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HIGH-GAIN, LONG-PERIOD SEISMOGRAPH STATION

INSTALLATION REPORT

EILAT, ISRAEL

by

Tracy L. Johnson

Lamont-Doherty Geological Observatory

of

Columbia University

Palisades, New York, 10964

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13. ABSTRACT

This report describes the installation of a high-gain, long-period seismograph system at Eilat, Israel. The station is located at 29.33°North latitude, 34.57° East longitude at an elevation of about 200 m above sea level in the same tunnel as the World Wide Standardized Seismic Network (WWSSN) station EIL. The system consists of three Geotech seismometers with natural periods of 30 sec (one vertical and two horizontal) each with two velocity transducers and one displacement transducer. One velocity transducer is coupled to a Kinemetrics galvanometer with a natural period of 100 sec from which the signal is amplified by a photo-tube amplifier (P.T.A.) and recorded photographically and digitally (designated high-gain component). The signal from the second velocity transducer is coupled directly to a recording galvanometer and recorded photographically (designated standard component). The displacement transducer signal is recorded digitally. The system can operate with gains up to 500,000 at periods of 35 to 45 seconds. This high sensitivity has been achieved by isolating the seismometer from barometric changes, by electronically filtering out the 6 second microseisms and by shaping the instrument response to correlate with a natural low in the earth-noise spectrum. The dynamic range of the digital system is over 70db and is limited by the phototube amplifiers.

The seismometers and phototube amplifiers are housed in a chamber sealed from the environment by three ship-type bulkhead doors. The photographic drum recorders, recording galvanometers, control console and digital data acquisition system are located near the front of the tunnel with the WWSSN photographic recorders and time console.

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LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

OF COLUMBIA UNIVERSITY

IN THE CITY OF NEW YORK

HIGH-GAIN, LONG-PERIOD SEISMOGRAPH STATION

STATION:	Eilat, Israel
	WWSSN Abbreviation -- EIL
STATION DIRECTOR:	Dr. Hans Jarosch
	Weizmann Institute of Science
	Rehovot, Israel
	Telephone: 951-721 ext. 618
STATION SUPERVISOR:	Mr. Miha Cohen
	P. O. Box 553
	Eilat, Israel
	Telephone: 2552 (Residence)
STATION INSTALLATION:	Dates: 12 November 1970 to 7 December 1970
	Personnel: Merrill Conner (L.D.G.O.)
	Tracy Johnson (L.D.G.O.)
	Marc Sbar (L.D.G.O.)
	Miha Cohen (Weizmann)

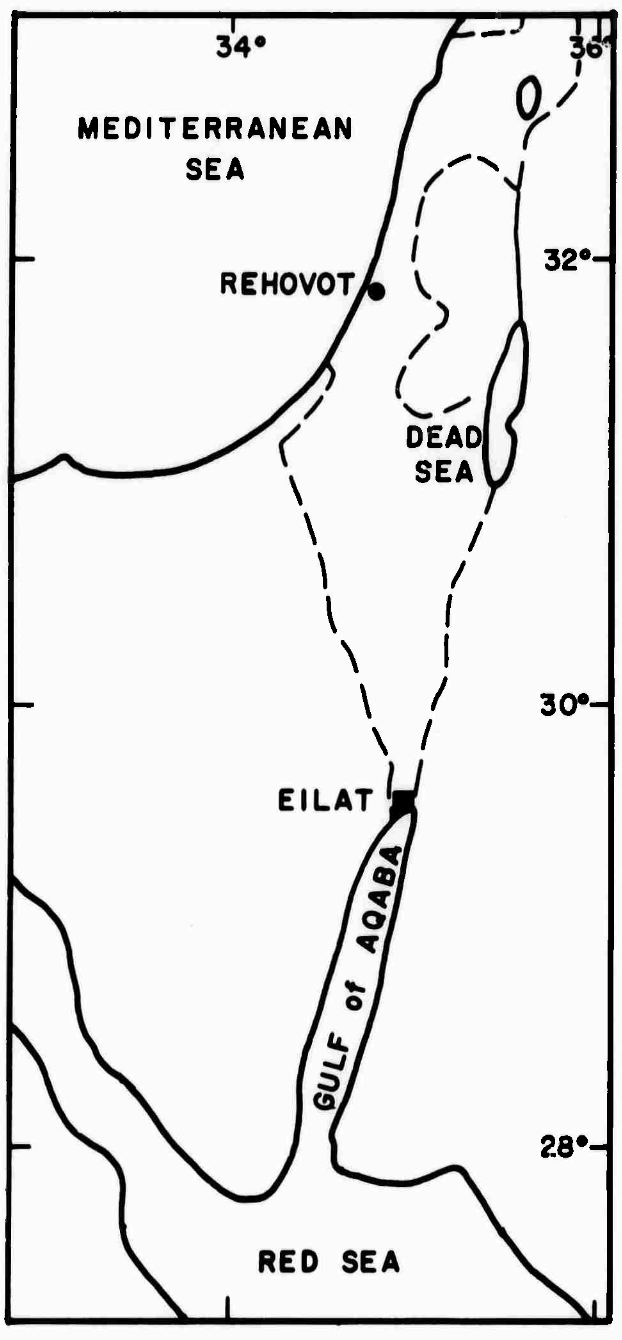


FIGURE I-1: General location map. The Weizmann Institute is located in Rehovot and the seismic station in Eilat. Figure 2 expands the area around Eilat.

I: STATION DESCRIPTION

STATION LOCATION

Coordinates: Latitude 29.33° North

Longitude 34.57° East

Elevation above sea level about 200 m.

The city of Eilat is located in the southern part of Israel at the northern end of the Gulf of Aqaba (Figure I-1). The population of Eilat is about 5,000 and there is no heavy industry. The high-gain seismic instruments are located in a tunnel about 13 km north of Eilat (Figure I-2). The tunnel also contains a World Wide Standardized Seismograph Network (WWSSN) Station (EIL) and two-component mercury tilt and quartz tube strain meters.

LOCAL PHYSIOGRAPHY

Eilat is located on the western edge of the Dead Sea rift. Regionally little deformed Paleozoic to Mesozoic continental and marine epicontinental sediments (mostly sandstone) form the plateaus that surround the rift valley. The plateau edge is extensively eroded. Many wadies extend several kilometers back into the plateau and alluvial fans extend from their mouths into the valley floor, providing relatively easy access to the interior

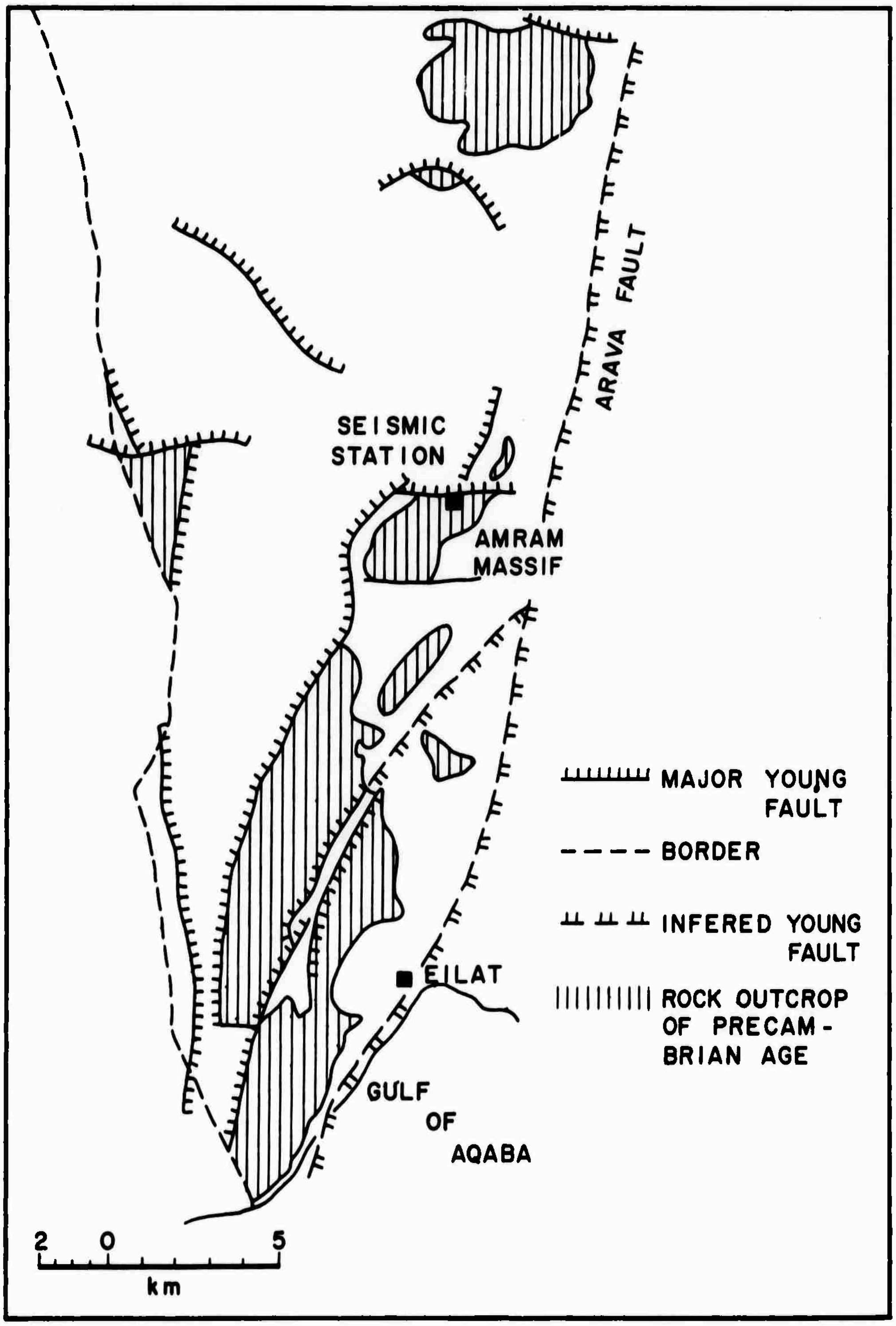


FIGURE I-2: The seismic station is located in the Amram Massif, north of Eilat. The Arava Fault is the inferred western border of the Dead Sea Rift. Nubian sandstone of Cambrian to Cretaceous surrounds the Precambrian outcrops. The rift valley is filled with Tertiary to Quaternary sediments.

of the plateau in some cases. Local maximum elevations are about 1600 m on the east side of the valley and about 900 m on the west side. The valley floor rises from sea level at Eilat to a level of about 100 m due east of the station. The seismic station is located about 3 km west of the valley floor in the Amram Massif, one of several Precambrian outcrops found north of Eilat and just west of the inferred western rift valley border along the Arava fault. The resistant rock of the Massif forms a small mountain separated from the surrounding plateau by a narrow valley. A wadi about 15 m wide and 10 m deep runs past the front of the tunnel. This wadi extends several kilometers back into the plateau and continues past the station into the valley proper. The black-top entrance road to the station from the main road roughly follows this wadi. Rain farther back in the plateau has flooded the wadi to depths of about 6 m for several hours and also blocked the entrance road with coarse debris, but the tunnel has never been flooded.

