This ATM presents the results of the structural dynamics analysis performed for the A2/SP-3 structural arrangement.

Section I describes the dynamics portion, and Section II presents the stress analysis.

CONTENTS:

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SECTION I DYNAMICS ANALYSIS

1.0 INTRODUCTION

The results of dynamic analyses performed for the Subpack 3 experiment packages and associated structure are presented in this ATM. The objectives of the analyses have been to estimate the acceleration environment at selected locations throughout the structure and to compute the associated dynamic loads resulting from both sinusoidal and random excitations.

Several iterations in the supporting structure were carried out during the design, and the launch random vibration environment was increased when the installation in LEM was changed from QUAD I to QUAD III.

2.0 ANALYSIS MODEL

The physical arrangement of the complete package is shown in Figure 1.

The mathematical model used in the analysis is a 15 degree of freedom, three-dimensional model which was derived from the coordinate definition drawing of Figure 2.

The drill box and structure is considered to be a rigid mass attached at 3 points having dimensions, mass and c.g. characteristics shown in Figure 3.

The H.F.E. electronic box is considered to be a rigid mass attached at four points and having the dimensions, mass-c.g. characteristics shown in Figure 4.

The H.F.E. probe box is not considered as part of the dynamics model since it is attached very close to the input or LEM attachment points and is relatively small in mass.

Structural support frame weight is lumped at four locations immediately below the electronics box attachments.

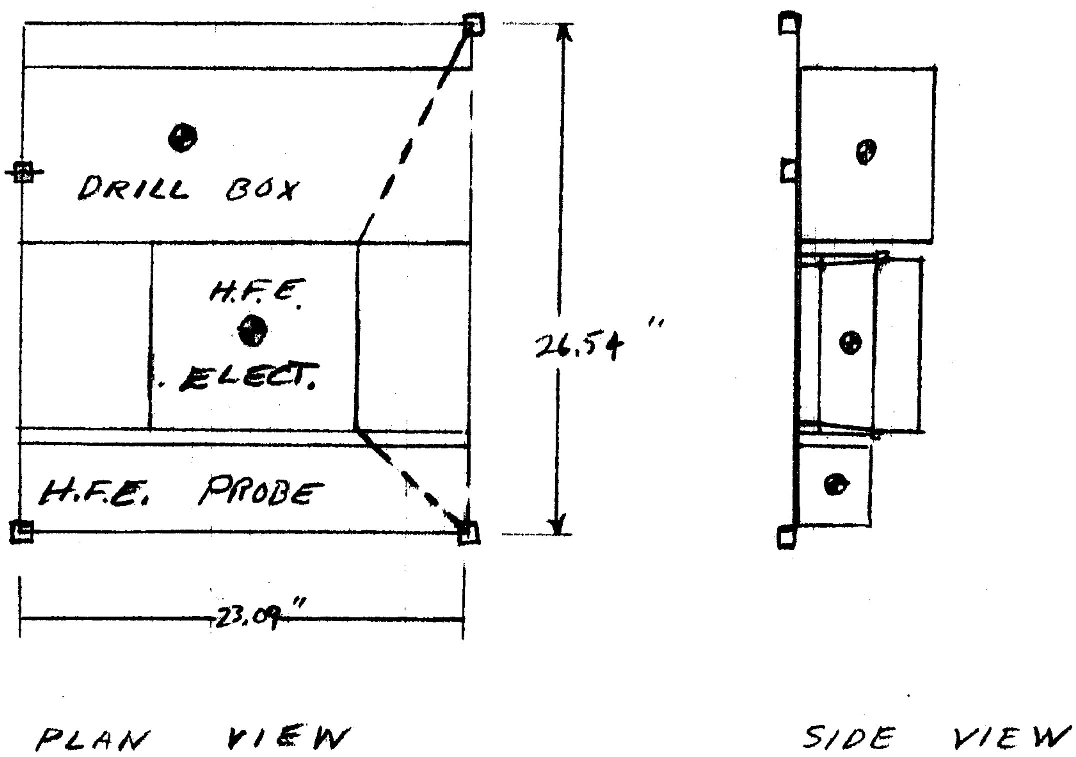
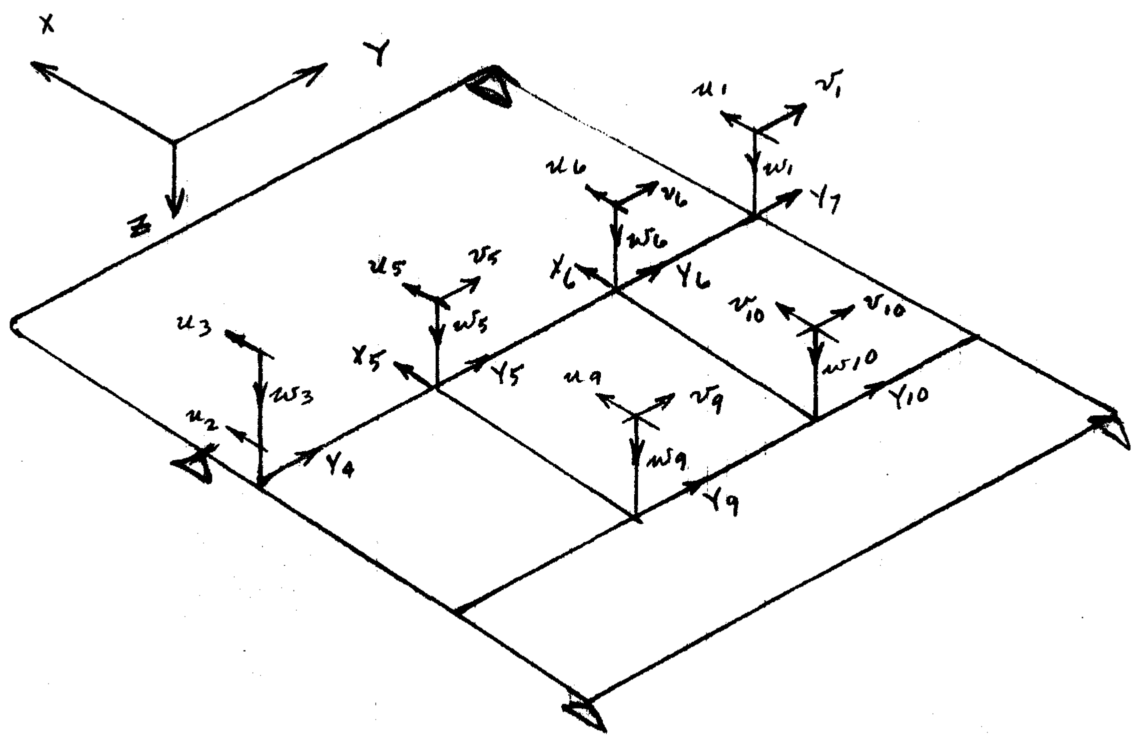


FIGURE 1

SUBPACK - 3

PYHYSICAL ARRANGEMENT



FRAME COORDINATE RELATIONS

$Z_4, Z_5, Z_6, Z_7, Z_9, Z_{10}$ SAME AS w_4, w_5, etc.

$Y_5 = Y_4 = Y_6 = Y_7$

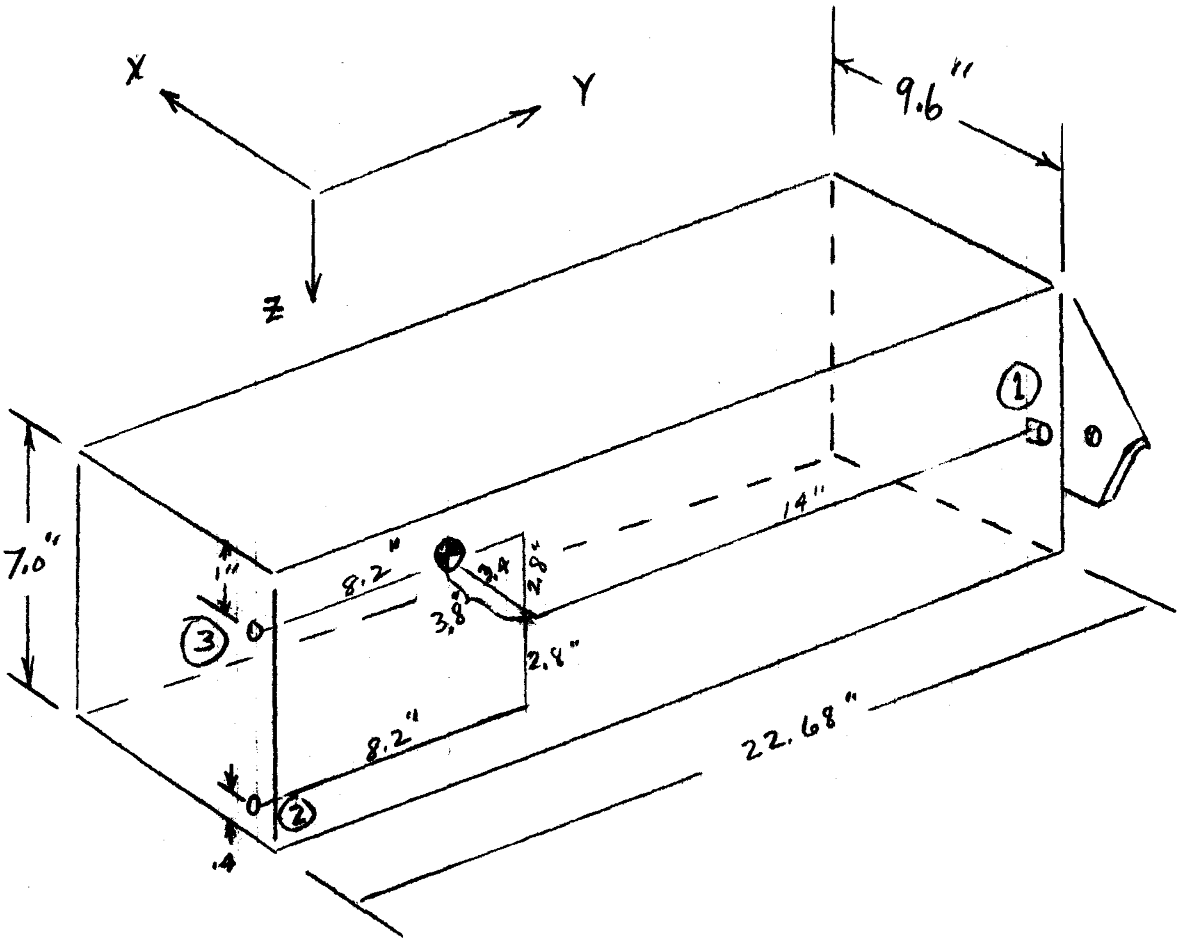
$Y_9 = Y_{10}$

$X_5 = X_9$

$X_6 = X_{10}$

FIGURE 2

COORDINATE SYSTEMS



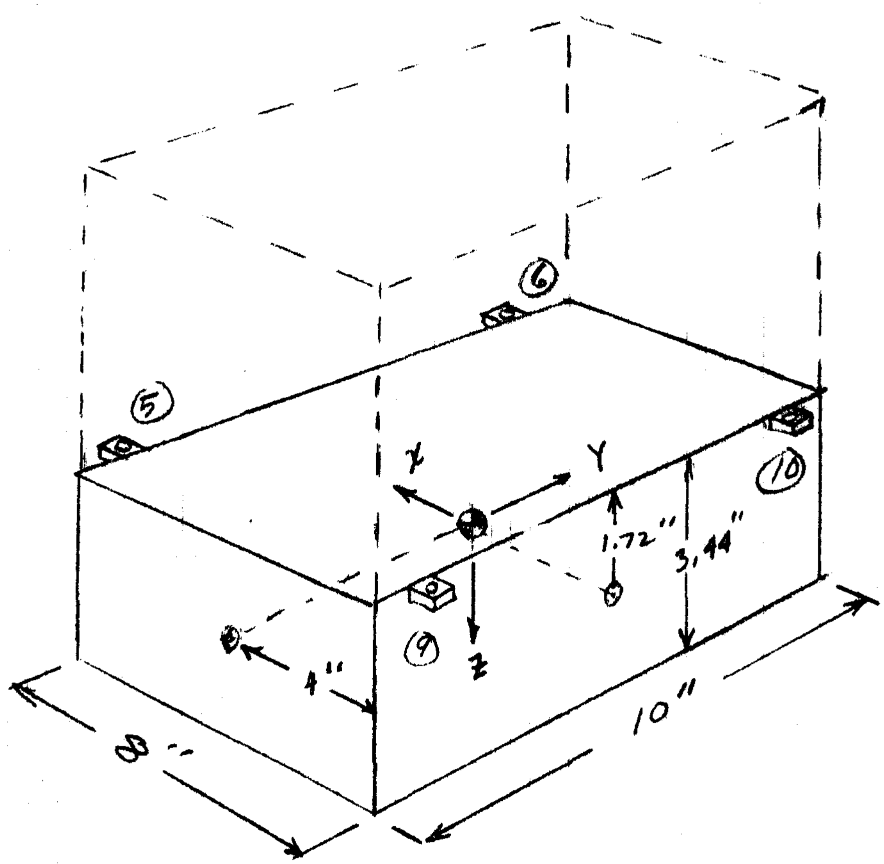
WEIGHT 30 LB.

I_x 3.65 lb-in-sec²

I_Y .915

I_Z 3.93

FIGURE 3 DRILL BOX



WEIGHT 6.6 LB.

$I_x = .159$

$I_y = .108$

$I_z = .234$

FIGURE 4 H.F.E. ELECTRONICS

Stiffness Matrix

The frame and experiment package attachment stiffness elements for use in the three-dimensional complete stiffness matrix were obtained mostly through the static structure analysis described in detail in Section II of this ATM.

There are 21 coordinates (and forces) associated with the unreduced stiffness matrix as follows:

TABLE 1

COORDINATES AND FORCES

Location	Coordinate	Forces
1	U3	F U3
2	U5 = U9	F U5 + F U9
3	V5 = V6	F V5 + F V6
4	U10 = U6	F U10 + F U6
5	V9 = V10	F V9 + F V10
6	U 1	F U1
7	V1	F V1
8	X5'	F X5'
9	X6'	F X6'
10	Y5'	F Y5'
11	Y9'	F Y9'
12	W3 = W4	F W3, W4
13	W5	F W5
14	W6	F W6
15	W1	F W1
16	W9	F W9
17	W10	F W10
18	X5	F X5
19	X6	F X6
20	Y5	F Y5
21	Y9	F Y9

Rigid body corner displacement relationships and attachment of the electronics box and drill package to the frame reduces the number of coordinates to 15 independent ones. This is defined by the matrix [B] and the following equation:

$$\{S\} = [B]\{q\}$$

where the vector $\{q\}$ is defined

$$\begin{Bmatrix} U1 \\ V1 \\ W1 \\ U3 \\ W3 \\ X5 \\ X6 \\ Y5 \\ Y9 \\ U5 \\ V5 \\ V9 \\ W6 \\ W10 \\ W5 \end{Bmatrix} = \{q\} = \begin{Bmatrix} q1 \\ q2 \\ q3 \\ q2 \\ q5 \\ q6 \\ q7 \\ q8 \\ q9 \\ q10 \\ q11 \\ q12 \\ q13 \\ q14 \\ q15 \end{Bmatrix}$$

See Figure 2 for coordinate direction and location. Subscript on q_i is computer program location number also.

The input matrices [K] and [B] are shown in Figures 5 and 6, and the reduced stiffness matrix [k] is shown in Figure 7. This is arrived at as follows:

$$[k] = [B]^T [K] [B] \qquad (1)$$

Mass Matrix

The mass matrix is formed to the 15 generalized coordinates by transforming the drill box six degrees of freedom to 5 by constraining the heavy end (U3, W3) to one translation and one rotation. Also the electronics box six degrees of freedom at the c.g. were transformed to six coordinates at the attachment points. Finally, the remaining four coordinates are the frame motion in the plane of the frame.

The mass matrix is shown in Figure 8.

ROW 1	0.3270000E 05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 2	0.0	0.7820000E 04	0.0	0.0	0.0	0.0	0.0	-0.7820000E 04
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 3	0.0	0.0	0.2670000E 05	0.0	0.0	0.0	0.0	0.0
	0.0	-0.2670000E 05	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 4	0.0	0.0	0.0	0.1666000E 05	0.0	0.0	0.0	0.0
	-0.1666000E 05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 5	0.0	0.0	0.0	0.0	0.2670000E 05	0.0	0.0	0.0
	0.0	0.0	-0.2670000E 05	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 6	0.0	0.0	0.0	0.0	0.0	0.8620000E 05	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 7	0.0	0.0	0.0	0.0	0.0	0.0	0.2045000E 05	0.0
	0.0	-0.2045000E 05	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 8	0.0	-0.7820000E 04	0.0	0.0	0.0	0.0	0.0	0.7820000E 04
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 9	0.0	0.0	0.0	-0.1666000E 05	0.0	0.0	0.0	0.0
	0.1666000E 05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 10	0.0	0.0	-0.2670000E 05	0.0	0.0	0.0	-0.2045000E 05	0.0
	0.0	0.4715000E 05	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 11	0.0	0.0	0.0	0.0	-0.2670000E 05	0.0	0.0	0.0
	0.0	0.0	0.2670000E 05	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0			
ROW 12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.1202800E 06	-0.2910400E 05	0.1507800E 05	-0.4744000E 04	-0.2960700E 05
	0.1503600E 05	0.0	0.0	0.0	0.0			
ROW 13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	-0.2910400E 05	0.5034800E 05	-0.3468700E 05	0.1250000E 05	-0.4000000E 02
	0.2180000E 03	0.0	0.0	0.0	0.0			
ROW 14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.1507800E 05	-0.3468700E 05	0.5013200E 05	-0.2288600E 05	0.3012998E 03
	-0.6570000E 04	0.0	0.0	0.0	0.0			

FIGURE 5

```
ROW 15 0.0             0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.0          0.0         -0.4744000E 04 0.1250000E 05-0.2288600E 05 0.2795200E 05 0.2023000E 04
      -0.4086000E 04   0.0          0.0          0.0          0.0

ROW 16 0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.0          0.0         -0.2960700E 05-0.4000000E 03 0.30129[illegible]E 03 0.[illegible]E 04 0.3673500E 05
      -0.2665100E 05   0.0          0.0          0.0          0.0

ROW 17 0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.0          0.0          0.1503600E 05 0.2180000E 03-0.6570000E 04-0.4086000E 04-0.2665100E 05
       0.4936900E 05   0.0          0.0          0.0          0.0

ROW 18 0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.1656800E 05-0.4634098E 04 0.3608000E 04 0.3823000E 04

ROW 19 0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0            -0.4634098E 04 0.2152670E 06 0.6941400E 05-0.5107100E 05

ROW 20 0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.3608000E 04 0.6941400E 05 0.5151800E 05-0.1095200E 05

ROW 21 0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0             0.3823000E 04-0.5107100E 05-0.1095200E 05 0.1002400E 06
```

FIGURE 5 (CONTINUED)

B MATRIX

ROW 1	0.0	0.0	0.0	0.1000000E 01	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.1000000E 01	0.0	0.0	0.0	0.0	0.0	
ROW 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.1000000E 01	0.0	0.0	0.0	0.0	
ROW 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.1000000E 01	-0.7880000E 00	0.7880000E 00	0.0	0.0	0.0	
ROW 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.1000000E 01	0.0	0.0	0.0	
ROW 6	0.1000000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 7	0.0	0.1000000E 01	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 8	0.0	0.0	0.0	0.0	0.0	0.1000000E 01	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 9	0.0	0.0	0.0	0.0	0.0	0.0	0.1000000E 01	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1000000E 01
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.1000000E 01	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 12	0.0	0.0	0.0	0.0	0.1000000E 01	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.1000000E 01	
ROW 14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.1000000E 01	0.0	0.0	
ROW 15	0.0	0.0	0.1000000E 01	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	-0.1000000E 01	0.1000000E 01	0.1000000E 01	
ROW 17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.1000000E 01	0.0	
ROW 18	0.0	0.0	0.0	0.0	0.0	0.1000000E 01	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 19	0.0	0.0	0.0	0.0	0.0	0.0	0.1000000E 01	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1000000E 01
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ROW 21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.1000000E 01	0.0	0.0	0.0	0.0	0.0	0.0	

FIGURE 6

STIFFNESS MATRIX* 0.1000000D-03

1	0.86200D 01	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
2	0.0	0.20450D 01	0.0	0.0	0.0	0.0
	0.0	-0.20450D 01	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
3	0.0	0.0	0.27952D 01	0.0	-0.47440D 00	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	-0.24909D 01	-0.20630D 00	0.14523D 01			
4	0.0	0.0	0.0	0.32700D 01	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
5	0.0	0.0	-0.47440D 00	0.0	0.12028D 02	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.44685D 01	-0.14571D 01	-0.58711D 01			
6	0.0	0.0	0.0	0.0	0.0	0.26388D 01
	-0.46341D 00	0.36080D 00	0.38230D 00	-0.78200D 00	0.0	0.0
	0.0	0.0	0.0			
7	0.0	0.0	0.0	0.0	0.0	-0.46341D 00
	0.23193D 02	0.69414D 01	-0.51071D 01	-0.16660D 01	0.13128D 01	-0.13128D 01
	0.0	0.0	0.0			
8	0.0	-0.20450D 01	0.0	0.0	0.0	0.36080D 00
	0.69414D 01	0.96680D 01	-0.10952D 01	0.0	-0.26700D 01	0.0
	0.0	0.0	0.0			
9	0.0	0.0	0.0	0.0	0.0	0.38230D 00
	-0.51071D 01	-0.10952D 01	0.12694D 02	0.0	0.0	-0.26700D 01
	0.0	0.0	0.0			
10	0.0	0.0	0.0	0.0	0.0	-0.78200D 00
	-0.16660D 01	0.0	0.0	0.24480D 01	-0.13128D 01	0.13128D 01
	0.0	0.0	0.0			
11	0.0	0.0	0.0	0.0	0.0	0.0
	0.13128D 01	-0.26700D 01	0.0	-0.13128D 01	0.37045D 01	-0.10345D 01
	0.0	0.0	0.0			
12	0.0	0.0	0.0	0.0	0.0	0.0
	-0.13128D 01	0.0	-0.26700D 01	0.13128D 01	-0.10345D 01	0.37045D 01
	0.0	0.0	0.0			
13	0.0	0.0	-0.24909D 01	0.0	0.44685D 01	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.56264D 01	-0.16353D 01	-0.71081D 01			
14	0.0	0.0	-0.20630D 00	0.0	-0.14571D 01	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	-0.16353D 01	0.32802D 01	0.10262D 01			
15	0.0	0.0	0.14523D 01	0.0	-0.58711D 01	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	-0.71081D 01	0.10262D 01	0.87003D 01			

FIGURE 7

MASS M[illegible]IX

1	0.20850D-01	-0.13300D-01	0.0	0.11180D-01	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
2	-0.13300D-01	0.77700D-01	0.0	0.19050D-01	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
3	0.0	0.0	0.18000D-01	-0.16140D-01	0.10680D-01	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
4	0.11180D-01	0.19050D-01	-0.16140D-01	0.12920D 00	-0.26400D-01	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
5	0.0	0.0	0.10680D-01	-0.26400D-01	0.38400D-01	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
6	0.0	0.0	0.0	0.0	0.0	0.25900D-02
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
7	0.0	0.0	0.0	0.0	0.0	0.0
	0.25900D-02	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
8	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.32400D-02	0.0	0.0	0.0	0.0
	0.0	0.0	0.0			
9	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.32400D-02	0.0	0.0	0.0
	0.0	0.0	0.0			
10	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.17090D-01	-0.68360D-02	0.68360D-02
	-0.33630D-02	0.36300D-02	0.0			
11	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	-0.68360D-02	0.10060D-01	-0.15190D-02
	-0.75670D-03	-0.13450D-02	0.21020D-02			
12	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.68360D-02	-0.15190D-02	0.10060D-01
	-0.34470D-02	0.13450D-02	0.21020D-02			
13	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	-0.33630D-02	-0.75670D-03	-0.34470D-02
	0.59840D-02	-0.27460D-02	-0.32380D-02			
14	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.36300D-02	-0.13450D-02	0.13450D-02
	-0.27460D-02	0.70190D-02	0.42730D-02			
15	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.21020D-02	0.21020D-02
	-0.32380D-02	0.42730D-02	0.75106D-02			

FIGURE 8

3.0 COMPUTED RESPONSES

A normal mode analysis was performed using the stiffness and mass matrices of Figures 7 and 8 to obtain the natural frequencies and mode shapes given in Figure 9.

Then, using an assumed damping factor of 10% of critical, the responses to sine and random base motion inputs at selected locations were computed by summing the responses of the normal modes. The sine input is shown in Figure 10 and the random inputs are shown in Figure 11. The higher curve of Figure 11 is the latest assessment of the environment in QUAD III. The analysis was also performed for the lower levels of QUAD I.

MODE 1	MODE 2	MODE 3	MODE 4
EIGENVALUE= 0.71298D-05	EIGENVALUE= 0.39166D-05	EIGENVALUE= 0.10666D-05	EIGENVALUE= 0.92789D-06
FREQUENCY= 0.59605D 02	FREQUENCY= 0.80421D 02	FREQUENCY= 0.15411D 03	FREQUENCY= 0.16522D 03
EIGENVECTOR	EIGENVECTOR	EIGENVECTOR	EIGENVECTOR
-0.12855D-01	0.57923D-01	0.45260D-01	0.89281D-02
0.10000D 01	-0.53893D 00	-0.55288D-01	0.51616D-02
-0.30794D-01	-0.34204D 00	0.10000D 01	0.22747D 00
0.18827D 00	0.10000D 01	0.22203D 00	0.53366D-01
-0.86456D-02	-0.11252D 00	0.16117D 00	0.68273D-01
-0.61164D-01	0.35987D-01	-0.11130D 00	0.36067D 00
-0.15393D 00	0.86140D-01	-0.14141D-01	0.61246D-01
0.44078D 00	-0.24433D 00	-0.24652D-01	-0.63295D-01
-0.17516D-01	0.93065D-02	-0.19714D-02	-0.22416D-01
0.82470D-01	-0.37546D-01	-0.34498D 00	0.10000D 01
0.42138D 00	-0.23925D 00	-0.95110D-01	0.44290D-01
0.21894D-01	-0.15291D-01	0.12076D-01	-0.18145D 00
-0.18921D-01	-0.22132D 00	0.76215D 00	0.89316D-01
-0.12504D-01	-0.12990D 00	0.40395D 00	0.23293D 00
-0.13461D-01	-0.18761D 00	0.56866D 00	0.64801D-01

MODE 5	MODE 6	MODE 7	MODE 8
EIGENVALUE= 0.53209D-06	EIGENVALUE= 0.40500D-06	EIGENVALUE= 0.28393D-06	EIGENVALUE= 0.24862D-06
FREQUENCY= 0.21819D 03	FREQUENCY= 0.25009D 03	FREQUENCY= 0.29868D 03	FREQUENCY= 0.31919D 03
EIGENVECTOR	EIGENVECTOR	EIGENVECTOR	EIGENVECTOR
0.57596D-01	0.24552D-01	-0.27571D-01	-0.31313D 00
-0.64071D-01	-0.37166D-01	0.20440D-01	-0.34079D-01
-0.41541D 00	0.68341D 00	0.64118D-01	0.41067D-01
0.52665D-01	-0.13332D-01	0.15375D-01	-0.62775D-01
0.45515D 00	-0.49545D 00	0.33709D-01	-0.47380D 00
-0.83358D-01	0.10273D-01	-0.20584D 00	-0.53938D-01
-0.89732D-01	-0.96926D-01	0.23632D 00	0.46944D-01
0.37162D 00	0.38158D 00	-0.35666D 00	-0.25785D-01
0.15947D 00	0.11030D 00	0.30763D 00	0.11059D 00
0.73194D-01	0.31367D 00	-0.61331D 00	-0.95912D-01
0.10000D 01	0.10000D 01	-0.72626D 00	0.18534D-01
0.72909D 00	0.52168D 00	0.10000D 01	0.38465D 00
0.52947D-02	-0.19283D 00	-0.18677D 00	0.10000D 01
0.22650D 00	-0.42731D 00	-0.12025D 00	0.83206D 00
0.54090D 00	-0.63542D 00	-0.14281D 00	0.68344D 00

FIGURE 9. FREQUENCIES AND MODE SHAPES

MODE 9	MODE 10	MODE 11	MODE 12
EIGENVALUE= 0.18271D-06	EIGENVALUE= 0.10880D-06	EIGENVALUE= 0.91579D-07	EIGENVALUE= 0.43307D-07
FREQUENCY= 0.37234D 03	FREQUENCY= 0.48251D 03	FREQUENCY= 0.52592D 03	FREQUENCY= 0.76479D 03
EIGENVECTOR	EIGENVECTOR	EIGENVECTOR	EIGENVECTOR
0.10000D 01	0.13618D-01	0.46285D-02	-0.16074D-01
0.22618D 00	0.78060D-02	0.38876D-02	-0.15767D-01
-0.10566D 00	-0.64346D-01	0.51960D-01	-0.18287D-01
-0.18713D 00	-0.46881D-02	-0.97110D-03	0.58552D-02
-0.22217D 00	0.28427D-01	-0.31558D-01	0.21338D-01
-0.67549D-01	0.10000D 01	0.10000D 01	0.17926D 00
0.33557D-02	0.93559D-01	0.34512D-01	-0.42367D 00
0.36327D-01	-0.14322D 00	-0.11322D 00	0.10000D 01
0.39005D-01	0.11522D-01	-0.21371D-01	-0.13601D 00
-0.71652D-01	0.21440D 00	-0.32528D 00	-0.12008D 00
-0.82227D-01	0.88055D-02	-0.29312D-01	-0.19043D 00
0.12855D 00	0.64899D-01	0.50327D-01	0.16035D 00
0.25035D 00	0.61982D 00	-0.52527D 00	0.10069D 00
0.24711D 00	-0.64251D 00	0.50848D 00	0.85586D-01
0.12256D 00	0.61196D 00	-0.47742D 00	-0.83918D-01

MODE 13	MODE 14	MODE 15
EIGENVALUE= 0.30035D-07	EIGENVALUE= 0.25201D-07	EIGENVALUE= 0.97061D-08
FREQUENCY= 0.91835D 03	FREQUENCY= 0.10026D 04	FREQUENCY= 0.16155D 04
EIGENVECTOR	EIGENVECTOR	EIGENVECTOR
-0.55040D-02	0.25910D-02	-0.60340D-03
-0.32584D-02	-0.94378D-03	-0.98447D-03
-0.68186D-01	0.96897D-01	0.20660D-03
0.51138D-02	-0.54498D-02	0.26693D-03
0.61841D-01	-0.85324D-01	0.12478D-03
0.48129D-01	0.50894D-01	-0.18405D-01
0.27910D 00	0.17497D 00	0.10000D 01
0.13116D 00	0.40948D 00	0.30499D 00
0.10000D 01	0.10000D 01	-0.26352D 00
0.15660D-01	0.77024D-01	-0.14803D-01
0.26942D 00	-0.43665D 00	-0.25686D-02
0.13336D 00	-0.55607D 00	0.12152D-02
0.42720D 00	-0.76362D 00	-0.69232D-02
0.52508D 00	-0.86599D 00	0.92997D-02
-0.53008D 00	0.86379D 00	-0.68127D-02

FIGURE 9. (CONTINUED)

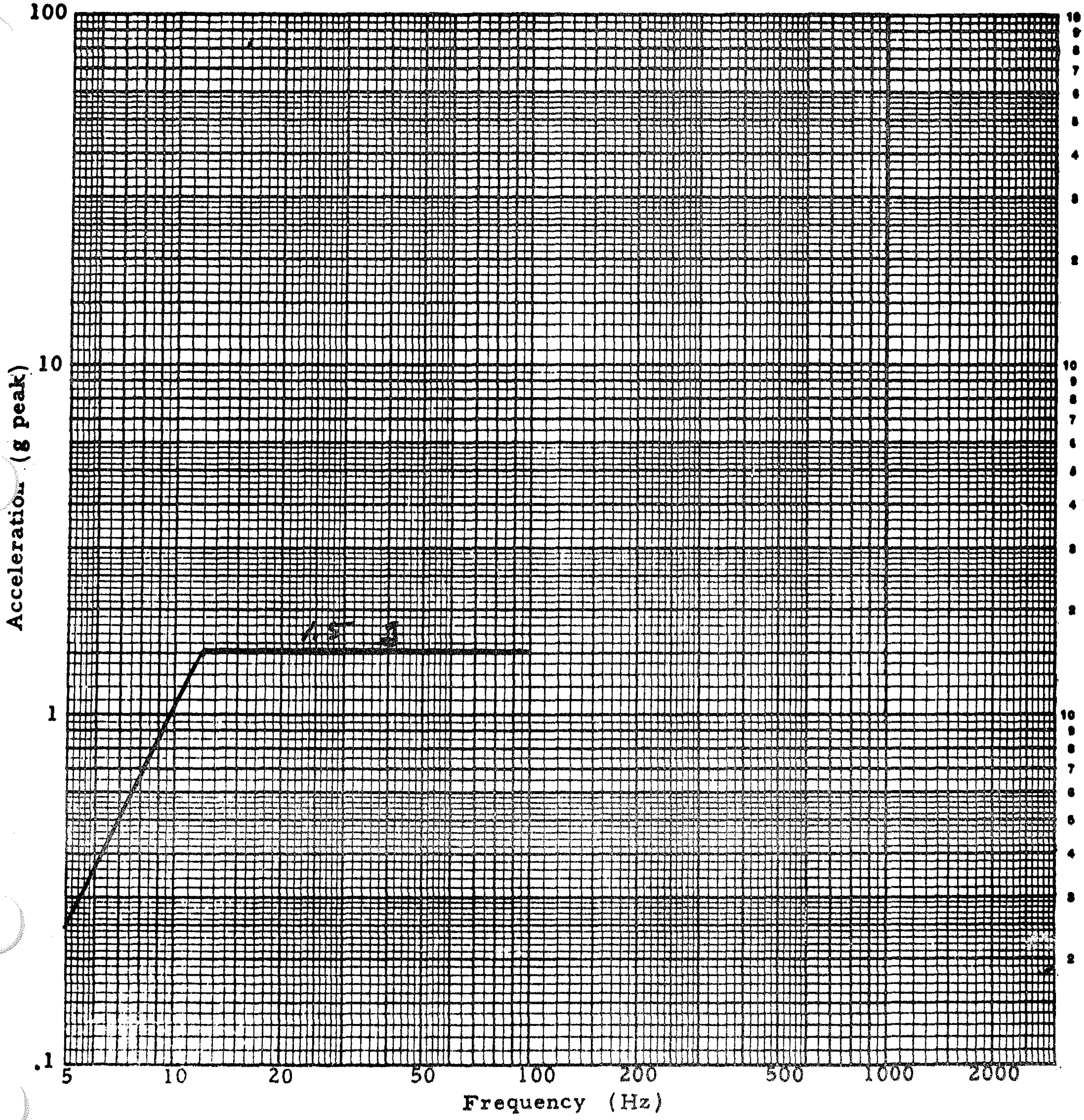
Bendix Aerospace Systems Division

Figure 10

SINUSOIDAL VIBRATION INPUT

Axis: X, Y, Z

Sweep Rate:



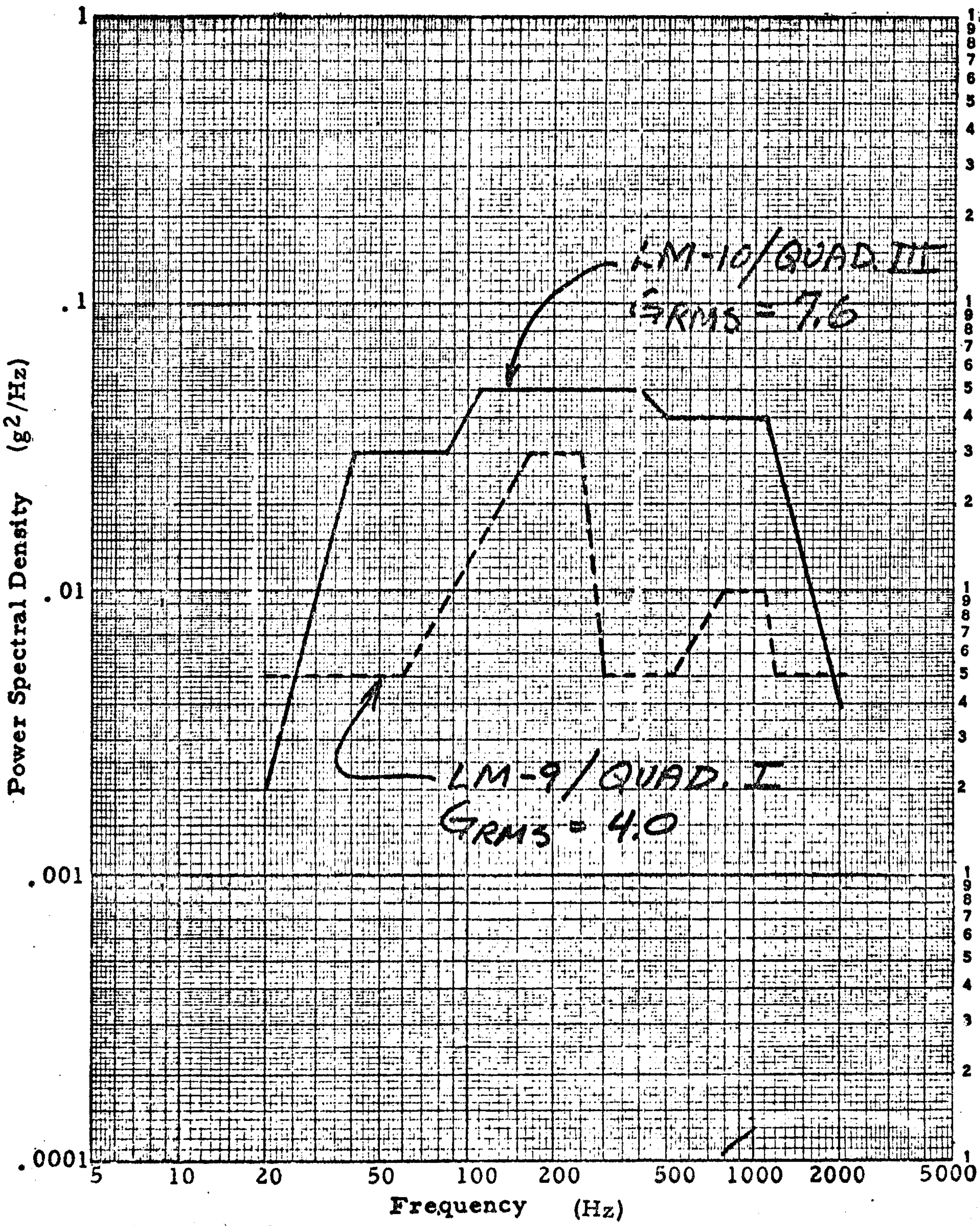
Bendix Aerospace Systems Division

SP-3 L&B

RANDOM VIBRATION SPECTRUM

Axis: x, y, z

Duration: 60 sec.



