 February 1964

TIME OF ORIGIN: 15:30:00.1Z

YIELD:

MAGNITUDE: 4.95 ± 0.40

LOCATION:

Site: Nevada Test Site - Area U10e

Geographic Coordinates:

Lat: 37°09'03" N

Long: 116°02'24" W

ENVIRONMENT:

Geologic Medium:	Tuff
Surface Elevation:	4266 Feet
Shot Elevation:	2641 Feet
Shot Depth:	1625 Feet

COMPUTED EPICENTER: All Stations

Geographic Coordinates:

Lat: 37°08'46" N

Long: 116°07'05" W

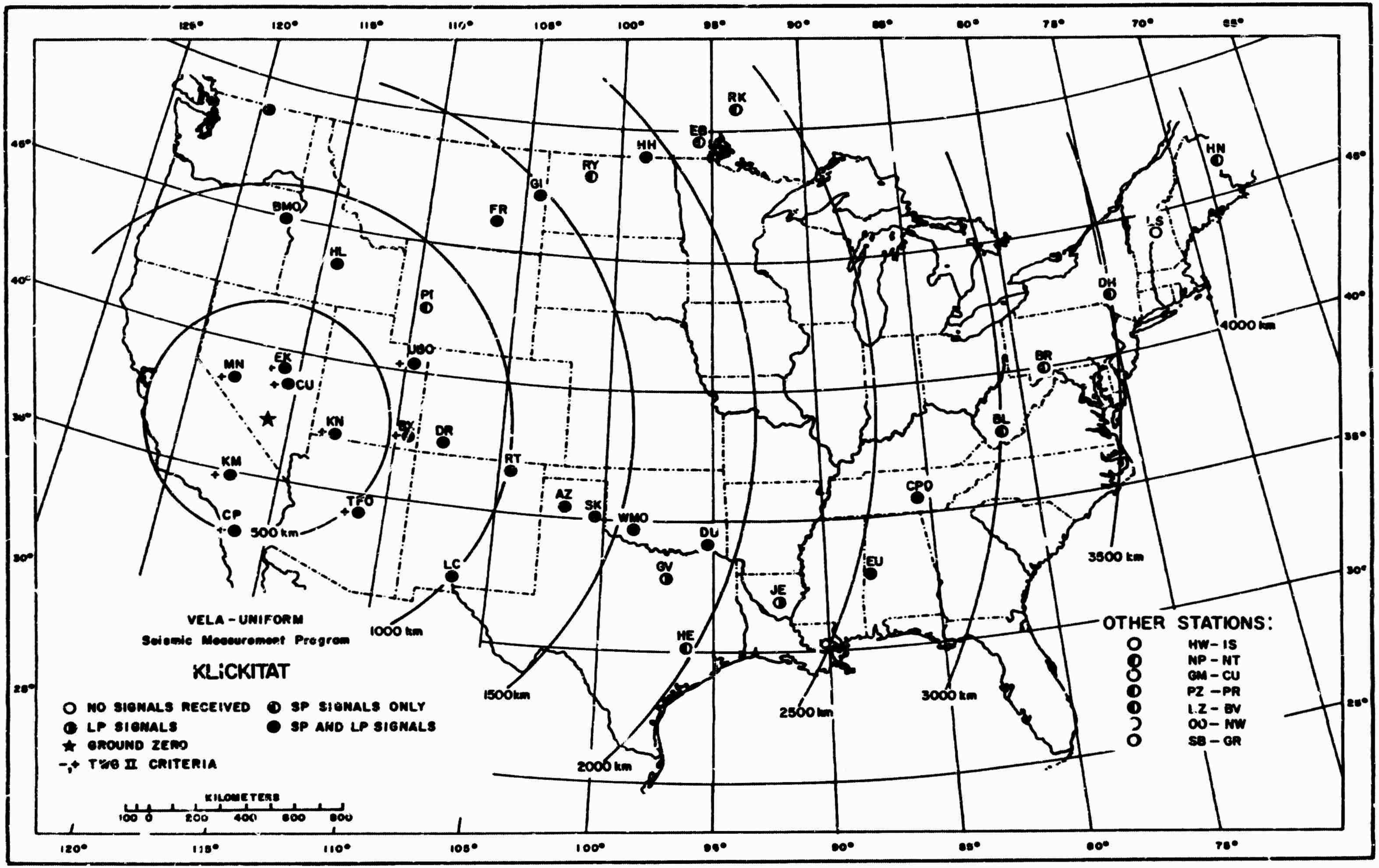
Time of Origin:	15:30:04.9Z
Depth:	41 Km
Epicenter Shift:	6.9 Km, N 266° E

Code	Station	Final SPZ	SPR	SPT	LPZ	LPR	LPT	Tape	Timing
CU-NV	Currant, Nevada	+	+	+	+	+	+	*	P
EK-NV	Eureka, Nevada	+	+	+	+	+	+	*	P
MN-NV	Mina, Nevada	+	+	+	+	+	+	*	P
KM-CL	Kramer, California	+	+	+	+	+	+	*	P
KN-UT	Kanab, Utah	+	+	+	+	+	+	*	P
CP-CL	Campo, California	+	+	+	+	+	+	*	P
TFSO	Tonto Forest Observatory, Arizona	+	+	+	+	+	+	*	P
BX-UT	Blanding, Utah	+	+	+	+	+	+	*	P
UBSO	Uinta Basin Observatory, Utah	+	+	+	+	+	+	*	P
DR-CO	Durango, Colorado	+	+	+	+	+	+	*	P
HL-ID	Hailey, Idaho	+	+	+	+	+	+	*	P
PI-WY	Pinedale, Wyoming	+	+	+	N	N	N	*	P
BMSO	Blue Mountain Observatory, Oregon	+	+	+	+	+	+	*	P
LC-NM	Las Cruces, New Mexico	+	+	+	+	+	I	*	S
RT-NM	Raton, New Mexico	+	+	+	+	+	+	*	P
FR-MA	Forsyth, Montana	+	+	+	+	+	+	*	P
AZ-TX	Amarillo, Texas	?	+	+	+	+	+	*	P
TK-WA	Tonasket, Washington	+	+	+	+	+	+	*	P
SK-TX	Shamrock, Texas	+	+	+	+	+	-	*	P
GI-MA	Glendive, Montana	+	+	+	+	+	-	*	P
WMSO	Wichita Mountain Observatory, Oklahoma	+	+	+	+	+	+	*	P
RY-ND	Ryder, North Dakota	+	+	+	-	-	-	*	P
GV-TX	Grapevine, Texas	-	-	-	+	N	N	*	P
DU-OK	Durant, Oklahoma	+	+	+	+	+	-	*	P
HH-ND	Hannah, North Dakota	+	+	+	+	+	-	*	P
HE-TX	Hempstead, Texas	+	+	-	N	N	N	*	S
EB-MT	East Braintree, Manitoba, Canada	+	+	+	-	-	-	*	P
JE-LA	Jena, Louisiana	-	-	-	+	-	-	*	P
RK-ON	Red Lake, Ontario, Canada	+	+	+	I	-	-	*	P
EU-AL	Eutaw, Alabama	-	-	+	+	-	-	*	S
CPSO	Cumberland Plateau Observatory, Tennessee	+	+	+	+	+	+	*	P
BL-WV	Beckley, West Virginia	+	-	-	-	-	-	*	P
BR-PA	Berlin, Pennsylvania	+	+	+	-	-	-	*	P
DH-NY	Delhi, New York	+	-	-	-	-	-	*	P
LS-NH	Lisbon, New Hampshire	-	-	-	-	-	-	*	P
HN-ME	Houlton, Maine	+	-	-	-	-	-	*	P
HW-IS	Kamuela, Hawaii	-	-	-	-	-	-	*	P
NP-NT	Mould Bay, Northwest Territories, Canada	+	-	-	-	-	-	*	P
GM-CU	Guantanamo, Cuba	-	-	-	-	-	-	*	P
PZ-PR	Ponce, Puerto Rico	+	-	-	-	-	-	*	P
LZ-BV	La Paz, Bolivia	+	-	-	-	-	-	*	P
OO-NW	Oslo, Norway	-	-	-	-	-	-	*	P
SB-GR	Grafenberg, Germany	-	-	-	-	-	-	*	P

I Inoperative
N No Instruments
P Primary Timing
S Secondary Timing
? Questionable Signal
+ Signal
- No Signal
* Magnetic Tape Available

Station Status Report - KLICKITAT

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 KLICKITAT 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 KLICKITAT is included in Table 1, placed opposite the operations map, Figure 1. This report gives the names of 43 stations and indicates which instruments were operational and which recorded usable signals.

An explanation of the procedure for amplitude measurements used in this report is illustrated in Appendix II. 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).

Appendix III quotes the Technical Working Group II (TWG II) first motion criteria, and includes diagrams illustrating the elements involved in determining a compression or rarefaction where satisfactory measurements can be made.

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 h: local velocity deviations. Since the method is based on P wave arrivals, this particular program does not

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

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.

Data and Results

Table 2 summarizes the measurements made of the principal phases from the KLICKITAT 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/T) of the Lg phase as measured on the short-period horizontal tangential component. Long-period Love and Rayleigh wave motion are also tabulated in (A/T) form. Thirty-five stations recorded short-period signals. Long-period signals from this event were recorded by twenty-six stations.

In addition, Table 2 and Figure 2 show the unified magnitudes (m) where measurable. The average magnitude for KLICKITAT is 4.95. PZ-PR with an anomalies magnitude of 6.12 is not included in this average nor in Figure 2 for $\Delta > 16^{\circ}$. Nine stations show compressional first motion as defined by the First Motion Criteria (TWG II).

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. Love and Rayleigh wave amplitudes are shown in Figures 7 and 8.

Attached to the report are illustrative seismograms showing the signals recorded at a number of locations. The most distant station analyzed that recorded KLICKITAT was LZ-BV at a distance of 7725 kilometers.

Principal Phases
KLICKITAT
20 February 1964
15:30:00.1Z

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	TWG II First Motion	Magnitude (m)
CU-NV	Currant, Nevada	177	SPZ	1.08	Pn	0	28.7	0.8	1225	C	
			SPZ	1.08	e	0	29.9	0.5	2933		
			SPZ	1.08	Pg	0	30.7	0.5	6704		
			SPT	1.08	Lg			0.6	8374		
			LPT	22.0	LQ			10.0	567		
			LPZ	21.5	LR			16.0	192		
EK-NV	Eureka, Nevada	230	SPZ	2.75	Pn	0	36.0	0.55	567	C	4.99
			SPZ	2.75	e	0	36.7	0.4	627		
			SPZ	2.75	Pg	0	38.6	0.4	4014		
			SPZ	2.75	e	0	42.5	0.6	4550		
			SPT	2.46	Lg			0.7	10,700		
			LPT	31.2	LQ			12.0	406		
			LPZ	3.27	LR			12.0	346		
MN-NV	Mina, Nevada	234	SPZ	3.70	Pn	0	36.3	0.5	1786	C	5.50
			SPZ	3.70	Pg		---	---	---		
			SPT	3.50	Lg			0.8	6,510		
			LPT	26.8	LQ			10.0	528		
			LPZ	2.59	LR			14.0	396		
KM-CL	Kramer, California	275	SPZ	4.44	Pn	0	41.4	0.6	615	C	5.25
			SPZ	4.44	e	0	43.3	0.5	693		
			SPZ	4.44	Pg	0	46.8	0.8	1966		
			SPT	9.33	Lg			0.8	4490		
			LPT	12.7	LQ			13.0	277		
			LPZ	15.4	LR			14.0	209		
KN-UT	Kanab, Utah	286	SPZ	5.65	Pn	0	42.9	0.6	635	C	5.28
			SPZ	5.65	e	0	43.6	0.5	865		
			SPZ	5.65	Pg	0	47.2	0.6	5923		
			SPT	5.16	Lg			0.6	6585		
			LPT	34.6	LQ			13.0	242		
			LPZ	34.0	LR			14.0	219		
CP-CL	Campo, California	491	SPZ	9.64	Pn	1	08.3	0.4	43.6		4.86
			SPZ	9.64	e	1	09.1	0.6	337		
			SPZ	9.64	Pg	1	19.9	0.5	514		
			SPT	12.95	Lg			0.8	390		
			LPT	10.03	LQ			13.0	95.7		
			LPZ	1.05	LR			11.0	360		
TFSO	Tonto Forest Observatory, Arizona	536	SPZ-74	157.5	Pn	1	14.9	0.45	20.4	C	4.66
			SPZ-1	38.0	e	1	24.3	0.5	592		
			SPZ-1	38.0	Pg	1	29.9	0.7	446		
			SPN	31.5	Lg			1.2	477		
			LPZ	2.9	LR			17.0	105		
BX-UT	Blanding, Utah	587	SPZ	16.85	Pn	1	20.3	0.4	[illegible]	C	5.79
			SPZ	16.85	e	1	21.6	0.4	[illegible]		
			SPZ	16.85	Pg	1	36.9	0.5	1429		
			SPT	16.4	Lg			0.6	1449		
			LPT	4.6[illegible]	LQ			13.0	138		
			LPZ	5.1	LR			13.0	168		
UBSO	Uinta Basin Observatory, Utah	664	SPZ-10	10.2	Pn	1	33.4	(0.6)	(45.4)	C	(5.25)
			SPZ-10	10.2	e	1	34.3	0.6	250		
			SPZ-10	10.2	Pg	1	50.9	0.7	437		
			SPE	10.8	Lg			1.2	438		
			LPZ	23.5	LR			12.0	105		
DR-CO	Durango, Colorado	732	SPZ	39.5	Pn	1	38.1	0.6	13.0		4.83
			SPZ	39.5	e	1	40.5	0.5	43.5		
			SPZ	39.5	Pg	1	59.9	0.6	415		
			SPT	37.0	Lg			0.8	415		
			LPT	20.0	LQ			(17.0)	(42.5)		
			LPZ	20.9	LR			14.0	88.1		
HL-ID	Hailey, Idaho	737	SPZ	41.5	Pn	1	39.6	0.8	8.86		4.68
			SPZ	41.5	e	1	42.5	0.6	28.8		
			SPZ	41.5	Pg	2	00.9	0.4	431		
			SPT	40.4	Lg			0.5	309		
			LPT	20.7	LQ			13.0	108		
			LPZ	22.8	LR			12.0	177		
PI-WY	Pinedale, Wyoming	809	SPZ	64.5	Pn	1	50.4	0.6	47.7	C	5.54
			SPZ	64.5	e	1	51.9	0.9	160		
			SPZ	64.5	Pg	2	13.1	0.8	254		
			SPT	52.7	Lg			(1.0)	(716)		
BMSO	Blue Mountain Observatory, Oregon	862	SPZ-3	28.8	Pn	1	57.1	0.6	10.1		4.95
			SPZ-3	28.8	e	1	59.4	0.9	28.9		
			SPZ-3	28.8	e	2	06.9	0.6	129		
			SPZ-3	28.8	Pg	2	(23.9)	(0.8)	(111)		
			SPE	38.1	Lg			1.0	236		
			LPE	6.8	LQ			13.5	102		
			LPZ	31.0	LR			15.0	82.7		

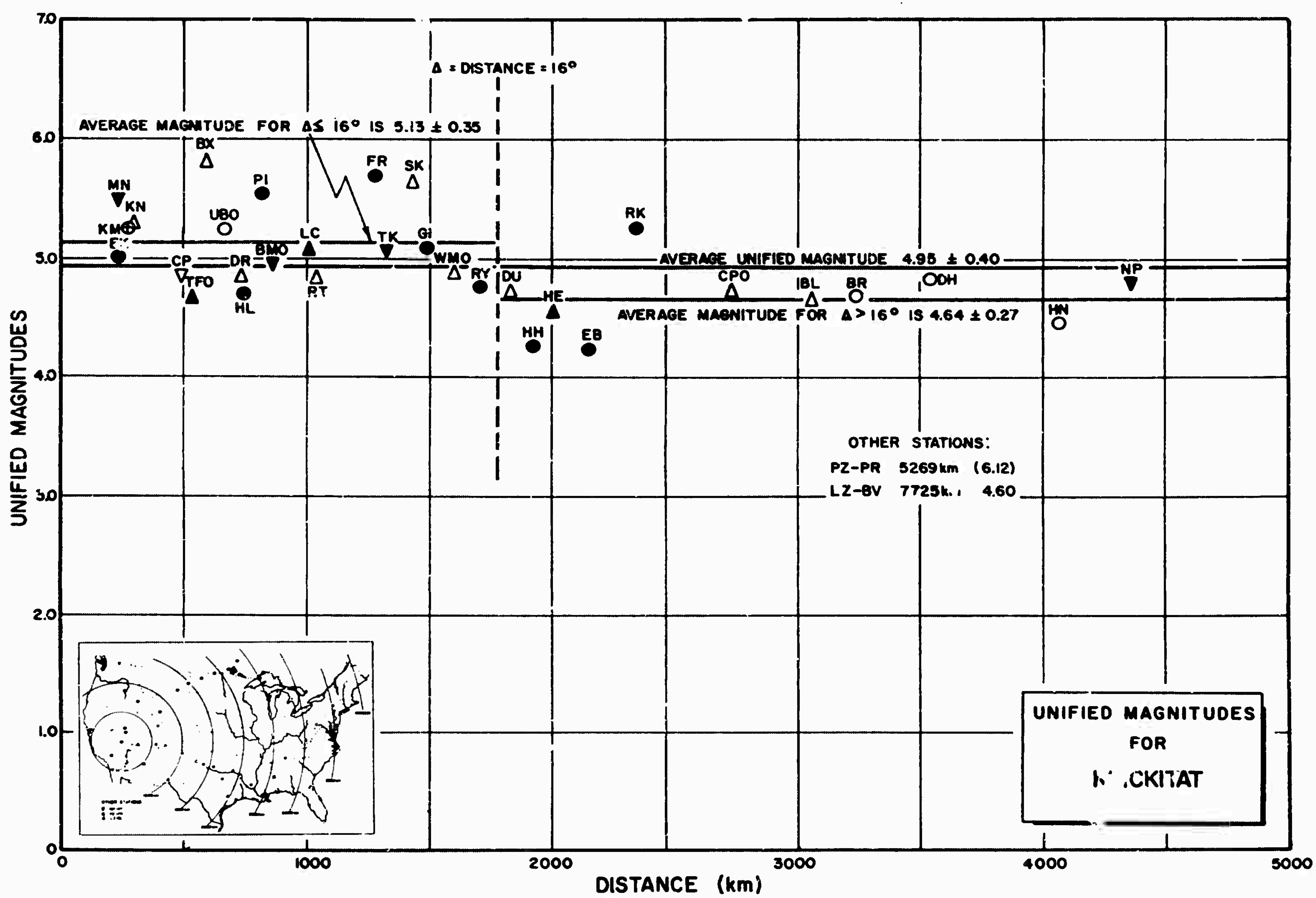
Principal Phases
KLICKITAT
20 February 1964
15:30:00.16

