

APPENDIX E

SEISMIC TEST REPORT
SOUTHWEST RESEARCH INSTITUTE
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8013-308-17-18-0

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SEISMIC TEST REPORT

December 13, 1976

SERIES 700 PLUG-IN
INSTRUMENT SYSTEM
(Five Card and Ten Card
Configuration)

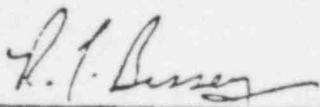
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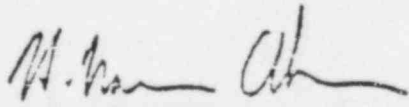
ACROMAG, Inc.
30765 Wixom Road
Wixom, Michigan 48096

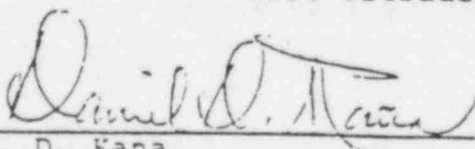
By

SOUTHWEST RESEARCH INSTITUTE
8500 Culebra Road
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SwRI Project No. 02-4744-001

APPROVED:


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Nuclear Quality Assurance Program
Approval

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TEST REPORT

1.0 Reference

- . SWRI Project No. 02-4744-001
Seismic Qualification Test

2.0 Equipment Identification

Two configurations of plug-in units were tested as contained in the Model 791-CG Plug-In Instrument System, Series 700. For the five-card configuration, the equipment was as follows:

- . Plug-In Instrument System, Model 791-CG
- . Power Supply Module, Model 781-AC
- . Power Jumper Card 7405
- . Multiplier/Divider Computation Transmitter, Model 712-MD
- . Hermetically sealed Relay, Model 731-C-5G
- . DC Voltage Transmitter, Model 712-M
- . DC Voltage Transmitter, Model 712-V

For the ten-card configuration, all of the above items were included plus the following:

- . Signal Isolator Model 712-L
- . Signal Isolator, Model 712-INT-L
- . AC Currents Transmitter, Model 712-CAC
- . Multiplier/Divider, Model 733-MD-1
- . Thermocouple Transmitter, Model 712-J

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3.0 Specifications and Standards

- . IEEE No. 323 - April 1971 - Trial - Use Standard: General Guide for Qualifying Class I Electric Equipment for Nuclear Power Generating Stations
- . IEEE Standard 323-1974 - IEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations
- . IEEE Standard 344-1975 - Guide for Seismic Qualification of Class I Electric Equipment for Nuclear Power Generating Stations
- . MIL-C-45662A - Calibration System Requirement, Military Specification
- . SWRI NQAP 1-1 and 2-1 - Nuclear Quality Assurance Program Manual, Feb 1, 1976
- . SWRI XI-EE-101-0, XII-AG-104-0, XII-EE-101-0, XVII-AG-102-0, Nuclear Projects Operating Procedure June 1976
- . Required Response Spectrum (RRS) For Control Systems Purposes for the Majority of Nuclear Power Plant Location in the Continental United States, Bechtel Specification 4S, Page 4S-12.

4.0 Test Facility

- Southwest Research Institute
Department of Mechanical Sciences
8500 Culebra Road
San Antonio, Texas 78284

5.0 Test Equipment

The following is a list of test equipment used for seismic testing. The equipment used for these tests is designated by an X.

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TABLE 5,0-1, TEST EQUIPMENT

Item No.	Item Identification	Make	Model	Serial No.	SwRI No.	Account Center	Remarks
1	Accelerometer	Endevco	2221D	JC-15	---	III Bay	1-5000 Hz
2	"	"	"	JC-16	---	"	"
3	"	"	"	JC-17	---	"	"
4	"	"	"	JC-18	---	"	"
5	"	"	"	JF-66	---	"	"
6	"	"	"	NH-75	---	"	"
7	"	"	"	NH-76	---	"	"
8	Accelerometer	Endevco	2220	MD-75	---	Instr. Room	1-5000 Hz
9	"	"	"	MD-76	---	"	"
10	"	"	"	JD-48	---	"	"
11	"	"	"	KC-53	---	"	"
X 12	Accelerometer	Wm. Miller	1402C	272	---	III Bay	0-100 Hz
13	"	"	"	274	---	"	"
14	"	"	"	275	---	"	"
15	"	"	"	281	---	"	"
16	"	"	"	283	---	"	"
17	"	"	"	284	---	"	"
18	"	"	"	285	---	"	"
19	"	"	"	287	---	"	"
20	"	"	"	288	---	"	"
21	"	"	"	292	---	"	"
X 22	Accelerometer	Dell & Howell	4-202-0001	19742	---	III Bay	Biaxial Table
X 23	"	"	"	19745	---	"	"
24	Accelerometer Calibrator	Kistler	5020/5617	764/0416	8436-A437	Instr. Room	NBS Traceable Reference Standard
X 25	Seismic Table	SwRI	---	---	---	III Bay	Biaxial, Horizontal, and Vertical
26	"	"	---	---	---	"	Uniaxial, Horizontal
X 27	Noise Generator	Elenco	211A	015-1055	1429	III Bay	Random Noise
28	Tone Generator	Mikrodor	F220A	3055	4032	III Bay	
X 29	Amplifier-Exciter	CEC	System D	29011-29279	---	Instr. Room	12 Channel
30	Amplifier	SwRI	---	---	136C5	III Bay	7 Channel
31	"	"	---	---	136C5	"	"
32	Amplifier	Kistler	504A	0645	4022	Instr. Room	
33	"	"	504D	1545	---	"	
34	Amplifier	Columbia	FW-401	130	---	Instr. Room	
35	"	"	"	131	---	"	
36	"	"	"	132	---	"	
37	"	"	"	133	---	"	
38	"	"	"	134	---	"	
39	"	"	"	135	---	"	
40	"	"	"	136	---	"	
41	"	"	"	137	---	"	
42	"	"	"	138	---	"	
43	"	"	"	139	---	"	
44	"	"	"	140	---	"	
X 45	Oscilloscope	Tektronix	212	01041474	11473	III Bay	Battery Power
46	"	"	5640	01112144	4462	"	Probe Scope
47	"	"	R-5610	01071522	4494	"	Back Mount
X 48	Oscilloscope Probe	Tektronix	2067	23214	---	III Bay	Time Base
X 49	"	"	2067	31456	10054	"	"

TABLE 5.0-1. TEST EQUIPMENT (cont'd)

Item No.	Item Identification	Make	Model	Serial No.	SWR No.	Account Center	Remarks
50	Oscilloscope Plug-In	Tektronix	3A74	5062	6443	Hi Bay	4 Channel Amplifier
51	"	"	3A74	8175	9403	"	"
52	Oscillograph	Hell & Howell	5-134-18	5042	13187	Hi Bay	18 Channel
X 53	Oscillograph	CIC	5-124	6277	1944	Instr. Room	18 Channel
X 54	Tape Recorder	Ampex	FR 1800	7040122	4458	Hi Bay	14 Channel, 0-20 kHz
55	"	"	FR 1800	200733M	10726	Ballistics	14 Channel, 0-500 kHz
X 56	X-Y Plotter	HP	7005B	1429	9660	Hi Bay	Analogue Input
57	Camera	Polaroid/Tek.	C-30A	1023377	10717	Hi Bay	Scope Camera
58	Camera	Mentax	Spotmatic	1071070	3656	Photo	35 mm Still
59	Counter	HP	5512A	440-01511	3275	Hi Bay	
X 60	Display Unit	Tektronix	602	1073764	13155	Ballistics	
X 61	Voltmeter	Weston	4442	1274	---	Hi Bay	Battery Power, Digital
X 62	Dynamic Analyzer	Spectral Dynamics	SD101A	356	2265	Hi Bay	Tracking Filter
63	"	"	SD101A	1076	6874	"	"
64	CO/QUAD Analyzer	"	SD109	27	6395	"	
65	Analyzer Tuner	"	SD102	1-115-1	3132	"	Oscillator/Counter
X 66	Response Spectrum Analyzer	"	SD321	12	---	"	Digital Minicomputer
X 67	Sweep Oscillator	"	SD104A-5	1119	10729	"	
68	Servo Monitor	"	SD105A	557	10730	"	For use with SD 105A
X 69	Oper. Amp. Manifold	Analog Devices	194	12171	---	"	Integrator, Summer
70	"	"	194	12125	---	"	" "
71	Multimeter	S&R	---	2	---	"	Analogue Multimeter
72	Potentiometer	S&R	---	1	---	"	5 Pots each, Analogue
73	"	"	---	2	---	"	" "
74	"	"	---	3	---	"	" "
75	Log Converter	Rad. Inst.	1020	173	2501	"	Analogue
76	"	"	1020	171	2502	"	"
X 77	Filter	Spencer Kenady	303A	407	4135	"	Variable Adjust
78	"	"	303A	368	3233	Instr. Room	" "
79	"	Line	EPN 100	1005	5473	Hi Bay	Peak/Notch Adjust
80	"	"	EPN 100	1110	5474	"	" "
X 81	Controller	S&R	---	1	---	"	Seismic Table Controller
X 82	"	"	---	2	---	"	" " "
83	"	"	---	3	---	Hydro-dynamics	" " "
84	Amplifier	Unholtz-Dickie	610RM-3	1491	---	Instr. Room	3 Channel
85	"	"	"	1492	---	"	"
86	"	"	"	1493	---	"	"
87	"	"	"	1494	---	"	"

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6.0 Calibration

- . The Bell and Howell, Model No. 4-202-001, Serial Nos. 19746 and 19742 and the William Miller 402C were calibrated traceable to National Bureau of Standards.
- . The calibration reference was a reference standard Kistler 808K/561T which is traceable to the National Bureau of Standards.
- . The Spectral Dynamics Frequency Counter, Serial No. 3132 was calibrated to a crystal frequency traceable to the National Bureau of Standards.
- . Hewlett-Packard Model 7005B X-Y recorder was set to read the output shown on each of the separate graphs.
- . Instrumentation calibration was performed at nominal 72°F temperature and 50% relative humidity, and in accordance with MIL-C-45662A, Military Specification, Calibration System Requirements.

