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COMPILATION OF ATLAS E AND F SERIES VEHICLE FLIGHT ENVIRONMENTAL VIBRATION DATA

PART I

TECHNICAL REPORT GD/A-DDE65-016

CONTRACT NAS1-4471

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LANGLEY RESEARCH CENTER

LANGLEY STATION

HAMPTON, VIRGINIA

1 March 1965

FOREWORD

This report is a compilation of the environmental vibrations measured during flight, on Atlas E and F series vehicles for the period of October, 1960 to April, 1964. The report is presented in two parts. Part I (Unclassified) contains all of the acoustic and vibration data evaluation and a description of the basic vehicle configuration. Part II (Secret) contains a brief description of vehicle nominal performance. Parts I and II are presented in separate documents. The information provided in Part I and II of this report satisfy the requirements of Contract NAS1-4471.

The project was conducted by the Dynamics Group of the Astronautics Division, General Dynamics Corporation. San Diego, California.

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ABSTRACT

This report contains the evaluation of all pertinent vibration measurements made during numerous flight tests of Atlas E and F series vehicles. The data sections are arranged in order of individual vehicle flight occurrences and preceeded by sections describing the basic vehicle and payload configurations. Vehicle nominal performance information is reported under a separate cover in Part II. An index system is provided in Part I that cross references vehicle test number, vibration instrumentation and measurement location information.

The vibration and acoustic data presented in the data sections was extracted from existing flight test reports. The basic data format for each vibration measurement consists of waveforms, RMS time histories, and power spectral density plots. The acoustic measurements were reduced to overall and octave band sound pressure level (SPL) time histories with some narrow band frequency analysis included. Where certain data analysis or raw data presentations were lacking in the original flight report, additional analysis was initiated and provided in this compilation to facilitate a complete data presentation for the individual measurement and/or measurement groups.

Instrumentation and data reduction techniques are described with specific emphasis on measurement calibration and recording techniques, telemetry and ground station instrumentation, and the various methods of providing the amplitude and frequency analysis of the acoustic and vibration measurements.

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LIST OF SYMBOLS AND ABBREVIATIONS

A	AIRFRAME OR ACCELERATION
AIG	ALL INERTIAL GUIDANCE
AMR	ATLANTIC MISSILE RANGE
A/P,S	AUTO PILOT
AWS	ATLAS WEAPON SYSTEM
B1, B2	BOOSTER ENGINES 1 and 2
BECO	BOOSTER ENGINE CUTOFF
db	DECIBEL
ΔF	BANDPASS FILTER
F, PNEU.	PNEUMATIC
FLT	FLIGHT
FBW	FULL BAND WIDTH. FOR MOST VIBRATION MEASUREMENTS FBW IS INTELLEGENCE BAND WIDTH OF IRIG CHANNEL USED.
G, I	GUIDANCE
GE	GENERAL ELECTRIC CO.
H, HYD.	HYDRAULIC
HIRS	HIGH IMPULSE ROCKET SYSTEM
HPF	HIGH PASS FILTER
LL	LANDLINE RECORDING

LIST OF SYMBOLS AND ABBREVIATIONS (Cont'd)

LAT.	LATERAL DIRECTION
LONG. (AXIAL)	LONGITUDINAL DIRECTION
LOX	LIQUID OXYGEN
LPF	LOW PASS FILTER
MSL	MISSILE
MA-3	ROCKETYNE NUMBER FOR E AND F SERIES ATLAS ENGINE CONFIGURATIONS
MIC	MICROPHONE
N	DENOTES LAUNCH SITE MEASUREMENT
O	DENOTES VIBRATION MEASUREMENT
OSTF	OPERATIONAL SYSTEMS TEST FACILITY
P	DENOTES PROPULSION SECTION
PMR	PACIFIC MISSILE RANGE
PROP.	PROPULSION
PSD (g^2/CPS)	POWER SPECTRAL DENSITY
RAD,, RADIAL	ACCELEROMETER SENSITIVITY DIRECTED TOWARD CENTER OF VEHICLE
R/V	RE-ENTRY VEHICLE
SECO	SUSTAINER ENGINE CUTOFF
STG., STG'G	BOOSTER STAGING

LIST OF SYMBOLS AND ABBREVIATIONS (Cont'd)

SPL	SOUND PRESSURE LEVEL
STL	SPACE TECHNOLOGY LAB., CORP.
TANG.	TANGENTIAL TO PERIPHERY OF TANK
TLM	TELEMETRY, RF-CH-SEG. DENOTES TLM NO.-CHANNEL NO.-SEGMENT NO.
VECO	VERNIER ENGINE CUTOFF
Y	ACOUSTIC MEASUREMENT

SECTION 1

INTRODUCTION

The primary purpose of this report was to provide a single publication that would represent all of the airborne and liftoff vibration and acoustic measurements obtained from the flight tests of the Atlas E and F series vehicles.

The material presented was taken, for the most part, from flight test evaluation reports of 22 vehicles flown within the Atlantic Missile Range and 4 at the Pacific Missle Range. A total of 42 separate structural points and/or components were monitored during powered flight or a portion of flight, following liftoff. Seventy-five individual measurements (varying sensitivity directions) were made at the 42 separate points and repeated on several flights to provide a total of 210 airborne measurements attempted during the flight program. A total of 33 separate points were monitored during liftoff, by landline means, with 41 individual measurements made and repeated on several launchings to accumulate a total of 112 measurements. For the purposes of this report, 157 airborne and 99 liftoff measurements were presented as representative of the environment of the locations mentioned above.

To maintain editorial simplicity, the flight test report excerpts, provided in Section 6, retain the table and figure number system originated in the flight reports. These data sections are presented in order of individual missile flight tests and are preceeded by Table 6.1.2, which is provided to aid the reader in determining the measurement locations of interest and the test vehicles that contained those measurements. The report excerpt illustrations and figures are not listed in the table of contents.

To facilitate the convenience of having all pertinent information available in one presentation and to adequately fullfill the contract requirements, a brief description of the flight vehicles and their nominal performance characteristics is provided.

SECTION 2

DESCRIPTION OF THE ATLAS E AND F SERIES TEST VEHICLE

2.1 BASIC CONFIGURATION. The general arrangement and design of the basic E and F Atlas vehicles are essentially the same. A layout of the vehicle is shown in Figure 2.1-1.

The vehicle airframe is constructed of bands of stainless steel that vary in thickness, longitudinally, (the maximum thickness is less than 40-thousandths of an inch), and welded to provide for propellant tankage. The tanks have no internal framework and are kept under pressure to retain shape. The airframe is adapted for the free launch concept. The equipment pods attached to the outer surfaces of the propellant tanks contain all of the electronic equipment necessary to support guidance, propellant utilization, flight control, telemetry and numerous other electrical functions necessary for flight. Some vehicles incorporated scientific passenger pods, as shown in Figure 2.1-2.

The power plant for the Atlas consists of two booster engines, one sustainer engine and two vernier rockets for fine trim. The engines are manufactured by the Rocketdyne Division of North American Aviation Corp., and consist of the MA-3 liquid propellant configuration. The rated thrust at lift off is 390,000 pounds. The booster engines and supporting thrust structure are separated from the sustainer portion and jettisoned immediately following booster engine cutoff (BECO). The separated structure (one half stage) consists of that portion between stations 1133 and 1310. The booster thrust section is guided in staging by two rails approximately 96 inches in length.

The basic geometric nomenclature as noted in Figure 2.1-1 consists of Axes X and Y and Quadrant I through IV. The cross section noted in Figure 2.1-1 is the flight attitude, as looking forward, for the vehicle.

2.2 TEST PROGRAMS AND LAUNCH SITES. The Atlas vehicles discussed in this report were flight tested within five separate test programs. Table 2.1 shows a summary of test vehicle basic information arranged in order of flight dates for these programs. Missiles 3E through 36E (not including missile 24E) were Series E R and D flight vehicles, and launched from the AMR complexes at Cape Kennedy. Missiles 24E, 65E and 67E were Series E operational vehicles and were launched from the PMR OSTF 1 sites, utilizing the coffin launch facility. Missiles 4E through 21F were Series F R and D vehicles, and were launched from AMR Complex 11. Missile 109F was

an operational test vehicle launched from the PMR OSTF 2 silo launch facility. Missiles 135F through 5E(F) were special test vehicles using various re-entry vehicle designs and were launched from AMR Complex 11.

The vehicles mentioned above were launched from three different types of launch facilities. The AMR complexes consisted of the open concrete launch facility. The PMR OSTF 1 launch facility consisted of the horizontal standby coffin placed below ground in a reinforced concrete and steel structure. The roof retracted to permit the missile to be erected. The PMR OSTF 2 facility consisted of the silo type launch configuration wherein the vehicle was retained in the vertical position. Immediately before launch the vehicle was raised to ground level.

TABLE 2.2
TEST VEHICLE BASIC INFORMATION

1 Measure Number	2 Payload Configuration	3 Test Site	4 Test Data	5 Flight Test Report Number	6 Vibration Data			7 Acoustic Data		
					Nose	Equip. Pods	Prop. Section	Nose	Equip. Pods	Prop. Section
* 3E	AVCO RVX4A-2	AMR Complex 13	11-10-60	AE60-0542			FLT			
* 4E	GE MK 3 MOD IB	AMR Complex 13	11-29-60	AE60-0750		FLT	FLT			
* 8E	AVCO MK 4 MOD IV	AMR Complex 13	1-24-61	AE60-0955		FLT	FLT			
9E	GE MK 3 MOD IIB	AMR Complex 13	2-24-61	AE60-0955		FLT	FLT			
*13E	GE MK 3 MOD IB	AMR Complex 13	3-13-61	AE60-0957		FLT	LL			
*12E	AVCO MK 5 MOD I	AMR Complex 11	5-12-61	AE61-0239		FLT	FLT			
*18E	AVCO MK 4 MOD IV	AMR Complex 13	5-26-61	AE61-0241			FLT			
*17E	GE MK 3 MOD IB	AMR Complex 11	6-22-61	AE61-0240		FLT				
*22E	GE MK 3 MOD IIB	AMR Complex 13	7-6-61	AE61-0642			FLT			
*21E	AVCO MK 5 MOD I	AMR Complex 11	6-31-61	AE61-0641			FLT			
*26E	AVCO MK 4 MOD 2A	AMR Complex 13	9-8-61	AE61-0797			FLT-LL			
*25E	AVCO MK 5 MOD I	AMR Complex 11	10-2-61	AE61-0798		FLT	FLT			
30E	AVCO MK 1 MOD I	AMR Complex 13	10-5-61	AE61-0972			LL			
* 4F	AVCO MK 5 MOD II	AMR Complex 11	11-22-61	AE61-0799			FLT			
*35F	AVCO MK 4 MOD IV	AMR Complex 13	12-1-61	AE61-1190			FLT			
5F	AVCO MK 4 MOD IIA	AMR Complex 11	12-12-61	AE61-1224			FLT			
*36E	AVCO MK 5 MOD IA	AMR Complex 13	12-19-61	AE61-1231			FLT			
* 6F	AVCO MK 5 MOD IA	AMR Complex 11	12-20-61	AE61-1282			FLT			
66F	AVCO MK 4 MOD 5B	OSTF No. 1	2-28-62	AE62-0076					LL	LL
67F	AVCO MK 4 MOD 5B	OSTF No. 1	7-13-62	AE62-0692			LL		LL	LL

*Vibration data in this report.

TABLE 2.2 (Continued)

TEST VEHICLE BASIC INFORMATION

1	2	3	4	5	6			7		
					Vibration Data			Acoustic Data		
Number	Payload Configuration	Test Site	Test Data	Flight Test Report Number	Nose	Equip. Pods	Prop. Section	Nose	Equip. Pods	Prop. Section
57F	AVCO MK 4 MOD 5B	OSTF No. 2	8-10-62	AE62-0731					LL	LL
7F	AVCO MK 4 MOD IV	AMR Complex 11	8-13-62	AOJ62-0007			Flt. (Stg'g) LL			LL
8F	AVCO MK 4 MOD I	AMR Complex 11	9-19-62	AOJ62-0047			LL			LL
*14F	AVCO MK 4 MOD I	AMR Complex 11	10-19-62	AOJ62-0054			LL			LL
*16F	AVCO MK 4 MOD IB	AMR Complex 11	11-7-62	AOJ62-0112			LL			LL
13F	AVCO MK 4 MOD 5B	OSTF No. 2	11-14-62	AOJ62-0055					LL	
*21F	AVCO MK 4 MOD IB	AMR Complex 11	12-5-62	AOJ62-0114			Flt. (Stg'g) LL			LL
64F	Type 33 NZT	OSTF No. 1	12-19-62	AOJ62-0010			LL			LL
134F	Chrysler REX-1 (ABRES)	AMR Complex 11	3-1-63	AOJ63-0032	(wet start)		Flt. (Stg'g) LL			LL
83F	AVCO MK 4 MOD 5B	OSTF No. 2	3-21-63	AOJ63-0054			LL		LL	LL
*65E	AVCO MK 4 MOD 5B	OSTF No. 1	4-24-63	GD/A63-0107			LL		LL	LL
* 135F	Chrysler REX-2(ABRES)	AMR Complex 11	4-26-63	GD/A63-0120			Flt. (Stg'g) LL			LL
62E	AVCO MK 4 MOD 5B	OSTF No. 1	6-4-63	GD/A63-0363		LL	LL		LL	LL
*24E	AVCO MK 4 MOD 5B	OSTF No. 1	7-26-63	GD/A63-0709			LL		LL	FLT LL
* 136F	GE WAC 1(ABRES)	AMR Complex 11	10-28-63	GD/A63-1092	FLT		FLT-LL	FLT		
* 109F	AVCO MK 4 MOD 5B	OSTF No. 2	12-18-63	GD/AAPZ-002						
*5E(F)	GE WAC-3	AMR Complex 11	2-25-64	GD/A APZ-018 (HIRS only)	FLT	LL	FLT-LL	FLT	LL	
* 137F	GE WAC	AMR Complex 11	4-1-64	None	FLT	LL	FLT-LL	FLT	LL	FLT

NOTE: ALL REPORTS REFERENCED ABOVE ARE CLASSIFIED SECRET

* Vibration data in this report

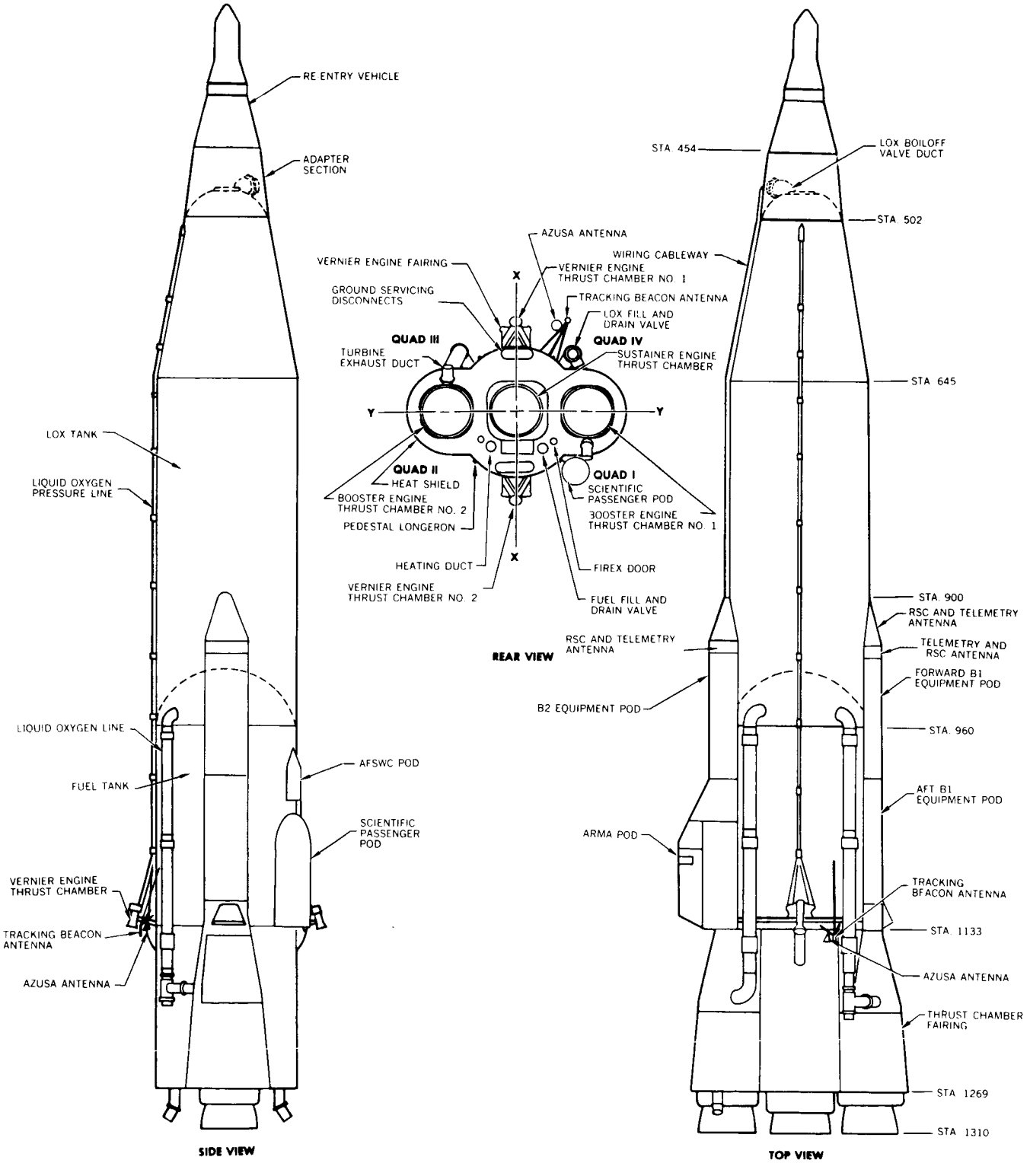


FIG. 2.1-1 VEHICLE CONFIGURATION

MISSILE 25E

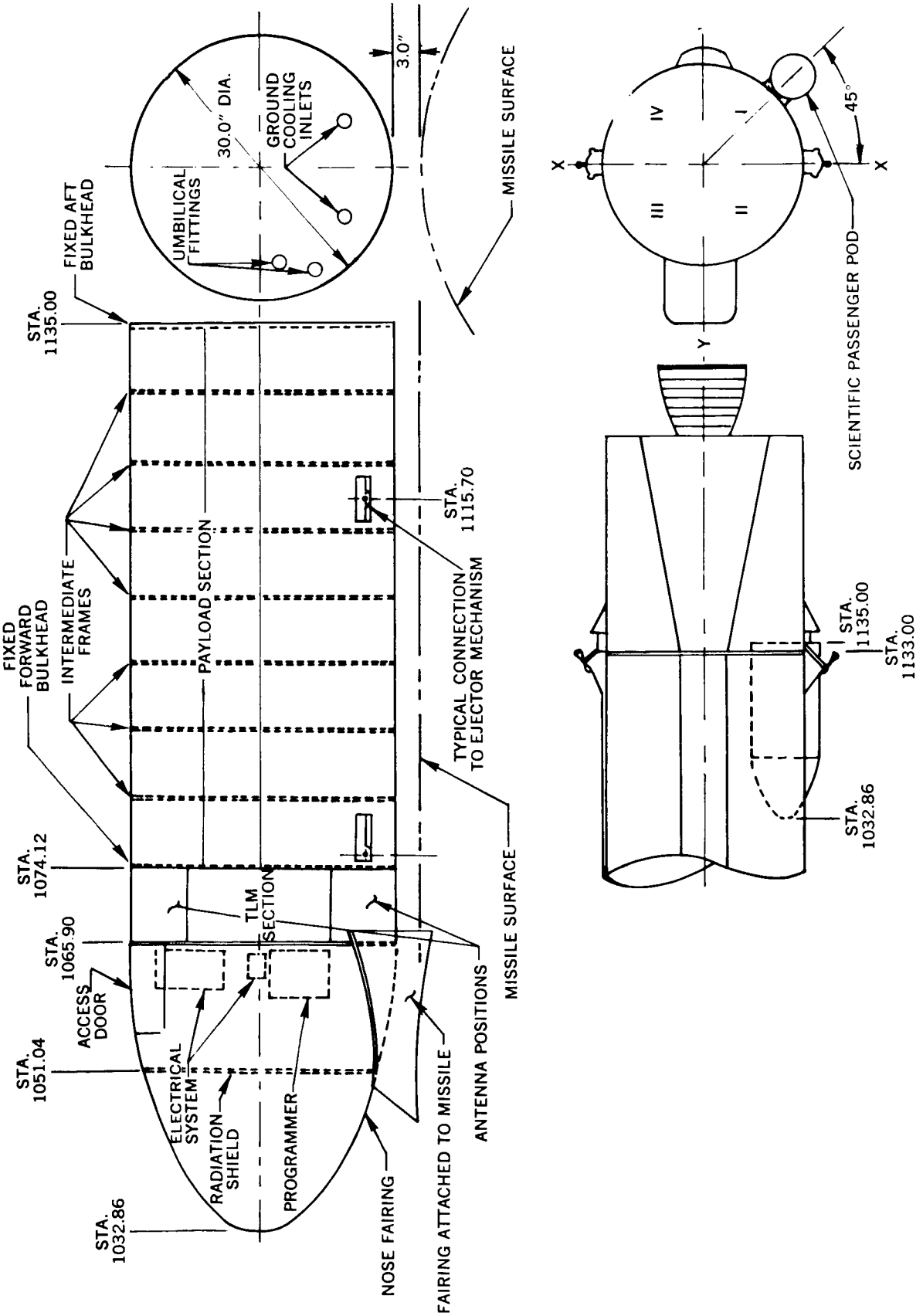


FIG. 2.1-2 GENERAL LAYOUT & LOCATION OF A TYPICAL SCIENTIFIC PASSENGER POD

SECTION 3

TEST VEHICLE PAYLOADS

A description of the payloads carried by the Atlas E and F series vehicles, discussed in this report, is shown here to provide the reader with the basic aerodynamic shapes utilized on each flight vehicle. All vehicles carried the re-entry type payload. Four basic shapes were flown as shown in Figure 3. The weights of the re-entry vehicle varied between 2450 and 3850 pounds.

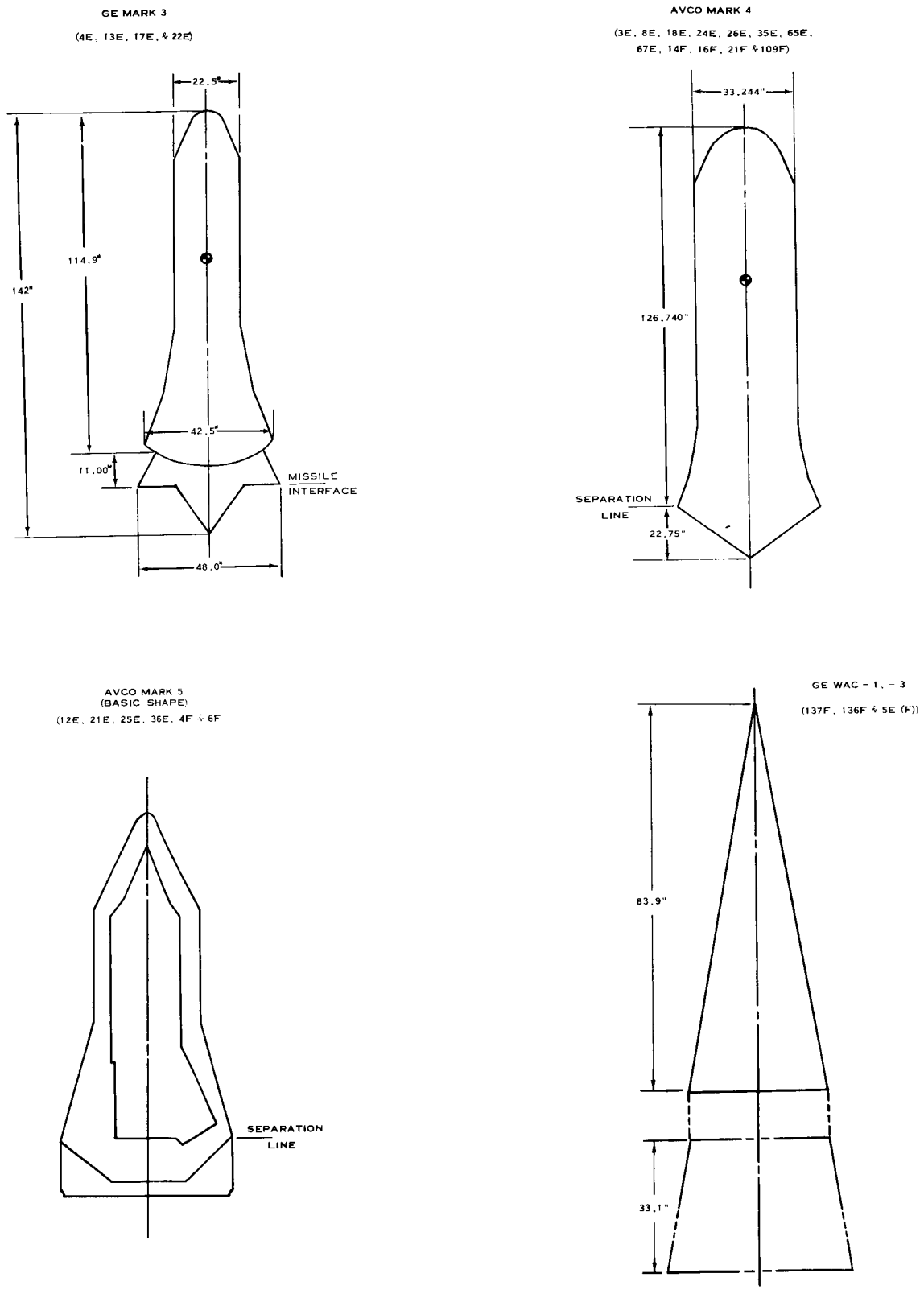


Figure 3.0 Re-entry Vehicle Basic Configurations

SECTION 4

TEST VEHICLE NOMINAL PERFORMANCE

[REFER TO SEPARATE REPORT GD/A-DDE65-016,
PART II (SECRET)]

SECTION 5

INSTRUMENTATION AND DATA REDUCTION TECHNIQUES

The acquisition of vibration and acoustic measurements for structural dynamic analysis involved the participation of several principle Engineering groups within the Astronautics organization. The usual sequence of events was as follows:

a. Technical or Design Group; measurement requests and requirements.

b. Program and Test Integration Groups; program integration and measurement assignments.

c. Telemetry Instrumentation Design Group; measurement planning and telemetry integration. Transducer acquisition and calibration procedures.

d. Field Test Group; test site installations and calibration procedure. Flight and/or landline data recording.

e. Test Evaluation and Data Processing Groups; data playback and raw data analysis.

f. Technical and Design Groups; utilization of experimental data.

5.1 INSTRUMENTATION. Acquisition of flight or landline vibration and sound measurements required the same basic support as the many other types of measurements required, such as proper choice of the end instruments, signal conditioning and transmittal functions, and the recording medium. The problems involved in frequency response, however, put the structural dynamic measurement in the position of requiring special attention in the areas of transducer systems installation procedures, calibrations, and recording medium procedures. Every attempt was made during the various Atlas E and F series flight test program to handle the acoustic and vibration measurements in a more controlled environment than most other types of measurements. The techniques to be described are considered nominal procedures within the industry and a high level of confidence has been placed on these measurements.

5.1.1 Vibration Pick-up Systems. The types of end instrument systems used for each measurement are listed in Table 6.1.2 of Section 6. In every installation, the end instruments acquired for high frequency measurements were capable of providing flat response within a frequency band of at least 20 and 2000 cps. In some cases the response of the system was limited to the choice of telemetry channelization where

the channel response was well below 2000 cps. For special programs, the systems were capable of recording frequencies to 10,000 cps, such as the landline measurements made investigating the vibration environment of computer mounts at vehicle liftoff (Missile 109F). The low frequency pick-up systems utilized were generally, capable of providing flat frequency response between zero and 250 cps and in all cases limited by the telemetry channel used. Low frequency pick-ups were used extensively for the booster staging investigations noted in Tables 6.1.1 and 6.1.2 of Section 6.

The pick-up systems were calibrated, upon receipt from the manufacturer, at the Astronautics Standards Laboratory. The crystal type systems (high frequency) and strain gage type systems (low frequency) were generally calibrated by comparative methods, which utilized a shake table controlled by a pick-up calibrated by the National Bureau of Standard Laboratories. In most instances the accelerometer systems were calibrated at ten amplitude levels to determine amplitude linearity and at least ten separate sinusoidal frequency components to determine frequency response and roll off.

After the accelerometer systems were installed on the test vehicles and connected to either the telemetry package or landlines, the test site personnel conducted electrical calibrations of the entire measuring system from the pick-up amplifier (simulating the pick-up signal) through the signal conditioning medium to the recording equipment. The airborne accelerometer system amplifier output signals were matched to the telemetry sub-carrier oscillators (usually ±2.5 volt systems) to provide the required vibratory acceleration level for full bandwidth intelligence. The same basic techniques were used in calibrating the measurements recorded by landline means. All calibration data whether computed or measured was delivered to the Test Evaluation Group for raw data analysis purposes.

5.1.2 Acoustic Transducer Systems. The Model NM125 high intensity microphone manufactured by the Chesapeake Instrument Corporation was used for most all sound pressure measurements reported here. The microphones were calibrated by comparative means with a transducer calibrated by the National Bureau of Standards. The associated preamplifiers used with the microphones were either the Columbia Model 5203-10 or Gulton Model FT-8150 or Gulton Model KA-1006A units. The transducer systems were end-to-end calibrated by both electrical and physical means and recorded on magnetic tape. The electrical calibrations consisted of inserting a constant voltage into the preamplifier at one discrete frequency at a time for the frequency band of interest. The physically calibrated system consisted of using the Bruel and Kjaer

Model 155 coupler. The coupler was placed over the microphone simulating sound pressure environment which was applied at various levels through the entire measuring system.

The sound measurements reported here were made, for the most part, utilizing the landline recording medium. In those instances where the maximum frequency was 20,000 cps a filter network was introduced at the input to the tape recorder to suppress the signal, as a means of increasing the dynamic range. An inverse filter network was used at the time the tapes were used for playback purposes.

5.1.3 Telemetry Airborne Instrumentation. The telemetry packages used throughout the E and F series flight test programs were manufactured by the Bendix Corporation. The standard configuration was the IRIG FM/FM System utilizing the 16 standard bands of 1 through 13, A, C, and E. Most high frequency vibration measurements were measured using the bands or sub-carrier channels A, C, and E which provided a nominal frequency band of response between 660 and 2100 cps. The low frequency measurements were usually measured on channels 6 through A, which provided a nominal frequency response of 25 to 660 cps.

In some instances, the nominal channel response was exceeded, in raw data playbacks, to extend the capabilities of the lower response channels. The filtered signal was usually limited to a modulation index of 3, where the channel response was extended and considered free of excessive noise or cross talk from the adjacent channels. Modulation index is the ratio of maximum frequency deviation to modulation frequency. After viewing a considerable number of wave forms recorded by oscillographic means during the test programs reported here, it was apparent that the total data acquisition noise level for the nominal response of each channel did not generally exceed 2 percent of the intelligence band (100 percent carrier bandwidth - FBW). The corresponding dynamic range or signal-to-noise ratio approached the limitations for the apparent magnetic tape capabilities of 40 db. For the measurements that were extended in frequency response to a modulation index of 3, the total data acquisition noise level did not exceed 5 percent of the intelligence band. The corresponding dynamic range was approximately 35 db. The airborne microphones when set up for a maximum intelligence of 155 db (SPL) exhibited a noise floor of 115 db (SPL).

The vibration and acoustic measurements were placed on continuous (with flight time) channels, however, the demand for measurements usually exceeded the availability of telemetry channels, therefore measurement commutation techniques were employed. The commutated data was recorded through telemetry channel C on a one-eighth revolution per second commutator providing six measurements, sampled for one second, once every 8 seconds. In some instances three measurements were

transmitted through channel C by providing two, one second samples, for each measurement, every eight seconds.

The test site ground receiving station recorded all telemetry signals on magnetic tape at a tape speed of 60 inches per second. All magnetic tapes were transmitted to the Astronautics, San Diego facility for playback and storage.

5.1.4 Landline Instrumentation. An extensive program, involving the acquisition of numerous acoustic and vibration measurements during the vehicle launch period was provided for both the Atlas E and F series vehicle. The launch measurements were recorded by direct landline means utilizing a 40 to 60 foot trailing umbilical cable, which extended the measurement acquisition time to approximately 2.5 seconds beyond the time of one inch of vehicle vertical rise. Both the vibration and acoustic measurements were recorded through the FM medium and recorded on magnetic tape. Generally, the vibration measurements were recorded on a tape facility utilizing a 54 kc, ±40 percent deviation, carrier frequency capability. The acoustic measurements were recorded using the same type of equipment, except during those tests where the desired maximum frequency was extended to 20,000 cps and required the use of a special mobile 108 kc tape facility.

The general procedures for calibration of the end instruments and "on board" transducer systems were as previously described.

5.2 DATA REDUCTION. The general procedure used for raw data reduction and analysis was as follows:

a. Examination of wave forms using oscillographic recordings.

b. Examination of overall RMS time histories.

c. Selected wave form time samples for power spectral density estimates.

d. Special treatment of wave forms for engine cutoff transient analysis.

The measurements of the vibration and acoustic environment presented in this report are considered completely valid except where noted as invalid or questionable. The existance of pick-up and transducer mounting configurations influencing the natural structural response was held to a minimum and within the state of the art for the period reported.

All vehicle test data were recorded on magnetic tapes and transported to the Astronautics Data Processing station. In each section of the reduction techniques described below, the test measurement signals were taken from the magnetic tapes, properly discriminated and inserted into the appropriate equipment for raw data analysis.

5.2.1 Vibration Data Reduction. The G (RMS) versus time plots presented in the data section were obtained from a Bruel and Kjaer Level Recorder Type 2305. The effective averaging time used varied between 0.02 and 0.1 second depending on the type of wave form to be analyzed. The levels were manually transferred to graph paper that was considered more suitable for reporting purposes than the original recorder graph paper.

The power spectral density (PSD) computations were accomplished by analog techniques wherein the selected data sample was placed on a magnetic tape loop along with other control signals to be utilized as input to a facility utilizing a Technical Products Company Model TP627 Wave Analyzer. Data from the tape loop was applied to continuous frequency scanning and analyzing circuits through a filter which determined the bandwidth of the frequency scan. One complete revolution of the tape loop was one scan. The amplitude values obtained were squared, integrated and applied to the Y axis arm of a X-Y plotter for each bandpass or tape loop revolution (the X axis co-ordinate was frequency).

The PSD computations conducted at the analog facility were made using the formula shown below.

$$G^2/CPS = \frac{\left[\frac{E_s \; G_{Fs}}{E_{Fs}}\right]^2}{\Delta f}$$

where: G^2/CPS = PSD Value (G in rms) per bandpass

E_{Fs} is the peak to peak data discriminatar output divided by 2.

E_s is the rms signal or simulation voltage.

G_{Fs} is the measurement (pick-up) system peak to peak calibration data divided by 2.

Δf is filter bandwidth in cps.

The choice of the bandwidth (Δf) for the PSD estimates usually depended on the nature of the waveform or data configuration. A bandwidth of 50 cps was used extensively throughout the program and selected as a reasonable statistical compromise. For the most part, a one second sample was used as an averaging time. This would

theoretically provide a 90 percent probability that the true spectral component would be between approximately 80 to 120 percent of the measured value. The bandpass effective values varied between 50 and 61 cps, noted in the various data sections, as the result of various modifications and updating changes made on the analyzer equipment. The effective bandwidth of the equipment filter network was usually checked periodically.

5.2.2 Acoustic Data Reduction. The acoustic data was presented in two basic formats, which were overall and octave band time histories and narrow band analysis consisting of Sound Pressure Level or Sound Pressure Density $(psi)^2/cps$ versus frequency.

The overall and octave band plots were provided by a General Radio Model 1550-4 Analyzer, a Moseley 60B Log Converter and calibration control functions that were subsequently fed to a X-Y plotter. The individual octave band graphs of SPL versus frequency were obtained from either the octave band time histories or direct meter readings of the octave band analyzer.

The techniques employed to provide the narrow band computation of Sound Pressure and/or Sound Pressure Level were accomplished by the same general techniques previously described in the vibration section, except for the log conversion treatment necessary for the SPL presentation.

SECTION 6

VIBRATION AND ACOUSTIC DATA

6.1 GENERAL DISCUSSION. The data shown in this section is predominately excerpts from existing flight test reports. To maintain editorial simplicity, the excerpts were organized in numerical order of the individual vehicles and retain the table and figure number system originated in the flight reports. The individual vehicle data sections are preceeded by Tables 6.1.1 and 6.1.2 which provide vehicle measurement locations and basic measurement information. Table 6.1.1 aid the reader in determining the measurement locations of interest and the test vehicles that contained those measurements.

The data prepared to supplement the excerpts were added to the individual data sections in the appropriate locations, precluding the need for supplemental figure numbers.

The data selected for this presentation was obtained from vehicles that provided no major operational problems that may have resulted in erroneously influencing the monitored vibration environment.

6.2 TEST REPORT TEXTS AND GRAPHIC PRESENTATIONS BY VEHICLE NUMBER. The remainder of this section contains the individual flight vehicle test data.

TABLE 6.1.1

MEASUREMENT INFORMATION BY VEHICLE SECTIONS
PAYLOAD ADAPTER AREA

Measure Number	Location	Axis	Sta.	Quad.	136F *	109F *	5E *	137F *
	FLIGHT VIBRATION DATA							
A502O	Interstage Adapter Gyro Panel	RAD	428	II	X		X	X
A503O	Interstage Adapter Gyrp Panel	LONS	428	II	X		X	X
A504O	High Impulse Retrorocket Pivot	RAD	428	II	X		X	
	LANDLINE VIBRATION DATA							
A1230O	Re-entry Adapter	Z	446	I		X		
	FLIGHT ACOUSTIC DATA							
A505Y	Interstage Adapt. Gyro Panel	-	428	II			X	X

*Data presented in this report

TABLE 6.1.1 (continued)

MEASUREMENT INFORMATION

VEHICLE SECTIONS
EQUIPMENT POD FLIGHT VIBRATION DATA

Measure Number	Location	Axis	Sta.	Quad	4E *	8E *	9E	12E *	13E *	17E *	25E *	8F'	14F *	16F *	21F *
I560O	AIG Platform Binnacle	X	1162	II-III	X	X									
I561O	AIG Platform Binnacle	Y	1162	II-III	X										
I562O	AIG Platform Binnacle	Z	1162	II-III	X	X									
I564O	AIG Computer Mount	X	1060	III	X										
I565O	AIG Computer Mount	Y	1060	III	X	X									
I566O	AIG Computer Mount	Z	1060	III	X	X									
G94O	Tracking Beacon Boom Antenna	-	1140	IV			X	X	X						
G197O	Rate Beacon Impact Predictor Pkg.	RAD	1110	IV			X	X	X						
G587O	Rate Beacon Wave Guide (Pod)	RAD	1120	IV			X	X	X	X					
G196O	Pulse Beacon Impact Predictor Pkg.	RAD	1100	IV						X					
G595O	Pulse Beacon Impact Wave Guide	RAD	1100	IV						X					
PB1	Passenger Pod Guid. Platform Mnt.	X	1075	I							X				
PB2	Passenger Pod Guid. Platform Mnt.	Y	1075	I							X				
PB3	Passenger Pod Guid. Platform Mnt.	Z	1075	I							X				
Y540O	Decoy Pod Base Structure	RAD	1032	III								X			
Y640O	Decoy Pod Base Fwd Outrigger	RAD	1032	III									X		
Y642O	Decoy Pod Base Fwd Outrigger	LAT	1032	III									X		
Y296O	Decoy Pod Fairing, Near Ejector	RAD	-	-									X		
Y643O	Decoy Pod Base, Outrigger	RAD	1045	III										X	X
Y644O	Decoy Pod Base, Outrigger	LAT	1045	III										X	X
Y657O	Decoy Pod Aft Base Structure	RAD	1067	III										X	

*Data Presented in This Report

TABLE 6.1.1 (continued)

MEASUREMENT INFORMATION BY VEHICLE SECTIONS
EQUIPMENT POD ACOUSTIC DATA

Measure Number	Location	Sta.	Quad	67E *	62E	64E	65E *	66E	24E	57F	83F	105F *	137F	5E(F)
	FLIGHT DATA													
A780Y	AIG Computer Constants BRD A	1060	II-III						X					
	LANDLINE DATA													
A1780Y	AIG Computer Constants BRD A	1060	II-III	X	X	X	X			X	X	X	X	X
A1550Y	AIG Computer Constants BRD A	1060	II-III				X							
A1778Y	AIG Pod Adjacent to Computer	1060	II-III	X							X			
A1779Y	AIG Pod Forward of Computer	1060	II-III	X							X			
N7223Y	Coffin Pole Micro Phone	962	I-IV		X	X			X					
N7534Y	Coffin MIC A	1105	II-II		X	X	X	X	X					
N7535Y	Coffin MIC B	1150	II-III		X	X	X	X	X					
N7536Y	Coffin MIC C	1244	II-III	X		X		X	X					
N7540Y	Silo MIC A	1105	II-III									X	X	
N7538Y	Silo MIC B	1150	II-III										X	

*Data presented in this report.

TABLE 6.1.1 (continued)

MEASUREMENT INFORMATION BY VEHICLE SECTIONS
EQUIPMENT POD LANDLINE VIBRATION DATA

Measure Number	Location	Axis	Sta.	Quad	62E	64E	65E *	24E *	83F	109F *	5E(F) *
A1450O	AIG Computer Mnt (soft side)	Y	1060	II		X					
A1575O	AIG Computer Mnt (soft side)	Z	1060	II				X	X	X	
A1575O	AIG Computer Mnt (soft side)	X	1060	II	X		X	X	X	X	
A1576O	AIG Computer Mnt (soft side)	Y	1060	II			X	X	X		
A1150O	AIG Computer Mnt (hard side)	X	1060	II						X	
A1151O	AIG Computer Mnt (hard side)	Y	1060	II						X	
A1152O	AIG Computer Mnt (hard side)	Z	1060	II						X	
A1562O	AIG Computer Circuit Brd Z218	-	1060	II						X	X
A1491O	AIG Computer Mnt (soft side)	X	1060	II							X
S1606O	Autopilot Gyro Canister	Z	1025	II				X		X	
S1607O	Autopilot Gyro Canister	Y	1025	II						X	

*Data presented in this report

TABLE 6.1.1 (continued)

MEASUREMENT INFORMATION BY VEHICLE SECTIONS
PROPULSION SECTION FLIGHT VIBRATION DATA

Measure Number	Location	Axis	Sta	Quad	3 E *	4 E *	8 E *	12 E *	18 E *	21 E *	22 F *	25 E *	26 E *	35 E *	36 E *	4 F *	5 F	6 F *	109 F *
P798O	Booster No. 1 Low Press Lox Line	Long	1111	IV	X														
P799O	Booster No. 1 Low Press Lox Line	Rad	1111	IV	X			X											
A862O	Booster No. 2 Turbopump	Y	1185	II-III		X													
A863O	Booster No. 2 Turbopump	Z	1185	II-III		X													
A945O	Booster No. 2 Gimbal Block	Y	1220	II-III		X													
A946O	Booster No. 2 Yaw Actuator End	Y	1211	II-III		X													
H411O	NAA Sust. Eng. Hyd. Contrl. Pkg.	X	1236	III			X												
H412O	NAA Sust. Eng. Hyd. Contrl. Pkg.	Y	1236	III			X												
H413O	NAA Sust. Eng. Hyd. Contrl. Pkg.	Z	1236	III			X												
A781O	Lox Tank Press. Regulator Mnt.	Rad	1222	IV					X	X			X						
A782O	Lox Tank Press. Regulator Mnt.	Long	1222	IV					X	X			X						
A783O	Lox Tank Press. Regulator Mnt.	Tang	1222	IV					X	X			X						
A925O	Lox Tank Press. Regulator Mnt.	Rad	1222	IV					X	X									
A926O	Lox Tank Press. Regulator Mnt.	Tang	1222	IV					X	X									
A786O	Fuel Tank Press. Regulator Mnt.	Rad	1230	II							X	X							
A787O	Fuel Tank Press. Regulator Mnt.	Long	1230	II							X	X							
A788O	Fuel Tank Press. Regulator Mnt.	Tang	1230	II							X	X							
A789O	Fuel Tank Pressure Regulator	Rad	1230	II										X					X
A790O	Fuel Tank Pressure Regulator	Tang	1230	II										X					
A930O	Fuel Tank Press. Regulator Mnt.	Rad	1230	II							X	X							
A931O	Fuel Tank Press. Regulator Mnt.	Tang	1230	II							X	X							
A785O	Lox Tank Press. Regulator Mnt.	Rad	1222	IV									X						
A786O	Lox Tank Press. Regulator Mnt.	Tang	1222	IV									X						
H426O	Sust. Hyd. Pump Tach.	X	1230	III-IV												X	X	X	
H427O	Sust. Hyd. Pump Tach.	Y	1230	III-IV												X	X	X	
H428O	Sust. Hyd. Pump Tach.	X	1240	III-IV												X	X	X	
H429O	Sust. Hyd. Pump Tach.	Y	1240	III-IV												X	X	X	
P531O	Sust. Gas Gen. Fuel Check Vlv.	Z	1225	I-IV										X	X	X	X		

* Data Presented in this Report.

TABLE 6.1.1 (continued)

MEASUREMENT INFORMATION BY VEHICLE SECTIONS
PROPULSION SECTION ACOUSTIC DATA

Measure Number	Location	Sta.	Quad	62E	64E	65E	67E	24E	7F	8F	14F	16F	134F	83F
	FLIGHT DATA													
P51Y	Thrust Section Microphone	1230	II					X						
	LANDLINE DATA													
P1051Y	Thrust Section Microphone	1230	II	X	X	X	X		X	X	X	X	X	X

*Data presented in this report

TABLE 6.1.1 (Continued)

MEASUREMENT INFORMATION BY VEHICLE SECTIONS
PROPULSION SECTION LANDLINE VIBRATION DATA

Measure Number	Location	Axis	Sta.	Quad.	22 E *	26 E *	30 E	62 E	64 E	65 E *	67 E *	24 E *	7 F	8 F	14 F *	16 F *	21 F *	134 F	135 F *	136 F *	137 F	57 F	83 F	109 E *	5 E(F)
P1206O	Sust. Engine Lox Dome	Z	1227	-	X	X							X	X	X	X	X	X	X	X	X	X	X		
P1208O	B1 Engine Lox Dome	Z	1227	I-IV		X	X					X	X	X	X	X	X		X	X	X			X	X
P1209O	B2 Engine Lox Dome	Z	1227	II-III		X	X				X		X	X	X	X	X			X	X	X			X
P1106O	Sust. Eng. Lox Pump Inlet Flg.	X	1220	III-IV									X	X	X	X		X	X	X	X				X
P1107O	Sust. Eng. Lox Pump Inlet Flg.	Y	1220	III-IV									X	X	X	X		X	X	X	X				
P1108O	Sust. Eng. Lox Pump Inlet Flg.	Z	1220	III-IV										X	X	X		X	X	X	X				
P1531O	Sust. Gas. Gen. Fuel Check Vlv.	Z	1225	I-IV				X		X		X											X	X	
P1533O	Sust. Gas. Gen. Fuel Line	Z	1225	I-IV				X		X		X											X	X	
P1532O	B1 Hydraulic Pump	Z	1190	II								X												X	
P1451O	Sustainer Hyd. Return Line	Y	1230	IV				X		X		X											X		
F1651O	He. Line Riseoff Disc. Panel	Z	1260	I-II				X		X		X												X	
F1650O	Fuel Tank Press. Regulator	Rad.	1230	II								X												X	
F1185O	Lox Tank Press. Regulator	Tang.	1222	IV				X	X	X	X	X													
H1428O	Sustainer Hyd. Pump	X	1234	III				X				X												X	
H1429O	Sustainer Hyd. Pump	Y	1234	III				X				X													
A1588O	Thrust Section Heat Shield	Z	1269	I-II					X														X		
A1278O	Fwd. Surface Jett. Rail A Frame	-	1224	IV				X				X													
A1571O	Thrust Sect. Heat Shield	Z	1269	III-IV				X				X												X	

*Data presented in this report

TABLE 6.1.1 (Continued)

MEASUREMENT INFORMATION BY VEHICLE SECTIONS
VIBRATION DURING BOOSTER STAGING
(Jettison Start +7 -3 Seconds)

Measure Number		Axis	Sta.	Quad	35 E *	36 E *	4 F *	5 F	7 F	8 F	14 F *	16 F *	21 F *	134 F	135 F *	136 F *	5 E(F)
A263O	Booster Jettison Rail @ A Frame	Tang	1224	II					X	X	X	X		X	X		
A265O	Booster Jettison Rail @ A Frame	Rad	1224	II					X	X	X	X		X	X		
A266O	Booster Jettison Rail @ Tank End	Tang	1165	II					X	X	X	X		X	X		
A270O	Booster Jettison Rail @ Tank End	Rad	1165	II					X	X	X	X		X	X		
A271O	Booster Jettison Rail @ A Frame	Tang	1224	IV					X	X	X	X		X	X		
A272O	Booster Jettison Rail @ A Frame	Rad	1224	IV					X	X	X	X		X	X		
A273O	Fuel Tank Apex	X	1200	III-IV					X	X	X	X	X	X	X		
A274O	Fuel Tank Apex	Y	1200	III-IV					X	X	X	X	X	X	X		
A275O	Fuel Tank Apex	Z	1200	III-IV					X	X	X	X	X	X	X		
A276O	Sust. Hyd. Pump Dischg. Line	-	1185	I					X	X	X	X	X	X	X		
A372O	Quad IV A Frame, Aft Side	-	1224	IV									X				
A239O	Quad IV A Frame, Aft Side	-	1224	IV									X				
A373O	Quad IV A Frame, Aft End	Rad	1265	IV									X				
A376O	Quad IV A Frame, Aft End	Tang	1265	IV									X				
A377O	Sust. Gas Gen. Fuel Line	Z	1225	IV									X				
A382O	QII Hydraulic Return Line	XY	1165	II									X				
A394O	QII Jettison Rail, Aft End	Rad	1265	II									X				
A395O	QII Jettison Rail, Aft End	Tang	1265	II									X				
A77A	Booster Jettison Rail, Aft End	Rad	1260	II	X	X	X	X									
A78A	Booster Jettison Rail, Aft End	Tang	1260	II													
H412O	Sust. Hyd. Control Pkg.	Y	1236	III						X	X	X		X	X	X	X
P531O	Sust. Gas Gen. Fuel Check Vlv.	Z	1225	IV						X	X	X	X	X	X	X	X

*Data presented in this report

TABLE 6.1.2

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
3E	P798Ø	Booster No. 1 Low Press. Lox Line Quad IV Sta 1111	Long.	2-12	Gulton KA1006	60	20 - 160
	P799Ø	Booster No. 1 Low Press. Lox Line	Rad.	2-13	Gulton KA1006	60	20 - 220
4E	A862Ø	Booster No. 2 Turbo Pump	Y	2-13	Gulton KA1006	30	20 - 220
	A863Ø	Booster No. 2 Turbo Pump	Z	2-12	Gulton KA1006	50	20 - 160
	A945Ø	Booster No. 2 Gimbal Block	Y	3-6	Gulton KA1006	50	25 -
	A946Ø	Booster No. 2 Yaw Act. Tie Point	Y	3-12	Gulton KA1006	30	20 - 160
	I560Ø	AIG Platform Binnacle	X	1-C-1	Installed by		20 - 1200
	I561Ø	AIG Platform Binnacle	Y	1-C-9	ARMA		20 - 1200
	I562Ø	AIG Platform Binnacle	Z	1-C-17			20 - 1200
	I564Ø	AIG Computer Mount (Soft)	X	1-C-25			20 - 1200
	I565Ø	AIG Computer Mount (Soft)	Y	1-C-33			20 - 1200
	I566Ø	AIG Computer Mount (Soft)	Z	1-C-41			20 - 1200
8E	P1452Ø	Booster No. 1 Engine Lox Dome	Z	LL	XTAL	125	20 - 2000
	P1453Ø	Booster No. 2 Engine Lox Dome	Z	LL	XTAL	125	20 - 2000
	H382Ø	Sustainer Hydraulic Pump	60° off Y	2-13	Gulton KA1006	60	20 - 220
	H411Ø	NAA Sust. Engine Control Package	X	1-C-9	Strain Gage	50	0 - 200
	H412Ø	NAA Sust. Engine Control Package	Y	1-C-25	Type	50	0 - 200
	H413Ø	NAA Sust. Engine Control Package	Z	3-10	(27-11720-67)	50	0 - 80
	I560Ø	AIG Platform Binnacle	X	1-C-1	Installed by		20 - 1200
	I562Ø	AIG Platform Binnacle	Z	1-C-17	ARMA		20 - 1200
	I565Ø	AIG Computer Mount (Soft)	Y	1-C-35			20 - 1200
	I566Ø	AIG Computer Mount (Soft)	Z	1-C-41			20 - 1200
9E	G94Ø	Tracking Beacon Boom Antenna	-	1-C-17	Glennite A501SU	120	20 - 1200

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
	G197Ø	Rate Beacon Impact Predictor Pkg.	Radial	1-C-1	Glennite A501SU	30	20 - 1200
	G587Ø	Rate Beacon Wave Guide (Pod)	Radial	1-C-33	Glennite A501SU	30	20 - 1200
	H382Ø	Sust. Engine Hyd. Pump	60° off Y	2-13	Gulton KA1006	60	20 - 220
13E	P1452Ø	Booster No. 1 Engine Lox Dome	Z	LL	Columbia	80	20 - 2000
	P1453Ø	Booster No. 2 Engine Lox Dome	Z	LL	562 I	80	20 - 2000
	G94Ø	Same as 9E					
	G197Ø	Same as 9E					
	G587Ø	Same as 9E					
12E	A799Ø	B1 Low Press. Lox Line	Radial	2-13	Gulton KA1006	70	20 - 220
	G94Ø	Same as 9E	This measurement did not show good signal until 85 seconds.				
	G197Ø	Same as 9E					
	G587Ø	Same as 9E					
18E	A781Ø	Lox Tank Press. Regulator Mount	Radial	1-C-1	Gulton KA 1006	30	20 - 1200
	A782Ø	Lox Tank Press. Regulator Mount	Long.	1-C-9	Gulton KA 1006	30	20 - 1200
	A783Ø	Lox Tank Press. Regulator Mount	Tang.	1-C-17	Gulton KA 1006	30	20 - 1200
	A925Ø	Lox Tank Press. Regulator Mount	Radial	1-C-25	Gulton KA 1006	30	20 - 1200
	A926Ø	Lox Tank Press. Regulator Mount	Tang.	1-C-33	Gulton KA 1006	30	20 - 1200
17E	G196Ø	Pulse Beacon Impact Predictor Pkg.	Radial	1-C-1	Glennite A501SU	100	20 - 1200
	G587Ø	Rate Beac. Impact Pred. Waveguide	Radial	1-C-17	Glennite A501SU	60	20 - 1200
	G595Ø	Pulse Beac. Imp. Pred. Waveguide	Radial	1-C-33	Glennite A501SU	90	20 - 1200
22E	A786Ø	Base Fuel Tank Press. Reg Mount	Radial	1-C-1	Gulton KA1006	60	20 - 1200
	A787Ø	Base Fuel Tank Press. Reg Mount	Long.	1-C-9	Gulton KA1006	60	20 - 1200
	A788Ø	Base Fuel Tank Press. Reg Mount	Tang.	1-C-17	Gulton KA1006	60	20 - 1200

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
	A930Ø	Fuel Tank Press. Reg.	Radial	1-C-25	Gulton KA1006	60	20 - 1200
	A931Ø	Fuel Tank Press. Reg.	Tang.	1-C-33	Gulton KA1006	60	20 - 1200
	P1206Ø	Sustainer Engine Lox Dome	Z	LL	XSTAL	112	20 - 2100
	P1208Ø	B1 Engine Lox Dome	Z	LL	XSTAL	84	20 - 2100
	P1209Ø	B2 Engine Lox Dome	Z			84	20 - 2100
21E	A781Ø	Base Lox Tank Press. Reg. Mount	Radial	1-C-1	Gulton KA1006	60	20 - 1200
	A782Ø	Base Lox Tank Press. Reg. Mount	Long.	1-C-9	Gulton KA1006	60	20 - 1200
	A783Ø	Base Lox Tank Press. Reg. Mount	Tang.	1-C-17	Gulton KA1006	60	20 - 1200
	A925Ø	Lox Tank Press. Reg.	Radial	1-C-25	Gulton KA1006	60	20 - 1200
	A926Ø	Lox Tank Press. Reg.	Tang.	1-C-33	Gulton KA1006	60	20 - 1200
26E	A781Ø	Base Lox Tank Press. Reg. Mount	Radial	1-C-1	Gulton KA1006	60	20 - 1200
	A782Ø	Base Lox Tank Press. Reg. Mount	Long.	1-C-9	Gulton KA1006	60	20 - 1200
	A783Ø	Base Lox Tank Press. Reg. Mount	Tang.	1-C-17	Gulton KA1006	60	20 - 1200
	A785Ø	Base Lox Tank Press. Reg. Mount	Radial	1-C-25	Gulton KA1006	60	20 - 1200
	A786Ø	Base Lox Tank Press. Reg. Mount	Tang.	1-C-33	Gulton KA1006	60	20 - 1200
	P1206Ø	Sustainer Engine Lox Dome	Z	LL	XTAL	120	20 - 2000
	P1208Ø	B1 Engine Lox Dome	Z	LL	XTAL	80	20 - 2000
	P1209Ø	B2 Engine Lox Dome	Z	LL	XTAL	80	20 - 2000
25E	A786Ø	Same as Missile 22E					
	A787Ø	Same as Missile 22E					
	A788Ø	Same as Missile 22E					
	A930Ø	Same as Missile 22E					
	A931Ø	Same as Missile 22E					
	PB1	Pass. Pod Guid. Platf. Mount	X		Gulton KA1006	35	20 - 2000

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ±g or db	Nominal Freq. Response in cps
	PB2	Pass. Pod Guid. Platf. Mount	Y	Piggy Back	Gulton KA1006	35	20 - 2000
	PB3	Pass. Pod Guid. Platf. Mount	Z	Pod Tape	Gulton KA1006		
30E	P1208Ø	B1 Engine Lox Dome	Z	LL	XTAL	85	20 - 2000
	P1209Ø	B2 Engine Lox Dome	Z	LL	XTAL		
4F	H426Ø	Sustainer Hyd. Pump Tachometer	X	1-C-1/4-C-1	Gulton KA1006	215	20 - 1200
	H427Ø	Sustainer Hyd. Pump Tachometer	Y	1-C-9/4-C-9	Gulton KA1006	215	20 - 1200
	H428Ø	Sustainer Hyd. Pump End	X	1-C-17/4-C-17	Gulton KA1006	215	20 - 1200
	H429Ø	Sustainer Hyd. Pump End	Y	1-C-33/4-C-33	Gulton KA1006	215	20 - 1200
	P531Ø	Sust. Gas Gen. Fuel Check Vlv.	Z	1-13/4-13	Gulton KA1006	115	20 - 220
	A77A	Booster Jettison Rail, Aft End	Radial	1-6-S/4-6-S	Stathan TA12A-15-2	25	0 - 25
	A78A	Booster Jettison Rail, Aft End	Tang.	1-7-S/4-7-S	(87-93900-103)	25	0 - 35
35E	A786Ø	Base Fuel Tank Press. Reg, Mount	Radial	1-C-1	Gulton KA1006		Invalid
	A787Ø	Base Fuel Tank Press. Reg, Mount	Long.	1-C-9	Gulton KA1006		Invalid
	A788Ø	Base Fuel Tank Press. Reg, Mount	Tang.	1-C-17	Gulton KA1006	60	20 - 1200
	A789Ø	Base Fuel Tank Press. Reg, Mount	Radial	1-C-25	Gulton KA1006	60	20 - 1200
	A790Ø	Base Fuel Tank Press. Reg, Mount	Tang.	1-C-33	Gulton KA1006	60	20 - 1200
	P531Ø		Z	1-13	Gulton KA1006	115	20 - 220
	A77A	Booster Jettison Rail, Aft End	Radial	1-6-S/4-6-S	Same as 4F		
	A78A	Booster Jettison Rail, Aft End	Tang.	1-7-S/4-6-S			
5F		Same test measurements as 4F					
36E	P531Ø	Sustainer Gas Gen. Fuel Check Vlv.	Z	1-13/4-13	Gulton KA1006	115	20 - 220

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
	A77A	Booster Jettison Rail, Aft End	Radial	1-6-S/4-6-S	Statham TA12A-15-2	20	0 - 25
	A78A	Booster Jettison Rail, Aft End	Tang.	1-7-S/4-7-S	(87-93900-103)	20	0 - 35
	H426Ø	Same as 4F					
	H427Ø	Same as 4F					
	H428Ø	Same as 4F					
	H429Ø	Same as 4F					
66E	N7534Y	Coffin Mic. A	Acoustic	LL	Altec Lansing	130-180db	20 - 15000
	N7536Y	Coffin Mic. C	Acoustic	LL	M14	130-180db	20 - 15000
67E	P1209Ø	B2 Engine Lox Dome	Z	LL	Qualitative Data Only		20 - 2000
	F1185Ø	Lox Tank Pressure Regulator		LL	Gulton KA1006	100	20 - 2000
	A1780Y	AIG Constants Dummy Board A	Acoustic	LL	Chesapeake	120-160	20 - 20000
	A1778Y	AIG Pod Adjacent to Computer	Acoustic	LL	Model	120-160	20 - 20000
	A1779Y	AIG Pod Forward of Computer	Acoustic	LL	NM125	120-160	20 - 20000
	N7534Y	Coffin Mic. A	Acoustic	LL	Chesapeake	130-170	20 - 20000
	N7535Y	Coffin Mic. B	Acoustic	LL	Model	130-170	20 - 20000
	N7536Y	Coffin Mic. C (Questionable Data)	Acoustic	LL	NM125	130-170	20 - 20000
	P1051Y	Thrust Section Microphone	Acoustic	LL	NM125	130-170	20 - 20000
57F	A1780Y	AIG Computer Constant Board A	Acoustic	LL	NM125	130-170	20 - 20000
	P1051Y	Thrust Section, QII"A"Frame	Acoustic	LL	NM125		20 - 20000
	P1206Ø	Sustainer Engine Lox Dome	Z	LL	Gulton KA1006	100	20 - 2000
	P1208Ø	B1 Engine Lox Dome	Z	LL	Gulton KA1006	100	20 - 2000

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
7F	A263Ø	Bstr. Jettison Rail @ QII"A"Frame	Tang.	STGG only 3-12	CEC-4-202-0001	25	0 - 150
	A265Ø	Bstr. Jettison Rail @ QII"A"Frame	Radial	3-13	CEC-4-202-0001	25	0 - 150
	A266Ø	Bstr. Jett. Rail @ QII Tank End	Tang.	3-5	CEC-4-202-0001	25	0 - 30
	A270Ø	Bstr. Jett. Rail @ QII Tank End	Radial	3-6	CEC-4-202-0001	25	0 - 30
	A271Ø	Bstr. Jett. Rail @ QIV"A"Frame	Tang.	3-A	CEC-4-202-0001	25	0 - 150
	A272Ø	Bstr. Jett. Rail @ QIV"A"Frame	Radial	3-C	CEC-4-202-0001	25	0 - 150
	A273Ø	Fuel Tank Apex	X	3-11	CEC-4-202-0001	25	0 - 30
	A274Ø	Fuel Tank Apex	Y	3-8	CEC-4-202-0001	25	0 - 30
	A275Ø	Fuel Tank Apex	Z	3-9	CEC-4-202-0001	25	0 - 30
	A276Ø	Sust. Hyd. Pump Dischg. Line	-	3-10	CEC-4-202-0001	25	0 - 30
	H412Ø	NAA Hyd. Contr. Pkg., Sust. Eng.	Y	1-6/4-6	Giannini 24158J-25-50	25	0 - 30
	P531Ø	Sustainer Gas Gen Fuel Check Vlv.	Z	1-7/4-7	Giannini 24158J-25-50	25	0 - 30
	P1206Ø	Sustainer Engine Lox Dome	Z	LL	Gulton KA1006	100	20 - 2000
	P1208Ø	B1 Engine Lox Dome	Z	LL	Gulton KA1006	100	20 - 2000
	P1209Ø	B2 Engine Lox Dome	Z	LL	Gulton KA1006	100	20 - 2000
	P1106Ø	Sustainer Eng. Lox Pump Inlet Flg.	X	LL	CEC-4-202-0001	25	0 - 200
	P1107Ø	Sustainer Eng. Lox Pump Inlet Flg.	Y	LL	CEC-4-202-0001	25	0 - 200
	P1108Ø	Sustainer Eng. Lox Pump Inlet Flg.	Z	LL	CEC-4-202-0001	25	0 - 200
	P1051Y	Thrust Section, QII"A" Frame	Acoustic	LL	Chesapeake NM125	125-156db	20 - 20000
8F		Thrust section measurements same as 7F (Note: P531Ø is invalid)					

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ±g or db	Nominal Freq. Response in cps
	Y540Ø	Decoy Rod Base Structure	Radial	1-11	Installed by Aeronutronics (ADP)	15	
14F		Thrust section measurements same as 7F					
	Y640Ø	Decoy Pod Base, Fwd Outrigger	Radial	1-11/4-11	Installed by	10	110
	Y642Ø	Decoy Pod Base, Fwd Outrigger	Lateral	2-9	Aeronutronics	10	60
	Y296Ø	Decoy Pod Fair., Near Ejector	Radial	1-C-1/4-C-1	(ADP)	10	1200
16F		Thrust section measurements same as 7F					
	Y643Ø	Decoy Pod Base, Outrigger	Radial	1-11/4-11	Installed by	5	110
	Y644Ø	Decoy Pod Base, Outrigger	Lateral	2-9	Aeronutronics	5	60
	Y657Ø	Aft Base Structure	Radial	1-C-1/4-C-1		25	1200
13F	A1780Y	AIG Computer Const. Board A	Acoustic	LL	Chesapeake Mod NM125	120-160	20 - 20,000
21F	P1206Ø	Sustainer Engine Lox Dome	Z	LL	XTAL	80	20 - 2000
	P1208Ø	B1 Engine Lox Dome	Z	LL	XTAL	80	20 - 2000
	P1209Ø	B2 Engine Lox Dome	Z	LL	XTAL	80	20 - 2000
	A273Ø	Fuel Tank Apex	X	3-11	CEC-4-202-0001	25	0 - 30
	A274Ø	Fuel Tank Apex	Y	3-8	CEC-4-202-0001	25	0 - 30
	A275Ø	Fuel Tank Apex	Z	3-9	CEC-4-202-0001	25	0 - 30
	A372Ø	Quad IV A Frame - Aft Side	Perpend.	3-10	CEC-4-202-0001	25	0 - 150
	A390Ø	Quad IV A Frame - Aft Side	Parallel	1-6	CEC-4-202-0001	25	0 - 30
	A373Ø	Quad IV Jettison Rail - Aft End	Radial	3-5	CEC-4-202-0001	25	0 - 30
	A376Ø	Quad IV Jettison Rail - Aft End	Tang.	3-6	CEC-4-202-0001	25	0 - 30

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-CEG	Transducer System Data Type	FBW ± g or db	Nominal Freq. Response in cps
21F	A337O	Sust. Eng. Gas Gen. Fuel Line	Z	3-A	CEC-4-202-0001	100	0 - 500
	A382O	Quad II Hyd. Return Line	Y Z Plane	3-C	CEC-4-202-0001	100	0 - 500
	A394O	Quad II Jettison Rail - Aft End	Radial	3-13	CEC-4-202-0001	100	0 - 150
	A395O	Quad II Jettison Rail - Aft End	Tang.	3-12	CEC-4-202-0001	100	0 - 150
	P531O	Sust. Eng. Gas Gen. Fuel Chk. Vlv.	Z	1-7	Giannini	100	0 - 150
				4-7	24158J-25-50	25	0 - 50
	Y643O	Decoy Pod Base - Outrigger Arm	Radial	1-11	Installed by	10	0 - 110
				4-11	Aeronutronics		
	Y644O	Decoy Pod Base - Outrigger Arm	Lateral	2-9	(ADP)	10	0 - 60
64E	A1588O	Thrust Section Heat Shield	Z	LL	Gulton KA1006	200	20 - 2000
	F1185O	Lox Tank Press. Reg.	Inboard	LL	Gulton KA1006	80	20 - 2000
	P1208O	B1 Engine Lox Dome	Z	LL	Columbia 562 I	80	20 - 2000
	A1450O	AIG Computer Mount (Soft Side)	Y	LL	Gulton KA1006	20	20 - 4000
	A1778Y	AIG Pod - Near Computer - Outbrd.	Acoustic	LL	Chesapeake MN 125	120-160	Invalid after start
	A1780Y	AIG Computer Constants Brd-A	Acoustic	LL	Chesapeake MN125	120-160	20 - 20,000
	P-1051Y	Thrust Section Microphone	Acoustic	LL	Chesapeake MN125	Invalid after start	
	N7534Y	Coffin Microphone A	Acoustic	LL	Chesapeake MN125	135-175	20 - 20,000
	N7535Y	Coffin Microphone B	Acoustic	LL	Chesapeake MN125	135-175	20 - 20,000
	N7536Y	Coffin Microphone C	Acoustic	LL	Chesapeake MN125	135-175	20 - 20,000

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
134F		Thrust Section Measurements Same as 7F				(P1208O & P1209O Invalid)	
83F	A1588O	Thrust Section Heat Shield	Z	LL	Gulton KA1006	100	20 - 2000
	F1651O	Helium Line Riseoff Disc. Panel	Z	LL	Gulton KA1006	80	20 - 2000
	P1206O	Sust. Eng. Lox Dome	Z	LL	Gulton KA1006	80	20 - 2000
	P1208O	B1 Eng. Lox Dome	Z	LL	Columbia 562 I	80	20 - 2000
	P1451O	Sust. Hyd. Pump Return Line	Y	LL	Gulton KA1006	100	20 - 2000
	P1531O	Sust. Gas Gen. Fuel Chk. Vlv.	Z	LL	Gulton KA1006	100	20 - 2000
	P1533O	Sust. Eng. Gas Gen. Fuel Line	Z	LL	Gulton KA1006	100	20 - 2000
	A1574O	AIG Computer Mount (Soft Side)	Z	LL	Gulton A122531	20	20 - 10,000
	A1575O	AIG Computer Mount (Soft Side)	Y	LL	Gulton A122531	20	20 - 10,000
	A1576O	AIG Computer Mount (Soft Side)	X	LL	Gulton A122531	20	20 - 10,000
	A1778Y	AIG Pod-Near Computer-Outbrd	Acoustic	LL	Chesapeake MN125	20	20 - 10,000
	A1779Y	AIG Pod-Near Computer - Fwd.	Acoustic	LL	Chesapeake MN125	20	20 - 10,000
	A1780Y	AIG Computer Constants Brd - A	Acoustic	LL	Chesapeake MN125	20	20 - 10,000
	P1051Y	Thrust Section Microphone	Acoustic	LL	Chesapeake MN125	20	20 - 10,000
	N7540Y	Silo Mic. A - Outside	Acoustic	LL	Chesapeake MN125	130-170	20 - 10,000
65E	A1588O	Thrust Section Heat Shield	Z	LL	Gulton KA1006	100	20 - 2000
	F1651O	He. Line Riseoff Disc. Panel	Z	LL	Gulton KA1006	80	20 - 2000
	P1208O	B1 Eng. Lox Dome	Z	LL	Invalid		20 - 2000
	P1451O	Sust. Hyd. Pump Return Line	Y	LL	Gulton KA1006	100	20 - 2000
	P1531O	SGG Fuel Check Valve	Z	LL	Gulton KA1006	100	20 - 2000

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-CEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
65E	F1185O	SGG Fuel Line	Z	LL	Gulton KA1006	100	20 - 2000
	F1185O	Lox Tank Press. Regulator	Tang.	LL	Gulton KA1006	80	20 - 2000
	A1575O	AIG Computer Mount (Soft Side)	Y	LL	Gulton A122531	20	20 - 2000
	A1576O	AIG Computer Mount (Soft Side)	X	LL	Gulton A122531	20	20 - 2000
	A1550Y	AIG Computer Constants Brd	Acoustic	LL	Chesapeake NM125		20 - 10,000
	A1780Y	AIG Computer Constants Brd	Acoustic	LL	Chesapeake NM125	115-155	20 - 10,000
	P1051Y	Thrust Section Microphone	Acoustic	LL	Chesapeake NM125	125-165	20 - 10,000
	N7223Y	Coffin Boom Mic. - B1 Side	Acoustic	LL	Chesapeake NM125	135-175	20 - 10,000
	N7534Y	Coffin Mic. A	Acoustic	LL	Chesapeake NM125	135-175	20 - 10,000
	N7535Y	Coffin Mic. B	Acoustic	LL	Chesapeake NM125	135-175	20 - 10,000
135F	Same	Same Instrumentation as 134F	(P1208O not valid)				
62E	A1588O	Same as 65E		LL	Gulton KA1006	100	20 - 2000
	A1278O	Fwd. Surface Q IV Jett. Rail A Frame	Parallel	LL	Gulton KA1006	25	20 - 2000
	F1185O	Same as 65E					
	F1650O	Fuel Tank Pressure Reg.	Radial	LL	Gulton KA1006	80	(Invalid)
	F1651O	Same as 65E					
	P1208O	Same as 65E			(Invalid)		
	P1451O	Same as 65E					
	P1531O	Same as 65E					

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data Type	FBW ± g or db	Nominal Freq. Response in cps
62E	P1533O	Same as 65E					
	P1532O	Booster Hydraulic Pump	Z	LL	Gulton KA1006	100	20 - 2000
	A1571O	Thrust Sect. Heat Shield Q III - IV	Z	LL	CEC-4-202-0001	25	0 - 300
	H1428O	Sustainer Hydraulic Pump	X	LL	Gulton KA1006	100	20 - 2000
	H1429O	Sustainer Hydraulic Pump	Y	LL	Gulton KA1006	100	20 - 2000
	A1514O	Same as 65E	Z	LL	(Invalid)		
	A1515O	Same as 65E	Y	LL			
	A1576O	Same as 65E	X	LL	(Invalid)		
	S1606O	Autopilot Gyro Canister	Z	LL		20	20 - 2000
	S1607O	Autopilot Gyro Canister	Y	LL		20	20 - 2000
	A1780Y	Same as 65E					
	N7223Y	Same as 65E					
	N7534Y	Same as 65E					
	N7535Y	Same as 65E					
	P1051Y	Same as 65E					
24E		All same as 62E (A1780Y and P1051Y were deleted from landline)					
	A780Y	AIG Computer Constants Brd A	Acoustic	2-E	Chesapeake MN125	120-160	20 - 3500
	P51Y	Thrust Section Microphone	Acoustic	2-C	Chesapeake MN125	130-170	20 - 2000
136F	A502O	Interstage Adapt. (HIRS) Gyro Pnl.	Radial	2-C	Gulton KA1006		20 - 1200
	A503O	Interstage Adapt. (HIRS) Gyro Pnl.	Long.	4-C	Gulton KA1006		20 - 1200
	A504O	High Impulse Ret. Rkt. Pivot Pnl.	Radial	4-A	Gulton KA1006		20 - 600
	A505O	Interstage Adapt. Gyro Panel	Acoustic	4-E	Chesapeake MN125	115-155	20 - 3500

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
136F	H412O	Sust. Hyd. Control Package	Y	1-6	Giannini 24158J-2S-50	45	0 - 25
	P531O	SGG Fuel Check Valve	Z	1-7	Giannini 24158J-2S-50	30	0 - 35
	P1206O	Same as 135F					
	P1208O	Same as 135F					
	P1209O	Same as 135F					
	P1106O	Same as 135F					
	P1108O	Same as 135F					
109F	A1150O	AIG Computer Mount (Hardside)	X	LL	Columbia 606-3	20	
	A1151O	AIG Computer Mount (Hardside)	Y	LL	Columbia 606-3	20	
	A1152O	AIG Computer Mount (Hardside)	Z	LL	Columbia 606-3	20	
	A1562O	AIG Computer Circuit Brd. Z218	-	LL	Columbia 606-3	20	
	A1574O	Same as 65E (Softside)					
	A1575O	Same as 65E (Softside)					
	A1576O	Same as 65E (Softside)					
	N7538Y	Silo Microphone B	Acoustic	LL	Chesapeake MN125	130-170	20 - 10,000
	N7540Y	Same as 83F					
	A1780Y	Same as 83F					
	A1230O	Re-entry Vehicle Adapter	Z	LL	CEC-4-202-0001	5	0 - 300
	A1571O, F1650O, F1651O, H1428O	Same as 62E					

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
109F	P1208O P1531O P1532O P1533O S1606O S1607O A1588O	Same as 62E					
	H429O	Sust. Hydraulic Pump	Y	2-C	Gulton KA1006	104	20 - 2000
5E(F)	A1491O	AIG Computer Mount	X	LL	Columbia 606-3	10	20 - 10,000
	A1562O	AIG Computer Circuit Brd Z218	-	LL	Columbia 606-3	10	20 - 10,000
	A1780Y	AIG Computer Constant Brd	Acoustic	LL	Chesapeake MN125	120-160	20 - 10,000
5E(F)	P1106O P1108O P1206O P1208O P1209O	Same as 62E					
	H412O	Same as 136F					
	P531O	Same as 136F					
	A502O A504O A503O A505Y	Same as 136F					

TABLE 6.1.2 (continued)

MEASUREMENT INFORMATION IN ORDER OF FLIGHT SEQUENCE

Missile Number	Measure Number	Measurement Location	Sensing Axis	TLM-LL RF-CH-SEG	Transducer System Data		
					Type	FBW ± g or db	Nominal Freq. Response in cps
137F	A1491O						
	*A1562O	Same as 5E					
	*A1780Y	* Questionable Data					
	P1106O P1107O P1108O P1206O P1208O P1209O	Same as 62E					
	A502O	Same as 136F					
	A503O	Same as 136F					
	A505Y	Same as 136F					
	A860O	Sust. Side-Hyd. Disconnect Flange	X	4-17	Gulton KA1006	100	20 - 800
	A51Y	Same as 24E					

SECTION 6.2.1

MISSILE 3E

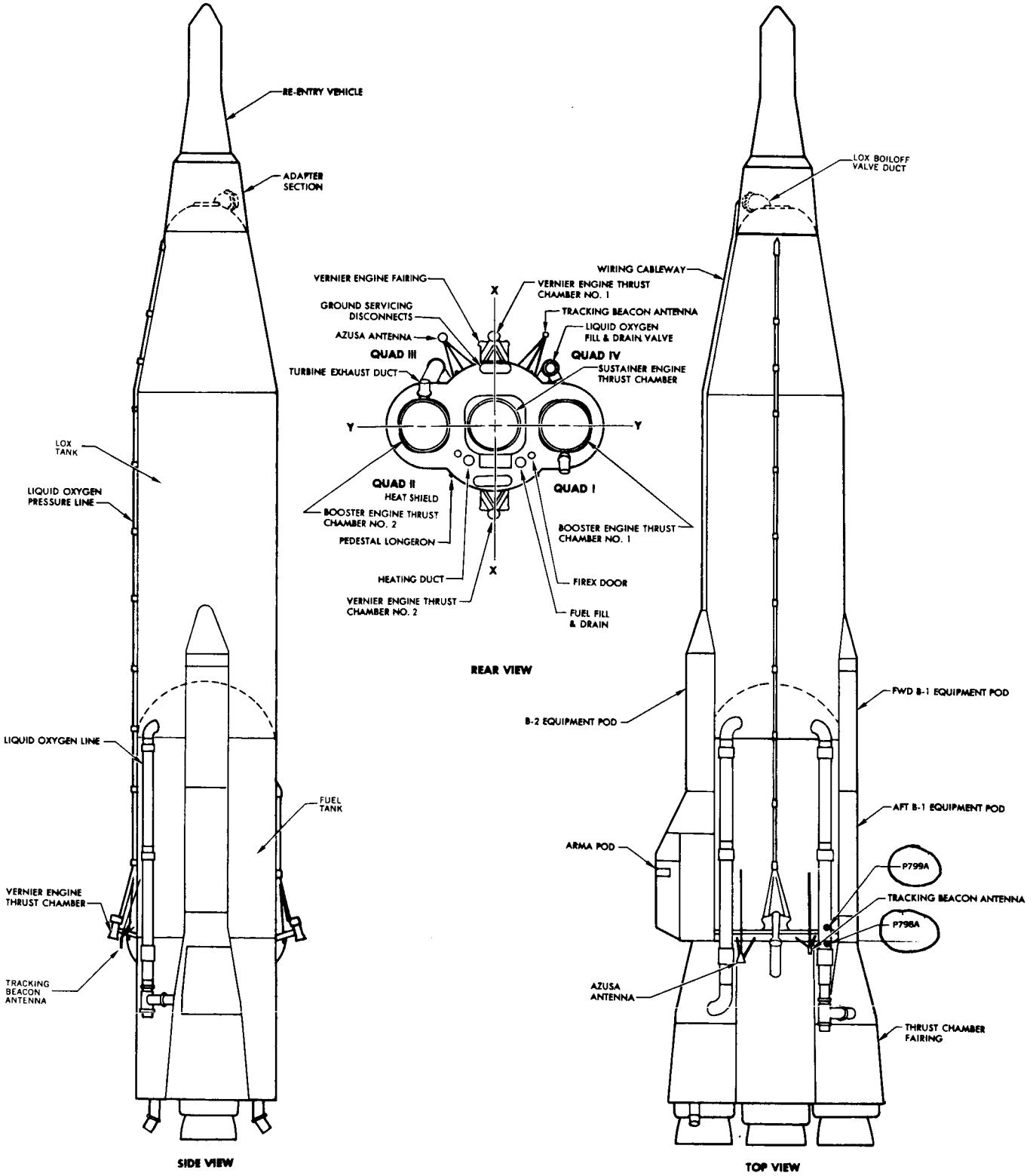
FLIGHT TESTED 11-10-60

AT AMR COMPLEX 13

TEST REPORT AE60-0542

MISSILE CONFIGURATION

MISSILE 3E



VIBRATION ANALYSIS

During the flight of missile 3E, two significant periods of missile vibration prevailed. The periods of significant activity were between launch and 45 seconds and from 103 seconds to booster cutoff. Generally, predominant frequencies between 12 and 26 cps were evident throughout the missile. An extensive study is now underway to determine the exact cause for the buildup in missile vibration.

The vibration measurements obtained from the flight of Missile 3E are presented below.

Booster No. 1 Low Pressure Lox Line Vibration

Two high frequency accelerometers were installed on the booster No. 1 low pressure lox line, for the first time, to determine the vibration environment imposed on the line during flight. The standard subcarrier channels used for monitoring the accelerometer outputs limited the frequency response within a band of approximately 10 to 300 cps. The general location of the measurements are shown in figure 15-1, while the detail installations are shown in Figures 15-5 and 15-6.

The vibration of the lox line appeared to follow the same general trend of inflight vibration as shown by the rate gyro outputs, the ARMA platform accelerometers and the A.I.G. equipment structural accelerometers. The most significant periods of duct vibration occurred immediately following launch to approximately 9 seconds and between 32 and 45 seconds of flight. The vibration levels imposed on the B1 lox line are shown

in figure 15-12 and summarized in table 1. Since the data shown herein was the first obtained from a"E" series missile during flight, reference to normal levels can not be made. No structural damage was obvious; however, it is apparent that the acceleration and frequencies obtained during the significant buildup periods previously mentioned represent rather large deflections. An extensive investigation of "E" series propellant line loads is now being conducted by the effected design groups.

TABLE 1

Vibration Environment of B_1 Low Pressure Lox Line

Lox Line, Axial, P-798-0

Flight Period	Predominant Frequency ~ cps	Maximum Acceleration ~ g Peak to Peak	Period of Maximum Accel ~ sec
-. 3 to . 5	10. 5	10. 5	-3. to . 5
. 5 to 1. 0	7. 5	26. 0	. 6 to . 95
1. 8 to 9. 0	12. 5 to 13. 8	15. 0	2. 0 to 4. 5
9 to 32	200	7. 0	Intermittent
32 to 45	16 to 17	23. 0	32. 6 to 33. 3
45 to 90	200	19. 0	50 to 60
90 to 104	200	3. 0	Steady State
104 to 110. 7	24. 5	4. 0	Intermittent
110. 7 to 117	Apparent Instrumentation Difficulties		
117 to 129	26. 5	5. 0	122 to 125
129. 3 to 130	5. 3	15 to 18	129. 6 to 129. 8
130 to 131	10. 1	5. 0	130 to 130. 8
132 to 154	Questionable Data Due To Apparent Instrumentation Difficulties		

Vibration Environment of B_1 Low Pressure Lox Line (Continued)

Lox Line, Radial, P-799-0

Flight Period	Predominant Frequency ~ cps	Maximum Acceleration ~ g Peak to Peak	Period of Maximum Accel ~ sec
-.3 to .5	10.5	4.0	-.3 to .5
.5 to 1.0	7.5	5.0	.6 to .95
1.8 to 9.0	12 to 13	6.0	2.3 to 4.5
9 to 32	320	15.0	Intermittent
32 to 45	16 to 17	22.0	32.6 to 33.3
45 to 90	300 to 400	Random; 15G(rms)	50 to 60
90 to 104	300 to 400	3.5	Steady State
104 to 110.7	24.5	4.0	Intermittent
110.7 to 117	Apparent Instrumentation Difficulties		
117 to 129	26.5	8.5	122 to 125
129.3 to 130	4.2	14 to 17	129.6 to 130.0
130 to 131	3.5	9.3	130 to 131
132 to 154	Questionable Data Due To Apparent Instrumentation Difficulties		

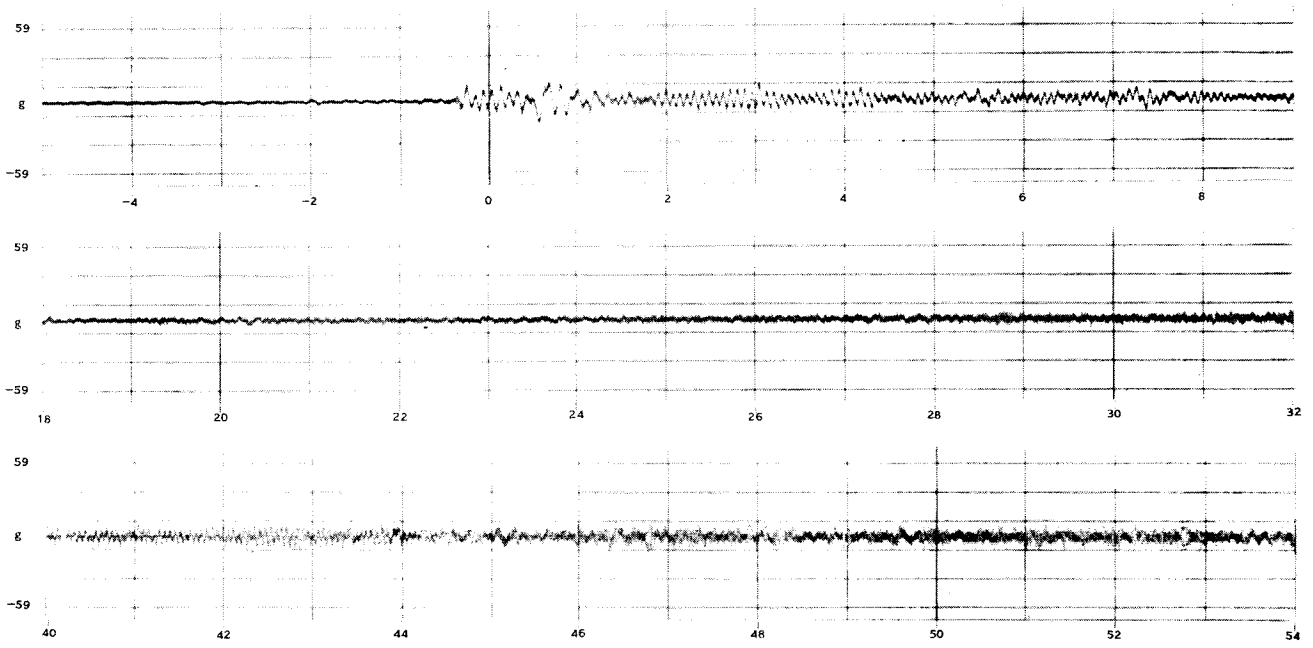
AIG Equipment Vibration

Six ARMA high frequency accelerometer outputs were monitored during flight. The accelerometers were located on the platform binnacle and computer, with acceleration being measured along the X, Y and Z axes on each package. The exact location and calibration data for the accelerometers have not been received to date; therefore only qualitative information has been obtained thus far.

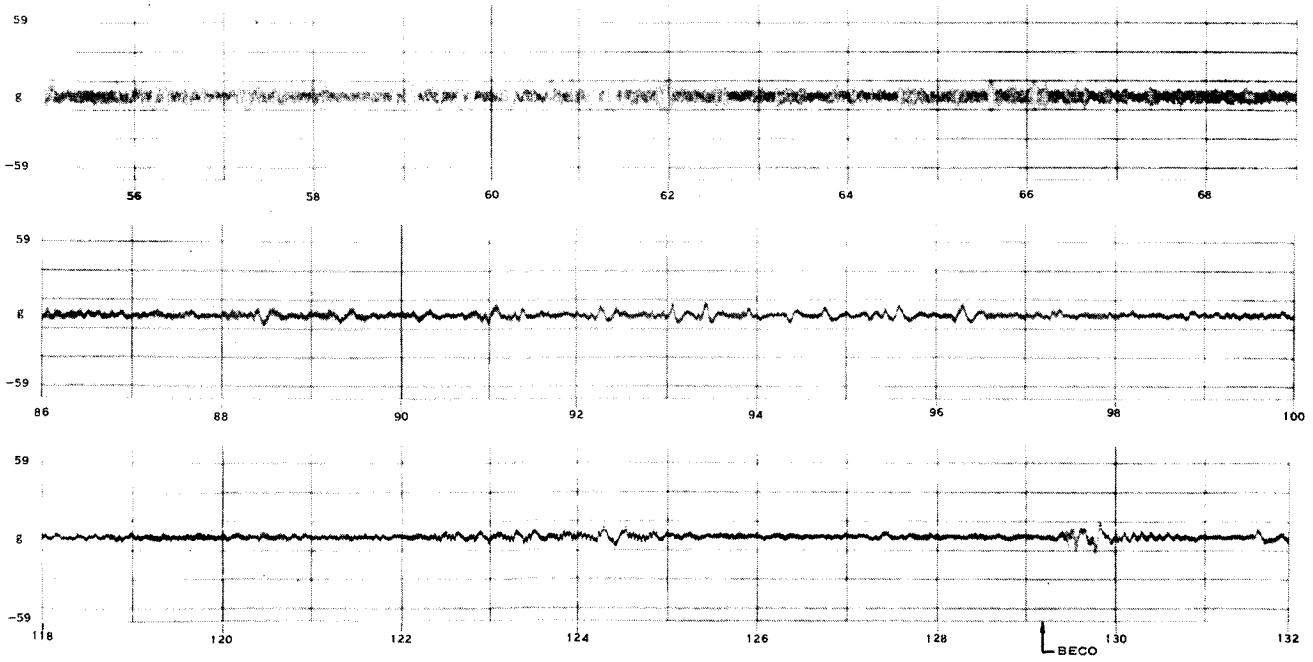
During launch the vibration appeared normal, displaying random outputs. Following launch between 4 and 10 seconds a predominant 13 to 14 cps frequency component was evident on the binnacle X and Y axes, while the remaining outputs were nearly quiescent or indicated a low random output. Between 13 and 19 seconds a predominant frequency of 24.5 cps prevailed on all measurements. The next significant buildup occurred between 32.5 and 45 seconds of flight, where a predominant frequency of 16 to 17 cps was shown on all outputs. During that same period, the outputs appeared erratic, indicating intermittent instrumentation difficulties. From 46 to approximately 100 seconds the measurements were again nearly quiescent or indicated an apparent low level random output. A predominant 24 cps component was again indicated between 105 and 110 seconds on all measurements. At 116 seconds of flight all measurements became quiescent, remaining there until telemetry was lost at 154 seconds.

In conclusion, it was evident that the Arma equipment responded to the airframe vibration inputs during the significant buildup periods.

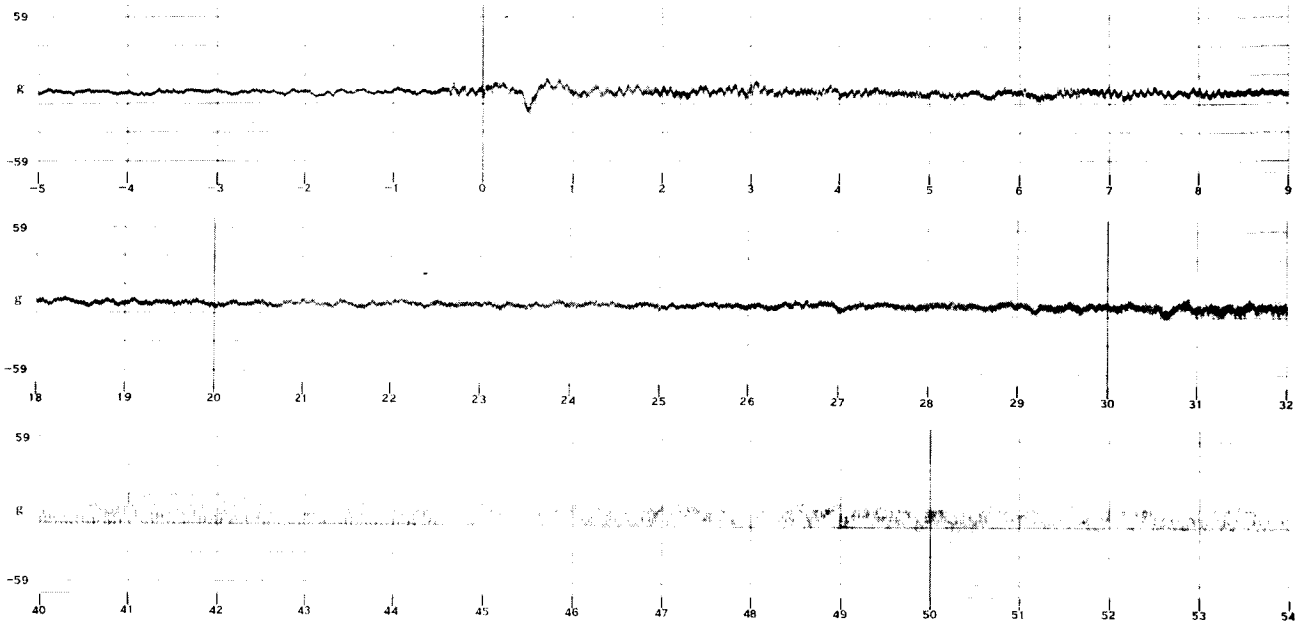
VIBRATION WAVEFORM
MISSILE 3E



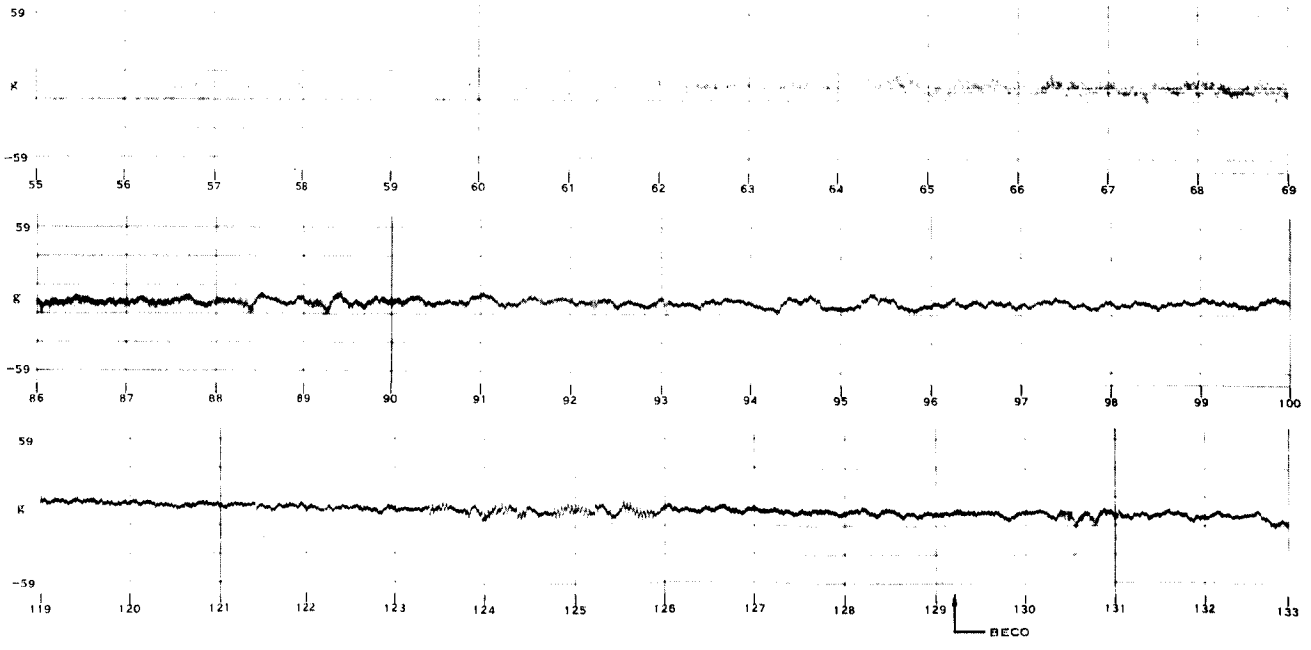
P7980 B1 LOW PRESSURE LOX LINE, LONG.
160 CPS LOW PASS FILTER



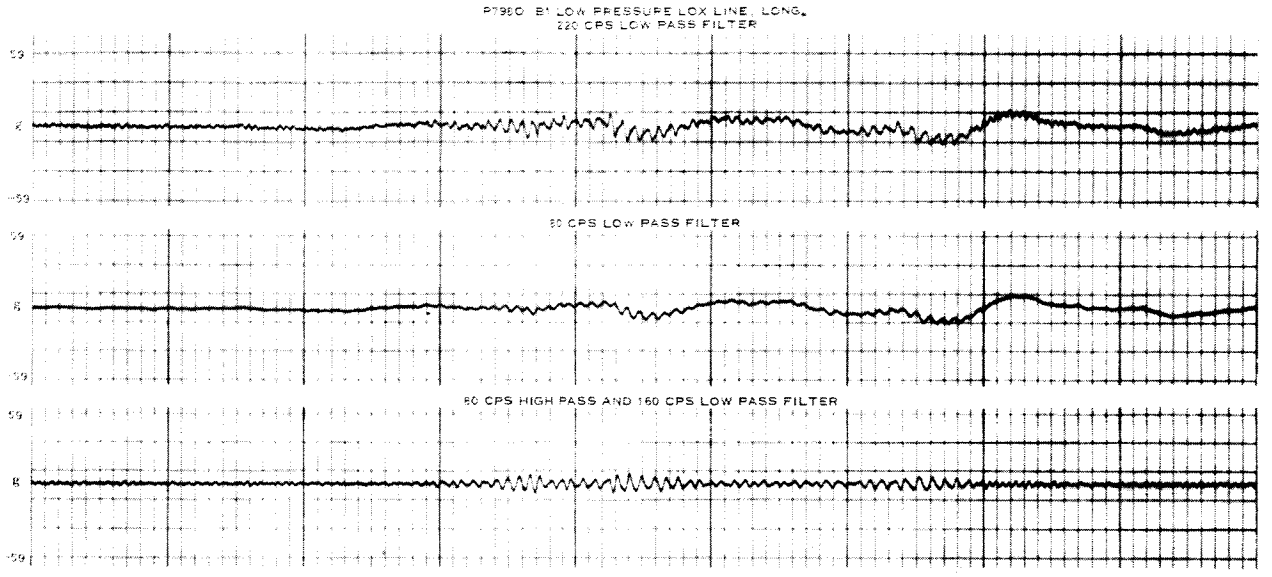
VIBRATION WAVEFORM
MISSILE 3E

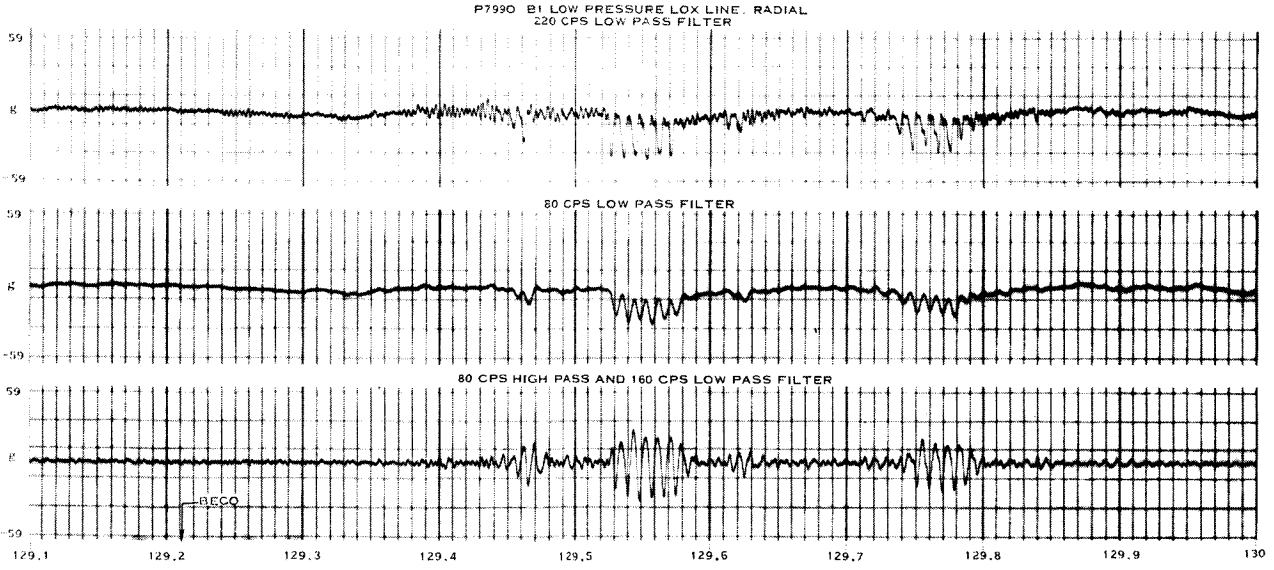


P7990 B1 LOW PRESSURE LOX LINE, RADIAL
160 CPS LOW PASS FILTER

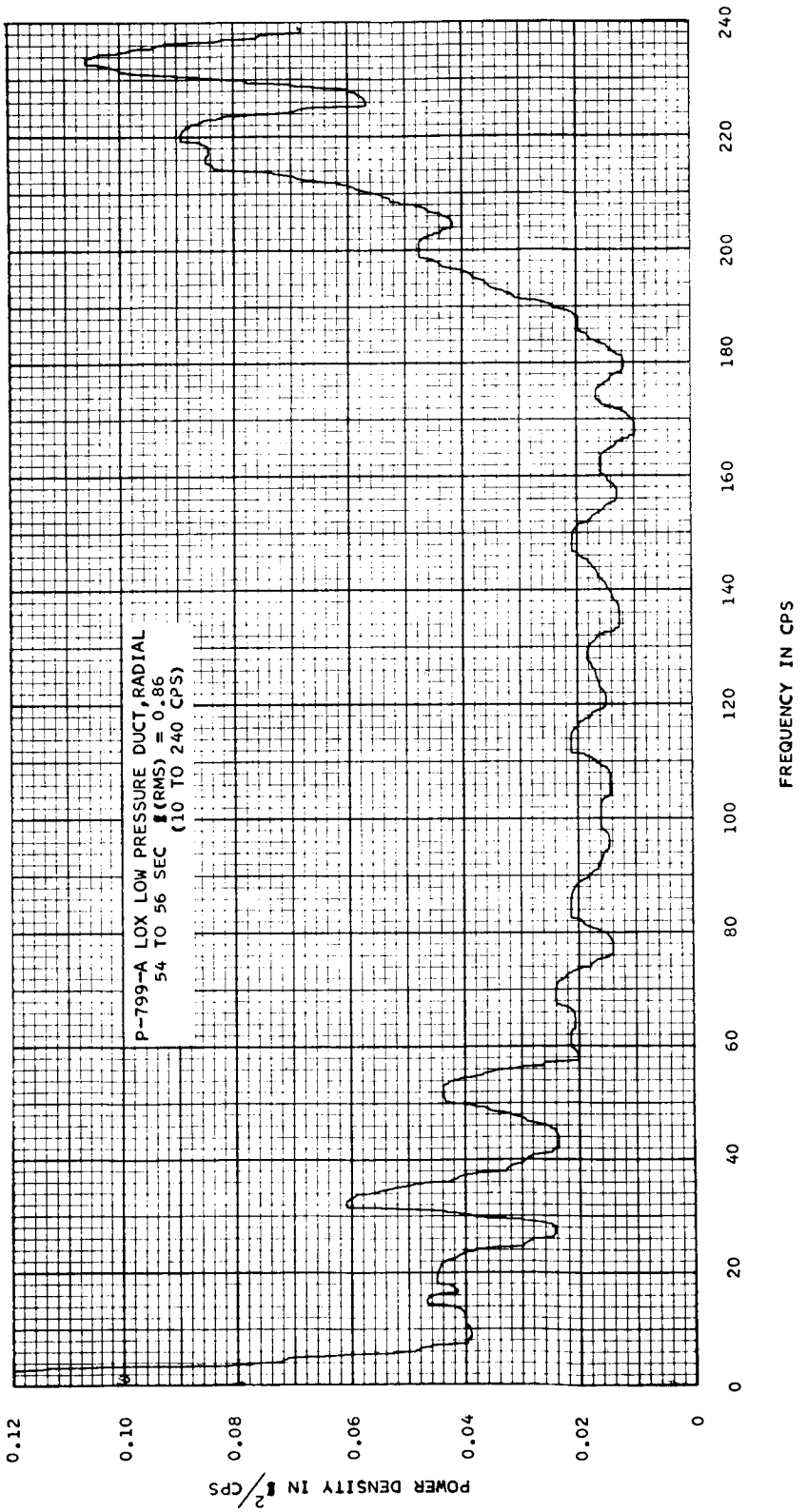


VIBRATION WAVEFORM
MISSILE 3E
BECO EXCITATION





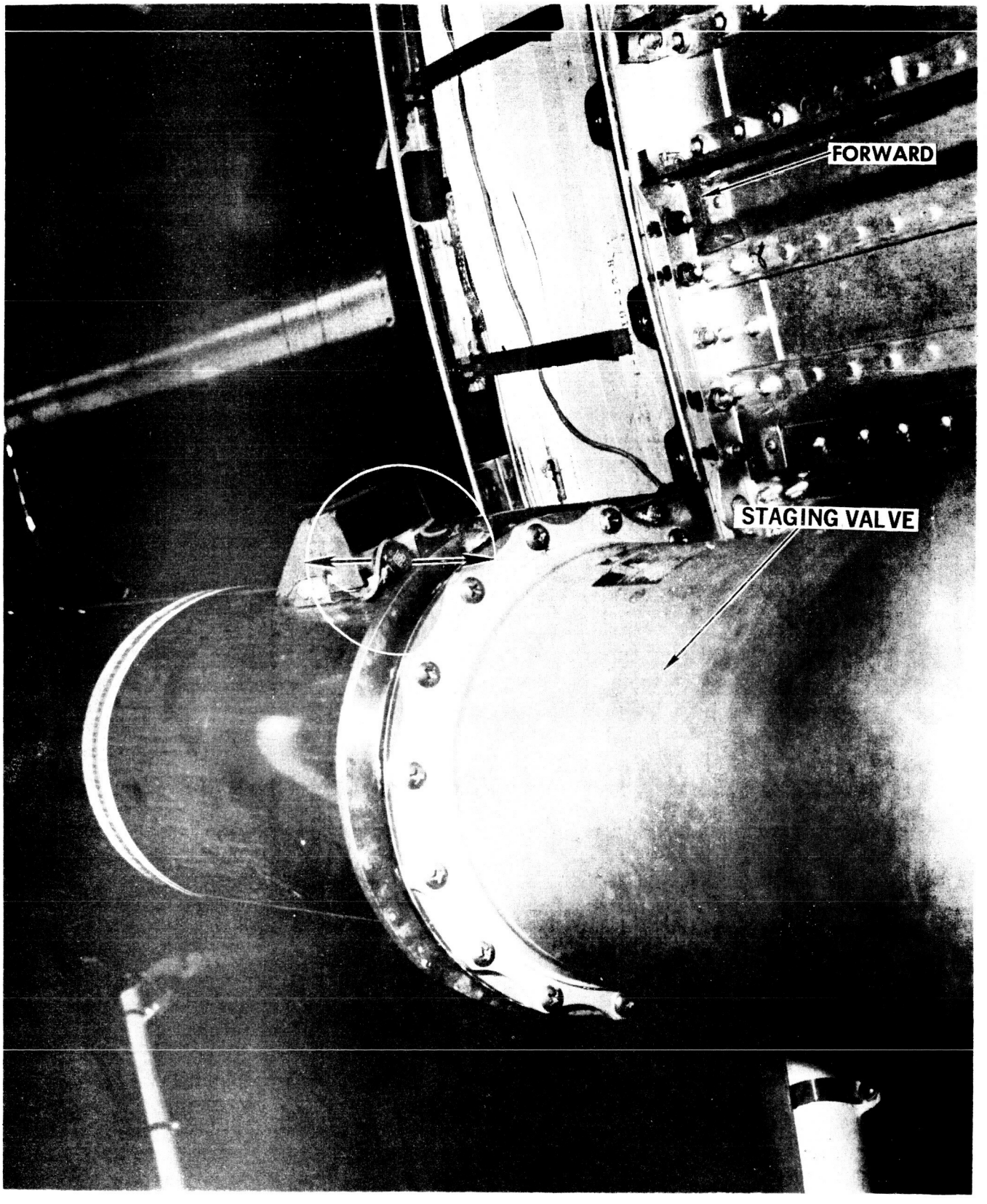
3E


P-799-A LOX LOW PRESSURE DUCT, RADIAL
54 TO 56 SEC ∑(RMS) = 0.86
(10 TO 240 CPS)
POWER DENSITY IN g²/CPS
0.12
0.10
0.08
0.06
0.04
0.02
0
FREQUENCY IN CPS
0
20
40
60
80
100
120
140
160
180
200
220
240

3E

MISSILE 3E

LOCATION OF B1 LOX LINE ACCELEROMETER P798A



LOCATION OF B1 LOX LINE ACCELEROMETER P799A



SECTION 6.2.2

MISSILE 4E

FLIGHT TESTED 11-29-60

AT AMR COMPLEX 13

TEST REPORT AE60-0750

In Flight Vibration Measurements

Four high frequency accelerometers were installed on the booster No. 2 engine configuration to determine booster engine vibratory response during booster stage. The data indicated no abnormal vibratory conditions during the initial portion of flight or within the period where the sustainer engine hydraulic system failed (approximately 40 seconds).

The accelerometers were located as follows:

A-862-0 B2 turbo pump, Y axis

A-863-0 B2 turbo pump, Z axis

A-945-0 B2 gimbal block, Y axis

A-946-0 B2 yaw actuator tie point, Y axis

Figures 4-4 and 4-5 show the details of their location.

The quality of the instrumentation was satisfactory except for a faulty bias condition noted at launch and between 10 and 20 seconds on both booster turbo pump measurements. It was evident that the data therein was questionable since the particular transducers used on the pumps were incapable of providing the predominant response displayed during those periods. A recording of each measurement is shown in Figure 4-14.

The steady-state levels observed during booster stage appeared to confirm the flight control data (engine displacement measurements), in that no unusual vibration was exhibited. The maximum steady-state vibration levels were as follows:

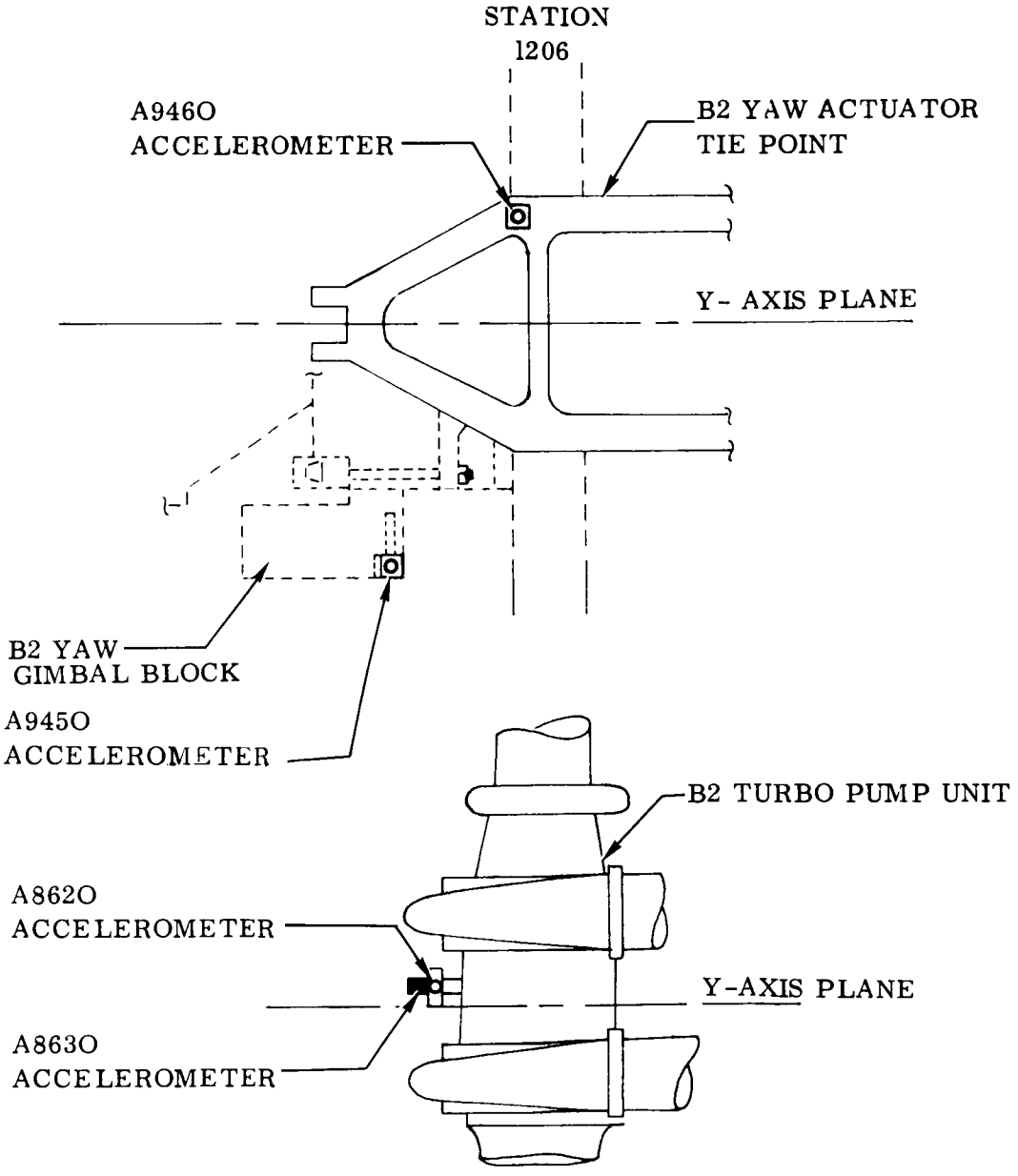
Measurement	Recording System Frequency Response (cps)	Predominant Frequency (cps)	G(RMS)
A-862-0	220	220+	1.6 to 1.8
A-863-0	160	160-180	0.7
A-945-0	25	28-30	0.7
A-946-0	160	100 & 220+	0.7

During launch (-1.3 to 1.7 seconds) the pump data was obscured by the aforementioned bias problem. However A-945-0 and A-946-0 were satisfactory, and indicated normal response with levels between 0.4 and 1.8 g(rms). These two measurements did show instantaneous response to lift off at 0.8 seconds, exhibiting maximum displacements of 9 and 4.5 g peak, respectively. The lift off transient was damped by 1 second.

Through most of the remainder of booster flight, the maximum steady state levels observed were as shown in the above table, except for two short duration disturbances discussed below.

Significant engine mount motion was evident between 112 and 120 seconds. From 112.17 to 114 seconds the gimbal block measurement displayed 4 separate single peak displacements. A maximum load of 9 g peak was observed at 112.55 seconds. The remainder of the measurements showed no significant response during that period. Between 118 and 119.5 a 10 cps oscillation was evident on the gimbal block and actuator tie point measurement. The maximum levels were 2.5 and 1.0 g peak to peak, respectively. The response therein probably reflects thrust section motion rather than local mount motion and do not represent critical loads.

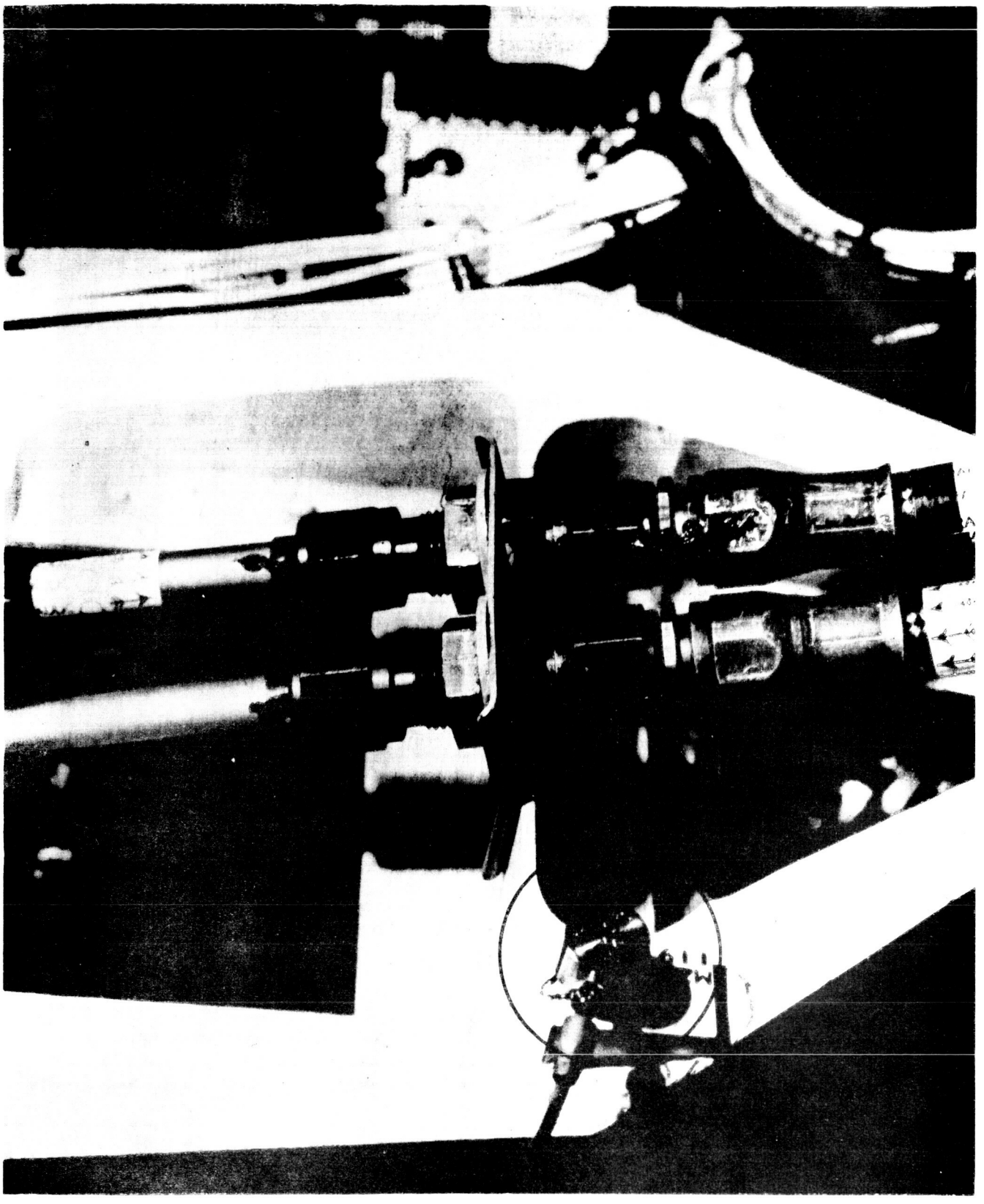
VIBRATION PICKUP LOCATIONS



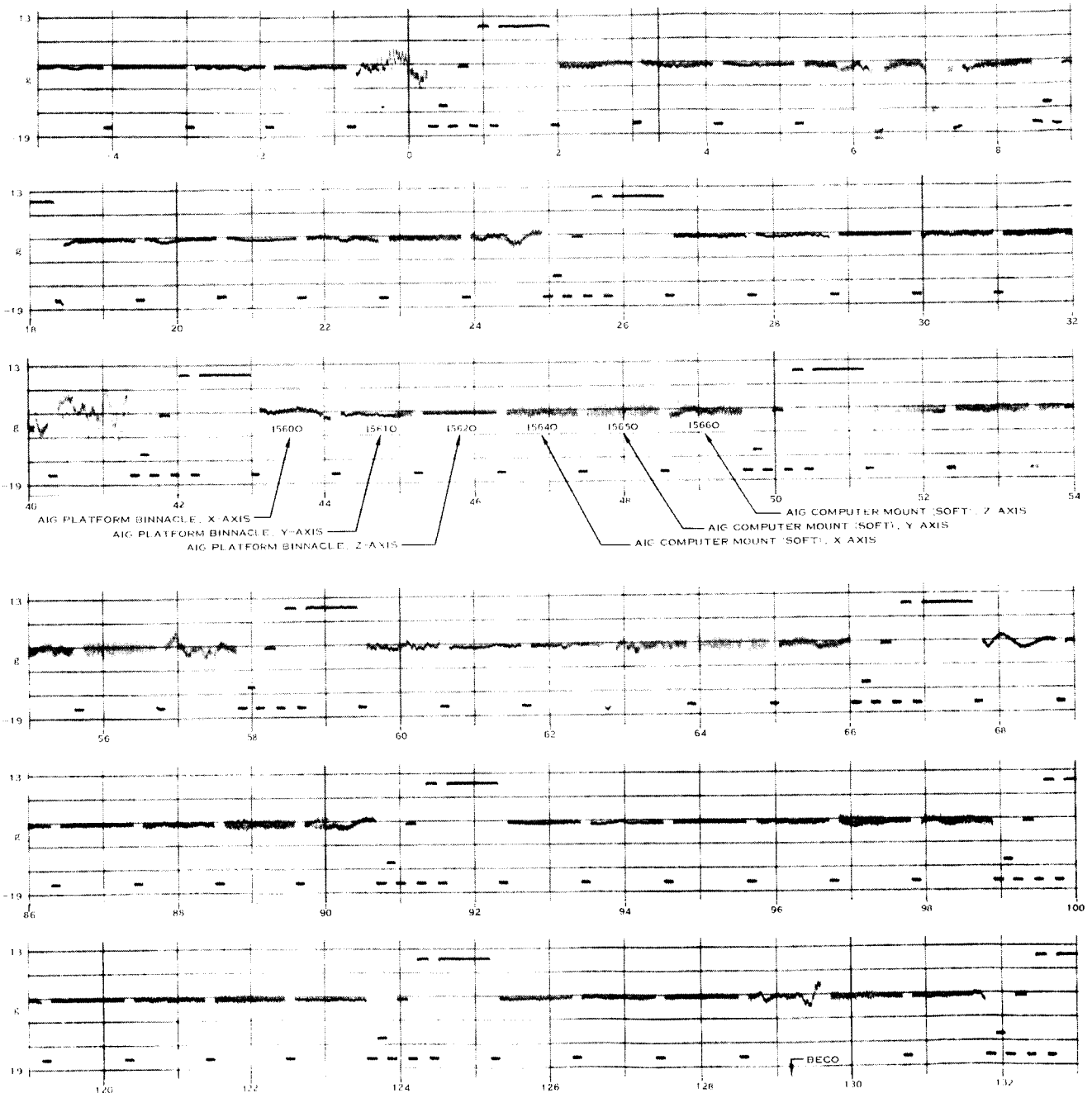
UNCLASSIFIED

MISSILE 4E

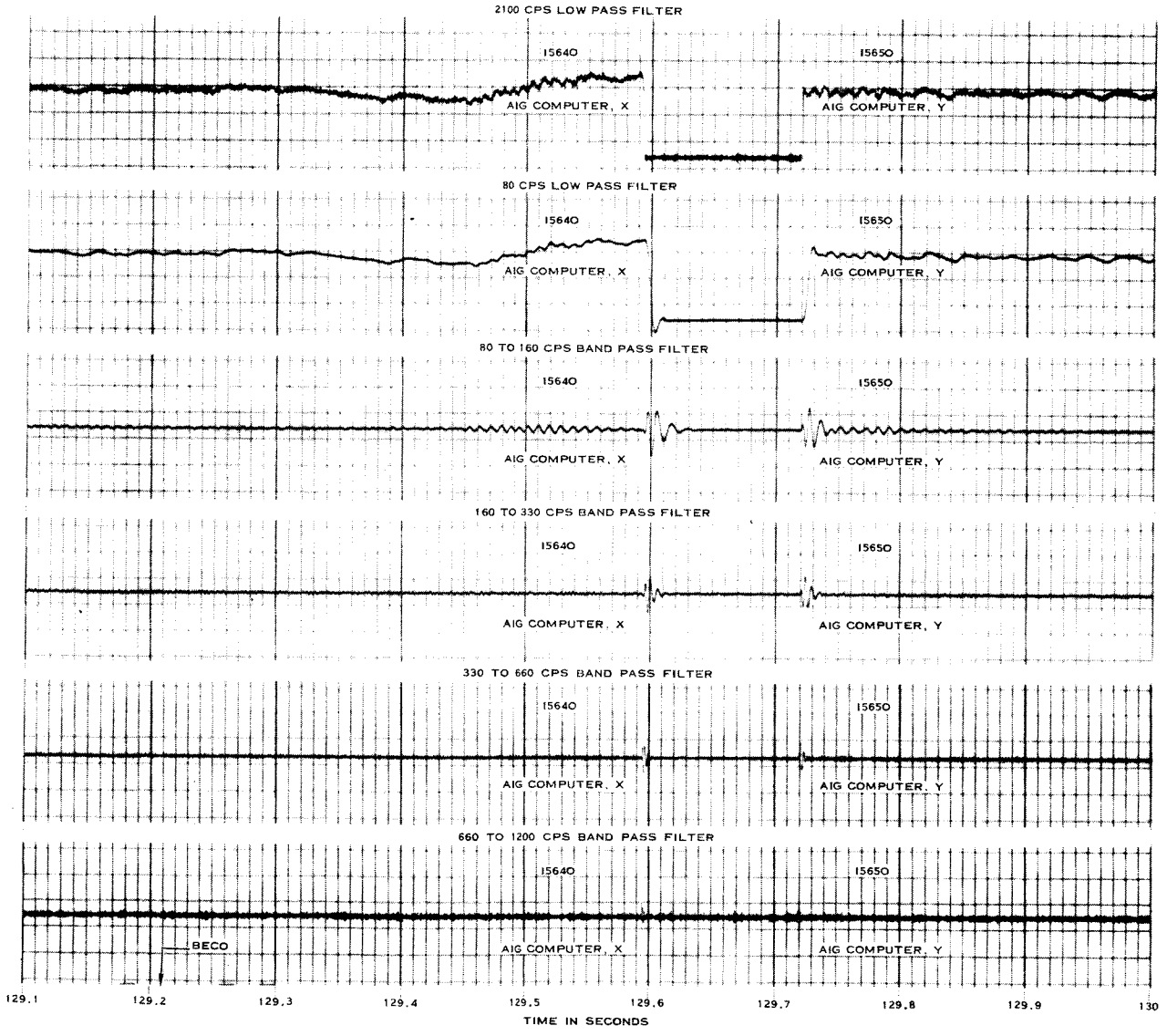
LOCATION OF B2 YAW ACTUATOR TIE POINT VIBRATION PICKUP



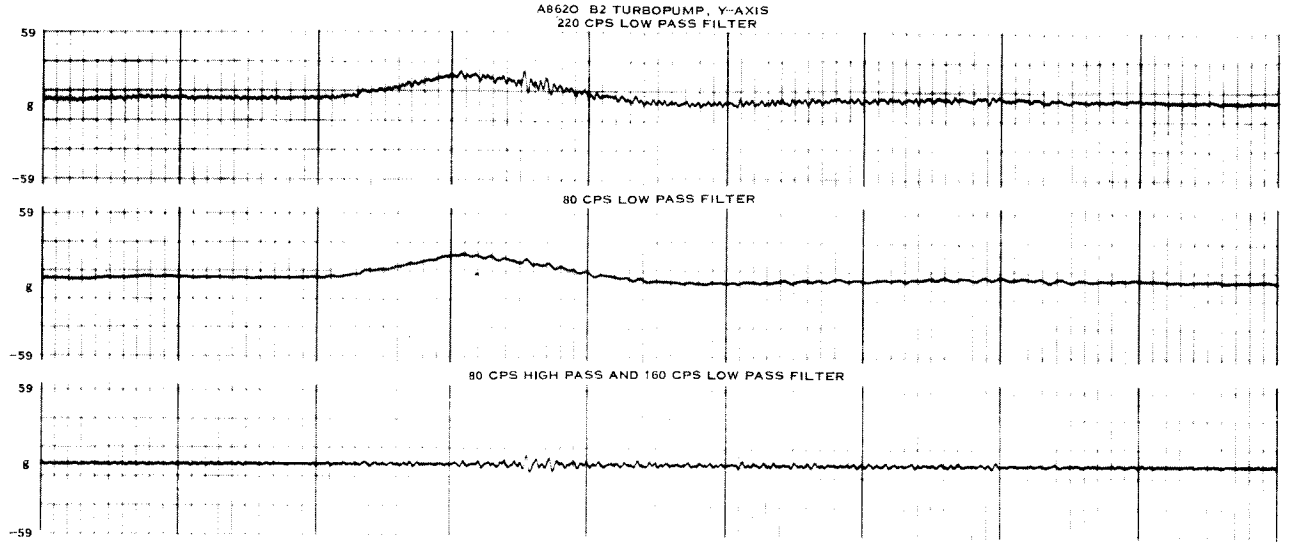
VIBRATION WAVEFORM
MISSILE 4E
2100 CPS LOW PASS FILTER

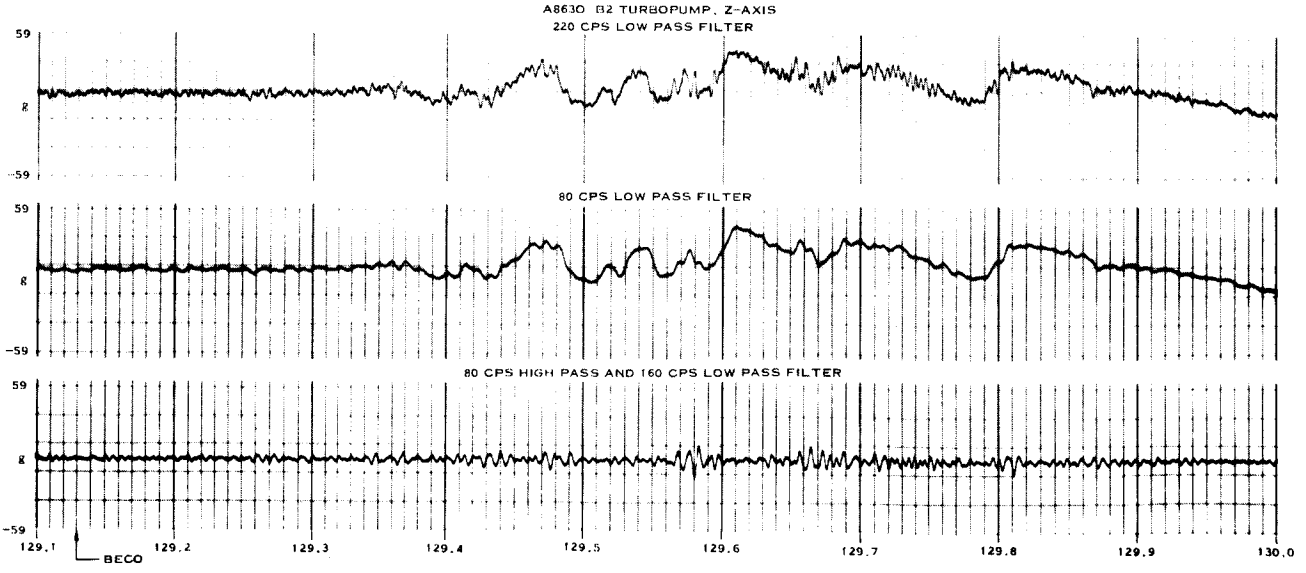


VIBRATION WAVEFORM
MISSILE 4E
BECO EXCITATION

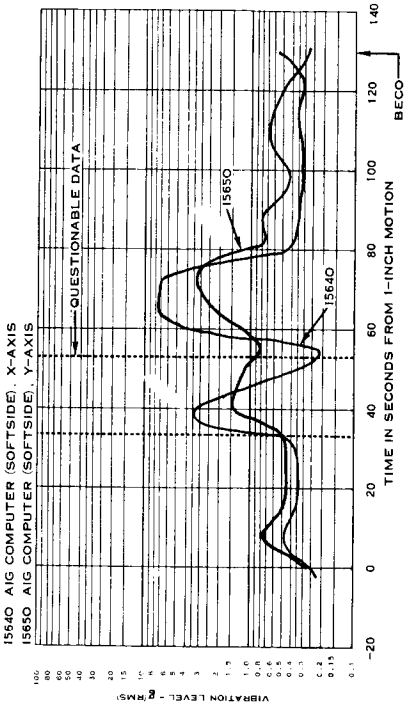


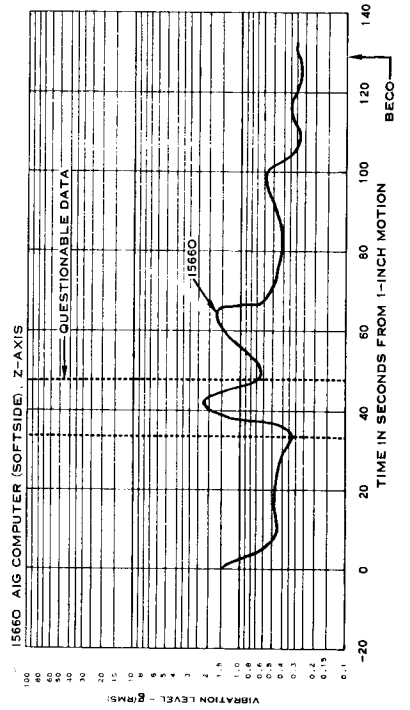
VIBRATION WAVEFORM
MISSILE 4E
BECO EXCITATION

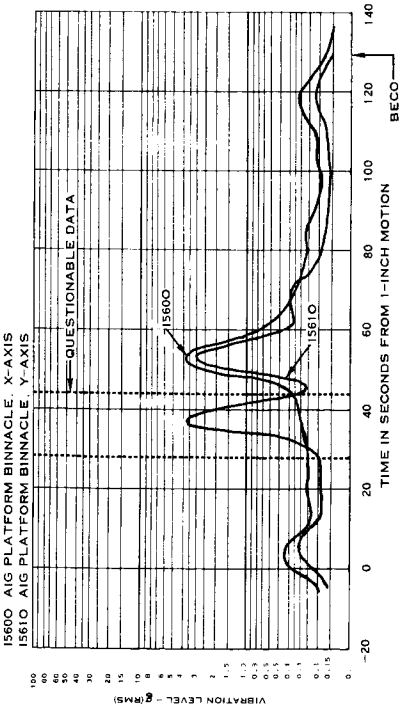


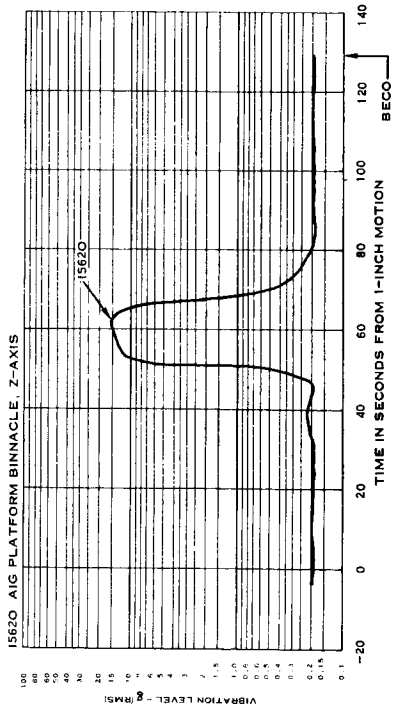


VIBRATING TIME HISTORIES
g (RMS) VS TIME
MISSILE 4E
2100 CPS LOW PASS FILTER

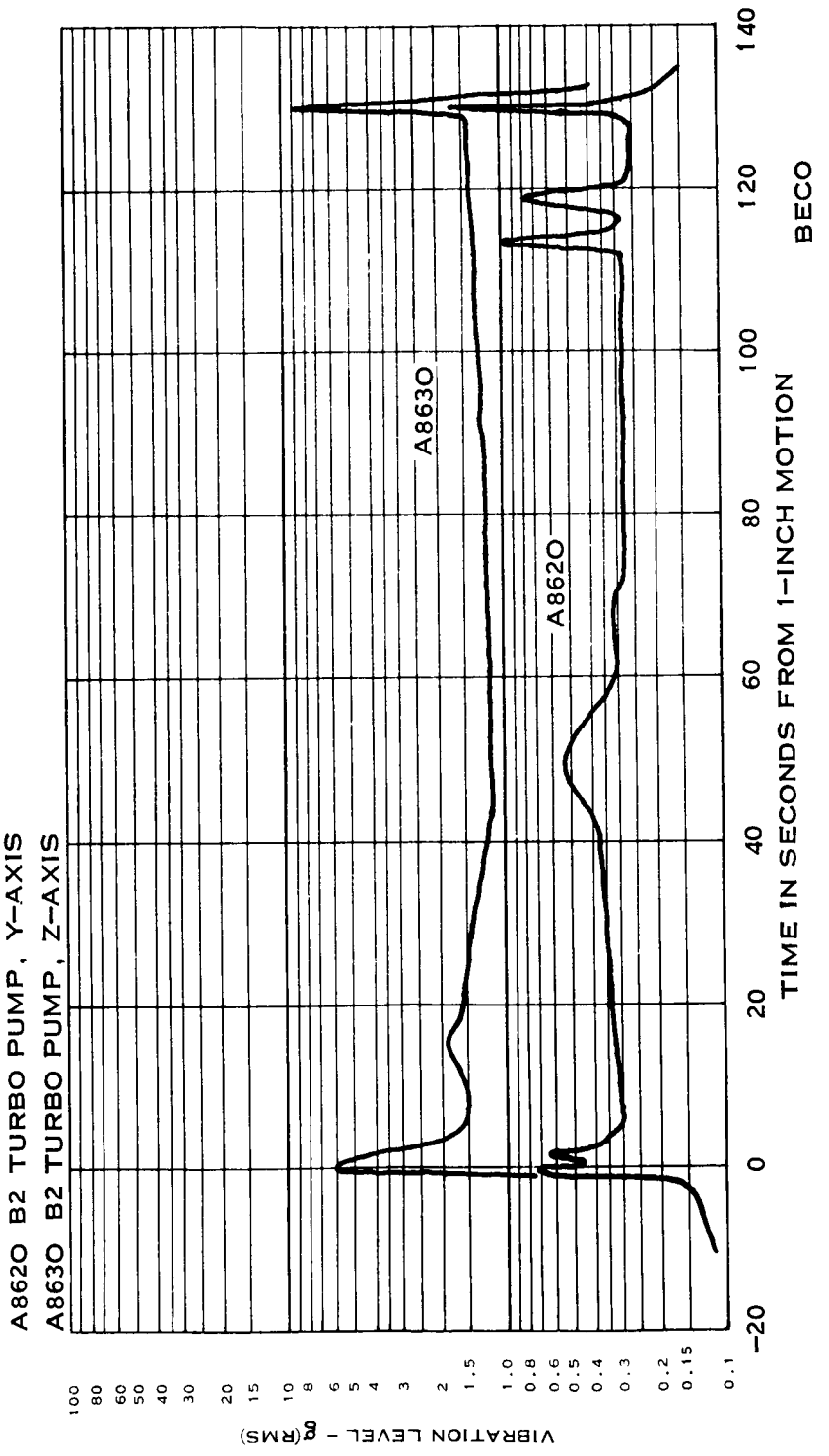


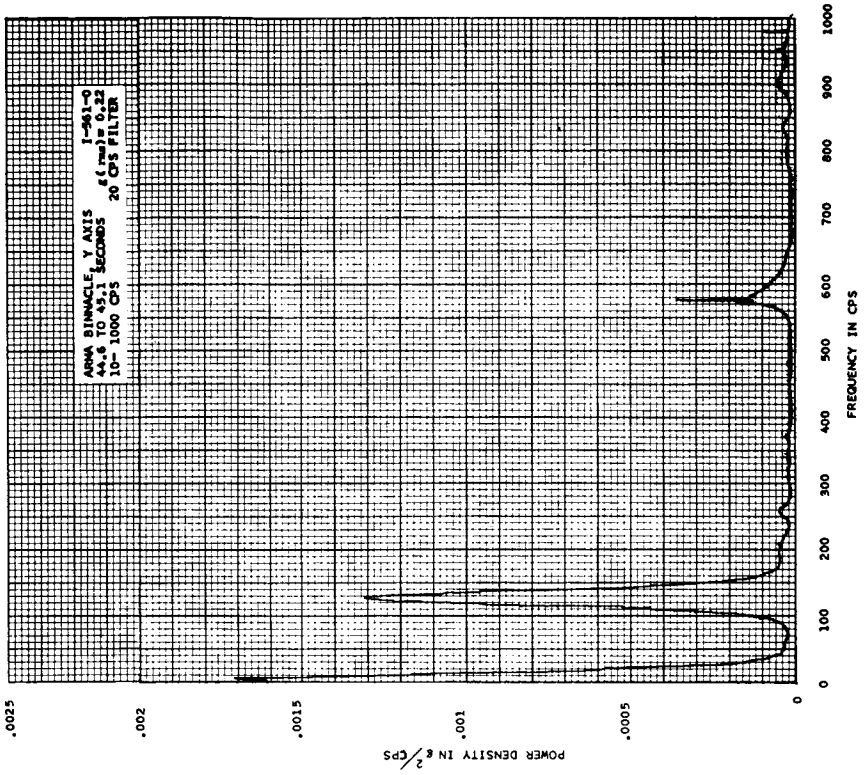


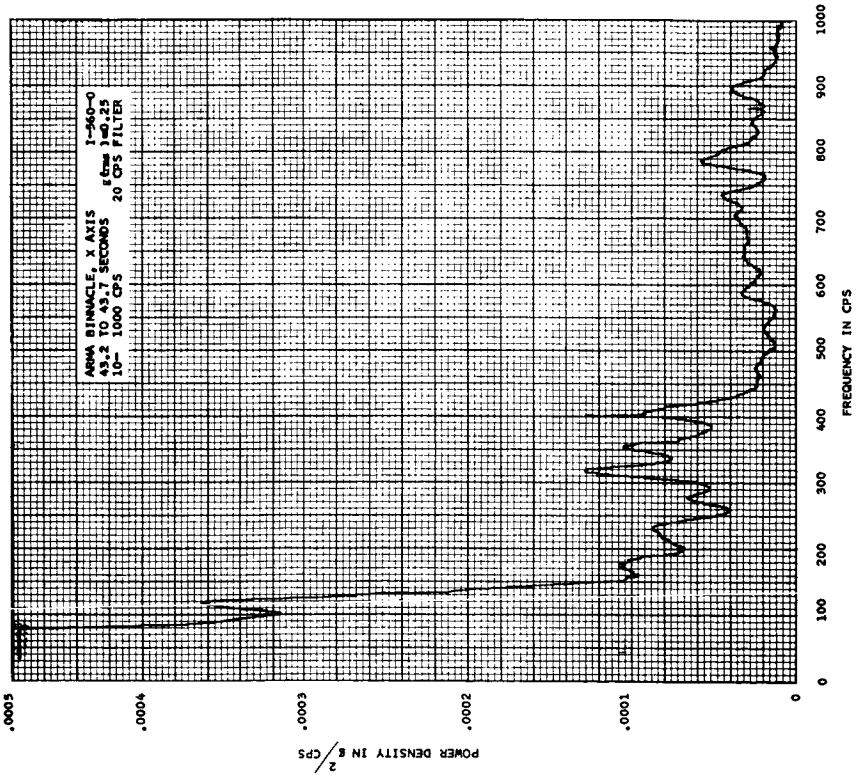


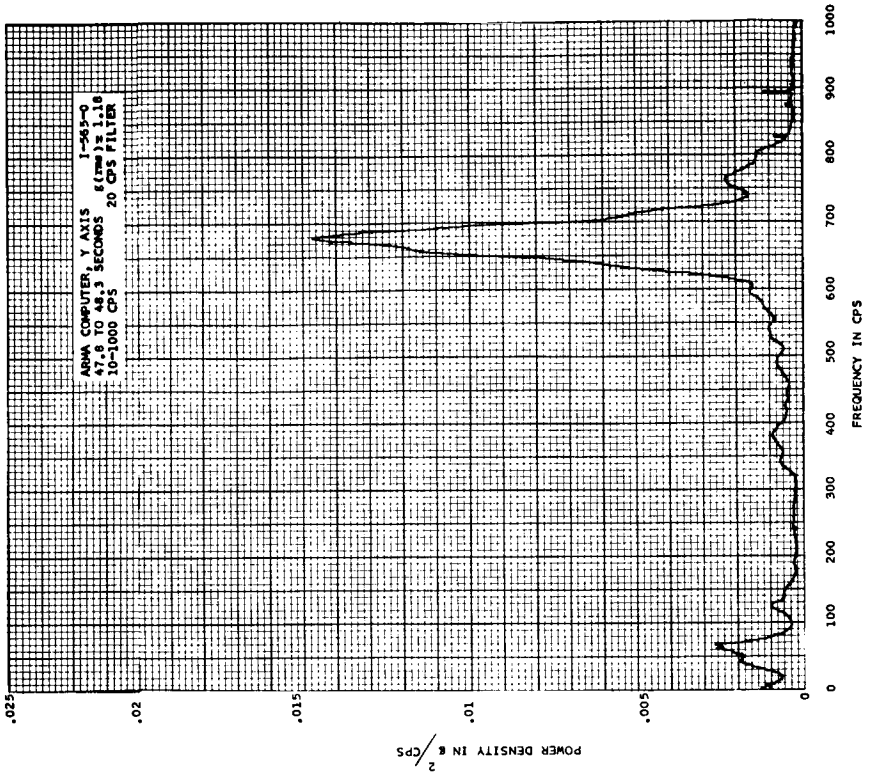


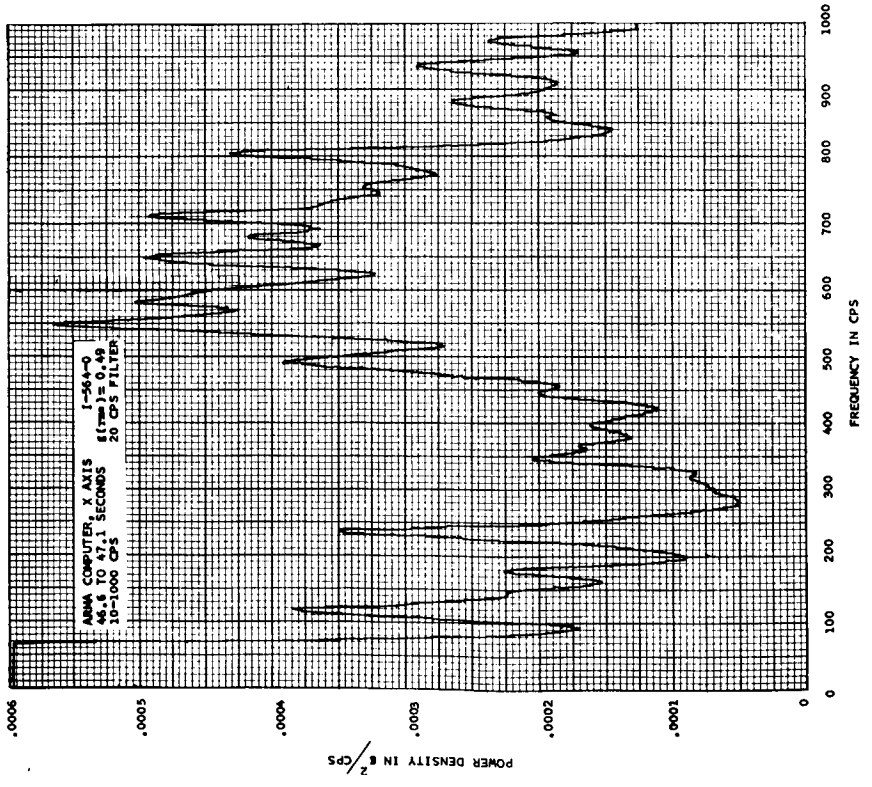
VIBRATION TIME HISTORY
g (RMS) VS TIME
MISSILE 4E
2100 CPS LOW PASS FILTER

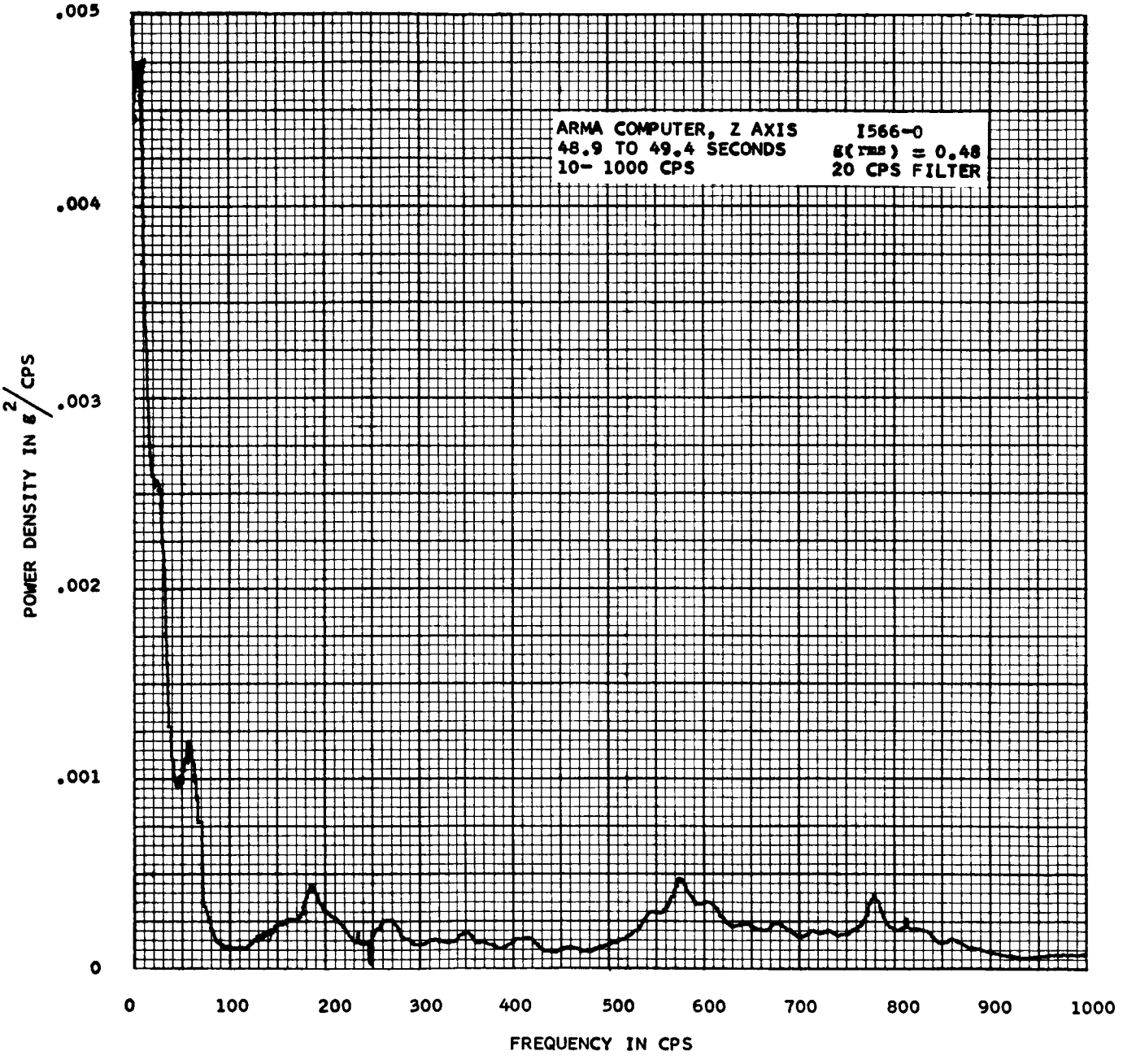



ARMA BINNACLE, Y AXIS
44.6 TO 49.1 SECONDS
10- 1000 CPS
I-561-Q
ε(rms)= 0.22
20 CPS FILTER
FREQUENCY IN CPS
POWER DENSITY IN g²/CPS


ARMA BINNACLE, X AXIS
43.2 TO 43.7 SECONDS
10- 1000 CPS
I-560-Q
ε(rms)=0.25
20 CPS FILTER
FREQUENCY IN CPS
POWER DENSITY IN g²/CPS


ARMA COMPUTER, Y AXIS
47.6 TO 48.3 SECONDS
10-1000 CPS
I-565-O
δ(τm) = 1.18
20 CPS FILTER
.025
.02
.015
.01
.005
0
100
200
300
400
500
600
700
800
900
1000
FREQUENCY IN CPS
POWER DENSITY IN g²/CPS


ARMA COMPUTER, X AXIS
46.6 TO 47.1 SECONDS
10-1000 CPS
I-564-O
δ(τm) = 0.49
20 CPS FILTER
.0006
.0005
.0004
.0003
.0002
.0001
0
100
200
300
400
500
600
700
800
900
1000
FREQUENCY IN CPS
POWER DENSITY IN g²/CPS


ARMA COMPUTER, Z AXIS
48.9 TO 49.4 SECONDS
10- 1000 CPS
I566-0
g(rms) = 0.48
20 CPS FILTER
POWER DENSITY IN g²/CPS
.005
.004
.003
.002
.001
0
0
100
200
300
400
500
600
700
800
900
1000
FREQUENCY IN CPS

SECTION 6.2.3

MISSILE 8E

FLIGHT TESTED 1-24-61

AT AMR COMPLEX 13

TEST REPORT AE60-0955

Thrust Chamber Vibration

High frequency accelerometers were installed on the lox dome of each thrust chamber (Z axis sensitivity) to monitor chamber vibrations as an aid in determining the adequacy of engine performance. The pickups were installed in positions comparable to the location of the rough combustion cutoff accelerometers utilized on Series D missile launchings. The accelerometer outputs were recorded via the FM landline recording system.

The sustainer thrust chamber accelerometer outputs were recorded until approximately the time of umbilical cord disconnect at zero time. The booster chamber recording system utilized a trailing cable with an effective vertical rise of 15 feet, which extended the recording time to approximately 1.6 seconds. The vibration levels observed at each chamber during launch were normal for a dry start condition of the MA-3 propulsion system. The accelerometer outputs were comparable to those observed during normal starts of the MA-3 system at Convair's static test facilities. An oscillograph recording of each accelerometer output is shown in Figure 4-16. A power density spectral computation was made on a sample of the B1 accelerometer outputs as shown in Figure 4-15. The sustainer chamber measurement displayed random outputs through thrust buildup with a maxium level of 5 g (rms).

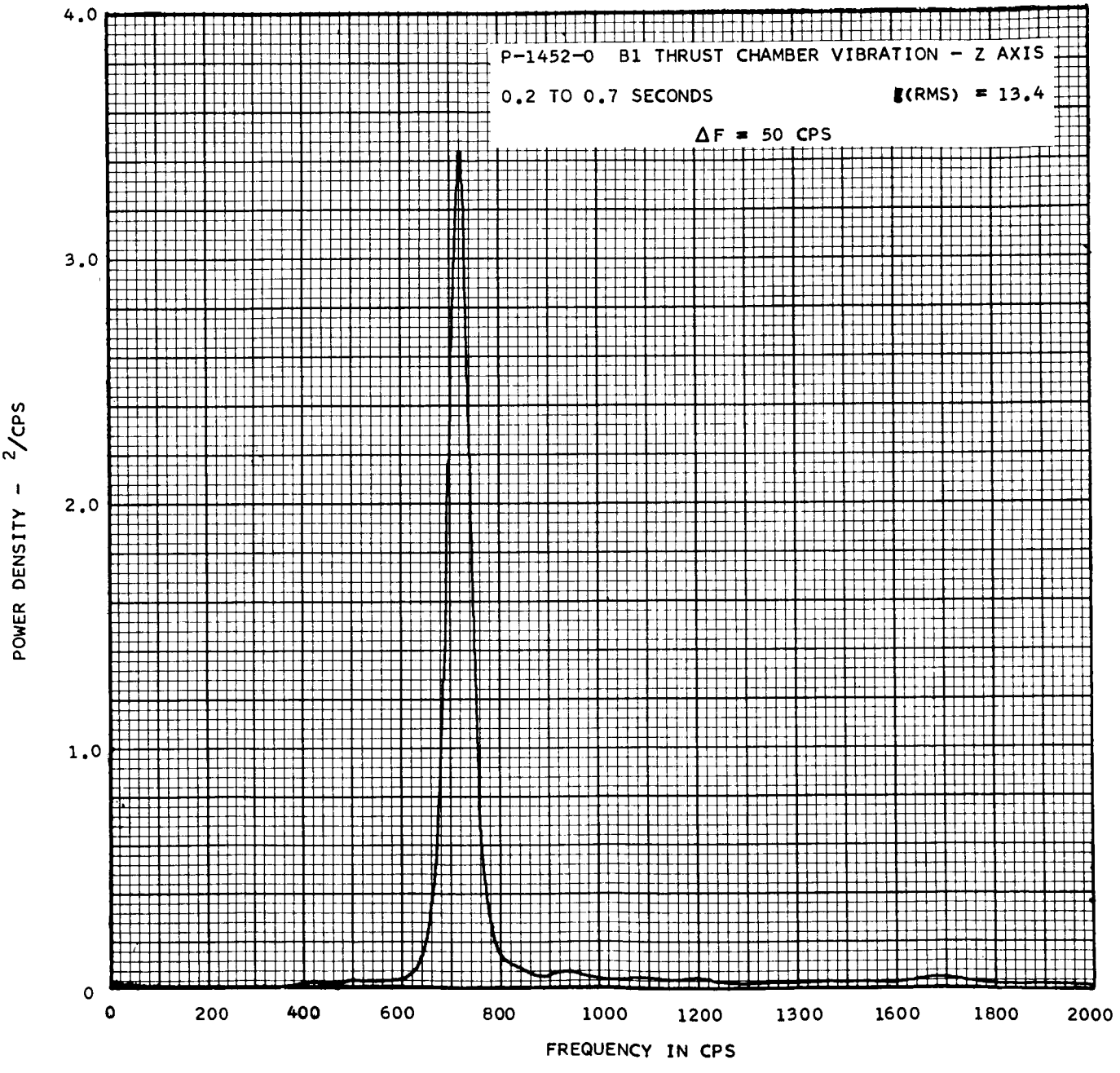
The booster chambers showed similar vibration characteristics, displaying the usual start transient (160 cps chugging that occurs at the first sharp rise in chamber pressure), and the bursts of the 710 cps frequency component characteristic of MA-3 engine combustion activity. The start transient displayed 3 to 5 cycles of the 160 cps frequency component with maximum instantaneous peaks on B1 and B2 boosters of 25 and 15 g's, respectively. The initial buildup (at approximately -0.10 seconds) of the 710 cps frequency showed a maximum level of 18 to 20 g (rms). The subsequent pulsation of outputs displayed a beat frequency between 17.5 and 21 cps. The maximum and minimum levels are shown below:

	Booster No. 1	Booster No. 2
Maximum	19.5	14.0
Minimum	4.0	5.0

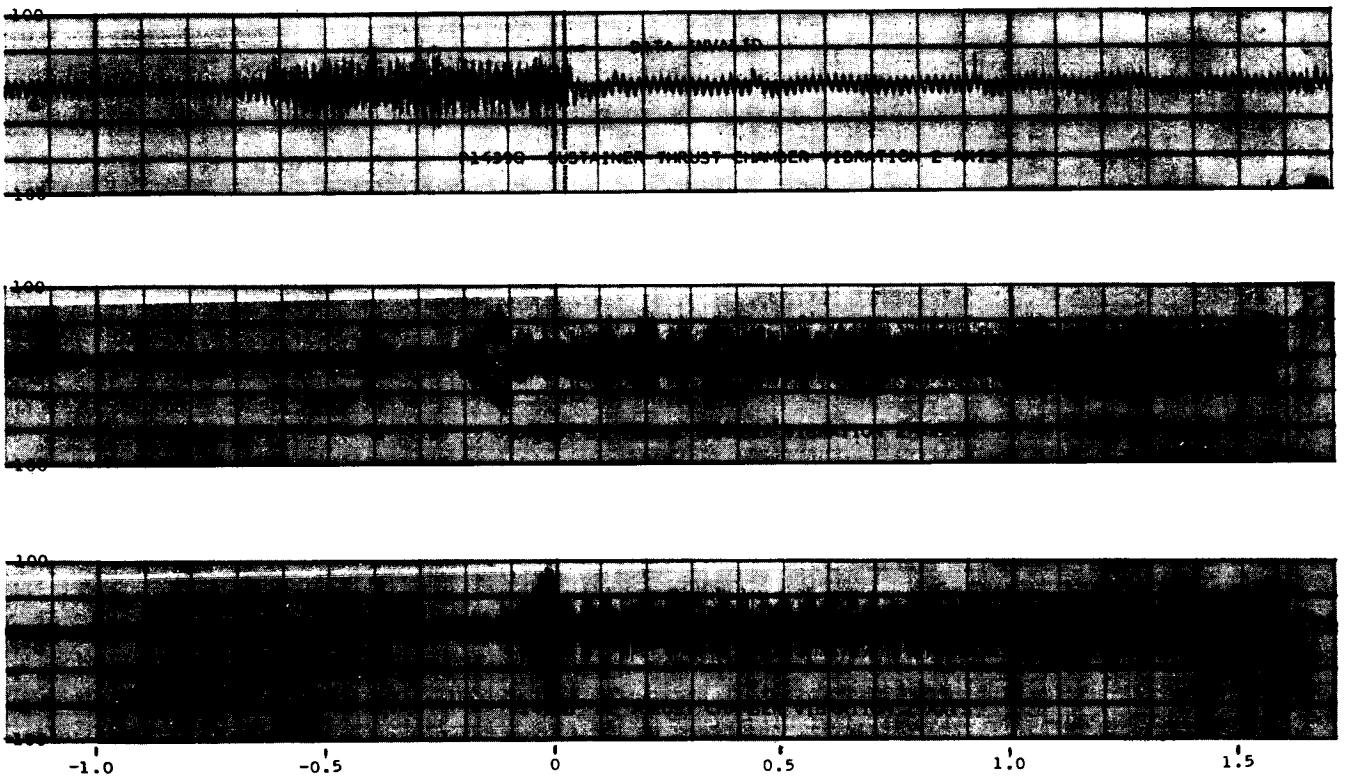
The exact cause for the preponderance of the 710 cps frequency component has not been determined to date.

VIBRATION DATA

MISSILE 8E



VIBRATION DATA



Vibration Measurements

Vibration measurements were made at the sustainer hydraulic pump and NAA sustainer control package to determine the vibratory reponse of these units through out powered flight. The accelerometer locations and associated recording system frequency response capabilities were as follows:

Measurement No.	Location	Wave Form	System Flat to - CPS
H-382-0	Sustainer hydraulic pump (sens. axis 60 deg. off Y axis in lateral direction)	Continuous	220
H-411-0	NAA sustainer control package X axis.	Commutated	200
H-412-0	NAA sustainer control package Y axis.	Commutated	200
H-413-0	NAA sustainer control package Z axis.	Continuous	80

Figure 7-4 shows the details of the accelerometer installations.

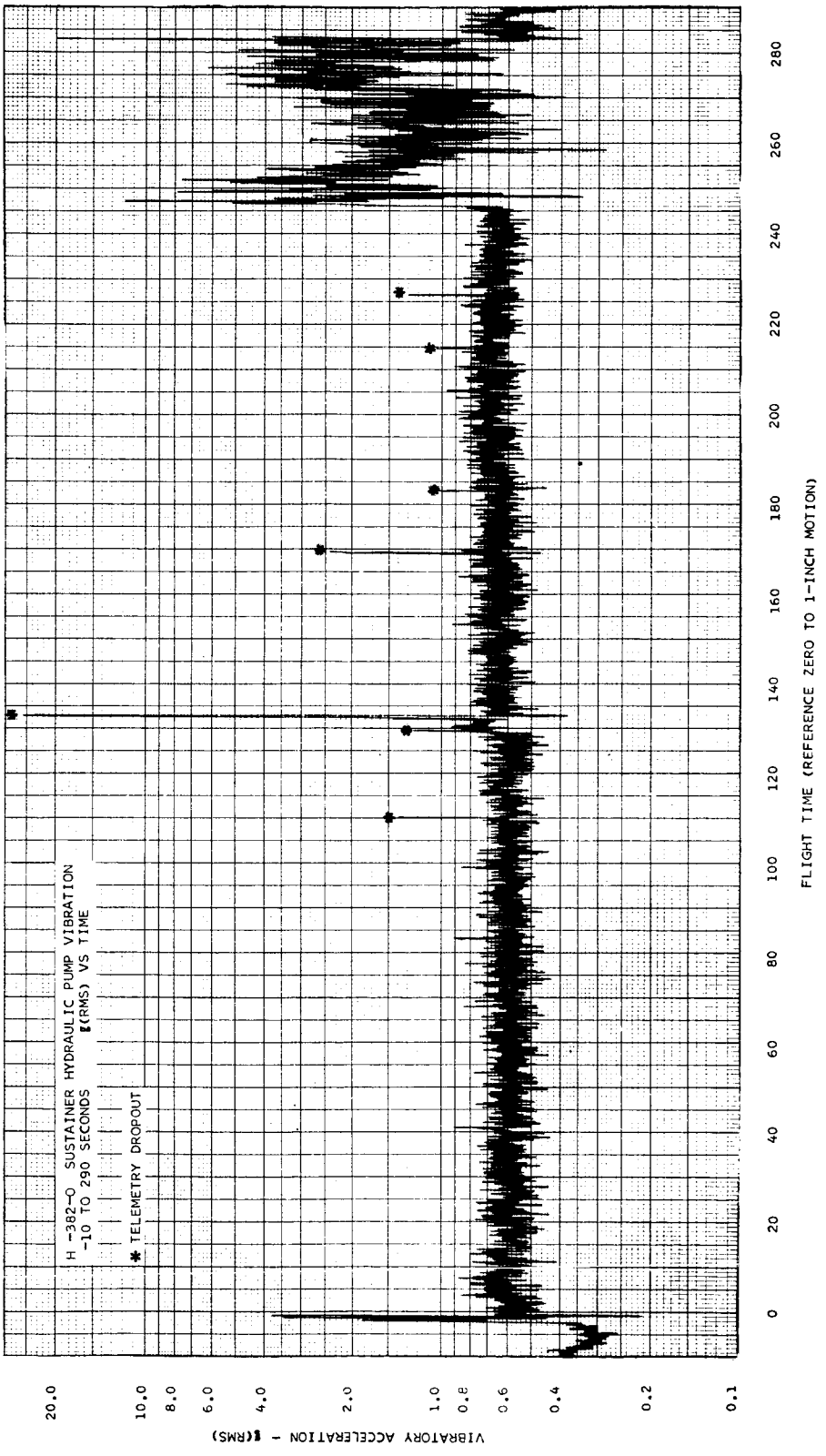
Generally, the accelerometer outputs observed at each unit were relatively steady throughout the flight and displayed steady state levels that were well within the levels normally accepted for engine compartment component specification testing. Figure 7-9 shows a g(rms) versus time plot of the sustainer hydraulic pump measurement, with Figures 7-10 through 7-12 displaying power density spectra of each measurement.

At launch the sustainer hydraulic pump measurement indicated an erroneous biasing of the trace (0.25 second impulse at 60 g peak magnitude) as the result of high frequency energy input into a relatively low frequency response channel. A crystal type accelerometer with frequency capabilities out to 2000 cps was used on the pump. The indicated displacement was completely unreasonable for a launch condition. Laboratory tests have shown that a faulty bias can result from the condition described above and recommendations have been made to avoid subsequent occurrence of faulty outputs. The data does indicate the existence of significant energy at frequencies above 300 cps, as may be expected, since sustainer turbopump operation has provided vibratory outputs with predominant frequencies between 700 and 1000 cps. The hydraulic pump is attached to the turbopump.

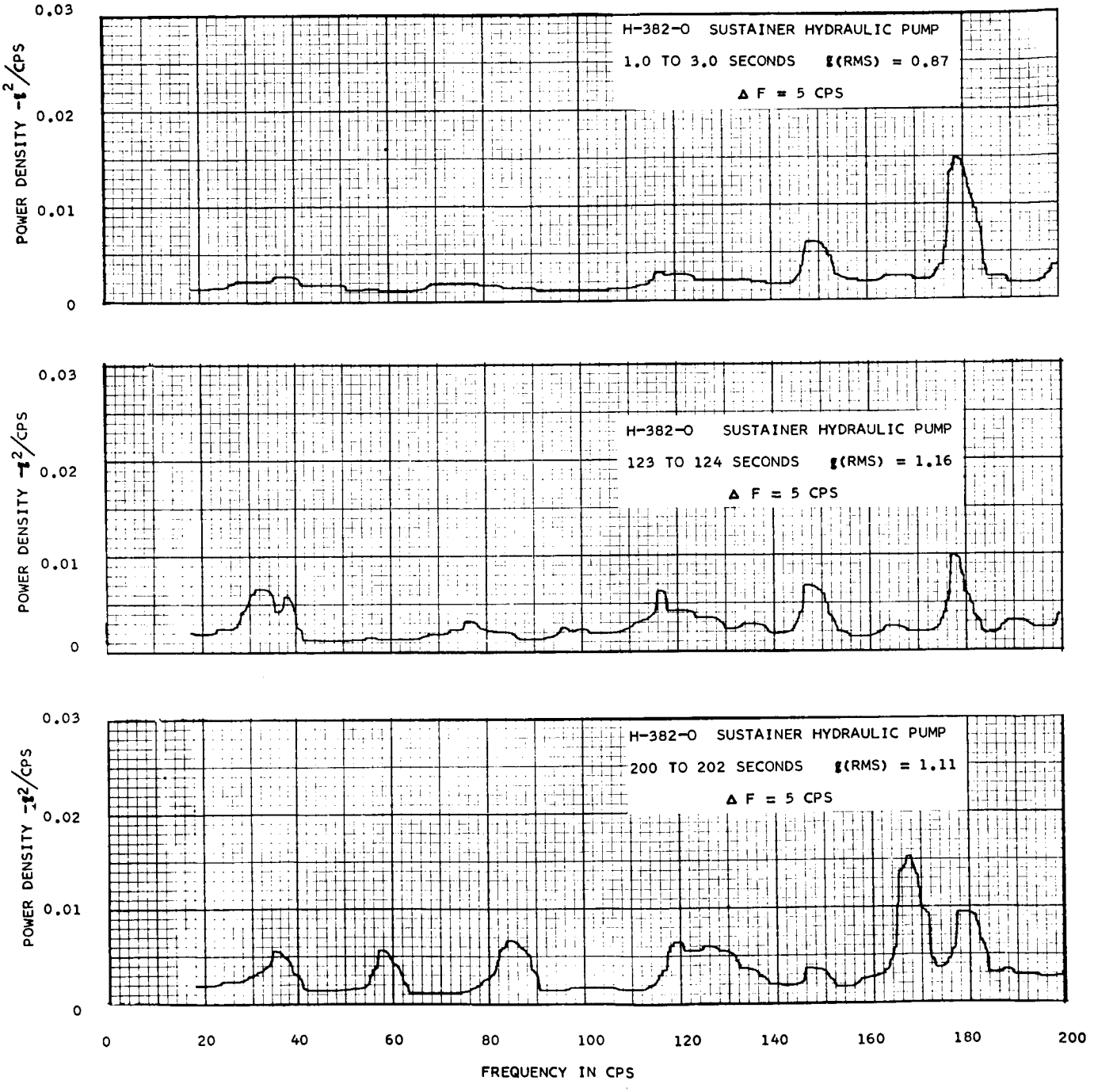
Sustainer hydraulic pump vibration measurements through booster stage indicated steady state levels between 0.5 and 0.9 g(rms), with a predominant frequency of 180 cps. Between 20 and 30 seconds, the missile bending frequency component of 7.6 to 8.0 cps was apparent with a maximum applitude of 0.5 g peak. The steady state levels indicated through sustainer stage were comparable to those observed through booster stage. Immediately following sustainer stage shut down the accelerometer outputs displayed an oscillation that was driven out of the intelligence band at ±73 g. The signal came back in band one second following sustainer shutdown showing approximately a 4 cps oscillation that damped out by about 4 seconds following sustainer shutdown. The outputs continued to display erratic oscillations until they were instantaneously terminated at approximately 284 seconds. Predominant frequency components between 4 and 20 cps were evident with maximum instantaneous acceleration levels running between 15 and 40 g peak. For that period the acceleration levels following sustainer engine shutdown indicate a extremely large deflection (destructive magnitude). The subsequent outputs are questionable since it is reasonable to assume accelerometer system failure as a result of the apparent load applied at sustainer engine shutdown. The wave form shape following the incident could represent an intermittent short condition in the system that eventually completely opens. Correlation may be made between the above condition and sustainer pump speed data. Propulsion system data indicated an increase in pump speed (went out of band) following sustainer engine shutdown, a condition that might result in turbopump failure.

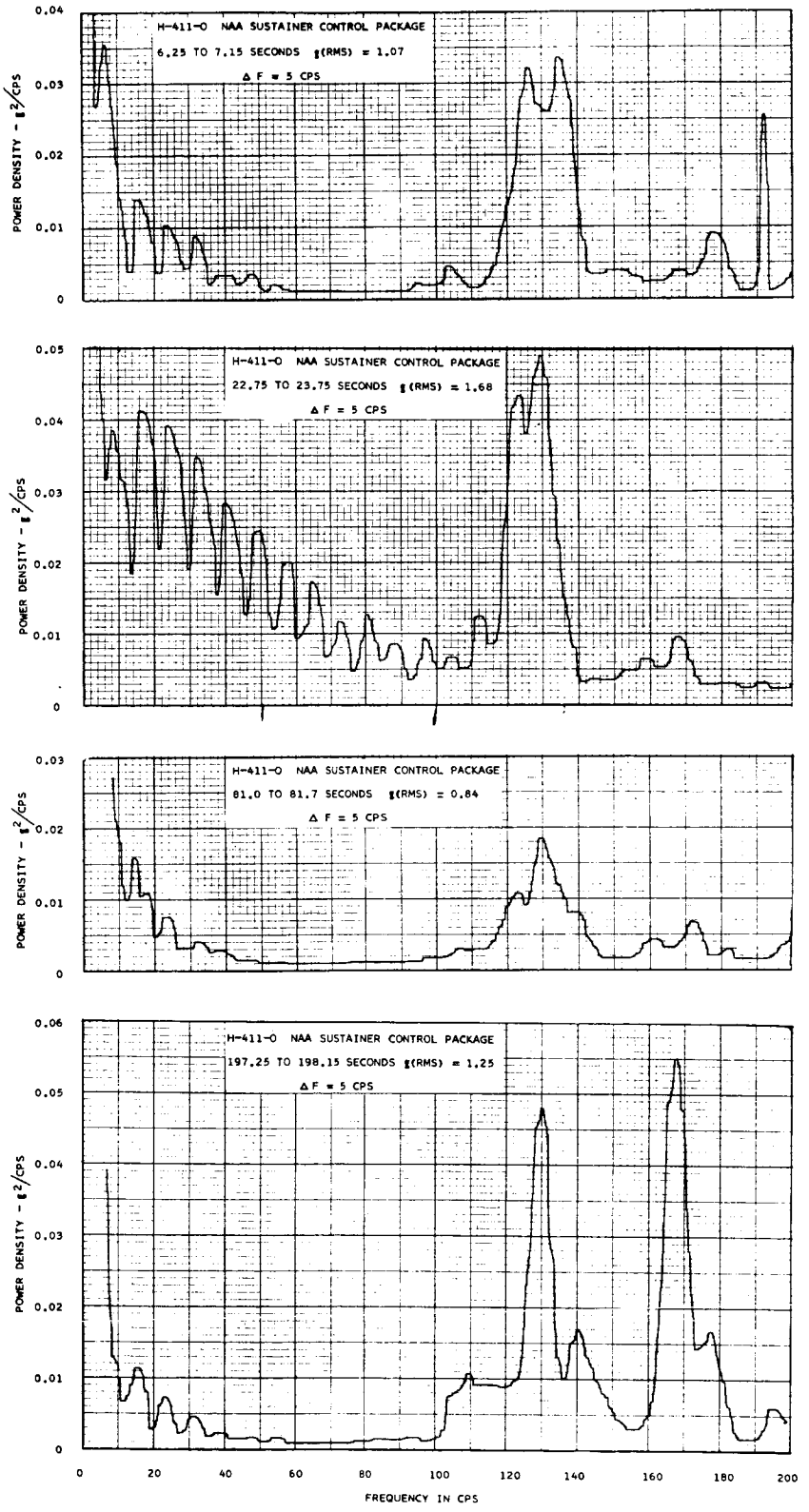
The NAA sustainer control package measurements indicated steady state vibration throughout booster and sustainer stage. The sustainer control package vibration pickups were flat to a frequency of approximately 200 cps and recorded on a commutated channel with a response of 1200 cps (X and Y axis only). Power density spectral computations were made on the X and Y axis data to 200 cps which indicated levels between 1.0 and 1.7 g(rms) through sustainer and booster stage. Values picked off the playback of the wave form for the X and Y measurements (standard cutoff frequency of 1200 cps; beyond the linear range of the pickup) showed levels between 2 to 3 g(rms). It was evident that there was additional energy contributing to package excitation within the frequency band of 200 to 500 cps. The control package Y axis wave form showed a data segment just prior to sustainer shutdown (247.3 to 247.7 seconds) that displayed a sharp increase in level to approximately 5 g(rms). The increase in magnitude showed evidence of a rise in thrust chamber excitation as a function of engine shutdown. The increased levels exhibited were not considered excessive. For the 10 to 200 cps frequency analysis the predominant frequency for the X axis was between 124 and 130 cps. Both the X and Y axis measurements showed the influence of missile bending during booster stage, displaying significant frequency components at approximately 8 and 16 cps. These frequencies were predominant components for the 10 to 200 cps analysis on the Y axis measurement through booster stage.

The sustainer control package Z axis measurement indicated levels between 0.5 and 0.75 g(rms) through powered flight. It was apparent that major energy contributions were beyond the standard frequency response capabilities of the telemetering channel utilized since the predominant frequencies prevailing were between 150 and 200 cps.

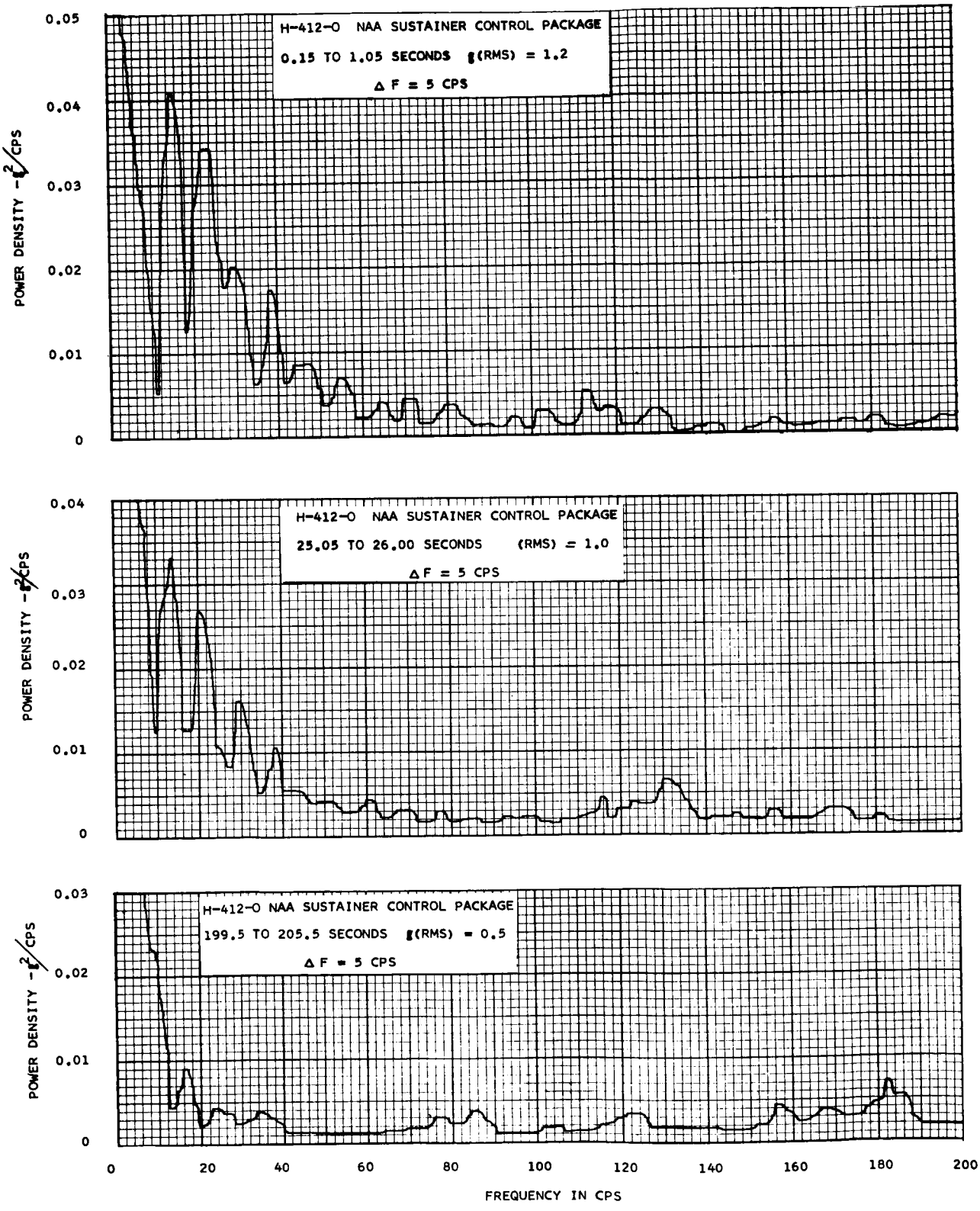

H -382-O SUSTAINER HYDRAULIC PUMP VIBRATION
-10 TO 290 SECONDS (RMS) VS TIME
* TELEMETRY DROPOUT
VIBRATORY ACCELERATION - g(RMS)
20.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
FLIGHT TIME (REFERENCE ZERO TO 1-INCH MOTION)

VIBRATION DATA




H-411-O NAA SUSTAINER CONTROL PACKAGE
6.25 TO 7.15 SECONDS g(RMS) = 1.07
Δ F = 5 CPS
H-411-O NAA SUSTAINER CONTROL PACKAGE
22.75 TO 23.75 SECONDS g(RMS) = 1.68
Δ F = 5 CPS
H-411-O NAA SUSTAINER CONTROL PACKAGE
81.0 TO 81.7 SECONDS g(RMS) = 0.84
Δ F = 5 CPS
H-411-O NAA SUSTAINER CONTROL PACKAGE
197.25 TO 198.15 SECONDS g(RMS) = 1.25
Δ F = 5 CPS
POWER DENSITY - g²/CPS
FREQUENCY IN CPS
0
20
40
60
80
100
120
140
160
180
200

VIBRATION DATA



Four high frequency accelerometers were installed on the guidance equipment by ARMA to determine equipment vibration environment during flight. The accelerometer locations were as follows:

I-560-0 Platform binnacle (support), X axis
I-562-0 Platform binnacle (support), Z axis

I-565-0 Computer (support), Y axis
I-566-0 Computer (support), Z axis

Except for theperiod where missile bending loads acted on the equipment, the vibration levels obtained followed the normal trend of equipment pod levels, wherein the maximum excitation occurred during launch and the maximum q region. In all instances the levels obtained during powered flight did not appear to be capable of causing damage. Figures 12-9 and 12-10 show power spectral samples computed during launch and a period near maximum q.

The commutated outputs displayed only computer vibration data at lift off. The X and Z axis measurements exhibited random outputs with levels between 1.0 and 2.5 g(rms). Predominant frequencies were 550 and 270 cps for each.

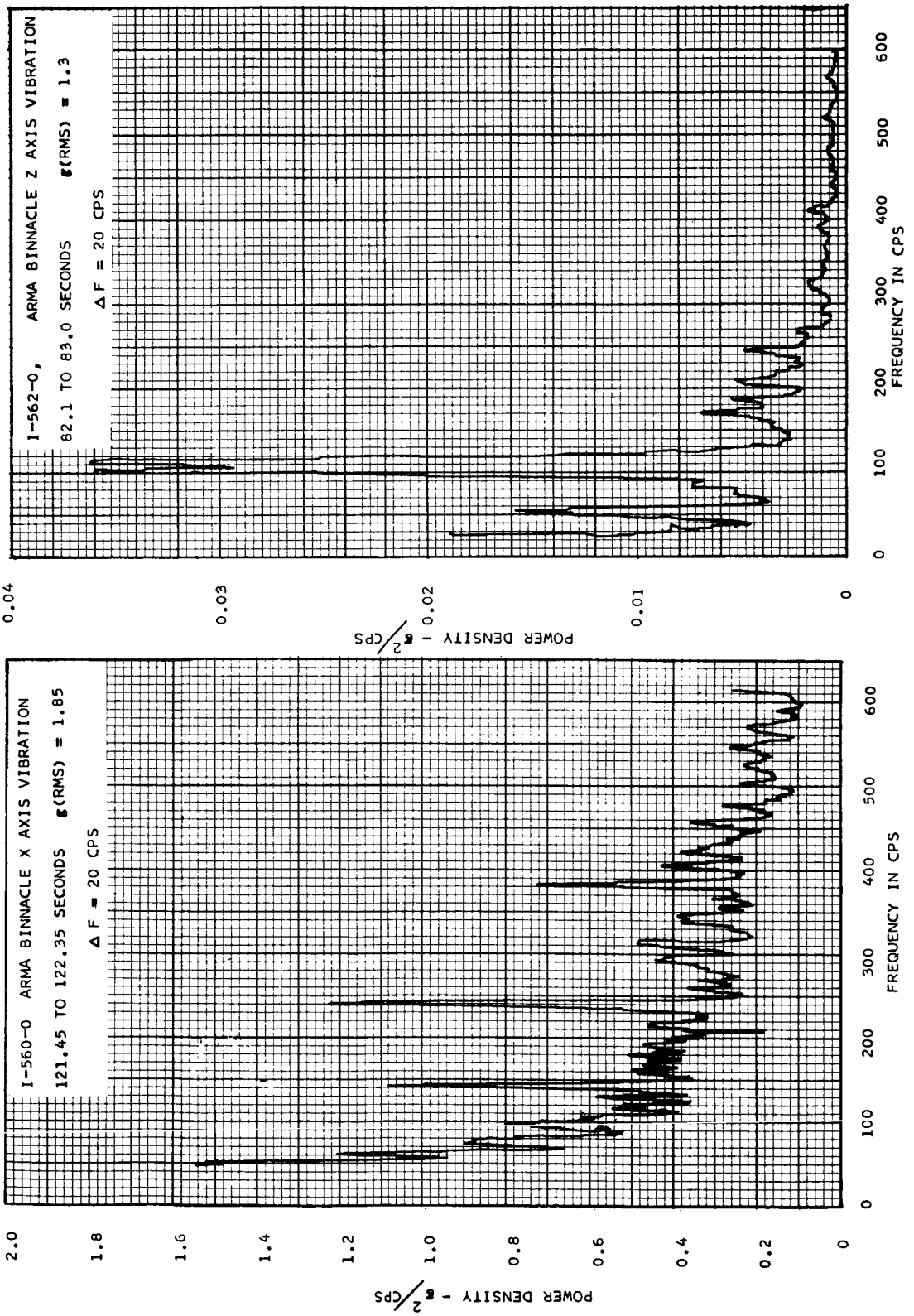
Early in the booster phase of flight (20 to 37 seconds), the data exhibited a predominant 8 cps frequency component on both binnacle measurements and the computer Y measurements. The maximum amplitude observed was between 0.5 and 0.8 g peak. Flight control system data supported the existence of a significant 8 cps missile bending component during that same period. Between 20 and 37 seconds, the computer Z axis measurement displayed a predominant 23 cps frequency component with a maximum level of 1.0 g peak.

During the maximum q period (63 to 70 seconds), all measurements, except the binnacle X measurement, exhibited near random outputs with maximum levels between 1.5 and 2.0 g(rms). During this interval the binnacle X measurement showed evidence of a transient instrumentation anomaly. The levels shown on all measurements for the remainder of booster stage ranged between 0.25 and 0.5 g(rms). Sustainer stage accelerometer outputs at each installation were steady state throughout, with levels indicated less than 0.25 g(rms).

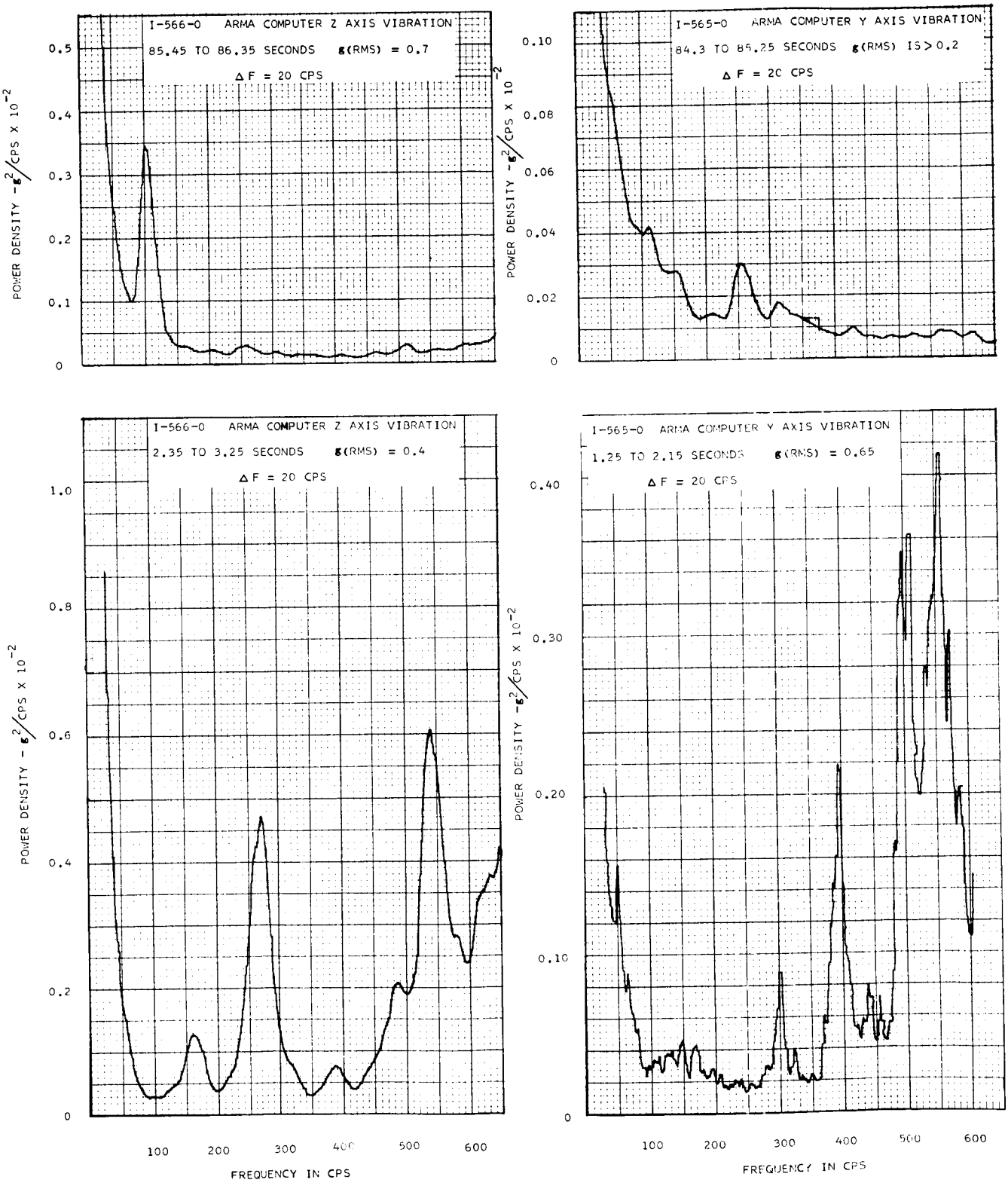
UNCLASSIFIED ~~REPORT NO. AE60-0955~~

VIBRATION DATA

MISSILE 8E



VIBRATION DATA



SECTION 6.2.4

MISSILE 12E

FLIGHT TESTED 5-12-61

AT AMR COMPLEX 11

TEST REPORT AE61-0239

Vibration Analysis

A high frequency accelerometer (Measurement No. A-799-O) was installed on the B1 low pressure lox line (lateral direction) as shown in Figures 4-14 and 15-1. The primary purpose of obtaining the data from this measurement was to determine the effects of lox surging on the line as the result of closing the staging valve at the time the booster section was jettisoned. The analysis herein will encompass all of powered flight. The subcarrier channel used limited the frequency response within a band of approximately 10 to 300 cps. A similar measurement was obtained during the flight test of Missile 3E.

Generally, the measurement followed the usual trend of inflight vibration, wherein the significant activity periods occurred at launch and through the Mach 1 - maximum q region. A

summary of results is shown in Table 1. Several transient low frequency oscillations (approximately 4 to 6 cps) were displayed throughout flight that appeared to be unreasonable for representing local displacements. No firm correlation could be established between the lox line vibration data and flight control gyro data during the transient periods, specifically that occurrence between 118 and 119 seconds, which may eliminate possible accelerometer response to missile bending and rigid body motion. The transient outputs may be due to the occurrence of an intermittent faulty instrumentation bias condition, which has been apparent on similar flight test accelerometer instrumentation systems. The response of the lox line lateral measurement to the booster section unlatching function (130.9 seconds) appeared moderate, however, a shock load was exhibited at 131.32 seconds (approximately the time the booster section separated from the jettison rails). The data was obscured by telemetry noise 70 milliseconds following the first indication of the shock load. A similar shock wave form was evident on the instrumentation beacon vibration data at that same time. The shock load at either location did not display critical levels. Generally, the lox line vibration environment was similar to that shown on the flight test of Missile 3E. A direct comparison of levels cannot be made, however, due to the preponderance of lox line response to missile bending and the apparent instrumentation anomalies exhibited by the Missile 3E measurement.

Predominant frequency components between 160 and 166 cps were exhibited throughout the flight. The maximum level occurred immediately following the time at which Mach 1 occurred (reference Table 1). The waveform showed a gradual buildup in amplitude, a steady output for approximately 0.8 seconds and then a sharp decrease of about one half amplitude at 48.8 seconds. The outputs displayed were apparently the response to Mach 1 aerodynamic shock wave disturbance. The above condition was not observed on Missile 3E flight test.

A power spectral computation was made through the period of maximum excitation as shown in Figure 4-10.

TABLE 1

LOW PRESSURE LOX LINE LATERAL VIBRATION

FLIGHT PERIOD Seconds	MAXIMUM ACCELERATION ~ g(rms) *Denotes zero to peak level	PREDOMINANT FREQUENCY ~ CPS	PERIOD OF MAXIMUM ACCELERATION ~ SEC
-1.2 to 3.0	3.9	164	0 to 1
0.6 to 1.5	*8.0	---	0.06 to 0.18 (questionable data)
3.0 to 23.0	2.5	---	Steady State
23.0 to 47.2	15.0	---	45 to 47
47.2 to 48.8	30.0	166	47.6 to 48.75
48.8 to 85	15.0	171	57 to 62
85 to 118	3.0	---	Steady State
118.0 to 119.4	*7.5	6.4	118.9 to 119.2 (questionable data)
127.7 to 129.6	*9.0	---	129.30 to 129.42 (questionable data)
130.9 to 131.32	*3.5	4	--- (questionable data)
	*2.0	20	---
	4.0	160	---
131.32 to 131.39	21.0	160	---
131.39 to 131.5	Noise	---	---
131.5 to 131.53	10.5	163	---
133 to SCO	3.5	160 and 370	150 to 165

Vibration Analysis

Three high frequency accelerometers were installed at three separate locations on the instrumentation beacon system equipment to determine their vibration environment during flight. The accelerometers were located as follows:

G-197-O	Rate Beacon-Impact Predictor Package, Radial
G-94-O	Boom Antenna
G-587-O	RB-IP Package Waveguide

The general location of the accelerometer installations are shown in Figures 13-4 and 15-1. Details of their installation are shown in Figures 13-9, 13-10, and 13-11. These same measurements were obtained during the flight tests of Missiles 71D, 9E and 13E.

Each measurement showed valid outputs throughout flight except A-94-O which displayed quiescent outputs until 85 seconds, when the outputs began to appear valid. The measurements were analyzed within a frequency band of 10 to 1200 cps.

The measurements again showed significant response to propulsion system operation. The 720 cps buzz condition was evident on the rate beacon package and waveguide throughout booster stage. Maximum levels were apparent at launch, through the Mach 1 - maximum q region and through a period between approximately 118 and 121 seconds where the apparent engine buzz condition produced the largest vibratory excitation on the equipment. The waveguide again displayed the greater vibration levels, showing 14.1 g(rms) through the period of maximum excitation. The maximum instantaneous level recorded during that period was 73g peak-to-peak. The maximum levels displayed at the waveguide on Missile 12E were considerably less than those displayed on flight tests of 9E and 13E. Static tests of the MA-3 propulsion system have shown that the content of the booster engine buzz condition would vary for each engine tested. In fact, tests have shown that the intensity of the buzz condition may vary from one run to the next on a single engine. 720 cps is apparently the resonant frequency of

the MA-3 injector plate and thrust chamber configuration. An investigation is now in progress to determine the effect of the flight vibration environment on the equipment. A summary of missile flight data is shown in Table 1.

It must be noted that the values presented herein do not reflect the correction for recording system line losses (signal attenuation). A calibration curve of the recording system was provided, in addition to the accelerometer system calibration, in which the data appeared erroneous. In the past, recording system calibrations have been deemed unnecessary.

A brief description of each measurement is shown below:

G-197-O, Rate Beacon Package, Radial

G-197-O displayed moderate levels throughout flight. Over-all levels shown during booster stage ranged between 2.0 and 3.0 g(rms). The predominant frequency ranged between 725 and 735 cps. During sustainer stage the outputs were nearly quiescent. The waveform displayed energy bursts throughout booster stage, which varied between 2 and 8 bursts per second. Maximum burst intensity was observed between approximately 114 and 117 seconds.

Booster section jettisoning was quite evident on this measurement. A shock load was noted at 130.90 seconds (time of booster section latch release). The maximum instantaneous level was 23g peak-to-peak at a frequency of 98 cps. The response appeared to be completely damped by approximately 131.10 seconds. A second shock load was observed at 131.32 seconds and shows a decreasing level until telemetry noise interference at 131.4 seconds. The maximum instantaneous level observed was 31g peak-to-peak. The second shock load occurred at about the time the booster section separated from the jettison rail. The levels observed at each incident did not represent critical local loads, but it is quite apparent that a shock load was applied to the missile at the time the booster section was jettisoned from the rails. No conclusive evidence to support the existence of the second shock load was found in viewing missile vibration data from previous E series flight tests.

G-94-O, Boom Antenna

This measurement displayed an apparent open condition until approximately 85 seconds. Following that time the maximum level observed during booster stage was 10.9 g(rms) and occurred at approximately 117 seconds. Predominant frequencies were 735 and 110 cps. Through sustainer stage, the output showed a gradual increase, reaching a maximum level of approximately 18 g(rms) immediately preceding sustainer cutoff. The flight test results of Missiles 9E and 13E did not show the buildup in level through sustainer stage. The vibration through sustainer stage on Missile 12E did not appear to affect the operation of the instrumentation beacon equipment.

G-587-O, RB Package, Radial

This measurement showed the greater response to the buzz condition. Maximum levels ranged between 8.0 and 14.1 g(rms) during booster stage. A very discrete frequency component of 730 cps prevailed through that same period. The outputs displayed energy bursts that varied between 2 and 15 bursts per second. Sustainer stage output showed a general decrease in level. The maximum steady state level was 2.0 g(rms) at a predominant frequency of 510 cps.