LOCAL GEOLOGY

Extensive faulting related to the formation of the Dead Sea rift occurred from Mid-Tertiary to Recent times (Figure I-2). About 100 km of horizontal motion is proposed along the rift and some vertical motion has undoubtedly taken place (Zak and Freund, 1966). The seismic station is located in the Amram

Massif (Bentor, 1961), a large block of Precambrian granite-porphyry, unconformably overlain by Precambrian lava flows and associated tufts and agglomerates. The Massif is bounded by fault zones on the north, west, and south along which Nubian sandstone (Cambrian to Cretaceous) is downthrown. The eastern edge of the Amram Massif is inferred to be formed by the Arava fault, which forms the western border of the rift in this area (Bentor, 1961). Extensive erosion has cut the surrounding sedimentary rocks back from the Massif. The rift valley is filled with Late Tertiary and Quaternary sediments. Faulted alluvial fans show that recent left-lateral strike-slip motion occurred in the rift several kilometers to the east of the station (Zak and Freund, 1966). Six hundred meters of horizontal motion is indicated of which 150 m is less than 20,000 years old. The recorded and historical seismicity indicates moderate to slight activity. Only seventeen destructive earthquakes have been recorded over 2,000 years in all of Israel.

CLIMATE AND VEGETATION

Average rainfall in Eilat is less than 30 mm per year. Rain is most probable from December to March. The average summer wind strength is about 25 KPH (15 MPH) and the average winter wind strength is about 16 KPH (10 MPH), both from the north.

The temperature averages 33°C (86°F) in the summer and 16°C (60°F) in the winter (see Table 1). Summer maximum temperatures are over 44°C (110°F). The average daily (day-night) temperature fluctuation is about 10°C (18°F). The steep northern face of the Massif, in which the tunnel is set, receives little direct sun light year round. Very sparse vegetation consisting of trees and shrubs occurs on the valley floor. The tallest trees are about 3 m high. No vegetation exists on the higher areas around the valley. There is essentially no vegetation around the seismic station or on the surrounding mountains.

STATION'S RELATION TO MAN-MADE STRUCTURES

There are no man-made structures near the tunnel. The main road north from Eilat is about 3 km to the east. Average traffic is about 10 vehicles per hour during the day and essentially none at night. Trucks and buses form about 60% of the traffic. A high-voltage power line passes about 2 km east of the station. Occasional explosions from mining at the Timna Copper Mines, located about 10 km to the north, are recorded at the station. An underground oil pipe line is at least 2 km east of the station, its exact position is not known.

TABLE I

Average Temperatures at Eilat

(degrees in Centigrade)

MONTH	MONTHLY MIN	TEMP MAX	AVERAGE Average	DAILY Min	TEMPERATURE Max
Jan.	4.9	25.8	15.5	10.1	20.9
Feb.	5.8	28.9	16.8	11.1	22.5
Mar.	9.0	33.3	19.8	13.7	25.8
Apr.	11.8	37.8	24.3	17.9	30.7
May	15.6	41.6	28.2	22.2	35.5
Jun.	20.0	43.1	31.0	23.8	38.3
Jul.	22.5	44.1	33.0	26.1	39.8
Aug.	22.7	43.8	33.4	26.5	40.2
Sep.	20.6	41.7	31.0	24.8	37.3
Oct.	15.8	38.8	27.2	21.2	33.2
Nov.	10.6	33.7	22.0	16.3	27.6
Dec.	6.8	28.0	16.9	11.4	22.4

II: STATION CONSTRUCTION AND INSTALLATION

The tunnel containing the seismic station was constructed as a geophysical observatory in 1968 by the Weizmann Institute in cooperation with the United States Air Force. The Lossinger Company, located in Switzerland, did the actual engineering and drove the tunnel. The rooms containing the high-gain instruments were constructed when the tunnel was built. New construction for the seismometer and P.T.A. vaults consisted of removing the floors and any loose rock below them, thoroughly cleaning the rock surface, re-pouring the floors and finally emplacing the three bulkhead doors. The photographic recorders and digital system are located in rooms that required no modification.

MAIN TUNNEL

The main tunnel, aligned north-south, is about 130 meters long (Figure II-1). The entrance is at the north end. Aside from the high-gain vault there are two rooms about 40 meters long off the main tunnel housing strain and tilt meters (Figure II-1) and another vault for the WWSSN instruments. The tunnel is entirely covered with shotcrete and has a cement floor. A pair of refrigerator doors set in a concrete bulkhead provide thermal stability. A third steel bulkhead door is installed half-way down the tunnel, enclosing the WWSSN vault.

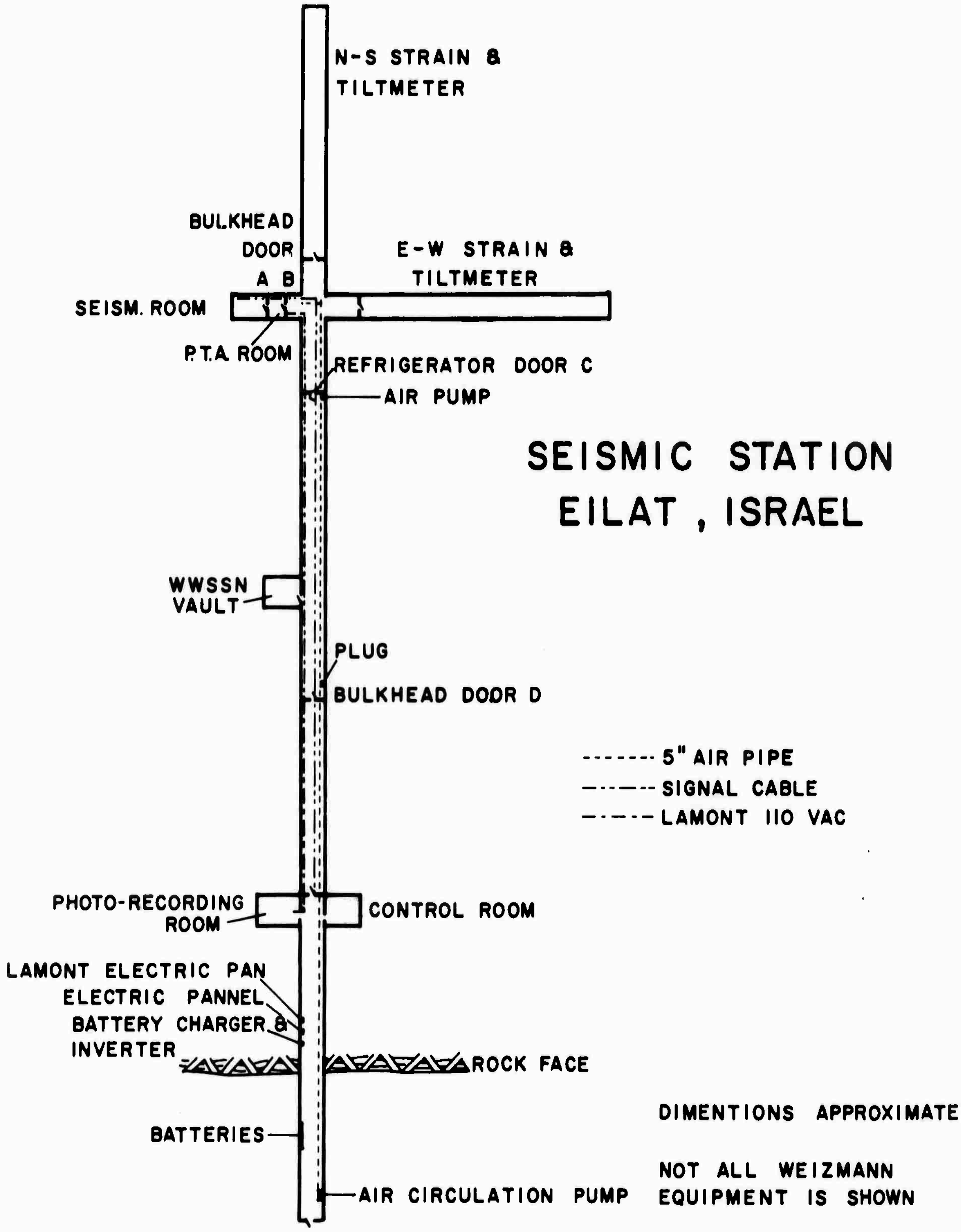


FIGURE II-1: Plan of the seismic station, Eilat, Israel. The tunnel entrance points toward the north.

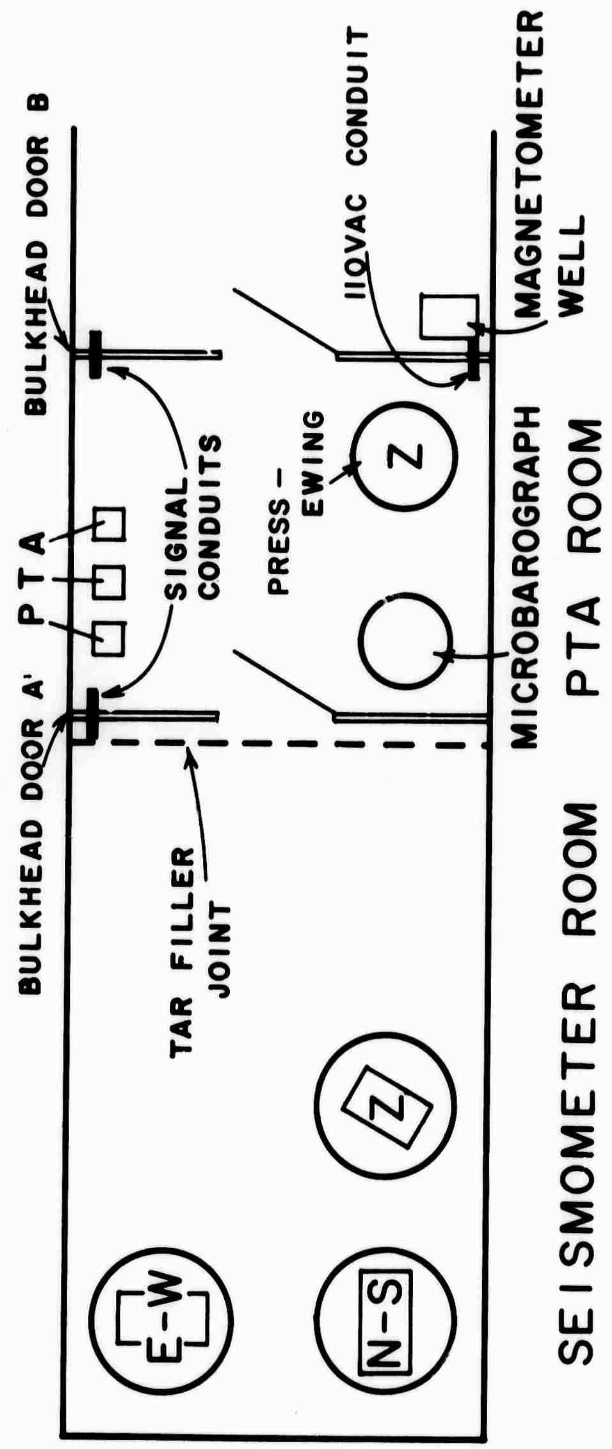


FIGURE II-2: Plan of the high-gain instrument rooms. The magnetometer well, 6 m deep, contains a magnetometer probe. The instrument rooms are aligned E-W. North is toward the bottom of the figure.