7.0 Test Method

7.1 Resonant Frequency Survey

The plug-in instrument system with five cards installed was mounted in its normal operating orientation (in a rack mount) on the SWRI biaxial shaker, such that it could be excited in either the X, Y or Z principal axes directions. Figure 1 shows the electrical diagram for the five-card test configuration. Figure 3 shows the mounting of the instrument system for the five-card configuration on the biaxial shaker and the pertinent Cartesian coordinate system axes. Figures 4, 5 and 6 show the location of the response accelerometers used to measure the response of the plug-in system during the resonance survey for the X, Y and Z excitation directions. The survey was conducted by exciting the structure uniaxially with an 0.2 g peak acceleration in the frequency range 1 - 35 Hz at a sweep rate of 0.2 decades per minute. The response was plotted as a function of frequency. These plots appear in Section 8.0. Resonances occurred where response acceleration was twice the excitation acceleration. During testing the front cover of the plug-in system was closed, as shown in Figure 7.

After the resonance survey had been made of the X, Y and Z principal axes of the five-card configuration, a similar test was performed for the ten-card configuration. The cards used in this configuration are shown in Figures 1 and 2, and the test setup is shown in Figures 8 and 9. Results for all resonance surveys appear in Section 10.0.

7.2 Random Motion Tests

While mounted on the biaxial shaker facility, the plug-in instrument system was subject to random excitation as defined by Figures 10 through 13. The random excitation was obtained by inputting narrow band random signals in 1/3 octave bands into the biaxial shaker system and measuring the resultant response accelerations at the table in the vertical and horizontal directions. A Test Response spectrum (TRS) was obtained from the output of these accelerometers by the use of a spectrum analyzer. Figures 10 and 11 show the comparison of this TRS with the Required Response Spectrum (RRS) as obtained from the Bechtel 4S Specification referenced in Section 3.0. These RRS's are for a Design Basis Earthquake (DBE). Figures 12 and 13 show a similar comparison for an Operating Basis Earthquake (OBE). DBE and OBE tests were performed for both the five and ten-card configurations. Each test was of 30 seconds duration and consisted of a simultaneous biaxial excitation of the structure with the random motion as defined by the TRS's. The horizontal axis was in one of the principal axis directions of the plug-in system for one test and then the plug-in system was rotated 90° about the vertical axis for a retest. For the OBE tests, a total of five tests were performed for each direction of the horizontal axis for each card configuration.

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It should be noted in Figures 10-13 that TRS's fall below the RRS's for low frequencies due to the displacement limits of the table.

7.3 Monitoring During Tests

During the resonance survey, the plug-in instrument system response was monitored as described in paragraph 7.1. During the random motion tests, test circuitry as shown in Figures 1 and 2 (Section 9.0) was set up to monitor up to eight test points in the system. Output of these test points was recorded on a recording galvanometer oscillograph. The oscillograph data is shown in Section 10.0. In addition, an isolation test was performed with a light monitor. The test points monitored for the five-card test configuration are shown in Figure 1. The test point correlation with the channels on the oscillograph data is shown on the data. Test points monitored for the ten-card configuration are shown in Figure 2 and are similarly correlated with the oscillograph data on the data sheets. Figure 14 shows the test apparatus used for functionality monitoring

8.0 Results and Conclusions

All results of these tests are delineated in Section 11.0 in the SwRI laboratory data logs. The following are the salient points:

- . The resonance survey for the five-card configuration revealed no resonances below 35 Hz for the X and Y-axis excitations and a resonance at 27 Hz for the Z-axis excitation.
- . The resonance survey for the ten-card configuration revealed no resonances for the X and Y-axis excitations below 35 Hz and a resonance at 27 Hz for the Z-axis excitation.
- . For the five-card configuration, functions monitored before, during and after test indicated normal operation for both the OBE and DBE random motion tests. DC outputs at TP2, TP3 and TP4 showed no drift during test. The light on the Isolation Test Indicator indicated isolation between the appropriate points and the output at TP6 and TP7 indicated switching was normal for the TP5 input.
- . For the ten-card test configuration, all functionality checks showed normal operation before, during and after the OBE and DBE tests. DC outputs at TP2, TP4 and TP8 showed no drift. Switching at TP3, TP6 and TP7 was normal for the input for all tests.
- . No structural failures were observed before, during or after tests for either card configuration.

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9.0 Report Figures

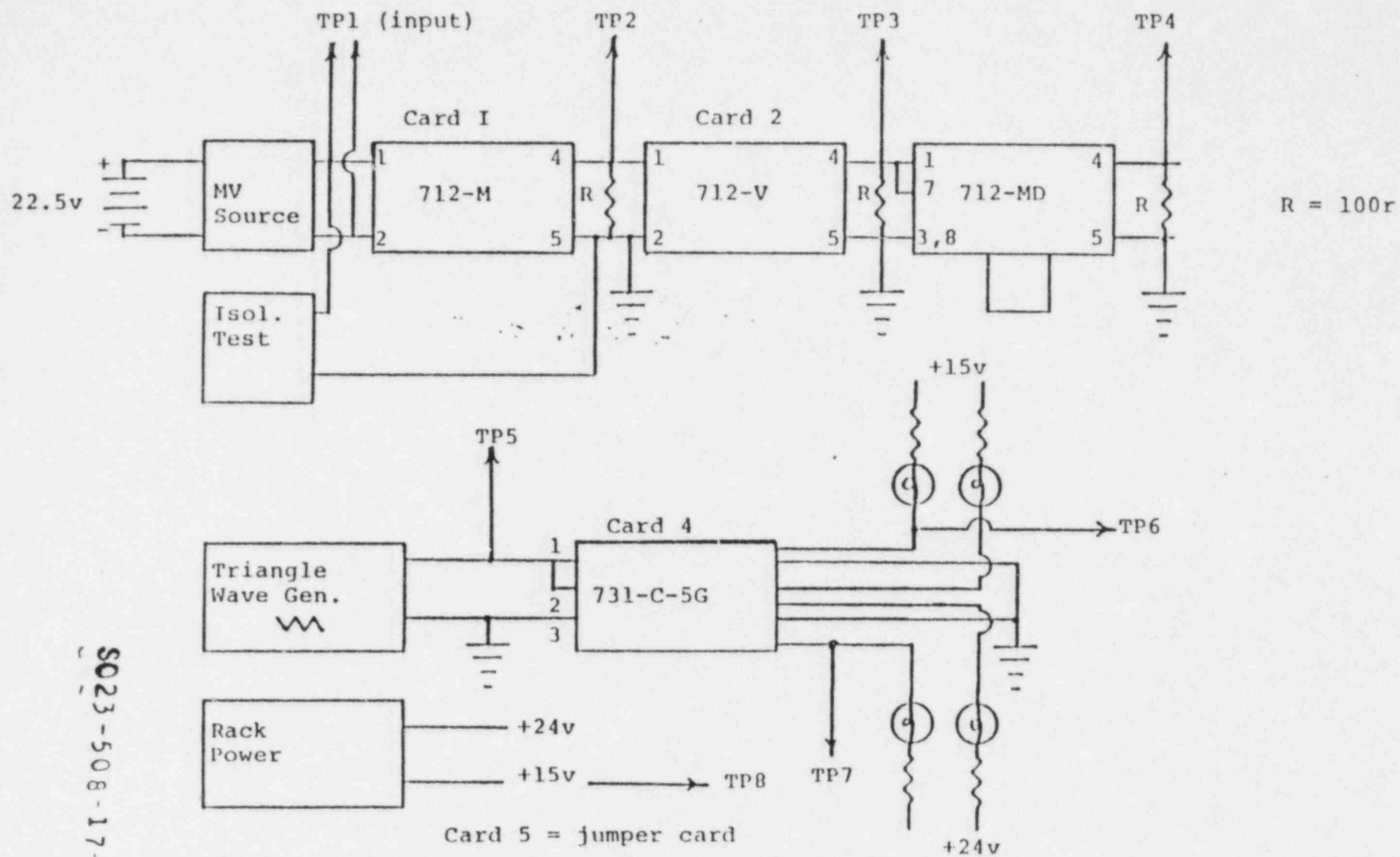


Figure 1. Five Card Test Configuration

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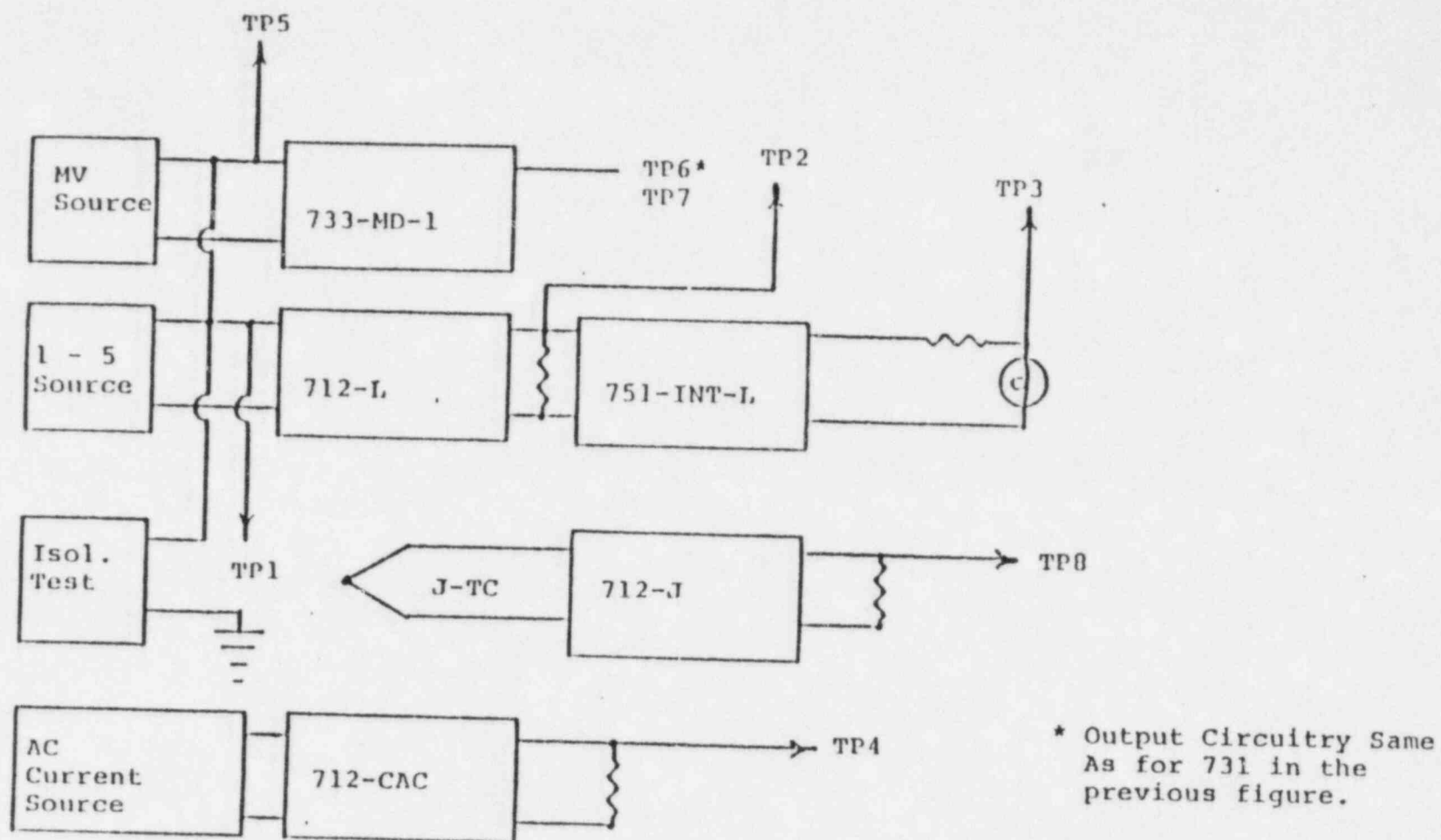


