

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Report 32-1185

Mariner Venus 67 Dynamic Flight Data

D. O. Brand

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JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

March 15, 1968

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Mariner Venus 67 Dynamic Flight Data

D. O. Brand

Approved by:

A handwritten signature in dark ink, appearing to read "W. S. Shipley", is written over a horizontal line.

W. S. Shipley, Manager
Environmental Requirements Section

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TECHNICAL REPORT 32-1185

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Preface

This report was prepared by D. O. Brand, Sperry Rand Corporation, under a contract with the Jet Propulsion Laboratory. Communications regarding the report or its subject matter should be directed to David B. Wiksten, Environmental Requirements Section, Jet Propulsion Laboratory, who supervised its preparation.

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Abstract

The dynamic flight environment of the *Mariner V* (Venus 1967) spacecraft is analyzed. Six environmental measurements were taken; data were obtained from two microphones attached to the launch complex umbilical tower, two microphones attached to the umbilical boom, and two accelerometers, one mounted on the spacecraft itself and one on the adapter ring. Recorded data from those transducers have been analyzed and are presented as oscillograms, power spectra, and shock spectra. The recorded data were of usable quality; however, recommendations are made to improve the signal-to-noise ratio and to provide more measurement locations on future spacecraft. The reduced data are compared with data obtained from *Mariners III* and *IV* and with ground test data. Results indicated that the *Mariner V* flight environment was comparable to those of previous *Mariners* and that the ground random vibration test levels were adequate. The ground pyrotechnic test appeared adequate; however, a less rigid spacecraft support is recommended during future pyrotechnic tests.

Mariner Venus 67 Dynamic Flight Data

I. Introduction

This report summarizes the dynamic data acquired from shortly before lift-off through spacecraft separation for the *Mariner V* (Venus 1967) mission. Lift-off acoustic conditions outside the spacecraft shroud were measured by four microphones located near the spacecraft on the launch tower and boom, and the data were recorded by ground instrumentation. The response of the spacecraft to the dynamic environment was measured by two accelerometers, one on the spacecraft and one on the adapter ring, and was telemetered by the transmitter aboard the *Agena* vehicle.

The instrumentation and the analysis techniques used to obtain the reduced data are described in detail. Included are descriptions of the telemetry system and discussions and illustrations defining the flight and ground instrumentation. The limitations of these systems are presented and discussed. The data analysis techniques and the particular purpose of each are discussed.

The *Mariner V* data are presented and discussed in Section IV. A comparison of *Mariner V* data with *Mariner III*, *Mariner IV*, and ground test data is presented and discussed in Section V.

II. Instrumentation

A. Flight Telemetry System

The flight instrumentation for the *Mariner V* spacecraft consisted of two accelerometers located as follows:

- (1) A high-frequency accelerometer (Endevco Model No. 2217) designated F4 was mounted on the adapter ring as shown in Figs. 1 and 2.
- (2) A high-frequency accelerometer (Endevco Model No. 2217) designated B3 was mounted on the spacecraft's main structure. The general location of B3 is approximately below the solar panel monoball support as shown in Fig. 3. The precise location of B3 is more clearly shown in Fig. 4.

The data from these accelerometers were transmitted to ground stations via the FM/FM telemetry system using channels 17 and 18 of the standard Inter-Range Instrumentation Group (IRIG) 18-channel system of the *Agena*. The transducer signal for each channel was used to deviate a voltage-controlled oscillator (VCO) from its subcarrier center frequency to a maximum of 7.5% deviation from that frequency. The summed subcarriers were



Fig. 1. Adapter instrumentation

transmitted on the 244.3-MHz-modulated carrier to the ground stations, where the carrier was demodulated and the subcarrier information was recorded directly. During playback, the original data signal was discriminated from the subcarrier and presented for analysis.

