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VIBRATION AND ACOUSTIC ANALYSES SATURN SA-10 FLIGHT

by MEASURING AND EVALUATION SECTION
Propulsion and Vehicle Engineering Laboratory

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George C. Marshall Space Flight Center, Huntsville, Alabama

TECHNICAL MEMORANDUM X-53366

VIBRATION AND ACOUSTIC ANALYSES SATURN SA-10 FLIGHT

By

Measuring and Evaluation Section

George C. Marshall Space Flight Center

Huntsville, Alabama

ABSTRACT

This report presents an analysis of the vibration and acoustic data measured during the flight of SA-10. Instrumentation and equipment used in the data acquisition and data reduction systems are described. The effects of the vibration and acoustic environment on the Saturn S-I stage, Instrument Unit, and Pegasus structure are evaluated. Structural response is described and presented pictorially in terms of power spectral density versus frequency. Internal Saturn SA-10 acoustic environments are discussed in terms of sound pressure spectrum level versus frequency. Installation sketches of all vibration and acoustic transducers used on the SA-10 flight vehicle are shown.

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TECHNICAL MEMORANDUM X-53366

VIBRATION AND ACOUSTIC ANALYSES SATURN SA-10 FLIGHT

By

Measuring and Evaluation Section

VIBRATION AND ACOUSTICS BRANCH
STRUCTURES DIVISION
PROPULSION AND VEHICLE ENGINEERING LABORATORY
RESEARCH AND DEVELOPMENT OPERATIONS

ACKNOWLEDGEMENT

This report was prepared by Chrysler Corporation Space Division, Huntsville Operations, Structures Branch of the Structures and Mechanics Engineering Department, for the George C. Marshall Space Flight Center, Propulsion and Vehicle Engineering Laboratory, Structures Division, Vibration and Acoustics Branch, under Contract NAS8-4016, Mod. 80, Task D.

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S-I STAGE

*Not Analyzed

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LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF SYMBOLS

B. W.	bandwidth
cps	cycles per second
dB	decibel (reference 0.00002 Newton/meter^2)
EST	eastern standard time
F-1	fuel tank no. 1
F-2	fuel tank no. 2
G	dimensionless acceleration value
G^2	mean square acceleration value
GOX	gaseous oxygen
IECO	inboard engine cutoff
I. U.	instrument unit
Mach 1	speed of sound in air
max Q	period of maximum dynamic pressure
OECO	outboard engine cutoff
PSD	power spectral density (G^2/cps)
RF	radio frequency
RMS, rms	root-mean-square
S-I	Saturn first stage
S-IV	Saturn second stage
sec	seconds

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VIBRATION AND ACOUSTIC ANALYSES SATURN SA-10 FLIGHT

SUMMARY

The SA-10 vibration and acoustic environments were normal and did not exceed expected levels. In general, the S-I stage vibration environments compared closely with previous Saturn I, Block II vehicles. The high vibration levels measured on the shear panel measurements on SA-8 and SA-9 were not present on this flight.

The SA-10 vehicle was the third to fly a prototype model of the production instrument unit (I. U.). The vibration environment recorded on this flight agreed closely with the past history envelope established on the flights of SA-8 and SA-9. Vibration of the I. U. during S-IV powered flight was negligible.

The Pegasus satellite data exhibited good agreement with the past history envelope established on the previous two flights. Vibration during S-IV powered flight was extremely low. Internal acoustic environments of the instrument unit and the Apollo adapter showed an excellent comparison with past history levels and with the predicted time history. The acoustic data obtained from the S-I stage was not reliable.

I. INTRODUCTION

The Saturn SA-10 vehicle was launched at 8:00 a.m. EST on July 30, 1965. This vehicle was the final Saturn I configuration to be flown. The SA-10 vehicle comprised the S-I stage, S-IV stage, instrument unit, a boilerplate model of the Apollo spacecraft, and the Pegasus satellite.

A discussion of the instrumentation and data acquisition systems is presented in Section II of this report. Information is given on the distribution of vibration and acoustic measurements by vehicle stage. The operating characteristics of the data acquisition and signal conditioning equipment are described in functional sequence.

The data reduction system and related equipment are described in Section III. A discussion of the role of the digital computer in the reduction of all measured data is presented. In addition, a flow chart is included to show the complete data acquisition and data reduction process.

An evaluation of the vibration environment is presented in Section IV. Emphasis is placed on the abnormal structural response characteristics. A discussion of the significant aspects of the measured data is given for each grouping of component or structural measurements.

The acoustic environment is evaluated and discussed in Section V. This evaluation shows the significant aspects of the internal acoustic environment during launch and of the aerodynamic environment induced during the region of maximum dynamic pressure (max Q).

The appendices include installation drawings for the vibration and acoustic transducers and present the reduced data in terms of G^2/cps amplitude versus frequency and amplitude versus time.

II. DATA ACQUISITION

The SA-10 vehicle was instrumented with 54 vibration transducers and 3 acoustic transducers, distributed as follows:

	Vibration	Acoustic	Total
S-I stage	23	1	24
Instrument unit	24	1	25
Apollo			
High frequency	4	1	5
Low frequency	3		3
	54	3	57

The data acquisition system for the vibration and acoustic data consists basically of a transducer, emitter follower, amplifier, multiplexer, transmitter, receiver, demultiplexer, and recorder.

The SS/FM telemetry systems utilizes frequency division multiplexing techniques to transmit the multiple data channels on a common RF carrier. The analog voltage from each transducer amplitude modulates a 455 kc channel carrier signal. The output at the first modulator, with the lower sideband removed by filtering, is transposed upward in frequency by a second modulator to its assigned position in the multiplexed spectrum.

The multiplexed signals are transmitted from the vehicle over ultra-high-frequency (UHF) radio channel and are detected by ground receiving stations. The receiving portion of the single sideband system reverses the process of the transmitting portion. The receiver output is fed through a demultiplexer and each channel is transposed from its assigned position in the spectrum to its original frequency.

III. DATA REDUCTION

At MSFC, the magnetic tapes are demultiplexed and the vibration and acoustic data is re-recorded on individual data channels. In this form, the data may be analyzed with the random vibration analysis program (RAVAN). This program was developed by the MSFC Computation Laboratory for use in conjunction with the IBM 7094 digital computer. A flow diagram of the complete data acquisition and data reduction processes is shown in Table I.

The RAVAN program performs an analysis on the random vibration data by computing the first four statistical moments. These moments are the mean value, standard deviation, skewness, and kurtosis.

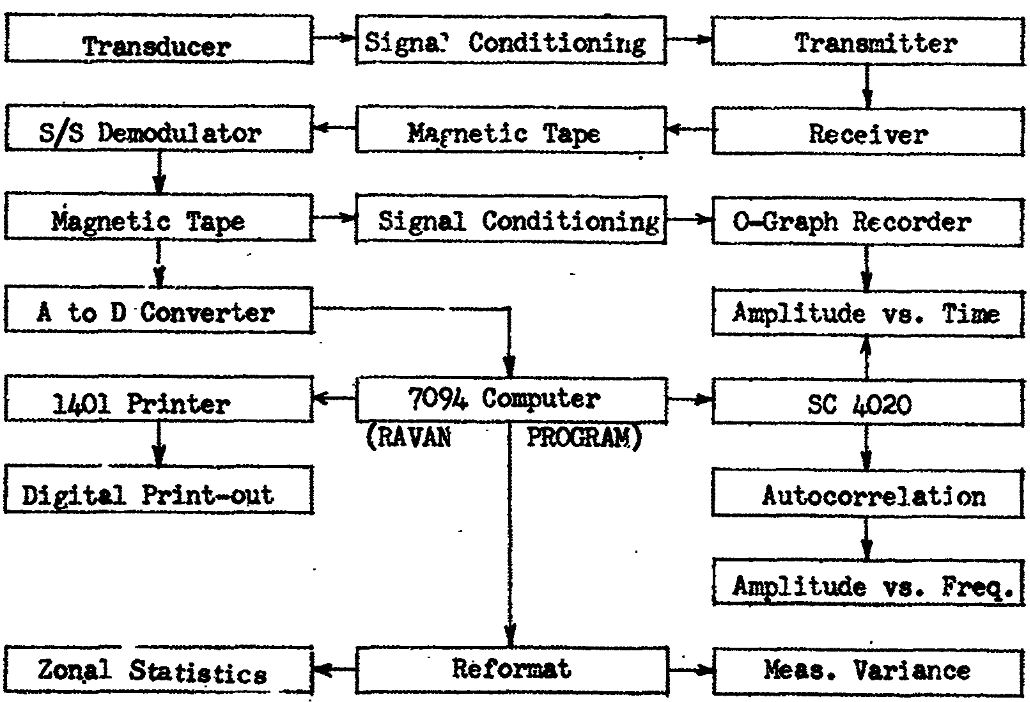
The most useful data obtained from the program are in the spectral analysis format. Spectral density plots are employed to define the frequencies of most severe vibration and the energy content of portions of the spectrum. It is important to note that the power spectrum is the Fourier transform of the autocorrelation function.

The vibration power spectrum, in terms of mean square amplitude per cycle per second (G^2/cps), and the sound pressure spectrum level, in terms of decibels per cycle per second (dB/cps), are the most convenient spectral analyses for engineering applications and are the ones presented in this report.

The spectral plots presented in Appendix B show the maximum response amplitudes (G^2/cps or dB/cps) that occurred during powered flight. In general, these maxima occurred during launch and max Q. The launch spectral analyses were not available for all measurements of time-shared telemetry assignments. For these measurements, the maximum available spectra are shown for the indicated flight times.

The vibration and acoustic data were analyzed with an effective bandwidth of ten cycles per second. No correction factor has been added to the data to account for the roll-off in the telemetry system frequency response. Therefore, vibration and acoustic amplitudes below a frequency of 200 cps have been attenuated (from 0.5 dB at 200 cps to 4 dB at 50 cps). Data amplitudes below 50 cps should be disregarded.

TABLE I. Telemetered Data Acquisition and Data Reduction Chart



IV. VIBRATION ENVIRONMENTS

The sources of vibratory excitation for the Saturn vehicle may be classed in three categories:

1. Acoustic
2. Mechanical
3. Aerodynamic

The acoustic noise is generated by the turbulent mixing of the engine exhaust gases with the surrounding atmosphere. It is most predominant at launch and gradually diminishes as the vehicle velocity approaches the speed of sound. Acoustic noise is the most damaging to skin and panel structures and to electronic components.

The mechanical vibrations are generated within the engine combustion chambers and take the form of structural vibration. This vibration is transmitted from the engines through the thrust structure and up into the vehicle. The mechanical vibration is most damaging to structures and components located adjacent to the engines.

The aerodynamic source is generated by the turbulent boundary layer surrounding the vehicles as the speed approaches Mach 1 and the vehicle passes through the condition of maximum dynamic pressure (max Q). These sources are often compared to the acoustic source because the pressure fluctuation effects are similar. Aerodynamic excitation is most damaging to the exterior structures and components attached thereon.

The vibration environments measured during the flight of SA-10 compared favorably with the past history levels established on previous Saturn I, Block II vehicles. The maximum environments for the S-I stage and the instrument unit occurred during the periods of launch and maximum dynamic pressure. Vibration excitation was extremely low during the S-IV portion of the flight. No evidence of structural fatigue or component malfunction was noted during the flight.

A. <u>S-I Stage Structure</u>

The SA-10 S-I stage structural vibration was measured with seven accelerometers. All telemetered data were valid throughout powered flight. The measured response of the S-I stage structure was normal and did not exceed expected levels.

Maximum vibration was induced by the acoustic and aerodynamic noise environments present during launch and max Q.

1. Shear Beam/Shear Panels: (E135-9, E136-9, E139-9 and E140-9)

The thrust frame structure was instrumented in three locations with four accelerometers. Transducers were located on the shear panel and the "E" beam between fin lines III and IV and on the shear panel between fin lines I and II. The shear panel transducers were located adjacent to the attachment of the shear panel and the respective thrust post of engines No. 1 and No. 3.

The composite response amplitude of the shear beam measurement (E135-9) showed excellent correlation with the past history envelope. A maximum amplitude of 7.03 G_{rms} was recorded shortly after max Q. The SA-8 maximum was 7.5 G_{rms} during the same flight period. The predominant frequency noted during critical flight periods was 600 cps. This compared favorably with the 570 cps recorded on SA-8.

The composite response amplitude of the shear panels between fin lines I and II was similar to that obtained during previous Saturn I, Block II flights. Greatest excitation occurred during the launch, Mach 1, and max Q periods of flight. A maximum vibration level of 13.71 G_{rms} was recorded during launch in the axis perpendicular to the panel (E140-9). This amplitude was 2.81 G_{rms} higher than that recorded on SA-8 during the launch period.

The composite response amplitude of the shear panel located between fin lines III and IV (E136-9) appeared to be normal throughout flight. The response on SA-10 was 12.2 G_{rms} less than SA-8 at T + 90 seconds. The data obtained on SA-10 compared closely with that received on SA-5 and SA-6.

An effort is being made to correlate data from E136-9 on flights SA-9, SA-8, and SA-10 to engine No. 3 performance. This irregular response phenomenon noted on the past three flights seems to be related to the chamber pressure of engine No. 3. However, the data from the combustion chamber domes is again questionable on this flight. For this reason, vibratory excitation from the engines cannot be adequately defined or correlated with shear panel response.

2. Spider Beam/Upper Structure: (E105-11, E107-11)

Spider beam response to vibratory excitation was measured in two mutually perpendicular axes. Accelerometers were located on a radial beam of the spider beam structure along fin line I. The response at the exterior location (spider beam) was generally consistent with previous data.

As expected, vibration at the exterior spider beam spoke was greatest in the yaw axis (E107-11). A maximum composite response of 9.94 G_{rms} (predominant at 590 cps) was measured in this axis during max Q. This compared with a maximum SA-8 composite response of 7.54 G_{rms} at the same flight event. The SA-8 excitation was greatest at 590 cps.

A maximum composite response of 5.57 G_{rms} was measured in the longitudinal axis (E105-11) at holddown The predominant frequency was 1404 cps.

B. S-I Engine Components

Sixteen vibration measurements were made on the S-I stage engine components. These components included the combustion chamber dome and turbine gear box. The vibration environment noted on the turbine gear box measurements indicated a normal S-I powered flight. The data obtained from the combustion chamber dome measurements were not considered valid.

1. Thrust Chamber Dome: (E11's, E33's)

The vibration of the thrust chamber domes was measured in the lateral direction on engines No. 2, 4, 6, and 8 and in the longitudinal direction on engines No. 1, 3, 5, and 7.

The vibration environment of the thrust chamber domes has not been defined satisfactorily on any Block II vehicle. It has been concluded that telemetry instrumentation from this region is affected by some type of external environment that prohibits the acquisition of valid vibration data. Further studies are being performed to define this problem.

2. Turbine Gear Box: (E12-1 through E12-8)

The SA-10 vehicle was the first to employ a gear box measurement on each of the eight booster engines. Each accelerometer measured vibration in a direction parallel to the pump axis. The vibratory responses showed excellent agreement with the levels established on previous Block II vehicles.

The predominant response frequencies associated with the turbopumps were approximately 1100, 1600, and 2200 cps. These frequencies shifted upward by about 50 cps during powered flight indicating an increasing turbopump rpm as flight progressed.

The eight turbine gear box measurements showed a constant composite response throughout flight with a maximum of 36 G_{rms} recorded on E12-4 just prior to the engine cutoff sequence at T + 142 seconds. The highest discrete frequency amplitude during this period was 5 Grms at 2200 cps.

C. S-I Fuel Tank Skirt Component

There was one accelerometer attached to the ring frame in the lower skirt region of fuel tank No. 1, adjacent to the 9A3 distributor. The response amplitudes and frequencies were consistent with the response parameters measured during previous Saturn I, Block II flights.

Vibratory response of the ring frame in the lower skirt region of fuel tank No. 1 was measured near the point of attachment of the 9A3 measuring distributor mounting bracket (E270-9). Data from a longitudinal axis vibration measurement at this location are indicative of input excitation to the distributor mounting bracket.

The maximum composite response reached 3.91 G_{rms} near max Q. The predominant frequency associated with this amplitude was 95 cps. The corresponding SA-8 maximum was 3.54 G_{rms} at 425 cps.

D. Instrument Unit

The instrument unit vibration environment was monitored with 24 accelerometers. The structural configuration was the same as that of SA-8 and SA-9. The I. U. vibration levels of SA-10 showed good correlation with those obtained on SA-8. All 24 measurements gave good data throughout powered flight.

1. Guidance System: (E90-802 through E95-802, E345-802, E346-802, E347-802)

The vibration environment for the ST-124 guidance system was very similar to the levels recorded on the SA-8 and SA-9 vehicles. The response levels were minimal except during the Mach 1 and max Q periods of flight.

The vibration levels between the mounting frame and the inertial gimbal were attenuated to a lesser degree than they were during the SA-8 flight. The attenuation between the support structure and the mounting frame was much less than on the SA-8 flight; however, the attenuation corresponded well with the SA-9 flight.

The vibration of the ST-124 guidance system was measured on the inertial gimbal, the mounting frame, and on the support structure. The support measurements were located on the upper mounting ring near the point of attachment of the mounting frame and the upper mounting ring.

The inertial gimbal measurements (E90-802 through E92-802), mounting frame measurements (E93-802 through E95-802), and the support measurements (E345-802 through E347-802) all recorded vibration levels that agreed with the past history environment established on SA-8 and SA-9.

The maximum response recorded on the inertial gimbal was 0.4 G_{rms} at 180 cps in the pitch direction at max Q and 0.4 G_{rms} at 120 cps in the pitch direction during liftoff.

The mounting frame response showed the highest amplitude, 1.4 G_{rms} at 175 cps recorded in the longitudinal direction at liftoff.

The maximum response on the support structure was 1.2 G_{rms} at 1534 cps at max Q.

2. Structure: (E359-802 through E362-802, E379-802 through E382-802)

The I.U. structural vibration environment was measured by eight accelerometers located on the upper (Apollo) and lower mounting rings. The SA-10 transducer locations and structural configuration were identical to those of SA-8 and SA-9.

A comparison of SA-10 flight data with those of SA-8 and SA-9 revealed that the SA-10 composite vibration levels compared favorably with the past history envelope established by the two previous flights. The maximum composite level recorded for SA-10 was 7.9 G_{rms} occurring at liftoff. This level was recorded by measurement E382-802, located on the lower mounting rings between fin line III and IV perpendicular to the flight path.

The maximum response of the lower mounting ring of the I U structure was 1.46 G_{rms} at 505 cps. The upper (Apollo) mounting ring experienced a maximum response of 0.74 G_{rms} at 695 cps.

Vibration levels measured on the I.U. structure during S-IV powered flight were minimal.

3. Components: (E348-802, E349-802, E352-802 through E356-802)

The vibration input to various components within the I.U. was measured on the honeycomb panel support structure with seven accelerometers. The composite vibration amplitudes compared very closely with the SA-8 and SA-9 levels and were not considered to be detrimental to the proper functioning of the air supply, RF assembly, or the guidance computer. As had been observed during SA-8 and SA-9, the vibration perpendicular to the panel surface was the highest for all three measurement groups.

The air bearing supply (E348-802 and E349-802) experienced a maximum input of 1.7 G_{rms} at 235 cps during liftoff and 1 G_{rms} at 245 cps at max Q.

The input to the RF assembly (E352-802 and E353-802) reached a maximum of 0.7 G_{rms} at 155 cps during liftoff and 0.5 G_{rms} at 155 cps at max Q.

The input to the guidance computer (E354-802 through E356-802) reached a maximum of 0.7 G_{rms} at 220 cps during launch and 1.3 G_{rms} at 220 cps at max Q.

E. Pegasus (Apollo) Vibration: (E369-900 through E372-900)

The vibration environment of the Pegasus micrometeoroid capsule (MMC) was measured by four accelerometers located on the mounting structure. Two measurements were made at the upper end of longeron No. 6, adjacent to the point of attachment to the Pegasus, and two were made at the lower end near the point of attachment to the Apollo boilerplate structure. The vibration levels of SA-10 compared closely with the past history envelope established by SA-8 and SA-9.

The maximum response at the upper point of attachment (E369-900 and E370-900) was 0.65 G_{rms} at 495 cps during launch, and 0.61 G_{rms} at 395 cps at max Q. At the lower attachment point (E371-900 and E372-900), the maximum response was 0.47 G_{rms} at 580 cps during launch and 0.36 G_{rms} at 260 cps at max Q.

The vibration levels recorded during S-IV powered flight were considered negligible.

F. Special Low Frequency Instrumentation (Pegasus): (E375-900, E376-900, and E384-900)

Three low frequency vibration measurements were installed on the Pegasus MMC to survey vibration environment in the 0 to 35 cps range. E375-900 and E376-900 were mounted on longeron No. 3 at approximate station 1580. E384-900 was located at the top tie point hub assembly, station 1768.5. E384-900 and E376-900 measured vibration in the lateral direction, or perpendicular to the line of flight. E375-900 measured the vibration in the longitudinal direction. Measurements E375-900 and E384-900 showed a close correlation with the low frequency data obtained on SA-9.

The maximum response denoted by E375-900 was 0.09 G_{rms} at 11 cps at liftoff. E384-900 indicated a maximum response of 0.056 G_{rms} at 7 cps, also at liftoff.

Measurement E376-900 showed a marked increase in vibration environment over the SA-9 flight data. A composite level of 3.36 G_{rms} was recorded on SA-10 at liftoff compared with 0.26 G_{rms} on SA-9 during the same flight event.

The maximum response of E376-900 was 0.58 G_{rms} at 6 cps at liftoff compared with 0.075 G_{rms} at 15 cps on SA-9, also at liftoff.

Since low frequency data have been reduced on only SA-9 previously, it is difficult to establish what a normal response for these measurements should be. In addition, the fact that E384-900 showed very low vibration levels in the lateral direction leaves some question as to the validity of the high levels recorded on E376-900.

V. ACOUSTIC ENVIRONMENT

Three internal acoustic measurements were made on the SA-10 flight vehicle. One measurement was located on the thrust structure of the S-I stage at station 171.75. The second measurement was located in the I.U. at station 1480, and the third was located in the Apollo stage at station 1495. The measurements on the Apollo and I.U. were in good agreement with the predicted levels and the past history environment of SA-8. The S-I stage acoustic measurement was considered invalid.

A. S-I Stage: (L28-9)

The acoustic measurement on the S-I stage was made at station 171.25, 22.5° off fin line III toward fin line II in the thrust structure area. This measurement was invalid and no usable data were obtained. The character of the data indicates that it is possible that condensation from the thrust area caused a malfunction in the data acquisition system.

B. Instrument Unit: (L66-802)

The internal measurement on the I. U. was located at station 1480, 45° off fin line II toward fin line III. The acoustic environment agreed very well with the predicted and the measured environments established on SA-8 and SA-9. The most severe acoustic environment measured during launch was 138.5 dB; at max Q, 128.5 dB.

C. Apollo Adapter: (L70-900)

The internal measurement in the Apollo adapter was located along fin line I at station 1495. The highest environment was 139.5 dB measured during launch. The in-flight environment near Mach 1 and max Q was 137.6 dB, 5 dB higher than that measured during SA-9. The SA-8 environment was comparable to the SA-10 environment during the period of Mach 1, however the max Q levels were more comparable to those during the flight of SA-9. The change in the acoustic environment at this location is the result of the addition of a control motor along fin line I upstream of this measurement location for flights SA-8 and SA-10. The motor was mounted externally and protruded into the boundary layer flow generating shocks and turbulence that influenced the acoustic environment immediately downstream. In contrast with SA-8, this excitation persisted in the SA-10 flight through max Q because the positive pitch angle created a thicker boundary layer than was generated in SA-8.

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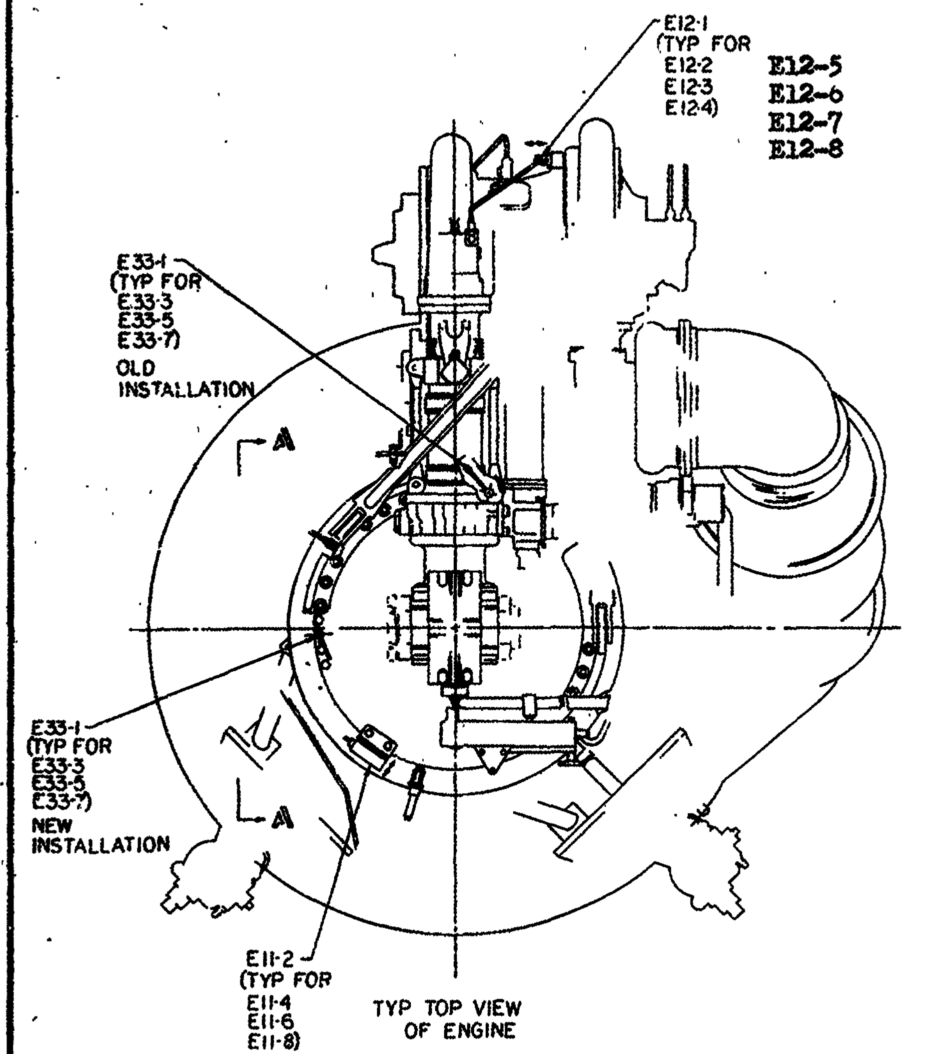
APPENDIX A

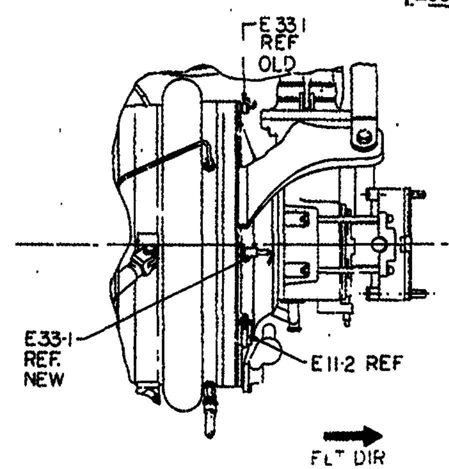
MEASUREMENT LOCATIONS

MEAS	SA5	SA6	SA7	SA8	SA9	SA10
E11-2	X	X	X	X	X	X
E11-4	X	X	X	X	X	X
E11-6	X	X	X	X	X	X
E11-8	X	X	X	X	X	X
E12-1	X	X	X	X	X	X
E12-2	X	X	X	X	X	X
E12-3	X	X	X	X	X	X
E12-4	X	X	X	X	X	X
E12-5						X
E12-6						X
E12-7						X
E12-8						X
E33-1	X	X	X	X	X	X
E33-3	X	X	X	X	X	X
E33-5	X	X	X	X	X	X
E33-7	X	X	X	X	X	X

SATURN I – BLOCK II EFFECTIVITY



TYP TOP VIEW OF ENGINE



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MEASUREMENT LOCATIONS S-I STAGE

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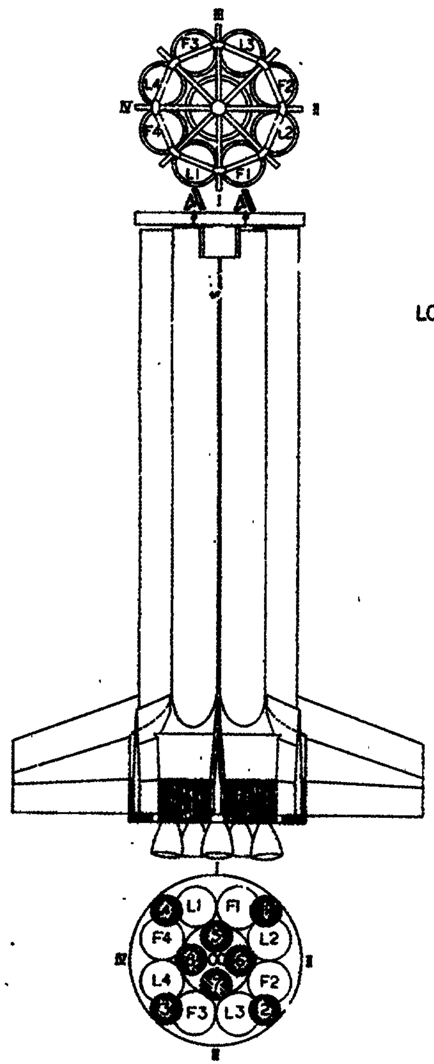

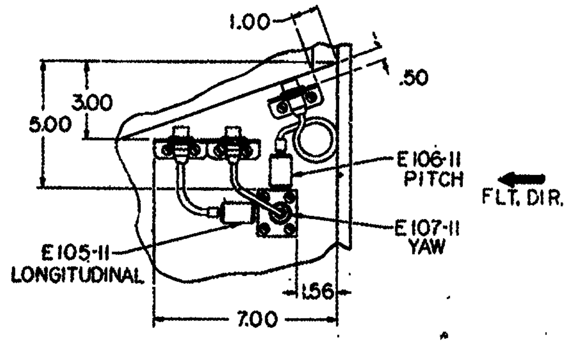

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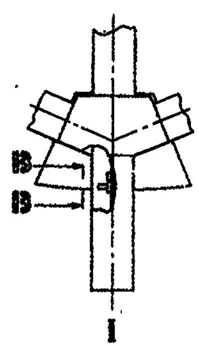

SECTION AA

SATURN I - BLOCK II

EFFECTIVITY

MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E 105-11	X	X	X	X	X	X
E 106-11	X	X	X	X	X	
E 107-11	X	X	X	X	X	X

MEASUREMENT
LOCATIONS
S-I STAGE

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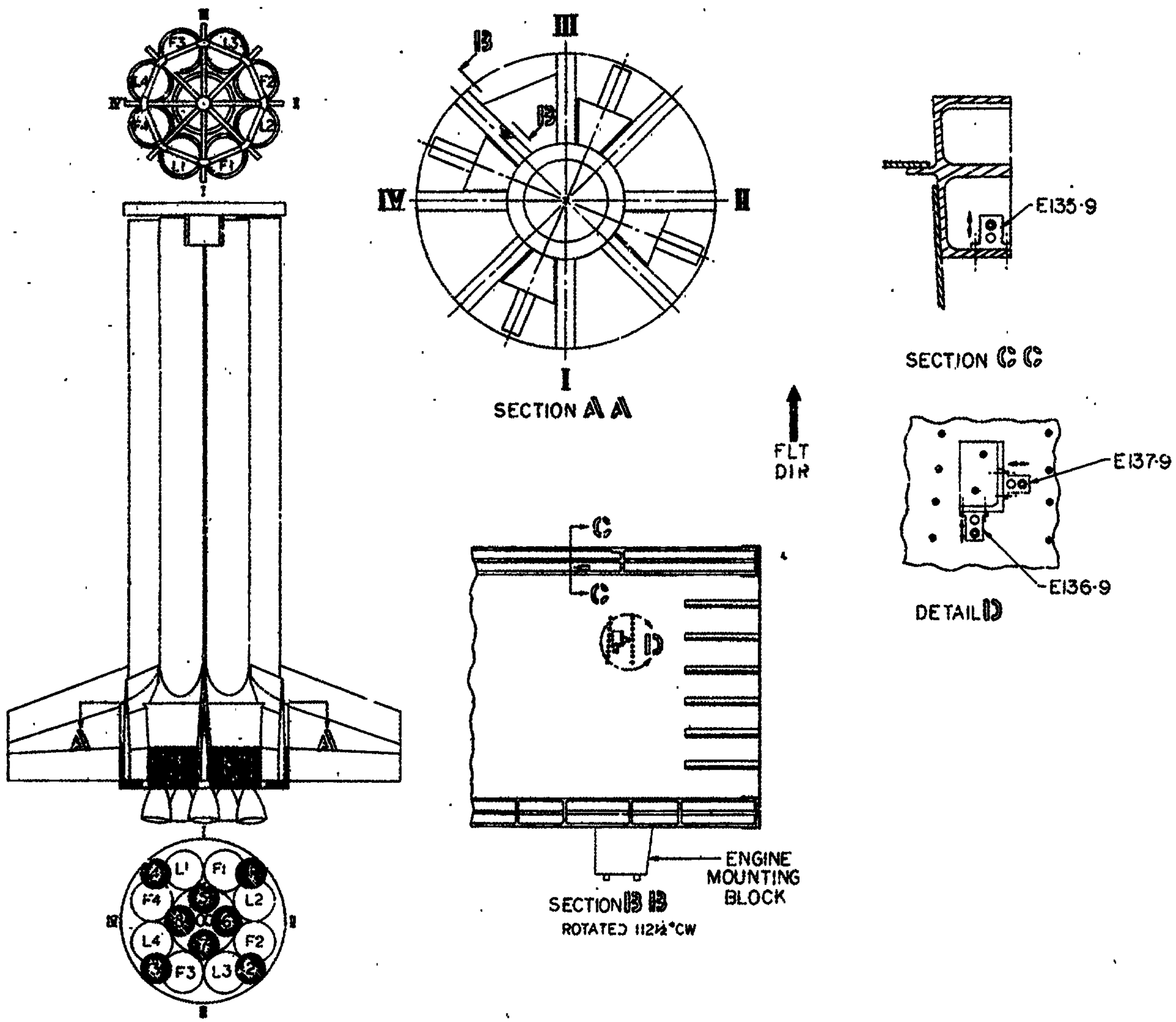