Figure 2. Additional Circuitry For Ten Card Configuration

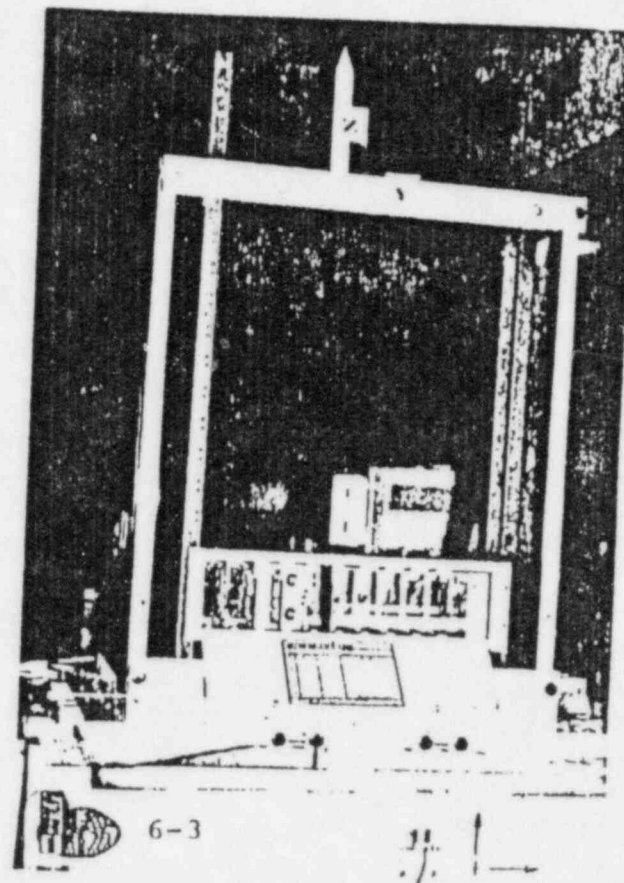
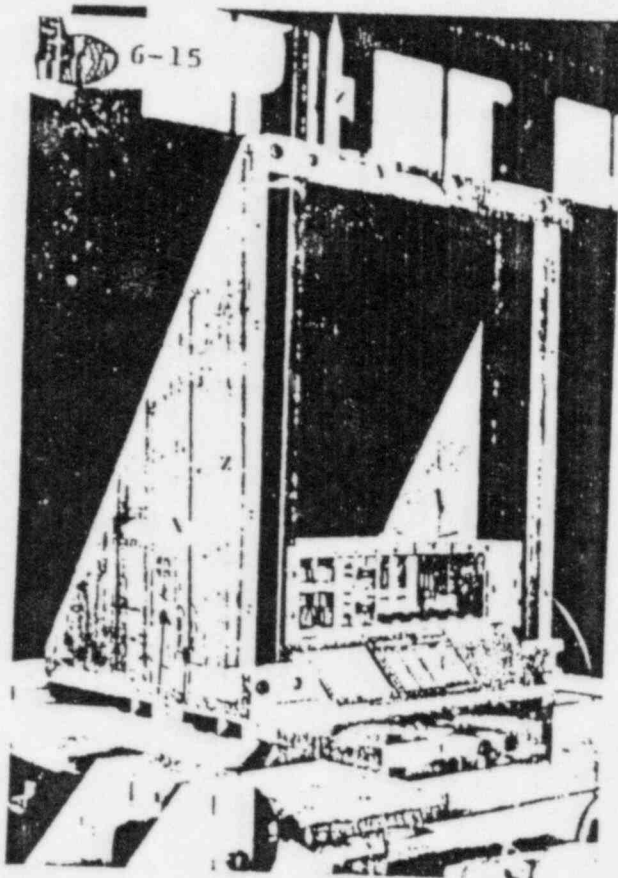


Figure 3. Mounting of 5-Card Configuration on the Biaxial Shaker System



Figure 4. Location of X-Axis Response Accelerometer (circled in red) for Resonance Survey

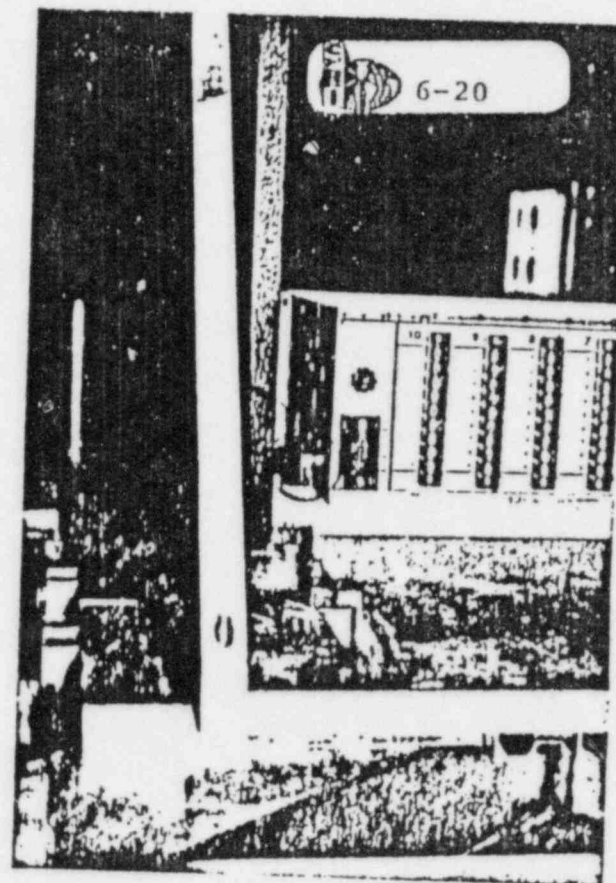


Figure 5. Location of Y-Axis Response Accelerometer (circled in red) for Resonance Survey

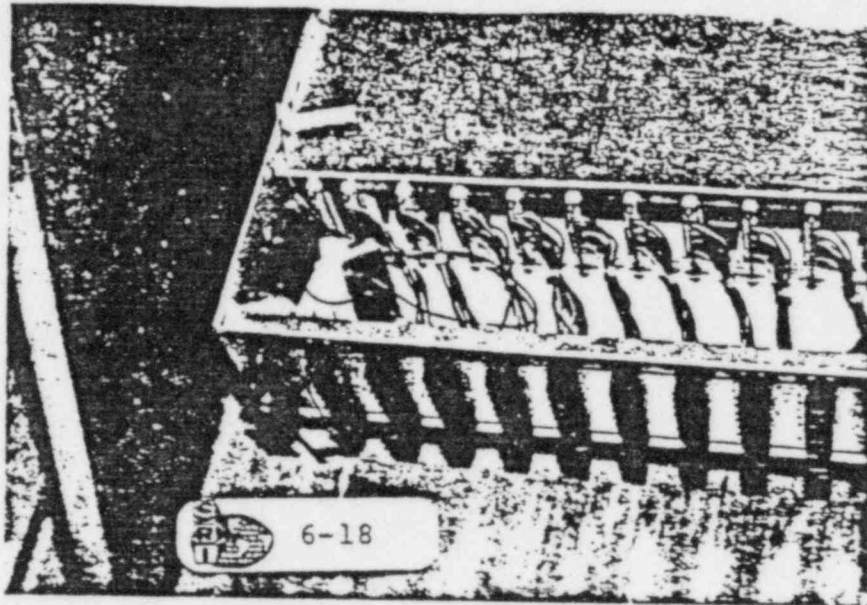
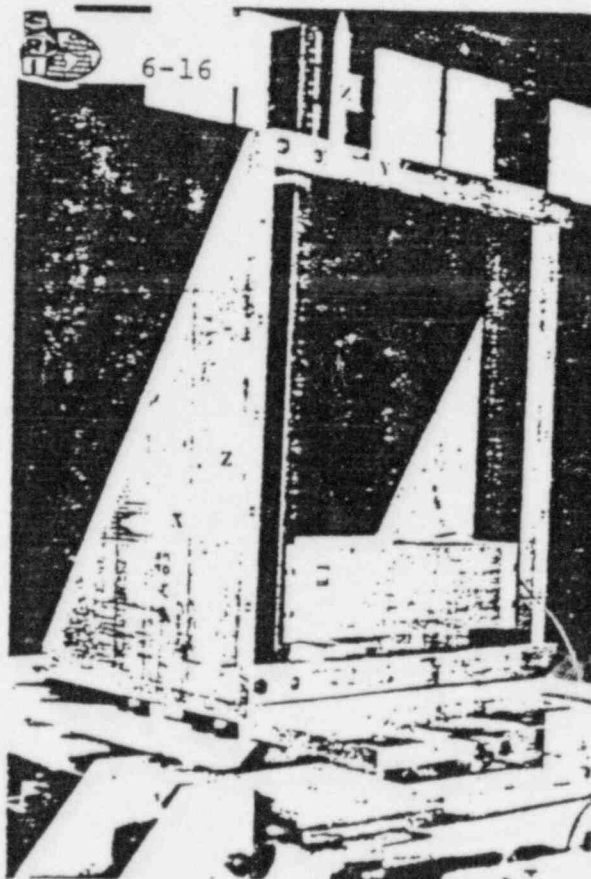