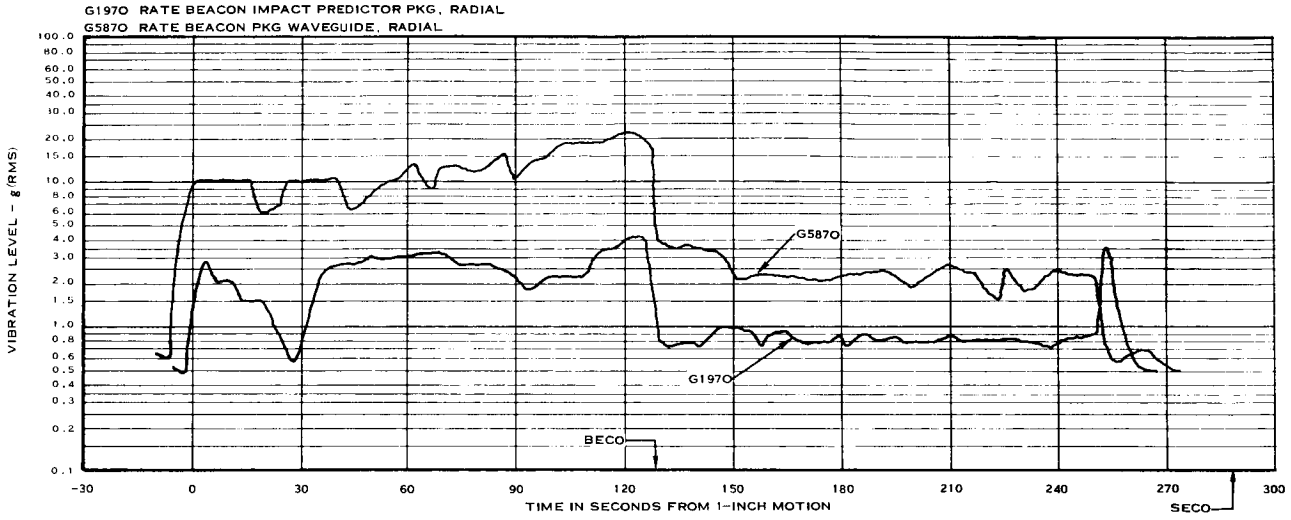
TABLE I

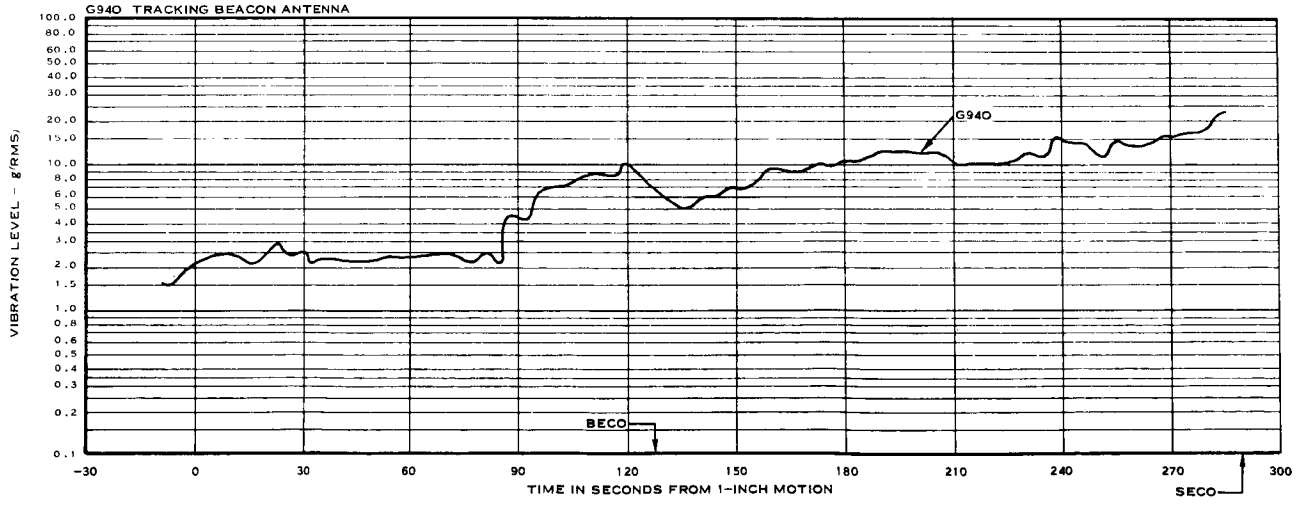
SUMMARY OF INSTRUMENTATION BEACON EQUIPMENT VIBRATION MAXIMUM LEVELS

	G-197-O RB PACKAGE, RAD			G-94-O BOOM ANT.			G-587-O WAVEGUIDE		
MISSILE	PERIOD	ACCEL g(rms) OA	PRED FREQ ~ CPS	PERIOD	ACCEL g(rms) OA	PRED FREQ	PERIOD	ACCEL g(rms) OA	PRED FREQ ~ CPS
71D	Near Max q	2.8	250	Faulty Instru.			Near Max q	8.8	700 710
9E	Near Max q	3.5	720	Near Max q	15.5	1190	Launch, Near Max q	25.0, 19.0	710 720
13E	Near Max q	4.2	720 565	Near Max q	6.7	720 1160	119 to 119.8 seconds	26.4	730
12E	115 to 116 seconds	3.2	735	116 to 118 seconds	10-9	735 110	119-120 seconds	14.1	730

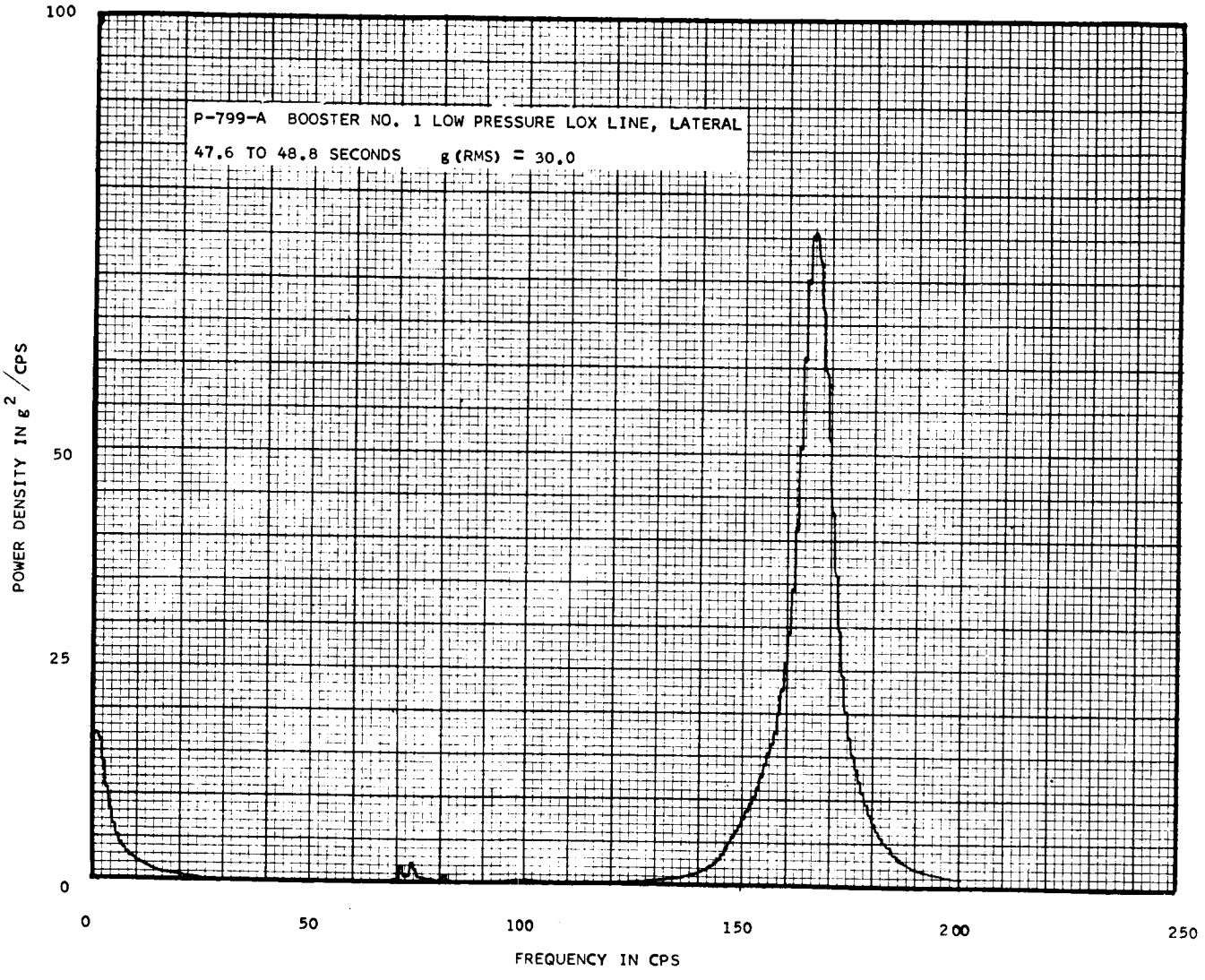
Questionable Data

VIBRATION TIME HISTORY
g (RMS) VS TIME
MISSILE 12E
2100 CPS LOW PASS FILTER





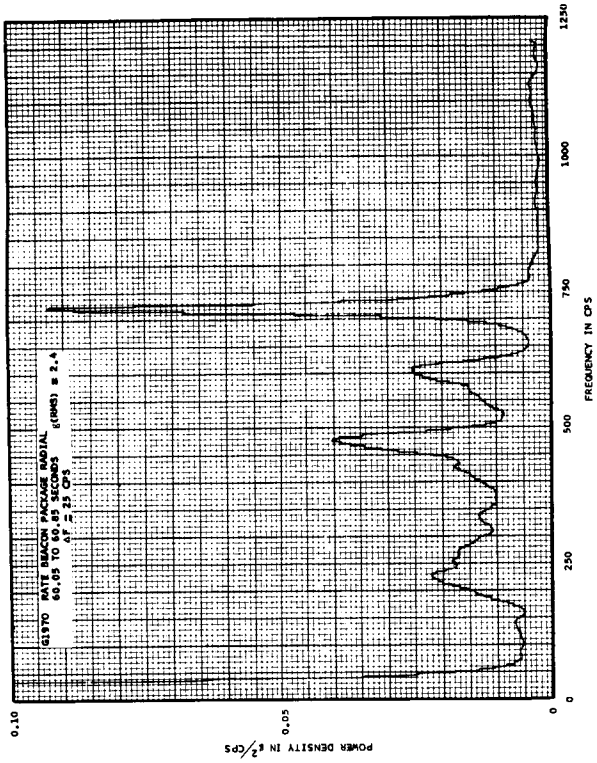
PROPULSION SYSTEM TELEMETERED DATA

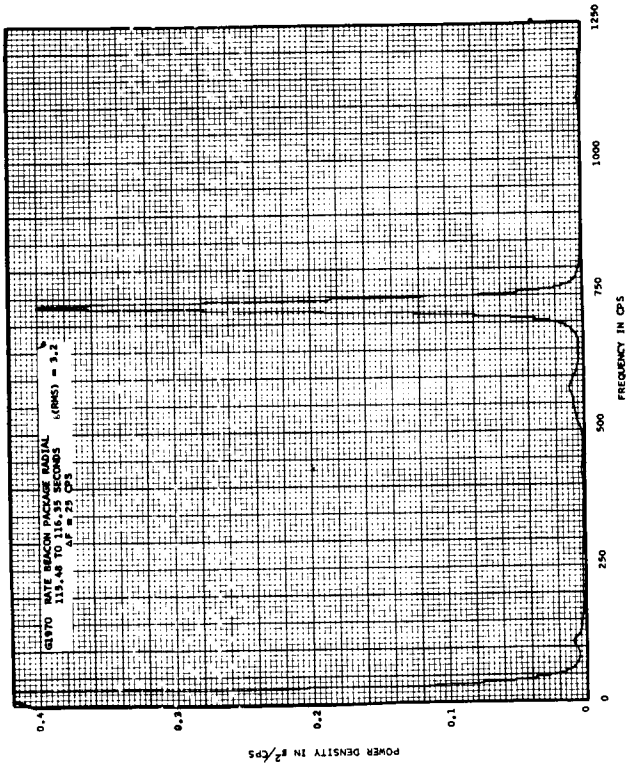


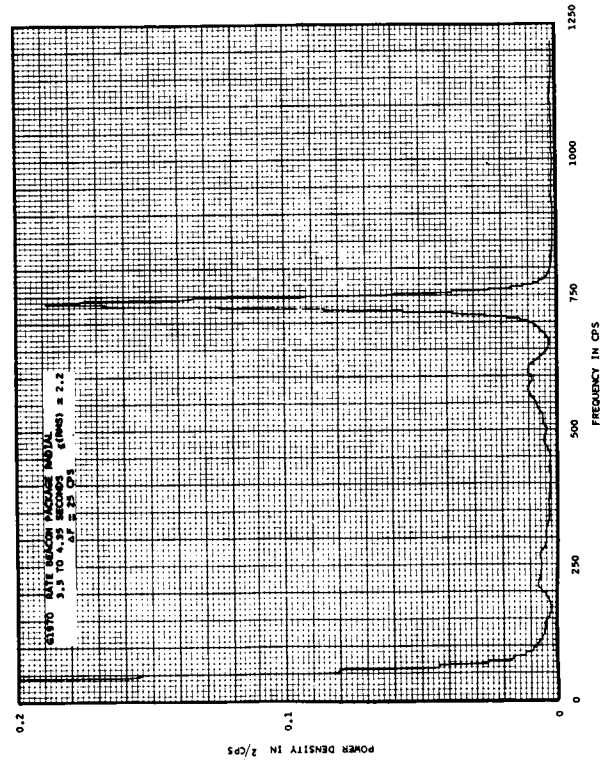
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INSTRUMENTATION BEACON SYSTEM VIBRATION DATA

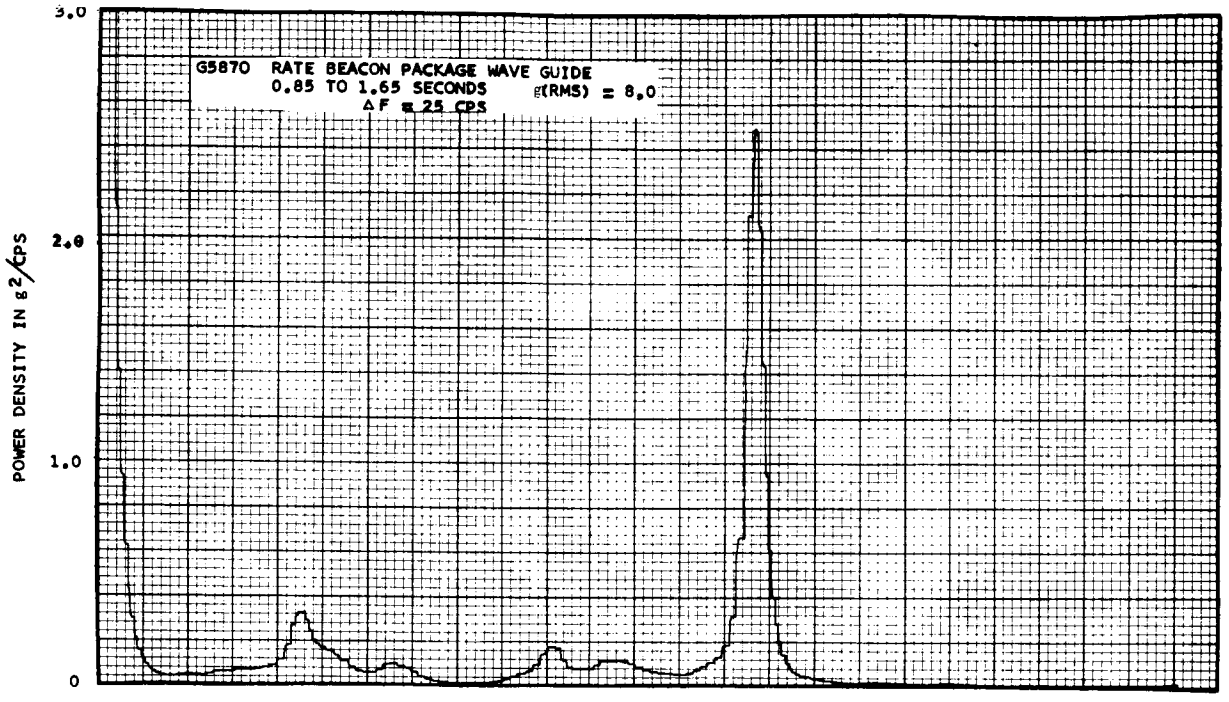
MISSILE 12E

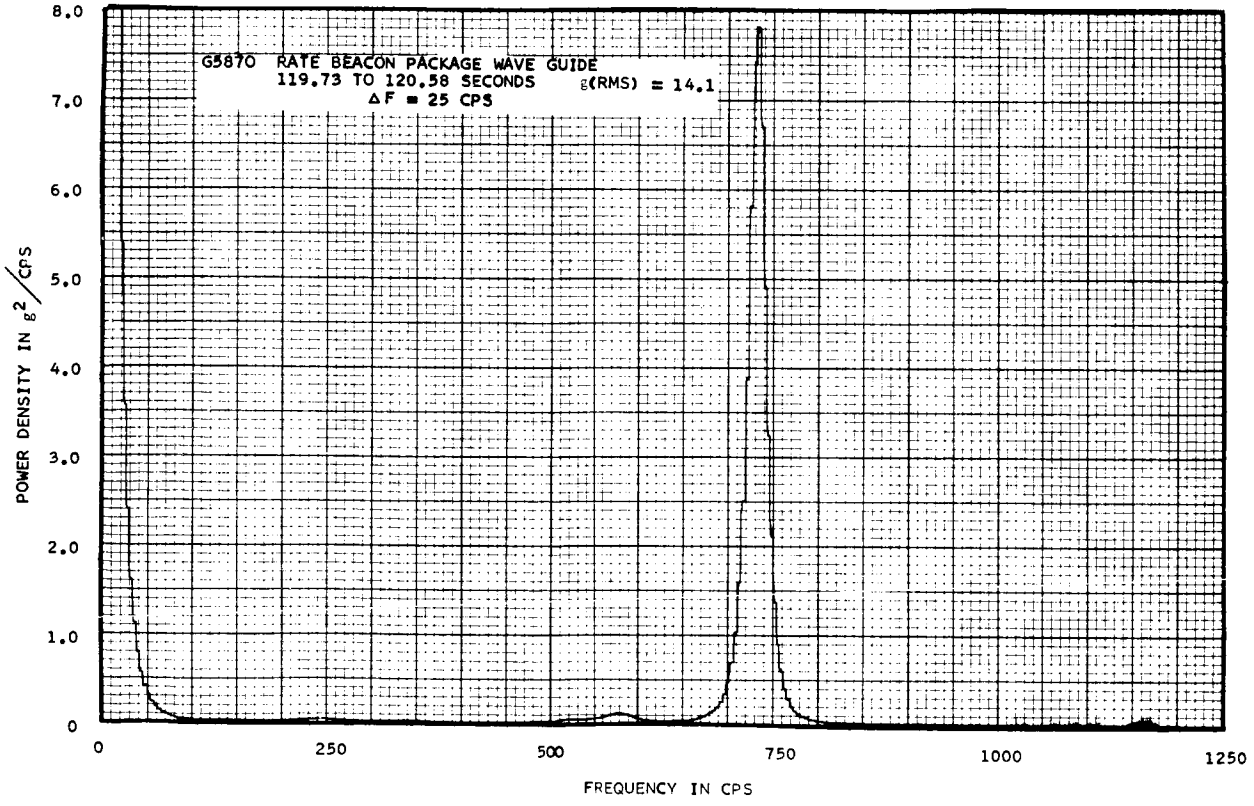


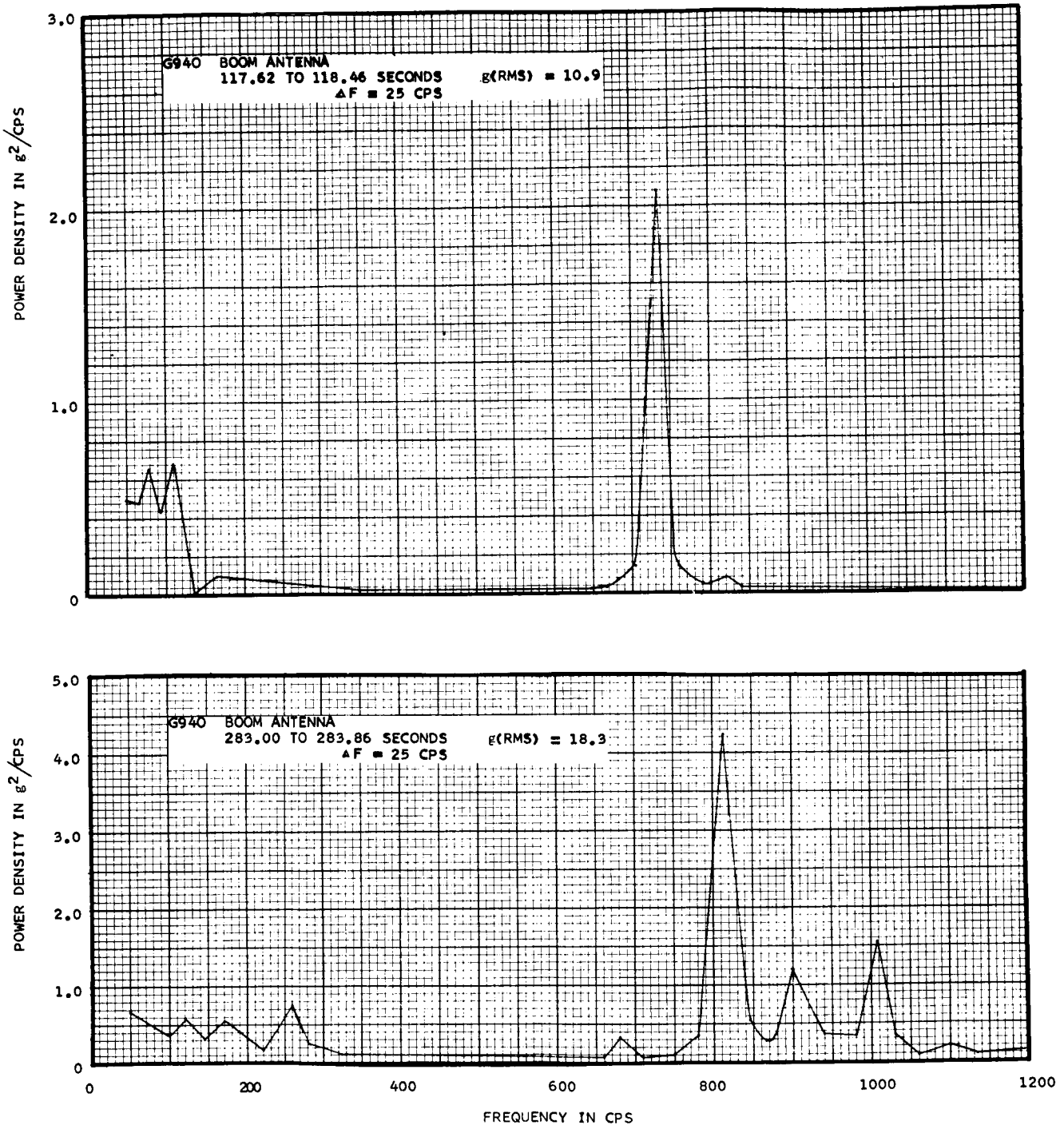




INSTRUMENTATION BEACON SYSTEM VIBRATION DATA



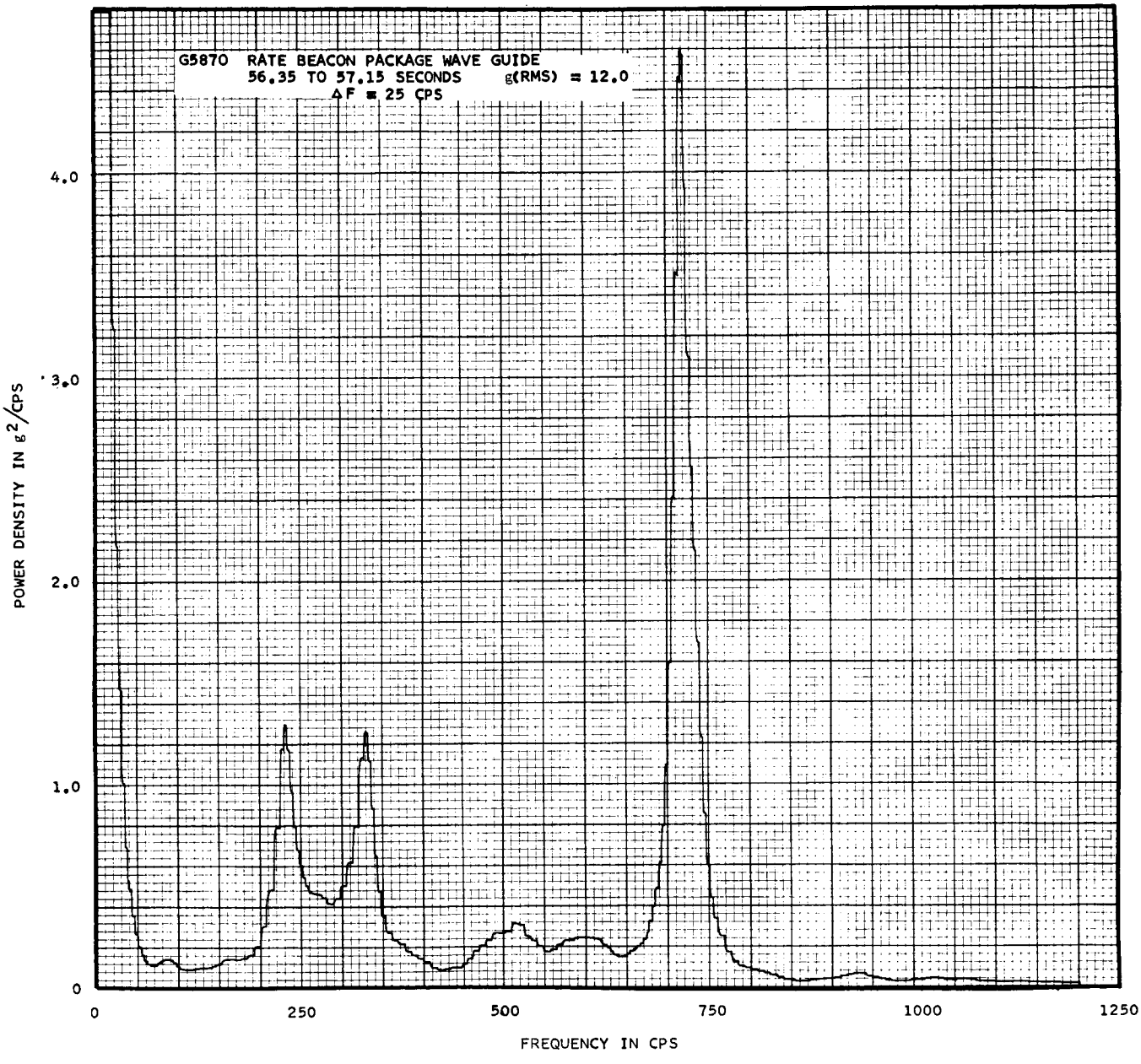



G940 BOOM ANTENNA
117.62 TO 118.46 SECONDS
ΔF = 25 CPS
g(RMS) = 10.9
POWER DENSITY IN g²/CPS
3.0
2.0
1.0
0
G940 BOOM ANTENNA
283.00 TO 283.86 SECONDS
ΔF = 25 CPS
g(RMS) = 18.3
POWER DENSITY IN g²/CPS
5.0
4.0
3.0
2.0
1.0
0
0
200
400
600
800
1000
1200
FREQUENCY IN CPS

12E

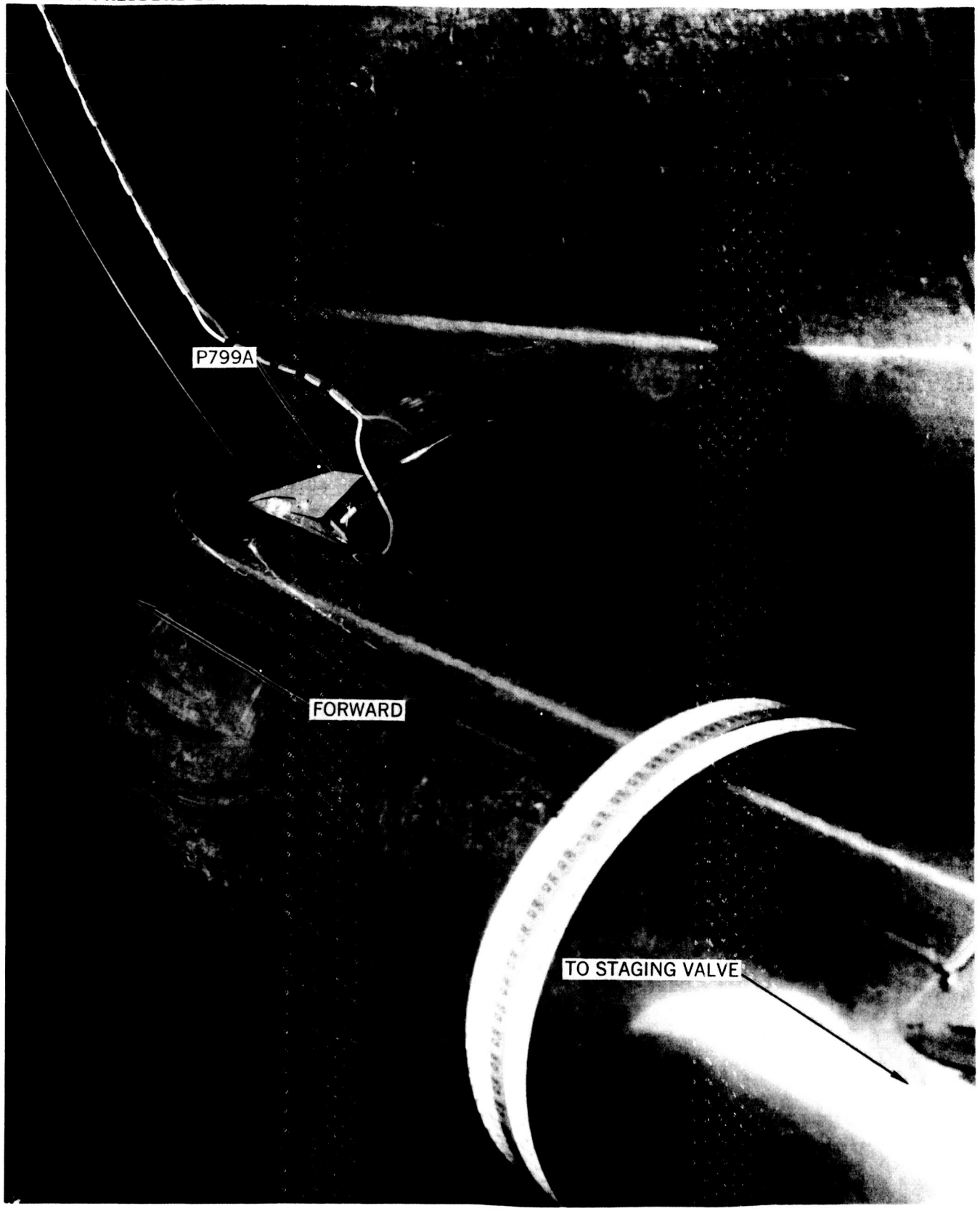
UNCLASSIFIED ~~REPORT NO. AE61-0239~~

INSTRUMENTATION BEACON SYSTEM VIBRATION DATA MISSILE 12E



LOCATION OF ACCELEROMETER ON B1 LOW PRESSURE LOX LINE

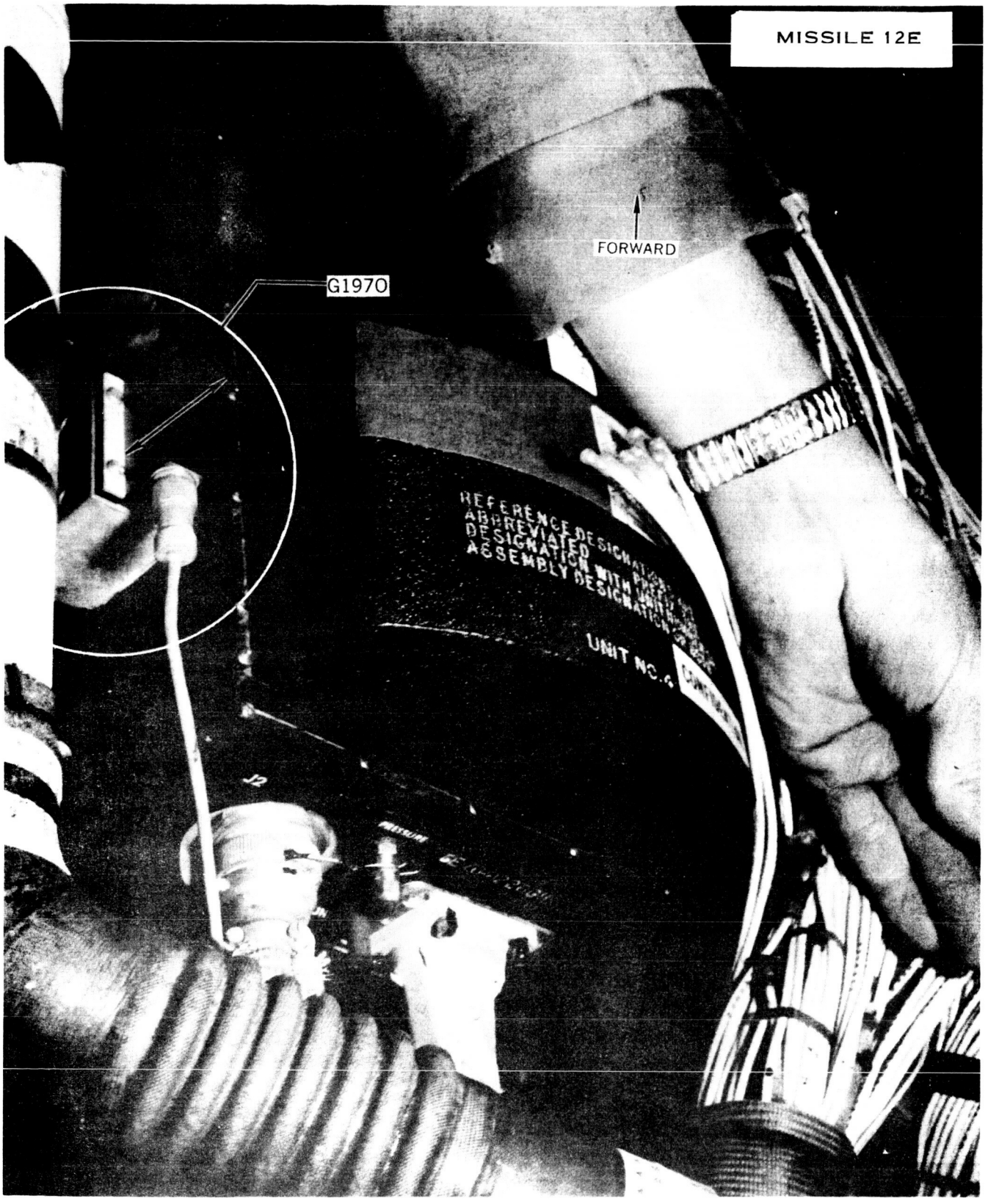
MISSILE 12E



12E

UNCLASSIFIED ~~REPORT NO. AE61-0239~~

LOCATION OF ACCELEROMETER ON RB PACKAGE



LOCATION OF ACCELEROMETER ON BOOM ANTENNA

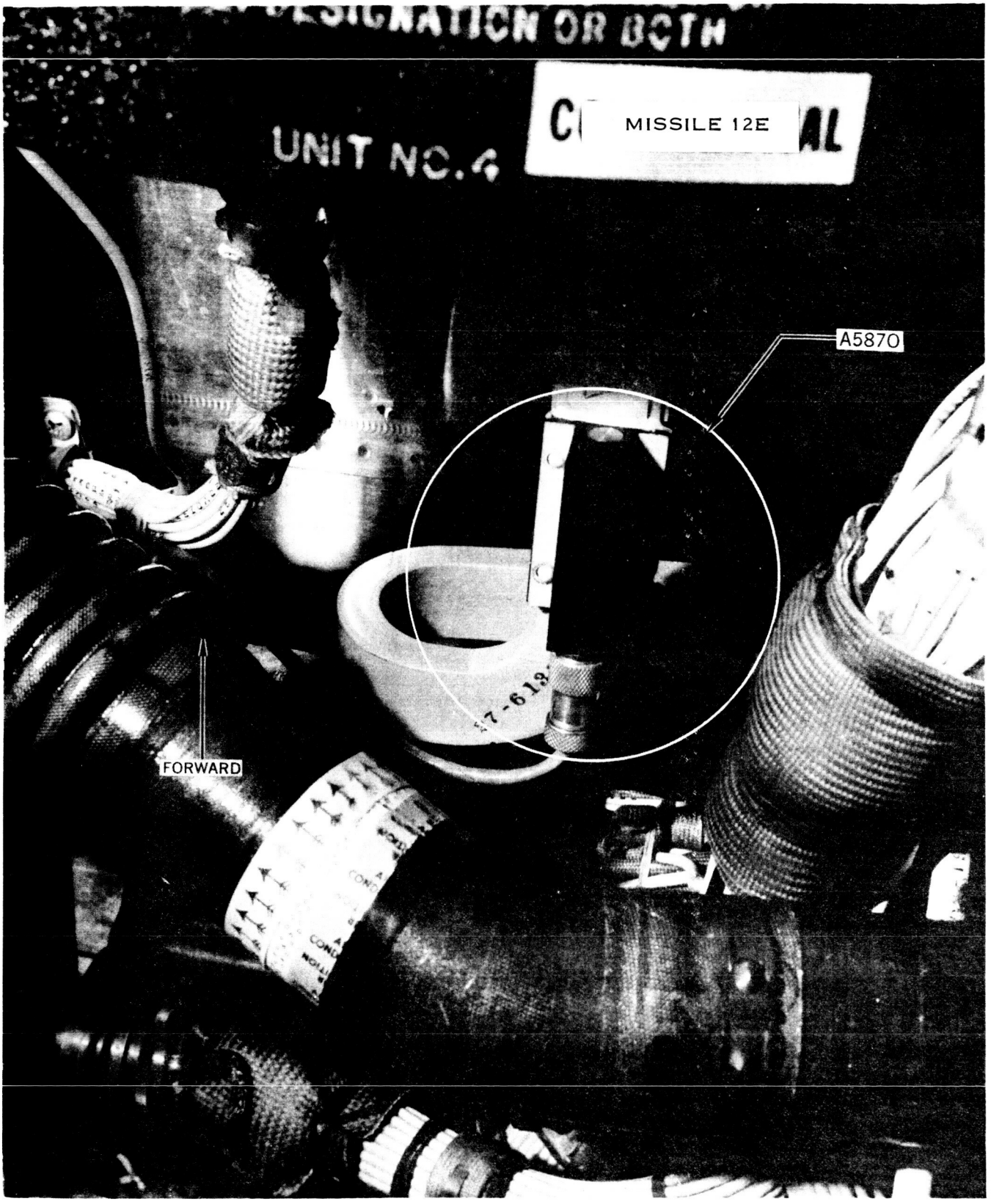


12E

UNCLASSIFIED

~~REPORT NO. AE61-0239~~

LOCATION OF ACCELEROMETER ON WAVEGUIDE



SECTION 6.2.5

MISSILE 13E

FLIGHT TESTED 3-13-61

AT AMR COMPLEX 13

TEST REPORT AE60-0957

VIBRATION ANALYSIS

Three high frequency accelerometers were installed at three separate locations on the instrumentation beacon system equipment to determine their vibration environment during flight. The accelerometers were located as follows:

G-197-O	Rate Beacon-Impact Predictor Package, Radial
G-94-O	Boon Antenna
G-587-O	RB-IP Package Waveguide

The general location of the accelerometer installations are shown in Figures 15-1 and 15-2. Details of their installation is shown in Figures 13-1, 13-4, and 13-5.

The measurements were also obtained from Missile 9E. Some confusion existed initially on Missile 9E data due to an apparent mix up in measurement assignments. It is felt at this time that the measurement assignments on Missile 13E were correct.

Generally, all locations appeared to respond rather discretely to propulsion system operation. The 720 cps buzz condition, characteristic of MA-3 engine operation (reference Propulsion System, Thrust Chamber Vibration), was evident on each accelerometer output, especially at the waveguide installation. Maximum amplitudes were apparent at the waveguide, and were in excess of the generally accepted test specification levels. Acoustic inputs appear quite significant. The measurements were analyzed within a frequency band of 10 and 1200 cps as described below:

G-197-O Rate Beacon - Impact Predictor Package, Radial

Maximum levels occurred at launch, through the Mach 1 - maximum q region and just prior to booster cutoff. The levels during those periods ranged between 2.0 and 3.5 g(rms) at predominant frequencies of 720 and 565 cps. The environment at the package was not excessive. Engine buzz effects were quite apparent starting at 99 seconds, which displayed 4 to 8 bursts per second of the 720 cps frequency component through the remainder of booster stage. Sustainer stage levels were below 1.0 g(rms). A power density spectral computation was made through the period of maximum intensity as shown in Figure 13-7.

G-94-O BOOM ANTENNA

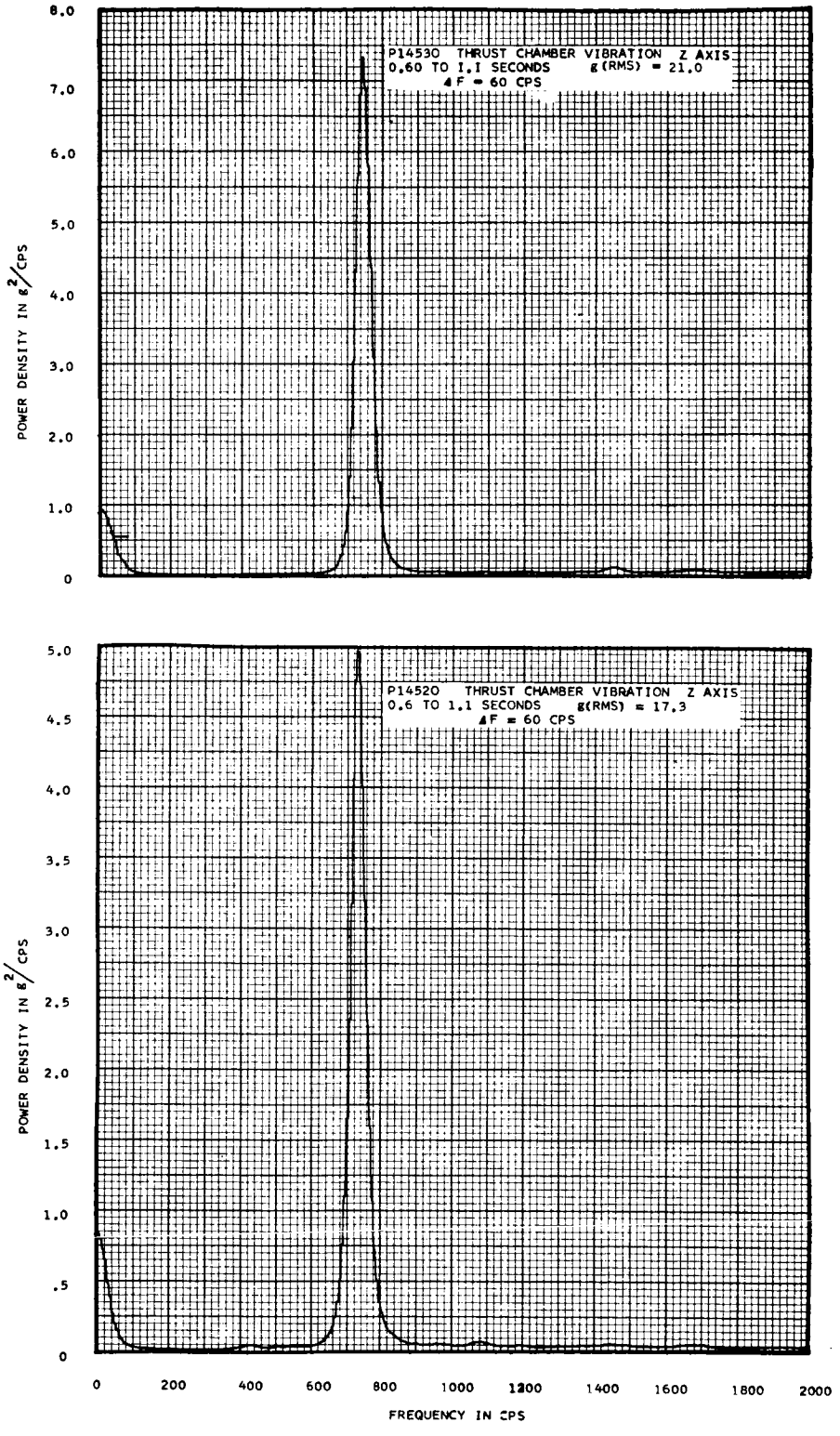
The levels observed at the boom antenna at launch, through the Mach 1 - maximum q region and from 90 seconds through the remainder of flight were 3.0 g(rms), 6.5 g(rms) and 2.5 g(rms), respectively. Predominant frequencies were 720 and 1150 cps through booster stage and 930 through sustainer stage. A power density spectral computation was made through the period of maximum intensity as shown in Figure 13-6.

G-587-O WAVEGUIDE

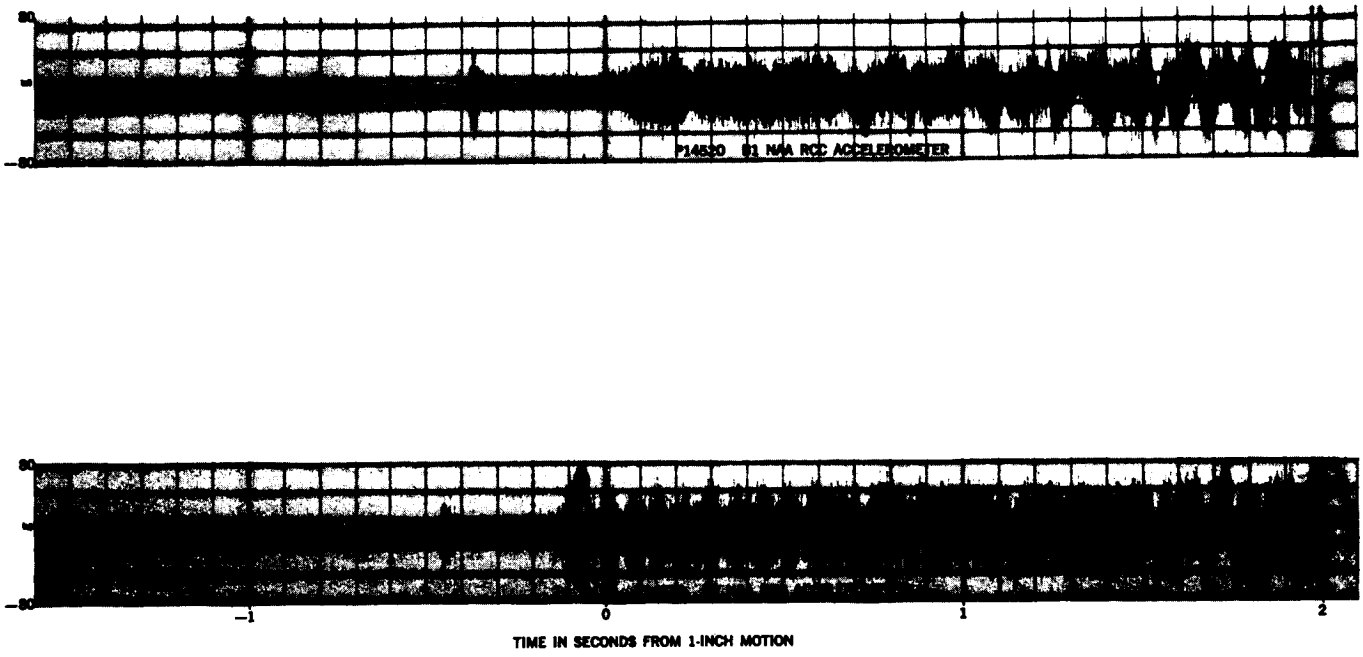
This measurement showed the most response to engine operation, displaying a discrete 720 cps buzz condition through booster stage at varying burst rates. The levels between launch and 80 seconds were between 6.0 and 10.0 g(rms). The vibration levels showed a gradual increase starting at approximately 80 seconds and reached a maximum just prior to booster cutoff. The maximum amplitude was displayed as a pulse wave form (7.4 pulses per second) with the peaks nearly out of band at ± 47g. A power spectral estimate was made during the period of maximum intensity (reference Figure), showing a RMS level of 17.1g. Sustainer steady-state levels were between 2.5 and 3.5 g(rms) with predominant frequencies at 910, 680 and 500 cps.

PROPULSION SYSTEM VIBRATION DATA

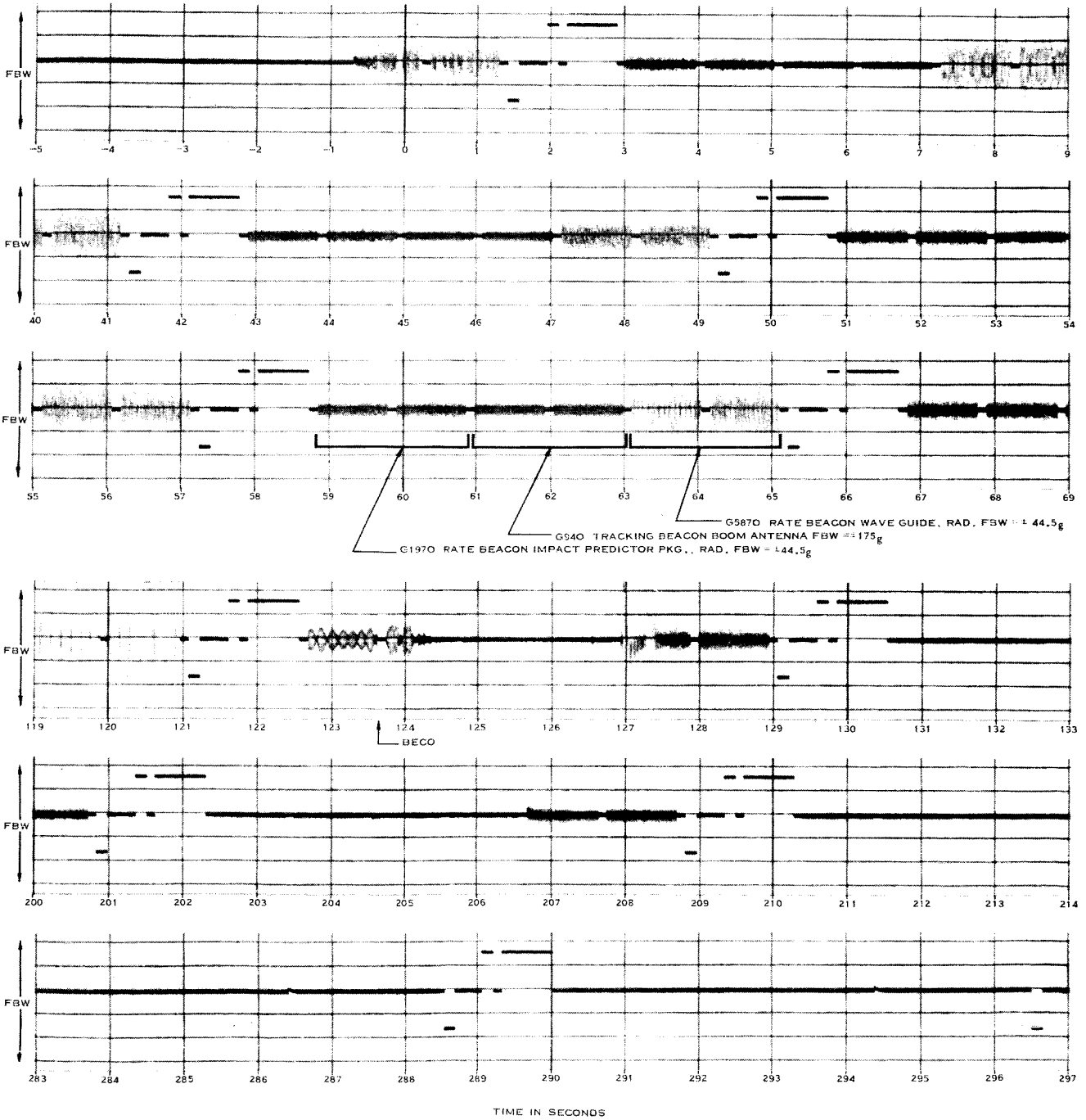
MISSILE 13E



PROPULSION SYSTEM VIBRATION DATA

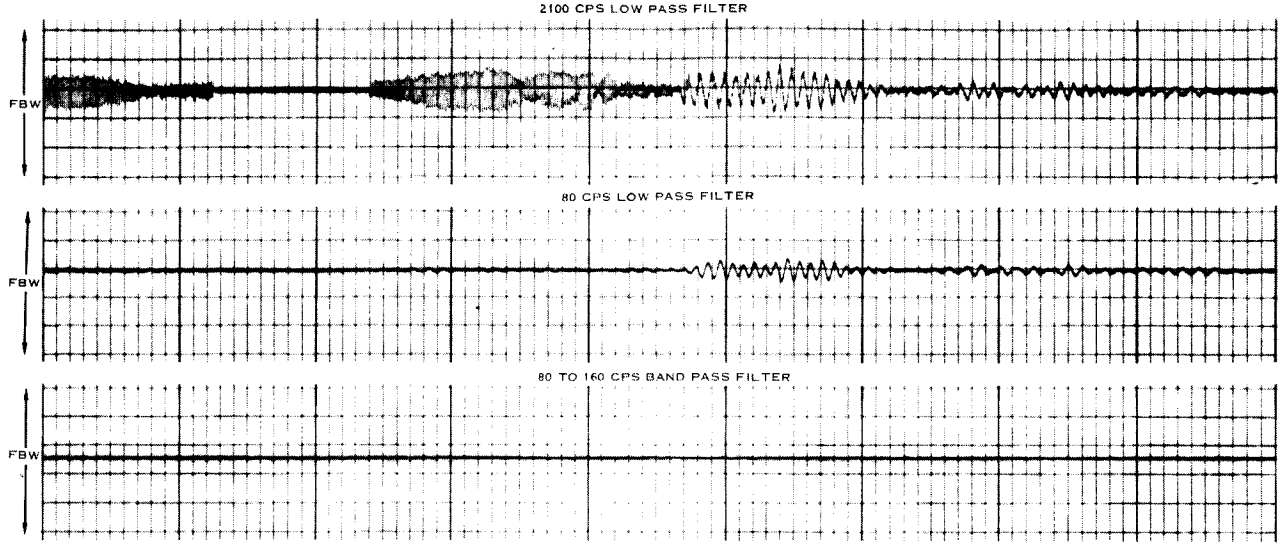


VIBRATION WAVEFORM
MISSILE 13F
2100 CPS LOW PASS FILTER

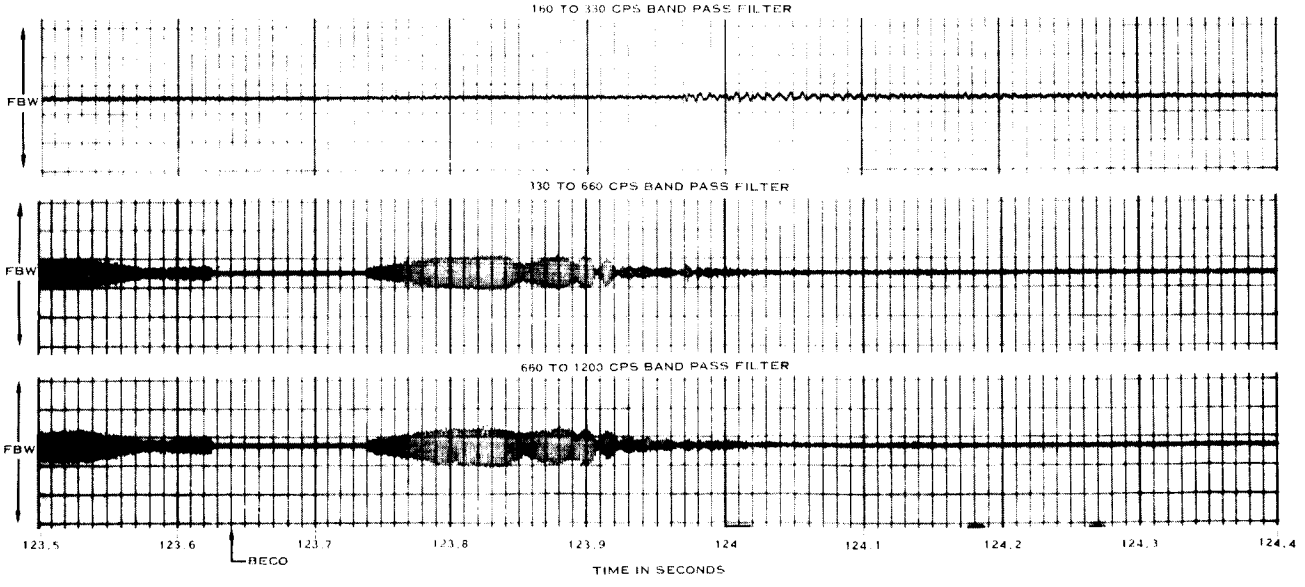


TIME IN SECONDS

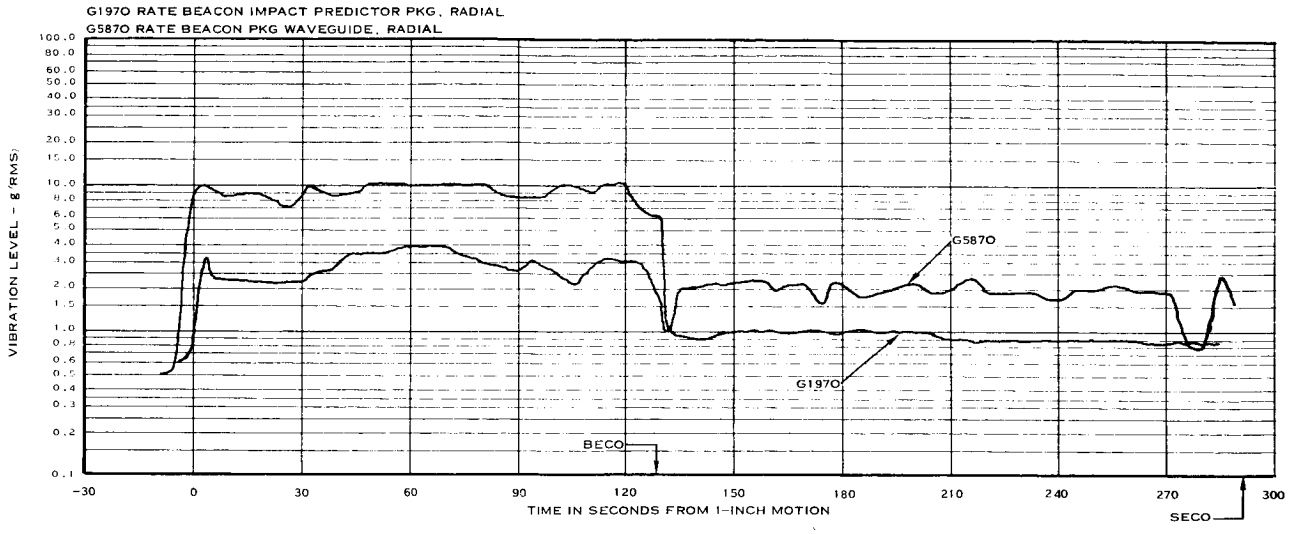
VIBRATION WAVEFORM
MISSILE 13E
BECO EXCITATION

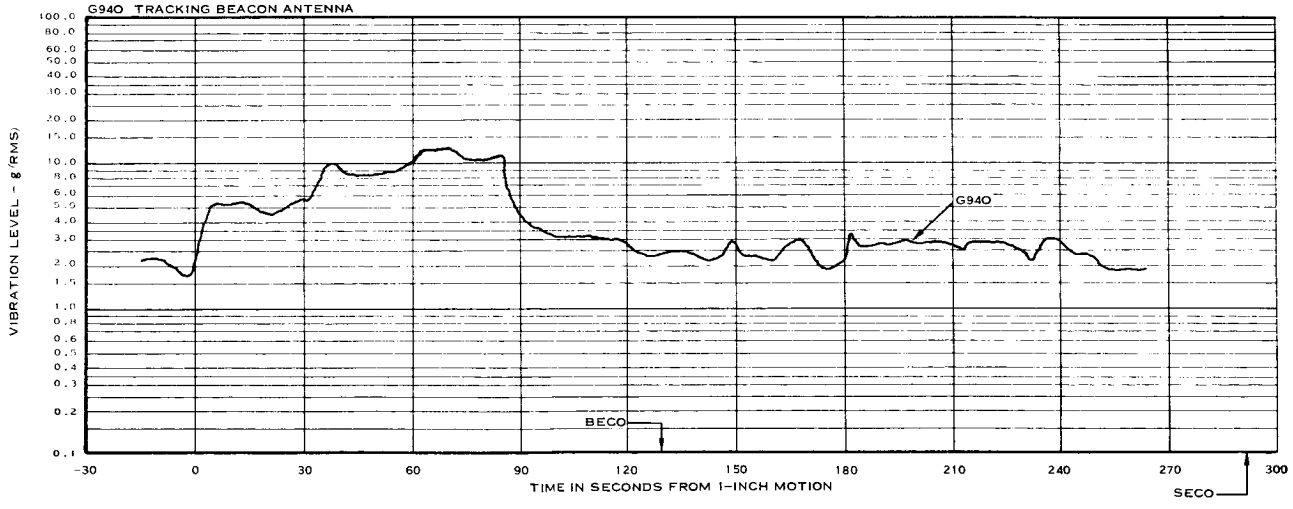


G1970 RATE BEACON IMPACT PREDICTOR PKG. RADIAL FBW = 44.5g

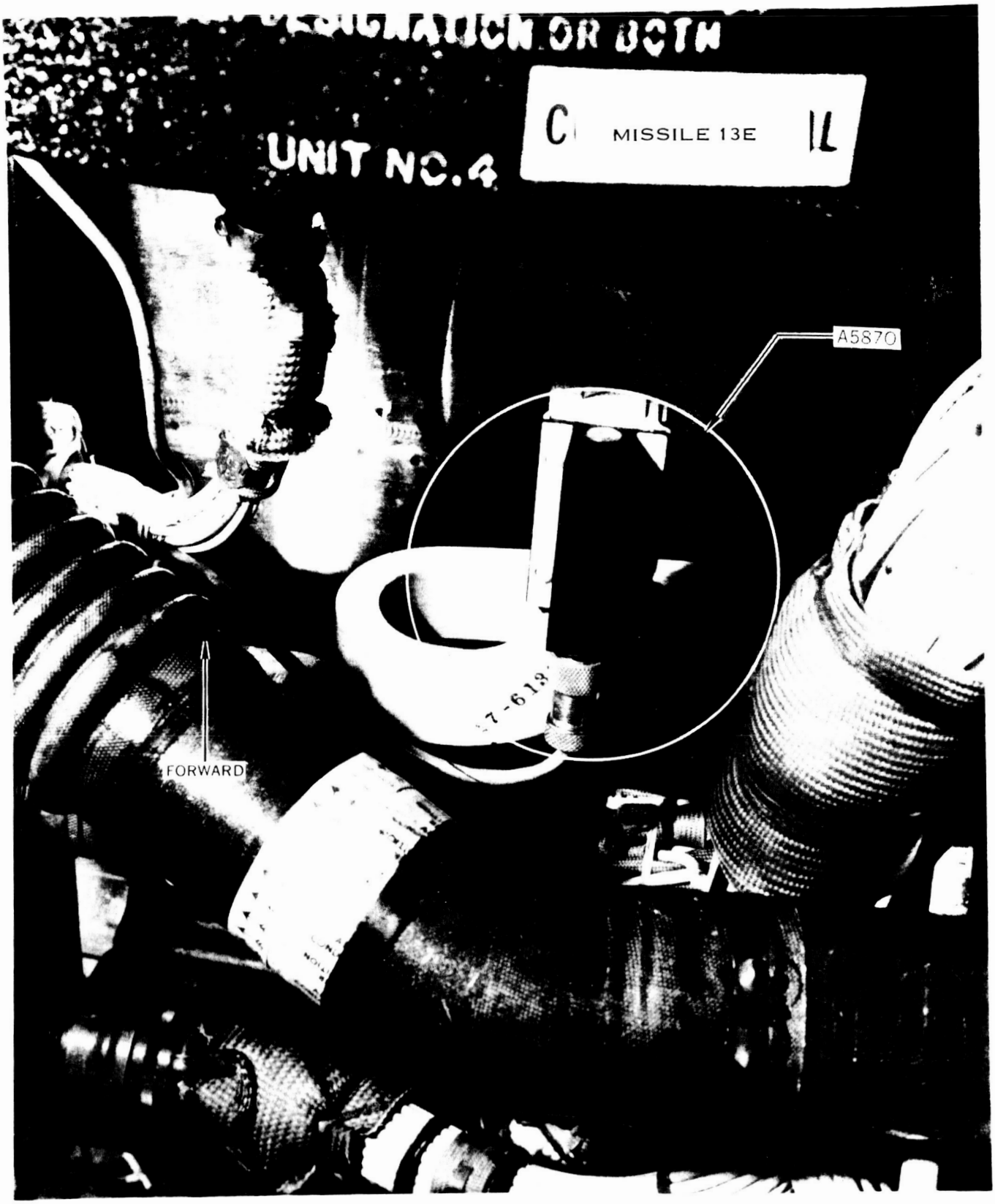


VIBRATION TIME HISTORY
g (RMS) VS TIME
MISSILE 13E
2100 CPS LOW PASS FILTER

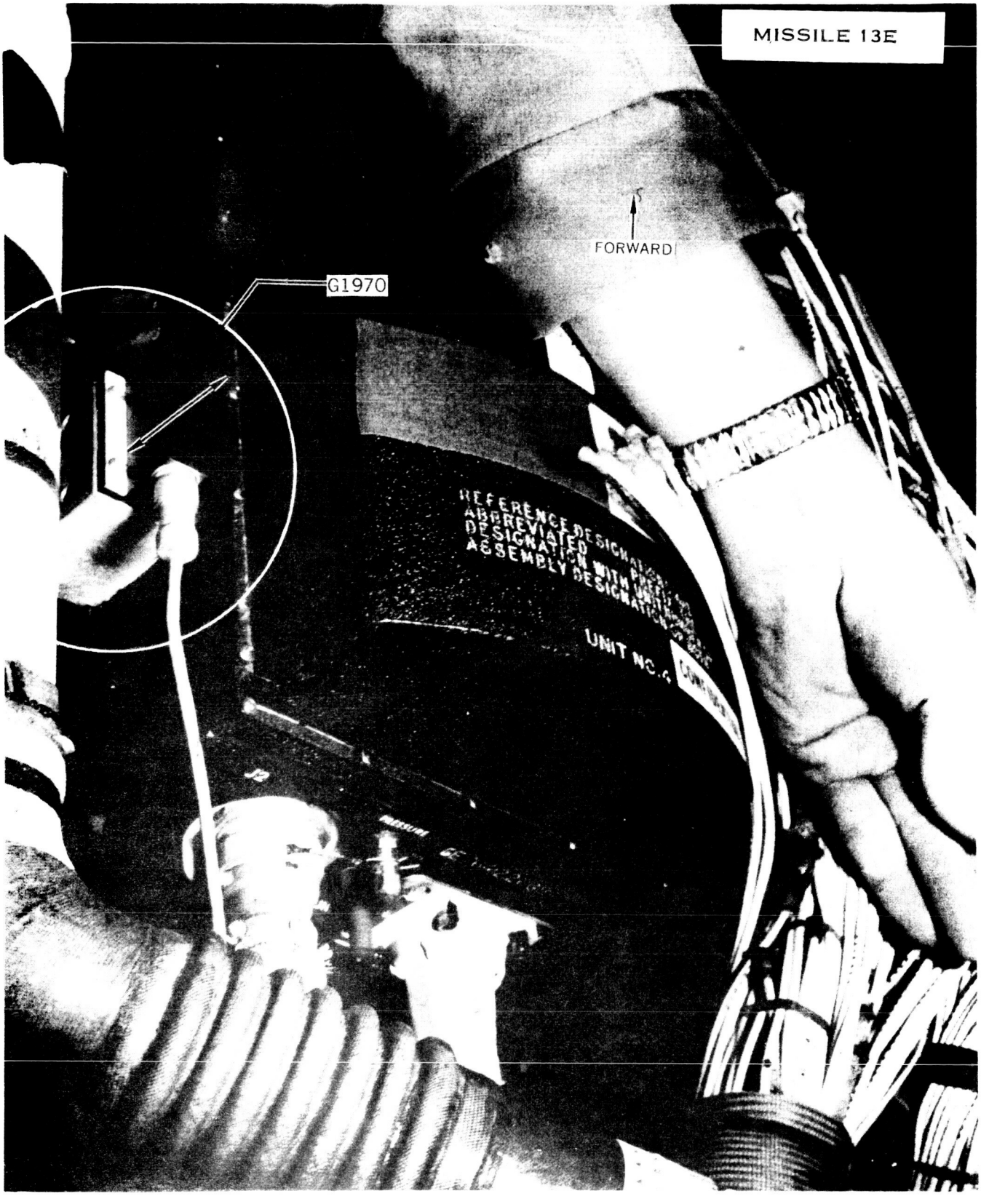




LOCATION OF ACCELEROMETER ON WAVEGUIDE

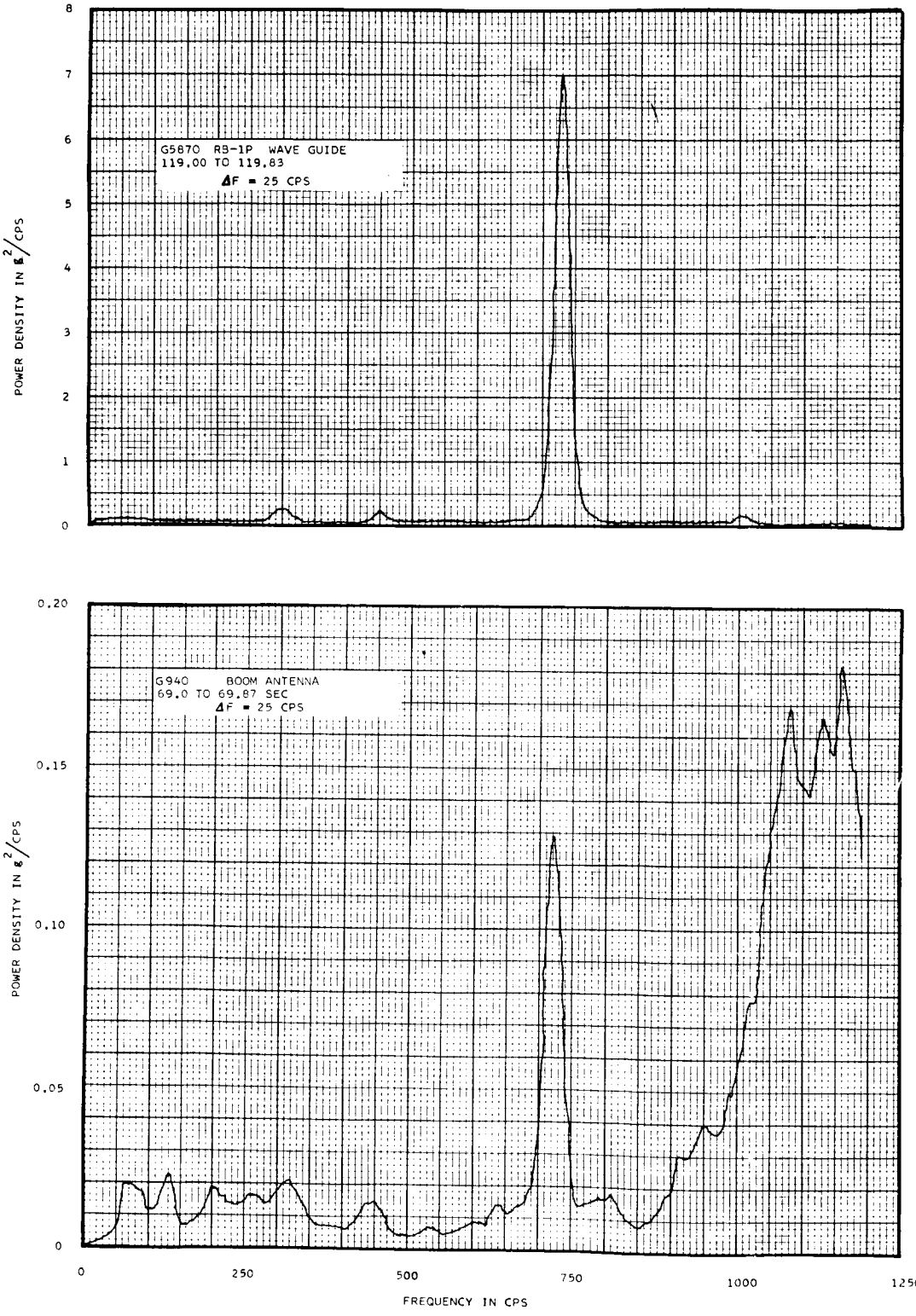


LOCATION OF ACCELEROMETER ON RB PACKAGE



INSTRUMENTATION BEACON SYSTEM TELEMETERED DATA

MISSILE 13E



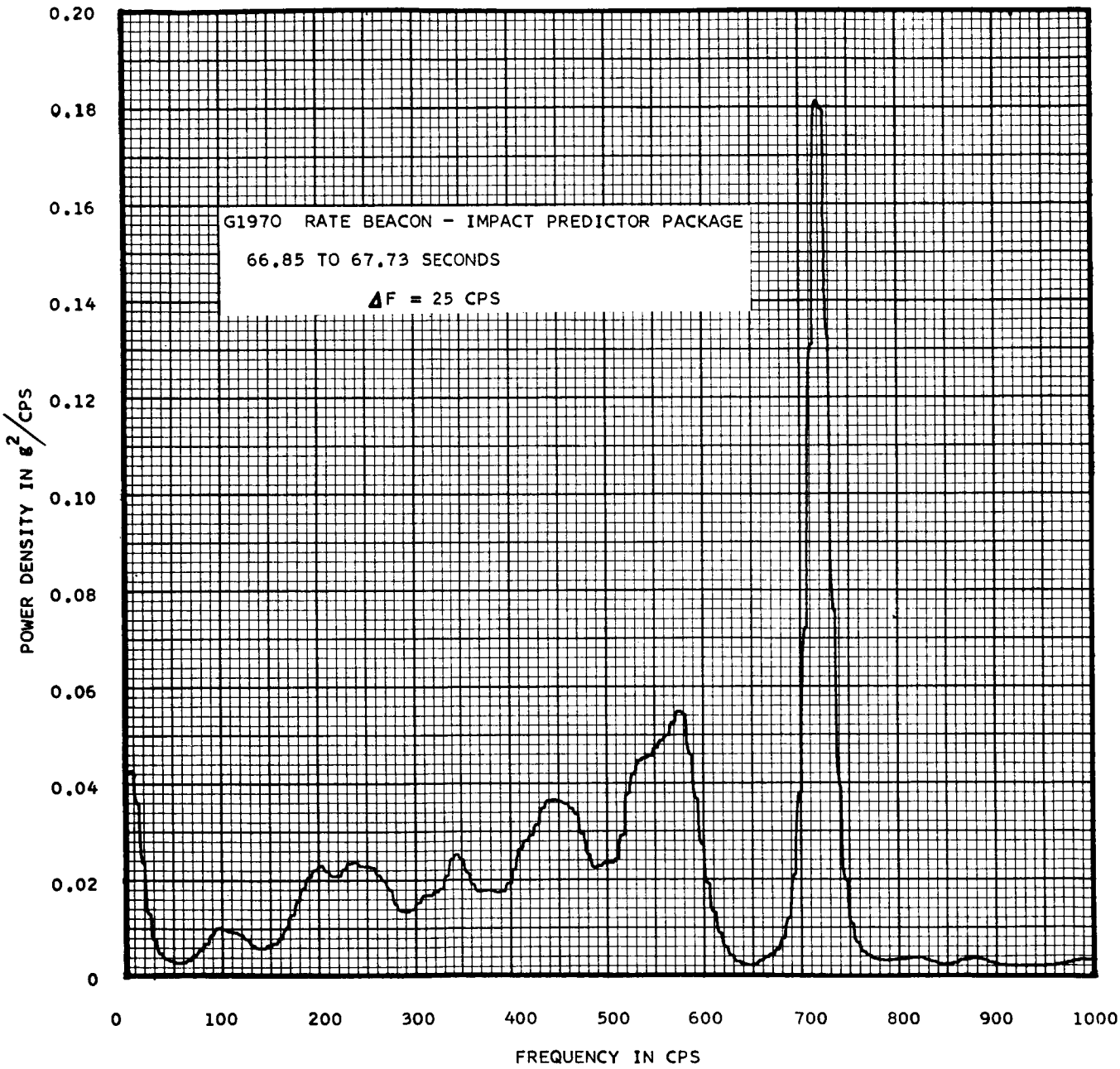
13E

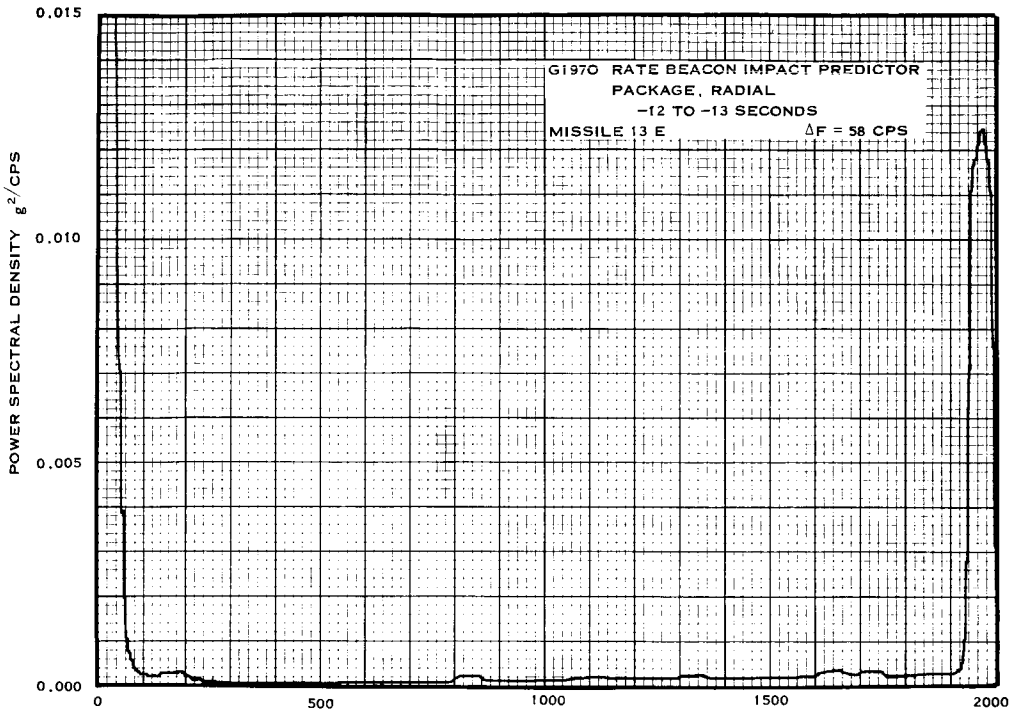
UNCLASSIFIED

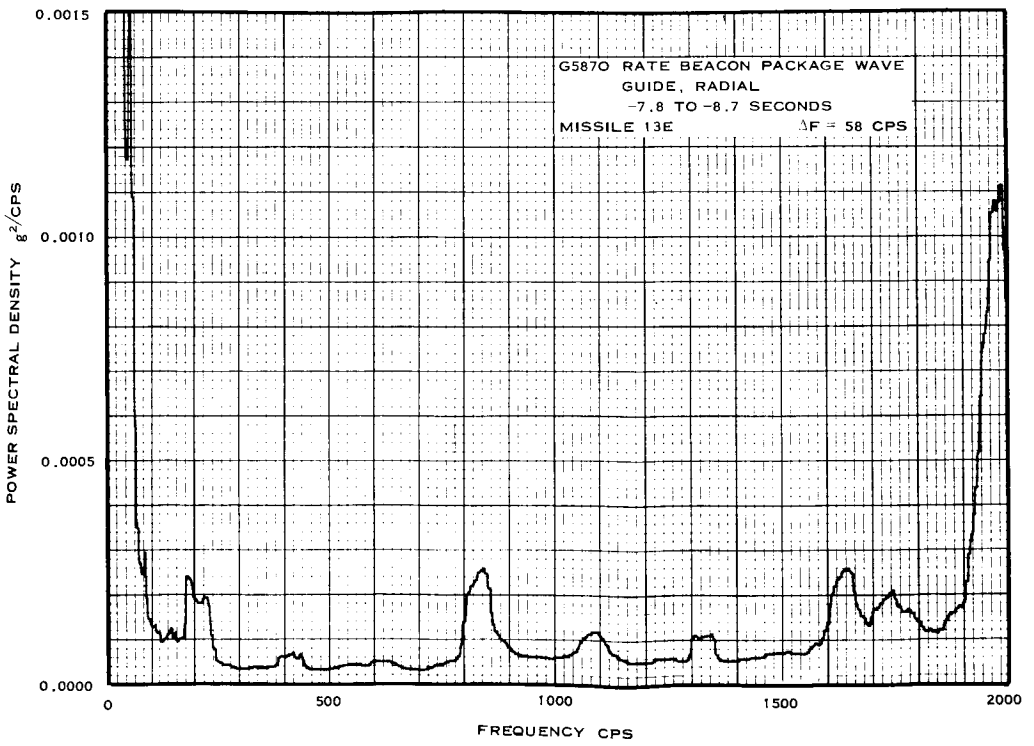
~~REPORT NO. AE60-0957~~

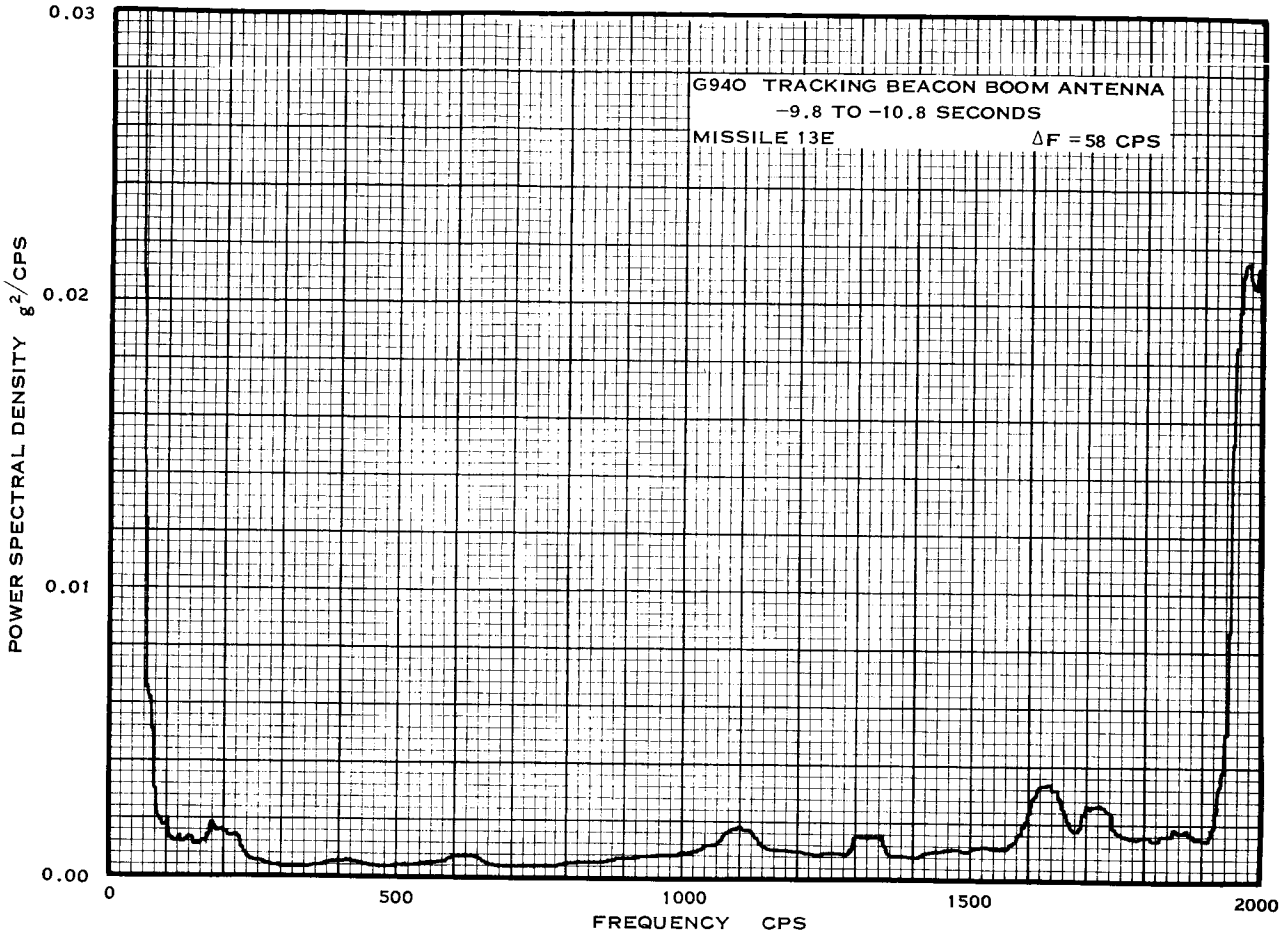
INSTRUMENTATION BEACON SYSTEM
TELEMETERED DATA

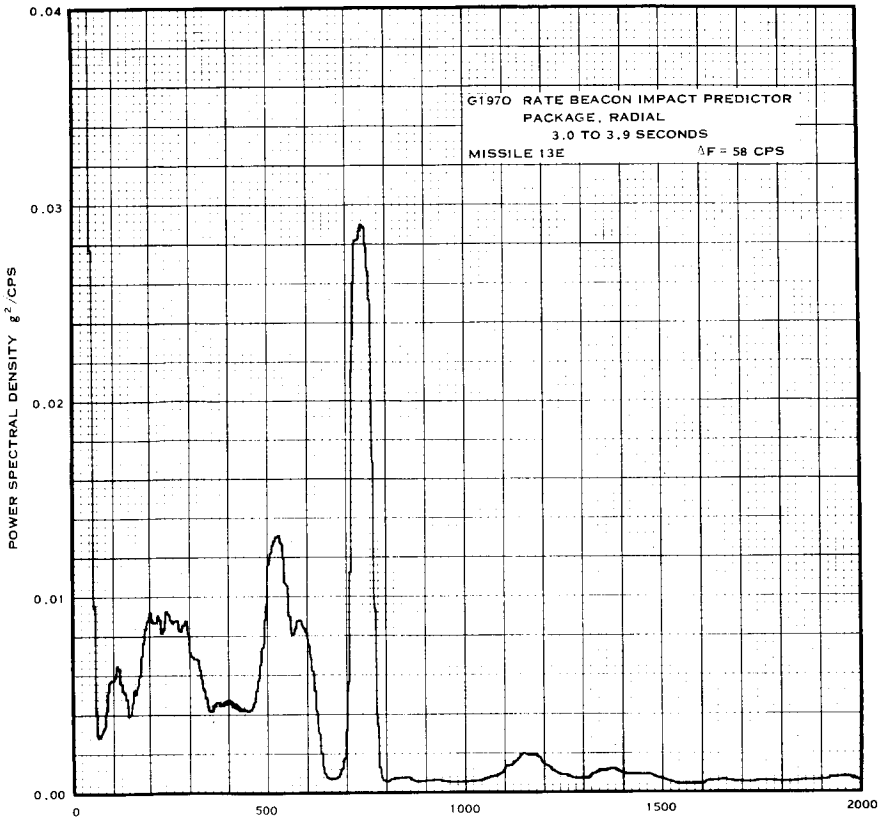
MISSILE 13E

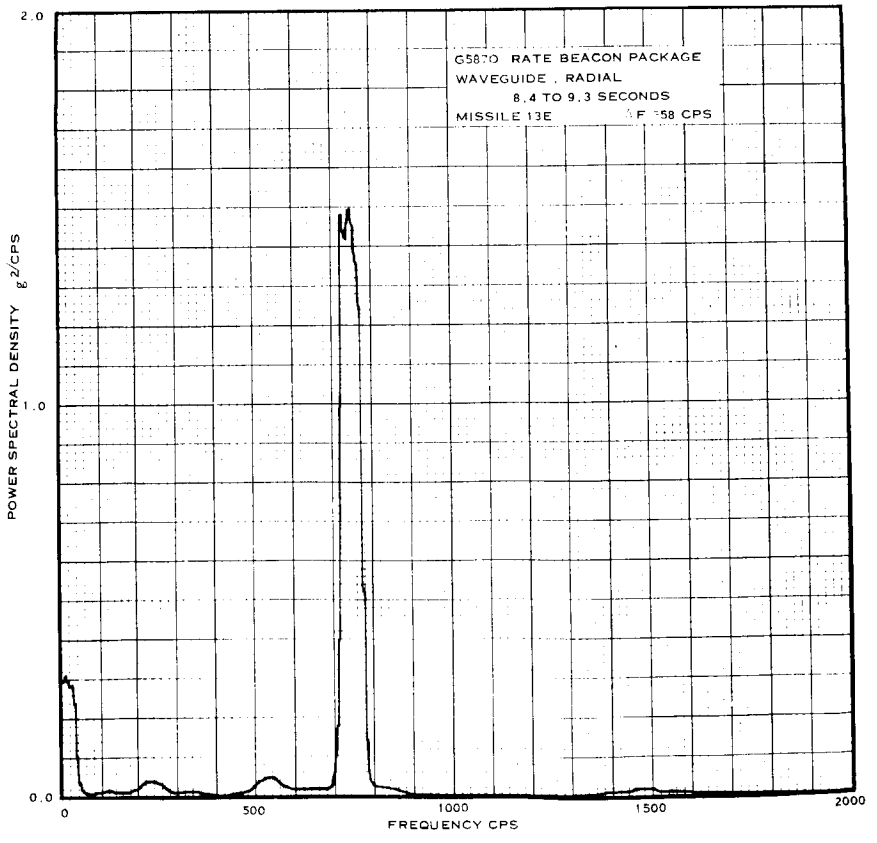


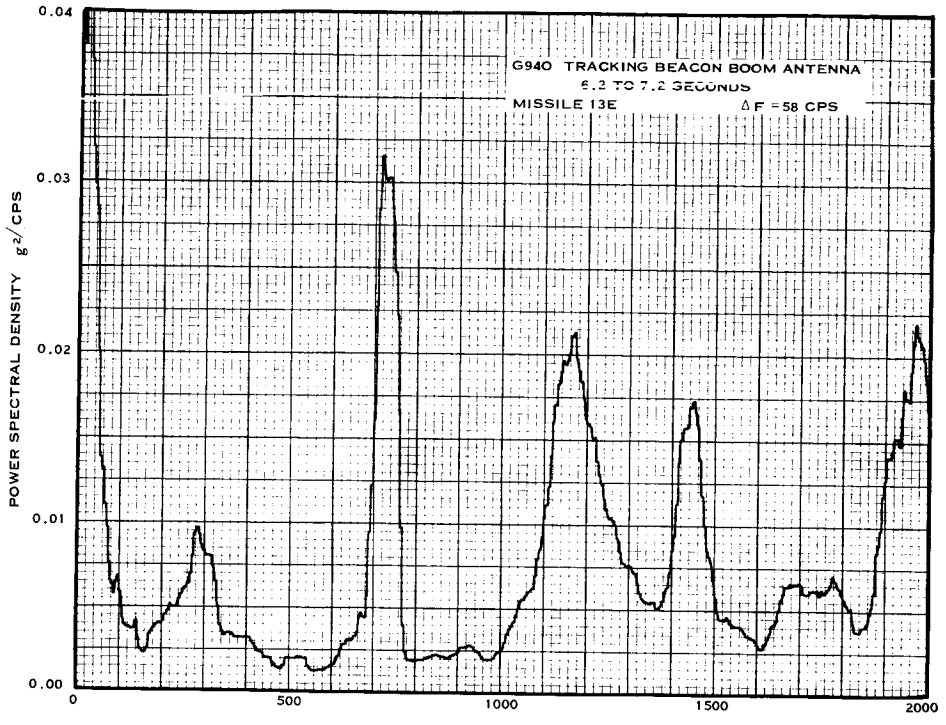

G1970 RATE BEACON IMPACT PREDICTOR PACKAGE, RADIAL
-12 TO -13 SECONDS
MISSILE 13 E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.015
0.010
0.005
0.000
0
500
1000
1500
2000

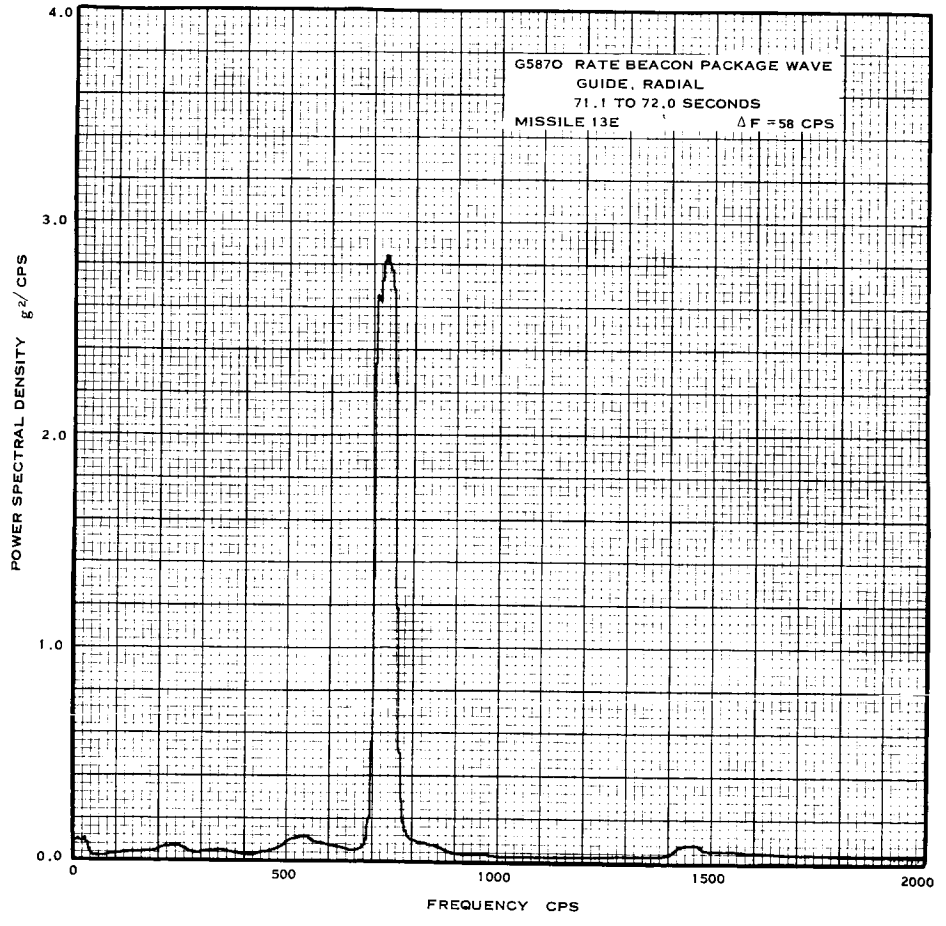

G5870 RATE BEACON PACKAGE WAVE GUIDE, RADIAL
-7.8 TO -8.7 SECONDS
MISSILE 13E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.0015
0.0010
0.0005
0.0000
0
500
1000
1500
2000
FREQUENCY CPS

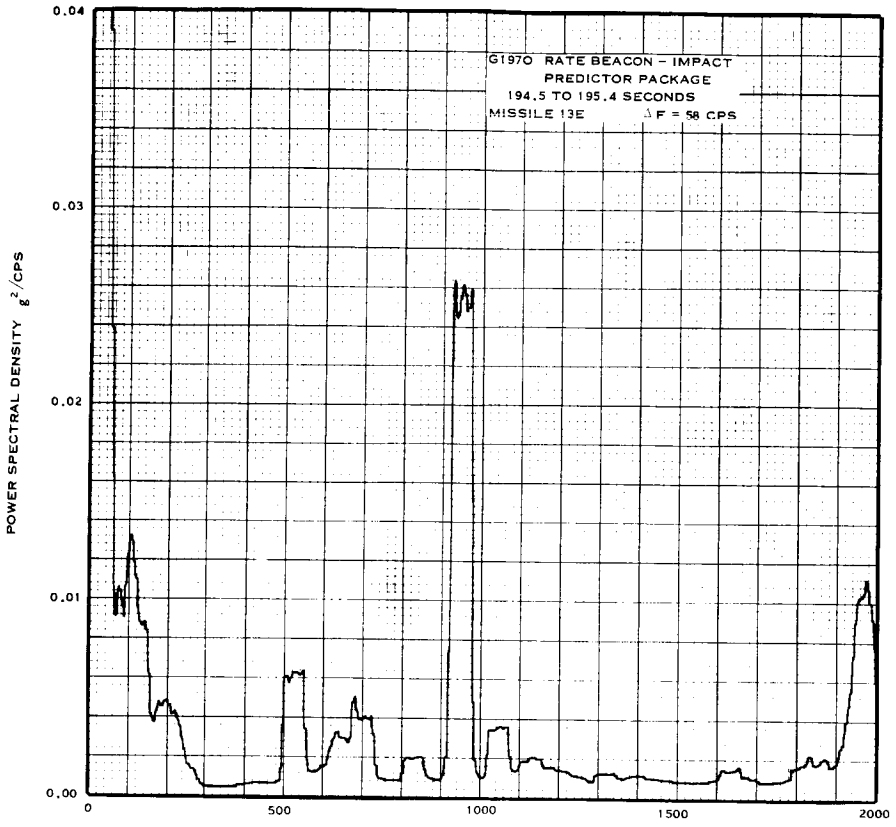

G940 TRACKING BEACON BOOM ANTENNA
-9.8 TO -10.8 SECONDS
MISSILE 13E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.03
0.02
0.01
0.00
0
500
1000
1500
2000
FREQUENCY CPS

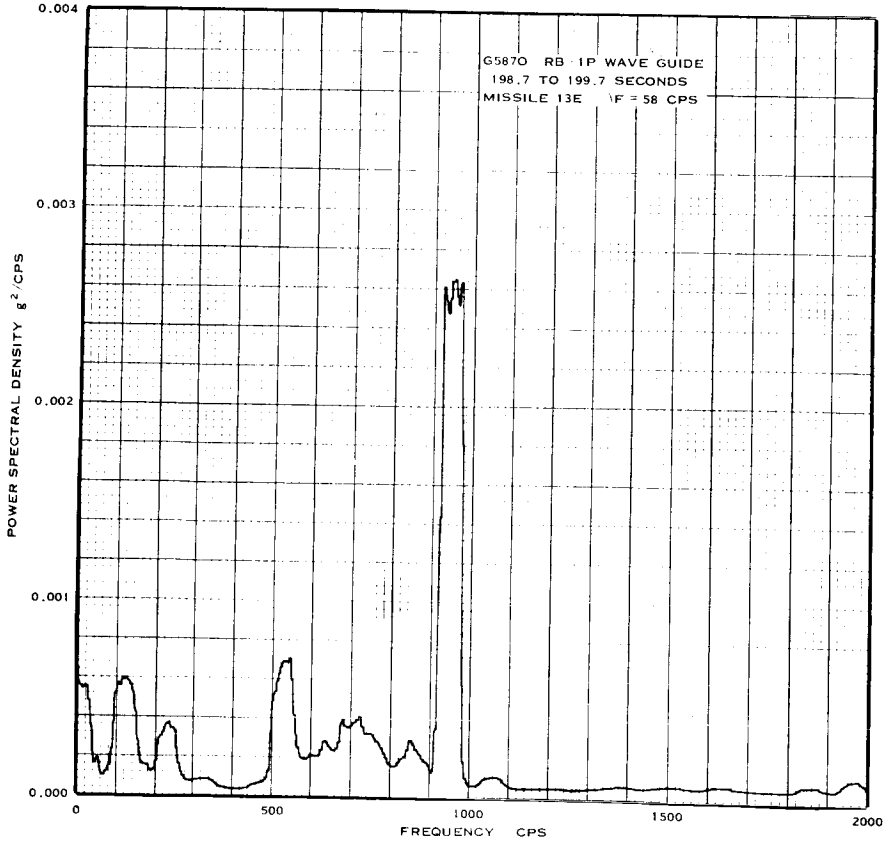

G1970 RATE BEACON IMPACT PREDICTOR
PACKAGE, RADIAL
3.0 TO 3.9 SECONDS
MISSILE 13E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.04
0.03
0.02
0.01
0.00
0
500
1000
1500
2000

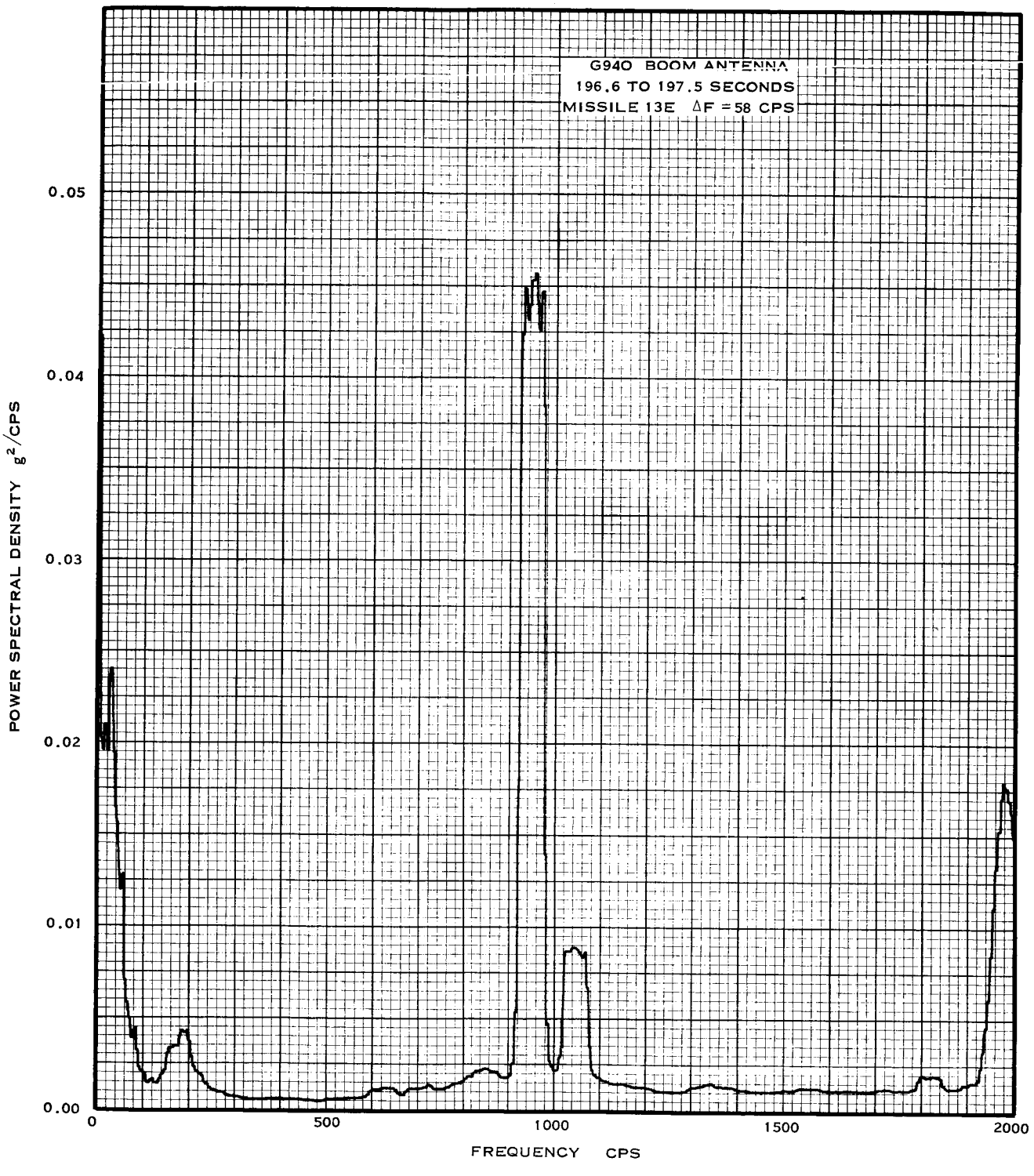

G5870 RATE BEACON PACKAGE
WAVEGUIDE, RADIAL
8.4 TO 9.3 SECONDS
MISSILE 13E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
2.0
1.0
0.0
0
500
1000
1500
2000
FREQUENCY CPS


G940 TRACKING BEACON BOOM ANTENNA
6.2 TO 7.2 SECONDS
MISSILE 13E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.04
0.03
0.02
0.01
0.00
0
500
1000
1500
2000


G587O RATE BEACON PACKAGE WAVE
GUIDE, RADIAL
71.1 TO 72.0 SECONDS
MISSILE 13E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
4.0
3.0
2.0
1.0
0.0
0
500
1000
1500
2000
FREQUENCY CPS


G1970 RATE BEACON - IMPACT
PREDICTOR PACKAGE
194.5 TO 195.4 SECONDS
MISSILE 13E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.04
0.03
0.02
0.01
0.00
0
500
1000
1500
2000


G5870 RB 1P WAVE GUIDE
198.7 TO 199.7 SECONDS
MISSILE 13E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.004
0.003
0.002
0.001
0.000
0
500
1000
1500
2000
FREQUENCY CPS


G940 BOOM ANTENNA
196.6 TO 197.5 SECONDS
MISSILE 13E ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.05
0.04
0.03
0.02
0.01
0.00
0
500
1000
1500
2000
FREQUENCY CPS

SECTION 6.2.6

MISSILE 17E

FLIGHT TESTED 6-22-61

AT AMR COMPLEX 11

TEST REPORT AE61-0240

SECTION 16

VIBRATION SYSTEM ANALYSIS

Three high frequency accelerometers were installed at three separate locations on the Instrumentation Beacon System equipment to determine their vibration environment during flight. The accelerometers were located as follows:

G-196-O	Pulse Beacon-Impact Predictor Package, Radial
G-587-O	Rate Beacon-Impact Predictor Package Waveguide
G-595-O	Pulse Beacon-Impact Predictor Package Waveguide

The general location of the accelerometers is shown in Figure 15-10. Details of their installation are shown in Figures 16-8, 16-9 and 16-10. Measurements G-196-O and G-595-O were made for the first time on an E Series missile flight test. G-587-O was measured on the flight tests of Missiles 9E, 13E and 12E and displayed maximum vibration levels between 14 and 26 g(rms) with a predominant frequency of 720 cps. These levels were considered of sufficient magnitude to warrant the addition of waveguide support brackets for damping purposes. The additional waveguide supports were used on Missile 17E. Figure 16-11 shows a sketch of the support brackets. Each measurement showed valid data throughout the flight until missile destruction. The measurements were analyzed within a frequency band of 10 to 1200 cps.

The predominant frequency component of 720 cps was evident on all three measurements, as it was evidenced on measurements of previous flight tests. The propulsion system was undoubtedly the energy source, since 720 cps has been a major frequency at the thrust chamber. Maximum levels occurred at launch and at approximately 42 seconds. The rate beacon package waveguide displayed the greater vibration levels, showing 40.5 g(rms) through the period of maximum steady-state excitation (42 seconds). The maximum instantaneous acceleration noted for that period was 80 g(zero to peak). The maximum levels on G-587-O for this flight were in excess of those observed on previous flight tests which indicates that the waveguide supports provided no damping action at the rate beacon package waveguide. It is difficult to determine if an amplification of the vibration input prevailed as the result of adding the brackets since the intensity of the propulsion system inputs have shown considerable variation. Also, the abnormal flight loads resulting from the irregular flight path of the missile may have contributed to a significant increase in vibration level. An oscillograph record displaying the vibration waveform is shown in Figure 16-2. A plot of acceleration versus flight time which displays the general trend of levels is shown in Figure 16-3. Power spectral computations made on each measurement are shown in Figures 4 through 7.

A description of each measurement is given below:

G-196-O Pulse Beacon-Impact Predictor Package, Radial

G-196-O showed moderate levels until missile destruct. The vibration levels ranged between 3.0 and 5.4 g(rms) with a 720 cps frequency component predominating through most of the flight. Between 70 seconds and the time of missile destruct, an increasing amount of energy was observed within a frequency band of 160 to 180 cps. Between 97.5 and 99.5 seconds, the major energy contribution was at a frequency of 180 cps. The levels observed at the pulse beacon package were nearly comparable to the levels obtained from the rate beacon package on previous flight tests.

G-587-O Rate Beacon Package Waveguide

The steady-state vibration levels at the waveguide ranged between 11.6 and 40.5 g(rms). A predominant frequency ranging between 715 and 730 cps prevailed through flight.

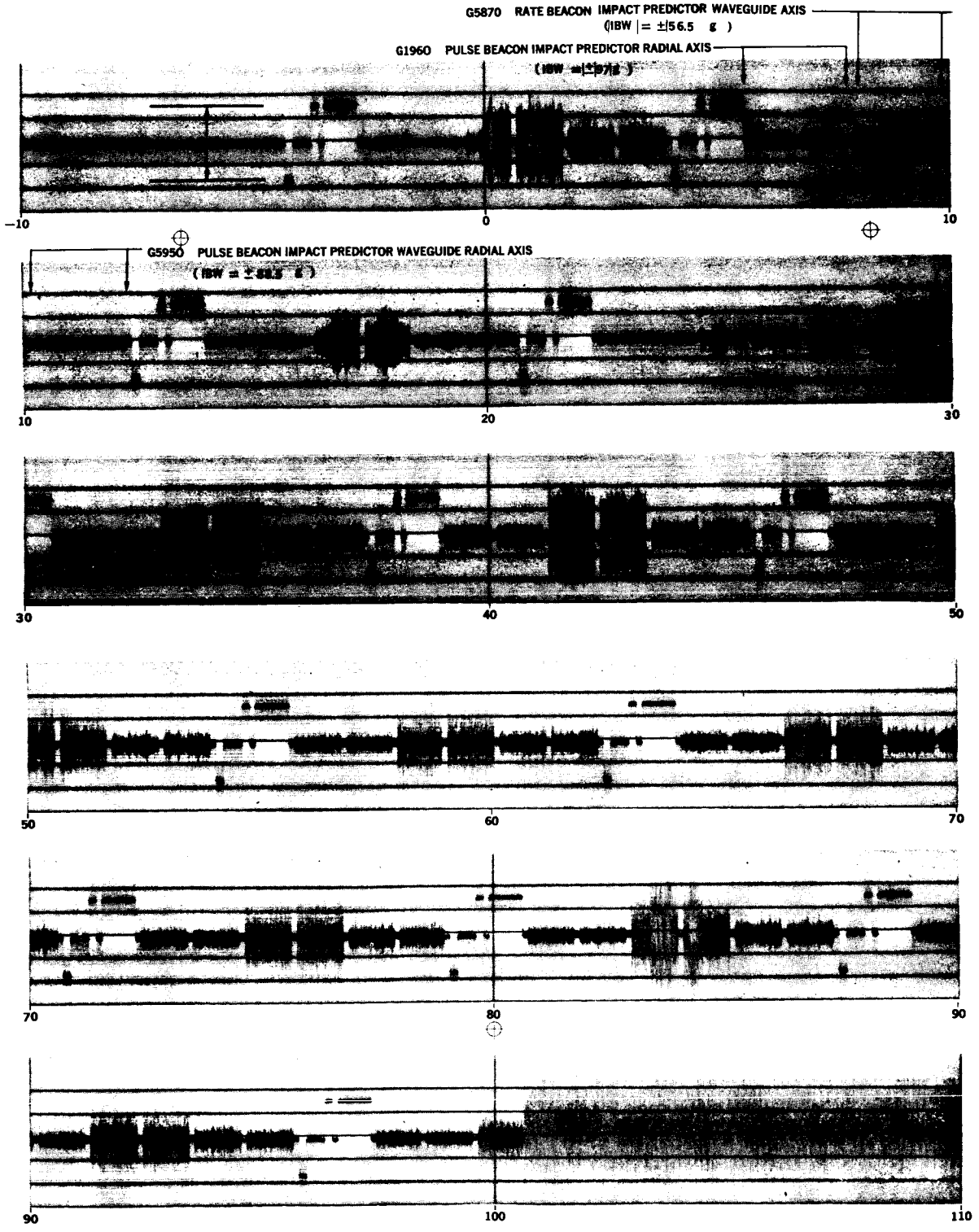
Between 83.4 and 84.4 seconds, a buildup in level was noted, and showed a maximum instantaneous level of 91.0 g(zero to peak). The response at that time may be attributed to either propulsion system input or the existence of an abnormal disturbance in the vicinity of the aft end of the equipment pod.

The exact cause for the lack of damping action and/or the altering of the outputs at the RB package waveguide is not known at this time. It is conceivable, however, that the RB package may be driving the waveguide, but that point is difficult to prove since cross-correlation of the commutated data is not feasible.

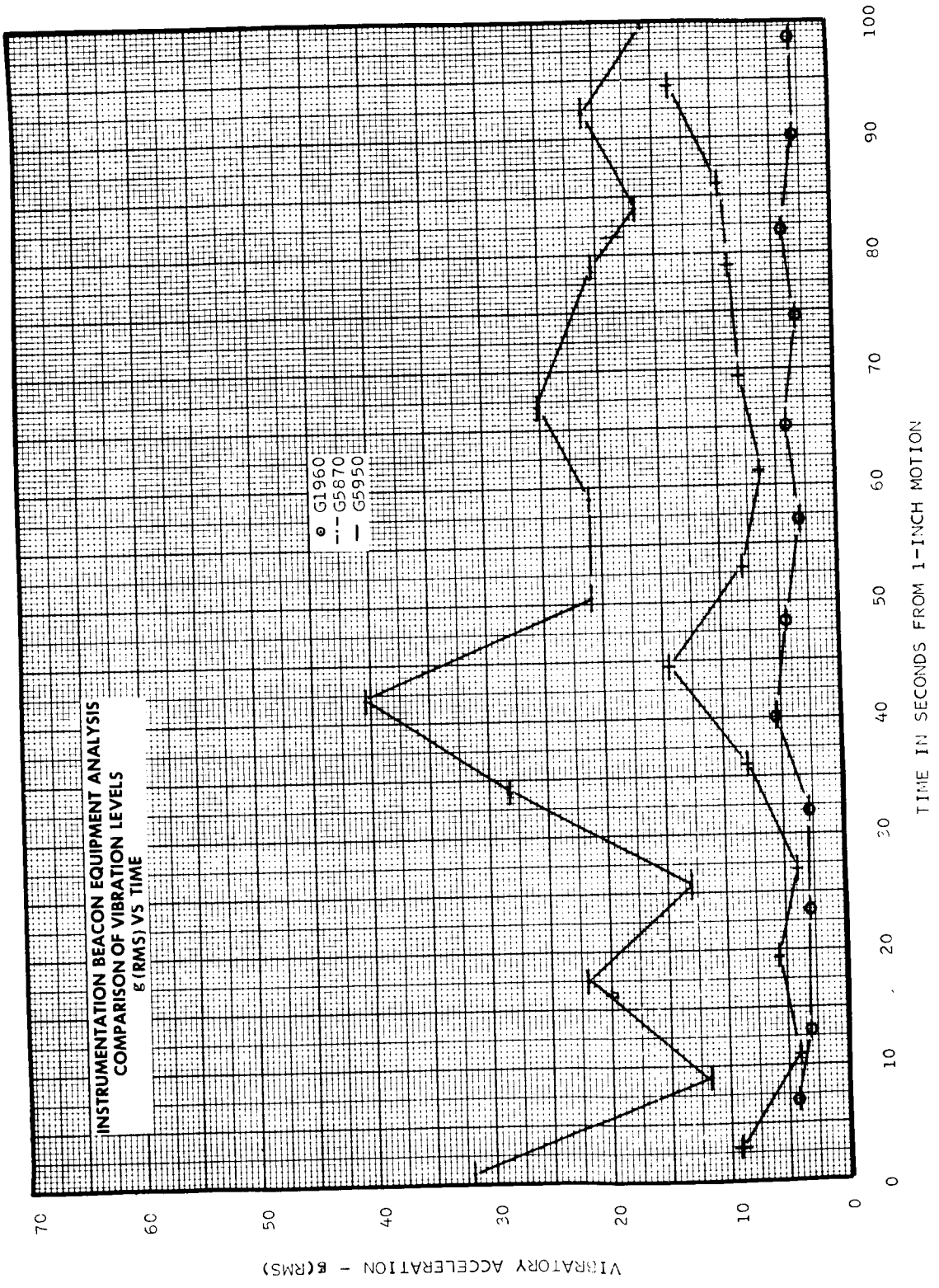
G-595-O Pulse Beacon Package Waveguide

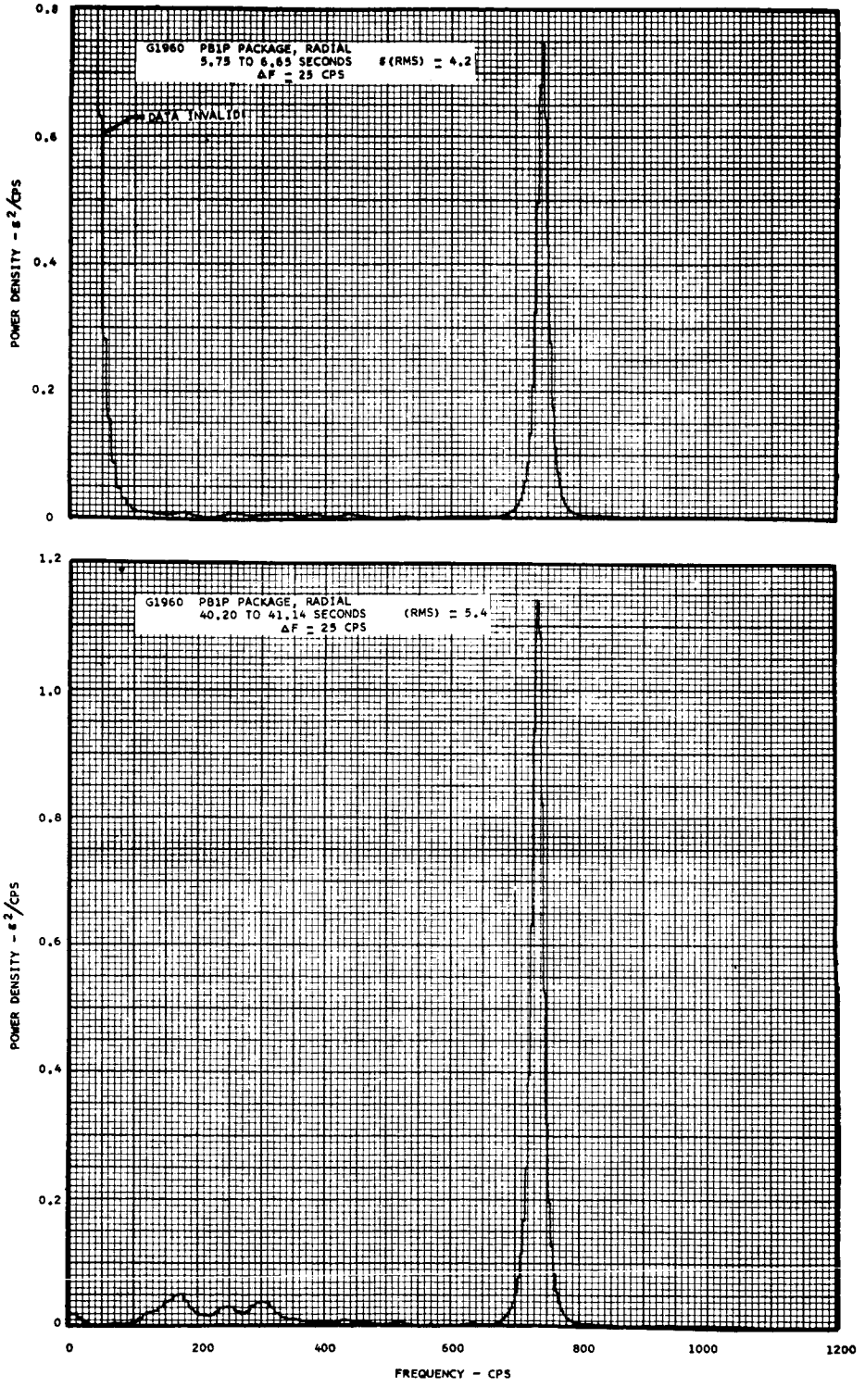
G-595-O displayed steady-state levels between 4.0 and 14.5 g(rms). The 720 cps frequency component was predominant through most of the flight. A secondary component of 300 cps was also exhibited. At approximately 80 seconds, the 300 cps component became the predominant frequency.

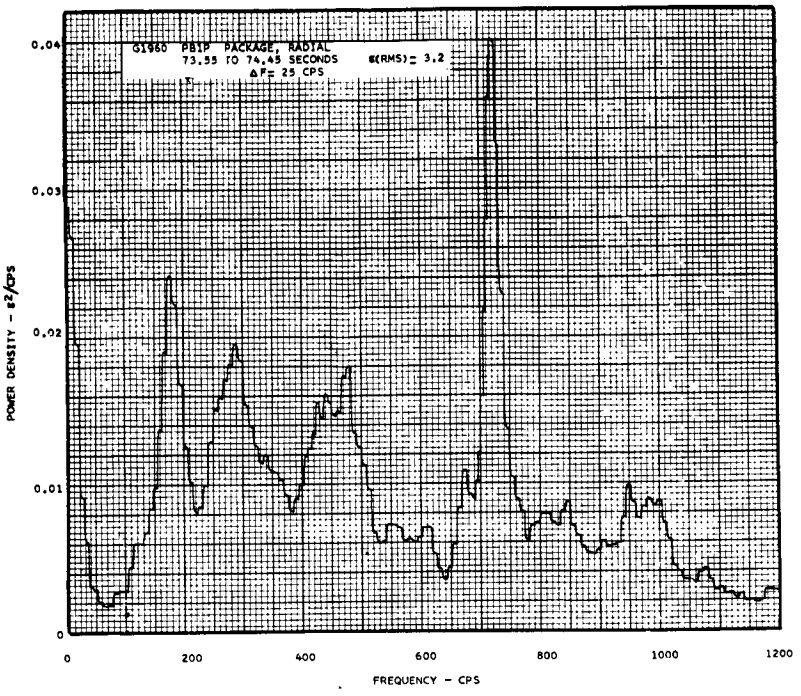
The vibration data did not give any indication of the mode of missile breakup nor did any vibration transients appear to correlate with the sharp fluctuation of instrumentation beacon signal at 82.95 seconds and the signal deterioration at 98.0 seconds.

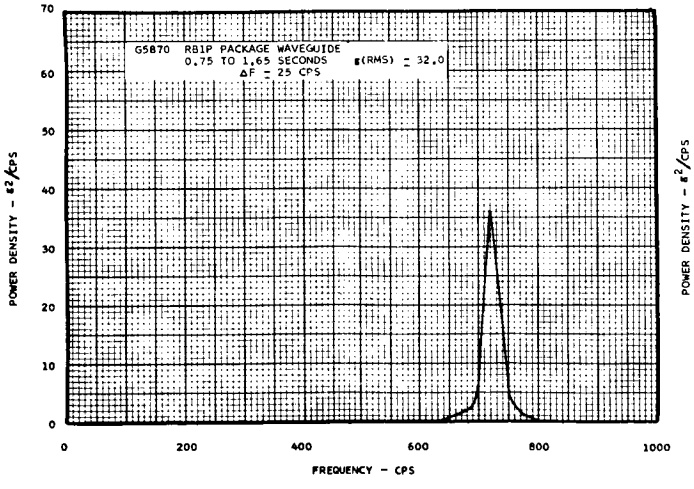


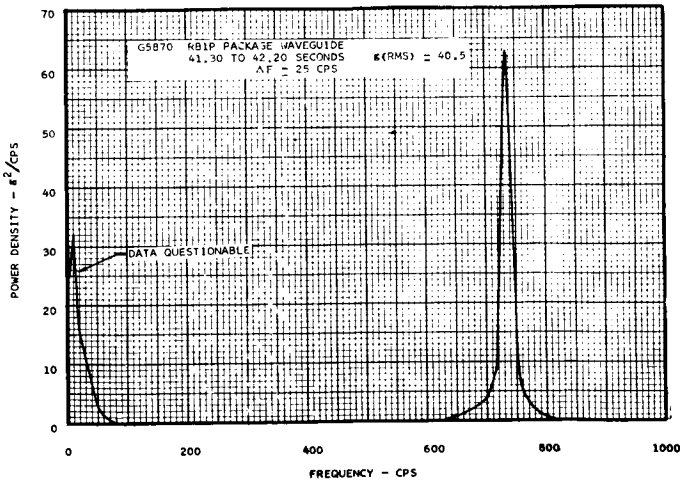
TIME IN SECONDS FROM 1-INCH MOTION

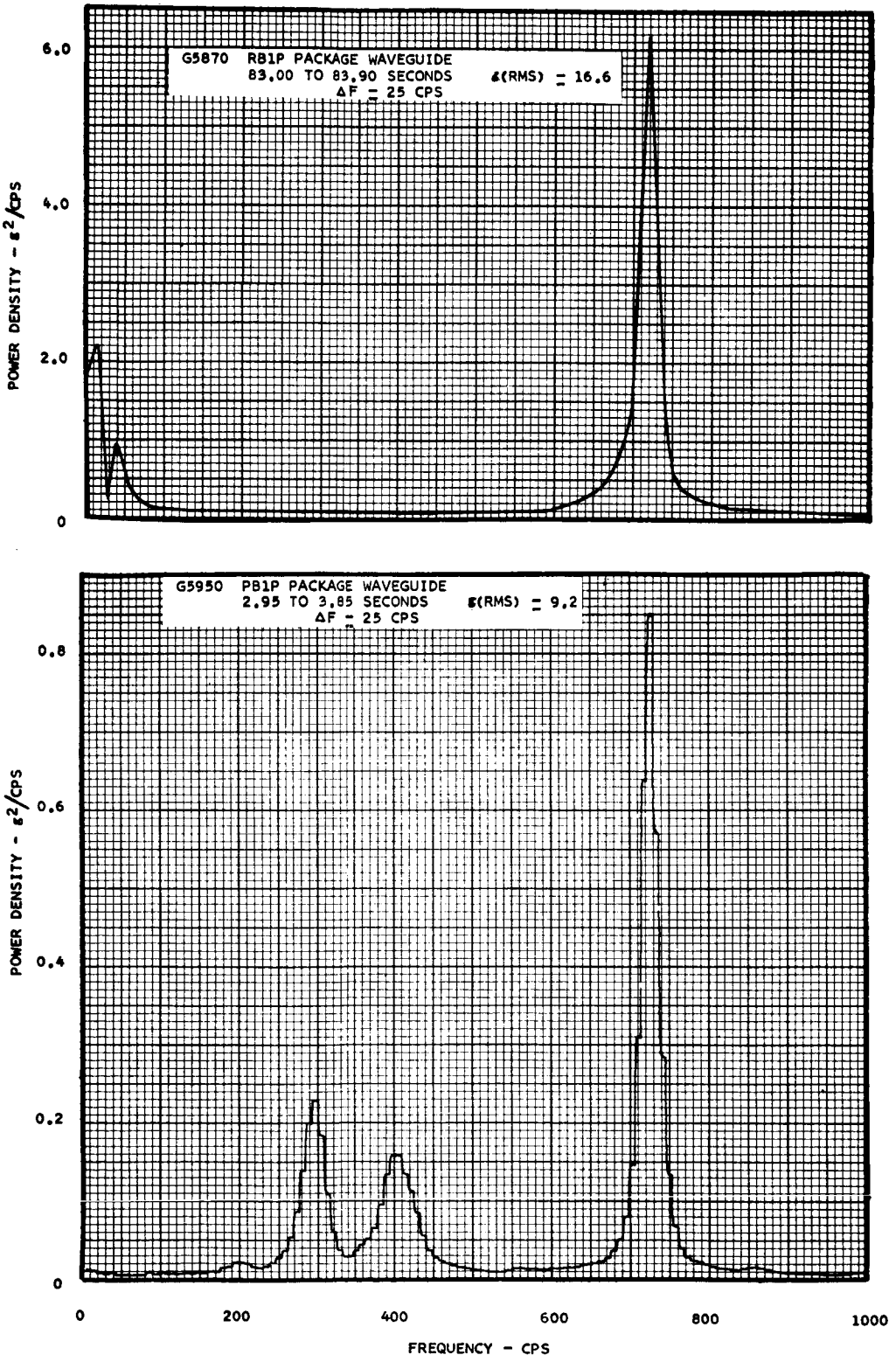

INSTRUMENTATION BEACON EQUIPMENT ANALYSIS
COMPARISON OF VIBRATION LEVELS
g (RMS) VS TIME
G1960
G5870
G5950
VIBRATORY ACCELERATION - g(RMS)
0
10
20
30
40
50
60
70
TIME IN SECONDS FROM 1-INCH MOTION
0
10
20
30
40
50
60
70
80
90
100


G1960 PB1P PACKAGE, RADIAL
5.75 TO 6.65 SECONDS
ΔF = 25 CPS
(RMS) = 4.2
DATA INVALID
POWER DENSITY - g²/CPS
0.8
0.6
0.4
0.2
0
G1960 PB1P PACKAGE, RADIAL
40.20 TO 41.14 SECONDS
ΔF = 25 CPS
(RMS) = 5.4
POWER DENSITY - g²/CPS
1.2
1.0
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
FREQUENCY - CPS


G1960 RB1P PACKAGE, RADIAL
73.55 TO 74.45 SECONDS
ΔF= 25 CPS
g(RMS)= 3.2
POWER DENSITY - g²/CPS
0.04
0.03
0.02
0.01
0
0
200
400
600
800
1000
1200
FREQUENCY - CPS


G5870 RB1P PACKAGE WAVEGUIDE
0.75 TO 1.65 SECONDS
ΔF = 25 CPS
g(RMS) = 32.0
POWER DENSITY - g²/CPS
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
FREQUENCY - CPS


G5870 RB1P PACKAGE WAVEGUIDE
41.30 TO 42.20 SECONDS
ΔF = 25 CPS
g(RMS) = 40.5
DATA QUESTIONABLE
POWER DENSITY - g²/CPS
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
FREQUENCY - CPS


G5870 RB1P PACKAGE WAVEGUIDE
83.00 TO 83.90 SECONDS
ΔF = 25 CPS
g(RMS) = 16.6
POWER DENSITY - g²/CPS
6.0
4.0
2.0
0
G5950 PB1P PACKAGE WAVEGUIDE
2.95 TO 3.85 SECONDS
ΔF = 25 CPS
g(RMS) = 9.2
POWER DENSITY - g²/CPS
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
FREQUENCY - CPS

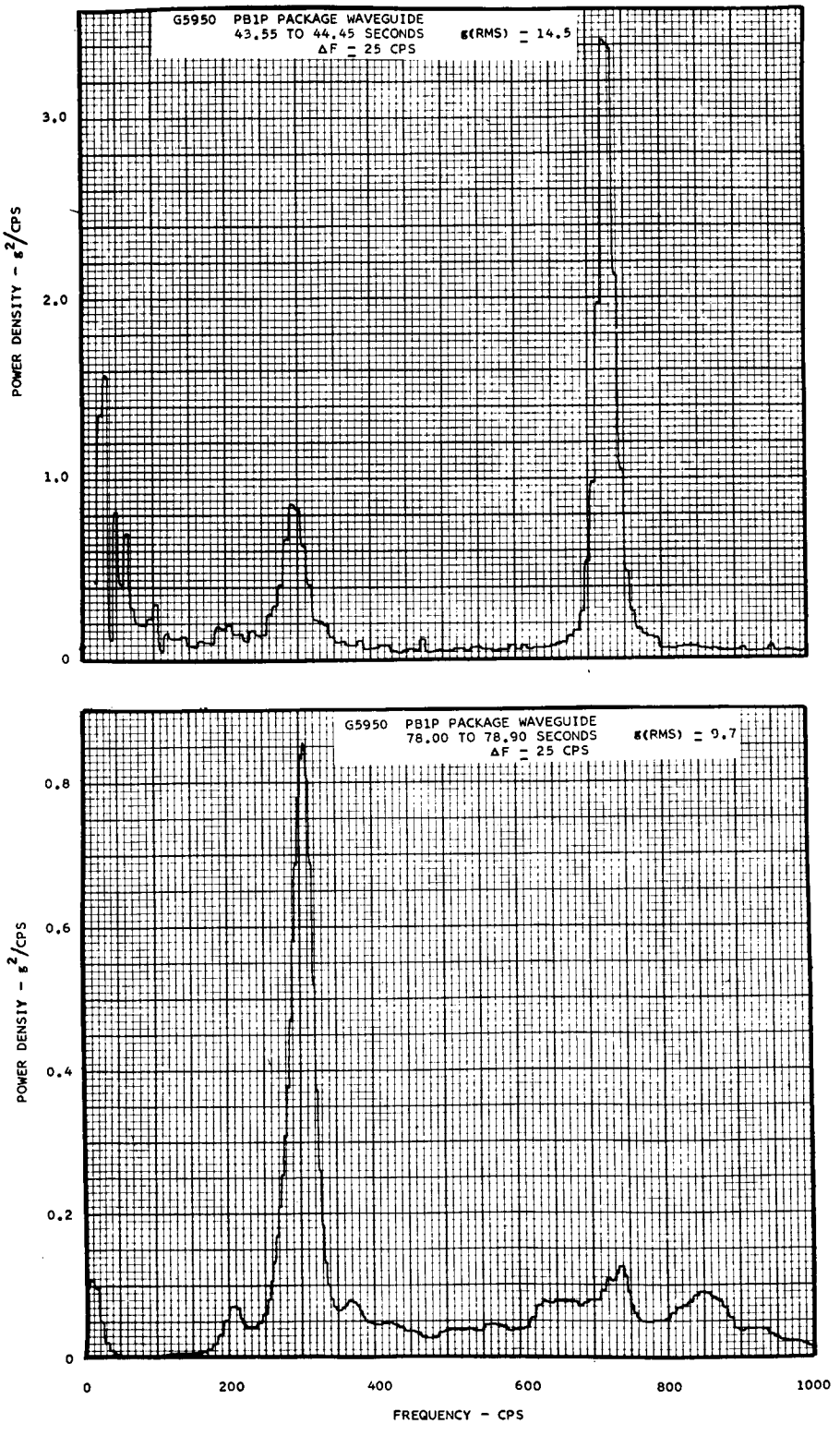

G5950 PB1P PACKAGE WAVEGUIDE
43.55 TO 44.45 SECONDS
ΔF = 25 CPS
g(RMS) = 14.5
POWER DENSITY - g²/CPS
3.0
2.0
1.0
0
G5950 PB1P PACKAGE WAVEGUIDE
78.00 TO 78.90 SECONDS
ΔF = 25 CPS
g(RMS) = 9.7
POWER DENSITY - g²/CPS
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
FREQUENCY - CPS

FIGURE NO. 16-8

GD/A-DDE65-016

~~REPORT NO. AE61-0240~~

UNCLASSIFIED

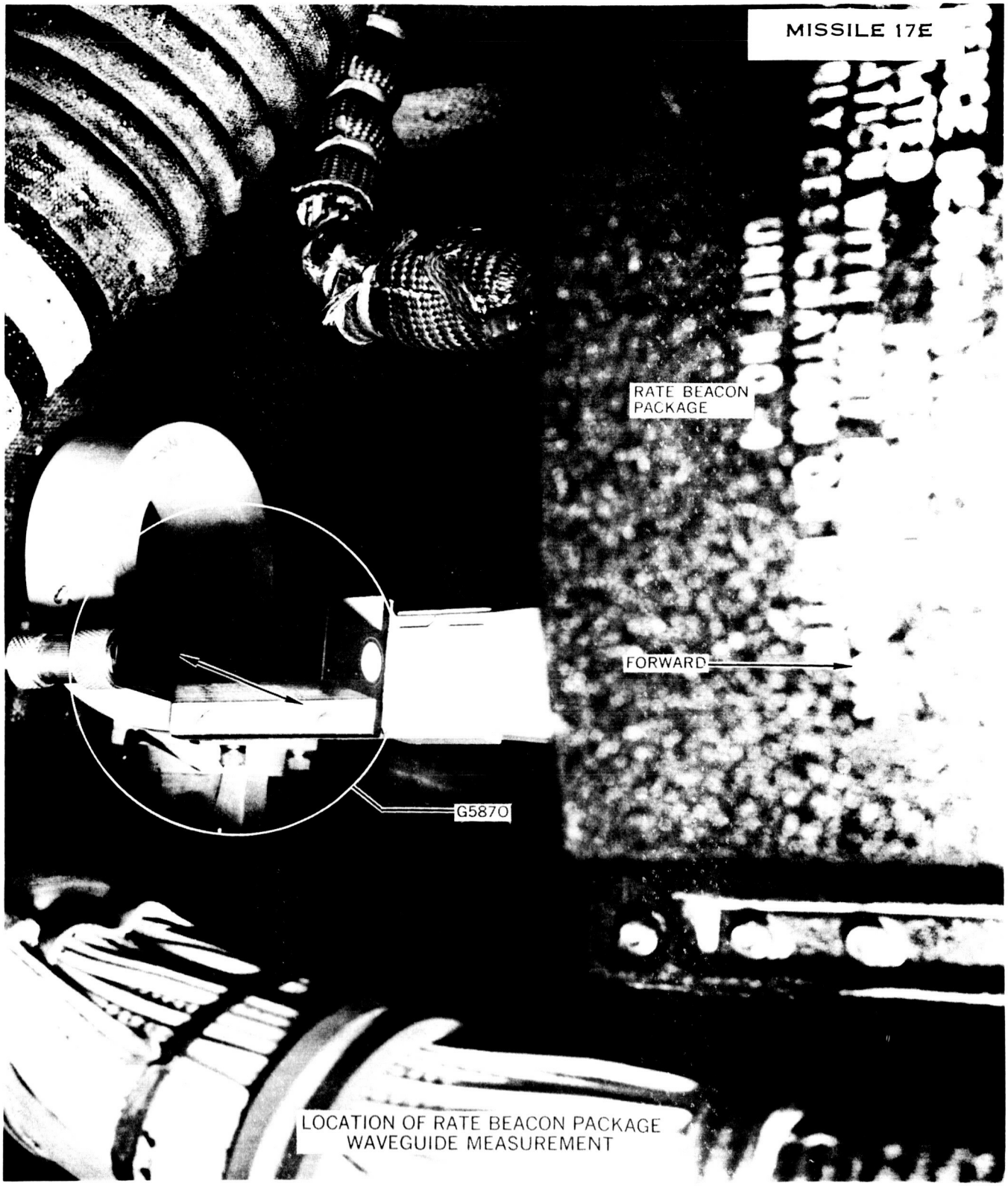
VIBRATION ANALYSIS
INSTRUMENTATION BEACON EQUIPMENT

MISSILE 17E

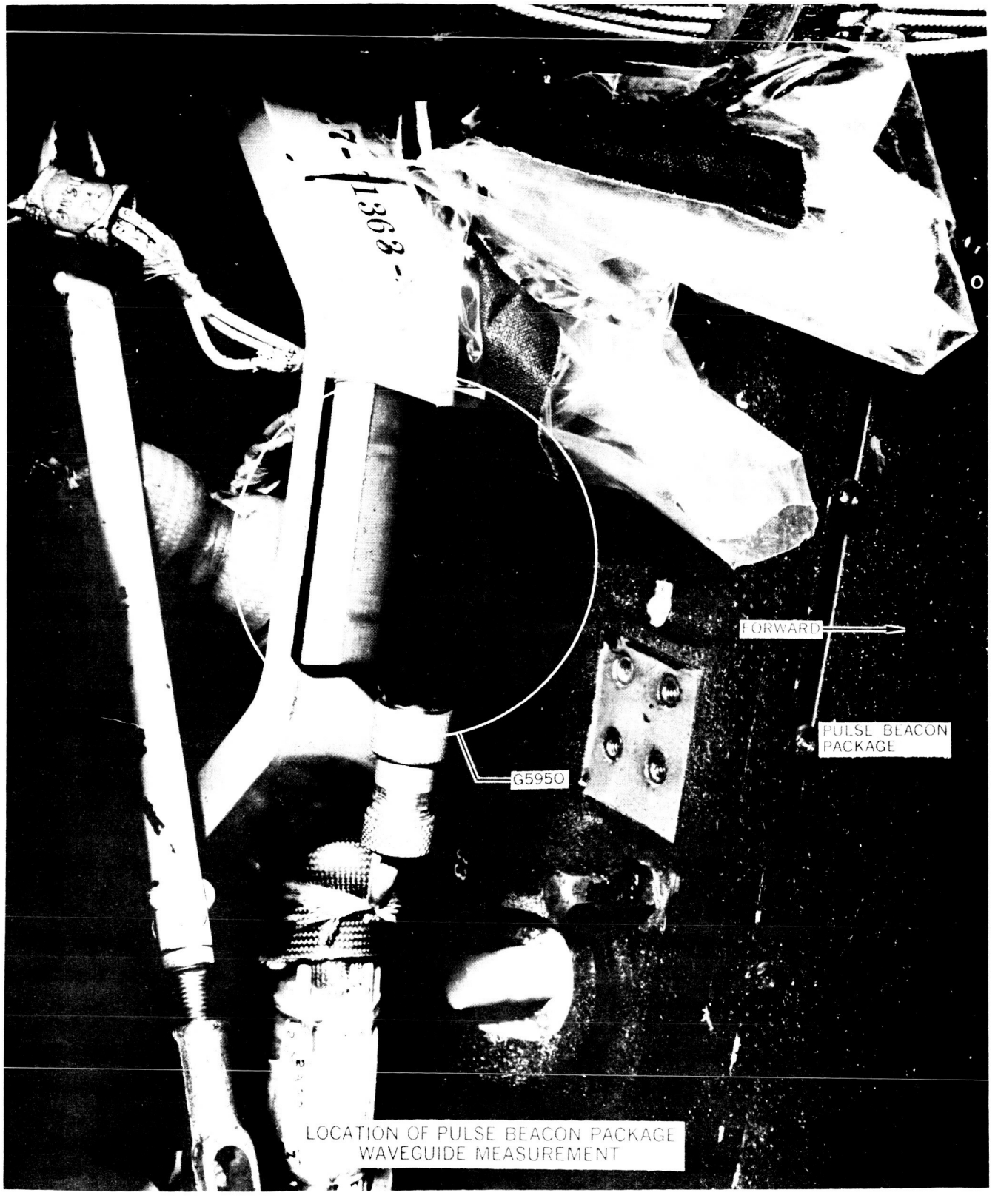


LOCATION OF PULSE BEACON – IMPACT PREDICTOR
MEASUREMENT, FORWARD END OF PACKAGE, RADIAL

VIBRATION ANALYSIS
INSTRUMENTATION BEACON EQUIPMENT



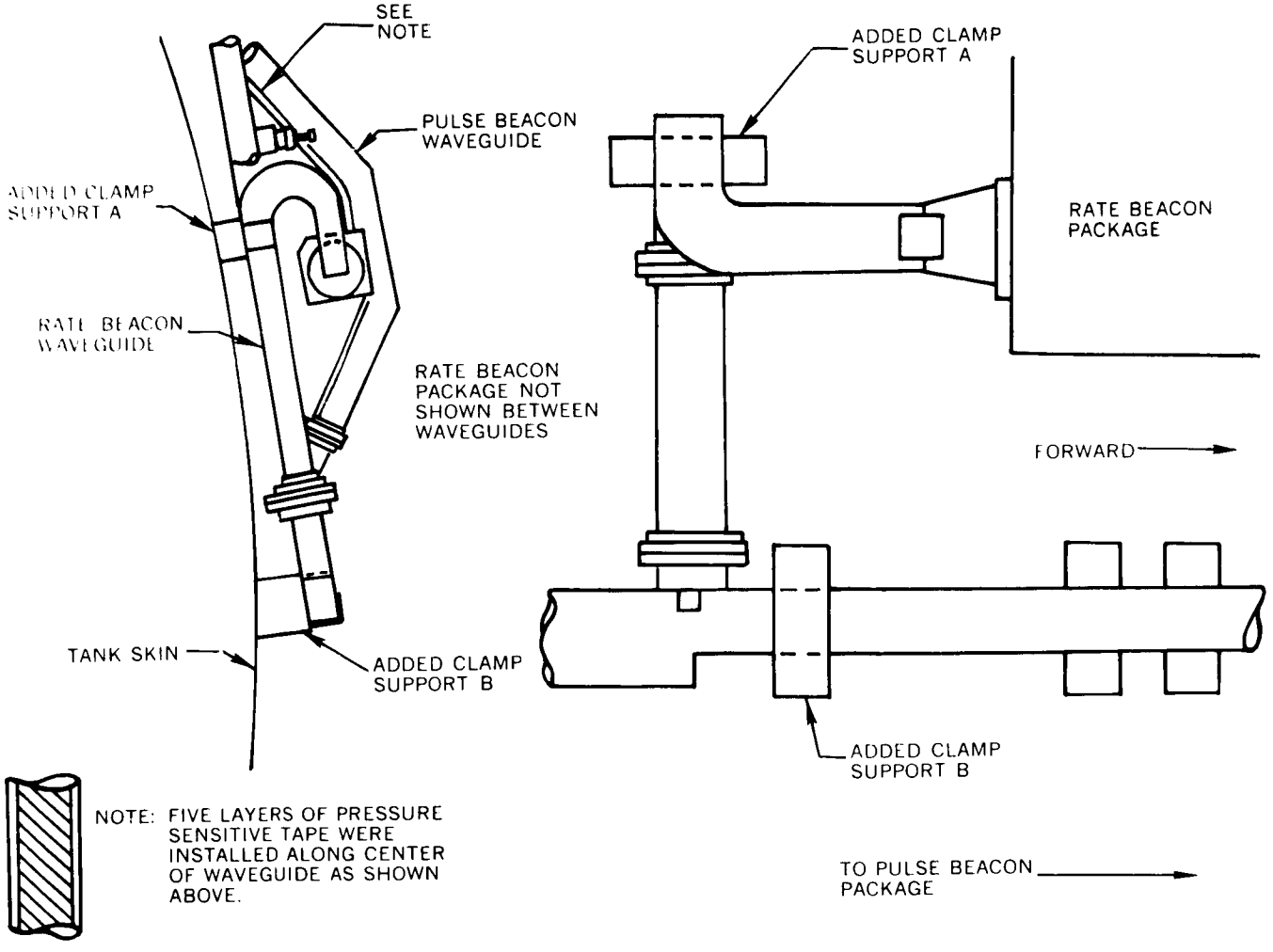
VIBRATION ANALYSIS
INSTRUMENTATION BEACON EQUIPMENT



VIBRATION ANALYSIS
INSTRUMENTATION BEACON EQUIPMENT

MISSILE 17E

SUPPORT ADDED TO WAVEGUIDE ASSEMBLY



VIEW LOOKING FORWARD

VIEW LOOKING INBOARD

SECTION 6.2.7

MISSILE 18E

FLIGHT TESTED 5-26-61

AT AMR COMPLEX 13

TEST REPORT AE61-241

SECTION 17

VIBRATION ANALYSIS

Five high frequency accelerometers were installed at two separate locations on the lox tank helium pressure regulator to determine the vibration environment during flight.

The accelerometers were located as follows:

A781-O	Lox Tank Pressure Regulator Base, Radial
A782-O	Lox Tank Pressure Regulator Base, Longitudinal
A783-O	Lox Tank Pressure Regulator Base, Tangential
A925-O	Lox Tank Pressure Regulator, Radial
A926-O	Lox Tank Pressure Regulator, Tangential

The general location of the accelerometer installations is shown in Figure 16-1. Details of their installation are shown in Figure 17-5. 18E is the first of eight E Series R&D flight missiles which will carry instrumentation to monitor the vibrational environment of the Stratos and F&G pressure regulators.

Each measurement showed valid outputs throughout flight except A782-O which displayed erratic outputs until 39 seconds, when the signal output appeared to become valid. The measurements were analyzed within a frequency band of 10 to 1,000 cps.

Generally, all locations appeared to respond to propulsion system operation. A 720 cps resonant frequency "buzz" of the MA-3 propulsion system was evident between approximately 100 to 125 seconds on four of the five accelerometer outputs. No shocks were recorded between engine start and thrust decay. However, shock loads were observed prior to engine ignition and during the booster jettison sequence. These shock loads were not excessive.

Lox Tank Regulator

Maximum levels occurred at launch, through the Mach 1 - maximum q region, and just prior to booster cutoff. The levels during those periods ranged between 5 and 10 g(rms) at predominant frequencies of 720, 920, and 1440 cps. The environment at the regulator was not excessive. Booster engine 720 cps "buzz" effects were evident to a minor degree on measurement A925-O between 70 and 105 seconds when this same discrete frequency existed alone on the waveform.

The start of the booster section jettison sequence was quite evident on measurement A925-O. A shock load was noted at 129.50 seconds (time of booster section latch release). The maximum instantaneous level was 17g (zero to peak) at a frequency of 45 cps. The shock appeared to be completely damped by 129.53 seconds.

Lox Tank Regulator Base

Maximum levels occurred at launch, through the Mach 1 - maximum q region, and between 100 and 125 seconds of booster operation. The levels during the first two periods ranged between 4 and 8 g(rms), the last period between 9 and 30 g(rms). The predominant frequency ranged between 700 and 1,400 cps. Low frequencies, within a frequency band of 4.5 to 5.2 cps, were displayed on all three accelerometer outputs between launch and 10 seconds. With the high frequency response accelerometer system, levels within this frequency range are unreliable. The waveform also displayed energy bursts on the 720 cps predominant frequency throughout the 100 to 125 second buzz period which varied between 6 to 10 bursts per second. Power density spectral computation made on the measurements are shown in Figures 17-2, 17-3, and 17-4.

Measurement A781-O, radial, showed the greatest response to the buzz condition with maximum levels consistently around 30 g(rms). A very discrete component of 720 cps prevailed through that same period. Somewhat lower levels during the buzz period were apparent on measurement A783-O, tangential. Maximum levels ranged between 20 and 26 g(rms) with a predominant frequency of 720 cps. Bursts of energy were not readily discernable in the waveform. Measurement A782-O, longitudinal (z-axis), showed only slight energy buildup during this same interval. Maximum levels were about 9 g(rms) with a predominant frequency of 720 cps.

UNCLASSIFIED
~~REPORT NO. AE61-0241~~

MISSILE CONFIGURATION

MISSILE 18E

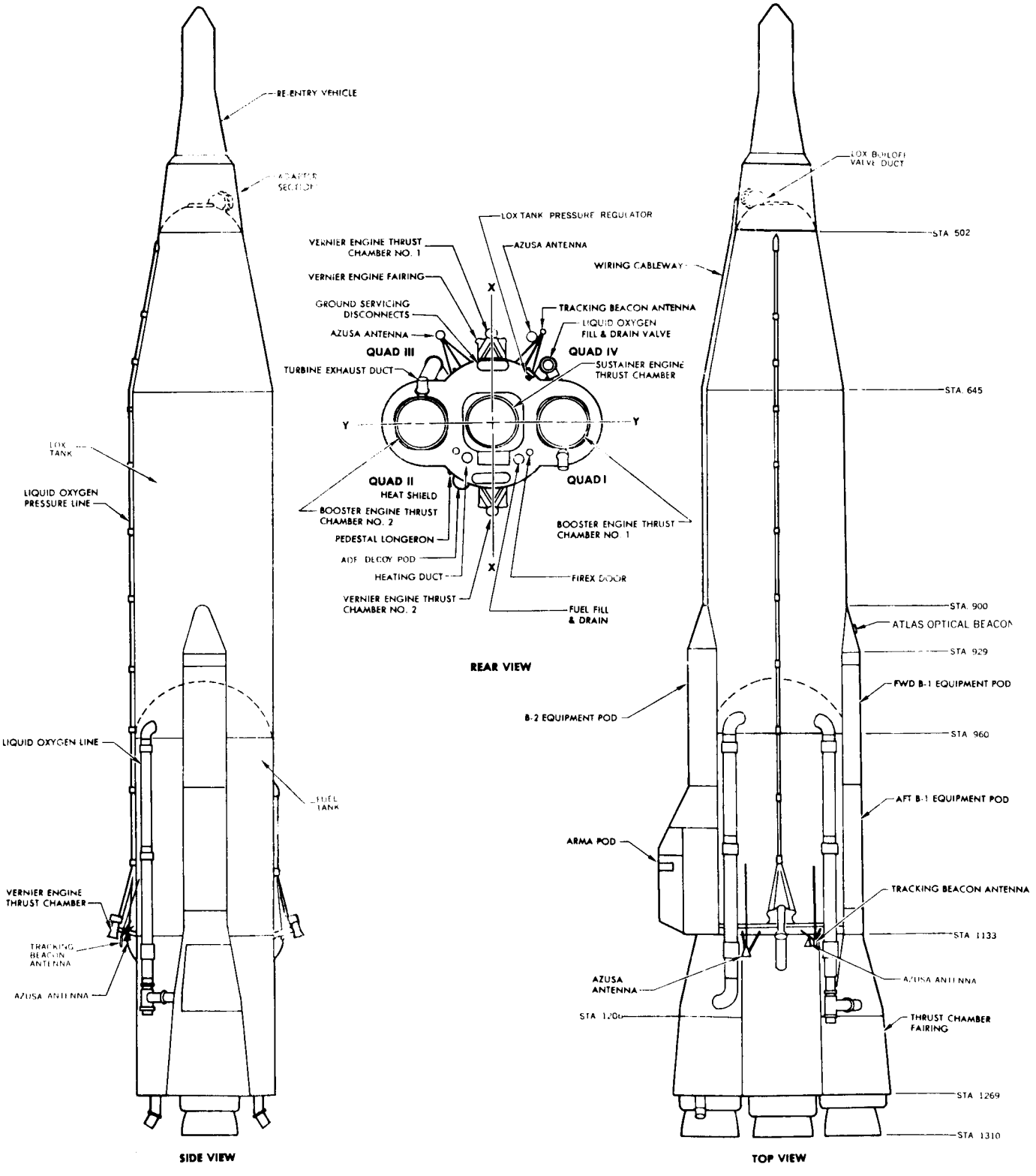
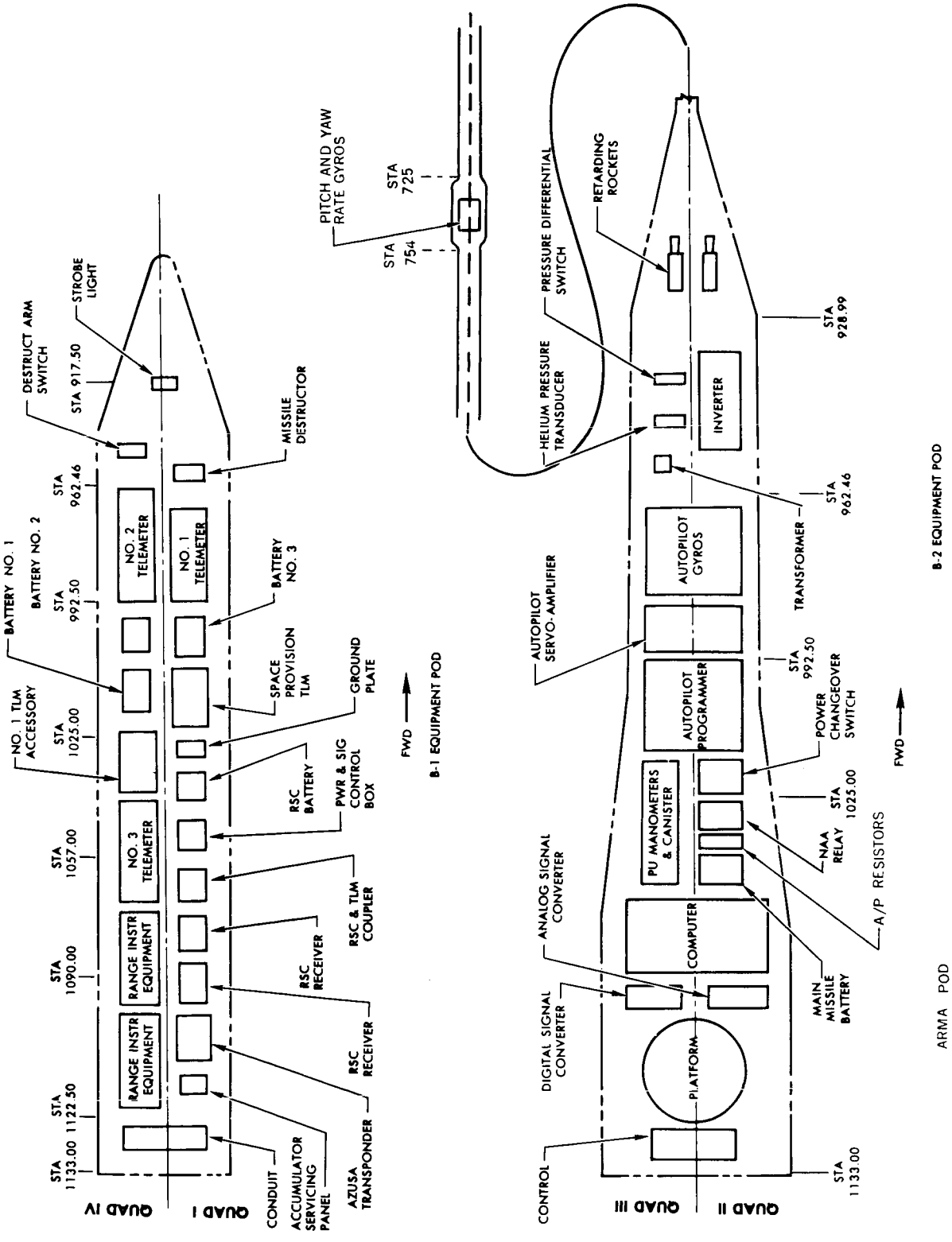


FIGURE NO. 16-2

GD/A-DDE65-016

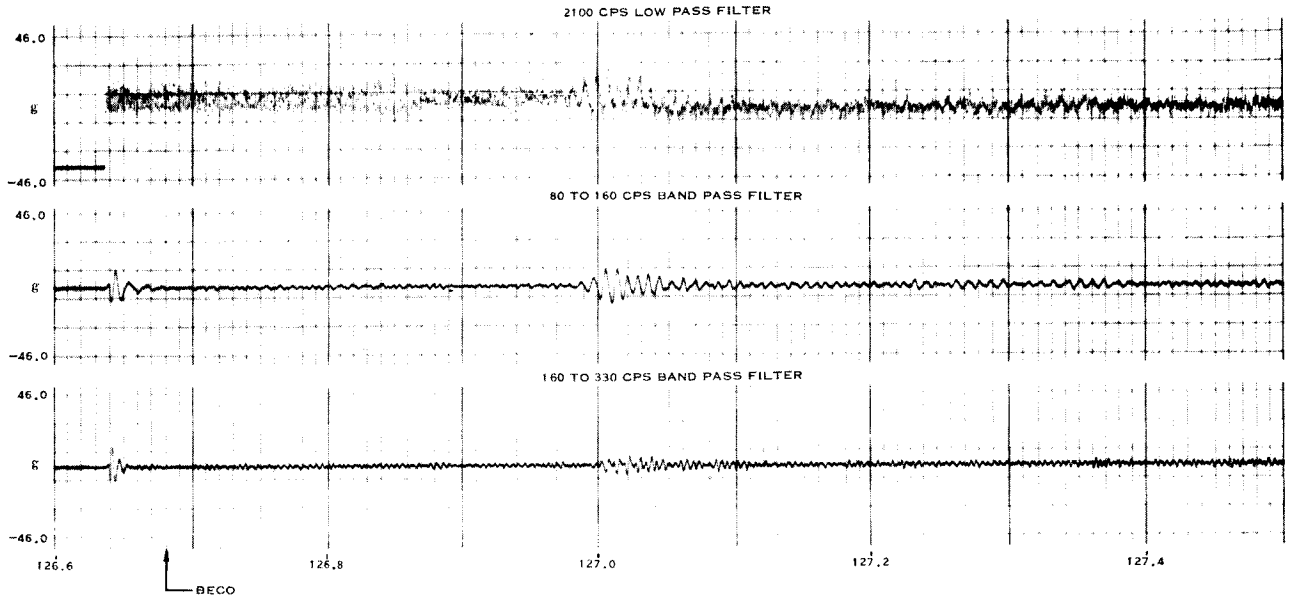
~~REPORT NO. AE61-0241~~

EQUIPMENT PODS CONFIGURATION

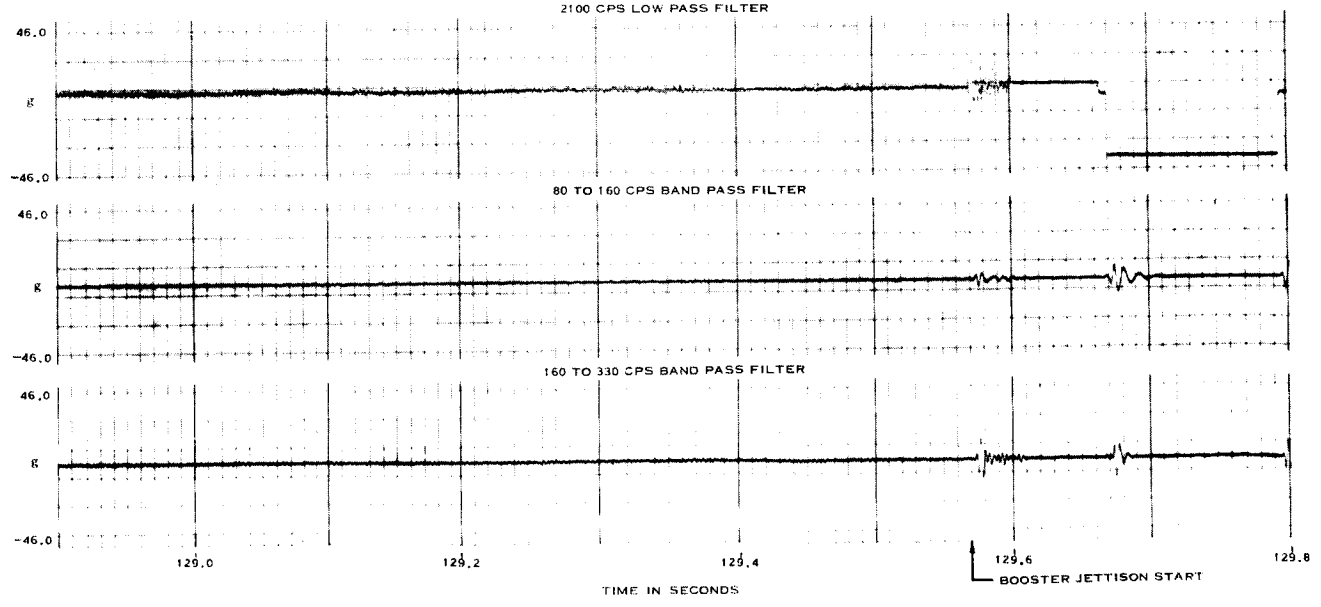


VIBRATION WAVEFORM
MISSILE 18E
BECO + BOOSTER
SEPARATION EXCITATION

A7820 LOX TANK PRESSURE REGULATOR MOUNT, LONGITUDINAL

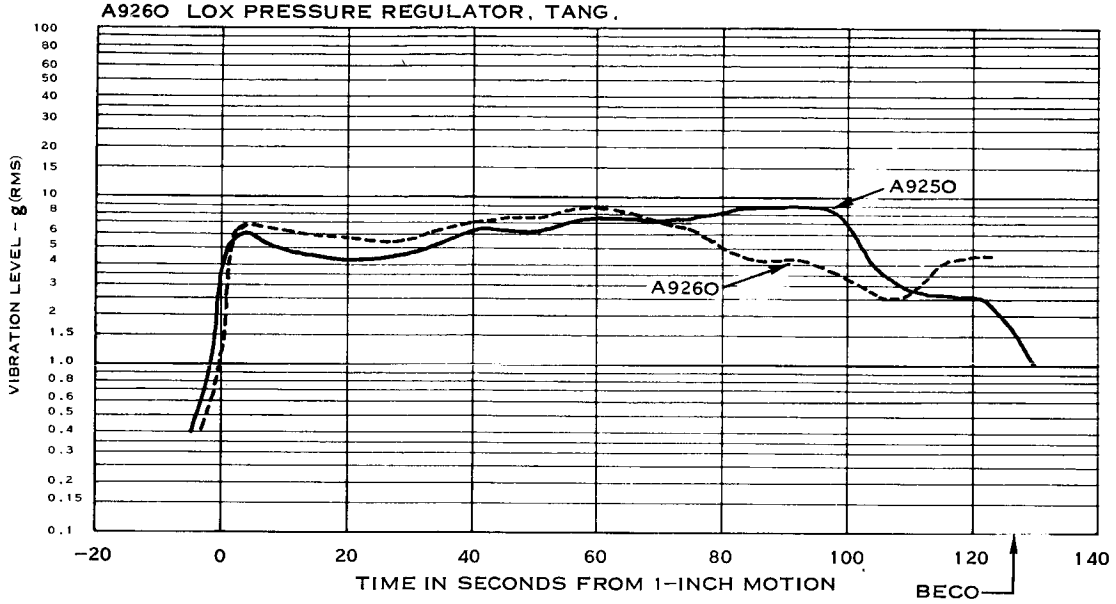


A9250 LOX TANK PRESSURE REGULATOR, RADIAL

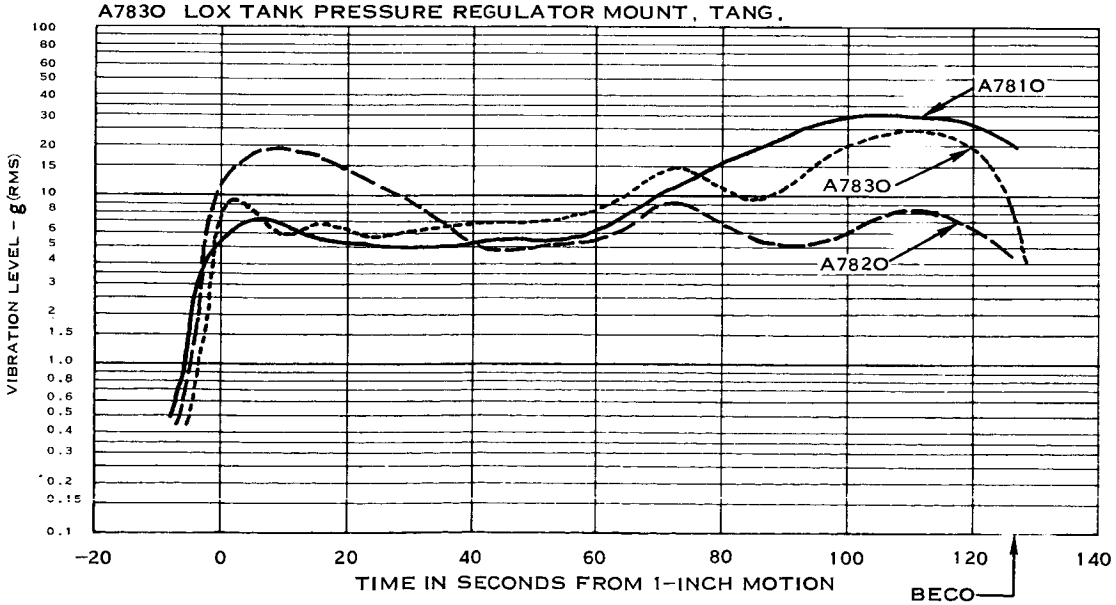


VIBRATION TIME HISTORY
g (RMS) VS TIME
MISSILE 18E
2100 CPS LOW PASS FILTER

A9250 LOX PRESSURE REGULATOR, RADIAL
A9260 LOX PRESSURE REGULATOR, TANG.

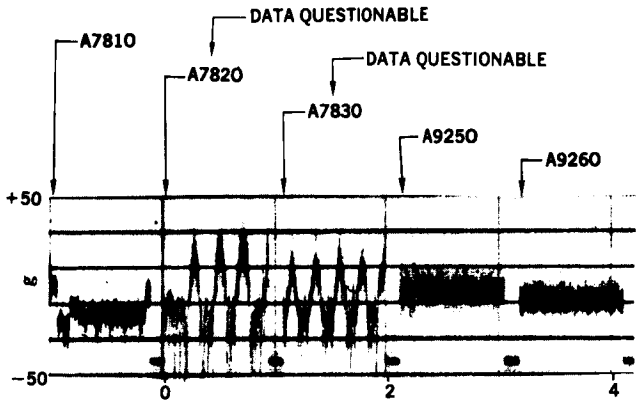


A7810 LOX TANK PRESSURE REGULATOR MOUNT, RADIAL
A7820 LOX TANK PRESSURE REGULATOR MOUNT, LONG.
A7830 LOX TANK PRESSURE REGULATOR MOUNT, TANG.

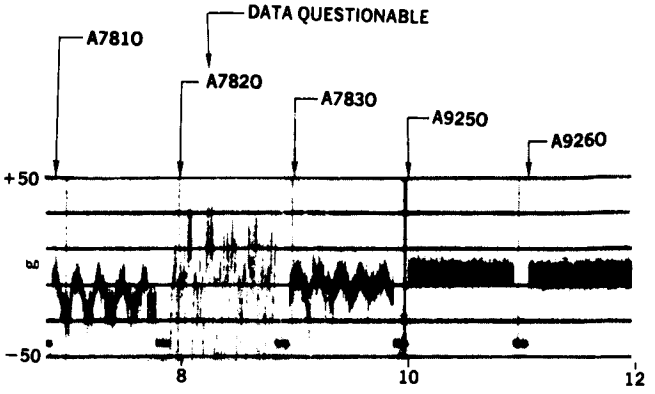


VIBRATION DATA

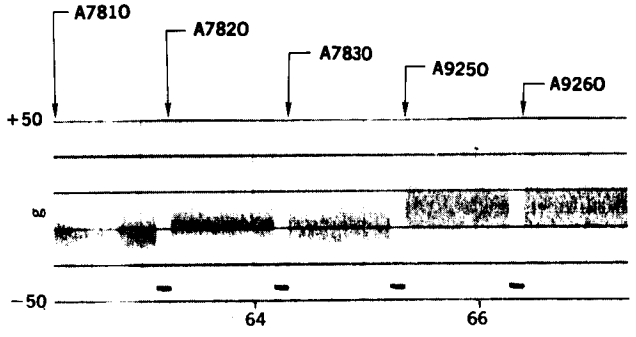
MISSILE 18E



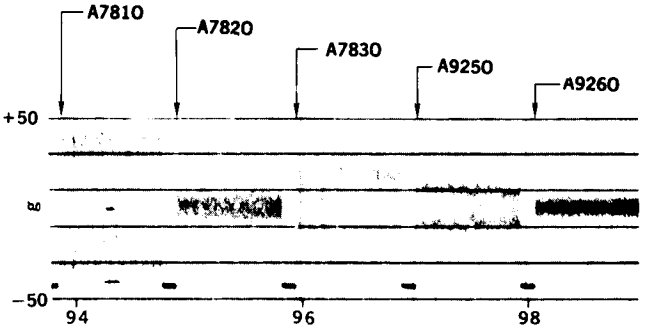
TIME IN SECONDS FROM 1-INCH MOTION



TIME IN SECONDS FROM 1-INCH MOTION



TIME IN SECONDS FROM 1-INCH MOTION



TIME IN SECONDS FROM 1-INCH MOTION

A7810 LOX TANK PRESSURE REGULATOR BASE, RADIAL

A7820 LOX TANK PRESSURE REGULATOR BASE, LONGITUDINAL

A7830 LOX TANK PRESSURE REGULATOR BASE, TANGENTIAL

A9250 LOX TANK PRESSURE REGULATOR , RADIAL

A9260 LOX TANK PRESSURE REGULATOR , TANGENTIAL

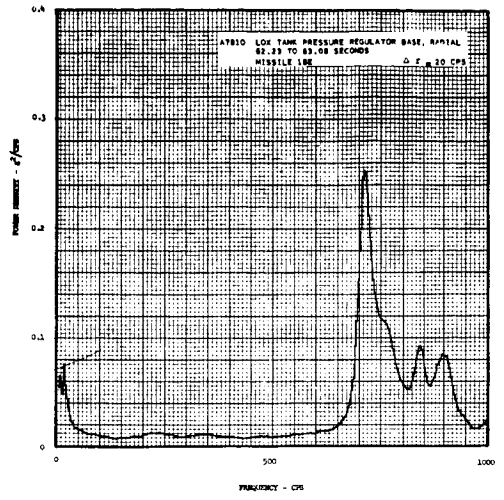
FIGURE NO. 17-2

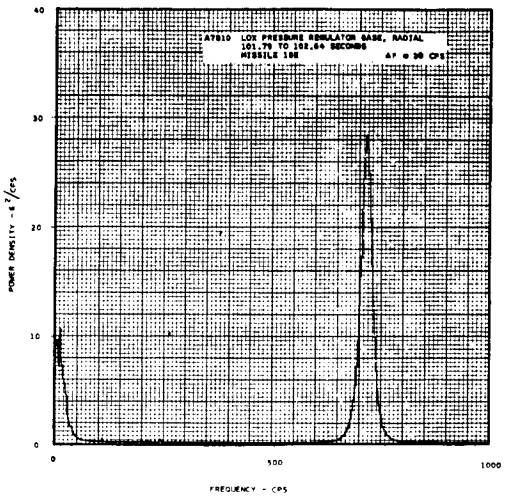
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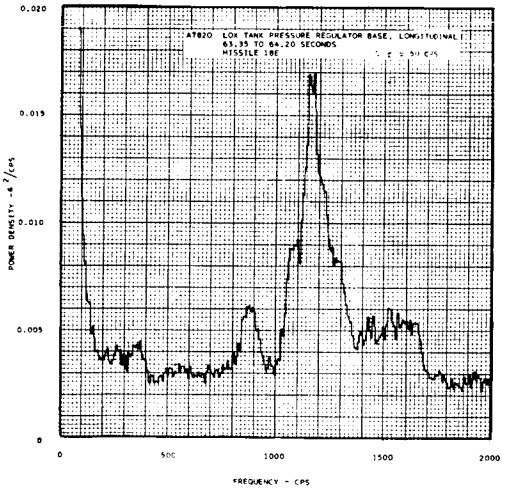
~~REPORT NO. AE61-0241~~ UNCLASSIFIED

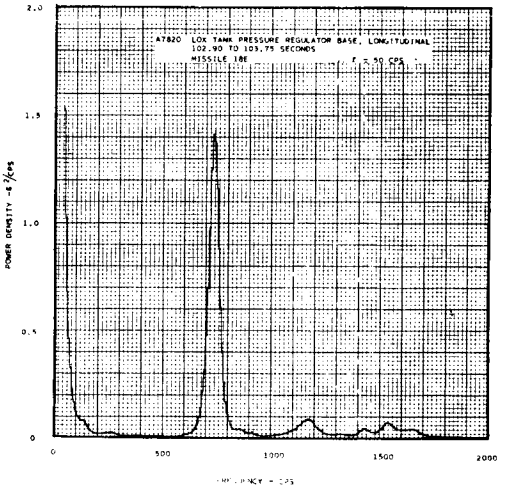
MISSILE 18E

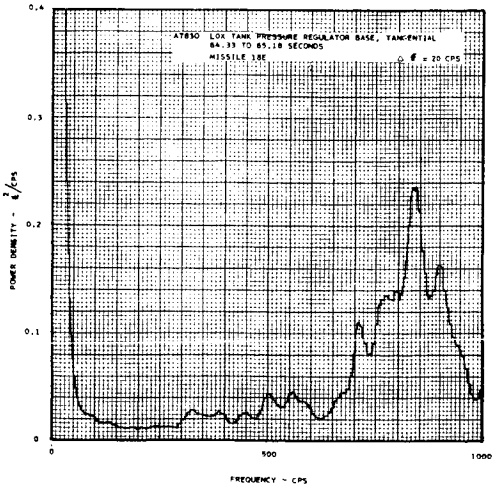
VIBRATION DATA

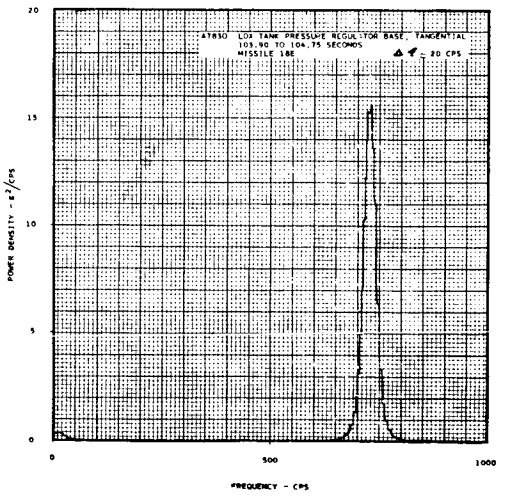


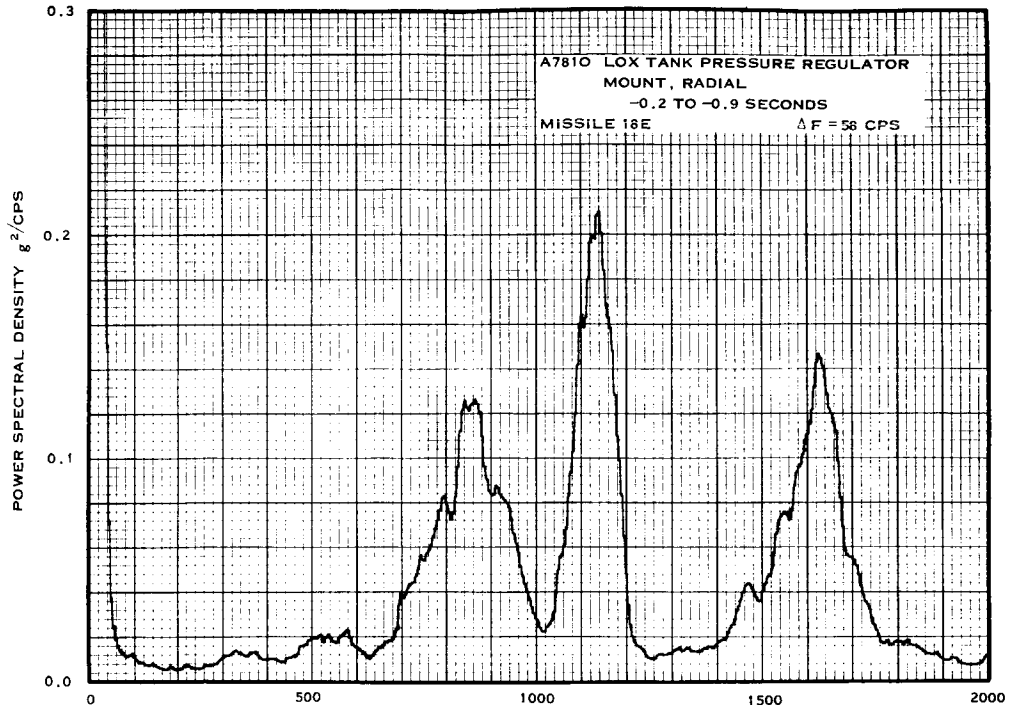


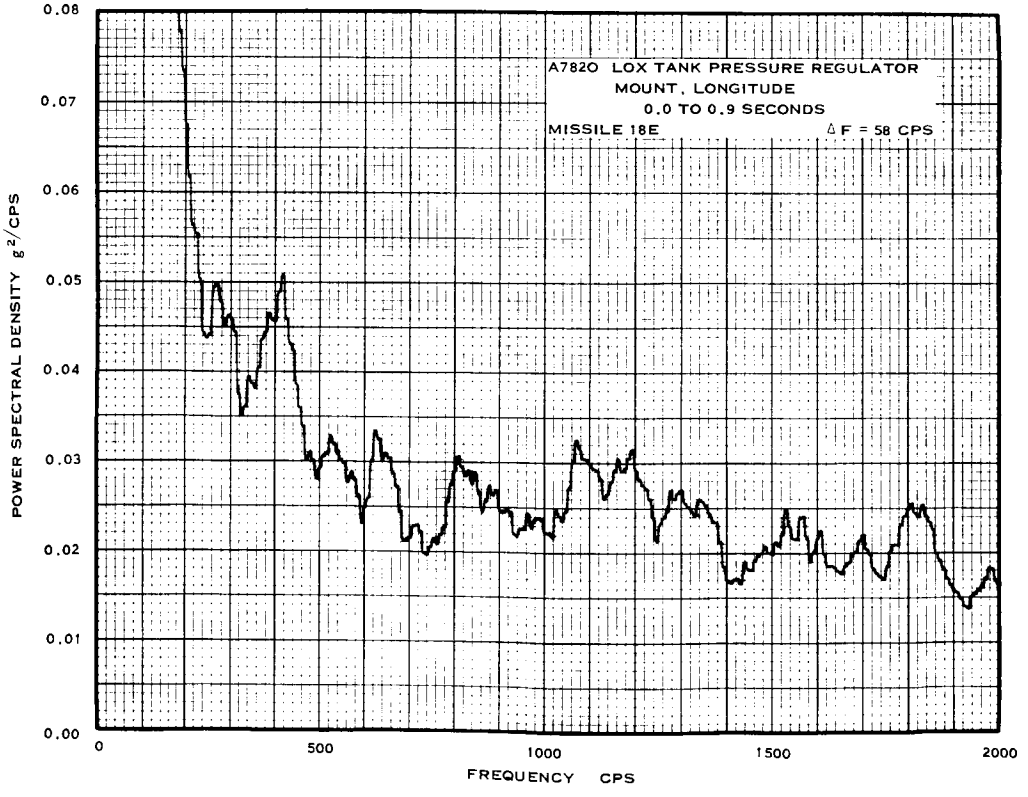


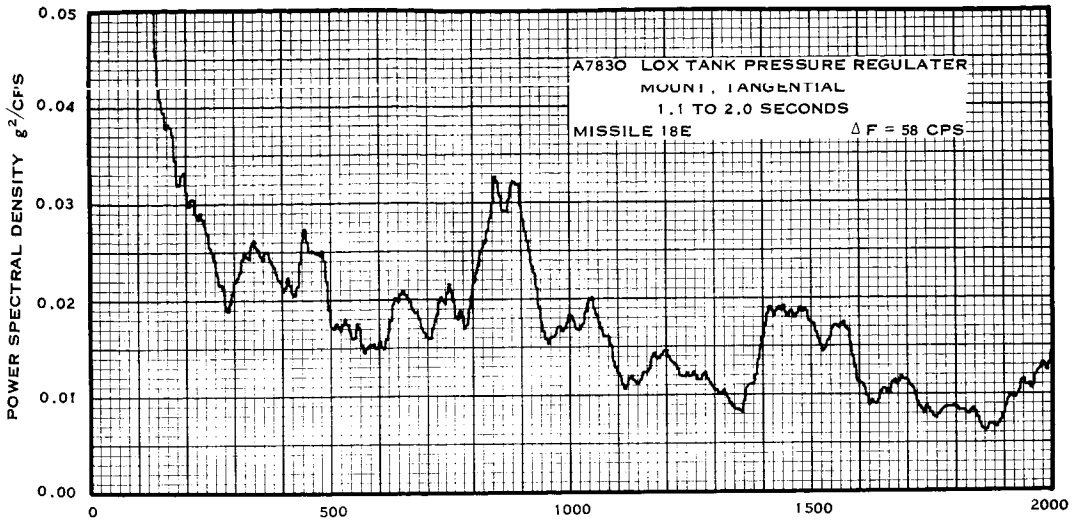


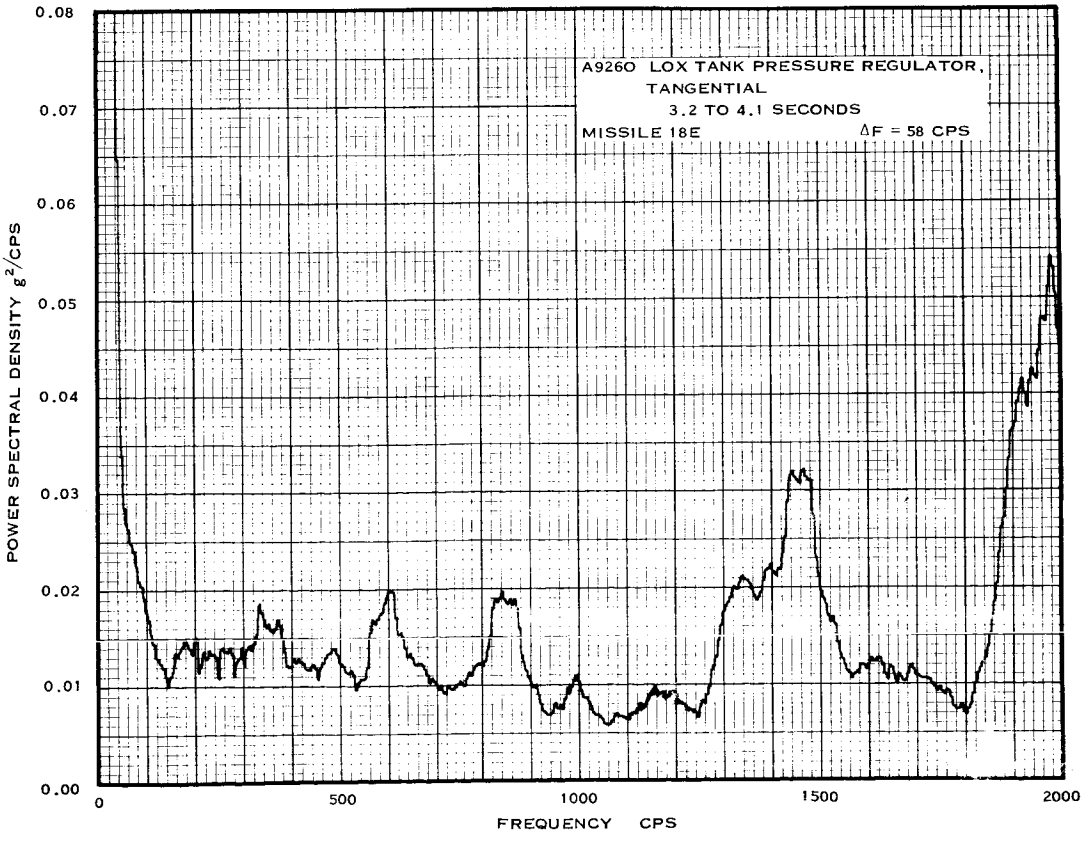


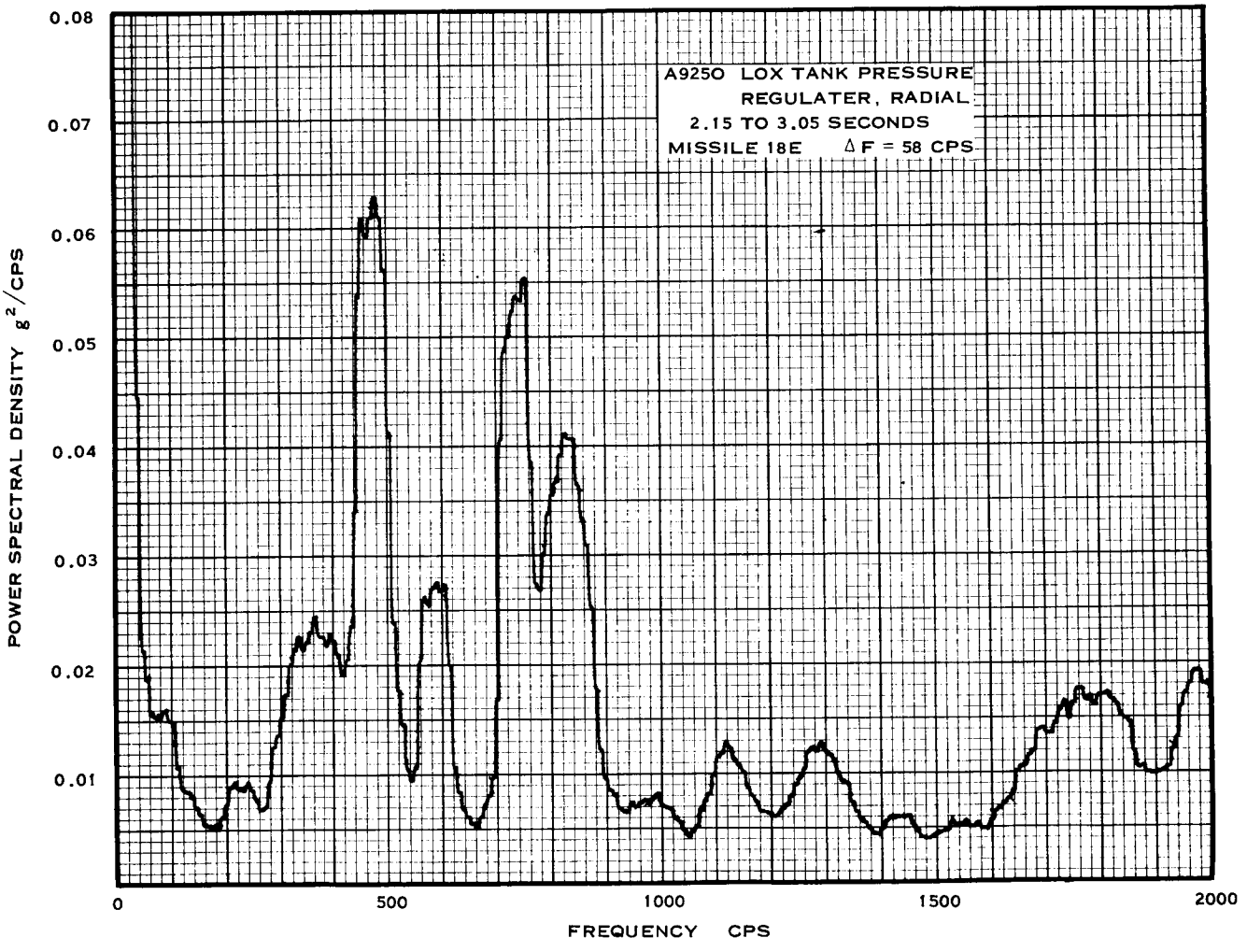



A7810 LOX TANK PRESSURE REGULATOR
MOUNT, RADIAL
-0.2 TO -0.9 SECONDS
MISSILE 18E
Δ F = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.3
0.2
0.1
0.0
0
500
1000
1500
2000


A7820 LOX TANK PRESSURE REGULATOR
MOUNT, LONGITUDE
0.0 TO 0.9 SECONDS
MISSILE 18E
Δ F = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
500
1000
1500
2000
FREQUENCY CPS

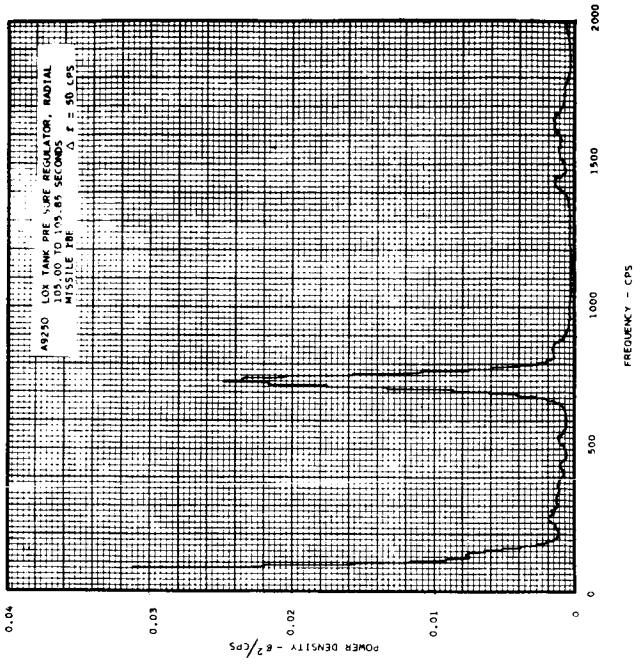

A7830 LOX TANK PRESSURE REGULATER
MOUNT, TANGENTIAL
1.1 TO 2.0 SECONDS
MISSILE 18E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.05
0.04
0.03
0.02
0.01
0.00
0
500
1000
1500
2000

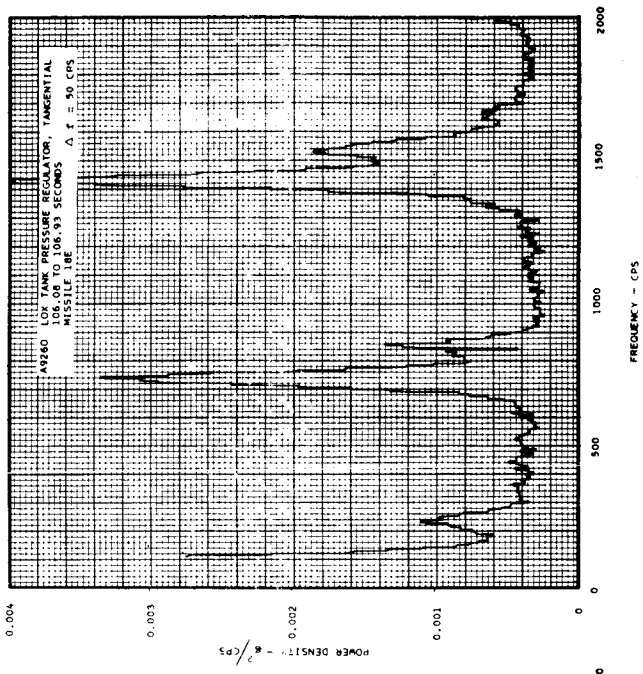

A9260 LOX TANK PRESSURE REGULATOR,
TANGENTIAL
3.2 TO 4.1 SECONDS
MISSILE 18E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
500
1000
1500
2000
FREQUENCY CPS

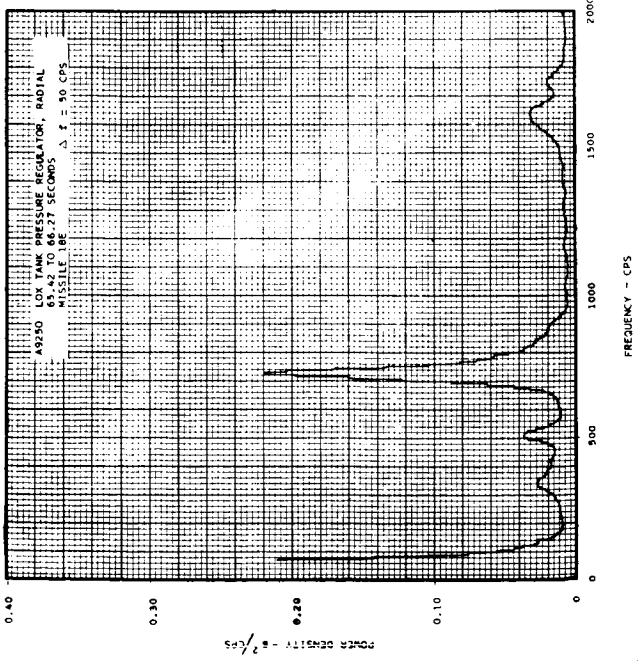

A9250 LOX TANK PRESSURE
REGULATER, RADIAL
2.15 TO 3.05 SECONDS
MISSILE 18E
ΔF = 58 CPS
POWER SPECTRAL DENSITY g²/CPS
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
500
1000
1500
2000
FREQUENCY CPS

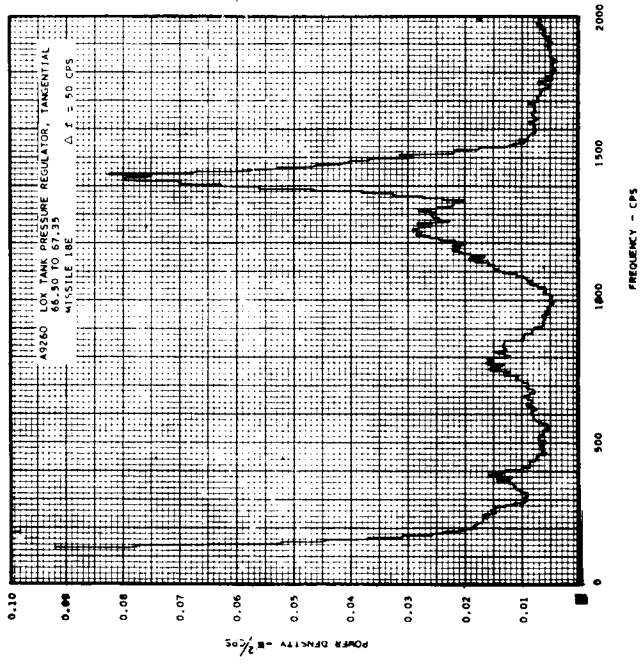
VIBRATION DATA

MISSILE 18E





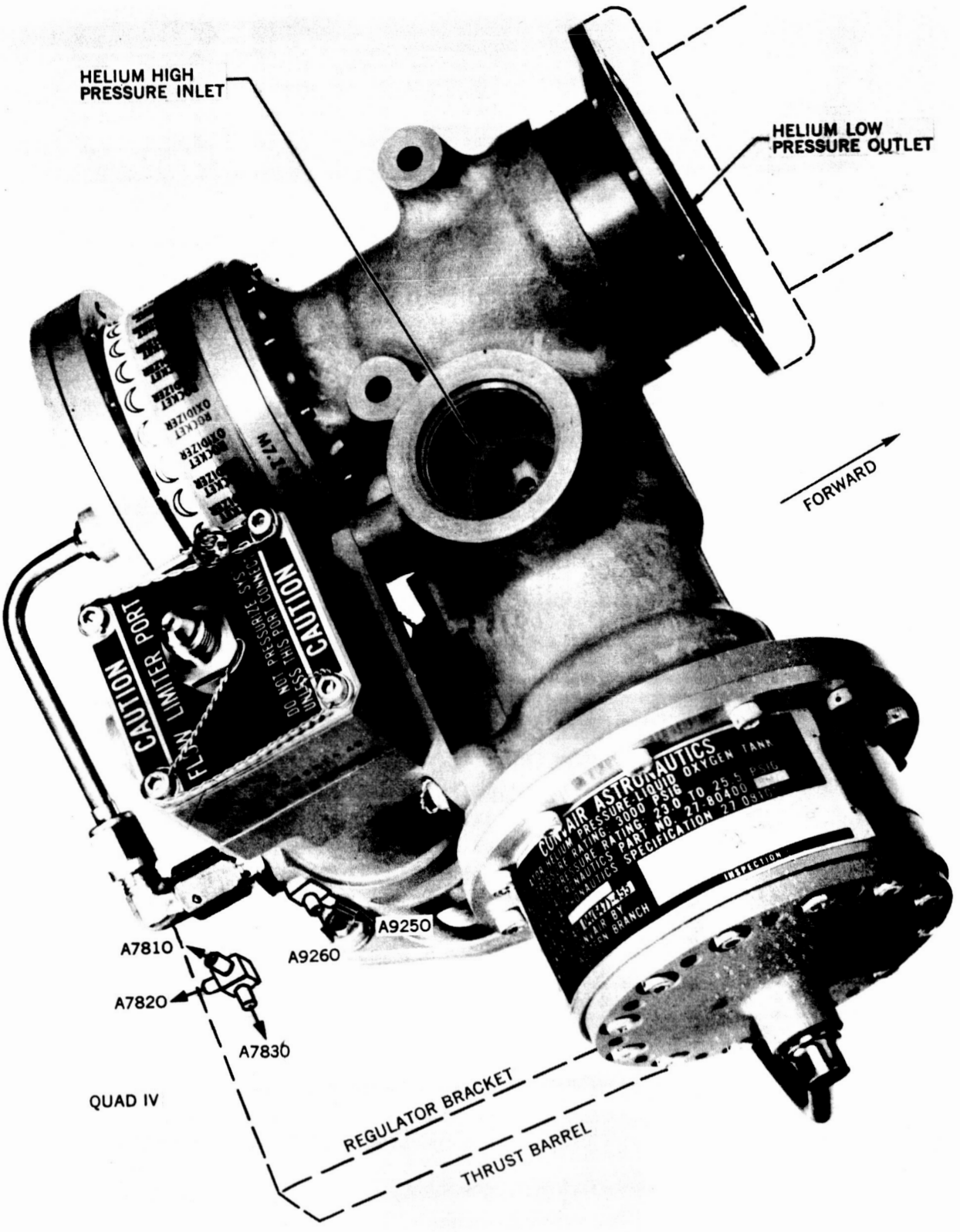




UNCLASSIFIED

MISSILE 18E

LOCATION OF ACCELEROMETERS ON STRATOS LOX TANK PRESSURE REGULATOR



SECTION 6.2 8

MISSILE 21E

FLIGHT TESTED 6-31-61

AT AMR COMPLEX 11

TEST REPORT AE61-0641

SECTION 17

VIBRATION ANALYSIS

High frequency vibration measurements were obtained from the lox tank pressure regulator (Stratos) during flight as part of a study to evaluate the vibration environment at each tank pressure regulator installation and to compare the two types of regulators (Stratos and F & G) utilized during the Series E flight test program. Lox tank pressure regulator vibration data has been obtained from Missiles 18E and 21E, both using the Stratos regulator. Generally, adequate data was obtained from the flight of Missile 21E to determine the vibration environment at the regulator. The levels observed at the regulator appeared to be within the currently prescribed design allowable limits. The analysis was made within a frequency band of 10 to 2000 cps.

Five high frequency accelerometers were installed on the regulator as shown in Figures 17-5, 17-6, and 17-7. The specific locations were as follows:

A781O Regulator Base, Radial
A782O Regulator Base, Longitudinal
A783O Regulator Base, Tangential
A925O Regulator, Radial
A926O Regulator, Tangential

Generally, the data was adequate for evaluation purposes; however, the first 60 seconds of data on A781O and A782O appeared erratic and was deemed questionable. It was apparent that each output mentioned above showed response to the first missile longitudinal mode (5.3 cps), but also contained an erroneous bias shift of the trace. The same effect was observed on Missile 18E data. This condition is now being investigated. It is hypothesized that a large magnitude high frequency signal (somewhere between 9 and 20 KC) was transmitted to the accelerometer amplifiers, which resulted in erratic operation of the amplifiers. The high frequency signal may also be the cause of noise on adjacent telemetry channels (Reference Section 19). Figure 17-1 shows an oscillograph recording of the measurements.

The regulator measurements showed the greatest response to vibration at launch and through the maximum q period (60 to 70 seconds). Over-all levels at the regulator base ranged between 1 and 10.8 g(rms) with predominant frequencies ranging between 740 and 1500 cps. The over-all levels indicated at the regulator ranged between 1 and 6 g(rms) with predominant frequencies ranging between 740 and 1630 cps. The regulator showed a general decrease in vibration between maximum q and BCO. Prior to BCO each measurement displayed levels ranging between 1 and 2 g(rms). As observed before, a good amount of damping action prevailed between the main base mount and regulator, since the vibratory response between the

mount and the regulator was attenuated by a factor of 2. A comparison of data from Missiles 18E and 21E is shown on Table 1.

The 720 cps buzz (input from Propulsion System operation) condition, was not noted to a significant degree on this flight. The 720 cps buzz condition was very apparent on the vibration data from Missile 18E.

Power density spectral computations were made for each measurement as shown in Figures 17-2, 17-3, and 17-4.

A brief discussion of each measurement is shown below.

Regulator Base Vibration

A781O and A782O showed erratic outputs that were out of the intelligence bandwidth until approximately 60 seconds. At that time the outputs appeared valid. A781O and A782O showed the maximum levels at approximately maximum q which were 10.79 and 9.05 g(rms), respectively. Predominant frequencies were 1400 and 860 cps, respectively.

A783O showed valid data at launch. Response to the missile's first longitudinal mode (5.3 cps) was evident until approximately 11 seconds. The maximum level indicated was approximately 1.7 g zero-to-peak, but the exactness of this level is questioned since the subject is below the calibrated range of the transducer. Also, the adequacy of accelerometer system operation below 10 cps is questionable. The maximum level of 8.28 g (rms) occurred between 68 and 70 seconds. The predominant frequency components evident through booster stage ranged between 1600 and 1870 cps.

Regulator Vibration

A925O showed maximum vibration levels at launch. The maximum over-all level observed within the frequency band of 10 and 2000 cps was 6.2 g (rms). Predominant frequencies were 68, 1430, and 1600 cps through booster stage. A 5.1 cps frequency component was observed at launch with a level comparable to that observed on Measurement A783O.

A926O also indicated maximum levels at launch. The maximum over-all level observed was 4.89 g (rms) with a predominant frequency of 940 cps. The 5 cps component was not evident on this measurement. Predominant frequencies throughout booster stage were 78, 740, 850, and 940 cps.

TABLE 1

LOX TANK PRESSURE REGULATOR VIBRATION

Comparison of Levels on Missiles 18E and 21E

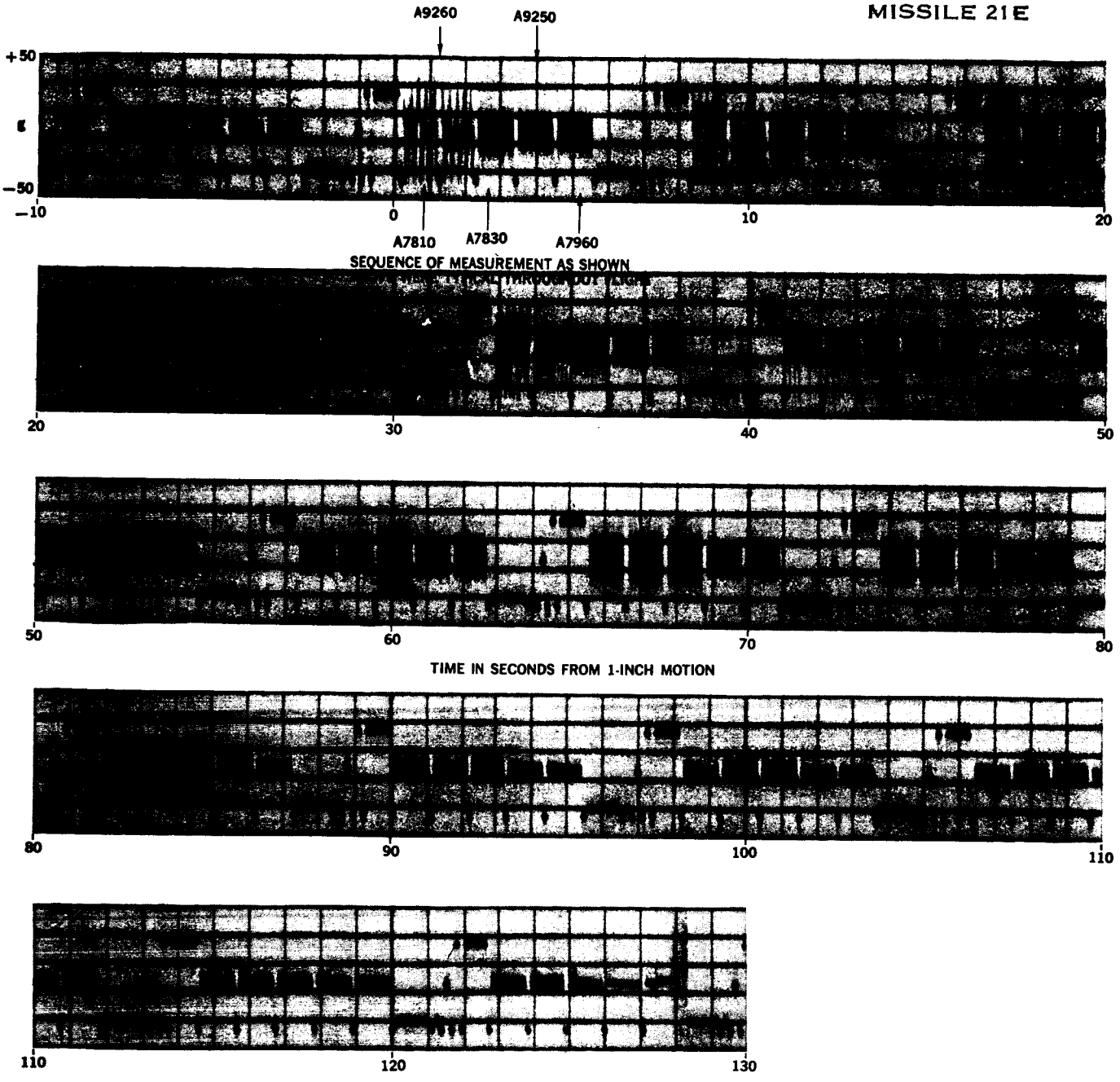
Missile/Flight Period	A7810		A7820		A7830		A9250		A9260	
	Accel., g(rms)	Pred. Freq. (cps)	Accel. g(rms)	Pred. Freq. (cps)	Accel. g(rms)	Pred. Freq. (cps)	Accel. g(rms)	Pred. Freq. (cps)	Accel. g(rms)	Pred. Freq. (cps)
18E										
Launch	Q	-	Q	-	Q	-	5	920	5	1400
Max. q	5	720	3.6	1160	7.3	840	5.7	715	6.3	1430
101 to 106 Seconds	30	720	9	730	22	720	1.6	740	1.4	1420
									-	740
21E										
Launch	Q	-	Q	-	3.8	970	6	1430	4.9	940
Max. q	10.8	1400	9	860	8.3	960	3.9	1600	4.3	740
									-	890
107 to 111 seconds	3	1460	1.9	860	1	740	0.8	1630	1	850

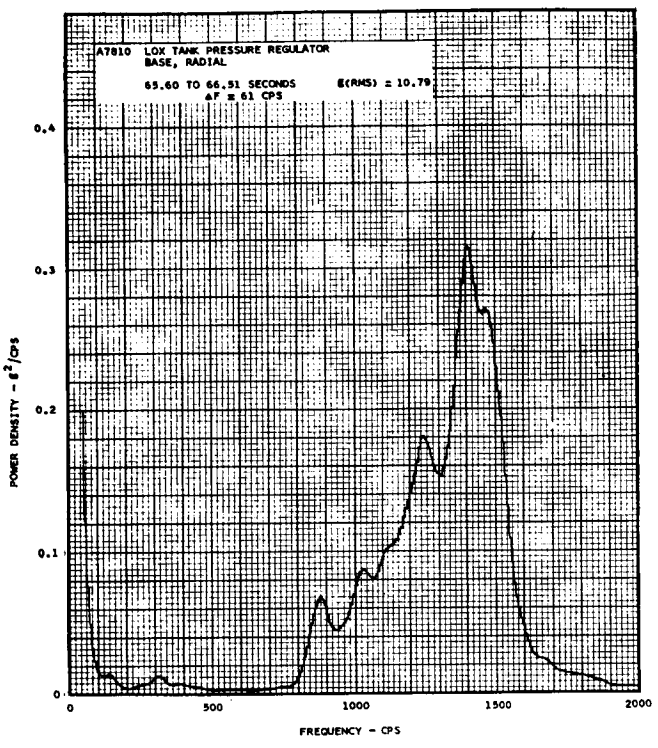
Q = Questionable data.

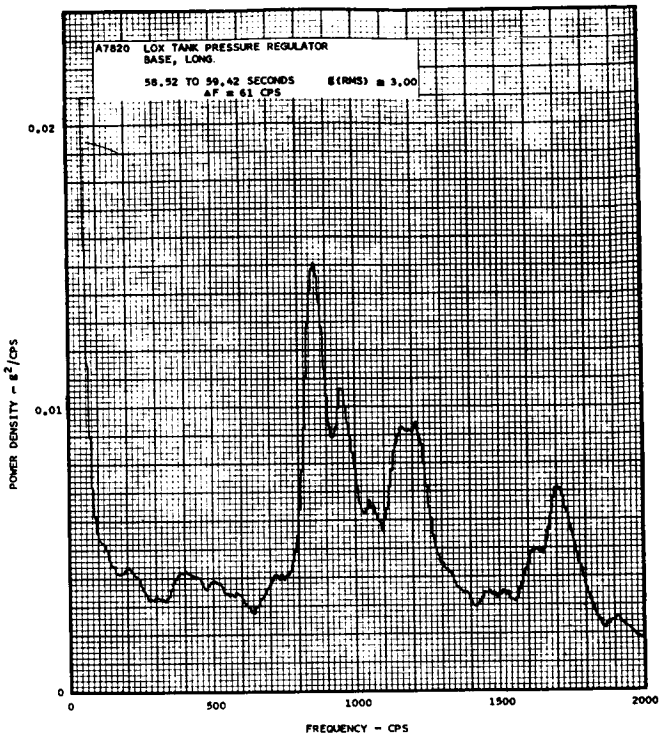
Analysis was conducted within frequency band of 10 to 2000 cps. Vibratory acceleration shown is over-all level for the frequency band analyzed.

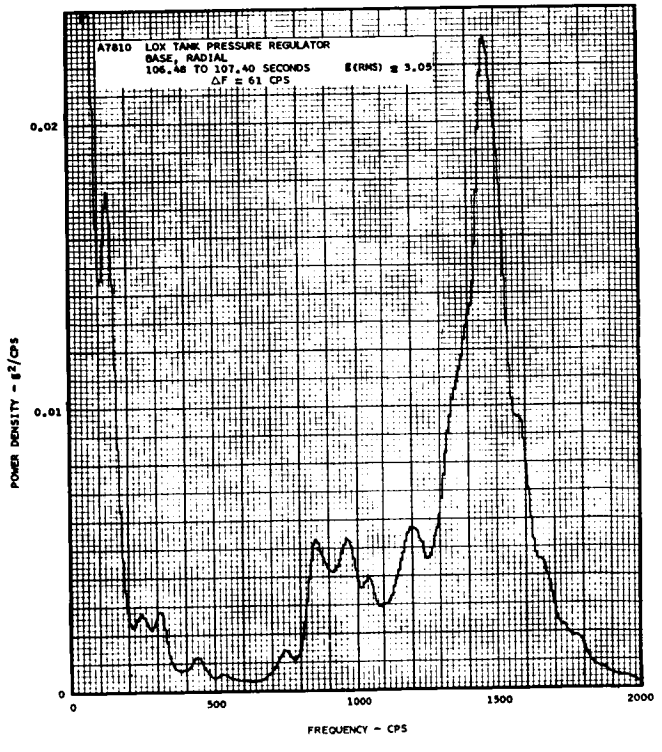
VIBRATION TELEMETERED DATA

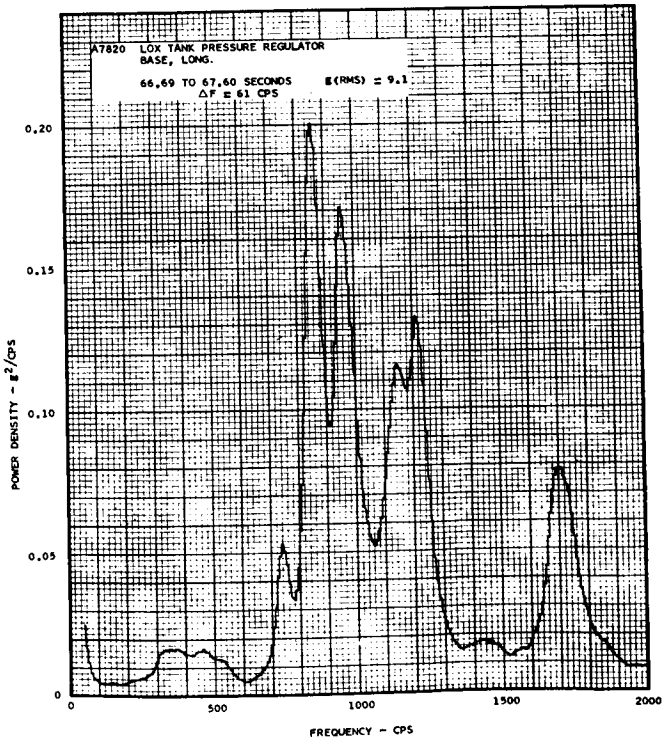
MISSILE 21E

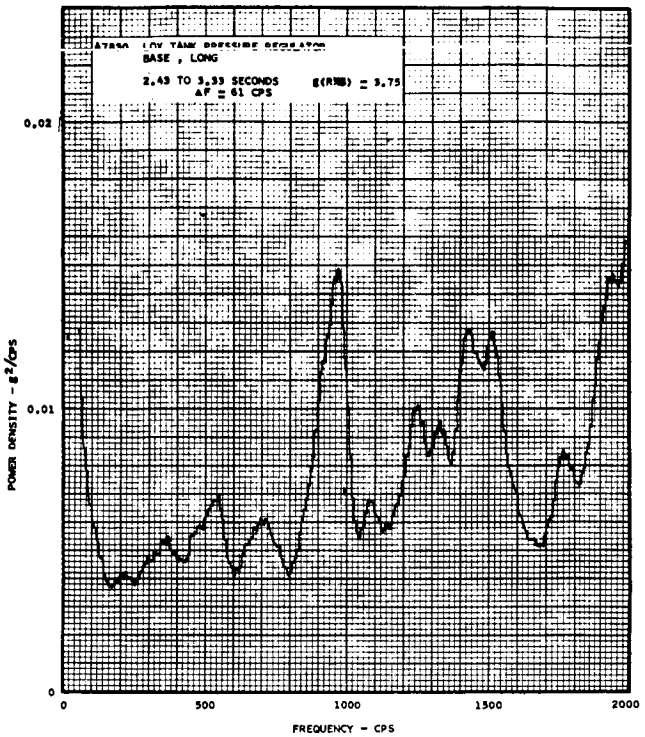


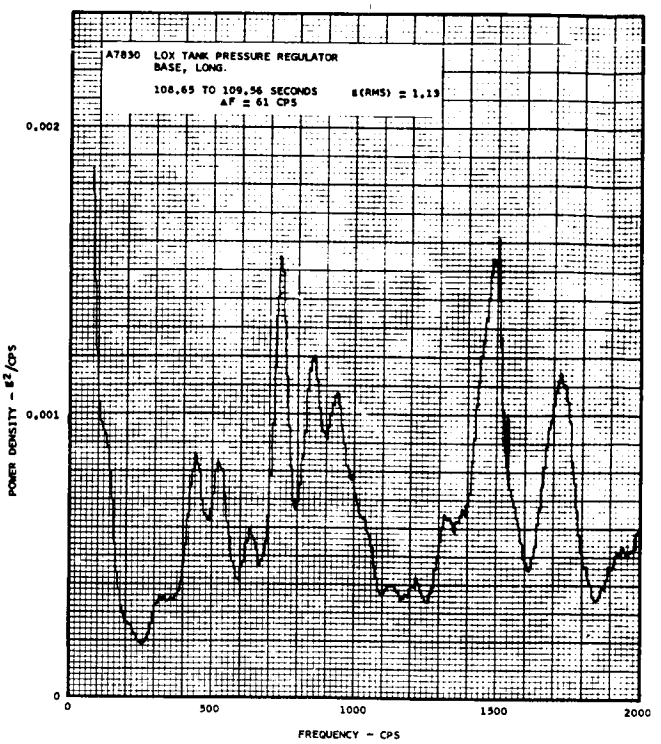

A7810 LOX TANK PRESSURE REGULATOR
BASE, RADIAL
65.60 TO 66.51 SECONDS
ΔF = 61 CPS
E(RMS) = 10.79
POWER DENSITY - g²/cps
FREQUENCY - CPS

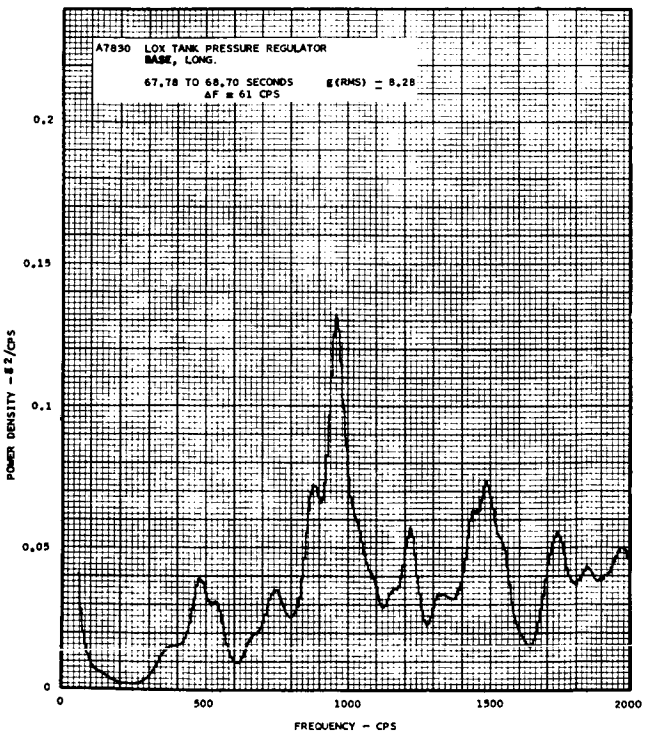

A7820 LOX TANK PRESSURE REGULATOR
BASE, LONG.
58.52 TO 59.42 SECONDS
ΔF = 61 CPS
E(RMS) = 3.00
POWER DENSITY - g²/cps
FREQUENCY - CPS

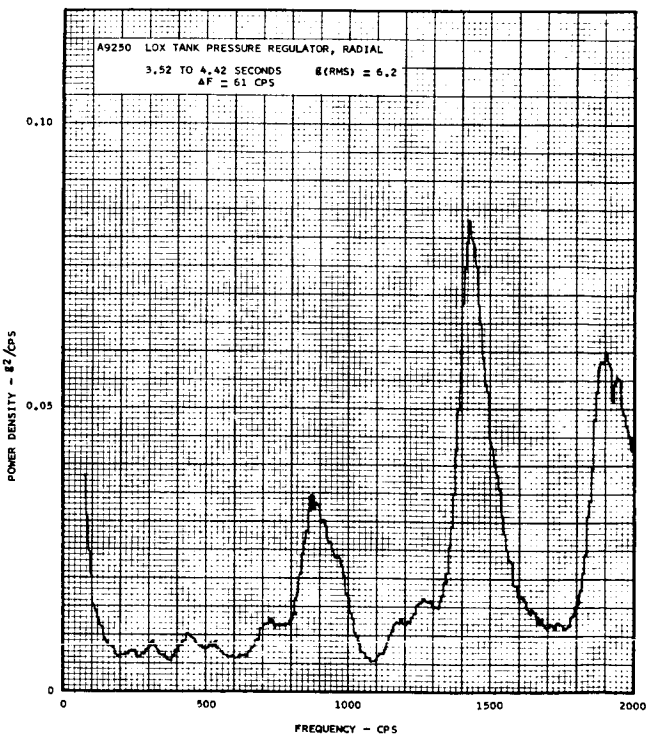

A7810 LOX TANK PRESSURE REGULATOR
BASE, RADIAL
106.48 TO 107.40 SECONDS
ΔF = 61 CPS
E(RMS) = 3.05
POWER DENSITY - g²/cps
FREQUENCY - CPS

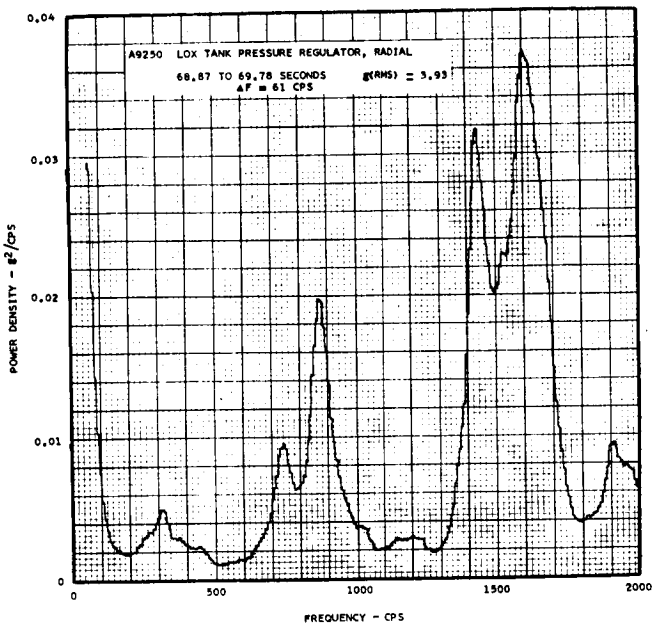

A7820 LOX TANK PRESSURE REGULATOR
BASE, LONG.
66.69 TO 67.60 SECONDS
ΔF = 61 CPS
E(RMS) = 9.1
POWER DENSITY - g²/cps
FREQUENCY - CPS

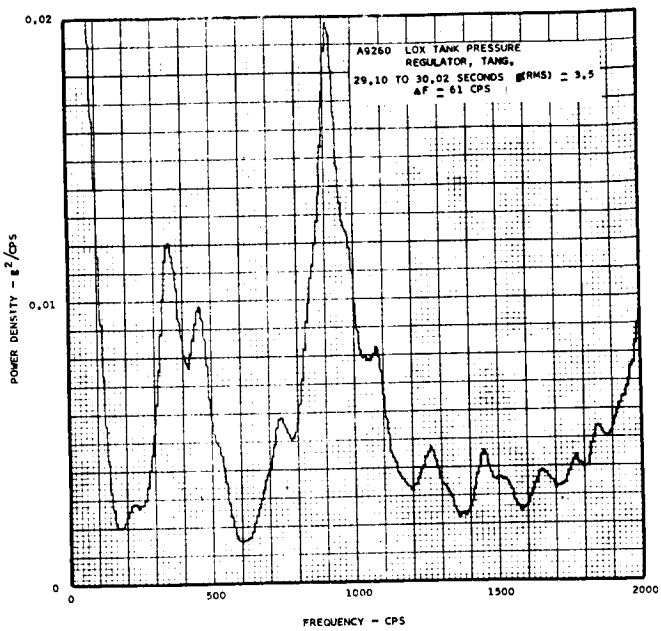

A7830 LOX TANK PRESSURE REGULATOR
BASE , LONG
2.43 TO 3.33 SECONDS
ΔF = 61 CPS
POWER DENSITY - g²/cps
FREQUENCY - CPS

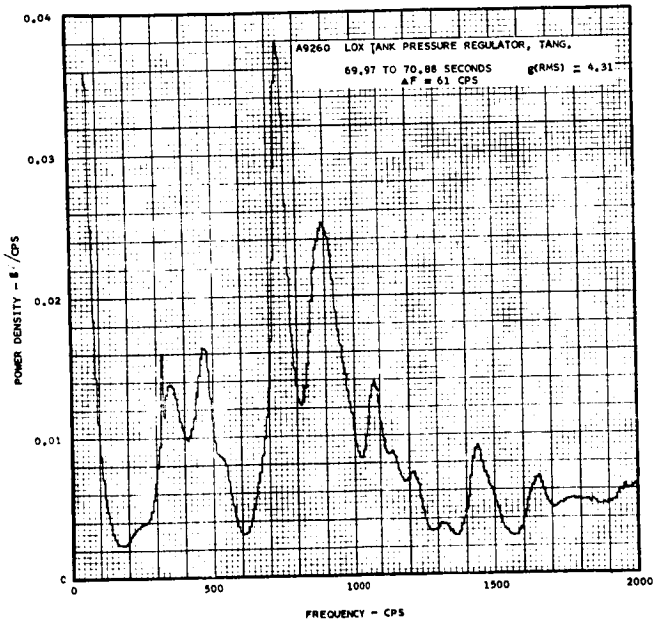

A7830 LOX TANK PRESSURE REGULATOR
BASE, LONG.
108.65 TO 109.56 SECONDS
ΔF = 61 CPS
POWER DENSITY - g²/cps
FREQUENCY - CPS

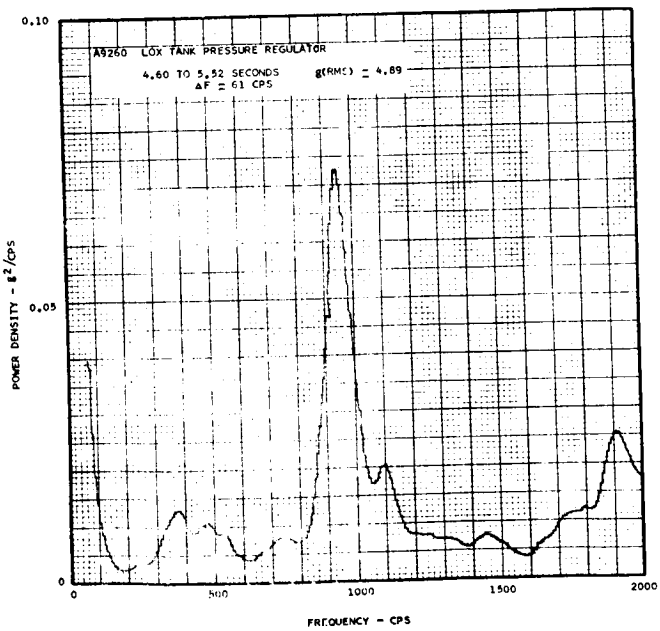

A7830 LOX TANK PRESSURE REGULATOR
BASE, LONG.
67.78 TO 68.70 SECONDS
ΔF = 61 CPS
POWER DENSITY - g²/cps
FREQUENCY - CPS

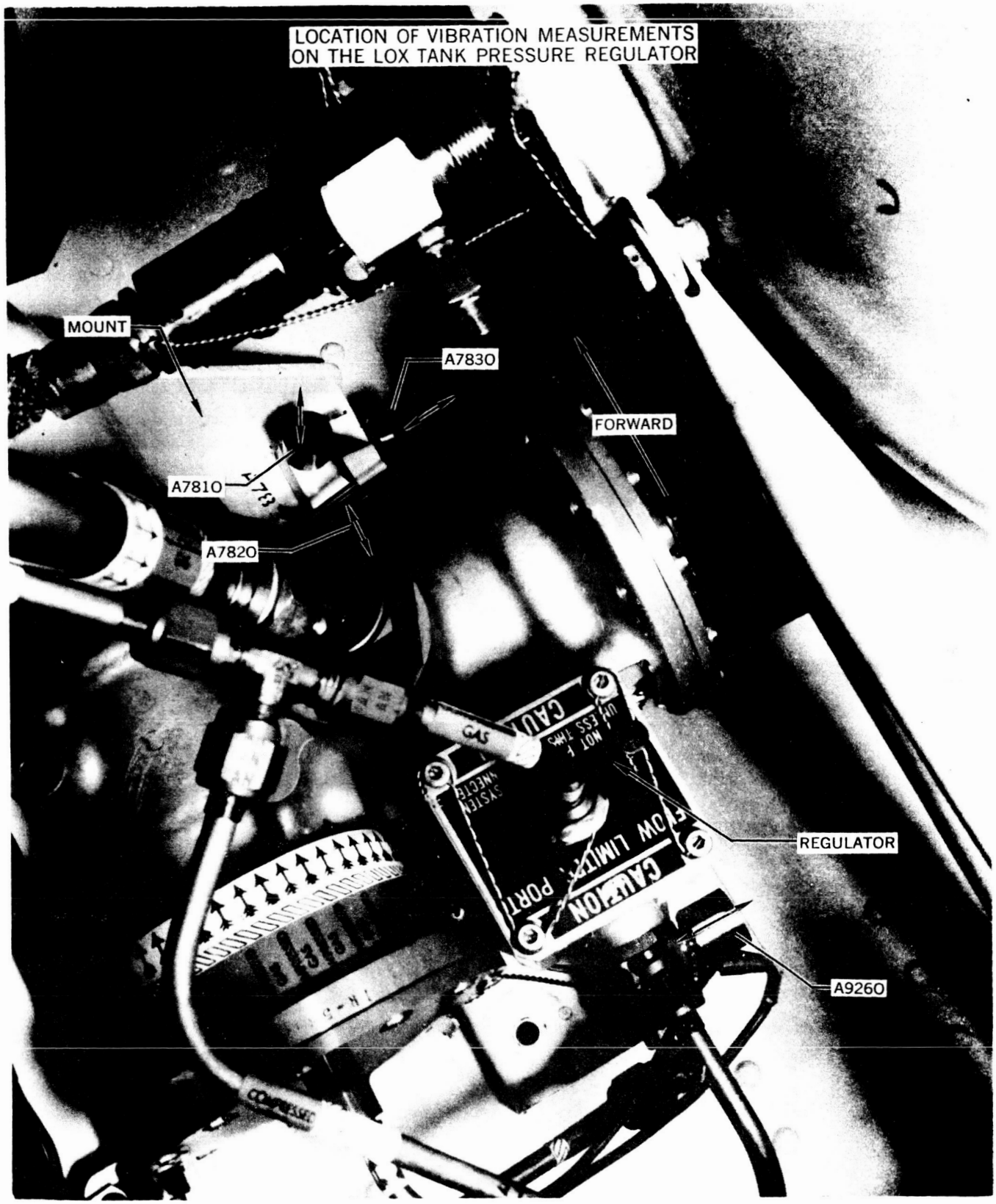

A9230 LOX TANK PRESSURE REGULATOR, RADIAL
3.52 TO 4.42 SECONDS
ΔF = 61 CPS
POWER DENSITY - g²/cps
FREQUENCY - CPS


A9250 LOX TANK PRESSURE REGULATOR, RADIAL
68.87 TO 69.78 SECONDS g(RMS) = 3.93
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS
0.04
0.03
0.02
0.01
0
500
1000
1500
2000


A9260 LOX TANK PRESSURE REGULATOR, TANG.
29.10 TO 30.02 SECONDS g(RMS) = 3.5
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS
0.02
0.01
0
500
1000
1500
2000


A9260 LOX TANK PRESSURE REGULATOR, TANG.
69.97 TO 70.88 SECONDS g(RMS) = 4.31
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS
0.04
0.03
0.02
0.01
0
500
1000
1500
2000

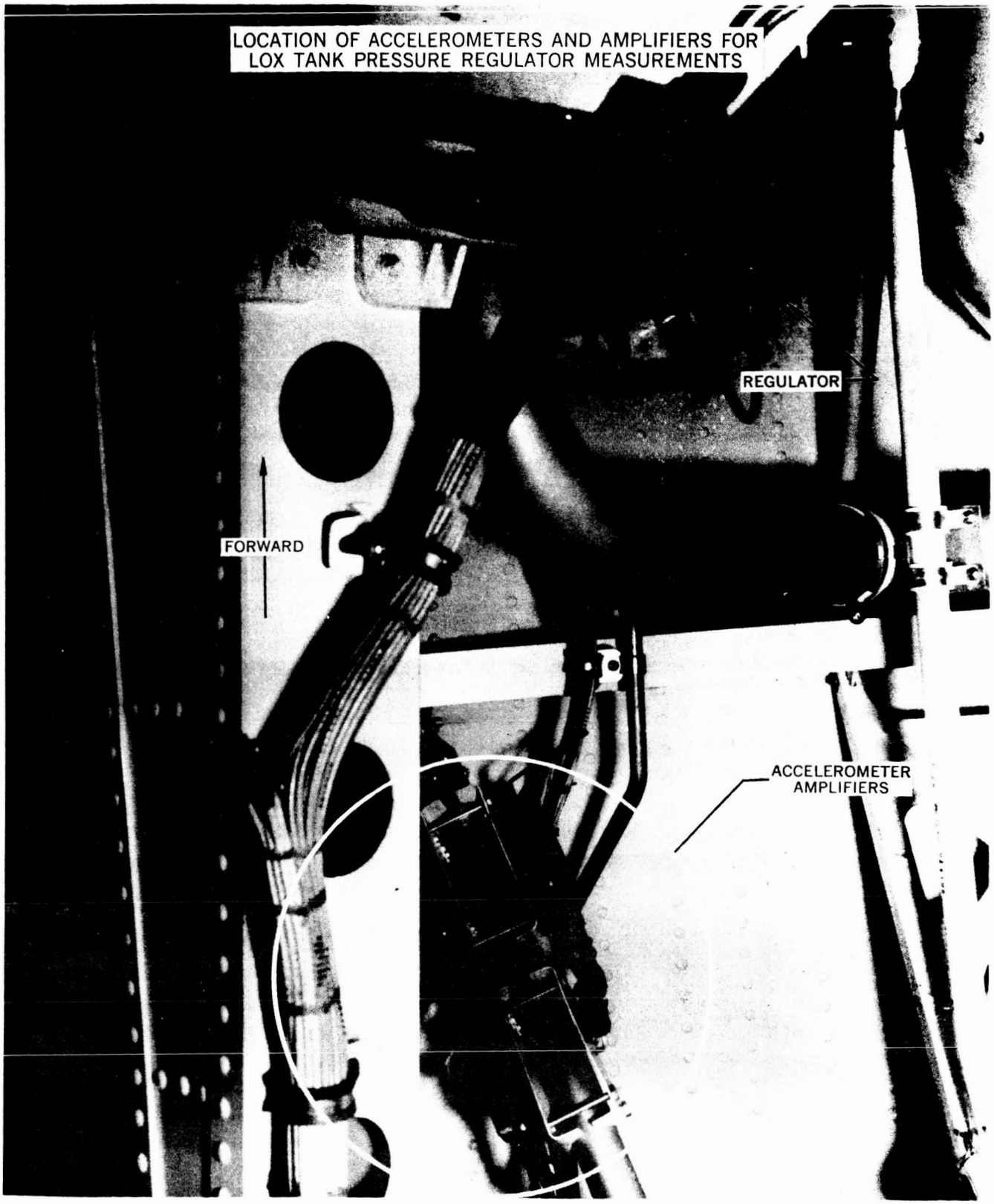

A9260 LOX TANK PRESSURE REGULATOR
4.60 TO 5.52 SECONDS g(RMS) = 4.89
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS
0.10
0.05
0
500
1000
1500
2000


LOCATION OF VIBRATION MEASUREMENTS
ON THE LOX TANK PRESSURE REGULATOR
MOUNT
A7830
FORWARD
A7810
A7820
REGULATOR
A9260

VIBRATION ANALYSIS

LOCATION OF VIBRATION MEASUREMENTS
ON THE LOX TANK PRESSURE REGULATOR




LOCATION OF ACCELEROMETERS AND AMPLIFIERS FOR LOX TANK PRESSURE REGULATOR MEASUREMENTS
REGULATOR
FORWARD
ACCELEROMETER AMPLIFIERS

SECTION 6.2.9

MISSILE 22E

FLIGHT TESTED 7-6-61

AT AMR COMPLEX 13

TEST REPORT AE61-0642

SECTION 16

VIBRATION ANALYSIS

Vibration measurements were obtained from the thrust section during the flight test of Missile 22E. Landline measurements were made on each engine thrust chamber during launch as part of an objective to determine the adequacy of propulsion system operation. The vibration portion of the launch objective was only partially satisfied due to faulty instrumentation. Measurements were obtained from the fuel tank pressure regulator (Stratos) during flight as part of a study to evaluate the vibration environment at each tank pressure regulator installation and to compare results of measurements made on the two types of regulators (Stratos and F&G) utilized during the E Series flight test program. Adequate data was obtained from the flight of Missile 22E to determine the vibration environment at the fuel tank regulator. The vibration at the regulator appeared to be within the currently prescribed design allowable limits. The analysis was made within a frequency band of 10 to 2000 cps.

