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HIGH-GAIN, LONG-PERIOD SEISMOGRAPH STATION INSTALLATION REPORT MATSUSHIRO, JAPAN

by
Charles R. Hutt

Open-file report 75-100
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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.

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ABBREVIATIONS USED IN REPORT

ASL - Albuquerque Seismological Laboratory
Cal. - Calibration
CDRX - Critical damping resistance - external
CMO - Central Meteorological Observatory
EW - East-West Component
G - Electromechanical constant
Galvo - Galvanometer
HGLP - High-Gain, Long-Period
Hz - Hertz (cycles per second)
JMA - Japan Meteorological Agency
km - kilometers
Lat. - Latitude
LDGO - Lamont-Doherty Geological Observatory
Long. - Longitude
LP - Long Period
m (or m.) - meter(s)
MAT - Matsushiro Seismological Observatory
N/A - Newtons per ampere
NS - North-South Component
Pri. - Primary
PTA - Phototube amplifier
Res. - Resistance
sec (or sec.) - seconds(s)
Sec. - Secondary
SP - Short Period
T - Free Period (or Natural Period)
Trans. - Transducer
V - Volts
VDC - Volts Direct Current
WWNSS - Word-Wide Network of Standardized Seismographs
Z - Vertical Component

HIGH-GAIN, LONG-PERIOD SEISMOGRAPH STATION
INSTALLATION REPORT, MATSUSHIRO, JAPAN

by

Charles R. Hutt

Albuquerque Seismological Laboratory
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A High-Gain, Long-Period Seismograph System, developed by the Lamont-Doherty Geological Observatory, was installed at the Matsushiro Seismological Observatory near Matsushiro, Japan, in December 1972. Magnifications of 40,000 for the vertical component, 36,000 for the north-south component, and 33,000 for the east-west component, at a period of 30 seconds were obtained. Velocity data are recorded both photographically and digitally. Displacement data are recorded digitally.

1. INTRODUCTION

A High-Gain, Long-Period Seismograph System was installed at Matsushiro, Japan, during November and December 1972. The system consists of two horizontal and one vertical seismometer with natural periods of 30 seconds. Each seismometer contains two velocity transducers and one displacement transducer.

The velocity transducers are coils moving within a magnetic field. One of these drives a 100-second galvanometer from which the signal is amplified by a PTA, split, and recorded both photographically and digitally. This portion of the system is called the "high-gain." The other velocity transducer drives a 100-second galvanometer from which the signal is recorded photographically. This portion of the system is called the "low-gain" or "standard-gain." (Fig 1)

The displacement transducer output is recorded digitally. The resolution of the digital recording system is sufficient to allow recording of earth tides. For the vertical seismometer, the instrument's response to changes in gravity is recorded, and for the horizontal components, tilt data is recorded.

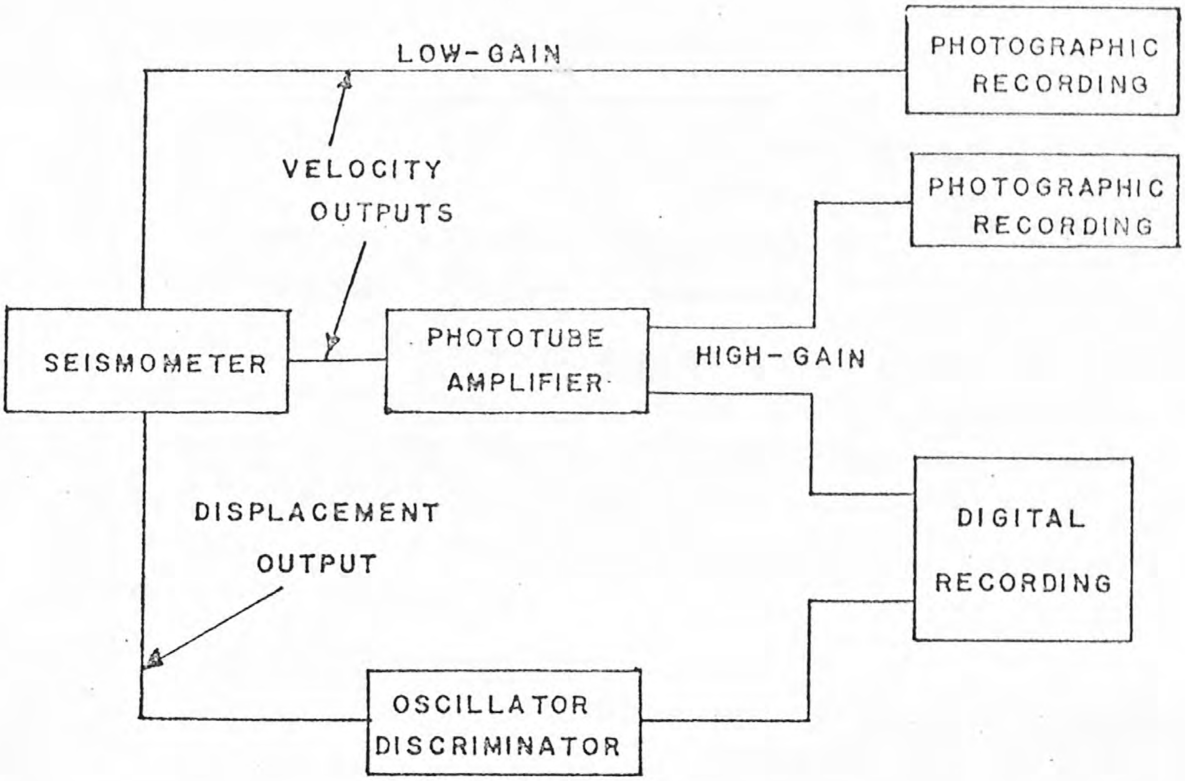


Figure 1. Single component block diagram of the HGLP System.

Magnification at MAT is limited to about 45,000 at periods of 35 to 45 seconds because of background noise. This magnification is achieved by isolating the seismometers from barometric and thermal changes, by filtering out the 6-second microseisms, and by shaping the system response to take advantage of a natural low in the earth noise spectrum.

The HGLP system was developed by the Lamont-Doherty Geological Observatory. A report by Choy and others (1971) contains a complete description of the instrumentation. Although Albuquerque Seismological Laboratory has made some minor changes, the instrumentation and installation procedures used were essentially those described in Choy and others (1971).

The Matsushiro Seismological Observatory is under the direction of the Seismological Division of the Japan Meteorological Agency in Tokyo.

2. STATION DESCRIPTION

2.1 Station Location

Coordinates:	36°	32'	30"	north latitude
	138°	12'	32"	east longitude
Elevation:	422 metres (approximate)			
Overburden:	48 metres (approximate)			

The Matsushiro Seismological Observatory (fig. 2) is located near the small town of Matsushiro, Japan, on the island of Honshu, about 200 km northwest of Tokyo (fig. 3). The nearest large city is Nagano, with a population of 300,000. Nagano is about 11 km north of Matsushiro (fig. 4). The nearest seacoast is the Sea of Japan, some 50 km north-northwest of the station.

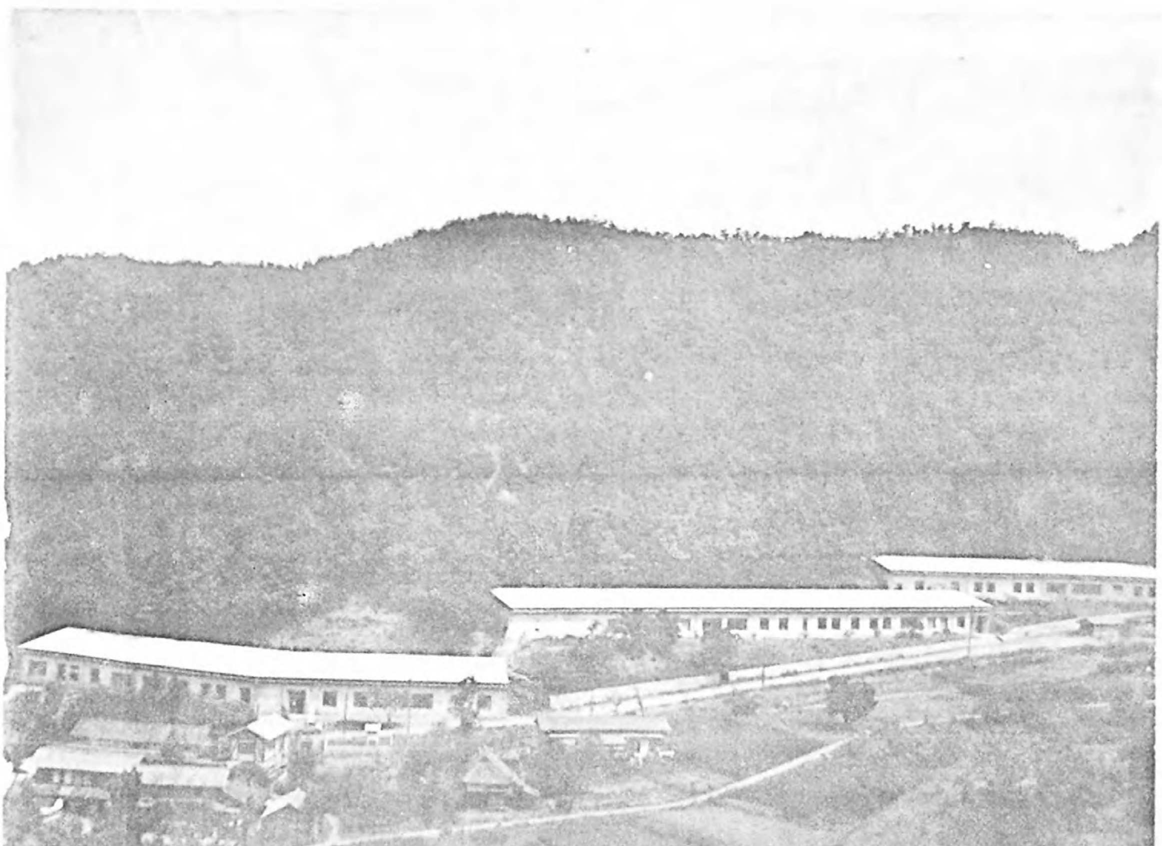


Figure 2. Photograph showing Matsushiro Seismological Observatory

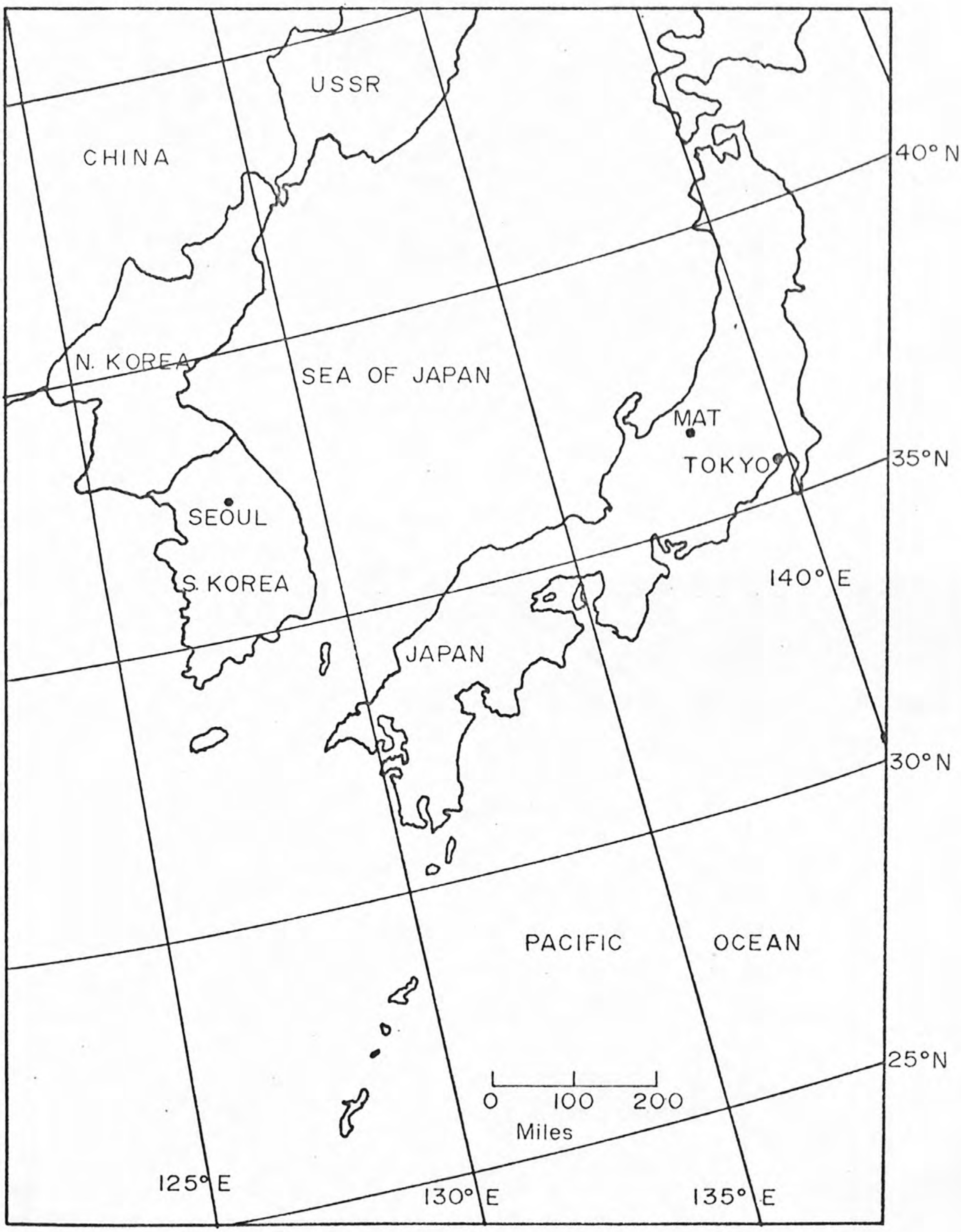


Figure 3. Index map of Japan and vicinity showing location of MAT HGLP Station.