Figures 12 through 28 present the computed plots of transmissibility sine response and random response at selected locations having the largest overall response. The figures are in 3 or 4 parts depending on whether both QUAD I and QUAD III levels were calculated for the random response. If the words "New Levels" appear in the random response curve title, QUAD III levels were used as input.

A summary of all the computed overall rms values is given in Table 2. The maximum sine responses can be observed on the sine response curves. None of the calculations indicate levels higher than 8g peak (Figure 18 b) for the sine accelerations, therefore the most attention is paid to the random vibration results.

4.0 DYNAMIC LOADS

As discussed previously the flexibility and stiffness influence coefficients were developed for the support structure in the three axes of loading. These results were then incorporated into the three-dimensional program from which the reduced stiffness matrix is determined for use in the dynamics analysis program.

The computed accelerations and the redundant frame stiffness matrix provide all the necessary information for computing the dynamic loads at the attachment points and in the frame.

The three-dimensional stiffness matrix for the structural system is shown in Figure 5. This is a 21 x 21 matrix with the displacement coordinates shown in Table 1. The forces associated with these coordinates are in the corresponding direction and location in the 21 locations.

This stiffness matrix is reduced in size to correspond to the selected 15 generalized coordinates by the transformation

$$[k] = [B]^T [K] [B] \qquad (1)$$

where [B] is a 21 x 15 matrix relating the coordinates of Figure 5 to the 15 generalized coordinates. This is given in Figure 6.

The internal loads on the structure and the associated displacements can be determined from the following relations:

$$\{P\} = [K] [B] [k]^{-1} \{Q\} \qquad (2)$$

and

$$\{S\} = [B] [k]^{-1} \{Q\} \qquad (3)$$

where P_n is an internal load and S_n is the displacement.

$n = 1, 2, --- 21$

TABLE 2

OVERALL RESPONSES TO RANDOM EXCITATION G-RMS

Computer Location Number	Coordinate	X		Y		Z	
		(a)*	(b)*	(a)	(b)	(a)	(b)
1	U_4	5.50	11.2		.54		1.54
2	V_1		2.73		3.6		1.1
3	W_1		5.55		2.2	8.24	11.3
4	U_3	2.22	4.46		.88		3.1
5	$W_{3,4}$		3.74		1.76	4.02	6.05
6	X_5	4.64	9.0		2.10		1.02
7	X_6		11.5		3.07		.614
8	Y_5		3.87	4.84	5.98		1.96
9	Y_9		3.73	6.80	13.1		1.40
10	U_5	5.24	8.79		2.47		2.57
11	V_5		2.43	4.95	7.06		4.4
12	V_9		2.28	6.34	8.38		3.1
13	W_6	4.15	6.99		2.61	6.30	9.35
14	W_{10}	3.73	6.37		2.94	4.64	7.19
15	W_5		5.28		3.33	6.07	9.11

(a)* QUAD I environment excitation

(b)* QUAD III environment excitation

The next step is to compute the load vectors, $\{Q\}$, resulting in this case from the dynamics environment.

Calculation of Load Vectors

Random Loading

The expression for the load vectors, $\{Q\}$, for the random loading case is

$$[Q]^T \equiv [m]\,[A] \qquad (4)$$

where

$[m]$ = mass matrix (Figure 8)

$[A]$ = a diagonal matrix composed of the local rms acceleration computed with the dynamics analysis program, i.e., Table 2 type values multiplied by the acceleration of gravity.

When the $\{Q\}$ column vectors have been determined, they are applied to equations (2) and (3) to compute the internal loads and displacements at the attachment points and on the array. For the random case the rms internal loads and displacements are computed for each modal equation giving 15 sets of rms values at the 21 coordinate locations. Then for each location the 15-modal rms values are combined by taking the square root of the sum of the squares of the 15 values, thus reducing the number to 21 load and 21 displacement values.

Sinusoidal Loading

The load vectors, $\{Q\}$, are again formed by Equation (4), but real and imaginary steps are computed separately and combined into one load vector for each frequency where a maximum sine response occurs.

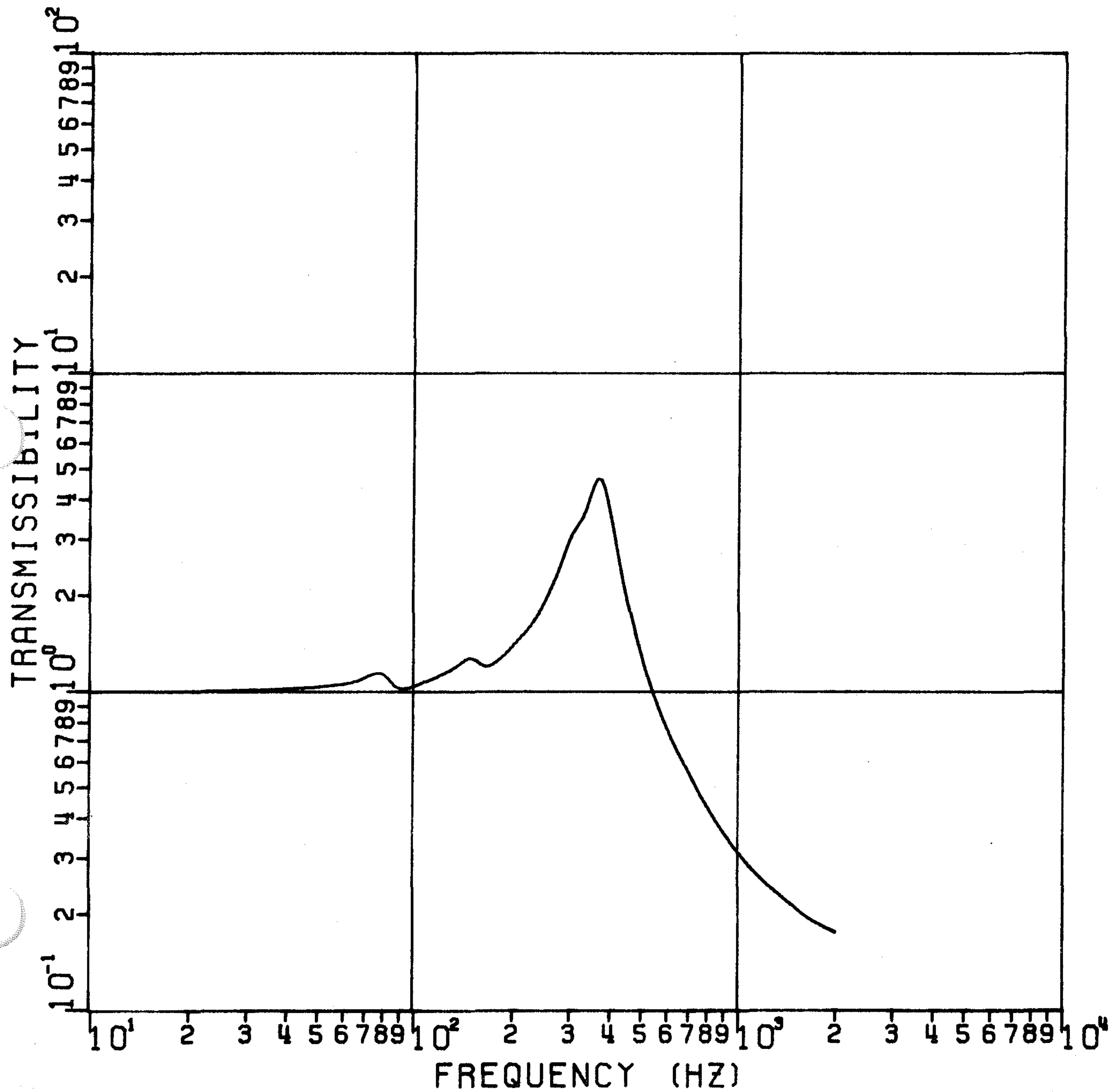
For the sinusoidal loading case there is only one $\{Q\}$ vector per frequency selected and each one will produce a set of internal loads and displacements.

Application of the foregoing procedure to the present structure results in the load and deflection sets due to the random excitation shown in Table 3. Loads due to sinusoidal excitation are all less than the 3-sigma random values obtained by multiplying the Table 3 loads by 3 and are therefore not shown.

1 X AXIS SUBPACK 3 SEP 1970

FIGURE 12 a TRANSMISSIBILITY

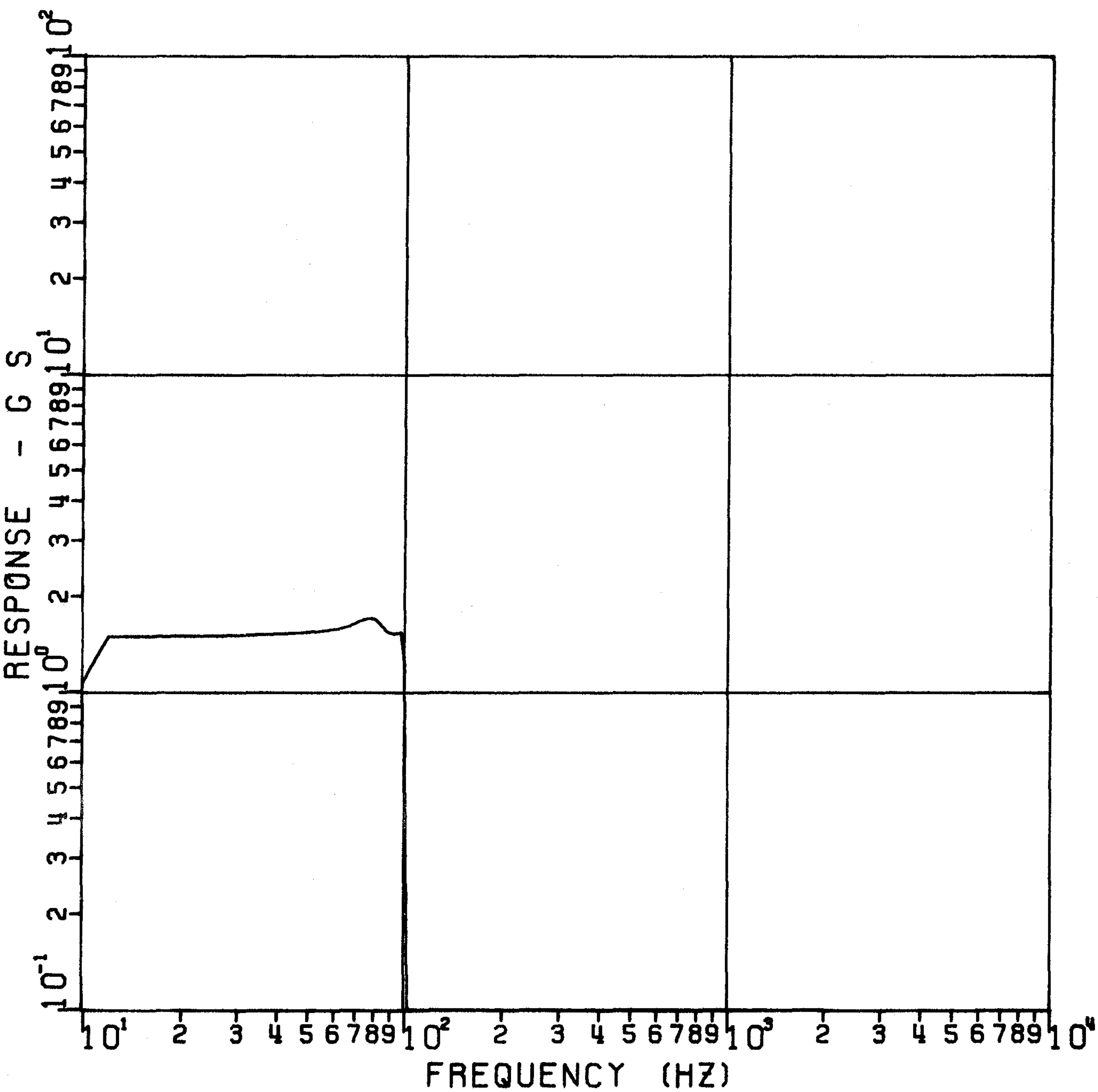
LOCATION 1 , u_1



1 X AXIS SUBPACK 3 SEP 1970

FIGURE 12 b SINE RESPONSE

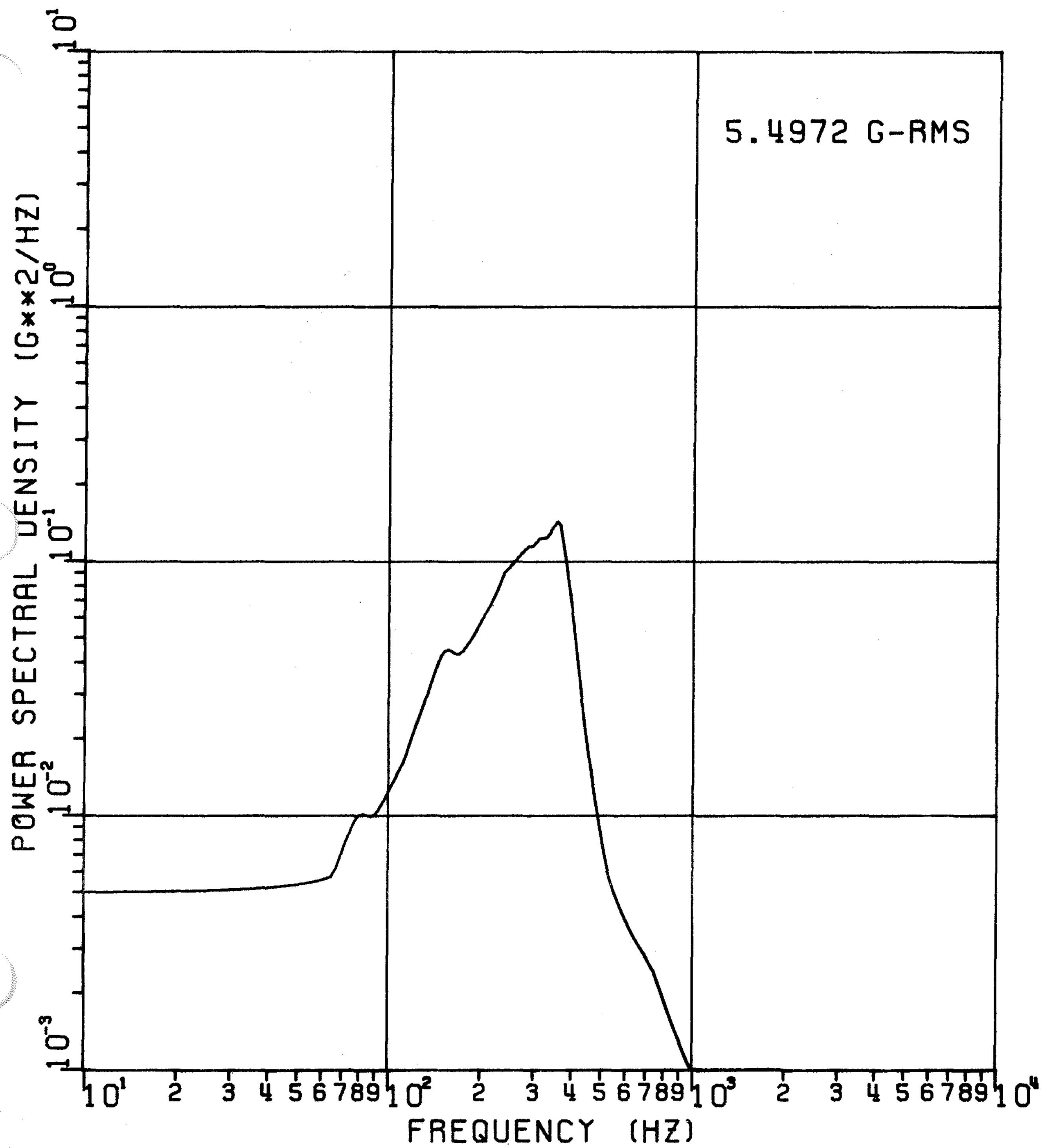
LOCATION 1



1 X AXIS SUBPACK 3 SEP 1970

FIGURE 12c RANDOM VIBRATION SPECTRUM

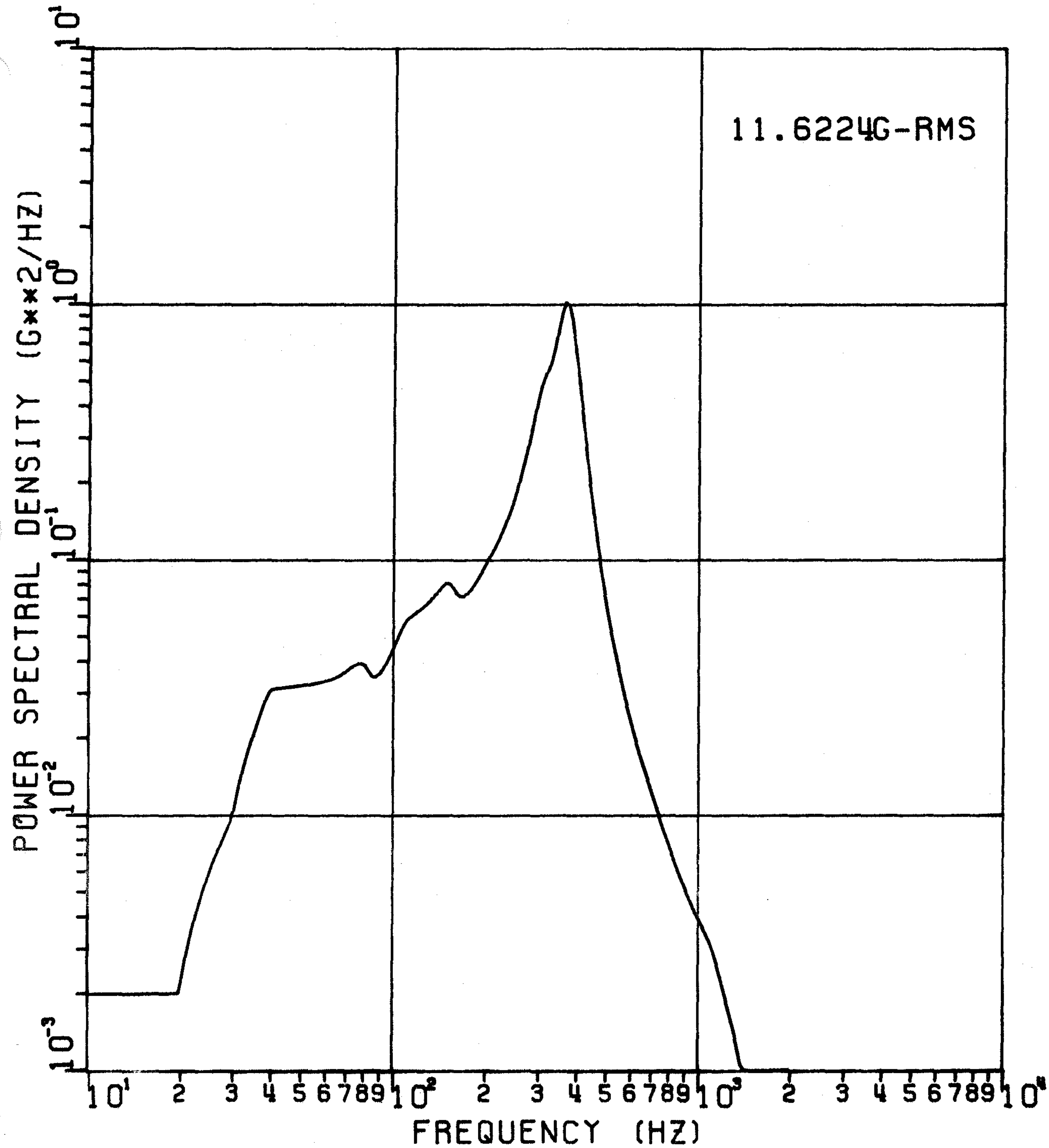
LOCATION 1



1 X AXIS SUBP. 3 SEP 70 NEW LEVELS

FIGURE 12 d RANDOM VIBRATION SPECTRUM

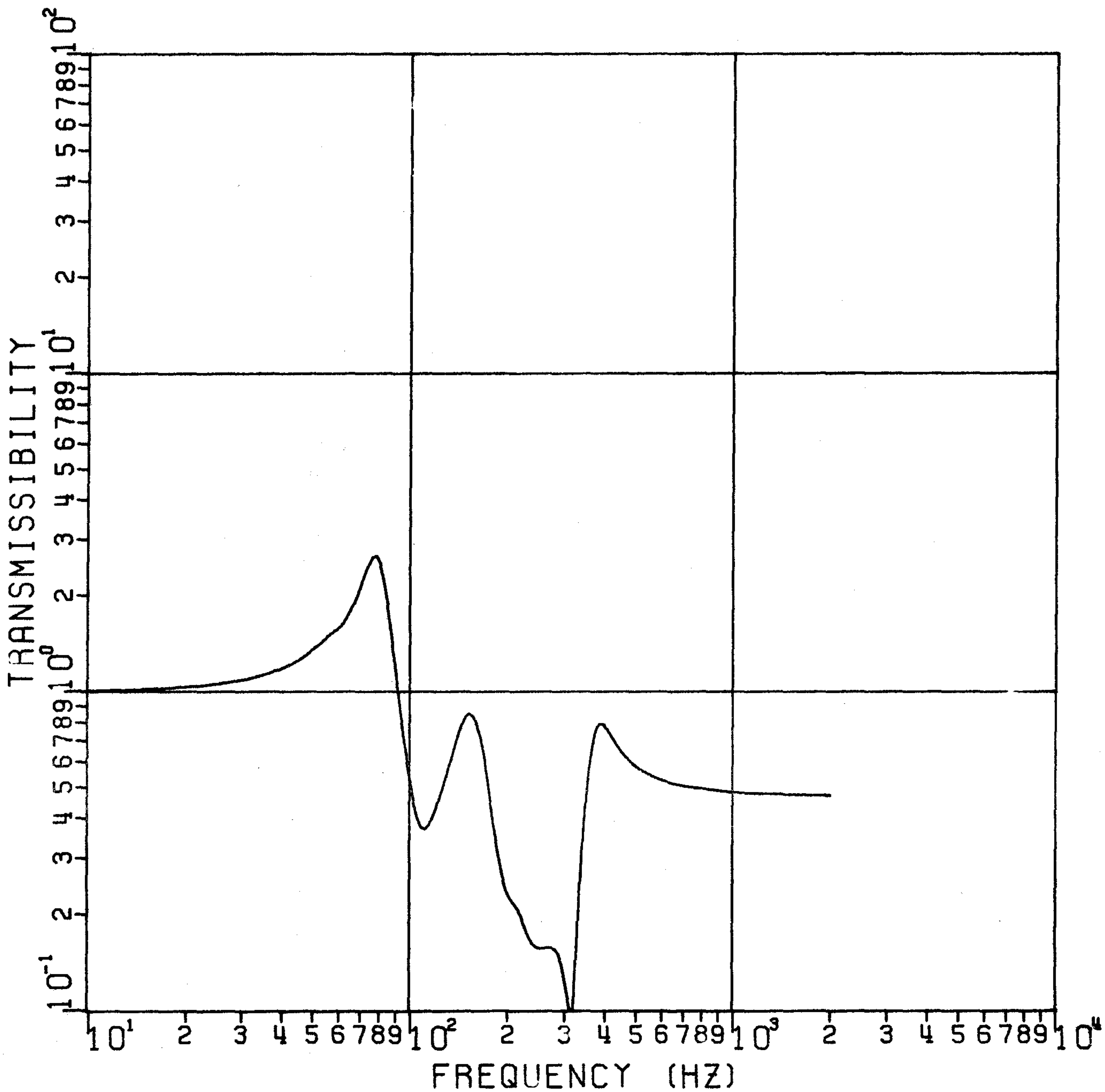
LOCATION 1



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 13a TRANSMISSIBILITY

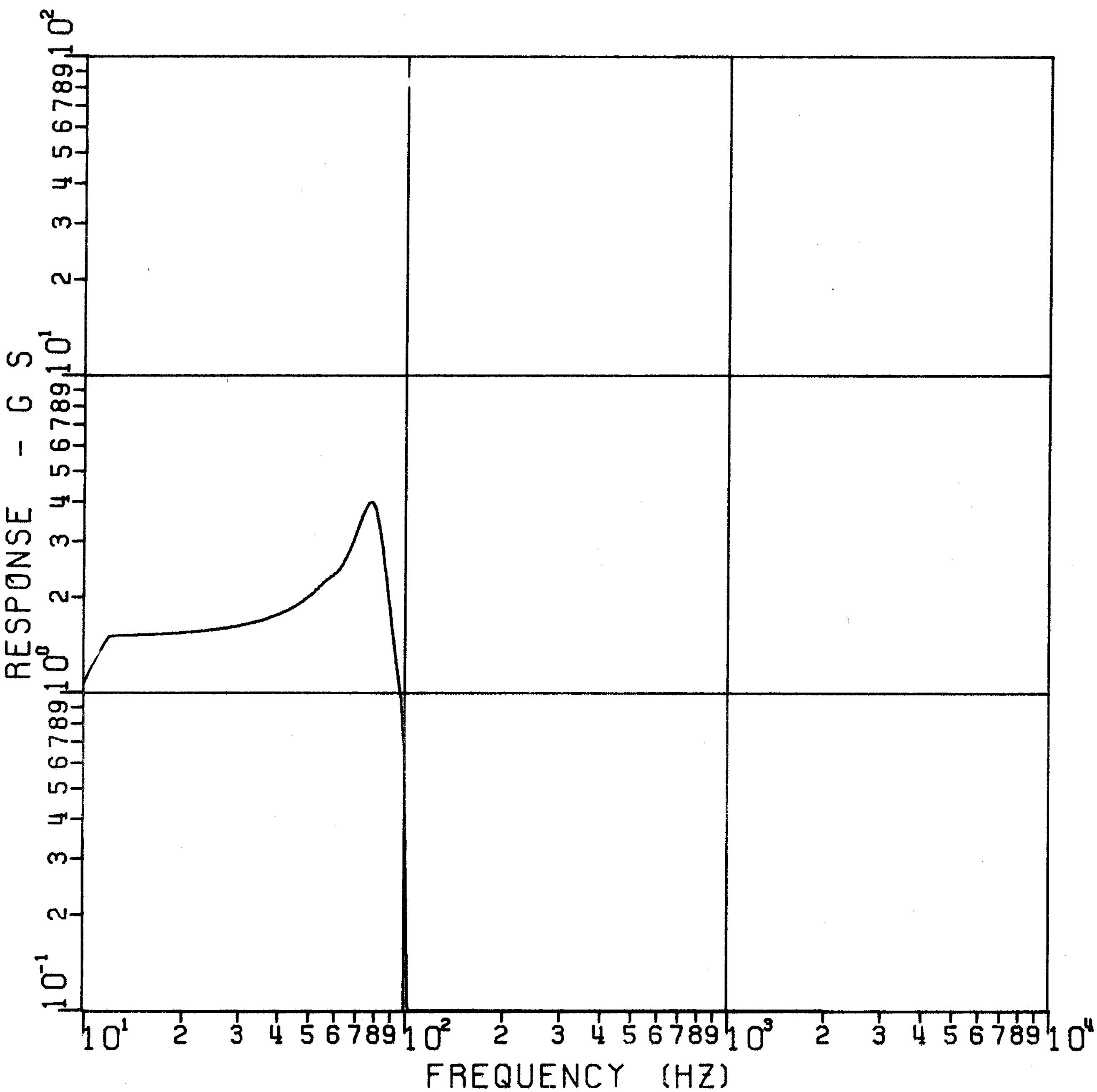
LOCATION 4



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 13b SINE RESPONSE

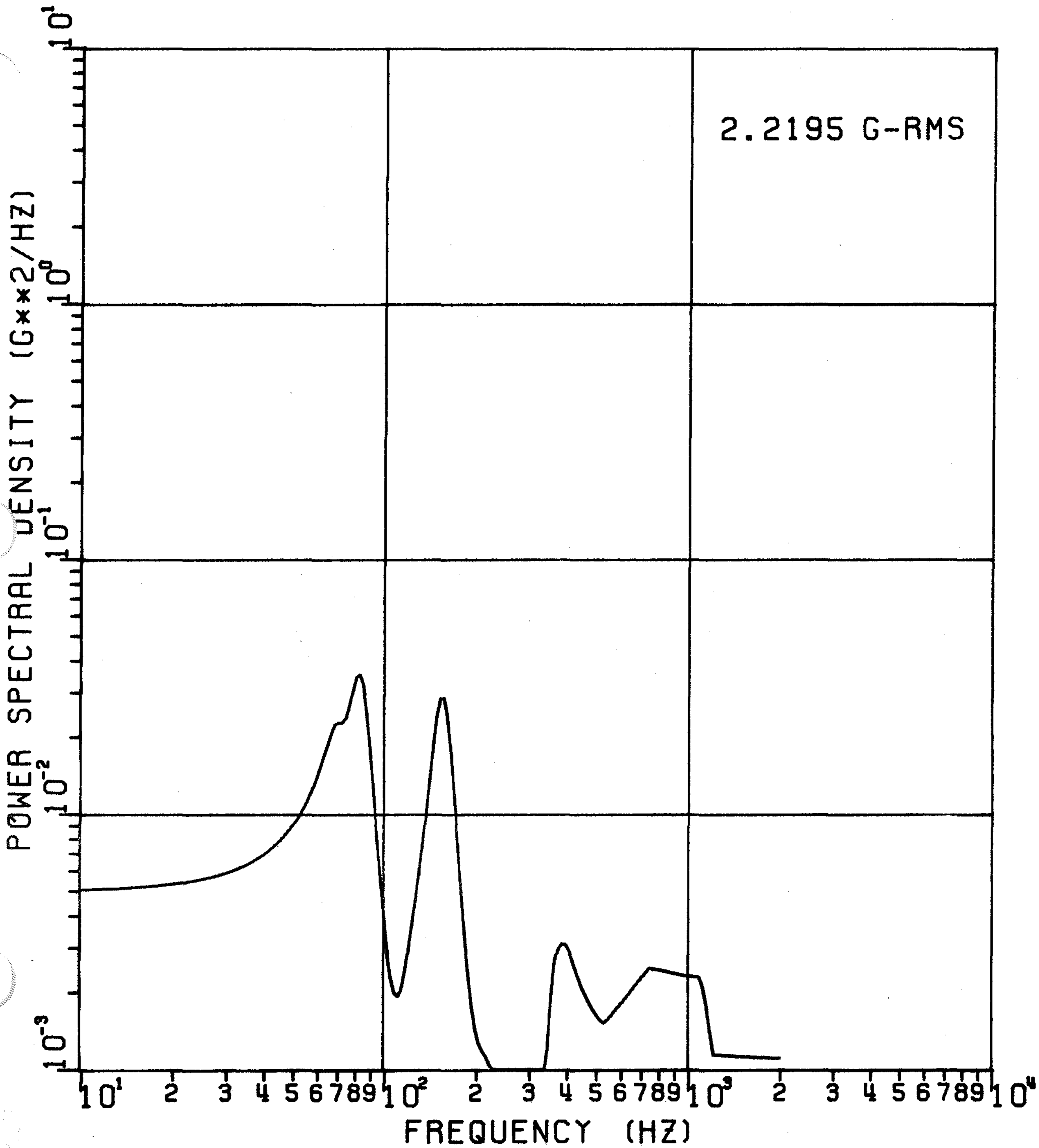
LOCATION 4



1 X AXIS SUBPACK 3 SEP 1970

FIGURE 13c RANDOM VIBRATION SPECTRUM

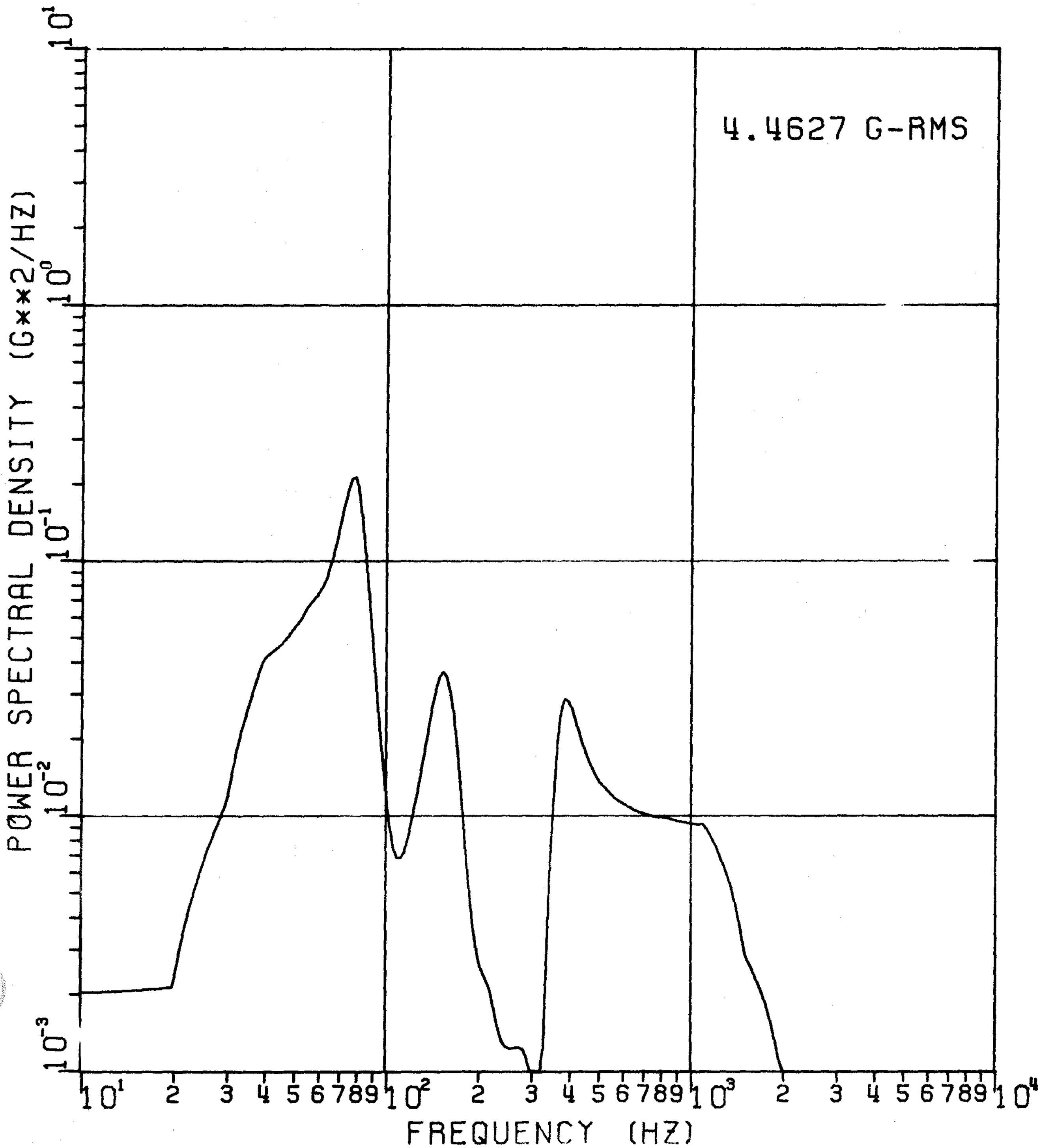
LOCATION 4



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 13 d RANDOM VIBRATION SPECTRUM