SATURN I - BLOCK II

EFFECTIVITY

MEAS.	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E135-9	X	X	X	X	X	X
E136-9	X	X	X	X	X	X
E137-9	X	X	X	X	X	

MEASUREMENT LOCATIONS SI STAGE

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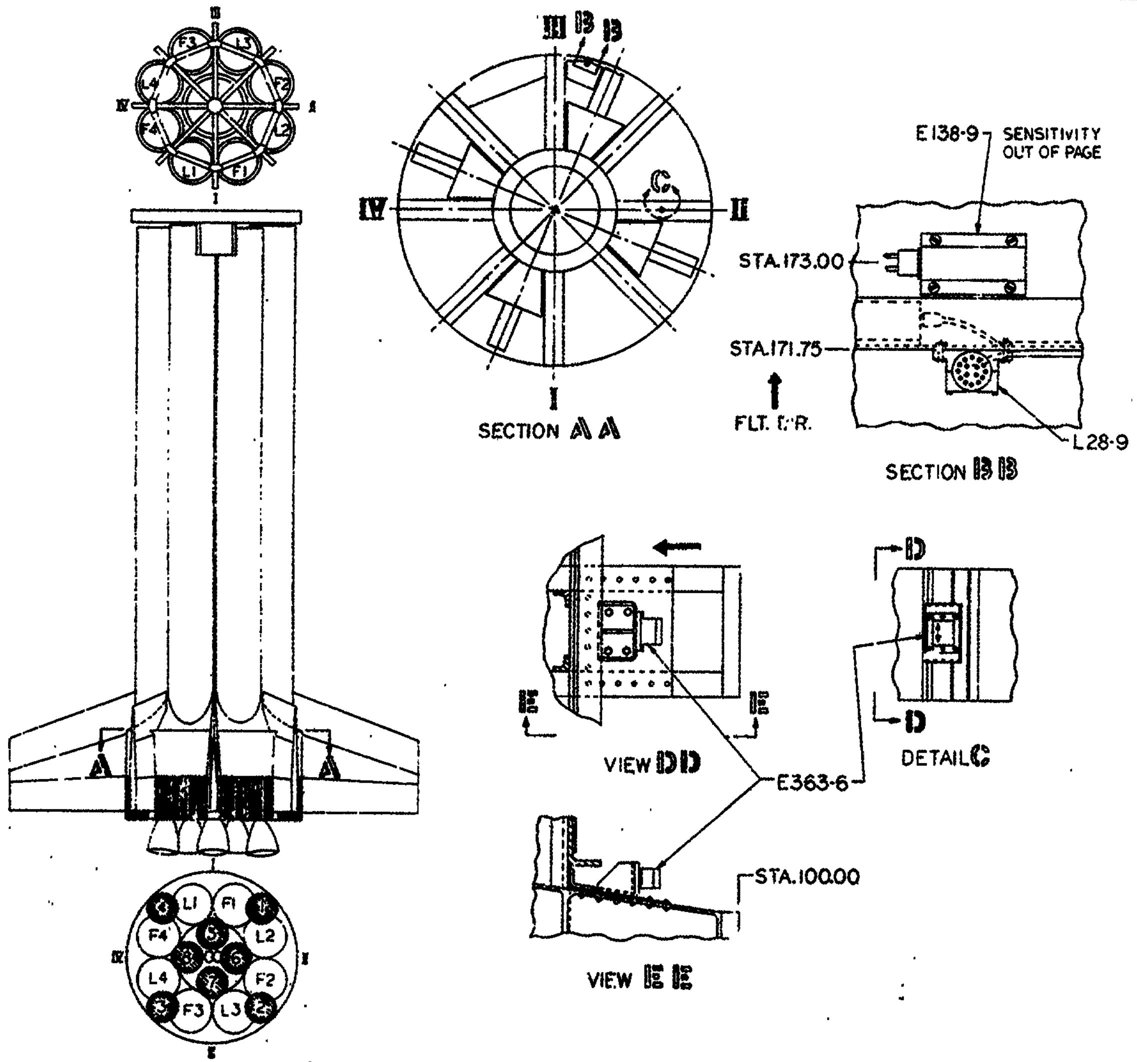
SATURN I - BLOCK II EFFECTIVITY						
MEAS.	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E138-9	X	X	X	X	X	
E363-6	X	X	X	X	X	
L28-9	X	X		X	X	X



MEASUREMENT LOCATIONS S-I STAGE

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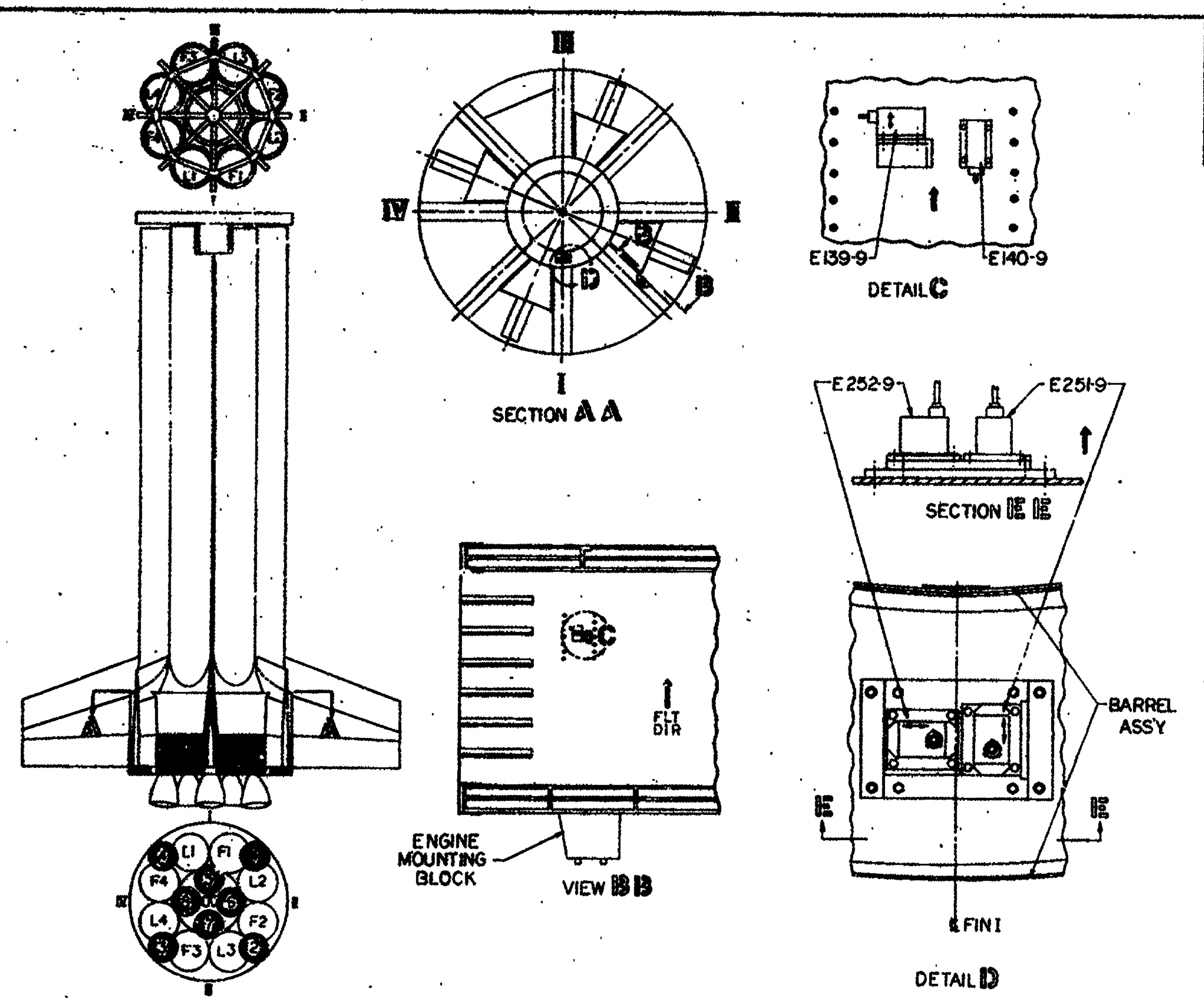

SATURN I - BLOCK II
EFFECTIVITY

MEAS.	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E139-9	X	X	X	X	X	X
E140-9	X	X	X	X	X	X
E251-9	X	X	X	X	X	
E252-9	X	X	X	X	X	

MEASUREMENT
LOCATIONS
SI STAGE

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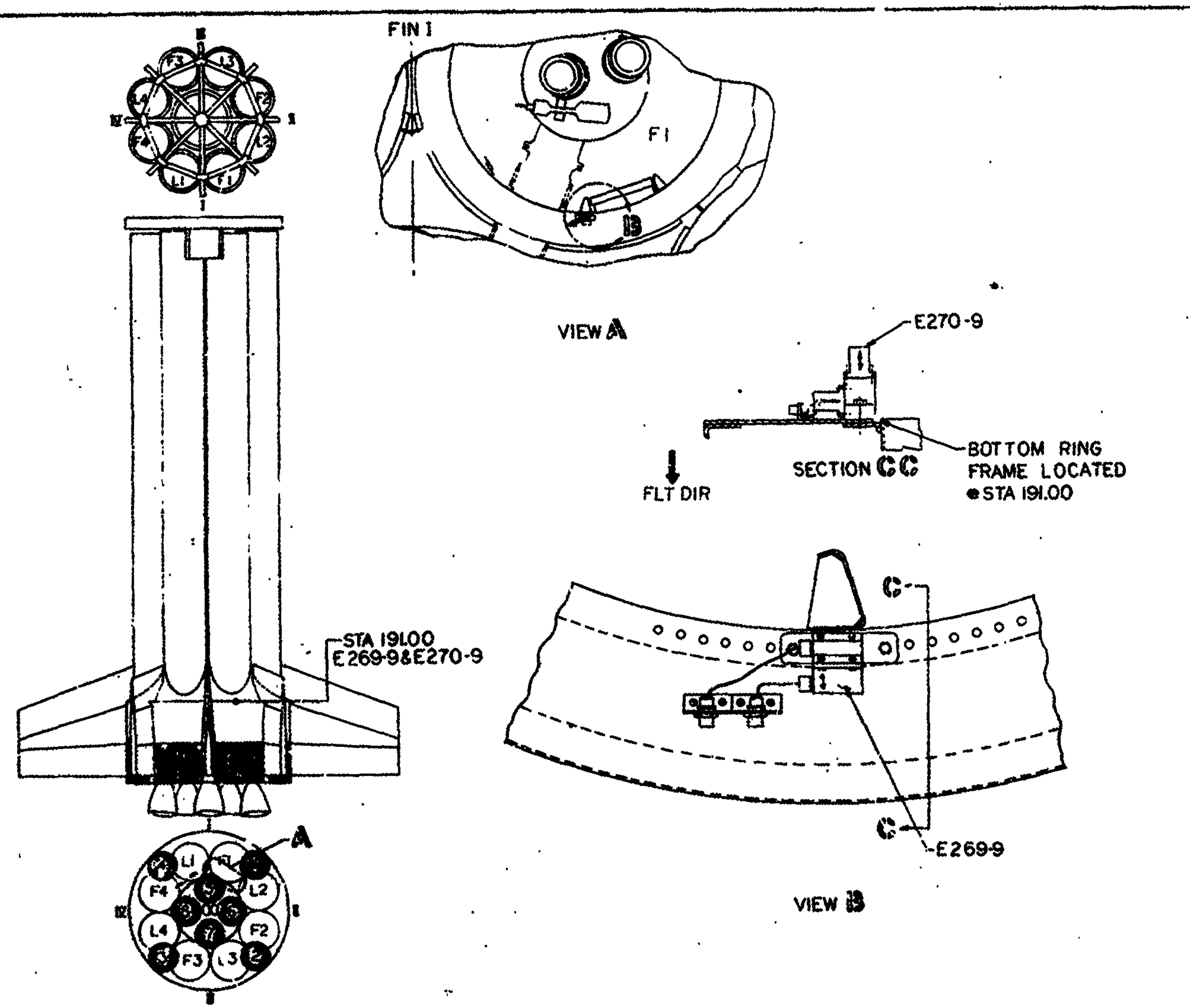
SATURN I - BLOCK II

EFFECTIVITY

MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E 269-9	X	X	X	X	X	
E 270-9	X	X	X	X	X	X



MEASUREMENT
LOCATIONS
S-I STAGE

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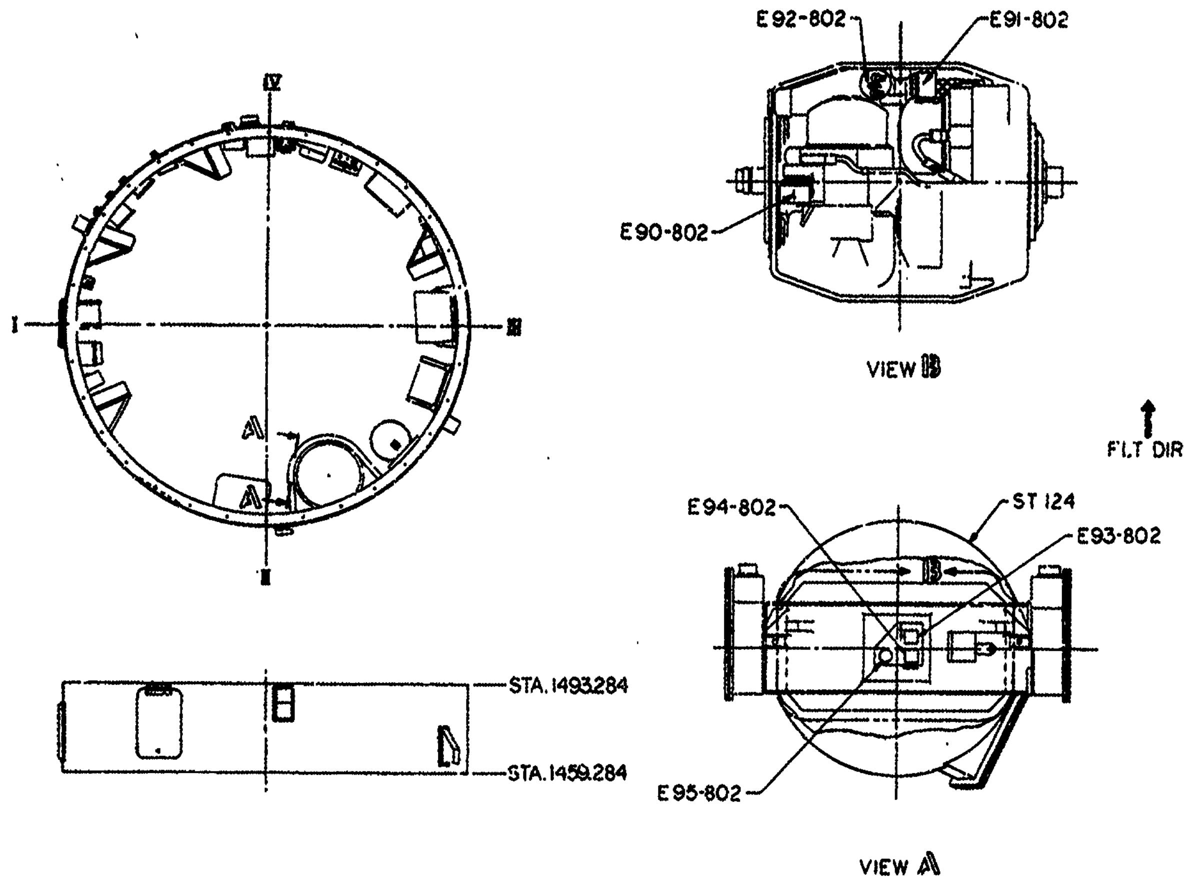
SATURN I - BLOCK II

EFFECTIVITY

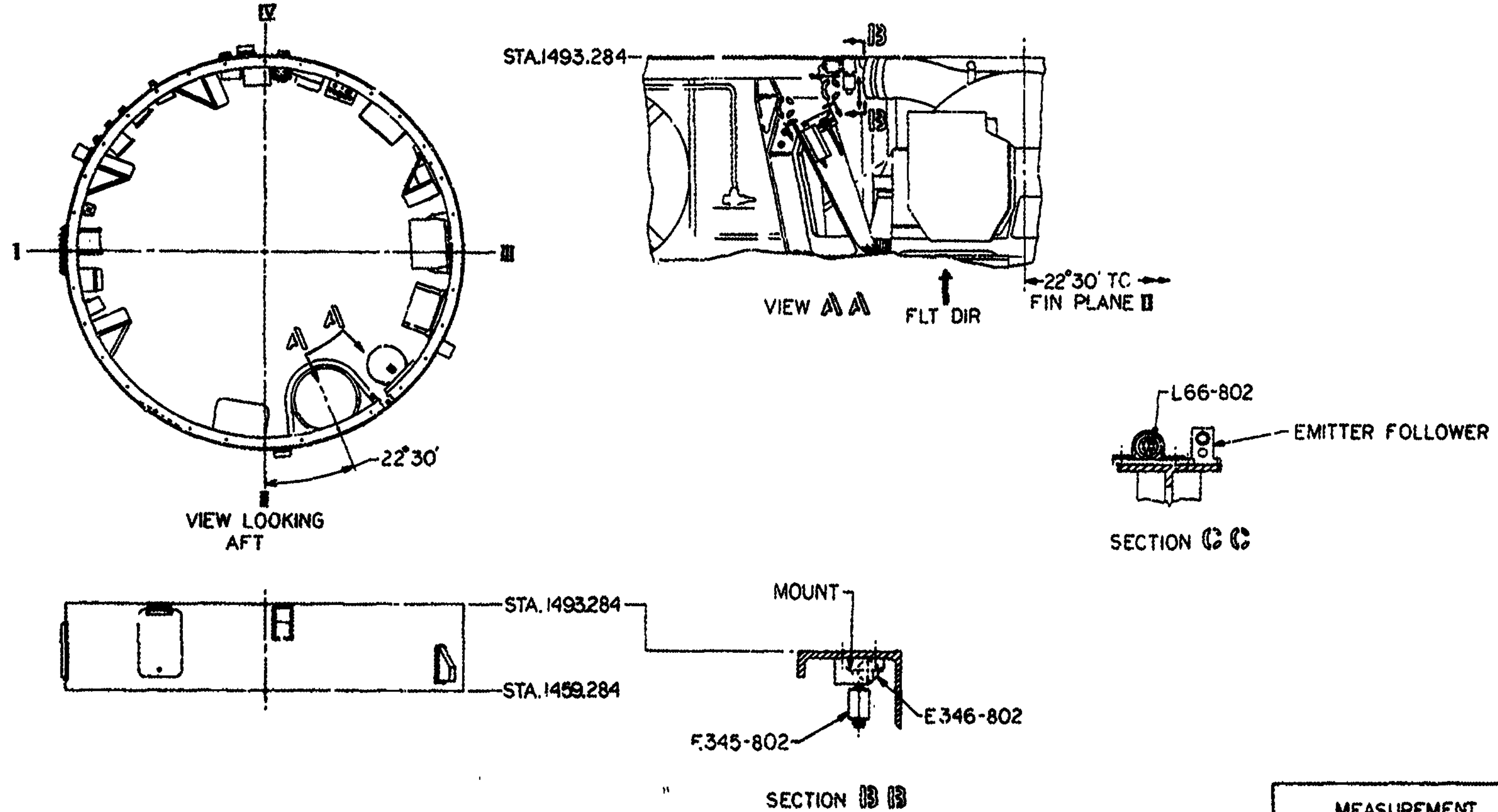
MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E90-802				X	X	X
E91-802				X	X	X
E92-802				X	X	X
E93-802				X	X	X
E94-802				X	X	X
E95-802				X	X	X



MEASUREMENT LOCATIONS IU

CHECKED BY | ORIGINATED BY
DATE 2-8-66 | SHEET 7 OF 17

SATURN I - BLOCK II EFFECTIVITY						
MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E345-802				X	X	X
E346-802				X	X	X
L66-802				X	X	X



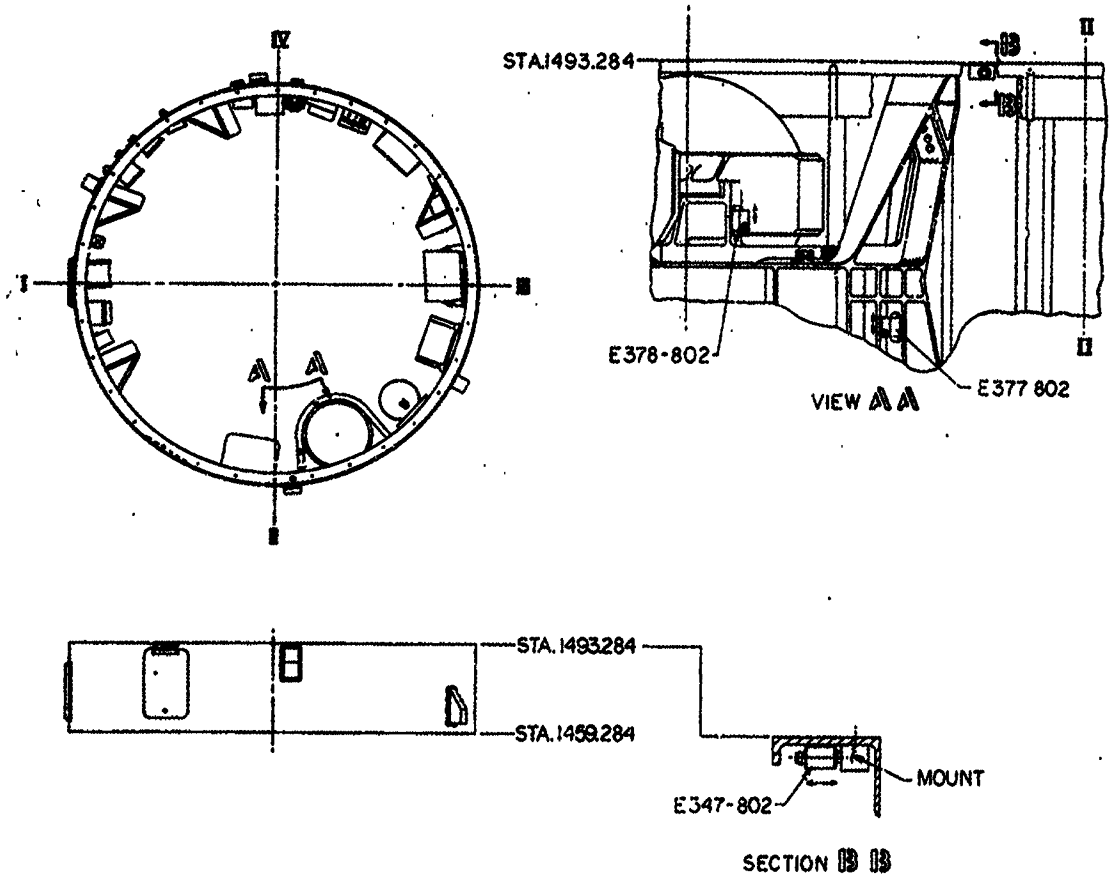
MEASUREMENT LOCATIONS IU

CHECKED BY
ORIGINATED BY
DATE 2-8-66
SHEET 8 OF 17

SATURN I-BLOCK II

EFFECTIVITY

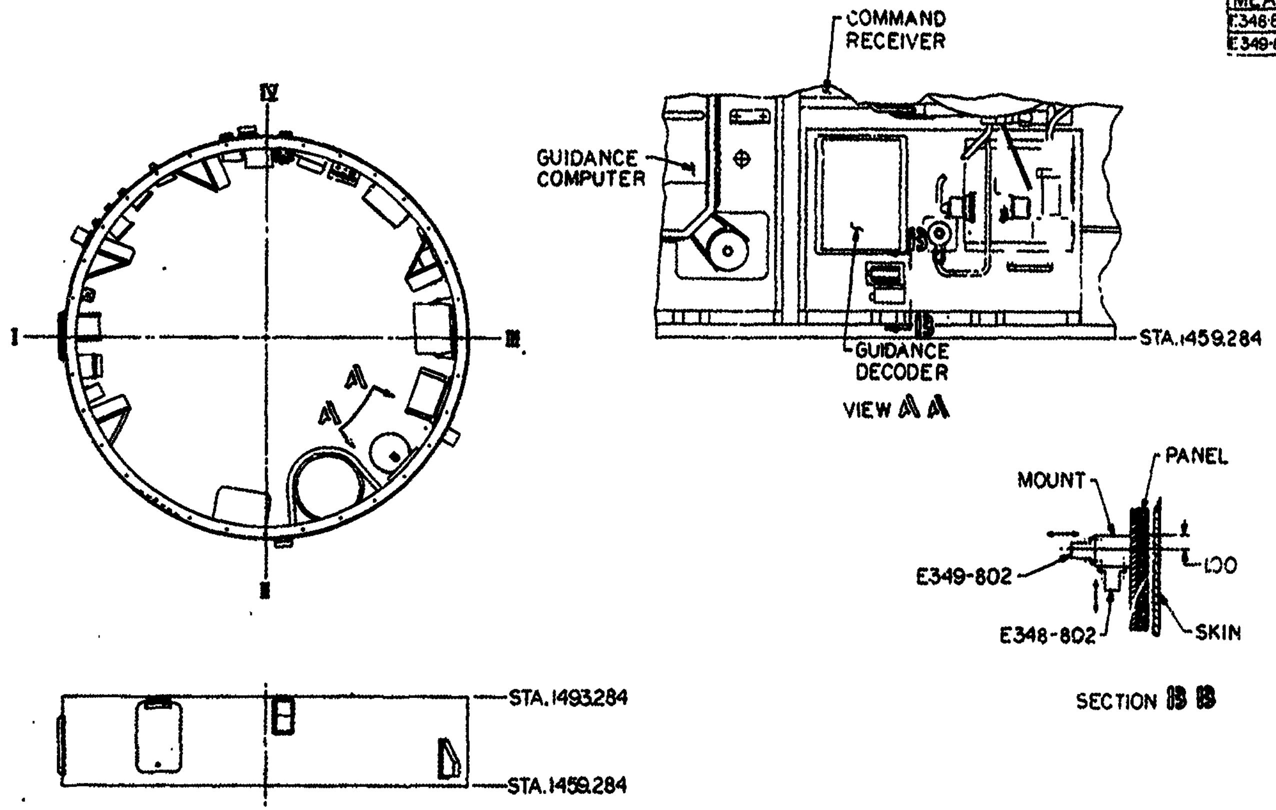
MEAS.	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E347-802				X	X	X
E377-802				X	X	
E378-802				X	X	



MEASUREMENT
LOCATIONS
IU

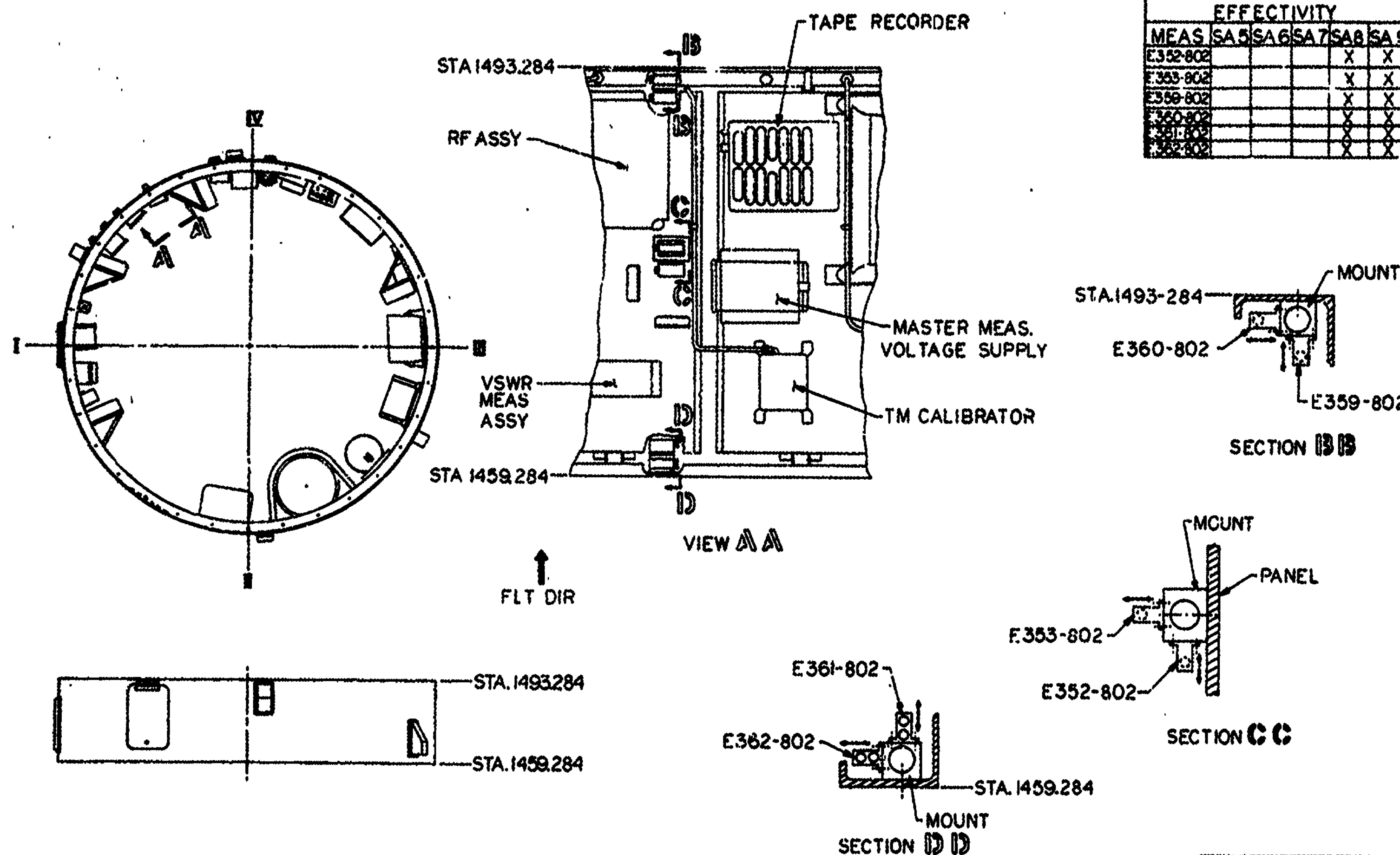
CHECKED BY | DRAWN BY
DATE 2-3-65 | SHEET 9 OF 17

SATURN I-BLOCK II EFFECTIVITY						
MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E348-802				X	X	X
E349-802				X	X	X



MEASUREMENT LOCATIONS IU

CHECKED BY		DRAWN BY	
DATE	2-8-66	SHEET	10 OF 17

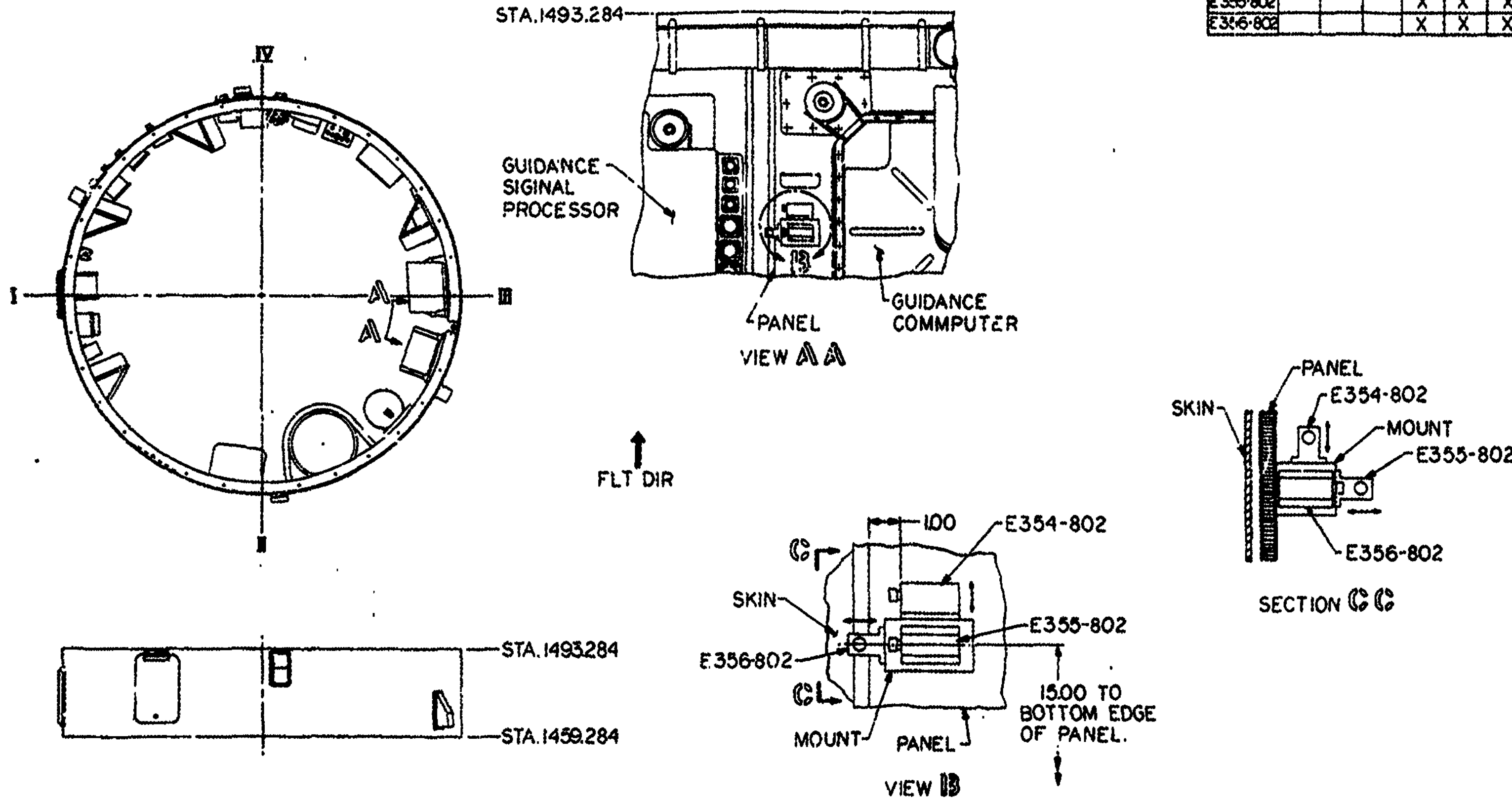


SATURN I-BLOCK II EFFECTIVITY						
MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E352-802				X	X	X
E353-802				X	X	X
E359-802				X	X	X
E360-802				X	X	X
E361-802				X	X	[illegible]
E362-802				X	X	[illegible]