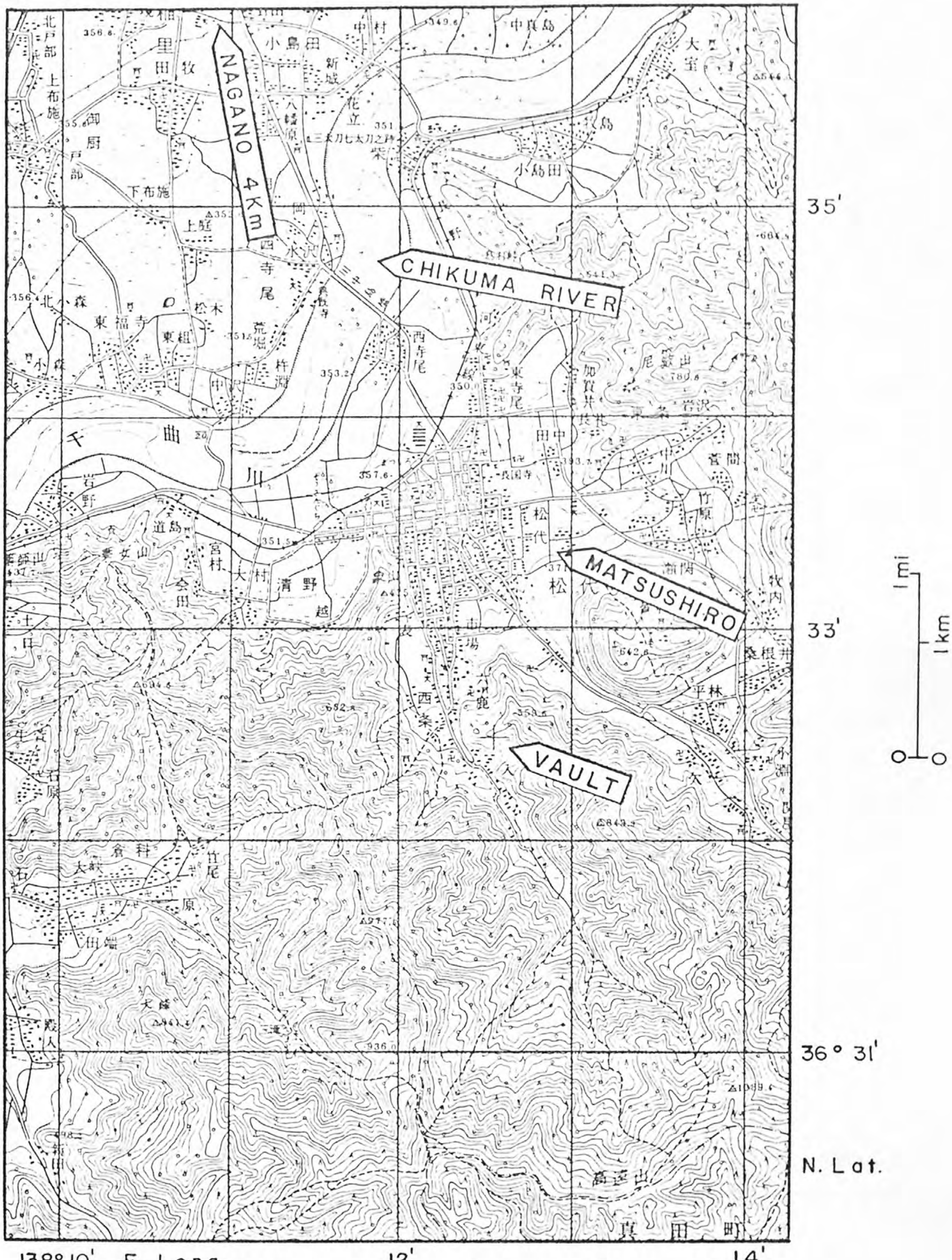


Figure 4. Topographic map of Matsushiro area, from Japanese Topographic Survey, 1912, by Kokudochiri-in (Japan Land and Topographical Organization). Nagano Quadrangle, revised 1960, new data 1966, scale = 1:50,000. Contour interval = 20 metres, elevations are in metres. "Vault" is station.

2.2 Local Physiography

The station is very near the town of Matsushiro (fig. 4). A small stream passes near the mouth of the tunnel network in which the seismometers are located (fig. 5). The Chikuma River passes within 5 km of the station in a general southwest to northeast direction (fig. 4). The Sei River lies about 8 km north of the station. The Sei and Chikuma Rivers join at a point about 9 km north-northeast of the station to form Japan's largest river, the Shinano River.

The tunnel network is inside a small mountain, dug into solid rock. Within a radius of a few kilometres are mountains of about 800 metres elevation, and within 40 km there are large mountains of about 2000 metres elevation (the Japan Alps). The area surrounding the station is heavily wooded (fig. 3). The trees range in size from seedlings to perhaps 20 metre trees. Some small lumbering operations take place near the station periodically.

2.3 Climate

The Matsushiro area enjoys a moderate climate due to its latitude and its proximity to a sea coast, even though the area is mountainous. Snowfall in winter is frequent, but usually does not stay on the ground more than a few days. In general, the climate can be described as warm and rainy with no definite dry season.

The wettest month is September, with about 6.5 inches (16.5 cm) of precipitation. Average annual precipitation is 27 inches (68 cm). The coldest month is January, with temperatures of 20°F to 40°F. The warmest month is July, with temperatures ranging from the lower 60's to the upper 80's. The average annual temperature is about 50°F.

2.4 Local Geology

Local formations are primarily Tertiary sedimentary rock intruded by quartz-diorite. A stratigraphic section is not available (Hill and Minsch, 1965).

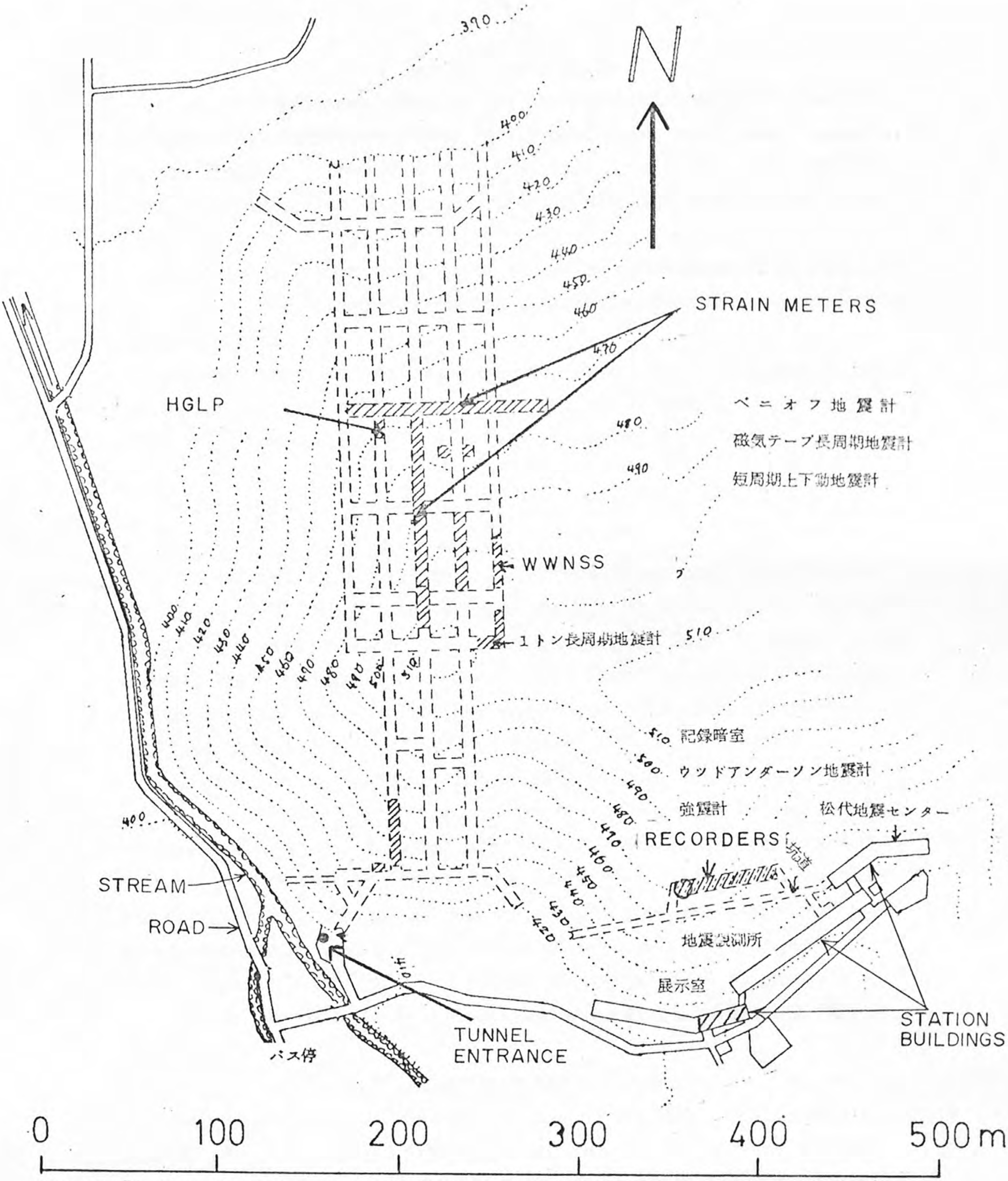


Figure 5. Map showing tunnel and topographic detail. Dashed lines indicate tunnels. Locations of HGLP instruments, WWNSS instruments, strain meters, and recorders are shown. Other cross hatched areas are locations of other instruments operated at MAT. Contour interval 10 metres. Elevations are in metres.

2.5 Cultural Noise

The only buildings close to the station are those of Matsushiro Seismological Observatory, some family dwellings, and a small school. The road leading to the observatory carries occasional, slow traffic. Normally, only traffic concerned directly with the observatory travels this road.

Occasionally some small scale lumbering operations occur near the observatory, but no noise connected with these operations was observed on the records.

Almost daily, observatory personnel enter the tunnel area close to the vault, but very seldom enter the HGLP vault itself. Some very small disturbances can be expected daily due to these visits.

3. STATION CONSTRUCTION AND INSTALLATION

3.1 General Description

The network of tunnels shown in figure 5 was originally blasted out during World War II for Japanese defense purposes. After the war (1947) the Central Meteorological Observatory in Tokyo installed seismographs there because of the ideal underground location. Since 1947, CMO has been upgraded to JMA, and many types of seismic instrumentation have been installed in this tunnel system.

In areas where instruments have been placed, concrete walls, ceilings, and floors have been constructed so there is no danger of rock debris falling. In particular, the HGLP vault was constructed just before the installation. Airtight concrete walls were installed across the tunnel to isolate the instruments from short-term temperature and pressure variations. The walls were painted to insure a good seal. Pressure-tight bulkhead doors provide entrance to the vault.

The construction work was done under contract by a local firm.

3.2 Seismometer and PTA Rooms

Figure 6 is a detailed plan drawing of the HGLP vault. The seismometer piers are circular in shape and are attached directly to rock. They are isolated horizontally from the floor by one inch of styrofoam material.

The anchor bolts holding down the seismometer tanks are set in the rock under the pier in most cases. The holes for these bolts were drilled to varying depths of 20 to 30 cm as required.

The tank bottoms were "prestressed" to a dome about 1.3 cm high at the center and placed on a dome of concrete on the pier. They were then anchored tightly to the pier with six anchor bolts each, so that excess concrete and air pockets were squeezed out from under the tank bottoms. The stress was then gradually relieved, with the tank bottom anchored tightly to the piers.

The cable entrance to the seismometer room is a series of plastic pipes sealed with "Scotchcast" resin to maintain the air seal of the room. Cable entrances to the seismometer tanks are "Scotchcast" resin castings and marine type connectors.

After placing the seismometers in the tanks, the tank tops were clamped securely to the bottoms with 12 C-clamps. Rubber gaskets coated with silicone grease were used to assure a good seal. The tanks were then purged with argon gas to reduce oxidation, growth of fungus, and thermal convection.

In the PTA room, the PTA's were placed on the floor, as no piers were provided. This room also contains a dehumidifier, but tests showed that it produced no appreciable noise on the records. The power supply for the displacement transducers was installed on top of the junction box shown in figure 6.

3.3 Recording and Console Rooms

The HGLP recording room was constructed adjacent to the WWNSS recording room (fig. 7). The piers are concrete with flat, smooth concrete tops.

There was sufficient space available in the existing console room to install the digital recorder and the HGLP cabinet in the center of the room.