The bandwidth of channels 17 and 18 for a standard IRIG system is shown in Table 1. Past experience (Ref. 1) indicates that these channels are capable of approximately three times the standard bandwidth when the data are analyzed with a three-times-IRIG discriminator filter. Therefore, all *Mariner V* data in this report were reduced with approximately three-times-IRIG low-pass discriminator filters. Table 1 indicates the resulting increase in bandwidth and the probable error associated with the measurement.

Before digital data reduction, all *Mariner V* data used to generate acceleration spectral density (ASD) plots (un-

less otherwise specified) were also conditioned through a 2500-Hz low-pass filter to eliminate aliasing.¹ The characteristics of the filter were -6 dB at 2500 Hz and

¹A frequency-shifting phenomenon occurring in the analog-digital conversion process.

Table 1. Telemetry channel descriptions

Chan- nel No.	Measurement	JPL No.	Information bandwidth, Hz		Nominal band-edge calibra- tion, g
			Std IRIG	Extended range	
17	Spacecraft bus axial acceleration	B3	790	2100	± 20
18	Spacecraft adapter axial acceleration	F4	1050	3000	± 30

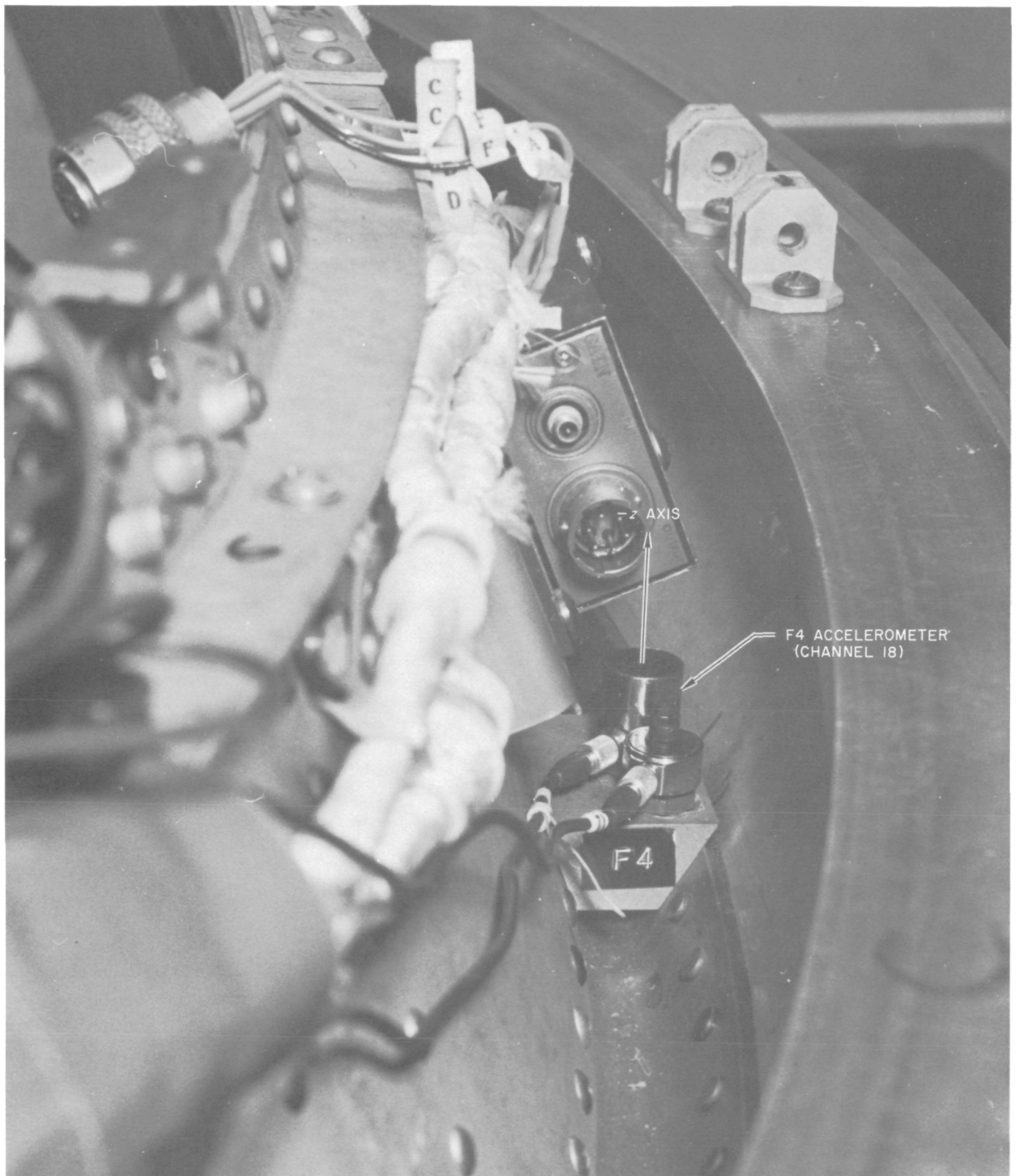


Fig. 2. Adapter instrumentation (detail)