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	TMG II First Motion	Magnitude (m)
LC-NM	Las Cruces, New Mexico	1011	SPZ	105.5	Pn	2	17.6	1.0	7.09		5.06
			SPE	105.5	Pg	2	48.4	1.0	151		
			SPT	104.5	Lg			1.1	147		
			LPZ	32.6	LR			13.0	182		
RT-NM	Raton, New Mexico	1041	SPZ	132	(Pn)	2	16.2	0.6	(3.90)		(4.82)
			SPE	132	e	2	24.8	(1.0)	(13.3)		
			SPZ	132	e	2	43.5	.6	25.0		
			SPE	132	Pg	2	(54.8)	.6	96.0		
			SPT	130	Lg			1.3	300		
			LPZ	17.2	LR			13.0	74.4		
FR-MA	Forsyth, Montana	1275	SPZ	131.9	P	3	45.6	0.8	34.8		5.69
			SPT	118.4	Lg			1.1	99		
			LPZ	20.3	LR			13.0	74.5		
AZ-TX	Amarillo, Texas	1281	SPT	37.6	Lg			(1.2)	(229)		
			LPZ	17.8	LR			17.0	35.4		
TK-WA	Tonasket, Washington	1326	SPZ	229.4	P	2	54.2	0.8	9.20		5.07
			SPE	229.4	e	3	45.0	(1.0)	(14.2)		
			SPT	226.	Lg			1.3	52.6		
			LPZ	37.7	LR			14.0	58.7		
SK-TX	Shamrock, Texas	1428	SPZ	156	P	3	(06.7)	(1.0)	(40.7)		(5.63)
			SPZ	156	Pg	3	58.9	(1.0)	(84.9)		
			SPT	140	Lg			(1.4)	(189)		
			LPZ	14.8	LR			17.0	28.4		
GI-MA	Glendive, Montana	1480	SPZ	108	P	3	10.1	0.8	16.3		5.09
			SPZ	108	a	3	21.5	0.8	27.2		
			SPT	110	Lg			1.0	(84.1)		
			LPZ	8.03	LR			13.	45.6		
WMSO	Wichita Mountain Observatory, Oklahoma	1595	SPZ-6	150	P	3	(26.7)	1.2	23.2		4.86
			SPZ-6	150	a	3	34.9	(1.2)	(15.4)		
			SPZ-6	150	Pg	4	(43.9)	1.1	52.6		
			SPN	160	Lg			1.5	(154)		
			LPN	22	LQ			16.0	42.5		
			LPZ	17.5	LR			16.0	43.2		
RY-ND	Ryder, North Dakota	1699	SPZ	30.2	P	3	(38.6)	(0.8)	(1[illegible].3)		(4.75)
			SPZ	30.2	e	3	44.2	0.8	158		
GV-TX	Grapevine, Texas	1796	LPZ	16.55	LR			14.0	66.9		
DU-OK	Durant, Oklahoma	1826	SPZ	106	P	3	53.0	(1.0)	(64.8)		(4.71)
			SPZ	106	a	4	13.3	(0.6)	(24.2)		
			SPT	106	Lg			(1.2)	(156)		
			LPZ	7.0	LR			13.0	39.5		
HN-ND	Hannah, North Dakota	1920	SPZ	33.4	P	4	02.9	(1.0)	(22.5)		(4.25)
			SPZ	33.4	a	4	05.0	1.1	202		
			SPT	31.0	(Lg)			(1.6)	(188)		
			LPZ	11.3	LR			10.0	116		
HE-TX	Hempstead, Texas	1999	SPZ	52.7	P	4	13.4	1.0	43.4		4.54
EB-MT	East Braintree, Manitoba, Canada	[illegible]147	SPZ	216	P	4	26.9	0.85	16.6		4.23
			SPT	193	Lg			1.5	36..		
JE-LA	Jena, Louisiana	2279	LPZ	9.92	LR			12.0	143		
RK-ON	Red Lake, Ontario, Canada	2337	SPZ	201	P	4	45.3	0.95	141		5.25
			SPZ	201	a	4	52.9	0.8	302		
			SPT	189	Lg			(1.6)	(71.2)		
EU-AL	Eutaw, Alabama	2607	SPT	73.3	Lg			2.0	176		
			LPZ	8.15	LR			13.0	78.5		
CPSO	Cumberland Plateau Observatory, Tennessee	2728	SPZ-8	310	P	5	21.8	0.7	20.2		4.72
			SPN	330	Lg			1.7	76		
			LPN	11.0	LQ			17.0	17.6		
			LPZ	10.0	LR			14.0	42.9		
BL-WV	Beckley, West Virginia	3056	SPZ	58.1	P	5	48.3	0.8	12.6		4.65
BR-PA	Berlin, Pennsylvania	3235	SPZ	137.5	P	6	(02.7)	0.8	12.0		4.68
			SPT	121.3	Lg			2.0	93.2		
DH-NY	Delhi, New York	3541	SPZ	51.7	P	6	26.5	0.7	13.3		4.82
			SPZ	51.7	e	6	45.7	0.9	12.2		
HN-ME	Houlton, Maine	4062	SPE	133	P	7	(10.1)	0.75	7.90		4.45
MP-NT	Mould Bay, Northwest Territories, Canada	4362	SPZ	284	P	7	31.2	0.9	25.2		4.60
			SPZ	184	e	7	33.0	1.0	19.4		
PZ-PR	Ponce, Puerto Rico	52[illegible]9	SPZ	15.3	P	6	(37.9)	(0.6)	(166)		(6.12)
LZ-BV	La Paz, Bolivia	7725	SPZ-1	181	P	11	11.2	0.7	4.45		4.60

A/T mu/sec
C Compressional
( ) Doubtful Values or Phases
--- Signal not Measurable because of Excessive Amplitude or Amplitude Clipping

Principal Phases - KLICKITAT

Table 2 - Page 2



UNIFIED MAGNITUDES
DISTANCE (km)
AVERAGE MAGNITUDE FOR Δ≤ 16° IS 5.13 ± 0.35
Δ = DISTANCE = 16°
AVERAGE UNIFIED MAGNITUDE 4.95 ± 0.40
AVERAGE MAGNITUDE FOR Δ > 16° IS 4.64 ± 0.27
OTHER STATIONS:
PZ-PR 5269km (6.12)
LZ-BV 7725k. 4.60
UNIFIED MAGNITUDES
FOR
MN
KN
KMO
CP
TFO
BX
UBO
PI
DR
HL
BMO
LC
RT
FR
TK
SK
GI
WMO
RY
DU
HH
HE
EB
RK
CPO
IBL
BR
DH
HN
NP

Figure 2

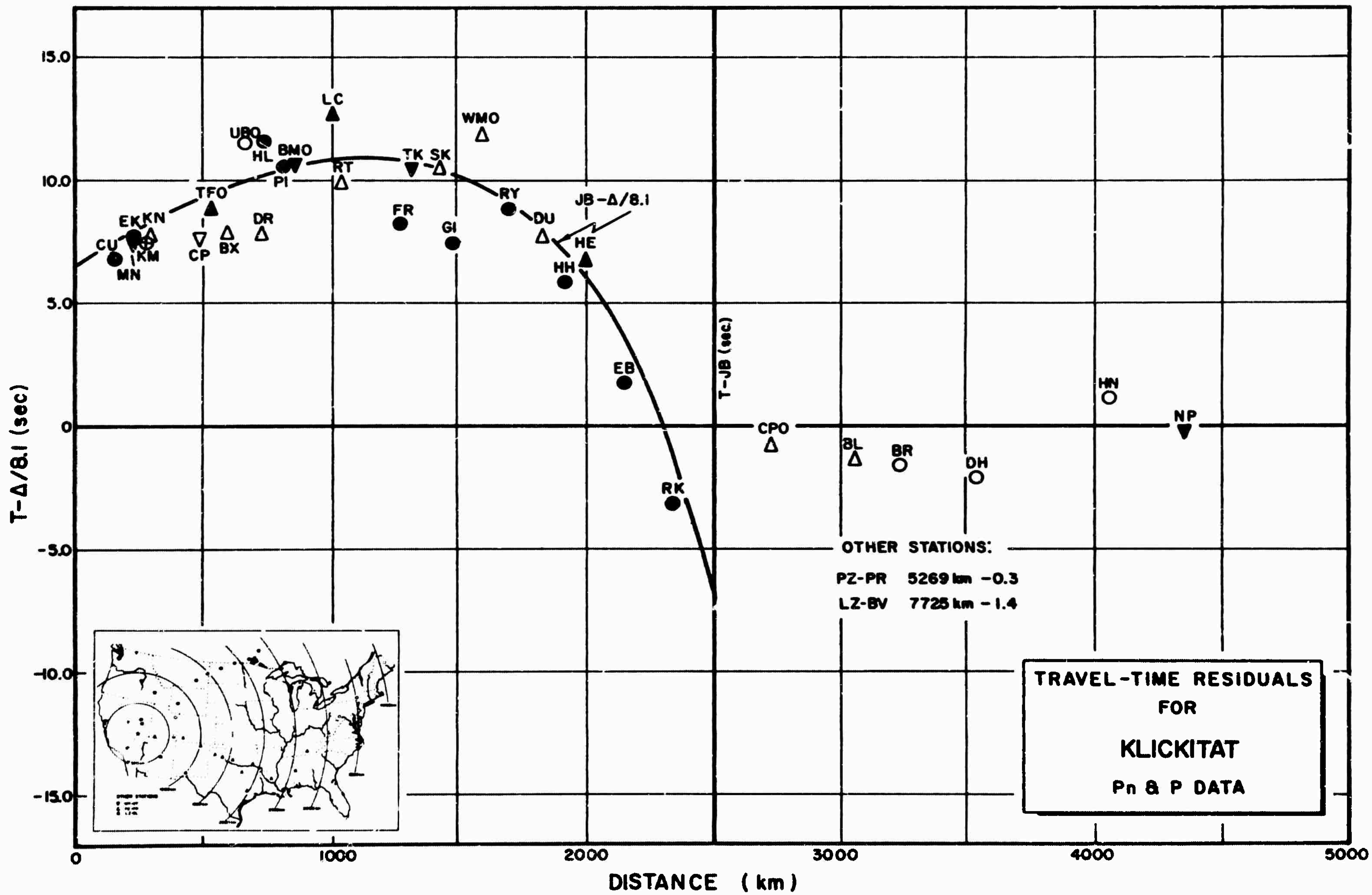
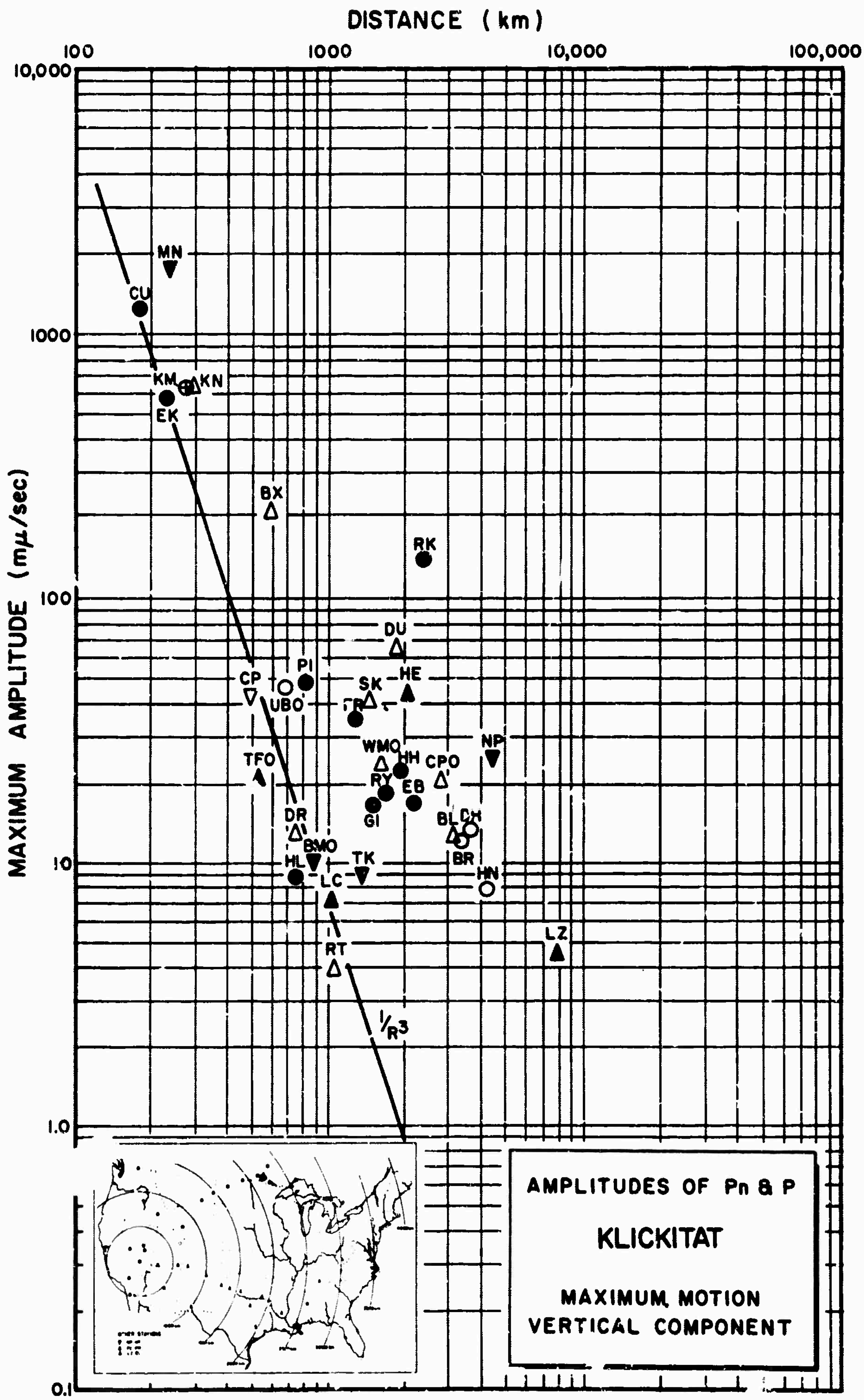

TRAVEL-TIME RESIDUALS
FOR
KLICKITAT
Pn & P DATA
OTHER STATIONS:
PZ-PR 5269 km -0.3
LZ-BV 7725 km -1.4
T-Δ/8.1 (sec)
DISTANCE (km)
T-JB (sec)
JB-Δ/8.1
15.0
10.0
5.0
0
-5.0
-10.0
-15.0
1000
2000
3000
4000
5000
CU
MN
EK
KN
KM
TFO
CP
BX
DR
UBO
HL
BMO
PI
LC
RT
FR
TK
SK
GI
WMO
RY
DU
HE
HH
EB
RK
CPO
BL
BR
DH
HN
NP

Figure 3


DISTANCE (km)
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1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
MN
CU
KM
KN
EK
BX
RK
DU
PI
CP
UBO
SK
HE
FR
WMO
NP
TFO
HH
CPO
RY
EB
GI
DR
BL
CH
BR
BMO
TK
HL
LC
HN
LZ
RT
1/R3
AMPLITUDES OF Pn & P
KLICKITAT
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 4

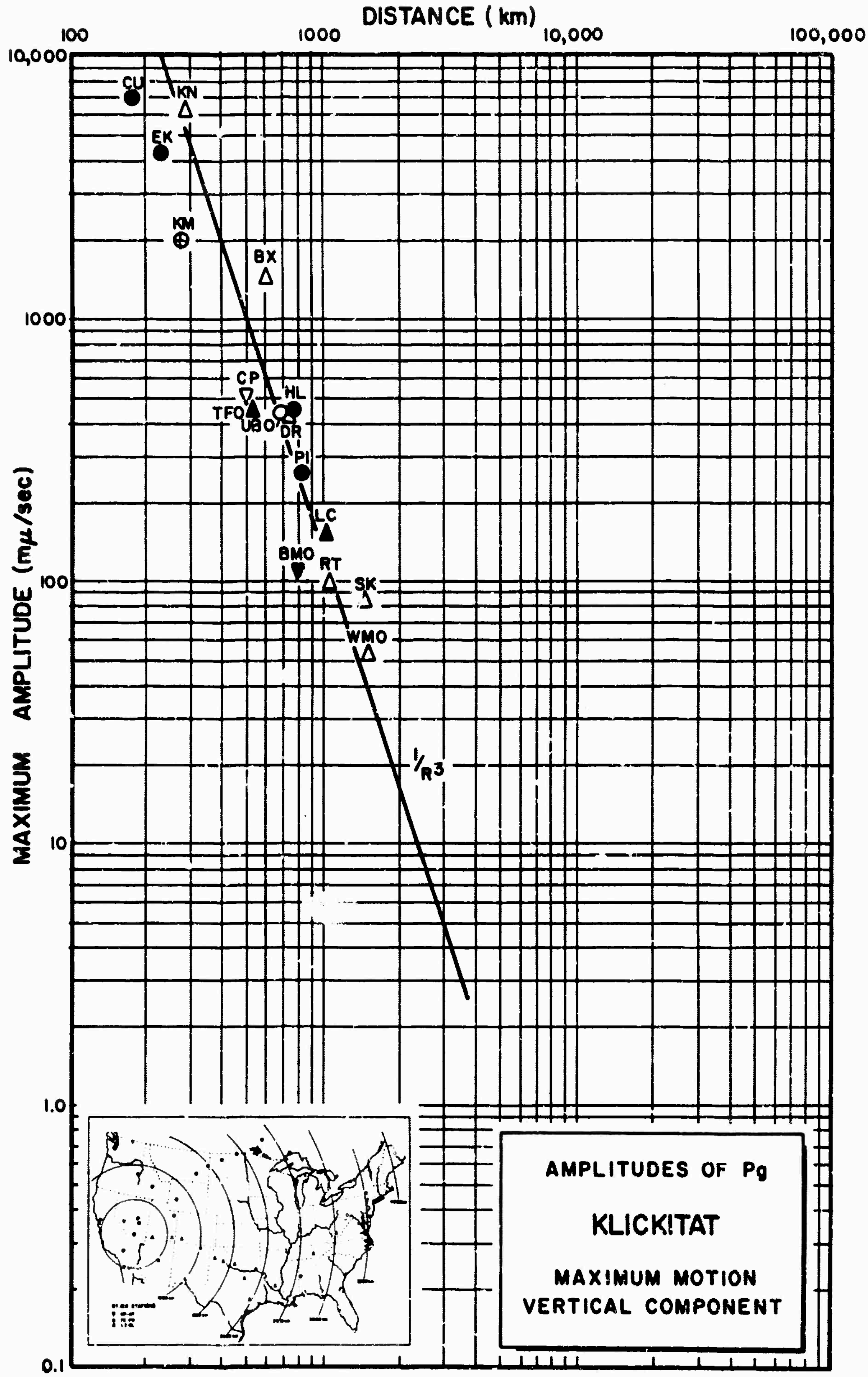
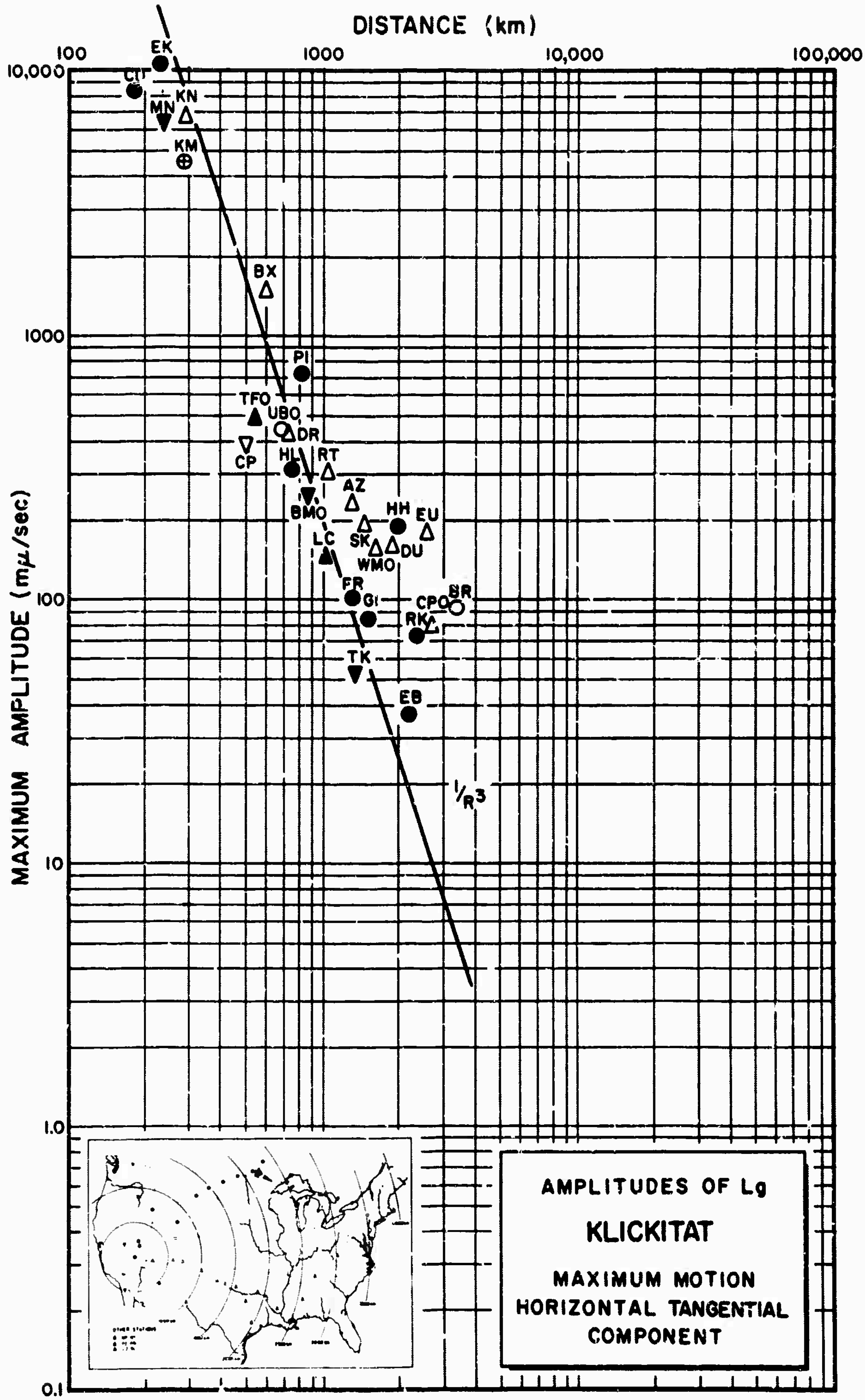