Figure 6. Location of Z-Axis Response Accelerometer (circled in red) for Resonance Survey



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Figure 7. Closed Corner Condition of Plug-In System During Test

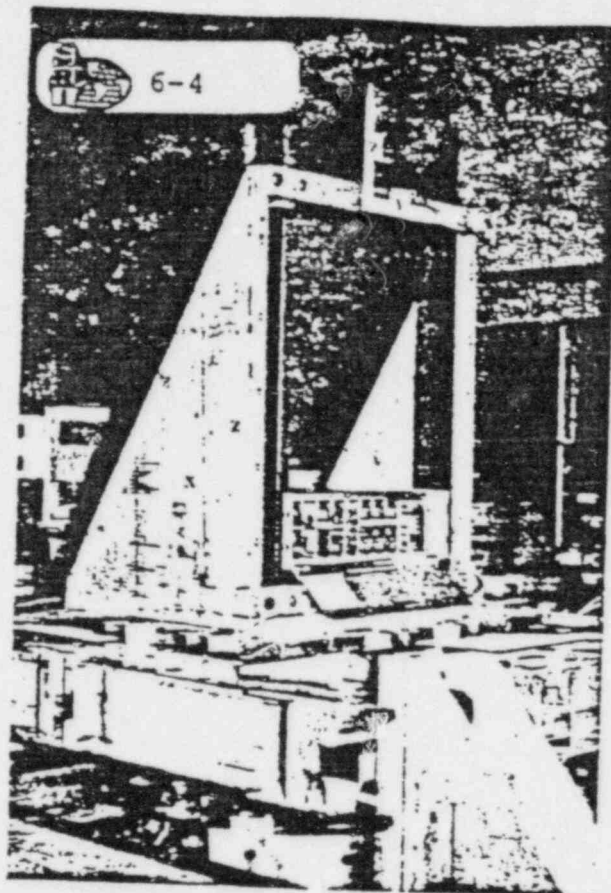


Figure 8. Mounting of the 10-Card Configuration on the Biaxial Shaker System

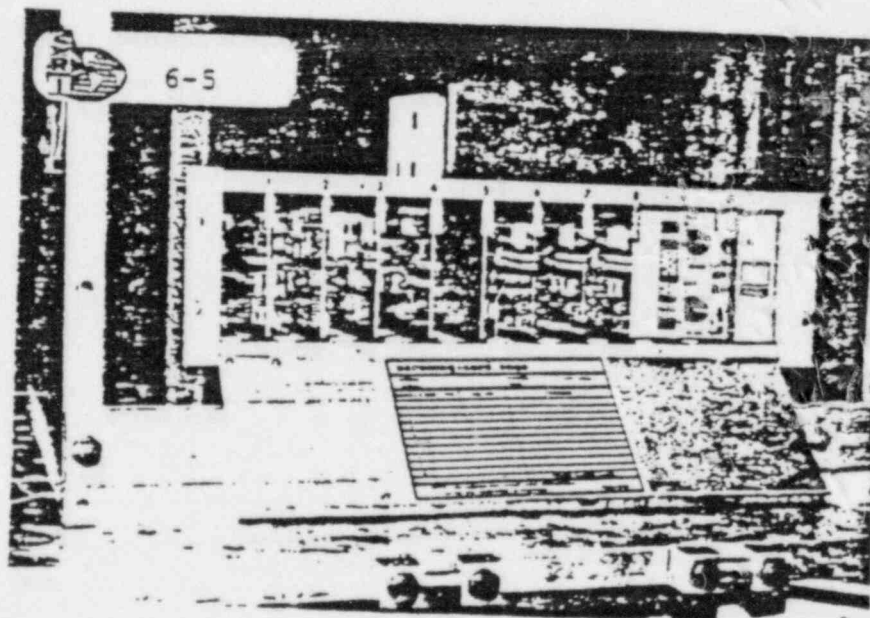
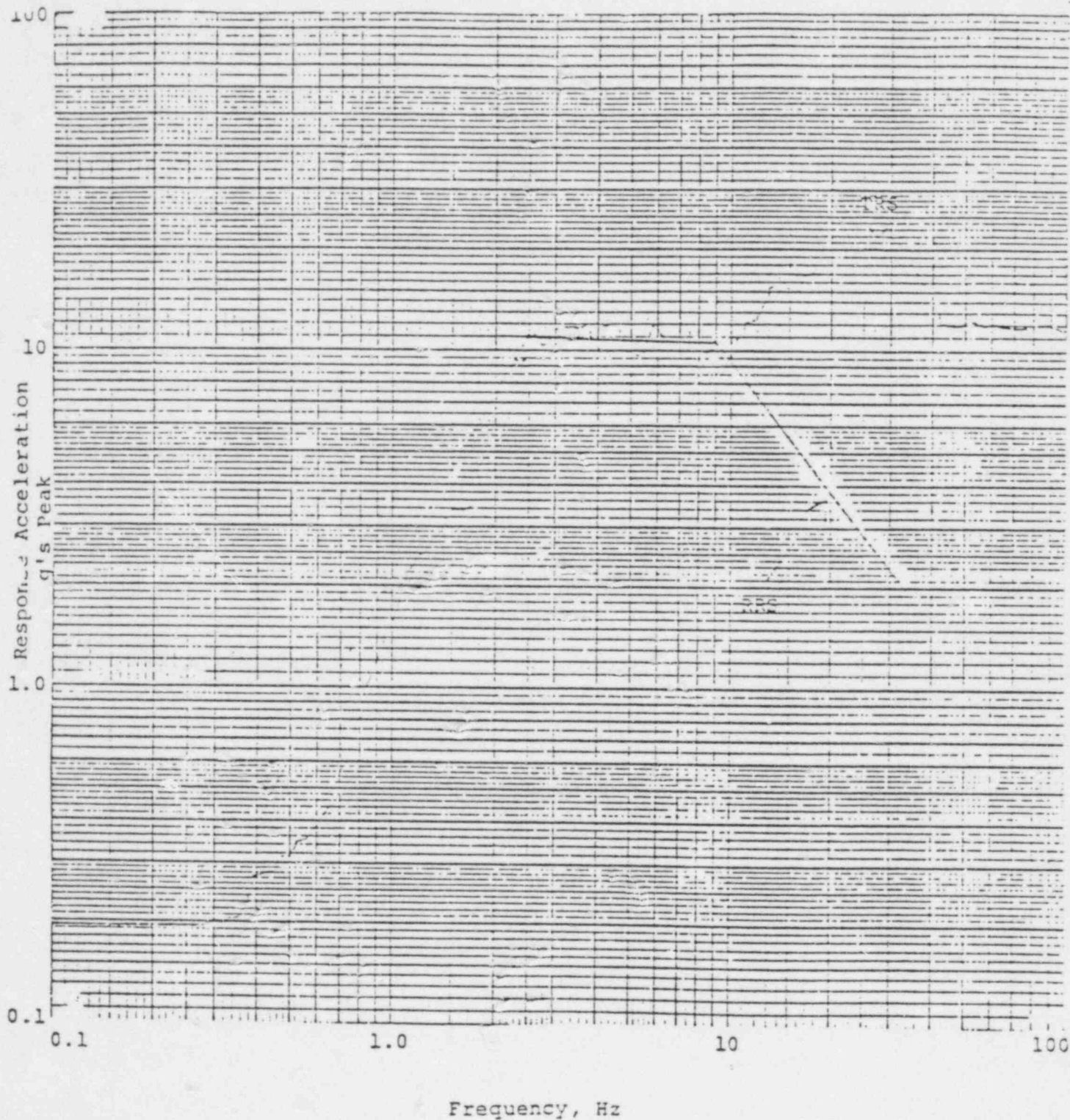


Figure 9. Closeup of the 10-Card Configuration



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Figure 10. Horizontal Excitation for DBE, 5% Damping