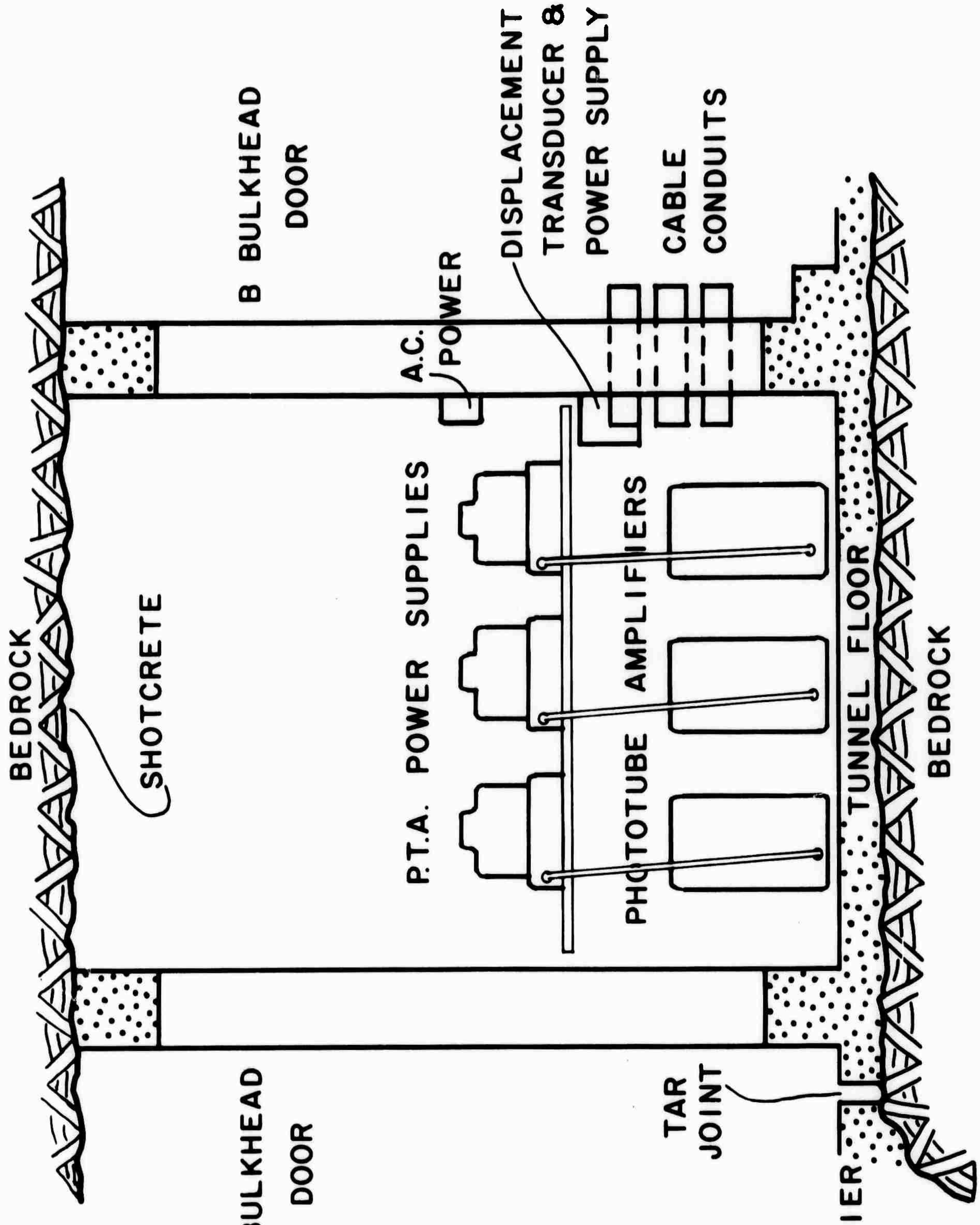


FIGURE II 3: East-West section through the P.T.A. room.

This door has several coats of Sauereisen cement paint on both sides, but only the exterior side has a coat of epoxy. Fluorescent lights located about every 20 m light the main tunnel. Both 110 V and 220 V power is available about half way down the tunnel and at the front and rear.

SEISMOMETER - P.T.A. ROOM

The seismometer room is about 5 m long by 3 m wide and 2.7 m high (Figure II-2, and II-3). Overburden is at least 200 m. The P.T.A. room is formed by two ship-type bulkhead doors separated by about 3 m (Figure II-4). These doors are primarily intended to minimize pressure fluctuations but also help to maintain temperature stability. Because the rock is closely jointed in several directions (about 5 cm spacing), the entire tunnel is coated with about 2 cm of shotcrete to prevent rock falls. This cover was chipped away where the concrete bulkheads meet the tunnel walls, but was left intact elsewhere. The shotcrete was found to be very solid. Both sides of both concrete bulkheads are coated with epoxy paint. The inner-most three sides have two coats and the exterior P.T.A. room wall has one coat of Sauereisen Insa-Lute #1 cement paint and one coat of epoxy over it.

All badly fractured rock was removed from the seis-memeter room and P.T.A. room floors before the concrete was poured. The resulting rock surface was very irregular. Since

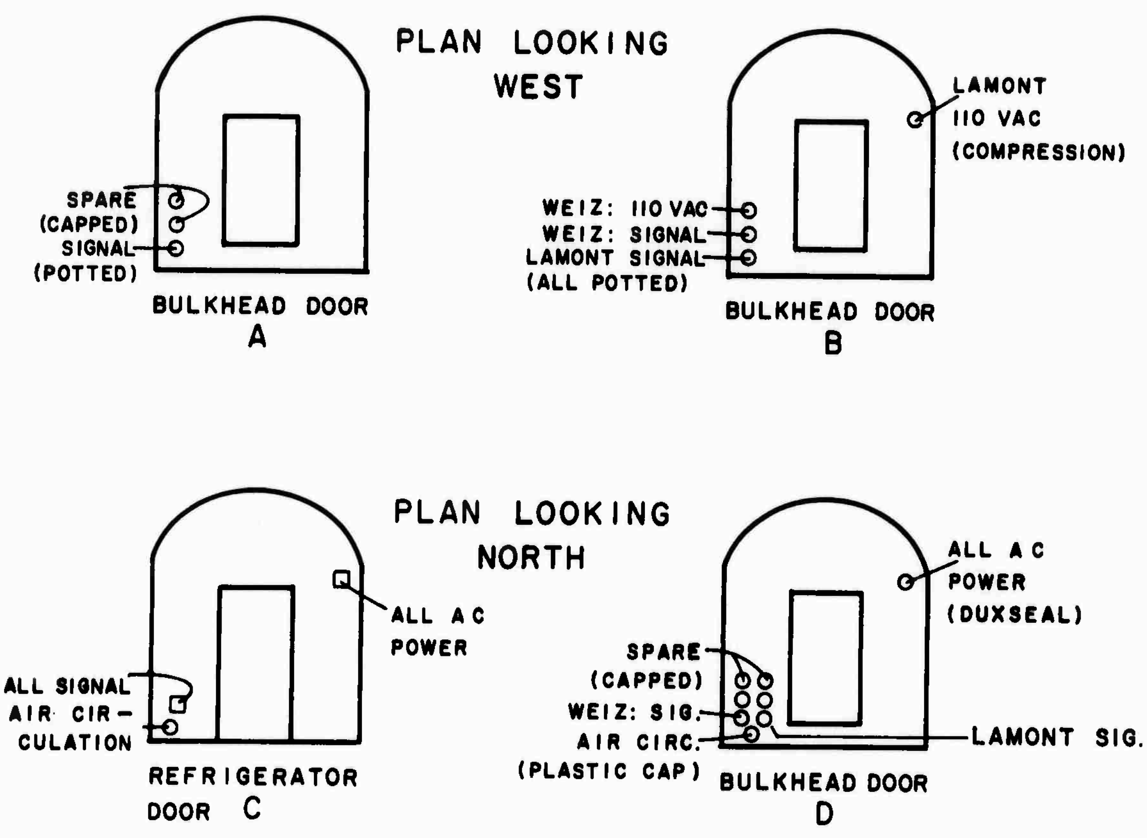


FIGURE II-4: Plan of the three Lamont installed bulkhead doors (A,B,D) and the previously existing refrigerator door (C) showing the locations of the feed-through conduits. The bulkhead width is about 3 m. The door frame width of the refrigerator door is about 1 m. Doors A and B are viewed from inside the seismometer room. Doors C and D are viewed from the rear of the tunnel looking north toward the entrance.

the concrete thickness would vary considerably anyway, the seismometer - P.T.A. room floor was made level with the tunnel floor. Concrete thickness is from 20 to 60 cm. A tar filler joint 2.5 cm wide was put between the P.T.A. room bulkhead and the pier floor of the seismometer room.

The seismometer tanks were initially prestressed by distorting the base into a dome about 1 cm high at the center. Each tank was then anchored in concrete with 3/4 inch cadmium-plated steel rods and roofbolt anchors in holes drilled into the pier. The anchors do not penetrate to the rock because of the thickness of the concrete. The space under each tank was carefully filled with Sakrete mortar mix. Eye bolts are anchored in the ceiling above each tank for use when removing the tank tops.

The P.T.A. room houses the phototube amplifiers, their power supplies, and the power supply for the displacement transducers. A microbarograph and a modified Press-Ewing long-period vertical seismometer are also present. The seismometer is not operating at this time and the status of the microbarograph is not known. It did not appear to be operating correctly during the installation. These instruments had been operating in the end of the tunnel that was rebuilt to house the Lamont high-gain seismometers.

