LEAM DYNAMIC ANALYSIS FLIGHT MODEL

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CONTENTS

1.0 INTRODUCTION AND SUMMARY

This ATM gives the results of the dynamic analysis on the LEAM Flight Model Experiment Package. The DVT model dynamic analysis and testing results were presented in ATM 1022, Reference 1. A comparison of the flight model hardware and DVT model hardware is made with the conclusion that the DVT model analysis results weill apply as well to the flight model within the correlation accuracy that can usually be expected between dynamic response calculations and test results.

As stated in Reference 1, the response levels at various locations throughout the structure are fairly high as might be expected since it is a stiff structure with few riveted or bolted joints, and the input levels are fairly high, i.e., on the order of 8 to 12 g--rms. However, the Up and East Sensor films in the DVT model have survived these environments with few film perforations, and it is expected that the actual Subpack 2 environment for the LEAM Flight Model will be somewhat less than the input levels used for Launch and Boost. The latter statement is based upon recent engineering test model vibration measurements made on Subpack 2.

The additional consideration is made here for providing small rubber isolators in the mount locations of the Up and East Sensors since these sub-packages contain the films. As expected the high frequency random vibration response of the packages is greatly diminished, but the low frequency sine response is increased. Thus more space would be required than presently exists for these two sub-packages if such an arrangement is to be used.

2.0 FLIGHT MODEL COMPARISON WITH THE DVT MODEL

Consideration of the hardware differences between the DVT model and flight model reveals that the principal difference is in the interface brackets. A fiberglass continuous structure is used on the Flight Model in place of the titanium tabs used for attachment of the DVT Model to the ALSEP structure or to the vibration fixture.

The EI or stiffness of the fiberglass attachment tabs is 40% higher in value than the titanium brackets on the DVT model, and this stiffness is the one which will most affect the lowest natural frequencies of the LEAM package. The frequencies are proportional to the square root of the stiffness ratio indicating that the lowest natural frequencies will be increased about 20% over the DVT model lowest natural frequencies.

The computed results of the DVT model proved to be about 20% higher in frequencies of resonsance at the lower end than measured values; therefore those caluculations will apply to the flight model even more closely than they do to the DVT model. As a result, the basic structural model was not changed for the response calculations, and the response curves of Reference 1 are considered valid for the flight model as presently established.

The computed random responses of Reference 1 for the Up and East Sensors have indicated high levels, and a proposed method of alleviating these levels is to insert rubber grommet isolators at the four attachment corners of each of these sensors. The computed results with this arrangement are included in this report.

The flight configuration is shown in Figures 1 and 2, and the location of the grommets is shown in Figure 2 for some of the Up and East sensors attachment points. The weight summary of the LEAM package is given in Table 1. The rubber grommet design is shown in Figure 3. Computed values of stiffness for these grommets are 600 lb/in in the axial direction and 310 lb/in in any lateral direction. The objective was to lower the sensor package resonance down to about 100 Hz in the direction perpendicular to the film planes. The design of Figure 2 proved to be effective for the Up sensor, but would require a stiffer rubber for the East sensor. This is shown in the response curves further on in Section 4.0.

3.0 METHOD OF ANALYSIS

The method of analysis used here was to add the flexibilities of the rubber mounts to the DVT model flexibilities originally obtained from the EASE structural analysis runs. This flexibility matrix was then used in the DYNLOAD (Reference 2) dynamics analysis program as in Reference 1. The resulting stiffness matrix is given in Appendix A along with the mass matrix.

LEAM STOWED [illegible]KAGE

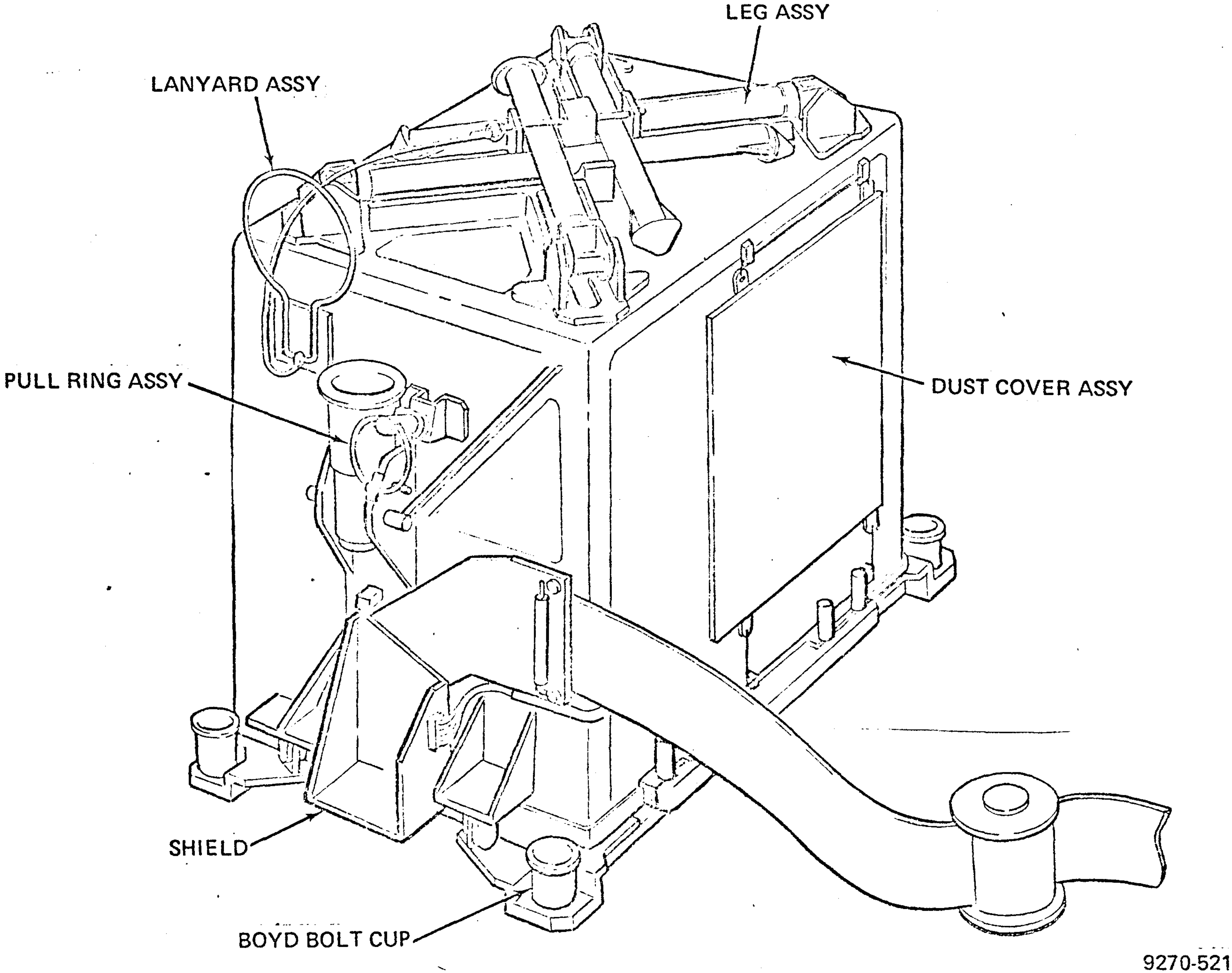


FIGURE 1

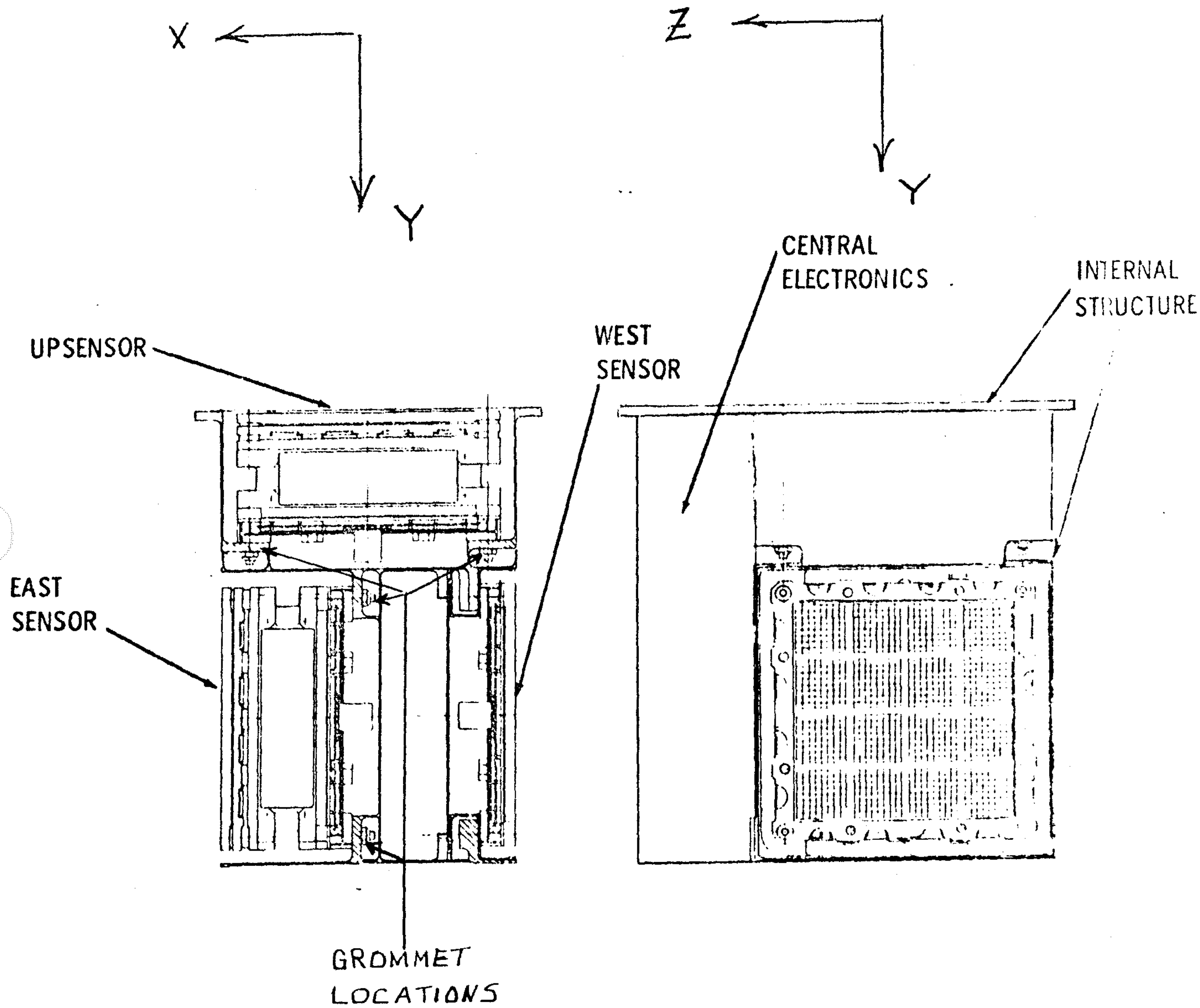


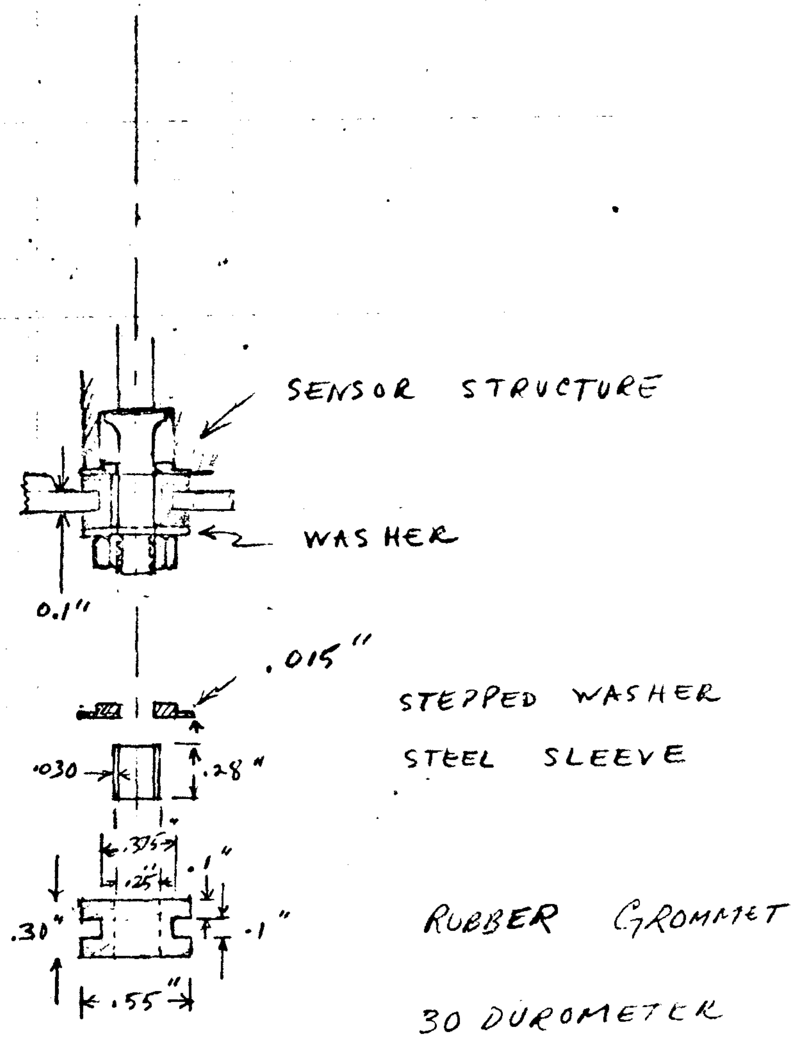
FIGURE 2 LEAM INTERNAL VIEWS

TABLE I
LEAM WEIGHT SUMMARY

WEST SENSOR	1.05 lbs.
EAST SENSOR	2.13
UP SENSOR	2.11
CENTRAL ELECTRONICS	3.25
INTERNAL STRUCTURE ASSY AND SHIELD	2.13
CABLE AND ASTROMATE CONN. ASSY.	1.30
THERMAL BAG AND MASKING	.69
OUTER HOUSING ASSY.	1.31
LEG ASSEMLBIES AND RELEASE	.60
BUBBLE LEVEL	.02
GNOMON ASSY.	.02
UHT SOCKET AND RELEASE	.29
THERMAL RADIATOR ASSY.	.32
DUST COVER AND RELEASE	.18
MISC. HARDWARE	.26
LEAM TOTAL WEIGHT (INCL. ASTROMATE CONN.)	15.66 lbs.

FIGURE 3

LEAM DUAL SENSOR ISOLATOR



30 DUROMETER
GENERAL PURPOSE
SILICONE RUBBER
OR
NATURAL RUBBER
SECOND CHOICE

SEE TABLE II-B P 15
ATM-242 REV "E"

K.H.W
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4.0 COMPUTED RESPONSES AND TEST RESULTS

Computed frequency responses are presented in the form of overall response at all locations due to random excitation and in the form of detailed frequency plots at selected coordinate locations.

The coordinate locations and definitions in relation to the internal packages are shown in Table 2. The six coordinates of the c. g. motion of each of the six component packages are grouped together with the three translations being given first. These response coordinates and their locations are shown in the following table:

TABLE 2 - Coordinate Definitions

Analysis Location No.	Component Package	Analysis Coordinate	ALSEP Axis
1	Up Sensor	X_1	Y
2	Up Sensor	Y_1	X
3	Up Sensor	Z_1	Z
4	Up Sensor	ϕ_1	
5	Up Sensor	θ_1	
6	Up Sensor	ψ_1	
7	West Sensor	X_2	Y
8	West Sensor	Y_2	X
9	West Sensor	Z_2	Z
10	West Sensor	ϕ_2	
11	West Sensor	θ_2	
12	West Sensor	ψ_2	
13	Central Electronics	X_3	Y
14	Central Electronics	Y_3	X
15	Central Electronics	Z_3	Z
16	Central Electronics	ϕ_3	
17	Central Electronics	θ_3	
18	Central Electronics	ψ_3	
19	East Sensor	X_4	Y
20	East Sensor	Y_4	X
21	East Sensor	Z_4	Z
22	East Sensor	ϕ_4	
23	East Sensor	θ_4	
24	East Sensor	ψ_4	
25	Outer Case	X_5	Y
26	Outer Case	Y_5	X
27	Outer Case	Z_5	Z
28	Outer Case	ϕ_5	
29	Outer Case	θ_5	
30	Outer Case	ψ_5	

The angle definitions are ϕ - rotation about the X axis, θ- rotation about the Y axis, and ψ- rotation about the Z axis.

The input levels were again those of launch and boost and are shown in Figures 4 and 5. Three part response curves are presented in Figures 6 through 18. These figures are arranged in the same manner as the corresponding ones in ATM 1022; therefore they compare directly by number. Table 3 presents the over all g-rms responses of all the coordinate locations.

The response curves of most interest are the Figures 6, 7, and 8 for the Up sensor and Figures 16, 17 and 18 for the East sensor. The natural frequency of the subpackages perpendicular tothe film planes turned out to be about 90 Hz when coupled with the complete package dynamics. This shows up in Figures 7 and 16. In the lateral directions the frequencies are about 60 Hz as shown in Figures 6 and 8 for the Up sensor and 17 and 18 for the East sensor.

While the random overall responses are reduced considerably (from 17.5 g-rms to 8.8 g-rms as shown in Figures 7c) the sine responses are increased considerably requiring as much as 0.1 inch clearance for this motion. Also, the sine response for the East sensor in the Y direction is excessive in amplitude since it falls in the high sine input range at 60 Hz.

The responses of the other coordinate locations remained essentially the same, and the response curves of the case motion were omitted from the present set.

5.0 CONCLUSIONS

The results of this study indicate that the grommet mounting for the sensor packages would be helpful in reducing the random environment to the Up and East sensors. However, clearance space of about 0.1 inch in all directions would need to be allowed for in the structure, and the grommets would need to be somewhat stiffer than the present design of Figure 3. This could be accomplished by using a stiffer rubber of 50 to 60 durometer rather than 30. This would remove the lateral frequencies from the high sine input range of 50 to 70 Hz and place it nearer to the desired 100 Hz frequency.

6.0 REFERENCES

1. ATM 1022 LEAM Dynamic Analysis and Testing Results - DVT Model 1 October 1971.

2. BSR 3995 DYNALOAD - An Integrated Dynamics and Loads Analysis Program March 1971.

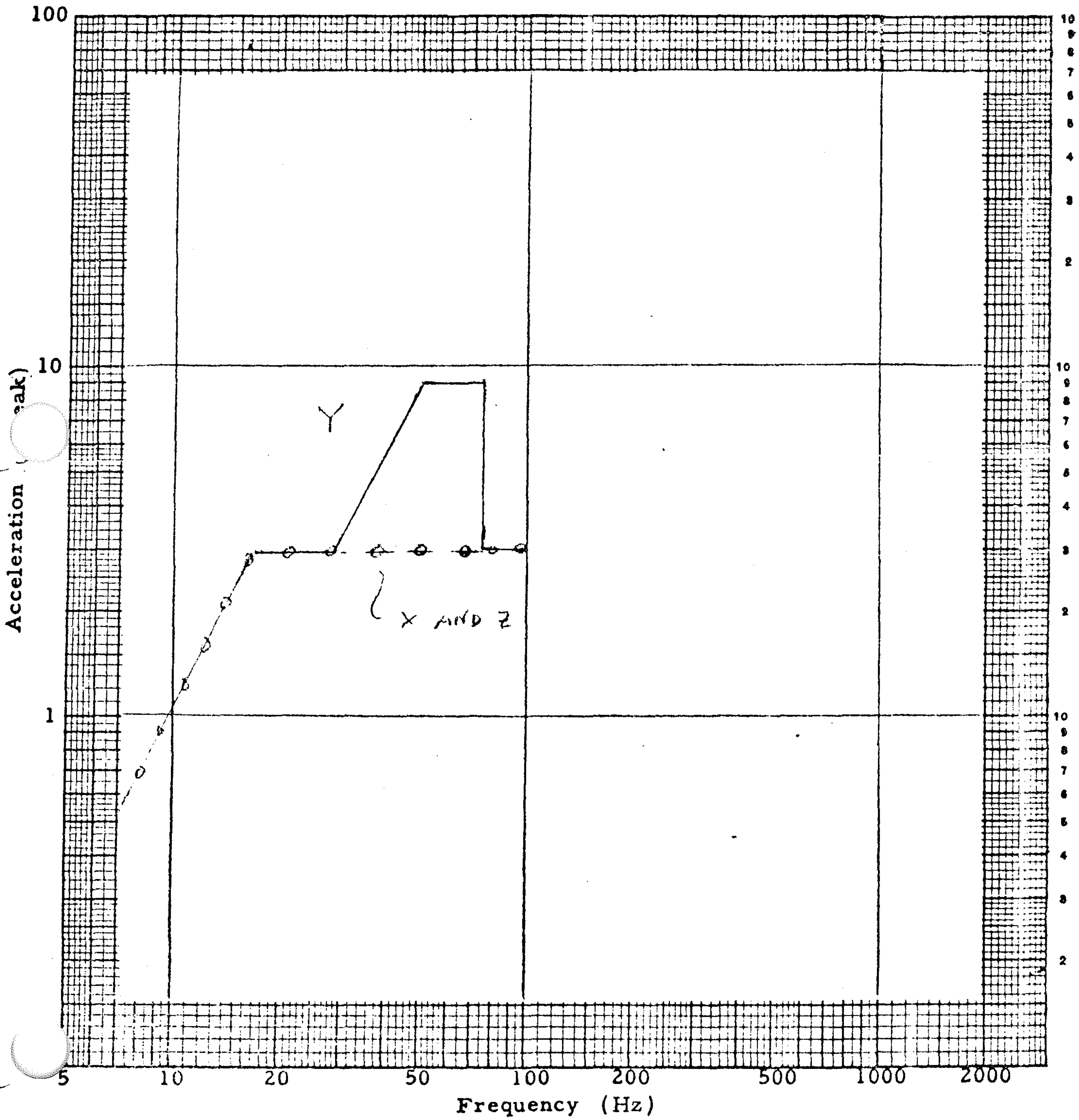
	X-AXIS			Y-AXIS		Z-AXIS	
	LOCATION	RMS RESPONSE		LOCATION	RMS RESPONSE	LOCATION	RMS RESPONSE
UP	1	0.32828E 01	G-RMS	1	0.28391E 00	1	0.91747E-01
	2	0.31327E 00	"	2	0.88076E 01	2	0.25855E 00
	3	0.79804E-01	"	3	0.48055E 00	3	0.28389E 01
	4	0.21381E 00	G-RMS/IN	4	0.13476E 01	4	0.16268E 01
	5	0.33441E-01	"	5	0.16489E-01	5	0.19730E-01
	6	0.17190E 01	"	6	0.74150E 00	6	0.20504E 00
WEST	7	0.71311E 01		7	0.89663E 01	7	0.47837E 01
	8	0.10626E 02		8	0.15123E 02	8	0.10144E 02
	9	0.57208E 01		9	0.79862E 01	9	0.95435E 01
	10	0.88226E 00		10	0.44056E 01	10	0.30505E 01
	11	0.35576E 01		11	0.77760E 00	11	0.15327E 01
	12	0.36614E 01		12	0.18936E 01	12	0.26825E 01
C. E.	13	0.60736E 01		13	0.30902E 01	13	0.15796E 01
	14	0.43600E 01		14	0.16677E 02	14	0.51672E 01
	15	0.17695E 01		15	0.80051E 01	15	0.10700E 02
	16	0.73692E 00		16	0.37496E 01	16	0.27509E 01
	17	0.22206E 01		17	0.45327E 01	17	0.17526E 01
	18	0.12993E 01		18	0.62823E 00	18	0.20425E 00
EAST	19	0.62373E 01		19	0.11893E 01	19	0.32379E 00
	20	0.55383E 00		20	0.70113E 01	20	0.16434E 00
	21	0.13386E 00		21	0.59927E 00	21	0.30583E 01
	22	0.64422E-01		22	0.38055E 00	22	0.33848E 00
	23	0.20421E 00		23	0.93936E 00	23	0.13752E 01
	24	0.12819E 01		24	0.21156E 01	24	0.23577E 00
OUTER C.	25	0.10423E 02		25	0.13470E 01	25	0.89790E 00
	26	0.69665E 00		26	0.24120E 02	26	0.20102E 01
	27	0.82984E 00		27	0.39416E 01	27	0.19811E 02
	28	0.15070E 00		28	0.77254E 00	28	0.39606E 01
	29	0.11534E-01		29	0.48387E-02	29	0.93104E-02
	30	0.23164E 01		30	0.26406E 00	30	0.20701E 00