Thrust Chamber Vibration

High frequency accelerometers were installed on the lox dome of each thrust chamber as shown in Figures 16-7 and 16-8. The outputs were recorded via an FM landline system utilizing extended cable lengths to provide data acquisition for approximately 40 feet of missile rise above the launcher. The measurement numbers and locations were as follows:

P-1206-O	Sustainer Thrust Chamber, Z Axis
P-1208-O	Booster No. 1 Thrust Chamber, Z Axis
P-1209-O	Booster No. 2 Thrust Chamber, Z Axis

Approximately 3.5 seconds of data was obtained during launch. P-1208-O provided no data due to faulty instrumentation. P-1209-O provided qualitative data only due to calibration problems encountered prior to the flight test. An oscillograph recording of each measurement is shown in Figure 16-1.

Sustainer thrust chamber vibration appeared normal at launch. The steady-state levels ranged between 6 and 10 g(rms) and displayed near random outputs within a frequency band of 500 and 1900 cps.

The Booster No. 2 data displayed the usual waveform for a MA-3 engine during launch. The characteristic dry start transient was evident between -0.40 and -0.35 seconds and displayed

a frequency of 150 cps. The ratio of the maximum instantaneous level of the start transient to the steady-state maximum instantaneous level was 1.3 to 1. During steady-state operation, the predominant frequency was 720 cps.

Power density spectral computations were made from the thrust chamber data as shown in Figure 16-3.

Fuel Tank Pressure Regulator Vibration

Five high frequency accelerometers were installed on the regulator as shown in Figures 16-4 and 16-5. The specific locations were as follows:

A-786-O	Regulator Base, Radial
A-787-O	Regulator Base, Longitudinal
A-788-O	Regulator Base, Tangential
A-930-O	Regulator, Radial
A-931-O	Regulator, Tangential

Each measurement displayed valid data except A-787-O which showed erratic outputs through most of booster stage. Figure 16-2 shows an oscillograph recording of the measurements. The erroneous bias of 5 to 10 percent of intelligence bandwidth exhibited on the first three data segments was attributed to a telemetry instrumentation anomaly resulting from the frequency content of the vibration accelerometer outputs. Telemetry Channel A was also affected. The source of the interference is now being investigated.

The regulator measurements displayed nearly steady-state levels between launch and 80 seconds of flight. A general decrease in levels was evident between 80 seconds and booster engine shutdown. The over-all levels observed at the regulator base ranged between 1.4 and 9.4 g(rms) with the major portion of the energy within a frequency band of 700 to 1900 cps. The measurements on the regulator showed levels ranging between 1.0 and 5 g(rms) with the energy distributed within frequency bands of 70 to 200 cps and 400 to 1600 cps. The vibration in the radial direction showed the greater intensity at each location. A good amount of damping action prevailed at the regulator since the vibratory response between the main mount and the regulator was attenuated by a factor of 2. The damping may be attributed to the restraint provided by the secondary regulator mount and the pneumatic lines attached to the regulator.

The 720 cps buzz (input from propulsion system operation) condition, noted on previous E Series flight test measurements, was again exhibited but provided considerably less intensity

than before. The lox tank pressure regulator (Stratos) vibration measurements on Missile 18E displayed maximum levels between 10 and 30 g(rms) on the base and 5 to 10 g(rms) on the regulator proper. These levels were displayed with a predominant frequency of 720 to 750 cps. Again, damping of the regulator was evident.

Power density spectral computations were made for each measurement as shown in Figures 16-4 through 16-6.

A brief discussion of each measurement is shown below.

Regulator Base Vibration

The steady-state levels observed in the radial direction ranged between 4.7 and 9.4 g(rms). The predominant frequency varied through booster stage and ranged between 740 and 1780 cps. A maximum instantaneous level of 32.5g (zero to peak) at 1780 cps was evident at approximately 50 seconds. At launch, a frequency component of 10 cps was observed for a 0.7 second duration. The maximum level was between 2.0 and 2.5 g(zero to peak). The 10 cps component was observed on the Arma guidance data and tank pressure measurements and was considered the result of missile longitudinal motion. Ten cps is apparently the first mode frequency for this missile.

A-787-O appeared to show faulty outputs throughout booster stage. The data presented herein is qualitative information only.

The steady-state vibration levels along the tangential direction ranged between 1.4 and 3.6 g(rms). The predominant frequency varied between 760 and 1750 cps. The maximum instantaneous level observed at approximately 50 seconds was 22.0 g(zero to peak). A 0.06 second transient was noted on this measurement at booster separation (127.62 seconds) and displayed a maximum instantaneous level of 35 g(zero to peak).

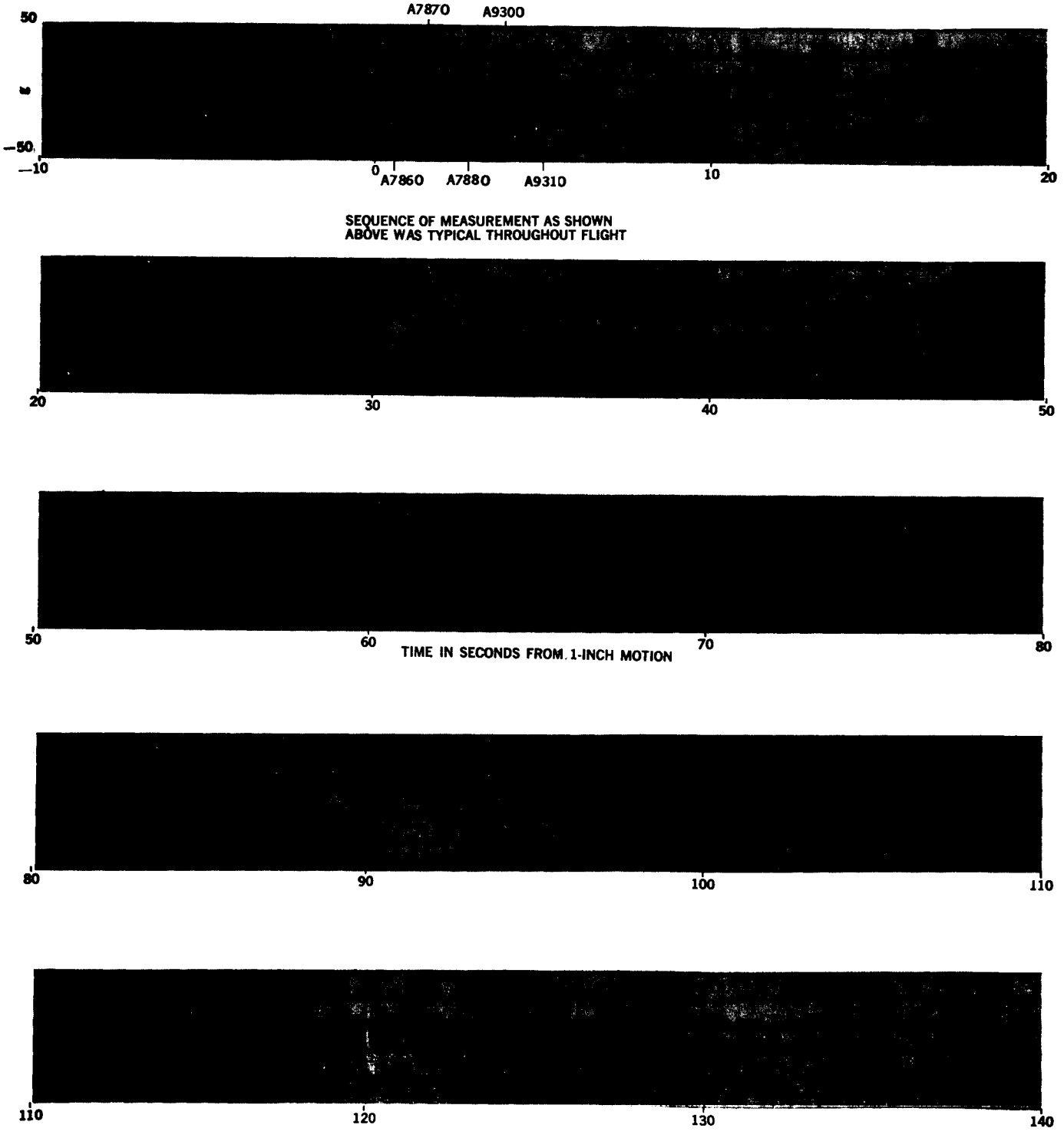
Regulator Vibration

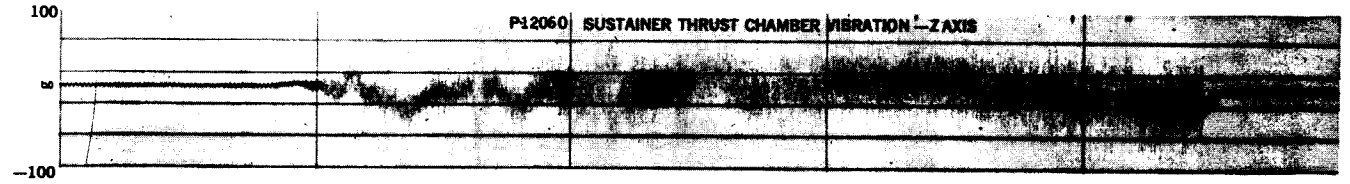
The steady-state levels exhibited in the radial direction ranged between 2.4 and 4.6 g(rms). Predominant frequencies through booster stage were 740, 190 and 70 cps. The maximum instantaneous level observed between 50 and 60 seconds of flight was 11.0 g(zero to peak). The frequency was 190 cps.

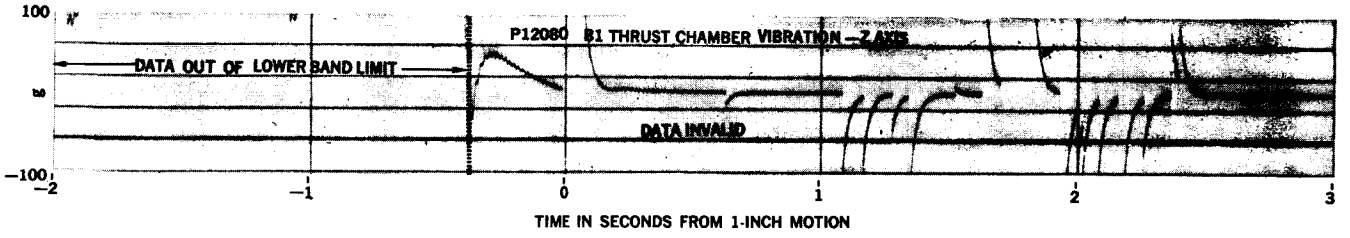
Vibration levels in the tangential direction were between 1.0 and 2.8 g(rms). The predominant frequencies were 725, 400, 200 and 70 cps. The maximum instantaneous level was 6.5 g(zero to peak) at 70 cps.

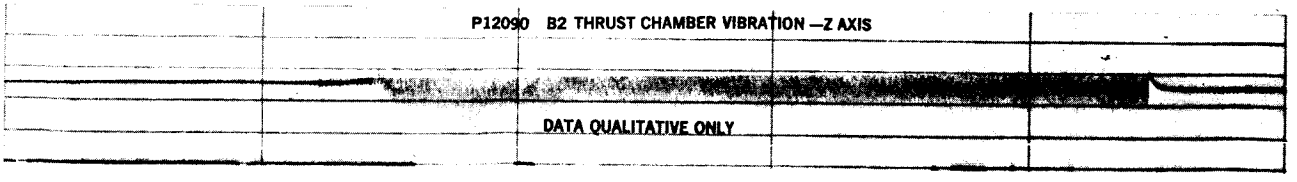
MISSILE 22E

VIBRATION SYSTEM TELEMETERED DATA



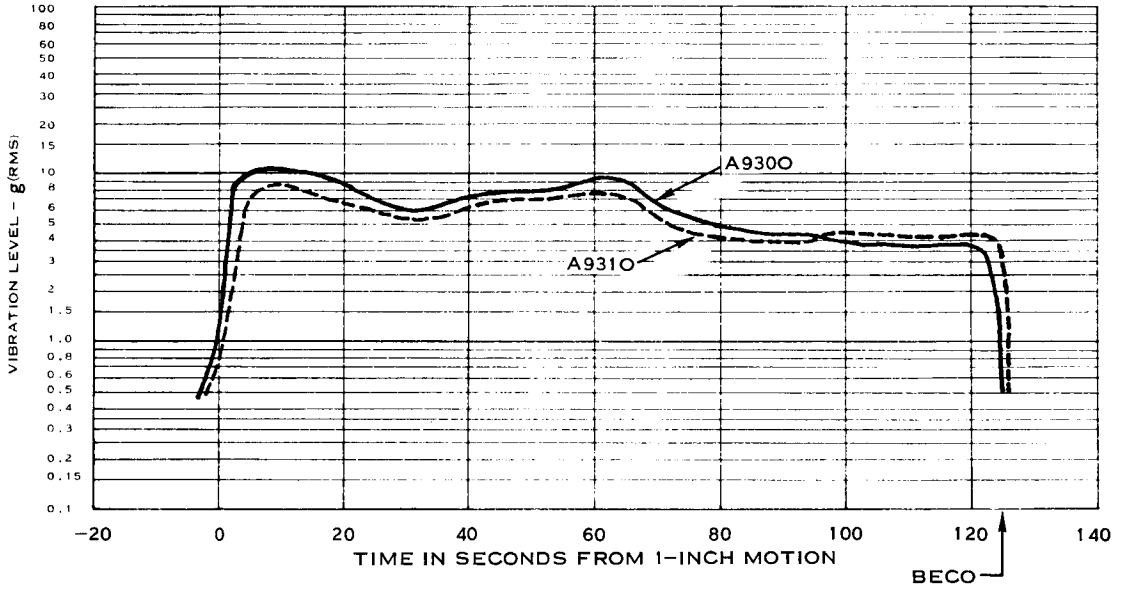

100
0
−100
P12060 SUSTAINER THRUST CHAMBER VIBRATION —Z AXIS


100
0
−100
DATA OUT OF LOWER BAND LIMIT
P12080 B1 THRUST CHAMBER VIBRATION —Z AXIS
DATA INVALID
−2
−1
0
1
2
3
TIME IN SECONDS FROM 1-INCH MOTION

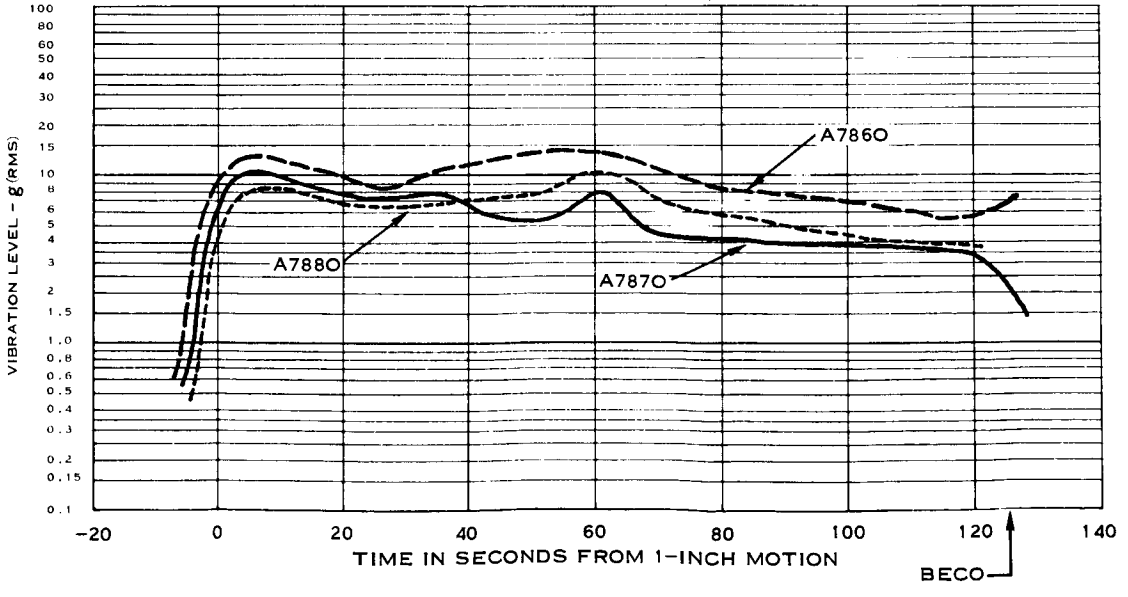

P12090 B2 THRUST CHAMBER VIBRATION —Z AXIS
DATA QUALITATIVE ONLY

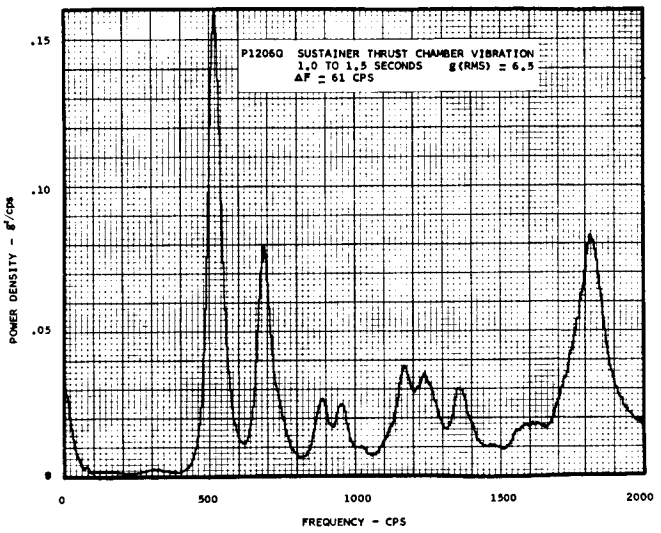
VIBRATION TIME HISTORY
g (RMS) VS TIME
MISSILE 22E
2100 CPS LOW PASS FILTER

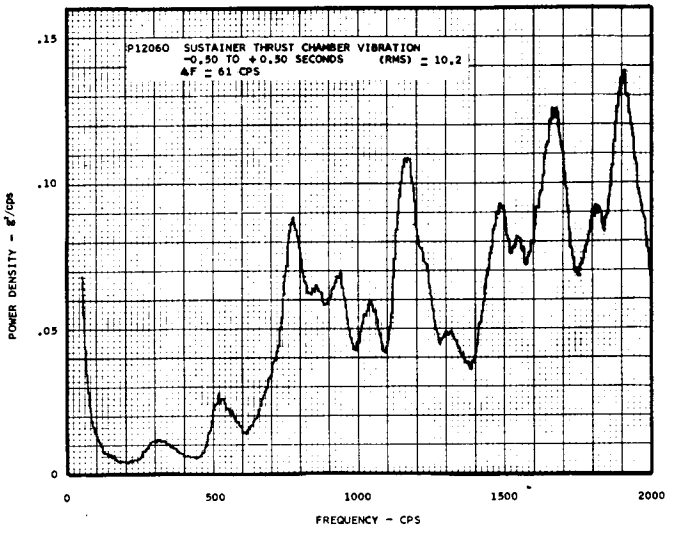
A9300 FUEL TANK PRESSURE REGULATOR, RADIAL
A9310 FUEL TANK PRESSURE REGULATOR, TANG.

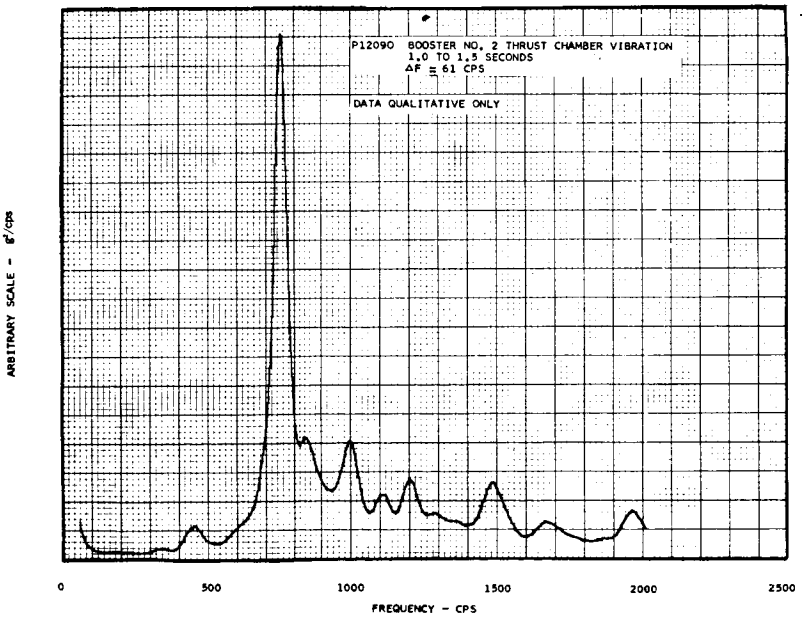


A7860 FUEL TANK PRESSURE REGULATOR MOUNT, RADIAL
A7870 FUEL TANK PRESSURE REGULATOR MOUNT, LONG.
A7880 FUEL TANK PRESSURE REGULATOR MOUNT, TANG.



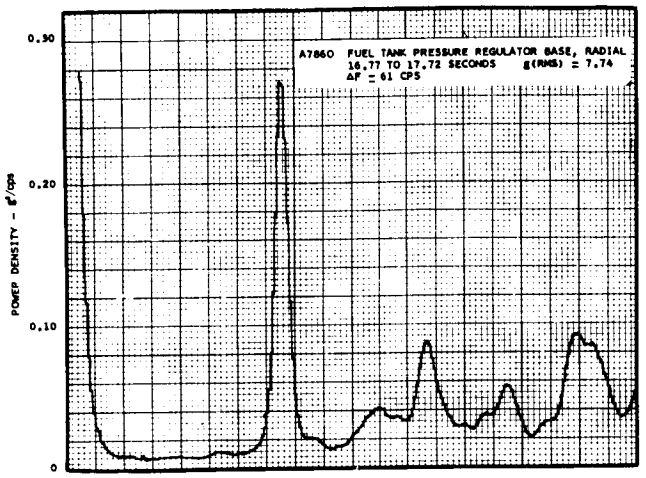

P1206Q SUSTAINER THRUST CHAMBER VIBRATION
1.0 TO 1.5 SECONDS g(RMS) = 6.5
ΔF = 61 CPS
POWER DENSITY - g²/CPS
.15
.10
.05
0
0
500
1000
1500
2000
FREQUENCY - CPS

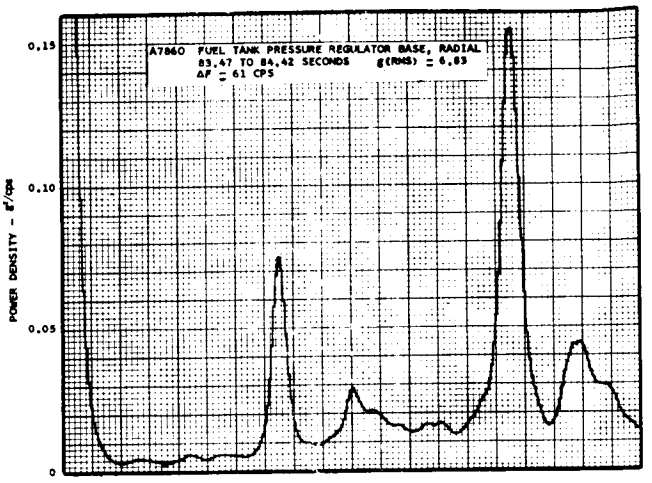

P1206Q SUSTAINER THRUST CHAMBER VIBRATION
-0.50 TO +0.50 SECONDS (RMS) = 10.2
ΔF = 61 CPS
POWER DENSITY - g²/CPS
.15
.10
.05
0
0
500
1000
1500
2000
FREQUENCY - CPS

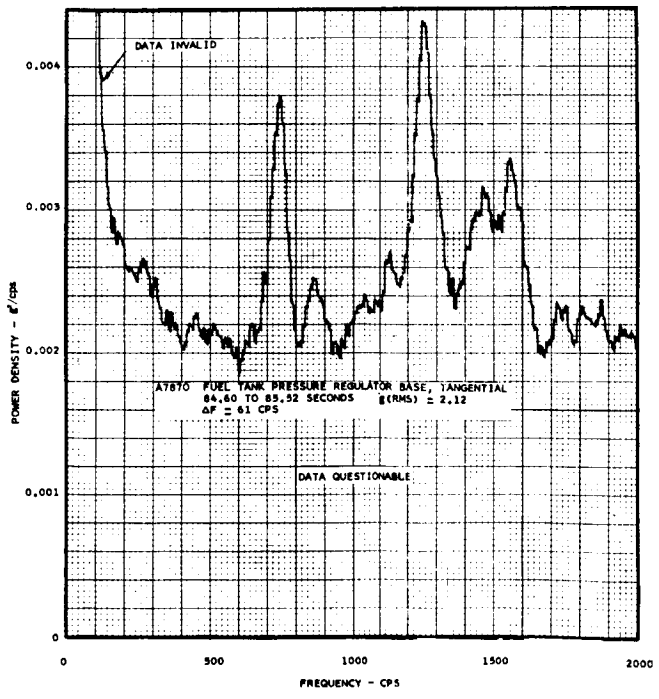

P12090 BOOSTER NO. 2 THRUST CHAMBER VIBRATION
1.0 TO 1.5 SECONDS
ΔF = 61 CPS
DATA QUALITATIVE ONLY
ARBITRARY SCALE - g²/CPS
0
500
1000
1500
2000
2500
FREQUENCY - CPS

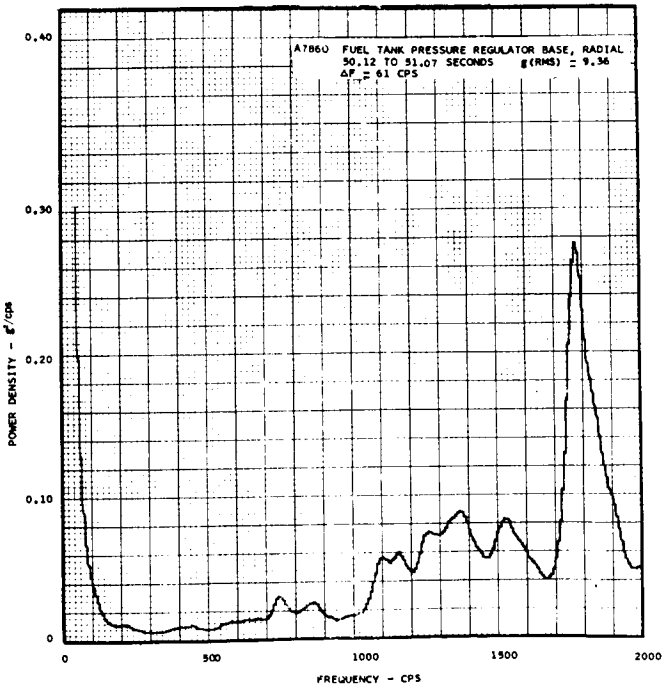
VIBRATION DATA

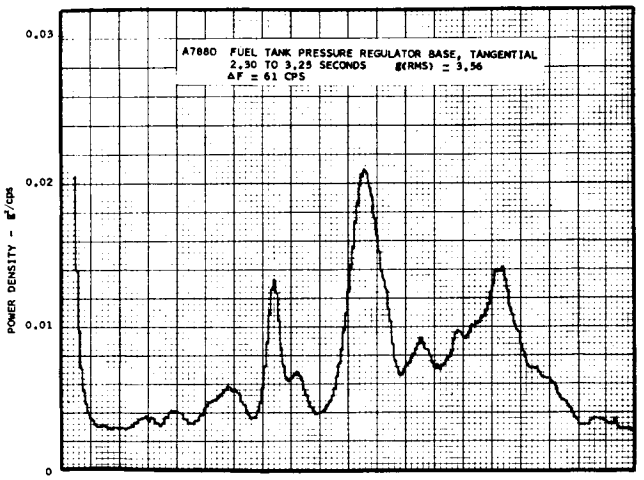
MISSILE 22E

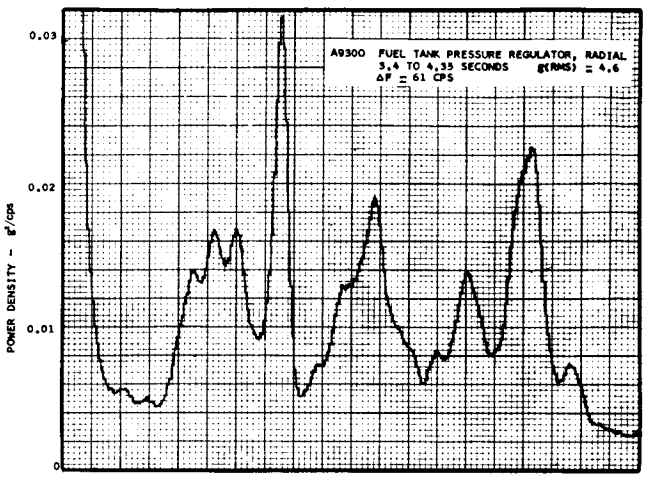


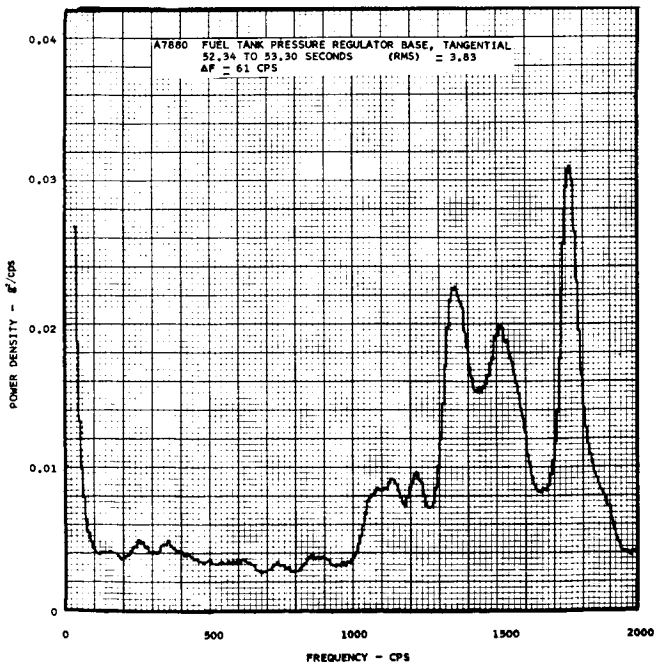


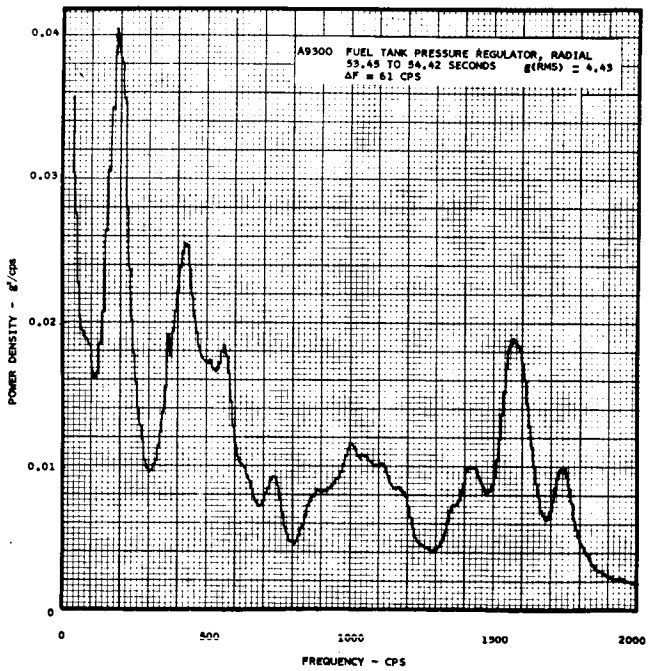





A7880 FUEL TANK PRESSURE REGULATOR BASE, TANGENTIAL
2.30 TO 3.25 SECONDS g(RMS) = 3.56
ΔF = 61 CPS
POWER DENSITY - g²/CPS
0.03
0.02
0.01
0

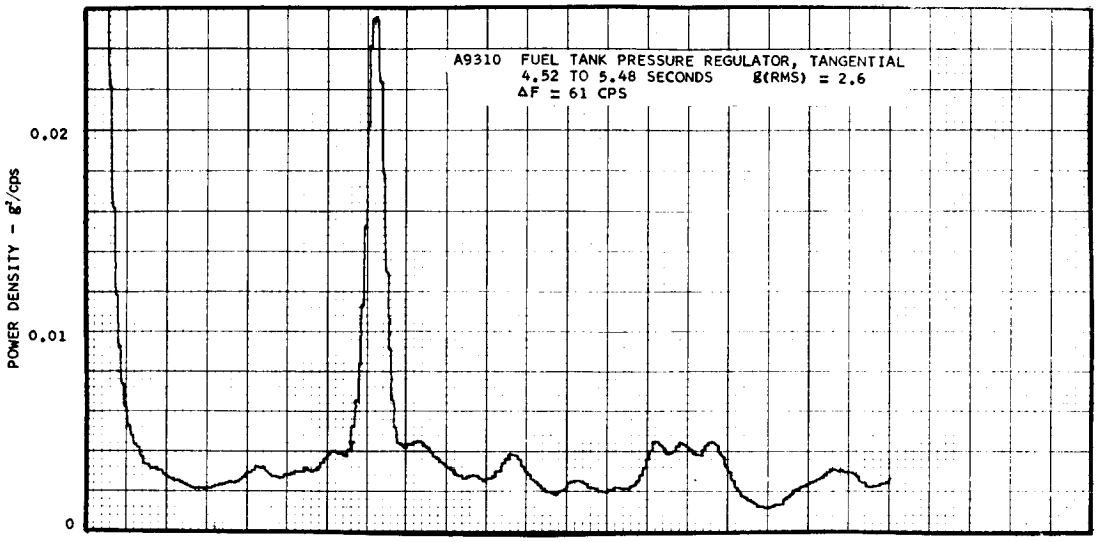

A9300 FUEL TANK PRESSURE REGULATOR, RADIAL
3.4 TO 4.35 SECONDS g(RMS) = 4.6
ΔF = 61 CPS
POWER DENSITY - g²/CPS
0.03
0.02
0.01
0

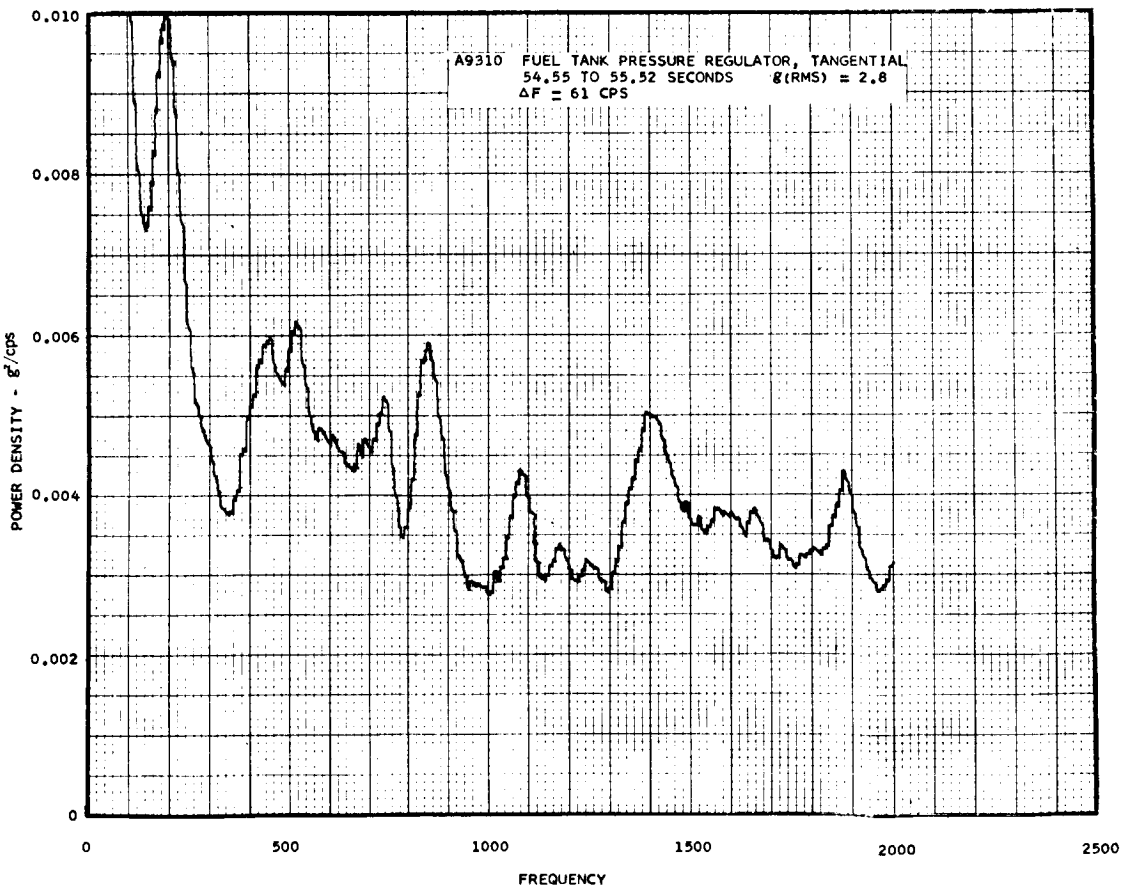

A7880 FUEL TANK PRESSURE REGULATOR BASE, TANGENTIAL
52.34 TO 53.30 SECONDS (RMS) = 3.83
ΔF = 61 CPS
POWER DENSITY - g²/CPS
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
FREQUENCY - CPS

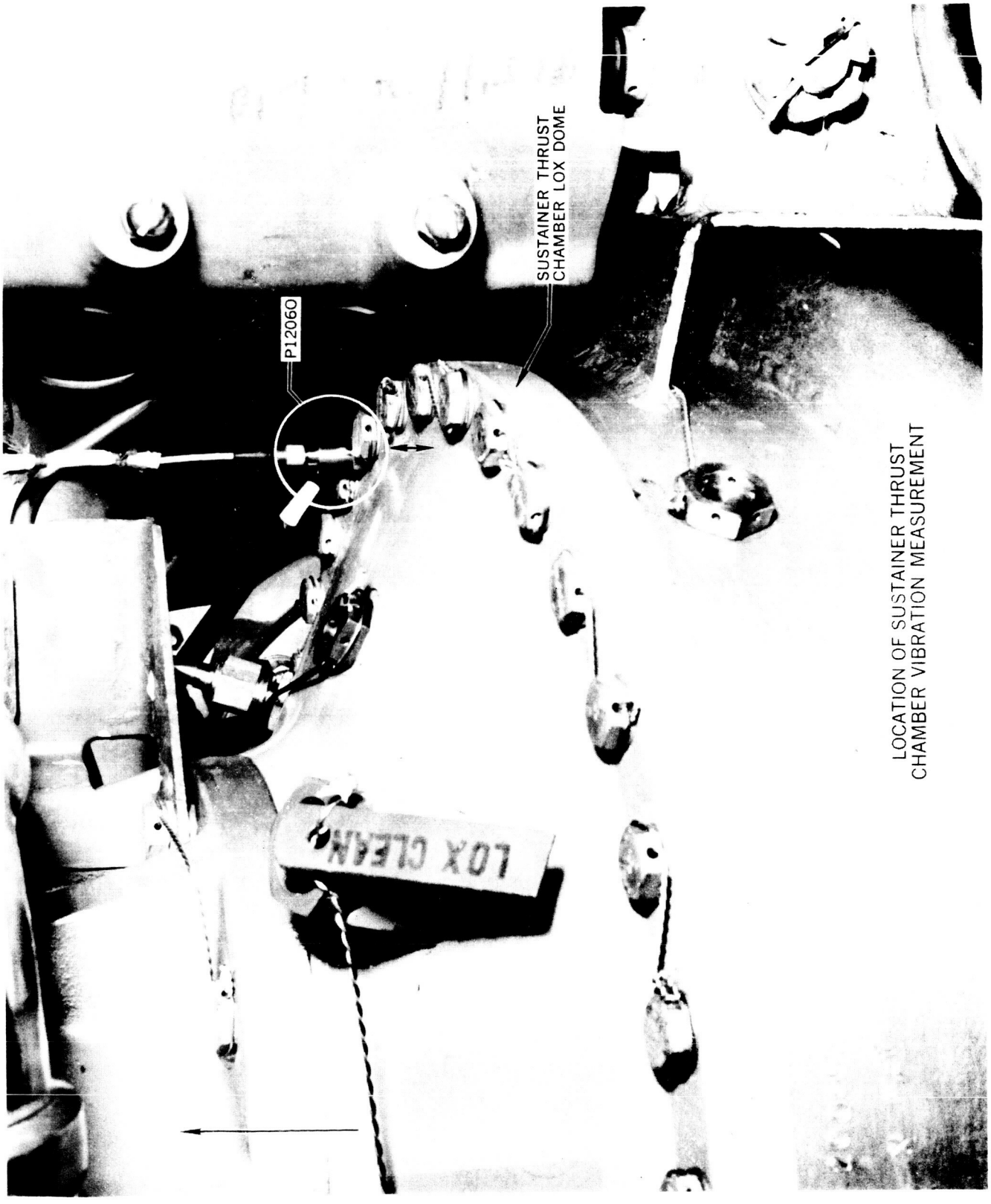

A9300 FUEL TANK PRESSURE REGULATOR, RADIAL
53.45 TO 54.42 SECONDS g(RMS) = 4.43
ΔF = 61 CPS
POWER DENSITY - g²/CPS
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
FREQUENCY - CPS

VIBRATION DATA

MISSILE 22E



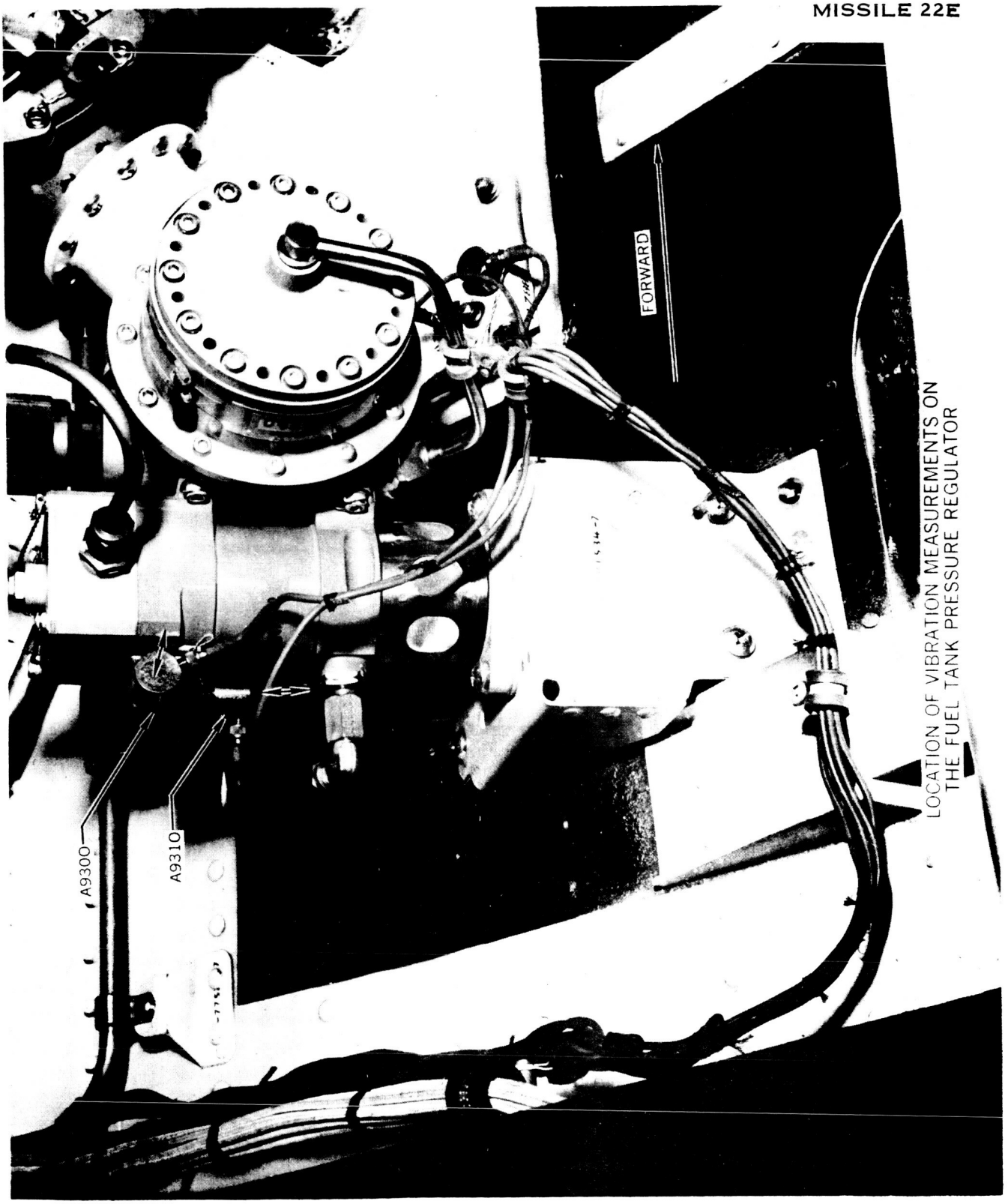




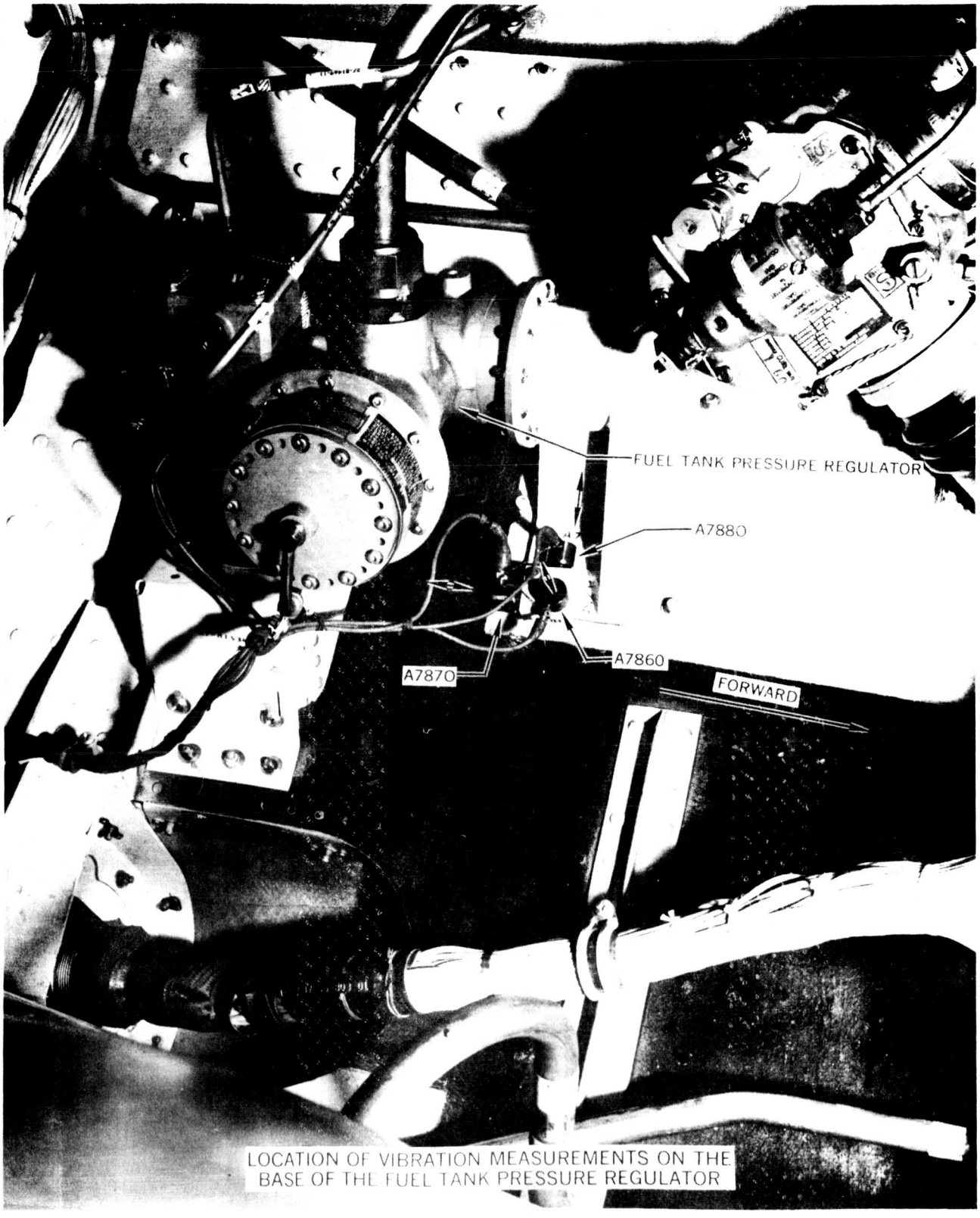
LOCATION OF SUSTAINER THRUST
CHAMBER VIBRATION MEASUREMENT



LOCATION OF BOOSTER NO. 2 THRUST CHAMBER VIBRATION MEASUREMENT


FORWARD
A9300
A9310
LOCATION OF VIBRATION MEASUREMENTS ON
THE FUEL TANK PRESSURE REGULATOR

VIBRATION ANALYSIS



LOCATION OF VIBRATION MEASUREMENTS ON THE BASE OF THE FUEL TANK PRESSURE REGULATOR

SECTION 6.2.10

MISSILE 24E

FLIGHT TESTED 7-26-63

AT OSTF 1

TEST REPORT GD/A63-0709

SECTION 12

LAUNCH ACOUSTIC AND VIBRATION ANALYSIS

Data was recorded during missile ignition and liftoff to monitor 1) the acoustic environment of the missile coffin area and the Arma computer, and 2) the vibration levels of the Arma computer and missile thrust section. During powered flight, acoustic levels in the Arma computer and the thrust section were monitored via telemetry. This was the first attempt to obtain acoustic data via telemetry.

Sound pressure levels recorded in the coffin and the thrust section areas during the launch of Missile 24E were moderate and similar to those obtained during the launch of Missiles 62E and 65E. Sound pressure levels within the Arma computer at launch were similar to those recorded on Missiles 62E and 65E. The telemetered data obtained from Arma computer and thrust section acoustic measurements confirmed some of the acoustic characteristics that were expected during missile flight. An unexplained buildup of low frequency energy was noted on the Arma computer acoustic measurement between 70 and 100 seconds. The maximum over-all sound pressure level (SPL) reached 136 db at 86 seconds. The energy exhibited was in the 20-75 cps frequency range. This unexplained phenomenon is presently under investigation and will be further evaluated from the data gathered from the flights of Missiles 45F and 109F.

Vibration levels of the thrust section components and the Arma computer mount were moderate and similar to those experienced during the launch of Missiles 62E and 65E. Data was obtained from 15 of the 18 installed accelerometers.

AIG Pod Configuration

The AIG pod was modified by the addition of interior fiberglass lining material (ECP 8411) and a production muffler on the air intake to the Arma computer (ECP 8409). The pod lining configuration consisted of lining the inside section of the Atlas B2 pod on all areas adjacent to the arma computer with 2-inch thick fiberglass. The section lined included the upper bulkhead, the access cover hatch, both sides, and pod floor down to the "rib" that separates the computer section from the guidance platform section. The above pod fix was previously incorporated on Missiles 65E and 62E.

Instrumentation (Launch Acoustic)

Five acoustic measurements were made in and around the missile at launch. The general locations of the microphones are shown schematically in Figure 12-35. The specific locations of all microphones are shown in Figures 12-36 through 12-40. The measurement numbers and locations were as follows:

Measurement Number	Location
A780Y	AIG computer dummy constants board microphone (via telemetry)
A7223Y	Pole Microphone B1 side
N7234Y	Coffin Microphone A
N7535Y	Coffin Microphone B
P51Y	Thrust section microphone (via telemetry)

The acoustic transducers utilized were Model NM125 high-intensity microphones manufactured by Chesapeake Instrument Corporation. The high-intensity microphones were self-generating piezoelectric ceramic acoustic sensors especially designed for measuring high noise levels under adverse environmental conditions. The base of the microphone holder had a vibration mount which isolated the sensor from lower frequency vibrations.

All five measurements provided completely or partially valid data. Measurement N7223Y, pole microphone B1 side, became invalid prematurely at 1.0 second when a data dropout occurred. Apparent reclamation of data output occurred at 1.8 seconds. However, data values are questionable after 1.8 seconds since the microphone becomes detrimentally influenced by the engine exhausts between 1.8 and 2.0 seconds. The cause of the dropout is presently under investigation.

Measurement A780Y (previously A1780Y), located inside the Arma computer, and Measurement P51Y (previously P1051Y), located in the thrust section, were monitored via telemetry (Channels E and C, respectively). This was the first attempt to obtain sound pressure levels throughout flight. Data for both measurements appeared valid until 60 to 70 seconds when the sound pressure level (SPL) in some cases became almost identical to the pre-ignition noise level. Data subsequent to this time in the missile flight was termed questionable or invalid. Intermittent RF dropouts and electrical noise appeared in the data of Measurement P51Y after 90 seconds and in the data of A780Y after 70 seconds.

Coffin Microphone B data (N7535Y) and Coffin Microphone A data (N7534Y) became invalid at approximately 1.25 seconds and 1.65 seconds, respectively. The vertical rise of the missile at these times was such that the thrust chamber cone was adjacent or just beyond the respective microphone location. Flame impingement at this time causes microphone failure.

Results

The general characteristics of the missile bay (coffin wall) acoustic intensities at launch were similar to those recorded on Missiles 66E, 67E, 64E, and 65E. Over-all octave band time histories of the two coffin microphones A and B (N7534Y and N7535Y) are shown in Figure 12-14.

Prior to 1.0 second, the pole microphone (A7223Y) acoustic intensities were similar to those recorded on Missiles 62E and 65E. The pole microphone data became invalid at 1.0 second. Octave band time histories of the pole microphone data (N7223Y) are shown in Figures 12-9 through 12-13.

The outside-the-pod to the inside-the-computer SPL reduction for Missile 24E could not be calculated to compare with previous reductions on other missiles. This reduction has in the past been calculated at 1.25 seconds, which is the time in missile flight when the Arma computer is approximately opposite the exterior reference microphone (N7223Y). Since the exterior reference microphone, N7223Y, exhibited invalid data after 1.0 second, it was not possible to calculate a reduction that could be accurately compared to those of previous missiles. However, an outside-to-inside reduction was calculated for Missile 24E at 1.0 second. This was the best possible time to check the effect of the new pod configuration (2" half-blanket plus muffler) under the circumstance. The calculated sound level reduction at 1.0 second was less than that of Missiles 62E and 65E calculated at 1.25 seconds with the same pod configuration, but greater than the reduction levels of Missiles 64E, with the 1" half-blanket pod configuration, and 67E, with no alteration in the pod configuration. Outside-the-pod to inside-the-computer SPL reduction information is shown in Figure 12-4.

In general, the computer constants board measurement (A780Y) showed acoustic intensities similar to those recorded on Missiles 62E and 65E during missile launch. Due to limited frequency response of Channel E, the SPL in the 4800 to 9600 cps octave could not be determined accurately.

The maximum over-all sound pressure level (0-10 kc analysis) was 142 db, recorded at -0.3 second during booster engine ignition. Between 6 and 50 seconds the over-all SPL varied between 126 and 136 db, much of the energy content during this period was in the 20-75 cps frequency range. Unexplained spikes were noted on the over-all time history data between 70 and 100 seconds; maximum over-all SPL's of 136 db were indicated by data spikes at approximately 86 seconds. A majority of the energy content appeared to be in the 20-75 cps frequency range. The validity of the output seems questionable; however, it is presently under investigation and this anomaly will be further evaluated on the flights of Missiles 45F and 109F. (See Figures 12-5 through 12-8.)

The thrust section microphone (P51Y) acoustic intensities in general appeared lower than those previously recorded on Missile 62E. The maximum over-all SPL ranged between 124 and 127 db.

Over-all time histories and power spectral density plots are presented in Figures 12-3 through 12-22.

Instrumentation (Vibration)

Guidance computer vibration was monitored by three high frequency piezoelectric accelerometers mounted on the computer mount as shown in Figure 12-41. The transducers were sensitive in the X-X, Y-Y, and Z-Z axes with a frequency response flat to approximately to approximately 4000 cps and a range of ± 20 g. All three measurements exhibited useful data; however, low frequency noise was evident throughout the data. Data was recorded until trailing umbilical disconnect at approximately 2.1 seconds.

Thirteen accelerometers were installed in the thrust section to determine the vibration environment during thrust rise and liftoff. Two accelerometers measured the vibration level of the gyro canister. Data was obtained through the use of a 40-foot trailing wire umbilical which permitted acquisition until the umbilical was ejected at +2.137 seconds. Photographs of accelerometer installations appear in Figures 12-42 through 12-47.

Valid data was obtained from the following measurements:

A12780	Forward surface of A-frame, Quad IV
A15880	Heatshield acceleration, Z-axis, Quad I-II
A15710	Heatshield acceleration, X-axis, Quad III-IV
F11850	Lox tank regulator, Z-axis
F16510	Helium line rise-off disconnect panel, Z-axis
H14280	Sustainer hydraulic pump end, X-axis
H14290	Sustainer hydraulic pump end, Y-axis
P14510	Sustainer hydraulic return line, Quad III
P15310	Sustainer gas generator fuel check valve
P15320	B1 hydraulic pump, Z-axis
P15330	Sustainer gas generator check valve tube
S16060	Gyro canister, Z-axis

The following were invalid:

F16500	Fuel tank regulator, Z-axis (no response)
P12080	B1 engine lox dome (erratic signal)
S16070	Gyro canister, Y-axis (no data, 400-cps signal)

Two measurements (P15310 and F16510) exhibited periods of amplifier saturation. Data obtained during these periods are considered invalid and are indicated in Figures 12-1 and 12-2.

Results

Response to the pressure pulse at engine ignition was evident on the tri-axial Arma computer vibration measurement. A shock transient was noted at approximately minus 0.4 second. Maximum accelerations indicated were 3.4 g peak-to-peak (p-p), 9.5 g (p-p), and 3.3 g (p-p) on the X-X, Y-Y, and Z-Z measurements, respectively. The estimated shock transient frequency was 8.4 cps. Over-all g(rms) levels were derived from power spectral density samples (0-2000 cps) taken at 1.25 to 2.25 seconds. The vibration output during this one-second time period most nearly represented a steady-state condition. Levels were 1.9 g(rms), 2.7 g(rms), and 1.4 g(rms) for the X-X, Y-Y, and Z-Z measurements, respectively. The table below shows predominant frequency components with the respective magnitudes.

Power spectral density samples and over-all g(rms) time histories of the three vibration measurements are illustrated in Figures 12-23 and 12-24.

AIG Computer Mount Vibration
20-2000 cps Analysis
Time Sample, +1.25 to +2.25 seconds

Measurement Number	Predominant Frequency	g(rms) (Δ f = 5 cps)
A15740, Z-Z	350	0.172
	220	0.155
A15750, Y-Y	550	0.354
	680	0.350
	780	0.324
	640	0.316
	750	0.314
	920	0.300
A15760, X-X	650	0.217
	730	0.217
	710	0.215
	780	0.215
	320	0.190
	560	0.170
	530	0.158

Thrust section vibration data is presented as over-all time history and spectrum analysis plots in Figures 12-25 through 12-34. Oscillographs are presented in Figures 12-1 and 12-2. In general, component vibration levels were moderate and similar to those recorded on Missiles 62E and 65E.

The following table shows the vibration levels for Missiles 24E, 62E, and 65E at +1.1 seconds. The time of 1.1 seconds was selected for this comparison because the trailing wire umbilical on Missile 62E ejected prematurely at +1.113 seconds. Vibration levels at any other time may be obtained by inspection of the time history plots (Figures 12-25 through 12-28).

Vibration Level in g(rms)
(+1.1 seconds)

Meas. No.	24E	62E	65E
A12780	10	7	(2)
A15880	12	14	24
F11850	9	12	26*
F16510	(1)	23	16
H14280	11	16	(2)
H14290	7	9	(2)
P14510	13	16	12
P15310	18	12	12
P15330	22	20	19
S16060	1.8	(1)	(2)
P15320	10	(1)	(2)
A15710	5	(1)	(2)

* Questionable
(1) Invalid
(2) Not recorded

Start transients were similar to those on Missiles 62E and 65E and were of very short duration.

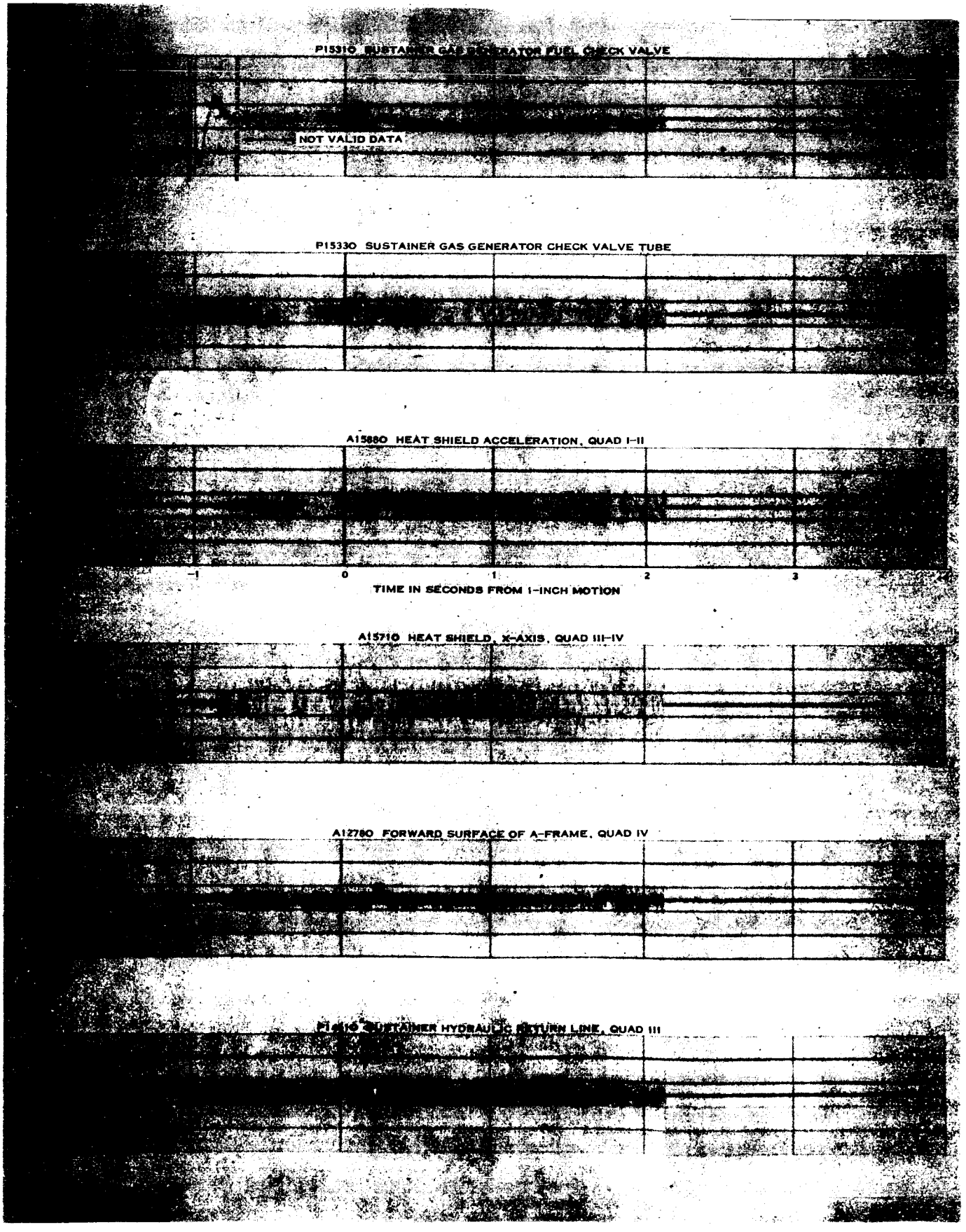
Meas. No.	24E	65E	62E
P15310	126 g(p-p)	56 g(p-p)	140 g(p-p)
P15330	220 g(p-p)	175 g(p-p)	190 g(p-p)
A15880	None	140 g(p-p)	160 g(p-p)

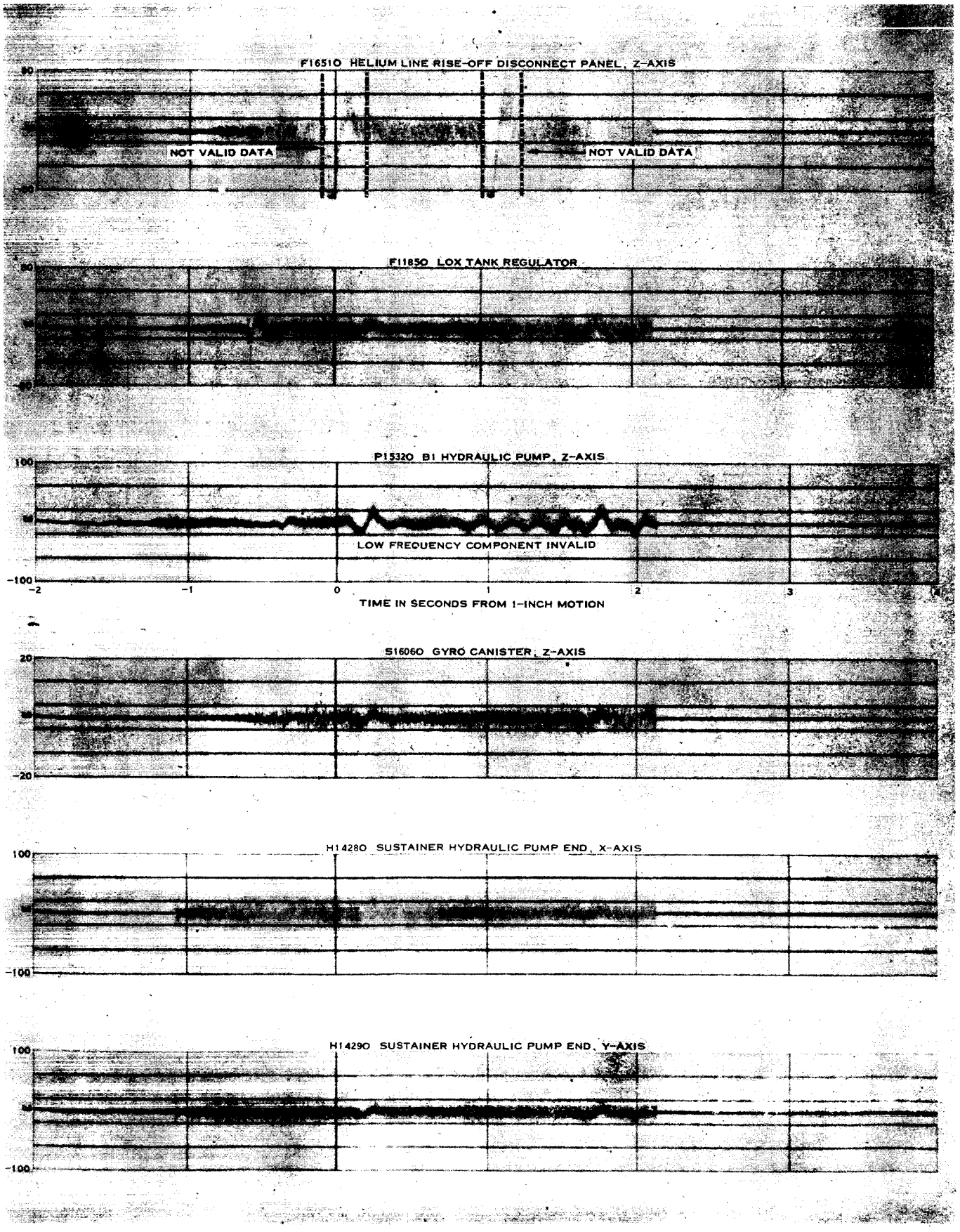
The table on the following page summarizes the data presented as time histories (Figures 12-25 through 12-28), spectrum analyses (Figures 12-29 through 12-34), and oscillographs (Figures 12-1 and 12-2).

UNCLASSIFIED

Meas. No.	Maximum Level (1) g(rms)	Maximum Level (1) time (sec)	Time Interval 0 to +2 sec Predominant Frequencies (cps) 1st	2nd
A12780	16	-0.1	780	1330
A15880	24	-0.1	470	740
A15710	13	-0.1	100	175
F11850	10	+1.9	360	490
F16510	26	+1.9	530	1000
H14280	17	+0.5	1520	1000
H14290	13	-0.4	1020	660
P14510	13	+0.5	1000	490
P15310	18	+1.0	680	1360
P15320	14	+0.3	1670	550
P15330	28	-0.2	680	1360
S16060	2.7	+2.1	90	200

* Questionable
(1) Excluding start transient

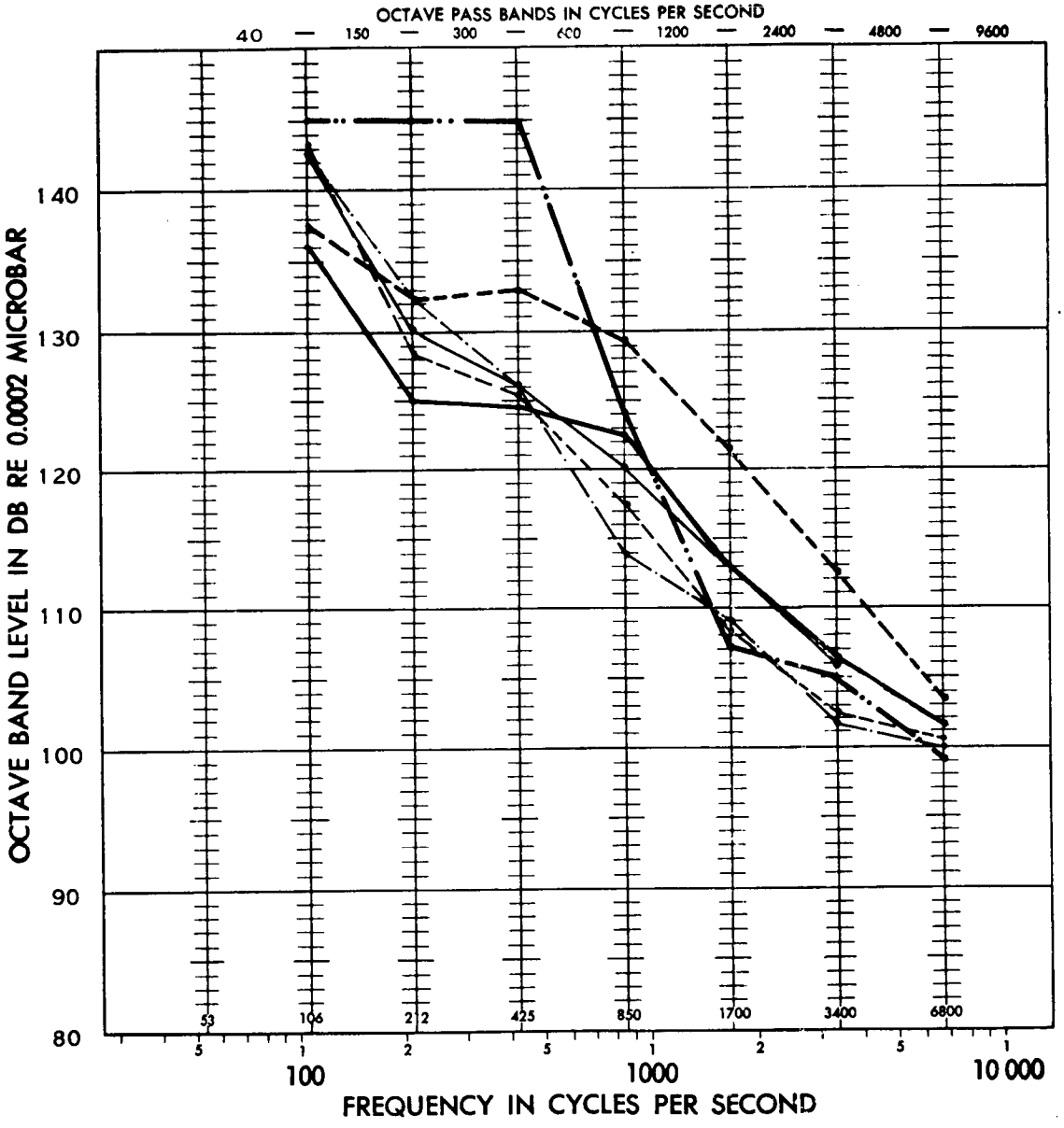

P15310 SUSTAINER GAS GENERATOR FUEL CHECK VALVE
NOT VALID DATA
P15330 SUSTAINER GAS GENERATOR CHECK VALVE TUBE
A15880 HEAT SHIELD ACCELERATION, QUAD I-II
-1
0
1
2
3
TIME IN SECONDS FROM 1-INCH MOTION
A15710 HEAT SHIELD, X-AXIS, QUAD III-IV
A12780 FORWARD SURFACE OF A-FRAME, QUAD IV
P14410 SUSTAINER HYDRAULIC RETURN LINE, QUAD III


F16510 HELIUM LINE RISE-OFF DISCONNECT PANEL, Z-AXIS
NOT VALID DATA
NOT VALID DATA
F11850 LOX TANK REGULATOR
P15320 B1 HYDRAULIC PUMP, Z-AXIS
LOW FREQUENCY COMPONENT INVALID
-100
-2
-1
0
1
2
3
TIME IN SECONDS FROM 1-INCH MOTION
S16060 GYRO CANISTER, Z-AXIS
20
-20
H14280 SUSTAINER HYDRAULIC PUMP END, X-AXIS
100
-100
H14290 SUSTAINER HYDRAULIC PUMP END, Y-AXIS
100
-100

UNCLASSIFIED

MISSILE 24E

ARMA COMPUTER SOUND PRESSURE LEVELS

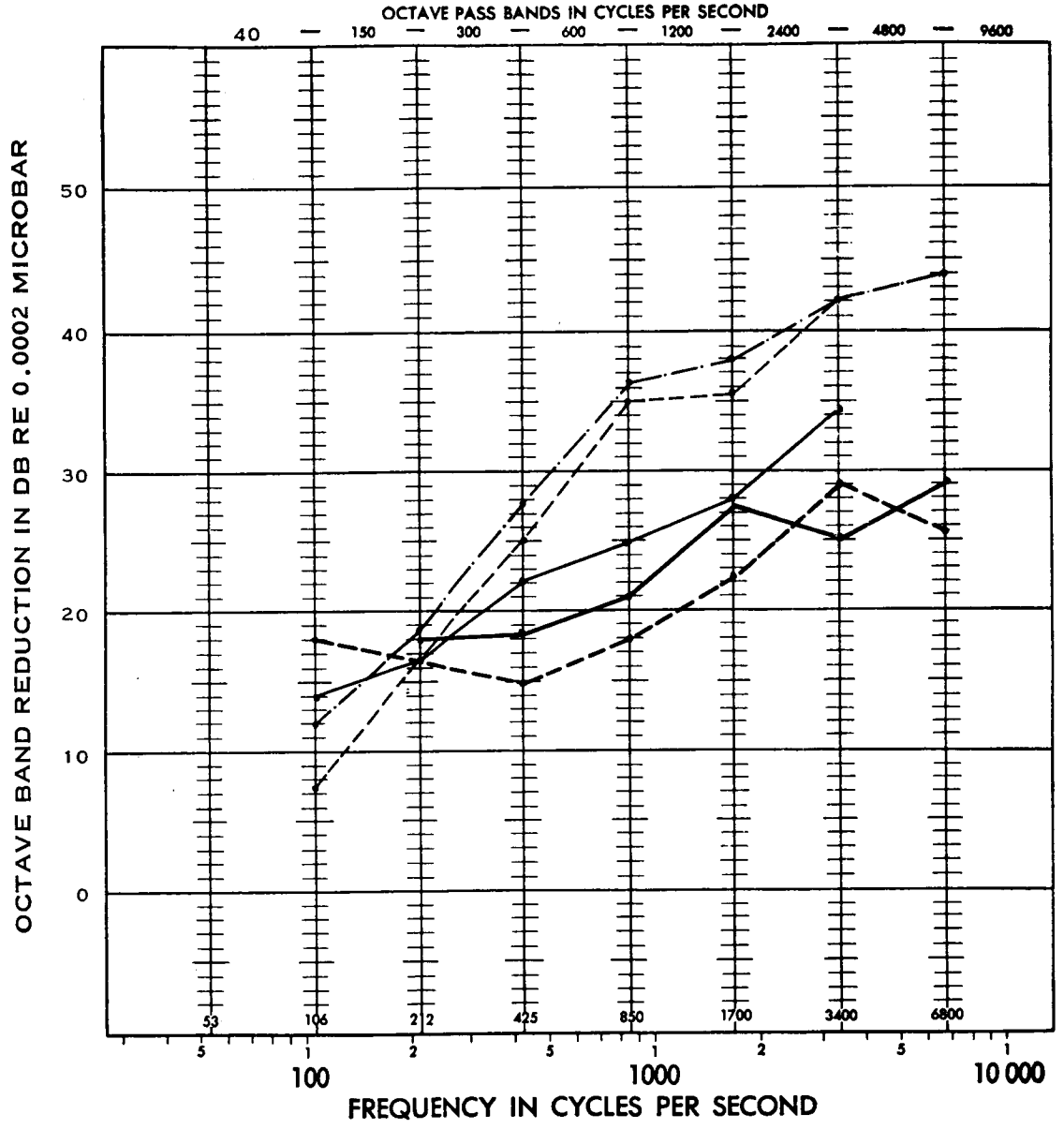


LEGEND:

- MISSILE 24E MEASUREMENT NO. A1780Y (2" HALF-BLANKET + MUFFLER)
- MISSILE 62E MEASUREMENT NO. A1780Y (2" HALF-BLANKET + MUFFLER)
- MISSILE 65E MEASUREMENT NO. A1780Y (2" HALF-BLANKET + MUFFLER)
- MISSILE 64E MEASUREMENT NO. A1780Y (1" HALF-BLANKET)
- MISSILE 67E MEASUREMENT NO. A1780Y (NO POD ACOUSTIC FIX)
- ARMA LEVEL 1 SPECIFICATION

NOTE: ALL VALUES ARE MAXIMUM RECORDED SPL. AN ACCURATE 24E SPL FOR THE 4800-9600 OCTAVE WAS NOT OBTAINABLE AND DOES NOT APPEAR ABOVE.

SOUND LEVEL REDUCTION BY OCTAVES



LEGEND:

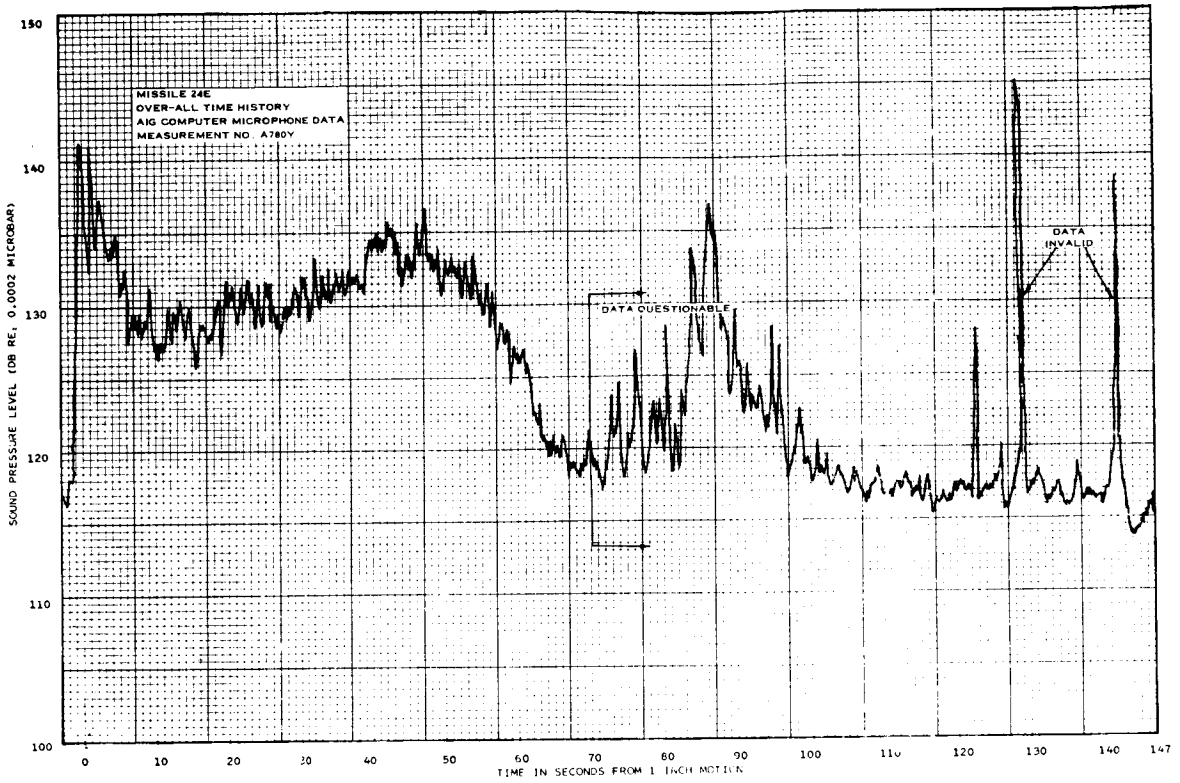
——— ••MISSILE 24E MEASUREMENT NO. N7223Y MINUS A1780Y
– – – – – – •MISSILE 62E MEASUREMENT NO. N7223Y MINUS A1780Y
—·—·— •MISSILE 65E MEASUREMENT NO. N7223Y MINUS A1780Y
———•••MISSILE 64E MEASUREMENT NO. N7534Y MINUS A1780Y
– – – –•••MISSILE 67E MEASUREMENT NO. N7534Y MINUS A1780Y

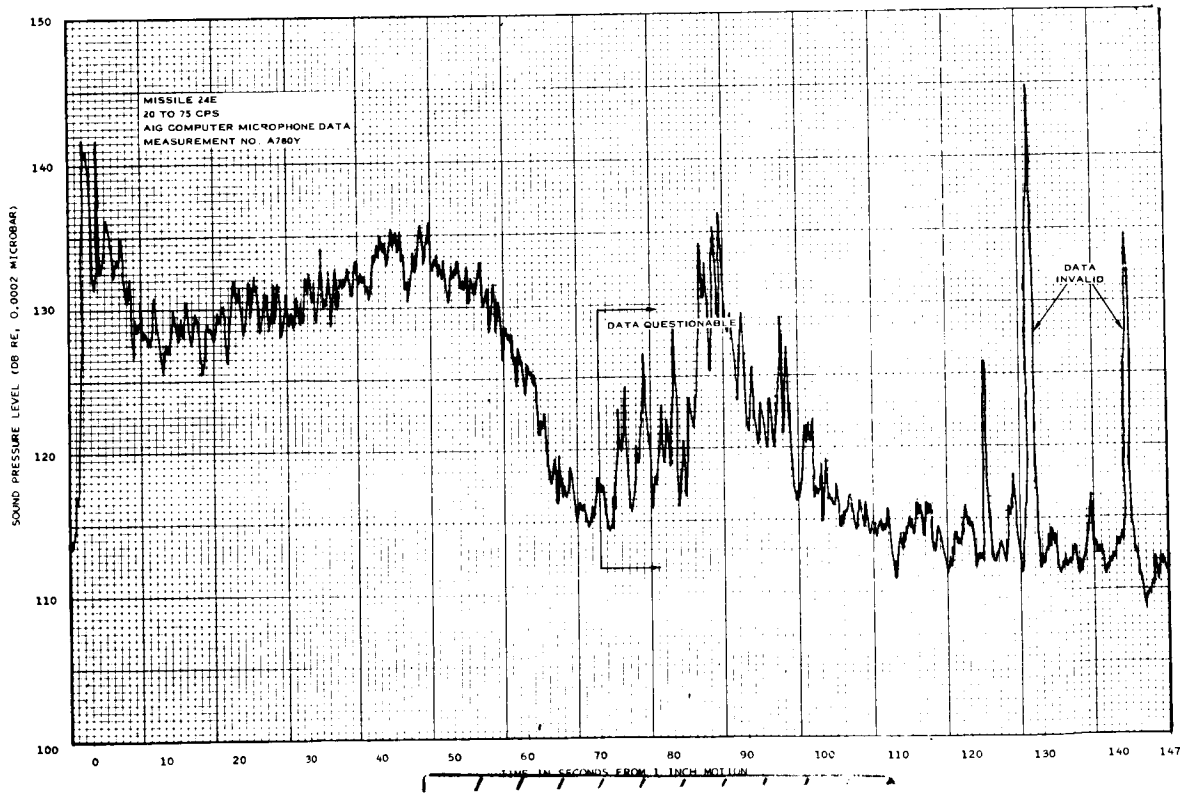
•SPL VALUES @ TIME COMPUTER IS OPPOSITE EXTERIOR MICROPHONE (APPROX. 1.25 SECONDS)

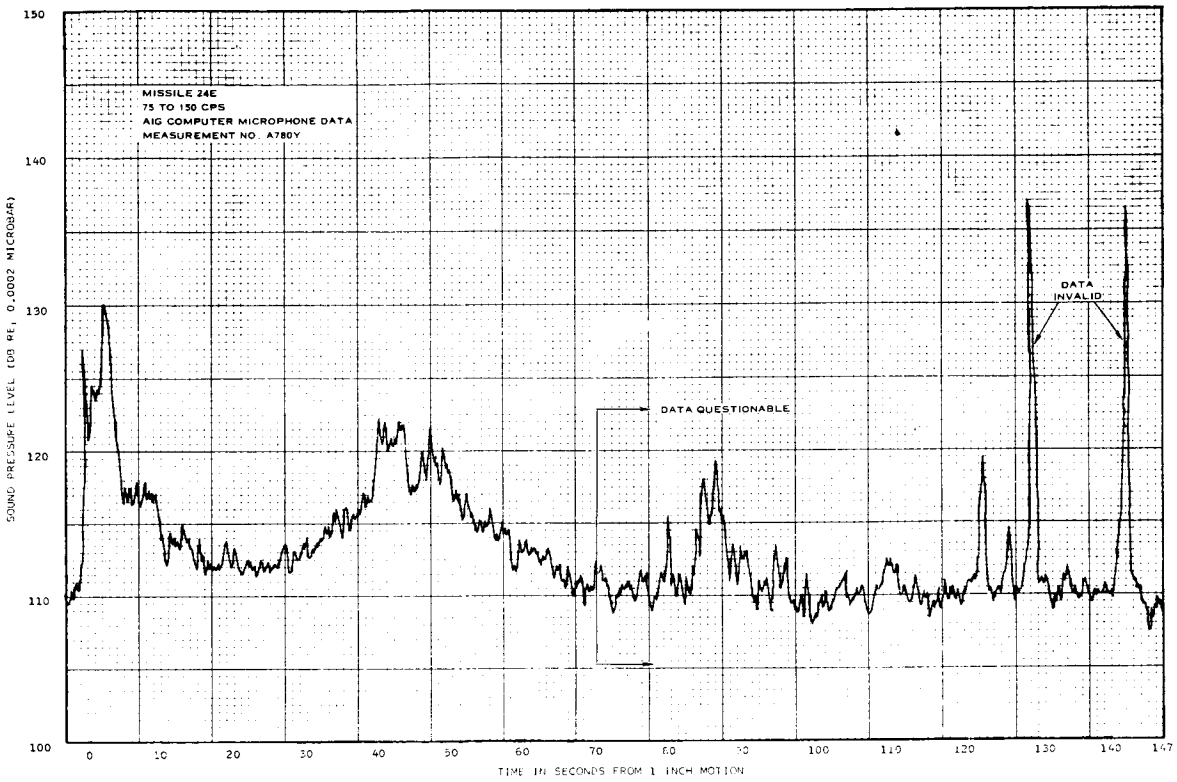
••SPL VALUES @ TIME COMPUTER IS APPROX. 3.5 FT. BELOW MICROPHONE (1.00 SECONDS)

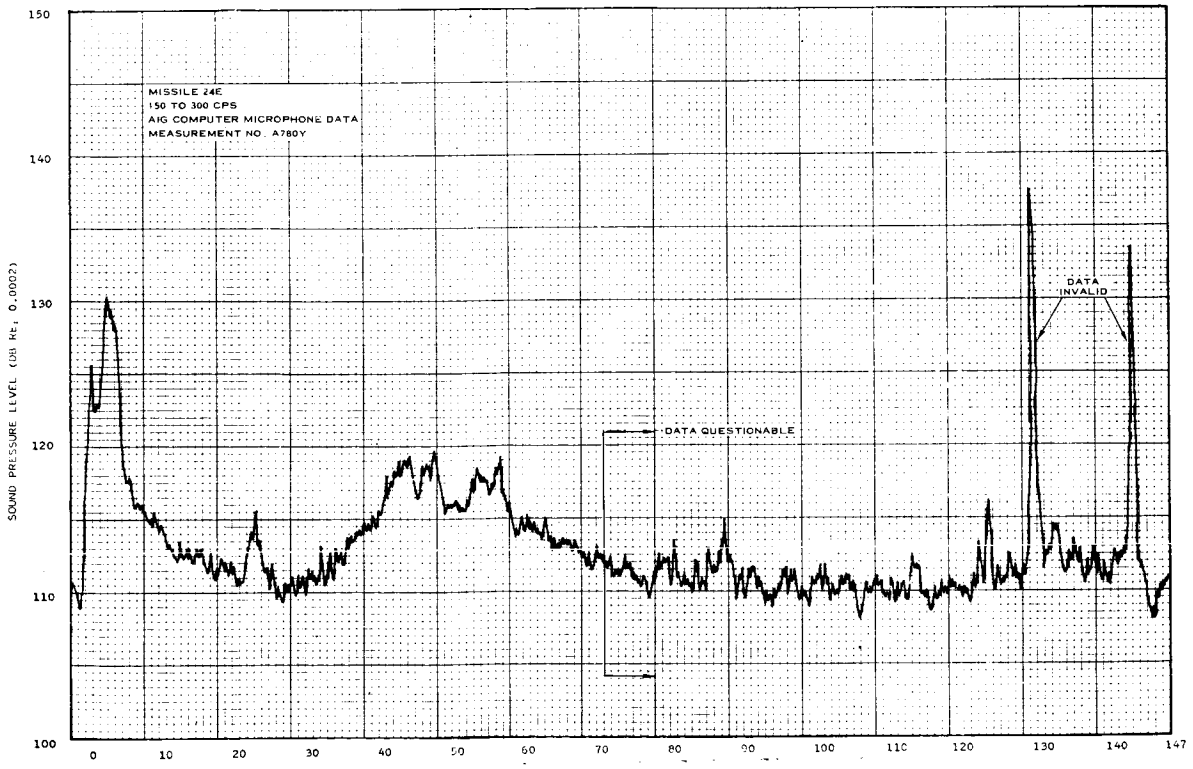
•••MEAN SPL VALUES

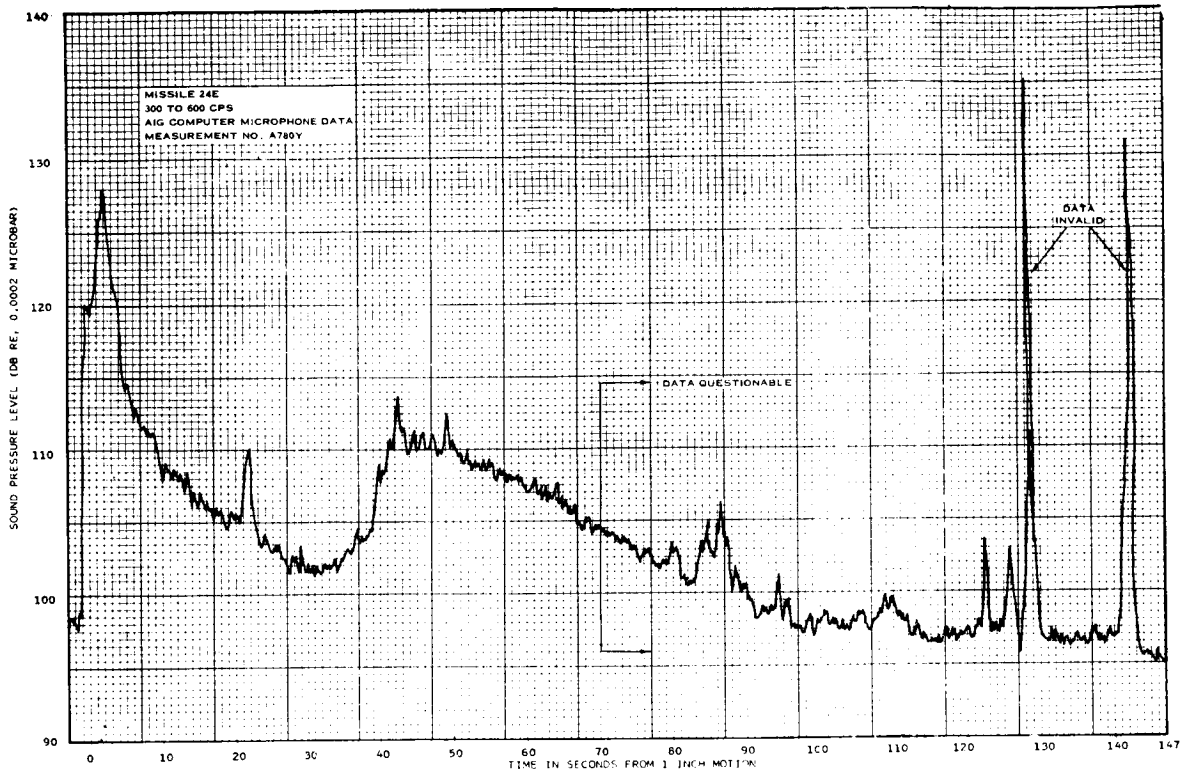
NOTE: THE 4800-9600 OCTAVE WAS NOT OBTAINABLE AND DOES NOT APPEAR ABOVE.

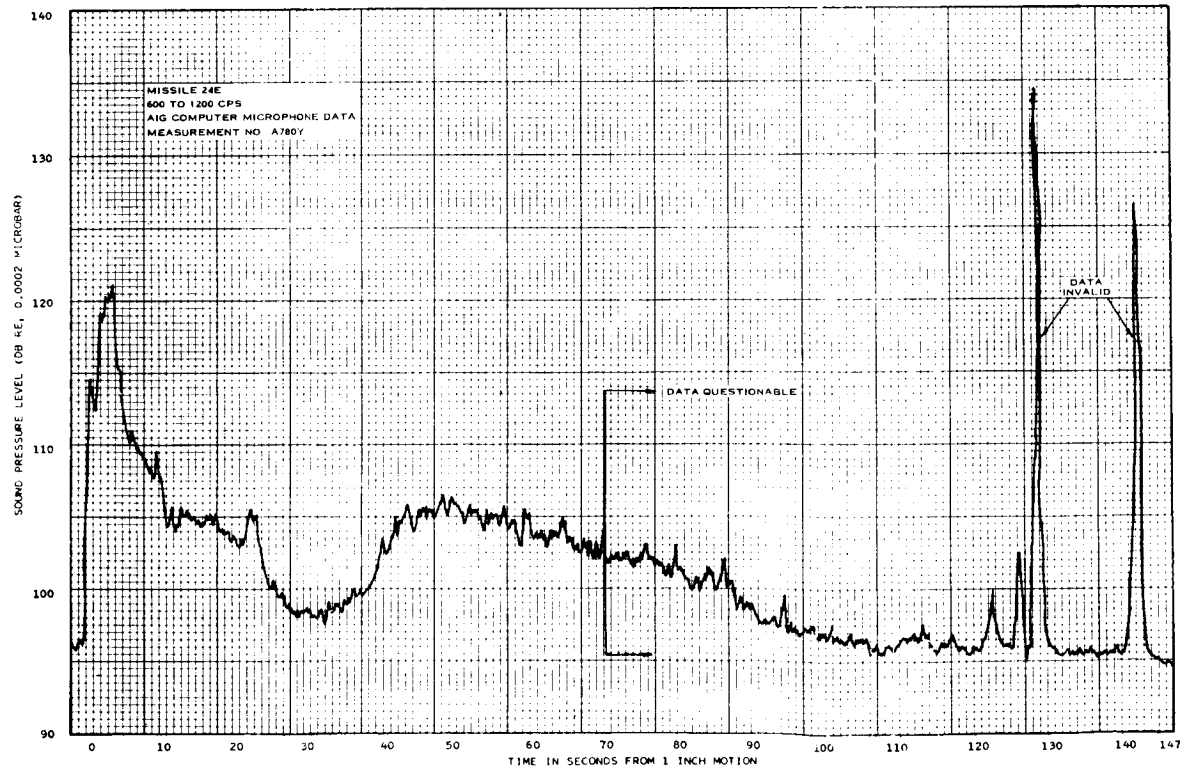

MISSILE 24E
OVER-ALL TIME HISTORY
AIG COMPUTER MICROPHONE DATA
MEASUREMENT NO. A780Y
DATA QUESTIONABLE
DATA INVALID
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
150
140
130
120
110
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147
TIME IN SECONDS FROM 1 INCH MOTION

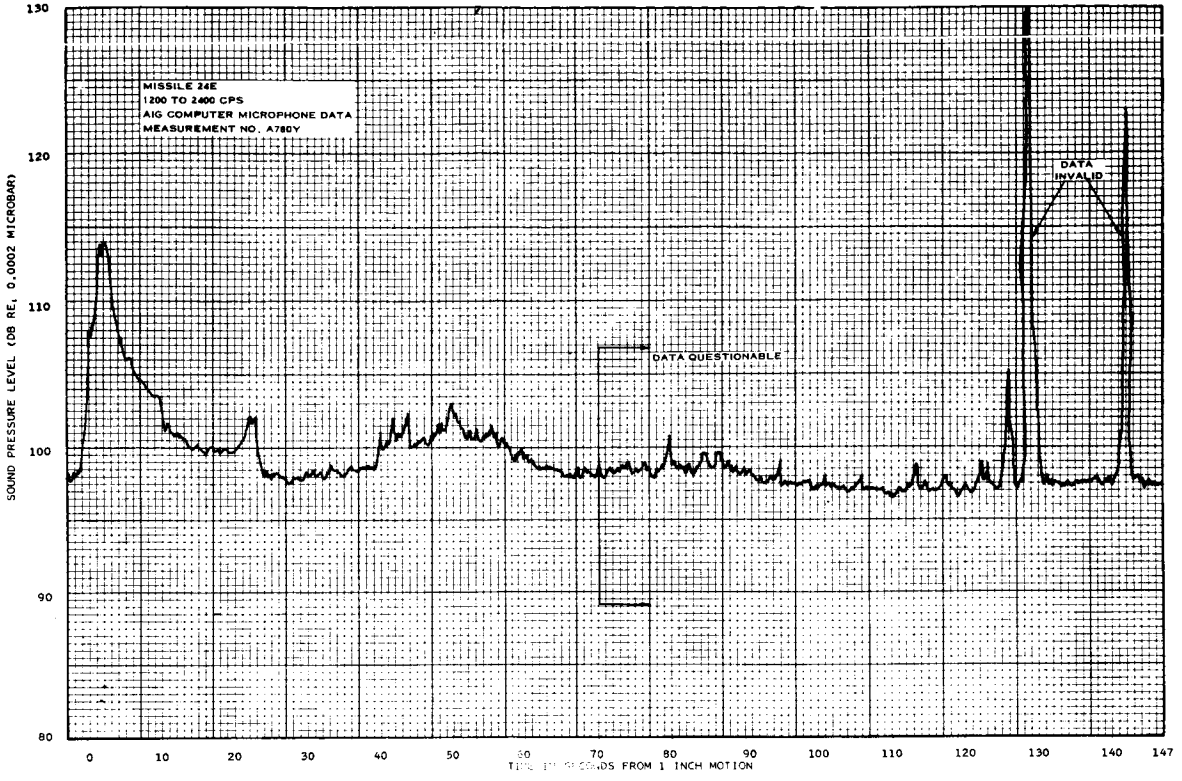

MISSILE 24E
20 TO 75 CPS
AIG COMPUTER MICROPHONE DATA
MEASUREMENT NO. A780Y
DATA QUESTIONABLE
DATA INVALID
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
150
140
130
120
110
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147
TIME IN SECONDS FROM 1 INCH MOTION


MISSILE 24E
75 TO 150 CPS
AIG COMPUTER MICROPHONE DATA
MEASUREMENT NO. A780Y
DATA INVALID
DATA QUESTIONABLE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
TIME IN SECONDS FROM 1 INCH MOTION
150
140
130
120
110
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147


MISSILE 24E
150 TO 300 CPS
AIG COMPUTER MICROPHONE DATA
MEASUREMENT NO. A780Y
DATA INVALID
DATA QUESTIONABLE
SOUND PRESSURE LEVEL (DB RE, 0.0002)
150
140
130
120
110
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147

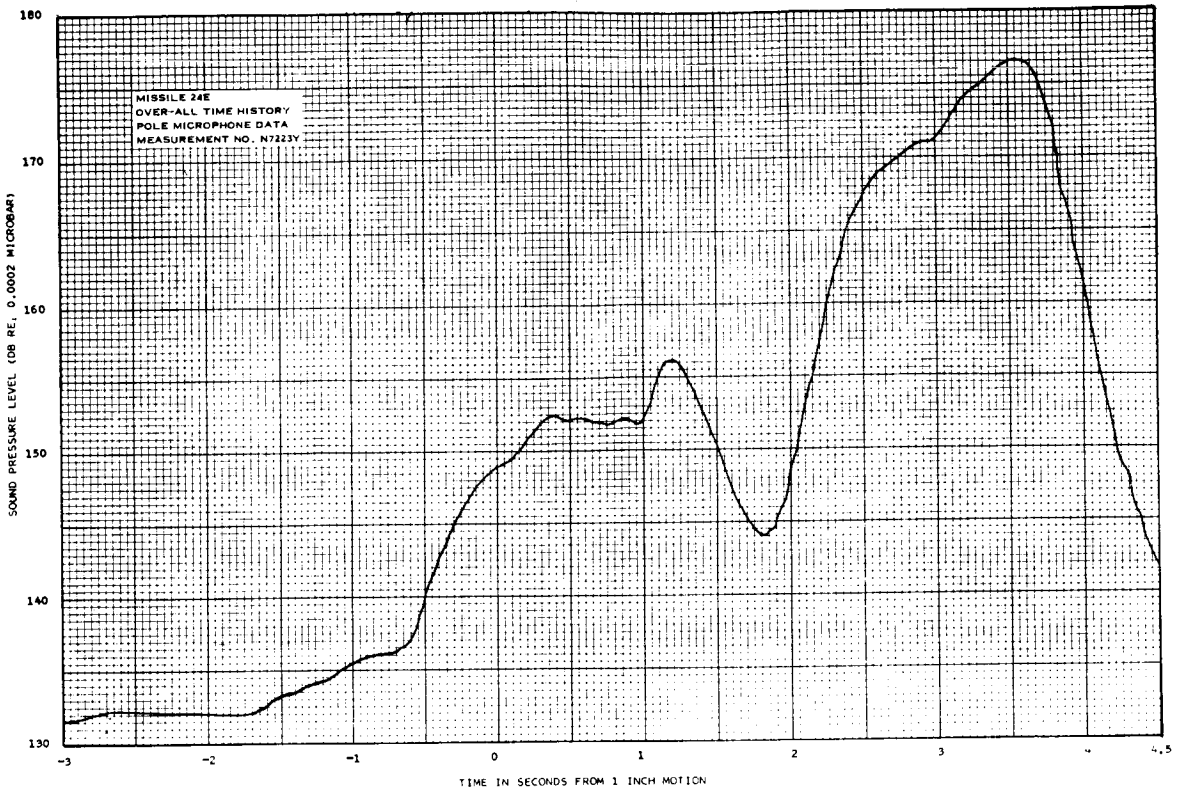

MISSILE 24E
300 TO 600 CPS
AIG COMPUTER MICROPHONE DATA
MEASUREMENT NO. A780Y
DATA INVALID
DATA QUESTIONABLE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
140
130
120
110
100
90
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147
TIME IN SECONDS FROM 1 INCH MOTION

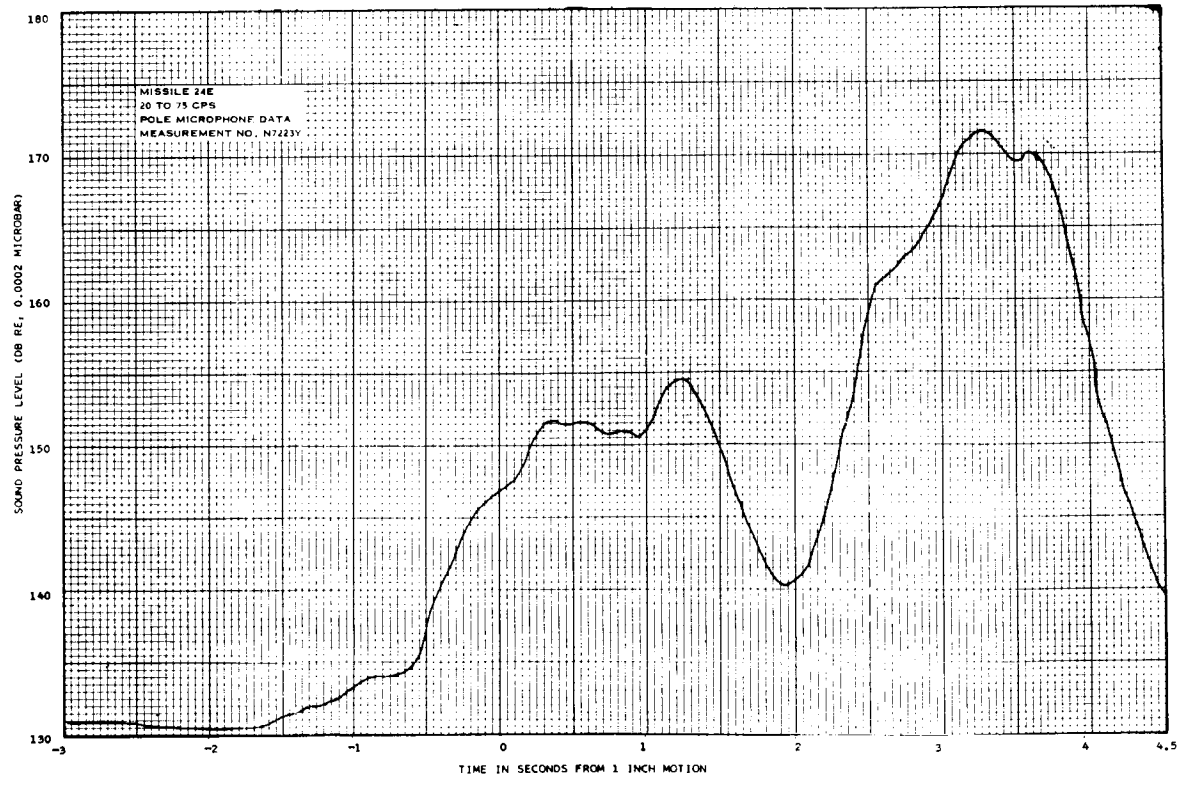

MISSILE 24E
600 TO 1200 CPS
AIG COMPUTER MICROPHONE DATA
MEASUREMENT NO A780Y
DATA INVALID
DATA QUESTIONABLE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
140
130
120
110
100
90
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147
TIME IN SECONDS FROM 1 INCH MOTION


MISSILE 24E
1200 TO 2400 CPS
AIG COMPUTER MICROPHONE DATA
MEASUREMENT NO. A780Y
DATA INVALID
DATA QUESTIONABLE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
130
120
110
100
90
80
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 147
TIME IN SECONDS FROM 1 INCH MOTION

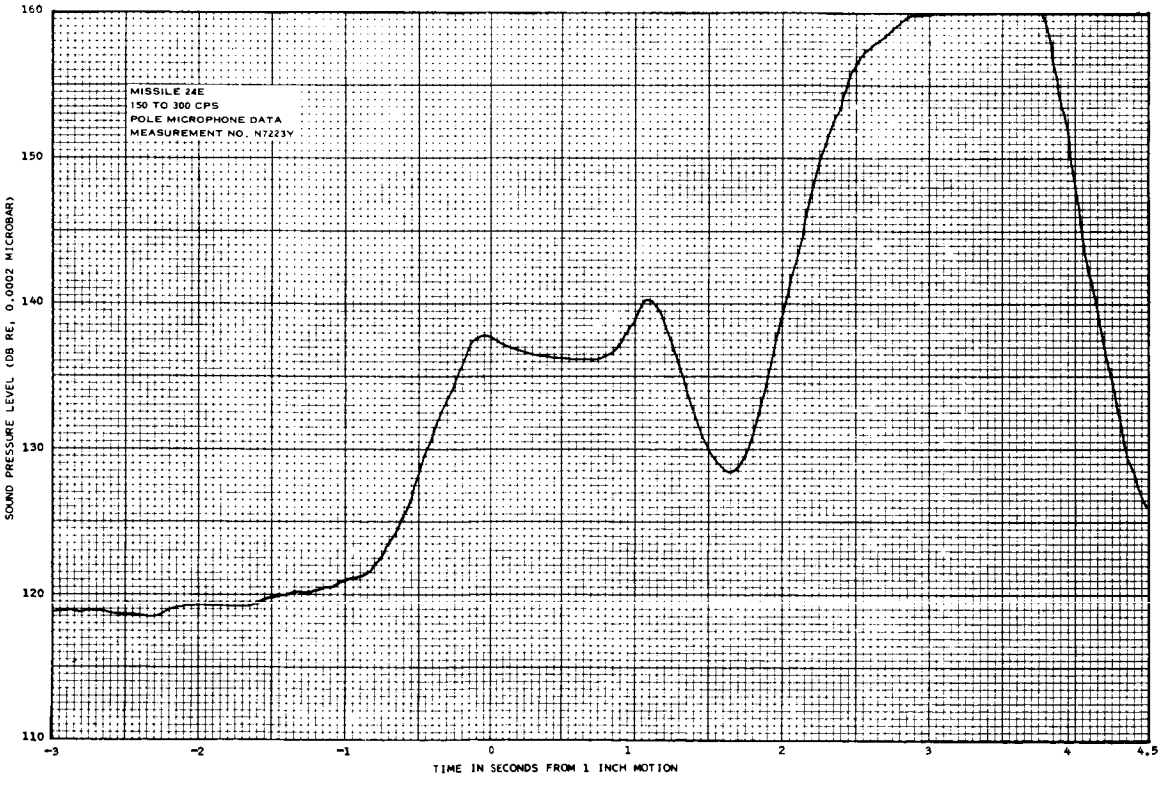

MISSILE 24E
2400 TO 4800 CPS
AIG COMPUTER MICROPHONE DATA
MEASUREMENT NO. A780Y
DATA INVALID
DATA QUESTIONABLE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
130
120
110
100
80
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 147
TIME IN SECONDS FROM 1 INCH MOTION

UNCLASSIFIED

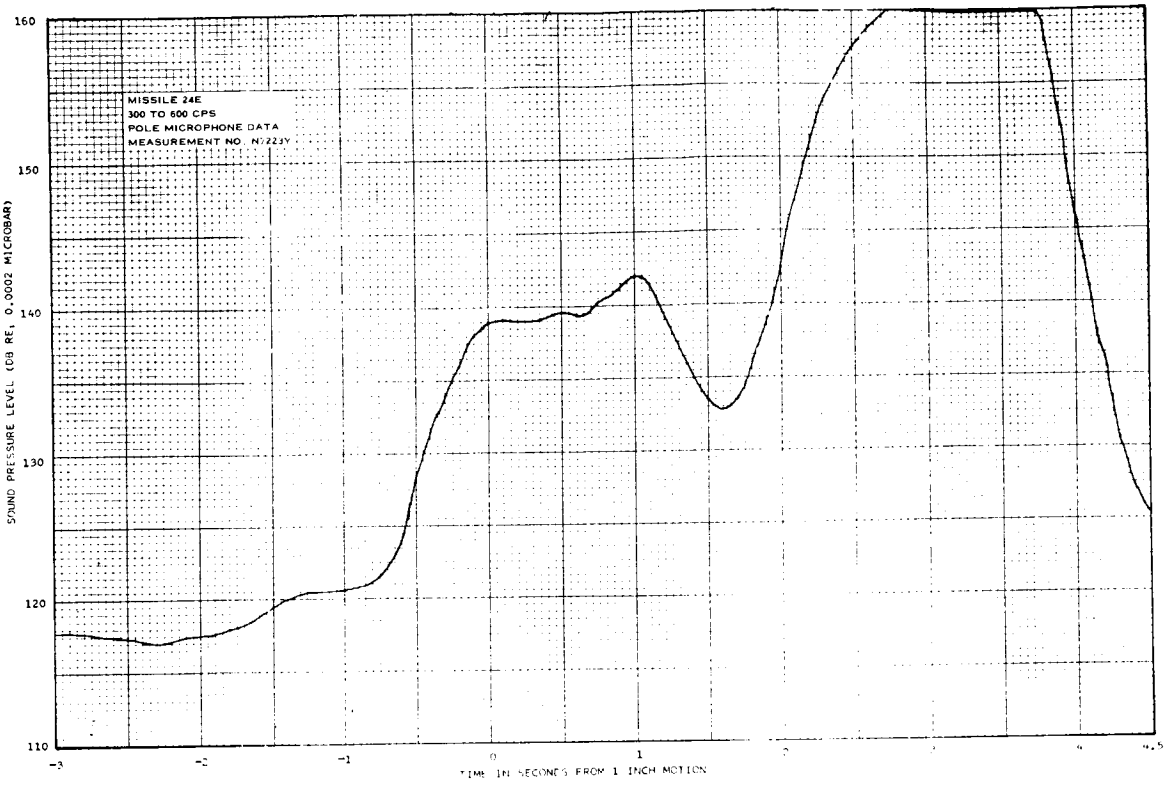


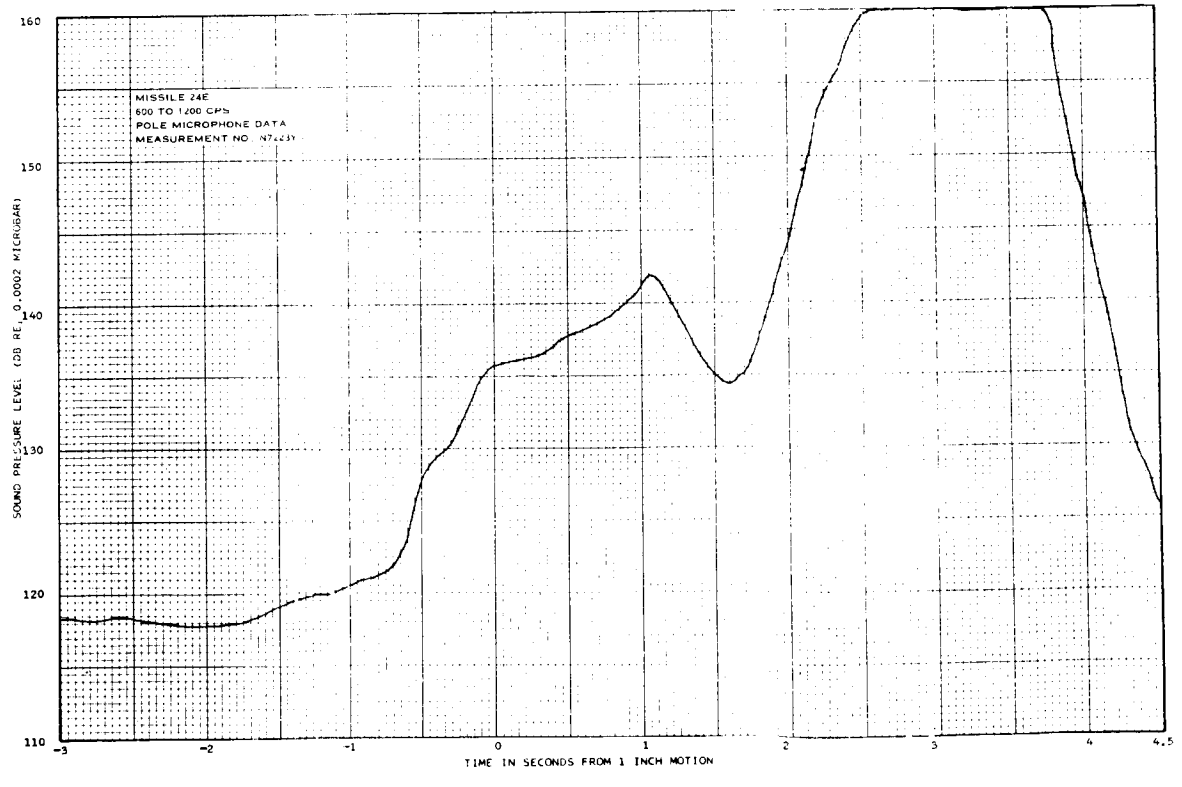


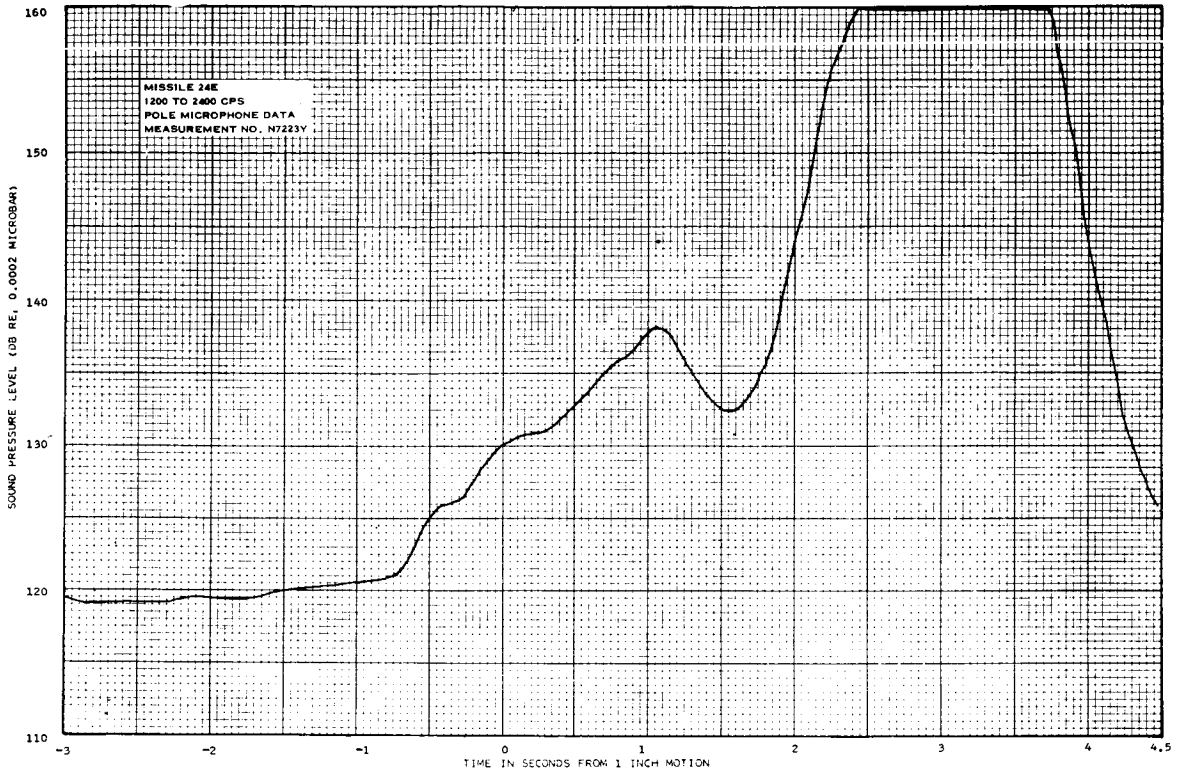

MISSILE 24E
75 TO 150 CPS
POLE MICROPHONE DATA
MEASUREMENT NO. N7223Y
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
4
4.5
TIME IN SECONDS FROM 1 INCH MOTION

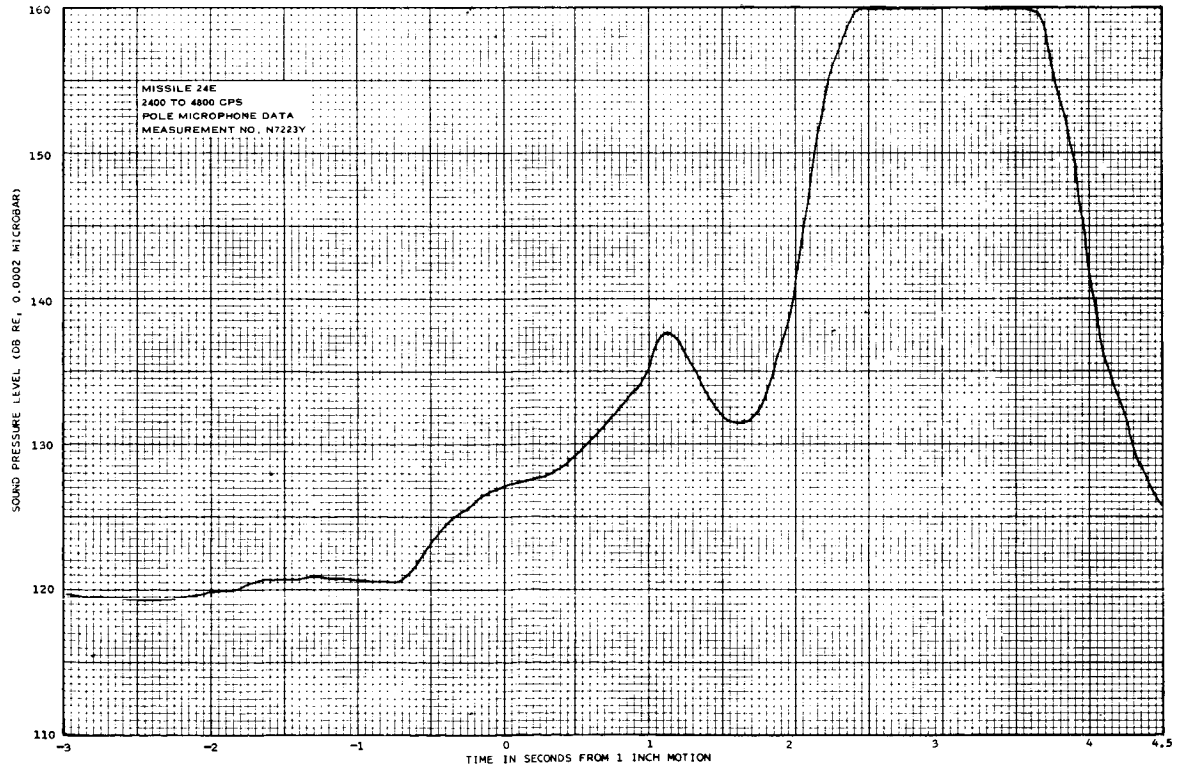

MISSILE 24E
150 TO 300 CPS
POLE MICROPHONE DATA
MEASUREMENT NO. N7223Y
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
4.5
TIME IN SECONDS FROM 1 INCH MOTION

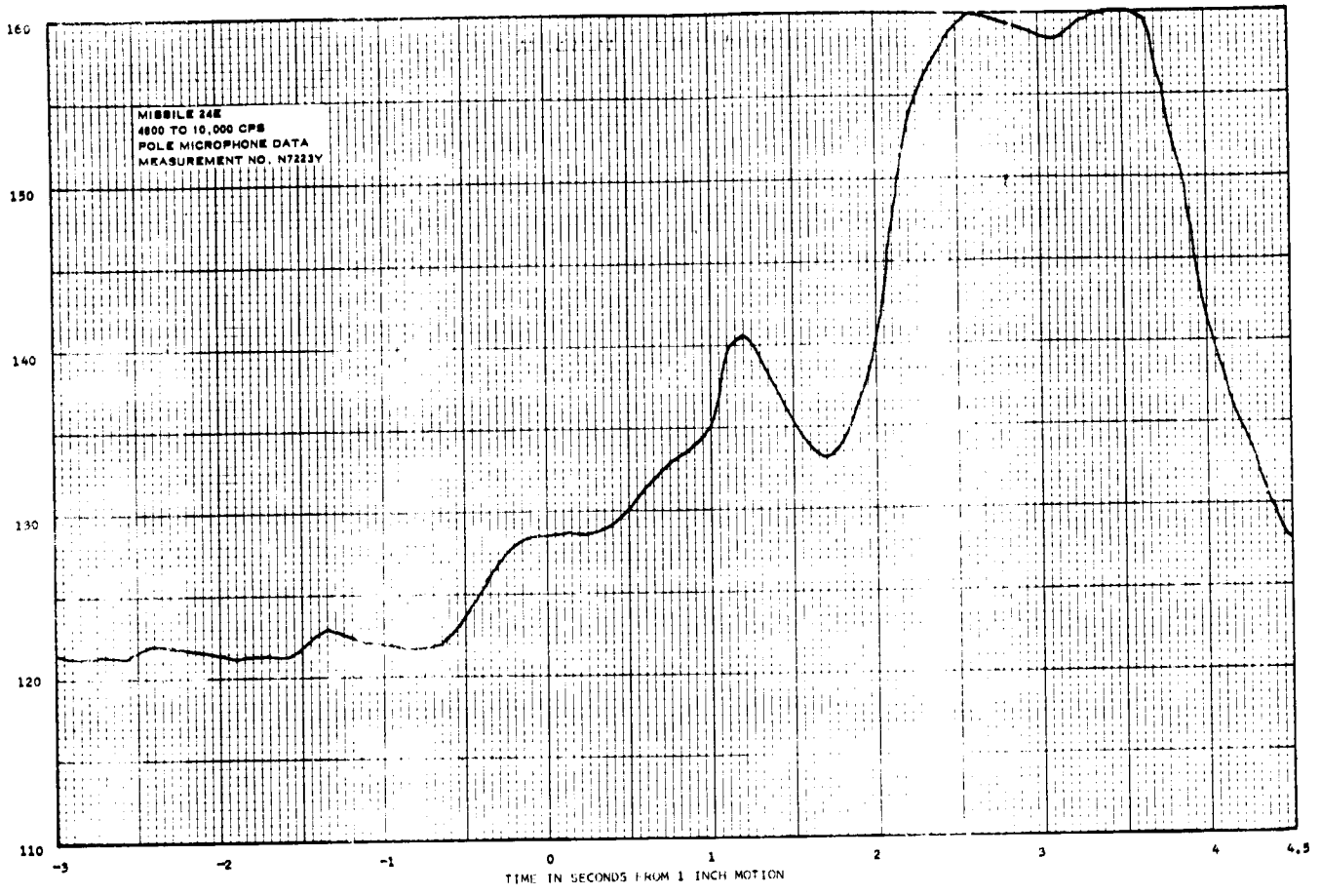
MISSILE 24E

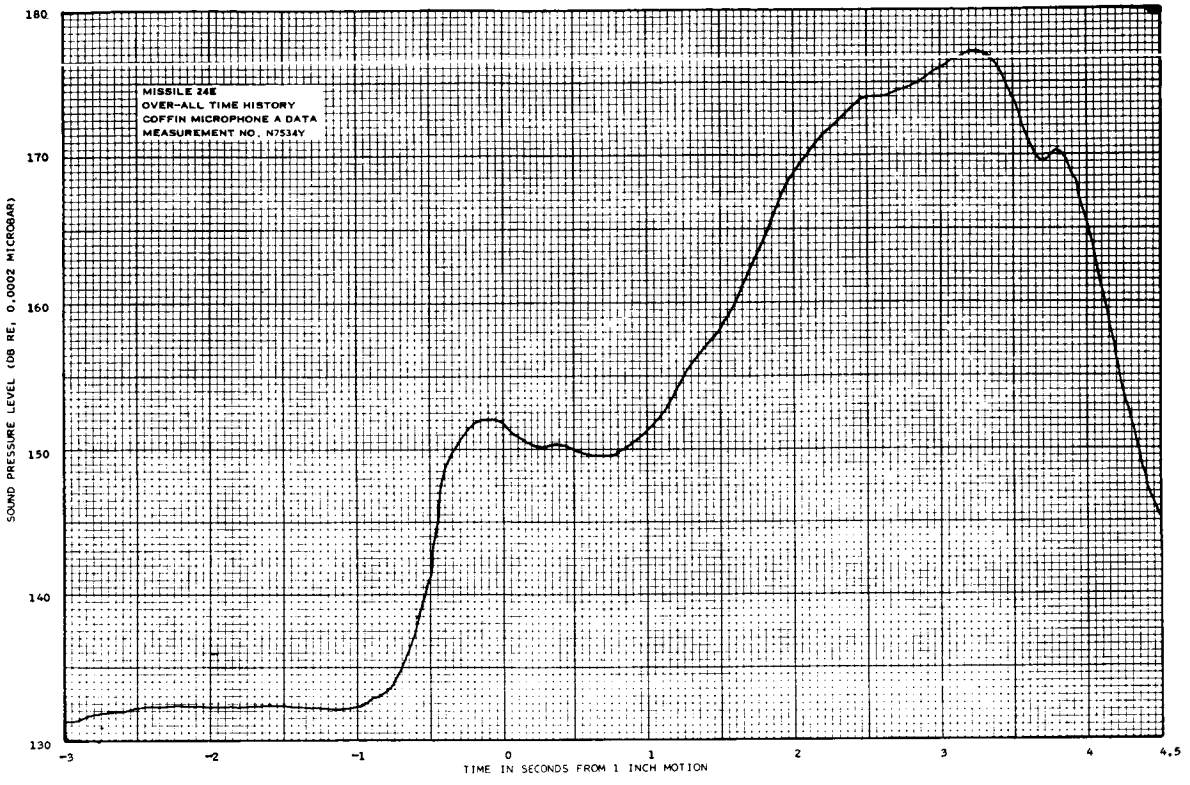

MISSILE 24E
300 TO 600 CPS
POLE MICROPHONE DATA
MEASUREMENT NO. N7223Y
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
TIME IN SECONDS FROM 1 INCH MOTION

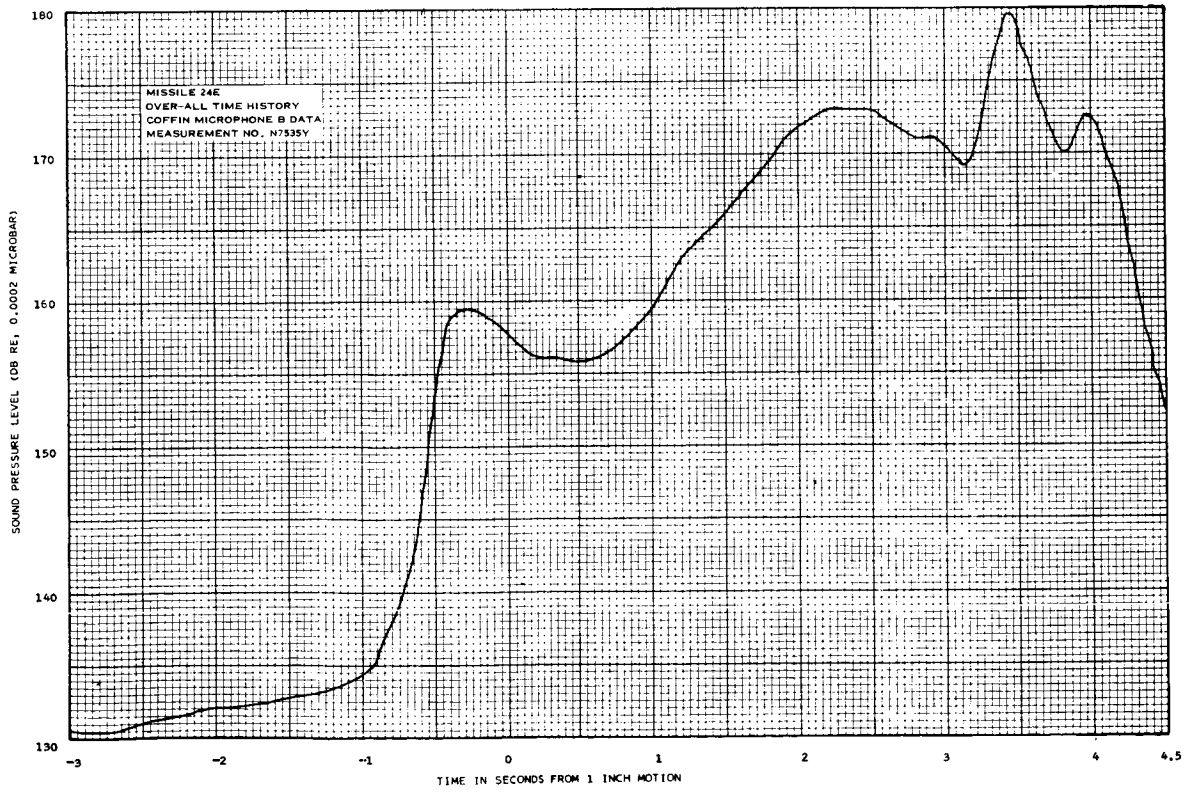

MISSILE 24E
600 TO 1200 CPS
POLE MICROPHONE DATA
MEASUREMENT NO. N7223Y
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
4.5
TIME IN SECONDS FROM 1 INCH MOTION


MISSILE 24E
1200 TO 2400 CPS
POLE MICROPHONE DATA
MEASUREMENT NO. N7223Y
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
4.5
TIME IN SECONDS FROM 1 INCH MOTION


MISSILE 24E
2400 TO 4800 CPS
POLE MICROPHONE DATA
MEASUREMENT NO. N7223Y
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
4.5
TIME IN SECONDS FROM 1 INCH MOTION

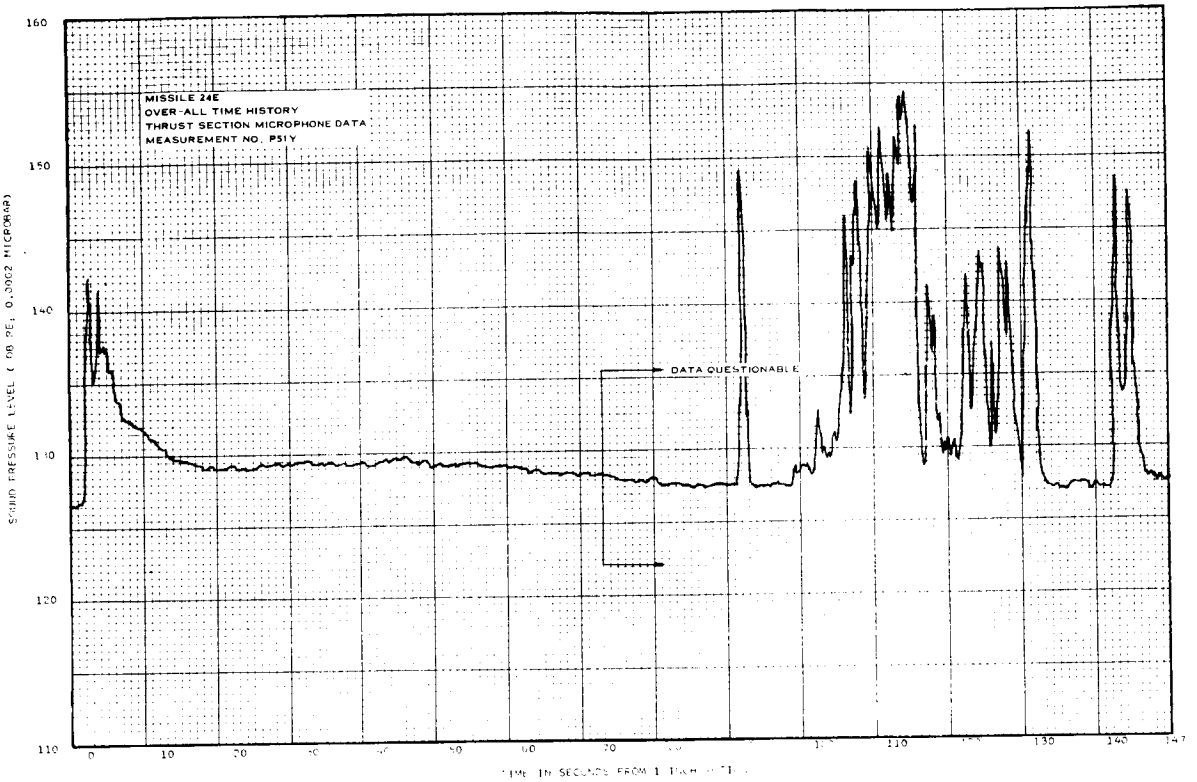

MISSILE 24E
4800 TO 10,000 CPS
POLE MICROPHONE DATA
MEASUREMENT NO. N7223Y
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
4.5
TIME IN SECONDS FROM 1 INCH MOTION

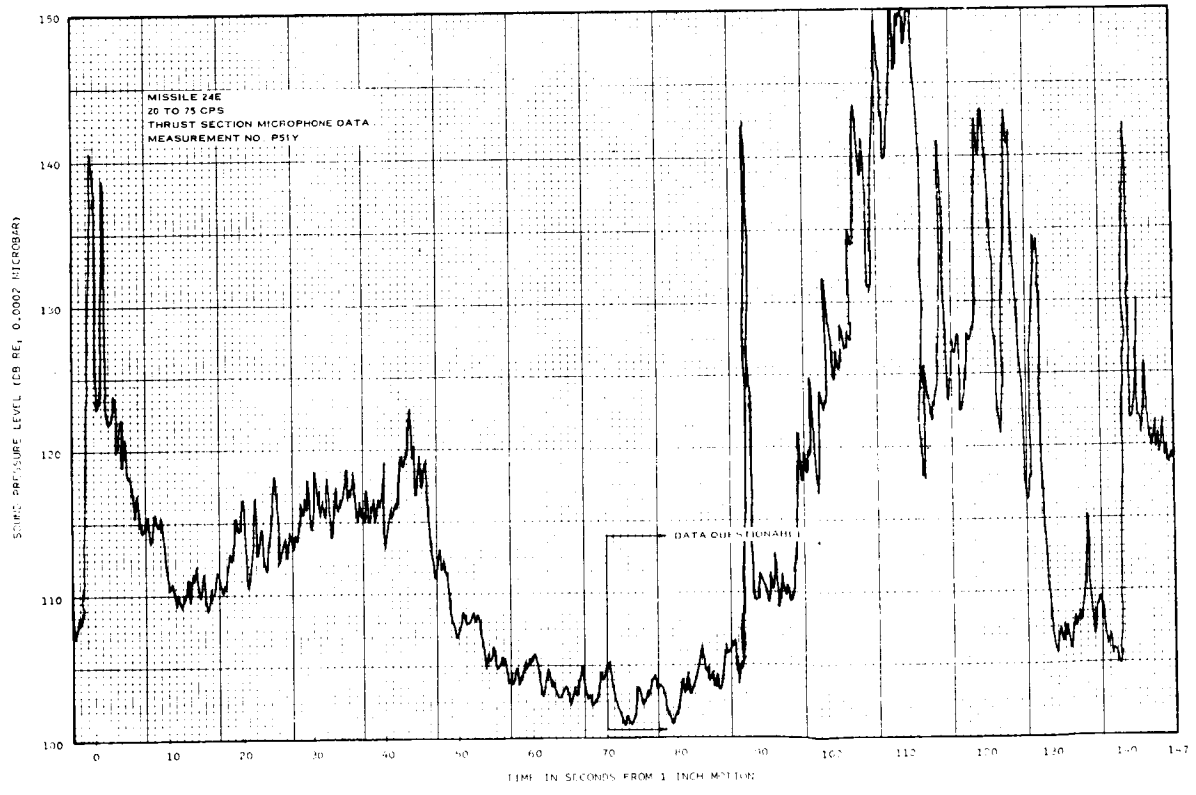

MISSILE 24E
OVER-ALL TIME HISTORY
COFFIN MICROPHONE A DATA
MEASUREMENT NO. N7534Y
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
180
170
160
150
140
130
-3
-2
-1
0
1
2
3
4
4.5
TIME IN SECONDS FROM 1 INCH MOTION

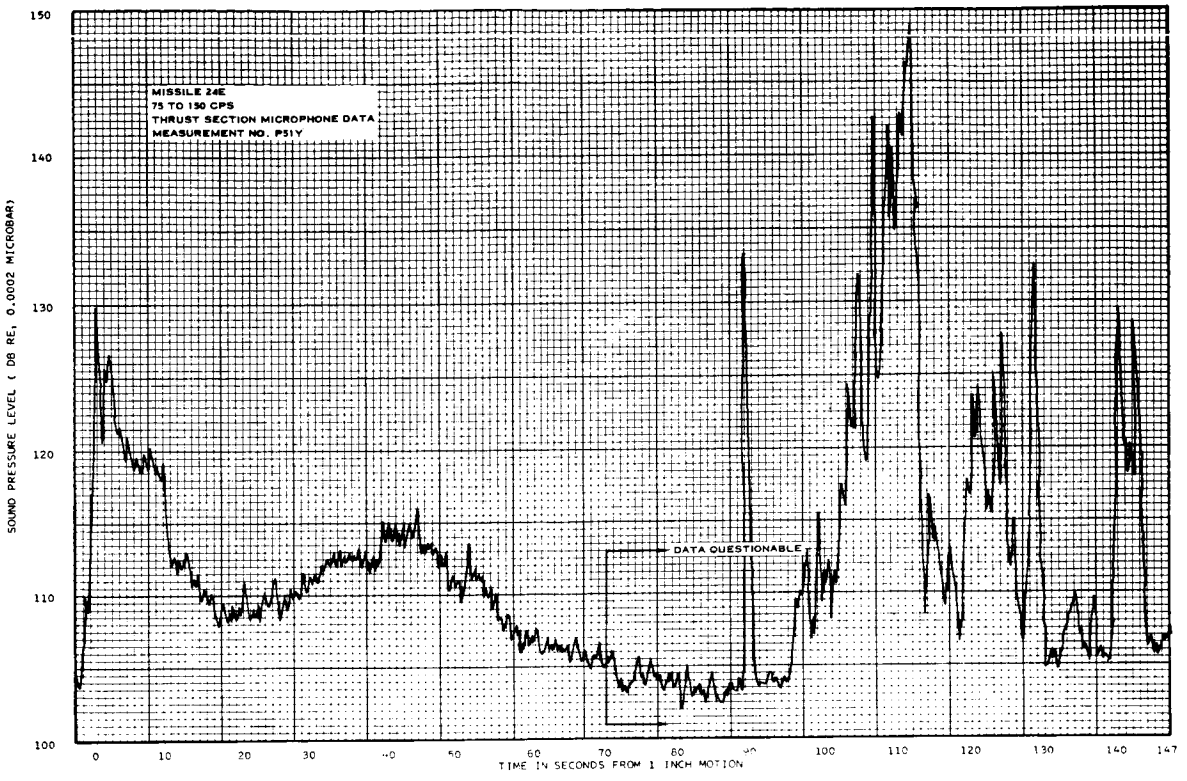

MISSILE 24E
OVER-ALL TIME HISTORY
COFFIN MICROPHONE B DATA
MEASUREMENT NO. N7535Y
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
180
170
160
150
140
130
-3
-2
-1
0
1
2
3
4
4.5
TIME IN SECONDS FROM 1 INCH MOTION

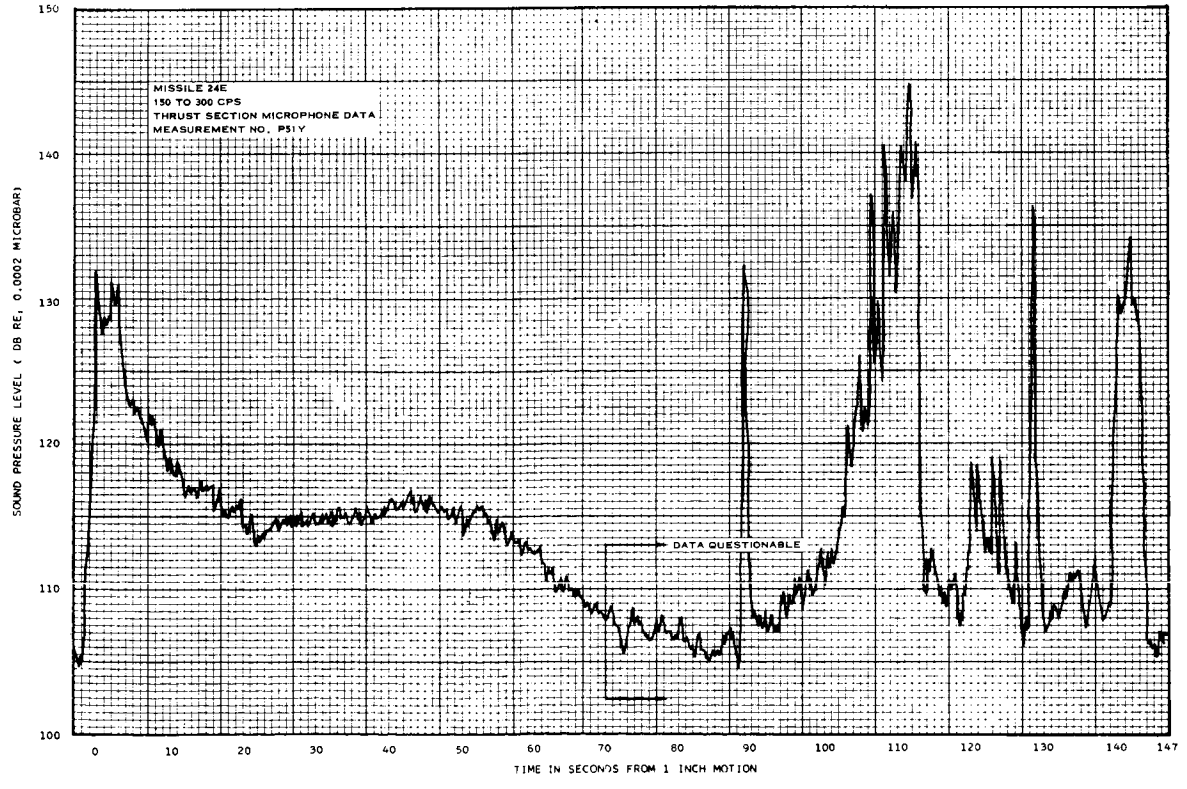
ACOUSTIC AND VIBRATION
FIGURE NO. 12-15
~~REPORT NO. GDA 63-0709~~

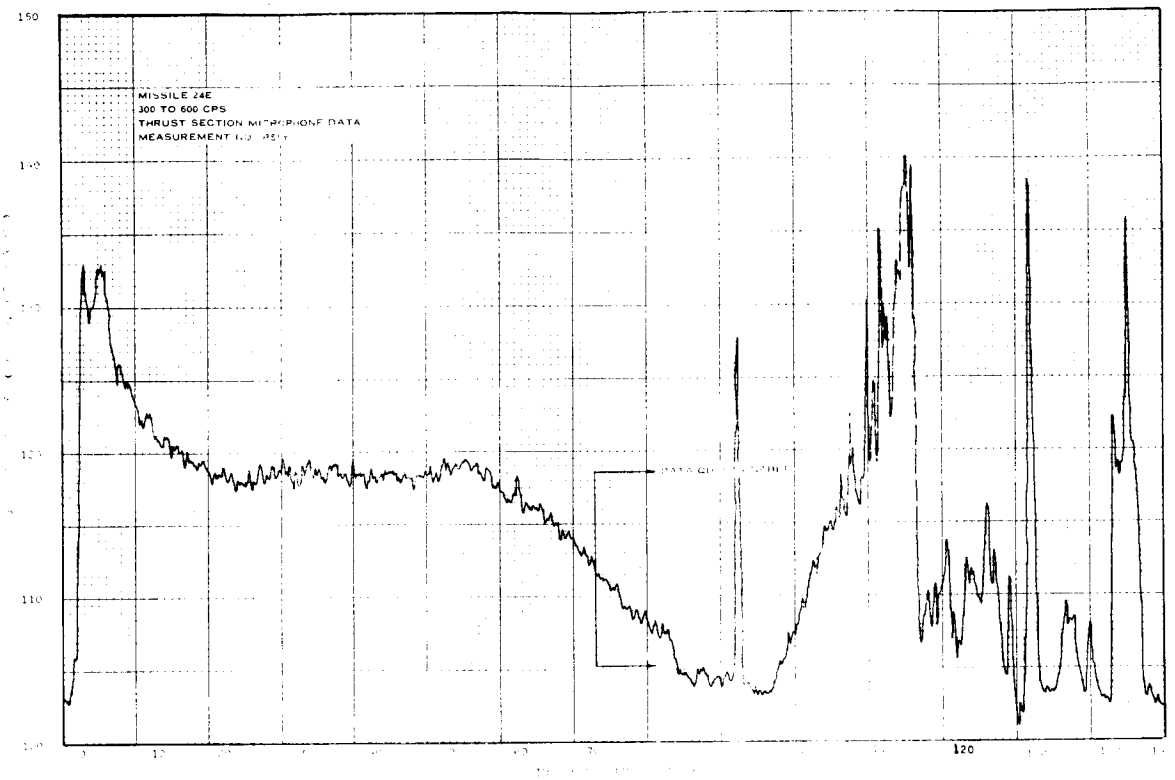
MISSILE 24E

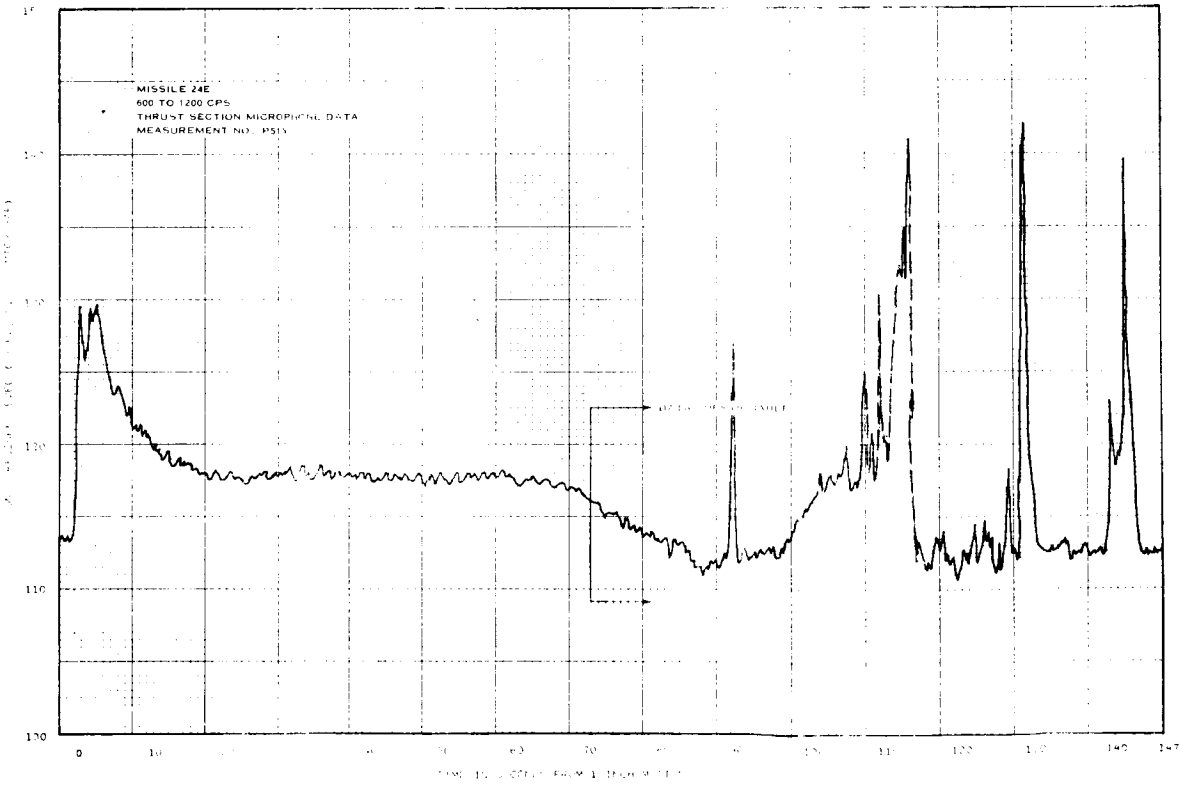


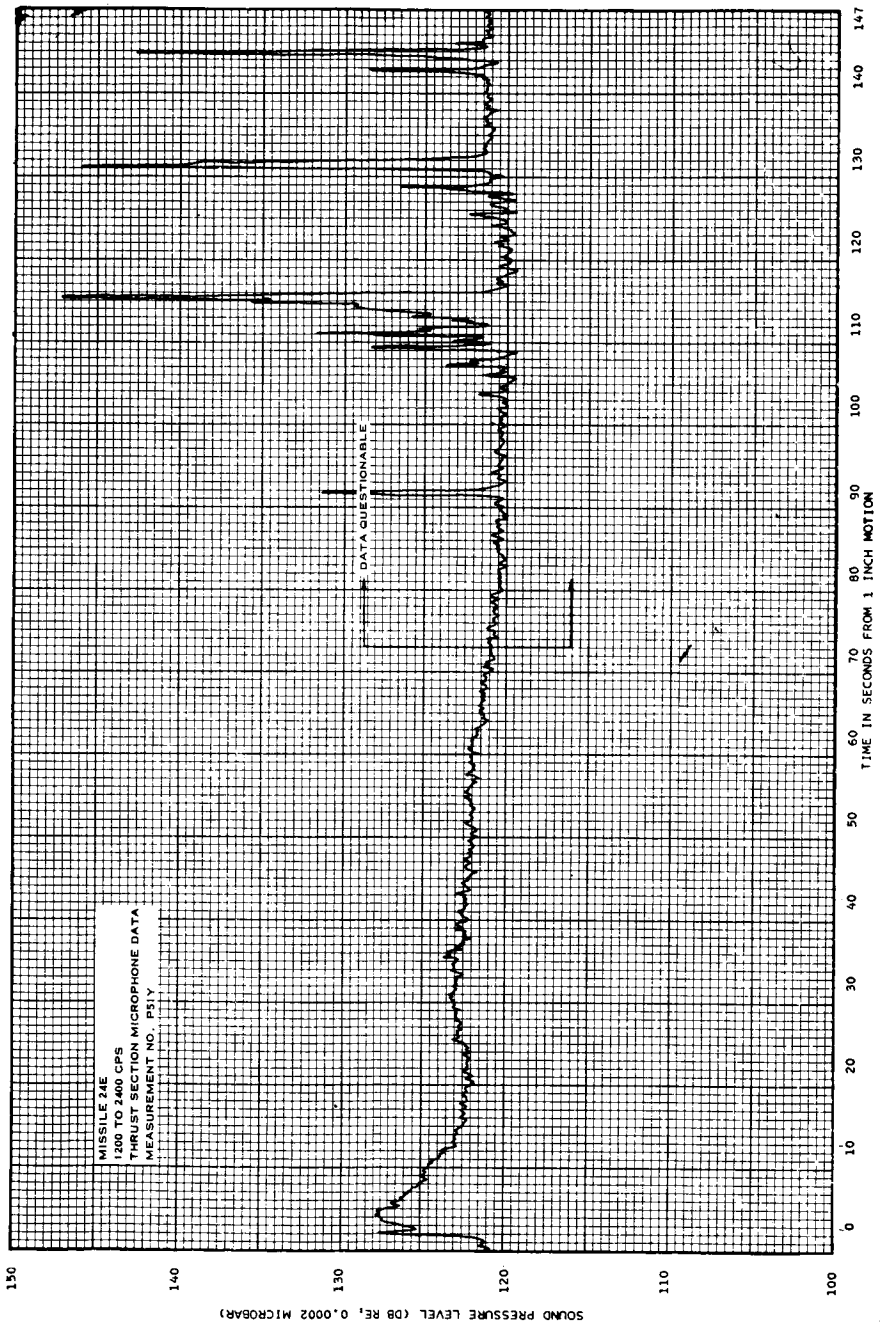



MISSILE 24E
75 TO 150 CPS
THRUST SECTION MICROPHONE DATA
MEASUREMENT NO. P51Y
DATA QUESTIONABLE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
TIME IN SECONDS FROM 1 INCH MOTION
150
140
130
120
110
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147

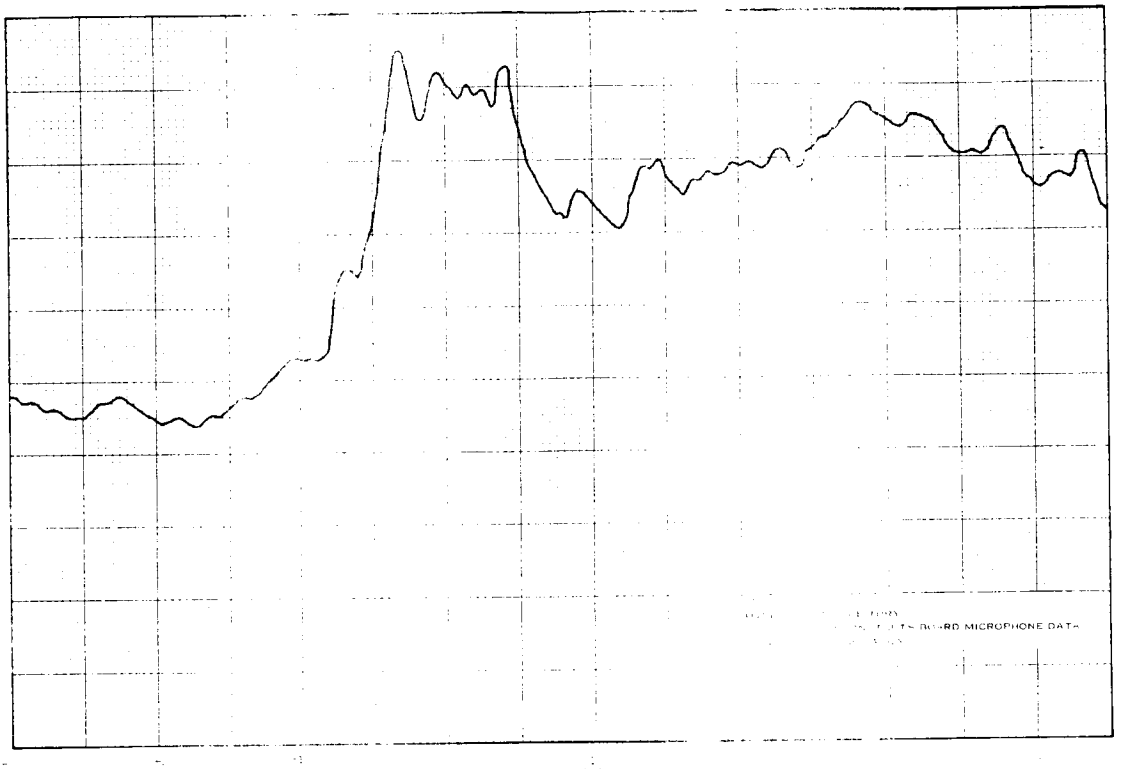

MISSILE 24E
150 TO 300 CPS
THRUST SECTION MICROPHONE DATA
MEASUREMENT NO. P51Y
DATA QUESTIONABLE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
TIME IN SECONDS FROM 1 INCH MOTION
150
140
130
120
110
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147

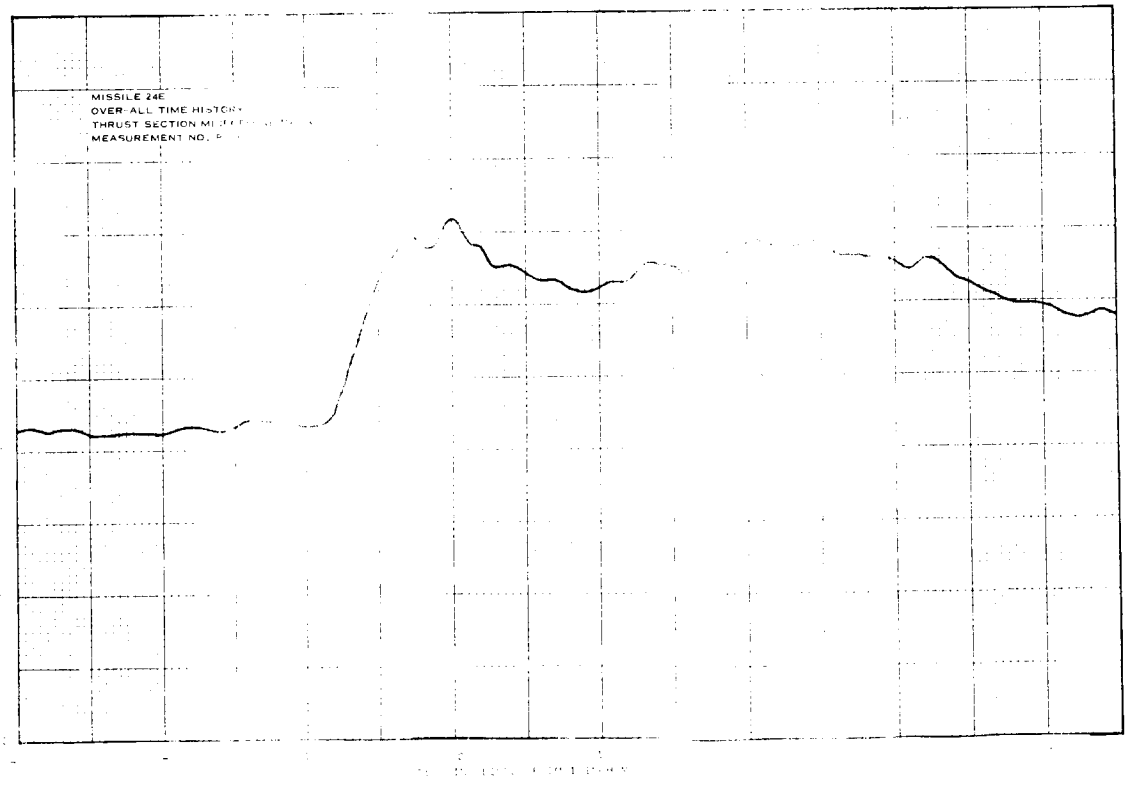

MISSILE 24E
300 TO 600 CPS
THRUST SECTION MICROPHONE DATA
150
140
130
120
110
100
120

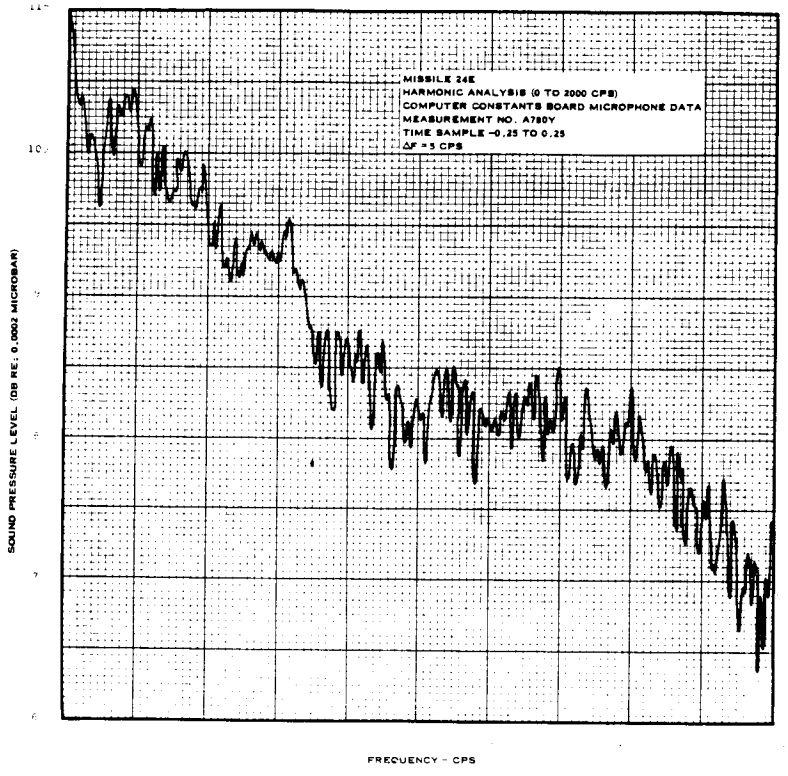

MISSILE 24E
600 TO 1200 CPS
THRUST SECTION MICROPHONE DATA
140
130
120
110
100
0

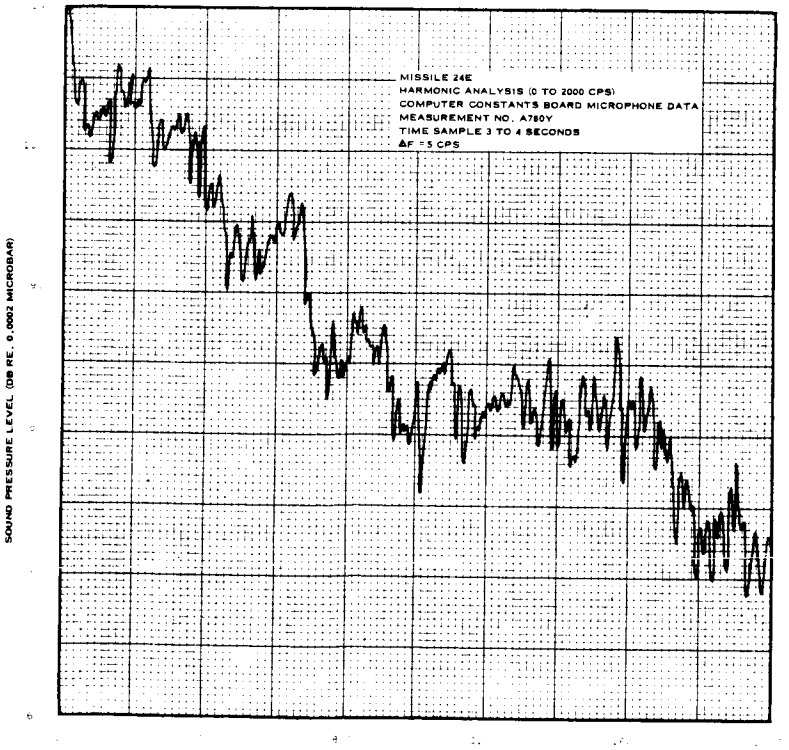

DATA QUESTIONABLE
MISSILE 24E
1200 TO 2400 CPS
THRUST SECTION MICROPHONE DATA
MEASUREMENT NO. P51Y
TIME IN SECONDS FROM 1 INCH MOTION
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
147
SOUND PRESSURE LEVEL (DB RE. 0.0002 MICROBAR)
150
140
130
120
110
100

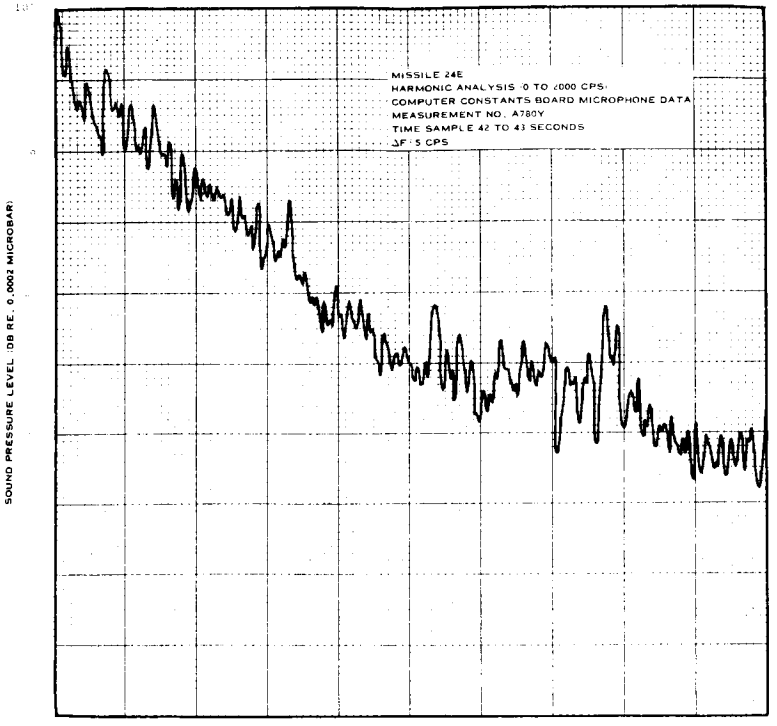
UNCLASSIFIED

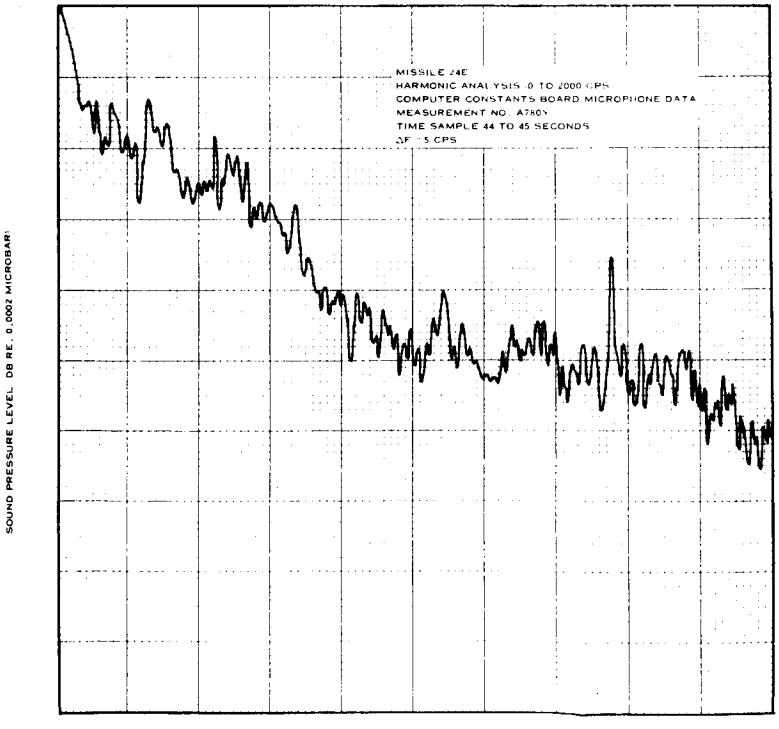




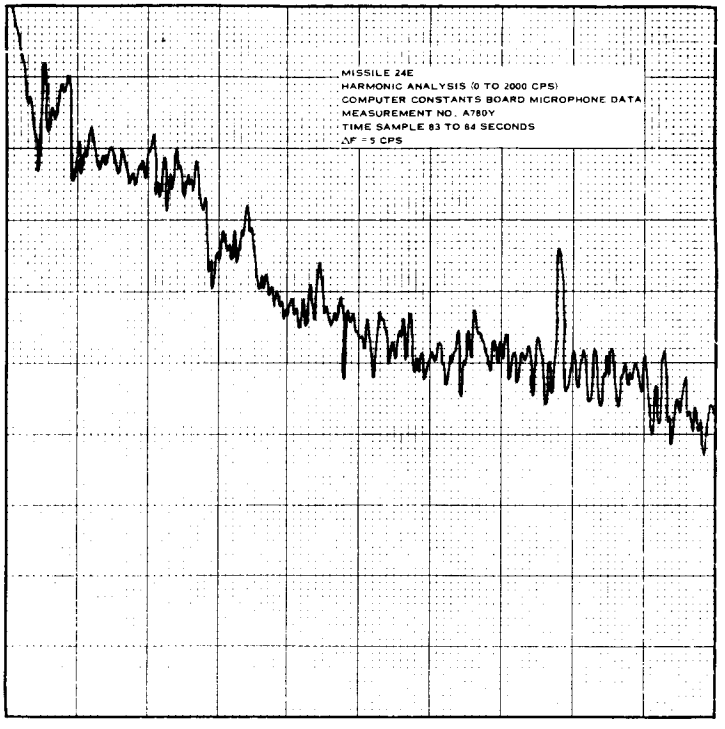

MISSILE 24E
HARMONIC ANALYSIS (0 TO 2000 CPS)
COMPUTER CONSTANTS BOARD MICROPHONE DATA
MEASUREMENT NO. A780Y
TIME SAMPLE -0.25 TO 0.25
ΔF = 5 CPS
SOUND PRESSURE LEVEL (DB RE: 0.0002 MICROBAR)
FREQUENCY - CPS

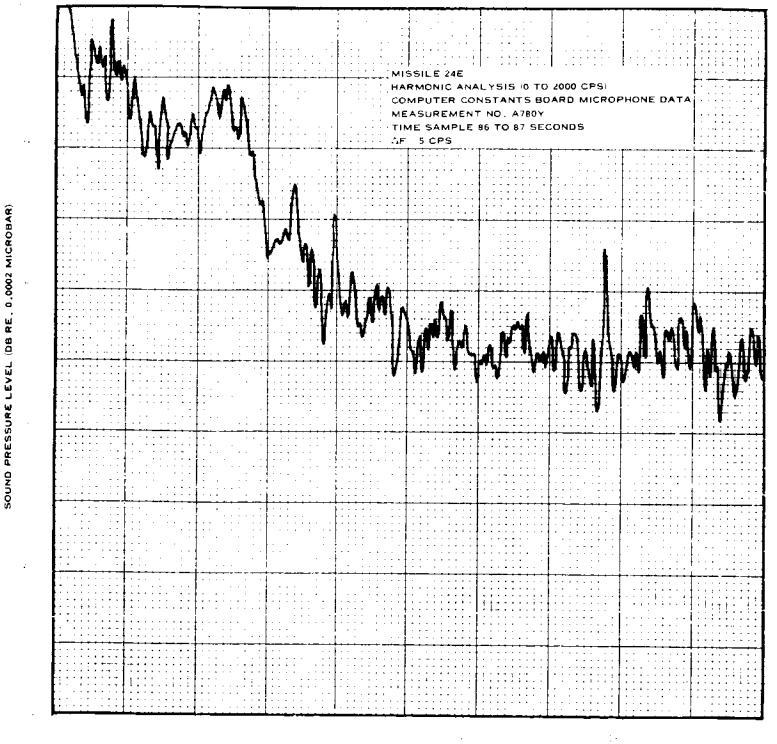

MISSILE 24E
HARMONIC ANALYSIS (0 TO 2000 CPS)
COMPUTER CONSTANTS BOARD MICROPHONE DATA
MEASUREMENT NO. A780Y
TIME SAMPLE 3 TO 4 SECONDS
ΔF = 5 CPS
SOUND PRESSURE LEVEL (DB RE: 0.0002 MICROBAR)


MISSILE 24E
HARMONIC ANALYSIS 0 TO 2000 CPS
COMPUTER CONSTANTS BOARD MICROPHONE DATA
MEASUREMENT NO. A780Y
TIME SAMPLE 42 TO 43 SECONDS
ΔF = 5 CPS
SOUND PRESSURE LEVEL (DB RE. 0.0002 MICROBAR)
FREQUENCY - CPS


MISSILE 24E
HARMONIC ANALYSIS 0 TO 2000 CPS
COMPUTER CONSTANTS BOARD MICROPHONE DATA
MEASUREMENT NO. A780Y
TIME SAMPLE 44 TO 45 SECONDS
ΔF = 5 CPS
SOUND PRESSURE LEVEL (DB RE. 0.0002 MICROBAR)
FREQUENCY - CPS

UNCLASSIFIED



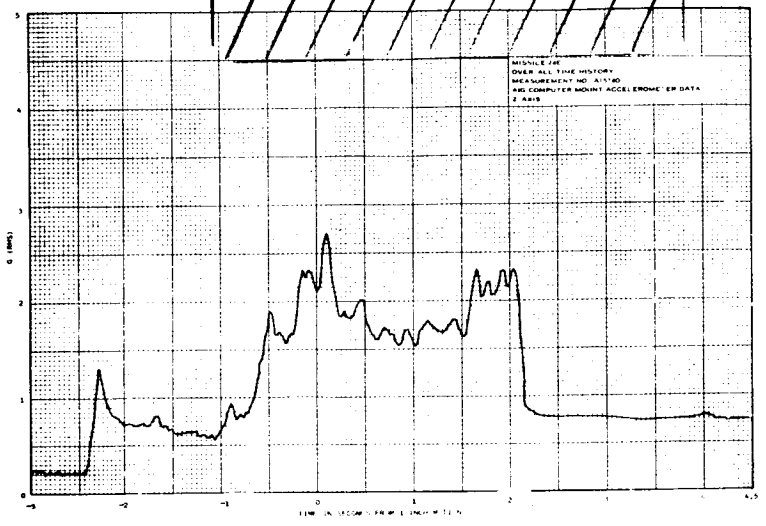


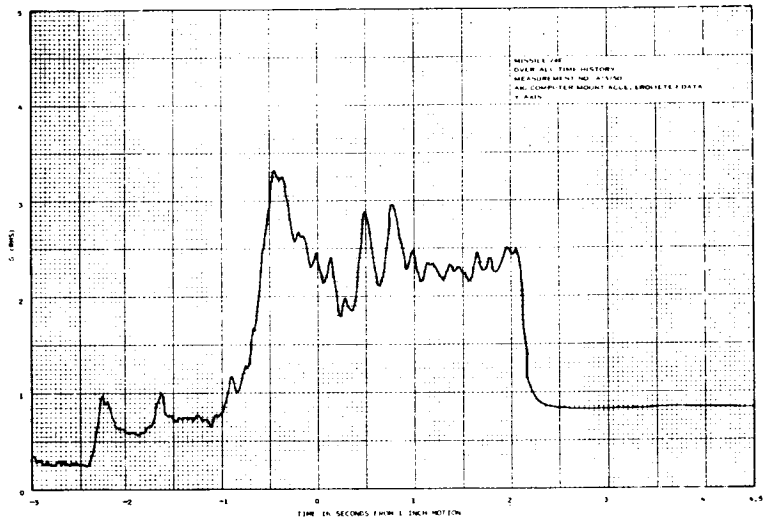
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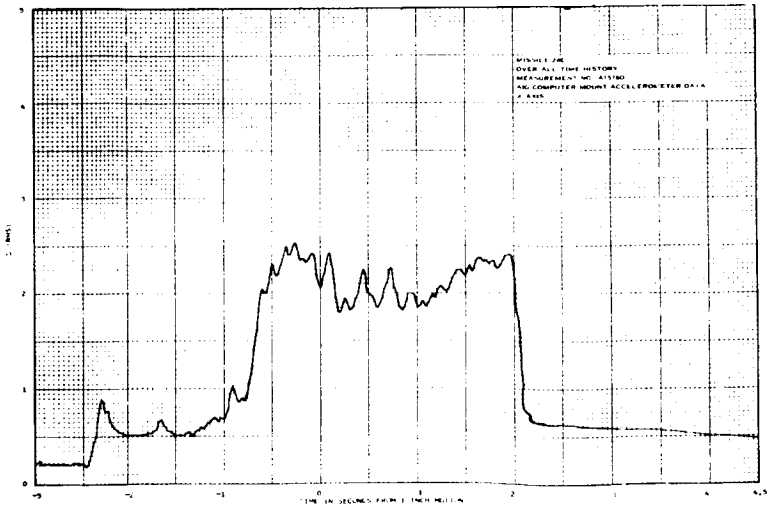
CONFIDENTIAL

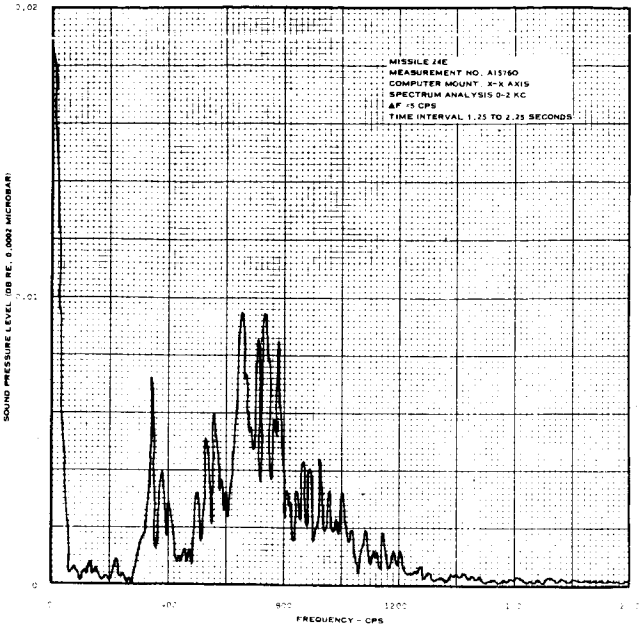
ACOUSTIC AND VIBRATION
FIGURE NO. 12-23
~~REPORT NO. GDA 63-0709~~

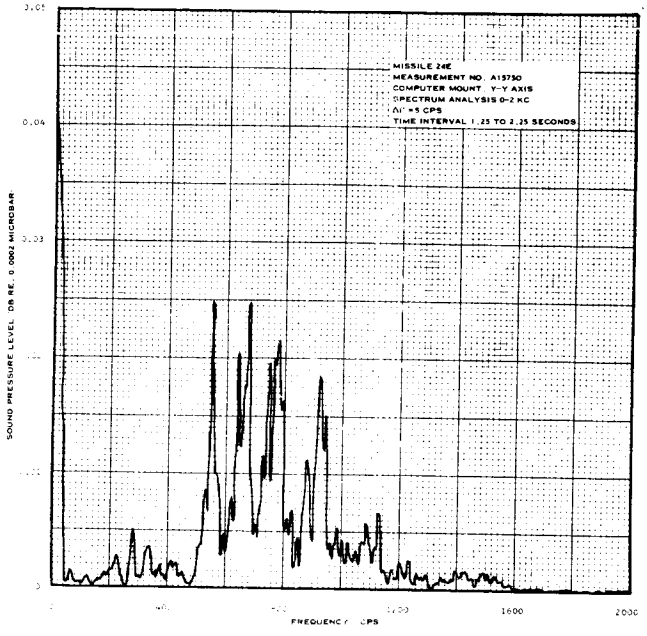
MISSILE 24E

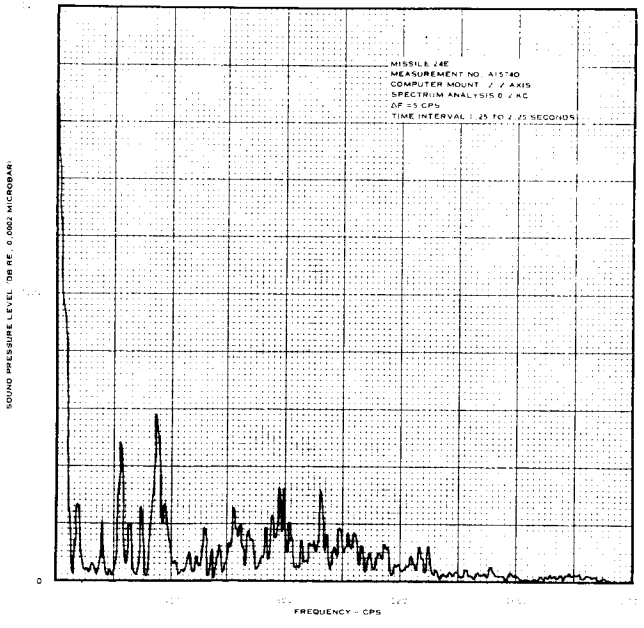


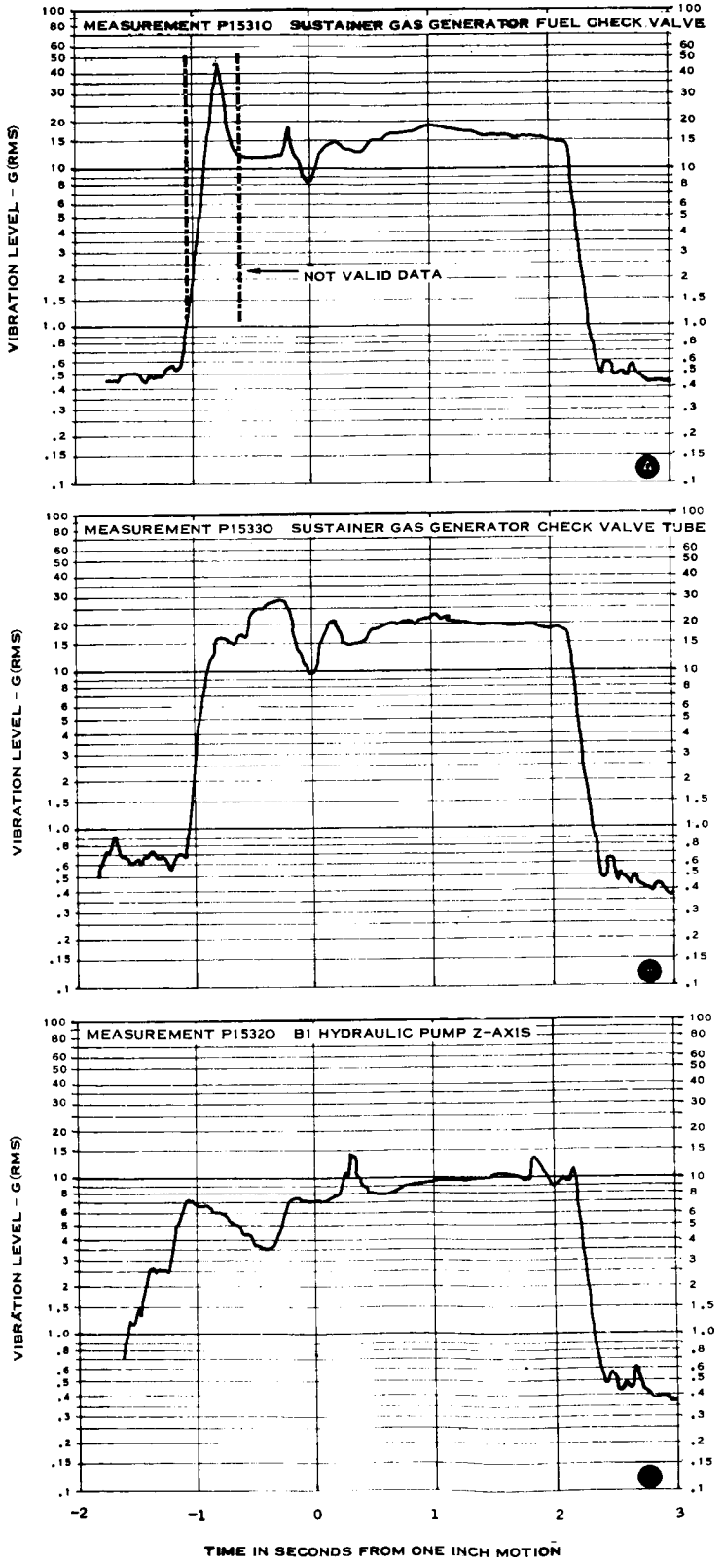


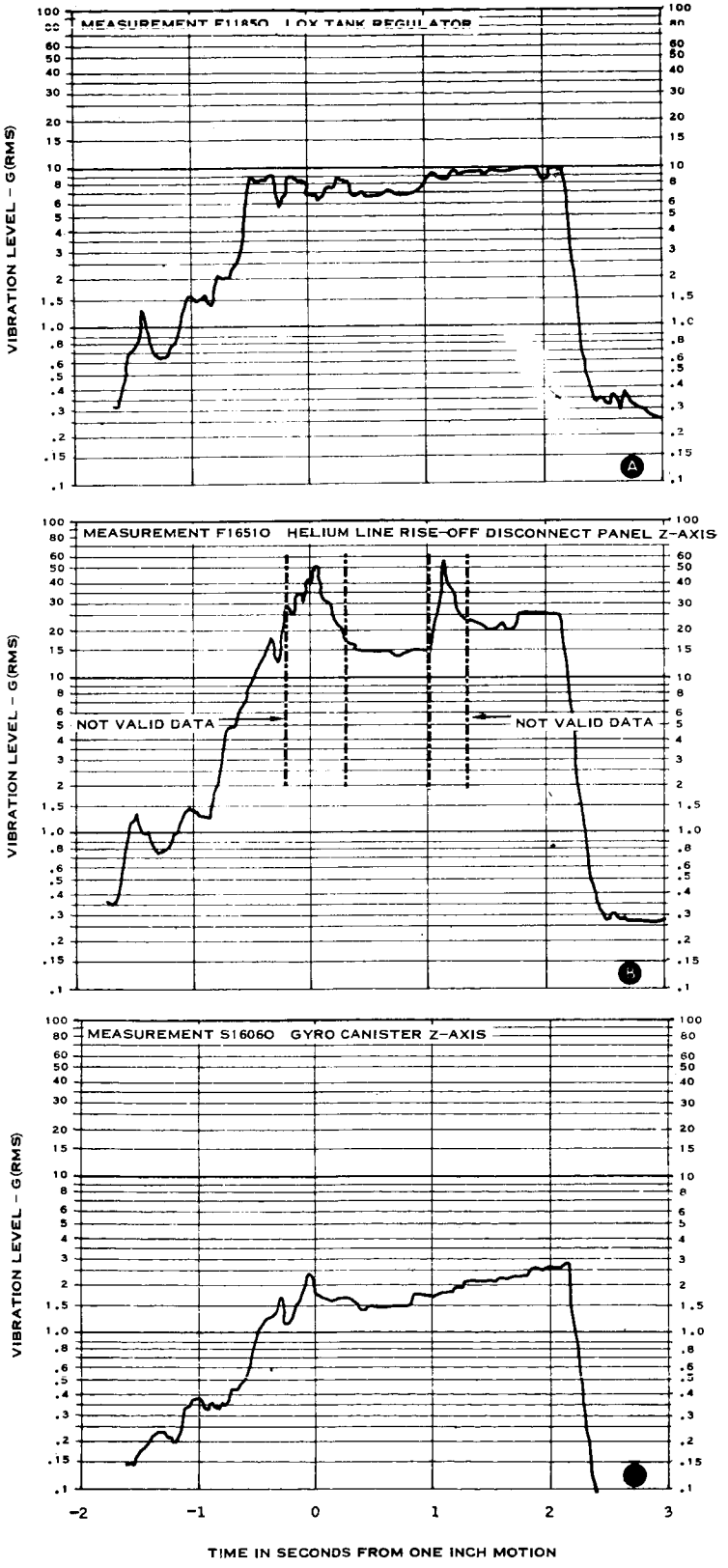



MISSILE 24E
MEASUREMENT NO. A15760
COMPUTER MOUNT X-X AXIS
SPECTRUM ANALYSIS 0-2 KC
ΔF = 5 CPS
TIME INTERVAL 1.25 TO 2.25 SECONDS
SOUND PRESSURE LEVEL (DB RE. 0.0002 MICROBAR)
FREQUENCY - CPS

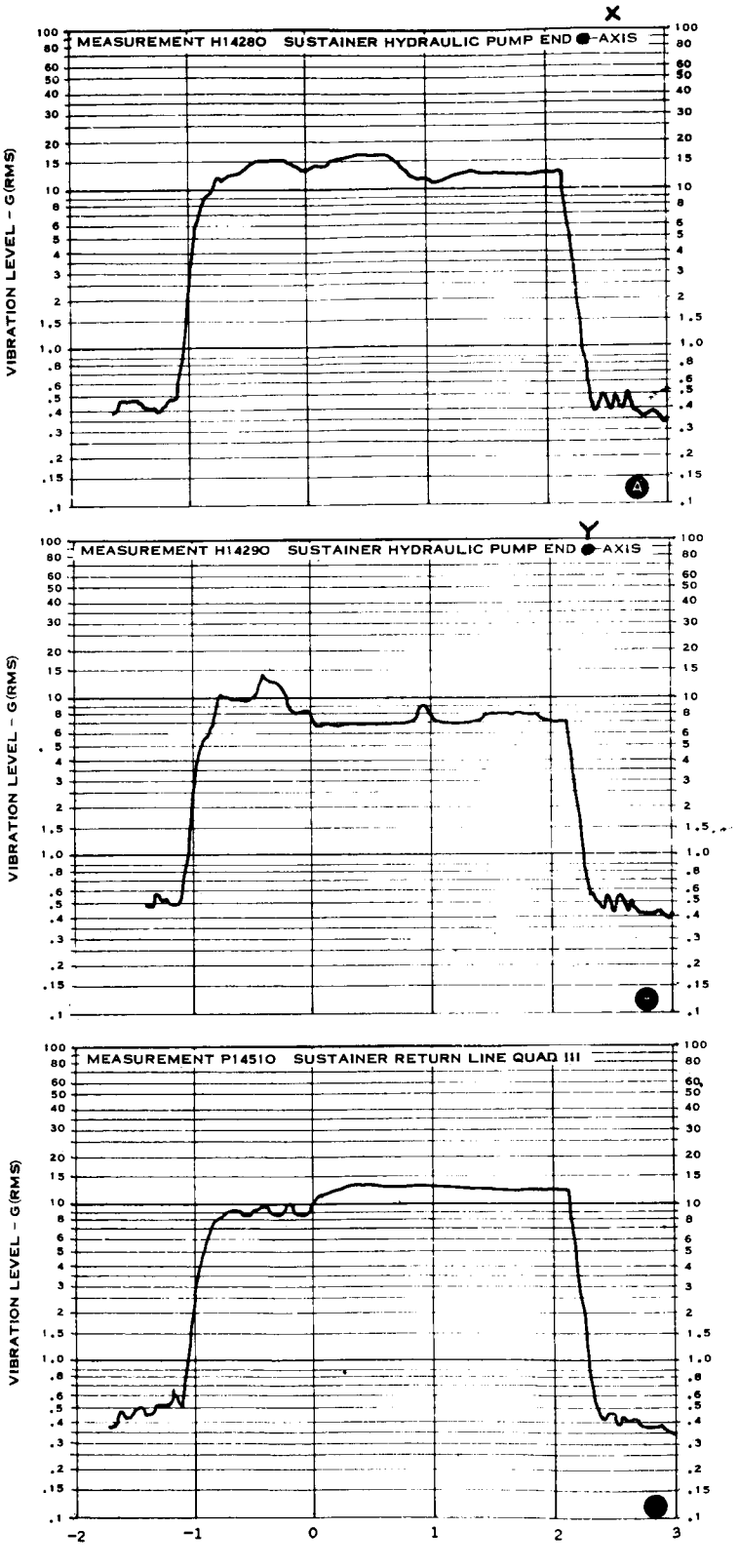

MISSILE 24E
MEASUREMENT NO. A15750
COMPUTER MOUNT Y-Y AXIS
SPECTRUM ANALYSIS 0-2 KC
ΔF = 5 CPS
TIME INTERVAL 1.25 TO 2.25 SECONDS
SOUND PRESSURE LEVEL DB RE. 0.0002 MICROBAR
FREQUENCY - CPS


MISSILE 24E
MEASUREMENT NO. A15740
COMPUTER MOUNT Z-Z AXIS
SPECTRUM ANALYSIS 0-2 KC
ΔF = 5 CPS
TIME INTERVAL 1.25 TO 2.25 SECONDS
SOUND PRESSURE LEVEL (DB RE. 0.0002 MICROBAR)
FREQUENCY - CPS

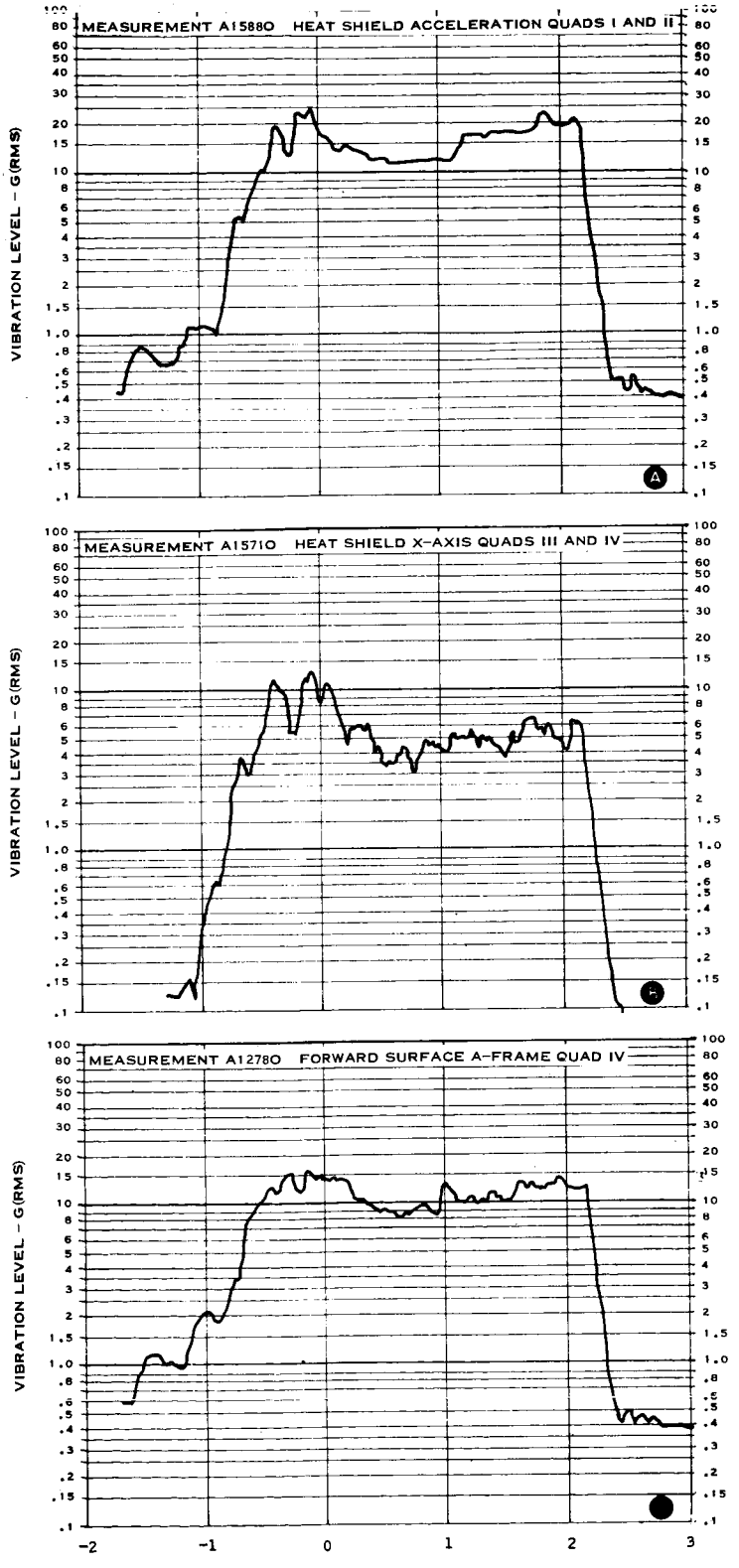

MEASUREMENT P15310 SUSTAINER GAS GENERATOR FUEL CHECK VALVE
NOT VALID DATA
MEASUREMENT P15330 SUSTAINER GAS GENERATOR CHECK VALVE TUBE
MEASUREMENT P15320 B1 HYDRAULIC PUMP Z-AXIS
VIBRATION LEVEL - G(RMS)
TIME IN SECONDS FROM ONE INCH MOTION

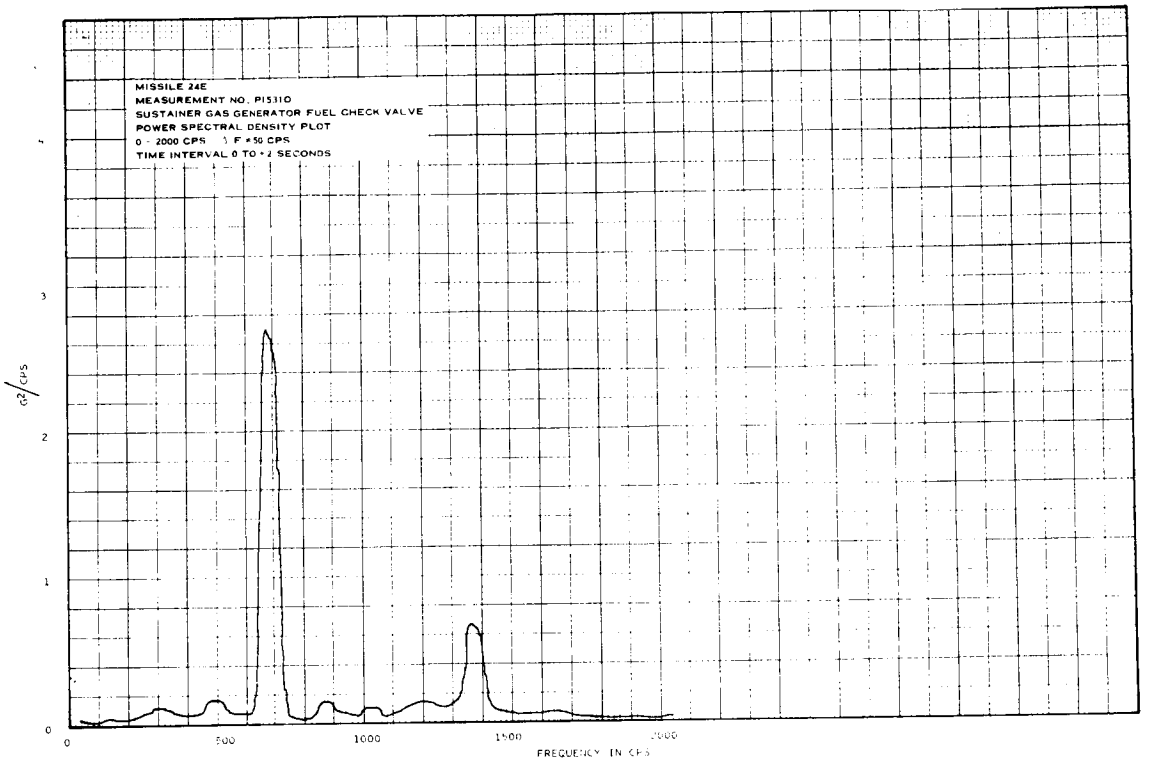

MEASUREMENT F11850 LOX TANK REGULATOR
VIBRATION LEVEL - G(RMS)
A
MEASUREMENT F16510 HELIUM LINE RISE-OFF DISCONNECT PANEL Z-AXIS
NOT VALID DATA
NOT VALID DATA
B
MEASUREMENT S16060 GYRO CANISTER Z-AXIS
-2
-1
0
1
2
3
TIME IN SECONDS FROM ONE INCH MOTION