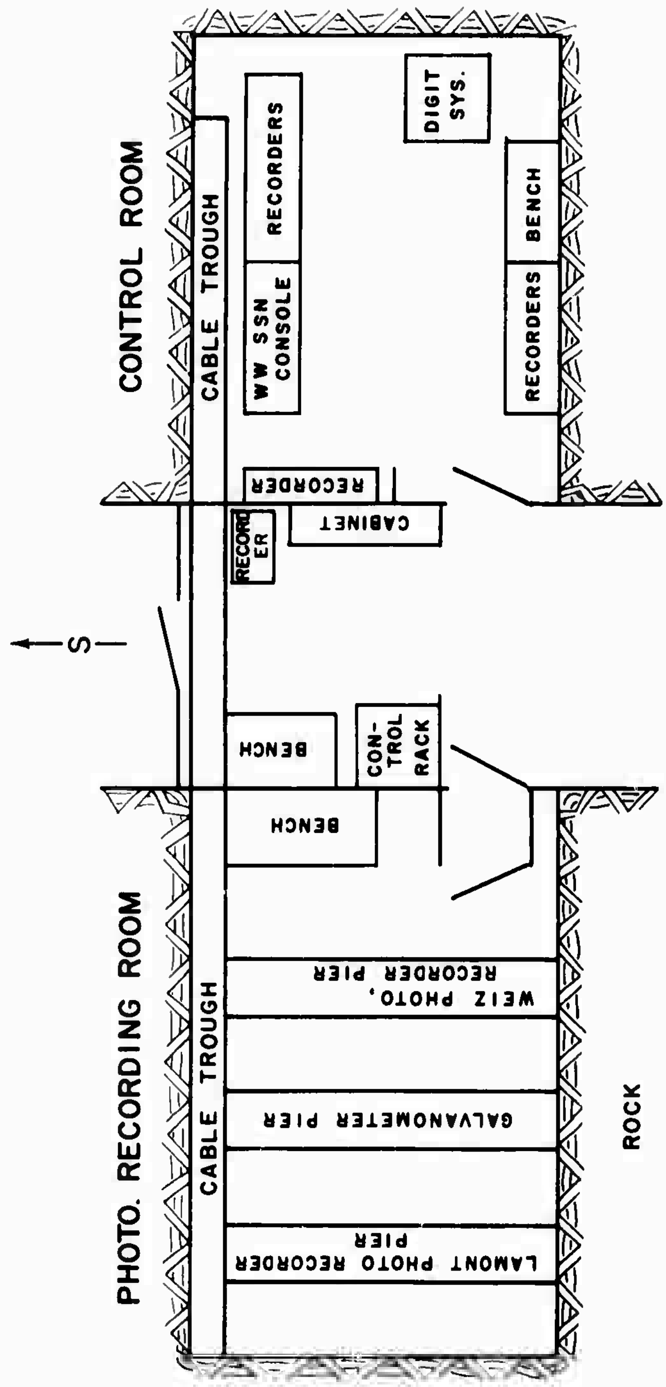


FIGURE II-5: Plan of photographic recording and control rooms. Details of the recording piers and cable trough are given in Figure II-6. The control room is airconditioned. The doors are light wooden frame type and open about 1 m. Signal cables run up the tunnel on the west side (right) and directly enter the cable trough where they are routed to the respective instruments.

RECORDING AND CONTROL ROOM

The recording and control instruments are located inside rooms near the front of the drift (Figure II-5). The two three-component photographic recorders are located in the eastern room, which also contains the WWSSN recorders. The galvanometers and recorders are standing on stacked, two-level concrete and cinder-block piers (Figure II-6). The 100-sec galvanometers are protected from humidity by sealed tanks containing silica gel desiccant. These tanks are too high to fit on the first level of the pier, thus the standard recorder is on top. The digital system is located in the western room with the WWSSN console and other digital equipment associated with the tiltmeters. The control console is located in the main tunnel between the two rooms. The power distribution panel is mounted on the wall near the front of the tunnel next to the main distribution panel (Figure II-1).

CABLES

Details of the cables used are given in Table 2. To seal the P.T.A. and seismometer rooms all cables entering them were plotted in 'Scotchcast' resin and routed through 5 cm (2 inch) galvanized pipe conduits in the bulkheads. Three 5 cm conduits enter the seismometer room on the south side, and three conduits on the south and one on the north enter the P.T.A. room (Figure II-4). The high-gain signal cables are potted into the lowest conduit through both doors. Other signal cables enter the P.T.A.

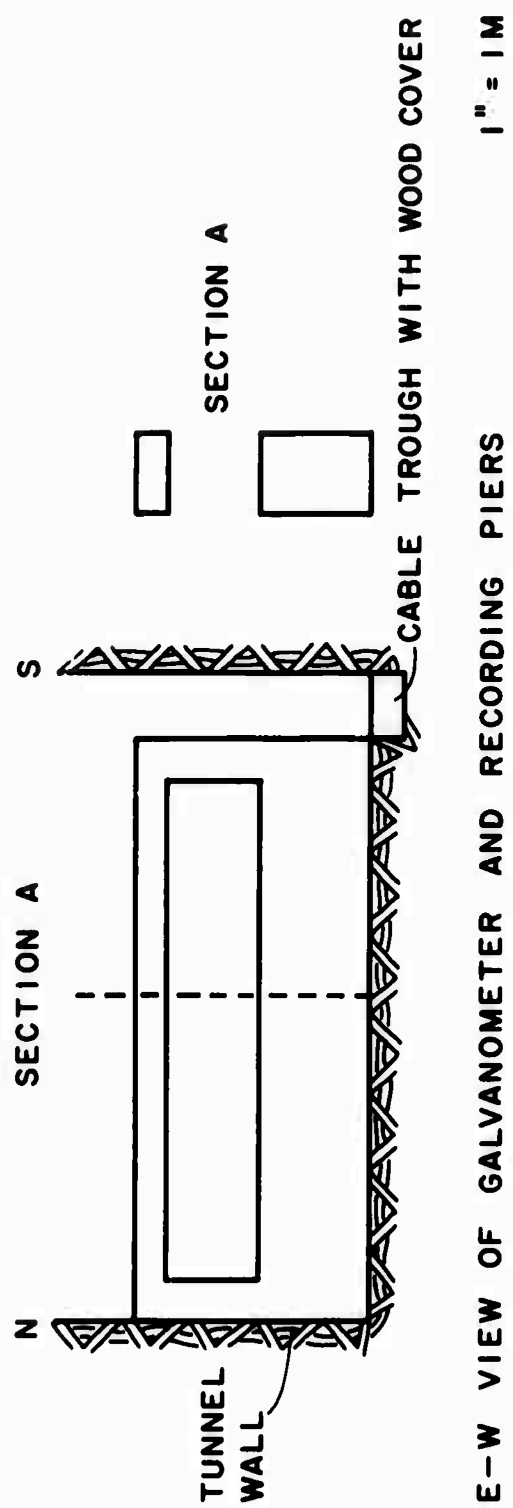


FIGURE II-6: North-South section of the photographic recording room through one of the piers. Section A shows an E-W section through one of the piers.

room only through the middle conduit (potted). The remaining conduits into the seismometer room are covered with pipe caps. All conduits entering the P.T.A. room are sealed with Scotchcast except for the Lamont 110 volt AC, which has a compression fitting. Six spare two-conductor shielded wires enter the P.T.A. room and 5 spares enter the seismometer room. All spares run the length of the tunnel. Along the drift the cables pass through cemented holes in the refrigerator door bulkhead and through the remaining steel bulkhead door in 5 cm conduits sealed with 'Duxseal'. The signal cables run the length of the tunnel on the western side of the floor (Figure II-1). The new high-gain cables and pre-existing cables are in separate bundles. The 110 volt AC power cables are suspended on the eastern wall of the tunnel, over three meters from the signal cables. At the control end, the signal and control cables split to run to the various instruments. The control console and photographic wires pass under the floor in a wooden covered trough to reach the instruments. The wires for the digital system follow the southwest wall of the control room to the rear of the recorder. Two separate 110 volt AC power lines and one 220 volt AC power line run down the drift. The 220 volt AC is available about 10 m outside the P.T.A. room and the 110 volt AC enters the P.T.A. room. The high-gain instruments are on a separate 110 volt line to allow easy installation of power regulators.

TABLE 2

Wire Labels and Types

	Z Label	Z Type	N/S		E/W	
Standard Signal	1	c	11	c	21	c
Calibration in use	2	c	12	c	22	d
Calibration spare	3	c	13	c	23	d
Signal to P.T.A.	4	c	14	c	24	c
Displacement Signal	5	b	15	b	25	b
Power to Displacement	6	a	16	a	26	a
Instrument to Remote Center	7	b	17	b	27	b
P.T.A. Signal to Digital	8	c	18	d	28	d
P.T.A. Signal to Galvo	9	d	19	d	29	d
P.T.A. Monitor	10	b	20	b	30	b
P.T.A. Remote Center	31	b	32	b	33	b

Spare wires run from the control room to the room listed. Wires A and B are type "b", all others are type "d".

Instrument room	A, B, C, D, E
P.T.A. room	F, G, H, I, J, K

All Wire has a foil type shield.

The wire type is:

a) 3 conductor #16 stranded

b) 2 conductor #16 stranded

c) 2 conductor #18 solid

d) 2 conductor #22 solid

The chief result of substituting #22 wire for #18 is to increase the lead resistance from 4.4 ohms to 14 ohms. This change is only important if the instrument motor constant is remotely determined.

III: STATION FACILITIES

AVAILABLE COMMERCIAL POWER

Voltage: 220 volts

Frequency: 50 Hz

Reliability: Rated voltage and frequency appear to be well maintained, although no records were obtained. Power failures generally occur about twice a month and have durations of less than half an hour. An uninterruptable power supply is scheduled to be installed in the spring of 1971.

AVAILABLE TIME STANDARDS

Time for the photographic records is taken from the existing WWSSN time console. The console time is checked daily against standard time signals broadcast from the U.S.S.R. at 15.20 M.C. The Astrodata digital system has a crystal oscillator time standard. This standard is manually corrected, if necessary, using time signals from the WWSSN console radio.

STATION TEMPERATURE AND HUMIDITY

No temperature or humidity recording equipment exists in the seismometer vault. Dehumidifiers, presently not in use, are available at the station, and the digital recording room is air-conditioned. The rear of the tunnel is very humid apparently due to the curing of the fresh concrete and poor ventilation, but the whole tunnel is generally dry and the front has low humidity. The rear of the tunnel is presently (March 1971) very hot, about 40°C (110°F). The high temperature is thought to be a result of the curing of the new concrete poured during the high-gain installation and is expected to decrease in time to about 28°C (80°F), the average yearly temperature.

BACKGROUND NOISE

The background noise level at Eilat is poorly known. Short period (6 sec) microseisms appear to be uniformly small year around based on a visual search of the EIL WWSSN records. Preliminary work indicates that the long-period noise spectrum, uncorrected for instrument response, is flat. Thus, the high-gain instruments have an optimum frequency response, but the absolute noise levels have not yet been determined.