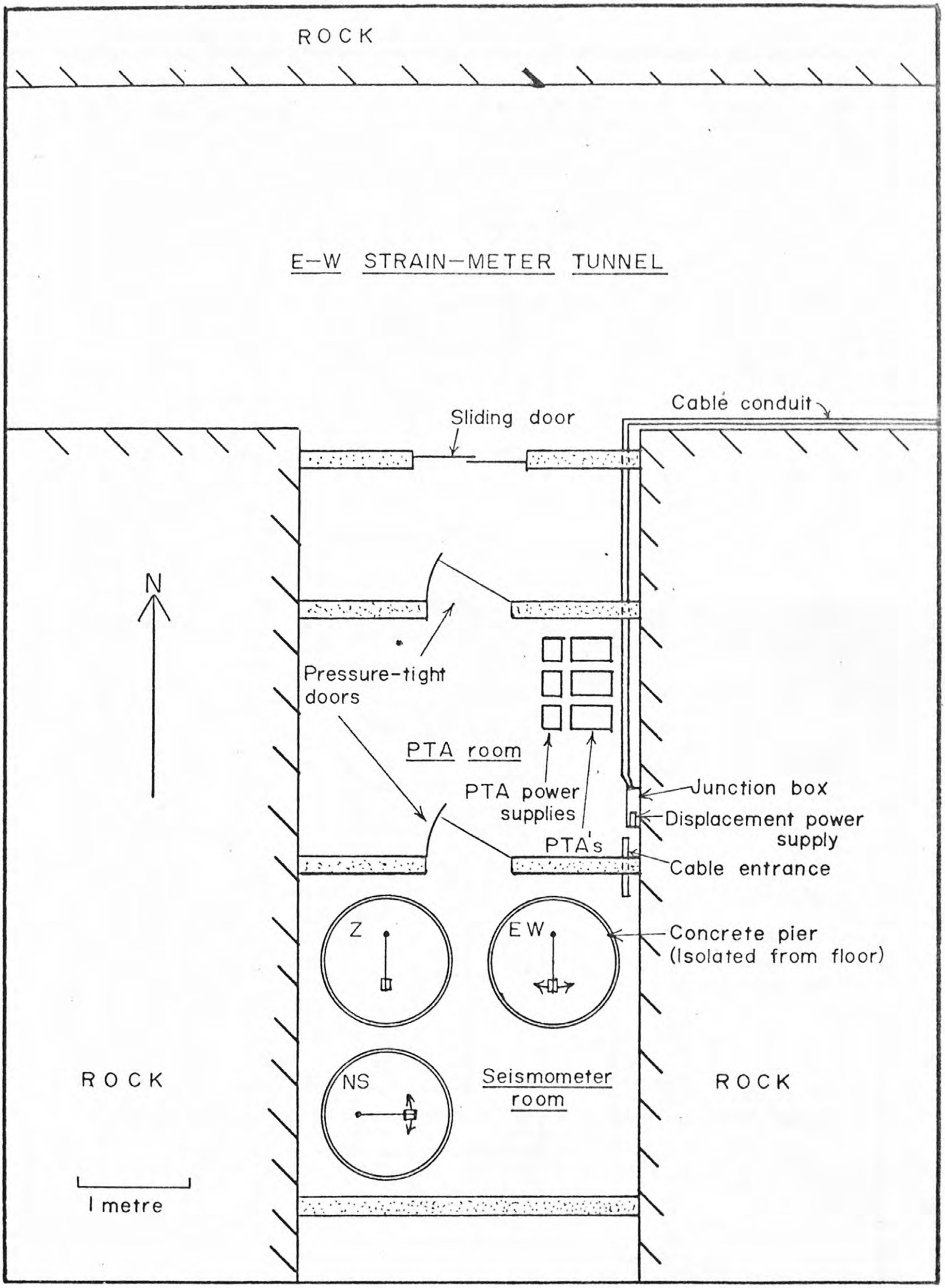


Figure 6. Plan drawing of seismometer and PTA rooms.

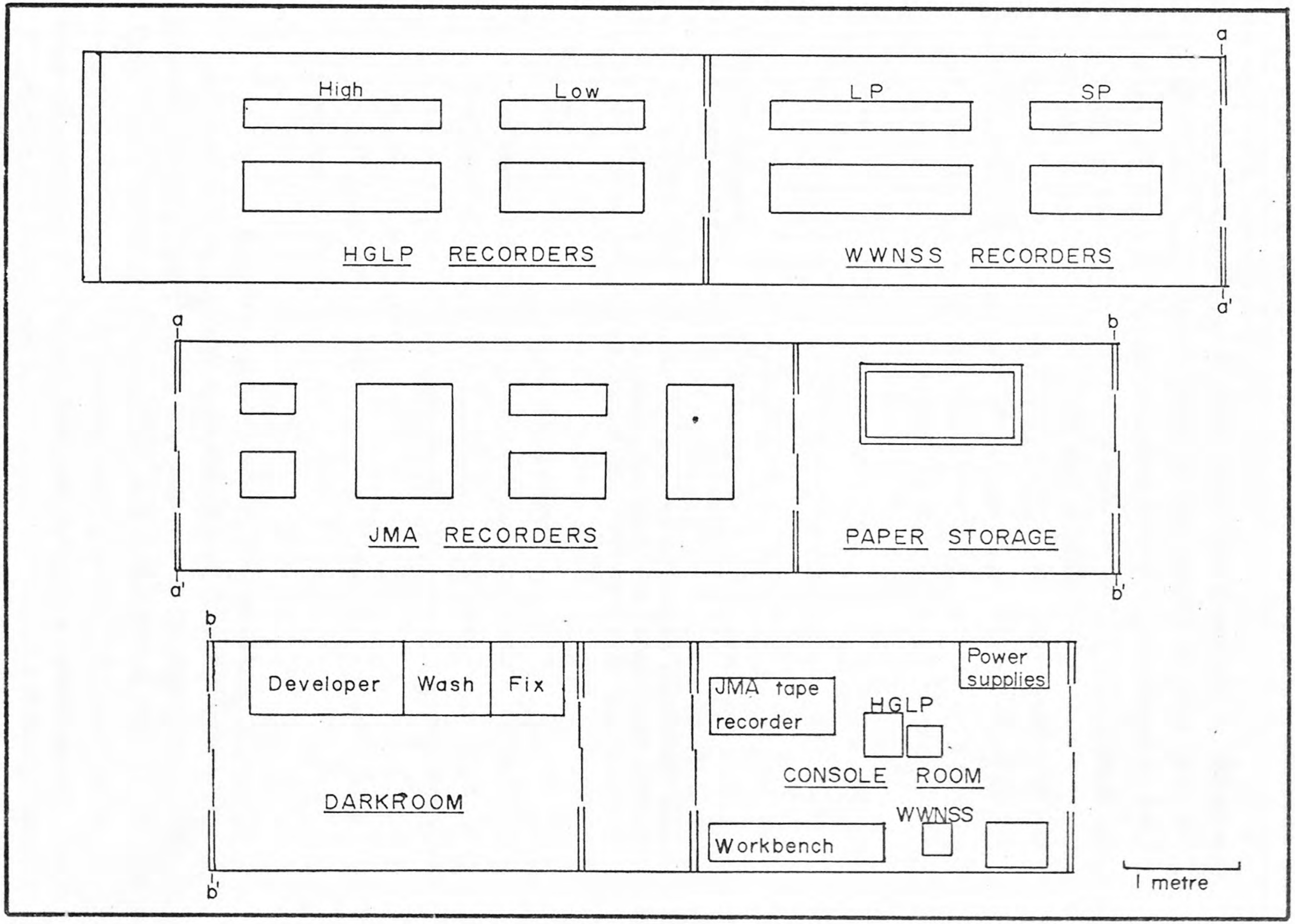


Figure 7. Plan drawing of recording and console rooms.

3.4 Cabling

Twenty-seven pairs of shielded cable were installed by MAT personnel before the installation. Since a total length of about 1600 feet of cable was required, it was necessary to splice the cables at the midpoint. Signal cables (solid copper) were spliced with crimped copper connectors; the rest of the cables were soldered.

The HGLP cables were routed along with the WWNSS cables. A small portion of this cable is above ground and exposed to the elements.

A shielded power cable in the HGLP bundle provides regulated A-C power to the PTA power supplies and the displacement transducer power supply.

4. STATION FACILITIES

4.1 Available Commercial Power

Voltage:	100 V
Frequency:	60 Hz
Reliability:	Power is very reliable with occasional short failures. An Exide emergency power system was installed in September 1973.

4.2 Time Standards

Time marks for the recorders is obtained through a buffer relay from the WWNSS console. This timing system is corrected daily to JJY radio time signals. In addition, several crystal-controlled secondary time sources are available.

The digital recorder has a built-in crystal controlled timing system with good accuracy.

4.3 Station Temperature and Humidity

The seismometer and PTA rooms should remain very constant in temperature (about 15°C) during the year due to the underground location. Daily fluctuations are almost zero. Humidity is high due to the recent construction (water from the new concrete). The seismometer room will probably remain very damp, as there is no dehumidifier. The PTA room is kept fairly dry with the constant use of a dehumidifier.

The recording room is also very temperature stable at about 15°C. A dehumidifier running constantly keeps this room fairly dry. Humidity is about 90%, but there is little or no water condensation on metal parts.

4.4 Background Noise

Predominant microseisms are present in the 4 to 6 second range with an amplitude of 1 micron. There is also noise present in the 16-22 second range with amplitudes from 50 to 100 millimicrons. Long period noise seems to be generated whenever the weather is changing. Some typical measured periods and amplitudes of this type of noise follow:

Period (sec.)	Amplitude (microns)
60	0.3 (Vertical)
90	0.5 (Vertical)
120	2 (Vertical)
80	0.4 (Horizontal)
180	11 (Horizontal)
240	10 (Horizontal)

Although this type of noise cannot technically be called "microseismic," it appears to be ground motion. Its probable cause is wind or a weather front in motion across the area (long period "acoustic" coupling).

5. OTHER INSTRUMENTATION

Although an exact and complete list is not available, many different types of seismic instruments are operating at this site. Short period and long period instruments are in use.

Of particular interest is a water tube tilt meter, which should correspond to the HGLP horizontal displacement data. Also of interest is the two component, 100 metre strain meter.

It should be noted here that the Matsushiro Seismological Observatory is used as a testing site for many types of new instruments.

6. ACKNOWLEDGMENTS

All of the personnel at MAT were very cooperative, friendly, and helpful. Of particular assistance were Dr. Suyehiro of JMA and Mr. Aihara of MAT, both of whom deserve hearty thanks.

Some valuable help in various things was received from Dr. Hiatt (Counselor for Scientific Affairs, U. S. Embassy, Tokyo) and his assistant, Mr. Zorn.

7. REFERENCES

Choy, G., Connor, M., Cory, S., England, F., Hade, G., Johnson, T., McCamy, K., Murphy, A., Pomeroy, P., Rynn, J., Savion, J., Sbar, M., and Ward, P., 1971, _High-Gain, Long-Period Seismograph Station Instrumentation,_ Vols. I & 2, Lamont-Doherty Geological Observatory of Columbia University.

Hill, Brian B., and Minsch, John H., 1965, MAT Installation Report, Station Participating in U. S. Coast and Geotetic Survey World-Wide Network of Standardized Seismographs, Albuquerque Seismological Center.

APPENDIX 1. SUMMARY OF PERSONNEL AT THE MATSUSHIRO SEISMOLOGICAL OBSERVATORY

Station:	Matsushiro Seismological Observatory Matsushiro, Japan
Station Abbreviation:	MAT
Station Director:	Mr. K. Kubota Chief, Matsushiro Seismological Observatory Telephone: 262-78-2235
Station Supervisor:	Mr. Aihara Matsushiro Seismological Observatory Telephone: 262-78-2235
Mailing Address:	Director, Matsushiro Seismological Observatory Japan Meteorological Agency Matsushiro, Honshu Japan
Station Installation:	November 27, 1972 to December 23, 1972
Installation Personnel:	Mr. Bill Strahle (ASL) Mr. West Gilbertson (Philco-Ford) Mr. Bob Hutt (ASL)

The Matsushiro Seismological Observatory is under Dr. S. Suyehiro, Head, Seismological Division, Japan Meteorological Agency, Tokyo, Japan. Telephone: 212-8341.

APPENDIX 2. HIGH-GAIN LONG-PERIOD INSTRUMENT CHARACTERISTICS

			COMPONENT		
			Z	N S	E W
SEISMOMETER	Model Number		Geotech 7505A	Geotech 8700	Geotech 8700
	Serial Number		7	211	178
	Free Period		30.1 sec.	30.2 sec.	28.6 sec.
	Linearity at T = 30 sec.		Less than ± 1 sec. from average for ± 3 mm boom displacement		
	Magnets		NOT MEASURED		
	Coil Resistance	Standard Signal	572 ohms (Top Coil)	570 ohms (South Coil)	550 ohms (East Coil)
		High Gain Signal	569 ohms (Bottom Coil)	567 ohms (North Coil)	548 ohms (West Coil)
		Primary Calibration	3.2 ohms[1] (Top Coil)	2.3 ohms[1] (South Coil)	3.5 ohms[1] (West Coil)
		Secondary Calibration	3.0 ohms[1] (Bottom Coil)	2.3 ohms[1] (North Coil)	2.6 ohms[1] (East Coil)
	G	Standard	84.8 N/A	88.3 N/A	90.8 N/A
		High Gain	84.8 N/A	82.3 N/A	90.8 N/A
		Pri. Cal.	.0251 N/A	.0264 N/A	.0277 N/A
		Sec. Cal.	.0245 N/A	.0273 N/A	.0291 N/A
Displacement Trans.	Model Number		Sprengnether VCT-201 BA		
	Serial Number		3990	3988	3984
	Sensitivity[2] (± 3mm range)		3.16 V/mm	3.17 V/mm	3.39 V/mm
	Range of Linearity[3]		± 1 mm	± 1.5 mm	± 1.5 mm
	Sensitivity[4] (linear range)		3.25 V/mm	3.20 V/mm	3.25 V/mm
Standard (Low Gain) Recording Galvo	Model Number		Kinemetrics LG-1		
	Serial Number		156	233	246
	Coil Res.		509 ohms	512 ohms	505 ohms
	CDRX Set at		3000 ohms	3000 ohms	3000 ohms
	Damping w/ 3K		Slightly under	Critical	Slightly over
	Free Period		100 sec.	100 sec.	100 sec.

