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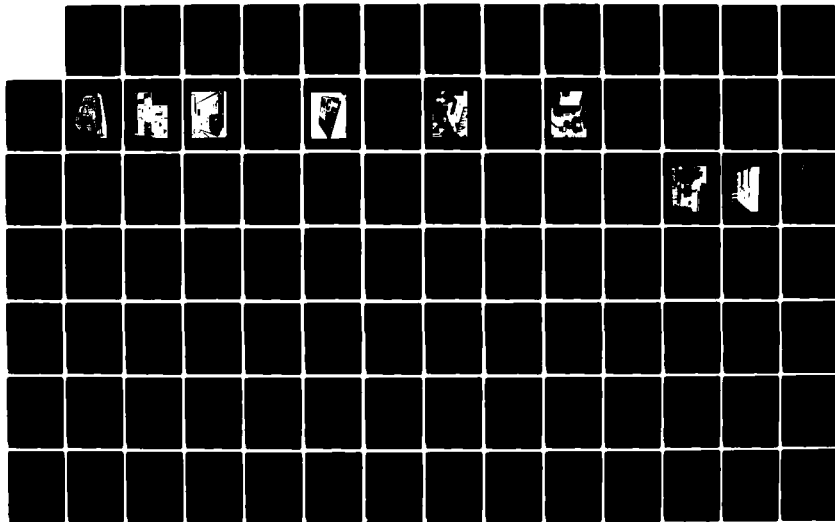
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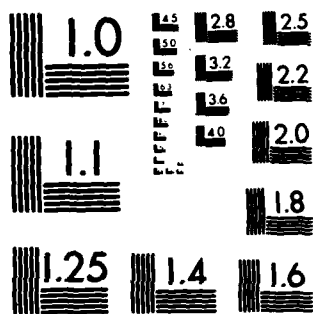
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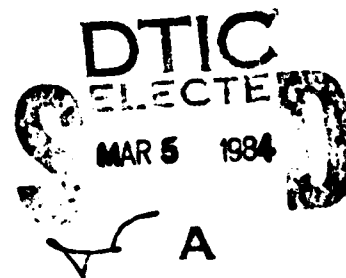
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## Certification Vibration Tests, SD802 Materials Experiment

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Materials Sciences Laboratory  
Laboratory Operations  
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El Segundo, Calif. 90245

15 December 1983

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This report was submitted by The Aerospace Corporation, El Segundo, CA 90245, under Contract No. F04701-83-C-0084 with the Space Division, P.O. Box 92960, Worldway Postal Center, Los Angeles, CA 90009. It was reviewed and approved for The Aerospace Corporation by L. R. McCreight, Director, Materials Sciences Laboratory. First Lieutenant Scott L. Hough, SD/Y00, was the project officer for the Mission Oriented Investigation and Experimentation (MOIE) Program.

This report has been reviewed by the Public Affairs Office (PAS) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>L → The SD802 materials experiment has been subjected to a certification vibration test as a <del>676</del> flight safety completion requirement. The test described within this report verifies the structural integrity and demonstrates the ability to satisfy functional requirements of the experiment. The final flight weight and center of gravity of each experiment tray were also determined. |                                     |                                                                |

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## I. BACKGROUND AND SUMMARY

The Long Duration Exposure Facility (LDEF) is a reusable structure designed to accommodate many self-contained experiments during a proposed 9-month exposure in space. The space shuttle will be used to deploy and retrieve LDEF.

The Long Duration Exposure Facility has been developed by the NASA office of Aeronautics and Space Technology and the NASA Langley Research Center (LRC). Through a memorandum of agreement between the Department of Defense (DoD) Space Test Program and NASA, a spacecraft materials experiment, comprised of 19 subexperiments, was integrated by the Materials Sciences Laboratory of The Aerospace Corporation for deployment on the LDEF spacecraft.

In this report the results of the certification vibrational tests, center of gravity and weight measurements required to conform to the LDEF Project Office safety policy, and requirements for payloads using the Space Transportation System (STS) are documented. Tests described herein were conducted by personnel of the System Engineering Division, NASA-LRC and the Materials Sciences Laboratory of The Aerospace Corporation. The test procedure was drafted by Mr. John F. Rogers of NASA-LRC.

Certification vibration tests were performed on the SD802 materials experiment, NASA experiment No. M0003, and the Air Force Geophysics Laboratory (AFGL) cosmic ray detection experiment, NASA experiment No. M0002. The tests were conducted to verify the structural integrity, assembly workmanship, and to demonstrate the ability to satisfy functional requirements of the experiment after it was subjected to such tests. Previous tests have included qualification vibration tests of experiment hardware and electronics and thermal vacuum exposure of the signal conditioning electronics package.<sup>1,2</sup>

## II. TEST DESCRIPTION

### A. TEST ARTICLES

Flight hardware for the SD802 materials experiment consists of four experiment trays. Each tray is divided into six equal rectangles for convenience in sizing and mounting experiments. Figures 1 and 2 provide tray dimensions for 3- and 6-in. depth trays. Engineering batteries were installed within the trays to accurately simulate the various states of stress concentration and fatigue associated with the placement of a large mass within a structure. Table 1 provides the tray location on the LDEF. Figure 3 shows these tray locations on the LDEF structure; Fig. 4 provides an overview of the basic LDEF structure.

#### 1. EXPERIMENT TRAYS (3 IN. DEPTH)

Both the leading and trailing edge 3-in. trays contain six individual experiment modules. Modules I through IV and Module VI of both trays are similar. Module V leading edge tray contains a fiber optic experiment and electronic plastic encapsulated devices; this module is an electronic active experiment. The trailing edge Module V contains a nonmetallic material and electronic piece part passive experiment. The power supply for the signal conditioning electronics consists of two 12 V batteries that are mounted at the nonexposed base surface of Module I, both trays. The AFGL experiments are located in Module VI, both trays. The leading edge experiment tray is shown in Fig. 5, and trailing edge tray experiment is depicted in Fig. 6.

#### 2. EXPERIMENT TRAYS (6 IN. DEPTH)

Both the leading and trailing edge 6-in. trays contain six individual experiment modules. The contents of both trays are similar but differ slightly in test sample types that are located within Modules III and VI. Modules I and II contain the experiment power and data system (EPDS) and a 7.5 and 12 V battery that supplies power for EPDS. Nonmetallic and metallic composite materials are combined within Module III along with a 7.5 and 28 V battery that powers the Environment Exposure Control Canister (EECC). The

| EXPERIMENT SIZE | TRAY SPACE    |
|-----------------|---------------|
| 1/6 TRAY        | 16.50 x 18.75 |
| 1/3 TRAY        | 16.50 x 37.50 |
| 2/3 TRAY        | 33.00 x 37.50 |
| FULL TRAY       | 37.50 x 49.50 |

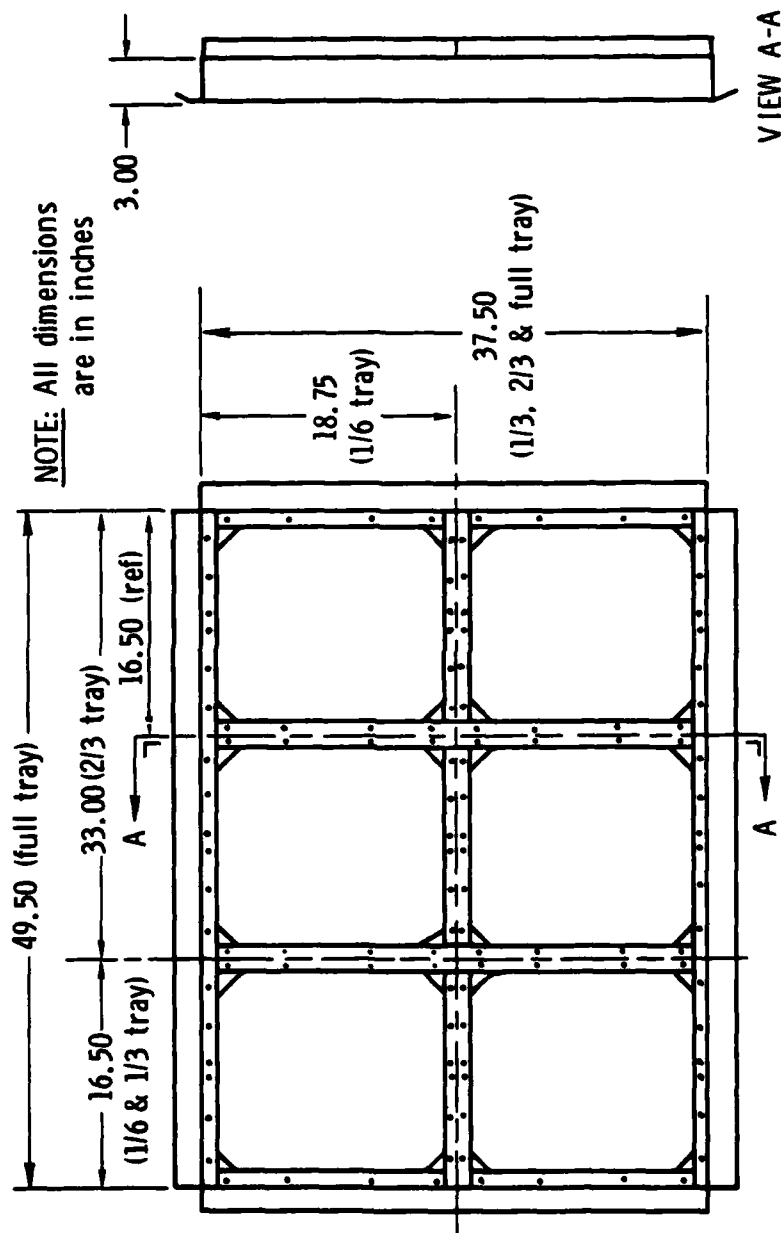
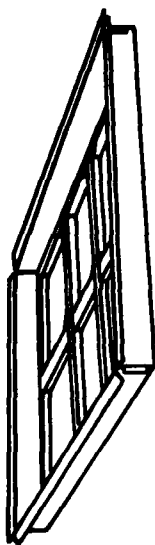


Fig. 1. LDEF Peripheral Tray Assembly, 3-in. Depth

| EXPERIMENT SIZE | TRAY SPACE    |
|-----------------|---------------|
| 1/6 TRAY        | 16.25 x 16.50 |
| 1/3 TRAY        | 16.25 x 33.00 |
| 2/3 TRAY        | 32.50 x 33.00 |
| FULL TRAY       | 33.00 x 48.75 |

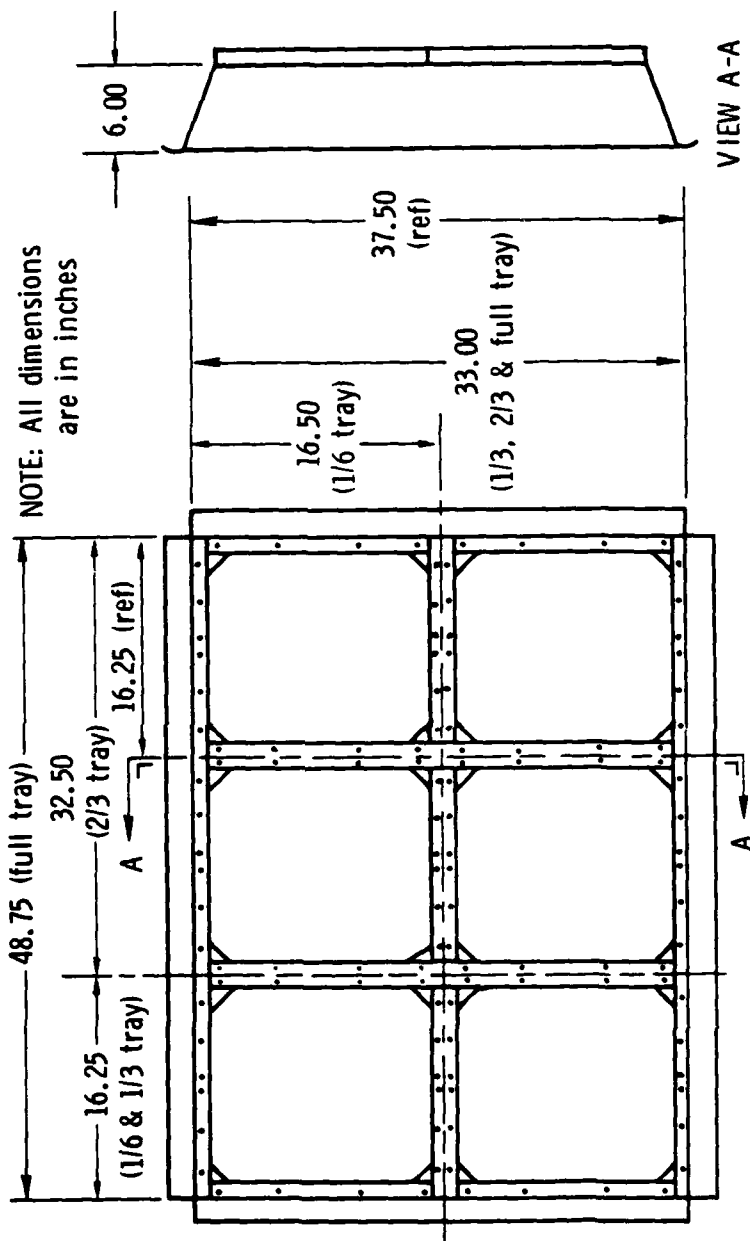
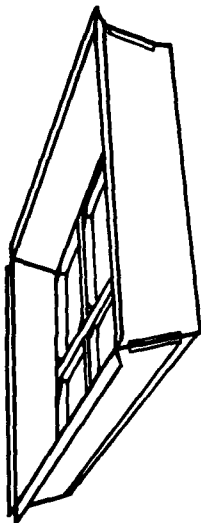


Fig. 2. LDEF Peripheral Tray Assembly, 6-in. Depth

Table 1. Tray Location on LDEF

| LDEF<br>Location | Tray S/N         | Description                            |
|------------------|------------------|----------------------------------------|
| D3               | LE 155621-A-1-11 | Trailing edge 3-in.<br>depth tray (T3) |
| D4               | LE 155629C-7     | Trailing edge 6-in.<br>depth tray (T6) |
| D8               | LE 155629C-10    | Leading edge 6-in.<br>depth tray (L6)  |
| D9               | LDE 155621A-1-3  | Leading edge 3-in.<br>depth tray (L3)  |

|    |    |   |   | D | E         | F |  |
|----|----|---|---|---|-----------|---|--|
| TE | 1  | A | B | C |           |   |  |
|    | 2  |   |   |   |           |   |  |
|    | 3  |   |   |   | I III V   |   |  |
|    | 4  |   |   |   | II IV VI  |   |  |
| G  | 5  |   |   |   | VI IV II  |   |  |
|    | 6  |   |   |   | V III I   |   |  |
|    | 7  |   |   |   |           |   |  |
|    | 8  |   |   |   |           |   |  |
| LE | 9  |   |   |   | VI IV II  |   |  |
|    | 10 |   |   |   | V III I   |   |  |
|    | 11 |   |   |   | I IV V    |   |  |
|    | 12 |   |   |   | II III VI |   |  |

# LDEF EXPERIMENT COMPLEMENT

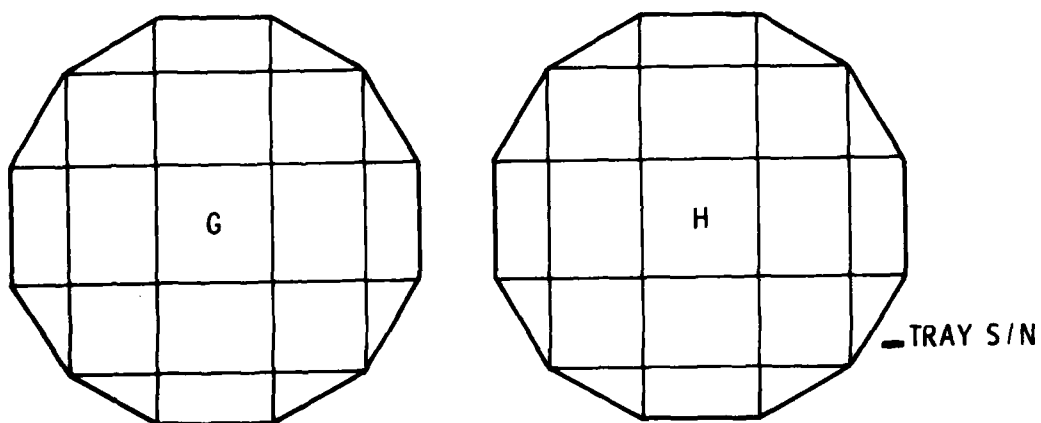


Fig. 3. Tray Location on LDEF Structure

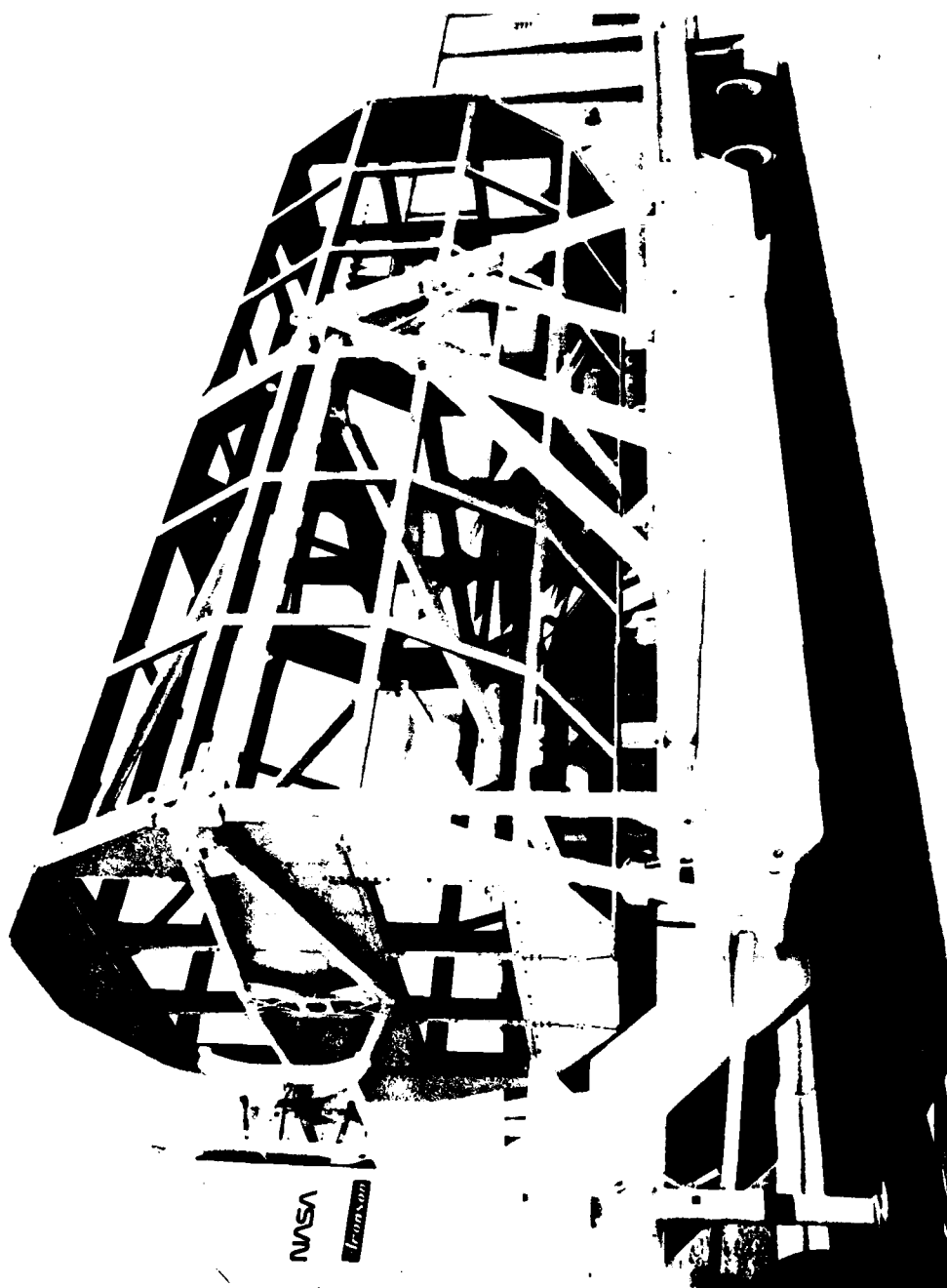


Fig. 4. LDEF, Overview of Structure



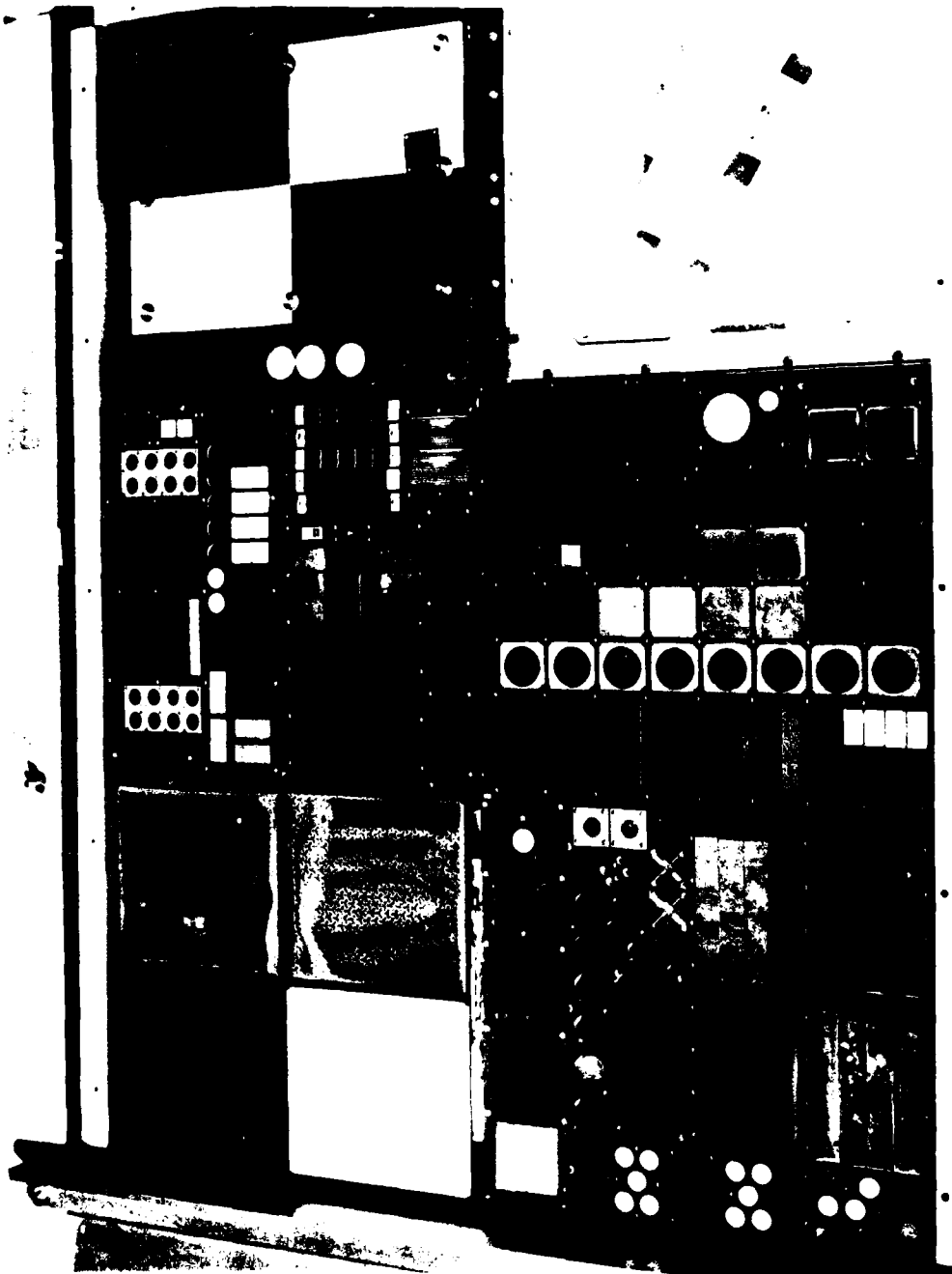


Fig. 5. Leading Edge 3-in. Depth Experiment Tray

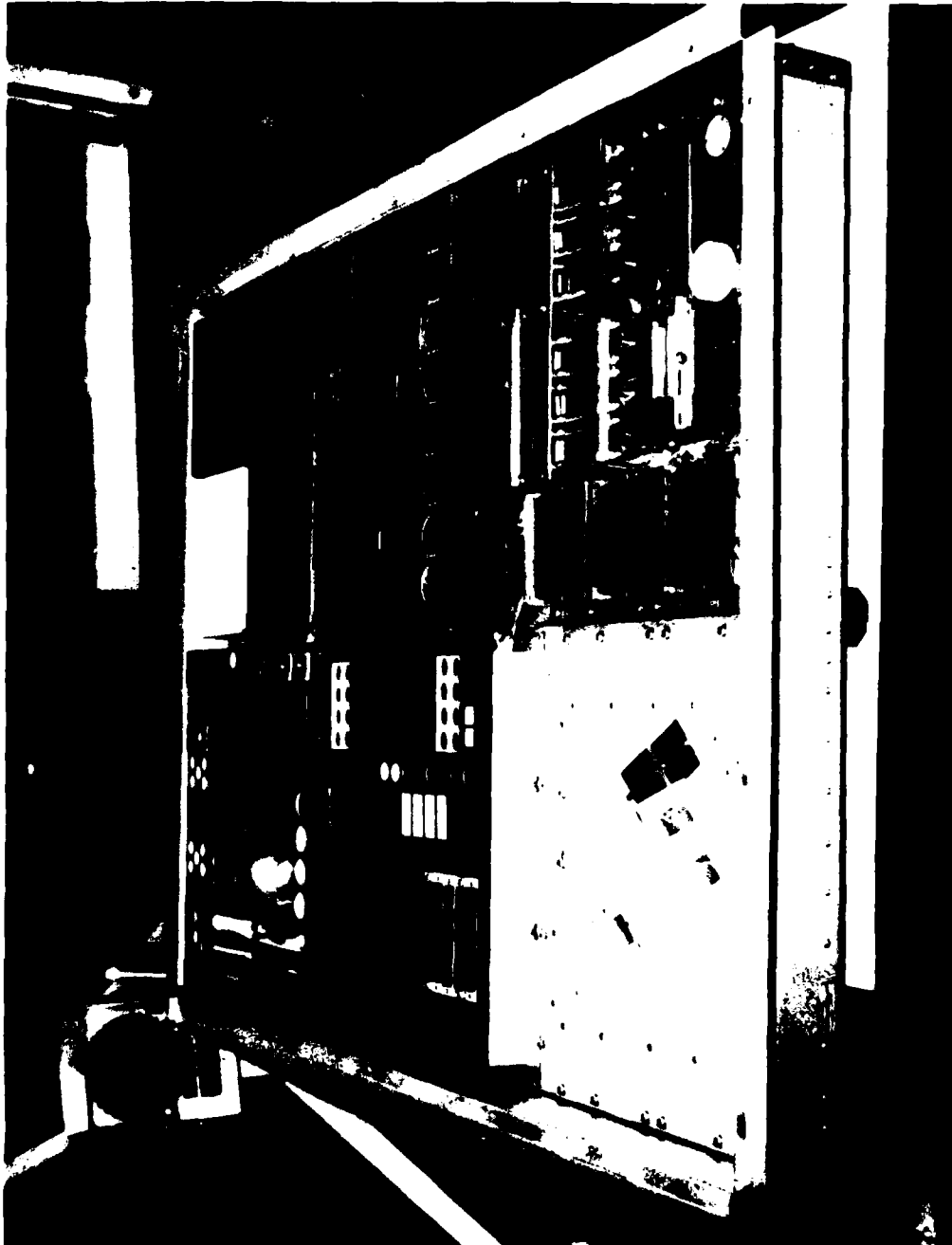


Fig. 6. Trailing Edge 3-in. Depth Experiment Tray

signal conditioning electronics package occupies Module IV, and the EECC occupies Modules V and VI. The trailing edge 6-in. depth experiment tray is shown in Fig. 7. The EECC heat shield is not installed.

### 3. TEST FIXTURE

The test fixture was manufactured to accommodate testing of 3- and 6-in. depth peripheral experiment trays. The tray to fixture mounting interface was designed to simulate the tray to LDEF structure coupling. Attachment of the tray to the fixture required the use of special shims and a procedure similar to that for attachment to LDEF. The aluminum test fixture weighs approximately 600 lb.

## B. TEST FACILITY

### 1. EXPERIMENT PROCESSING

The sequence of events from receiving inspection to the bonded storage area for experiment processing and preparations at LRC are summarized in Fig. 8. Written procedures were required for all operations; experiment log sheets were maintained to document operations performed; adherence to procedures were monitored by the NASA Quality Assurance unit. A brief summary of the activity of each station follows. The procedure used for electronic functional tests is presented in Appendix A.

### 2. RECEIVING INSPECTION

The LRC receiving dock is the arrival point for all experiments. The experiments remain within their container at this facility and were inspected for exterior physical damage only.

### 3. LAMINAR FLOW CLEAN ROOM

#### a. Inspection

The laminar flow clean room is maintained at a cleanliness level of 100,000. The air flow within the room is from end to end. Within the laminar flow room the shipping container cover is removed and the interior of the container, exterior of the experiment, and the silica gel desiccant were inspected. The aluminum protective cover attached to each experiment tray was not removed at this time. In Fig. 9 is shown a photograph taken during this inspection. Upon completion of this examination the experiments were returned to the bonded storage area.



Fig. 7. Trailing Edge 6-in. Depth Experiment Tray

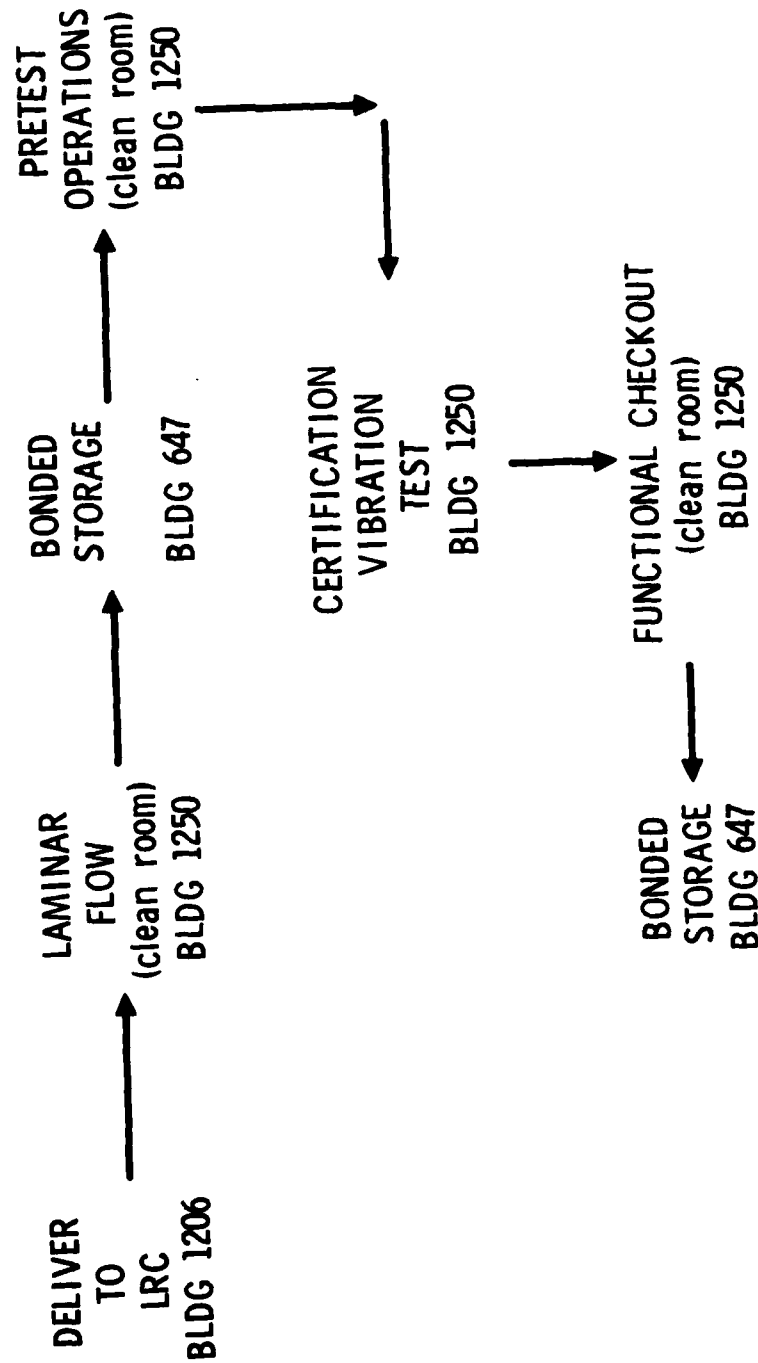


Fig. 8. Experiment Processing and Preparation



Fig. 9. Receiving Inspection, Laminar Flow Clean Room

b. Operations

When the experimenters arrive at LRC, the experiments are returned to the laminar flow clean room and prepared for electronic functional tests. The following steps summarize the activity within the laminar flow room:

1. Postshipment, premodification, electronic functional tests
2. EPDS modification and removal of EPDS magnetic tape recorder
3. Postmodification and precertification vibration electronic functional tests
4. Postcertification vibration electronic functional tests
5. Preparation of experiments for storage

4. BONDED STORAGE AREA, BUILDING 647

This is a controlled number access area; items are logged in and out by Quality Assurance personnel and moved only by written request. The following environment is maintained:

|             |                                                                    |
|-------------|--------------------------------------------------------------------|
| Temperature | 40 to 90°F<br>Heat and air conditioning                            |
| Humidity    | Less than 60% relative                                             |
| Cleanliness | Similar to office space (experiment remains in shipping container) |

5. VIBRATION FACILITY, BUILDING 1250

This room is not maintained as a clean room, but every effort is made to assure that clean room practices are adhered to; through traffic is minimized, and the use of polyethelene protective covers is extensive. Temperature is maintained between 40 to 90°F, humidity < 60% relative. Floor space within this area is also provided to accommodate the weight and center of gravity test set up. This test arrangement is shown in Fig. 10.

a. Vibration Equipment

A description of the equipment used for vibration testing is as follows:

One Unholtz-Dickie T1000 electrodynamic shaker with self-contained slip table and T145 amplifier



Fig. 10. Vibration, Weight, and CG Test Area in Building 1250



- 17,500 force lb, peak sine capability
- 14,000 force lb, random RMS capability (34,000 LBF peak instantaneous)

Two H-P 5427A digital vibration controller/analyzers

- 4 channel control capability
- Controls sine, random, or shock
- 512 line resolution for random or shock
- Floppy disk program and data storage
- Tabular or graphic hard copy data output
- Extensive analysis capability

Fourteen channel analog tape recorder/playback with digimark and voice annotation

## C. PROCEDURE

### 1. VIBRATION

Each experiment tray was subjected to the following vibratory sequences: (1) transfer function determination, (2) self-check signal determination, (3) sinusoidal vibration test, and (4) random vibration test. Individual test procedures were provided for each of the four experiment trays. Again, verification of adherence to the test procedure was documented by Quality Assurance personnel. A copy of the Experiment Certification Vibration test procedure is provided as Appendix B. A copy of each completed test procedure is on file at the Materials Sciences Laboratory of The Aerospace Corporation and the LDEF Project Office at LRC.

The trailing edge 3-in. depth tray was the first unit to be subjected to three axes of vibration tests. A drawing of each axis of vibration is provided in Figs. 11 through 13. A 6-in. depth trailing edge tray followed the 3-in. depth tray. The test sequence for the leading edge trays were altered. Both the 3- and 6-in. trays were tested in a given axis to reduce the amount of fixture handling.

#### a. Transfer Function

To identify unacceptable amplitude excursions that might occur within the frequency range of the test, transfer function plots were obtained and

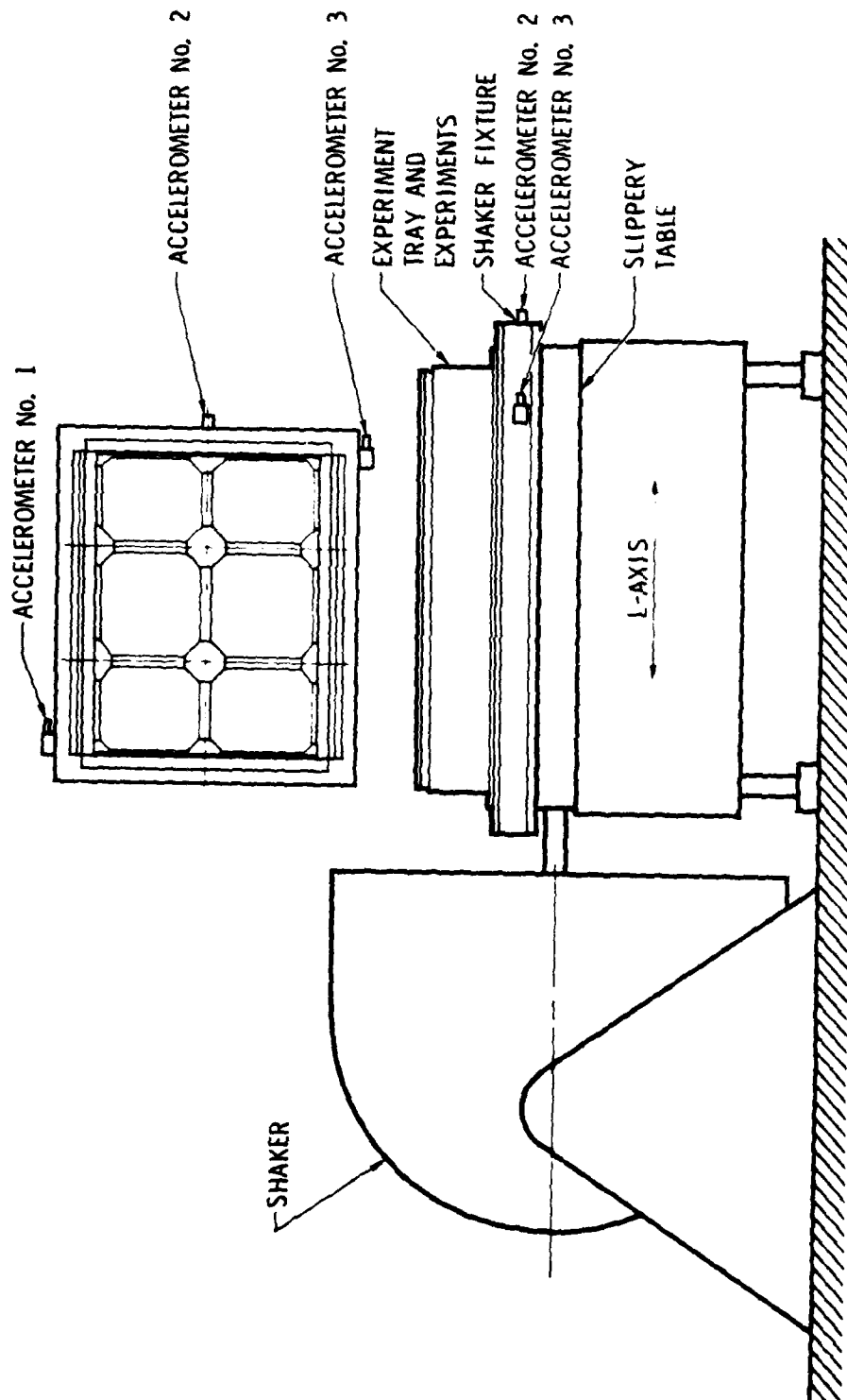


Fig. 11. L-Axis Test Set Up

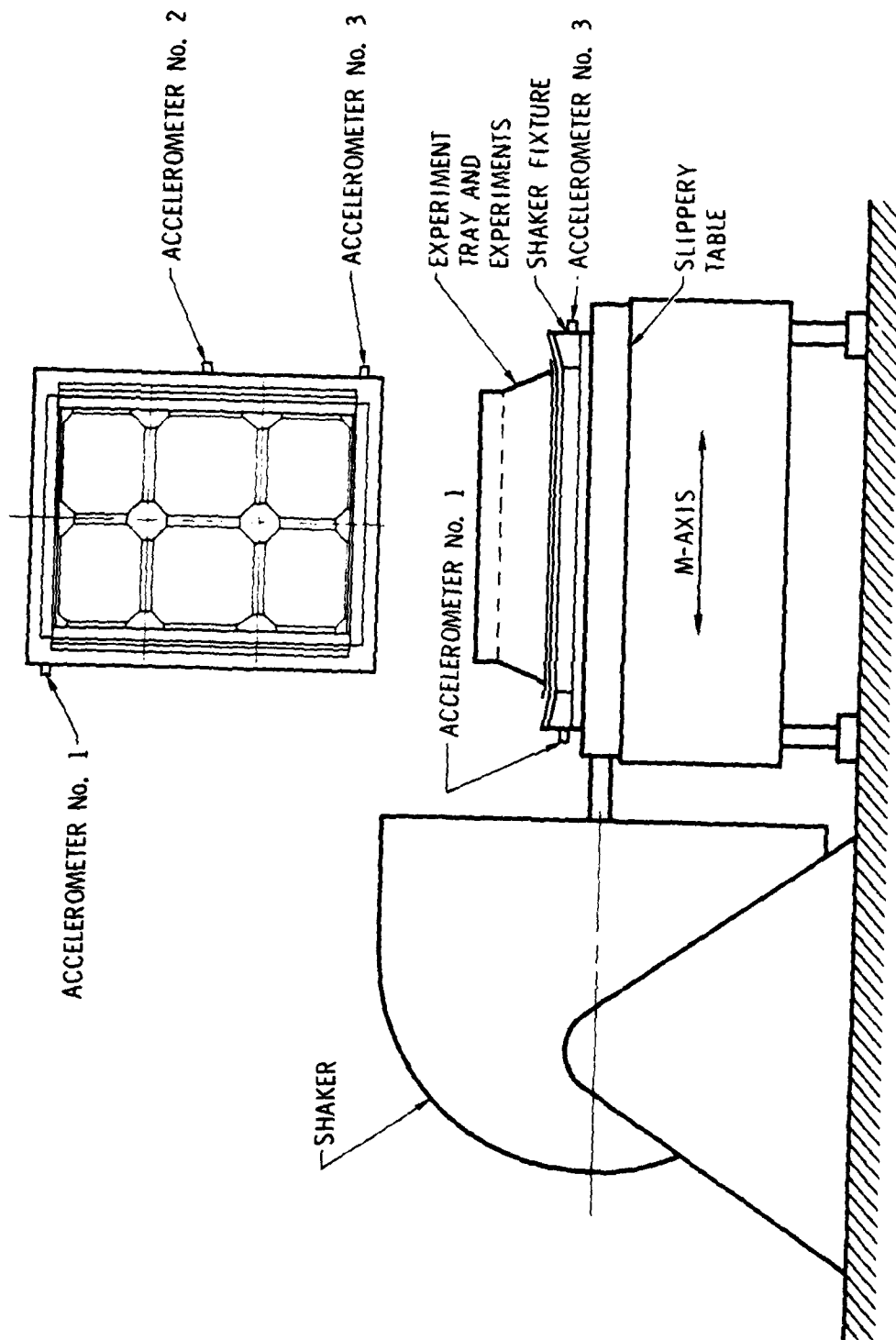


Fig. 12. M-Axis Test Set Up

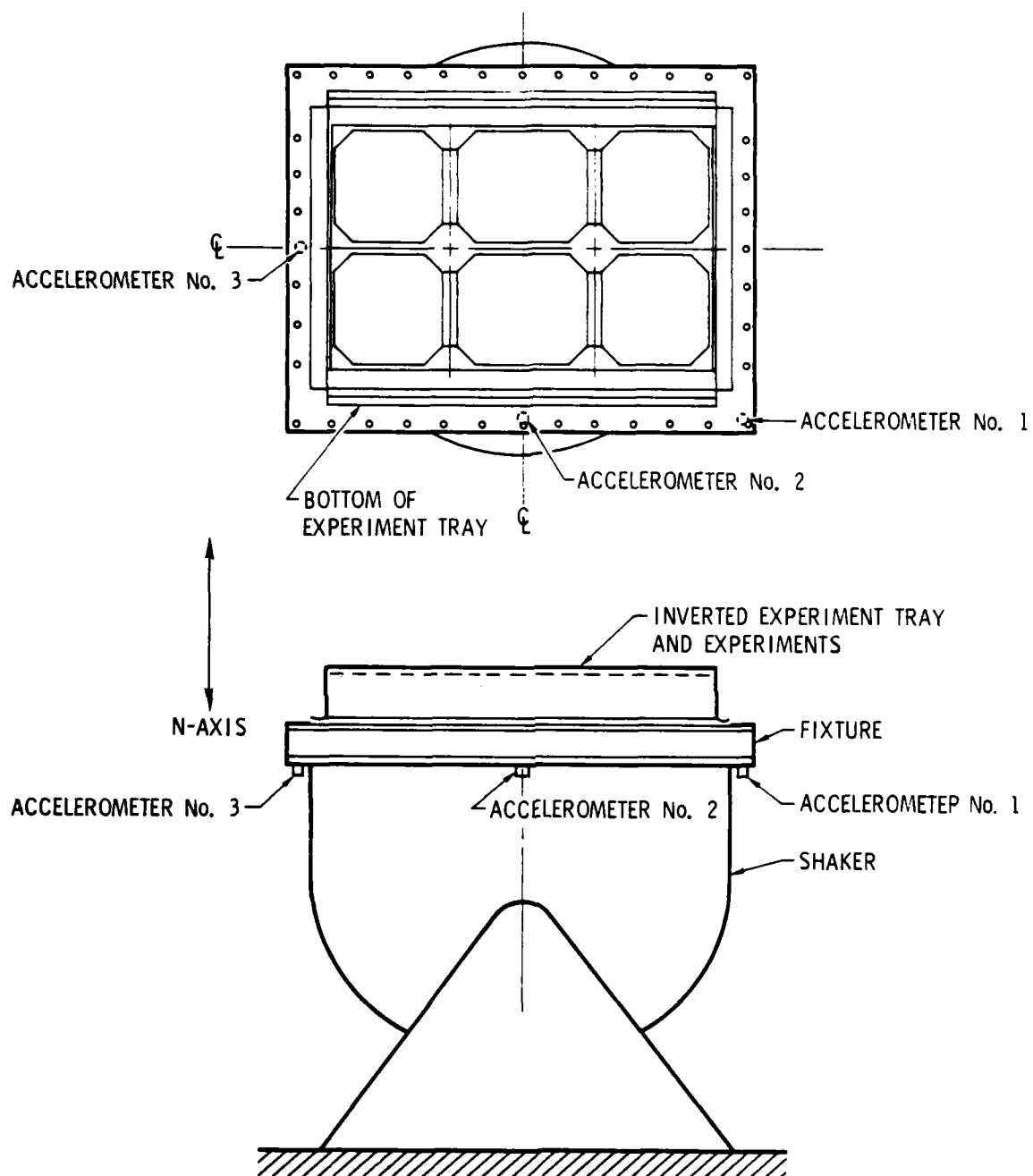


Fig. 13. N-Axis Test Set Up

reviewed prior to progressing with sine and random vibration tests. The vibration system provided the capability of examining the ratio of excitation amplitude and forced vibration by ratioing the output of a control and monitor accelerometer.