OTHER INSTRUMENTS IN OPERATION

The WWSSN station EIL has three short-period (T_o = 1 sec) Benioff and three long-period (T_o = 15 sec) Sprengnether seismometers. The magnifications are 3000 for the long-period components and 200,000 for the short-period components.

Two-component quartz-tube strainmeters, installed by Dr. M. Major of the Colorado School of Mines, and long baseline mercury tiltmeters, installed by Dr. Sheldon Buck of the Massachusetts Institute of Technology, are in operation. The tiltmeters have a gain of about 15,000.

A magnetometer, recording photographically, is also recording at the station.

IV: INSTRUMENTATION

The details of the system instrumentation are given in the Lamont-Doherty Geological Observatory Technical Report entitled "High-Gain, Long-Period Seismograph Station Instrumentation". The complete system is shown in Figure IV-1, which is a large foldout at the end of this report. Amendments to the system and specific details that pertain only to the Eilat installation are given below. All tests were performed directly on the instruments; that is, the long cable leads to the control console were not used. Frequency response was determined remotely from the control console.

AMENDMENTS TO SYSTEM DIAGRAM

STATION: Eilat, Israel

1. The following parts are not at this station:
L.D.G.O. part numbers: 1115, 1211, 2500, 2501, 3102, 3218, 3219, 3240, 3410-1, 3414, 4101, 4103, 4104, 4105, 4106, 4301.

2. Voltage regulator (#3270) not in operation. AC power from power distribution panel (#3424) to specific parts. Photographic recorders are run off station 60 Hz regulated power.

3. Dehumidifiers (#3600, #4400) not in operation.

4. Radio (#3218) not installed at station.

5. Antenna (#3219) not installed at station.

6. Time marks for standard and high-gain photographic recorders (#4100) taken directly from existing WWSSN time console and not via time relay closures from digital clock (#3100).

7. Bulkhead door #3 (#5100) installed.

8. Some 18-gauge cable (#5150) is replaced by 22-gauge. See Table 2 for details.

VERTICAL

Seismometer:

Serial Number:	15	
Free Period:	31 Seconds	
Magnets:	Lower - before attachment:	2,200 gauss
	Upper - before attachment:	2,150 gauss
Coil Resistances:	Standard signal:	500 ohm
	Hi-Gain signal:	500 ohm
	Primary Calibration:	2 ohm
	Secondary Calibration:	2 ohm
CDRX (Critical for one signal coil):		3,500 ohm

Electromechanical Constant, G:

Standard Signal Coil:	R^1 =	143,000	ohm
	V =	1.40	volts
	G =	100.1	newtons amp^{-1}
Hi-Gain Signal Coil:	R^1 =	142,000	ohm
	V =	1.40	volts
	G =	99.4	newtons amp^{-1}
Primary Calibration:	R^1 =	42	ohm
	V =	1.4	volts
	G =	0.0308	newtons amp^{-1}

Secondary Calibration:	R^1 =	43	ohm
	V =	1.4	volts
	G =	0.0315	newtons amp^{-1}

Cable Resistances:

Cable # 1 : 4.4 ohm

Cable # 2 : 4.4 ohm

Cable # 3 : 4.4 ohm

Lo-Gain Galvanometer:

Serial Number:	101
Free Period:	100.5 Seconds
CDRX Set:	6,000 ohm
Damping:	Critical
Current Sensitivity:	2.2×10^{-11} amp mm^{-1} at 1 metre with 8,500 ohms CDRX

P.T.A. Galvanometer:

Free Period:	100 Seconds
CDRX Set:	6,000 ohm
Damping:	Critical
Current Sensitivity:	1.1×10^{-10} amp mm^{-1} at 1 metre

Hi-Gain Recording Galvanometer:

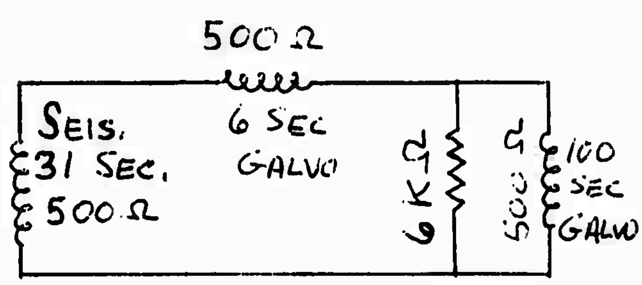
Serial Number:	3588
Free Period:	0.3 Seconds
CDRX Set:	82 ohm
Damping:	Critical
Current Sensitivity:	2.5 x 10^{-8} amp mm^{-1} at 1 metre
Gain Resistor:	510,000 ohm

Component Magnification:

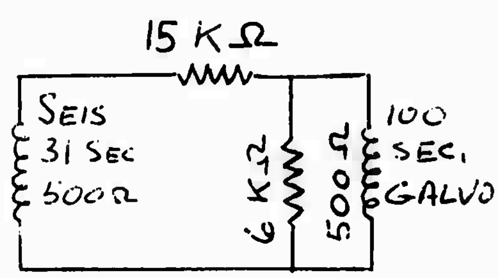
Lo-Gain:	8,900	at	30	seconds
Hi-Gain:	19,500	at	40	seconds

Remarks:

The final settings of the L-pad attenuators are as follows:

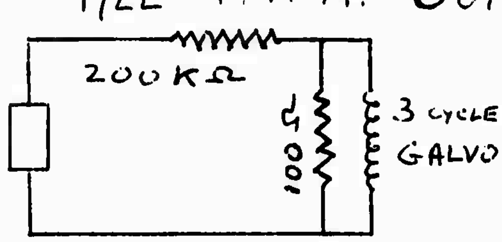


STANDARD OUTPUT

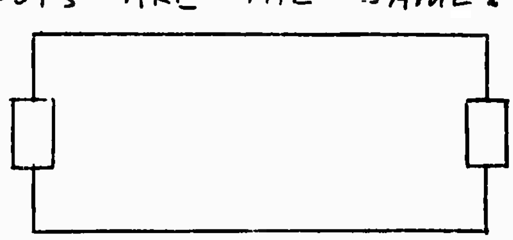


P.T.A. INPUT

ALL P.T.A. OUTPUTS ARE THE SAME.



P.T.A. OUTPUT



P.T.A. OUTPUT TO DIGITAL

NORTH - SOUTH

Seismometer:

Serial Number:	177		
Free Period:	30.8 Seconds		
Magnets:	North Side:	2,300	gauss
	South Side:	2,335	gauss
Coil Resistance:	Standard signal:	500	ohm
	Hi-Gain signal:	500	ohm
	Primary calibration:	2	ohm
	Secondary calibration:	2	ohm
CDRX (Critical for one signal coil):		7,000	ohm

Electromechanical Constant, G:

Standard signal coil:	R^1 =	199,000	ohm
	V =	1.4	volts
	G =	137.3	newtons amp^{-1}
Hi-Gain signal coil:	R^1 =	210,000	ohm
	V =	1.4	volts
	G =	147.1	newtons amp^{-1}
Primary caibration coil:	R^1 =	61	ohm
	V =	1.4	volts
	G =	0.0441	newtons amp^{-1}

Secondary calibration coil:	R^1 =	62	ohm
	V =	1.4	volts
	G =	0.0448	newtons amp^{-1}

Cable Resistances:

Cable # 11	:	4.4 ohm
Cable # 12	:	4.4 ohm
Cable # 13	:	4.4 ohm

Lo-Gain Galvanometer:

Serial Number	163
Free Period:	101.5 Seconds
CDRX Set:	6,000 ohm
Damping:	Critical
Current Sensitivity:	2×10^{-11} amp mm^{-1} at 1 metre with 8,500 ohms CDRX

P.T.A. Galvanometer:

Free Period:	100 Seconds
CDRX Set:	6,000 ohm
Damping:	Critical
Current Sensitivity:	1.1×10^{-10} amp mm^{-1} at 1 metre

Hi-Gain Recording Galvanometer:

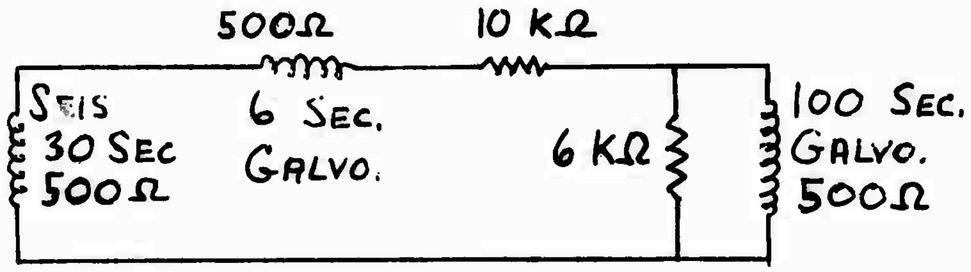
Serial Number:	3599
Free Period:	3 Seconds
CDRX Set:	82 ohm
Damping:	Critical
Current Sensitivity:	2.5×10^{-8} amp mm^{-1} at 1 metre
Gain Resistor:	510,000 ohm

Component magnification:

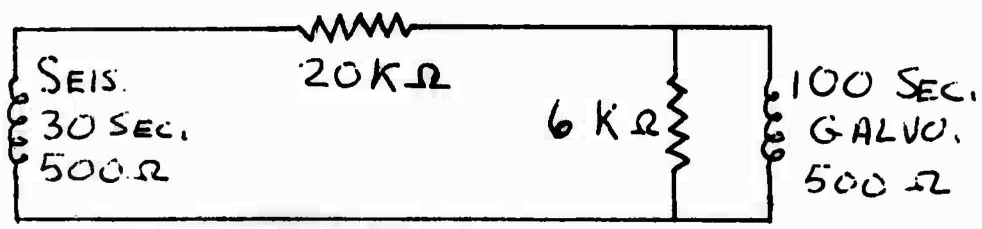
Lo-Gain:	6,500	at	30	Seconds
Hi-Gain:	10,500	at	40	Seconds

Remarks:

The final settings of the L-pad attenuators are as follows:



STANDARD



P.T.A INPUT

EAST-WEST

Seismometer:

Serial Number:	176			
Free Period:	30.5 Seconds			
Magnets:	East Side:		2,400	gauss
	West Side:		2,425	gauss
Coil Resistances:	Standard Signal:		500	ohm
	Hi-Gain Signal:		500	ohm
	Primary Calibration:		2	ohm
	Secondary Calibration:		2	ohm
CDRX (Critical for one signal coil):			7,400	ohm

Electromechanical Constant, G:

Standard Signal Coil:	R^1 =	199,000	ohm
	V =	1.4	volts
	G =	137.3	newtons amp^{-1}
Hi-Gain Signal Coil:	R^1 =	206,000	ohm
	V =	1.4	volts
	G =	144.2	newtons amp^{-1}

Primary Calibration Coil:	R^1 =	59	ohm
	V =	1.4	volts
	G =	0.0427	newtons amp^{-1}

Secondary Calibration Coil:	R^1 =	60	ohm
	V =	1.4	volts
	G =	0.0434	newtons amp^{-1}

Cable Resistances:

Cable # 21	:	4.4 ohm
Cable # 22	:	14 ohm
Cable # 23	:	14 ohm

Lo-Gain Galvanometer:

Serial Number:	119
Free Period:	99.2 Seconds
CDRX Set:	6,000 ohm
Damping:	Critical
Current Sensitivity:	2.2×10^{-11} amp mm^{-1} at 1 metre with 8,500 ohms CDRX

P.T.A. Galvanometer:

Free Period:	100 Seconds
CDRX Set:	6,000 ohm
Damping:	Critical
Current Sensitivity:	1.1×10^{-10} amp mm^{-1} at 1 metre

Hi-Gain Recording Galvanometer:

Serial Number:	2957
Free Period:	3 Seconds
CDRX Set:	82 ohm

Damping: Critical

Current Sensitivity: 2.5×10^{-8} amp mm^{-1} at 1 metre

Gain Resistor: 510,000 ohms

Component Magnification:

Lo-Gain:	6,600	at	30	Seconds
Hi-Gain:	20,000	at	40	Seconds

Remarks:

The final settings of the L-pad attenuators are as follows:

SAME AS NORTH-SOUTH.

