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LONG RANGE SEISMIC MEASUREMENTS

COMMODORE

20 MAY 1967

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER

Washington, D. C.

14 AUGUST 1967

By

TELEDYNE, INC.

Under

Project VELA UNIFORM

Sponsored By

ADVANCED RESEARCH PROJECTS AGENCY

Nuclear Test Detection Office

ARPA Order No. 624

LONG RANGE SEISMIC MEASUREMENTS

COMMODORE

SEISMIC DATA LABORATORY REPORT NO. 193

AFTAC Project No.:	VELA T/6702
Project Title:	Seismic Data Laboratory
ARPA Order No.:	624
ARPA Program Code No.:	5810
Name of Contractor:	TELEDYNE, INC.
Contract No.:	F 33657-67-C-1313
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Amount of Contract:	$ 1,736,617
Contract Expiration Date:	1 March 1968
Project Manager:	William C. Dean (703) 836-7644

P. O. Box 334, Alexandria,Virginia

AVAILABILITY

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ABLE OF CONTENTS

COMMODORE

EVENT DESCRIPTION

DATE: 20 May 1967

TIME OF ORIGIN: 15:00:00.2Z

YIELD:

MAGNITUDE: 5.68 ± 0.56

LOCATION:

SITE: Nevada Test Site, Area U2am

GEOGRAPHIC COORDINATES:

Lat: 37° 07' 49.0" N

Long: 116° 03'50.0" W

ENVIRONMENT:

GEOLOGIC MEDIUM: TUFF

SURFACE ELEVATION: 4258 ft.

SHOT ELEVATION: 1773 ft.

SHOT DEPTH: 2485 ft.

COMPUTED EPICENTER: ALL STATIONS

GEOGRAPHIC COORDINATES:

Lat: 37° 07' 12.0" N

Long: 116° 09' 36.0" W

TIME OF ORIGIN: 15:00:013Z

DEPTH CONSTRAINED TO: 0 km

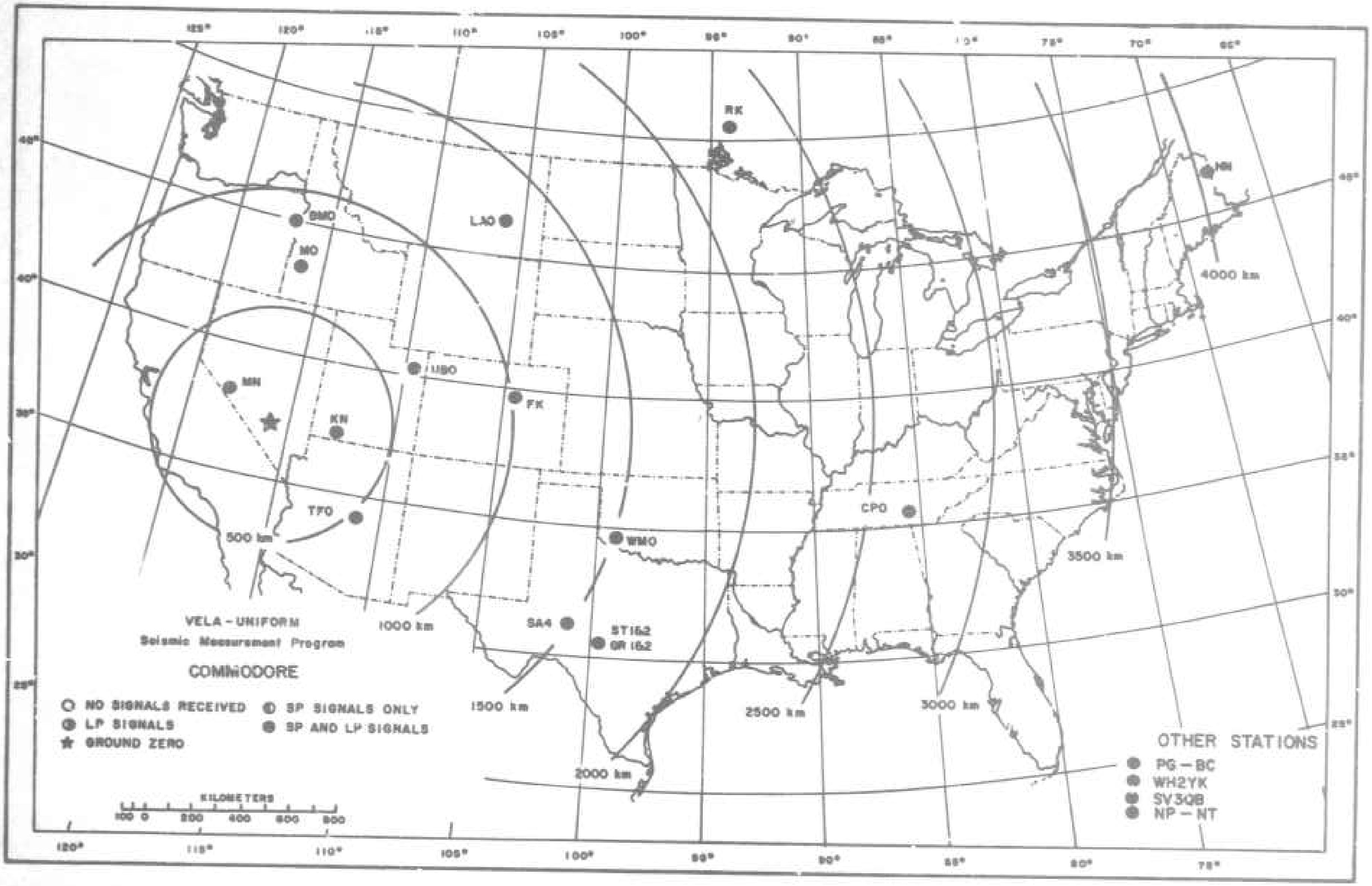
EPICENTER SHIFT: 8.6 km S 80° W

Code	Station					Final			
		SPZ	SPR	SPT	LPZ	LPR	LPT	Tape	Timing
MN-NV	Mina, Nevada	+	+	+	+	+	+	*	P
KN-UT	Kanab. Utah	+	+	+	+	+	+	*	P
TFSO	Tonto Forest Seismological Observatory, Arizona	+	+	+	+	+	+	*	P
MO-ID	Mountain Home, Idaho	+	+	+	+	+	+	*	P
UBSO	Uinta Basin,Seismological Observatory, Utah	+	+	+	+	+	+	*	S
BMSO	Blue Mountain,Seismological Observatory, Oregon	+	+	+	+	+	+	*	P
FK-CO	Franktown, Colorado	+	+	+	+	+	+	*	P
LAO	Subarray, AO-10, Montana	+	N	N	+	+	+		P
SA4TX	San Angelo, Texas	+	N	N	+	+	+		P
WMSO	Wichita Mountain Seismological Observatory, Oklahoma	+	+	+	+	+	+	*	P
ST2TX	Streeter, Texas	+	N	N	**	**	**		P
GR2TX	Grit, Texas	+	N	N	+	+	+		P
GR1TX	Grit, Texas	+	N	N	+	+	+		P
ST1TX	Streeter,Texas	**	N	N	+	-	-		P
PG-BC	Prince George, British Columbia, Canada	+	+	+	+	+	+	*	P
RK-ON	Red Lake, Ontario, Canada	+	+	+	+	+	+	*	P
CPSO	Cumberland Plateau, Seismo- logical Observatory, Tenn.	+	+	+	+	+	+	*	P
WH2YK	Whitehorse, Yukon Territory, Canada	+	+	+	+	+	+	*	P
HN-ME	Houlton, Maine	+	+	+	+	+	+	*	P
SV3QB	Schefferville, Quebec, Canada	+	+	+	+	+	+	*	P
NP-NT	Mould Bay, Northwest Territories, Canada	+	+	+	+	+	+	*	P

I	Inoperative	+	Signal
N	No Instrument	-	No Signal
P	Primary Timing	*	Magnetic Tape Available
S	Secondary Timing	**	Magnification Unreliable

Station Status Report - COMMODORE

Table 1



Recording Stations and Signals Received

Figure 1

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:

Wichita Mountains Seismological Observatory (WMSO)
Lawton, Oklahoma

Uinta Basin Seismological Observatory (UBSO)
Vernal, Utah

Tonto Forest Seismological Observatory (TFSO)
Payson, Arizona

Large Aperture Seismic Array (LASA)
Billings, Montana

The purpose of this report is to provide an analysis of data resulting from the COMMODORE event recorded by the LRSM teams and the VELA observatories and a preliminary summary of 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 one-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 Report 66-27, "The LRSM Mobile Seismological 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 Appendix 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° are from Gutenberg and Richter*. For distance less than 16° values were read from a curve in the Gutenberg and Richter paper back to 10° and then extrapolated to 2°, using an inverse cube relationship. An additional magnitude for less than 16° was computed using a method described by Evernden**. (Figure 3)

A standard hypocenter location program for a digital computer is 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. 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. This method is based on P-wave arrivals with depth constrained to zero.

DATA AND RESULTS (LRSM AND VELA OBSERVATORIES)

The parameters of the COMMODORE event and a summary of the seismic evaluation is shown on the Event Description page. The operational status of the 21 LRSM stations and observatories is given in Table I, and illustrated in Figure 1.

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

**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), pp. 6,13.

Table 2 summarizes the measurements made of the principal phases from the COMMODORE 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 wave motion are also tabulated in (A/T) form. In addition, individual station Rayleigh wave areas (mm^2) is indicated as measured on the LPZ only. Although reduced to 1K magnification, they have not been normalized to any magnitude. Twenty-one stations recorded short-period and long-period signals from this event.

The unified magnitudes determined from the LRSM and VELA observatories are shown in Figure 2. The average magnitude is 5.68 $\pm$ 0.56. The adjusted unified magnitude is 5.41 $\pm$ 0.55 and is shown 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 COMMODORE was NP-NT at a distance of 4364 kilometers.

Code	Station	Distance (km)	Inst.	Magni-fication (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	Magnitude (m) mb	Magnitude (m) ms	Area(mm²) LPZ
MN-NV	Mina, Nevada	234	SPZ	0.296*	Pn		36.2	0.6	4846	5.94	5.63	
			SPZ	0.296*	Pg		38.7	0.5	23,236			
			SPT	0.415	Lg			0.6	45,053			
			LPZ	0.463	LR			10.0	17,893			863.93
			LPZ	0.463	*	9	55	11.0	5382			
KN-UT	Kanab, Utah	288	SPZ	0.344	Pn		43.2	0.6	3424	6.03	5.77	
			SPZ	0.344	*		44.5	0.6	4467			
			SPZ	0.344	*		48.0	0.5	11,576			
			SPZ	0.344	Pg		49.1	0.6	18,779			
			SPT	3.34	Lg			0.8	25,967			
			LPZ	0.817	LR			9.0	4125			122.40
			LPZ	0.817	*	[illegible]	01	(11.0)	(109)			
TFSO	Tonto Forest Seismological Observatory, Arizona	536	SPZ-60	5.5	Pn	1	15.1	0.3	477	6.03	5.74	
			SPZ-60	5.5	*	1	21.4	0.5	346			
			SPZ-60	1.0	Lg	1	29.1	0.75	1966			
			SPN	1.0	Lg			1.3	1419			
			SPZ	1.0	Lg			1.3	2995			
					LR			---	---			
			LPZ	4.0	*	11	30	16.0	111			
MO-ID	Mountain Home, Idaho	660	SPZ	16.89	Pn	1	30.8	0.45	423	6.22	6.00	
			SPZ	16.89	Pg	1	(49.0)	(0.4)	(5131)			
			SPT		Lg			---	---			
			LPT	8.26	LQ			11.0	(3543)			
			LPZ	1.28	LR			12.0	2510			342.31
			LPZ	13.9	*	12	22	(12.0)	(341)			
UBSO	Uinta Basin Seismological Observatory, Utah	667	SPZ-10	5.0	Pn	01	33.2	0.9	1327	6.72	6.59	
			SPZ-10	5.0	*	01	34.2	0.7	1007			
			SPZ-10	5.0	Pg	01	50.4	0.8	1610			
			SPN	0.9	Lg			1.2	5474			
			SPE	0.93	Lg			1.2	3632			
			LPZ	2.25	LQ			14.0	(111)			
			LPZ		LR			---	---			
			LPZ	1.88	*	12	23	15.0	113			
BMSO	Blue Mountain Seismological Observatory, Oregon	864	SPZ-3	25.0	Pn	01	56.5	0.45	96.4	5.93	5.66	
			SPZ-3	25.0	*	01	59.8	0.6	140			
			SPZ-3	25.0	Pg	02	23.4	---	---			
			SPN		Lg			---	---			
			SPZ		Lg			---	---			
			LPZ	1.0	LR			15.0	742			420.00
			LPZ	8.8	*	13	25	15.0	108			
FK-CO	Franktown, Colorado	1049	SPZ	30.0	Pn	02	19.4	(0.8)	(124)	(6.33)	(4.86)	
			SPZ	30.0	*	02	32.0	0.6	137			
			SPZ	30.0	Pg	02	59.5	1.2	1111			
			SPT	29.45	Lg			1.8	2495			
			LPT	4.2	LQ			12.0	2198			
			LPZ	0.627	LR			11.0	4116			398.72

			LPZ	1.0	LR			15.0	742			420.00
			LPZ	8.6	•	13	25	15.0	108			
FR-CO	Franktown, Colorado	1049	SPZ	30.0	Pn	02	19.4	(0.8)	(124)	(6.22)	(4.86)	
			SPZ	30.0	•	02	32.0	0.6	137			
			SPZ	30.0	Pg	02	59.5	1.2	3111			
			SPT	29.45	Lg			1.8	2495			
			LPT	4.2	LQ			12.0	2198			
			LPZ	0.627	LR			11.0	4116			398.72
			LPZ	0.627	•	14	25	12.0	452			
LAO	Sshurrey, AO-10 Monta...	1338	SPZ	87.7	Pn	02	52.8	(1.0)	(31.9)	(5.60)	(4.49)	
			SPZ	87.7	•	02	55.1	0.7	38.6			
			SPZ	87.7	•	02	(08.2)	0.9	117			
			SPZ	87.7	•	03	14.5	(1.1)	(159)			
			SPZ	87.7	(Pg)	02	40.6	(0.9)	(129)			
			LPZ		LR			---	---			
[illegible]ATX	San Angelo, Texas	1467	SPZ-2	60.0	P	03	11.5	(1.0)	(154)	(6.12)	(5.22)	
			SPZ-2	60.0	•	03	17.4	1.0	106			
			SPZ-2	60.0	PP	03	22.6	1.0	142			
			SPZ-2	60.0	•	03	31.4	1.2	159			
			SPZ-2	60.0	Pg	04	02.8	1.1	(354)			
			LPT	1.25	LQ			(13.0)	(384)			
			LPZ	1.35	LR			(12.0)	(2123)			218.09
			SPZ-2	60.0	•	12	17.8	3.4	(833)			
WMSO	Wichita Mountain Seismological Observatory, Oklahoma		SPZ-6	10.0	P	03	26.5	1.1	83.6	5.41	5.03	
			SPZ-6	35.0	•	03	34.5	(1.5)	(202)			
			SPZ-6	25.0	•	02	42.6	1.35	235			
			SPZ-6	25.0	Pg	04	29.5	0.9	216			
			SPN	10.5	Lg			(1.8)	(724)			
			SPE	10.0	Lg			([illegible])	(125)			
			LPN	1.0	LQ			15.0	294			
			LPZ	2.5	LR			15.0	352			280.00
			LPZ	24.0	•	17	23	16.0	40.2			
[illegible]TX	Streeter, Texas	1686	SPZ-1	112	P	03	36.5	0.8	41.2	[illegible].84	4.79	
			SPZ-1	112	•	03	38.1	0.8	55.8			
			SPZ-1	112	•	02	40.9	1.0	100			
			SPZ-1	112	Pg	04	(40.6)	0.8	62.6			
			LPZ	**	LR			12.0	**			
GRTX	Grit, Texas	1689	SPZ-1	472	P	02	37.0	0.8	32.5	4.74	4.70	
			SPZ-1	472	•	02	38.6	0.8	41.0			
			SPZ-2	112	•	03	42.2	1.0	102			
			SPZ-2	112	PP	02	49.7	0.9	51.9			
			SPZ-2	112	•	02	54.2	0.8	42.7			
			SPZ-2	112	(Pg)	04	50.9	1.2	104			
			LPT	9.05	LQ			15.0	226			
			LPZ	1.65	LR			13.0	1054			215.15
			SPZ-1	472	•	16	05.8	2.4	224			
			LPZ	9.2	•	17	51	12.0	125			

Principal Phases- COMMODORE

Table 2 - Page 1

1

2

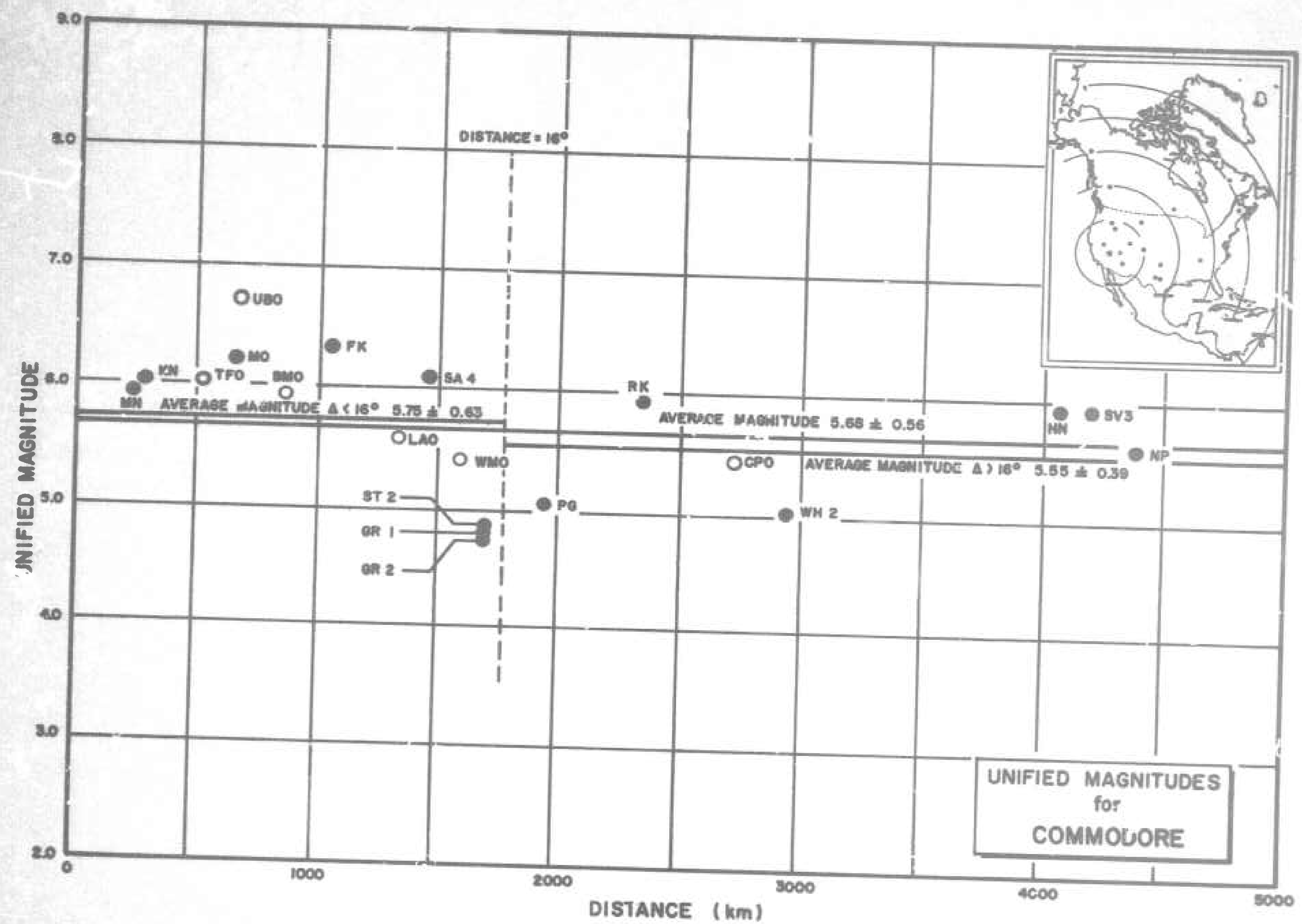
Code	Station	Distance (km)	Inst.	Magni-fication (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	Magnitude (m) mb	Magnitude (m) ms	Area (mm^2) LPZ
GRITX	Grit, Texas	1692	SPZ-1	122.5	P	03	37.4	0.8	38.7	4.80	4.73	
			SPZ-1	122.5	e	03	39.3	0.7	36.1			
			SPZ-1	122.5	(Pg)	04	41.8	1.2	152			
			LPT	0.5	LQ			15.0	336			
			LPZ	0.5	LR			12.0	1159			180.00
			LPZ	0.5	e	18	00	(12.0)	(151)			
SFLTX	Streeter, Texas	1696	SPZ-1	**	P	03	37.6	0.9	**			
			SPZ-1	**	e	03	42.4	0.8	**			
			SPZ-1	**	(Pg)	04	41.8	0.8	**			
			LPZ	0.17	LR			12.0	1519			176.47
PG-BC	Prince George, British Columbia, Canada	1940	SPZ	54.2	P	04	06.4	1.4	187	5.06		
			SPZ	54.2	e	04	09.5	1.3	511			
			SPZ	54.2	e	04	13.1	1.3	321			
			SPZ	54.2	PP	04	22.7	1.2	187			
			LPR	47.4	S	07	24	20.0	7.3			
			SPR	54.7	Lg			1.8	253			
			SPT	56.9	Lg			1.8	177			
			LPR	47.4	LQ			13.0	209			
			LPT	43.8	LQ			13.0	224			
			LPZ	5.6	LR			13.0	474			116.07
			LPZ	5.6	e	19	33	12.0	104			
RK-ON	Red Lake, Ontario, Canada	2340	SPZ	8.85	[illegible]	04	45.4	0.9	713	5.95		
			SPZ	8.85	e	05	3.3	1.1	199			
			LPT	51.9	S	08	37	11.0	36.7			
			SPT	8.92	Lg			(1.6)	(183)			
			LPT	51.9	LQ			12.0	163			
			LPZ	9.5	LR			12.0	391			125.26
			LPZ	93.0	e	21	37	12.0	102			
CPSO	Cumberland Plateau Seismological Observatory, Tenn.	2730	SPZ	40.0	P	05	21.8	0.85	115	5.47		
			SPZ	40.0	e	05	23.4	0.9	184			
			LPN	4.0	S	09	41	(15.0)	(22.9)			
			LPZ	2.6	S	09	41	15.0	44.6			
			SPN		Lg			---	---			
			LPN	4.0	LQ			17.0	83.3			
			LPZ	2.0	LR			15.0	824			350.00
			LPZ	2.0	e	23	(25)	12.0	158			
WH2YK	Whitehorse, Yukon Territory Canada	2942	SPZ	7.4	P	05	38.9	1.0	36.9	5.02		
			SPZ	47.4	e	05	40.9	0.85	41.4			
			SPZ	47.4	PP	06	28.0	1.2	36.3			
			SPZ	47.4	PcP	09	(04.2)	0.7	5.4			
			SPT	36.7	Lg			(2.6)	(151)			
			LPT	17.2	LQ			18.0	[illegible]			

			LPN	4.0	LQ			17.0	83.3			
			LPZ	2.0	LR			15.0	824			
			LPZ	2.0	e	23	(25)	12.0	158			350.00
WH2YK	Whitehorse, Yukon Territory Canada	2942	SPZ	47.4	P	05	38.9	1.0	36.9	5.02		
			SPZ	47.4	e	05	40.9	0.85	41.4			
			SPZ	47.4	PP	06	28.0	1.2	36.3			
			SPZ	47.4	PcP	09	(04.2)	0.7	5.4			
			SPT	36.7	Lg			(2.6)	(151)			
			LPT	17.2	LQ			18.0	120			
			LPZ	1.94	LR			14.0	590			
			LPZ	19.3	e	25	11	15.0	43.5			256.44
HN-ME	Houlton, Maine	4065	SPZ	40.7	P	07	07.7	1.3	222	5.89		
			SPZ	40.7	e	07	20.0	1.0	43.0			
			SPZ	40.7	e	07	23.6	0.95	39.3			
			SPZ	40.7	PP	08	(28.1)	1.4	43.8			
			SPZ	40.7	PcP	09	(30.6)	0.8	13.0			
			LPT	40.9	LQ			(15.0)	(183)			
			LPZ	1.88	LR			15.0	229			
			LPZ	20.8	e	30	45	17.0	36.5			119.68
SV3QB	Schefferville, Quebec Canada	4186	SPZ	54.4	P	07	15.9	1.2	240	5.88		
			SPZ	54.4	e	07	18.0	1.0	239			
			SPZ	54.4	e	07	20.2	1.0	115			
			SPZ	54.4	PP	08	39.8	0.8	30.4			
			SPR	59.0	Lg			(1.[illegible])	(49.0)			
			SPT	[illegible]6.2	Lg			(1.5)	(48.0)			
			LPR	28.6	LQ			14.0	62.5			
			LPT	26.2	LQ			13.0	55.9			
			LPZ	17.9	LR			14.0	264			149.72
MP-NT	Mould Bay, Northwest Territories, Canada	4364	SPZ-1	134.0	P	07	30.4	0.85	161	5.61		
			SPZ-1	134.0	e	07	33.5	1.0	59.7			
			SPZ-1	134.0	PP	08	59.6	1.40	107			
			SPZ-1	134.0	PcP	09	38.6	0.8	21.5			
			SPZ-1	134.0	e	09	40.2	1.0	31.7			
			SPT	105.0	S	13	27.0	(1.4)	(43.5)			
			SPT	105.0	Lg			2.8	283			
			LPT	9.56*	LQ			17.0	139			
			LPZ	11.47*	LR			16.0	295			209.21

A/T mu/sec
() Doubtful Values or Phases
* Measurements Made from Playouts
— Maximum Amplitudes Clipped on Film and Tape
** Magnification Unreliable

2

Principal Phases- COMMODORE
Table 2 - Page 2



UNIFIED MAGNITUDES for COMMODORE
UNIFIED MAGNITUDE
DISTANCE (km)
DISTANCE = 16°
AVERAGE MAGNITUDE Δ < 16° 5.75 ± 0.63
AVERAGE MAGNITUDE 5.68 ± 0.56
AVERAGE MAGNITUDE Δ > 16° 5.55 ± 0.39
UBO
MO
FK
KN
TFO
BMO
MN
SA 4
LAO
WMO
ST 2
GR 1
GR 2
PG
RK
CPO
WH 2
HN
SV3
NP
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
0
1000
2000
3000
4000
5000

Figure 2

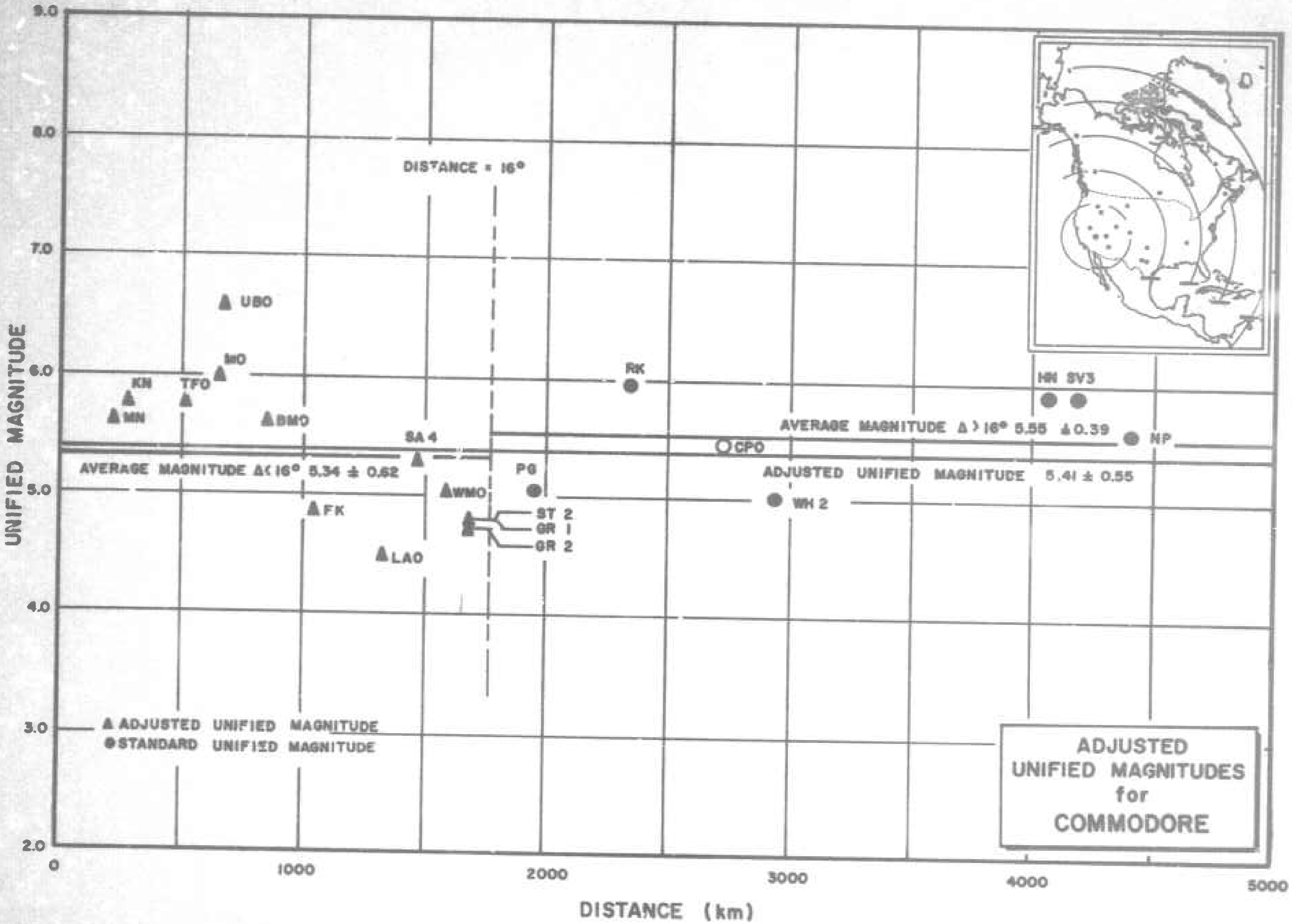

ADJUSTED
UNIFIED MAGNITUDES
for
COMMODORE
UNIFIED MAGNITUDE
DISTANCE (km)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
0
1000
2000
3000
4000
5000
DISTANCE = 16°
AVERAGE MAGNITUDE Δ< 16° 5.34 ± 0.62
AVERAGE MAGNITUDE Δ > 16° 5.55 ± 0.39
ADJUSTED UNIFIED MAGNITUDE 5.41 ± 0.55
▲ ADJUSTED UNIFIED MAGNITUDE
● STANDARD UNIFIED MAGNITUDE
UBO
MO
KN
TFO
MN
BMO
SA 4
WMO
FK
LAO
ST 2
GR 1
GR 2
PG
RK
CPO
WH 2
HN
SV3
NP