TABLE 3. RMS RESPONSE VALUES

SINUSOIDAL VIBRATION

Axis:

Sweep Rate:

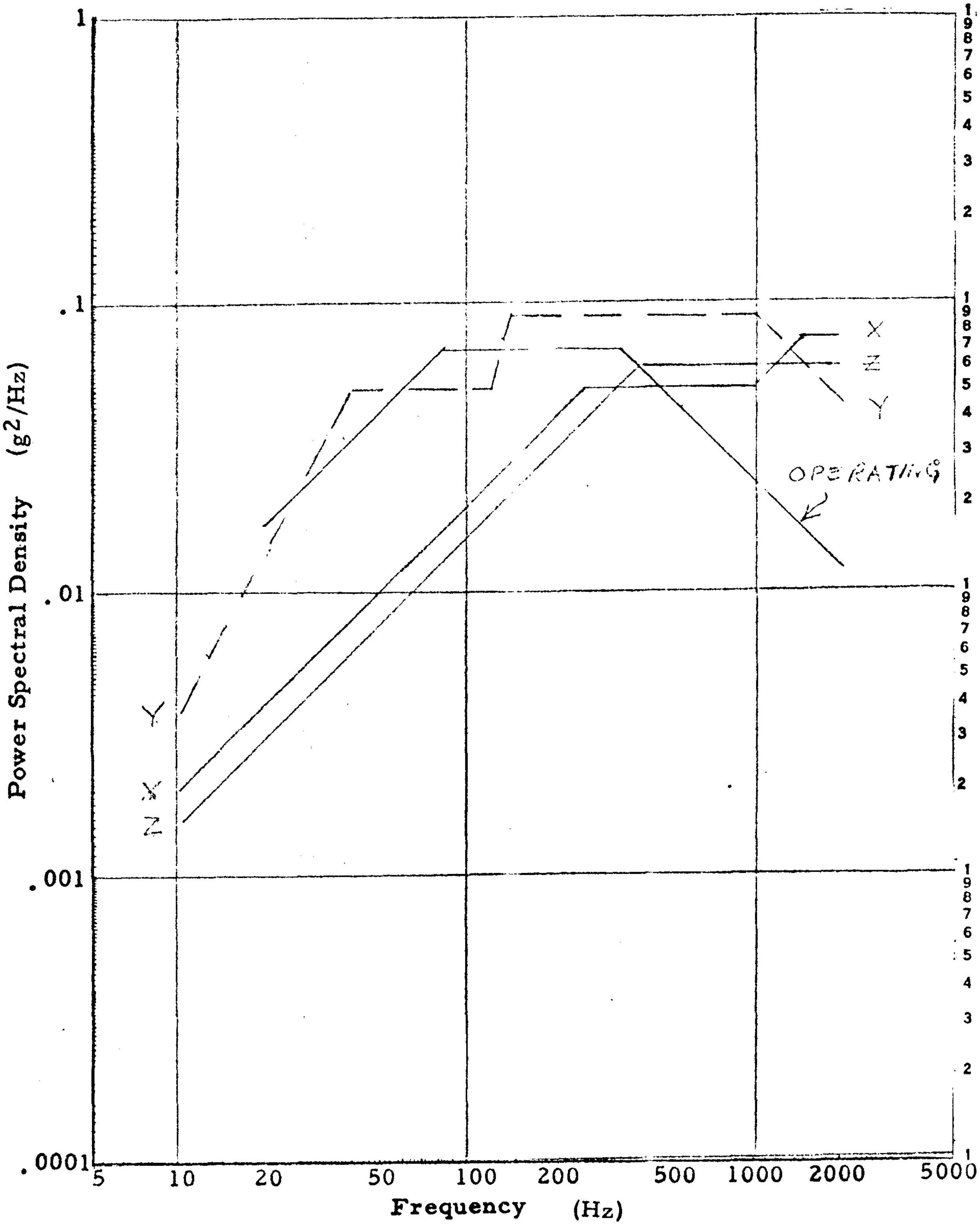


Bendix Aerospace Systems Division

Axis:

RANDOM VIBRATION SPECTRUM

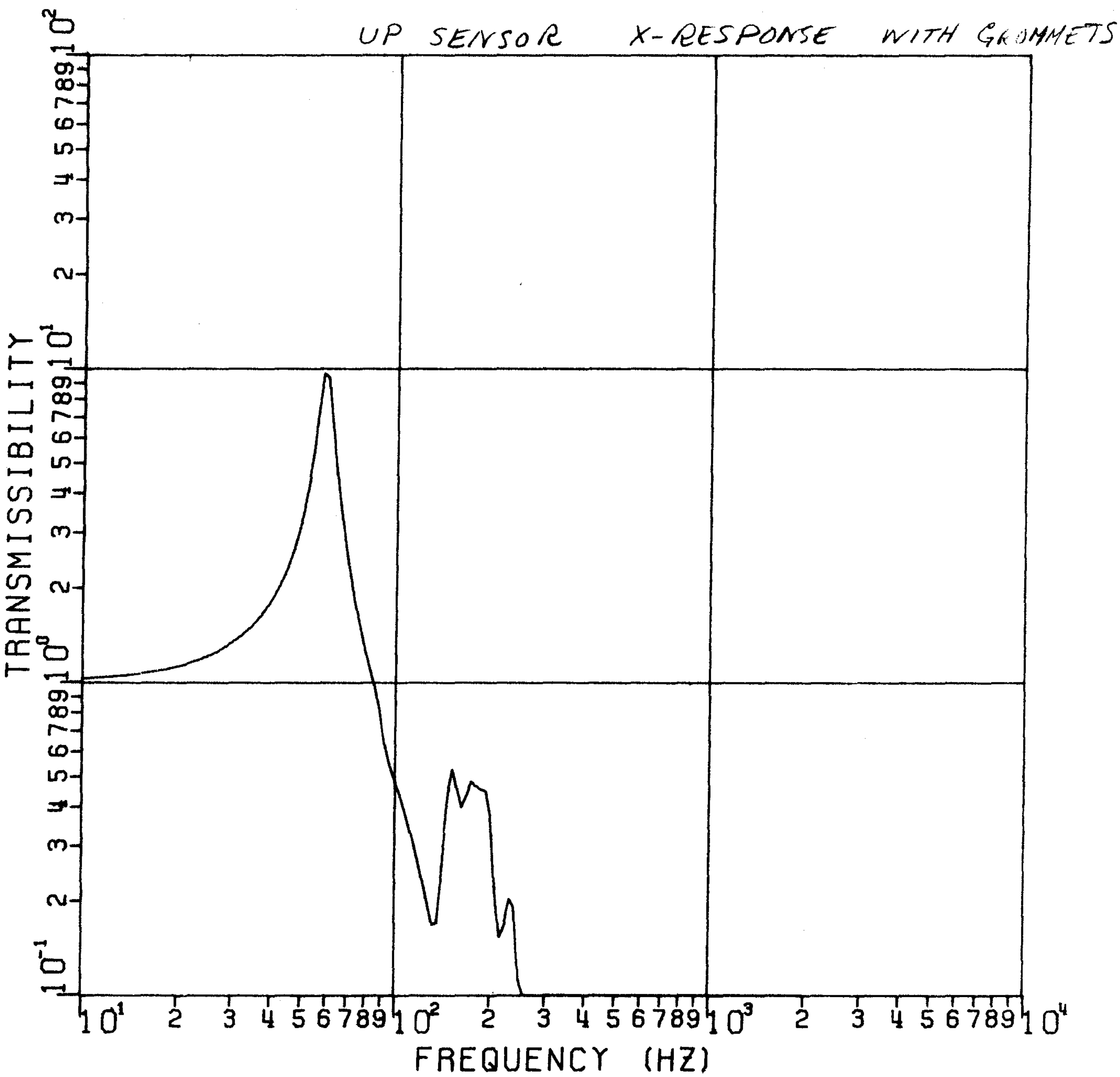
Duration:



LEAM __ FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 6 a TRANSMISSIBILITY

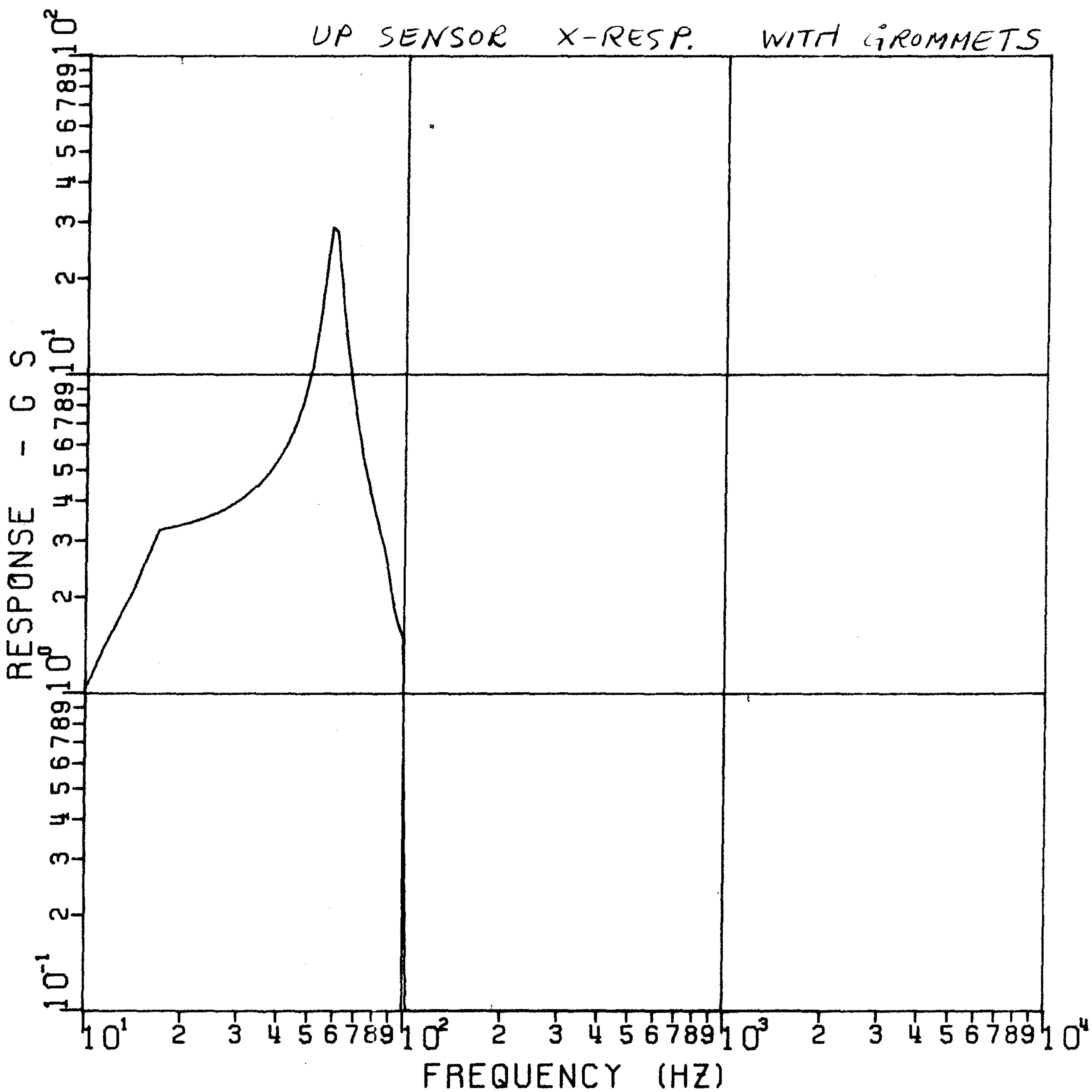
LOCATION 1



LEAM ___ FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 6 b SINE RESPONSE

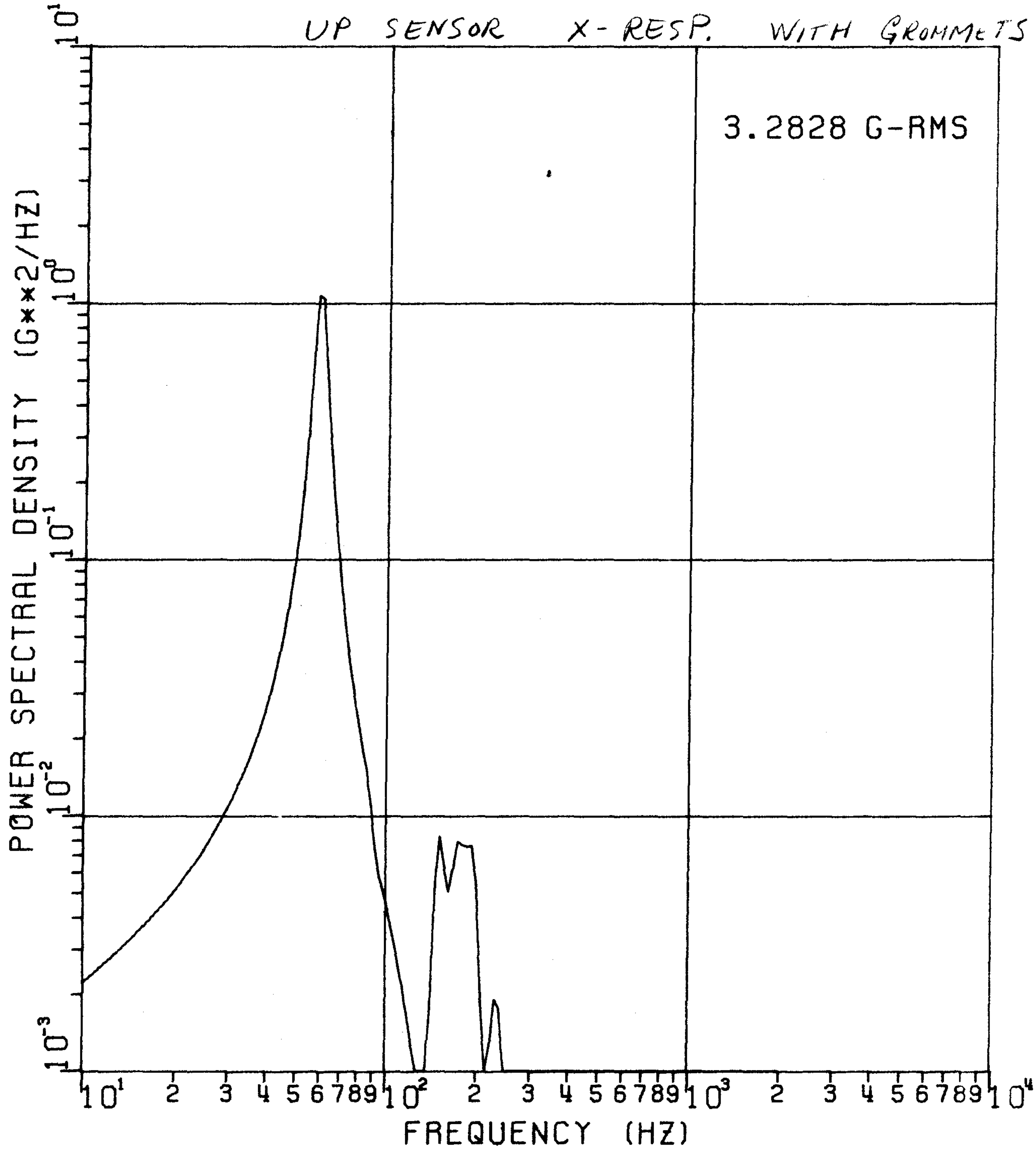
LOCATION 1



LEAM ___ FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 6 c RANDOM VIBRATION SPECTRUM

LOCATION 1

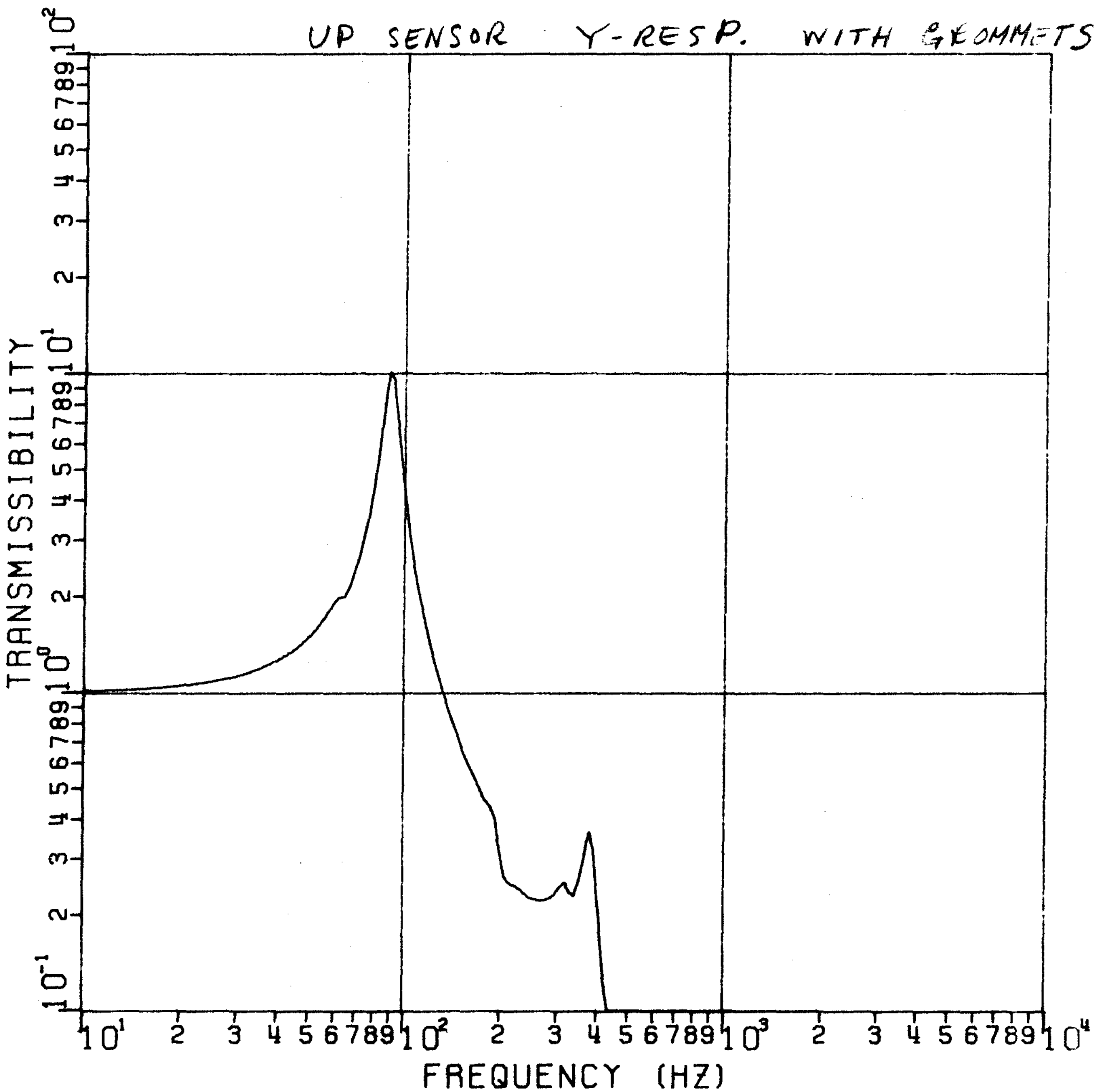


LEAM ___ FREQ. RESP.,Y-AXIS FORCING,L&B

FIGURE 7a TRANSMISSIBILITY

LOCATION 2

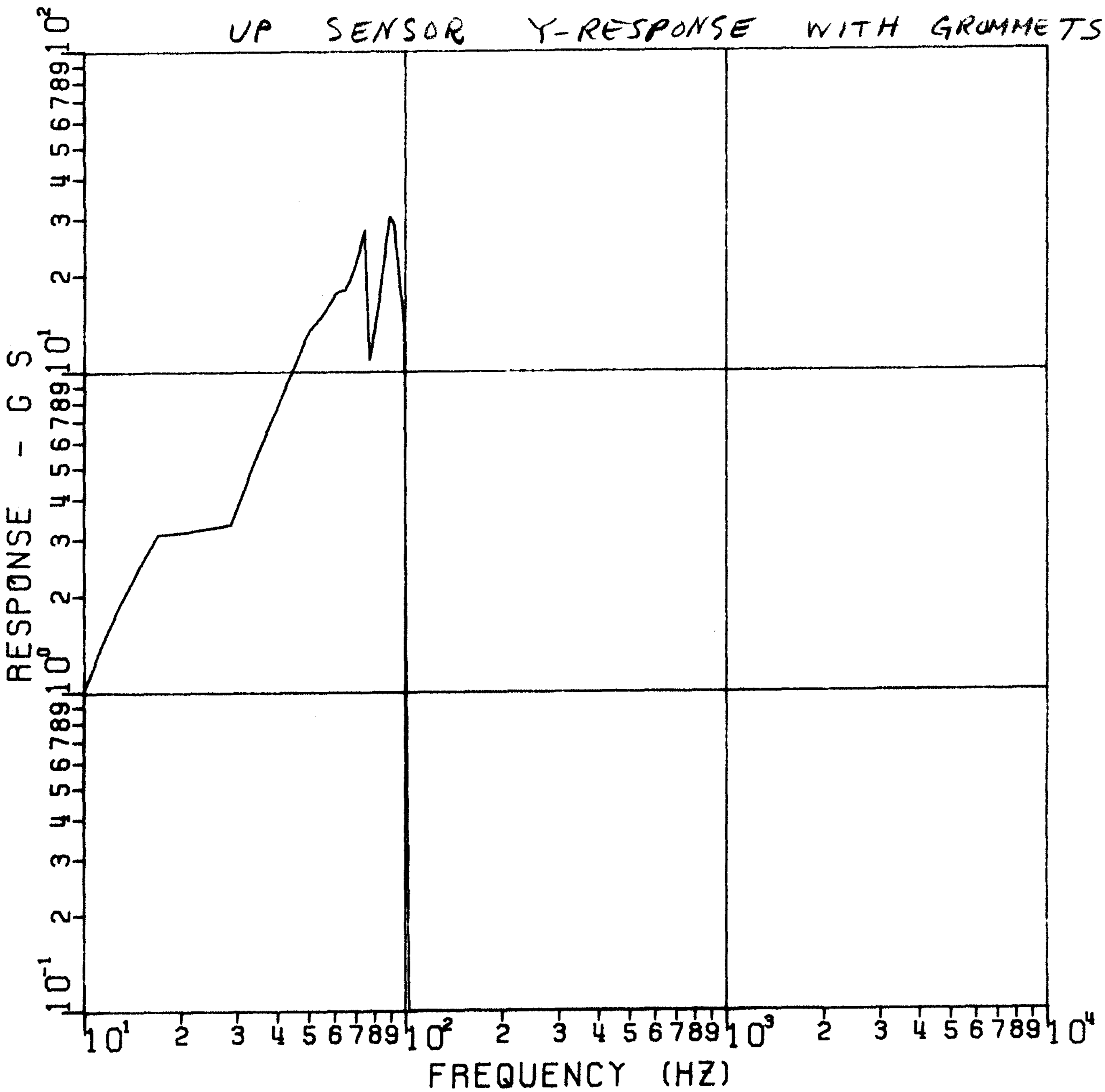
UP SENSOR Y-RESP. WITH GROMMETS



LEAM ___ FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE 7 b SINE RESPONSE