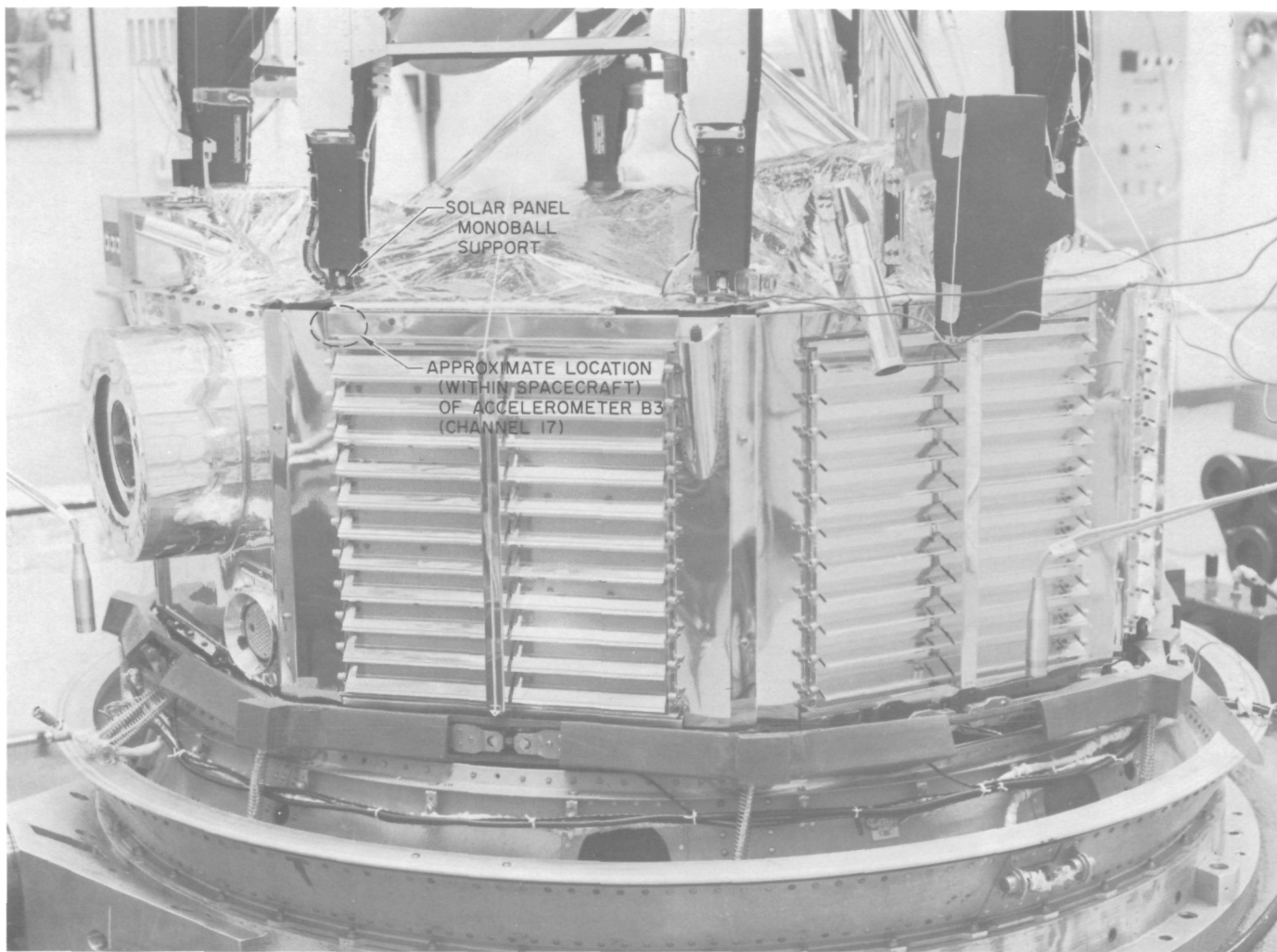


Fig. 3. Spacecraft bus configuration

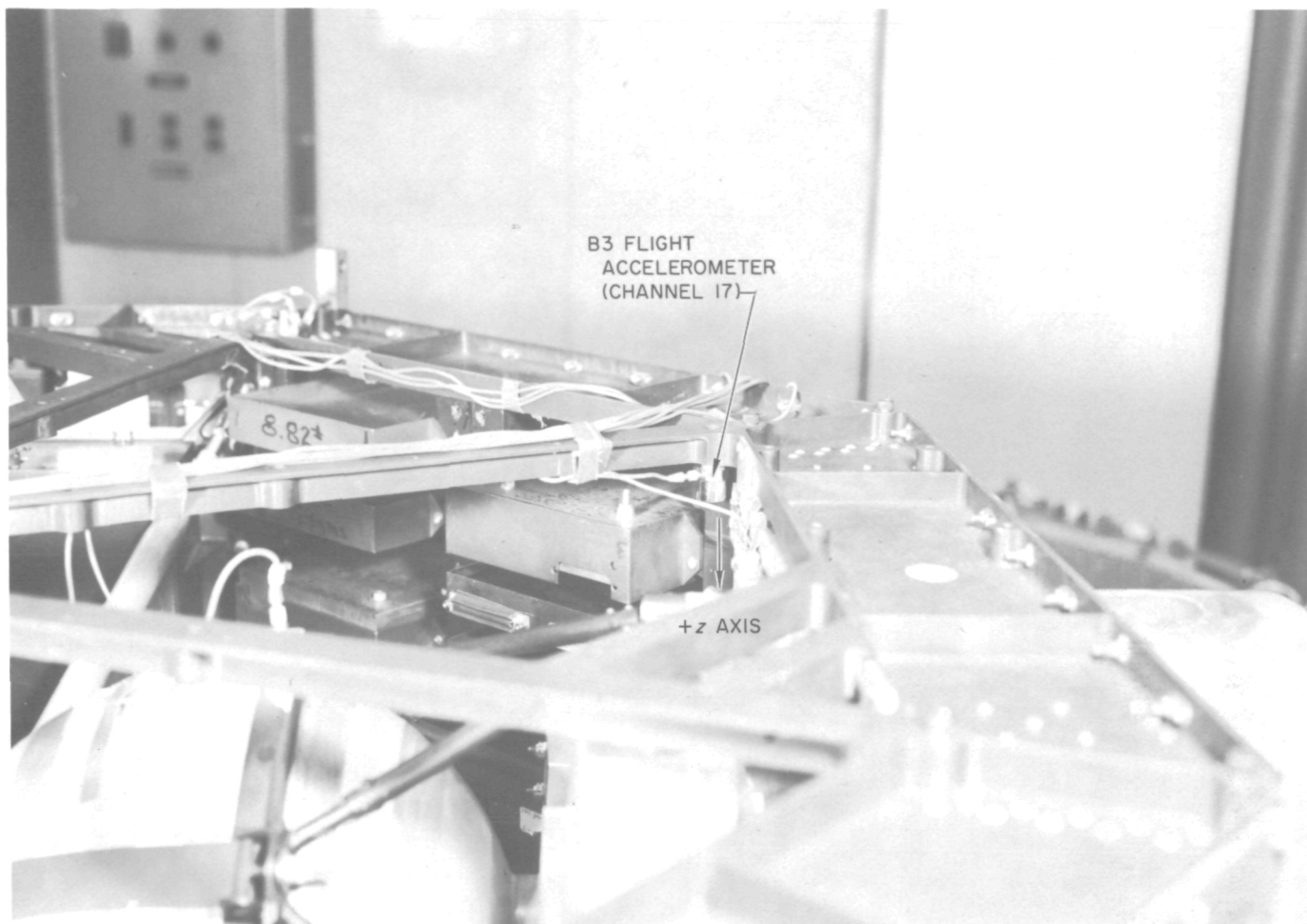


Fig. 4. Spacecraft bus configuration (detail)

-72 dB/octave above 2500 Hz. The resulting overall frequency response for the ASD data, including both aliasing and IRIG filters, is shown in Fig. 5. All other data were reduced without the aliasing filter, and therefore some differences were noted in comparing the data. These are discussed in Section IV.