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
CU
KN
EK
KM
BX
CP
HL
TFO
UBO
DR
PI
LC
BMO
RT
SK
WMO
1/R3
AMPLITUDES OF Pg
KLICKITAT
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 5


DISTANCE (km)
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1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
EK
CIT
KN
MN
KM
BX
PI
TFO
UBO
DR
CP
HL
RT
AZ
BMO
HH
EU
LC
SK
DU
WMO
FR
GI
CPO
BR
RK
TK
EB
1/R3
AMPLITUDES OF Lg
KLICKITAT
MAXIMUM MOTION
HORIZONTAL TANGENTIAL
COMPONENT

Figure 6

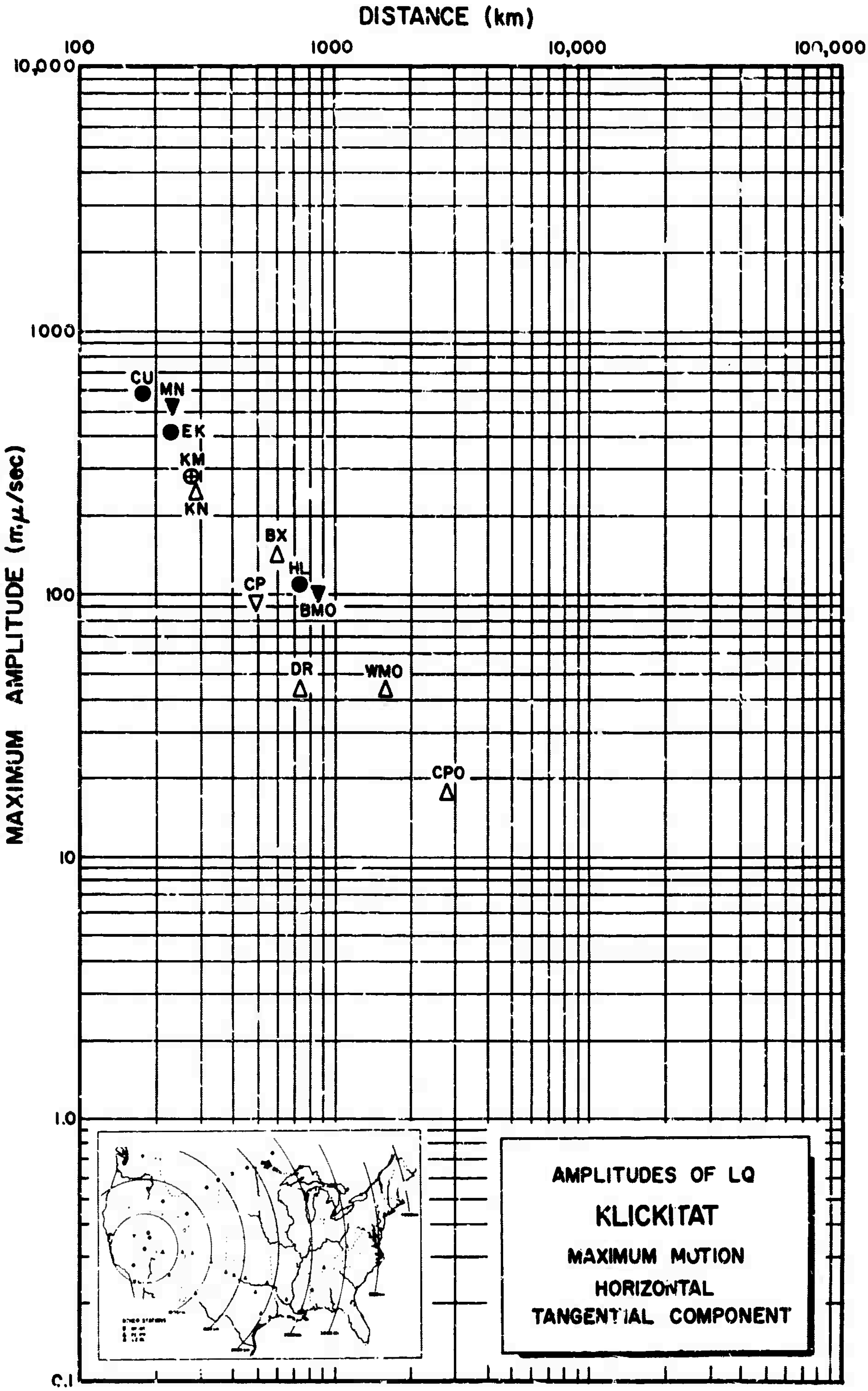

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
CU
MN
EK
KM
KN
BX
HL
CP
BMO
DR
WMO
CPO
AMPLITUDES OF LQ
KLICKITAT
MAXIMUM MOTION
HORIZONTAL
TANGENTIAL COMPONENT

Figure 7

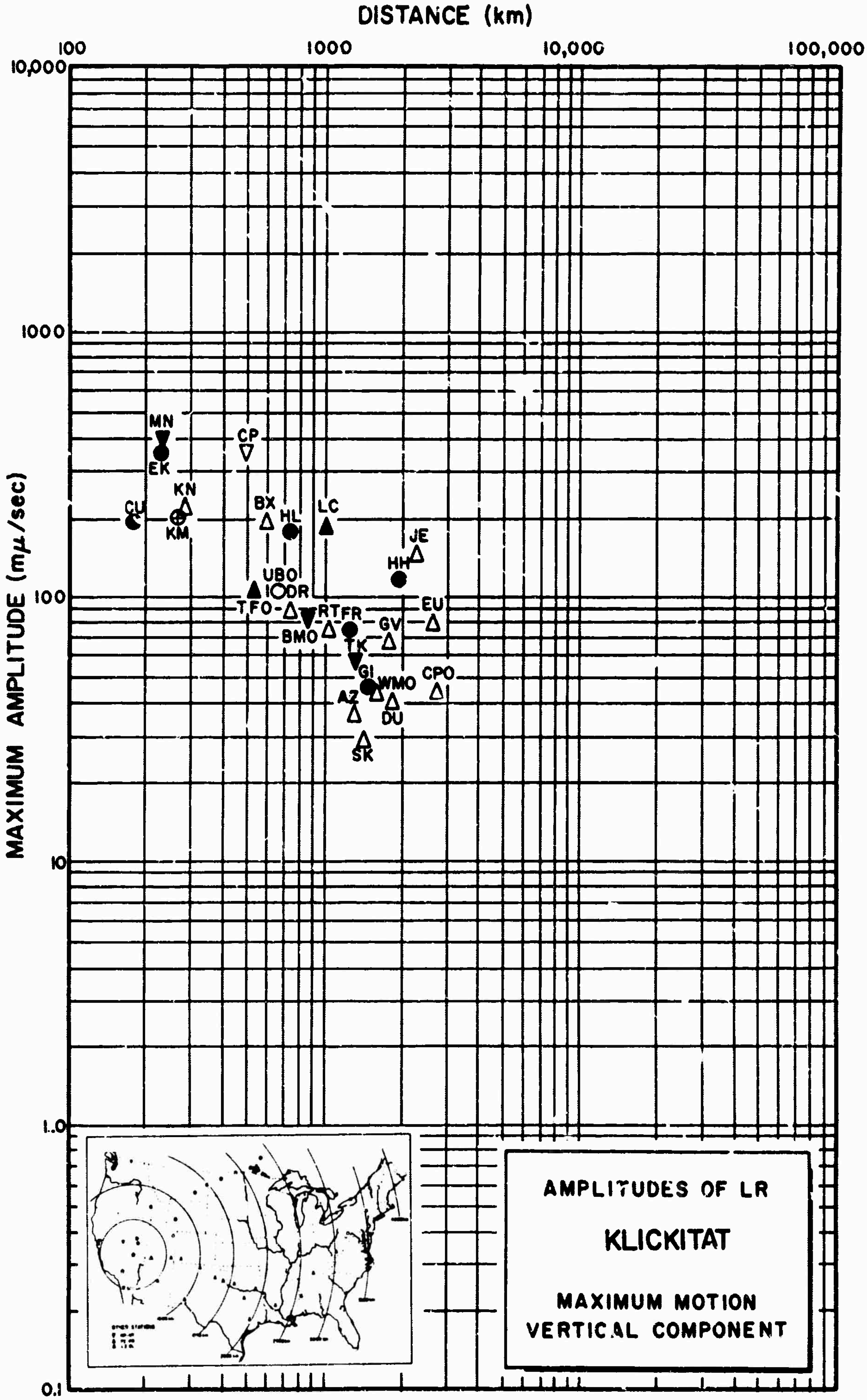

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
MN
EK
CP
KN
CU
KM
BX
HL
LC
JE
HH
UBO
DR
TFO
RT
FR
BMO
EU
GV
TK
GI
WMO
CPO
AZ
DU
SK
AMPLITUDES OF LR
KLICKITAT
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 8

Code	Station	Distance (km)	Geographic Latitude	Geographic Longitude	Elev. (km)	Computed Azimuth Epi.-Sta.	Computed Azimuth Sta.-Epi.	Installed Azimuth Radial	Installed Azimuth Tang.	Large or Small SP	LP Inst.
[illegible]J-NV	[illegible]t, Nevada	177	38°40'38" N	115°27'18" W	1.646	17°	197°	22°	112°	S	X
EK-NV	Eureka, Nevada	230	39°12'32" N	115°42'37" W	1.951	7°	187°	11°	101°	L	X
MN-NV	Mina, Nevada	234	38°26'10" N	118°08'53" W	1.524	308°	127°	308°	38°	L	X
KM-CL	Kramer, California	275	34°52'52" N	117°15'24" W	0.850	204°	23°	200°	290°	L	X
KN-UT	Kanab, Utah	286	37°01'22" N	112°49'39" W	1.737	92°	274°	95°	185°	L	X
CP-CL	Campo, California	491	32°43'44" N	116°22'16" W	1.189	184°	3°	182°	272°	L	X
TFSO 21	Tonto Forest Observatory, Arizona	536	34°17'12" N	111°16'03" W	1.492	125°	308°	90°	0°	JM	X
BX-UT	Blanding, Utah	587	37°33'48" N	109°26'05" W	1.707	84°	268°	88°	178°	L	X
UBSO Z10	Uinta Basin Observatory, Utah	664	40°19'18" N	109°34'07" W	1.60[illegible]	56°	240°	90°	0°	JM	X
DR-CO	Durango, Colorado	732	37°27'53" N	107°47'00" W	2.225	85°	270°	107°	197°	L	X
HL-ID	Hailey, Idaho	737	43°38'50" N	11[illegible]°15'02" W	1.890	11°	192°	14°	104°	L	X
PI-WY	Pinedale, Wyoming	809	42°27'10" N	109°32'55" W	2.170	41°	225°	46°	136°	S	-
BMSO 23	Blue Mountain Observatory, Oregon	862	44°50'56" N	117°18'20" W	1.189	353°	172°	0°	90°	JM	X
LC-NM	Las Cruces, New Mexico	1011	32°24'08" N	106°35'58" W	1.585	119°	304°	124°	214°	L	LPZ-LPR
RT-NM	Raton, New Mexico	1041	36°43'[illegible]6" N	104°21'37" W	1.951	89°	276°	96°	186°	S	X
FR-MA	Forsyth, Montana	1275	46°06'00" N	106°26'25" W	0.820	36°	222°	43°	133°	S	X
AZ-TX	Amarillo, Texas	1281	35°25'48" N	101°55'50" W	0.988	94°	283°	103°	193°	L	X
TK-WA	Tonasket, Washington	1326	48°47'38" N	119°35'16" W	0.549	349°	166°	347°	77°	L	X
SK-TX	Shamrock, Texas	1428	35°04'58" N	100°21'50" W	0.671	95°	284°	104°	194°	L	X
GI-MA	Glendive, Montana	1480	47°11'34" N	104°13'10" W	0.732	37°	225°	46°	136°	S	X
WMSO Z6	Wichita Mountain Observatory, Oklahoma	1595	34°43'05" N	98°35'21" W	0.505	95°	285°	90°	0°	JM	X
RY-ND	Ryder, North Dakota	1699	48°05'50" N	101°29'40" W	0.640	40°	230°	50°	140°	S	X
GV-TX	Grapevine, Texas	1798	32°53'09" N	96°59'54" W	0.150	100°	291°	111°	201°	L	LPZ
DU-OK	Durant, Oklahoma	1826	34°02'11" N	96°13'04" W	0.20[illegible]	95°	287°	107°	197°	L	X
HH-ND	Hannah, North Dakota	1920	48°56'53" N	98°41'33" W	0.488	41°	[illegible]	54°	144°	S	X
HE-TX	Hempstead, Texas	1999	30°11'59" N	96°05'31" W	0.070	107°	298°	116°	208°	L	-
EB-MT	East Braintree, Manitoba, Canada	2147	49°37'40" N	95°37'20" W	0.312	43°	237°	58°	148°	S	X
JE-LA	Jena, Louisiana	2279	31°47'05" N	92°00'55" W	0.050	98°	292°	112°	202°	L	X
RK-ON	Red Lake, Ontario, Canada	2337	50°50'20" N	93°40'20" W	0.472	42°	239°	58°	148°	S	X
EU-AL	Eutaw, Alabama	2607	32°47'10" N	87°52'00" W	0.050	92°	289°	109°	199°	S	X
CPSO Z8	Cumberland Plateau Observatory, Tennessee	2728	35°35'41" N	85°34'13" W	0.574	84°	283°	90°	0°	JM	X
BL-WV	Beckley, West Virginia	3056	37°47'56" N	81°18'36" W	0.610	78°	279°	100°	190°	S	X
BE-PA	Berlin, Pennsylvania	3235	39°55'27" N	78°50'41" W	0.664	73°	277°	97°	187°	L	X
DH-NY	Delhi, New York	3541	42°14'39" N	74°53'18" W	0.652	68°	275°	95°	185°	S	X
LI-NH	Lisbon, New Hampshire	3756	44°14'18" N	71°55'21" W	0.287	64°	273°	110°	200°	S	X
HN-ME	Houlton, Maine	4062	46°09'43" N	67°59'09" W	0.210	60°	273°	93°	183°	S	X
HW-IS	Kamuela, Hawaii	4280	19°58'49" N	155°42'20" W	0.705	255°	55°	235°	325°	L	X
MP-NT	Mould Bay, Northwest Territories, Canada	4362	76°15'08" N	119°22'18" W	0.059	359°	176°	356°	86°	JMZ-SBH	X
GM-CU	Guantanamo, Cuba	4391	19°58'01" N	75°05'14" W	0.016	104°	305°	125°	215°	S	X
PZ-PR	Ponce, Puerto Rico	5269	17°58'12" N	66°25'04" W	0.005	100°	304°	124°	214°	S	X
LZ-B[illegible]	La Paz, Bolivia	7725	16°15'31" S	68°28'47" W	3.993	131°	321°	141°	231°	JMZ-LBH	X
OO-NW	Oslo, Norway	8120	61°03'17" N	10°51'58" E	0.555	24°	318°	138°	228°	L	X
SB[illegible]	G[illegible]fenberg, Germany	9093	49°41'32" N	11°12'55" E	0.530	31°	320°	140°	230°	L	X

Recording Site Information - KLICKITAT

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

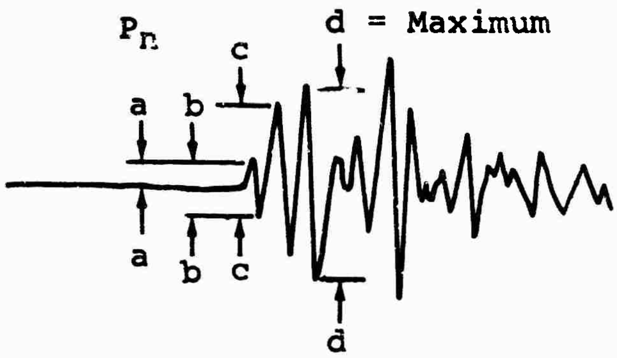
K = magnification in thousands at signal frequency

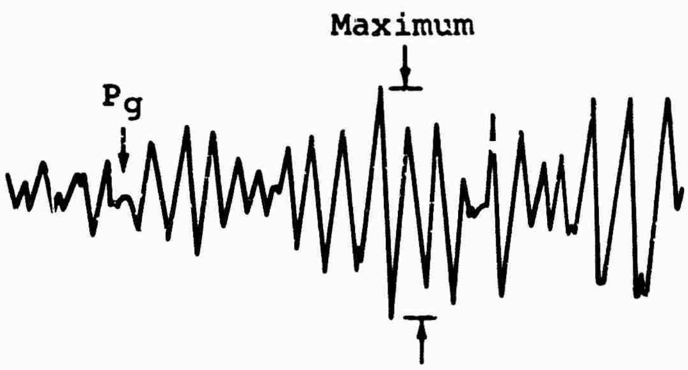
Table of Distance Factors (B) for Zero Depth

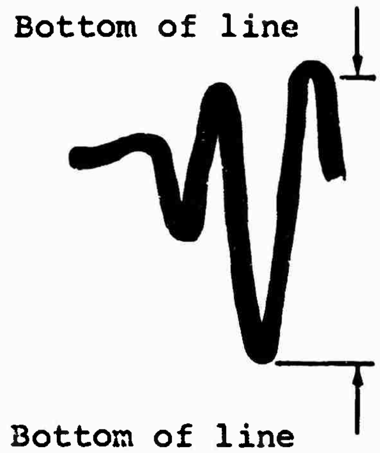
Dist (deg)	B	Dist (deg)	B	Dist (deg)	B	Dist (deg)	B
0°	-	27°	3.5	54°	3.8	80°	3.7
1	-	28	3.6	55	3.8	81	3.8
2	2.2	29	3.6	56	3.8	82	3.9
3	2.7	30	3.6	57	3.8	83	4.0
4	3.1	31	3.7	58	3.8	84	4.0
5	3.4	32	3.7	59	3.8	85	4.0
6	3.6	33	3.7	60	3.8	86	3.9
7	3.8	34	3.7	61	3.9	87	4.0
8	4.0	35	3.7	62	4.0	88	4.1
9	4.2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

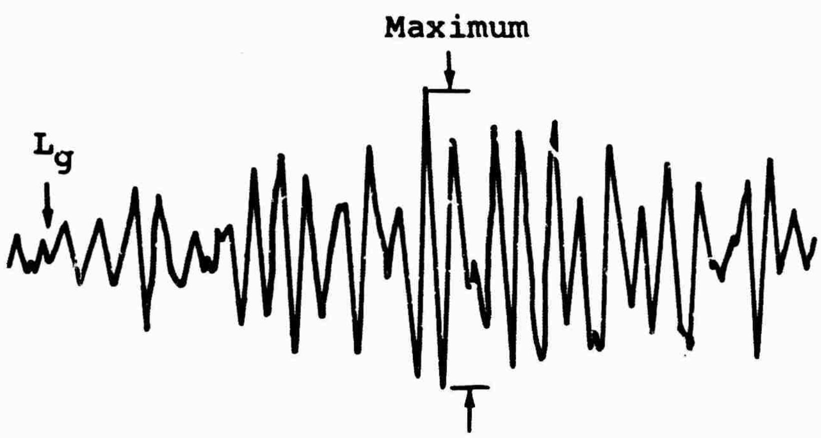
Appendix I(B)







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

FIRST MOTION CRITERIA
TECHNICAL WORKING GROUP II (TWG II)

Excerpt from Appendices to Hearings before the Special Subcommittee on Radiation and the Subcommittee on Research and Development of the Joint Committee on Atomic Energy; 86th Cong., 2d Sess.; April 19-22, 1960; on Technical Aspects of Detection and Inspection Controls of a Nuclear Weapons Test Ban; Part 2 of 2 Parts, pp 632-633:

"2. Identification of Earthquakes

A located seismic event shall be ineligible for inspection if, and only if, it fulfills one or more of the following criteria:

a. Its depth of focus is established as below 60 kilometers;

b. Its epicentral location is established to be in the deep open ocean and the event is unaccompanied by a hydroacoustic signal consistent with the seismic epicenter and origin time;

c. It is established within 48 hours to be a foreshock by the occurrence of a larger event of at least magnitude 6 whose epicenter coincides with that of the given event within the accuracy of the determination of the two epicenters. The eligibility of the second event for inspection must be determined separately.

d. The directions of clearly recorded first motions define a pattern which strongly indicates a faulting source. First motions recorded at distances between 1100 kilometers and 2500 kilometers will not be used. First motions beyond 3500 kilometers will not be used for events of magnitude smaller than 5.5. The apparent direction of first motion must also meet both the following minimum conditions to be considered to be clearly recorded:

(1) The amplitude of the half-cycle of apparent first motion is at least two (2) times as large as any half-cycle of apparent noise in the preceding few minutes, and

(2) The largest of the amplitudes of the half-cycle of apparent first motion and the two immediately following half-cycles:

(a) at epicentral distances less than 700 kilometers is twenty (20) times larger than any half-cycle of noise in the preceding few minutes;

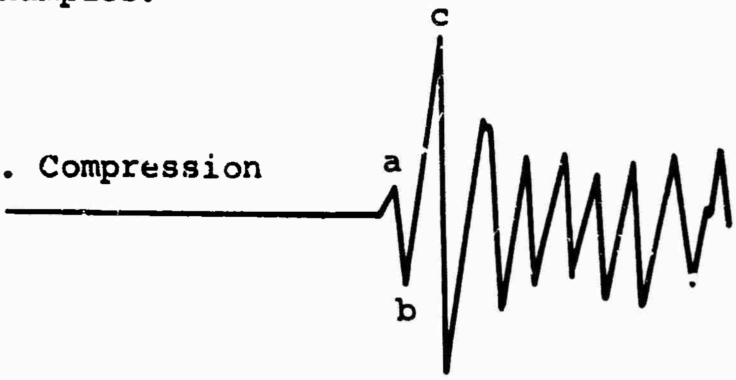
(b) at epicentral distances more than 700 kilometers is forty (40) times larger than any half-cycle of noise in the preceding few minutes.