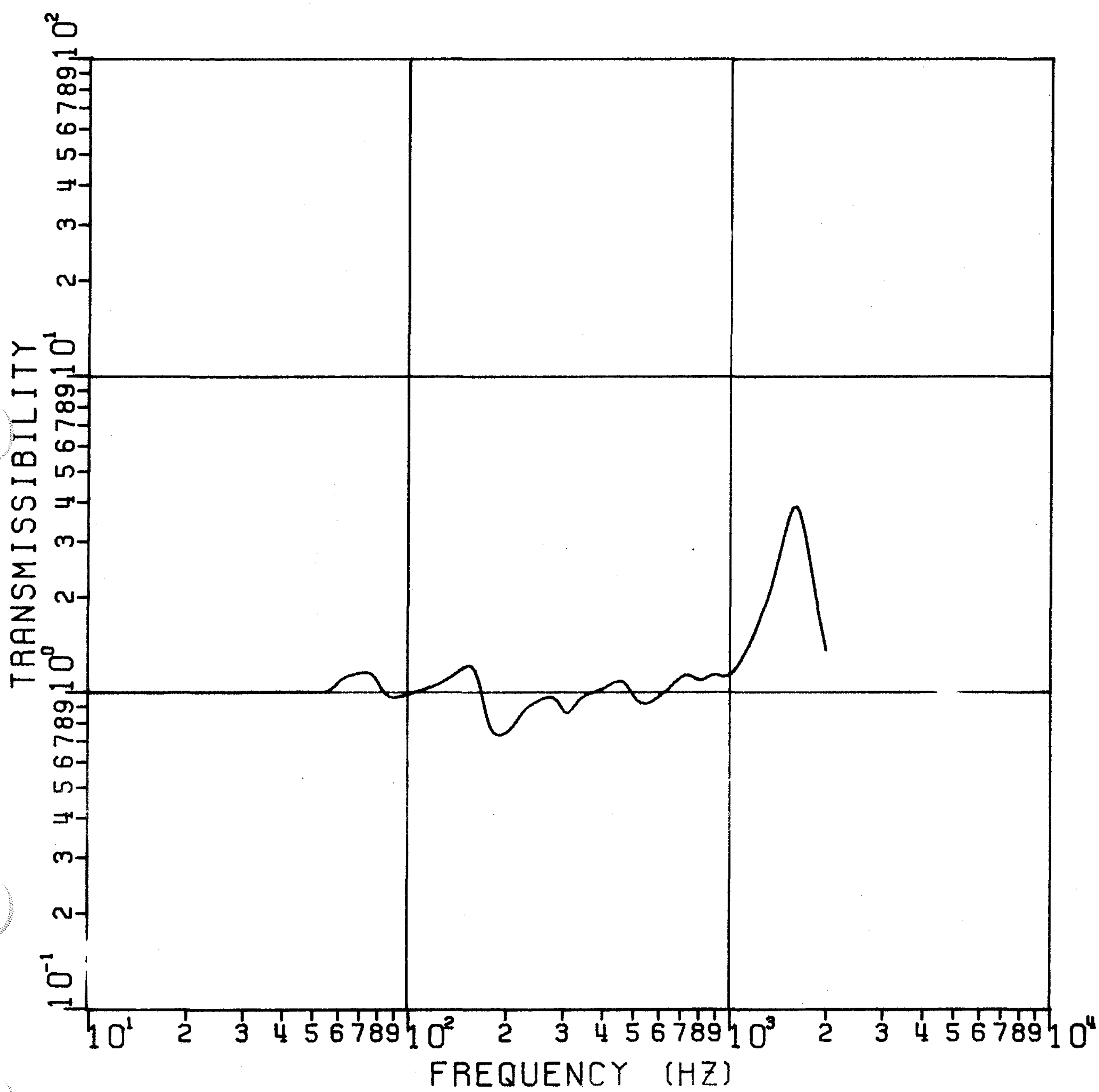
LOCATION 4



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 14a TRANSMISSIBILITY

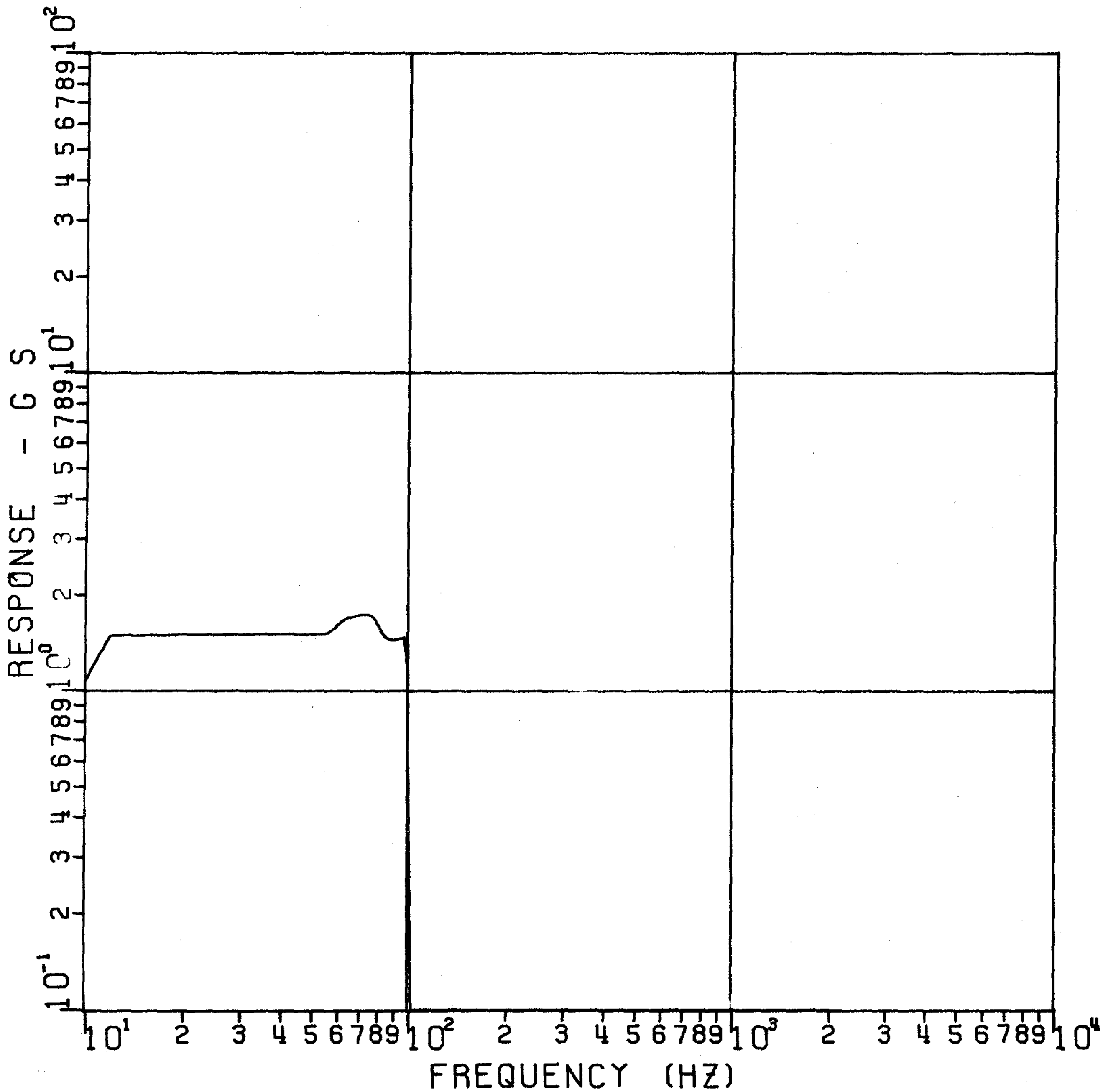
LOCATION 7



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 14b SINE RESPONSE

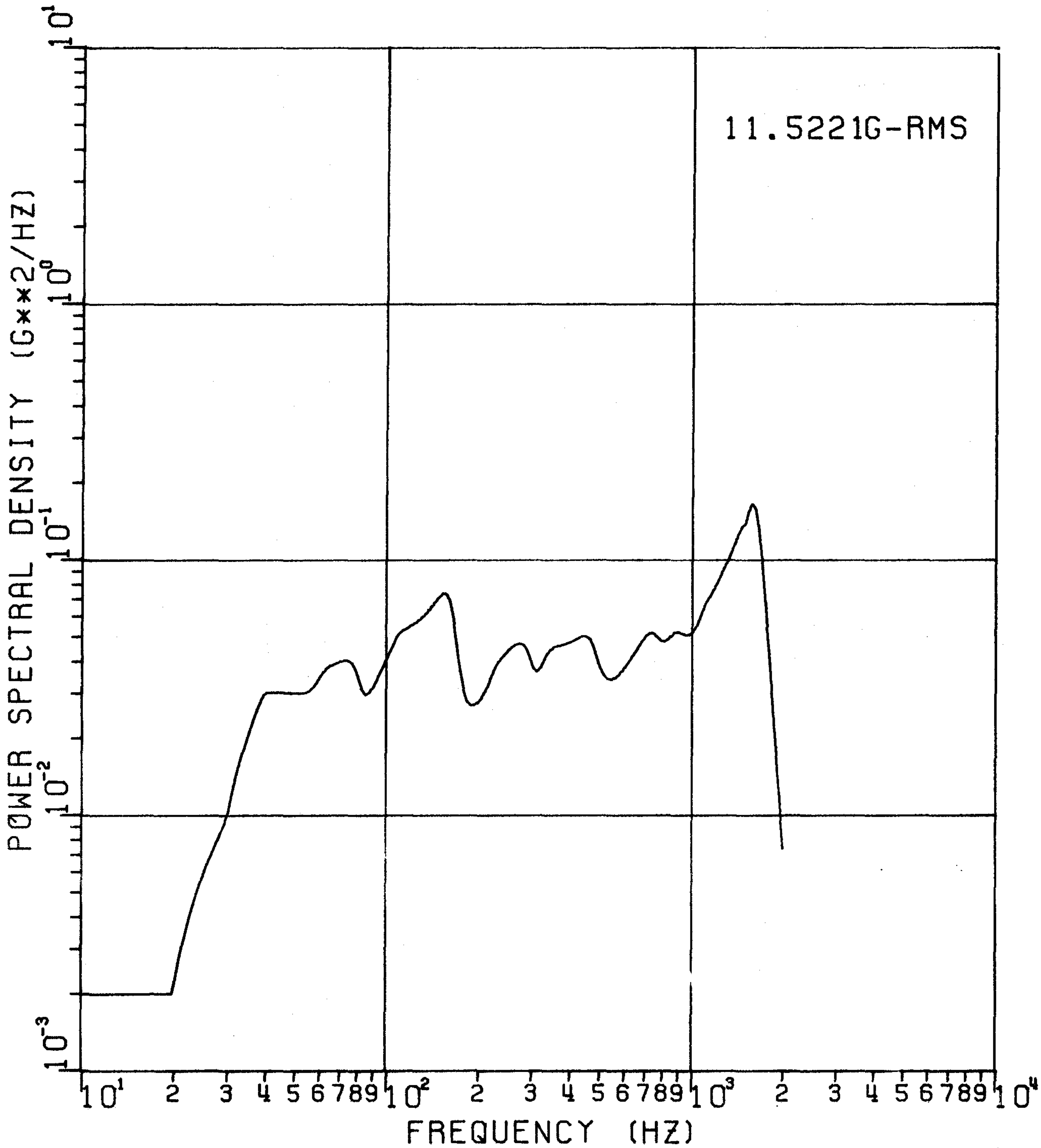
LOCATION 7



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 14C RANDOM VIBRATION SPECTRUM

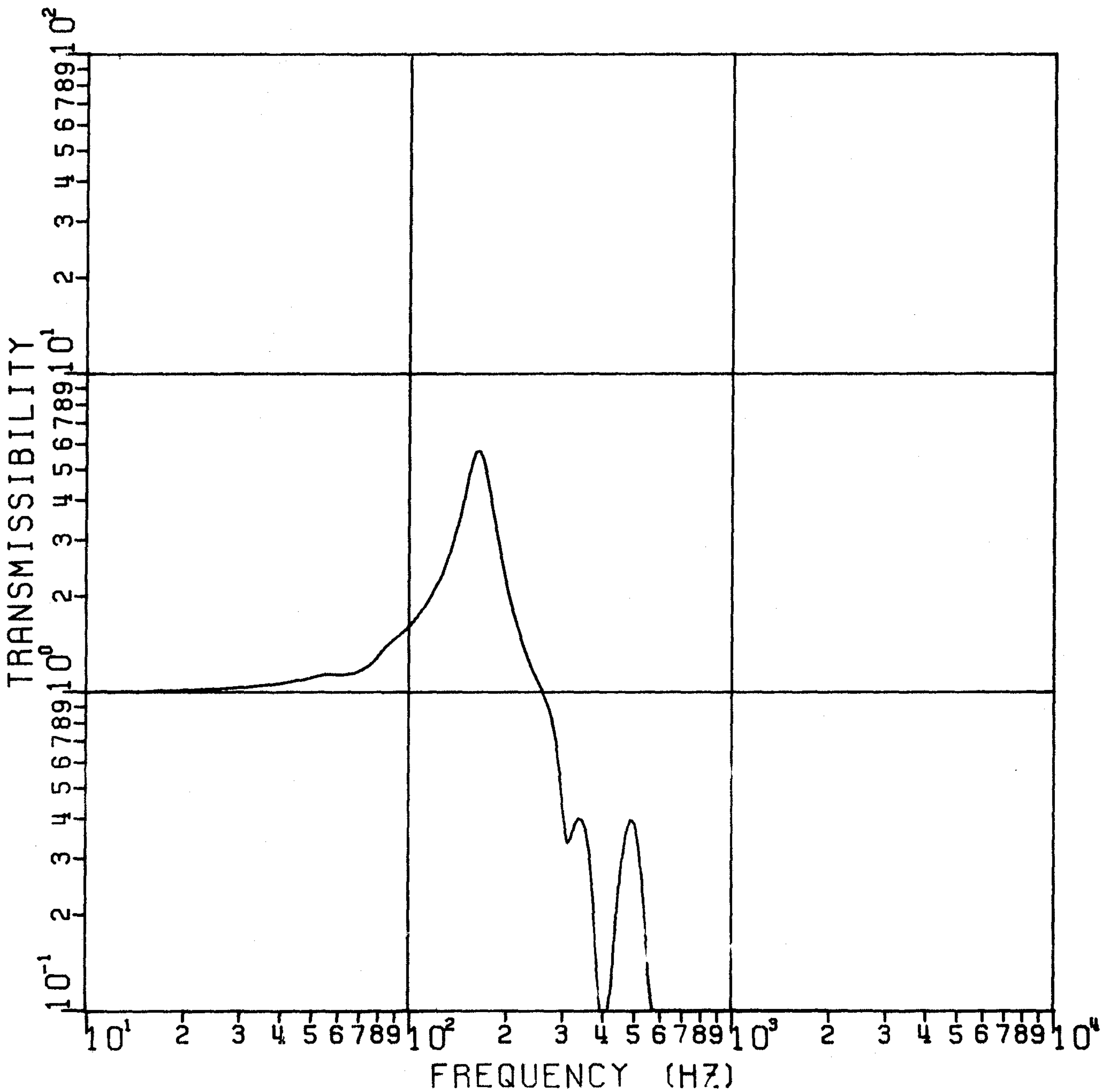
LOCATION 7



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 15a TRANSMISSIBILITY

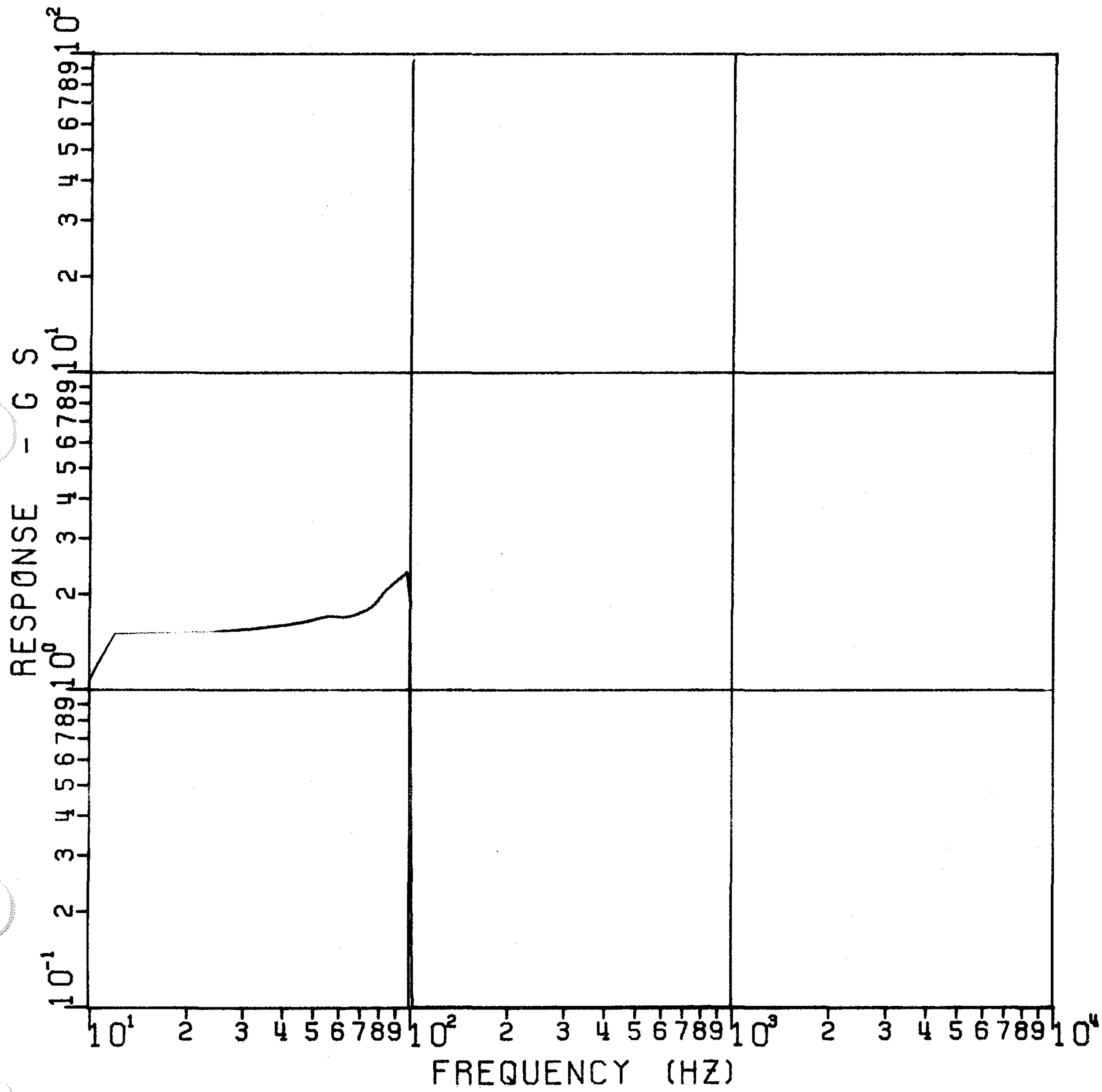
LOCATION 10



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 15b SINE RESPONSE

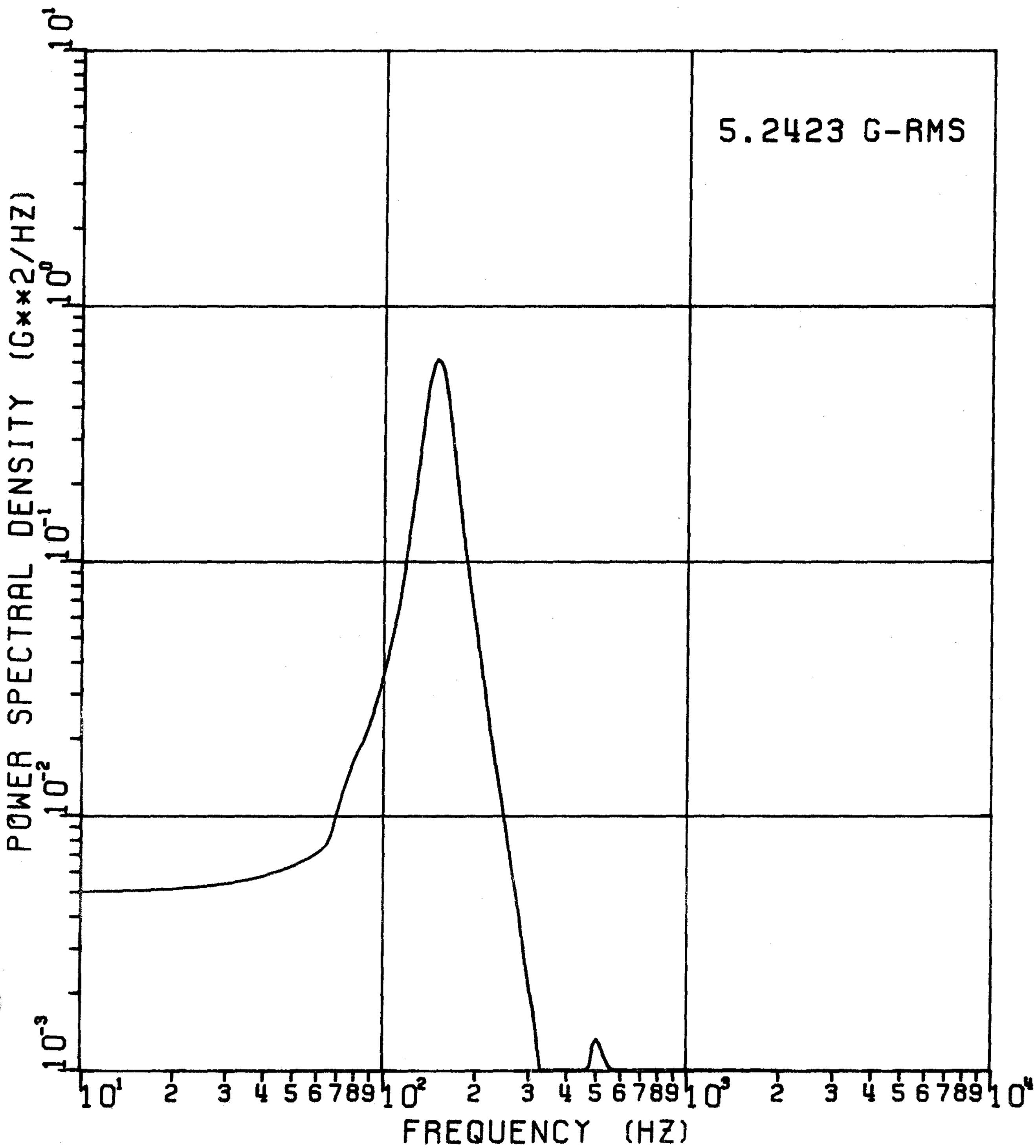
LOCATION 10



1 X AXIS SUBPACK 3 SEP 1970

FIGURE 15c RANDOM VIBRATION SPECTRUM

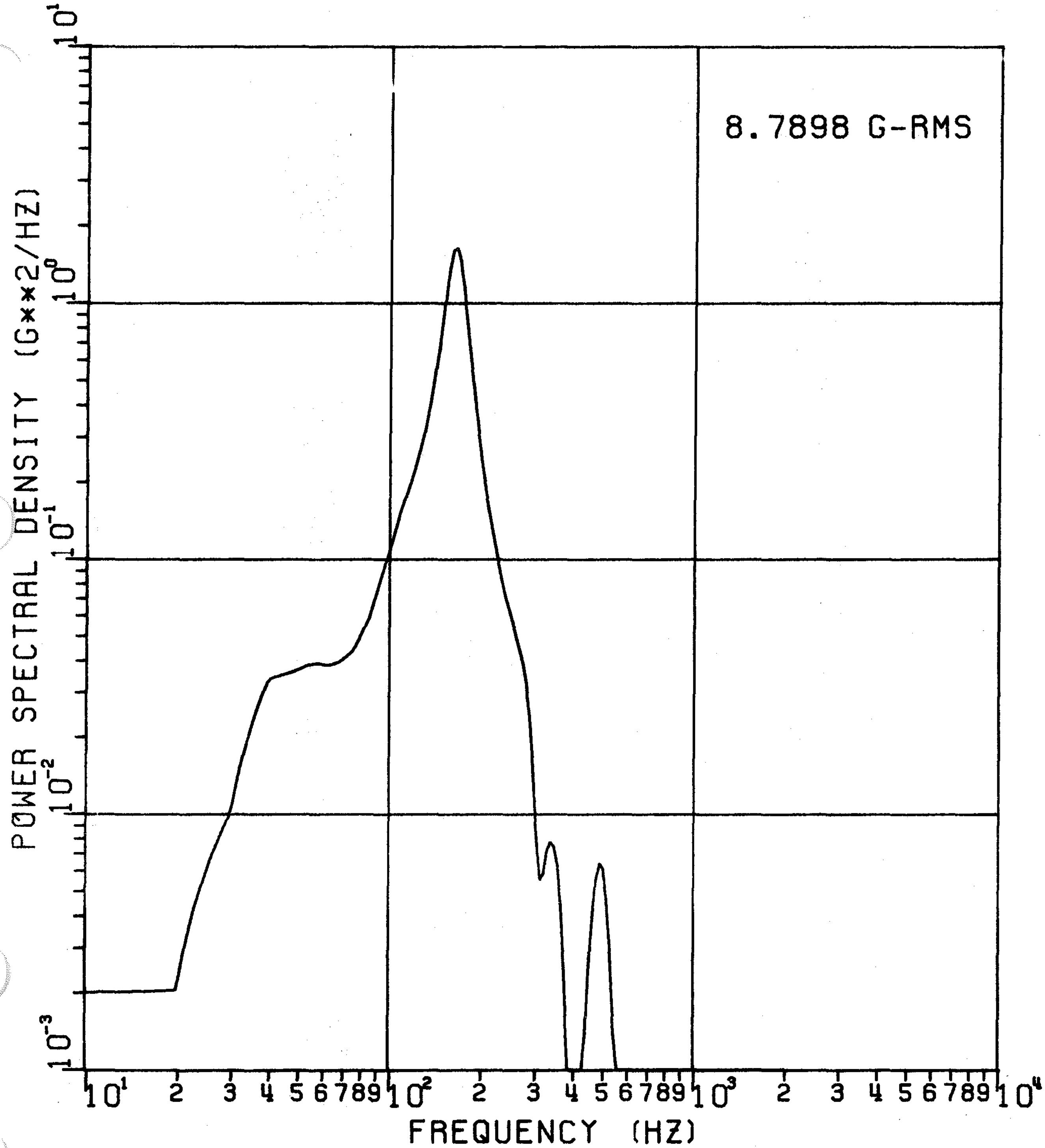
LOCATION 10



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 15d RANDOM VIBRATION SPECTRUM