PHOTOGRAPHIC RECORDERS:

Lo-Gain:	Rotation Speed:	15mm/minute
	Translation Speed:	10mm/revolution
High-Gain:	Rotation Speed:	15mm/minute
	Translation Speed:	10mm/revolution

DISPLACEMENT TRANSDUCERS:

All displacement transducers are linear to better than ±0.5% over the full range of seismometer boom travel (±3mm). Maximum output of the transducers is ±10V. The sensitivity is about 4.5 mV/μ at the instrument center of oscillation.

DIGITAL ACQUISITION SYSTEM:

Serial Number:	107
Station I.D.:	05

Channels	Instrument	Sampling Rate
1	Z Velocity	One per second
2	N-S Velocity	One per second
3	E-W Velocity	One per second
4	NR	
5	NR	
6	NR	
7	NR	
8	NR	
9	NR	
10	Test Channel NR	
11	Z Displacement	One per 5 seconds
12	N-S Displacement	One per 5 seconds
13	E-W Displacement	One per 5 seconds
14	NR	
15	NR	
16	NR	

Channels not recorded on magnetic tape are labled NR.

ACKNOWLEDGMENTS

The author wishes to thank the Weizmann Institute for making available the site at Eilat for the installation of this seismograph system. Particular thanks are due to Professor C. L. Pekeris, Dr. Hans Jarosch, and Professor Air Ben-Menahem of the Weizmann Institute and to Mr. Miha Cohen for their aid during the many phases of the project. Drs. Tosimatu Matumoto, Bryan Isacks, and Peter Ward critically read the report.

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APPENDIX I

PHOTOGRAPHS OF INSTALLATION

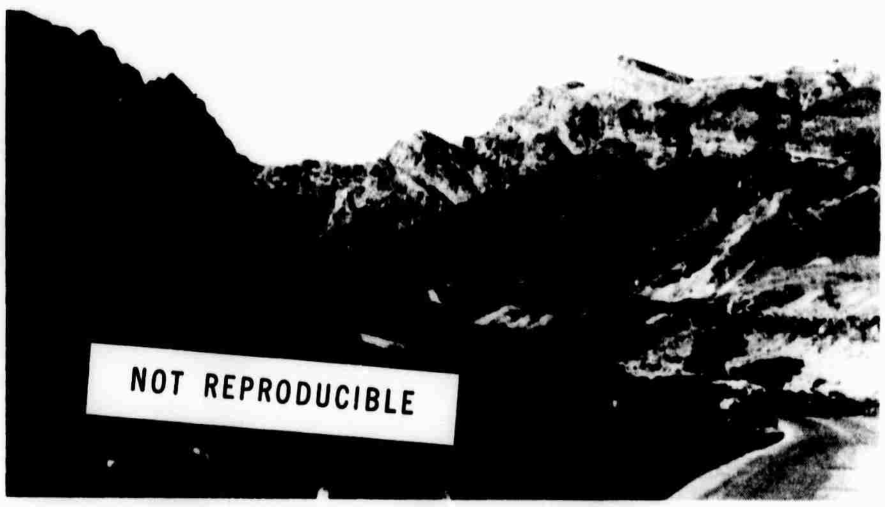


PLATE 1: View of the entrance to the valley in which the seismic station is located, taken about half way along the entrance road and looking west. The dark Precambrian rock of Amram Massif is on the left and the Nubian sandstone of the surrounding plateau is on the right. Typical vegetation is located in the lower right corner of the plate.

PLATE 2: View from the seismic station parking area looking eastward toward the eastern edge of the Rift Valley (Jordan) in the distance. The dark rock on the right is Precambrian while the lighter rock is Nubian sandstone.

PLATE 3: Entrance to the seismic station. The box on legs in the right foreground is part of the airconditioning unit. Part of the steep front face of the Massif forms the background. The photo is aimed to the southwest.

PLATE 4: The high-gain control panel, located in the front section of the tunnel, is in the foreground. The wooden covered cable trough is visible at the middle right of the picture just in front of the door. Power cables run along the ceiling, which is covered with shotcrete. The chart recorder was used during the high-gain installation. The view is aimed approximately south.

PLATE 5: View of the southern side of the P.T.A. room during installation showing the P.T.A.'s and their power supplies. The light wall is shotcrete covered rock and the dark wall is the epoxy covered bulkhead. Note the bundle of signal and control cables entering the seismometer room through the lower conduit.

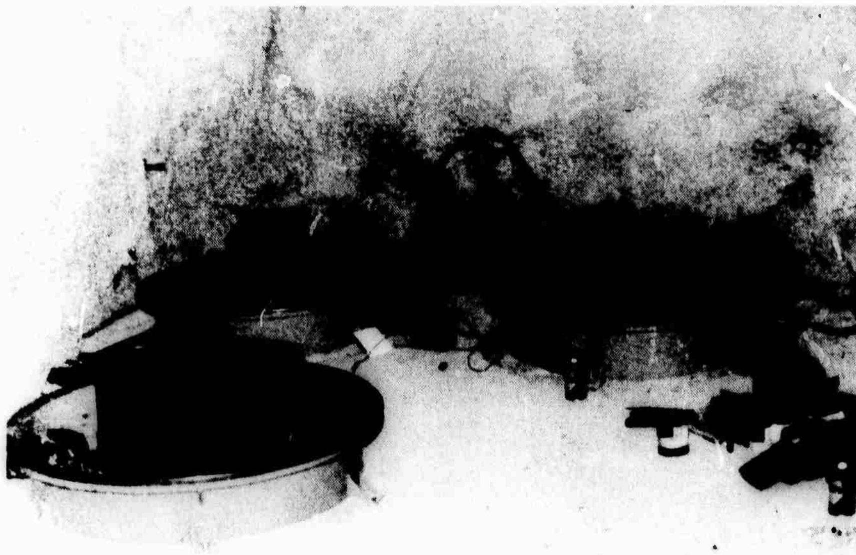


PLATE 6: View of the seismometer room looking east. The vertical seismometer is in the foreground, the north-south in the center, and the east-west is on the right. The cables are hung on wooden pegs along the right and front walls from the P.T.A. room to the respective instruments. Sakrete mortar, placed under the tanks when they were set in, is visible along the edges of the tanks as are the hold down bolts. Some details of the cable inlets into the tanks are visible.

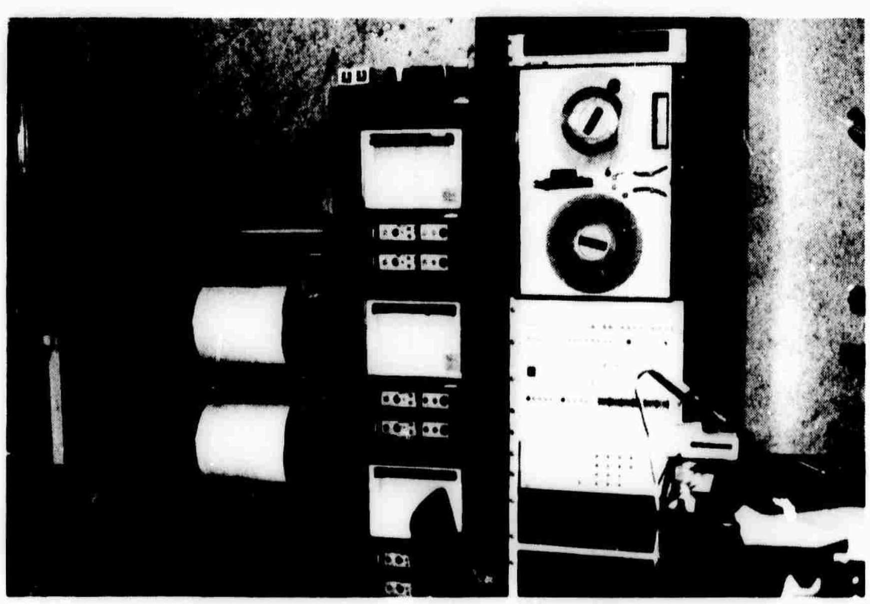


PLATE 7: View toward the west in the control room showing the high-gain digital recorder on the right. The other recorders display strain and tiltmeter outputs. Cables to the digital and other recorders are visible along the base of the wall at the left.

APPENDIX II

FREQUENCY RESPONSE CURVES

FREQUENCY RESPONSE CURVES OF THE HIGH-GAIN AND STANDARD COMPONENTS AT EILAT, ISRAEL

These frequency responses were obtained on December 2, 1970. Since then the North-South component has changed characteristics drastically and the Vertical may have changed slightly, thus these curves should be used with caution.