Figure 3

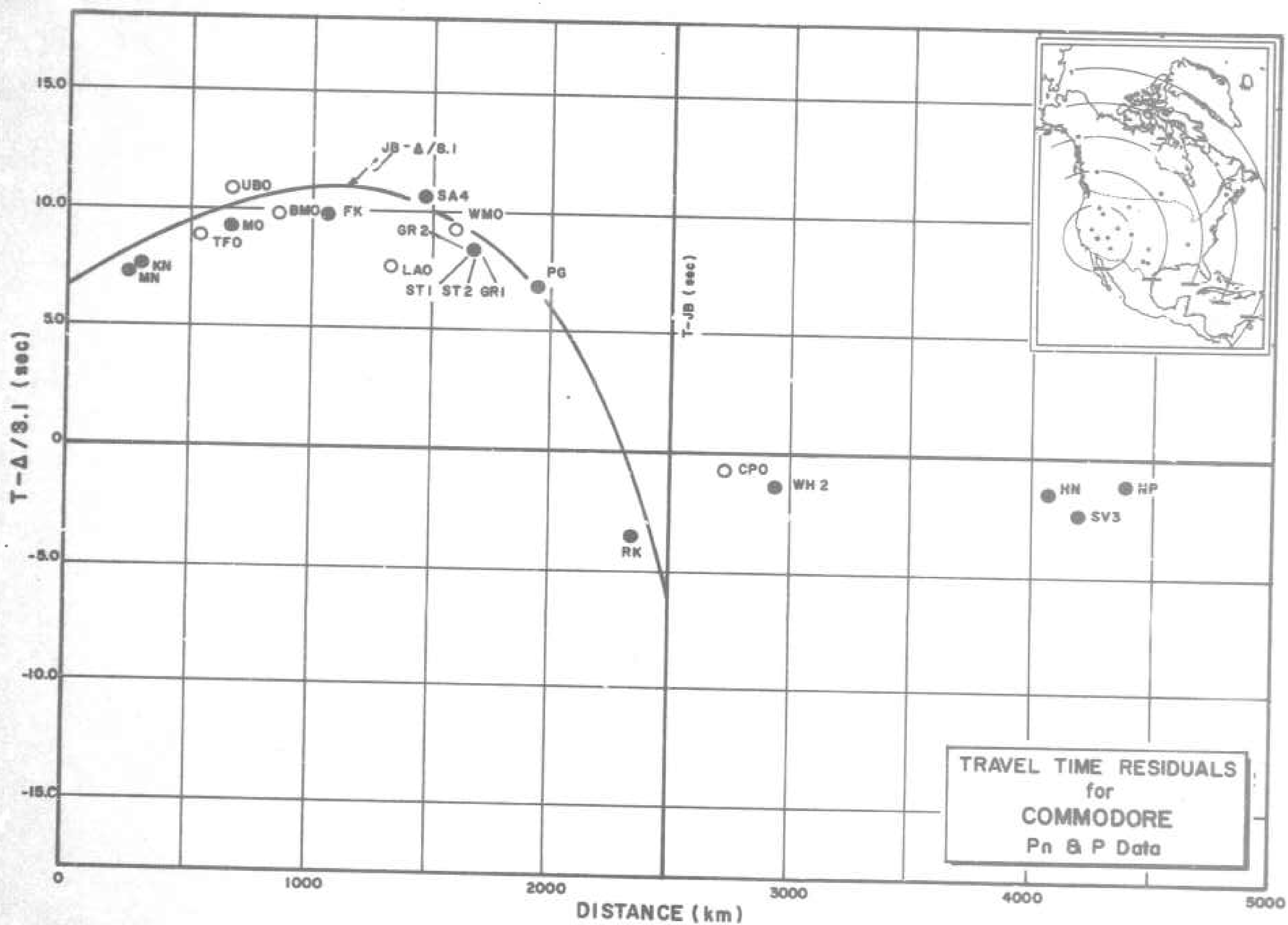
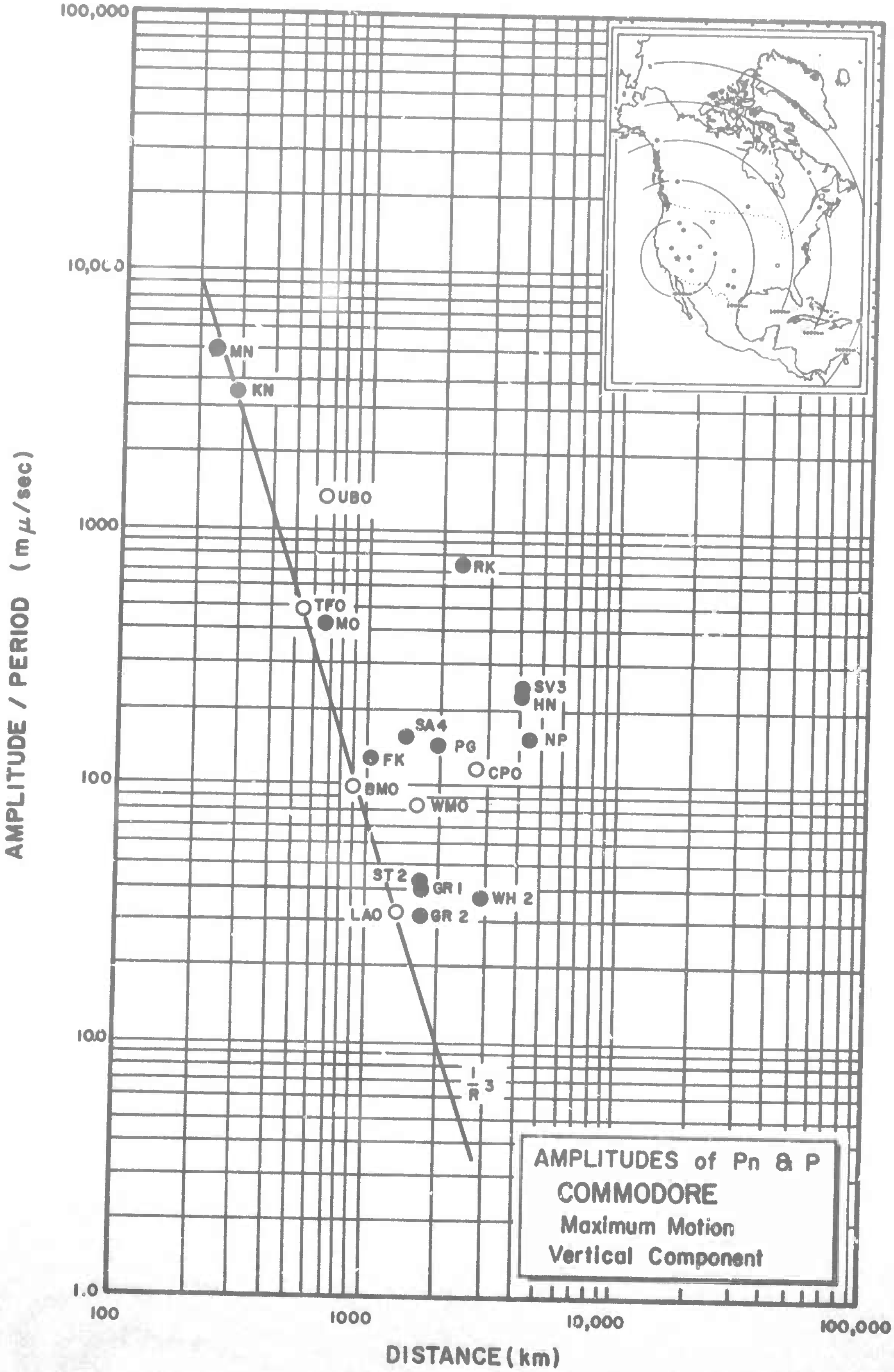

TRAVEL TIME RESIDUALS
for
COMMODORE
Pn & P Data
T-Δ/8.1 (sec)
DISTANCE (km)
T-JB (sec)
JB-Δ/8.1
15.0
10.0
5.0
0
-5.0
-10.0
-15.0
0
1000
2000
3000
4000
5000
UBO
BMO
FK
SA4
WMO
GR 2
MO
TFO
KN
MN
LAO
ST1
ST2
GR1
PG
RK
CPO
WH 2
HN
HP
SV3

Figure 4



AMPLITUDES of Pn & P
COMMODORE
Maximum Motion
Vertical Component
AMPLITUDE / PERIOD (mμ/sec)
DISTANCE (km)
100,000
10,000
1000
100
10.0
1.0
100
1000
10,000
100,000
MN
KN
UBO
RK
TFO
MO
SV3
HN
NP
SA4
PG
FK
CPO
BMO
WMO
ST 2
GR I
WH 2
LAO
GR 2

Figure 5

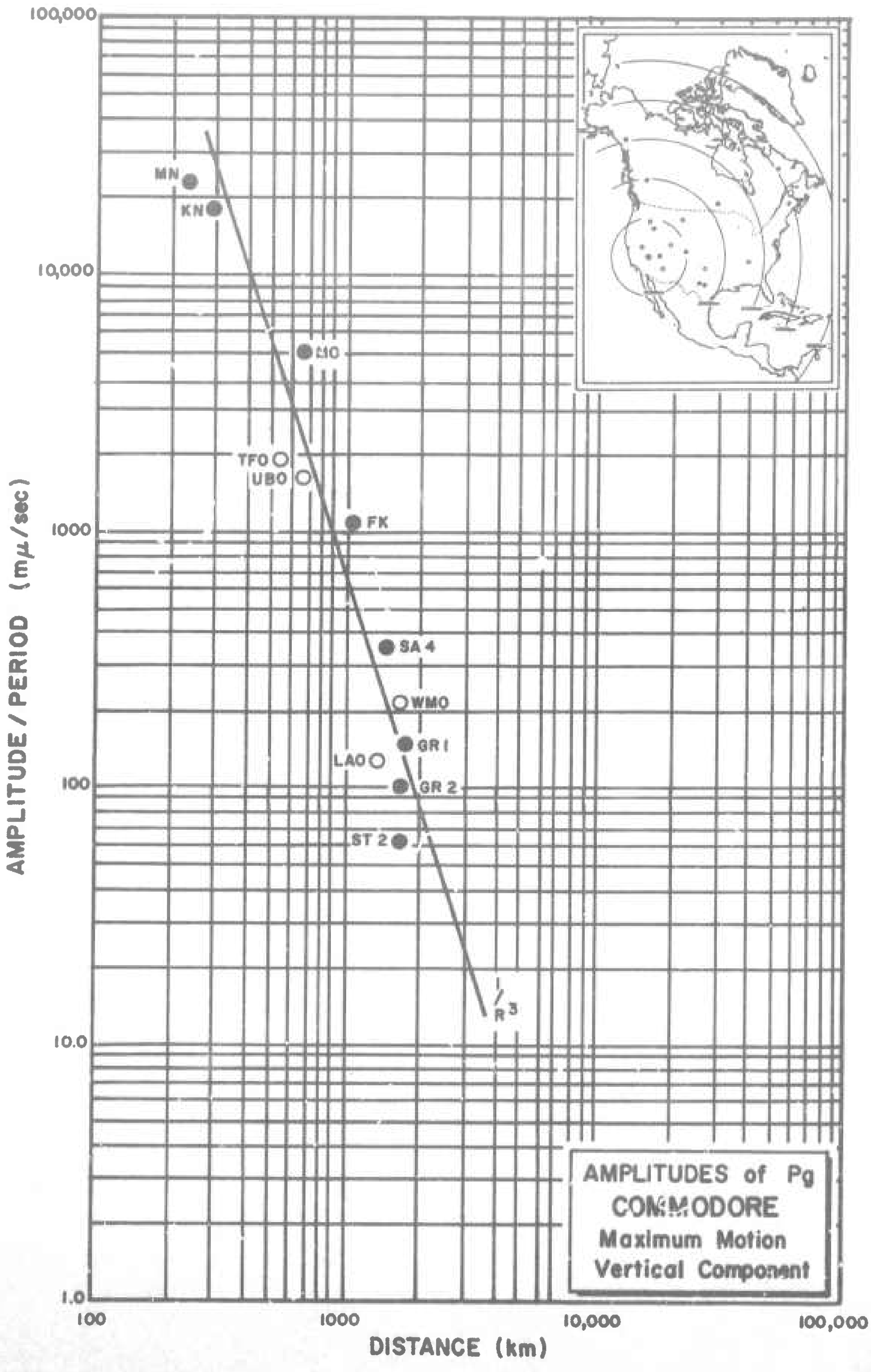

100,000
10,000
1000
100
10.0
1.0
AMPLITUDE / PERIOD (mμ/sec)
100
1000
10,000
100,000
DISTANCE (km)
MN
KN
TFO
UBO
FK
SA 4
WMO
GR I
LAO
GR 2
ST 2
1/R3
AMPLITUDES of Pg
COMMODORE
Maximum Motion
Vertical Component

Figure 6

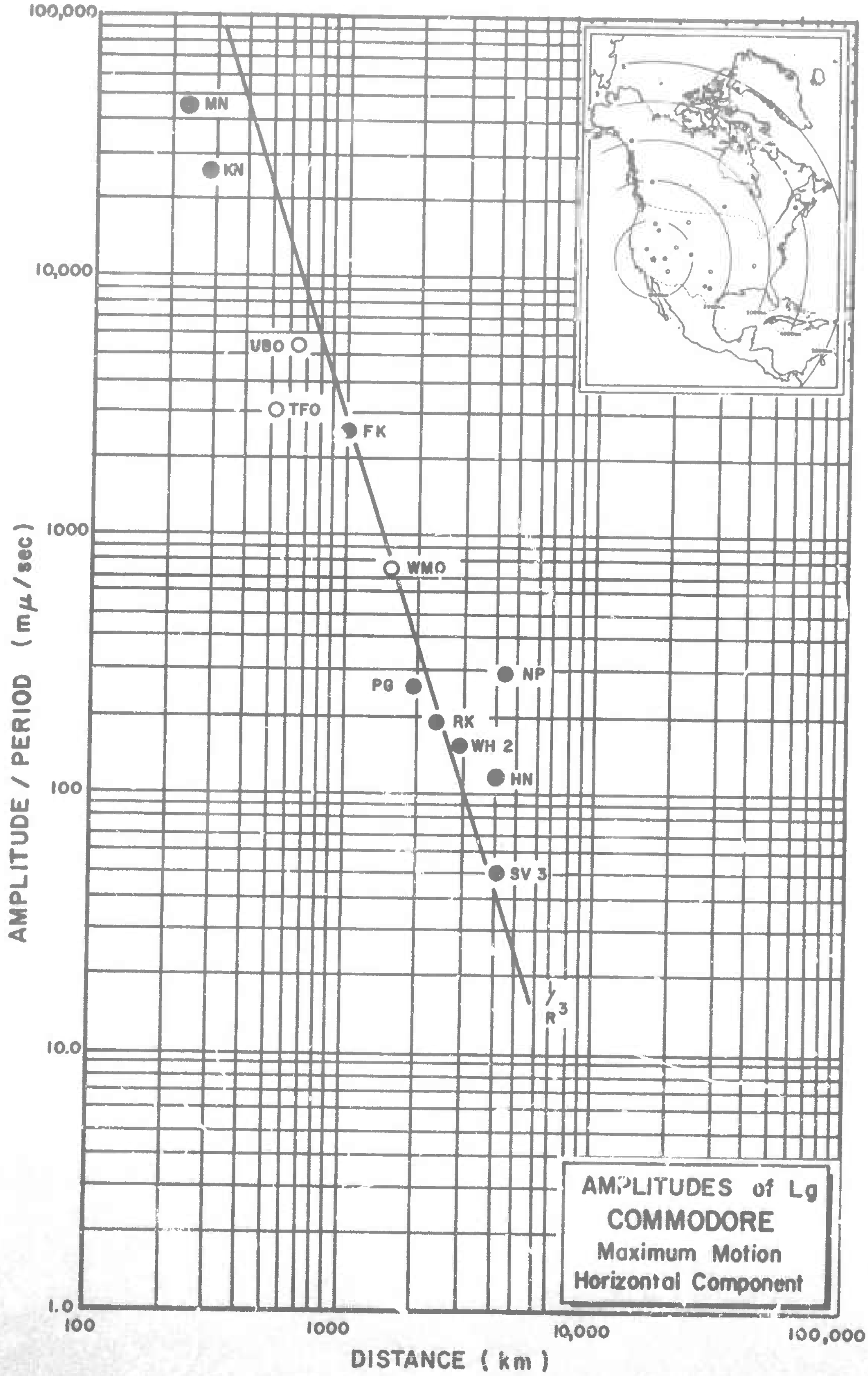

100,000
10,000
1000
100
10.0
1.0
AMPLITUDE / PERIOD (mμ/sec)
100
1000
10,000
100,000
DISTANCE (km)
MN
KN
UBO
TFO
FK
WMO
NP
PG
RK
WH 2
HN
SV 3
1/R³
AMPLITUDES of Lg
COMMODORE
Maximum Motion
Horizontal Component

Figure 7

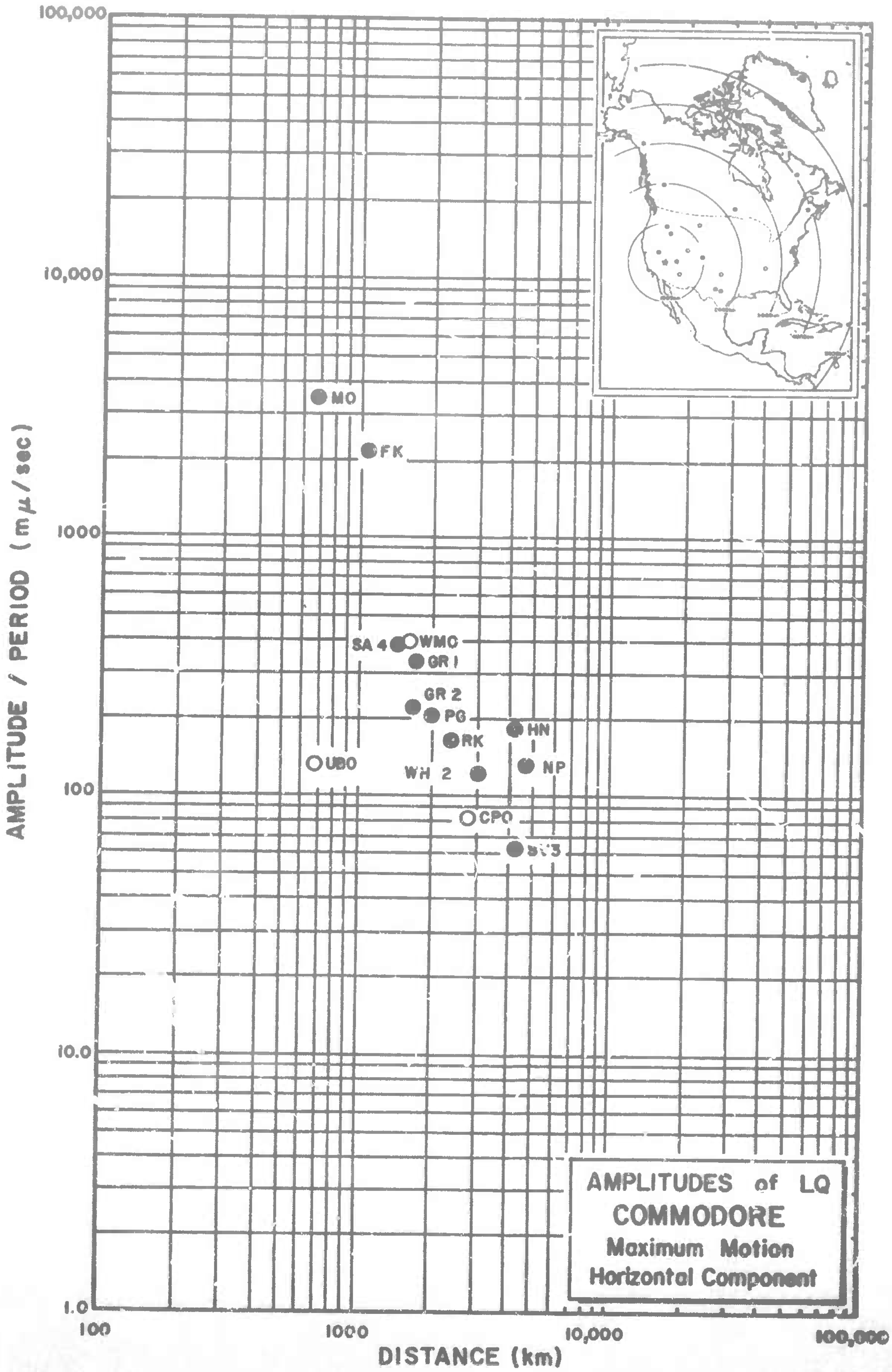
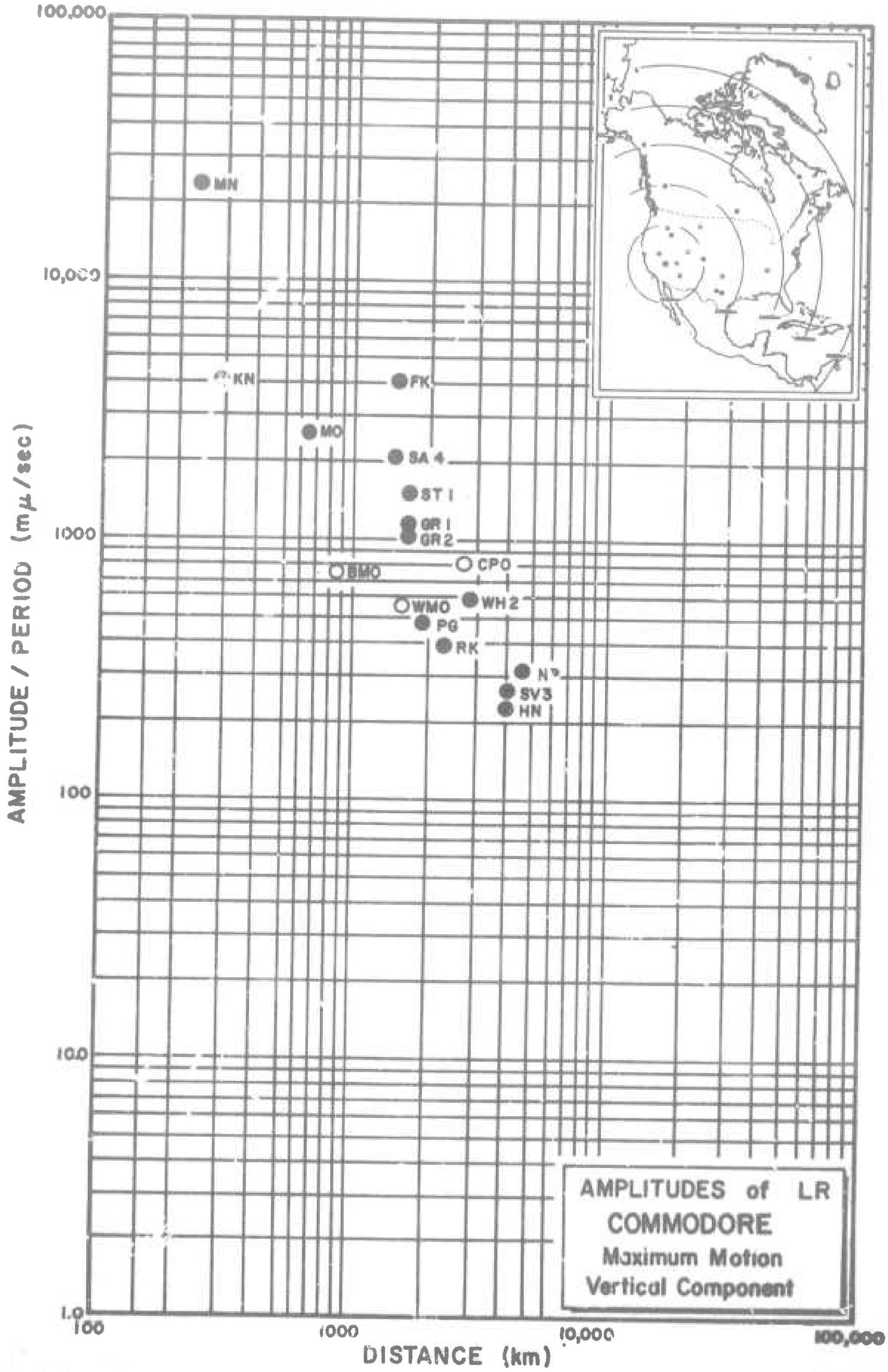

AMPLITUDE / PERIOD (mμ/sec)
DISTANCE (km)
100,000
10,000
1000
100
10.0
1.0
100
1000
10,000
100,000
MO
FK
SA 4
WMO
GR 1
GR 2
PG
HN
RK
UBO
WH 2
NP
CPO
AMPLITUDES of LQ
COMMODORE
Maximum Motion
Horizontal Component

Figure 8



100,000
10,000
1000
100
10.0
1.0
100
1000
10,000
100,000
AMPLITUDE / PERIOD (mμ/sec)
DISTANCE (km)
MN
KN
FK
MO
SA 4
ST I
GR I
GR 2
CPO
BMO
WMO
WH 2
PG
RK
SV3
HN
AMPLITUDES of LR
COMMODORE
Maximum Motion
Vertical Component

Figure 9

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.		
MN-NV	Mina, Nevada	234	38°26'10" N	118°08'53" W	1.52	309°	128°	308°	38°	L	X
KN-UT	Kanab, Utah	288	37°01'22" N	112°49'39" W	1.74	91°	273°	95°	185°	L	X
TFSO-Z60*	Tonto Forest Seismological Observatory, Arizona	536	34°17'12" N	111°16'03" W	1.49	125°	307°	90°	0°	JM	X
MO-ID	Mountain Home, Idaho	660	43°04'19" N	116°15'56" W	0.79	359°	178°	359°	89°	L	X
UBSO-Z10*	Uinta Basin Seismological Observatory, Utah	667	40°19'1[illegible]" N	109°34'07" W	1.60	56°	240°	90°	0°	JM	X
BMSO-Z3*	Blue Mountain Seismological Observatory, Oregon	864	44°50'56" N	117°18'20" W	1.19	353°	173°	0°	90°	JM	X
FK-CO	Franktown, Colorado	1049	39°35'12" N	104°27'42" W	1.80	71°	259°	79°	169°	L	X
LAO*	Subarray, AO-10, Montana	1338	46°41'19" N	106°13'20" W	0.90	34°	221°	90°	0°	HSZ	X
SA4TX	San Angelo, Texas	1466	31°49'29" N	101°25'29" W	0.79	109°	298°	118°	208°	Geotech	X
WMSO-Z6*	Wichita Mountain Seismological Observatory, Okla.	1597	34°43'05" N	98°35'21" W	0.51	94°	285°	90°	0°	JM	
ST2TX	Streeter, Texas	1606	30°47'32" N	99°26'52" W	0.58	110°	299°	119°	209°	Geotech	X
GR2TX	Grit, Texas	1689	30°47'11" N	99°24'58" W	0.55	110°	299°	119°	209°	Geotech	X
GR1TX	Grit, Texas	1692	30°46'40" N	99°23'03" W	0.52	110°	299°	119°	209°	Geotech	X
ST1TX	Streeter, Texas	1696	30°45'08" N	99°21'20" W	0.52	110°	299°	119°	209°	Geotech	X
PG-BC*	Prince George, British Columbia, Canada	1940	53°5[illegible]'50" N	122°31'23" W	0.91	347°	163°	110°	200°	L	X
RK-ON	Red Lake, Ontario, Canada	2340	50°50'20" N	93°40'20" W	0.37	42°	238°	58°	148°	S	X
CPSO-Z8*	Cumberland Plateau Seismological Observatory, Tenn.	2731	35°35'41" N	85°34'13" W	0.57	84°	283°	90°	0°	JM	X
WH2YK	Whitehorse, Yukon Territory, Canada	[illegible]342	60°41'41" N	134°58'02" W	0.85	339°	144°	325°	55°	L	X
HN-ME	Houlton, Maine	4065	46°09'43" N	67°59'09" W	0.21	60°	273°	93°	183°	S	X
SV3QB*	Schefferville, Quebec, Canada	4186	54°48'39" N	66°45'00" W	0.58	46°	263°	139°	229°	S	X
MP-NT	Mould Bay, Northwest Territories, Canada	4364	76°15'08" N	119°22'18" W	0.06	359°	176°	356°	86°	JMZ S	X