MEASUREMENT LOCATIONS
IU

CHECKED BY | ORIGINATED BY
DATE 2-8-66 | SHEET 11 of 17

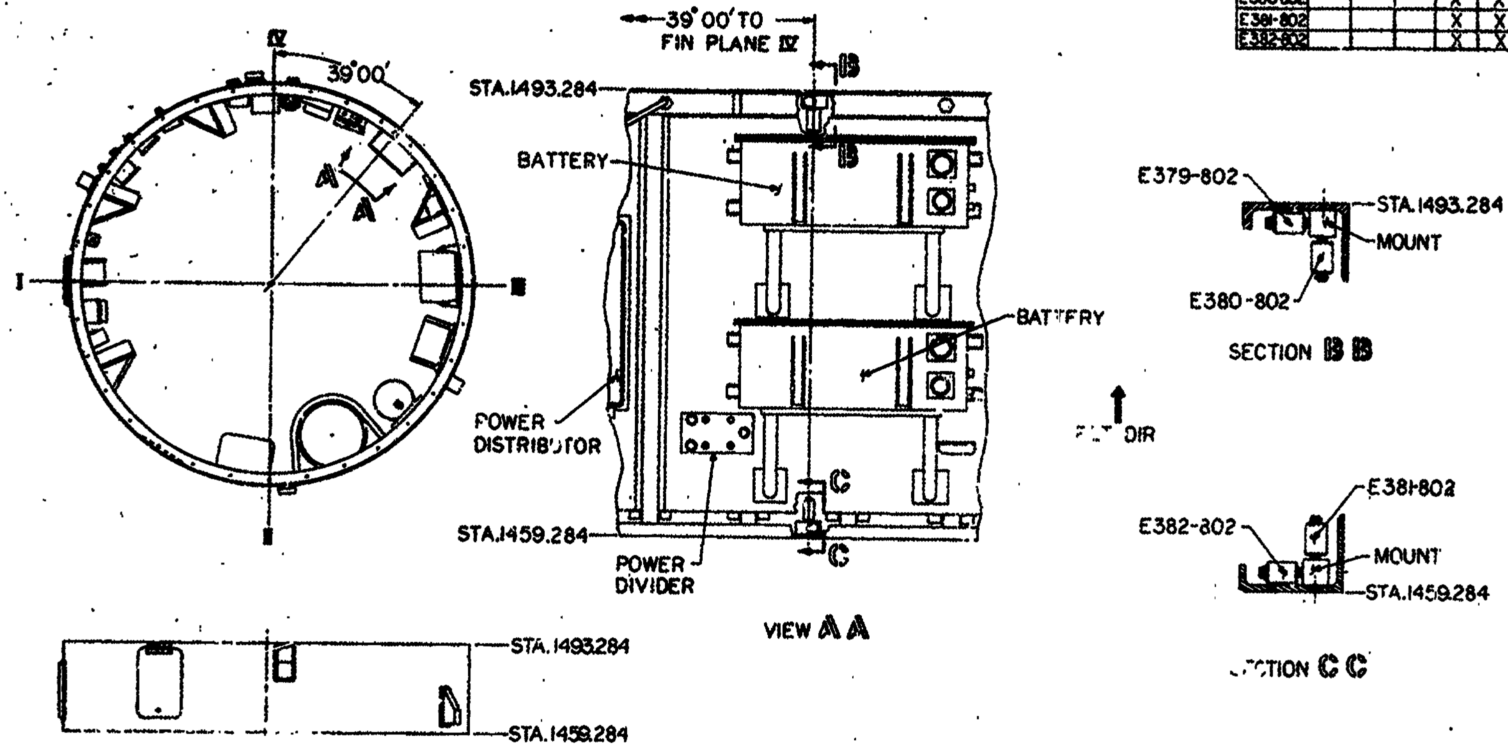
SATURN I - BLOCK II						
EFFECTIVITY						
MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E354-802				X	X	X
E355-802				X	X	X
E356-802				X	X	X



MEASUREMENT LOCATIONS IU

CHECKED	ORIGINATED BY
DATE 2-8-66	SHEET 12 OF 17

SATURN I-BLOCK II EFFECTIVITY						
MEAS.	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E379-802				X	X	X
E380-802				X	X	X
E381-802				X	X	X
E382-802				X	X	X



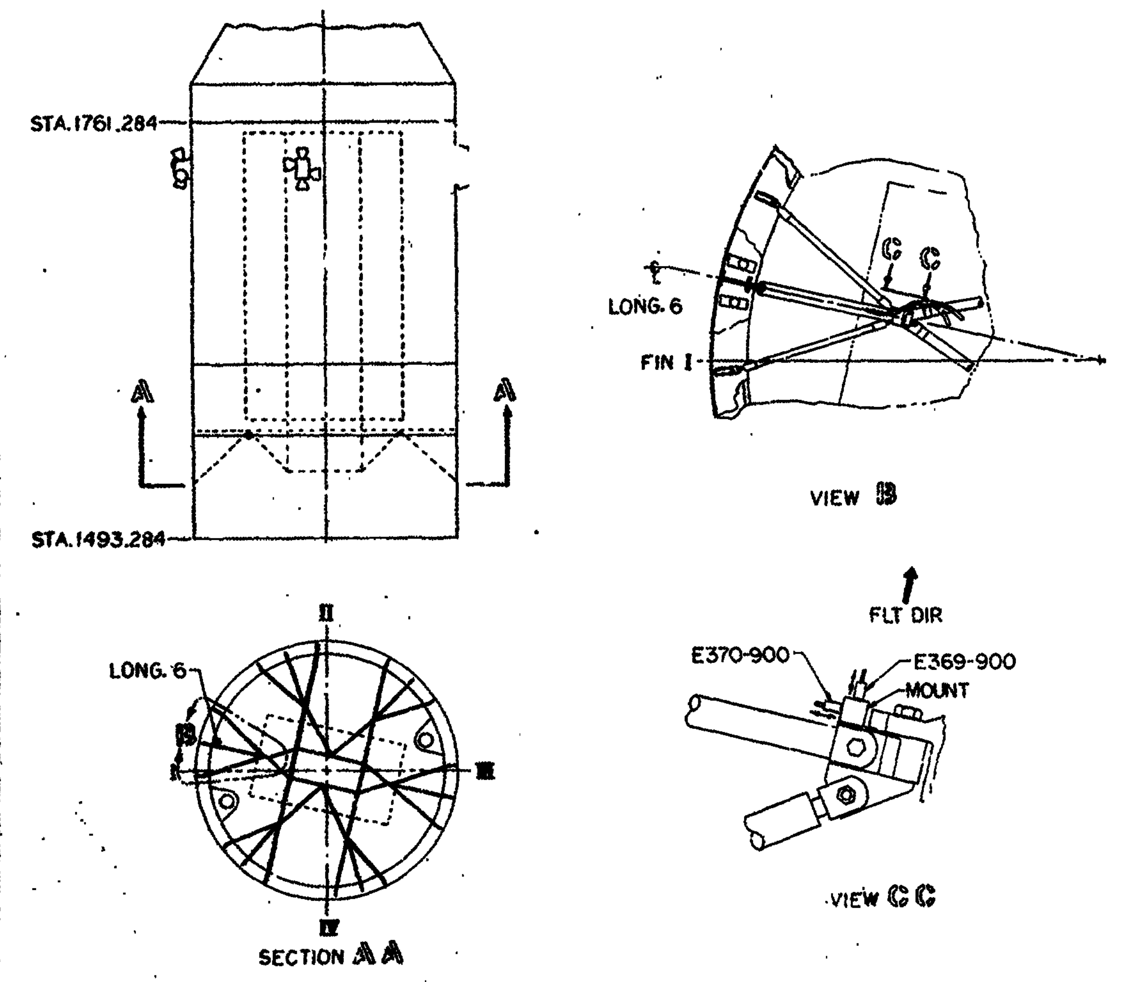
MEASUREMENT LOCATIONS IU

CHECKED BY | ORIGINATED BY
DATE 2-8-65 | SHEET 13 OF 17

SATURN I - BLOCK II

EFFECTIVITY

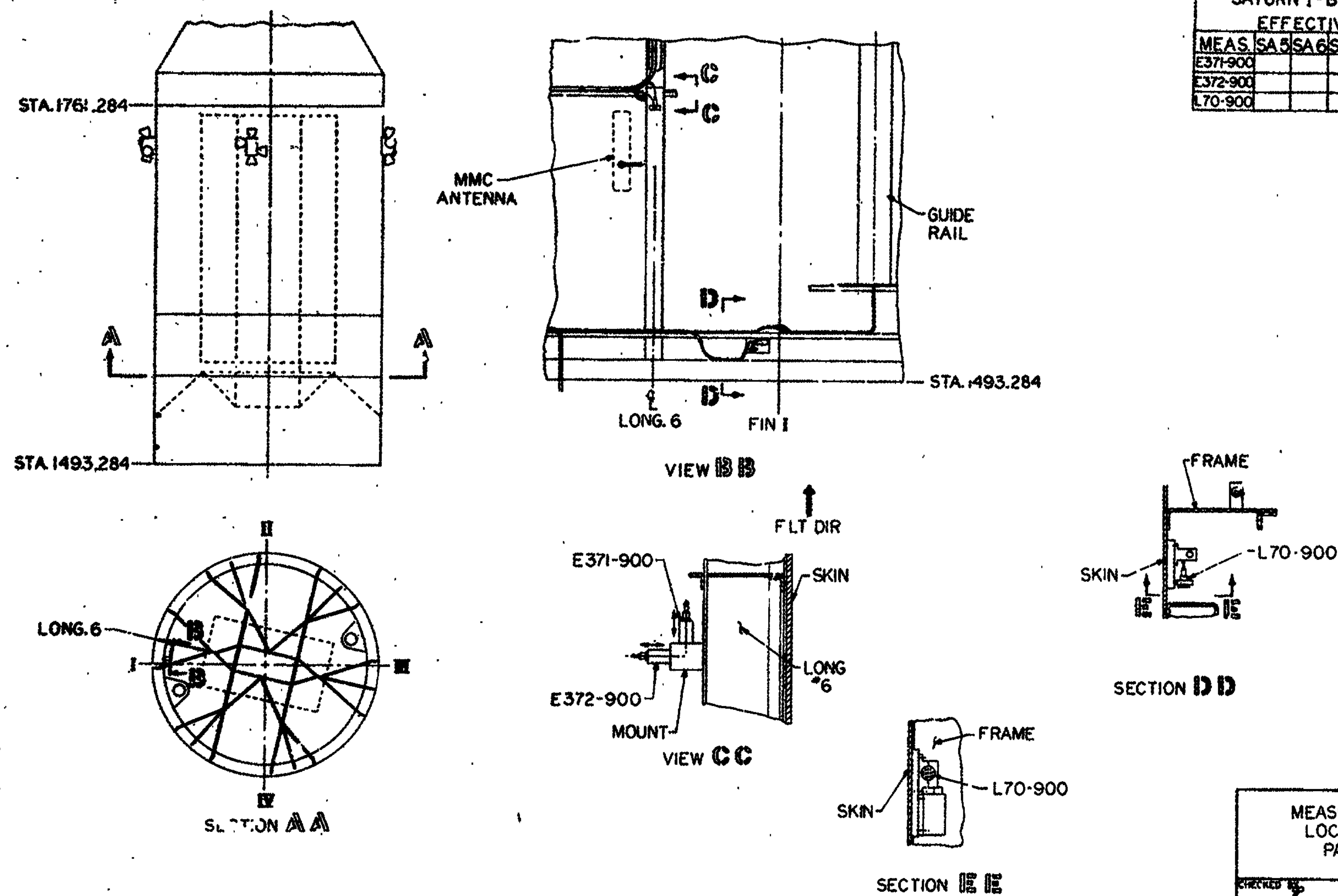
MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E369-900				X	X	X
E370-900				X	X	X



MEASUREMENT LOCATIONS PAYLOAD

CHECKED | DRAWN BY | DATE 3-23-65 | SHEET 14 OF 17

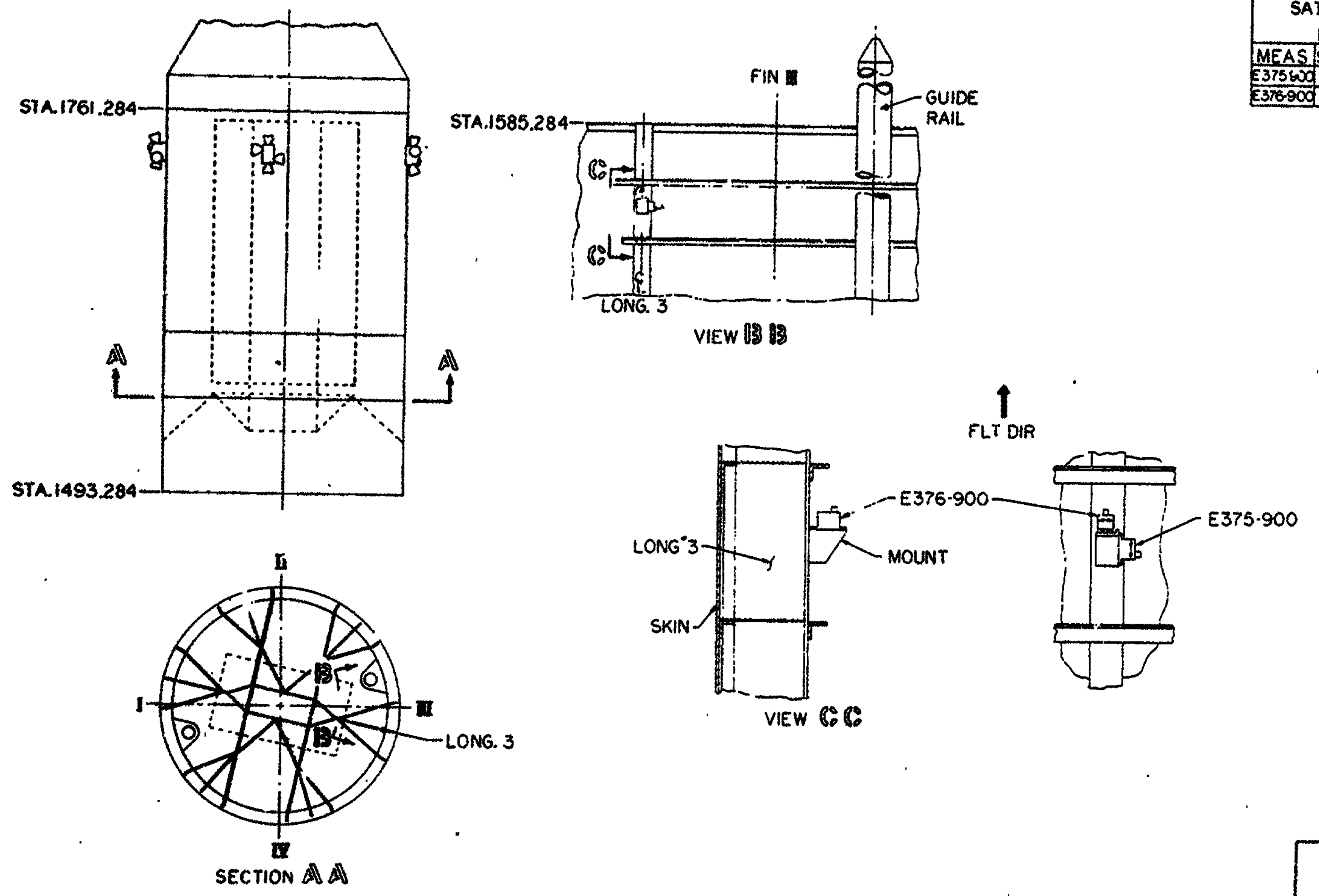
SATURN I-BLOCK II EFFECTIVITY						
MEAS.	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E371-900				X	X	X
E372-900				X	X	X
L70-900				X	X	X



MEASUREMENT LOCATIONS PAYLOAD

CHECKED BY | ORIGINATED BY
DATE 3-23-65 | SHEET 15 OF 17

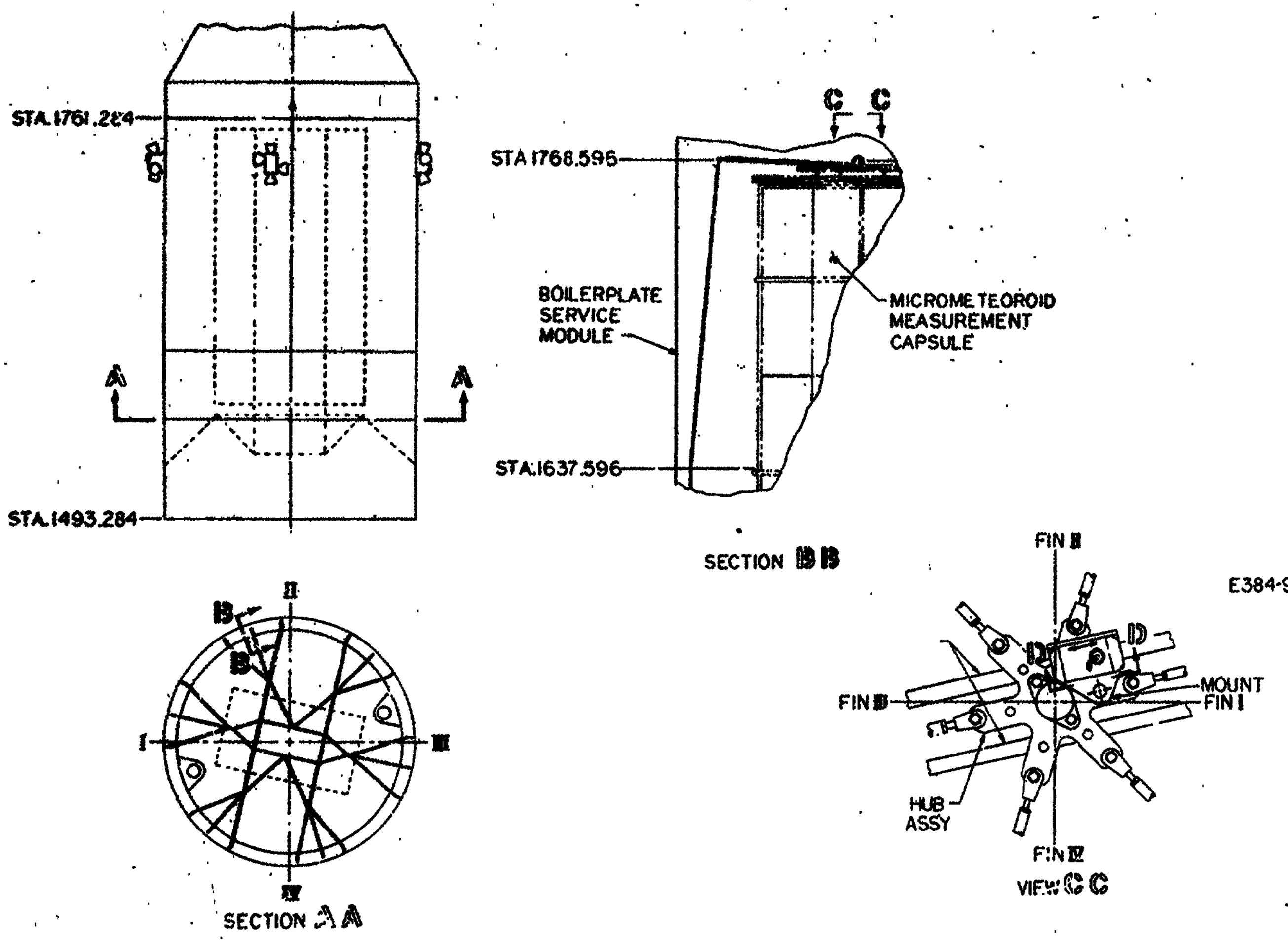
SATURN I - BLOCK II						
EFFECTIVITY						
MEAS	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E375-900				X	X	X
E376-900				X	X	X



MEASUREMENT
LOCATIONS
· PAYLOAD

CHECKED BY | ORIGINATED BY
DATE 3-23-65 | SHEET 16 OF 17

SATURN I - BLOCK II						
EFFECTIVITY						
MEAS.	SA 5	SA 6	SA 7	SA 8	SA 9	SA 10
E384 900				X	X	X



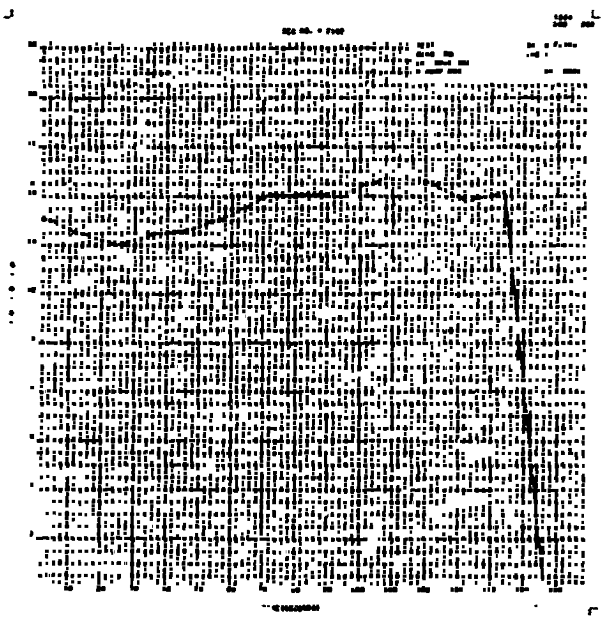
MEASUREMENT LOCATIONS PAYLOAD

CHECKED BY | ORIGINATED BY

DATE 3-23-65 | SHEET 17 OF 17

APPENDIX B

VIBRATION AND ACOUSTIC DATA



TIME HISTORY

Meas. No. E12-1

Description Turbine Gear Box

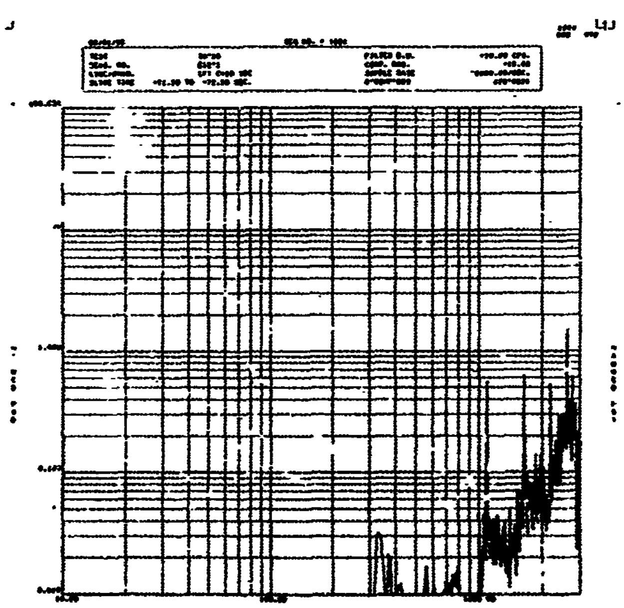
Engine 1

Sensitivity Parallel to Pump Axis

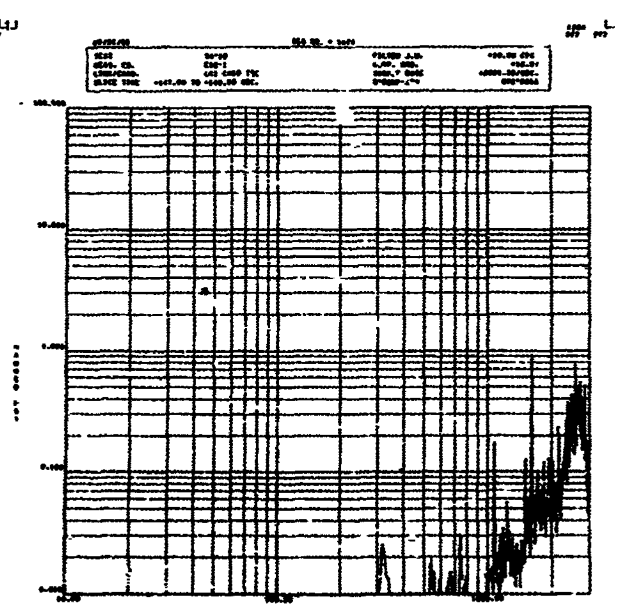
Location: Page 15

Calibration ± 50 G

Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E12-2

Description Turbine Gear Box

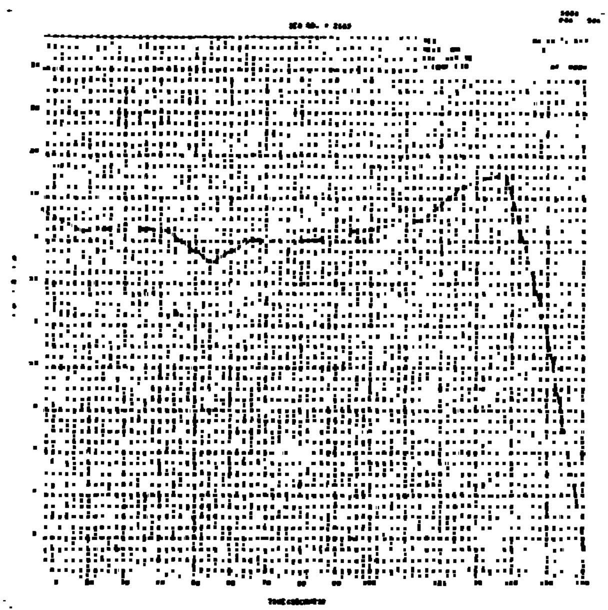
Engine 2

Sensitivity Parallel to Pump Axis

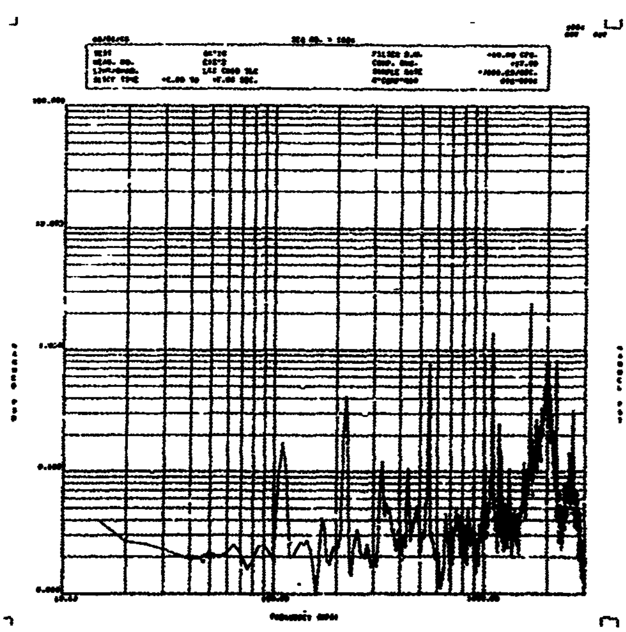
Location: Page 15

Calibration ± 50 G

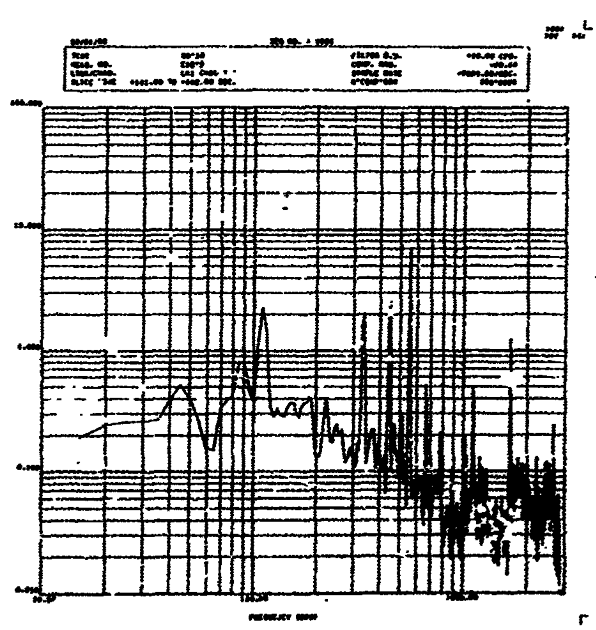
Remarks



TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E12-3

Description Turbine Gear Box

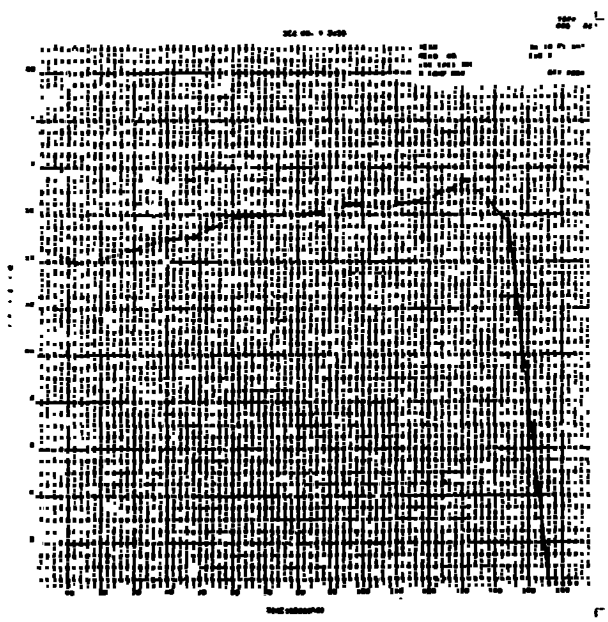
Engine 3

Sensitivity Parallel to Pump Axis

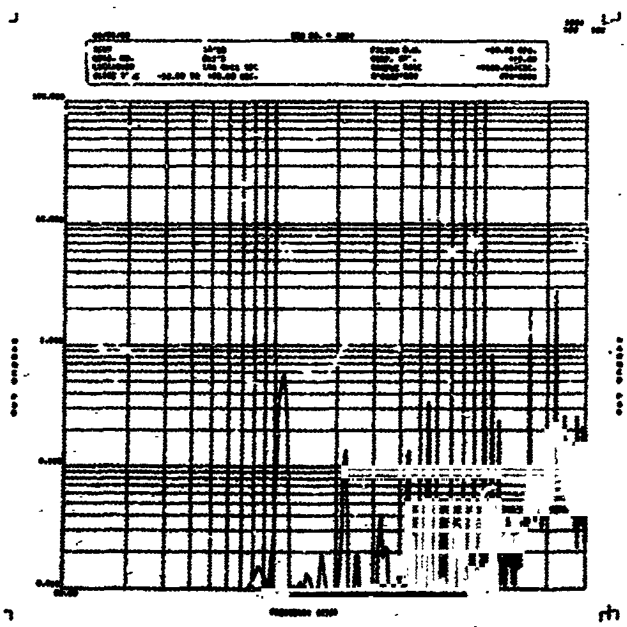
Location: Page 15

Calibration ± 50 G

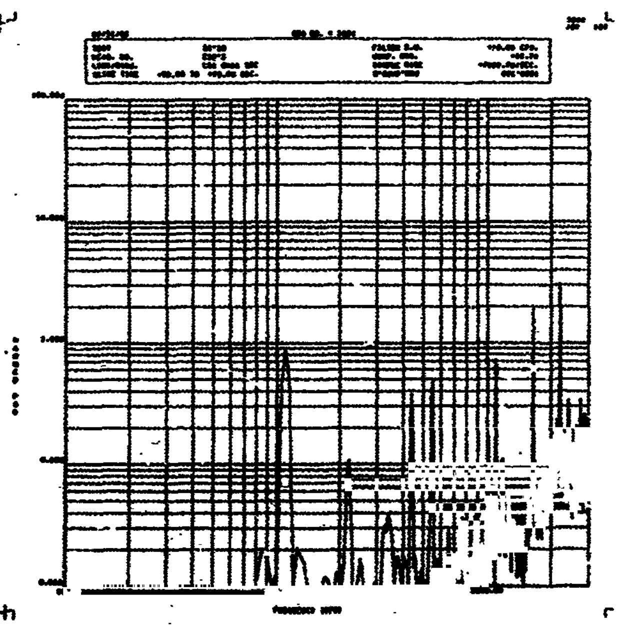
Remarks



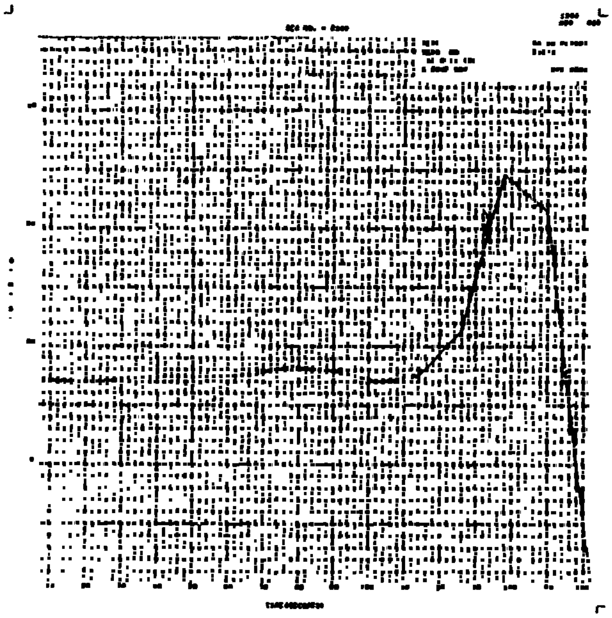
TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E12-4