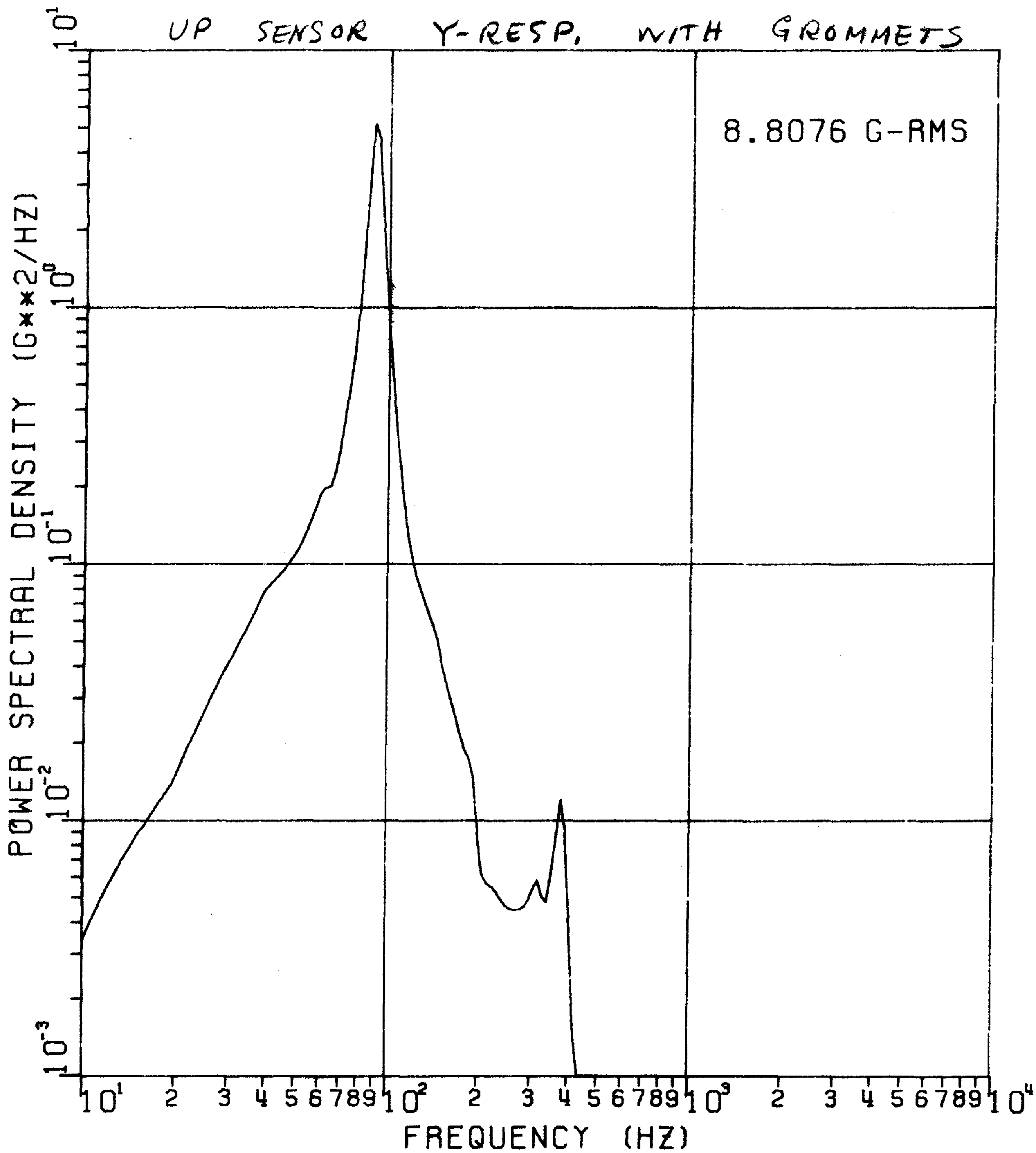
LOCATION 2



LEAM __ FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE 7c RANDOM VIBRATION SPECTRUM

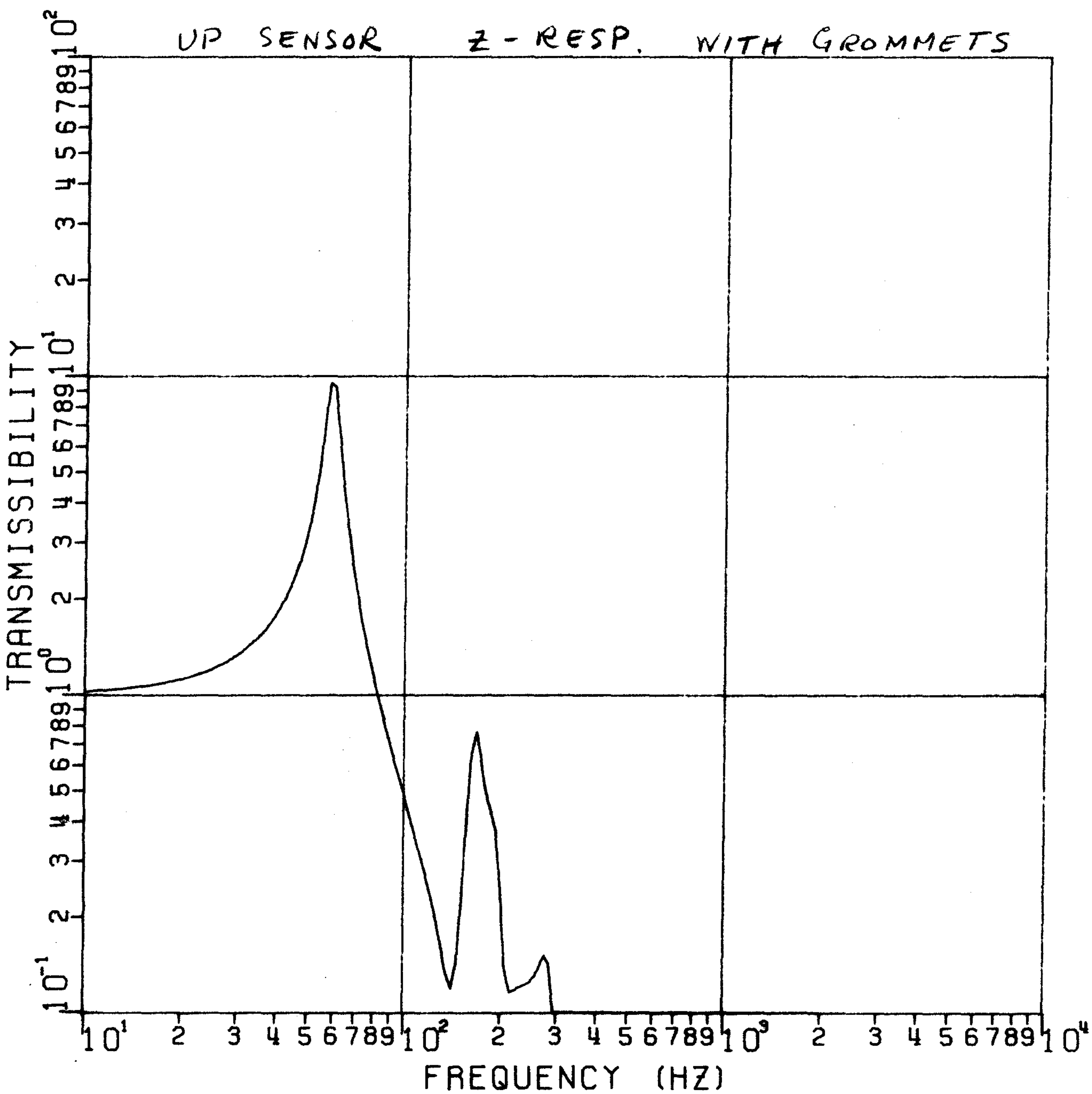
LOCATION 2



LEAM — FREQ. RESP.,Z-AXIS FØRCING,L&B

FIGURE 8a TRANSMISSIBILITY

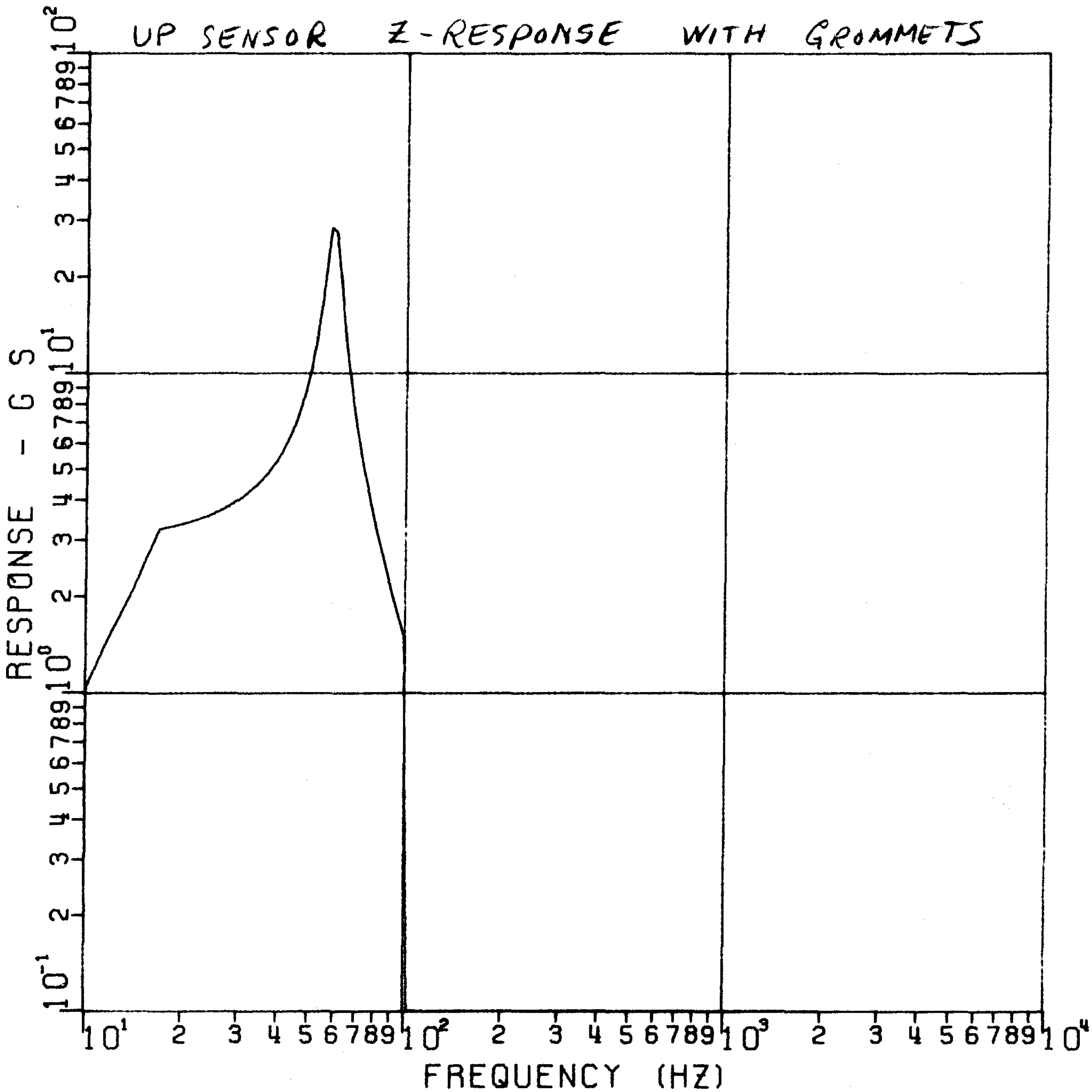
LOCATION 3



LEAM _ FREQ. RESP., Z-AXIS FORCING, L&B

FIGURE 8 b SINE RESPONSE

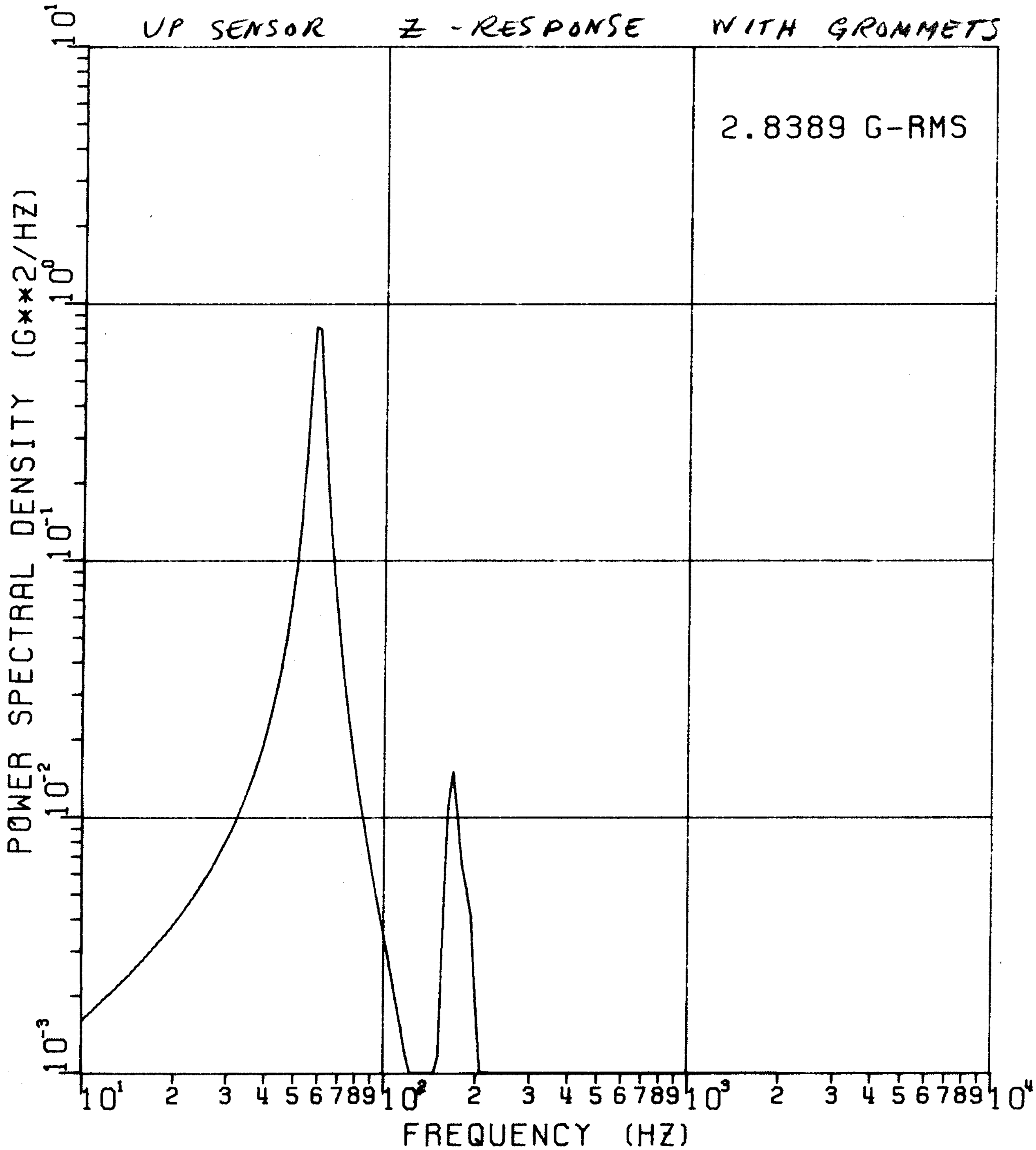
LOCATION 3



LEAM FREQ. RESP., Z-AXIS FORCING, L&B

FIGURE 8c RANDOM VIBRATION SPECTRUM

LOCATION 3

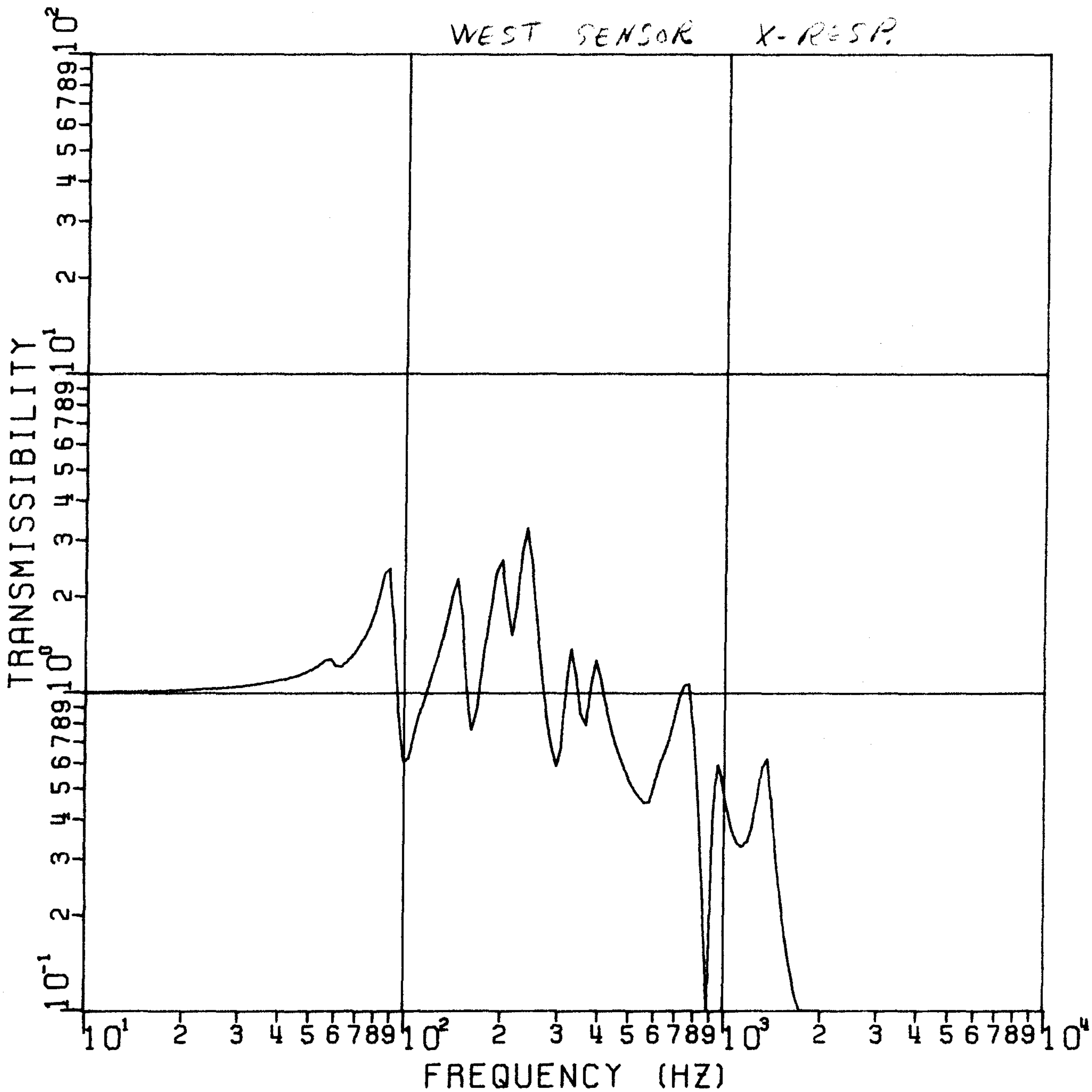


LEAM FREQ. RESP.,X-AXIS FORCING,L&B

FIGURE 9a TRANSMISSIBILITY

LOCATION 7

GROMMETS IN EAST AND UP SENSORS



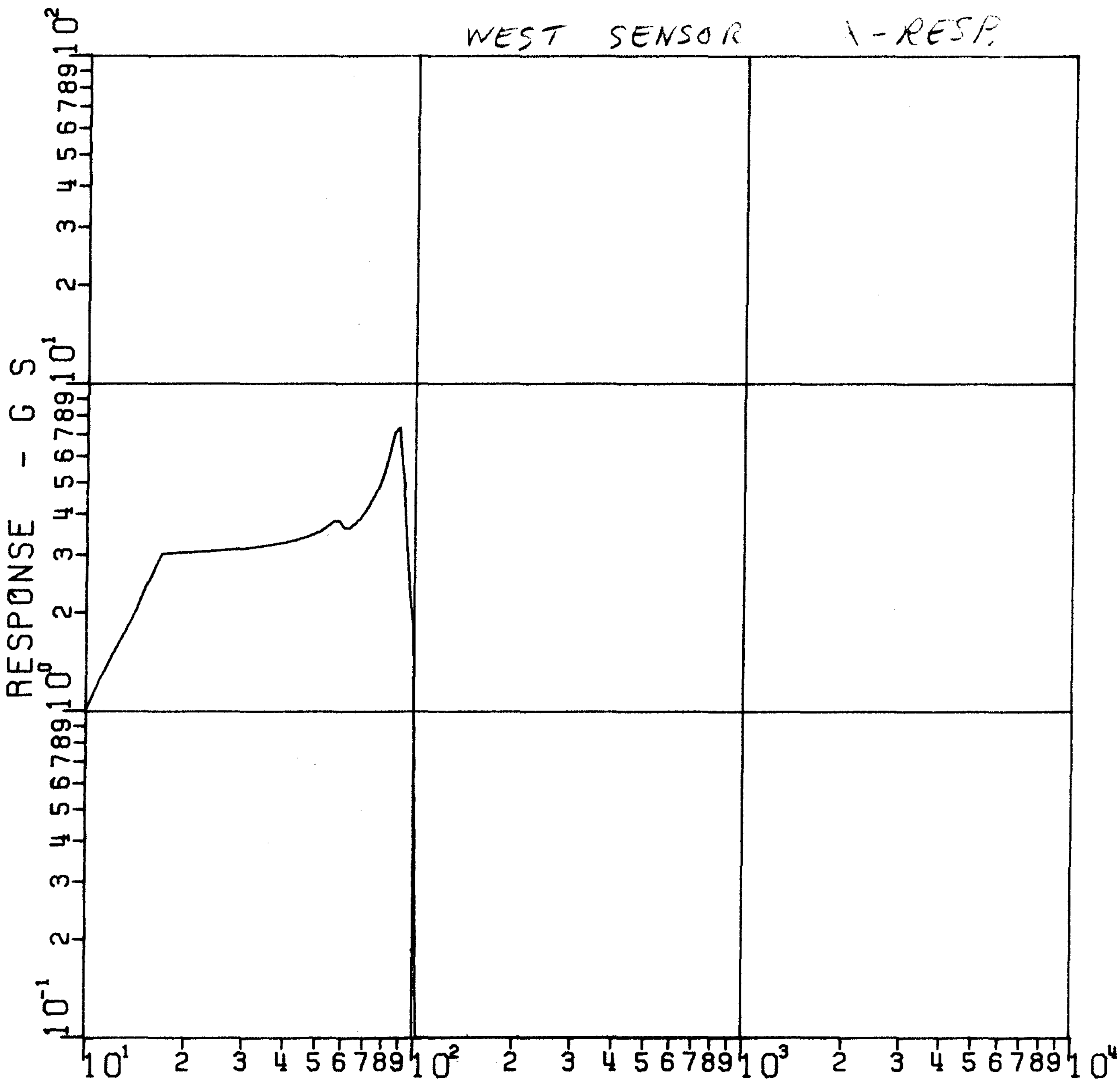
LEAM FREQ. RESP.,X-AXIS FORCING,L&B

FIGURE 9b SINE RESPONSE

GROMMETS IN UP AND EAST SENSORS

LOCATION 7

WEST SENSOR X-RESP.