* Seismometer Not Oriented Toward NTS

Recording Site Information
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

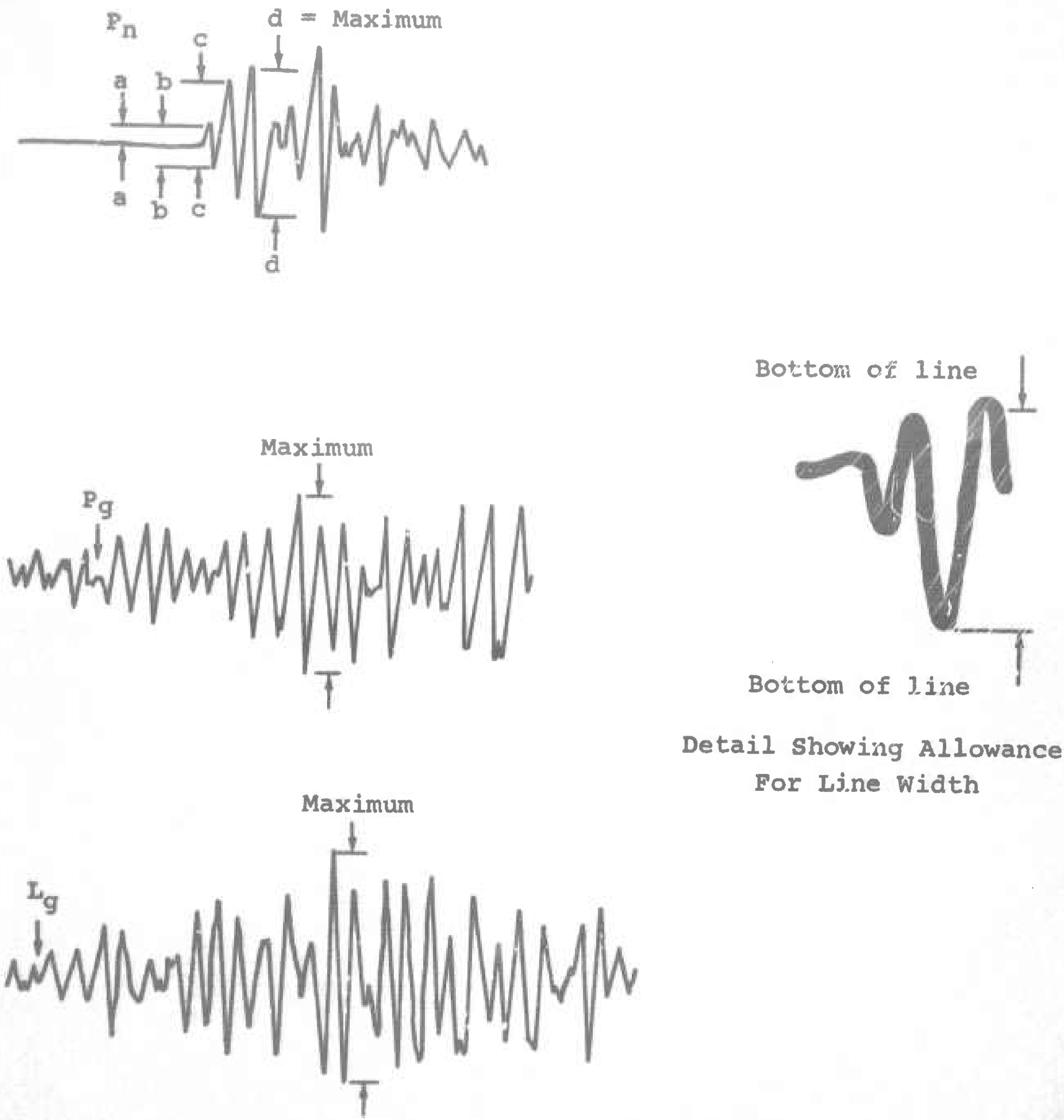
B = distance factor (see Table below)

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

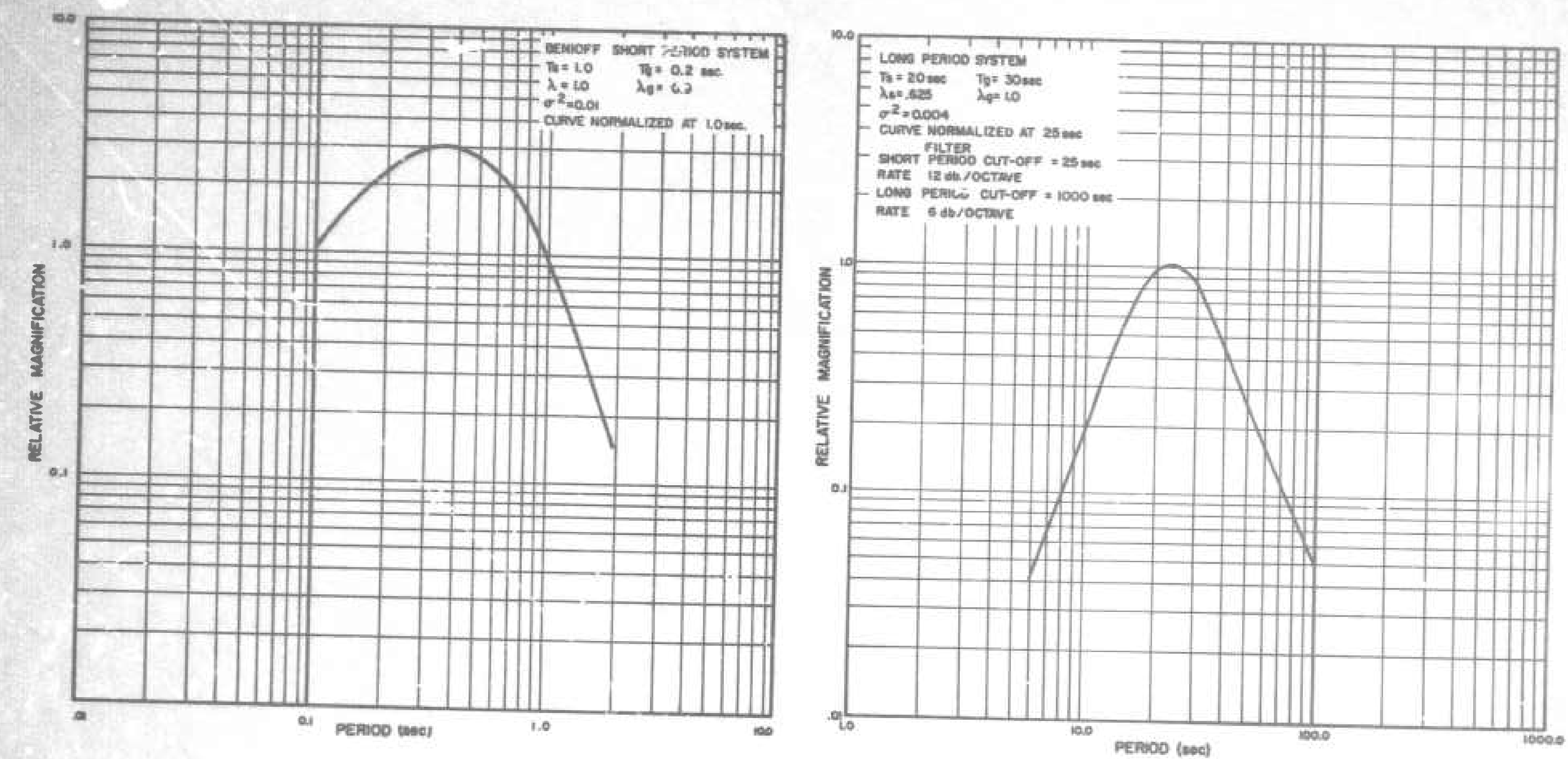
Pick <u>time</u> of <u>Pn</u> at beginning of "a" half cycle.

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.

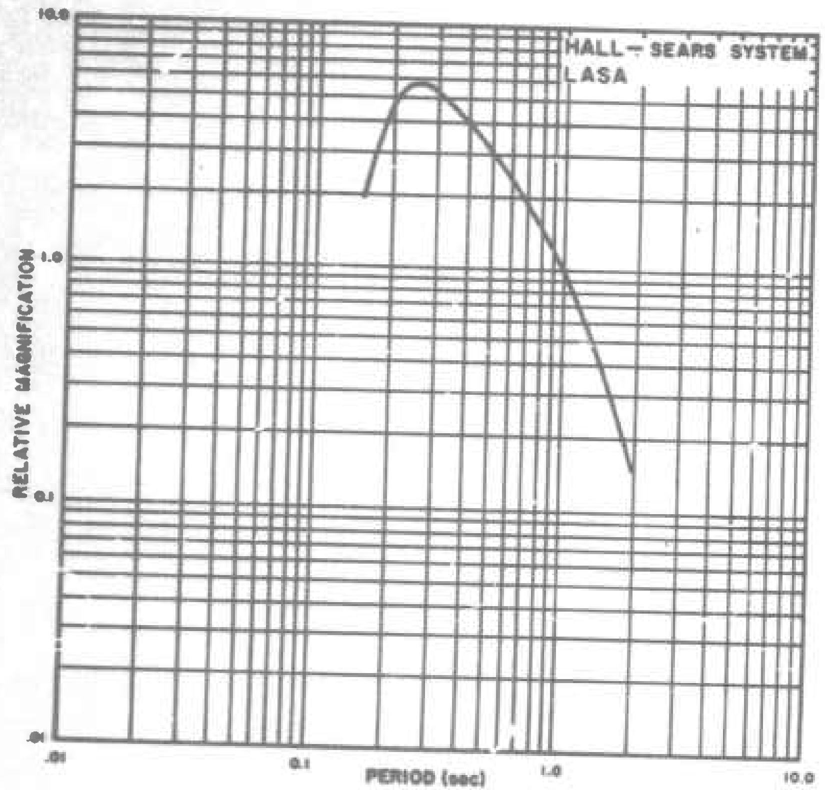
Seismic Analysis Diagram

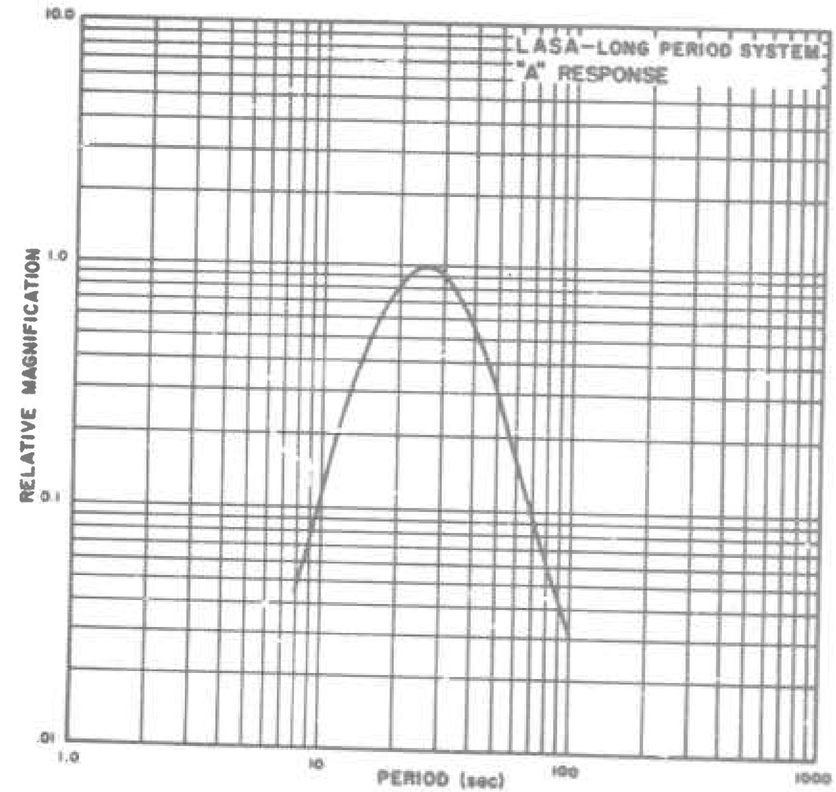
APPENDIX II(A)



INSTRUMENT RESPONSE CURVES - LRSM

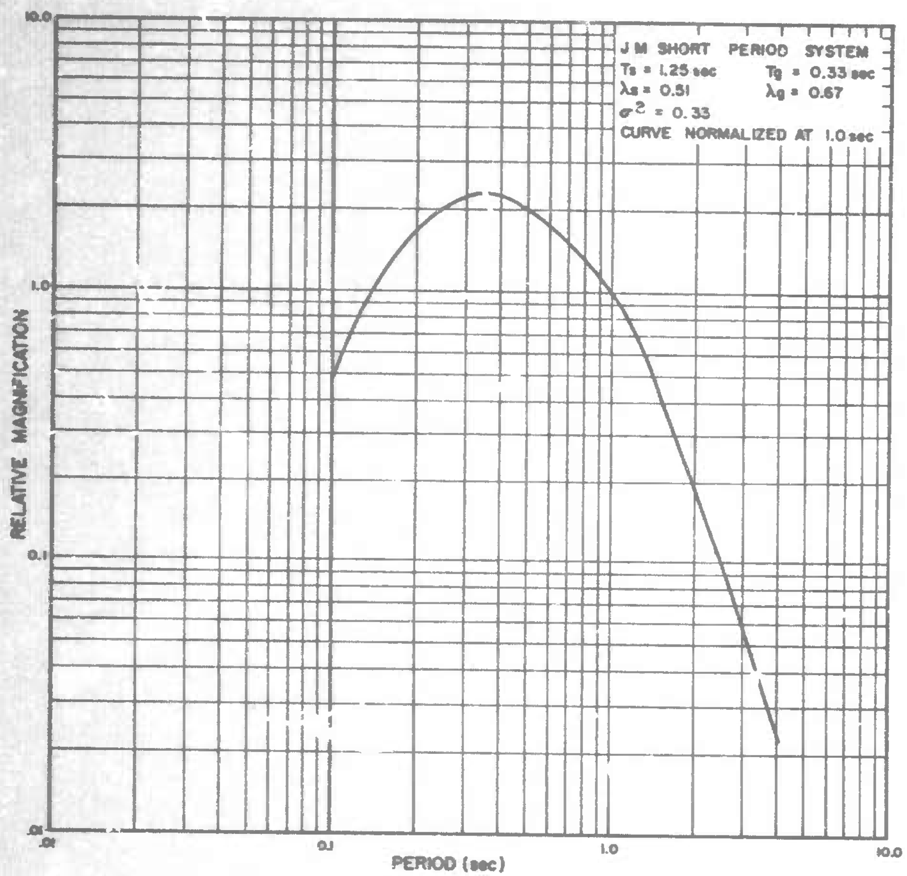
APPENDIX II(B)

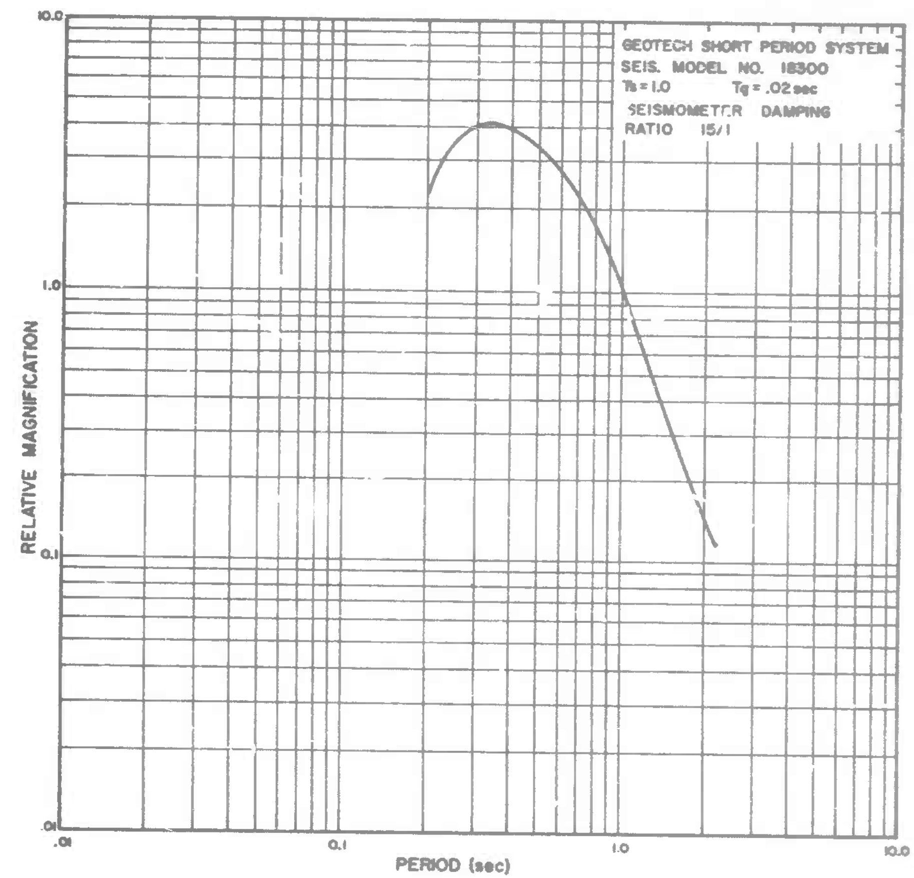




INSTRUMENT RESPONSE CURVE - LASA

APPENDIX II(C)





INSTRUMENT RESPONSE CURVES - OTHER SHORT PERIOD

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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3. REPORT TITLE

Long Range Seismic Measurements - COMMODORE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Scientific

5. AUTHOR(S) (Last name, first name, initial)

Clark, Don M.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 14, 1967	26	2

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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.

Unclassified

Security Classification

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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GPO 886-551

Unclassified

Security Classification

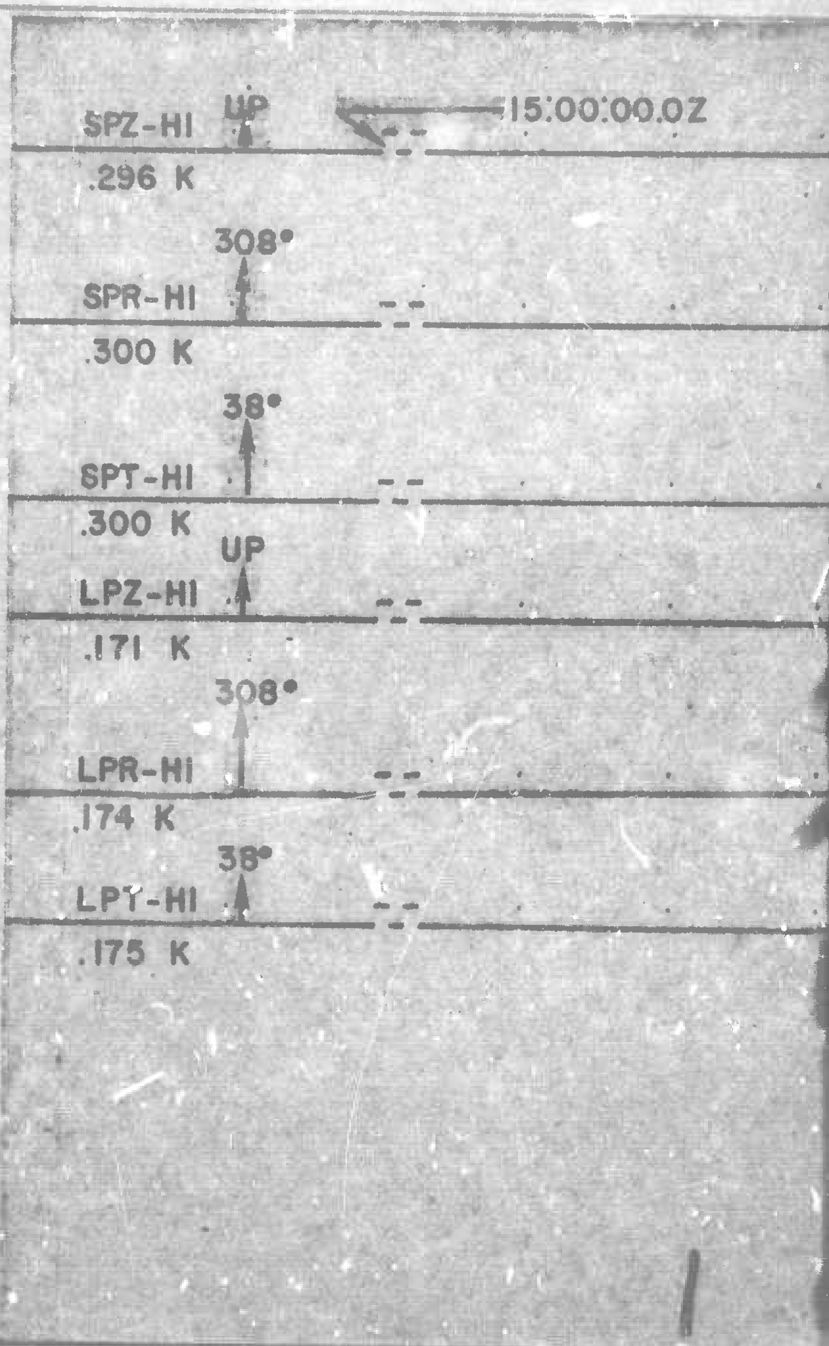
COMMODORE

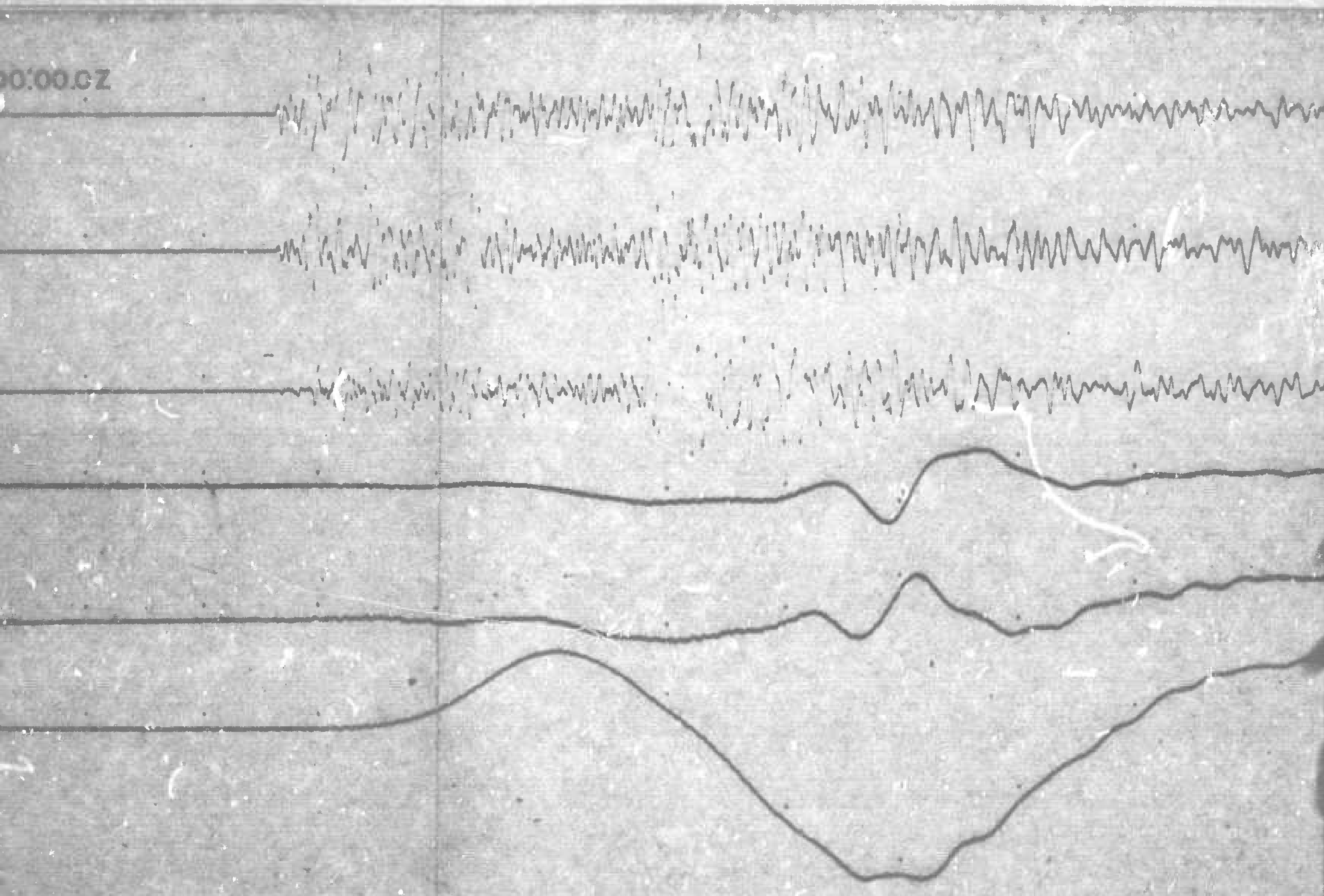
MN-NV

MINA, NEVADA

20 MAY 1967

Δ = 254 km

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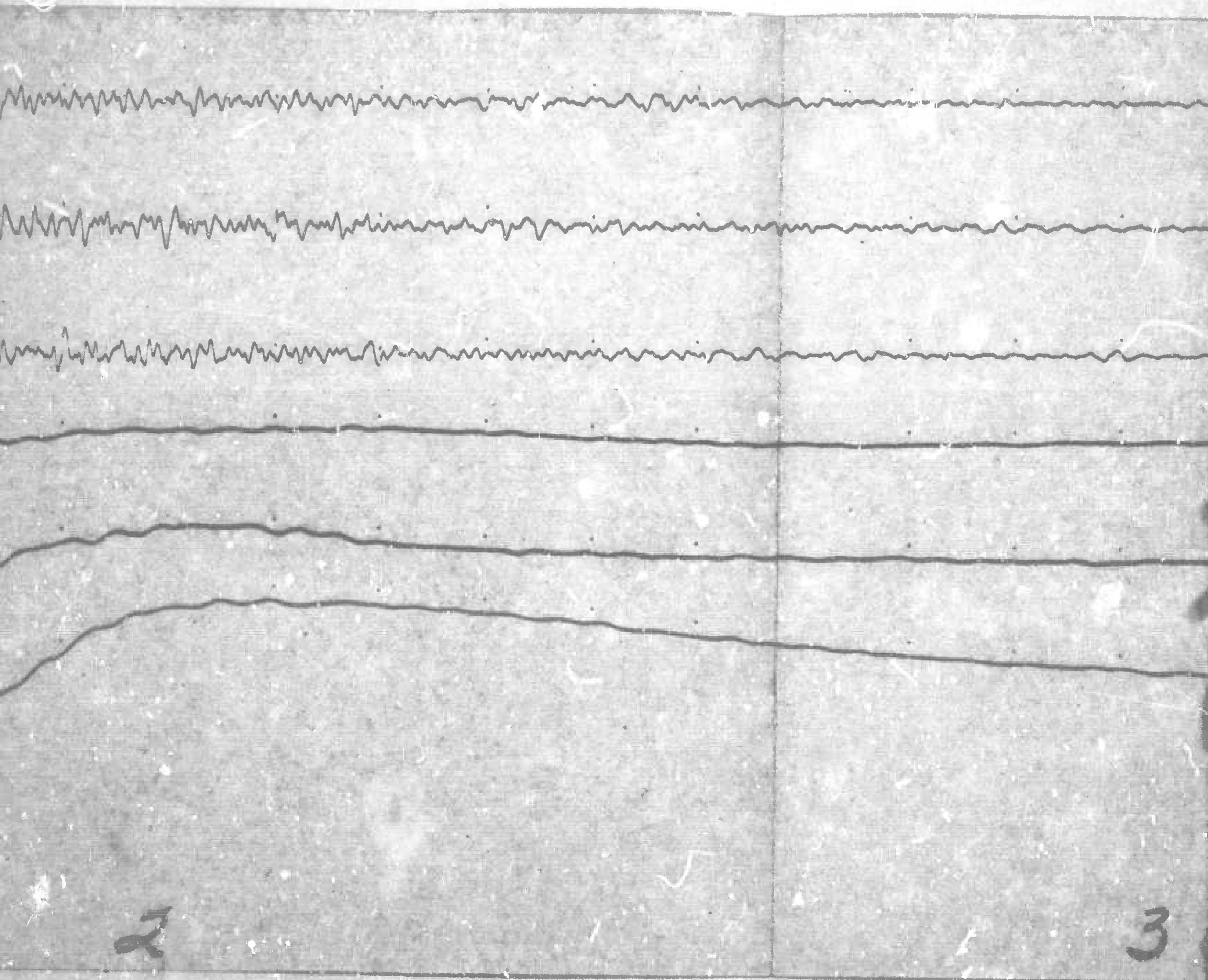