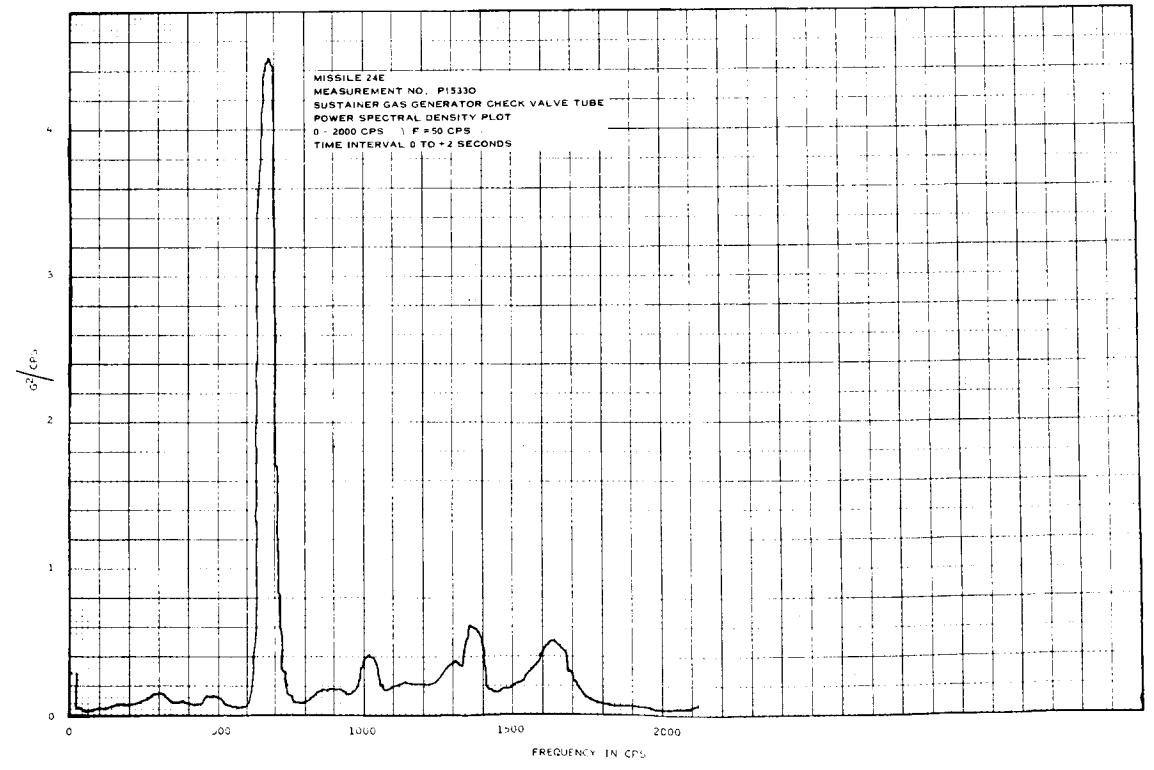
UNCLASSIFIED



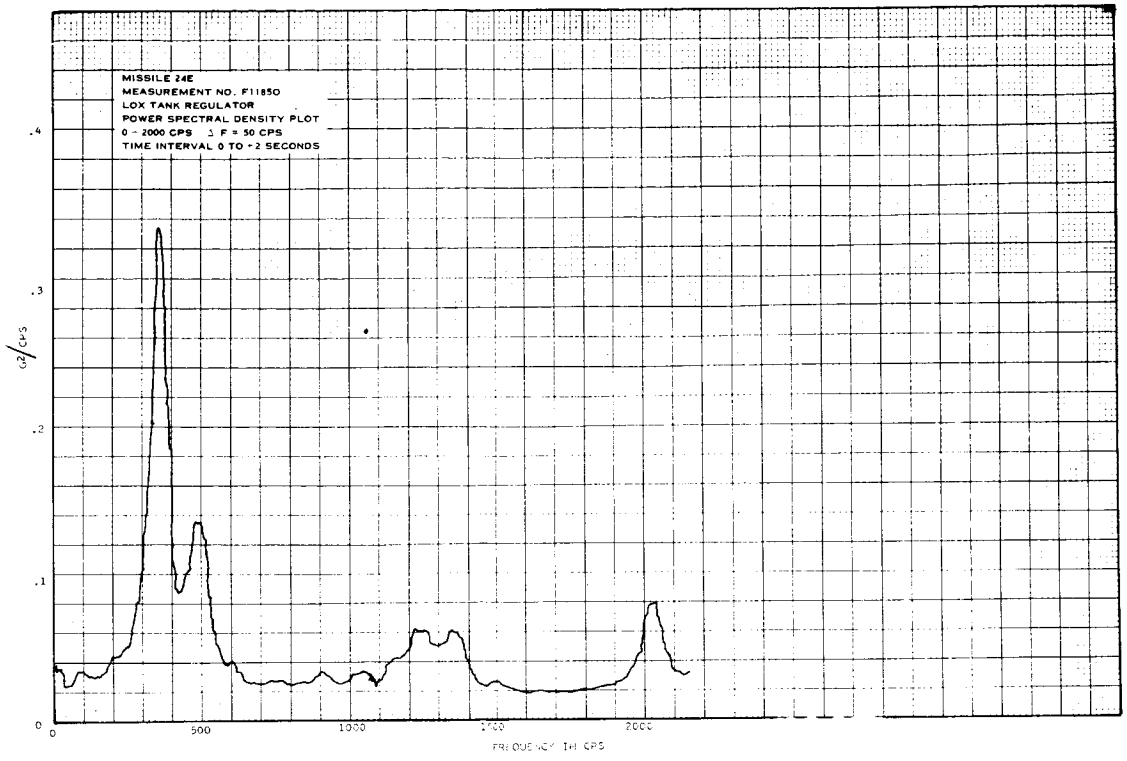
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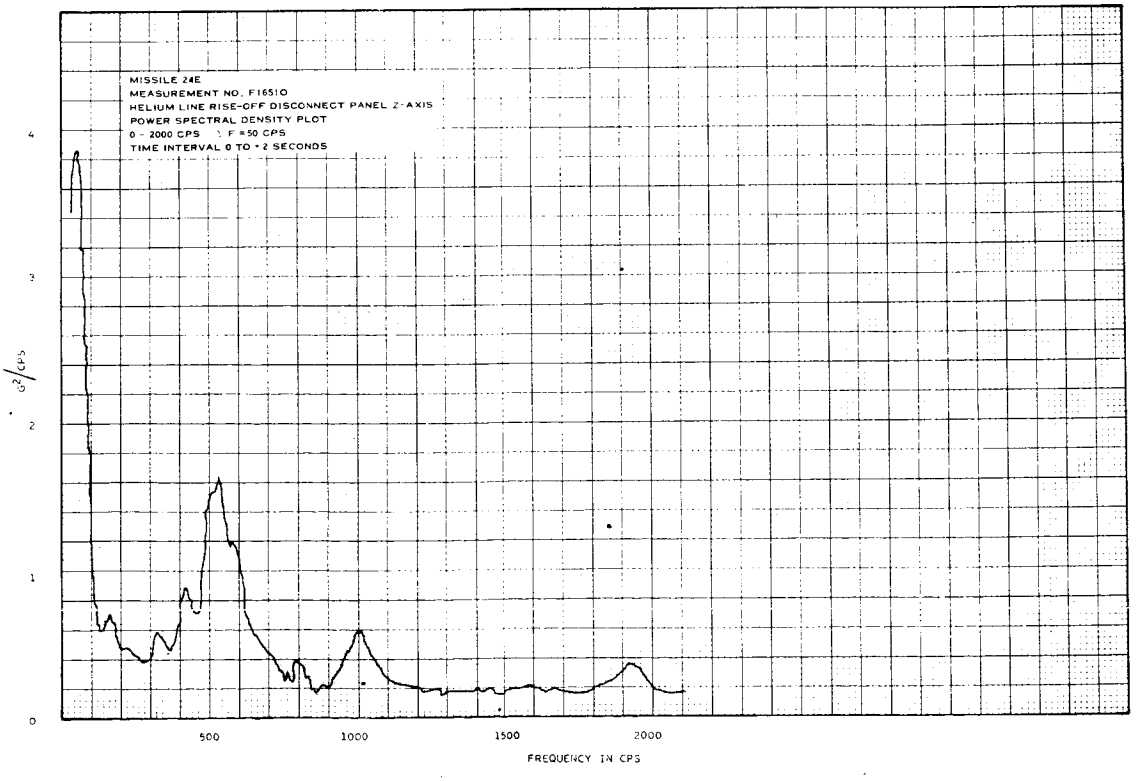


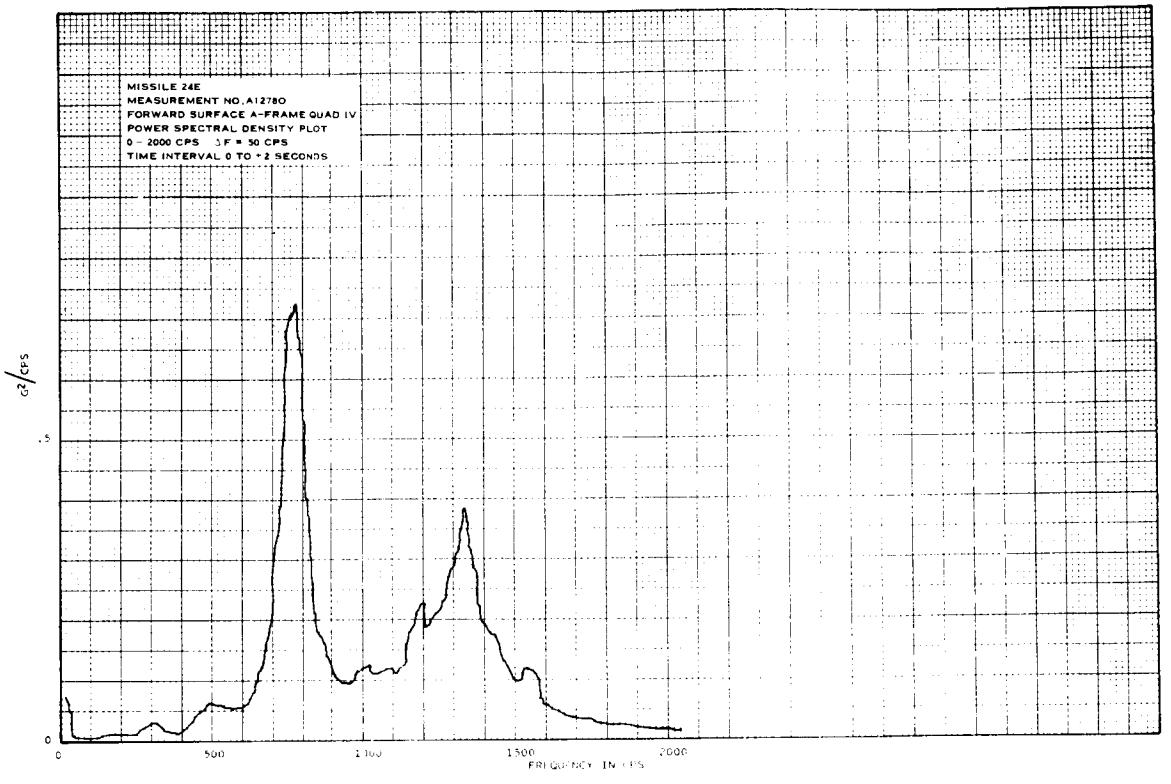

MISSILE 24E
MEASUREMENT NO. P1531O
SUSTAINER GAS GENERATOR FUEL CHECK VALVE
POWER SPECTRAL DENSITY PLOT
0 - 2000 CPS \ F = 50 CPS
TIME INTERVAL 0 TO +.2 SECONDS
G2/CPS
0
1
2
3
0
500
1000
1500
2000
FREQUENCY IN CPS

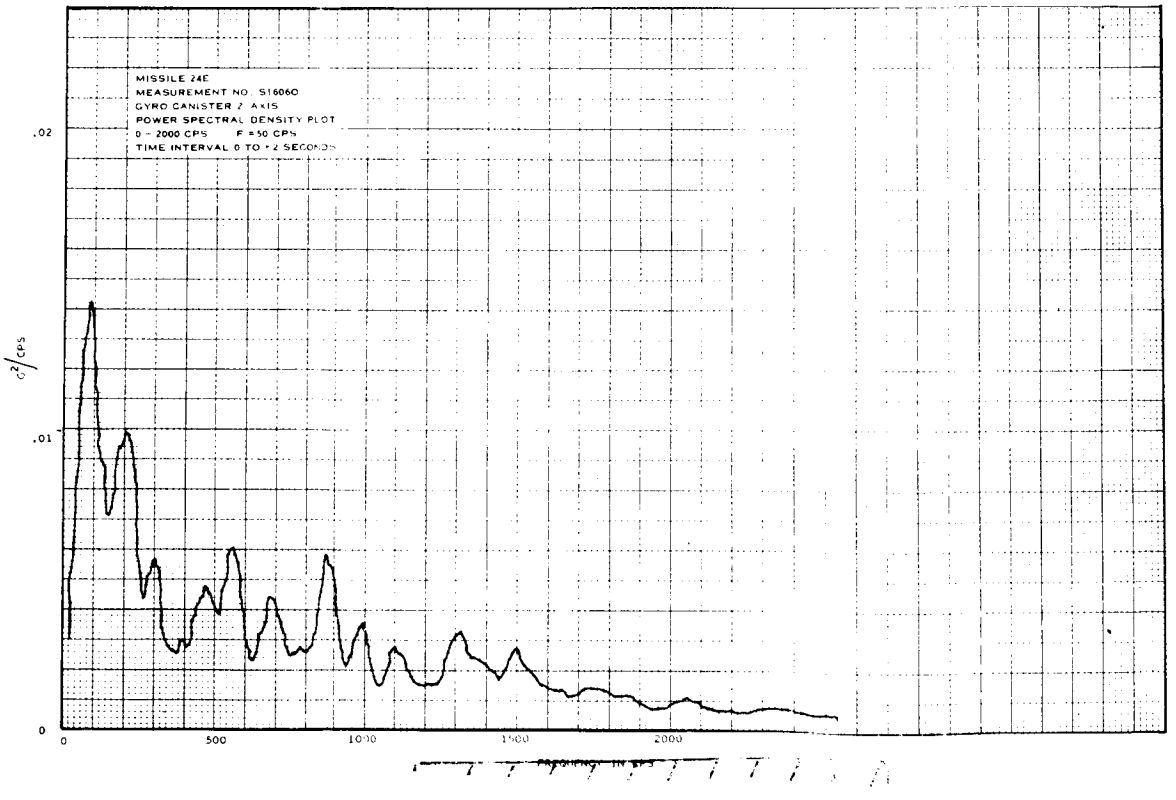

MISSILE 24E
MEASUREMENT NO. P1533O
SUSTAINER GAS GENERATOR CHECK VALVE TUBE
POWER SPECTRAL DENSITY PLOT
0 - 2000 CPS \ F = 50 CPS
TIME INTERVAL 0 TO +.2 SECONDS
G2/CPS
0
1
2
3
4
0
1000
1500
2000
FREQUENCY IN CPS

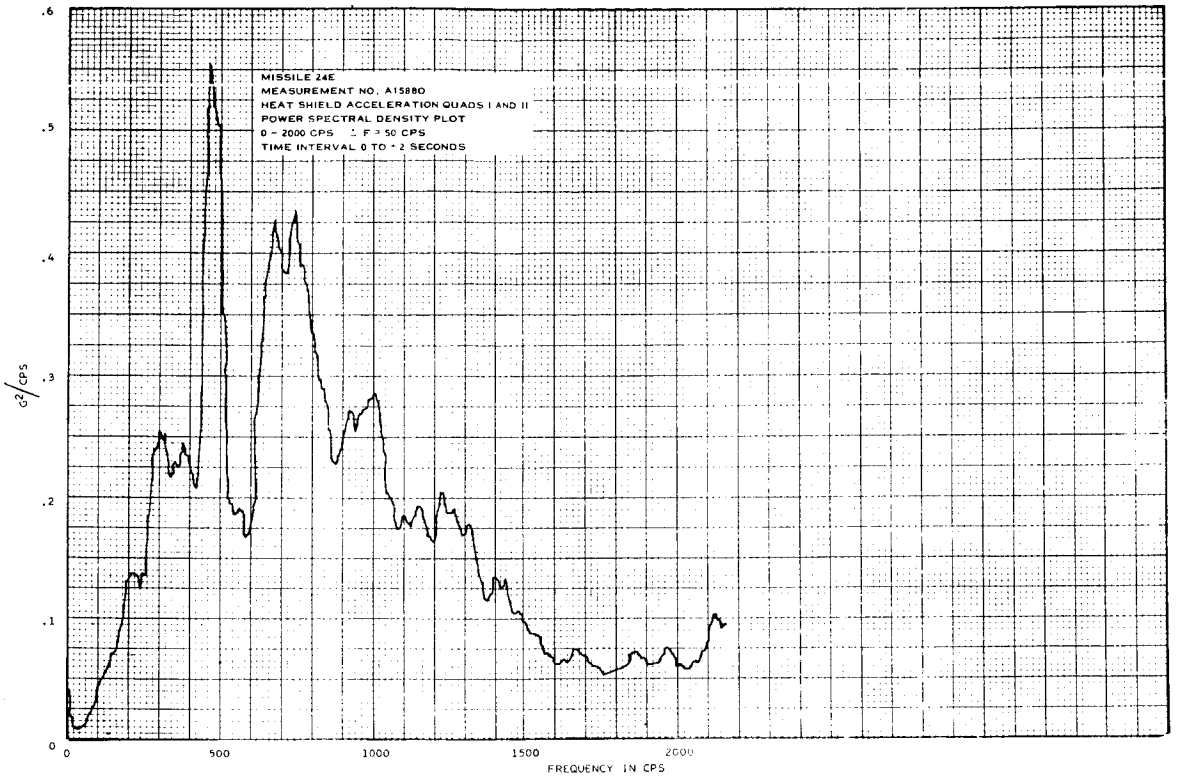
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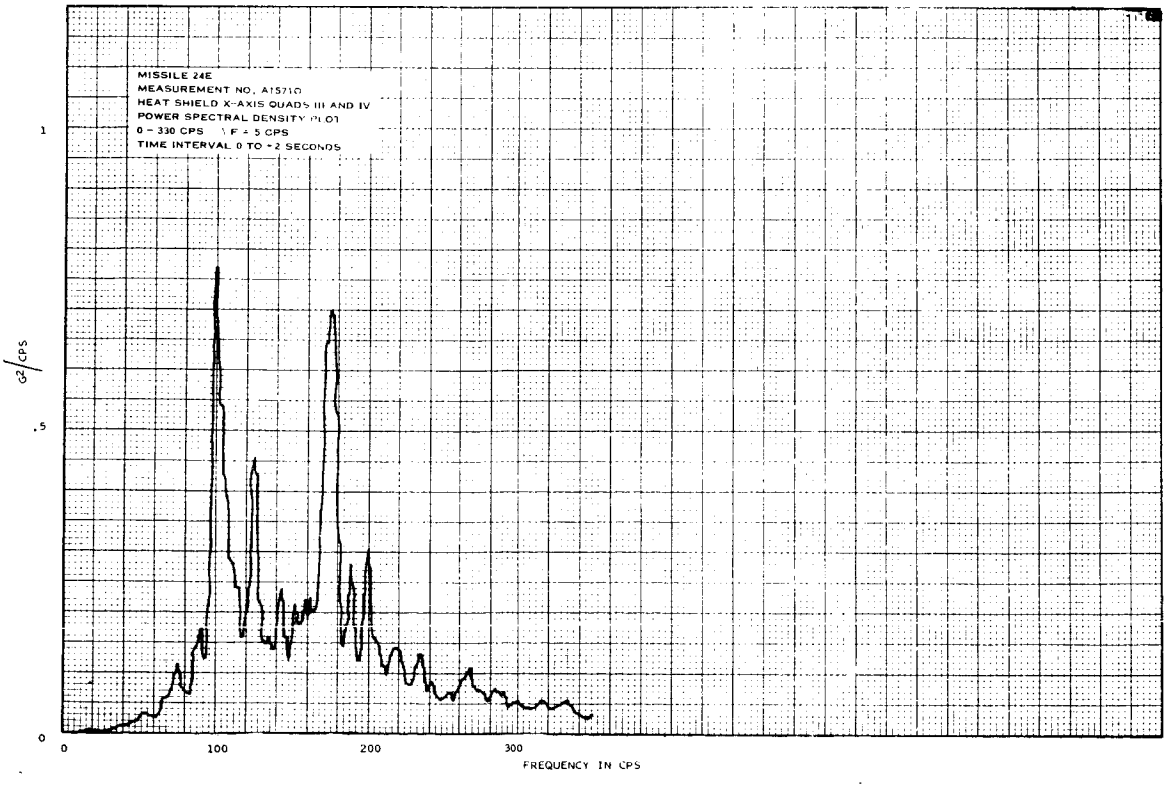


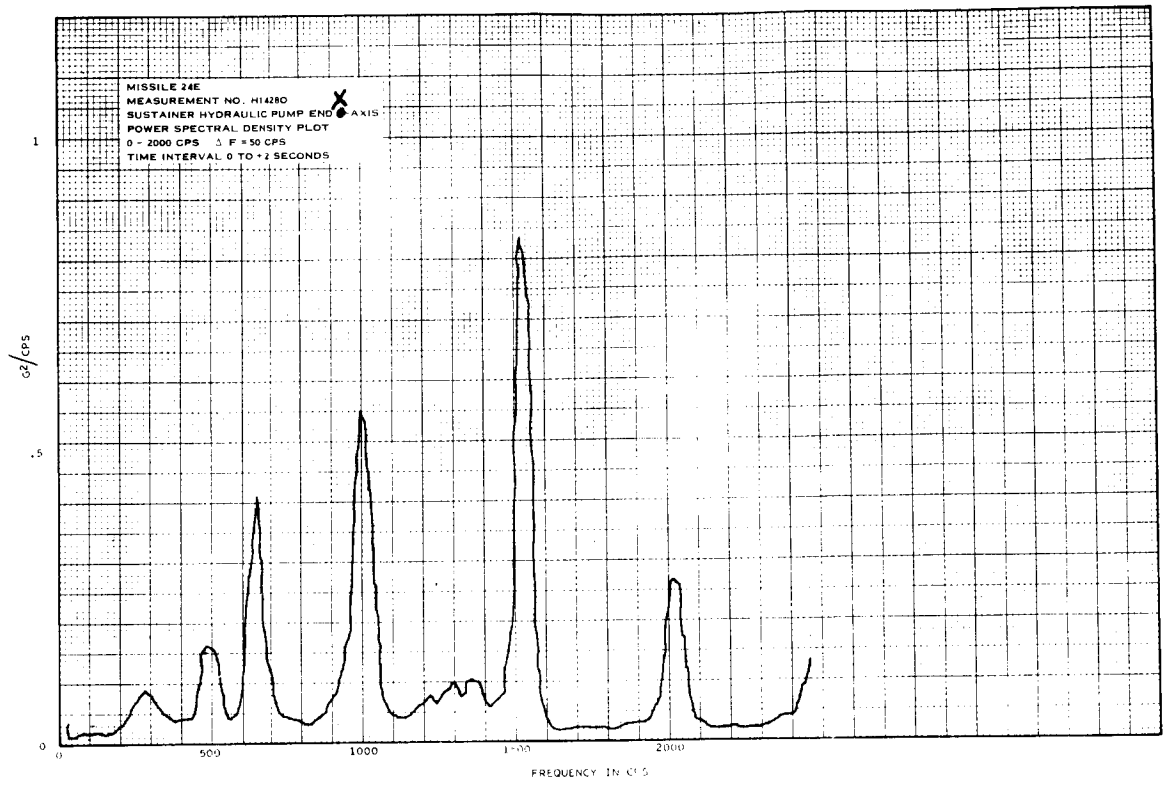


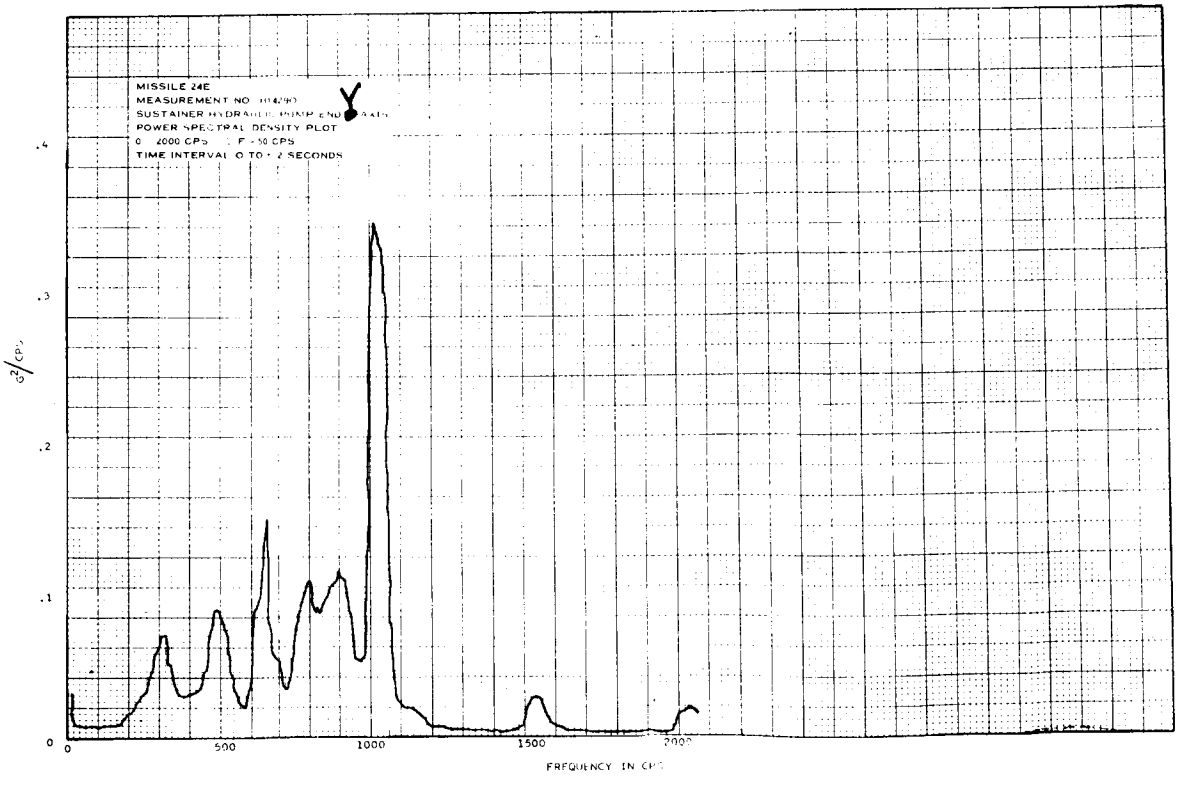

MISSILE 24E
MEASUREMENT NO. A12780
FORWARD SURFACE A-FRAME QUAD IV
POWER SPECTRAL DENSITY PLOT
0 - 2000 CPS ΔF = 50 CPS
TIME INTERVAL 0 TO +2 SECONDS
G²/CPS
.5
0
0
500
1000
1500
2000
FREQUENCY IN CPS

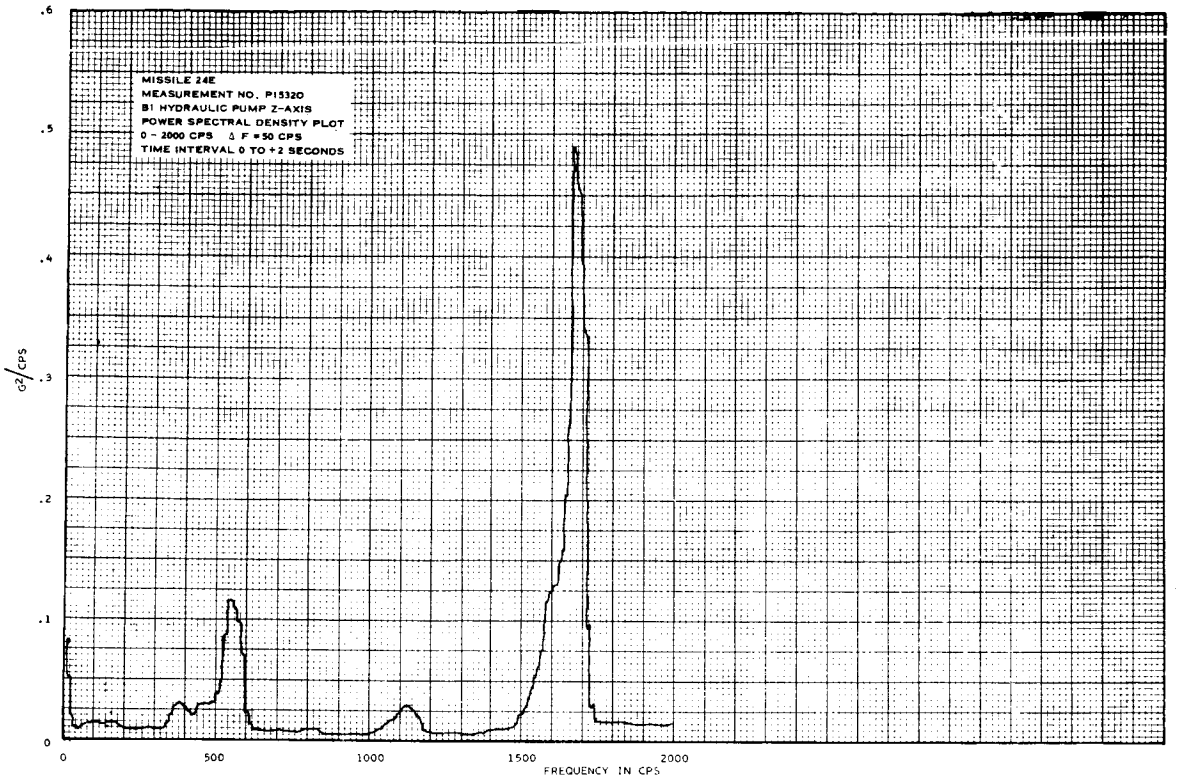

MISSILE 24E
MEASUREMENT NO. S1606O
GYRO CANISTER Z AXIS
POWER SPECTRAL DENSITY PLOT
0 - 2000 CPS F = 50 CPS
TIME INTERVAL 0 TO +2 SECONDS
G²/CPS
.02
.01
0
0
500
1000
1500
2000

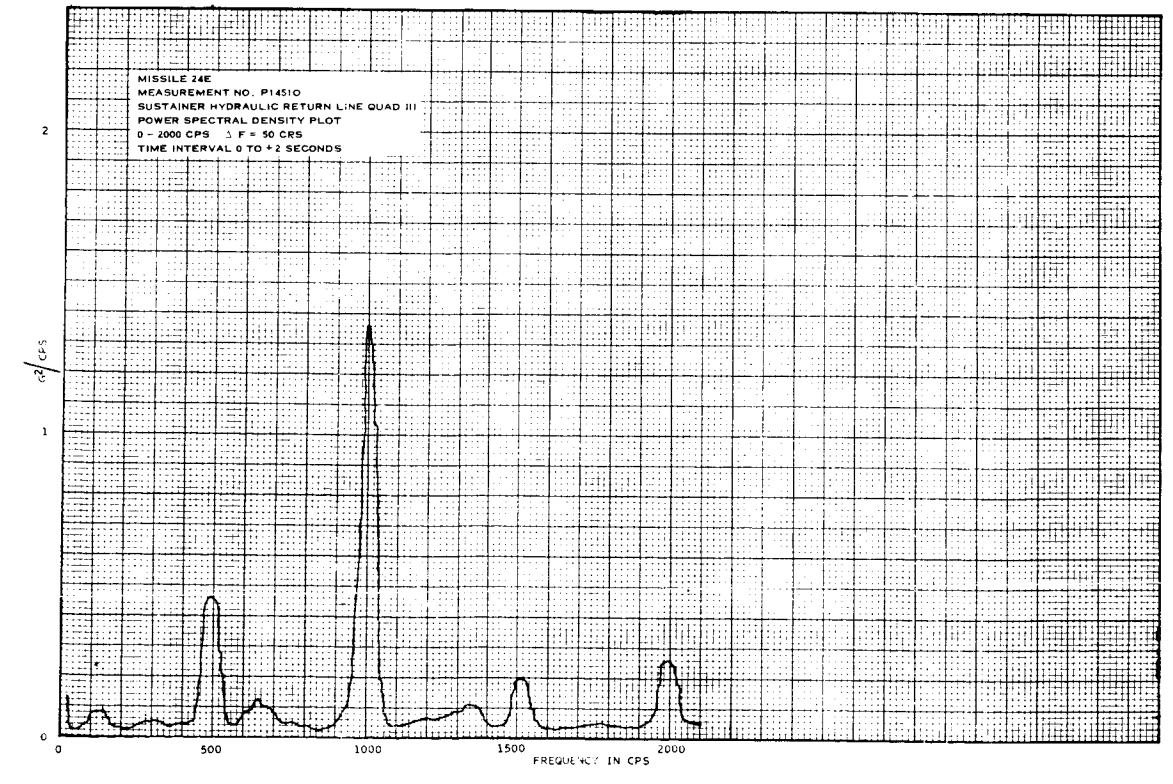

MISSILE 24E
MEASUREMENT NO. A15880
HEAT SHIELD ACCELERATION QUADS I AND II
POWER SPECTRAL DENSITY PLOT
0 - 2000 CPS Δ F = 50 CPS
TIME INTERVAL 0 TO +2 SECONDS
G²/CPS
.6
.5
.4
.3
.2
.1
0
0
500
1000
1500
2000
FREQUENCY IN CPS


MISSILE 24E
MEASUREMENT NO. A15710
HEAT SHIELD X-AXIS QUADS III AND IV
POWER SPECTRAL DENSITY PLOT
0 - 330 CPS Δ F = 5 CPS
TIME INTERVAL 0 TO +2 SECONDS
G²/CPS
1
.5
0
0
100
200
300
FREQUENCY IN CPS


MISSILE 24E
MEASUREMENT NO. H14280
SUSTAINER HYDRAULIC PUMP END X AXIS
POWER SPECTRAL DENSITY PLOT
0 - 2000 CPS Δ F = 50 CPS
TIME INTERVAL 0 TO +2 SECONDS
G²/CPS
1
.5
0
0
500
1000
1500
2000
FREQUENCY IN CPS

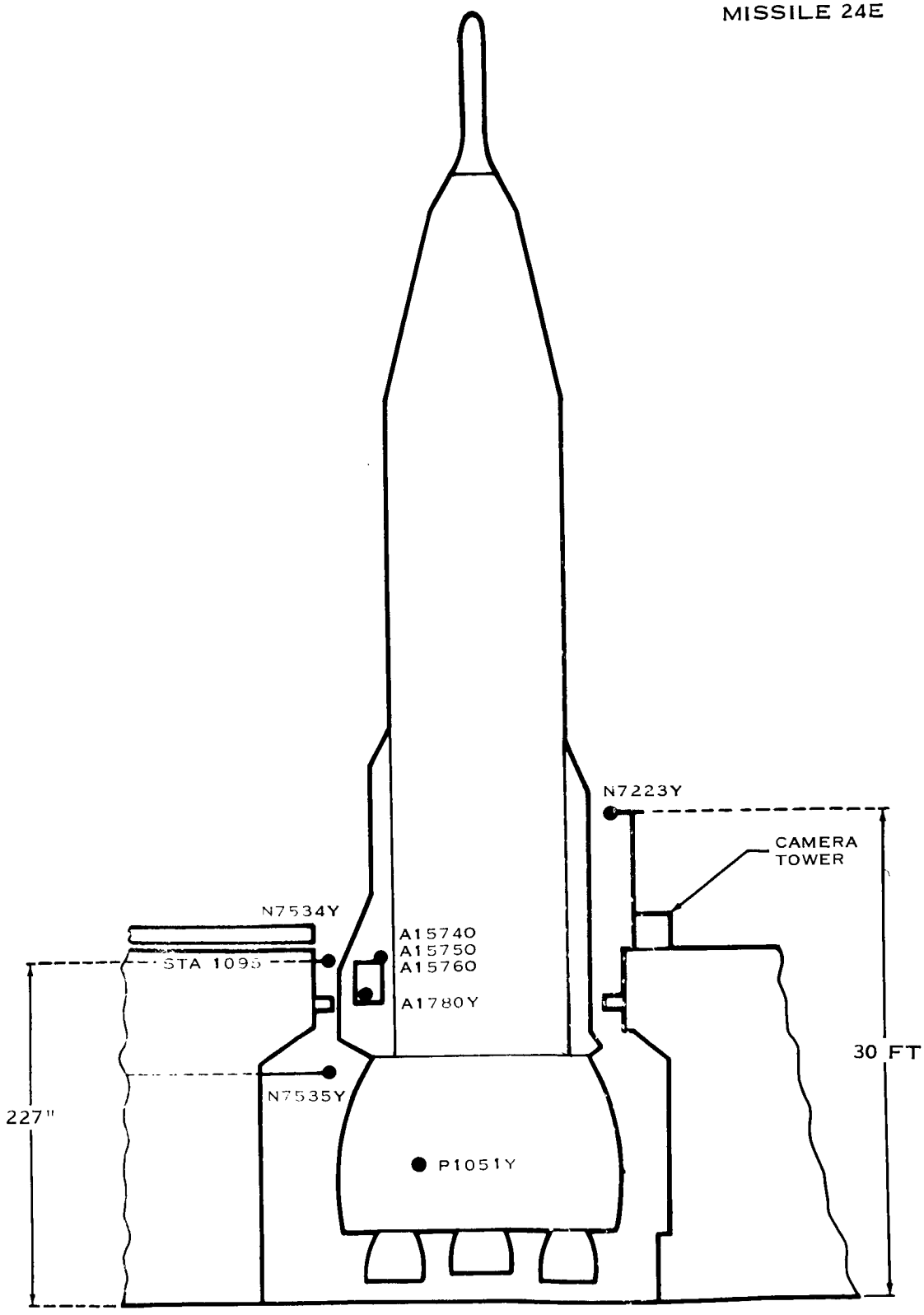

MISSILE 24E
MEASUREMENT NO H14280
SUSTAINER HYDRAULIC PUMP END Y AXIS
POWER SPECTRAL DENSITY PLOT
0 2000 CPS Δ F = 50 CPS
TIME INTERVAL 0 TO +2 SECONDS
G²/CPS
.4
.3
.2
.1
0
0
500
1000
1500
2000
FREQUENCY IN CPS

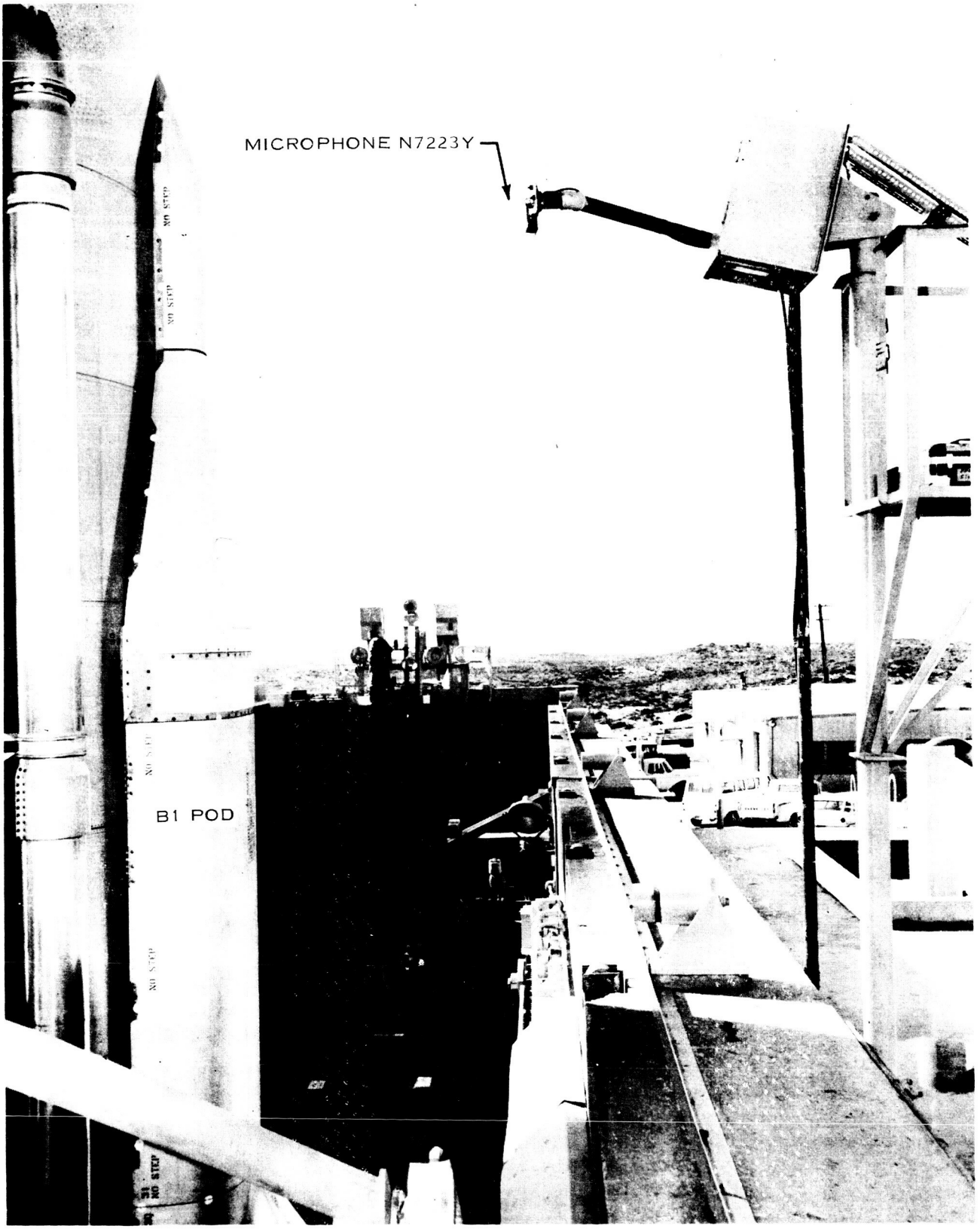

MISSILE 24E
MEASUREMENT NO. P15320
B1 HYDRAULIC PUMP Z-AXIS
POWER SPECTRAL DENSITY PLOT
0 - 2000 CPS Δ F = 50 CPS
TIME INTERVAL 0 TO +2 SECONDS
G2/CPS
.6
.5
.4
.3
.2
.1
0
0
500
1000
1500
2000
FREQUENCY IN CPS


MISSILE 24E
MEASUREMENT NO. P14510
SUSTAINER HYDRAULIC RETURN LINE QUAD III
POWER SPECTRAL DENSITY PLOT
0 - 2000 CPS Δ F = 50 CPS
TIME INTERVAL 0 TO +2 SECONDS
G2/CPS
2
1
0
0
500
1000
1500
2000
FREQUENCY IN CPS

INSTRUMENTATION LOCATIONS

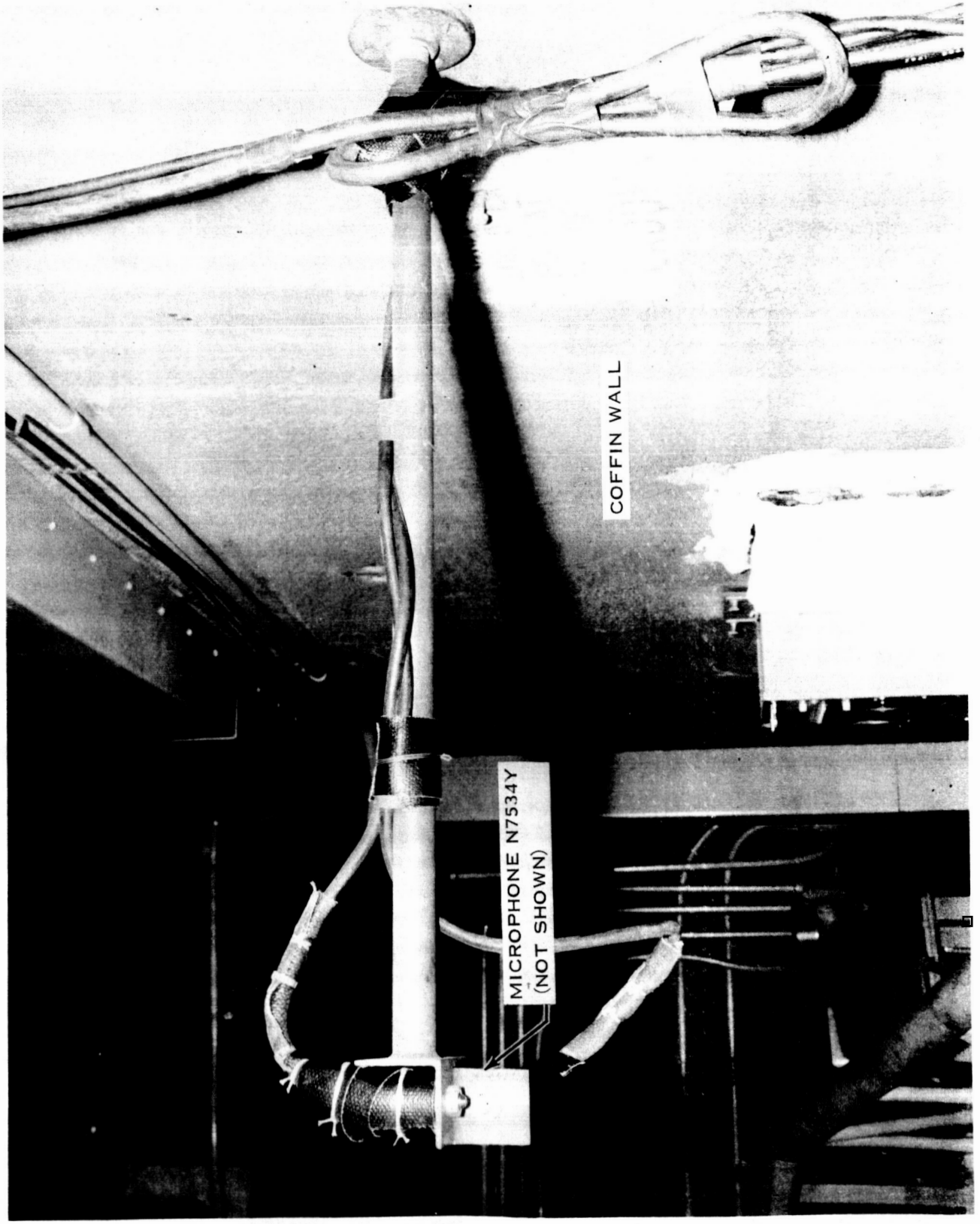
MISSILE 24E

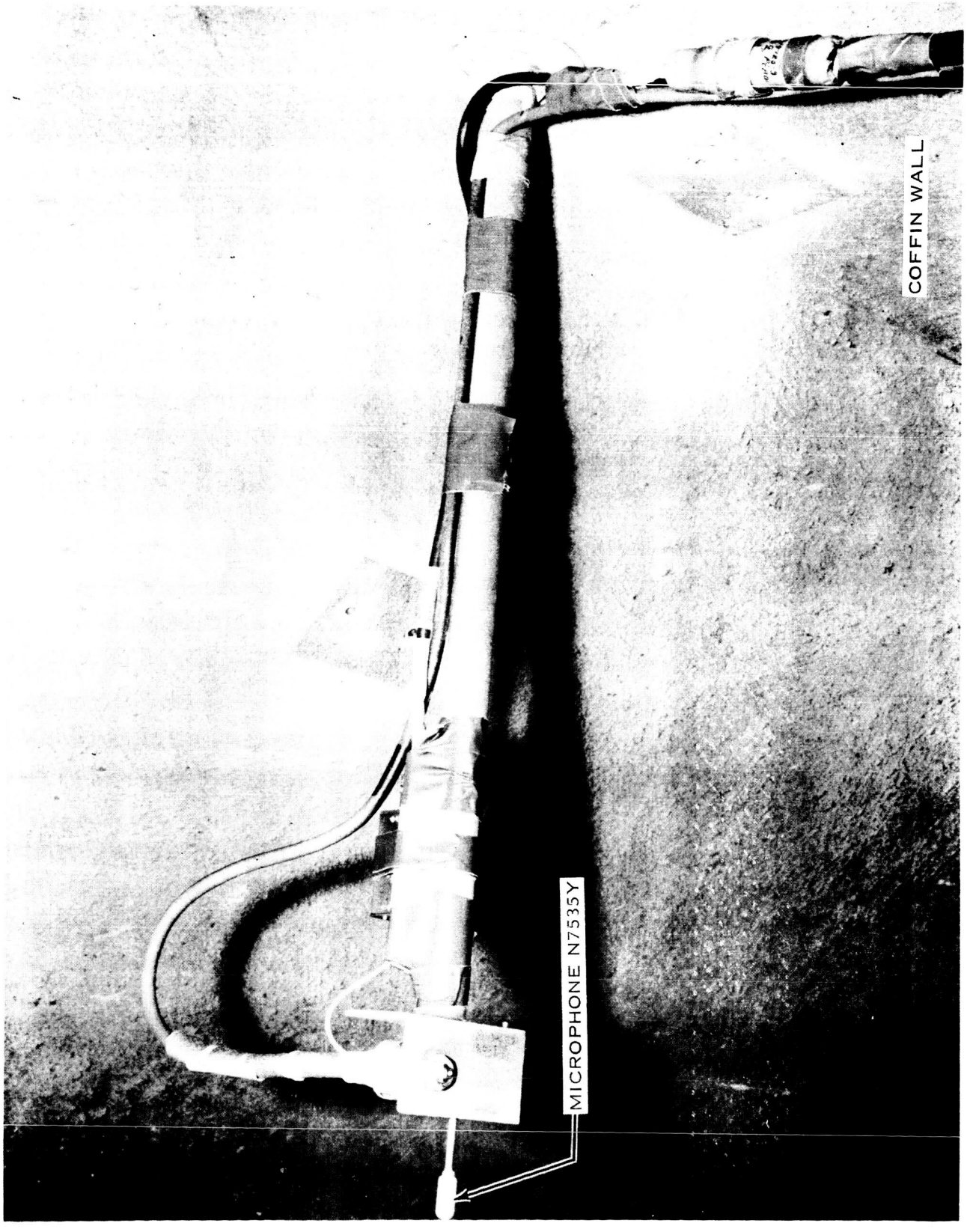


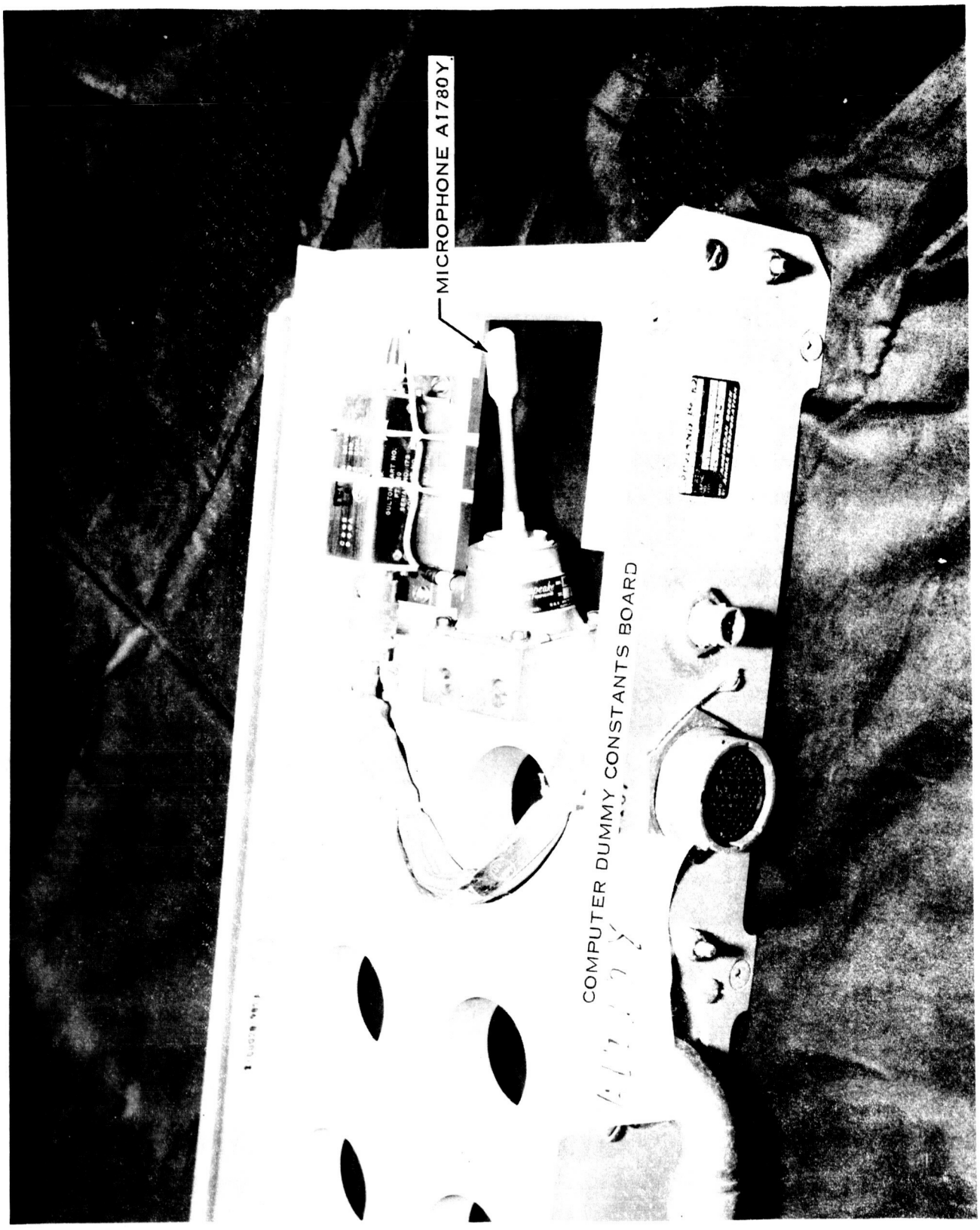

MICROPHONE N7223Y
B1 POD
NO STEP

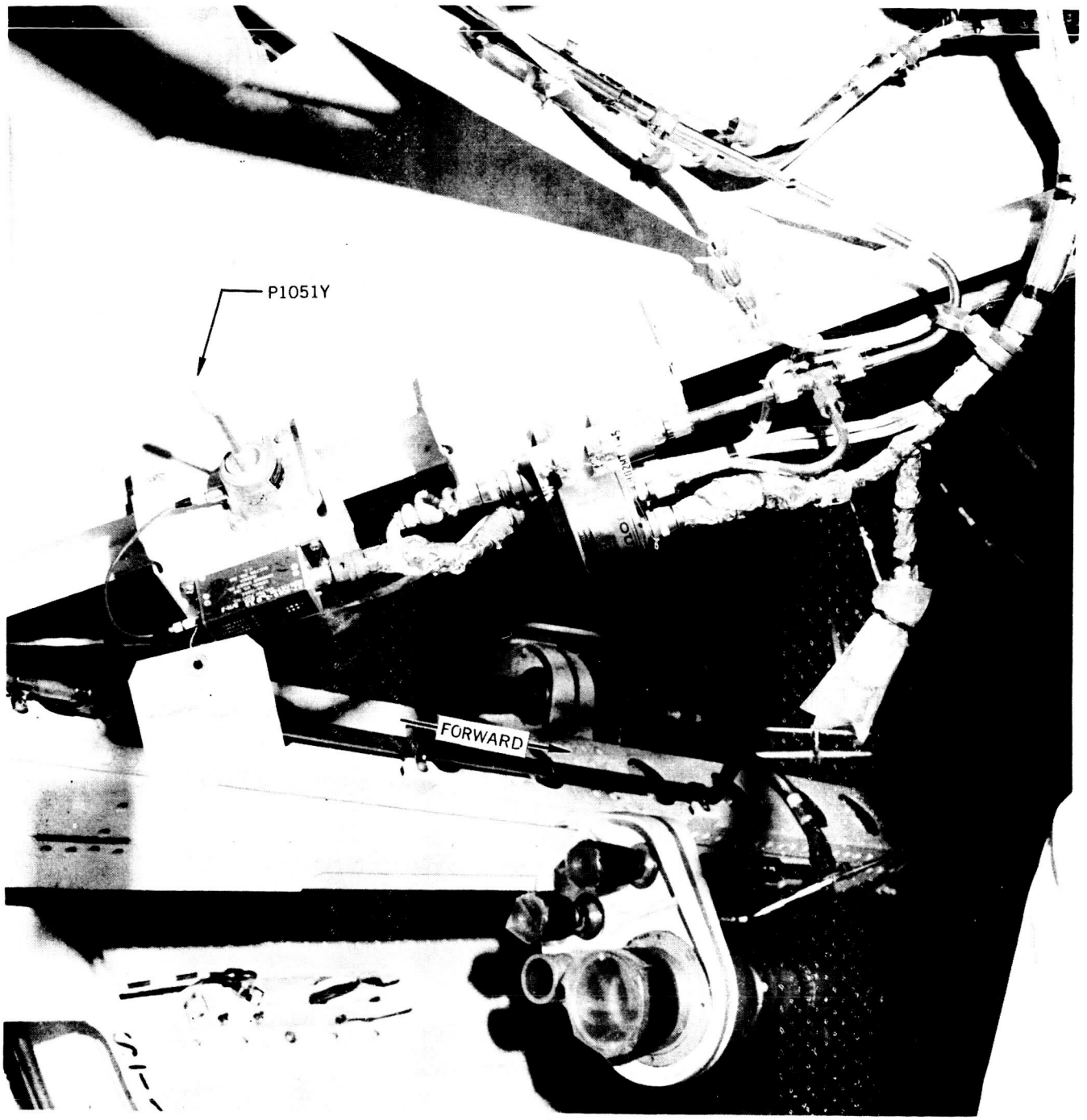
ACOUSTIC AND VIBRATION
FIGURE NO. 12-37
~~REPORT NO. GDA 63-0799~~

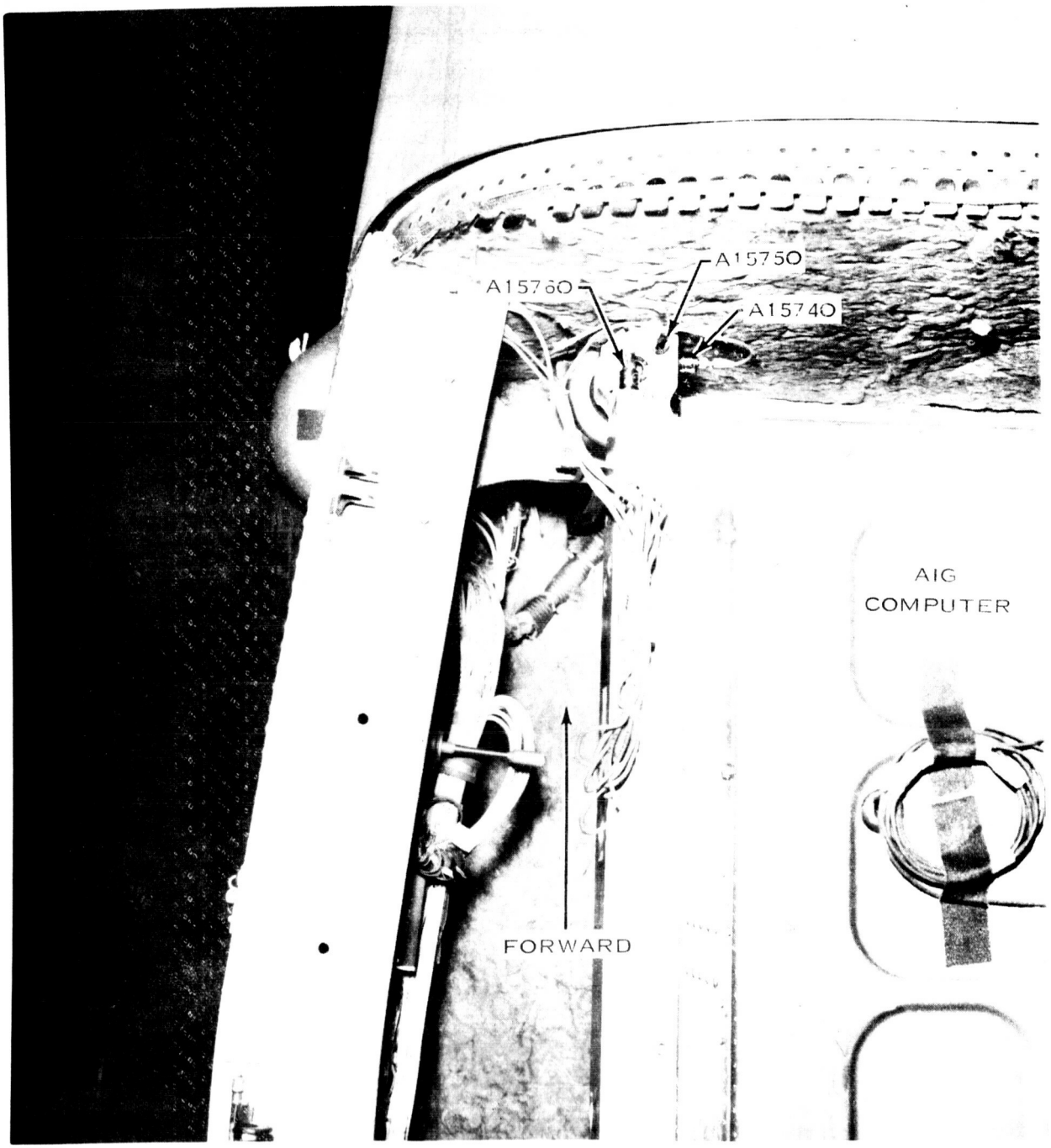
MISSILE 24E

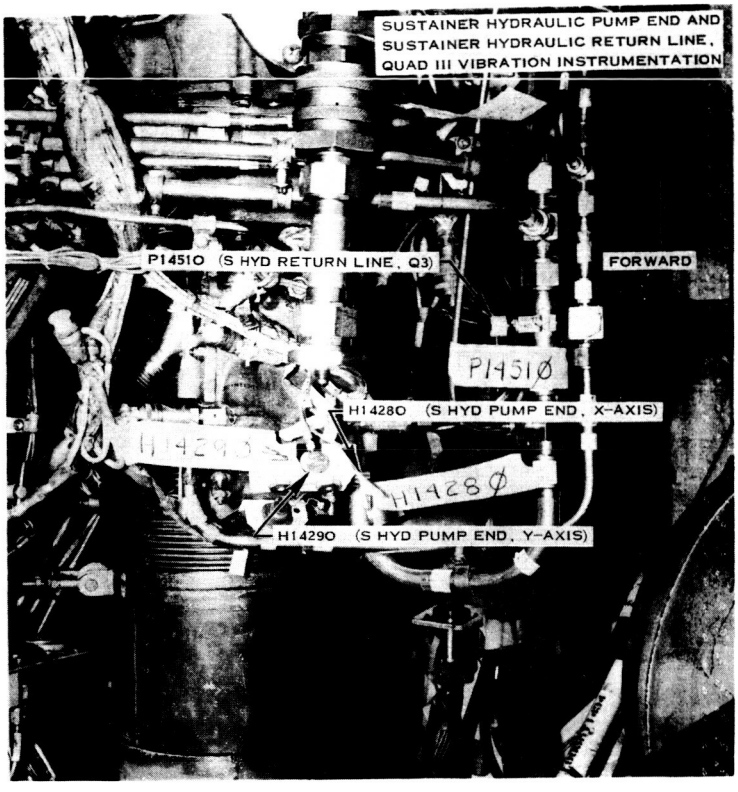


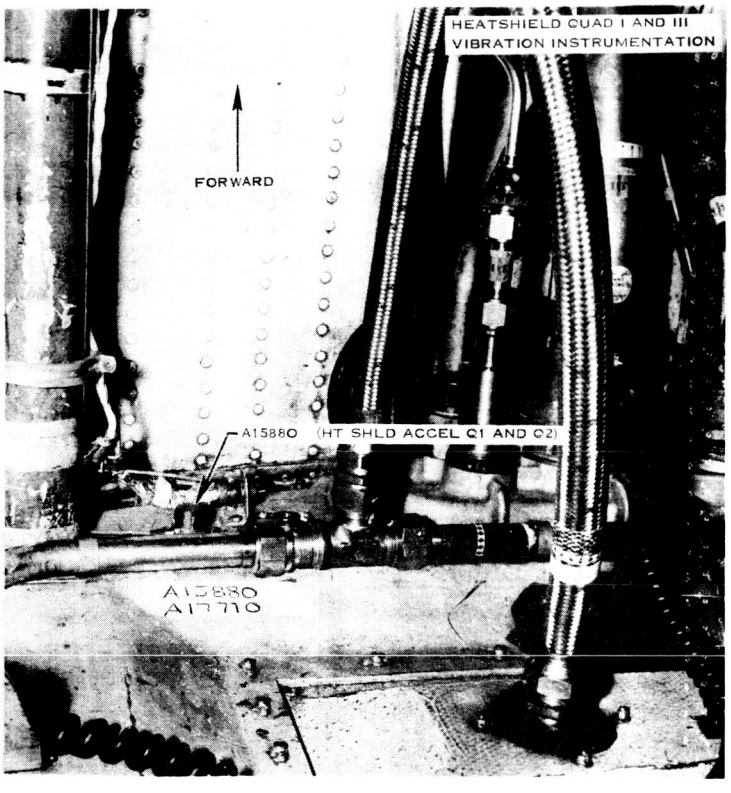

COFFIN WALL
MICROPHONE N7535Y


MICROPHONE A1780Y
COMPUTER DUMMY CONSTANTS BOARD


P1051Y
FORWARD


A15760
A15750
A15740
AIG
COMPUTER
FORWARD

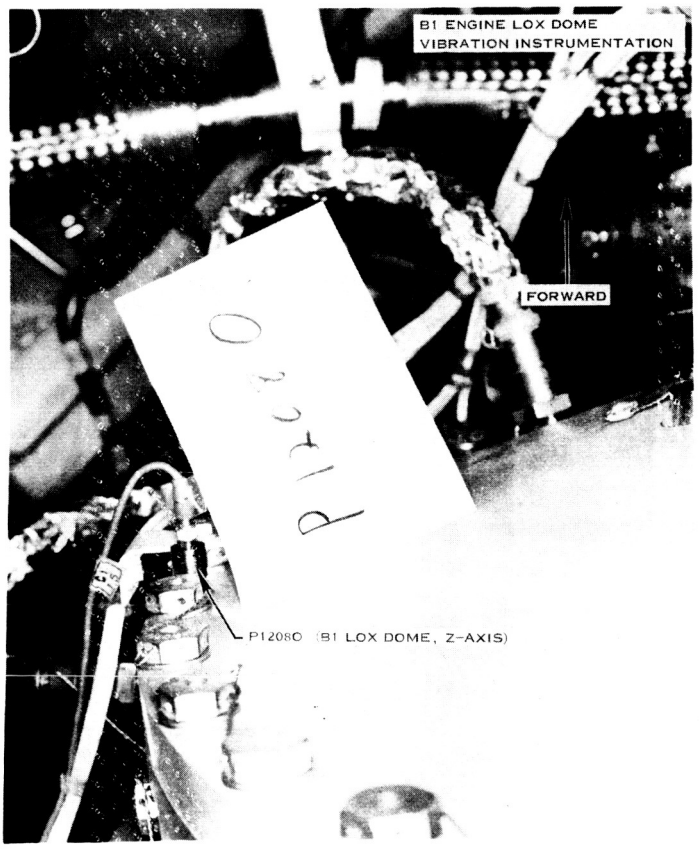

SUSTAINER HYDRAULIC PUMP END AND
SUSTAINER HYDRAULIC RETURN LINE,
QUAD III VIBRATION INSTRUMENTATION
P14510 (S HYD RETURN LINE, Q3)
FORWARD
P14510
H14280 (S HYD PUMP END, X-AXIS)
H14280
H14290 (S HYD PUMP END, Y-AXIS)


HEATSHIELD QUAD I AND III
VIBRATION INSTRUMENTATION
FORWARD
A15880 (HT SHLD ACCEL Q1 AND Q2)
A15880
A17710


SUSTAINER GAS GENERATOR
FUEL CHECK VALVE
VIBRATION INSTRUMENTATION
P15310 (SGG FUEL CK VLV)
FORWARD

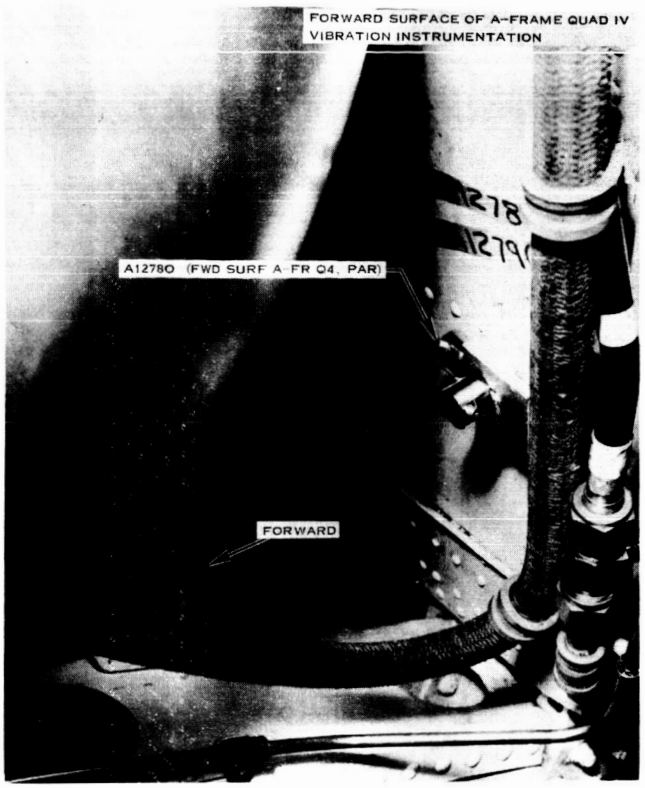

SUSTAINER GAS GENERATOR
CHECK VALVE TUBE
VIBRATION INSTRUMENTATION
FORWARD
P15330 (SGG CK VLV TUBE)

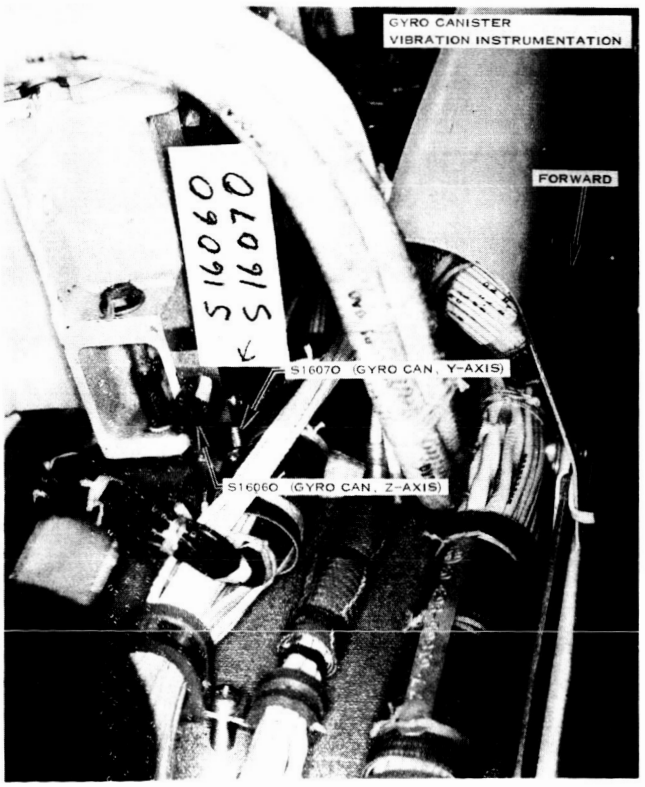

B1 HYDRAULIC PUMP
VIBRATION INSTRUMENTATION
P15320 (B1 HYD PUMP, Z-AXIS)
VIEW LOOKING AFT

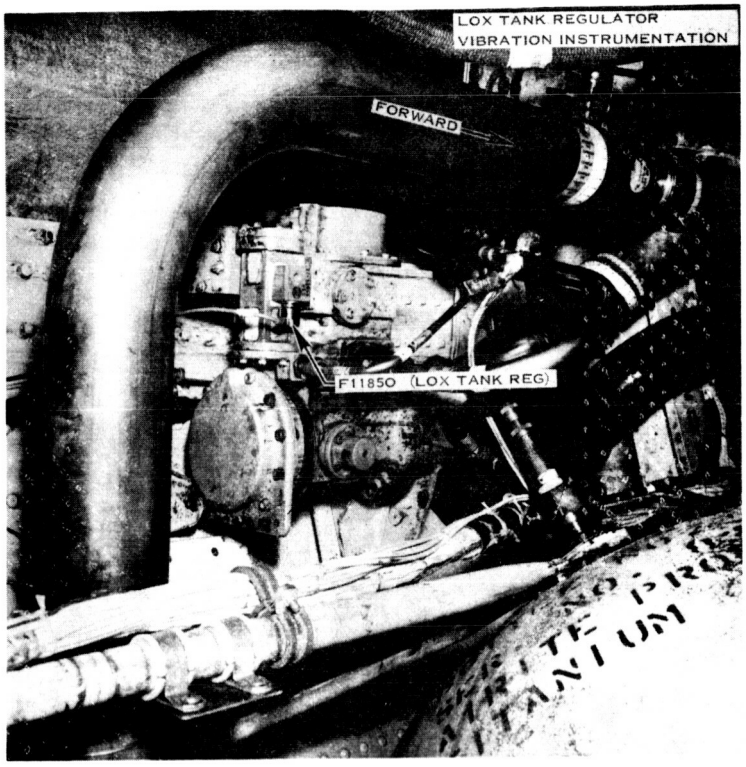

B1 ENGINE LOX DOME
VIBRATION INSTRUMENTATION
FORWARD
P12080 (B1 LOX DOME, Z-AXIS)


FUEL TANK REGULATOR
VIBRATION INSTRUMENTATION
F16500 (FUEL TANK REG, Z-AXIS)
F1650 0
FORWARD


HELIUM LINE RISE OFF DISCONNECT PANEL
VIBRATION INSTRUMENTATION
F16510 (HE LN ROD PNL, Z-AXIS)
F 1651 0
A 1516 5
FORWARD


FORWARD SURFACE OF A-FRAME QUAD IV
VIBRATION INSTRUMENTATION
A1278O (FWD SURF A-FR Q4, PAR)
FORWARD


GYRO CANISTER
VIBRATION INSTRUMENTATION
S16060
S16070
FORWARD
S1607O (GYRO CAN, Y-AXIS)
S1606O (GYRO CAN, Z-AXIS)


LOX TANK REGULATOR
VIBRATION INSTRUMENTATION
FORWARD
F11850 (LOX TANK REG)


HEAT SHIELD X-AXIS QUAD III AND IV
VIBRATION INSTRUMENTATION
A15710 (HT SHLD X-AXIS, Q3 AND 4)
VIEW LOOKING AFT

SECTION 6.2.11

MISSILE 25E

FLIGHT TESTED 10-2-61

AT AMR COMPLEX 11

TEST REPORT AE61-0798

Passenger Pod Vibration Analysis

Vibration measurements were made on the guidance platform mounting fixture to evaluate the vibrational input to the platform during powered flight. Three high frequency accelerometers (X, Y and Z axis sensitivities) were installed on the mounting fixture as shown in Figures 13-32 and 13-33. Generally, the data obtained from the flight was adequate for establishing the vibration environment at the mounting fixture. The periods of significant vibration occurred at liftoff and within the Mach 1-maximum q region (45 to 70 seconds). The greater intensities occurred within the Mach I-maximum q region. The levels at frequencies below 50 cps did not appear to be in excess of 1.0 g zero-to-peak. There was no apparent buildup in the resonant frequency of either the structure or platform (20 to 40 cps). The mounting fixture did show significant response to frequency components ranging between 1400 and 1600 cps.

The X and Y axis measurements showed a portion of the instantaneous peaks being driven out of the intelligence bandwidth (±19.6 g's, approximately 80 percent of full bandwidth) between 45 and 75 seconds of flight. It was apparent, however, that a good portion of the peaks were retained within the full bandwidth of the telemetry channel utilized. Both the transducer system and telemetry system capabilities remained proportional and did provide valid data within FBW. The X axis measurement showed the highest levels between 45 and 70 seconds. The maximum RMS g and instantaneous zero-to-peak level apparent was 11.5 and 33, respectively, with a predominant frequency of 1400 cps. Since some of the peaks on the X and Y axis data exceeded FBW, the maximum levels observed are considered questionable. These levels were greater than expected and warrant further investigation as to the effect of the environment on the pod structure. The prevailing vibration environment apparently did not effect the operation of the guidance platform. Generally, the data was analyzed within a frequency band of 10 to 2100 cps. Table 1 shows a summary of the maximum levels on the mount.

The general trend of vibration through powered flight showed an increase in level at liftoff, a decrease in level between approximately 10 and 25 seconds, a gradual increase starting at 25 seconds that peaked between 47 and 70 seconds, and finally a decrease to negligible levels

at 100 seconds. The levels through the remainder of powered flight were negligible. Figure 13-24 shows an oscillograph recording of the significant periods of vibratory response. Figures 13-25 and 13-26 show power density spectral plots computed during the significant periods of vibratory response.

TABLE 1

SUMMARY OF MAXIMUM VIBRATION LEVELS ON THE PASSENGER POD GUIDANCE PLATFORM MOUNTING

FLIGHT PERIOD	CODE	X AXIS	Y AXIS	Z AXIS
Liftoff	1	6.7/2500	5.9/2500	3.1/2500
(1 to 4 sec)	2	400-1800	700-1200	300-1200
	3	700/.073	850/.011	1050/.0185
	4	1250/.059	1180/.0095	820/.0146
	5	22/1200	21/900	10/1080
		(Q)	(Q)	
MACH I-MAX. q	1	9.2/2500	11.5/2500	6.5/2500
REGION	2	500-700	700-1500	200-1500
(50 to 60 sec)	3	1550/.0237	1400/.356	760/.063
	4	570/.0173	820/.300	1080/.061
	5	31/1500	33/1400	22/760

CODE:
1 Over-all RMS g/limit of frequency band (cps) analyzed.

2 Frequency band where maximum energy prevailed.

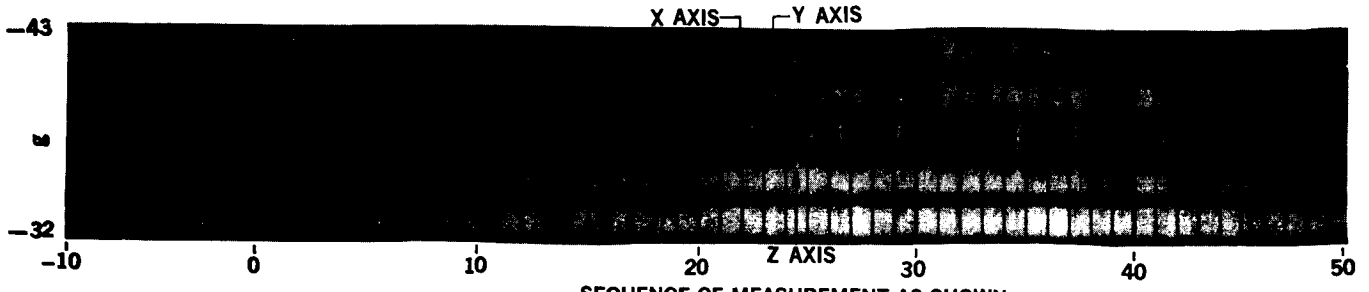
3 Predominant frequency/power density level at that frequency.

4 Second most predominant frequency/power density level.

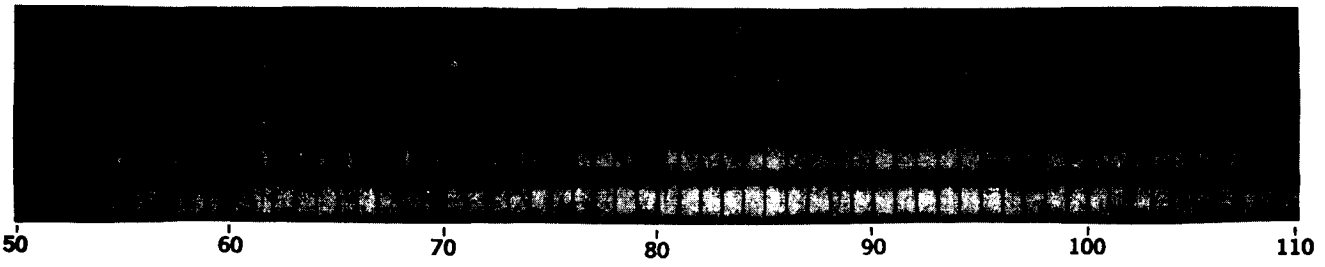
5 Maximum instantaneous acceleration g (zero-to-peak)/frequency (cps) for that level.

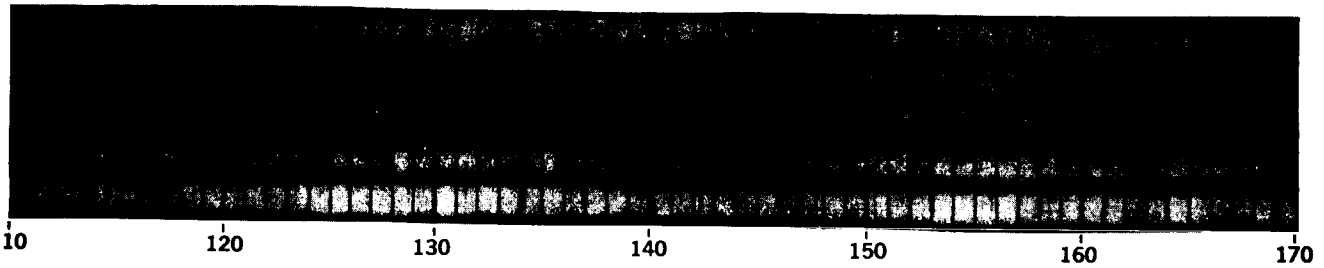
(Q) Denotes questionable data.

MISSILE 25E



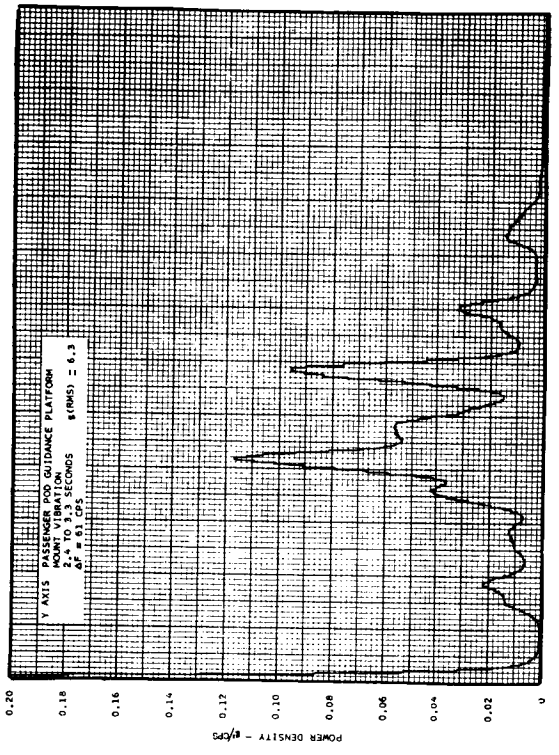
SEQUENCE OF MEASUREMENT AS SHOWN ABOVE WERE TYPICAL THROUGHOUT FLIGHT

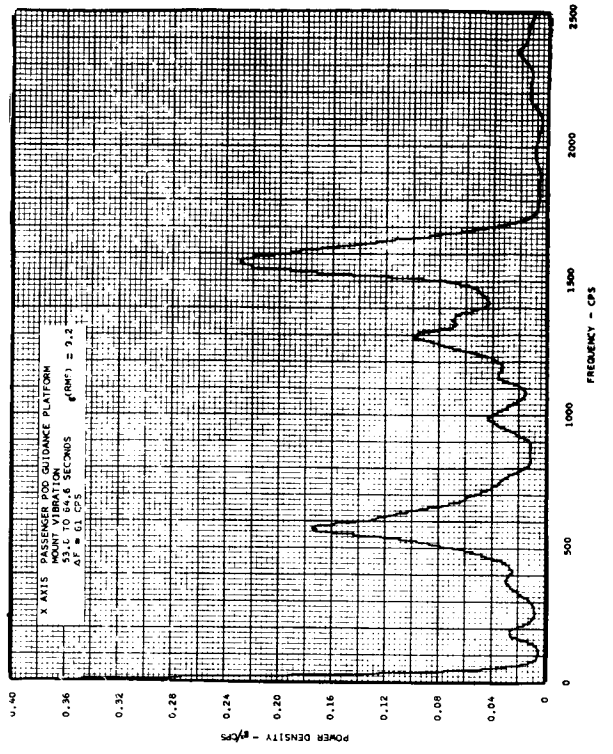


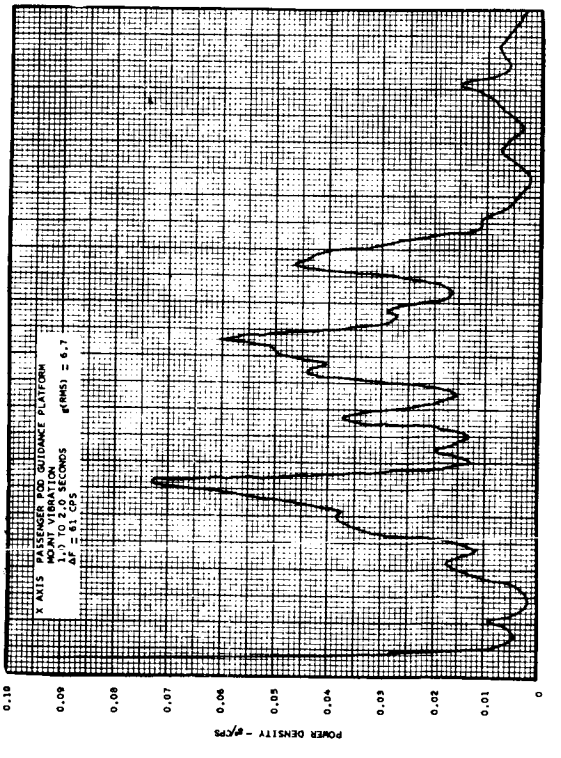


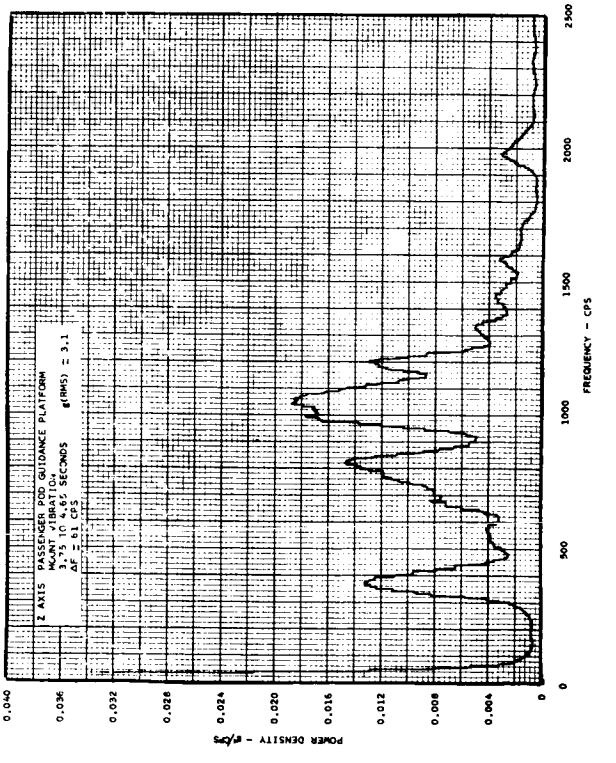
TIME IN SECONDS FROM 1-INCH MOTION

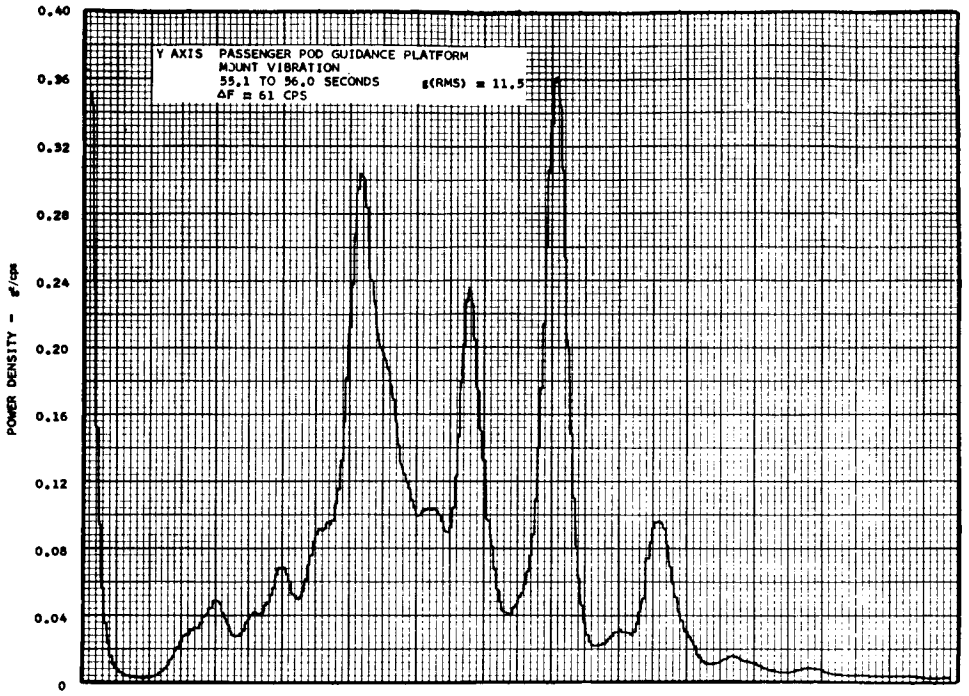
UNCLASSIFIED

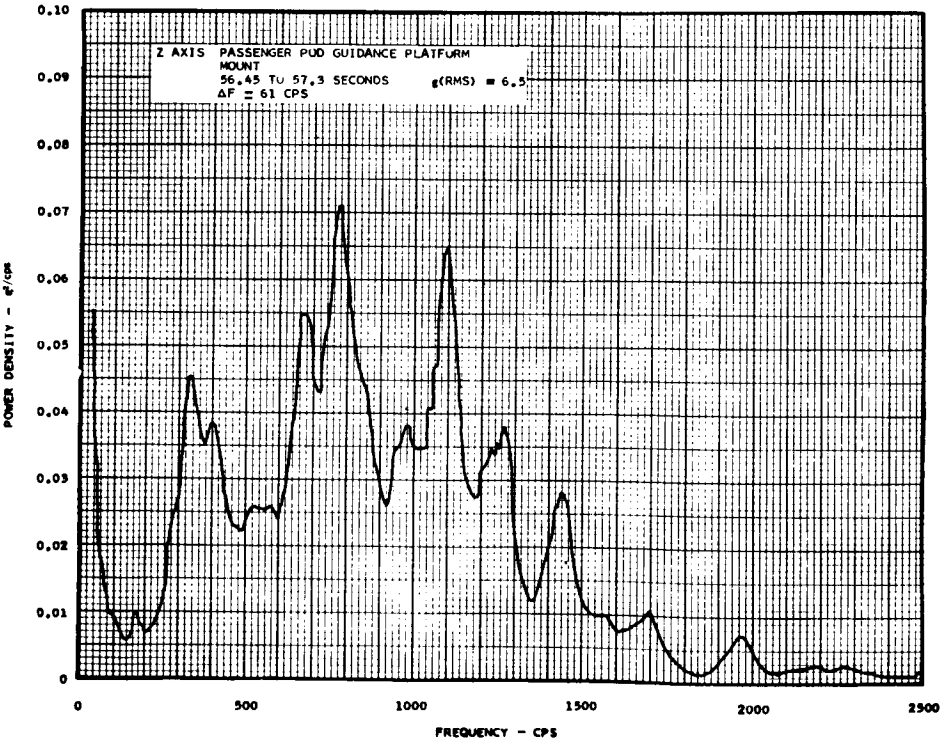




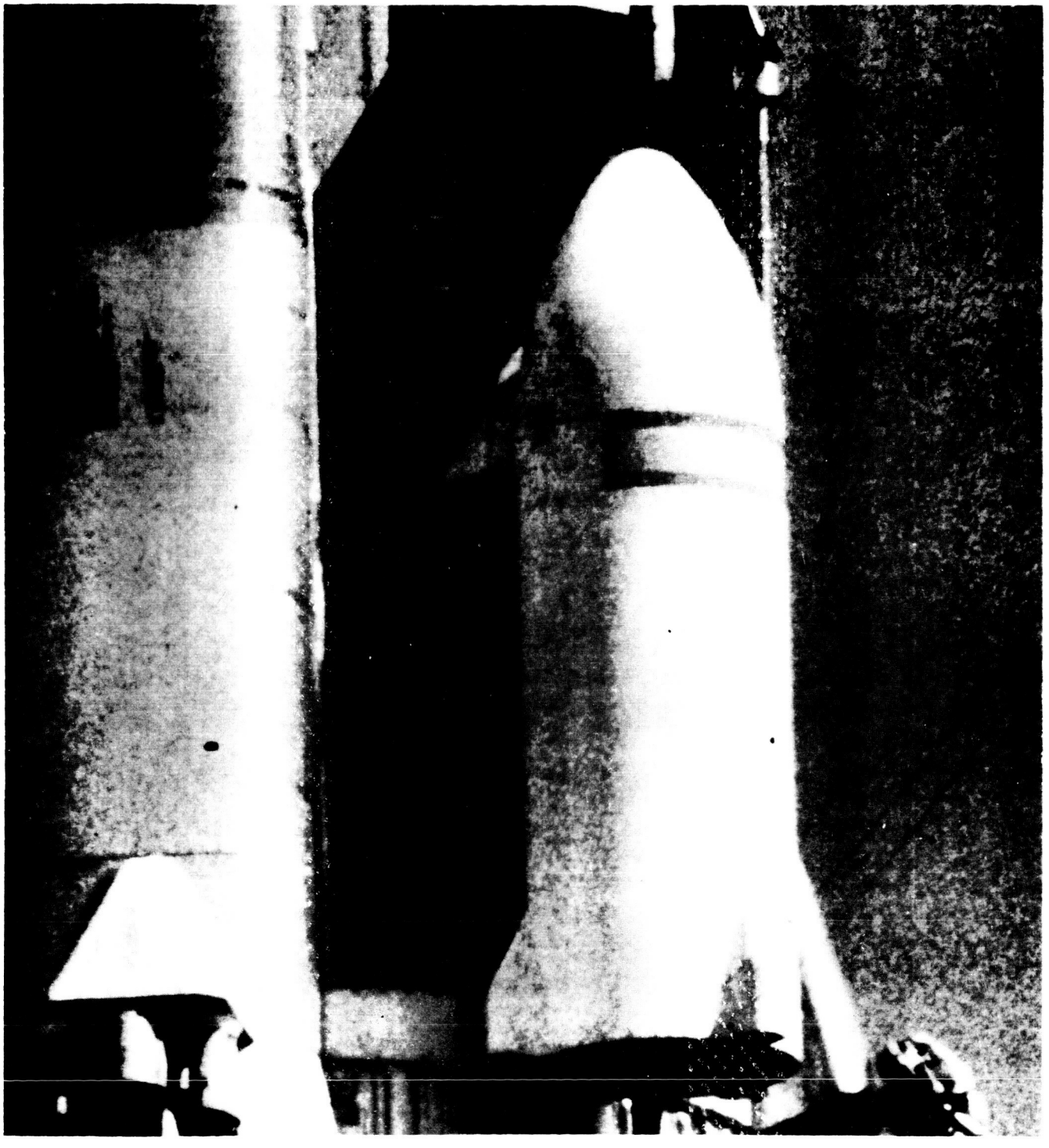


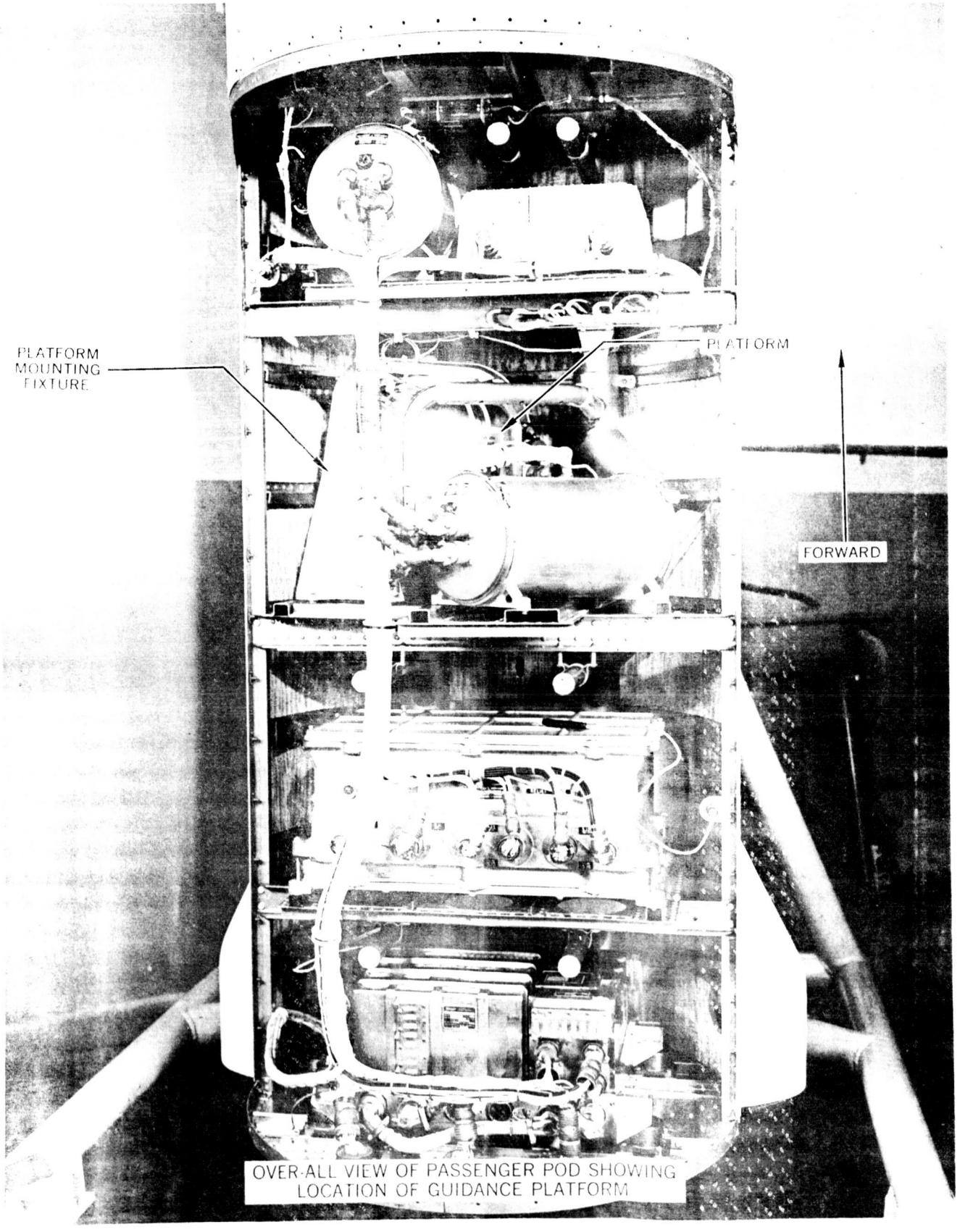



Y AXIS PASSENGER POD GUIDANCE PLATFORM MOUNT VIBRATION
55.1 TO 56.0 SECONDS g(RMS) = 11.5
ΔF = 61 CPS
POWER DENSITY - g²/cps
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0

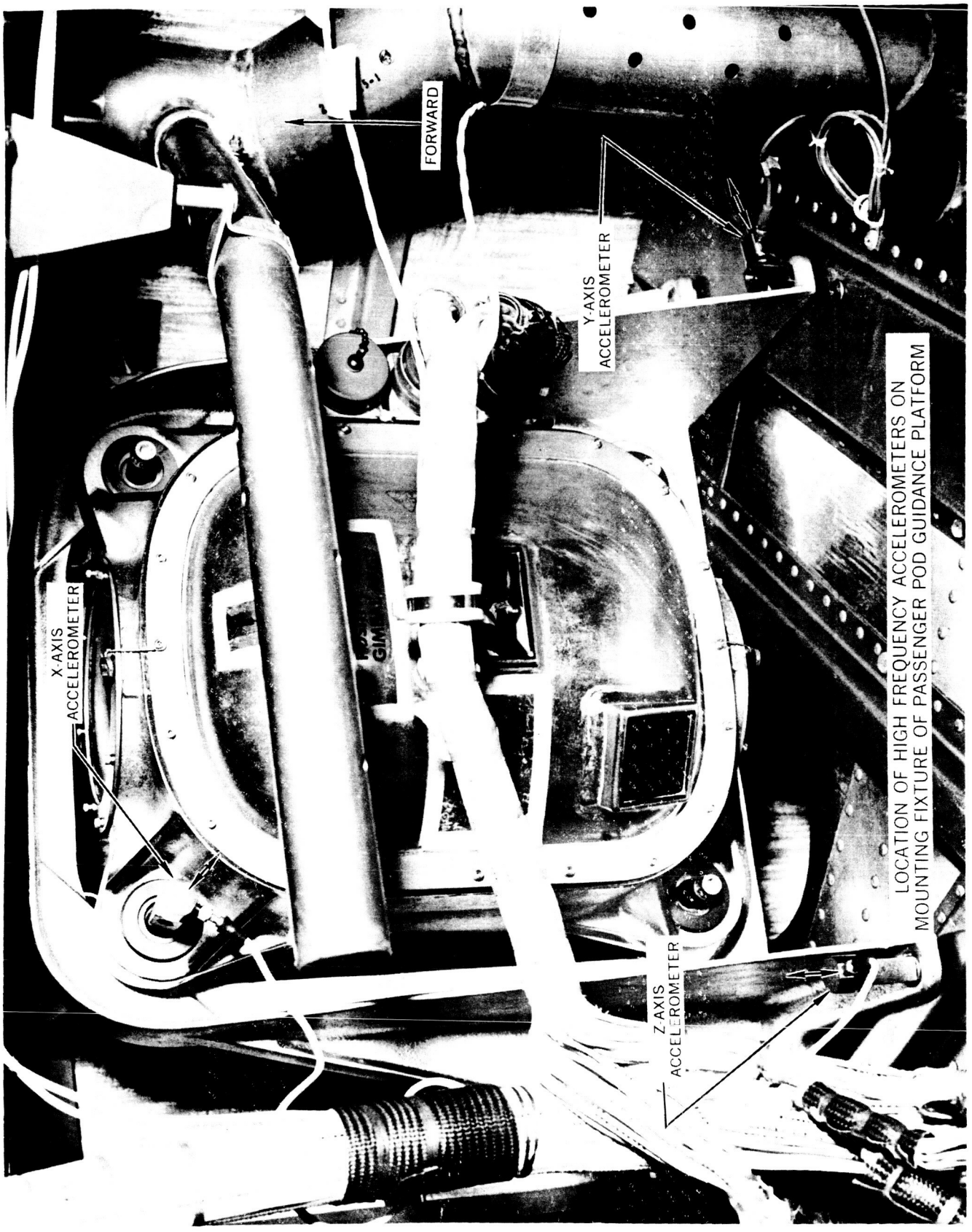

Z AXIS PASSENGER POD GUIDANCE PLATFORM MOUNT
56.45 TO 57.3 SECONDS g(RMS) = 6.5
ΔF = 61 CPS
POWER DENSITY - g²/cps
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
FREQUENCY - CPS

SCIENTIFIC PASSENGER POD





OVER-ALL VIEW OF PASSENGER POD SHOWING LOCATION OF GUIDANCE PLATFORM


FORWARD
Y-AXIS ACCELEROMETER
X-AXIS ACCELEROMETER
Z-AXIS ACCELEROMETER
LOCATION OF HIGH FREQUENCY ACCELEROMETERS ON MOUNTING FIXTURE OF PASSENGER POD GUIDANCE PLATFORM

SECTION 18

VIBRATION ANALYSIS

Vibration measurements were obtained from the fuel tank pressure regulator (Stratos), during booster stage only, as part of a study to evaluate the vibration environment at each regulator installation and to compare the results of measurements made on the two types of regulators (Stratos and F&G) utilized during the Series E flight test program. Thus far, only the Stratos fuel tank pressure regulator has been instrumented for vibration, with data obtained from Missile 22E and 25E flight tests.

Adequate data was obtained from the flight of Missile 25E to determine the vibration environment at the fuel tank regulator. The vibration at the regulator appeared to be within the currently prescribed design allowable limits. The vibration data was purposely discontinued at booster jettison, since the regulators leave with the booster section. Vibration outputs at booster engine shutdown and booster section unlatch appeared normal. The analysis of data was made within a frequency band of 10 to 2000 cps.

Five high frequency accelerometers were installed on the regulator as shown in Figures 18-5 and 18-6. The specific locations were as follows:

A-786-O Regulator Mount, Radial

A-787-O Regulator Mount, Longitudinal

A-788-O Regulator Mount, Tangential

A-930-O Regulator, Radial

A-931-O Regulator, Tangential

Each measurement provided satisfactory data for analysis except A7860 which showed erratic outputs through most of booster stage. Figure 18-1 shows an oscillograph record of the measurements.

The regulator measurements showed maximum steady-state levels at launch and through the Mach 1-maximum q region. A gradual decrease in levels was observed between approximately 80 seconds and booster cutoff. The measurements on the mount showed levels ranging between 2.6 and 6 g (rms) with predominant frequency components ranging between 800 and 1600 cps. The regulator measurements, longitudinal and tangential, showed levels of 2.7 and 4.4 g (rms) respectively, with frequency components ranging between 400 and 1750 cps. In comparing the levels between the mount and the regulator, the outputs appeared very similar in regard to over-all energy content. Generally, the vibration environment during the flight

test of Missile 22E was similar to this flight, except for A7860 on 22E which showed additional energy content as the result of the 720 cps booster engine buzz that prevailed through booster stage. The 720 cps buzz condition showed negligible vibratory energy content at the regulator installation during the flight of Missile 25E. Table 1 shows a summary of the fuel tank pressure regulator measurements.

Measurement A7880 showed a 4.6 cps oscillation, between 4 and 13 seconds, in response to either the first lateral bending mode or the propellant tank breathing mode of the missile. The resulting vibratory acceleration is questionable since the frequency component noted is within an unreliable frequency band (validity of amplitude) for the transducer utilized.

The waveform exhibited by Measurement A7860 showed erratic outputs through booster stage, possibly as the result of a faulty accelerometer system. A7870 on Missile 22E showed identical outputs. Further work will be conducted in an attempt to determine the cause for the erratic outputs. Power density computations were made on each measurement as shown in Figures 18-5 and 18-6.

TABLE 1

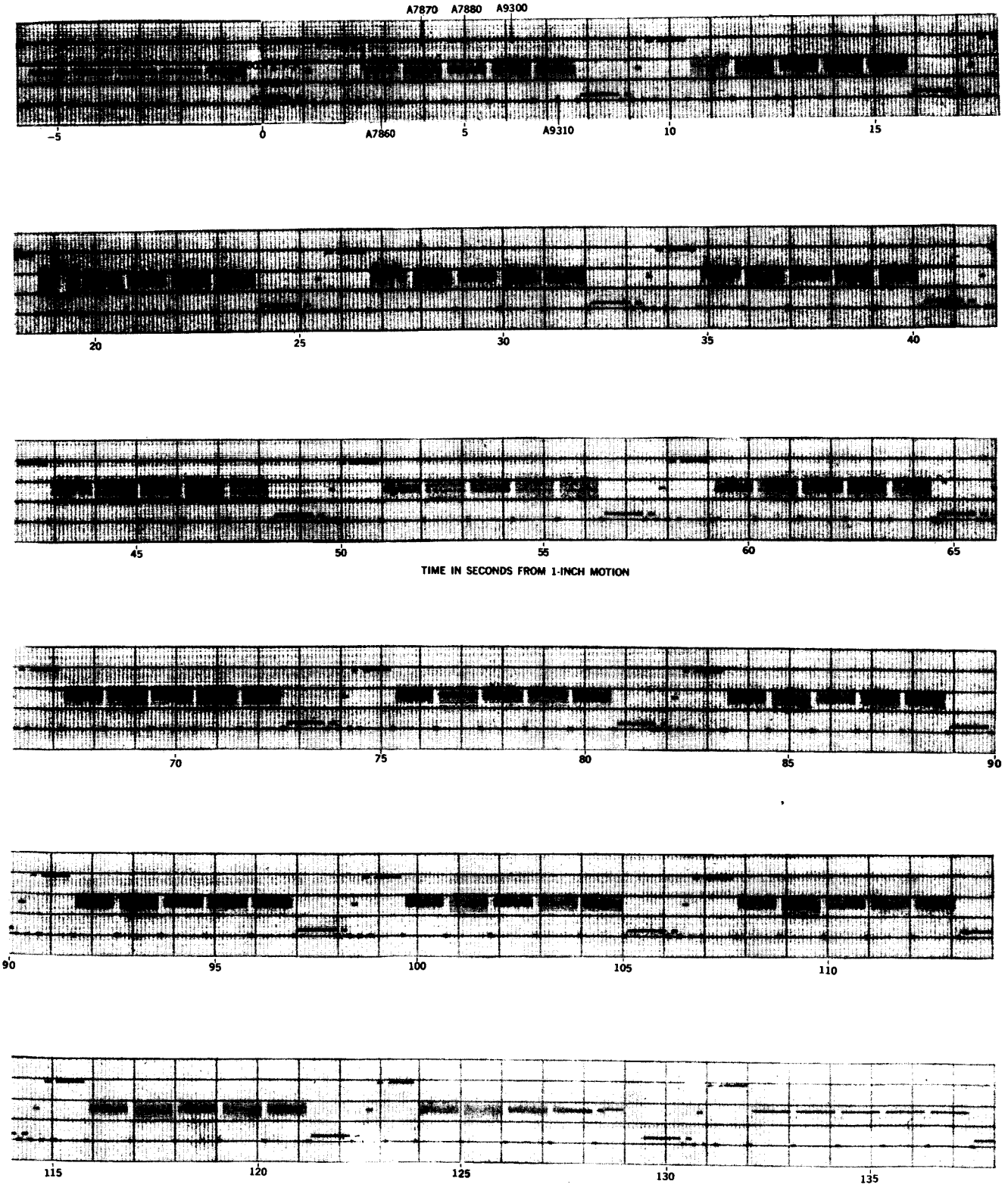
FUEL TANK PRESSURE REGULATOR VIBRATION
COMPARISON OF LEVELS ON MISSILES 22E AND 25E

Missile/ Flight Period	A-786-O		A-787-O		A-788-O		A-930-O		A-931-O	
	Accel. g (rms)	Pred. Freq. cps	Accel. g (rms)	Pred. Freq. cps	Accel. g (rms)	Pred. Freq. cps	Accel. g (rms)	Fred. Freq. cps	Accel. g (rms)	Pred. Freq. cps
22E										
Launch (2 to 6 sec)	–	-	Q	-	3.6	1050 and 1540	4.6	750	2.6	720
16.8 to 17.7 seconds	7.7	750	-	-	-	-	-	-	-	-
Mach 1-Max. q Region (50 to 60 sec)	9.4	1780	Q	-	3.8	1750 and 1350	4.4	190	2.8	200
83.5 to 85.5 seconds	6.8	1550	Q 2.1	1250 and 740	-	-	-	-	-	-
25E										
Leakage Fill (3 bursts btwn. -0.9 and -0.7 seconds)	-	-	-	-	-	-		-	60*	550
Launch (2.4 to 7.7 sec)	Q 6.2	135	4.0	880	2.6 2.5*	970 4.6	4.4	1500	2.7	1275
Mach 1-Max. q Region (59 to 64 sec)	Q 4.5	950 and 1550	4.8	800 and 470	3.4	950	4.3	1500	4.2	380
116 to 121 sec.	Q 3	850	4	900	2.8	700	3.8	1500	2.2	700
128.47 sec. (unlatch)	-	-	-	-	-	-	-	-	32*	1/2 Cycle of 300 cps

NOTE:
1. The analysis was conducted within a frequency band of 10 to 2000 cps. The RMS vibratory acceleration shown is the over-all for the band analyzed.
2. Q, denotes questionable data.
3. *, denotes g zero-to-peak level.

VIBRATION TELEMETERED DATA

MISSILE 25E

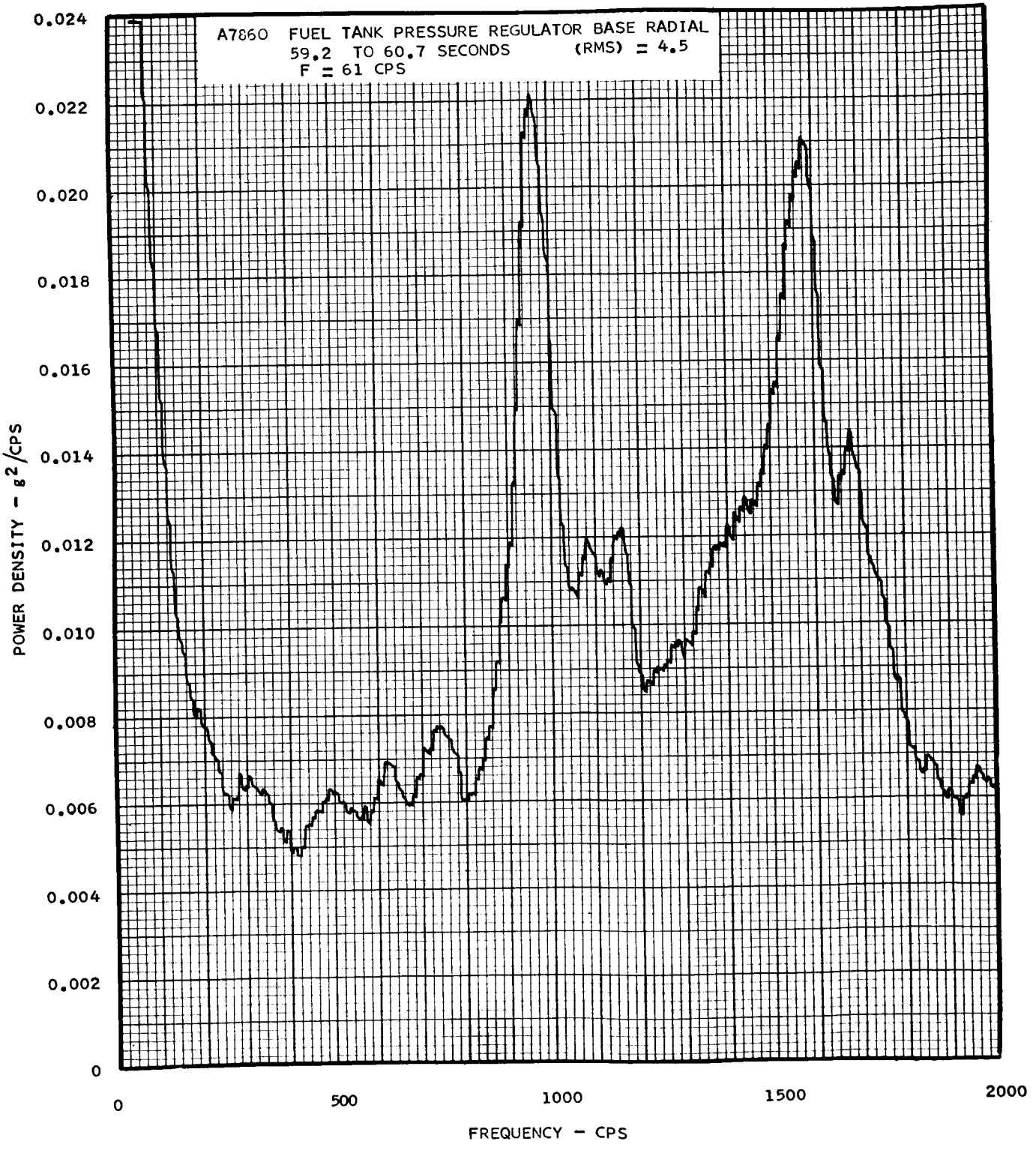


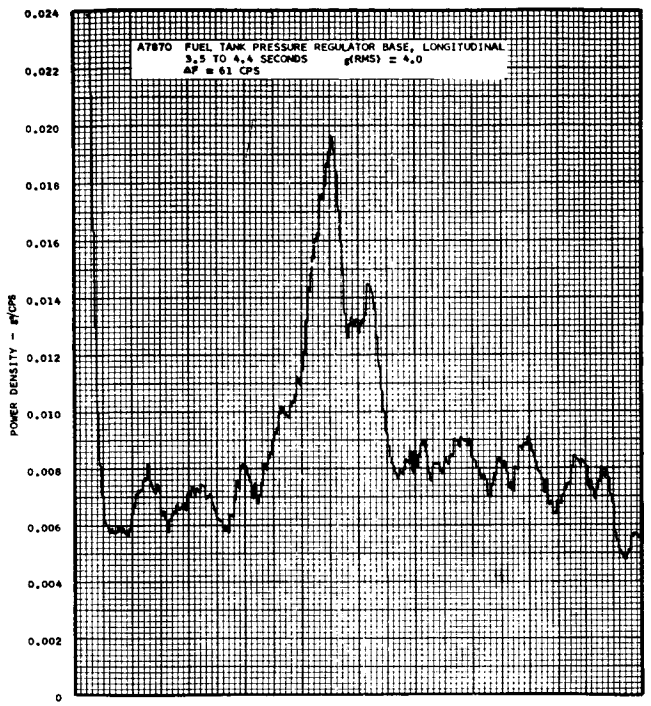
VIBRATION

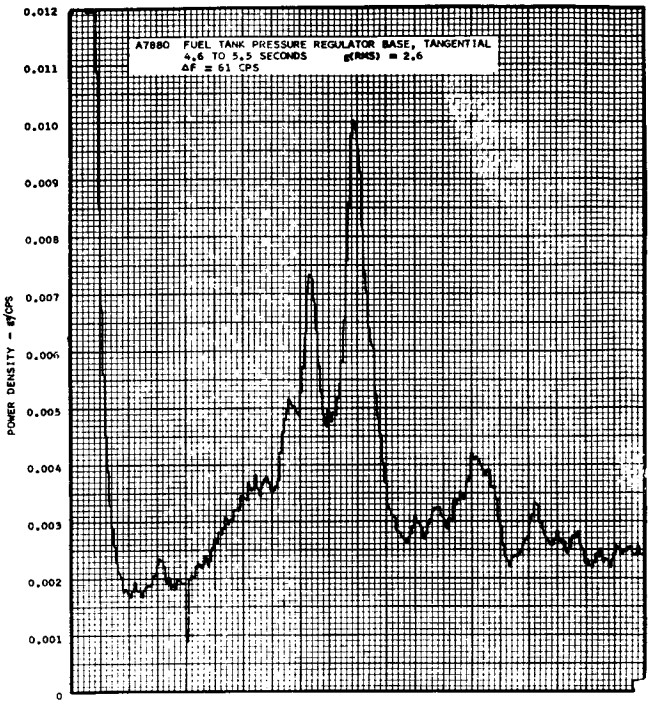
FIGURE NO. 18-2

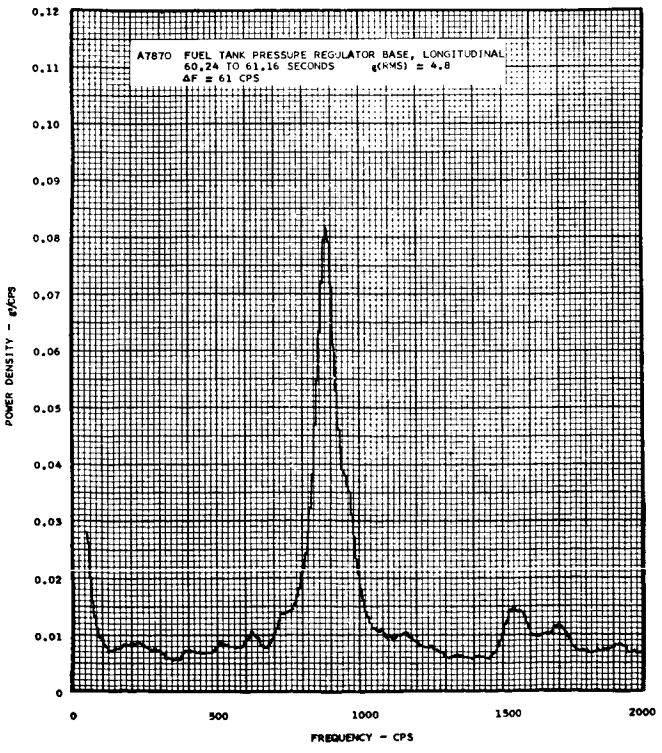
~~REPORT NO. AE61-0798~~

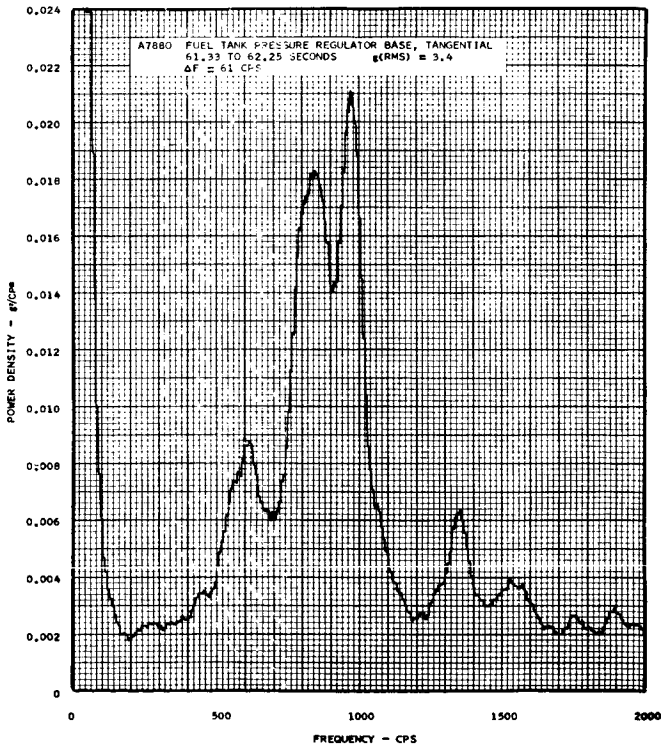
MISSILE 25E

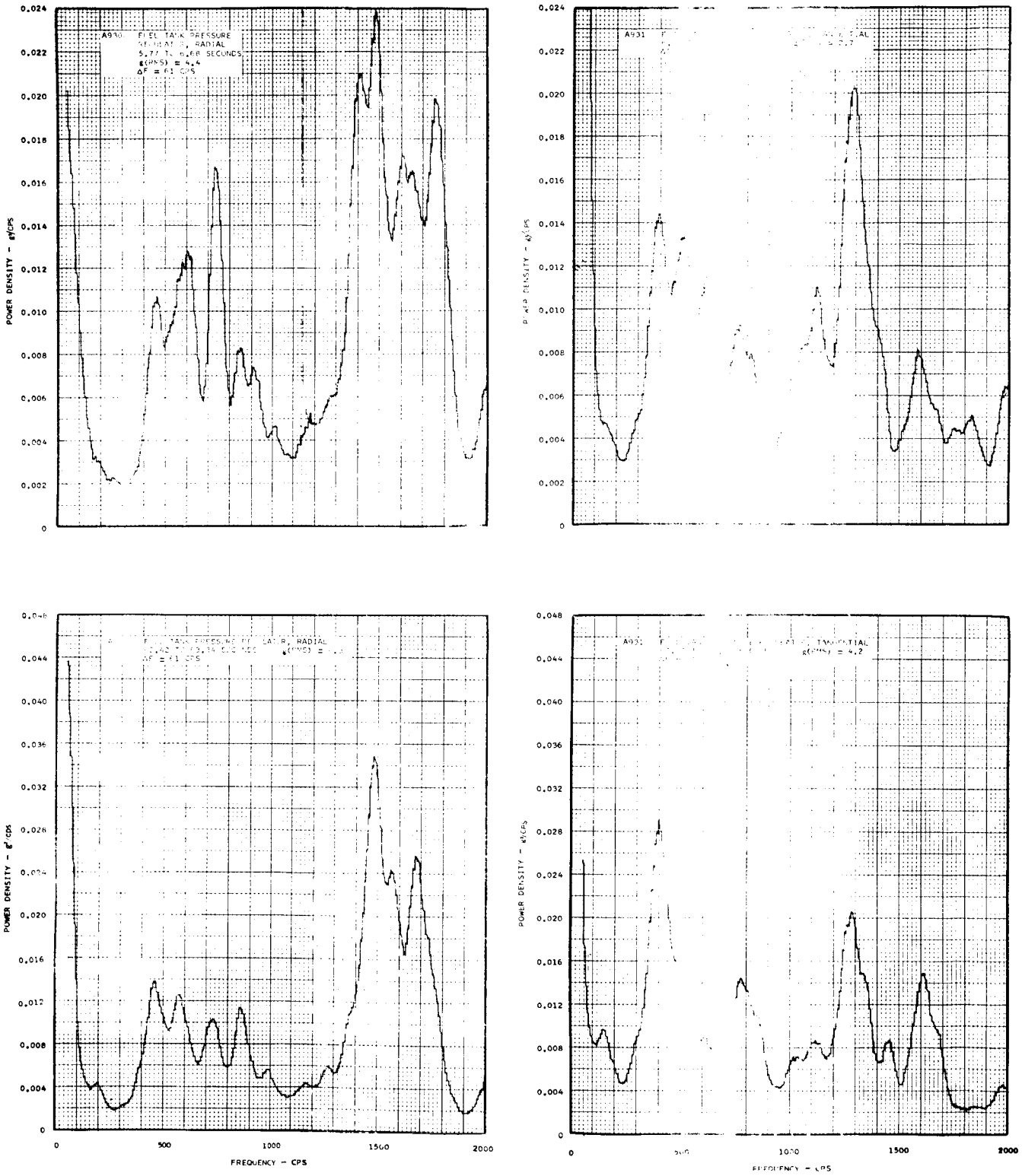


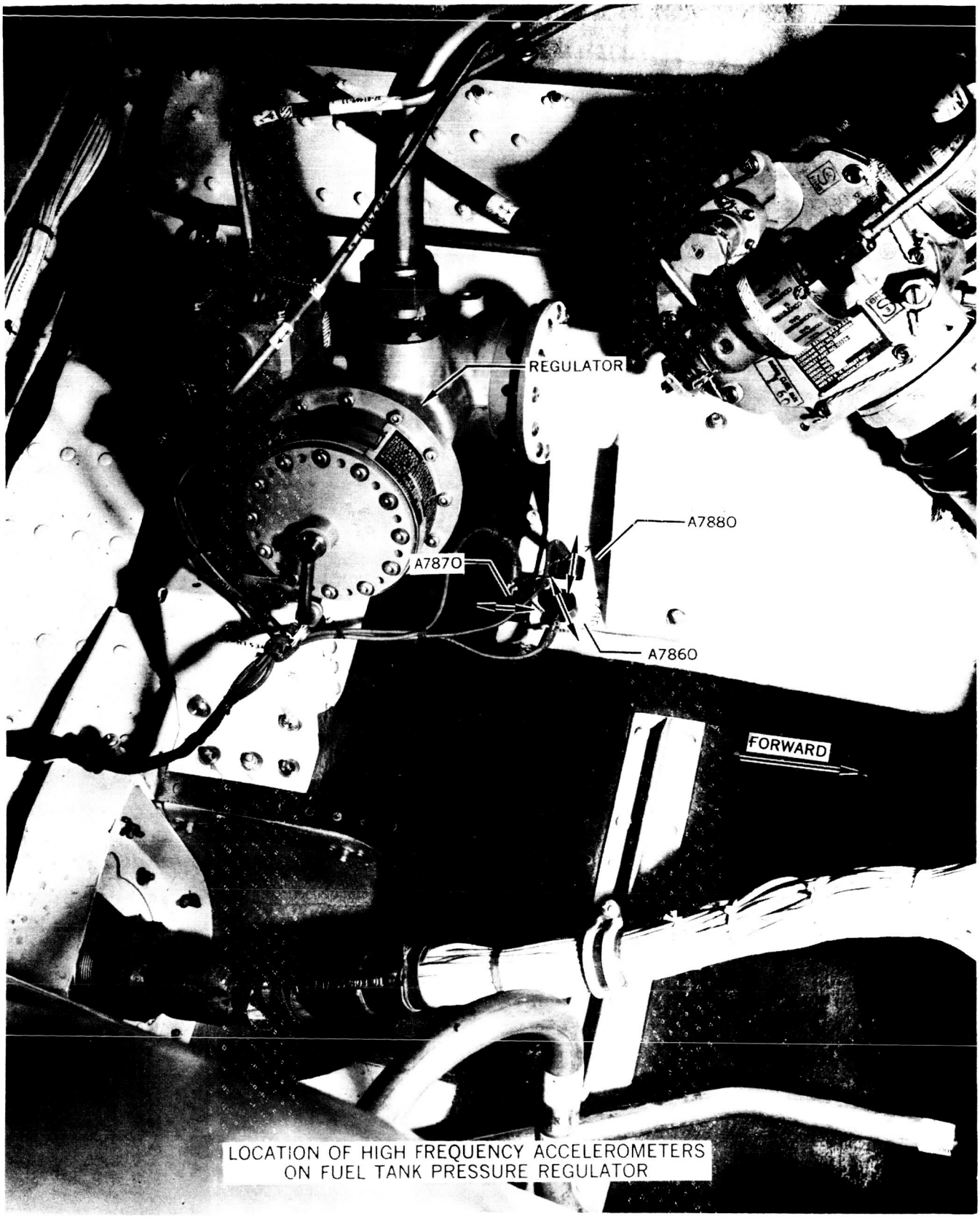

A7870 FUEL TANK PRESSURE REGULATOR BASE, LONGITUDINAL
3.5 TO 4.4 SECONDS g(RMS) = 4.0
ΔF = 61 CPS
POWER DENSITY - g²/CPS
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0


A7880 FUEL TANK PRESSURE REGULATOR BASE, TANGENTIAL
4.6 TO 5.5 SECONDS g(RMS) = 2.6
ΔF = 61 CPS
POWER DENSITY - g²/CPS
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0


A7870 FUEL TANK PRESSURE REGULATOR BASE, LONGITUDINAL
60.24 TO 61.16 SECONDS g(RMS) = 4.8
ΔF = 61 CPS
POWER DENSITY - g²/CPS
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
FREQUENCY - CPS


A7880 FUEL TANK PRESSURE REGULATOR BASE, TANGENTIAL
61.33 TO 62.25 SECONDS g(RMS) = 3.4
ΔF = 61 CPS
POWER DENSITY - g²/CPS
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0
0
500
1000
1500
2000
FREQUENCY - CPS

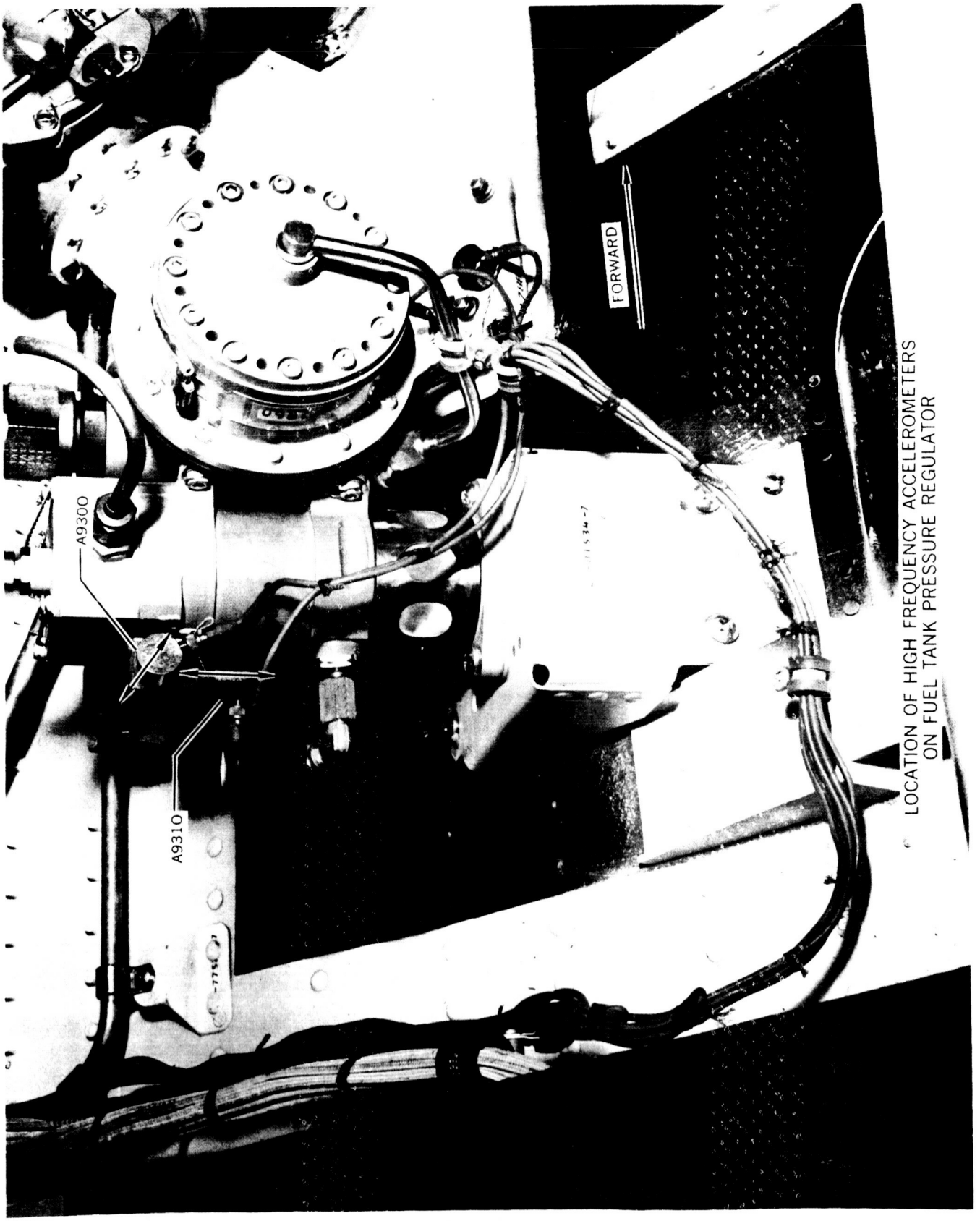

POWER DENSITY - g²/CPS
FREQUENCY - CPS
0
500
1000
1500
2000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
0.016
0.018
0.020
0.022
0.024
0.028
0.032
0.036
0.040
0.044
0.048



LOCATION OF HIGH FREQUENCY ACCELEROMETERS ON FUEL TANK PRESSURE REGULATOR

VIBRATION

MISSILE 25E



SECTION 6.2.12

MISSILE 26E

FLIGHT TESTED 9-8-61

AT AMR COMPLEX 13

TEST REPORT AE61-0797

SECTION 18

VIBRATION ANALYSIS

Vibration measurements were obtained from the thrust section during the flight test of Missile 26E. Landline measurements were made on each thrust chamber during launch as part of an objective to determine the adequacy of propulsion system operation. Measurements were obtained from the lox tank pressure regulator (F&G), during booster stage only, as part of a study to evaluate the vibration environment at each tank pressure regulator installation and to compare results of measurements made on the two types of regulators (Stratos and F&G) utilized during the E Series flight test program. This was the first flight with vibration measurements on an F&G regulator.

Adequate data was obtained from the flight of Missile 26E to determine the vibration environment at the lox tank regulator. The vibration at the regulator appeared to be within the currently prescribed design allowable limits. The vibration data measurements were terminated at booster jettison. Vibration outputs at booster engine cutoff and booster section unlatch appeared normal. The analysis was made within a frequency band of 10 to 2000 cps.

Thrust Chamber Vibration

High frequency accelerometers were installed on the lox dome of each thrust chamber (verniers excluded). The outputs were recorded via an FM landline system utilizing extended cable lengths to provide data acquisition for approximately 60 feet of missile rise above the launcher. The measurement numbers and locations were as follows:

P1206O	Sustainer Thrust Chamber, Z Axis
P1208O	Booster No. 1 Thrust Chamber, Z Axis
P1209O	Booster No. 2 Thrust Chamber, Z Axis

Approximately 3.5 seconds of data was obtained during launch. P1209O exhibited erratic outputs (invalid intermittent wandering of the trace about zero reference) which resulted in obtaining qualitative data only. An oscillograph recording of each measurement is shown in Figure 18-1.

Sustainer thrust chamber vibration appeared normal at launch. The steady-state levels ranged between 2.5 and 9.5 g(rms) and displayed predominant frequency components at 510, 680 and 1155 cps.

Booster No. 1 vibration was characteristic of normal operation of the MA-3 configuration. The steady-state outputs showed a nearly discrete frequency of 720 cps at 7.1 g(rms).

Power density spectral computations were made from the thrust chamber data as shown in Figure 18-3.

Lox Tank Pressure Regulator Vibration

Five high frequency accelerometers were installed on the regulator as shown in Figure 18-6. The specific locations were as follows:

A781O	Regulator Mount, Radial
A782O	Regulator Mount, Longitudinal
A783O	Regulator Mount, Tangential
A784O	Regulator, Radial
A785O	Regulator, Tangential

Each measurement provided satisfactory data for analysis purposes within a frequency band of 10 to 2000 cps. Figure 18-2 shows an oscillograph recording of the measurements.

The regulator measurements showed significant outputs at launch, a gradual buildup and peak in intensity as the missile approached and passed through the Mach 1 -maximum q region, and a gradual decrease in levels between 80 seconds and booster cutoff. The measurements on the mount showed levels ranging between 1.0 and 7.2 g(rms) during booster stage.

The predominant frequencies ranged between 1100 and 1900 cps. The regulator, proper, showed levels ranging between 1.0 and 3.5 g(rms) with predominant frequency components between 720 and 1900 cps. The vibration in the radial direction showed the greater intensity on the mount, while the regulator showed the greater intensity on the tangential measurement. As was observed on previous flights utilizing Stratos regulators, a good amount of damping action prevailed at the regulator since the vibratory response between the main mount and the regulator was attenuated by a factor of approximately 2. Generally, the flight vibration of the two types of lox tank pressure regulators was comparable. Table 1 shows a summary of lox tank pressure regulator vibration measurements made during the E Series flight test program.

Regulator leakage fill action was noted prior to engine start on Measurements A781O, A783O and A784O. Between -10 and ignition, three leakage fill bursts were evident, displaying predominant frequencies of 1200 and 180 cps at 34.5 and 7.0 g zero-to-peak, respectively.

The accelerometers showed response to low frequency oscillations between launch and approximately 10 seconds. At launch, frequency components of 3, 6, 8 and 10 cps were noted on the various measurements. The missile 5 cps breathing mode frequency was apparent between launch and 10 seconds. The levels observed for these periods are shown in Table 1. The resulting magnitudes are questionable since the frequency components noted are within an unreliable frequency band for the transducer utilized.

Power density computations were made on each measurement as shown in Figures 18-4 and 18-5.

TABLE 1

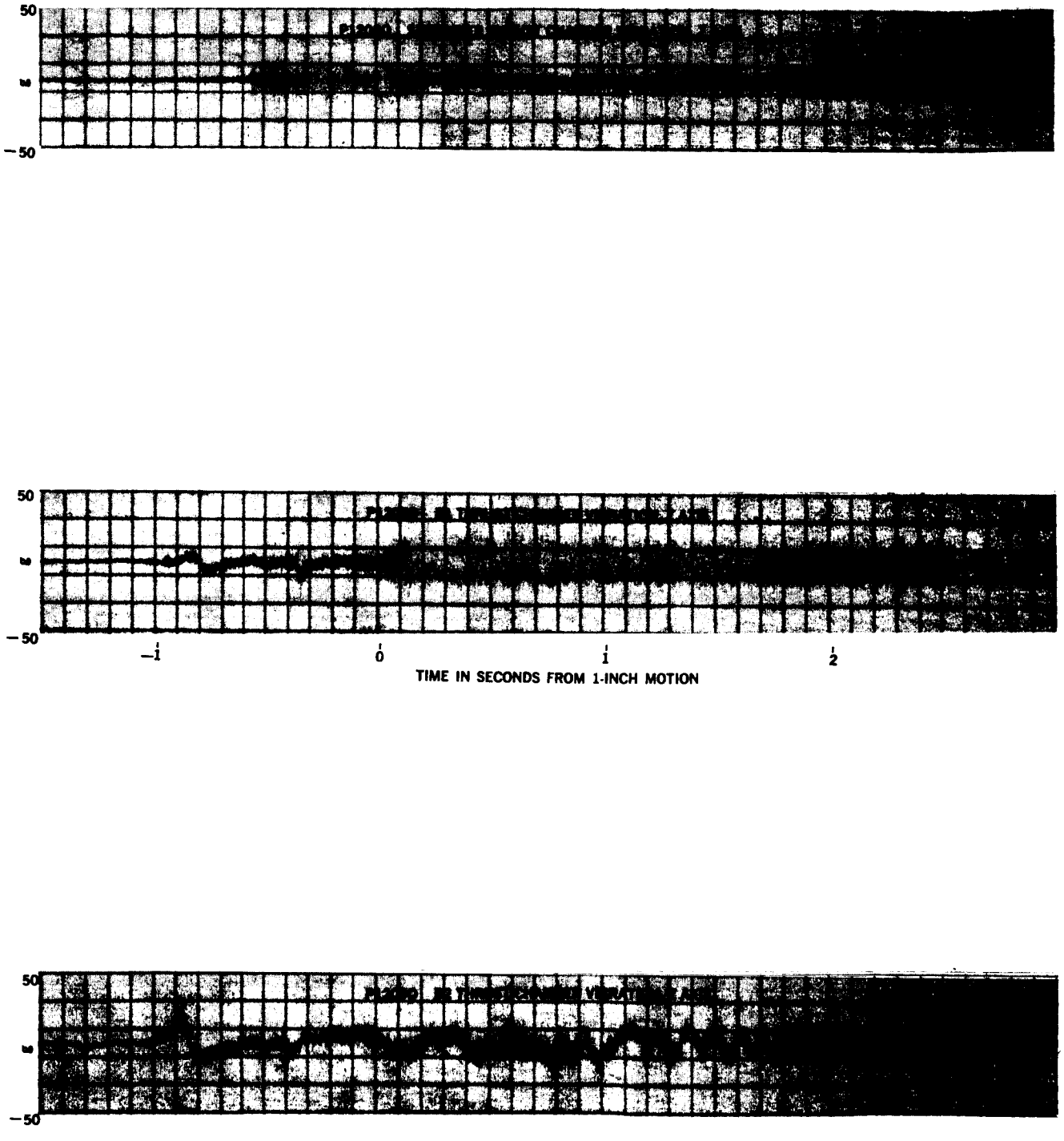
LOX TANK PRESSURE REGULATOR VIBRATION
COMPARISON OF LEVELS ON MISSILES 18E, 21E AND 26E

Missile/ Flight Period	A781O		A782O		A783O		A925O A784O(26E)		A926O A785O(26E)	
	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps
18E										
Stratos										
Launch	Q	-	Q	-	Q	-	5	920	5	1400
Max. q	5	720	3.6	1160	7.3	840	5.7	715	6.3	1430
101 to 106 seconds	30	720	9	730	22	720	1.6	740	1.4	1420 720
21E										
Stratos										
Launch	Q	-	Q	-	Q	-	6	1430	4.9	940
Max. q	10.8	1400	9	860	8.3	960	3.9	1600	4.3	740
107 to 111 seconds	3	1460	1.9	860	1	740	0.8	1630	1	850
26E										
F&G										
-0.84 to 0.68 secs.	-	-	10*	one cycle 3.0	-	-	-	-	-	
-0.5 to +0.4 secs.	-	-	-	-	4.0*	one cycle 6.0	-	-	-	
	-	-	-	-	1.25*	10.0	-	-	-	
0.6 to 1.4 seconds	-	-	-	-	-	-	2.5*	8.0	-	-
6.2 to 8.5 seconds	2.5*	5.0	3.3*	5.0	4.1	200	1.2	720	3.52	357
	-	-	-	-	1.0*	5.0	3.2*	5.0	-	-
Max. q	7.2	1335	6.6	1100	5.9	1010 and 1896	1.1	10-2000	1.9	1900
117 to 122 seconds	1	-	1	-	1	-	0.5	-	0.5	-

NOTE:
1. The analysis was conducted within a frequency band of 10 to 2000 cps. The RMS vibratory acceleration shown is the over-all level for the band analyzed.
2. A784O and A785O (F&G) were installed similar to A926O and A925O (Stratos).
3. Q, denotes questionable data.
4. *, denotes g zero-to-peak level.

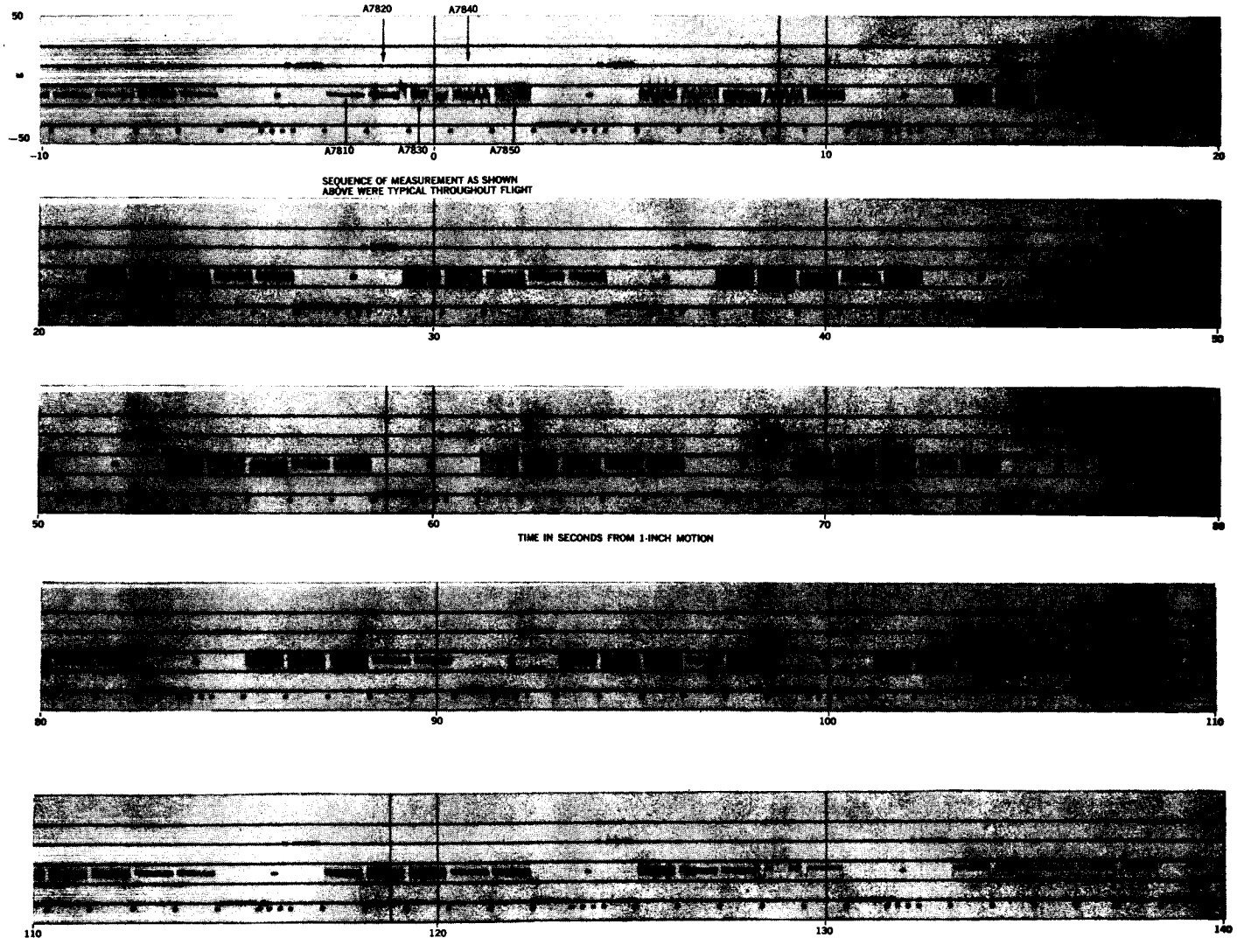
VIBRATION TELEMETERED DATA

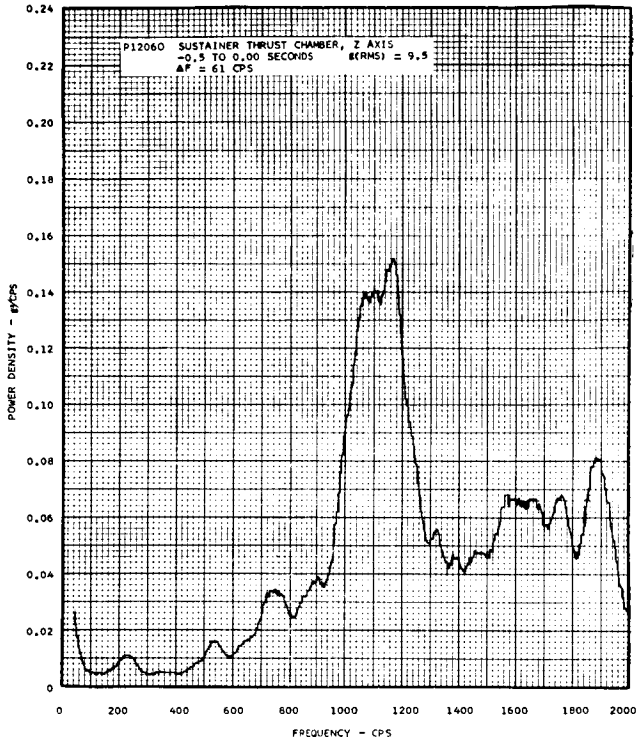
MISSILE 26E

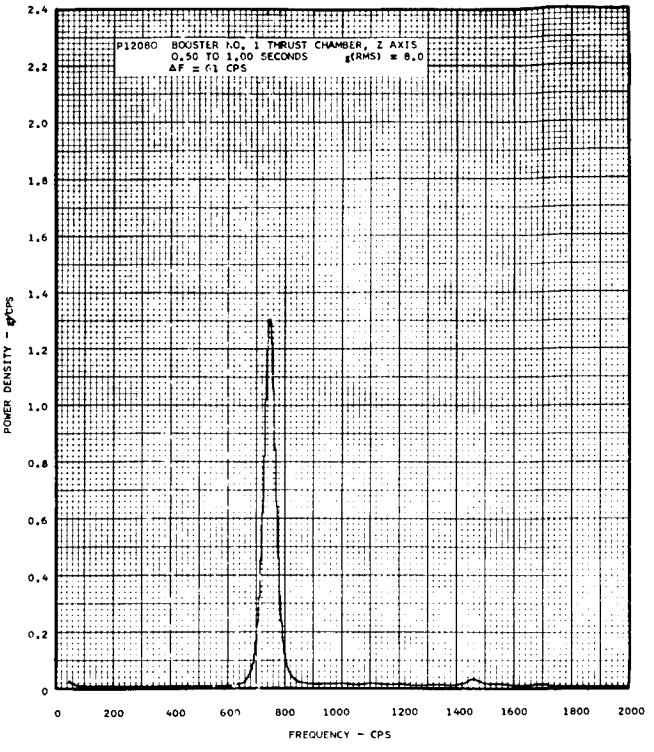


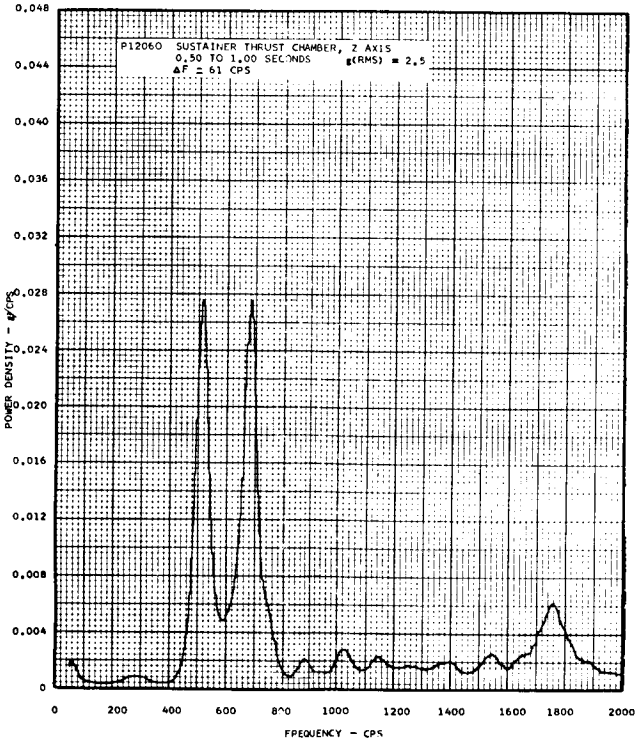
VIBRATION TELEMETERED DATA

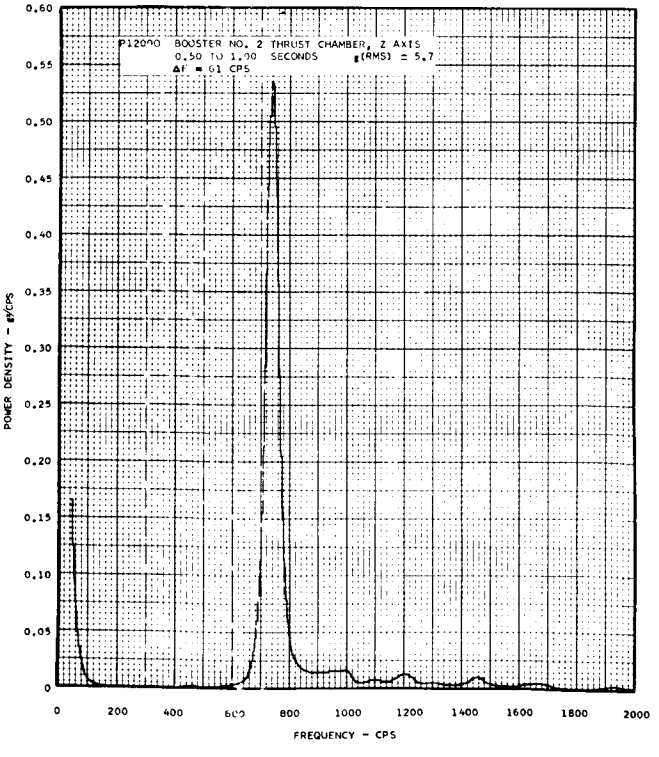
MISSILE 26E

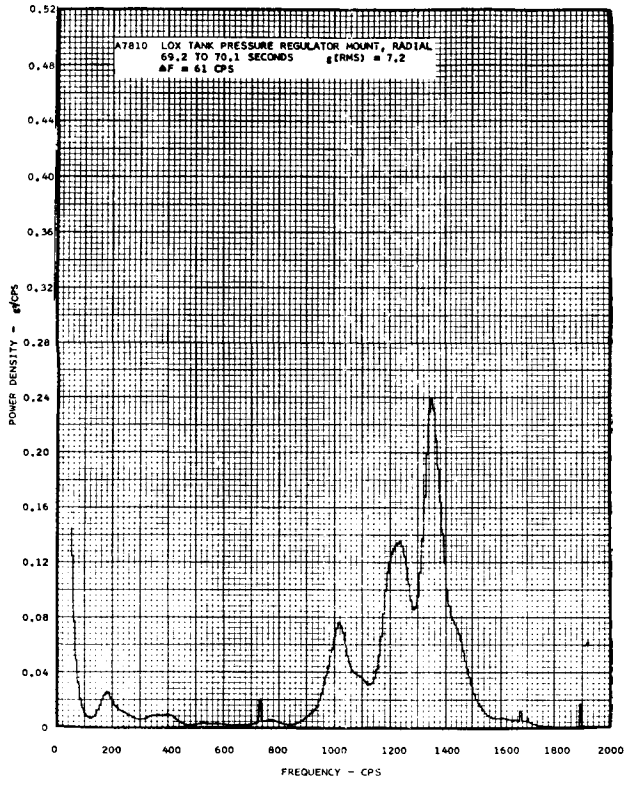


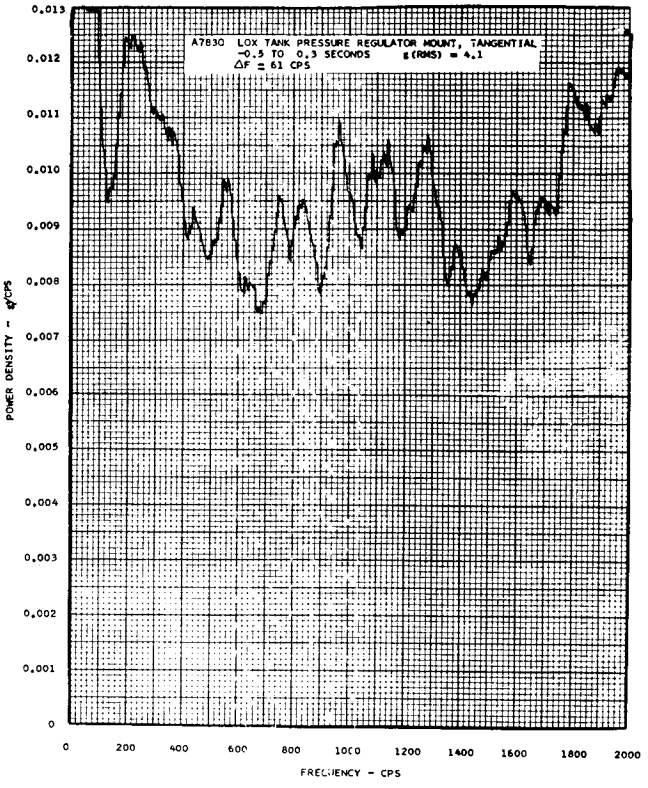

P12060 SUSTAINER THRUST CHAMBER, Z AXIS
-0.5 TO 0.00 SECONDS g(RMS) = 9.5
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS

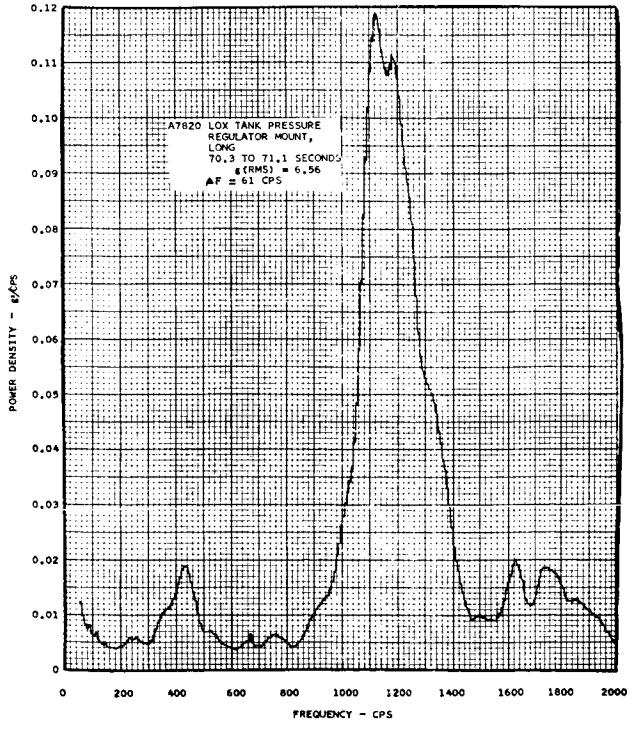

P12080 BOOSTER NO. 1 THRUST CHAMBER, Z AXIS
0.50 TO 1.00 SECONDS g(RMS) = 8.0
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS

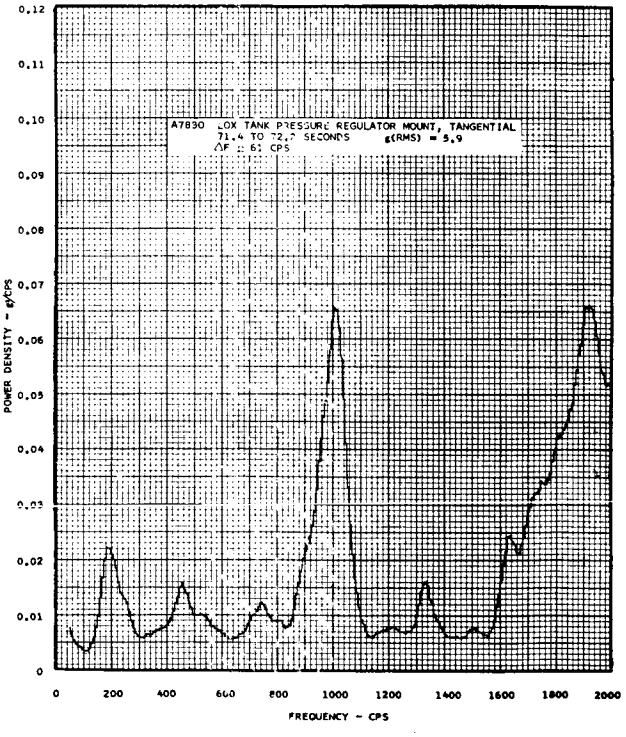

P12060 SUSTAINER THRUST CHAMBER, Z AXIS
0.50 TO 1.00 SECONDS g(RMS) = 2.5
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS

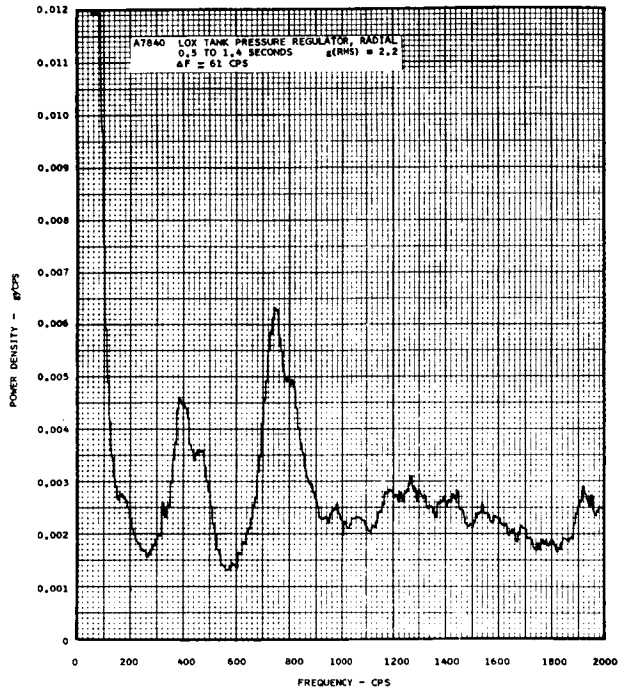

P12080 BOOSTER NO. 2 THRUST CHAMBER, Z AXIS
0.50 TO 1.00 SECONDS g(RMS) = 5.7
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS

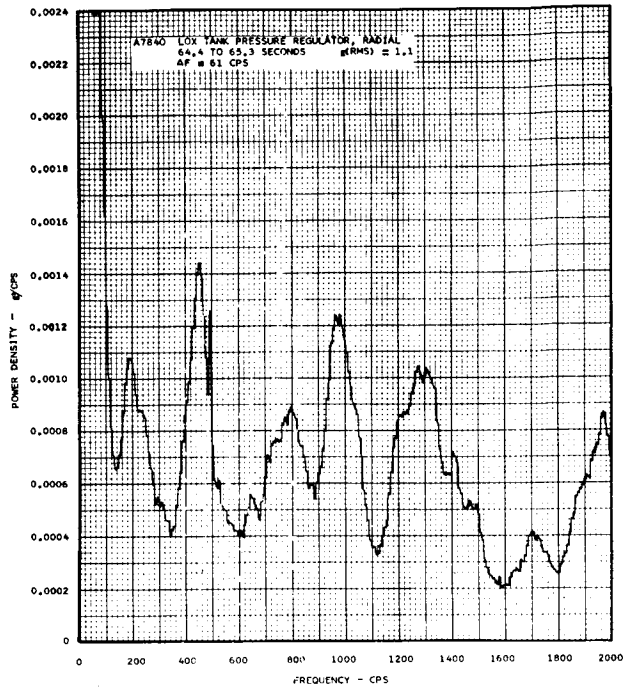

A7810 LOX TANK PRESSURE REGULATOR MOUNT, RADIAL
69.2 TO 70.1 SECONDS g(RMS) = 7.2
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS

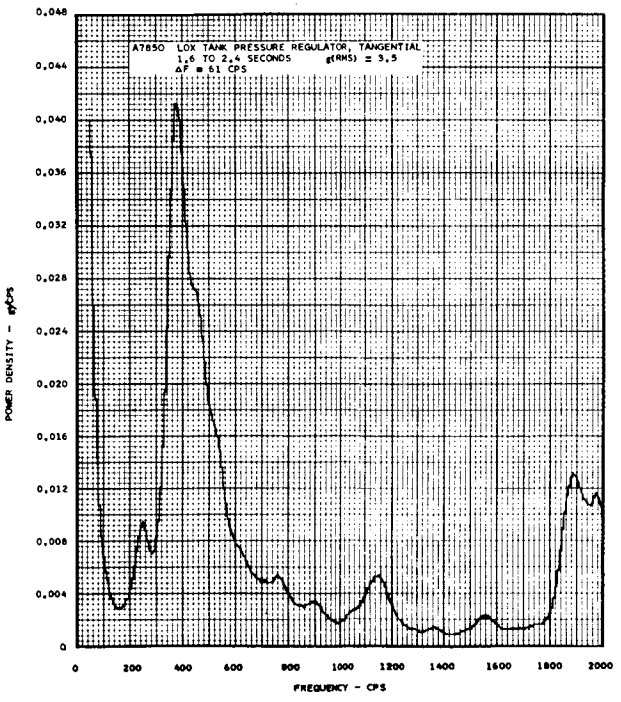

A7830 LOX TANK PRESSURE REGULATOR MOUNT, TANGENTIAL
-0.5 TO 0.3 SECONDS g(RMS) = 4.1
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS

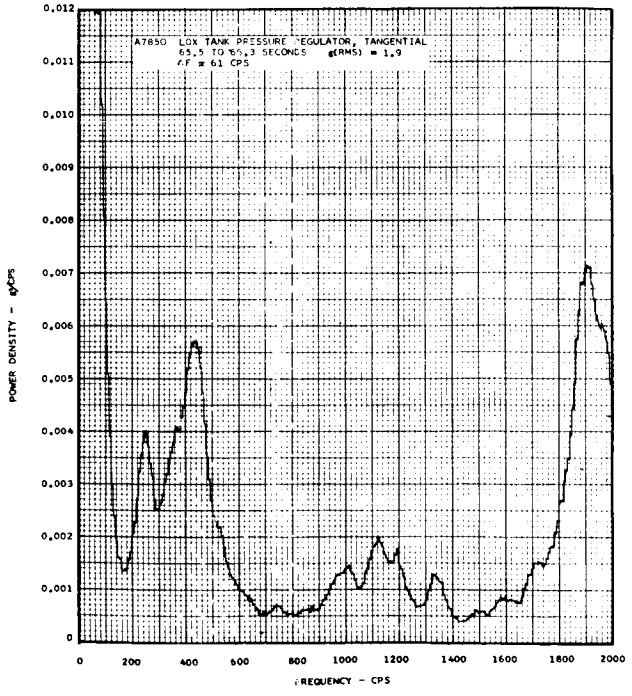

A7820 LOX TANK PRESSURE REGULATOR MOUNT, LONG
70.3 TO 71.1 SECONDS
g(RMS) = 6.56
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS


A7830 LOX TANK PRESSURE REGULATOR MOUNT, TANGENTIAL
71.4 TO 72.2 SECONDS g(RMS) = 5.9
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS

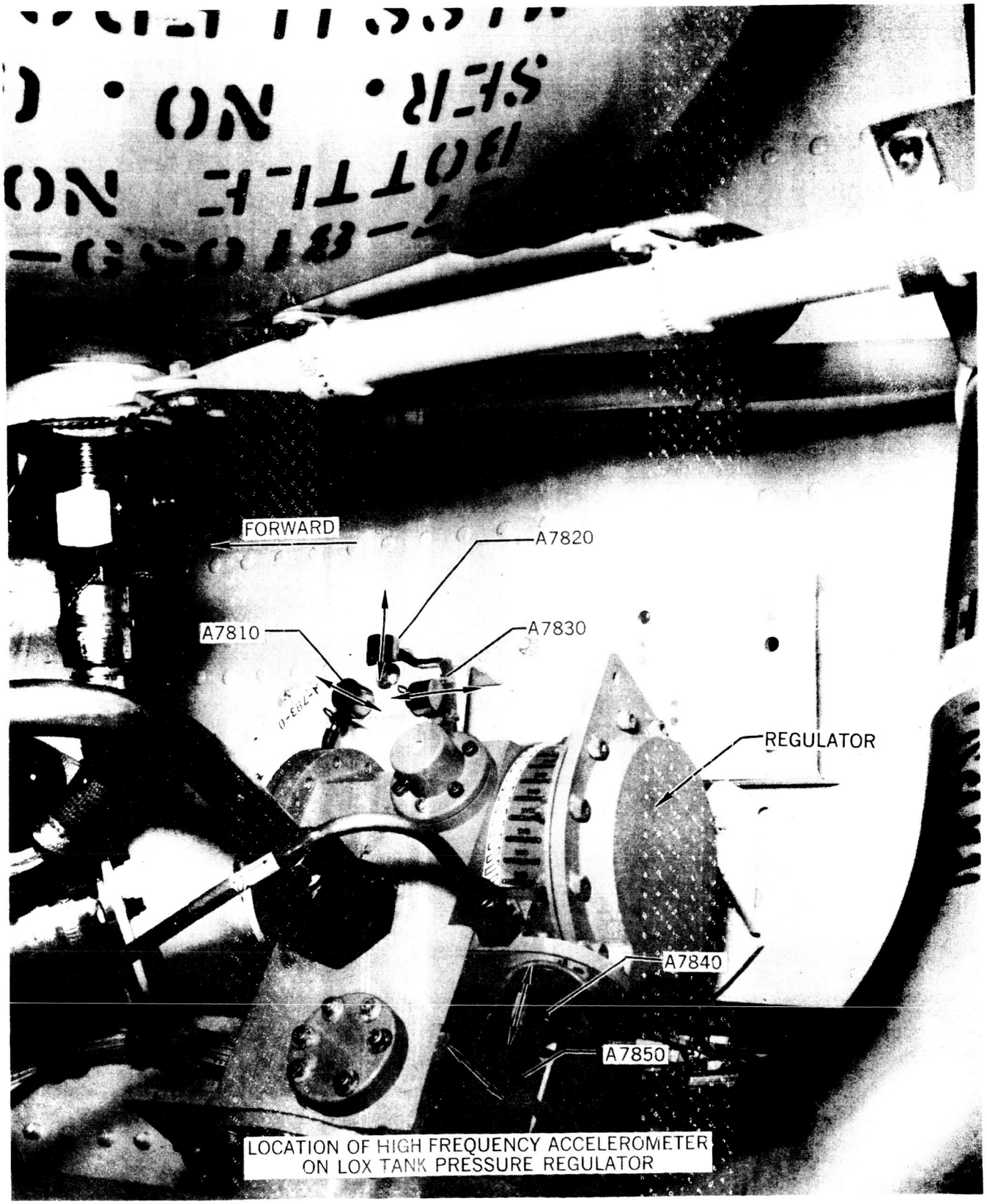

A7840 LOX TANK PRESSURE REGULATOR, RADIAL
0.5 TO 1.4 SECONDS g(RMS) = 2.2
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS


A7840 LOX TANK PRESSURE REGULATOR, RADIAL
64.4 TO 65.3 SECONDS g(RMS) = 1.1
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS


A7850 LOX TANK PRESSURE REGULATOR, TANGENTIAL
1.6 TO 2.4 SECONDS g(RMS) = 3.5
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS


A7850 LOX TANK PRESSURE REGULATOR, TANGENTIAL
65.5 TO 65.3 SECONDS g(RMS) = 1.9
ΔF = 61 CPS
POWER DENSITY - g²/CPS
FREQUENCY - CPS

26E



LOCATION OF HIGH FREQUENCY ACCELEROMETER ON LOX TANK PRESSURE REGULATOR

SECTION 6.2.13

MISSILE 35E

FLIGHT TESTED 12-1-61

AT AMR COMPLEX 13

TEST REPORT AE61-1190

SECTION 19

VIBRATION ANALYSIS

Six high frequency vibration measurements were obtained from the thrust section during flight. One was obtained from the sustainer gas generator fuel check valve to aid in the investigation of the apparent failure of the sustainer gas generator fuel bootstrap line on Missile 26E. The remainder of the measurements was made on the fuel tank pressure regulator (F&G; reference pneumatic section) as part of a study to evaluate the vibration environment at each installation and to compare the results of measurements made on the two types of regulators (Stratos and F&G) utilized during the Series E flight test program. Missile 35E flight was the last test for regulator vibration measurements.

A total of 7 missiles was instrumented for the regulator vibration study. A summary of the data is shown in Tables 2 and 3. In summarizing the tank pressure regulator vibration data obtained to date, it is apparent that the levels obtained from all tests were well within the allowable design limits for a frequency band of 15 to 2000 cps. In comparing the response of the two types of regulators, it was apparent that the general over-all level of vibration was similar. The study of the fuel regulator environment was not as complete as the lox regulator due to the failure of one instrumented missile and the loss of a portion of the data from another missile. In viewing the data obtained from the area of the lox regulator, it was apparent that the Stratos regulator, generally, provided over-all levels between 30 to 50 percent greater than that obtained from the F & G regulator. Each regulator displayed similar major frequency components. Each installation showed a ratio of mount to regulator vibration (over-all level) of approximately 2.5 to 1.

Due to the limited amount of data on the F & G fuel tank pressure regulator, it is difficult to compare it with the Stratos regulator installation. It was apparent, however, that the over-all levels, on each, at the regulator proper were comparable. There was some variation in the major frequency components of each. Of the two installations, the F & G fuel regulator showed the greater response to the missile 5 cps breathing mode (zero to 10 seconds of flight).

Sustainer Gas Generator Fuel Check Valve Vibration (P-531-O)

The flight test of Missile 35E was the first time that valid information was obtained from Measurement P531O for the full duration of powered flight (reference Figures 19-7 and 19-8 for transducer location). Previous attempts were made on Missile 32E and 4F. Missile 32E flight provided only launch data, due to flight failure, and P531O on Missile 4F flight was considered invalid. Launch vibration data from Missile 32E compared well with the launch data observed on Missile 35E. The data was analyzed within a frequency band of

approximately 15 and 500 cps. The normal telemetry channel response was 220cps. Table 1 displays a tabular summary of the environment. Figure 19-5 shows a power density spectral plot computed from a time sample at launch.

Generally, the outputs from P531O indicated moderate vibrations through flight. A one cycle component of approximately 6 cps frequency was observed between 130.35 seconds and the time the telemetry dropout commenced (approximately 130.51 seconds). The instantaneous level indicated was 13 g(zero-to-peak) which appears to be erroneous since the representative single amplitude displacement would be in excess of 6 inches. The displacement indicated (if valid) would cause damage to the sustainer gas generator; however, propulsion system data does not reflect a condition of this kind. Below approximately 15 cps, the accelerometer outputs become unreliable and no quantitative values are valid within that frequency band. A Gulton Industries Accelerometer System (Astro. DRWG. NO. 27-11756) was utilized. It is apparent, however, that significant excitation did exist during that period and may be of significance in regard to determining the source of the Missile 26E failure. On future missile flights, it would be advantageous to measure P531O utilizing an accelerometer capable of providing valid response between 0 and 15 cps.

At launch, a buildup in level was noted between -0.85 (ignition) and 3 seconds. The vibration level appeared normal at approximately 3 g(rms). Between 3 seconds and booster cutoff, the levels were very low and difficult to extract due to the relative high scale sensitivity utilized. The levels for that period were below 1 g (rms). Between the time the telemetry dropout terminated and 138 seconds, the levels ranged between 2.5 and 3 g (rms). A discrete frequency of 170 cps prevailed through that period. For the remainder of sustainer stage, the outputs remained steady at approximately 2 g (rms).

Fuel Tank Pressure Regulator Vibration

Five high frequency accelerometers were installed on the regulator (Missile 35E) as shown in Figure 19-6. The specific locations were as follows:

A786O	Regulator base, radial
A787O	Regulator base, longitudinal
A788O	Regulator base, tangential
A789O	Regulator, radial
A790O	Regulator, tangential

Measurements A786O and A787O provided no data through flight, possibly as the result of an open circuit in each accelerometer system. The remainder of the measurements appeared

satisfactory for analysis purposes. The basic analysis was conducted within a frequency band of 15 to 2000 cps.

The regulator measurements remained nearly steady-state between liftoff and approximately 80 seconds. A788O showed a gradual buildup in level, peaking at approximately 62 seconds, as may be expected of the regulator mount since it is attached to a structure that can respond to an excitation force external to the thrust section. The regulator and regulator mount vibration levels (15 to 2000 cps) were within the currently prescribed design allowable limits.

The regulator measurements showed levels ranging between 2.9 and 3.8 g(rms) with the energy distributed within a wide frequency spectrum of 200 to 1700 cps. The regulator mount measurement displayed levels ranging between 5 and 8 g(rms) with major frequency contributions concentrated within a band of 1160 to 1650 cps. After approximately 80 seconds, each measurement showed a general decrease in level until the time the booster engines were shut down. These measurements were terminated at booster jettison, since the regulator is attached to the booster section. A summary of the data is shown in Table 3. An oscillograph recording of each measurement is shown in Figure 19-1. Selected power density spectral computations were made as shown in Figures 19-3 and 19-4.

A 7.4 cps oscillation was observed prior to main engine ignition on Measurements A788O and A789O. The maximum instantaneous level indicated was 4.5 g zero-to-peak; however, these levels are questionable due to the lack of transducer reliability (amplitude consideration) for frequencies within a band of approximately 0 to 15 cps. A790O showed response to the 7.4 cps oscillation but the level indicated was very low and difficult to read. In attempting to determine the source of the oscillation, the missile tank pressure measurement and propellant control unit sensing line pressure measurement were studied. No data correlation was evident to determine the source of the oscillation. It is apparent that no significant missile motion prevailed and the excitation (if valid) was local to the regulator installation. The intensity indicated on A788O (reg. mount, tang.) and A789O (Reg. rad) were nearly identical, while A790O (reg. tang) showed considerably less intensity. The combination mentioned above is not a logical one when considering that excitation can only be provided by the regulator and/or the mounting structure. This line of reasoning would lead to a possible instrumentation anomaly. This condition has not been observed on previous missile launchings where regulator vibration measurements were obtained. The investigation will continue.

As shown on previous instrumented flights, the regulator showed significant response to the 5 cps missile tank breathing mode. Significant outputs were displayed between liftoff and approximately 10 seconds of flight. No amplitude information was extracted from the measurements due to the limitations in the accelerometer system utilized, as described above.

TABLE I

SUMMARY OF SPECTRUM ANALYSIS ON MEASUREMENT P5310,
SUSTAINER GAS GENERATOR FUEL CHECK VALVE VIBRATION

Flight Period Sample ~ Sec.	Freq. Band Analyzed ~ cps	Accel. Over-all ~ g(rms)	Freq. Band of Major Energy ~ cps	First Predominant Frequency ~ cps		Second Predominant Frequency ~ cps	
				1 Freq	g2/cps	Freq	g2/cps
-0.6 to 0.4	25 to 500	3.45	300-470	428	0.049	327	0.0415
"	7 to 250	2.92	0-60	6	0.093	38	0.070
53 to 57*	25 to 500	--	350-500	410	0.057	280	0.052
"	7 to 250		WHITE NOISE				
132 to 136	25 to 500	3.09	150-225	170 to 180	0.128	-	-
260 to 264	25 to 500	2.18	330-460	417	0.025	250	0.0120
260 to 264	7 to 250	0.79	56-74	62	0.0068	-	-

NOTE: Band pass filter utilized for 500 and 250 cps analysis were 25 and 7.2 respectively.

* Sample includes telemetry noise.

TABLE 2
LOX TANK PRESSURE REGULATOR VIBRATION
COMPARISON OF LEVELS ON MISSILES 18E, 21E AND 26E

Missile/ Flight Period	A7810		A7820		A7830		A9250 A7840(26E)		A9260 A7850(26E)	
	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps
18E (Stratos) Launch	Q	-	Q	-	Q	-	5	920	5	1400
Max q	5	720	3.6	1160	7.3	840	5.7	715	6.3	1430
101 to 106 seconds	30	720	9	730	22	720	1.6	740	1.4	1420 720
21E (Stratos) Launch	Q	-	Q	-	Q	-	6	1430	4.9	940
Max q	10.8	1400	9	860	8.3	960	3.9	1600	4.3	740
107 to 111 seconds	3	1460	1.9	860	1	740	0.8	1630	1	850
26E (F&G) -0.84 to 0.68 seconds	-	-	10*	one cycle 3.0	-	-	-	-	-	
-0.5 to +0.4 seconds	- -	- -	- -	- -	4.0* 1.25*	one cycle 6.0 10.0	- -	- -	- -	
0.6 to 1.4 seconds	-	-	-	-	-	-	2.5*	8.0	-	-
6.2 to 8.5 seconds	2.5* -	5.0 -	3.3* -	5.0 -	4.1 1.0*	200 5.0	1.2 3.2*	720 5.0	3.52 -	357 -
Max q	7.2	1335	6.6	1100	5.9	1010 and 1896	1.1	10-2000	1.9	1900
117 to 122 seconds	1	-	1	-	1	-	0.5	-	0.5	-

NOTE: 1. The analysis was conducted within a frequency band of 15 to 2000 cps. The RMS vibratory acceleration shown is the over-all level for the band analyzed.
2. A784O and A785O (F&G) were installed similar to A926O and A925O (Stratos).
3. Q, denotes questionable data.
4. *, denotes g zero-to-peak level.

TABLE 3
FUEL TANK PRESSURE REGULATOR VIBRATION
COMPARISON OF LEVELS ON MISSILES 22E, 25E,
32E AND 35E

Missile/ Flight Period	A7860		A7870		A7880		A9300 (22E & 25E) A7890 (32E & 35E)		A9310 (22E & 25E) A7900 (32E & 35E)	
	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps	Accel. g(rms)	Pred. Freq. cps
22E (Stratos) Launch (2 to 6 sec)	-	-	Q	-	3.6	1050 and 1540	4.6	750	2.6	720
16.8 to 17.7 seconds	7.7	750	-	-	-	-	-	-	-	
Mach 1-Max q Region (50 to 60 sec)	9.4	1780	Q	-	3.8	1750 and 1350	4.4	190	2.8	200
83.5 to 85.5 seconds	6.8	1550	2.1Q	1250 and 740	-	-	-	-	-	-
25E (Stratos) Leakage Fill (3 bursts btwn. -0.9 and -0.7 seconds)	-	-	-	-	-	-	-	-	60	550
Launch (2.4 to 7.7 sec)	Q6.2	135	4.0	880	2.6 2.5*	970 4.6	4.4	1500	2.7	1275
Mach 1-Max q Region (59 to 64 sec)	4.5Q	950 and 1550	4.8	800 and 470	3.4	950	4.3	1500	4.2	960
116 to 121 sec	3Q	850	4	900	2.8	700	3.8	1500	2.2	700
128.47 sec (unlatch)	-	-	-	-	-	-	-	-	32*	1/2 cycle of 300 cps
32E (F&G) -1.5 to 2.0	-	-	-	-	2.0*	10	16.0*	10	1.1	720
5.0 to 10.5	2.3 22*Q	720 5	N 1.3*Q	- 5	N -	5 -	1.7 7.5*Q	1460 5	2.3*Q -	5 -
13.5 to 18.5	3.3 6.0*Q	470 11	1.0*Q	5	2.5*Q	5	2.0*Q	5	0.5	720
35E (F&G) -13 to -1 sec	-	-	-	-	4.5*Q	7.4	4.5*Q	7.4	N	7.4
3.5 to 6.6 sec	-	-	-	-	5.1	1330	2.9	590	3.4	1450
35.5 to 38.6 sec	-	-	-	-	-	-	3.4	1340	3.4	860
Mach 1-Max q Region (61.3 to 64.4 sec)	-	-	-	-	7.95	1340	3.7	1150	3.8	520
80 sec to BCO	GENERALLY DECREASING LEVELS									

NOTE: 1. The analysis was conducted within a frequency band of 15 to 2000 cps. The RMS vibratory acceleration shown is the over-all level for the band analyzed.
2. Q, denotes questionable data.
3. *, denotes g zero-to-peak level.
4. N, negligible level
5. A7890 and A7900 (F&G) were installed similar to A9300 and A9310 (Stratos).

Jettison Rail End Accelerometers, A77A and A78A

Two accelerometers were installed on the aft end of the jettison rail in Quad II to determine rail end motion during booster jettison. These accelerometers were active in the radial (A77A) and tangential (A78A) direction. Rail motion was moderate during the period between jettison start and the start of the telemetry dropout. Since the RF #4 capability was not active on this flight, no data was obtained through the telemetry dropout period.

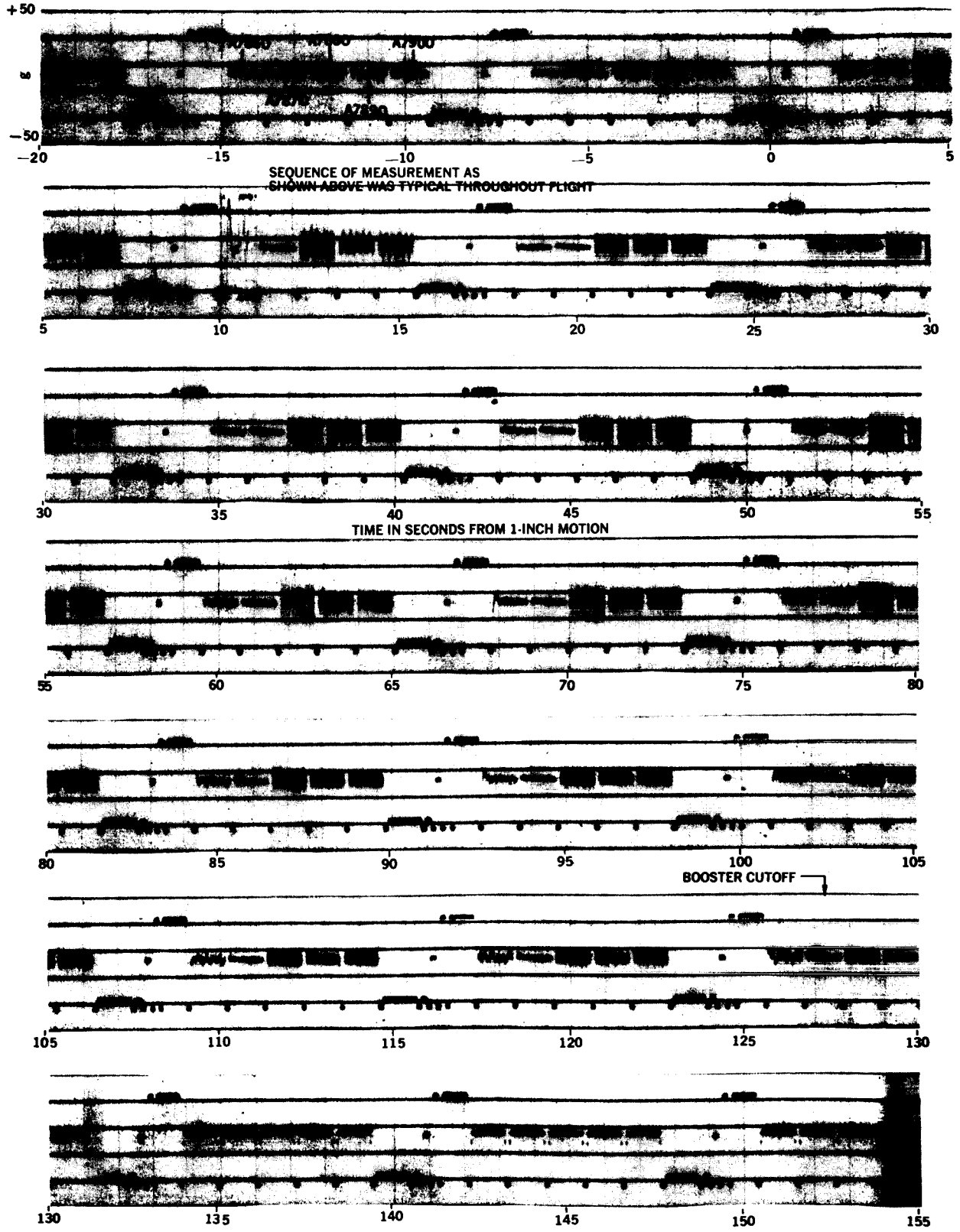
A general view of the accelerometer location is shown in Figure 13-15, while Figures 13-19 and 13-23 show the details of the installation.

The response of the accelerometers was flat to a frequency of approximately 200 cps. The nominal frequency response for the telemetry channels used for A77A and A78A was 25 and 35 cps, respectively. The analysis was extended to view the data frequency content to 60 cps. Since the objective was to study rail motion during staging, the measurements were set to "switch in" at the time of booster cutoff.

A summary of staging outputs is shown below. Graphic presentations of the analog traces are shown in Figure 13-4. The single amplitude displacements represented by the data obtained from Missile 35E did not exceed approximately 0.13 inches.

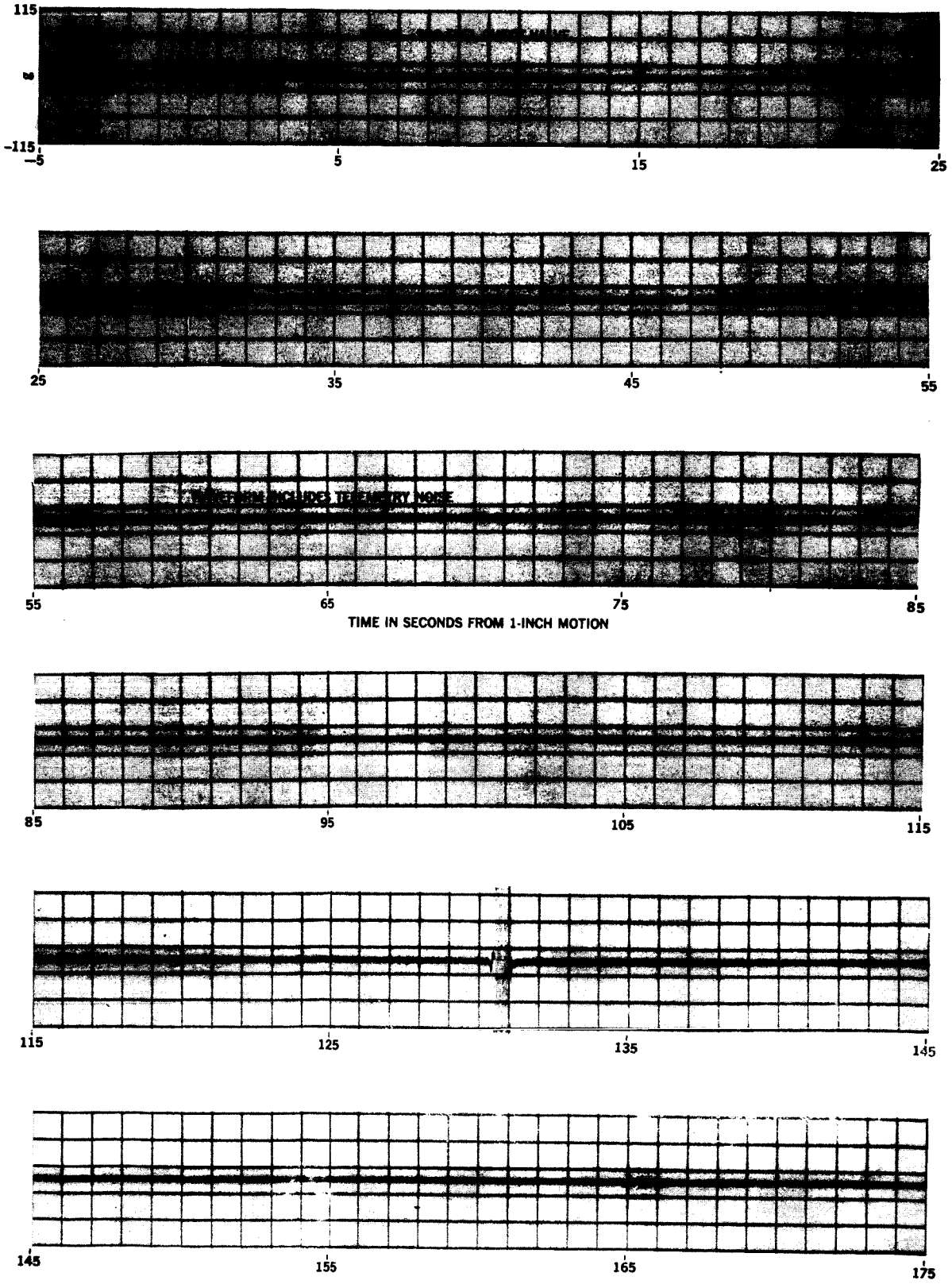
	A77A (Radial)		A78A (Tangential)	
Missile	Maximum Accel. ~ g (O-P)	Frequency ~ cps	Maximum Accel. ~ g (O-P)	Frequency ~ cps
4F	1.5	55	2.4	45
	0.2	11	0.5	11
35E	1.0	40	0.5	20
	5-6	67		42
			4.5	85

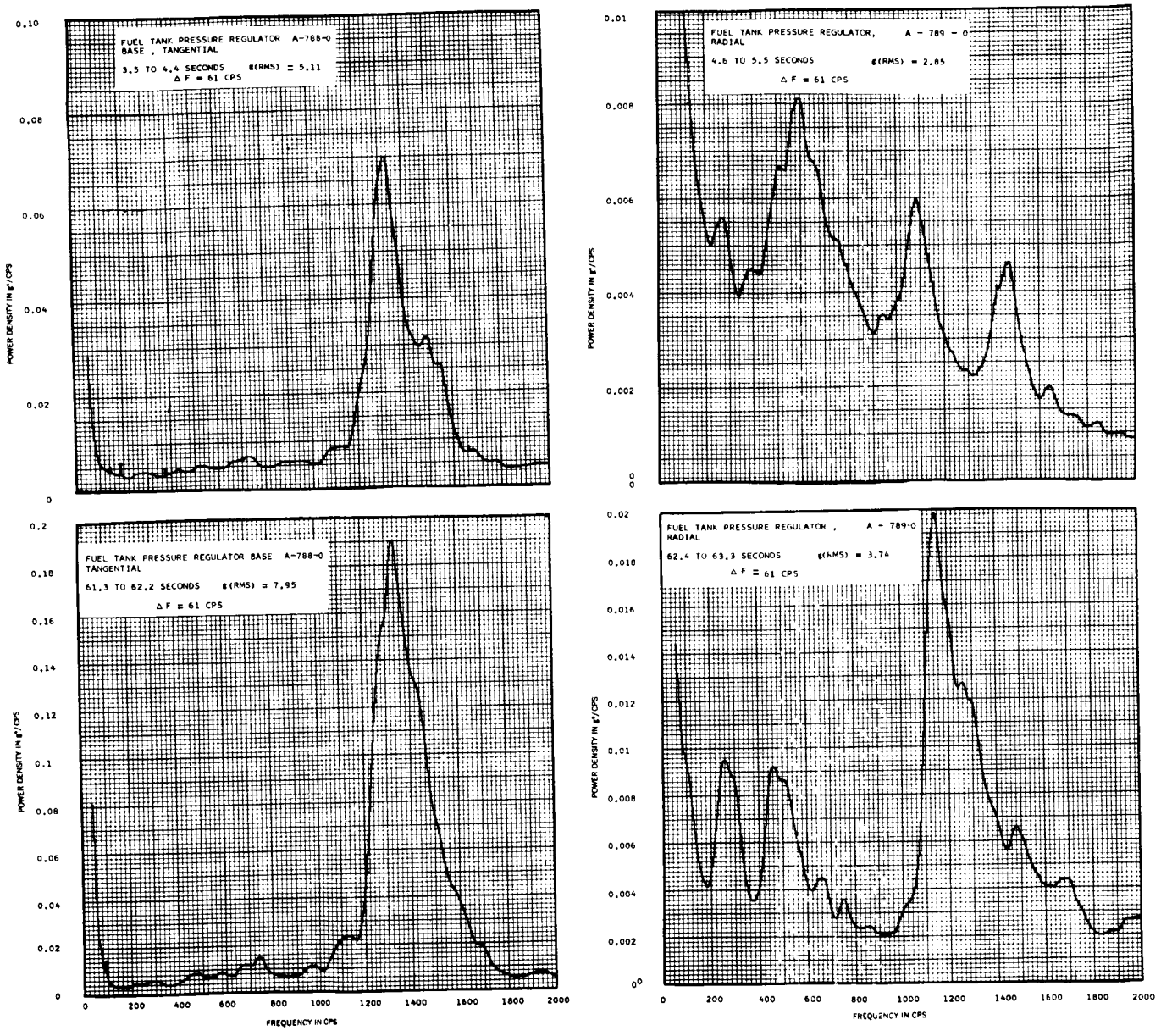
Note: Values shown above were maximum levels taken while booster section traveled along rails.

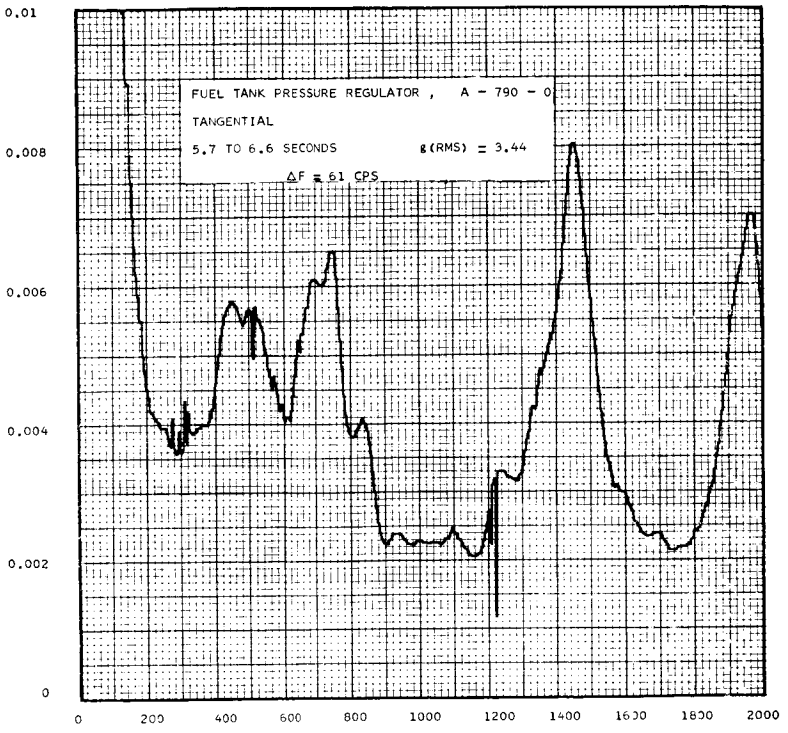

+50
g
−50
−20
−15
−10
−5
0
5
SEQUENCE OF MEASUREMENT AS
~~SHOWN ABOVE WAS TYPICAL THROUGHOUT FLIGHT~~
5
10
15
20
25
30
30
35
40
45
50
55
TIME IN SECONDS FROM 1-INCH MOTION
55
60
65
70
75
80
80
85
90
95
100
105
BOOSTER CUTOFF
105
110
115
120
125
130
130
135
140
145
150
155

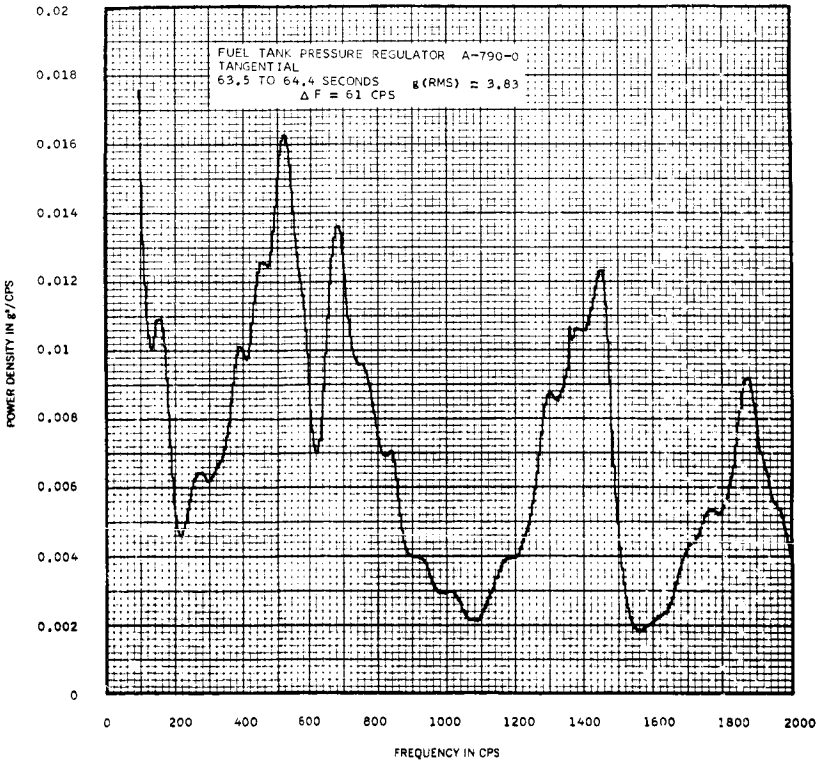
VIBRATION DATA

MISSILE 35E



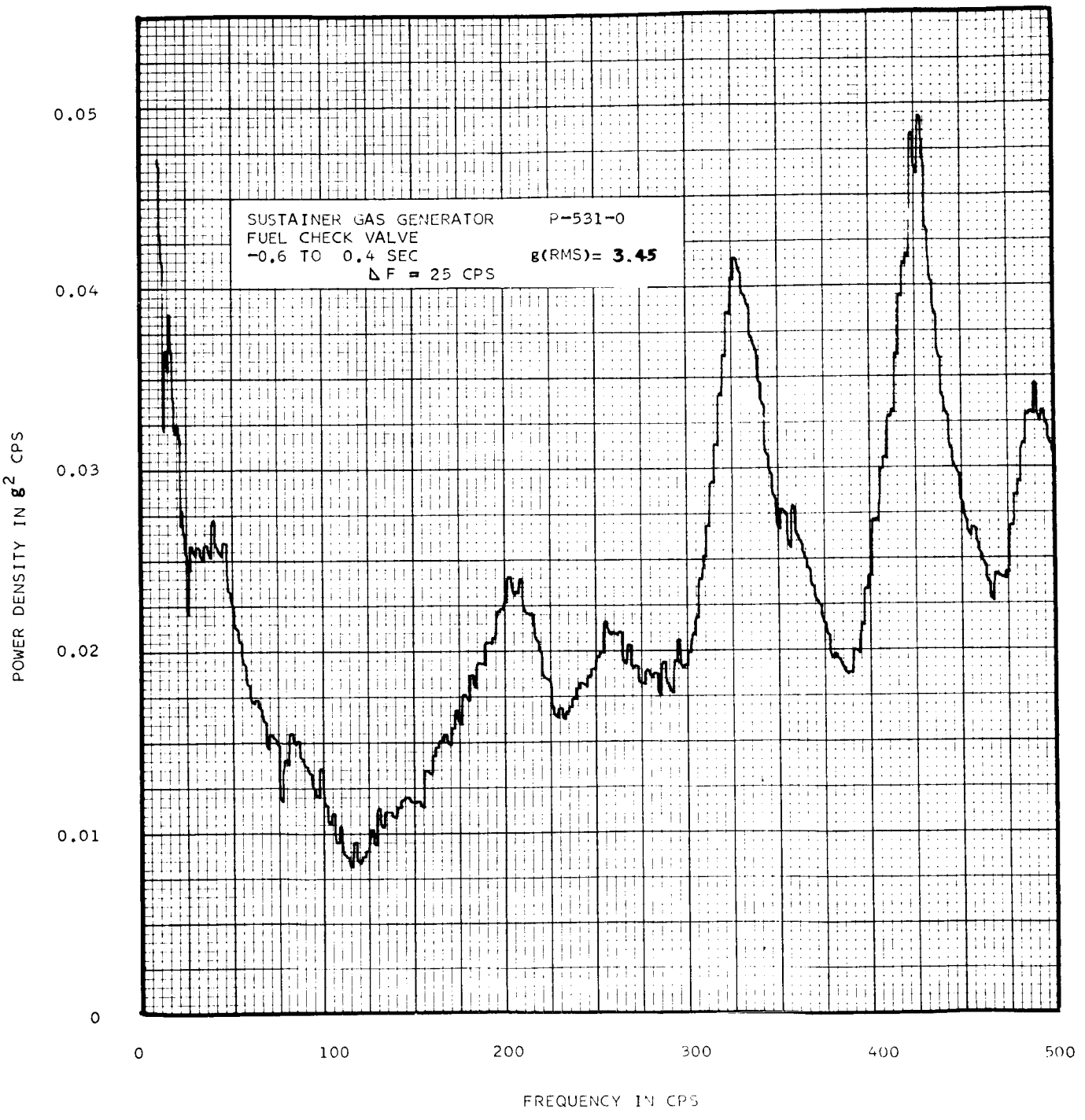

FUEL TANK PRESSURE REGULATOR A-788-0 BASE , TANGENTIAL
3.5 TO 4.4 SECONDS g(RMS) = 5.11
Δ F = 61 CPS
FUEL TANK PRESSURE REGULATOR, A - 789 - 0 RADIAL
4.6 TO 5.5 SECONDS g(RMS) = 2.85
Δ F = 61 CPS
FUEL TANK PRESSURE REGULATOR BASE A-788-0 TANGENTIAL
61.3 TO 62.2 SECONDS g(RMS) = 7.95
Δ F = 61 CPS
FUEL TANK PRESSURE REGULATOR , A - 789-0 RADIAL
62.4 TO 63.3 SECONDS g(RMS) = 3.74
Δ F = 61 CPS
POWER DENSITY IN g²/CPS
FREQUENCY IN CPS
0 200 400 600 800 1000 1200 1400 1600 1800 2000


FUEL TANK PRESSURE REGULATOR , A - 790 - 0
TANGENTIAL
5.7 TO 6.6 SECONDS
g(RMS) = 3.44
ΔF = 61 CPS
0.01
0.008
0.006
0.004
0.002
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000


FUEL TANK PRESSURE REGULATOR A-790-0
TANGENTIAL
63.5 TO 64.4 SECONDS
g(RMS) = 3.83
ΔF = 61 CPS
POWER DENSITY IN g²/CPS
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
FREQUENCY IN CPS

UNCLASSIFIED

MISSILE 35E



LOCATION OF HIGH FREQUENCY ACCELEROMETERS ON THE FUEL TANK PRESSURE REGULATOR

MISSILE 35E



SECTION 6.2.14

MISSILE 36E

FLIGHT TESTED 12-19-61

AT AMR COMPLEX 13

TEST REPORT AE61-1231

Engine Compartment Vibration Measurements

Three vibration measurements were made in the engine compartment during the flight of Missile 36E. The location of each was as follows:

A77A	Jettison Rail End, Radial, Quad II
A78A	Jettison Rail End, Tangential, Quad II
P531O	Sustainer Gas Gen. Fuel Line Check Valve, Z Axis

The jettison rail measurements were made to study rail motion during staging. The instrumentation system was set up to "switch in" the rail accelerometer outputs at booster engine cutoff. P531O measurement was made to determine the vibratory response of the check valve in support of the Missile 26E failure analysis. The above measurements were also obtained from the flights of Missiles 4F, 5F and 35E.

Generally, the quality of the data was satisfactory for analysis purposes and the resulting accelerometer outputs were similar to those obtained on previous flights. Vibratory response of the rail end, prior to the time the first slider separated from the rail, appeared moderate. As the first and second sliders separated from the rail, a "ringing" of the rail was evident. The ringing condition was completely damped by 1.0 seconds after jettison start time. The maximum vibratory load at the time the second slider separated was approximately 1500 lbs (tangential) which was well within the design allowable load for the rail. An apparent bias of the trace of A77A was observed following the time the first slider separated from the rail. A discussion of that condition is shown below.

P531O displayed moderate levels through most of powered flight. The outputs compared favorably with the levels obtained on Missile 35E. The accelerometer outputs appeared erratic through the booster jettison period. A discussion of the staging data is shown below.

Jettison Rail End Vibration

The jettison rail accelerometers were located as shown in Figures 13-17 and 13-24. A Statham Model TA12A accelerometer was utilized at each location. The pickup was flat to approximately 200 cps. The telemetry channels used had a nominal response of 25 and 35 cps. Generally, the analysis was made within a frequency band of 0 to 60 cps. Figure 13-9 shows the accelerometer outputs during staging, which were played back with the standard low pass filter for the existing telemetry channel. Prior to the time booster jettison commenced, the rail measurements exhibited levels between 1 and 2.5 g zero-to-peak with major frequency components between 40 and 60 cps. Prior to the time the first slider separated from the rail, A77A showed frequency components ranging between 40 and 60 cps at a maximum level of 4 g zero-to-peak. For that same period, A78A displayed a maximum level of 6 g zero-to-peak with major frequency components between 50 and 60 cps.

Measurement A77A, radial, exhibited an impulse type output following the time the first staging slide separated from the rail, approximately 0.37 second from jettison start. That output was evident on Missiles 5F and 36E. A maximum of 3 g peak was noted on Missile 36E data. The time duration of the bias was 0.11 seconds. The waveform shape implies that rail motion was initiated and not terminated, which would, generally, invalidate the output at that time. The accelerometer outputs before and after the impulse appeared valid. Additional work was done to investigate the output on A77A at that time. A double integration computation of the single peak output showed a representative displacement of approximately 3 inches in the direction of the sustainer engine. GD/A stress group computations show that a three inch displacement at the rail end, in the radial direction, would require a force of 37,000 lbs. The computed failure load for a force applied at the rail end was 10,000 lbs. (bending). An applied load as shown above would probably cause considerable damage to the fuel tank cone and jettison rail, which would be evident on other test measurements (fuel tank pressure, autopilot data, etc). These measurements did not support the existence of the load magnitude mentioned above. In addition, since the booster section loading at staging was predominately in the pitch plane, it follows that A78A should have exhibited a greater load than A77A at the time mentioned above, due to the fact that the rail contains less rigidity in the tangential direction than in the radial direction. The above condition was not evident in the test data. Computations of missile rigid body motion (integrating rate gyro data), during the period in question, showedan acceleration of the rail end in the radial direction (yaw left) of approximately 0.1g and 0.04g in tangential direction (pitch up).

Laboratory tests are now being conducted on the accelerometer system to determine the effects of high magnitude, high frequency excitation on the accelerometer when the unit is tied to a low response telemetry channel. An erroneous bias of the outputs resulting from an over limiting condition within the complete system may have prevailed at that time. This condition is presently the prime suspect for explaining the apparent erroneous bias condition on Measurement A77A.

The rail accelerometer outputs at the time the second slider separated from the rail appeared normal. Each measurement displayed a "ringing" condition at the time the load was released. The greater vibratory displacement was noted in the tangential direction, which was approximately 0. 13 inch/single amplitude. Table 1 shows a summary of the significant outputs on the rail vibration measurements during staging.

Following staging, the levels were comparable to the levels observed prior to booster jettison.

SUSTAINER GAS GENERATOR FUEL LINE CHECK VALVE VIBRATION

P531O was located as shown in Figures 13-21 and 13-24. A piezoelectric crystal type high frequency accelerometer was utilized for this measurement. The transducer was capable of providing frequency components between approximately 20 and 2000 cps. The telemetry channel utilized provided a normal response of 220 cps. No filter was employed between the accelerometer system and the telemetry package. The accelerometer outputs are shown in Figure 13-7. Power spectral computations performed on the measurement are shown in Figure 13-11. A summary of the spectrum analysis is shown in Table 2.

P531O accelerometer outputs during staging appeared erratic. At 0. 065 second following jettison start (unlatch), the trace showed initiation of one cycle of approximately a 3 cps frequency component. The maximum level was 21g zero-to-peak. The representative displacement was in excess of 1 foot, which represents failure condition and is unreasonable since propulsion system data did not reflect a failure condition at the sustainer engine. At 0. 350 second following booster section unlatch, the trace started for the upper intelligence band limit (114. 7g) and reached the limit at 0. 370 second. The subsequent response was typical for the instrumentation system in returning from a saturated condition. The trace appeared to stabilize by approximately 0. 6 second following the time of unlatch. Between 133. 8 seconds and 134. 0 seconds, the outputs displayed a steady oscillation at 37 cps that terminated at 134 seconds. The maximum level observed was 2. 0g zero-to-peak which reflects a single amplitude vibratory displacement of 0. 03 inch. Between 134. 05 and 134. 3 seconds, the trace showed response to a one and one-half cycle oscillation at a frequency of 7. 5 cps. The maximum amplitude was 8g zero-to-peak.

No explanation can be made, at this time, to substantiate the exact cause for the erratic accelerometer outputs during staging. The data within a frequency band of 0 to 15 cps is questionable, however, since the type of accelerometer system utilized is unreliable within that frequency band. Missiles 8F, 7F, 14F and 21F will incorporate a low frequency type accelerometer at the location of P531O to further study the check valve vibration during staging.

The outputs of P531O following staging appeared normal.

TABLE 1

JETTISON RAIL VIBRATION

SIGNIFICANT OUTPUTS DURING STAGING

MISSILE	OUTPUT FOLLOWING FIRST SLIDER SEPR (0.34 to 0.37 seconds)		OUTPUT FOLLOWING SECOND SLIDER SEPR (0.43 to 0.45 seconds)	
	A77A	A78A	A77A	A78A
4F	Data out of band	6g(o-p)Max. at 45 cps	Data out of band	15g(o-p)Max. at 55 cps
5F	Apparent single peak bias for 0.1 second. Approximately 2.5g peak	13g(o-p)Max. at 53 cps	6g(o-p)Max. at 70 cps	21g(o-p) at 40 cps
36E	Apparent single peak bias for 0.11 second. Max. at 3.0g high frequency output superimposed on bias difficult to interpret	5g(o-p)Max. at 14 cps 9g(o-p)Max. at 54 cps	16g(o-p)Max. at 62 cps	19g(o-p) at 38 cps

NOTE: Data taken from playback of outputs using 60 cps low pass filter - nominal T/M channel response was 25 to 35 cps.