Description Turbine Gear Box

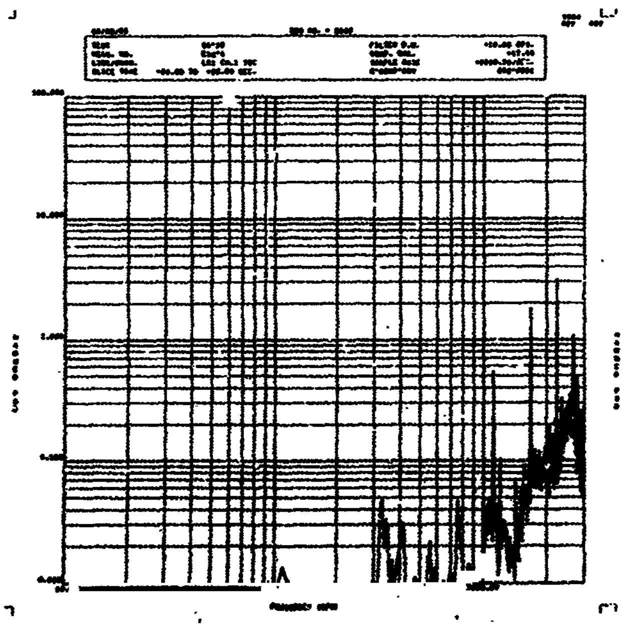
Engine 4

Sensitivity Parallel to Pump Axis

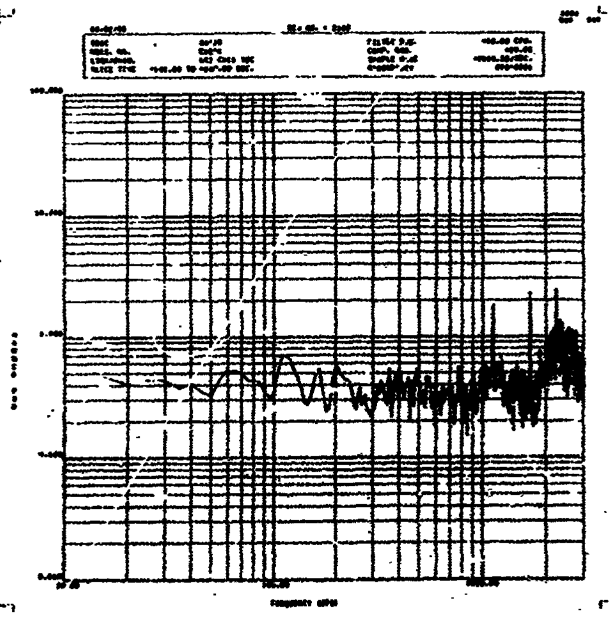
Location: Page 15

Calibration ± 50 G

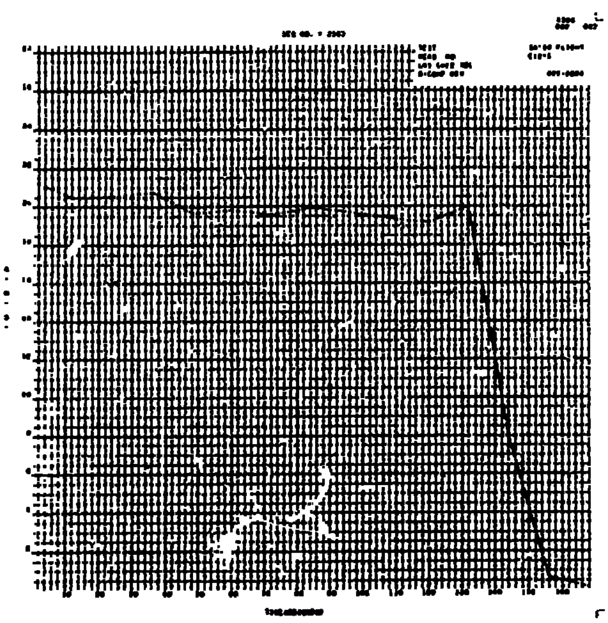
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E12-5

Description Turbine Gear Box

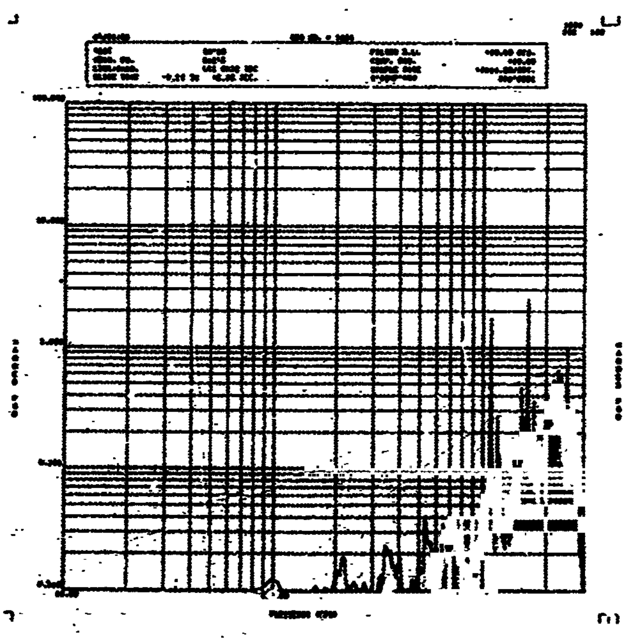
Engine 5

Sensitivity Parallel to Pump Axis

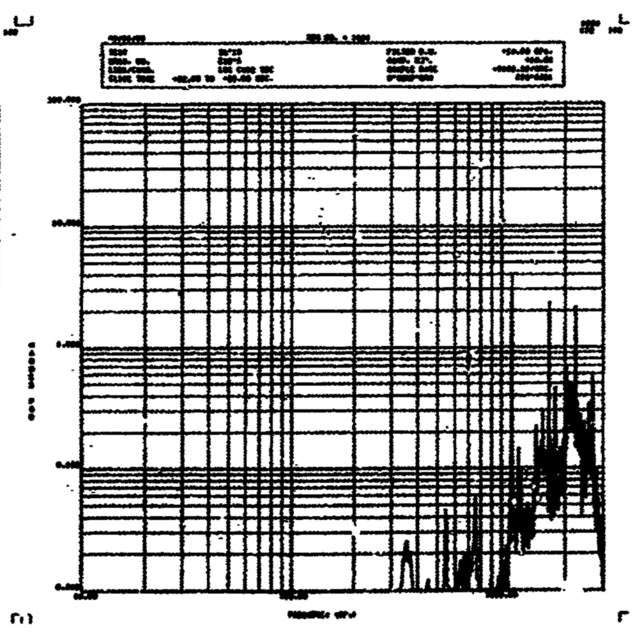
Location: Page 15

Calibration ± 50 G

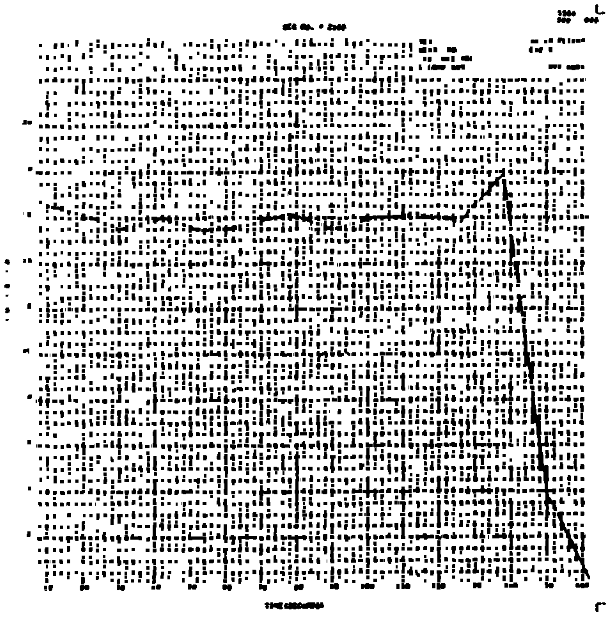
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E12-6

Description Turbine Gear Box

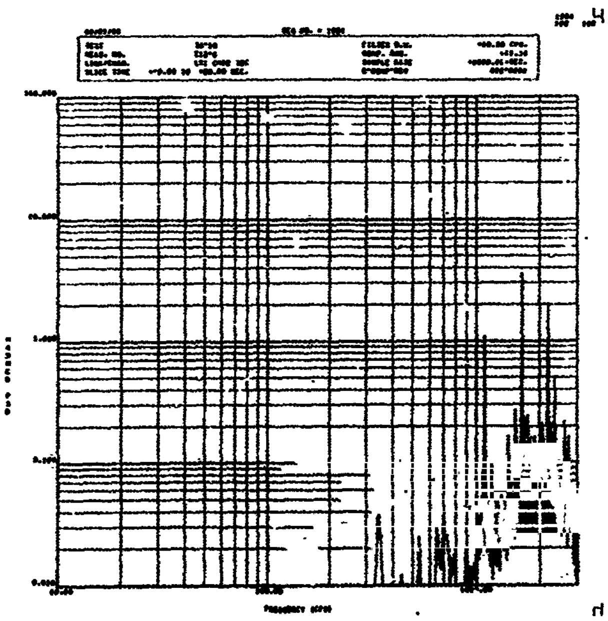
Engine 6

Sensitivity Parallel to Pump Axis

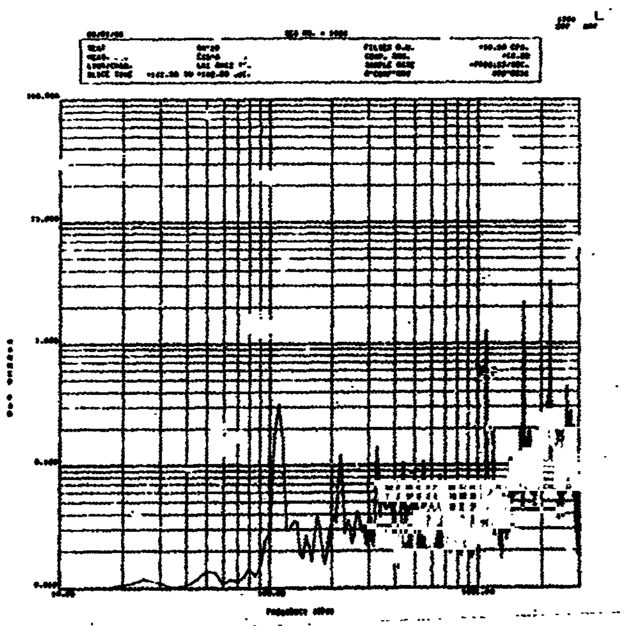
Location: Page 15

Calibration $\pm$ 50 G

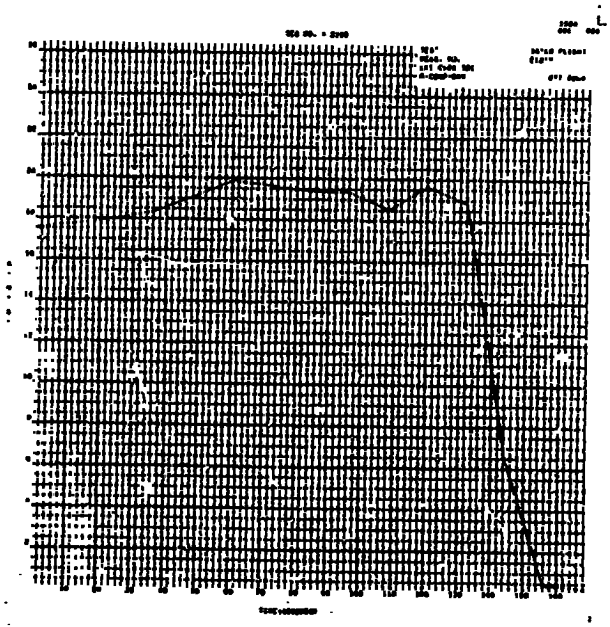
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E12-7

Description Turbine Gear Box

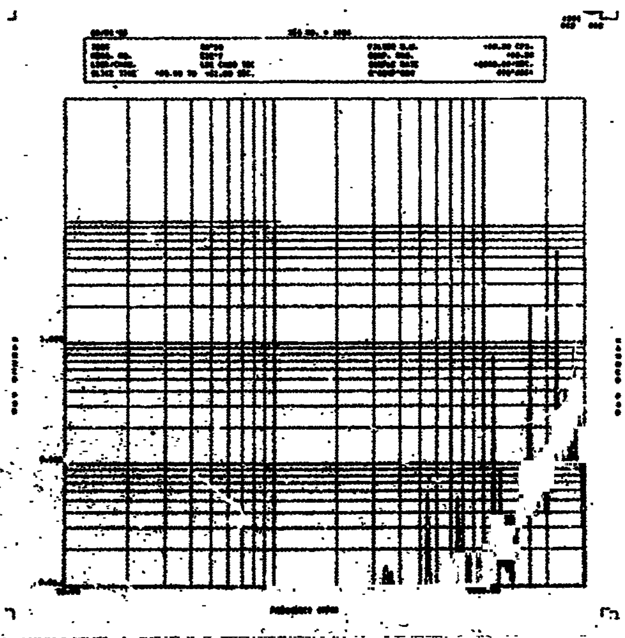
Engine 7

Sensitivity Parallel to Pump Axis

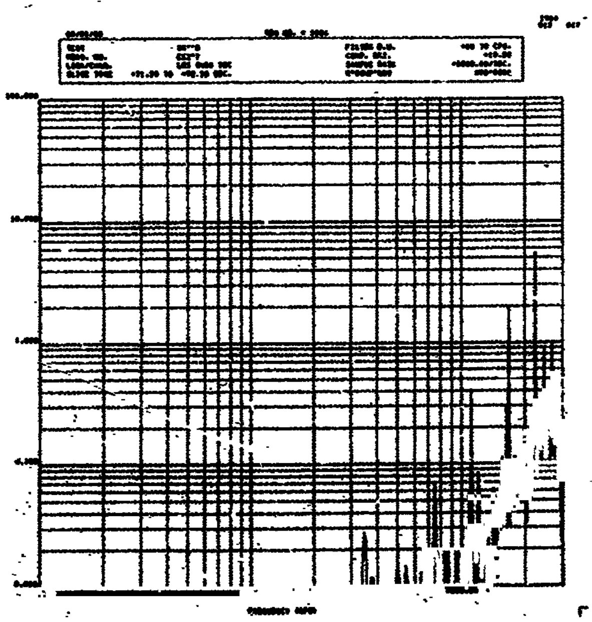
Location: Page 15

Calibration ± 50 G

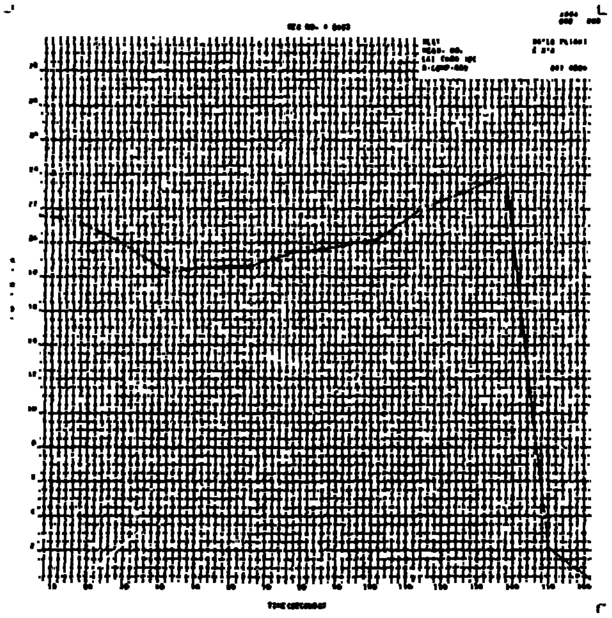
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E12-8

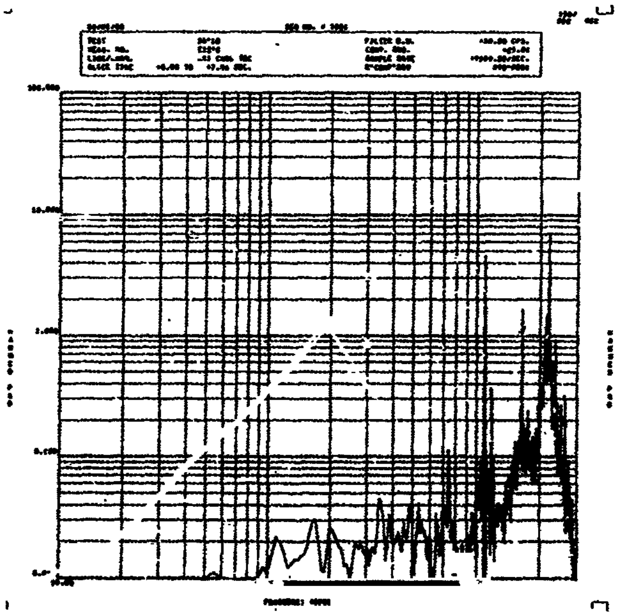
Description Turbine Gear Box
Engine 8

Sensitivity Parallel to Pump Axis

Location: Page 15

Calibration ± 50 G

Remarks



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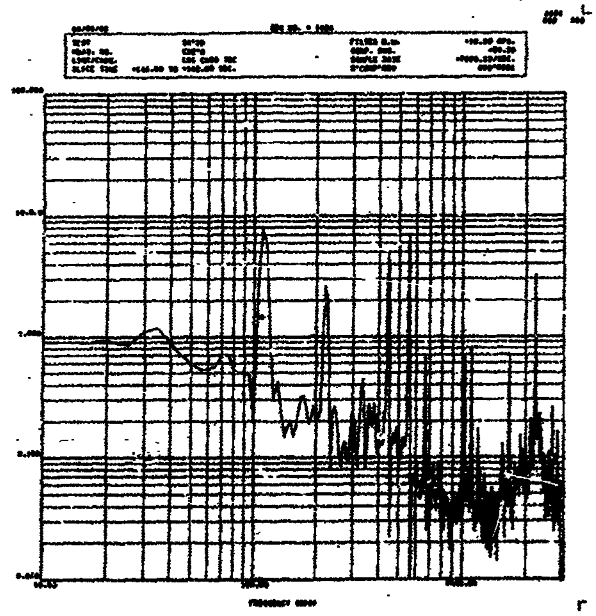
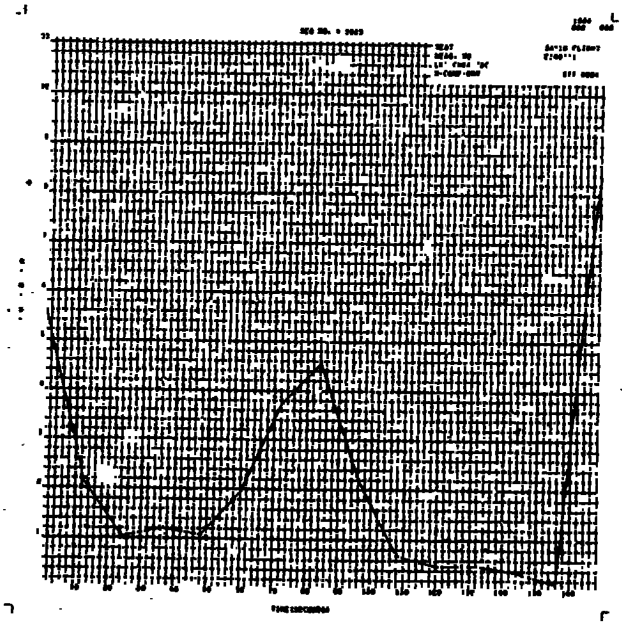


FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E105-11

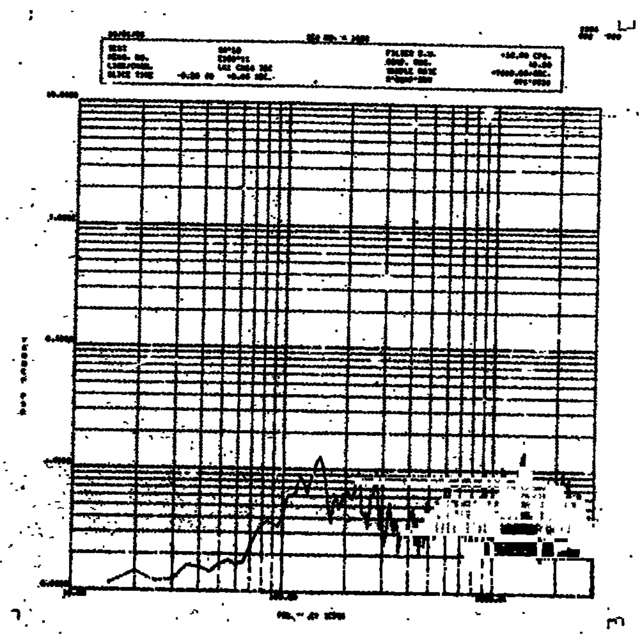
Description Spider Beam

Sensitivity Longitudinal

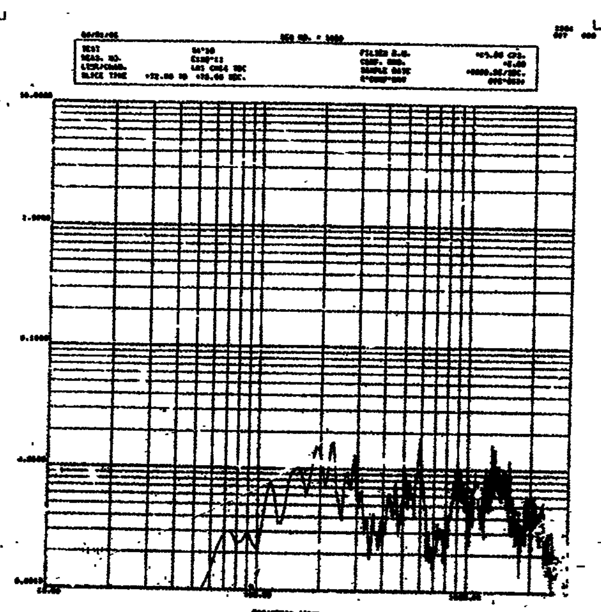
Location: Page 16

Calibration ± 25 G

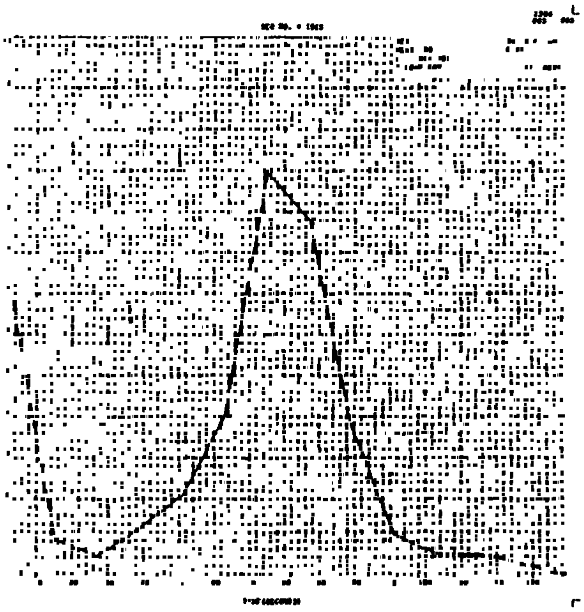
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E107-11

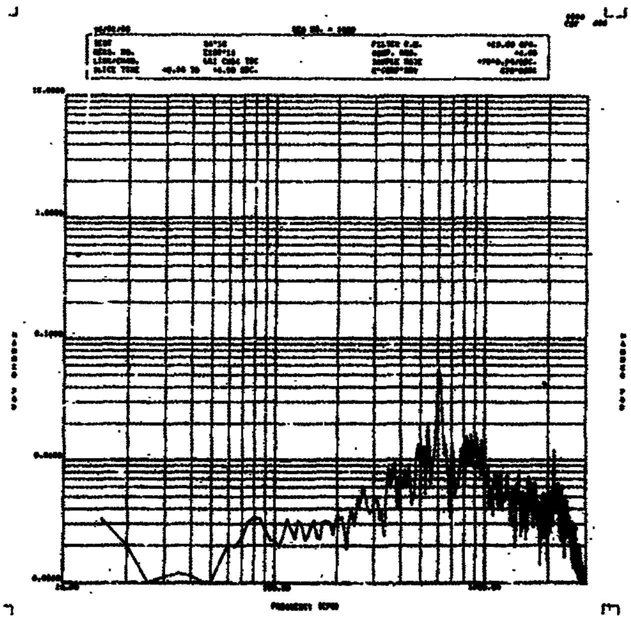
Description Spider Beam

Sensitivity Pitch

Location: Page 16

Calibration $\pm$ 25 G

Remarks



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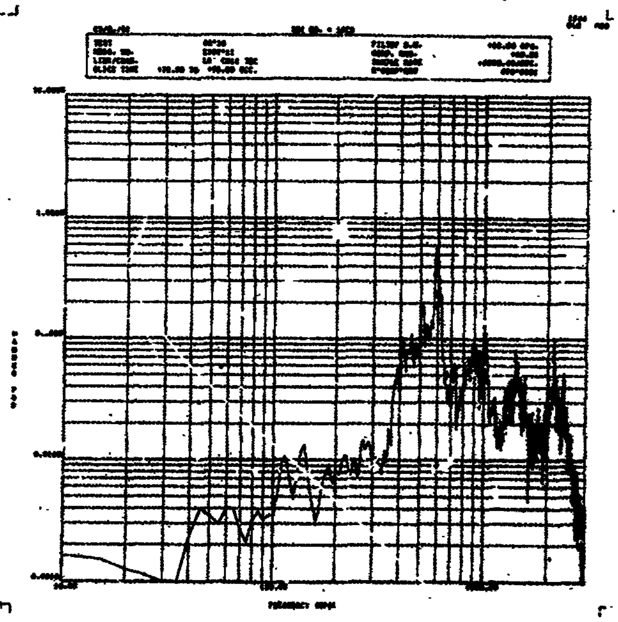

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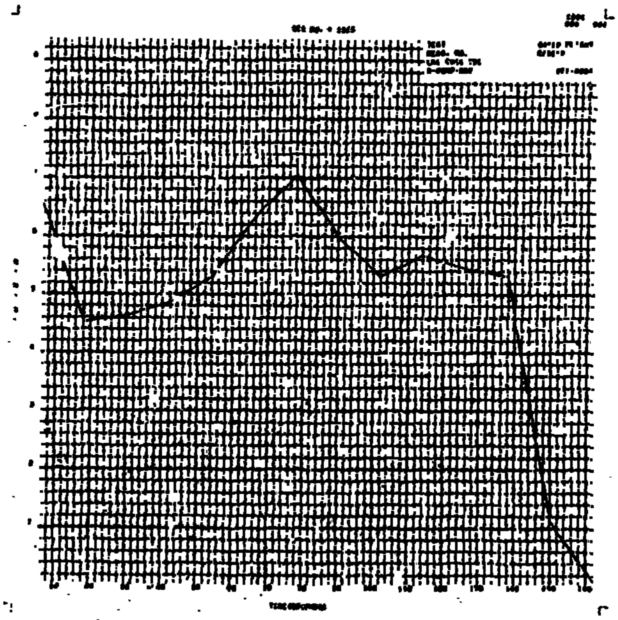


TIME HISTORY

Meas. No. E135-9

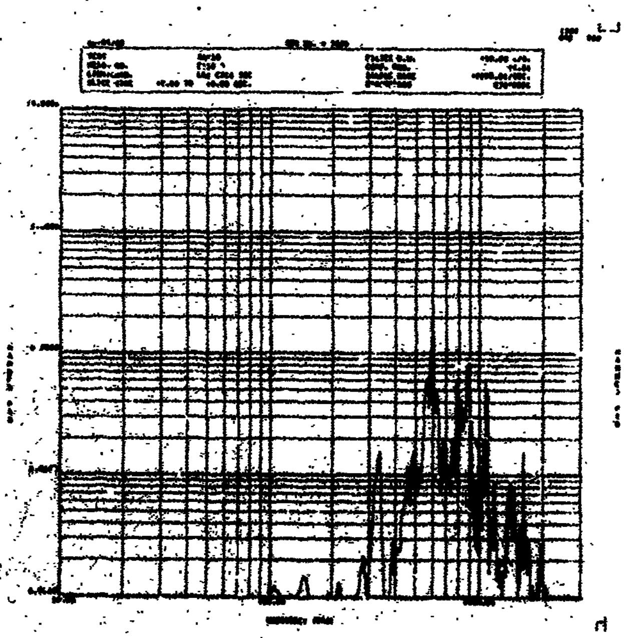
Description Thrust Beam Between Fins III and IV

Sensitivity Longitudinal

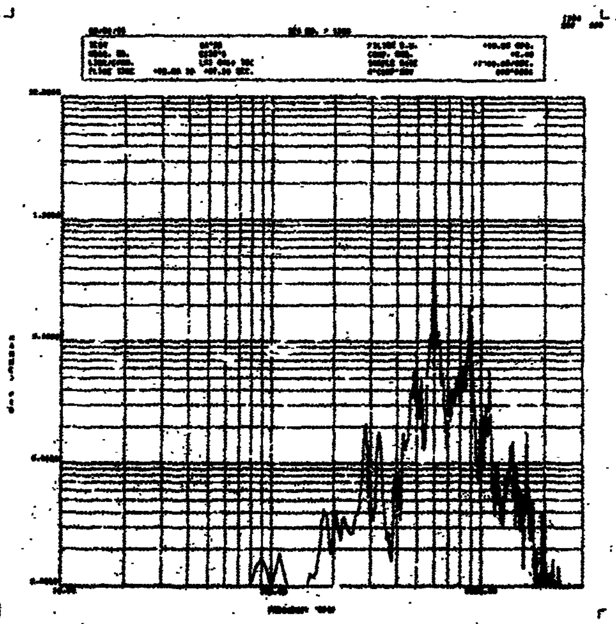
Location: Page 17

Calibration ± 30 G

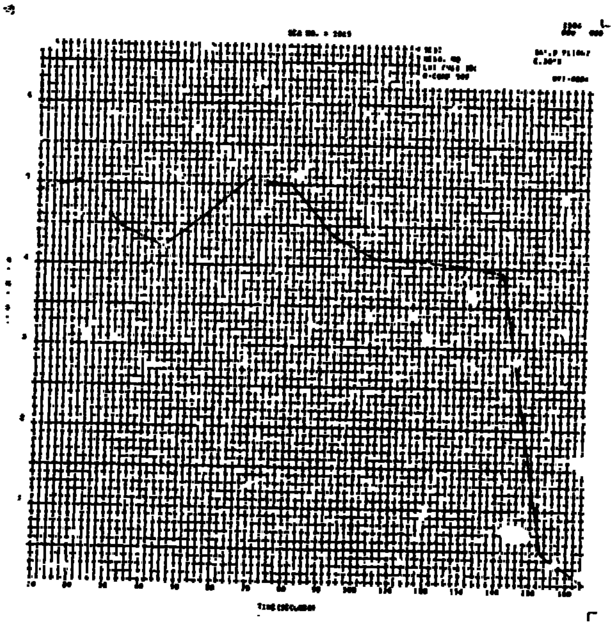
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E136-9

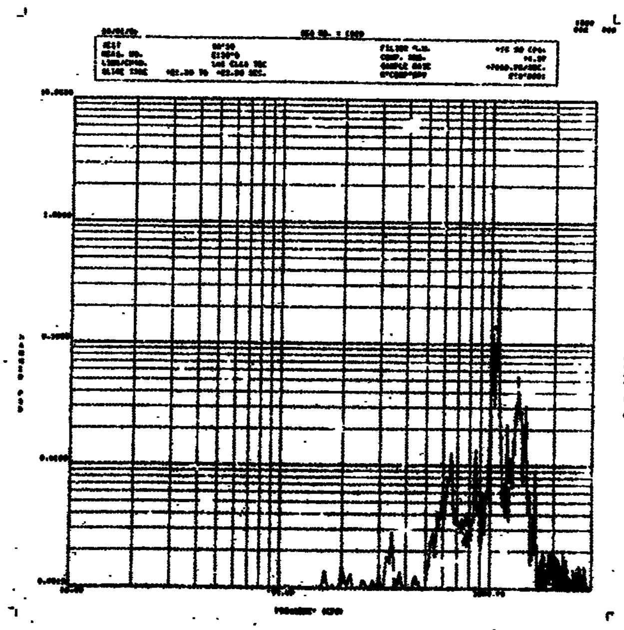
Description Shear Panel Between Fins III and IV

Sensitivity Longitudinal

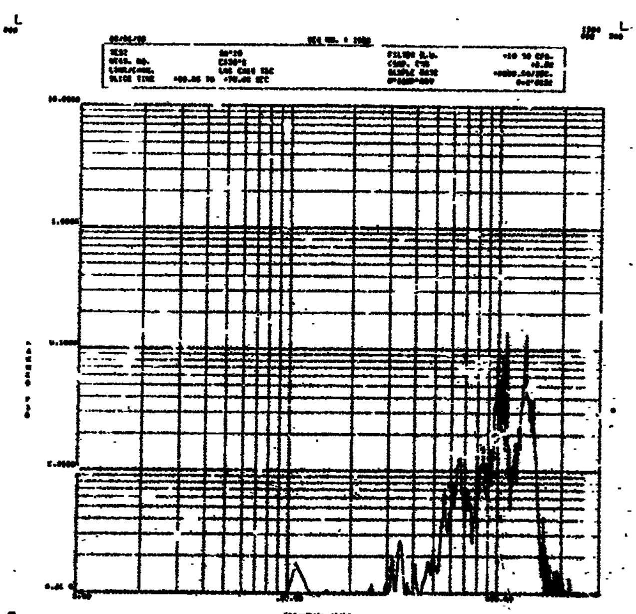
Location: Page 17

Calibration ± 30 G

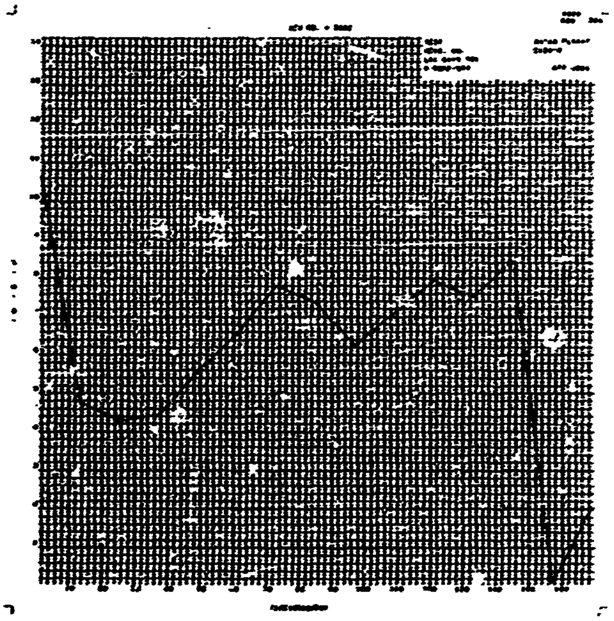
Remarks Launch environment not available due to commutation.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E139-9

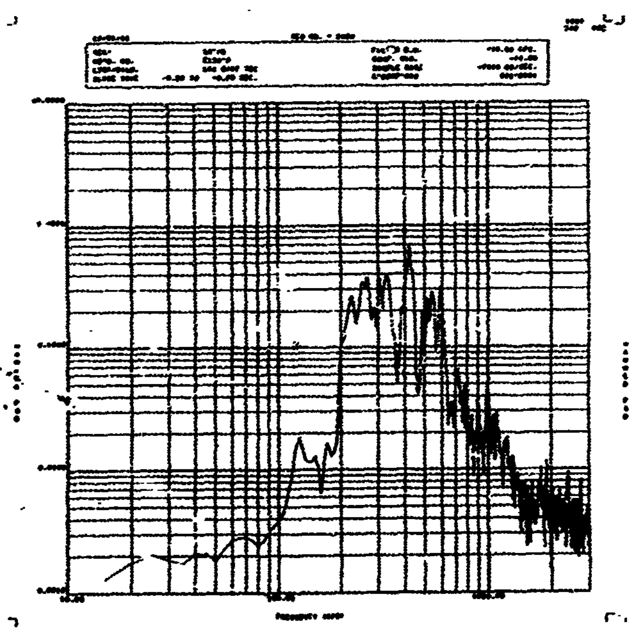
Description Shear Panel Between Fins I and II