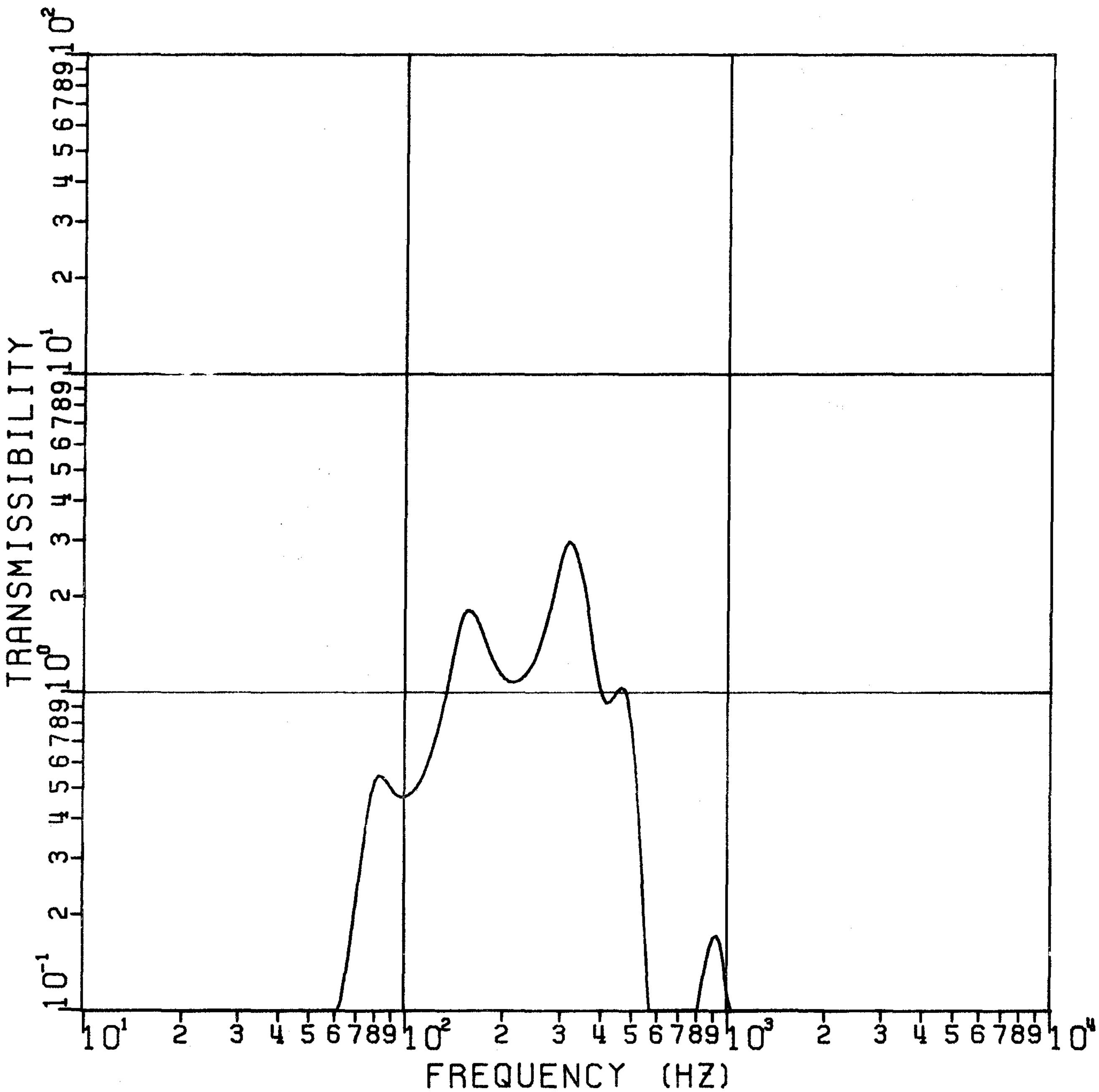
LOCATION 10



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 16a TRANSMISSIBILITY

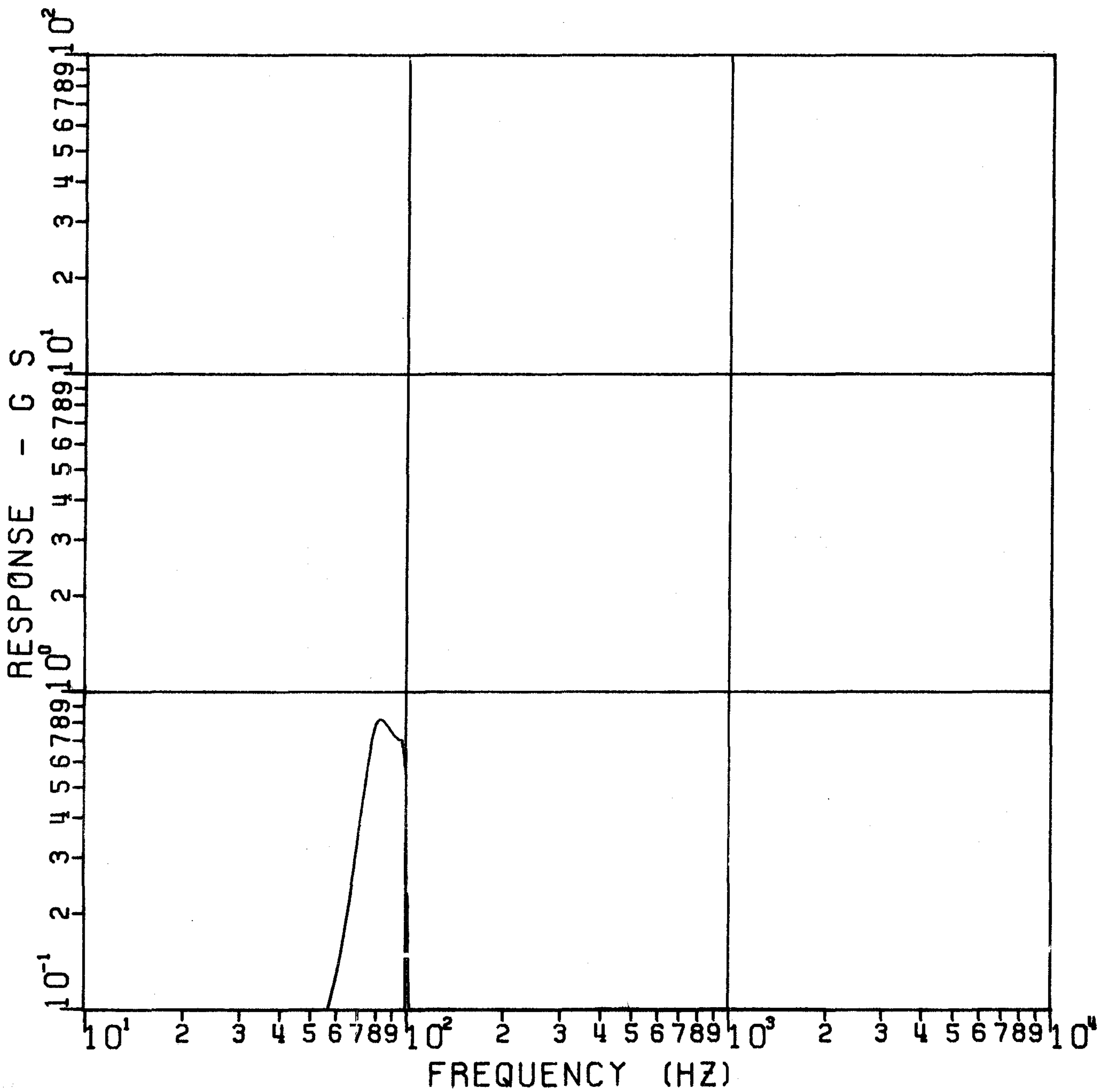
LOCATION 13



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 16 b SINE RESPONSE

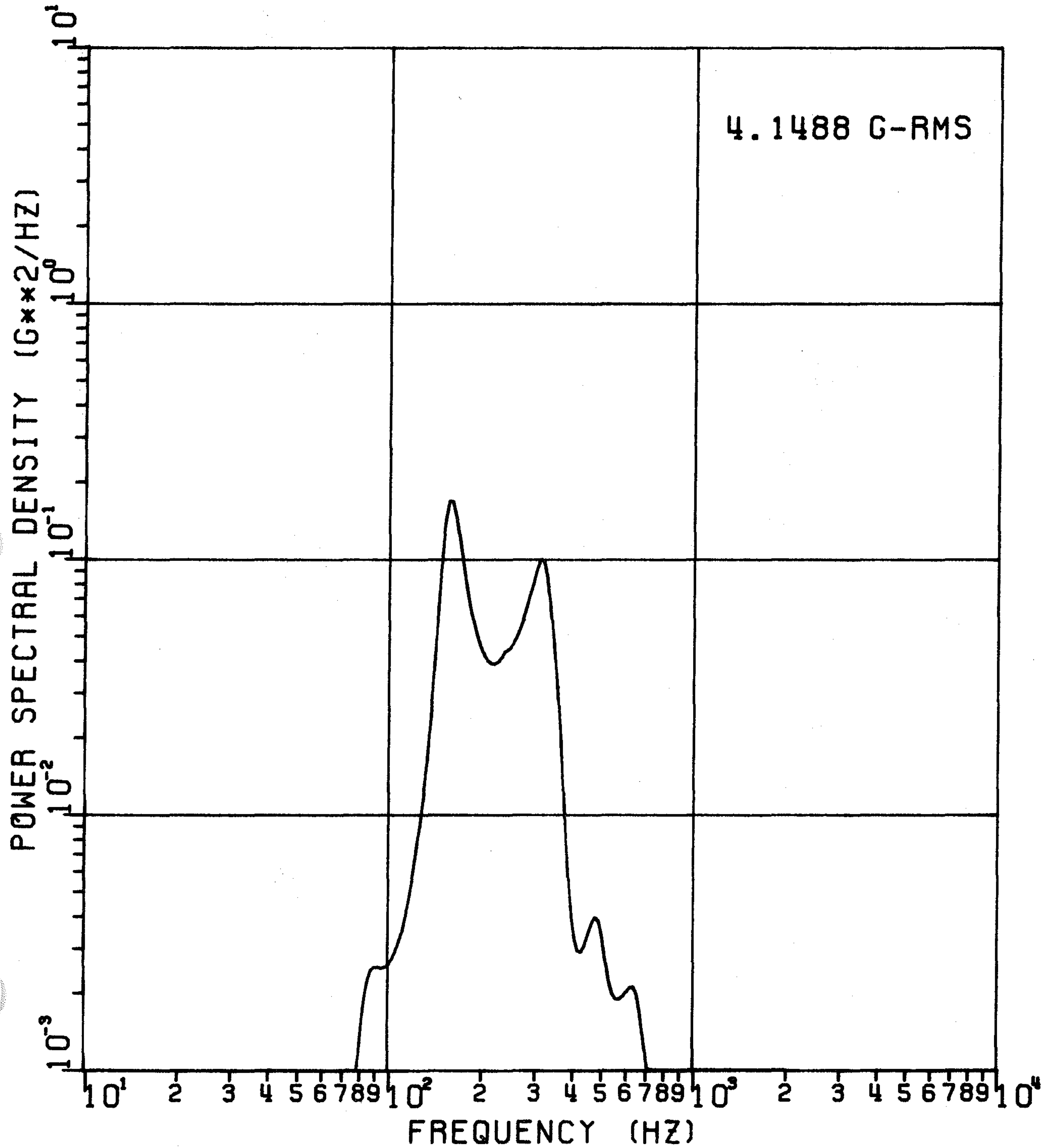
LOCATION 13



1 X AXIS SUBPACK 3 SEP 1970

FIGURE 16c RANDOM VIBRATION SPECTRUM

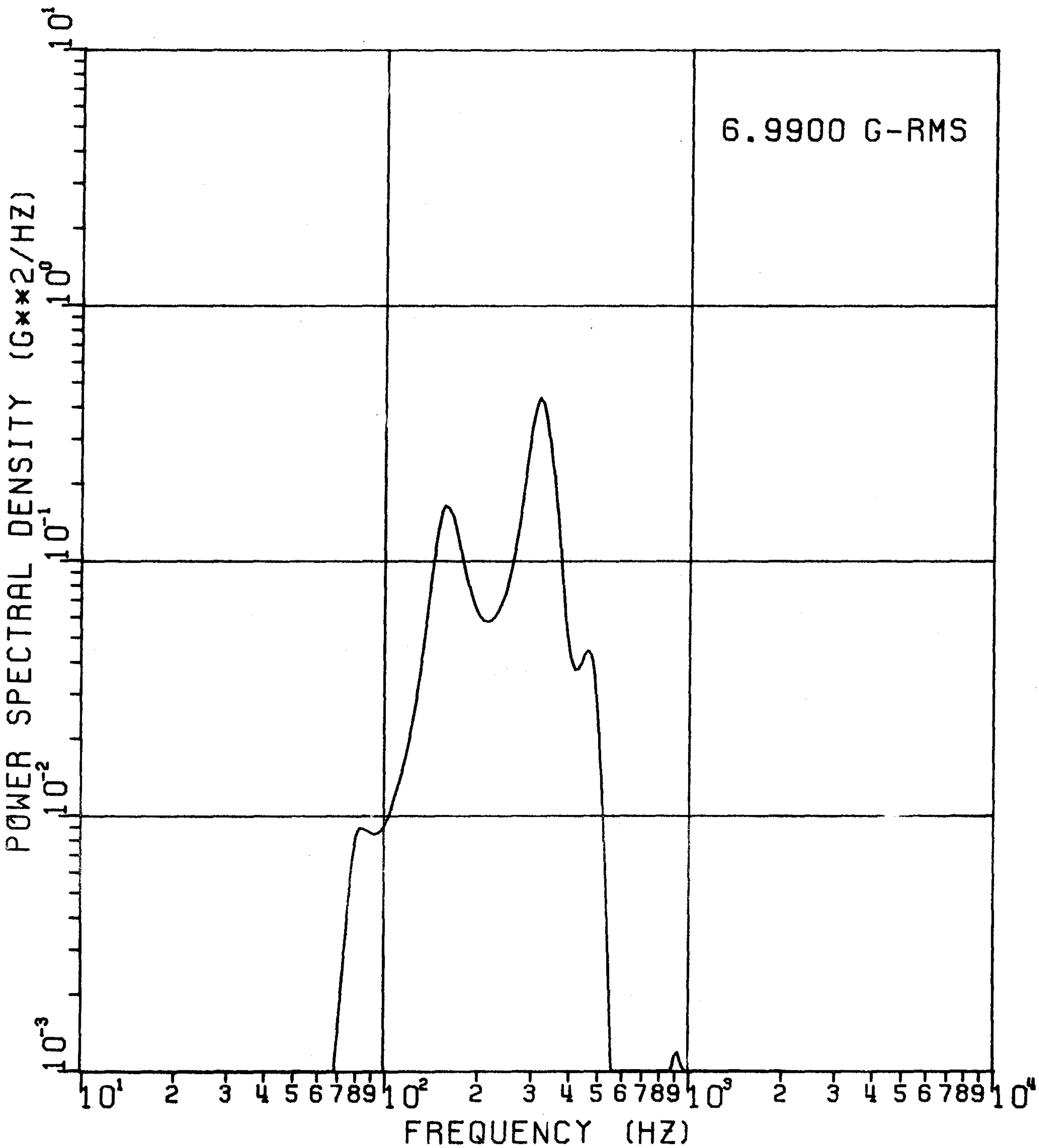
LOCATION 13



1 X AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 16d RANDOM VIBRATION SPECTRUM

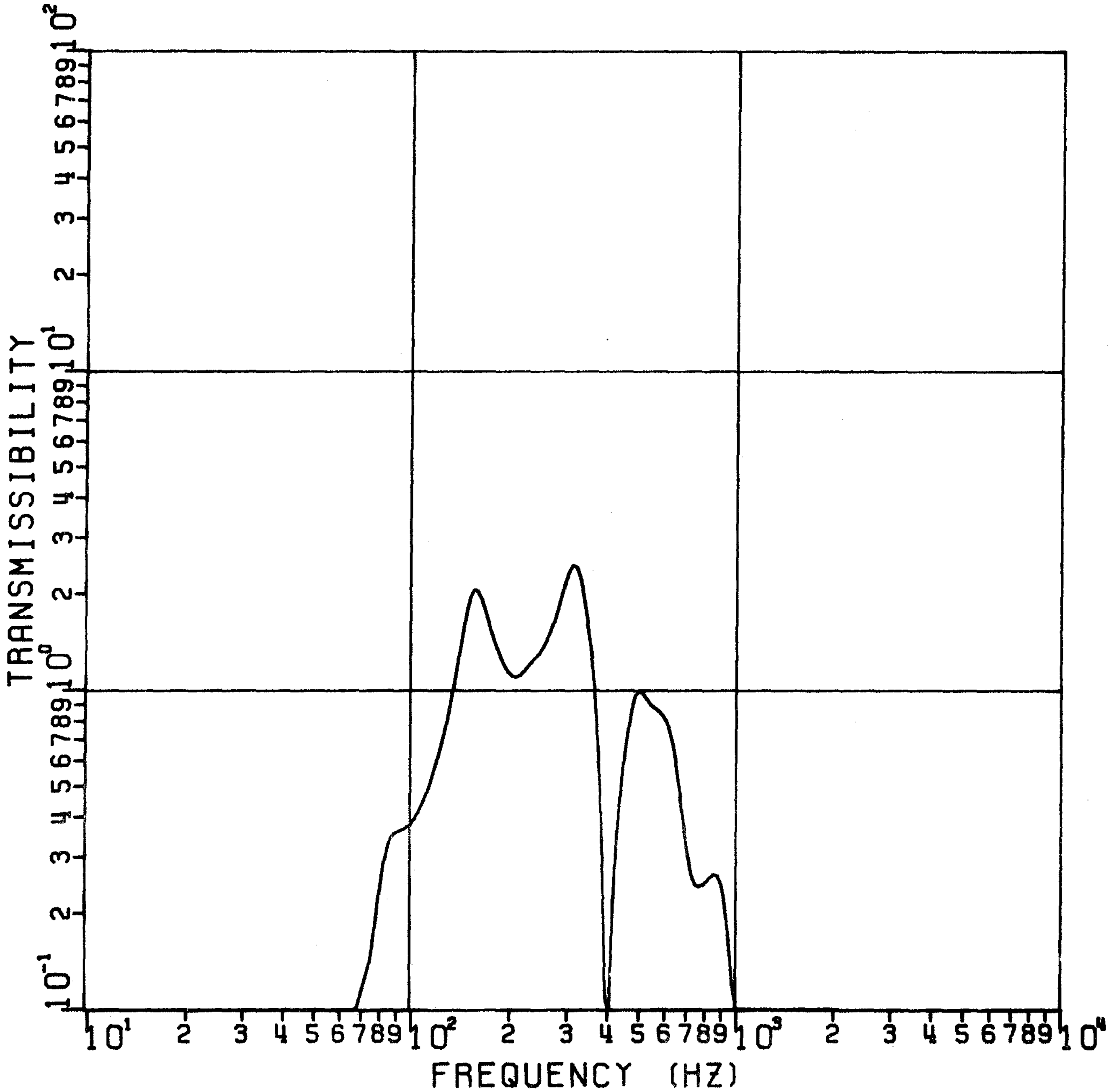
LOCATION 13



1 X AXIS SUBPACK 3 SEP 1970

FIGURE 17a TRANSMISSIBILITY

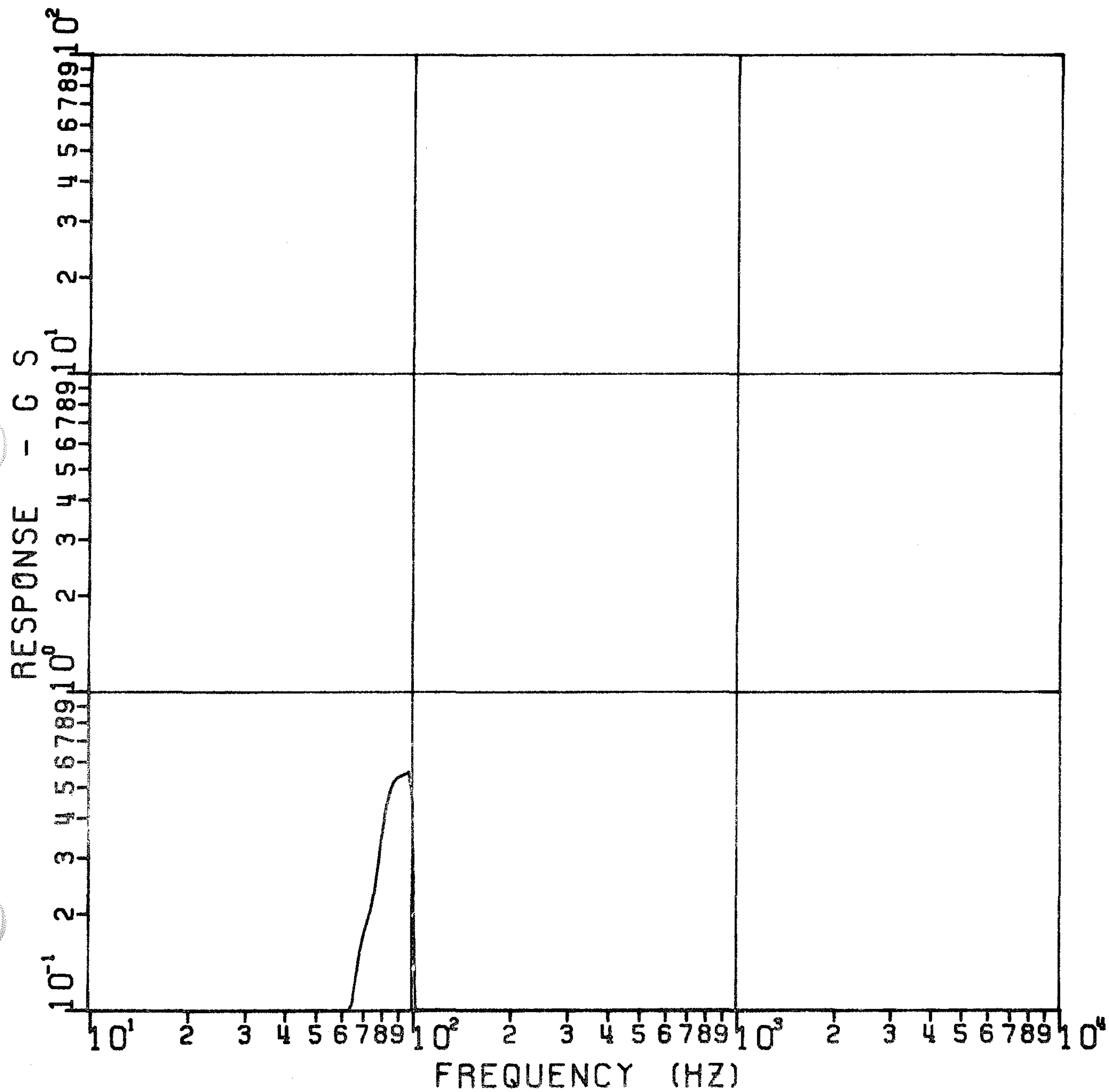
LOCATION 14



1 X AXIS SUBPACK 3 SEP 1970

FIGURE 17b SINE RESPONSE

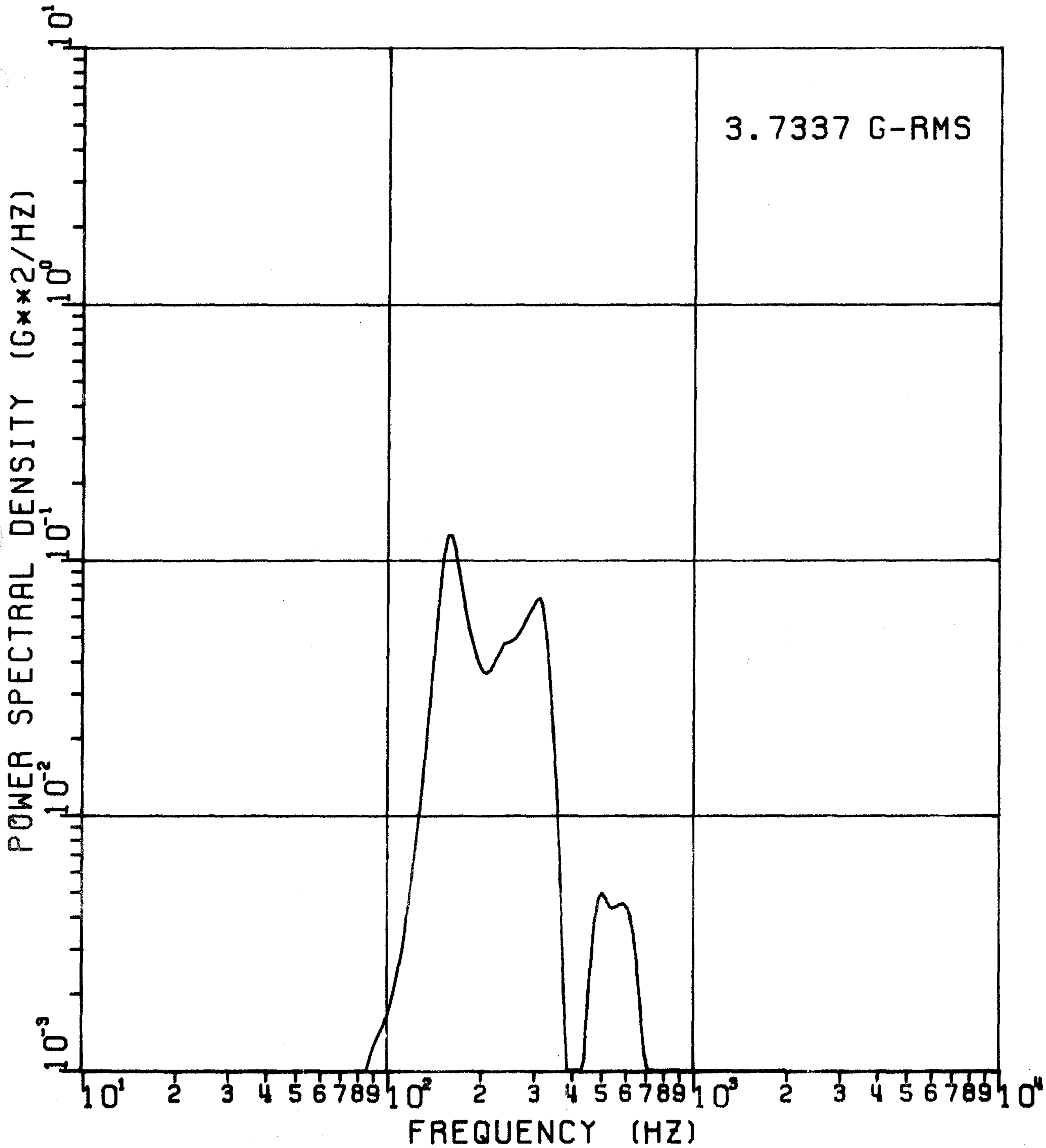
LOCATION 14



1 X AXIS SUBPACK 3 SEP 1970

FIGURE 17c RANDOM VIBRATION SPECTRUM

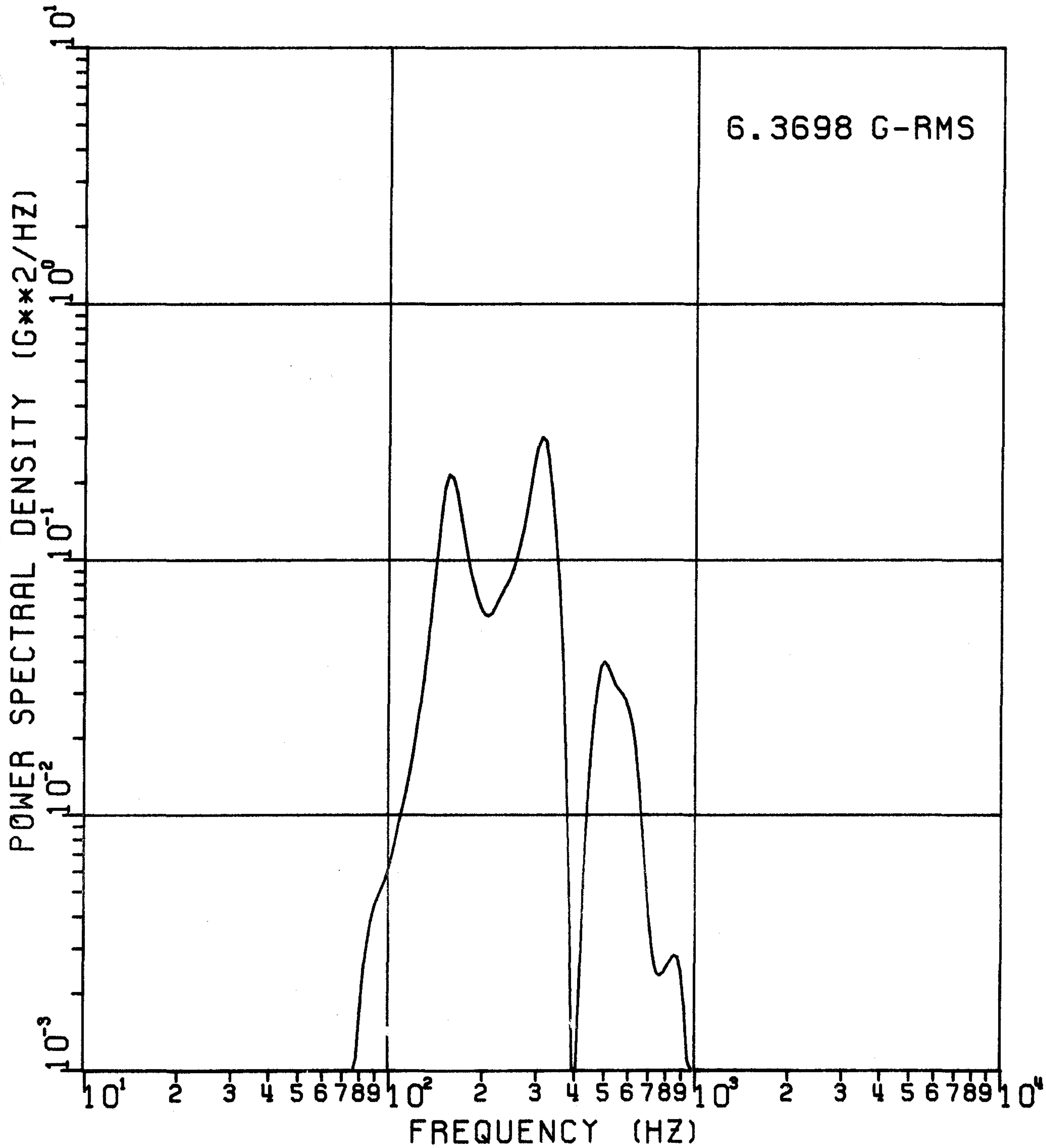
LOCATION 14



1 X AXIS SUBP. 3 SEP 70 NEW LEVELS

FIGURE 17d RANDOM VIBRATION SPECTRUM

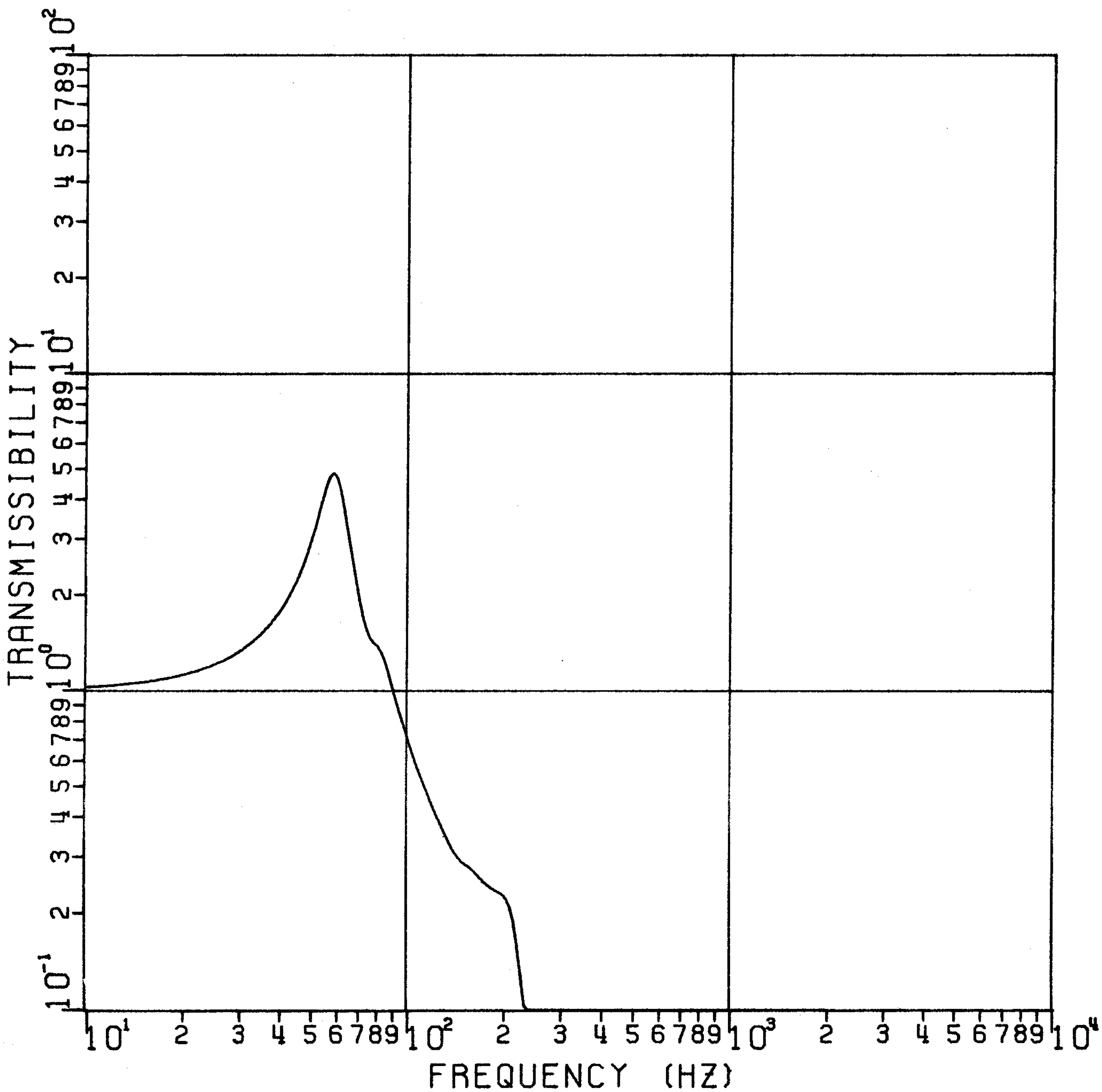
LOCATION 14



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 18 a TRANSMISSIBILITY

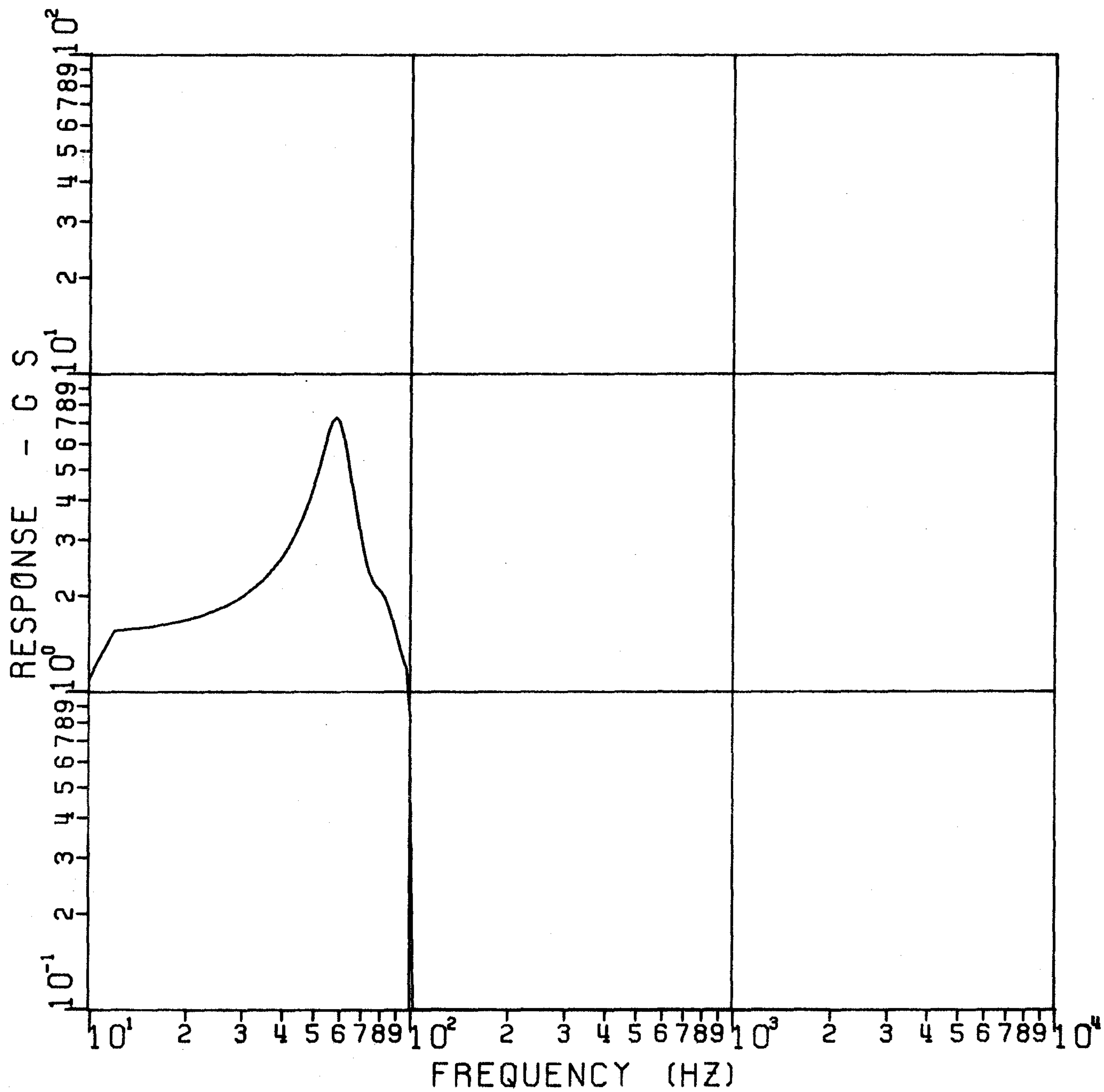
LOCATION 2



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 18b SINE RESPONSE

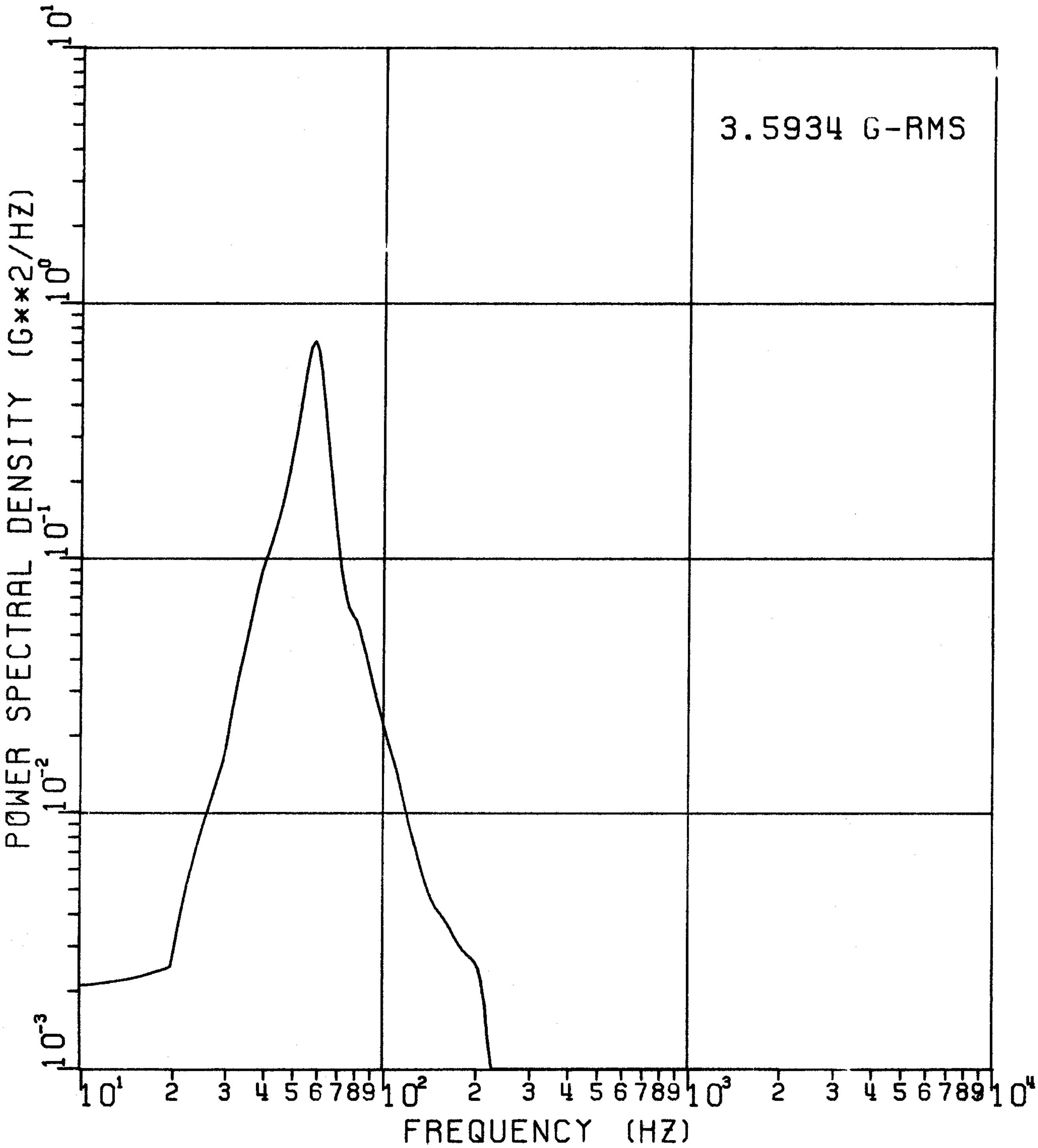
LOCATION 2



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 18c RANDOM VIBRATION SPECTRUM

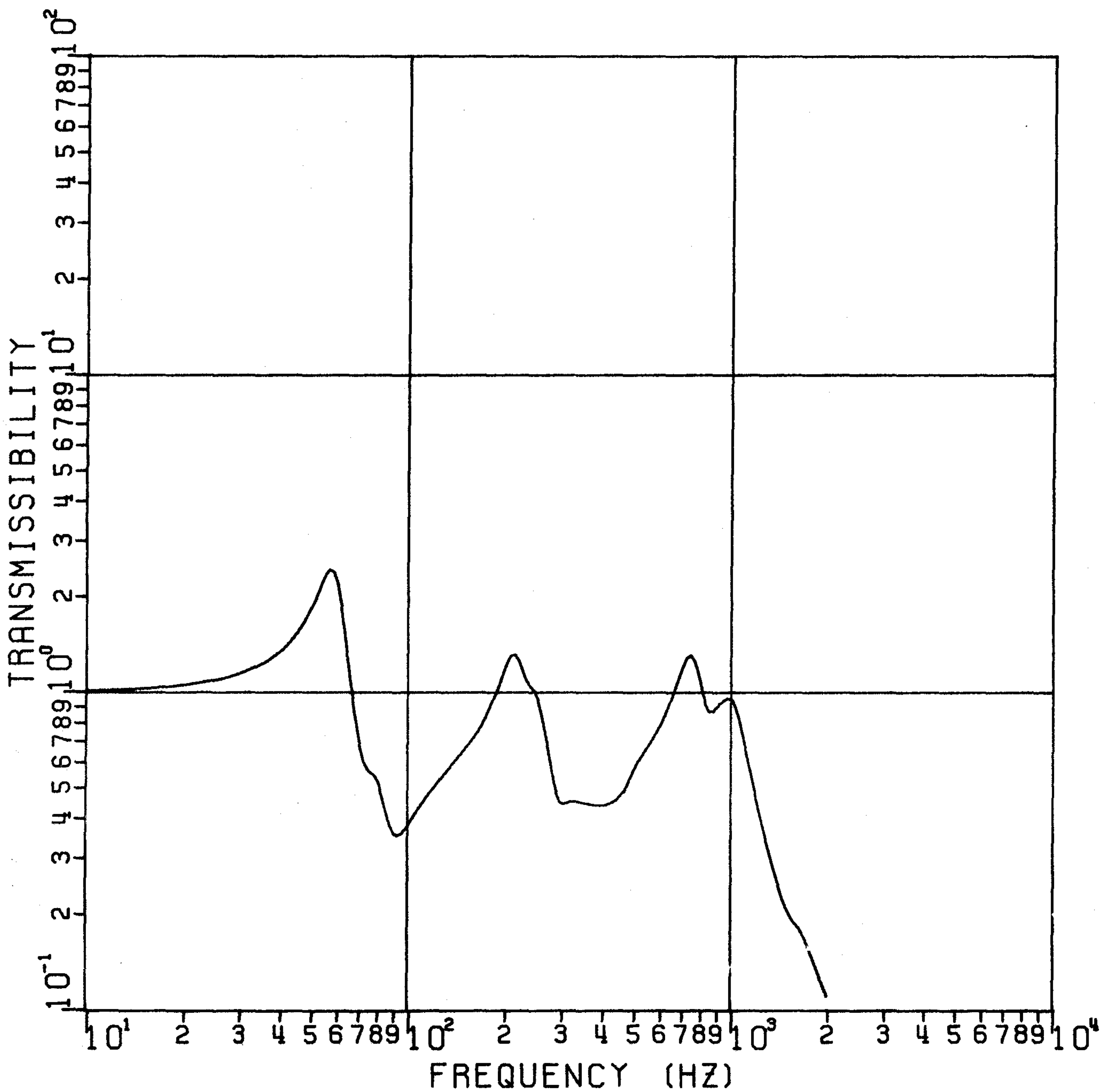
LOCATION 2



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 19a TRANSMISSIBILITY

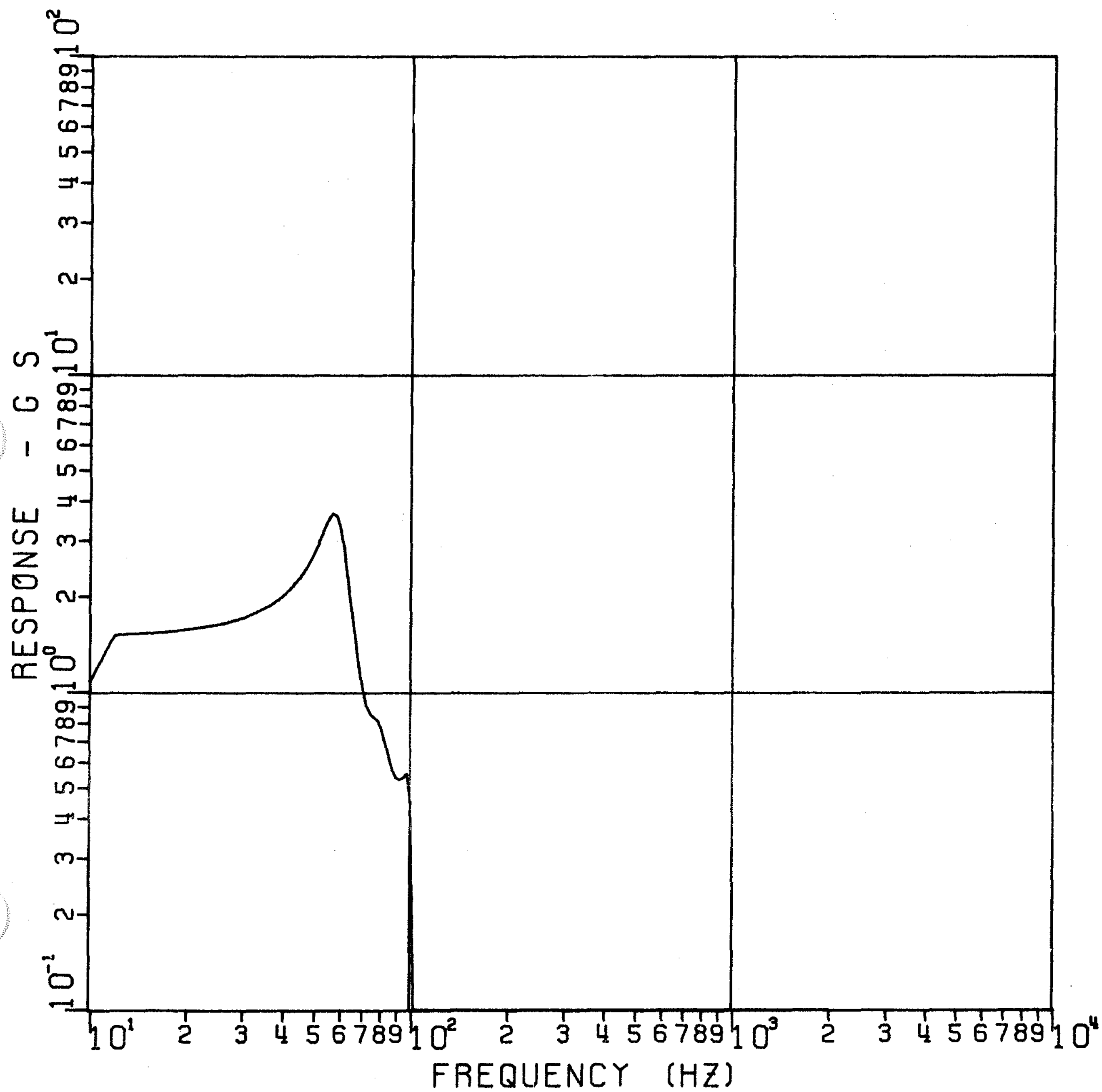
LOCATION 8



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 19b SINE RESPONSE

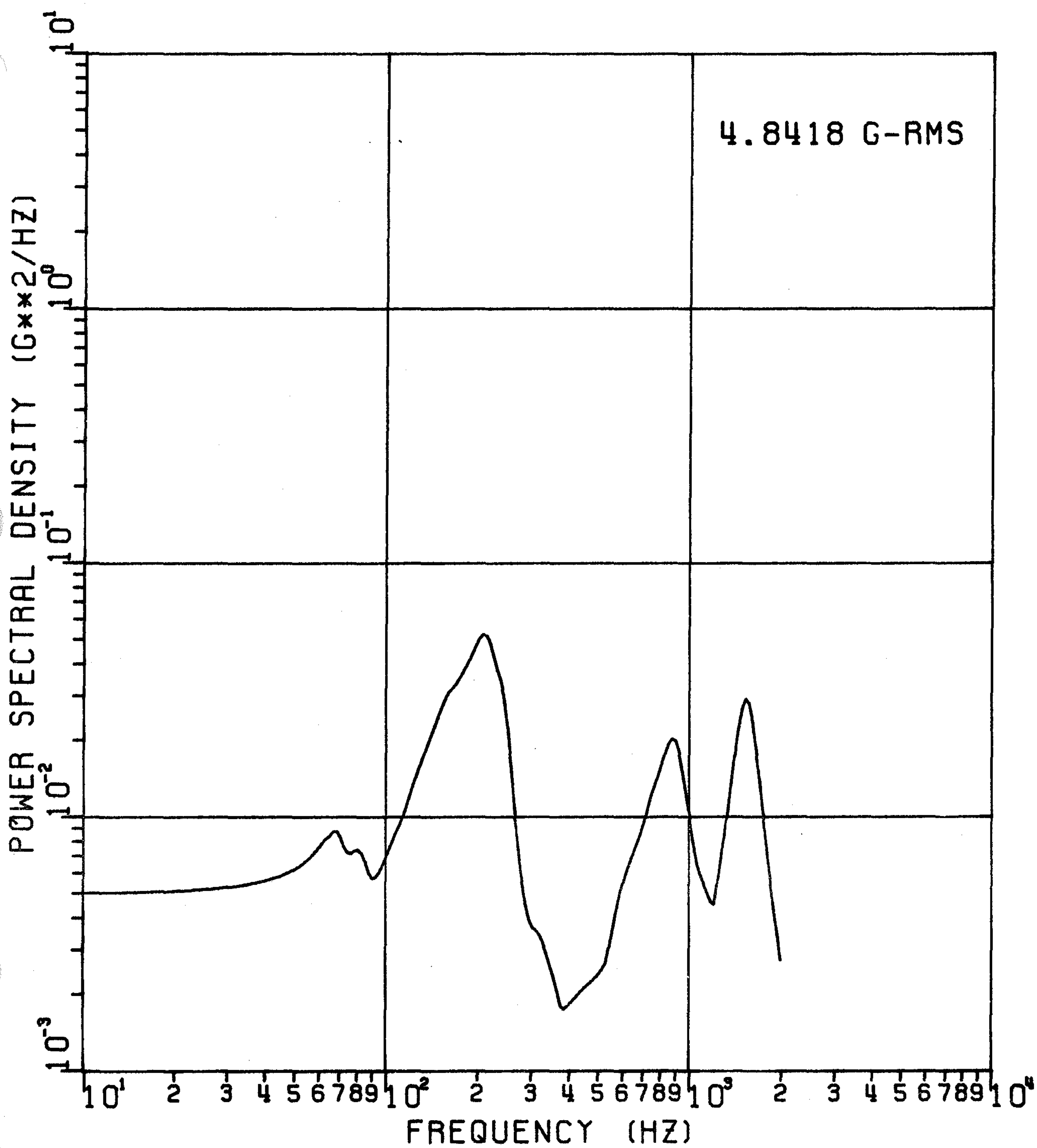
LOCATION 8



1 Y AXIS SUBPACK 3 SEP 1970

FIGURE 19c RANDOM VIBRATION SPECTRUM

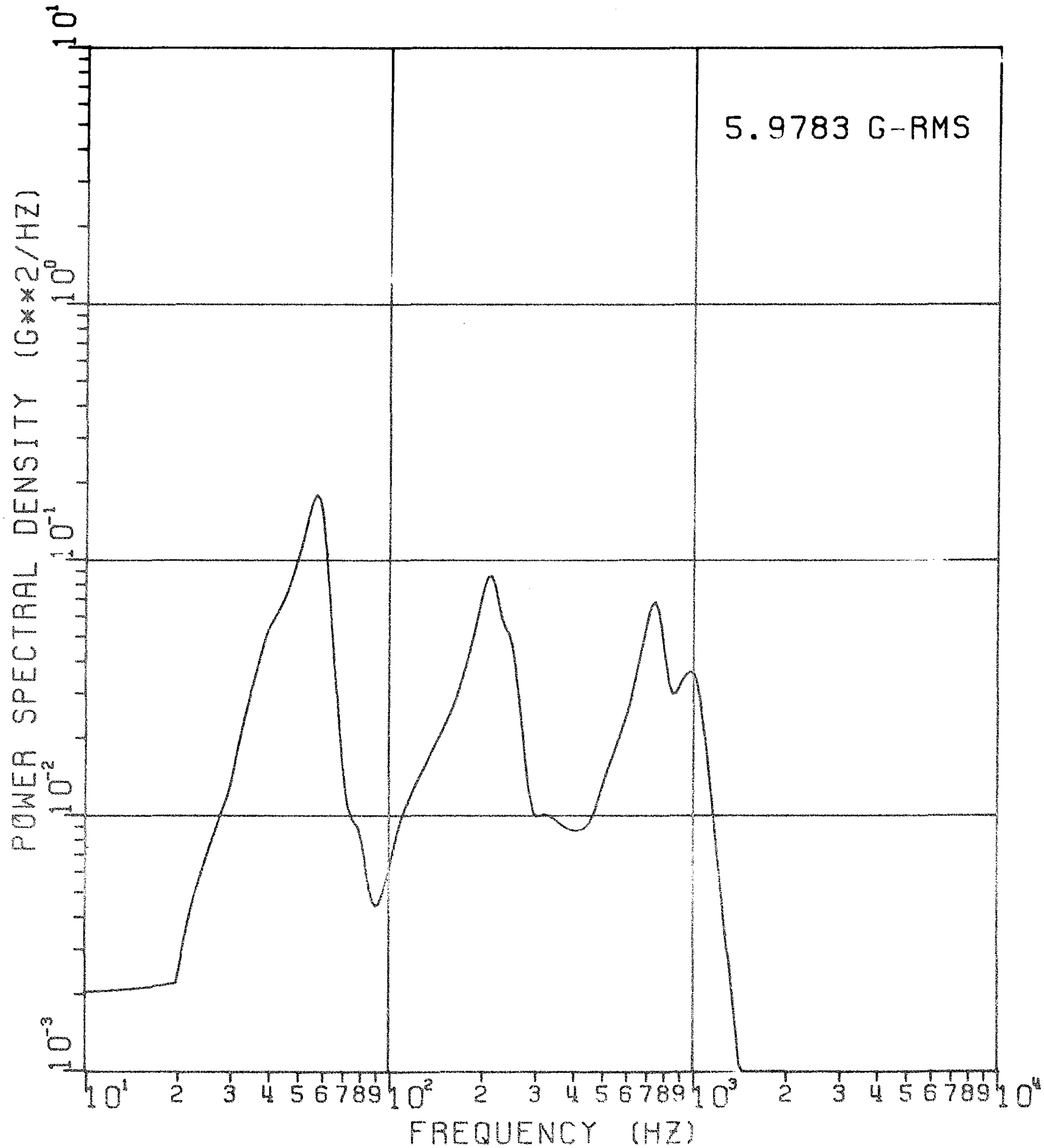
LOCATION 8



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 19d RANDOM VIBRATION SPECTRUM