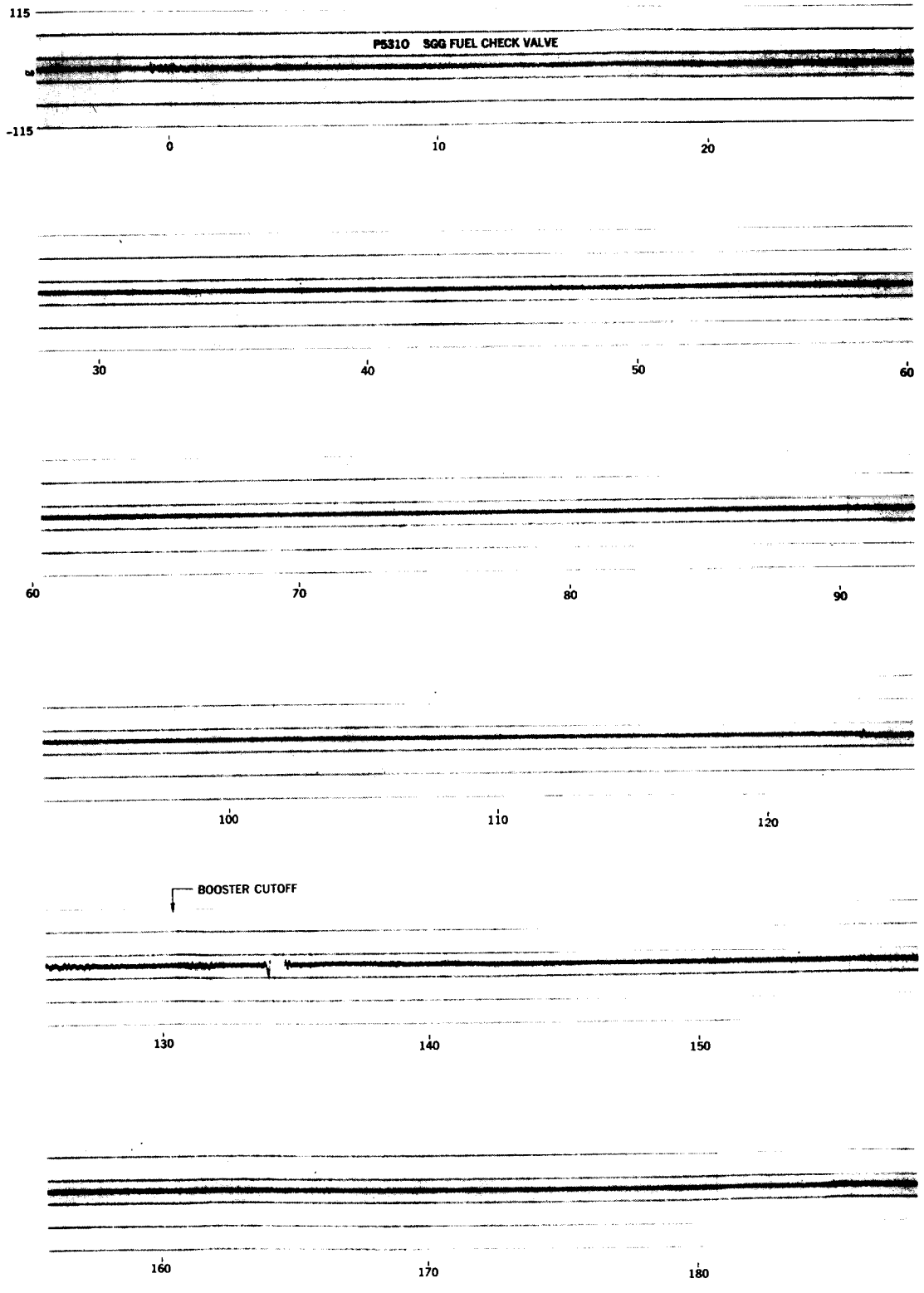
TABLE 2

SUMMARY OF SPECTRUM ANALYSIS ON MEASUREMENT P5310

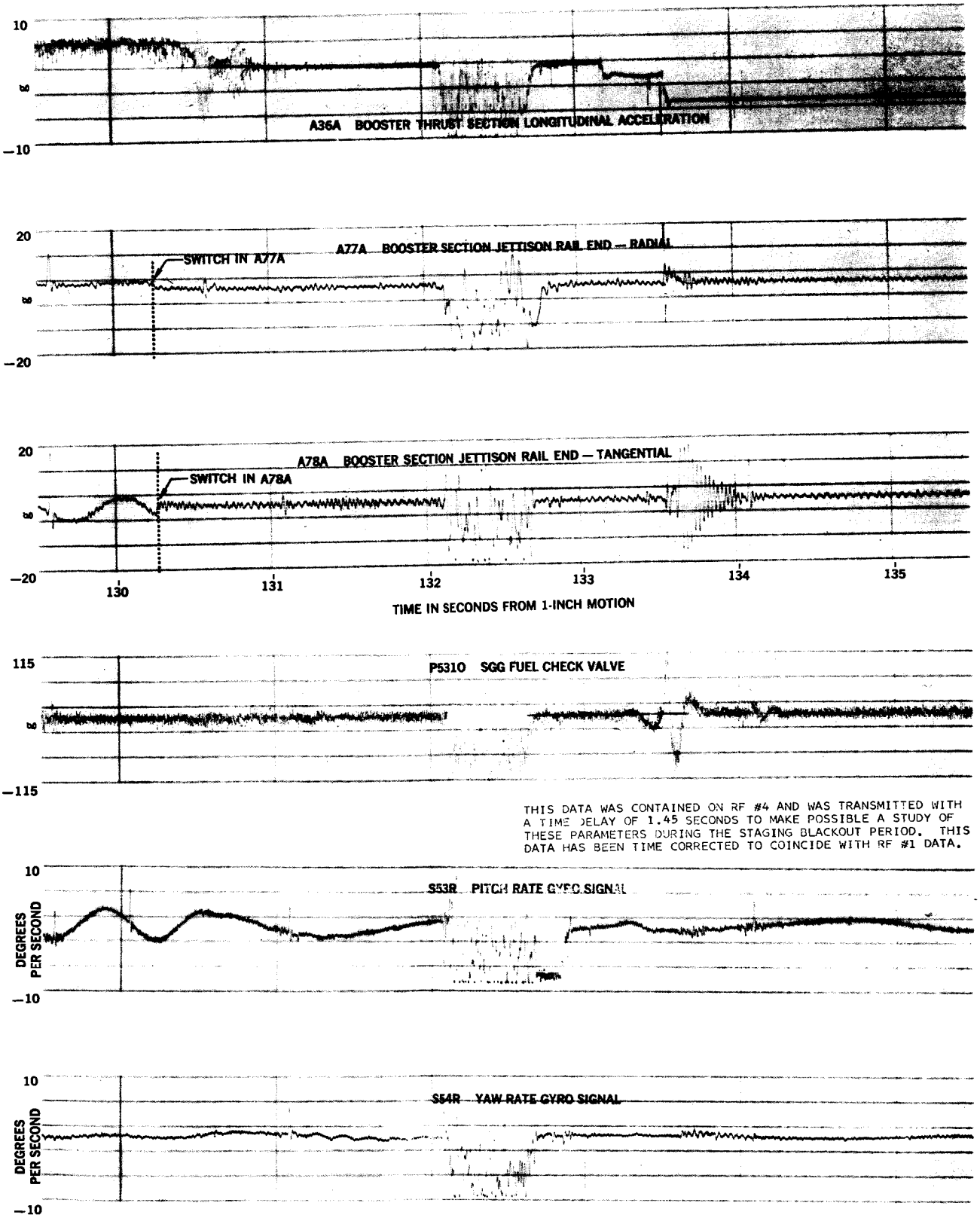
SUSTAINER GAS GENERATOR FUEL CHECK VALVE VIBRATION

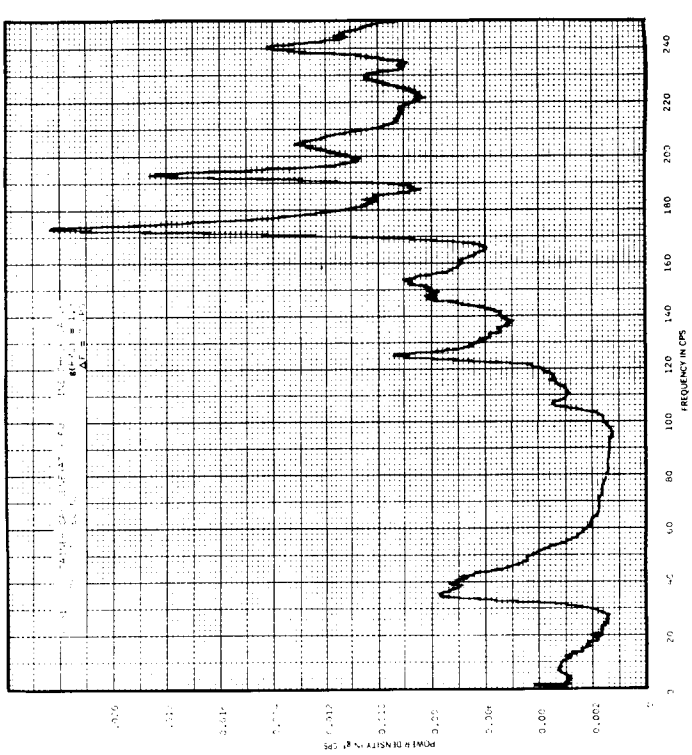
Flight Period sec.	Freq. Band Anal. cps	Accel. over-all g (rms)	Freq. Band Of Major Energy cps	First Predominant Frequency cps		Second Predominant Frequency cps	
-0.65 to 1.0	25-500	5.7	300 - 500	420	0.075	320	0.047
-0.65 to 1.0	7-250	3.3	-	6	0.370	-	-
53 to 57	25-500	5.6	250 - 500	405	0.155	270	0.092
53 to 57	7-250	1.33	-	40	0.027	193	0.018
75 to 79	25-500	4.00	150 - 500	515	0.090	180	0.045
75 to 79	7-250	1.3	120 - 250	173	0.022	193	0.019
260 to 264	25-500	1.5	120 - 500	430	0.009	-	-
260 to 264	7-250	0.75	-	32	0.007	123	0.005

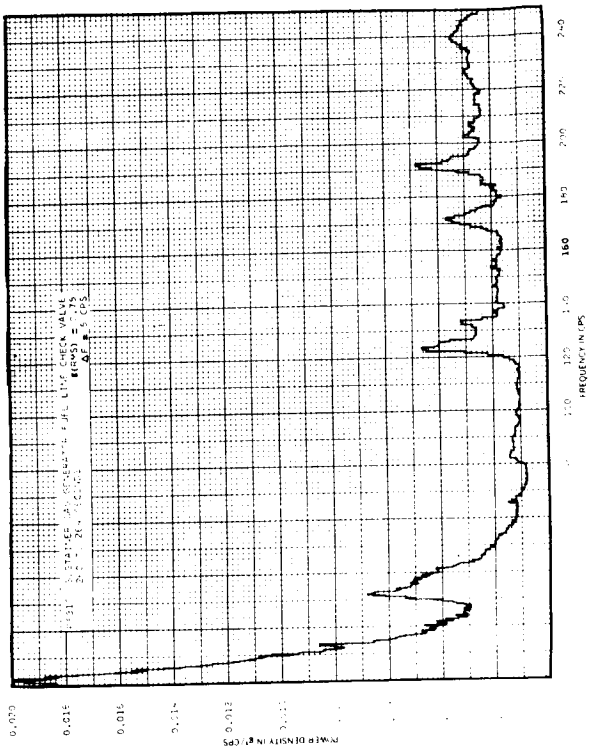
GD/A-DDE65-016
UNCLASSIFIED
AIRFRAME
~~PAGE NO. 12-7~~
~~REPORT NO. AE61-1231~~
MISSILE 36E

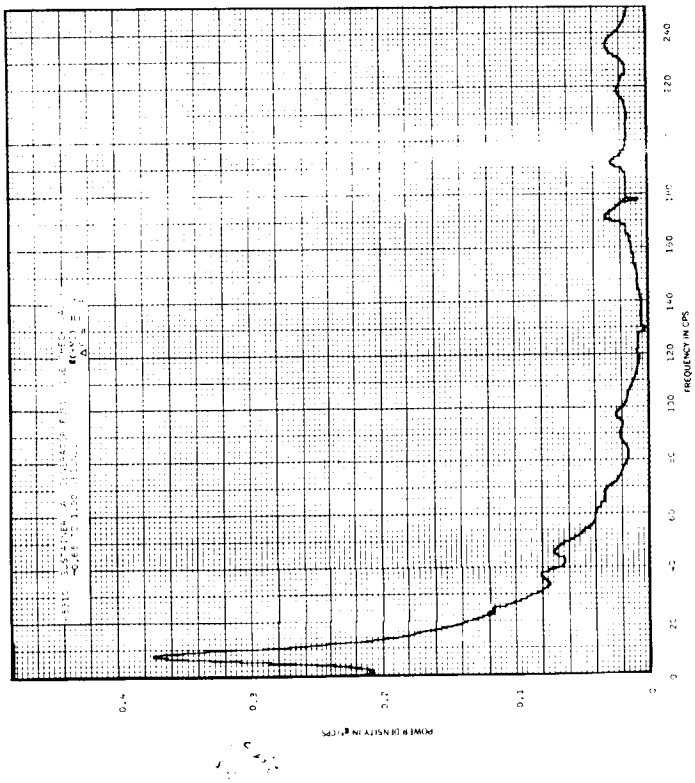


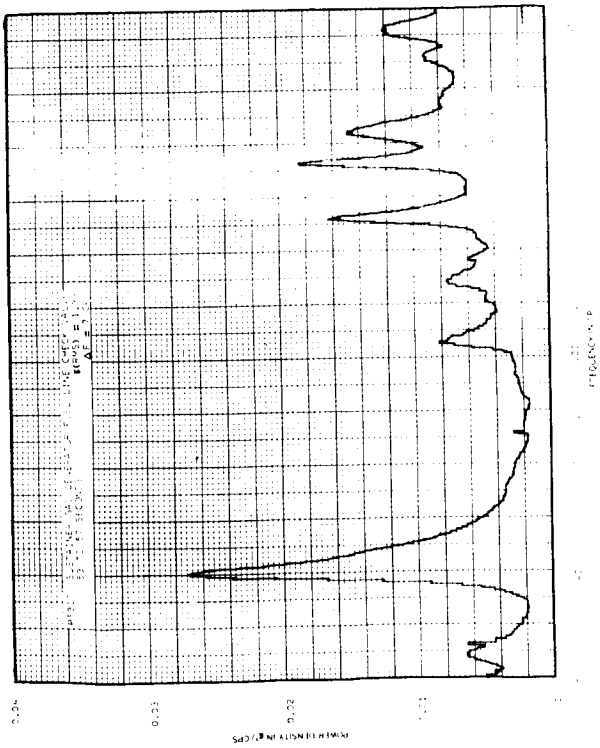
TIME IN SECONDS FROM 1-INCH MOTION


10
0
−10
A36A BOOSTER THRUST SECTION LONGITUDINAL ACCELERATION
20
0
−20
SWITCH IN A77A
A77A BOOSTER SECTION JETTISON RAIL END — RADIAL
20
0
−20
SWITCH IN A78A
A78A BOOSTER SECTION JETTISON RAIL END — TANGENTIAL
130
131
132
133
134
135
TIME IN SECONDS FROM 1-INCH MOTION
115
0
−115
P5310 SGG FUEL CHECK VALVE
THIS DATA WAS CONTAINED ON RF #4 AND WAS TRANSMITTED WITH A TIME DELAY OF 1.45 SECONDS TO MAKE POSSIBLE A STUDY OF THESE PARAMETERS DURING THE STAGING BLACKOUT PERIOD. THIS DATA HAS BEEN TIME CORRECTED TO COINCIDE WITH RF #1 DATA.
10
DEGREES PER SECOND
−10
S53R PITCH RATE GYRO SIGNAL
10
DEGREES PER SECOND
−10
S54R YAW RATE GYRO SIGNAL









SECTION 6.2.15

MISSILE 65E

FLIGHT TESTED 4-24-63

AT OSTF NO. 1

TEST REPORT GD/A63-0107

SECTION 11

LAUNCH ACOUSTIC AND VIBRATION ANALYSES

Six Acoustic Measurements were made in and around the missile at launch. The general location of the microphones are shown schematically in Figure 11-1. The specific locations of all microphones are shown in Figures 11-32 through 11-36. The measurement numbers and locations were as follow:

Meas. No.	Location
A1550Y	AIG Computer Dummy Constants Board
A1780Y	AIG Computer Dummy Constants Board (via 100-foot trailing wire umbilical)
N7223Y	Boom Microphone, B1 Side
N7534Y	Coffin Microphone A
N7535Y	Coffin Microphone B
P1051Y	Thrust Section Microphone

The AIG pod was modified by the addition of interior fiberglass lining material (ECP 8409) and a production muffler on the air intake to the Arma computer (ECP 8411). The pod lining configuration consisted of lining the inside section of the Atlas pod in all areas adjacent to the Arma computer with 2-inch thick fiberglass. The section lined included the upper bulkhead, the access cover hatch, both sides , and pod floor down to the "rib" that separates the computer section from the guidance platform section.

This is the first flight missile with the above mentioned pod fix in an attempt to establish an operational pod acoustic configuration.

INSTRUMENTATION

The acoustic transducers utilized were (Model NM 125) high intensity microphones manufactured by Chesapeake Instrument Corporation. The high intensity microphones are self-generating piezoelectric ceramic acoustic sensors especially designed for measuring high noise levels under adverse environmental conditions. The base of the microphone holder had a vibration mount which isolated the sensor from lower frequency vibrations.

TEST RESULTS

Four of the six measurements provided satisfactory data Measurement A1550Y provided questionable data levels in the higher frequency range; and Coffin Microphone A (N7534Y) provided valid data only until 0.09 second; at which time, the microdot cable failed. Coffin Microphone-B (N7535Y) outputs were valid until 1.12 second; the pole microphone (N7223Y) data became questionable at approximately 1.95 seconds. All of the aforementioned times are referred to 1-inch motion. The vertical rise of the missile at these times was such that the thrust chamber cone was adjacent to or just beyond the respective microphone location. Satisfactory data was obtained from the microphone inside the Arma computer (A1780Y) and the thrust section microphone (P1051Y).

Octave band time history plots of the sound pressure levels (SPL) are shown in Figures 11-6 through 11-17 inclusive. The general characteristics of Missile 65E coffin acoustic intensities at launch were similar to Missiles 66E, 67E, and 64E coffin acoustic data. A comparison of SPL from flight test missiles 67E, 64E, and 65E is shown in Figures 11-2 and 11-3. SPL outside the pod to inside the computer reduction calculations are shown in Figure 11-4.

The computer constants board measurement (A1780Y) was recorded on an extended landline trailing wire (100 feet) to increase data acquisition time for determination of SPL after the normal 40-foot umbilical eject time. Past tests have shown the SPL was increasing at umbilical eject (approximately 2.2 seconds). Data from Missile 65E (Figure 11-13) shows that, as expected, the SPL reaches a peak at approximately 2.2 to 2.3 seconds in the last four octaves and then gradually decreases until the trailing wire ejects.

The outside-the-pod to inside-the-computer SPL reduction of 65E was significantly greater than that obtained on Missile 64E, which utilized only 1-inch thick half-blanket and no muffler. Sound pressure reduction in the higher octaves ranged from 36.5 db in the 600 to 1200-cps octave to 44 db in the 4800 to 9600-cps octave on Missile 65E. (Missile 64E had a maximum SPL reduction of 9 db.) Approximately the same reduction factors were obtained on static tests of Missile 75F (Runs 608 and 609) with the same pod configuration as that of Missile 65E. The actual sound pressure levels, obtained at the computer, were within the established No Failure specifications of the Arma computer (V1Z, 124 db maximum for 600 to 1200 cps and 99 db maximum for 4800 to 9600 cps).

Harmonic analysis, between 20 and 10,000 cps (ΔF = 200 cps), of all the valid microphone outputs on 65E (Figures 11-18 through 11-21), did not exhibit any significant discrete frequency components.

AIG GUIDANCE COMPUTER VIBRATION

Guidance computer vibration was monitored from three high frequency piezoelectric accelerometers mounted on the computer mount as shown in Figure 11-37. The transducers were sensitive in the X-X, Y-Y, and Z-Z axes with a frequency response flat to approximately 4,000 cps and a range of ±20 g. Measurement A1574O (Z-Z axis) data was termed invalid throughout data acquisition.

A shock transient was recorded at approximately minus 0.96 second on both the valid computer mount accelerometer outputs. The maximum transient level noted was 7.4 g(rms) and 6.2 g(rms) on the X-X and Y-Y axes, respectively. Following the shock condition, levels decreased to between 1.3 and 1.5 g(rms). At 0.1 second, a transient, lasting for between 0.16 and 0.21 second, was observed on both measurements. Peak magnitude of the response transient was between 2.3 and 2.6 g(rms). The general trend of the mount accelerometer outputs showed a moderately steep rise rate until umbilical disconnect at 2.2 seconds. Maximum mainstage g(rms) levels were 3.6 (A1576O) and 3.8 (A1575O). Spectral analysis (0 to 10,000 cps) revealed that the major energy in both axes of sensitivity was between 20 and 2000 cps.

Power spectrum data for zero to 250 cps (ΔF = 5 cps) and zero to 2000 cps (ΔF = 100 cps) analyses are presented in Figure 11-22 and 11-23 and summarized in Table 11-1.

TABLE 11-1. AIG COMPUTER MOUNT VIBRATION

MEAS. NO.	TIME SAMPLE IN SECONDS	PRD. FREQ. COMPONENTS	g(RMS)
	0-2000 cps Analysis		
A1576O	1 to 2	775	0.436
		660	0.400
		690	0.381
		480	0.316
A1575O	1 to 2	780	0.400
		750	0.352
		630-665	0.346
		390	0.284
		1050	0.282

TABLE 11-1. AIG COMPUTER MOUNT VIBRATION (Continued)

MEAS. NO.	TIME SAMPLE IN SECONDS	PRD. FREQ. COMPONENTS	g(RMS)
		0-250 cps Analysis	
A1576O	1 to 2	32	0.166
		196-198	0.166
		223	0.108
		60	0.105
A1575O	1 to 2	32	0.328

THRUST SECTION VIBRATION

Seven accelerometers were installed in the thrust section area to determine the environment during thrust rise and liftoff. Data were obtained through the use of a 40-foot trailing wire umbilical which permitted acquisition until the umbilical was ejected at 2.26 seconds. Six measurements provided valid data. The following discussion summarizes the data presented as over-all time history and spectrum analysis plots in Figures 11-24 through 11-31. Photographs of accelerometer installations appear in Figures 11-38 through 11-40. Oscillographs are presented in Figure 11-5.

The accelerometer on the sustainer gas generator fuel check valve (P1531O) indicated an initial transient response of 56 g(P-P), 1600 cps at minus 0.96 second. This transient damped out within 0.01 second. The vibration level then increased to 10 g(rms) at minus 0.1 second. At minus 0.1, the vibration level started to decrease and reached a low of 4.7 g(rms) at +0.1 second. Following this drop in rms acceleration level, the energy increased to 11.5 g(rms) at +0.4 second. The vibrational energy remained at this level of 11.5 g until umbilical disconnect.

The sustainer gas generator check valve tube acceleration was monitored by measurement P1533O. Initial response occurred at minus 0.96 second and indicated a transient which reached 175 g(P-P) at approximately 1200 cps. The transient damped out in 0.01 second after which the vibration level increased to a level of 23 g(rms) at minus 0.2 second. At minus 0.2 seconds, the vibration level started to decrease and reached a minimum of 8 g (rms) at +0.1 second. The level then increased to and remained at 20 g(rms) until umbilical eject.

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Measurement P1451O (Sustainer Hydraulic Return Line, Quad III) did not reflect a transient burst of energy. Response started at minus 0.94 second and indicated a steady rise to 8.5 g (rms) by minus 0.1 second.

During the period minus 0.1 to +0.1, the vibration level dipped to 7.5 g(rms). The energy then built up to a maximum of 15.5 g(rms) at +1.6 seconds and then started to decrease and stabilized at 11.7 g(rms) at +1 second for the remainder of data aquisition time.

An accelerometer was installed on the heat shield between Quads I and II near the riseoff disconnect panel (A1588O). The first response of this accelerometer was noted at minus 0.83 second. Maximum energy measured was 34.5 g(rms). Time history data are displayed in Figure 11-31.

Vibration of the lox tank regulator was monitored by Measurement F1185O. This measurement showed a steady increase in vibrational energy starting at minus 0.825 second and reaching a maximum of 28.5 g(rms) between +0.5 and +1.0 second. Time history data are presented in Figure 11-30.

The helium line riseoff disconnect panel was instrumented to determine acceleration in the Z-axis by Measurement F1651O. Initial response occurred at minus 0.93 second. The energy level varied throughout the run, reaching a maximum of 24 g(rms) as shown in Figure 11-30.

Data from the B1 engine lox dome accelerometer, P1208O, was invalid.

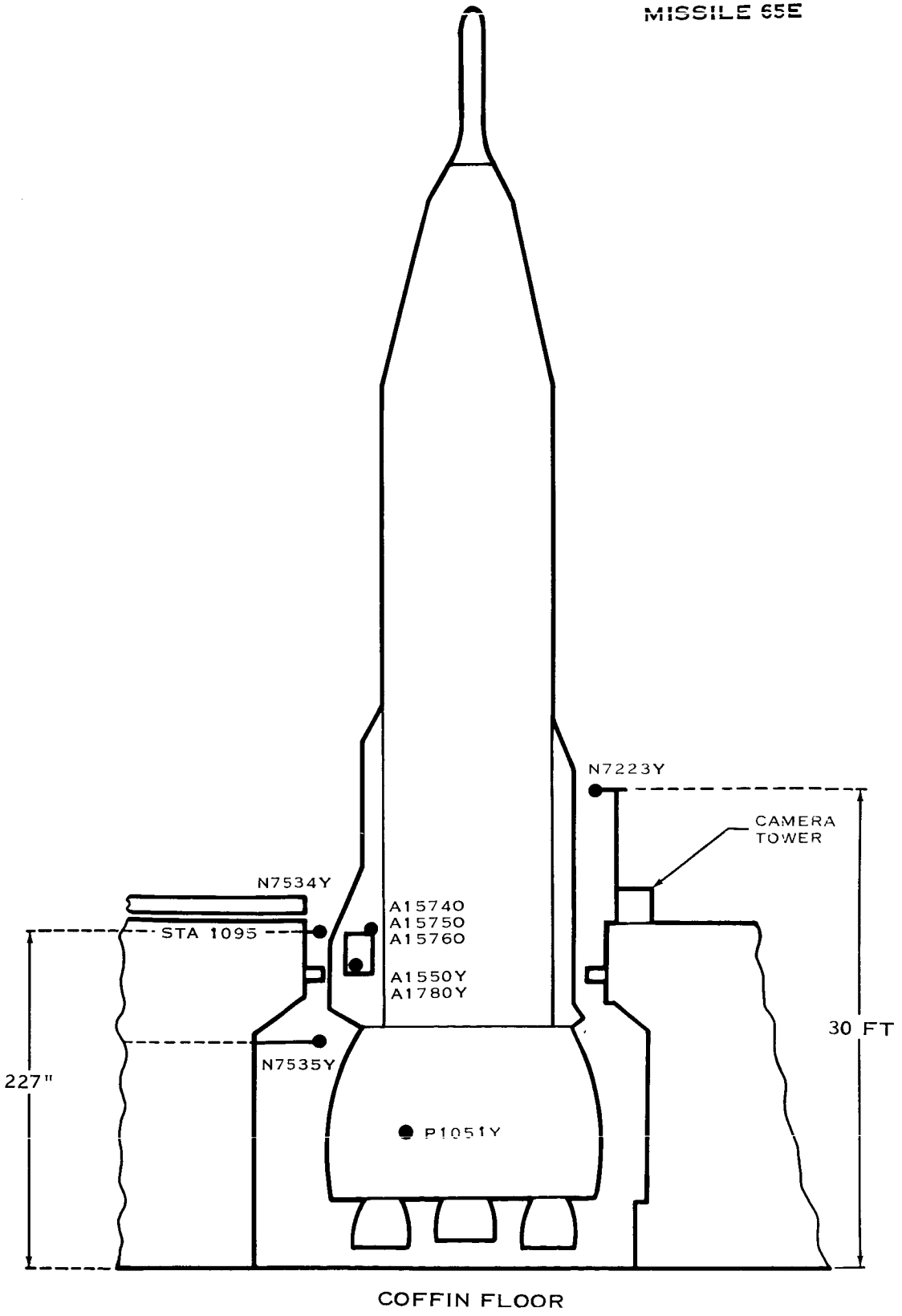
Predominant frequencies indicated by spectrum analysis were obtained from Figures 11-24 through 11-28 and are tabulated below for the time intervals minus 1 to zero second and +1 to +2 seconds. This same table shows maximum energy levels determined from time history data.

Meas. No.		Max. Energy Level g(rms)	TIME INTERVAL: -1 To 0 Second Predominant Frequency (cps) 1st	2nd	3rd	+1 To +2 Seconds Predominant Frequency (cps) 1st	2nd	3rd
P1531O	SGG Fuel Check Valve	11.5	1030	490	1160	660	1350	--
P1533O	SGG Check Valve Tube	23	1150	1020	1520	460	1330	--
P1451O	Sustainer Hydraulic Return Line, Quad III	15.5	1490	1120	1000	1000	1520	650
A1588O	Heat Shield, Quad I/II	34.5	Not presented			650	840	1120
F1185O	Lox Tank Regulator	28.5	Not presented			1290	--	--
F1651O	Helium Line Rod Panel Z-Axis	24	Not presented			240	490	--

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INSTRUMENTATION LOCATIONS

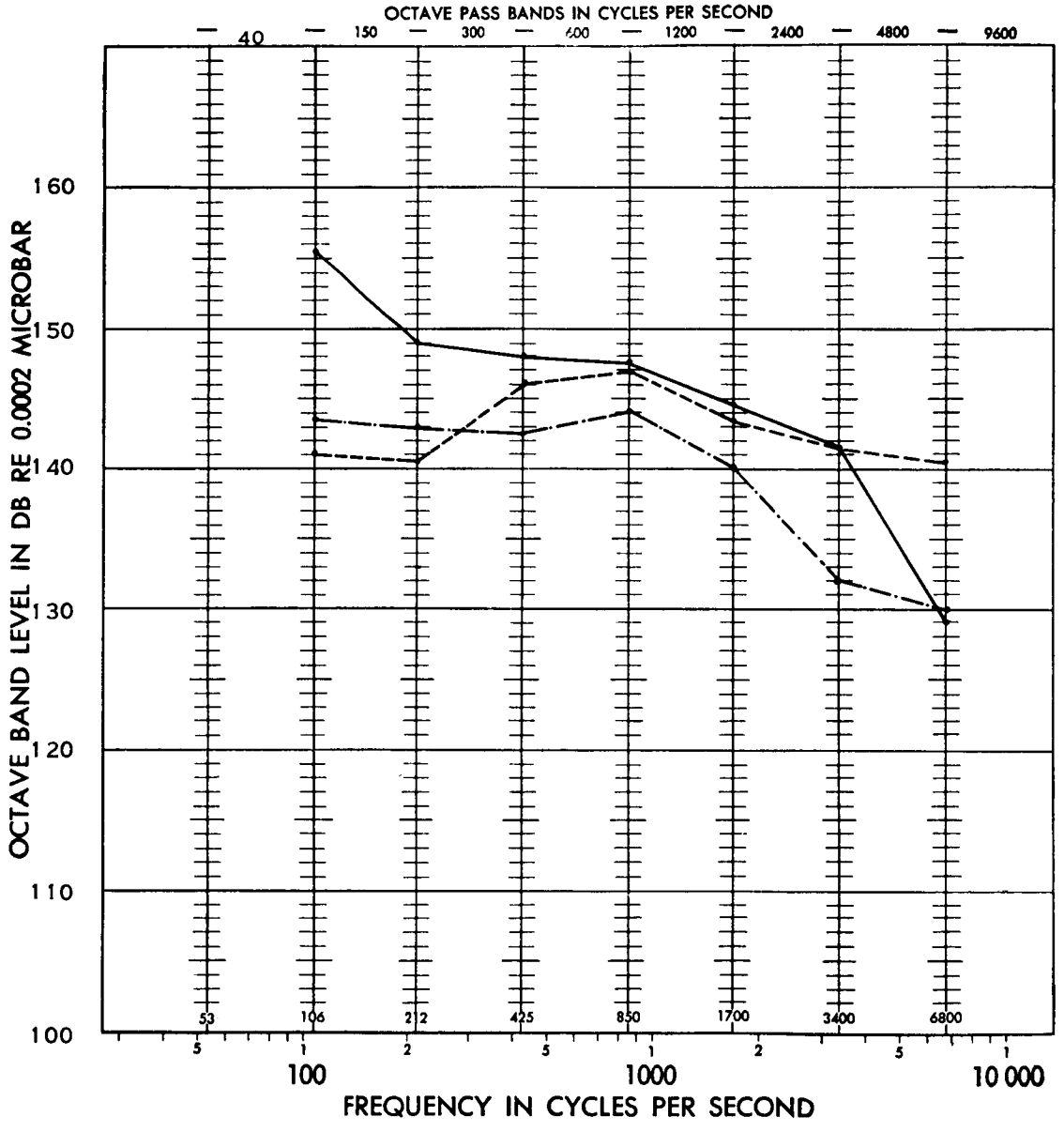
MISSILE 65E



UNCLASSIFIED

EXTERIOR SOUND PRESSURE LEVELS

MISSILE 65E



LEGEND:

------ MISSILE 65E MEASUREMENT NO. N7223Y

—·—·— MISSILE 64E MEASUREMENT NO. N7534Y

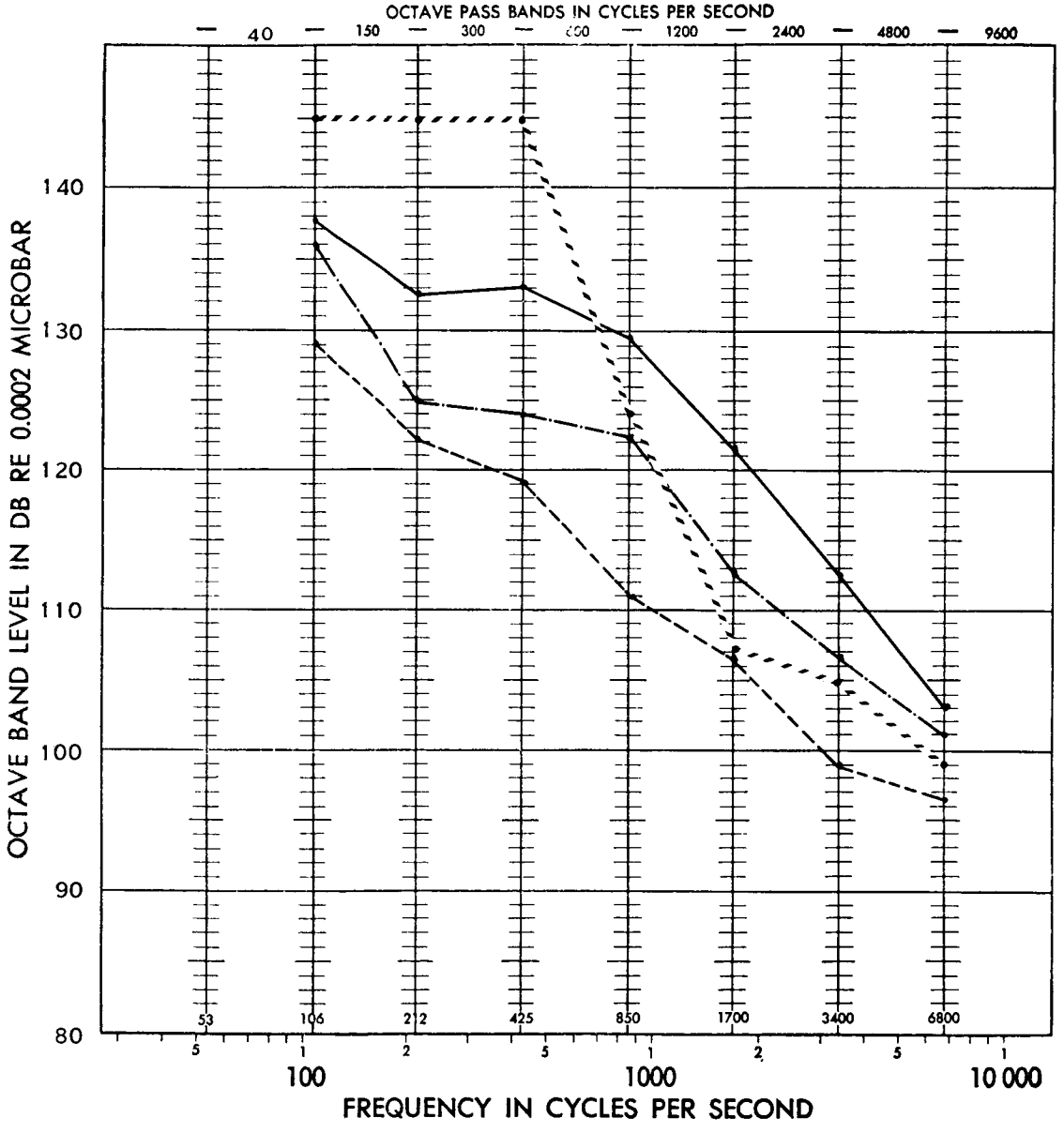
——— MISSILE 67E MEASUREMENT NO. N7534Y

65E

UNCLASSIFIED

ARMA COMPUTER SOUND PRESSURE LEVELS

MISSILE 65E



LEGEND:

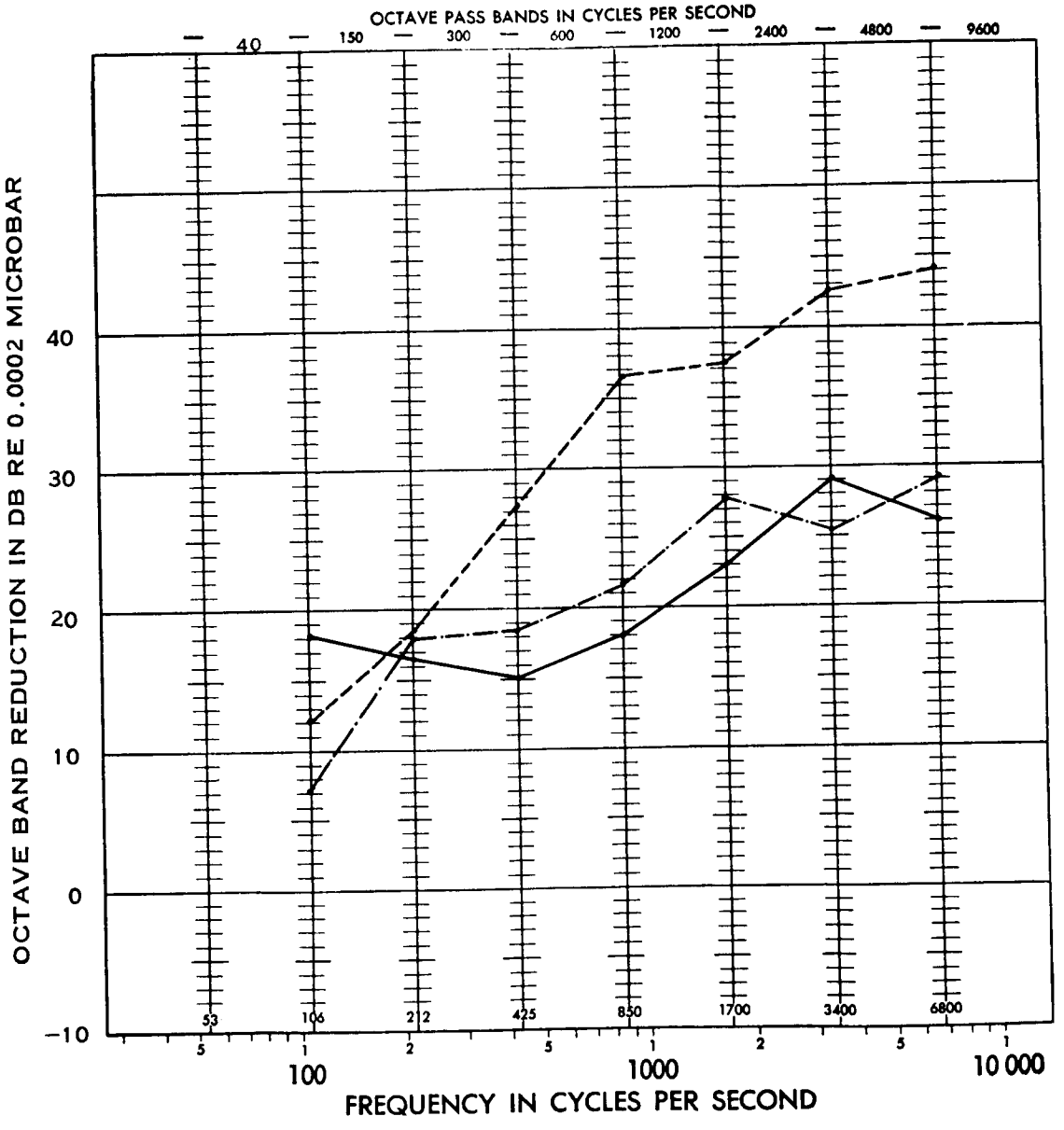
------ MISSILE 65E MEASUREMENT NO. A1780Y (2" HALF-BLANKET - MUFFLER)

—·—·— MISSILE 64E MEASUREMENT NO. A1780Y (1" HALF-BLANKET)

——— MISSILE 67E MEASUREMENT NO. A1780Y

- - - - - - ARMA SOUND PRESSURE LEVEL 1

SOUND LEVEL REDUCTION BY OCTAVES



LEGEND:

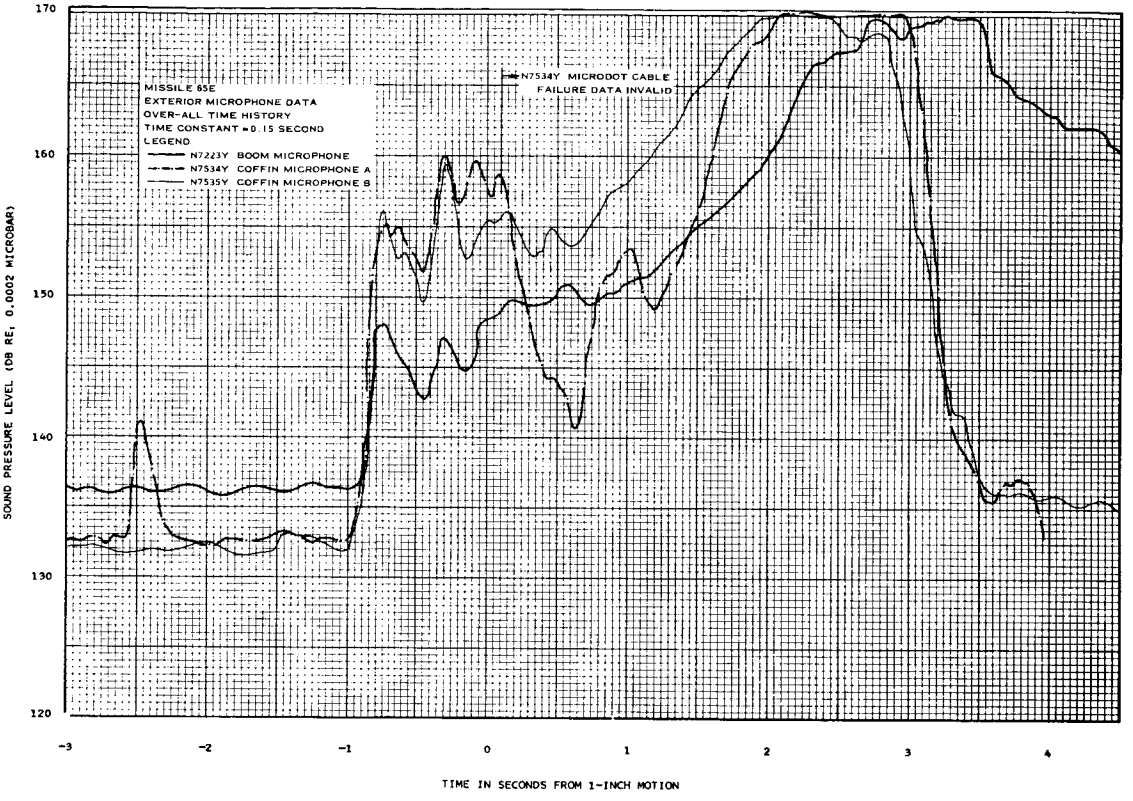
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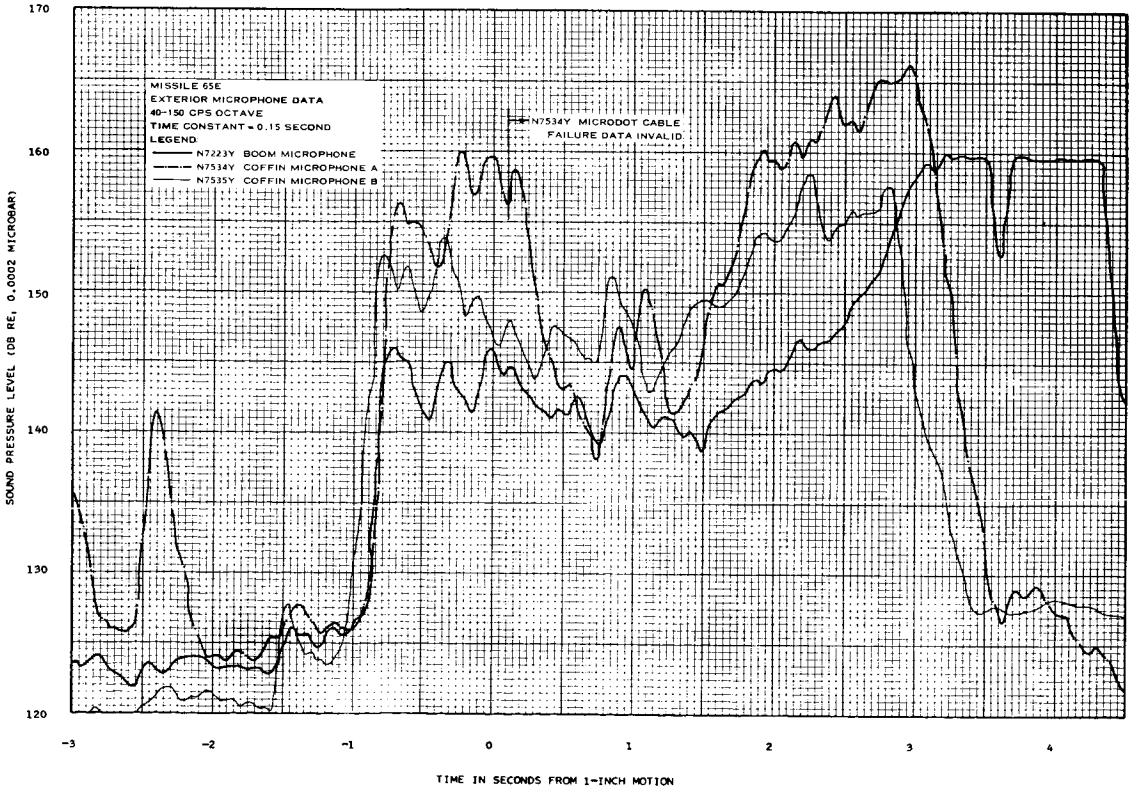
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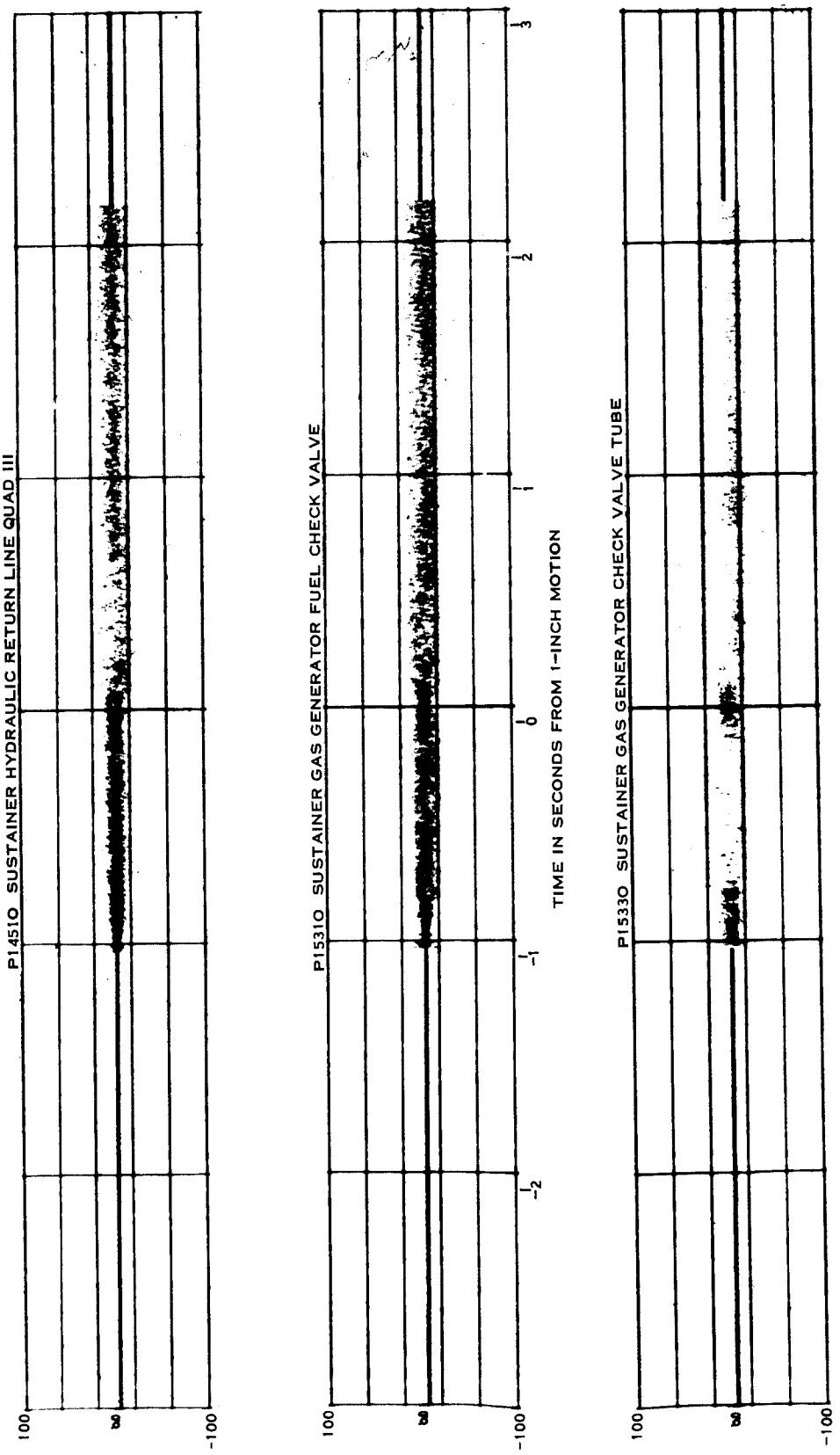
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ACOUSTIC AND VIBRATION
FIGURE NO. 11-6
~~REPORT NO. GD/A63-0107~~

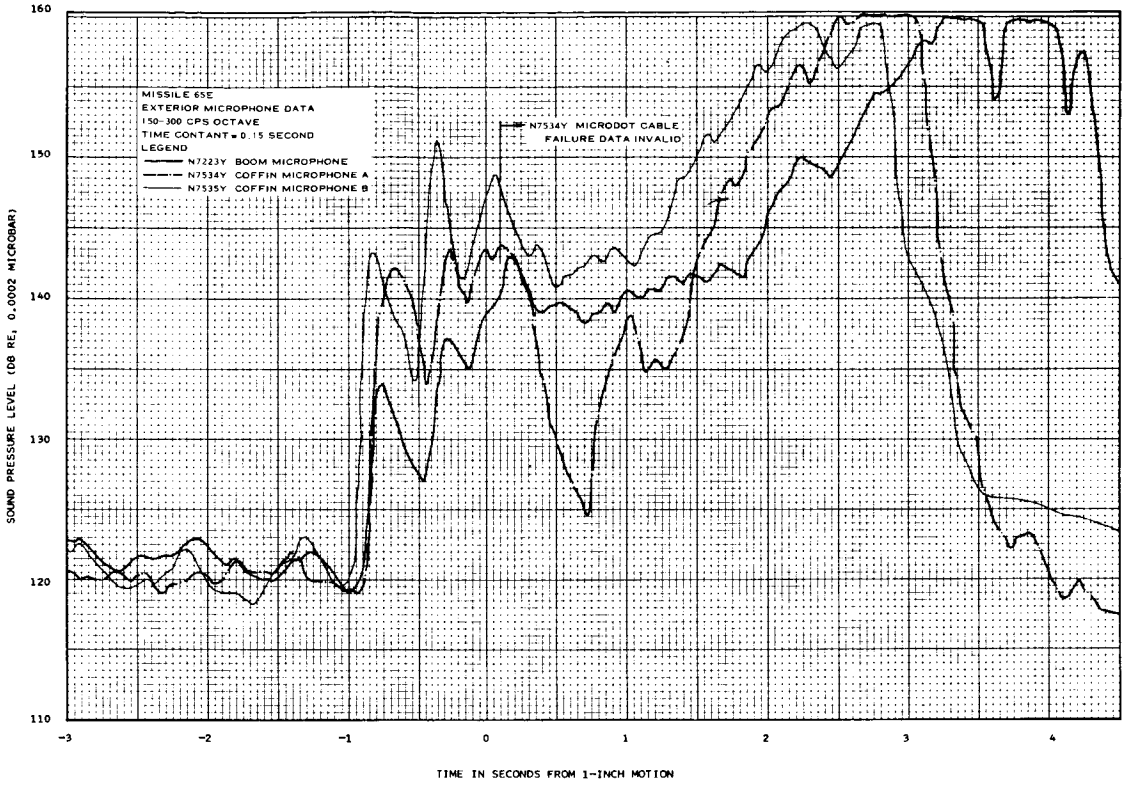
MISSILE 65E

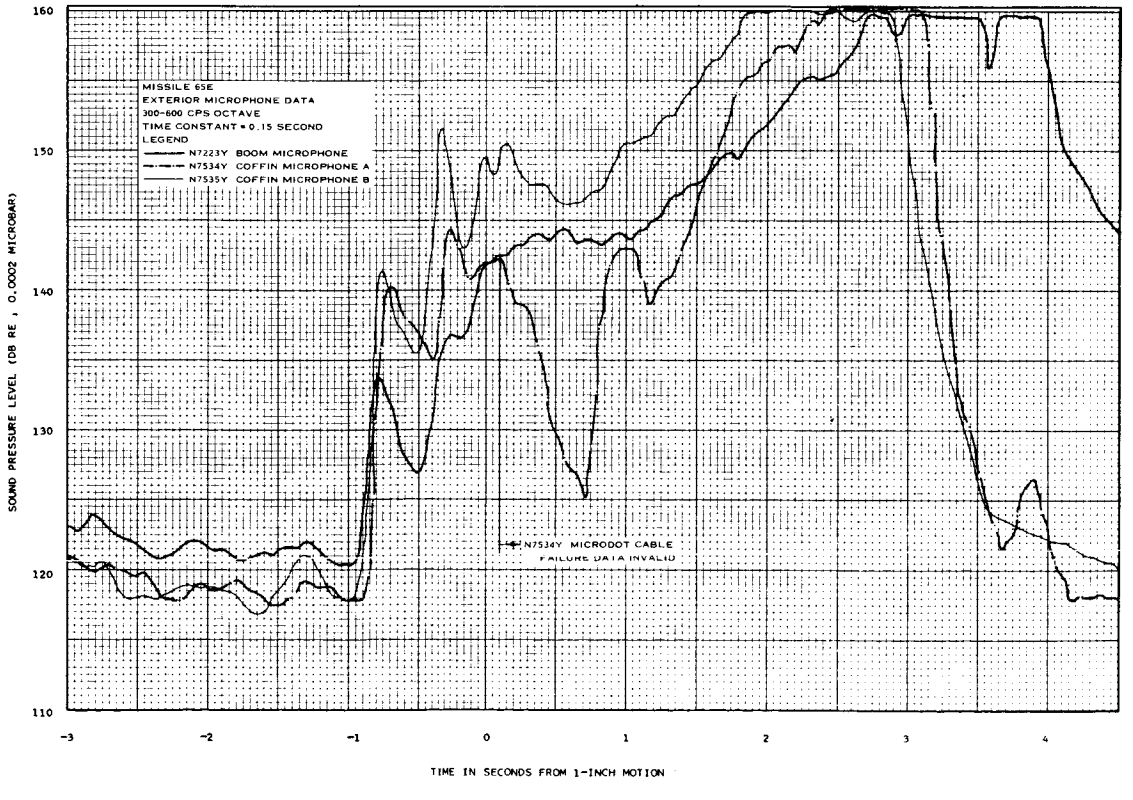




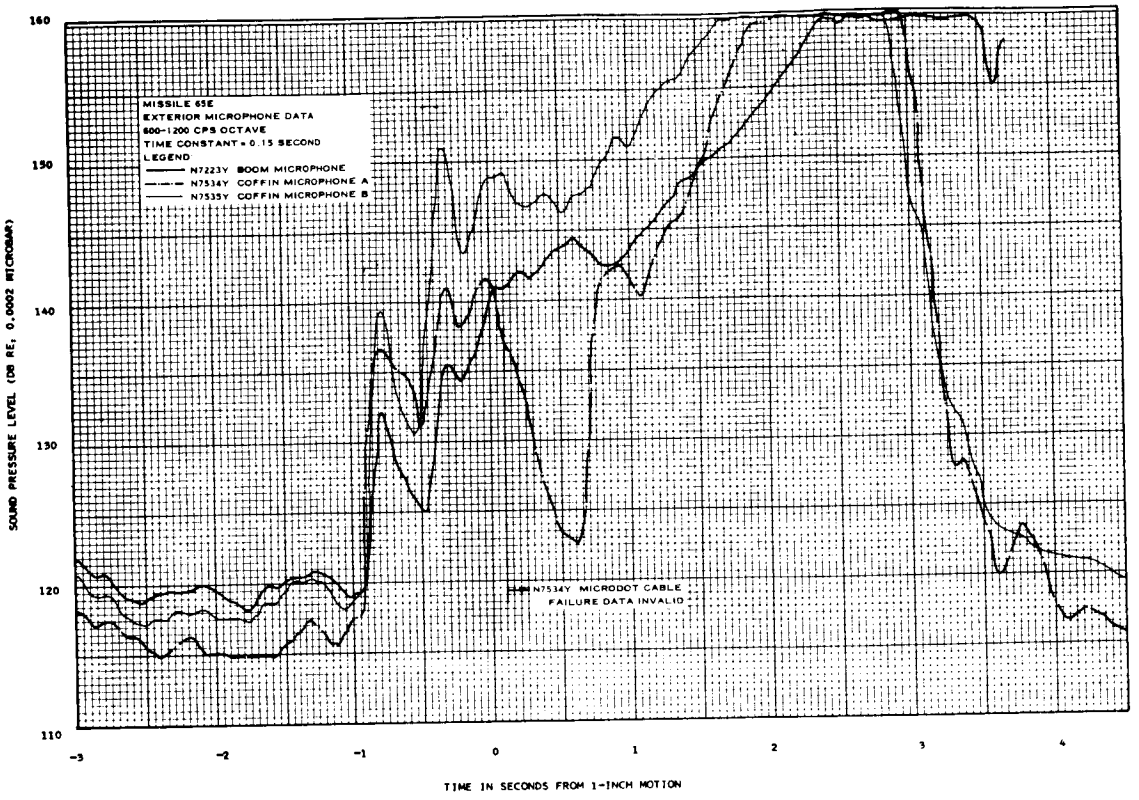

P14510 SUSTAINER HYDRAULIC RETURN LINE QUAD III
100
-100
P15310 SUSTAINER GAS GENERATOR FUEL CHECK VALVE
100
-100
3
2
1
0
-1
-2
TIME IN SECONDS FROM 1-INCH MOTION
P15330 SUSTAINER GAS GENERATOR CHECK VALVE TUBE
100
-100

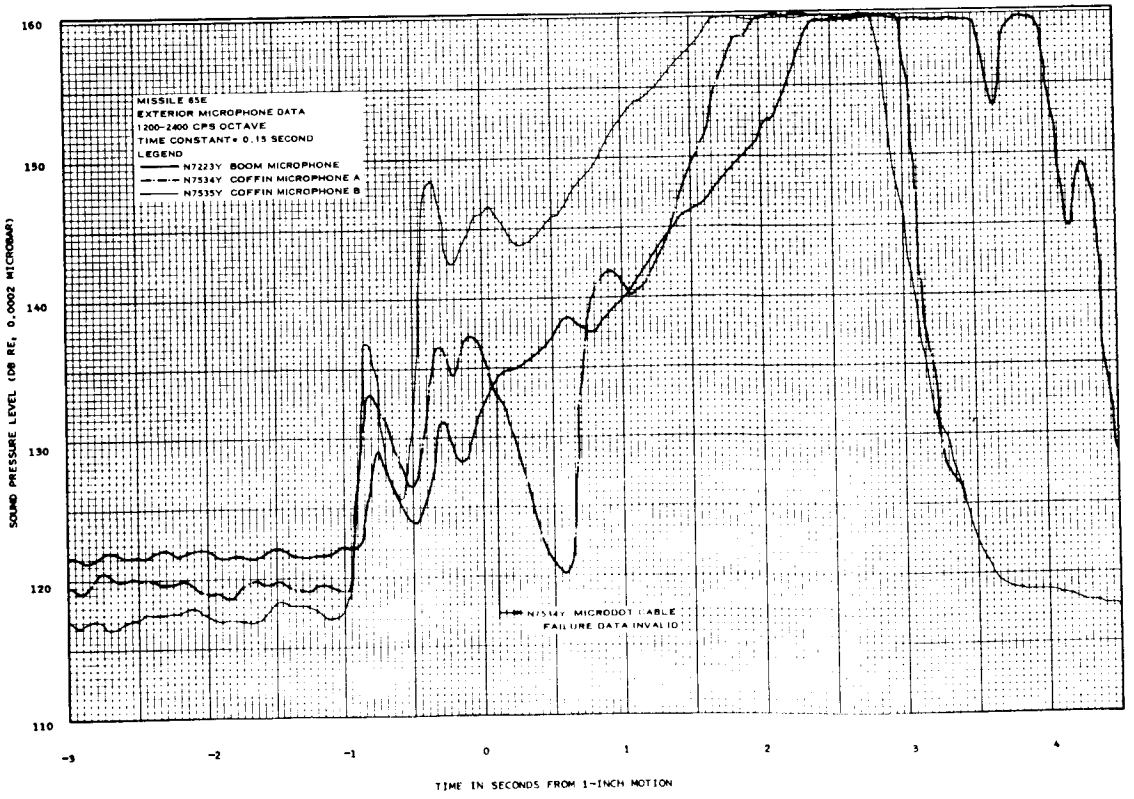
UNCLASSIFIED

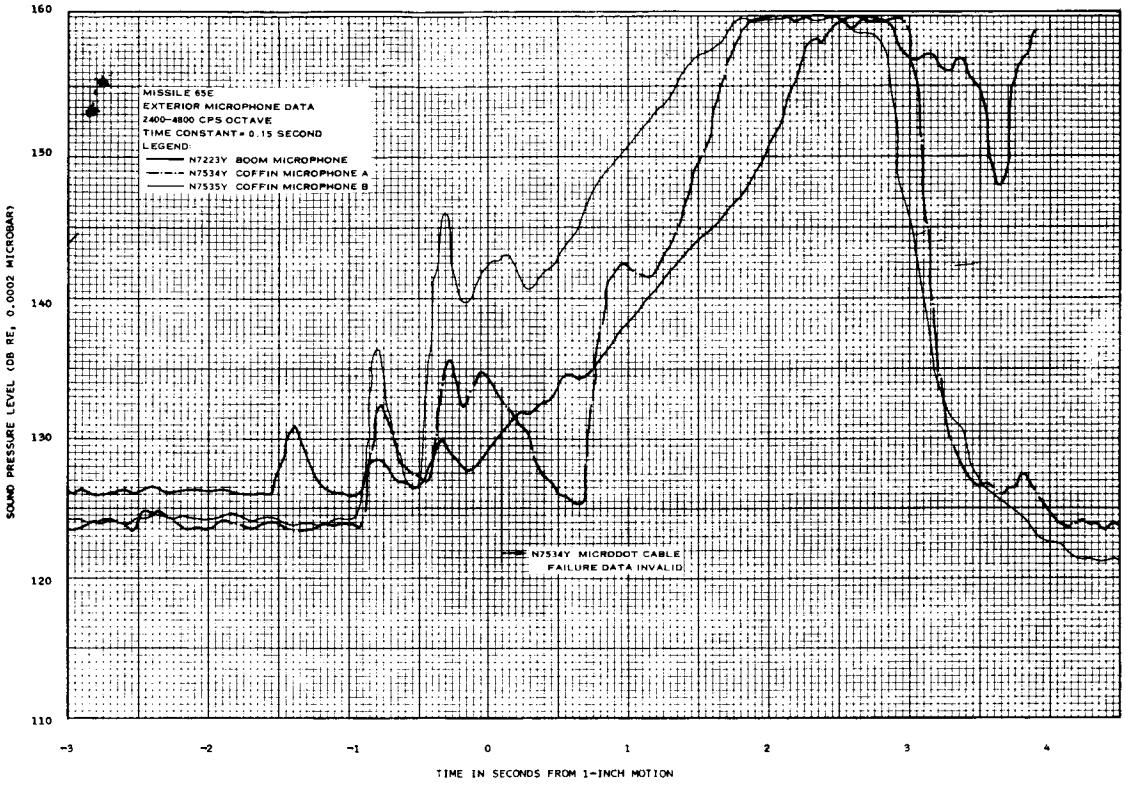


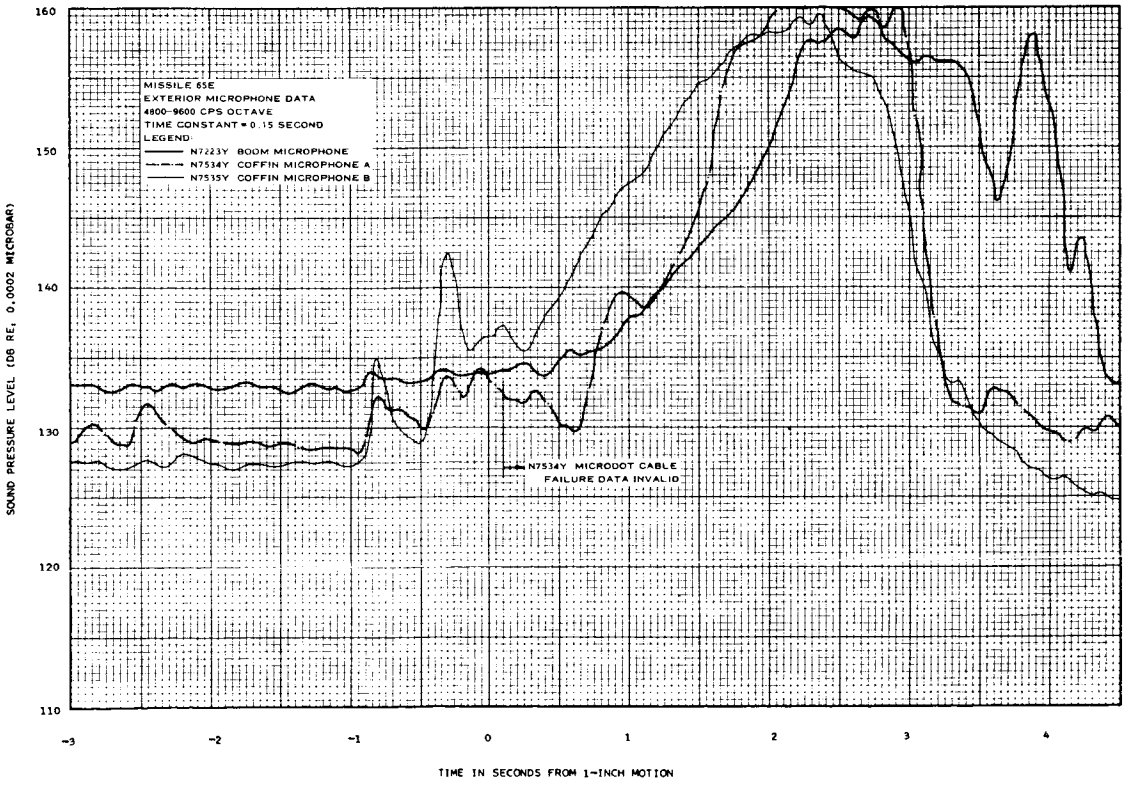


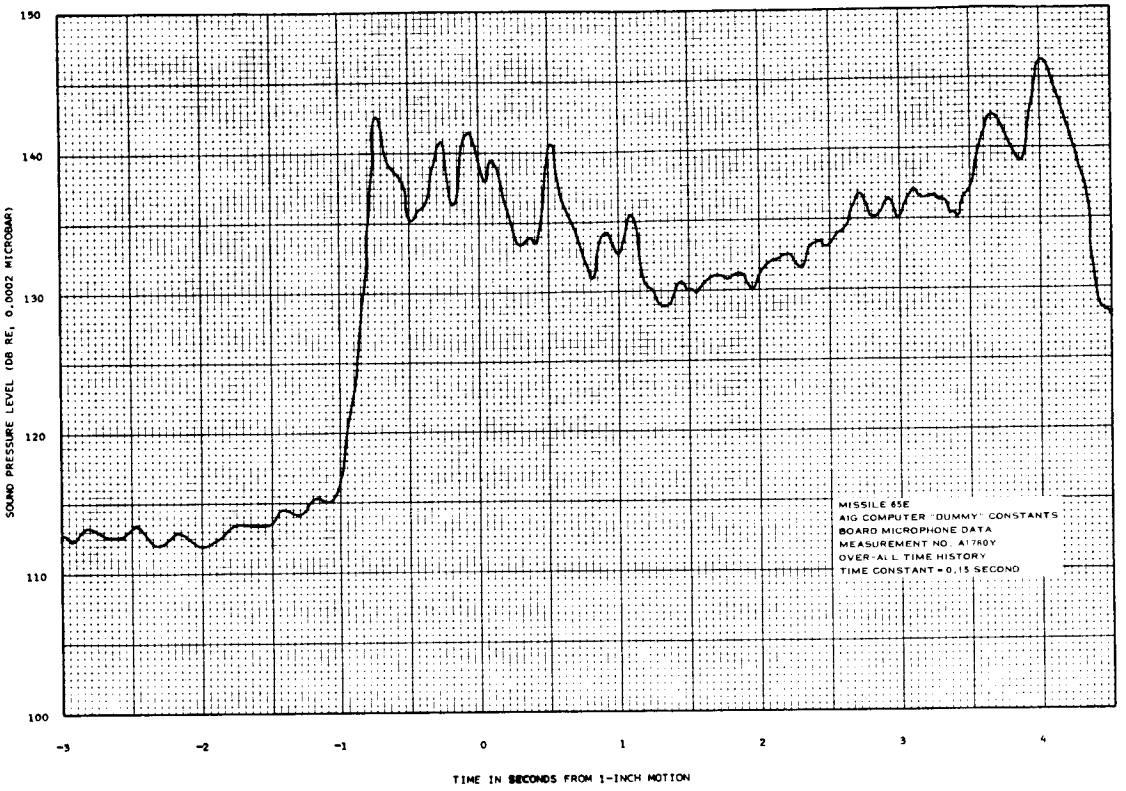
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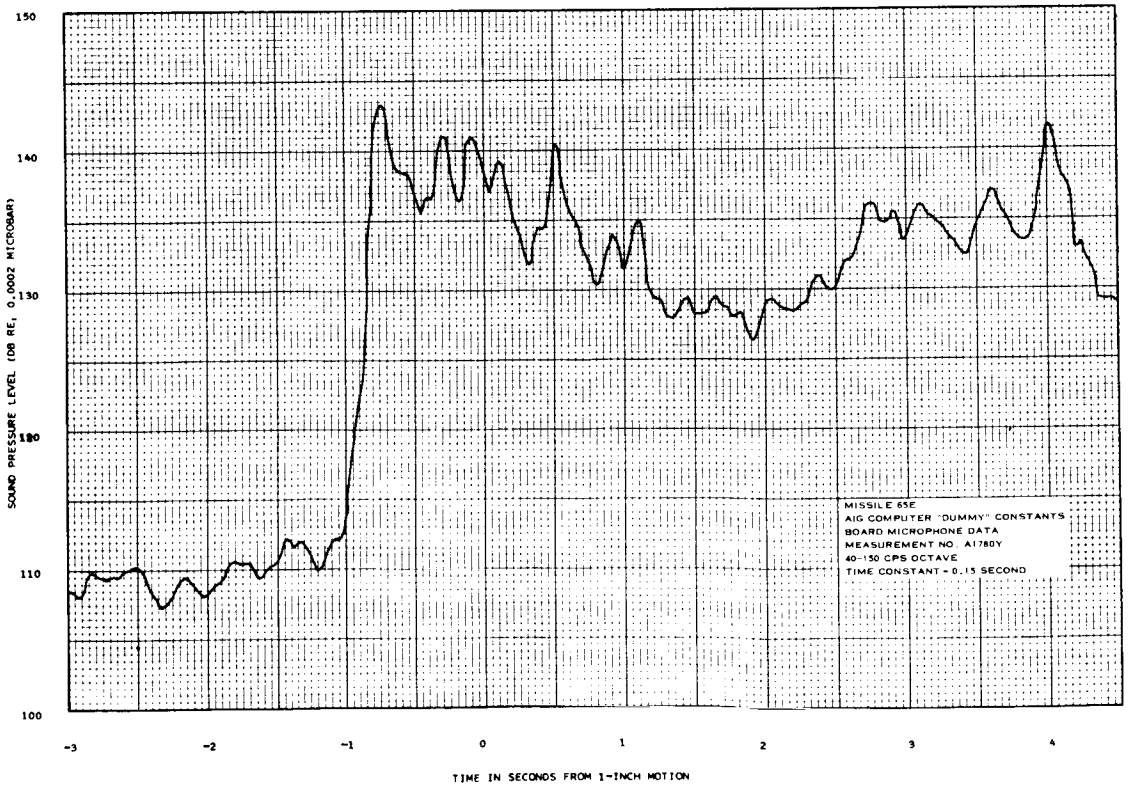


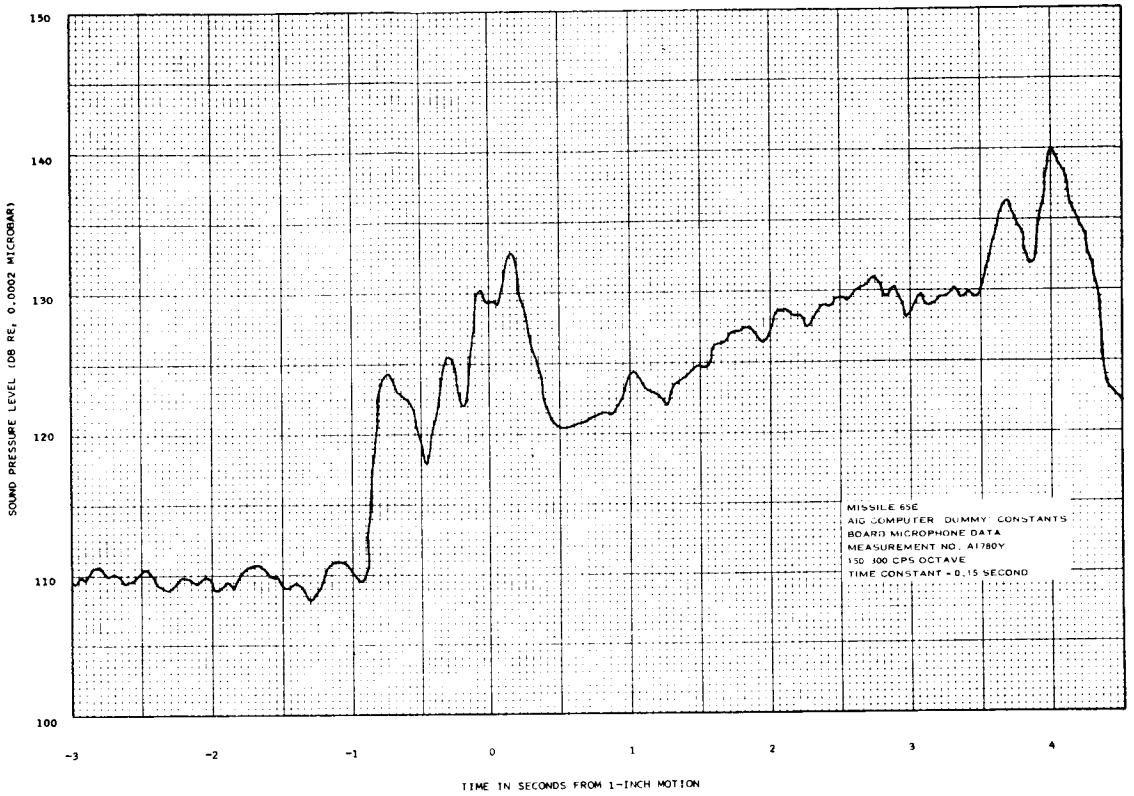



MISSILE 65E
EXTERIOR MICROPHONE DATA
2400-4800 CPS OCTAVE
TIME CONSTANT = 0.15 SECOND
LEGEND:
N7223Y BOOM MICROPHONE
N7534Y COFFIN MICROPHONE A
N7535Y COFFIN MICROPHONE B
N7534Y MICRODOT CABLE FAILURE DATA INVALID
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION


MISSILE 65E
EXTERIOR MICROPHONE DATA
4800-9600 CPS OCTAVE
TIME CONSTANT = 0.15 SECOND
LEGEND:
N7223Y BOOM MICROPHONE
N7534Y COFFIN MICROPHONE A
N7535Y COFFIN MICROPHONE B
N7534Y MICRODOT CABLE FAILURE DATA INVALID
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION

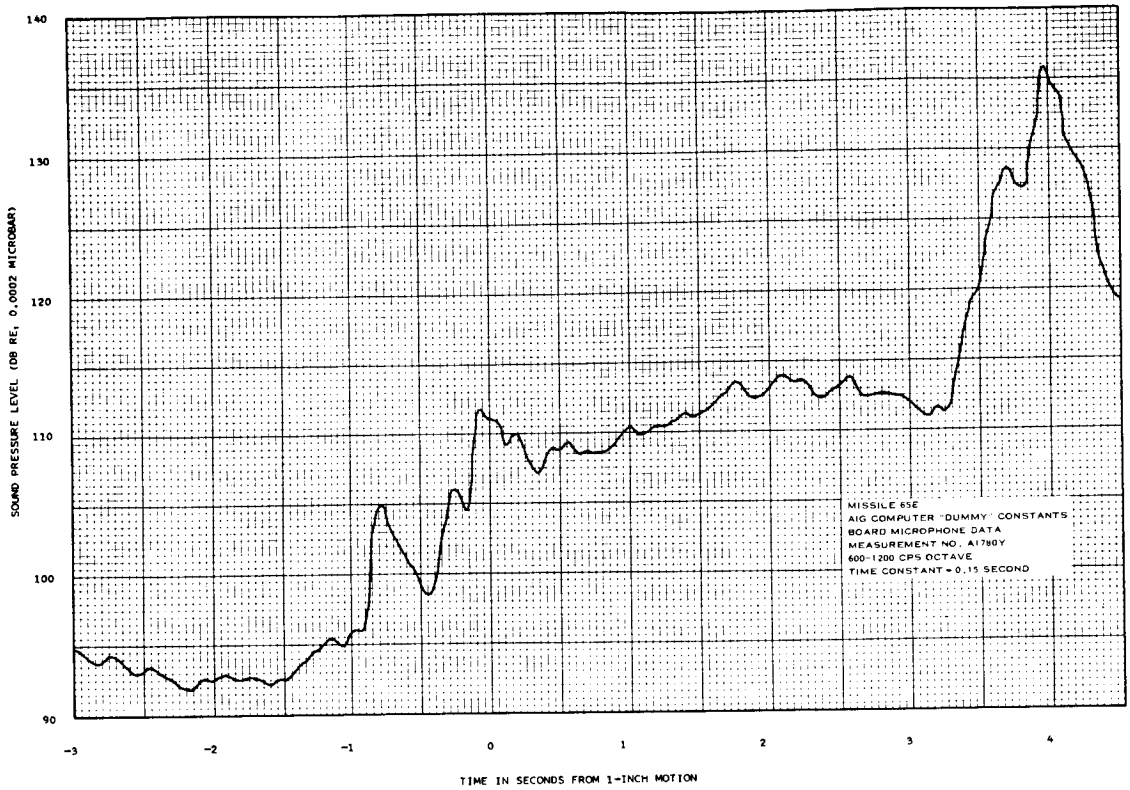

SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
150
140
130
120
110
100
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION
MISSILE 65E
AIG COMPUTER "DUMMY" CONSTANTS
BOARD MICROPHONE DATA
MEASUREMENT NO. A1780Y
OVER-ALL TIME HISTORY
TIME CONSTANT = 0.15 SECOND

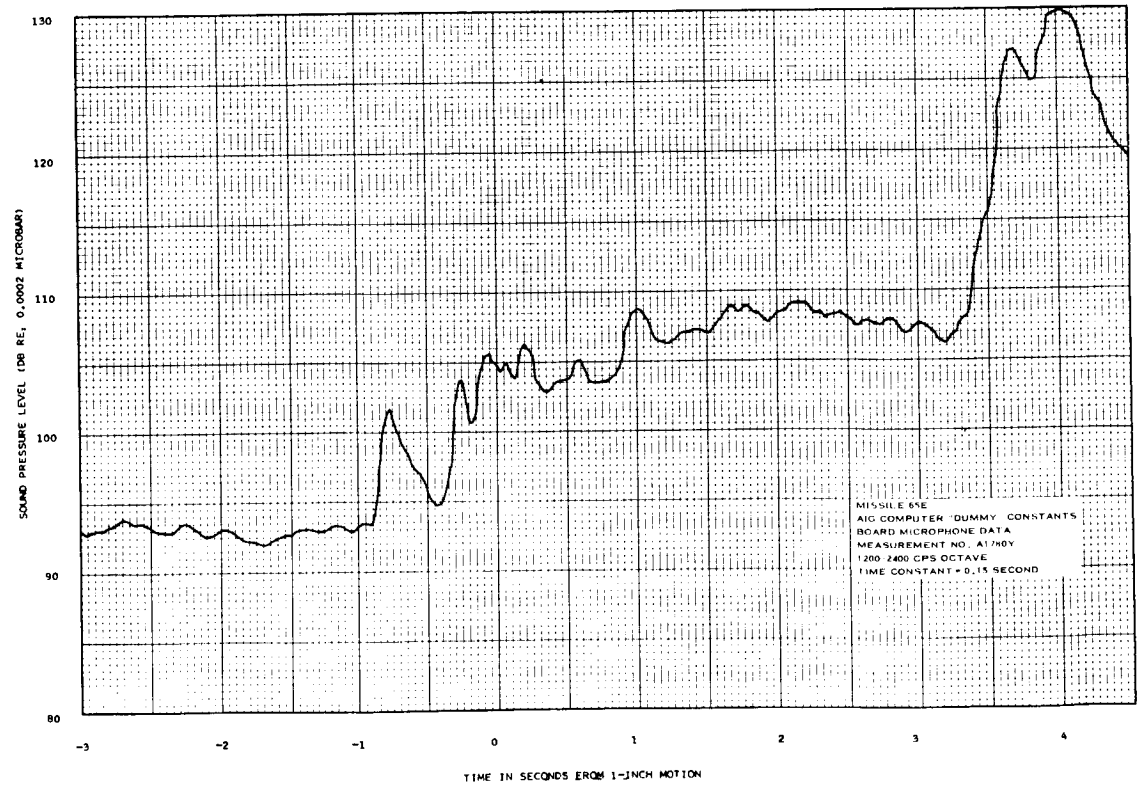

SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
150
140
130
120
110
100
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION
MISSILE 65E
AIG COMPUTER "DUMMY" CONSTANTS
BOARD MICROPHONE DATA
MEASUREMENT NO. A1780Y
40-150 CPS OCTAVE
TIME CONSTANT = 0.15 SECOND

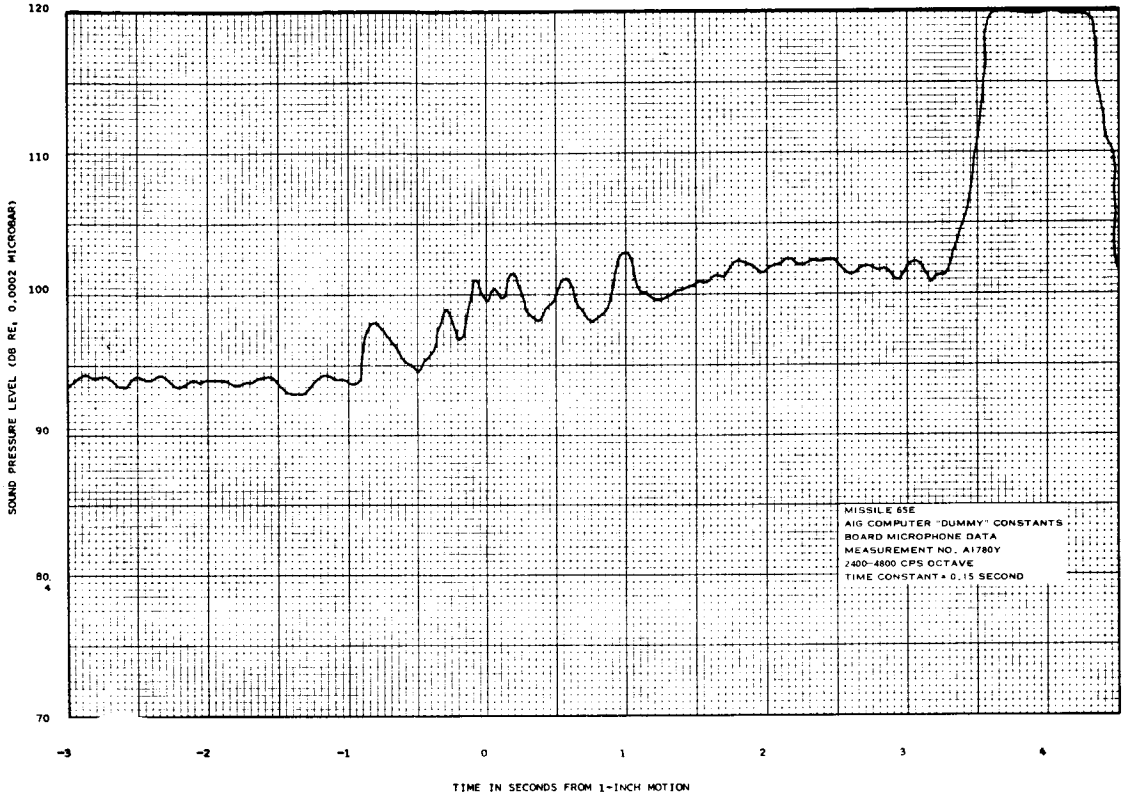

SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
150
140
130
120
110
100
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION
MISSILE 65E
AIG COMPUTER "DUMMY" CONSTANTS
BOARD MICROPHONE DATA
MEASUREMENT NO. A1780Y
150 100 CPS OCTAVE
TIME CONSTANT = 0.15 SECOND

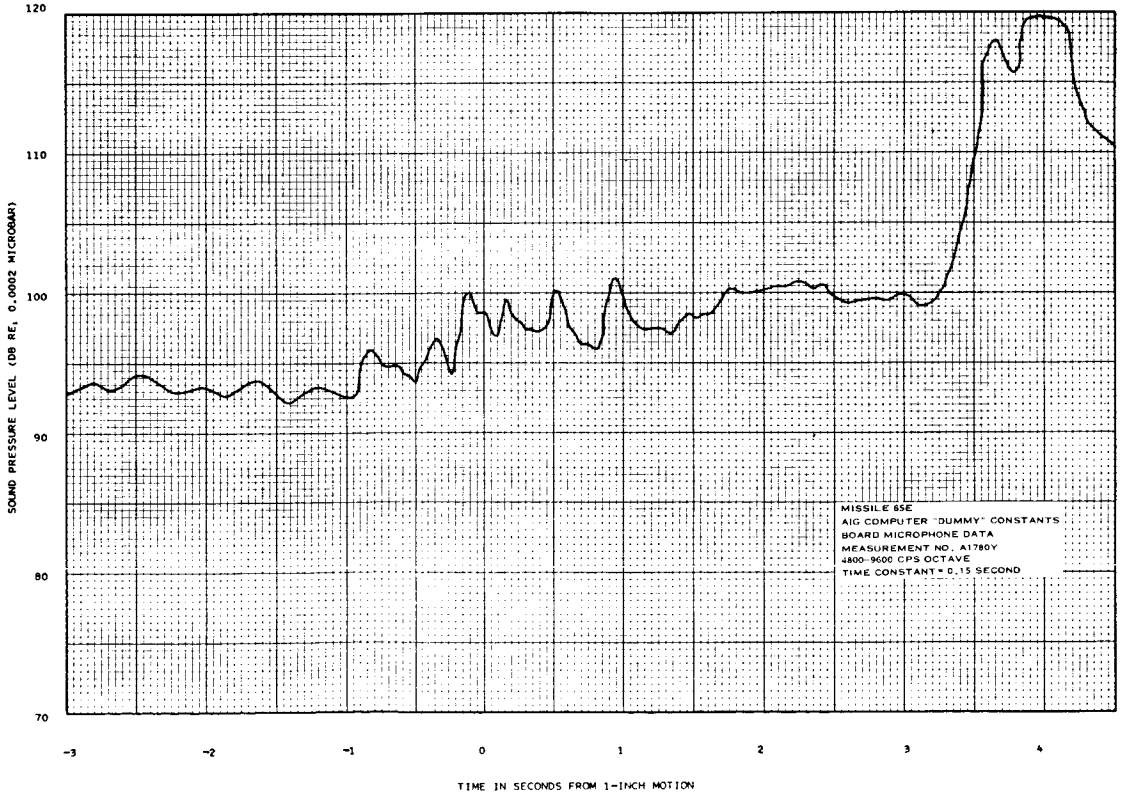

SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
140
130
120
110
100
90
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION
MISSILE 65E
AIG COMPUTER "DUMMY" CONSTANTS
BOARD MICROPHONE DATA
MEASUREMENT NO. A1780Y
300-600 CPS OCTAVE
TIME CONSTANT = 0.15 SECOND

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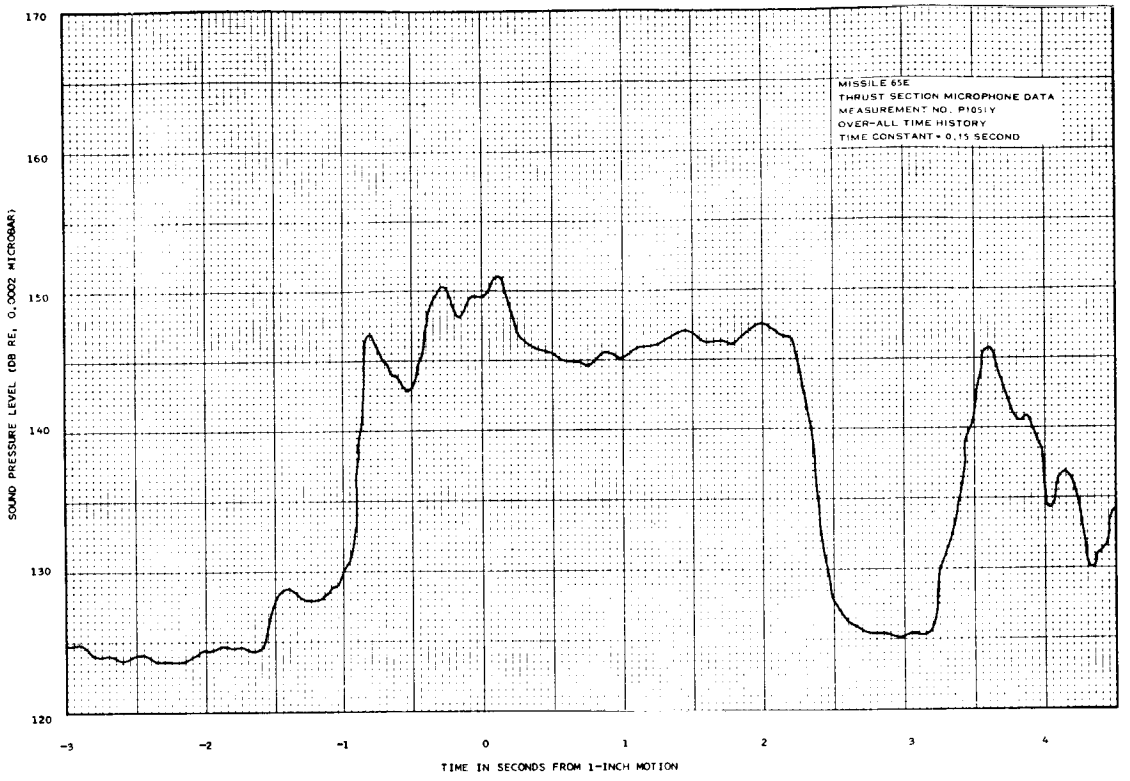


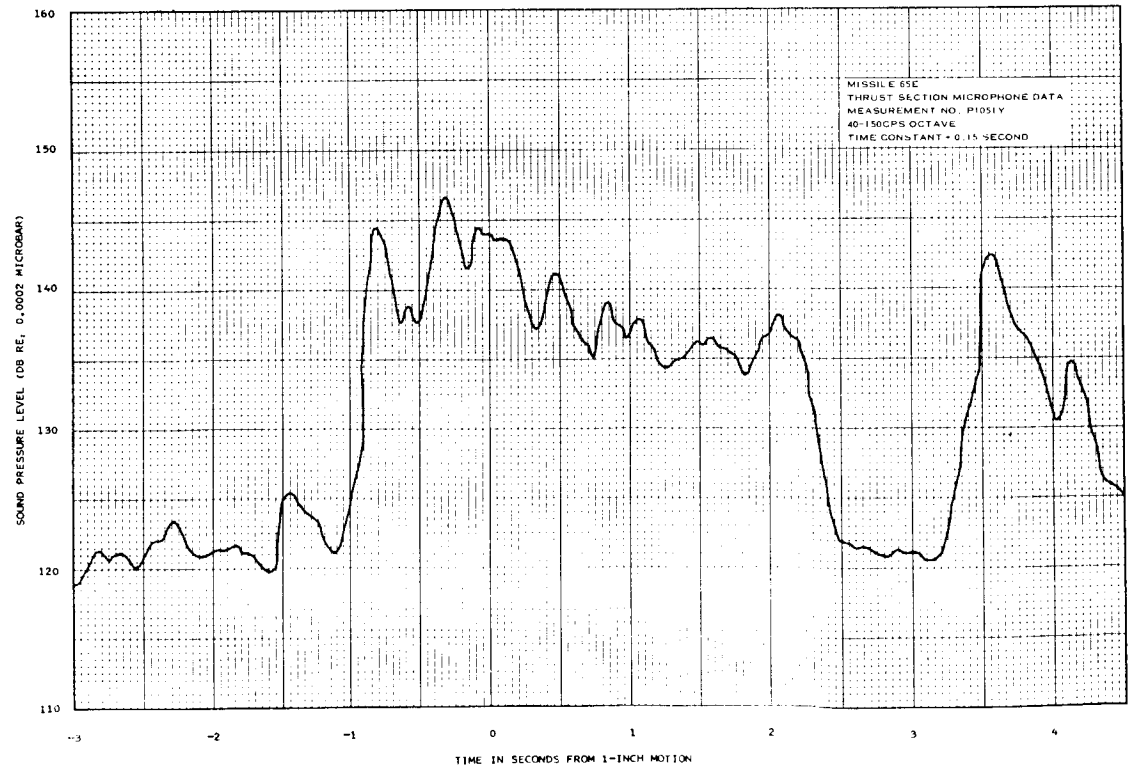



120
110
100
90
80
70
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION
MISSILE 65E
AIG COMPUTER "DUMMY" CONSTANTS
BOARD MICROPHONE DATA
MEASUREMENT NO. A1780Y
2400-4800 CPS OCTAVE
TIME CONSTANT = 0.15 SECOND


120
110
100
90
80
70
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION
MISSILE 65E
AIG COMPUTER "DUMMY" CONSTANTS
BOARD MICROPHONE DATA
MEASUREMENT NO. A1780Y
4800-9600 CPS OCTAVE
TIME CONSTANT = 0.15 SECOND

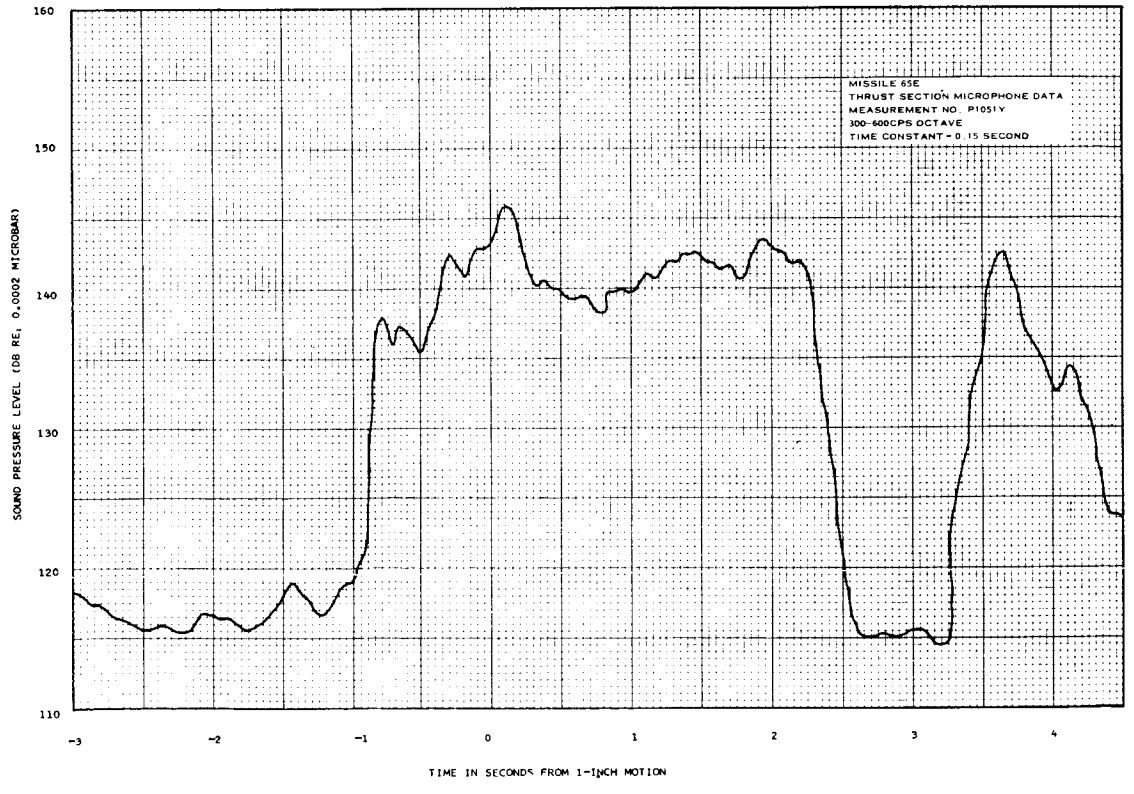
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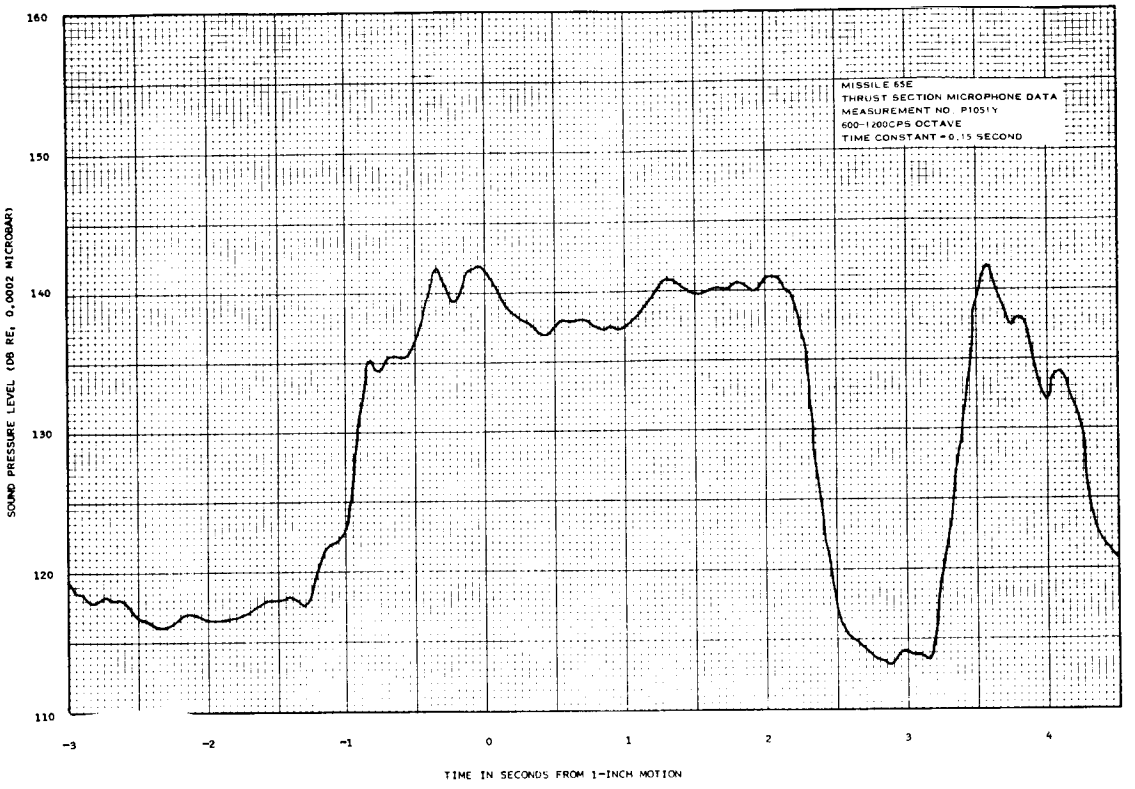


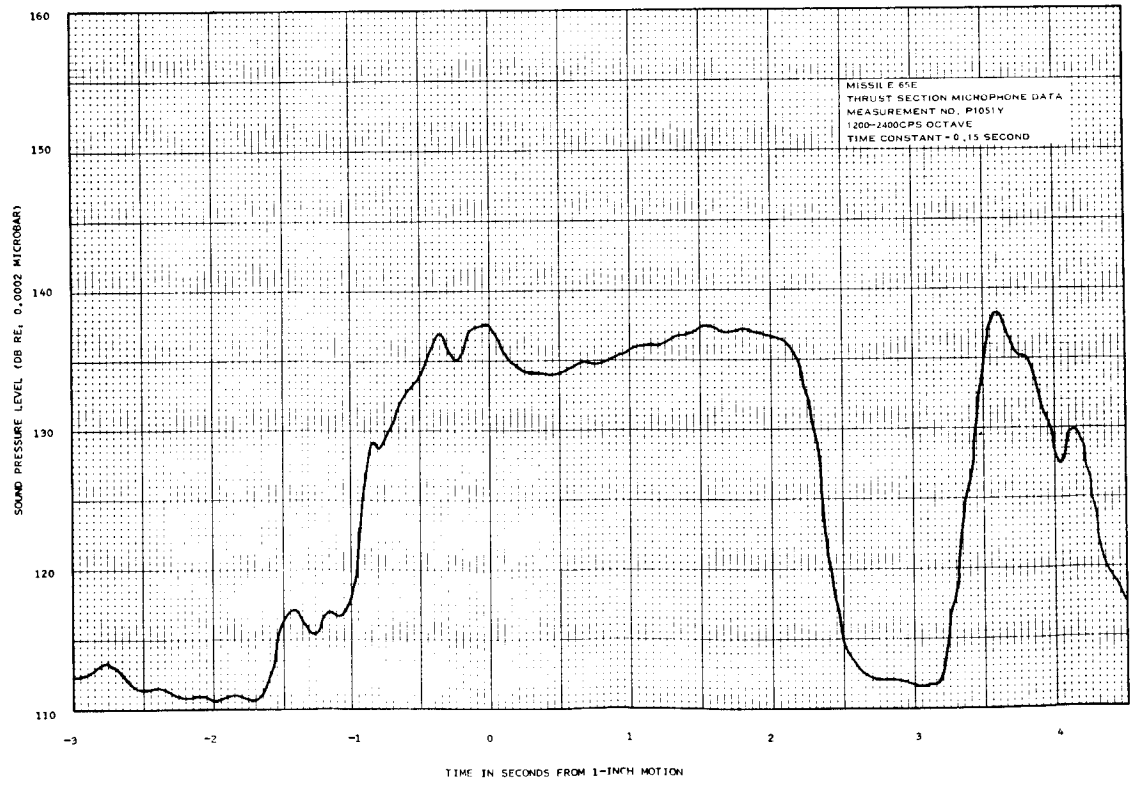


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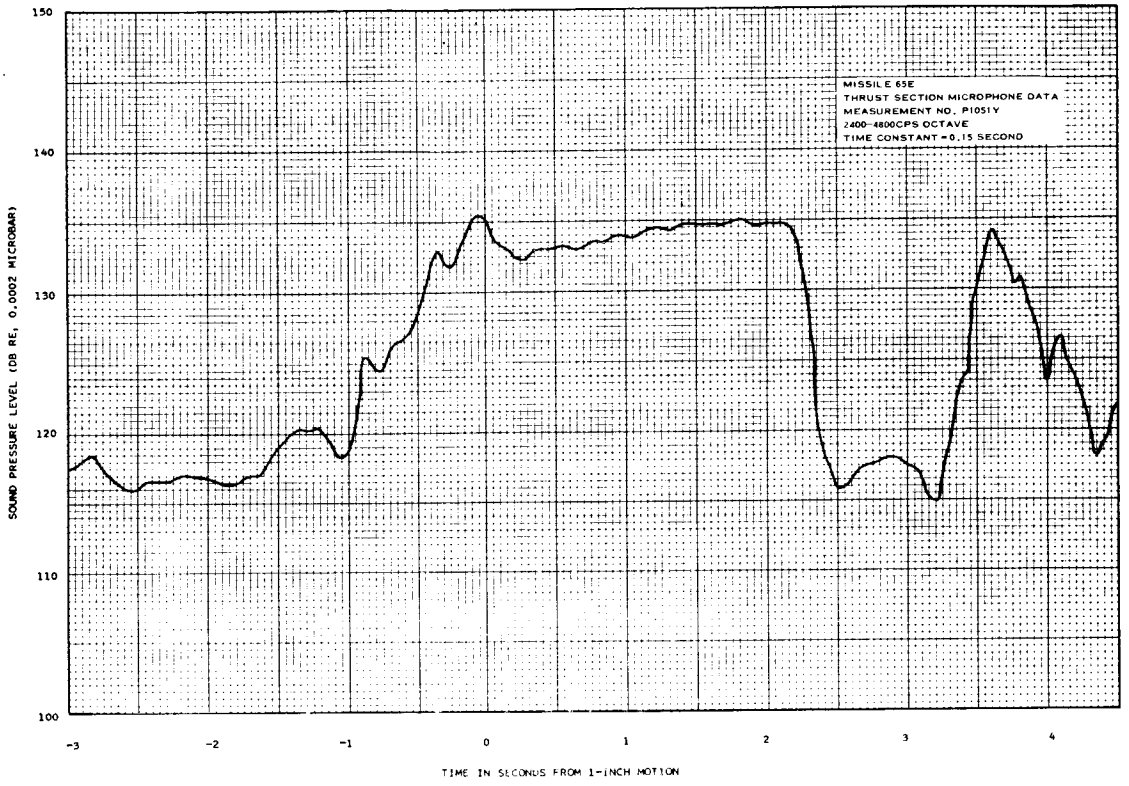


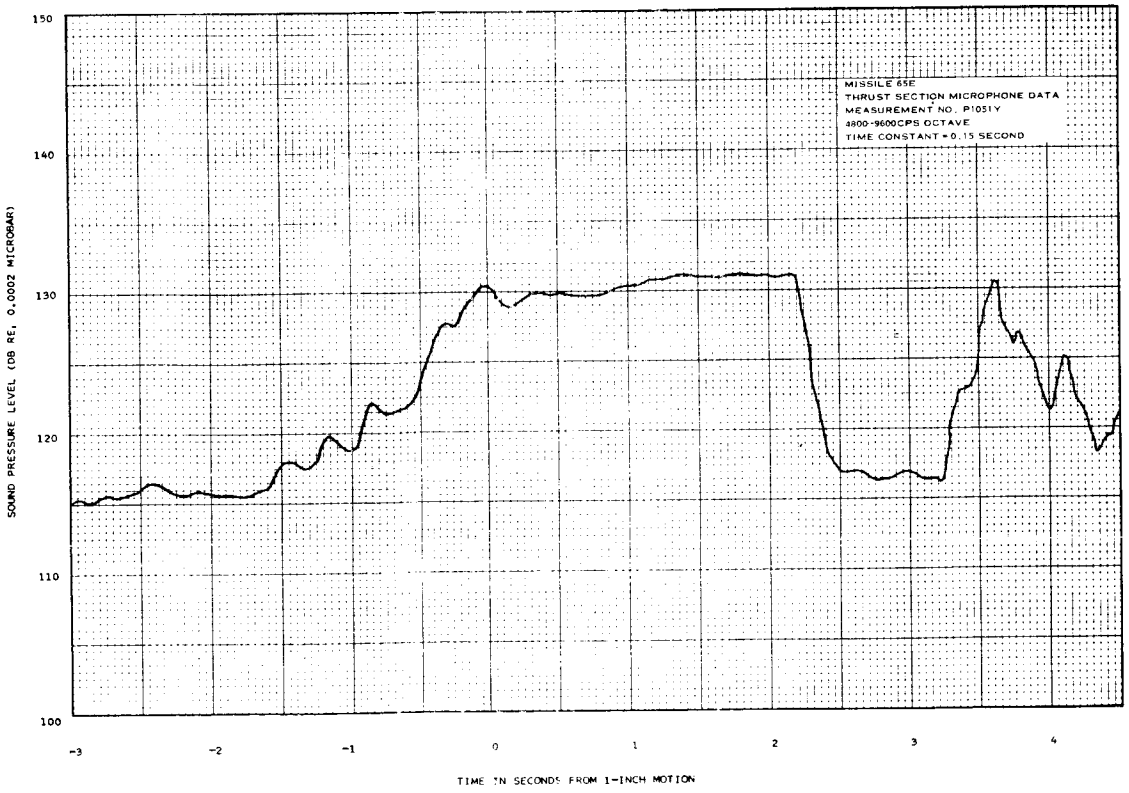


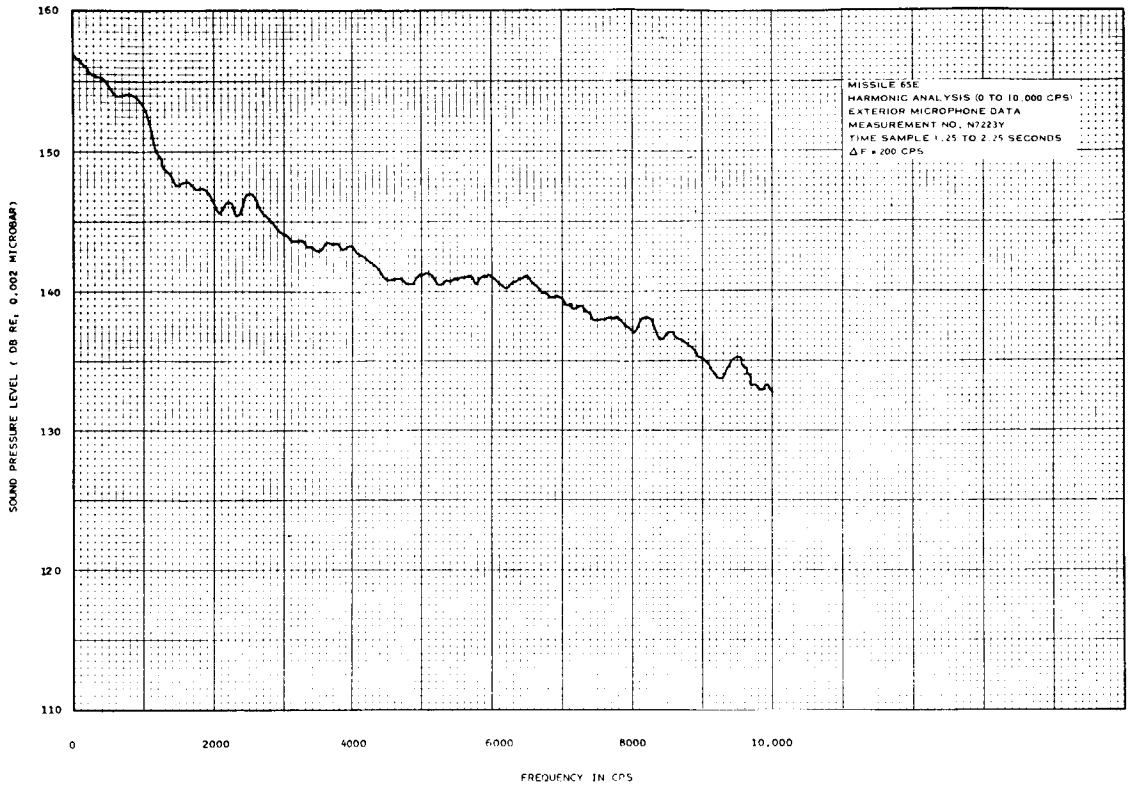

MISSILE 65E
THRUST SECTION MICROPHONE DATA
MEASUREMENT NO. P1051Y
600-1200CPS OCTAVE
TIME CONSTANT = 0.15 SECOND
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION

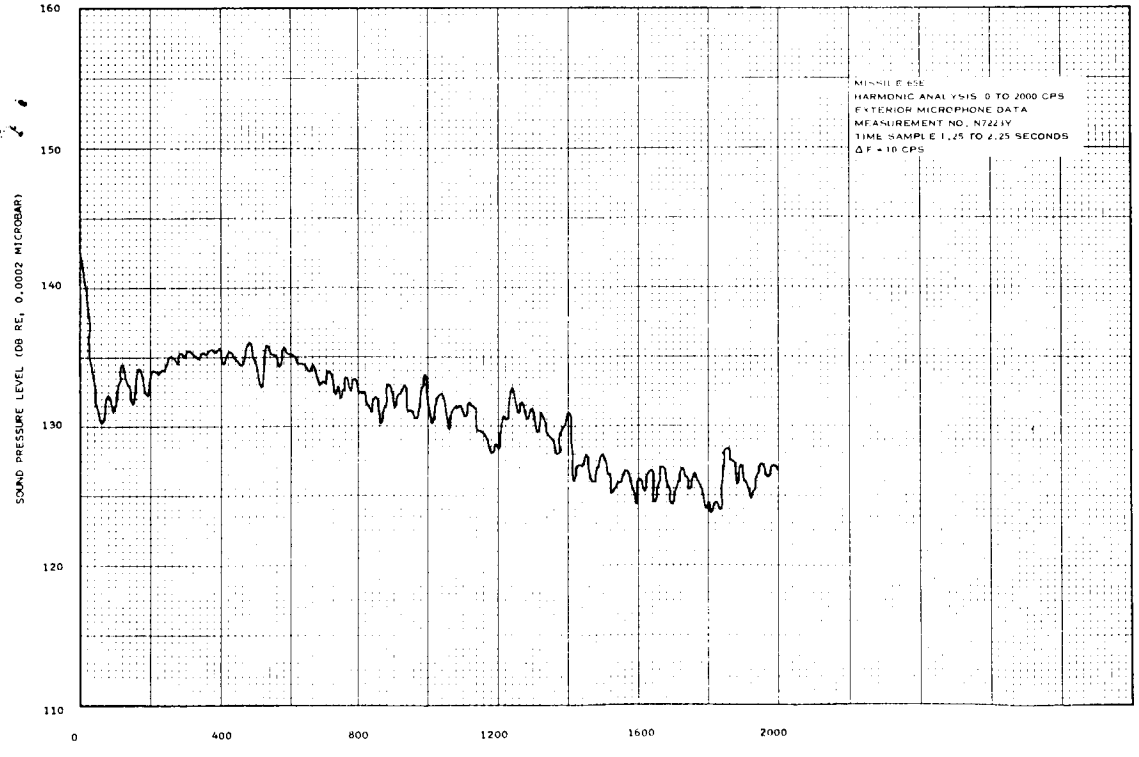

MISSILE 65E
THRUST SECTION MICROPHONE DATA
MEASUREMENT NO. P1051Y
1200-2400CPS OCTAVE
TIME CONSTANT = 0.15 SECOND
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
160
150
140
130
120
110
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION

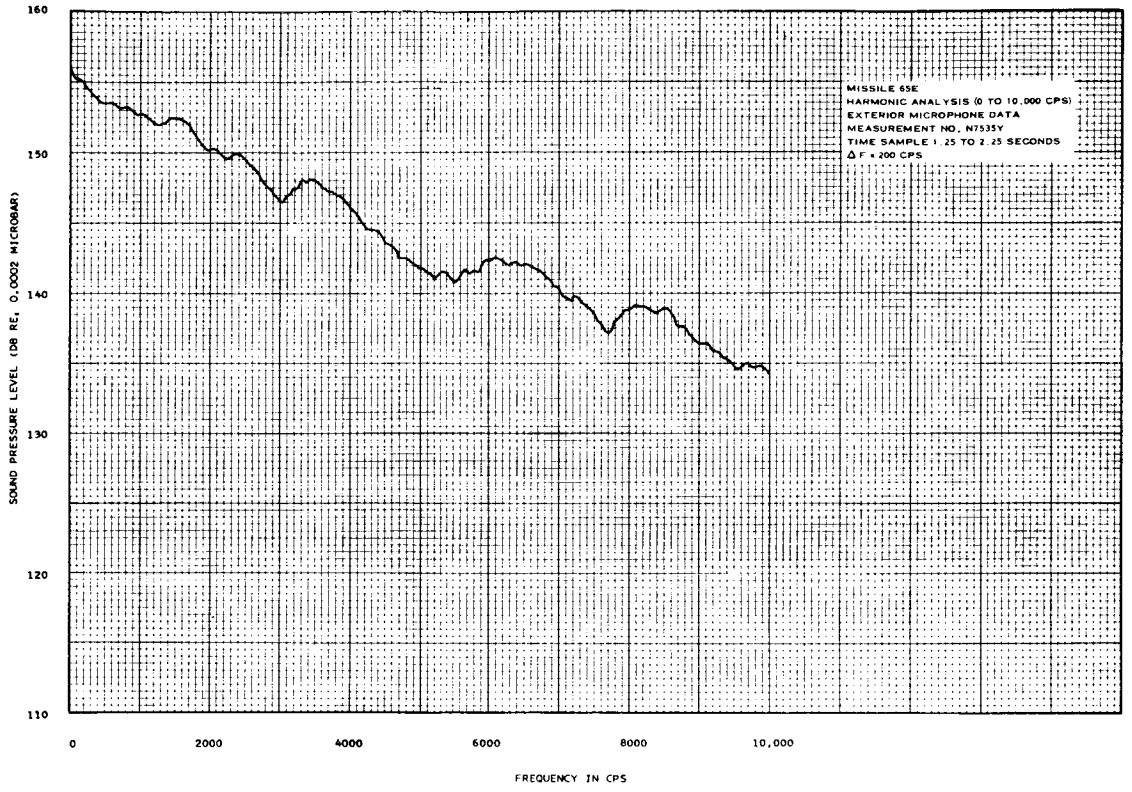
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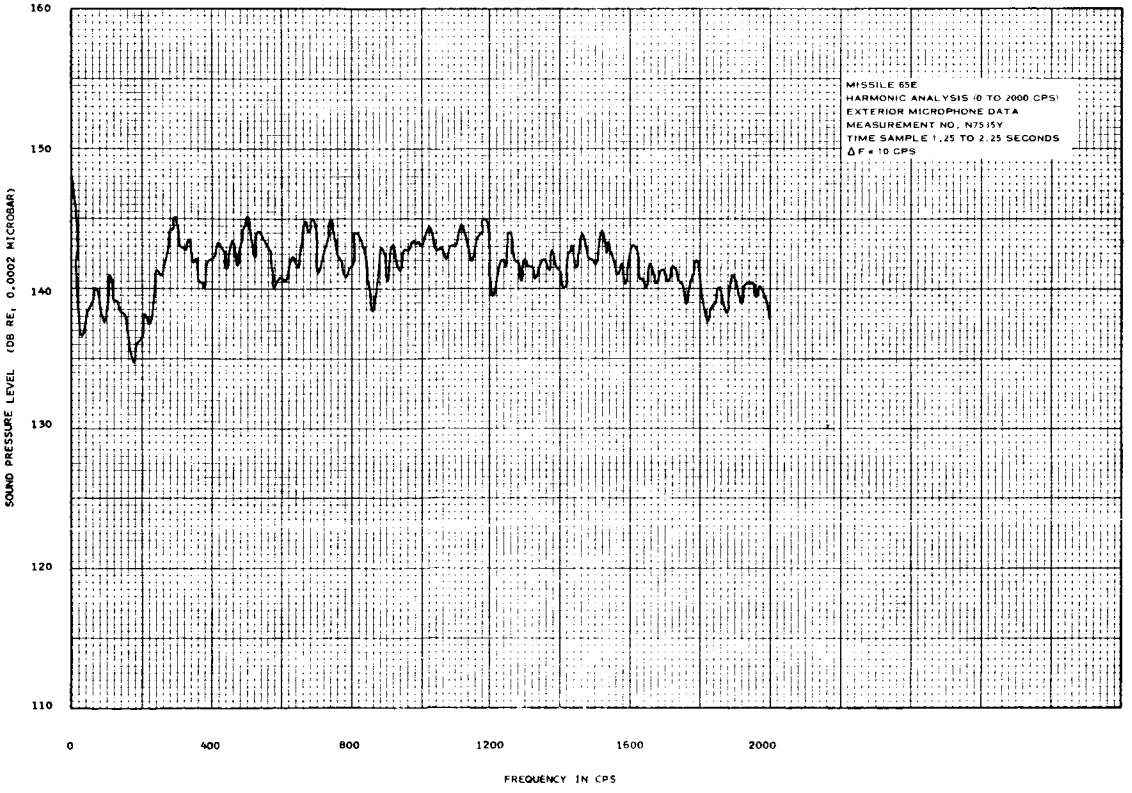




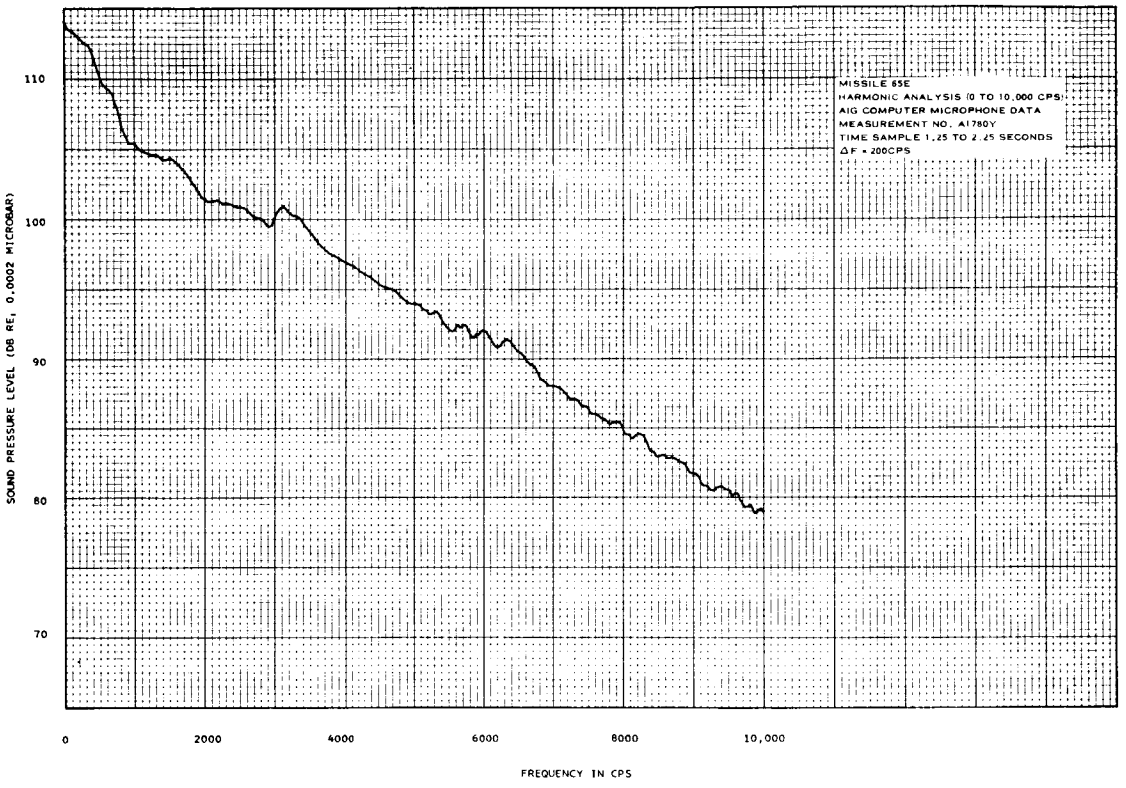

MISSILE 65E
HARMONIC ANALYSIS (0 TO 10,000 CPS)
EXTERIOR MICROPHONE DATA
MEASUREMENT NO. N7223Y
TIME SAMPLE 1.25 TO 2.25 SECONDS
ΔF = 200 CPS
SOUND PRESSURE LEVEL (DB RE, 0.002 MICROBAR)
160
150
140
130
120
110
0
2000
4000
6000
8000
10,000
FREQUENCY IN CPS

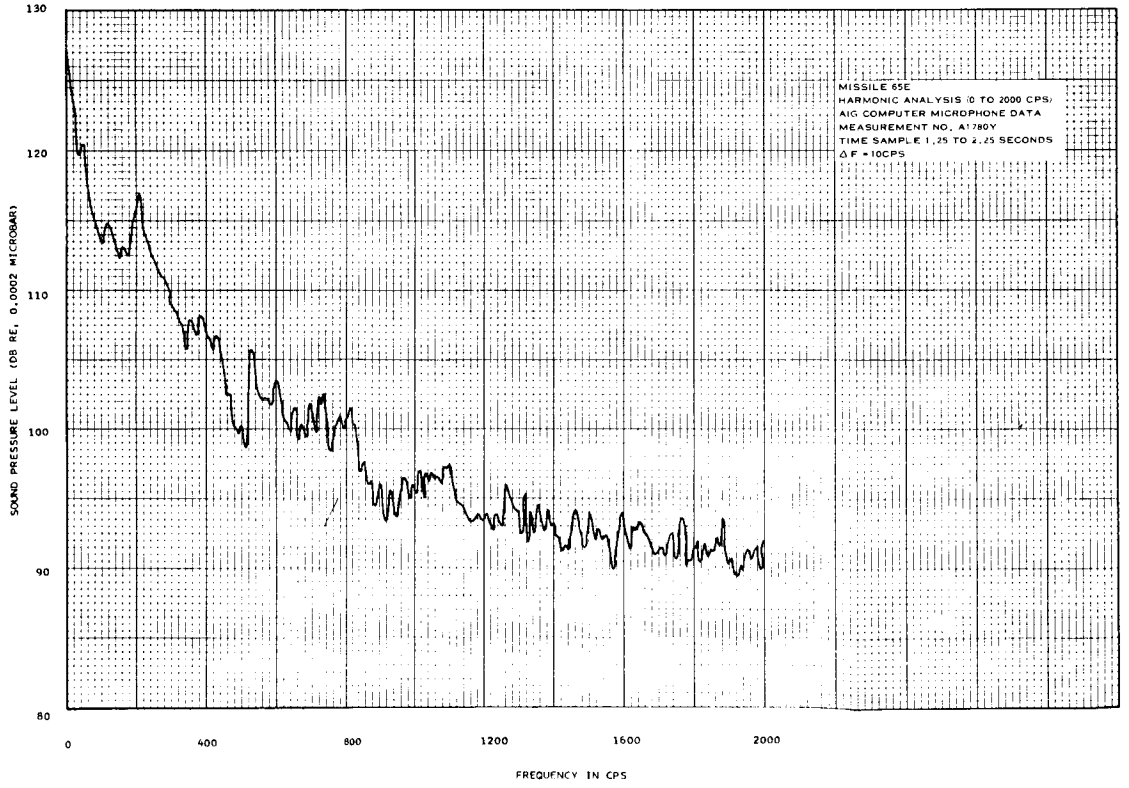

MISSILE 65E
HARMONIC ANALYSIS 0 TO 2000 CPS
EXTERIOR MICROPHONE DATA
MEASUREMENT NO. N7221Y
TIME SAMPLE 1.25 TO 2.25 SECONDS
ΔF = 10 CPS
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
0
400
800
1200
1600
2000

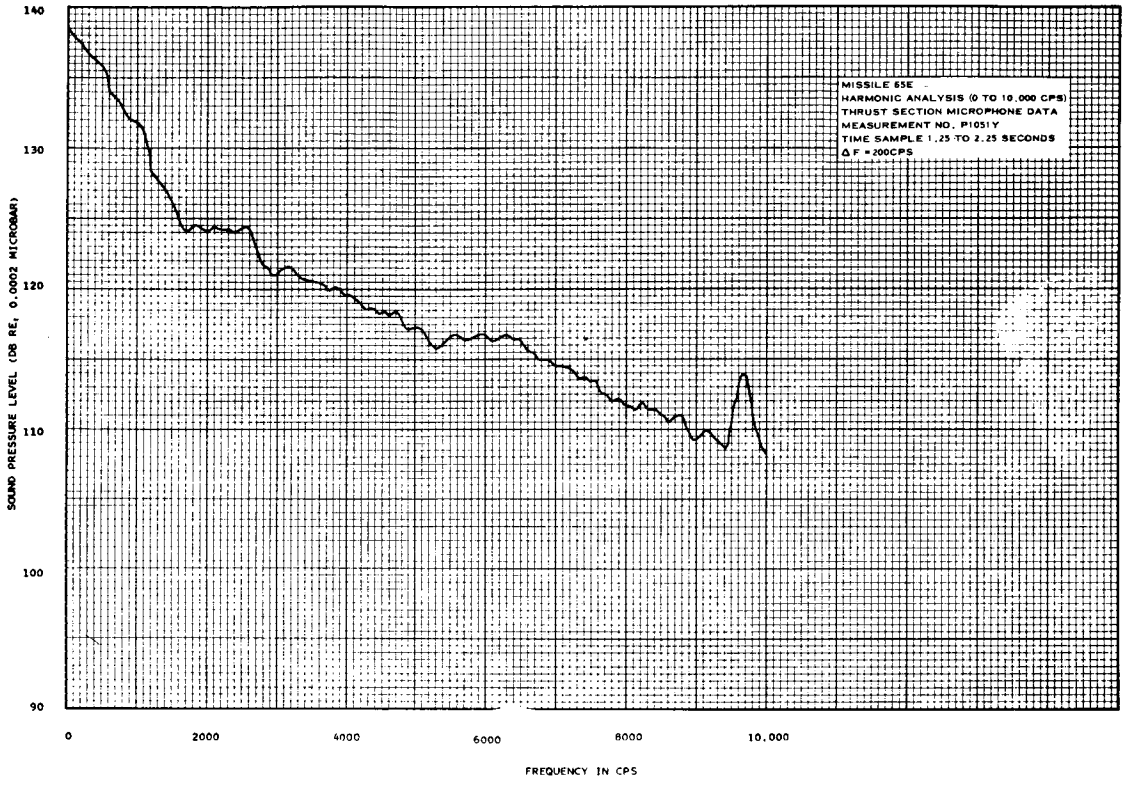

MISSILE 65E
HARMONIC ANALYSIS (0 TO 10,000 CPS)
EXTERIOR MICROPHONE DATA
MEASUREMENT NO. N7535Y
TIME SAMPLE 1.25 TO 2.25 SECONDS
ΔF = 200 CPS
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
0
2000
4000
6000
8000
10,000
FREQUENCY IN CPS

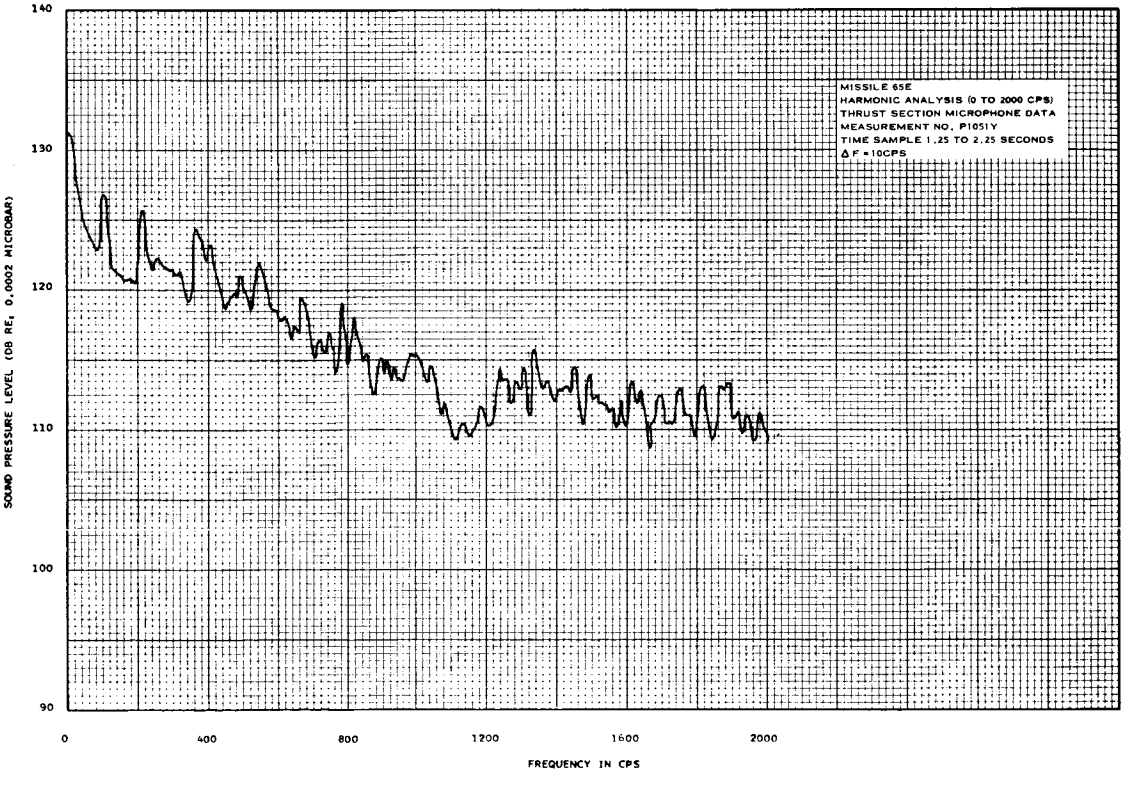

MISSILE 65E
HARMONIC ANALYSIS (0 TO 2000 CPS)
EXTERIOR MICROPHONE DATA
MEASUREMENT NO. N7535Y
TIME SAMPLE 1.25 TO 2.25 SECONDS
ΔF = 10 CPS
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
150
140
130
120
110
0
400
800
1200
1600
2000
FREQUENCY IN CPS

UNCLASSIFIED

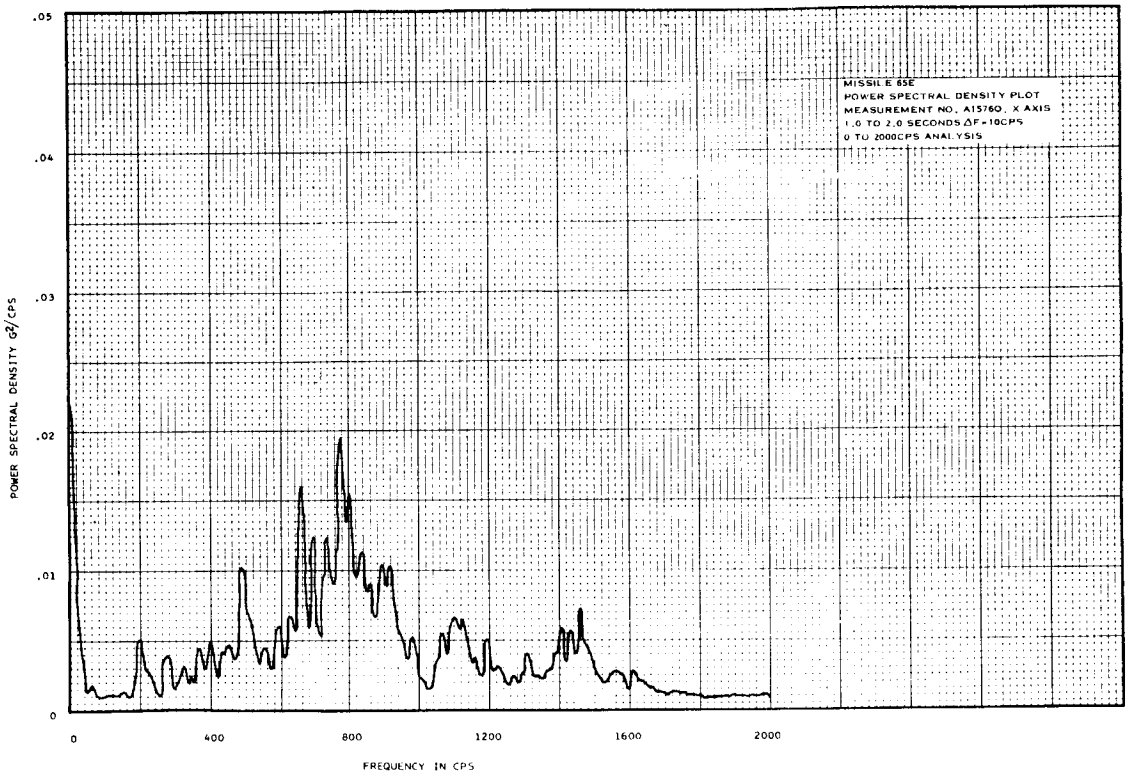


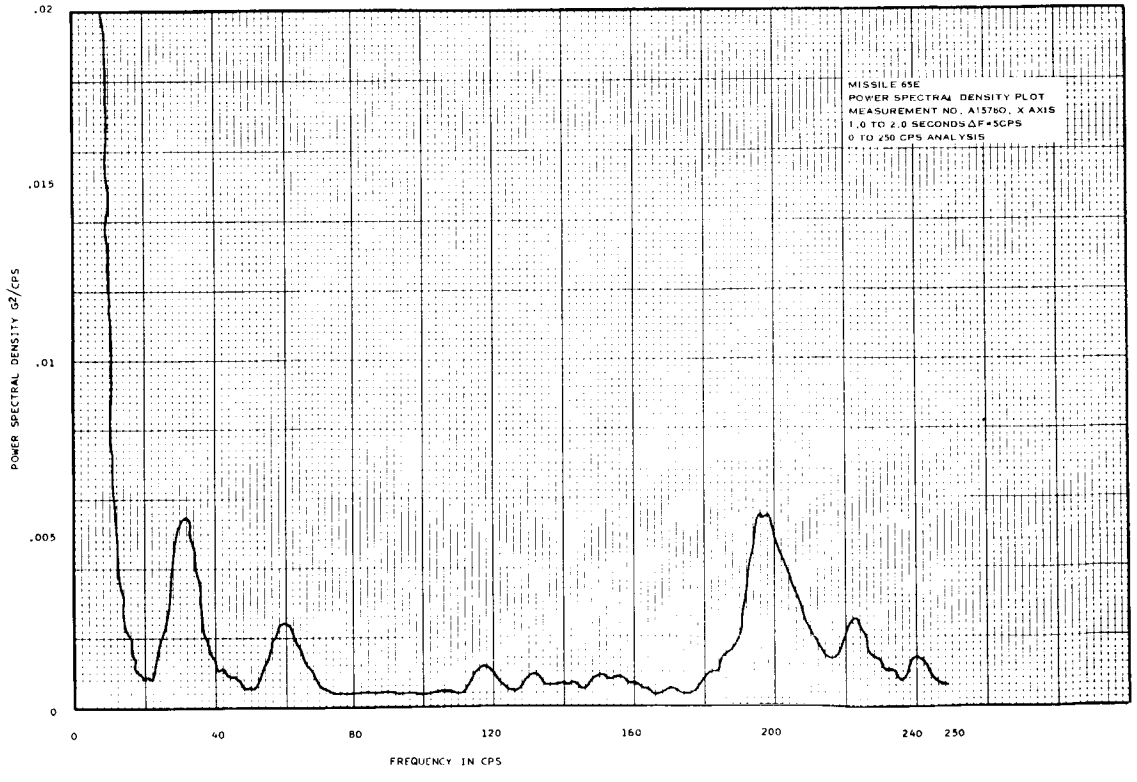


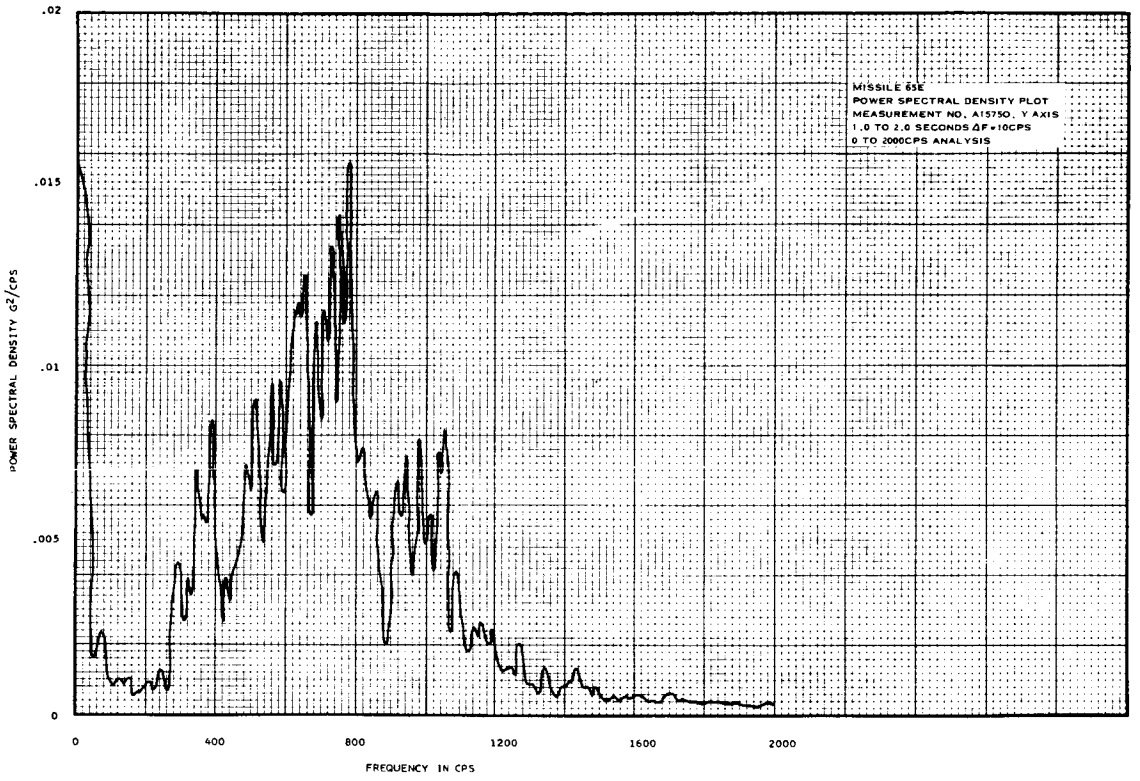

MISSILE 65E
HARMONIC ANALYSIS (0 TO 10,000 CPS)
THRUST SECTION MICROPHONE DATA
MEASUREMENT NO. P1051Y
TIME SAMPLE 1.25 TO 2.25 SECONDS
ΔF = 200CPS
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
140
130
120
110
100
90
0
2000
4000
6000
8000
10,000
FREQUENCY IN CPS

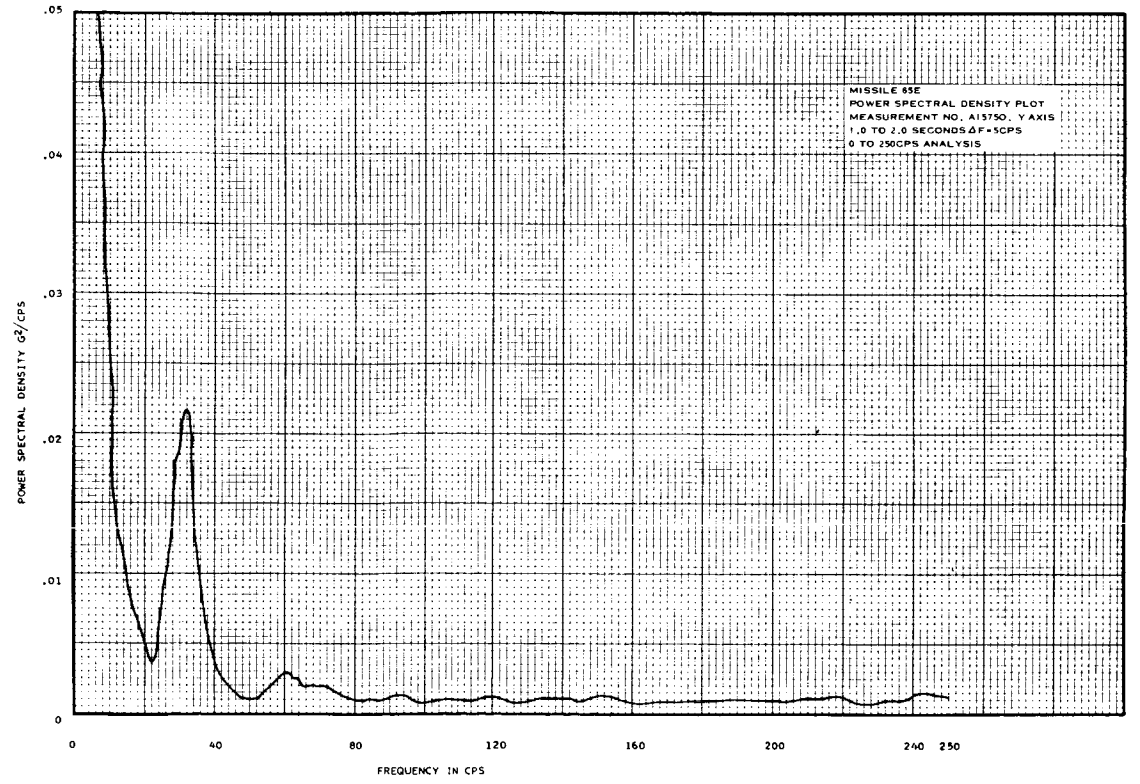

MISSILE 65E
HARMONIC ANALYSIS (0 TO 2000 CPS)
THRUST SECTION MICROPHONE DATA
MEASUREMENT NO. P1051Y
TIME SAMPLE 1.25 TO 2.25 SECONDS
ΔF = 10CPS
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
140
130
120
110
100
90
0
400
800
1200
1600
2000
FREQUENCY IN CPS

MISSILE 65E

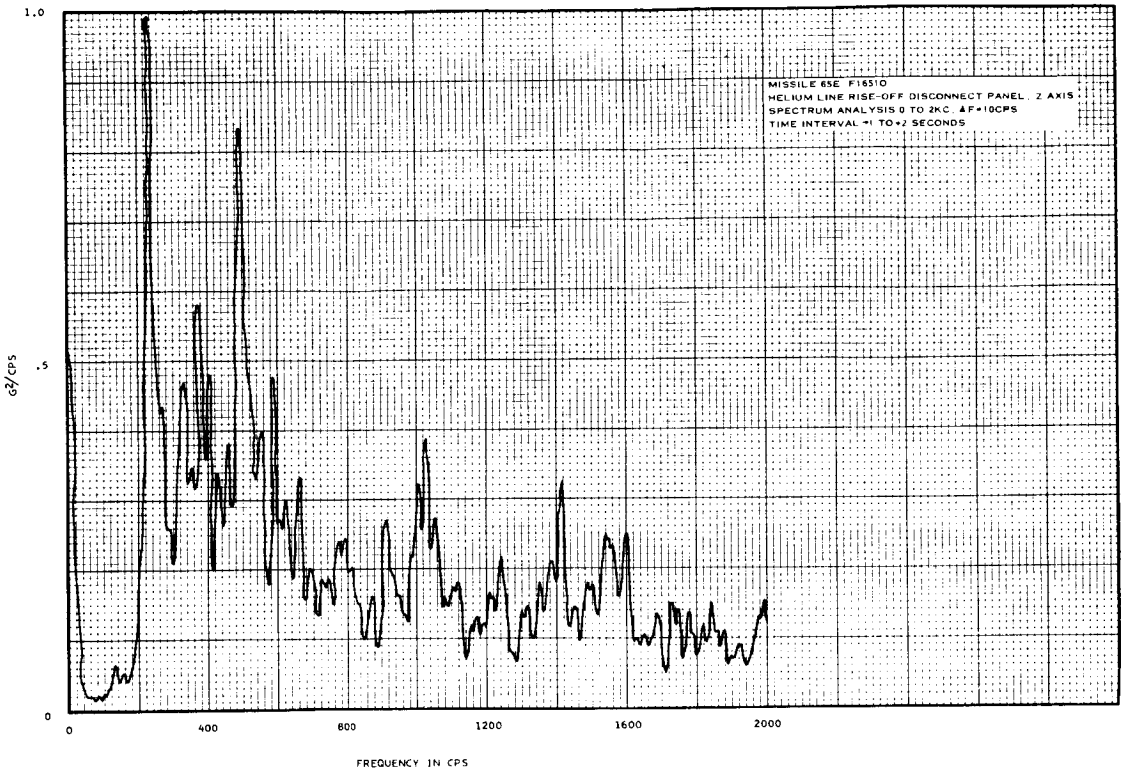

MISSILE 65E
POWER SPECTRAL DENSITY PLOT
MEASUREMENT NO. A15760, X AXIS
1.0 TO 2.0 SECONDS ΔF=10CPS
0 TO 2000CPS ANALYSIS
POWER SPECTRAL DENSITY G²/CPS
.05
.04
.03
.02
.01
0
0
400
800
1200
1600
2000
FREQUENCY IN CPS

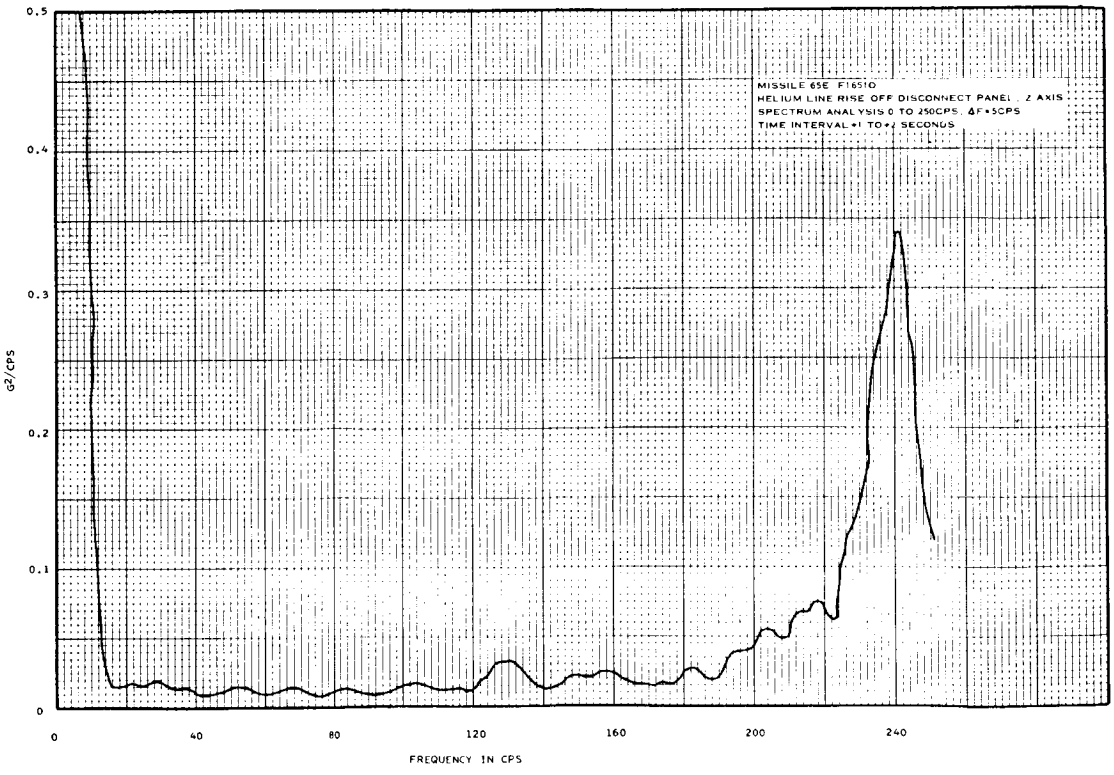

MISSILE 65E
POWER SPECTRAL DENSITY PLOT
MEASUREMENT NO. A15760, X AXIS
1.0 TO 2.0 SECONDS ΔF=5CPS
0 TO 250 CPS ANALYSIS
POWER SPECTRAL DENSITY G²/CPS
.02
.015
.01
.005
0
0
40
80
120
160
200
240
250
FREQUENCY IN CPS

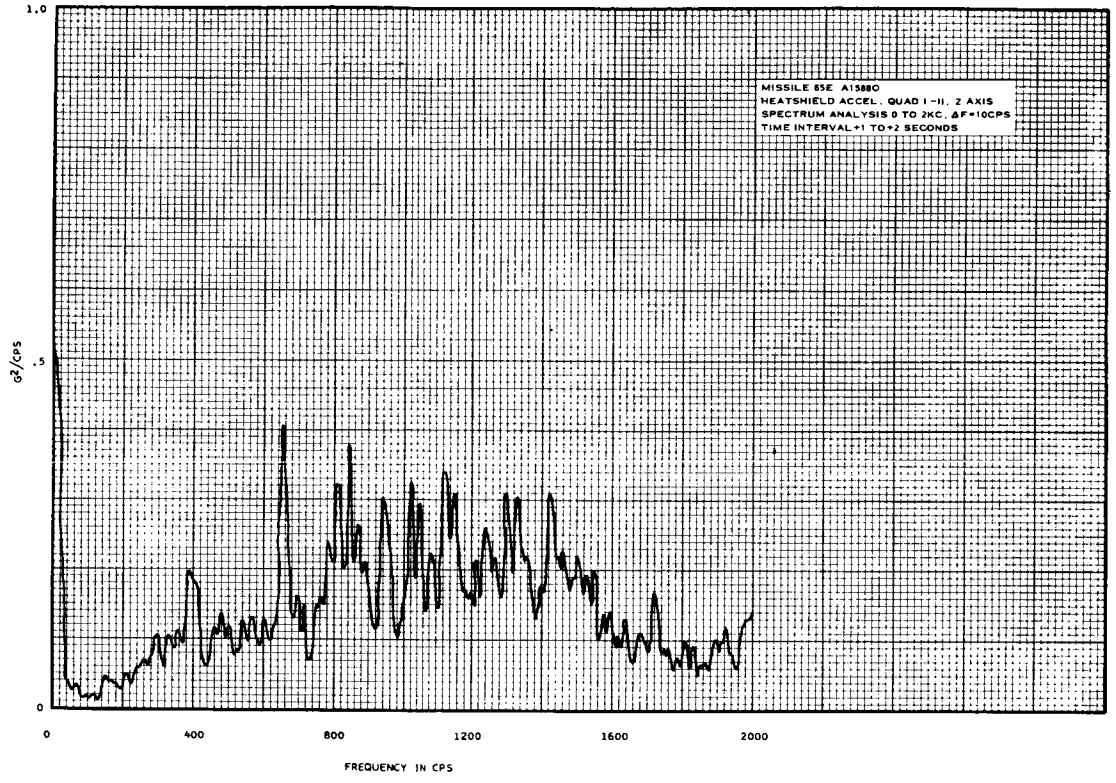

MISSILE 65E
POWER SPECTRAL DENSITY PLOT
MEASUREMENT NO. A15750, Y AXIS
1.0 TO 2.0 SECONDS ΔF=10CPS
0 TO 2000CPS ANALYSIS
POWER SPECTRAL DENSITY G²/CPS
.02
.015
.01
.005
0
0
400
800
1200
1600
2000
FREQUENCY IN CPS

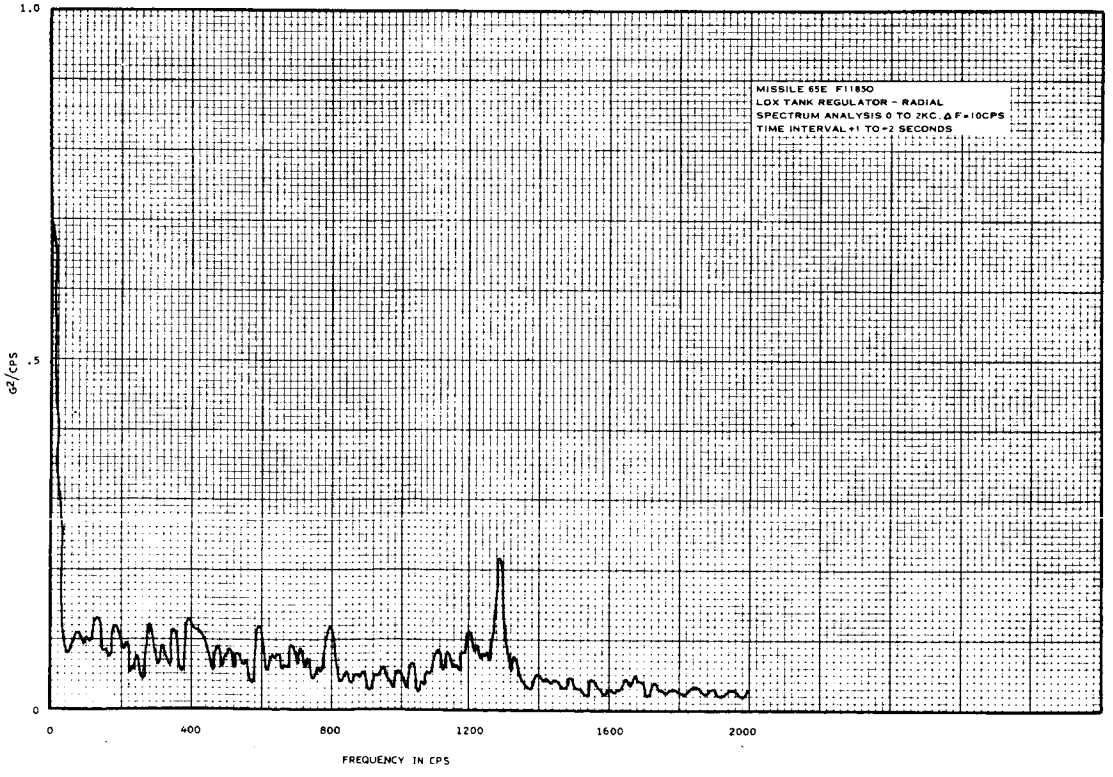

MISSILE 65E
POWER SPECTRAL DENSITY PLOT
MEASUREMENT NO. A15750, Y AXIS
1.0 TO 2.0 SECONDS ΔF=5CPS
0 TO 250CPS ANALYSIS
POWER SPECTRAL DENSITY G²/CPS
.05
.04
.03
.02
.01
0
0
40
80
120
160
200
240
250
FREQUENCY IN CPS

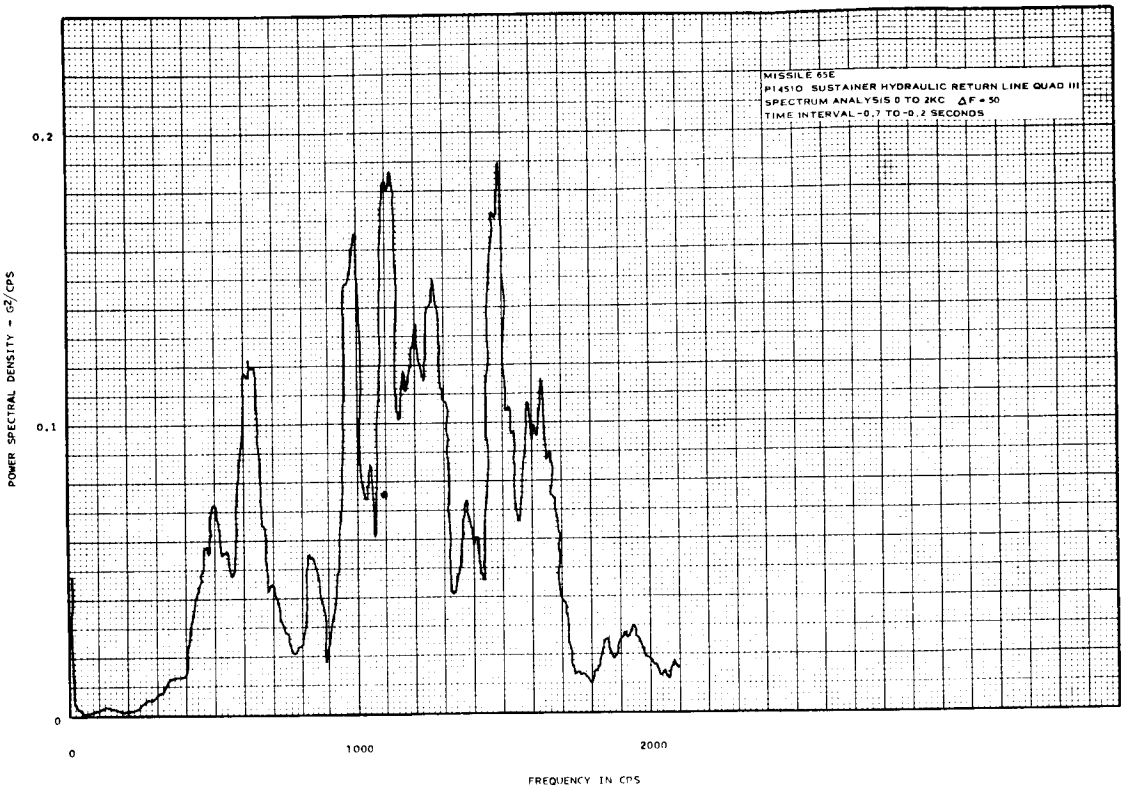
UNCLASSIFIED

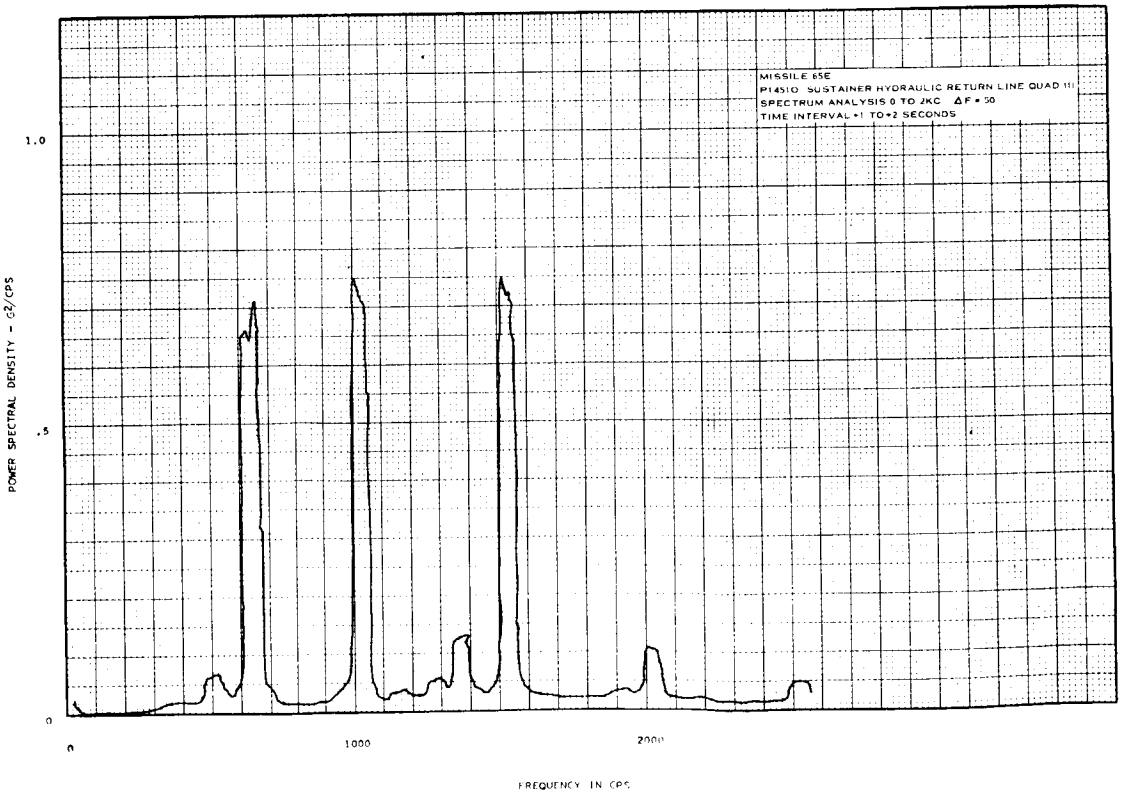




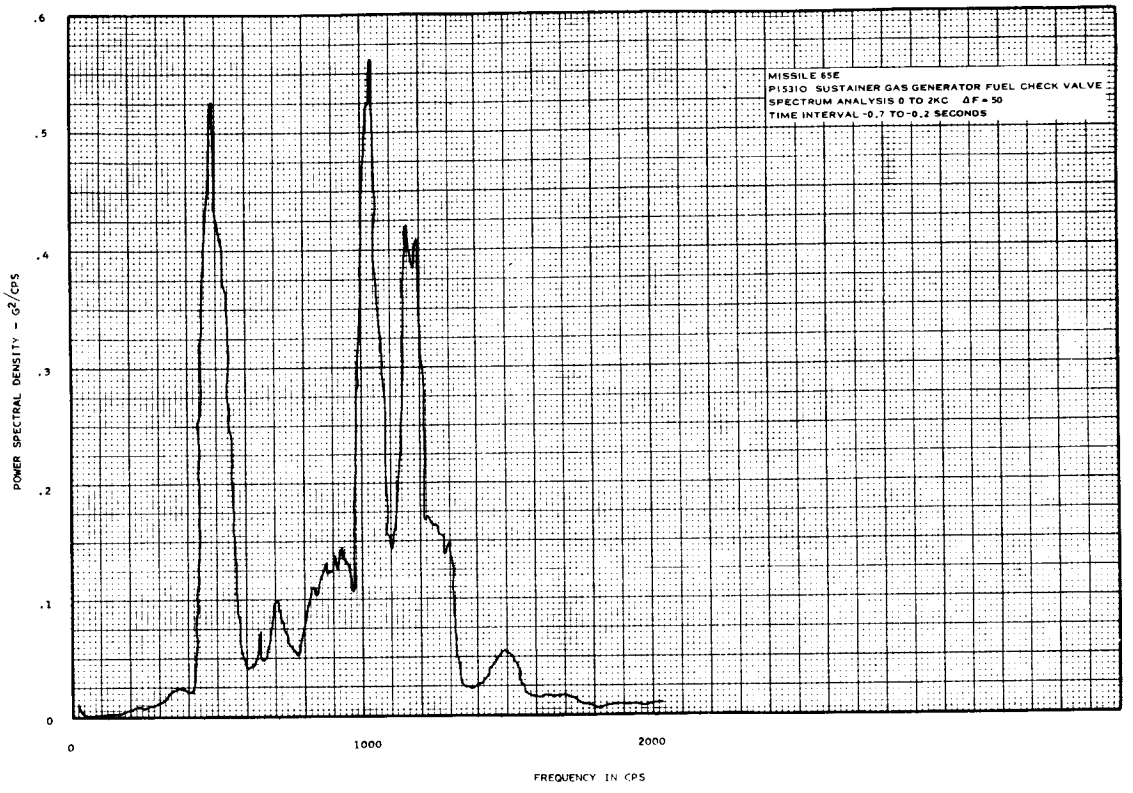

MISSILE 65E A1588O
HEATSHIELD ACCEL., QUAD I-II, Z AXIS
SPECTRUM ANALYSIS 0 TO 2KC, ΔF=10CPS
TIME INTERVAL +1 TO +2 SECONDS
1.0
.5
0
G²/CPS
0
400
800
1200
1600
2000
FREQUENCY IN CPS

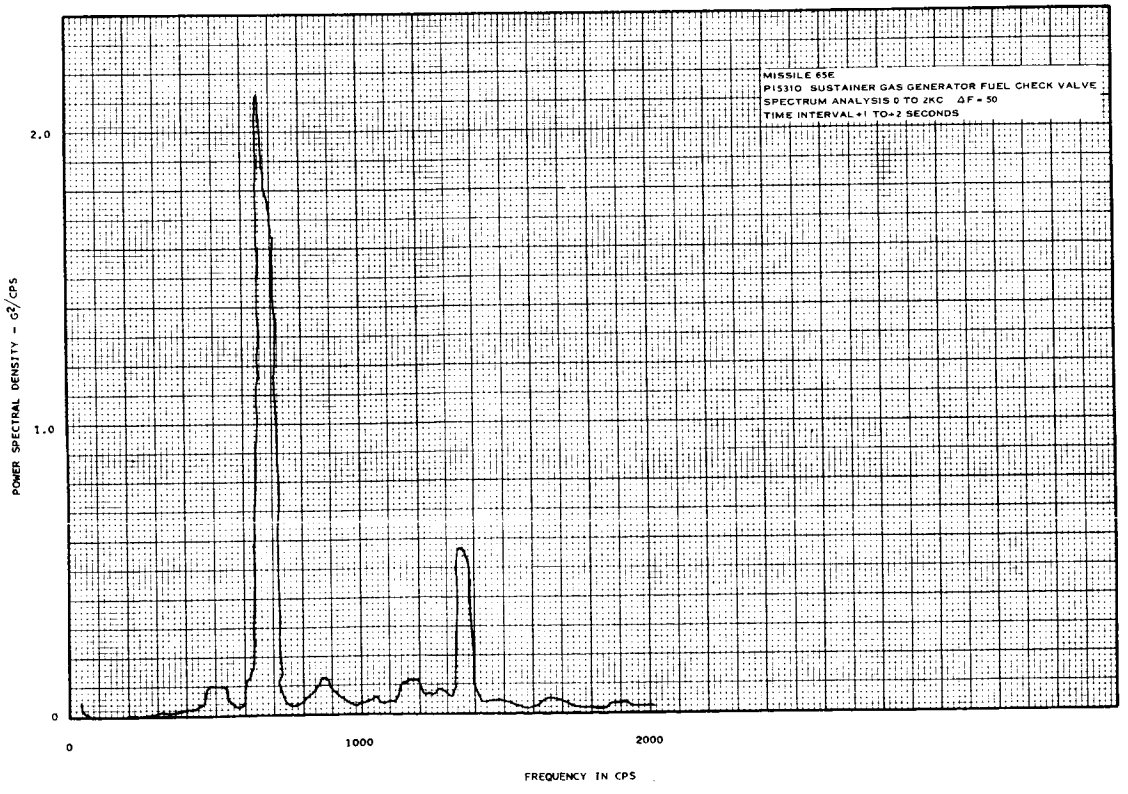

MISSILE 65E F1185O
LOX TANK REGULATOR - RADIAL
SPECTRUM ANALYSIS 0 TO 2KC, ΔF=10CPS
TIME INTERVAL +1 TO +2 SECONDS
1.0
.5
0
G²/CPS
0
400
800
1200
1600
2000
FREQUENCY IN CPS

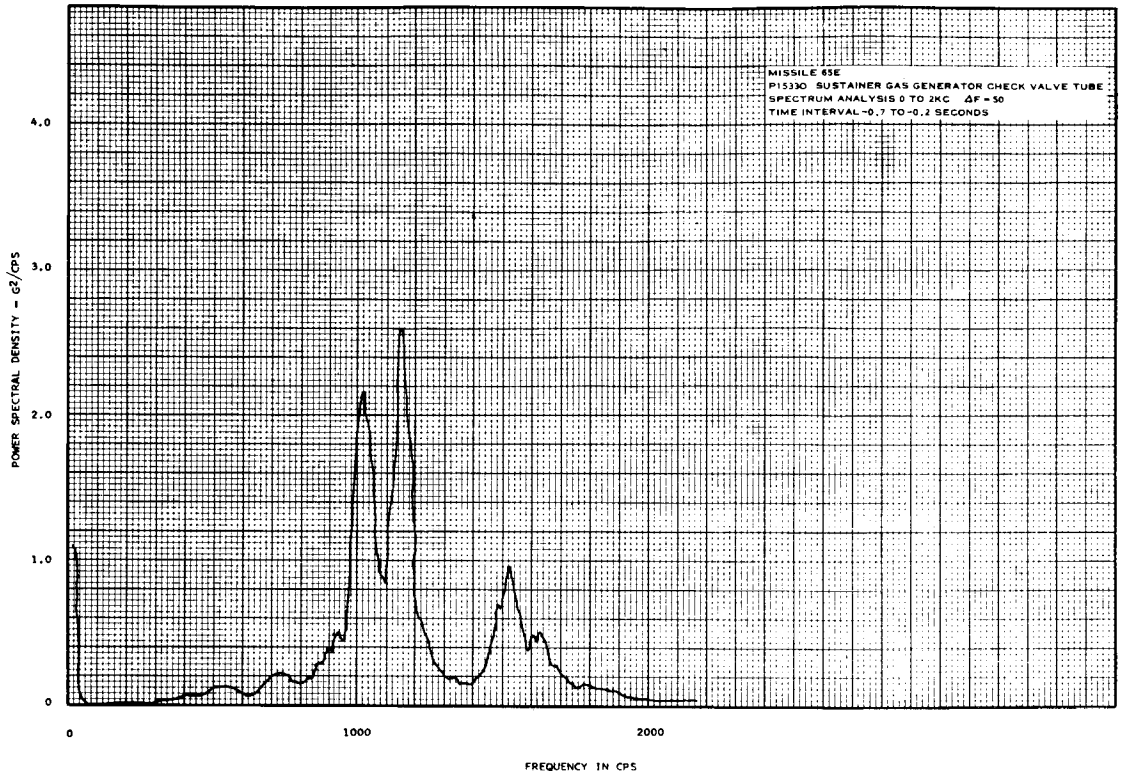

MISSILE 65E
P14510 SUSTAINER HYDRAULIC RETURN LINE QUAD III
SPECTRUM ANALYSIS 0 TO 2KC ΔF = 50
TIME INTERVAL -0.7 TO -0.2 SECONDS
POWER SPECTRAL DENSITY - G²/CPS
0.2
0.1
0
0
1000
2000
FREQUENCY IN CPS

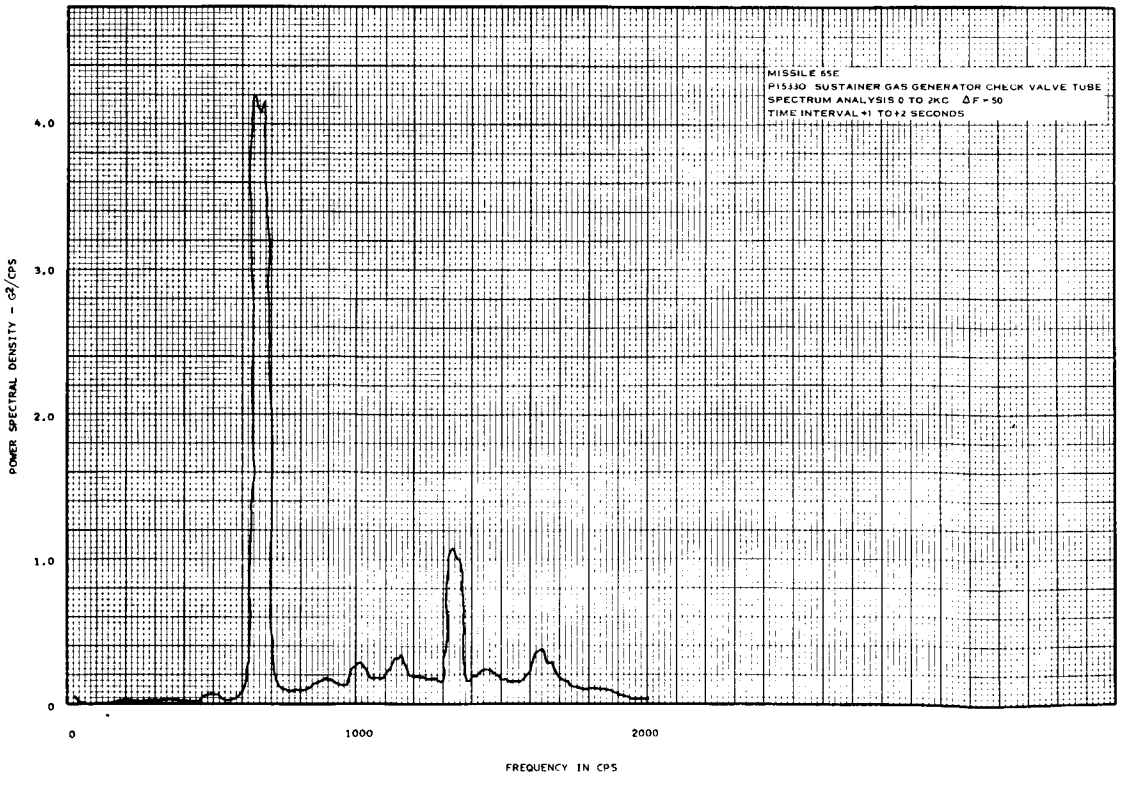

MISSILE 65E
P14510 SUSTAINER HYDRAULIC RETURN LINE QUAD III
SPECTRUM ANALYSIS 0 TO 2KC ΔF = 50
TIME INTERVAL +1 TO +2 SECONDS
POWER SPECTRAL DENSITY - G²/CPS
1.0
.5
0
0
1000
2000
FREQUENCY IN CPS

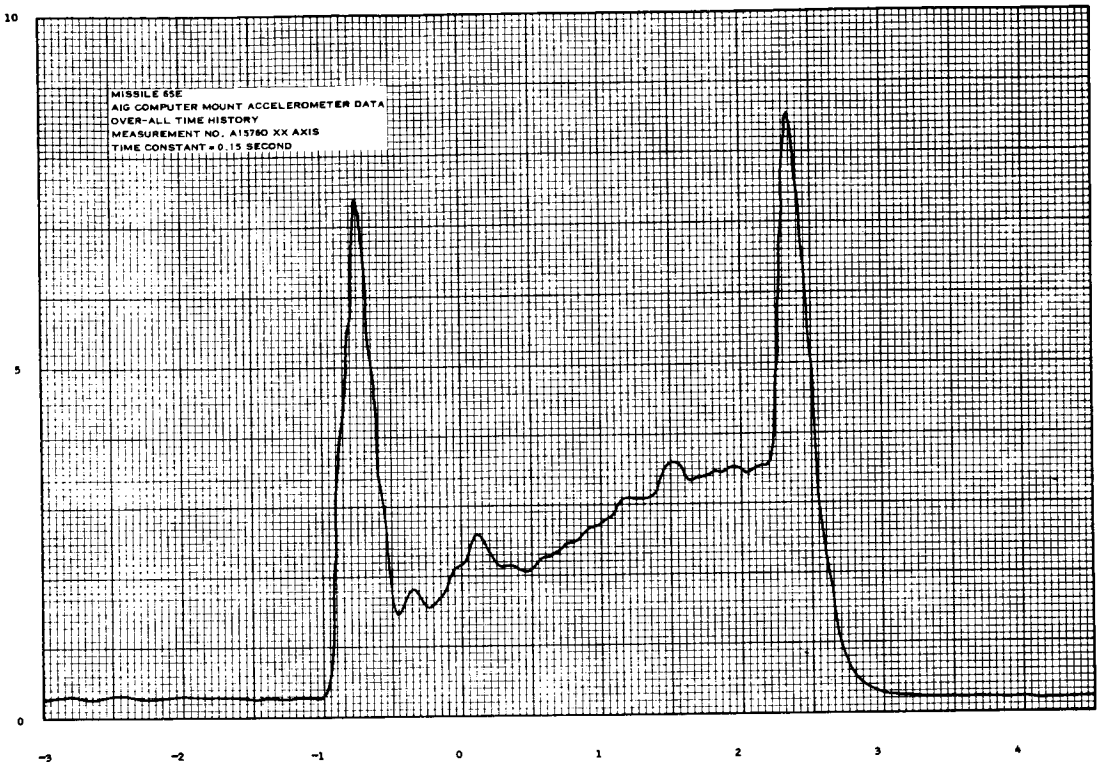
65E

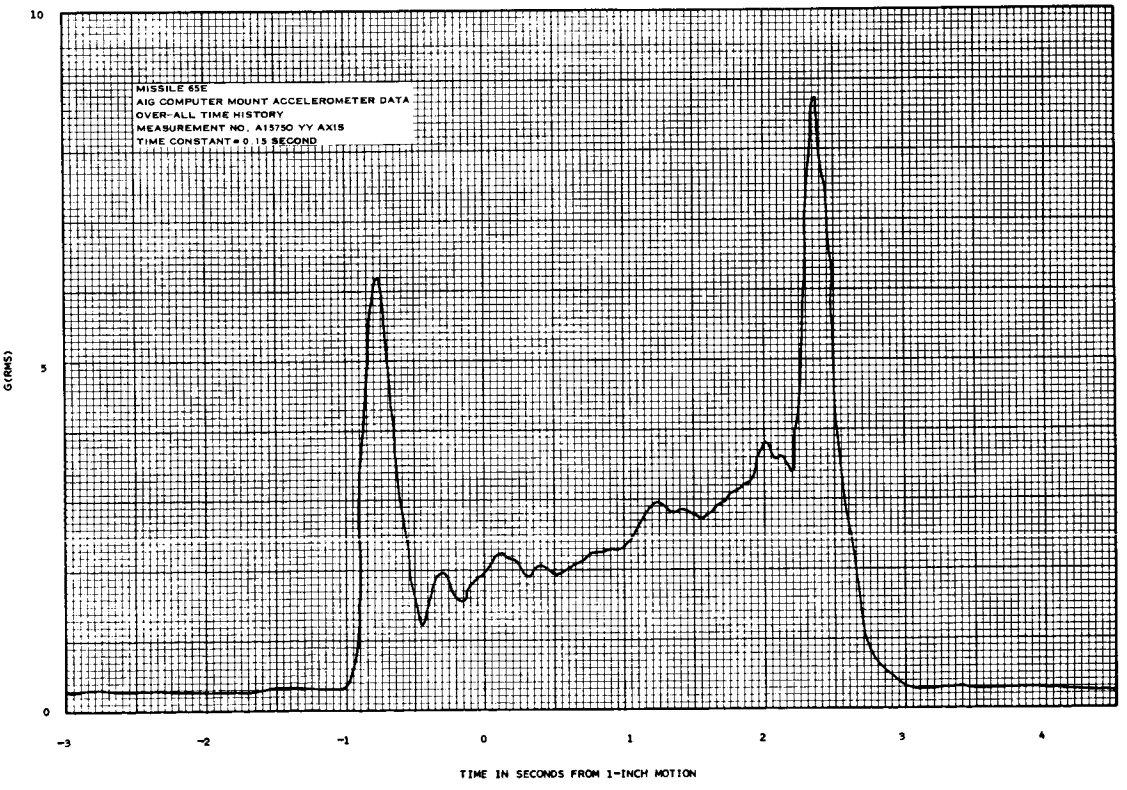

MISSILE 65E
P15310 SUSTAINER GAS GENERATOR FUEL CHECK VALVE
SPECTRUM ANALYSIS 0 TO 2KC ΔF = 50
TIME INTERVAL -0.7 TO -0.2 SECONDS
POWER SPECTRAL DENSITY - G²/CPS
.6
.5
.4
.3
.2
.1
0
0
1000
2000
FREQUENCY IN CPS

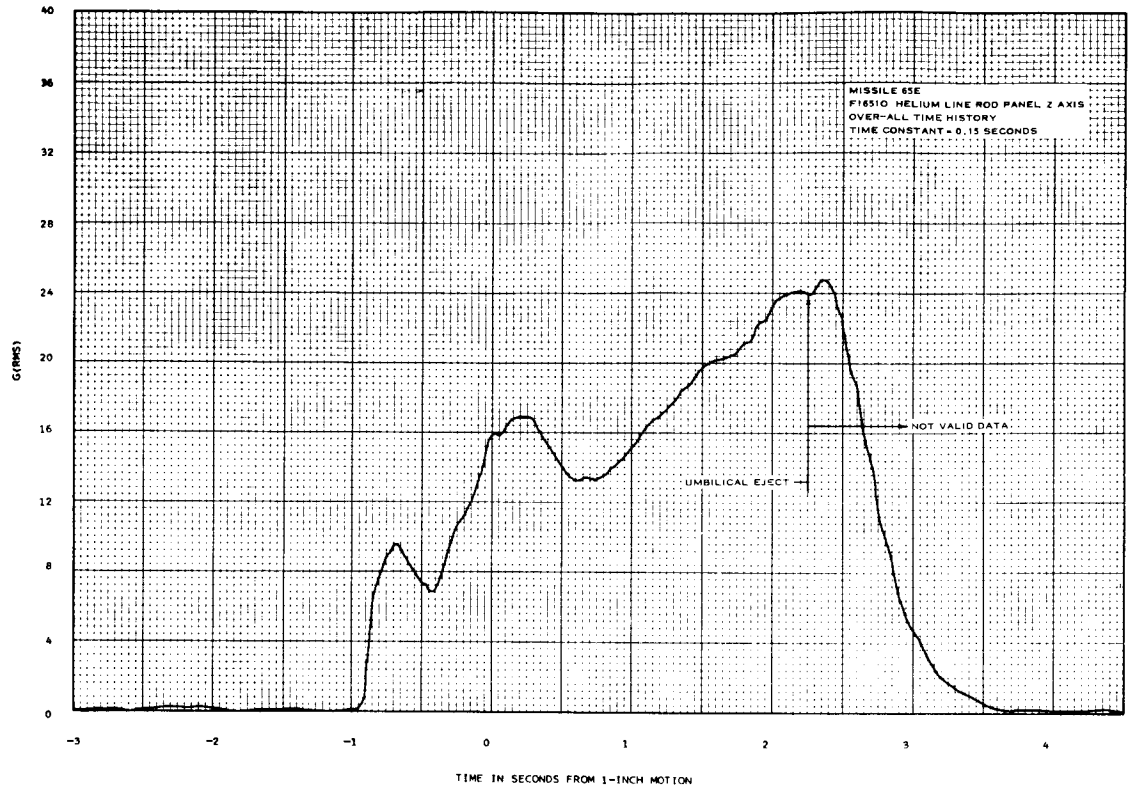

MISSILE 65E
P15310 SUSTAINER GAS GENERATOR FUEL CHECK VALVE
SPECTRUM ANALYSIS 0 TO 2KC ΔF = 50
TIME INTERVAL +1 TO +2 SECONDS
POWER SPECTRAL DENSITY - G²/CPS
2.0
1.0
0
0
1000
2000
FREQUENCY IN CPS

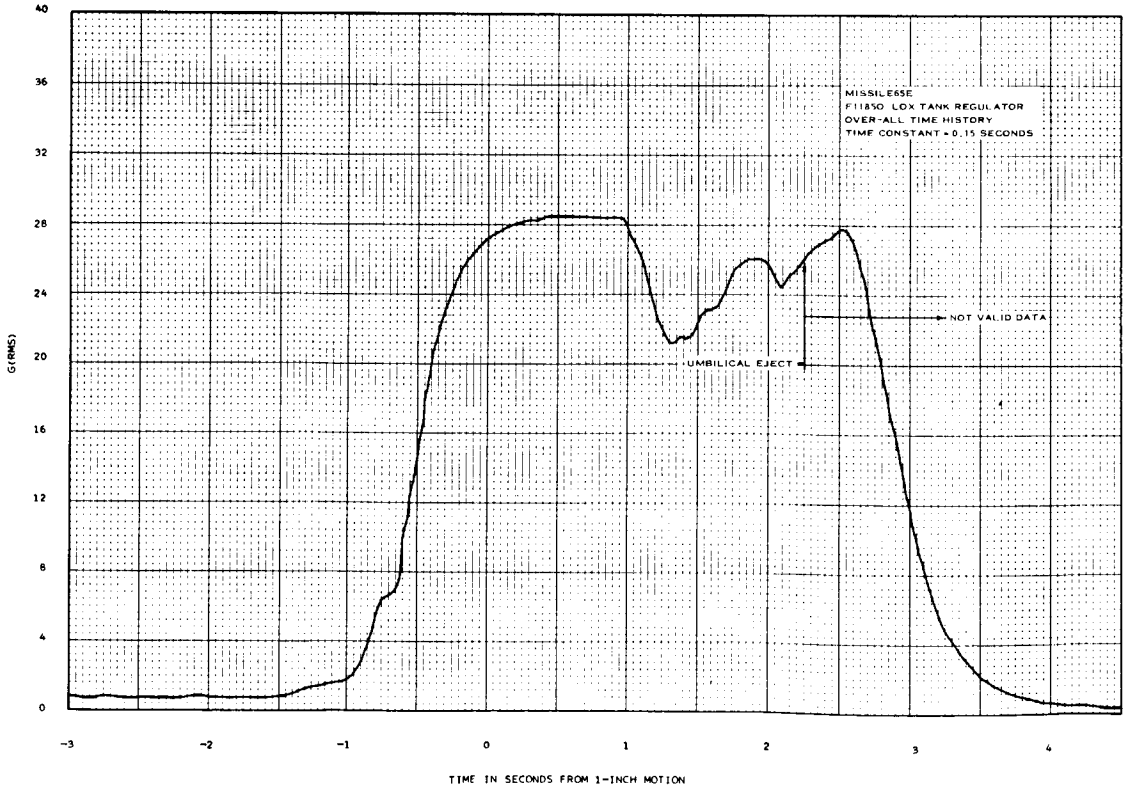

MISSILE 65E
P15330 SUSTAINER GAS GENERATOR CHECK VALVE TUBE
SPECTRUM ANALYSIS 0 TO 2KC ΔF = 50
TIME INTERVAL -0.7 TO -0.2 SECONDS
POWER SPECTRAL DENSITY - G²/CPS
4.0
3.0
2.0
1.0
0
0
1000
2000
FREQUENCY IN CPS


MISSILE 65E
P15330 SUSTAINER GAS GENERATOR CHECK VALVE TUBE
SPECTRUM ANALYSIS 0 TO 2KC ΔF = 50
TIME INTERVAL +1 TO +2 SECONDS
POWER SPECTRAL DENSITY - G²/CPS
4.0
3.0
2.0
1.0
0
0
1000
2000
FREQUENCY IN CPS

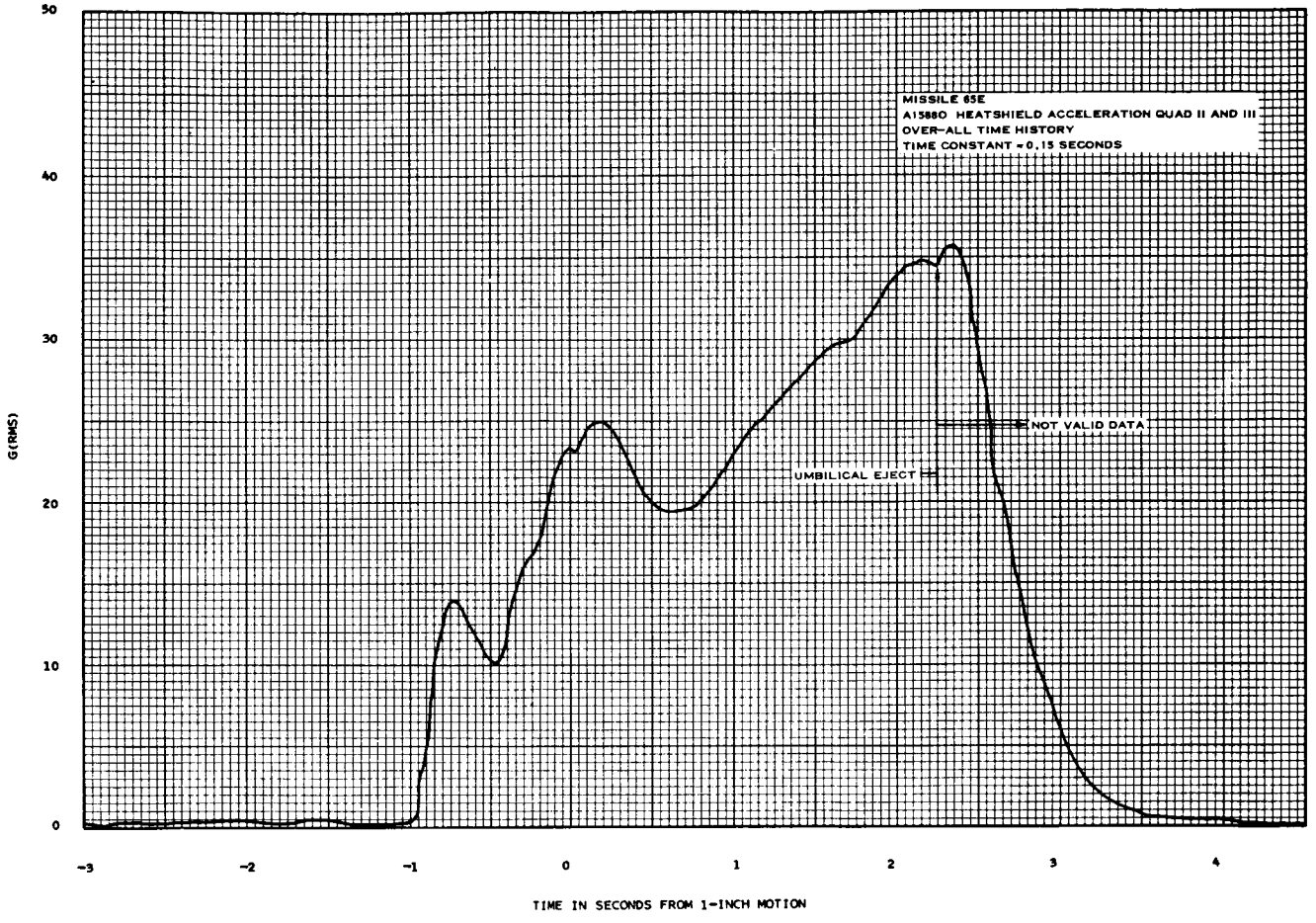

MISSILE 65E
AIG COMPUTER MOUNT ACCELEROMETER DATA
OVER-ALL TIME HISTORY
MEASUREMENT NO. A15780 XX AXIS
TIME CONSTANT = 0.15 SECOND
10
5
0
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION


MISSILE 65E
AIG COMPUTER MOUNT ACCELEROMETER DATA
OVER-ALL TIME HISTORY
MEASUREMENT NO. A15750 YY AXIS
TIME CONSTANT = 0.15 SECOND
G(RMS)
10
5
0
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION


MISSILE 65E
F16510 HELIUM LINE ROD PANEL Z AXIS
OVER-ALL TIME HISTORY
TIME CONSTANT = 0.15 SECONDS
NOT VALID DATA
UMBILICAL EJECT
G(RMS)
TIME IN SECONDS FROM 1-INCH MOTION


MISSILE65E
F11850 LOX TANK REGULATOR
OVER-ALL TIME HISTORY
TIME CONSTANT = 0.15 SECONDS
NOT VALID DATA
UMBILICAL EJECT
G(RMS)
TIME IN SECONDS FROM 1-INCH MOTION

65E

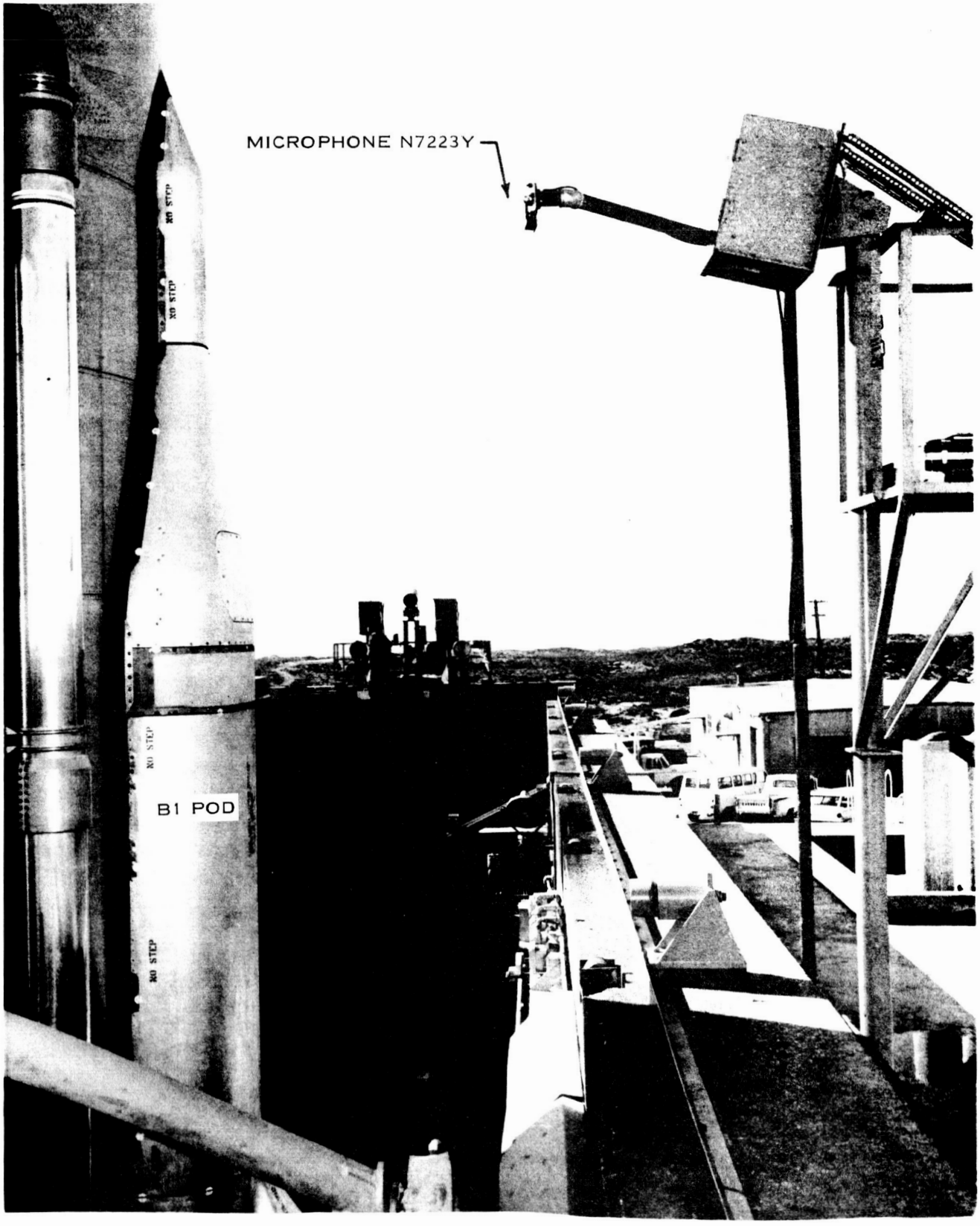

MISSILE 65E
A1588O HEATSHIELD ACCELERATION QUAD II AND III
OVER-ALL TIME HISTORY
TIME CONSTANT = 0.15 SECONDS
NOT VALID DATA
UMBILICAL EJECT
G(RMS)
50
40
30
20
10
0
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION

ACOUSTIC AND VIBRATION
FIGURE NO. 11-32
~~REPORT NO. GD/A63-0107~~

GD/A-DDE65-016

BOOM MICROPHONE INSTALLATION

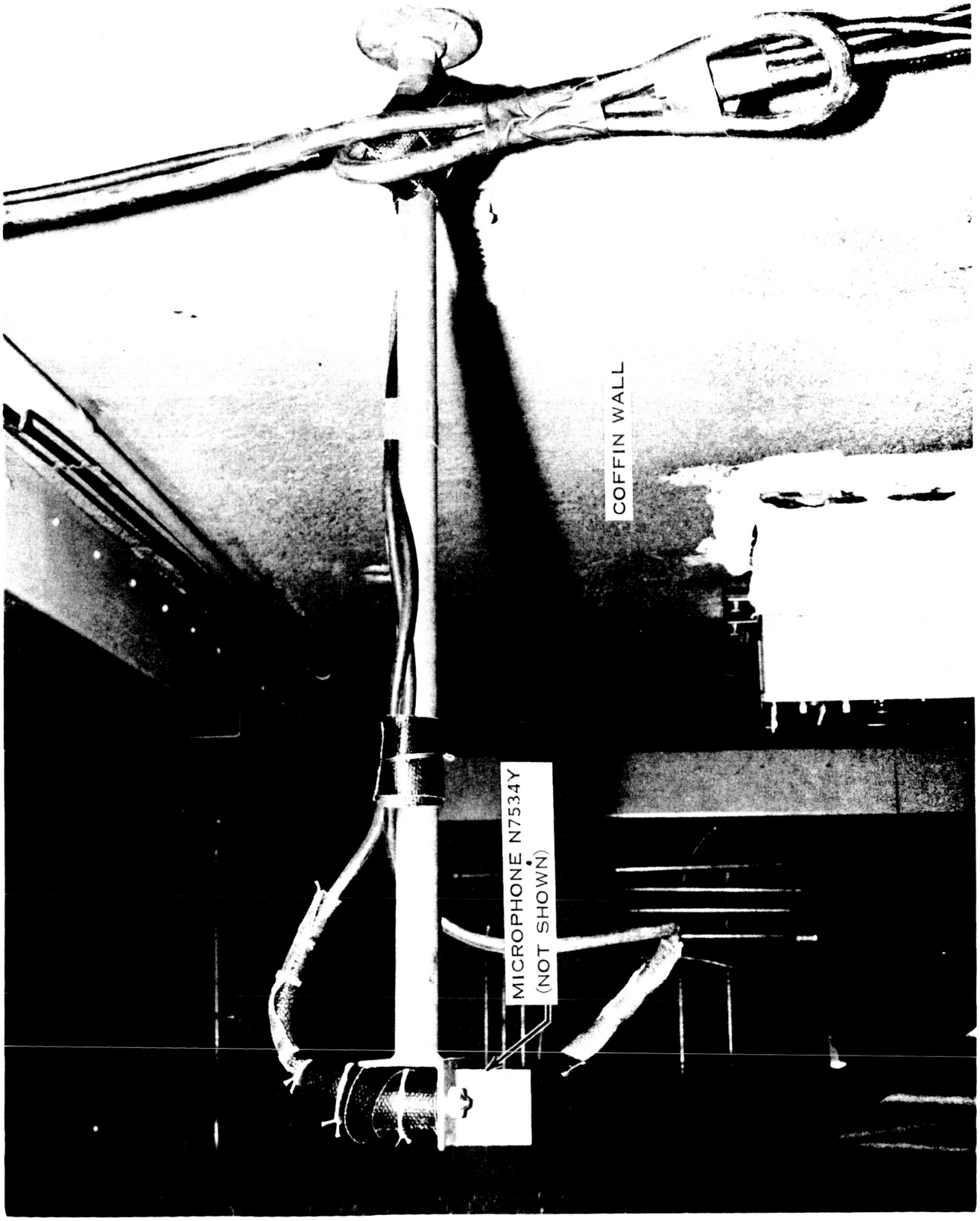
MISSILE 65E



65E

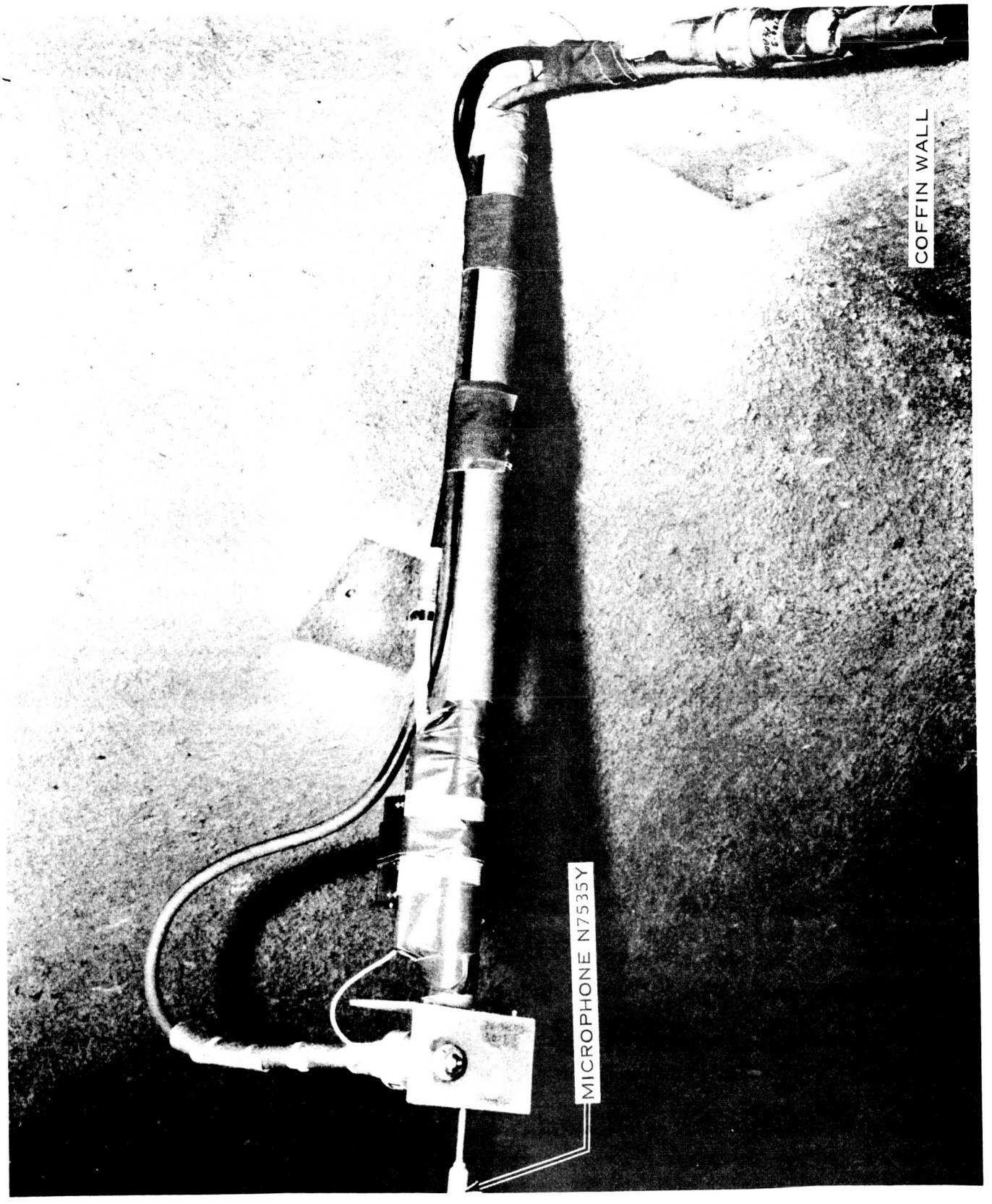
COFFIN MICROPHONE A

MISSILE 65E



MISSILE 65E

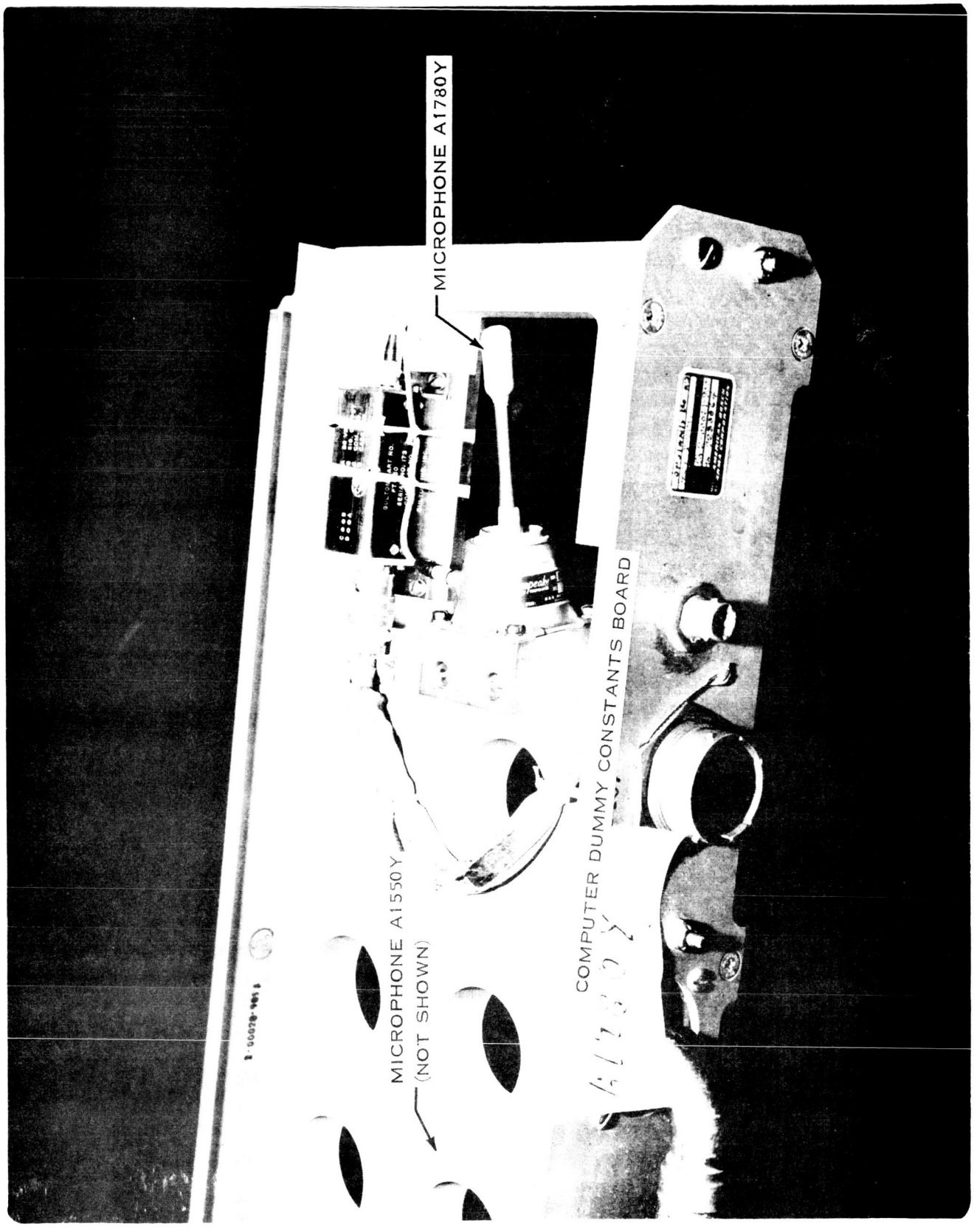
COFFIN MICROPHONE B



65E

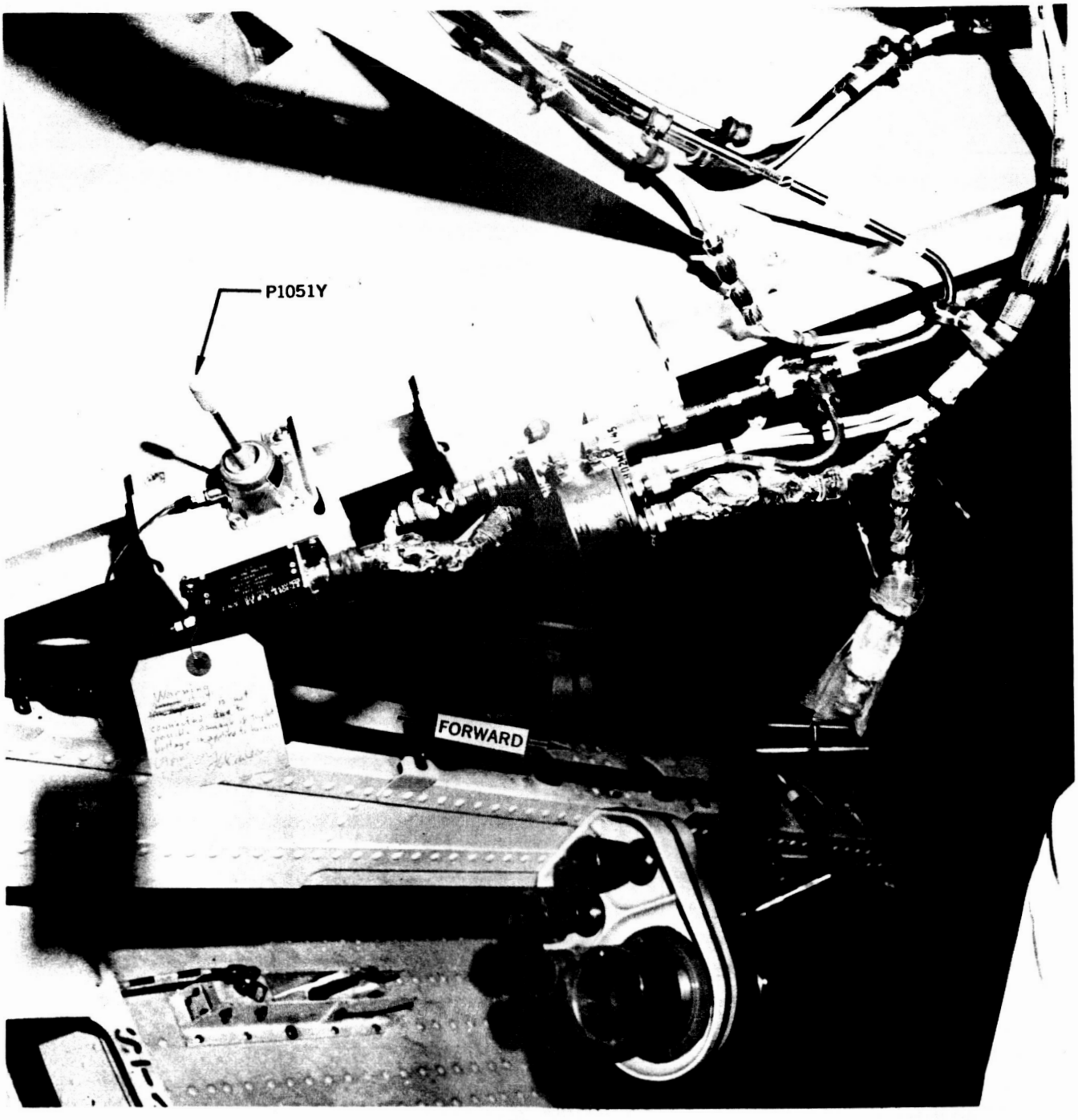
CONSTANTS BOARD

MISSILE 65E



ENGINE COMPARTMENT ACOUSTIC
MICROPHONE INSTALLATION

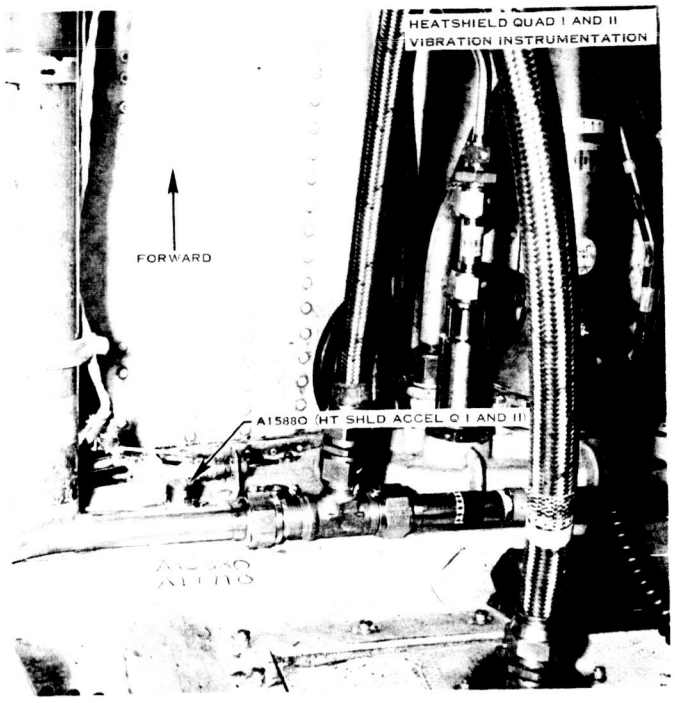
MISSILE 65E

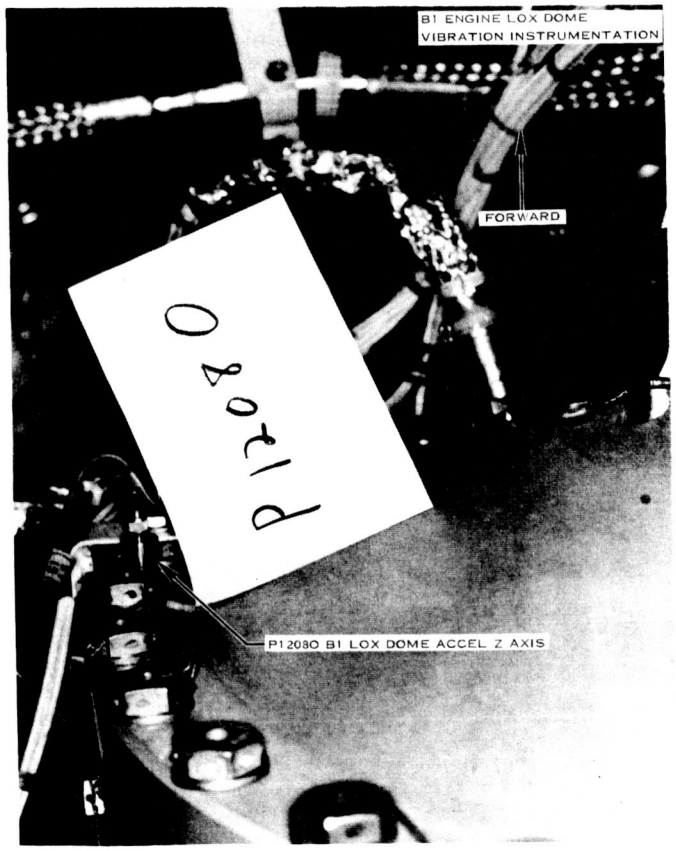


65E

AIG COMPUTER MOUNT ACCELEROMETER
INSTRUMENTATION (MISSILE 75F PHOTO)

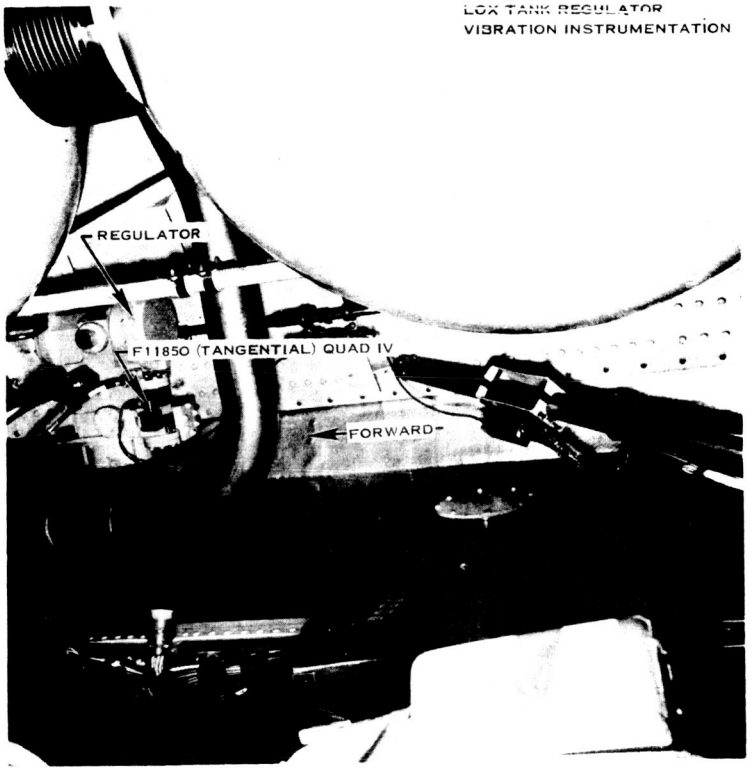



HEATSHIELD QUAD I AND II
VIBRATION INSTRUMENTATION
FORWARD
A15880 (HT SHLD ACCEL Q I AND II)

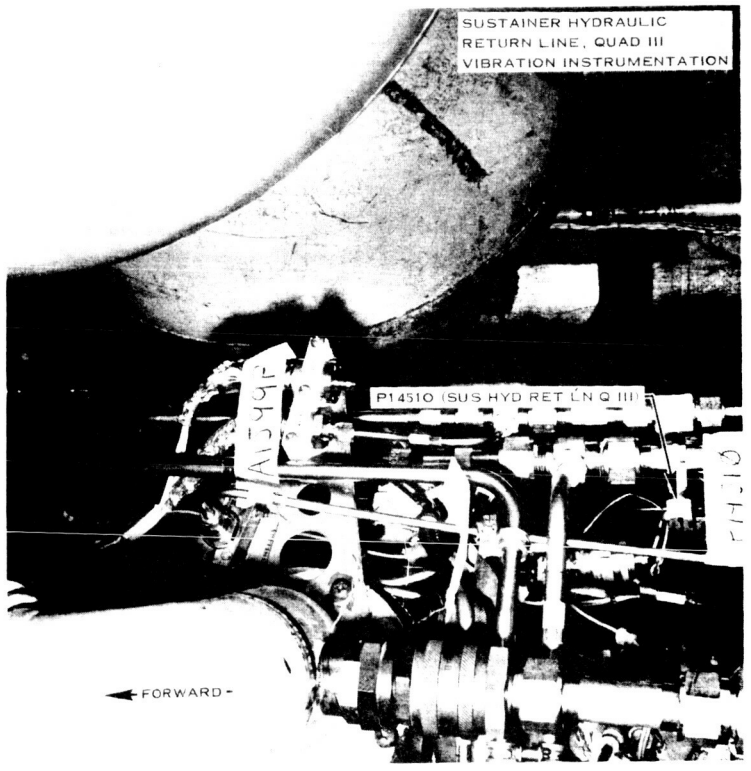

B1 ENGINE LOX DOME
VIBRATION INSTRUMENTATION
FORWARD
P12080
P12080 B1 LOX DOME ACCEL Z AXIS

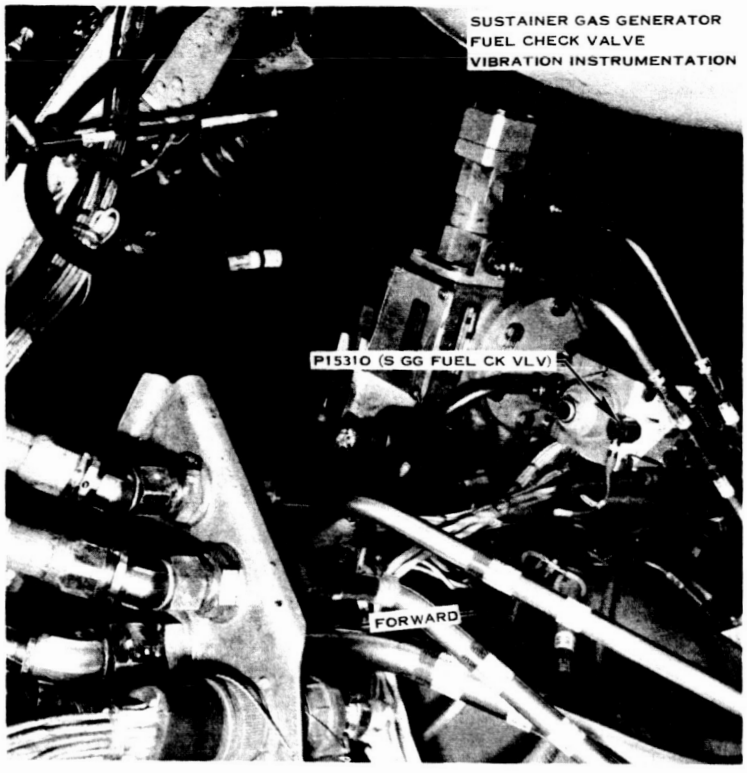
65E

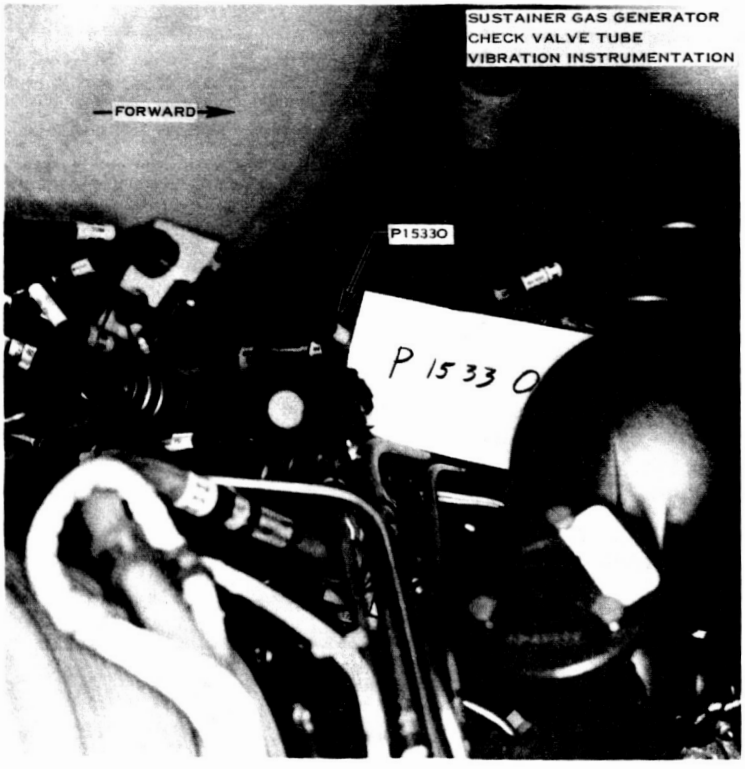
LOX TANK REGULATOR
VIBRATION INSTRUMENTATION



SUSTAINER HYDRAULIC
RETURN LINE, QUAD III
VIBRATION INSTRUMENTATION




SUSTAINER GAS GENERATOR
FUEL CHECK VALVE
VIBRATION INSTRUMENTATION
P15310 (S GG FUEL CK VLV)
FORWARD


SUSTAINER GAS GENERATOR
CHECK VALVE TUBE
VIBRATION INSTRUMENTATION
FORWARD
P15330
P 15330

SECTION 6.2.16

MISSILE 67E

FLIGHT TESTED 7-13-62

AT OSTF NO. 1

TEST REPORT AE62-0692

SECTION 10

LAUNCH VIBRATION AND ACOUSTIC ANALYSIS

Three vibration and seven acoustic measurements were attempted during the launch of Missile 67E. Specific components within the thrust section were monitored for vibrations to study their response to the launch environment of a coffin configuration. The acoustic measurements were made primarily to determine the acoustic environment around the Arma AIG computer. The manufacturer of the AIG system (Arma) believed that recent inflight problems with the operation of the AIG computer may be attributed to the effects (at launch) of excessive sound pressure on the computer electronic components. The environment was to be established so that test specifications could be formulated for pending laboratory acoustic ground tests to be performed on the computer.