Sensitivity Longitudinal

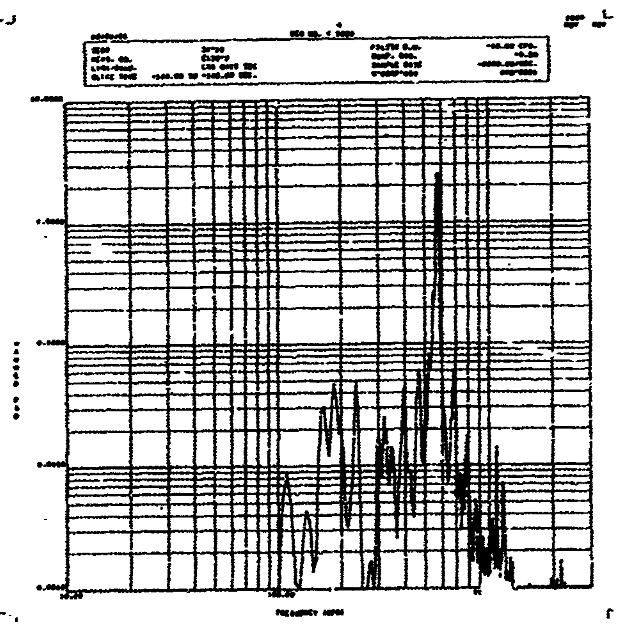
Location: Page 19

Calibration ± 30 G

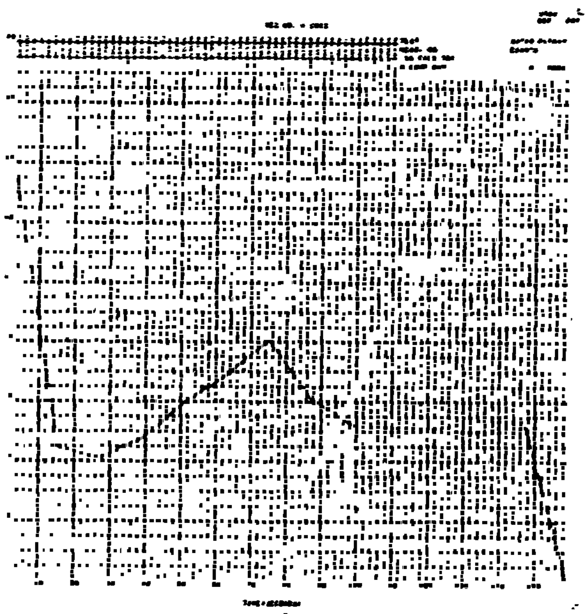
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E140-9

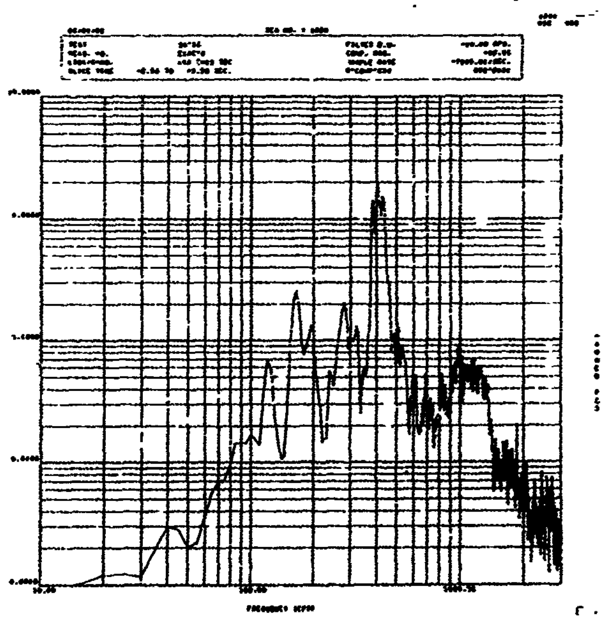
Description Shear Panel Between Fins I and II

Sensitivity Perpendicular to panel

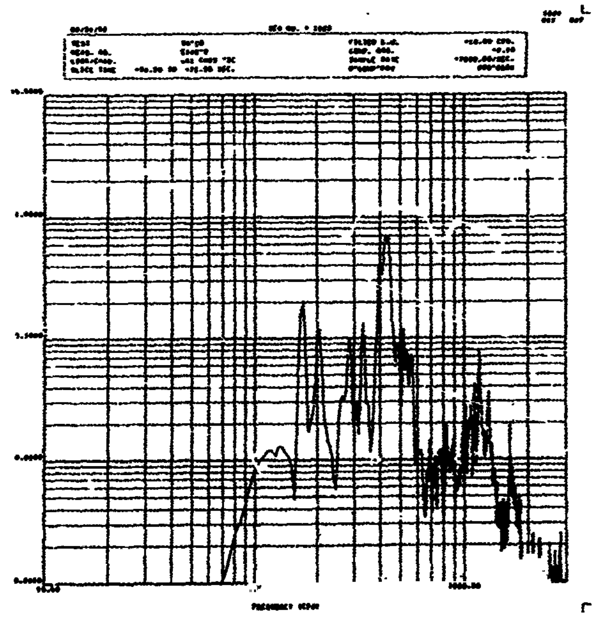
Location: Page 19

Calibration ± 30 G

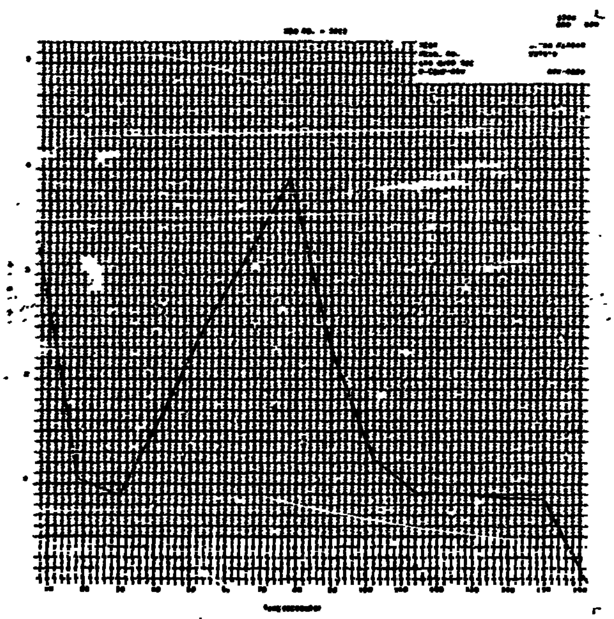
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E270-9

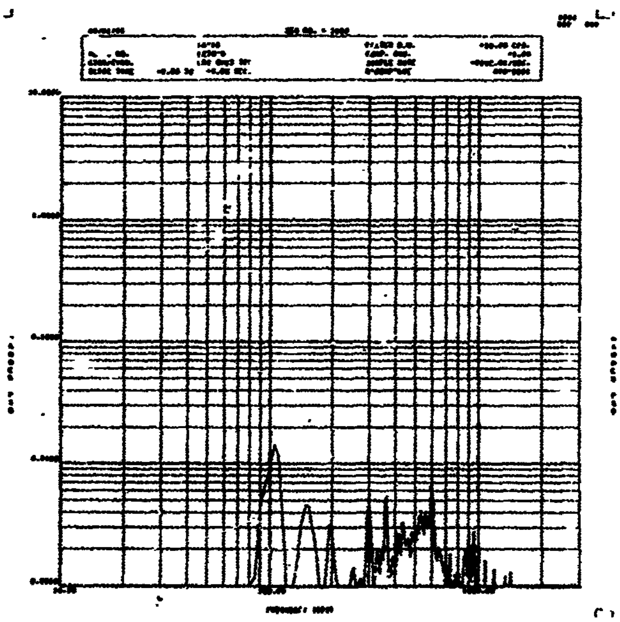
Description Mounting Bracket

Sensitivity Perpendicular to Ring frame

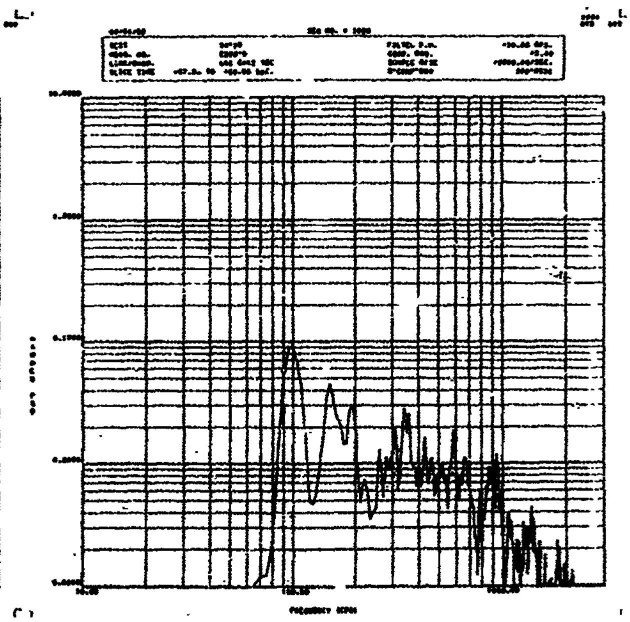
Location: Page 20

Calibration ± 20 G

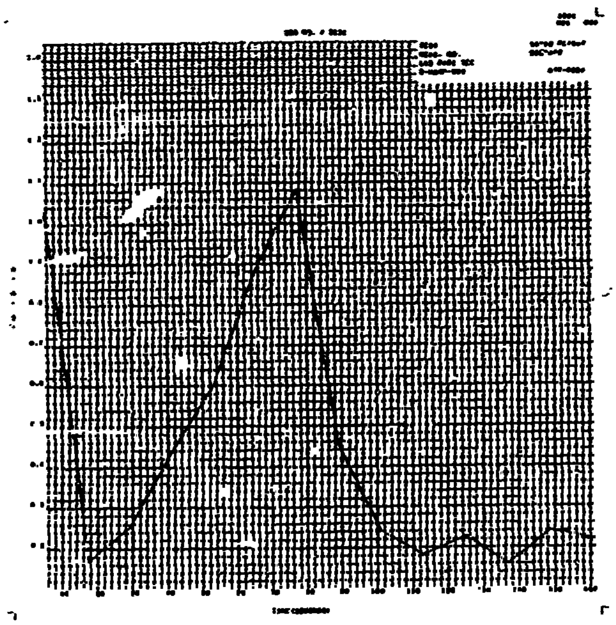
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E90-802

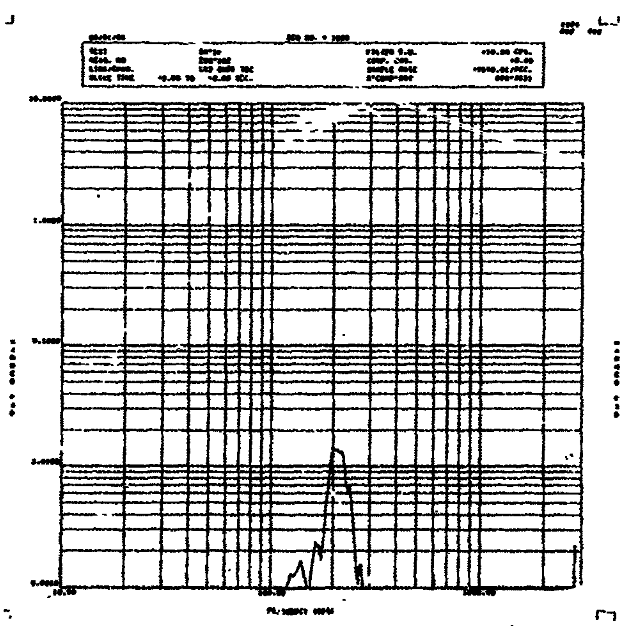
Description ST-124 Inertial Gimbal

Sensitivity X axis (longitudinal)

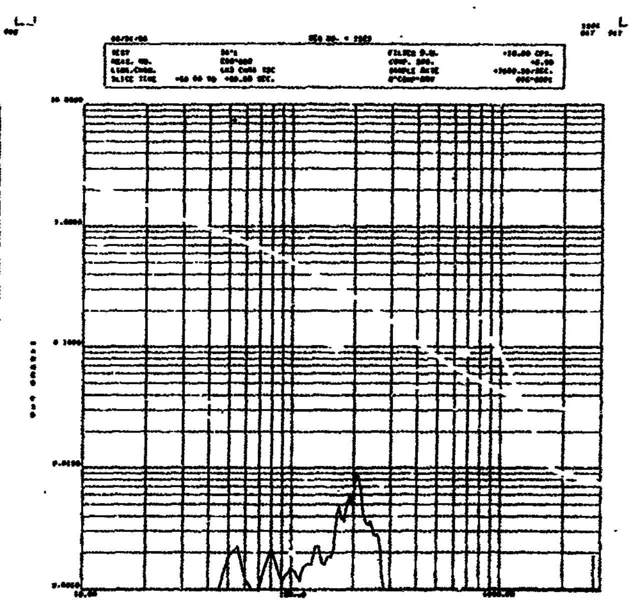
Location: Page 21

Calibration ± 5G

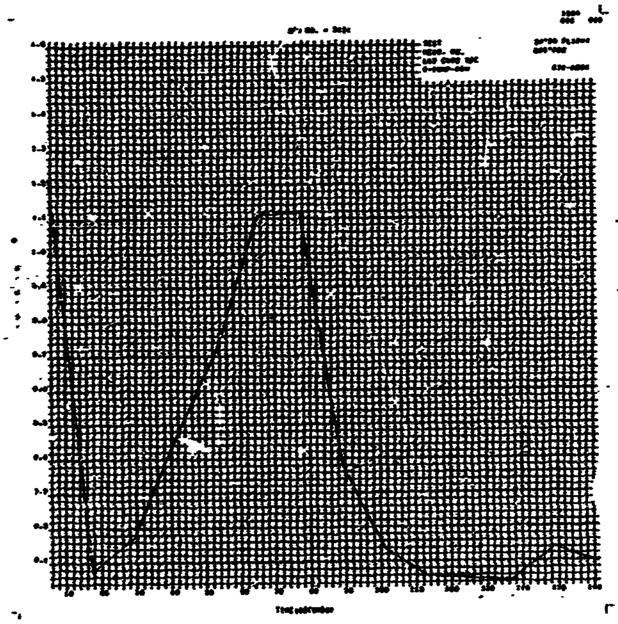
Remarks The launch environment was not available due to commutation. Service channel dropout from 149.2 seconds to 150.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E91-802

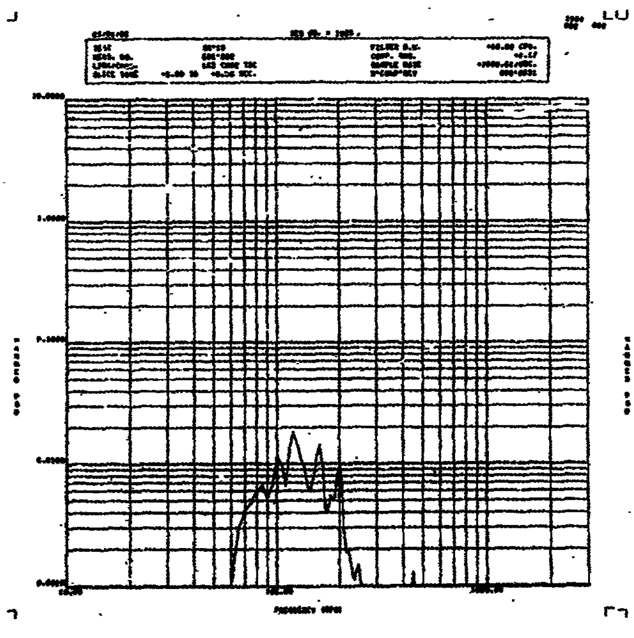
Description ST-124 Inertial Gimbal

Sensitivity Y axis (pitch)

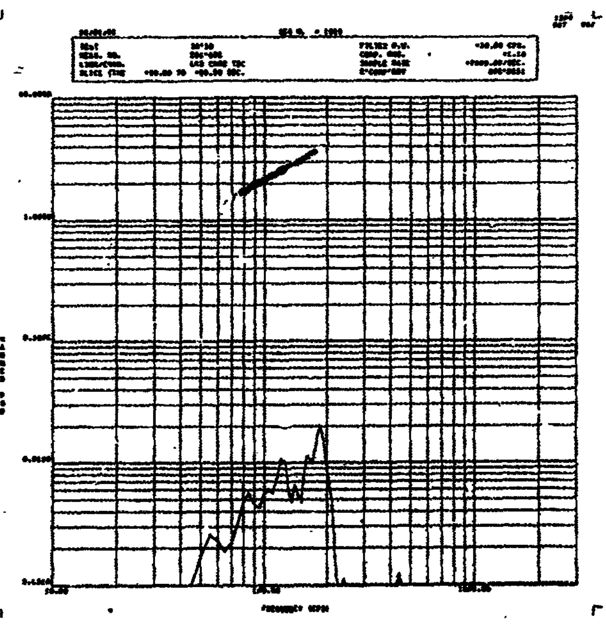
Location: Page 21

Calibration ± 5 G

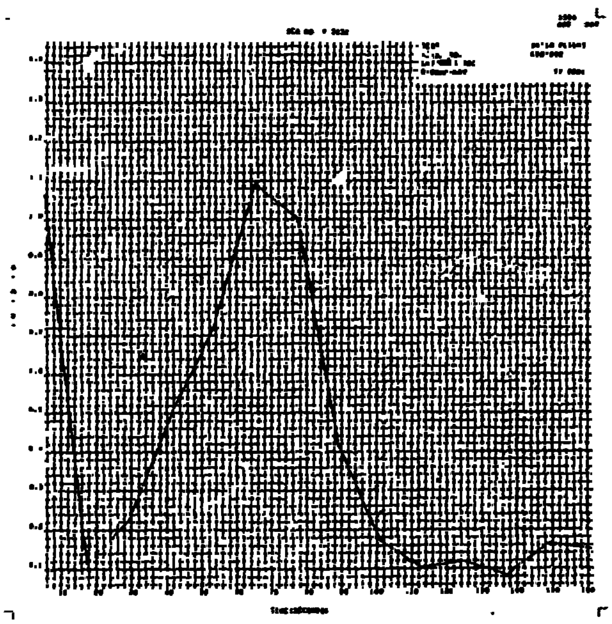
Remarks The launch environment was not available due to commutation. Service channel dropout from 149.2 seconds to 150.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E92-802

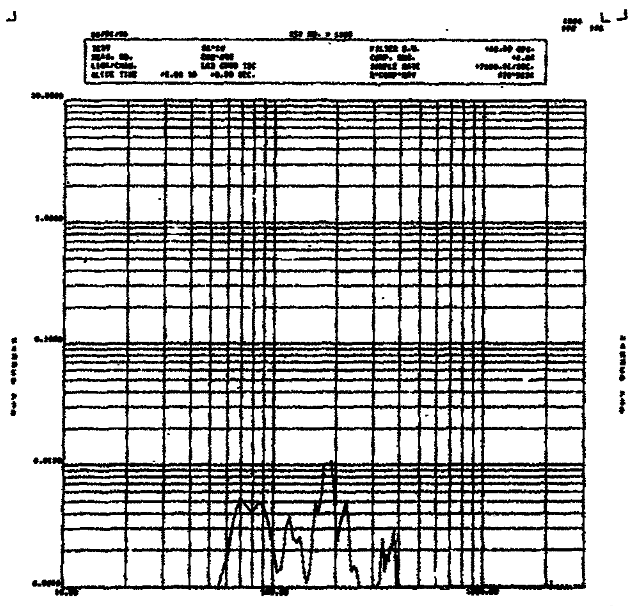
Description ST-124 Inertial Gimbal

Sensitivity Z axis (yaw)

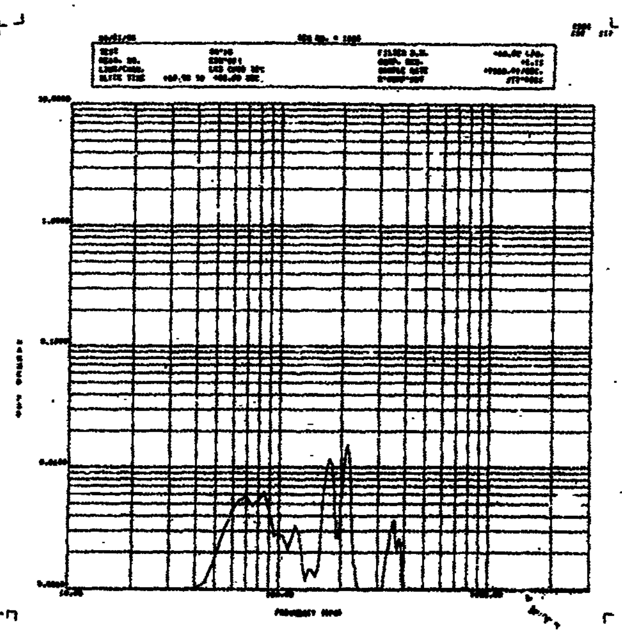
Location: Page 21

Calibration ± 5 G

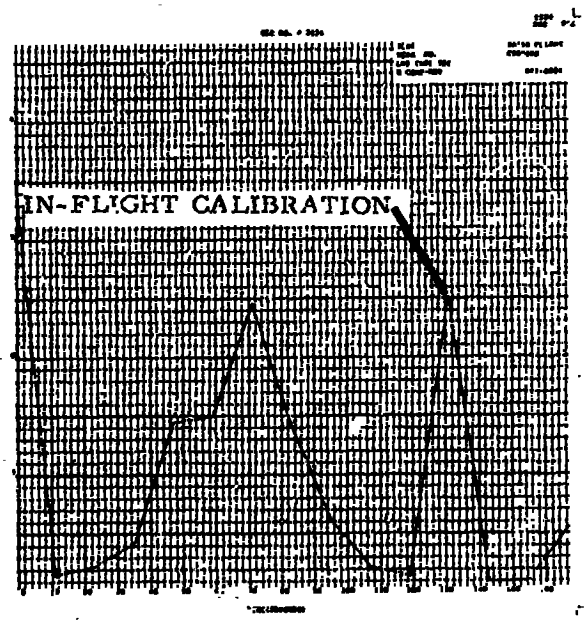
Remarks The launch environment was not available due to commutation. Service channel dropout from 149.2 seconds to 150.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E93-802

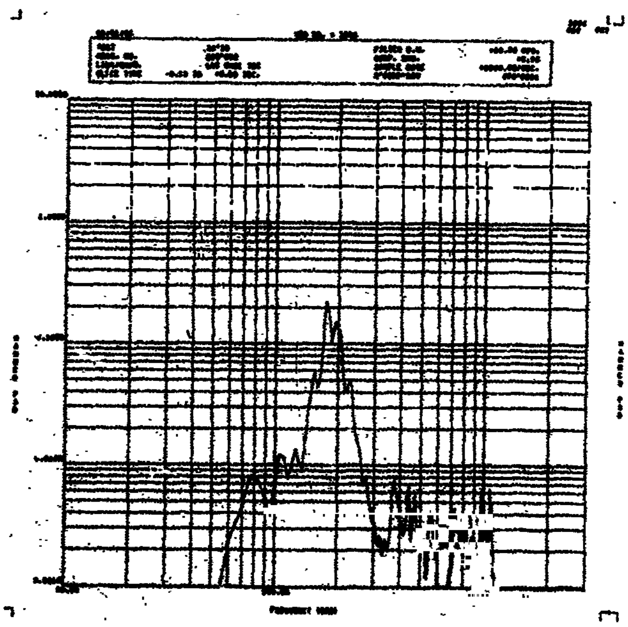
Description ST-124 Mounting Frame.

Sensitivity Longitudinal

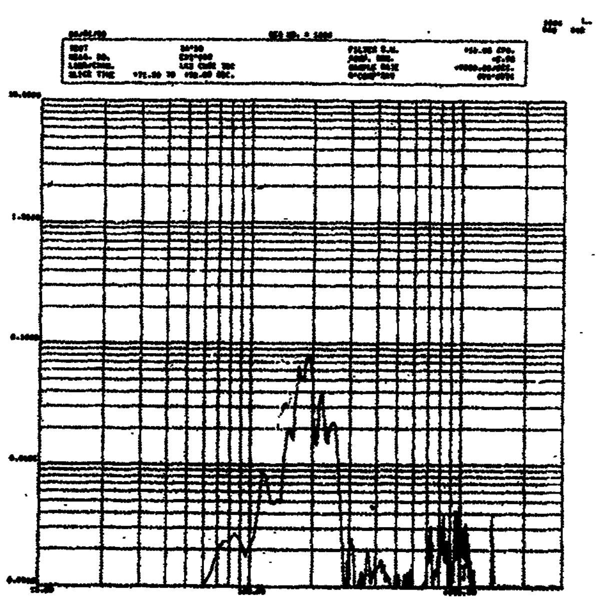
Location: Page 21

Calibration ± 10 G

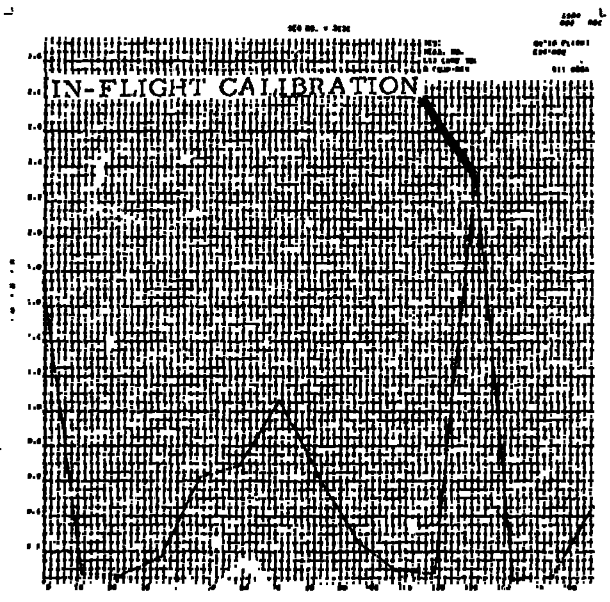
Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E94-802

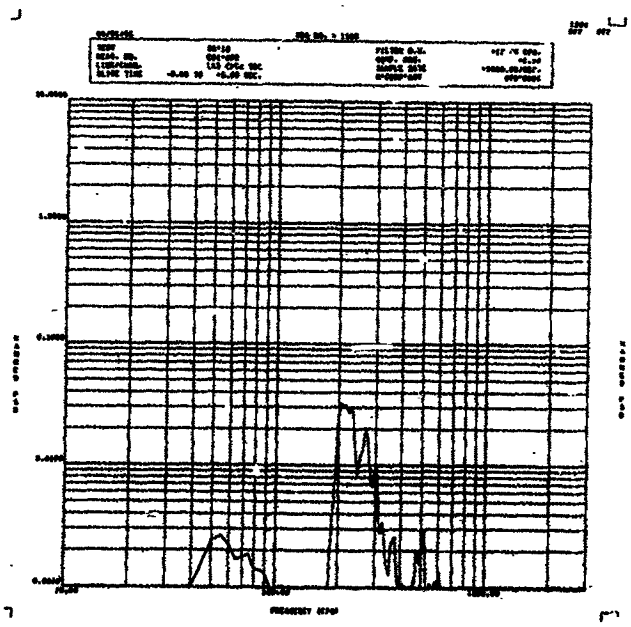
Description ST-124 Mounting Frame

Sensitivity Pitch

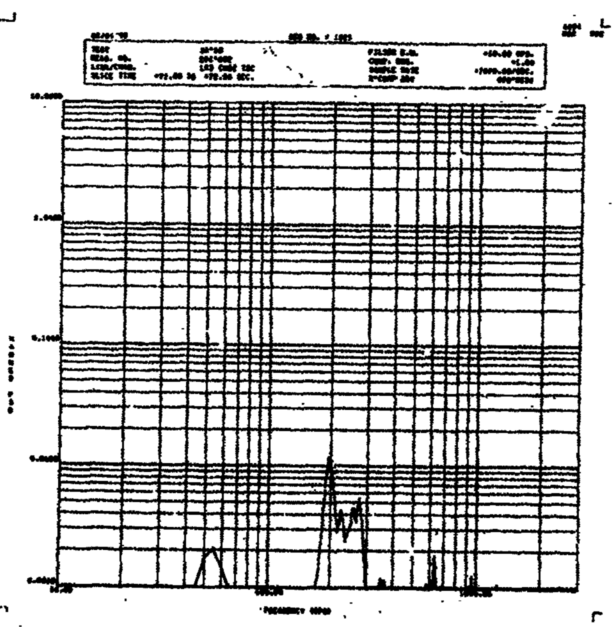
Location: Page 21

Calibration ± 10 G

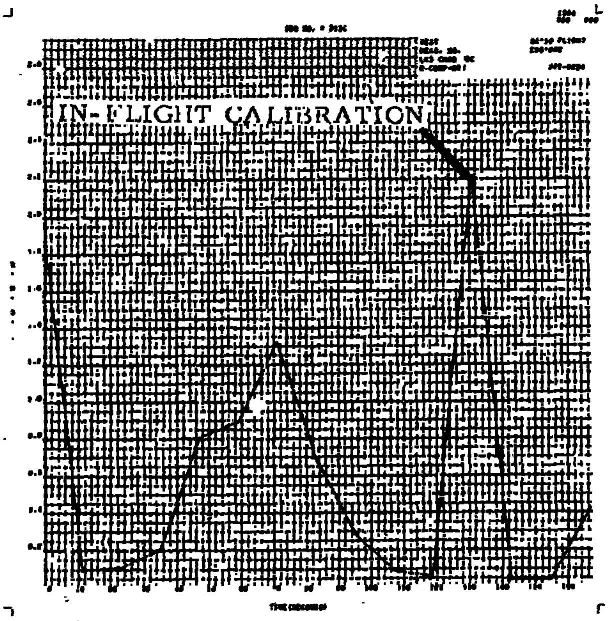
Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E95-802

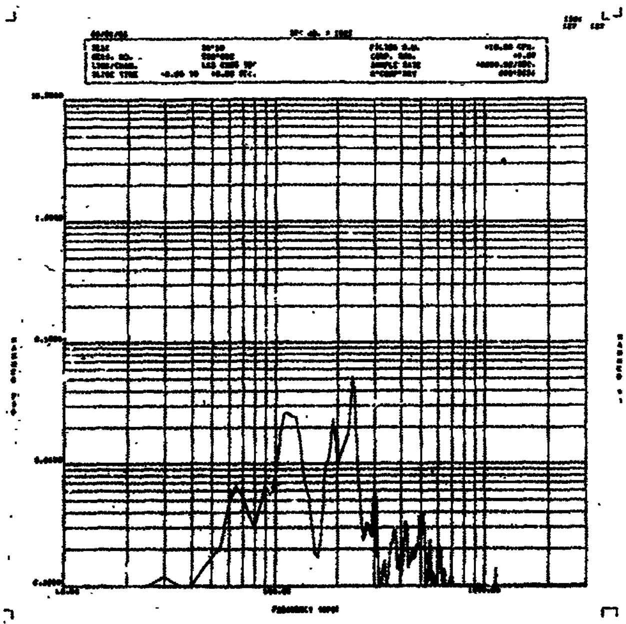
Description ST-124 Mounting Frame

Sensitivity Yaw

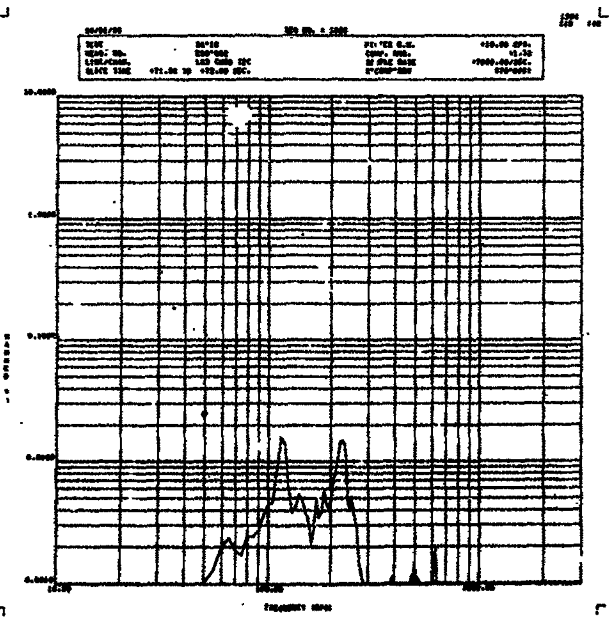
Location: Page 21

Calibration ± 10 G

Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E345-802

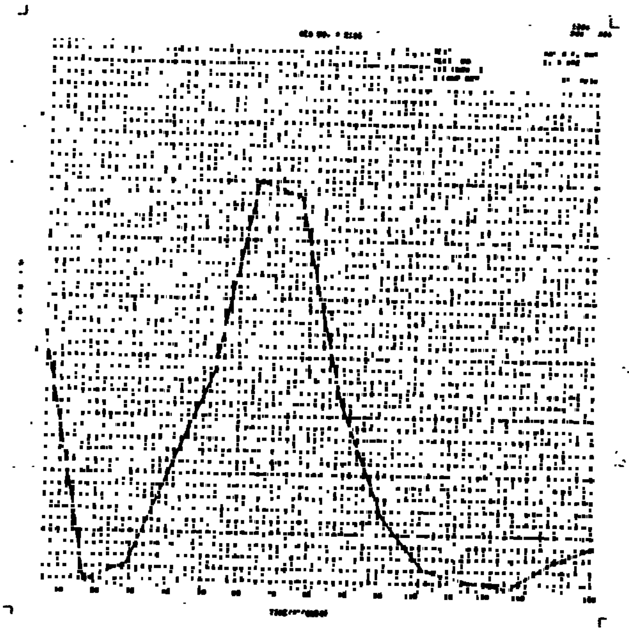
Description ST-124 Support

Sensitivity Longitudinal

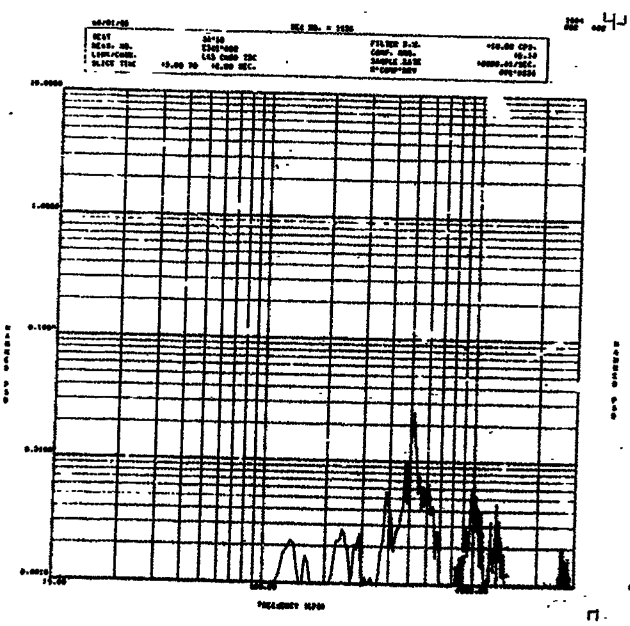
Location: Page 22

Calibration ± 10 G

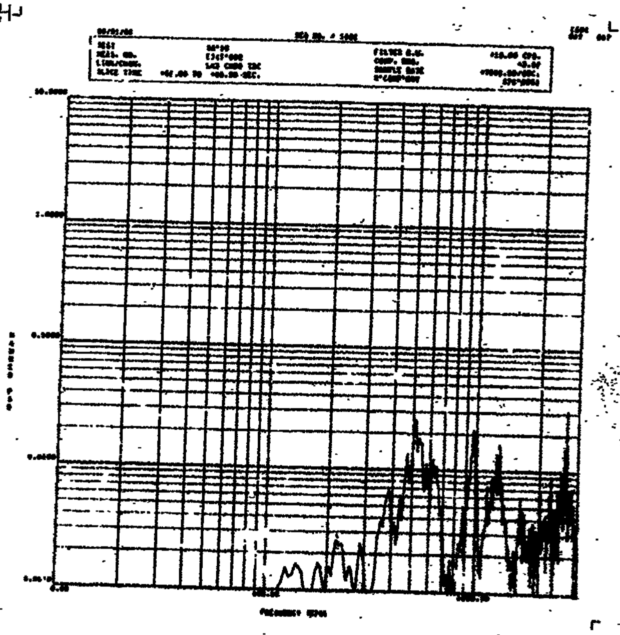
Remarks The launch environment was not available due to commutation.