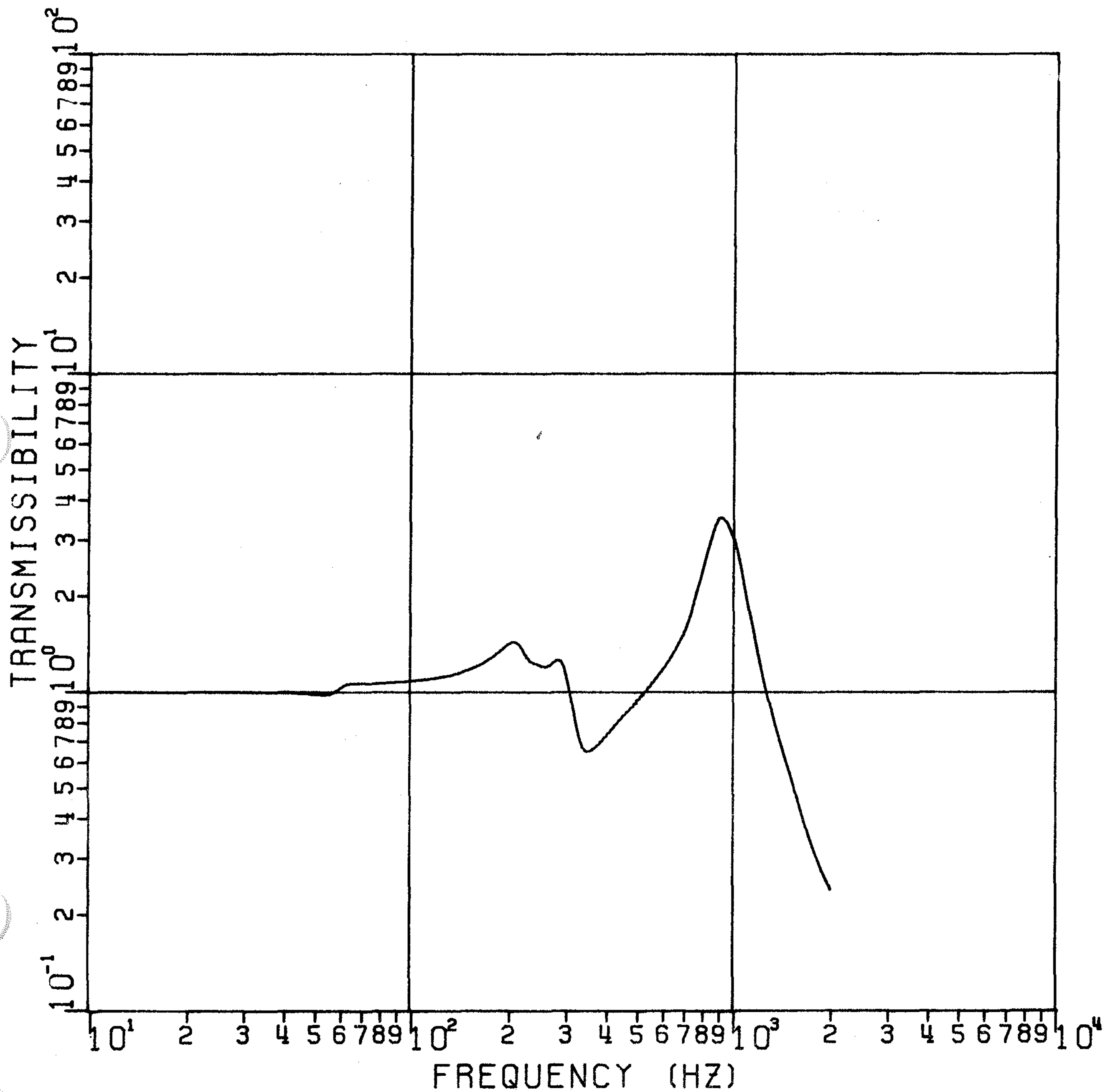
LOCATION 8



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 20a TRANSMISSIBILITY

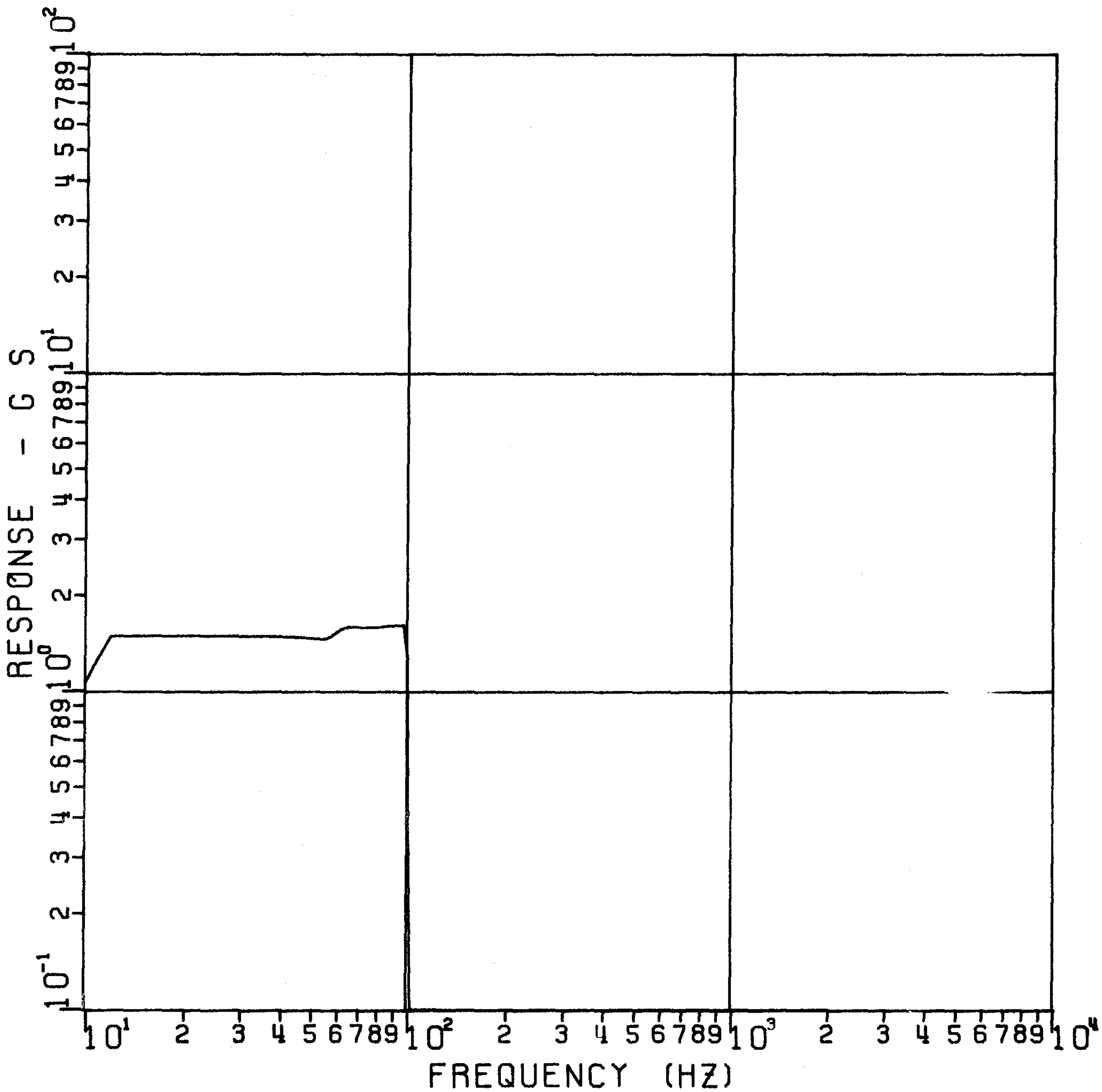
LOCATION 9



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 20b SINE RESPONSE

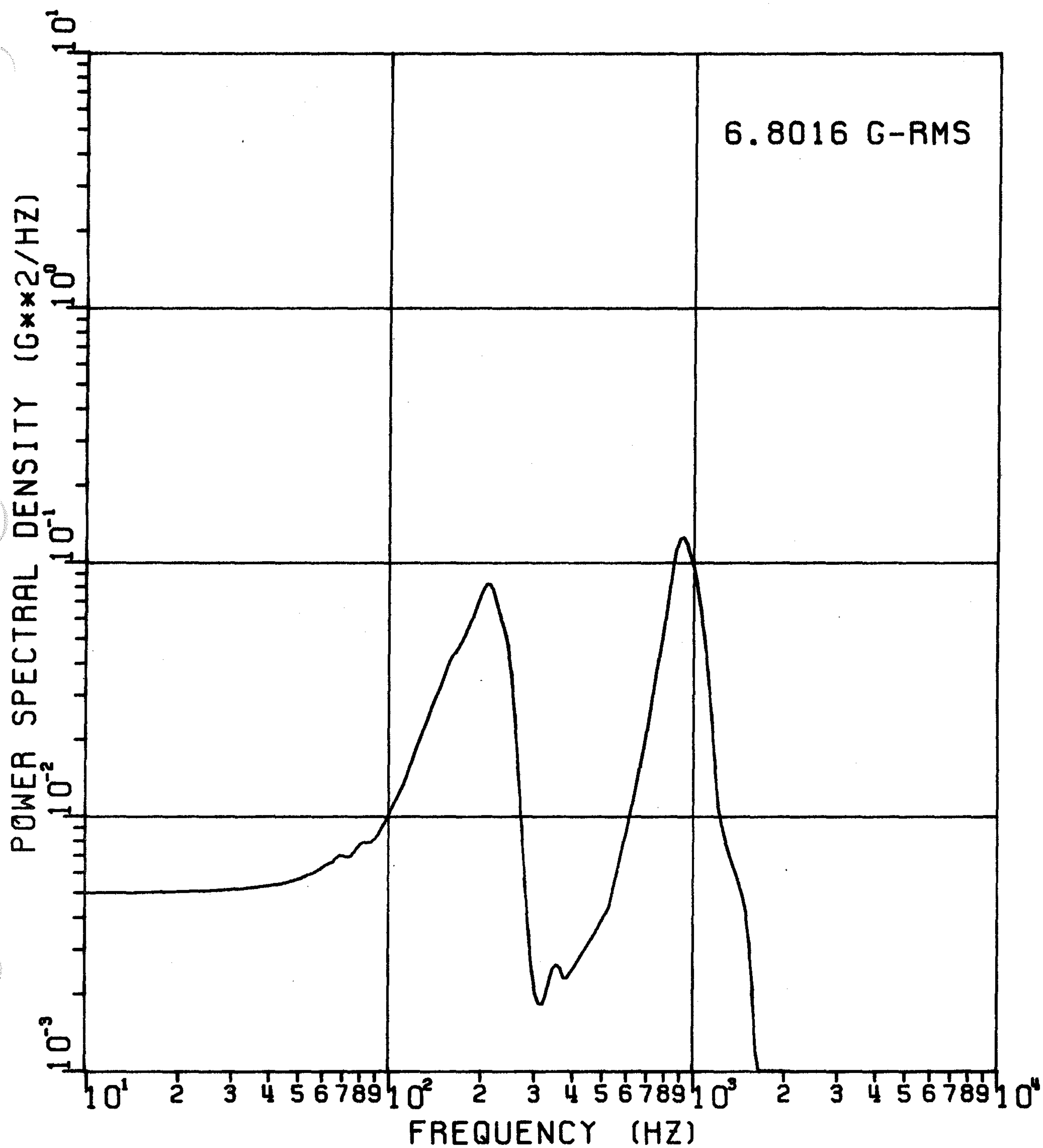
LOCATION 9



1 Y AXIS SUBPACK 3 SEP 1970

FIGURE 20c RANDOM VIBRATION SPECTRUM

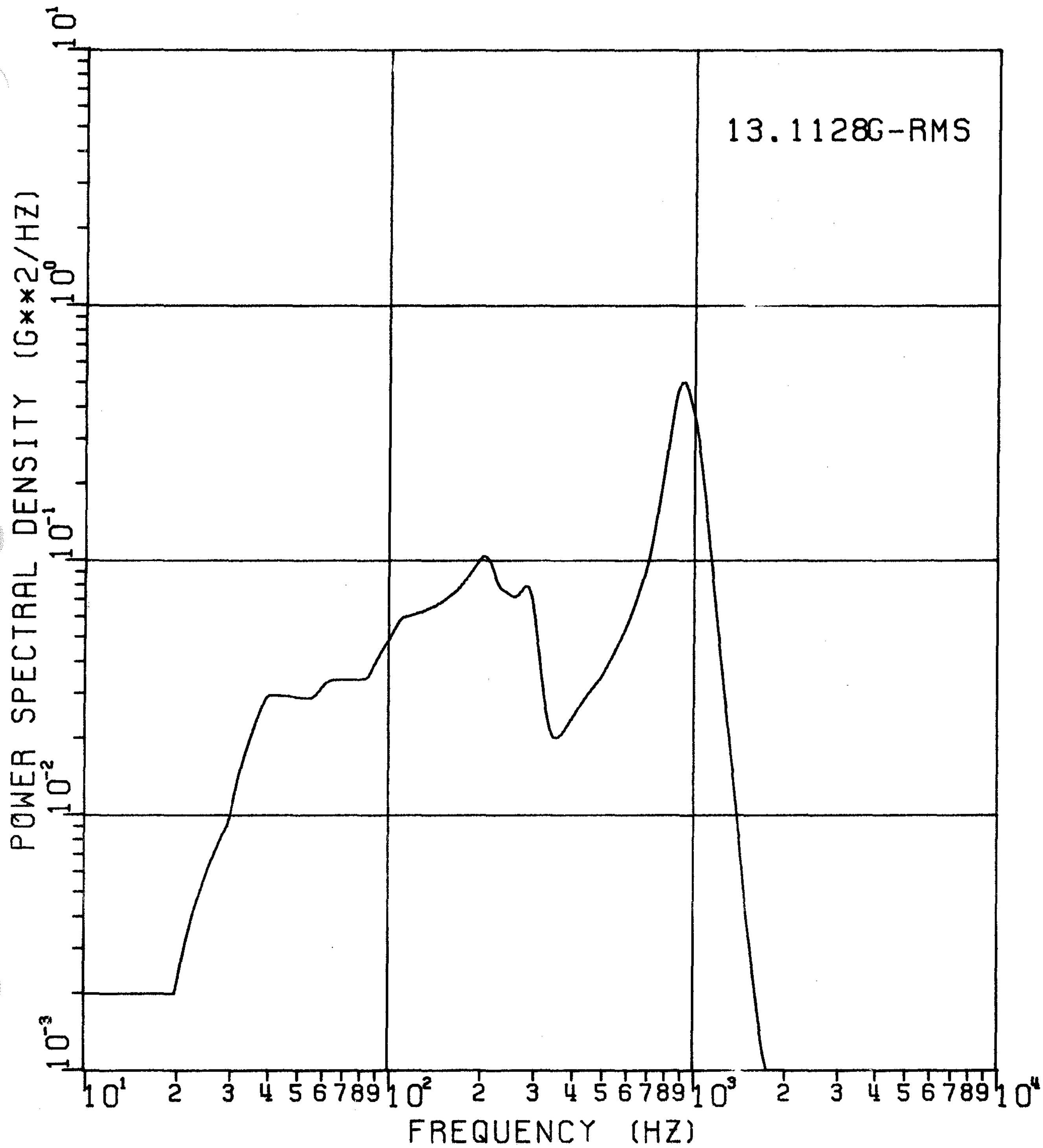
LOCATION 9



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 20d RANDOM VIBRATION SPECTRUM

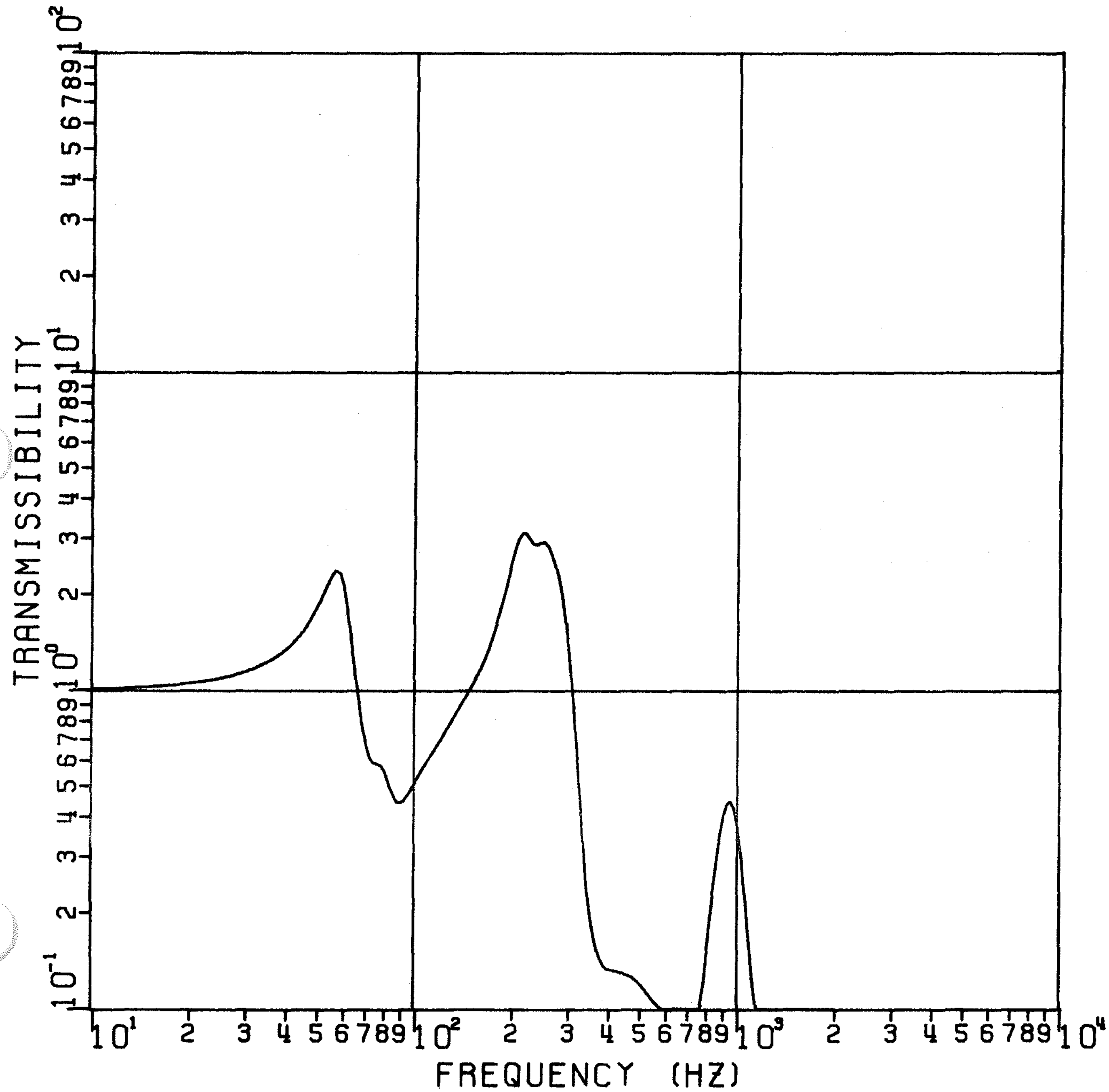
LOCATION 9



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 21a TRANSMISSIBILITY

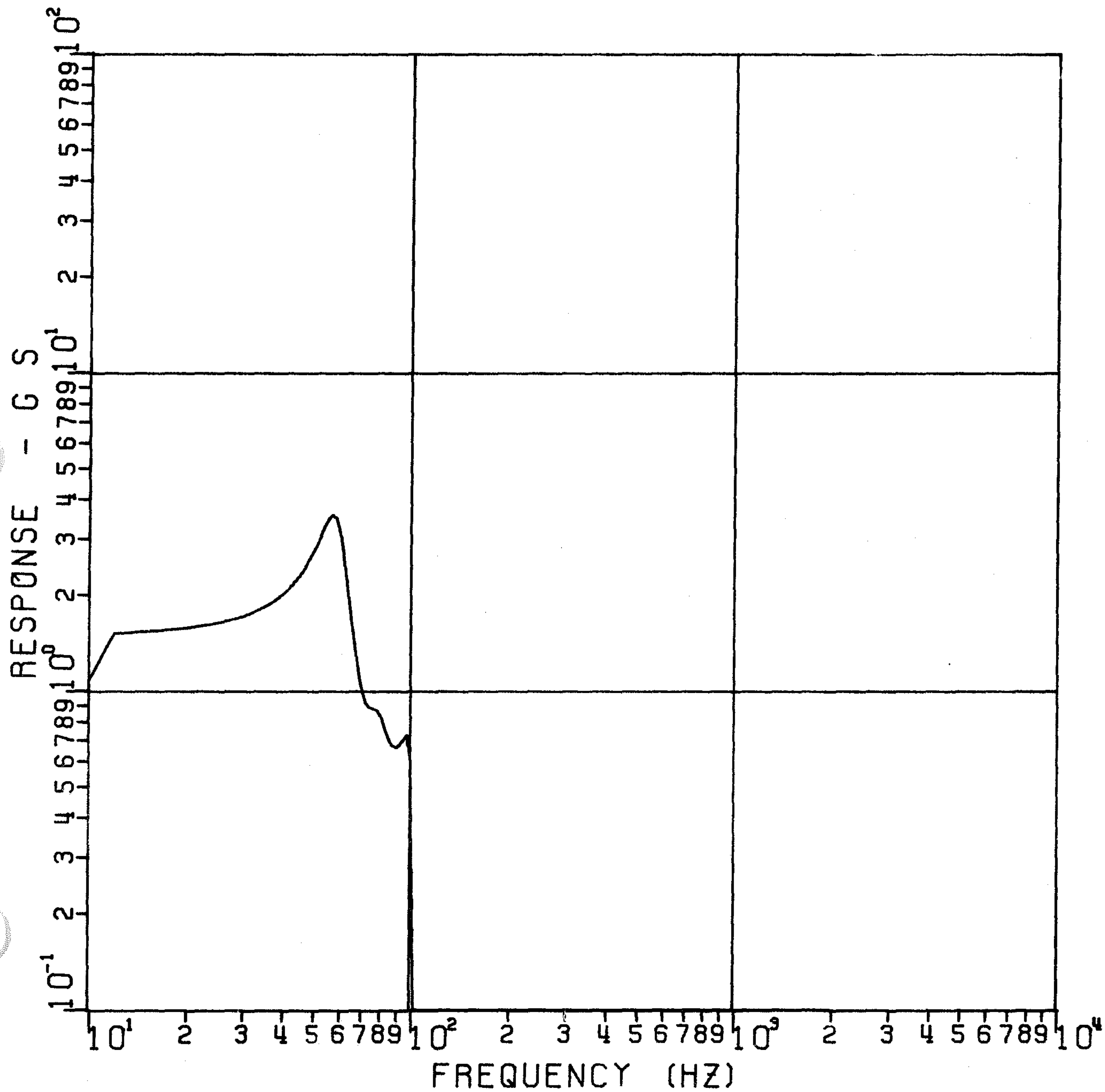
LOCATION 11



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 21b SINE RESPONSE

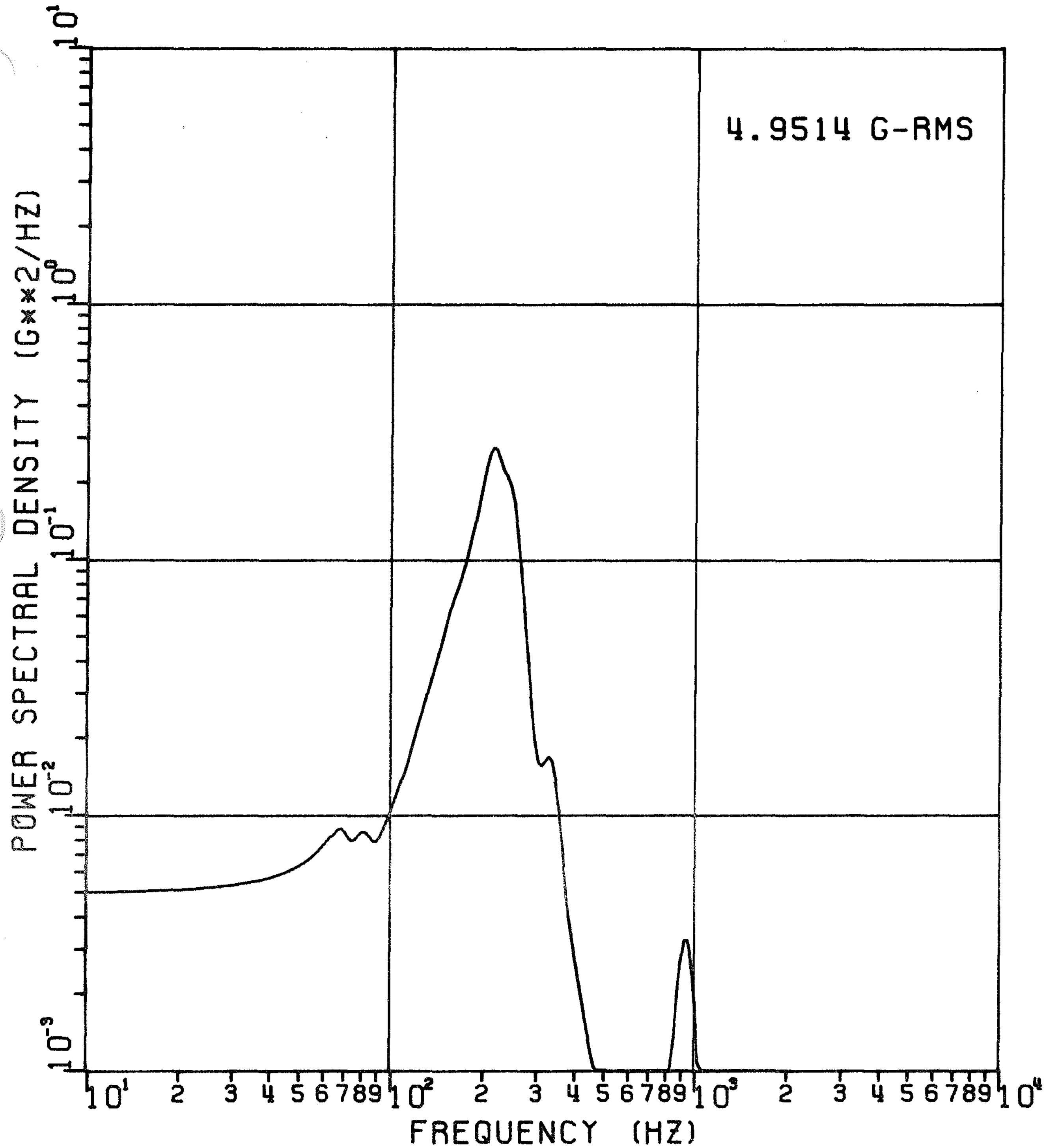
LOCATION 11



1 Y AXIS SUBPACK 3 SEP 1970

FIGURE 2/c RANDOM VIBRATION SPECTRUM

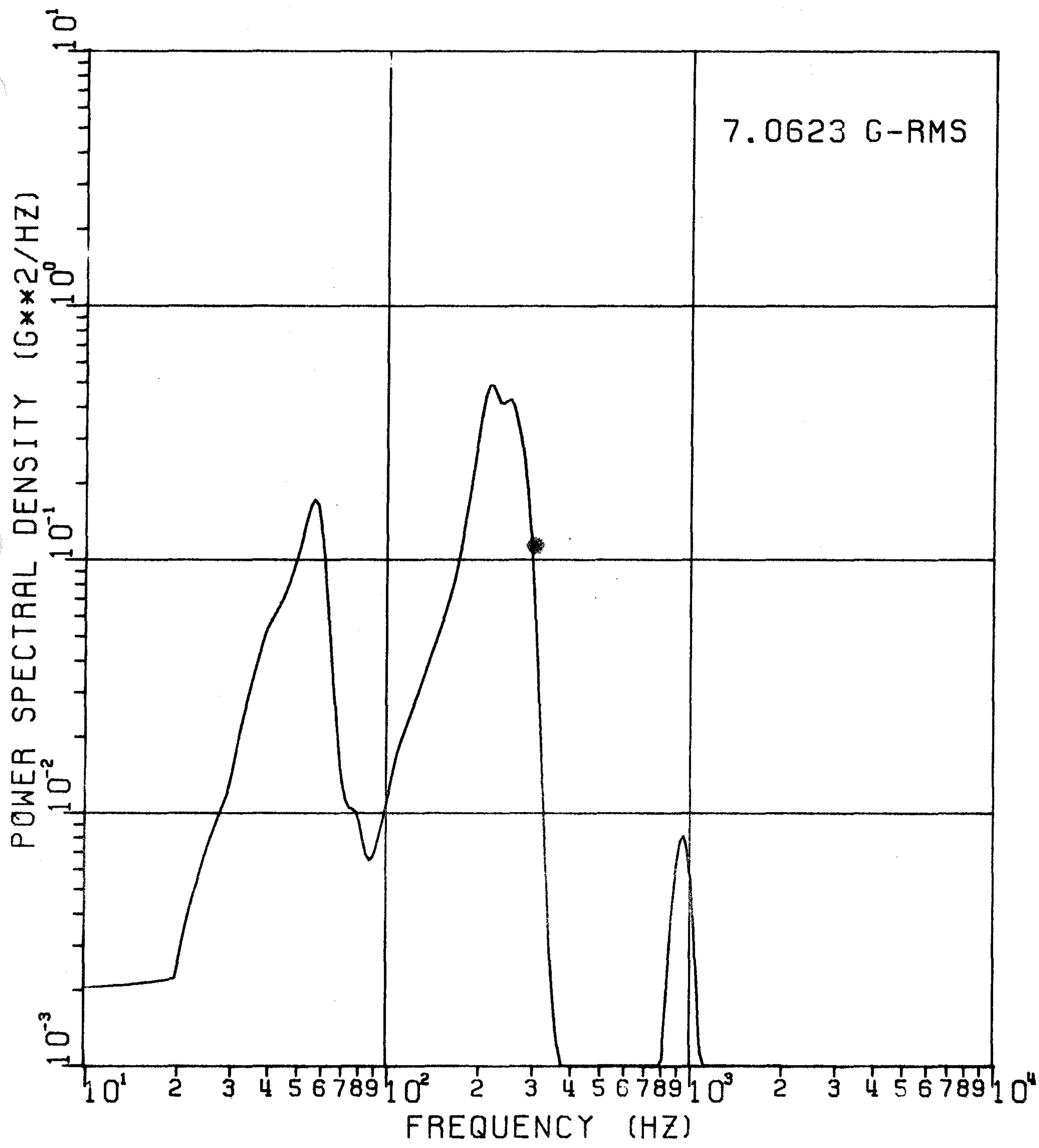
LOCATION 11



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 21d RANDOM VIBRATION SPECTRUM