Transfer function response test options are as follows:

Bandwith

- 20 to 2000 Hz
- 10 to 100 Hz
- 10 to 50 Hz

Amplitude  $> 1 \text{ g} < 2 \text{ g pk}$

Duration 30 to 50 sec

b. Self-Check Signal

The purpose of the control system is to maintain the acceleration at pre-determined levels independent of the response of the structure. To assure that the system has the proper signal-to-noise ratio to maintain the system gain, a self-check signal is run, and the drive display is viewed prior to each test. The self-check signal is a pseudorandom signal having the spectral shape of the user-specified reference spectrum. When the self-check signal is applied to the system, the response is measured, and from this the "System Gain" is computed. To avoid overtesting, the self-check signal was applied at approximately -12 dB for a time duration of 10 to 20 sec.

c. Sine Vibration Certification

Test levels for the sine vibration vary both as a function of tray location and tray size. The frequency sweep for all sine tests starts at 35 Hz and sweep down to 16 Hz. The down sweep was used to eliminate equipment overload problems. The frequency sweep test level is shown as follows:

| <u>Input Amplitude</u> | <u>Frequency Range</u> | <u>Sweep Rate</u> |
|------------------------|------------------------|-------------------|
| 1.4 g rms              | 35 to 20 Hz            | 4 oct/min         |
| 5 to 10.6 g rms        | 20 to 16 Hz            | 4 oct/min         |

A graphic representation of the test levels for the 3-in. depth experiment trays is shown in Fig. 14. The 6-in. depth tray test levels are shown in Fig. 15. An overview of the experiment tray location on the LDEF structure versus the sine vibration test levels is shown in Table 2.

d. Random Vibration Certification

The random vibration frequency spectrum and input test level are identical for all the experiment trays. They are as follows:

1. +3 dB/oct between 20 and 80 Hz
2.  $\pm 3$  dB/oct between 80 and 350 Hz
3. -3 dB/oct between 350 and 2000 Hz
4. Overall test level 6.1 g rms
5. Test duration 30 sec

A graphic representation is shown in Fig. 16.

2. INSTRUMENTATION

a. Accelerometers

Preliminary vibration tests in each of the three mutually perpendicular axis of vibration were conducted using the tray vibration fixture, NASA No. LE 155606C, and a 3-in. depth experiment tray loaded with a dummy mass to simulate experiments. The purpose of these tests was to determine whether single or multiple point accelerometer control would be required to stay within the bounds of the input specifications. A survey of the accelerometer response data revealed that a single-input control accelerometer could be used for the sine vibration tests. A three point accelerometer input control would be best suited to control the random vibration test spectrum.

Since all the experiment trays were tested in an inverted position, it was impractical to record response data from each experiment module within the tray. A decision was made to limit the number of accelerometer channels to six. Table 3 identifies the accelerometer function, and Figs. 11, 12, and 13 depict the approximate placement of the control accelerometers. Location of the three monitor accelerometers on the 3- and 6-in. depth experiment trays

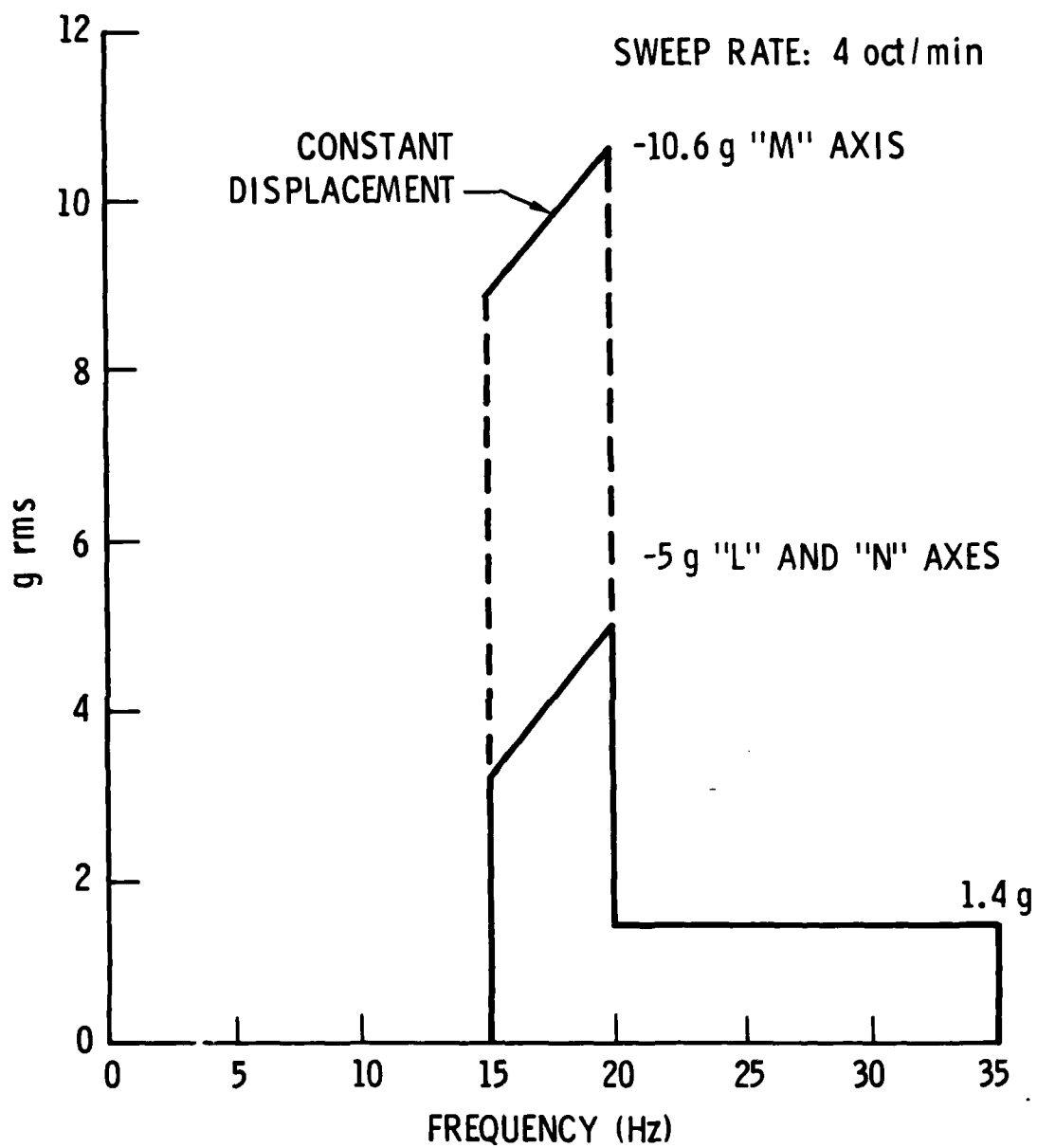


Fig. 14. Sine Vibration Spectrum, 3-in. Depth Experiment  
Trays, Locations D3 and D9

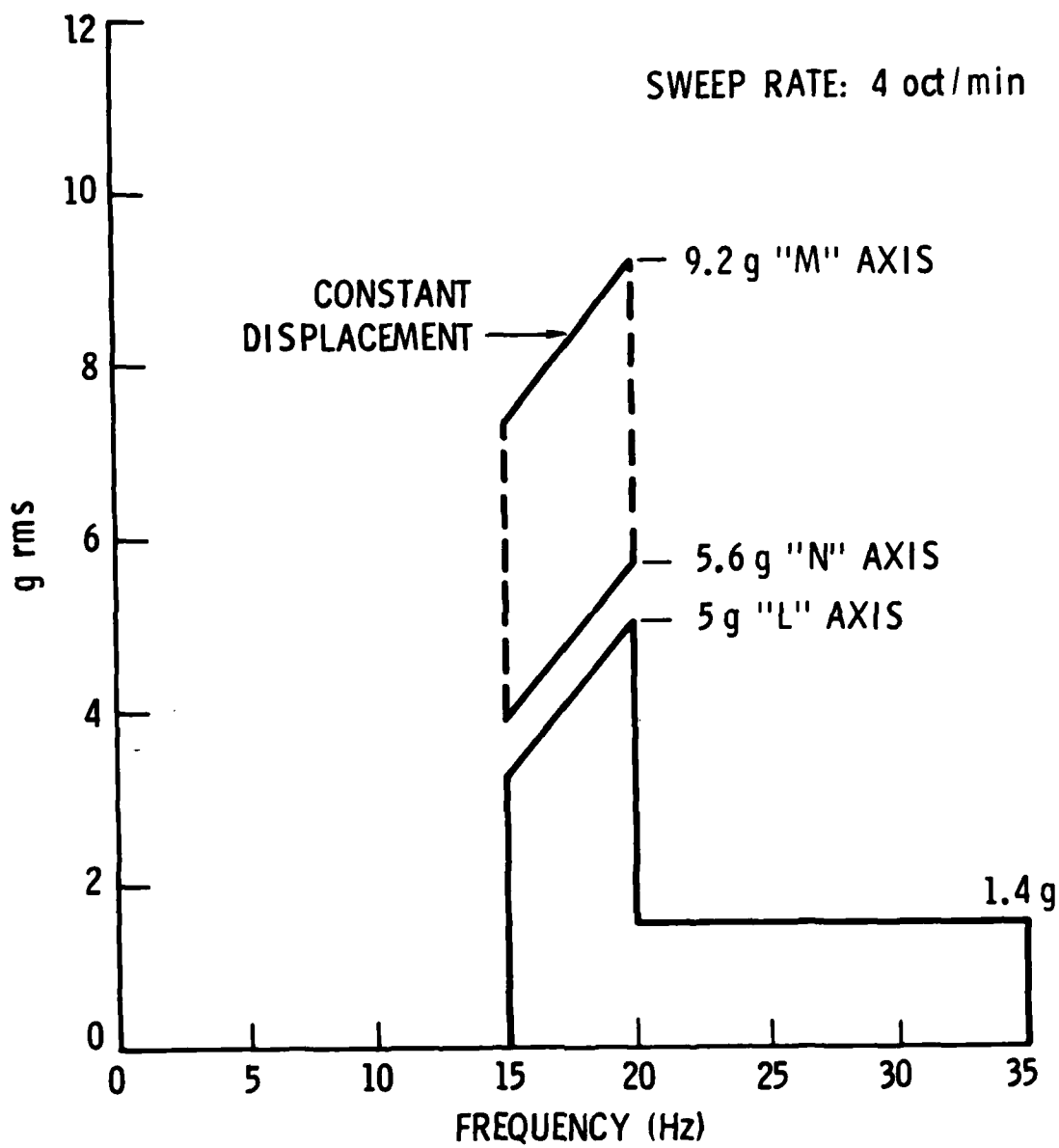


Fig. 15. Sine Vibration Spectrum, 6-in. Depth Experiment Tray, Locations D4 and D8



Table 2. Sine Vibration Test Levels Versus LDEF  
Structure Location

| Experiment<br>No.  | LDEF<br>Structure<br>Location | Sine Test Levels (g rms) |      |     |
|--------------------|-------------------------------|--------------------------|------|-----|
|                    |                               | L                        | M    | N   |
| M0003              | D4, D8                        | 5.0                      | 9.2  | 5.6 |
| M0002 and<br>M0003 | D3, D9                        | 5.0                      | 10.6 | 5.0 |

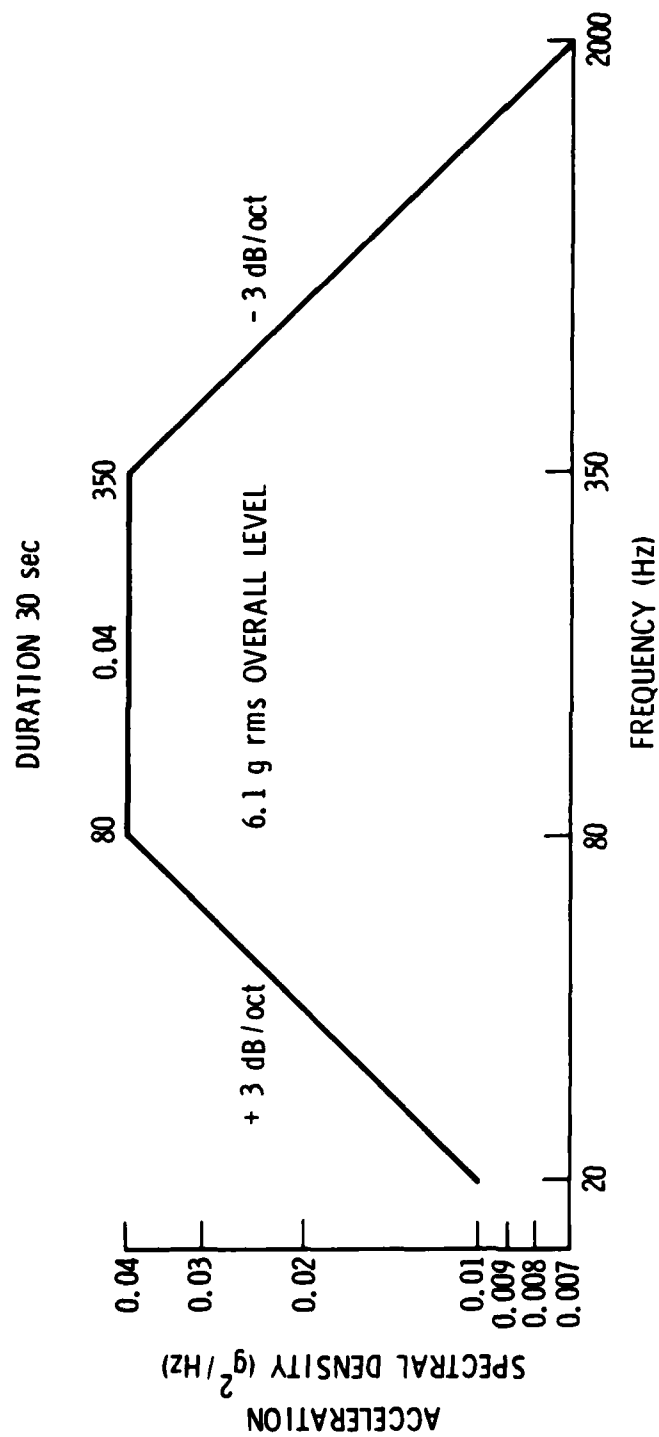
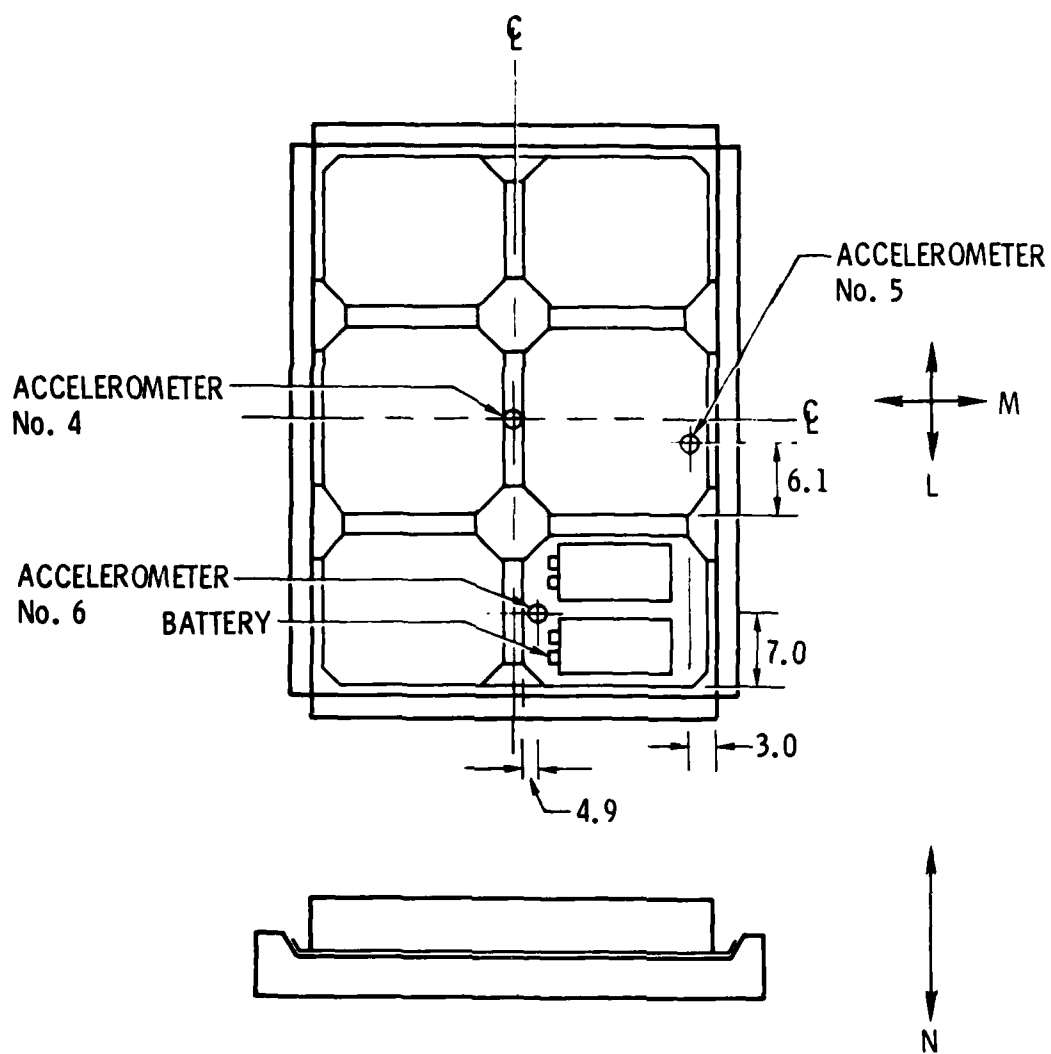


Fig. 16. Random Vibration Spectrum for Certification Acceptance

Table 3. Accelerometer Function

| Accelerometer No. | Control |        | Monitor | Description                                                                  |
|-------------------|---------|--------|---------|------------------------------------------------------------------------------|
|                   | Sine    | Random |         |                                                                              |
| 1                 | X       | X      |         | Sine drive accelerometer, averaged for random vibration                      |
| 2                 |         | X      | X       | Monitors fixture during sine test, averaged for random vibration             |
| 3                 |         | X      | X       | Monitors fixture during sine test, averaged for random vibration             |
| 4                 |         |        | X       | Always placed on main I beam of tray                                         |
| 5                 |         |        | X       | L3, Module IV, base<br>T3, Module III, base<br>LT6, Module IV, base (SCU)    |
| 6                 |         |        | X       | LT3, Module I, battery attach plate<br>LT6, Module III, battery attach plate |

are shown in Figs. 17 and 18. The monitor accelerometers were removed and remounted for each axis of testing, and the sensitive axis of the accelerometer was oriented to the axis of applied vibration. Actual location of the accelerometer placement may vary from the coordinate points by  $\pm 0.25$  in.



DIMENSIONS IN INCHES

Fig. 17. Monitor Accelerometer Location for the 3-in. Depth Experiment Tray



### III. TEST RESULTS

#### A. OVERVIEW

Four experiment trays were subjected to the certification vibration tests. No physical structural damage was detected on the tray structure or to the module hardware that retained the test samples. Two test samples, EA3-5 and EA3-7 passive hybrid circuits, debonded during the random vibration test L axis. These test samples were mounted within Module V, 3-in. trailing edge tray. After visual examination of the test samples, the cause of the bond failure was evident. The existing bond covered less than 50% of the bondable area on both test samples. By mutual agreement of the project personnel involved, it was decided to rebond the test samples and not retest in the L axis, but continue testing in the M axis. The amplitude of the sine test is double for the M axis test as compared with the L axis. Random vibration test levels were the same for all axes.

After completing the vibration tests, the data collection and data storage system of tray pairs were exercised using battery power. All data channels and the EPDS timing sequence functioned properly.

#### B. TRAILING EDGE TRAY (3-IN.)

The N-axis of vibration was first completed. This axis of vibration in respect to all the experiment trays is the most severe from the standpoint of controlling fixture-induced resonant conditions. The test fixture and experiment tray mounted on the vibration exciter in the N axis is shown in Figs. 19 and 20. Note in Fig. 19 that the test fixture extends beyond the vibration exciter head. Transfer function plots are shown in Figs. 21 and 22. The frequency scale on Fig. 22 has been expanded to provide a more detailed look at the low-frequency response.

The ability of the vibration system to control the sine and random input vibration spectrum is shown in Figs. 23 and 24. On both figures the input spectrum curve is flanked by an upper and lower 6 dB boundary. The control accelerometer output is also plotted establishing the system response versus the desired input spectrum.

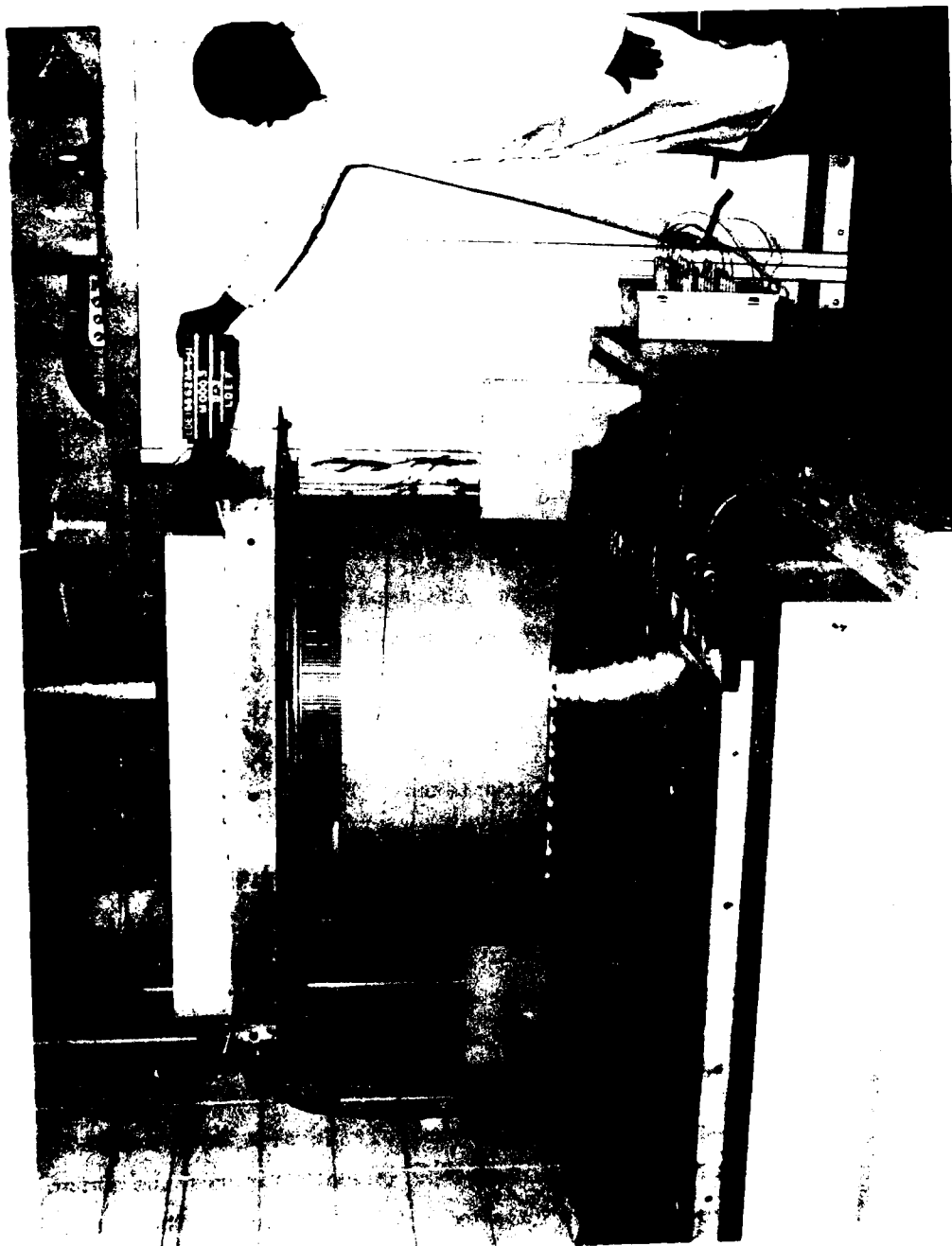


Fig. 19. T3, Experiment Tray, N Axis Test Set Up



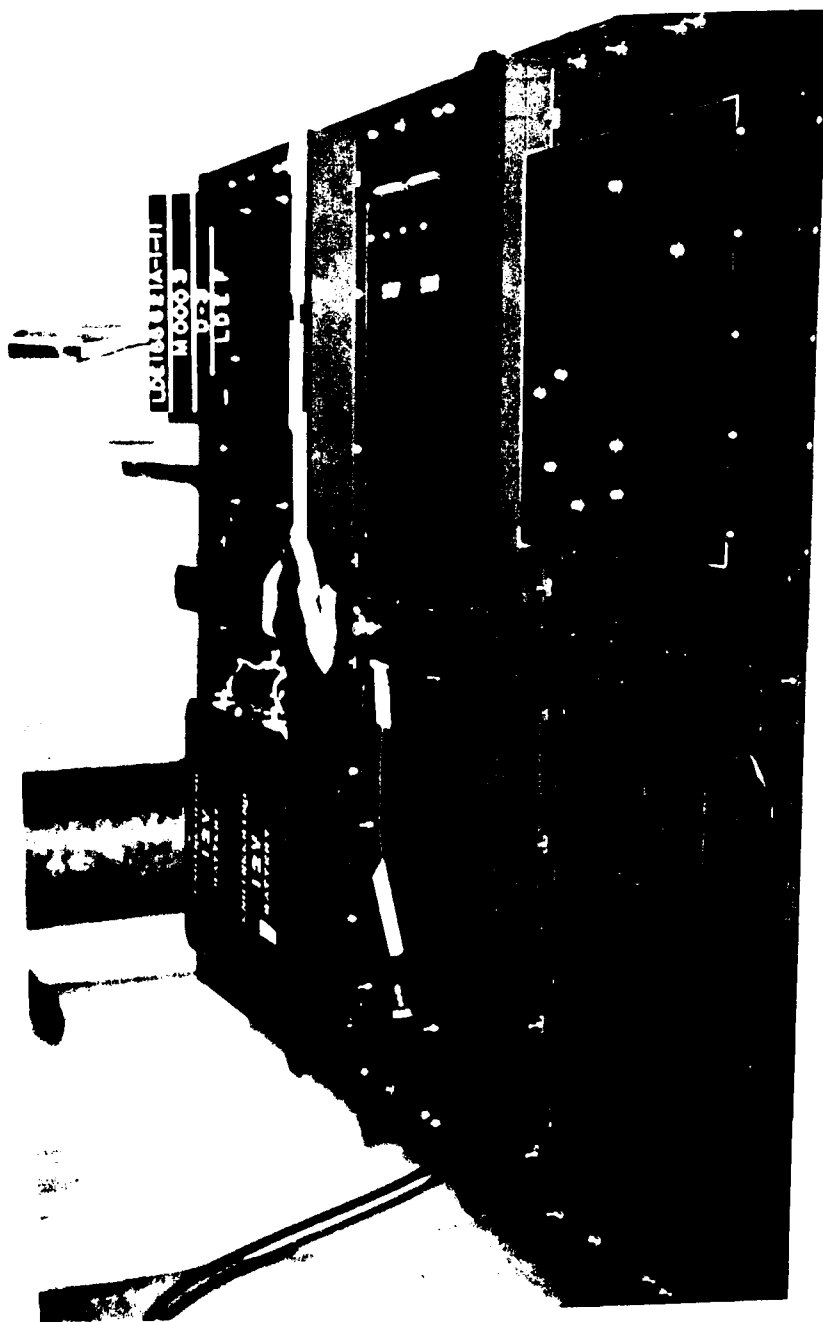


Fig. 20. T3, Experiment Tray, N Axis, Tray Base

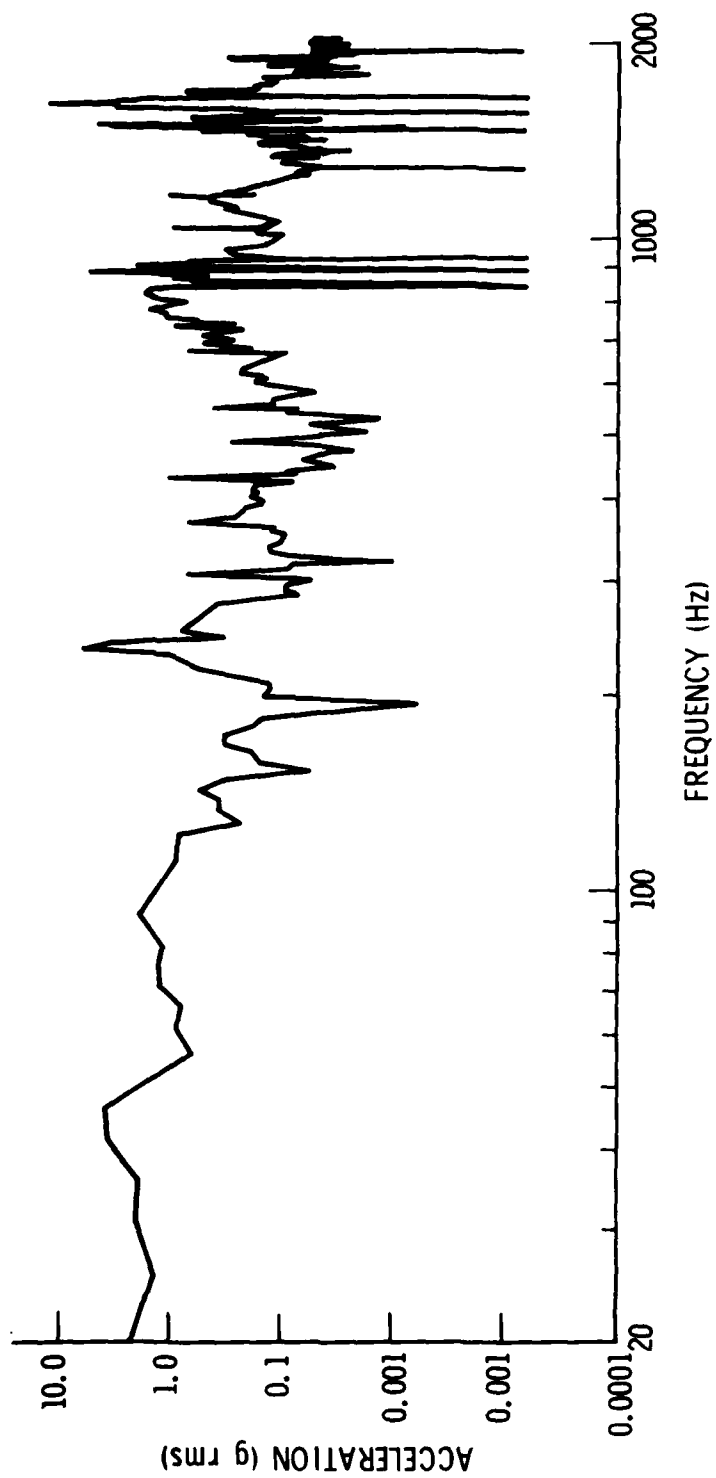


Fig. 21. T3, Transfer Function, N-Axis, 20 to 2 KHz,  
Accelerometer 4/1

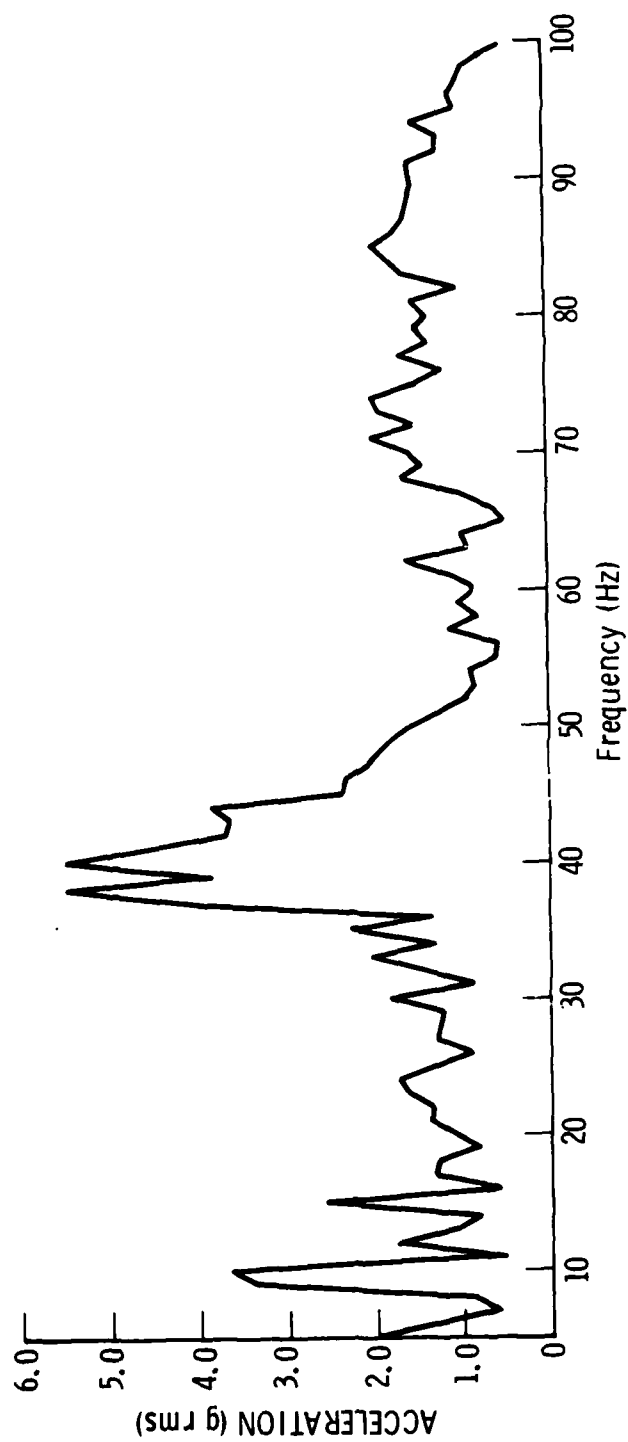


Fig. 22. T3, Transfer Function, N-Axis, 10 to 100 Hz, Accelerometer 4/1

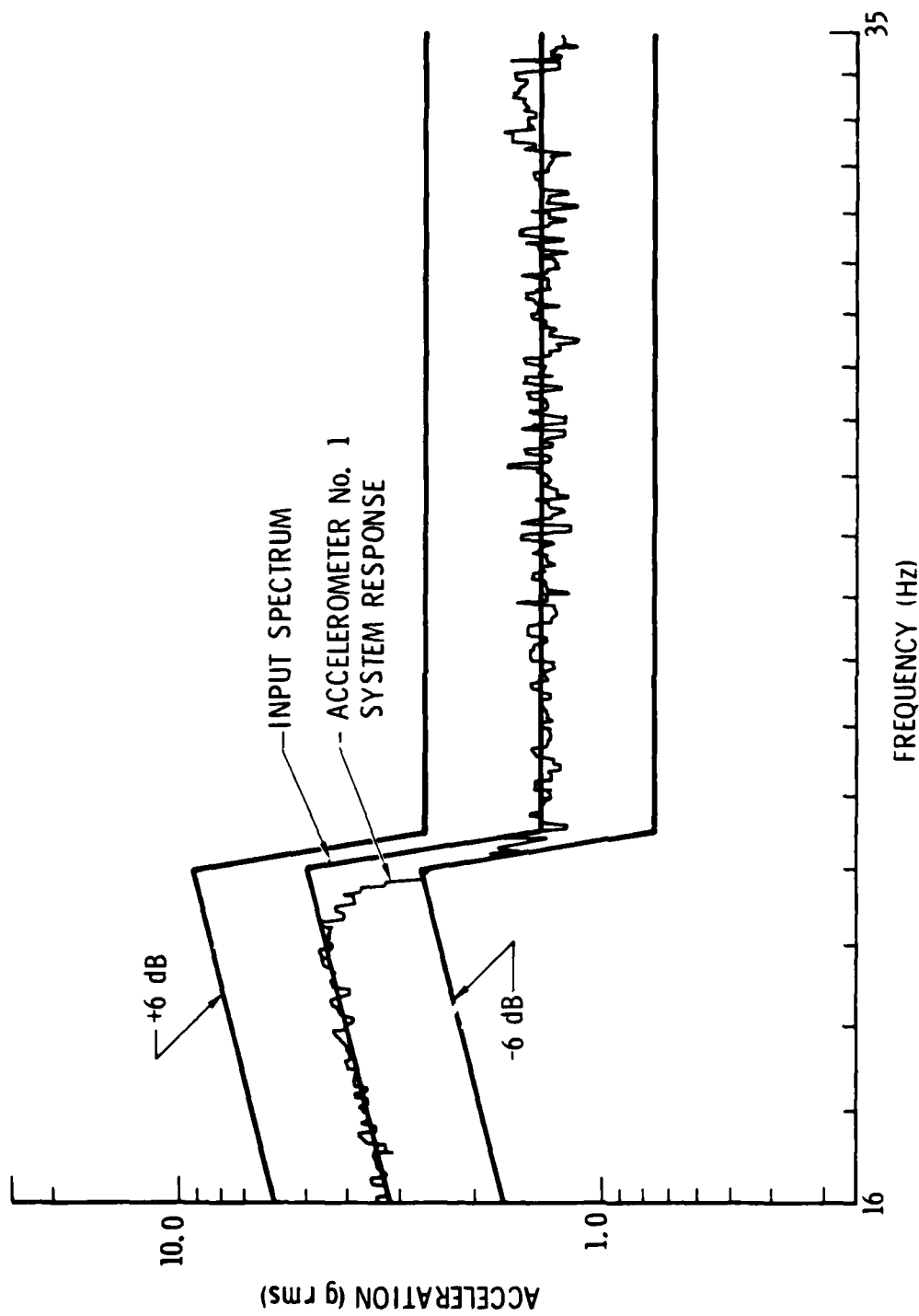


Fig. 23. T3, N-Axis, Sine Certification Input Spectrum, Accelerometer No. 1

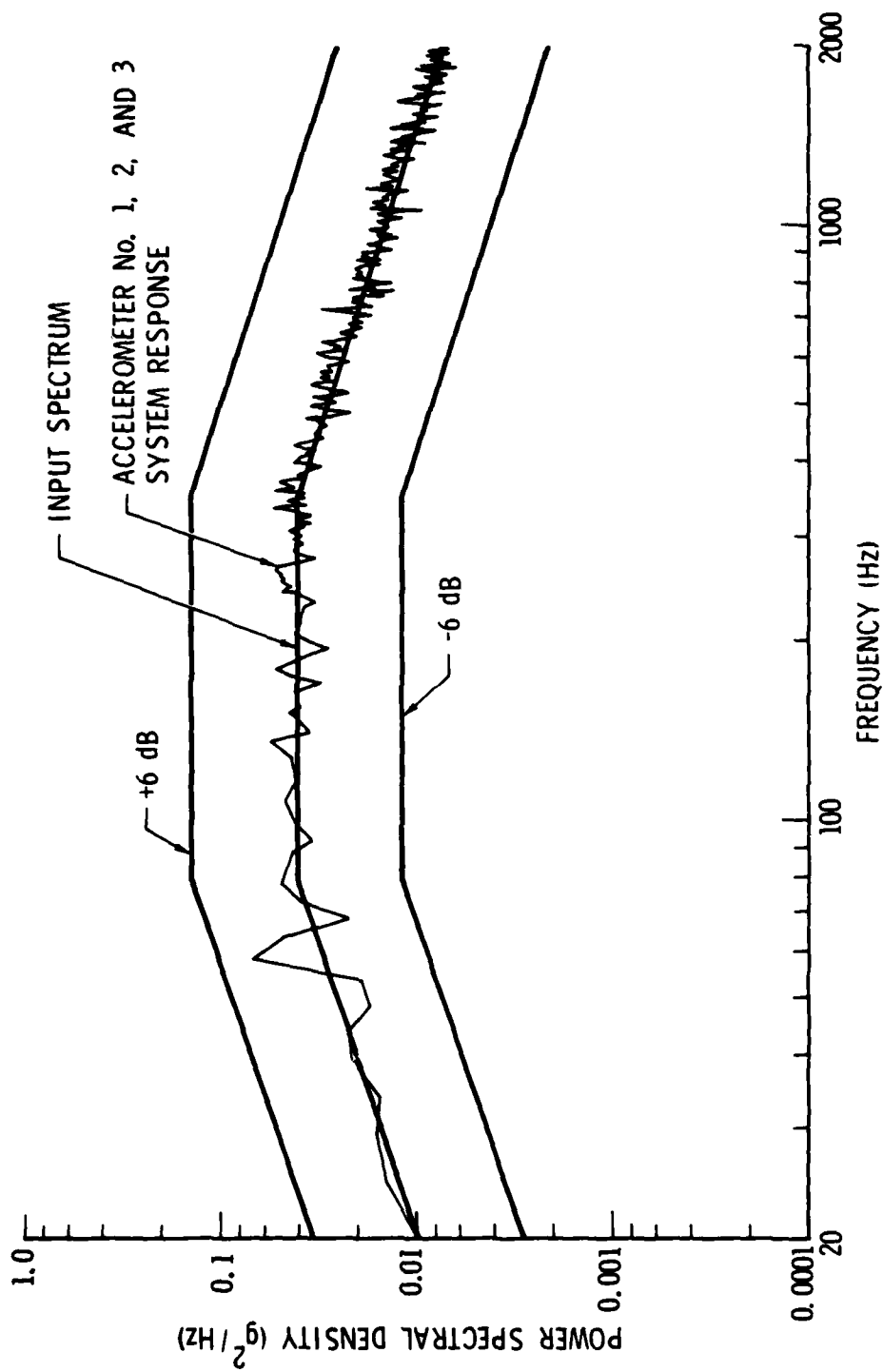


Fig. 24. T3, N-Axis, Random Certification Input Spectrum, Accelerometer No. 1, 2, and 3

Transfer function plots for the L axis of vibration is shown in Figs. 25, 26, and 27. The frequency scale on the plots was again expanded to examine the low-frequency response. These plots indicate that in the frequency band between 15 to 20 Hz, there are no high-Q resonant peaks. Figures 28 and 29 present the output of the sine and random test control accelerometer.

Transfer function plots for the M axis and Figs. 30, 31, and 32 also indicate the absence of high-Q resonant peaks between 15 to 20 Hz. In Figs. 33 and 34 the output of the sine and random test control accelerometers are presented.

#### C. OTHER TRAY RESPONSE DATA

A review of the input and monitor accelerometer data for the remaining L3, L6, and T6 three experiment trays show similar low amplitude response data for the transfer function plots. For the other trays the specified input spectrum versus the actual drive accelerometer output is also similar to Figs. 33 and 34. The input and monitor accelerometer data for the remaining three trays are presented as Appendix C.

#### D. DATA RECORDING

##### 1. BACKGROUND

A SD/LDEF Technical Users Manual has been published and provides a complete review of the flight and ground support electronics, programming, qualification testing, and transducer location.<sup>3</sup>

Briefly, the data recording system consists of duplicate electronic packages for the leading and trailing edge trays. Data from the system are a mix of high and low analog and parallel digital signals. The magnetic tape memory provides storage for approximately 14 megabits of data. Data are obtained by periodically scanning strain gage, thermister, solar power, quartz crystal microbalance, and the monitor of electronic piece part circuits.