TIME HISTORY

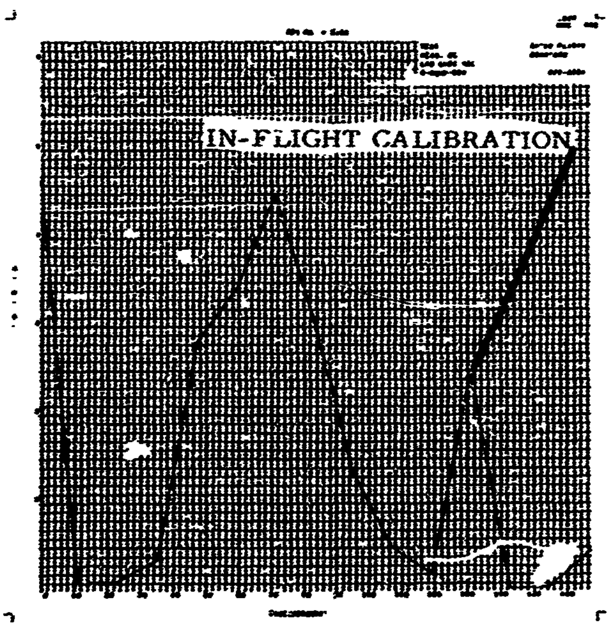


FREQUENCY SPECTRUM

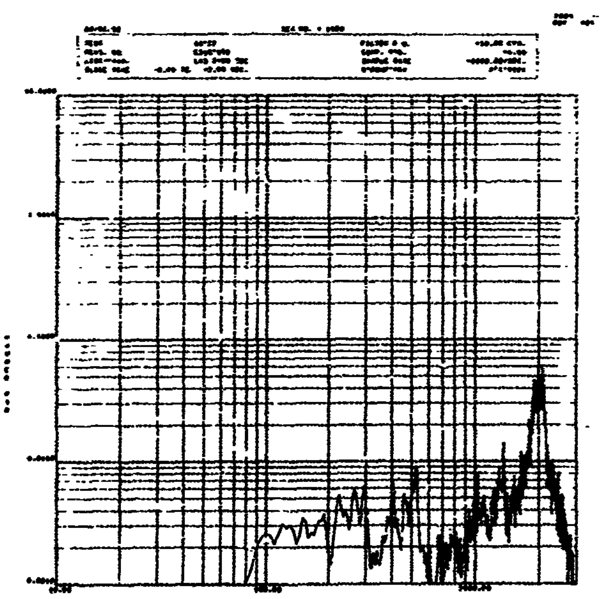


FREQUENCY SPECTRUM

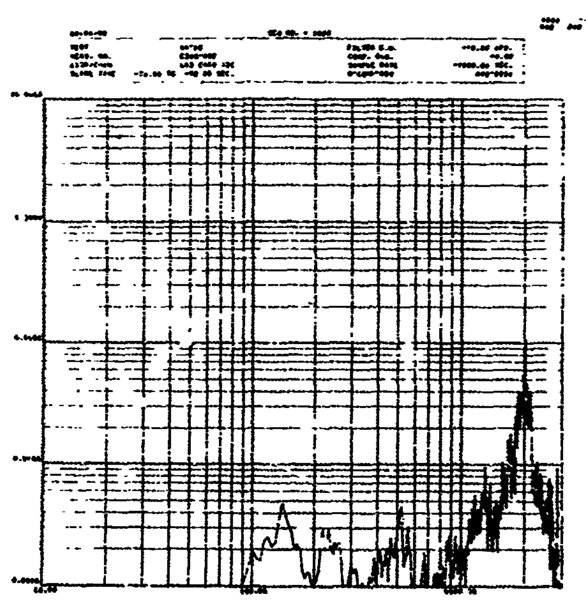
Meas. No.	E346-802
Description	ST-124 Support
Sensitivity	Tangential
Location: Page	22
Calibration	± 10 G
Remarks	In-flight calibration at 130.7 seconds.



TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E347-802

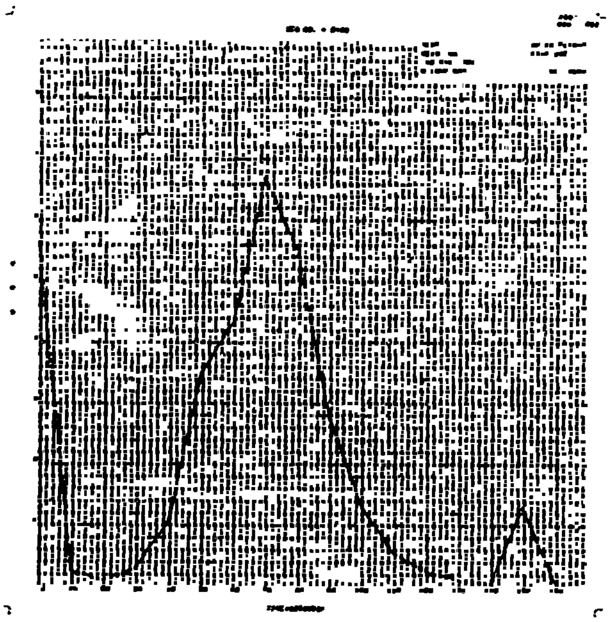
Description ST-124 Support

Sensitivity Perpendicular to Support

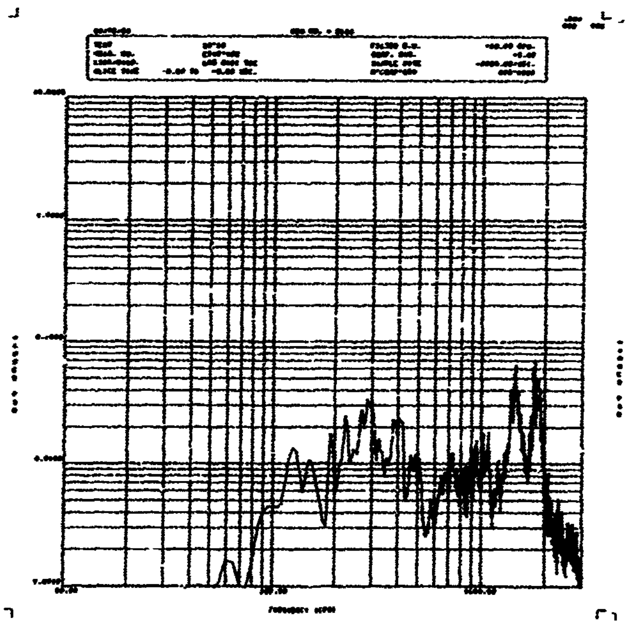
Location: Page 23

Calibration ± 10 G

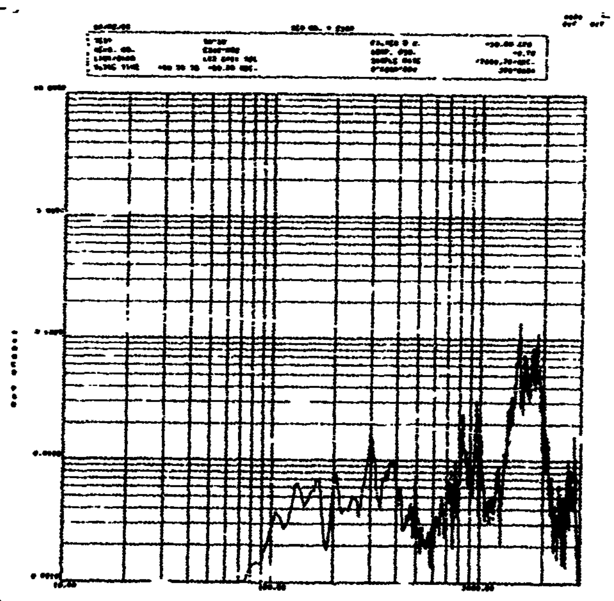
Remarks Service channel dropout from 149.2 seconds to 150.7 seconds.



TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E348-802

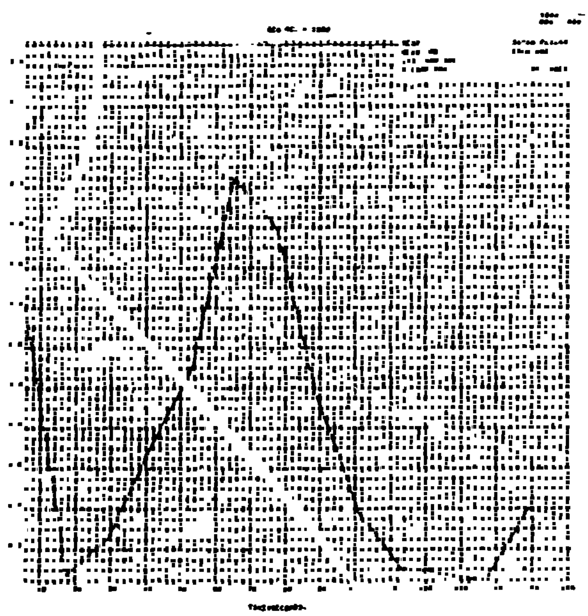
Description Air Bearing Supply Mounting Panel

Sensitivity Longitudinal

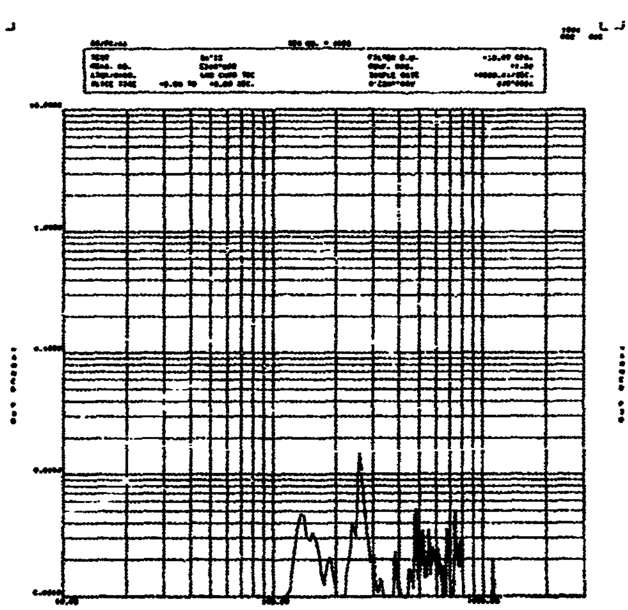
Location: Page 24

Calibration ± 10 G

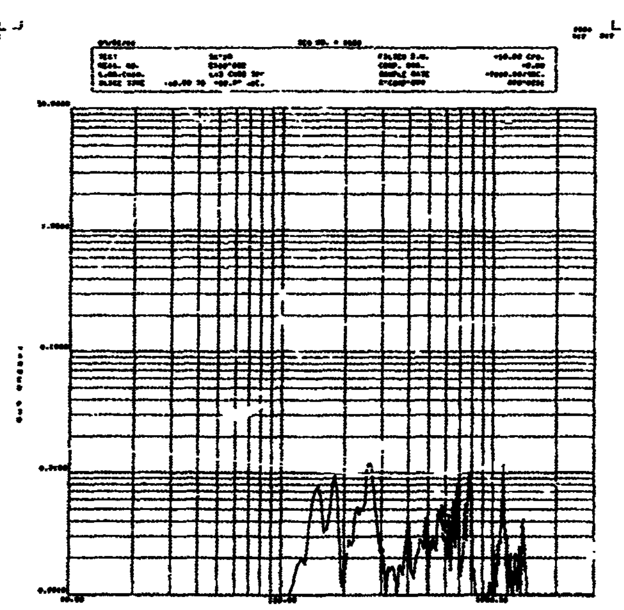
Remarks The launch environment was not available due to commutation. Service channel dropout from 149.2 seconds to 150.7 seconds.



TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E349-802

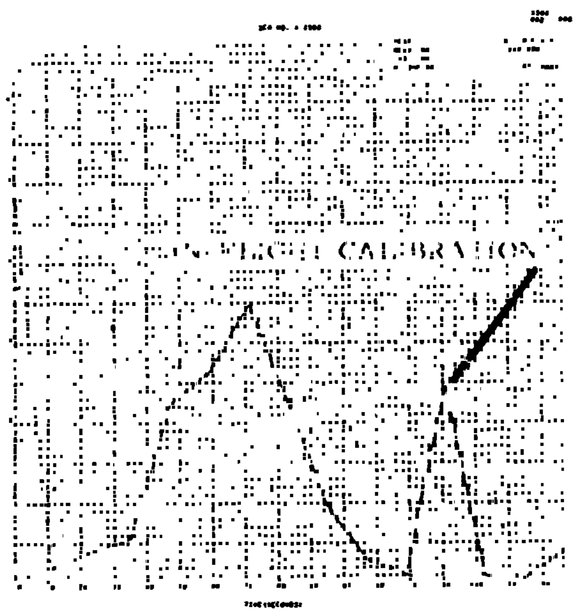
Description Air Bearing Supply Mounting Panels

Sensitivity Perpendicular to Panel

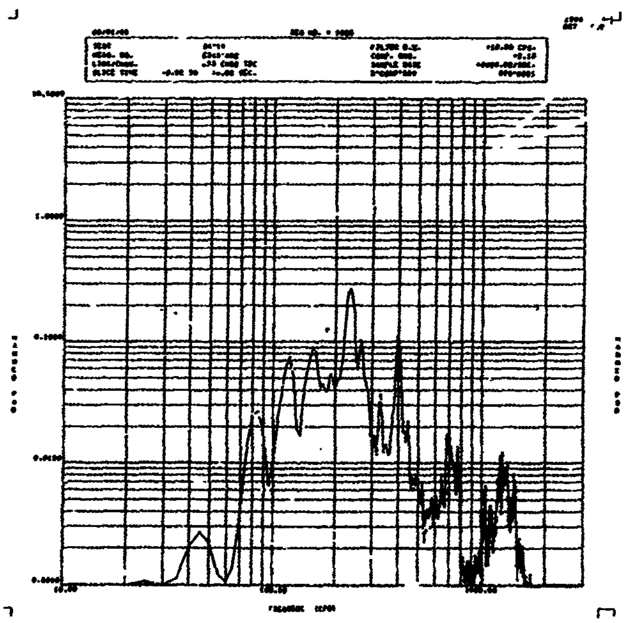
Location: Page 24

Calibration ± 10 G

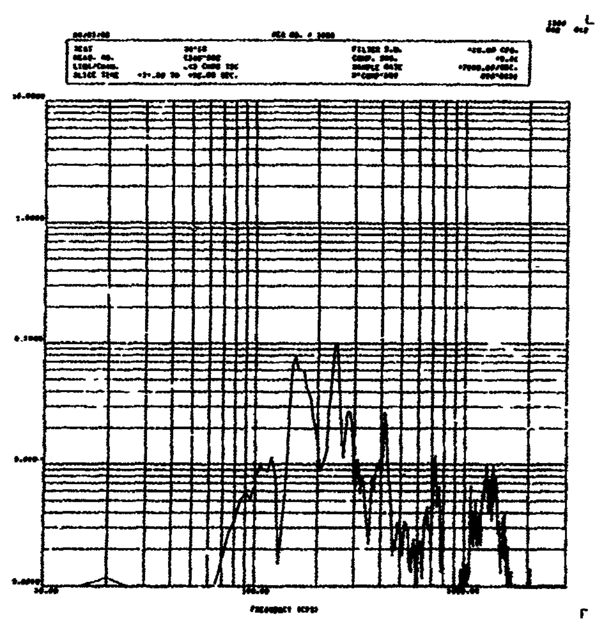
Remarks In-flight calibration at 130.7 seconds.



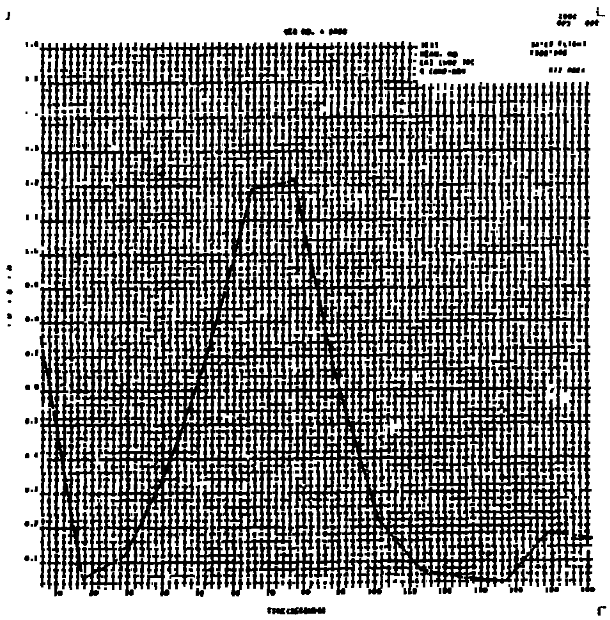
TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E352-802

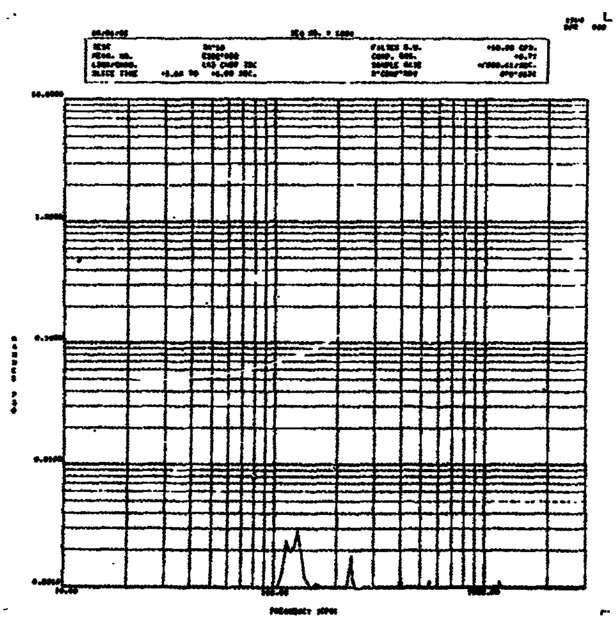
Description RF Assembly Mounting

Sensitivity Longitudinal

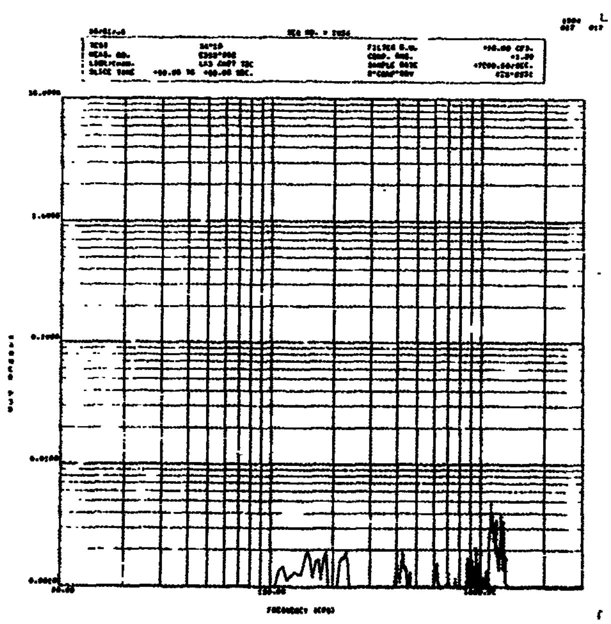
Location: Page 25

Calibration ± 10 G

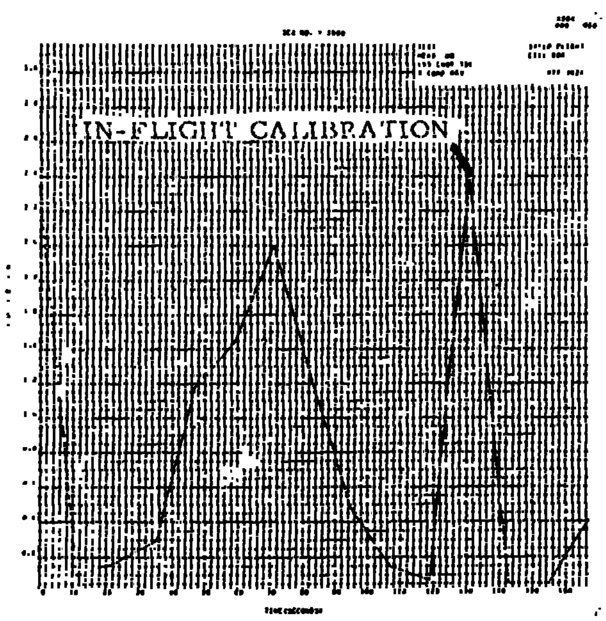
Remarks The launch environment was not available due to commutation. Service channel dropout from 149.2 seconds to 150.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E353-802

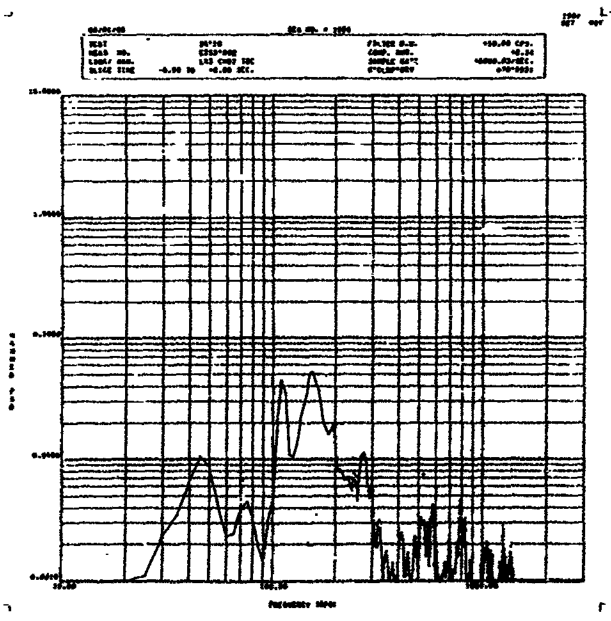
Description RF Assembly Mounting Panel.

Sensitivity Perpendicular to Panel

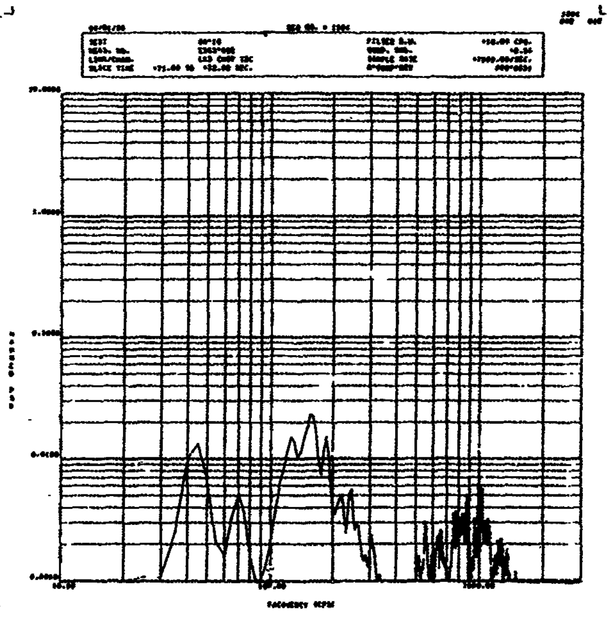
Location: Page 25

Calibration ± 10 G

Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E354-802

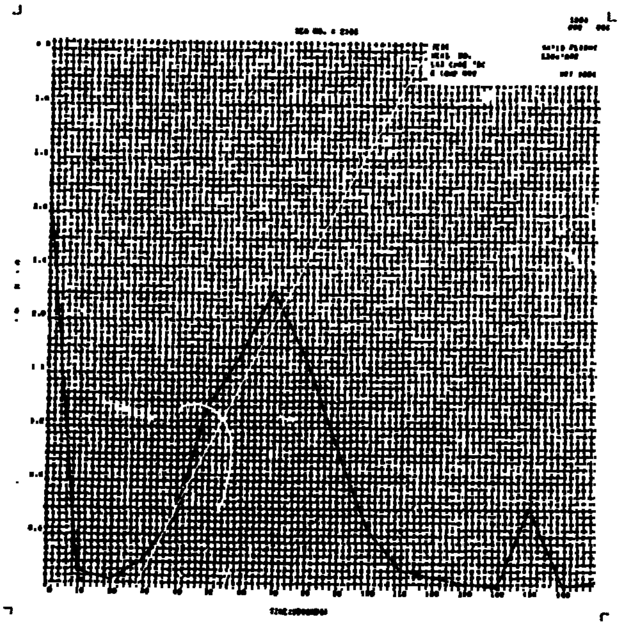
Description Guidance Computer Support Panel

Sensitivity Longitudinal

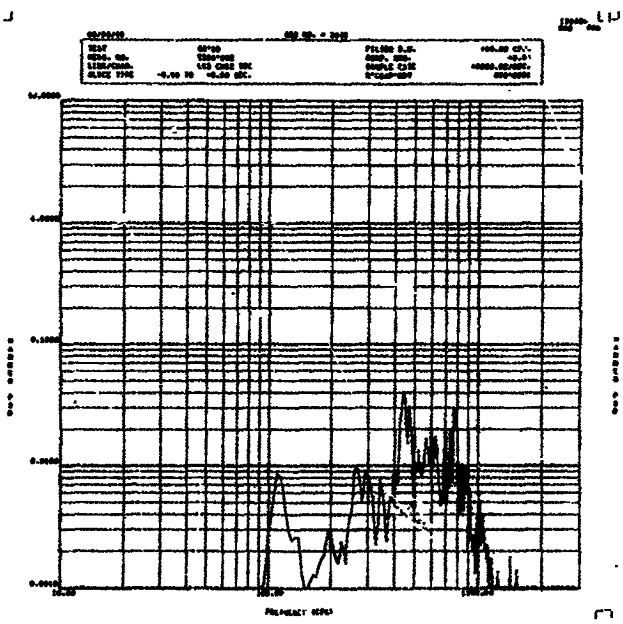
Location: Page 26

Calibration ± 10 G

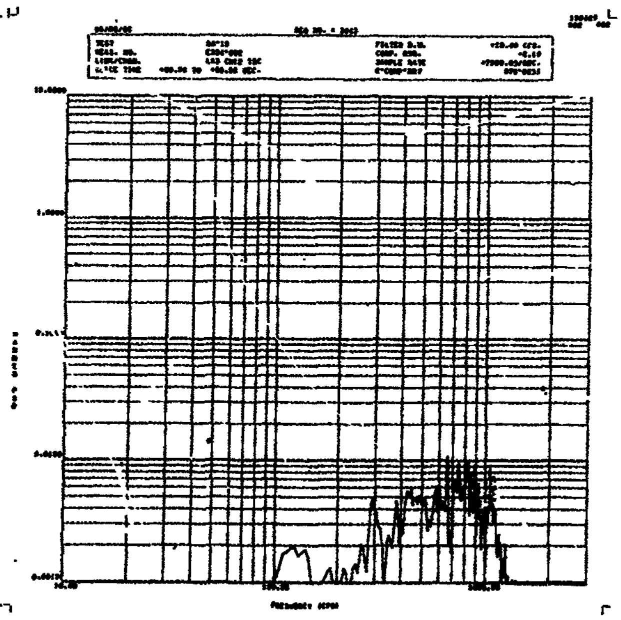
Remarks Service channel dropout from 149.2 seconds to 150.7 seconds.