2
3

3

4

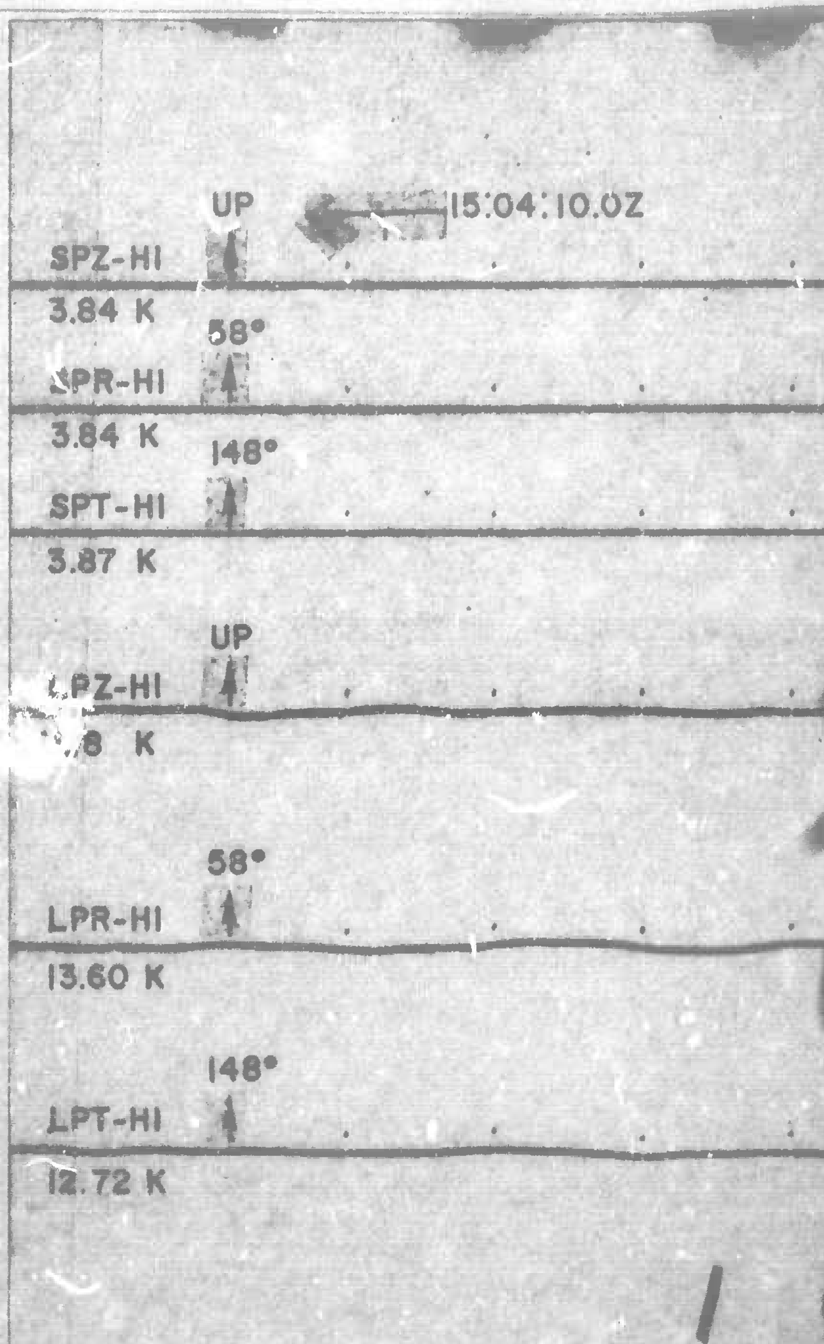
COMMODORE

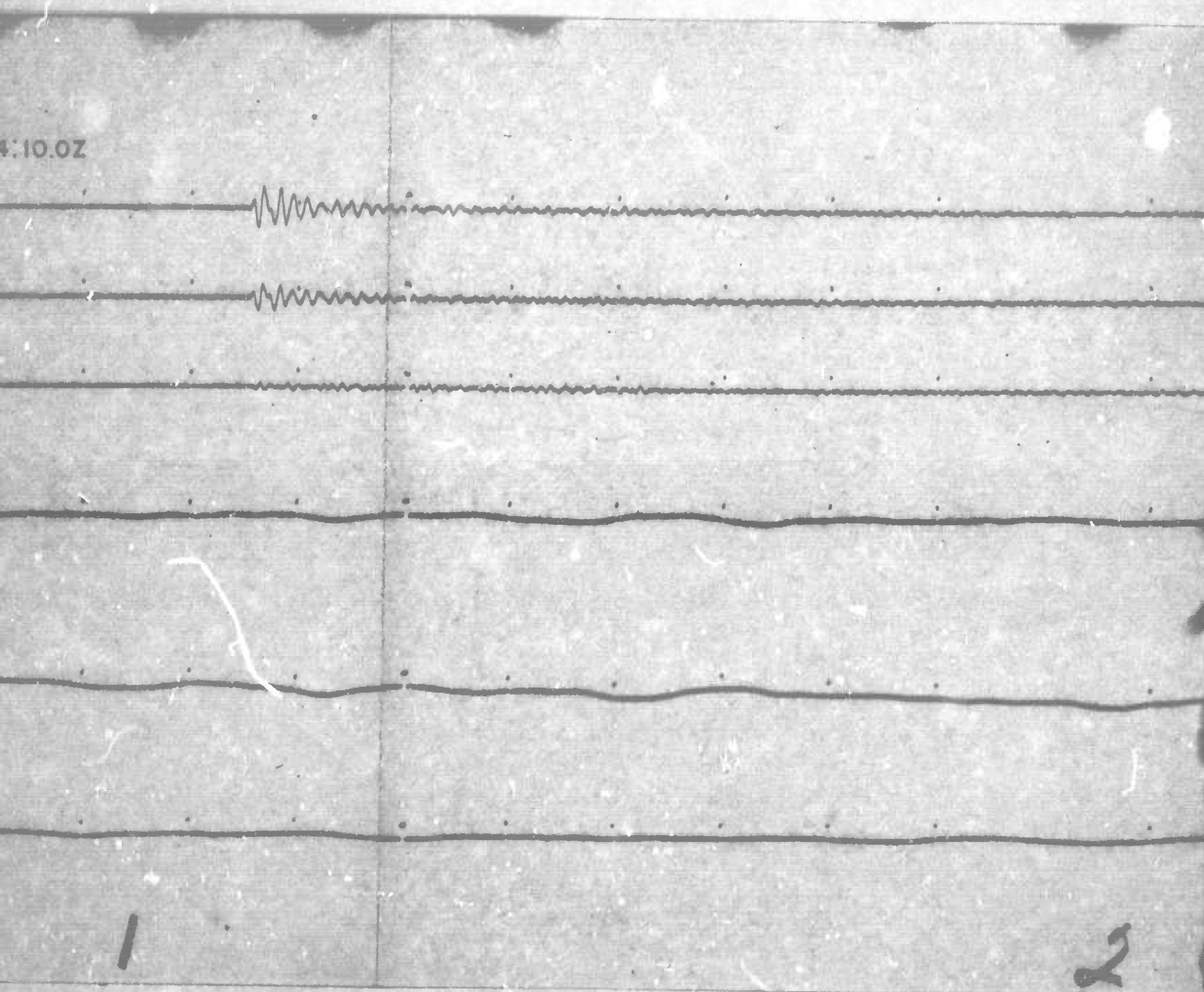
RK-ON

RED LAKE, ONTARIO, CANADA

20 MAY 1967

Δ = 2340 km

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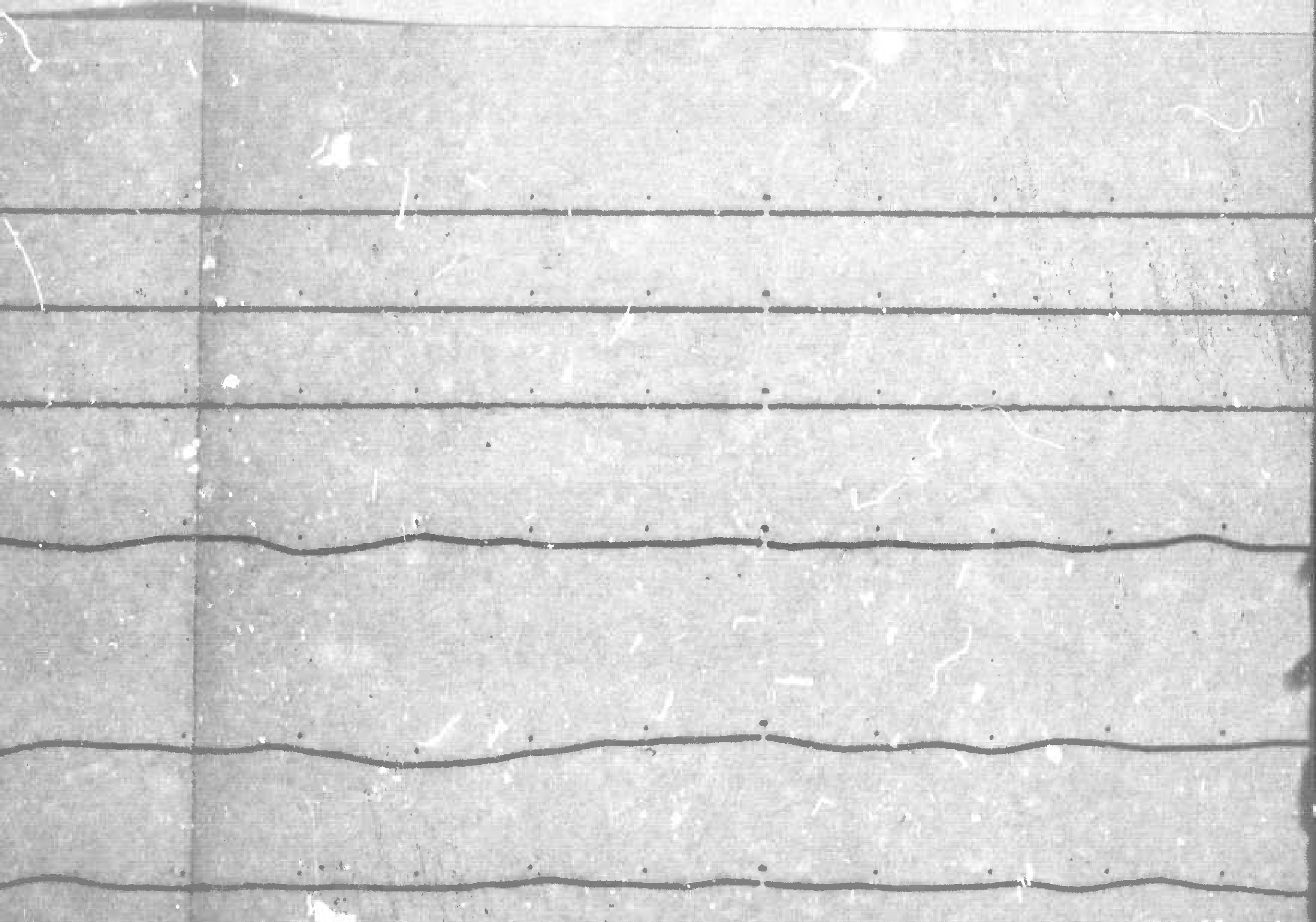
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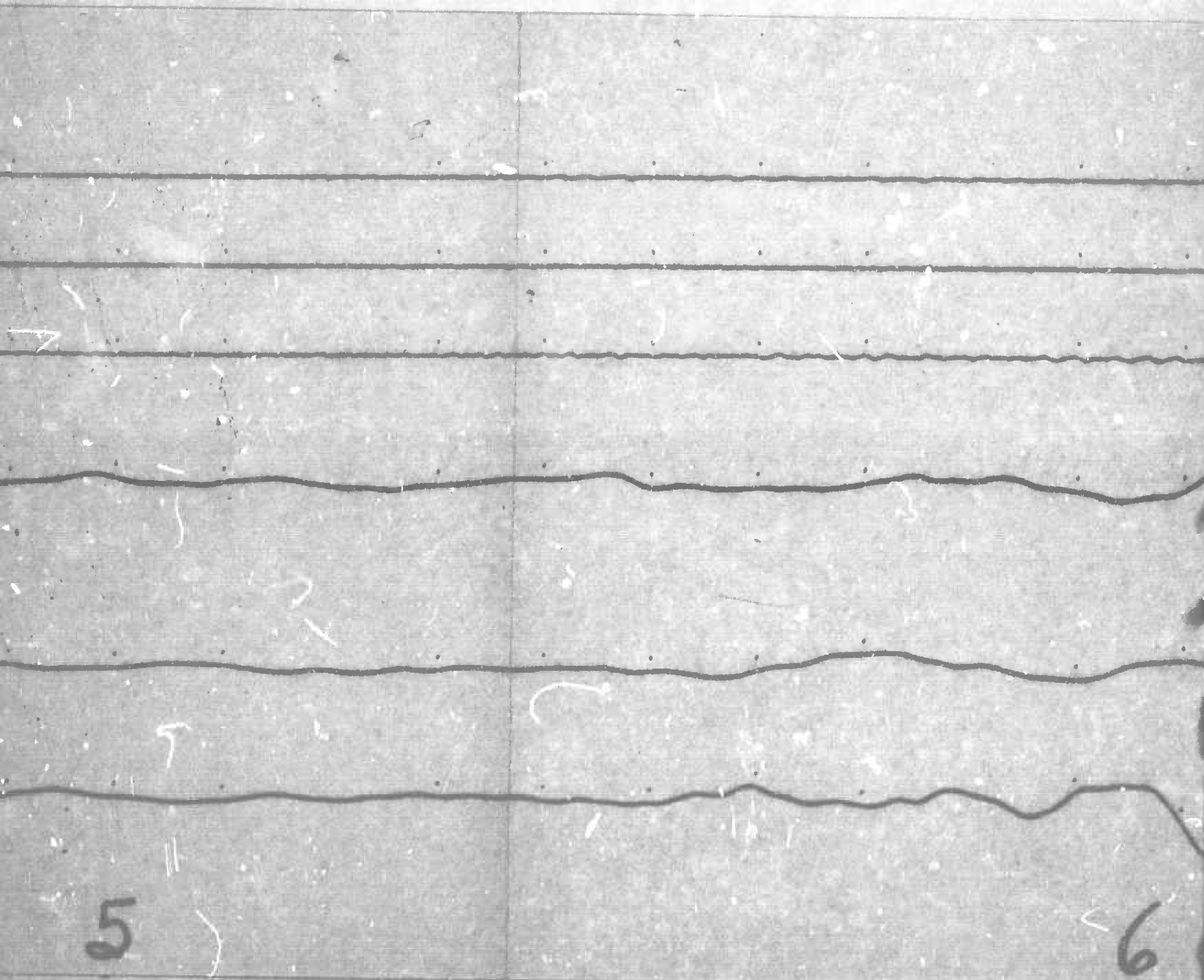
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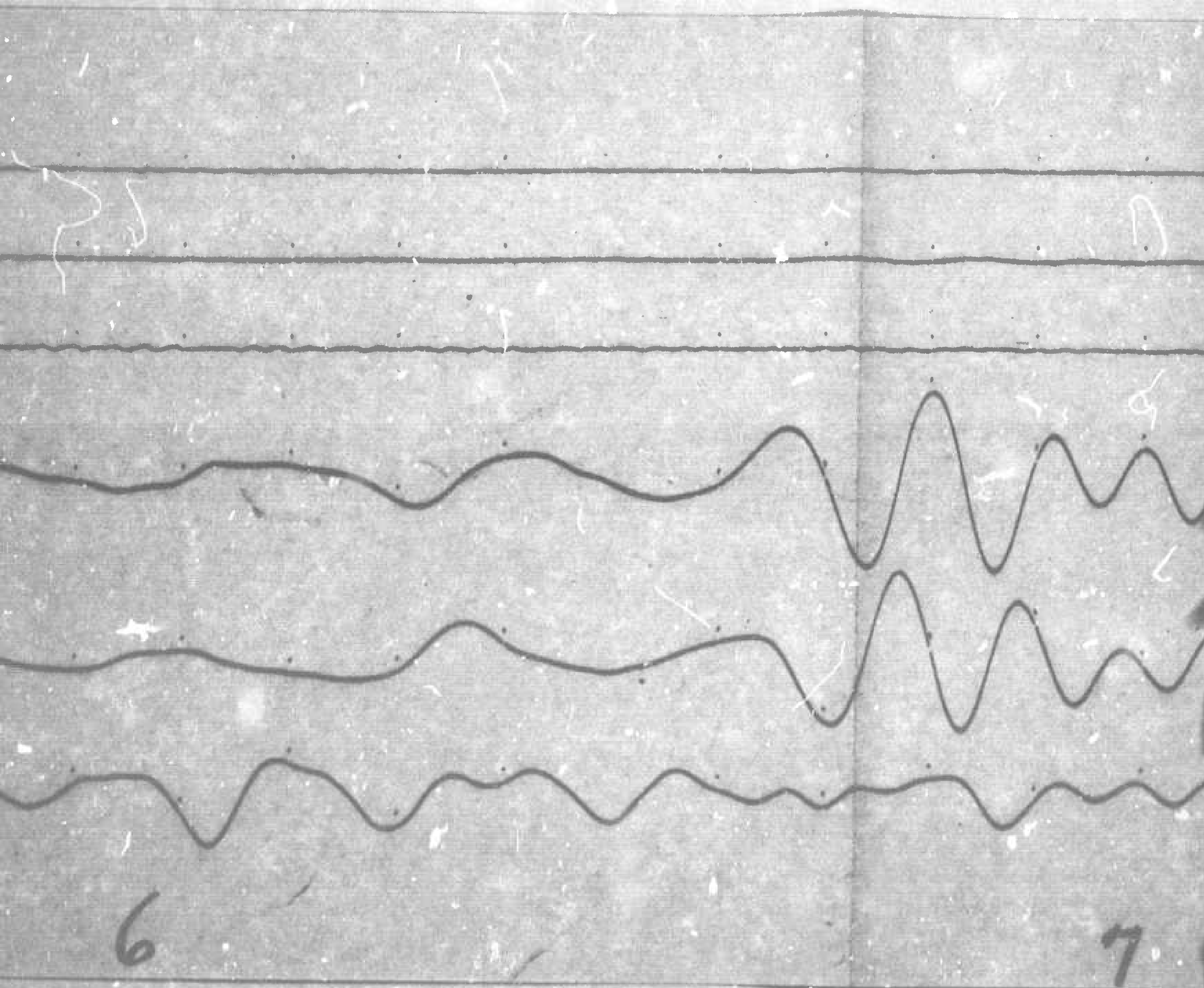
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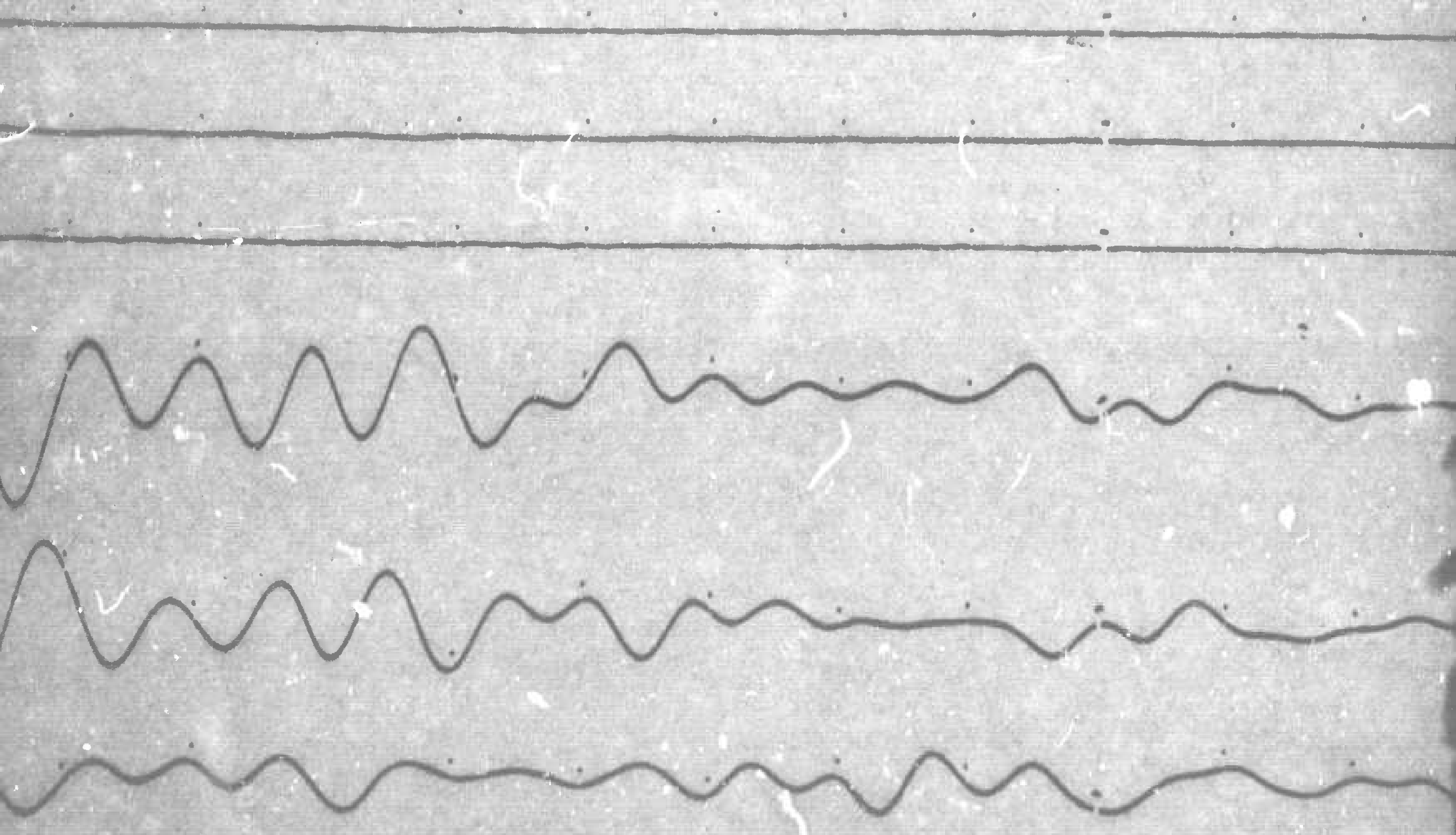

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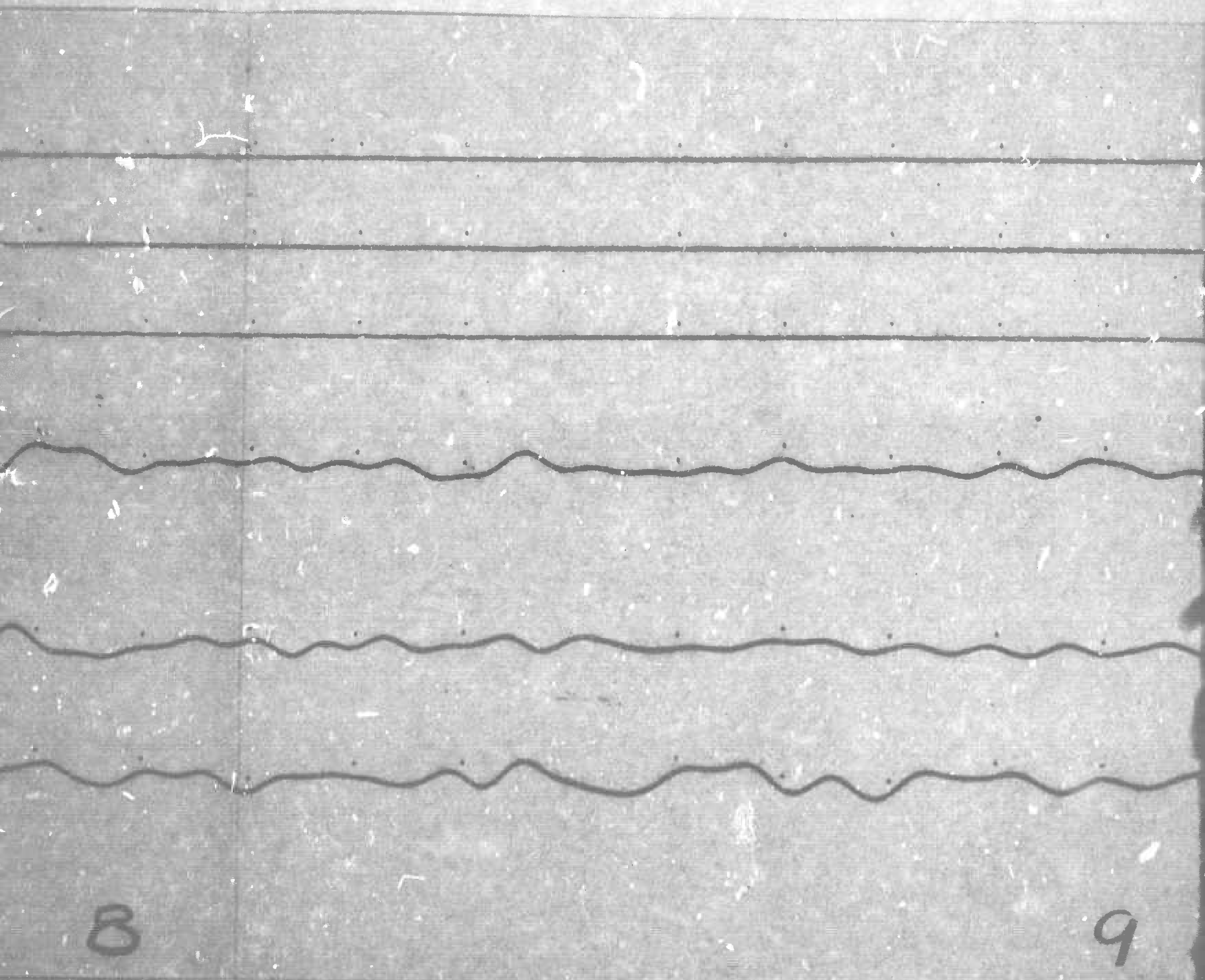
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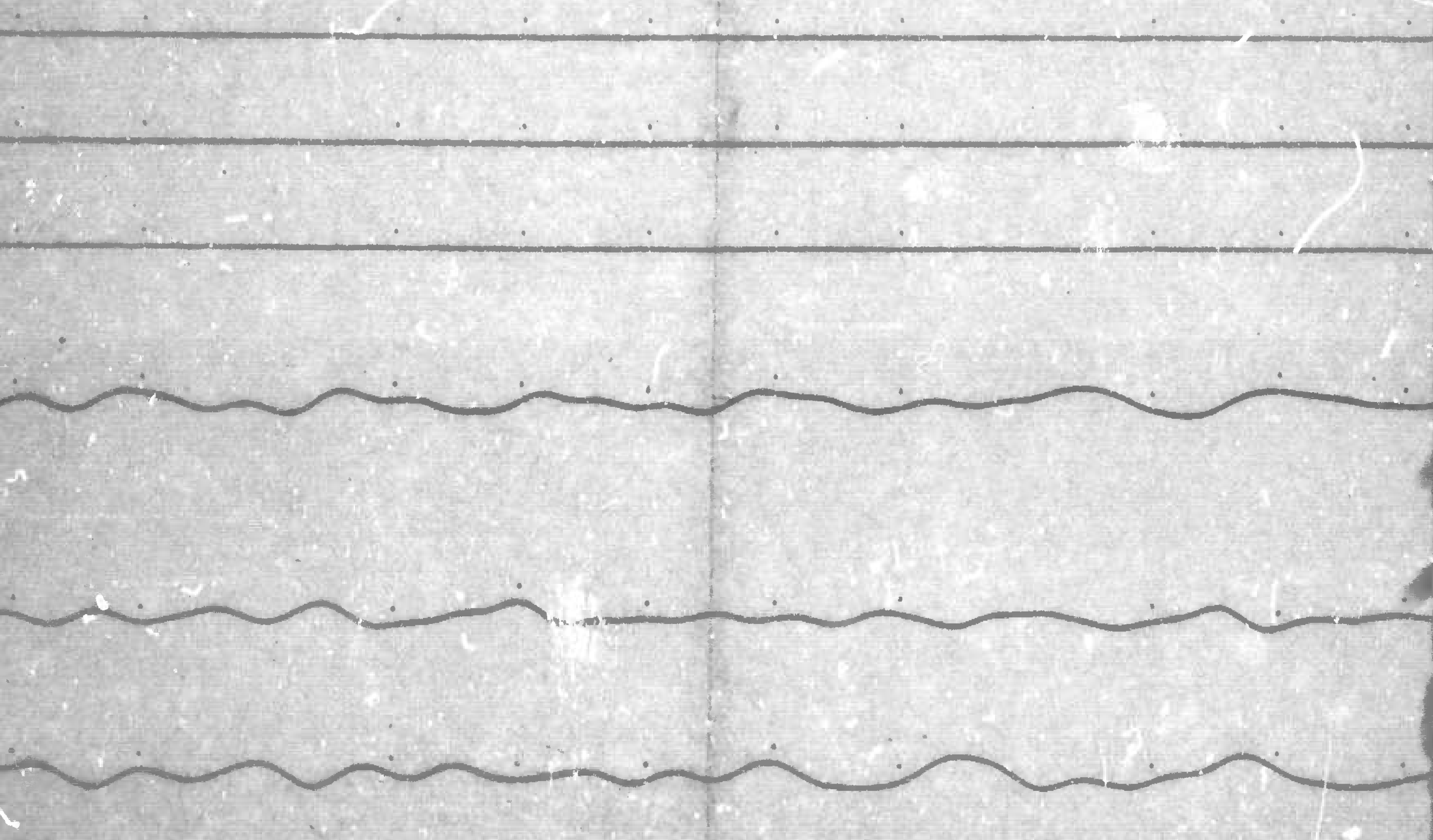