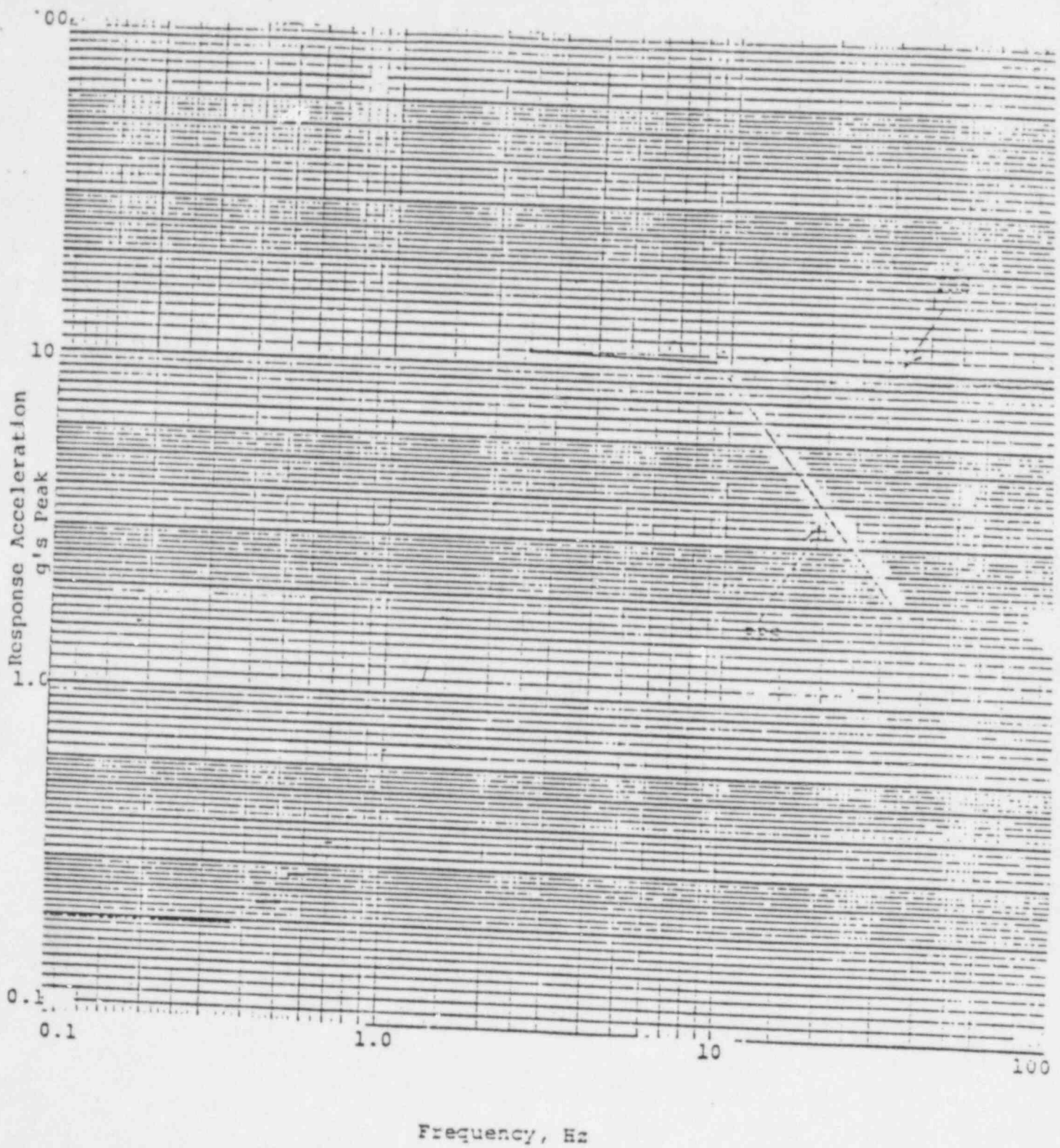


Figure 11. Vertical Excitation for UBF, 5% Damping

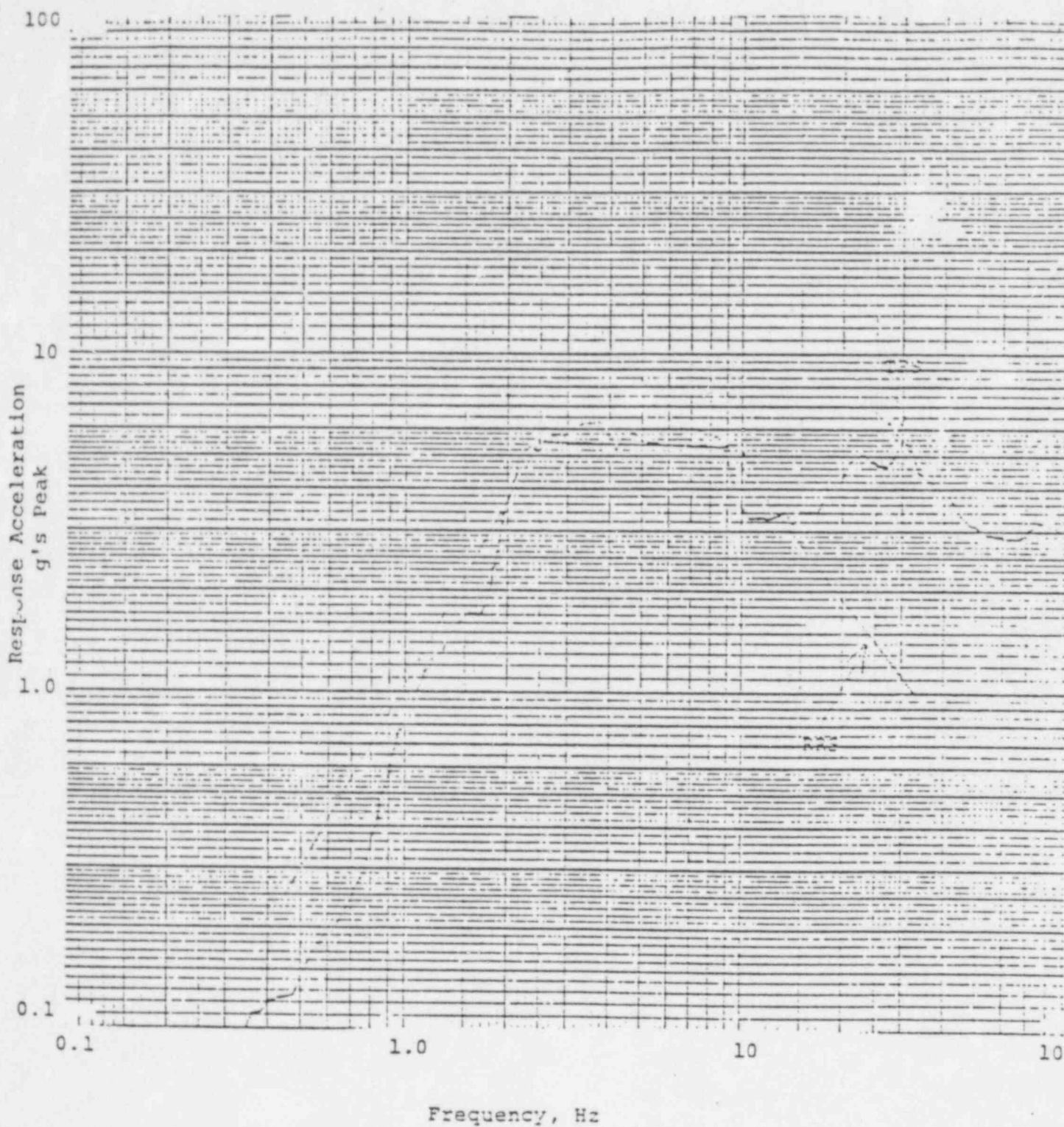


Figure 12. Horizontal Excitation for OBE, 5% Damping

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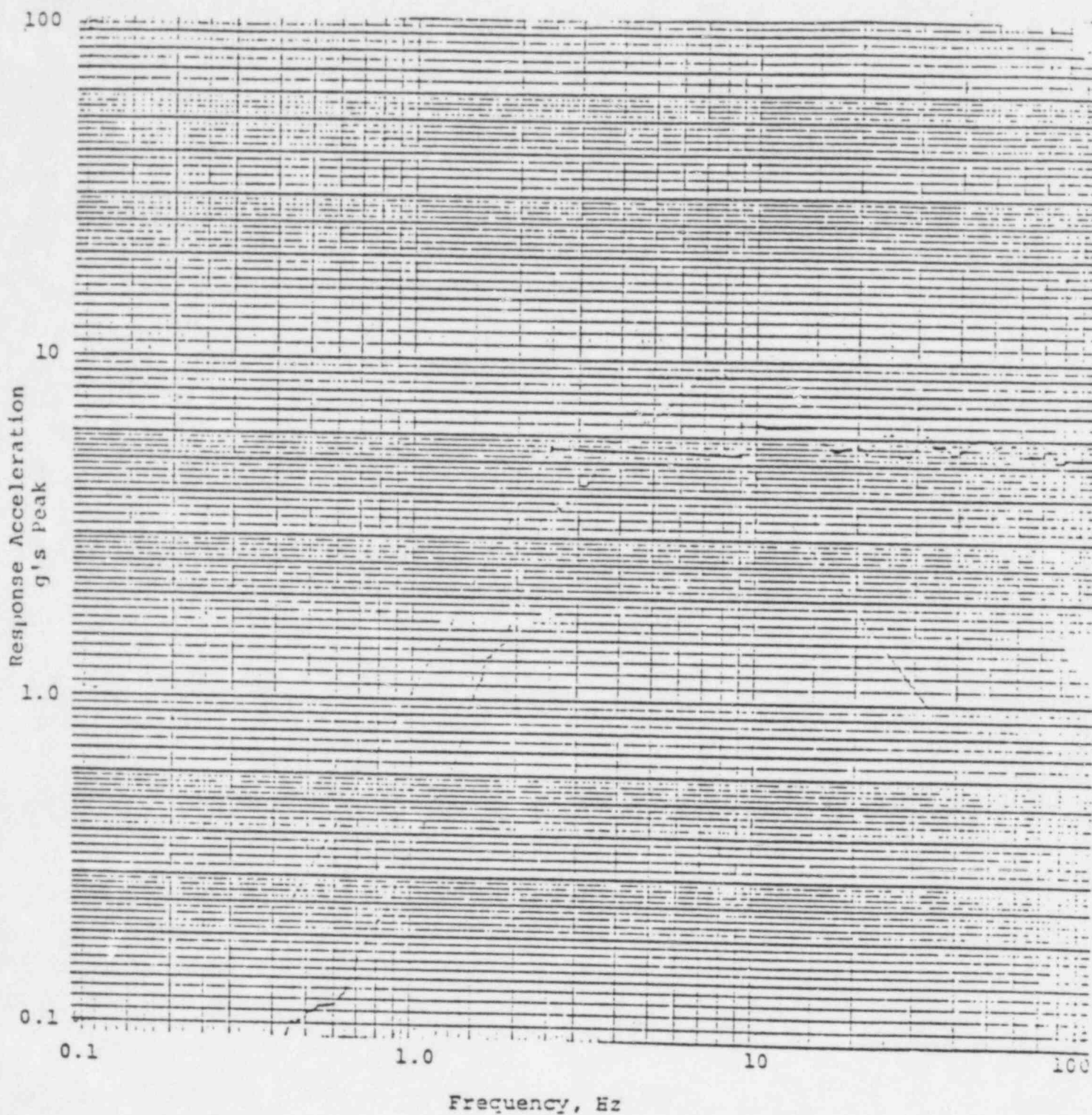