A pattern of clearly recorded first motions strongly indicates a faulting source if the observed motions, extended backward to a small sphere about the focus, can be separated into alternate quadrants by two orthogonal great circles drawn on the small sphere, with the requirement that two opposite quadrants combined (i) contain at least 4 clearly recorded rarefactive first motions and (ii) contain not more than 15% compressions among the clearly recorded first motions."

Application of the TWG II Criteria

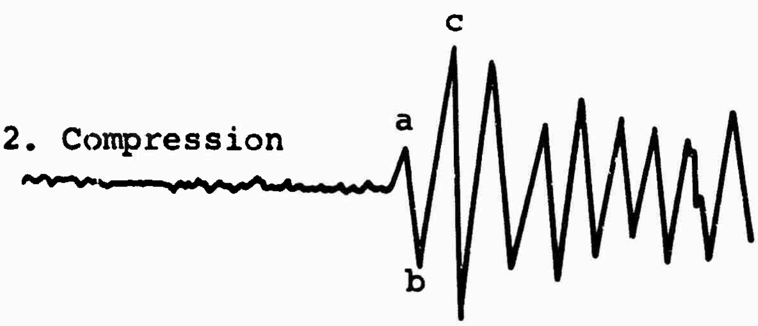
Examples:

1. Compression



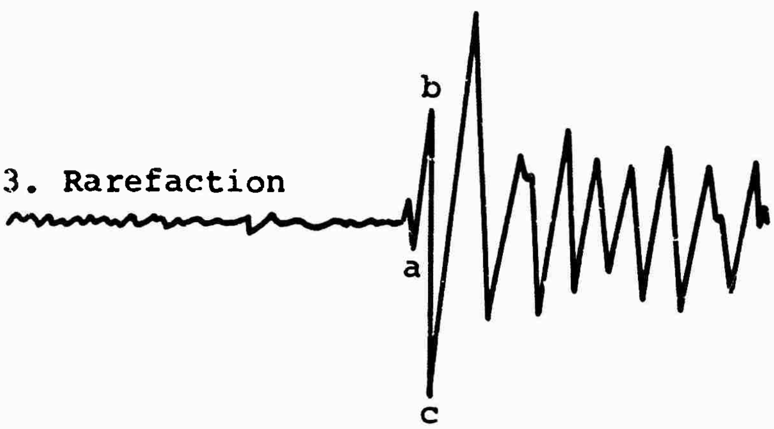
$700 < \Delta < 1100$ Km

2. Compression



$\Delta < 700$ Km

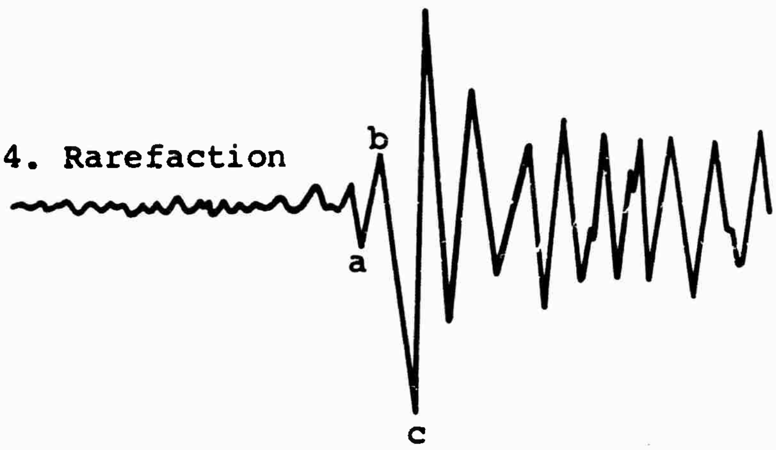
3. Rarefaction



$\Delta < 700$ Km. Example shows what may be interpreted to be earlier signal; however, motion is less than 2 times the noise level and may be interpreted as noise.

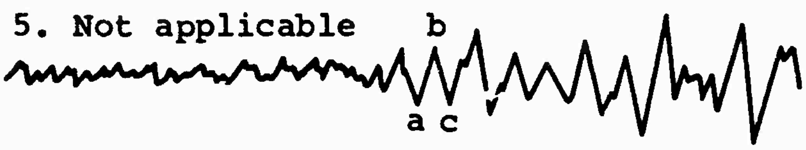
Application of the TWG II Criteria

4. Rarefaction

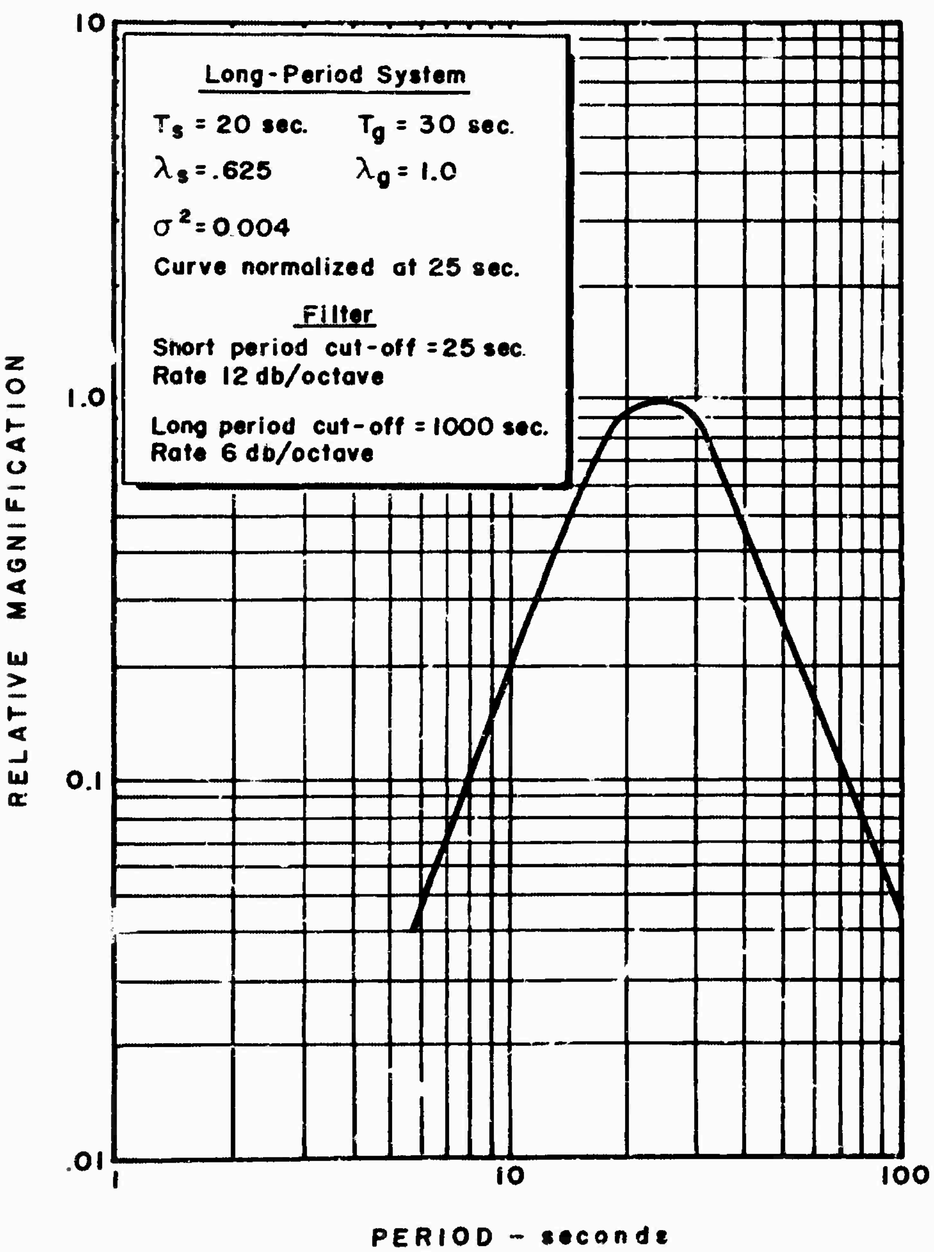


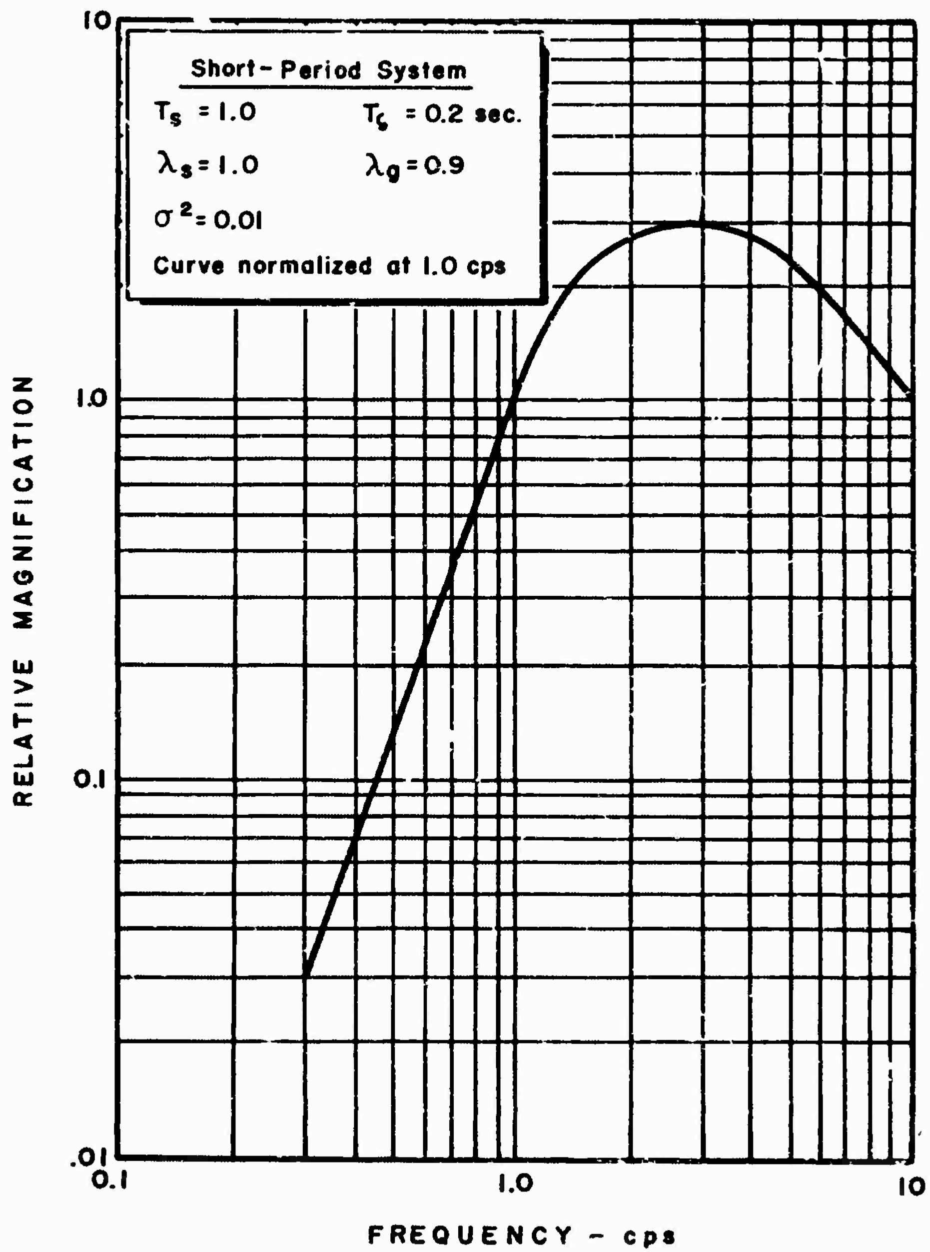
$\Delta < 700$ Km
Similar to Example 3.

5. Not applicable



$\Delta < 700$ Km
Amplitude of first
3 half-cycles is less
than 20 times noise.