		COMPONENT		
		Z	NS	EW
Filter Galvanometer	Model Number	Kinemetrics LG-1		
	Serial Number	258	253	252
	Coil Res.	491 ohms	491 ohms	493 ohms
	Free Period	6 sec.	6 sec.	6 sec.
PTA Galvanometer	Model Number	Kinemetrics LG-1		
	Serial Number	247	181	206
	Coil Res.	500 ohms[5]	500 ohms[5]	500 ohms[5]
	CDRX Set AT	3000 ohms	3000 ohms	3000 ohms
	Damping w/ 3K	Critical	Critical	Critical
	Free Period	101 sec.	100 sec.	99 sec.
High Gain Recording Galvanometer	Model Number	Geotech 4100-281		
	Serial Number	UNKNOWN		
	Coil Res.	80 ohms	80 ohms	80 ohms
	CDRX	80 ohms	80 ohms	80 ohms
	Damping	Critical	Critical	Critical
	Free Period	0.75 sec.	0.75 sec.	0.75 sec.
	Gain Resistor	1 Megohm	1 Megohm	1 Megohm

[1]Resistance value shown includes pigtail leads. Actual resistance of inductive portion of coil is nominally 0.2 ohms (Geotech specification).

[2]Sensitivity value shown is the slope of the best fit straight line of the form Y = a + bX. The method of least squares was used to determine the best fit.

[3]Value shown is the largest boom displacement for which the actual data points do not deviate from a best fit straight line more than ± 0.1 Volt.

[4]This sensitivity is the slope of the best fit straight line (by the least squares method) used to determine the linear range.

[5]Value is approximate (not measured).

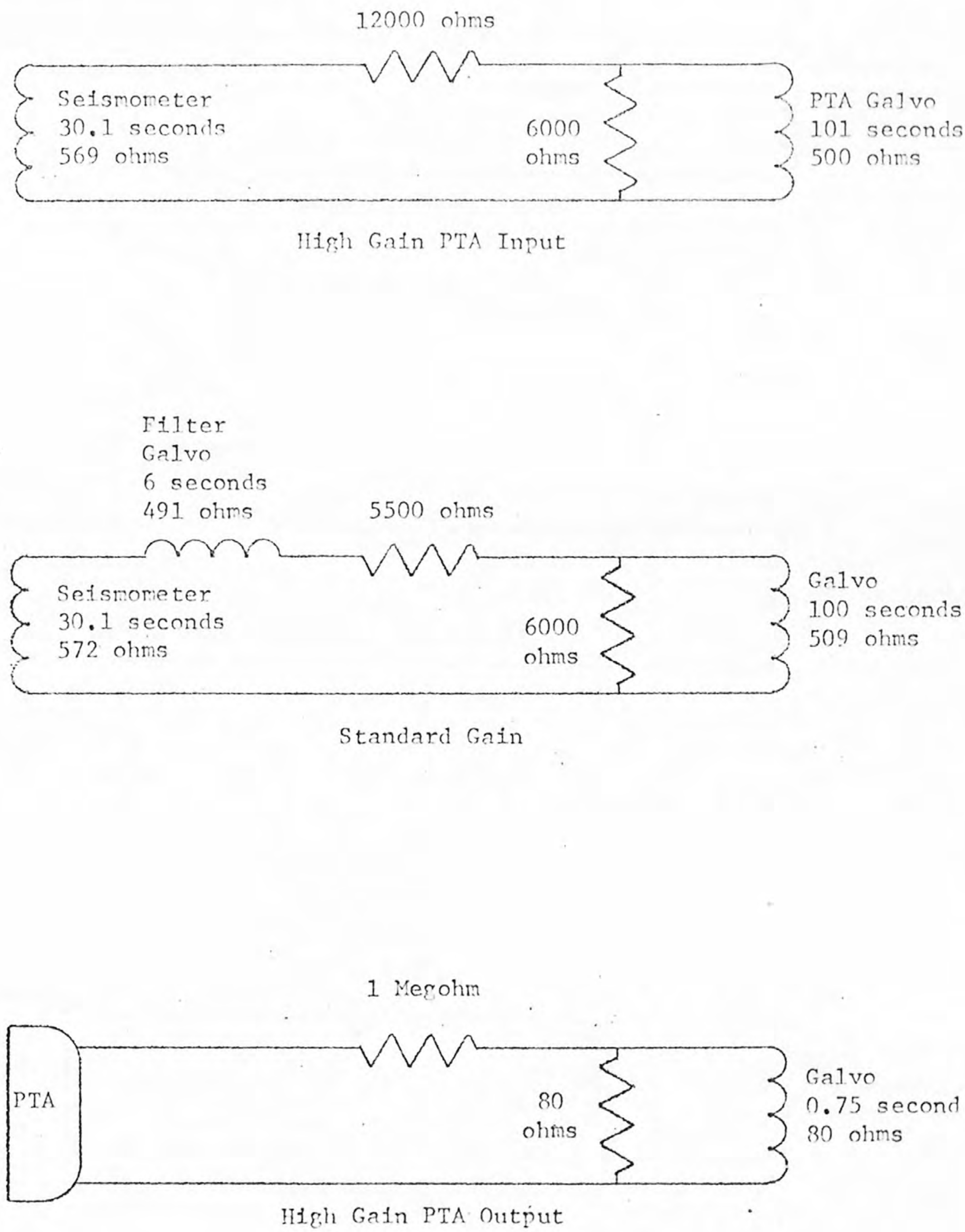


Figure A1. Diagram showing attenuation networks for vertical component.

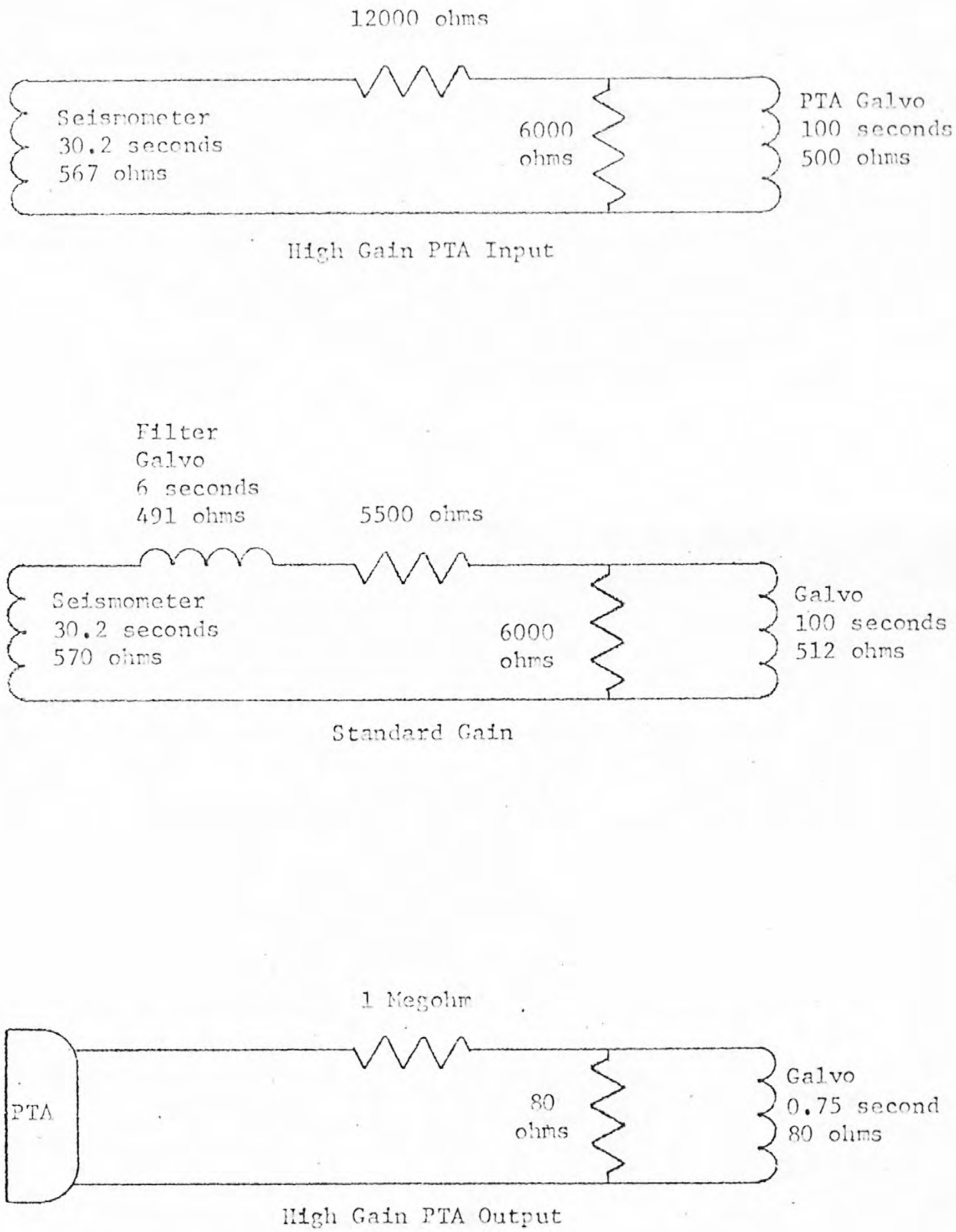


Figure A2. Diagram showing attenuation networks for North-South component.

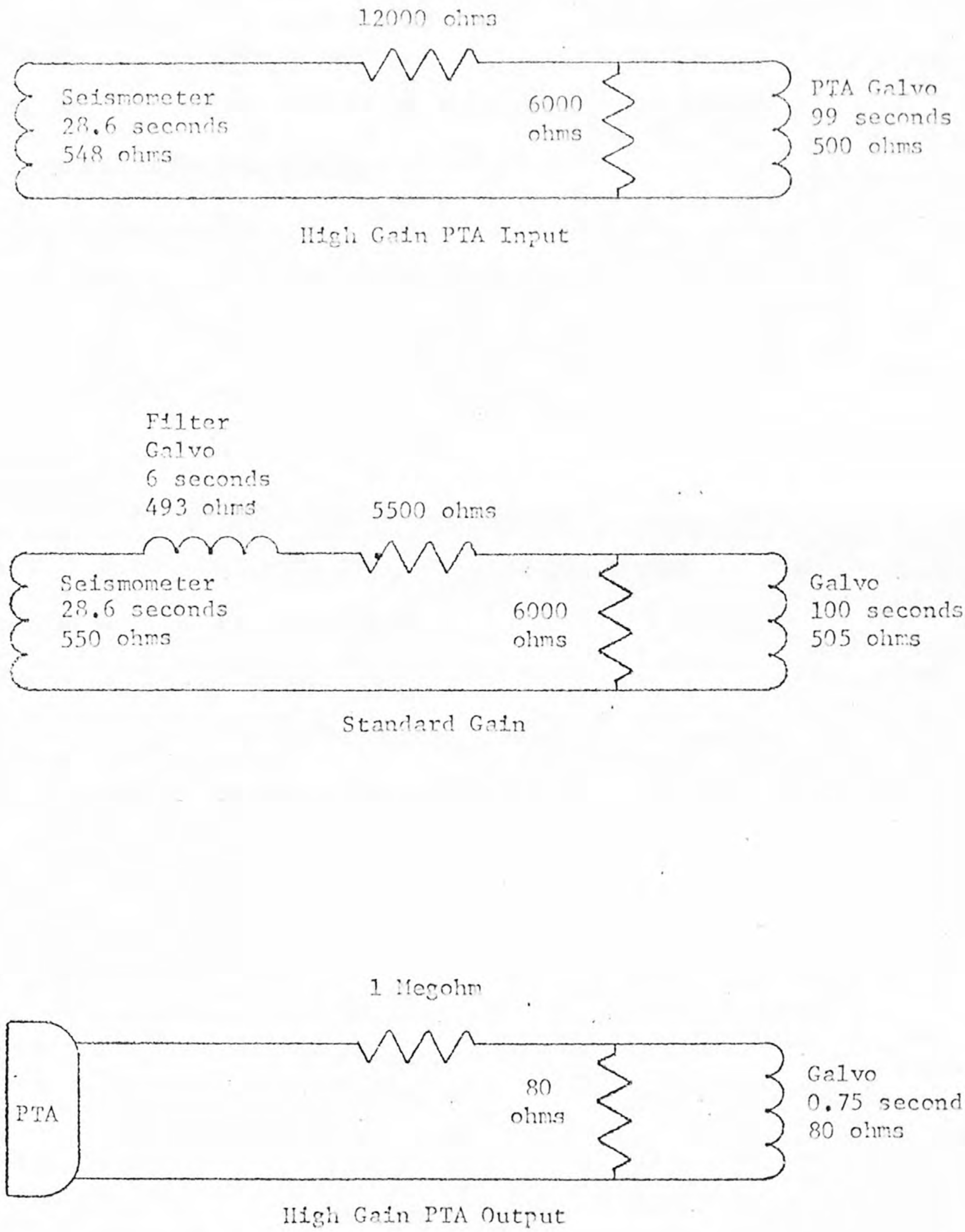


Figure A3. Diagram showing attenuation networks for East-West component.