##### 2. DATA

The tray pairs must be put in flight electrical configuration to prepare the system to record data. Engineering batteries must be installed, and tray-

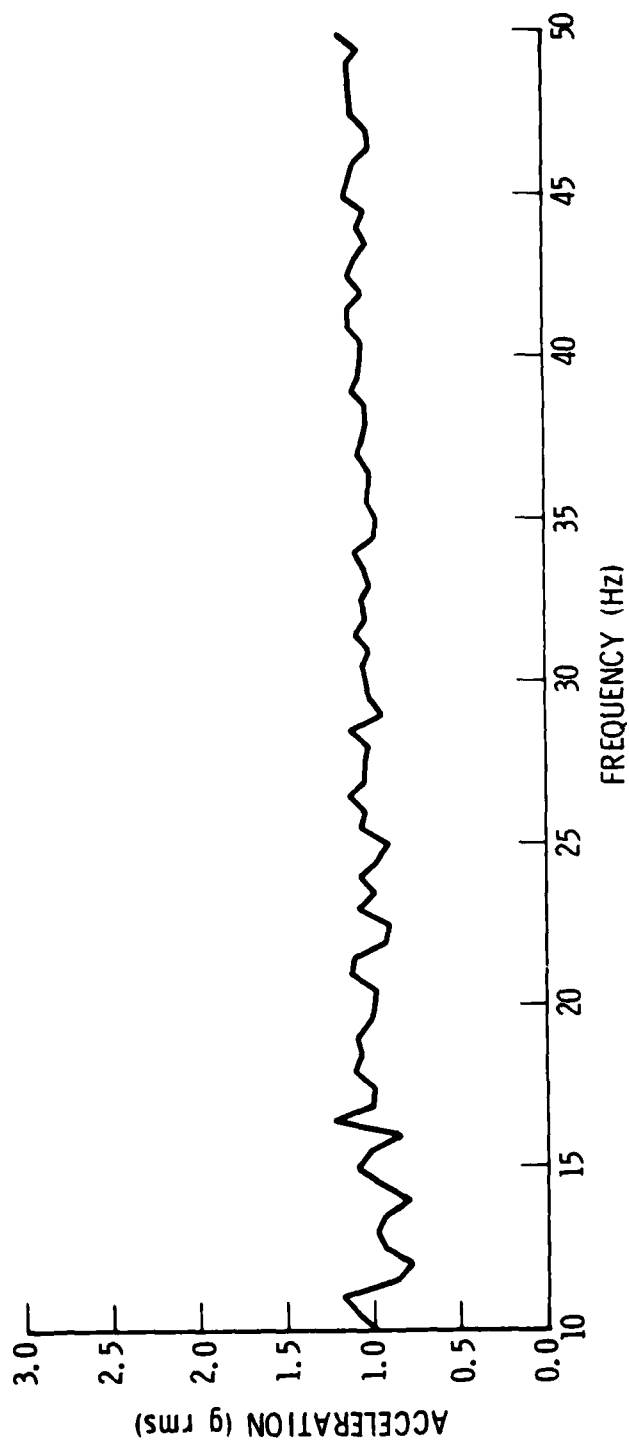


Fig. 25. T3, L-Axis, Transfer Function, Accelerometer No. 4/3

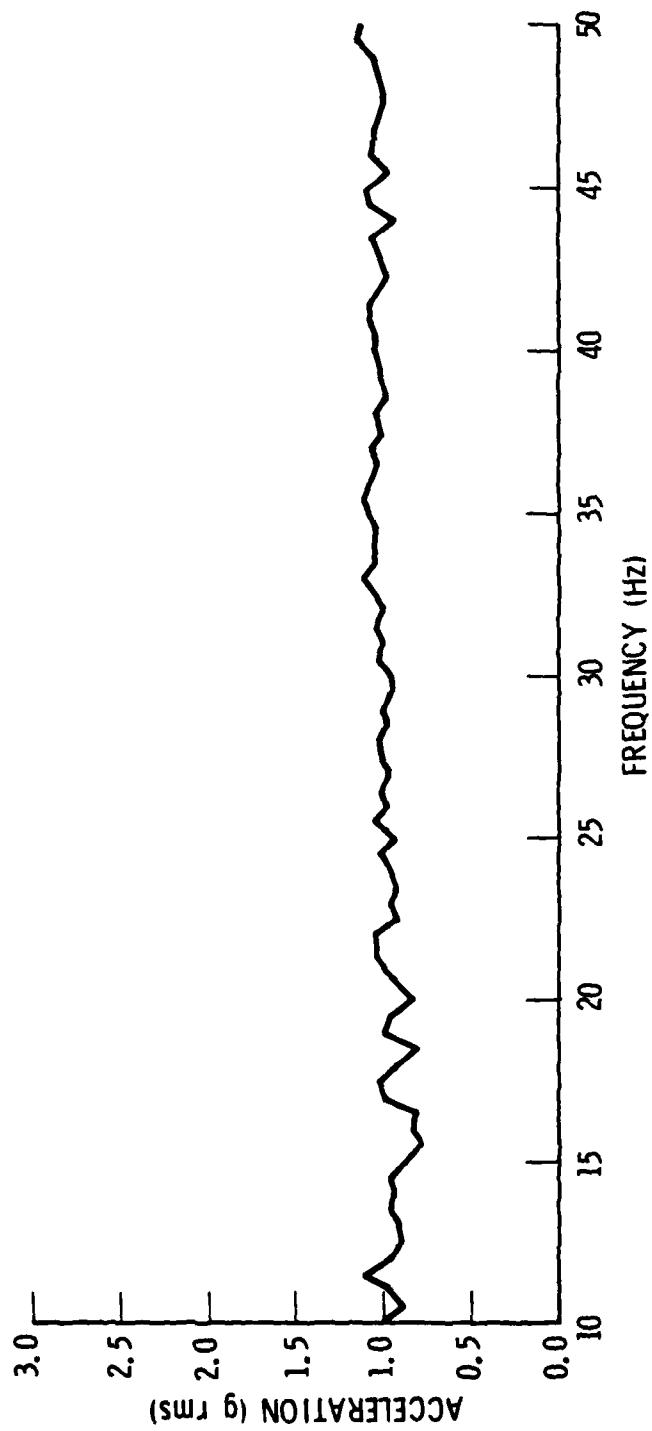


Fig. 26. T3, L-Axis, Transfer Function, Accelerometer No. 5/3



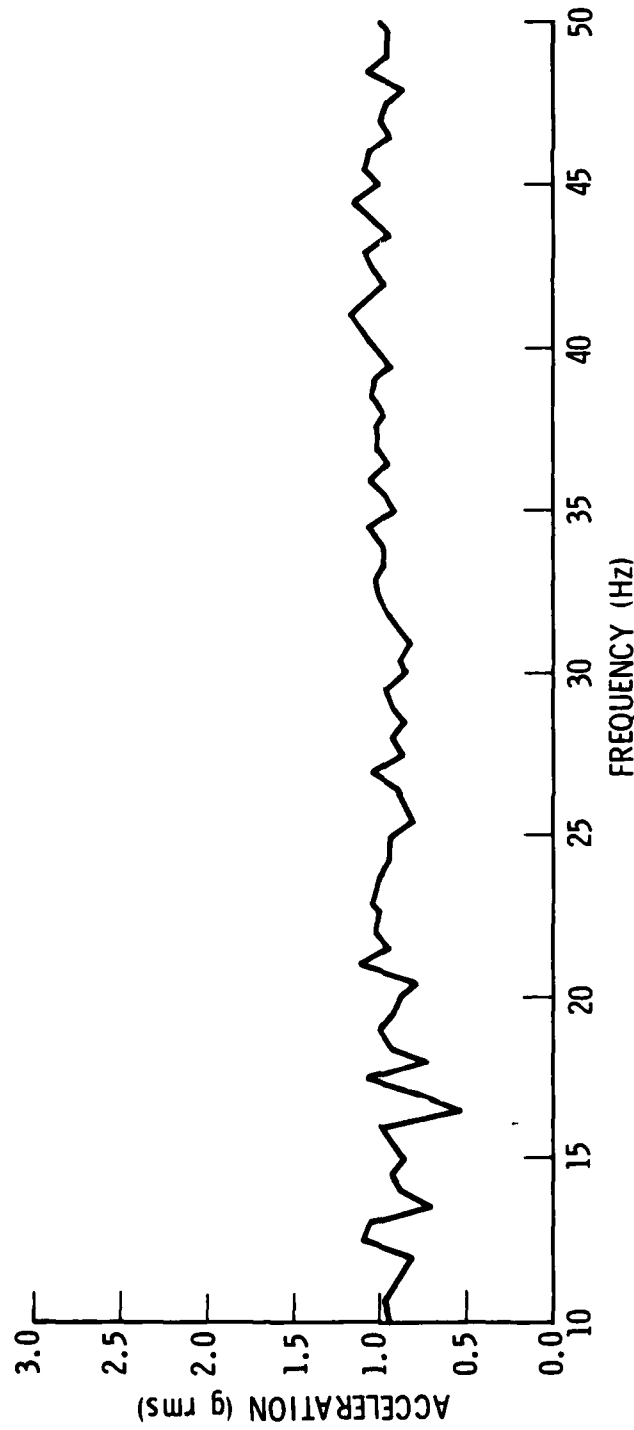


Fig. 27. T3, L-Axis, Transfer Function Accelerometer No. 6/3

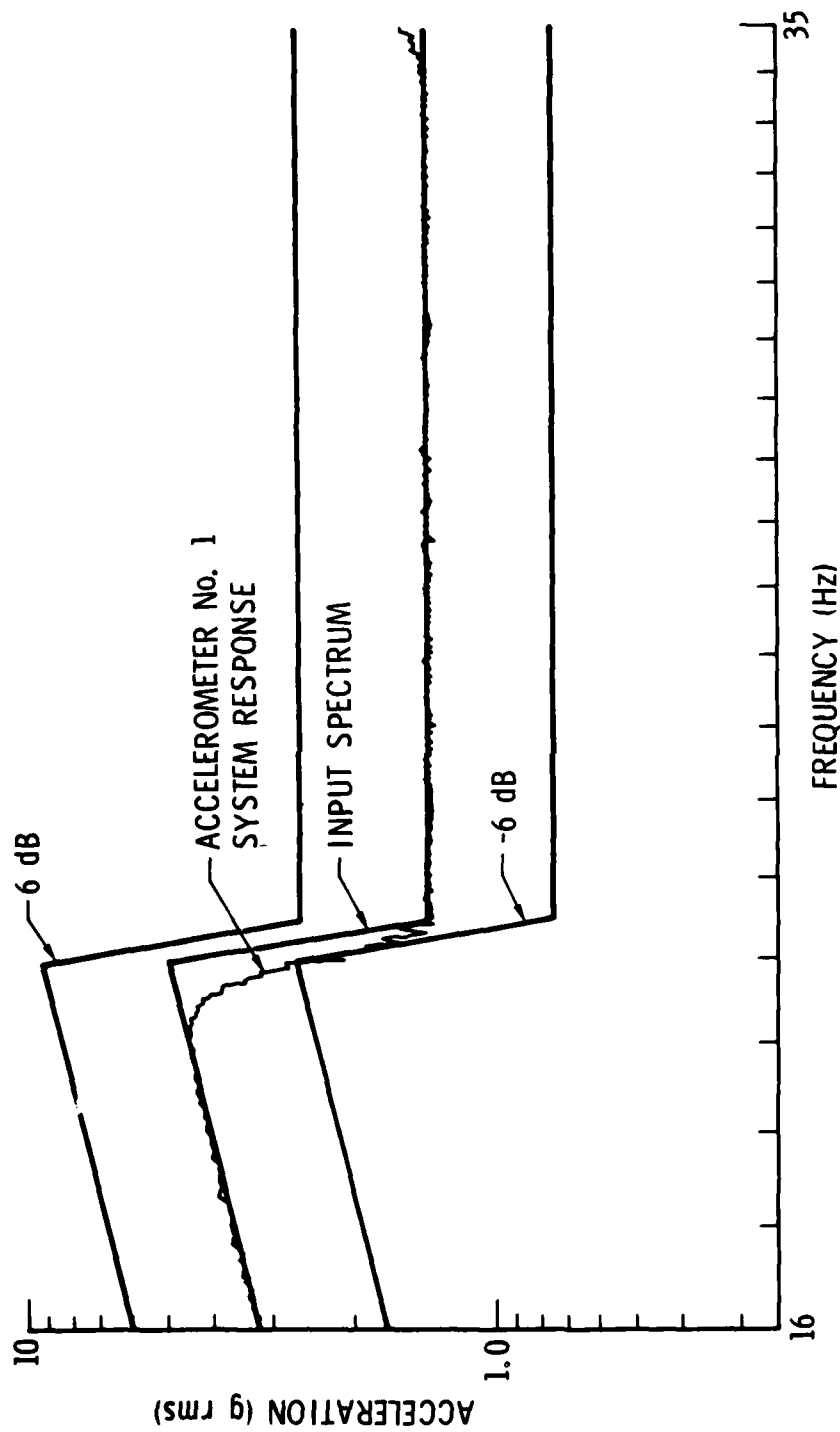


Fig. 28. T3, L-Axis, Sine Certification Input Spectrum, Accelerometer No. 1

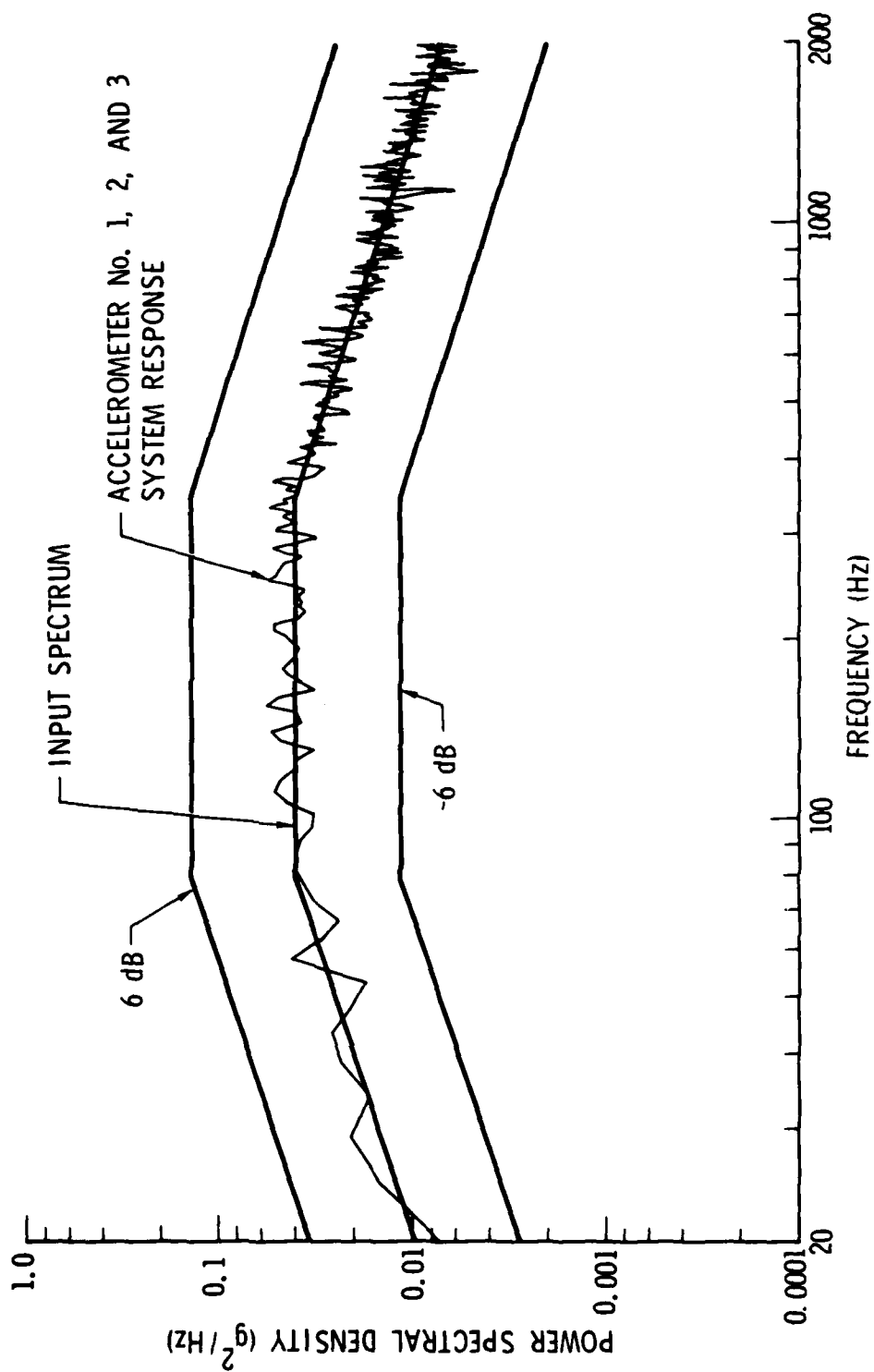


Fig. 29. T3, L-Axis, Random Certification Input Spectrum, Accelerometer No. 1, 2, and 3

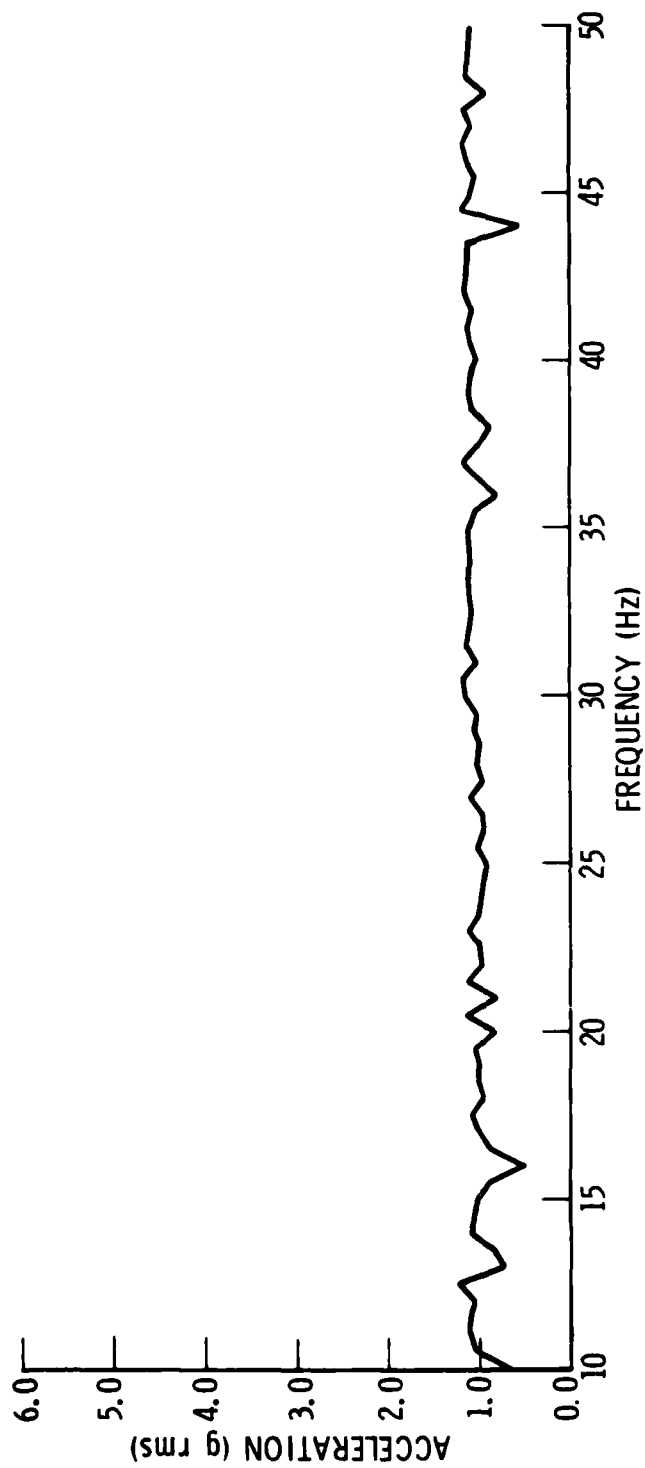


Fig. 30. T3, M-Axis, Transfer Function, Accelerometer No. 4/1

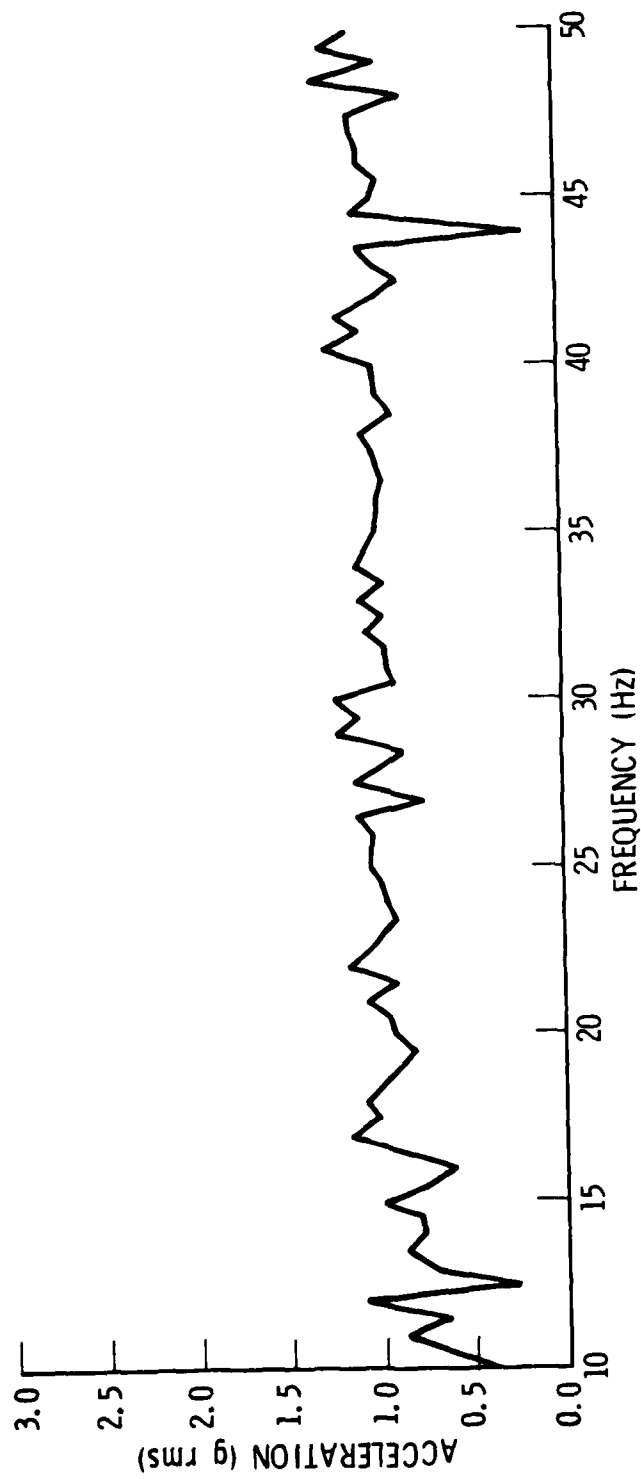


Fig. 31. T3, M-Axis, Transfer Function, Accelerometer No. 5/1

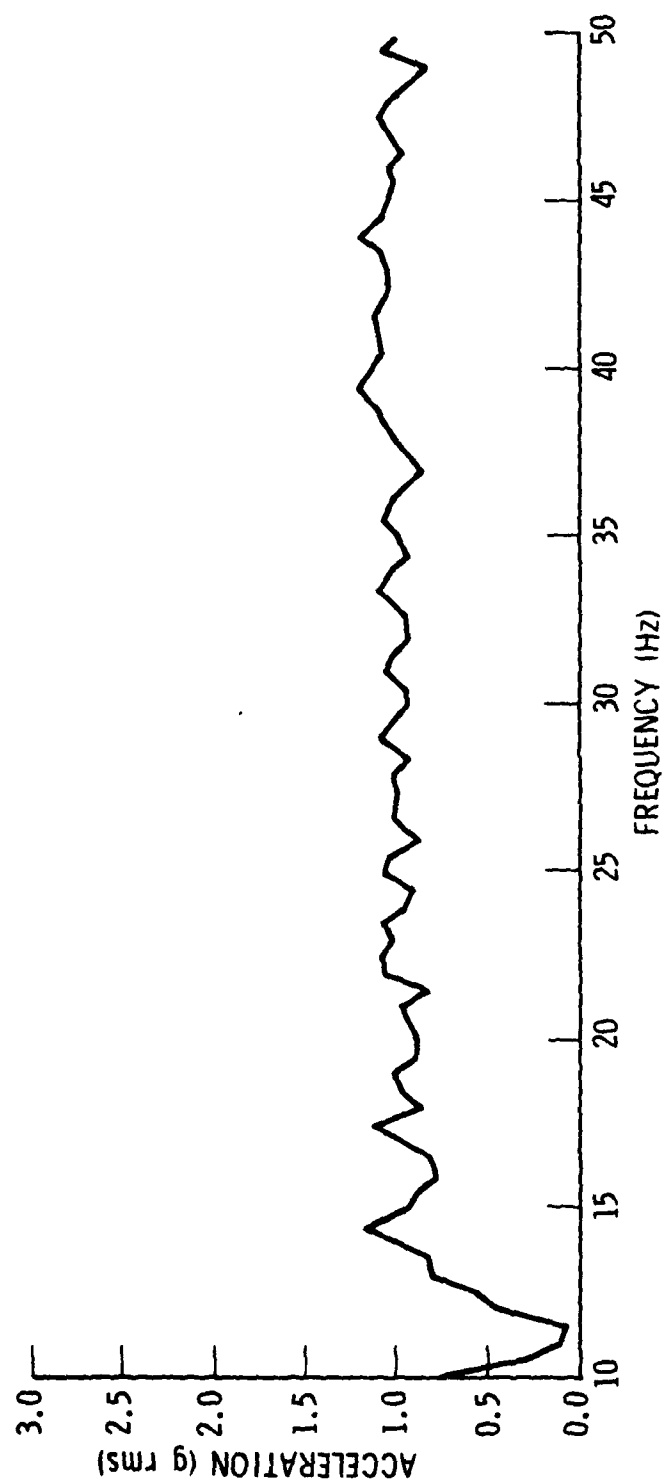


Fig. 32. T3, M-Axis, Transfer Function, Accelerometer No. 6/1

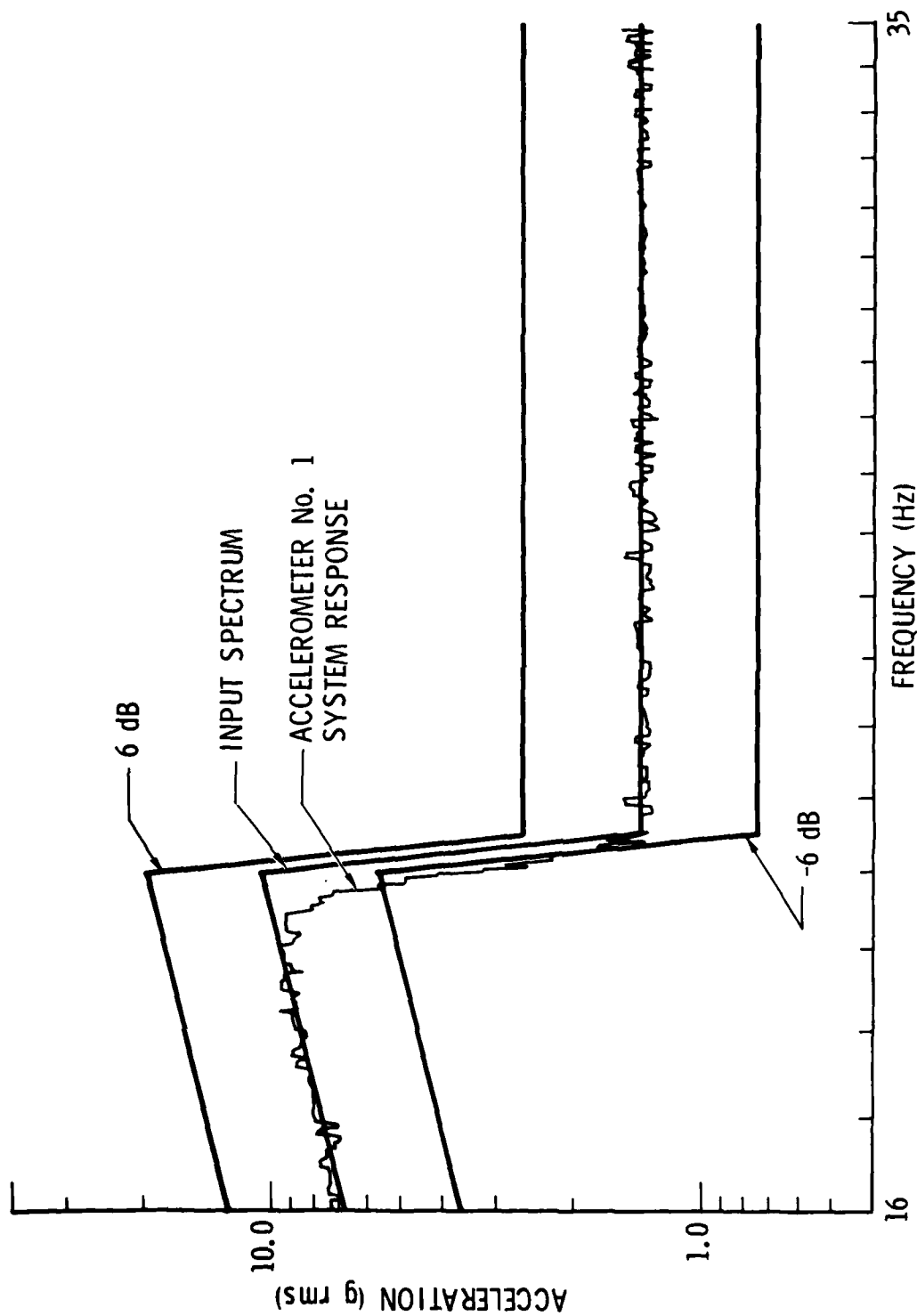


Fig. 33. T3, Z-Axis, Sine Certification Input Spectrum, Accelerometer No. 1

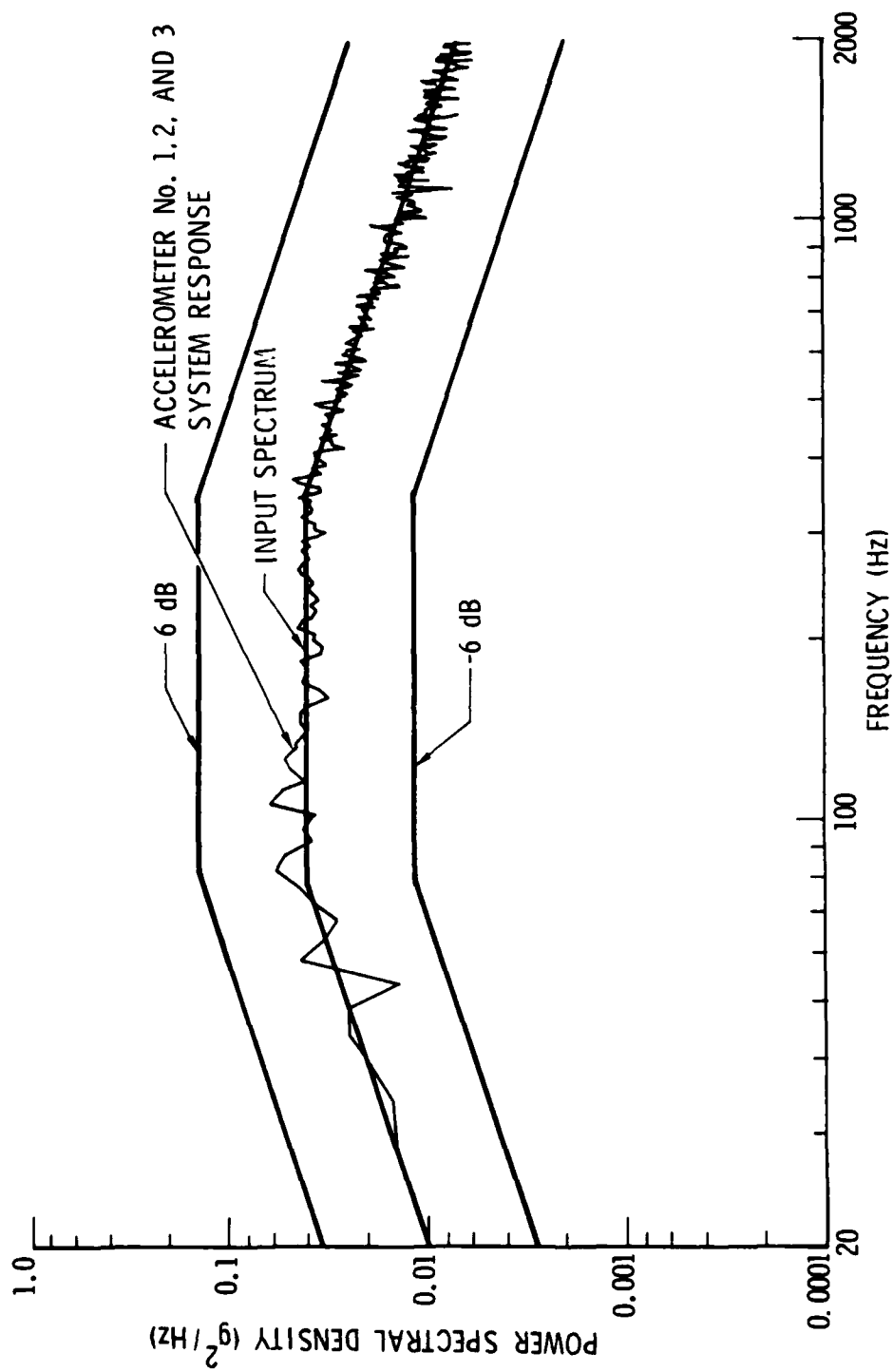


Fig. 34. T3, M-Axis, Random Certification Input Spectrum, Accelerometer No. 1, 2, and 3



tray jumper cables attached. Data collection is started by initiating the Engineering Power and Data System (EPDS). After a suitable data collection period has elapsed, the EPDS must again be initiated to terminate the data collection. Using ground support equipment, the data on the flight tape must be transcribed onto a computer compatible tape (CCT). The CCT is then read out by a microcomputer.

Both pre- and posttest data scans were conducted by first taking a quick look data scan to establish the state of each data channel. A 48-hr test run was then initiated to test the EPDS data timing function. A representative sample of the pre- and posttest data scans for the leading and trailing edge experiment trays are shown in Tables 4 and 5.

Table 4. Leading Edge Flight Trays, Pre- and Posttest Data Scans, Read-Averaged Values

| Pretest                      |               |             |               | Posttest                     |               |             |               |
|------------------------------|---------------|-------------|---------------|------------------------------|---------------|-------------|---------------|
| Number of Scans Averaged = 5 |               |             |               | Number of Scans Averaged = 5 |               |             |               |
| Channel No.                  | Average Value | Channel No. | Average Value | Channel No.                  | Average Value | Channel No. | Average Value |
| 7 BOE                        | 0000000000    | 40 WRT-7    | 2.3808        | 7 BOE                        | 0000000000    | 40 WRT-7    | 2.36128       |
| 8 QCM                        | 1621          | 41 WRT-8    | 2.39056       | 8 QCM                        | 1597          | 41 WRT-8    | 2.37104       |
| 9 SC-1                       | 9.70383E-03   | 42 WRT-9    | 2.37104       | 9 SC-1                       | 5.70946E-03   | 42 WRT-9    | 2.35152       |
| 10 SC-2                      | 0.0296757     | 43 WRT-10   | 2.3808        | 10 SC-2                      | 0.0256813     | 43 WRT-10   | 2.35152       |
| 11 SC-3                      | 1.71509E-03   | 44 WRT-11   | 2.37104       | 11 SC-3                      | -6.27365E-03  | 44 WRT-11   | 2.35152       |
| 12 SC-4                      | -0.0142624    | 45 WRT-12   | 2.37104       | 12 SC-4                      | -0.010268     | 45 WRT-12   | 2.35152       |
| 13 SC-5                      | 0.865625      | 46 WRT-13   | 2.36128       | 13 SC-5                      | 0.0536421     | 46 WRT-13   | 2.34176       |
| 14 SC-6                      | 0.0136982     | 47 WRT-14   | 2.3808        | 14 SC-6                      | 5.70946E-03   | 47 WRT-14   | 2.35152       |
| 15 EPDS I                    | 2.67397       | 48 WRT-15   | 2.37104       | 15 EPDS I                    | 2.67397       | 48 WRT-15   | 2.35152       |
| 16 EPDS 12V                  | 4.03024       | 49 EPDSVT   | 0.836768      | 16 EPDS 12V                  | 4.03024       | 49 EPDSVT   | 0.0830912     |
| 17 EPDS 5V                   | 3.87798       | 50 ANA-1    | 1.71517       | 17 EPDS 5V                   | 3.8448        | 50 ANA-1    | 1.71712       |
| 18 CTS-1                     | 2.36909       | 51 V TEMP   | 2.37104       | 18 CTS-1                     | 2.35152       | 51 V TEMP   | 2.37104       |
| 19 CTS-2                     | 2.37299       | 52 V TEMP   | 2.37104       | 19 CTS-2                     | 2.35738       | 52 V TEMP   | 2.37104       |
| 20 CTS-3                     | 2.3808        | 53 SC-1     | -0.02992      | 20 CTS-3                     | 2.36128       | 53 SC-1     | -0.063104     |
| 21 CTS-4                     | 2.3808        | 54 SC-2     | 0.081344      | 21 CTS-4                     | 2.36128       | 54 SC-2     | -4.54388E-03  |
| 22 LTT-1                     | 4.61584       | 55 SC-3     | -0.033824     | 22 LTT-1                     | 4.61584       | 55 SC-3     | -0.067008     |
| 23 LTT-2                     | 4.6256        | 56 SC-4     | -0.0299201    | 23 LTT-2                     | 4.61584       | 56 SC-4     | -8.44803E-03  |
| 24 LTT-3                     | 4.61584       | 57 SC-5     | -0.035776     | 24 LTT-3                     | 4.61584       | 57 SC-5     | -0.63104      |
| 25 LTT-4                     | 4.61584       | 58 SC-6     | -0.0318721    | 25 LTT-4                     | 4.61194       | 58 SC-6     | -0.0494399    |
| 26 LTT-5                     | 4.61584       | 59 SC-7     | -0.061152     | 26 LTT-5                     | 4.61194       | 59 SC-7     | -0.13728      |
| 27 LTT-6                     | 4.61584       | 60 SC-8     | -0.0338241    | 27 LTT-6                     | 4.60608       | 60 SC-8     | -0.0787201    |
| 28 HIT-1                     | 1.15104       | 61 SC-9     | -0.084576     | 28 HIT-1                     | 1.14128       | 61 SC-9     | -0.11776      |
| 29 HIT-2                     | 1.1608        | 62 SC-10    | 1.31207E-03   | 29 HIT-2                     | 1.14128       | 62 SC-10    | -0.11776      |
| 30 HIT-3                     | 1.1608        | 63 SC-11    | -0.0104       | 30 HIT-3                     | 1.15104       | 63 SC-11    | -0.0338241    |
| 31 HIT-4                     | 1.1608        | 64 SC-12    | -0.055296     | 31 HIT-4                     | 1.14128       | 64 SC-12    | -0.0787201    |
| 32 HIT-5                     | 1.15104       | 65 SC-13    | -0.065056     | 32 HIT-5                     | 1.14128       | 65 SC-13    | -0.108        |
| 33 HIT-6                     | 1.15104       | 66 SC-14    | -0.0260161    | 33 HIT-6                     | 1.13152       | 66 SC-14    | -0.0591999    |
| 34 WRT-1                     | 1.15104       | 67 SC-15    | -0.0650561    | 34 WRT-1                     | 2.37104       | 67 SC-15    | -0.197792     |
| 35 WRT-2                     | 2.3808        | 68 SC-16    | -0.0494399    | 35 WRT-2                     | 2.36128       | 68 SC-16    | -0.11776      |
| 36 WRT-3                     | 2.37104       | 69 SC-17    | -0.070912     | 36 WRT-3                     | 2.36128       | 69 SC-17    | -0.08848      |
| 37 WRT-4                     | 2.3808        | 70 SC-18    | -0.0513919    | 37 WRT-4                     | 2.36714       | 70 SC-18    | -0.0728642    |
| 38 WRT-5                     | 2.39056       | 71 SC-19    | -0.0709121    | 38 WRT-5                     | 2.36128       | 71 SC-19    | -0.08848      |
| 39 WRT-6                     | 2.3808        | 72 SC-20    | -0.0572479    | 39 WRT-6                     | 2.36128       | 72 SC-20    | -0.0318721    |

Table 5. Trailing Edge Flight Trays, Pre- and Posttest Data Scans, Read-Averaged Value

| Pretest                      |               |                              |               | Posttest                     |               |                              |               |
|------------------------------|---------------|------------------------------|---------------|------------------------------|---------------|------------------------------|---------------|
| Number of Scans Averaged = 5 |               | Number of Scans Averaged = 5 |               | Number of Scans Averaged = 5 |               | Number of Scans Averaged = 5 |               |
| Channel No.                  | Average Value | Channel No.                  | Average Value | Channel No.                  | Average Value | Channel No.                  | Average Value |
| 7 BOE                        | 0.0000000000  | 40 WRT-7                     | 2.40192       | 7 BOE                        | 0.0000000000  | 40 WRT-7                     | 2.33374       |
| 8 QCM                        | 1.305         | 41 WRT-8                     | 2.41166       | 8 QCM                        | 1.313         | 41 WRT-8                     | 2.33374       |
| 9 SC-1                       | 0.0142677     | 42 WRT-9                     | 2.40192       | 9 SC-1                       | 0.0142677     | 42 WRT-9                     | 2.33374       |
| 10 SC-2                      | 0.0222069     | 43 WRT-10                    | 2.39218       | 10 SC-2                      | 0.0142677     | 43 WRT-10                    | 2.33374       |
| 11 SC-3                      | 0.0182373     | 44 WRT-11                    | 2.39218       | 11 SC-3                      | 0.0102982     | 44 WRT-11                    | 2.33374       |
| 12 SC-4                      | 6.32858E-03   | 45 WRT-12                    | 2.41166       | 12 SC-4                      | 6.32858E-03   | 45 WRT-12                    | 2.34322       |
| 13 SC-5                      | 0.0261765     | 46 WRT-13                    | 2.40192       | 13 SC-5                      | 0.0142677     | 46 WRT-13                    | 2.35322       |
| 14 SC-6                      | 6.32858E-03   | 47 WRT-14                    | 2.41166       | 14 SC-6                      | 0.0102982     | 47 WRT-14                    | 2.36296       |
| 15 EPDS I                    | 2.72947       | 48 WRT-15                    | 2.41166       | 15 EPDS I                    | 2.7136        | 48 WRT-15                    | 2.36296       |
| 16 EPDS 12V                  | 4.05772       | 49 EPDSVT                    | 0.9604        | 16 EPDS 12V                  | 4.05772       | 49 EPDSVT                    | 0.808456      |
| 17 EPDS 5V                   | 3.8785        | 50 WRT-16                    | 2.41166       | 17 EPDS 5V                   | 3.84149       | 50 WRT-16                    | 2.3727        |
| 18 CTS-1                     | 2.40192       | 51 V TEMP                    | 2.4214        | 18 CTS-1                     | 2.324         | 51 V TEMP                    | 2.34348       |
| 19 CTS-2                     | 2.40192       | 52 V TEMP                    | 2.4214        | 19 CTS-2                     | 2.324         | 52 V TEMP                    | 2.34348       |
| 20 CTS-3                     | 2.41166       | 53 SC-1                      | -0.107104     | 20 CTS-3                     | 2.324         | 53 SC-1                      | -0.116844     |
| 21 CTS-4                     | 4.63238       | 54 SC-2                      | -0.525603     | 21 CTS-4                     | 2.324         | 54 SC-2                      | -0.0623002    |
| 22 LTT-1                     | 4.63238       | 55 SC-3                      | -0.0291842    | 22 LTT-1                     | 4.6129        | 55 SC-3                      | 0.0350281     |
| 23 LTT-2                     | 4.63238       | 56 SC-4                      | -0.0213923    | 23 LTT-2                     | 4.6129        | 56 SC-4                      | -0.233402     |
| 24 LTT-3                     | 4.62264       | 57 SC-5                      | -0.0895723    | 24 LTT-3                     | 4.60316       | 57 SC-5                      | -0.16944      |
| 25 LTT-4                     | 4.62459       | 58 SC-6                      | -0.0934683    | 25 LTT-4                     | 4.6129        | 58 SC-6                      | -0.10126      |
| 26 LTT-5                     | 4.63238       | 59 SC-7                      | -0.08178      | 26 LTT-5                     | 4.60316       | 59 SC-7                      | -0.0895722    |
| 27 LTT-6                     | 4.63238       | 60 SC-8                      | -0.0525603    | 27 LTT-6                     | 4.6129        | 60 SC-8                      | -0.0545082    |
| 28 HTT-1                     | 1.16494       | 61 SC-9                      | -0.08178      | 28 HTT-1                     | 1.11624       | 61 SC-9                      | -0.0973642    |
| 29 HTT-2                     | 1.17468       | 62 SC-10                     | -0.0545083    | 29 HTT-2                     | 1.13182       | 62 SC-10                     | -0.0837281    |
| 30 HTT-3                     | 1.16494       | 63 SC-11                     | -0.0486642    | 30 HTT-3                     | 1.11624       | 63 SC-11                     | -0.0467161    |
| 31 HTT-4                     | 1.16494       | 64 SC-12                     | -0.038924     | 31 HTT-4                     | 1.11624       | 64 SC-12                     | -0.0584043    |
| 32 HTT-5                     | 1.16494       | 65 SC-13                     | -0.0642482    | 32 HTT-5                     | 1.11624       | 65 SC-13                     | -0.0661962    |
| 33 HTT-6                     | 1.17468       | 66 SC-14                     | -0.0720401    | 33 HTT-6                     | 1.14546       | 66 SC-14                     | -0.0876242    |
| 34 WRT-1                     | 2.39218       | 67 SC-15                     | -0.10126      | 34 WRT-1                     | 2.324         | 67 SC-15                     | -0.157752     |
| 35 WRT-2                     | 2.39218       | 68 SC-16                     | -0.12074      | 35 WRT-2                     | 2.324         | 68 SC-16                     | -0.185024     |
| 36 WRT-3                     | 2.39218       | 69 SC-17                     | -0.0506123    | 36 WRT-3                     | 2.33374       | 69 SC-17                     | -0.0408721    |
| 37 WRT-4                     | 2.39218       | 70 SC-18                     | -0.08178      | 37 WRT-4                     | 2.33374       | 70 SC-18                     | -0.0934683    |
| 38 WRT-5                     | 2.39218       | 71 SC-19                     | -0.0798321    | 38 WRT-5                     | 2.324         | 71 SC-19                     | -0.0934683    |
| 39 WRT-6                     | 2.41166       | 72 SC-20                     | -0.044768     | 39 WRT-6                     | 2.34543       | 72 SC-20                     | -0.0564563    |

#### IV. EXPERIMENT WEIGHT AND CENTER OF GRAVITY

Prior to the certification vibration tests, the weight and center of gravity of each experiment tray were determined.

The equipment used for this experiment consisted of a tray holding fixture, three load cells and associated readout instrumentation, and an HP85 computer. Experiment weight and geometric center versus measured center of gravity data are presented in Table 6. The location of the center of gravity for each tray is shown in Figs. 35 through 38.

Table 6. Tray Weight and Center of Gravity

| Tray | Weight<br>(lb) | Geometric<br>Center |        | Measured<br>Center of Gravity |        | Error<br>Radius<br>(in.) | Unbalance<br>(ft-lb) |
|------|----------------|---------------------|--------|-------------------------------|--------|--------------------------|----------------------|
|      |                | x <sup>a</sup>      | y      | x                             | y      |                          |                      |
| T3   | 122.31         | 23.375              | 29.437 | 25.723                        | 29.301 | 2.35                     | 23.57                |
| L3   | 107.25         | 23.375              | 29.437 | 25.061                        | 27.153 | 2.83                     | 25.37                |
| T6   | 241.19         | 23.375              | 29.437 | 20.654                        | 27.485 | 3.34                     | 67.29                |
| L6   | 240.01         | 23.375              | 29.437 | 20.743                        | 27.366 | 3.34                     | 66.97                |

<sup>a</sup>All x,y values are distances from a fixed reference point outside the tray boundaries.