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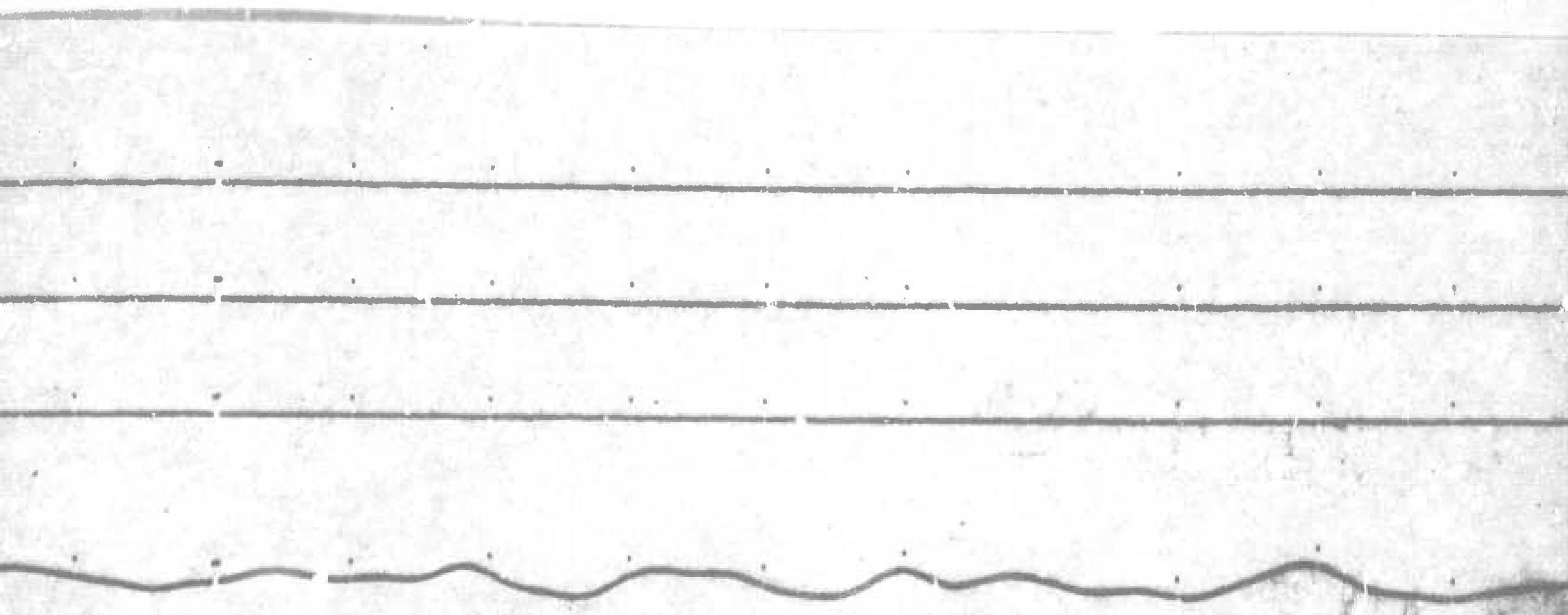
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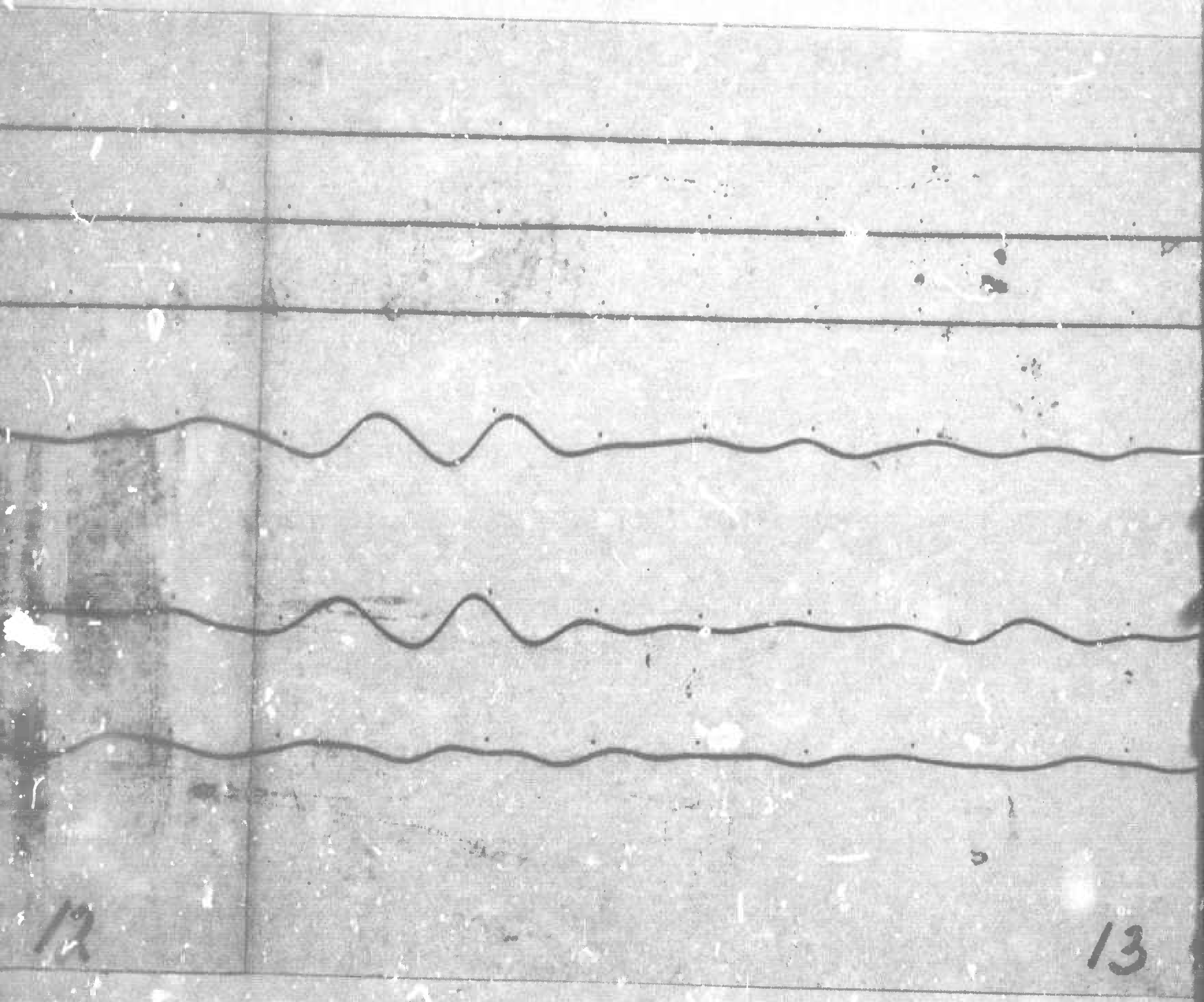