On *Mariners III* and *IV*, channels 17 and 18 were dual-purpose channels and were switched to "spacecraft separation rate monitor" before spacecraft separation. Therefore, the transient acceleration data associated with spacecraft separation were not available. The dual-purpose feature for channels 17 and 18 was deleted for *Mariner V*, and the spacecraft separation transient data were recovered.

The nominal band-edge calibration for channel 17 was ± 20 g peak and for channel 18 was ± 30 g peak. These values were selected because the peak value had to be low enough to provide a reasonable signal-to-noise ratio

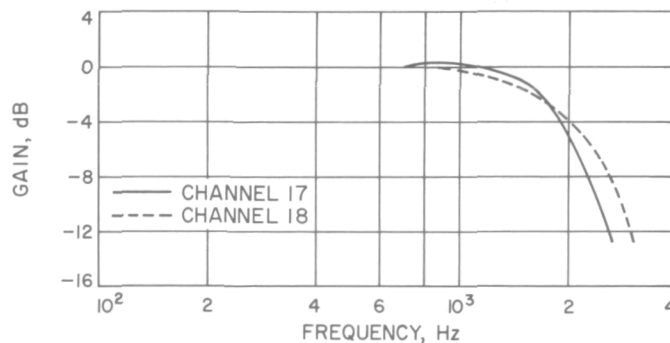


Fig. 5. System response (telemetry, playback, and analysis systems)

during the low-level random vibration period, and yet high enough to recover most of the high-level transient responses. The tracking time of the various ground stations and the sequence and time of pertinent events are shown in Fig. 6.