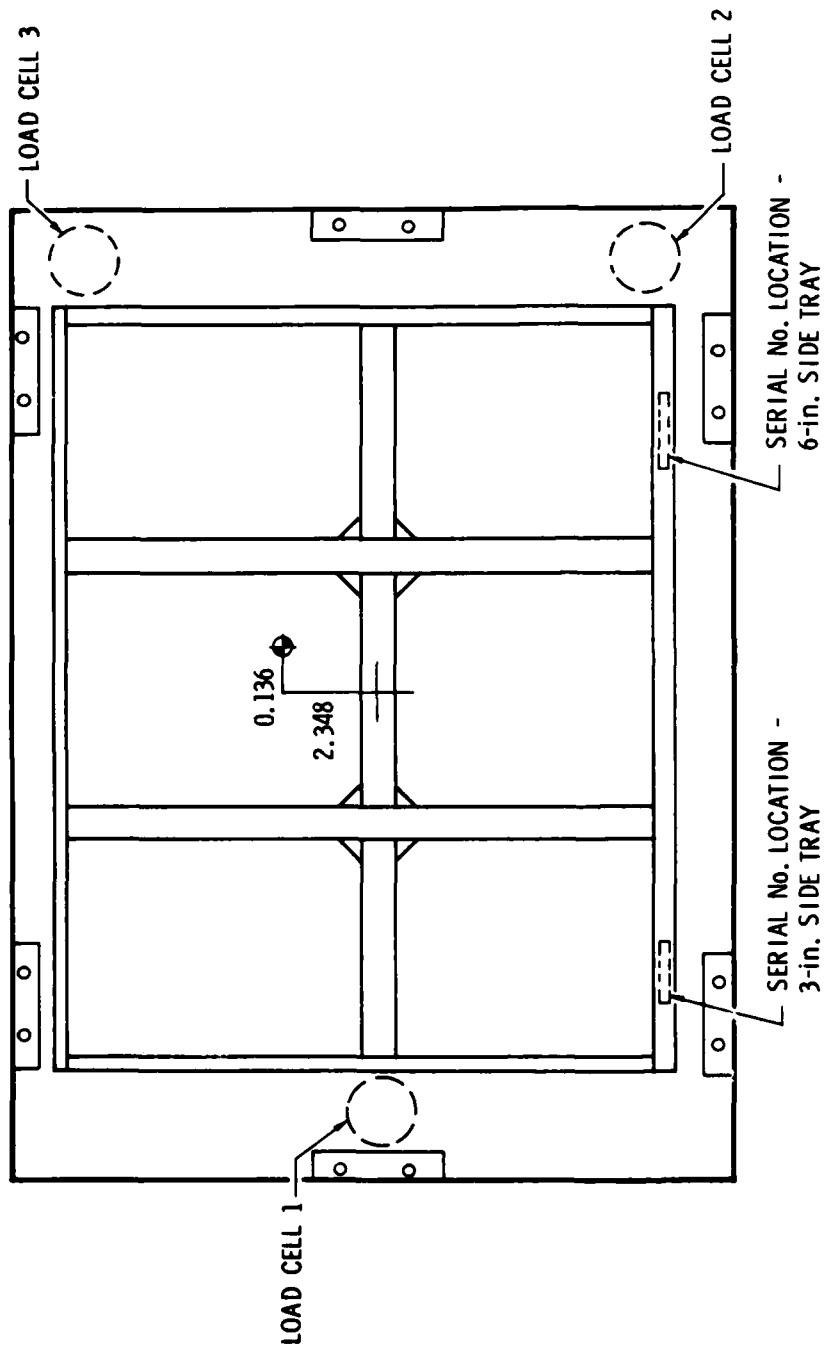


Fig. 35. T3, Measured Center of Gravity

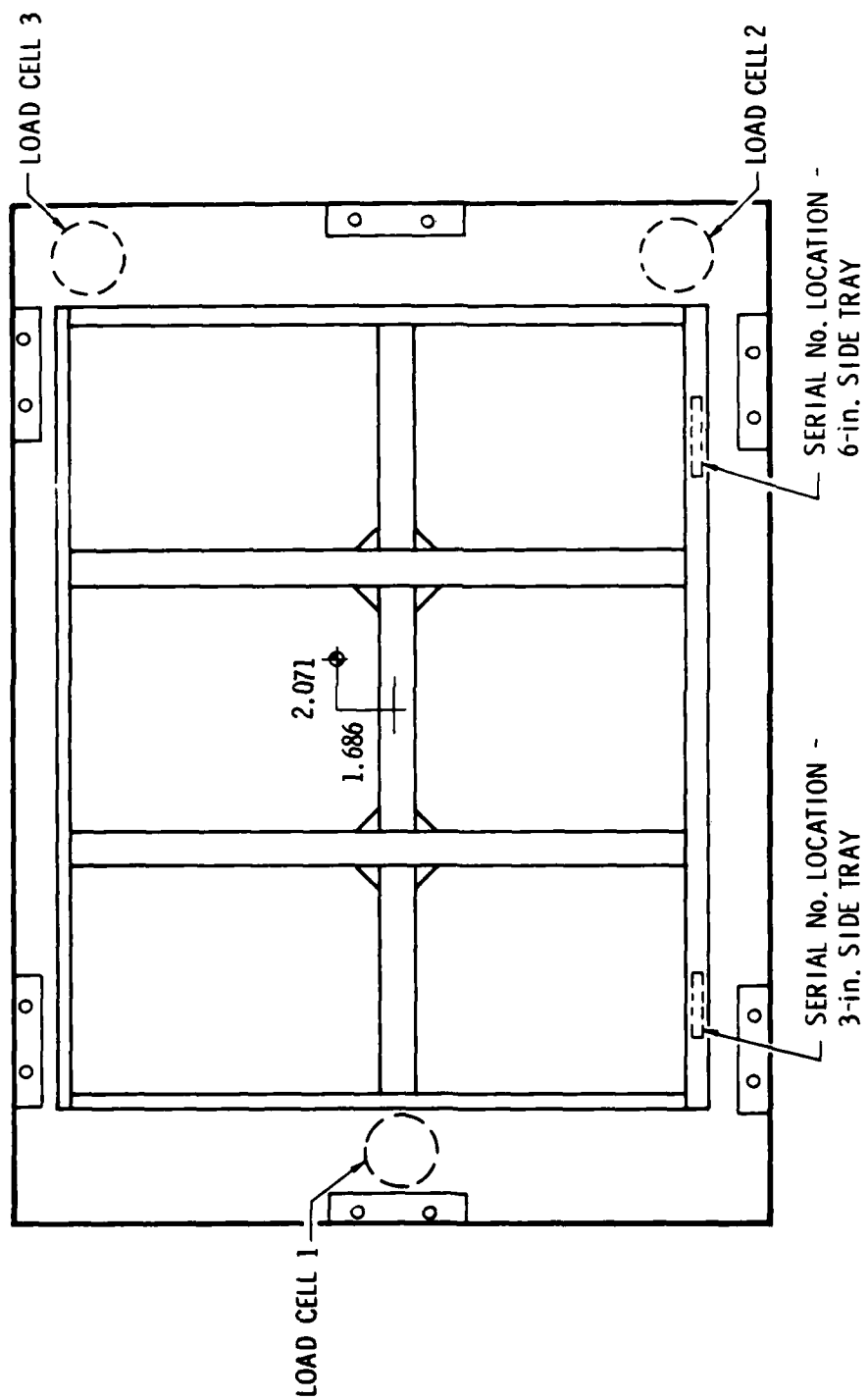


Fig. 36. L3, Measured Center of Gravity

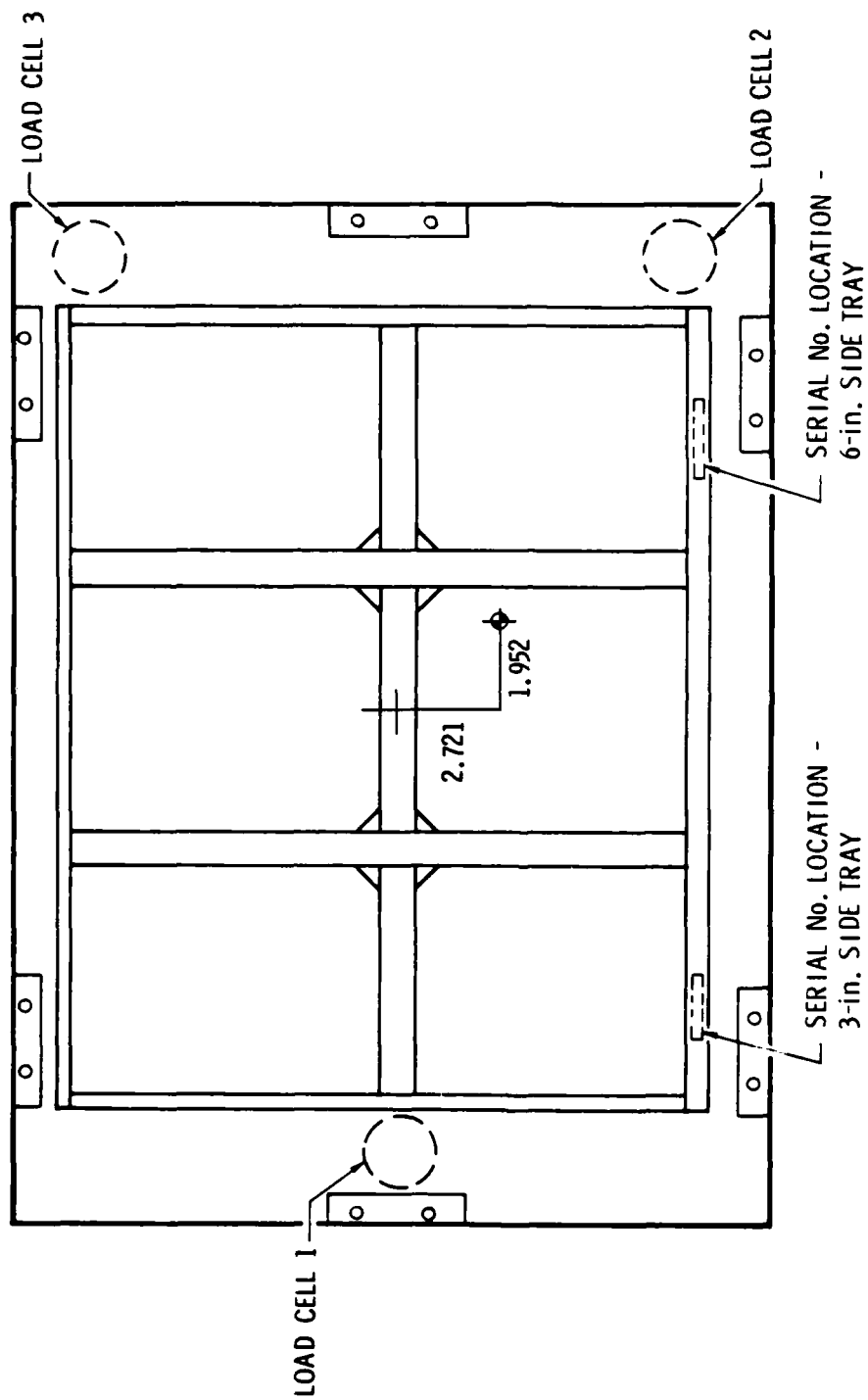


Fig. 37. T6, Measured Center of Gravity

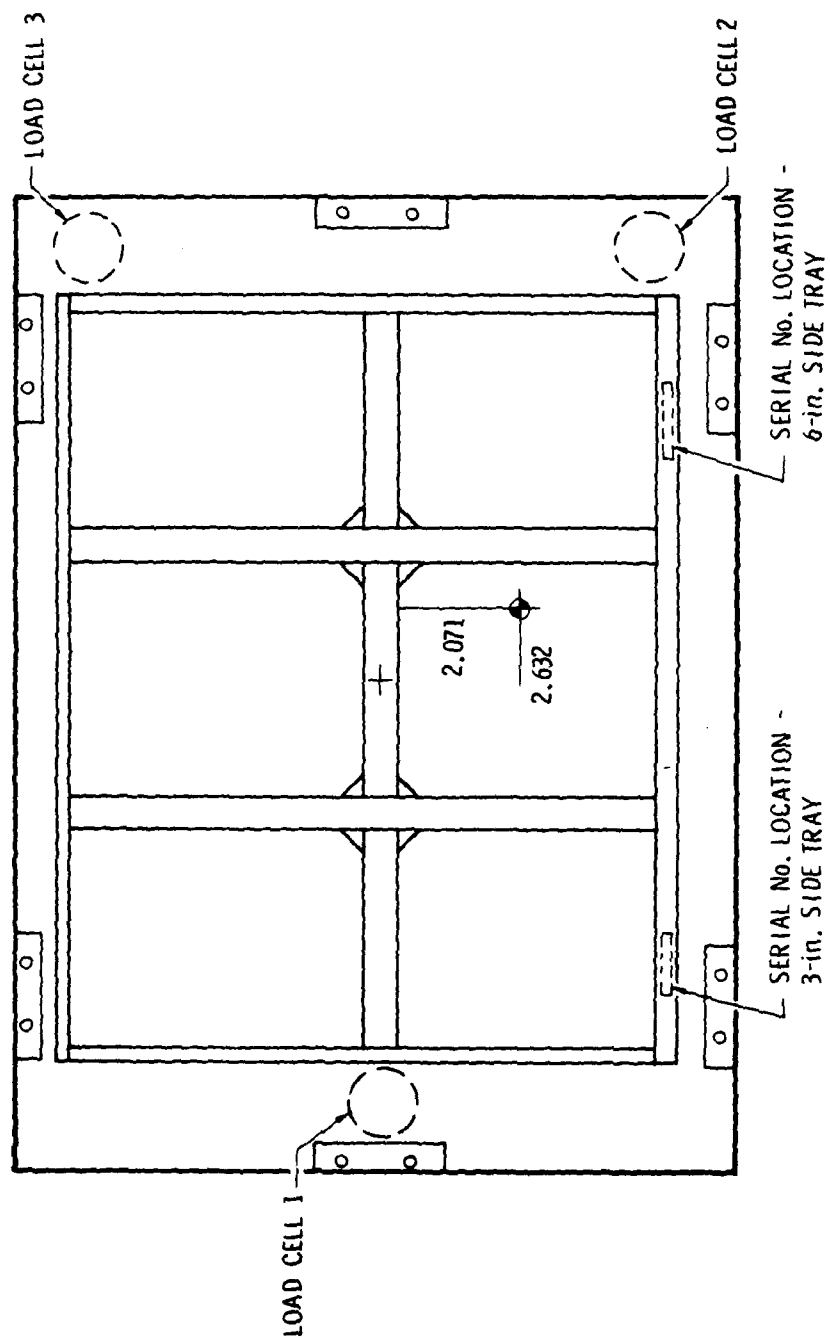


Fig. 38. L6, Measured Center of Gravity



#### REFERENCES

1. A. F. DiGiacomo, Qualification Vibration Test Report for SD802 Materials Experiment, TR-0081(6950-05)-3, The Aerospace Corporation, El Segundo, Calif. (3 August 1981).
2. A. F. DiGiacomo, W. C. Burns, and P. Schall, Environmental Qualification Tests, Signal Conditioning Unit, SD802 Materials Experiment, TR-0083(3935-05)-1, The Aerospace Corporation, El Segundo, Calif. (to be published).
3. R. P. Giguere, SD/LDEF Technical User's Manual, TR-0081(6603)-1, The Aerospace Corporation, El Segundo, Calif. (30 September 1981).

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APPENDIX A  
M0003 DATA RECORDING  
FUNCTIONAL TESTS

Revised 23 November 1982

## M0003 DATA RECORDING FUNCTIONAL TESTS

### 1.0 Battery Installation

#### 1.1 Function Tests

1.1.1 Experiment Power, Two (12V) Batteries, 3 Inch Trays

1.1.2 EPDS, 7.5 and 12V Battery, 6 Inch Trays

1.1.3 EECC, Not to be opened before flight

#### 1.2 Flight Readiness

1.2.1 Experiment Power, Two (12V) Batteries, 3 Inch Trays

1.2.2 EPDS, 7.5 and 12V Battery, 6 Inch Trays

1.2.3 EECC, 7.5 and 28V Battery, 6 Inch Trays

### 2.0 Wire Connections

#### 2.1 Connect 3" Tray to 6" Tray Interface Cables

##### 2.1.1 Leading Edge Trays

| 6" Tray (LE155 629C-10) | <u>Cable Connection</u> | <u>Tray Connection</u> |
|-------------------------|-------------------------|------------------------|
|                         | S110                    | to P110                |
|                         | S111                    | to P111                |
|                         | S112                    | to P112                |

3" Tray (LE155 621A-1-3)

|      |    |      |
|------|----|------|
| P107 | to | S107 |
| P108 | to | S108 |
| P109 | to | S109 |

##### 2.1.2 Trailing Edge Trays

|                          |      |    |      |
|--------------------------|------|----|------|
| 3" Tray (LE155621A-1-11) | P207 | to | S207 |
|                          | P208 | to | S208 |
| 6" Tray (LE155 629C-7)   | S209 | to | P209 |
|                          | P210 | to | S210 |

#### 2.2 Remove flight jumper connection located on bottom surface of EPDS

## 2.3 Ground Support Equipment Connections

### 2.3.1 P1 DPCA to

a) S703 (EPDS)

b) P - MTM Controller

c) J5 Power MTM Controller

### 2.3.2 P2 CCT INT/FACE to P1 Kennedy CCT

## 3.2 GSE Power Turn On

- . Turn on the 115 VAC Power Switch
- . The Initiate Monitor RESET Lamp Should Be On
- . The 10 VDC Meter Should Read 7.5V
- . The 15 VDC Meter Should Read 12V
- . Move Spring Loaded Printer Switch to the RESET Position
- . 12 VDC EPDS Power Switch to the ON Position
- . 7.5 VDC EPDS Power Switch to the ON Position
- . 12 VDC Experiment Power Switch to the ON Position
- . 7.5 VDC Experiment Power Switch to the ON Position
- . External 12 VDC, Negative Power Supply, to the ON Position
- . Zero Current Reading on the Current Meter

## 3.3 EPDS Tape to Starting Position for Data Recording

### 3.3.1 Set Tape to Track #1

- . DPCA-Manual Switch to the MANUAL Position
- . Press Fast-Reverse (F-REV) button
  - a) Allow tape to remain in this mode until the stop lamp indicates stop
  - b) When the stop lamp is on the Track #2 indicating lamp will light
- . press the forward switch (FWD) then press the record switch (REC)
  - a) Track #2 lamp will shut off, Track #1 lamp will turn on
  - b) Remain in the mode for three minutes and press the stop button
  - c) Track #1 lamp will turn off, Track #2 lamp will turn on

- . ERASE ENABLE Switch to the ERASE ENABLE Position  
ERASE ENABLE Lamp will light
- . Press the fast reverse (F REV) button and allow the tape to run until the tape STOP lamp turns on
- . Turn the ERASE ENABLE Switch to the deactivated position
- . Press the forward (FWD) button then press the record (REC) button, let the tape run for one minute and press the STOP button
- . STOP lamp and Track #2 lamp should be on

#### 4.0 Functional Tests

##### 4.1 Primary checkout procedure

Data recording for the purpose of playing the data back through the CCT and TRS-80 Computer and printer

Experiment powered through the DDB

- 4.1.1 For the combined post shipment and pre and post EPDS modification electronic functional test, record data for a minimum of thirty minutes
- 4.1.2 For subsequent electronic functional tests, record data for a minimum of 112 minutes
- 4.1.3 Switch arrangements for data recording
  - a) DPCA-MANUAL Switch to the DPCA Position
  - b) DDP Printer RESET Switch to the RESET Position
  - c) INITIATE SET-RESET Switch to the SET Position. This switch arrangement will provide a GSE print tape while the EPDS is recording data
  - d) 7.5 V current meter switch to the 1.5 ma position, meter should read  $\approx 0.6$  ma. (will overshoot initially)
  - e) After approximately 3.5 minutes the system will start recording data. The GSE printer will also start printing.  
NOTE: The GSE print tape will only print 5 channels of data during one print sequence, to print a full data scan on the GSE printer the system must remain activated for two hours. The printer will stop after it has printed the 72 data channels.

4.2 To transfer data from the EPDS tape to the CCT then to the TRS-80 computer

- . Reset the INITIATE switch from the SET position to RESET position. Stops the data collection sequence
- . DPCA-MANUAL switch to the manual position
- . MTM Controller, press the fast reverse (F REV) button, allow the tape to run until the stop lamp turns on. At this point the Track #2 lamp will also turn on
- . Press MTM controller forward (FWD) and (REC) button and let the tape run for 30-45 sec.
- . Press the Stop button, the EPDS tape is now advanced

The next step is to transfer the data from EPDS to the Kennedy CCT

- . Read-Write switch to the WRITE position
- . Kennedy CCT, turn on the 115 VAC power switch and press the LOAD button. Install magnetic tape if required - See Kennedy Manual
- . Press the ON LINE button, when the CCT is ready to accept data the ON LINE, WRITE ENABLE, WRITE STATUS and LOAD lamps will light
- . MTM Controller, press the forward (FWD) button and then the reproduce (REPRO) button. This will start the transfer of data from the EPDS tape to the Kennedy CCT
- . The Kennedy CCT will move in short increments, 10-15 seconds between increments, until all the data is transferred - the incremental movement of the Kennedy CCT will stop
- . Push the STOP button on the MTM controller to stop the EPDS tape
- . Push the ON LINE button, ON LINE lamp will go off

4.2.1 To Transfer Data from the Kennedy CCT to the TRS-80 Computer then onto the printer

- . READ-WRITE switch to the READ position
- . Press REWIND on the Kennedy CCT, the CCT will rewind and stop

- . Turn on the 115 VAC power to the TRS-80 computer, printer and cassette recorder
- . Load LDEF Program tape and read the program from the cassette into the TRS-80 computer
  - a) Load cassette into the cassette player
  - b) Press the LOAD switch on the cassette player
  - c) Type CLOAD on the keyboard and press the ENTER key on the keyboard
  - d) The cassette tape will start running, when it stops the program is loaded into the TRS-80 computer, rewind the cassette tape.
  - e) To insure that all the data was transferred from the program tape to the computer repeat steps a) thru d).  
In Line c) replace CLOAD with CLOAD?
- . Press the ON LINE button on the Kennedy CCT, the ON LINE lamp will light, the WRITE ENABLE lamp will turn on
- . Type the word RUN on the keyboard and press the enter key
  - a) The computer will ask which set of data are we working with leading or trailing edge trays, type in the appropriate letter L or T and press the ENTER key
  - b) If a time printout only is wanted answer "YES" to the next question the computer displays. If the answer is "NO" just press the ENTER key
  - c) The computer now will transcribe and printout the data on the CCT, data Channels 7 through 72

4.3 Alternate test #1, this procedure may be used in case of electronic problems with the Kennedy tape or TRS-80 Computer. GSE Paper Tape Printout Only, Experiment Power Supplied by the Data Display Box (DDB)

4.3.1 Initiate, SET-RESET Switch Move to the SET position will now provide a GSE Paper Tape Printout

- 4.3.2 INITIATE Switch to the SET Position
  - a) The initiate monitor set lamp will light
  - b) -7.5 current meter, on the 1.5 ma scale, will read full scale then drop to .6 ma
  - c) 12V current meter will be < 100 ma
- 4.3.3 After approximately 3.5 minutes the GSE printer will start displaying data in bursts of 5 data channels. This sequence will continue until the 72 data channels are displayed ( $\approx$  2 Hrs)
- 4.3.4 To Stop the system in this mode, SET and RESET Switch to the RESET position. If GSE Paper Tape is to be restarted, PRINTER RESET Switch to RESET position
- 4.4 Alternate test #2, this procedure may be used in case of
  - a) partial malfunction of GSE equipment
  - b) data recording with the experiment in the Flight Configuration (Flight battery power)
  - c) Data recording for the purpose of checking the data collection timing sequence from initiate to beyond 94 hours continuous recording
- 4.4.1 Switch Arrangements
  - a) INT-EXT EPDS Power switch to INT position
  - b) DPCA-MANUAL switch to the MANUAL position
  - c) Initiate SET and RESET switch to the SET position.  
NOTE: No GSE tape printout
  - d) To stop the collection of data, initiate SET-RESET Switch to the RESET position. RESET lamp will turn on
- 4.4.2 To obtain a TRS-80 Computer printout repeat Steps 4.2 & 4.2.1



APPENDIX B  
LDEF PROJECT

LDEF PROJECT

Procedure No.: \_\_\_\_\_

Procedure Title: Experiment Certification Vibration Test Procedure

Item Nomenclature: \_\_\_\_\_

Item Identification No.: \_\_\_\_\_

Prepared By: John F. Rogers 1-10-83  
John F. Rogers - LDEF Experiment Test Engineer

Concurrence: Carol C. Kiser 1-10-83  
Carol C. Kiser - LDEF Experiment Integration Manager

Approved By: W. H. Kinard  
W. H. Kinard - Chief Scientist and Experiment Manager

L. P. Daspit, Jr. 1-10-83  
L. P. Daspit, Jr. - LDEF Project Manager

C. T. Moore  
C. T. Moore - Quality Assurance

Test Engineer: \_\_\_\_\_

Date Started: \_\_\_\_\_

Date Completed: \_\_\_\_\_

## 1.0 GENERAL

### 1.1 Test Objective

1.1.1 To verify the structural integrity of the experiment when subjected to the certification vibration test levels.

1.1.2 To demonstrate the ability of the experiment to satisfy functional requirements after being subjected to the certification vibration test levels.

### 1.2 Test Description

1.2.1 The experiment vibration fixture (LE155606C) will be mounted on the Unholtz-Dickie shaker in Building 1250. The experiment will then be tested to the sine and random vibration spectrums as identified in Figure 3 and 4.

### 1.3 Personnel Requirements

#### 1.3.1 Test Engineer (T.E.)

1.3.1.1 The test engineer shall have the overall responsibility for direction of this test.

#### 1.3.2 Test Facility Operator (T.F.O.)

#### 1.3.3 Quality Assurance Technician (R&QA)

#### 1.3.4 Experiment Development Organization Representative (E.D.O.)

1.3.4.1 Personnel from the Experiment Development Organization will be present when appropriate.

### 1.4 Safety

1.4.1 Safety requirements are specified in the individual steps of section 2.3 (Vibration Testing).

## 1.5 Quality Assurance

- 1.5.1 A quality assurance representative will observe and assure adherence to this test procedure.

## 1.6 Test Facility and Equipment

### 1.6.1 Facility

- 1.6.1.1 Environment test lab located Building 1250.

### 1.6.2 Equipment

- 1.6.2.1 Shaker and associated vibration controller/analyzer available in the specified test facility.

- 1.6.2.2 Integrated Experiment Tray/Module

## 1.7 Failure Criteria

- 1.7.1 Loose parts, cracks in the structure, or evidence of component failure based on accelerometer response data will constitute a failure.

## 1.8 Log Book

- 1.8.1 A log book will be maintained for each experiment.

## 2.0 TESTING

### 2.1 Test Sequence

- 2.1.1 The vibration tests shall be conducted in the following sequence for each axis (N, L, M).

- 2.1.1.1 Transfer functions

- 2.1.1.2 Certification level sine sweep

- 2.1.1.3 Certification level random vibration

## 2.2 Instrumentation

### 2.2.1 Sine Test

2.2.1.1 The locations of the control and response accelerometers for each axis are identified in figure 5, 6, 7.

2.2.1.2 Control and response accelerometer data will be plotted in G's vs. frequency at the completion of the test.

### 2.2.2 Random Test

2.2.2.1 The location of the control accelerometer for each axis is identified in figure 5, 6, and 7.

2.2.2.2 Control accelerometer data will be plotted in GRM's vs frequency at the completion of the test.

## 2.3 Vibration Testing

### 2.3.1 Transfer Functions (N Axis)

2.3.1.1 Install the experiment vibration fixture (LE155606C) on the vertical shaker for "N" axis testing. Torque the 1/2" bolts to 90 ft-lbs.

2.3.1.2 Attach the integrated experiment tray/module to the vibration fixture using clamp blocks and shims as per LE155639 for side trays or LE155652 for end trays. Torque the 1/4-28 bolts to 75 in-lbs.

2.3.1.3 Assure that all instrumentation has been properly calibrated.

2.3.1.4 Attach the control \_\_\_\_\_ and response \_\_\_\_\_ accelerometers as shown in figure 5.

2.3.1.5 Determine the transfer function between these points and additional points as deemed necessary by the test engineer.

2.3.1.6 Review the transfer function data noting fundamental frequencies. If a fundamental frequency of 35Hz is noted then special consideration should be given to this experiment package.

\_\_\_\_\_  
QA

## 2.3.2 Certification Level Sine Sweep (N Axis)

2.3.2.1 Verify that the proper sine test has been recorded on the disk (the "G" level is specified in Figure 2, the spectrum is as shown in Figure 3, the test will be conducted from 35-16 Hz).

\_\_\_\_\_  
QA

2.3.2.2 Subject the experiment package to the certification level sine sweep.

2.3.2.3 Review the response acceleration data and perform a visual inspection of the experiment package to insure compliance with the failure criteria.

\_\_\_\_\_  
QA

2.3.3 Certification Level Random Vibration (N Axis)

2.3.3.1 Verify that the random certification test level has been recorded on the disk (see Figure 4).

\_\_\_\_\_  
QA

2.3.3.2 Verify that the control accelerometer is \_\_\_\_\_ as shown in Figure 5.

2.3.3.3 Subject the experiment package to the random certification test.

2.3.3.4 Perform a visual inspection of the experiment package to insure compliance with the failure criteria.

\_\_\_\_\_  
QA

2.3.4 Transfer Functions (L Axis)

2.3.4.1 Remove the accelerometers from the experiment tray and vibration fixture.

2.3.4.2 Remove the integrated experiment tray/module from the vibration fixture and attach it to the handling fixture.

- 2.3.4.3 Remove the vibration fixture from the shaker head and install it on the slippery table oriented for "L" axis testing (see Figure 6). Torque the 1/2" bolts to 90 ft-lbs.
- 2.3.4.4 Rotate the shaker head 90° and attach it to the slippery table. Torque the 1/2" bolts to 90 ft-lbs.
- 2.3.4.5 Attach the integrated experiment tray/module to the vibration fixture using clamp blocks and shims as per LE155639 for side trays or LE155652 for end trays. Torque the 1/4-28 bolts to 75 in-lbs.
- 2.3.4.6 Attach the control \_\_\_\_\_ and response \_\_\_\_\_ accelerometers as shown in Figure 6.
- 2.3.4.7 Determine the transfer function between these points and additional points as deemed necessary by the test engineer.
- 2.3.4.8 Review the transfer function data noting fundamental frequencies. If a fundamental frequency 35 Hz is noted then special consideration should be given to this experiment package.

\_\_\_\_\_  
QA



2.3.5 Certification Level Sine Sweep (L Axis)

- 2.3.5.1 Verify that the proper sine test has been recorded on the disk (the "G" level is specified in Figure 2, the spectrum is as shown in Figure 3, the test will be conducted from 35-16 Hz).

\_\_\_\_\_  
QA

- 2.3.5.2 Subject the experiment package to the certification level sine sweep sine sweep.
- 2.3.5.3 Review the response acceleration data and perform a visual inspection of the experiment package to insure compliance with the failure criteria.

\_\_\_\_\_  
QA

2.3.6 Certification level random vibration (L axis)

- 2.3.6.1 Verify that the random certification test level has been recorded on the disk (see Figure 4).
- 2.3.6.2 The control accelerometer is \_\_\_\_\_ as shown in Figure 6.

\_\_\_\_\_  
QA

- 2.3.6.3 Subject the experiment package to the random certification test.
- 2.3.6.4 Perform a visual inspection of the experiment package to insure compliance with the failure criteria.

\_\_\_\_\_  
QA

### 2.3.7 Transfer function (M Axis)

- 2.3.7.1 Remove the accelerometers from the experiment tray and vibration fixture.
- 2.3.7.2 Remove the integrated experiment tray/module from the vibration fixture and attach it to the handling fixture.
- 2.3.7.3 Rotate the vibration fixture on the slippery table so that it is oriented for "M" axis testing. Torque the 1/2" bolts to 90 ft-lbs.
- 2.3.7.4 Attach the integrated experiment tray/module to the vibration fixture using clamp blocks and shims as per LE155639 for side trays or LE155652 for end trays. Torque the 1/4-28 bolts to 75 in-lbs.
- 2.3.7.5 Attach the control \_\_\_\_\_ and response \_\_\_\_\_ accelerometers as shown in Figure 7.
- 2.3.7.6 Determine the transfer function between these points and additional points as deemed necessary by the test engineer.

2.3.7.7 Review the transfer function data noting fundamental frequencies. If a fundamental frequency 35 Hz is noted then special consideration should be given to this experiment package.

\_\_\_\_\_  
QA

2.3.8 Certification Level Sine Sweep (M Axis)

2.3.8.1 Verify that the proper sine test has been recorded on the disk. (The "G" level is specified in Figure 2, the spectrum is as shown in Figure 3, the test will be conducted from 35-16 Hz).

\_\_\_\_\_  
QA

2.3.8.2 Subject the experiment package to the certification level sine sweep.

2.3.8.3 Review the response acceleration data and perform a visual inspection of the experiment package to insure compliance with the failure criteria.

\_\_\_\_\_  
QA

2.3.9 Certification level random vibration (M Axis)

2.3.9.1 Verify that the random certification test level has been properly recorded on the disk (see Figure 4).

2.3.9.2 The control accelerometer is \_\_\_\_\_ as shown in Figure 7.

\_\_\_\_\_  
QA

2.3.9.3 Subject the experiment package to the random certification test.

2.3.9.4 Perform a visual inspection of the experiment package to insure compliance with the failure criteria.

---

QA

2.3.9.5 Remove the accelerometers from the experiment package and vibration fixture.

2.3.9.6 Remove the integrated experiment tray/module from the vibration fixture and attach it to the handling fixture.

2.3.9.7 Generate all plots as required by this procedure.

2.3.10 This concludes certification vibration testing of this experiment.

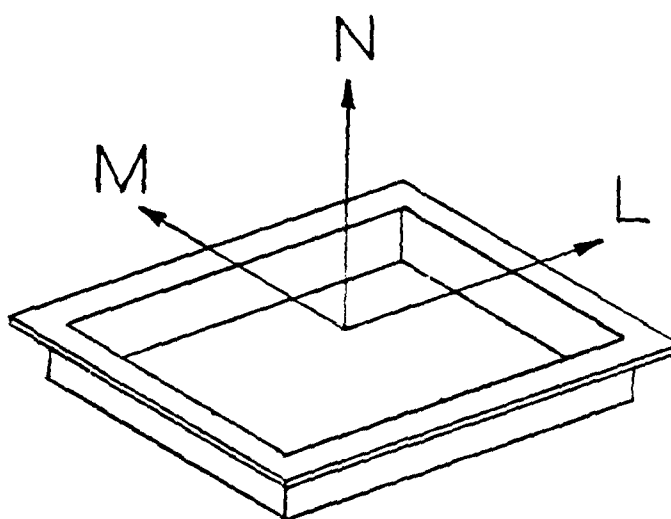


Figure 1. Experiment Coordinate System

| EXPERIMENT NO.             | LOCATION     | SINE TEST LEVELS |      |      |
|----------------------------|--------------|------------------|------|------|
|                            |              | L                | M    | N    |
| A0175                      | A1, A7       | 6.3              | 5.9  | 9.7  |
| A0133                      | H7           | 11.9             | 11.9 | 6.4  |
| A0019, A0180, A0023        | D12          | 6.4              | 5.0  | 8.4  |
| A0076                      | F9           | 5.0              | 12.0 | 5.0  |
| M0003                      | D4, D8       | 5.0              | 9.2  | 5.6  |
| M0002, M0003               | D3, D9       | 5.0              | 10.6 | 5.0  |
| S1001                      | F12          | 6.4              | 5.0  | 11.6 |
| S1001                      | H1           | 11.9             | 11.9 | 6.4  |
| A0023, S1006, S1003, M0002 | E6           | 5.0              | 5.0  | 9.8  |
| A0135, S0050, A0044        | E5           | 5.0              | 5.2  | 9.0  |
| M0002, A0147, A0056, A0172 | G12          | 8.1              | 8.1  | 6.3  |
| A0139A                     | G6           | 8.1              | 8.1  | 6.3  |
| P0003                      | CR           |                  |      |      |
| A0189, A0172, S0001        | D2           | 5.6              | 9.7  | 5.6  |
| M0004                      | F8           | 5.0              | 10.5 | 6.0  |
| A0056, A0147, S0001        | B8           | 5.0              | 12.3 | 8.7  |
| A0023, A0114, A0034, A0201 | C3           | 5.0              | 14.3 | 5.0  |
| A0023, A0114, A0034, A0201 | C9           | 5.0              | 13.4 | 5.0  |
| S0109                      | C12          | 6.3              | 5.0  | 8.3  |
| A0201, S0001               | D6           | 5.0              | 5.0  | 8.1  |
| S0079                      | F2           | 5.6              | 10.2 | 6.4  |
| A0023, A0201               | H11          | 11.9             | 11.9 | 6.4  |
| A0015, A0187, M0006        | C2           | 5.6              | 11.5 | 7.4  |
| A0201                      | B12          | 6.3              | 5.0  | 8.8  |
| S0001                      | A12, F1, B11 | 11.9             | 12.9 | 10.2 |
| S0001                      | G8           | 8.1              | 8.1  | 6.3  |

Figure 2. Certification Level Sine Sweep (L, M, and N Axes)