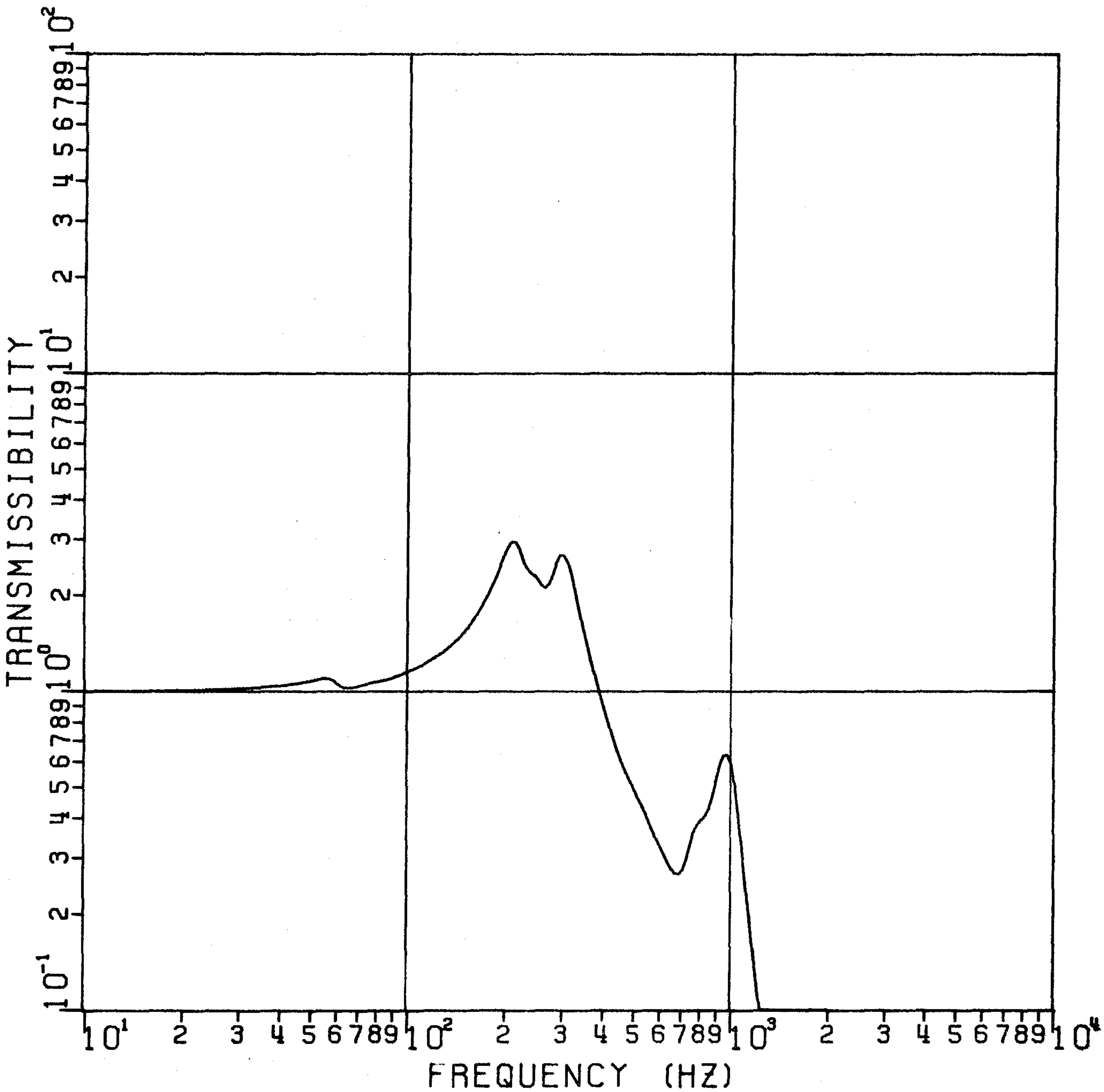
LOCATION 11



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 22 a TRANSMISSIBILITY

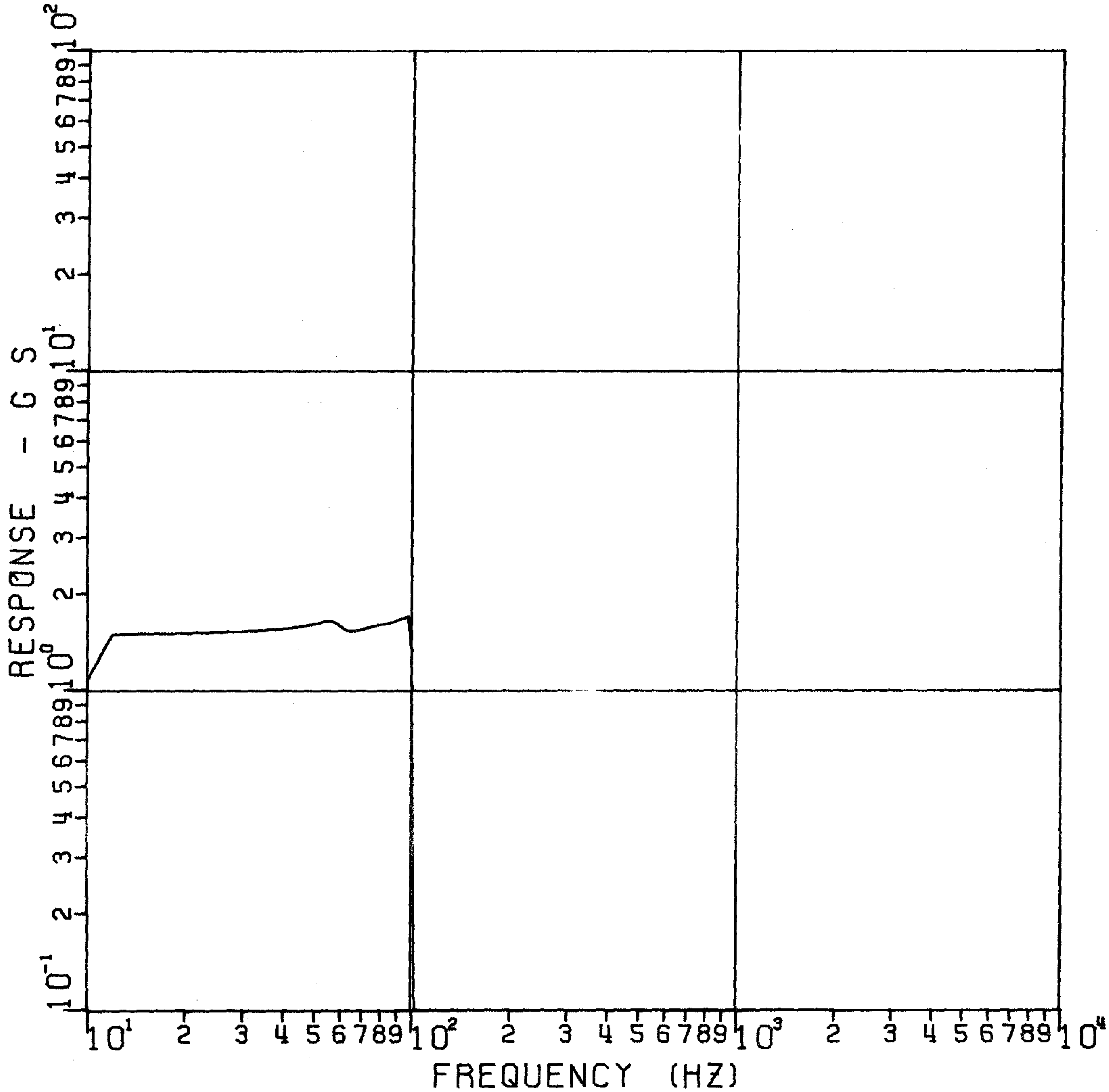
LOCATION 12



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 22 b SINE RESPONSE

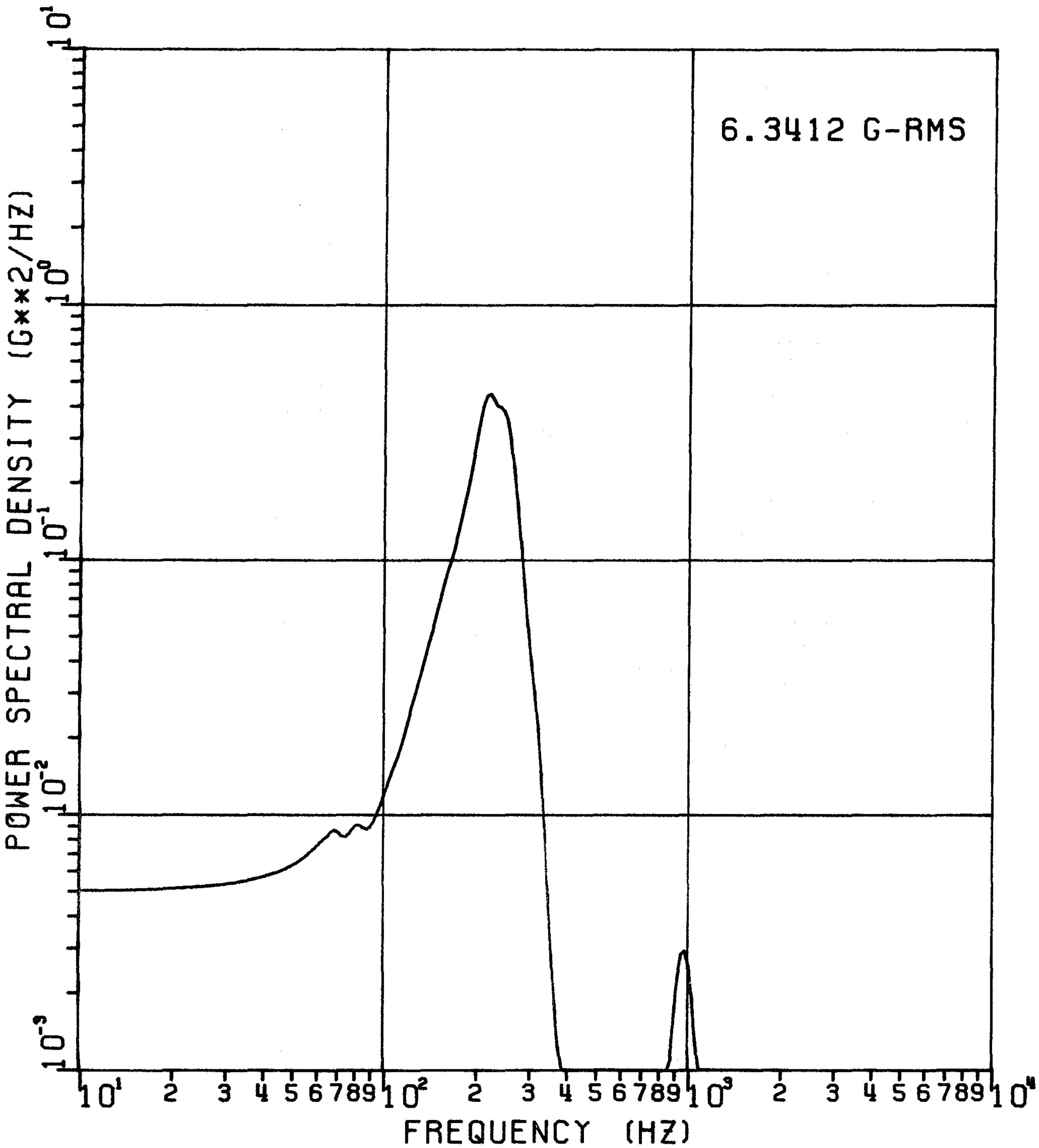
LOCATION 12



1 Y AXIS SUBPACK 3 SEP 1970

FIGURE 22c RANDOM VIBRATION SPECTRUM

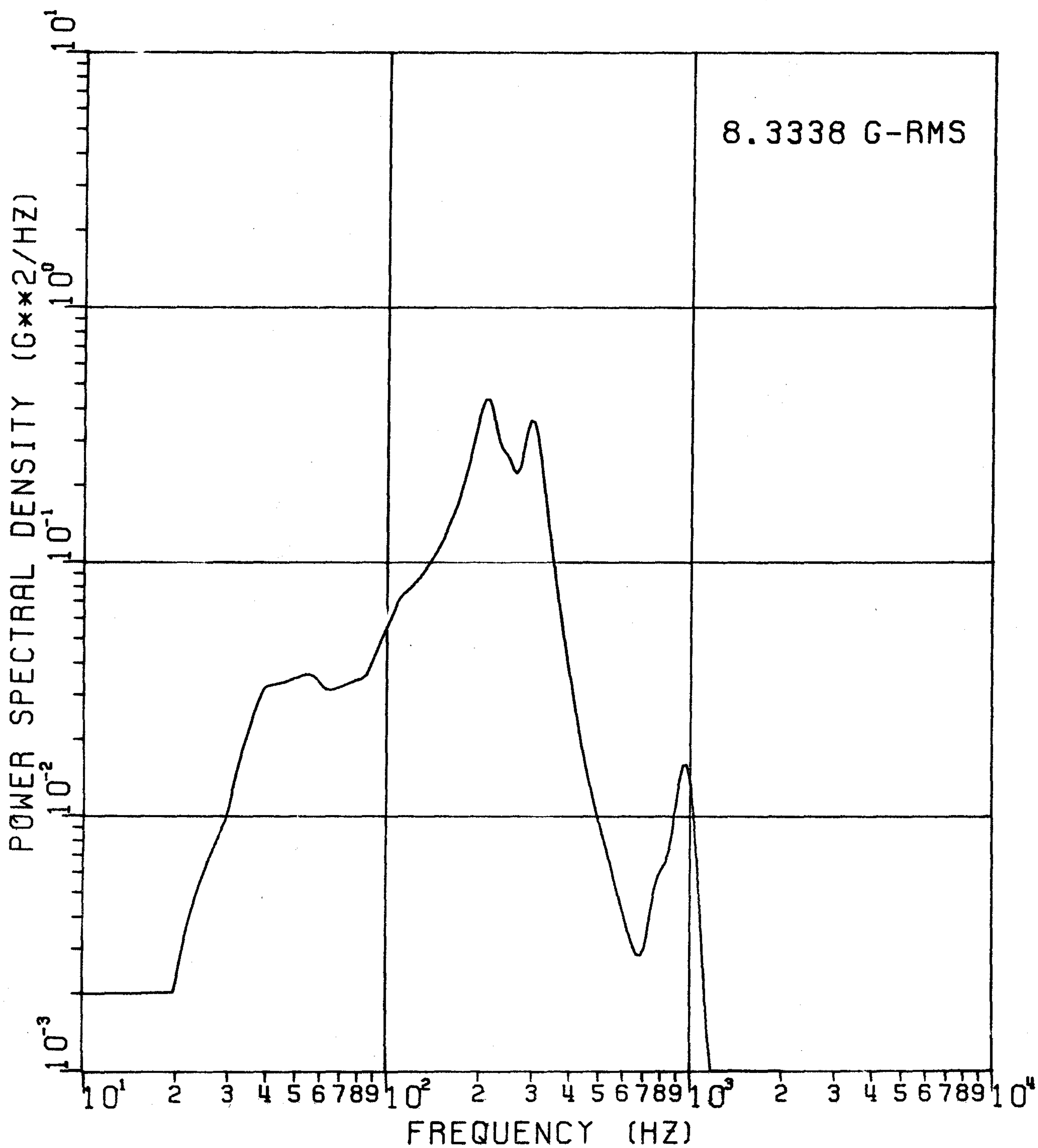
LOCATION 12



1 Y AXIS SUBP.-3 SEP 70 NEW LEVELS

FIGURE 22 d RANDOM VIBRATION SPECTRUM

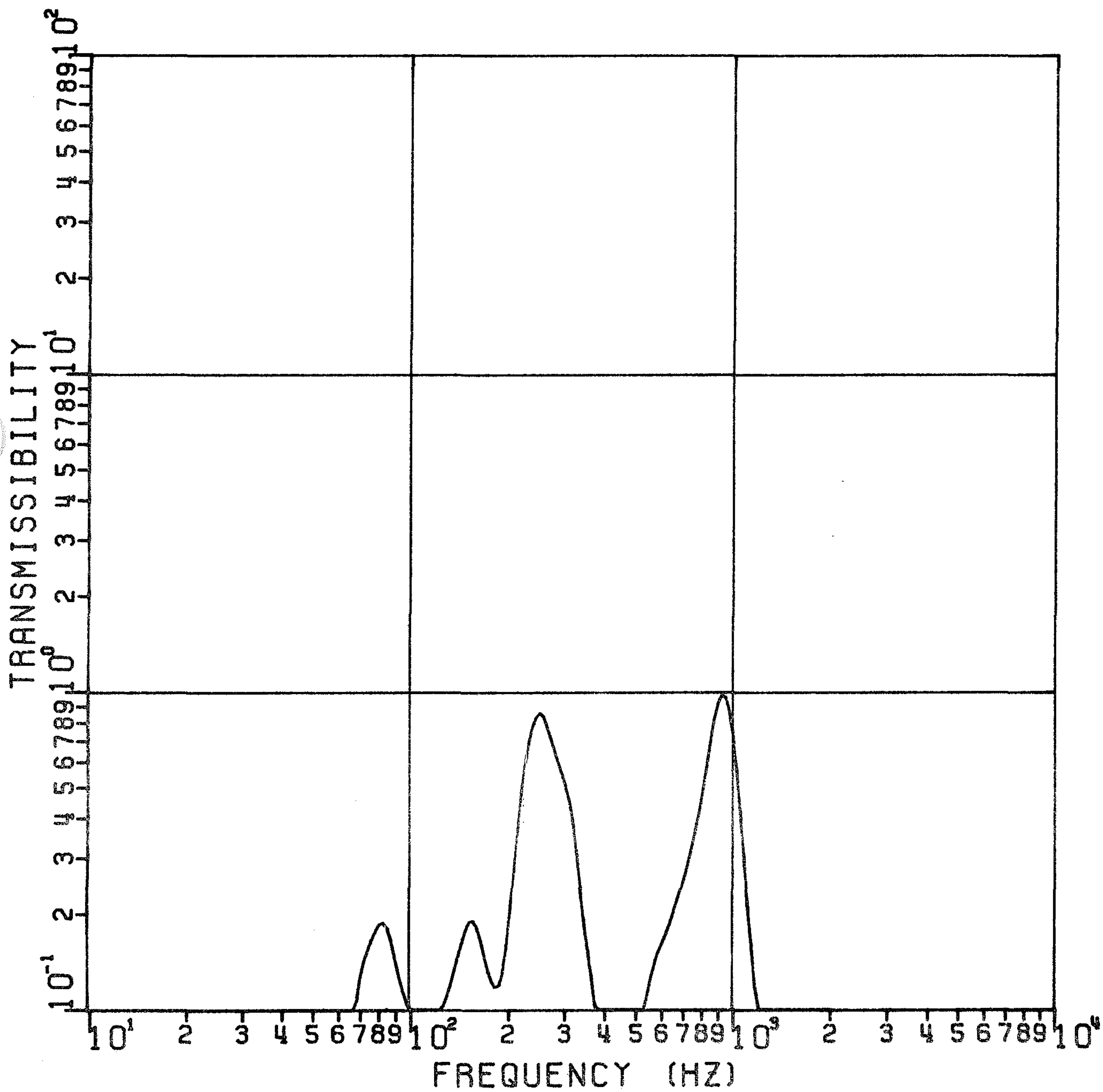
LOCATION 12



1 Y AXIS SUBPACK 3 SEP 1970

FIGURE 23a TRANSMISSIBILITY

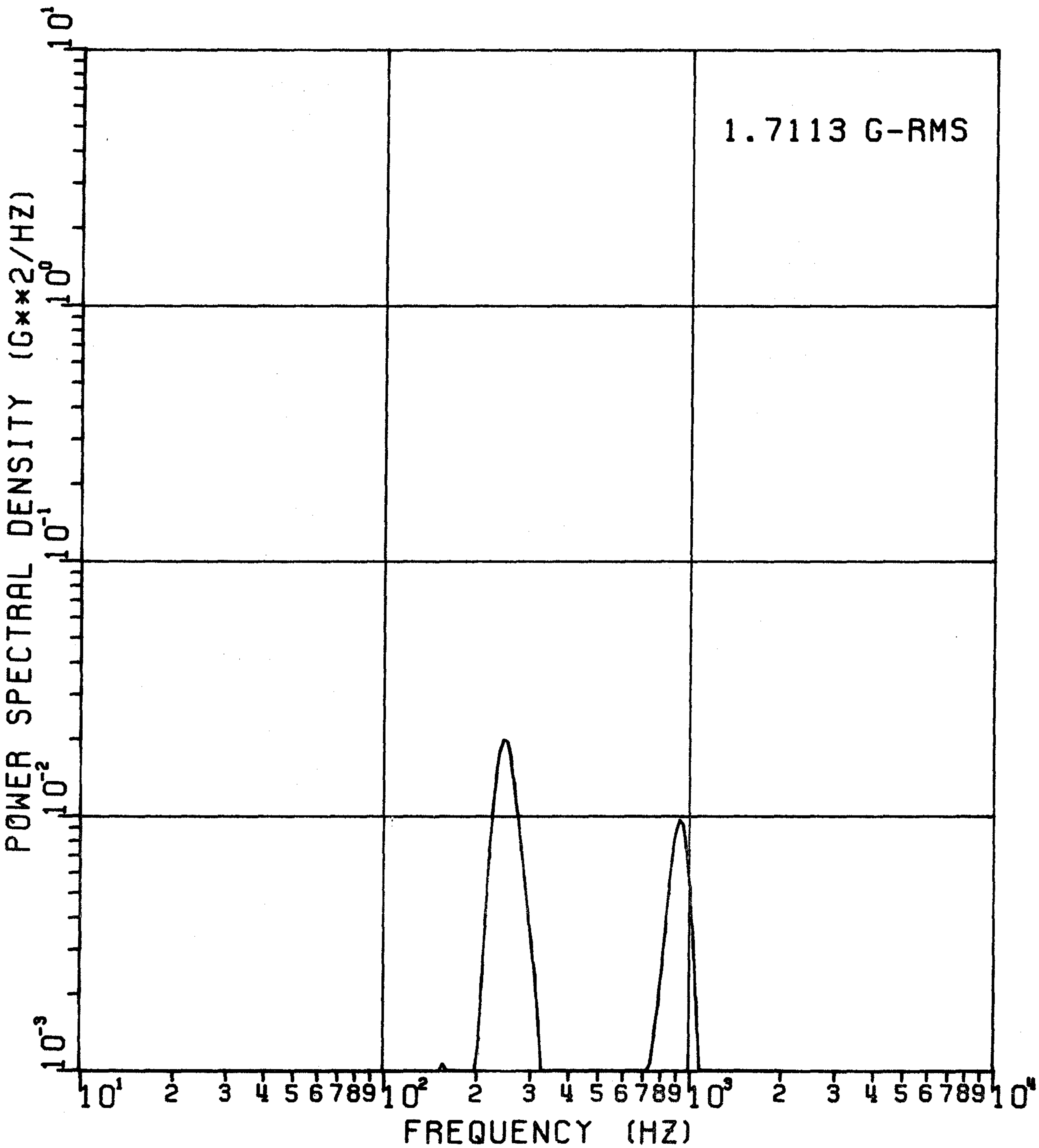
LOCATION 14



1 Y AXIS SUBPACK 3 SEP 1970

FIGURE 23b RANDOM VIBRATION SPECTRUM

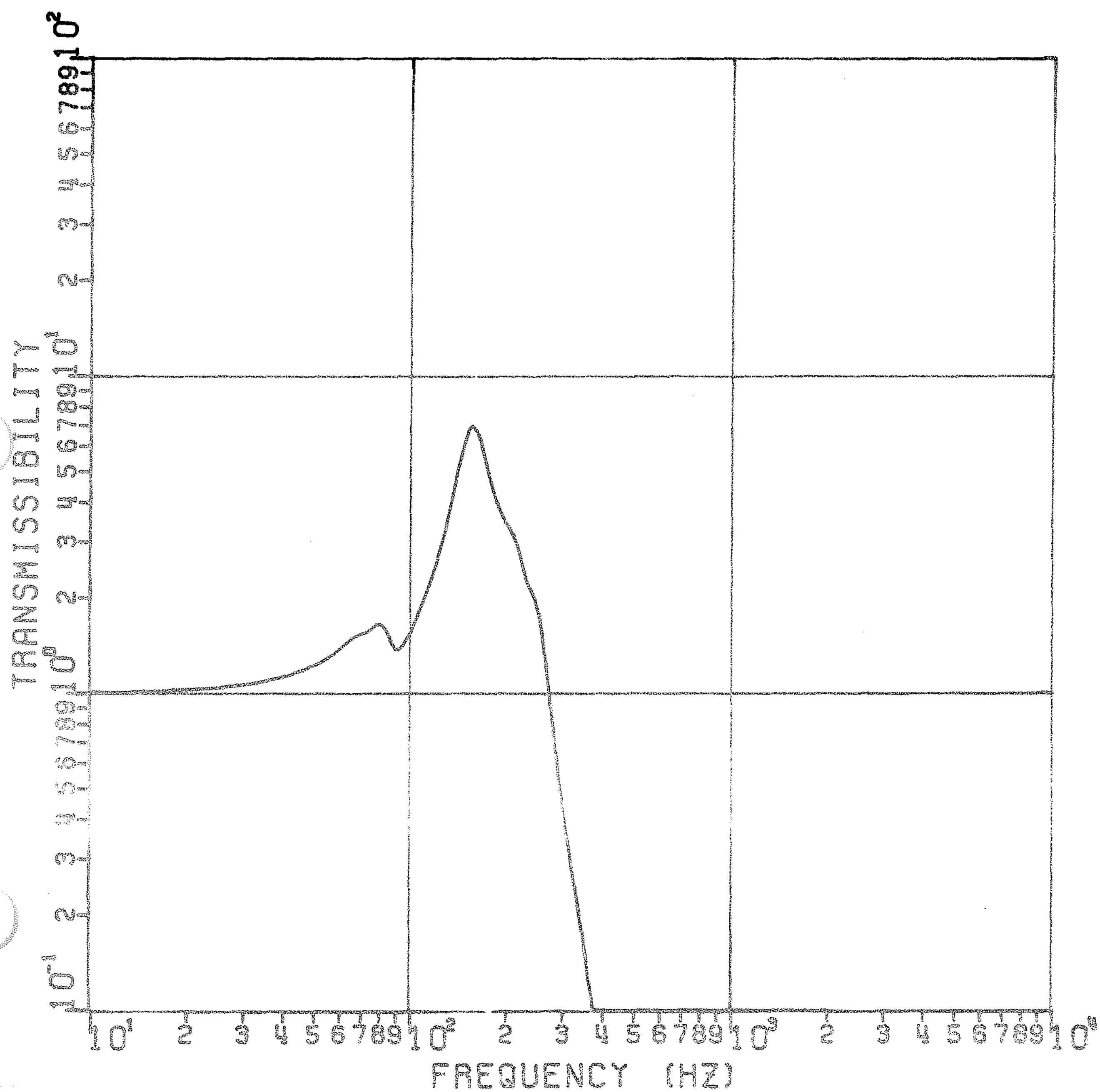
LOCATION 14



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 24a TRANSMISSIBILITY

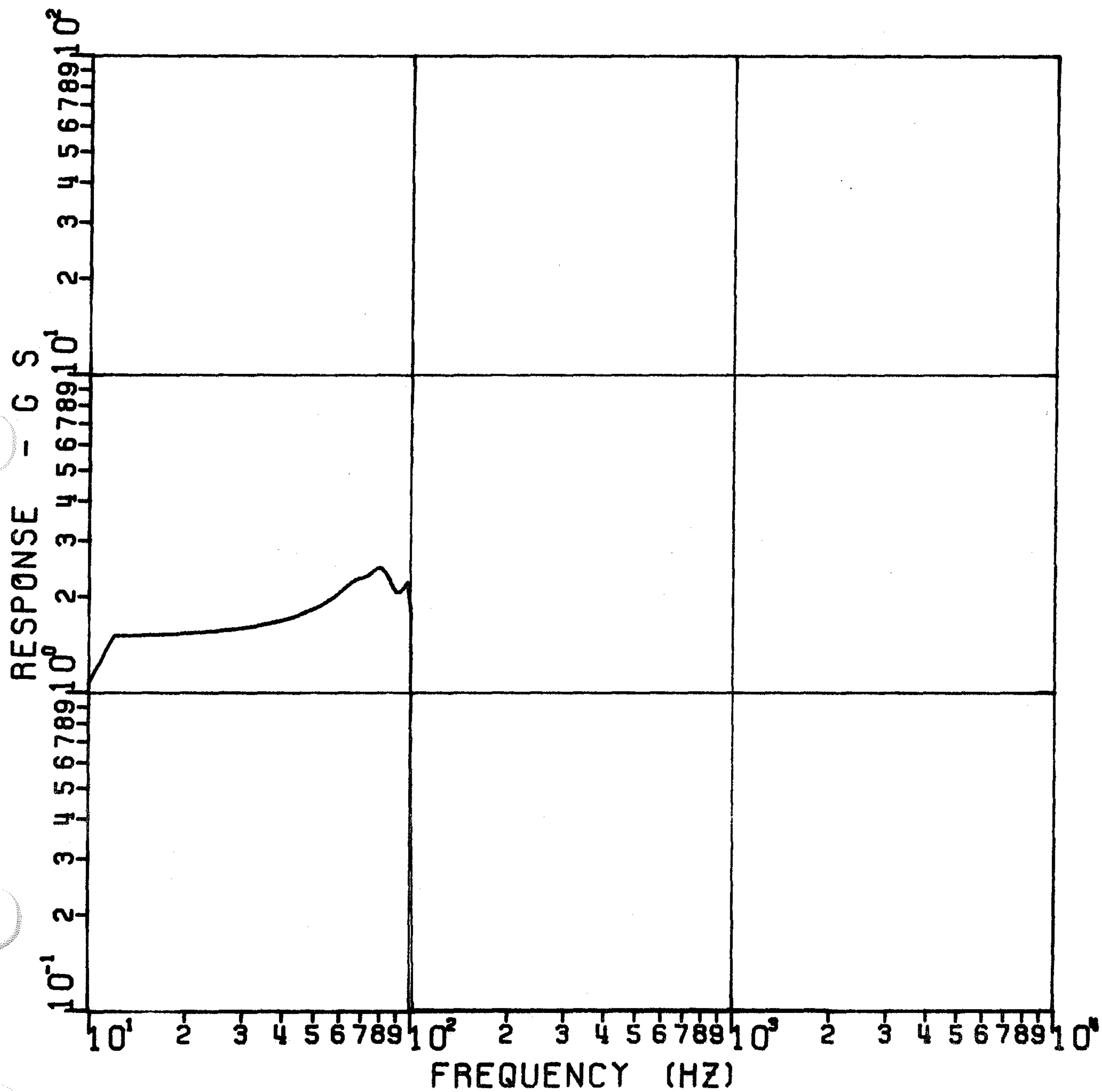
LOCATION 3



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 24b SINE RESPONSE

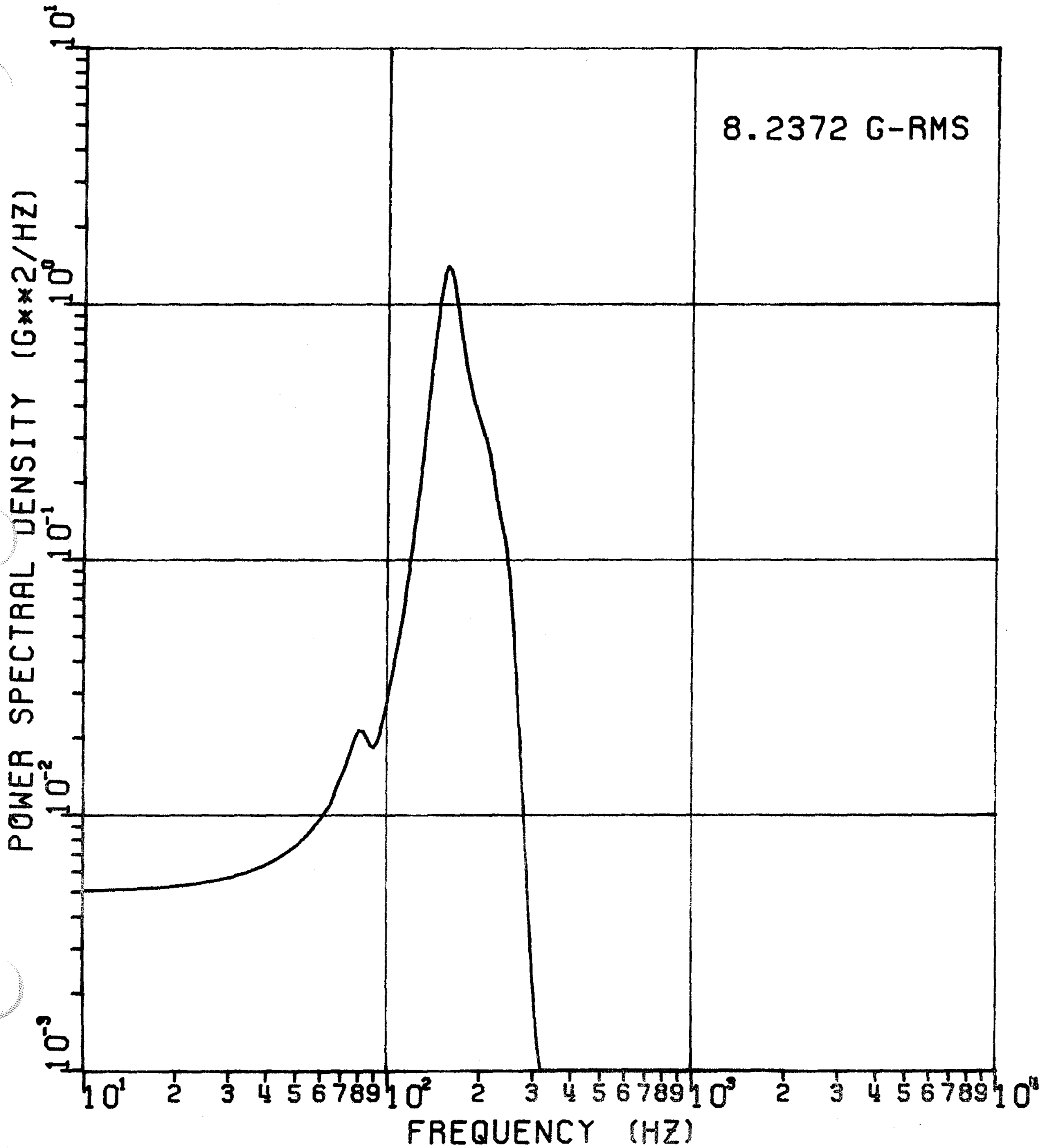
LOCATION 3



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 24c RANDOM VIBRATION SPECTRUM