Figure 13. Vertical Excitation for CBE, 5% Damping

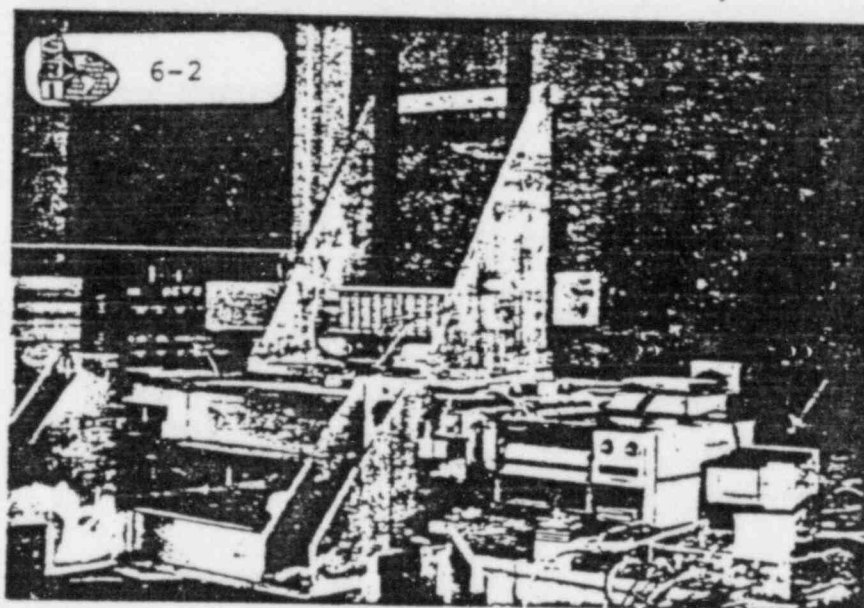
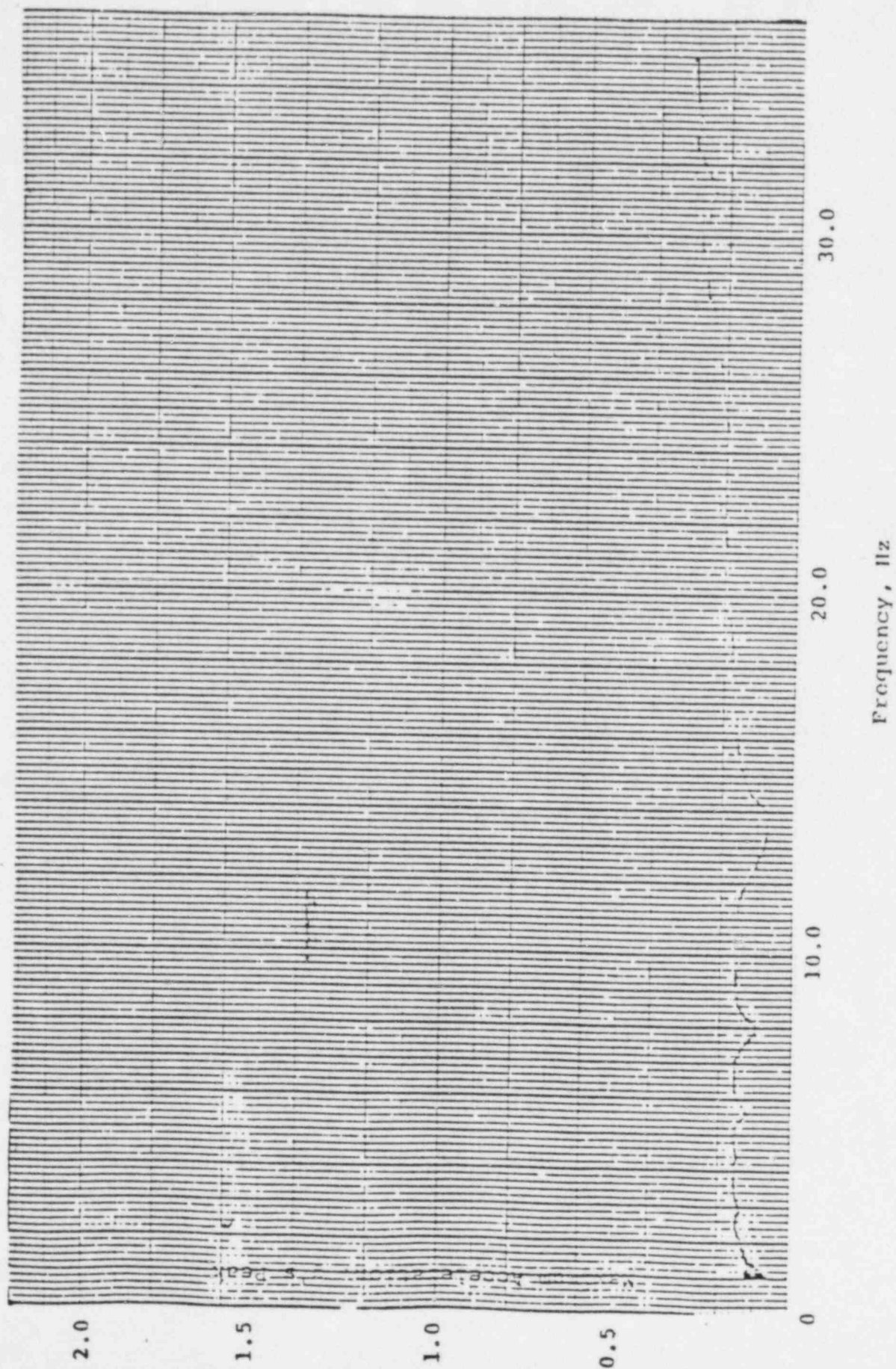


Figure 14. Test Apparatus for Functionality Monitor
(red arrow)

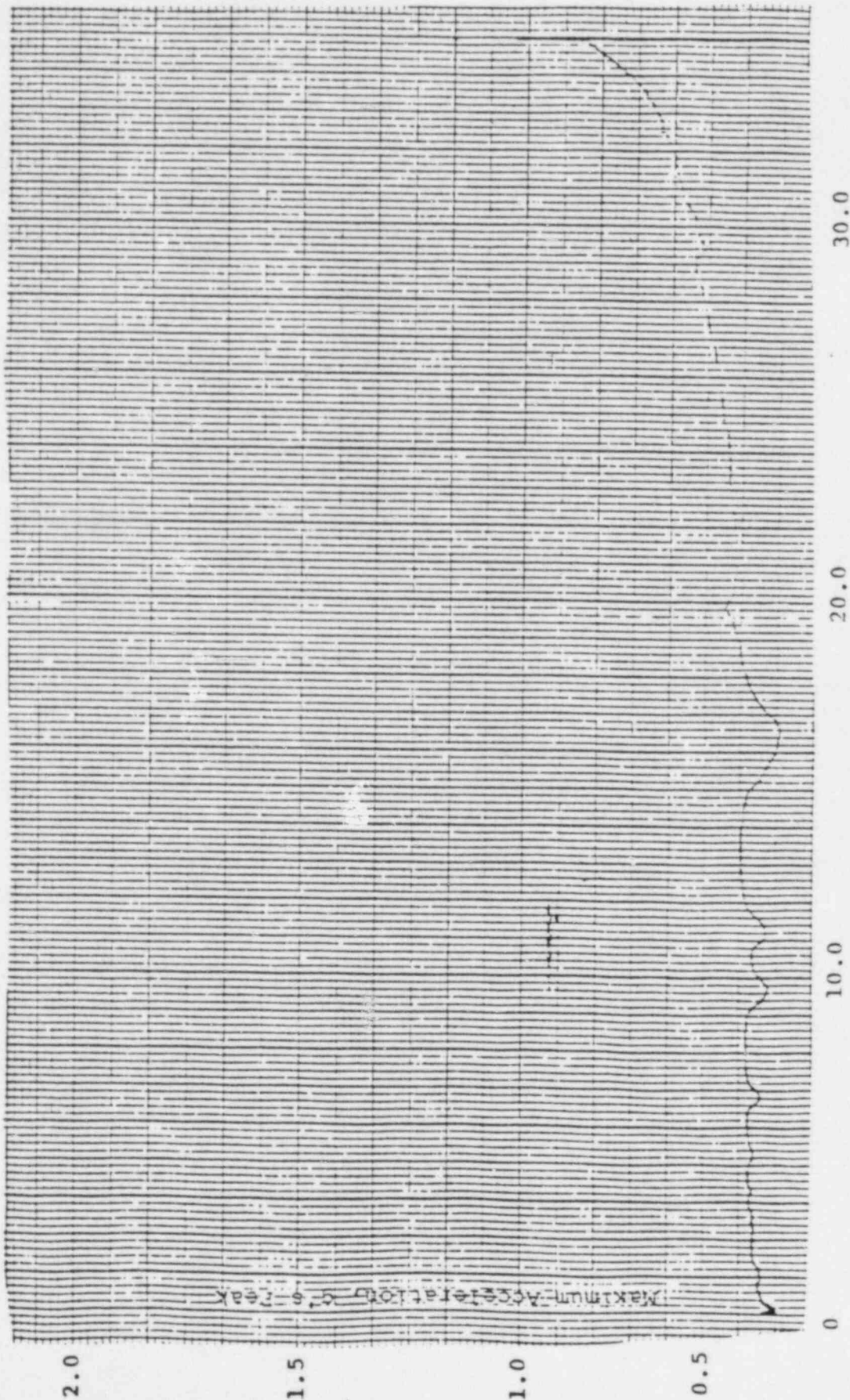
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10.0 Test Data