APPENDIX 3. DIGITAL DATA ACQUISITION SYSTEM

Digital Data Logger

Manufacturer: Astrodata

Serial Number: 101

Preset Information in Data Logger

- Station I.D.: 25
- Record Type: 1
- Year: 2 (3 as of January 1, 1973)
- Number of Days: 366 (365 as of January 1, 1973)
- Filter: Low Pass Position

Information Written to Tape

- Channels 1-3: Velocity data, 1 sample per second
- Channels 4-9: Not connected
- Channel 10 (Test Channel): Shorted
- Channels 11-13: Displacement data, 1 sample per 5 seconds.
- Channels 14-16: Not connected

APPENDIX 4. FREQUENCY RESPONSE AND MAGNIFICATION CURVES

MATSUSHIRO SEISMOLOGICAL OBSERVATORY

HGLP CALIBRATION DATA FOR STANDARD GAIN PHOTOGRAPHIC SYSTEM

December 1972

Calibration Period (sec.)	Component Magnification Z	NS	EW
8	2730	1940	1630
10	3380	3400	3030
12	3940	4000	3730
14	4660	4330	4190
16	5290	4530	4460
18	5790	4640	4620
20	6350	4820	4790
25	6340	4630	4860
30	5850	4480	4840
35	5060	4140	4760
40	4290	3800	4550
45	3710	3480	4280
50	3190	3140	4030
60	2470	2500	3320
80	1490	1570	2100
100	950	1010	1340

MATSUSHIRO SEISMOLOGICAL OBSERVATORY

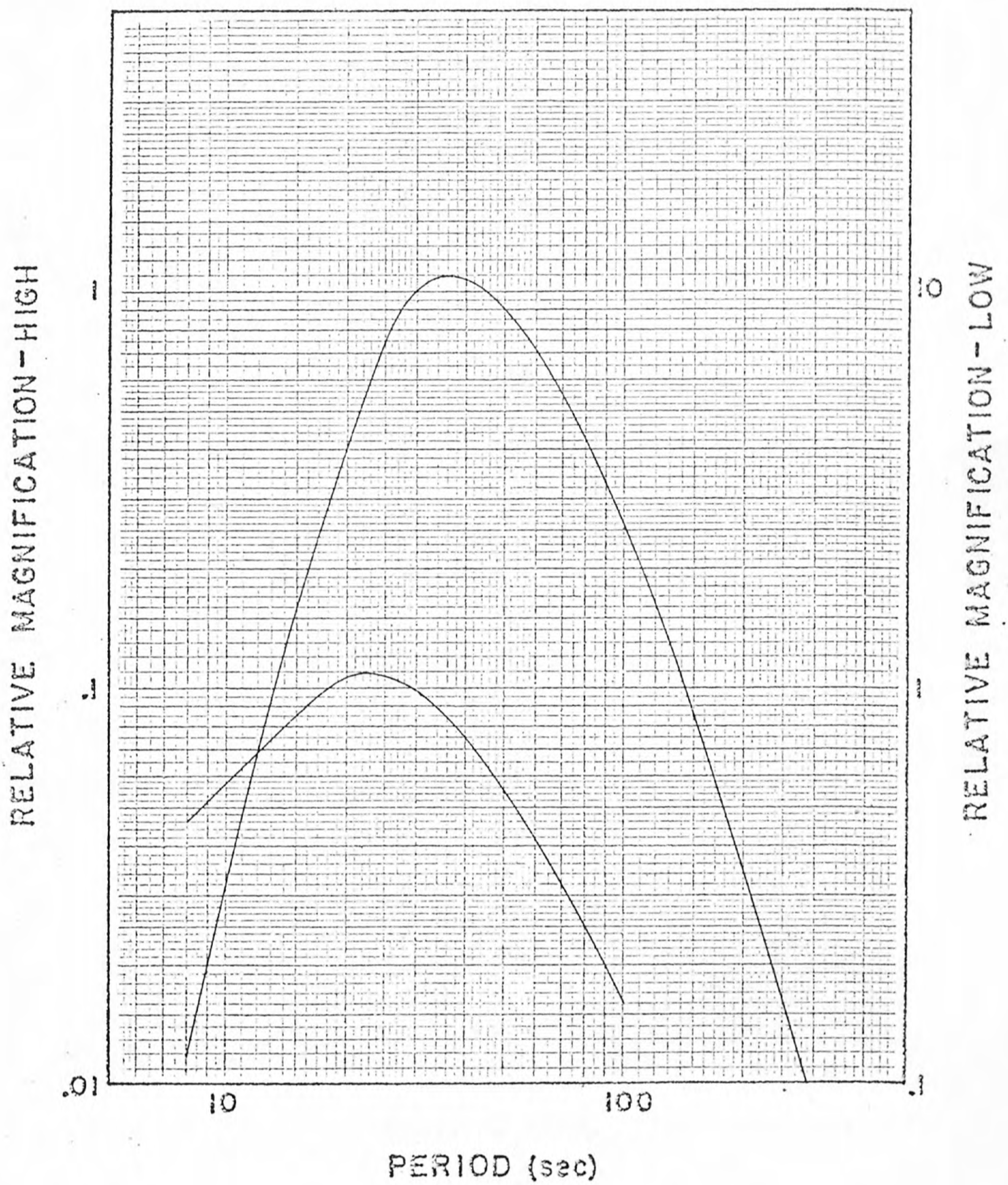
HGLP CALIBRATION DATA FOR
HIGH GAIN PHOTOGRAPHIC SYSTEM

December 1972

Calibration Period (sec.)	Component Magnification Z	NS	EW
8	480	680	645
10	1220	1600	1550
12	2640	3200	2930
14	4490	5730	4980
16	7210	8150	7620
18	11400	11960	10800
20	21500	18700	15800
25	30300	28800	25300
30	40400	36300	33300
35	44500	44400	39600
40	44000	45900	42800
45	40100	45300	42600
50	36400	41900	41500
60	28500	34700	36100
70	22000	27300	29900
80	17000	21700	23600
90	13300	16700	18500
100	10000	13300	14600
145	3640	4630	4910
195	1460	2020	1910
293	373	495	506

STATION: MAT

COMPONENT: Z



DATE: DEC 22, 1972
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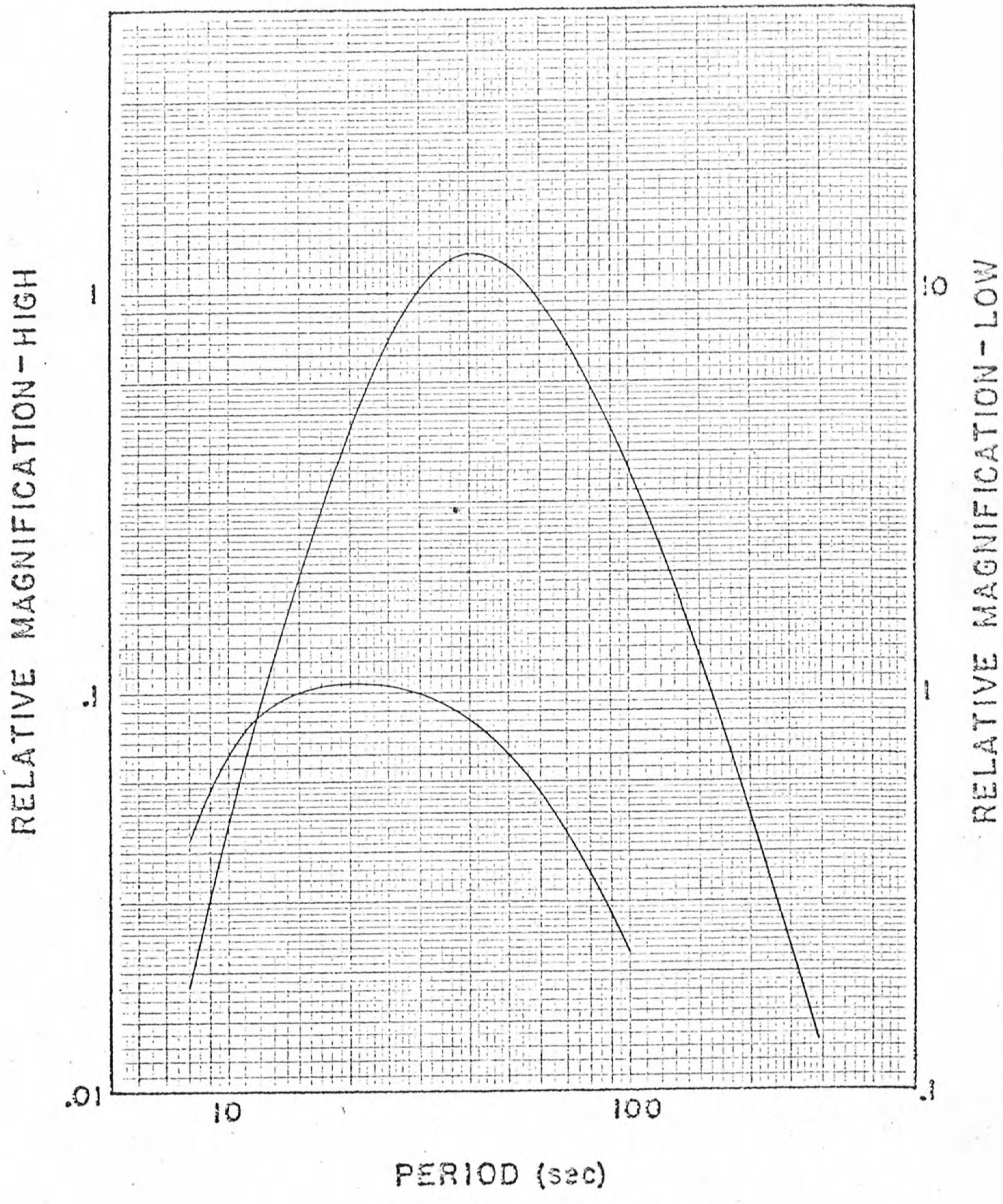
STATION: MAT

COMPONENT: NS



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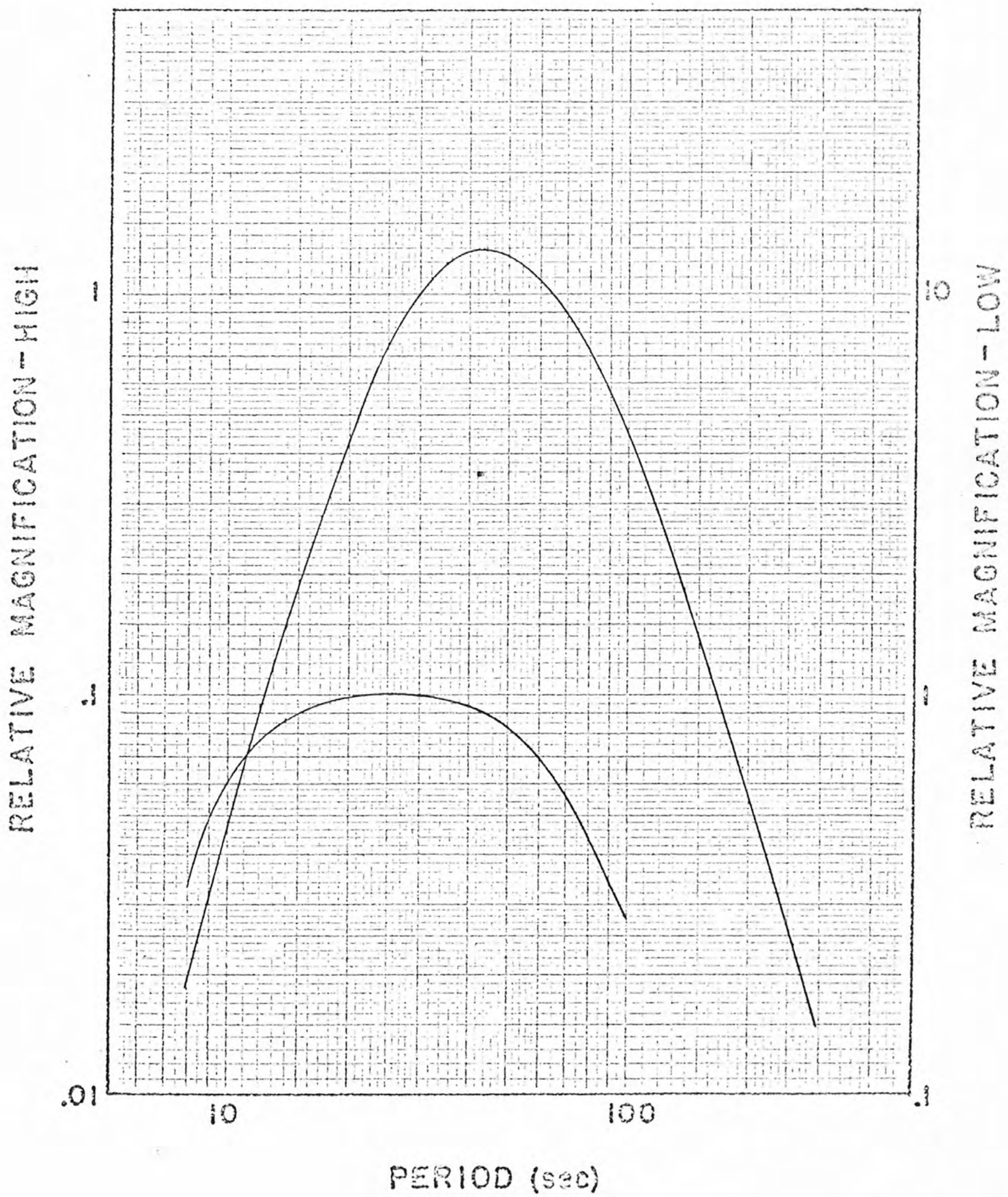
STATION: MAT