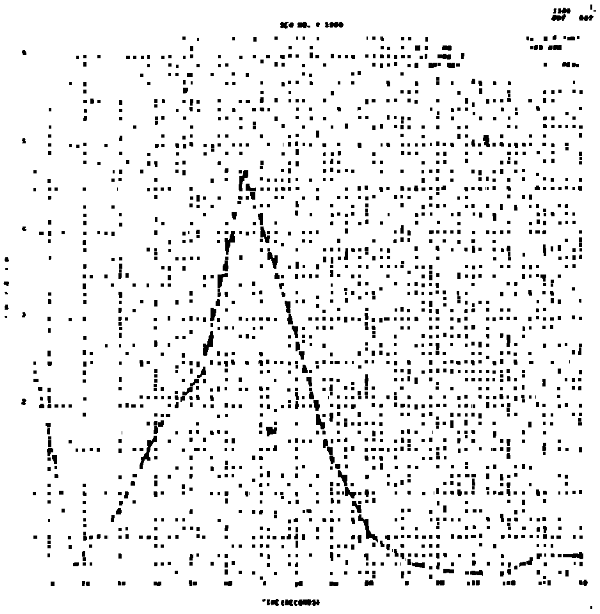
TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E355-802

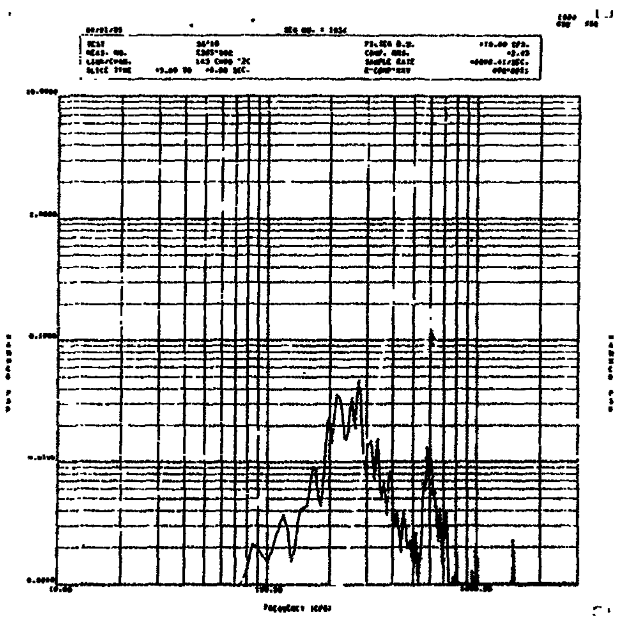
Description Guidance Computer Support Panel

Sensitivity Perpendicular to Panel

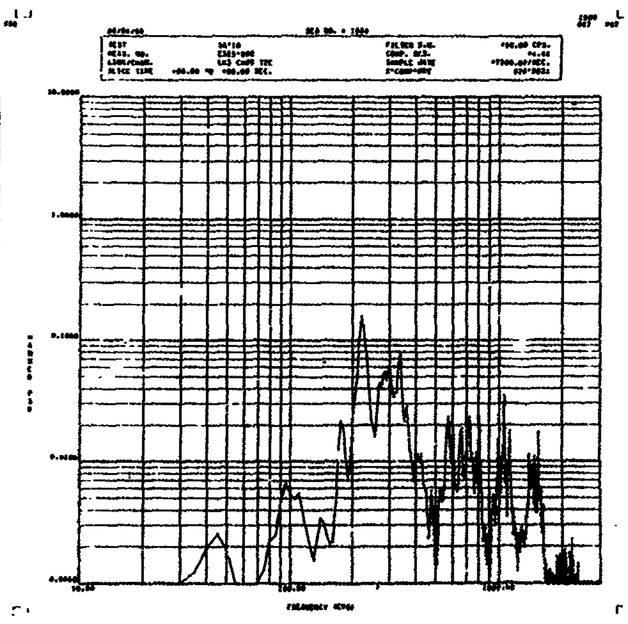
Location: Page 26

Calibration ± 10 G

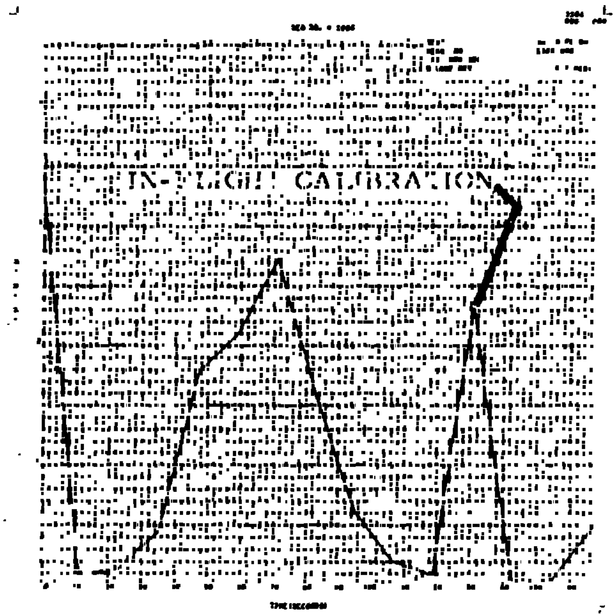
Remarks Launch environment not available due to commutation. Service channel dropout from 149.2 seconds to 150.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E356-802

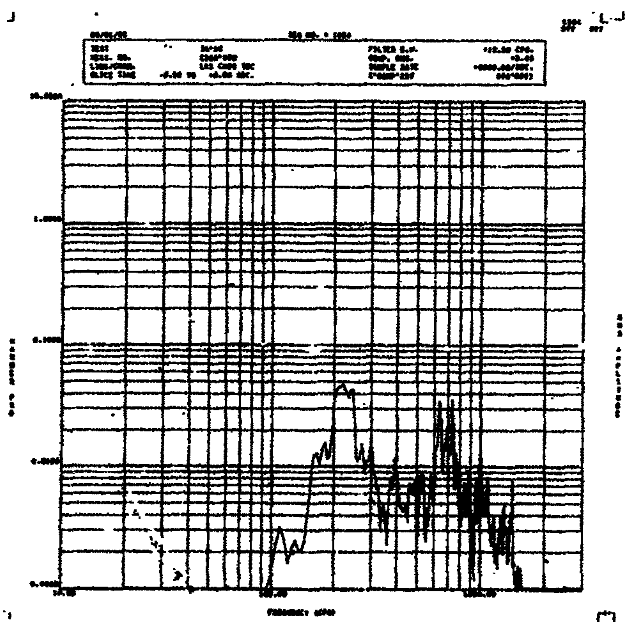
Description Guidance Computer Support Panel

Sensitivity Tangential (Parallel to Panel)

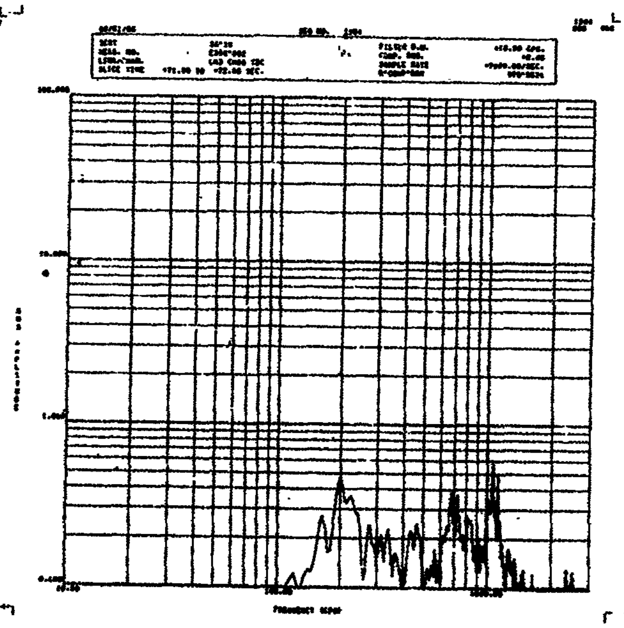
Location: Page 26

Calibration ± 10 G

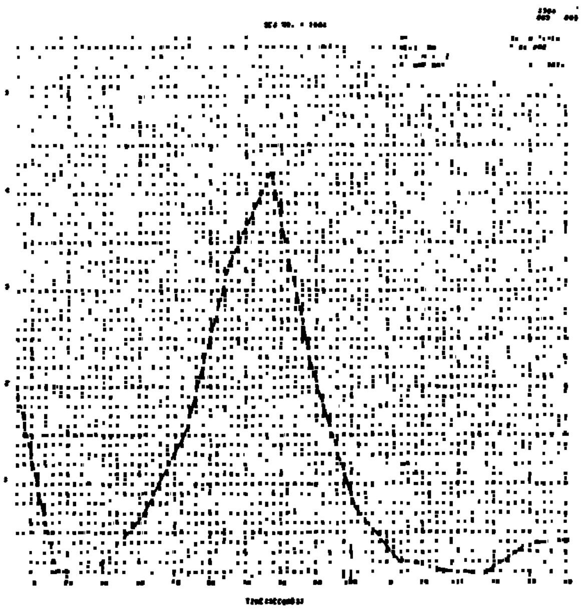
Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E359-802

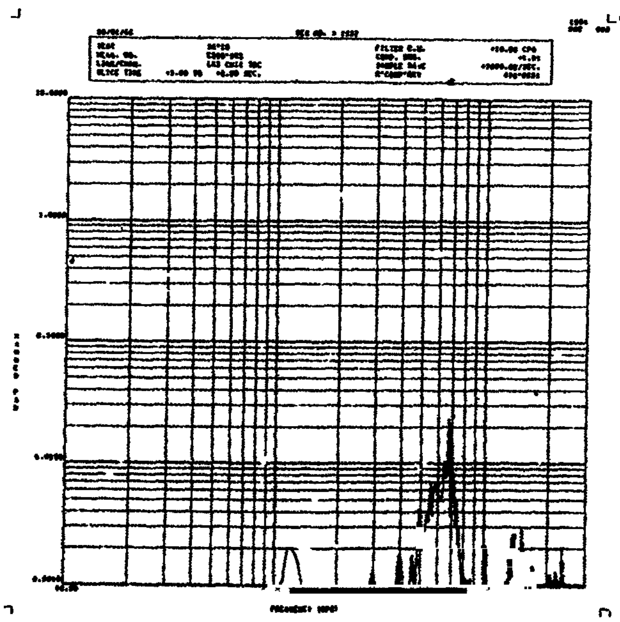
Description Upper Instrument Unit Mounting Ring

Sensitivity Longitudinal

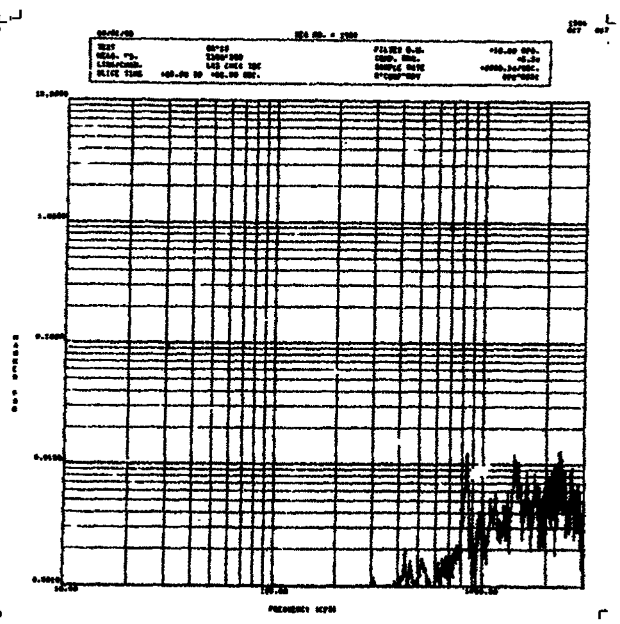
Location: Page 25

Calibration ± 10 G

Remarks Launch environment not available due to commutation.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E360-802

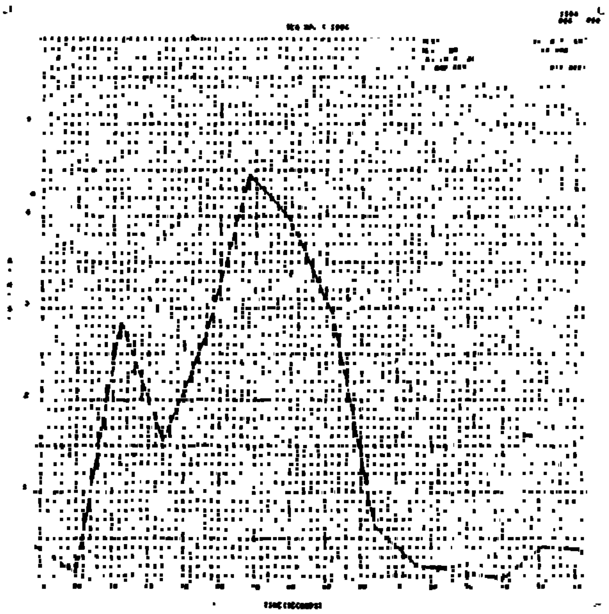
Description Upper Instrument Unit Mounting Ring

Sensitivity Perpendicular to ring

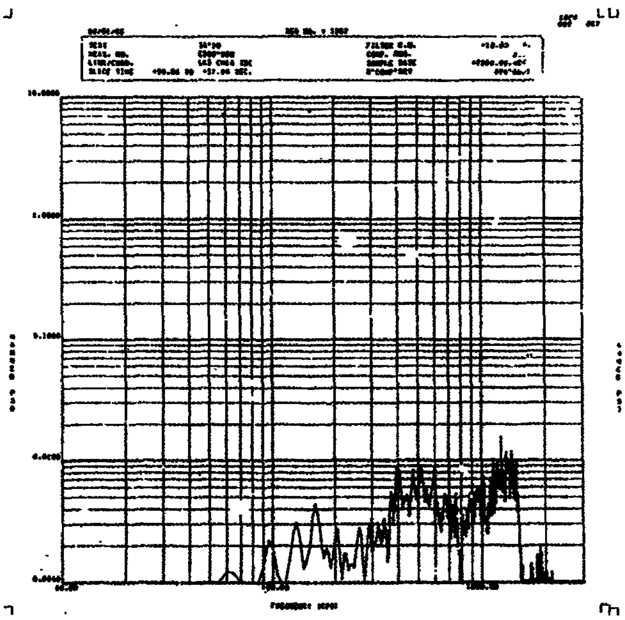
Location: Page 25

Calibration ± 10 G

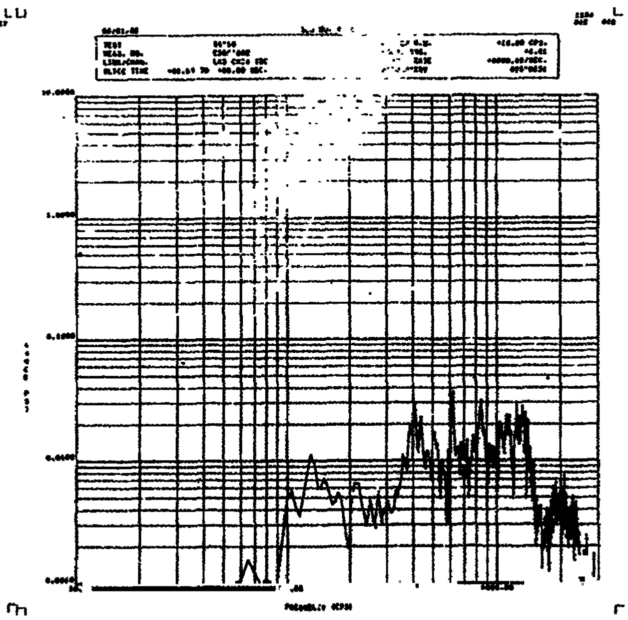
Remarks In-flight calibration at 31.7 seconds. Launch environment not available due to commutation.



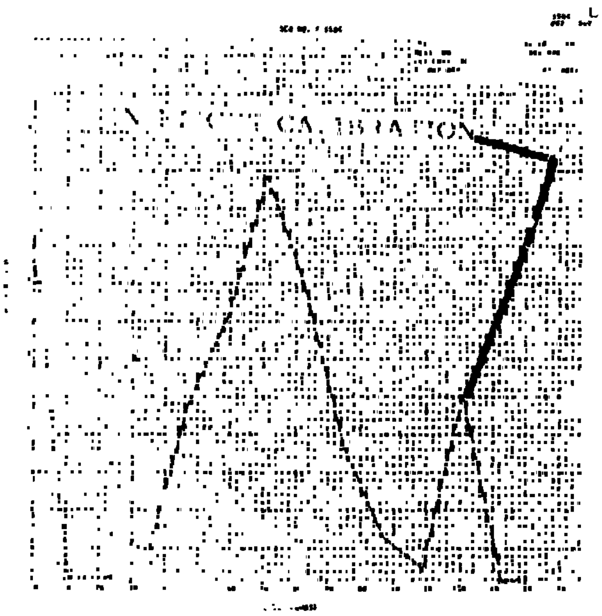
TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E361-802

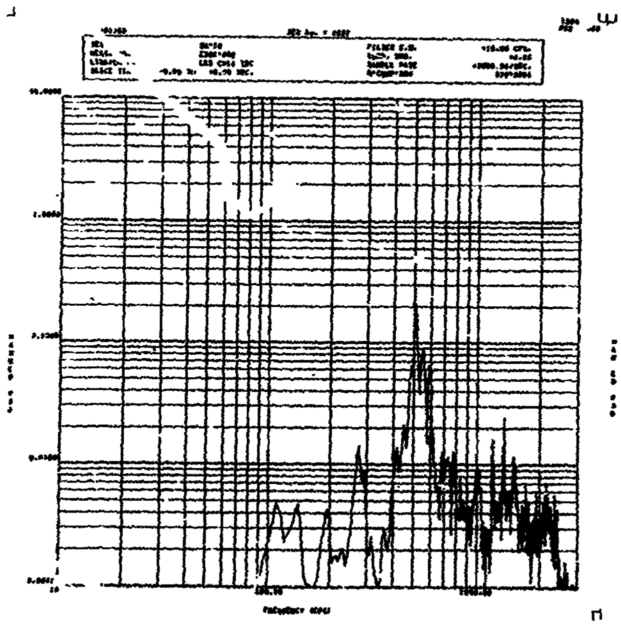
Description Lower Instrument Unit Mounting Ring

Sensitivity Longitudinal

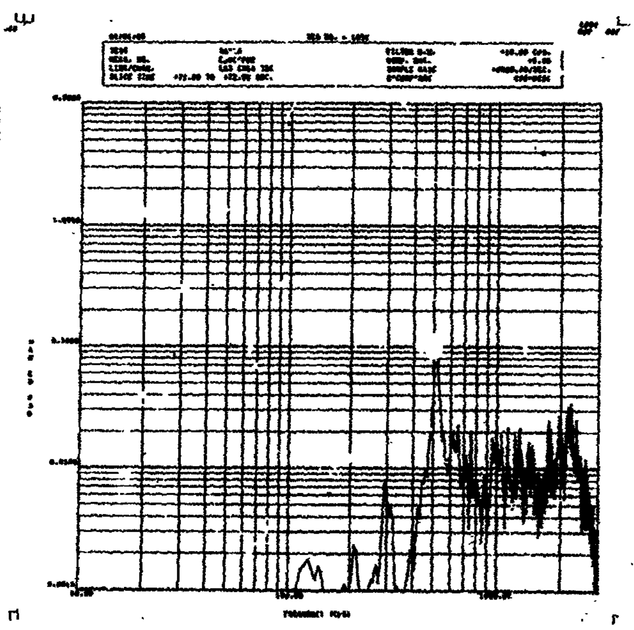
Location: Page 25

Calibration ± 10 G

Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. E362-802

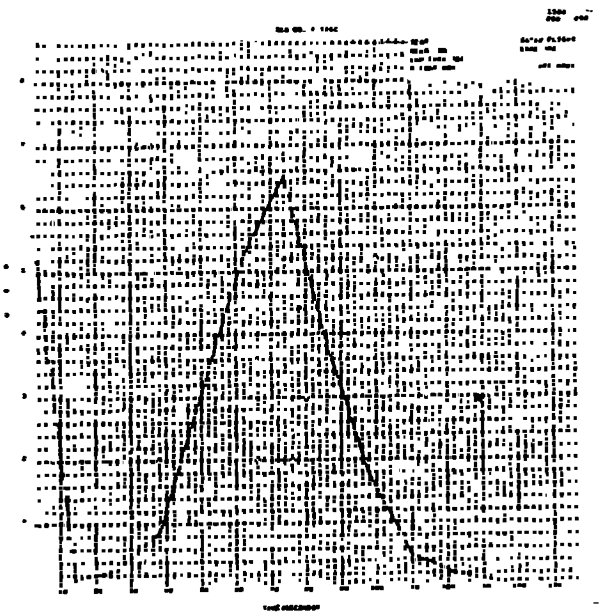
Description Lower Instrument Unit Mounting Ring

Sensitivity Perpendicular to ring

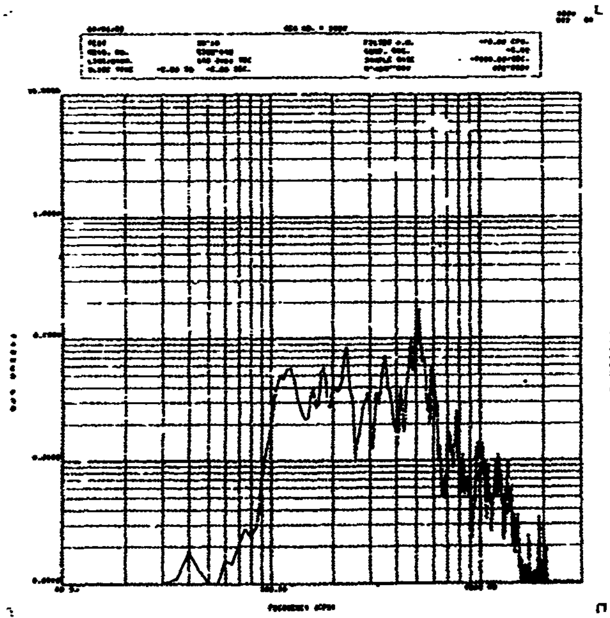
Location: Page 25

Calibration ± 10 G

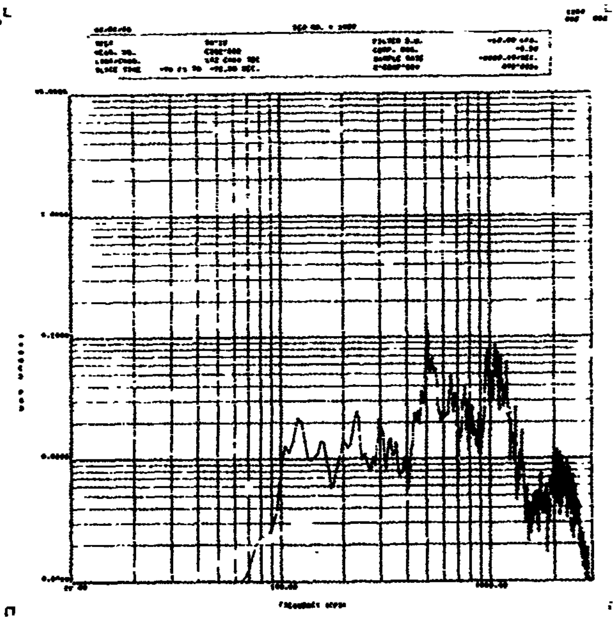
Remarks



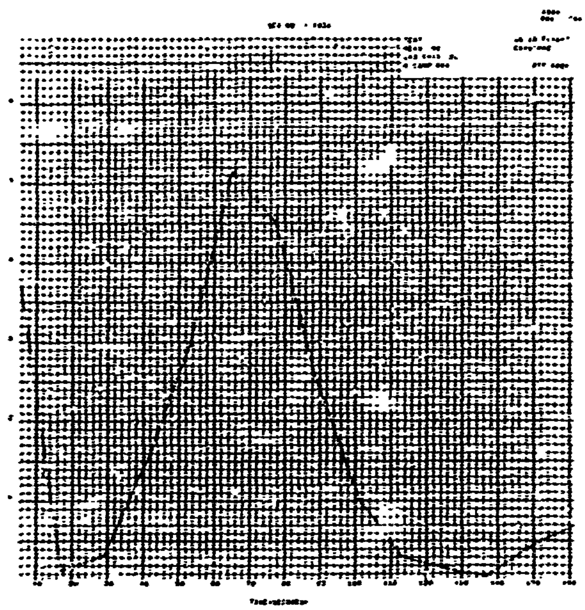
TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E379-802

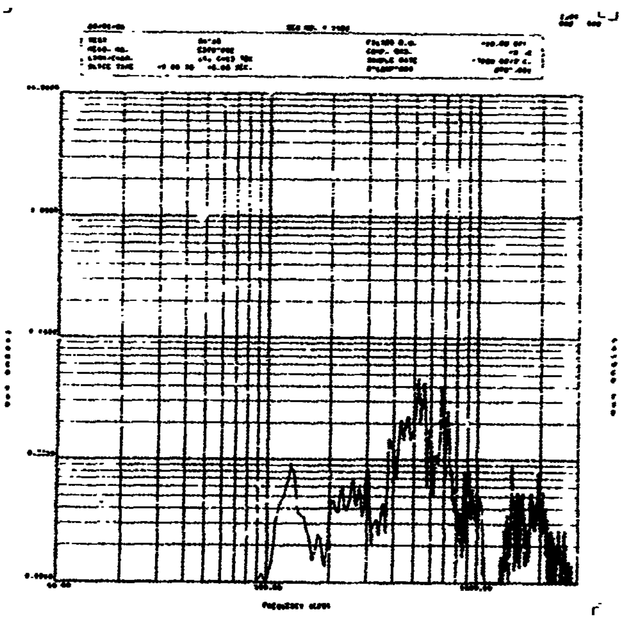
Description Upper Instrument Unit Mounting Ring

Sensitivity Longitudinal

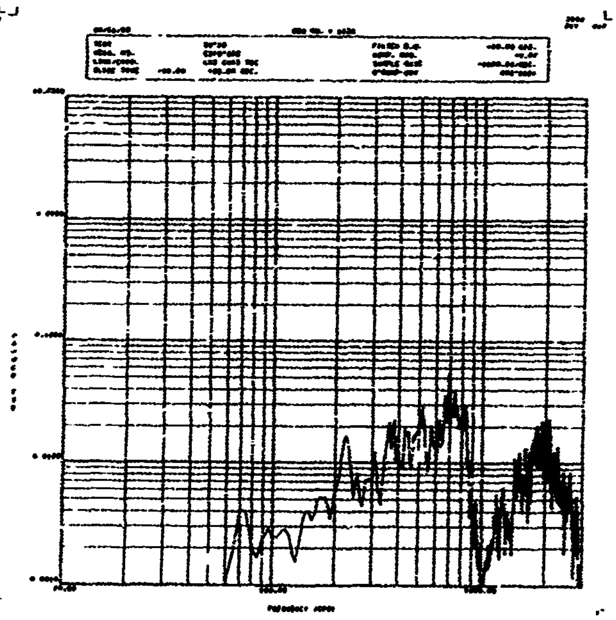
Location: Page 27

Calibration ± 10 G

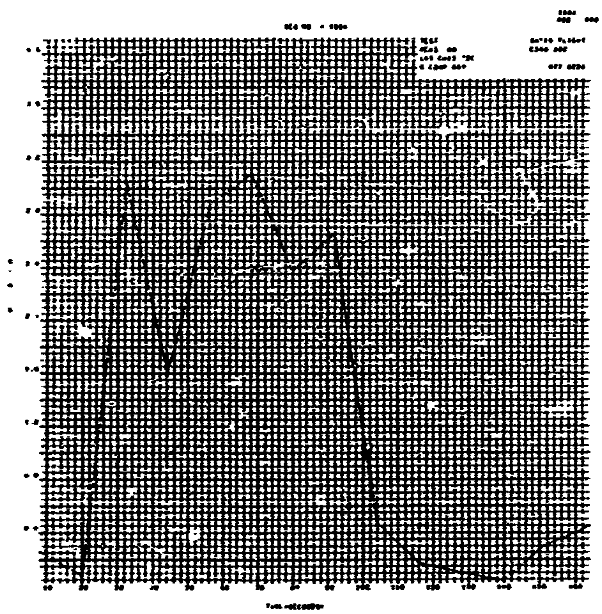
Remarks Launch environment not available due to commutation.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E380-802

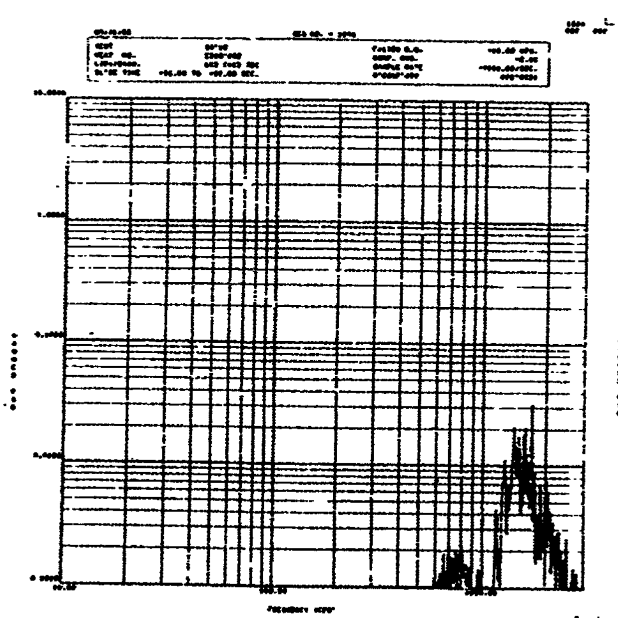
Description Upper Instrument Unit Mounting Ring

Sensitivity Perpendicular to ring

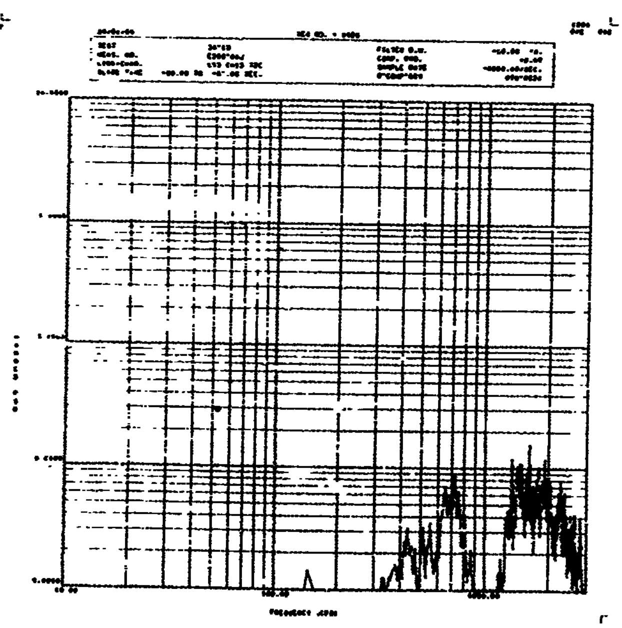
Location: Page 27

Calibration ± 10 G

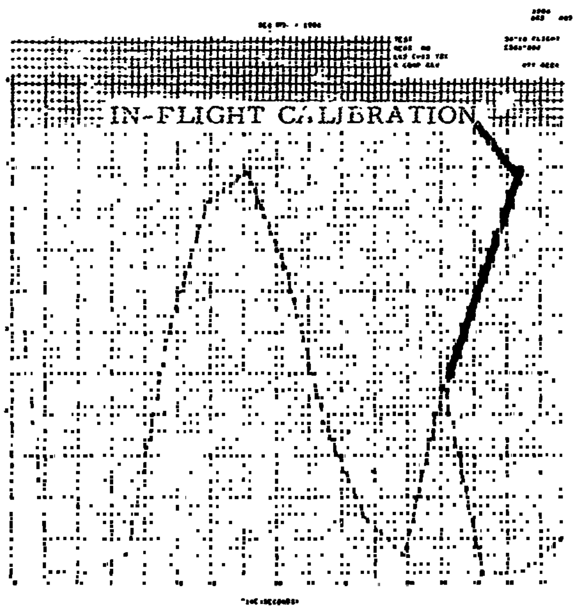
Remarks Launch environment not available due to commutation. In-flight calibrations at 31.7 and 91.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E381-802

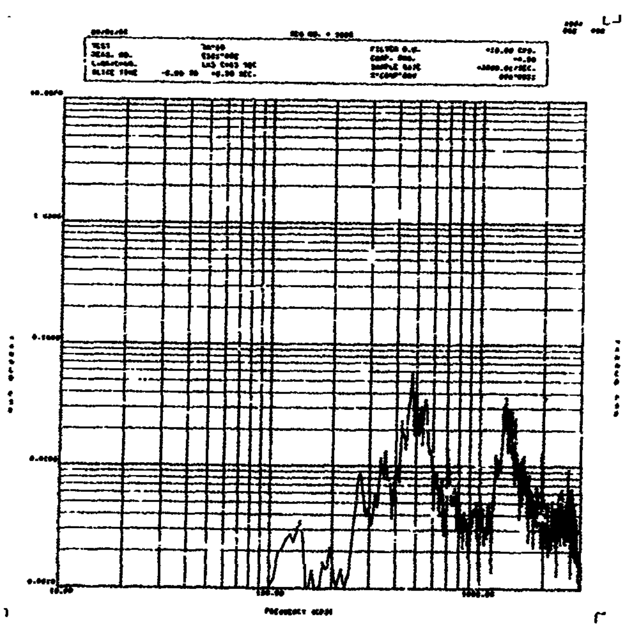
Description Lower Instrument Unit Mounting Ring

Sensitivity Longitudinal

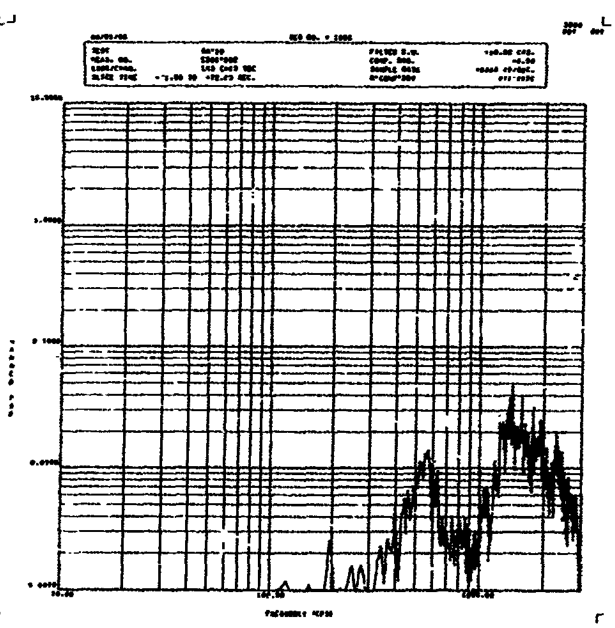
Location: Page 27

Calibration ± 10 G

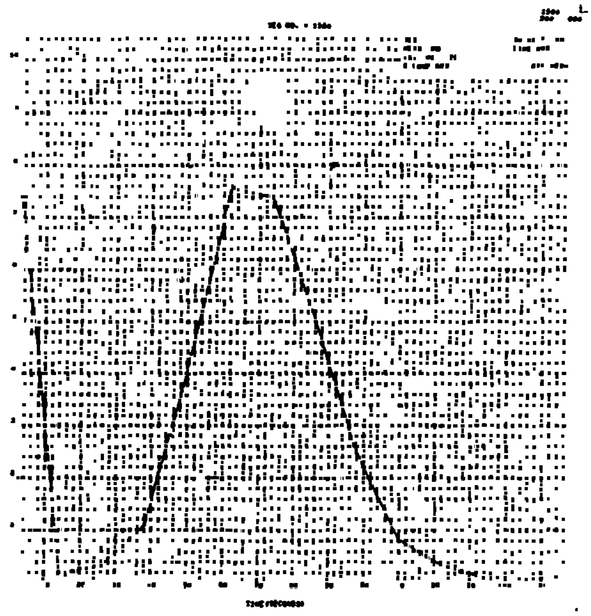
Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E382-802

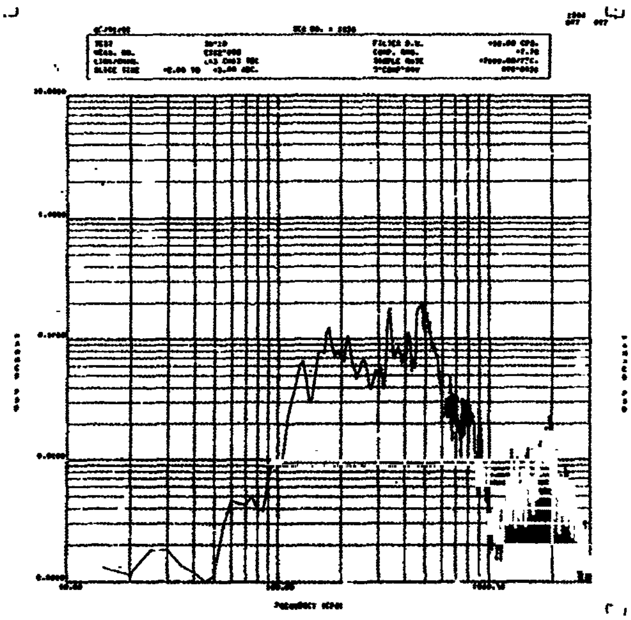
Description Lower Instrument Unit Mounting Ring

Sensitivity Perpendicular to ring

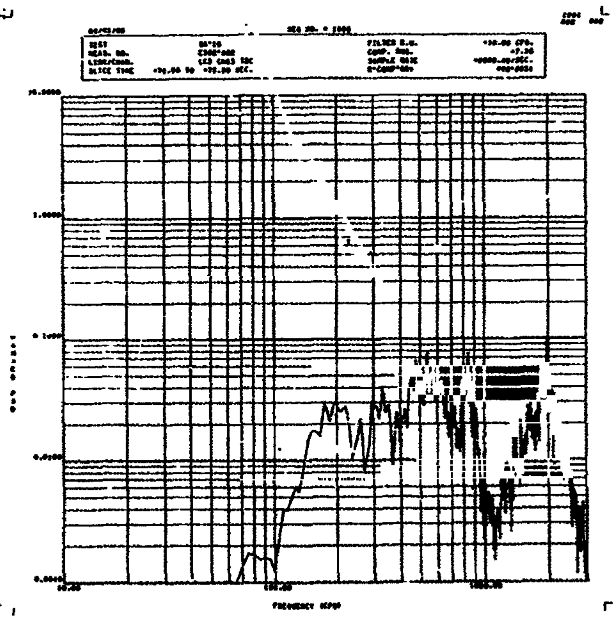
Location: Page 27

Calibration ± 10 G

Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. F369-900

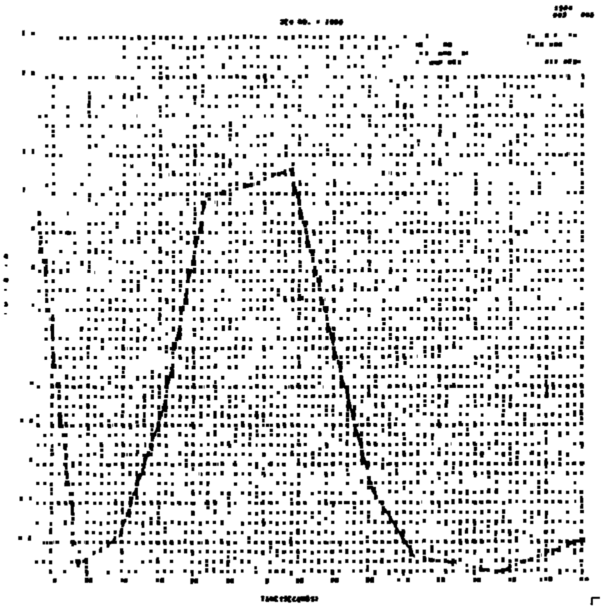
Description Upper IMC Mounting Longeron #6