LP and SP Response Curves

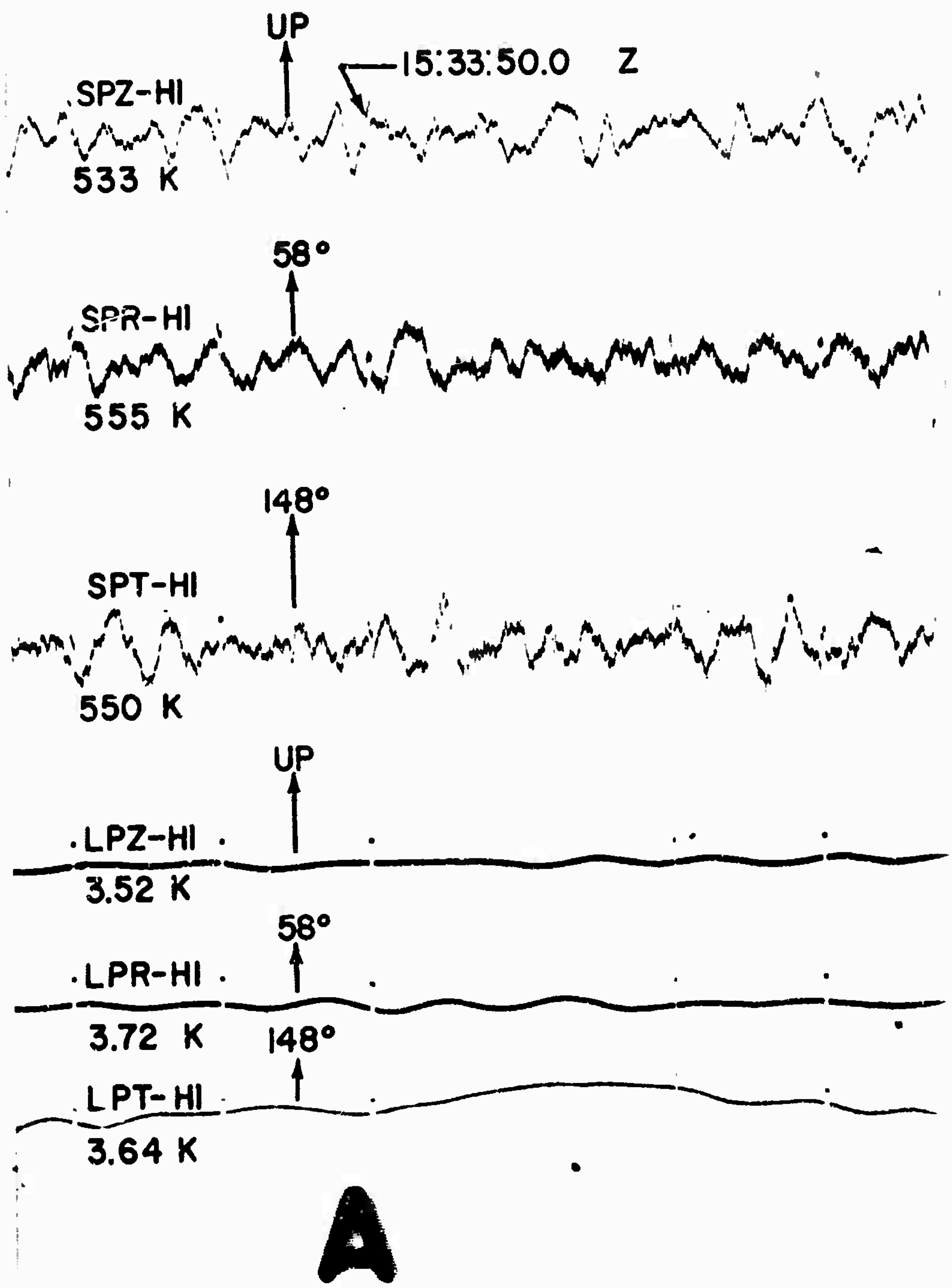
KLICKITAT

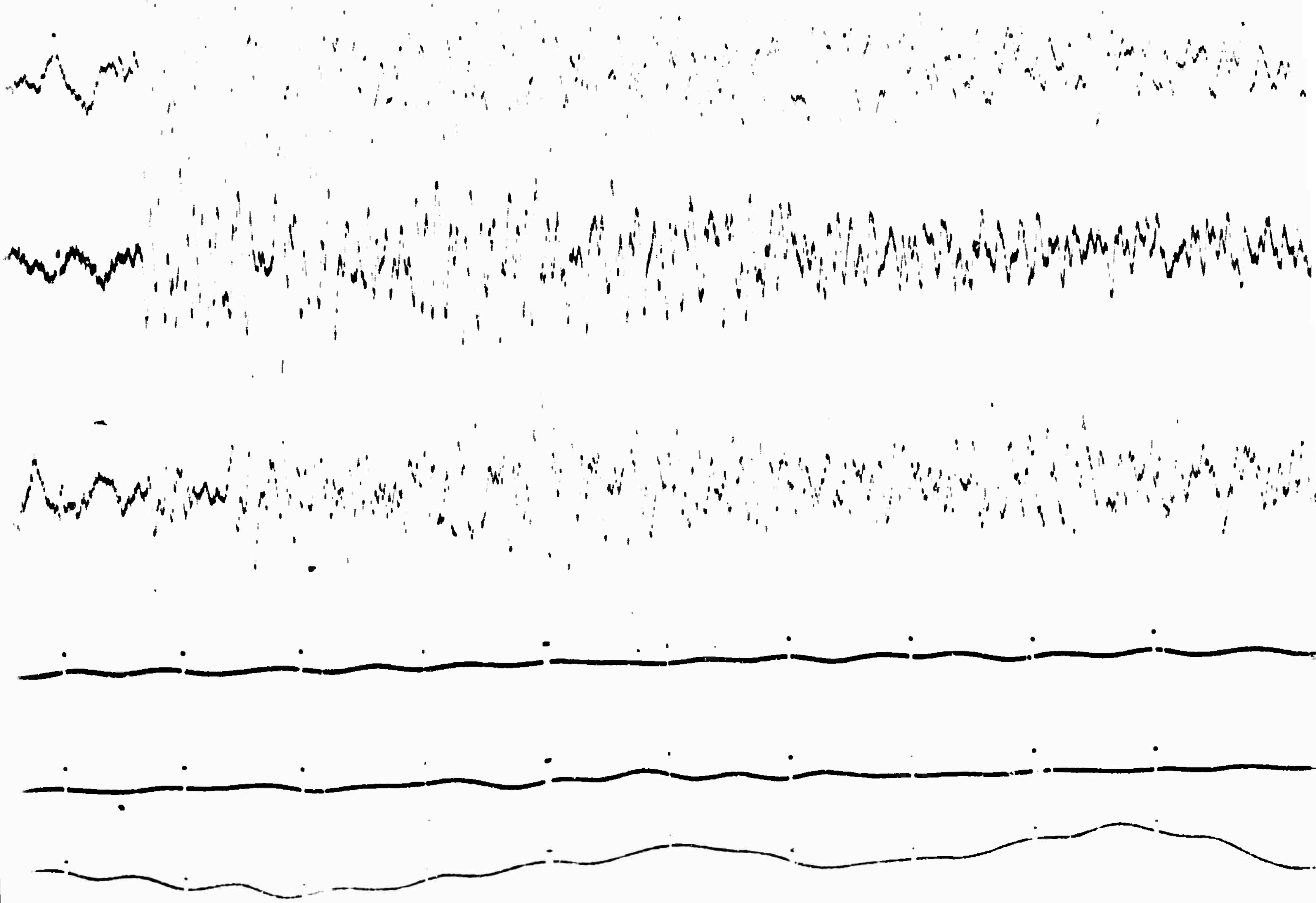
EB-MT

East Braintree, Manitoba

20 February 1964

Δ = 2147 km





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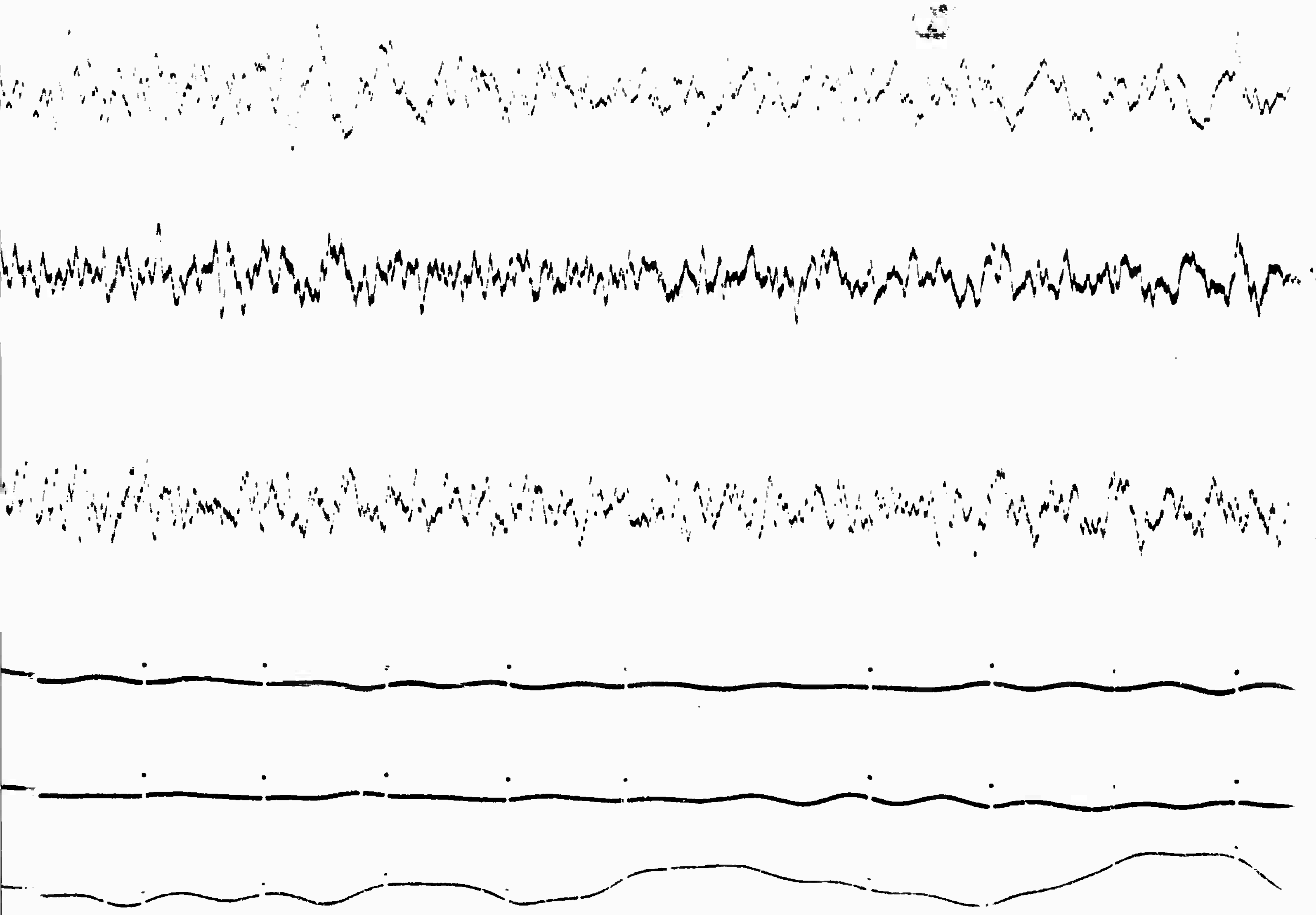
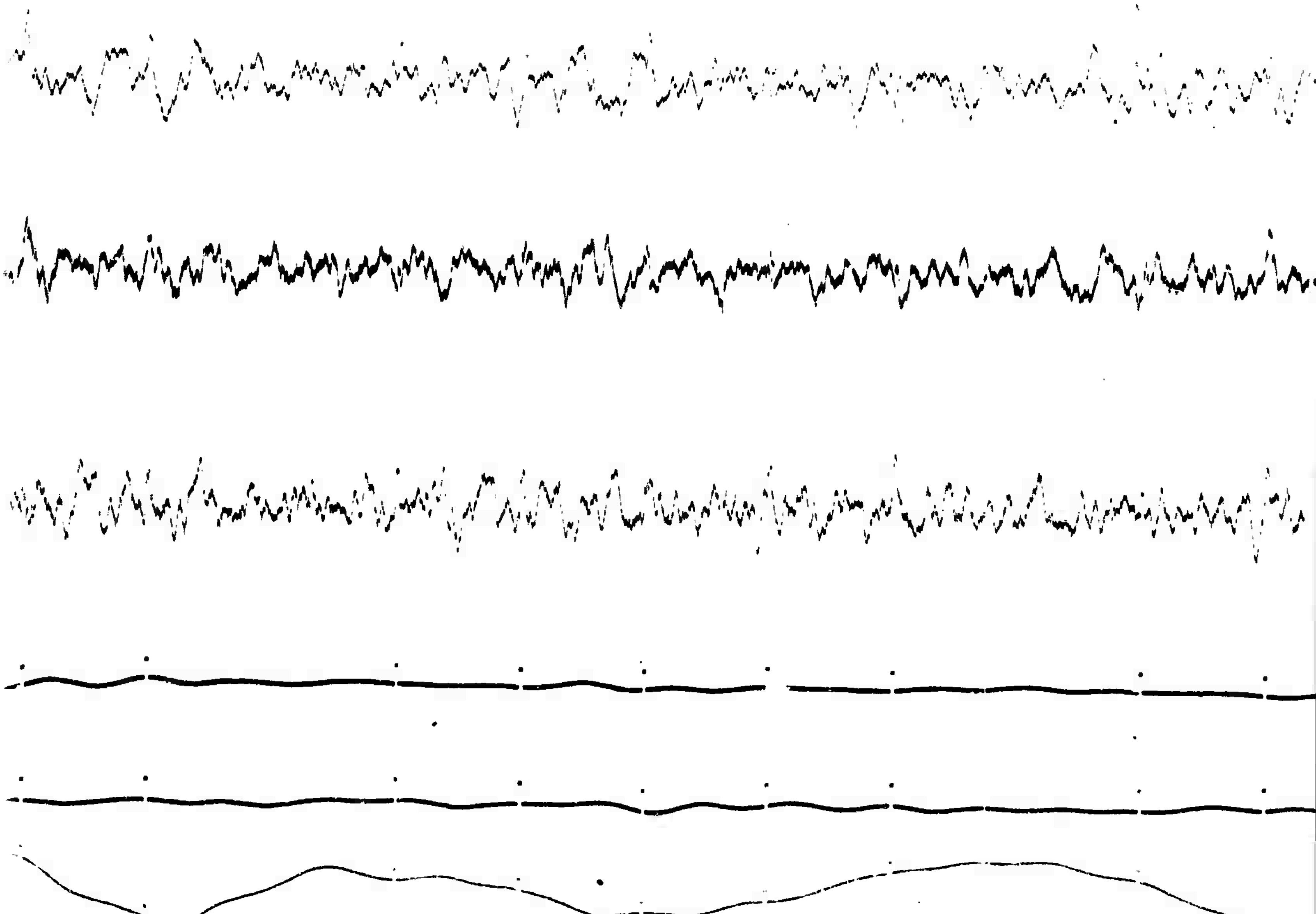
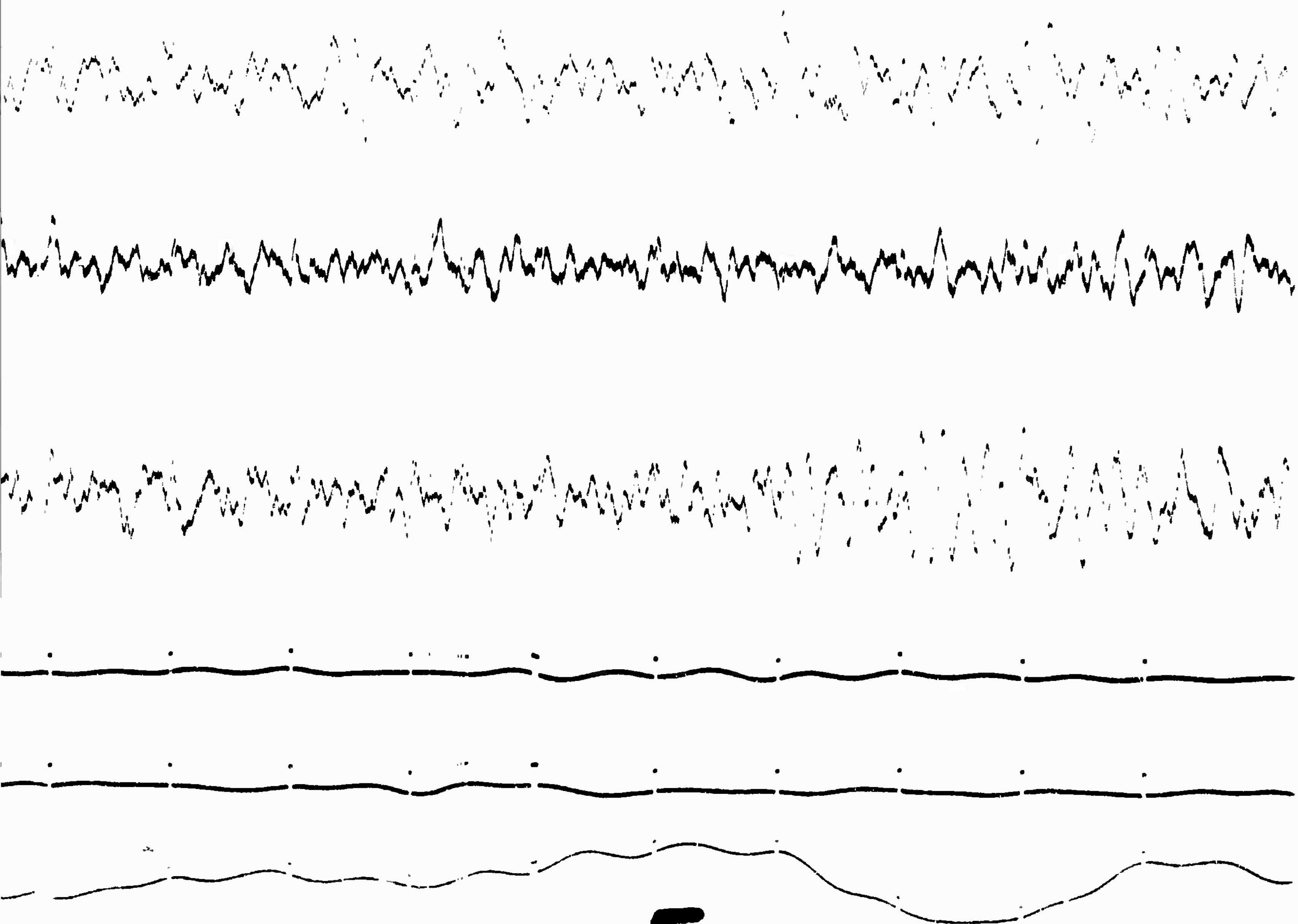


C



D



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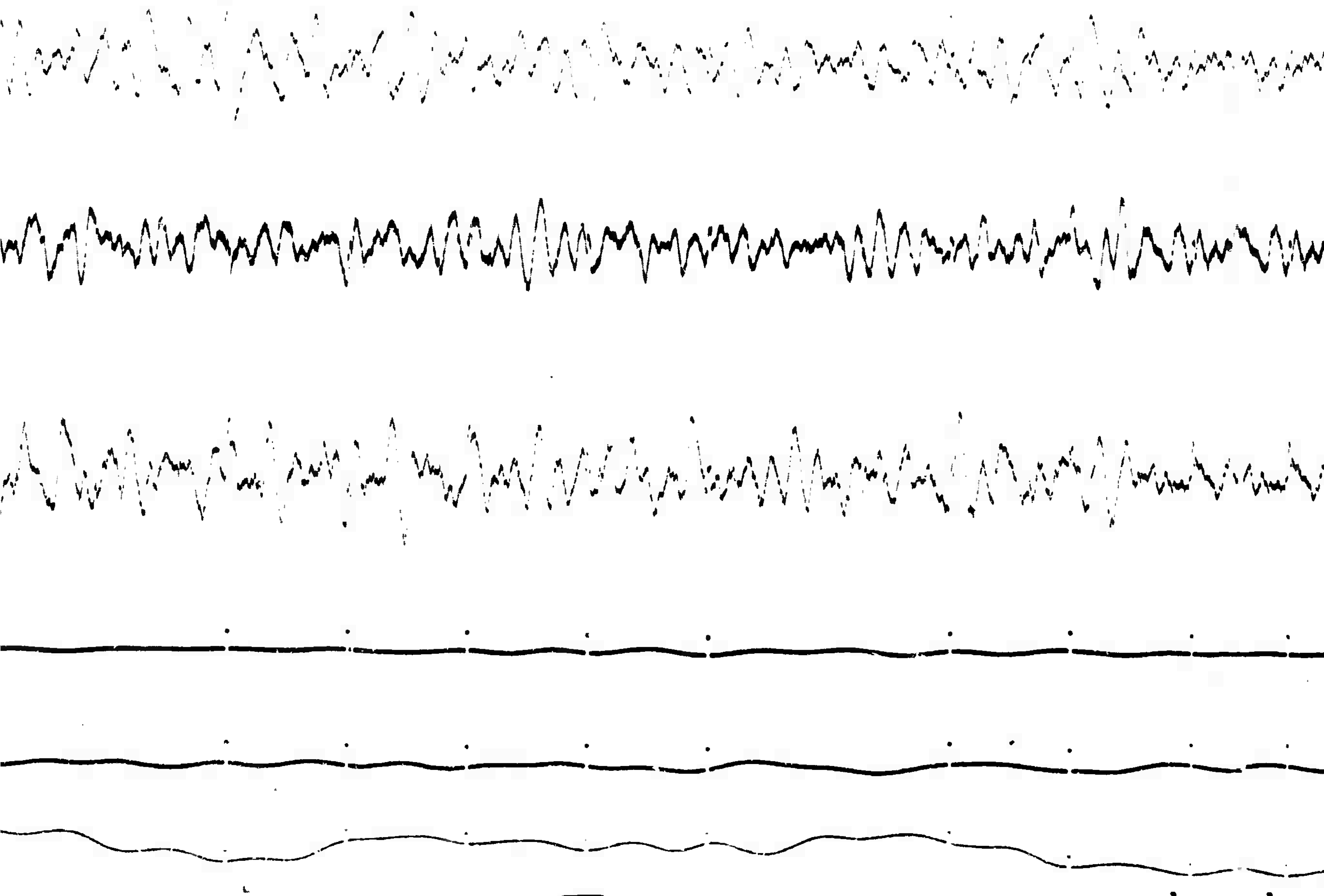

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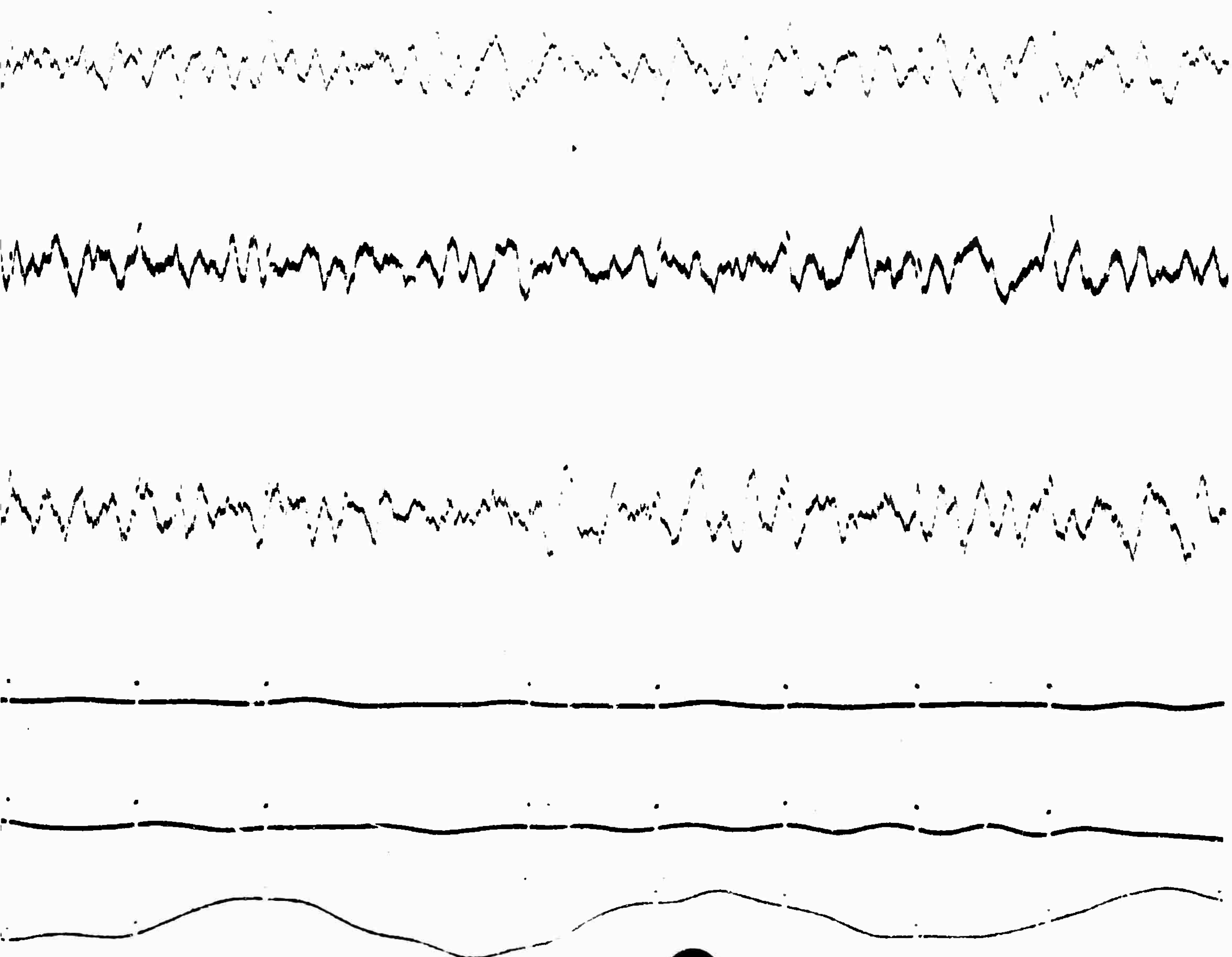