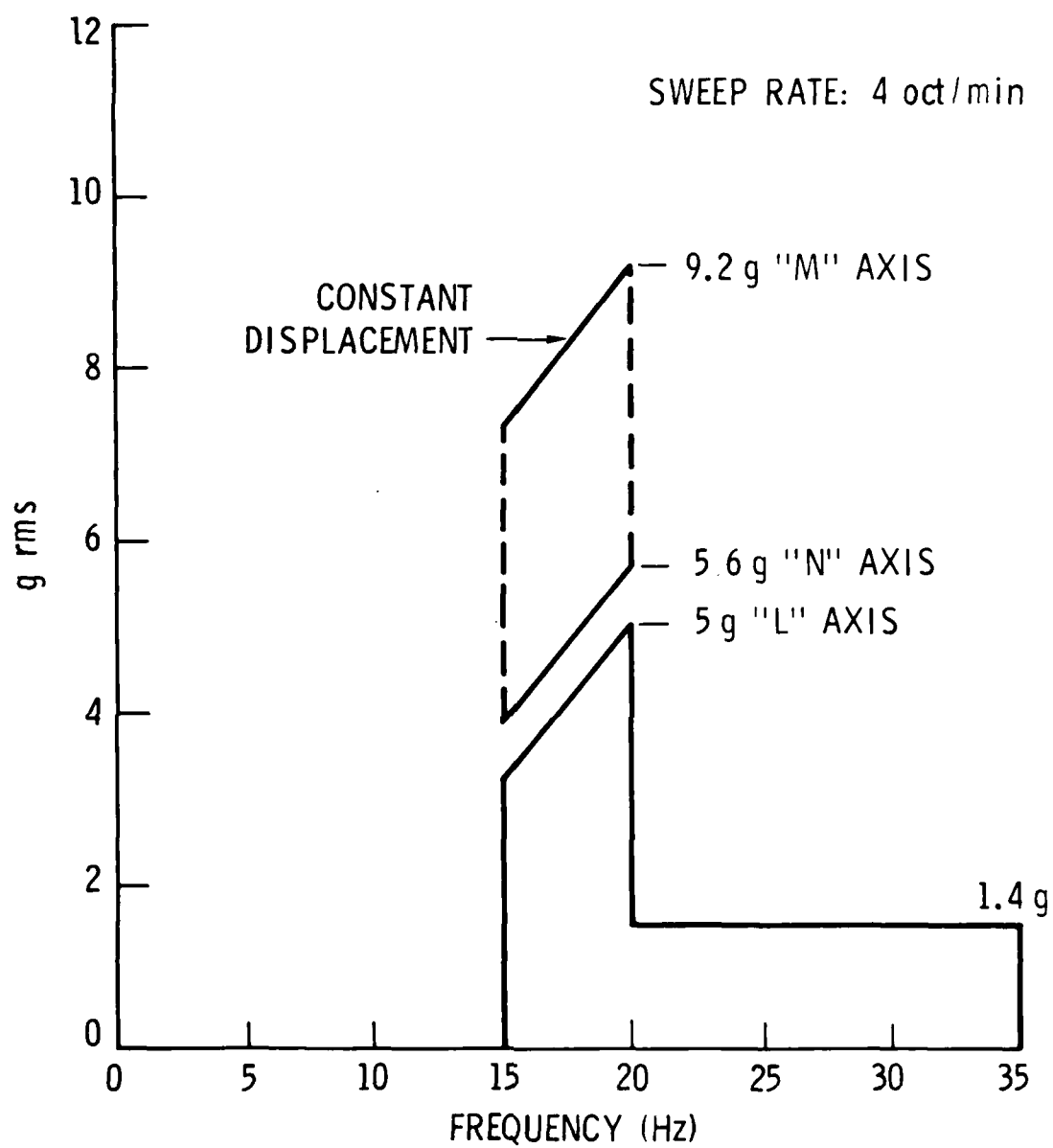


Figure 3. Sine Vibration Spectrum for Certification Acceptance

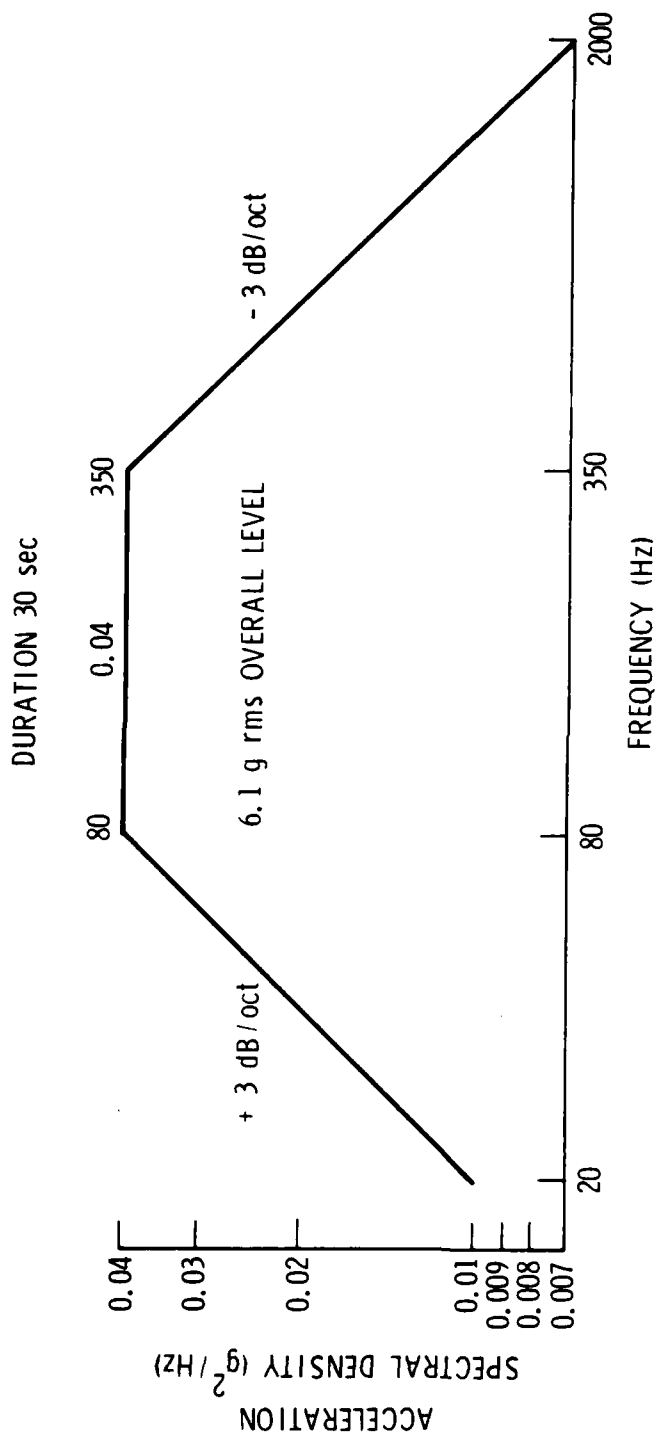


Figure 4. Random Vibration Spectrum for Certification Acceptance



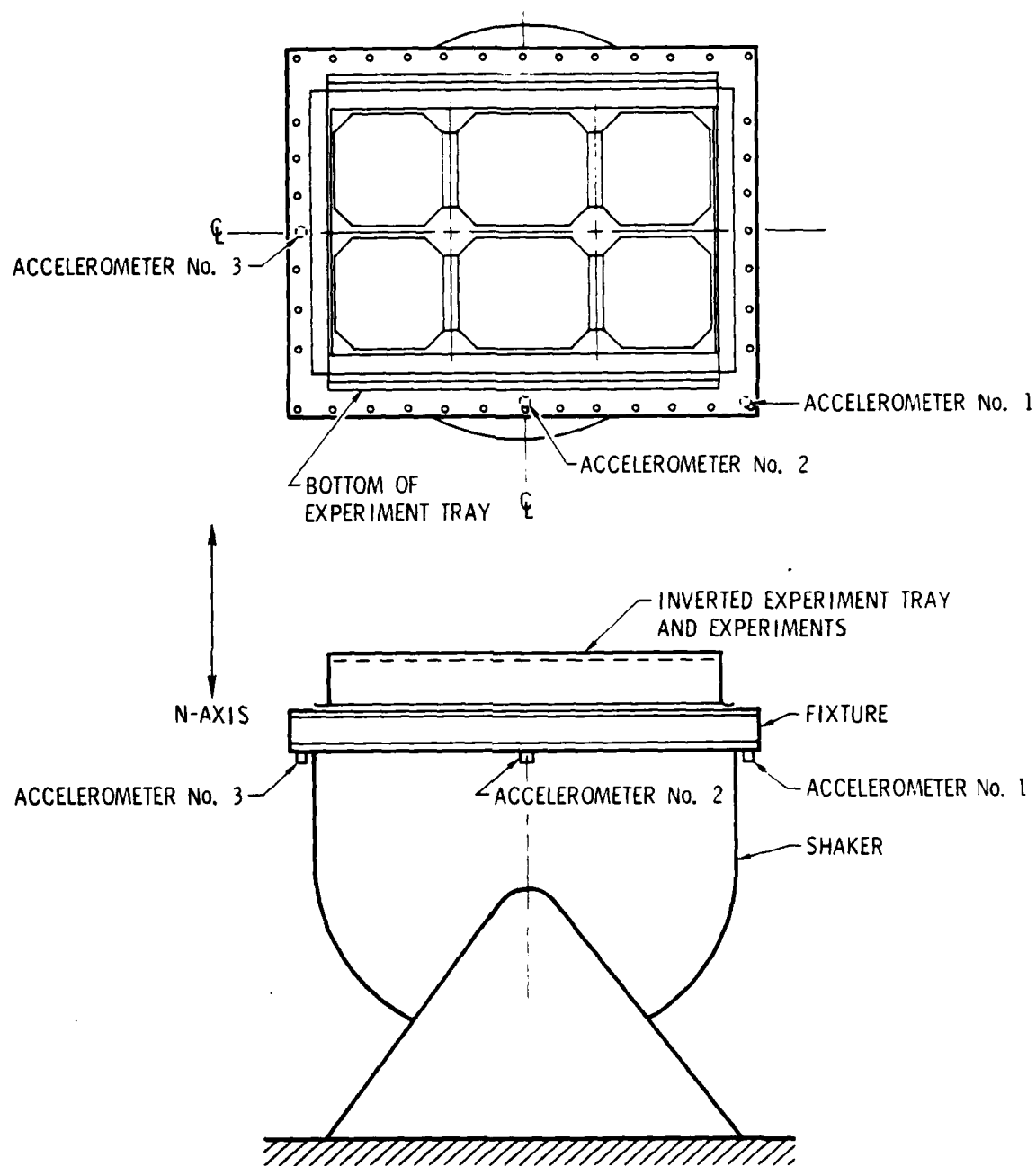


Figure 5. N-Axis Test Set Up

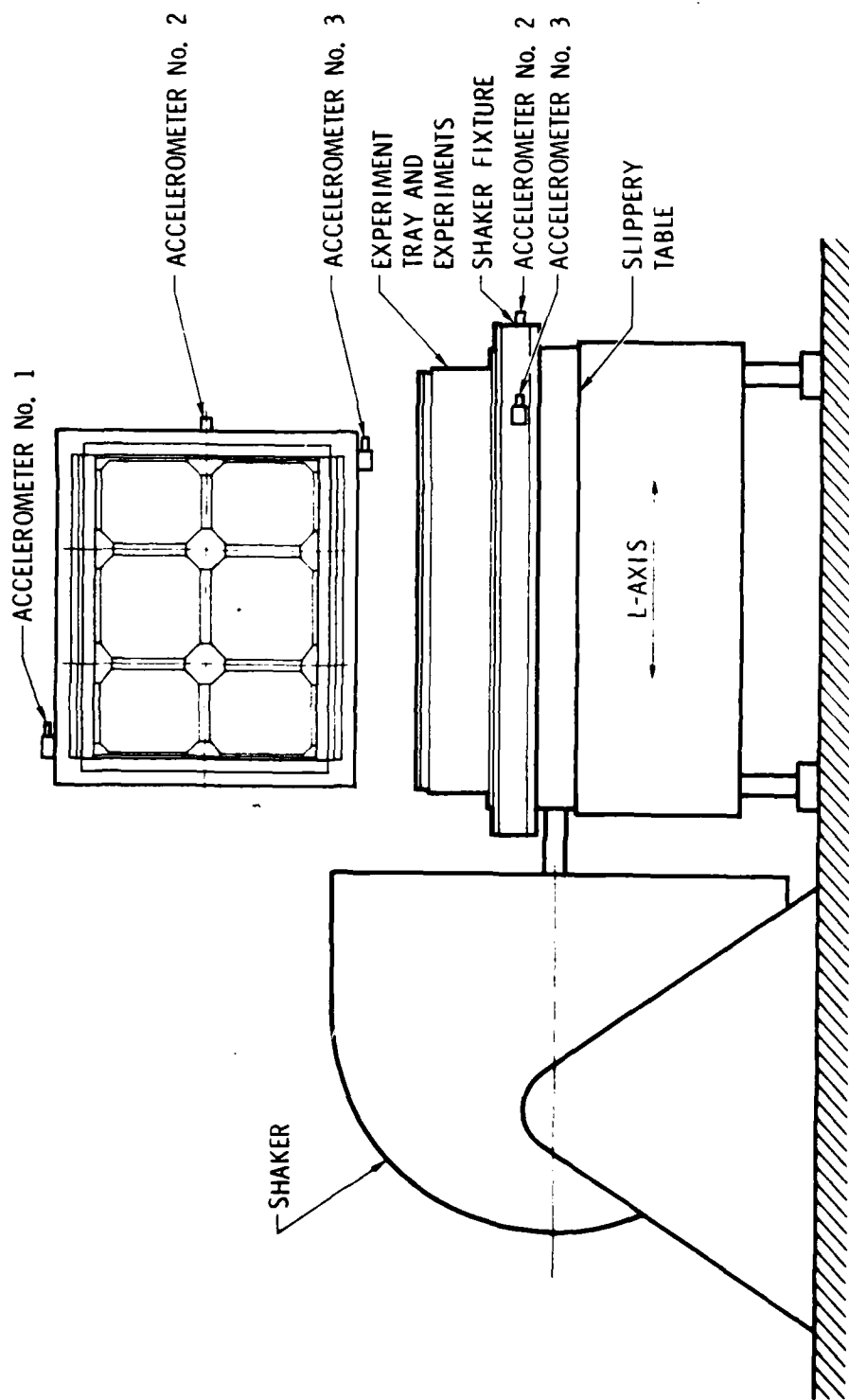


Figure 6. L-Axis Test Set Up

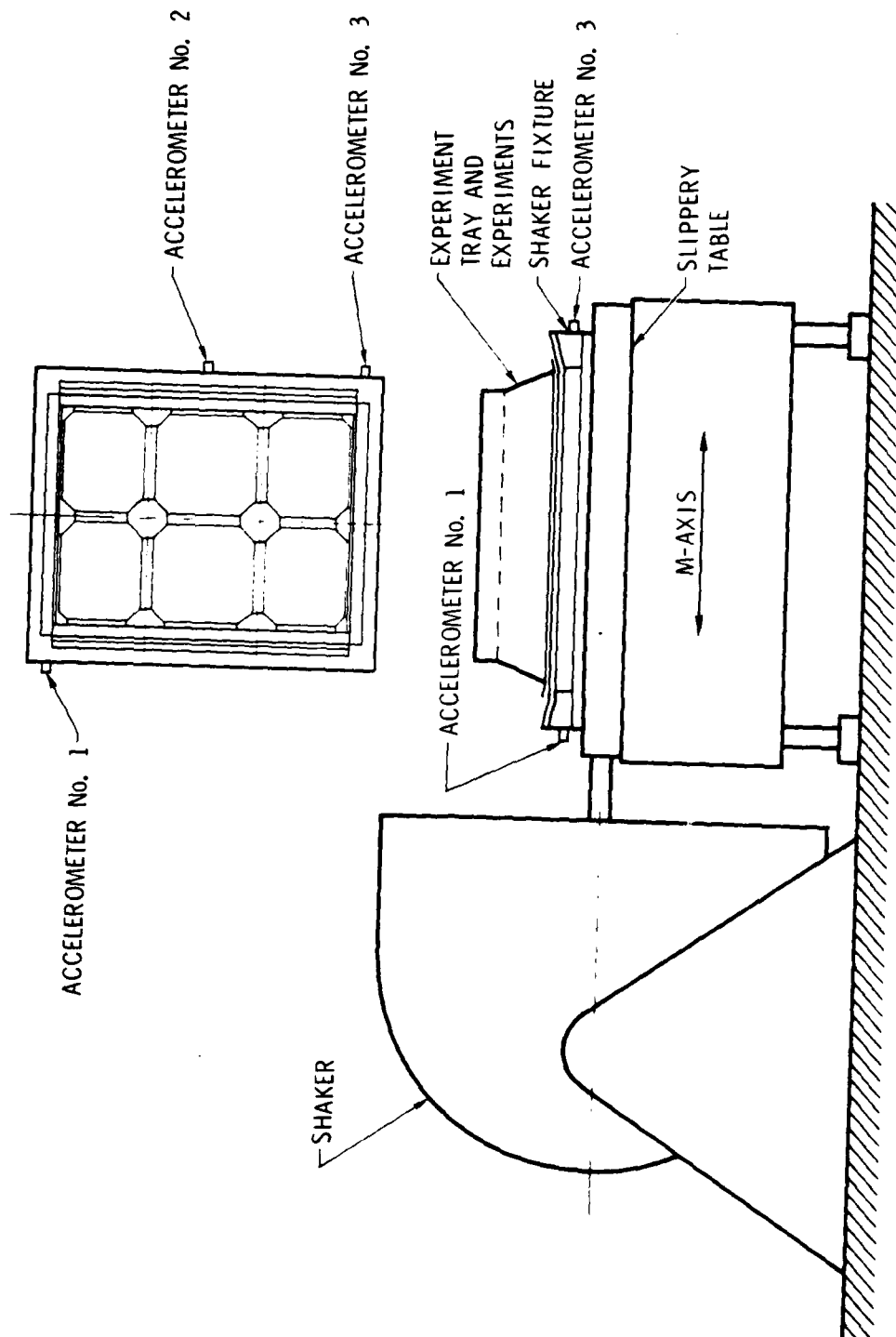


Figure 7. M-Axis Test Set Up

APPENDIX C  
INPUT AND MONITOR ACCELEROMETER DATA

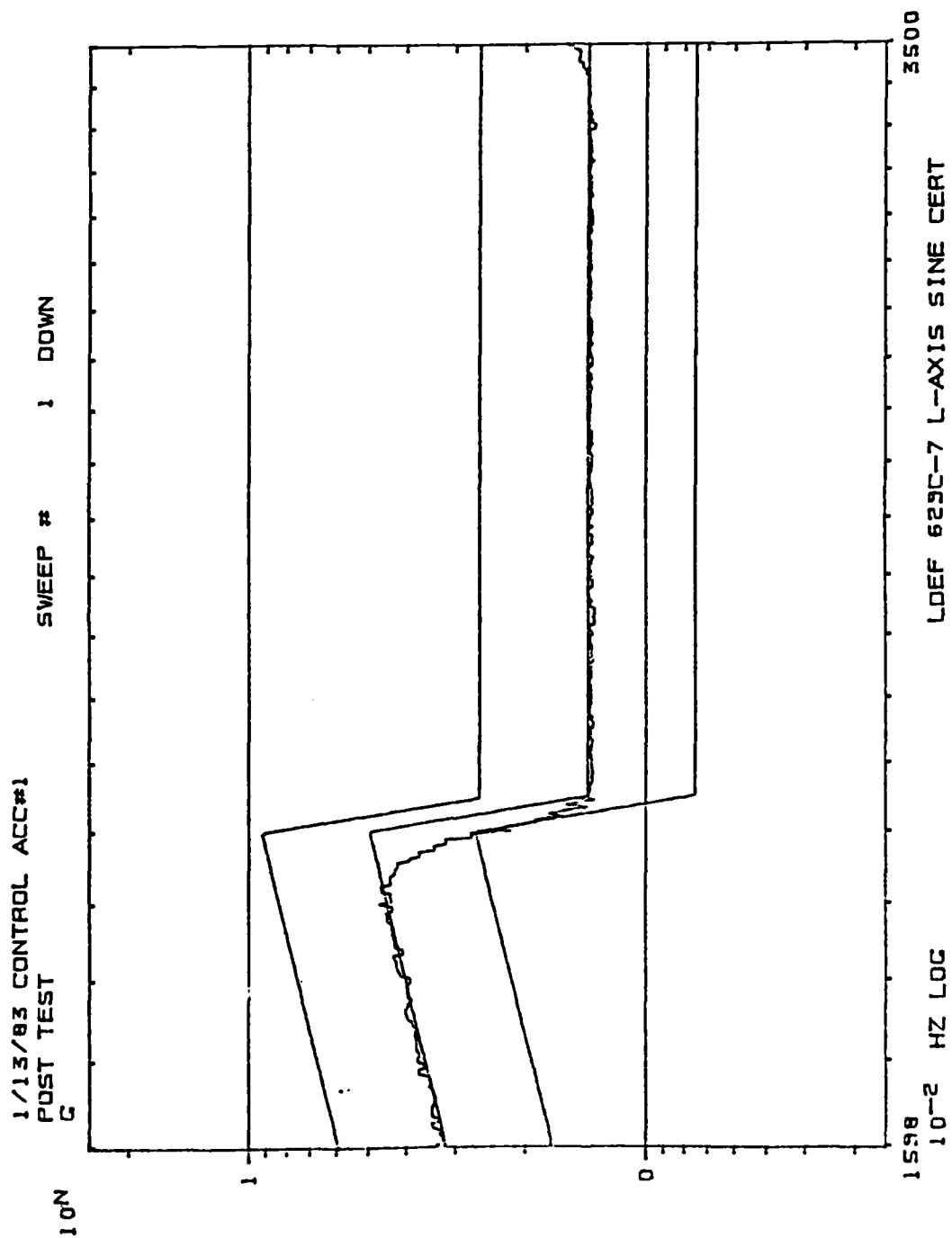


Fig. C-1.

1/13/83 L-AXIS CONTROL ACC#1, 2, 3

POST TEST

RMS LEVEL = 6.083 G'S

ELAPSED TIME = 31 SECS AT .00 DB

DELTA F = 4.883

DOF = 215

AMF = 5

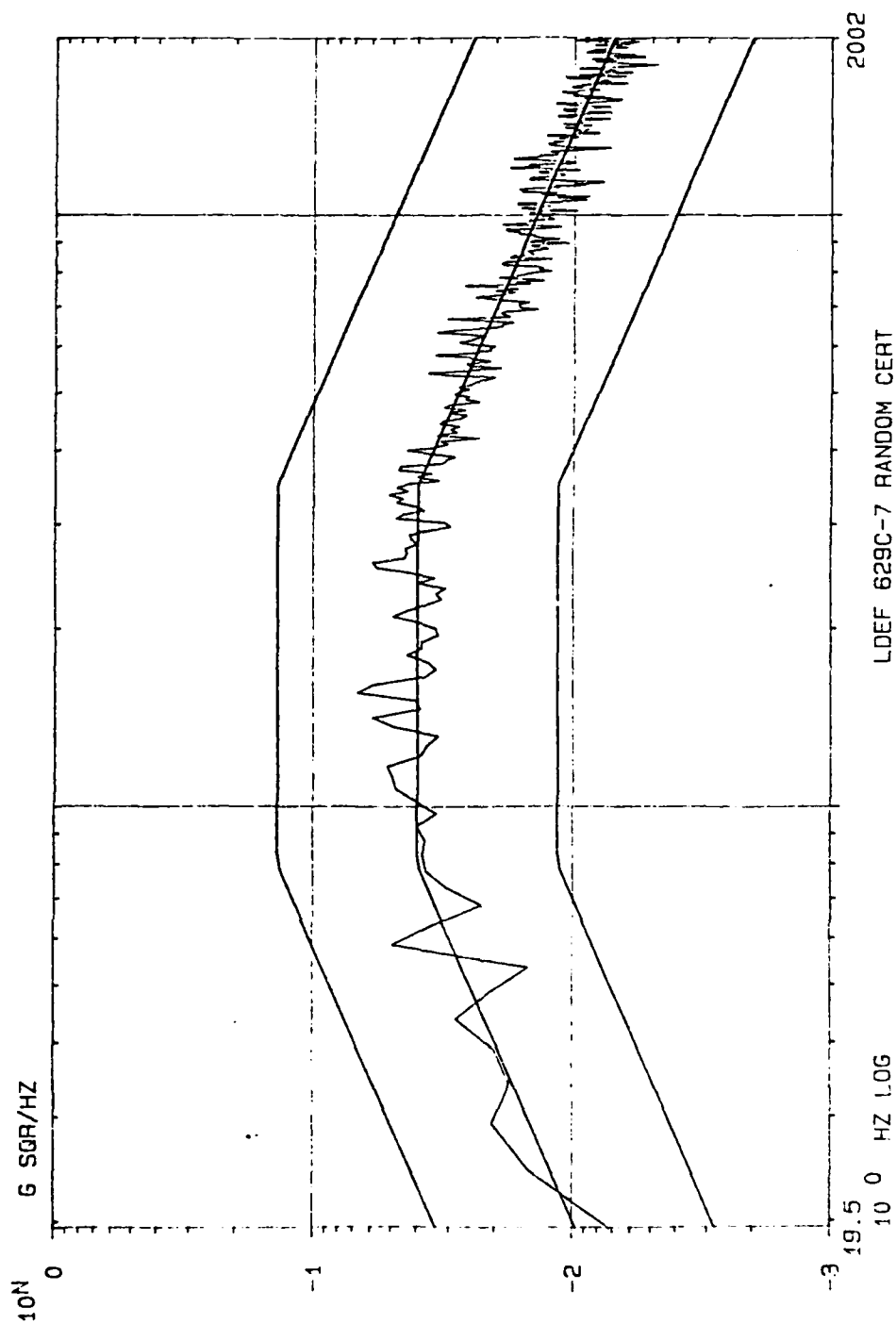


Fig. C-2.

1/13/83 ACC# 4/1  
TRANSFER FUNCTION

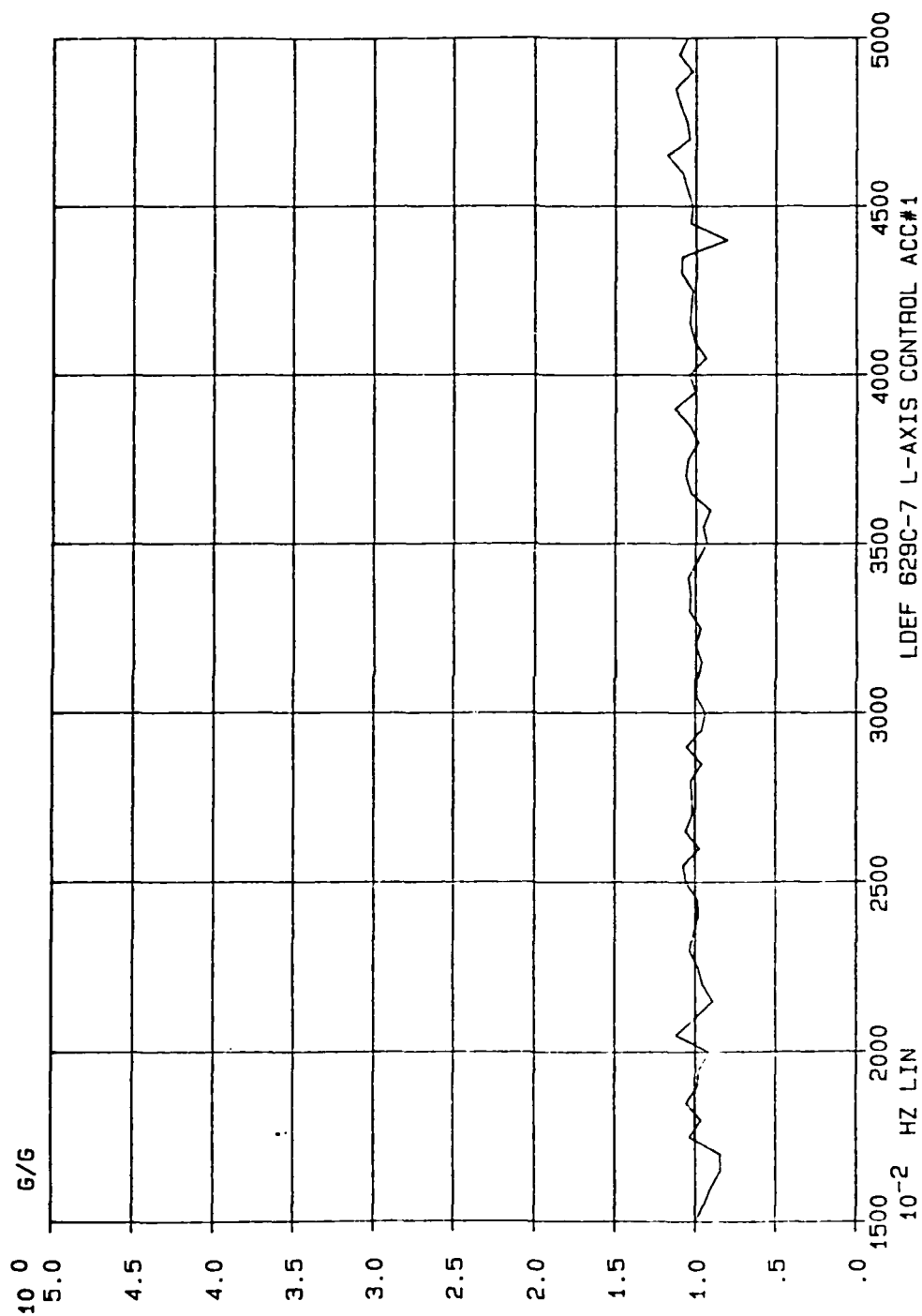


Fig. C-3.

1/13/83 ACC# 5/1  
TRANSFER FUNCTION

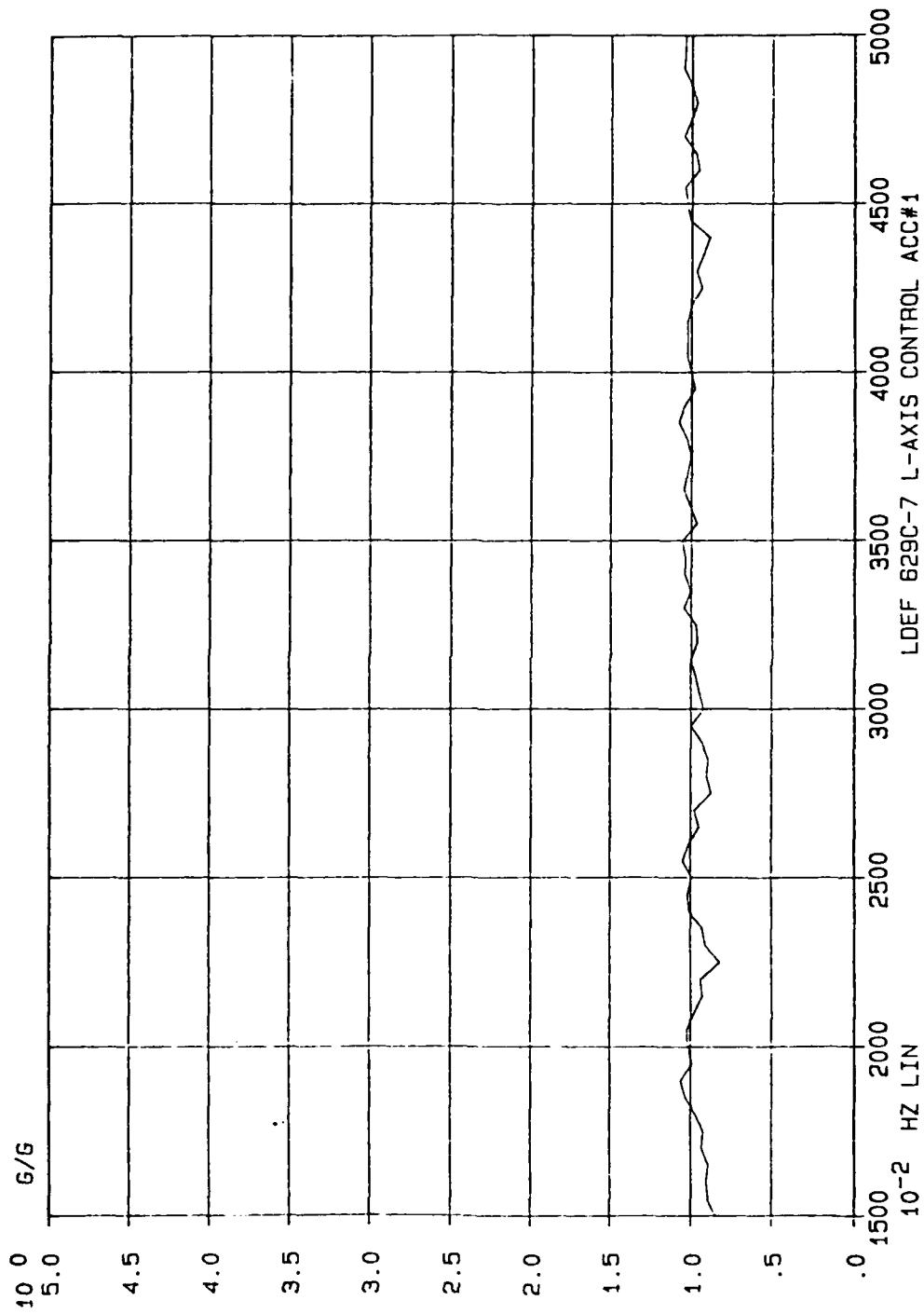


Fig. C-4.



1/13/83 ACC# 6/1  
TRANSFER FUNCTION

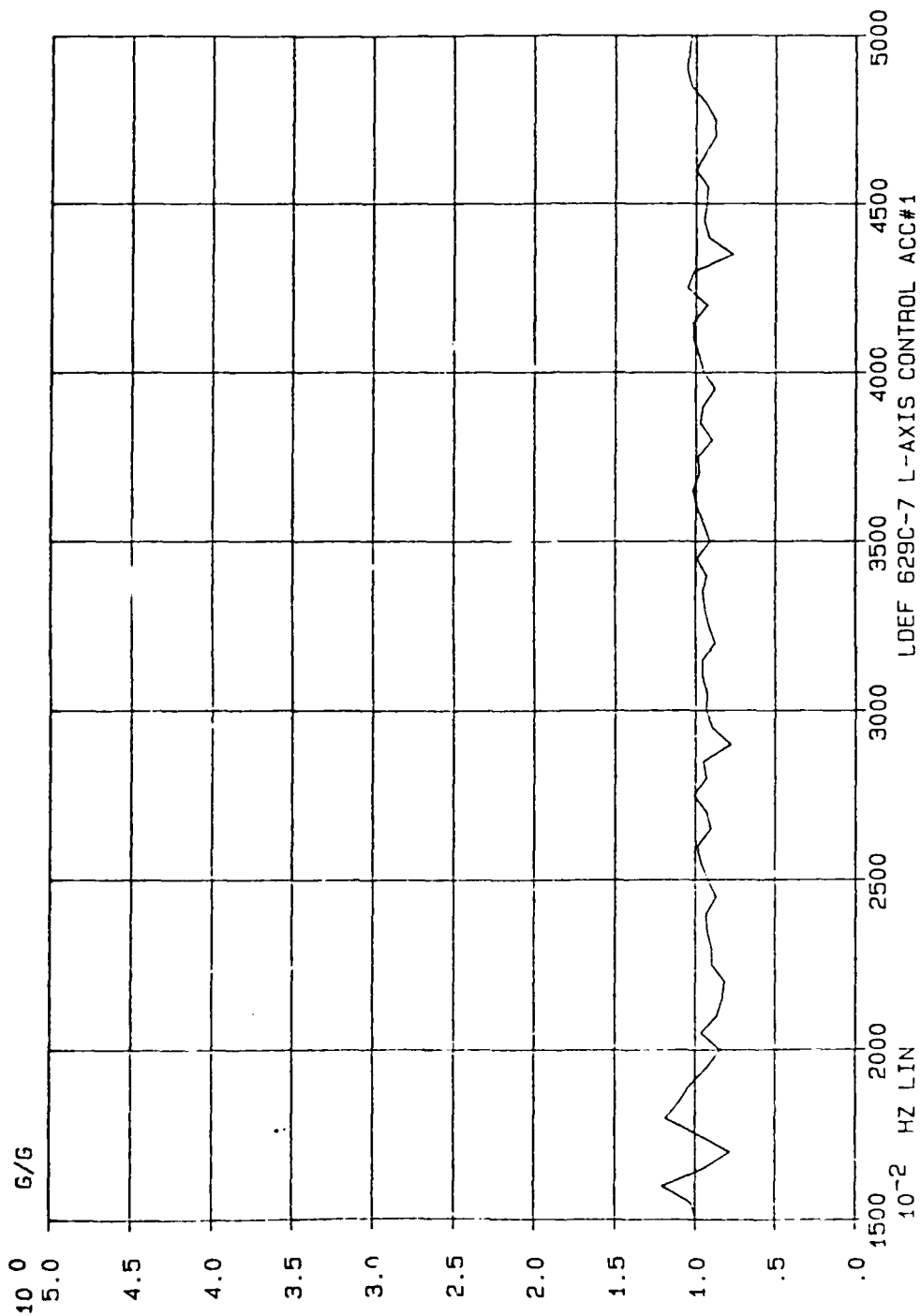


Fig. C-5.

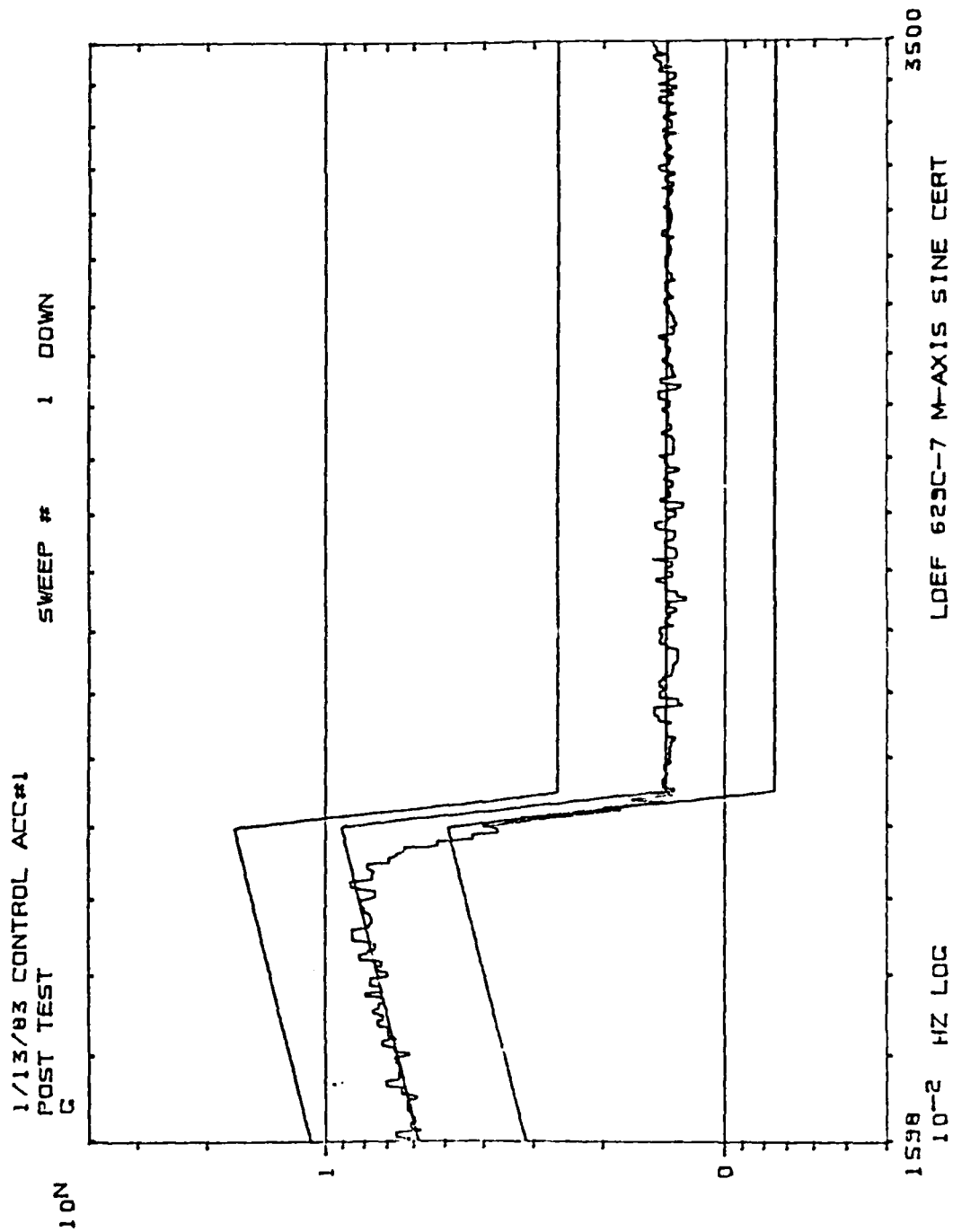


Fig. C-6.

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CERTIFICATION VIBRATION TESTS SD802 MATERIALS  
EXPERIMENT(U) AEROSPACE CORP EL SEGUNDO CA MATERIALS  
SCIENCES LAB A F DIGIACOMO ET AL. 15 DEC 83

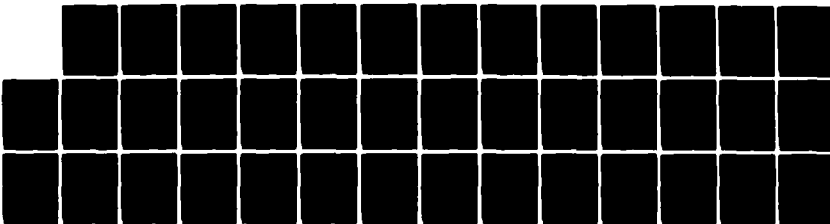
22

UNCLASSIFIED

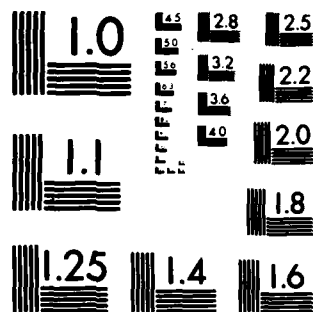
TR-0084(4935-05)-2 SD-TR-83-87

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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

1/13/83 M-AXIS CONTROL ACC#1, 2, 3

POST TEST

RMS LEVEL = 6.064 G'S

ELAPSED TIME = 30 SECS AT .00 DB

DELTA F = 4.863

DOF = 215

AMF = 5

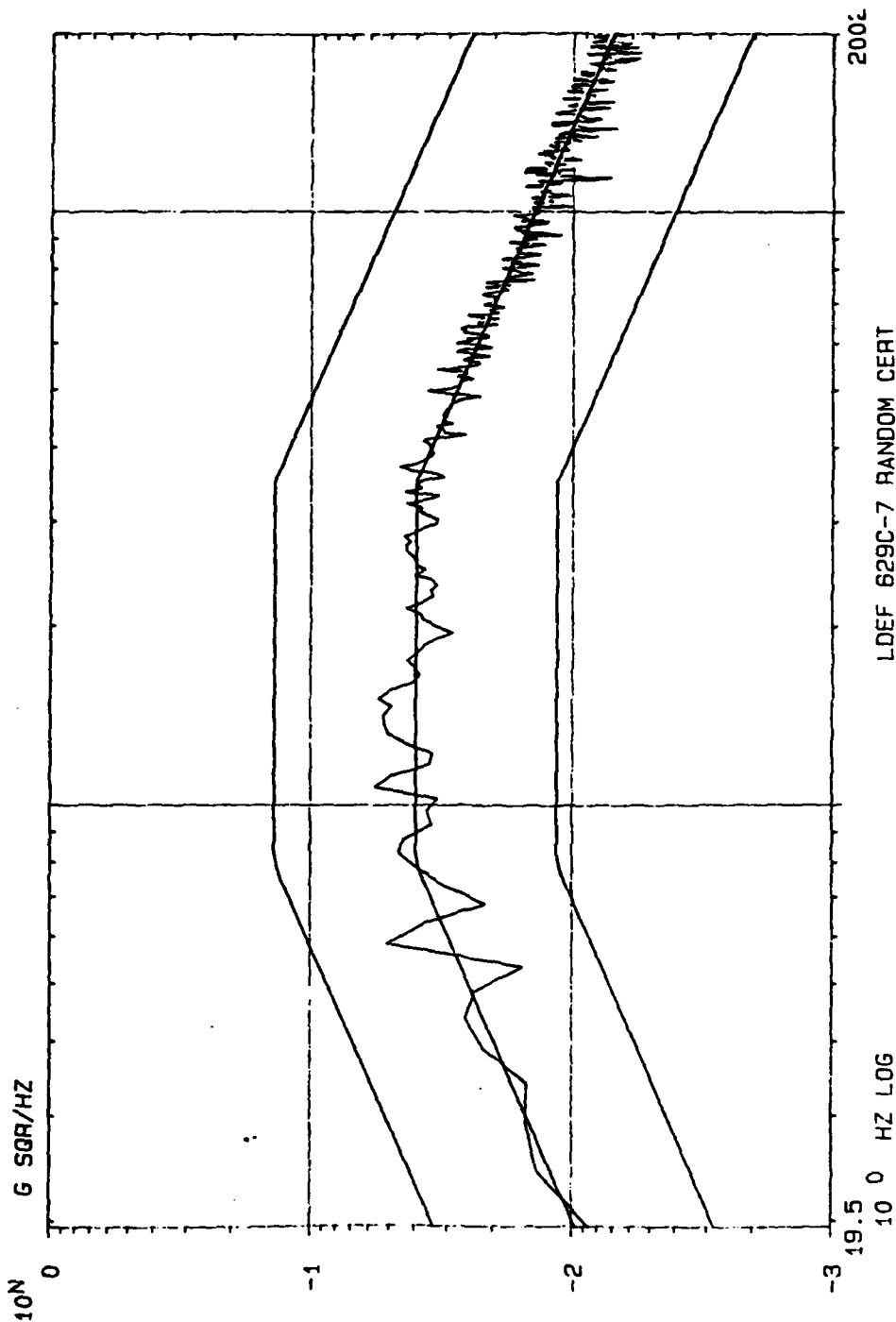


Fig. C-7.

1/13/83 ACC# 4/1  
TRANSFER FUNCTION

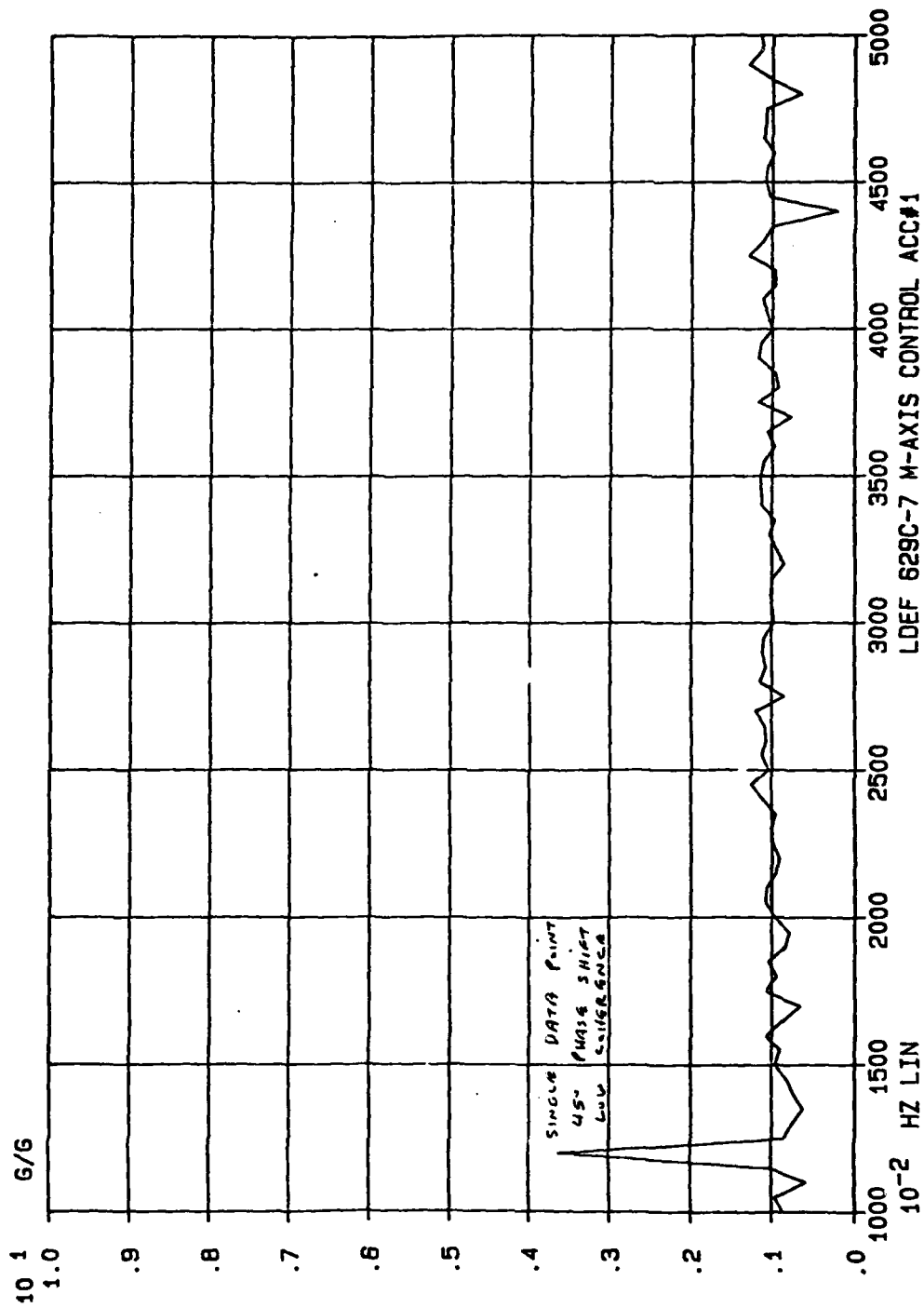


Fig. C-8.

1/13/83 ACC# 5/1  
TRANSFER FUNCTION

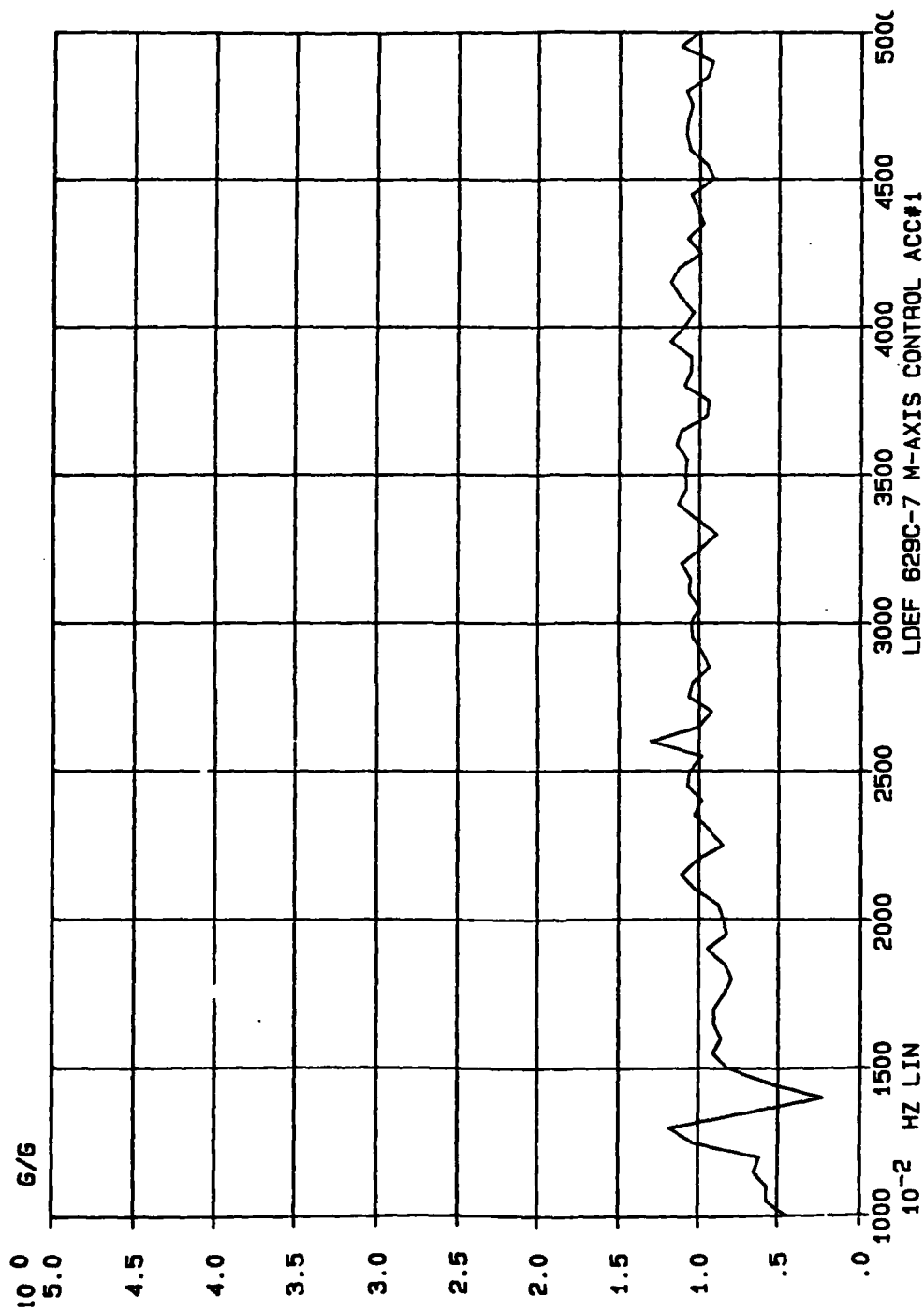


Fig. C-9.