The high frequency vibration environment appeared normal within the thrust section during launch. Significant low frequency components ranging between 12 and 16 cps were noted, however, and effort is now being made to validate the outputs. A comparison of the vibration data and other coffin environmental measurements is being made in an attempt to better understand the source and the effects of the apparent thrust rise transient pressure shock at approximately -0.5 seconds.

The acoustic environment around and within the AIG pod was established. Specific test specifications have been formulated for subsequent acoustic lab tests to be conducted on the AIG computer configuration. The results of the lab tests should provide an acoustic envelope for safe computer operation. The acoustic environment around the AIG computer will be measured again on Missile 64E from OSTF-1 test site.

Vibration Analysis

Three landline vibration measurements were obtained from Missile 67E launch operations for the evaluation of the vibration environment of the booster engine thrust chambers and the lox tank pressure regulator. Objectives were only partially successful due to instrumentation difficulties encountered on the booster thrust chamber measurements.

The B2 engine thrust chamber measurement and the lox tank regulator measurement were recorded via an FM landline system. The B1 engine thrust was recorded on a direct-writing oscillograph. The frequency band of analysis for each was 20-2000 cps.

Thrust Chamber Vibration

High frequency accelerometers were installed on the lox dome of the booster engines thrust chambers. The measurement numbers and locations were as follows:

P1208O Booster No. 1 thrust chamber, Z-axis

P1209O Booster No. 2 thrust chamber, Z-axis

Approximately 3.5 seconds of data were obtained; from -1.5 to +2.29 seconds. Measurement P1208O was recorded on a direct-writing oscillograph and could not be spectral-analyzed. P1209O yielded qualitative data only due to difficulties in obtaining calibration data at the test site. An oscillograph recording is shown for measurement P1209O in Figure 10-1.

B1 steady-state vibration appeared normal with outputs ranging from 7.2 to 7.8 g (rms) and predominant frequency components of 1154 and 600 cps.

B2 yielded an erratic waveform with high noise content. Information was completely obscurred by noise from -1.8 to -0.3 seconds. Observed frequencies were a low level 12 to 14 cps oscillation and an 1100 to 1400 cps component. Data were qualitative only because of the lack of calibration information. The data became completely invalid at 1.5 seconds.

Lox Tank Pressure Regulator Vibration

Measurement F1185O mounted on the F&G type lox tank regulator showed satisfactory data for analysis purposes within the prescribed frequency band. A buildup was noted at -0.5 to -0.4 seconds with levels ranging between 30 and 40 g-peak at a frequency of 170 cps. The remainder of the recorded period was nearly steady-state with over-all levels fluctuating between 8.5 and 10.4 g(rms) and predominant frequency components of 12-14, 180, and 320 cps.

An oscillograph recording of measurement F1185O is shown in Figure 10-1. Power density spectra computations are presented in Figure 10-9.

Acoustic Analysis

Seven acoustic measurements were made around the missile at launch. The general locations of the coffin microphones are shown in Figure 10-11. The specific locations of all microphones are shown in Figures 14 through 16. The measurement numbers and pickup locations were as follows:

A1780Y AIG computer constants dummy board A

A1778Y AIG pod adjacent to computer

A1779Y AIG pod forward of computer

N7534Y Coffin opposite AIG pod

N7535Y Between N7534Y and N7536Y

N7536Y Coffin, opposite engine nacelle

Acoustic Test Setup

The instrumentation systems consisted of acoustic transducers, signal conditioners and a tape recorder.

The acoustic transducer utilized was a Model NM 125 high intensity microphone manufactured by Chesapeake Instrument Corporation. The high intensity microphones were self-generating piezoelectric ceramic acoustic sensors especially designed for measuring high noise levels under adverse environmental conditions. The base of the microphone holder had a vibration mount which isolated the sensor from lower frequency vibrations. The microphones had a nominal sensitivity of -106 db, db re. IV/microbar, and a linear dynamic pressure range from 95-250 db, db re. 0.0002 dynes/om^2.

The signal conditioner consisted of preamplifier, filter, attenuator, and line amplifier. The preamplifiers used were the Model 5203-10 Columbia and the Model FT-8150 and Model KA-1006A Gulton units. These are transistorized preamplifiers that are physically located close to the microphones and used to match long cables. These units require 28 vdc to operate and were powered by a Model C-880M Lambda regulated power supply. The microphones and preamplifiers were located where the sounds were to be measured. The remaining portion of the instrumentation system was located in a safe area some distance away from the microphone locations and connected by low capacitance cable to the preamplifiers.

The signal from the preamplifier was fed into a filter network. This filter network was used to compress the signal before it was placed on the magnetic tape to retain the 20 to 20,000 cps frequency band within the desired dynamic range. After the signal leaves the filter it goes into a Model 350B attenuator set and a Model 450 line amplifier, both manufactured by the Hewlett-Packard Co. The attenuator and amplifier were used to set the signals that were to be recorded at a correct level for recording. The signal from the amplifier was then fed into the Model PI 200 "Recorder-Reproducer" magnetic tape recorder manufactured by Precision Instrument Company. This is a 14 channel tape recorder that was operated in the FM mode at 60 IPS with a center carrier frequency of 108K cps.

The tape recorder was controlled during the firing using a remote control setup located in the blockhouse.

Calibration

The calibration procedure used consisted of microphone calibration, instrumentation system calibration, and tape recorder calibration.

The microphones were calibrated by Western-Electro-Acoustic Laboratories in Los Angeles, California. They were calibrated at perpendicular incidence in a frequency range from 20 to 20,000 cps.

The instrumentation system was level calibrated end-to-end using the Model 155 coupler manufactured by Bruel and Kjaer Co. The coupler was placed over the microphone and the acoustic signal from the coupler was converted into an electrical signal by the microphone and sent through the entire instrumentation system and onto magnetic tape. The instrumentation system was frequency calibrated by inserting into the preamplifier input a constant voltage, one frequency at a time in the frequency range from 20 to 20,000 cps. This was also placed on magnetic tape.

The tape recorder was calibrated according to its instruction manual. It was adjusted for a 1 volt rms (1.414 volt peak) input to produce a full 40% deviation.

After the calibration procedure had been completed and before the missile firing took place, the attenuator and line amplifiers were set for a maximum utilization of the dynamic range of the tape recorder using estimated sound-pressure levels as a guide.

In playing the magnetic tapes back for data reduction purposes the outputs were expanded to compensate for the filtered treatment accomplished during the recording period. A schematic of the data reduction facility is shown in Figure 10-12. Constant band width analysis was selected for evaluation purposes since significant emphasis was being placed on determining the near discrete frequency components of the signal that may have existed within the 20 to 20,000 cps frequency band.

Test Results

All measurements provided good data except N7536Y which was partially valid or extremely questionable. The coffin data was usable until approximately 1.3 seconds following 1-inch motion at which time the missile vertical rise was such that the engine thrust chamber cone end was even with or just beyond the microphone locations. Figure 10-10 shows the missile vertical rise data obtained from several Series E missile flight tests. Significant data were obtained from the microphones within the missile AIG pod area until 2.3 seconds, which was the approximate time the trailing wire umbilical cable (40 feet in length) disconnected.

The time history plots of Sound Pressure Level (SPL) are shown in Figures 10-2 and 10-3. Each measurement showed significant response to the pressure shock condition (reference airframe section) that occurred at approximately -0.5 seconds and a subsequent leveling off of intensities until the time all data was terminated. The same general characteristics were exhibited by the two coffin acoustic measurements obtained from the launch of Missile 66E, which was launched from the same site. The over-all sound pressure levels are shown in Table 10-1, while Table 10-2 shows the instantaneous peak pressure level obtained at each location during the thrust rise transient (pressure pulse) period. SPL spectral plots are shown in Figures 10-4 through 10-7 inclusive. Power spectral density plots are shown of A1780Y and A1779Y in Figure 10-8 which depicts the power difference prevailing through the exhaust vents at the forward end of the computer. Figure 10-7 shows a spectral composite of AIG pod acoustic data obtained from various test missiles.

In viewing the time history plots it was evident that the pre-ignition over-all levels (background) were higher than expected. Preliminary investigations of the raw data showed that frequency terms below approximately 100 cps were being amplified in playback of the tape as the result of applying the correction for signal conditioning during the recording period. It was quite evident, however, that all measurements were displaying a space background level of less than 90 db at 20,000 cps and between approximately 100 and 110 db from 200 to 10,000 cps. It was apparent that the test data was not effected by the aforementioned condition. The pre-ignition over-all background levels noted in the referenced time history plots are uncorrected.

In viewing Table 10-1 it was quite evident that N7534Y showed considerable variation. The level obtained from Missile 67E would appear to be more reasonable than that obtained from Missile 66E (N7534Y) since the coffin configuration would support an increase in over-all sound intensity. Missile 66E data appeared comparable to the levels resulting from the static tests. In comparing N7534Y spectra plots, Missile 67E data showed a 15 db increase across the spectrum. In comparing spectral plots of N7536Y the two missile test results were fairly similar, and within expected differential tolerances. The difference that N7534Y displays between missile tests can not be explained at this time, but shall be verified during the forthcoming launch of Missile 64E.

The over-all levels indicated that the acoustic intensity at the computer forward exhaust and constants board area were nearly identical. The A1778Y data indicated 7 to 11 db difference (decrease) adjacent to the computer. The increased level within the computer may be explained by the A1779Y measurement. Since A1779Y is identical to A1780Y, it is evident that the increase is emanating from the reflective properties of the pod forward bulkhead. Static tests have shown that open or closed pod coolant ducts have no effect on the levels within the computer. The over-all levels also indicate a reduction through the AIG pod cover of 15.5 db which compares very closely to reduction levels obtained from AIG pod acoustic ground tests.

Generally, the SPL spectral computations show a random output that exhibited the greater energy content within the 10 to 2000 cps frequency band. The general shape of the spectra on all measurements was very similar except for A1778Y which showed discrete or predominant components at 800 and 1600 cps. The data was re-run for verification purposes and did not change. These discrete outputs may be associated with the resonance characteristics of the pod cover.

The acoustic environment within the thrust section was moderate.

The discussions shown above were for the period following the approximate time that 90 per cent thrust occurred. Significant outputs were noted during the thrust rise period. High level response to a pressure shock condition was noted between -0.5 and -0.25 seconds. The microphone outputs displayed a maximum buildup within approximately two cycles with the maximum instantaneous peaks as shown in Table 10-2. Following the pressure pulse condition, all outputs decreased to a near steady level with a very apparent predominant frequency of approximately 10 cps. The higher frequency components were superimposed on the lower term, naturally. The pressure levels within the AIG pod were well below the allowable structural level and Arma representatives indicated that the computer would probably function properly within the level and frequency environment noted above. The effects of the pressure shock condition on components within the thrust section is presently of concern. Investigations are now in progress utilizing the acoustic data and other environmental measurements obtained from the launch of Missile 67E.

The conclusions to be drawn are as follows:

1. The engine thrust rise transient provided a pressure shock condition that should be investigated. The potentially bad effects are of main concern in the thrust section area.

2. The coffin environment during the missile rise-off period was as expected.

3. The transmission of sound waves through the AIG computer forward exhaust vents should be investigated in the forthcoming laboratory tests, since the Missile 67E launch data showed nearly comparable over-all levels outside the vent and within the constants board area.

4. The data obtained from the Missile 67E test indicated that the acoustic environment is such that additional laboratory tests of several test computers would be necessary to prove that the present computer components are suitably isolated and that computer operation would be satisfactory within said environment. Ground laboratory tests to satisfy Items 3 and 4 are now in progress.

Table 10-1

Comparison of over-all sound pressure levels on Missiles 67E, 75F*, 66E, and 2E* for the period immediately following approximately the time 90 percent thrust occurred.

Measurement Number	Missile Number/OA SPL (db) 67E Max	67E Min	66E Max	66E Min	75F Max	75F Min	2E Max	2E Min
A1780Y	152	146						
A1779Y	152.4	144						
A1778Y (A1761Y*)	143.5	139			140		143.5	
N7534Y (A1763Y*)	161	154.5	154	150	153		152	
N7535Y	161	159						
N7536Y (A1771Y*)	161Q	159Q	163.5	159.5	155		157	
P1051Y	149.5	145						

Q - Questionable Data

* - Static test missiles

Table 10-2

Missile 67E maximum instantaneous peak pressure during the thrust rise transient period (-0.5 to -0.25 second)

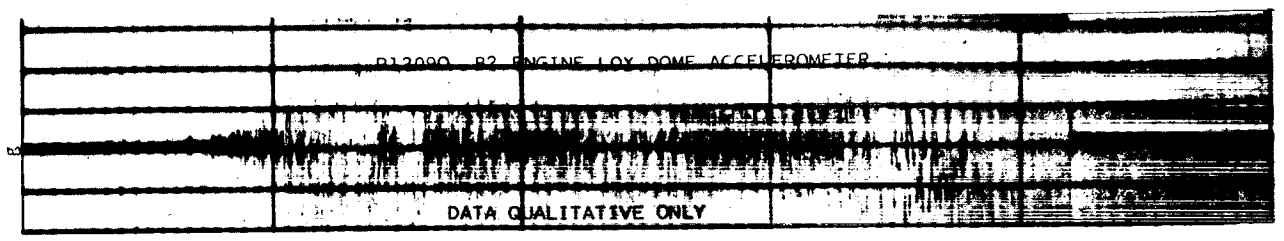
Measurement	Time (sec)	Peak Press (psi)
A1780Y	-0.430	0.68
A1778Y	-0.425	0.61
A1779Y	-0.425	0.68
N7534Y	-0.332	3.50
P1051Y	-0.430	1.34
N7535Y	-0.440	3.40

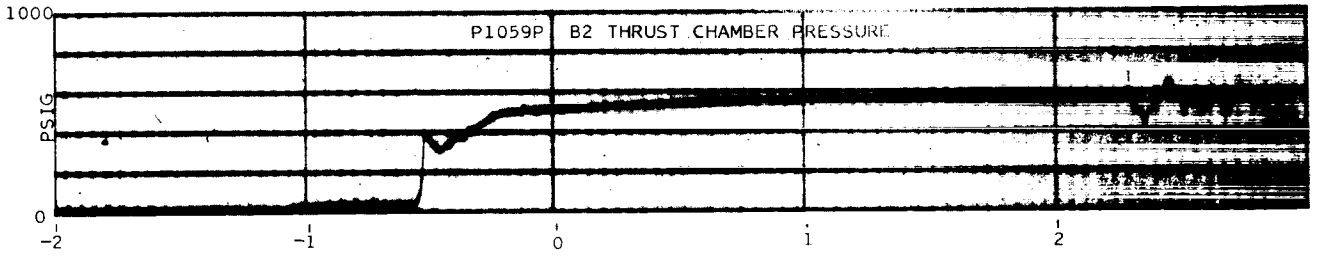
Note: Polarity of outputs could not be determined; however, the above peaks were in the same direction from reference zero.

Table 10-3

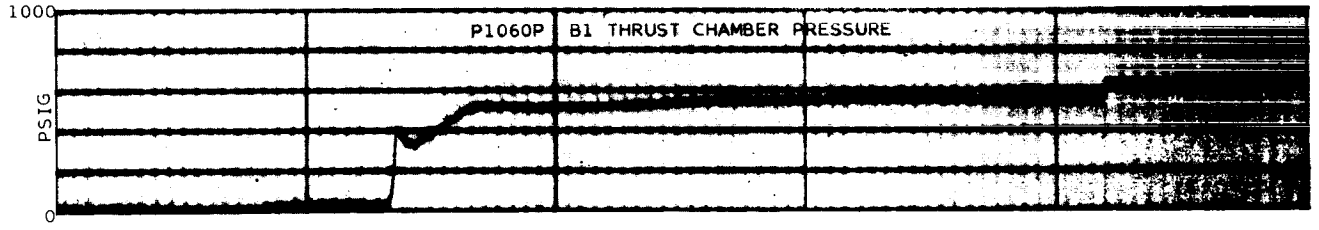
Summary of sound pressure levels at specific frequency components (+0.3 to +2.3 seconds)

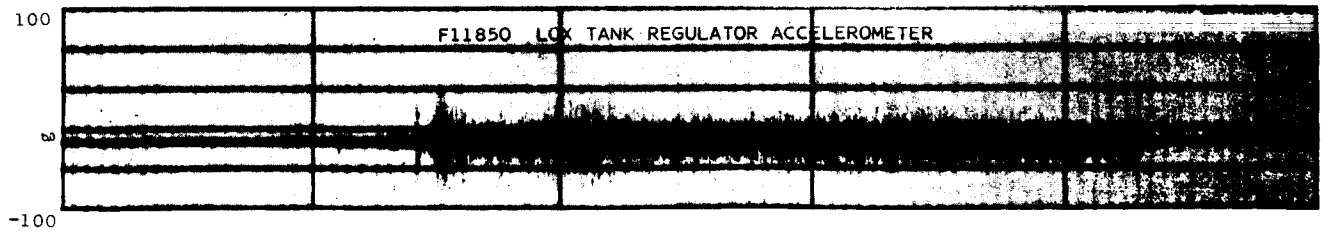
	20,000 cps F = 200	10,000 cps F = 200	5,000 cps F = 200	2,000 cps F = 50	200 cps F = 5
A1780Y	102.3 db	113.0 db	119.5 db	113.0 db	115.7 db
A1779Y	109.0 db	114.2 db	119.2 db	112.6 db	114.6 db
A1778Y	109.5 db	113.0 db	119.5 db	112.0 db	117.7 db
N7534Y	137.7 db	140.9 db	146.5 db	149.0 db	151.0 db
P1051Y	114.6 db	110.5 db	119.2 db	118.5 db	122.5 db
N7535Y	137.3 db	144.0 db	148.1 db	138.5 db	137.0 db





TIME IN SECONDS FROM 1-INCH MOTION





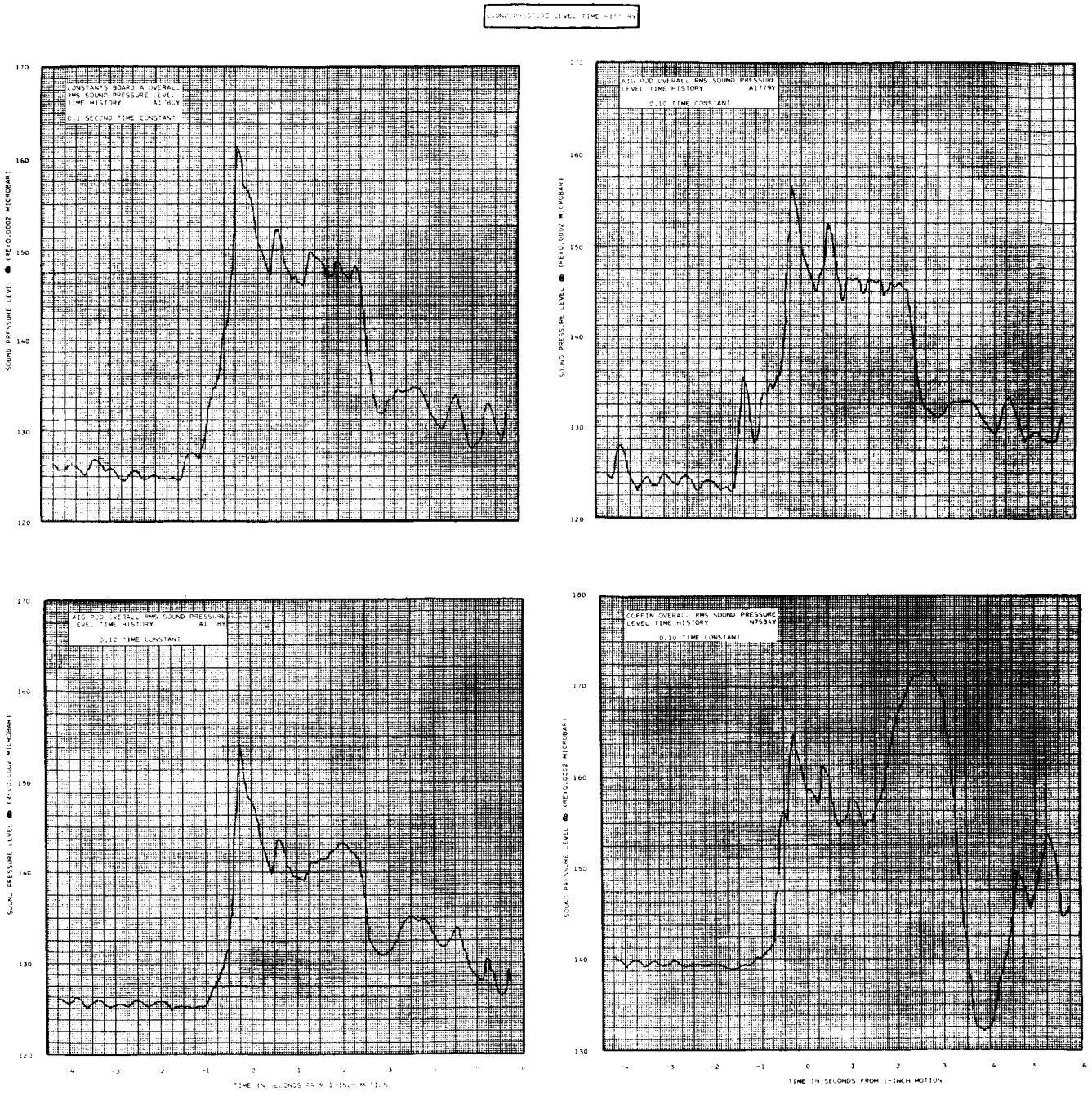
LAUNCH ACOUSTIC

FIGURE NO. 10-2

~~REPORT NO. AE62-0692~~

GD/A-DDE65-016

MISSILE 67E



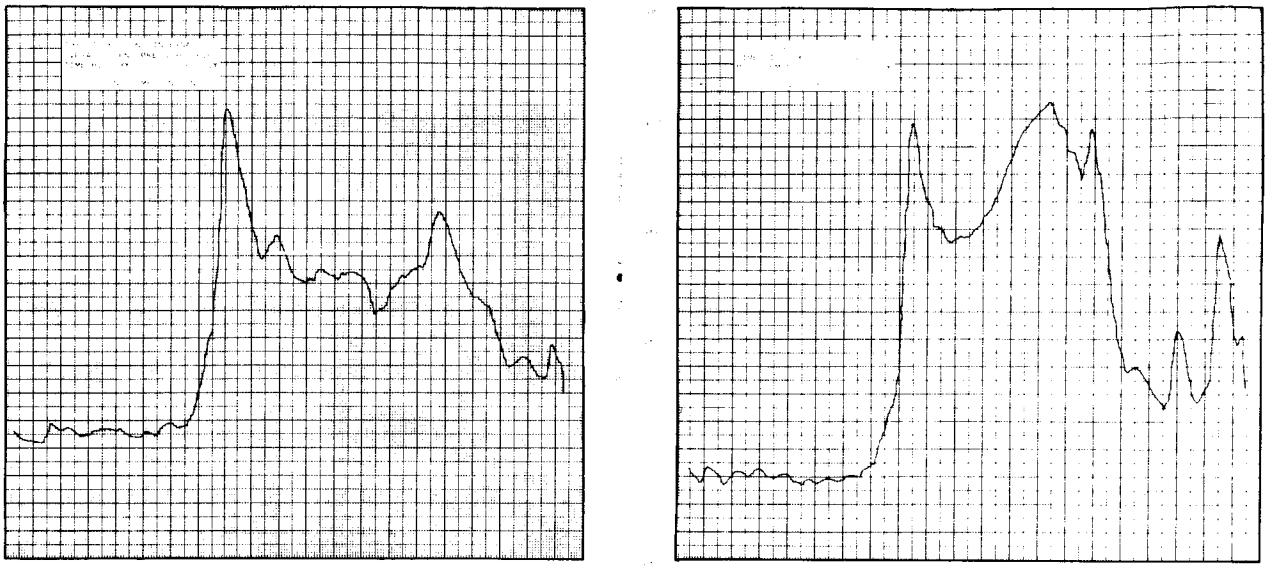
UNCLASSIFIED

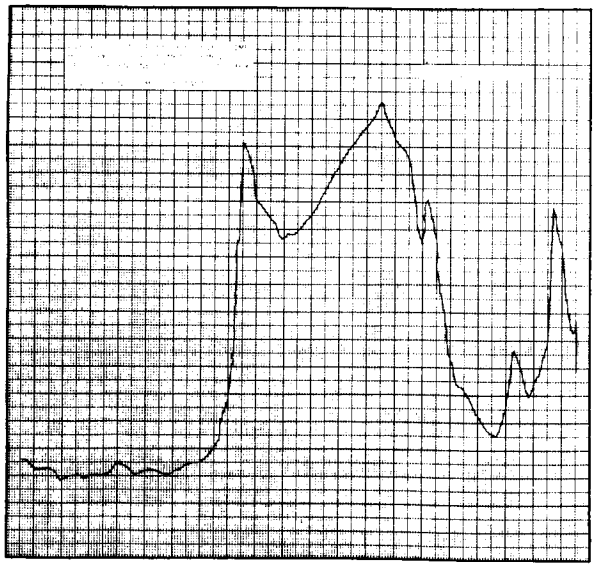
LAUNCH ACOUSTIC

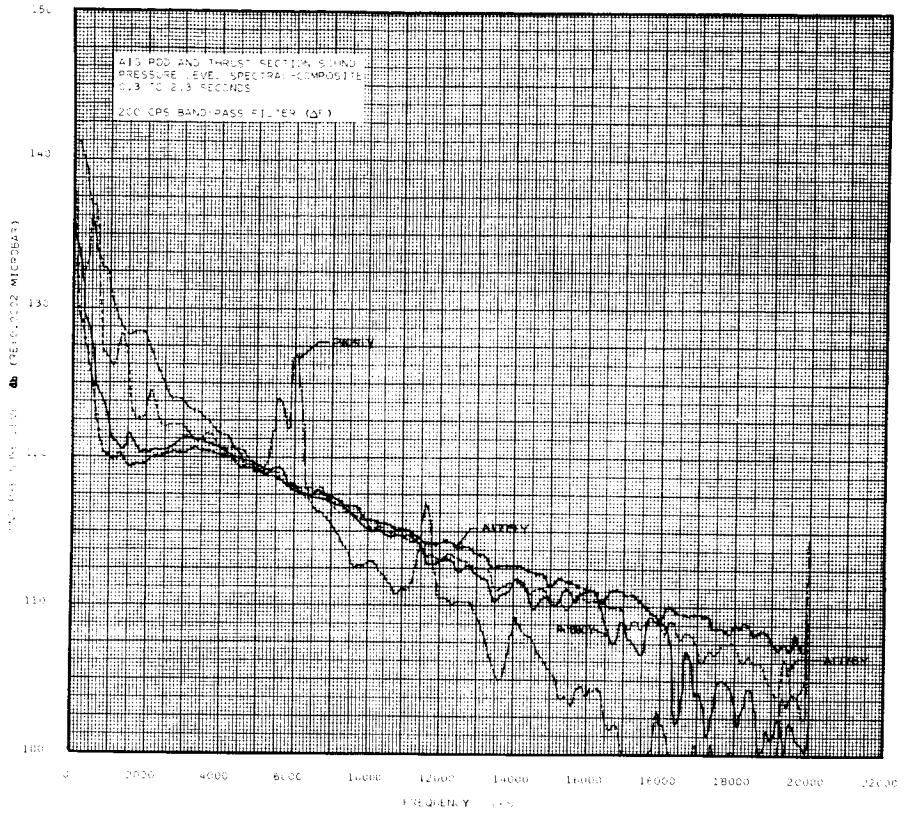
FIGURE NO. 10-3

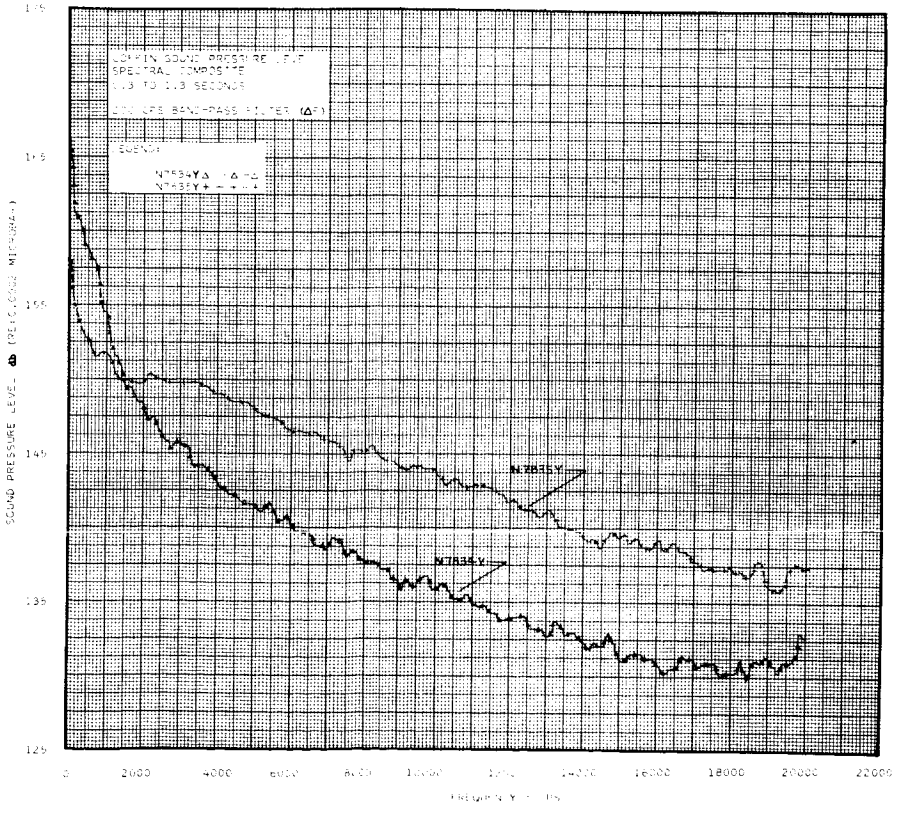
~~REPORT NO. AE62-0692~~

MISSILE 67E

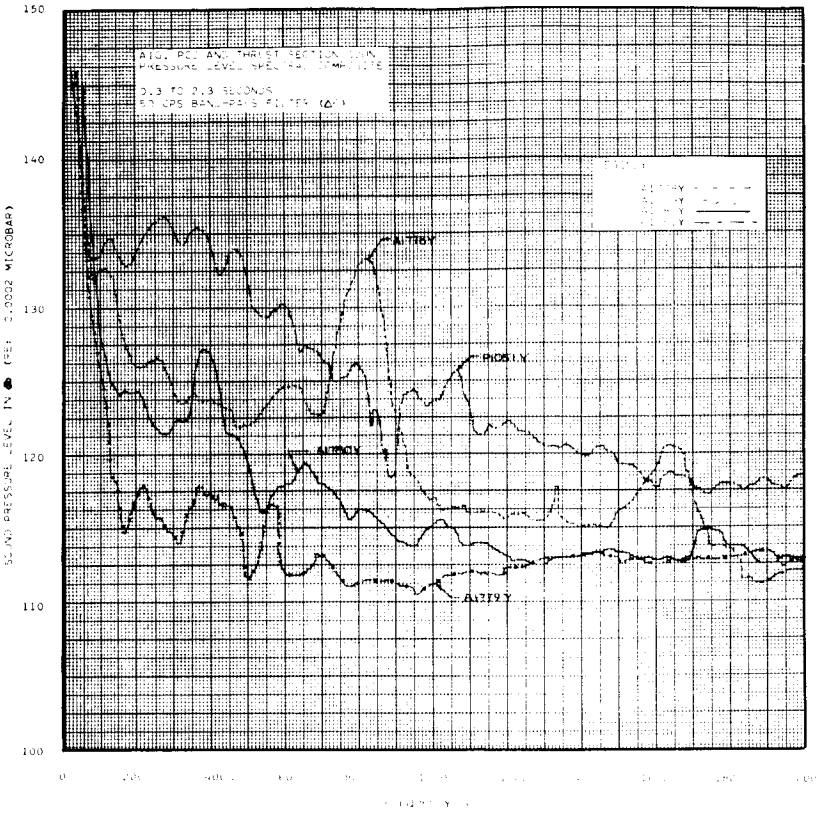


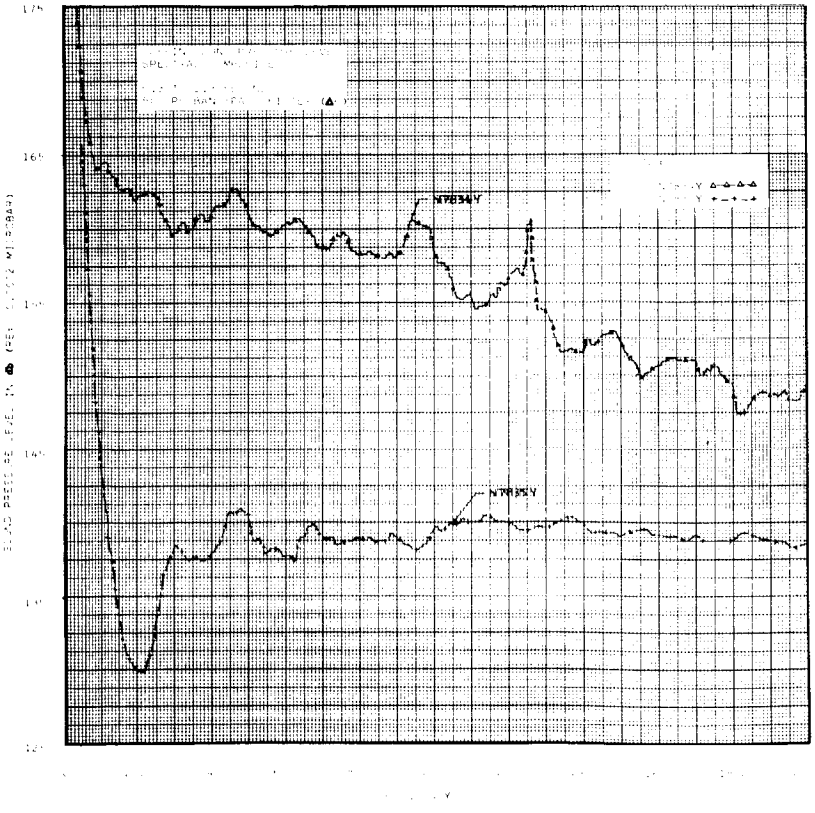


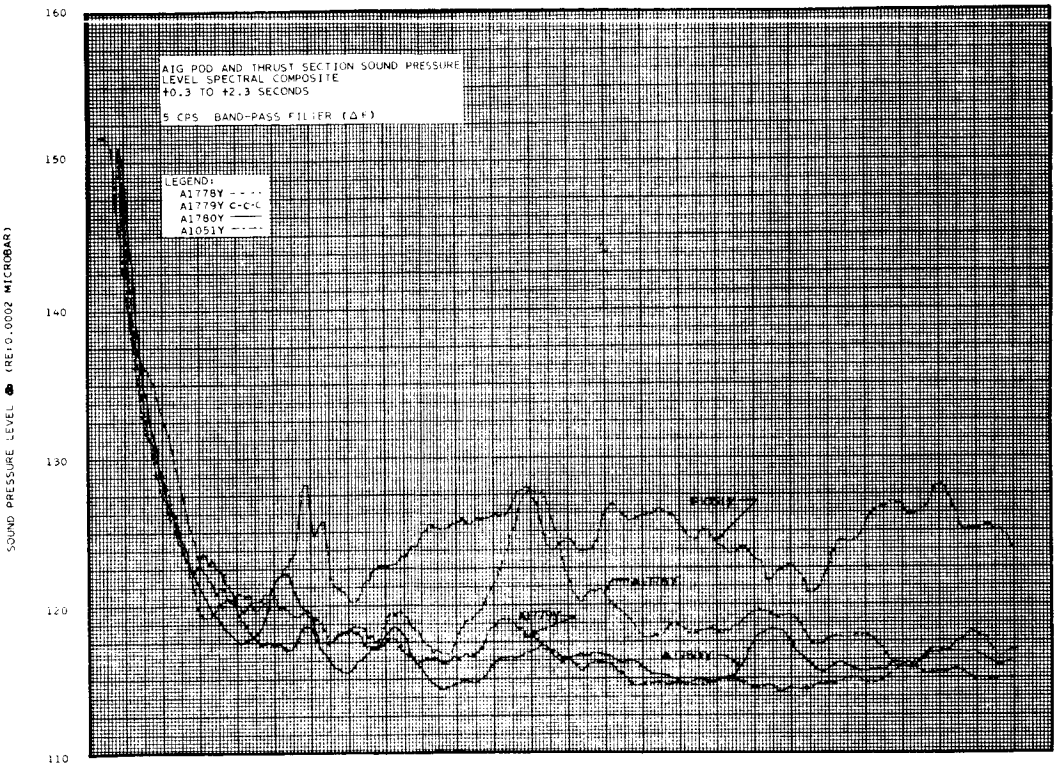

AIS POD AND THRUST SECTION SOUND PRESSURE LEVEL SPECTRA COMPOSITE
-1.3 TO 2.3 SECONDS
200 CPS BAND-PASS FILTER (ΔF)
SOUND PRESSURE LEVEL dB (REF 0.0002 MICROBAR)
FREQUENCY
N785Y
A1705Y
A1705Y
A1705Y

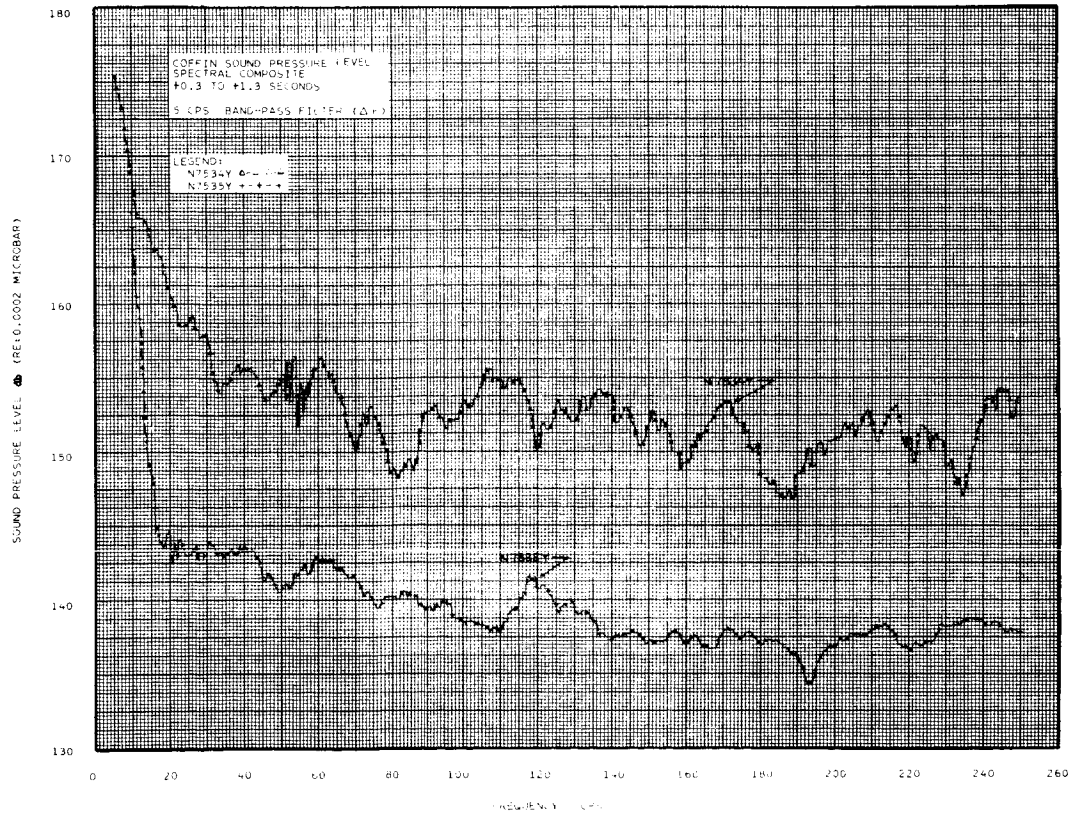

SOUND PRESSURE LEVEL dB (REF 0.0002 MICROBAR)
N785Y
N785Y

UNCLASSIFIED

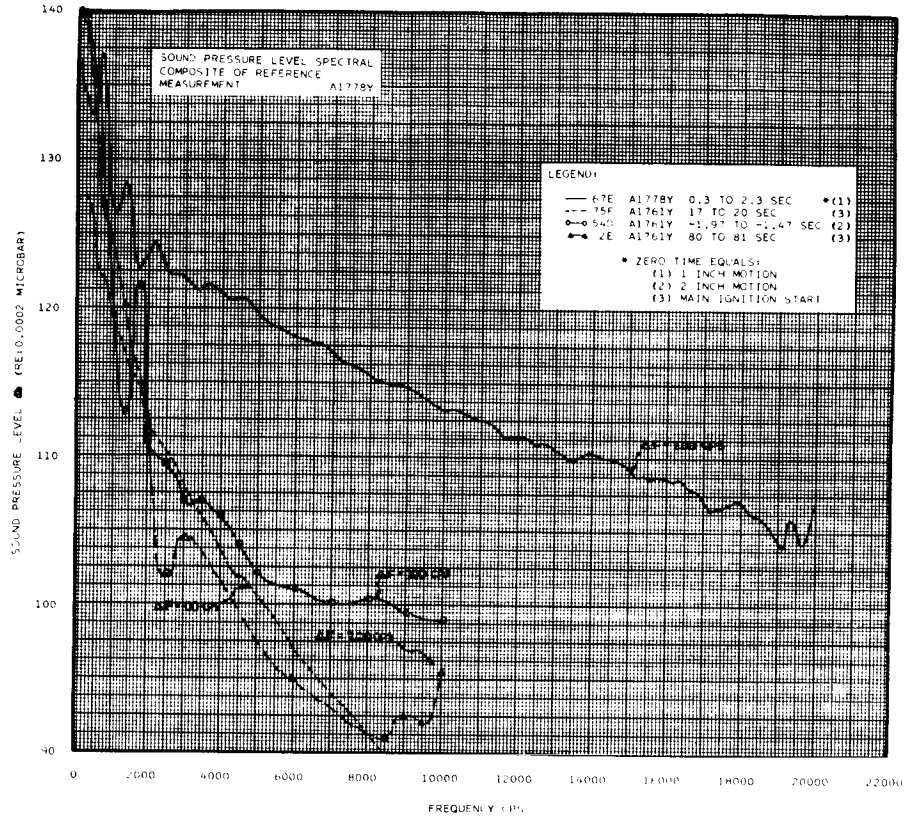


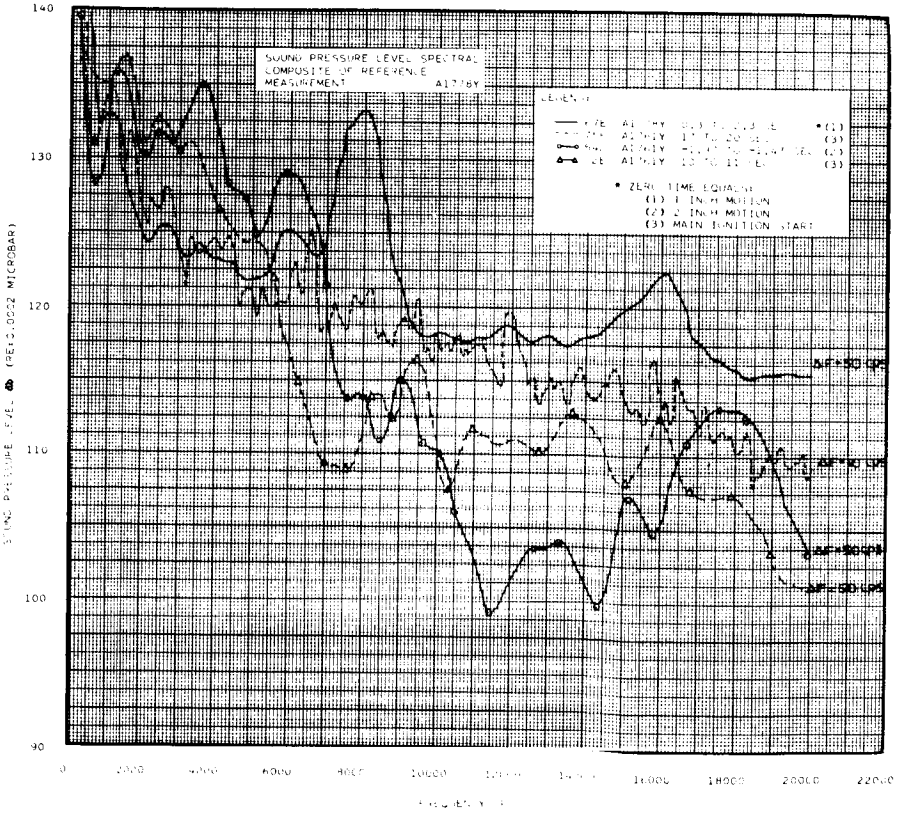



AIG POD AND THRUST SECTION SOUND PRESSURE LEVEL SPECTRAL COMPOSITE
+0.3 TO +2.3 SECONDS
5 CPS BAND-PASS FILTER (ΔF)
LEGEND:
A1778Y
A1779Y
A1780Y
A1051Y
SOUND PRESSURE LEVEL, dB (RE:0.0002 MICROBAR)
160
150
140
130
120
110


COFFIN SOUND PRESSURE LEVEL SPECTRAL COMPOSITE
+0.3 TO +1.3 SECONDS
5 CPS BAND-PASS FILTER (ΔF)
LEGEND:
N7534Y
N7535Y
SOUND PRESSURE LEVEL, dB (RE:0.0002 MICROBAR)
180
170
160
150
140
130
0
20
40
60
80
100
120
140
160
180
200
220
240
260

UNCLASSIFIED





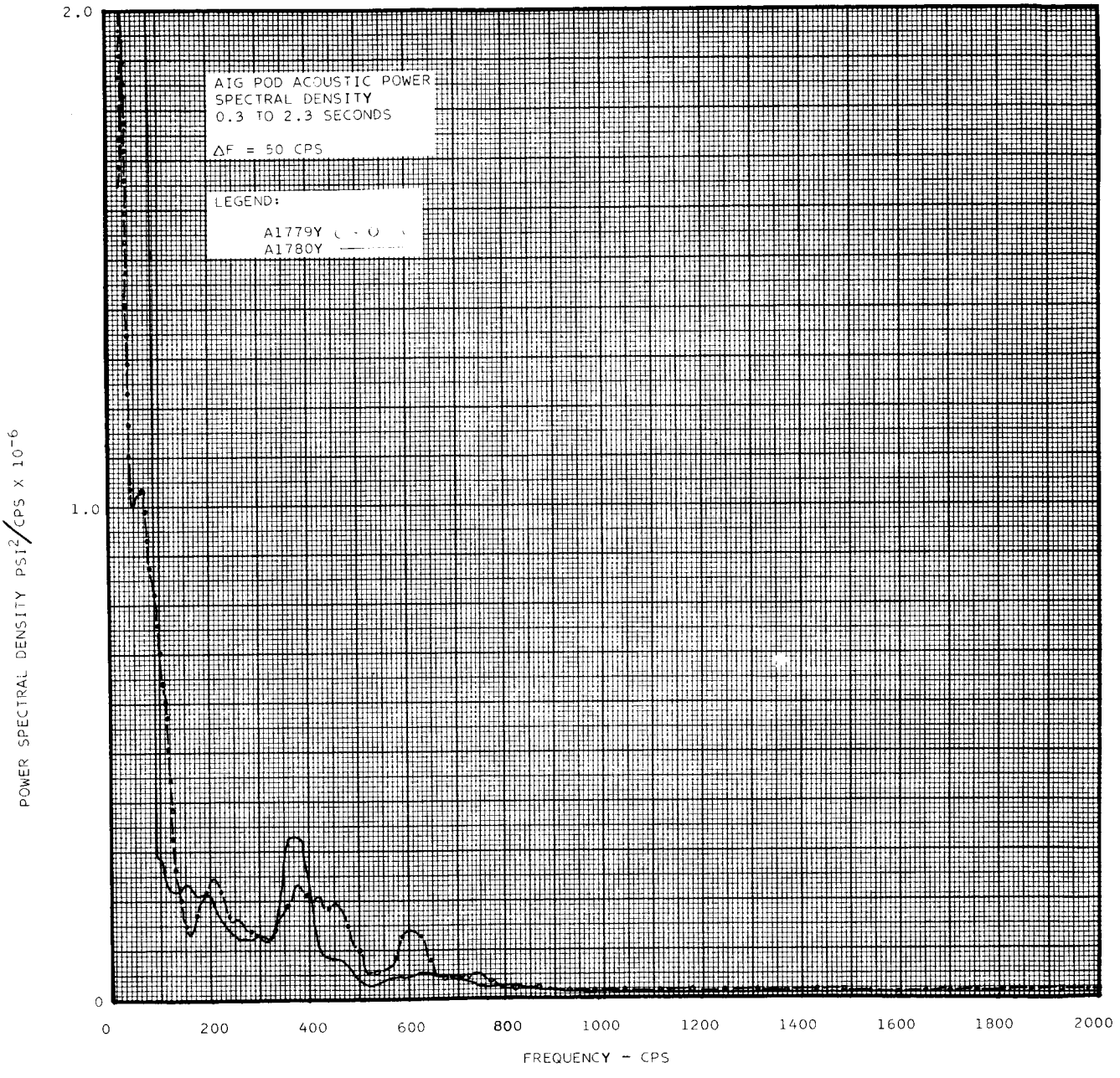
LAUNCH ACOUSTIC

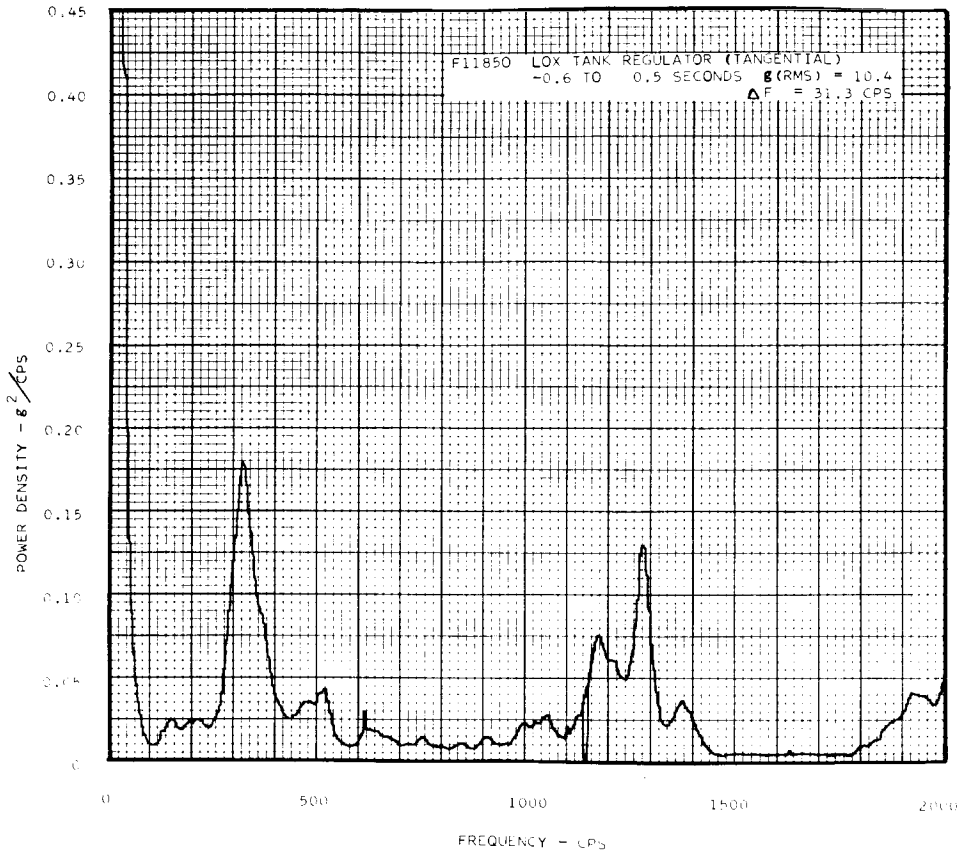
FIGURE NO. 10-8

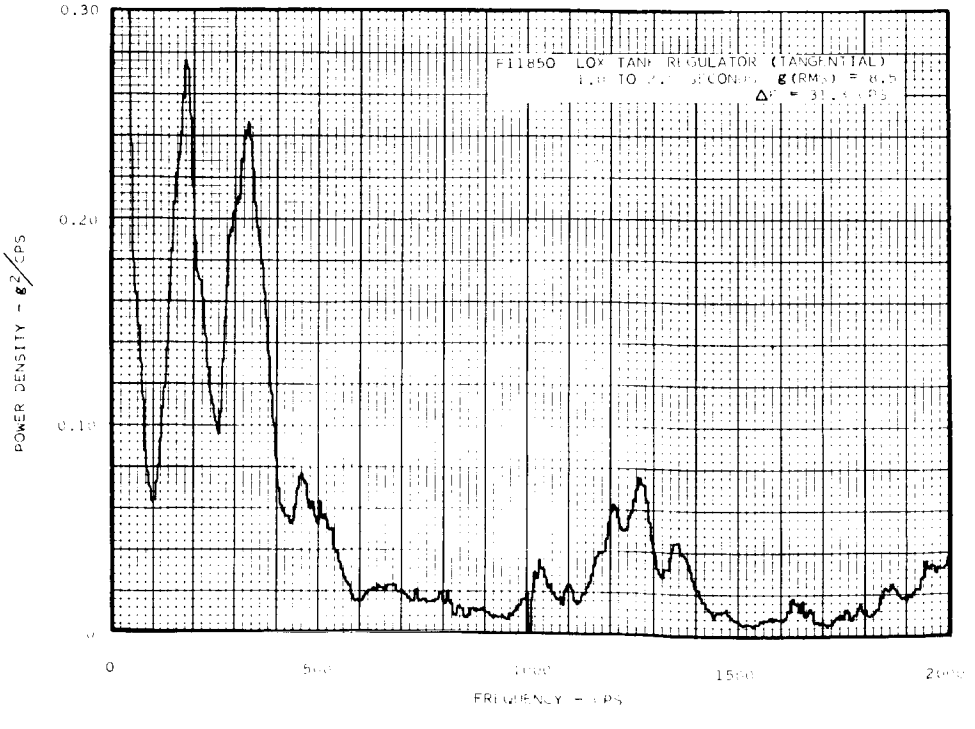
GD/A-DDE65-016

~~REPORT NO. AE62-0692~~

MISSILE 67E




F11850 LOX TANK REGULATOR (TANGENTIAL)
-0.6 TO 0.5 SECONDS g(RMS) = 10.4
ΔF = 31.3 CPS
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
POWER DENSITY - g²/CPS
0
500
1000
1500
2000
FREQUENCY - CPS


F11850 LOX TANK REGULATOR (TANGENTIAL)
0.30
0.20
0.10
0
POWER DENSITY - g²/CPS
0
1500
2000
FREQUENCY - CPS

LAUNCH ACOUSTIC

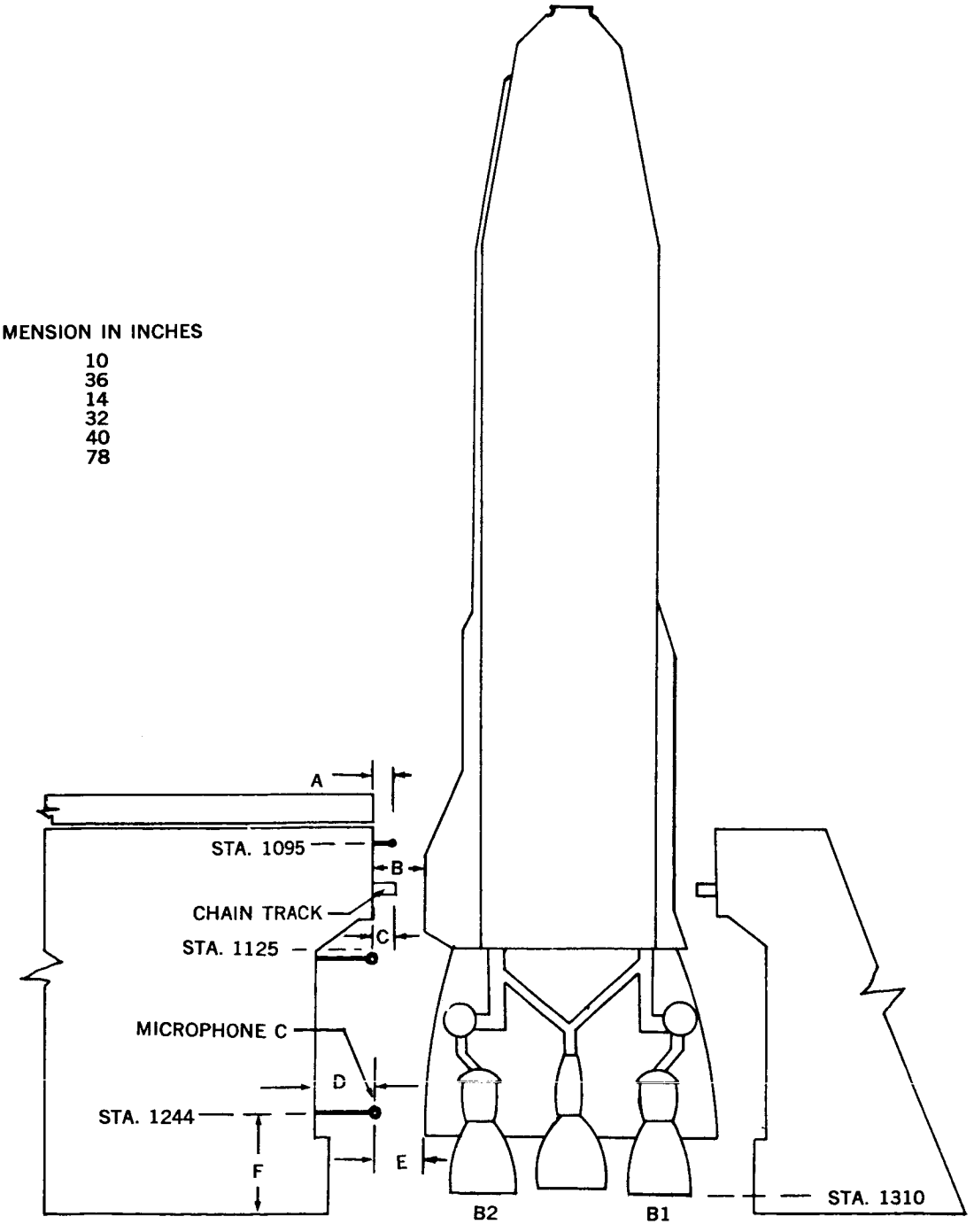
FIGURE NO. 10-11

~~REPORT NO. AE62-0692~~

OVER-ALL VIEW OF MICROPHONE LOCATION

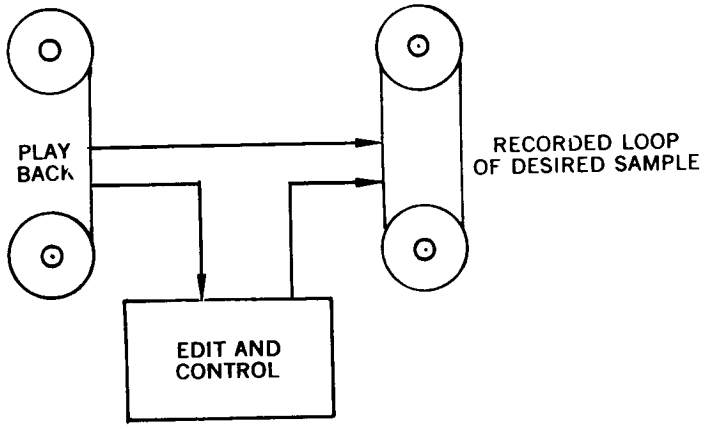
MISSILE 67E

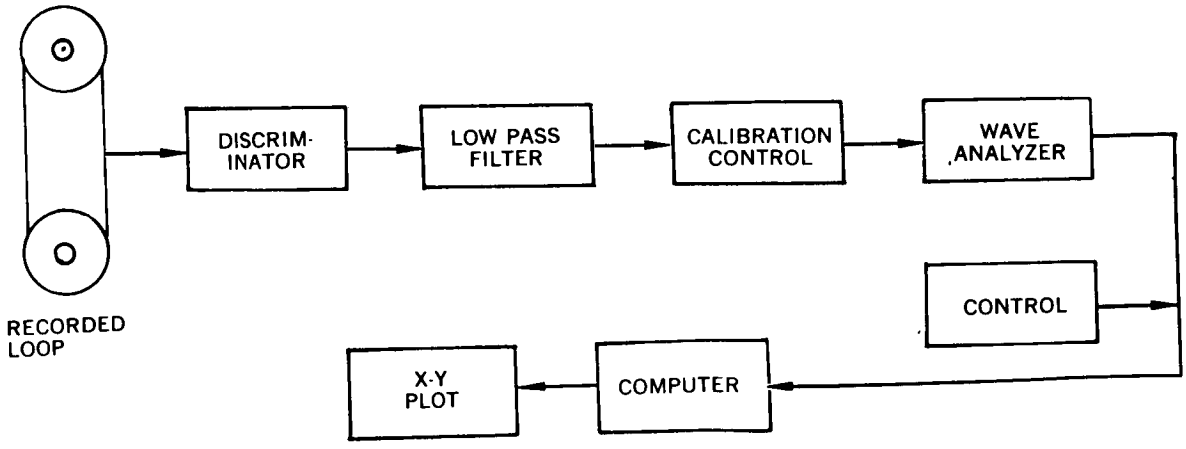
ITEM	DIMENSION IN INCHES
A	10
B	36
C	14
D	32
E	40
F	78



ACOUSTIC DATA REDUCTION SYSTEM

MISSILE 67E





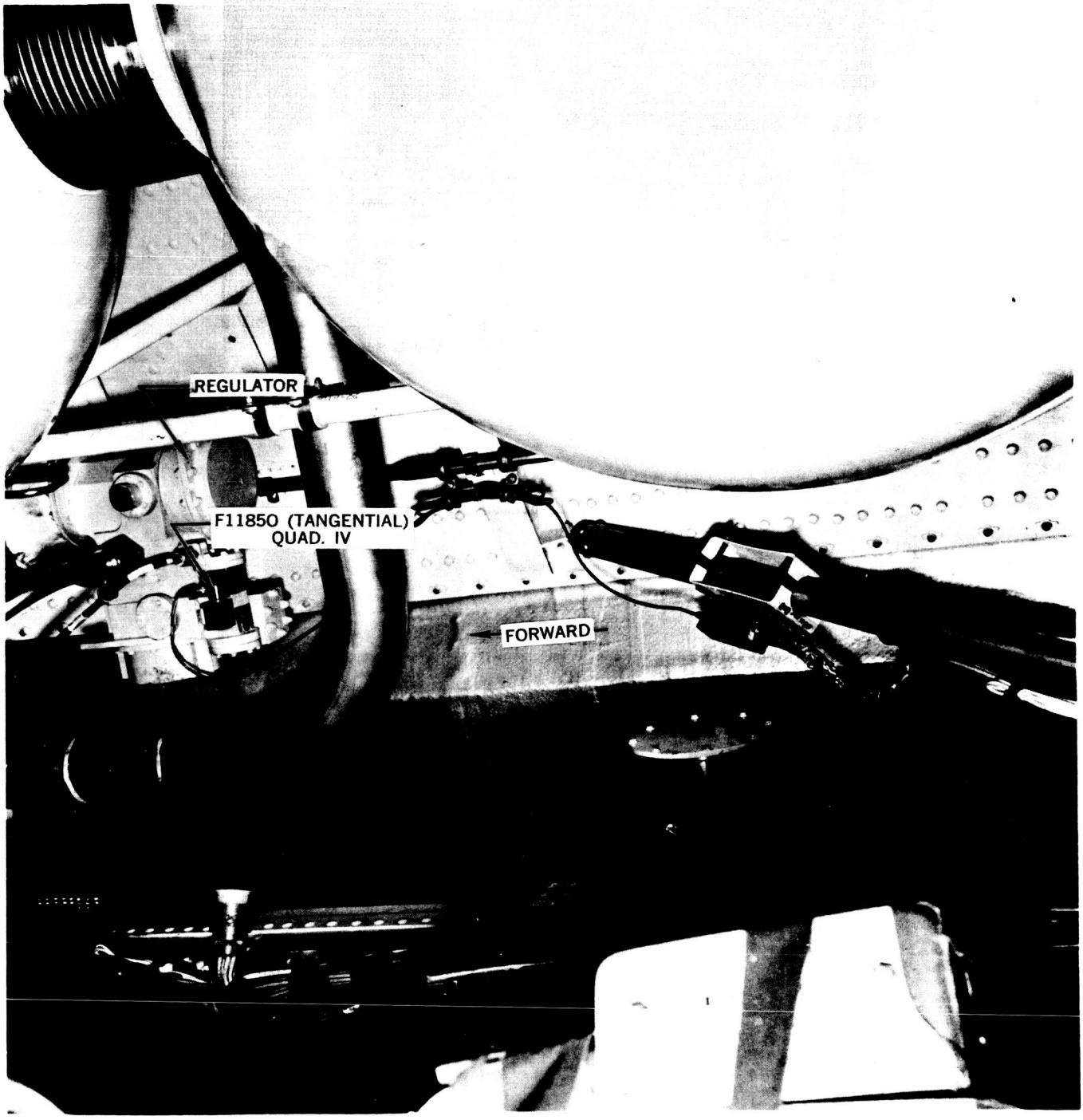
LAUNCH ACOUSTIC

FIGURE NO. 10-13

~~REPORT NO. AE62-0692~~

LOX TANK REGULATOR VIBRATION INSTRUMENTATION

MISSILE 67E



LAUNCH ACOUSTIC

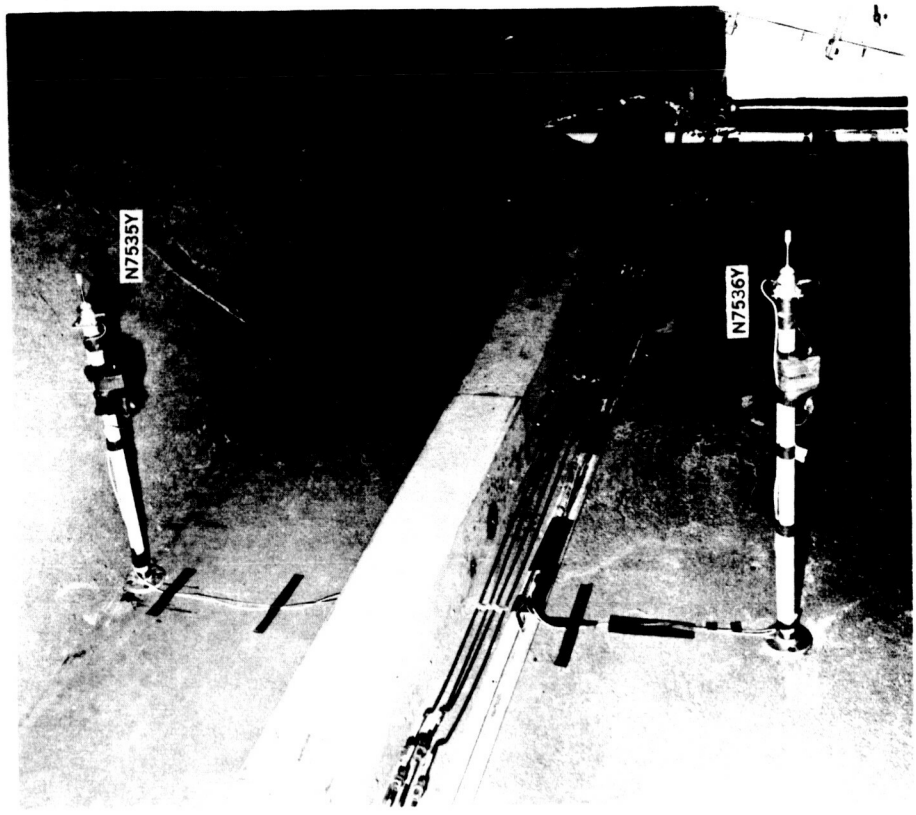
FIGURE NO. 10-14

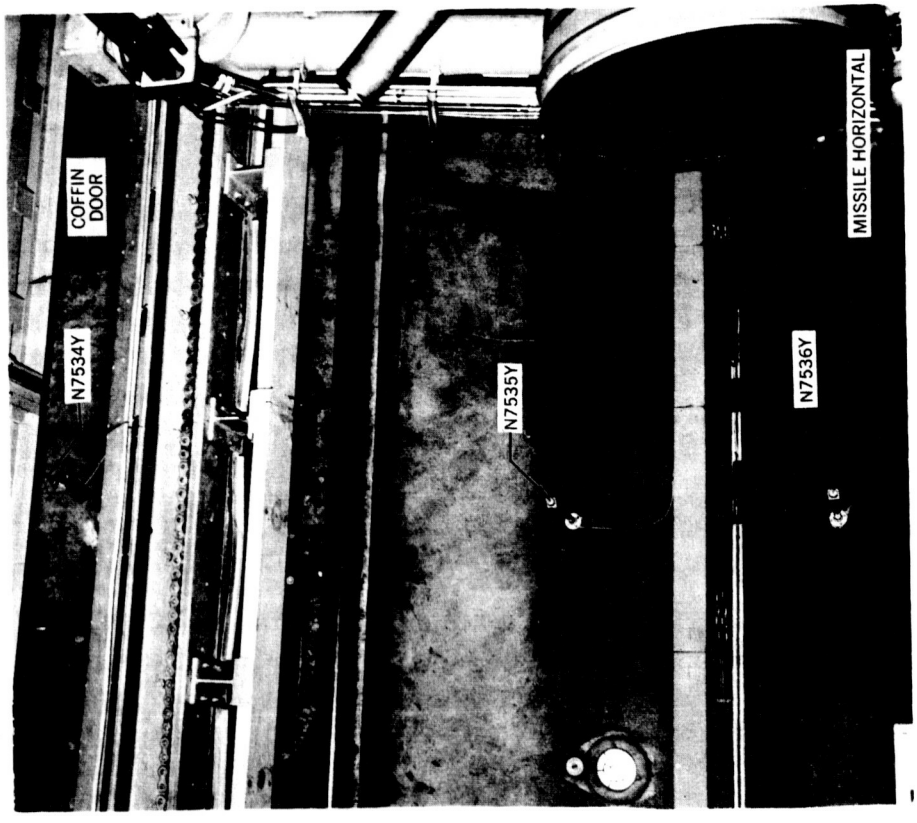
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GD/A-DDE65-016

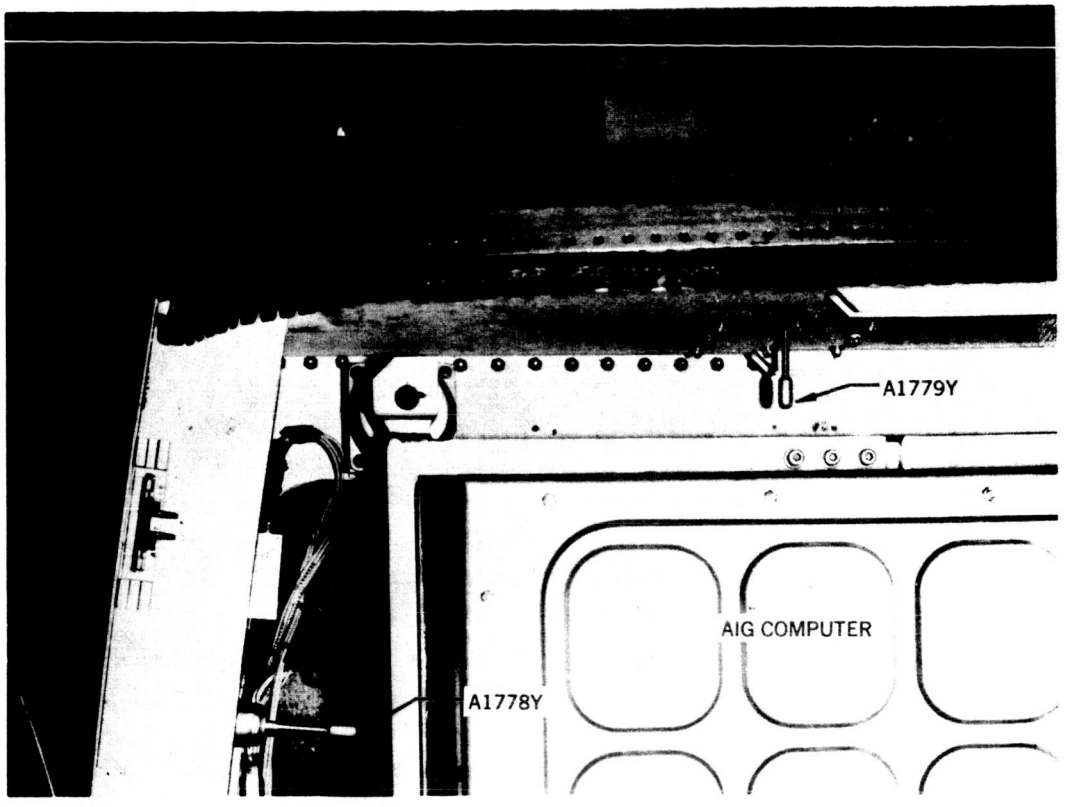
MISSILE 67E

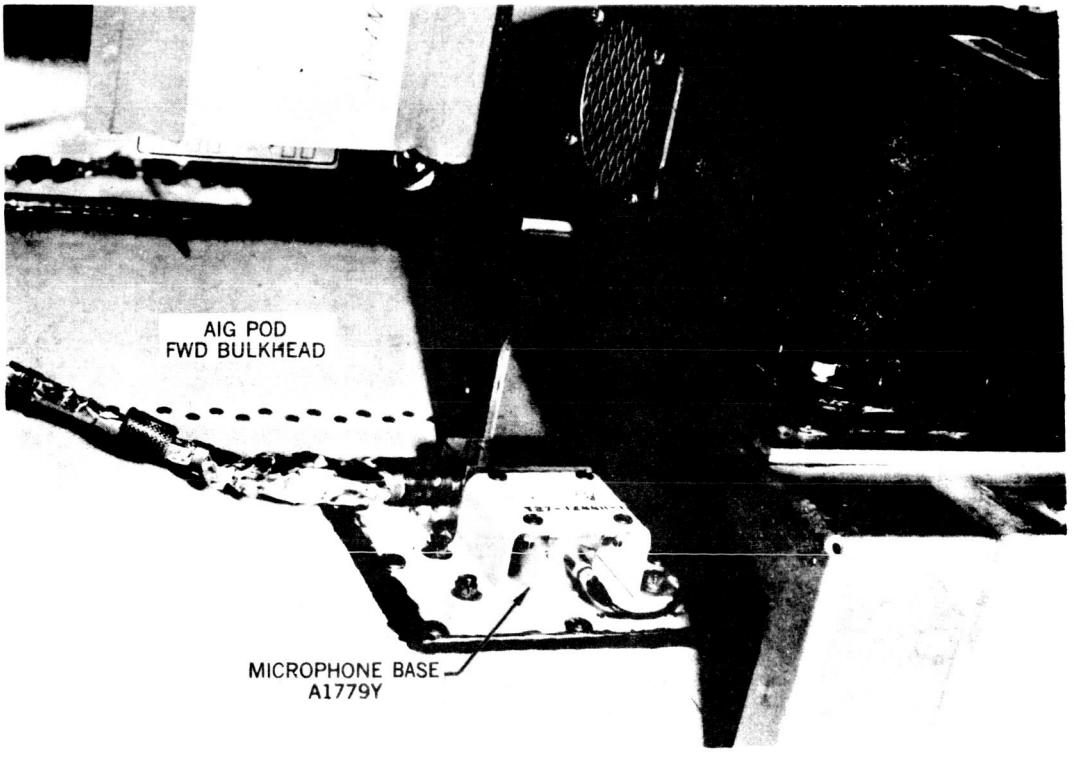
LOCATION OF MICROPHONES



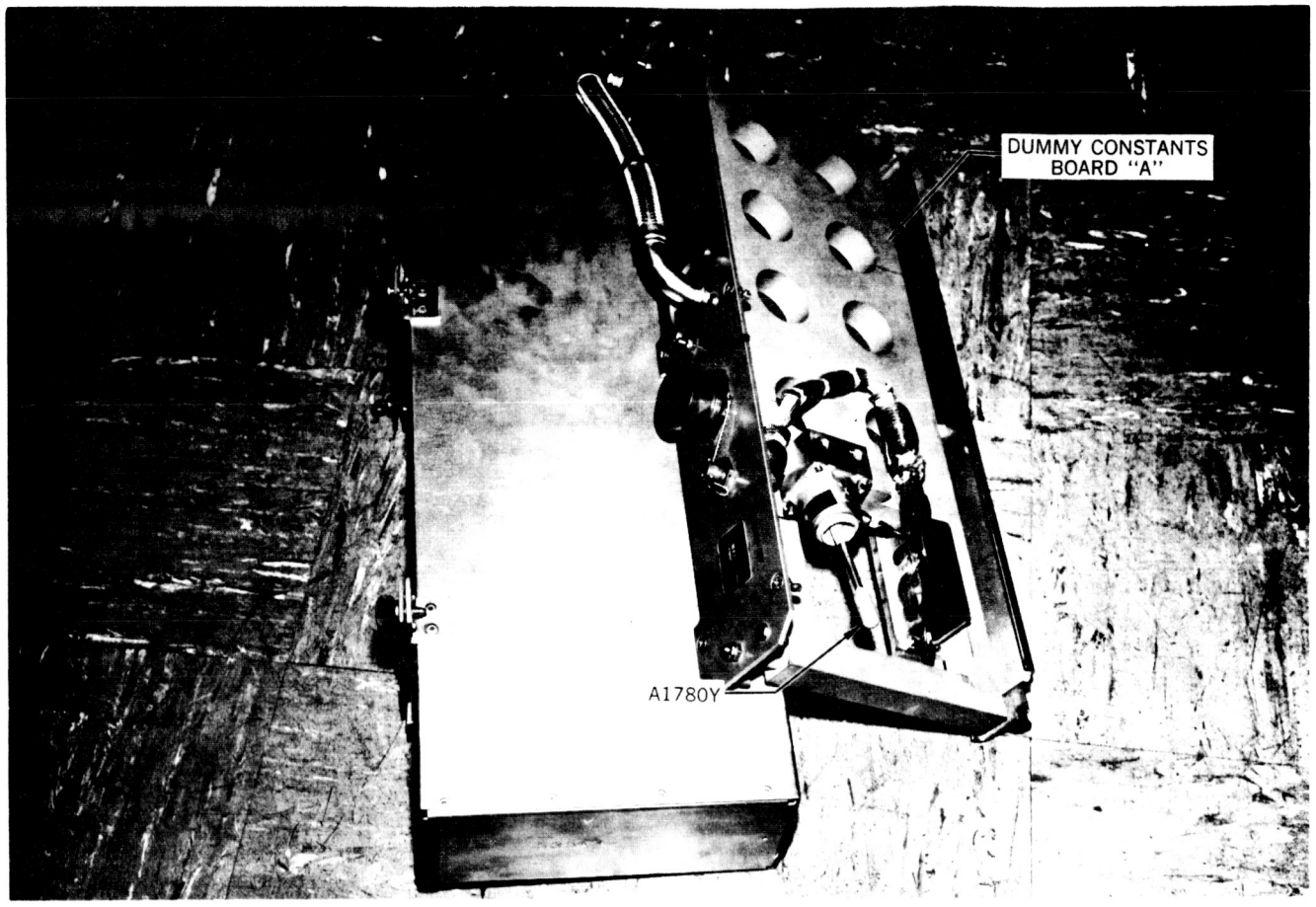


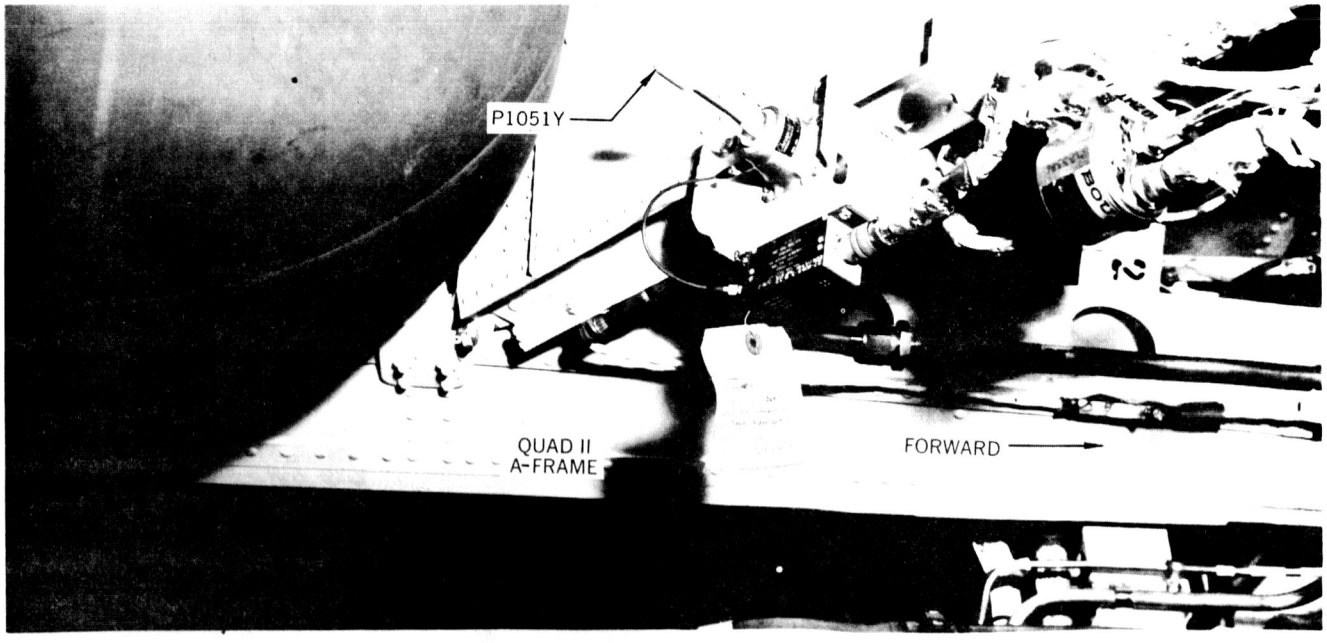
LOCATION OF MICROPHONES





LOCATION OF MICROPHONES





SECTION 6.2 17

MISSILE 4F

FLIGHT TESTED 11-22-61

AT AMR COMPLEX 11

TEST REPORT AE61-0799

SECTION 19

VIBRATION ANALYSIS

Four vibration measurements were recorded from the sustainer hydraulic pump and one from the sustainer gas generator fuel check valve to determine the vibratory response of these units during powered flight. Useful data was obtained from the four sustainer hydraulic pump accelerometers throughout the 4F flight. Much of the flight data obtained from the sustainer gas generator accelerometer was termed questionable. The accelerometer locations and associated recording system frequency response capabilities were as follows:

MEAS. NO.	LOCATION	WAVEFORM	CHANNEL RESPONSE-CPS
H426O	Sustainer hydraulic pump/tachometer, X-Axis	Commutated	1200
H427O	Sustainer hydraulic pump/tachometer, Y-Axis	Commutated	1200
H428O	Sustainer hydraulic pump end, X-Axis	Commutated	1200
H429O	Sustainer hydraulic pump end, Y-Axis	Commutated	1200
P531O	Sustainer gas generator fuel check valve	Continuous	220

NOTE: See Figures 19-8, 19-9, and 19-10.

The four sustainer hydraulic pump measurements provided steady-state vibration levels for the duration of the powered flight except for approximately 0.46 seconds of telemetry drop-out during booster jettison.

Maximum steady-state outputs of 30 g(rms) were recorded from the end of the sustainer hydraulic measurement H429O, Y-Axis. The measurement exhibited a single frequency near sinusoidal output at a frequency of 1025 cps. This maximum 30 g(rms) level was twice that recorded for a corresponding measurement on static Missile 1F, during previous static testing at Sycamore Canyon Test Site (S1-1F).

Measurement H428O located on the end of the pump (X-Axis) showed levels of 13 g(rms), which were somewhat lower than those seen during 1F static testing for a corresponding measurement. The two measurements located on the sustainer hydraulic pump tachometer, H426O and H427O, displayed moderate steady state vibration levels of 8 g(rms) and 11.5 g(rms) respectively. Measurement H426O (X-Axis) displayed levels comparable to 1F static test levels, while measurement H427O (Y-Axis) showed vibration levels nearly twice those recorded during 1F static testing for its corresponding measurement. A partial explanation of this varying difference between static and flight results is that the accelerometer mountings on flight Missile 4F were different from those on static Missile 1F. For this reason, the results of the two types of testing, with respect to the intensity of the vibration levels, could not be compared directly with full meaning. However, there was consistency between the two types of testing with respect to major frequency components.

Predominant frequencies were 640 cps and 2050 cps for H426O, 2050 cps and 1020 cps for H427O, and 670 cps and 1540 cps for H428O. Spectrum analysis samples of the 4 measurements are shown in Figures 19-3 through 19-6. Also, a tabulation of flight and static sustainer hydraulic pump vibration levels is shown below.

Sustainer gas generator fuel check valve vibration data (P531O) exhibited questionable outputs throughout the recorded flight. Erratic oscillations of the data trace [max. 80 g(o-p)] appeared from -1 to +2 seconds implying unreasonable destructive displacement characteristics. At 128.6 seconds, the data trace drifted from the zero reference, exceeded the intelligence bandwidth twice before the telemetry dropout at 128.9 seconds, then continued with an erroneous 6 to 8 cps oscillations to approximately 144 seconds. These outputs in many cases also implied destructive displacement characteristics. Low amplitude oscillations [(5-15g (p-p)] continued from 144 seconds to sustainer cutoff at 288.9 seconds. Steady-state vibration levels during this time, not regarding the low amplitude oscillations, were 2.6 g(rms). At 165 seconds, a biased data trace again exceeded the intelligence bandwidth for approximately 0.1 seconds. Erroneous data was also noted at approximately 330 seconds. All in all, the data recorded from this measurement (P531O) was not dependable or consistent and was of little conclusive use. Figure 19-2 shows samples of the data.

Accelerometers A77A and A78A

Two accelerometers were installed on the aft end of the jettison rail in Quad II to determine rail end motion during booster jettison. Rail motion, in response to jettison forces prior to approximately the time the booster section reached the rail ends, was moderate. No significant response to the missile pitchup condition (apparent on gyro data) was evident. At approximately the time the booster section separated from the jettison rails, the radial measurement, A77A, displayed an apparent normal buildup in intensity, while the tangential measurement, A78A, displayed a permanent bias to the band edge, indicative of an open circuit condition. The erroneous bias may have resulted from a severed transducer cable.

A general view of the accelerometer location is shown in Figure 13-17, while Figures 13-23 and 13-24 show the details of the installation.

The response of the accelerometers utilized was flat to a frequency of approximately 200 cps. The nominal frequency responses for the telemetry channels used for A77A and A78A were 25 and 35 cps, respectively. Since the objective was to study rail motion during staging, the measurements were "switched in" at booster cutoff.

A summary of staging outputs is shown in Table 1, Page No. 13-4. Graphic presentations of the analog traces are shown in Figures 13-6, 13-7 and 13-3. Figures 13-6 and 13-7 were presented to show the accelerometer outputs with the remainder of the missile "pitchup transient study" instrumentation. Figure 13-3 was presented to display the outputs as the booster section approached the end of the jettison rails.

TABLE 1

SUMMARY OF JETTISON RAIL VIBRATION ON FLIGHT OF MISSILE 4F

Flight Period	A-77-A (Radial)		A-78-A (Tangential)	
	Maximum Accel. ~g (O-P)	Frequency ~cps	Maximum Accel. ~g (O-P)	Frequency ~cps
Prior to Unlatching (126.15 to 128.45 sec)	0.6	57	0.6	42 to 55
Jettisoning (On Rails) (128.45 to 128.85)	1.5 0.2	55 11	2.4 0.5	45 11
Booster Section Separation (128.86)	3.1	One half cycle of approximately 34 cps.	16.0 1.0	48 to 52 11.5
128.90	Biased beyond intelligence band		-	-

4F

TABULATION OF SUSTAINER HYDRAULIC PUMP VIBRATION LEVELS

STATIC TEST DATA (Missile 1F)

	H426O	H427O	H428O	H429O
S1-608-A8-01				
Steady-state levels, g(rms)	8.5	4.6	24	12
Freq. range of analysis, cps	0-2000	0-2000	0-2000	0-2000
Time, Sec.	35.0-35.5	35.0-35.5	35.0-35.5	35.0-35.5
Predom freq., cps/(power density, g^2/cps)	625/0.45	1010/.048	1500/3.6	1505/1.07
	1000/0.04	1500/.048	2000/1.6	1020/0.47
	1865/0.04	670/.040	640/1.2	1800/0.21
	1320/0.04	1880/.024	1020/0.8	520/0.20
		520/.023		
S1-609-A10-01				
Steady-state levels, g(rms)	5.5	5.3		13.6
Freq. range of analysis, cps	0-2000	0-2000		0-2000
Time, sec.	2.0-3.0	2.0-3.0		2.0-3.0
Predom. Freq, cps/(Power density g^2/cps)	625/0.10	665/0.070		1495/0.60
	995/0.05	1000/0.045		1980/0.55
	495/0.04	495/0.045		1025/0.50
	1305/0.03	1475/0.045		2490/0.35
		2000/0.045		535/0.23

TABULATION OF SUSTAINER HYDRAULIC PUMP VIBRATION LEVELS (Continued)

S1-610-A10-01	H426O	H427O	H428O	H429O
Steady-state levels, g(rms)	6.2	5.8	20.5	14.7
Freq. range of analysis, cps	0-2500	0-2500	0-2500	0-2500
Time, sec.	18.0-19.0	18.0-19.0	18.0-19.0	18.0-19.0
Predom. freq., cps/(Power density g^2/cps)	620/0.5	655/.065	1480/2.8	1485/1.70
		980/.050	1950/2.3	1955/0.60
		1455/.040	640/1.0	1015/0.48
		2285/.037	1010/0.4	515/0.28
		2435/.035		2455/0.20

FLIGHT TEST (Missile 4F)

P1-601-00-04	H426O	H427O	H428O	H429O
Steady-state levels, g(rms)	7.5	10	12	27
Freq. range of analysis, cps	0-2500	0-2500	0-2500	0-2500
Time, sec.	44.9-45.7	46.0-46.8	48.2-49.0	49.3-50.1
Predom. freq., cps/(Power density g^2/cps)	640/0.16	2035/0.45	1530/0.66	1025/8.8
	2000/0.10	1020/0.17	660/0.42	720/0.7
	1870/0.05	1510/0.09	2030/0.20	2020/0.4
	510/0.04	690/0.08	1130/0.16	
		1270/0.06		

TABULATION OF SUSTAINER HYDRAULIC PUMP VIBRATION LEVELS (Continued)

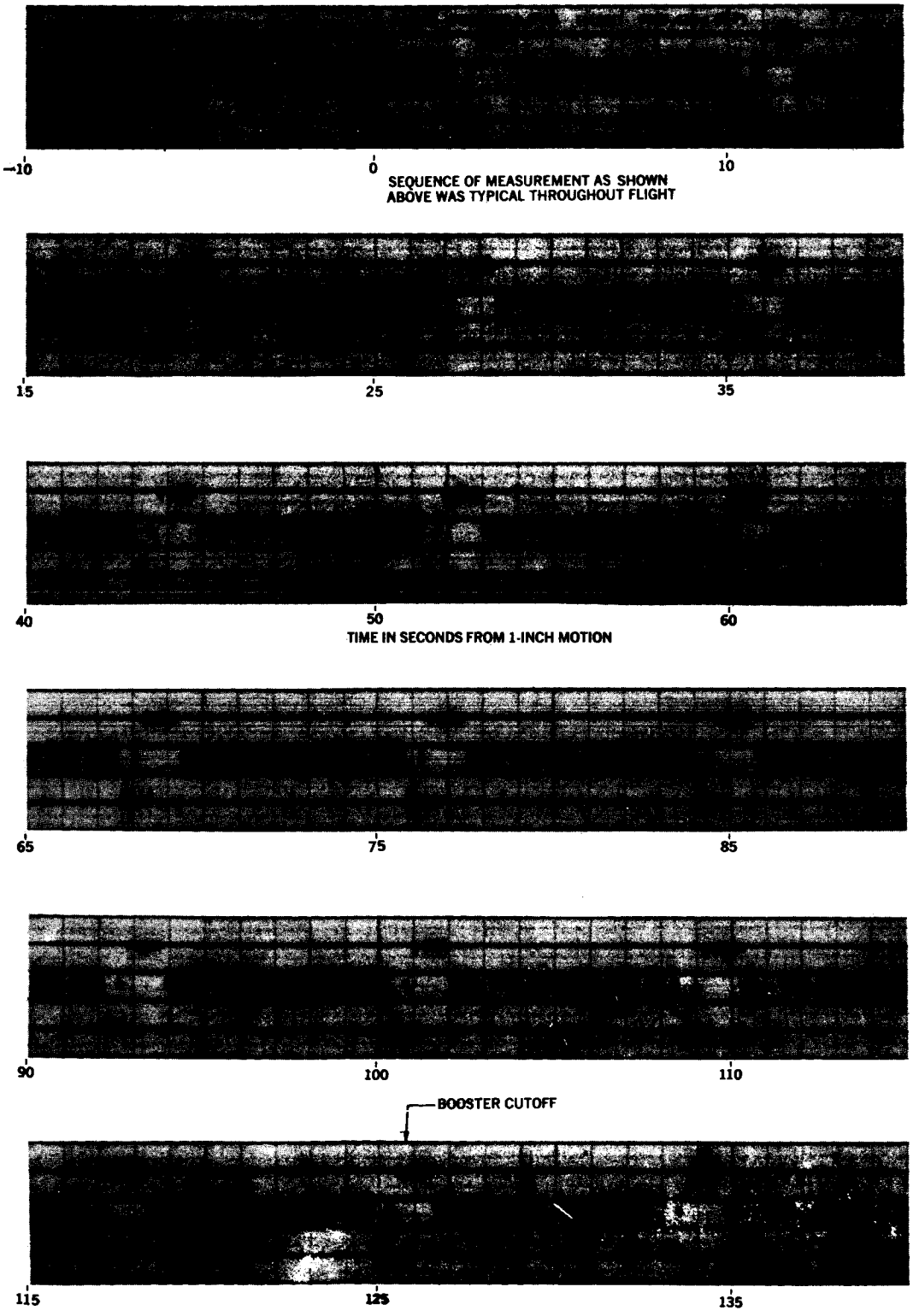
	H426O	H427O	H428O	H429O
Steady state-levels, g(rms)	8	11.5	13	30
Freq. range of analysis	0-2500	0-2500	0-2500	0-2500
Time, sec.	53.1-53.9	54.2-55.0	56.3-57.2	57.4-58.3
Predom. freq., cps(Power density g^2/cps)	2050/0.16	2050/0.68	1540/1.0	1025/11.0
	670/0.15	1540/0.10	670/0.5	680/ 0.5
	1910/0.05	690/0.09	2045/0.5	2020/ 0.3
	540/0.04	1050/0.08	1050/0.2	

FIGURE NO. 19-1

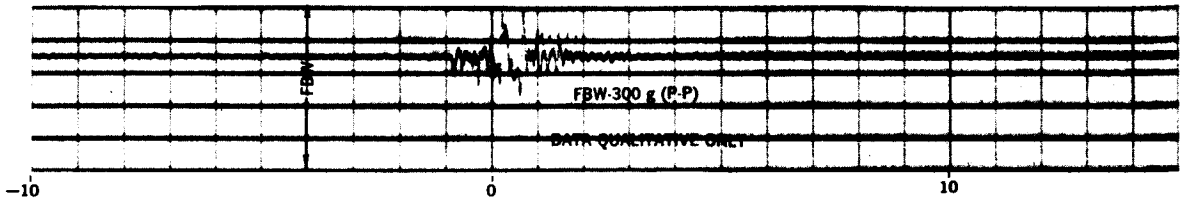
GD/A-DDE65-016

~~REPORT NO. AE61-0799~~

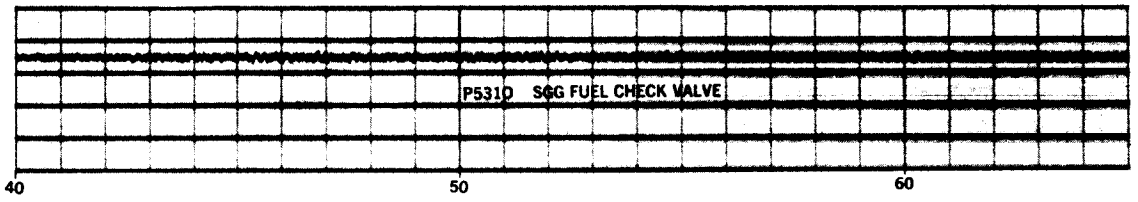
VIBRATION
TELEMETERED DATA
MISSILE 4F

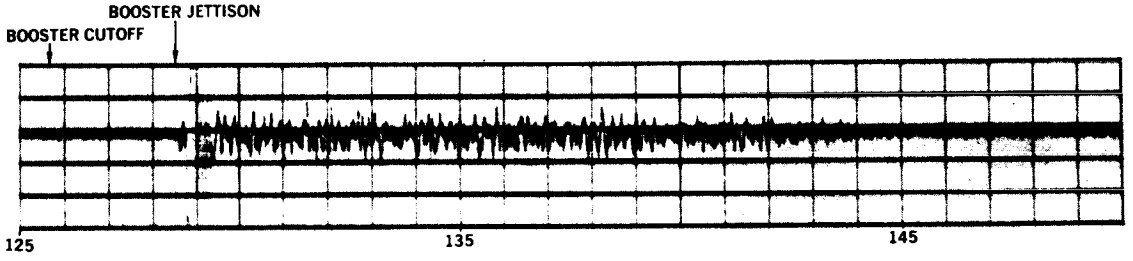


VIBRATION
TELEMETERED DATA

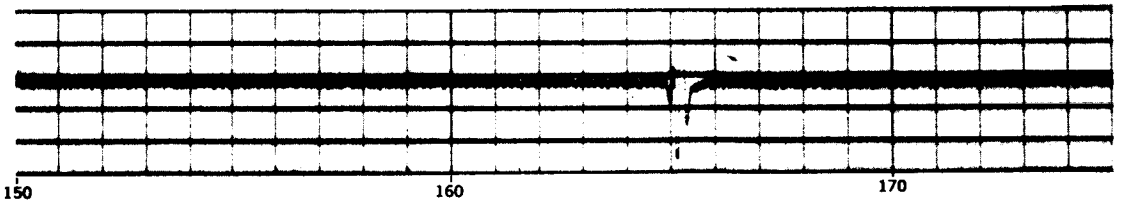


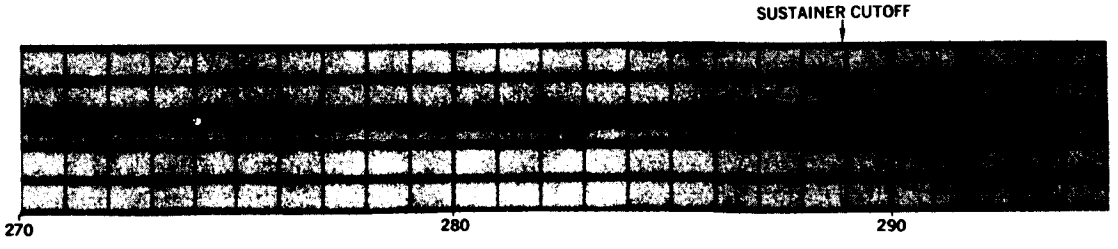
FULL BANDWIDTH EQUAL TO 300 g (P-P)
WAS TYPICAL THROUGHOUT FLIGHT

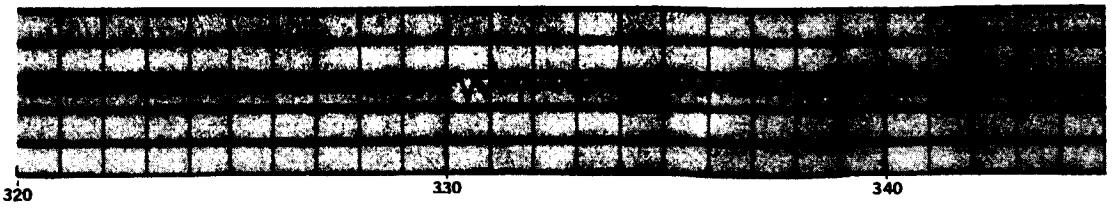


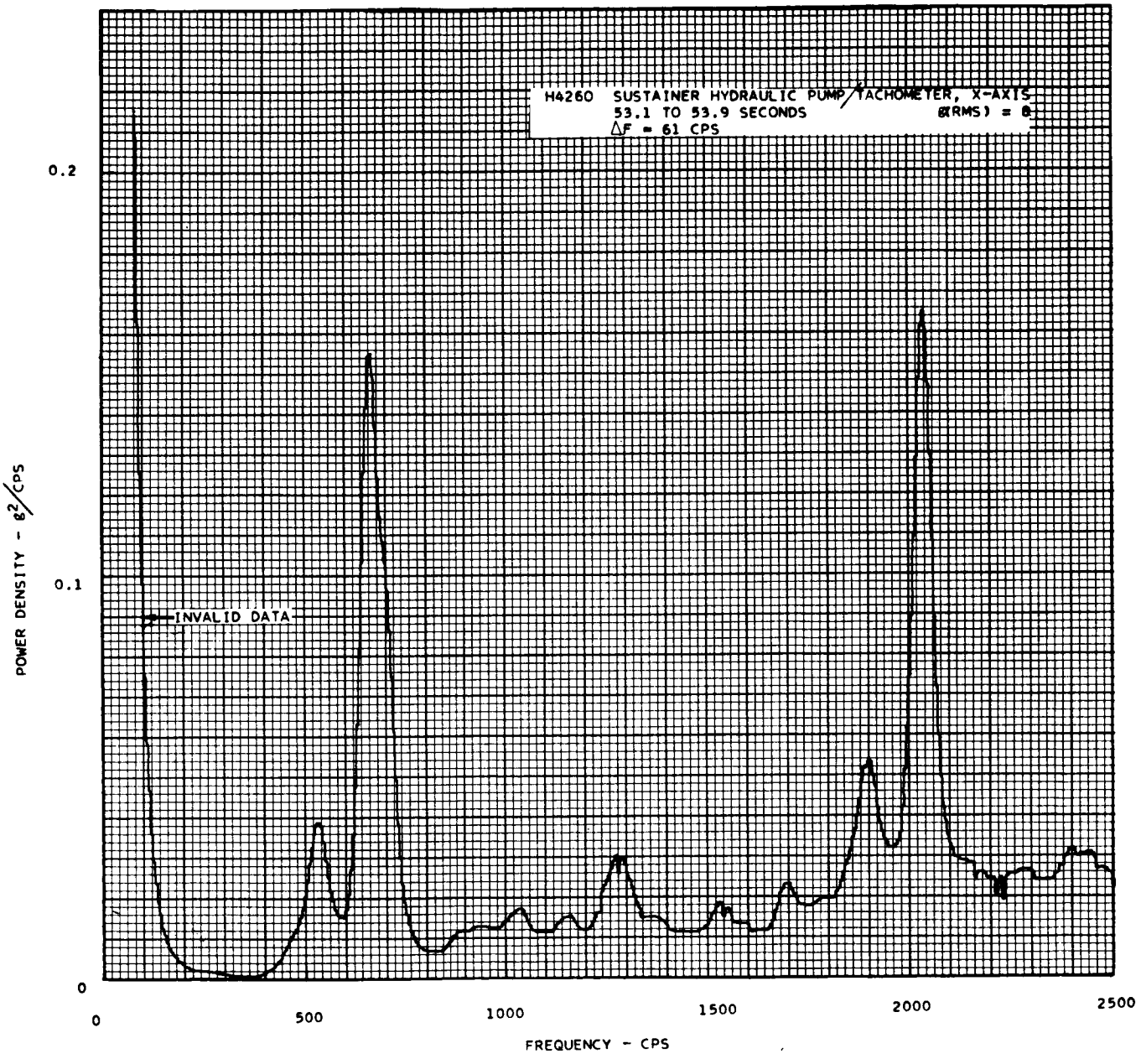


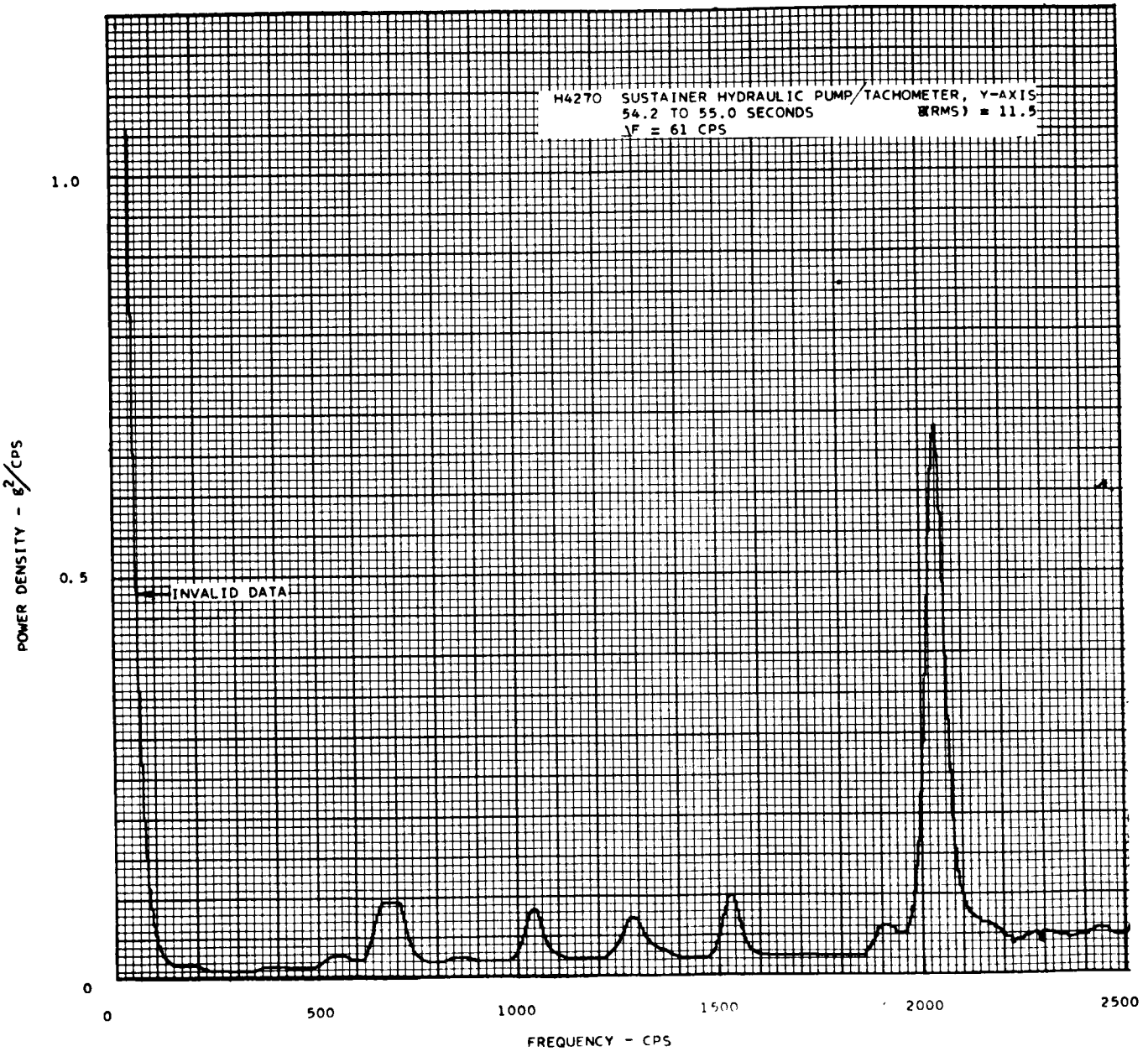
TIME IN SECONDS FROM 1-INCH MOTION





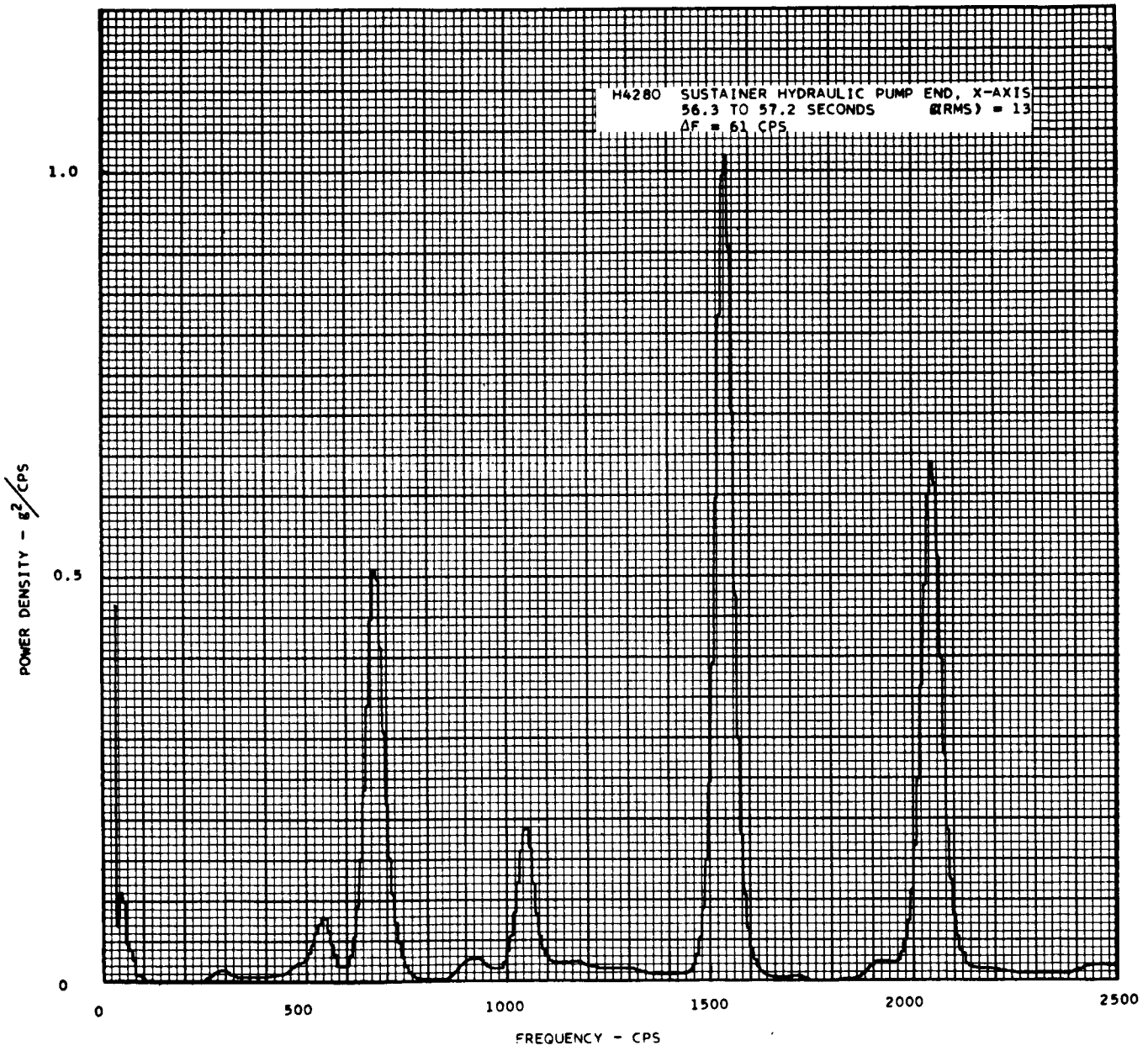


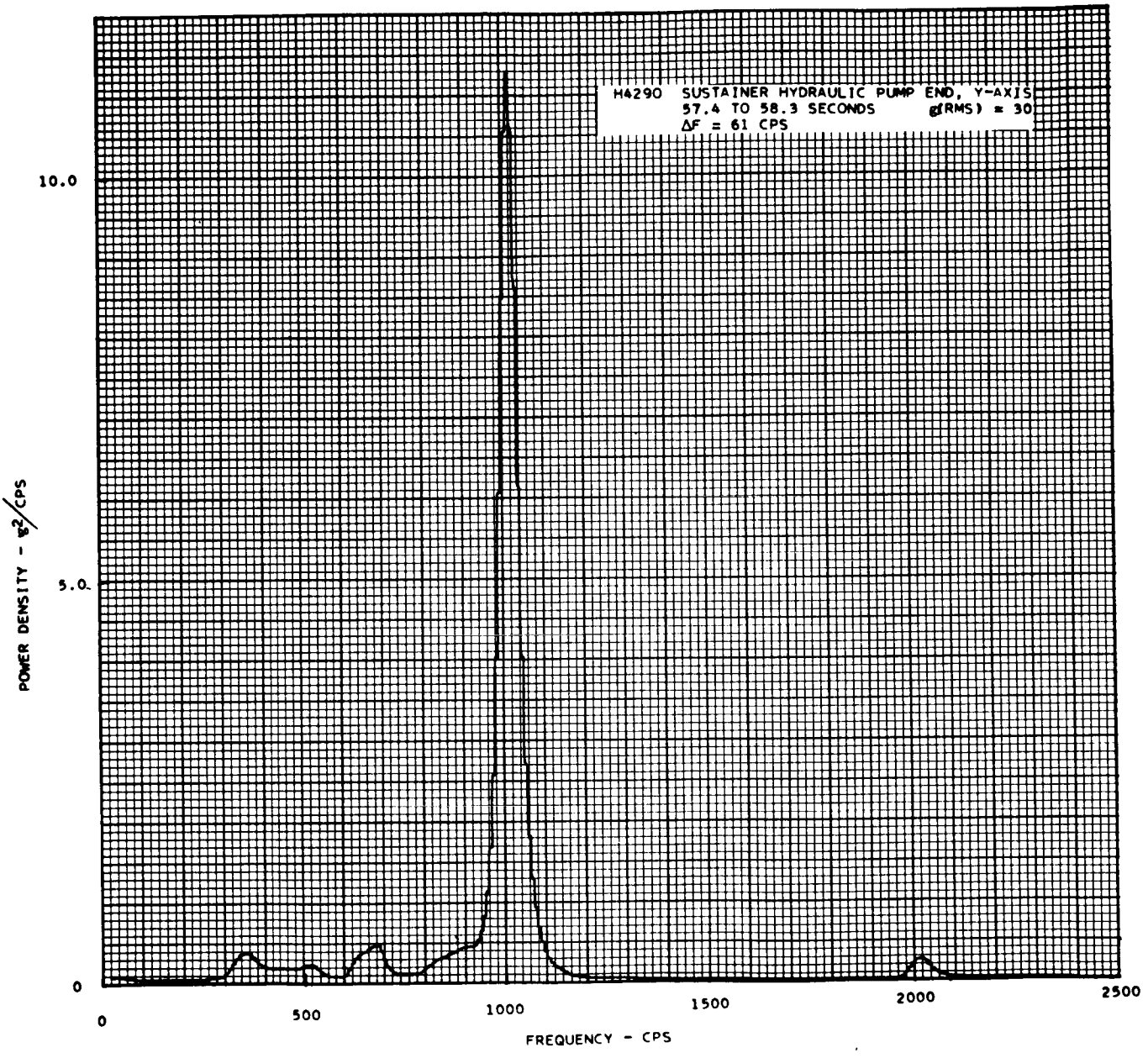

H4260 SUSTAINER HYDRAULIC PUMP/TACHOMETER, X-AXIS
53.1 TO 53.9 SECONDS
ΔF = 61 CPS
g(RMS) = 0
0.2
0.1
0
POWER DENSITY - g²/CPS
INVALID DATA
0
500
1000
1500
2000
2500
FREQUENCY - CPS


H4270 SUSTAINER HYDRAULIC PUMP/TACHOMETER, Y-AXIS
54.2 TO 55.0 SECONDS
(RMS) = 11.5
F = 61 CPS
INVALID DATA
POWER DENSITY - g²/CPS
1.0
0.5
0
0
500
1000
1500
2000
2500
FREQUENCY - CPS

4F

UNCLASSIFIED




H4290 SUSTAINER HYDRAULIC PUMP END, Y-AXIS
57.4 TO 58.3 SECONDS g(RMS) = 30
ΔF = 61 CPS
10.0
5.0
0
POWER DENSITY - g²/CPS
0
500
1000
1500
2000
2500
FREQUENCY - CPS

4F

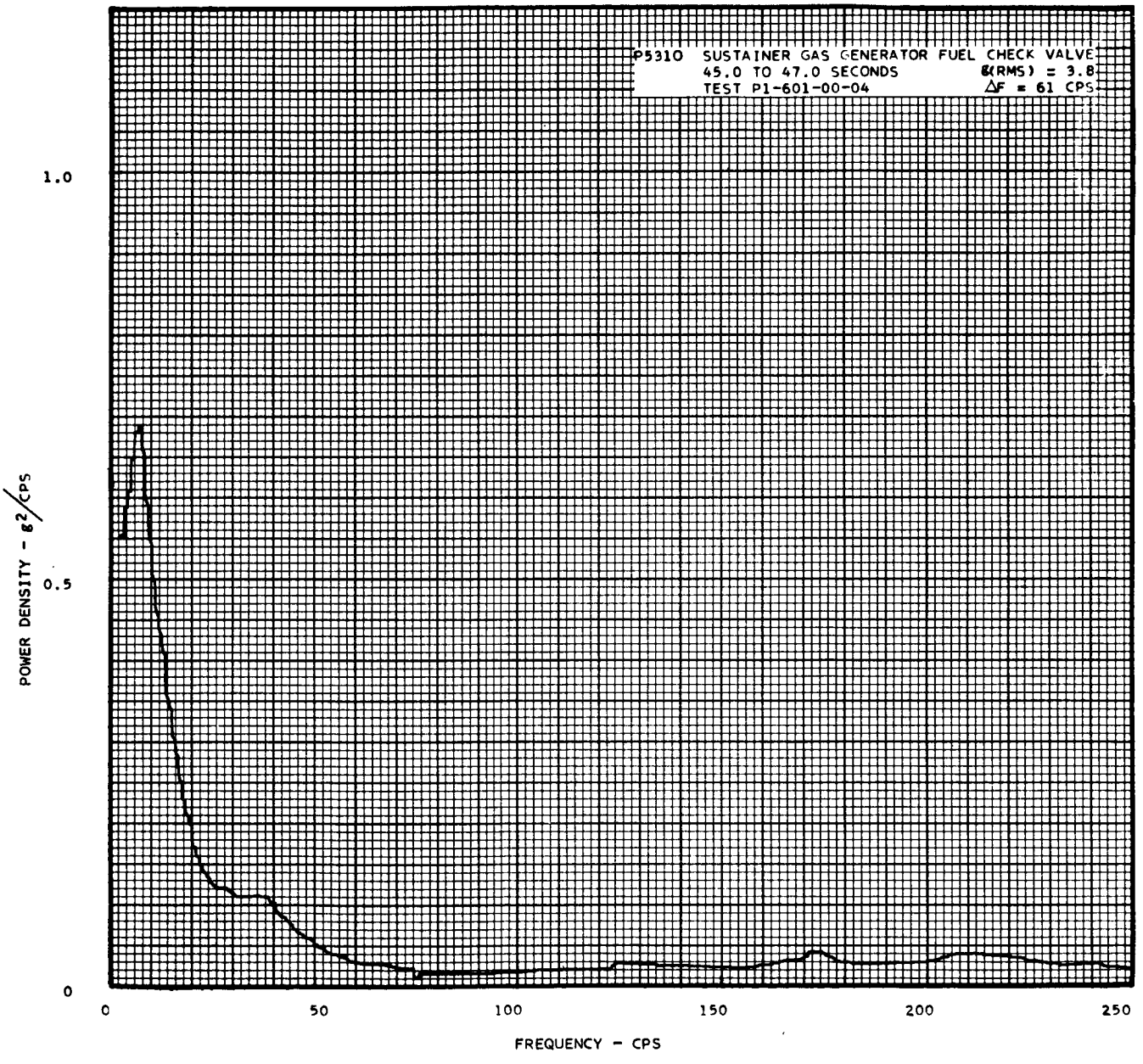

P5310 SUSTAINER GAS GENERATOR FUEL CHECK VALVE
45.0 TO 47.0 SECONDS
TEST P1-601-00-04
G(RMS) = 3.8
ΔF = 61 CPS
1.0
0.5
0
POWER DENSITY - g²/CPS
0
50
100
150
200
250
FREQUENCY - CPS

FIGURE NO. 19-8

~~REPORT NO. AE61-0709~~

LOCATION OF ACCELEROMETERS ON SUSTAINER HYDRAULIC PUMP

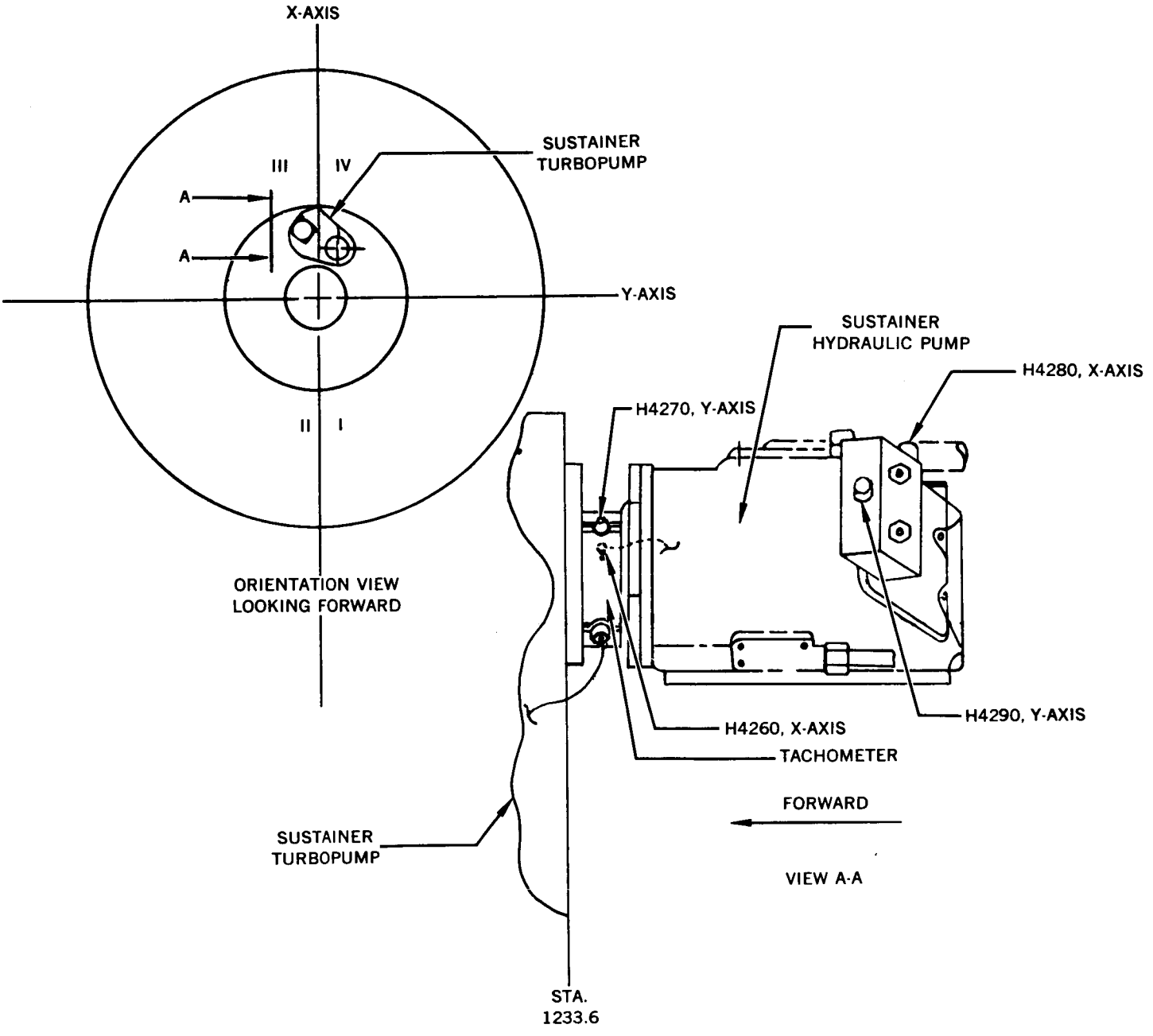
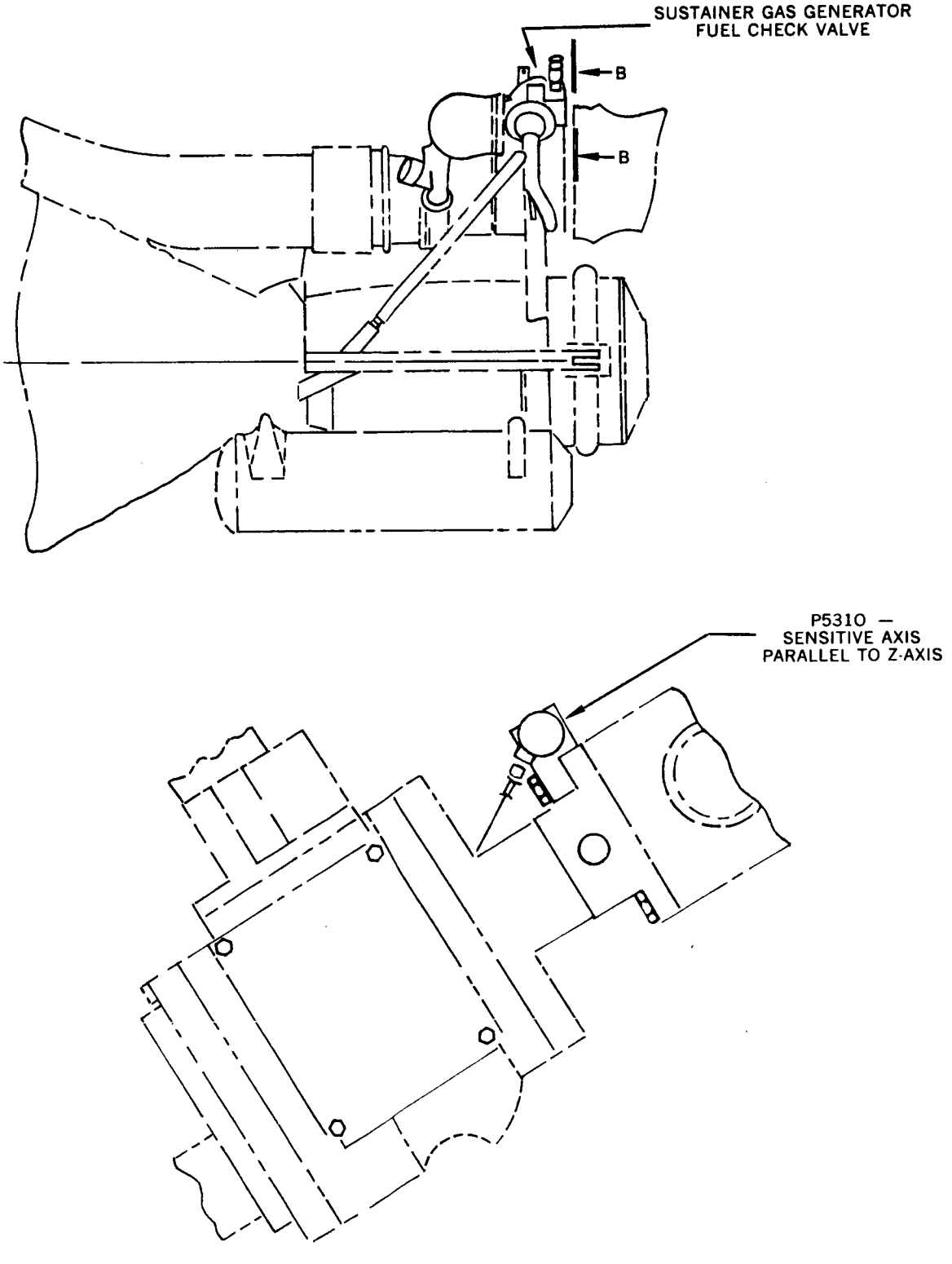


FIGURE NO. 19-9

~~REPORT NO. AE61-0799~~

SUSTAINER GAS GENERATOR CHECK VALVE VIBRATION PICKUP LOCATION

MISSILE 4F

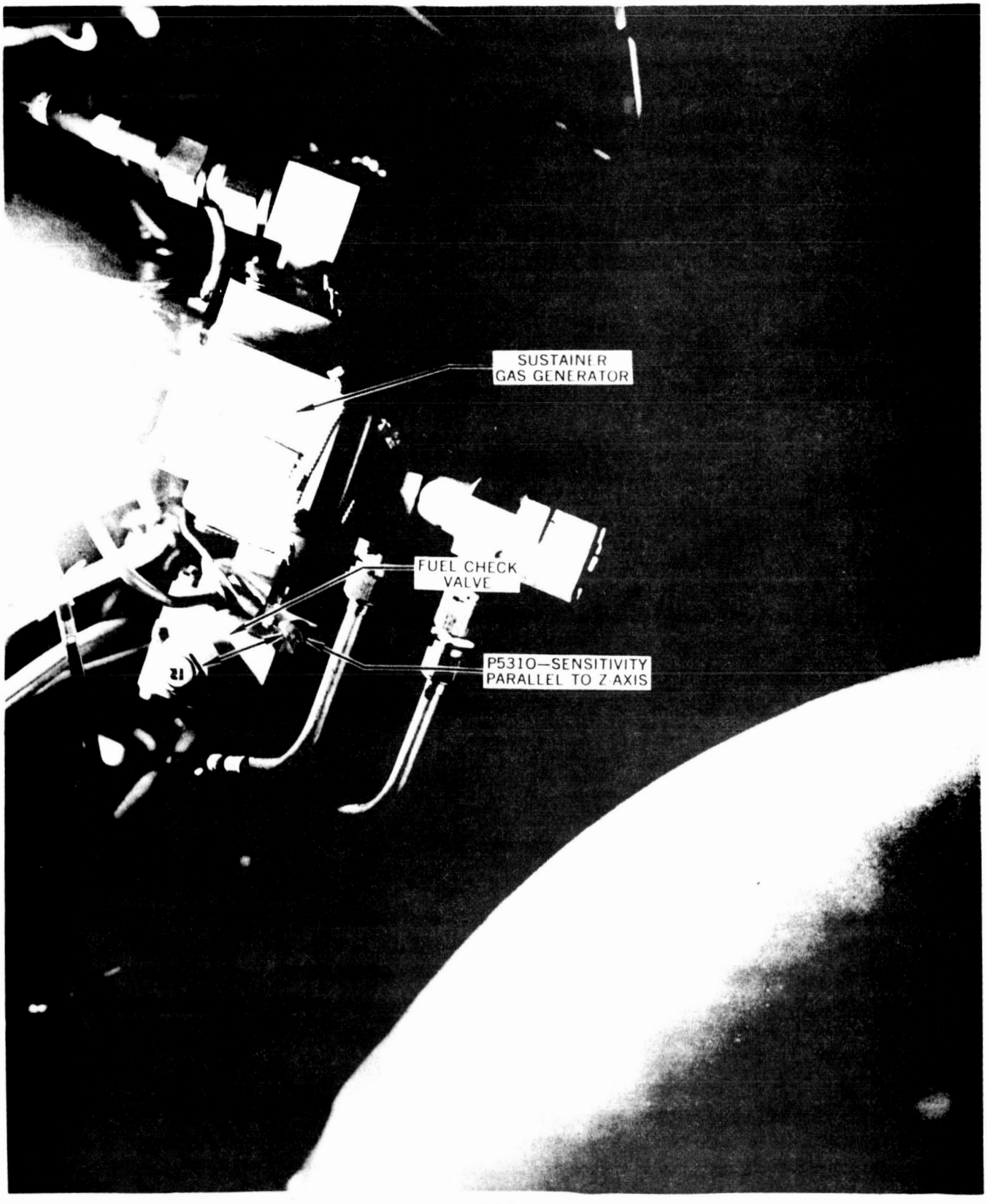


VIEW B-B

FIGURE NO. 19-10

~~REPORT NO. AE61-0799~~

VIBRATION



GD/A-DDE65-016

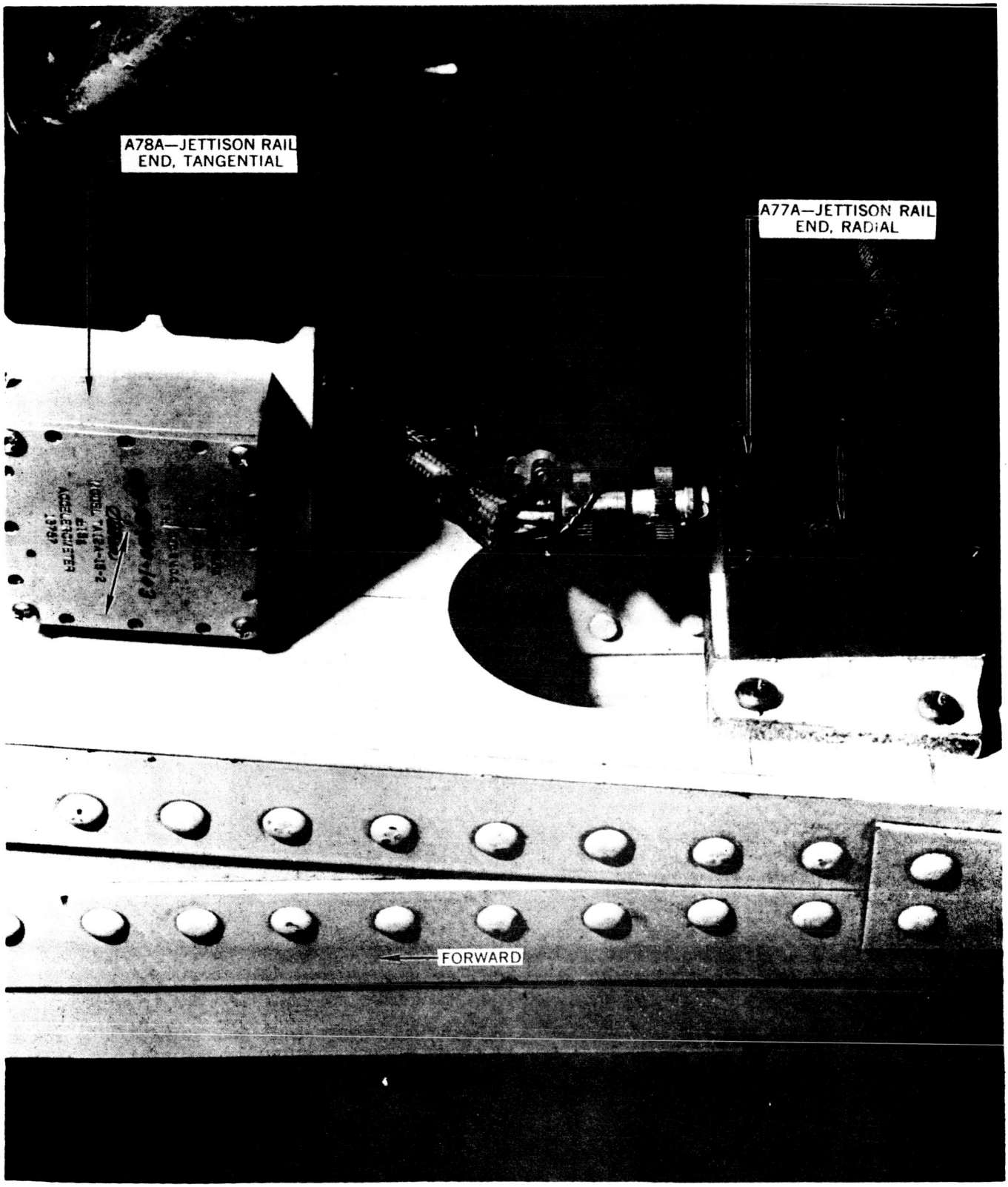
FIGURE NO. 13-23

~~REPORT NO. AE61-0799~~

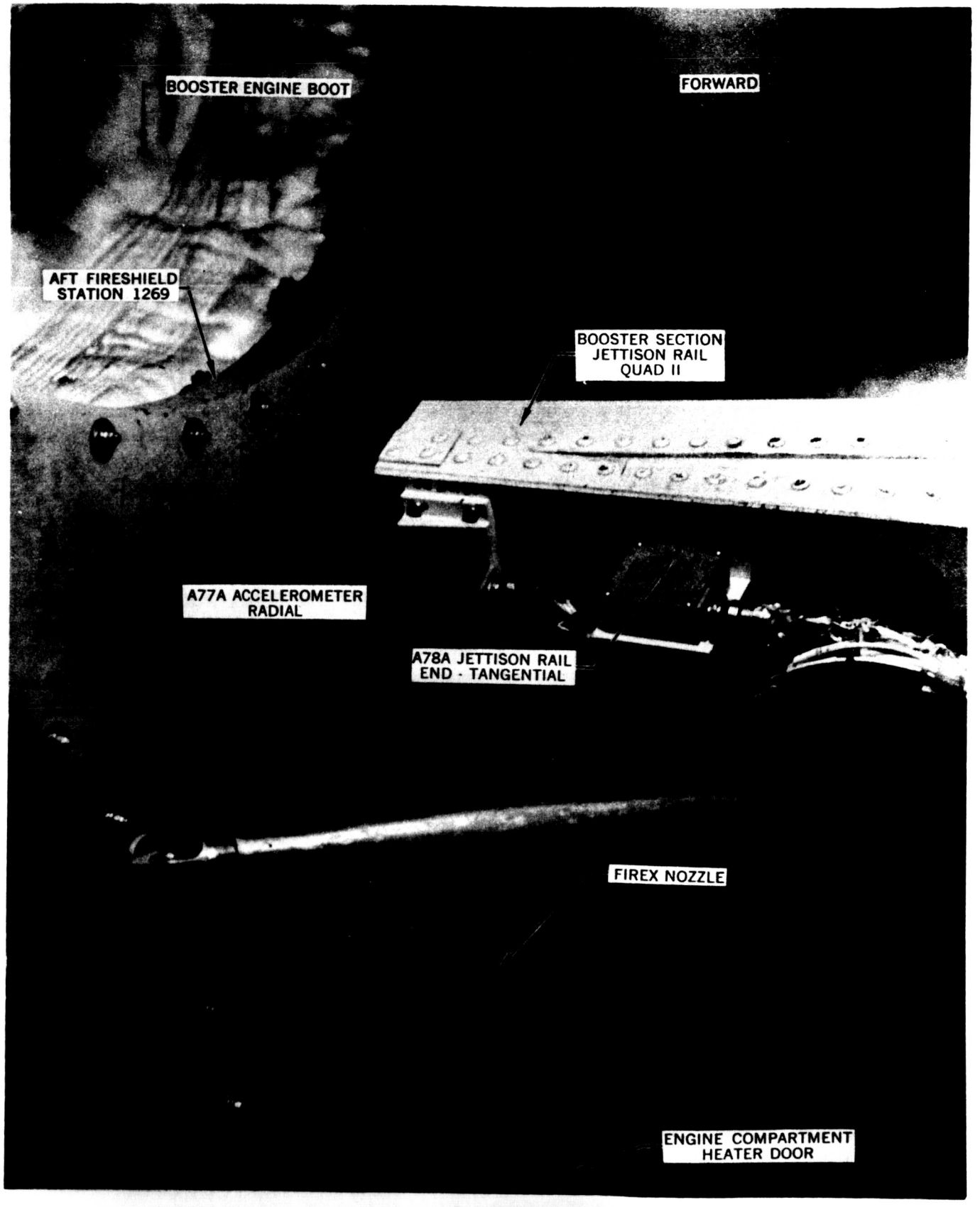
4F

JETTISON RAIL ACCELEROMETERS

MISSILE 4F



MISSILE AFT FIRESHIELD AND JETTISON RAIL



SECTION 6.2.18

MISSILE 6F

FLIGHT TESTED 12-20-61

AT AMR COMPLEX 11

TEST REPORT AE61-1282

SECTION 20

VIBRATION ANALYSIS

Four vibration measurements were taken from the sustainer hydraulic pump to determine the vibratory response of the unit during powered flight. Useful data was recorded from these measurements during the first 260 seconds of flight time. At approximately 260 seconds, there was a loss of telemetry. The recorded data was useful in investigating the cause of the sustainer hydraulic failure. The accelerometer locations and associated recording system frequency response capabilities were as follows:

Meas. No.	Location	Waveform	Channel Response (cps)
H426O	Sustainer Hydraulic Pump/Tachometer, X-Axis	Commutated	1200
H427O	Sustainer Hydraulic Pump/Tachometer, Y-Axis	Commutated	1200
H428O	Sustainer Hydraulic Pump End, X-Axis	Commutated	1200
H429O	Sustainer Hydraulic Pump End, Y-Axis	Commutated	1200

Details of the accelerometer installations are shown in Figures 20-5 and 20-6. Steady-state vibration levels recorded from the four sustainer hydraulic pump measurements during the first 147.5 seconds of 6F powered flight indicated normal pump operation. Maximum steady-state vibration levels during this period were 9.5 g(rms) and 8.5 g(rms), respectively, for Measurements H426O (X-axis) and H427O (Y-axis) located on the tachometer; and 12.5 g(rms) and 14 g(rms), respectively, for H428O (X-axis) and H429O (Y-axis), located on the end of the sustainer hydraulic pump.

Predominant frequencies for each measurement during this 147 second steady-state period were approximately 2375 cps for H426O, 2040 cps for H427O, 1525 cps for H428O, and 1020 cps for H429O. Power density spectra samples are shown in Figure 20-2.

At approximately 147.5 seconds, following a sharp drop in the sustainer hydraulic pump inlet pressure (H185P), there was a marked increase in vibration intensity from the two measurements on the end of the hydraulic pump. Outputs from these two measurements (H428O and H429O) displayed an increase in intensity until approximately 180 seconds. Maximum overall acceleration levels noted were 26 g(rms) (including a discrete 1025 cps frequency component with a mean level of 23 g zero-to-peak) for H428O'(X-axis) at 167 seconds; and 24 g(rms) (including a discrete 515 cps frequency component with a mean level of 19 g zero-to-peak) for

H429O (Y-axis) at 169 seconds. During this period, acceleration levels from the tachometer Measurements H426O and H427O increased only slightly from previous steady-state rms levels. Discrete frequency components of 515 cps, 1025 cps, 1515 cps, and 2020 cps were predominant on the end of the hydraulic pump during this buildup period.

The vibration intensity leveled off and decreased slightly from approximately 180 seconds to 201 seconds. At 201 seconds, a sharp drop in the sustainer hydraulic high pressure to the manifold (H191P) again resulted in rapidly increasing vibration intensity from Measurement H428O (X-axis) on the end of the hydraulic pump. This measurement exhibited maximum over-all acceleration levels of 38 g(rms) (including a 515 cps discrete frequency with a mean level of 27 g zero-to-peak) at 223 seconds. The major frequency components were 515 cps, 2550 cps and 1510 cps. There was no simultaneous increase in acceleration levels from the other three measurements on the hydraulic pump. At approximately 219 to 224 seconds when Measurement H428O (X-axis) on the end of the pump was exhibiting maximum output [38 g(rms)], Measurements H426O, H427O, and H429O were displaying over-all acceleration levels of only 13 g(rms), 11 g(rms) and 14 g(rms), respectively. Samples of power density spectra over this time period (219 to 224 seconds) are shown in Figure 20-3. Oscillograph samples of the commutated data are shown in Figure 20-1. A tabulation of 6F vibration levels and predominant frequencies is shown in this section

Acceleration intensity dropped off rapidly after 225 seconds. Steady-state levels not exceeding 8 g(rms) prevailed until the loss of RF #1 telemetry data at approximately 260 seconds. These moderate steady-state acceleration levels recorded after 225 seconds were a possible indication that the sustainer hydraulic pump was still functioning (most likely with a minimum of hydraulic fluid present) when the loss of telemetry occurred.

Vibration output from the four measurements on the sustainer hydraulic pump during the 260 seconds of available data did not exceed the current standard thrust section vibration specifications. Hydraulic pressure data indicates that the higher vibration levels occurring after 147.5 seconds were a result of hydraulic failure rather than the cause. Figure 20-4 shows time history plots [g(rms) versus seconds] of the four sustainer hydraulic pump vibration measurements.

Summary of Sustainer Hydraulic Pump Vibration

To date, a study of sustainer hydraulic pump vibration has been made from a series of static tests on Missile 1F at Sycamore Canyon Test Site and from flight test Missiles 4F, 5F, and 6F. A comparison of the results of these tests shows some consistency regarding vibration intensity and predominant frequencies. A failure in the sustainer hydraulic system during the flight of Missile 6F resulted in the highest vibration levels recorded from the hydraulic pump to date. Maximum over-all levels of 38 g(rms) (including a mean level of 27g zero-to-peak at

515 cps) were recorded from measurement H428O (X-axis), located on the end of the hydraulic pump.

Except for Measurements H1428O on 1F static testing and H429O on the 4F flight, comparison of results from 1F static firing tests and from flight tests 4F and 6F shows steady-state vibration levels to be in the same over-all general range. During 1F testing, Measurement H4280 recorded over-all steady-state acceleration levels (max. 24 g(rms) twice those recorded from the corresponding measurement during flights 4F and 6F, and nearly three times those recorded during the flight of 5F. During flight 4F, Measurement H429O displayed over-all steady-state levels [max. over-all 30 g(rms), including a mean 26 g zero-to-peak at 1025 cps] twice those displayed during flights 5F and 6F, and 1F static firings. However, erroneous calibration figures were anticipated for this measurement on Missile 4F. With the exception of these two irregularities above, the average of the steady-state outputs of each measurement for the three 1F static tests and two tests flights (4F, 6F) was approximately 7 g(rms) and 6.5 g(rms) for the tachometer Measurements H426O (X-axis) and H427O (Y-axis), respectively; and 10.5 g(rms) and 13 g(rms) for the two hydraulic pump measurements H428O (X-axis) and H429O (Y-axis), respectively. In general, steady-state vibration levels recorded during flight 5F were considerably lower than 1F, 4F, and 6F levels.

Major frequency components showed considerable consistency from test to test through both static firings and flights. Some of the predominant frequency ranges, consistent from test to test, were 500-520 cps, 625-670 cps, 1475-1525 cps, and 2000-2050 cps. In general, sustainer stage steady-state acceleration levels were 1 to 3 g(rms) lower than booster stage steady-state levels. With the exception of the abnormally high output from Measurement H429O on Missile 4F (calibration error anticipated), the normal steady-state vibration levels from all sustainer hydraulic pump testing to date (static Missile 1F; flight Missiles 4F, 5F, 6F) have been within current standard thrust section vibration specifications. See the tabulation of vibration levels.

TABULATION OF SUSTAINER HYDRAULIC PUMP VIBRATION
(SPECTRUM ANALYSIS**)

PERIOD (Sec. from 1" motion)	CODE	H426O	H427O	H428O	H429O
		MISSILE 6F			
		(P1-601-00-06)			
		BOOSTER STAGE			
41-47	1	9.5/2500	8/2500	12/2500	12.5/2500
	2	41.1-42.0	42.2-43.0	43.2-44.0	45.3-46.1
	3	2375/0.21	2020/0.27	1525/0.52	1020/2.3
	4	2020/0.10	2380/0.08	2025/0.25	520/0.05
	5	670/0.07	1520/0.06	2380/0.25	2020/0.03
	6	540/0.07		540/0.20	
	7			1040/0.20	
64-69	1	8.5/2500	8.5/2500	12/2500	14/2500
	2	64.4-65.2	65.4-66.2	66.4-67.2	68.5-69.3
	3	2380/0.22	2040/0.35	1530/0.65	1015/3.2
	4	540/0.07	2400/0.11	1040/0.28	2040/0.12
	5	670/0.06	1380/0.05	2390/0.24	520/0.12
	6	2040/0.06	720/0.04	540/0.18	
	7	1900/0.04	1500/0.04	2560/.75*	
			*2580/.32		
111-116	1	9.5/2500	7.5/2500	12.5/2500	13/2500
	2	110.7-111.5	111.8-112.6	112.8-113.6	115.9-116.8
	3	2370/0.24	2035/0.23	1525/0.90	1015/1.65
	4	525/0.09	2390/0.07	2030/0.25	520/0.12
	5	700/0.06	720/0.04	1040/0.22	2015/0.06
	6	2540/0.16*	1540/0.04	2400/0.22	
	7		1380/0.04	540/0.16	
		SUSTAINER STAGE			
138-145	1	5.5/2500	7/2500	9.5/2500	10/2500
	2	141.8-142.3	142.8-143.3	143.8-144.3	138.2-138.7
	3	2380/0.12	2040/0.29	1530/0.20	1020/1.35
	4	510/0.03	1510/0.05	1040/0.18	
165-170	1	8.5/2500	10/2500	26/2500	24/2500
	2	164.9-165.7	165.9-166.7	166.9-167.7	169.0-169.8
	3	515/0.125	2570/0.62	1025/4.1	515/3.0
	4	2375/0.065	2040/0.53	1515/2.3	1020/1.2
	5	1515/0.055	1050/0.13	2020/1.8	2020/0.3
	6		1530/0.12	2550/1.6*	1520/0.2
180-185	1	6.5/2500	7/2500	16/2500	17/2500
	2	180.5-181.0	181.5-182.0	182.5-183.0	184.5-185.0
	3	510/0.2	2040/0.07	1025/4.1	515/3.0
	4	680/0.06	1070/0.06	1515/2.3	1020/1.2
	5	1020/0.05		2020/1.8	2020/0.3
	6	2380/0.05		2550/1.6*	1520/0.2
219-225	1	13/2500	11/2500	38/2500	14/2500
	2	219.0-219.8	220.1-220.9	222.1-222.9	223.2-224.0
	3	525/0.78	515/0.26	515/6.3	1020/0.28
	4	1515/0.15	1510/0.16	1510/3.6	1520/0.22
	5	2025/0.10	2020/0.14	1020/0.8	520/0.12
	6		2300/0.10	2020/1.0	2030/0.11
	7			2550/5.4	
227-2333	1	8/2500	5.5/2500	12/2500	9/2500
	2	226.8-227.6	227.8-228.6	228.8-229.6	230.9-231.7
	3	685/0.084	1370/.038	515/0.28	1025/0.29
	4	2425/0.079	2325/.038	1010/0.12	690/0.11
	5	510/0.048	2440/.023	1510/0.11	345/0.08
	6		2210/.022	690/0.10	525/0.06
	7		700/.019		
	8		530/.017		
		MISSILE 5F			
		(P1-603-00-05)			
		BOOSTER STAGE			
3-8	1	5/2000	3.8/2000	6.8/2000	
	2	3.8-4.3	4.8-5.3	5.8-6.3	Data Not
	3	640/.074	2000/.105	1500/0.32	Recorded
	4	540/.042	1300/.027	2000/0.31	

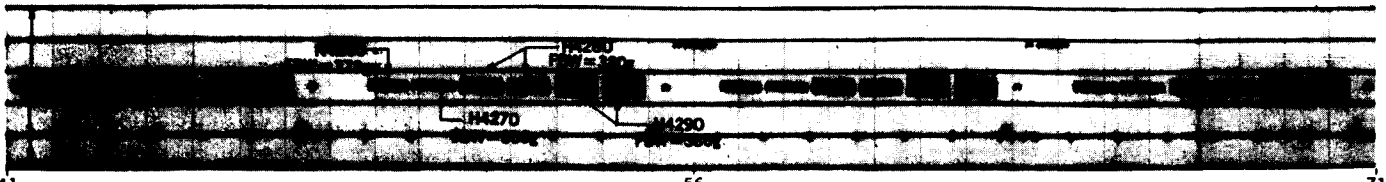
PERIOD (Sec. from 1" motion)	CODE	H426O	H427O	H428O	H429O
95-100	1	4/2000	3/2000	9/2000	13/2000
	2	95.6-96.2	96.6-97.2	97.6-98.2	99.6-100.2
	3	670/.070	2000/.036	1530/1.05	1050/2.5
	4	540/.025	1350/.033	2050/0.40	550/0.4
		SUSTAINER STAGE			
156-161	1	5/2000	4.7/2000	7/2000	
	2	156.8-157.3	157.8-158.3	159.9-160.4	
	3	635/.098	2000/.05	1530/1.1	Data Not
	4	1540/.024	200/.048		Recorded
		MISSILE 4F			
		(P1-601-00-04)			
		BOOSTER STAGE			
45-50	1	7.5/2500	10/2500	12/2500	27/2500
	2	44.9-45.7	46.0-46.8	48.2-49.0	49.3-50.1
	3	640/0.16	2035/0.45	1530/0.66	1025/8.8
	4	2000/0.10	1020/0.17	660/0.42	720/0.7
	5	1870/0.05	1510/0.09	2030/0.02	2020/0.4
	6	510/0.04	690/0.08	1130/0.16	
	7		1270/0.06		
53-58	1	8/2500	11.5/2500	13/2500	30/2500
	2	53.1-53.9	54.2-55.0	56.3-57.2	57.4-58.3
	3	2050/0.16	2050/0.68	1540/1.0	1025/11.0
	4	670/0.15	1540/0.10	670/0.5	680/0.5
	5	1910/0.05	690/0.09	2045/0.5	2020/0.3
	6	540/0.04	1050/0.08	1050/0.2	
		STATIC			
		MISSILE 1F			
		H1426O	H1427O	H1428O	H1429O
		S1-610-A10-01			
18-19	1	6.2/2500	5.8/2500	20.5/2500	14.7/2500
	2	18.0-19.0	18.0-19.0	18.0-19.0	18.0-19.0
	3	620/0.05	655/0.065	1480/2.8	1485/1.70
	4		980/0.050	1950/2.3	1955/0.60
	5		2285/0.037	640/1.0	1015/0.48
	6		2435/0.035	1010/0.4	515/0.28
	7				2455/0.20
		S1-609-A10-01			
2-3	1	5.5/2000	5.3/2000	Data Not	13.6/2000
	2	2.0-3.0	2.0-3.0	Recorded	2.0-3.0
	3	625/0.10	655/0.70		1495/0.60
	4	995/0.05	1000/0.050		1980/0.55
	5	495/0.04	495/0.045		1025/0.050
	6	1305/0.03	1475/0.045		2490/0.35
	7		2000/0.045		535/0.23
		S1-608-A8-01			
35.0-35.5	1	8.5/2000	4.6/2000	24/2000	12/2000
	2	35.0-35.5	35.0-35.5	35.0-35.5	35.0-35.5
	3	625/0.45	1010/0.048	1500/3.6	1505/1.07
	4	1000/0.04	1500/0.048	2000/1.6	1020/0.47
	5	1865/0.04	670/0.004	640/1.2	1800/0.21
	6	1320/0.04	1880/0.024	1020/0.8	520/0.20
	7		520/0.023		

CODE:
1. Over-all acceleration levels, g(rms) frequency range of analysis, cps.
2. Time sample period, sec.
3. First predominant frequency, cps/power density, g^2/cps.
4. Second predominant frequency, cps/power density, g^2/cps.
5. Third predominant frequency, cps/power density, g^2/cps.
6. Fourth predominant frequency, cps/power density, g^2/cps.
7. Fifth predominant frequency, cps/power density, g^2/cps.
8. Sixth predominant frequency, cps/power density, g^2/cps.

NOTE: *A predominant frequency beyond the frequency range of analysis, cps/estimated power density, g^2/cps.

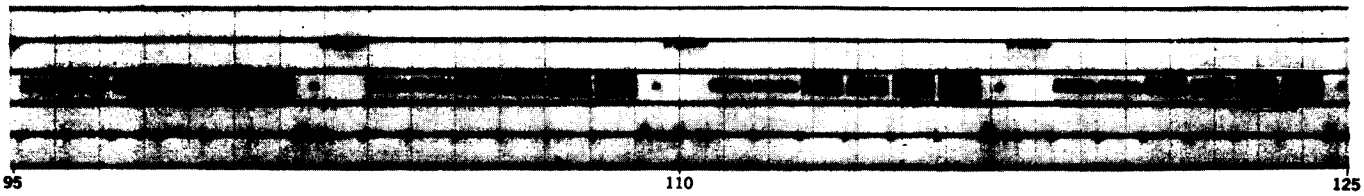
**Band width = 61 cps

g(rms) = {power density (g^2/cps) x band width (cps)}$^{1/2}$

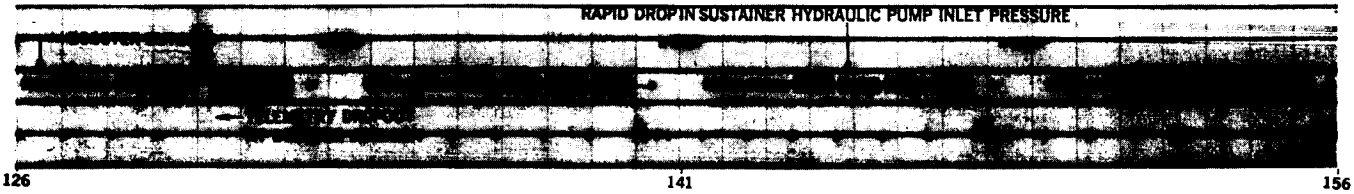


41 56 71

SEQUENCE OF MEASUREMENT AS SHOWN ABOVE WAS TYPICAL THROUGHOUT FLIGHT

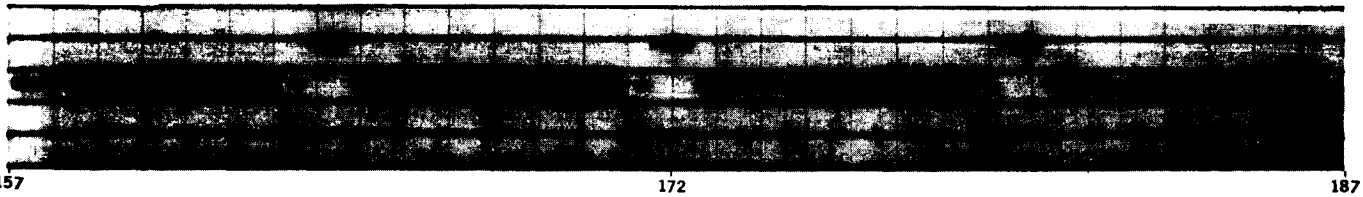


95 110 125

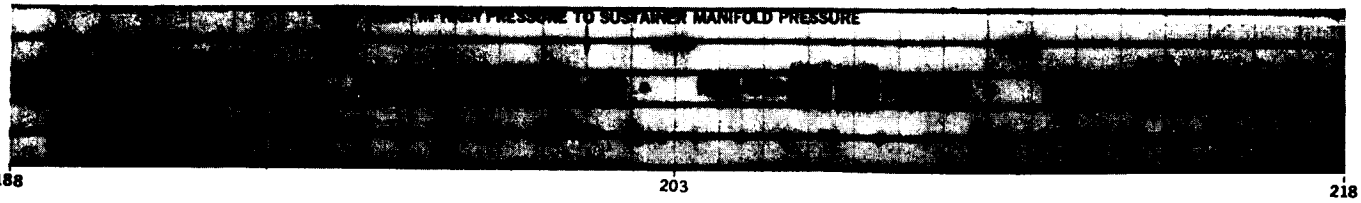


126 141 156

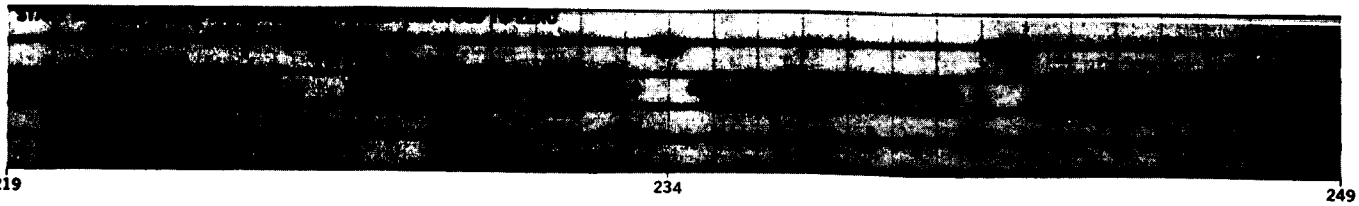
TIME IN SECONDS FROM 1-INCH MOTION



157 172 187



188 203 218



219 234 249

VIBRATION

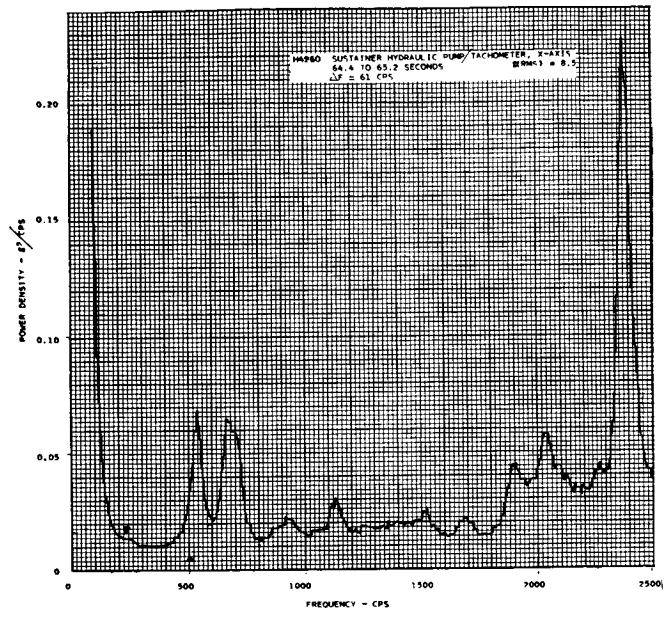
FIGURE NO. 20-2

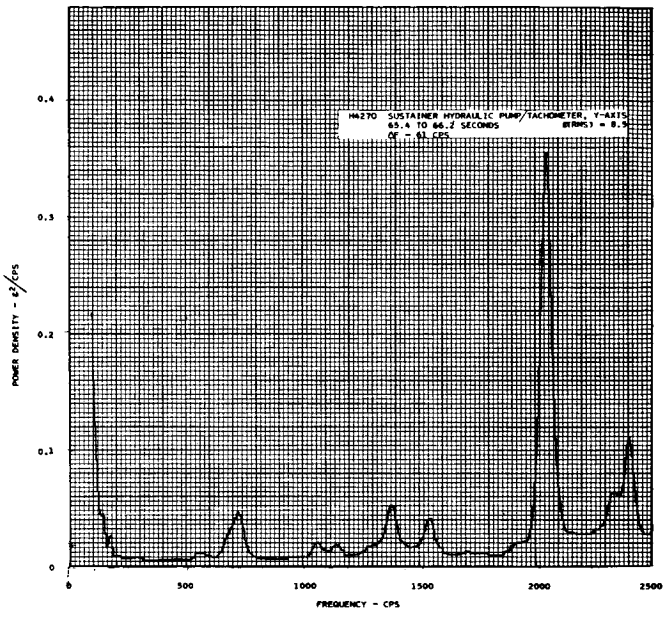
GD/A-DDE65-016

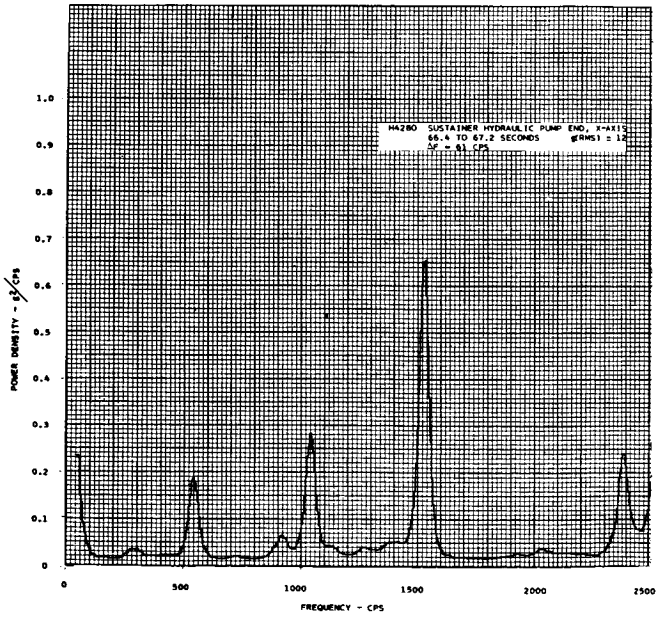
~~REPORT NO. AE61-1282~~

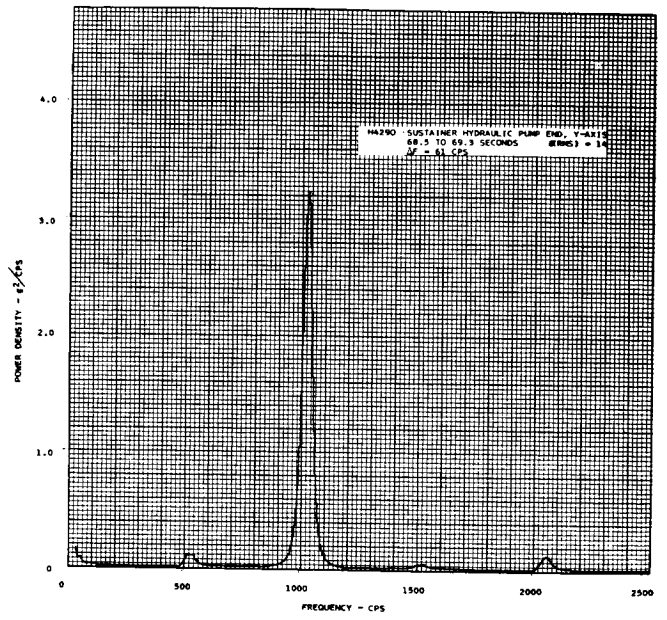
VIBRATION
TELEMETERED DATA

MISSILE 6F







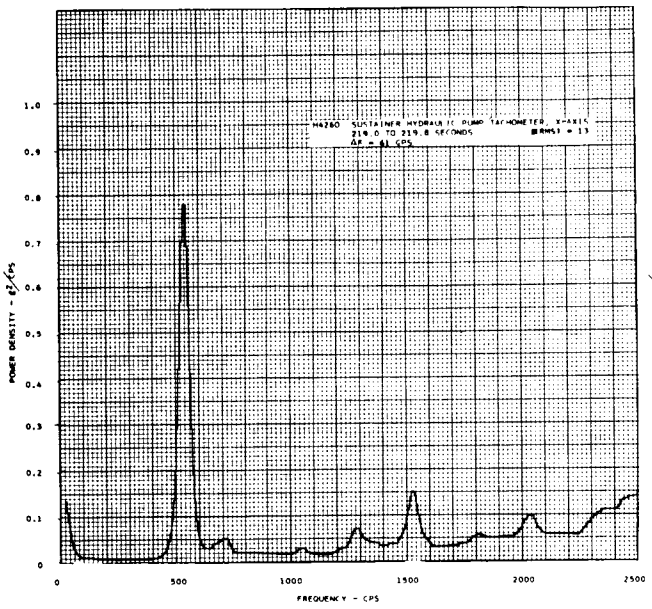


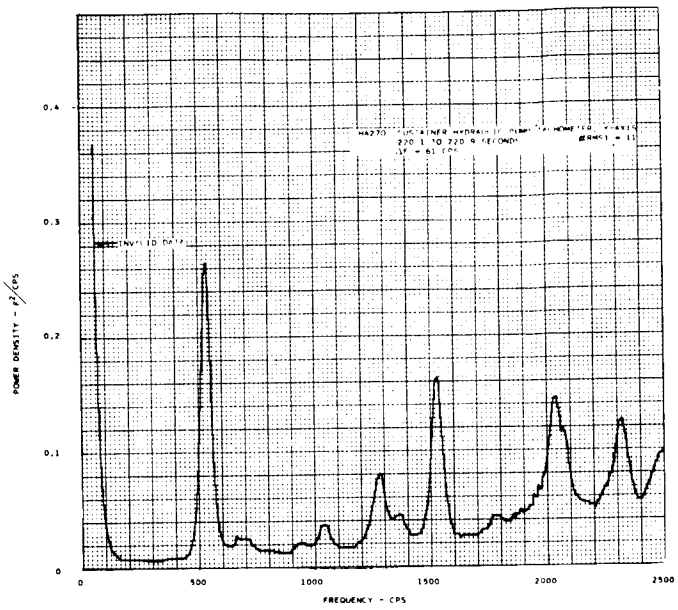
UNCLASSIFIED

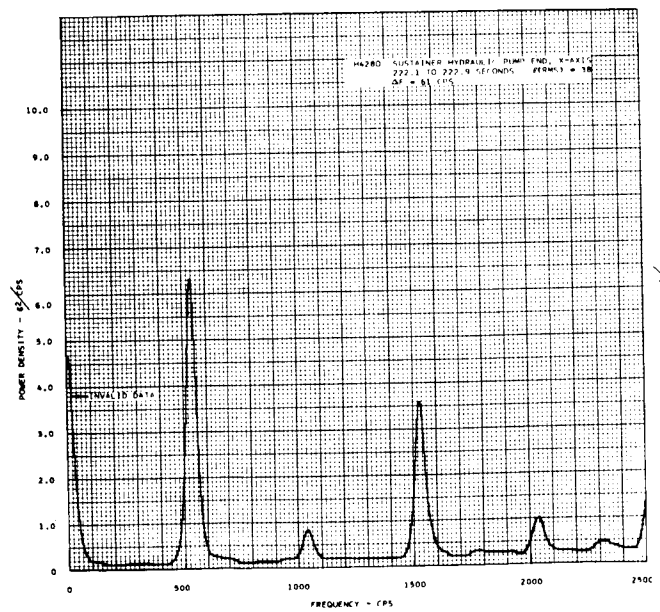
~~REPORT NO. AE61-1282~~

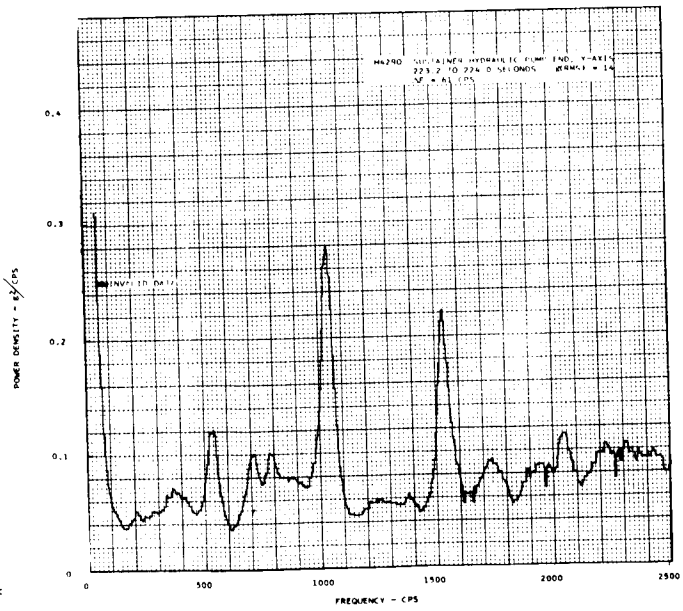
VIBRATION TELEMETERED DATA

MISSILE 6F

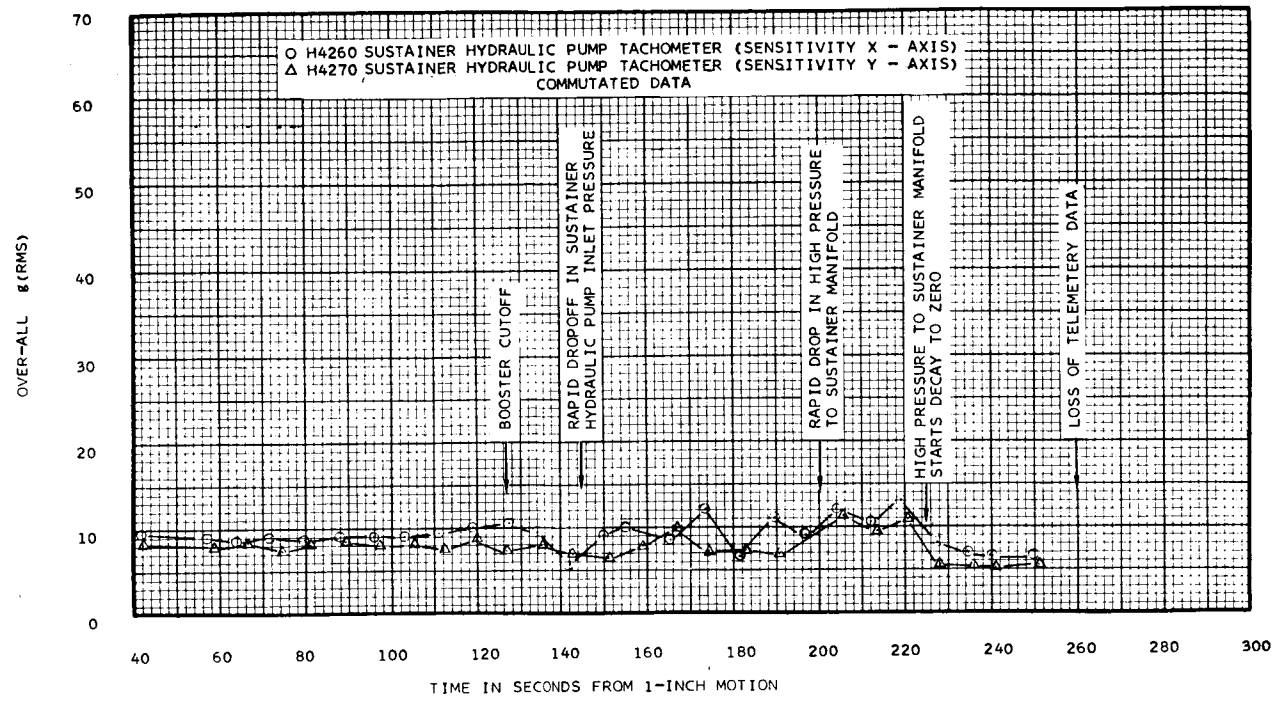


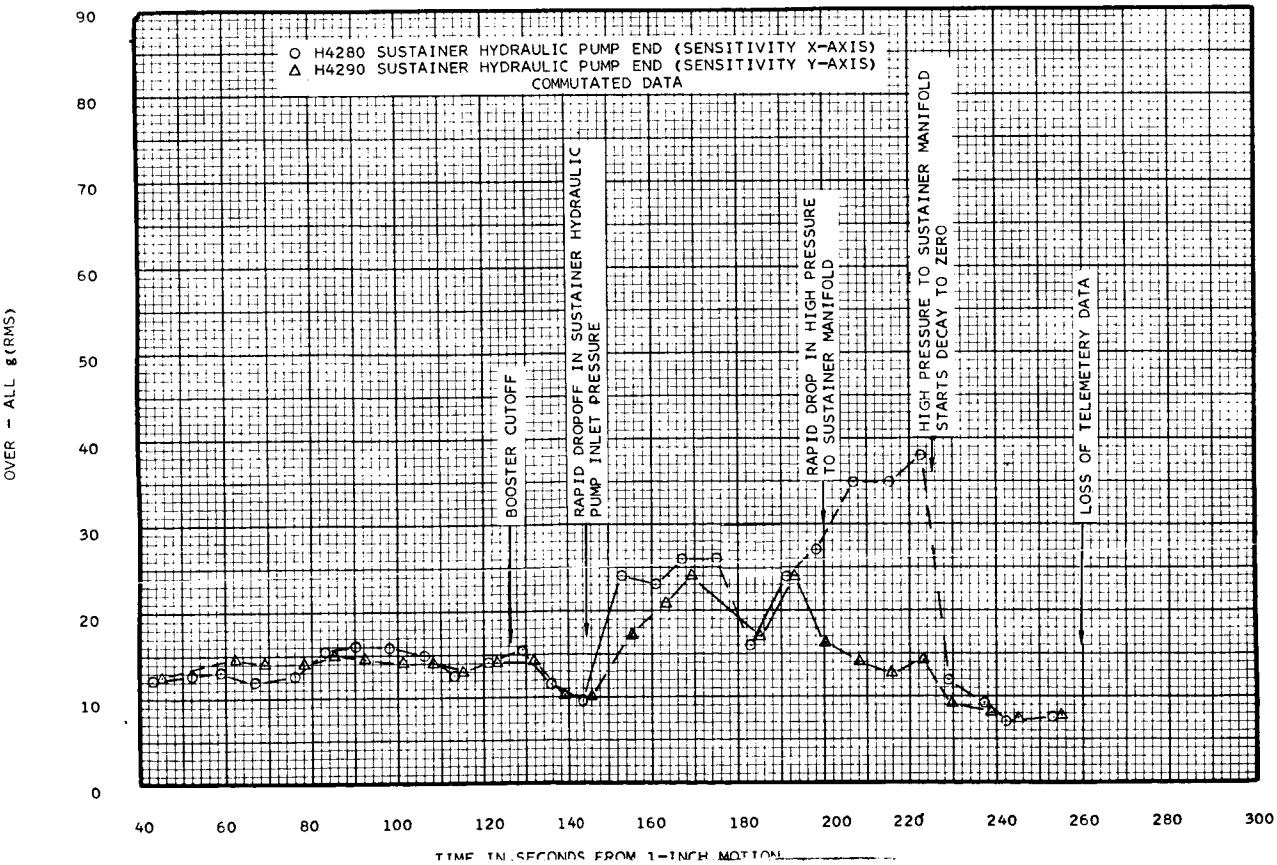






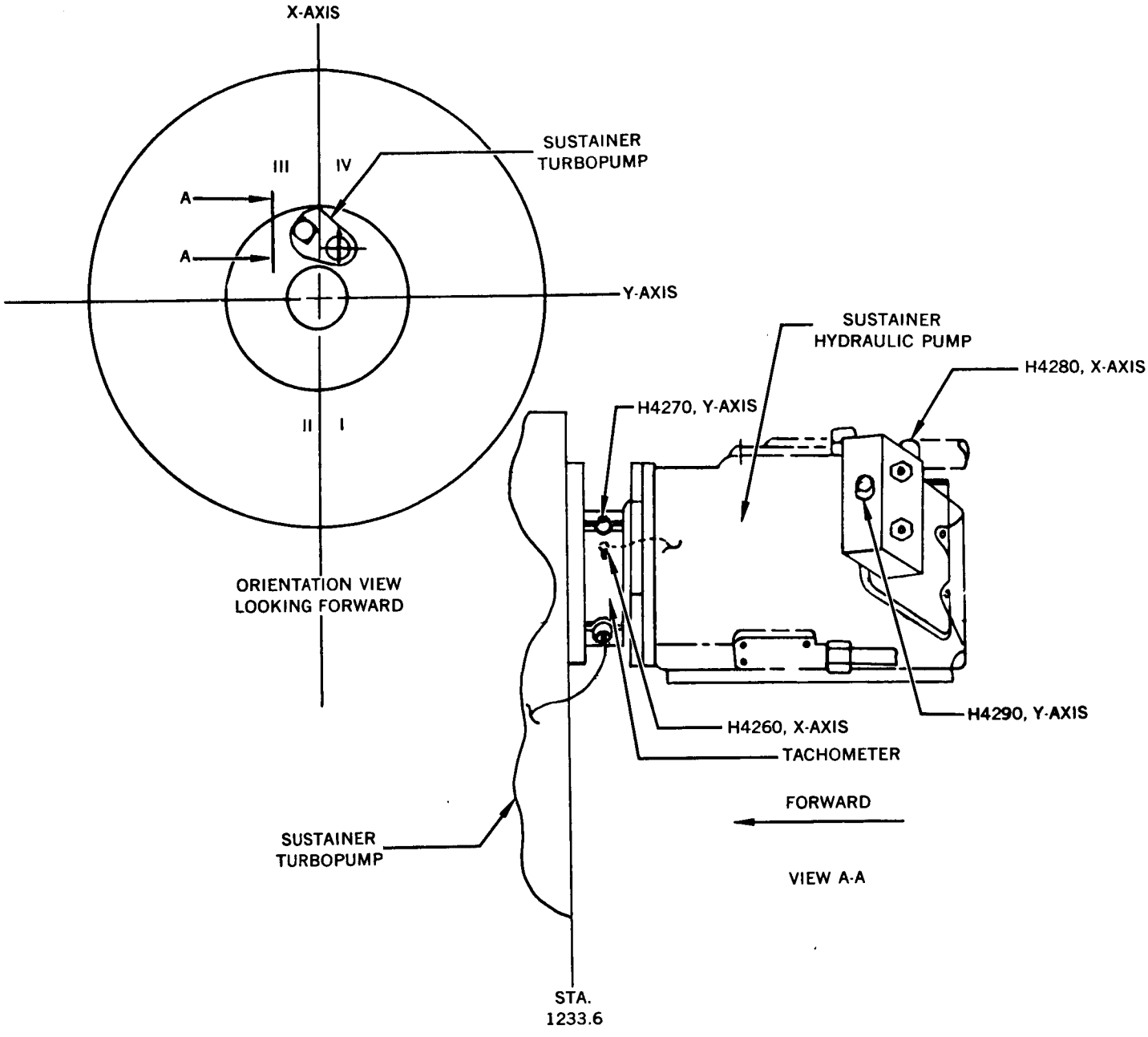
VIBRATION
TELEMETERED DATA



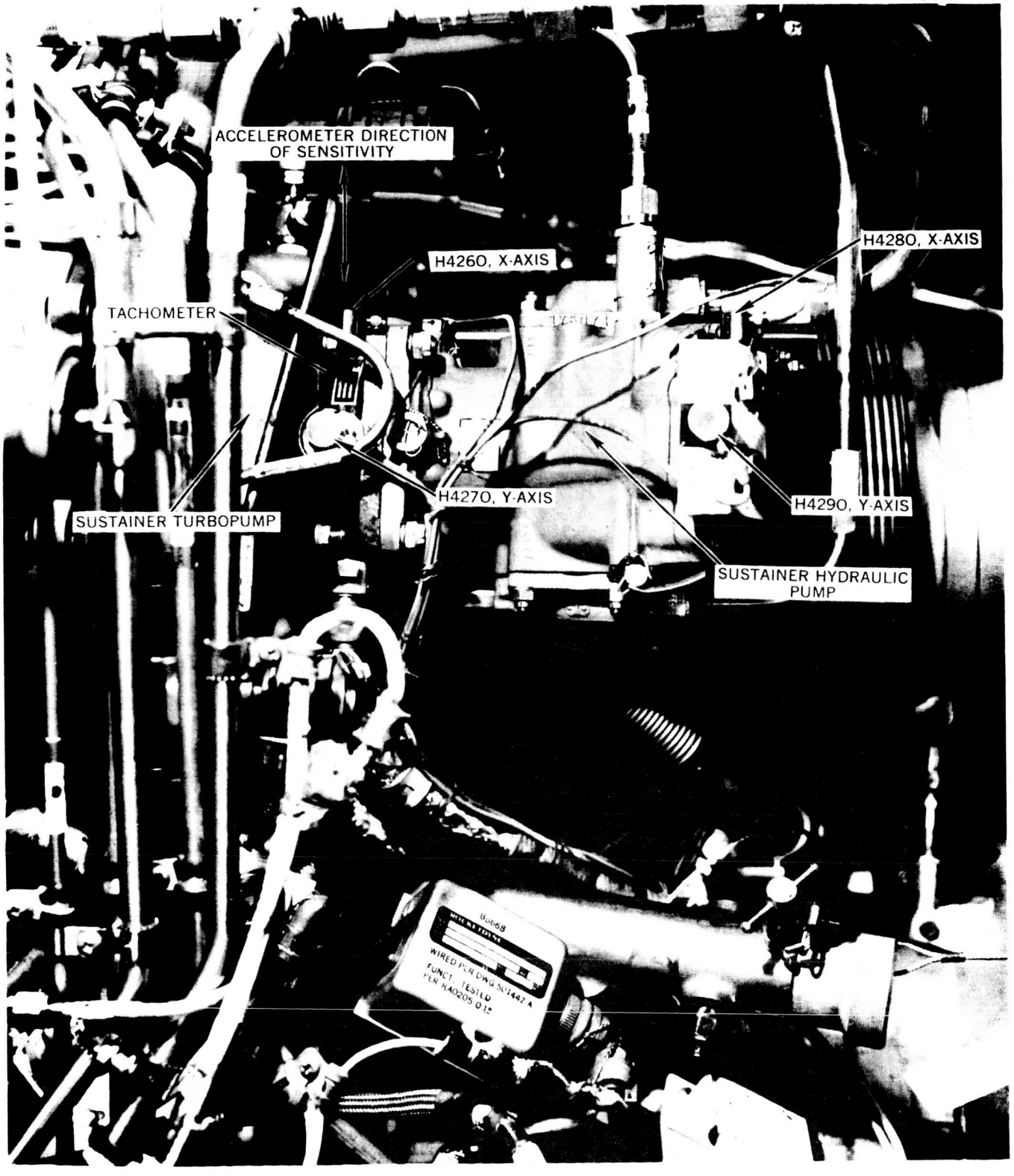


LOCATION OF ACCELEROMETERS ON SUSTAINER HYDRAULIC PUMP

MISSILE 6F



SUSTAINER HYDRAULIC PUMP VIBRATION



SECTION 6.2.19

MISSILE 14F

FLIGHT TESTED 10-19-62

AT AMR COMPLEX 11

TEST REPORT AOJ62-0054

Vibration Analysis

Two low frequency accelerometers mounted on the sustainer lox pump inlet flange and three high frequency accelerometers located on the booster sustainer engine lox domes were monitored during the time period between pre-ignition and the first 33 feet of missile vertical rise. The vibration data was recorded via the FM landline umbilical. Useful data was obtained from the two sustainer lox pump inlet flange accelerometers. Two of the three lox dome measurements P1208O (B1) and P1209O (B2) provided some useful data, however, a-c noise and d-c shift of the data trace limited its quantitative confidence level. The outputs were questionable. Measurement P1206O (sustainer) was invalid due to excessive noise.

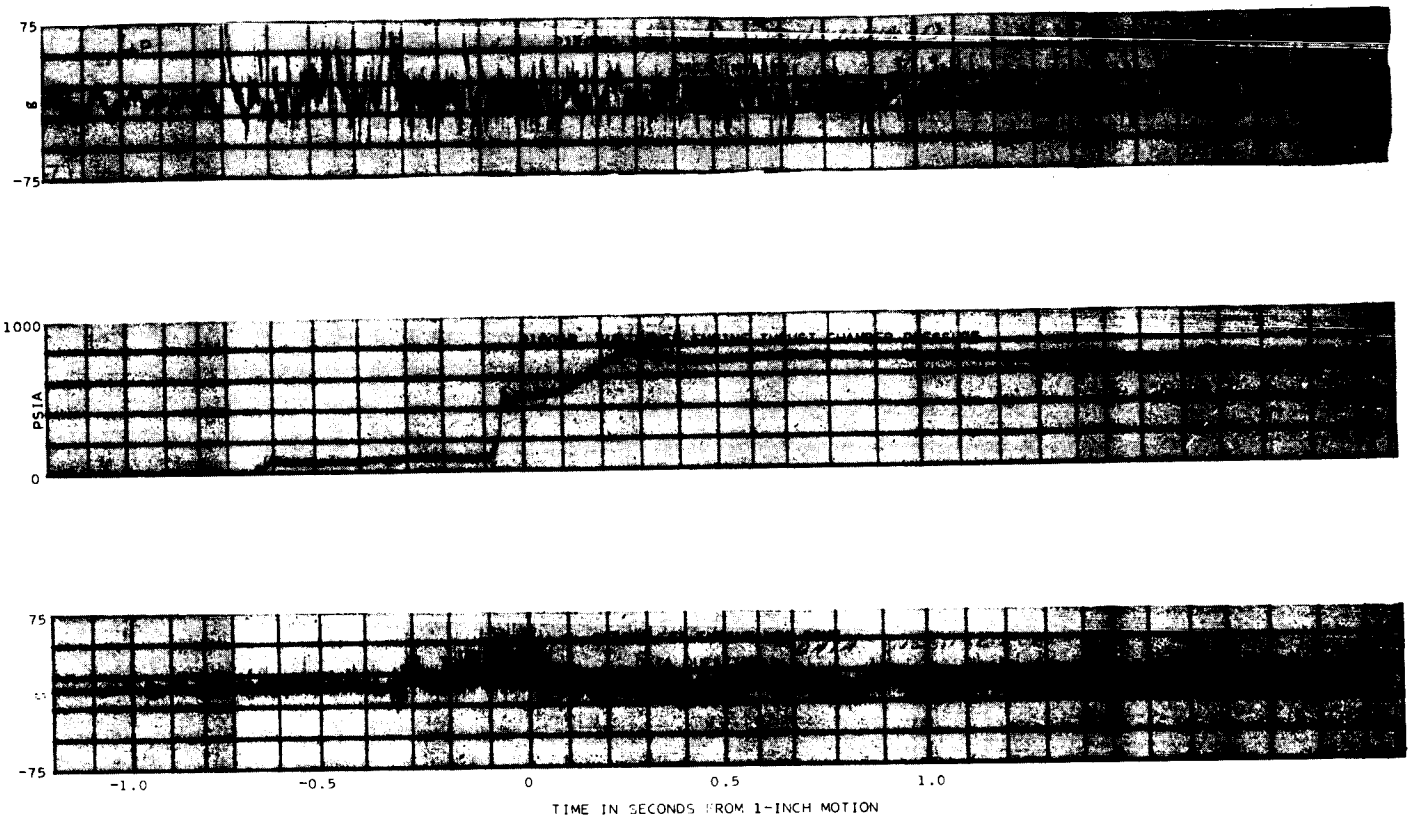
The data recorded from the sustainer lox pump inlet flange indicated some small shock transients in response to initial sustainer engine ignition burning and main propellant ignition. Between -0.62 and -0.58 seconds, the Y-Axis measurement, P1107O, exhibited a short duration shock transient in response to initial sustainer ignition burning. The initial maximum instantaneous acceleration peak was 8 g(peak-to-peak) damping out at a frequency of 60 - 70 cps within 0.04 seconds.

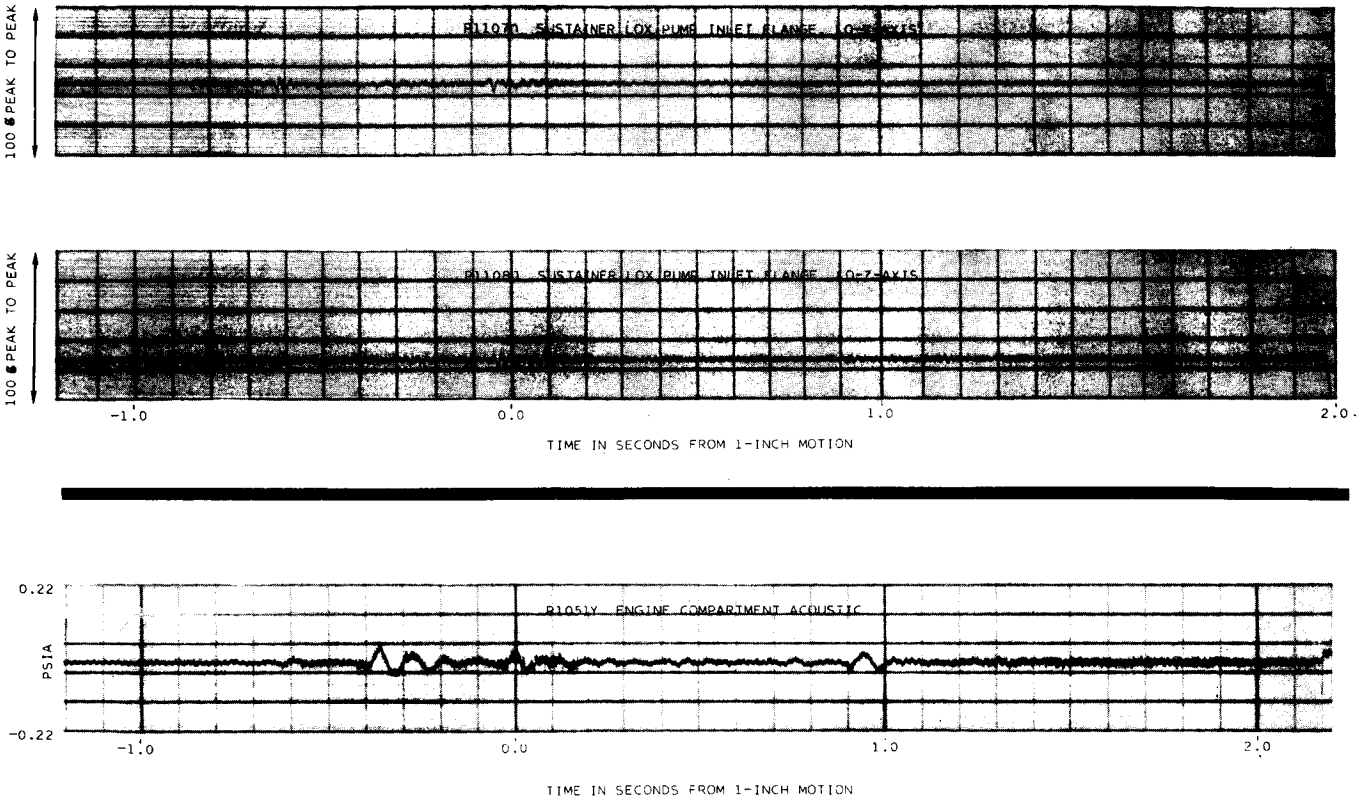
Response to the main propellant ignition of the sustainer engine was evident at -0.05 seconds. The data exhibited transient vibration between -0.05 and +0.10 seconds. Maximum instantaneous acceleration peaks during this period were 8 g(peak-to-peak) for both the Y and Z Axis measurements at a frequency of 44 cps. These vibrations exhibited at the sustainer lox pump inlet flange during the recorded period were normal and were within maximum design conditions.

Analysis of the lox dome vibration was limited by excessive noise in the data. The B1 and B2 measurements exhibited complex steady-state vibration between liftoff and two seconds. The over-all acceleration levels during this period (reference power spectral density analysis) were 7.3 g(rms) and 8.9 g(rms) for the B1 and B2 measurements, respectively. The predominant frequency was 670 cps for both engines. Figures 13-15 through 13-17 illustrate the data waveforms.

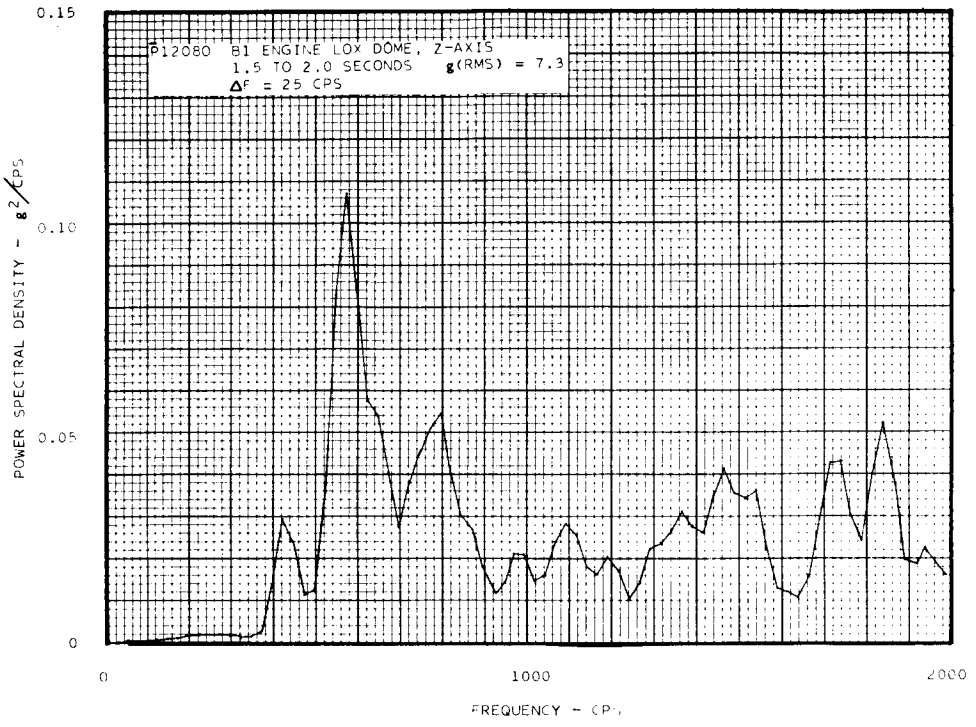
Thrust Section Acoustic Environment

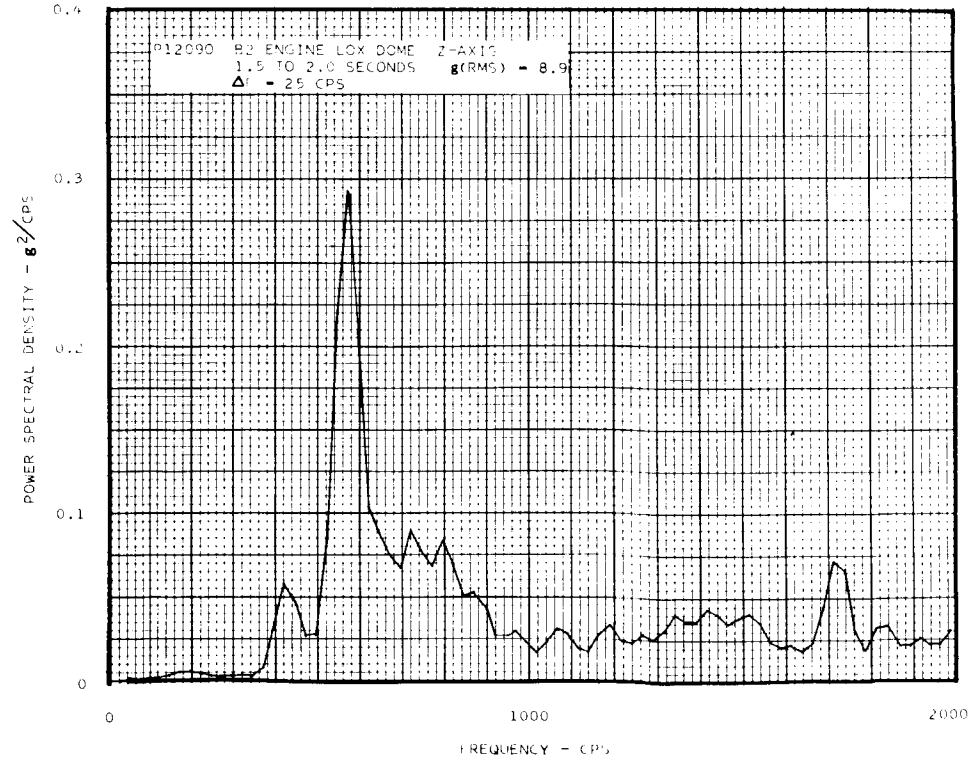
Missile 14F was instrumented with a high intensity microphone, P1051Y, located at the A-Frame near the sustainer engine. Useful data was recorded from the measurement via the FM landline umbilical. However, due to data reduction problems, the analysis of this data will not be included in this report. The analysis will be included in Missile 16F flight report.


75
g
-75
1000
PSIA
0
75
-75
-1.0
-0.5
0
0.5
1.0
TIME IN SECONDS FROM 1-INCH MOTION
1000
PSIA
0
75
-75
1000
PSIA
0


100 G PEAK TO PEAK
100 G PEAK TO PEAK
-1.0
0.0
1.0
2.0
TIME IN SECONDS FROM 1-INCH MOTION

0.22
PSIA
-0.22
R1051Y ENGINE COMPARTMENT ACOUSTIC
-1.0
0.0
1.0
2.0
TIME IN SECONDS FROM 1-INCH MOTION


P12080 B1 ENGINE LOX DOME, Z-AXIS
1.5 TO 2.0 SECONDS g(RMS) = 7.3
ΔF = 25 CPS
POWER SPECTRAL DENSITY - g²/CPS
0.15
0.10
0.05
0
0
1000
2000
FREQUENCY - CPS


P12090 B2 ENGINE LOX DOME Z-AXIS
1.5 TO 2.0 SECONDS g(RMS) = 8.9
ΔF = 25 CPS
POWER SPECTRAL DENSITY - g²/CPS
0.4
0.3
0.1
0
0
1000
2000
FREQUENCY - CPS

Staging Vibration

The missile thrust section was instrumented with 13 accelerometers to study vibration and shock characteristics during booster staging. The 13 measurements were "switched in" at BCO, along with other special staging instrumentation for a period of approximately 10 seconds. Useful data was obtained from all 13 measurements. The following is a tabulation of the measurements, the types of accelerometer systems, and the flat frequency response of the accelerometer systems. Locations of the instrumentation are shown in Figures 13-25 through 13-29.