COMPONENT: EW



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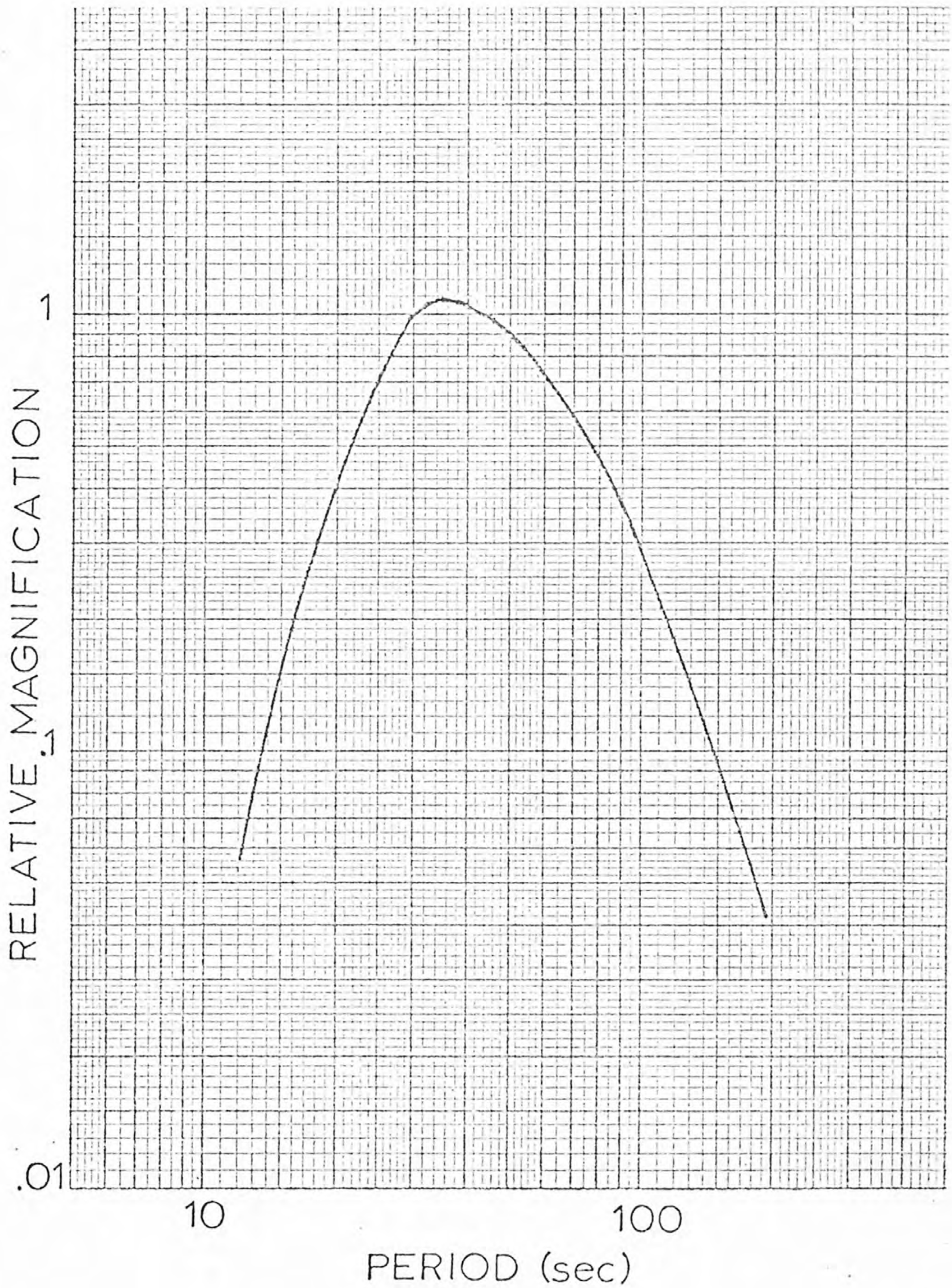
MATSUSHIRO SEISMOLOGICAL OBSERVATORY

HGLP CALIBRATION DATA FOR
DIGITAL DATA SYSTEM

December 1972

Calibration Period (sec.)	Component Gain in Digits Per Micron A1(Z)	A2(NS)	A3(EW)
12	62	74	66
14	133	130	126
16	221	179	192
18	349	253	275
20	459	308	366
25	832	493	612
30	1156	583	862
35	1257	709	1050
40	1227	730	1190
45	1141	699	1207
50	1051	668	1198
60	853	578	1069
70	681	469	893
80	522	388	715
90	427	312	561
100	328	247	439
145	119	91	153
195	49	39	61
293	13	9	15



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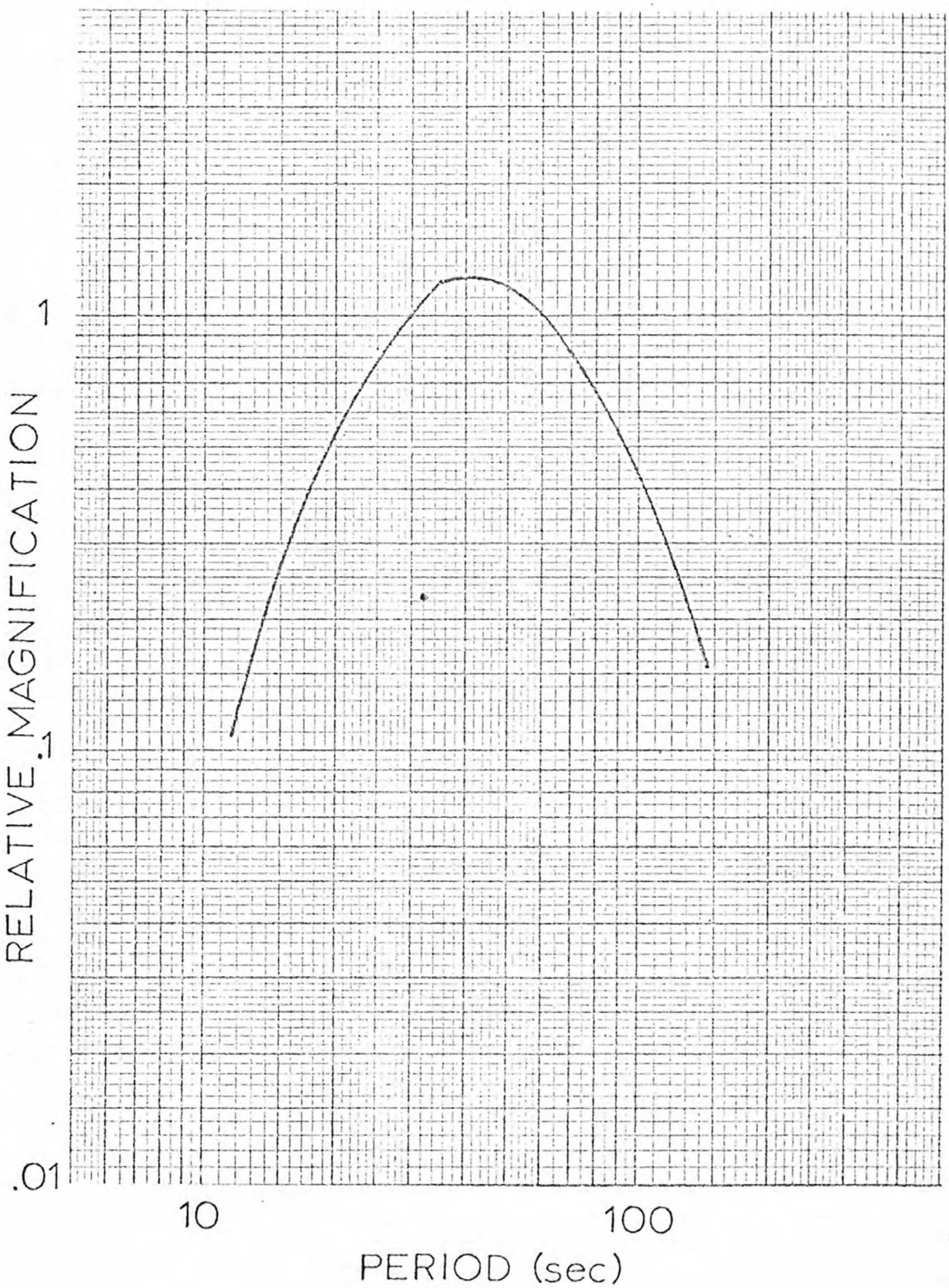

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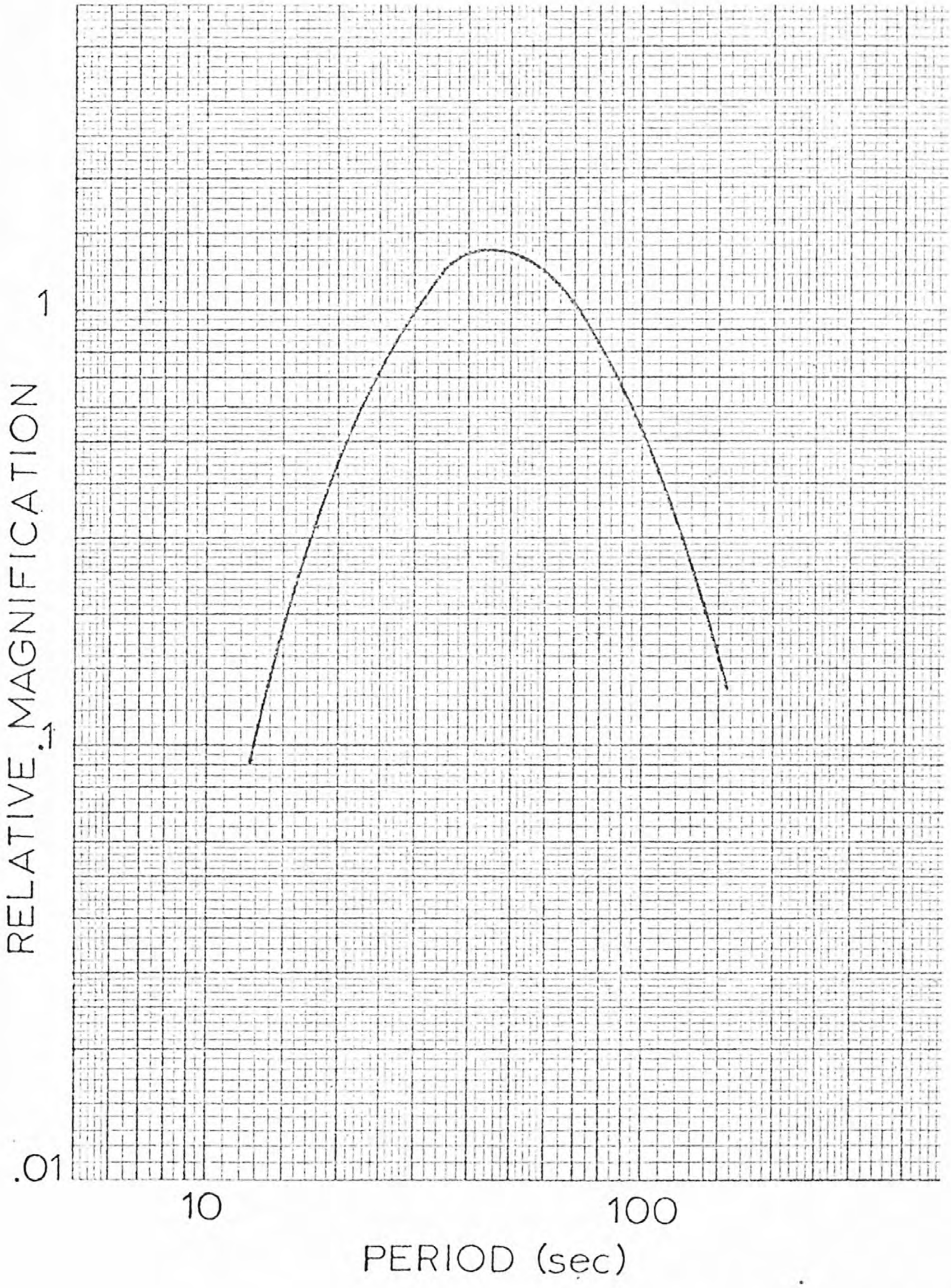


DATE: DEC 1972
SOURCE: ASC

APPENDIX 5. DISPLACEMENT TRANSDUCER CURVES

MATSUSHIRO SEISMOLOGICAL OBSERVATORY

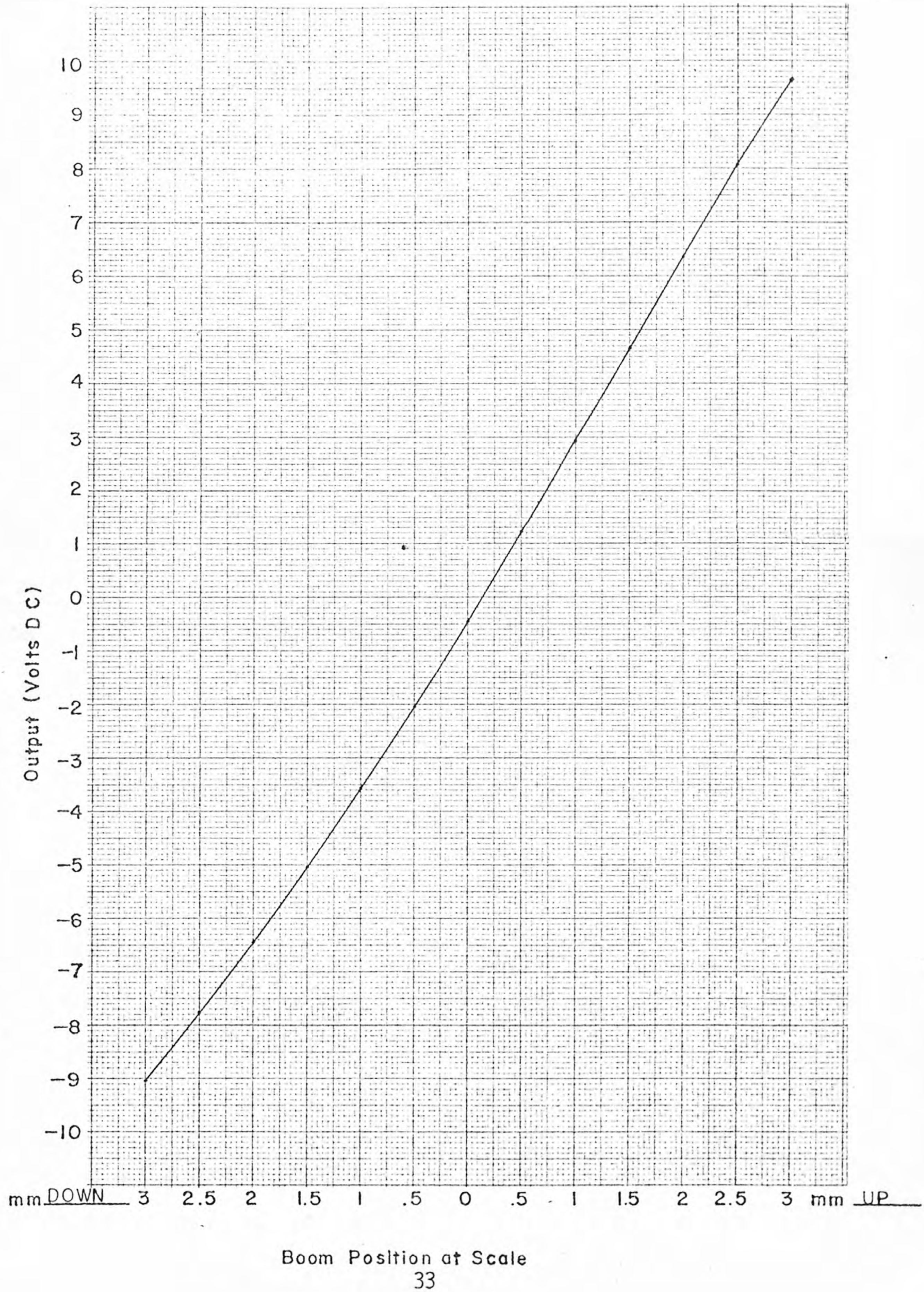
HGLP CALIBRATION DATA FOR DISPLACEMENT TRANSDUCERS