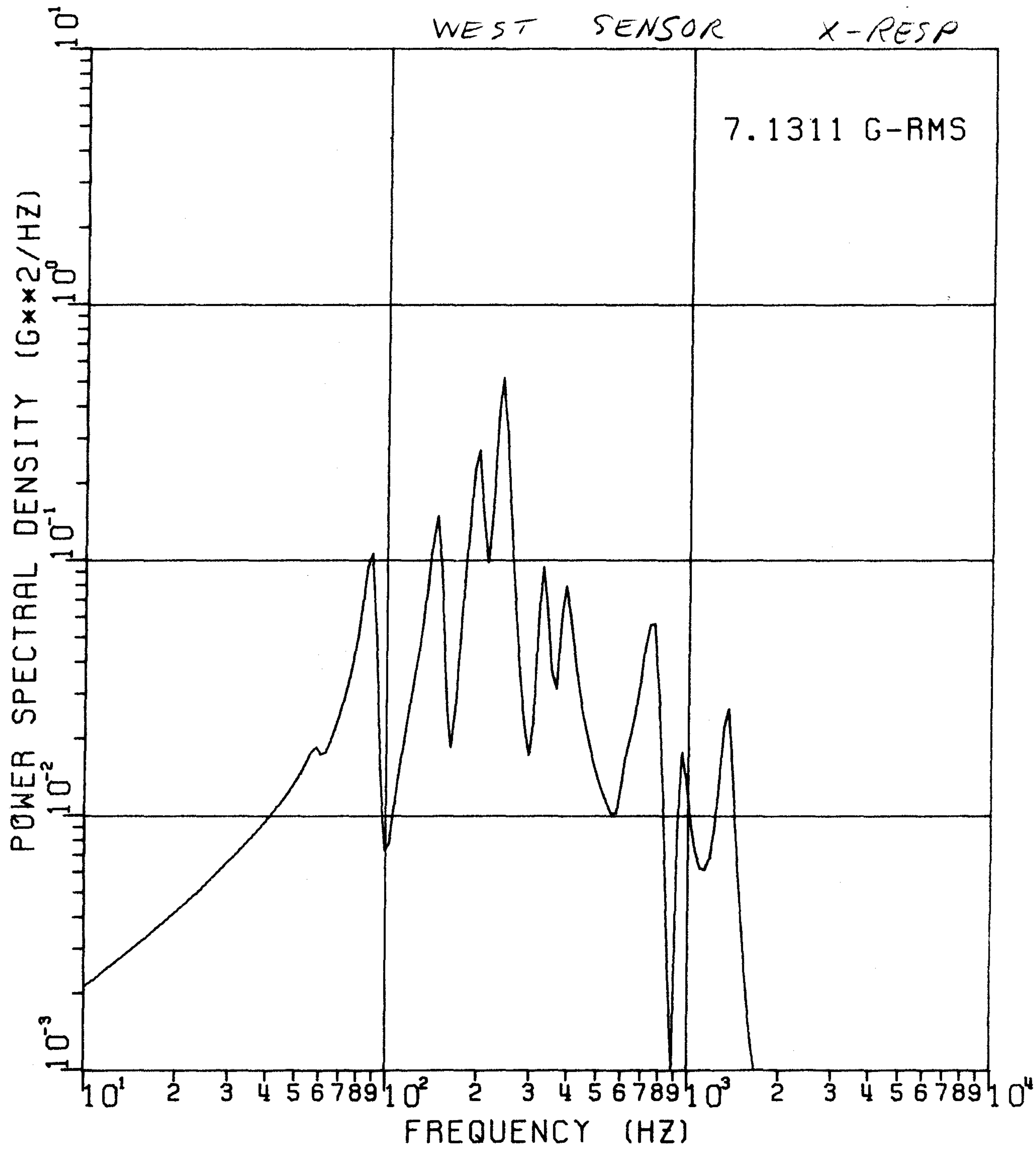
LEAM ___ FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 9c RANDOM VIBRATION SPECTRUM

LOCATION 7

GROMMETS IN UP AND EAST SENSORS

WEST SENSOR X-RESP



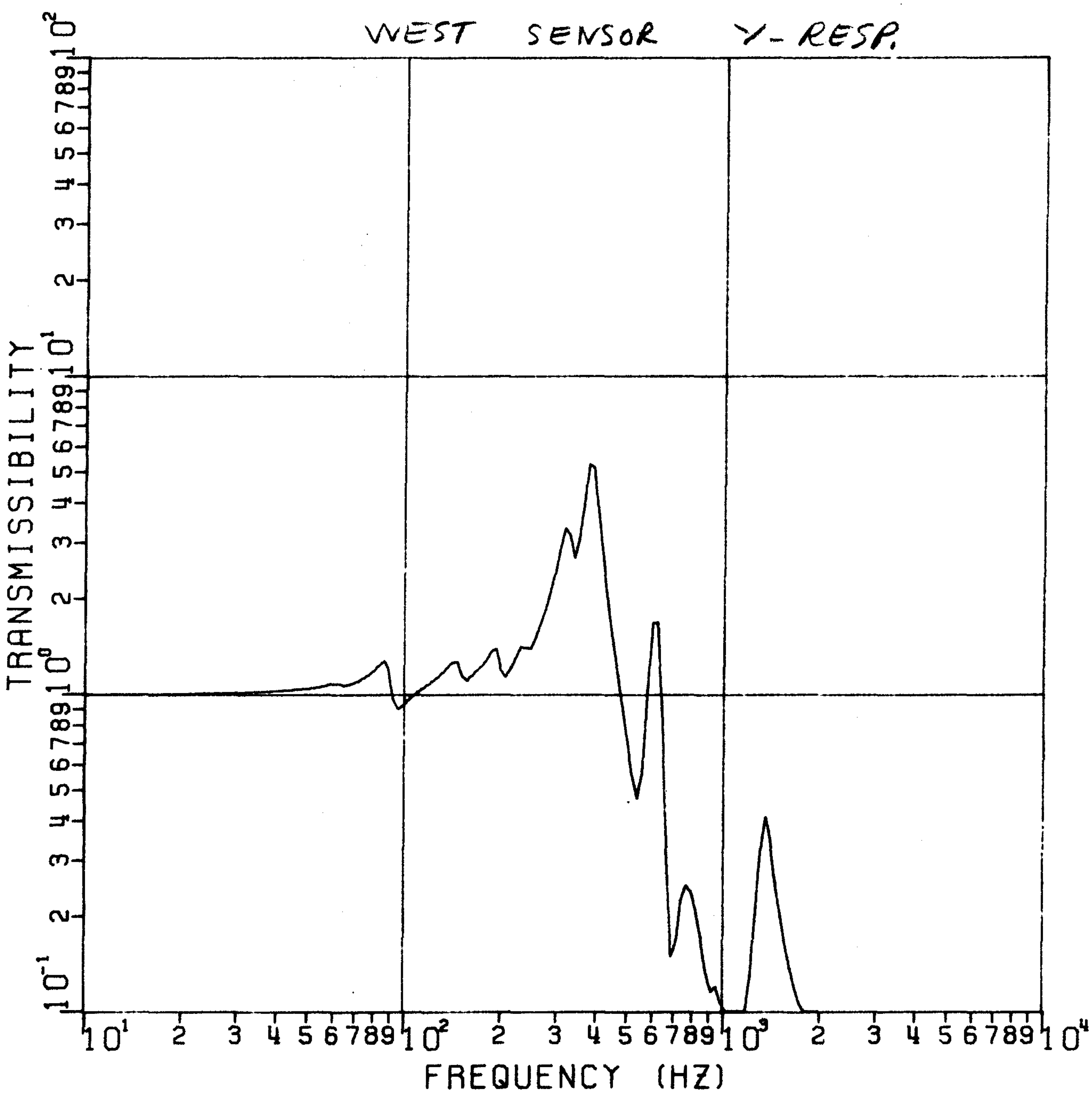
LEAM ___ FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE *10a* TRANSMISSIBILITY

GROMMETS IN UP AND EAST SENSORS

LOCATION 8

WEST SENSOR Y-RESP.



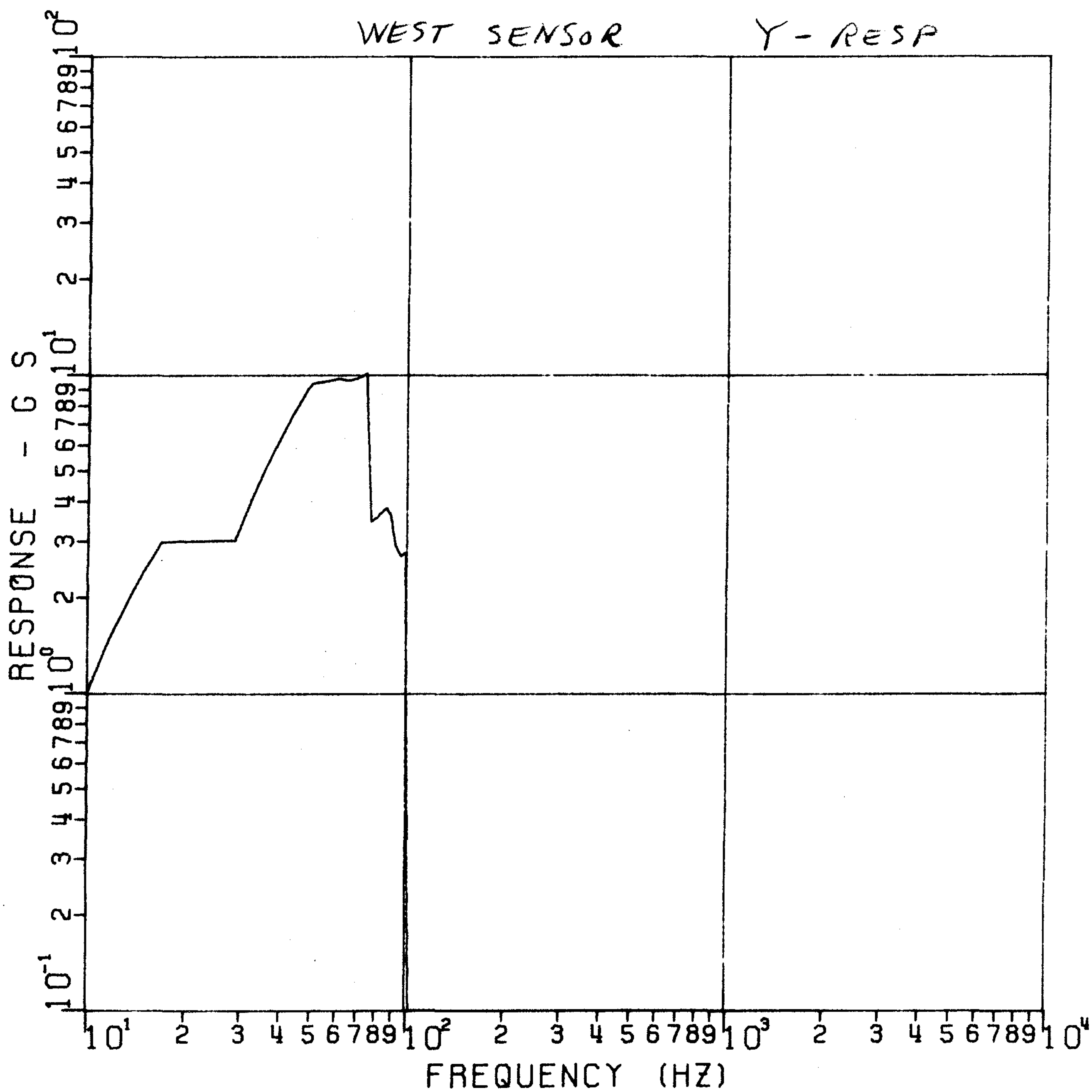
LEAM — FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE 10b SINE RESPONSE

GROMMETS IN UP AND EAST SENSORS

LOCATION 8

WEST SENSOR Y-RESP



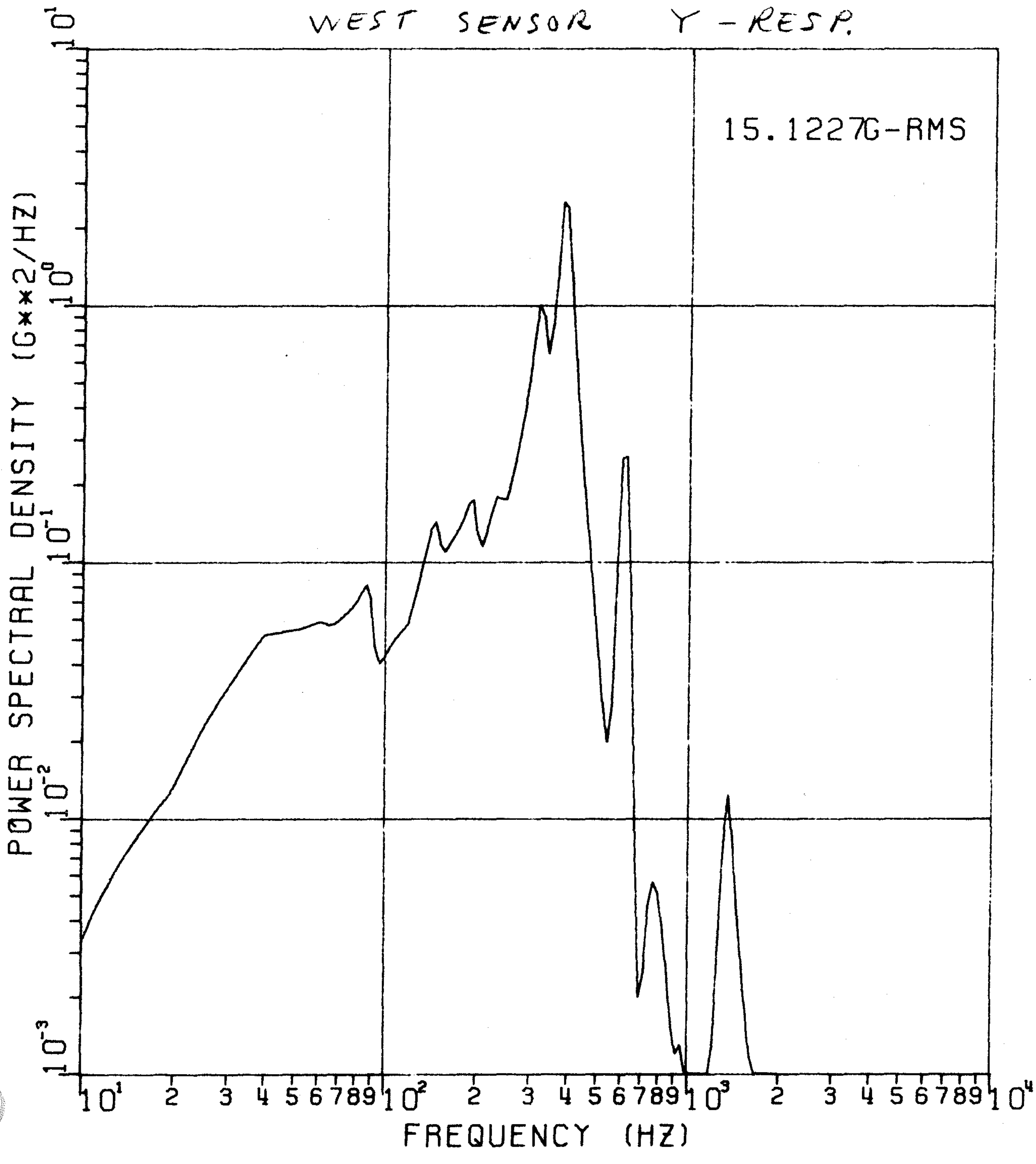
LEAM FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE 10c RANDOM VIBRATION SPECTRUM

LOCATION 8

GROMMETS IN UP AND EAST SENSORS

WEST SENSOR Y-RESP.



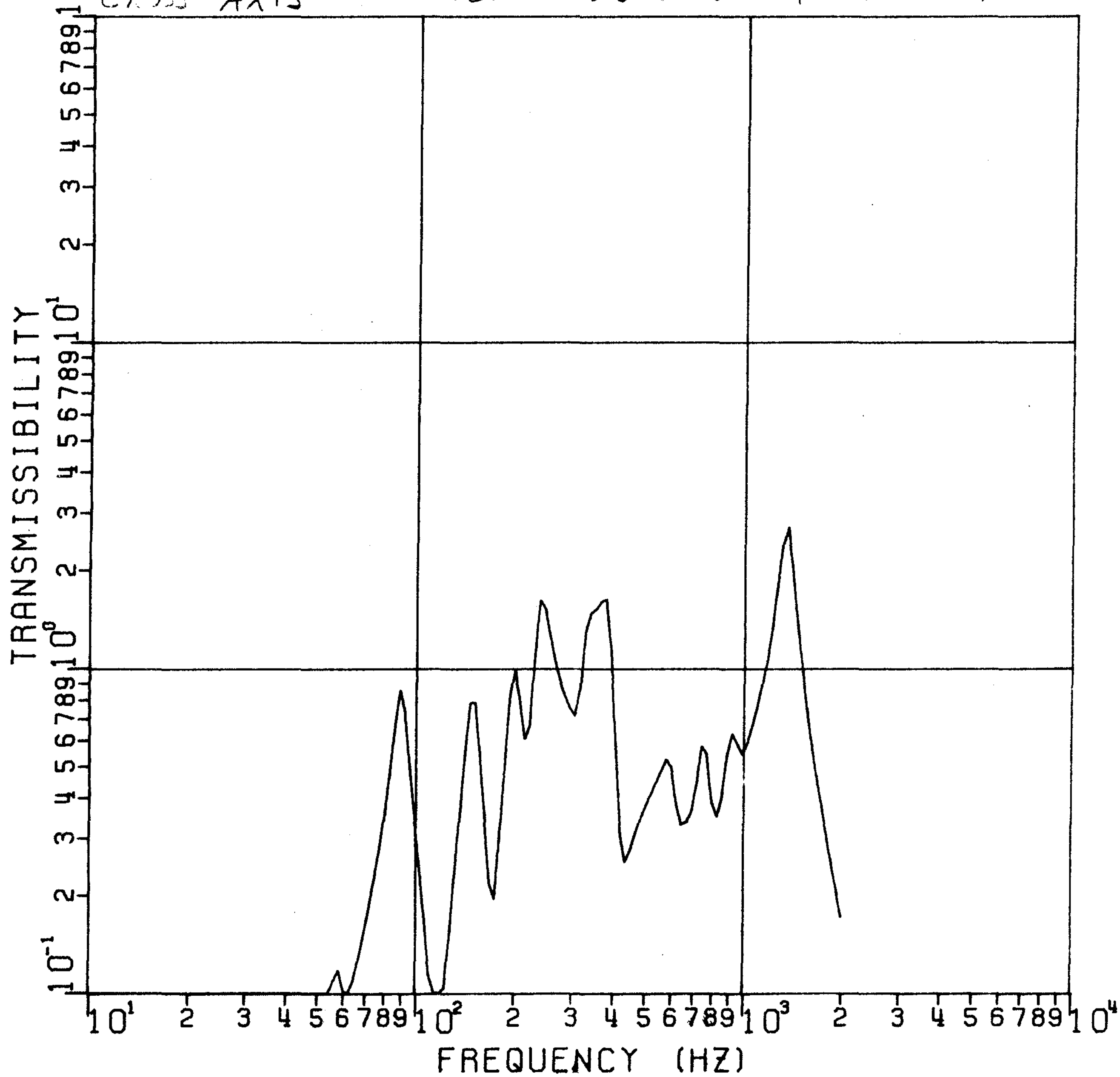
LEAM FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 11 a TRANSMISSIBILITY

LOCATION 8

GROMMETS IN UP AND EAST SENSORS

CROSS AXIS WEST SENSOR Y-RESP.