Measurement Number	Description	Accelerometer System Type	Flat Frequency Response of Accel Systems, CPS
A260O	Jettison Rail Tangential at A-Frame Quad II	CEC and Pac Tel ±25g	150
A265O	Jettison Rail Radial at A-Frame Quad II	CEC and Pac Tel ±25g	150

14F

Measurement Number	Description	Accelerometer System Type	Flat Frequency Response of Accel Systems, CPS
A266O	Jettison Rail Tangential at Tank Quad II	CEC and Pac Tel ±25g	30
A270O	Jettison Rail Radial at A-Frame Quad II	CEC and Pac Tel ±25g	30
A271O	Jettison Rail Tangential at A-Frame Quad IV	CEC and Pac Tel ±25g	150
A272O	Jettison Rail Radial at A-Frame Quad IV	CEC and Pac Tel ±25g	150
A273O	Missile Tank Apex X-Axis	CEC and Pac Tel ±25g	30
A274O	Missile Tank Apex Y-Axis	CEC and Pac Tel ±25g	30
A275O	Missile Tank Apex X-Axis	CEC and Pac Tel ±25g	30
A276O	Sustainer Hyd Pump Discharge Line	CEC and Pac Tel ±25g	30
A36A	Booster Thrust Section Longitudinal Accel.	Giannini ±25g	30
H412O	NAA Control Y-Axis	Giannini ±25g	30
P531O	Sustainer Gas Generator Fuel Check Valve	Giannini ±25g	30

Generally, vibration outputs were similar to those observed during Missiles 7F and 8F staging sequences. No excessive shock loads were apparent, and the transfer of vibration energy through the staging rails to the sustainer engine was negligible. Booster staging was initiated at 130.48 seconds. The aft shoes appeared to leave the rails at 130.87 seconds, 0.39 seconds after the start of jettison. The booster package was off the rails at 130.97 seconds, 0.49 seconds after the start of jettison.

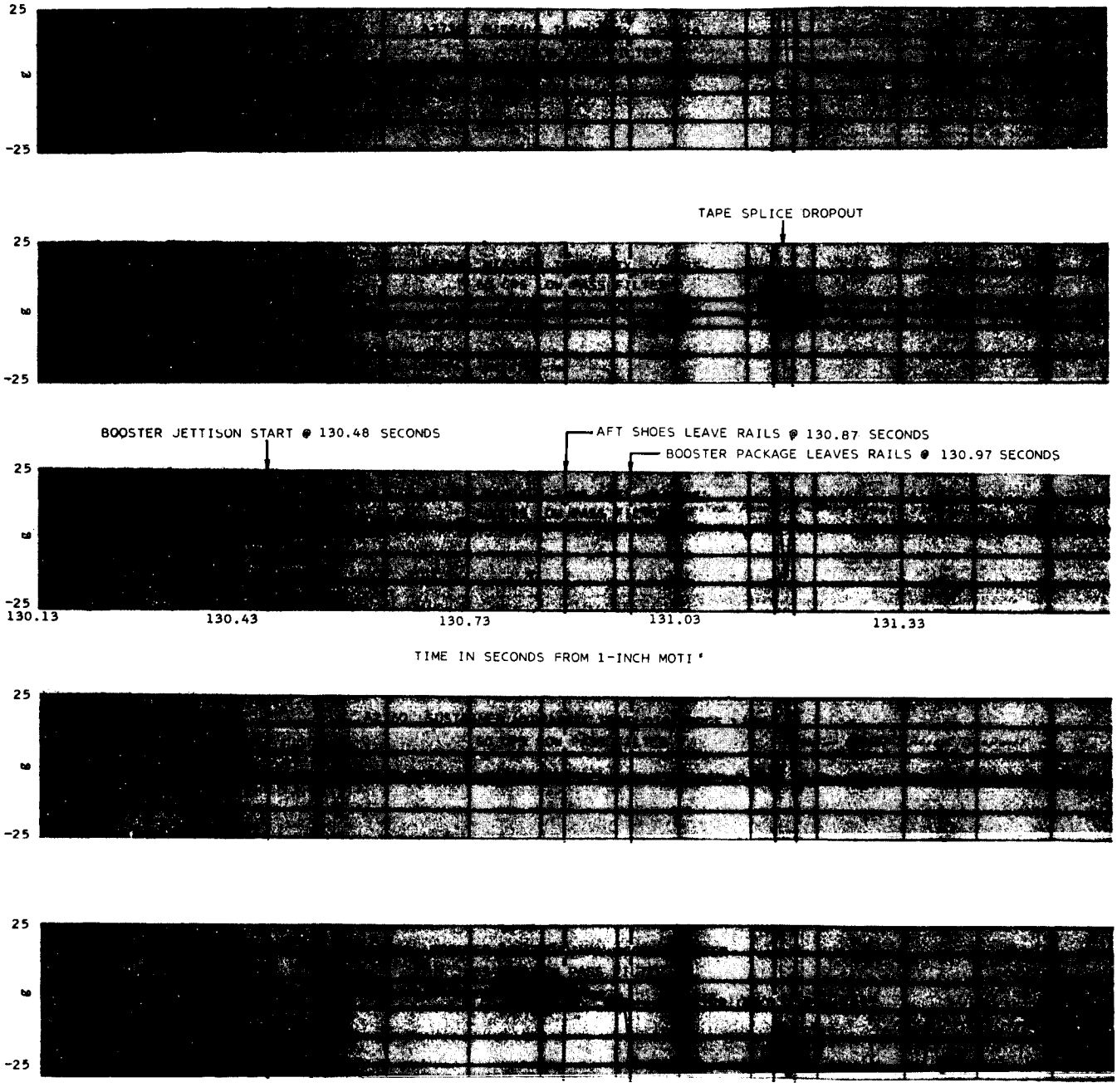
The Quad II and Quad IV staging rails exhibited some vibration response to the staging sequence. Nominal acceleration levels were recorded at the Quad II rail near the missile fuel tank (A266O and A270O) and at the Quad IV rail near the A-Frame (A271O and A272O). Maximum acceleration levels at these locations during the staging sequence did not exceed 2 to 3g (peak-to-peak) at frequencies between 50 and 80 cps. The Quad II rail measurements near the A-Frame (A260O and A265O) showed response to the forward and aft shoes leaving the jettison rails. Maximum acceleration levels between 130.87 and 130.93 seconds in response to the aft shoes leaving the rails were 5g (peak-to-peak) at 54 cps for the tangential measurement, A260O, and 3g (peak-to-peak) at 68 cps for the radial measurement, A265O. Maximum acceleration levels between 130.97 and 131.09 seconds in response to the forward shoes leaving the rails were 8g (peak-to-peak) at 52 cps and 7g (peak-to-peak) at 62 cps for the tangential and radial measurements, respectively.

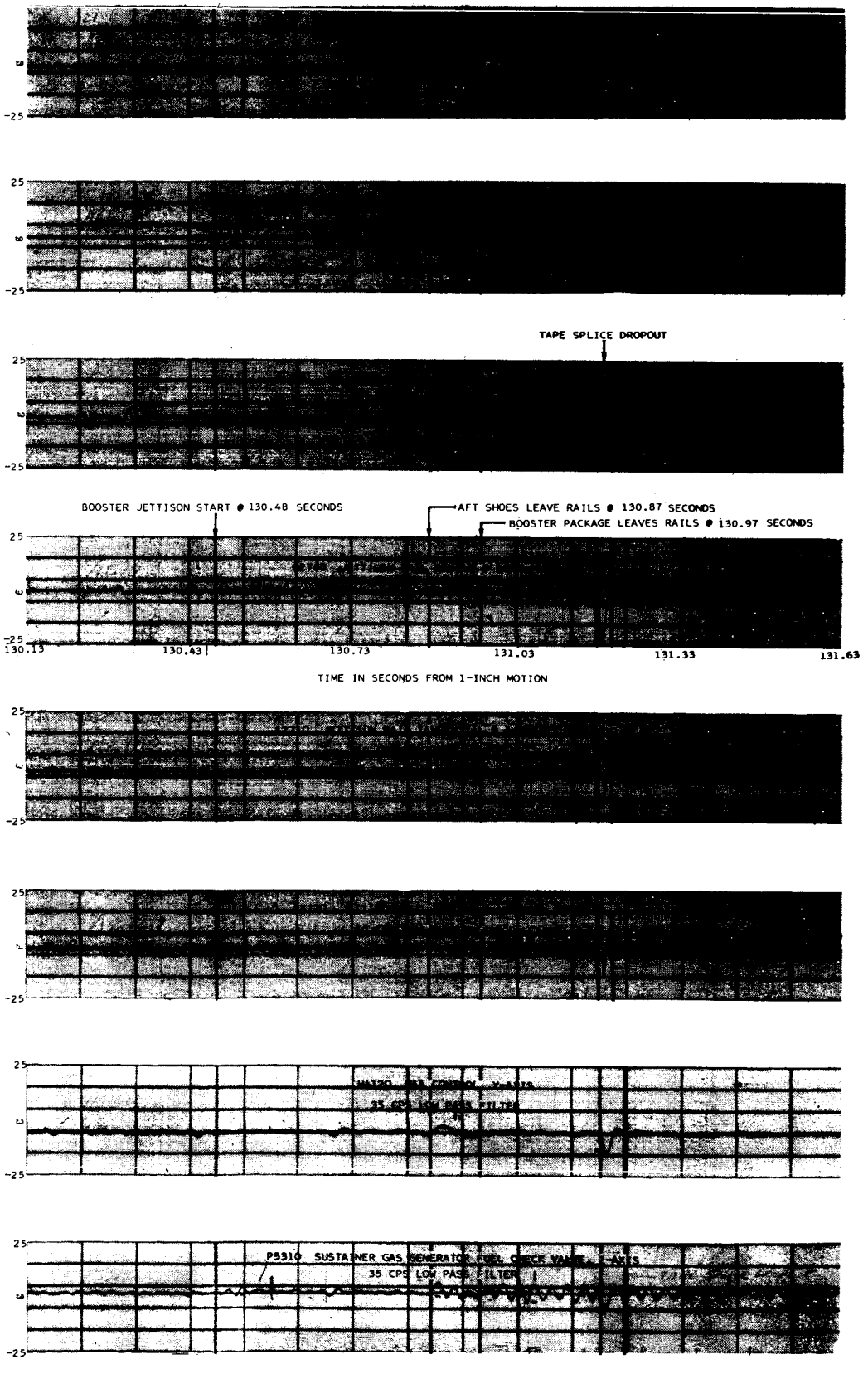
Negligible vibration output was exhibited at the missile tank apex, indicating no significant transfer of vibration energy through the staging rails A-Frame to the sustainer engine area. Indicated acceleration levels were less than 1g (peak-to-peak).

Nominal acceleration levels were also recorded at the Rocketdyne control package (H4120), the sustainer hydraulic pump discharge lines (A1276O) and the booster section longitudinal accelerometer, A36A. Maximum levels recorded by any of the three measurements during the staging sequence did not exceed 2 to 3g (peak-to-peak) at frequencies between 40 and 48 cps.

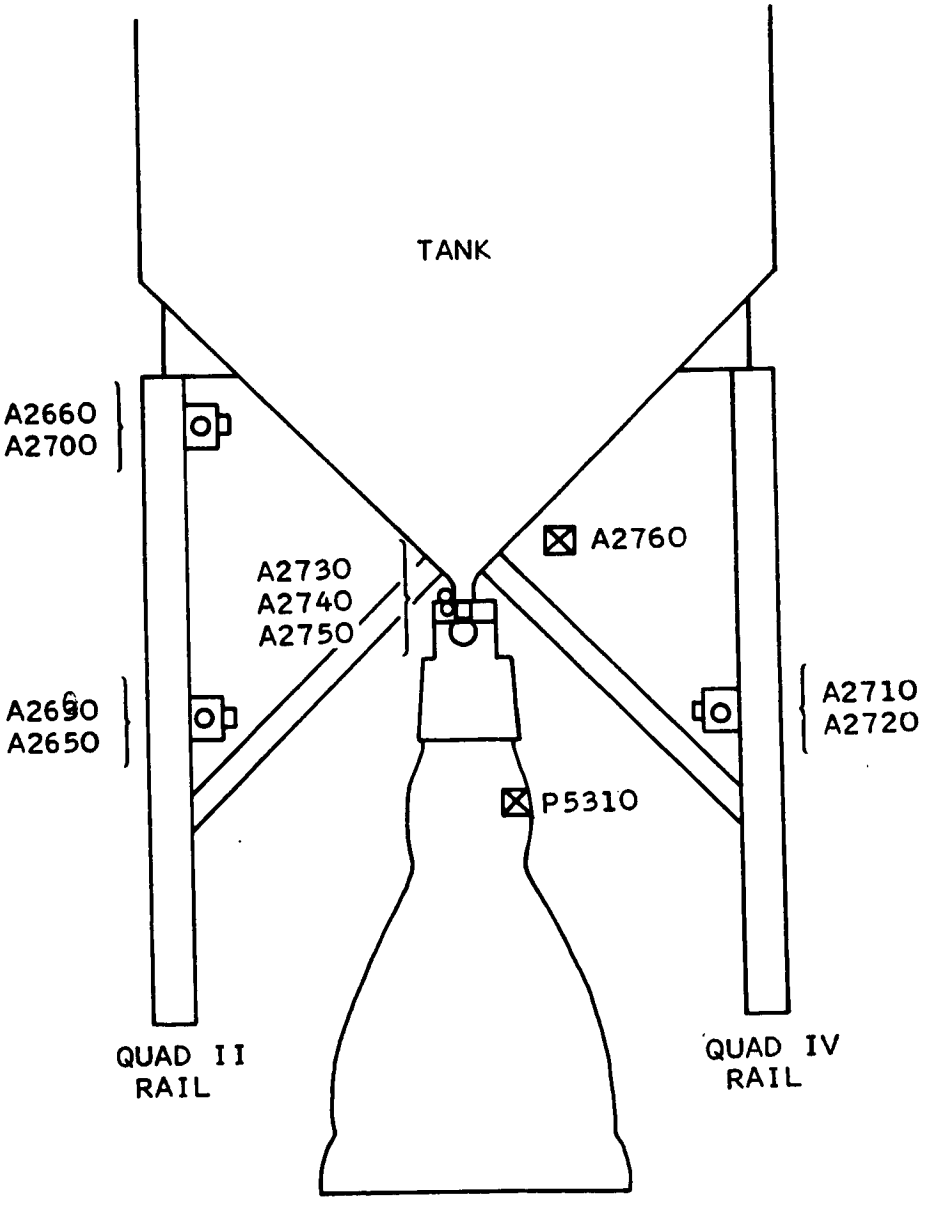
The sustainer gas generator fuel check valve (P5310), exhibited a discrete 34 cps sinusoidal output in response to the aft shoes leaving the staging rails at 130.87 seconds. The output was sustained and amplified slightly at 130.97 seconds in response to the forward shoes leaving the rails. The output was sustained at a mean acceleration level of 7.5g (peak-to-peak) between 130.87 and 131.3 seconds. Maximum instantaneous peaks during this period were 11g (peak-to-peak). Between 131.3 seconds and 131.7 seconds the output was damped to a 2g (peak-to-peak) mean level lasting approximately 1.1 seconds. The 34 cps frequency was exhibited occasionally through the remainder of the 10 second special recording period at acceleration levels near 2g (peak-to-peak). The 7.5g (peak-to-peak) mean acceleration level is indicative of a single amplitude linear displacement of approximately 0.03 inches. An investigation of the output did not reveal its cause. Similar outputs were not exhibited by this measurement during the staging sequence Missile 7F and 8F. Figures 13-17 and 13-18 illustrate the data waveforms.

MISSILE 14F


25
g
-25
TAPE SPLICE DROPOUT
BOOSTER JETTISON START @ 130.48 SECONDS
AFT SHOES LEAVE RAILS @ 130.87 SECONDS
BOOSTER PACKAGE LEAVES RAILS @ 130.97 SECONDS
130.13
130.43
130.73
131.03
131.33
TIME IN SECONDS FROM 1-INCH MOTI

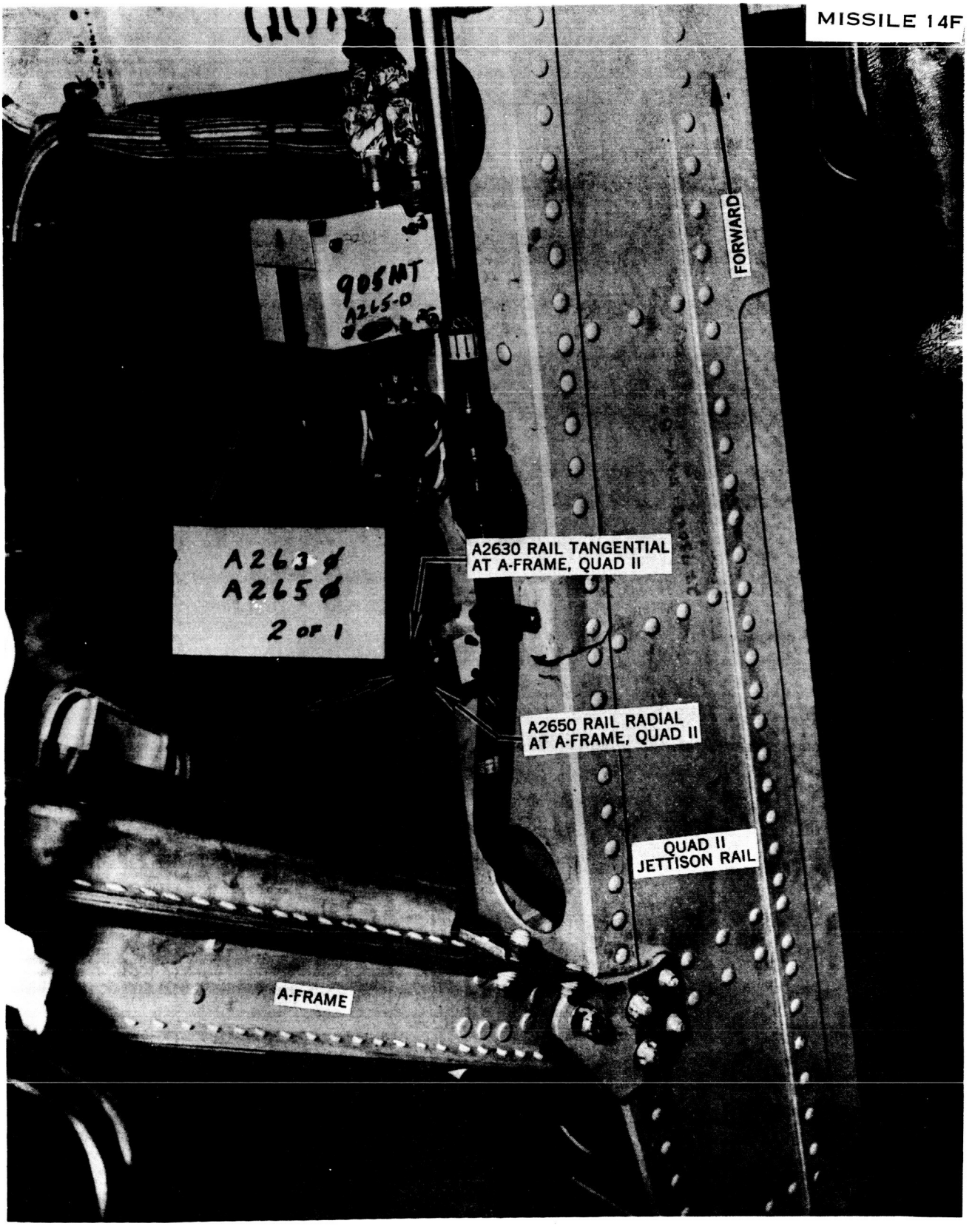

25
-25
TAPE SPLICE DROPOUT
BOOSTER JETTISON START @ 130.48 SECONDS
AFT SHOES LEAVE RAILS @ 130.87 SECONDS
BOOSTER PACKAGE LEAVES RAILS @ 130.97 SECONDS
130.13
130.43
130.73
131.03
131.33
131.63
TIME IN SECONDS FROM 1-INCH MOTION
35 CPS LOW PASS FILTER

14F VIBRATION STAGING INSTRUMENTATION



14F

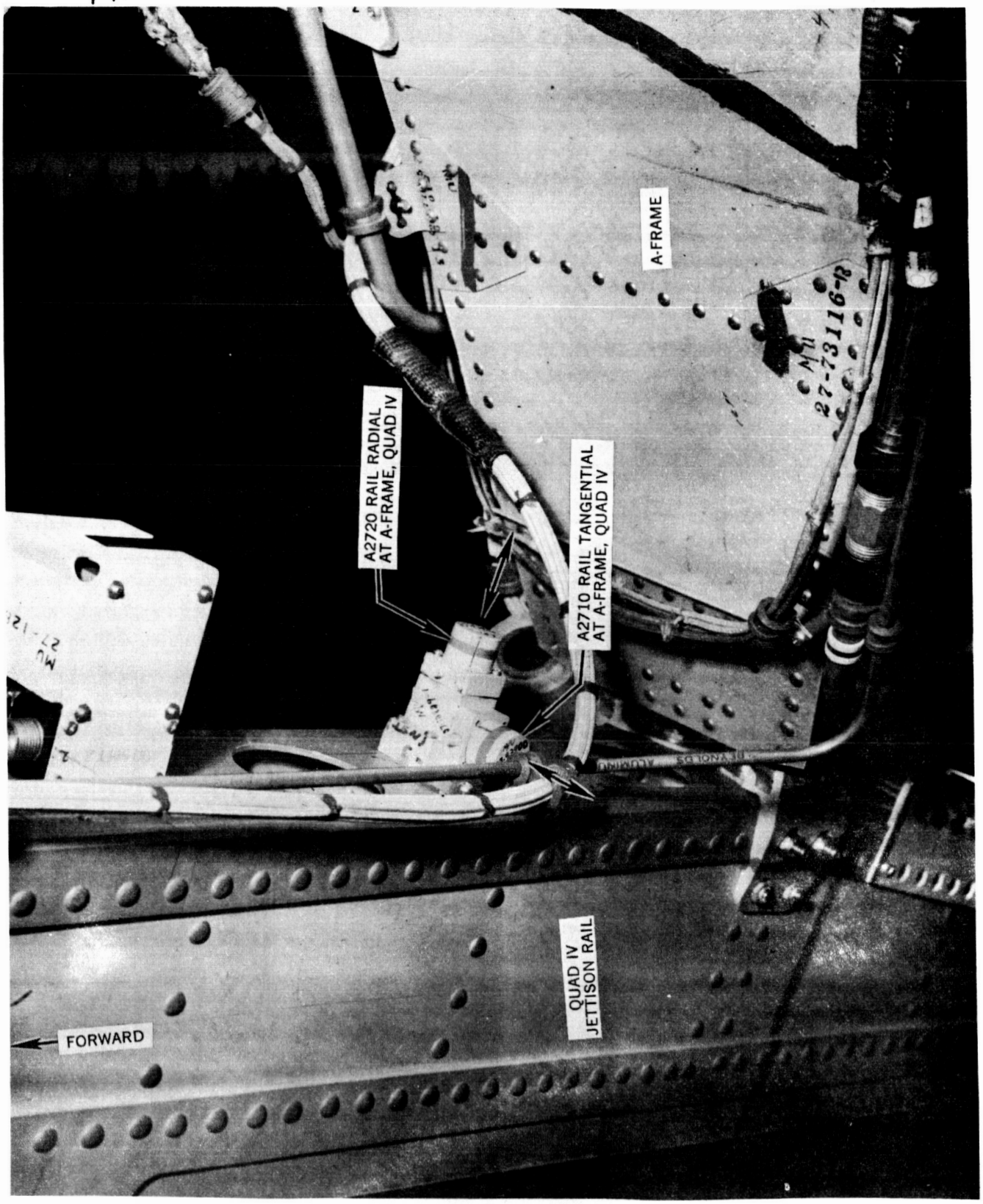
JETTISON RAIL ACCELEROMETERS - QUAD II



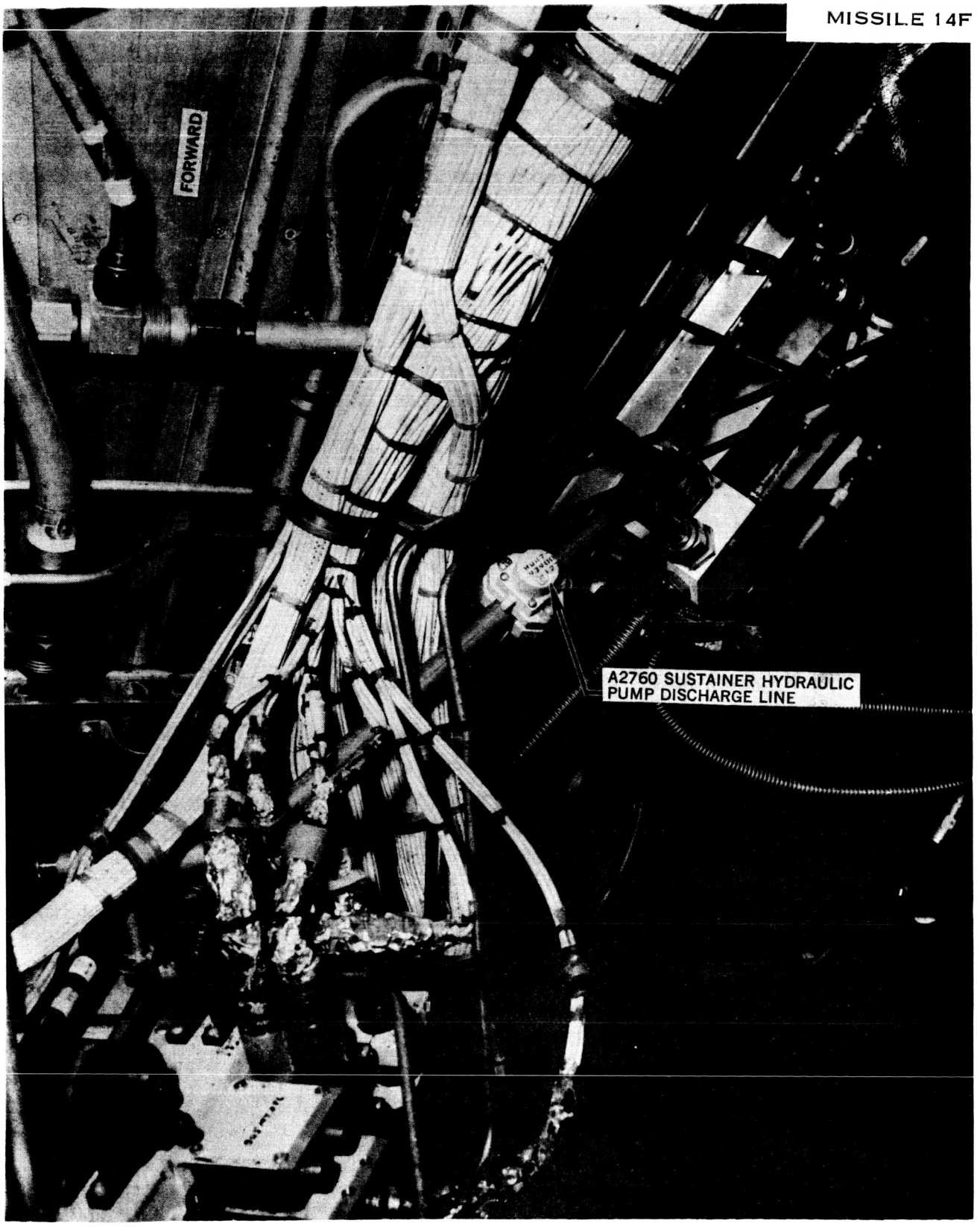
JETTISON RAIL ACCELEROMETERS - QUAD IV

MISSILE 14F

14F



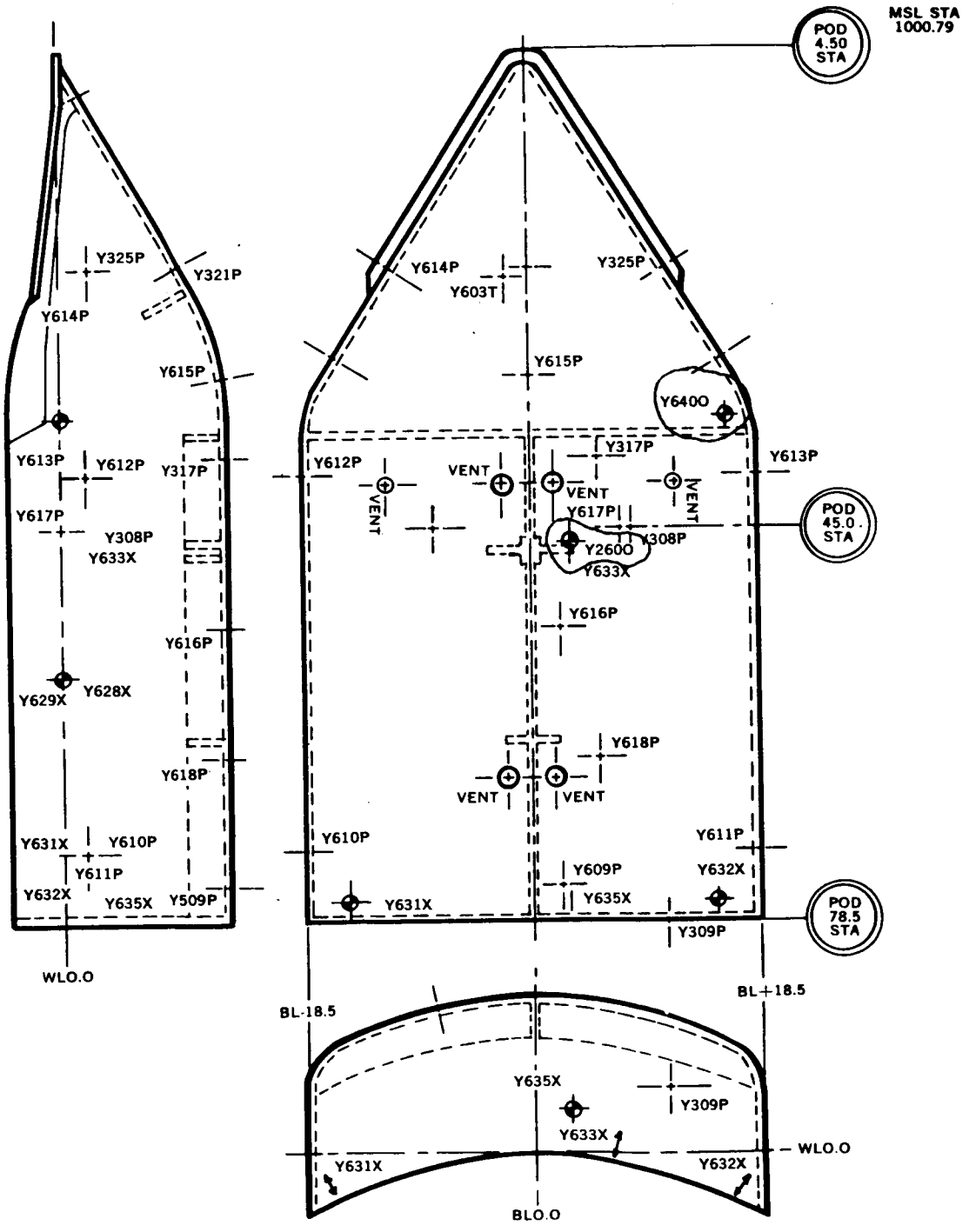
14F



ENVIRONMENTAL INSTRUMENTATION LOCATION POD B

MISSILE 14F

14F



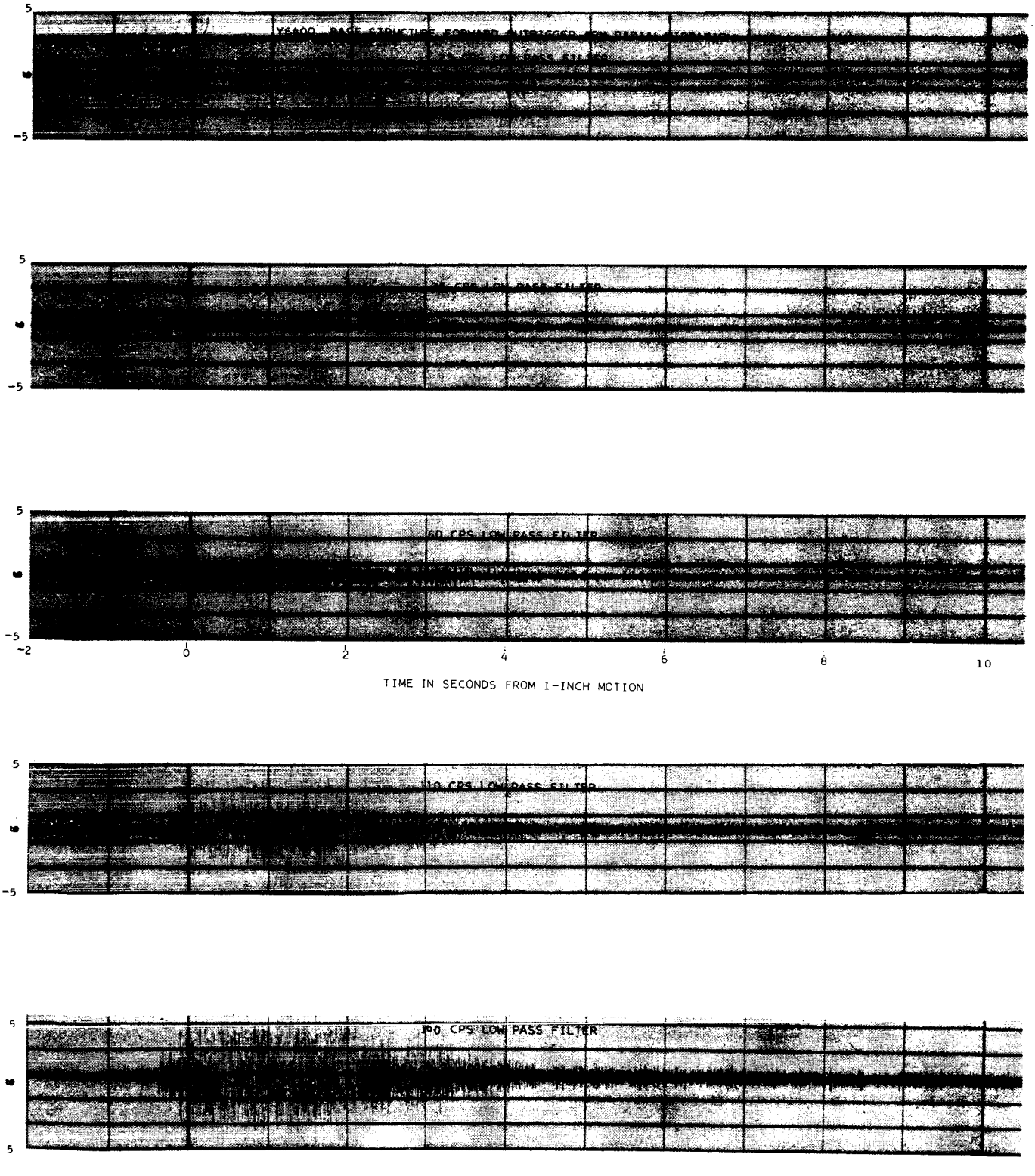
DECOY

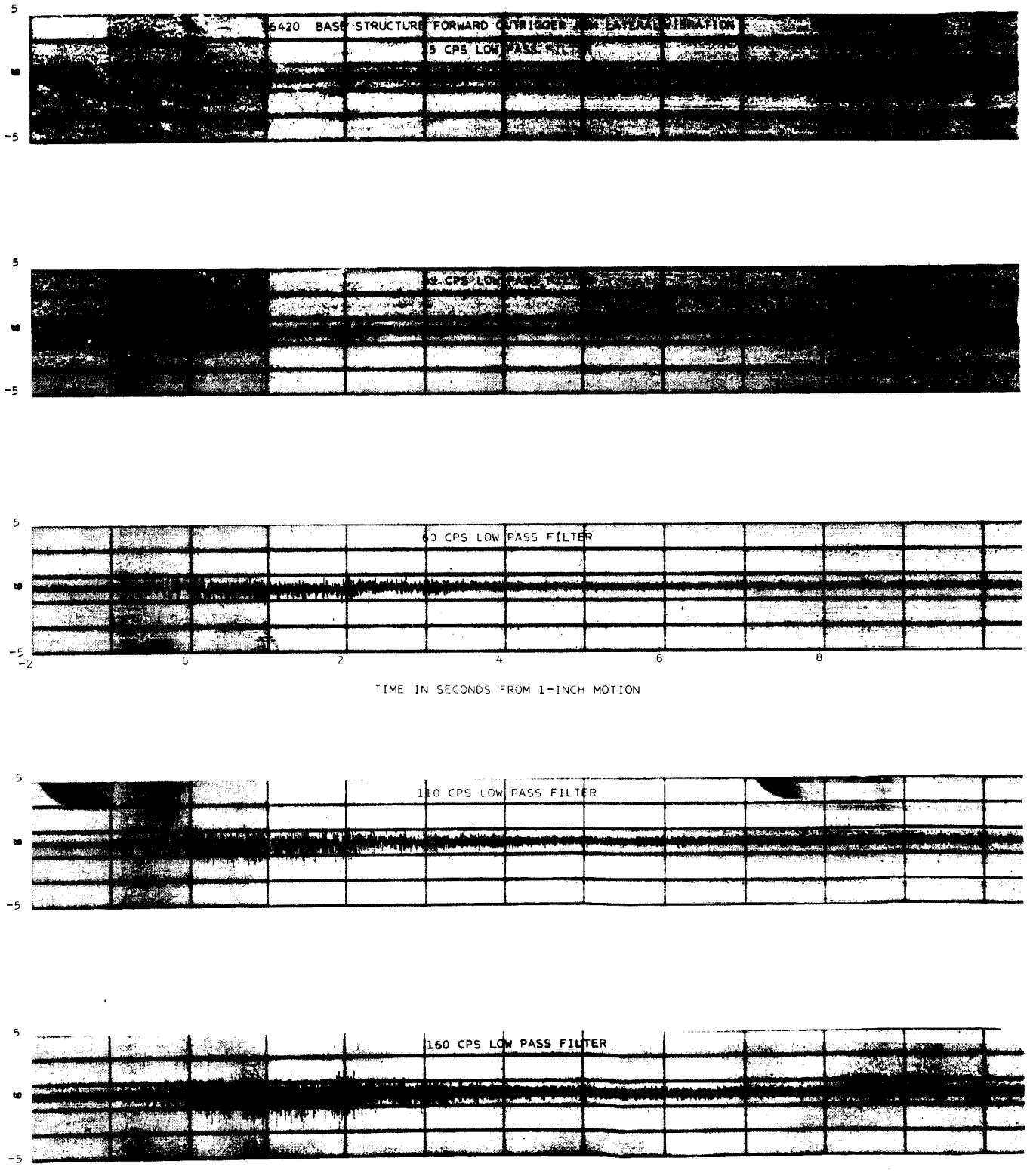
FIGURE NO. 16-18

~~REPORT NO. AOJ62-0054~~

POD B
TELEMETERED DATA

MISSILE 14F




5
g
-5
6420 BASE STRUCTURE FORWARD OUTRIGGER LATERAL VIBRATION
5 CPS LOW PASS FILTER
5
g
-5
5 CPS LOW PASS FILTER
5
g
-5
60 CPS LOW PASS FILTER
-2
0
2
4
6
8
TIME IN SECONDS FROM 1-INCH MOTION
5
g
-5
110 CPS LOW PASS FILTER
5
g
-5
160 CPS LOW PASS FILTER

DECOY

FIGURE NO. 16-20

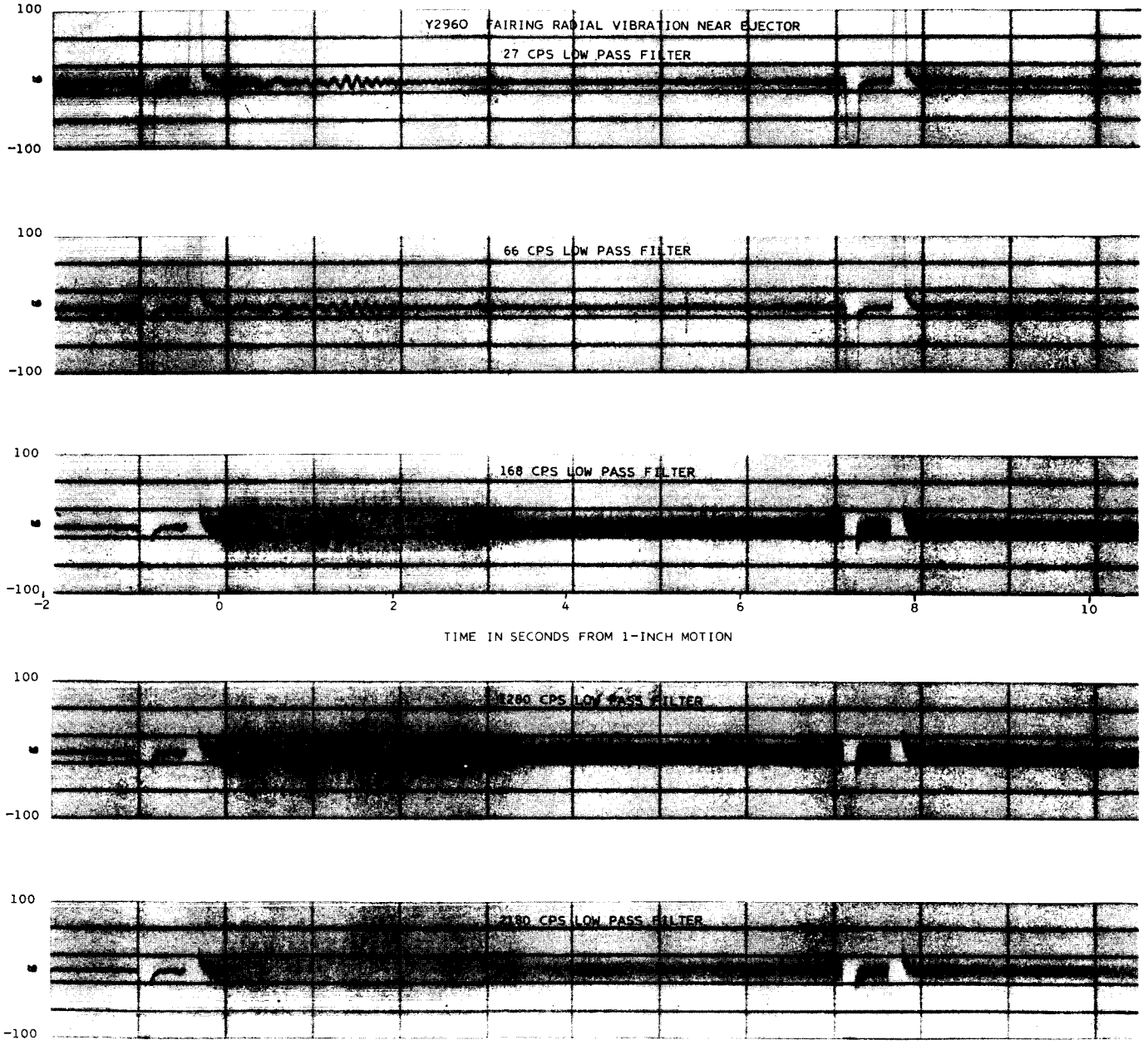
GD/A-DDE65-016

~~REPORT NO. AOJ62-0054~~

MISSILE 14F

POD B

TELEMETERED DATA



DECOY

FIGURE NO. 16-21

~~REPORT NO. AOJ02-0054~~

POD B

TELEMETERED DATA

MISSILE 14F

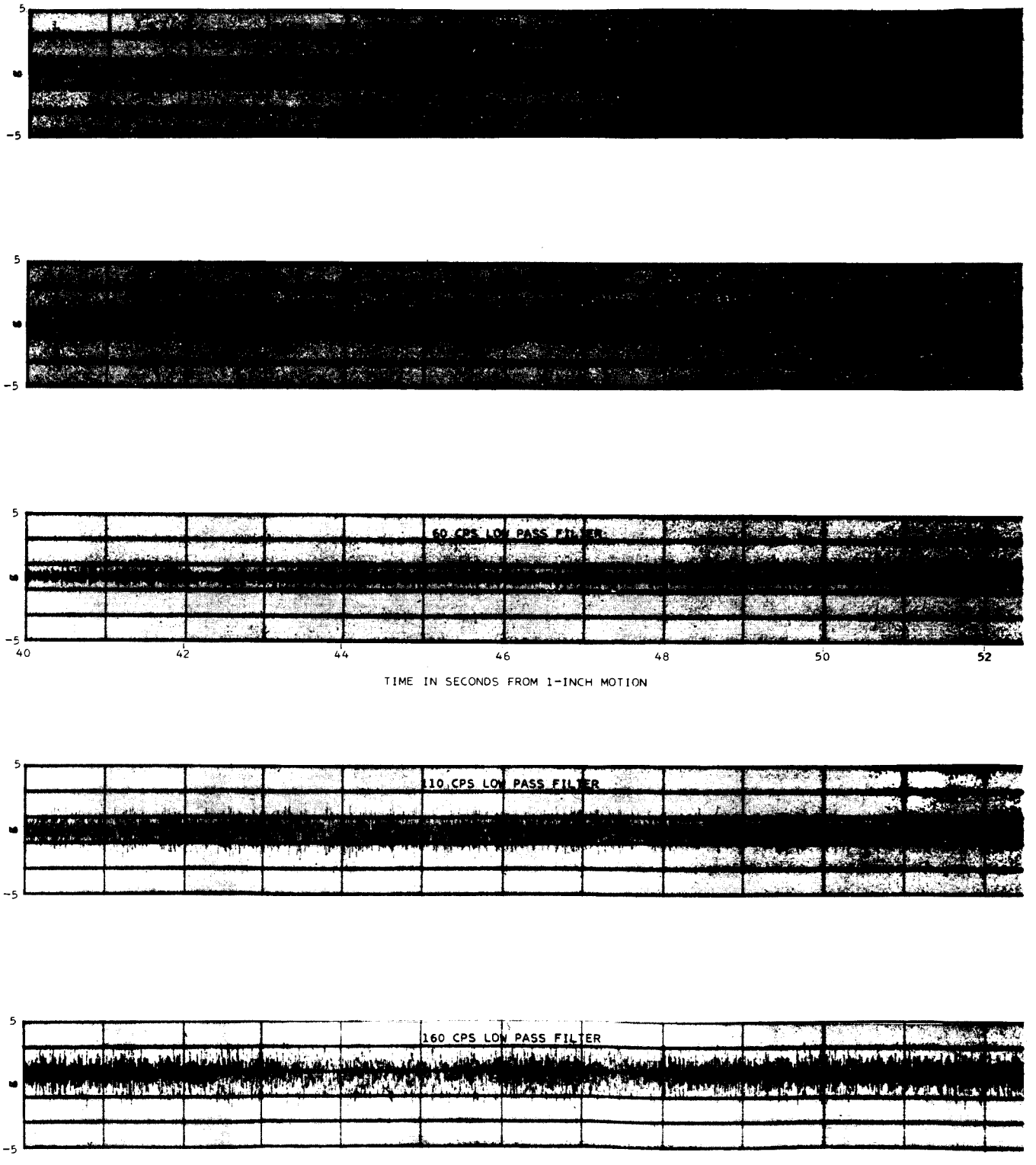
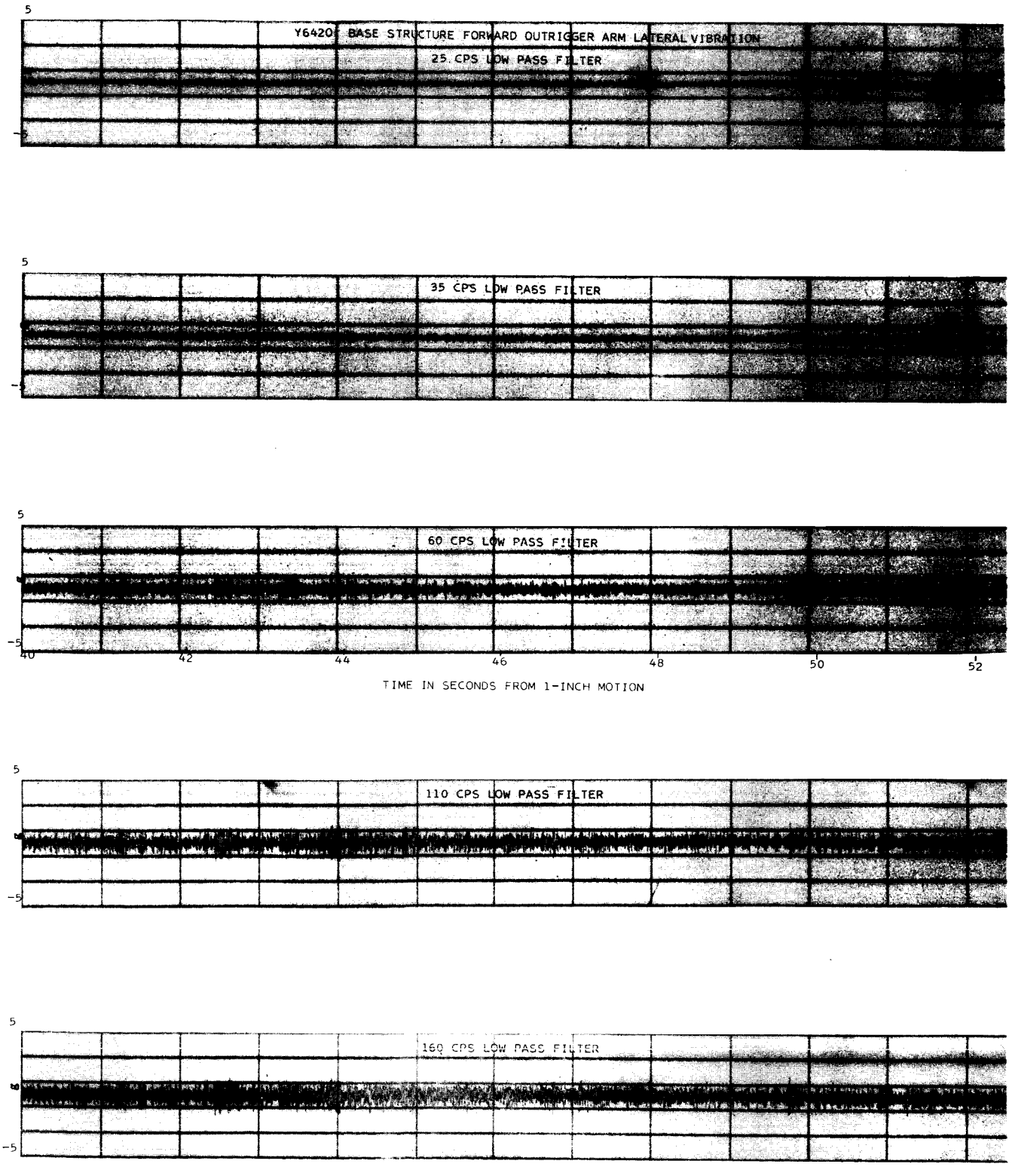


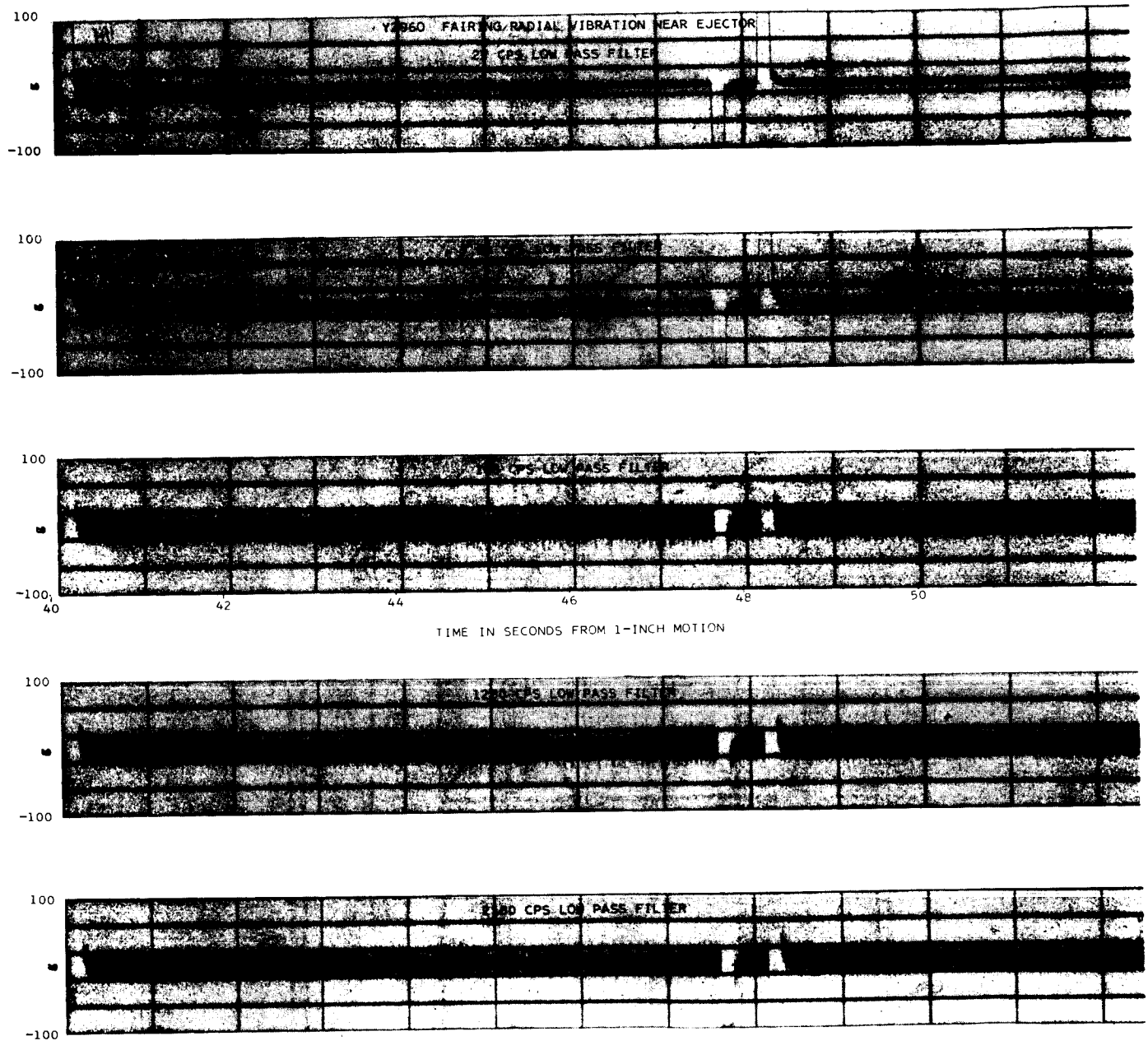
FIGURE NO. 16-22

~~REPORT NO. AOJ62-0054~~ GD/A-DDE65-016

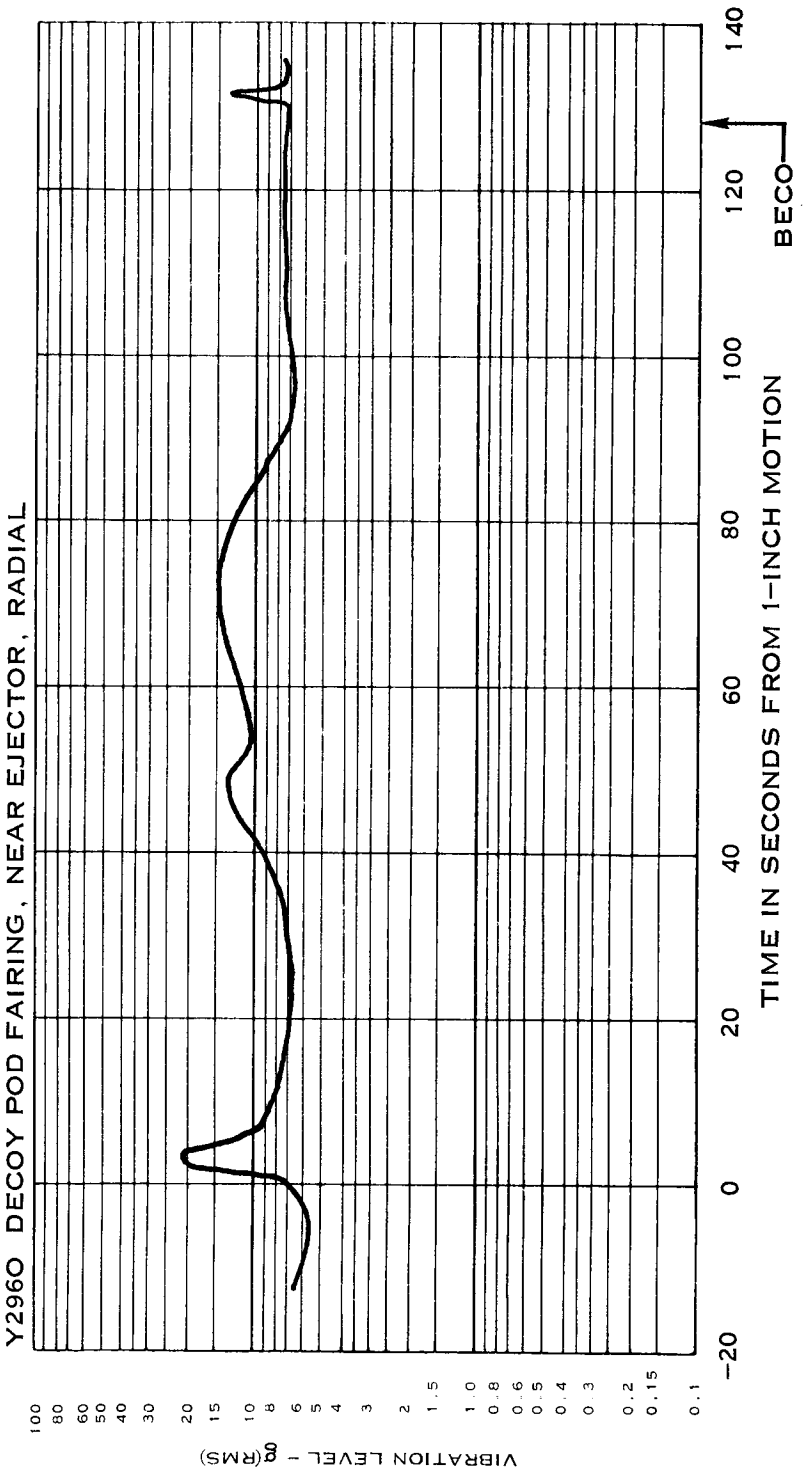
POD B
TELEMETERED DATA

MISSILE 14F




100
0
-100
Y2960 FAIRING RADIAL VIBRATION NEAR EJECTOR
2 CPS LOW PASS FILTER
100
0
-100
100
0
-100
40
42
44
46
48
50
TIME IN SECONDS FROM 1-INCH MOTION
100
0
-100
100
0
-100

VIBRATION TIME HISTORY
g (RMS) VS TIME
MISSILE 14F
2100 CPS LOW PASS FILTER



SECTION 6.2.20

MISSILE 16F

FLIGHT TESTED 11-7-62

AT AMR COMPLEX 11

TEST REPORT AOJ62-0112

Thrust Section Vibration Analysis

Three low frequency accelerometers mounted on the sustainer lox pump inlet flange and three high frequency accelerometers located on the booster and sustainer engine lox domes were monitored during the period between pre-ignition and the first 36 feet of missile vertical. rise. The vibration data was recorded via the FM landline umbilical. Useful data was obtained from all six measurements. However, noisy outputs from the three lox dome accelerometers were evident throughout the recorded interval.

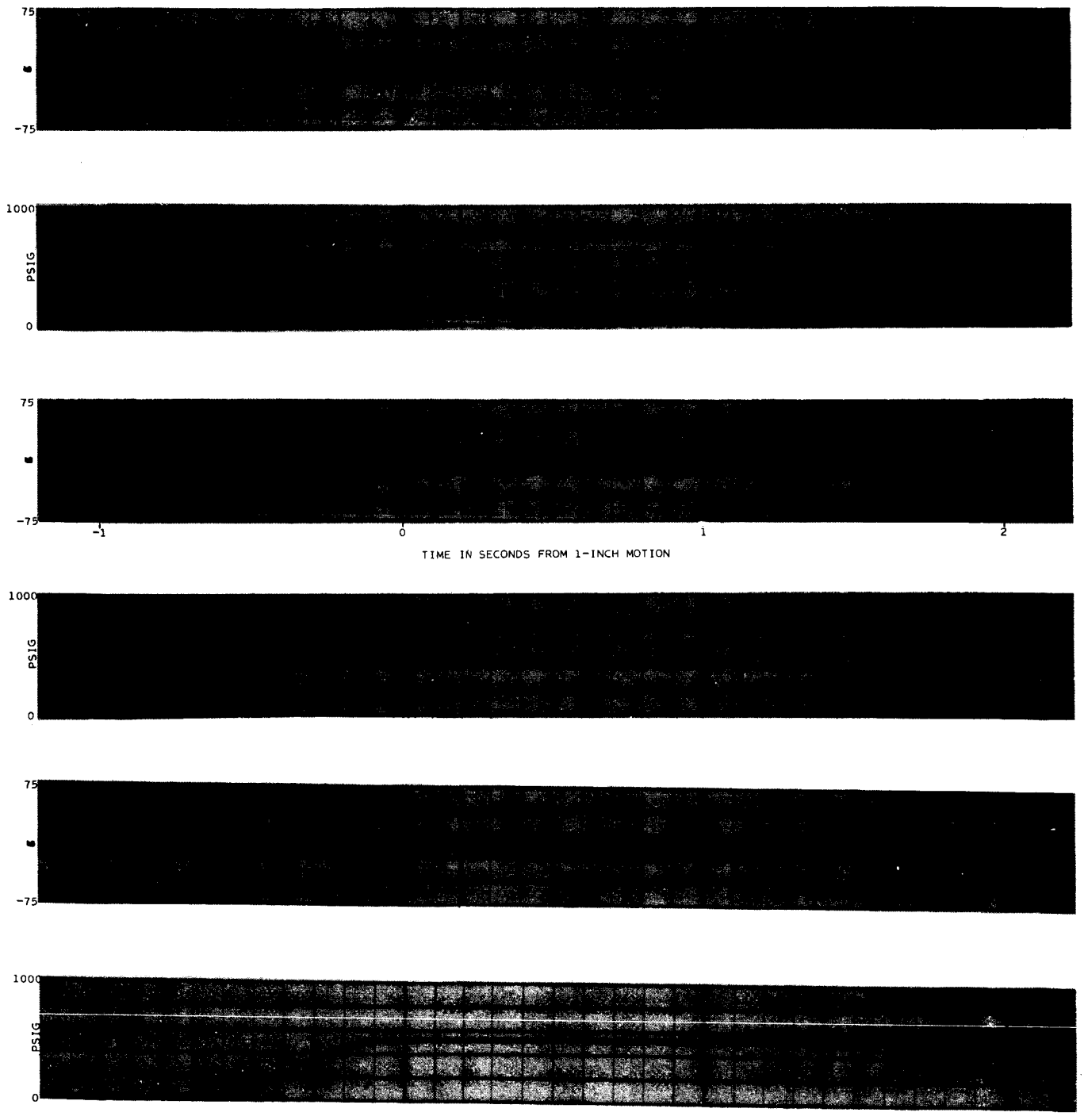
Between -0.65 seconds and -0.50 seconds, response to initial sustainer ignition burning was evident on all three sustainer lox pump inlet flange measurements. Initial maximum instantaneous acceleration peaks were 3.0 g (peak-to-peak) at a frequency of 40 cps on the X-Axis measurement, 4.8 g (peak-to-peak) at a frequency of 41 cps on the Y-Axis measurement and 5.4 g (peak-to-peak) at 68 cps on the Z-Axis measurement.

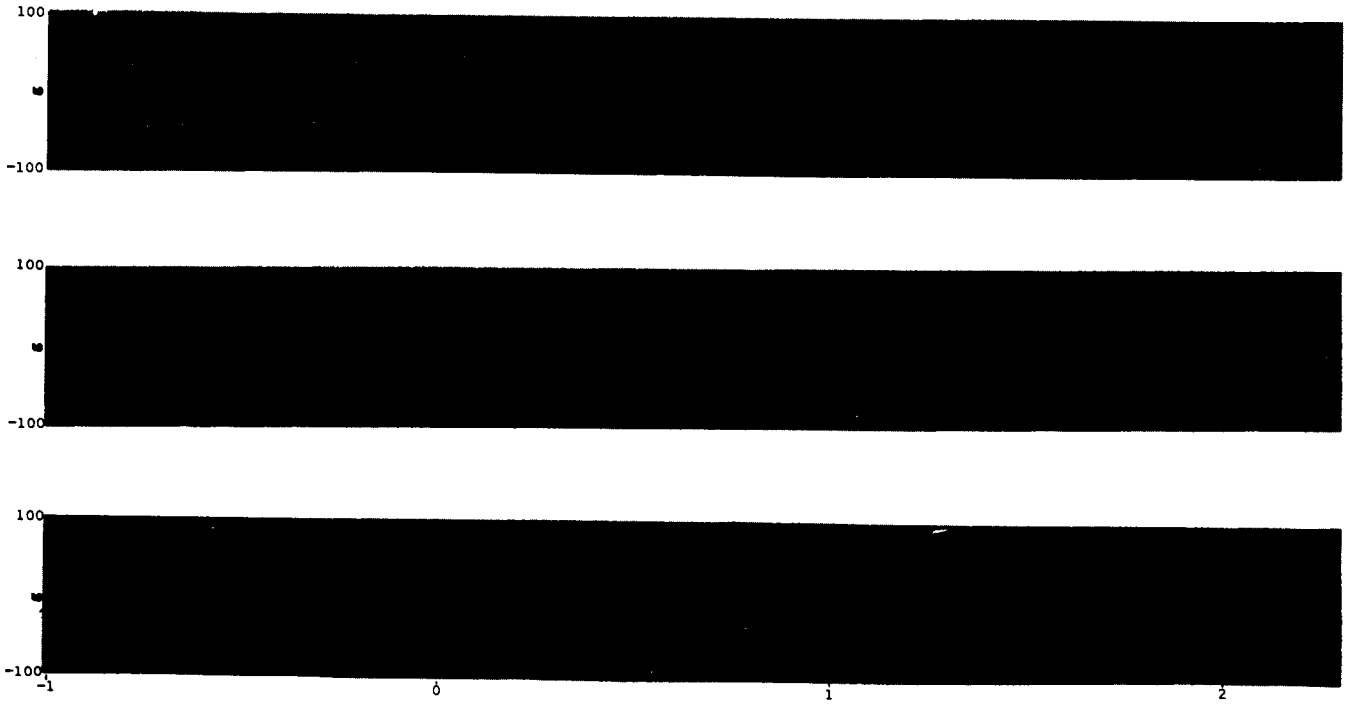
Response to booster engine main propellant ignition was noted at -0.39 seconds on all three axes of the triaxial transducer. Maximum transient acceleration peaks of 4.5 g (peak-to-peak) at a frequency of 25 cps were exhibited by the X-Axis measurement. The transient vibration was damped out by -0.2 seconds. The Y-Axis measurement exhibited maximum transient acceleration peaks of 3.5 g (peak-to-peak), damping out at a frequency of 42 cps within 0.17 seconds. Z-Axis response indicated maximum transient vibration peaks of 4.8 g (peak-to-peak), damping out at a frequency of 23 cps within 0.2 seconds.

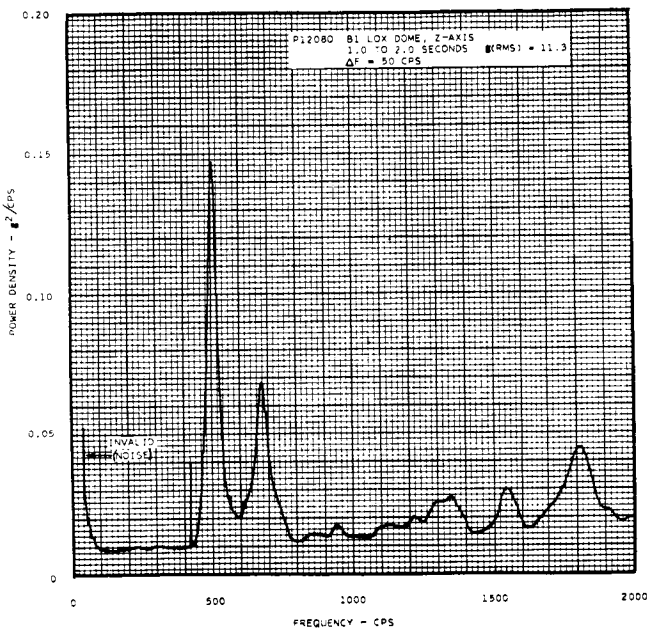
The main propellant ignition of the sustainer engine at -0.07 seconds was also evident at the sustainer lox pump inlet flange in the X, Y and Z-Axis. The X-Axis and the Y-Axis measurement exhibited maximum instantaneous transient vibration during the period of 5.0 g (peak-to-peak) at frequencies between 40 cps and 42 cps. The transient vibration was completely damped out by 0.1 second. Z-Axis response indicated a maximum instantaneous transient acceleration peak of 5.4 g (peak-to-peak), damping out at a frequency of 34 cps within 0.46 seconds.

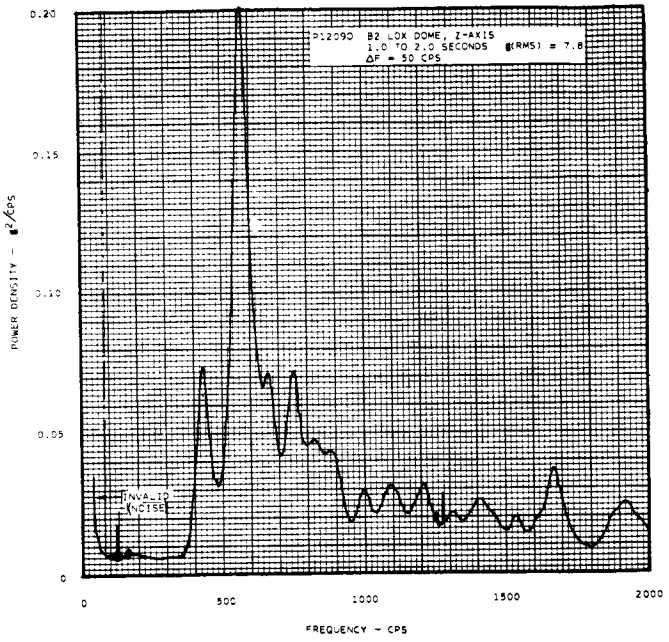
Location of the triaxial sustainer engine lox pump inlet flange accelerometer is shown in Figure 4-29. The waveform is presented in Figure 4-24.

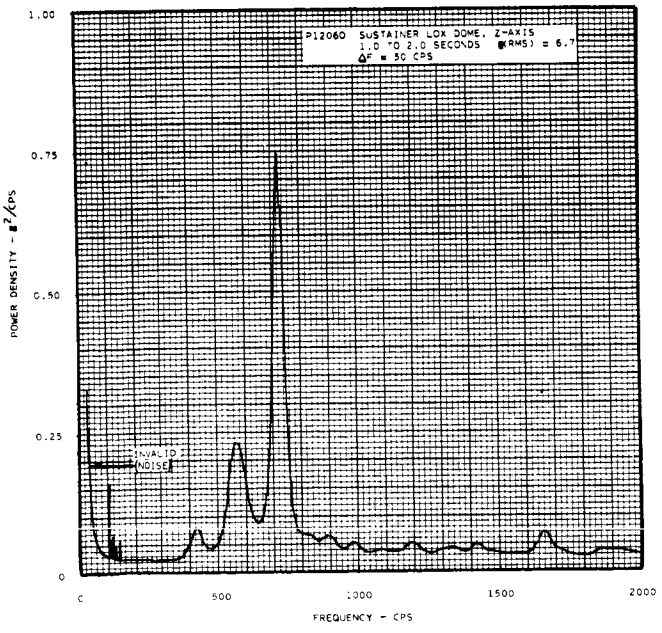
The three lox dome accelerometers displayed noisy outputs thus limiting data analysis. The waveforms are presented in Figure 4-23. Spectral analysis, Figure 4-8, between 1.0 seconds and 2.0 seconds show an over-all steady-state level of 6.7 g (rms) on the sustainer engine, 11.3 g (rms) on B1 and 7.8 g (rms) on B2. Maximum energy was concentrated between 500 cps and 720 cps.


75
g
-75
1000
PSIG
0
75
g
-75
-1
0
1
2
TIME IN SECONDS FROM 1-INCH MOTION
1000
PSIG
0
75
g
-75
1000
PSIG
0


100
0
-100
100
0
-100
100
0
-100
-1
0
1
2
TIME IN SECONDS FROM 1-INCH MOTION


P12080 B1 LOX DOME, Z-AXIS
1.0 TO 2.0 SECONDS σ(RMS) = 11.3
ΔF = 50 CPS
INVALID (NOISE)
POWER DENSITY - g²/CPS
FREQUENCY - CPS
0.20
0.15
0.10
0.05
0
0
500
1000
1500
2000


P12090 B2 LOX DOME, Z-AXIS
1.0 TO 2.0 SECONDS σ(RMS) = 7.8
ΔF = 50 CPS
INVALID (NOISE)
POWER DENSITY - g²/CPS
FREQUENCY - CPS
0.20
0.15
0.10
0.05
0
0
500
1000
1500
2000


P12060 SUSTAINER LOX DOME, Z-AXIS
1.0 TO 2.0 SECONDS σ(RMS) = 6.7
ΔF = 50 CPS
INVALID (NOISE)
POWER DENSITY - g²/CPS
FREQUENCY - CPS
1.00
0.75
0.50
0.25
0
0
500
1000
1500
2000

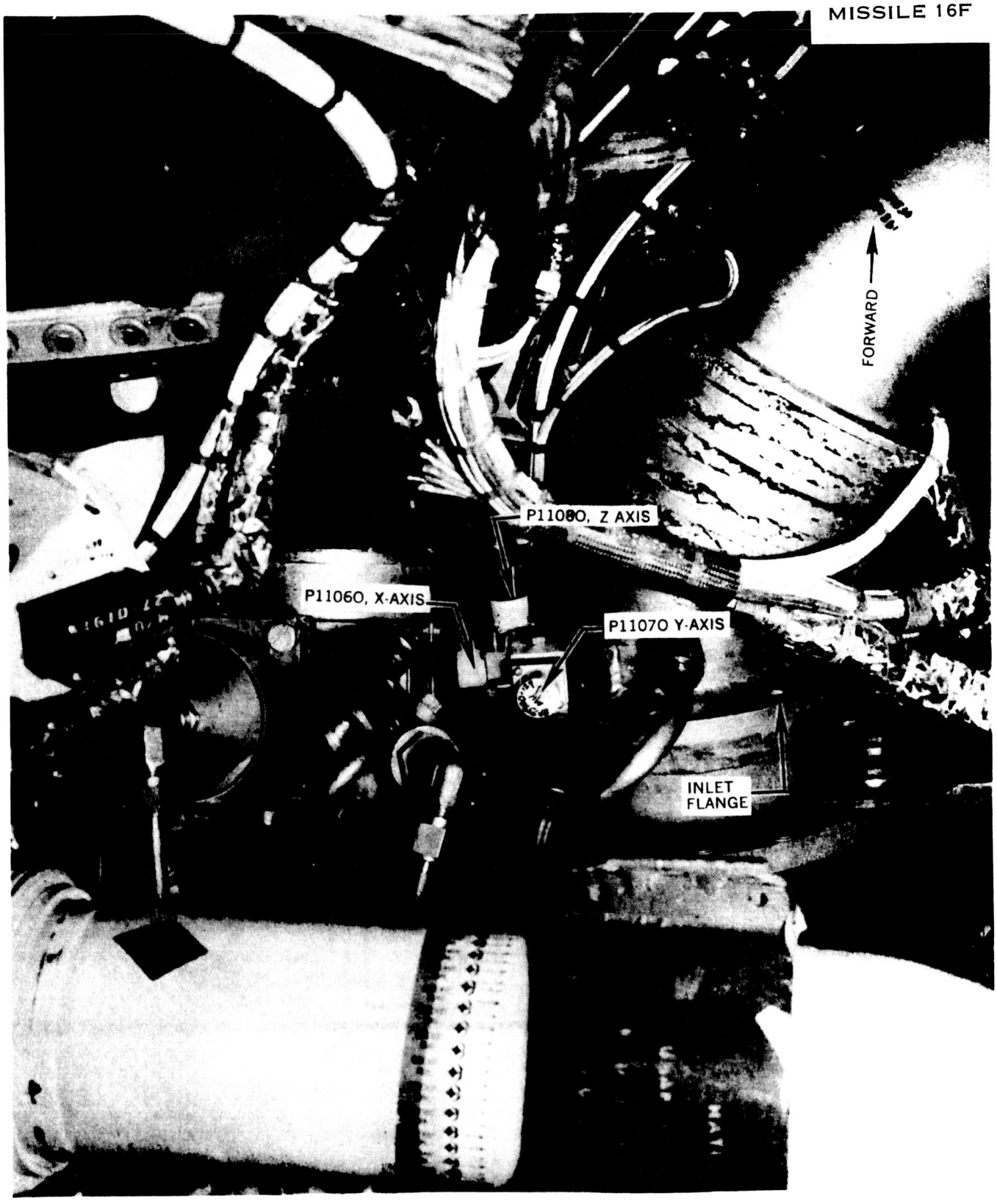
UNCLASSIFIED

16F

~~REPORT NO. AOJ62-0112~~

SUSTAINER PUMP INLET FLANGE ACCELEROMETER INSTALLATION

MISSILE 16F



Vibration Data

The missile thrust section was instrumented with 13 low frequency accelerometers to monitor the vibration and shock environment during booster staging. The 13 accelerometers were "switched in" at BCO, along with other special staging instrumentation for a period of approximately 10 seconds. Useful data was obtained from 11 of the 13 measurements. Measurement A2710, Jettison Rail at A-Frame, Quad IV, tangential, produced noisy outputs and was not used for analysis. Measurement A2760, Sustainer Hydraulic Pump Discharge Line, was invalid. Measurement A36A, Booster Thrust Section Longitudinal Accelerometer, was invalid subsequent to 129.14 seconds. The following is a tabulation of the measurements, the type of accelerometer systems and the linear range of the system. Locations of the instrumentation are shown in Figures 13-18 through 13-21.

Measurement Number	Description	Accelerometer System Type	Flat Frequency Response of Accel System, CPS
A2600	Jettison Rail Tangential at A-Frame Quad II	CEC and Pac Tel ±25g	150
A2650	Jettison Rail Radial at A-Frame Quad II	CEC and Pac Tel ±25g	150

Measurement Number	Description	Accelerometer System Type	Flat Frequency Response of Accel Systems, CPS
A2660	Jettison Rail Tangential at Tank Quad II	CEC and Pac Tel ±25g	30
A2700	Jettison Rail Radial at Tank Quad II	CEC and Pac Tel ±25g	30
A2710	Jettison Rail Tangential at A-Frame Quad IV	CEC and Pac Tel ±25g	150
A2720	Jettison Rail Radial at A-Frame Quad IV	CEC and Pac Tel ±25g	150
A2730	Missile Tank Apex X-Axis	CEC and Pac Tel ±25g	30
A2740	Missile Tank Apex Y-Axis	CEC and Pac Tel ±25g	30
A2750	Missile Tank Apex Z-Axis	CEC and Pac Tel ±25g	30
A2760	Sustainer Hyd Pump Discharge Line	CEC and Pac Tel ±25g	30
A36A	Booster Thrust Section Longitudinal Accel.	Giannini ±25g	30
H4120	NAA Control Y-Axis	Giannini ±25g	30
P5310	Sustainer Gas Generator Fuel Check Valve	Giannini ±25g	50

Generally, the acceleration levels during staging were low. No excessive shock loads were apparent, and the transfer of vibration energy through the staging rails to the sustainer engine was negligible. Booster staging was initiated at 128.93 seconds. From data sources the booster package appeared to leave the staging rails at 129.39 seconds.

During the staging sequence (128.93-129.39 seconds) primary vibration energy was indicated on the staging rail at the A-Frame in Quad II. Maximum acceleration levels, prior to the time the package left the rails, were 3.0 g (peak-to-peak) at frequencies between 46-cps and 74-cps on both the tangential and radial measurements. The measurement on the Quad II rail at the tank (radial) during staging, indicated a maximum acceleration level of 2.9 g (peak-to-peak) at 48 cps. Outputs from the remaining rail accelerometers during this period were negligible.

Subsequent to the staging sequence at 129.39 seconds, maximum acceleration levels were 3.7 g (peak-to-peak) at 52 cps on the Quad II rail at the A-Frame (tangential) and 3.1 g (peak-to-peak) at 48 cps on the radial measurement.

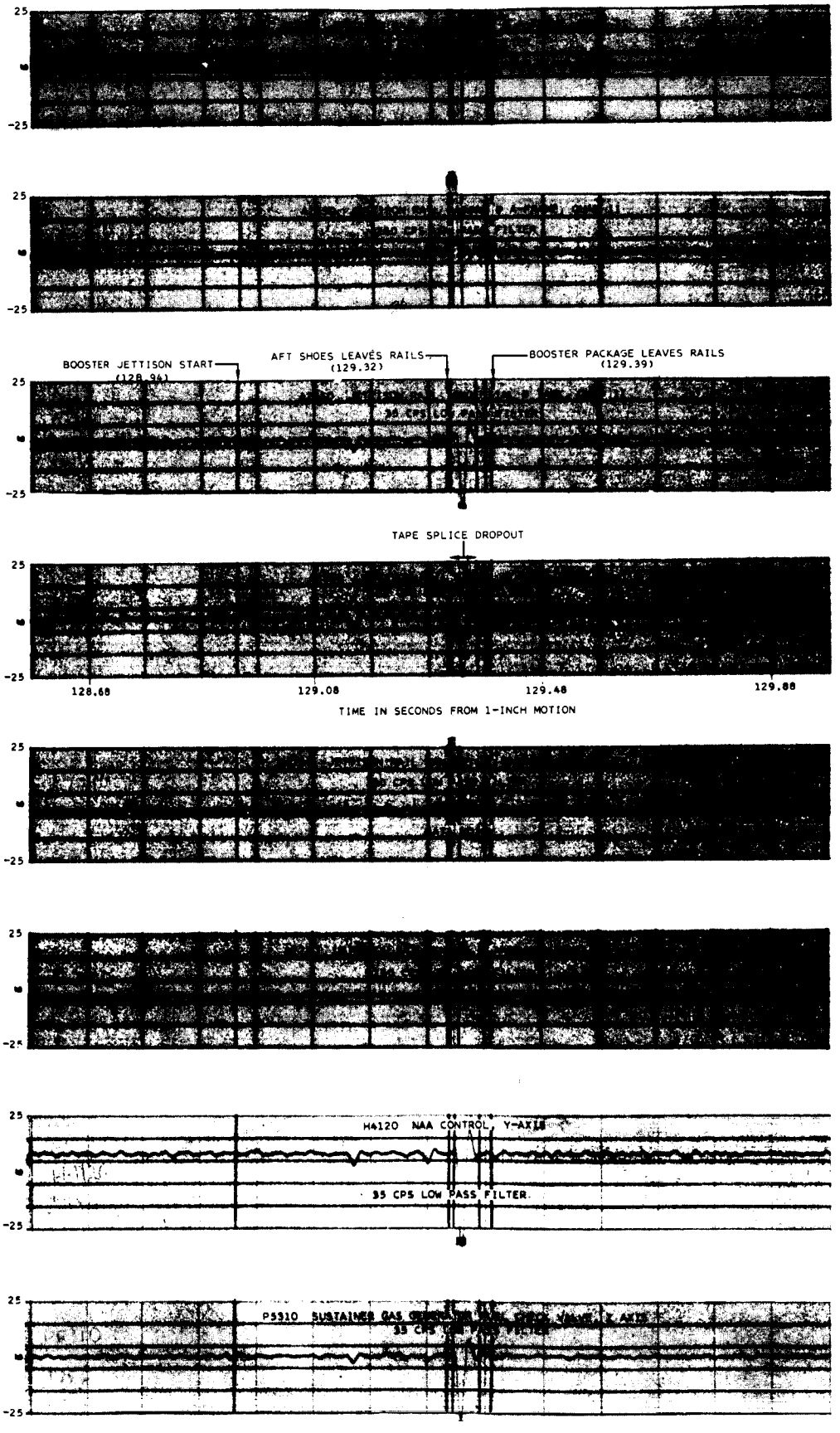
The Quad II rail at the tank indicated a maximum acceleration level of 1.8 g (peak-to-peak) at a frequency of 48 cps. Outputs from the other rail measurements subsequent to staging were negligible.

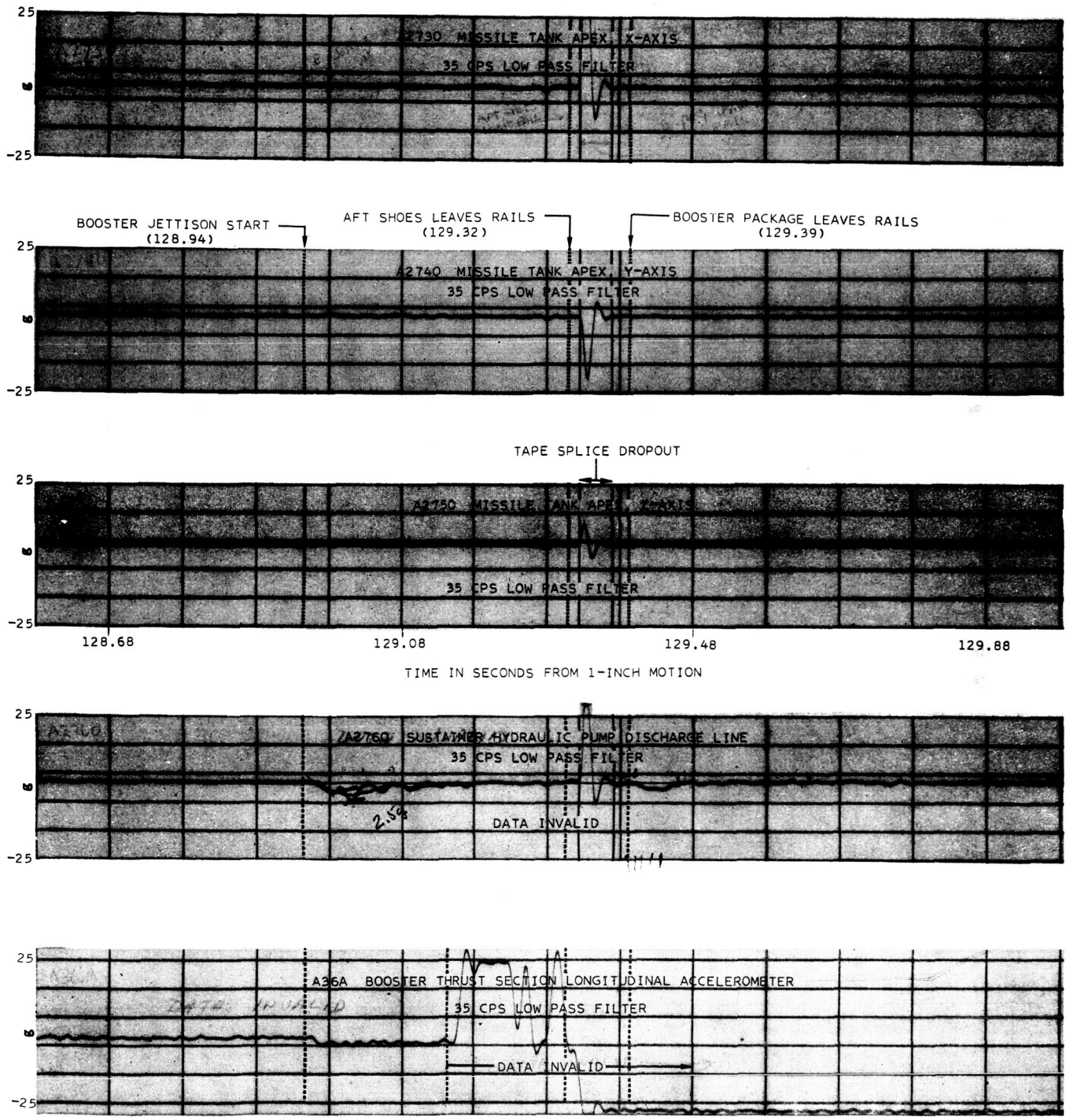
Negligible vibration output (less than 1 g peak-to-peak) was indicated, during the staging sequence, on the missile tank apex, indicating little or no transfer of vibration energy from the staging rails to the tank apex and sustainer engine. Measurement H4120 on the NAA control package also showed negligible vibration outputs.

Measurement A36A located on the booster thrust section, to record missile axial acceleration, became invalid at 129.14 seconds. The maximum acceleration recorded, prior to becoming invalid, was 1.8 g (peak-to-peak) at a frequency of 56 cps.

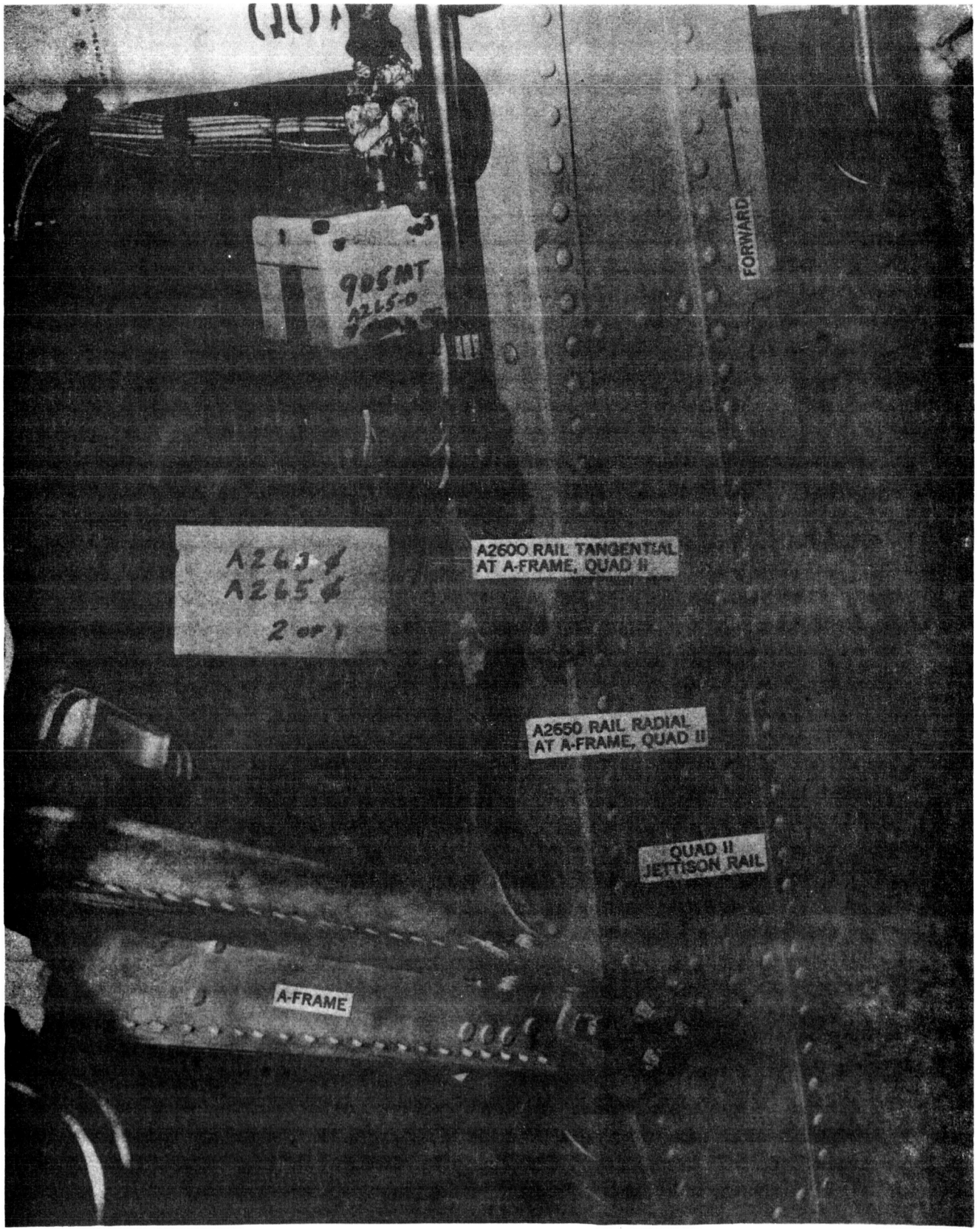
Some response to booster staging was evident on the Sustainer Gas Generator Fuel Check Valve Accelerometer (P5310). Maximum acceleration during the staging sequence was 2.5 g (peak-to-peak) at a frequency of 42 cps. Maximum response immediately following 129.39 seconds (booster package off the rails) was 3.5 g (peak-to-peak) at a frequency of 42 cps.

An oscillograph time history of each measurement is shown in Figures 13-16 and 13-17.

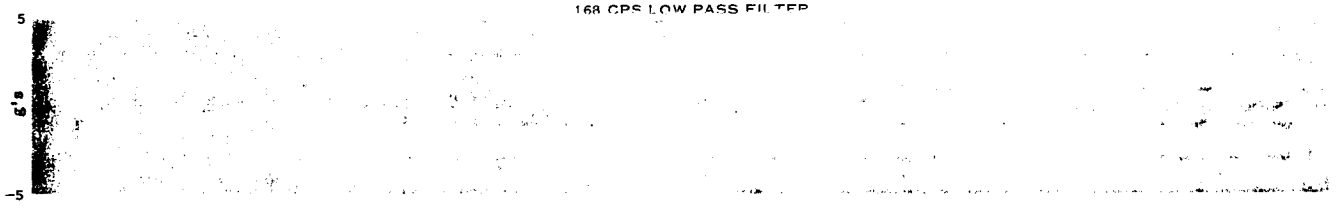

25
0
-25
BOOSTER JETTISON START
(128.94)
AFT SHOES LEAVES RAILS
(129.32)
BOOSTER PACKAGE LEAVES RAILS
(129.39)
TAPE SPLICE DROPOUT
128.68
129.08
129.48
129.88
TIME IN SECONDS FROM 1-INCH MOTION
H4120 NAA CONTROL, Y-AXIS
35 CPS LOW PASS FILTER


25
g
-25
A2730 MISSILE TANK APEX, X-AXIS
35 CPS LOW PASS FILTER
BOOSTER JETTISON START
(128.94)
AFT SHOES LEAVES RAILS
(129.32)
BOOSTER PACKAGE LEAVES RAILS
(129.39)
A2740 MISSILE TANK APEX, Y-AXIS
35 CPS LOW PASS FILTER
TAPE SPLICE DROPOUT
A2750 MISSILE TANK APEX, Z-AXIS
35 CPS LOW PASS FILTER
128.68
129.08
129.48
129.88
TIME IN SECONDS FROM 1-INCH MOTION
A2760 SUSTAINER HYDRAULIC PUMP DISCHARGE LINE
35 CPS LOW PASS FILTER
DATA INVALID
A36A BOOSTER THRUST SECTION LONGITUDINAL ACCELEROMETER
35 CPS LOW PASS FILTER
DATA INVALID

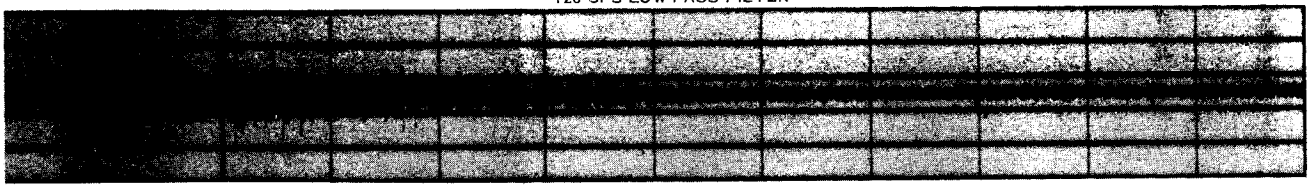
JETTISON RAIL ACCELEROMETERS - QUAD II



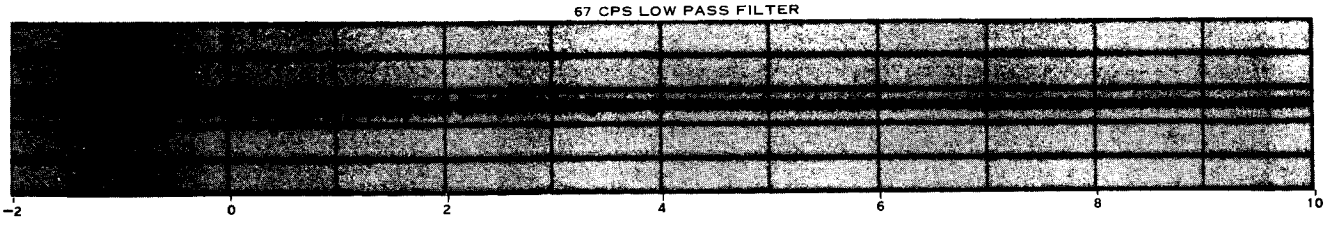
Y6430 OUTRIGGER ARM – RADIAL VIBRATION
168 CPS LOW PASS FILTER



Y6430 OUTRIGGER ARM – RADIAL VIBRATION
128 CPS LOW PASS FILTER

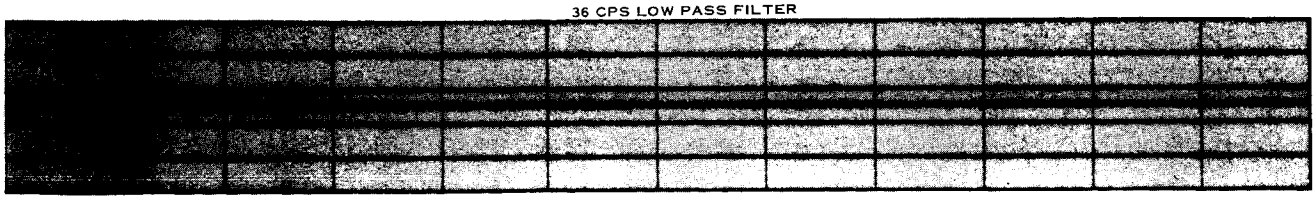


Y6430 OUTRIGGER ARM – RADIAL VIBRATION
67 CPS LOW PASS FILTER

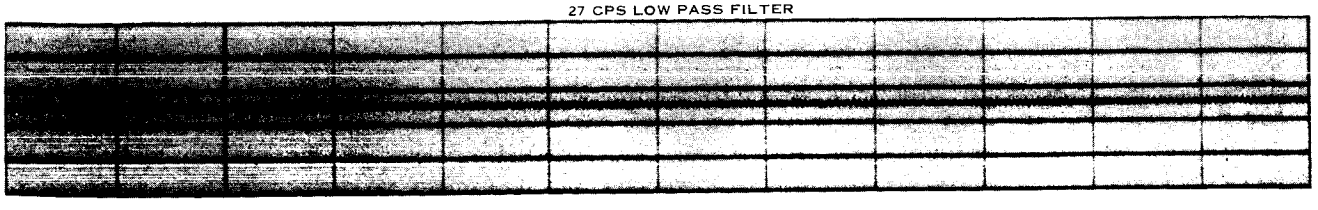


TIME IN SECONDS FROM 1-INCH MOTION

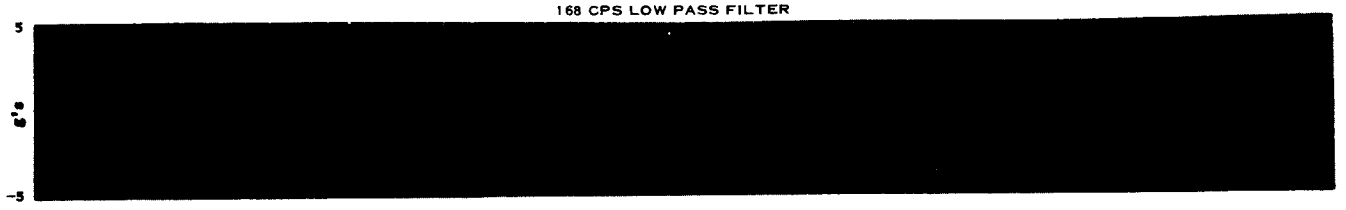
Y6430 OUTRIGGER ARM – RADIAL VIBRATION
36 CPS LOW PASS FILTER



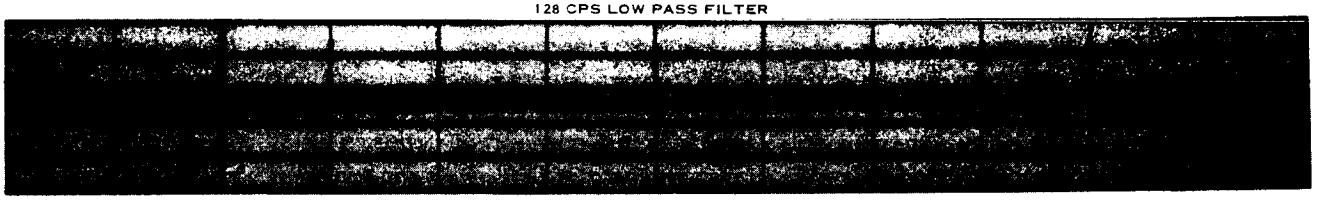
Y6430 OUTRIGGER ARM – RADIAL VIBRATION
27 CPS LOW PASS FILTER



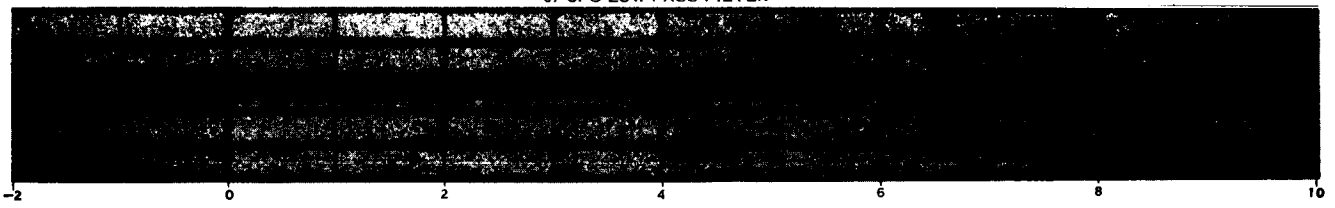
Y6440 OUTRIGGER ARM – LATERAL VIBRATION
168 CPS LOW PASS FILTER



Y6440 OUTRIGGER ARM – LATERAL VIBRATION
128 CPS LOW PASS FILTER

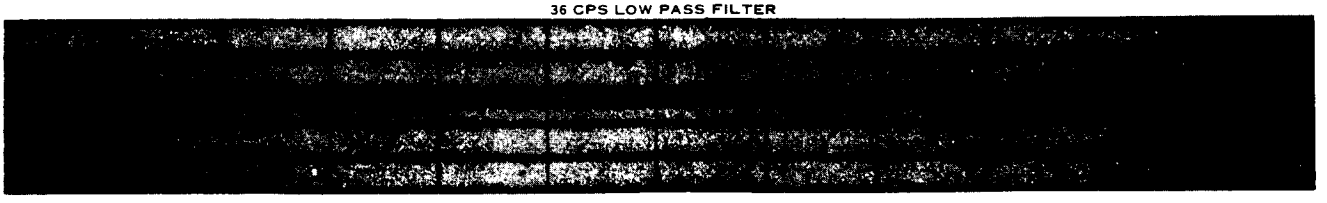


Y6440 OUTRIGGER ARM – LATERAL VIBRATION
67 CPS LOW PASS FILTER

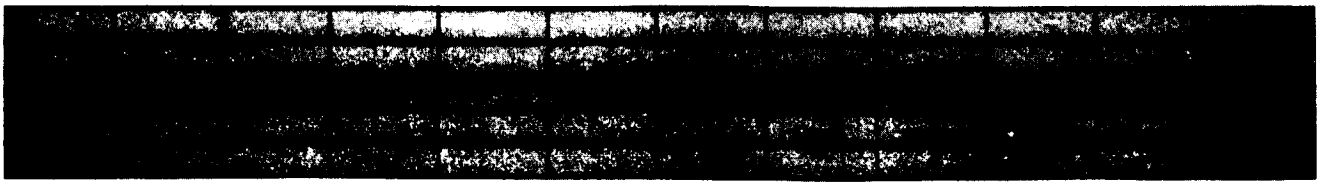


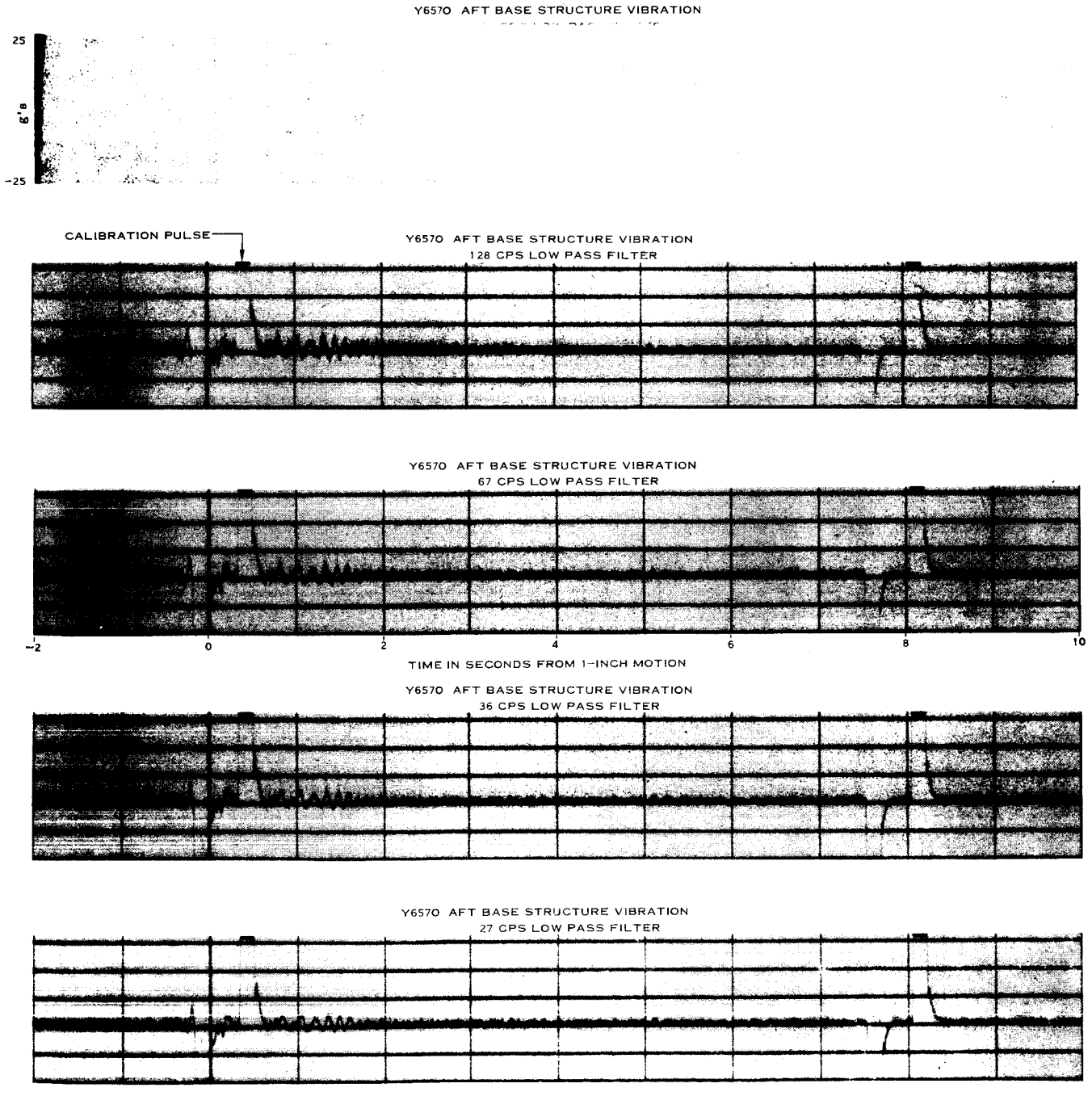
TIME IN SECONDS FROM 1-INCH MOTION

Y6440 OUTRIGGER ARM – LATERAL VIBRATION
36 CPS LOW PASS FILTER



Y6440 OUTRIGGER ARM – LATERAL VIBRATION
27 CPS LOW PASS FILTER




Y6570 AFT BASE STRUCTURE VIBRATION
25
g's
-25
CALIBRATION PULSE
Y6570 AFT BASE STRUCTURE VIBRATION
128 CPS LOW PASS FILTER
Y6570 AFT BASE STRUCTURE VIBRATION
67 CPS LOW PASS FILTER
-2
0
2
4
6
8
10
TIME IN SECONDS FROM 1-INCH MOTION
Y6570 AFT BASE STRUCTURE VIBRATION
36 CPS LOW PASS FILTER
Y6570 AFT BASE STRUCTURE VIBRATION
27 CPS LOW PASS FILTER

DECOY

FIGURE NO. 16-20

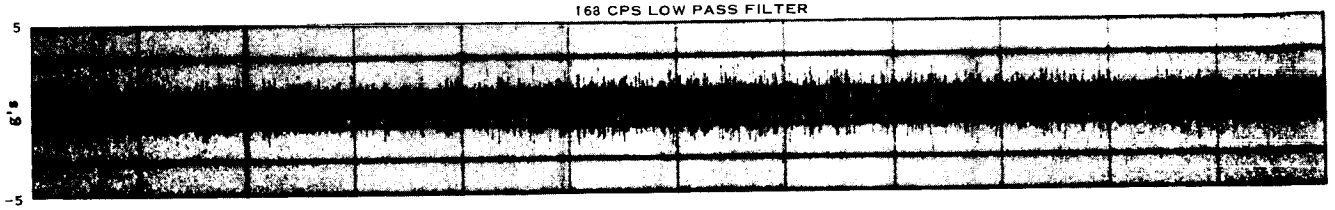
GD/A-DDE65-016

~~REPORT NO. AOJ62-0112~~

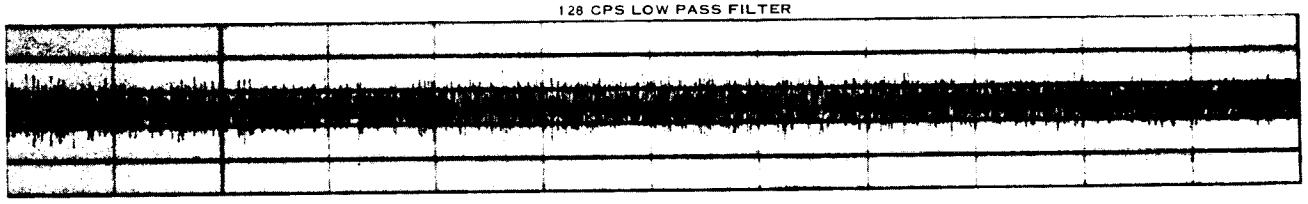
POD B
TELEMETERED DATA

MISSILE 16F

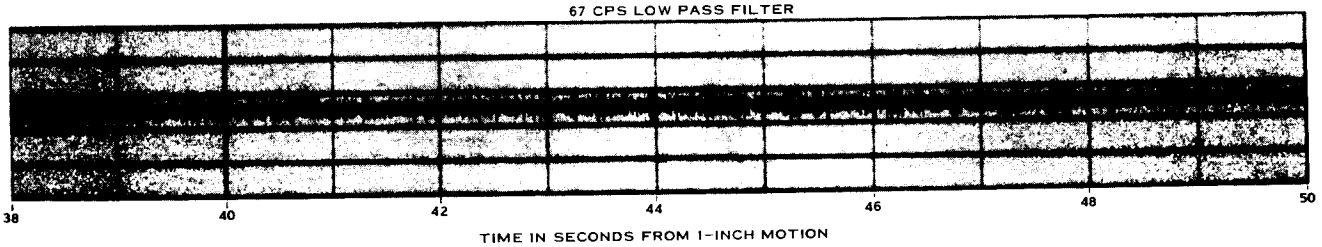
Y6430 OUTRIGGER ARM - RADIAL VIBRATION
168 CPS LOW PASS FILTER



Y6430 OUTRIGGER ARM - RADIAL VIBRATION
128 CPS LOW PASS FILTER

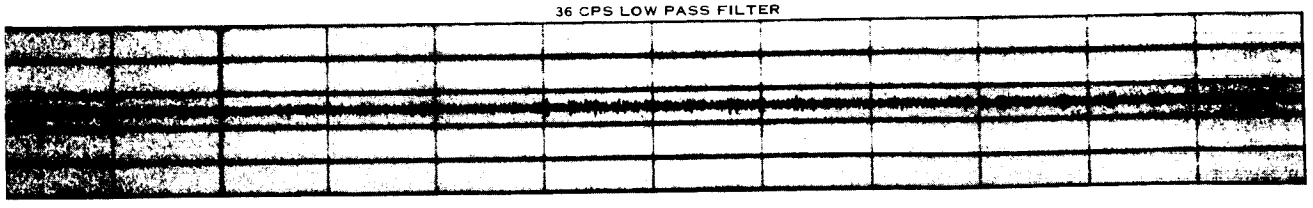


Y6430 OUTRIGGER ARM - RADIAL VIBRATION
67 CPS LOW PASS FILTER

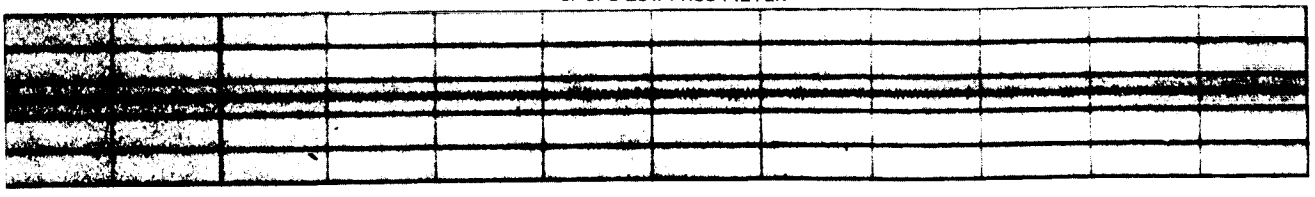


TIME IN SECONDS FROM 1-INCH MOTION

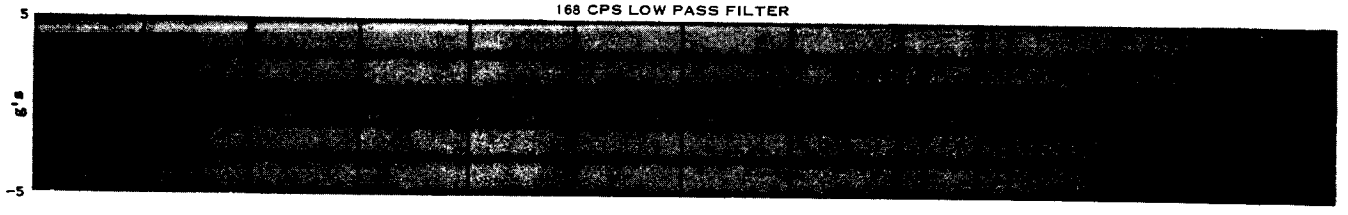
Y6430 OUTRIGGER ARM - RADIAL VIBRATION
36 CPS LOW PASS FILTER



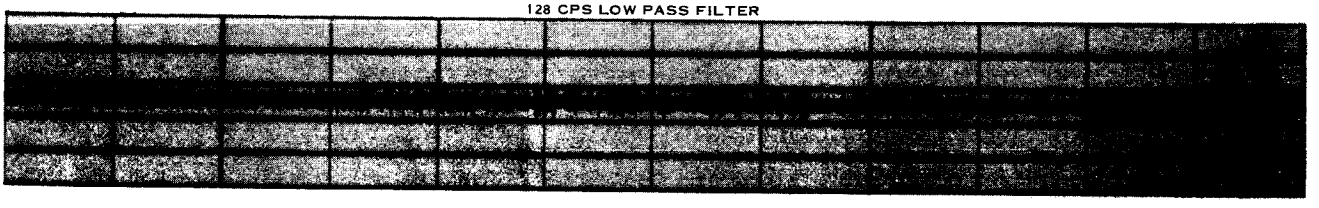
Y6430 OUTRIGGER ARM - RADIAL VIBRATION
27 CPS LOW PASS FILTER



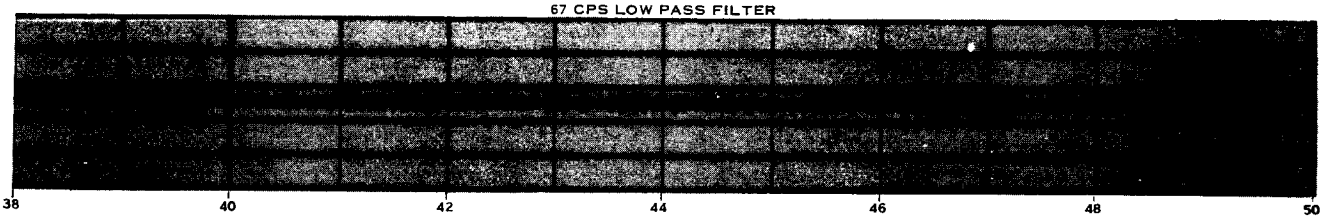
Y6440 OUTRIGGER ARM – LATERAL VIBRATION
168 CPS LOW PASS FILTER



Y6440 OUTRIGGER ARM – LATERAL VIBRATION
128 CPS LOW PASS FILTER

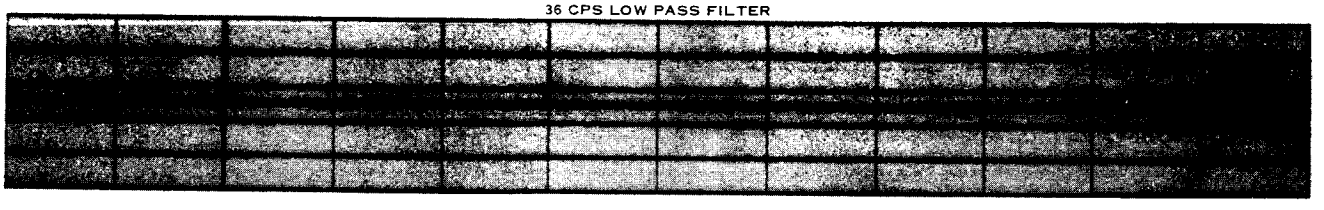


Y6440 OUTRIGGER ARM – LATERAL VIBRATION
67 CPS LOW PASS FILTER

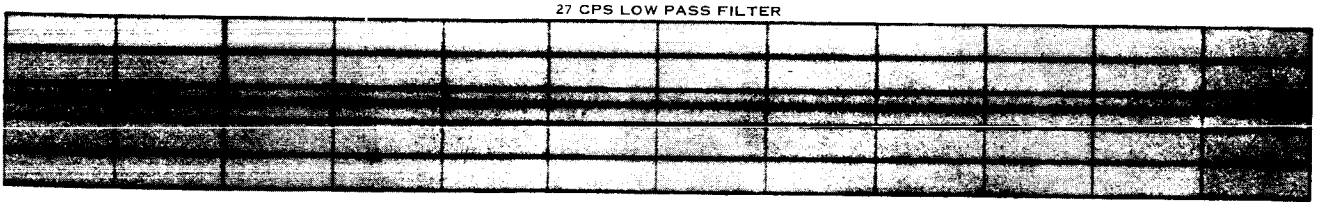


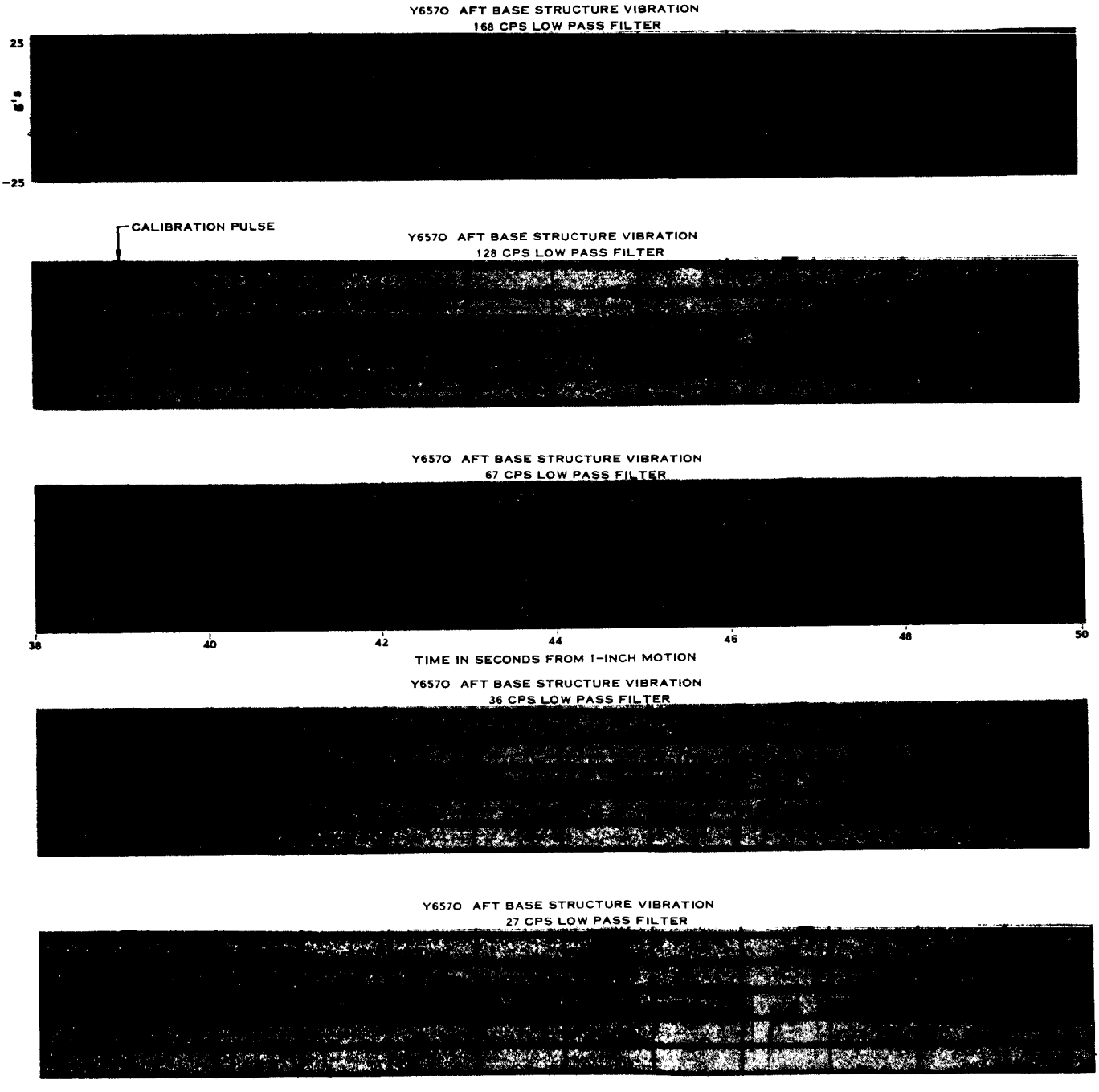
TIME IN SECONDS FROM 1-INCH MOTION

Y6440 OUTRIGGER ARM – LATERAL VIBRATION
36 CPS LOW PASS FILTER

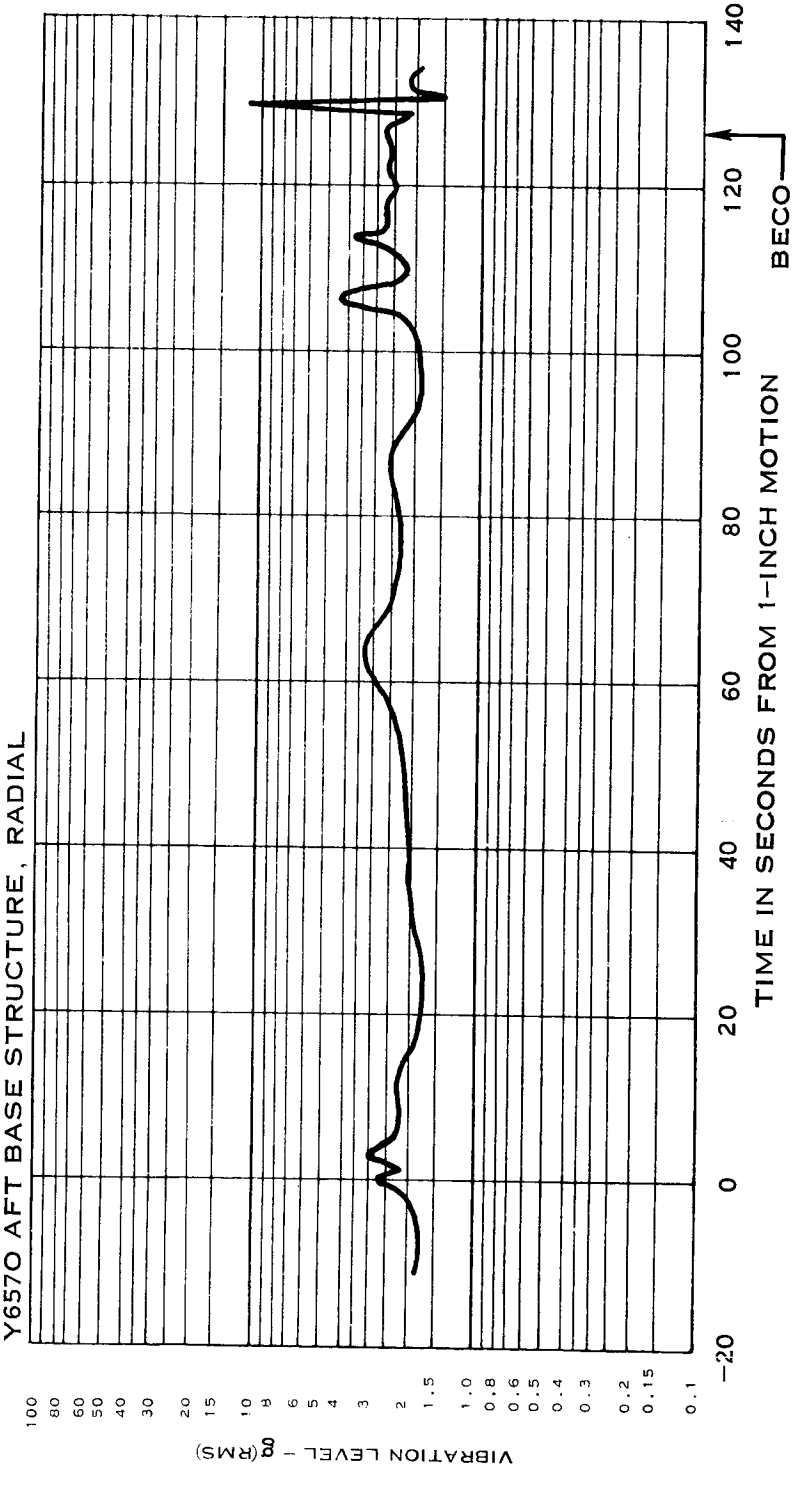


Y6440 OUTRIGGER ARM – LATERAL VIBRATION
27 CPS LOW PASS FILTER

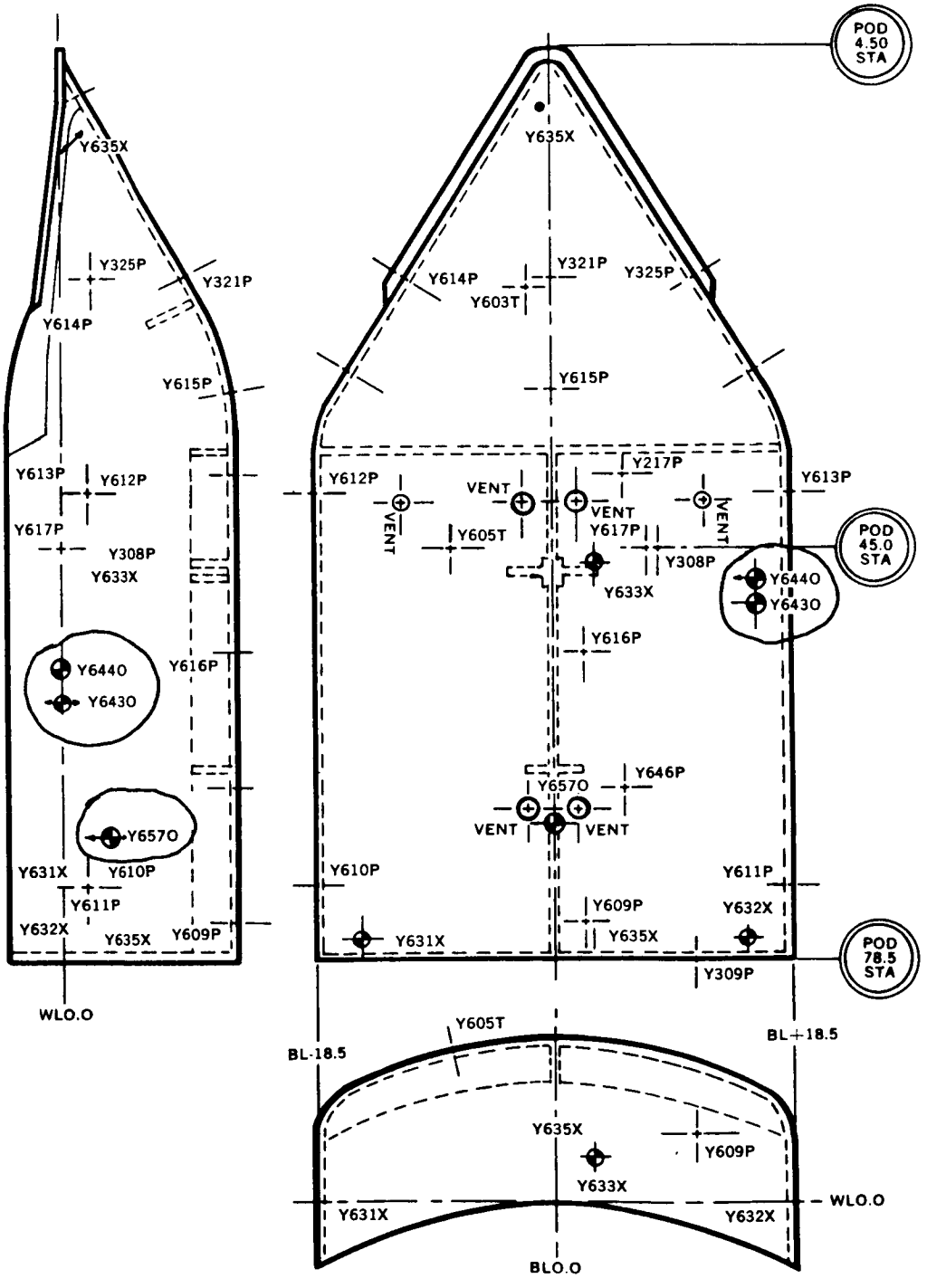



Y6570 AFT BASE STRUCTURE VIBRATION
168 CPS LOW PASS FILTER
25
g's
-25
CALIBRATION PULSE
Y6570 AFT BASE STRUCTURE VIBRATION
128 CPS LOW PASS FILTER
Y6570 AFT BASE STRUCTURE VIBRATION
67 CPS LOW PASS FILTER
38
40
42
44
46
48
50
TIME IN SECONDS FROM 1-INCH MOTION
Y6570 AFT BASE STRUCTURE VIBRATION
36 CPS LOW PASS FILTER
Y6570 AFT BASE STRUCTURE VIBRATION
27 CPS LOW PASS FILTER

VIBRATION TIME HISTORY
g (RMS) VS TIME
MISSILE 16F
2100 CPS LOW PASS FILTER



UNCLASSIFIED



ENVIRONMENTAL INSTRUMENTATION LOCATION

SECTION 6.2.21

MISSILE 21F

FLIGHT TESTED 12-5-62

AT AMR COMPLEX 11

TEST REPORT AOJ62-0114

Engine Vibration

Data were obtained from high frequency accelerometers installed on the booster and sustainer lox domes of each main thrust chamber. The transducers were aligned to measure the z-axis vibrational component. Baffled injectors were incorporated on the booster engines. Three low frequency accelerometer systems were installed on the sustainer lox pump inlet flange to record the vibration environment of the flange during launch and the initial phase of missile flight.

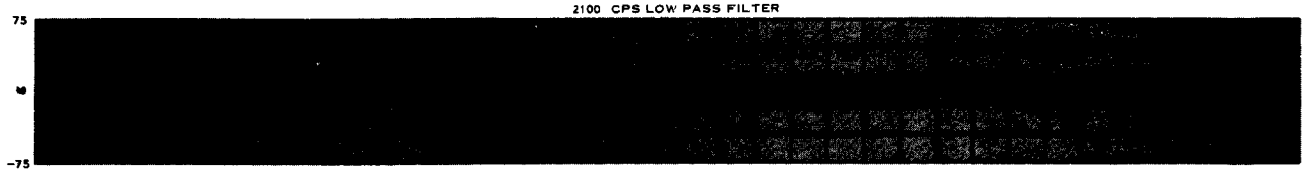
The measurements were recorded via on FM landline system utilizing a trailing wire umbilical in order to retreive performance information during the first 40 ft of missile vertical rise.

Valid data were obtained from all six measurements. The X, Y, and Z vibration components on the sustainer lox pump inlet flange displayed maximum acceleration levels of 6 to 8 g (peak-to-peak) at 110 cps, 3 to 4 g (peak-to-peak) at 55 cps, and 3 to 4 g (peak-to-peak) at 43 cps, respectively.

All of these levels are in line with previous testing of missiles 8F, 14F, & 16F and are not considered to be representative of a severe environment.

The sustainer, B1, and B2 lox dome vibrations (z-component) also displayed data representative of past F Series R&D flights. The over-all acceleration levels for the sustainer lox dome (P1206 0) was 6 to 7 g (rms) with the expected predominant frequencies of 500 cps and 680 cps normally associated with sustainer operation and a contributing component at 1120 cps. The B1 lox dome measurement (P1208 0) recorded levels of 7 to 8 g (rms) with primary energy at 575 cps. The B2 lox dome vibration (P1209 0) recorded 4 to 11 g (rms) at primary frequencies of 575 cps and 700 cps. The low levels on the data precluded a highly quantitative analysis since the signal to noise ratio is small enough to make the data comparable to the quiescent noise.

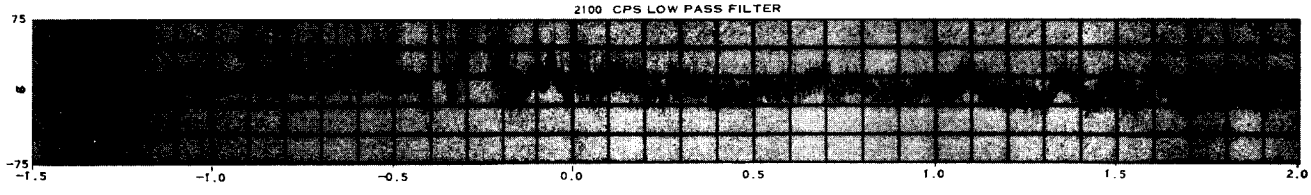
P1206O SUSTAINER ENGINE LO2 DOME
2100 CPS LOW PASS FILTER



P1006P SUSTAINER THRUST CHAMBER PRESSURE

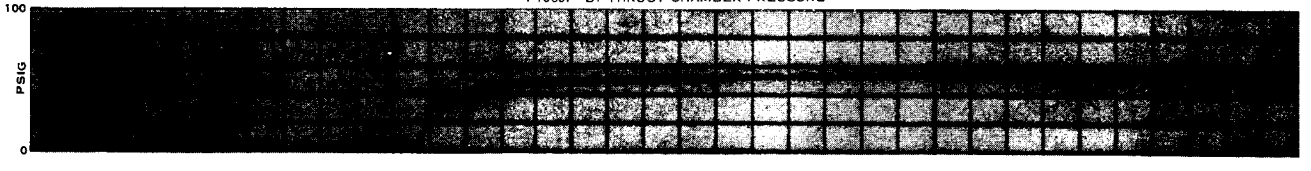


P1208O B1 ENGINE LO2 DOME
2100 CPS LOW PASS FILTER

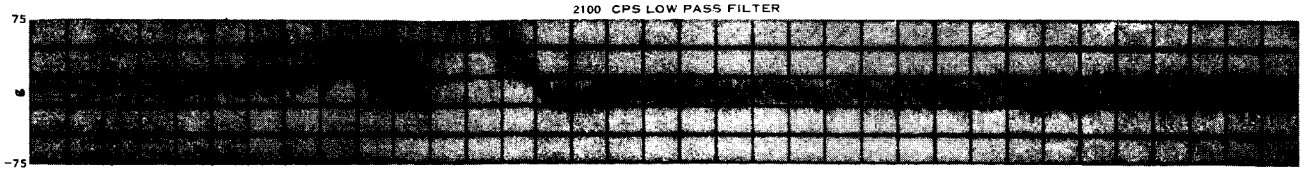


TIME IN SECONDS FROM 1-INCH MOTION

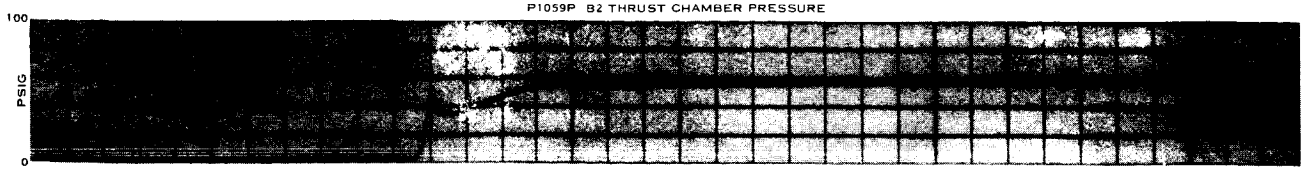
P1060P B1 THRUST CHAMBER PRESSURE



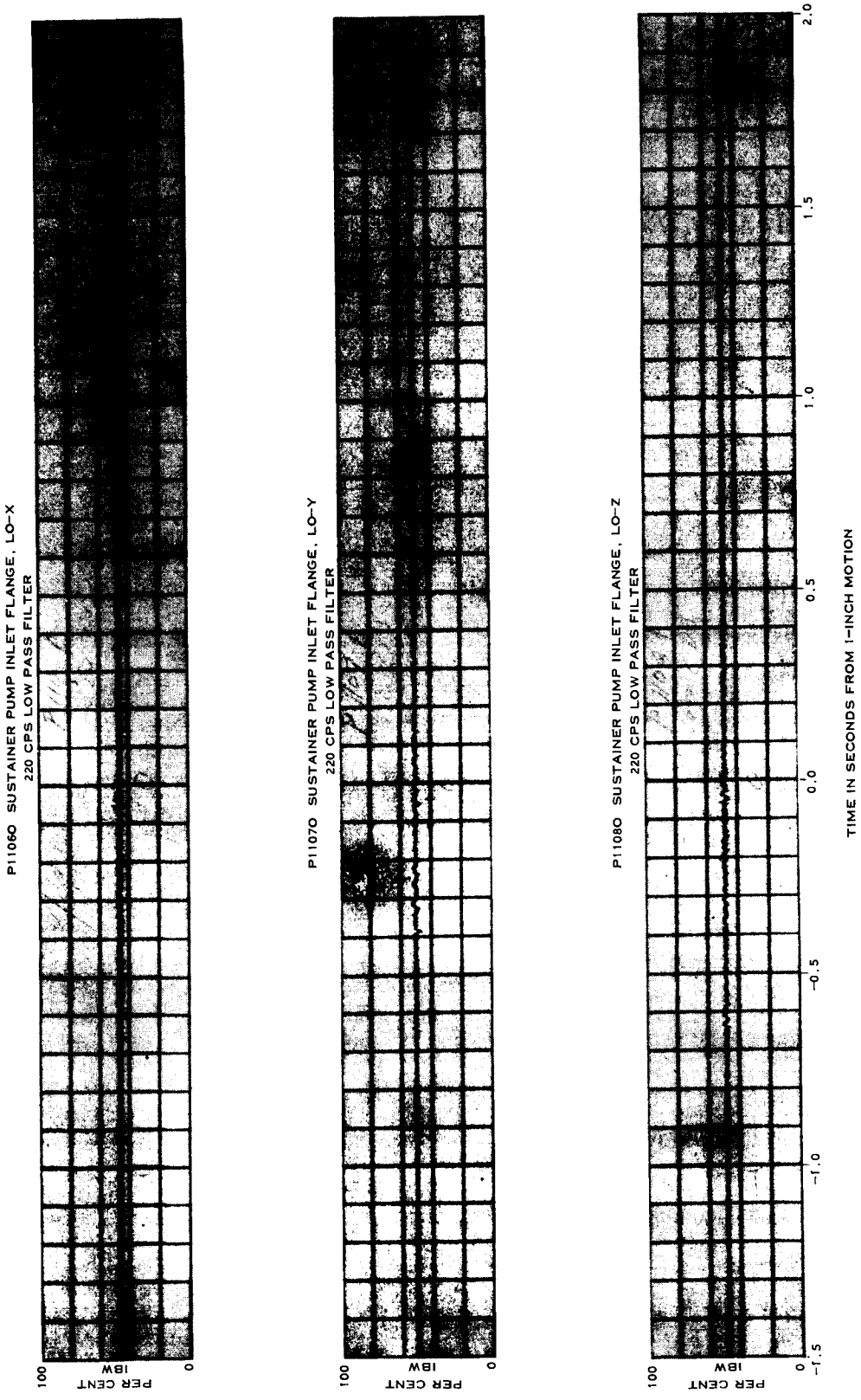
P1209O B2 ENGINE LO2 DOME
2100 CPS LOW PASS FILTER



P1059P B2 THRUST CHAMBER PRESSURE



LANDLINE DATA



Staging Vibration

No significant data reflecting the existence of an adverse vibrational environment were seen during booster engine shutdown and jettison. The missile thrust section was instrumented with 13 accelerometers to study the vibration and shock environment during the staging operation. The measurements were switched in at the activation of the booster cutoff relay and yielded approximately 8.5 seconds of useful data. During the staging event, the measurements were retrieved via the airborne tape recorder introducing a 1.422 second data time delay. This was done in order to yield redundant data if telemetry experienced a significant signal dropout following staging.

Useful data were retrieved from 11 of the 13 measurements. Both the radial and tagential accelerometers at the Quad IV rail end (A3730 & A3760) yielded data which were excessively noisy. No useful data was obtained from either transducer. Following is a tabulation describing pertinent transducer systems used on this vehicle. Locations of the various accelerometers are shown in Figures.

Meas. No.	Description	Accelerometer System Type	Flat Freq. Response of Accel. System (cps)
A36A	Booster Thrust Section Longitudinal acceleration	GIANNINI ± 25g	30
A2730	Missile Tank Apex, X Axis	CEC & PAC. Tel ± 25g	30
A2740	Missile Tank Apex, Y Axis	CEC & PAC. Tel ± 25g	30

Meas. No.	Description	Accelerometer System Type	Flat Freq. Response of Accel. System (cps)
A2750	Missile Tank Apex, Z Axis	CEC & PAC. Tel ± 25g	30
A3720	Quad IV Airframe-Aft Side Perpendicular	CEC & PAC. Tel ± 25	150
A3730	Quad IV Rail End-Radial	CEC & PAC. Tel ± 25g	30
A3760	Quad IV Rail End-Tangential	CEC & PAC. Tel ± 25g	30
A3770	Sustainer Gas Generator Fuel Line, Z direction	CEC & PAC. Tel ± 100g	500
A3820	Quad II Hydraulic Return Line - YZ Plane	CEC & PAC. Tel ± 100	500
A3900	Quad IV Airframe-Aft Side Parallel	CEC & PAC. Tel ± 25g	50
A3940	Quad II Rail End-Radial	CEC & PAC. Tel ± 100g	150
A3950	Quad II Rail End-Tangential	CEC & PAC. Tel ± 100g	150
P5310	Sustainer Gas Generator Fuel Check Valve	GIANNINI ± 25g	50

Generally, as on past F R&D series missiles, the vibration levels during staging were low. No excessive shock loading was shown in the data, and the energy transfer from the staging rails to the sustainer engine was negligible. Booster staging was initiated at 130.417 seconds as indicated by Conax Valve instrumentation. The aft shoes of the booster section appeared to leave the staging rails at 0.40 seconds after the start of jettison.

Immediately following jettison start, the Quad II rail end experienced a radial vibrational component of 10 to 11g peak-to-peak at approximately 130 cps while the tangential component displayed negligible response during the first movement of the booster section. The Quad IV

rail end as previously mentioned provided spurious data through their data transmission period. Ringing of the staging rail structure was evident in both radial and tangential components of Quad II rail end vibration coincident with the completion of jettison. A damped oscillation, characteristic of structural ringing, of 23g peak-to-peak and 15 to 16 g's peak-to-peak at approximately 130 cps were sensed by the radially and tangentially oriented accelerometers respectively.

The perpendicular and parallel vibrational components were instrumented along the bottom aft side of the Quadrant IV A-frame. No perceptible transient response to the staging sequence was seen on the data indicating that the transmissability of the rail to A frame structure is low. As expected, the Missile Tank Apex x, y, and z axis components also reflected negligible energy transfer either from the sustainer engine or the A-frame structure.

The accelerometer mounted on the Quad II hydraulic return line YZ-plane relayed line response both to initial and terminal shocks at jettison start and completion. Initial primary vibrational response was 11g (peak-to-peak) at about 280 cps for 100 milliseconds. Following jettison completion the hydraulic return line again responded to primary energy insertion of approximately 6g (peak-to-peak) at 280 cps for 50 milliseconds.

The measurement of the Z component of vibration on the sustainer gas generator fuel line exhibited a quasi-stationary environment with primary energy insertion at 10g (rms) at 690 cps (normal sustainer engine primary frequency characteristic). Both the sustainer gas generator fuel line and the sustainer gas generator fuel check valve measurements failed to show any appreciable response to the staging event. The booster thrust section longitudinal acceleration showed a slight deflection at initiation of staging which persisted until umbilical ejection. No significant data were retrieved from this measurement.

Landline Acoustic Analysis (Missiles 14F, 16F, 21F)

As part of a study to define the launch acoustic environment within the thrust section for various launch pad configurations, a microphone was placed in the thrust section to determine the sound pressure level (SPL) near the sustainer engine thrust chamber on Missiles 14F, 16F, 21F. The microphone (P1051Y) was located on the Quad II jettison rail A-Frame. A trailing wire was used to obtain data during the first 40 ft of missile vertical motion.

The acoustic transducer utilized was a model NM125, high intensity microphone manufactured by Chesapeak Instrument Corporation. The high intensity microphone was a self generated piezoelectric ceramic Acoustic sensor especially designed for measuring high noise levels under adverse environmental conditions. The instrumentation setup was identical for all three vehicles.

The quality of the data appeared satisfactory for Missiles 16F and 21F. Data retrieved from the launch of Missile 14F appeared to contain an excessively high background noise level and as a result, the data was considered of a more qualitative nature. An overall SPL (20 cps to 20 kc) time history for all three missiles is presented in Fig. 13-26. Spectrum analysis of the acoustic environment is presented for Missiles 16F and 21F. This analyses was not shown for Missile 14F due to the aforementioned noise difficulties.

Table 1 shows a comparison of the P1051Y overall levels for 6 missile launchings. This tabulation suggests that the effects of the "dry" flame bucket vs the "wet" flame bucket upon the launch acoustic environment appear to be negligible.

Included in the figures are various spectral plots showing predominant frequencies at pertinent sample times.

TABLE 1

COMPARISON OF THRUST SECTION OVER-ALL SPL

COMPLEX	MISSILE NO.	Oa SPL db	TIME OF MAX. SPL-SECONDS	MISSILE VENT DIST. @ MAX. SPL - ft	UMBILICAL EJECT
AMR 11	21F	146.5	-0.3	0	2.13
AMR 11	16F	151.5	0.2	0.8	2.35
AMR 11	14F	*148	-0.2	0	2.18
OSTF 2	57F	153.5	1.5	15	2.15
OSTF 1	67E	149	0.5	2	2.29

* Data of a qualitative nature due to excessive background noise.

~~REPORT NO. AOJ62-0114~~

FILTERS FOR A2730, A2740, A2750 MISSILE TANK APEX, (ACCELEROMETERS NOT INSTALLED)

MISSILE 21F

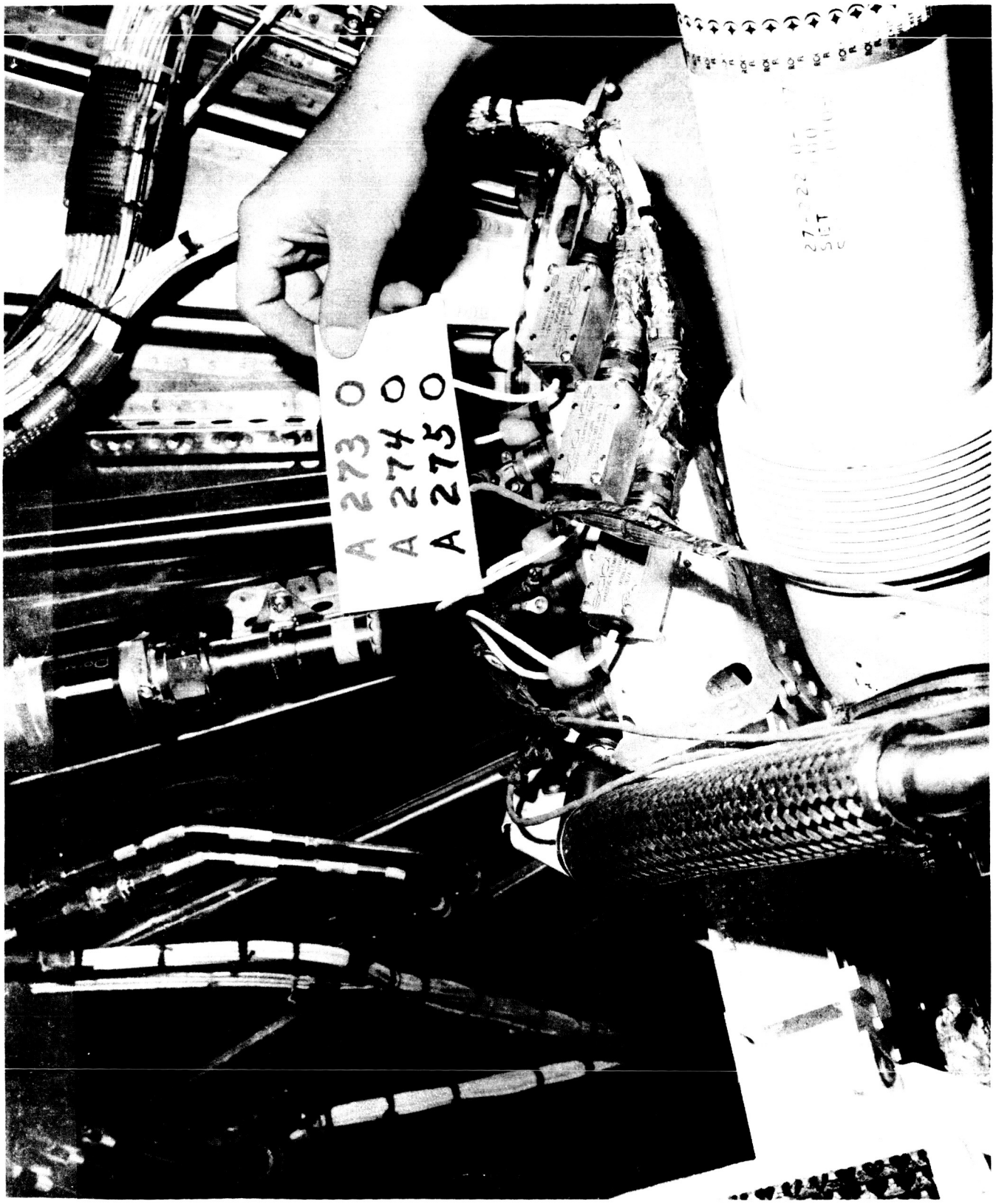
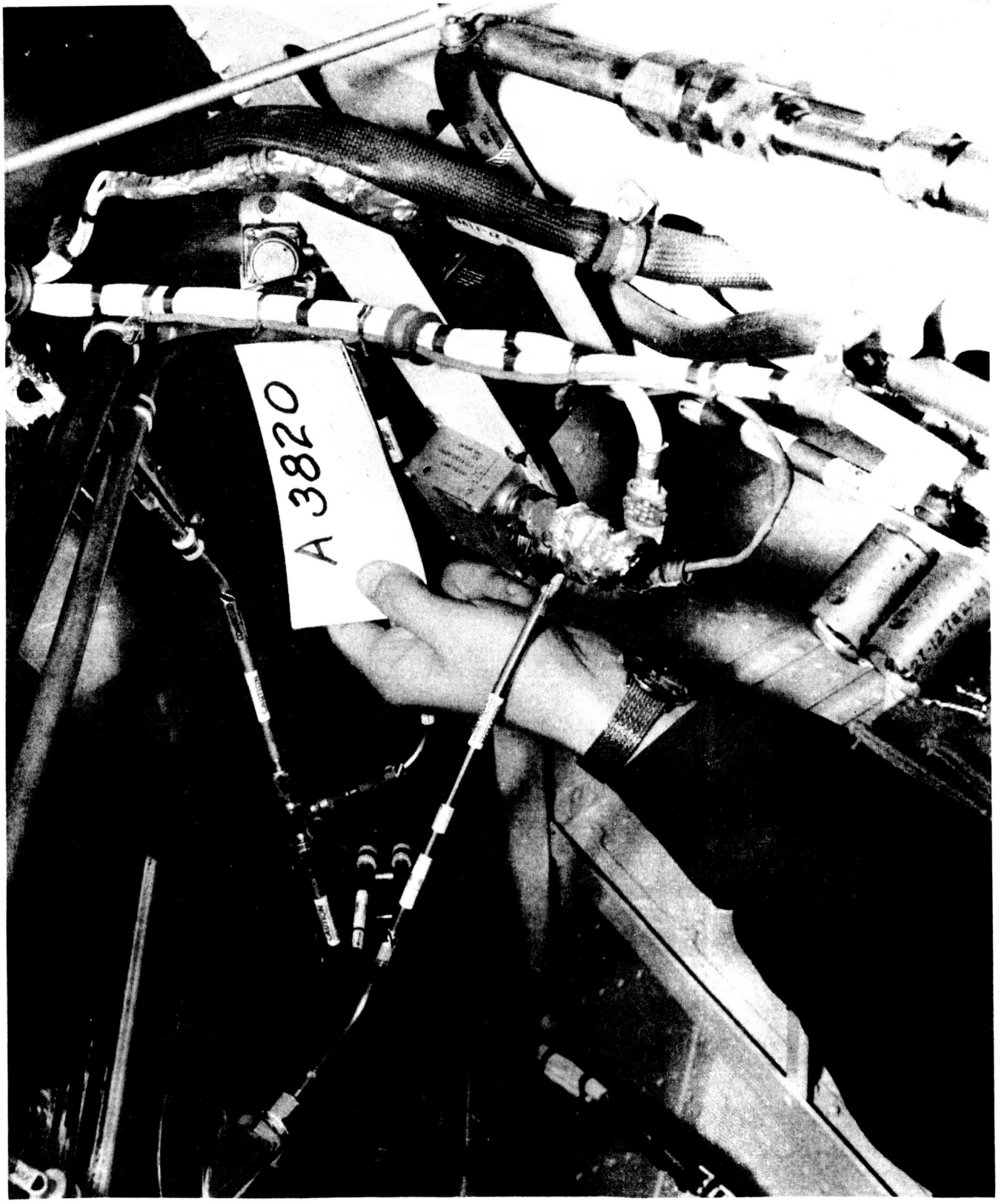


FIGURE NO. 13-23

~~REPORT NO. AOJ62-0114~~

ACCELEROMERER A3820, QUAD 2
HYDRAULIC FUEL RETURN LINE.

MISSILE 21F



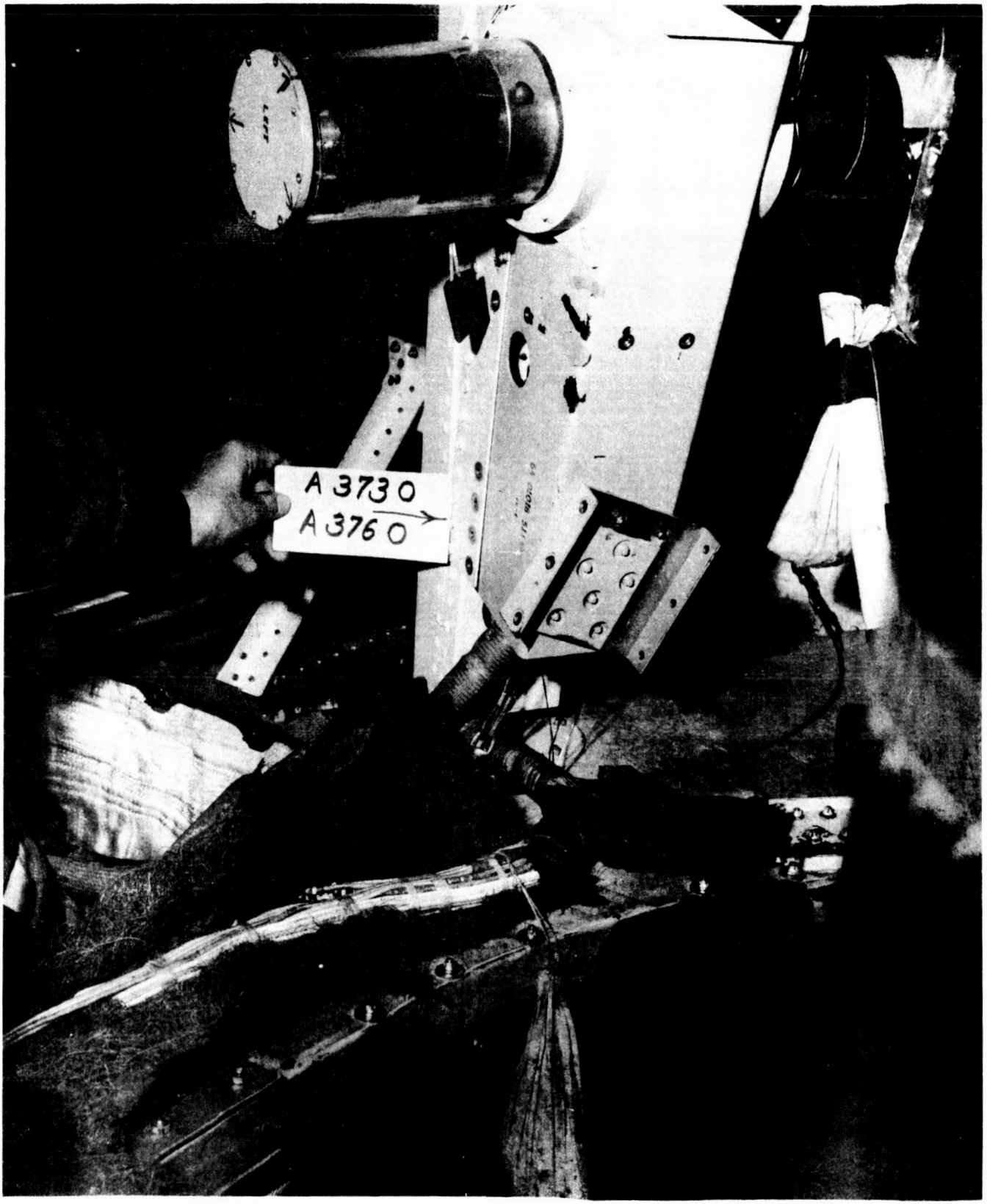
ACCELEROMETERS A3900, A3720,
QUAD 4 "A" FRAME AFT SIDE.

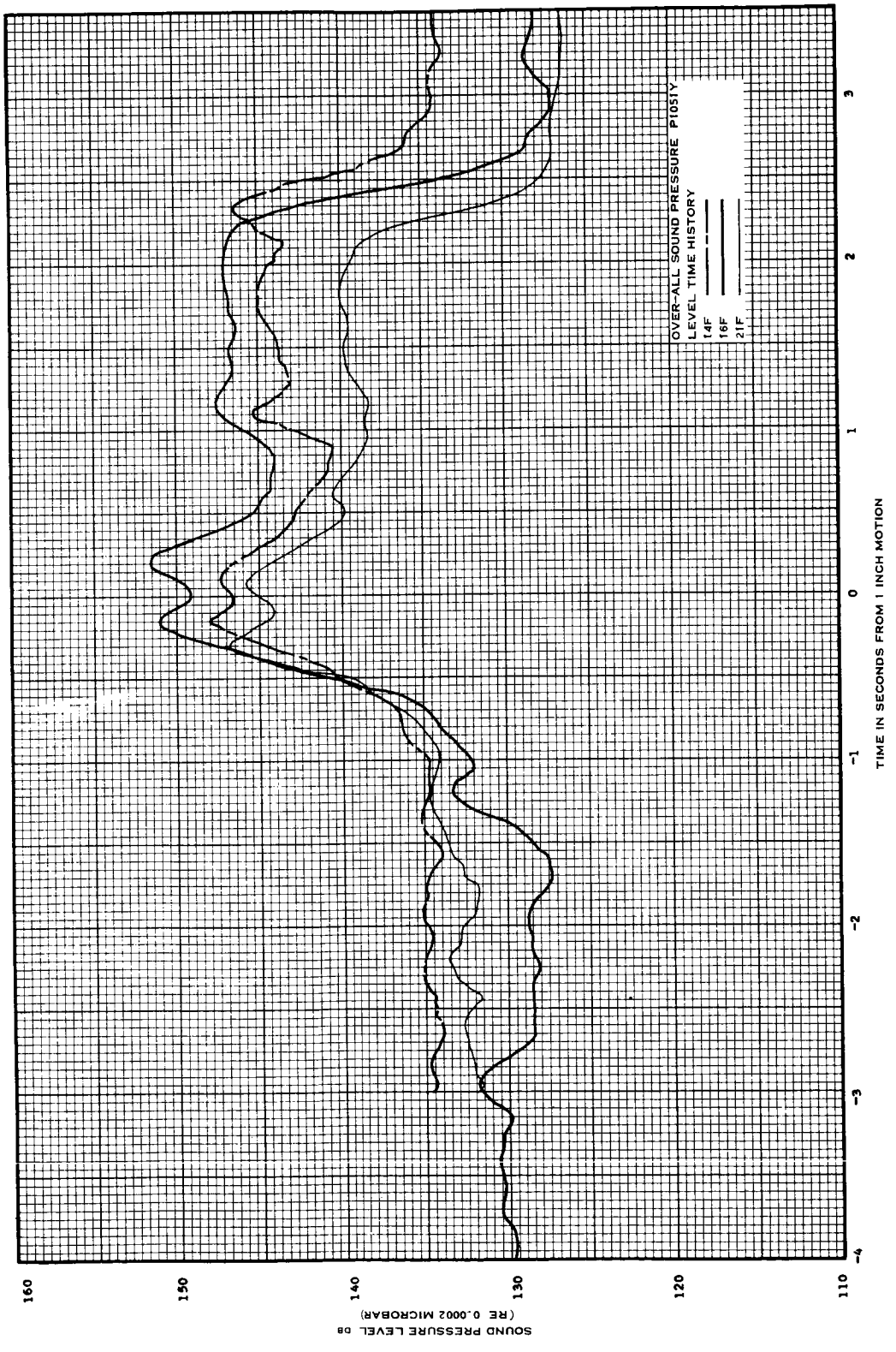


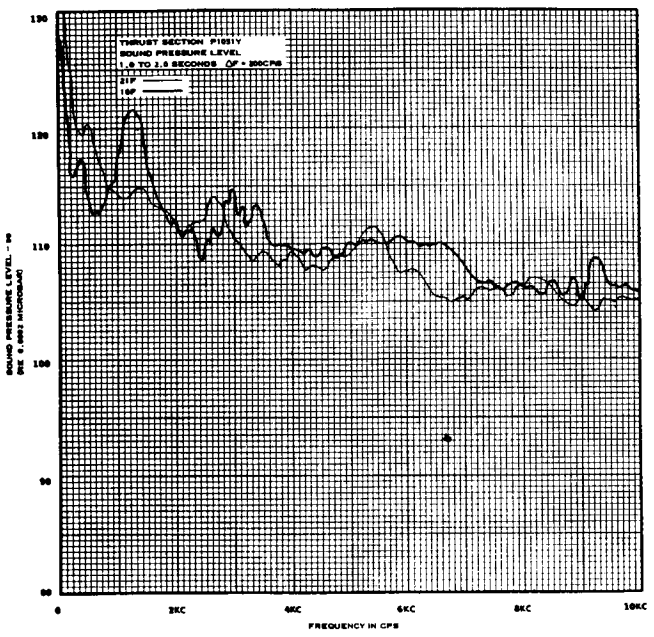
~~REPORT NO. AOJ62-0114~~

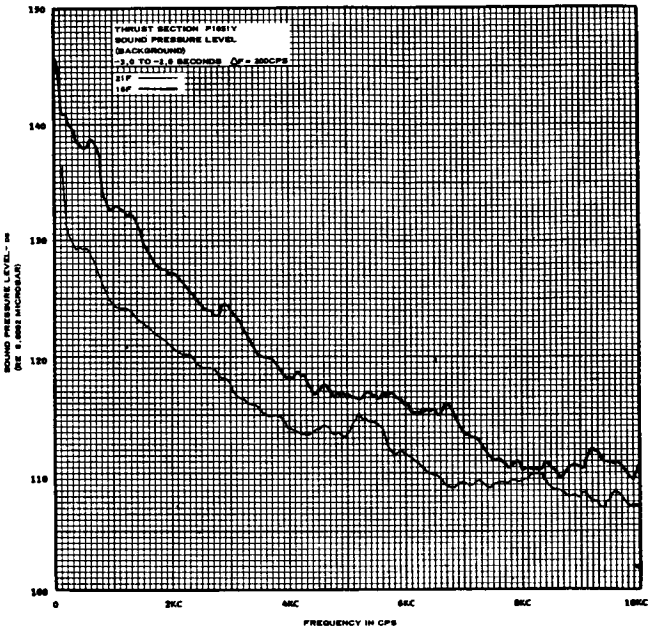
LOCATION OF A3730 AND A3760
QUAD 4 RAIL ENI

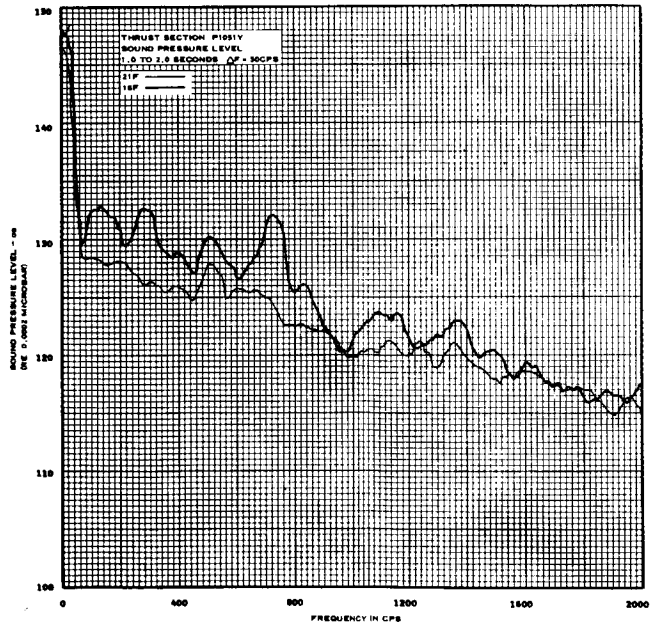
MISSILE 21F

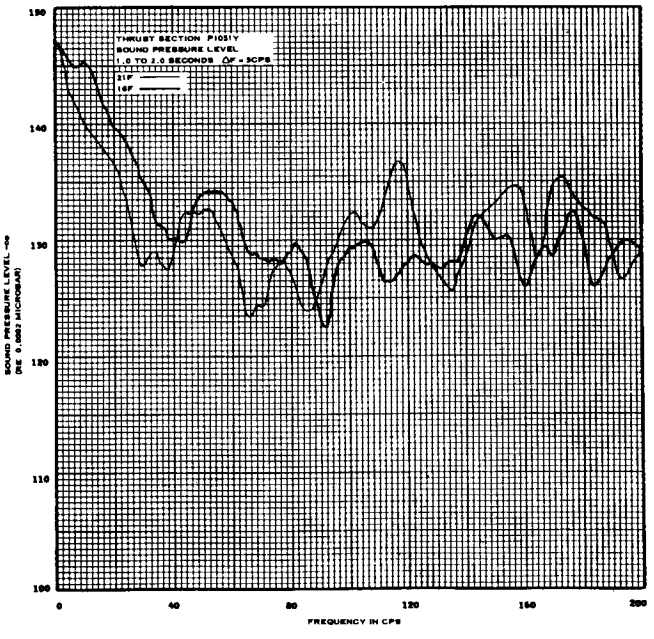



OVER-ALL SOUND PRESSURE P1051Y
LEVEL TIME HISTORY
14F
16F
21F
SOUND PRESSURE LEVEL DB
(RE 0.0002 MICROBAR)
160
150
140
130
120
110
TIME IN SECONDS FROM I INCH MOTION
3
2
1
0
-1
-2
-3
-4


THRUST SECTION P1031Y
SOUND PRESSURE LEVEL
1.0 TO 2.0 SECONDS Δf = 200CPS
21F
15F
SOUND PRESSURE LEVEL - DB
(RE 0.0002 MICROBAR)
130
120
110
100
90
80
0
2KC
4KC
6KC
8KC
10KC
FREQUENCY IN CPS

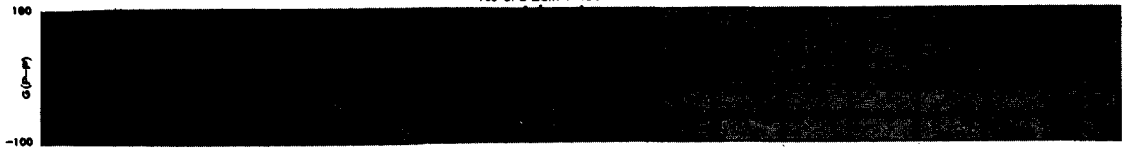

THRUST SECTION P1031Y
SOUND PRESSURE LEVEL
(BACKGROUND)
-2.0 TO -1.0 SECONDS Δf = 200CPS
21F
15F
SOUND PRESSURE LEVEL - DB
(RE 0.0002 MICROBAR)
150
140
130
120
110
100
0
2KC
4KC
6KC
8KC
10KC
FREQUENCY IN CPS


THRUST SECTION P1031Y
SOUND PRESSURE LEVEL
1.0 TO 2.0 SECONDS Δf = 50CPS
21F
15F
SOUND PRESSURE LEVEL - DB
(RE 0.0002 MICROBAR)
150
140
130
120
110
100
0
400
800
1200
1600
2000
FREQUENCY IN CPS


THRUST SECTION P1031Y
SOUND PRESSURE LEVEL
1.0 TO 2.0 SECONDS Δf = 5CPS
21F
15F
SOUND PRESSURE LEVEL - DB
(RE 0.0002 MICROBAR)
150
140
130
120
110
100
0
40
80
120
160
200
FREQUENCY IN CPS

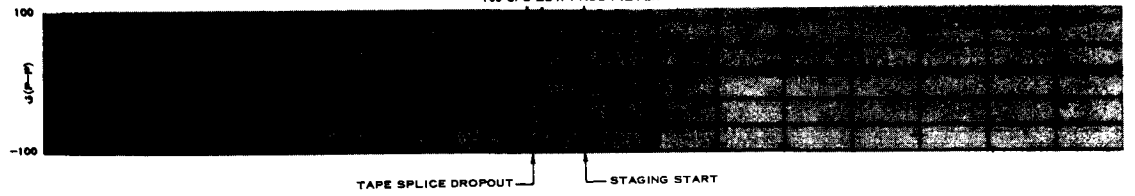
TELEMETERED DATA

A3950 QUAD 2 RAIL END VIBRATION–TANGENTIAL
160 CPS LOW PASS FILTER

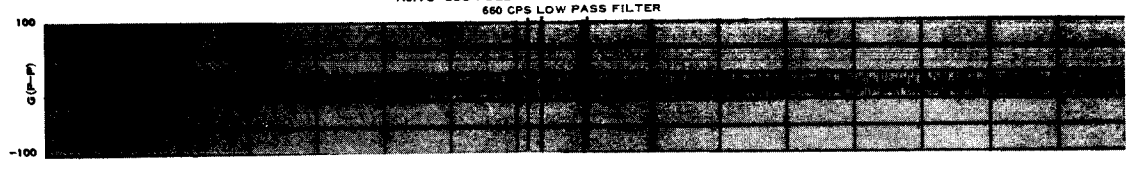


NOTE–DATA DISPLACED BY 1.493 SECONDS DUE TO CONTINUOUS LOOP AIRBORNE TAPE RECORDER

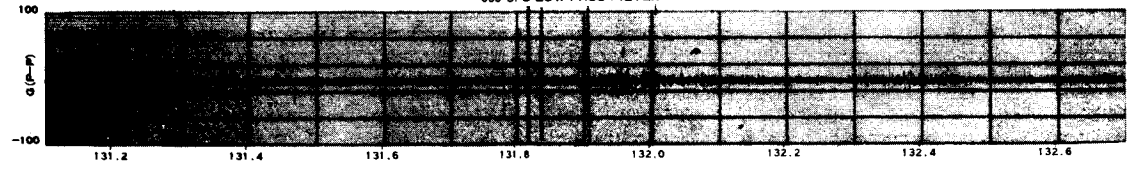
A3940 QUAD 2 RAIL END VIBRATION–RADIAL
160 CPS LOW PASS FILTER



A3770 SGG FUEL LINE VIBRATION–Z DIRECTION
660 CPS LOW PASS FILTER

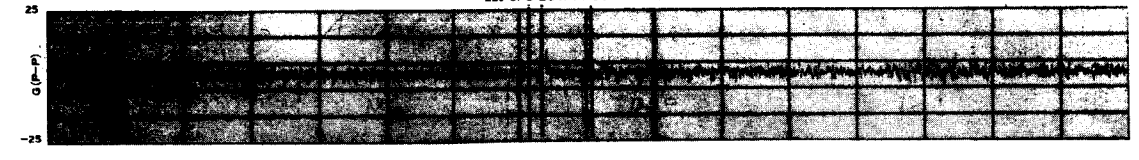


A3820 QUAD 2 HYDRAULIC RETURN LINE VIBRATION–YZ PLANE
660 CPS LOW PASS FILTER

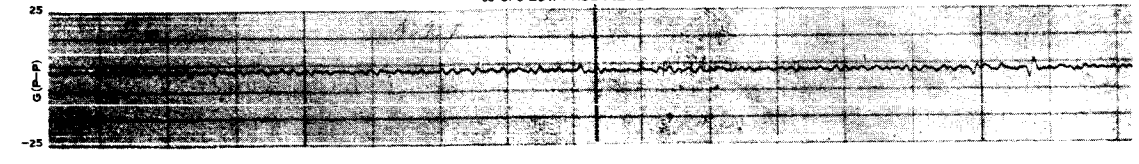


TIME IN SECONDS FROM 1–INCH MOTION

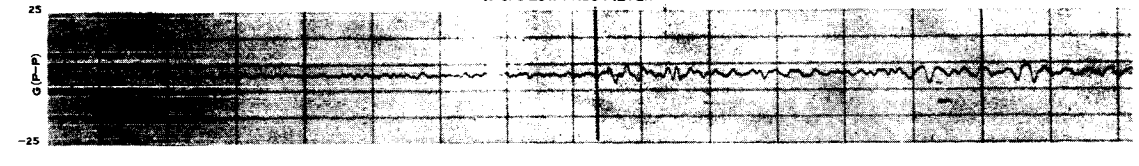
A3720 QUAD 4 A–FRAME VIBRATION–AFT SIDE PERPENDICULAR
220 CPS LOW PASS FILTER



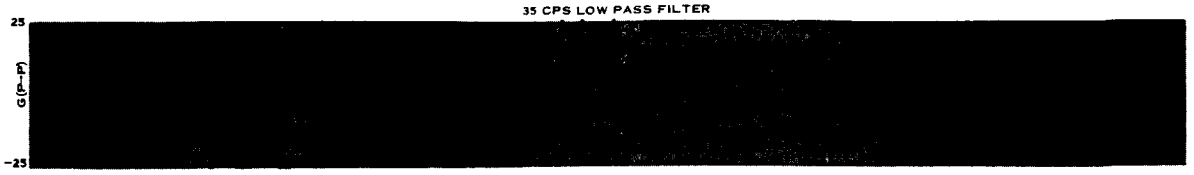
A3900 QUAD 4 A–FRAME VIBRATION–AFT SIDE PARALLEL
60 CPS LOW PASS FILTER



P5310 SGG FUEL CHECK VALVE VIBRATION
50 CPS LOW PASS FILTER

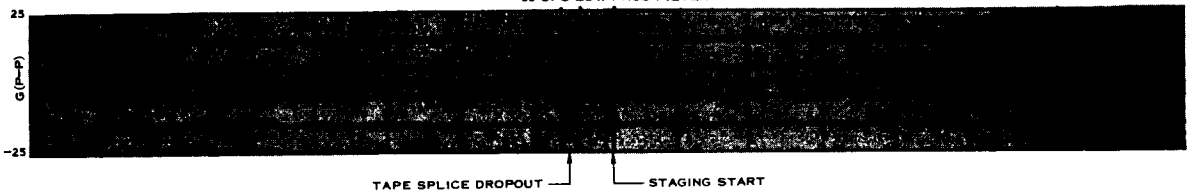


A3730 QUAD 4 RAIL END VIBRATION–RADIAL
35 CPS LOW PASS FILTER



NOTE–DATA DISPLACED BY 1.493 SECONDS DUE TO CONTINUOUS LOOP AIRBORNE TAPE RECORDER

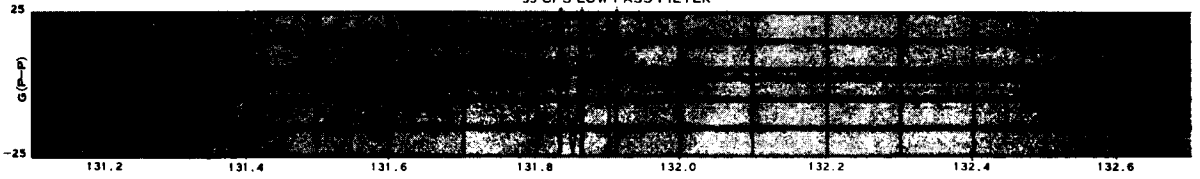
A3760 QUAD 4 RAIL END VIBRATION–TANGENTIAL
35 CPS LOW PASS FILTER



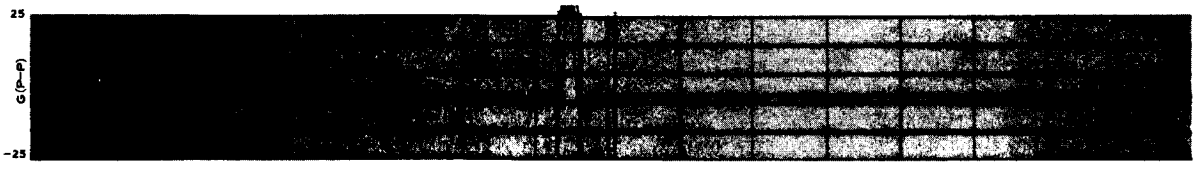
A2740 MISSILE TANK APEX, Y-AXIS
35 CPS LOW PASS FILTER



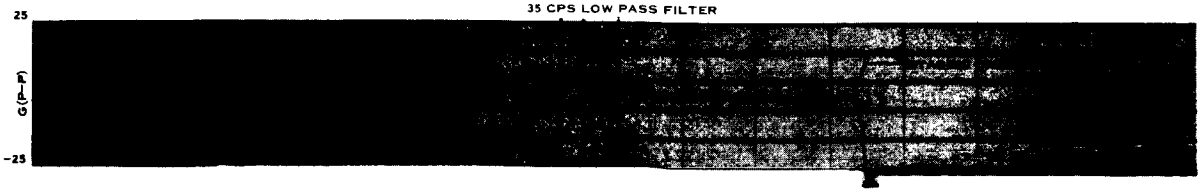
A2750 MISSILE TANK APEX, Z-AXIS
35 CPS LOW PASS FILTER



A2730 MISSILE TANK APEX, X-AXIS
35 CPS LOW PASS FILTER



A36A BOOSTER LONGITUDINAL ACCELEROMETER
35 CPS LOW PASS FILTER



AIRFRAME

FIGURE NO. 13-30

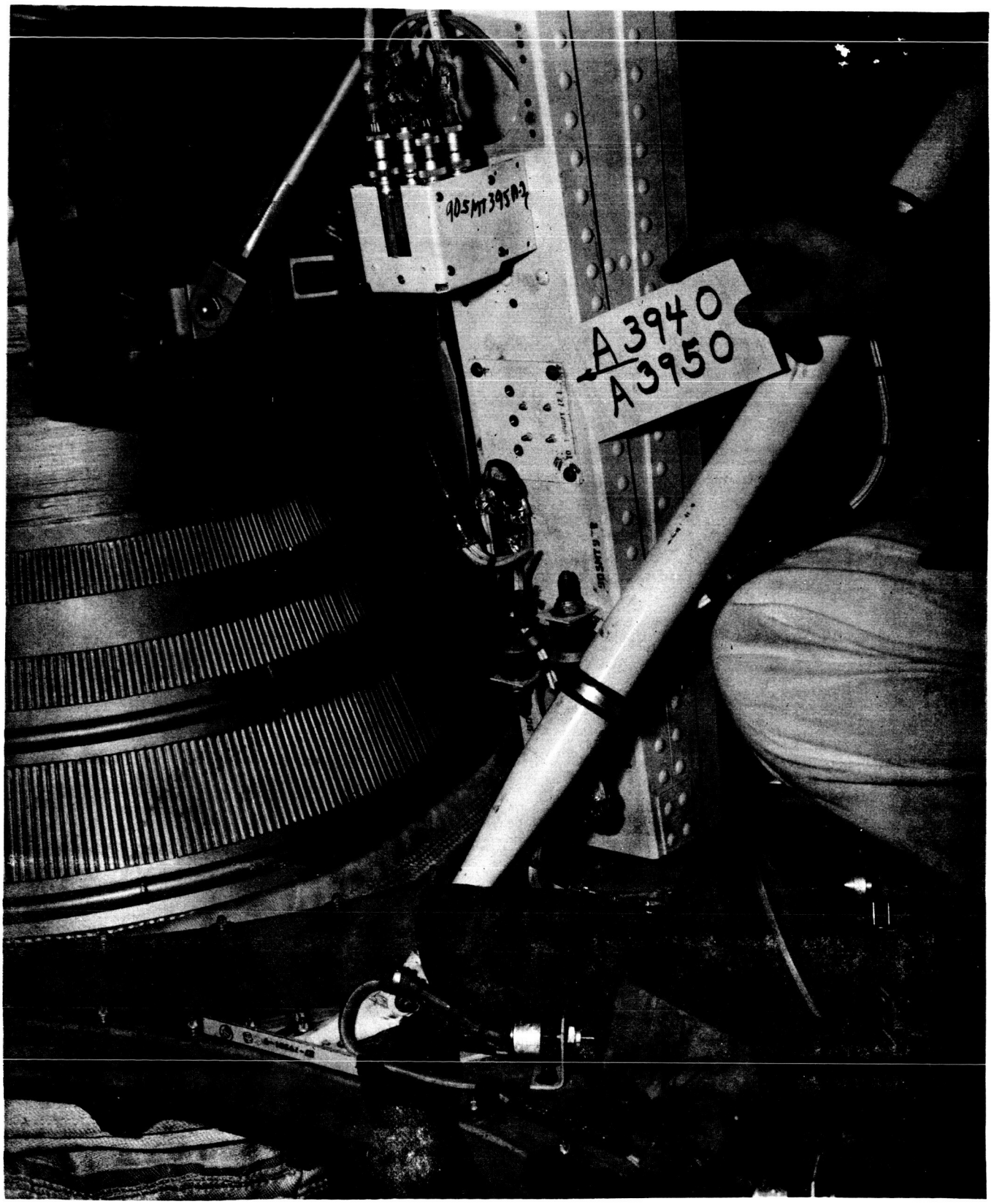
GD/A-DDE65-016

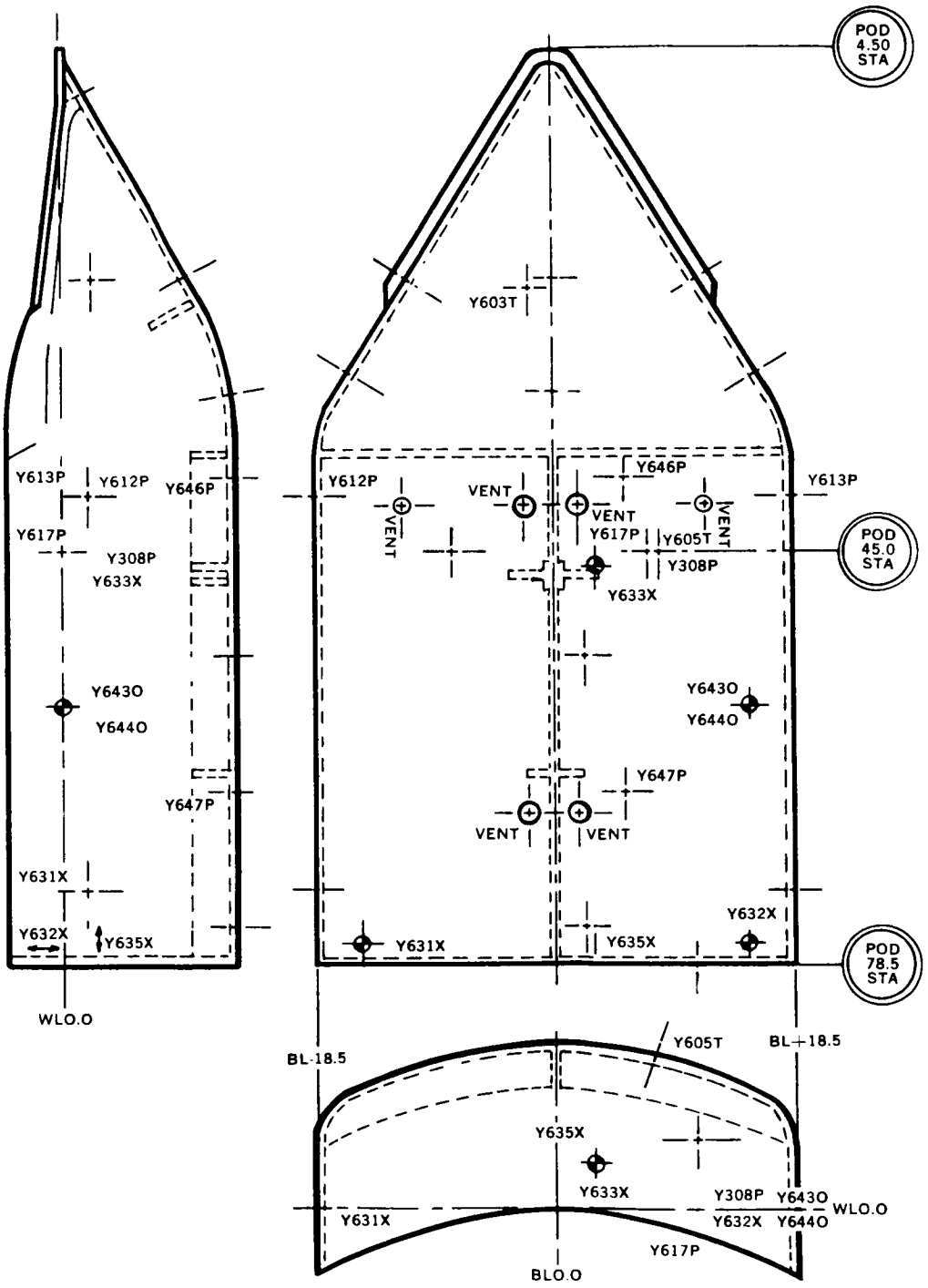
~~REPORT NO. AOJ62-0114~~

ACCELEROMERERS A3940, A3950

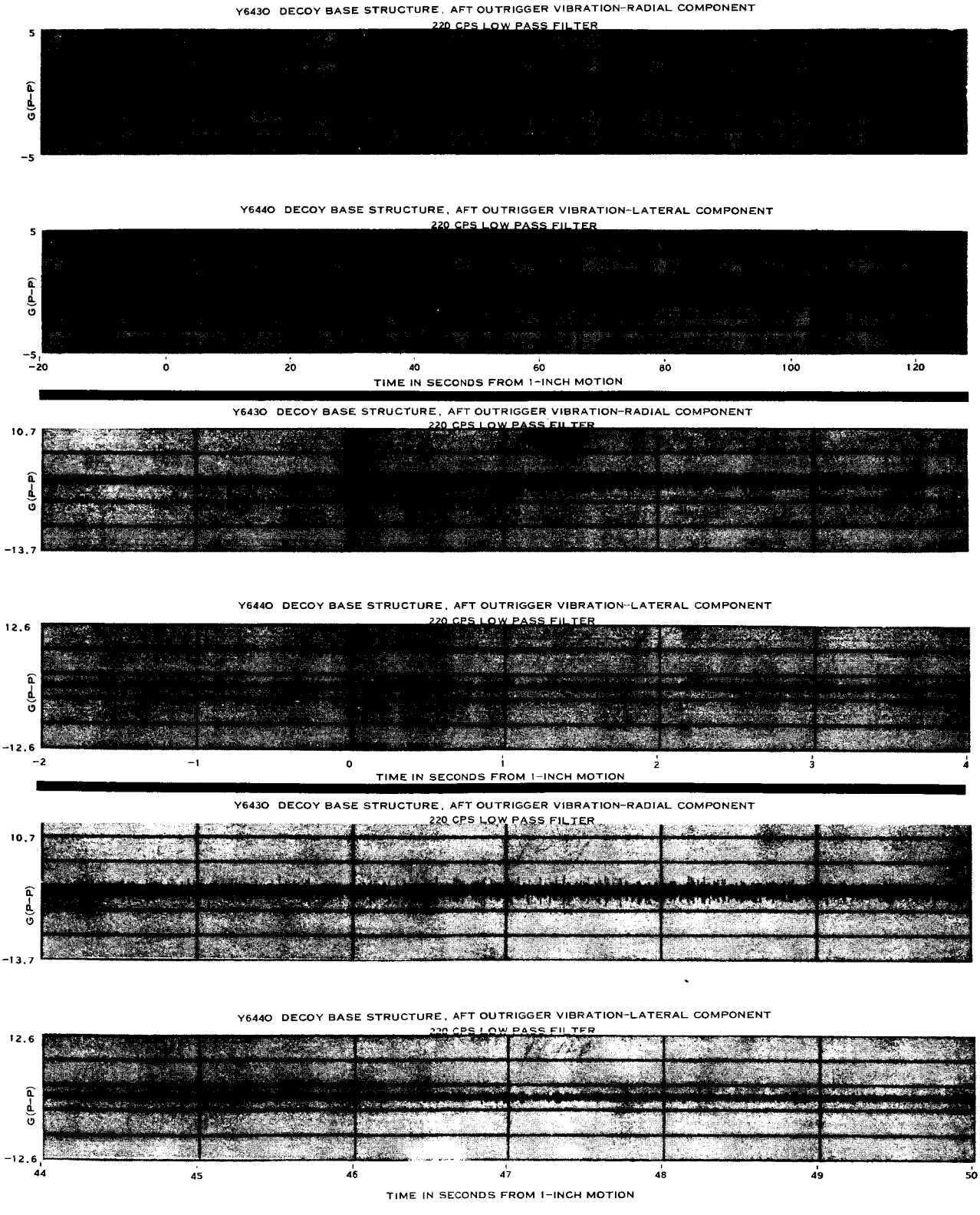
QUAD 2 STAGING RAIL

MISSILE 21F





ENVIRONMENTAL INSTRUMENTATION LOCATION


Y6430 DECOY BASE STRUCTURE, AFT OUTRIGGER VIBRATION-RADIAL COMPONENT
220 CPS LOW PASS FILTER
5
G(P-P)
-5
Y6440 DECOY BASE STRUCTURE, AFT OUTRIGGER VIBRATION-LATERAL COMPONENT
220 CPS LOW PASS FILTER
5
G(P-P)
-5
-20
0
20
40
60
80
100
120
TIME IN SECONDS FROM 1-INCH MOTION
Y6430 DECOY BASE STRUCTURE, AFT OUTRIGGER VIBRATION-RADIAL COMPONENT
220 CPS LOW PASS FILTER
10.7
G(P-P)
-13.7
Y6440 DECOY BASE STRUCTURE, AFT OUTRIGGER VIBRATION-LATERAL COMPONENT
220 CPS LOW PASS FILTER
12.6
G(P-P)
-12.6
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION
Y6430 DECOY BASE STRUCTURE, AFT OUTRIGGER VIBRATION-RADIAL COMPONENT
220 CPS LOW PASS FILTER
10.7
G(P-P)
-13.7
Y6440 DECOY BASE STRUCTURE, AFT OUTRIGGER VIBRATION-LATERAL COMPONENT
220 CPS LOW PASS FILTER
12.6
G(P-P)
-12.6
44
45
46
47
48
49
50
TIME IN SECONDS FROM 1-INCH MOTION

SECTION 6.2.22

MISSILE 109F

FLIGHT TESTED 12-18-63

AT OSTF NO. 1

TEST REPORT GD/A-APZ64-002

SECTION 12

ACOUSTIC AND VIBRATION

Launch Acoustic

The AIG pod was modified by the addition of interior fiberglass lining material (ECP 8411) and a production muffler on the air intake to the Arma computer (ECP 8409). The pod lining configuration consisted of lining the inside section of the Atlas B2 pod on all areas adjacent to the Arma computer with 2-inch thick fiberglass. The section lined included the upper bulkhead, the access cover hatch, both sides and pod floor down to the rib that separates the computer section from the guidance platform section.

Instrumentation

Six acoustic measurements were made in and around the missile at launch. The general locations of the microphones are shown schematically in Figure 12-1. The specific locations of the microphones are shown in Figure 12-19. A break-wire (N7631X) was installed to record the separation time of the pod air conditioning duct. Data obtained indicated the A/C duct became disconnected at 0.268 second following 1-inch motion.

The measurement numbers and locations were as follows:

Measurement	Location
A550Y	AIG computer dummy constants board microphone (Via telemetry)
A1780Y	AIG computer dummy constants board microphone (Landline)

Measurement	Location
N7538Y	Silo acoustic microphone B
N7540Y	Silo acoustic microphone A
N7632Y	AIG pod air conditioning duct
P51Y	Thrust section microphone
N7631X	Pod air conditioning duct separation breakwire

The acoustic transducers utilized were Model NM125 high-intensity microphones manufactured by Chesapeake Instrument Corporation. The high-intensity microphones were self-generating piezoelectric ceramic acoustic sensors especially designed for measuring high noise levels under adverse environmental conditions. The base of the microphone holder has a vibration mount which isolated the sensor from lower frequency vibrations.

Three of the six measurements provided satisfactory data. Measurements N7632Y, pod air conditioning duct; A550Y, AIG computer dummy constants board; and P51Y, thrust section microphone failed to provide valid data.

Silo acoustic microphone data, N7538Y and N7540Y, became invalid at approximately 0.65 second and 1.25 seconds, respectively. The vertical rise of the missile at these times (referred to 1-inch motion) was such that the thrust chamber cone was adjacent to or just beyond the respective microphone location. Flame impingment at these times apparently caused microphone failure. The microphone in the Arma computer (A1780Y) provided satisfactory data until 2.63 seconds, at which time the landline umbilical was ejected.

UNCLASSIFIED

The general characteristics of the exterior silo acoustic intensities at launch were similar to those recorded on recent "E" and "F" Series launches. Maximum over-all sound pressure level (SPL) was 156 db. A complete octave band analysis for measurements N7538Y and N7540Y is shown in Figures 12-8 through 12-10. A comparison of Missile 109F exterior acoustic intensities with recent "E" and "F" series is shown in Figure 12-3.

The recorded SPL at the Arma computer was generally lower than levels observed on the launch of Missile 45F launched from the same site with the same pod configuration. Maximum over-all SPL (0-10,000 cps analysis) was 142.5 db recorded at 0.1 second. Maximum acoustic energy was noted in the 20-75 cps frequency range. An octave band plot is shown in Figure 12-2 which compares 109F computer acoustic levels with Arma level 1 requirement and previous missiles with the same AIG pod configuration. SPL vs. time is shown for each octave in Figures 12-5 through 12-7.

Outside-the-pod to inside-the-computer SPL reduction information is shown in Figure 12-4. Values shown were calculated at approximately 0.5 second following 1-inch motion.

Spectral analysis, 2,000 cps and 10,000 cps utilizing a bandpass filter of 10 cps and 50 cps, respectively, was performed on the AIG computer microphone (A1780Y) and silo acoustic microphone A (N7540Y). No significant discrete frequency components were noted.

Guidance computer vibration was monitored by six high frequency piezoelectric accelerometers mounted on the computer mount-missile side, and computer mount-

computer side (Figure 12-20). The transducers were sensitive in the X-X, Y-Y and Z-Z axes with a frequency response to 10,000 cps and a range of ± 20g. The measurements were installed to monitor the input to the guidance computer and the attenuation across from the missile-side to the computer-side of the computer mounts. An accelerometer (A15620) was installed by Arma on the computer circuit board (Z218) to monitor vibrational energy being propagated to the circuit board (Figure 12-21). Data from the circuit board measurement was questionable.

Guidance computer vibration intensities recorded at the mount on the missile side were higher by approximately a factor of three (3) than levels on the computer side of the mount. Steady-state over-all levels on the missile side (20 to 10,000 cps analysis) were 7.8 g(rms), 13.0 g(rms) and 4.4 g(rms) on the X, Y, and Z axes, respectively. A significant concentration of energy (2.9 g(rms)) was observed on the X axis measurement between 4800 and 5500 cps between zero and one second following one-inch motion. The Y-axis and Z-axis predominant frequencies were between 200 cps and 480 cps. This was the first flight missile on which missile-side mount vibration was monitored. Steady-state over-all levels on the computer side of the mount were similar to previous missile launch data. Analysis (20 to 10,000 cps) showed 3.1 g(rms), 3.3 g(rms), and 1.4 g(rms) on the X-axis, Y-axis, and Z-axis, respectively. Predominant frequencies were between 350 cps and 1000 cps during the launch period.

An octave band analysis was performed on the accelerometers and the maximum values obtained are presented in Table 12-1. Power spectral density computations are shown in Figures 12-11 and 12-12.

TABLE 12-1. ARMA COMPUTER VIBRATION

X-Axis

CPS	109F Msl Side Accel g(rms)	109F Comp Side Accel g(rms)	45F Comp Side Accel g(rms)
Over-all	7.8	3.1	3.5
20-75	0.29	0.28	0.36
75-150	0.50	0.29	0.50
150-300	1.75	0.72	0.90
300-600	3.3	1.2	1.4
600-1200	4.3	2.3	2.4
1200-2400	3.0	1.3	2.3
2400-4800	3.0	0.23	0.37
4800-9600	2.8	0.09	0.25
Y-Axis			
Over-all	13.0	3.3	3.0
20-75	10.5	0.39	1.0
75-150	4.2	0.27	1.1
150-300	4.3	0.60	0.57
300-600	3.5	1.8	1.8
600-1200	5.6	2.4	2.1
1200-2400	3.8	0.75	0.88
2400-4800	1.8	0.25	0.28
4800-9600	1.4	0.15	0.25
Z-Axis			
Over-all	4.4	1.4	2.2
20-75	0.37	0.54	1.0
75-150	0.32	0.21	0.60
150-300	1.5	0.48	0.52
300-600	3.0	0.74	1.1
600-1200	1.8	0.90	1.3
1200-2400	1.2	0.54	1.2
2400-4800	0.76	0.12	0.36
4800-9600	0.84	0.096	0.34

Airframe Instrumentation

Fourteen accelerometers located in the missile thrust section area and three accelerometers mounted on the re-entry adapter were monitored during the launch period of Missile 109F. The data was recorded via the FM trailing wire until approximately 2.63 seconds. Photographs of the transducer installations are shown in Figures 12-22 through 12-28.

Valid data was obtained from the following measurements:

A12300 R/V Adapter Vibration, Z-Axis

A15710 Heat Shield, Quad III-IV, X-Axis

A15880 Heat Shield, Quad I-II, Z-Axis

F16500 Fuel Tank Regulator, Z-Axis

F16510 Helium Line Rise-off Disconnect Panel, Z-Axis

H14280 Sustainer Hydraulic Pump, Z-Axis

P12080 B1 Engine Lox Dome, Z-Axis

P15310 Sustainer Gas Generator Fuel Check Valve, Z-Axis

P15320 B2 Hydraulic Pump, Z-Axis

P15330 Sustainer Gas Generator Check Valve Tube

S16070 Gyro Canister, Y-Axis

S16060 Gyro Canister, Z-Axis

The following measurements exhibited either invalid data or no response:

A12310 R/V Adapter Vibration, Y-Axis

A12320 R/V Adapter Vibration, X-Axis

A12780 Forward Surface A-Frame Quad IV

F11850 Lox Tank Regulator, X-Axis

P12060 Sustainer Engine Lox Dome, Z-Axis

Results

A tri-axial accelerometer system was installed on the re-entry vehicle (R/V) adapter to determine acceleration levels at the payload during the missile launch period. Transducer installation is shown in Figure 12-22. Measurement A12310 (Y-Axis) showed no response during the data acquisition period. The recorded data was analyzed in the 20 to 220 cps frequency range. Generally, low frequency (0-60 cps) acceleration levels recorded at the R/V adapter were negligible. Maximum acceleration levels were 0.7 g peak-to-peak (p-p) on the Z-axis and 0.5 g(p-p) on the X-Axis recorded between 0.5 and 0.6 second. No detrimental impulsive or transient accelerations were evident. Both measurements exhibited an expected steady buildup of vibration levels between booster ignition and sustainer mainstage. Maximum acceleration levels were well within maximum design specifications. Time history plots and oscillographs are shown in Figures 12-15 and 12-17, respectively.

Thrust section vibration data is presented as over-all time history and spectrum analysis plots in Figures 12-13, 12-14 and 12-16. Representative oscillographs of the raw data are presented in Figure 12-17.

Generally, component vibration characteristics in the missile thrust section were similar to recent E and F series launches (Missiles 65E, 62E, 24E and 45F).

Table 12-2 shows a tabulation of vibration levels recorded at approximately 1.1 seconds following 1-inch missile motion. This time was chosen because a premature umbilical ejection during the launch of Missile 62E caused loss of data at 1.1 seconds. A comparitive time for Missile 75F captive tests was 2.7

seconds. The following levels are significant in that they indicate the general thrust section vibration environment as well as specific component vibration environment during the initial phase of missile flight.

Table 12-2. VIBRATION LEVELS - g(rms)

(+1.1 seconds)

Meas. No.	Sycamore Canyon - Missile 75F				OSTF-1	OSTF-1	OSTF-1	OSTF-2	OSTF-2
	Test No. 612	Test No. 613	Test No. 614	Test No. 615	Msl 65E	Msl 62E	Msl 24E	Msl 45F	Msl 109F
	Freq. Range of Analysis (50-2100 cps)	Freq. Range of Analysis (50-2100 cps)	Freq. Range of Analysis (50-2100 cps)	Freq. Range of Analysis (50-2100 cps)	Freq. Range of Analysis (50-2100 cps)	Freq. Range of Analysis (50-2100 cps)	Freq. Range of Analysis (20-2100 cps)	Freq. Range of Analysis (20-2100 cps)	Freq. Range of Analysis (20-2100 cps)
A1230Ø	(2)	(2)	(2)	(2)	(2)	(2)	(2)	1.7	1.4**
A1231Ø	(2)	(2)	(2)	(2)	(2)	(2)	(2)	0.7**	0.5**
A1232Ø	(2)	(2)	(2)	(2)	(2)	(2)	(2)	0.7**	(1)
A1278Ø	11	11	12	11	(2)	7	10	11	9
A1571Ø	7***	9.5***	8***	(1)	(2)	(2)	5***	(1)***	1.5
A1588Ø	18	(2)	33	20	24	14	12	12.5	35
F1185Ø	6	6	7	5	26	12	9	8*	(1)
F1650Ø	(2)	(2)	(2)	(2)	(2)	(2)	(1)	11.2*	28
F1651Ø	(2)	(2)	(2)	(2)	16	23	(1)	13.4	28
H1428Ø	(1)	(1)	(1)	(1)	(2)	16	11	10.2	11.5
H1429Ø	17	16	16	16	(2)	9	7	10.2	(2)
P1206Ø	9.5	7.5	9.5	6.5	(2)	(2)	(2)	9*	(1)
P1208Ø	7	6	8	7	(1)	(2)	(1)	2.7	9.5
P1451Ø	18	16	14	11	12	16.5	13	(1)	(2)
P1531Ø	16	(2)	(2)	(2)	11.5	12	18	11	(2)
P1532Ø	6	8	8	10	(2)	(2)	10	1.8	7
P1533Ø	(2)	(2)	(2)	(2)	19	20	22	(1)	15
S1606Ø	4	1.5	1.5	1.6	(2)	(2)	1.8	(1)	2.9
S1607Ø	1.6	1.5	1.5	1.7	(2)	(2)	(1)	(1)	2.9

Notes: * - Level questionable, since data only partially valid.

** - 20-220 cps frequency range of analysis.

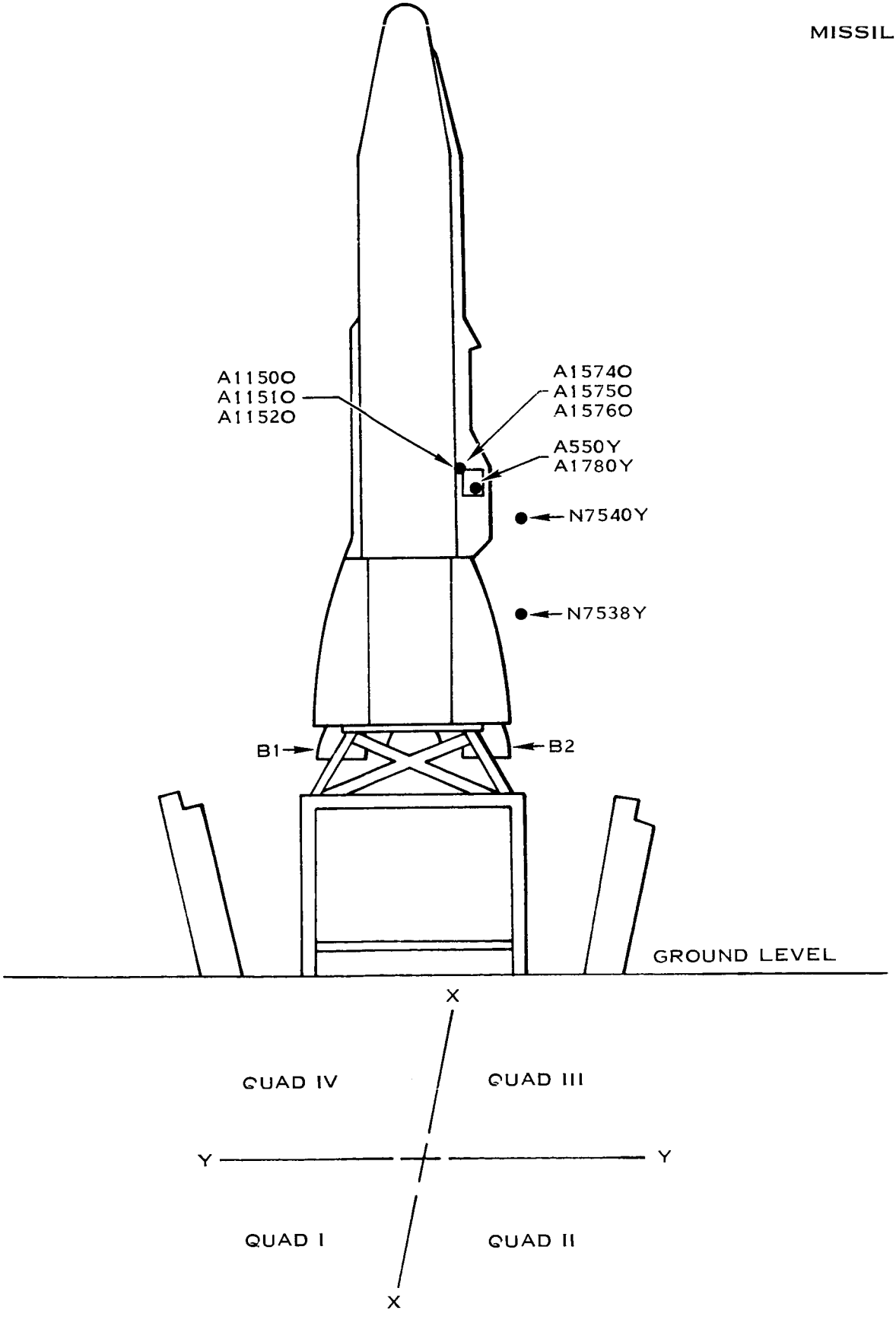
*** - 20-330 cps frequency range of analysis.

(1) - Data invalid.

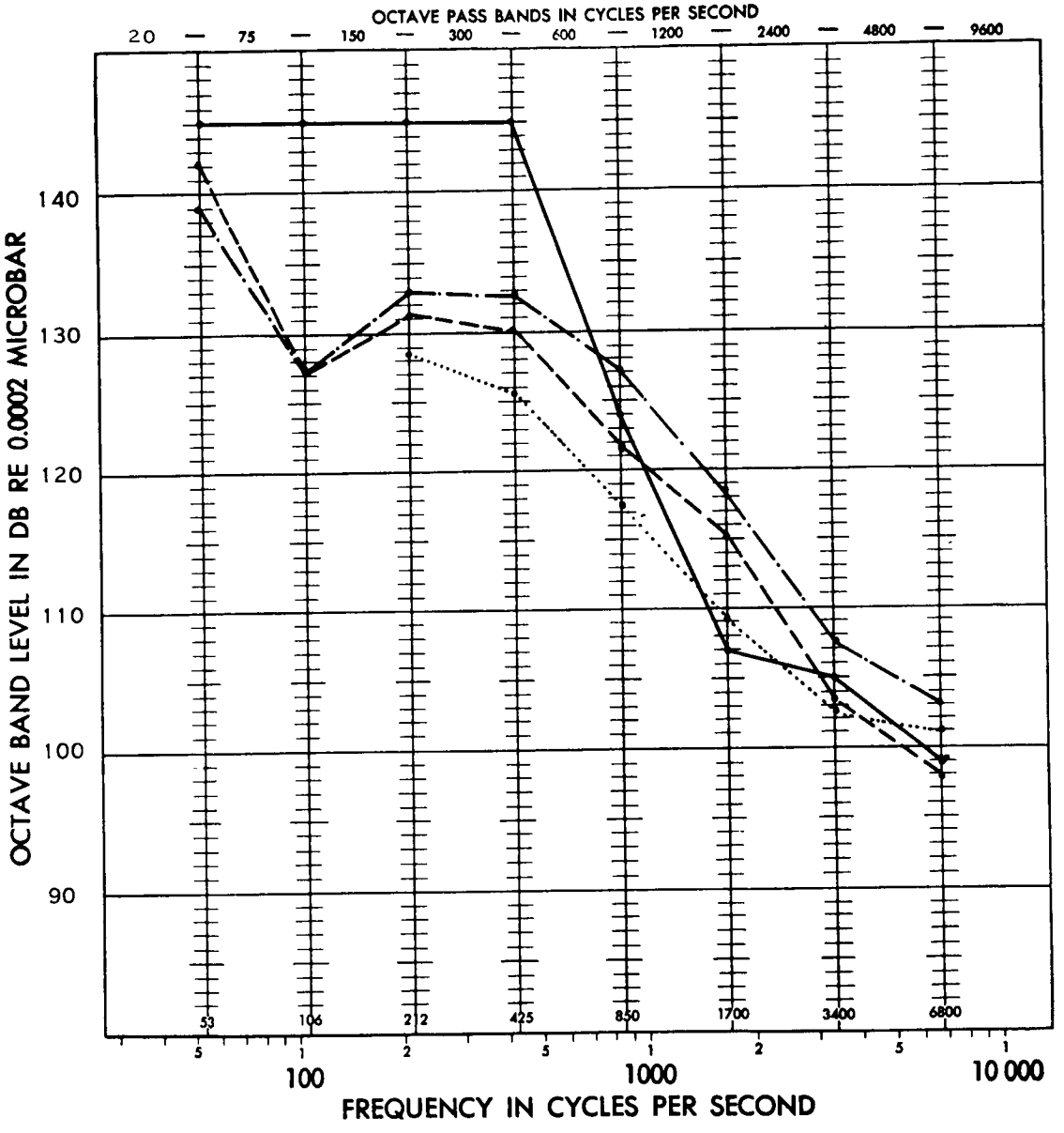
(2) - Not recorded.