December 1972

Polarity	Boom Position at Scale (mm)	Z Output (VDC)	NS Output (VDC)	EW Output (VDC)
Up, N, E	+3.0	+9.64	+9.80	+9.55
	+2.5	+8.06	+8.50	+8.22
	+2.0	+6.37	+6.75	+6.77
	+1.5	+4.65	+5.05	+5.16
	+1.0	+2.92	+3.35	+3.53
	+0.5	+1.21	+1.70	+1.81
Center	0.0	-0.44	+0.10	+0.01
	-0.5	-2.03	-1.55	-1.83
	-1.0	-3.58	-3.05	-3.62
	-1.5	-5.04	-4.55	-5.41
	-2.0	-6.43	-6.00	-7.14
	-2.5	-7.77	-7.50	-8.78
Down, S, W	-3.0	-9.03	-9.00	-10.17

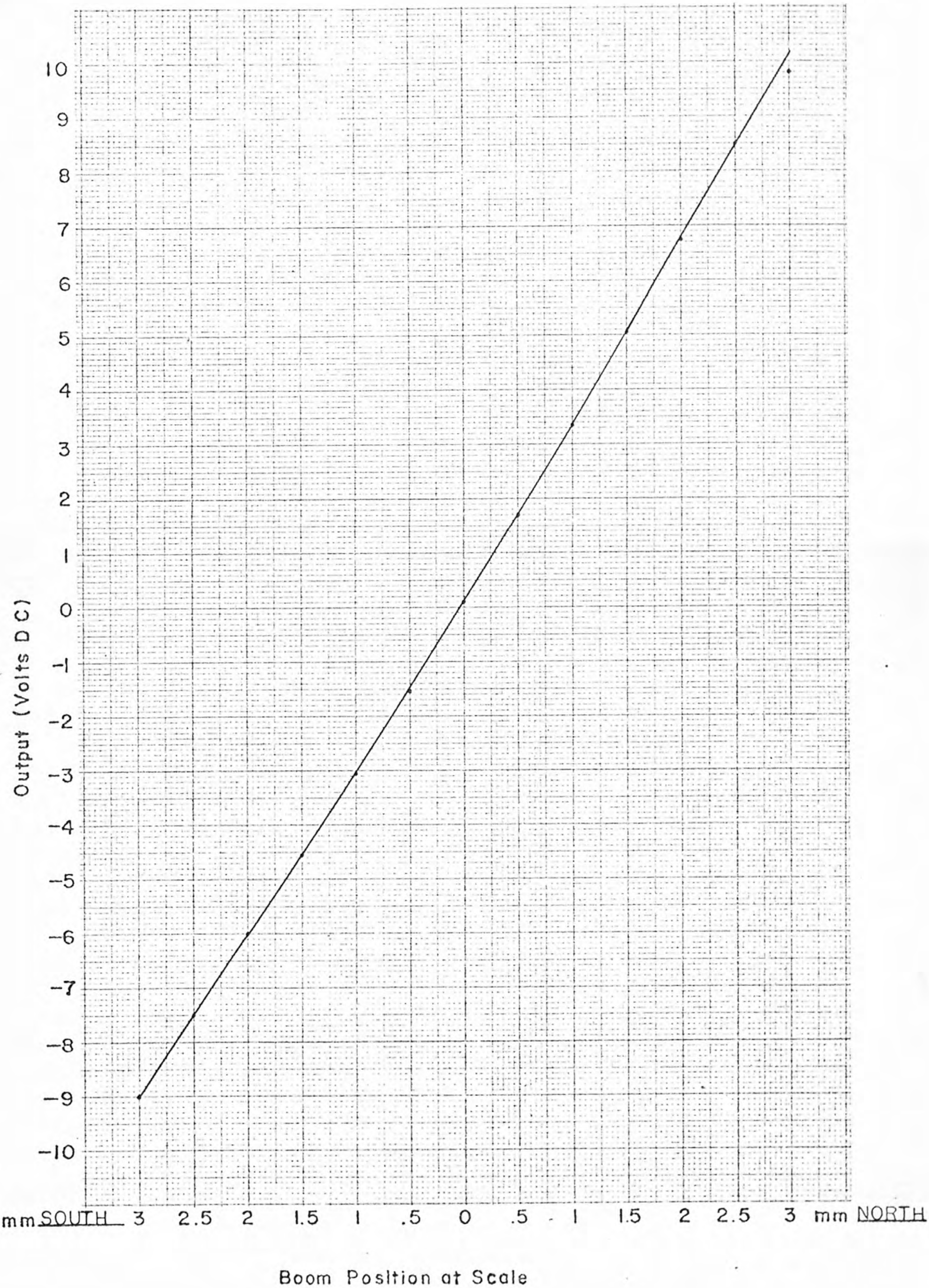
DISPLACEMENT TRANSDUCER CALIBRATION
Serial Number 3990

Station: MAT
Component: Z
Date: DEC. 1972



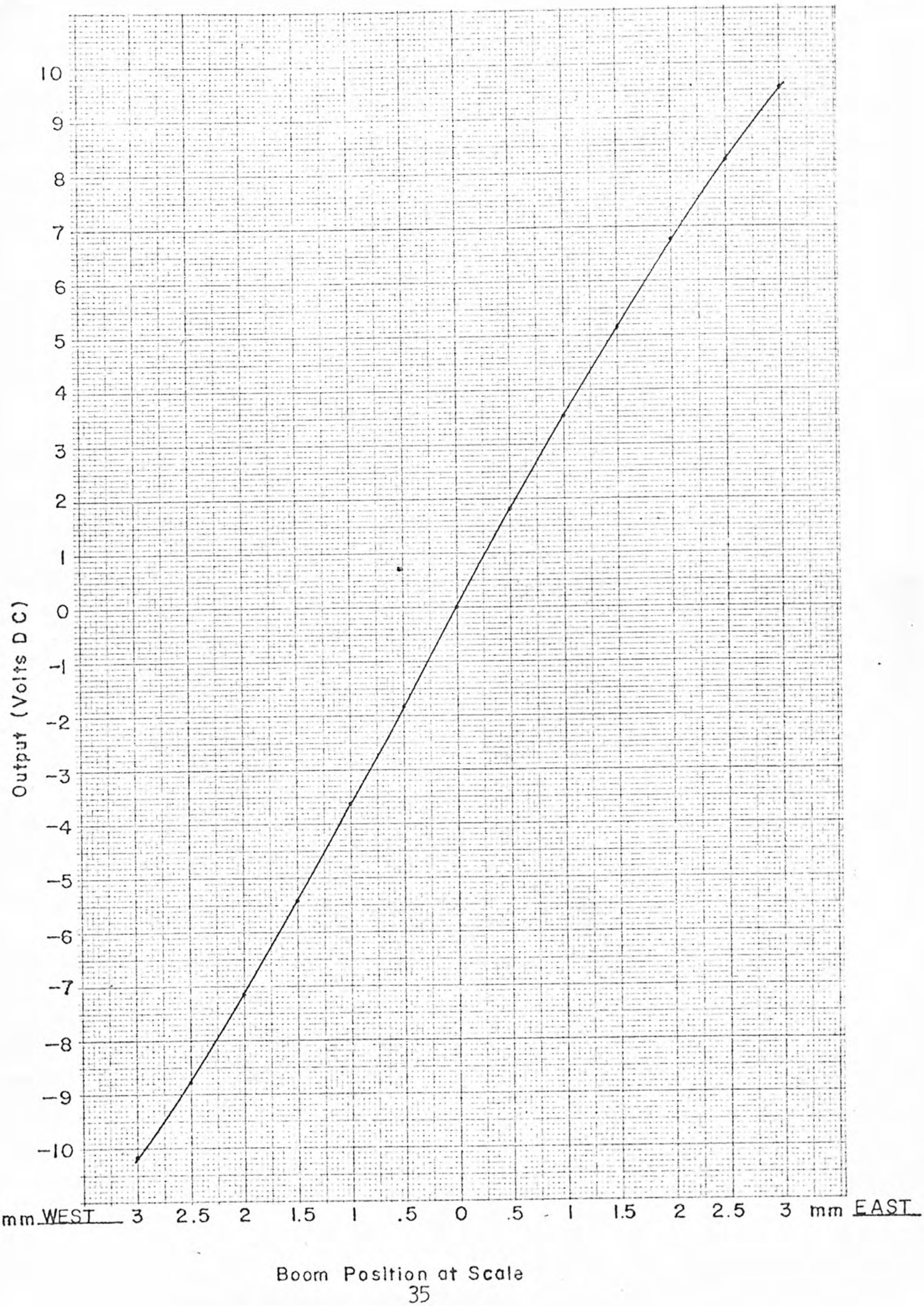
DISPLACEMENT TRANSDUCER CALIBRATION
Serial Number 3988

Station: MAT
Component: NS
Date: DEC. 1972



DISPLACEMENT TRANSDUCER CALIBRATION
Serial Number 3984

Station: MAT
Component: EW
Date: DEC. 1972



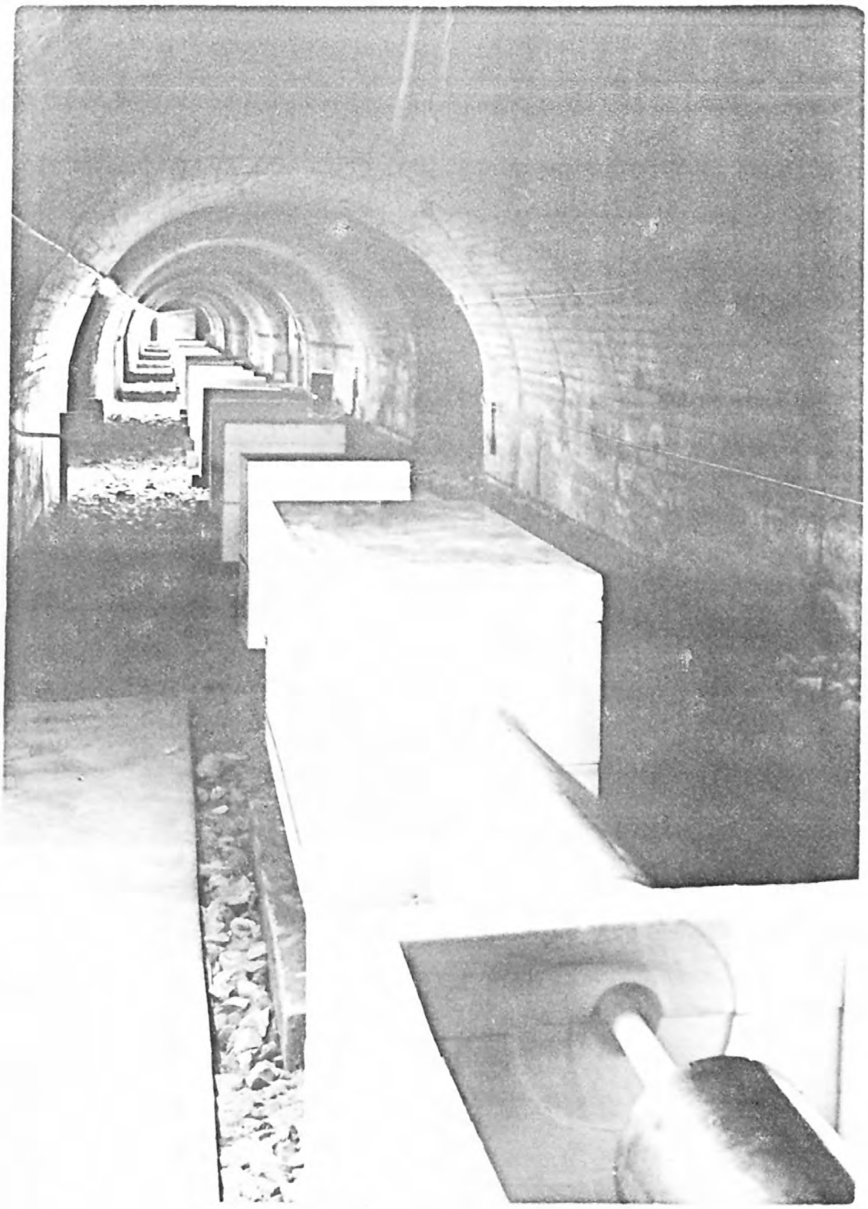


Figure A4. Photograph showing 100 metre quartz tube strain meter (looking east).