1/13/83 ACC# 6/1  
TRANSFER FUNCTION

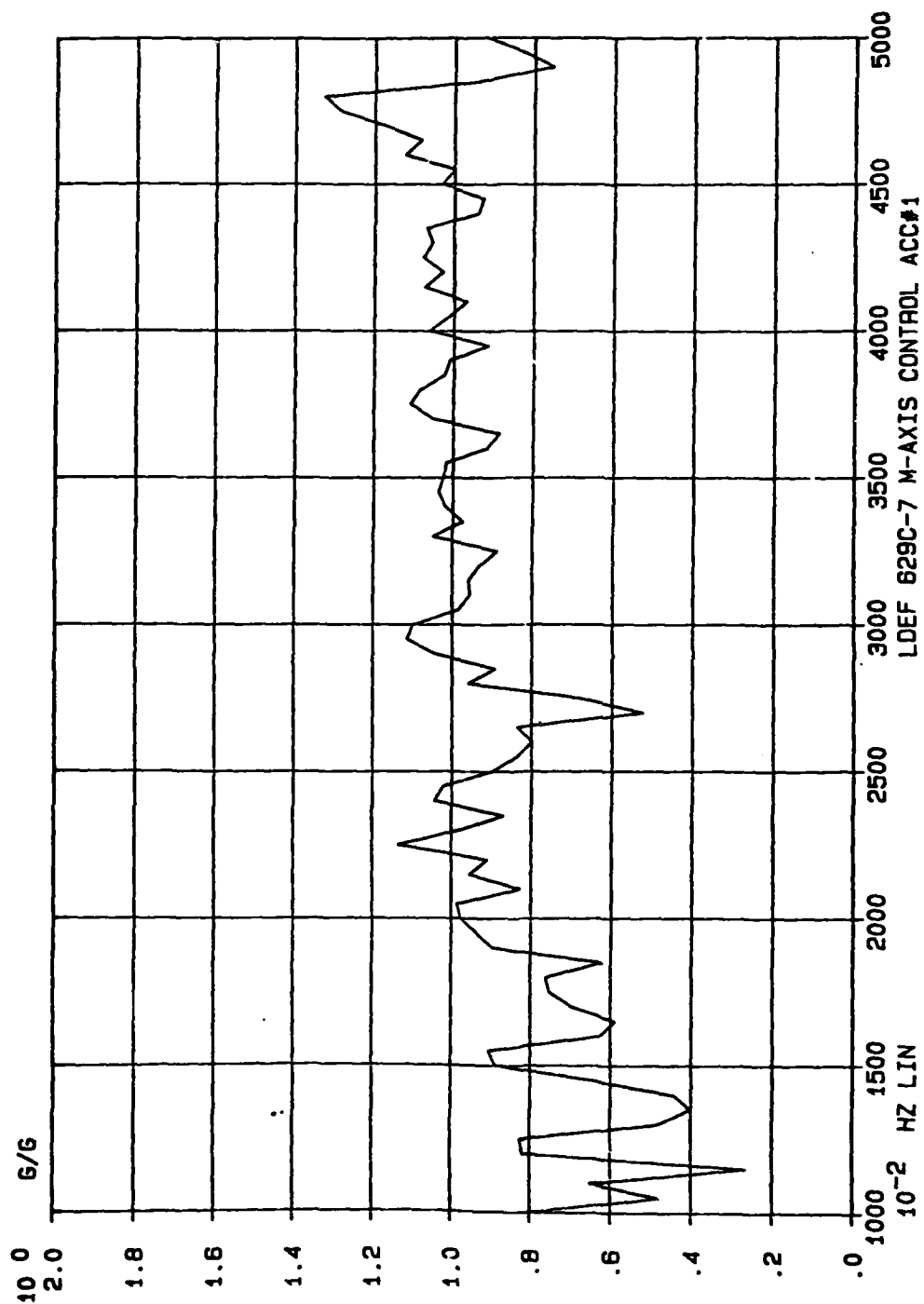


Fig. C-10.



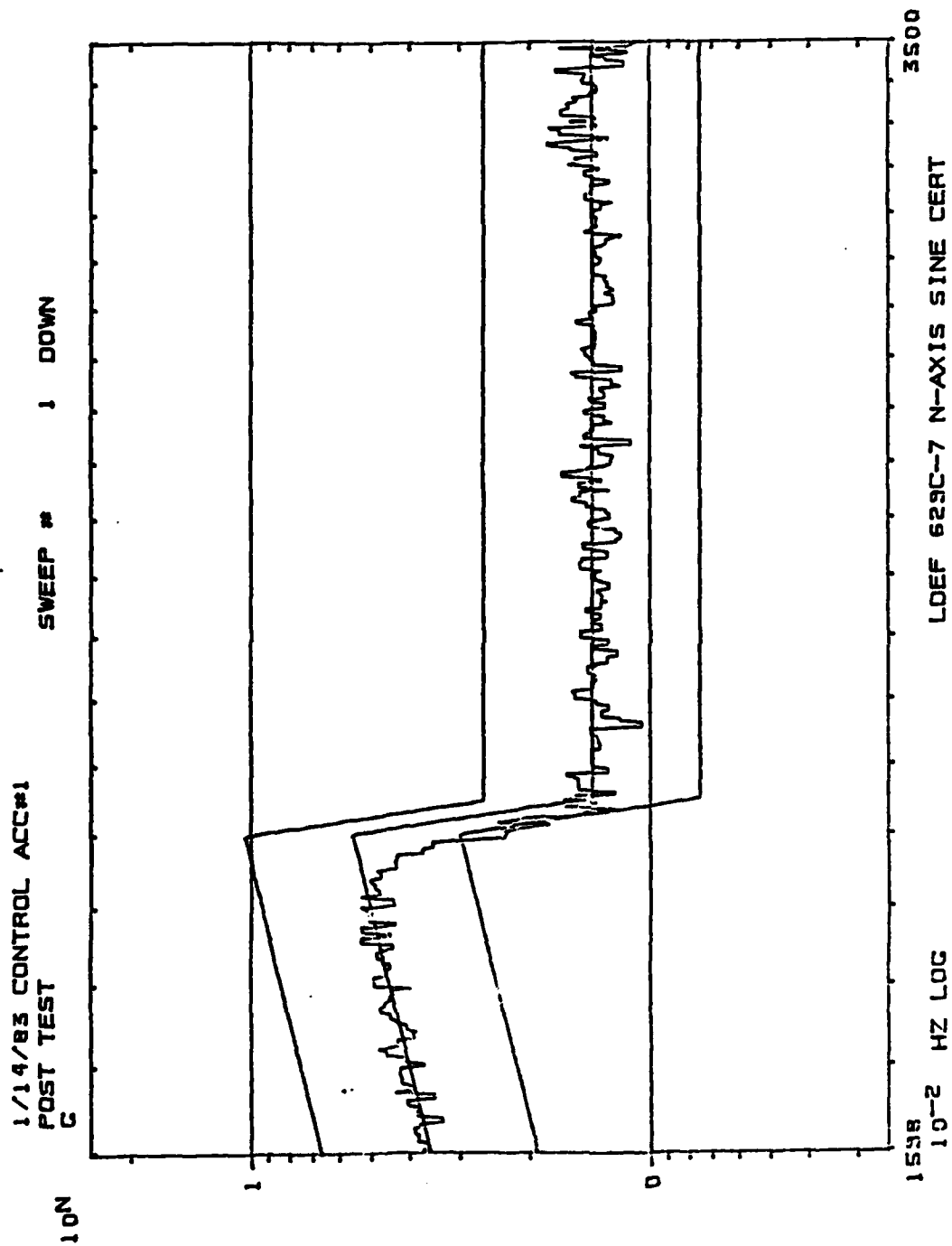


Fig. C-11.

1/14/83 N-AXIS CONTROL ACC#1, 2.3  
 POST TEST ELAPSED TIME - 30 SECS AT .00 DB  
 RMS LEVEL - 6.110 G'S DELTA F - 4.883 DOF - 215 AWF - 5  
 C SQR/HZ

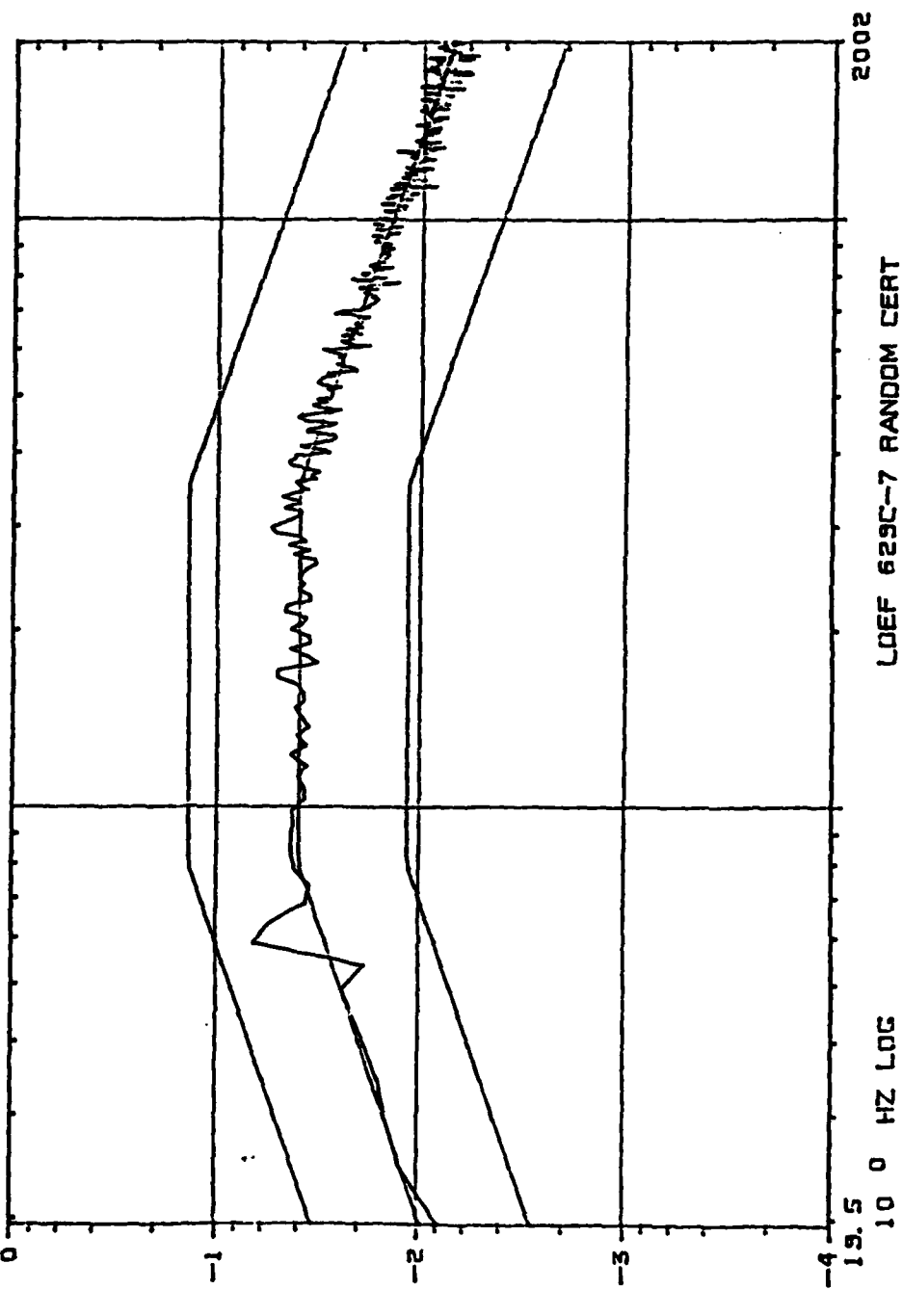


Fig. C-12.

1/14/83 ACC# 4/1  
TRANSFER FUNCTION

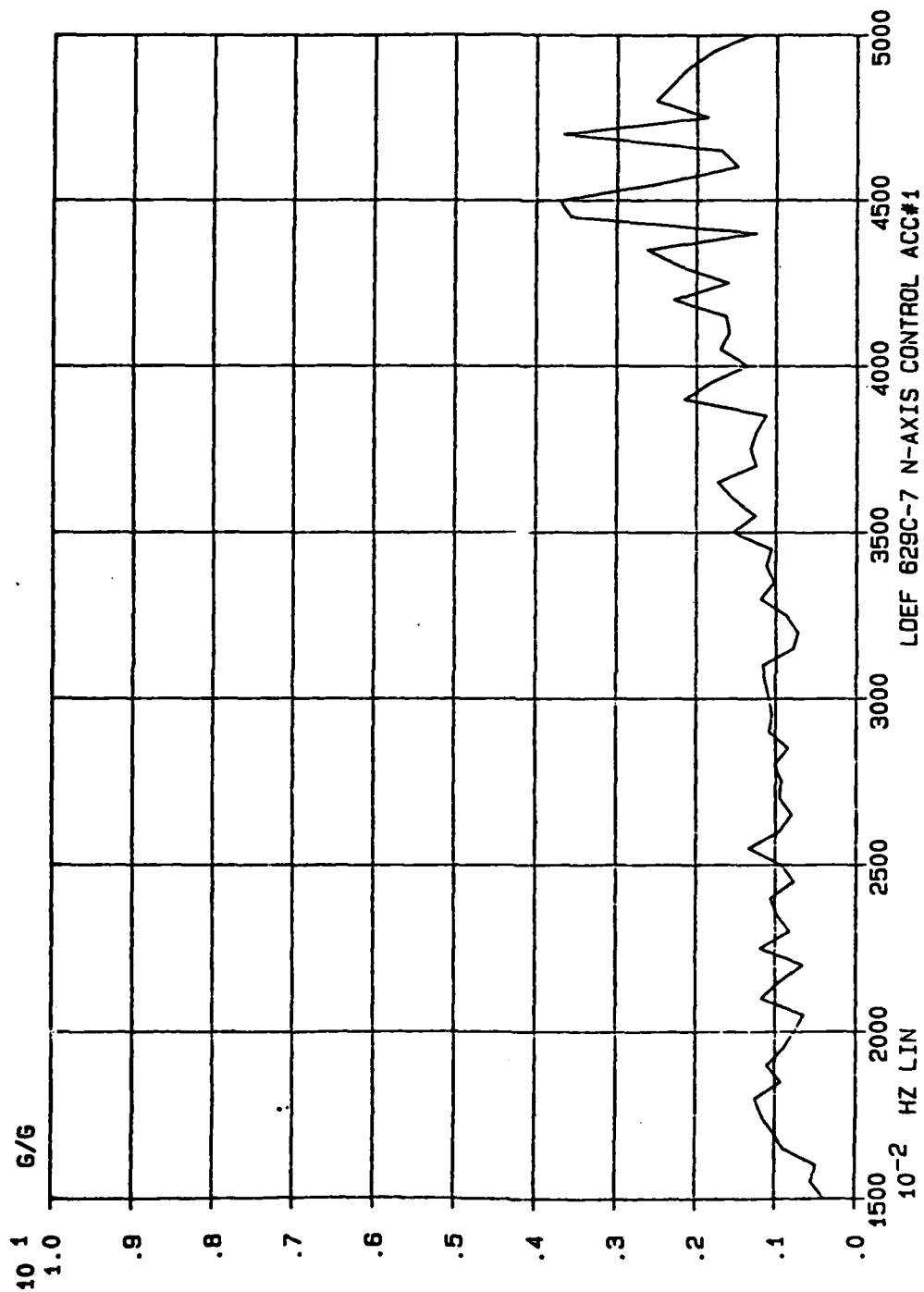


Fig. C-13.

1/14/83 ACC# 5/1  
TRANSFER FUNCTION

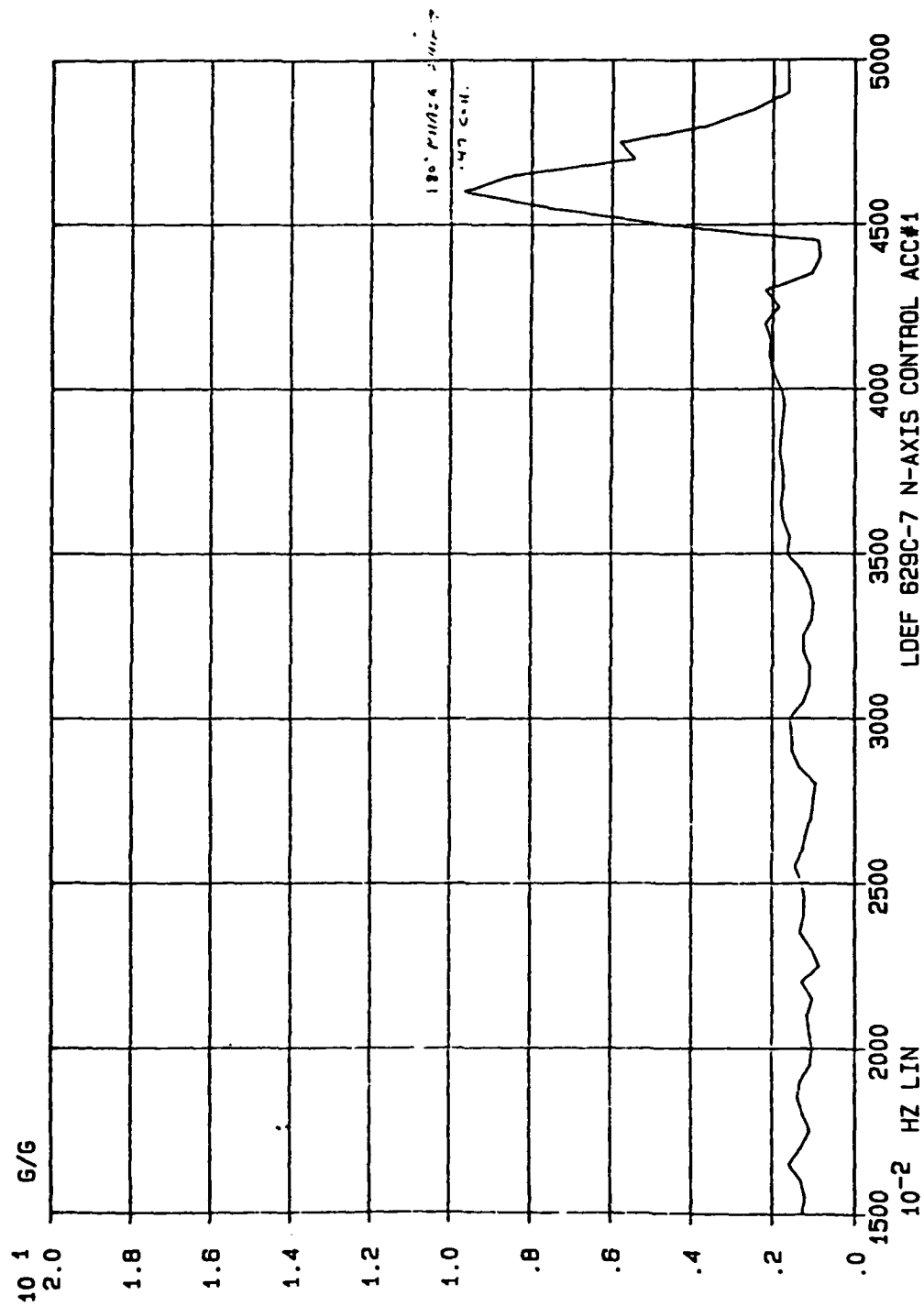


Fig. C-14.

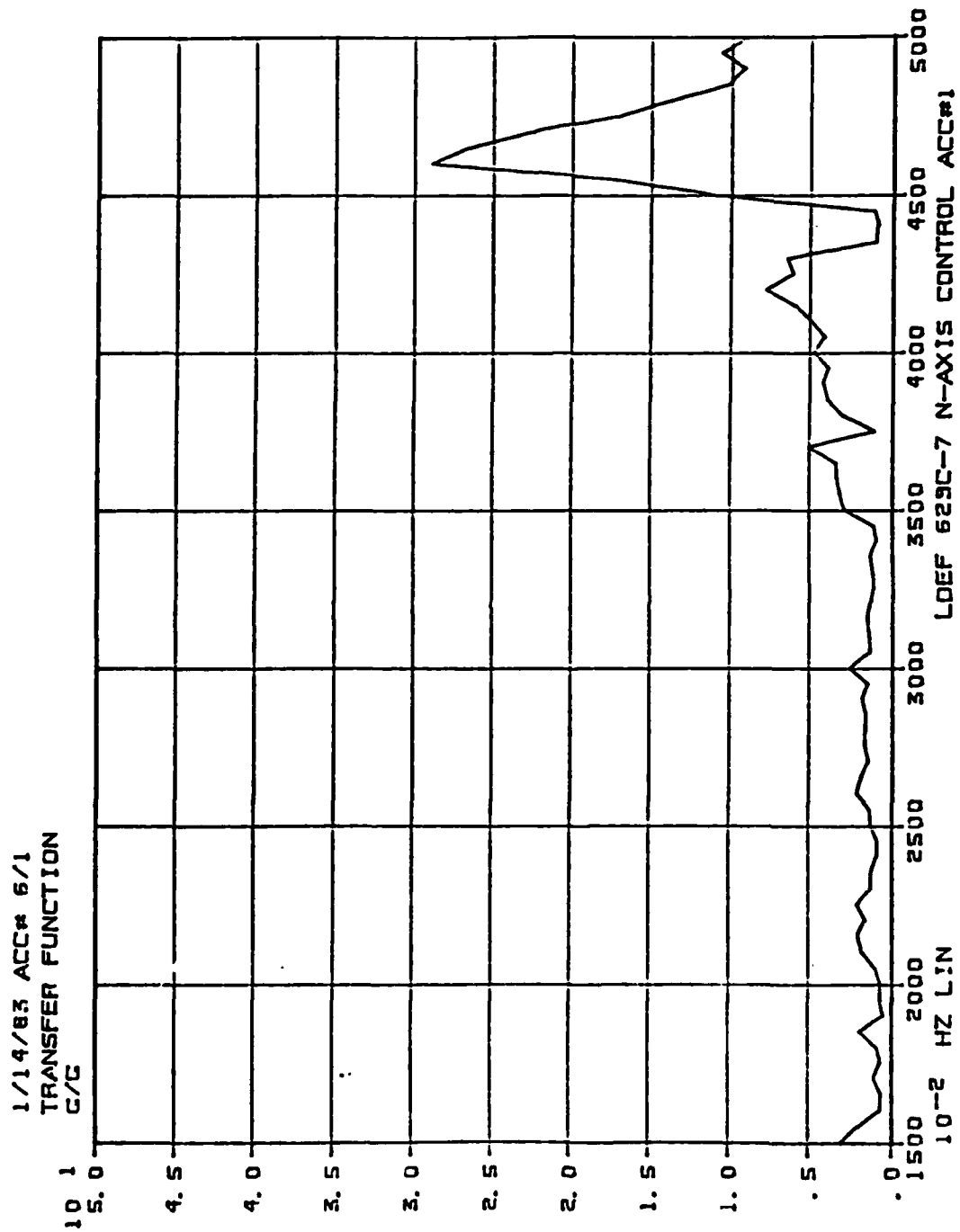


Fig. C-15.

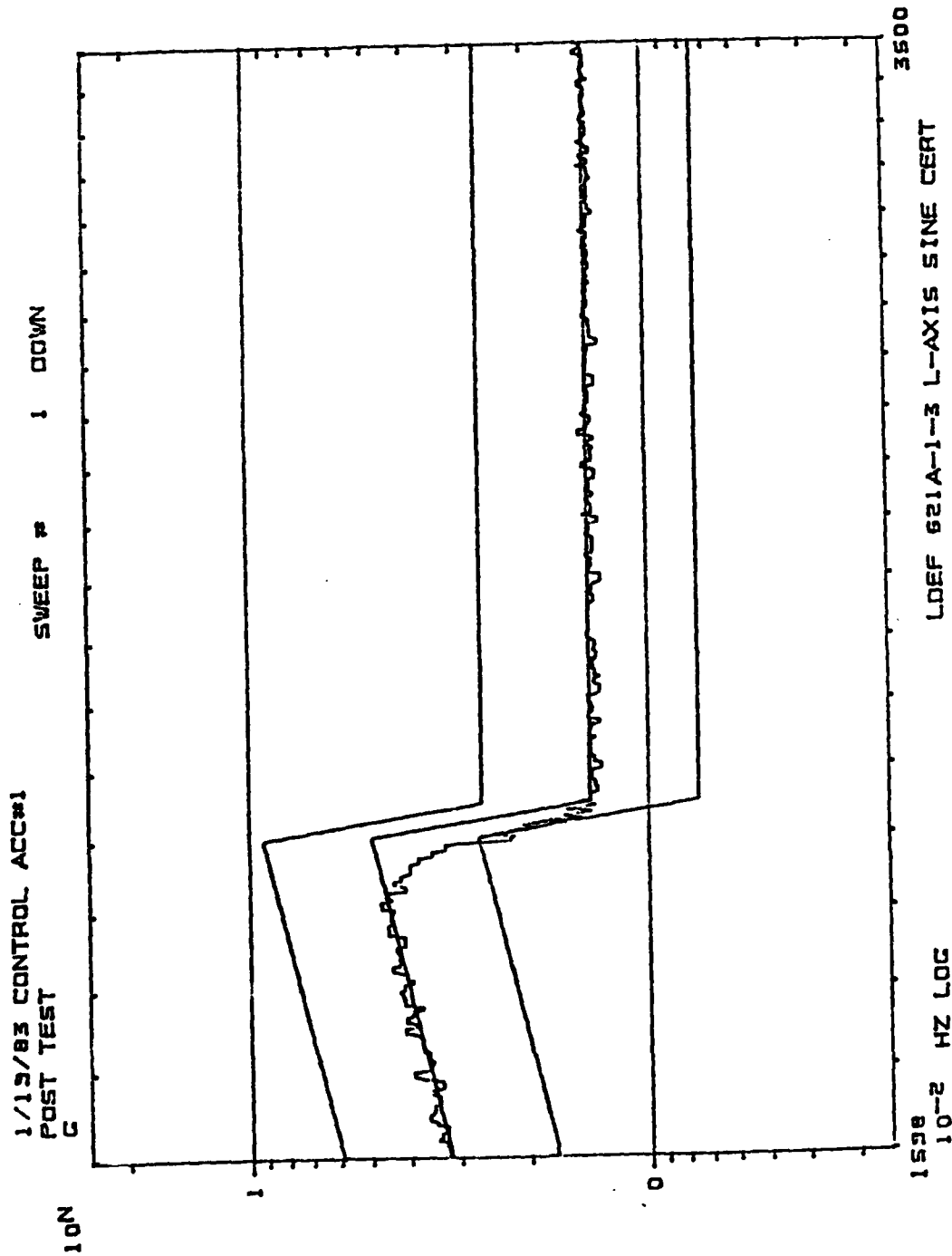


Fig. C-16.

1/19/83 CONTROL ACC#1,2,3

POST TEST

RMS LEVEL = 6.101 G'S

ELAPSED TIME =

29 SECS AT .00 DB

DELTA F = 4.883

DOF= 215

AMF= 5

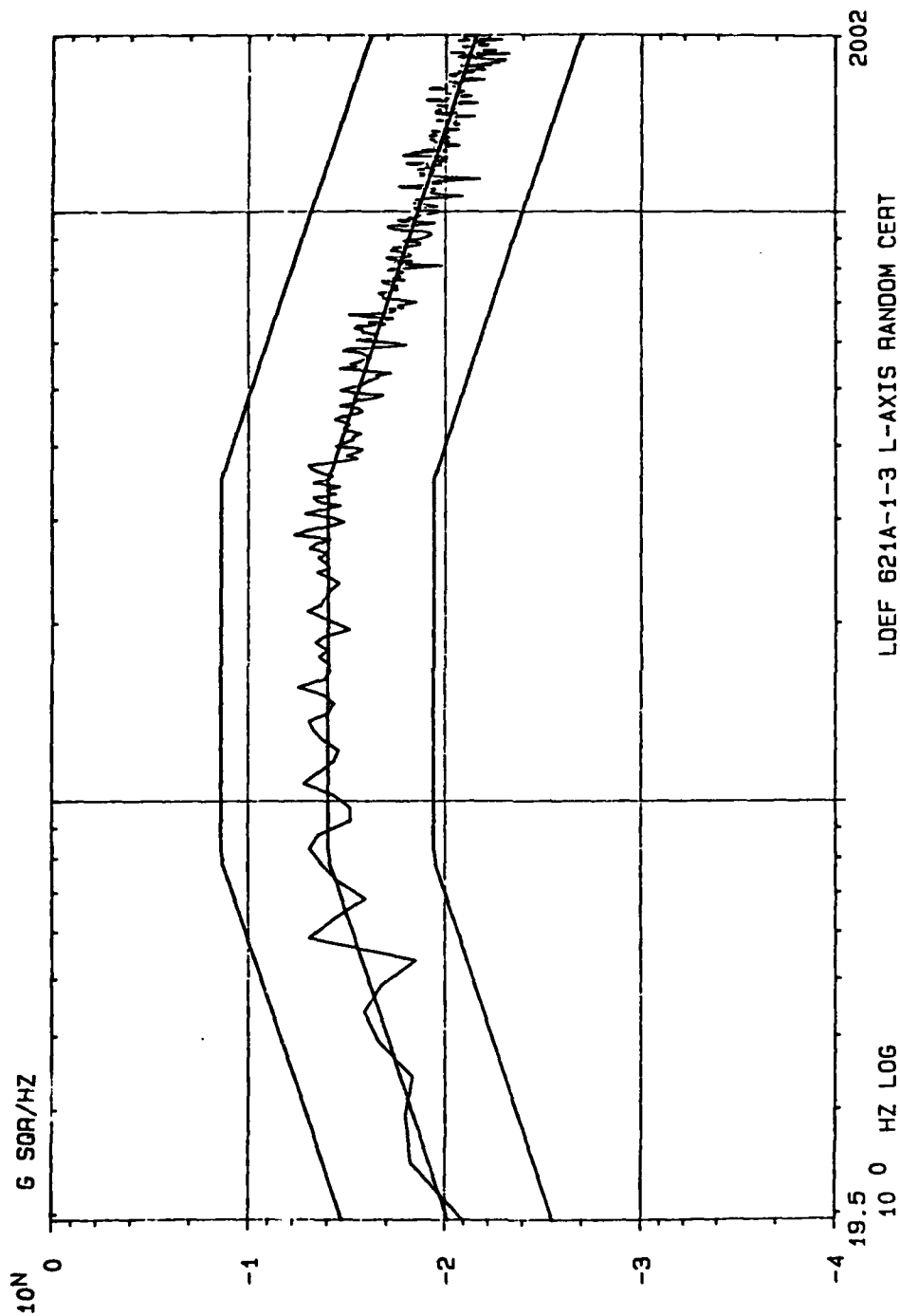


Fig. C-17.

1/19/83 ACC# 4/1  
TRANSFER FUNCTION

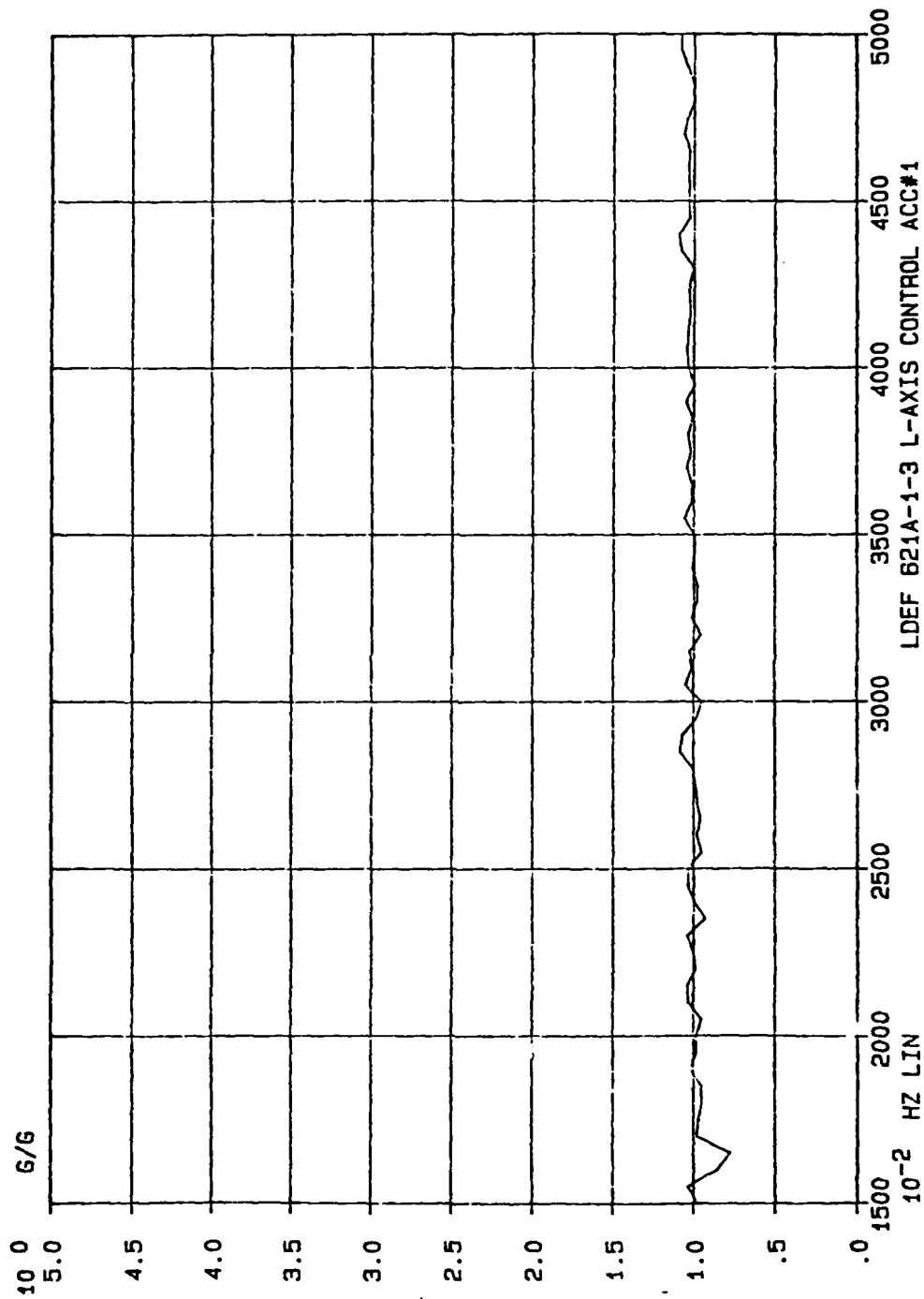


Fig. C-18.



1/19/83 ACC# 5/1  
TRANSFER FUNCTION

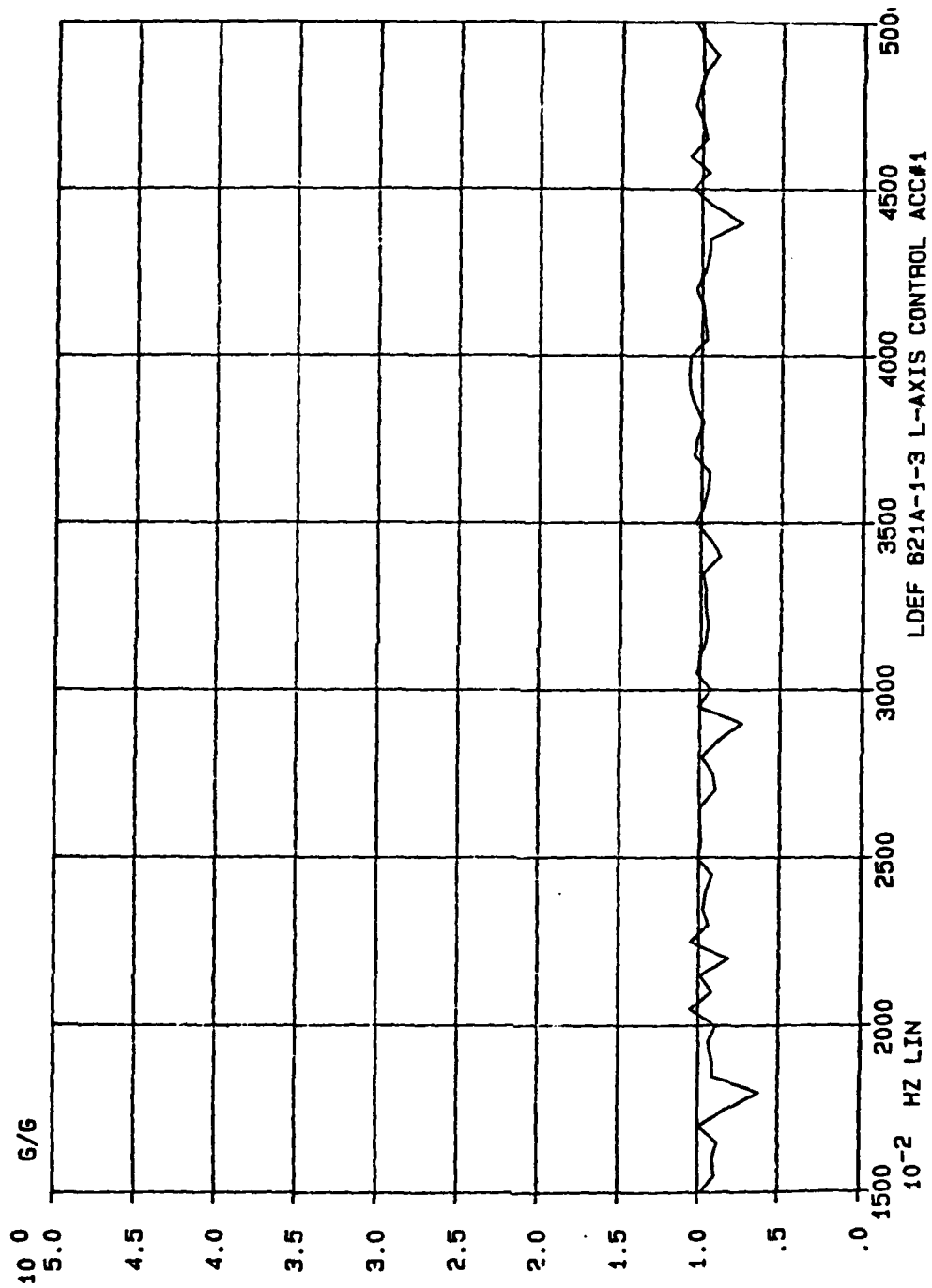


Fig. C-19.

1/19/83 ACC# 8/1  
TRANSFER FUNCTION

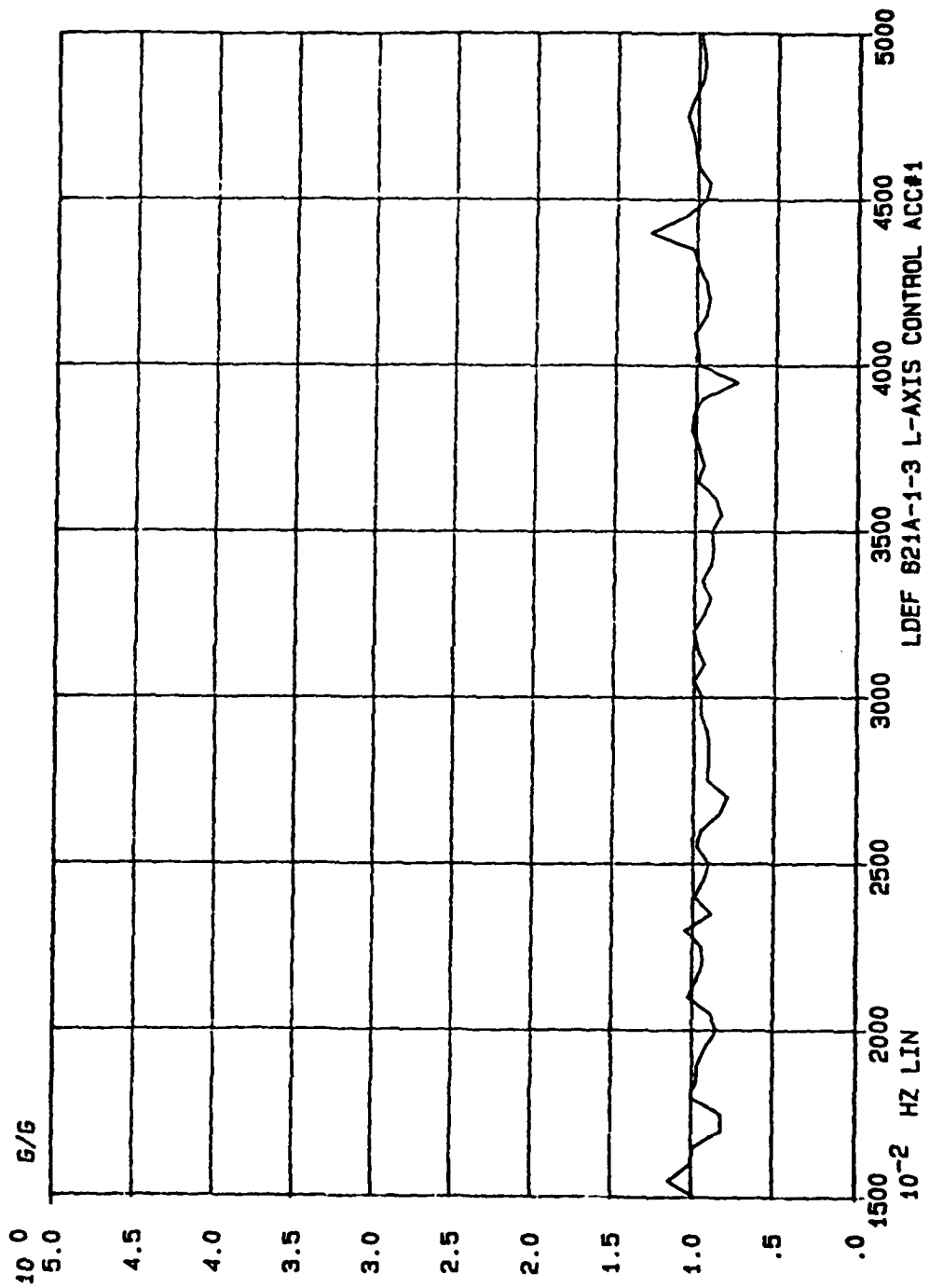


Fig. C-20.

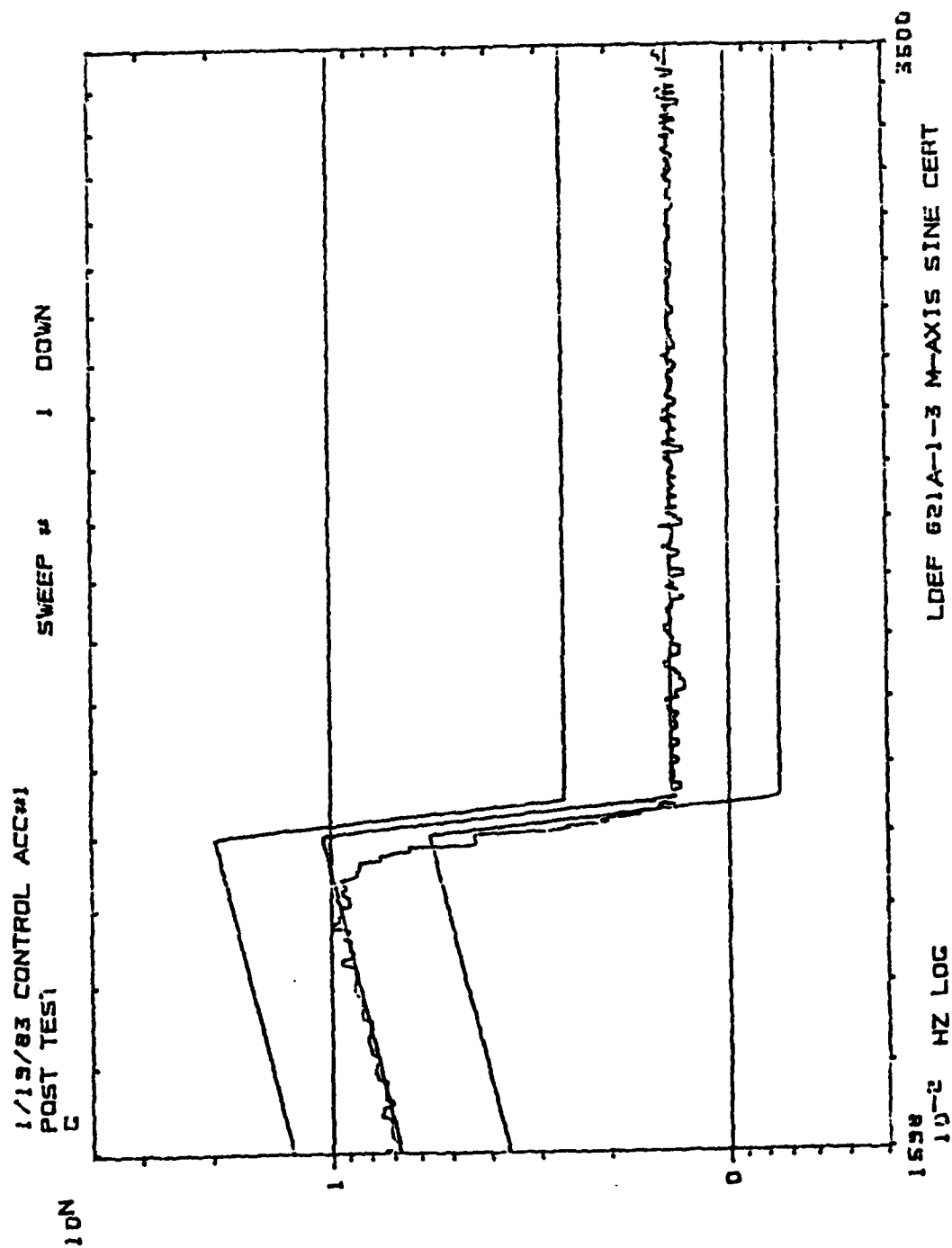


Fig. C-21.