INSTRUMENTATION LOCATIONS

MISSILE 109F



ARMA COMPUTER SOUND PRESSURE LEVELS



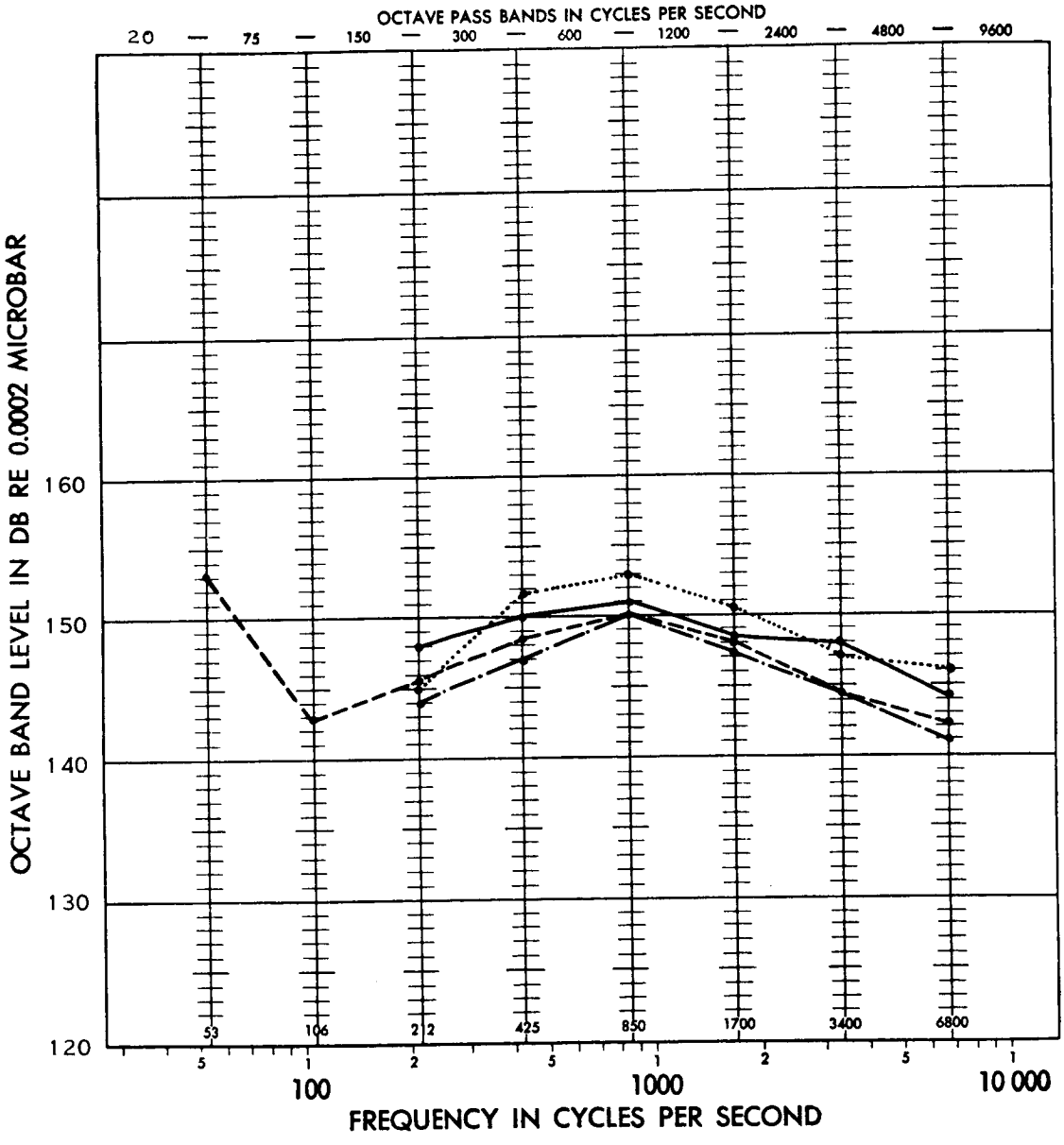
LEGEND:

- – – – – – MISSILE 109F MEASUREMENT NO. A1780Y
- —·—·— MISSILE 45F MEASUREMENT NO. A1780Y
- ..... MISSILE 62E MEASUREMENT NO. A1780Y
- ——— ARMA LEVEL I

NOTE:

ALL VALUES ARE MAXIMUM RECORDED SPL.

EXTERIOR SOUND PRESSURE LEVELS



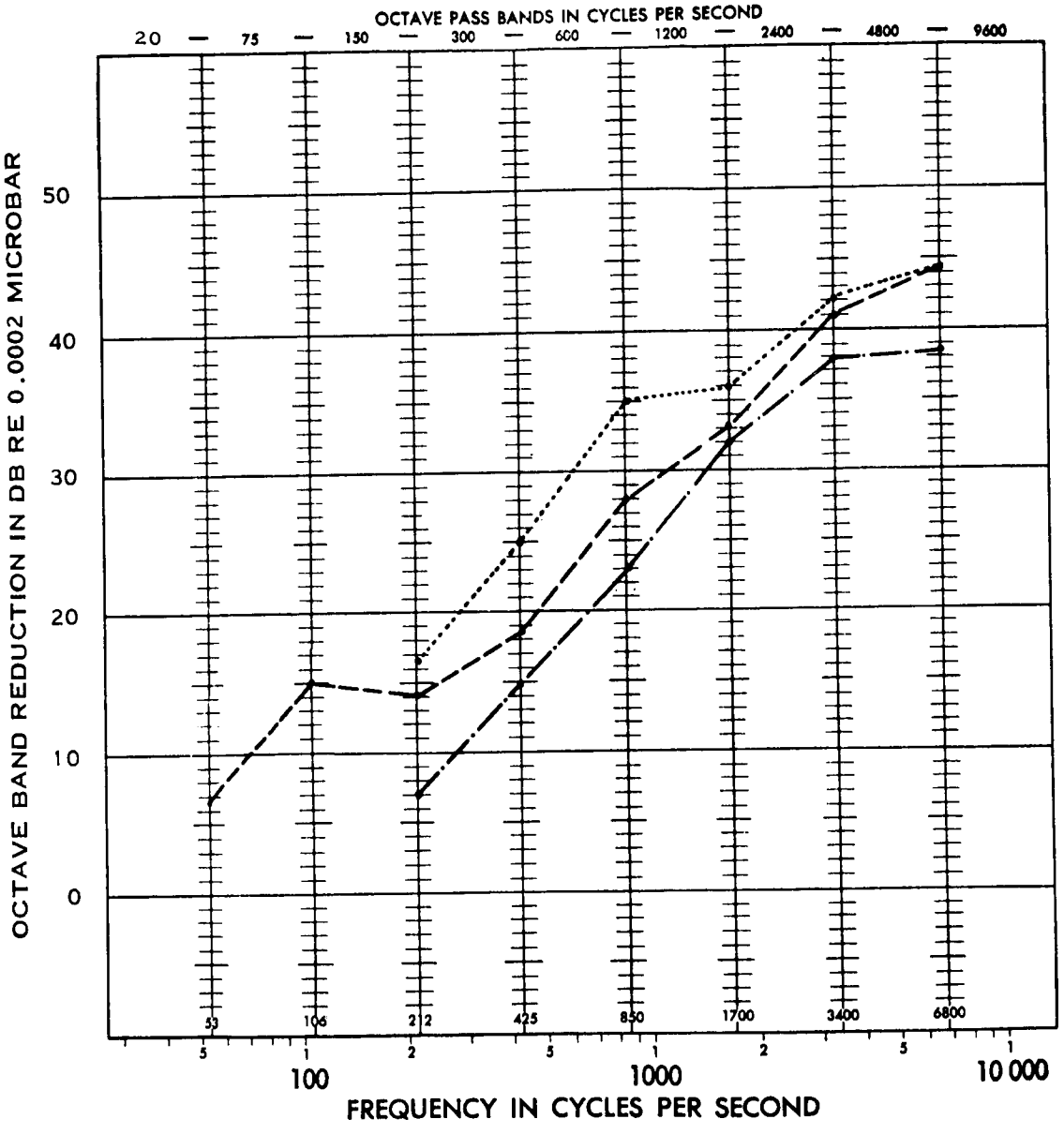
LEGEND:

- MISSILE 109F MEASUREMENT NO. N7540Y
- MISSILE 45F MEASUREMENT NO. N7540Y
- MISSILE 83F MEASUREMENT NO. N7540Y
- MISSILE 62E MEASUREMENT NO. N7223Y

NOTE:

ALL VALUES ARE MAXIMUM RECORDED SPL.

SOUND LEVEL REDUCTION BY OCTAVES

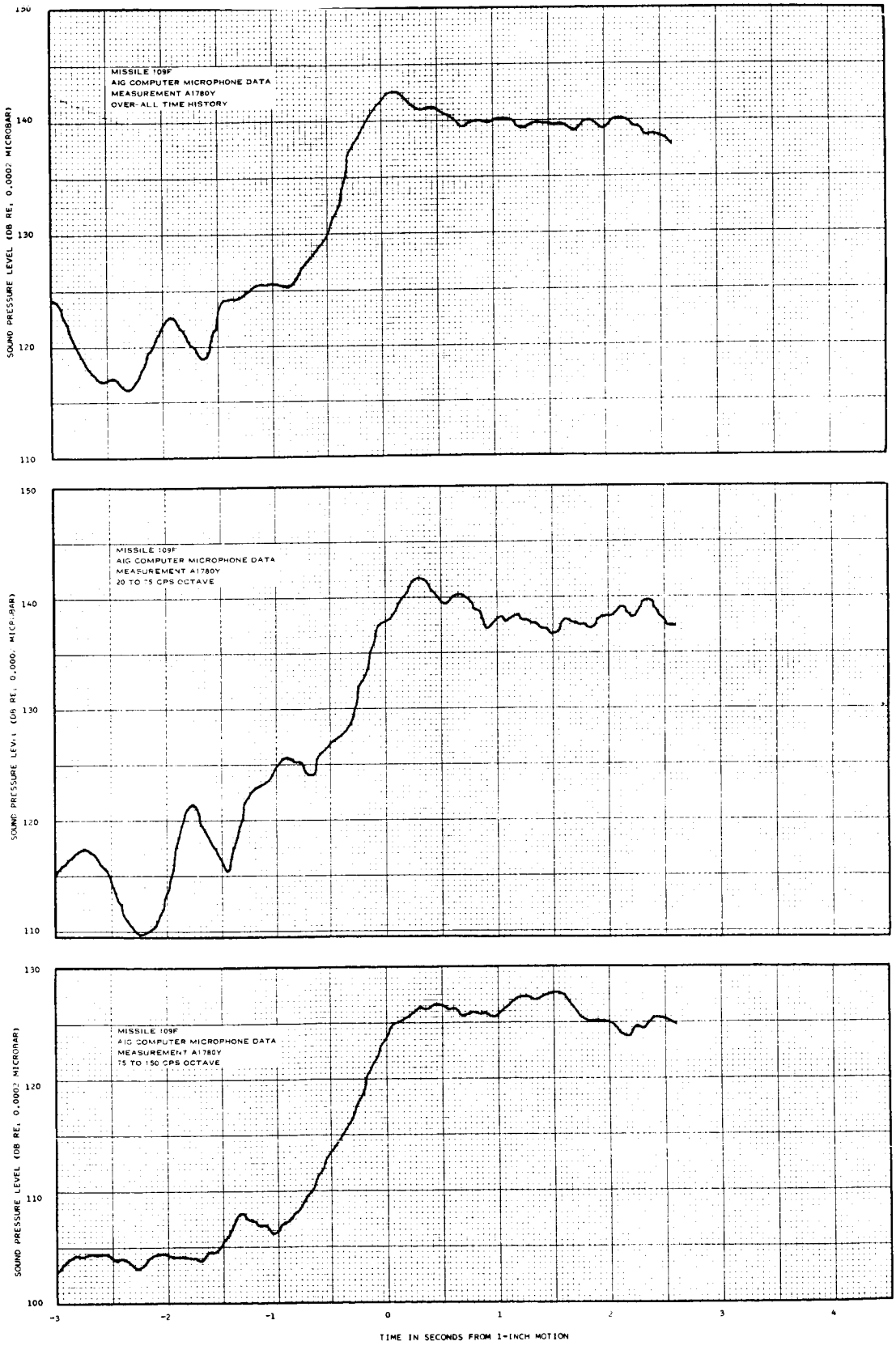


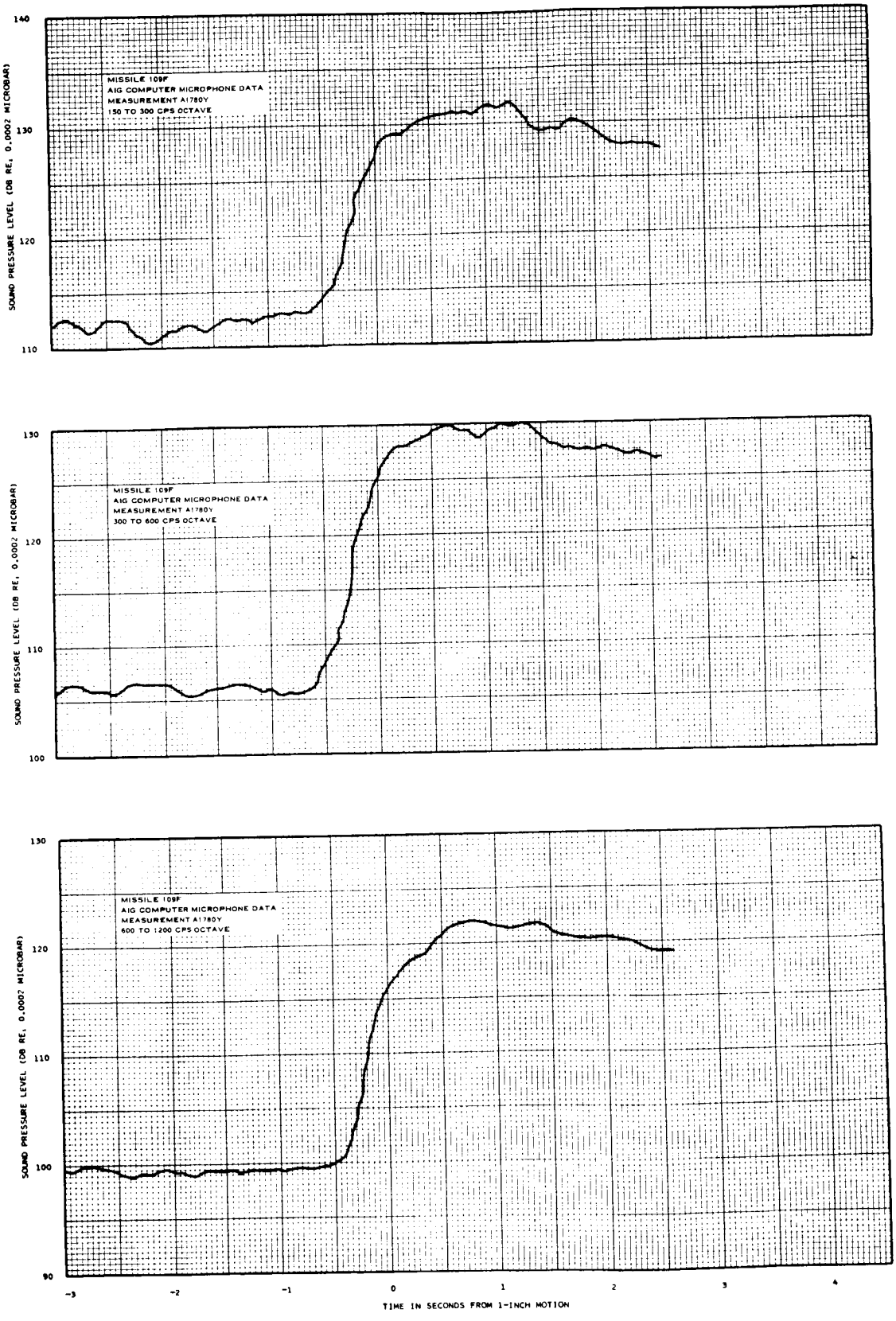
LEGEND:

- ●MISSILE 109F MEASUREMENT NO. N7540Y MINUS A1780Y
- ●MISSILE 45F MEASUREMENT NO. N7540Y MINUS A1780Y
- ●●MISSILE 62E MEASUREMENT NO. N7223Y MINUS A1780Y

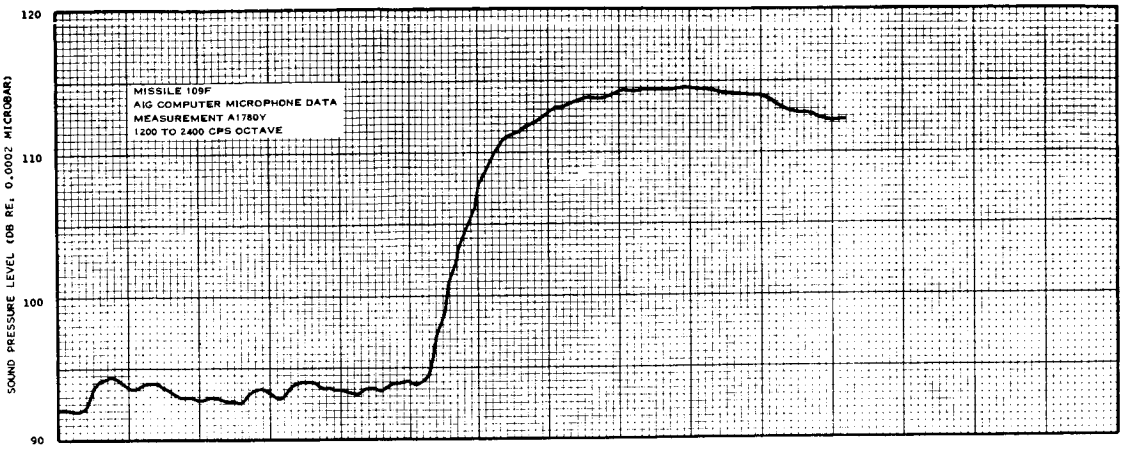
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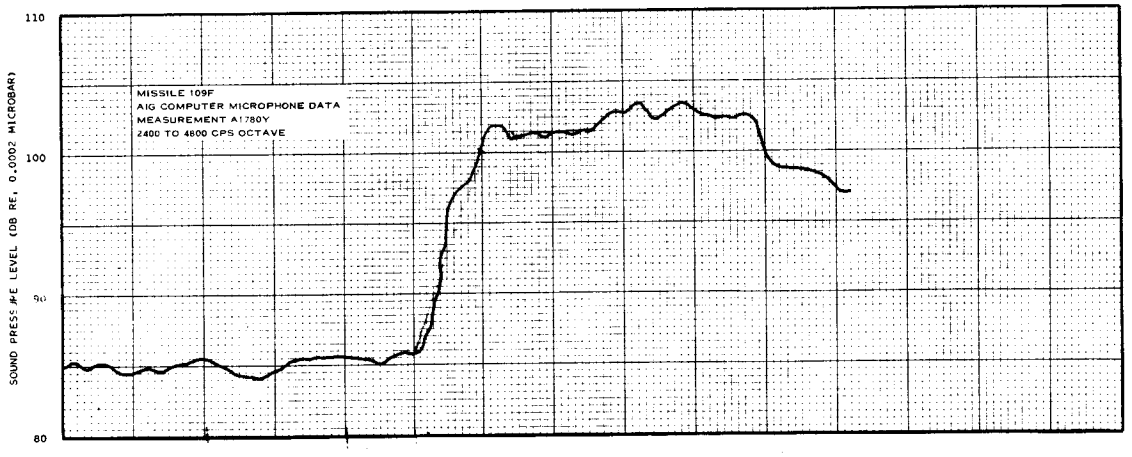
- ●SPL VALUES @ 0.5 SECOND.
- ●●SPL VALUES @ TIME COMPUTER IS OPPOSITE EXTERIOR MICROPHONE (APPROX. 1.25 SECONDS).

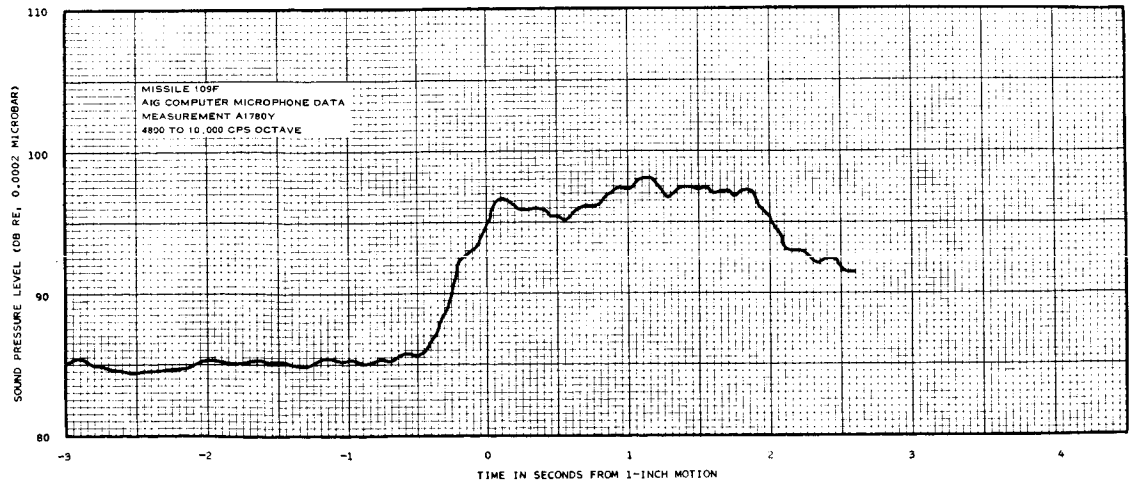

MISSILE 109F
AIG COMPUTER MICROPHONE DATA
MEASUREMENT A1780Y
OVER-ALL TIME HISTORY
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
130
140
120
110
MISSILE 109F
AIG COMPUTER MICROPHONE DATA
MEASUREMENT A1780Y
20 TO 75 CPS OCTAVE
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
150
140
130
120
110
MISSILE 109F
AIG COMPUTER MICROPHONE DATA
MEASUREMENT A1780Y
75 TO 150 CPS OCTAVE
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
130
120
110
100
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION

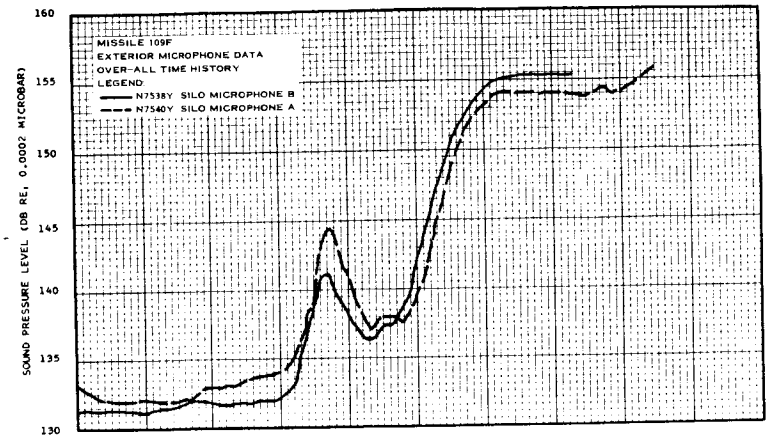

MISSILE 109F
AIG COMPUTER MICROPHONE DATA
MEASUREMENT A1780Y
150 TO 300 CPS OCTAVE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
140
130
120
110
MISSILE 109F
AIG COMPUTER MICROPHONE DATA
MEASUREMENT A1780Y
300 TO 600 CPS OCTAVE
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
130
120
110
100
MISSILE 109F
AIG COMPUTER MICROPHONE DATA
MEASUREMENT A1780Y
600 TO 1200 CPS OCTAVE
SOUND PRESSURE LEVEL (DB RE, 0.0007 MICROBAR)
130
120
110
100
90
-3
-2
-1
0
1
2
3
4
TIME IN SECONDS FROM 1-INCH MOTION

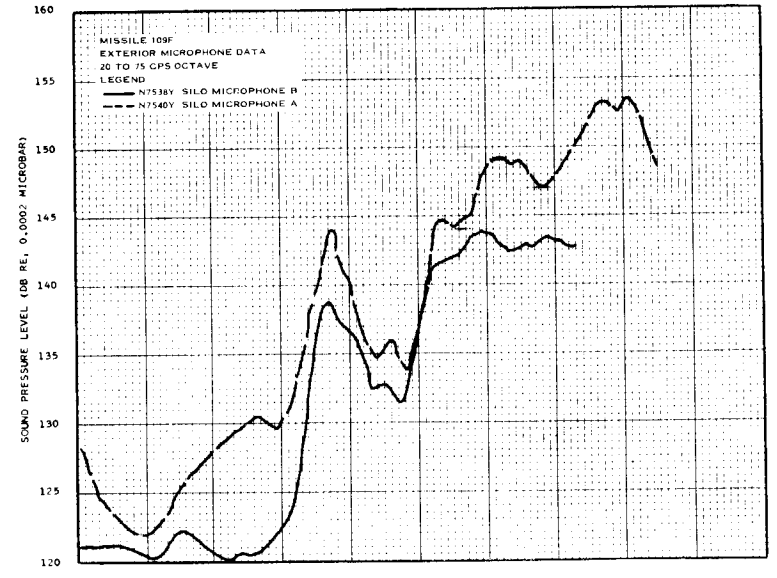
MISSILE 109F

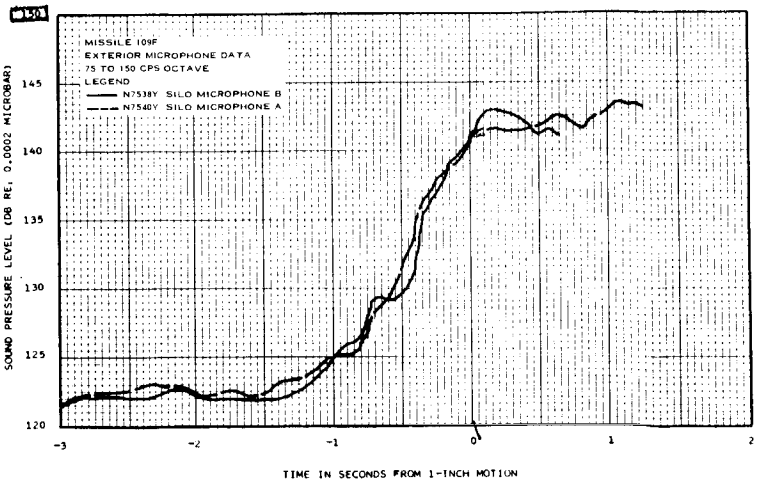


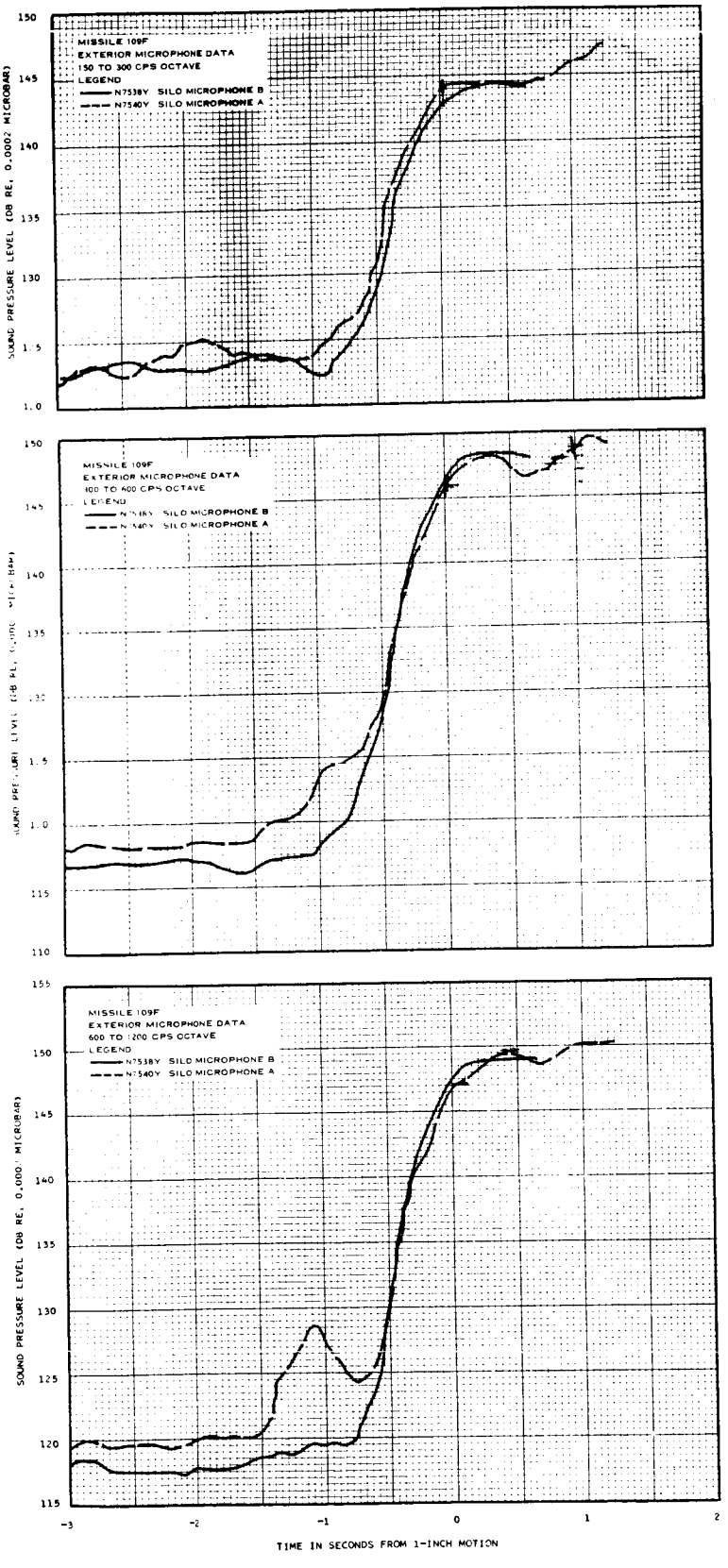


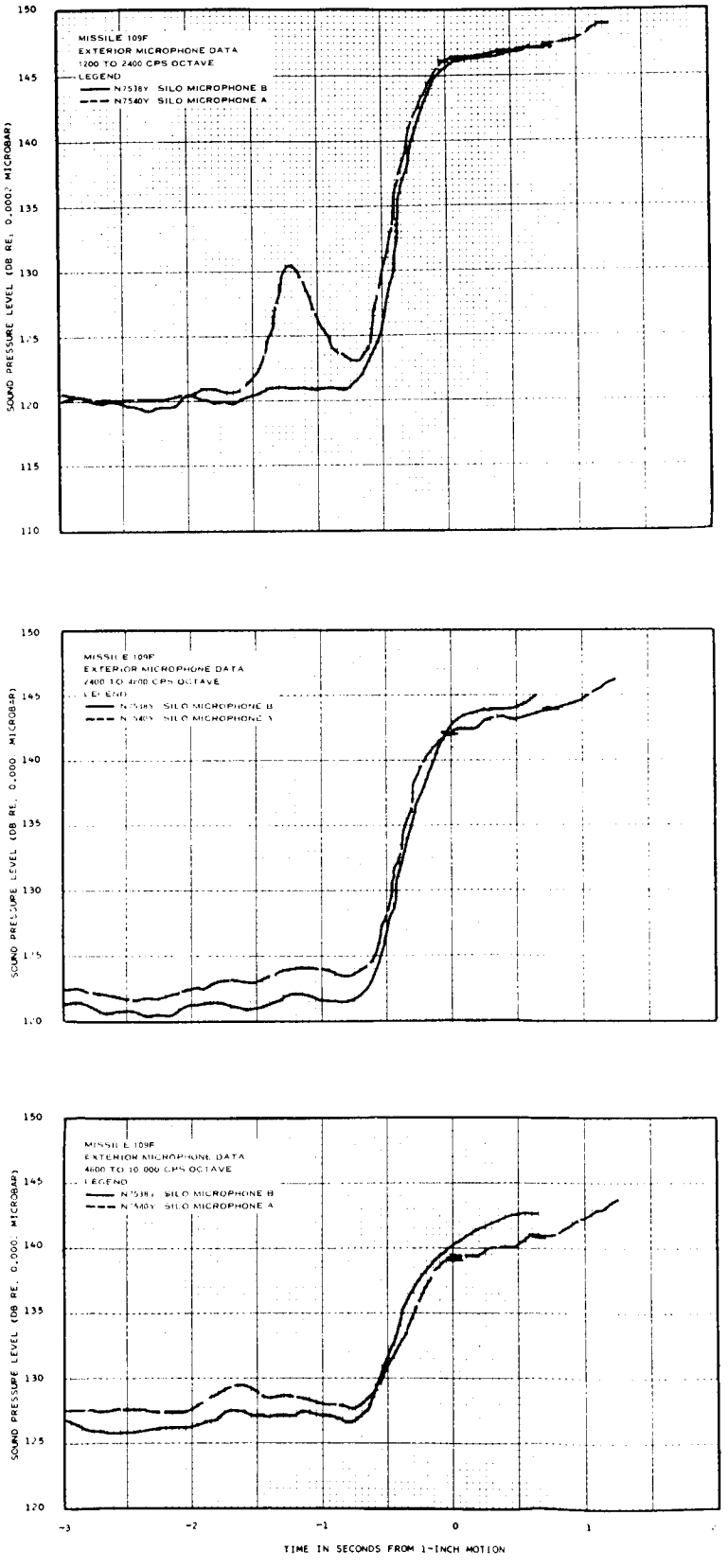



MISSILE 109F
EXTERIOR MICROPHONE DATA
OVER-ALL TIME HISTORY
LEGEND
N7538Y SILO MICROPHONE B
N7540Y SILO MICROPHONE A
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
155
150
145
140
135
130


MISSILE 109F
EXTERIOR MICROPHONE DATA
20 TO 75 CPS OCTAVE
LEGEND
N7538Y SILO MICROPHONE B
N7540Y SILO MICROPHONE A
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
160
155
150
145
140
135
130
125
120


MISSILE 109F
EXTERIOR MICROPHONE DATA
75 TO 150 CPS OCTAVE
LEGEND
N7538Y SILO MICROPHONE B
N7540Y SILO MICROPHONE A
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
145
140
135
130
125
120
-3
-2
-1
0
1
2
TIME IN SECONDS FROM 1-INCH MOTION


MISSILE 109F
EXTERIOR MICROPHONE DATA
150 TO 300 CPS OCTAVE
LEGEND
N7538Y SILO MICROPHONE B
N7540Y SILO MICROPHONE A
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
150
145
140
135
130
1.5
1.0
MISSILE 109F
EXTERIOR MICROPHONE DATA
400 TO 600 CPS OCTAVE
LEGEND
SILO MICROPHONE B
SILO MICROPHONE A
150
145
140
135
1.5
1.0
115
110
MISSILE 109F
EXTERIOR MICROPHONE DATA
600 TO 1200 CPS OCTAVE
LEGEND
N7538Y SILO MICROPHONE B
N7540Y SILO MICROPHONE A
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
155
150
145
140
135
130
125
120
115
-3
-2
-1
0
1
2
TIME IN SECONDS FROM 1-INCH MOTION

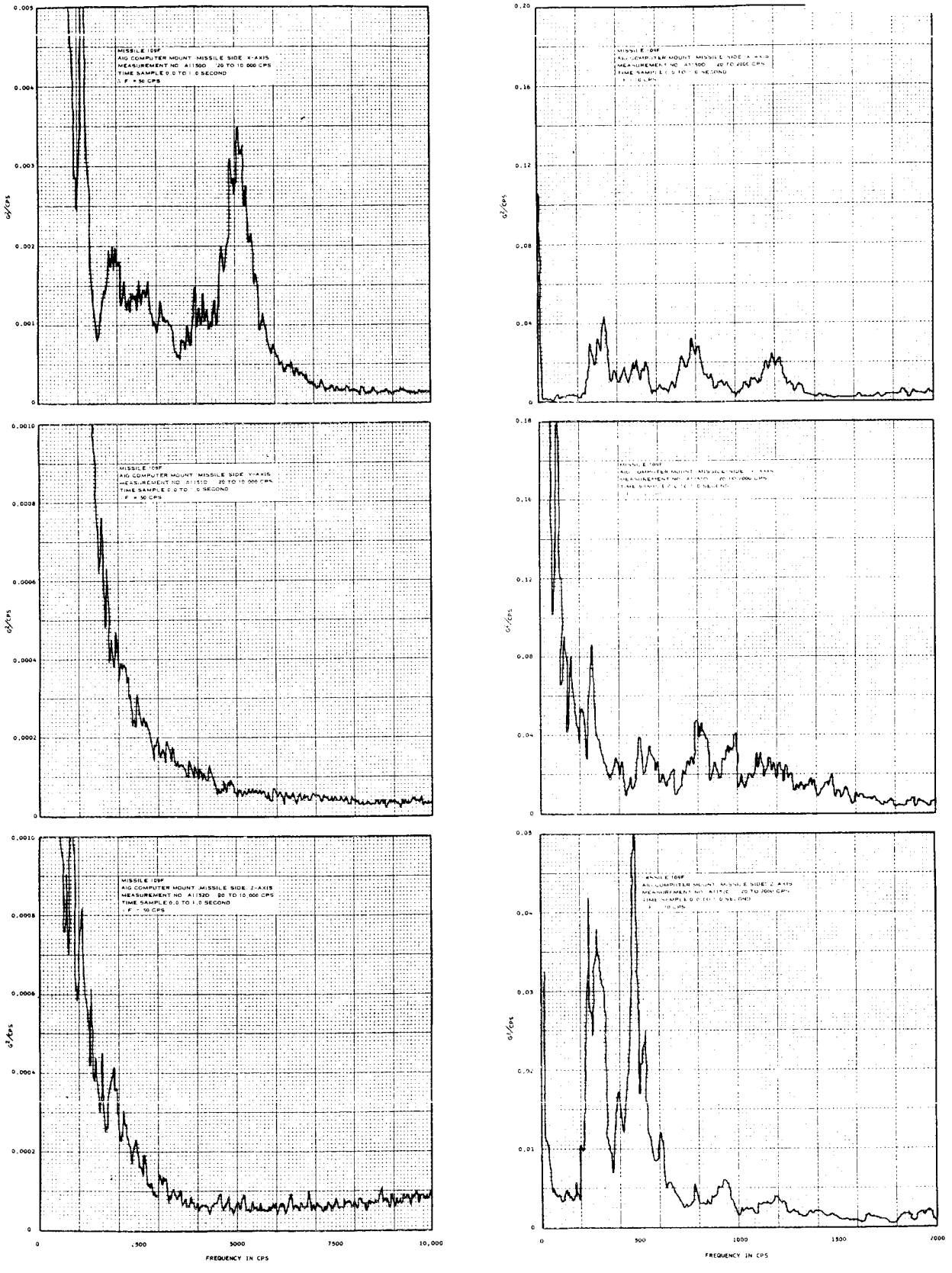

MISSILE 109F
EXTERIOR MICROPHONE DATA
1200 TO 2400 CPS OCTAVE
LEGEND
N7538Y SILO MICROPHONE B
N7540Y SILO MICROPHONE A
SOUND PRESSURE LEVEL (DB RE. 0.0002 MICROBAR)
150
145
140
135
130
125
120
115
110
MISSILE 109F
EXTERIOR MICROPHONE DATA
2400 TO 4800 CPS OCTAVE
LEGEND
SOUND PRESSURE LEVEL (DB RE. 0.0002 MICROBAR)
150
145
140
135
130
125
120
MISSILE 109F
EXTERIOR MICROPHONE DATA
4800 TO 10 000 CPS OCTAVE
LEGEND
N7538Y SILO MICROPHONE B
N7540Y SILO MICROPHONE A
SOUND PRESSURE LEVEL (DB RE. 0.0002 MICROBAR)
150
145
140
135
130
125
120
-3
-2
-1
0
1
TIME IN SECONDS FROM 1-INCH MOTION

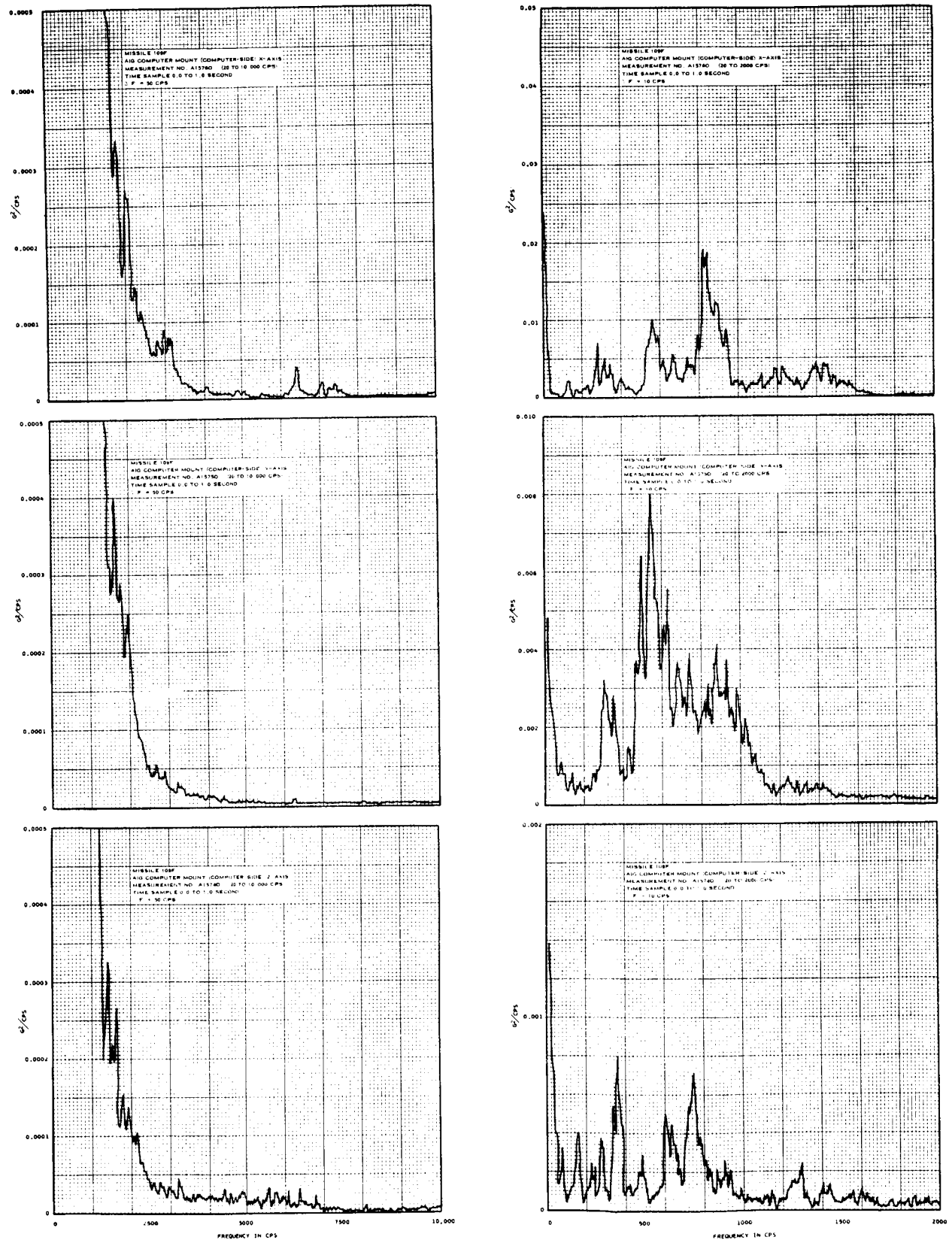
ACOUSTIC AND VIBRATION

FIGURE NO. 12-11

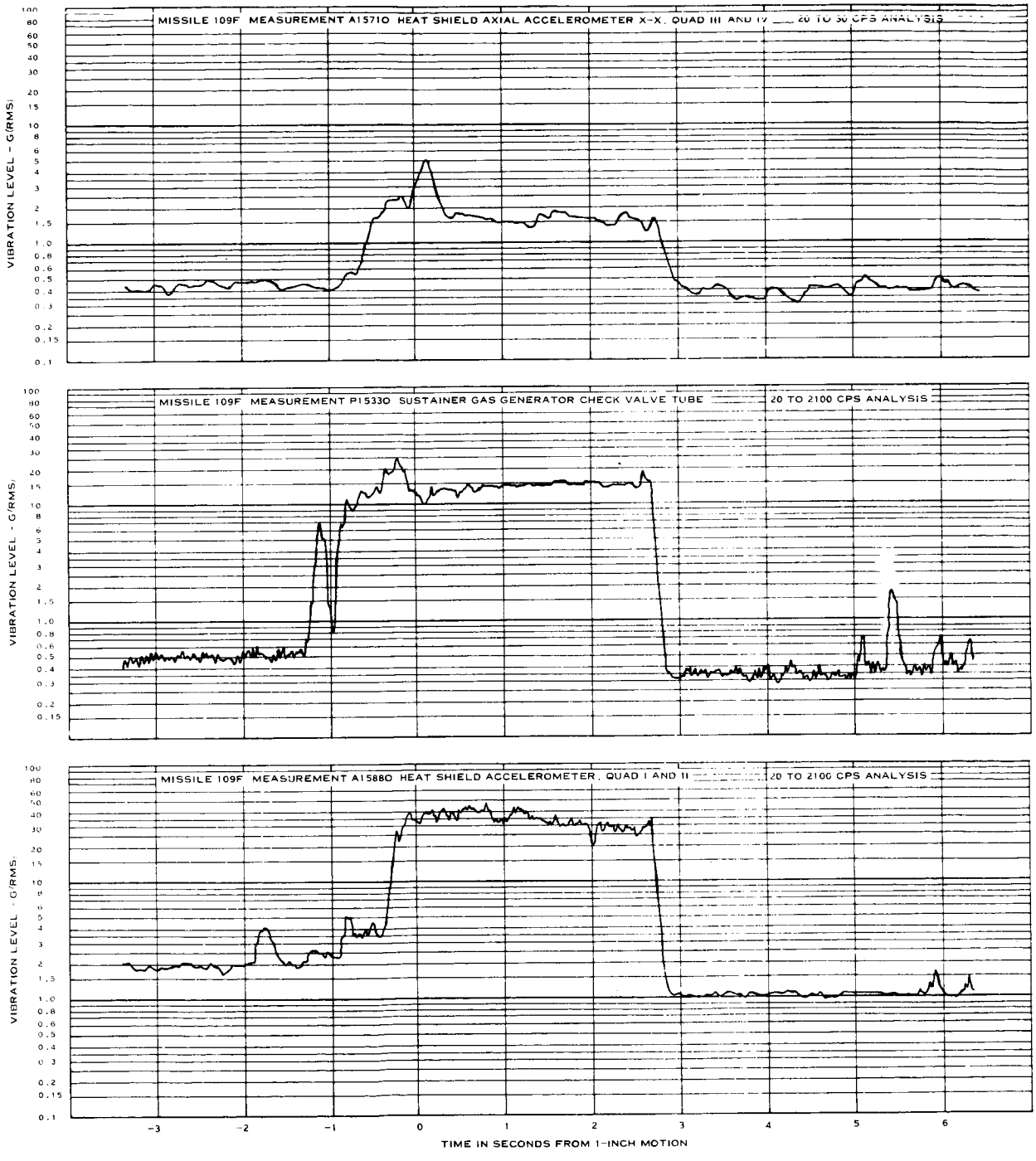
~~REPORT NO. GD/A*AP364-002~~

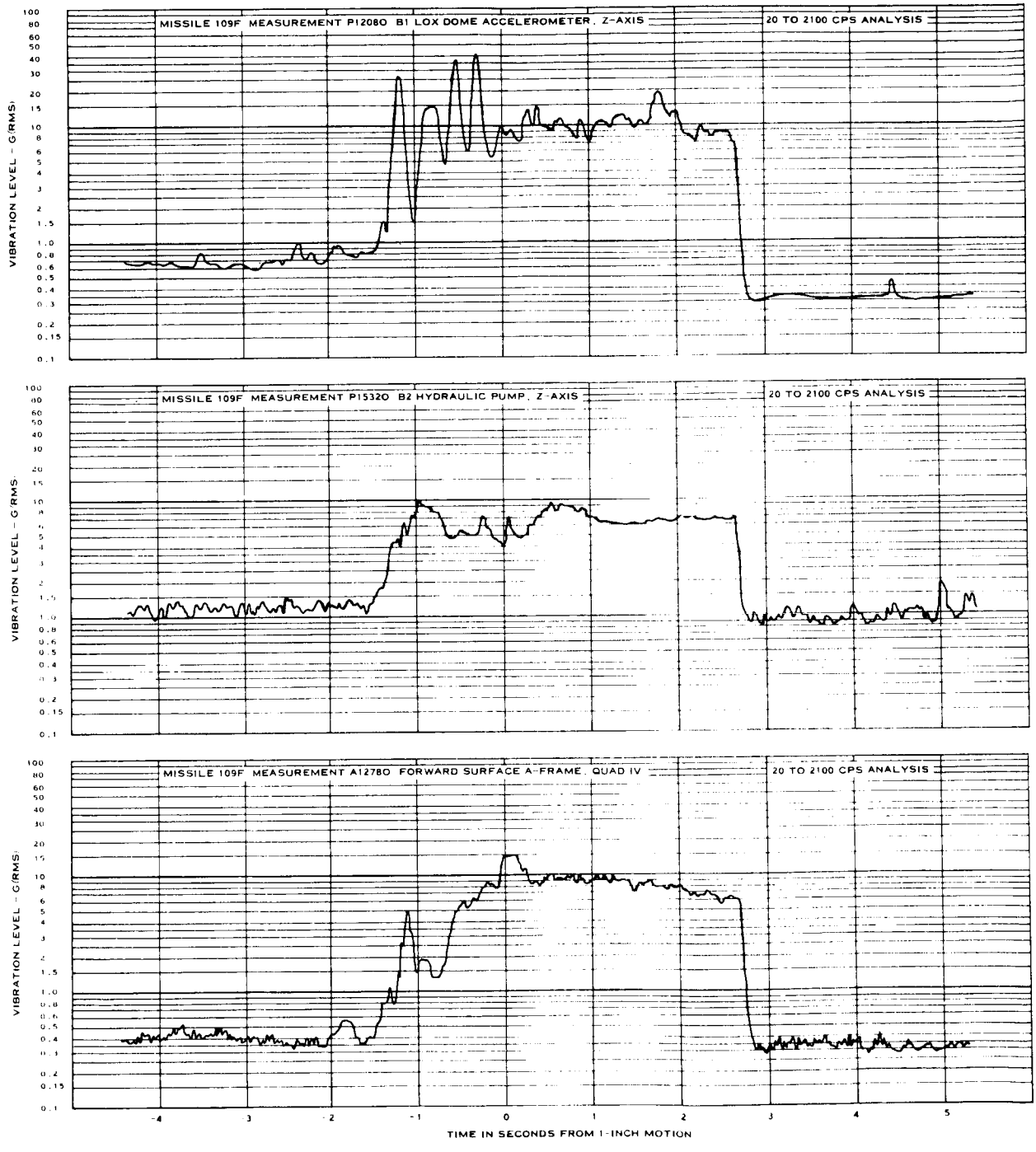
MISSILE 109F

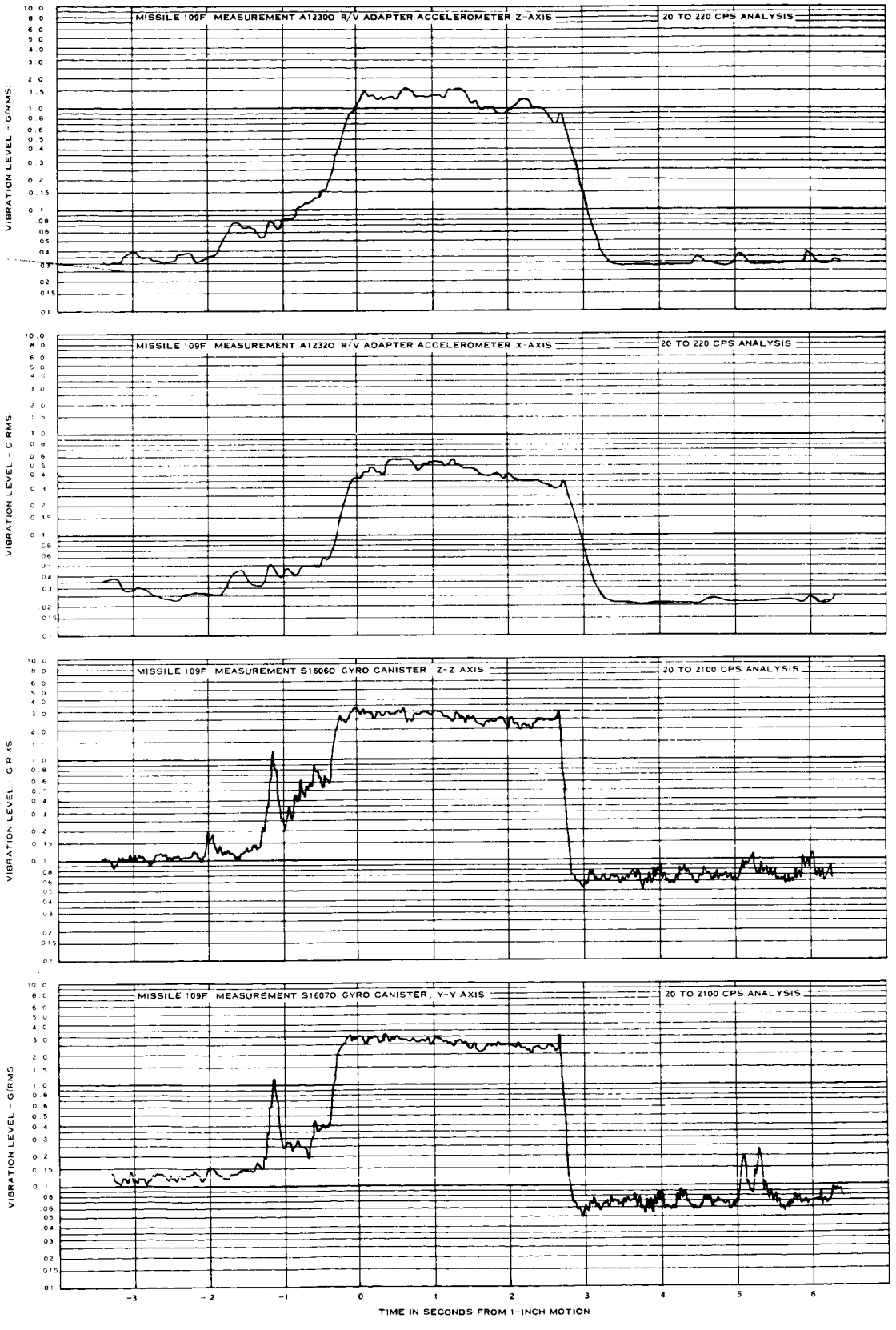


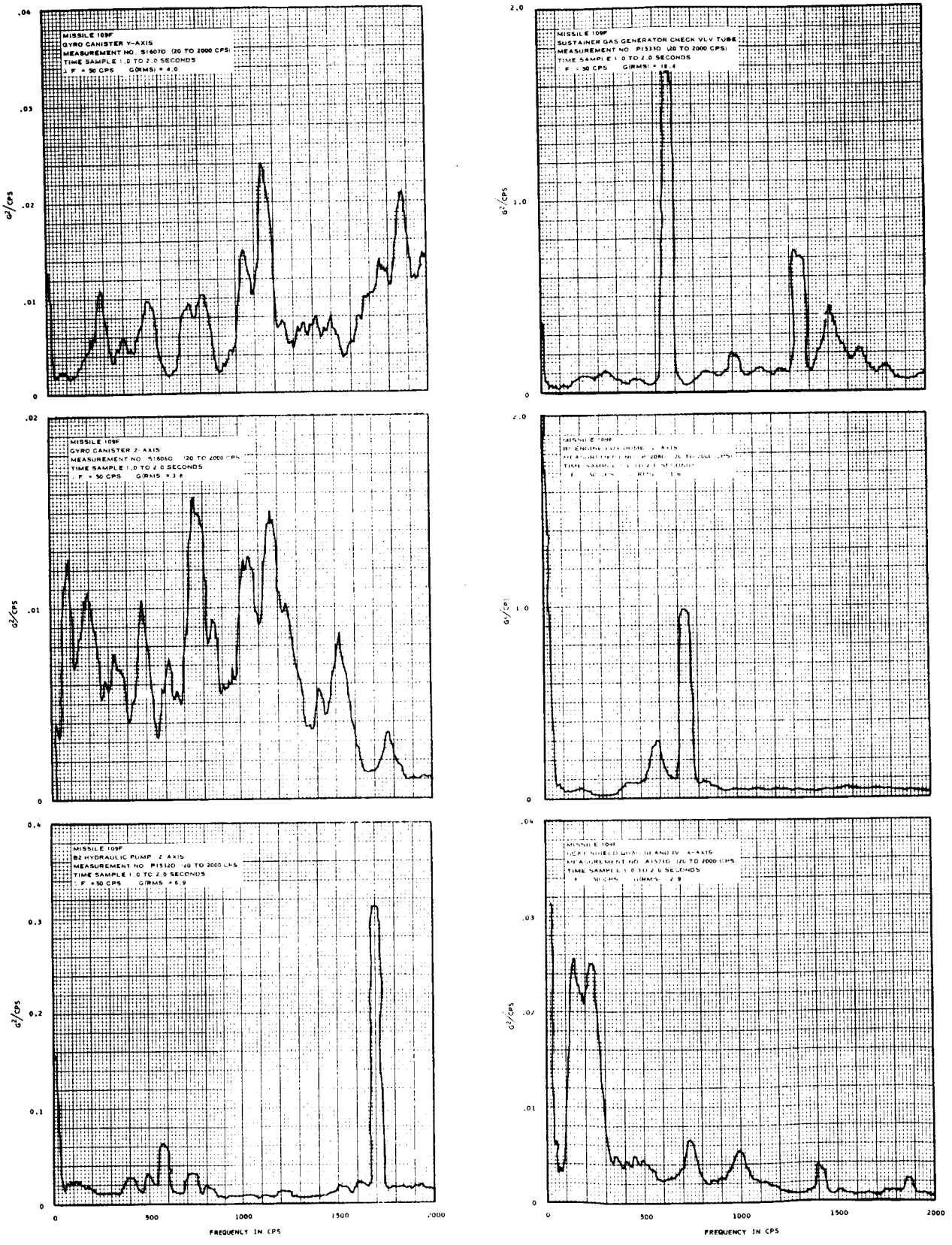

MISSILE 109F
AIG COMPUTER MOUNT (COMPUTER-SIDE) X-AXIS
MEASUREMENT NO. A1S780 (20 TO 10,000 CPS)
TIME SAMPLE 0.0 TO 1.0 SECOND
F = 50 CPS
MISSILE 109F
AIG COMPUTER MOUNT (COMPUTER-SIDE) X-AXIS
MEASUREMENT NO. A1S780 (20 TO 2000 CPS)
TIME SAMPLE 0.0 TO 1.0 SECOND
F = 10 CPS
MISSILE 109F
AIG COMPUTER MOUNT (COMPUTER-SIDE) Y-AXIS
MEASUREMENT NO. A1S750 (20 TO 10,000 CPS)
TIME SAMPLE 0.0 TO 1.0 SECOND
F = 50 CPS
MISSILE 109F
AIG COMPUTER MOUNT (COMPUTER-SIDE) Y-AXIS
MEASUREMENT NO. A1S750 (20 TO 2000 CPS)
TIME SAMPLE 0.0 TO 1.0 SECOND
F = 10 CPS
MISSILE 109F
AIG COMPUTER MOUNT (COMPUTER SIDE) Z AXIS
MEASUREMENT NO. A1S780 (20 TO 10,000 CPS)
TIME SAMPLE 0.0 TO 1.0 SECOND
F = 50 CPS
MISSILE 109F
AIG COMPUTER MOUNT (COMPUTER SIDE) Z AXIS
MEASUREMENT NO. A1S780 (20 TO 2000 CPS)
TIME SAMPLE 0.0 TO 1.0 SECOND
F = 10 CPS
G²/CPS
FREQUENCY IN CPS

MISSILE 109F

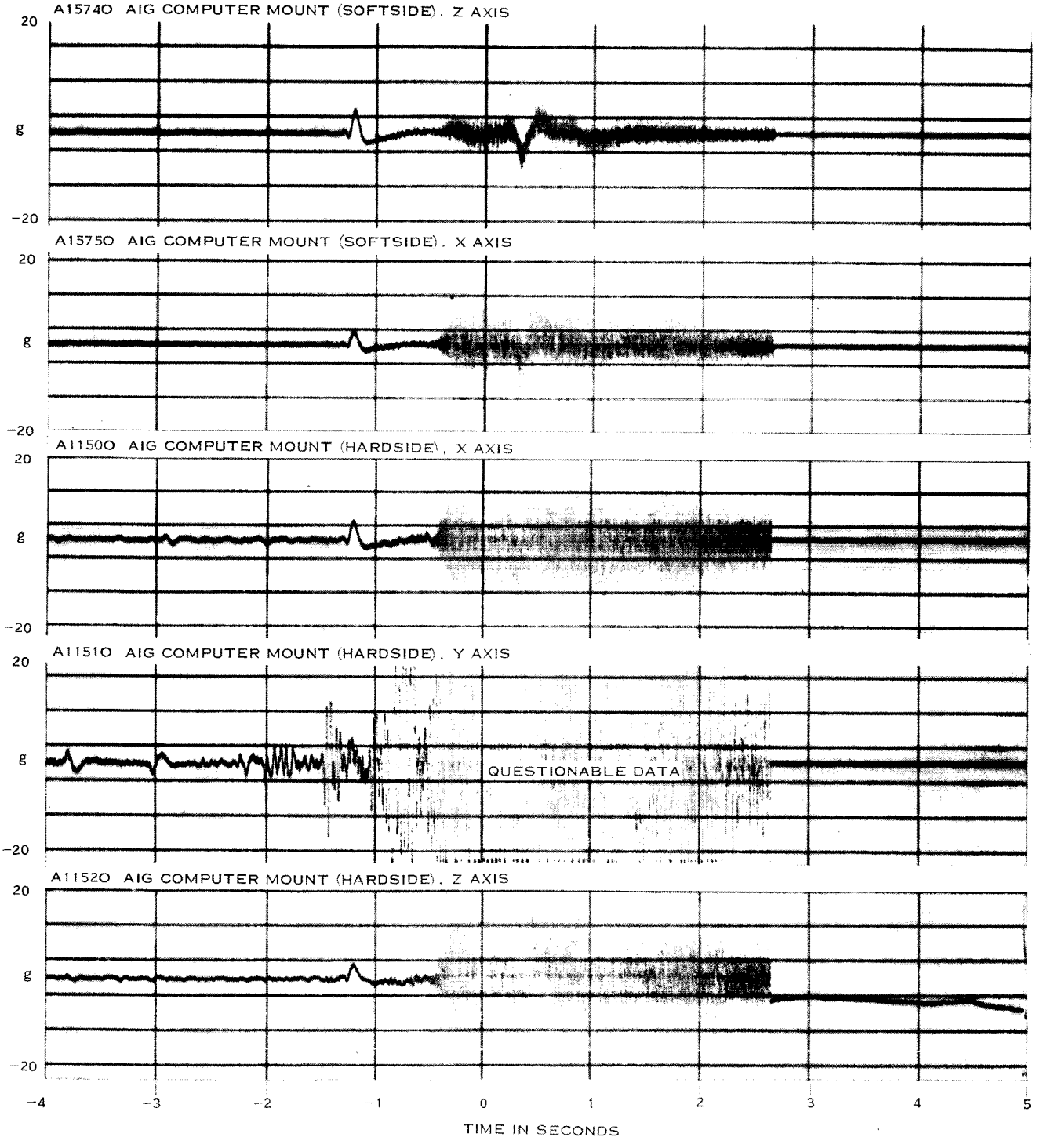



MISSILE 109F MEASUREMENT P12080 B1 LOX DOME ACCELEROMETER, Z-AXIS
20 TO 2100 CPS ANALYSIS
MISSILE 109F MEASUREMENT P15320 B2 HYDRAULIC PUMP, Z-AXIS
20 TO 2100 CPS ANALYSIS
MISSILE 109F MEASUREMENT A12780 FORWARD SURFACE A-FRAME, QUAD IV
20 TO 2100 CPS ANALYSIS
VIBRATION LEVEL - G(RMS)
100
80
60
50
40
30
20
15
10
8
6
5
4
3
2
1.5
1.0
0.8
0.6
0.5
0.4
0.3
0.2
0.15
0.1
-4
-3
-2
-1
0
1
2
3
4
5
TIME IN SECONDS FROM 1-INCH MOTION


MISSILE 109F MEASUREMENT A12300 R/V ADAPTER ACCELEROMETER Z-AXIS
20 TO 220 CPS ANALYSIS
MISSILE 109F MEASUREMENT A12320 R/V ADAPTER ACCELEROMETER X-AXIS
20 TO 220 CPS ANALYSIS
MISSILE 109F MEASUREMENT S16060 GYRO CANISTER, Z-Z AXIS
20 TO 2100 CPS ANALYSIS
MISSILE 109F MEASUREMENT S16070 GYRO CANISTER, Y-Y AXIS
20 TO 2100 CPS ANALYSIS
VIBRATION LEVEL - G RMS
-3 -2 -1 0 1 2 3 4 5 6
TIME IN SECONDS FROM 1-INCH MOTION

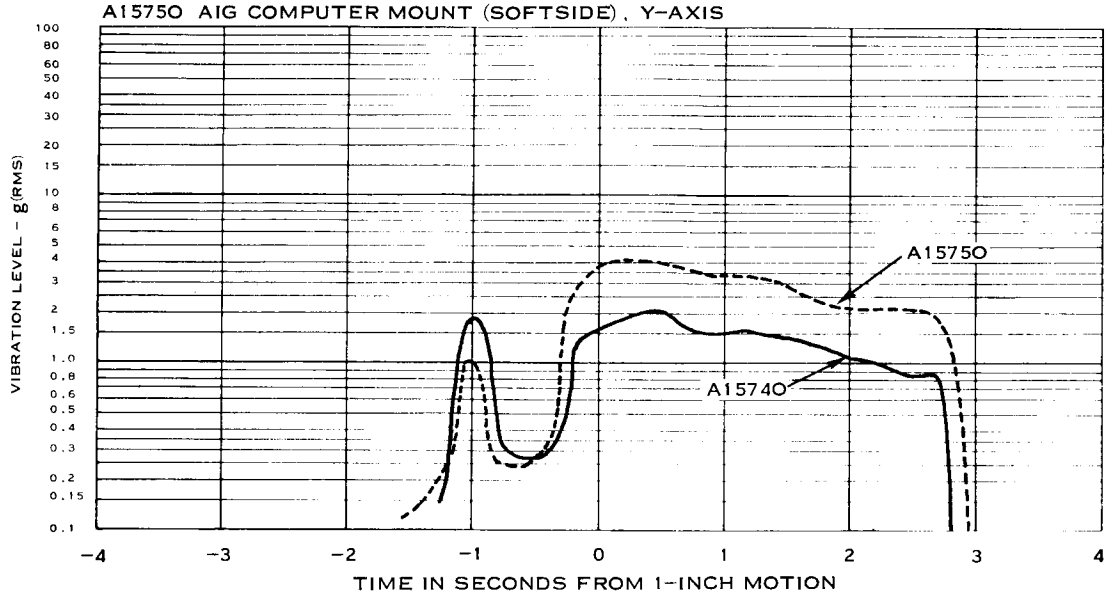

MISSILE 109F
GYRO CANISTER Y-AXIS
MEASUREMENT NO. S16070 (20 TO 2000 CPS)
TIME SAMPLE 1.0 TO 2.0 SECONDS
F = 50 CPS G(RMS) = 4.0
MISSILE 109F
SUSTAINER GAS GENERATOR CHECK VLV TUBE
MEASUREMENT NO. P15330 (20 TO 2000 CPS)
TIME SAMPLE 1.0 TO 2.0 SECONDS
F = 50 CPS G(RMS) = 18.4
MISSILE 109F
GYRO CANISTER Z AXIS
TIME SAMPLE 1.0 TO 2.0 SECONDS
F = 50 CPS G(RMS) = 3.8
MISSILE 109F
B2 HYDRAULIC PUMP Z AXIS
MEASUREMENT NO. P15120 (20 TO 2000 CPS
TIME SAMPLE 1.0 TO 2.0 SECONDS
F = 50 CPS G(RMS) = 6.9
G²/CPS
FREQUENCY IN CPS

VIBRATION WAVEFORM
MISSILE 109F

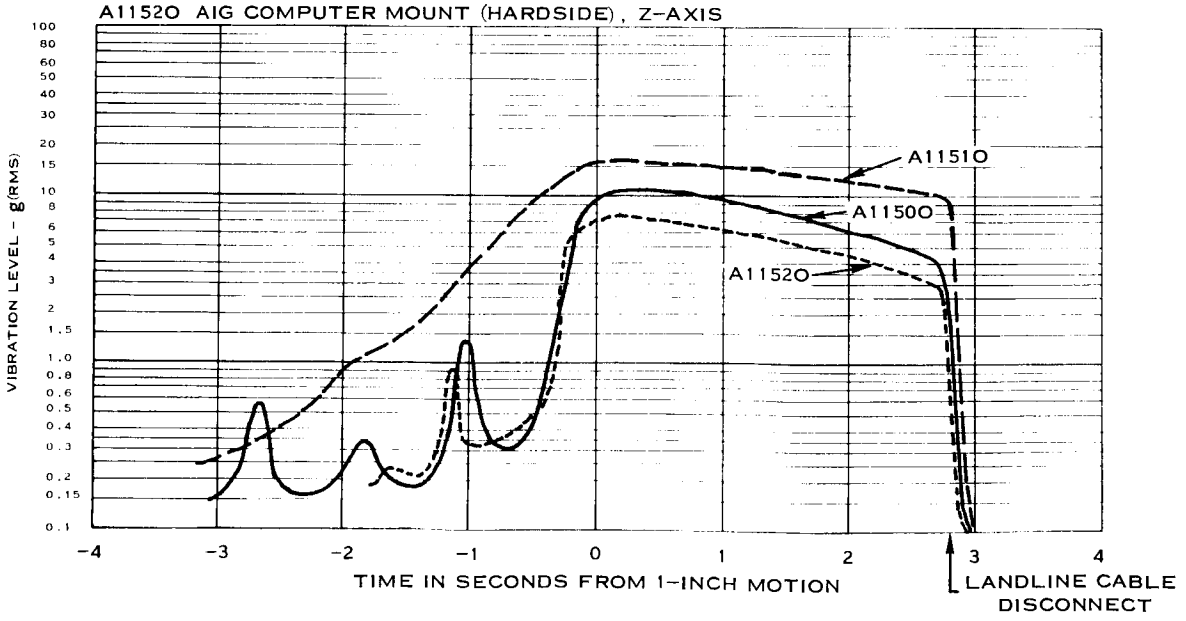


VIBRATION TIME HISTORY
g (RMS) VS TIME
MISSILE 109F
10,000 CPS LOW PASS FILTER

A15740 AIG COMPUTER MOUNT (SOFTSIDE), Z-AXIS
A15750 AIG COMPUTER MOUNT (SOFTSIDE), Y-AXIS



A11500 AIG COMPUTER MOUNT (HARDSIDE), X-AXIS
A11510 AIG COMPUTER MOUNT (HARDSIDE), Y-AXIS
A11520 AIG COMPUTER MOUNT (HARDSIDE), Z-AXIS



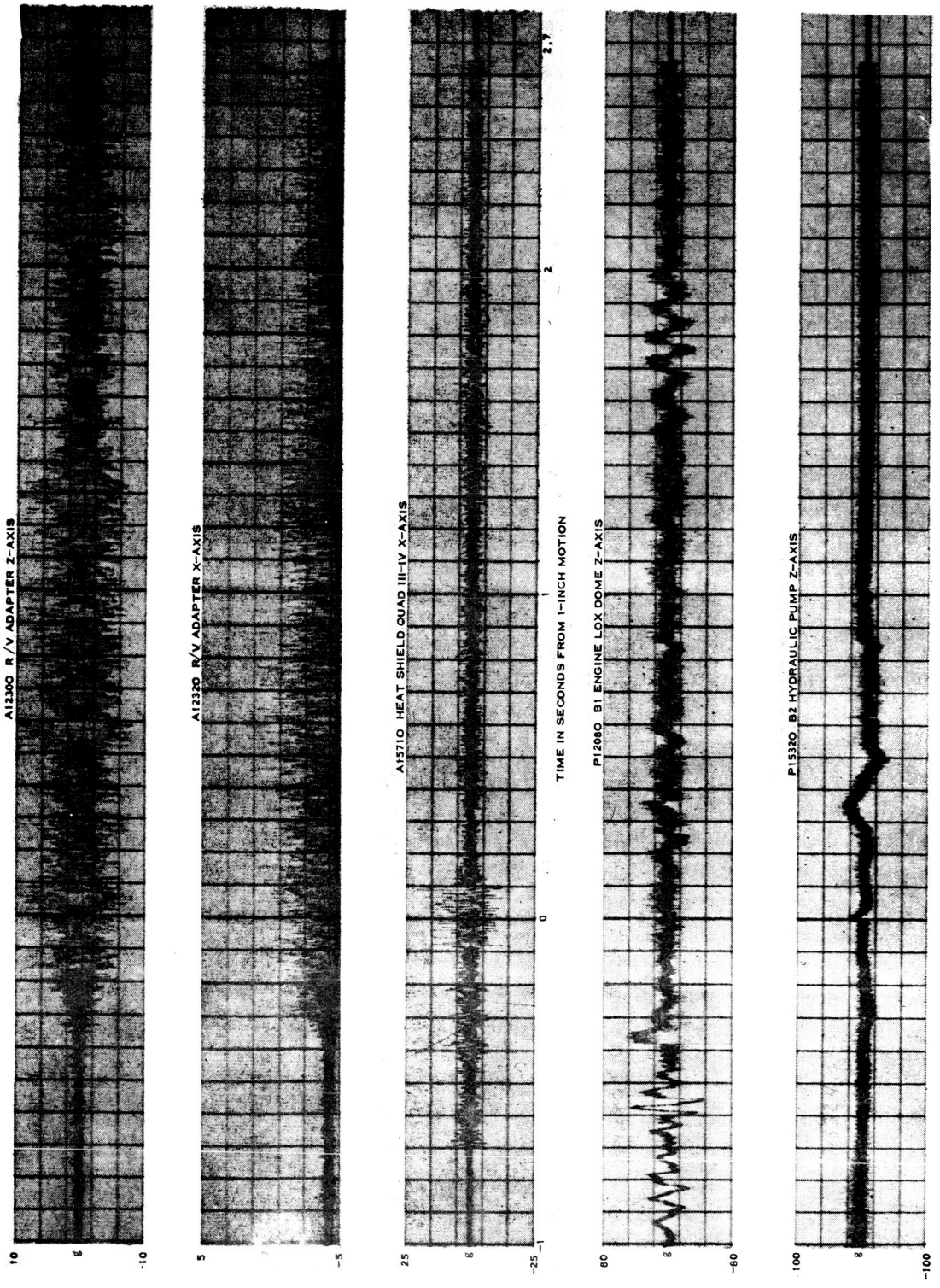
ACOUSTIC AND VIBRATION

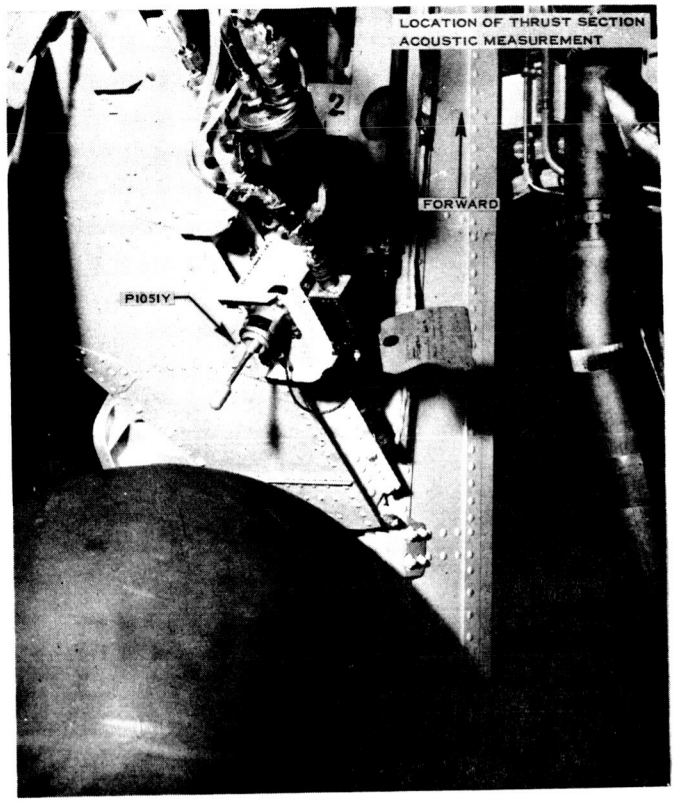
FIGURE NO. 12-17

~~**REPORT NO. GD/A-APZ64-002**~~

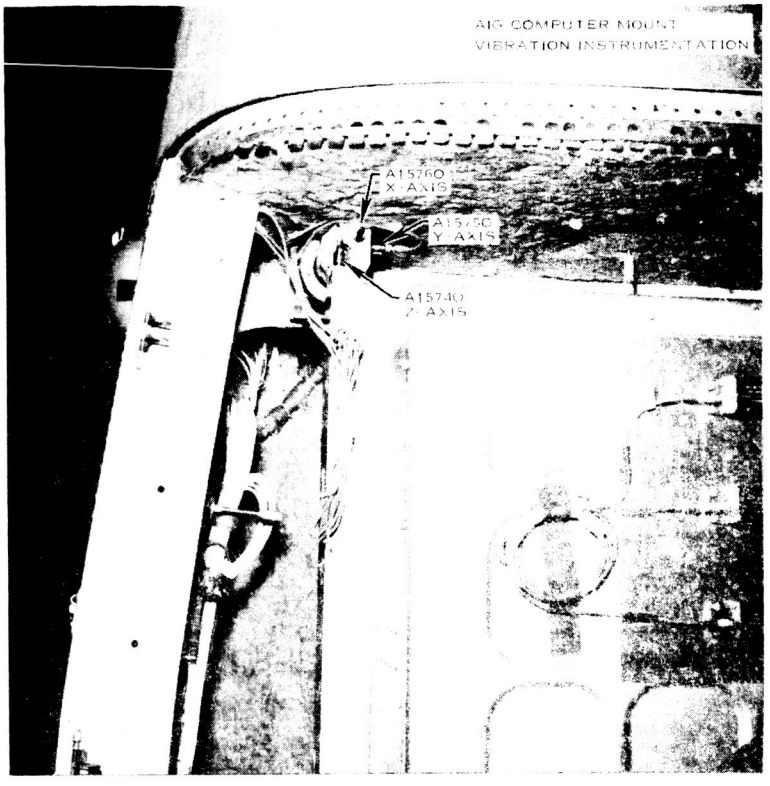
LANDLINE DATA

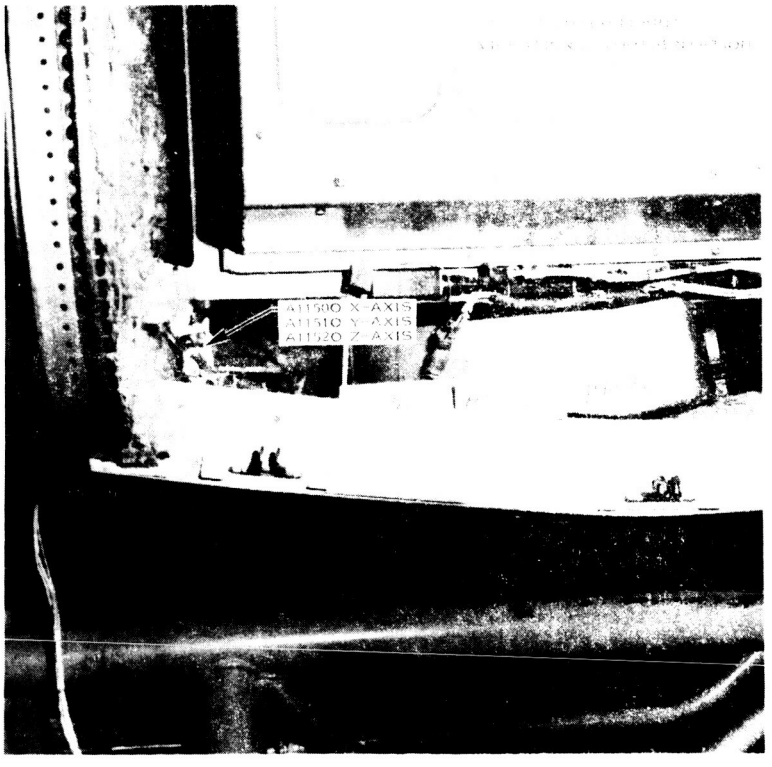
MISSILE 109F

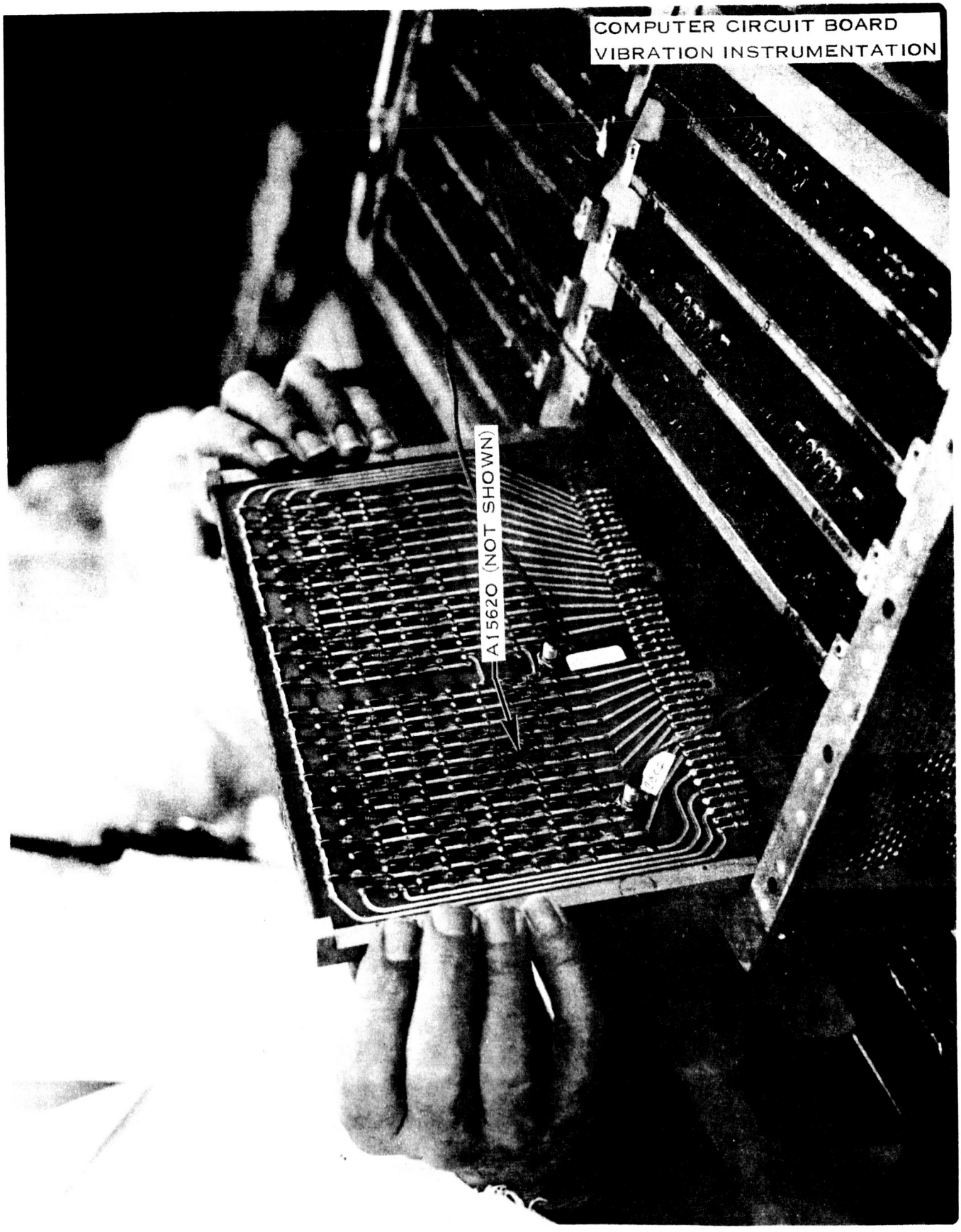


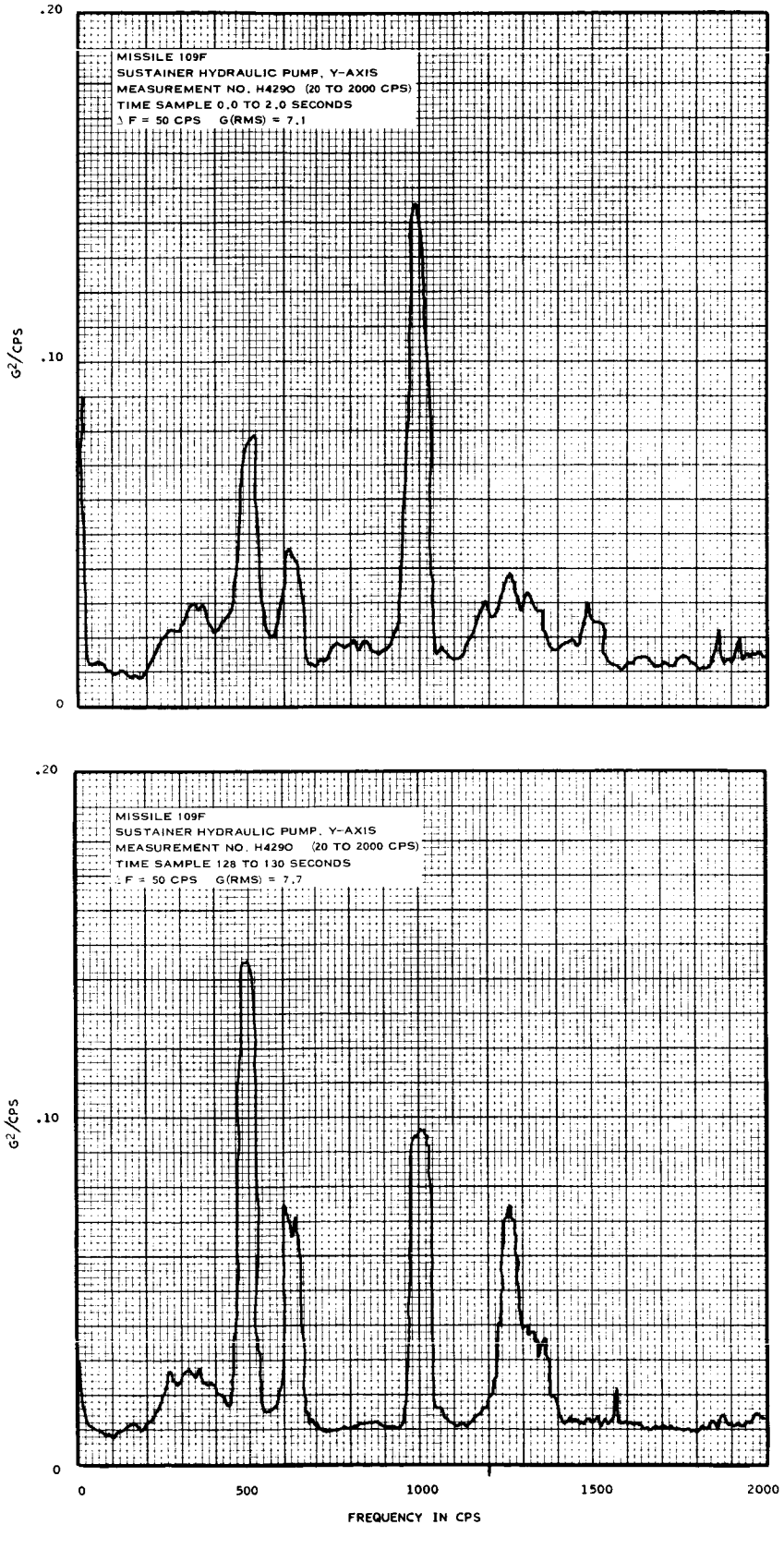

LOCATION OF THRUST SECTION
ACOUSTIC MEASUREMENT
2
FORWARD
P1051Y


ARMA COMPUTER DUMMY CONSTANTS
BOARD MICROPHONE INSTRUMENTATION
A1780Y
A550Y
(NOT SHOWN)


AIG COMPUTER MOUNT
VIBRATION INSTRUMENTATION
A15760
X AXIS
A15750
Y AXIS
A15740
Z AXIS


A11500 X AXIS
A11510 Y AXIS
A11520 Z AXIS


COMPUTER CIRCUIT BOARD
VIBRATION INSTRUMENTATION
A15620 (NOT SHOWN)


MISSILE 109F
SUSTAINER HYDRAULIC PUMP, Y-AXIS
MEASUREMENT NO. H4290 (20 TO 2000 CPS)
TIME SAMPLE 0.0 TO 2.0 SECONDS
Δ F = 50 CPS G(RMS) = 7.1
.20
.10
0
G²/CPS
MISSILE 109F
SUSTAINER HYDRAULIC PUMP, Y-AXIS
MEASUREMENT NO. H4290 (20 TO 2000 CPS)
TIME SAMPLE 128 TO 130 SECONDS
Δ F = 50 CPS G(RMS) = 7.7
.20
.10
0
G²/CPS
0
500
1000
1500
2000
FREQUENCY IN CPS

SECTION 6.2.23

MISSILE 135F

FLIGHT TESTED 4-26-63

AT AMR COMPLEX 11

TEST REPORT GD/A63-0120

Staging Vibration

During staging, no adverse vibrational environment was shown by the airborne instrumentation. In an effort to define the vibration in certain areas relative to the staging event, eleven accelerometers were monitored during the staging sequence via the airborne Time Transposition Telemeter (TTT). All measurements relayed valid data (see Figures 13-13 through 13-14).

The Booster Thrust Section Longitudinal Accelerometer (A36A) indicated staging start at 128.976 seconds. The booster thrust section accelerated smoothly away from the tank structure with the last staging shoe indicating "separation complete" at 129.480 seconds.

The radial and tangential vibration components measured on the staging rails at the A-Frame connections showed some low level ringing coincident with the fore and aft shoe separation. The Quad II Rail Tangential Vibration Component (A260O) recorded approximately 12 g (peak-to-peak) at 195 cps. The radial component (A2650O) displayed a 13 g (peak-to-peak) complex wave with primary energy at 195 cps.

The Quad IV rail showed essentially the same ringing characteristics with an 11 g (peak-to-peak) tangential component (A271O) and a 7 g (peak-to-peak) radial component (A272O). Primary energy was at about 307 cps. Rail ringing was effectively damped in 0.1 second.

Measurement of the rail vibration at the tank structure (Quad II rail) showed that the transmission of vibration energy past the A-Frame juncture was low. Despite noisy data, the appearance of a qualitative data change was not evident at the occurrence of aft shoe separation. A quantitative analysis of these data (A266O and A270O) was not possible due to excessive noise.

Monitoring of the X, Y and Z vibration components on the missile fuel tank apex (A273O, A274O and A275O, respectively) showed that negligible energy of a low frequency nature (below 35 cps) was transmitted through the A-Frame and engine thrust structure to the tank apex.

A transducer mounted on the Sustainer Hydraulic Pump Discharge Line (A276O) showed negligible energy levels prior to and during staging. The intent of this measurement was to monitor low frequency vibration (below 35 cps).

Two other low response transducers systems (flat to 40 cps) were installed to monitor the vibration environment of the Hydraulic Control Package (H412O) and the Sustainer Gas Generator Fuel Check Valve (P531O) during sustainer phase. The SGG Fuel Check Valve Vibration (P531O) showed 35 cps excitation coincident with separation complete. The vibration amplitude reached about 7 g (peak-to-peak) decaying to its quiescent level in about 0.2 seconds. The Hydraulic Control Package Vibration (H412O) showed negligible levels throughout sustainer phase.

Thrust Section Acoustic Environment

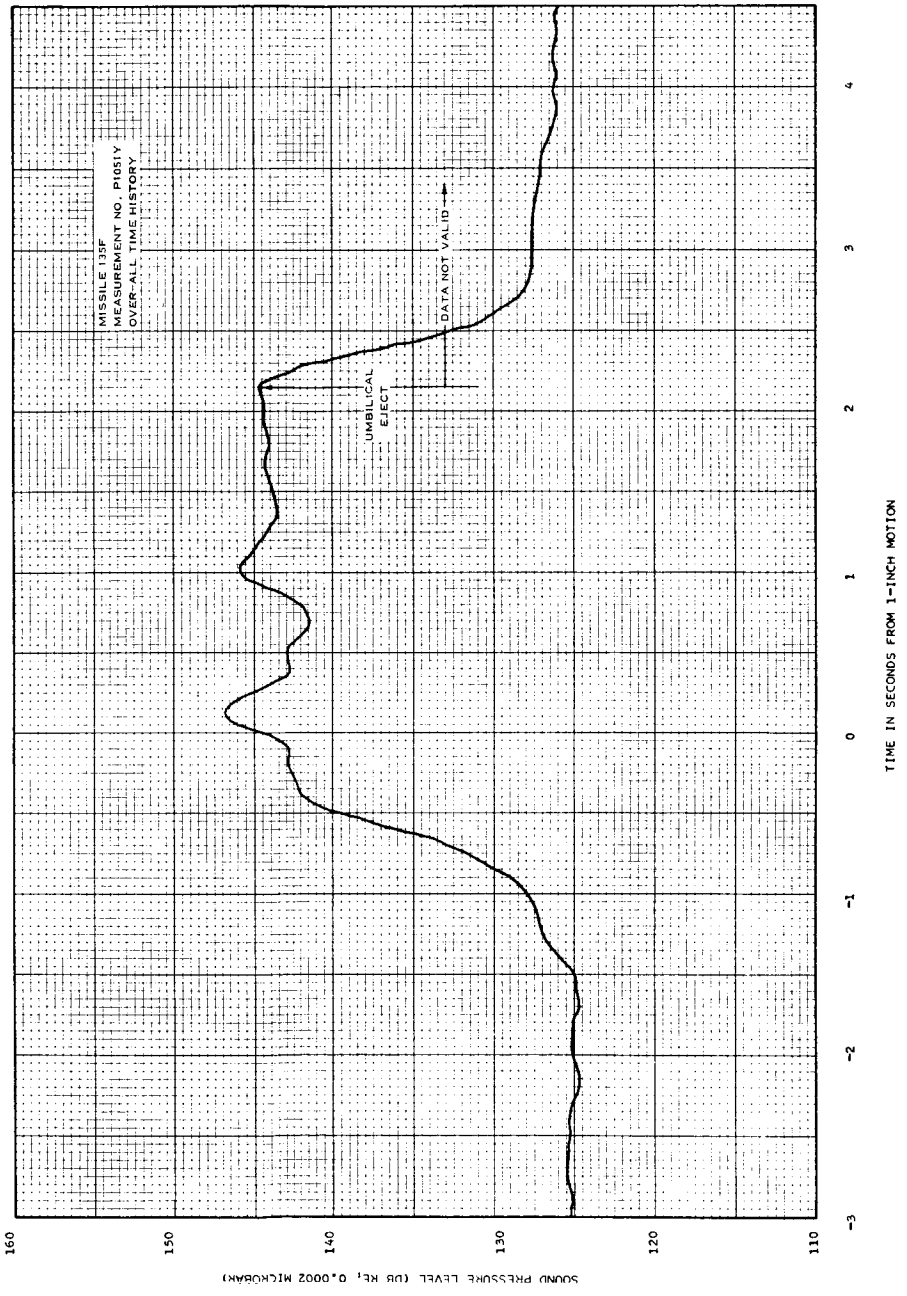
One microphone (P1051Y) was installed in the thrust section on the A-Frame in Quad II. Data was obtained through the use of a 40 foot trailing wire umbilical that provided acquisition until the umbilical was ejected at +2.15 seconds.

Over-all time history data (Figure 13-9) indicated that the maximum Sound Pressure Level (SPL) of 146.7 db was attained at +0.1 second. All db levels quoted in this section are referenced to a zero db level of 0.0002 microbar. Maximum sound pressure levels for other Series F missiles at AMR have been as follows:

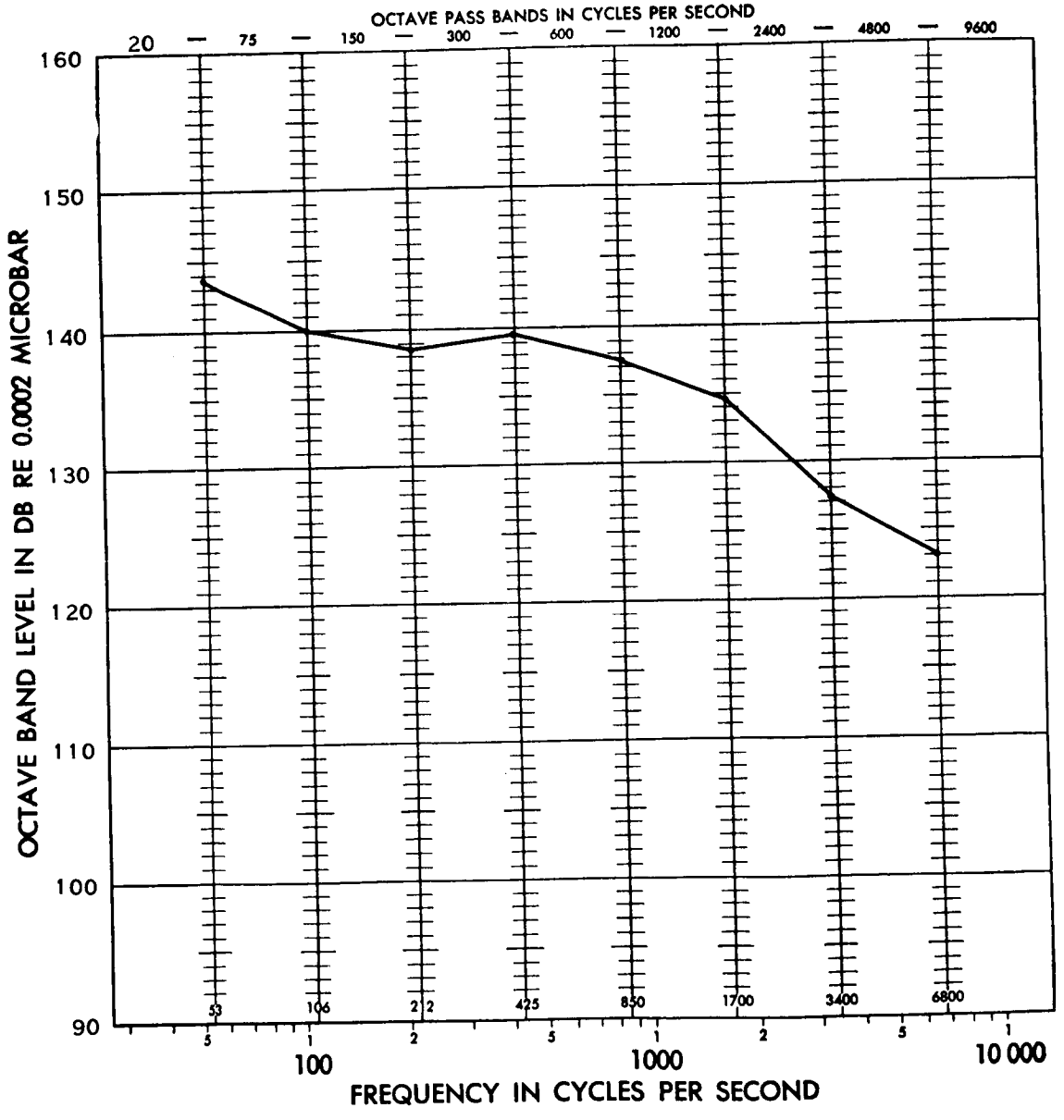
Missile	Maximum SPL-db
134F	153.4
21F	146.7
16F	154.0
14F	152.0

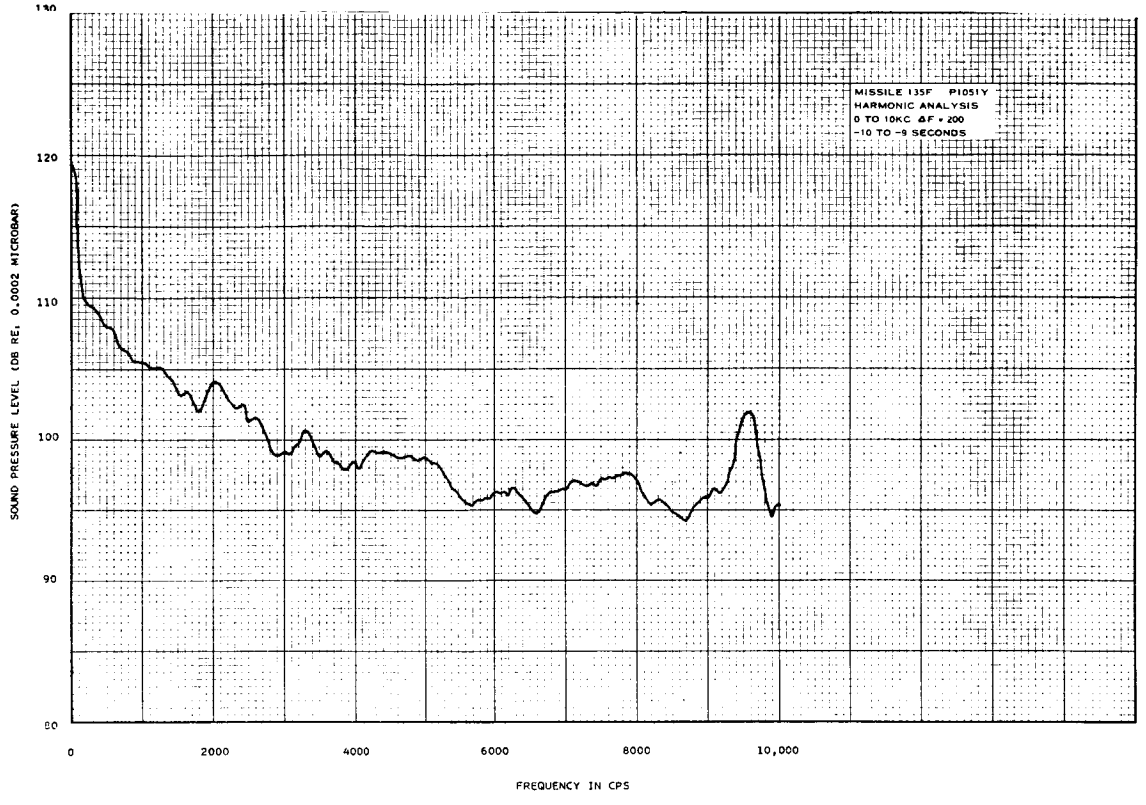
A plot of the maximum SPL obtained in each octave is presented in Figure 13-10.

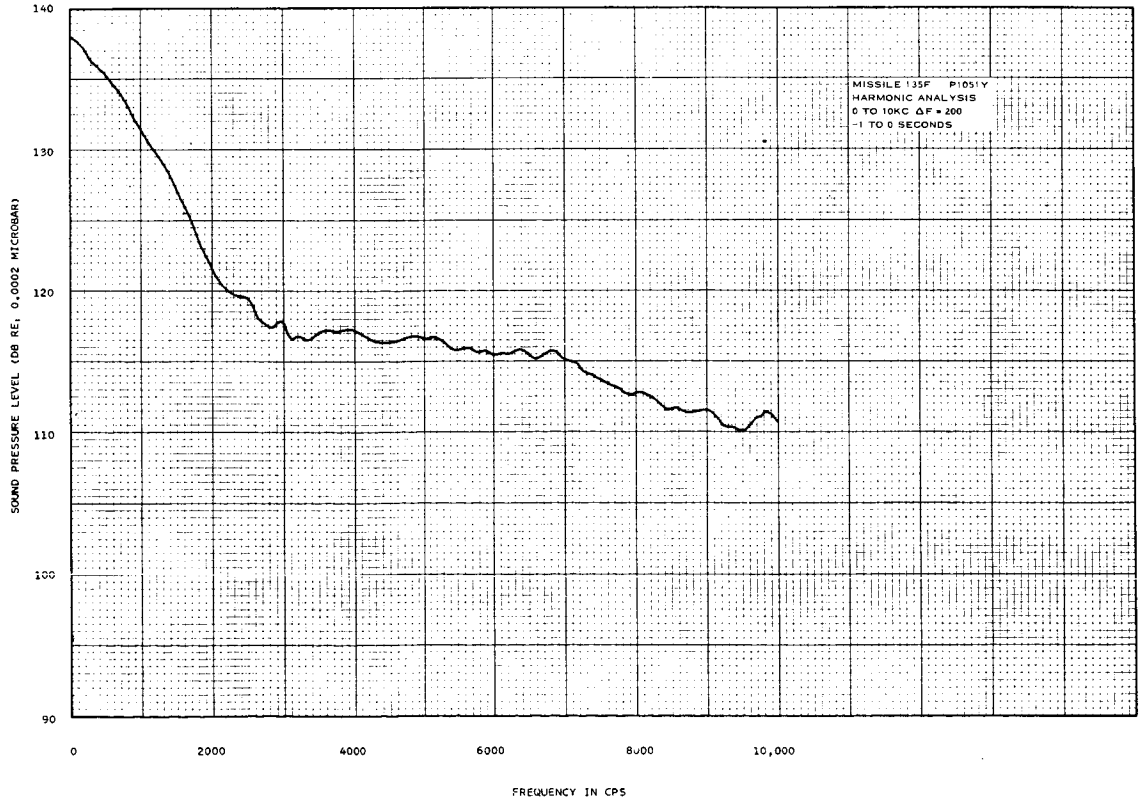
Harmonic analyses of the data appear in Figures 13-11 and 13-12. These analyses include four different one-second time intervals before ignition and during thrust rise and liftoff. The main purpose of the harmonic analyses was to reveal any predominant frequencies. No predominant frequencies were present and in general the data indicates that SPL decreases with increasing frequency.

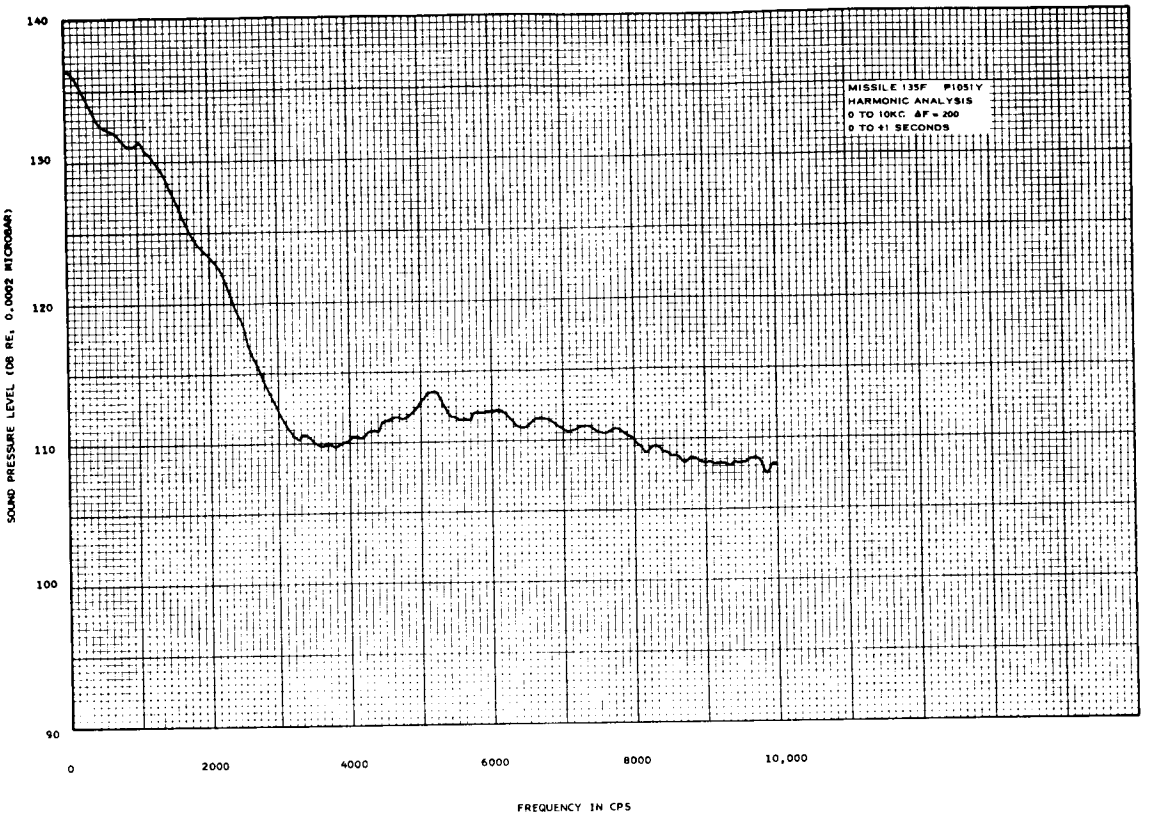

MISSILE 135F
MEASUREMENT NO. P1051Y
OVER-ALL TIME HISTORY
DATA NOT VALID
UMBILICAL
EJECT
160
150
140
130
120
110
4
3
2
1
0
-1
-2
-3
TIME IN SECONDS FROM 1-INCH MOTION

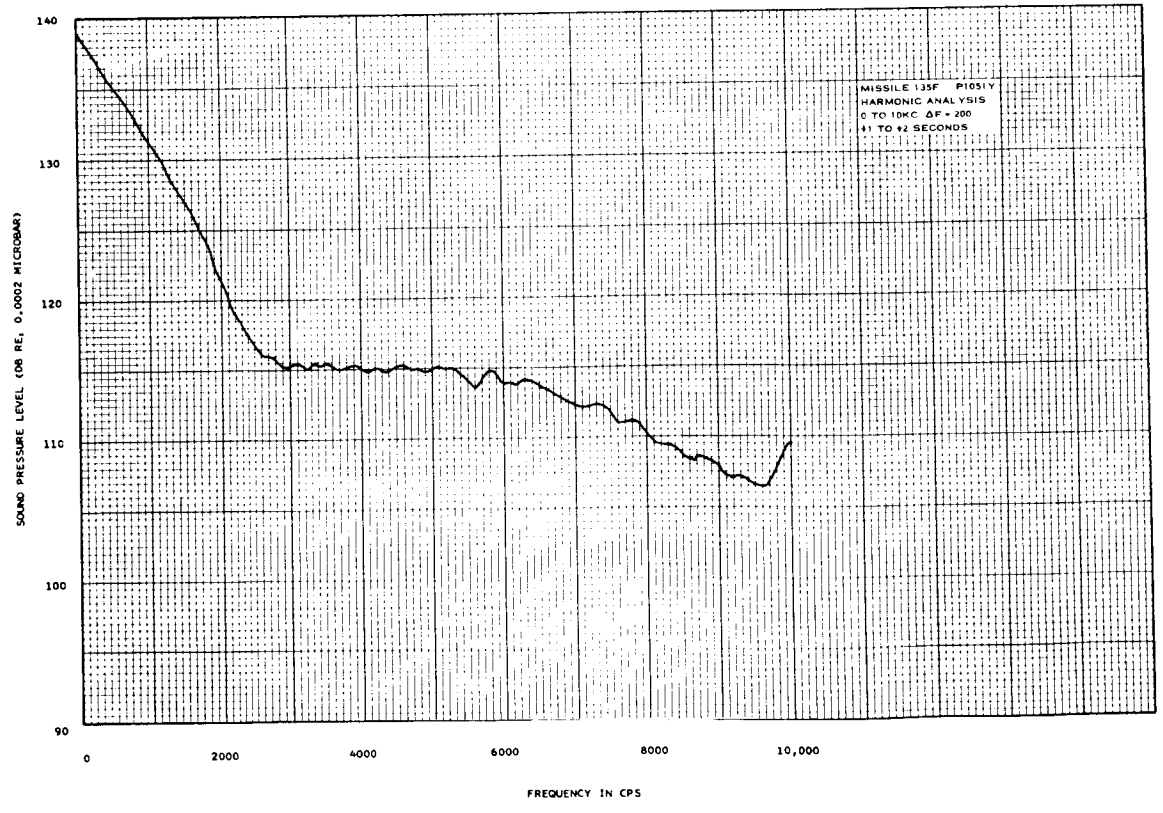
MISSILE 135F
MEASUREMENT NO. P1051Y
THRUST SECTION MICROPHONE DATA
MAXIMUM SPL IN EACH OCTAVE

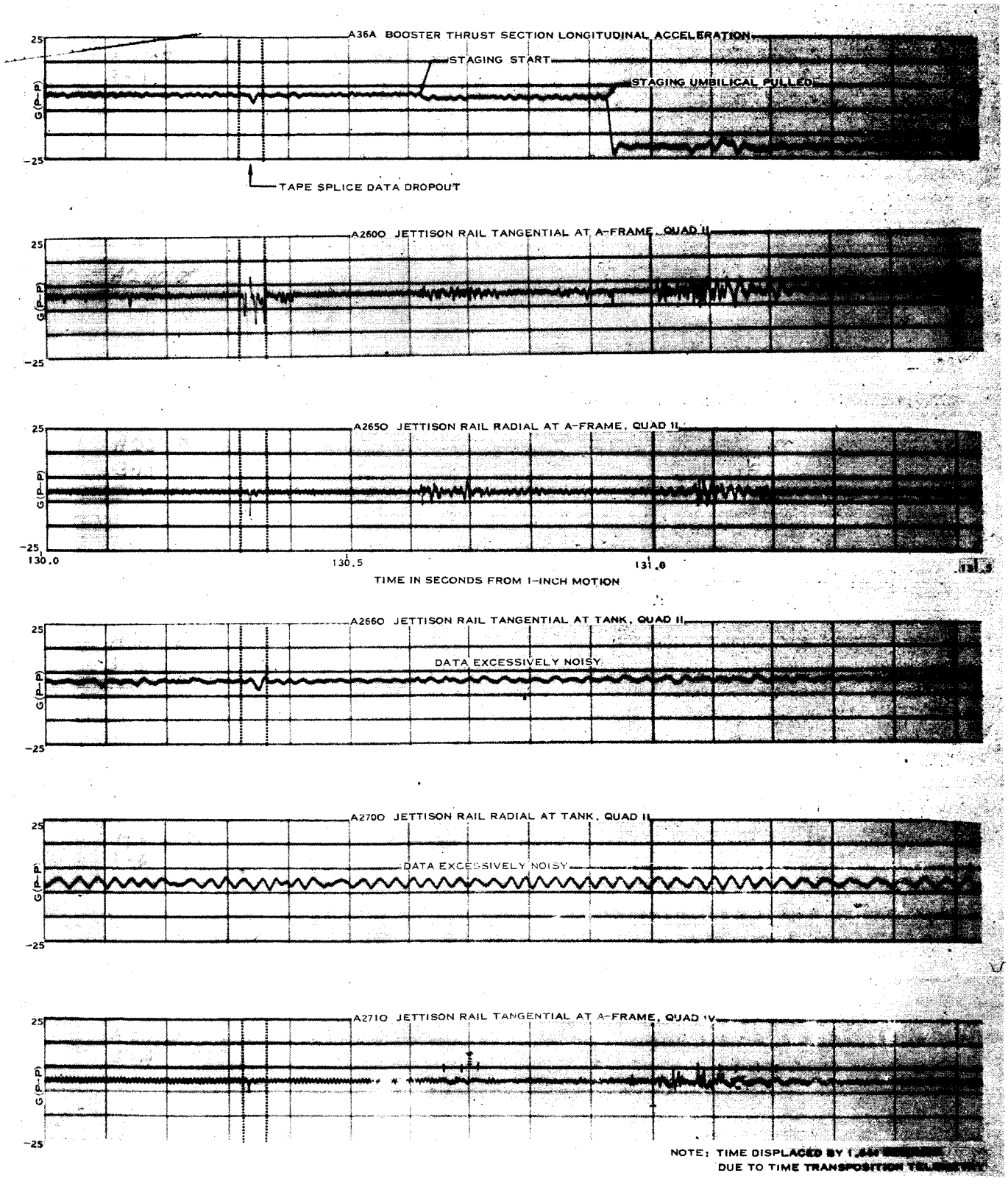



MISSILE 135F P1051Y
HARMONIC ANALYSIS
0 TO 10KC ΔF = 200
-10 TO -9 SECONDS
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
130
120
110
100
90
80
0
2000
4000
6000
8000
10,000
FREQUENCY IN CPS


MISSILE 135F P1051Y
HARMONIC ANALYSIS
0 TO 10KC ΔF = 200
-1 TO 0 SECONDS
SOUND PRESSURE LEVEL (DB RE, 0.0002 MICROBAR)
140
130
120
110
100
90
0
2000
4000
6000
8000
10,000
FREQUENCY IN CPS


MISSILE 135F P1051Y
HARMONIC ANALYSIS
0 TO 10KC ΔF = 200
0 TO +1 SECONDS
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
140
130
120
110
100
90
0
2000
4000
6000
8000
10,000
FREQUENCY IN CPS


MISSILE 135F P1051Y
HARMONIC ANALYSIS
0 TO 10KC ΔF = 200
+1 TO +2 SECONDS
SOUND PRESSURE LEVEL (DB RE; 0.0002 MICROBAR)
140
130
120
110
100
90
0
2000
4000
6000
8000
10,000
FREQUENCY IN CPS



NOTE: TIME DISPLACED BY [illegible]
DUE TO TIME TRANSPOSITION [illegible]

VIBRATION DATA

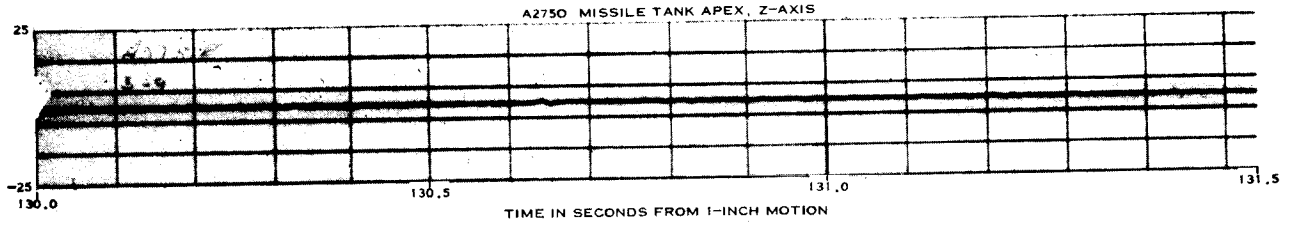
135F

A2720 JETTISON RAIL RADIAL AT A-FRAME, QUAD IV

A2730 MISSILE TANK APEX, X-AXIS

A2740 MISSILE TANK APEX, Y-AXIS

A2750 MISSILE TANK APEX, Z-AXIS



TIME IN SECONDS FROM 1-INCH MOTION

A2760 SUSTAINER HYDRAULIC PUMP DISCHARGE LINE

H4120 NAA CONTROL Y AXIS

P531 SUSTAINER GAS GENERATOR FUEL CHECK VALVE

NOTE: TIME DISPLACED BY 1.644 SECONDS DUE TO TIME TRANSPOSITION TELEMETRY

STATION 6.2.24

MISSILE 136F

FLIGHT TESTED 10-28-63

AT AMR COMPLEX 11

TEST REPORT GD/A63-1092

Staging Vibration

Two low frequency accelerometers (0 to 30 cps) were installed in the missile thrust section to monitor vibration outputs during the staging sequence and for the remainder of powered flight. The measurement numbers and locations were as follows:

Meas. Number	Location	Response
H4120	NAA Control, Y-Axis	±50 g's 30 cps
P5310	SGG Fuel Check Valve	±30 g's 30 cps

A photo showing the instrumentation location of the sustainer gas generator (SGG) fuel check valve accelerometer is shown in Figure 13-27.

An oscillographic display of the staging portion of the flight data is shown in Figure 13-23.

No significant data reflecting the existence of an adverse vibrational environment were seen during the staging sequence. The maximum vibration level recorded on the sustainer gas generator fuel check valve at the initiation of staging (approximately 130.92 seconds) was 4.5 g peak-to-peak (P-P) at 78 cps. Response of the NAA control package accelerometer at staging start was negligible. Response to the aft and forward shoes leaving the staging rails was obscured by telemetry dropout. Vibration levels immediately following staging showed 4 g (P-P) at 36 cps on the sustainer gas generator fuel check valve for a duration of approximately 0.2 seconds. The NAA control package measurement again showed neglibible response.

Beginning at approximately 149 seconds outputs from the sustainer gas generator accelerometer indicated response to loss of missile pitch and yaw stability. Sinusoidal oscillations (0.5 to 1.2 cps) throughout the remainder of data acquisition indicate a complex missile motion. Superimposed upon the low frequency sinusoids, periodic bursts (approximately 47 cps and a maximum level of 8 g peak) were recorded until sustainer shutdown indicating response of the sustainer engine to gimbaling hard-over and hitting the stops.

At sustainer engine shutdown, approximately 261.43 seconds, a disturbance was indicated on the sustainer gas generator fuel check valve (P5310) and the NAA control package (H4120). Maximum levels were 25 g (P-P) at 43 cps and 11 g (P-P) at 69 cps on P5310 and H4120, respectively. These vibration levels are higher than seen on previous missiles with similar instrumentation.

During the firing of the HIRS rockets, a 5 g (P-P) response at 41 cps was observed on measurement P5310. No significant response was indicated on NAA control package, (H4120).

Engine Vibration

Data was obtained from high frequency accelerometers installed on the booster and sustainer lox domes of each main engine thrust chamber with transducer sensitivity along the missile Z-axis. Three low frequency accelerometers (0-300 cps) were installed on the sustainer lox pump inlet flange, as shown in Figure 13-26, to record the vibration levels of the flange during launch and the initial phase of missile flight. The sustainer pump inlet flange X and Z-axis measurements appeared normal. The Y-axis measurement was invalid.

The outputs were recorded via an FM landline system utilizing extended cable lengths that provided data acquisition for approximately 30 feet of missile rise above the launcher. Approximately 2.1 seconds of data were obtained following missile liftoff. The measurement numbers and locations were as follows:

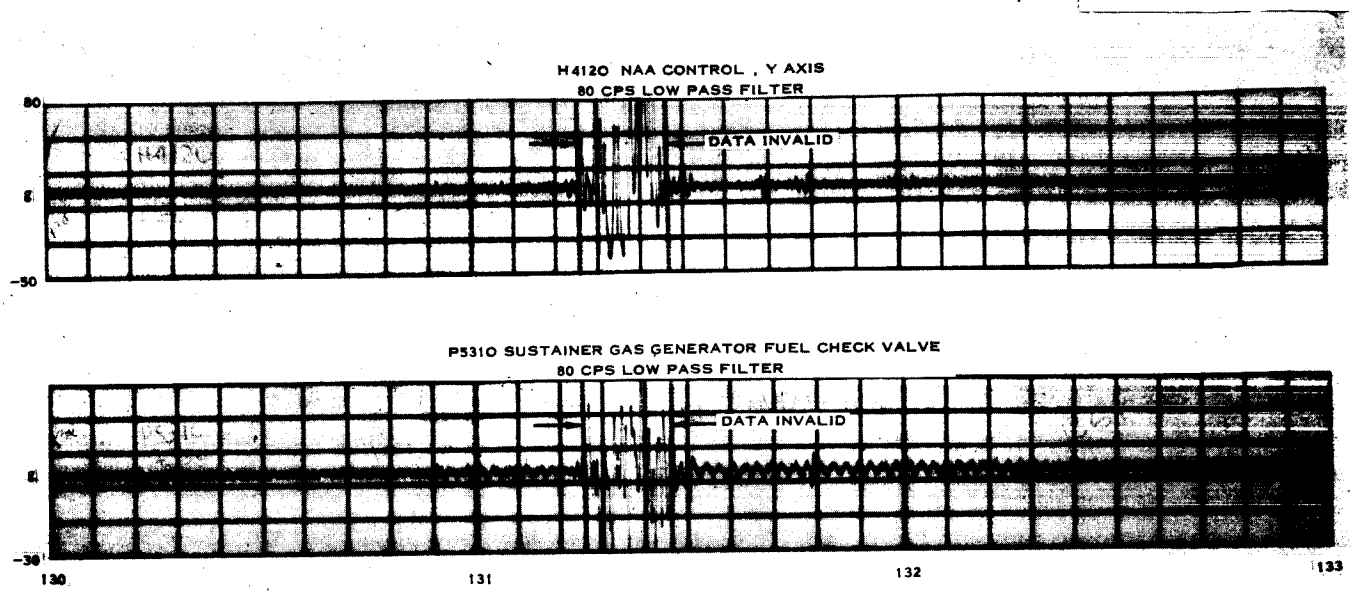
P12060	Sustainer Lox Dome, Z-Axis
P12080	B1 Lox Dome, Z-Axis
P12090	B2 Lox Dome, Z-Axis
P11060	Sustainer Lox Pump Inlet Flange, X-Axis
P11070	Sustainer Lox Pump Inlet Flange, Y-Axis
P11080	Sustainer Lox Pump Inlet Flange, Z-Axis

Sustainer thrust chamber vibration data prior to 1-inch motion was questionable because of instrumentation noise. Subsequent to 1-inch motion sustainer engine vibration data appeared valid. The steady-state vibration level was 8.4 g(rms) between 1.0 and 1.5 seconds at predominant frequencies of 730 and 540 cps. This is normal for sustainer engine lox dome vibration. B1 and B2 was obscured by noise prior to launch. The data traces were biased with the zero reference level shifting and exceeding the intelligence bandwidth. Subsequent to launch the booster engine vibration appeared valid except for a low frequency oscillation, approximately 5 cps, on the B2 measurement that was termed invalid. B1 steady-state vibration (1.0 to 1.5 seconds) was 9.2

g(rms) with predominant frequencies of 740 and 570 cps. B2 steady-state vibration (1.0 to 1.5 seconds) was 9.3 g(rms) with predominant frequencies of 580 and 720 cps. Oscillographic data are presented in Figure 13-22 and time history plots in Figure 13-24.

The data recorded from the sustainer lox pump inlet flange (Figure 13-22) indicated some small shock transients in response to initial sustainer engine ignition burning and main propellant ignition. Between -0.73 and -0.70 seconds, both measurements exhibited a short duration shock transient in response to initial sustainer ignition burning. The initial maximum instantaneous acceleration peak was 7 g(peak-to-peak) on the X-axis measurement and 5 g(peak-to-peak) on the Z-axis measurement damping out at frequencies between 60-70 cps within 0.03 second.

Response to the main propellant ignition of the sustainer engine was evident at -0.15 second. Maximum instanteneous acceleration peaks were between 9 and 12 g(peak-to-peak) at frequencies of 35-45 cps on measurements P11060 and P11080, respectively. The response was essentially damped by +0.05 second. The vibration levels exhibited at the sustainer lox pump inlet flange during the recorded period were nominal and were within maximum design conditions. Time history plots are presented in Figure 13-25.


H4120 NAA CONTROL , Y AXIS
80 CPS LOW PASS FILTER
80
0
-50
DATA INVALID
P5310 SUSTAINER GAS GENERATOR FUEL CHECK VALVE
80 CPS LOW PASS FILTER
0
-30
DATA INVALID
130
131
132
133
TIME IN SECONDS FROM 1-INCH MOTION

AIRFRAME

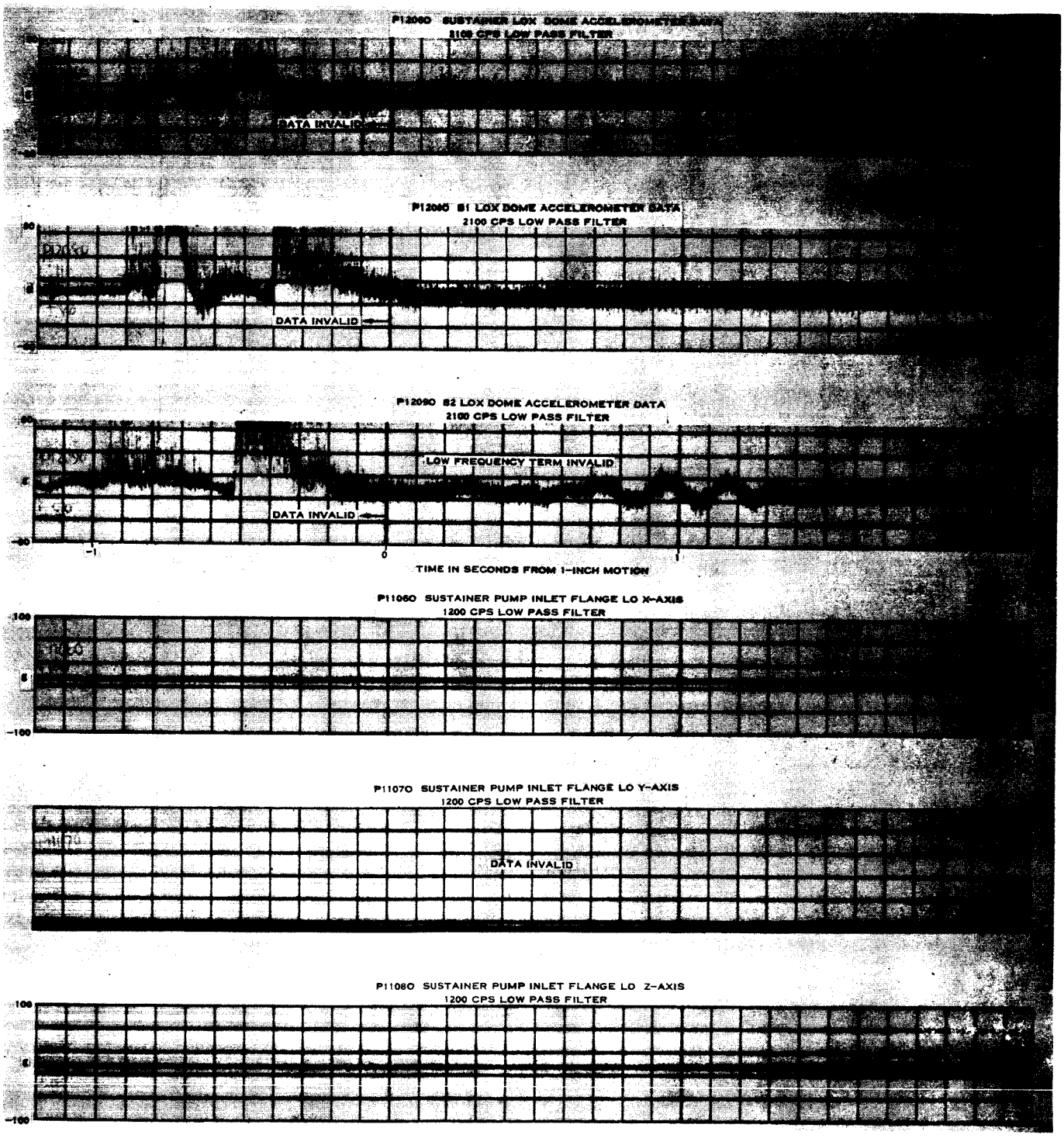
FIGURE NO. 13-18

~~REPORT NO. GDA 63-1092~~

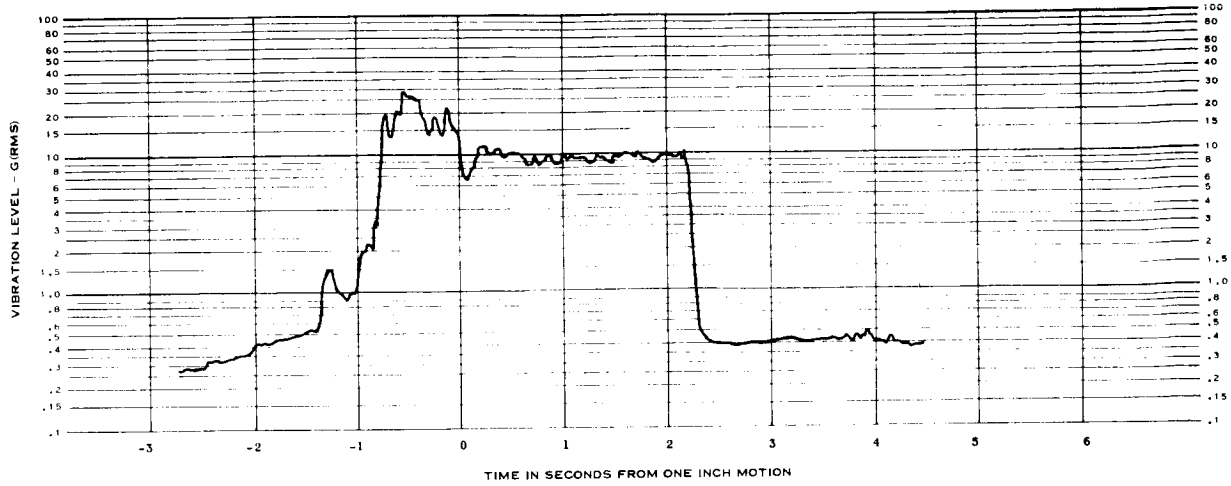
LANDLINE DATA

136F

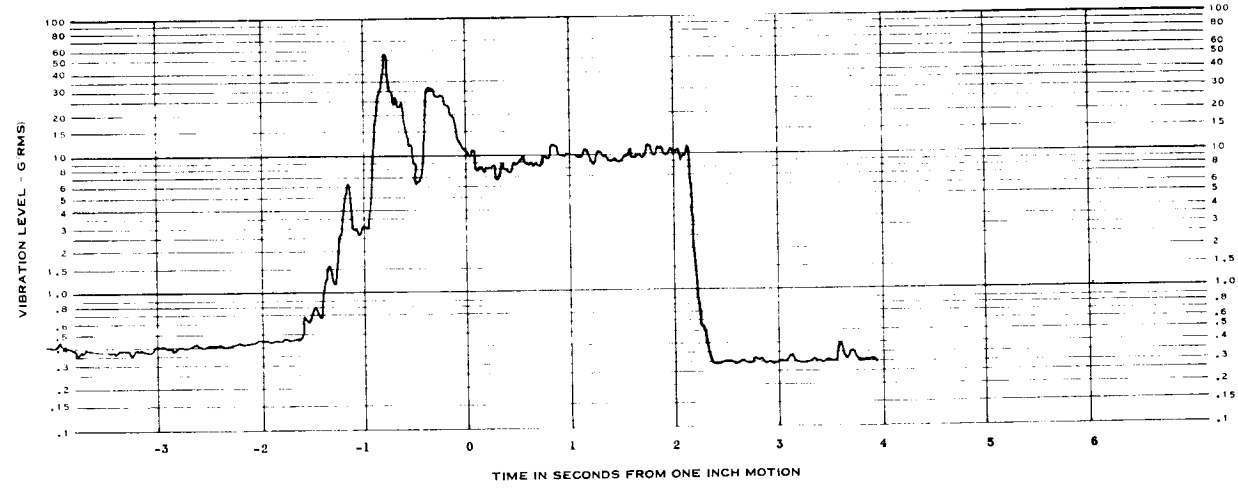
MISSILE 136F



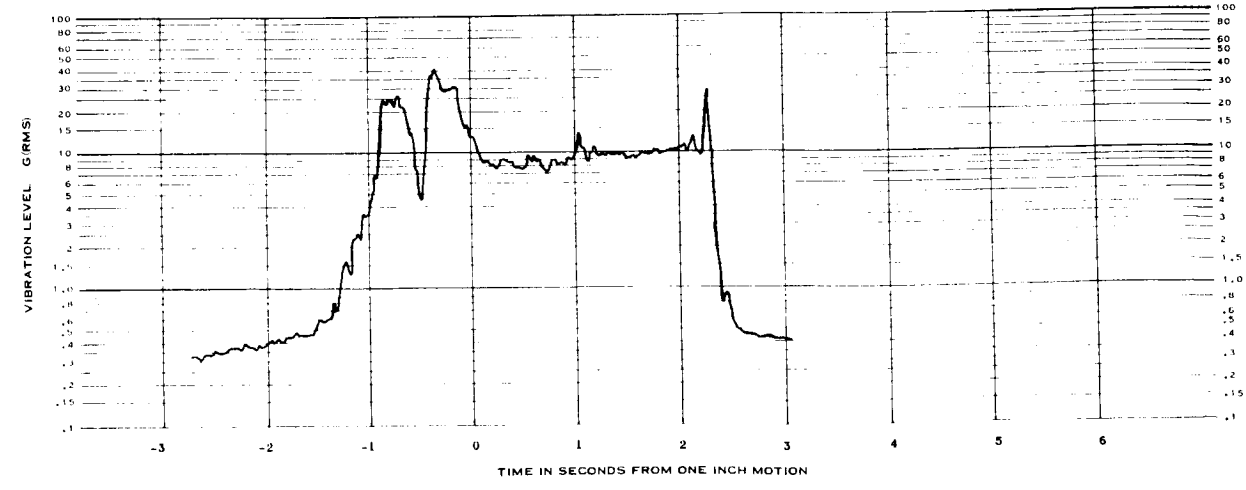
MISSILE 136F MEASUREMENT NUMBER P12080 DESCRIPTION SUSTAINER LOX DOME ACCELEROMETER DATA (Z-AXIS)

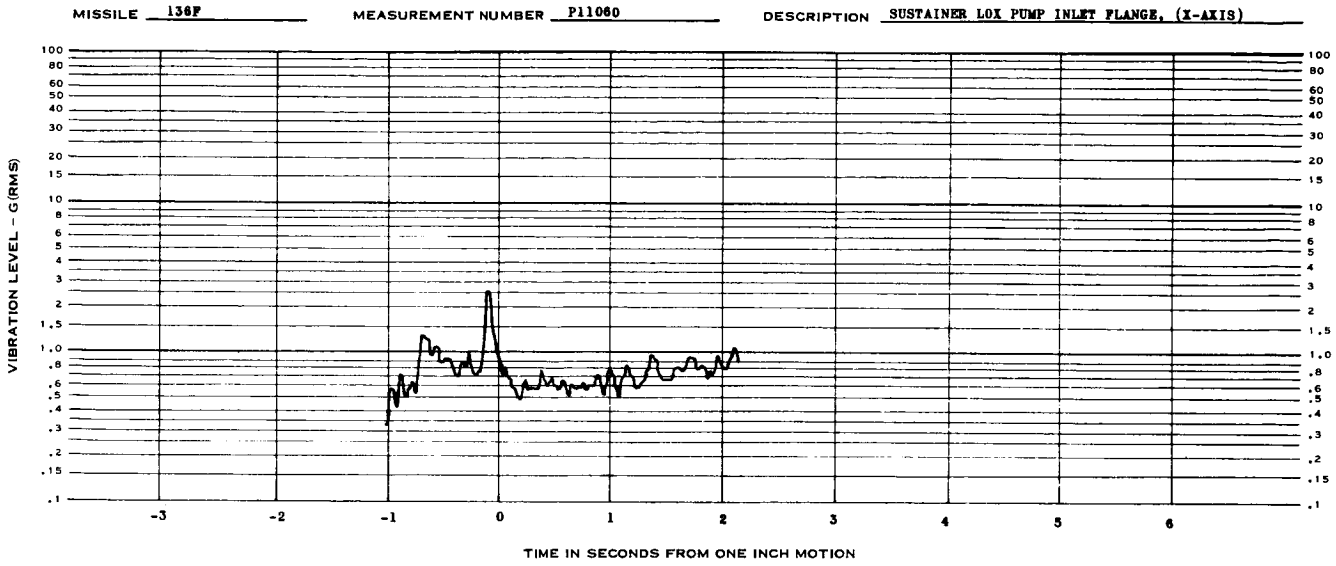


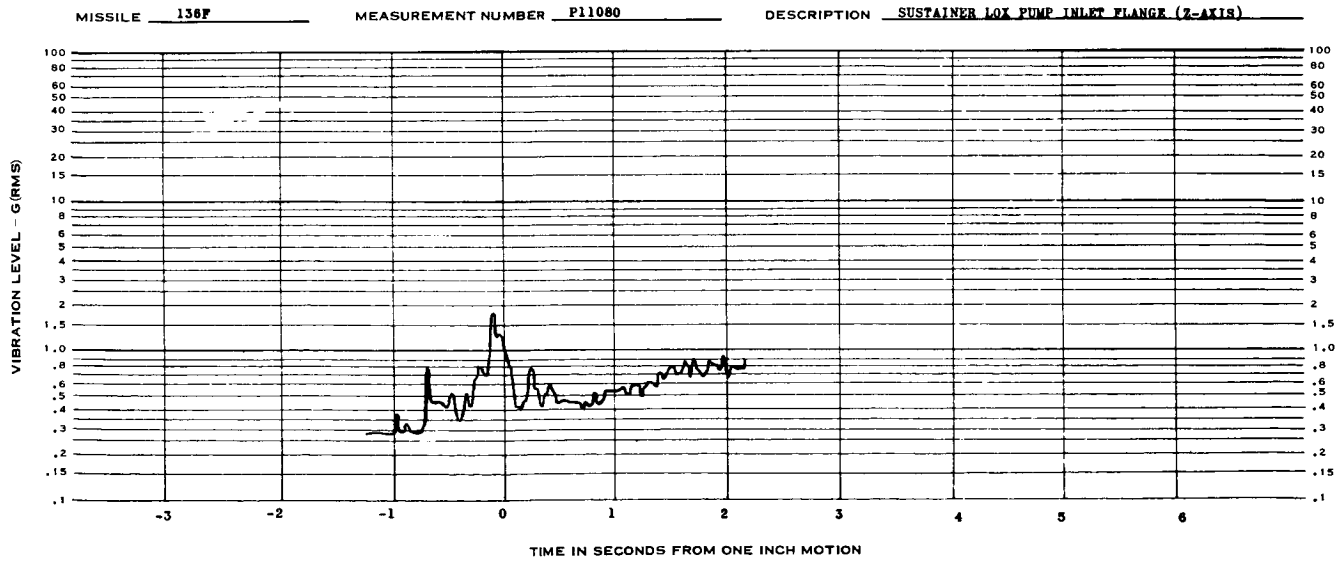
MISSILE 136F MEASUREMENT NUMBER P12080 DESCRIPTION B1 LOX DOME ACCELEROMETER DATA (Z-AXIS)



MISSILE 136F MEASUREMENT NUMBER P12090 DESCRIPTION B2 LOX DOME ACCELEROMETER DATA (Z-AXIS)




MISSILE 136F
MEASUREMENT NUMBER P11060
DESCRIPTION SUSTAINER LOX PUMP INLET FLANGE, (X-AXIS)
VIBRATION LEVEL - G(RMS)
TIME IN SECONDS FROM ONE INCH MOTION


MISSILE 136F
MEASUREMENT NUMBER P11080
DESCRIPTION SUSTAINER LOX PUMP INLET FLANGE (Z-AXIS)
VIBRATION LEVEL - G(RMS)
TIME IN SECONDS FROM ONE INCH MOTION

Three high frequency accelerometers and one acoustic microphone were installed in the upper GD/A adapter to define environmental conditions and determine the effects of these conditions upon system performance. Satisfacotry data was obtained from the three accelerometers; however, the outputs of the microphone were termed invalid throughout the flight. The measurement numbers and locations were as follows:

Measurement No.	Location	Range	Flat Freq. Resp.
A5020	HIRS Gyro Panel - Radial	±30 g	20 to 2000 cps
A5030	HIRS Gyro Panel - Long	±30 g	20 to 2000 cps
A5040	HIRS Pivot Panel - Radial	±30 g	20 to 2000 cps
A505Y	Gyro Panel - Adapter Acoustic	125-155 db	20 to 2000 cps

Vibration measurements A5020 and A5030 are located on the sub-routine programmer in Quad II at approximately Station 428. These measurements monitor the vibration energy transmitted to the control package in radial and longitudinal axes of sensitivity, respectively. Measurement A5040 is located on the HIRS rocket pivot plate between Quad II and Quad III at approximately Station 453 and measures the vibrational energy input to the solid propellant rocket.

Instrumentation locations are shown in Figures 14-1 and 14-5 through 14-9.

Adapter Vibration

Vibration amplitudes appear to be within the specifications defined by the structural qualification tests and component specifications in the HIRS adapter area.

Maximum steady-state levels were recorded during the launch period and the transonic region. Measurement A5020 indicated a mean of 1 g(rms) during launch and through the transonic region. Measurement A5030 recorded a mean g(rms) of 1.3 during launch and transonic region. The accelerometer on the pivot panel (A5040) displayed the most response indicating a mean level of 1.8 to 1.9 g(rms) at launch and 2.1 g(rms) in the transonic area. Predominant frequencies for the three accelerometers were between 130 cps and 690 cps during the steady-state periods. Except for the already indicated region, steady-state amplitudes remained below 0.5 g(rms) throughout the flight. Power spectral density computations are presented in Figure 14-15.

The pertinent time periods and/or event times with maximum vibration levels were as follows:

Event and/or Time Period	Meas. Number	Max g Level (pk-pk)	Frequency (cps)
Launch	A5020	2.5	130
	A5030	7	130
	A5040	11	500
Transonic	A5020	3.5	690
	A5030	5	140
	A5040	6.5	495
261.45 Sustainer Shutdown	A5020	2.5	33
	A5030	7	43
	A5040	3	20
397.64 R/V Separation	A5020	23	1800
	A5030	22	1800
	A5040	*	-
410.23 HIRS Positioning	A5020	5	1400
	A5030	5	1020
	A5040	41	840
414.33 HIRS Rockets Fire	A5020	6	Complex
	A5030	21	90
	A5040	*	-

* Measurement A5040 indicated amplifier saturation due to transients at these times.

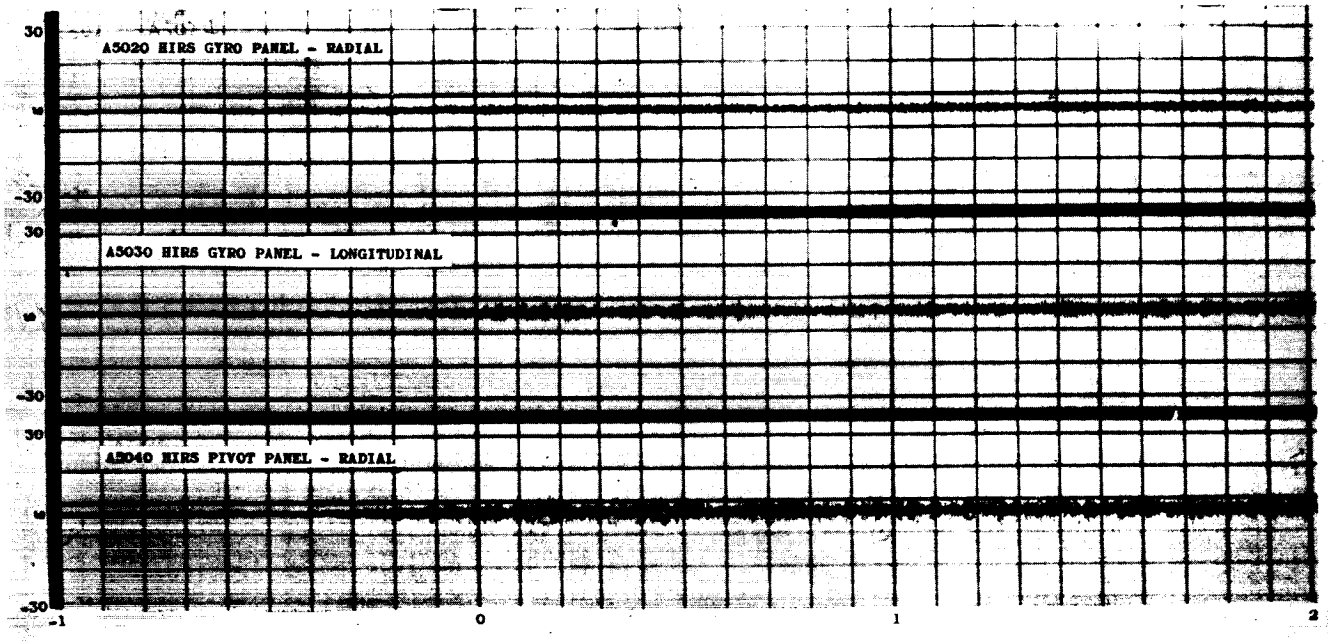
HIRS

FIGURE NO. 14-12

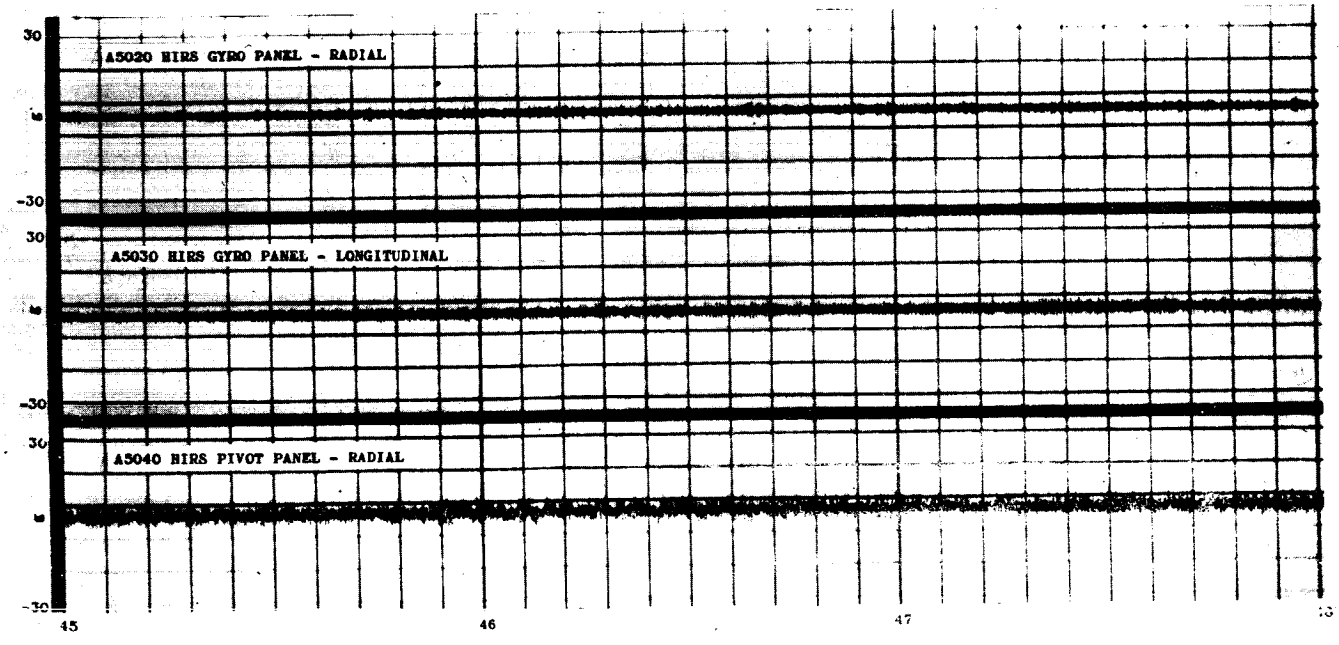
~~REPORT NO. GDA 63-1092~~ GD/A-DDE65-016

TELEMETERED DATA

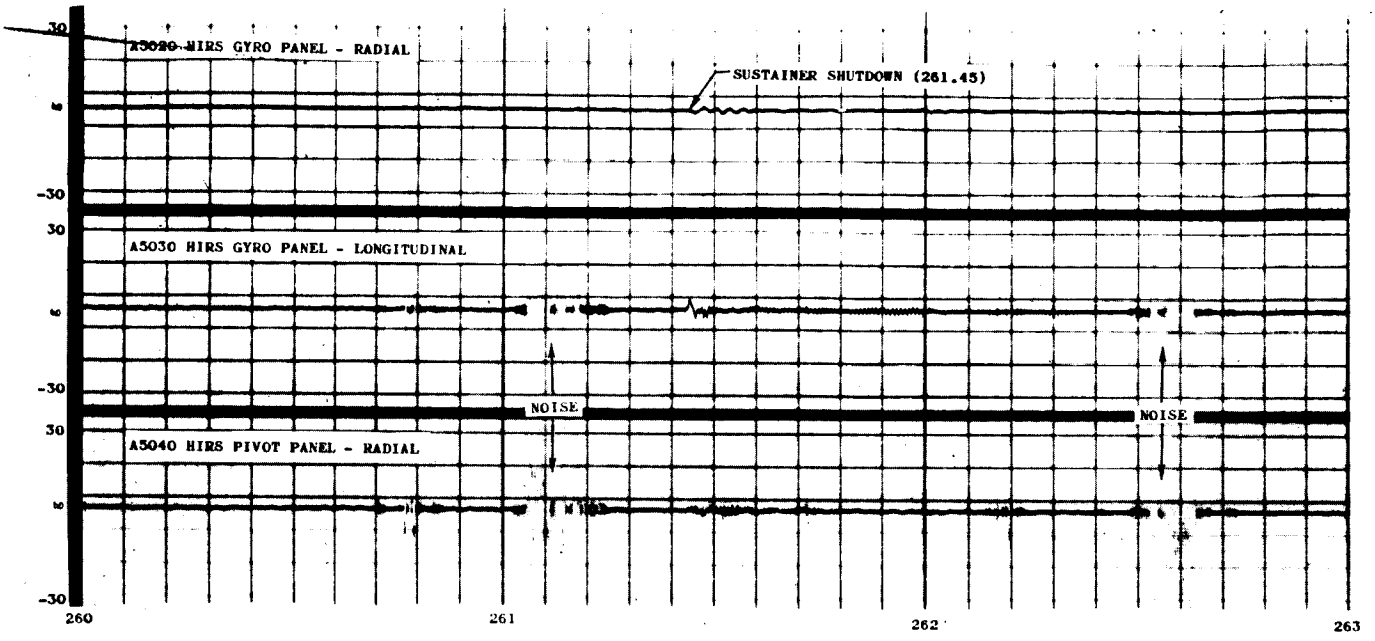
MISSILE 136F



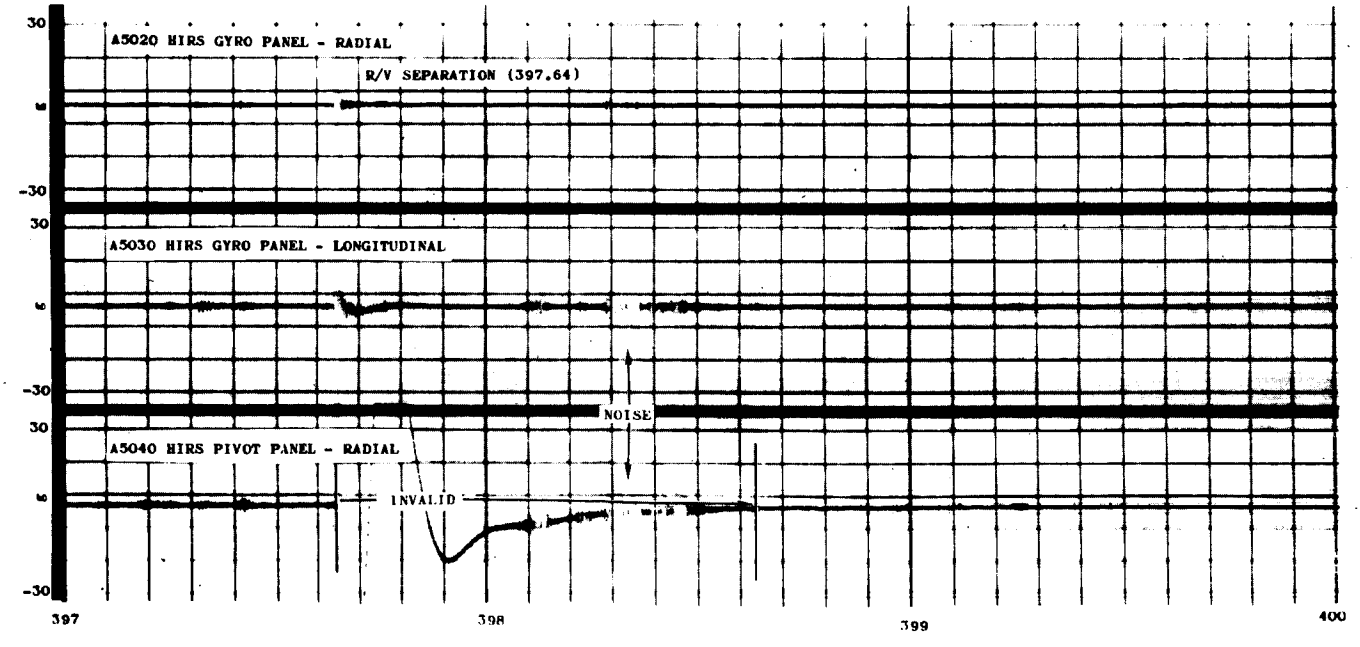
TIME IN SECONDS FROM 1-INCH MOTION



TIME IN SECONDS FROM 1-INCH MOTION



TIME IN SECONDS FROM 1-INCH MOTION



TIME IN SECONDS FROM 1-INCH MOTION

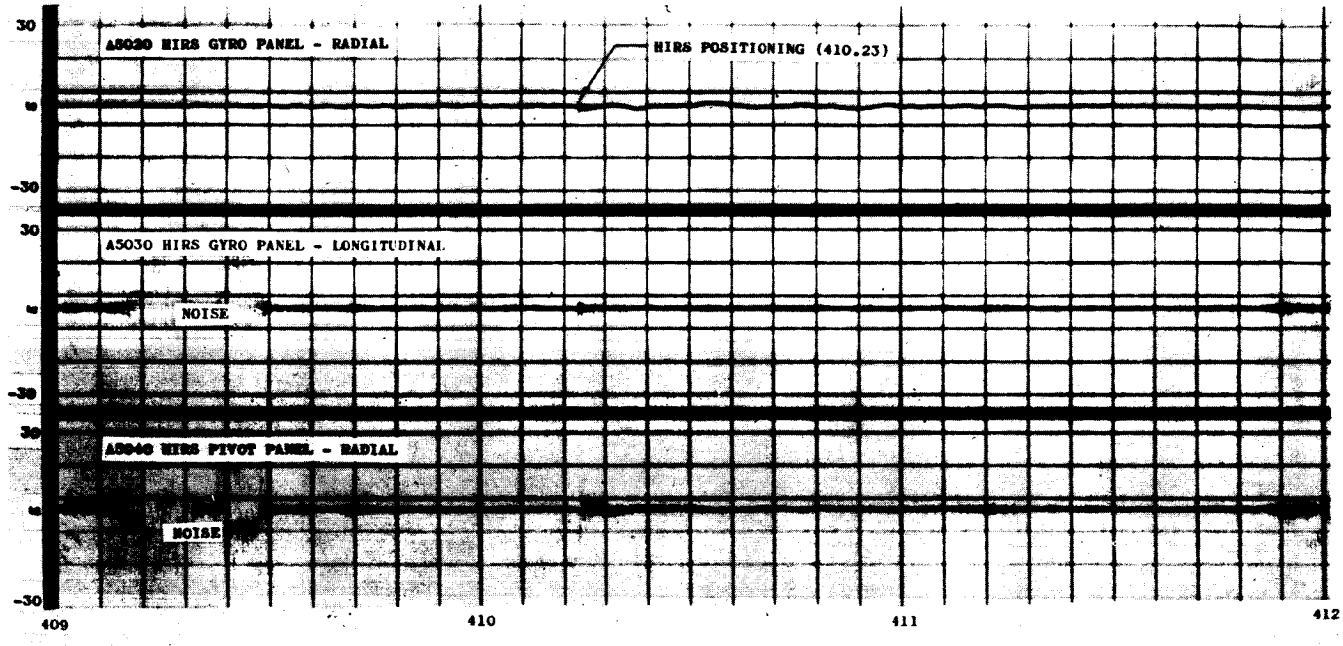
HIRS

FIGURE NO. 14-14

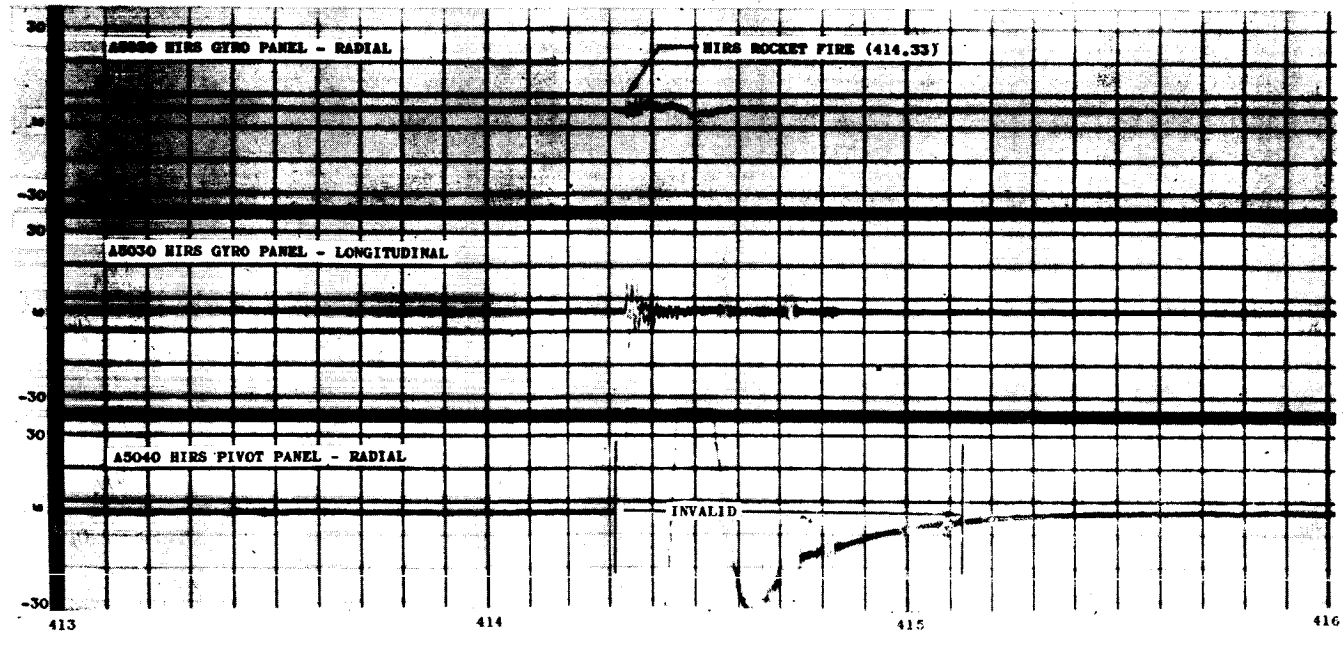
~~REPORT NO. GDA 63-1092~~ GD/A-DDE65-016

TELEMETERED DATA

MISSILE 136F



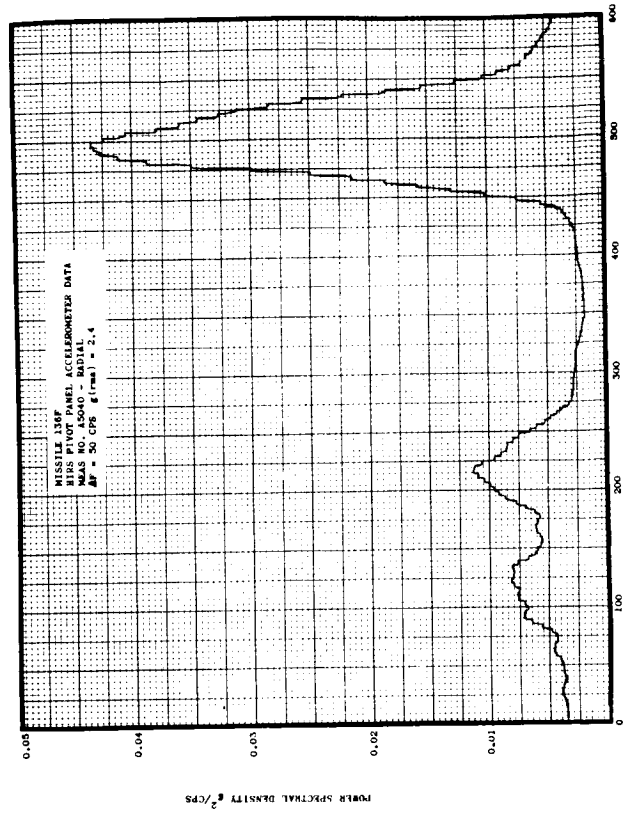
TIME IN SECONDS FROM 1-INCH MOTION

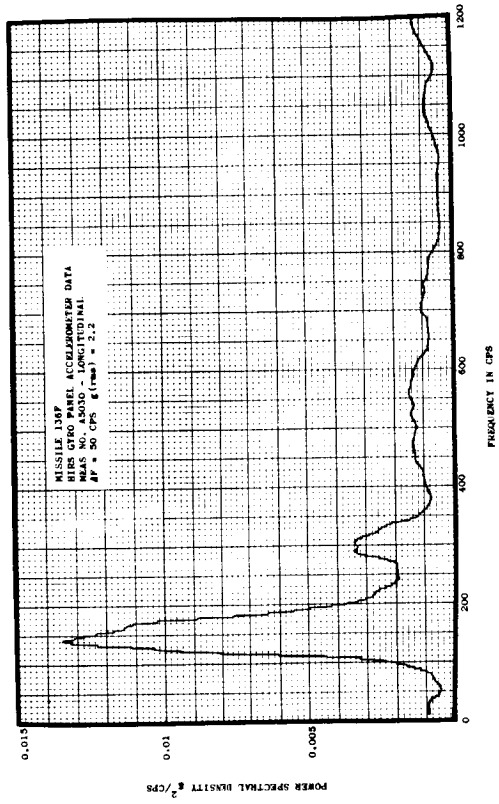


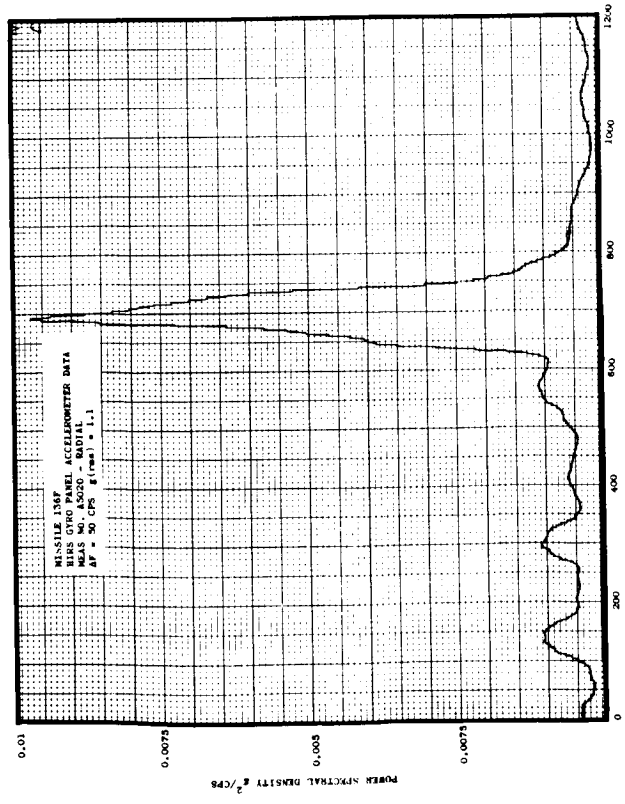
TIME IN SECONDS FROM 1-INCH MOTION

136F

MISSILE 136F







SECTION 6.2.25

MISSILE 5E (F)

FLIGHT TESTED 2-25-64

AT AMR COMPLEX 11

TEST REPORT GD/A-APZ64-018

5E(F)

Adapter Acoustic and Vibration Levels

The acoustic environment experienced to date has had no discernable detrimental effect upon the HIRS system or its components within the adapter.

One high intensity microphone (Model NM 125, manufactured by the Chesapeake Instrument Corporation) similar to those utilized on previous HIRS flights yielded valid data during the flight of Missile 5E. The Missile 5E acoustic noise levels were slightly greater than those experienced during the two previous HIRS flights (by approximately 4-7 db). Commutation of the data for the two previous flights precluded recovery of data for eight seconds of every 24 seconds; hence, an exact comparison of the noise levels for the specific events cannot be made. The peak sound pressure levels recorded for specific events of this flight are presented in the HIRS Adapter Acoustic and Vibration Environment Summary, on Page 21.

The vibration environment experienced to date has had no discernable deleterious effect upon the operation of the HIRS system or upon its components within the adapter.

Three accelerometers were mounted in the adapter section; a radial and a longitudinal vibration measurement of the HIRS gyro panel and a longitudinal vibration measurement of the pivot plate of the Quad II/III HIRS rocket, all of which yielded valid data. The vibration levels measured on the HIRS

rocket pivot plate were generally higher than that measured on the gyro panel. The vibration levels during the flight of Missile 5E were approximately the same as those experienced during previous flights.

The HIRS Adapter Acoustic and Vibration Environment Summary, on Page 21 presents a comparison of the levels experienced during the flight of Missile 5E with those of the previous HIRS flights.

Figures 12 though 14 present the oscillograph playbacks of the vibration data at the critical times presented in the HIRS Adapter Acoustic and Vibration Summary. Figure 15 presents the spectral density plots for the launch, transonic, and maximum dynamic pressure (Q) regions of flight. Time histories of the vibration and acoustic levels as determined by the Brüel and Kjar Analyzer are presented in Figure 16.

HIRS ADAPTER ACOUSTIC AND VIBRATION ENVIRONMENT SUMMARY

	Missile 136F	Missile 232D	Missile 233D	Missile 5E
Adapter Acoustic Environment (A505Y) - Sound Pressure Level (db)				
Launch	(1)	131	128	135
Transonic Region	(1)	123	123	128
R/V Separation	(1)	143	143	(2)
Rockets Positioning	(1)	(2)	(2)	129
Rockets Firing	(1)	(2)	(2)	(2)
Gyro Package Mount Vibration (A502Ø and A503Ø) - Acceleration (g-rms)/Frequency (cps)				
Launch - Radial Acceleration (A502Ø)	1.4/130	(2)	3.9/1030,655	1.5/520,160
- Longitudinal Acceleration (A503Ø)	1.9/130	(2)	4.2/310-780	1.9/180
Transonic - Radial	1.6/690	2.7/400,1650	3.2/730	1.8/520,180
- Longitudinal	1.7/140	3.2/400,1600	3.5/565	2.3/180
R/V Separation - Radial	8.1/1800	(2)	(2)	7.6/1500-1700
- Longitudinal	7.8/1800	(2)	(2)	9.2/1500-1700
Rockets Positioning - Radial	1.8/1400	(2)	(2)	2.6/1600-1800
- Longitudinal	1.8/1020	3.8/1650	3.9/595	3.3/1400-1600
Rockets Firing - Radial	2.1/Complex	23.2+/1900	4.6/540	8.9/70
- Longitudinal	7.4/90	(2)	(2)	17.7/70
Rocket Pivot Plate Vibration (A504Ø) - Radial Acceleration (g-rms)/Frequency (cps)				
Launch	3.9/500	(4)	(4)	3.1
Transonic Region	2.3/495	(4)	(4)	5.5
R/V Separation	(3)/ -	(4)	(4)	8.9
Rockets Positioning	14.5/840	(4)	(4)	13.4
Rockets Firing	(3)/ -	(4)	(4)	(3)

Notes:

(1) Measurement A505Y was invalid throughout the flight of Missile 136F.
(2) Data not recorded for this measurement due to being commutated with the other HIRS acoustic and/or vibration measurements at one-eight rps.
(3) Data indicated amplifier saturation due to transients at these times.
(4) Not instrumented for this flight.

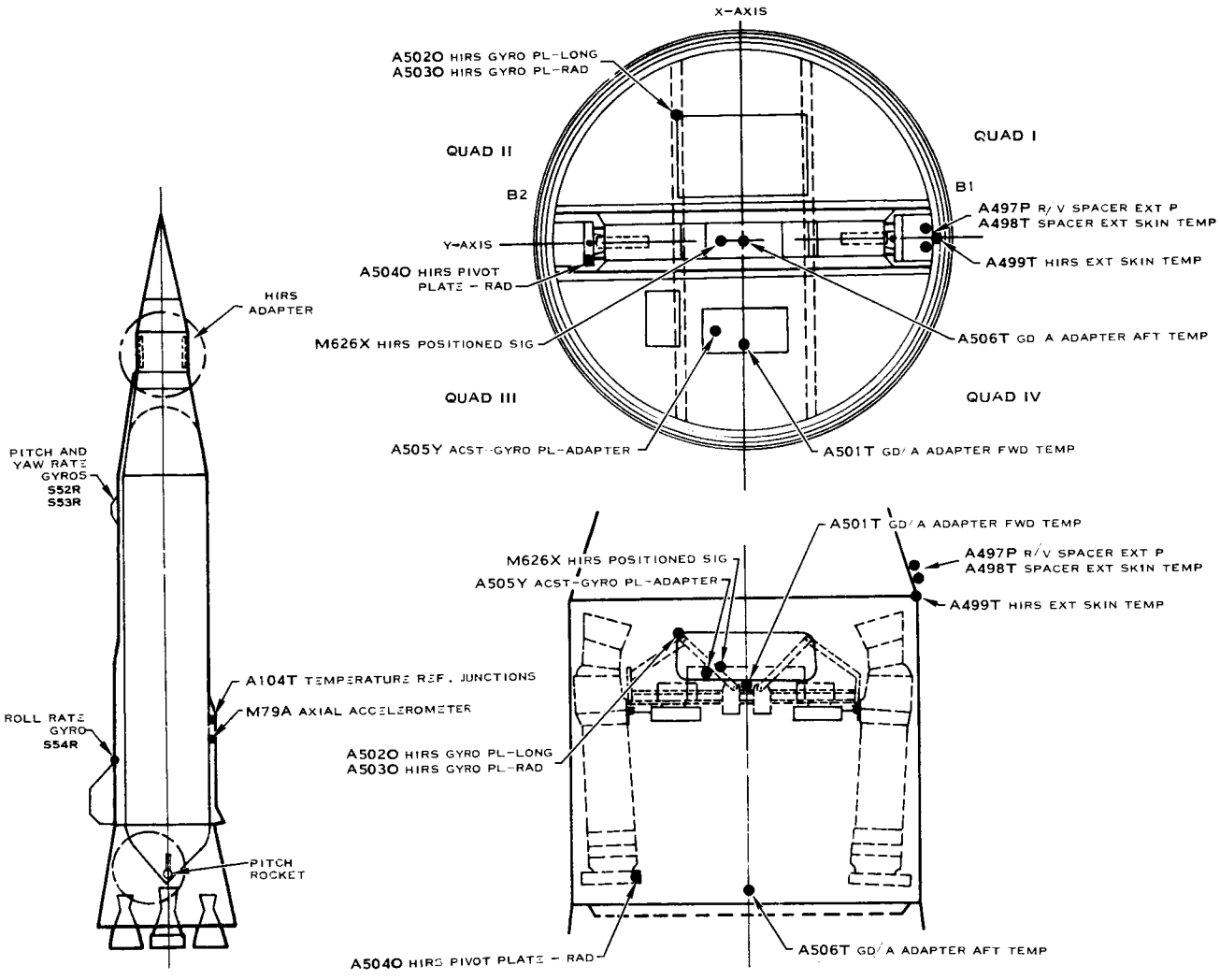


Figure 1. HIRS Equipment and Instrumentation Locations

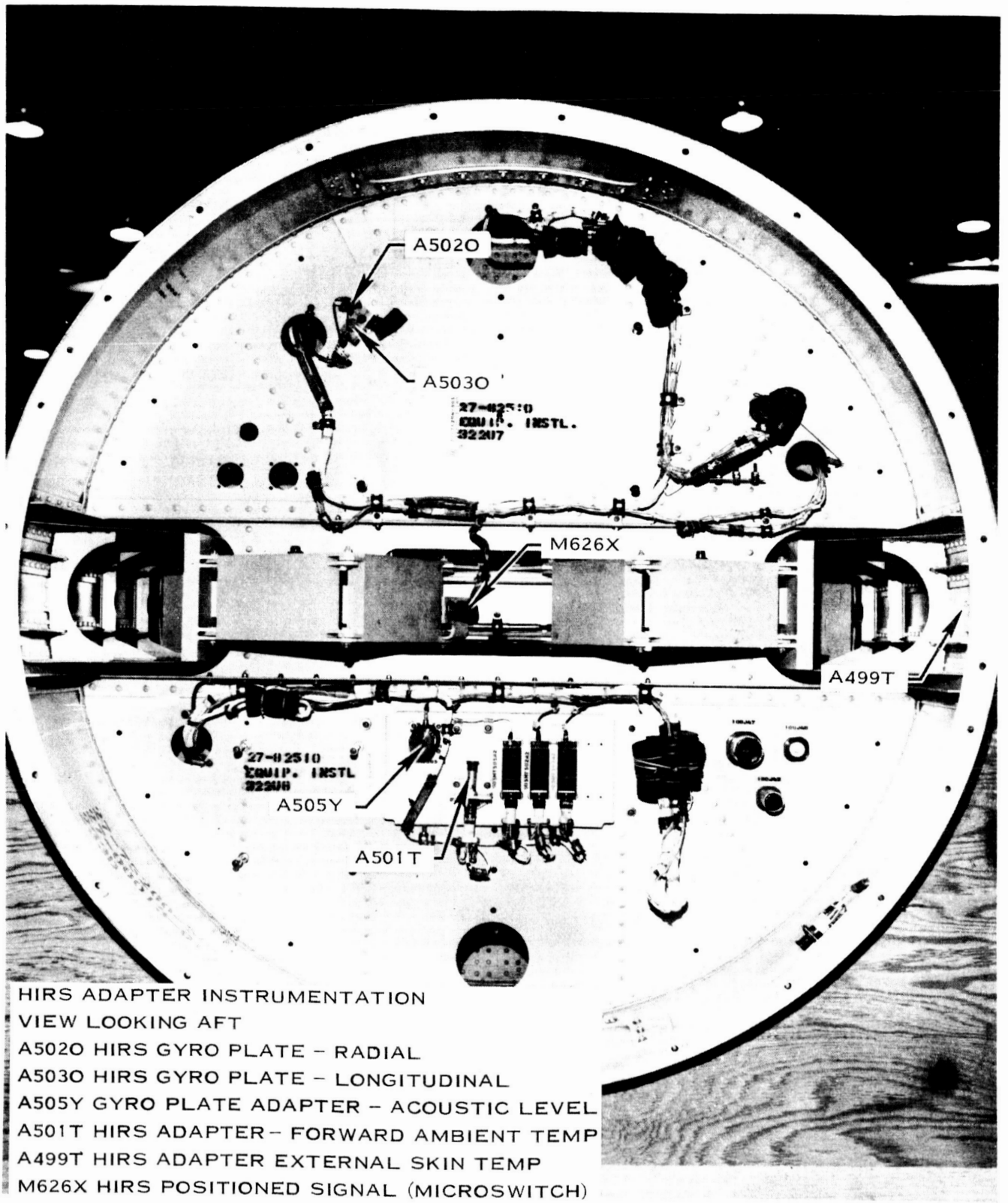


Figure 3. HIRS Adapter Instrumentation and Rocket Positioning Mechanism

5E(F)

MISSILE 5E(F)

VIEW OF MICROSWITCH M626X
LOOKING AFT
M626X ACTIVATES WHEN POSITIONING
MECHANISM ARM STARTS TO MOVE
ALSO SHOWN ARE THE CABLE CUTTERS
AND MICROPHONE A505Y (COVER INSTALLED)



Figure 4. HIRS Adapter Instrumentation and Rocket Positioning Mechanism

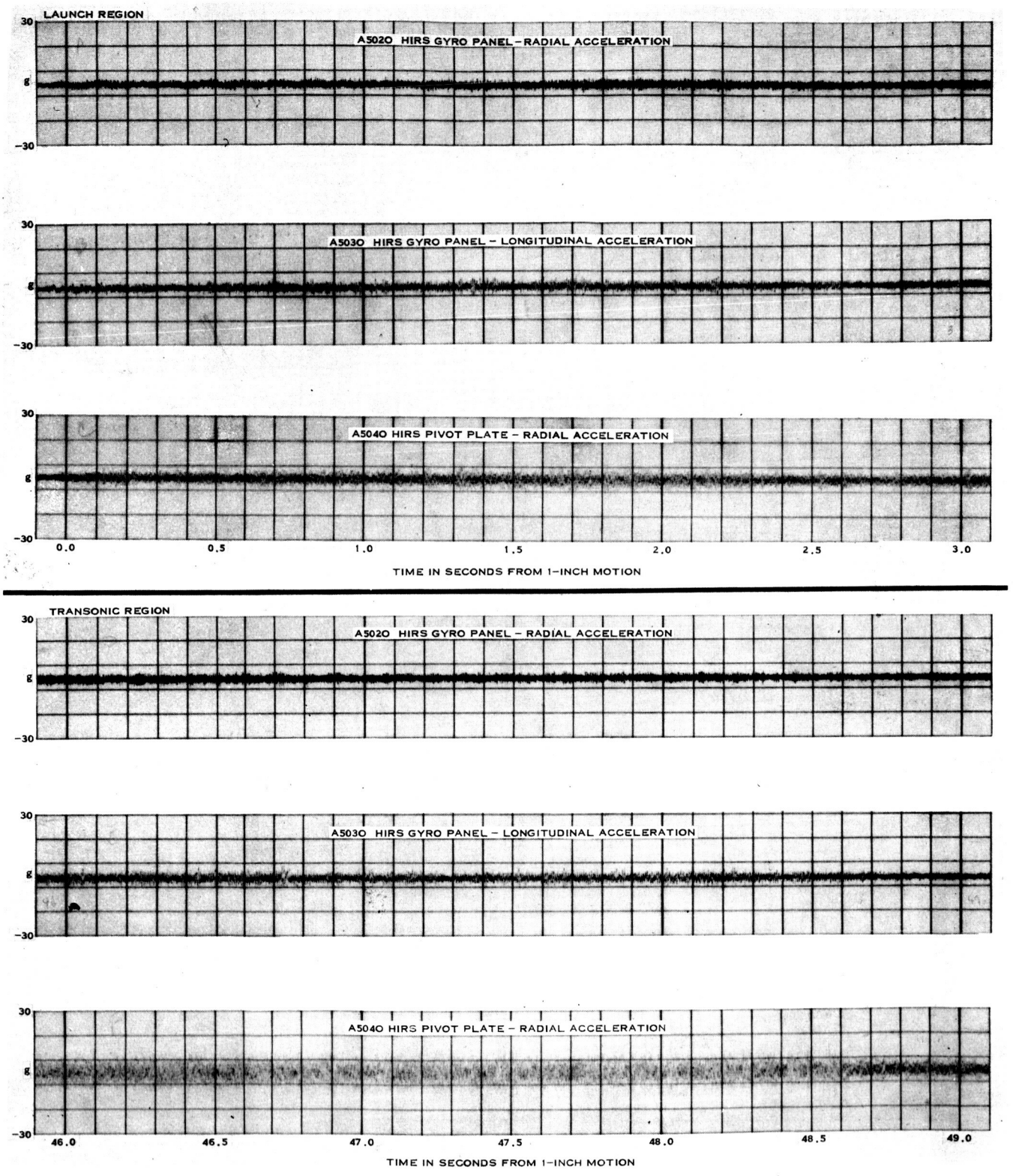
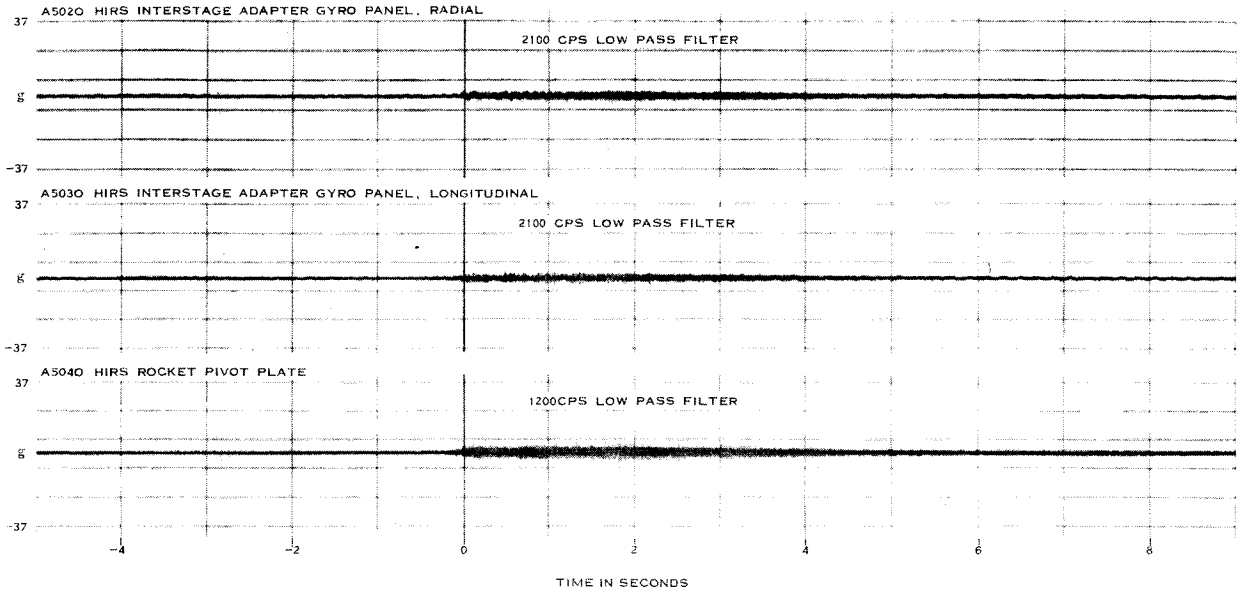
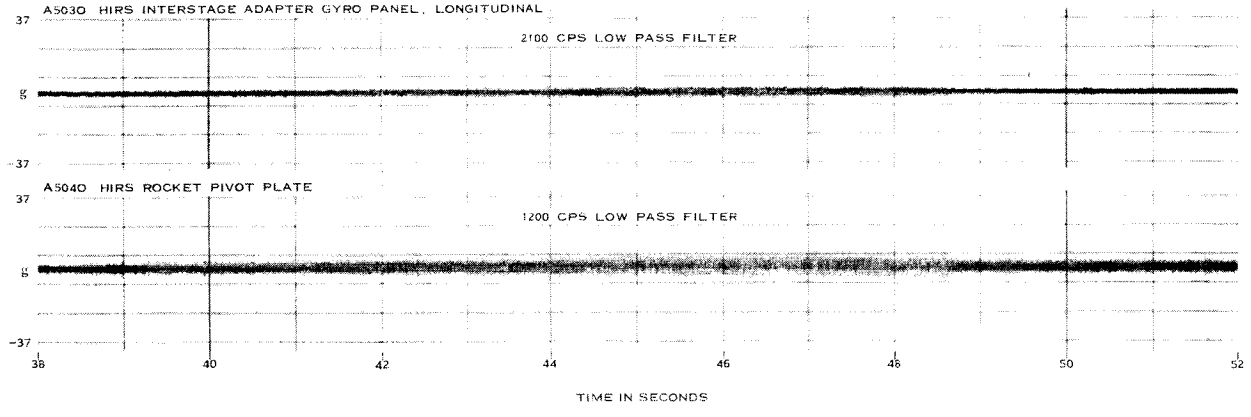


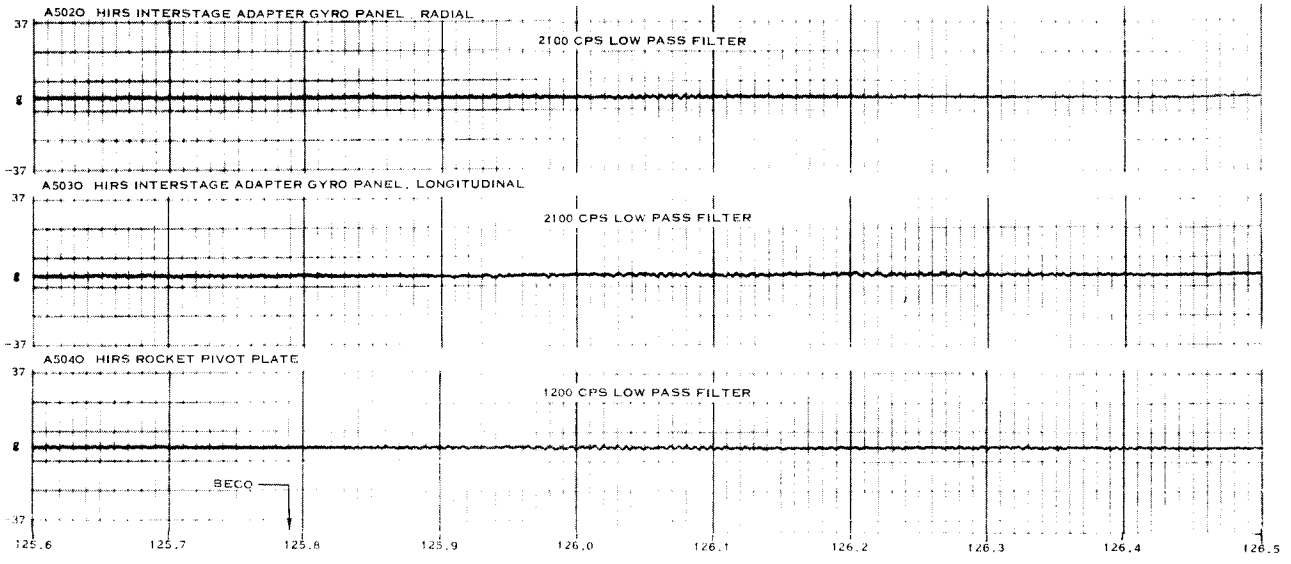
Figure 12. Vibration and Acoustic Data - Transient Conditions

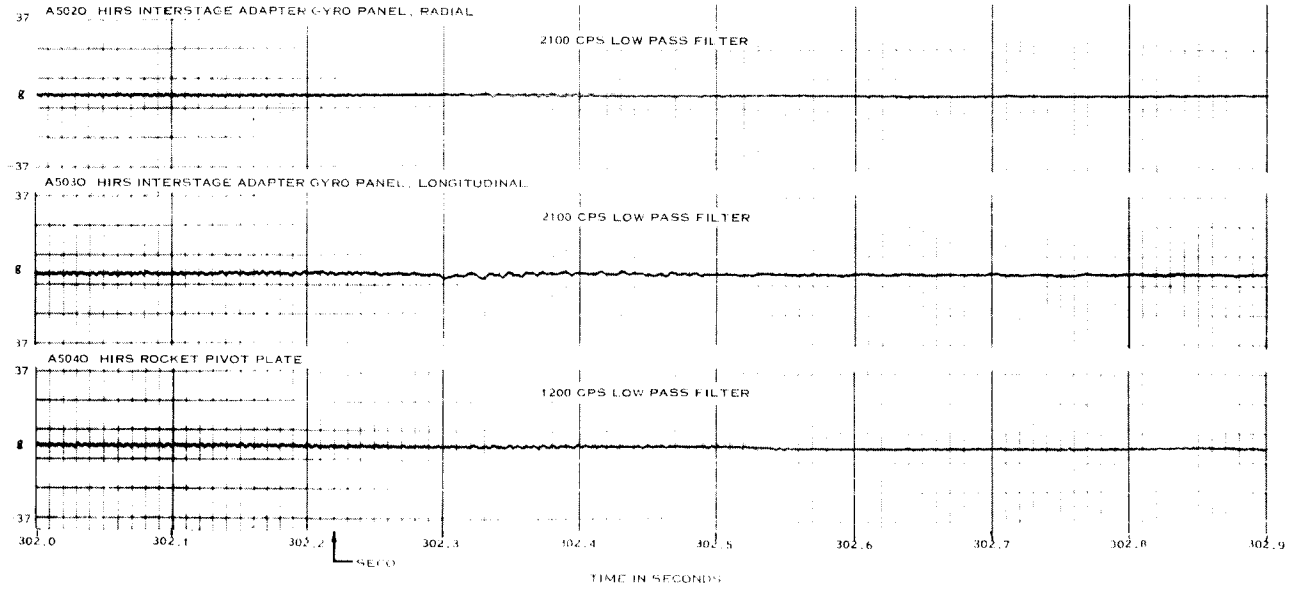
VIBRATION WAVEFORM
MISSILE 5E(F)





VIBRATION WAVEFORMS
MISSILE 5E(F)
BECO, SECO EXCITATION





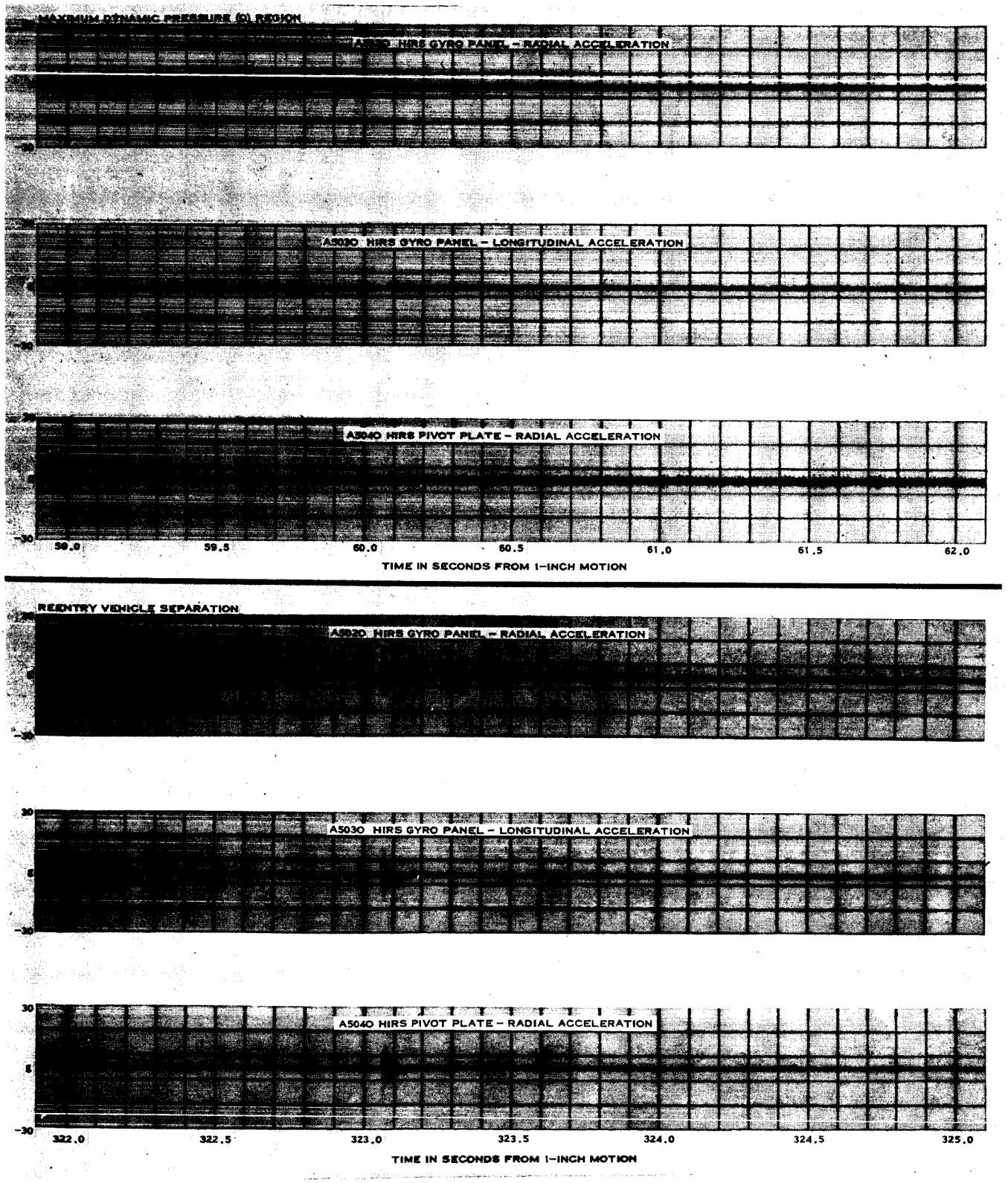


Figure 13. Vibration and Acoustic Data - Transient Conditions

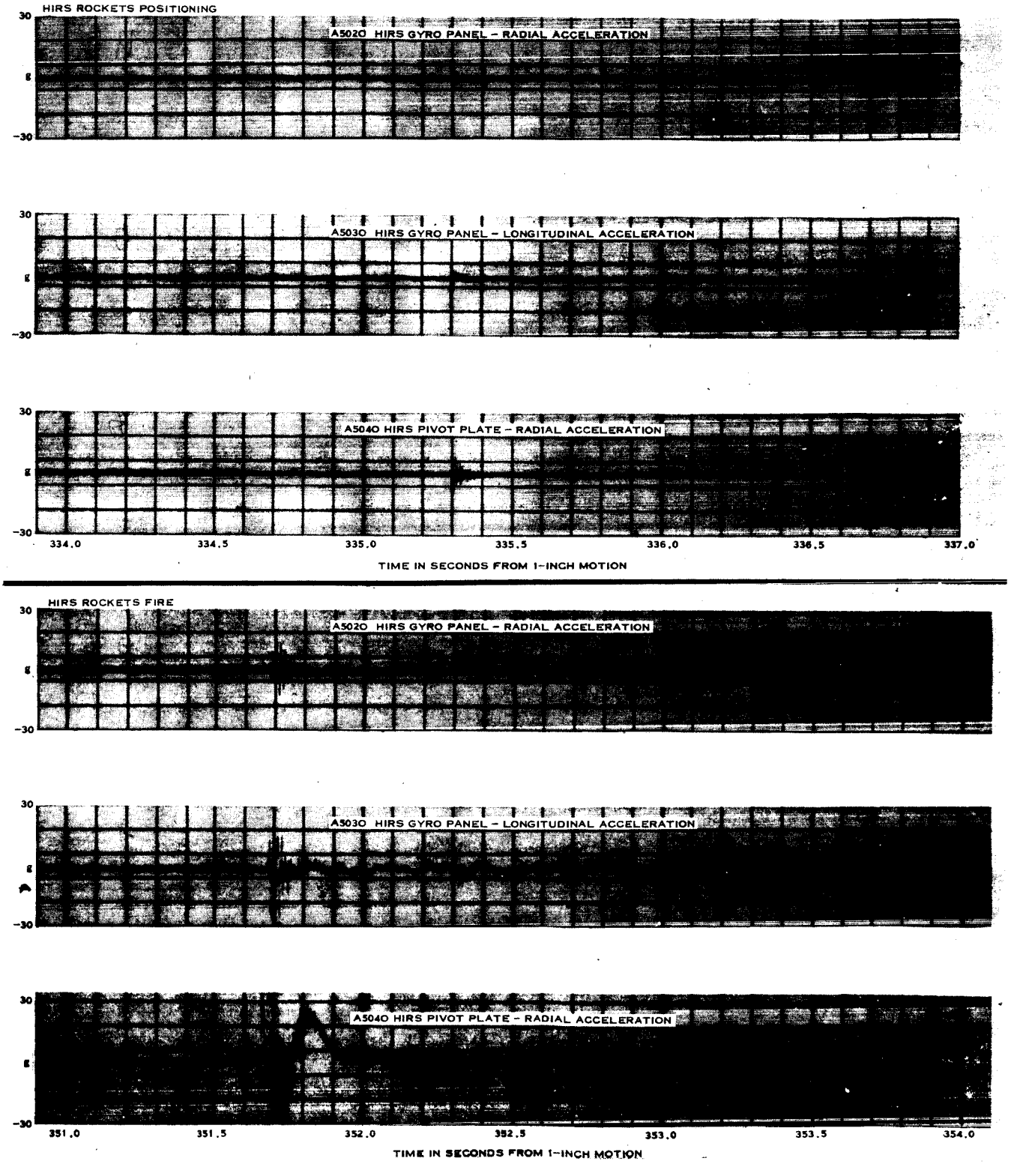


Figure 14. Vibration and Acoustic Data - Transient Conditions

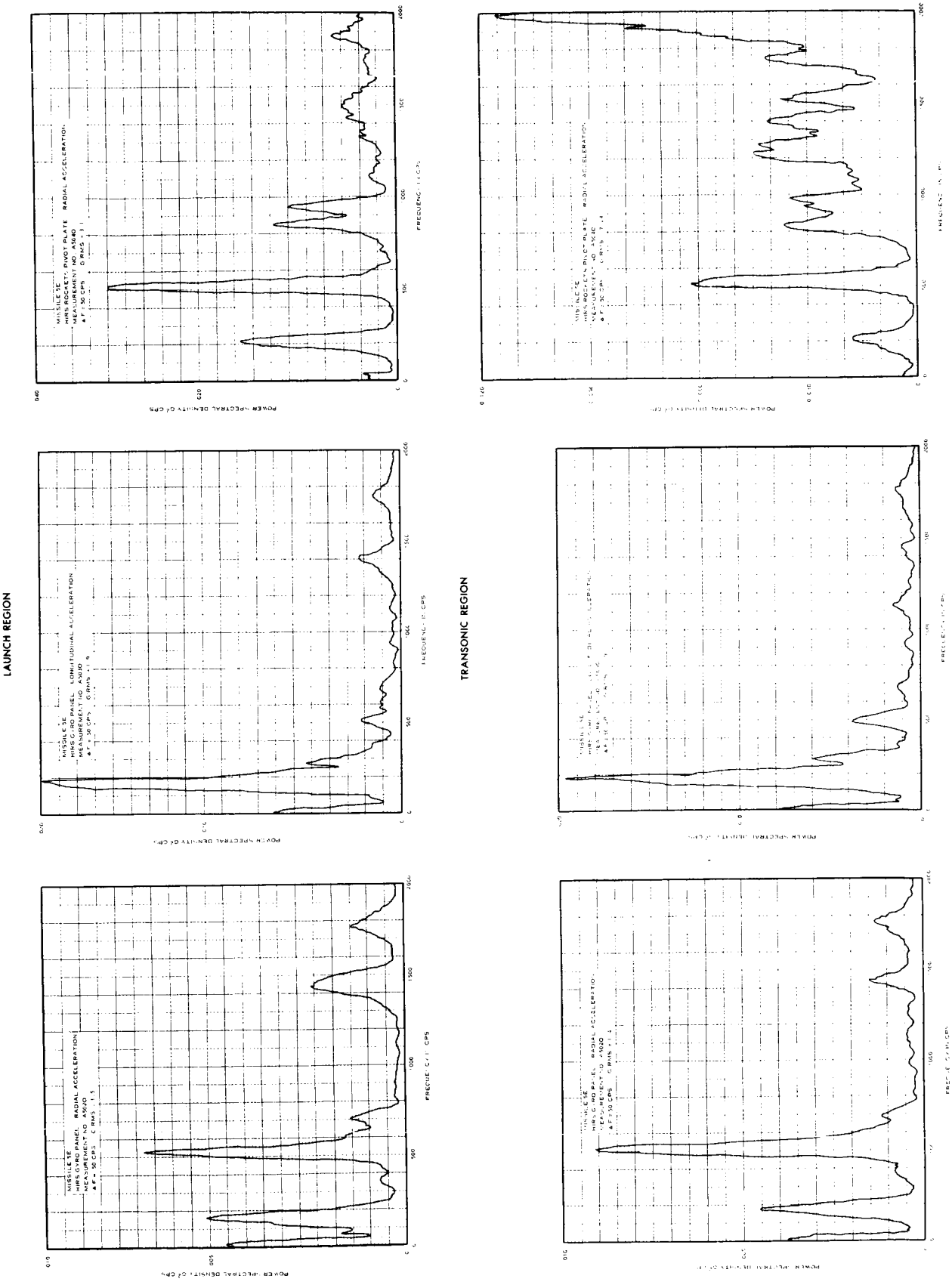


Figure 15. Vibration and Acoustic Data - Spectral Analysis

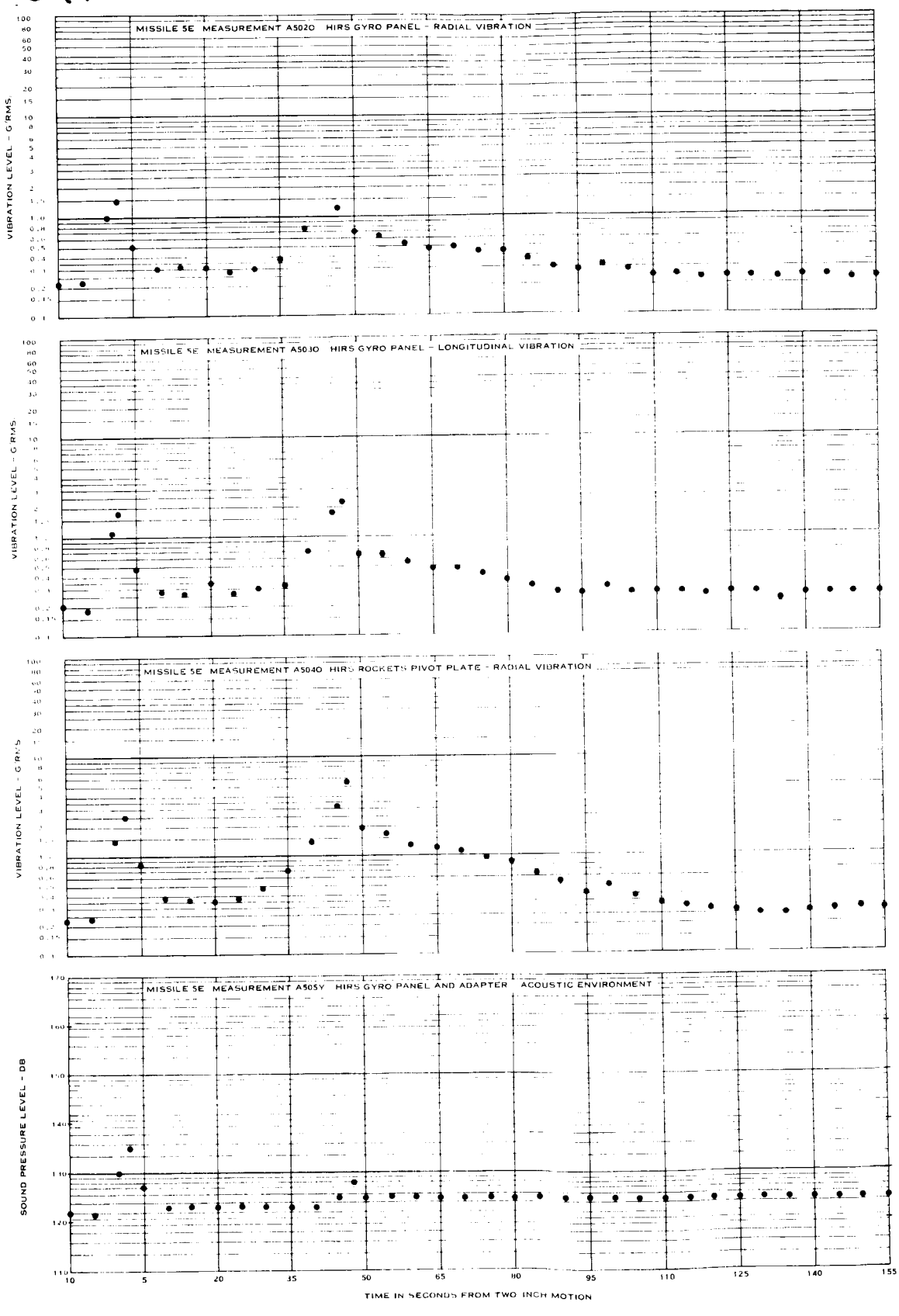


Figure 16. Vibration and Acoustic Data - Time Histories

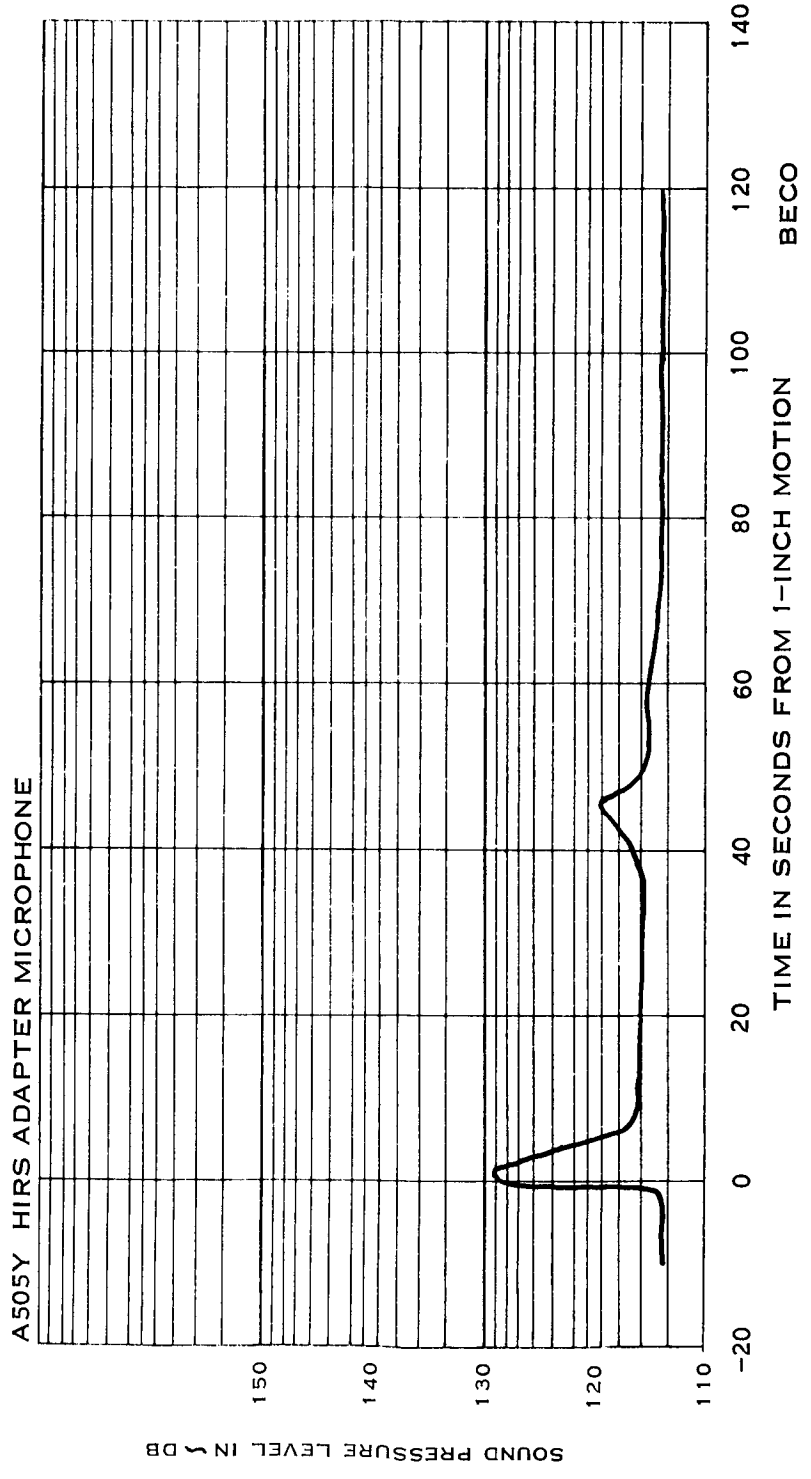
SECTION 6.2.26

MISSILE 137F

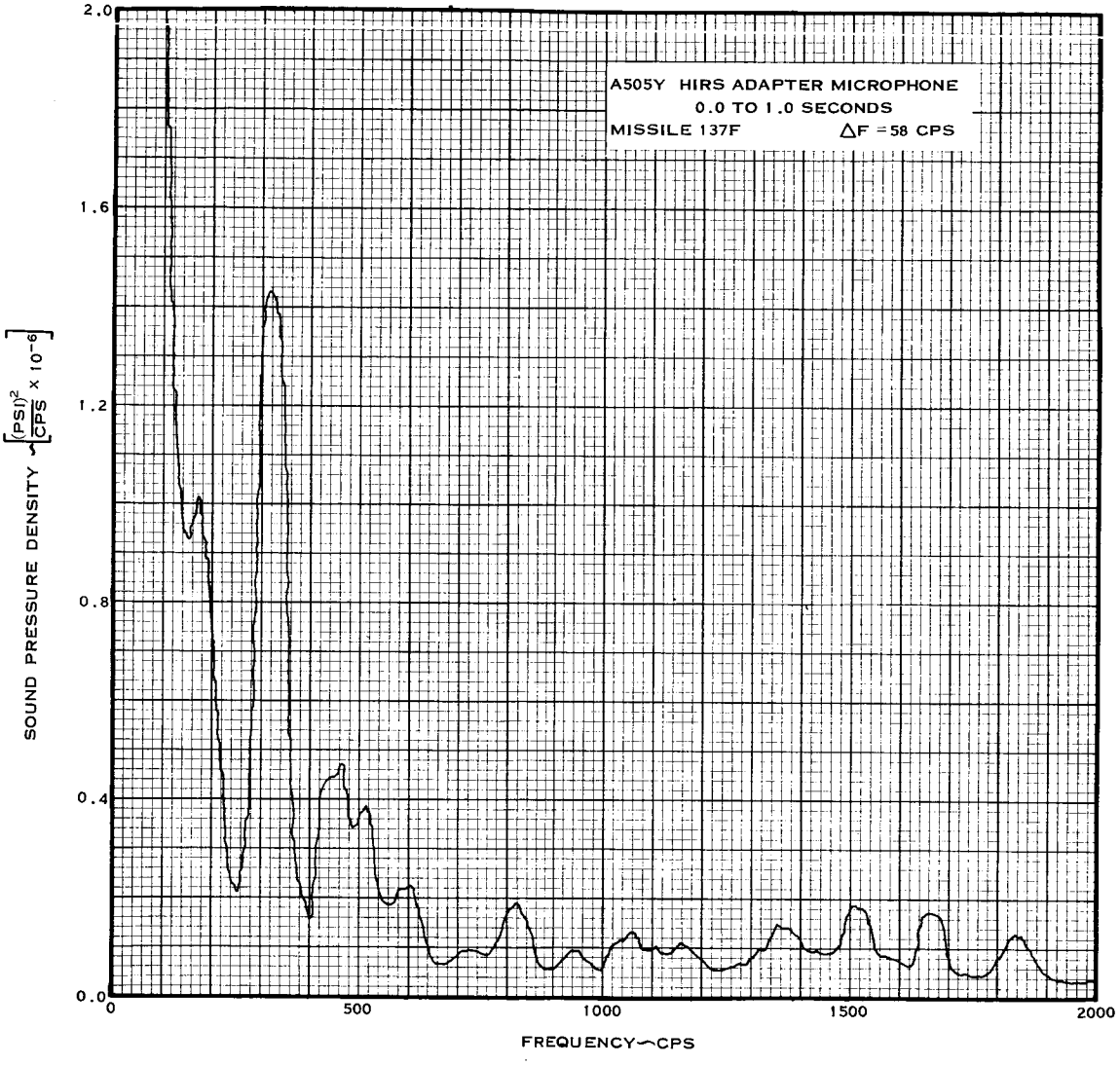
FLIGHT TESTED 4-1-64

AT AMR COMPLEX 11

SOUND PRESSURE HISTORY
SPL VS TIME
MISSILE 137F
2100 CPS LOW PASS FILTER



ACOUSTIC DATA
MISSILE 137F
HIRS ADAPTER



ACOUSTIC DATA
MISSILE 137F
HIRS ADAPTER