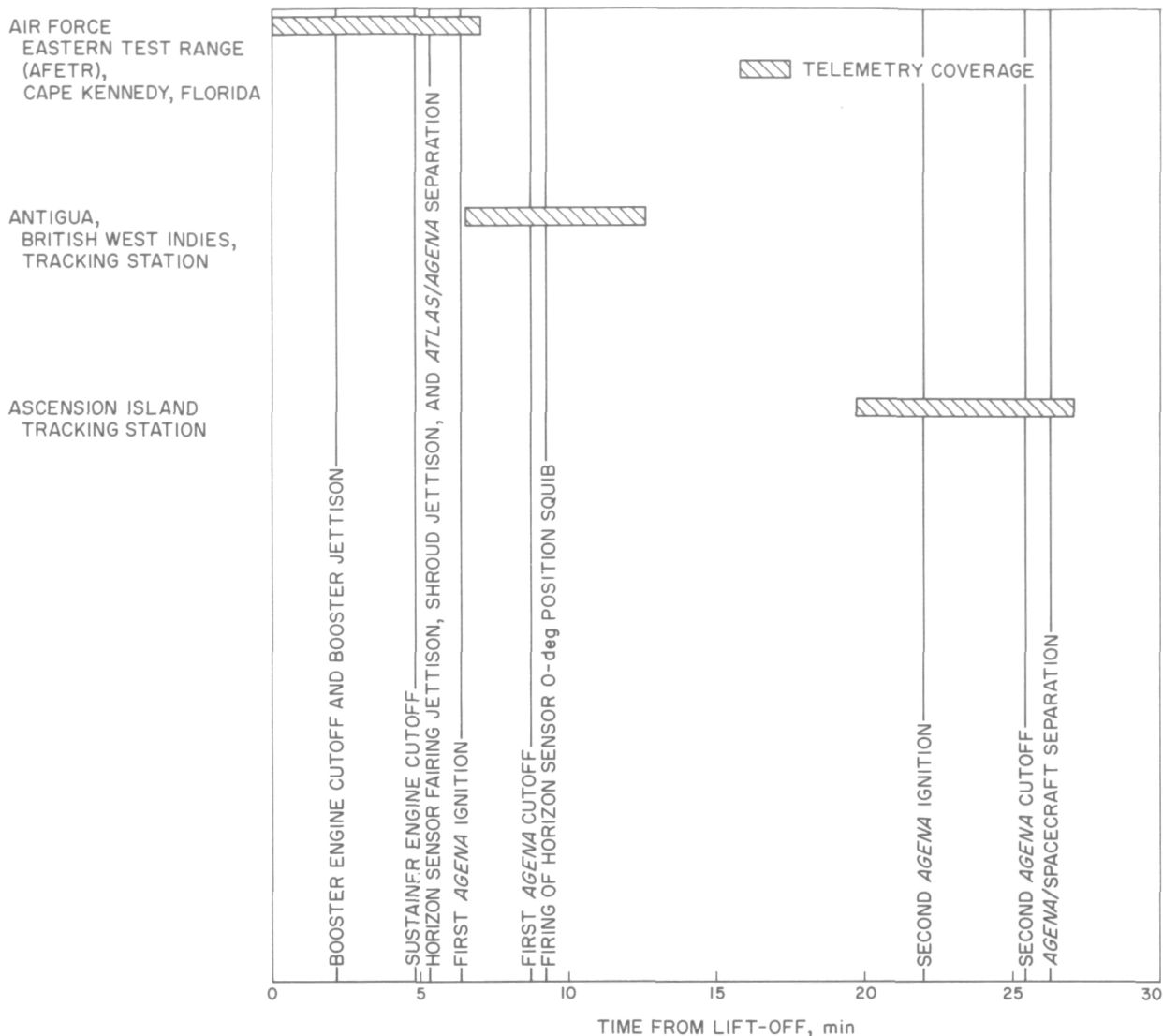


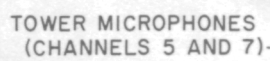
Fig. 6. Tracking station telemetry coverage and events. (All three stations are part of the AFETR. However, when the identification "AFETR" is used in this report, the Cape Kennedy station is the one referred to.)

B. Launch Pad Acoustic Instrumentation

The launch pad was equipped with two redundant pairs of microphones to record the acoustic field near the spacecraft during ignition and lift-off. Two microphones were mounted on the umbilical tower as shown in Figs. 7 and 8 and two were mounted on the boom as shown in Fig. 9. A detailed sketch showing the instrumentation location relative to the vehicle is shown in Fig. 10. All microphones were B and K Model NM 125 with Endevco 2609 amplifiers. To provide a wide dynamic range, each microphone output was recorded on two channels, one calibrated for 150 dB ref 2×10^{-4} μ bar and the other calibrated for 160 dB, full-scale output. In this report, data from the higher-level channels were analyzed.

The location of the tower microphones for *Mariner V* was identical to the location of the tower microphones for *Mariners III* and *IV*. There were no boom microphones on *Mariner III* or *IV*, although there were microphones near the ground.

The acoustic data were recorded on a standard wide-band FM recorder at a tape speed of 30 ips. The instrumentation system frequency response was flat to approximately 10 kHz, but the range utilized in this report was limited to less than 3 kHz since the data from previous flights indicated that most of the acoustic energy was at lower frequencies.