1/19/83 CONTROL ACC#1, 2, 3

POST TEST

RMS LEVEL = 6.058 G'S

ELAPSED TIME = 31 SECS AT .00 DB  
DELTA F = 4.883  
DOF = 215  
ANF = 5

SQR/HZ

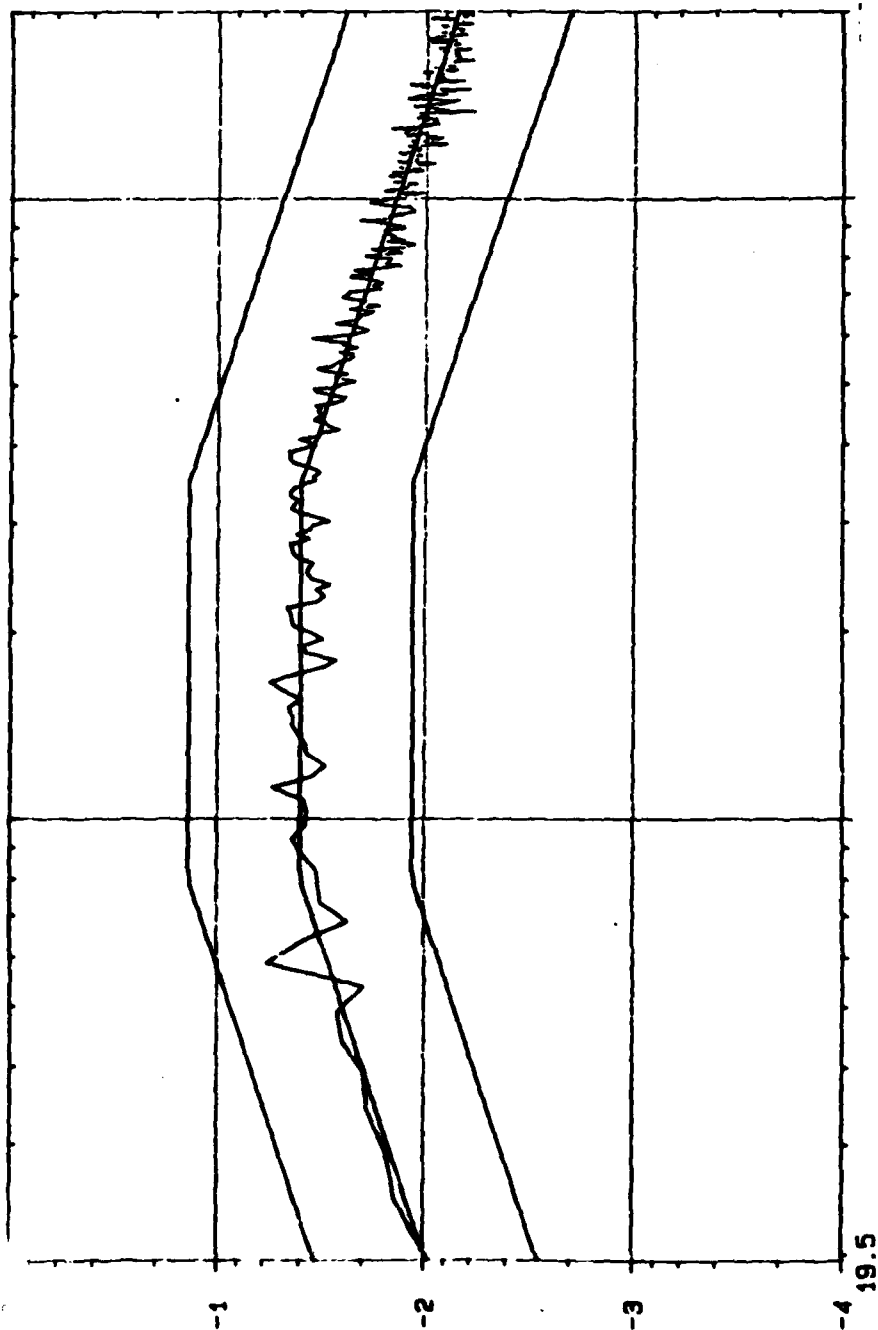


Fig. C-22.

1/19/83 ACC# 4/1  
TRANSFER FUNCTION

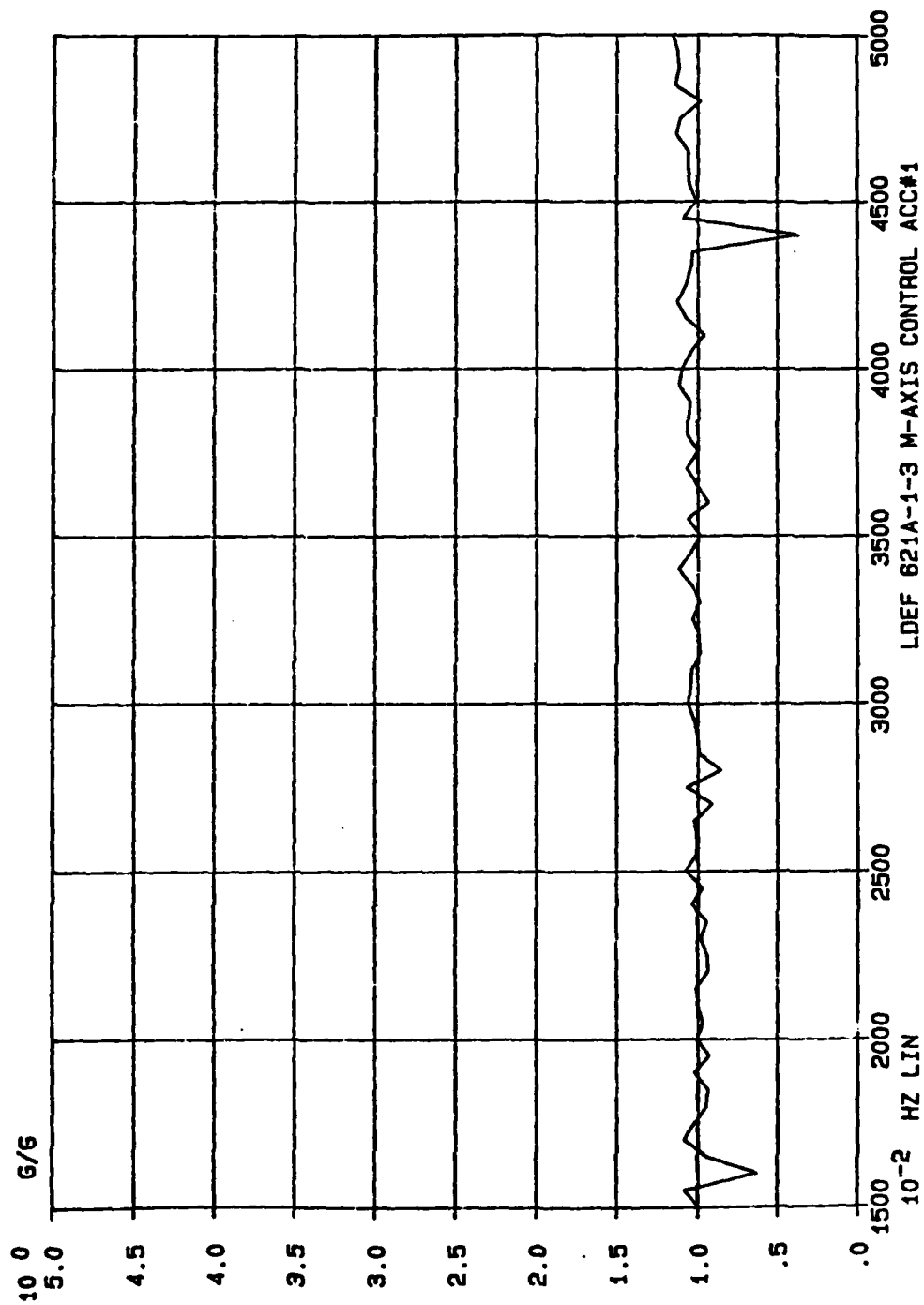


Fig. C-23.

1/19/83 ACC# 5/1  
TRANSFER FUNCTION

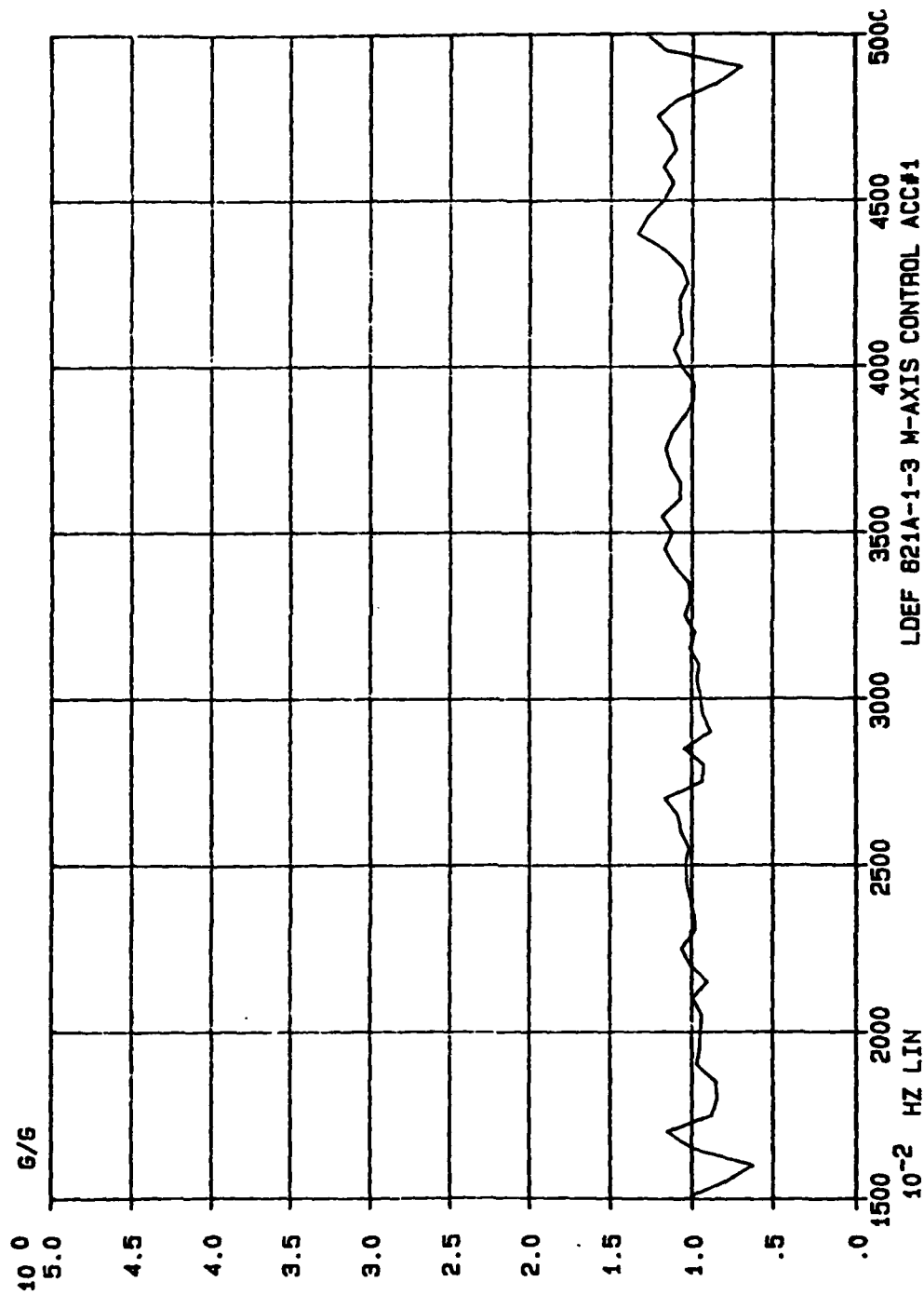


Fig. C-24.

1/19/83 ACC# 8/1  
TRANSFER FUNCTION

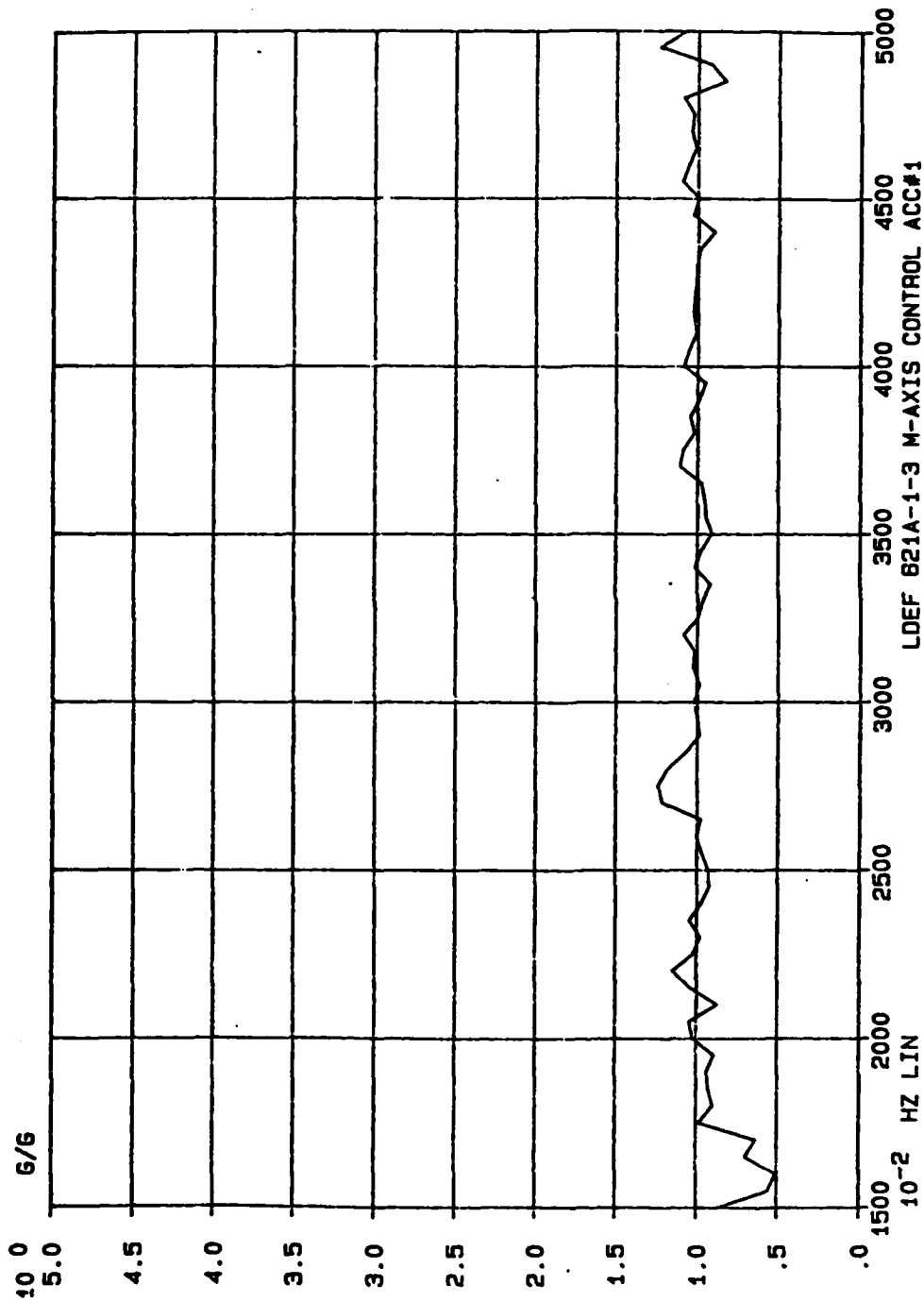


Fig. C-25.

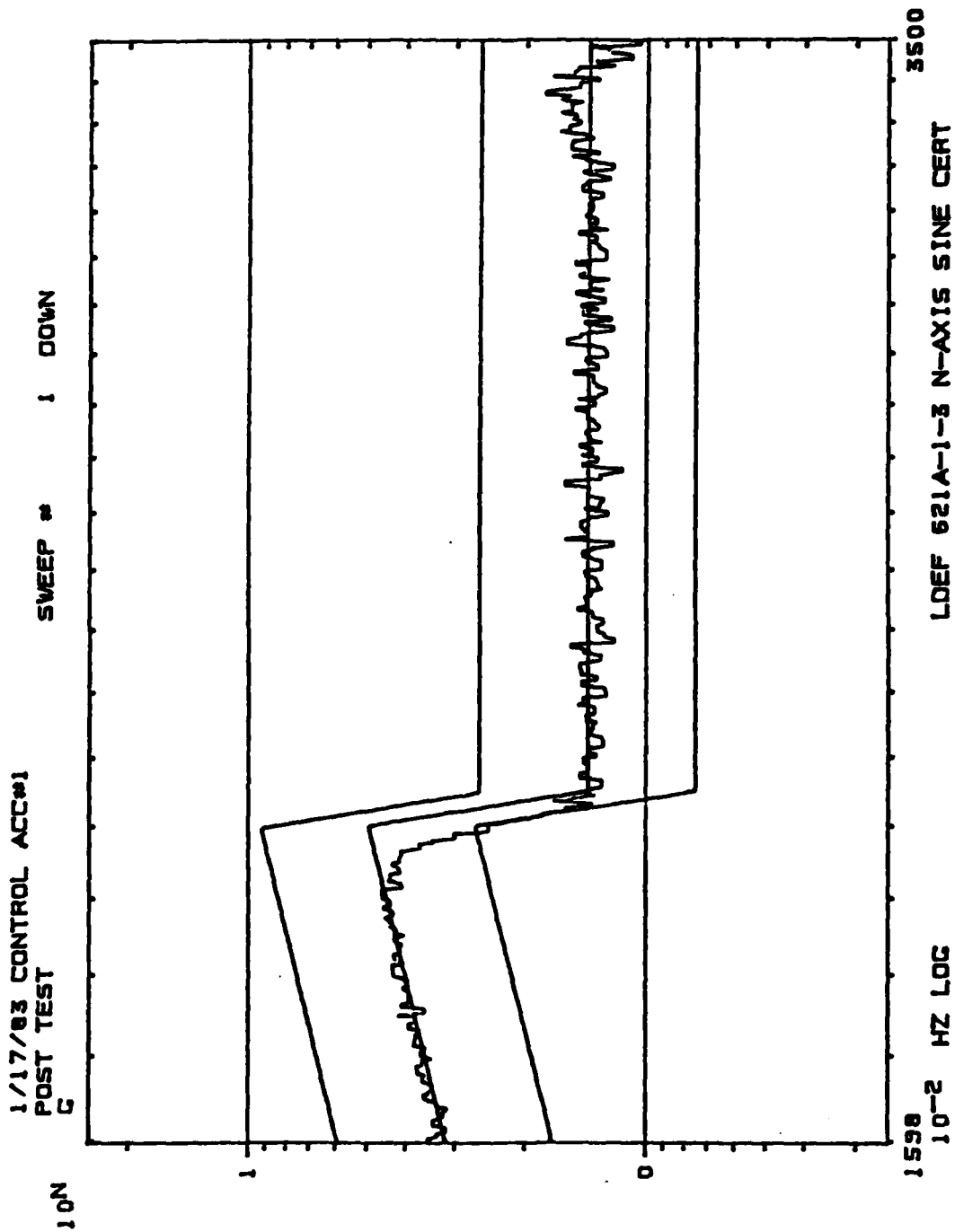


Fig. C-26.



1/17/83 CONTROL ACC#1.2.3

POST TEST

RMS LEVEL - 6.098 G'S  
G SQR/HZ

ELAPSED TIME - 31 SECS AT  
DELTA F - 4.883 DOF - 215

.00 DB  
AMF - 5

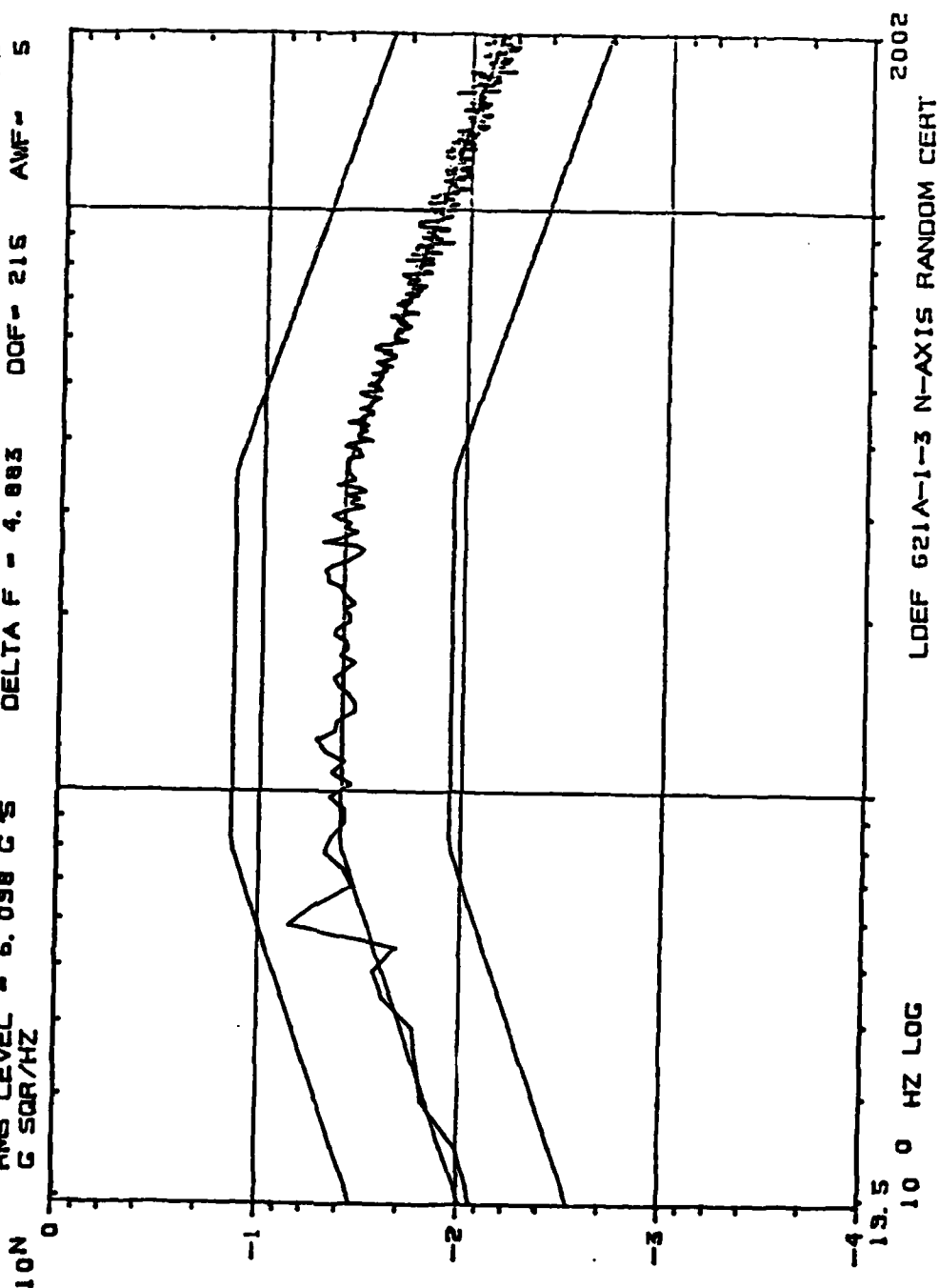


Fig. C-27.

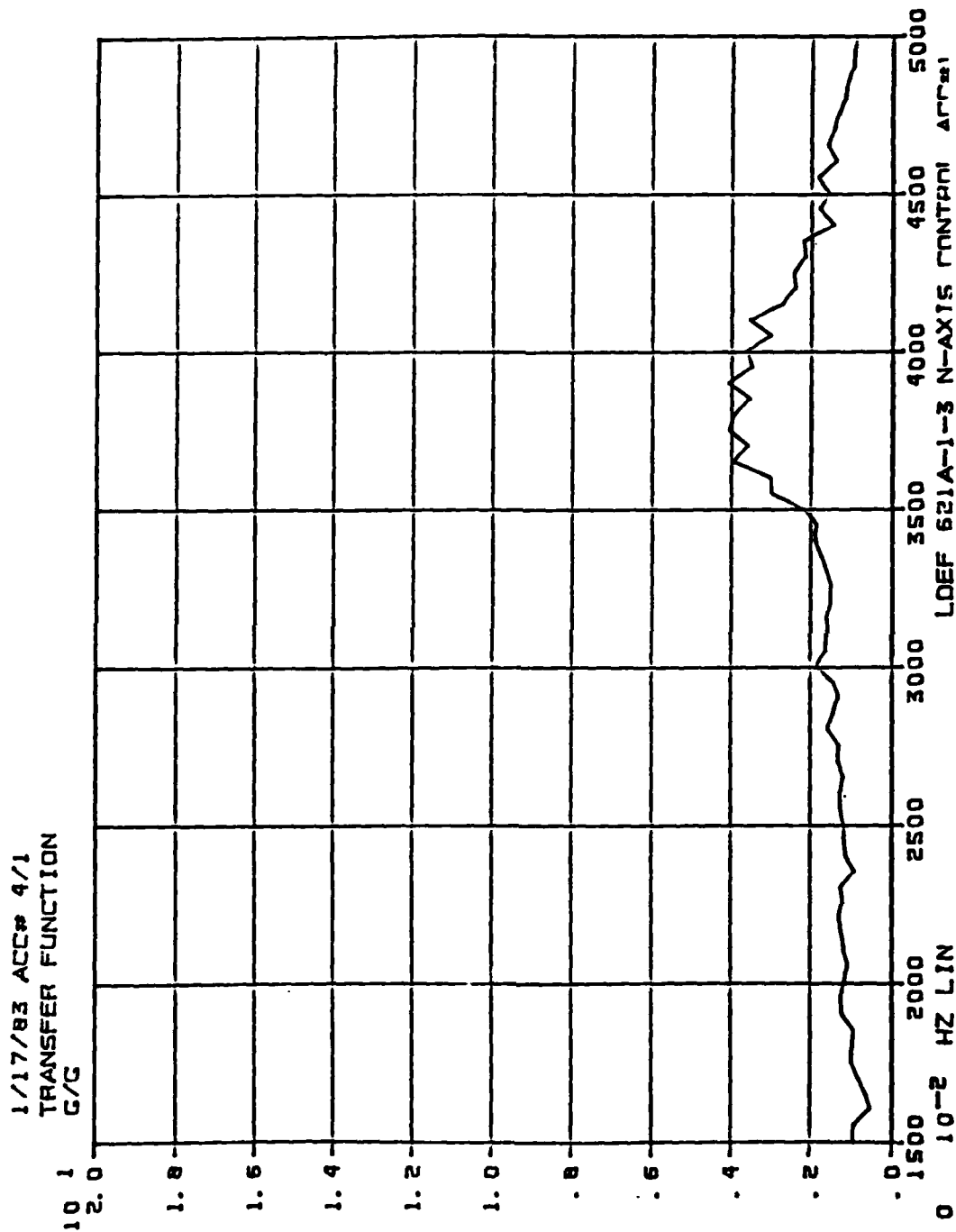


Fig. C-28.

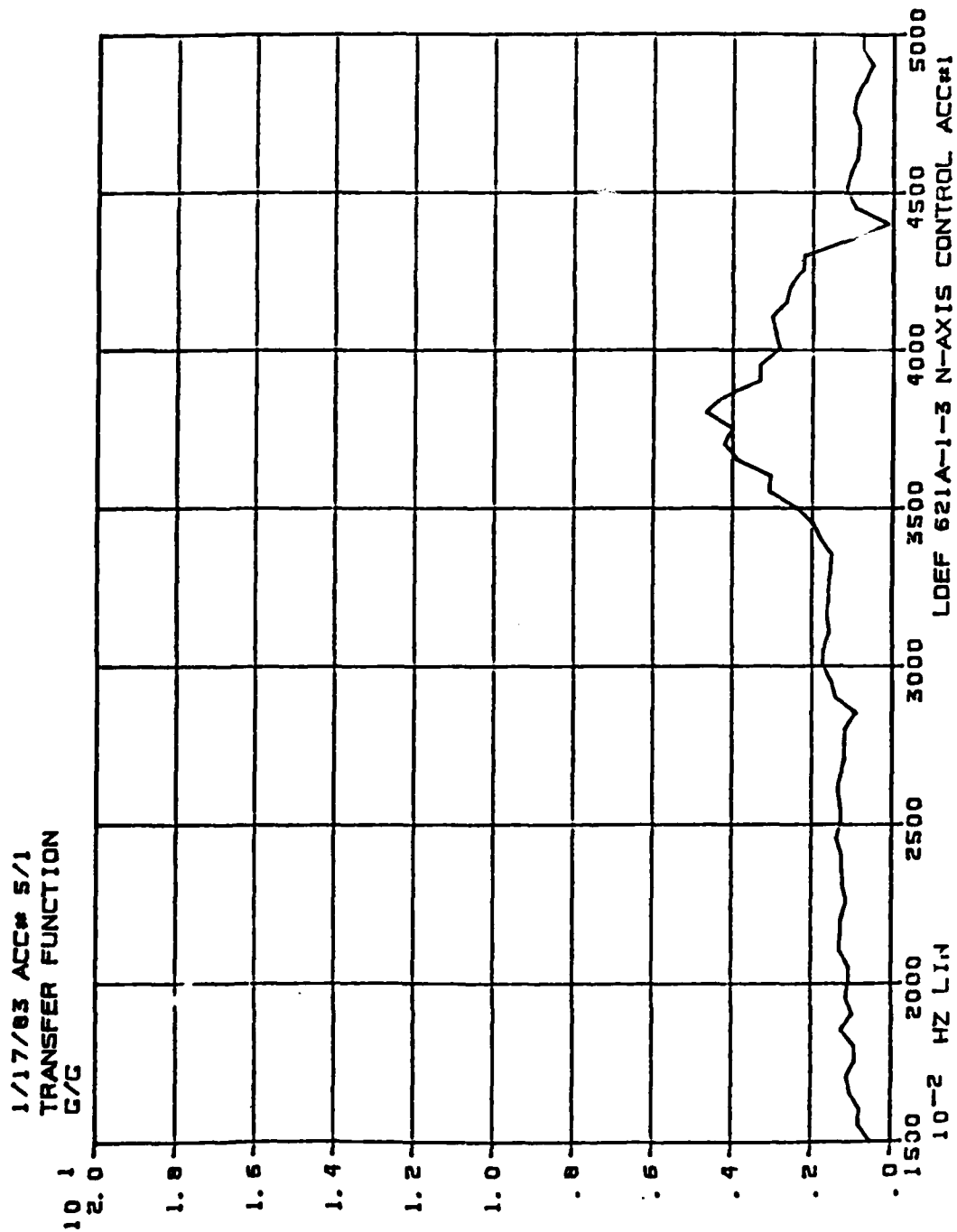


Fig. C-29.

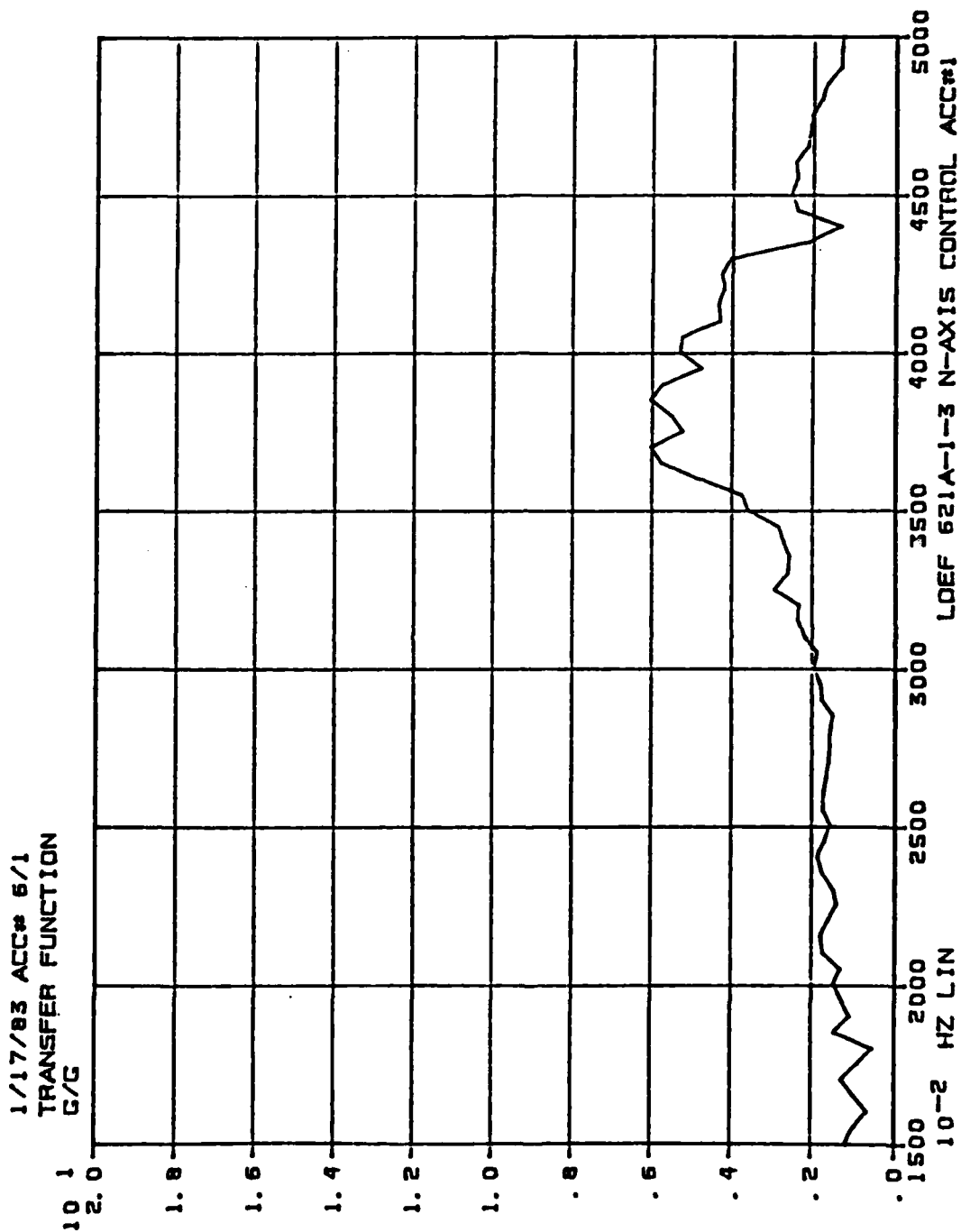


Fig. C-30.

1/18/83 CONTROL ACC#1 L-AXIS SWEEP # 1 DOWN  
 POST TEST  
 C

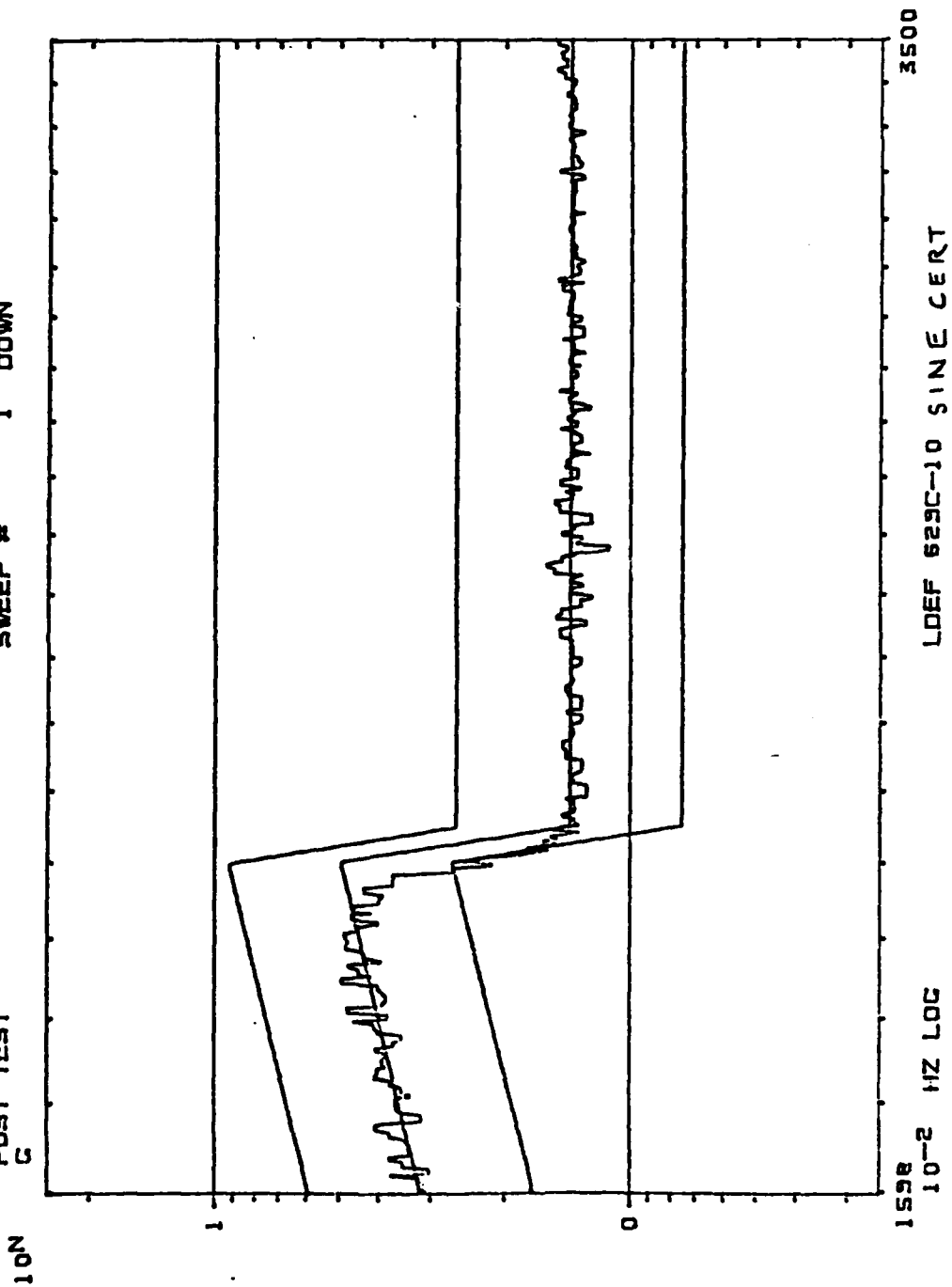
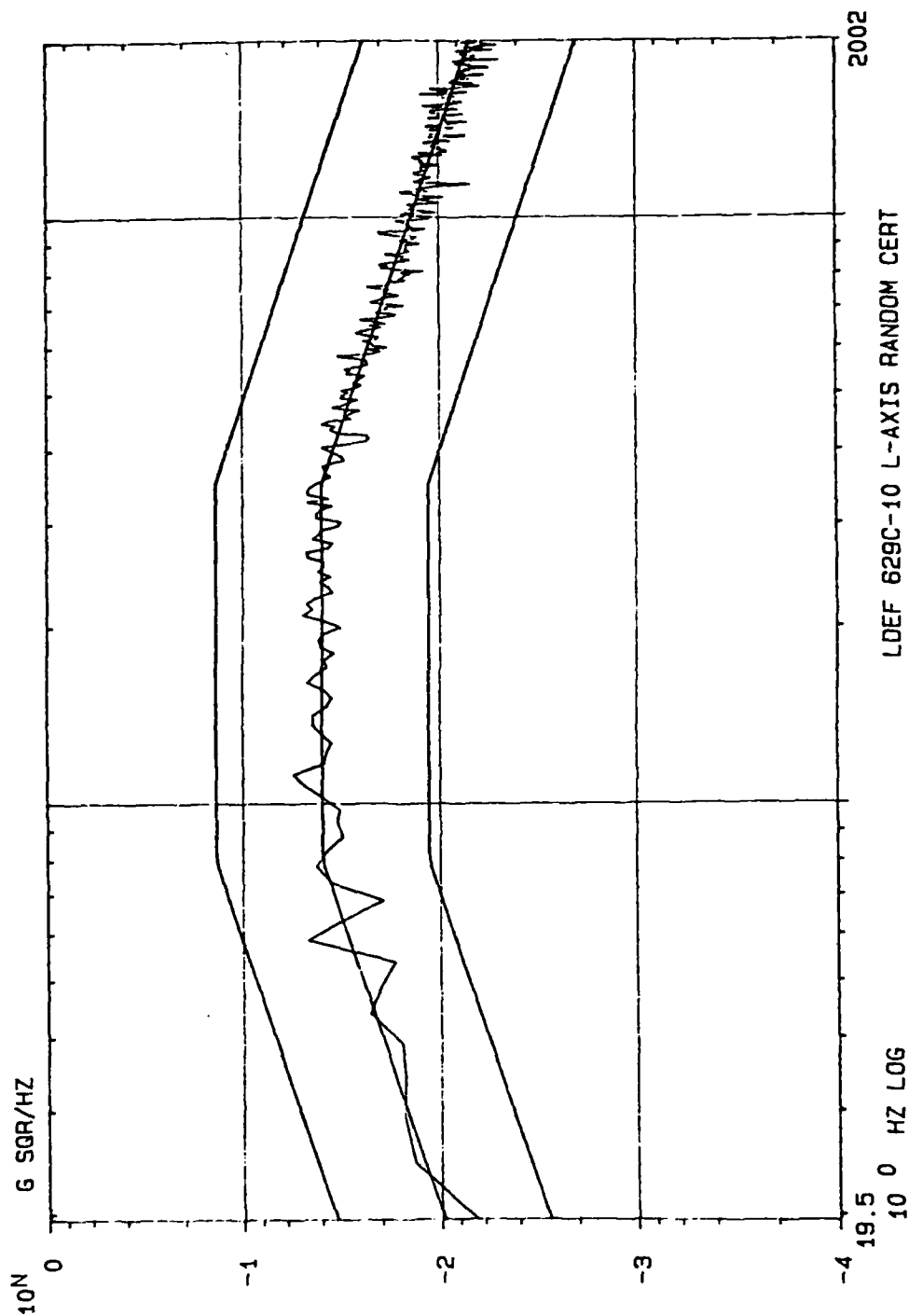


Fig. C-31.

1/18/83 CONTROL ACC#1, 2, 3  
 POST TEST  
 RMS LEVEL = 6.035 G'S

ELAPSED TIME = 30 SECS AT .00 DB  
 DELTA F = 4.883 DOF = 215 AWF = 5



LDEF 629C-10 L-AXIS RANDOM CERT

Fig. C-32.

1/18/83 ACC# 4/1  
TRANSFER FUNCTION

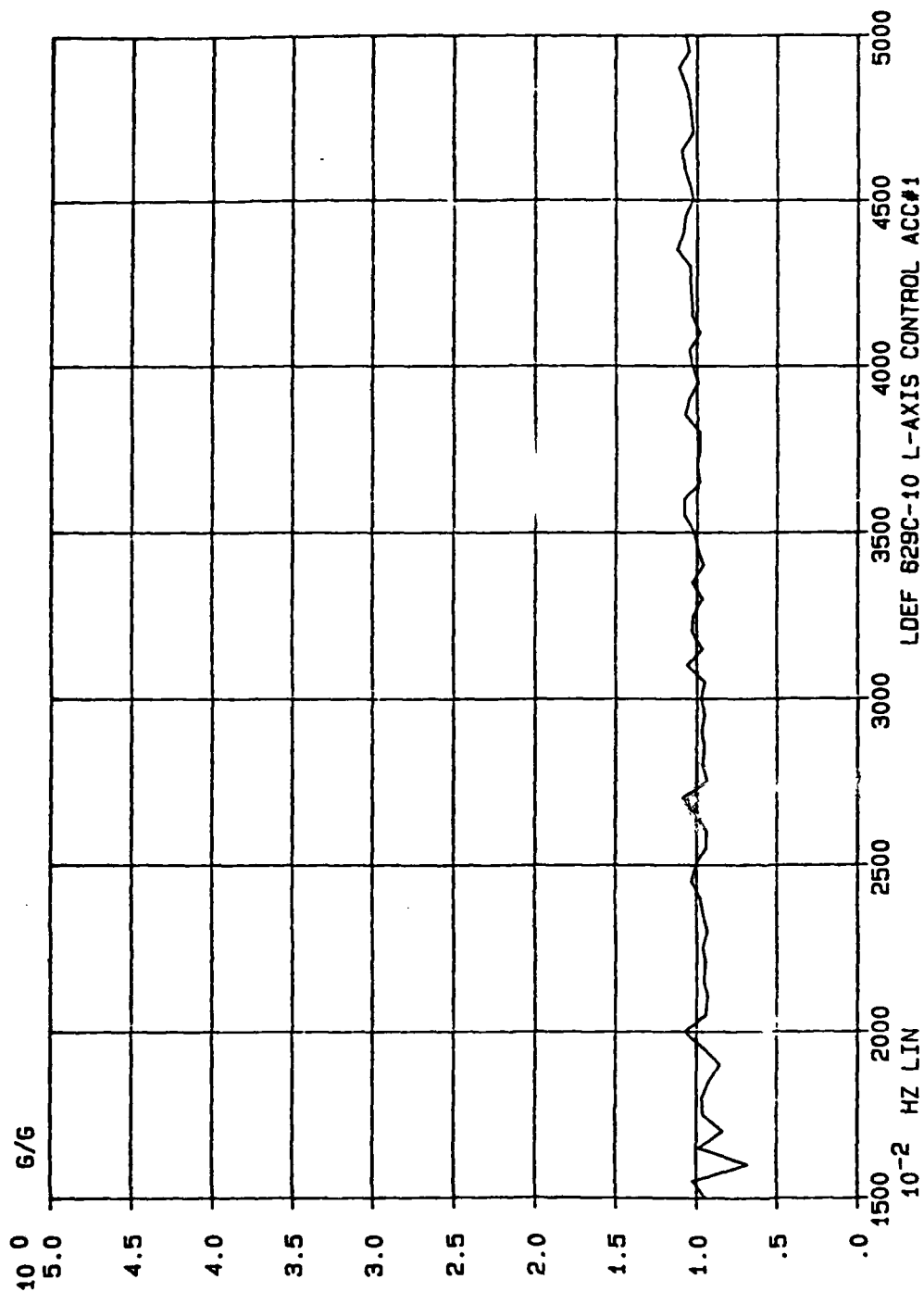


Fig. C-33.

1/18/83 ACC# 5/1  
TRANSFER FUNCTION

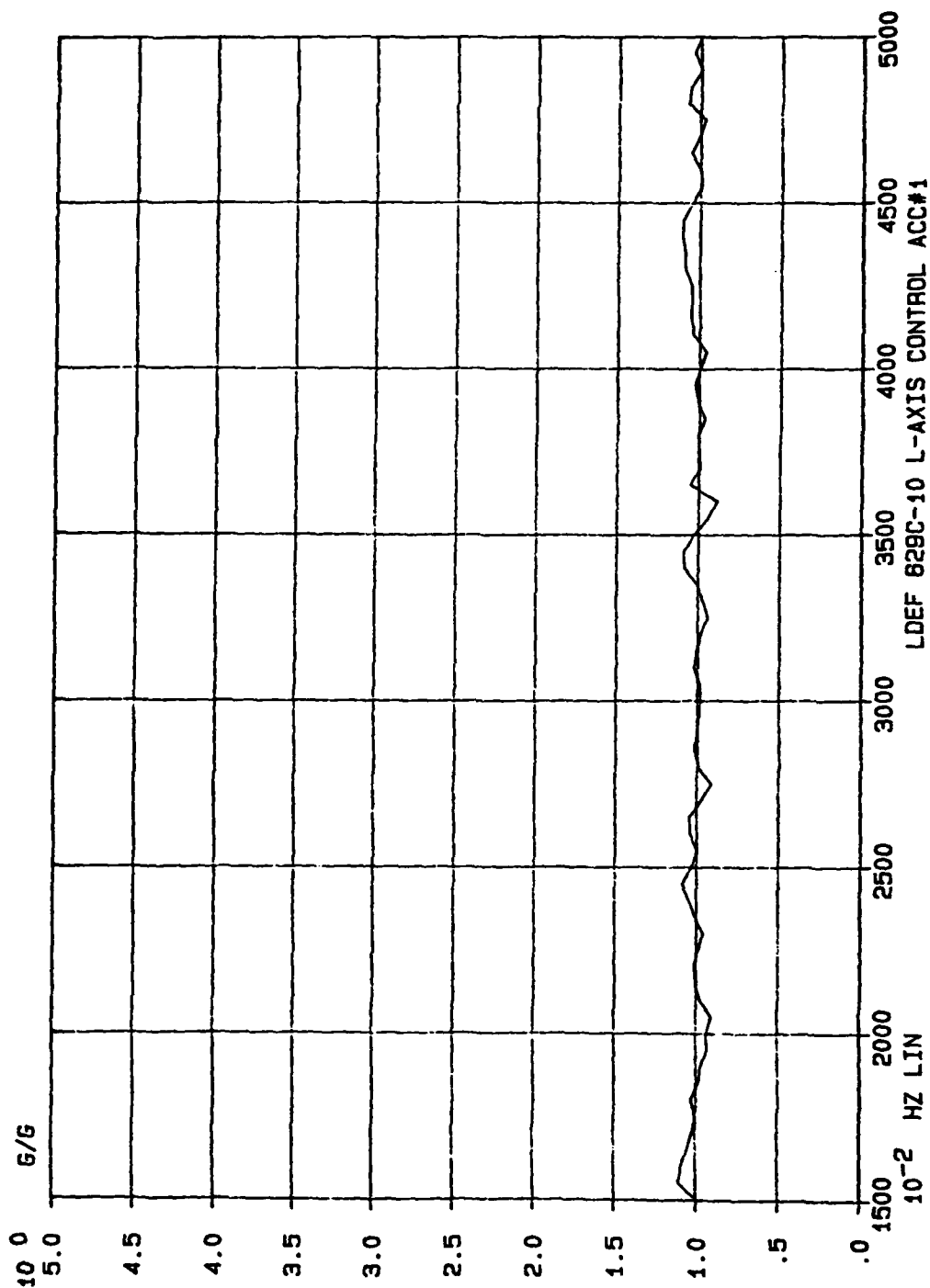


Fig. C-34.