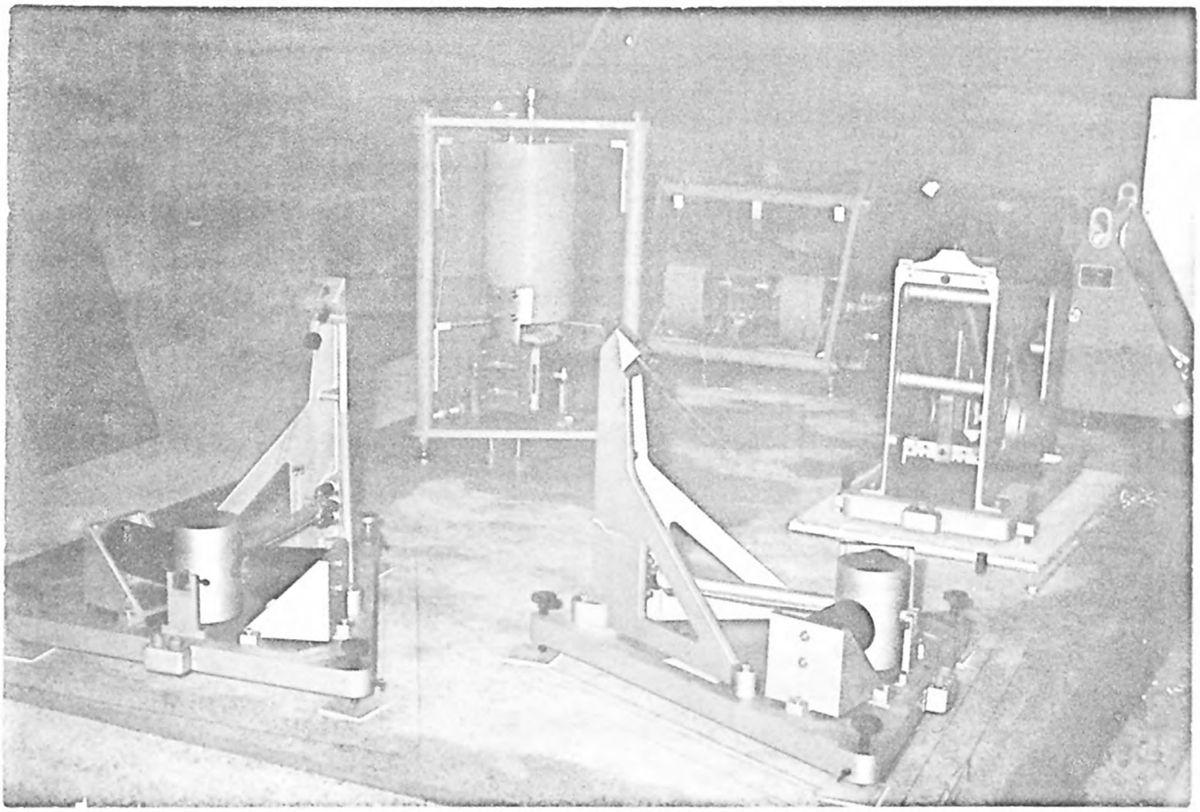


Figure A5. Photograph showing WWNSS seismometers in place.

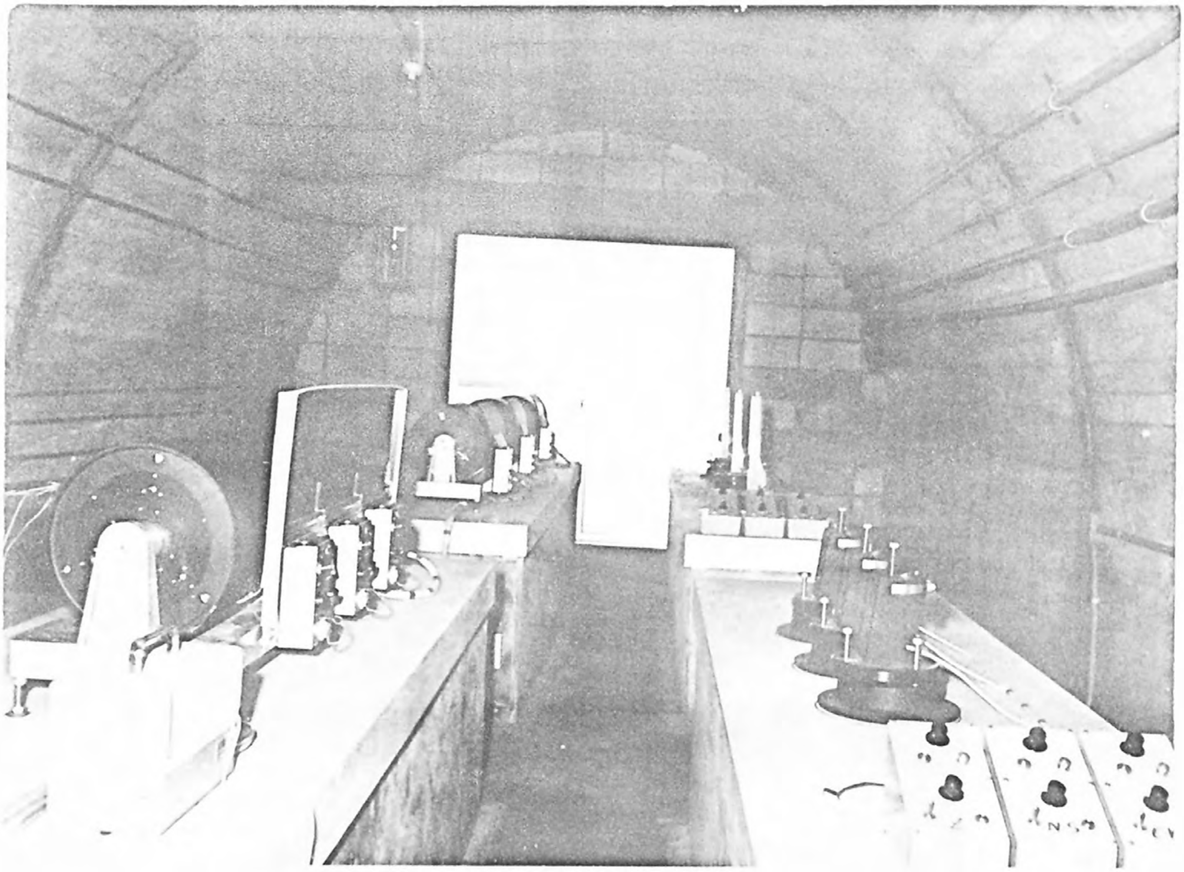


Figure A6. Photograph showing WWNSS recording room.

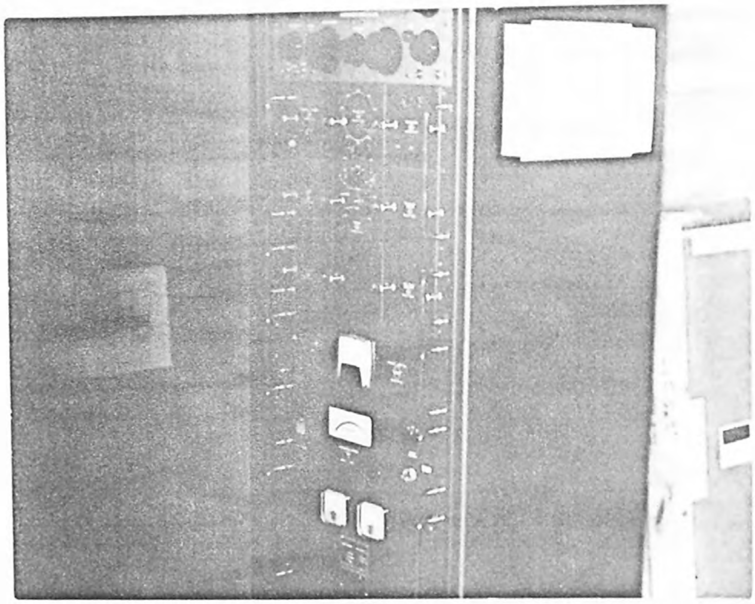


Figure A7. Photograph showing WWNSS console.

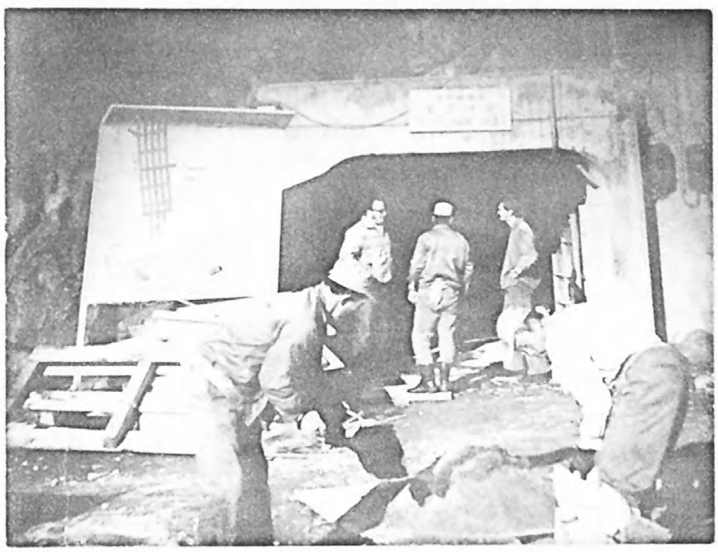


Figure A8. Photograph showing entrance to tunnel.

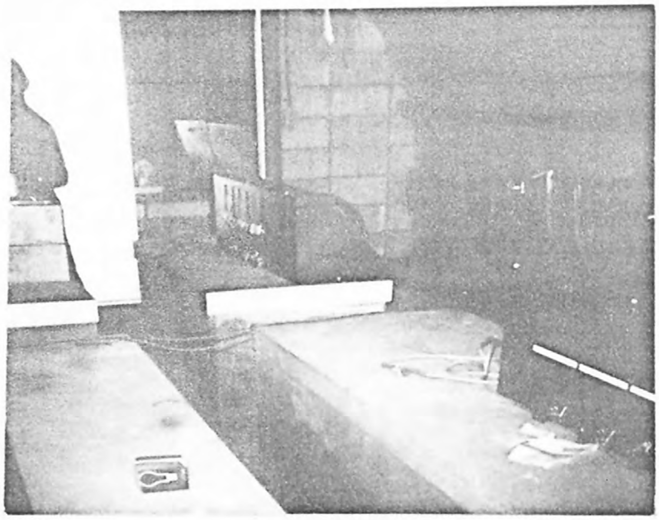


Figure A9. Photograph showing HGLP recording room.

Figure A10. Photograph of area being cleaned prior to the pouring of seismometer pier .

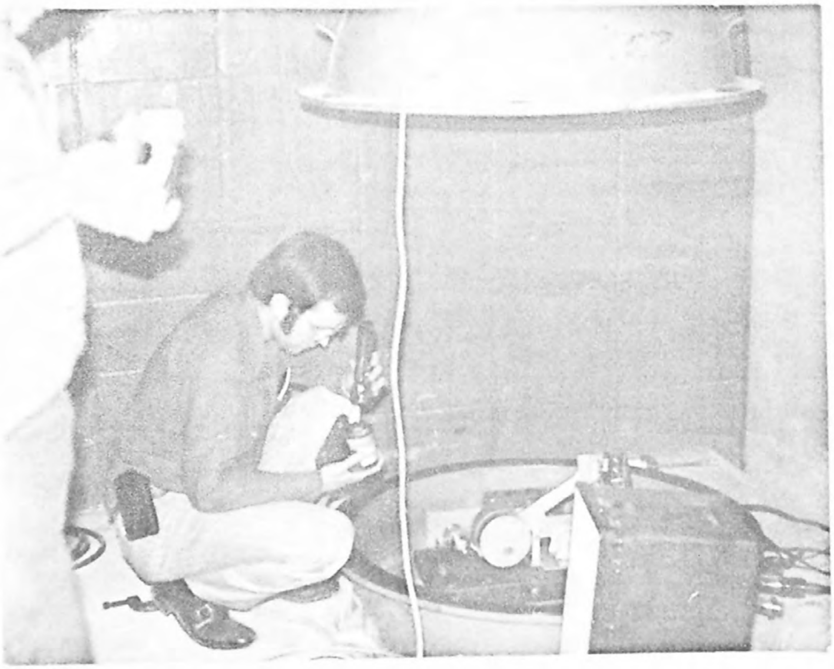


Figure A11. Photograph showing horizontal seismometer in place.

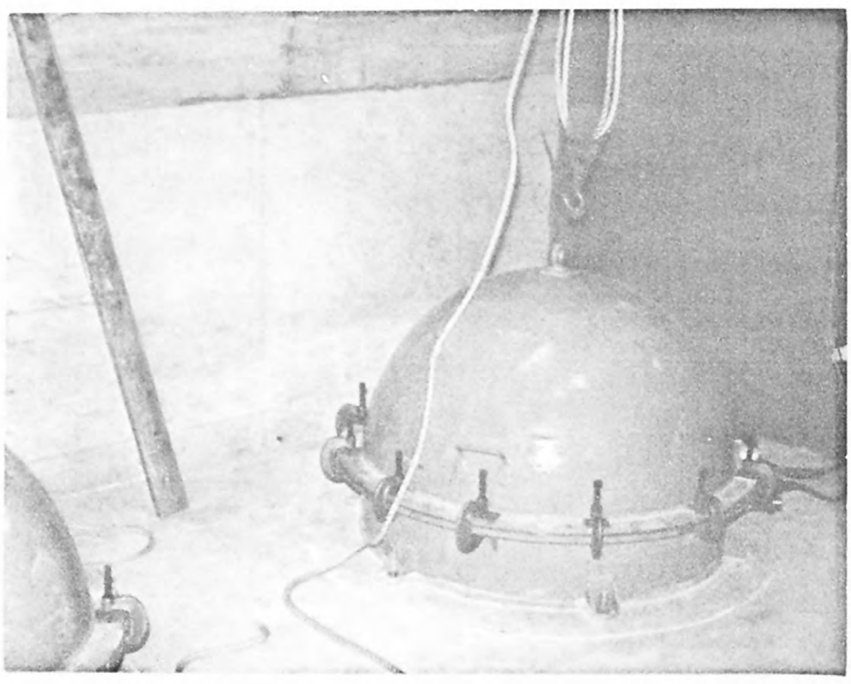


Figure A12. Photograph showing sealed seismometer tank.