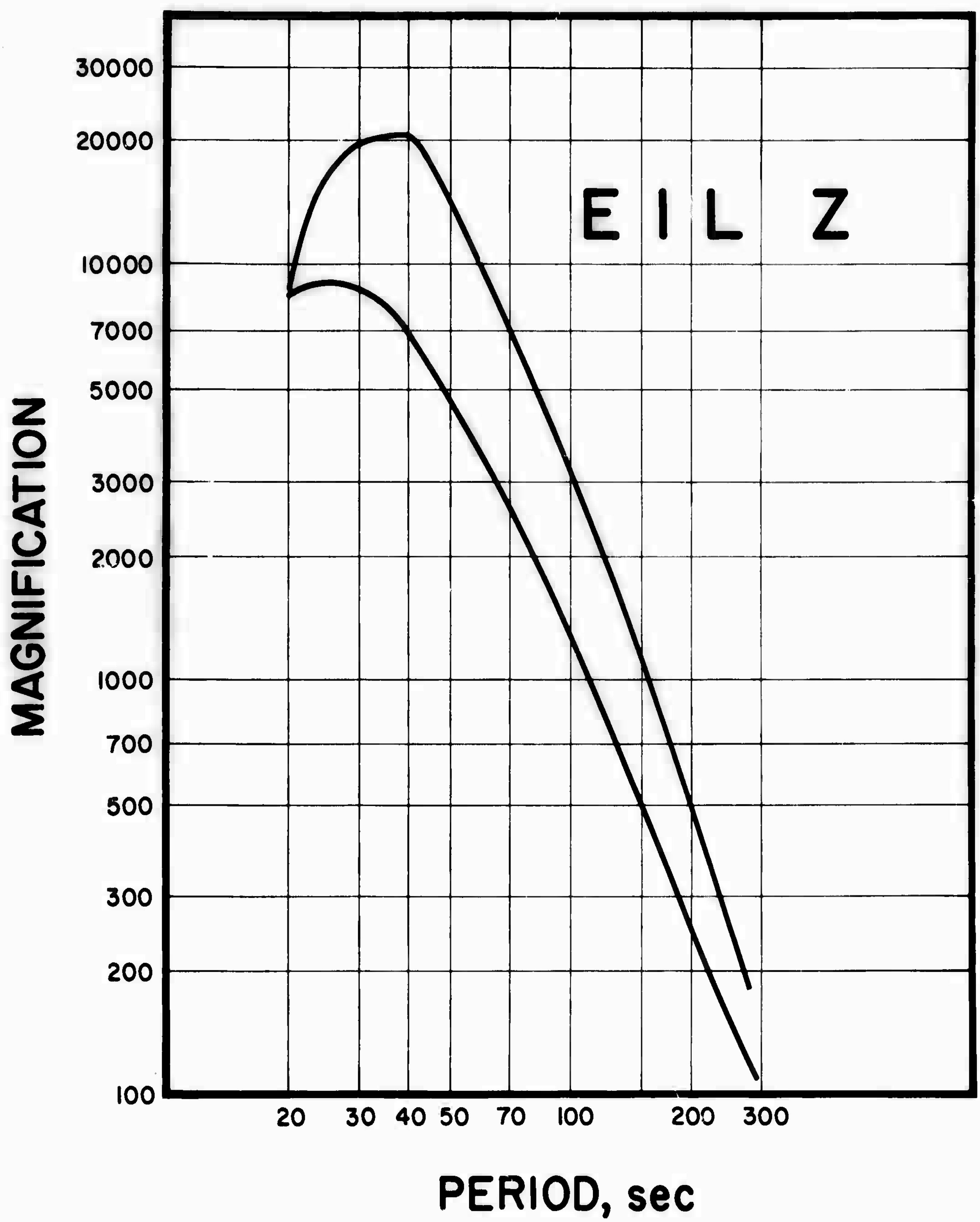
Peak Magnifications for December 1970 to April 1971:

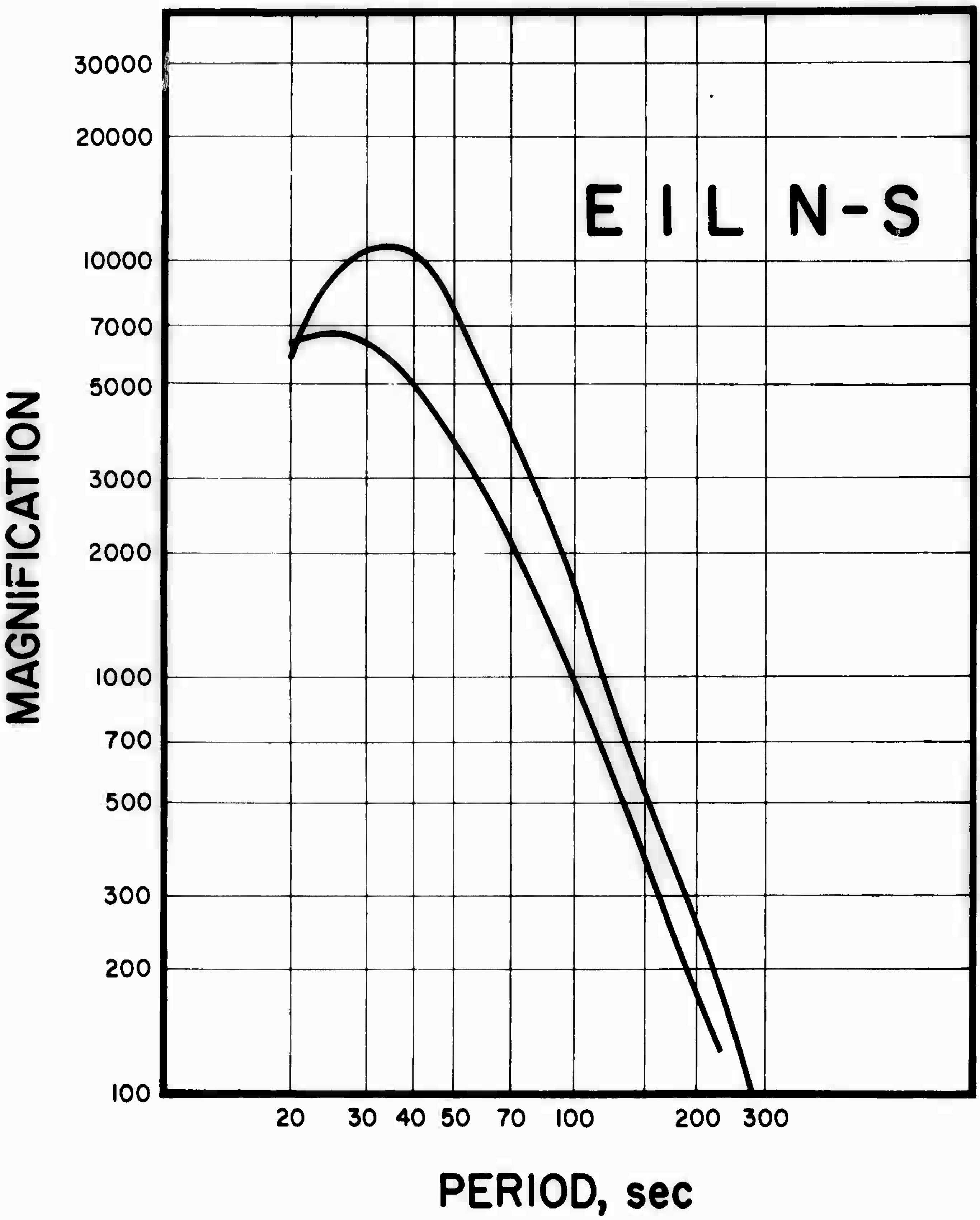
Z	Hi	--	20,600	at	40	Sec
	Lo	--	8,900	at	30	Sec
N-S	Hi	--	10,600	at	40	Sec
	Lo	--	6,500	at	30	Sec
E-W	Hi	--	20,300	at	40	Sec
	Lo	--	6,600	at	30	Sec

The magnification of the high-gain instruments was increased about four times in April 1971. New calibration curves will be prepared.

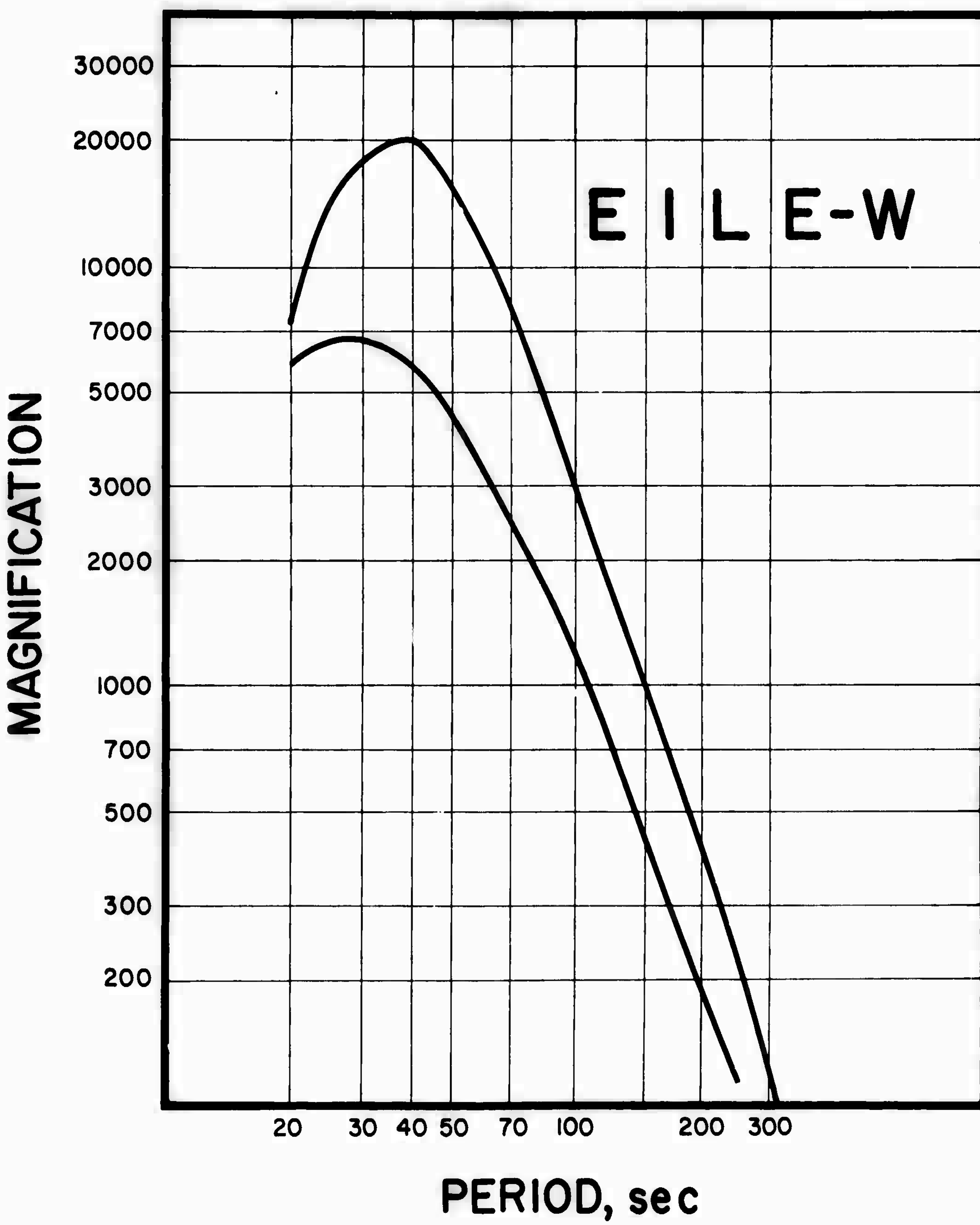
The high magnification of the vertical standard output may be due to the seismometer being nearly resonate at 30 seconds instead of overdamped.