1/18/83 ACC# 6/1  
TRANSFER FUNCTION

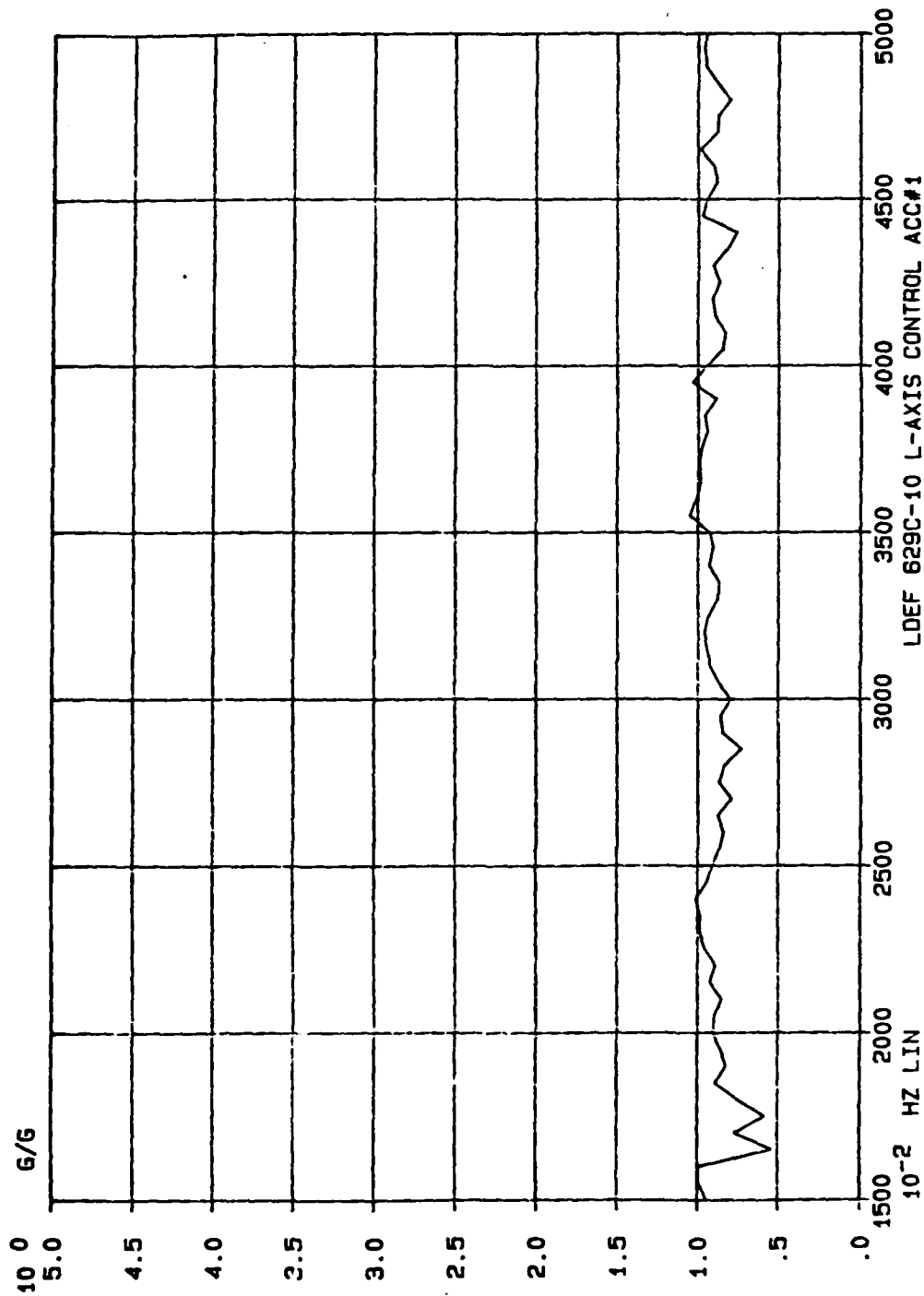


Fig. C-35.

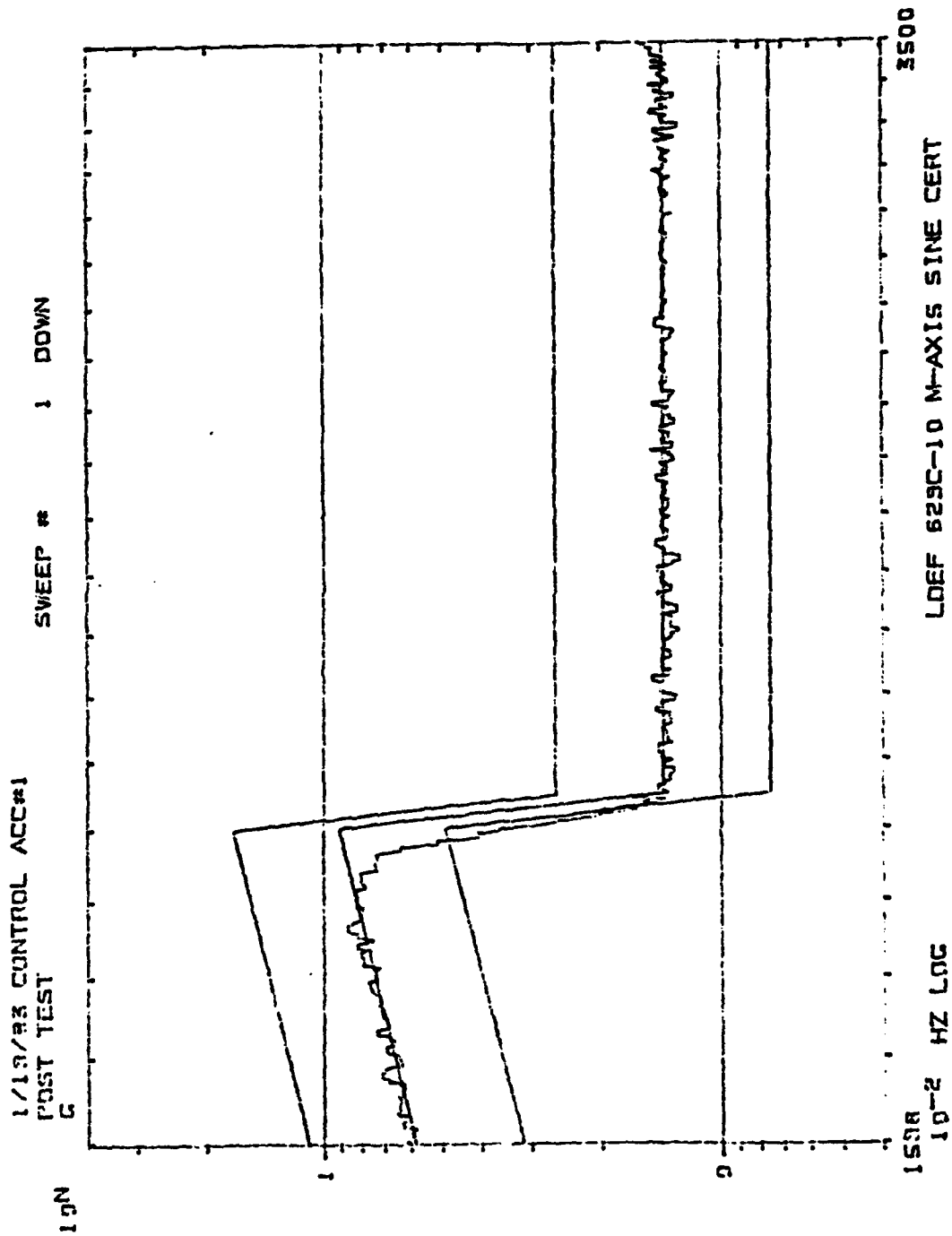


Fig. C-36.

1/19/83 CONTROL ACC#1,2,3

POST TEST

RMS LEVEL = 6.081 G'S

ELAPSED TIME = 31 SECS AT .00 DB

DELTA F = 4.883

DOF = 215

AMF = 5

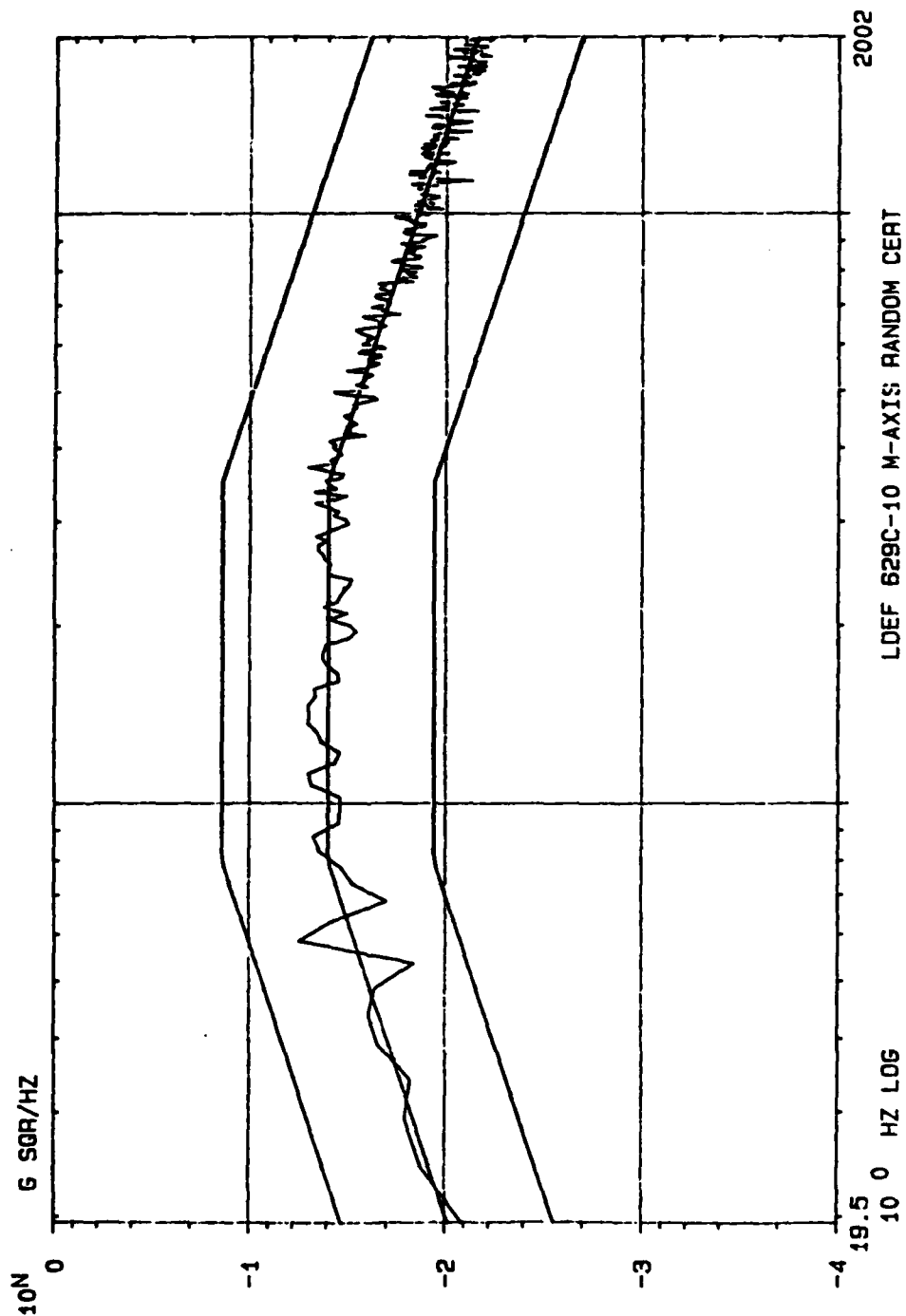


Fig. C-37.

1/19/83 ACC# 4/1  
TRANSFER FUNCTION

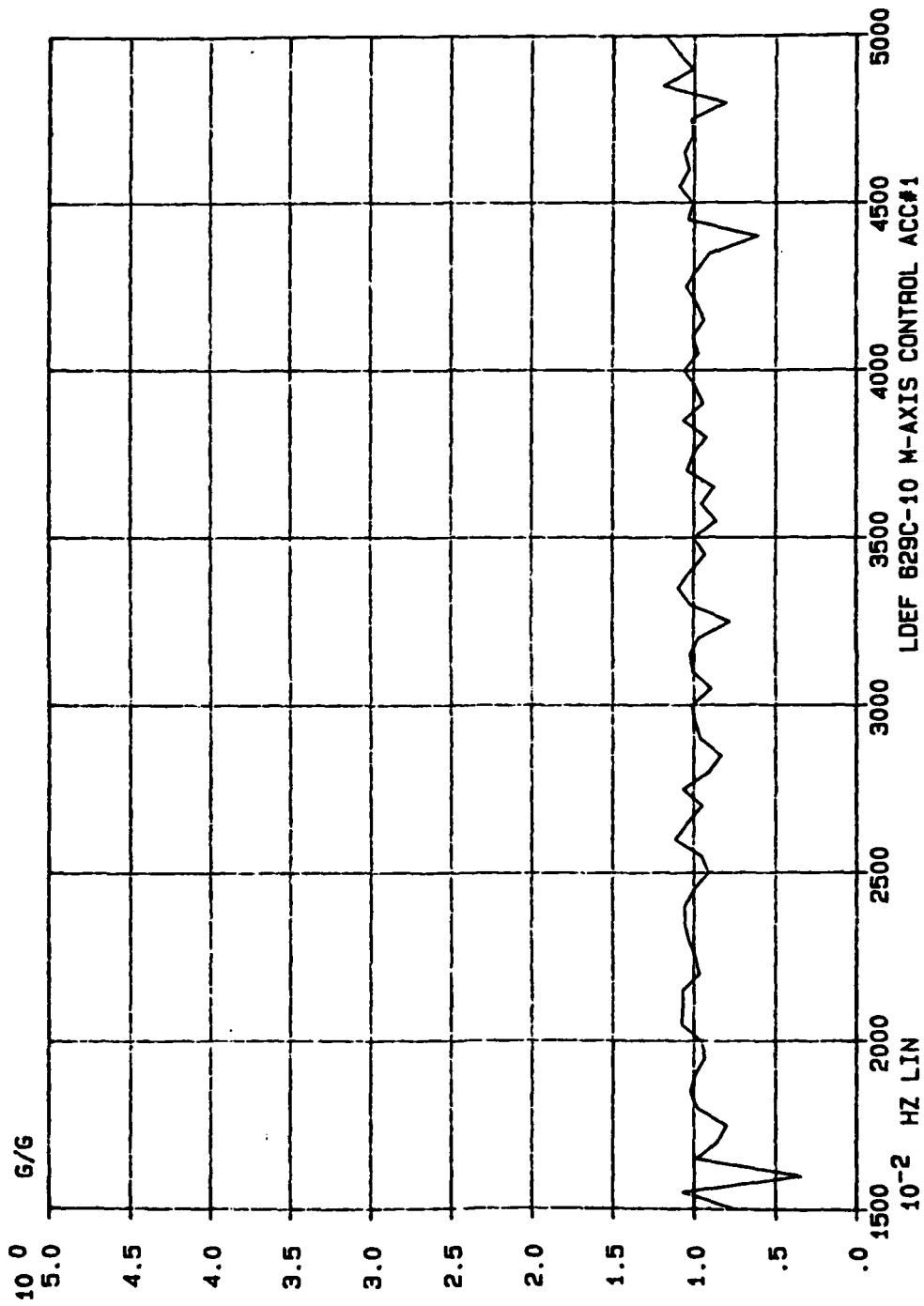


Fig. C-38.

1/19/83 ACC# 5/1  
TRANSFER FUNCTION

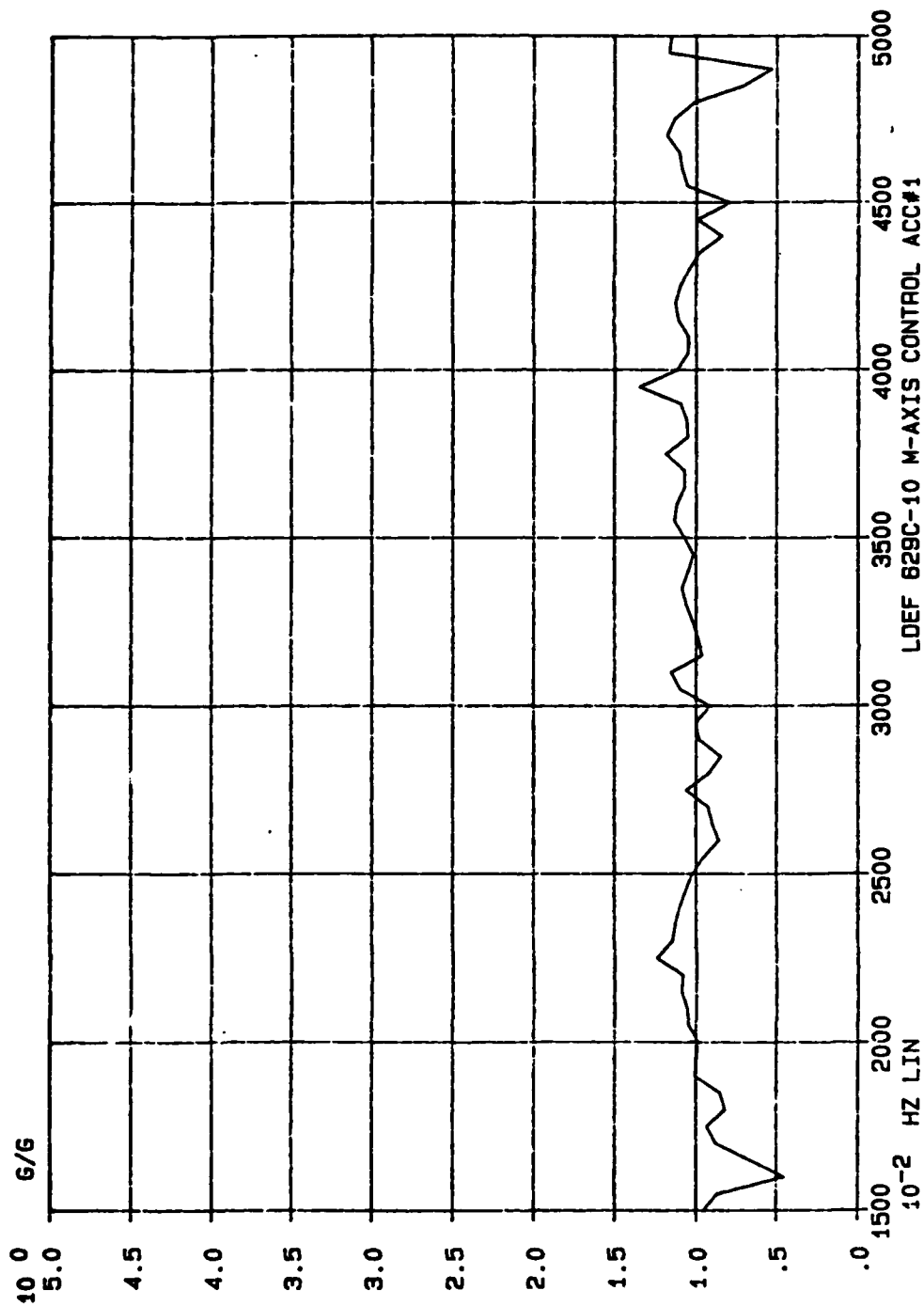


Fig. C-39.

1/19/83 ACC# 6/1  
TRANSFER FUNCTION

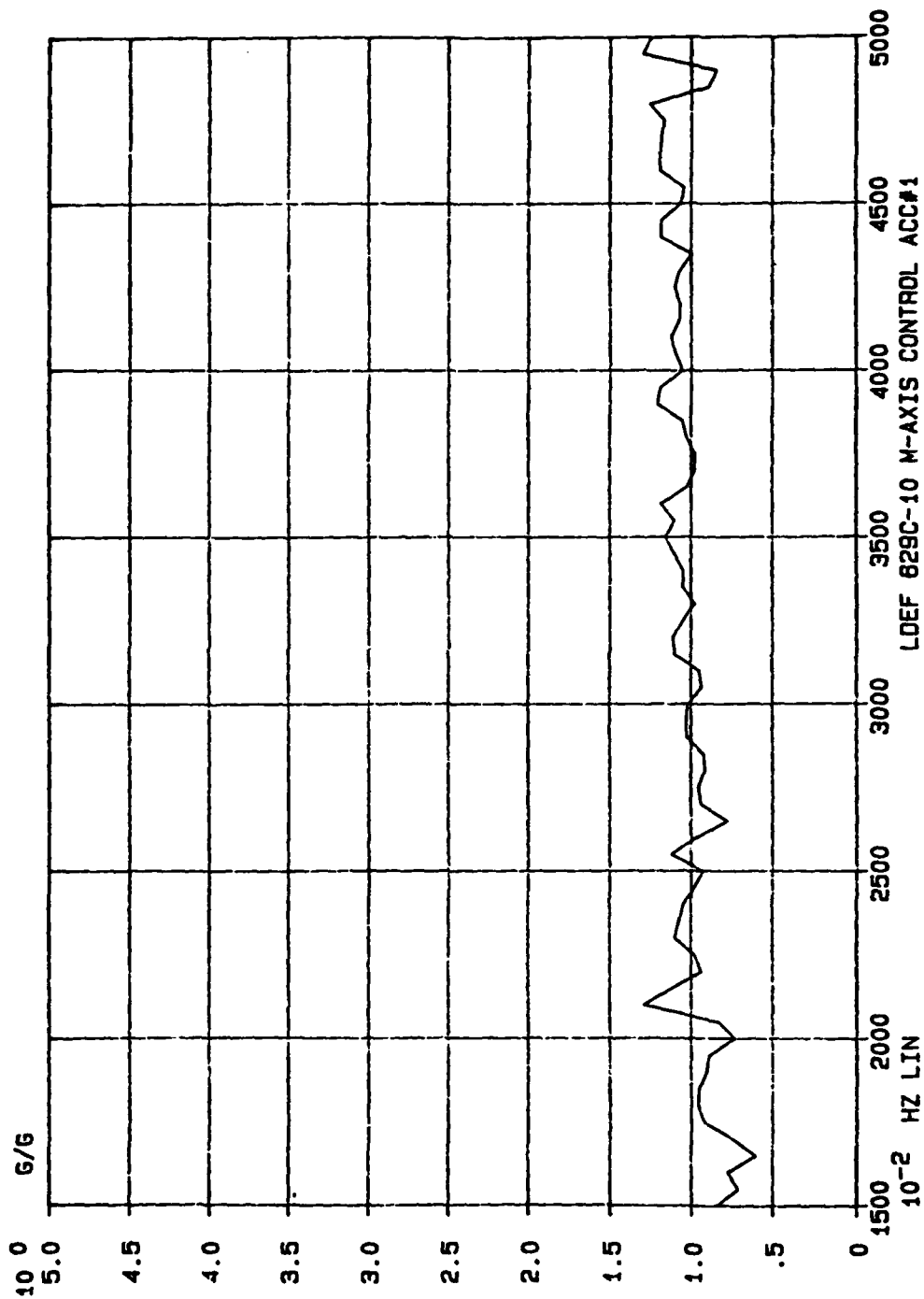


Fig. C-40.

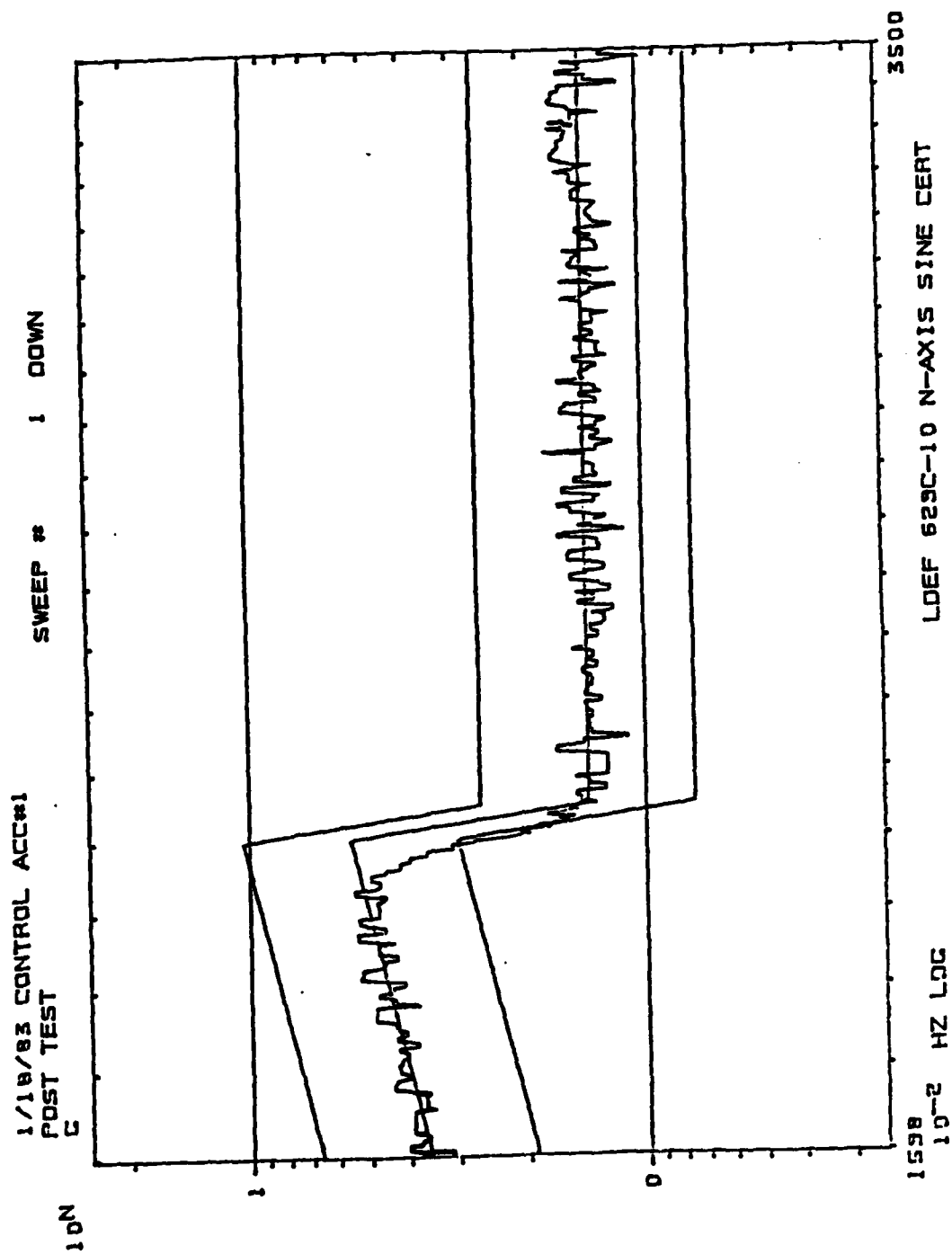


Fig. C-41.

1/18/83 CONTROL ACC#1,2,3

POST TEST

RMS LEVEL = 6.068 G'S

ELAPSED TIME = 30 SECS AT .00 DB

DELTA F = 4.883

DOF = 215

AMF = 5

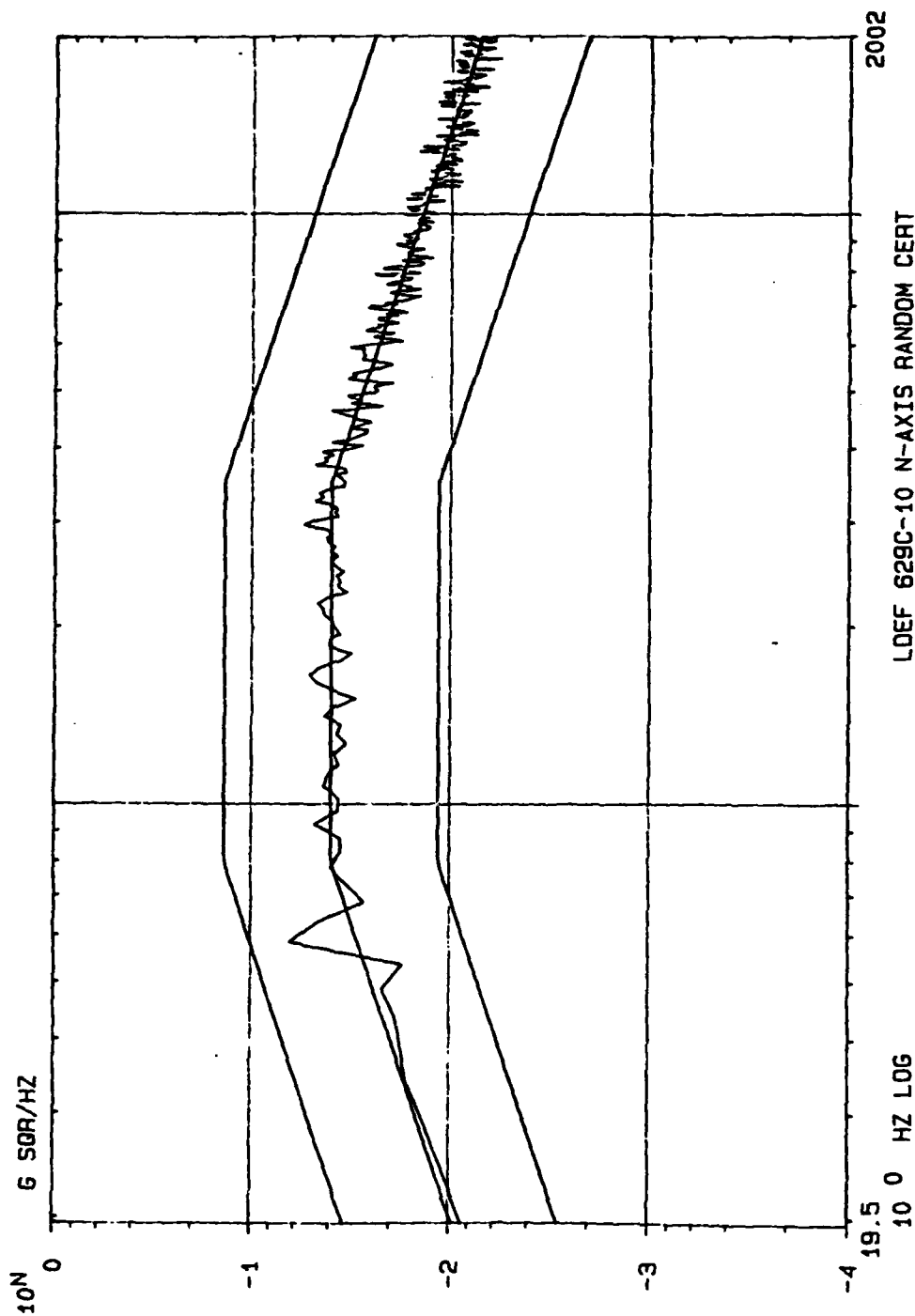


Fig. C-42.



1/18/83 A<sup>CC</sup># 4/1  
TRANSFER FUNCTION

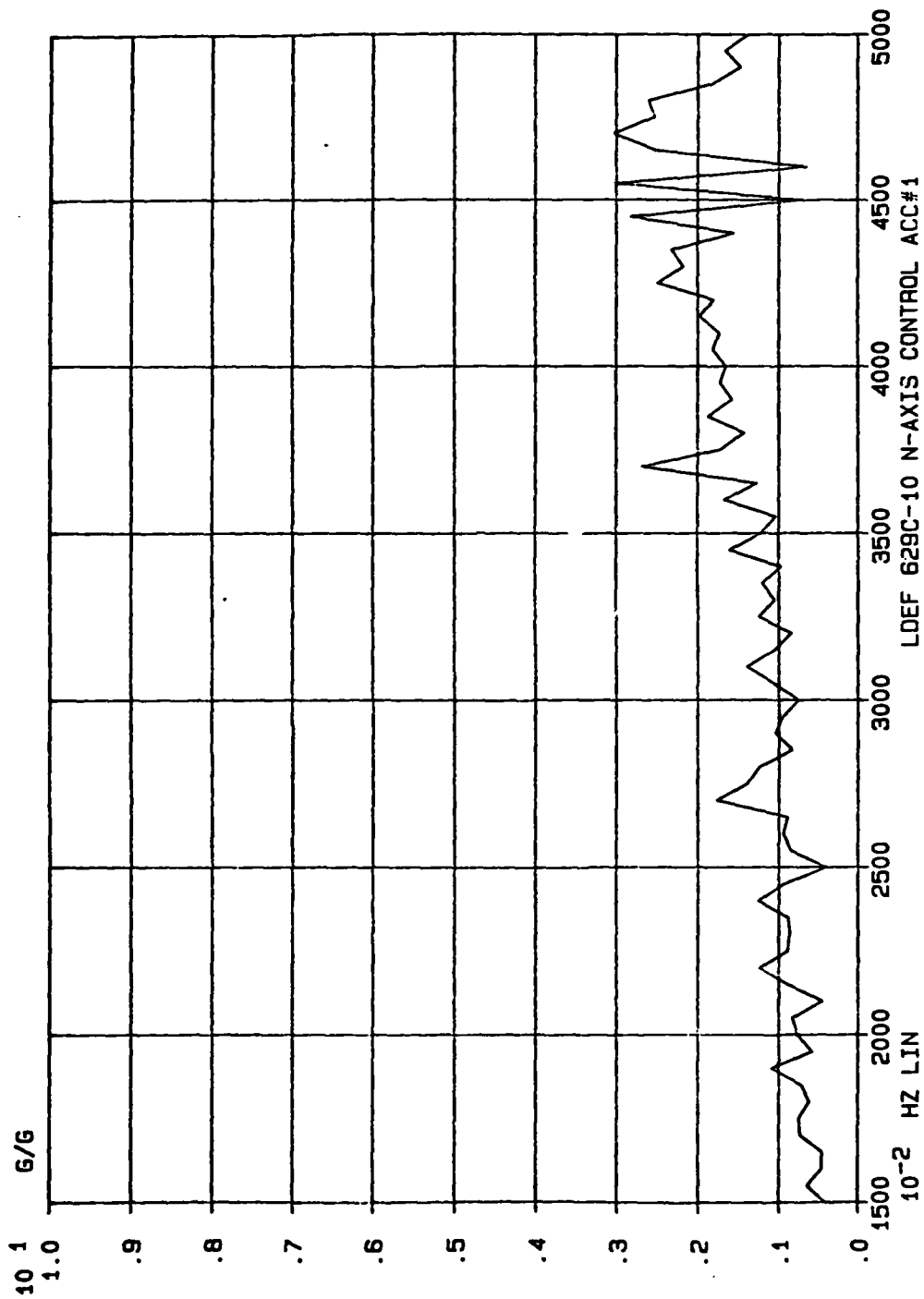


Fig. C-43.

1/18/B3 ACC# 5/1  
TRANSFER FUNCTION

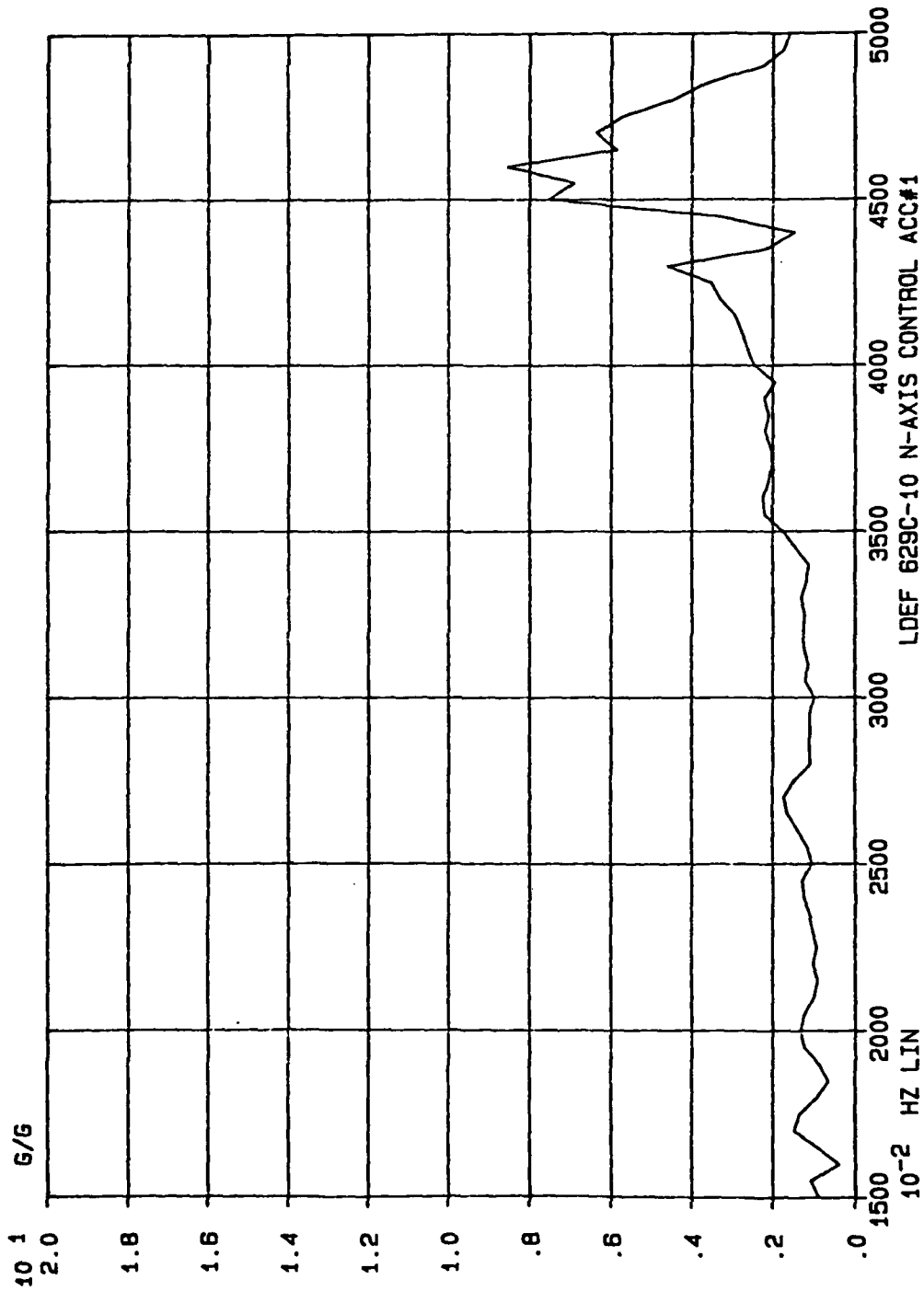


Fig. C-44.

1/18/83 AL-# 6/1  
TRANSFER FUNCTION

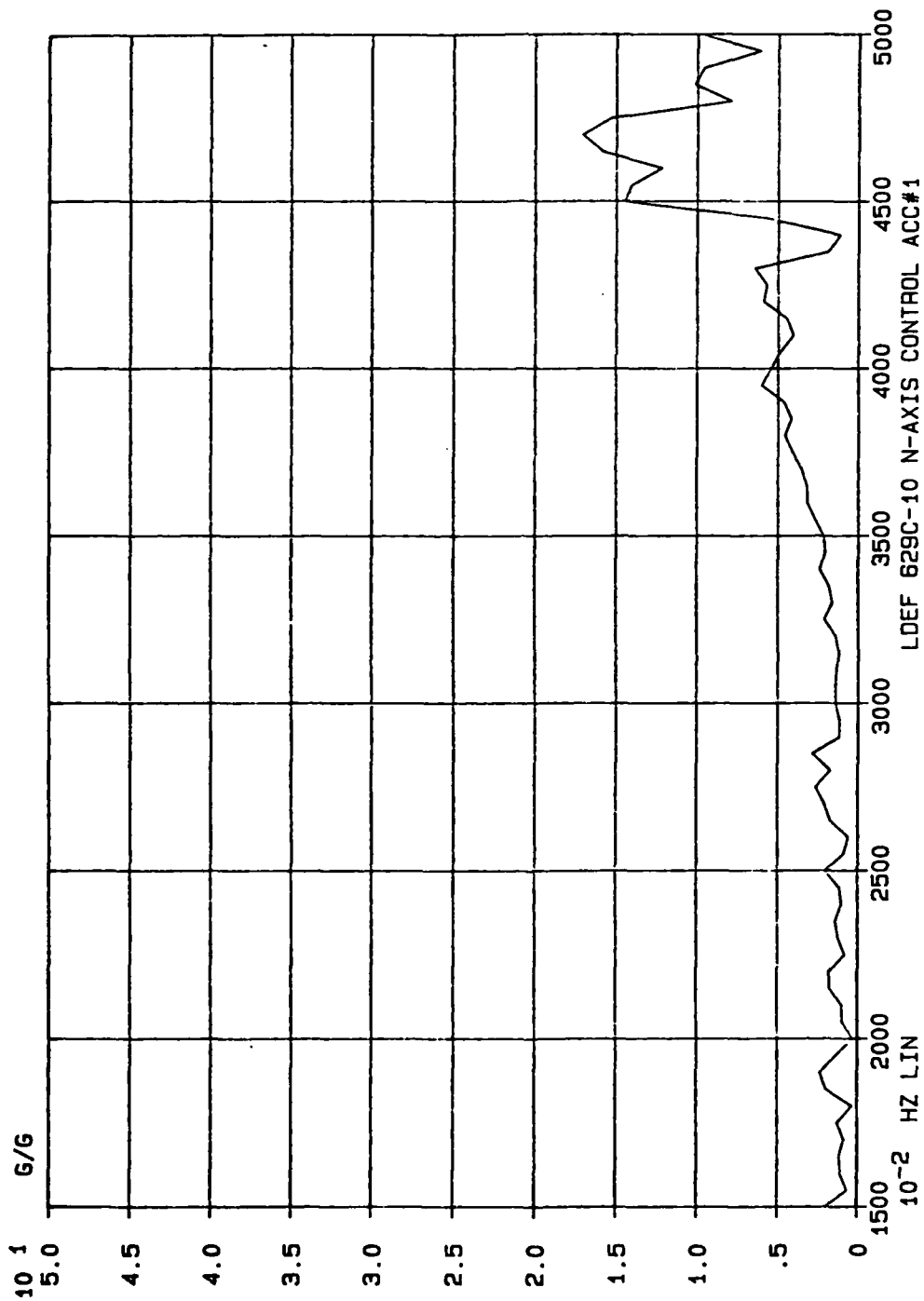


Fig. C-45.

#### LABORATORY OPERATIONS

The Laboratory Operations of The Aerospace Corporation is conducting experimental and theoretical investigations necessary for the evaluation and application of scientific advances to new military space systems. Versatility and flexibility have been developed to a high degree by the laboratory personnel in dealing with the many problems encountered in the nation's rapidly developing space systems. Expertise in the latest scientific developments is vital to the accomplishment of tasks related to these problems. The laboratories that contribute to this research are:

Aerophysics Laboratory: Launch vehicle and reentry aerodynamics and heat transfer, propulsion chemistry and fluid mechanics, structural mechanics, flight dynamics; high-temperature thermomechanics, gas kinetics and radiation; research in environmental chemistry and contamination; cw and pulsed chemical laser development including chemical kinetics, spectroscopy, optical resonators and beam pointing, atmospheric propagation, laser effects and countermeasures.

Chemistry and Physics Laboratory: Atmospheric chemical reactions, atmospheric optics, light scattering, state-specific chemical reactions and radiation transport in rocket plumes, applied laser spectroscopy, laser chemistry, battery electrochemistry, space vacuum and radiation effects on materials, lubrication and surface phenomena, thermionic emission, photosensitive materials and detectors, atomic frequency standards, and bioenvironmental research and monitoring.

Electronics Research Laboratory: Microelectronics, GaAs low-noise and power devices, semiconductor lasers, electromagnetic and optical propagation phenomena, quantum electronics, laser communications, lidar, and electro-optics; communication sciences, applied electronics, semiconductor crystal and device physics, radiometric imaging; millimeter-wave and microwave technology.

Information Sciences Research Office: Program verification, program translation, performance-sensitive system design, distributed architectures for spaceborne computers, fault-tolerant computer systems, artificial intelligence, and microelectronics applications.

Materials Sciences Laboratory: Development of new materials: metal matrix composites, polymers, and new forms of carbon; component failure analysis and reliability; fracture mechanics and stress corrosion; evaluation of materials in space environment; materials performance in space transportation systems; analysis of systems vulnerability and survivability in enemy-induced environments.

Space Sciences Laboratory: Atmospheric and ionospheric physics, radiation from the atmosphere, density and composition of the upper atmosphere, aurorae and airglow; magnetospheric physics, cosmic rays, generation and propagation of plasma waves in the magnetosphere; solar physics, infrared astronomy; the effects of nuclear explosions, magnetic storms, and solar activity on the earth's atmosphere, ionosphere, and magnetosphere; the effects of optical, electromagnetic, and particulate radiations in space on space systems.

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