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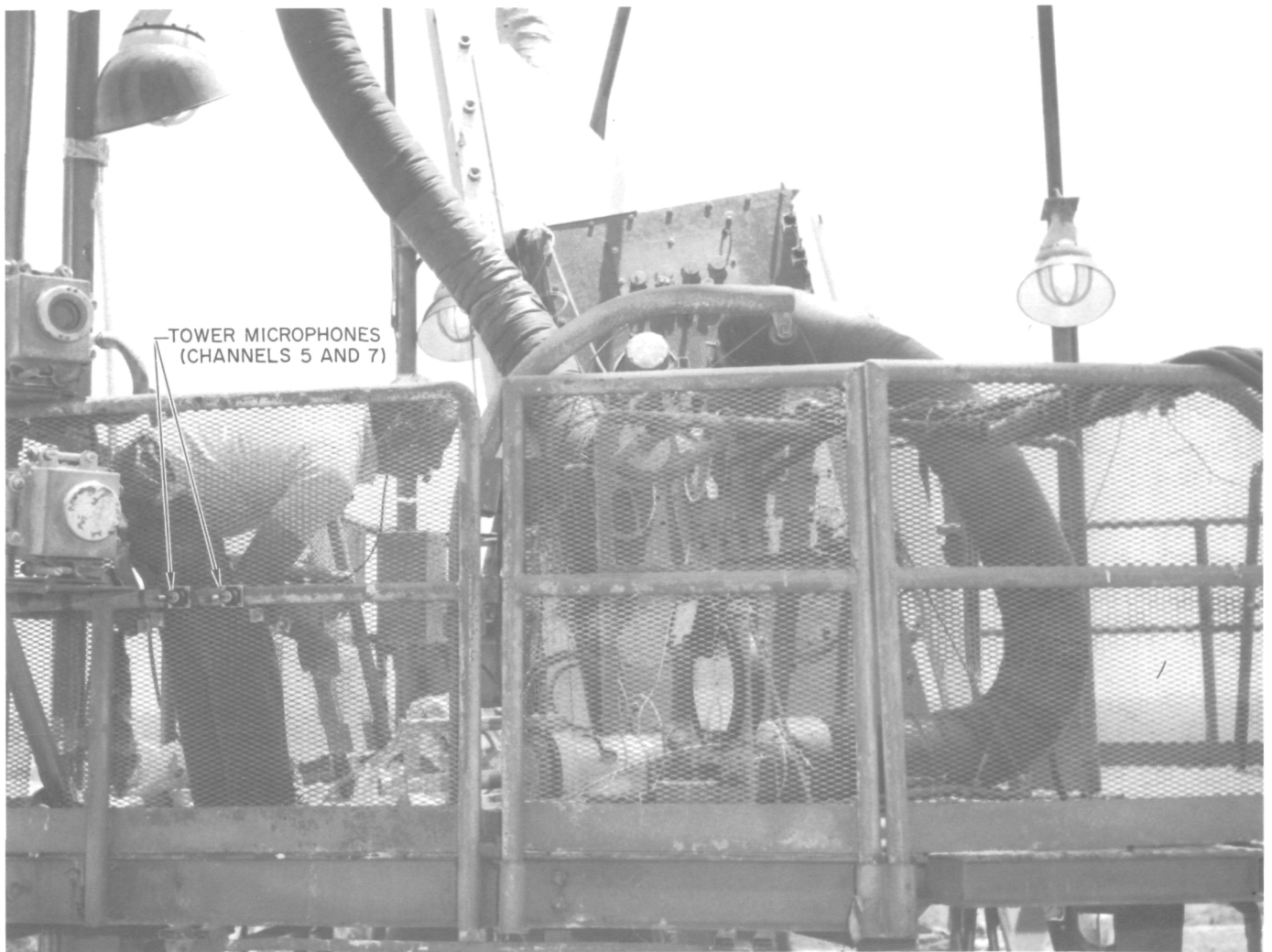