G

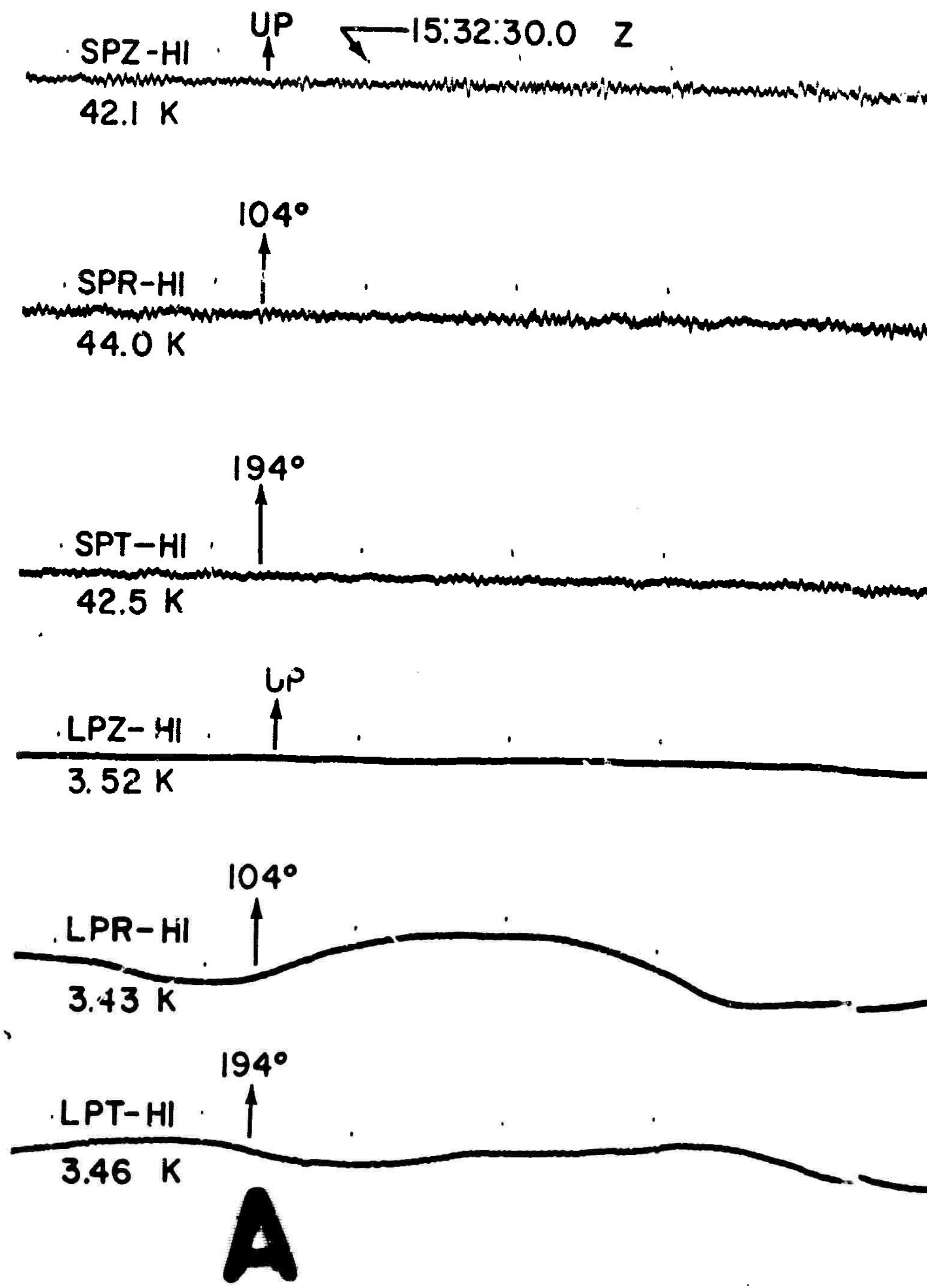
KLICKITAT

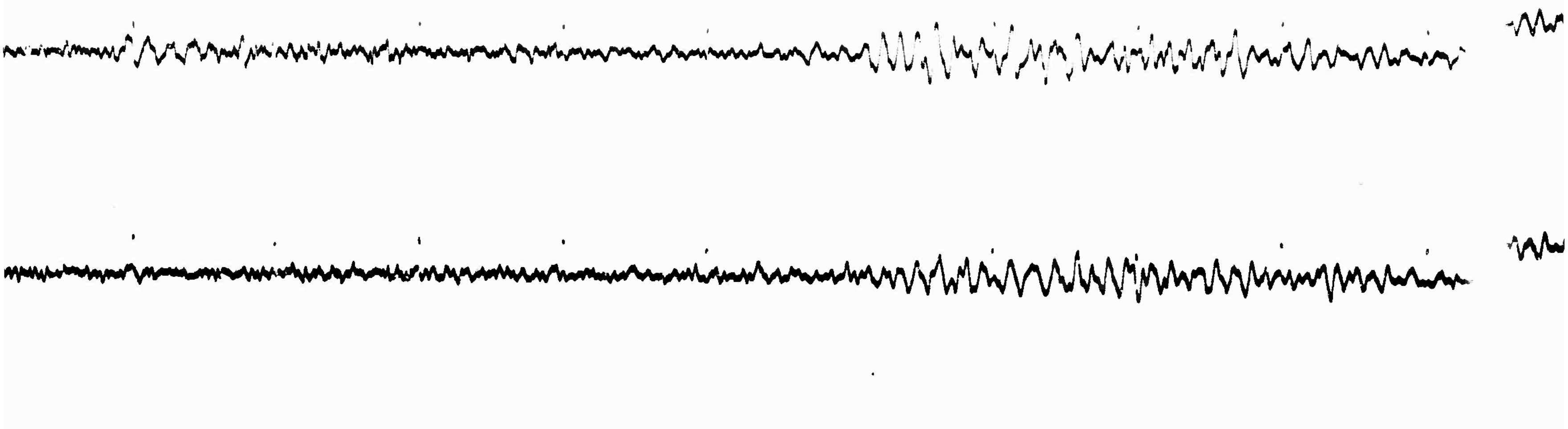
SK–TX

Shamrock, Texas

20 February 1964

Δ = 1428 km





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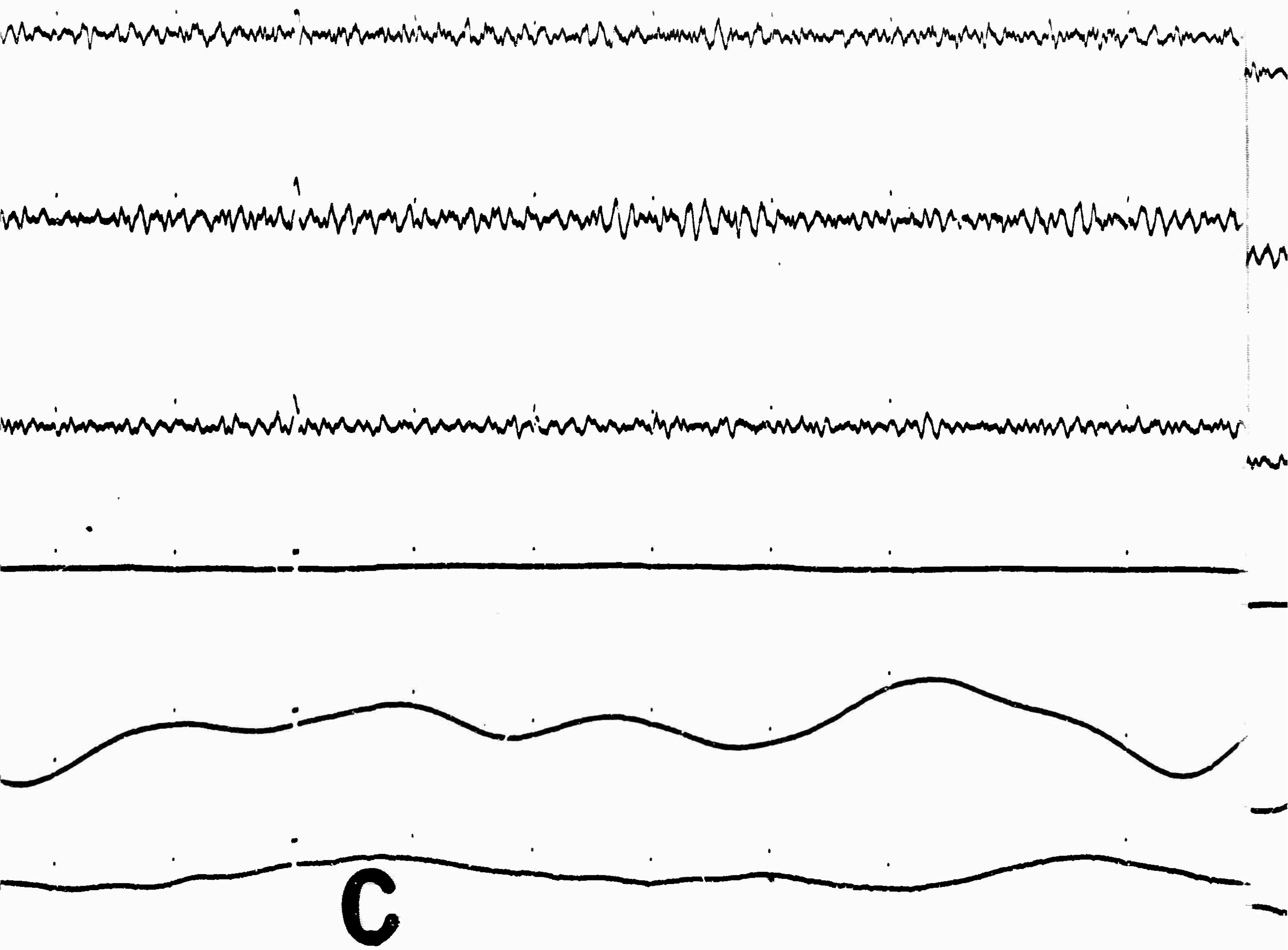
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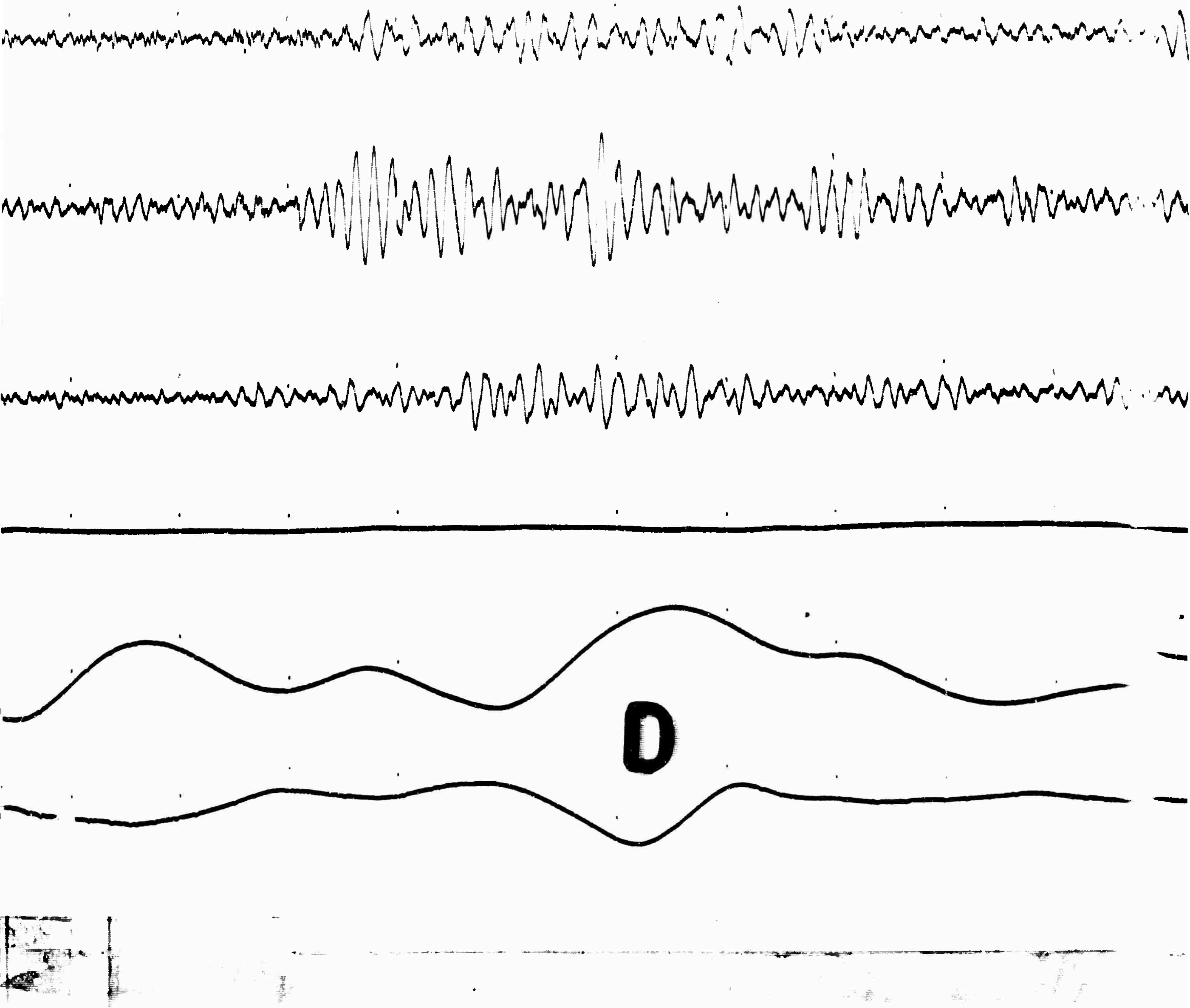
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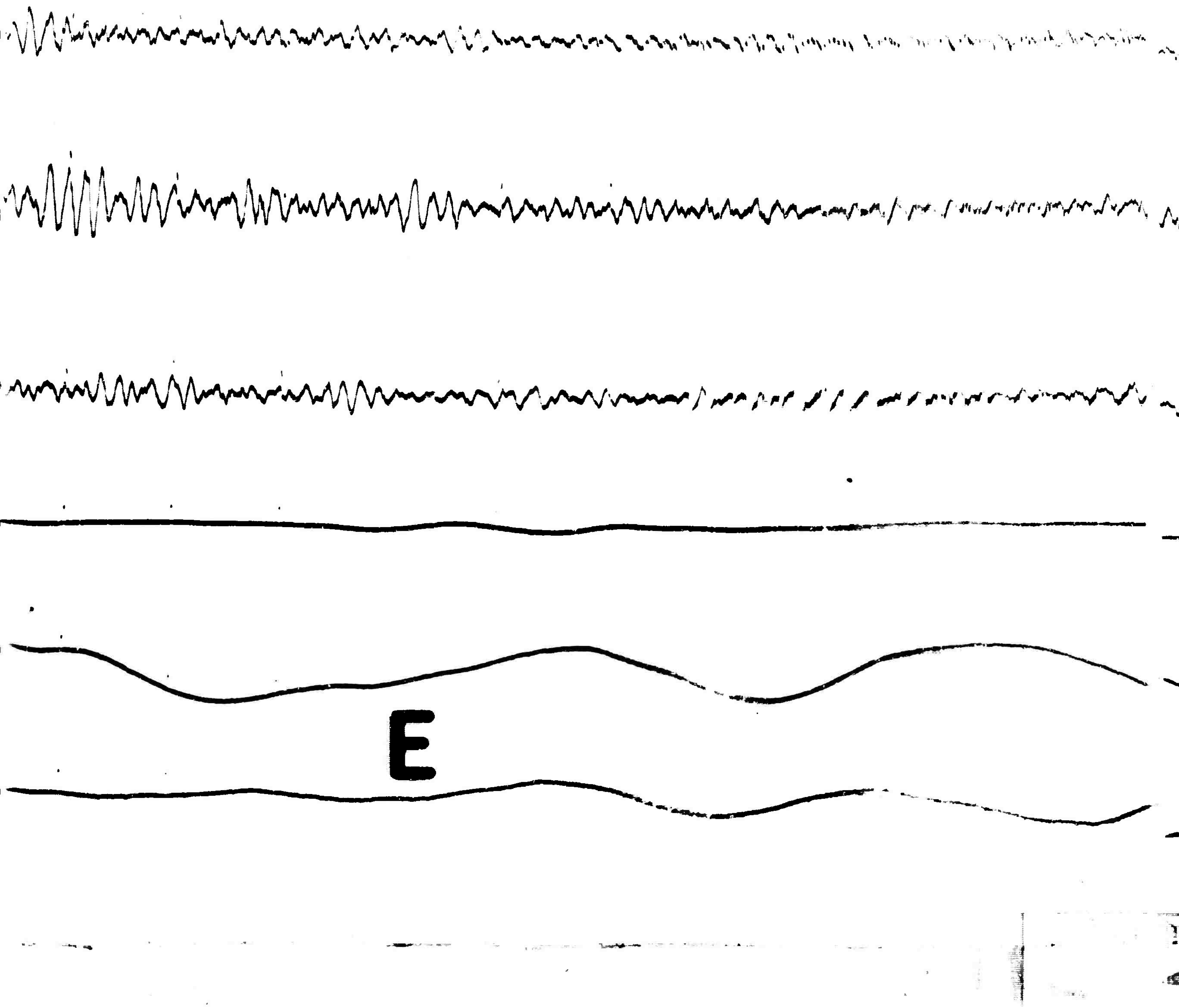
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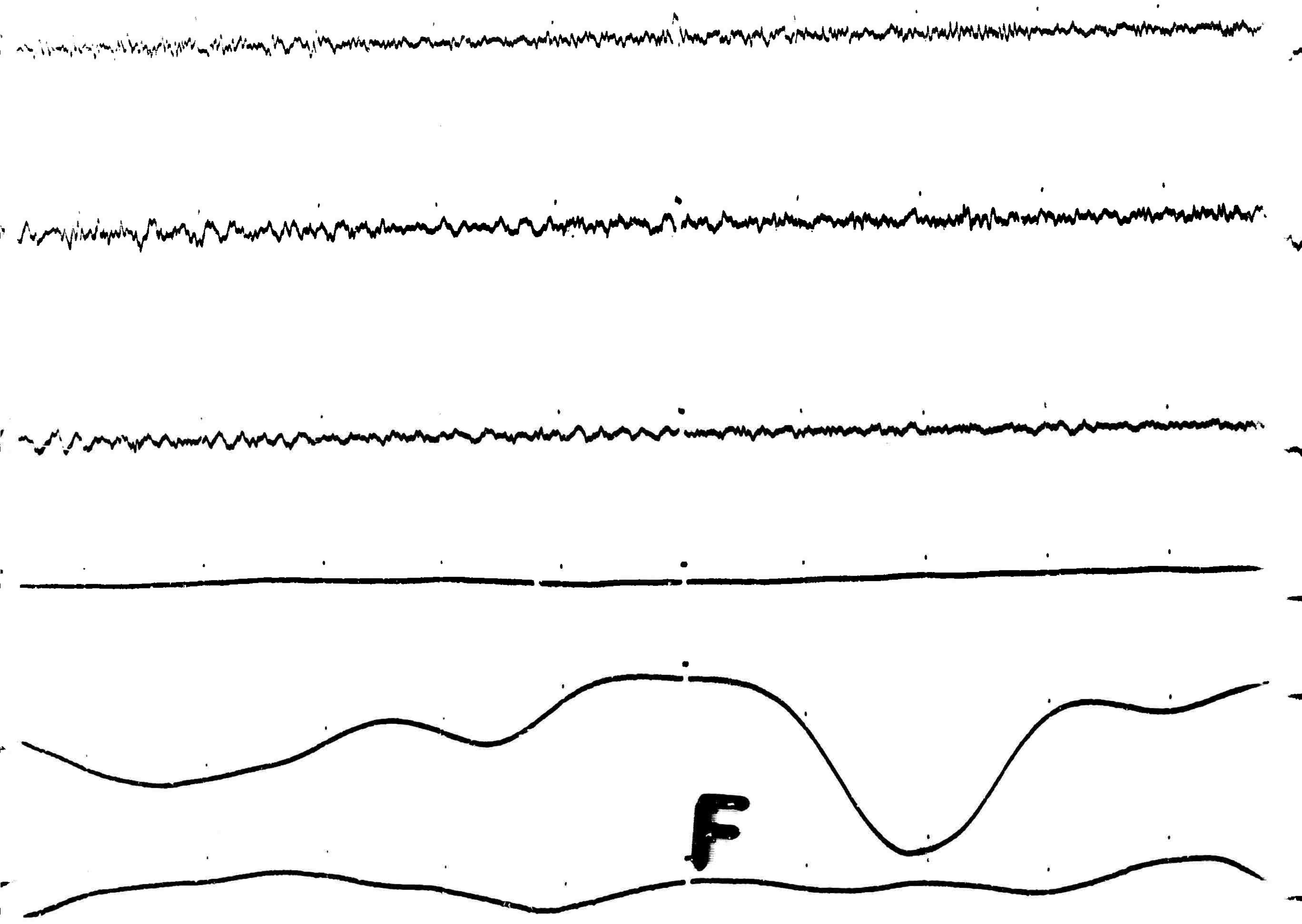
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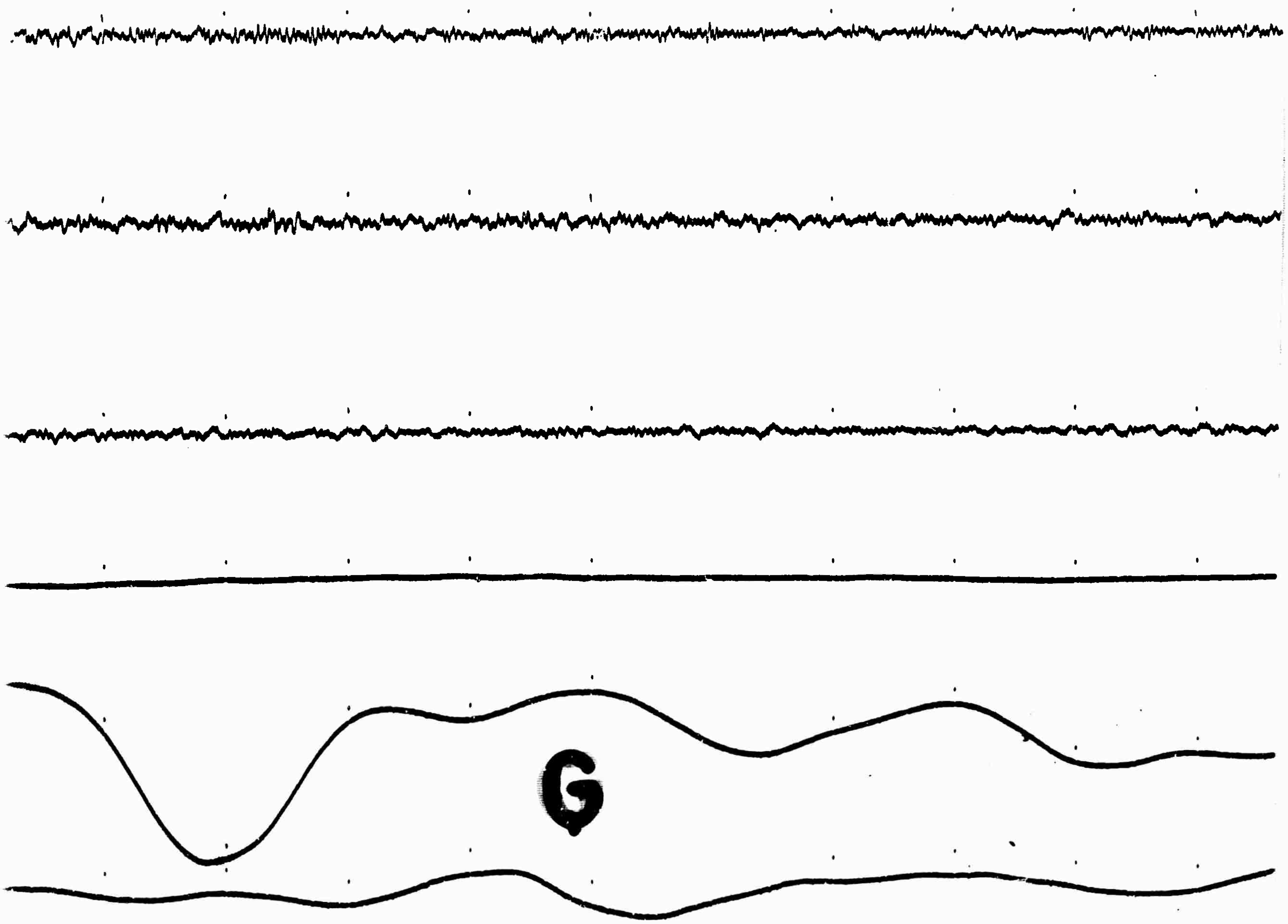