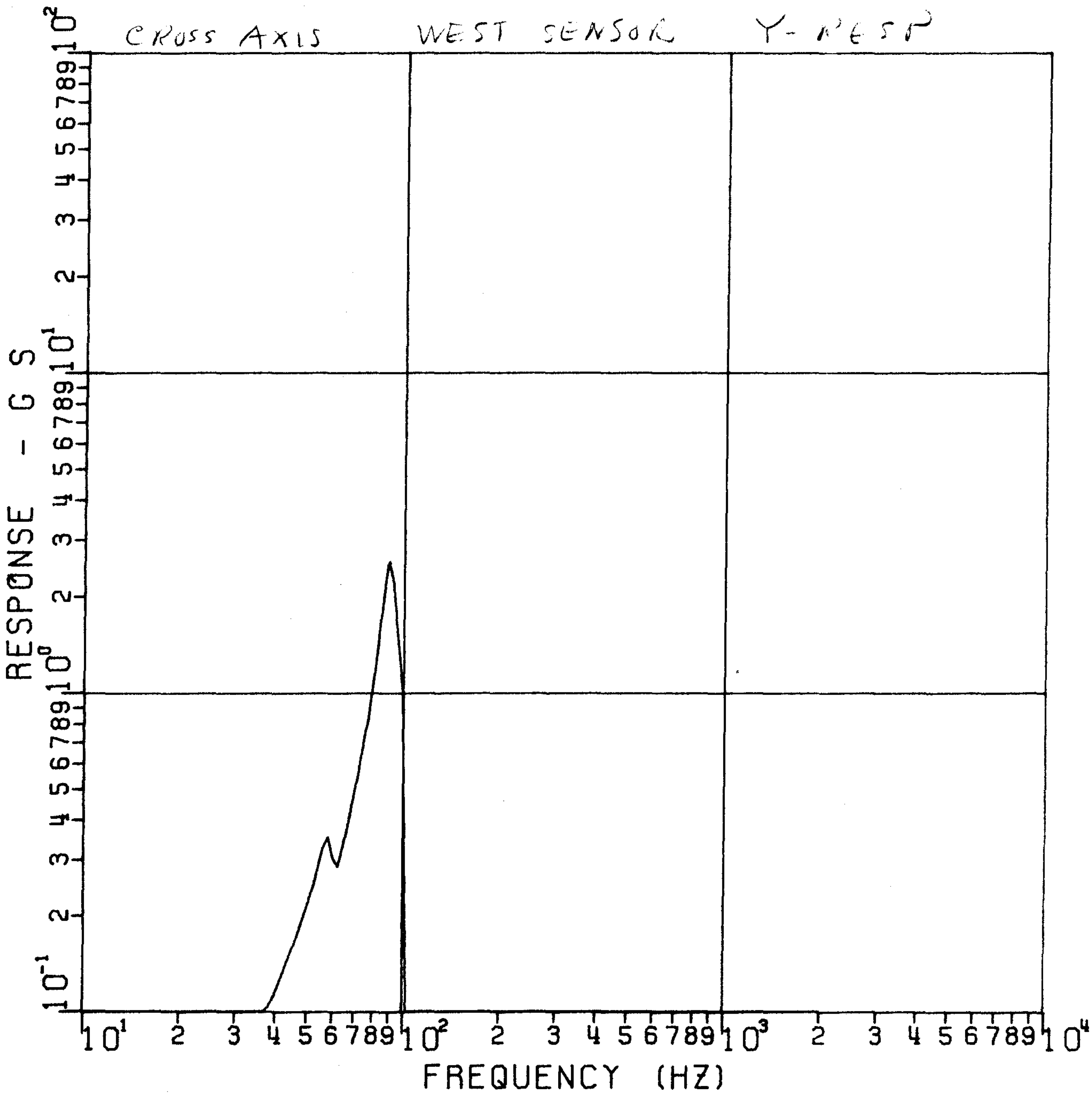


LEAM FREQ. RESP.,X-AXIS FORCING,L&B

FIGURE 11b SINE RESPONSE

GROMMETS IN UP AND EAST SENSORS

LOCATION 8

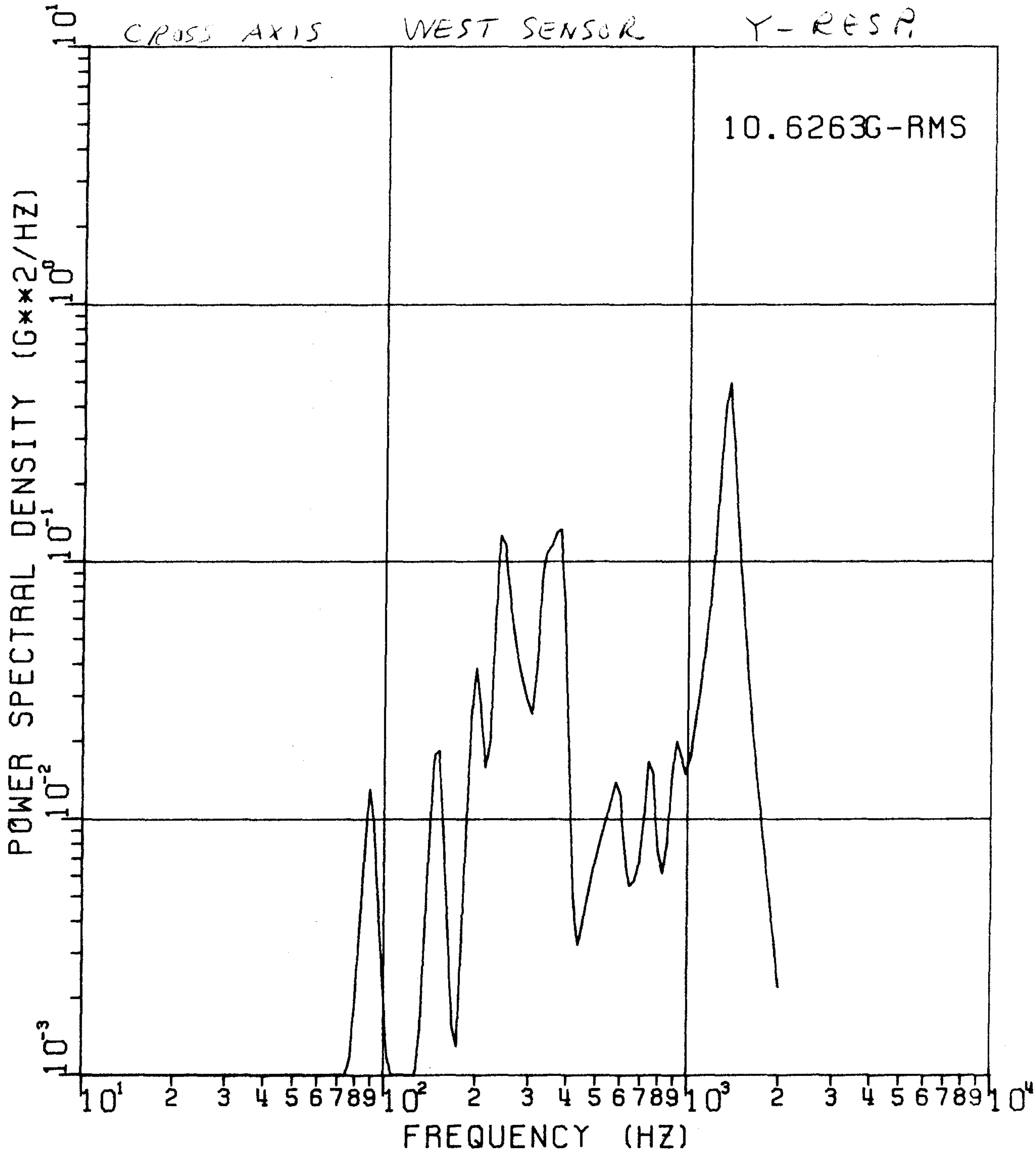


LEAM FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 11c RANDOM VIBRATION SPECTRUM

LOCATION 8

GROMMETS 11c UP AND EAST SENSORS

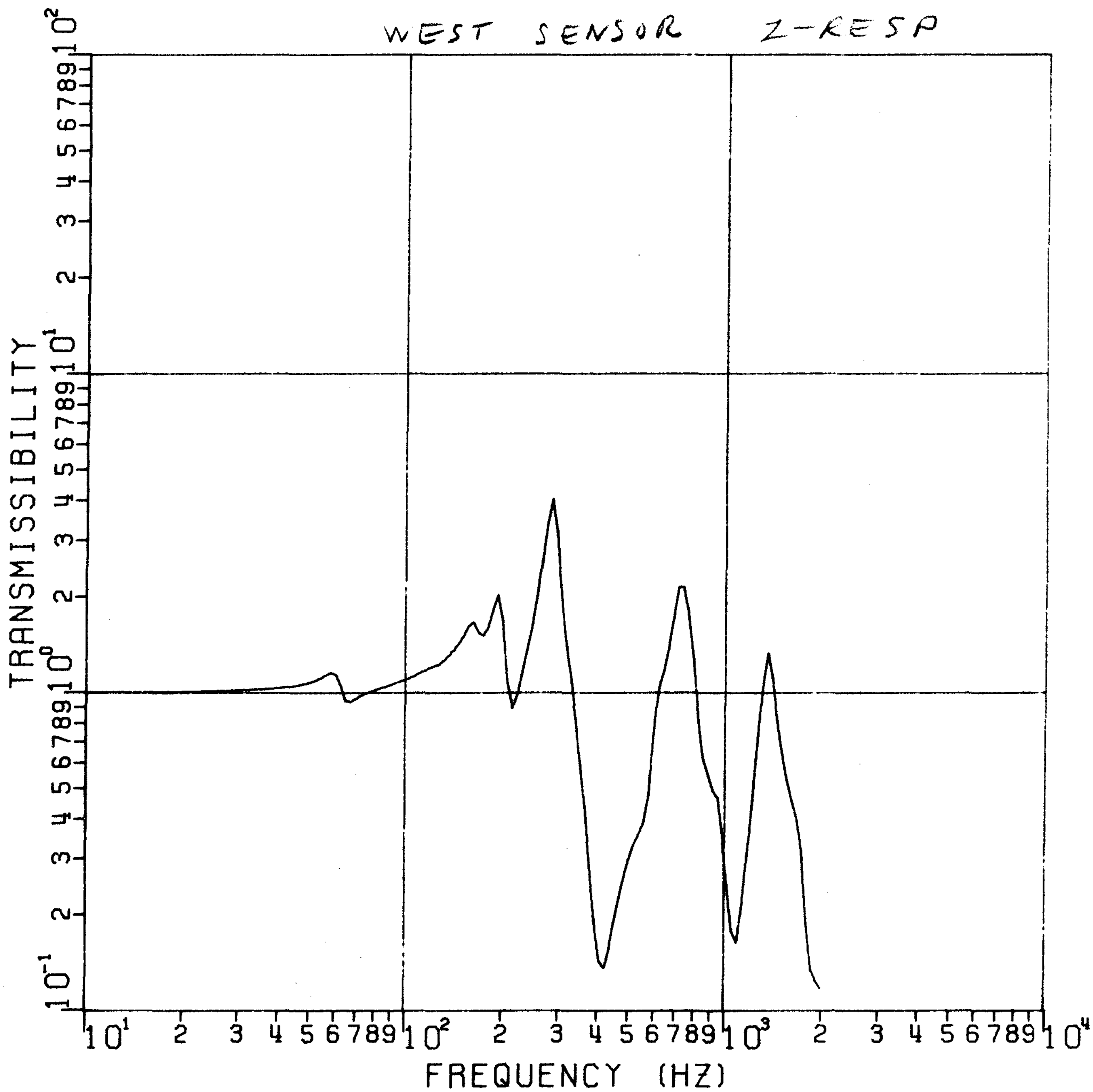


LEAM FREQ. RESP., Z-AXIS FORCING, L&B

FIGURE 12a TRANSMISSIBILITY

GROMMETS IN UP AND EAST SENSORS

LOCATION 9

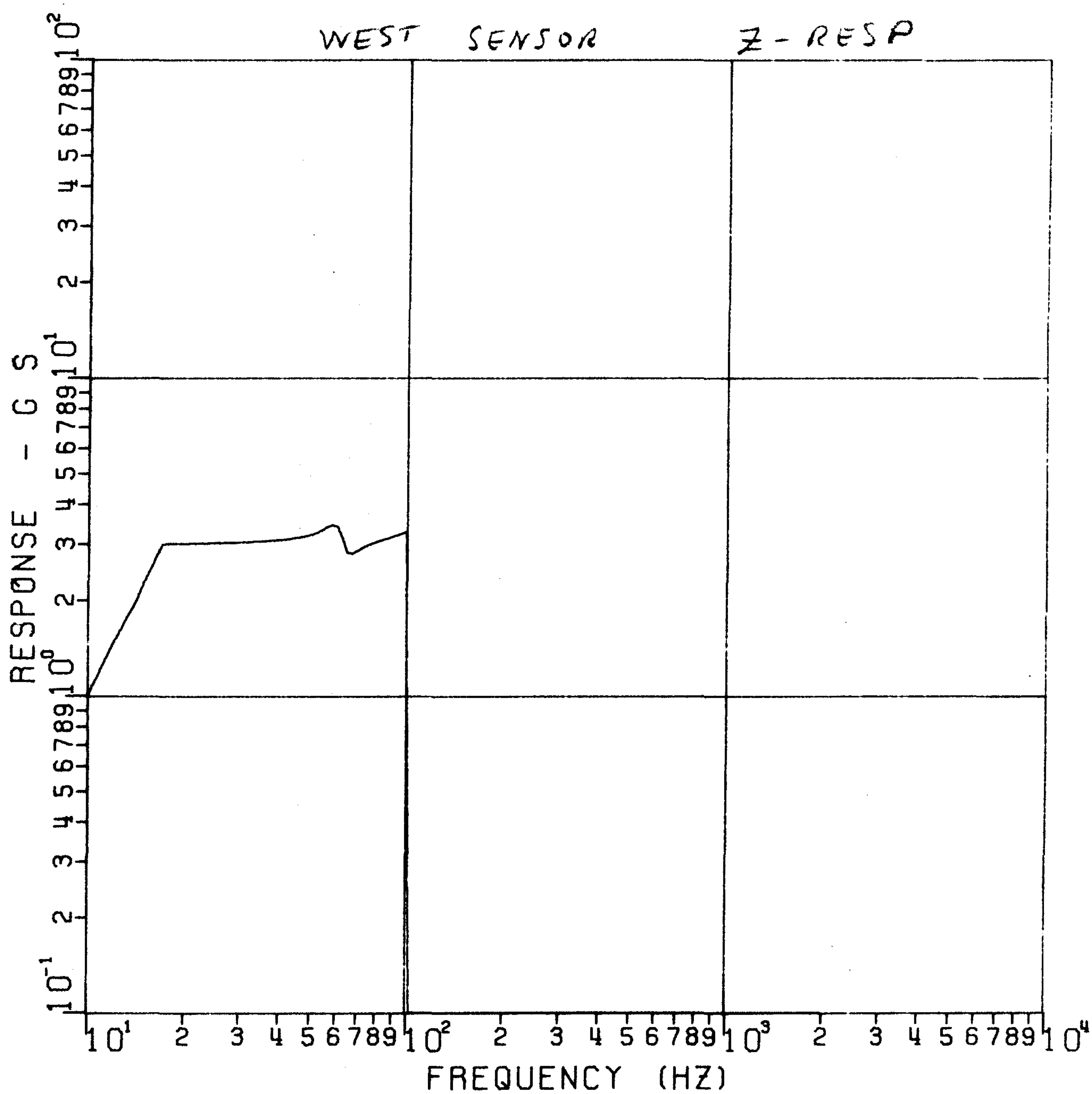


LEAM FREQ. RESP.,Z-AXIS FORCING,L&B

FIGURE 12b SINE RESPONSE

GROMMETS IN VP AND EAST SENSORS

LOCATION 9



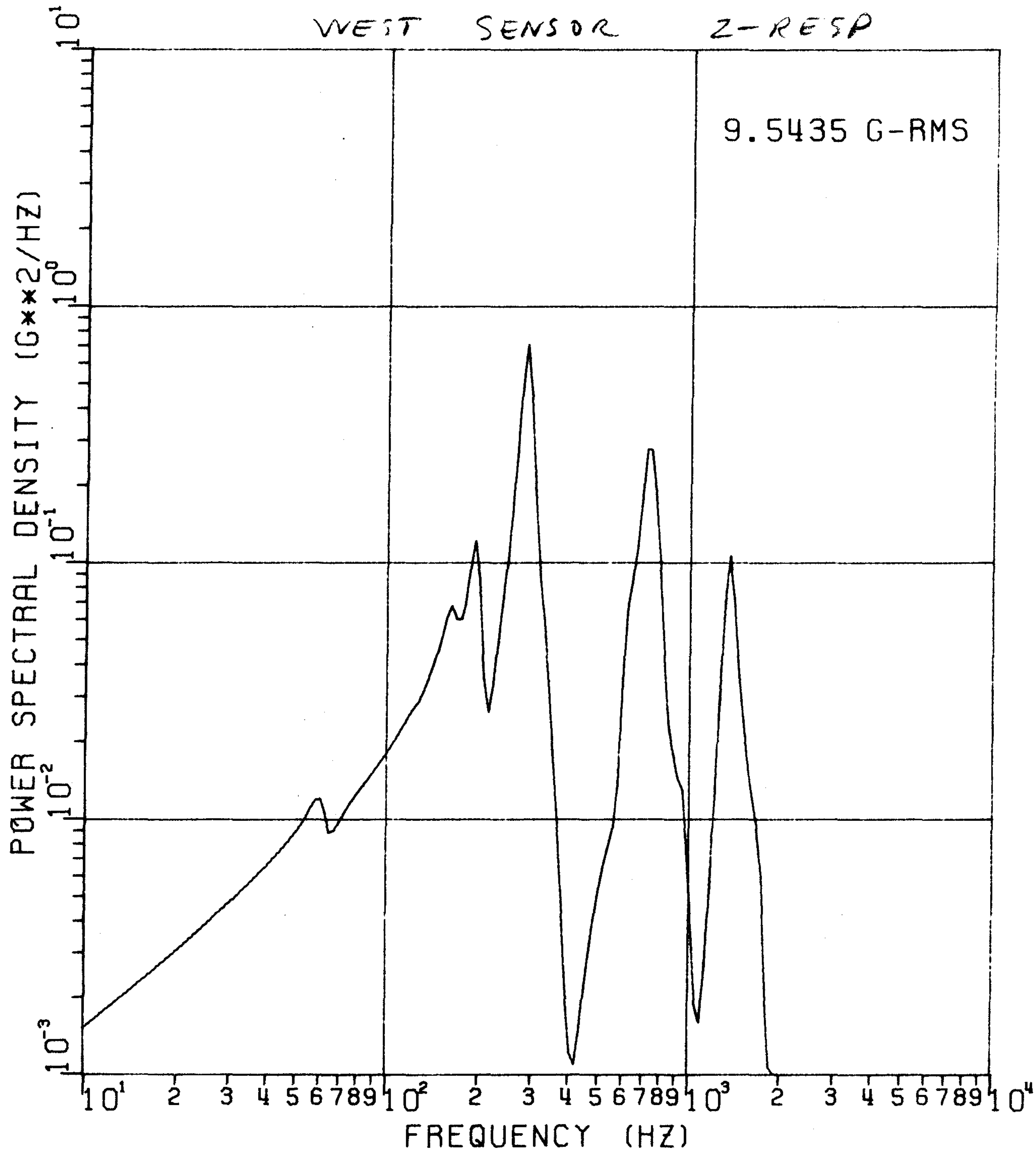
LEAM FREQ. RESP.,Z-AXIS FORCING,L&B

FIGURE 12c RANDOM VIBRATION SPECTRUM

LOCATION 9

GROMMETS IN UP AND EAST SENSORS

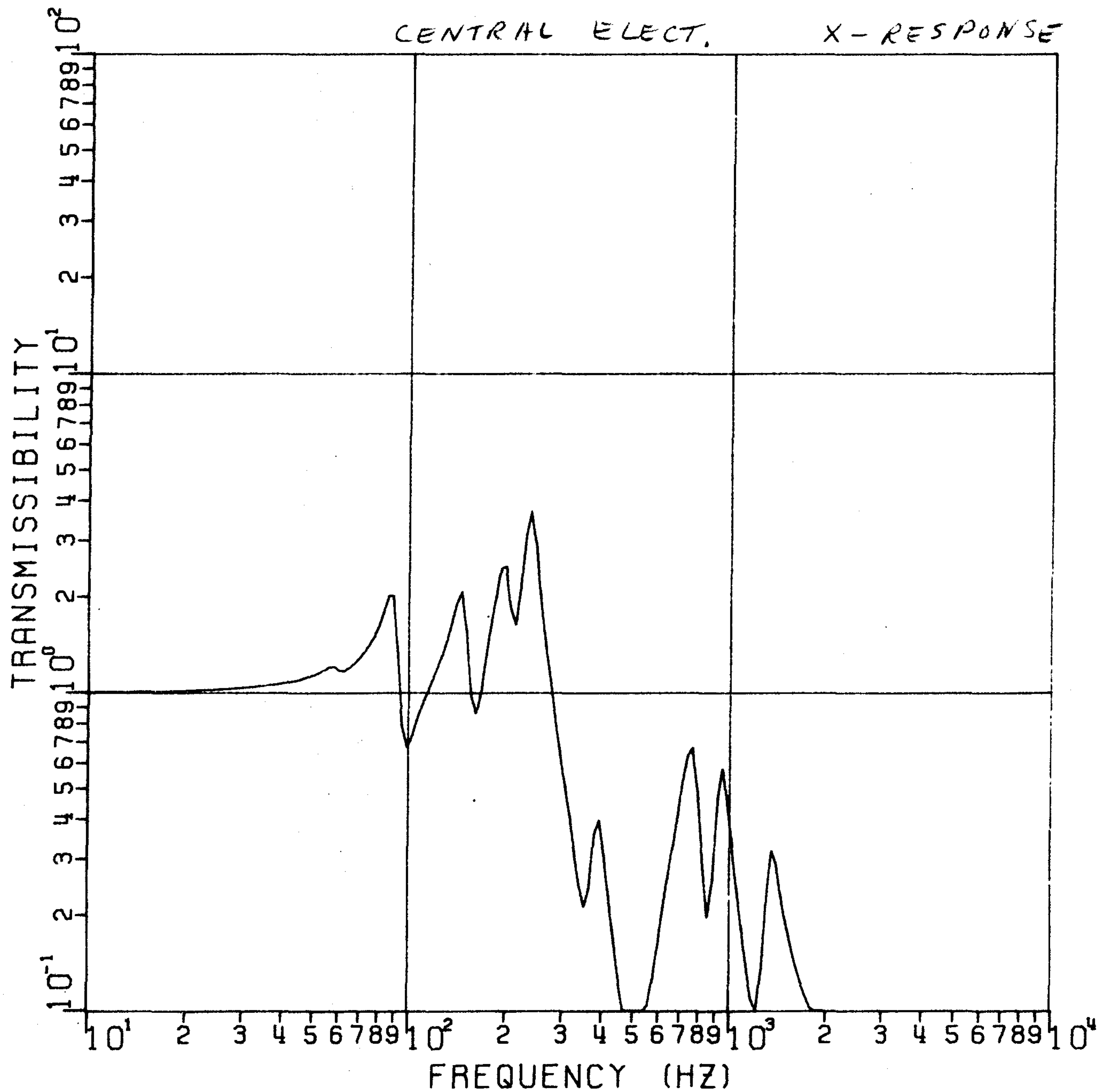
WEST SENSOR Z-RESP



LEAM ___ FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 13 a TRANSMISSIBILITY GROMMETS IN UP AND EAST SENSORS

LOCATION 13

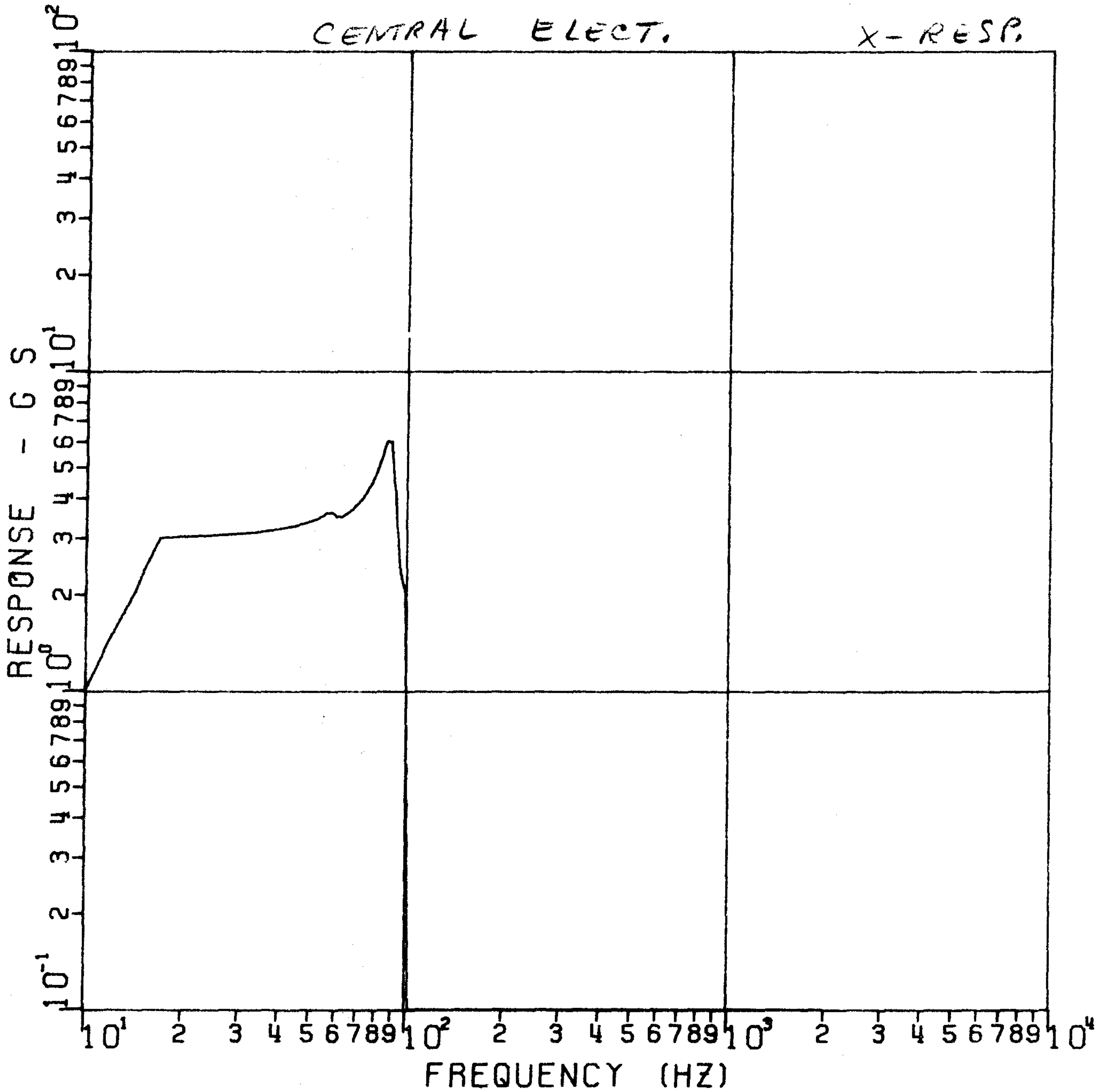


LEAM ___ FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 136 SINE RESPONSE