S023-508-17-18-0



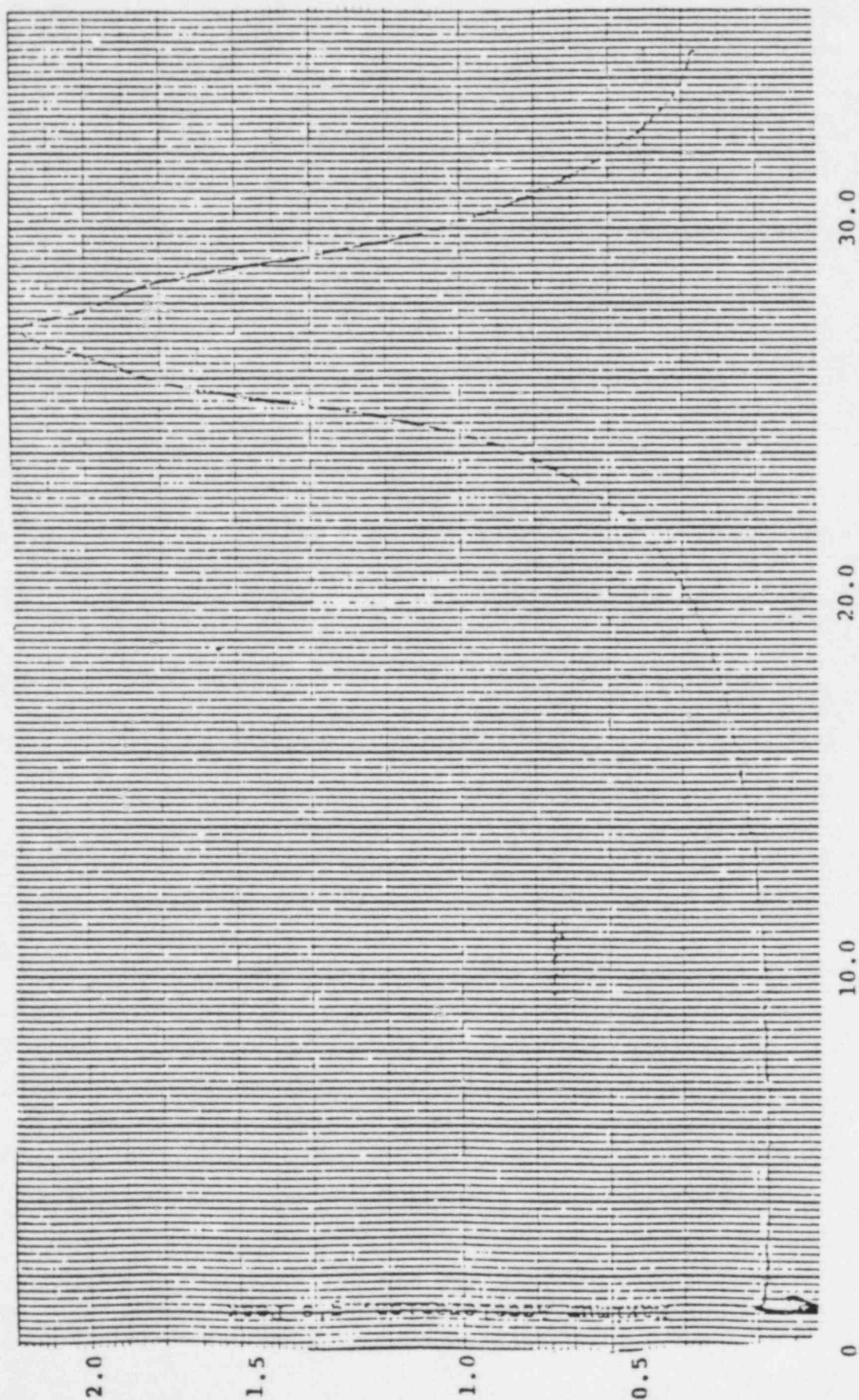
Resonance Survey, 5-Card Configuration, X Axis