G

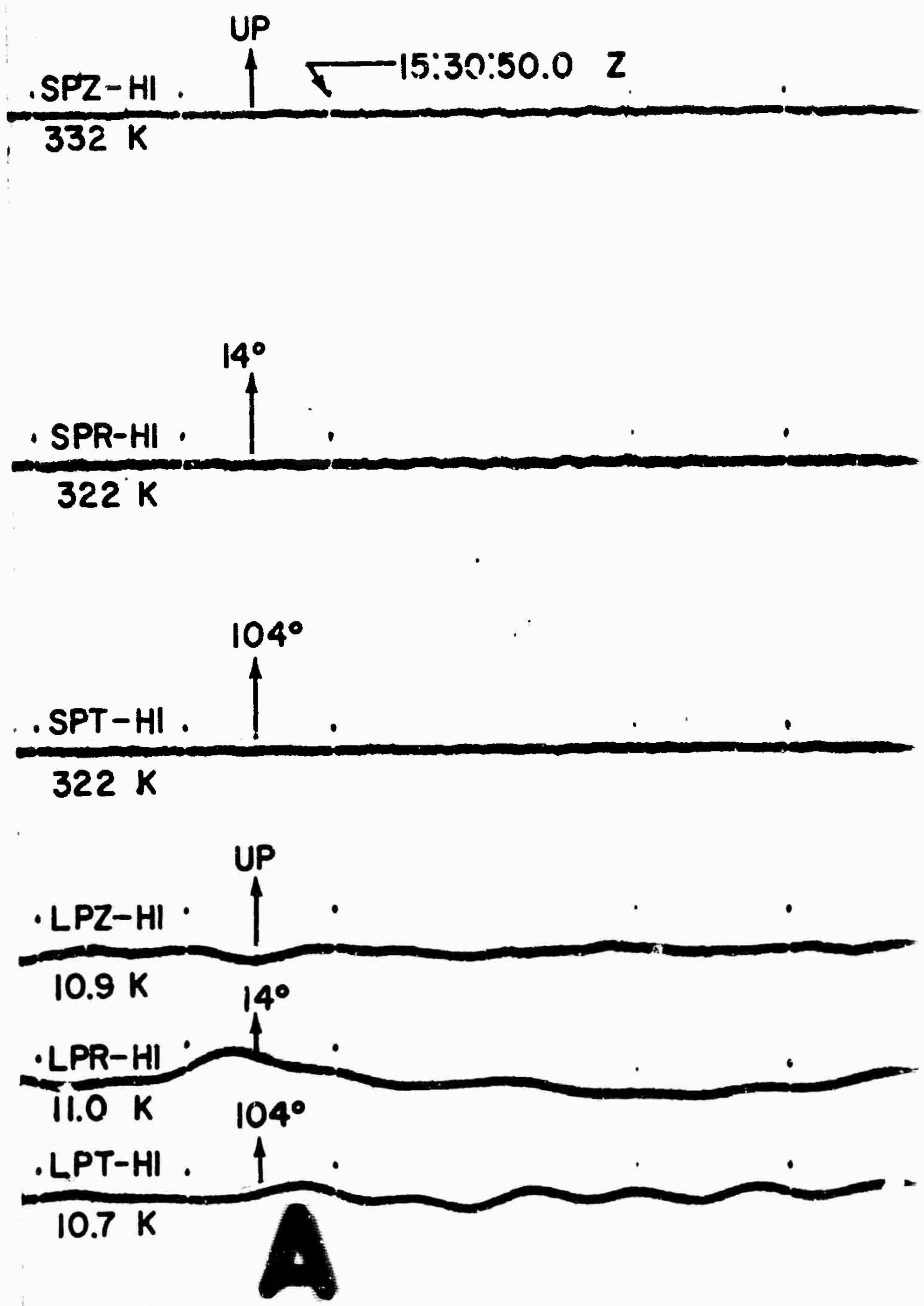
KLICKITAT

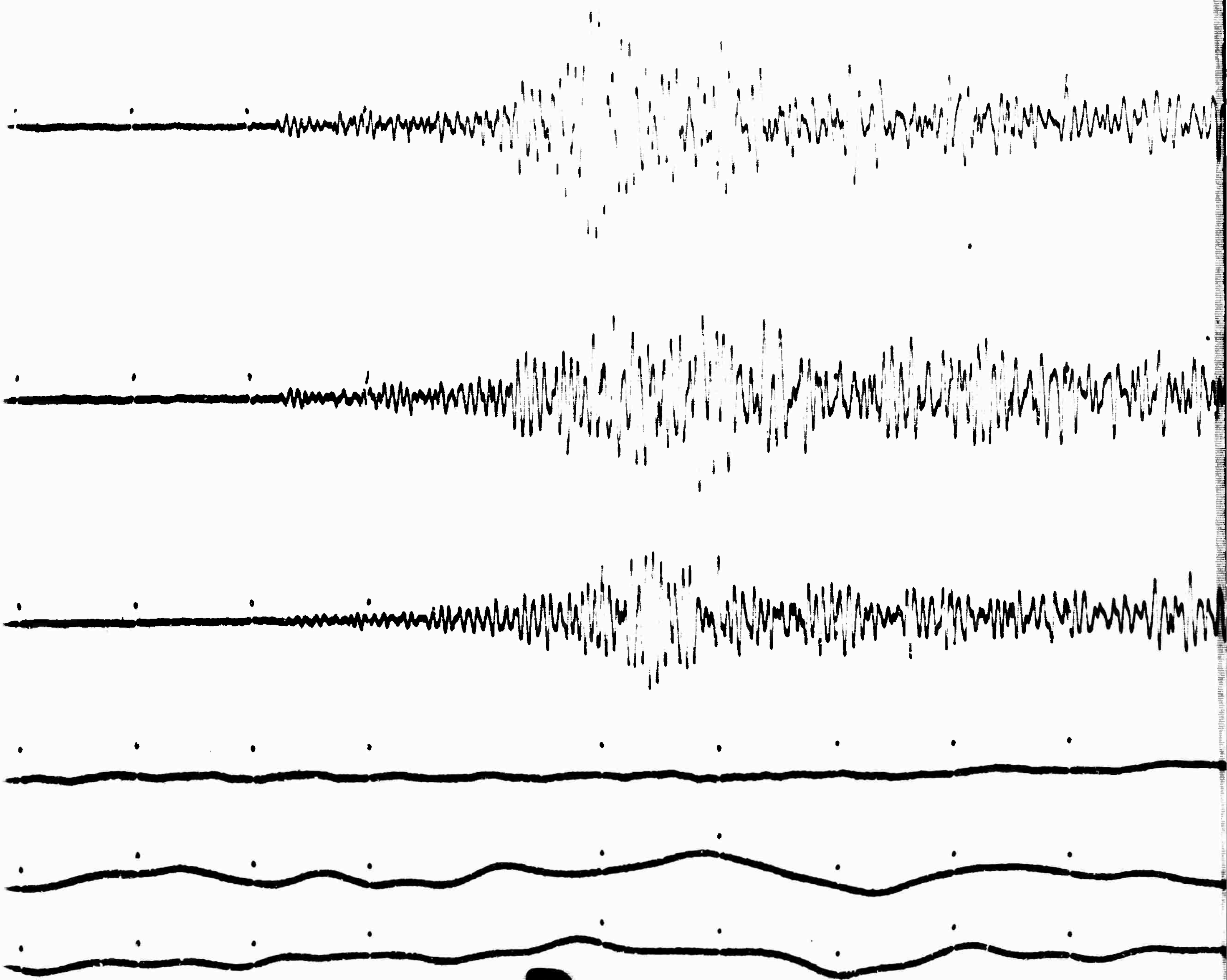
HL-ID

Hailey, Idaho

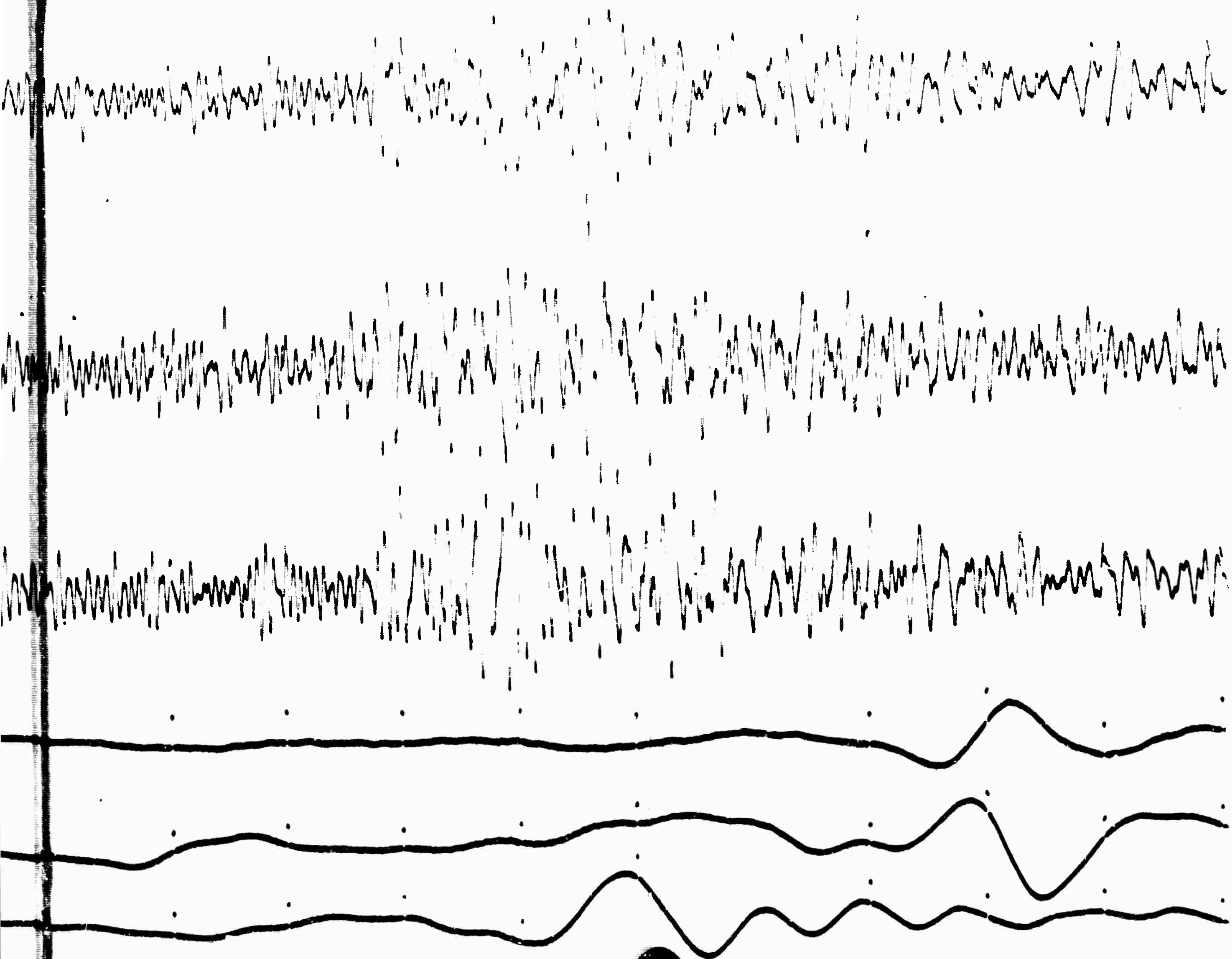
20 February 1964

Δ = 737 km

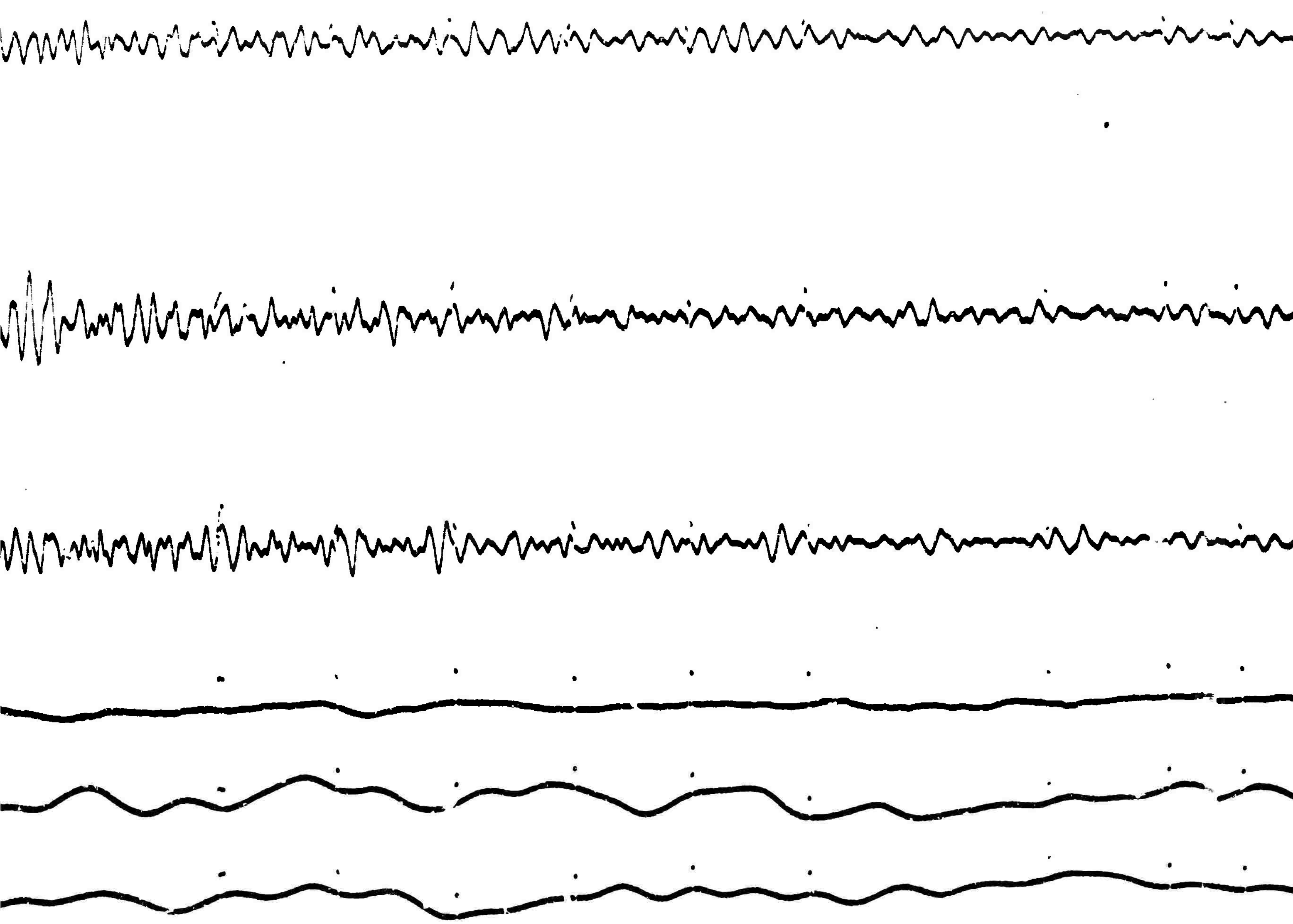




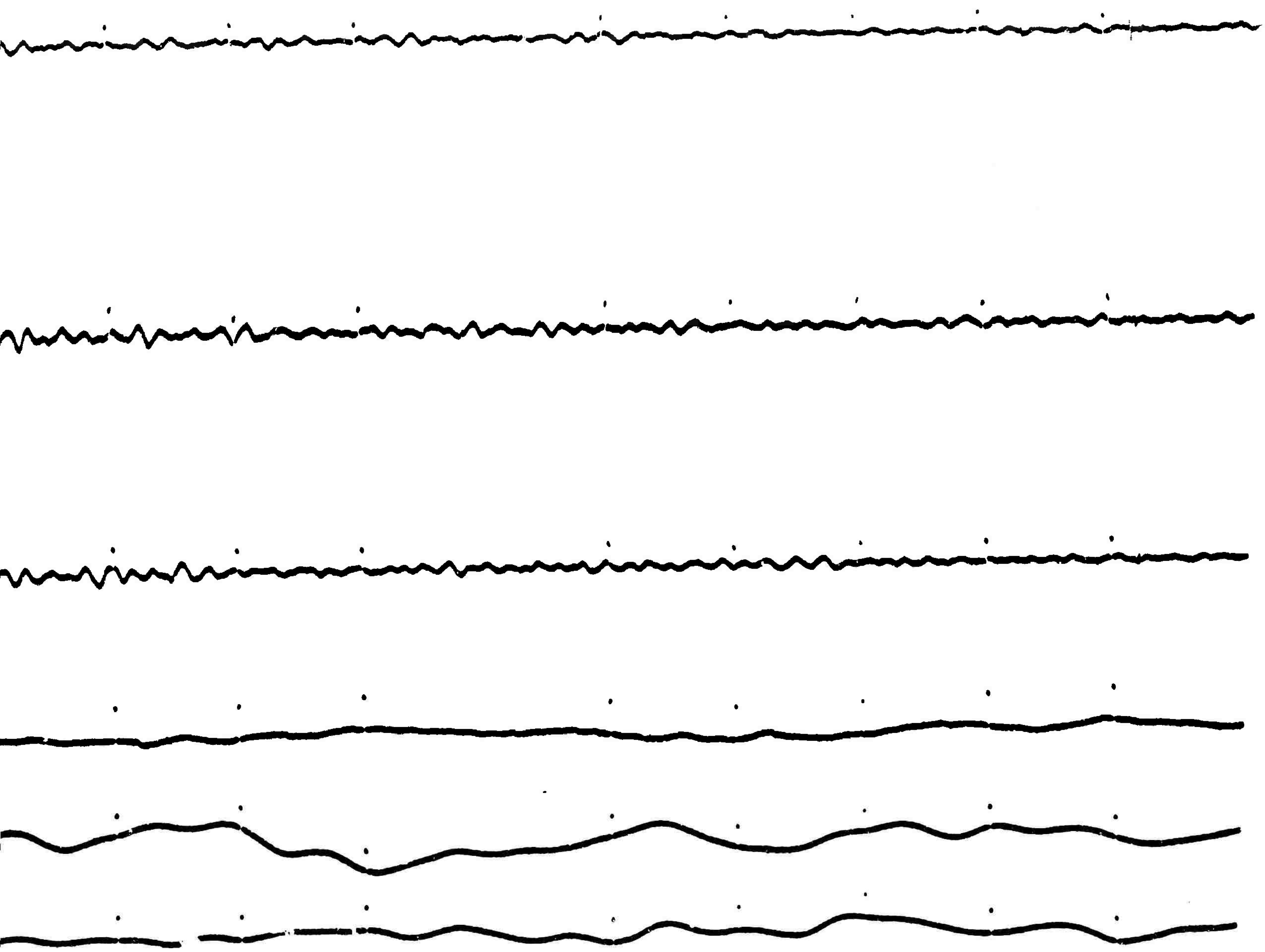
B



C



D



E

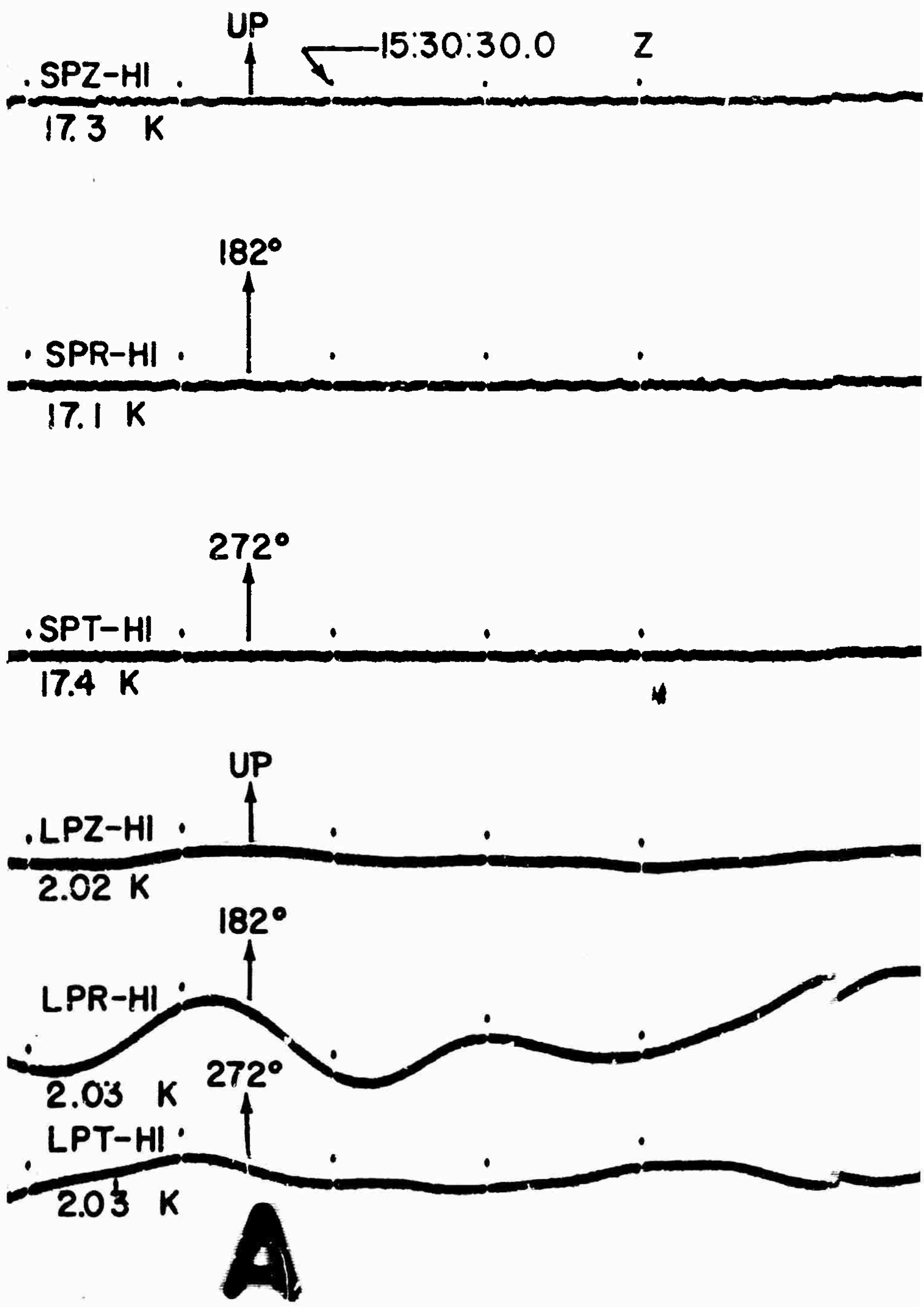
KLICKITAT

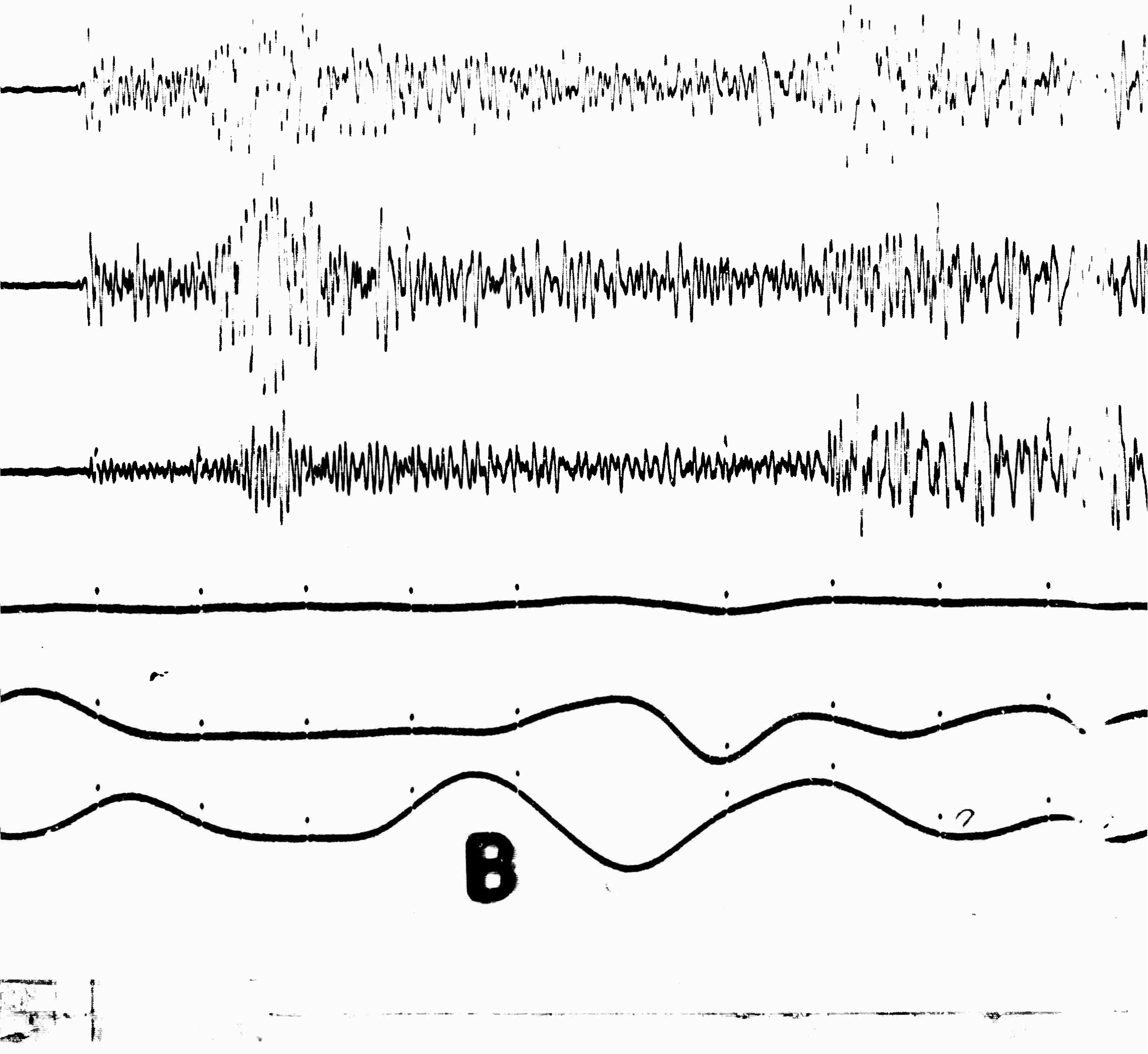
CP – CL

Campo, California

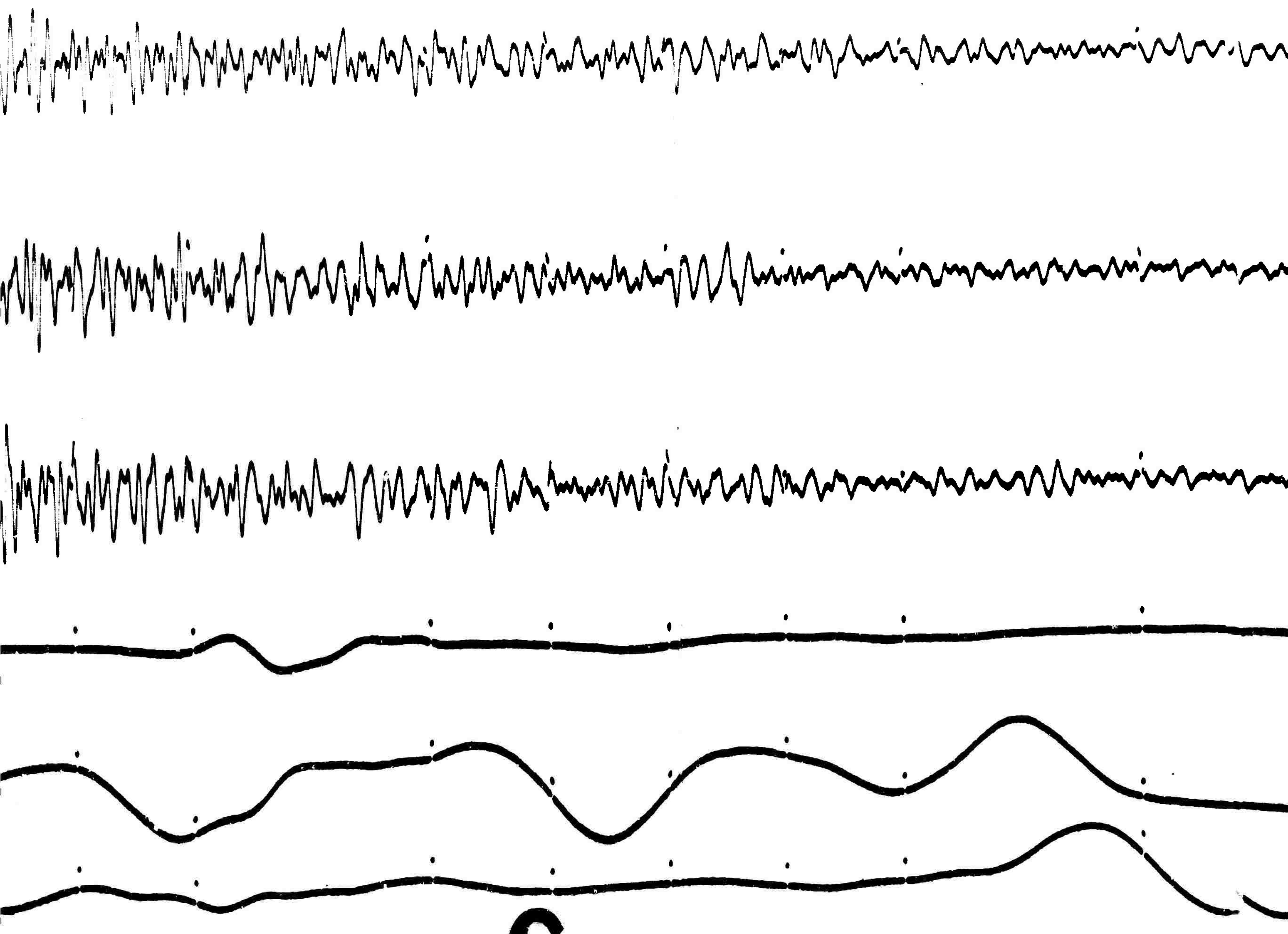
20 February 1964

Δ = 491 km

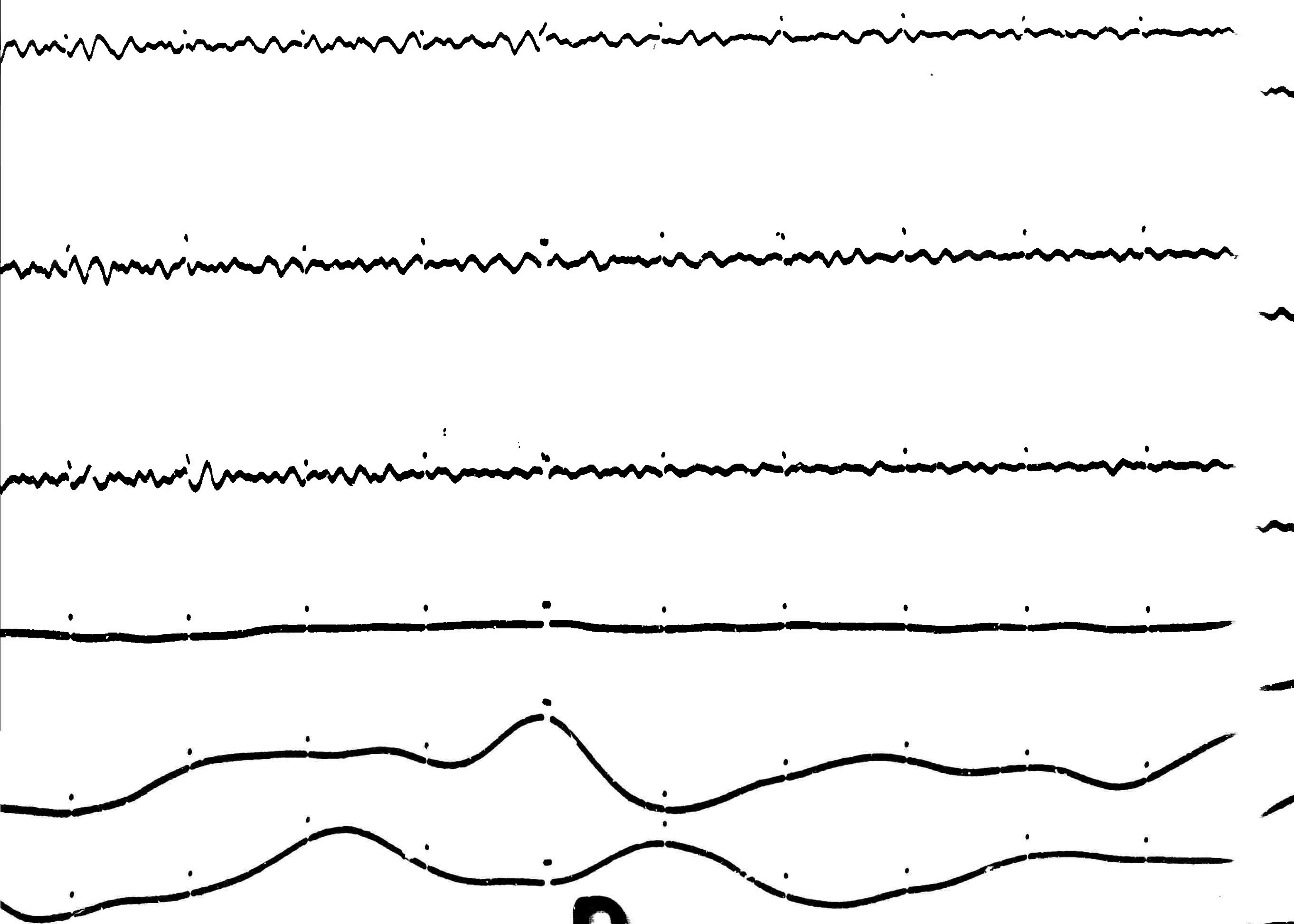




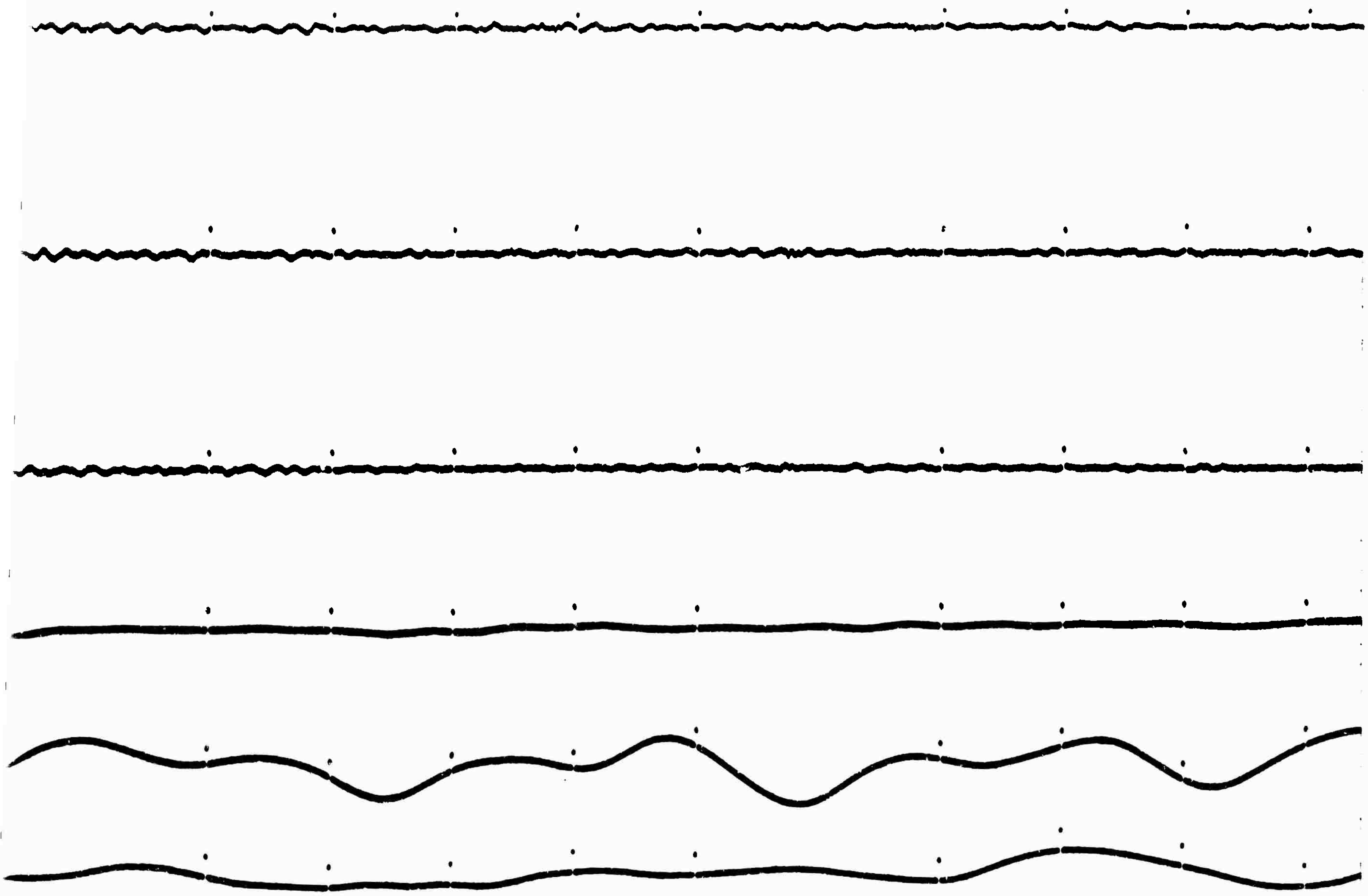
B



C



D



E

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3. REPORT TITLE Long Range Seismic Measurements - KLICKITAT		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Scientific Report		
5. AUTHOR(S) (Last name, first name, initial) Clark, Don M.		
6. REPORT DATE 24 November 1965	7a. TOTAL NO. OF PAGES 21	7b. NO. OF REFS 1
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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 ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Seismic Magnitude						
Seismic Travel-Time						
Seismic Amplitude						
VELA-UNIFORM						
Nuclear Tests						

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