LOCATION 13

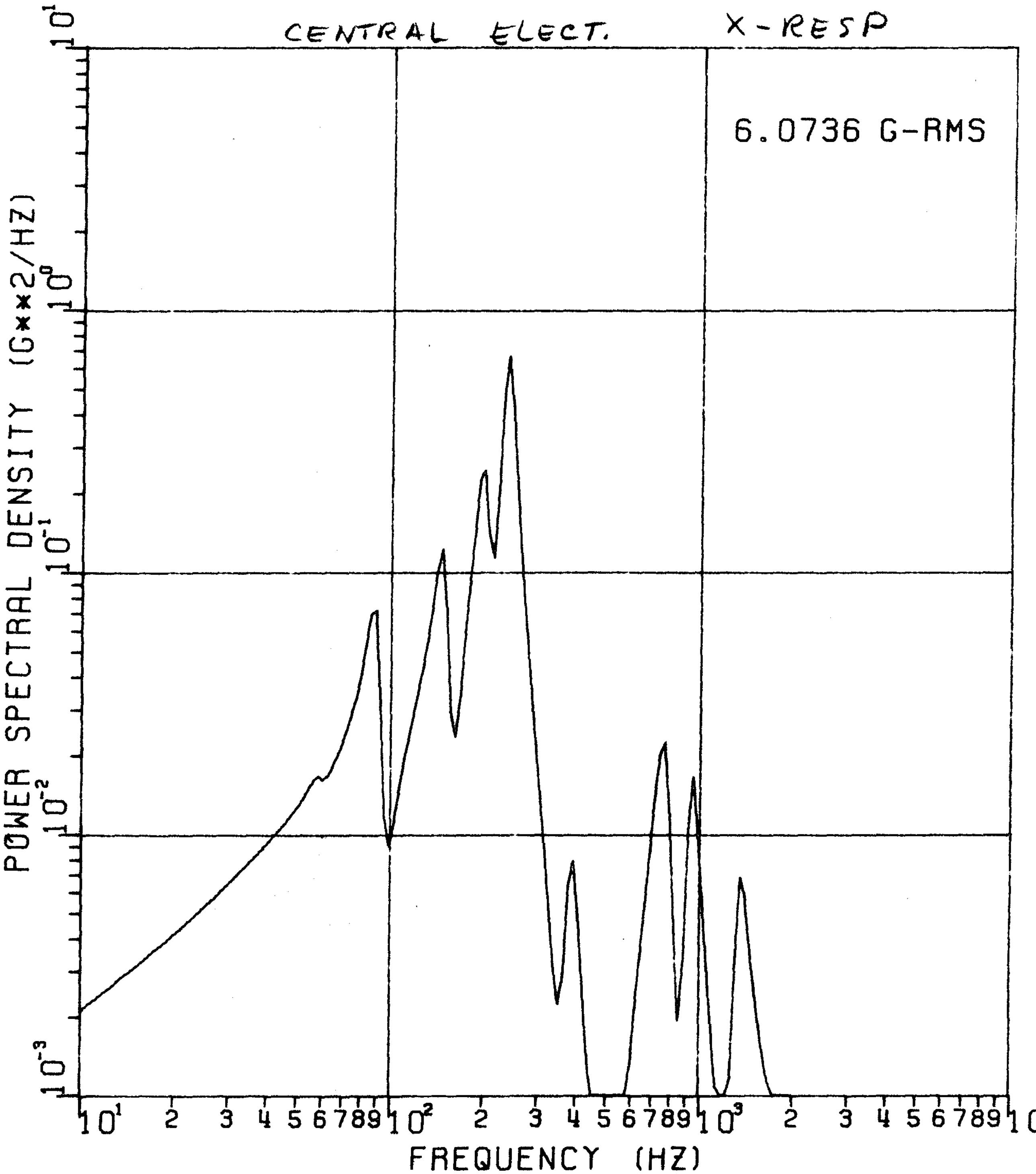
GROMMETS IN UP AND EAST SENSORS



LEAM — FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 13 c RANDOM VIBRATION SPECTRUM

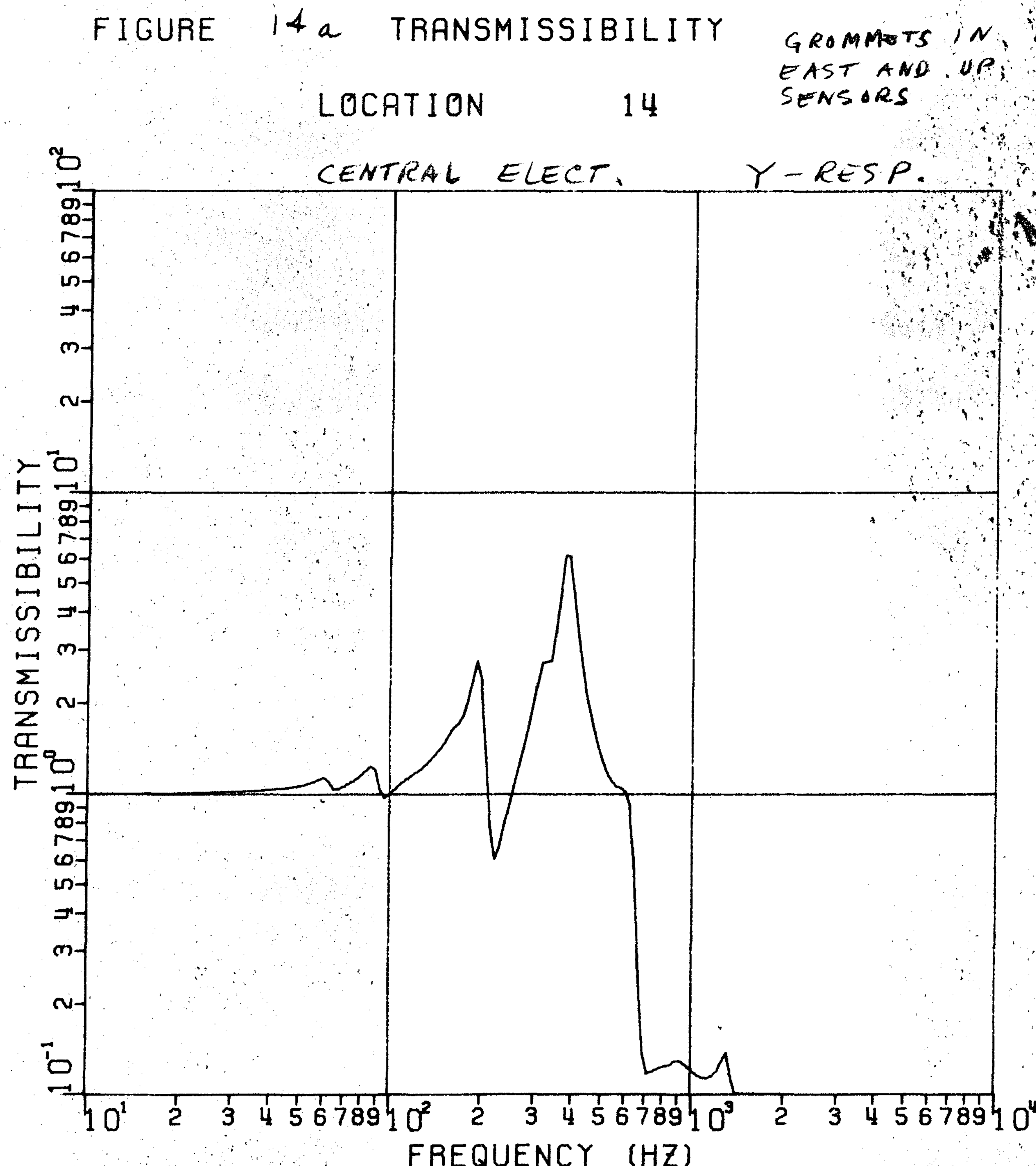
LOCATION 13 GROMMETS IN UP AND EAST SENSORS



LEAM FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE 14a TRANSMISSIBILITY

LOCATION 14

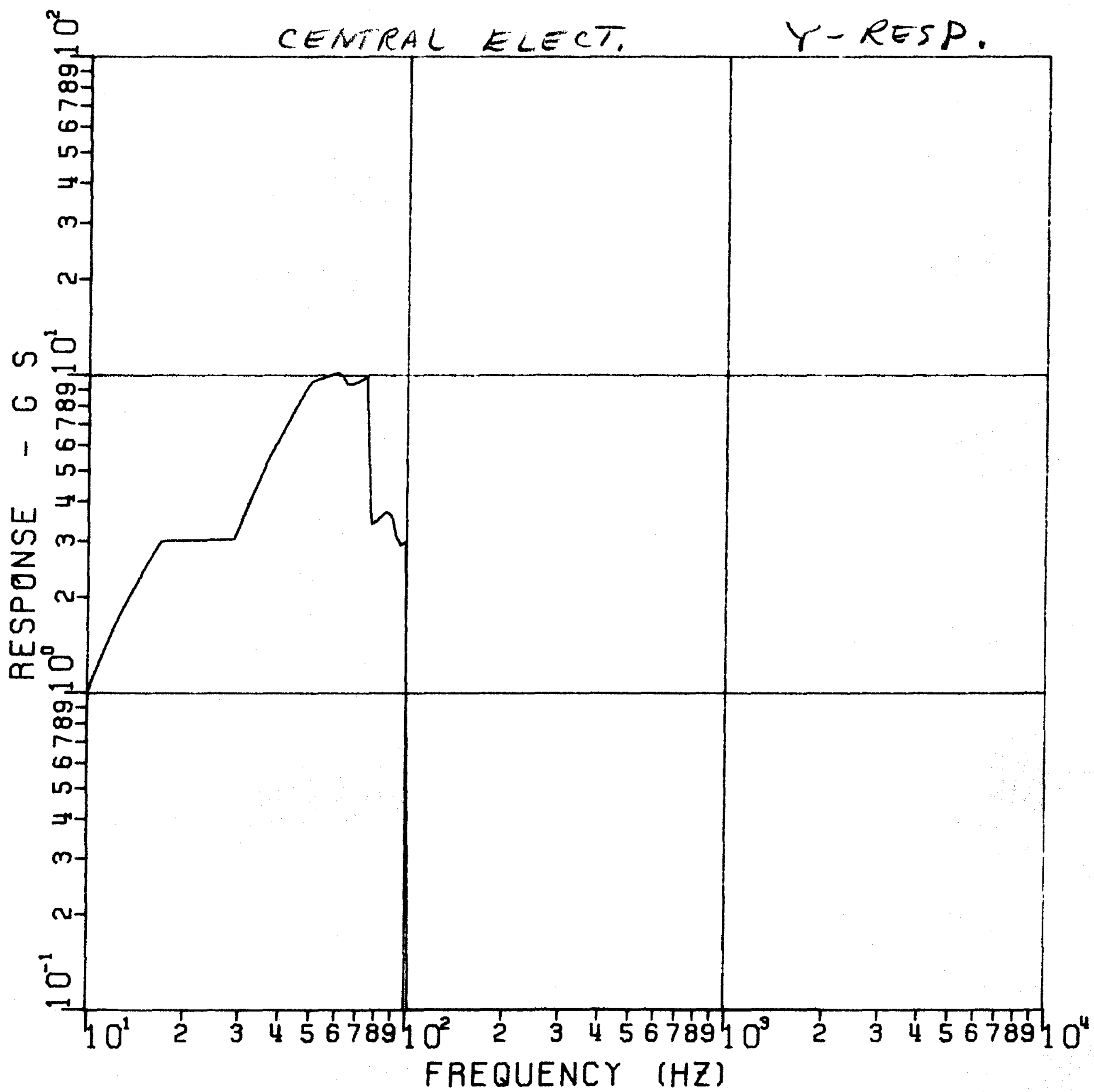


LEAM ___ FREQ. RESP.,Y-AXIS FORCING,L&B

FIGURE 14 b SINE RESPONSE

GROMMETS IN EAST AND UP SENSORS

LOCATION 14



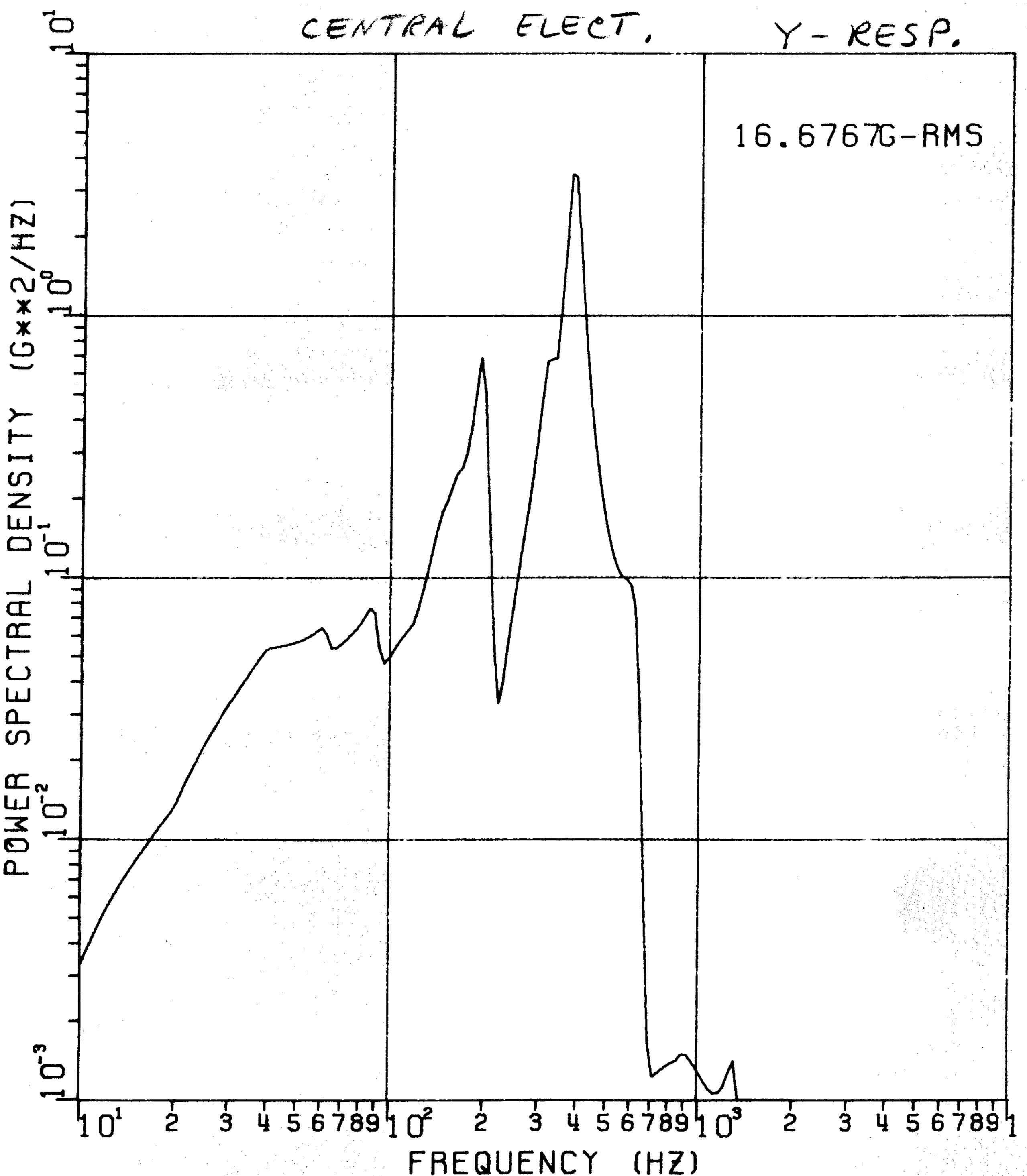
LEAM FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE 14c RANDOM VIBRATION SPECTRUM

LOCATION 14

GROMMETS IN EAST AND UP SENSORS

CENTRAL ELECT. Y-RESP.