0-81-21-805-5209

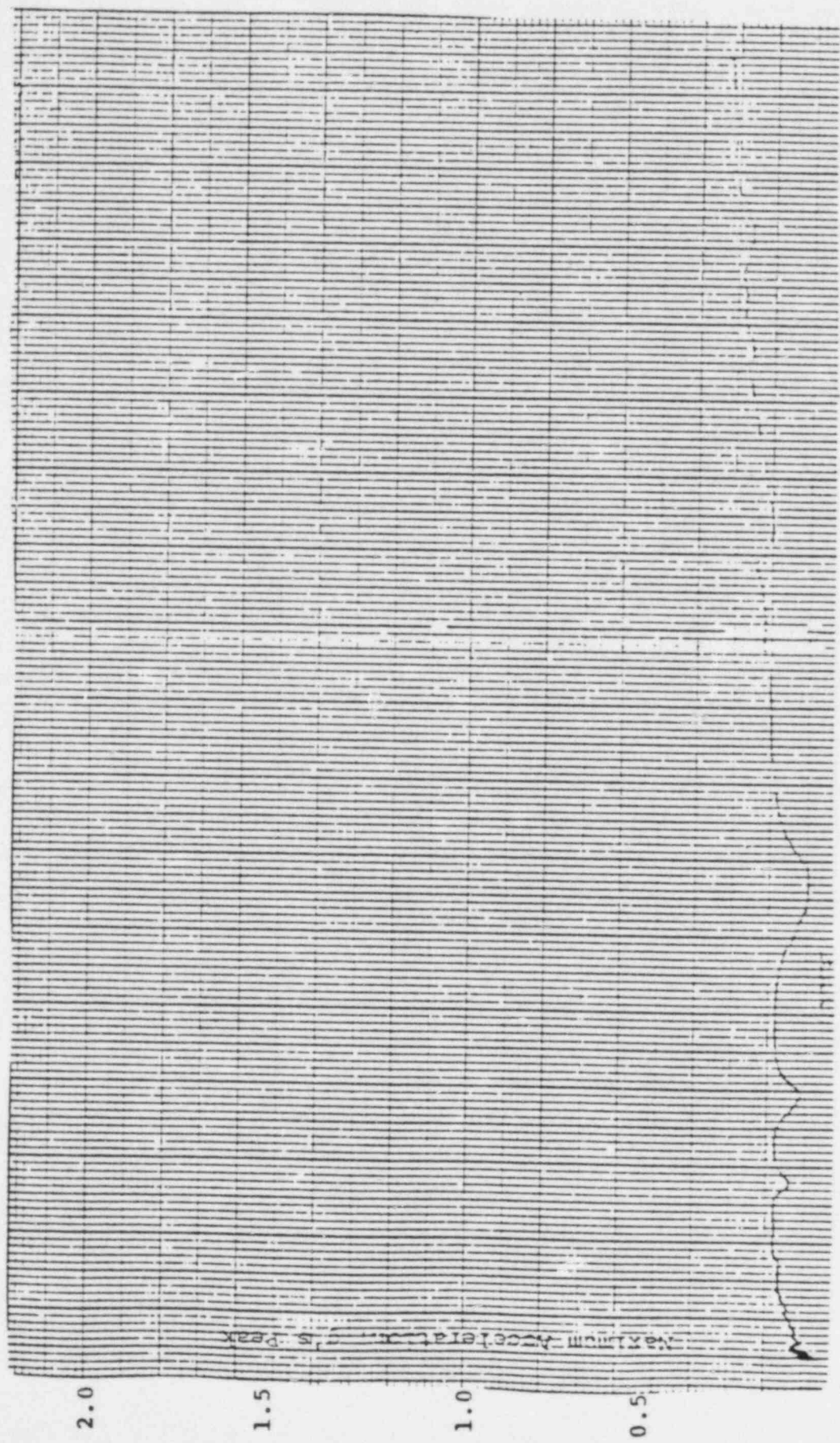
Frequency, Hz

Resonance Survey, 5-Card Configuration, Y Axis



Frequency, Hz

Resonance Survey, 5-Card Configuration, Z Axis



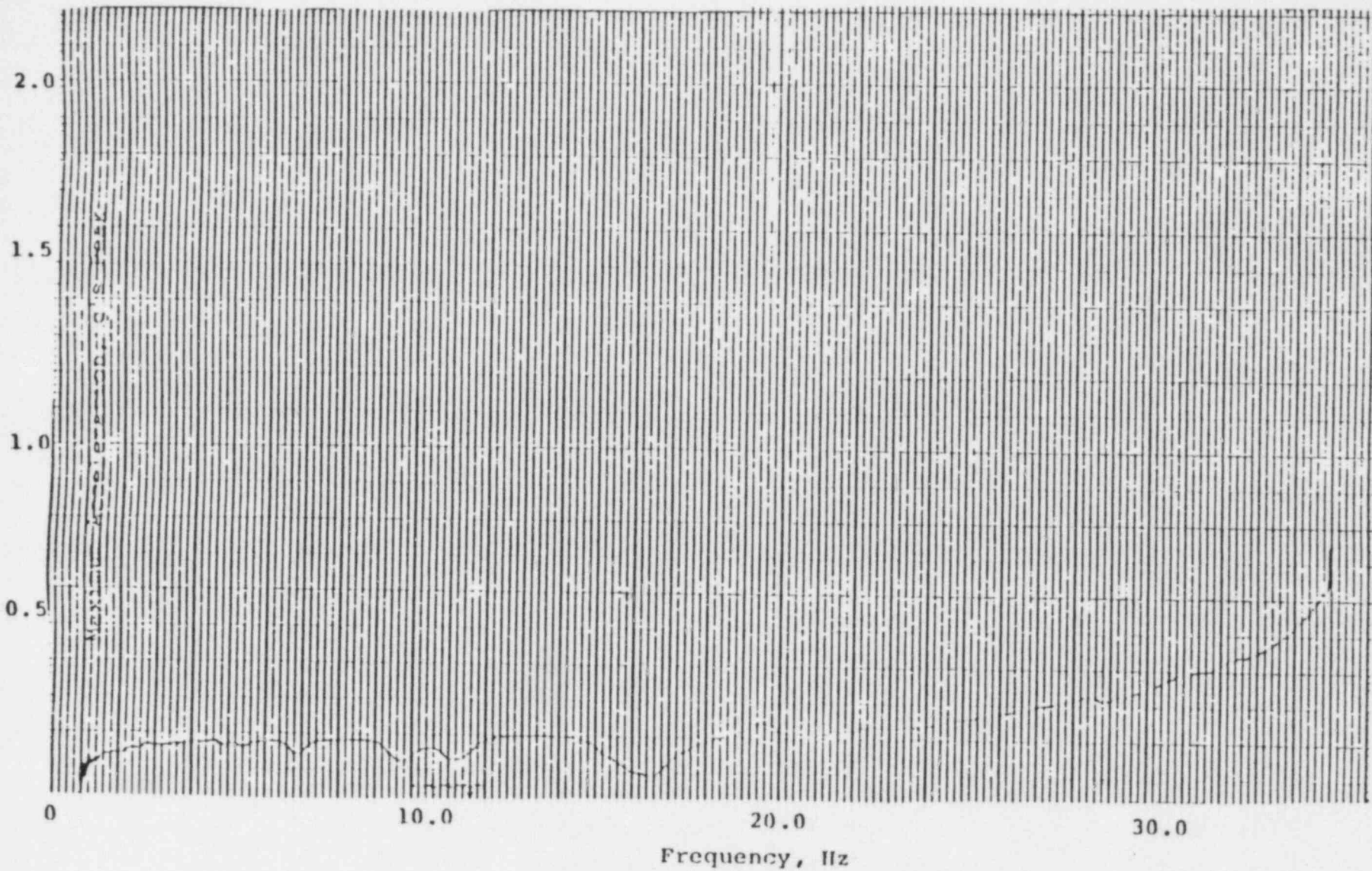
30.0

20.0

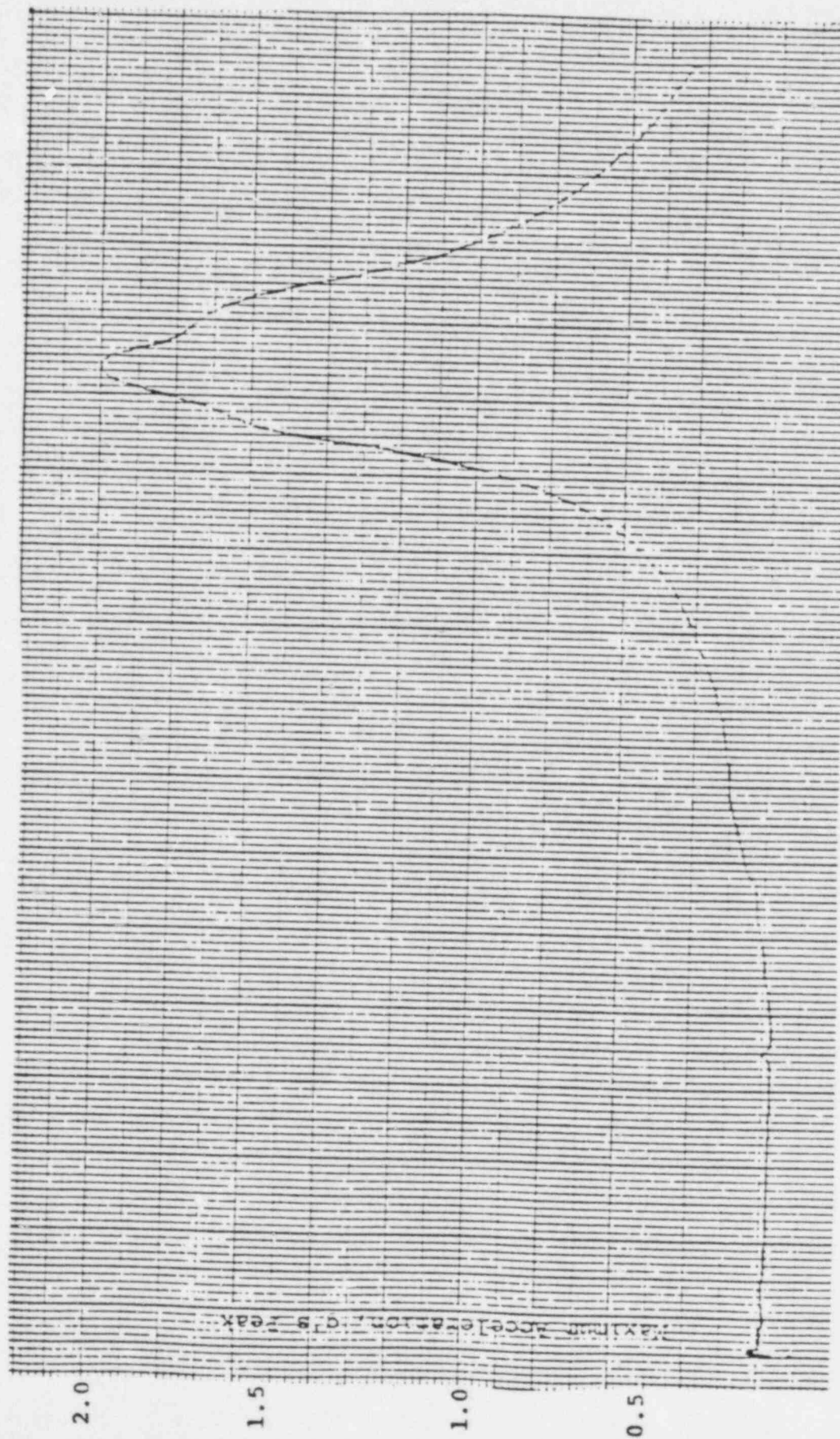
Frequency, Hz

10.0
0-81-71-805-620S

Resonance Survey, 10-Card Configuration, Z Axis



Resonance Survey, 10-Card Configuration, Y Axis



0-81-21-805-120S
Frequency, Hz

Resonance Survey, 10-Card Configuration, 7 Axis

Data For Oscillograph All Records

- 1) Channel Correlation: (Right to left from bottom of each page)

 | | | | | | |
 TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8

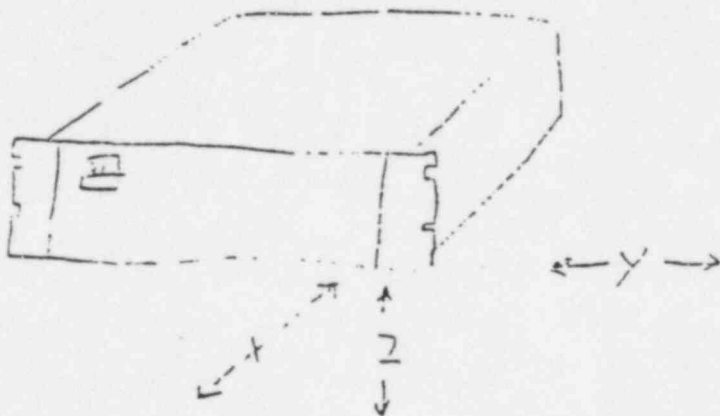
- 2) Strip Chart Rate: 1/2 inch per second
- 3) OBE and DSE (SSE) beginning of runs indicated on the data sheets
- 4) Time progression from bottom of each sheet to the top

11.0 Laboratory Data Logs

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SOUTHWEST RESEARCH INSTITUTE
LABORATORY DATA LOG

TEST ITEM IDEN. PLUG IN INST. 144 717 PAGE 1 OF
TEST PROCEDURE REF. 1001-5774 10-21-71 PROJECT NO: 02-5774-111
TEST NAME VIBRATION TEST

Date	Time	Observations
11-1-71	0930	 PLUG-IN CASE WITH 5 CARDS INSTALLED MOUNTED ON TURN TABLE SHAKER FOR VIBRATION IN X-Z DIRECTIONS MINIATURE ACCEL MOUNTED ON TURN TABLE X AXIS
	0935	START RESONANCE SEARCH 1-3500 0.2 DECADES / MIN Y AXIS
	0949	COMPLETE RESONANCE SEARCH Y AXIS NO SIGNATURES FOUND
	1010	START RESONANCE SEARCH 1-3500 0.2 DECADES / MIN Z AXIS
	1022	COMPLETE RESONANCE SEARCH Z AXIS ONE RESONANCE AT 27 HZ

Test Conducted by: _____

Witness: SwRI Gov't

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SOUTHWEST RESEARCH INSTITUTE LABORATORY DATA LOG

TEST ITEM IDEN. _____ PAGE 2 OF _____
 TEST PROCEDURE REF. _____ PROJECT NO: _____
 TEST NAME _____

Date	Time	Observations
11-15-76	1437	START RESONANCE SEARCH Y AXIS MONITOR ON RT SIDE AT THRESHOLD BASS
	1444	COMPLETE R.S. NO RESONANCE FOUND
	1510	CAGE NOW HAS 10 CARS INSTALLED
	1512	START RESONANCE SEARCH Y AXIS
	1522	COMPLETE R.S. NO RESONANCE FOUND
	1548	START RESONANCE SEARCH Z AXIS
	1551	COMPLETE R.S. RESONANCE AT 27 HZ
	1623	START RESONANCE SEARCH X AXIS
	1637	COMPLETE R.S. NO RESONANCE FOUND
11-17-76	1407	RAN SSE X-Z GE (5 CARS) ALL NORMAL
	1342	RAN OBE X-Z GE ALL NORMAL
	1352	RAN OBE X-Z GE ALL NORMAL
	1405	RAN OBE X-Z GE ALL NORMAL
	1407	RAN OBE X-Z GE ALL NORMAL
	1411	RAN OBE X-Z GE ALL NORMAL
	1415	FOUND 2 SCREWS ON LEFT SIDE LOWER THRESHOLD BTH
	1449	RAN SSE Y-Z GE ALL NORMAL
	1452	RAN OBE Y-Z GE ALL NORMAL
	1456	RAN OBE Y-Z GE ALL NORMAL
	1459	RAN OBE Y-Z GE ALL NORMAL
	1503	RAN OBE Y-Z GE ALL NORMAL
	1516	RAN OBE Y-Z GE ALL NORMAL

Test Conducted by: _____

Witness: SwRI Gov't

SUB-STANDARD
 ORIGINAL
 NOT SUITABLE FOR
 LEGIBLE REPRODUCTION
 CONTACT

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SOUTHWEST RESEARCH INSTITUTE
LABORATORY DATA LOG

TEST ITEM IDEN. _____ PAGE 3 OF _____
 TEST PROCEDURE REF. _____ PROJECT NO: _____
 TEST NAME _____

Date	Time	Observations		
11-13-76	0800	RAN SCS Y-Z	10 CARD	ALL NORMAL
	0805	RAN CBE Y-Z	10 CARD	ALL NORMAL
	0837	RAN CBE Y-Z	10 CARD	ALL NORMAL
	0841	RAN CBE Y-Z	10 CARD	ALL NORMAL
	0845	RAN CBE Y-Z	10 CARD	ALL NORMAL
	0850	RAN CBE Y-Z	10 CARD	ALL NORMAL
	0917	RAN SCS X-Z	10 CARD	ALL NORMAL
	0918	RAN CBE X-Z	10 CARD	ALL NORMAL
	0919	RAN CBE X-Z	10 CARD	ALL NORMAL
	0924	RAN CBE X-Z	10 CARD	ALL NORMAL
	0927	RAN CBE X-Z	10 CARD	ALL NORMAL
	0932	RAN CBE X-Z	10 CARD	ALL NORMAL
SUB-STANDARD FOR LEG ACTION				

Test Conducted by: _____

Witness: SwRI Gov't

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