Calibration pulses on the North-South instrument are being Fourier analyzed to determine the new instrument response.


EIL Z
MAGNIFICATION
30000
20000
10000
7000
5000
3000
2000
1000
700
500
300
200
100
20
30
40
50
70
100
200
300
PERIOD, sec

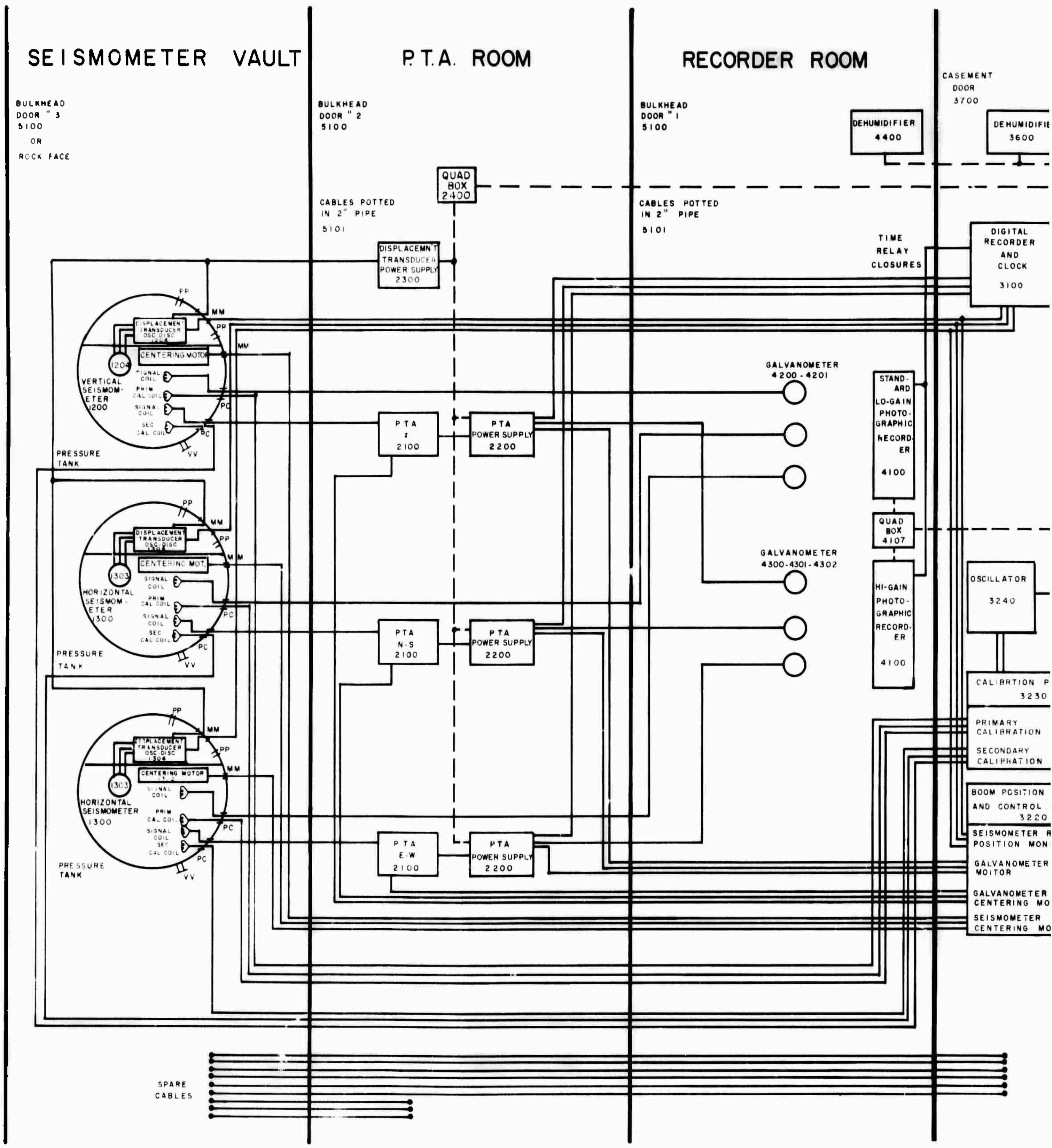


EIL N-S
MAGNIFICATION
30000
20000
10000
7000
5000
3000
2000
1000
700
500
300
200
100
20
30
40
50
70
100
200
300
PERIOD, sec



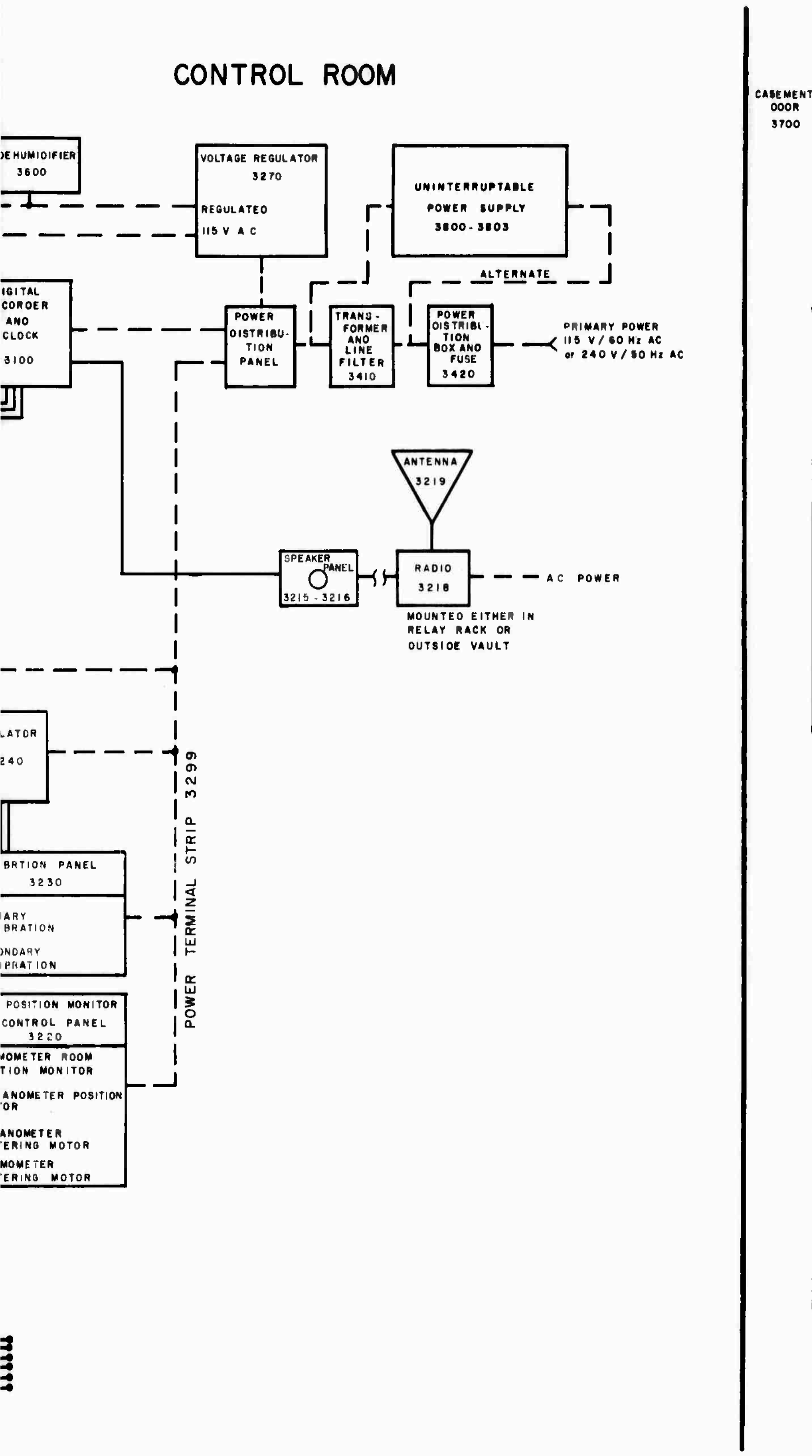
E I L E-W
MAGNIFICATION
30000
20000
10000
7000
5000
3000
2000
1000
700
500
300
200
20
30
40
50
70
100
200
300
PERIOD, sec

A



SEISMOMETER VAULT
P.T.A. ROOM
RECORDER ROOM
BULKHEAD DOOR " 3 5100 OR ROCK FACE
BULKHEAD DOOR " 2 5100
BULKHEAD DOOR " 1 5100
CASEMENT DOOR 3700
DEHUMIDIFIER 4400
DEHUMIDIFIE 3600
QUAD BOX 2400
CABLES POTTED IN 2" PIPE 5101
CABLES POTTED IN 2" PIPE 5101
DISPLACEMN'T TRANSDUCER POWER SUPPLY 2300
TIME RELAY CLOSURES
DIGITAL RECORDER AND CLOCK 3100
VERTICAL SEISMOMETER 1200
HORIZONTAL SEISMOMETER 1300
HORIZONTAL SEISMOMETER 1300
CENTERING MOTOR
DISPLACEMENT TRANSDUCER OSC-DISC
SIGNAL COIL
PRIM CAL COIL
SEC CAL COIL
PRESSURE TANK
PP
MM
PC
VV
1204
1303
1304
GALVANOMETER 4200-4201
GALVANOMETER 4300-4301-4302
PTA Z 2100
PTA N-S 2100
PTA E-W 2100
PTA POWER SUPPLY 2200
STANDARD LO-GAIN PHOTOGRAPHIC RECORDER 4100
QUAD BOX 4107
HI-GAIN PHOTOGRAPHIC RECORDER 4100
OSCILLATOR 3240
CALIBRTION P 3230
PRIMARY CALIBRATION
SECONDARY CALIPRATION
BOOM POSITION AND CONTROL 3220
SEISMOMETER R POSITION MON
GALVANOMETER MOITOR
GALVANOMETER CENTERING MO
SEISMOMETER CENTERING MO
SPARE CABLES

1 B



SYMBOLS USED ON PRESSURE TANK		
VV	PRESSURE TANK VENT VALVE	1102
PC	POTTED CABLES	8208
MM	MARSH - MARINE CONNECTORS	1101 1103
PP	PIPE PLUG	1104

LAMONT - DOHERTY GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY

HIGH - GAIN BROAD - BAND LONG - PERIOD SEISMIC SYSTEM

END