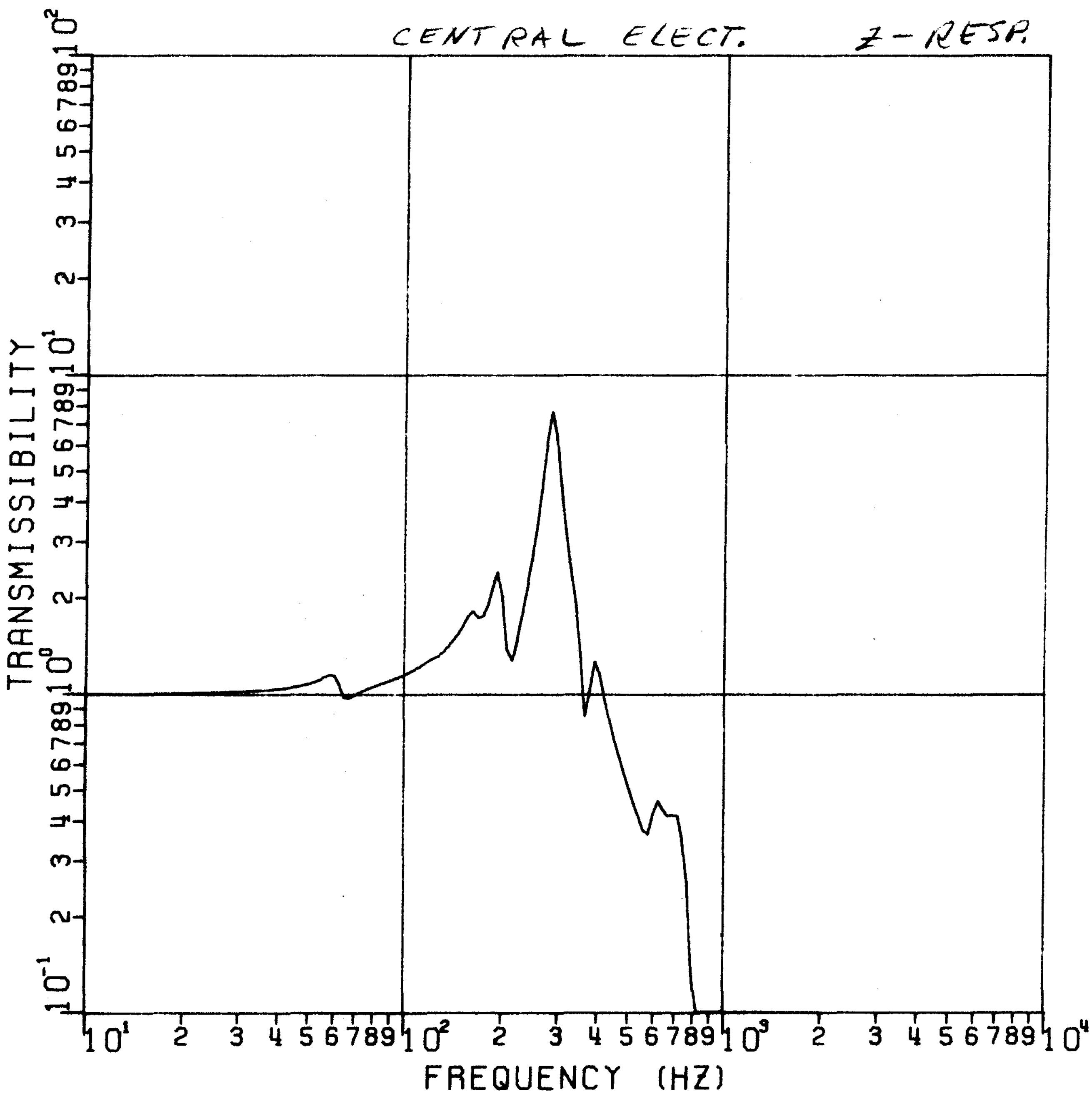


LEAM ___ FREQ. RESP., Z-AXIS FORCING, L&B

FIGURE 15a TRANSMISSIBILITY

GROMMETS IN EAST AND UP SENSORS

LOCATION 15

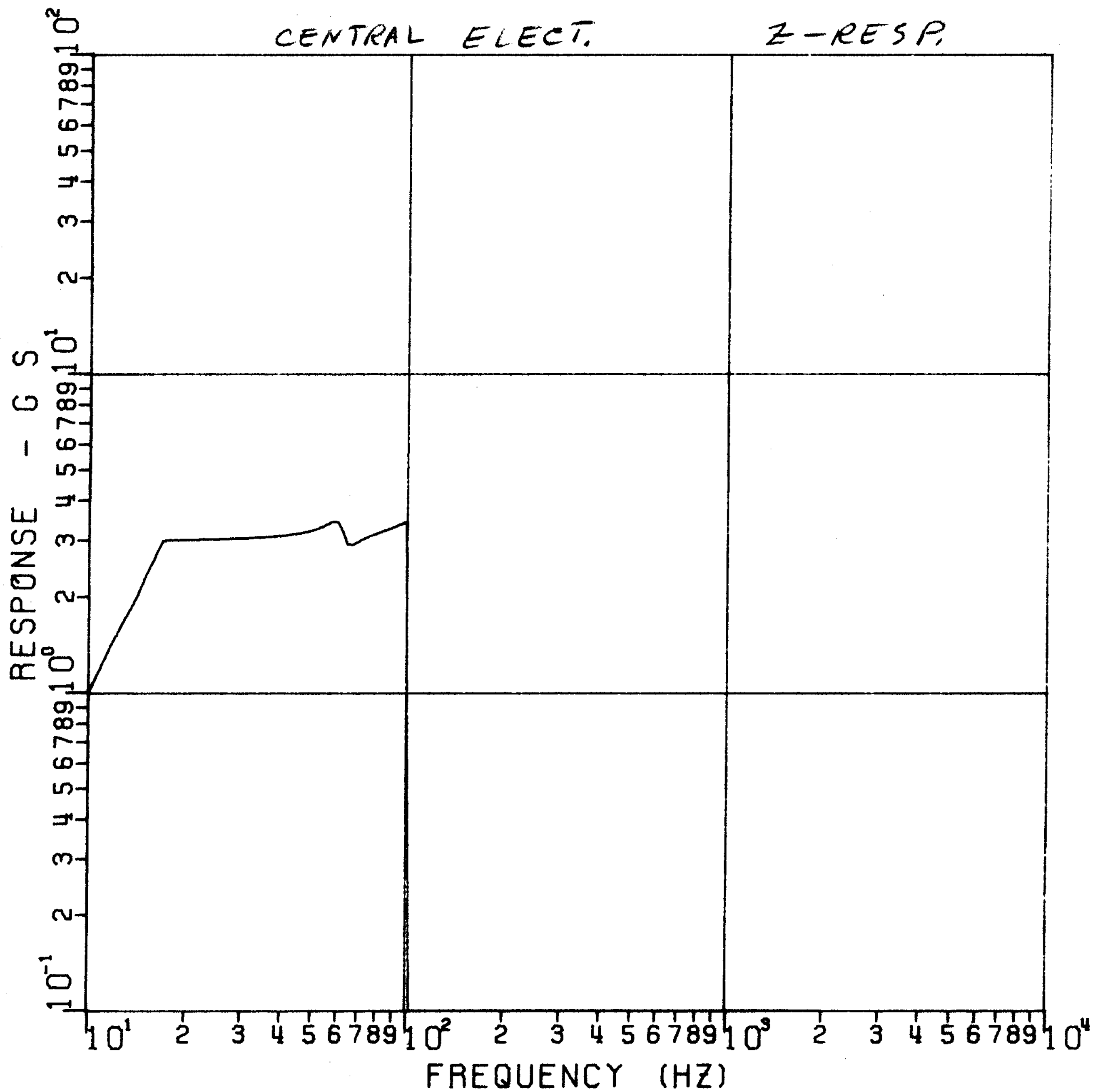


LEAM — FREQ. RESP., Z-AXIS FORCING, L&B

FIGURE 15 b SINE RESPONSE

GROMMETS IN EAST AND UP SENSORS

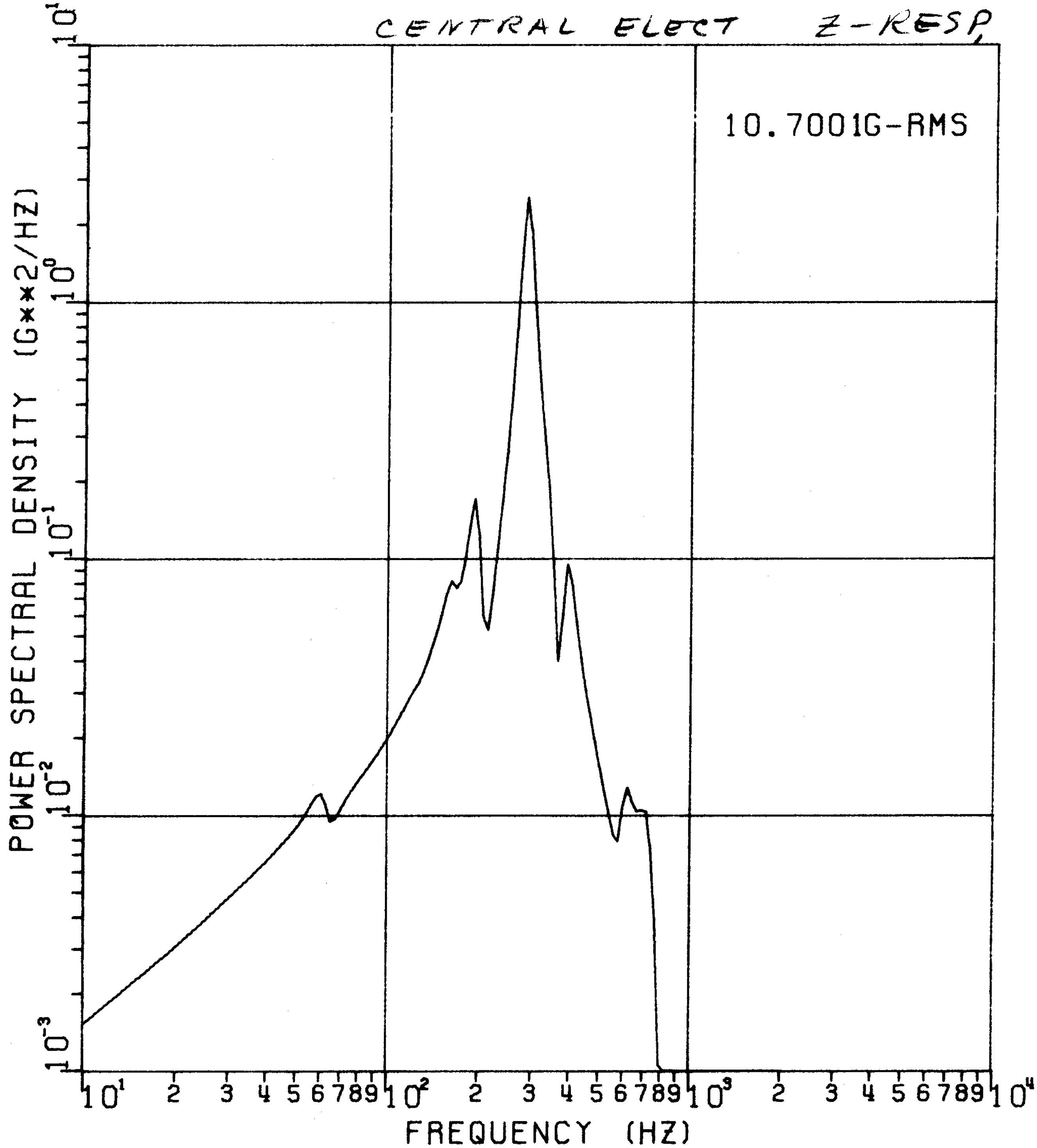
LOCATION 15



LEAM ___ FREQ. RESP., Z-AXIS FORCING, L&B

FIGURE 15c RANDOM VIBRATION SPECTRUM

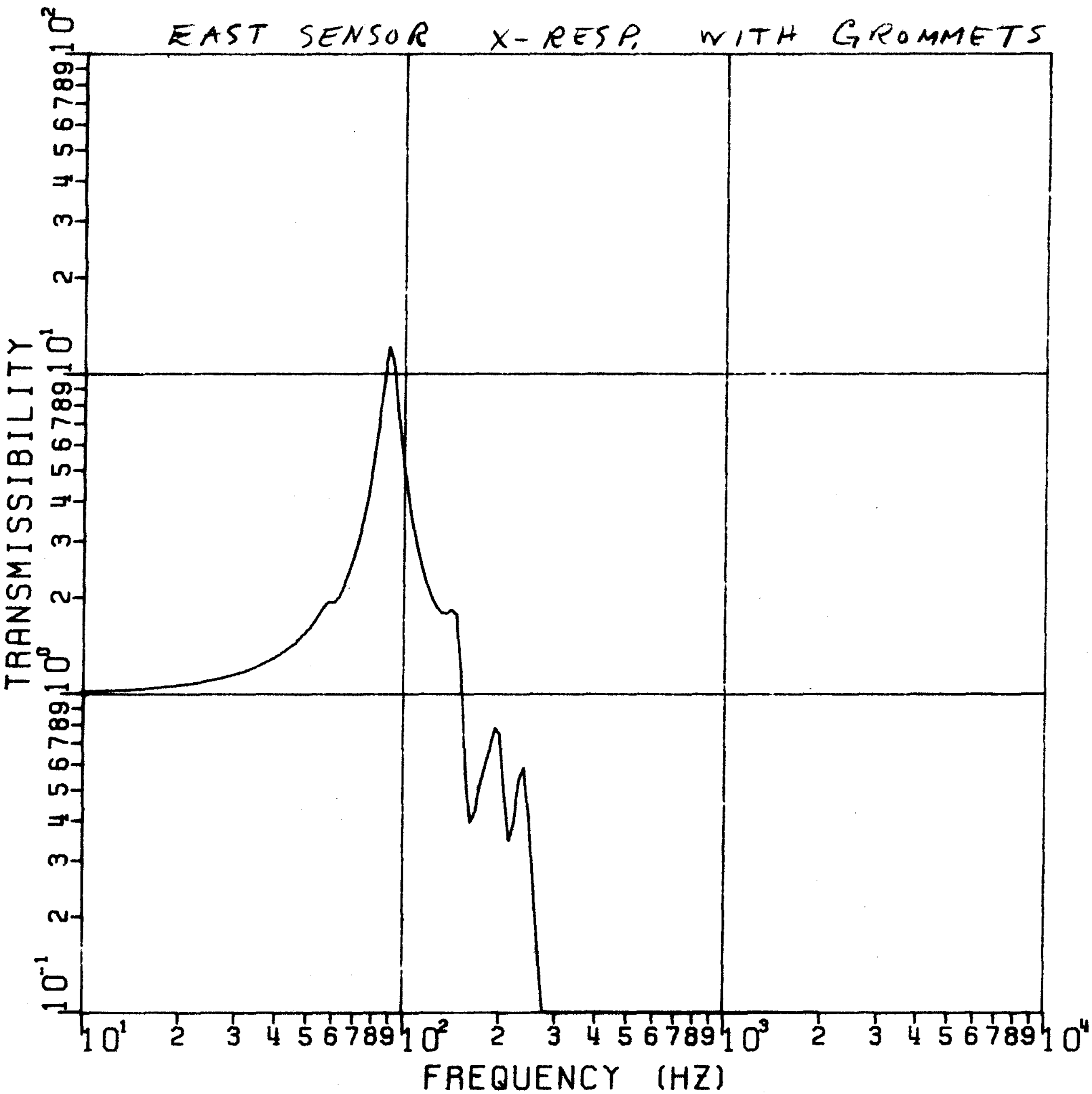
LOCATION 15 GROMMETS IN EAST AND UP SENSORS



LEAM ____ FREQ. RESP.,X-AXIS FORCING,L&B

FIGURE 16a TRANSMISSIBILITY

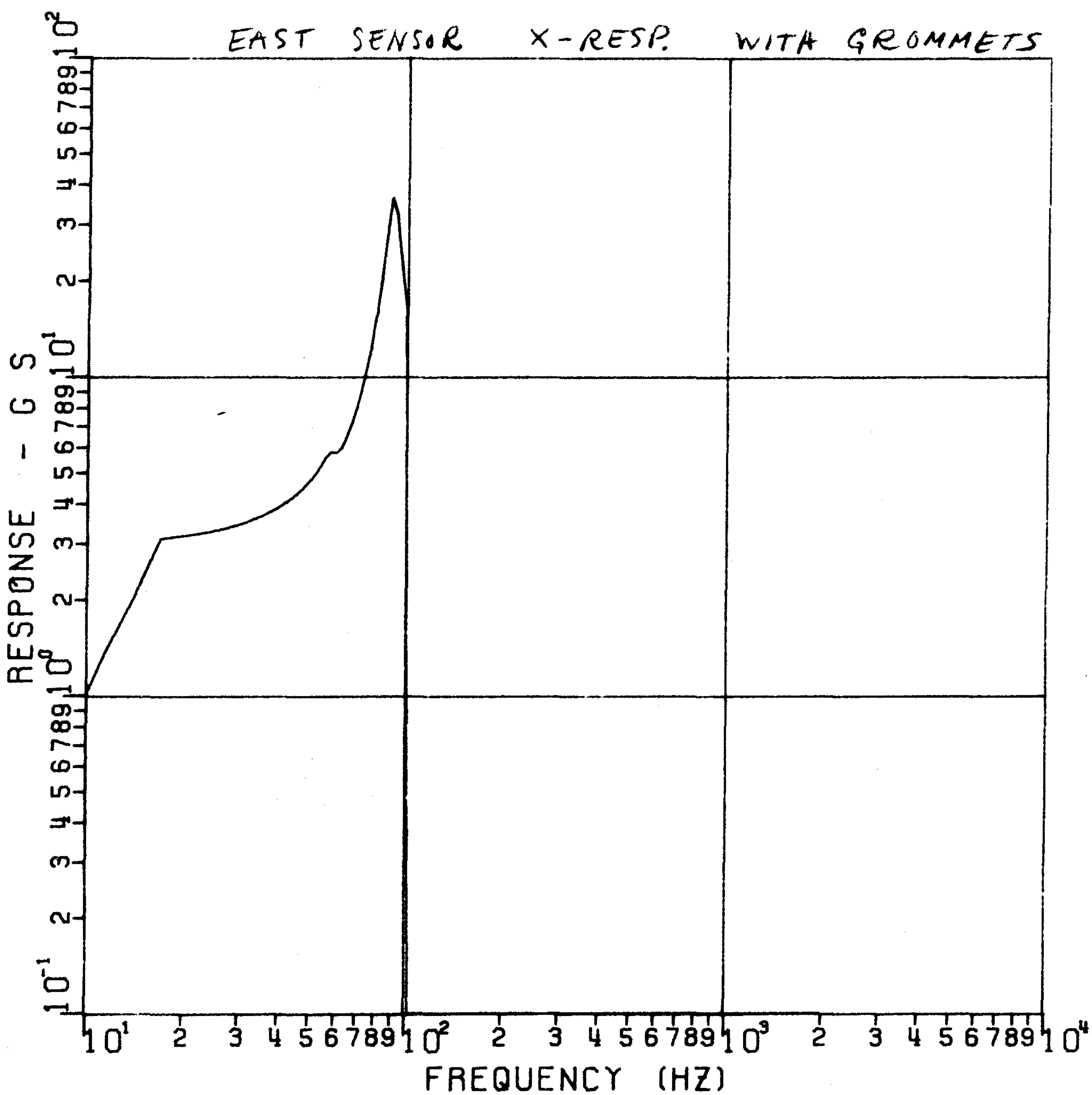
LOCATION 19



LEAM — FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 16 b SINE RESPONSE

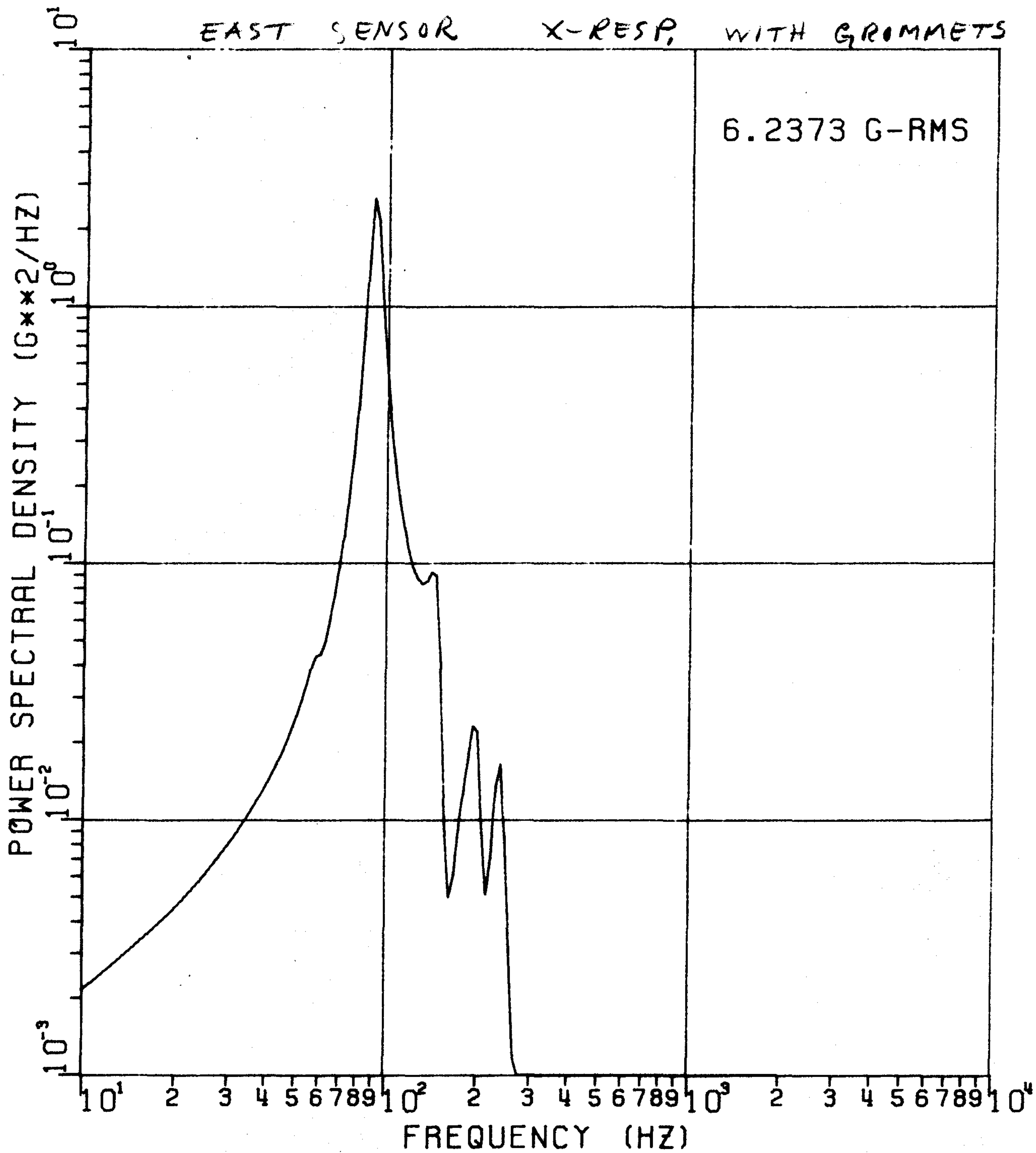
LOCATION 19



LEAM ___ FREQ. RESP., X-AXIS FORCING, L&B

FIGURE 16c RANDOM VIBRATION SPECTRUM

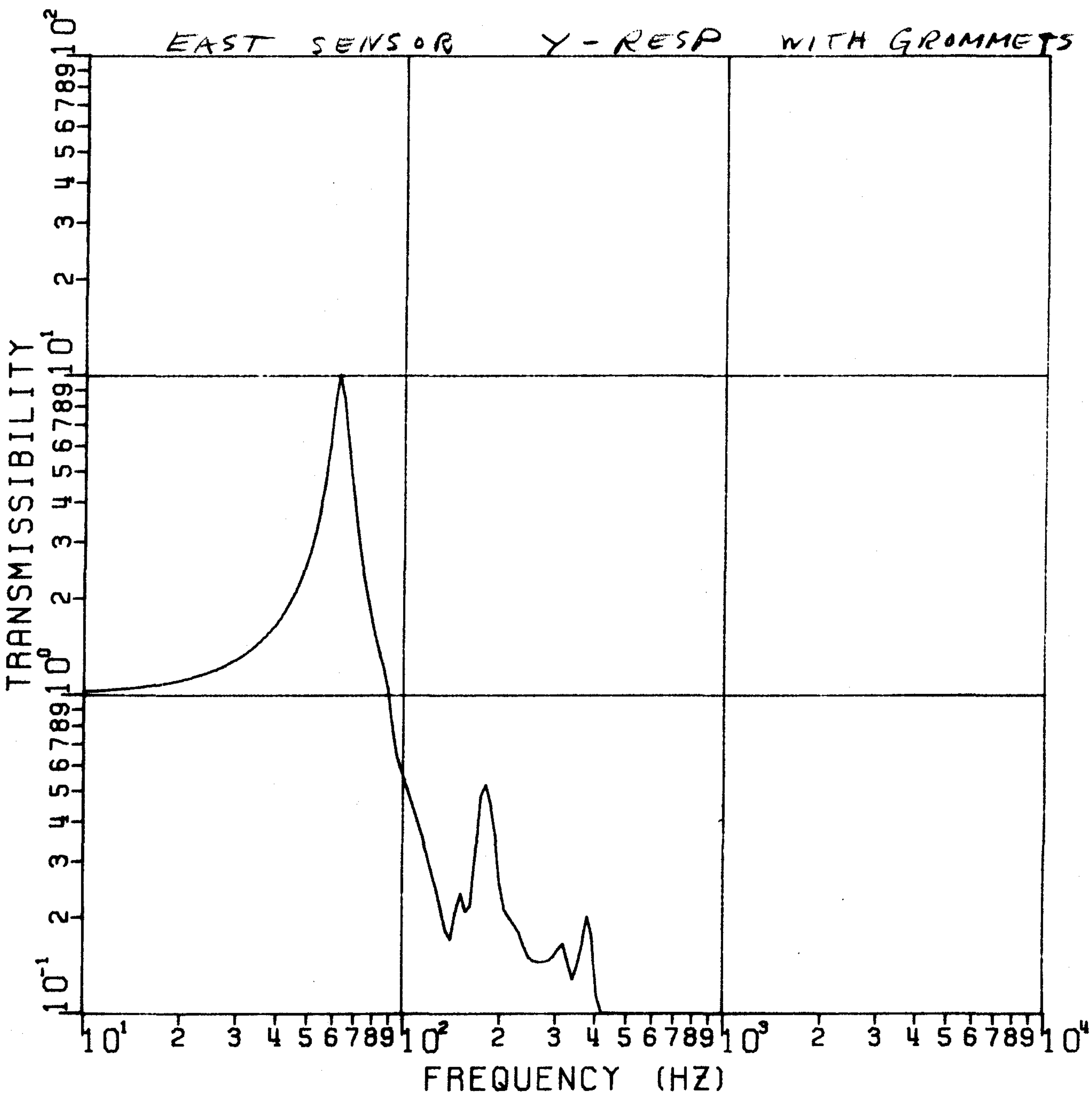
LOCATION 19



LEAM ___ FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE 17a TRANSMISSIBILITY