12
13

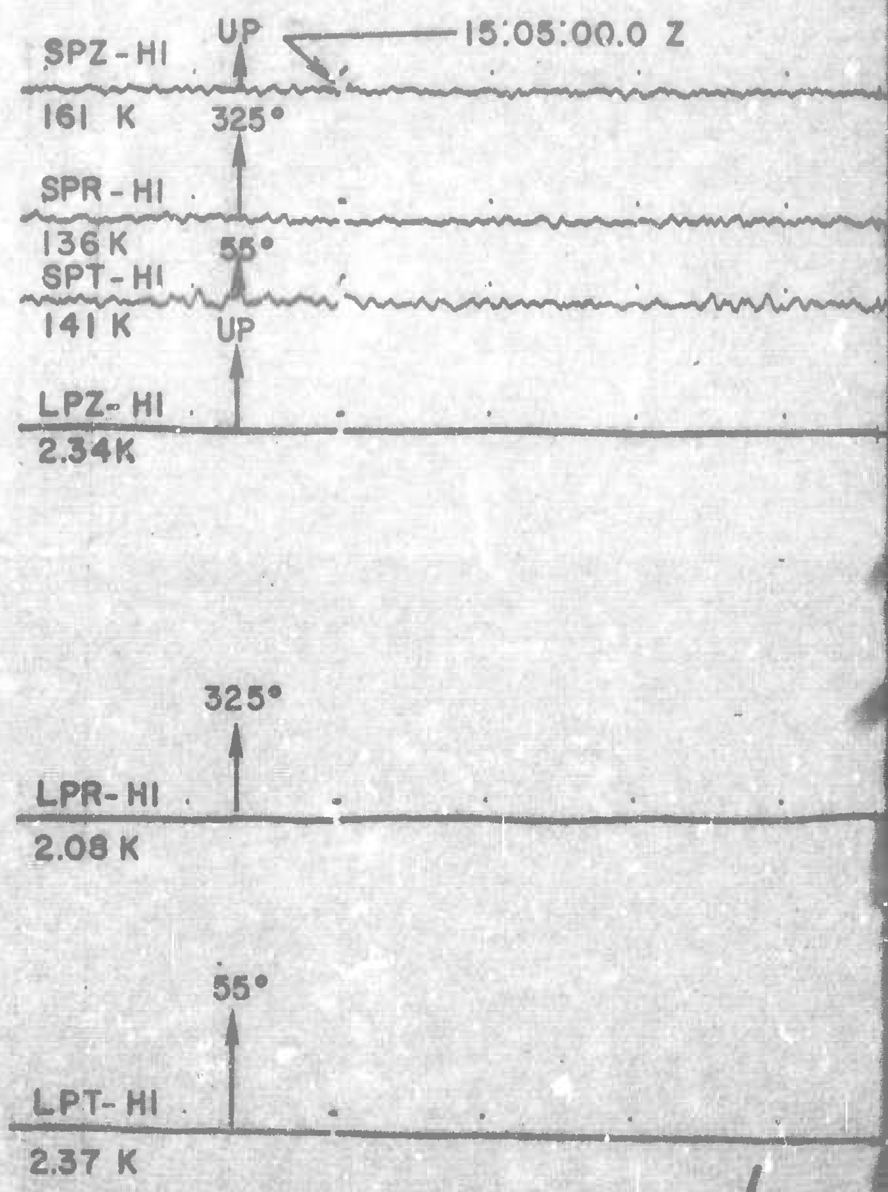
COMMODORE

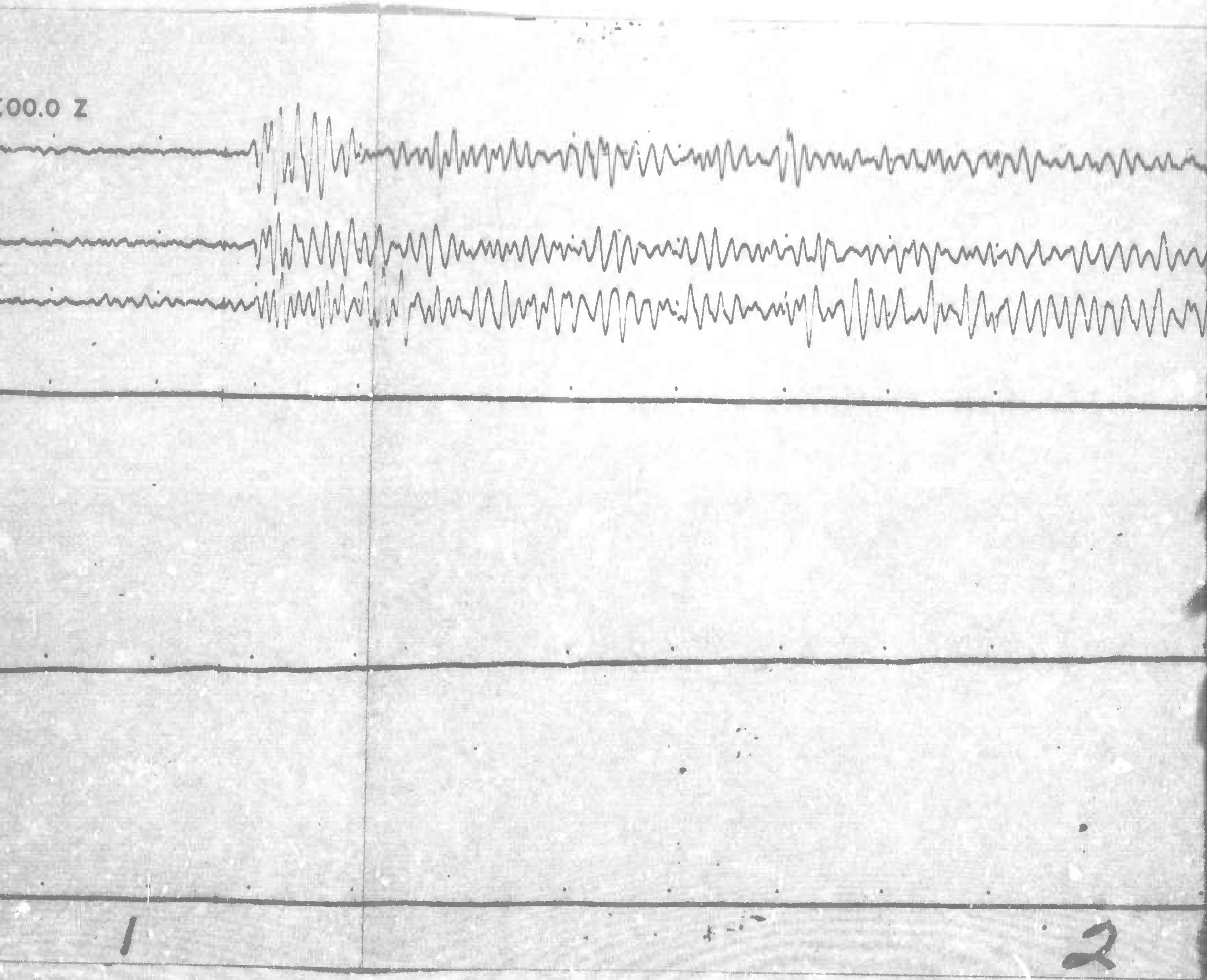
WH2YK

WHITEHORSE, YUKON TERRITORY
CANADA

20 MAY 1967

Δ= 2942 km





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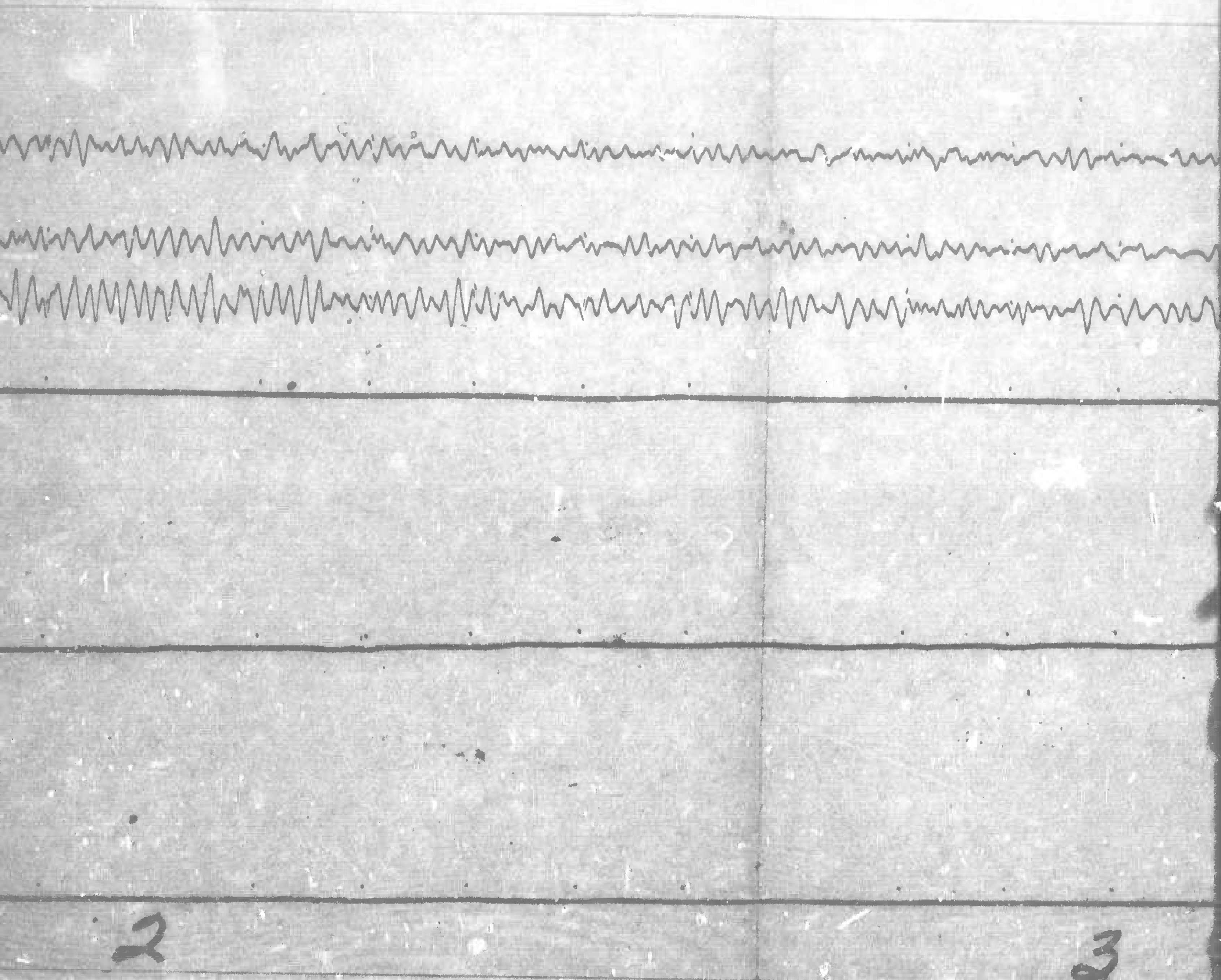
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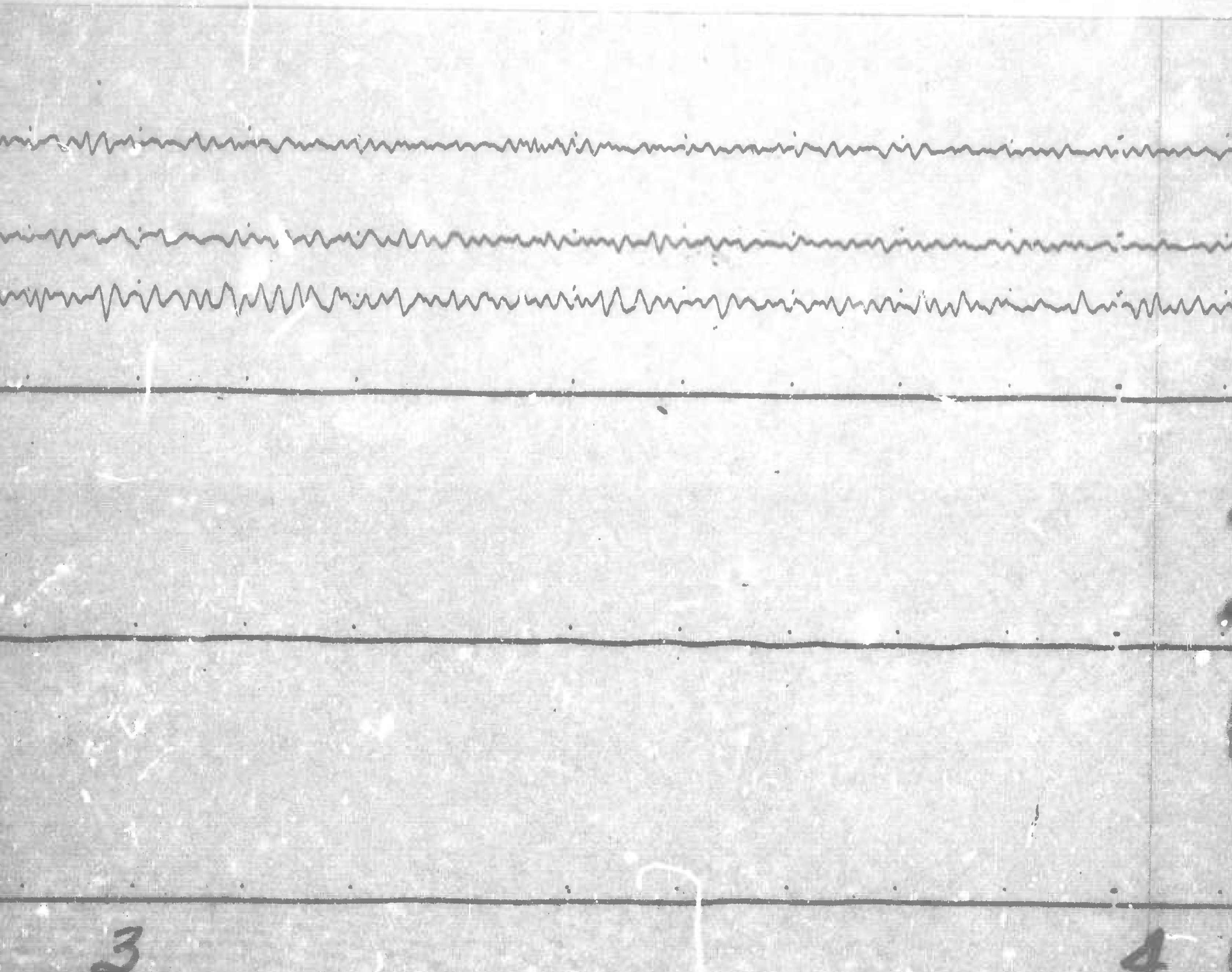
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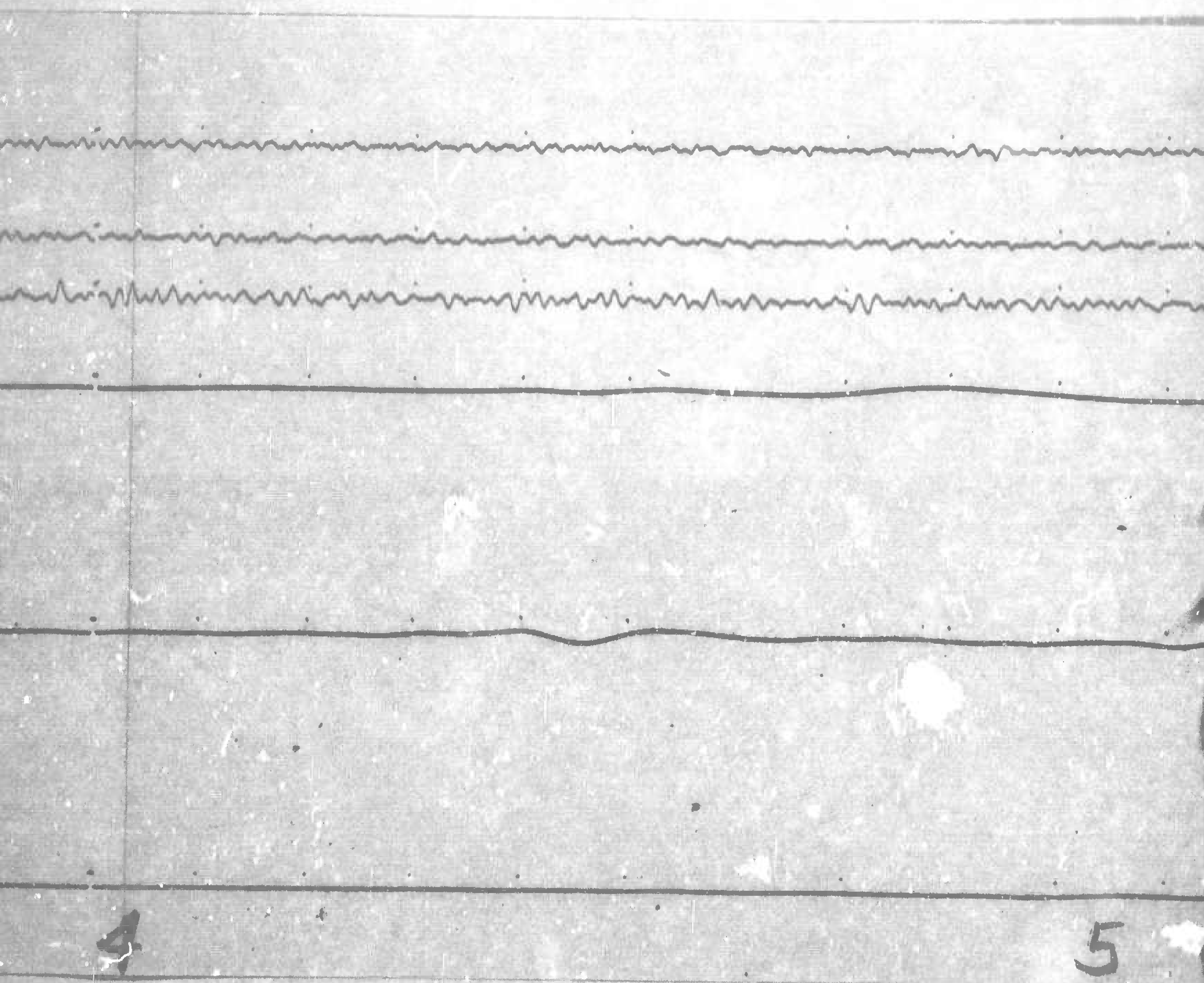
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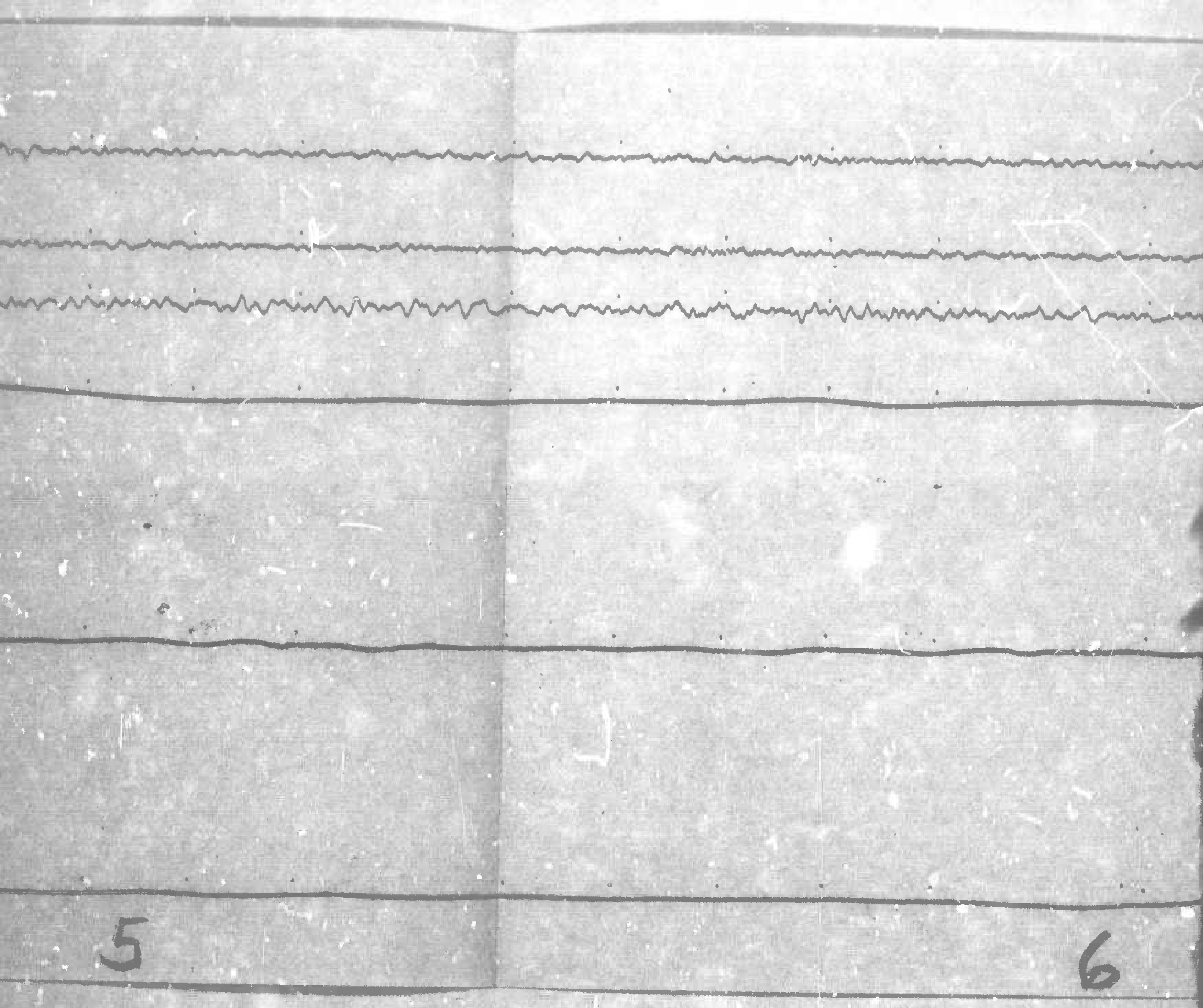
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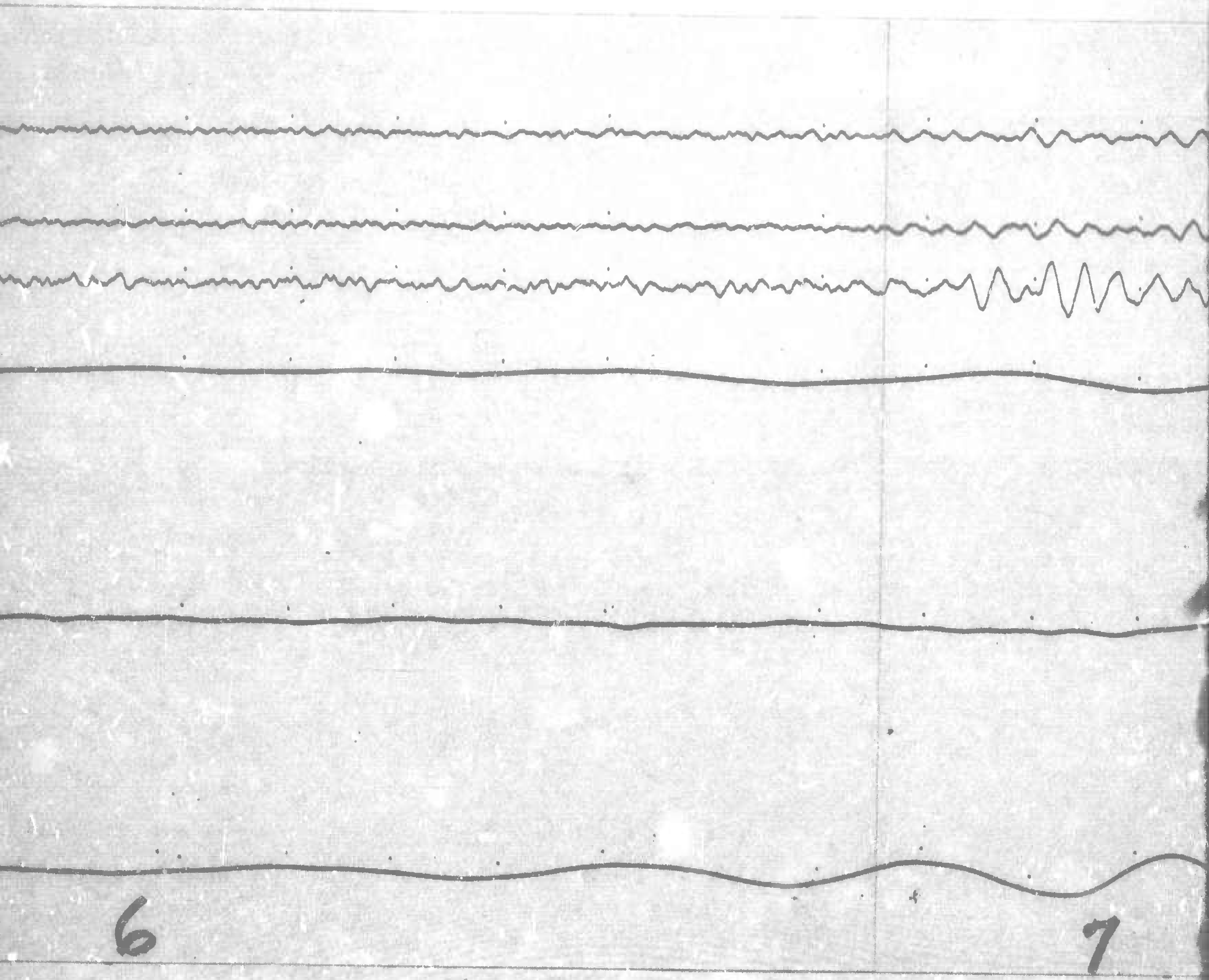
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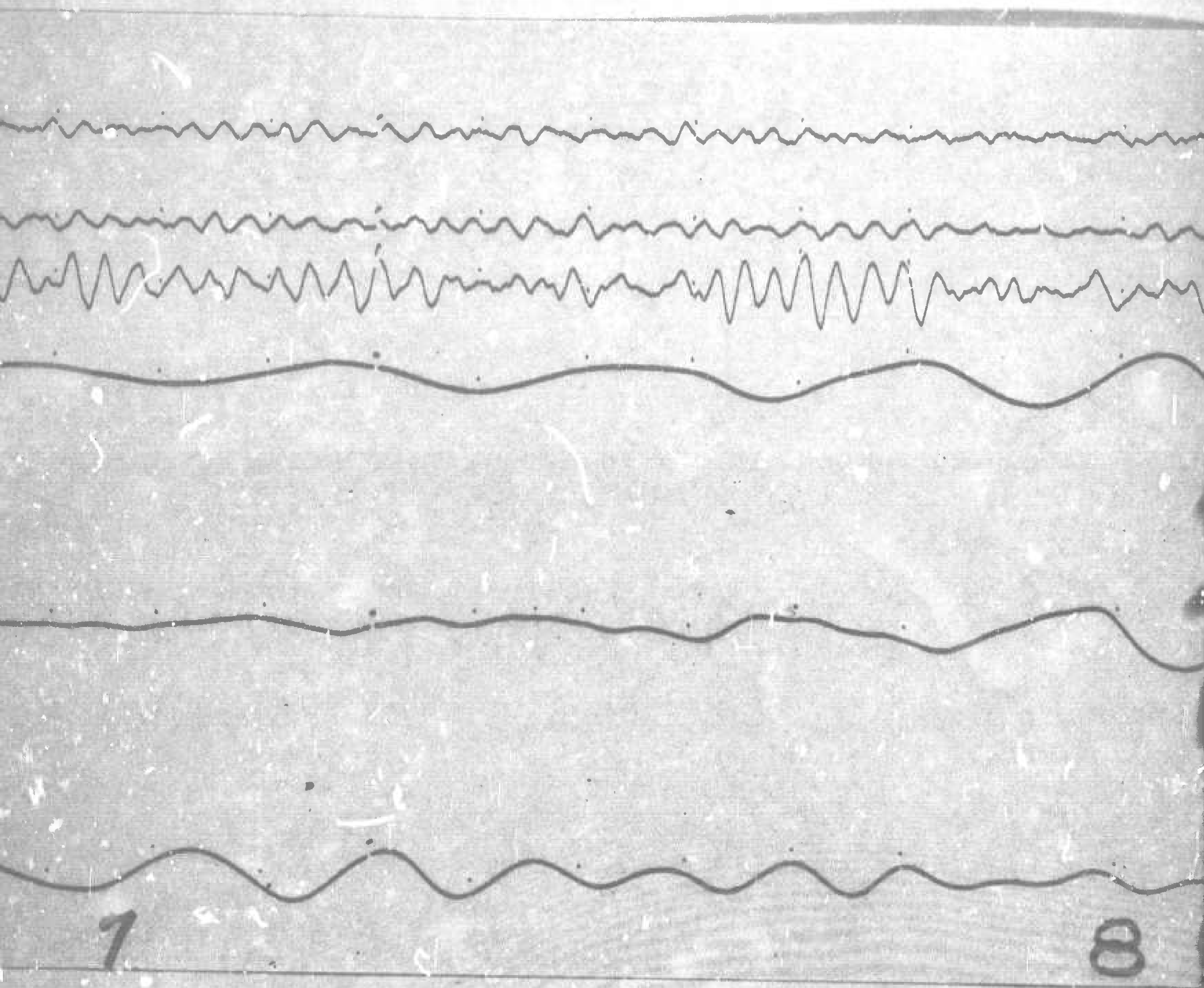
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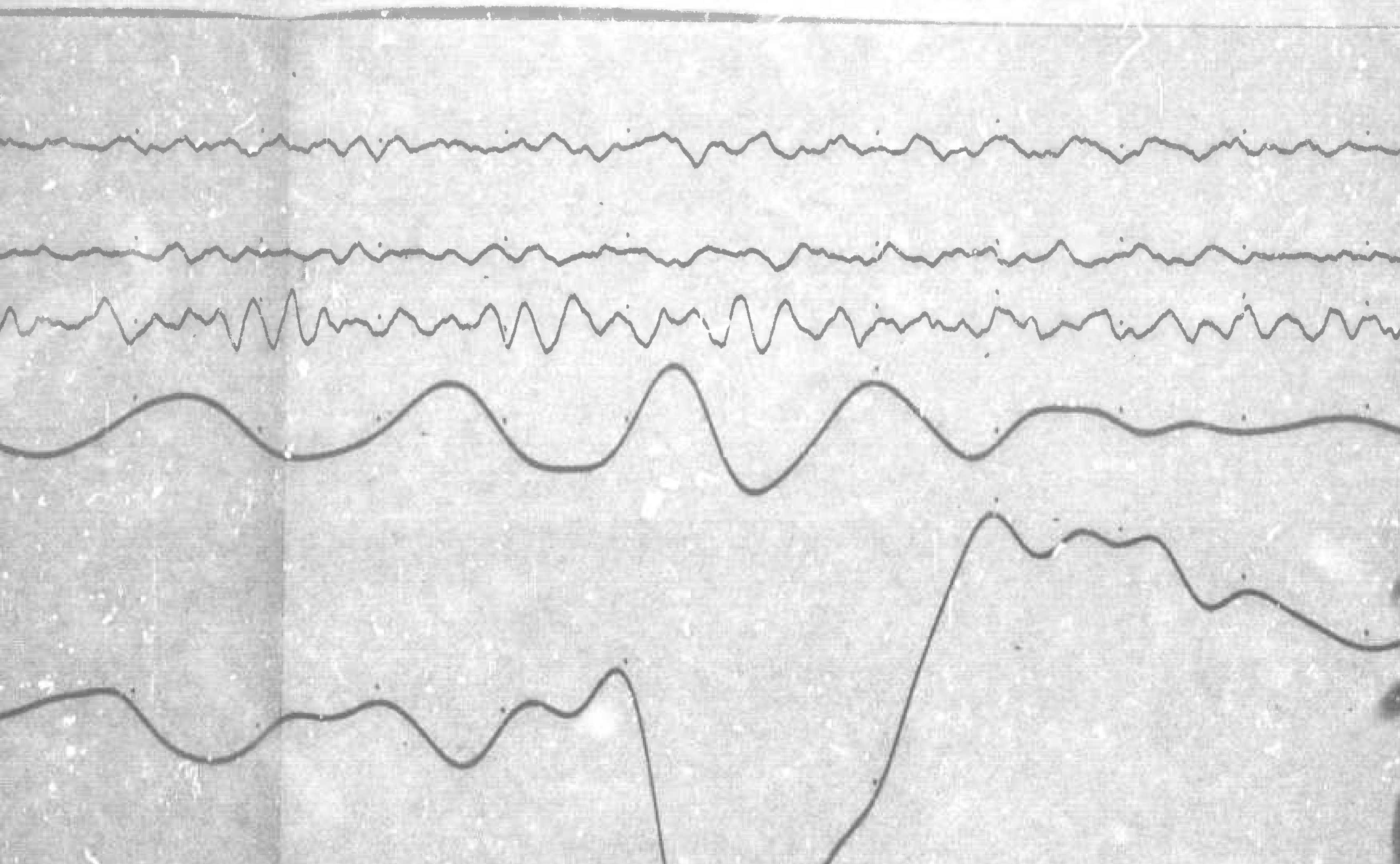
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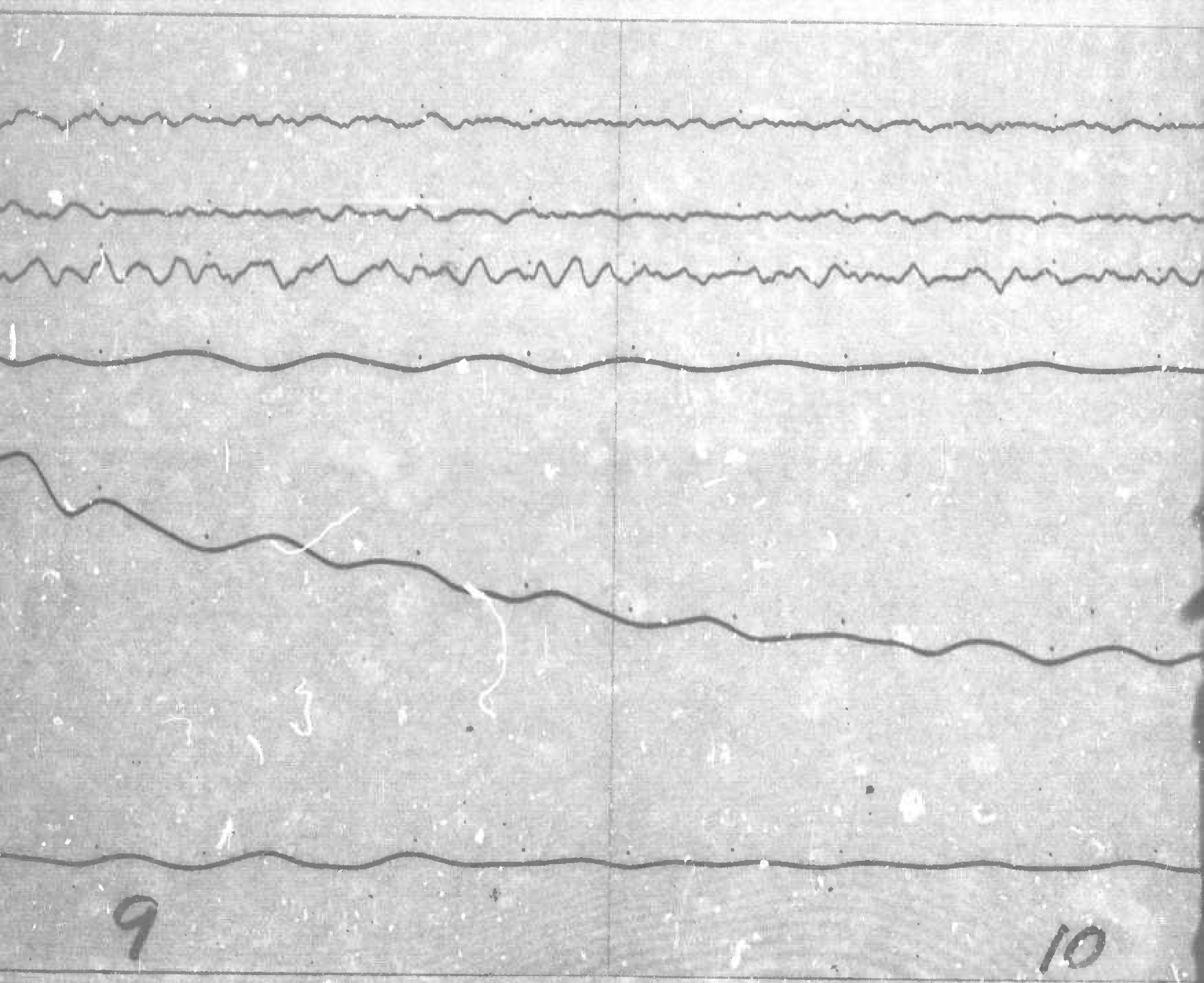
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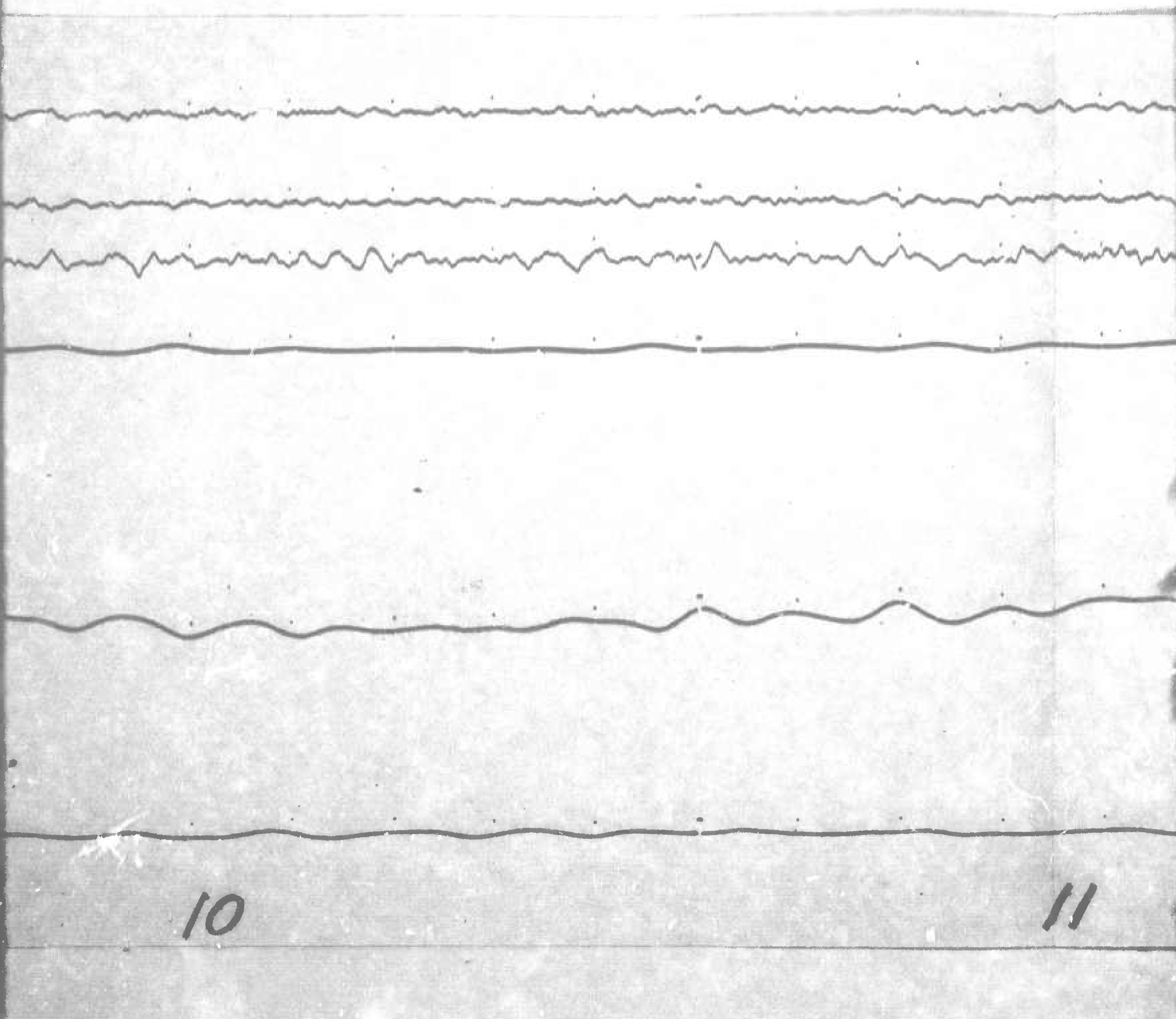
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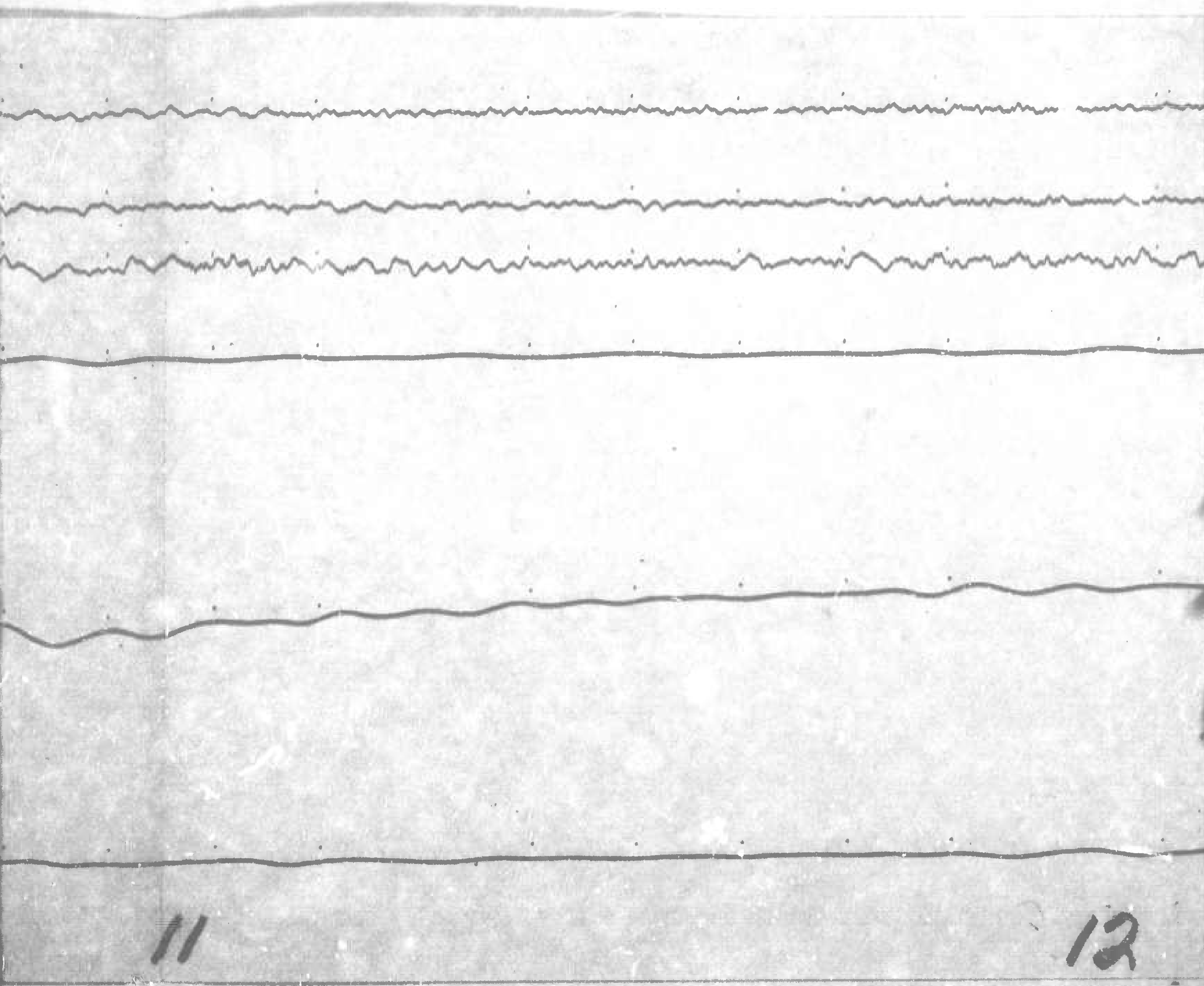
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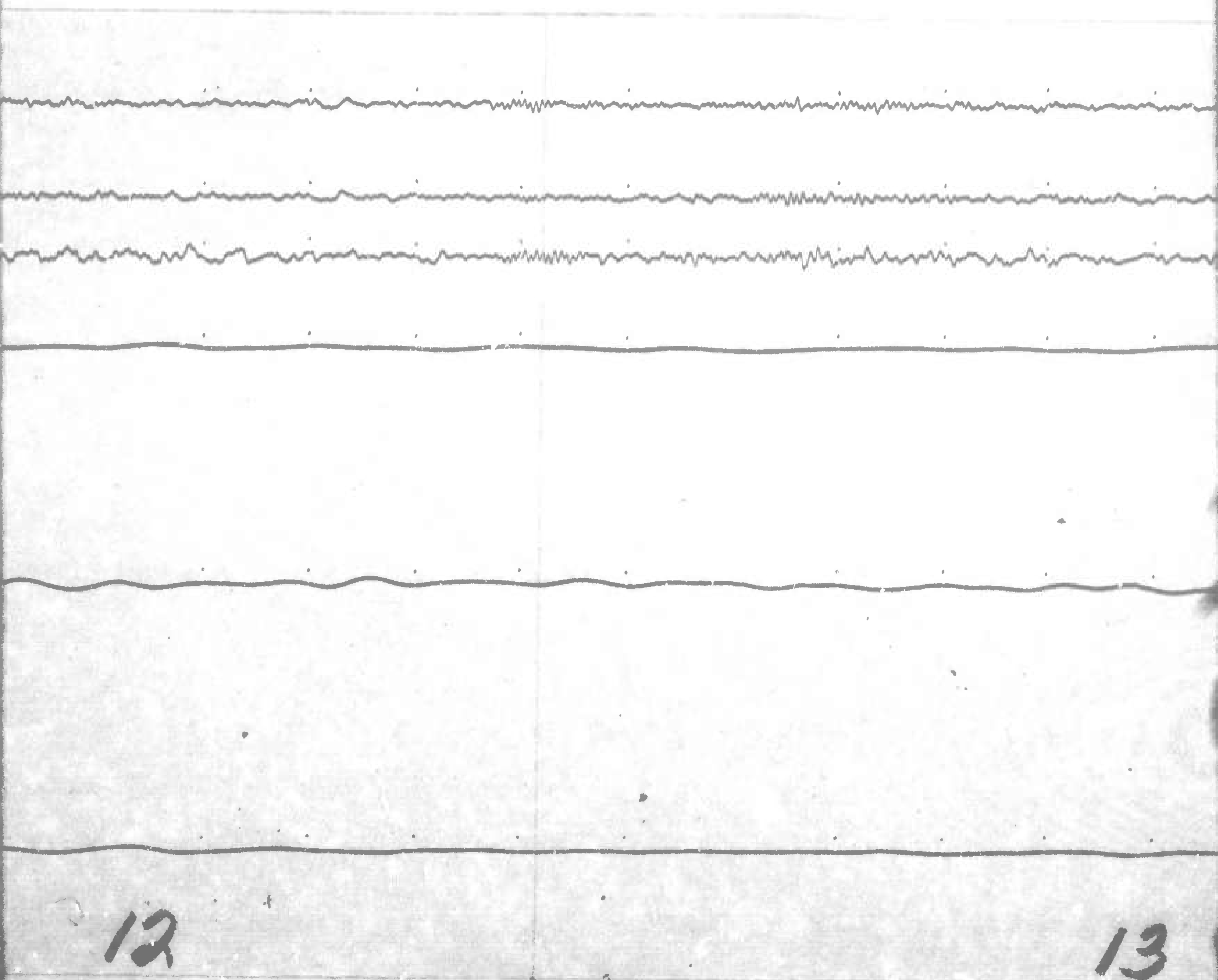
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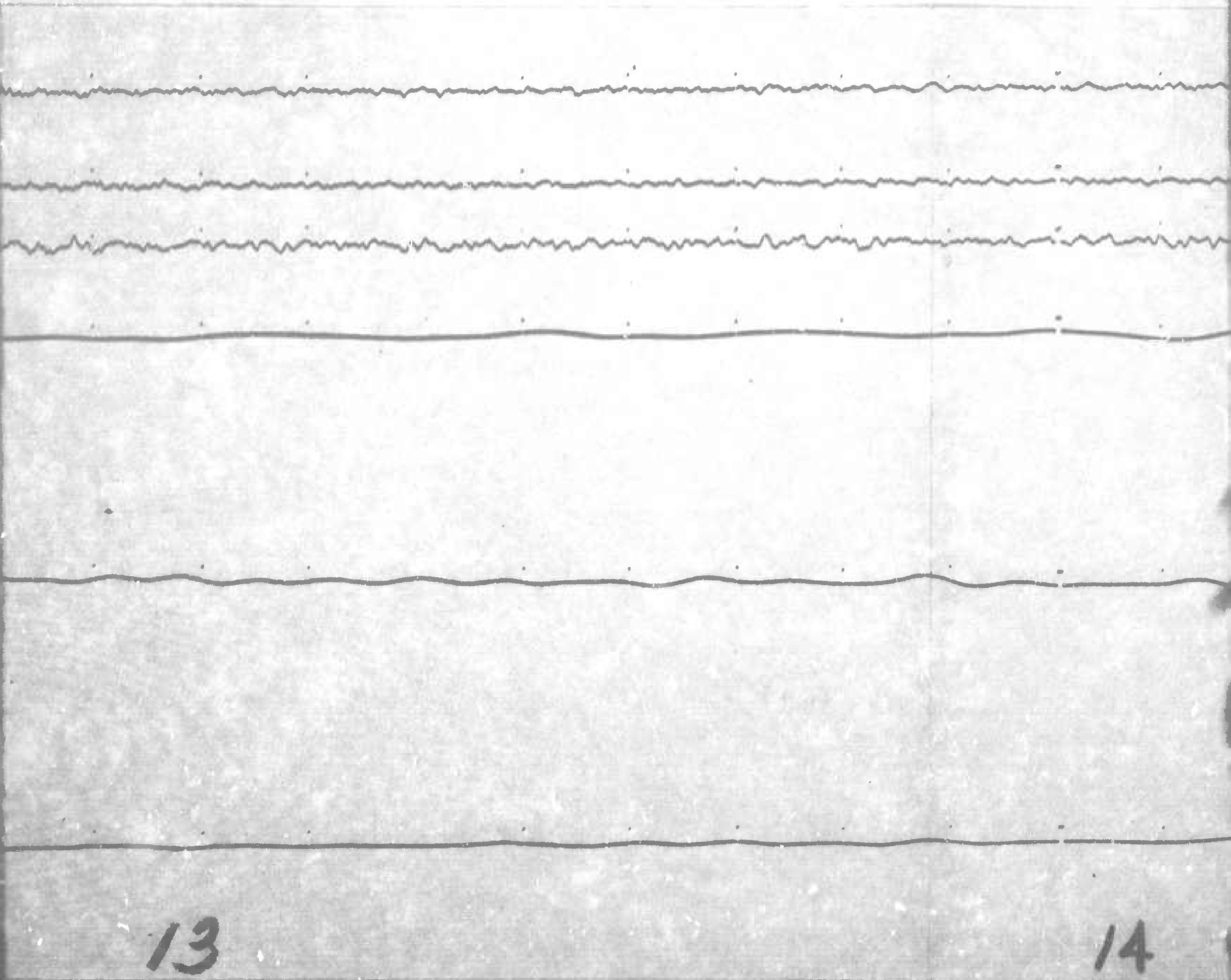
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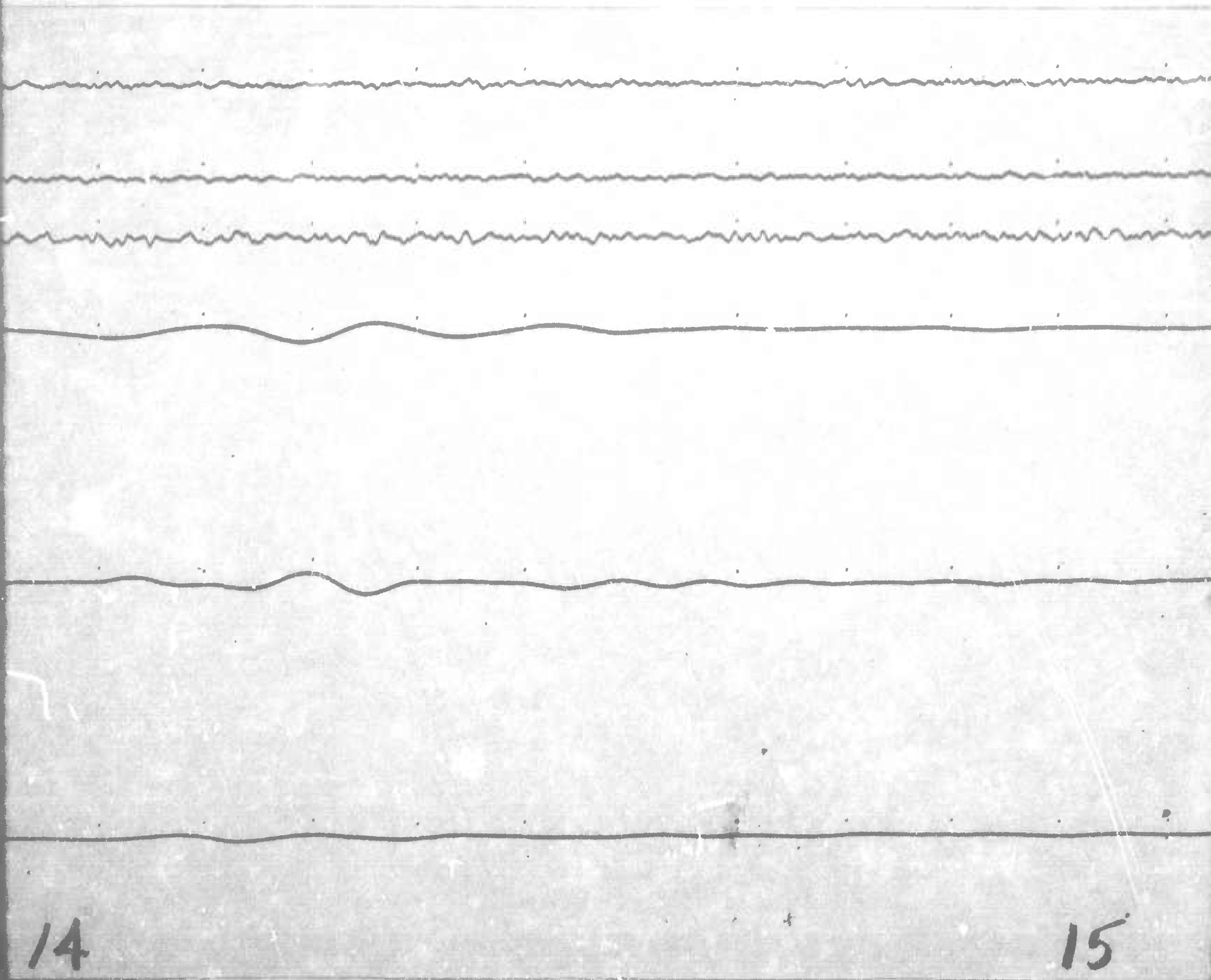
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COMMODORE