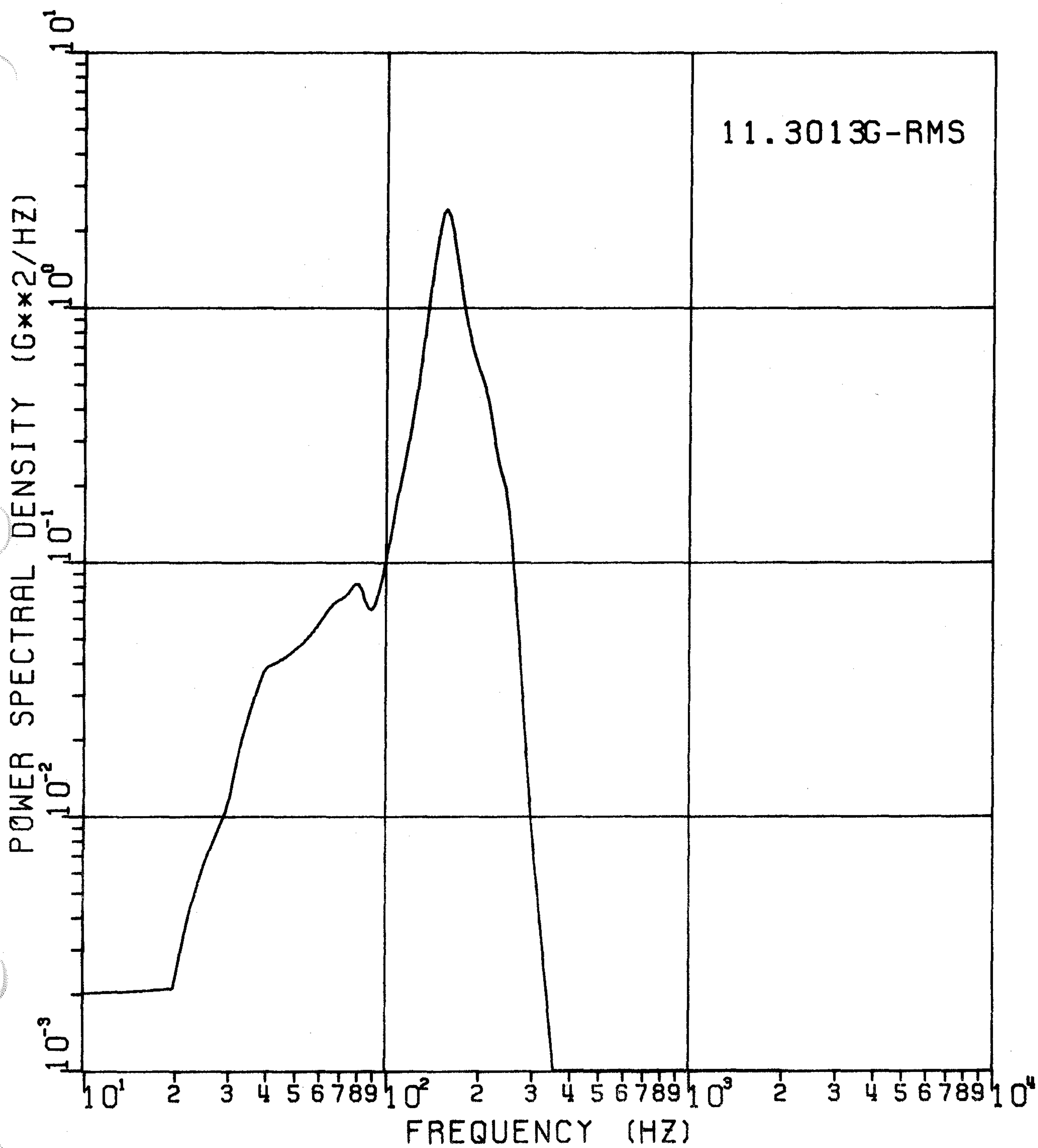
LOCATION 3



1 Z AXIS SUBP. 3 SEP 70 NEW LEVELS

FIGURE 24d RANDOM VIBRATION SPECTRUM

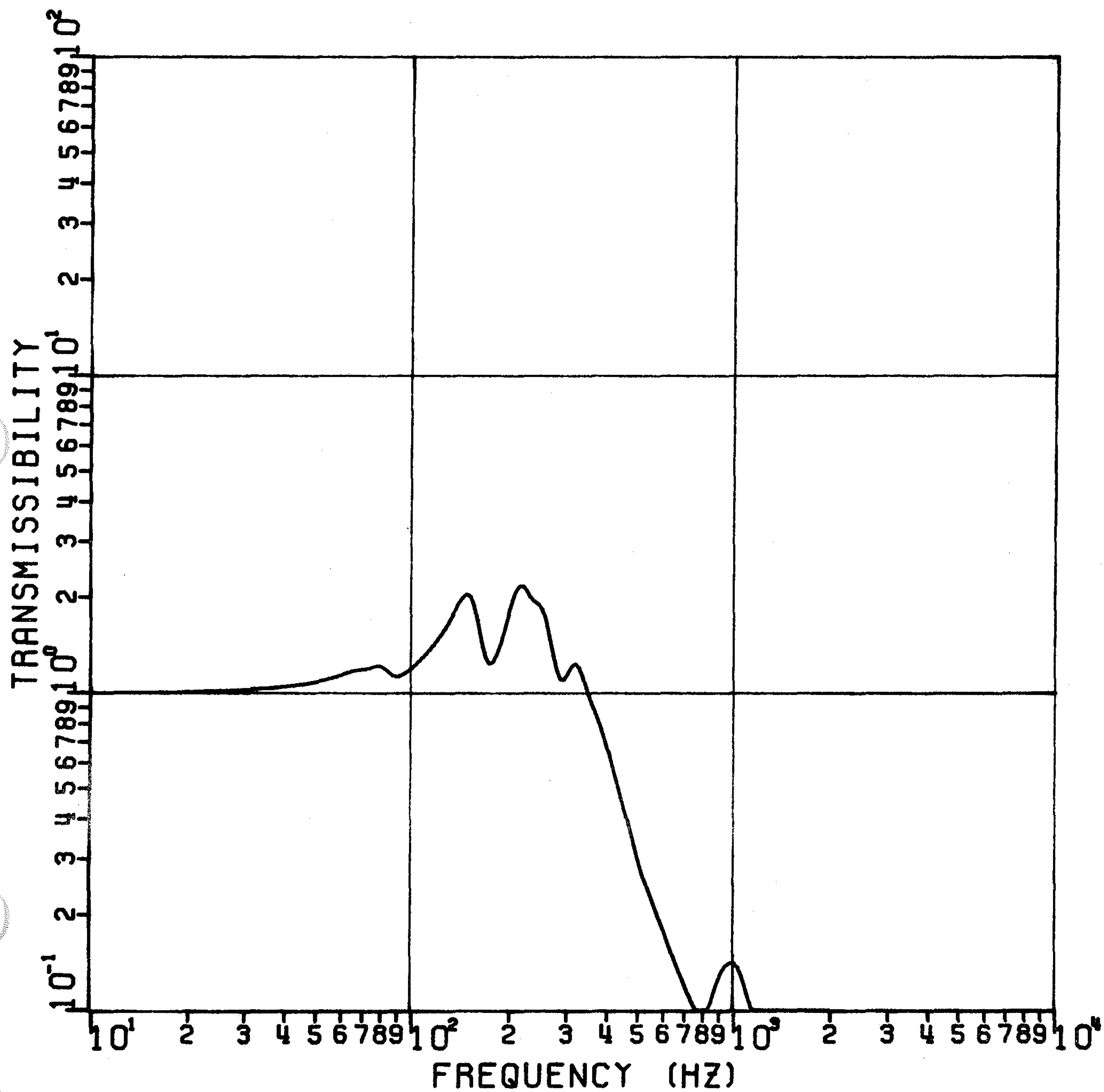
LOCATION 3



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 25a TRANSMISSIBILITY

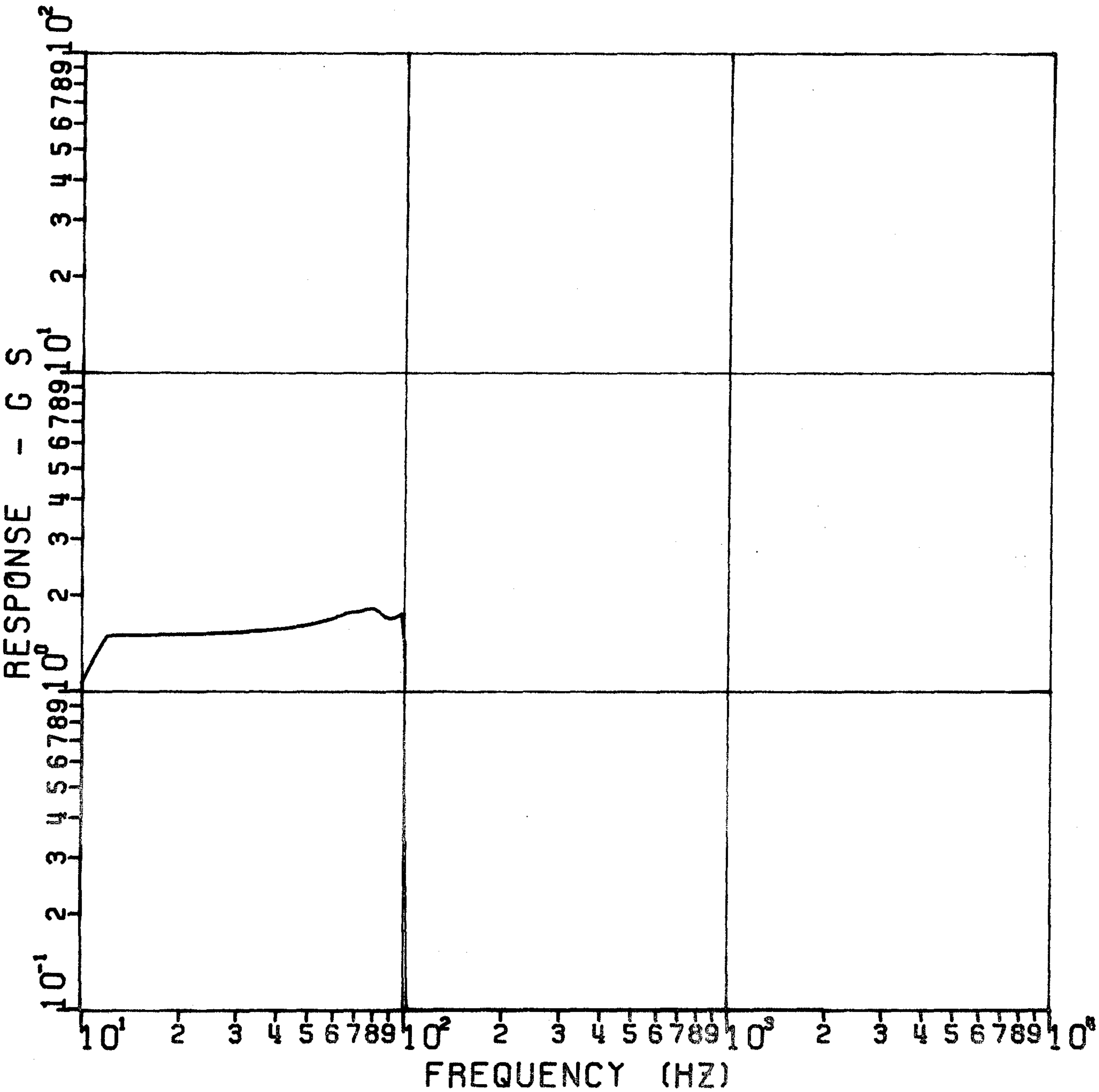
LOCATION 5



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 25b SINE RESPONSE

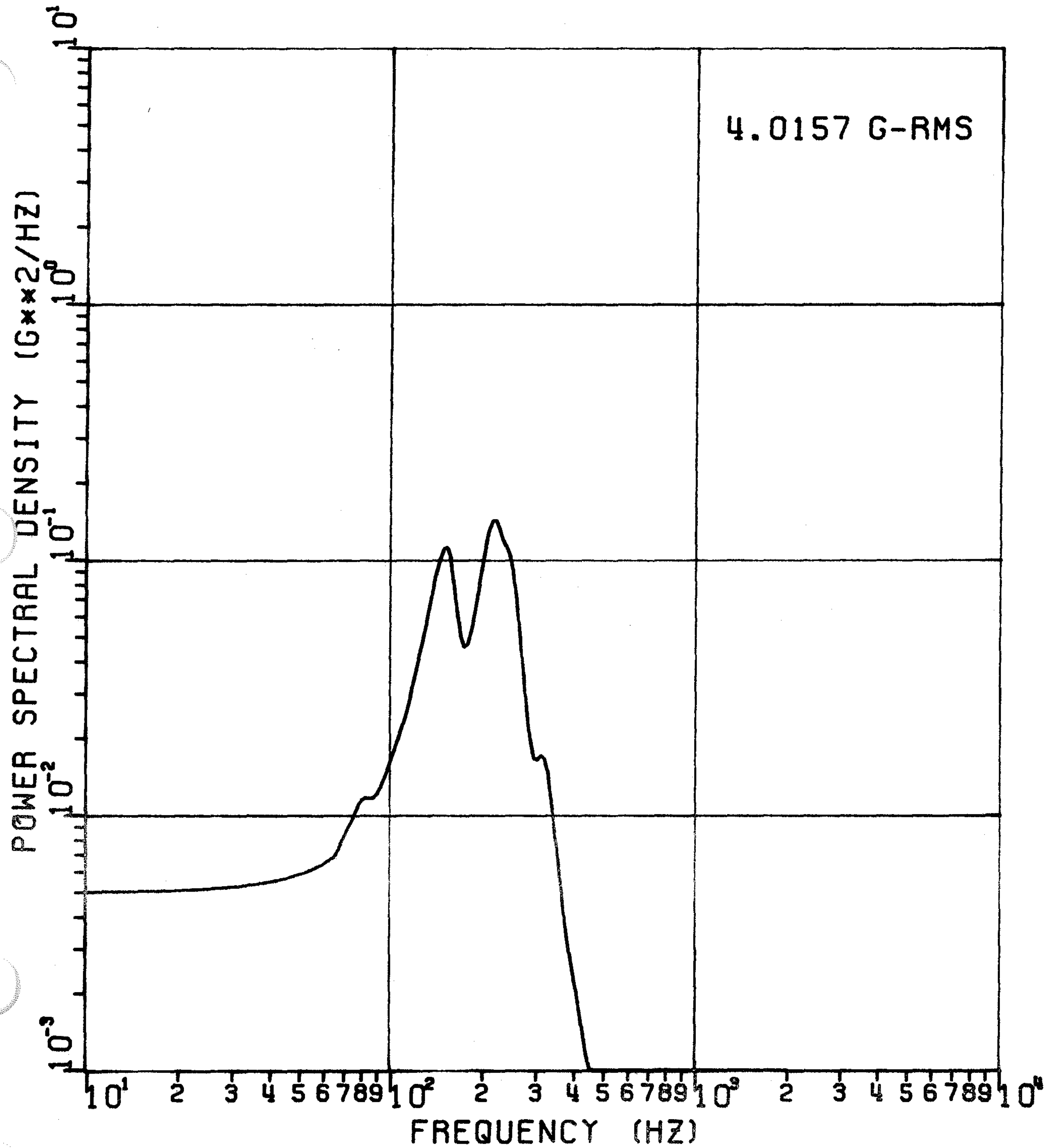
LOCATION 5



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 25c RANDOM VIBRATION SPECTRUM

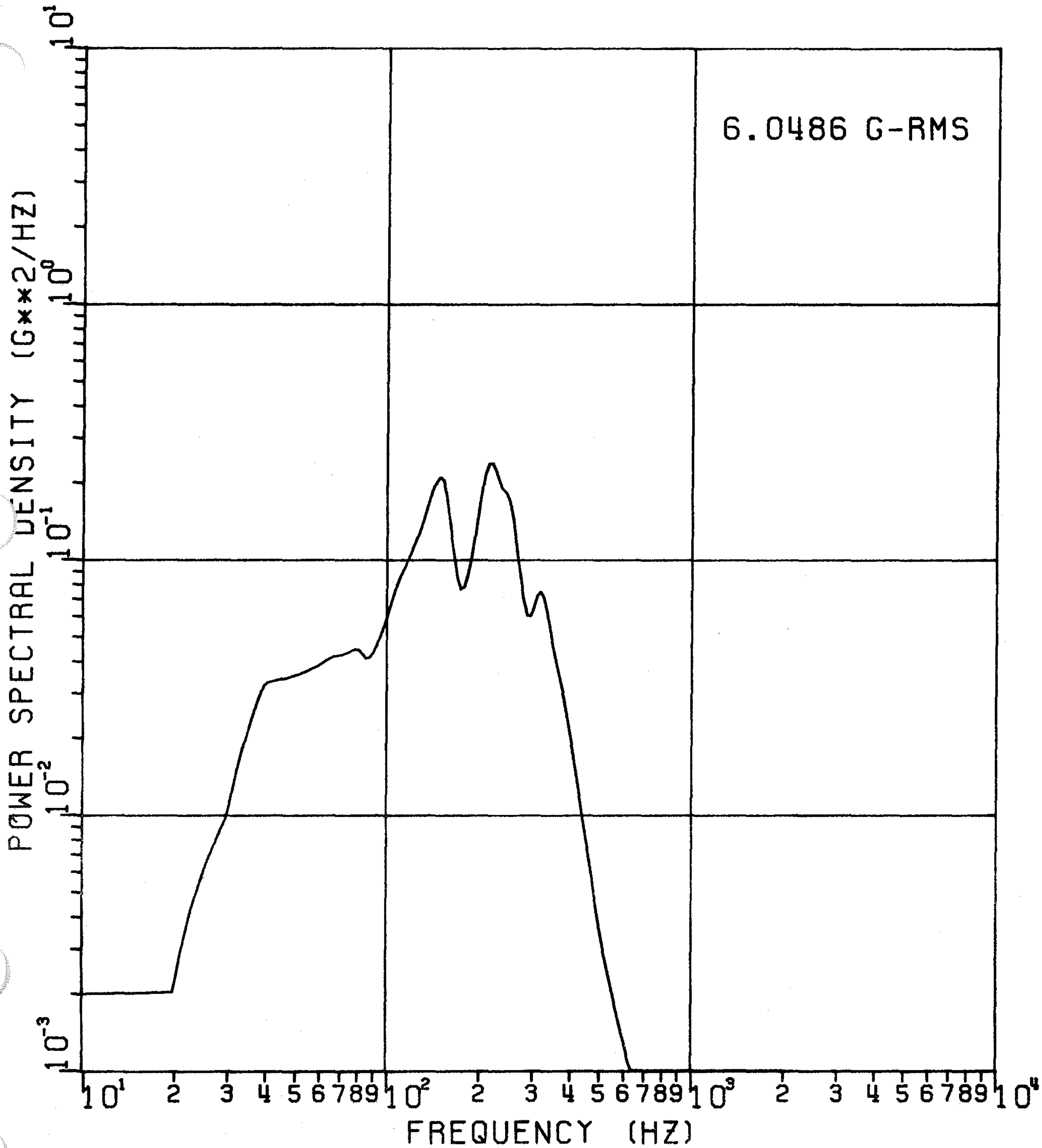
LOCATION 5



1 Z AXIS SUBP. 3 SEP 70 NEW LEVELS

FIGURE 25d RANDOM VIBRATION SPECTRUM

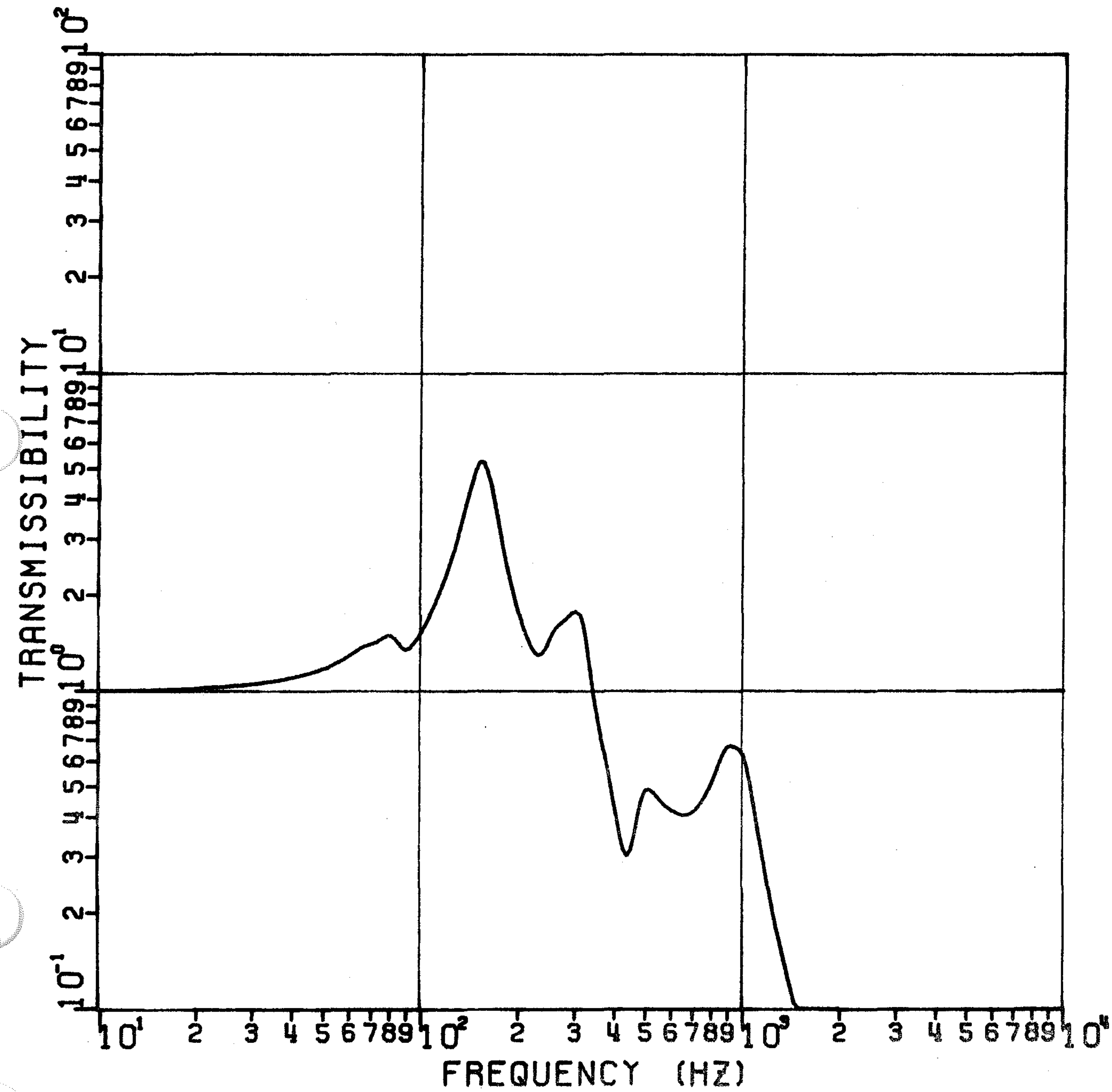
LOCATION 5



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 26a TRANSMISSIBILITY

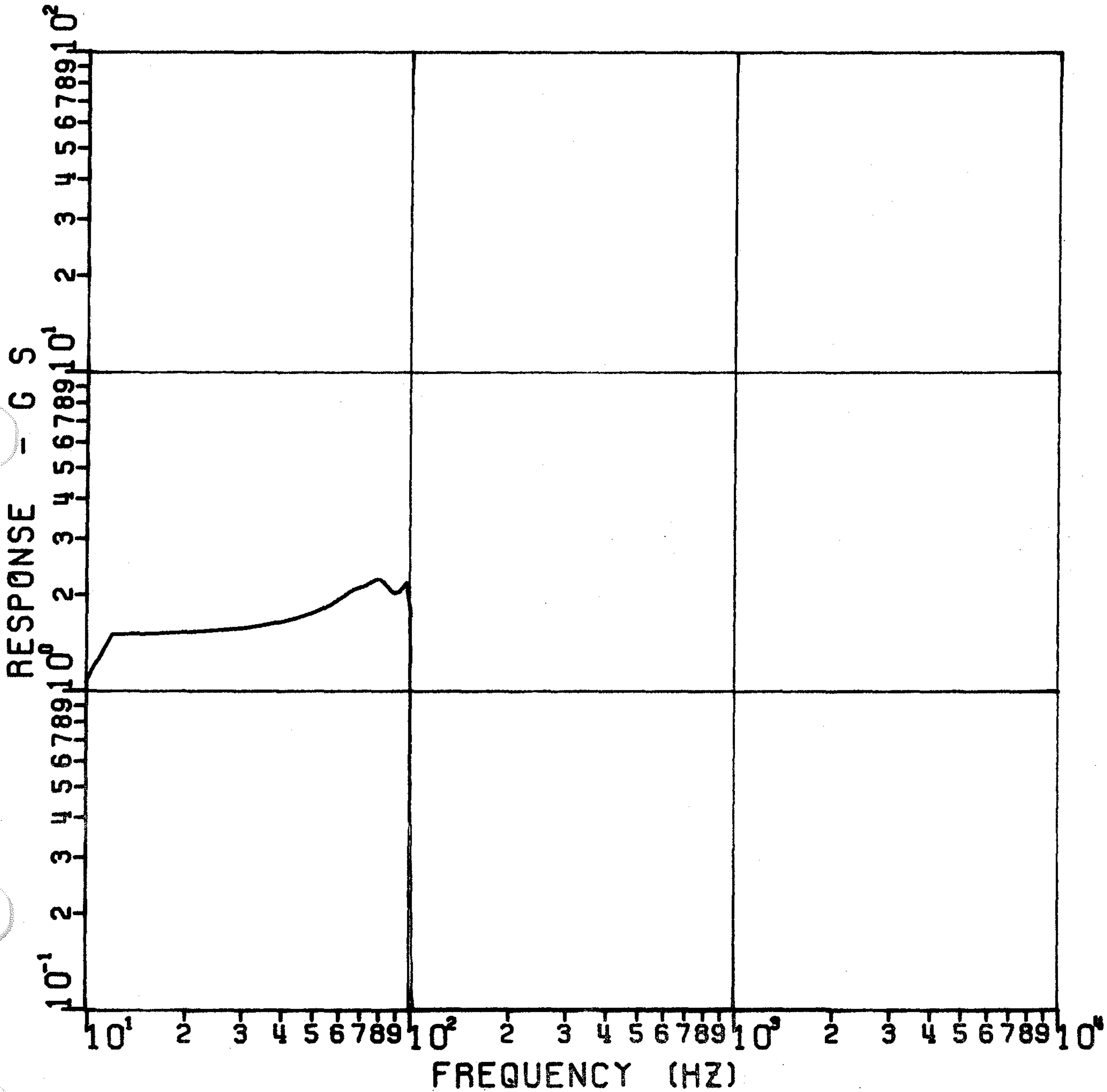
LOCATION 13



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 26 b SINE RESPONSE

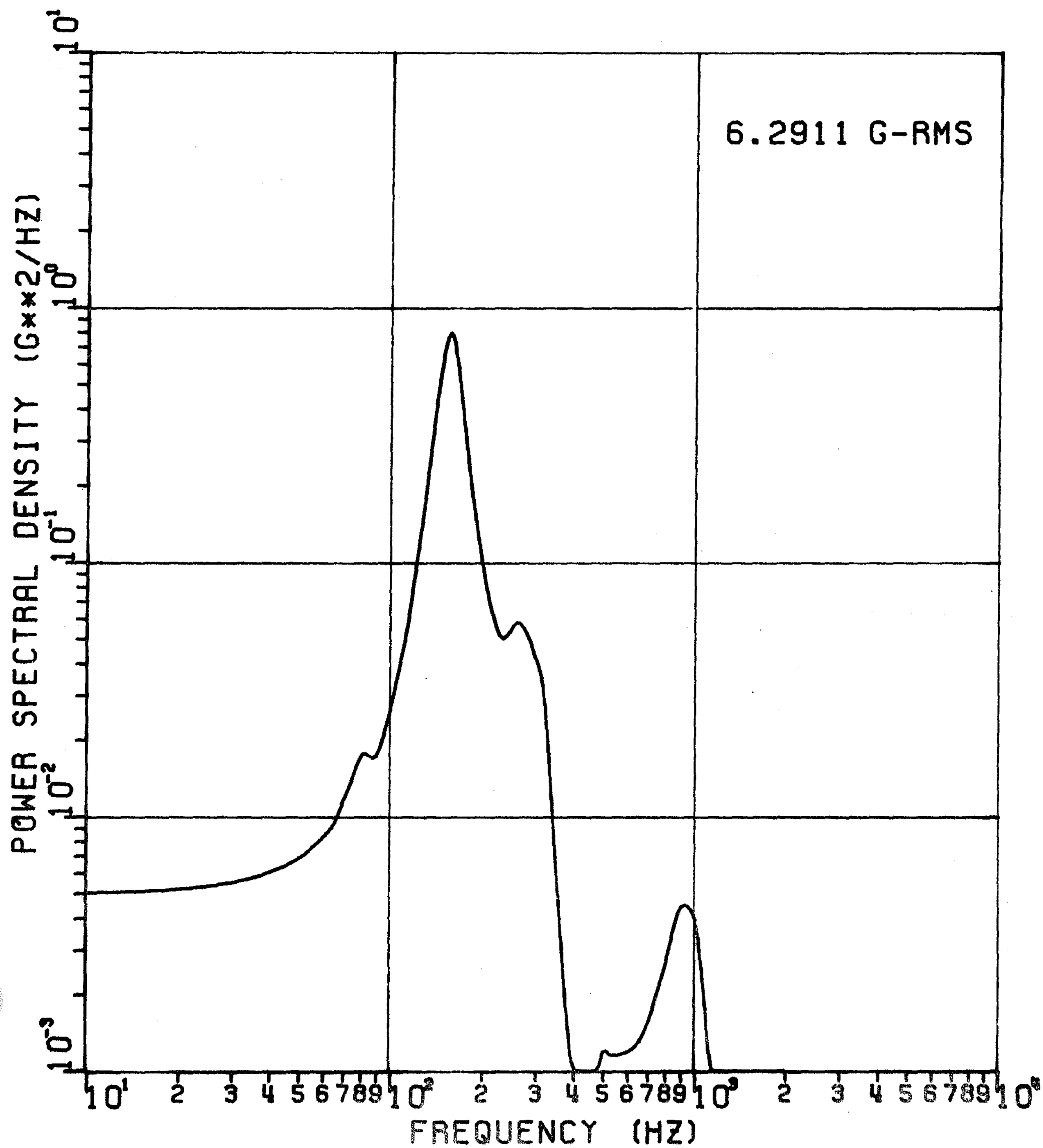
LOCATION 13



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 26c RANDOM VIBRATION SPECTRUM

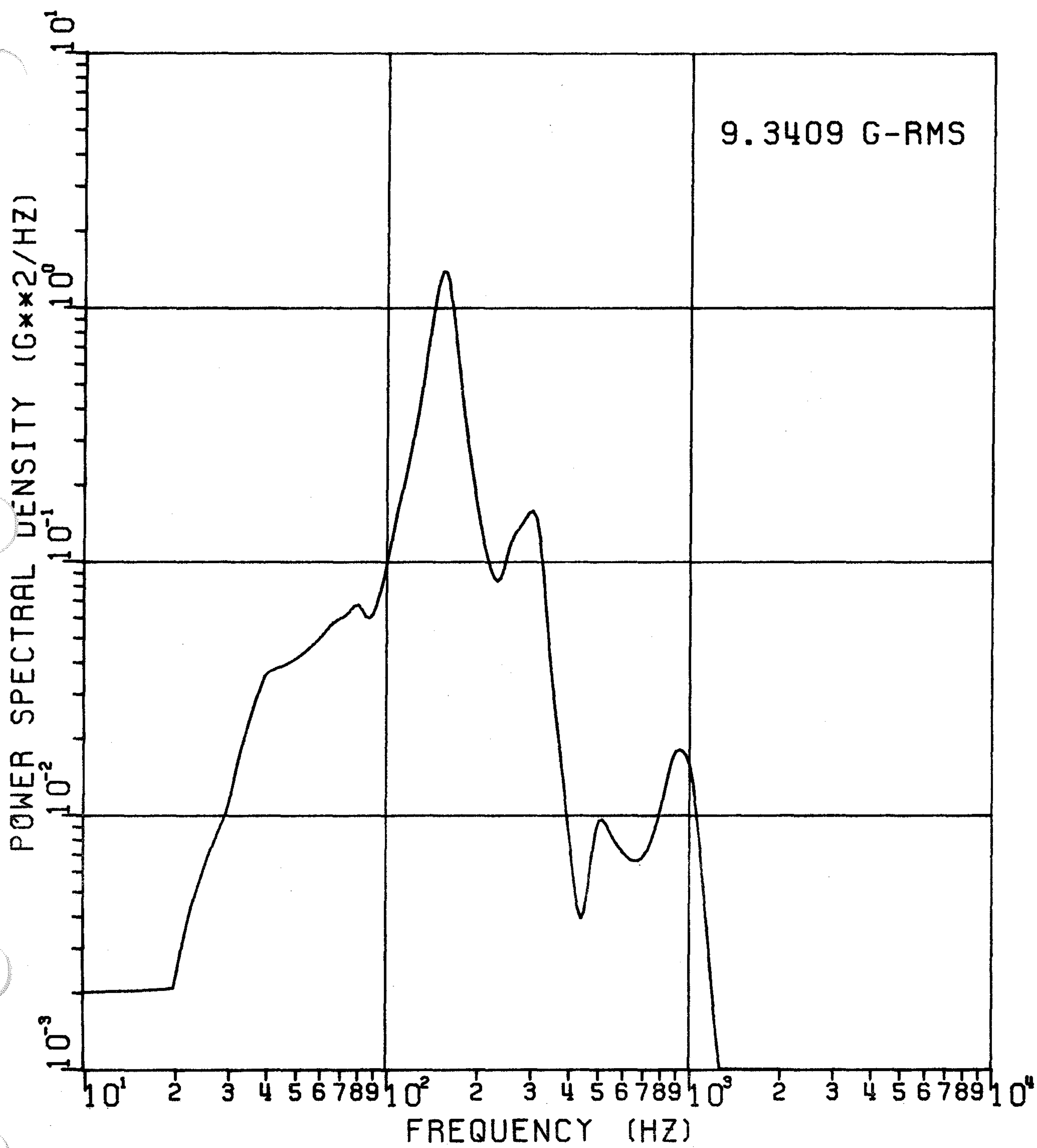
LOCATION 13



1 Z AXIS SUBP. 3 SEP 70 NEW LEVELS

FIGURE 26 d RANDOM VIBRATION SPECTRUM

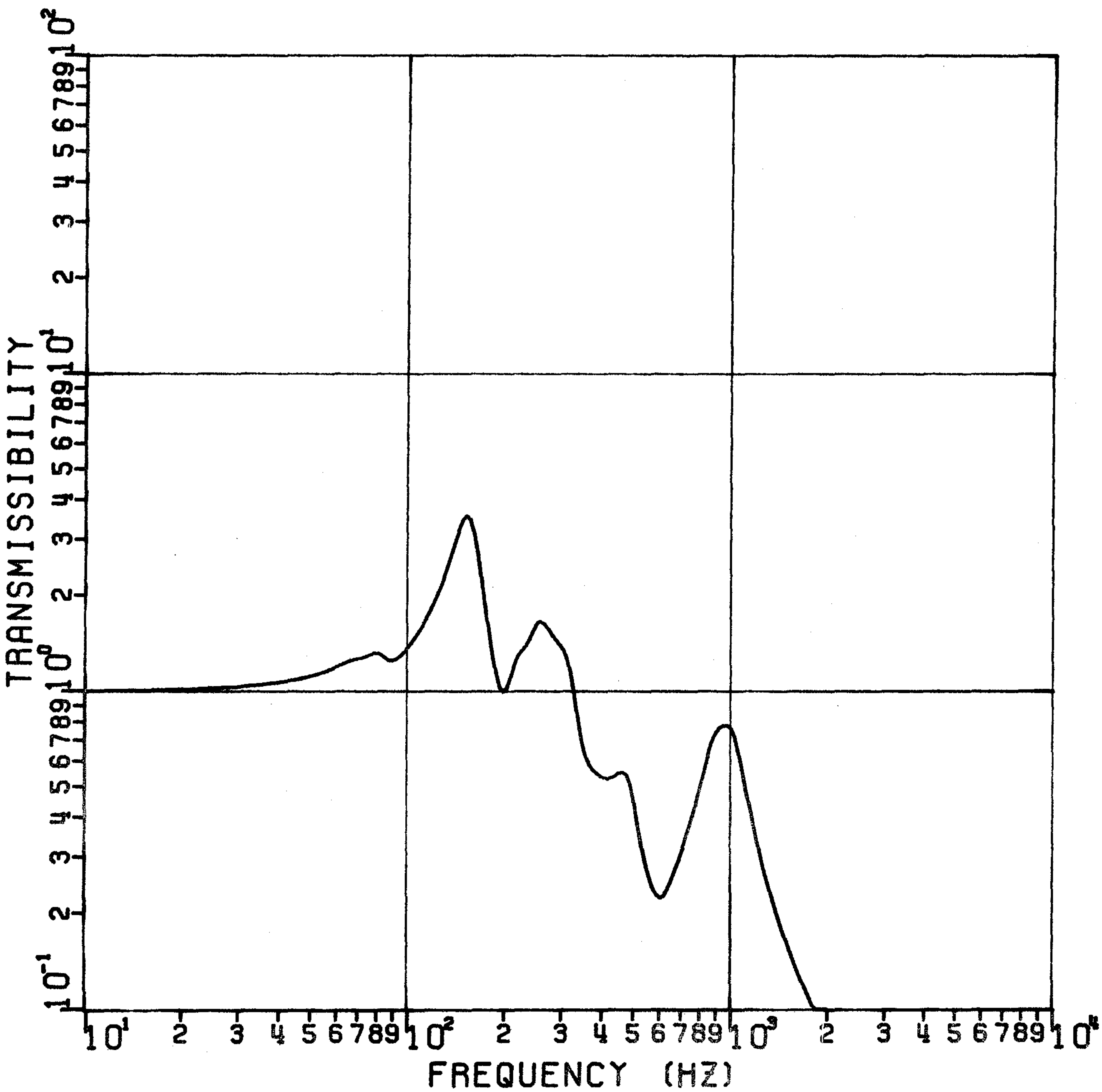
LOCATION 13



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 27a TRANSMISSIBILITY

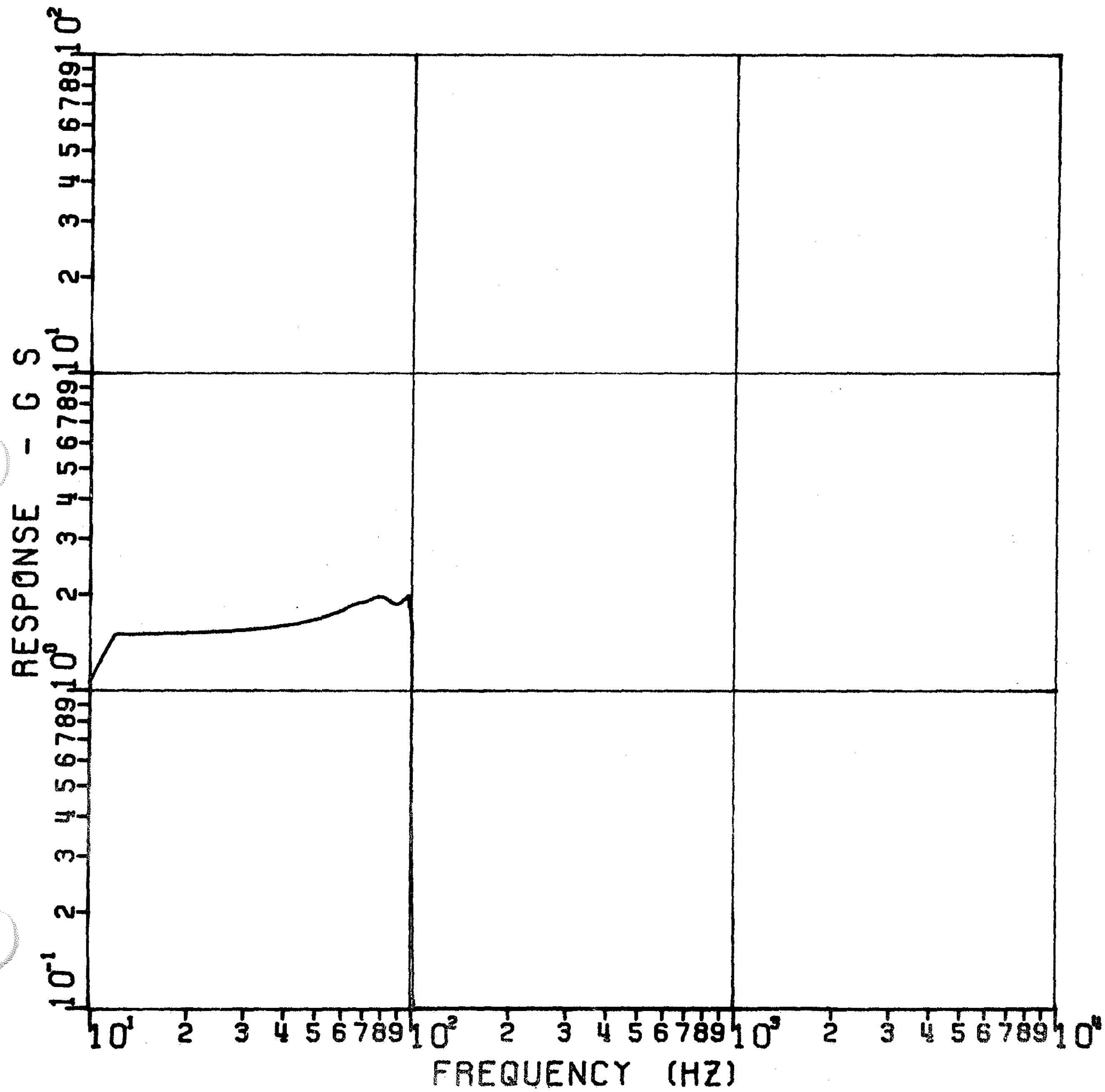
LOCATION 14



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 27b SINE RESPONSE

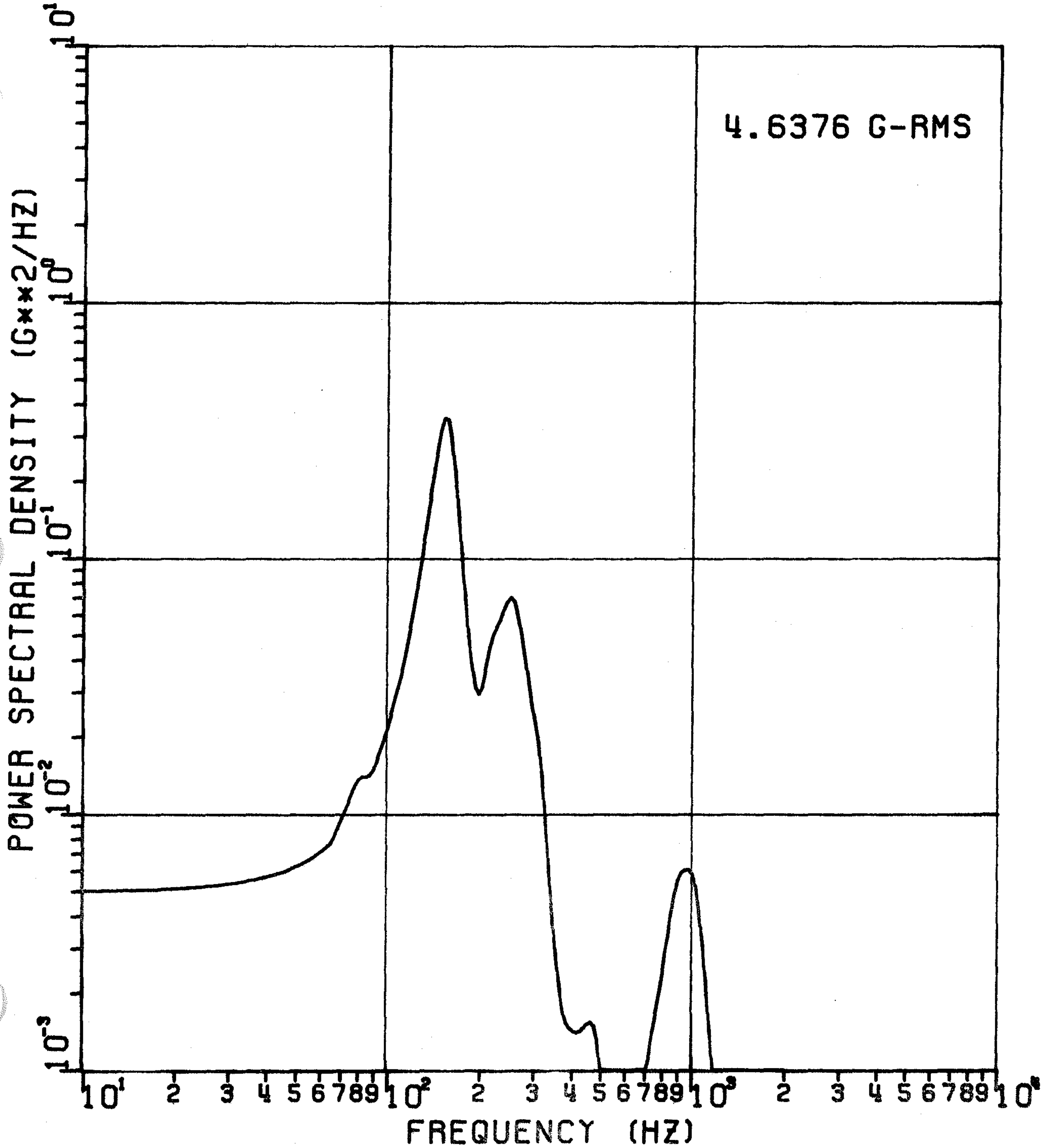
LOCATION 14



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 27c RANDOM VIBRATION SPECTRUM