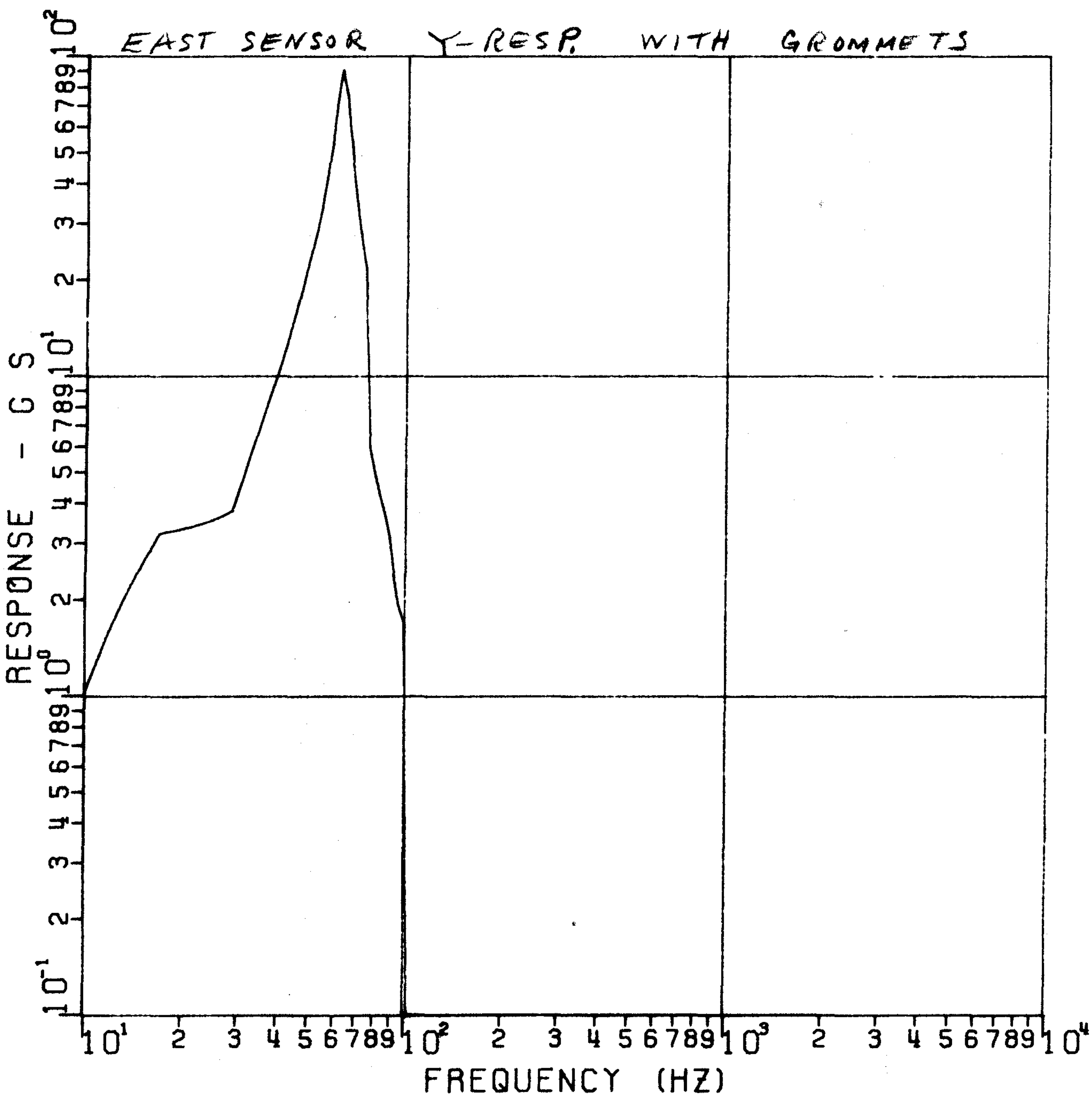
LOCATION 20



LEAM ___ FREQ. RESP.,Y-AXIS FORCING,L&B

FIGURE 176 SINE RESPONSE

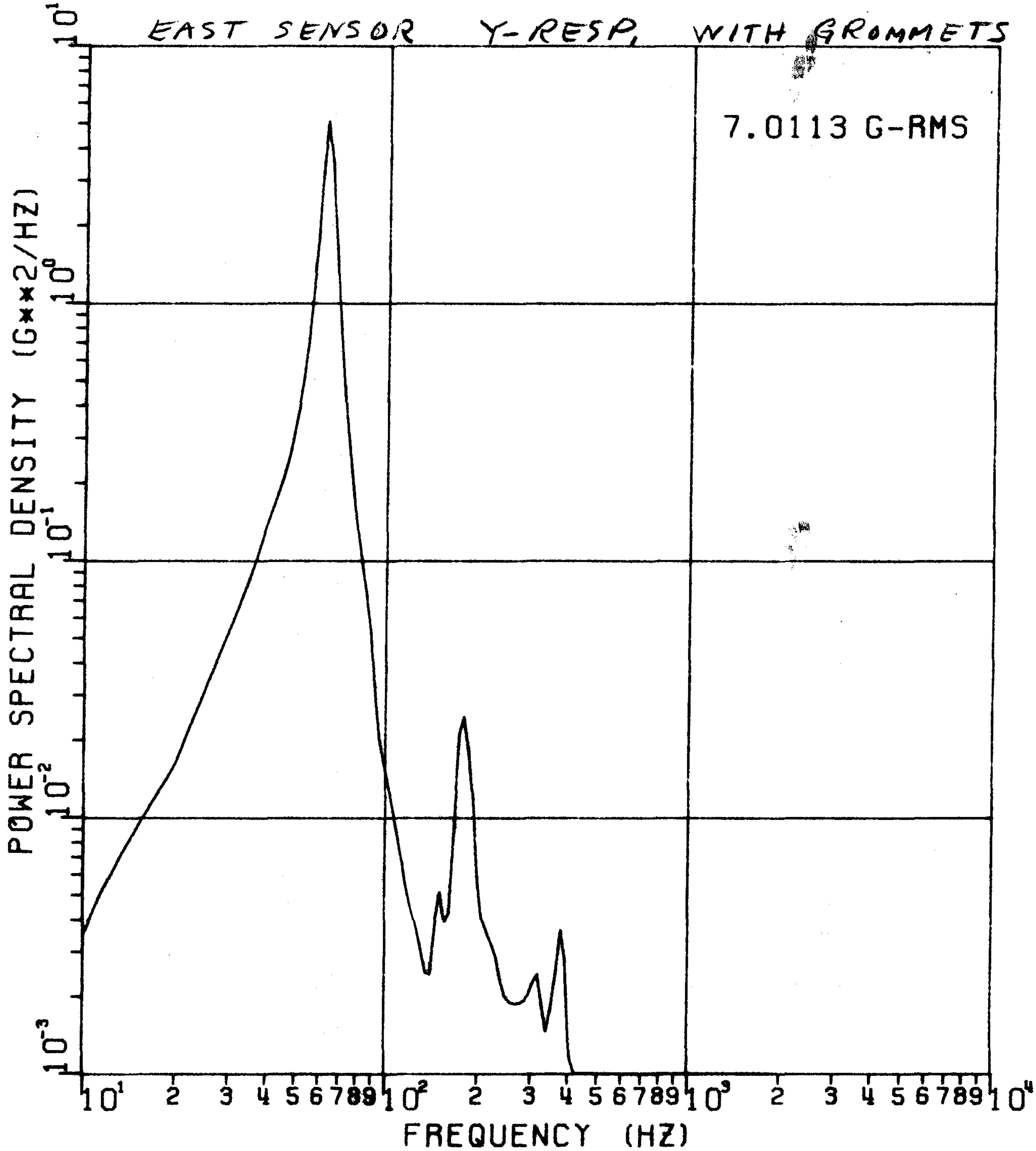
LOCATION 20



LEAM ___ FREQ. RESP., Y-AXIS FORCING, L&B

FIGURE 17c RANDOM VIBRATION SPECTRUM

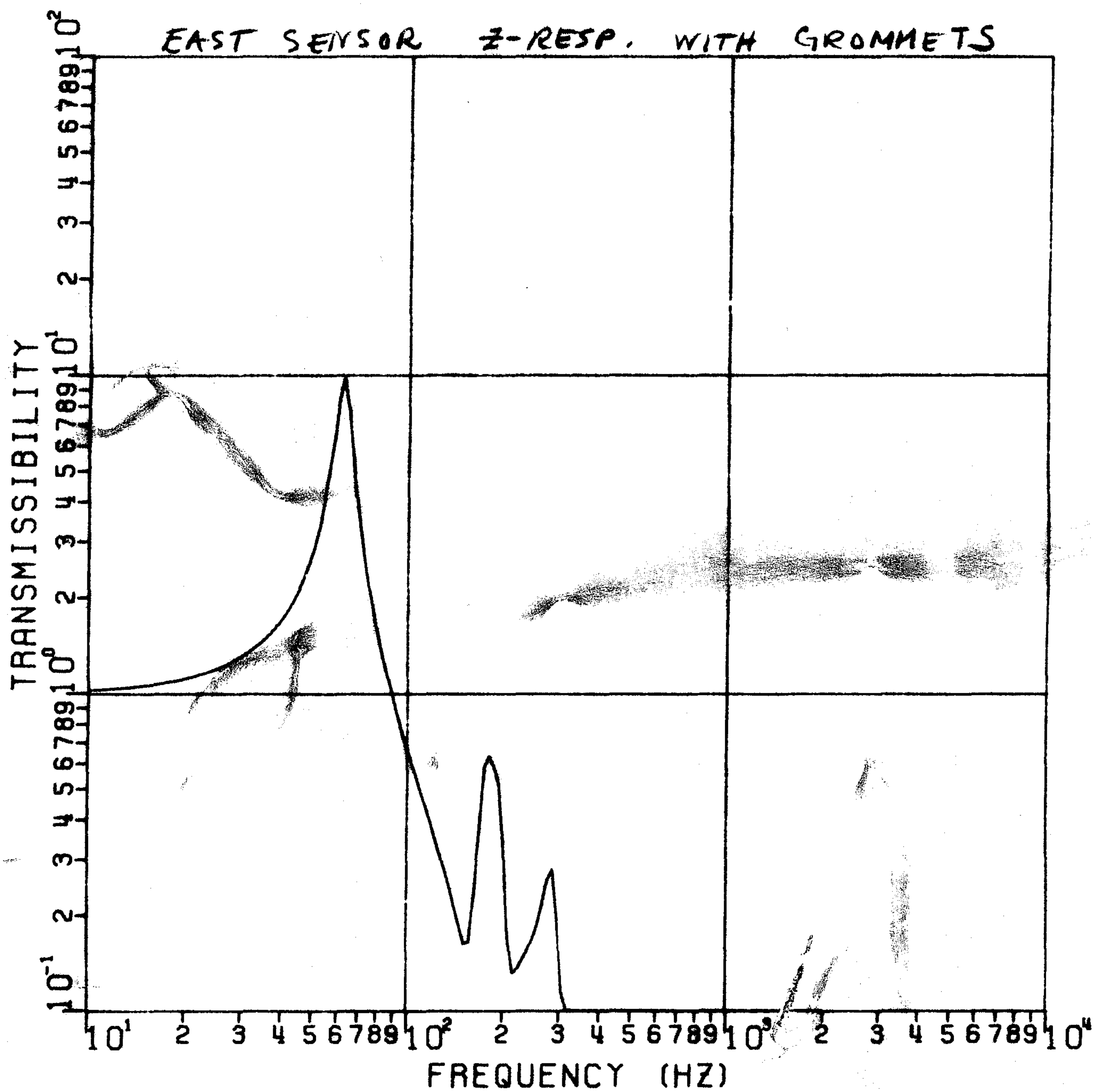
LOCATION 20



LEAM ___ FREQ. RESP.,Z-AXIS FORCING,L&B

FIGURE 18 a TRANSMISSIBILITY

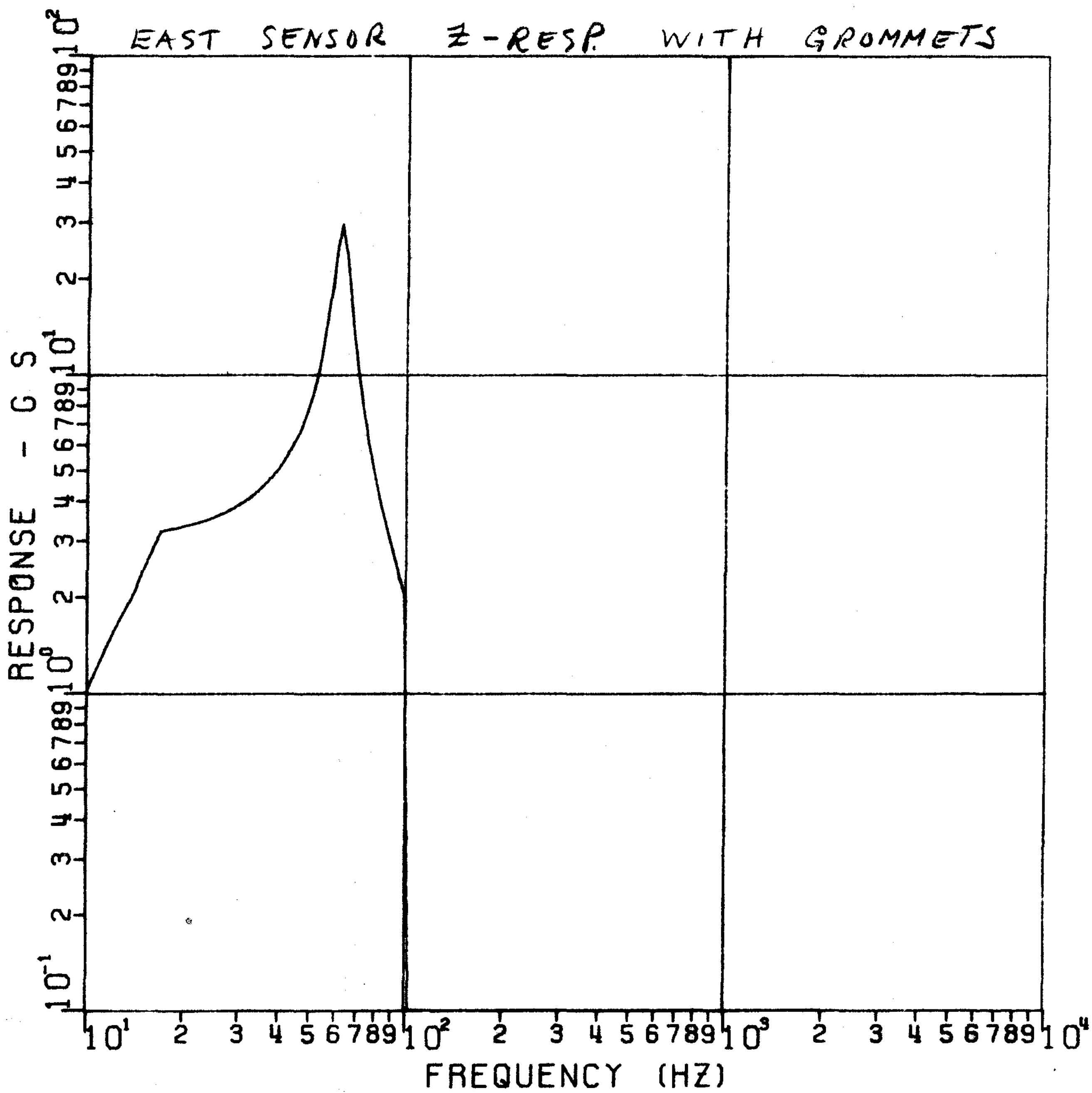
LOCATION 21



LEAM ____ FREQ. RESP., Z-AXIS FORCING, L&B

FIGURE 18 b SINE RESPONSE

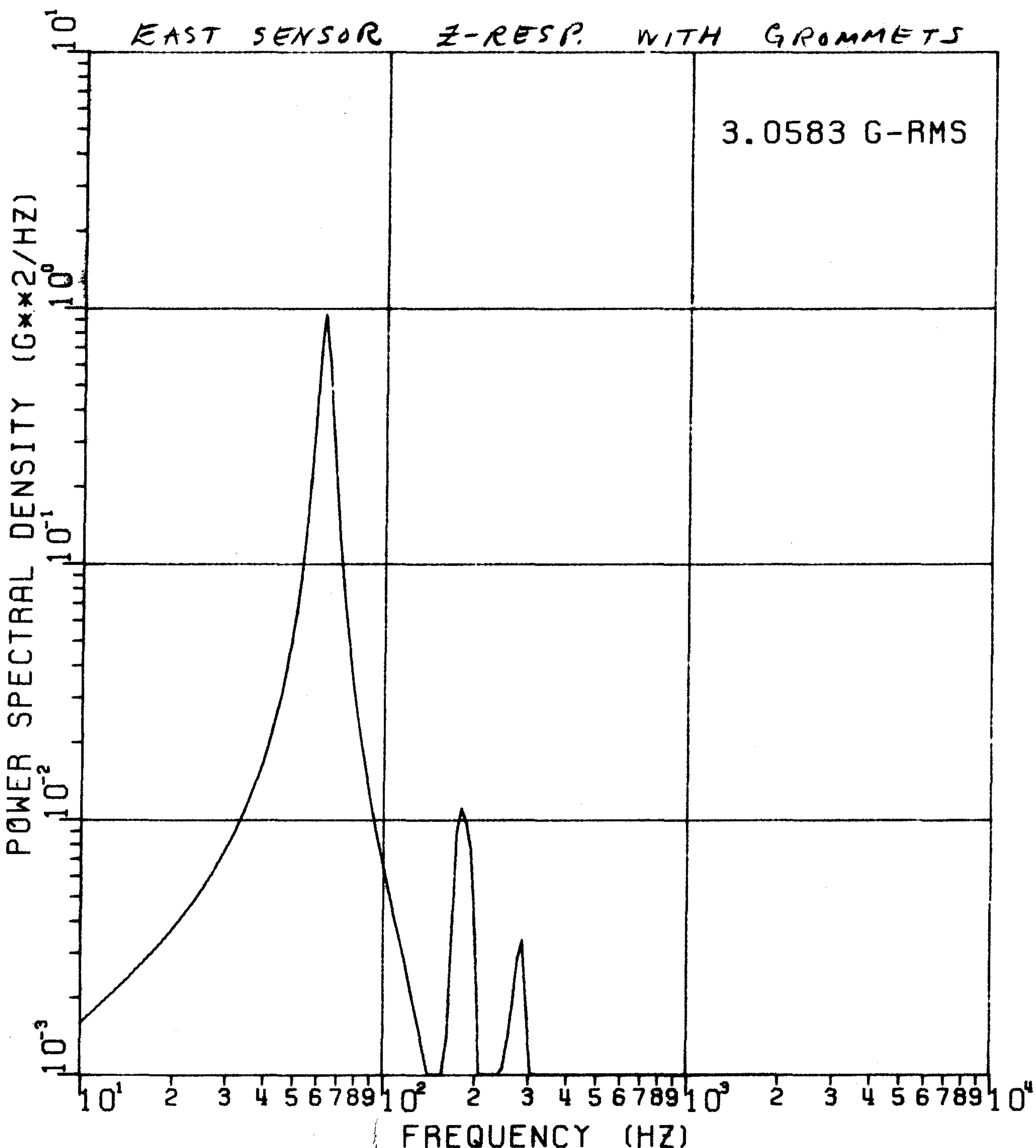
LOCATION 21



LEAM FREQ. RESP., Z-AXIS FORCING, L&B

FIGURE 18c RANDOM VIBRATION SPECTRUM

LOCATION 21



APPENDIX A

This appendix contains the stiffness matrix and the mass matrix for the LEAM model with grommets in the Up and East sensor atta achments.

```
30    30
1     10.1226E-01-.1216E-040.3559E-060.1126E-040.1720E-05-.2234E-01-.3049E-02
1     8-.2415E-020.7957E-030.1965E-030.6030E-03-.8779E-03-.2578E-020.1743E-02
1     15-.4653E-040.1423E-020.2404E-020.2121E-03-.5407E-040.1326E-04-.3985E-06
1     220.2917E-050.2850E-04-.6056E-04-.4044E-030.1571E-030.6326E-04-.6769E-04
1     290.1101E-03-.2104E-02
2     20.2337E-01-.1139E-05-.4374E-040.2292E-04-.2630E-030.5539E-02-.1537E-01
2     9-.2166E-02-.5123E-03-.2924E-030.5108E-020.1442E-02-.5488E-02-.3474E-03
2     16-.5024E-02-.1084E-02-.4205E-030.4111E-05-.2565E-04-.8119E-05-.4182E-04
2     230.3547E-05-.1963E-040.4363E-03-.4520E-03-.3186E-030.6015E-030.4922E-04
2     300.2146E-0
3     30.1228E-010.2244E-010.5677E-04-.6146E-05-.7728E-050.7642E-04-.5826E-02
3     100.5395E-03-.1145E-020.5176E-040.2566E-04-.3490E-03-.2017E-03-.3146E-03
3     170.7674E-040.6975E-04-.2807E-05-.1499E-05-.1435E-040.2484E-04-.7859E-05
3     240.6551E-05-.9042E-040.5773E-04-.1630E-030.4107E-030.1079E-03-.4971E-03
4     40.2343E 000.4311E-03-.1467E-030.1699E-02-.6909E-02-.2875E-01-.4334E-02
4     11-.1652E-010.2087E-020.2246E-020.1255E-01-.1259E-020.8944E-02-.1545E-02
4     18-.7466E-040.2259E-04-.4028E-04-.5229E-04-.1862E-03-.1955E-040.2550E-04
4     250.1006E-03-.2513E-03-.1443E-020.2727E-020.5563E-030.4802E-04
5M    50.1933E 000.4170E-040.6085E-030.5055E-02-.8047E-020.2476E-02-.9753E-02
5     12-.2083E-02-.4959E-02-.6084E-020.1257E-02-.3953E-020.3305E-020.8390E-03
5     190.2990E-040.2022E-040.5362E-040.5660E-04-.2111E-03-.6179E-04-.2081E-02
5     260.2866E-030.3382E-03-.1661E-020.2440E-03-.1295E-01
6     60.2343E 000.1261E-010.2648E-01-.7253E-02-.1975E-02-.2988E-02-.8314E-02   (10^5 FACTORED)
6     130.1773E-01-.1725E-01-.4379E-03-.1500E-01-.1553E-01-.2745E-020.2463E-03
6     20-.1061E-03-.1816E-04-.1091E-03-.1105E-030.4875E-040.3490E-02-.1575E-02
6     27-.1058E-020.1863E-02-.1997E-030.1777E-01
7     70.6500E 00-.3276E 000.1623E 000.5982E-010.2439E 000.3164E 00-.5124E 00
7     140.2522E 00-.5944E-010.1019E 000.4955E 000.1094E 00-.9699E-020.5399E-03
7     21-.4768E-03-.1254E-020.7067E-020.8808E-02-.1205E 000.1649E-010.7588E-02
7     28-.1274E-010.9570E-02-.5396E 00
8     80.1814E 1-.5733E 00-.2692E 00-.1491E 00-.4050E 00-.5006E 00-.1402E 01
8     15-.6181E-01-.1194E 010.4043E 000.1239E 00-.7350E-02-.5285E-02-.2417E-02
8     22-.1104E-01-.4267E-030.2106E-01-.1375E 00-.8230E-01-.4466E-010.7554E-01
8     290.1761E-01-.7435E 00
9     90.1019E 01-.2484E 000.2034E 000.6999E-010.2945E-010.6790E 00-.3117E 00
9     160.3450E 00-.1104E 00-.2859E-010.3351E-02-.1806E-02-.8409E-02-.1352E-01
9     23-.2277E-01-.1974E-020.4106E-01-.2268E-01-.9539E-010.1928E 00-.2043E-01
9     300.1842E 00
10    100.3352E 010.1349E-010.4787E-010.6215E-010.3177E 00-.8720E-010.2052E 00
10    17-.7718E-01-.3099E-010.1179E-02-.4197E-03-.7916E-03-.5104E-020.7159E-03
10    24-.1113E-020.3242E-01-.1187E-01-.1022E-010.1415E-010.5029E-020.1861E 00
11    110.3180E 01-.1055E 00-.3044E 000.1711E 00-.3930E-010.1242E 000.1798E 00
11    180.5123E-010.6401E-020.5472E-05-.7674E-030.1095E-02-.1864E-01-.6941E-02
11    25-.4402E-01-.2493E-02-.2201E-010.6756E-010.2431E-02-.2909E 00
12    120.3255E 010.3982E 000.2799E 000.7563E-010.2947E 00-.3914E 00-.1015E 00
12    190.6965E-020.2056E-020.1102E-020.4543E-02-.4312E-02-.2222E-010.1066E 00
12    260.2143E-010.1094E-01-.1533E-01-.5434E-020.5926E 00
13    130.1247E [illegible] .1550E 000.[illegible] 00-.1136E 010.1805E 01-.1139E-01
13    200.1609E-020.2070E-020.7452E-02-.1162E-010.1027E-01-.2232E 000.3358E-01
13    270.1671E-01-.2509E-01-.3351E-01-.1247E 01
14    140.1754E 010.7101E-010.1490E 01-.3508E 00-.9945E-010.5896E-02-.5147E-02
14    210.2776E-020.1471E-010.5561E-03-.9057E-040.1132E 00-.7012E-010.2300E-01
14    28-.3425E-01-.1809E-010.6929E 00
15    150.5437E 000.2631E-01-.4014E-01-.2033E-01-.7321E-03-.3070E-03-.1428E-02
15    22-.4130E-020.1910E-020.1054E-020.2223E-01-.6070E-02-.7609E-020.1309E-01
15    290.3798E-020.1266E 00
16    160.3115E 01-.3379E 00-.9865E-010.4371E-02-.4352E-020.1136E-020.8223E-02
16    230.2420E-030.8499E-030.1105E 00-.5946E-010.1259E-01-.1904E-01-.1221E-01
16    300.5979E 00
17    170.2635E 01-.1454E 000.1105E-01-.1194E-02-.9440E-03-.4077E-020.7723E-02
17    24-.1106E-010.1827E 00-.2591E-01-.1308E-010.2042E-010.3312E-010.1015E 01
18    180.1324E 010.1575E-02-.2763E-03-.4149E-03-.1692E-020.1044E-02-.2411E-02
18    25-.2047E 010.2583E-01-.4641E-010.1061E 00-.3628E-01-.1221E 02
19    190.2313E-01-.5512E-05-.1536E-04-.3773E-040.2424E-030.1583E-03-.1966E-02
19    260.2953E-030.1140E-03-.1368E-030.2321E-03-.1065E-01
20    200.1222E-01-.9421E-05-.4653E-040.2705E-05-.2192E-010.3642E-03-.4745E-03
20    27-.2850E-030.4677E-030.1608E-040.1723E-02
21    210.1221E-01-.8945E-040.2261E-010.4328E-040.4272E-03-.1075E-03-.2980E-03
21    280.5704E-030.1410E-030.2461E-02
22    220.1867E 000.2124E-030.1542E-030.1892E-02-.9650E-03-.1001E-020.1447E-02
22    290.1496E-030.1045E-01
23    230.2240E 01-.3029E-03-.6934E-03-.6213E-04-.1648E-030.3778E-030.7608E-03
23    30-.6083E-02
24    240.2260E-010.2334E-020.4361E-030.2748E-03-.2636E-03-.6192E-040.1346E-01
25    250.7456E 01-.1673E 000.1591E 00-.3690E 000.1265E 000.4445E 02
26    260.1431E 01-.1376E 000.2646E 00-.1948E-02-.3074E 00
27    270.5702E 01-.2795E 020.4528E-020.5488E 00
28    280.1622E 01-.1004E-01-.1437E 01
29    290.6850E 000.7515E 00
30    300.2744E 0
```

TABLE A-1

STIFFNESS MATRIX

TABLE A-2
MASS MATRIX

.6997E-02 LB-SEC^2/IN

.6997E-02

.6997E-02

.02175 LB-SEC^2-IN

.03411

.02175

.3950E-02

.3950E-02

.3950E-02

.0193

.0102

.0102

.1051E-01

.1051E-01

.1051E-01

.079

.035

.107

.6110E-02

.6110E-02

.6110E-02

.0298

.01895
.01895
.9260E-02
.9260E-02
.9260E-02
.249
.215
.2125