SV3QB

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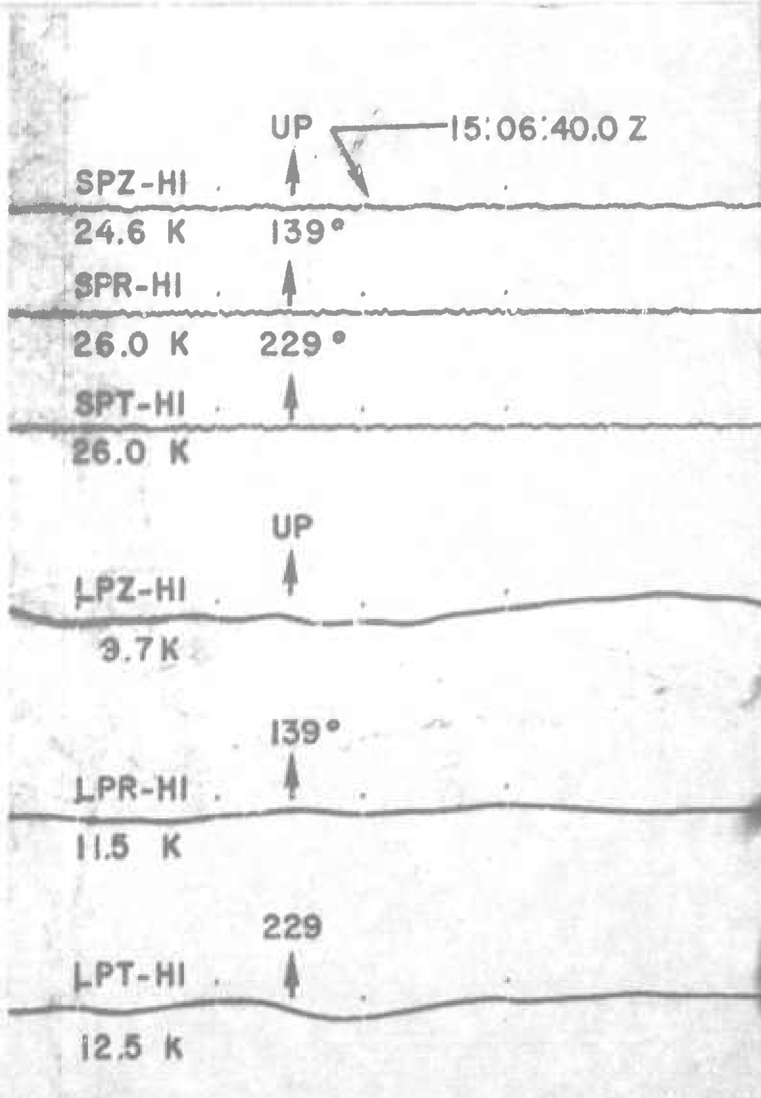