Sensitivity Longitudinal

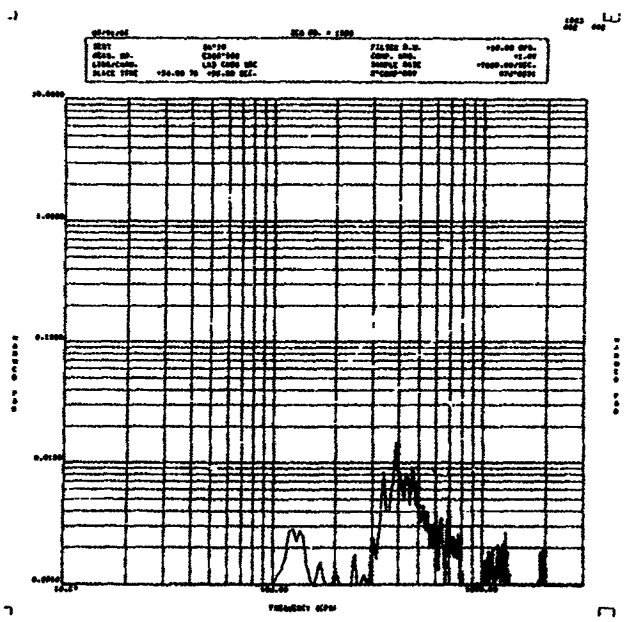
Location: Page 28

Calibration ± 10 g

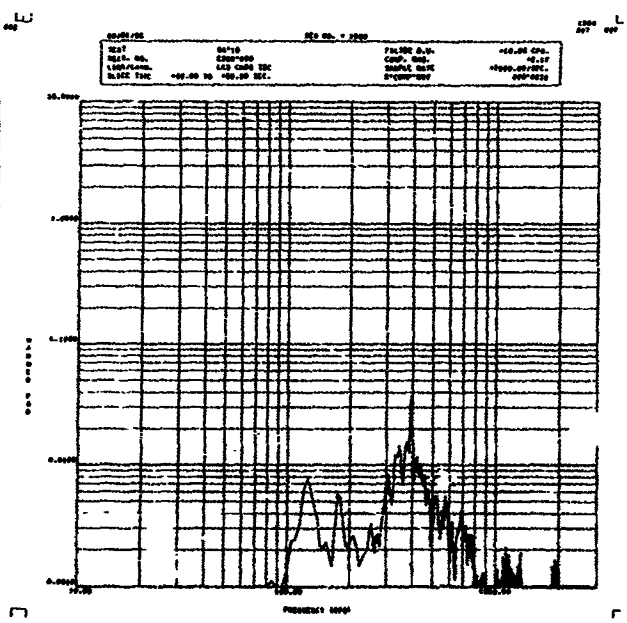
Remarks



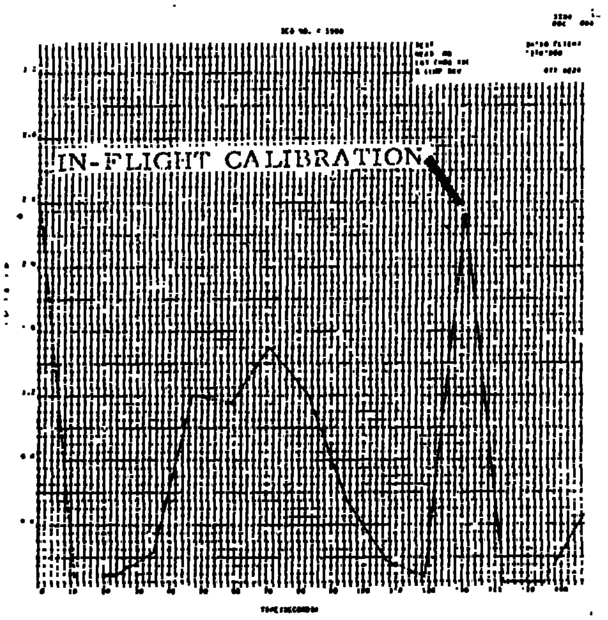
TIME HISTORY



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E370-900

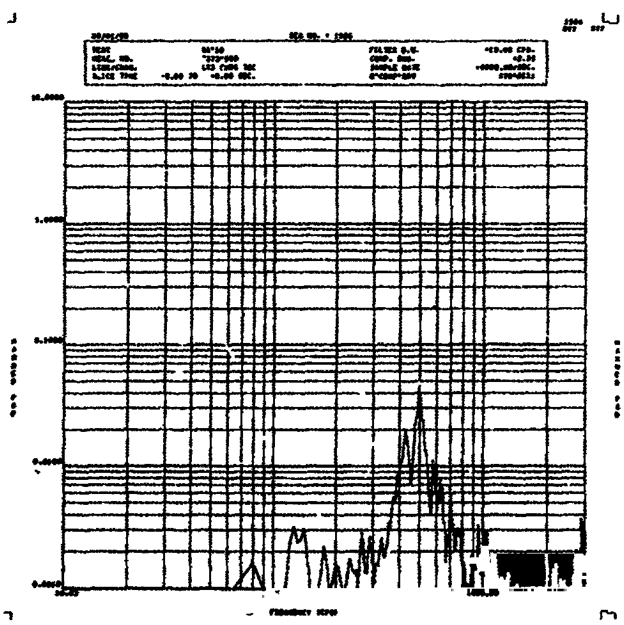
Description Upper MMC Mounting Longeron #6

Sensitivity Perpendicular

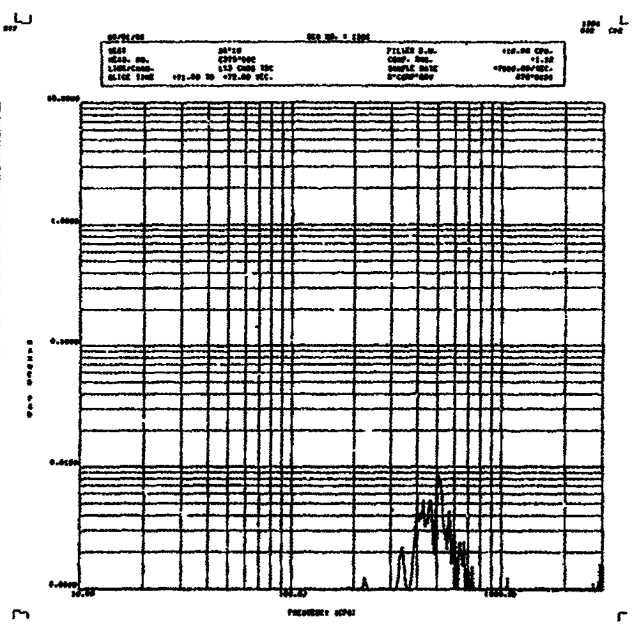
Location: Page 28

Calibration ± 10 G

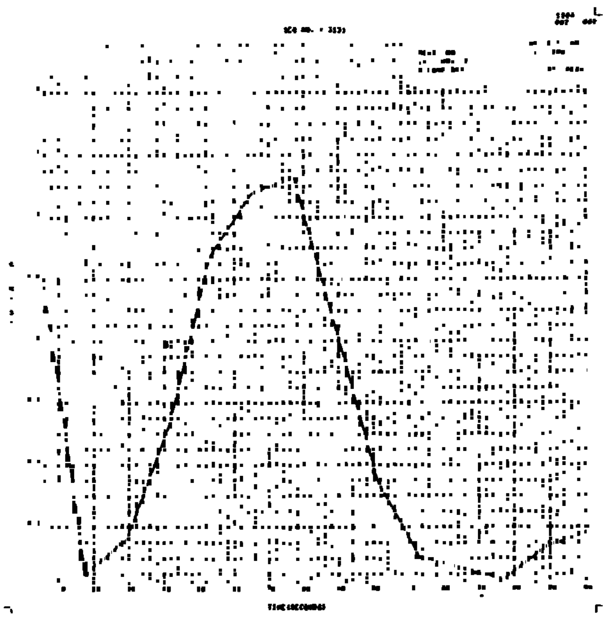
Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E371-900

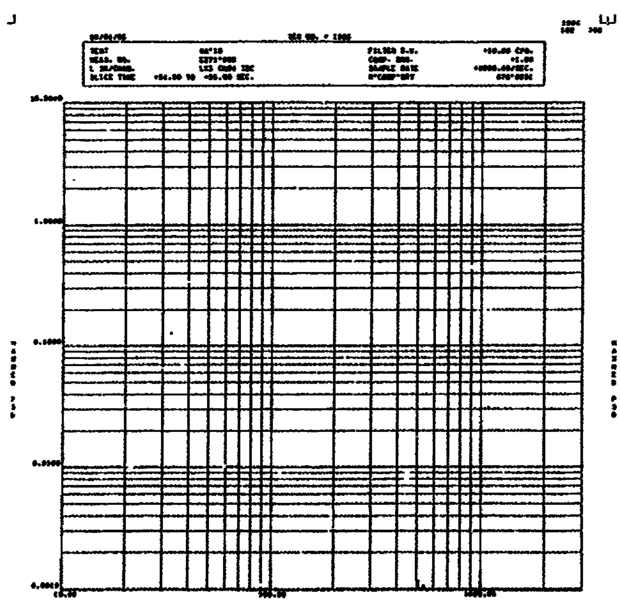
Description Lower MHC Mounting Longeron #6

Sensitivity Longitudinal

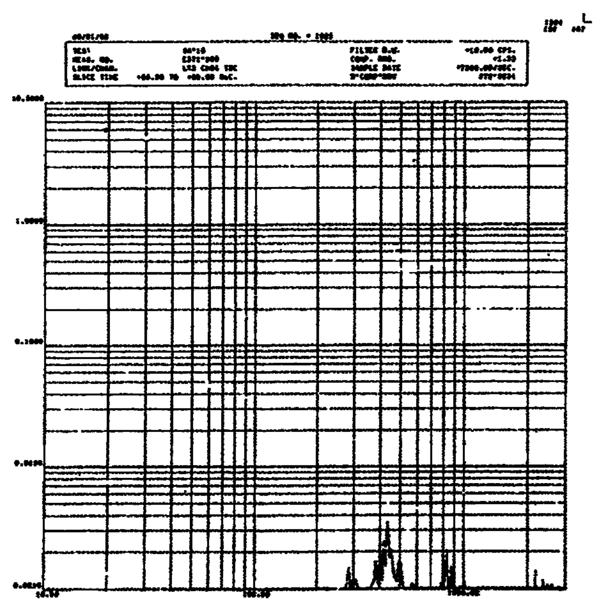
Location: Page 29

Calibration ± 10 G

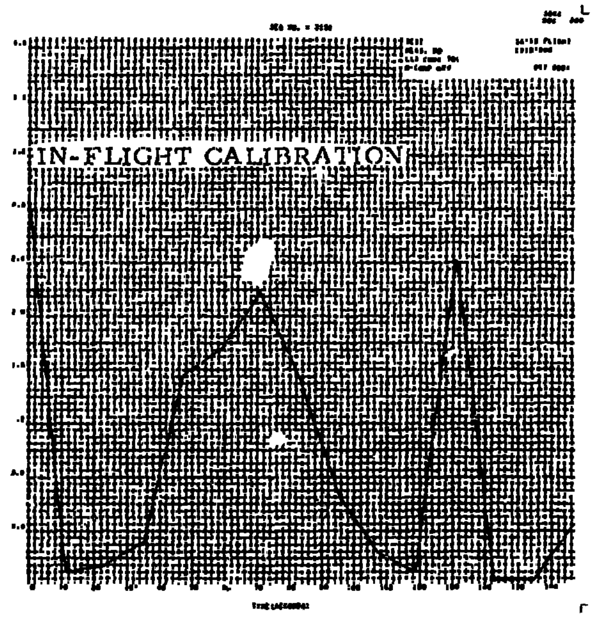
Remarks Launch Environment not available due to commutation.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. E372-900

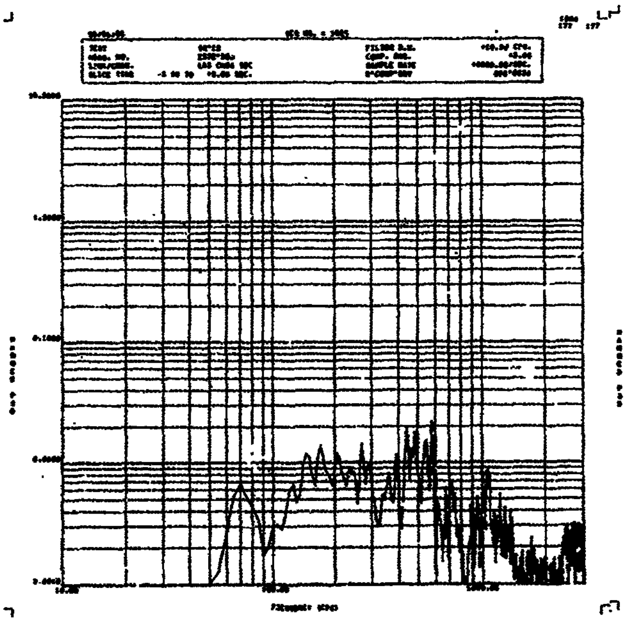
Description Lower MMC Mounting Longeron #6

Sensitivity Perpendicular

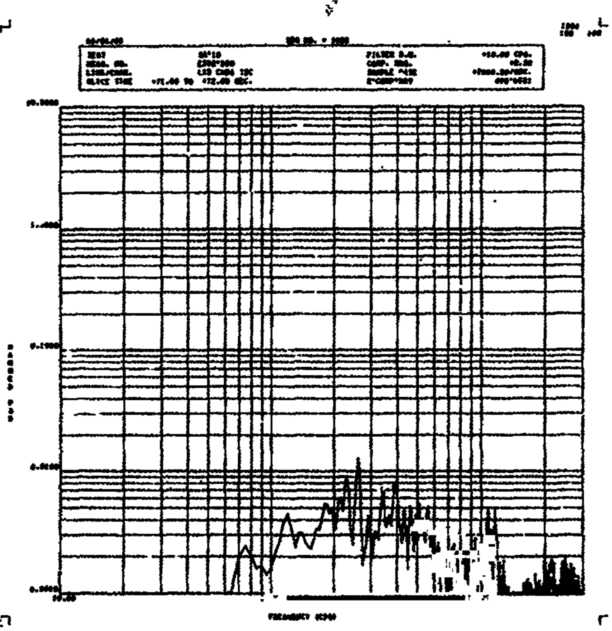
Location: Page 29

Calibration ± 10 G

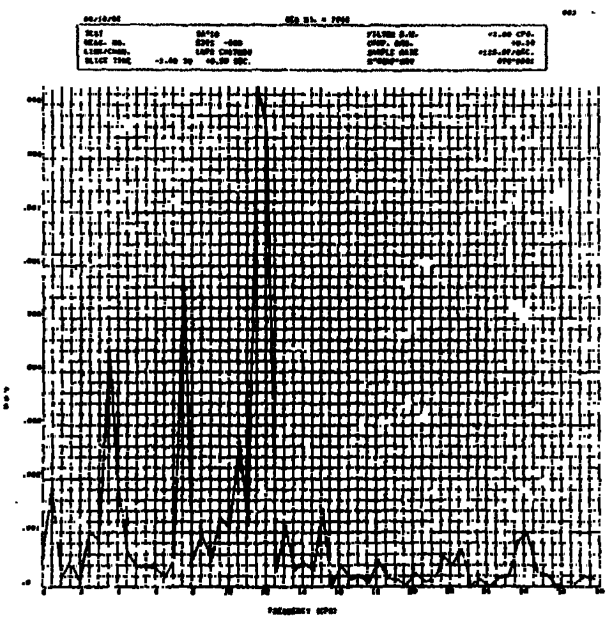
Remarks In-flight calibration at 130.7 seconds.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. [illegible]

Description [illegible]

Longeron No. 3 Approx. Sta. 1580

Sensitivity [illegible] axis [illegible]

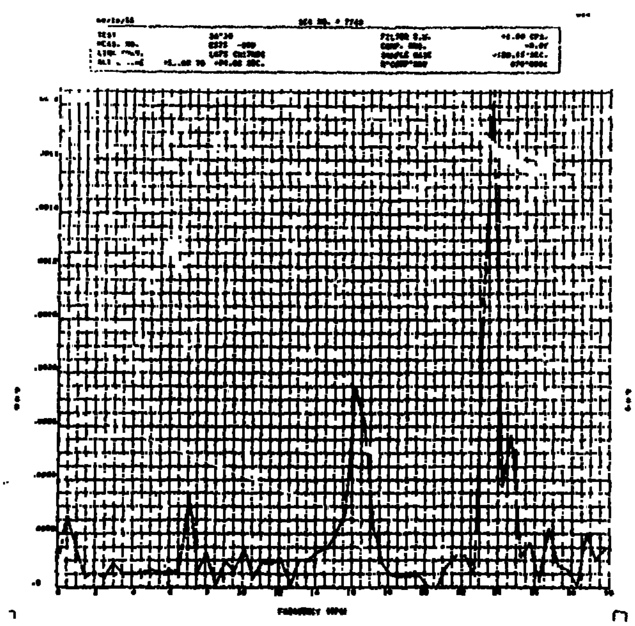
Location: Page 30

Calibration [illegible]

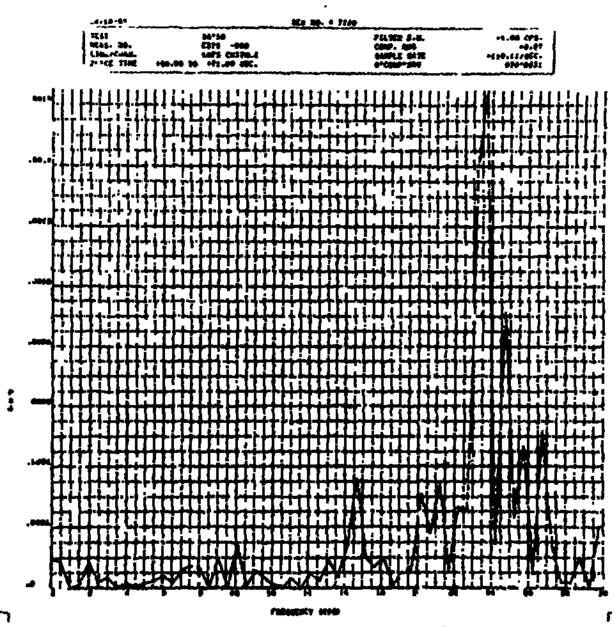
Remarks [illegible]

available, Special low frequency

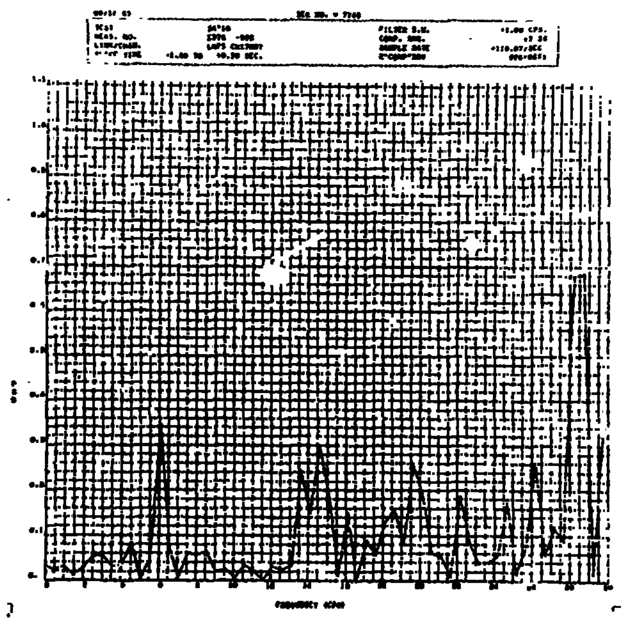
instrumentation.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. [illegible]-900

Description Upper [illegible] Mounting

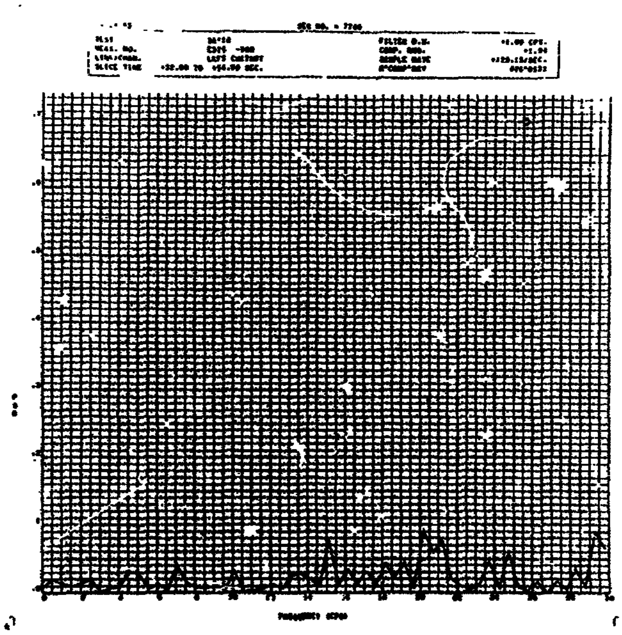
Longeron No. 3 Approx. Sta. 1580

Sensitivity [illegible] axis perpendicular

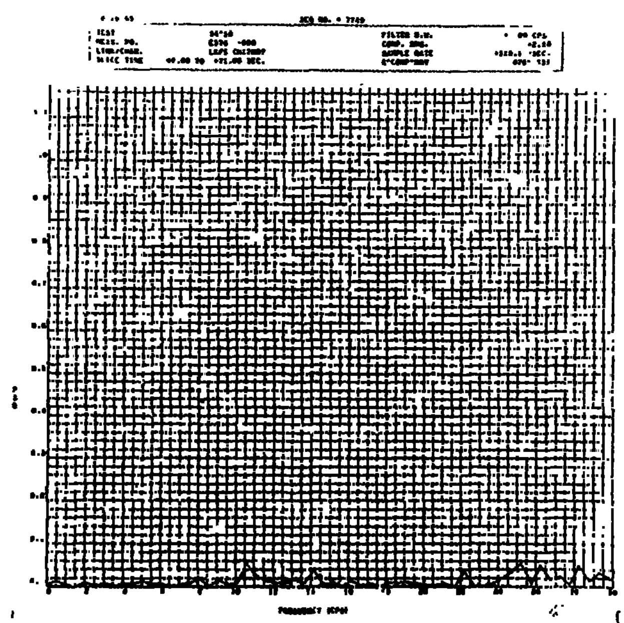
Location: Page 30

Calibration ± 5 G

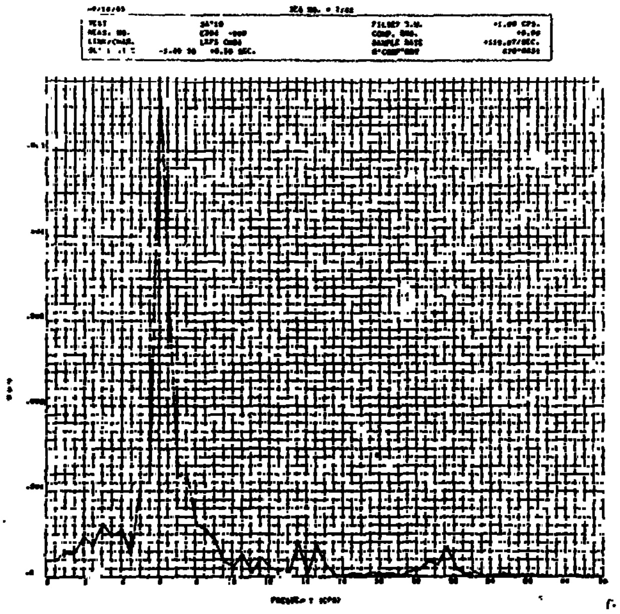
Remarks Time history plot not available. Special low frequency instrumentation.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM

Meas. No. [illegible]334-900

Description Top [illegible] Point [illegible]

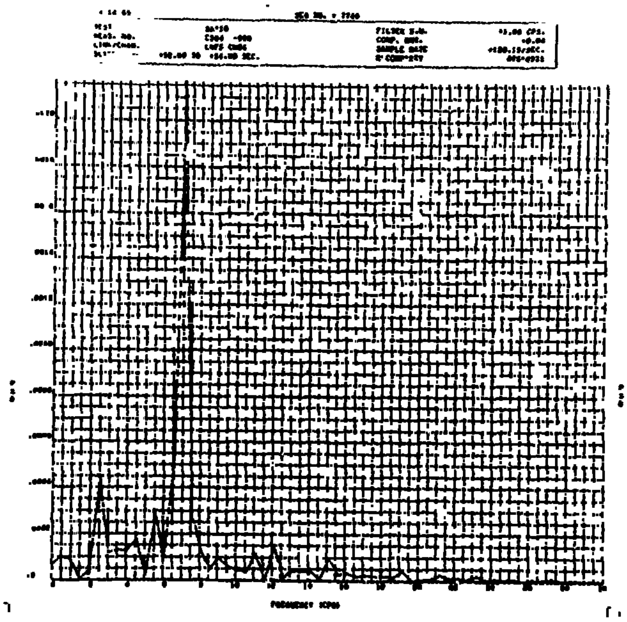
Station 17[illegible].5

Sensitivity [illegible] axis perpendicular

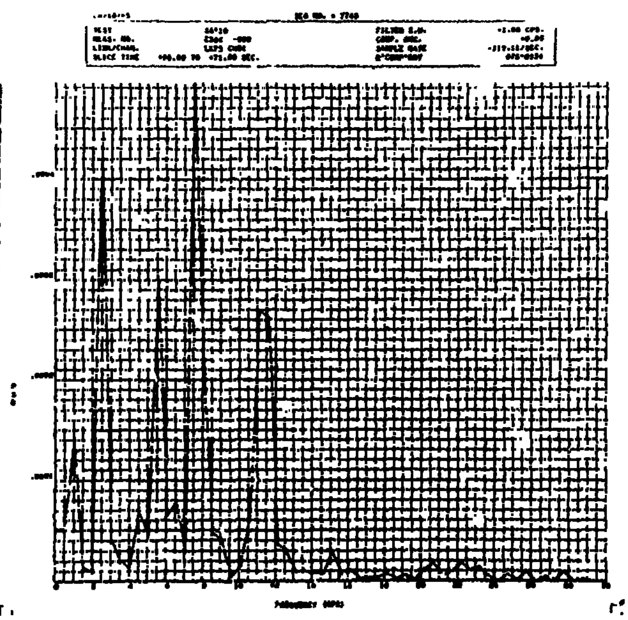
Location: Page 31

Calibration ± 50

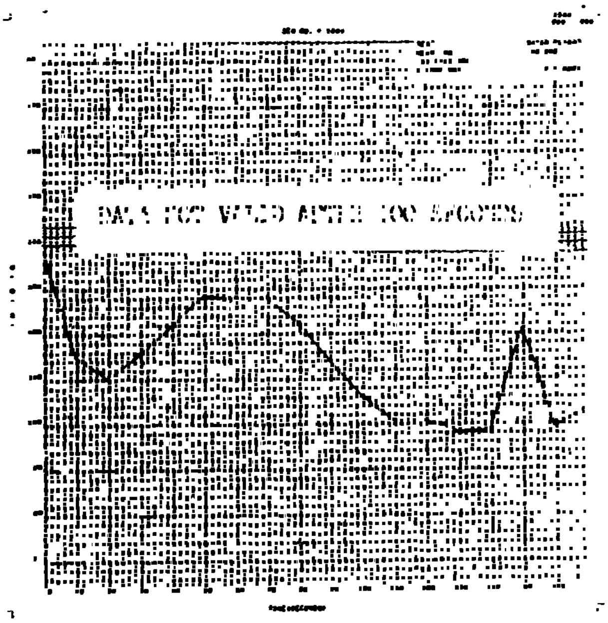
Remarks Time history plot not available. Special low frequency instrumentation.



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. L66-802

Description Sound Intensity

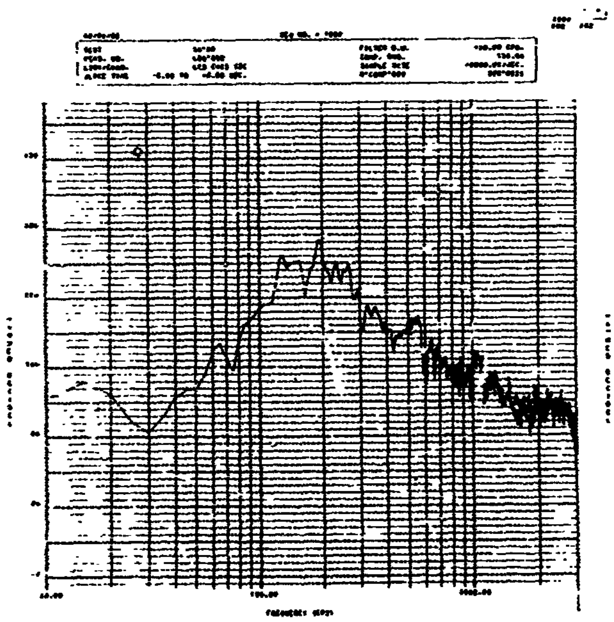
Station 1480 near ST-124

Sensitivity I.U. Internal Noise

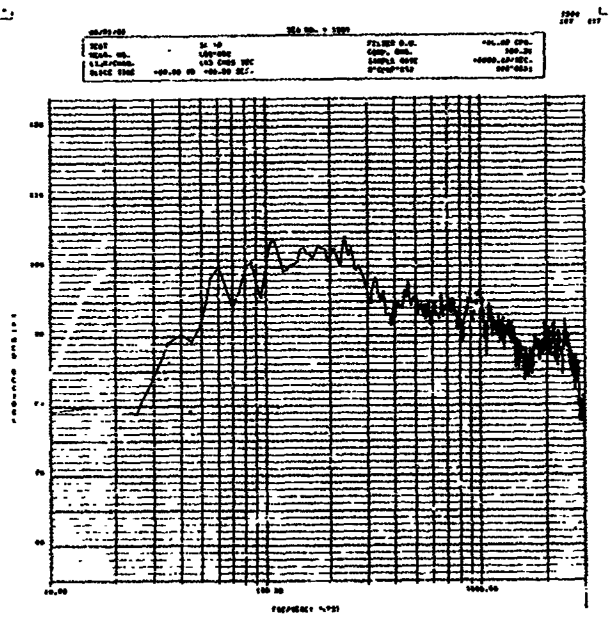
Location: Page 22

Calibration 120-140 dB

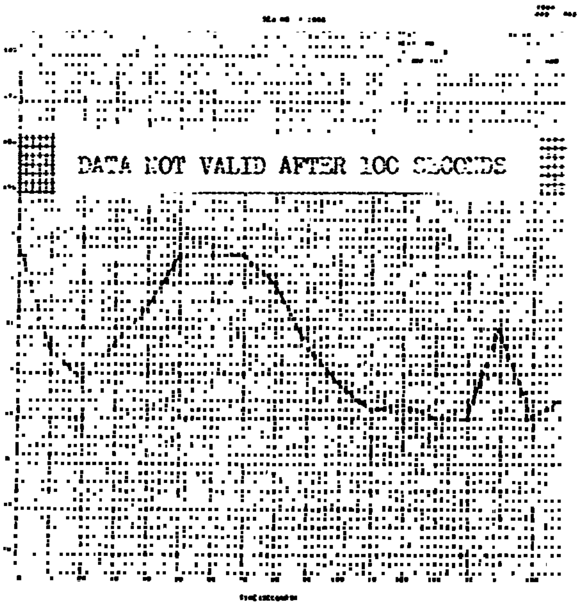
Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM



TIME HISTORY

Meas. No. L70-900

Description Sound Intensity

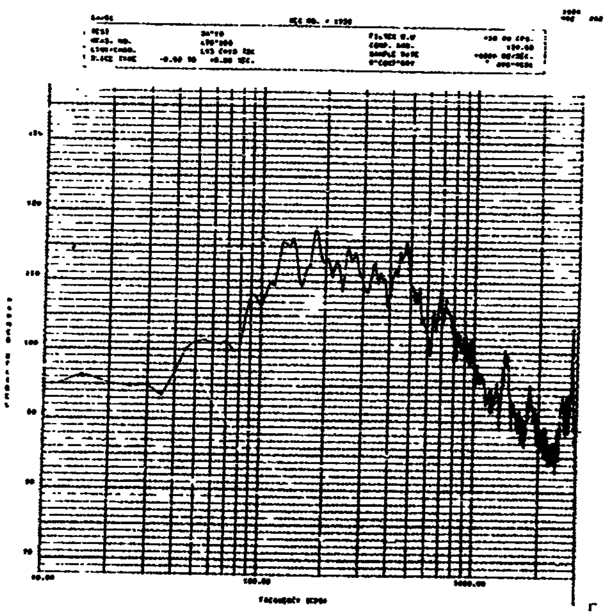
Station 1495 Fin I

Sensitivity Apollo Adapter Internal Noise

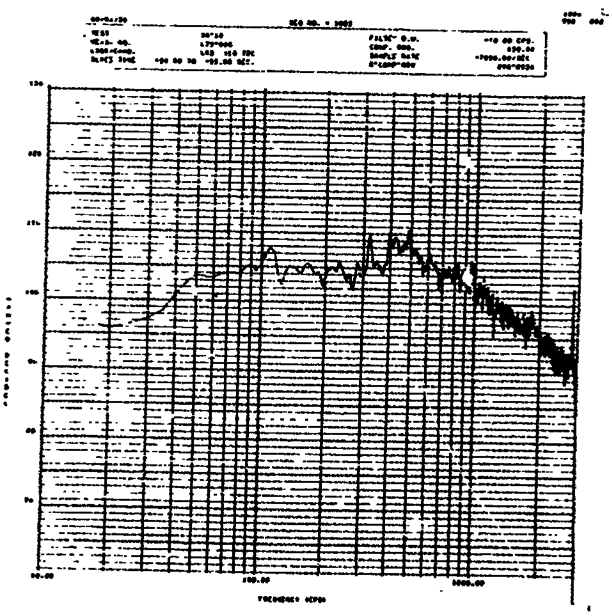
Location: Page 29

Calibration 123-143 dB

Remarks



FREQUENCY SPECTRUM



FREQUENCY SPECTRUM