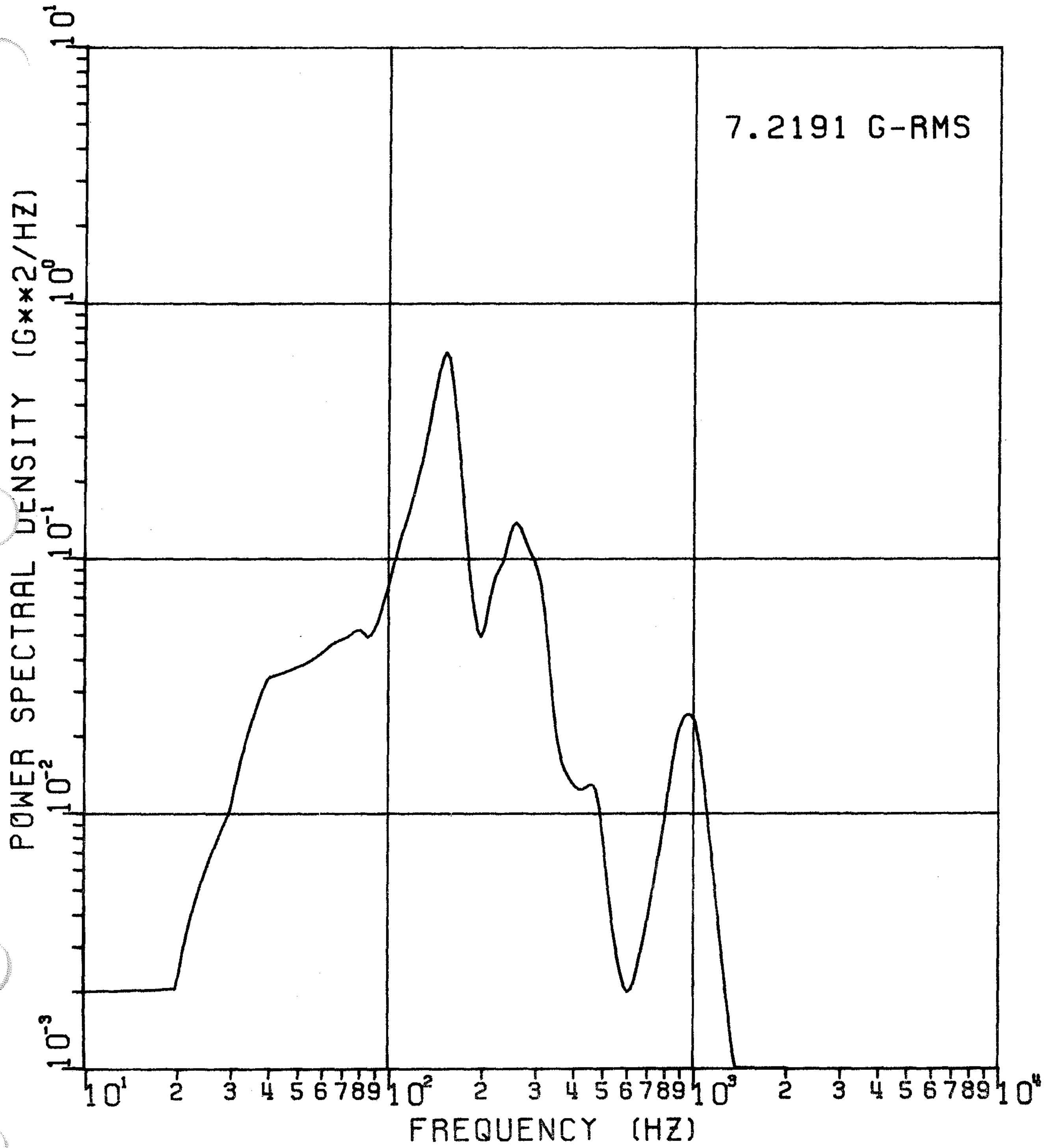
LOCATION 14



1 Z AXIS SUBP. 3 SEP 70 NEW LEVELS

FIGURE 27d RANDOM VIBRATION SPECTRUM

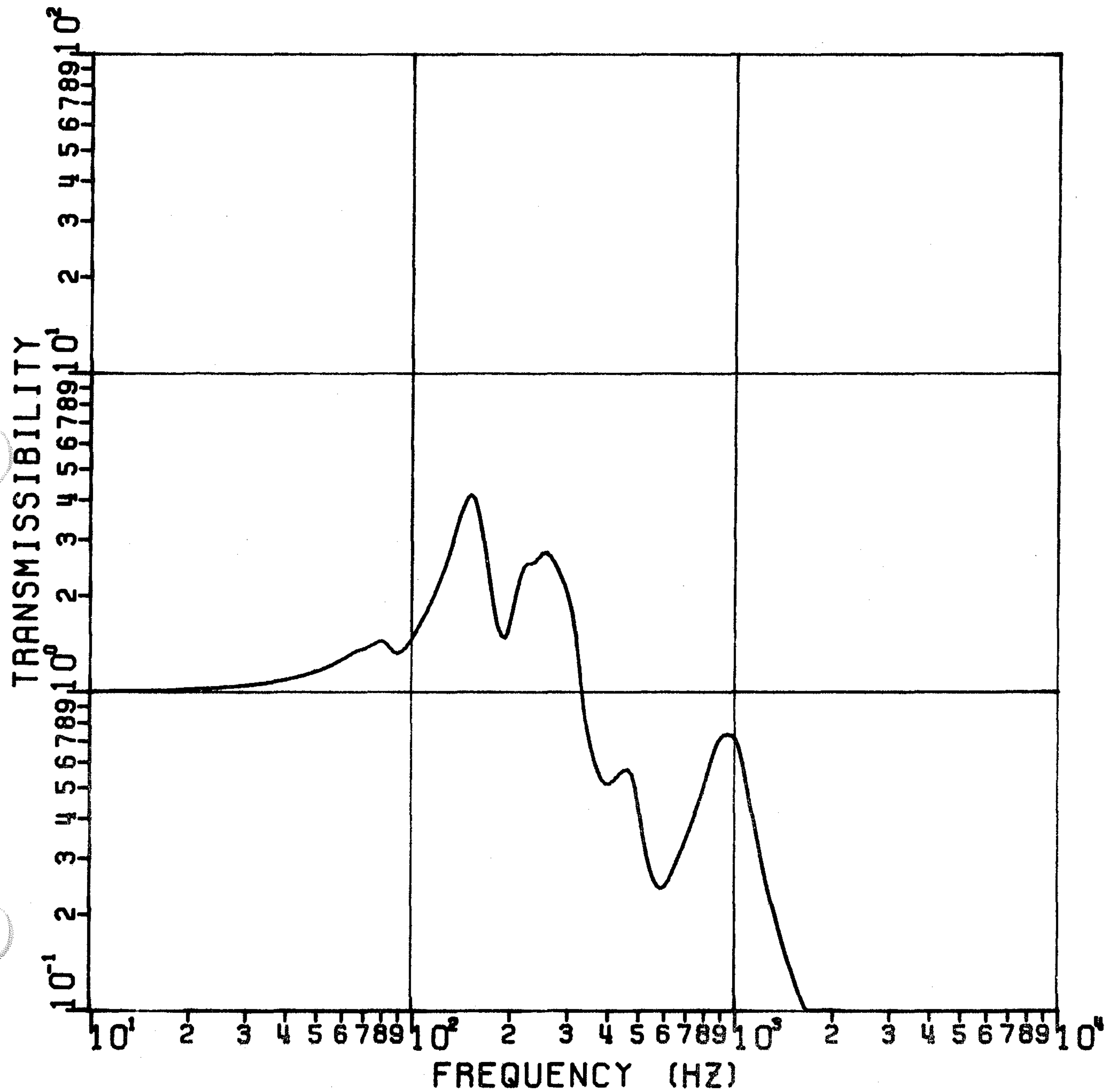
LOCATION 14



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 28a TRANSMISSIBILITY

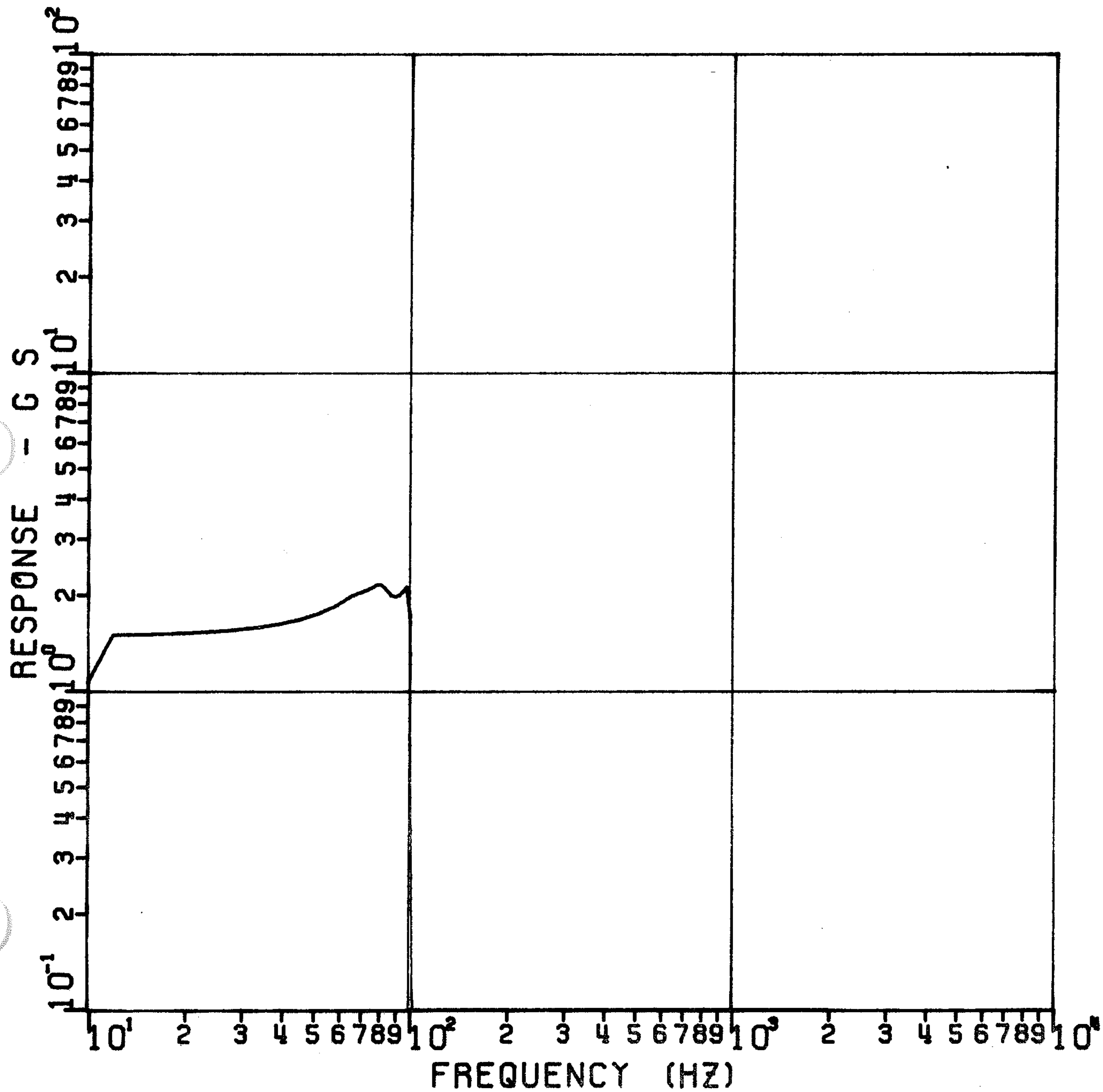
LOCATION 15



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 28b SINE RESPONSE

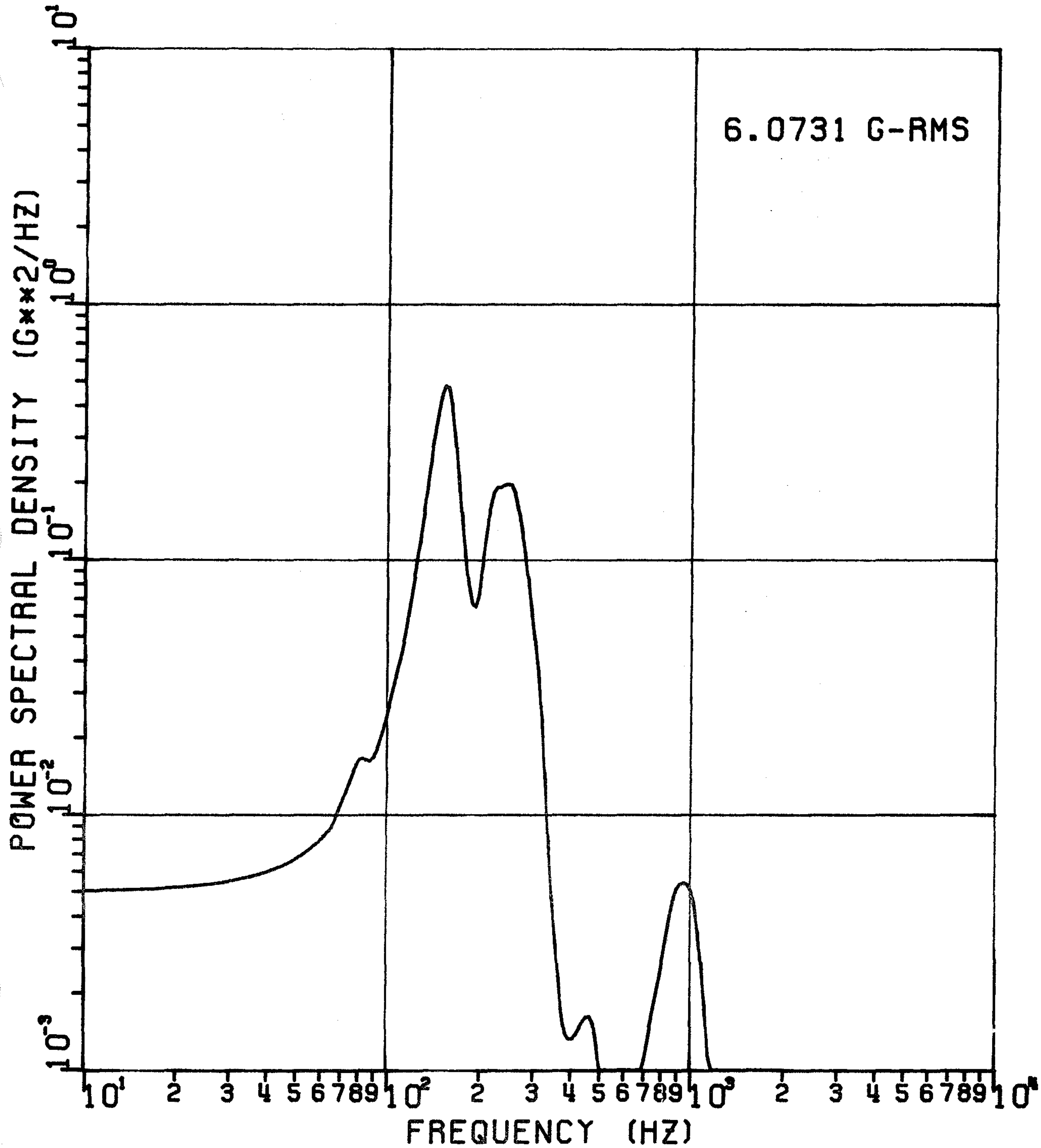
LOCATION 15



1 Z AXIS SUBPACK 3 SEP 1970

FIGURE 28c RANDOM VIBRATION SPECTRUM

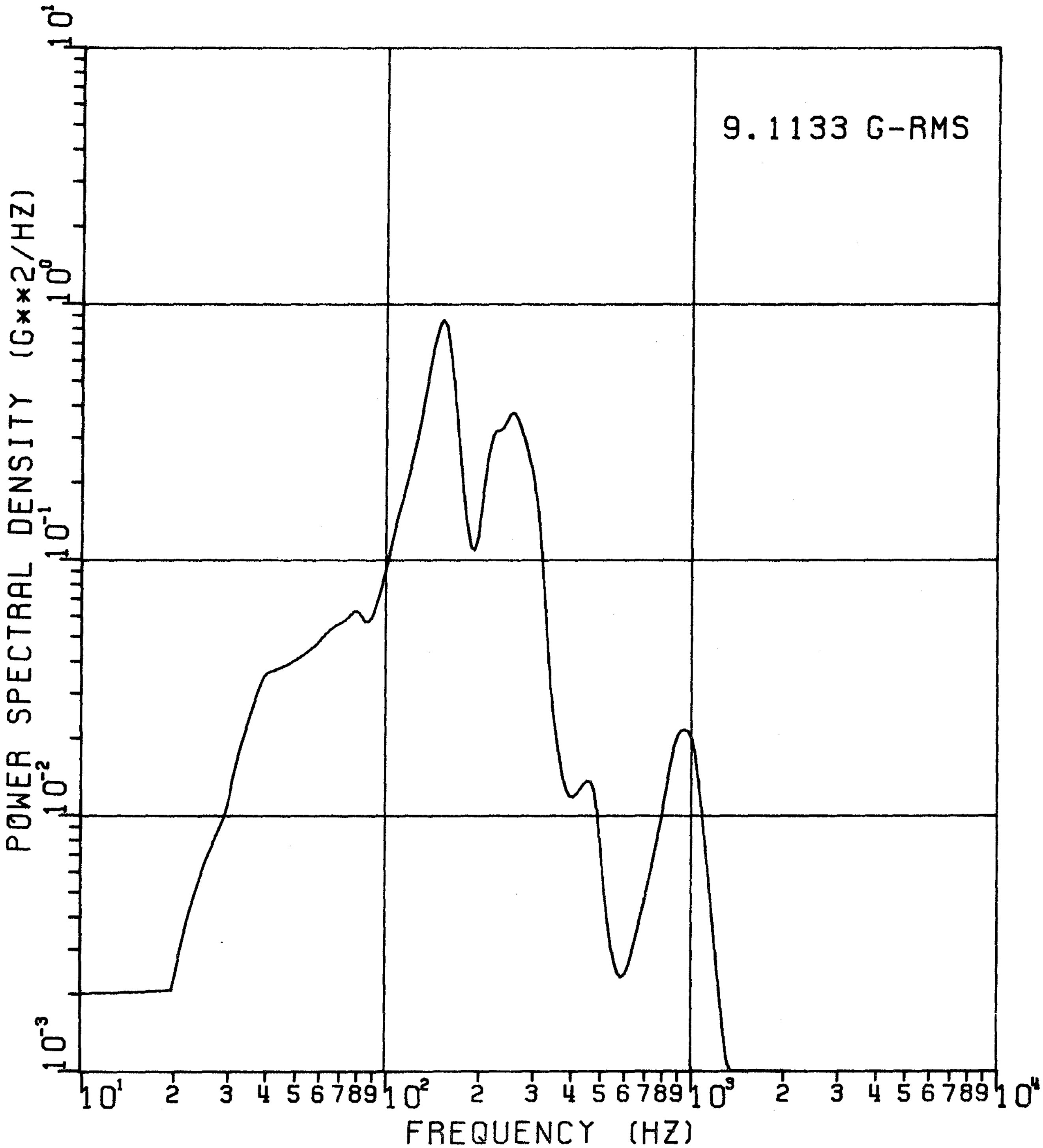
LOCATION 15



1 Z AXIS SUBP. 3 SEP 70 NEW LEVELS

FIGURE 28 d RANDOM VIBRATION SPECTRUM

LOCATION 15



T 3

ROOT MEAN SQUARE--COMBINED LOADS

X-AXIS

	DEFLECTIONS - IN	INTERNAL LOADS - LB.
1	0.7094701D-02	0.2319968D 03
2	0.4608755D-02	0.2609940D 02
3	0.2959569D-02	0.2688653D 02
4	0.3122792D-02	0.4449155D 02
5	0.1220524D-02	0.2685657D 02
6	0.1417060D-02	0.1221506D 03
7	0.7096074D-02	0.8550271D 02
8	0.1493043D-02	0.2609940D 02
9	0.1026659D-02	0.4449155D 02
10	0.2928775D-02	0.8378591D 02
11	0.2728582D-03	0.2685657D 02
12	0.8744010D-03	0.6900272D 02
13	0.1521901D-02	0.2519445D 02
14	0.1985936D-02	0.2551793D 02
15	0.3195734D-02	0.5664197D 02
16	0.1183953D-02	0.2524956D 02
17	0.1273187D-02	0.2707783D 02
18	0.1493043D-02	0.2704213D 02
19	0.1026859D-02	0.4602286D 02
20	0.2928775D-02	0.8390648D 02
21	0.2728582D-03	0.2724551D 02

Y-AXIS

	DEFLECTIONS - IN.	INTERNAL LOADS - LB.
1	0.1391058D-02	0.4548761D 02
2	0.9295478D-03	0.1054610D 02
3	0.3957980D-02	0.2359141D 02
4	0.2534793D-02	0.2278111D 02
5	0.1519744D-02	0.3095613D 02
6	0.6548087D-04	0.5644452D 01
7	0.9375525D-02	0.1124881D 03
8	0.5625381D-03	0.1054610D 02
9	0.1401983D-02	0.2278111D 02
10	0.3948728D-02	0.1070323D 03
11	0.4627058D-03	0.3095613D 02
12	0.4254323D-03	0.3251171D 02
13	0.7435613D-03	0.1237598D 02
14	0.8314524D-03	0.1000171D 02
15	0.1264849D-02	0.2247157D 02
16	0.6034202D-03	0.1037646D 02
17	0.5822539D-03	0.1160442D 02
18	0.5625381D-03	0.1067412D 02
19	0.1401983D-02	0.2299541D 02
20	0.3948728D-02	0.1072570D 03
21	0.4627058D-03	0.3491328D 02

Z - AXIS

	DEFLECTIONS - IN	INTERNAL LOADS - LB
1	0.4941035D-02	0.1615719D 03
2	0.8552128D-03	0.5212988D 01
3	0.1507073D-02	0.1273879D 02
4	[illegible]	[illegible]
5	0.4483461D-03	0.9778412D 01
6	0.1869445D-03	0.1611462D 02
7	0.2992364D-02	0.3543264D 02
8	0.3586161D-03	0.5212988D 01
9	0.4923270D-03	0.1692591D 02
10	0.1334141D-02	0.3526608D 02
11	0.1207562D-03	0.9778412D 01
12	0.1395676D-02	0.1116054D 03
13	0.2738530D-02	0.4920356D 02
14	0.3834076D-02	0.4700833D 02
15	0.6494432D-02	0.1152635D 03
16	0.1644290D-02	0.4716092D 02
17	0.2170335D-02	0.4698504D 02
18	0.3586161D-03	0.5275135D 01
19	0.4923270D-03	0.1693752D 02
20	0.1334141D-02	0.3533946D 02
21	0.1207562D-03	0.9928922D 01

REFER TO TABLE I FOR COORDINATE DEFINITIONS

SECTION II STRESS ANALYSIS OF A2/SP-3 FRAME ASSEMBLY

Enclosures: (1) Schematic Layout of A-2/SP-3 Frame Assembly
(2) Results of Stress Analysis Including In-Plane and Out-of-Plane Loading Conditions

1.0 INTRODUCTION

A stress analysis of the subject frame assembly was performed in accordance with the requirements specified in the statement of work for the design of the A-2/SP-3.

The methods of analyses were based on BxA computer programs BSR 2909 and BSR 2910 which are rigid frame analysis and plane grid analysis programs, respectively. In addition to the computer programs, manual analyses of clips, joints, beam columns, etc. were performed.

Stiffness influence coefficients were printed out for use in the formulation of the dynamics analysis performed on the A-2/SP-3.

2.0 SUMMARY

The analysis shows that the design satisfies all requirements of structural integrity. Most elements of the structure have relatively low internal stress levels for all conditions of externally applied loads. Hence, cross-sectional geometry of the members was more a function of displacement limits than stress limits. The critical design loads are those acting in the plane of the frame parallel to the X-axis.

3.0 RESULTS

Results of the analysis are shown in Enclosure (2). A maximum displacement of 0.04 inches occurs at node 3, and a maximum bending stress of 32,500 psi occurs at node 6 on member 14. Bending stress levels between nodes are all less than the end moment acting on member 14.

The analysis without members 15 and 18 showed excessive displacements of the nodes in the middle section the frame assembly in the X-axis direction. Therefore, in order to limit these displacements members 15 and 18 were added to the structure.

The minimum margin of safety occurs adjacent to node 6 on member 14.

M.S. = 0.06 (combined bending and comp.).

4.0 DISCUSSION

Design ultimate loads were determined by multiplying the design limit loads by 20 g load factors and then applying safety factors of 1.5. Using this procedure, the following ultimate loads were determined for use in the analysis.

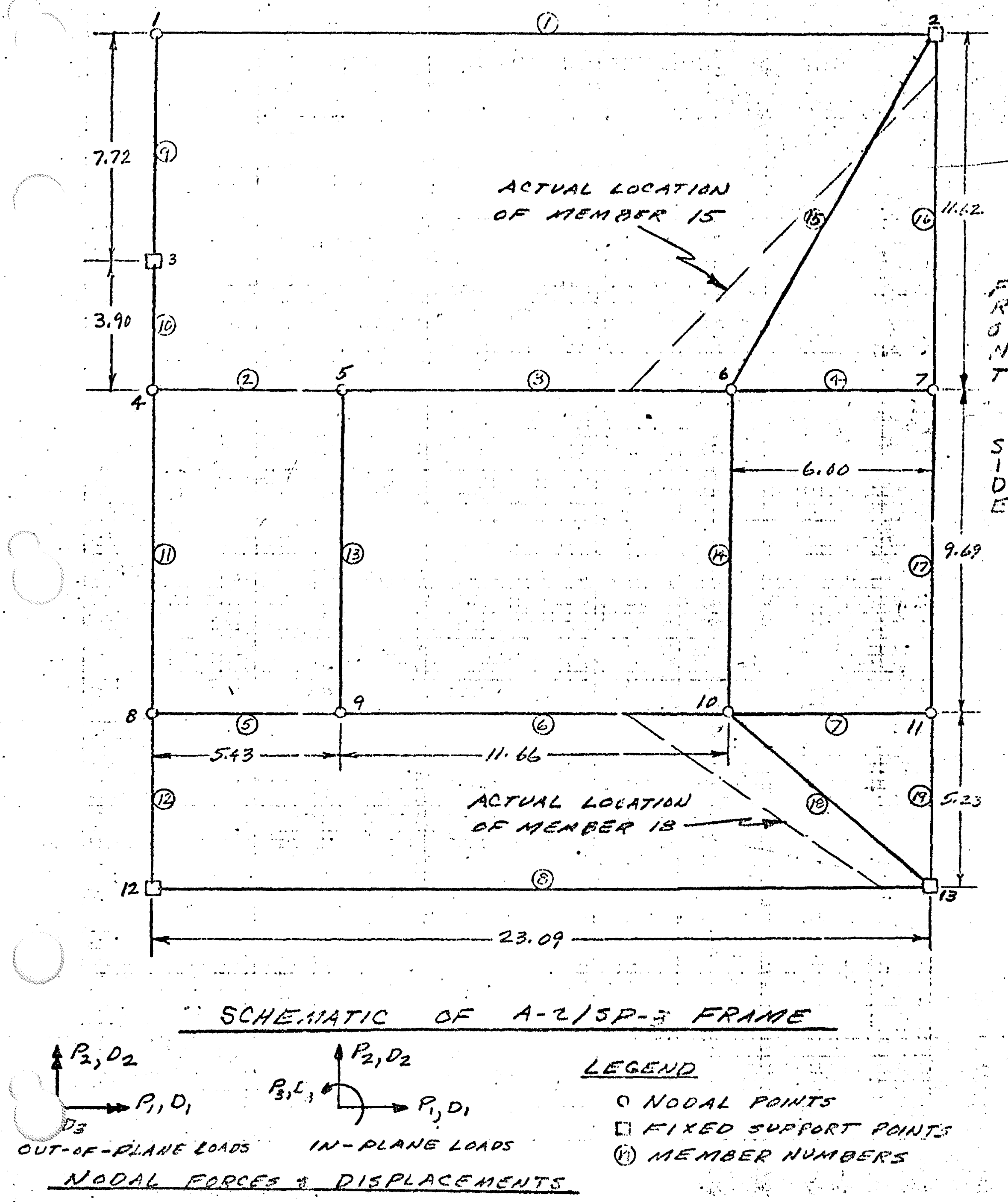
Item	Ult. Load (lb.)
ALSD	700
HFE	200
Probe Box	100

The externally applied loading conditions are defined as follows:

1. Loads applied normal to the frame parallel to the Z-axis.
2. Loads applied in the plane of the frame parallel to the X-axis.
3. Loads applied in the plane of the frame parallel to the Y-axis.

It should be noted in Enclosure (1) that the true locations of elements 15 and 18 are as indicated by the dashed lines. The analysis was performed before these members were added to the drawing. Subsequently, the problem of securing these members to nodal points 2, 6, 10 and 13 became nearly insurmountable. The dashed lines indicate the compromise locations of the members that still insures adequate strength of the frame.

The stiffness characteristics of the assembly in the Y-direction are such as to reduce stress and displacement levels to negligible values. Therefore, results of the analysis for in-plane loading parallel to the Y-axis (cond. 3) are not shown in Enclosure (2).



1
2
3
4
5
6
7
8
9
10
11
12
13
7.72
3.90
11.62
9.69
5.23
6.60
5.43
11.66
23.09
FRONT
SIDE
ACTUAL LOCATION
OF MEMBER 15
ACTUAL LOCATION
OF MEMBER 18
SCHEMATIC OF A-2/SP-3 FRAME
P2, D2
P1, D1
D3
OUT-OF-PLANE LOADS
P2, D2
P3, L3
P1, D1
IN-PLANE LOADS
NODAL FORCES + DISPLACEMENTS
LEGEND
NODAL POINTS
FIXED SUPPORT POINTS
MEMBER NUMBERS

LOADING CONDITION NO. 1

MEMBER FORCES AND STRESSES

MEMBER	BENDING MOMENTS @ LOW NODE NO. F1	BENDING MOMENTS @ HIGH NODE NO. F2	TORSIONAL MOMENT F3	BENDING STRESSES @ LOW NODE NO. S1	BENDING STRESSES @ HIGH NODE NO. S2	TORSIONAL STRESS = F3Q/J S3
1	0.1120	103.1264	-0.0732	1.2977	1194.9128	-49.7058
2	1.5273	428.1563	-1.2798	8.6463	2423.8071	-358.3564
3	-428.0586	184.8459	0.6940	-1665.8428	719.3508	135.0206
4	160.9023	0.4570	-1.5662	910.8735	2.5873	-438.5317
5	-0.2227	470.4297	0.4892	-1.2605	2663.1187	136.9625
6	-470.5012	313.9524	-1.5512	-1851.0134	1221.7844	-262.8748
7	40.2625	-0.5720	-0.0212	256.0232	-3.6374	-11.4433
8	0.0	0.0	0.1345	0.0	0.0	91.3261
9	0.0784	-34.5861	0.1119	0.9081	-400.7681	75.9493
10	34.6328	2122.8086	-1.2239	78.7109	4824.5625	-455.3398
11	-2121.4688	1482.3555	0.3001	-4821.5156	3368.9893	111.6573
12	-1482.3372	-0.1418	0.0688	-17181.4414	-1.6435	46.7340
13	-1.5731	1.8413	0.0730	-57.8976	54.0292	41.0091
14	-329.9045	-35.6250	0.0983	-9680.3320	-1045.3364	51.6491
15	658.2725	453.7236	-154.7204	5473.4414	3772.6484	-106.5751
16	1107.2903	1273.4765	-0.0166	12830.0273	14755.6289	-11.2851
17	-1275.3549	32.5037	0.4410	-2897.8516	73.8719	164.0734
18	-244.5715	-612.1816	258.6760	-2033.5781	-6753.1758	178.1822
19	-32.5474	-723.7717	-0.1208	-377.1221	-8386.2461	-82.0093

LOADING CONDITION NO. 1

MAXIMUM BENDING STRESS = 17181.4414
ASSOC. MEMBER NUMBER = 12

MAXIMUM TORSIONAL STRESS = 455.3398
ASSOC. MEMBER NUMBER = 10

NODAL DISPLACEMENTS

NODE	D1 ROTATION X-AXIS	D2 ROTATION Y-AXIS	D3 Z-AXIS (IN)
1	0.0032	0.0016	0.0251
2	0.0	0.0	0.0
3	0.0034	0.0	0.0
4	0.0026	0.0017	-0.0122
5	0.0004	0.0012	-0.0206
6	0.0017	0.0001	-0.0273
7	-0.0013	0.0004	-0.0290
8	-0.0005	0.0007	-0.0214
9	0.0003	0.0000	-0.0239
10	-0.0023	-0.0013	-0.0162
11	-0.0025	-0.0012	-0.0088
12	-0.0059	0.0	0.0
13	0.0	0.0	0.0

MEMBER FORCES, STRESSES, AND DISPLACEMENTS DUE TO OUT-OF-PLANE APPLIED LOADS

NODAL REACTIONS

NODE	R1	R2	R3
2	-1763.2510	61.3965	285.4443
3	0.0	-1.3358	557.6602
12	0.0	-0.0688	283.5530
13	1452.5696	442.3892	277.3789

MEMBER FORCES AND STRESSES

MEMBER	BENDING MOMENTS @ LOW NODE NO. F1	BENDING MOMENTS @ HIGH NODE NO. F2	AXIAL FORCE F3	BENDING STRESSES @ LOW NODE NO. S1	BENDING STRESSES @ HIGH NODE NO. S2	AXIAL STRESS S3	SHEAR STRESS $=(F_1+F_2)/LA$ S12
1	89.8090	44.8901	-40.6694	5367.8906	2683.0837	-265.8130	38.1285
2	-52.3295	-109.9975	-35.5078	-2600.7134	-5417.0469	-107.0480	-99.5699
3	-180.7889	17.2726	-21.5703	-5097.4297	487.0085	-50.5969	-32.8963
4	-210.9814	-291.4858	784.0117	-10485.5195	-14486.4922	2363.6169	-252.4707
5	-50.2999	-61.7393	-123.5571	-2499.8455	-3068.3679	-372.4966	-62.2050
6	-267.6196	-155.8623	-237.4548	-7545.6602	-4394.6094	-557.0134	-65.1963
7	-246.1082	-304.7764	148.9124	-10921.9570	-13525.5742	612.8081	-377.8359
8	0.0	0.0	26.7172	0.0	0.0	174.6220	0.0
9	-89.8101	-224.1591	-5.8337	-5367.9570	-13398.0117	-38.1265	-265.8142
10	19.6948	-178.2996	-171.7738	428.8354	-3862.3276	-713.9392	-169.0270
11	230.6223	223.2639	27.9551	5021.6516	4601.5607	[illegible]	134.6076
12	-172.9628	-97.5171	48.5689	-10338.0039	-5828.6055	317.4434	-338.0193
13	269.7888	329.3599	-15.6853	8503.2227	9664.3516	-128.0433	521.5972
14	1107.1187	1010.0449	-828.8032	32485.9961	29637.5781	-6765.7422	1783.5891
15	-1098.0352	-913.4102	-1090.6597	-9130.0078	-7594.8750	-4077.2324	-574.9836
16	-155.9194	-157.6640	146.4816	-9319.3164	-9423.5938	957.3962	-176.3824
17	449.1504	413.4353	-107.2626	9779.6828	9002.2148	-445.8130	369.9839
18	-608.0762	-606.8569	-1001.7688	-5056.0664	-5045.9297	-3744.9302	-570.6179
19	-108.6589	-73.8313	-199.0759	-6494.5508	-4412.8964	-1301.1499	-228.0585

MAXIMUM BENDING STRESS # 32485.9961
ASSOC. MEMBER NUMBER # 14

MAXIMUM AXIAL STRESS # 6765.7422
ASSOC. MEMBER NUMBER # 14

MAXIMUM SHEAR STRESS # 1783.5891
ASSOC. MEMBER NUMBER # 14

MEMBER FORCES, STRESSES, AND DISPLACEMENTS DUE TO IN-PLANE APPLIED LOADS

LOADING CONDITION NO. 1

NODAL DISPLACEMENTS

NODE	D1 X-AXIS (IN)	D2 Y-AXIS (IN)	D3 ROTATION Z-AXIS (RAD)
1	0.0006	-0.0000	0.0060
2	0.0	0.0	0.0
3	0.0415	0.0	0.0
4	0.0396	0.0003	-0.0021
5	0.0385	-0.0111	-0.0030
6	0.0385	-0.0139	0.0013
7	0.0399	-0.0011	-0.0001
8	-0.0016	0.0002	-0.0023
9	-0.0018	-0.0110	-0.0025
10	-0.0024	-0.0073	-0.0000
11	-0.0020	-0.0007	-0.0010
12	-0.0004	0.0	0.0
13	0.0	0.0	0.0

NODAL REACTIONS

NODE	R1	R2	R3
2	-704.7139	-757.8782	-1209.0640
3	0.0	-165.9401	-204.4644
12	0.0	-48.5689	-97.5171
13	-593.2456	972.3816	-680.6877

LOADING CONDITION NO. 2

MEMBER FORCES AND STRESSES

MEMBER	BENDING MOMENTS @ LOW NODE NO. F1	 @ HIGH NODE NO. F2	TORSIONAL MOMENT F3	BENDING STRESSES @ LOW NODE NO. S1	 @ HIGH NODE NO. S2	TORSIONAL STRESS = F3 S/J S3
1	-0.0454	-41.8050	0.0297	-0.5260	-484.3887	20.1496
2	0.4216	-246.4121	0.3805	2.3869	-1394.9473	106.5358
3	246.4302	123.3945	0.5207	959.0134	480.2046	101.3008
4	232.5273	0.3867	-0.8065	1316.3452	2.1692	-225.8104
5	0.0291	-171.5852	-0.3624	0.1645	-971.3496	-101.4811
6	171.5779	357.6299	-0.3104	667.7163	1391.7607	-60.3828
7	-31.9226	-0.2817	-0.1173	-202.9913	-1.7915	-63.3421
8	0.0	0.0	-0.0473	0.0	0.0	-32.0976
9	-0.0310	14.0225	-0.0453	-0.3593	162.4764	-30.7880
10	-14.0234	-994.4453	-0.4013	-31.8714	-2260.1025	-149.2925
11	994.0508	-492.8716	0.0198	2259.2061	-1120.1624	7.3554
12	493.2295	0.0469	0.0507	5714.5644	.5432	34.4151
13	-0.1403	-0.0522	0.0120	-4.1165	-1.5308	6.2844
14	-204.9781	-86.6607	0.0484	-6014.6357	-2548.7353	25.4557
15	359.3694	346.5762	-221.5371	2988.1062	2881.7324	-152.6000
16	755.9932	868.6079	-0.0665	8759.5938	10064.4453	-45.1619
17	-869.4231	32.4060	0.3152	-1975.9612	73.6500	117.2711
18	-188.6124	-260.0195	279.3777	-1568.2854	-2162.0259	192.4420
19	-32.5376	-504.8206	0.0351	-377.0083	-5849.2891	23.8036

MAXIMUM BENDING STRESS # 10064.4453
ASSOC. MEMBER NUMBER # 16

MAXIMUM TORSIONAL STRESS # 225.8104
ASSOC. MEMBER NUMBER # 4

MEMBER FORCES, STRESSES, AND DISPLACEMENTS DUE TO OUT-OF-PLANE APPLIED LOADS

LOADING CONDITION NO. 1

NODAL DISPLACEMENTS

NODE	D1 ROTATION X-AXIS	D2 ROTATION Y-AXIS	D3 Z-AXIS (IN)
1	-0.0013	-0.0007	-0.0102
2	0.0	0.0	0.0
3	-0.0014	0.0	0.0
4	-0.0010	0.0006	0.0049
5	-0.0003	0.0009	0.0012
6	0.0007	0.0011	-0.0118
7	-0.0009	0.0015	-0.0198
8	0.0003	0.0005	0.0077
9	-0.0003	0.0007	0.0045
10	-0.0010	0.0004	-0.0039
11	-0.0017	0.0003	-0.0061
12	0.0021	0.0	0.0
13	0.0	0.0	0.0

NODAL REACTIONS

NODE	R1	R2	R3
2	-1176.9185	9.7723	195.6043
3	0.0	-0.3559	-260.3906
12	0.0	-0.0507	-94.3169
13	886.2275	12.3998	159.1100

[illegible] (Cont.)