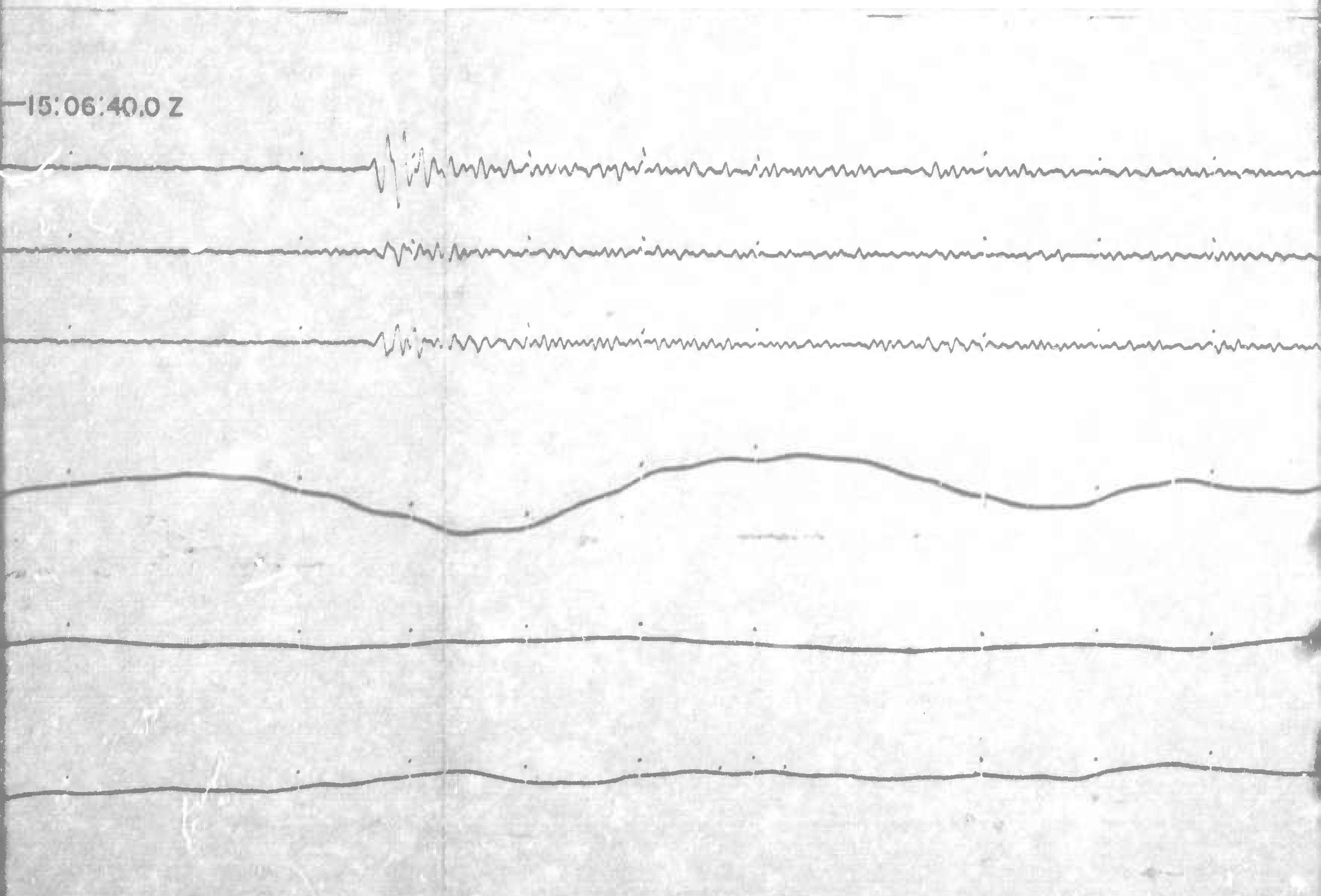
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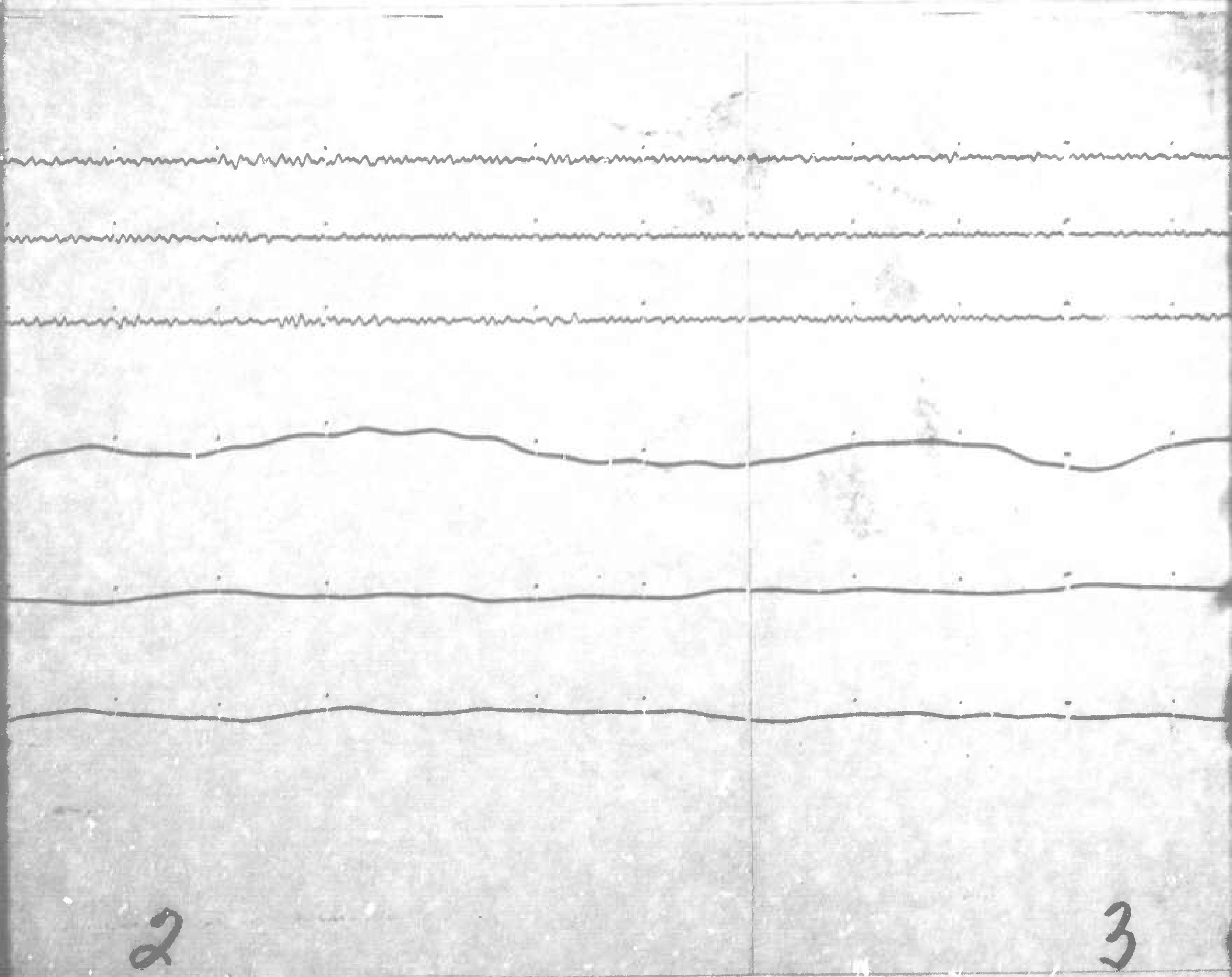
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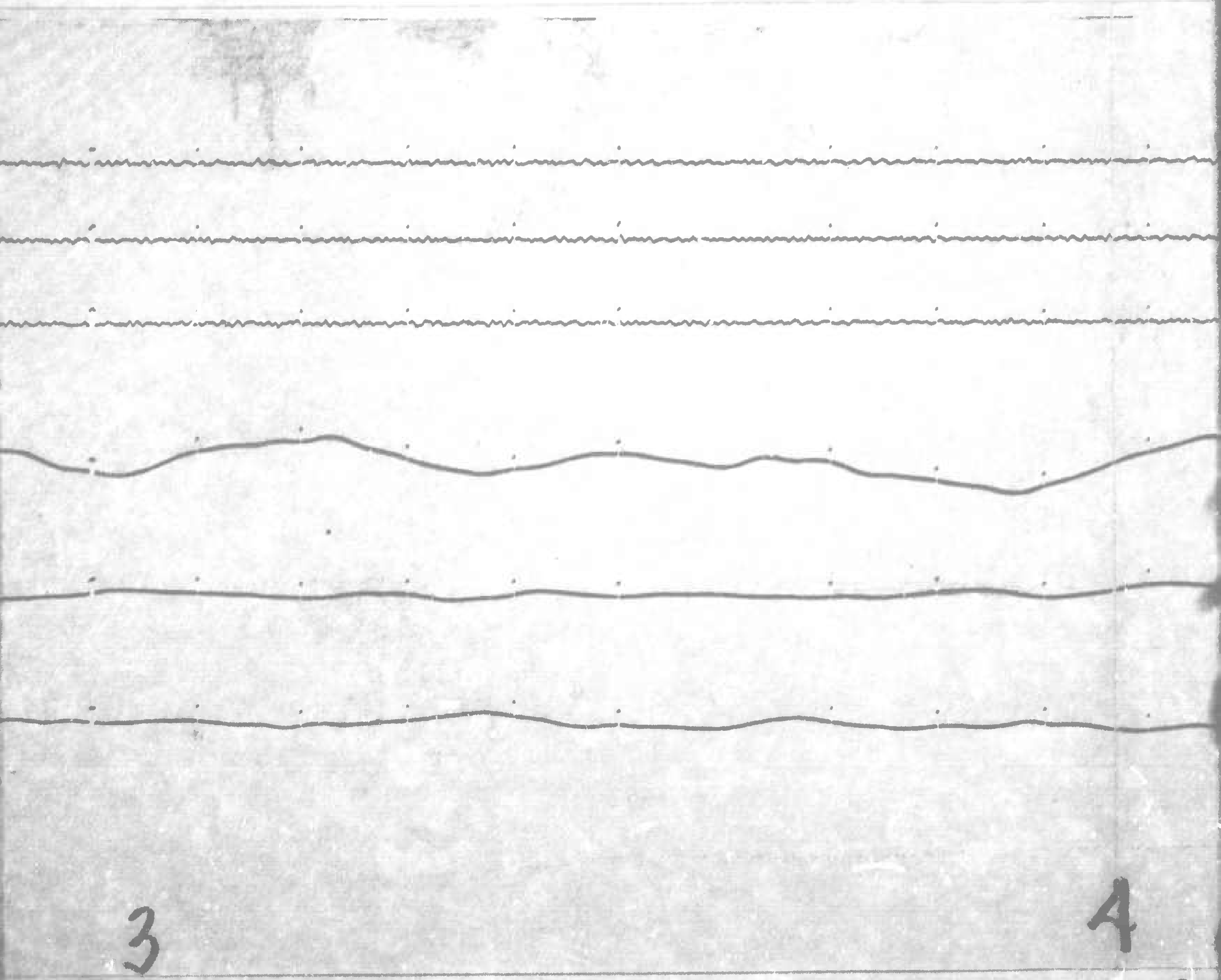
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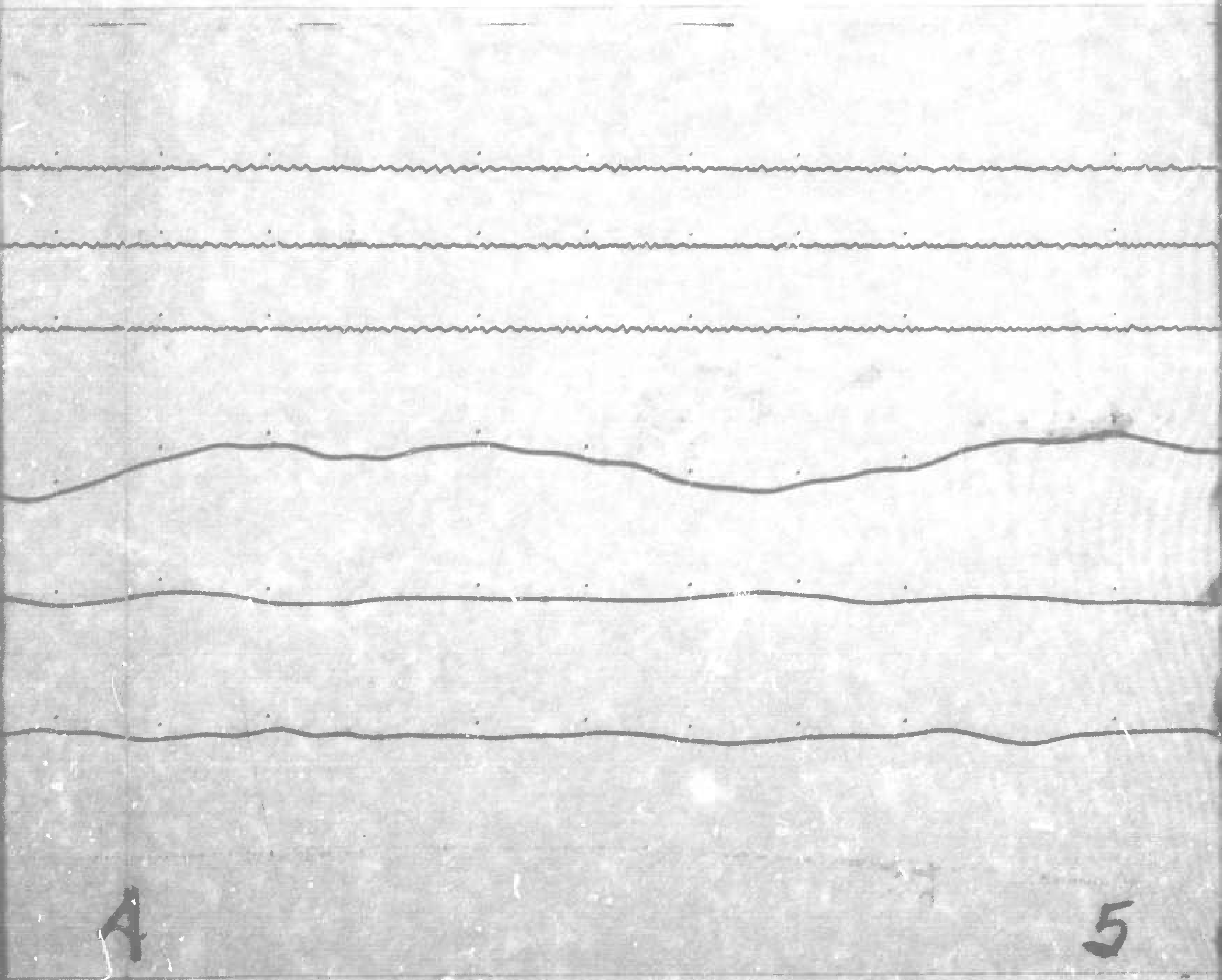
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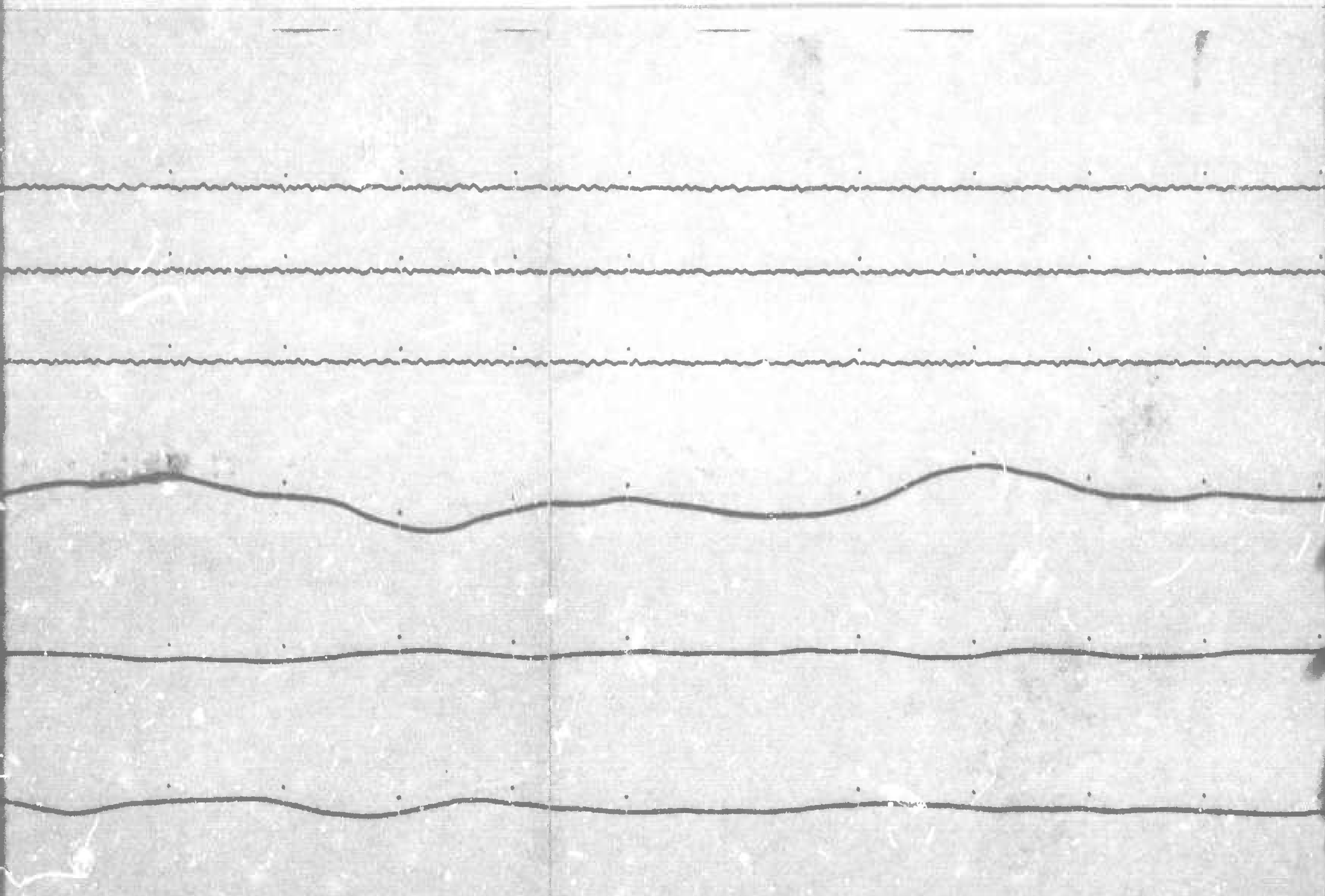
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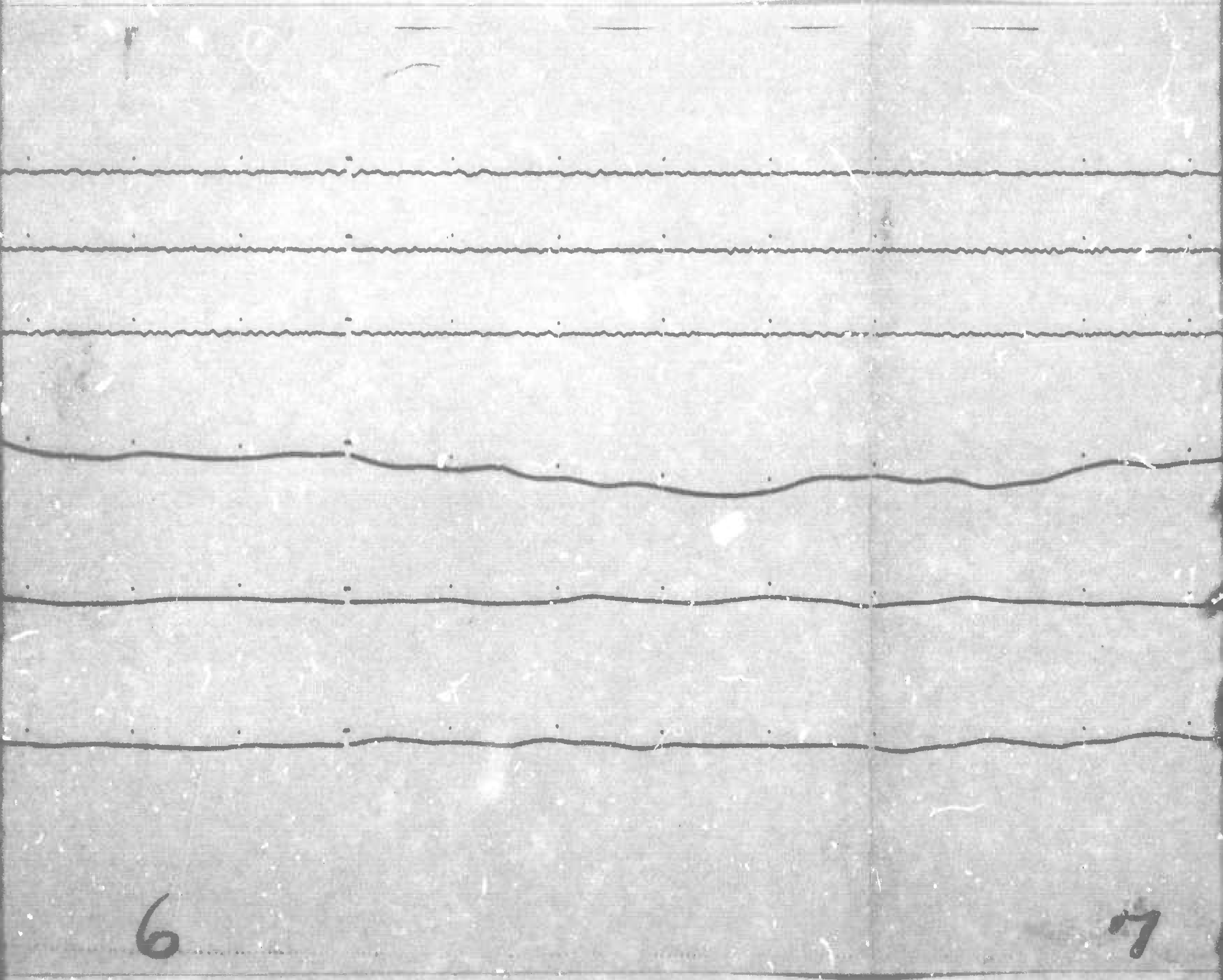
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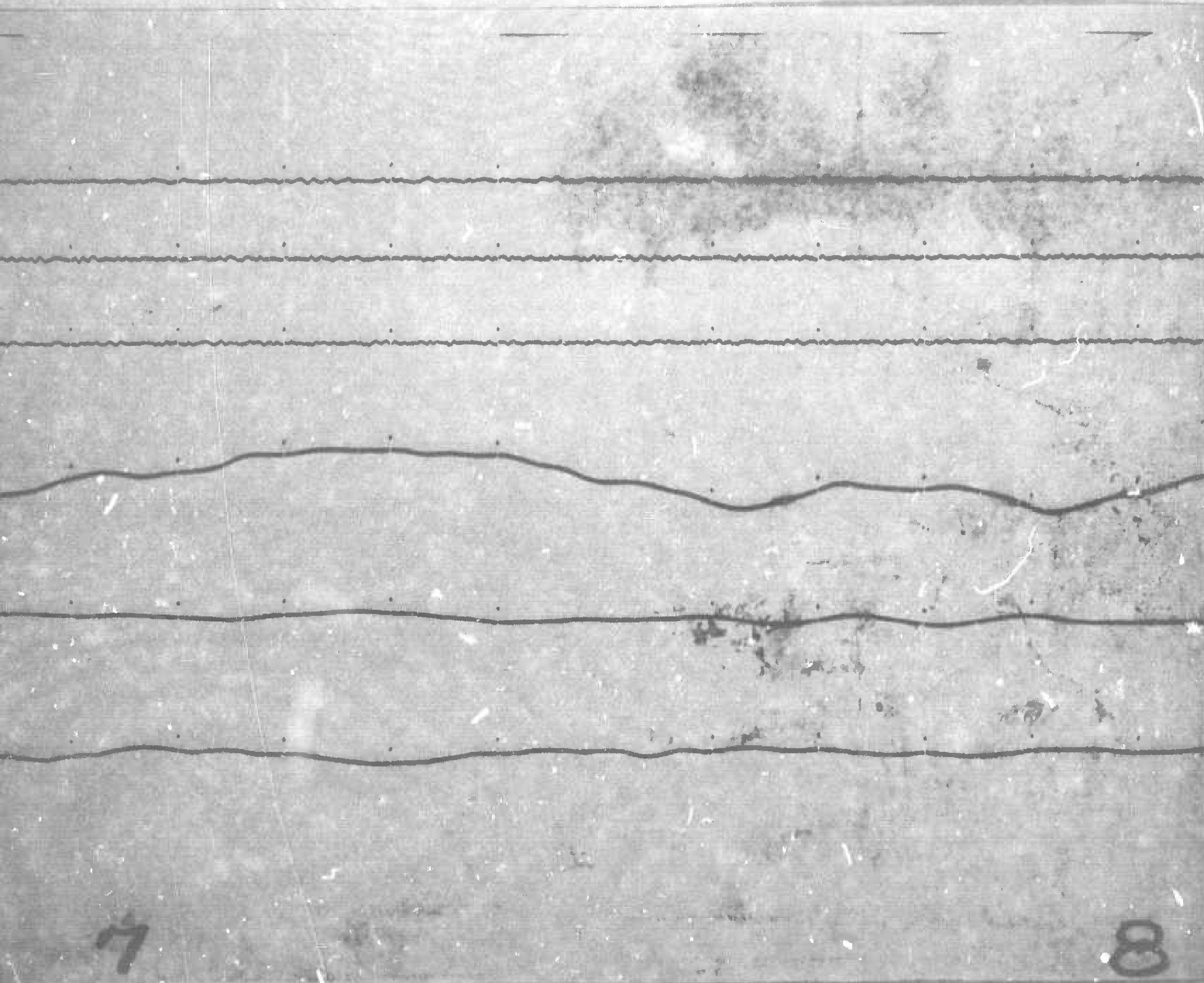
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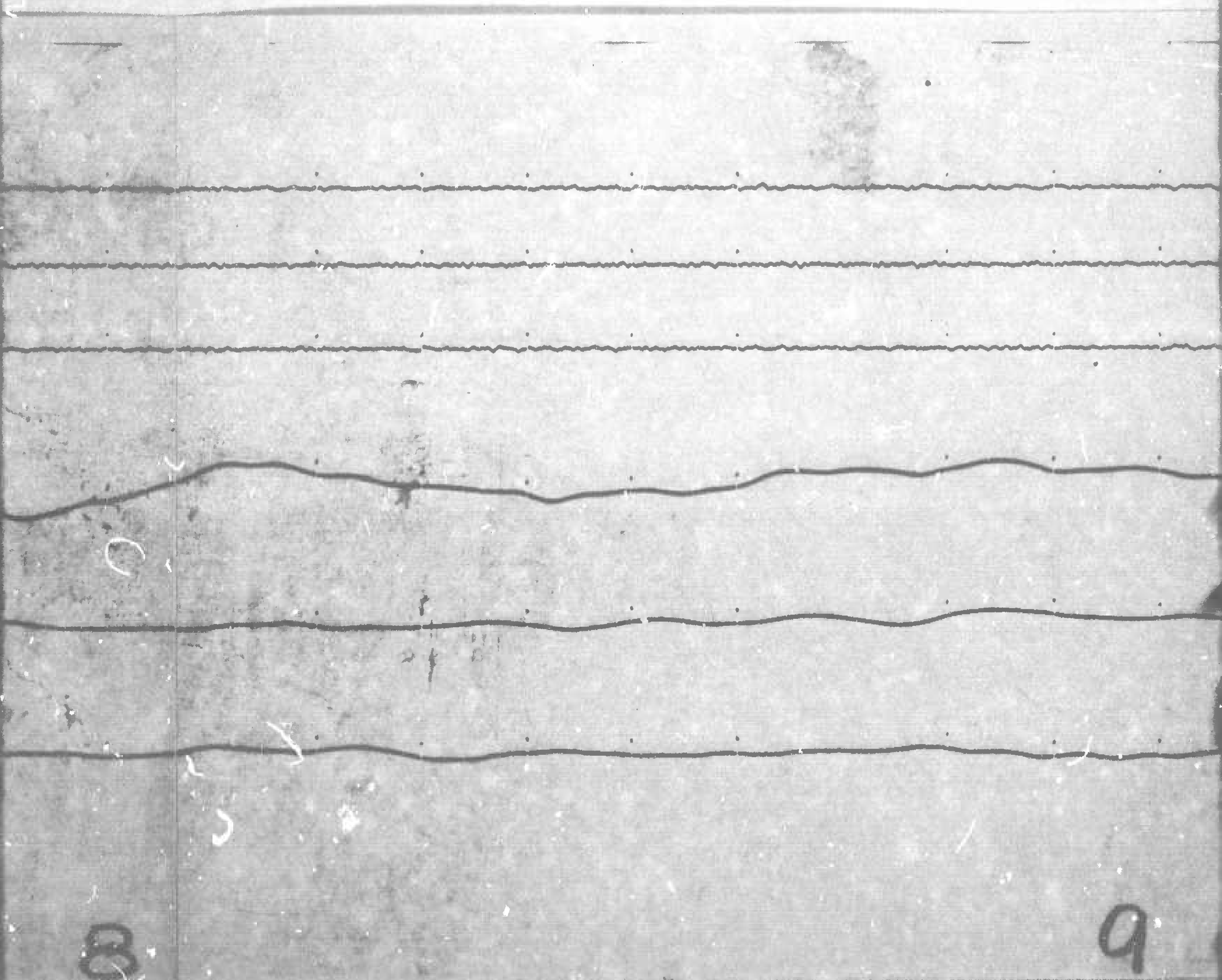
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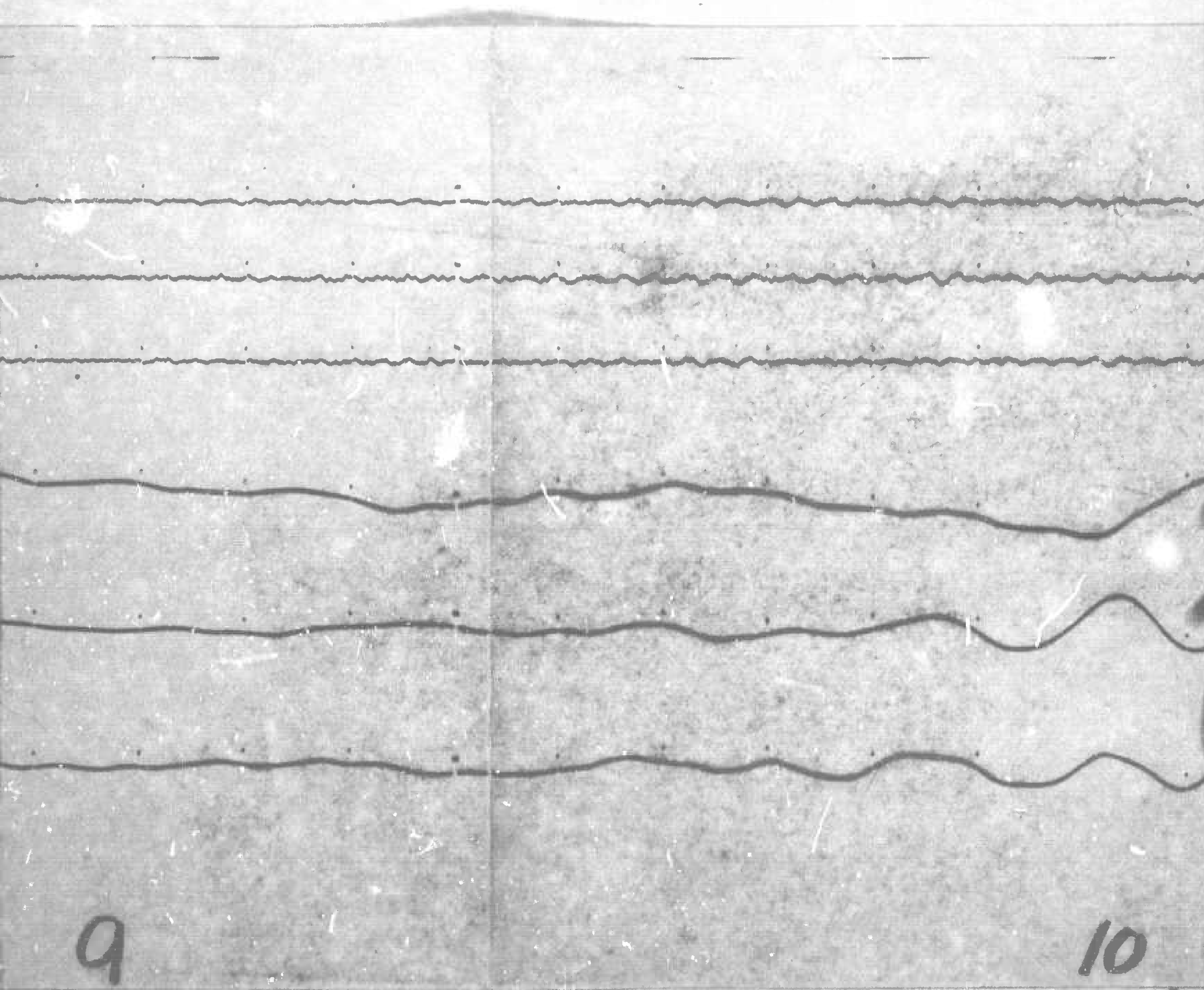
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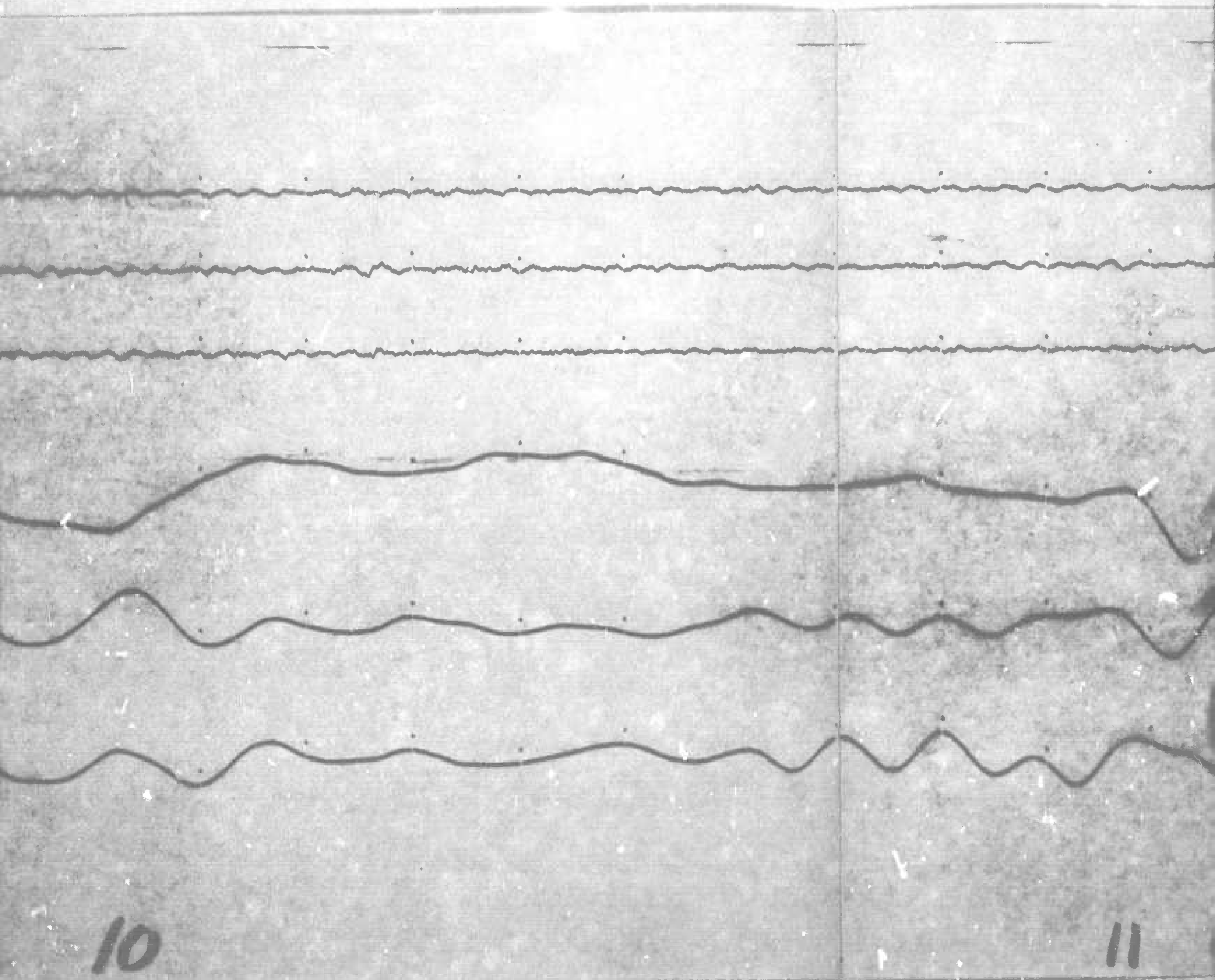
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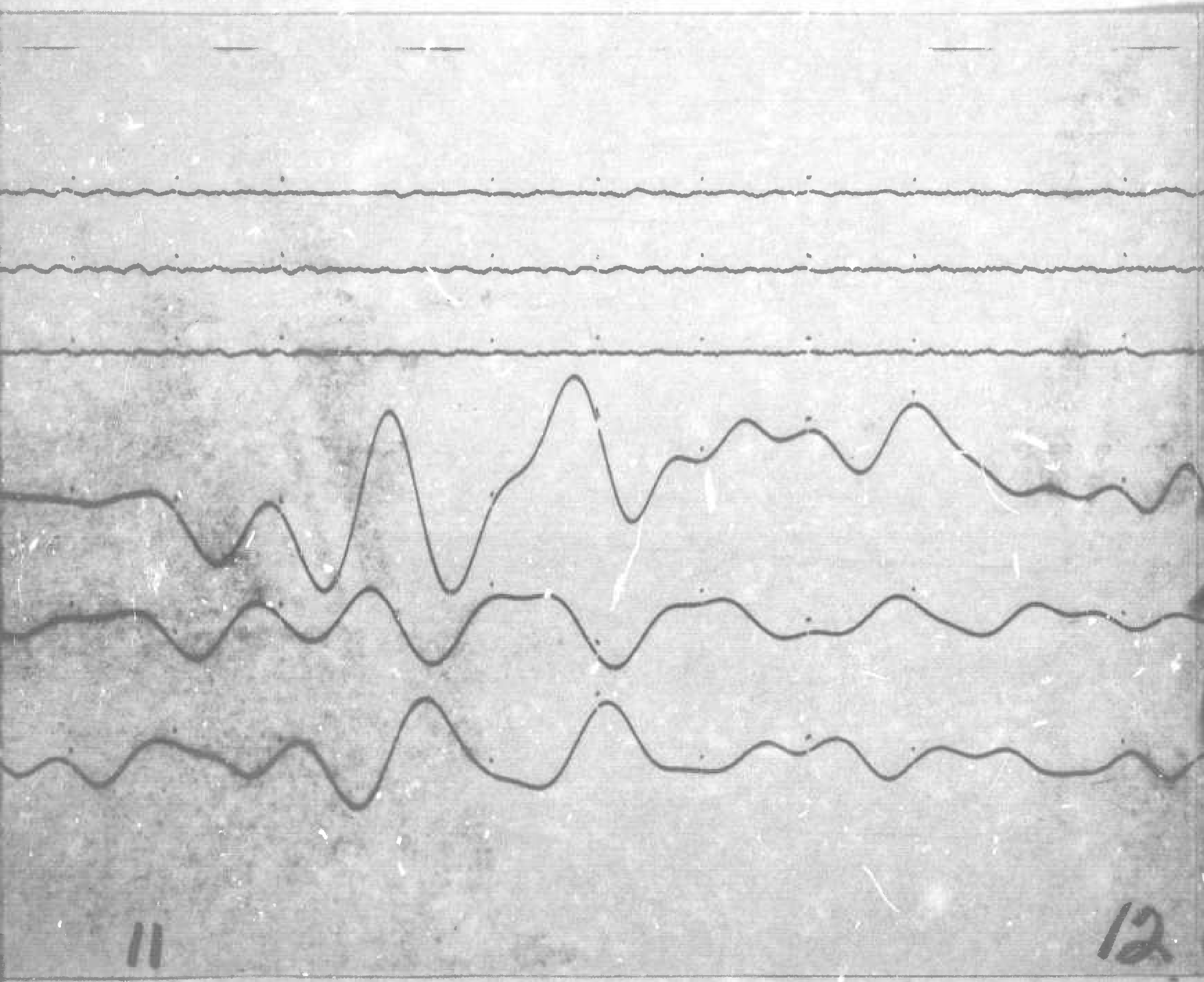
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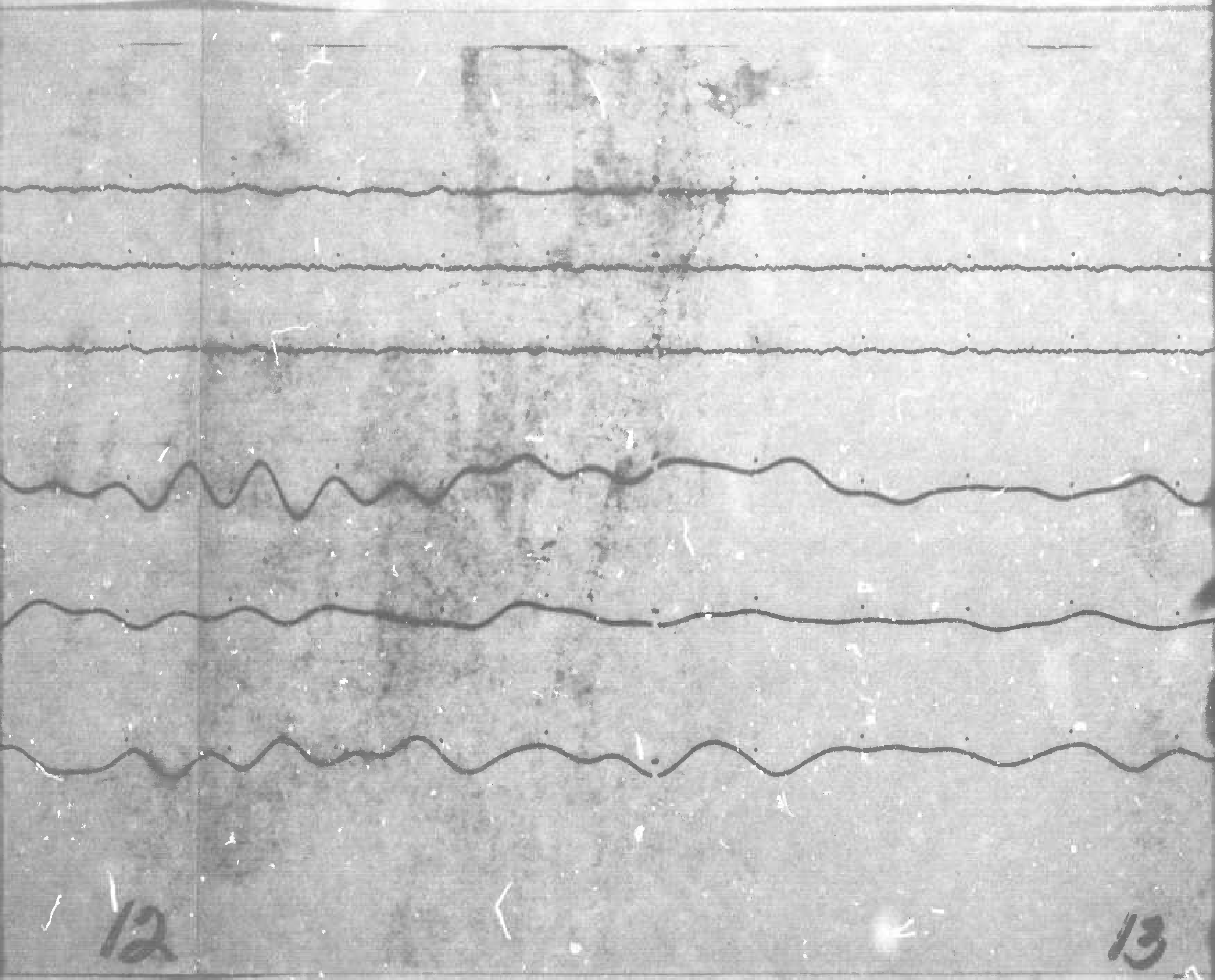
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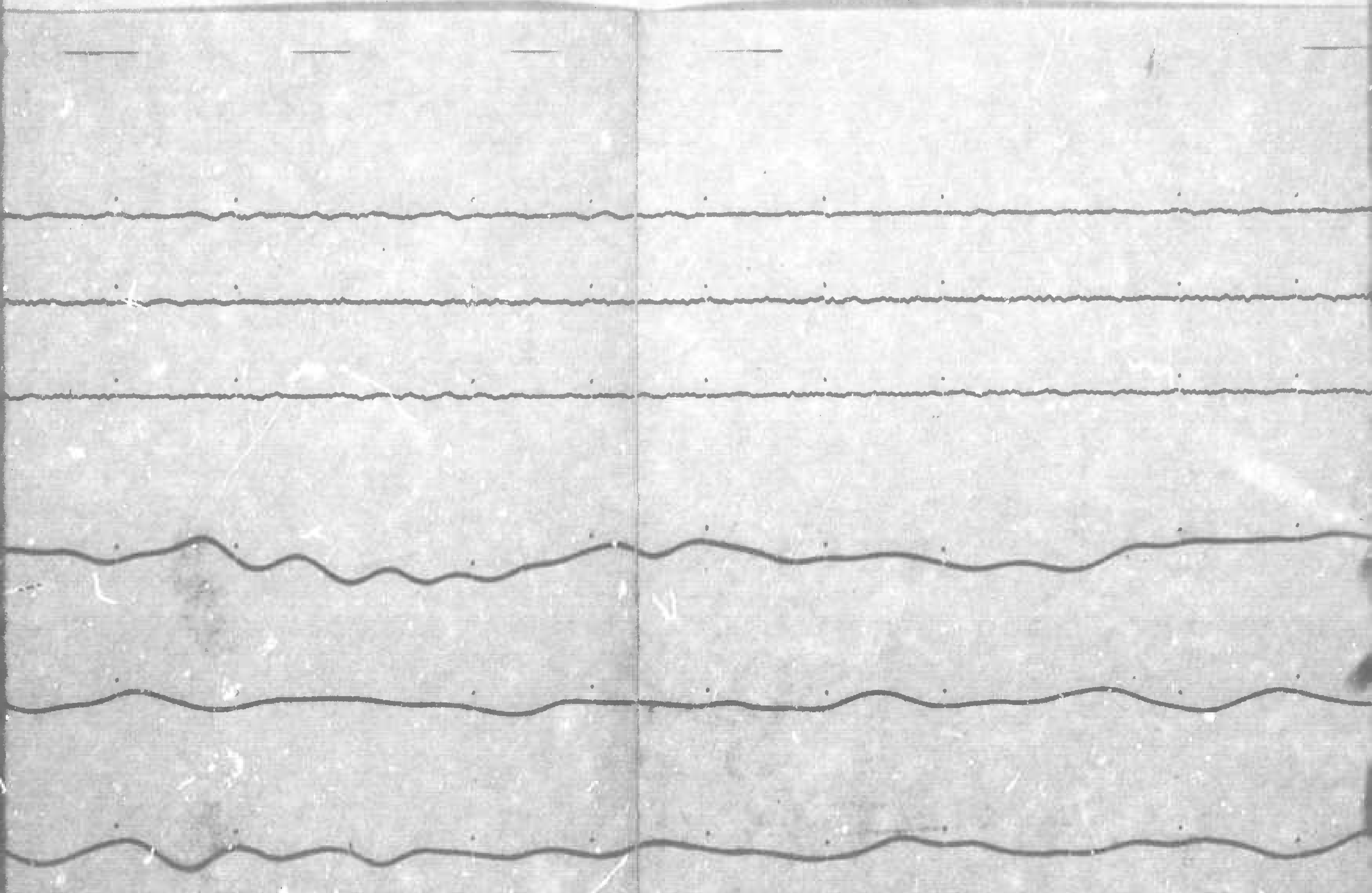

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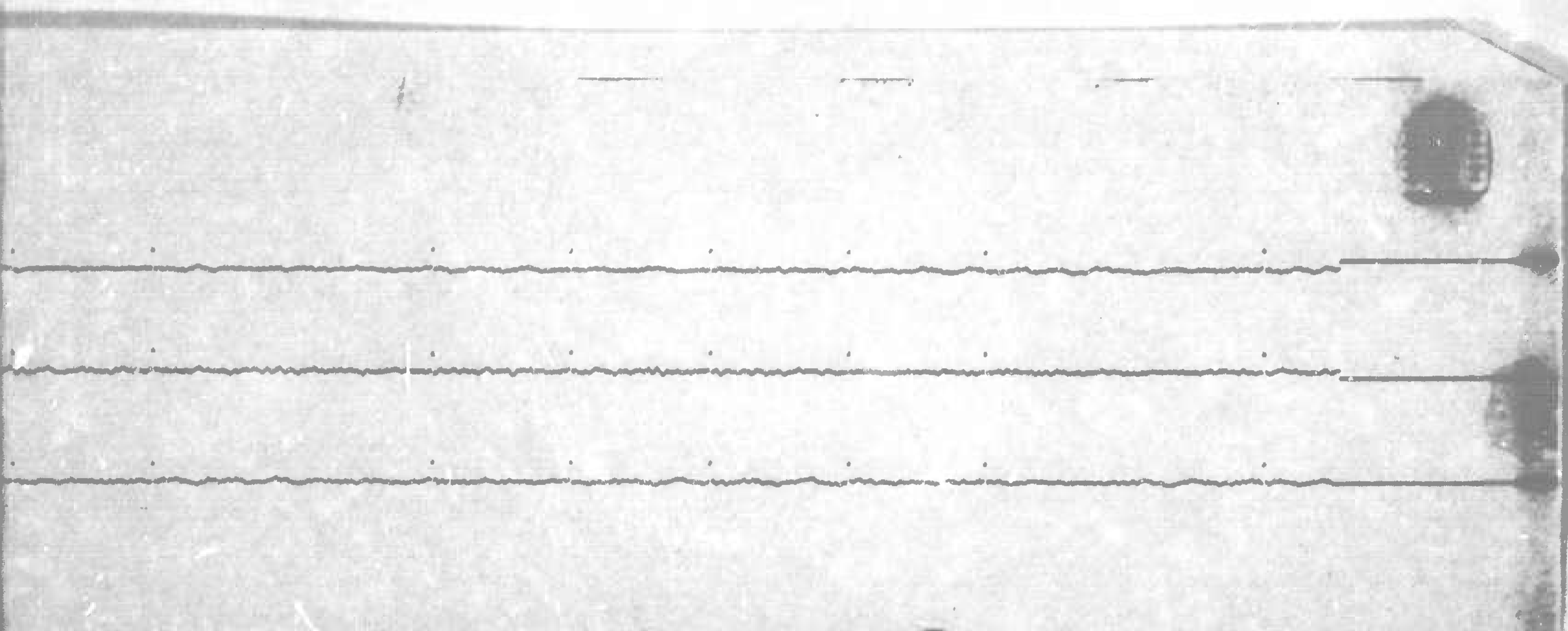
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