Fig. 8. Tower microphone location (detail)

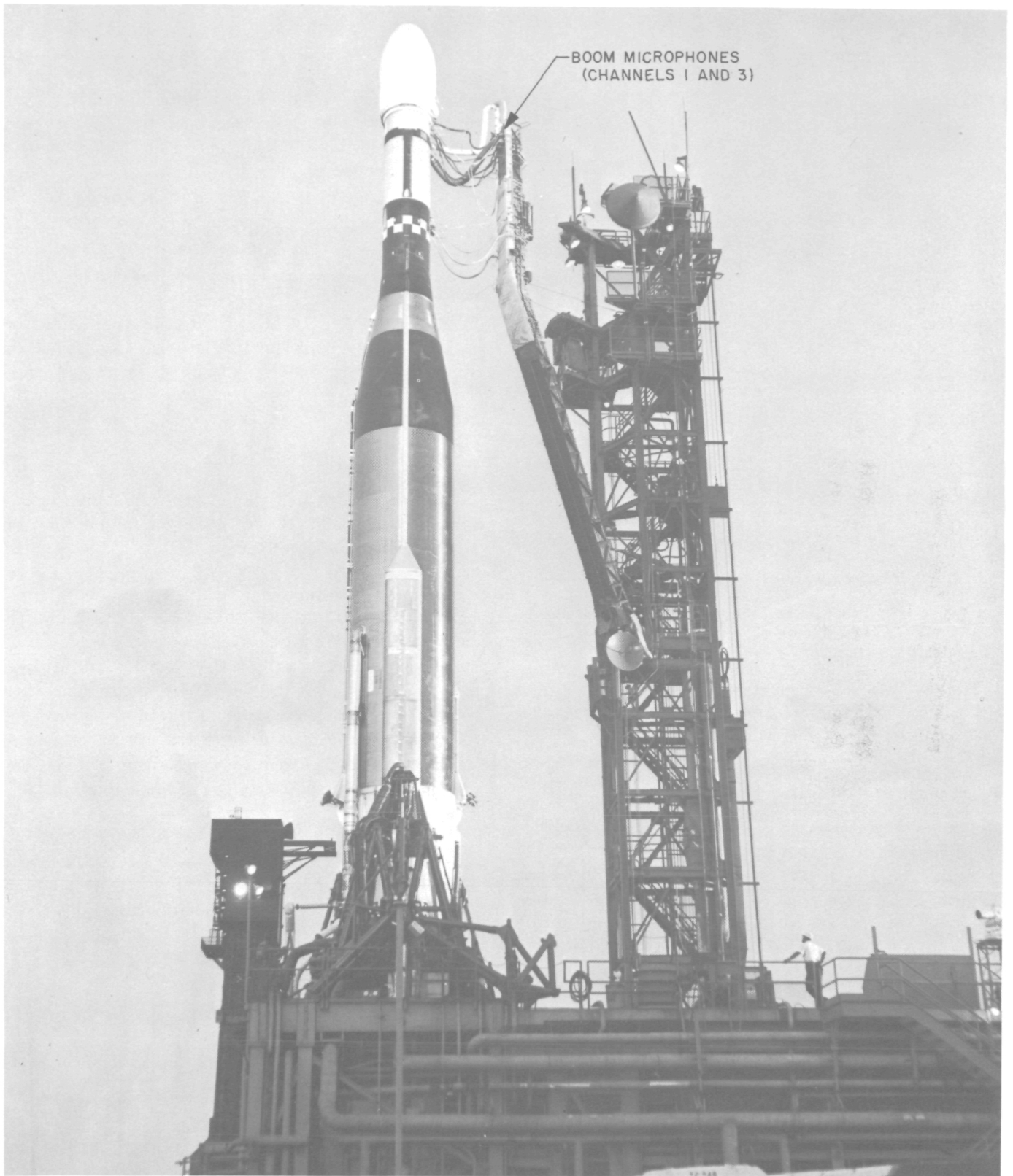


Fig. 9. Boom microphone location

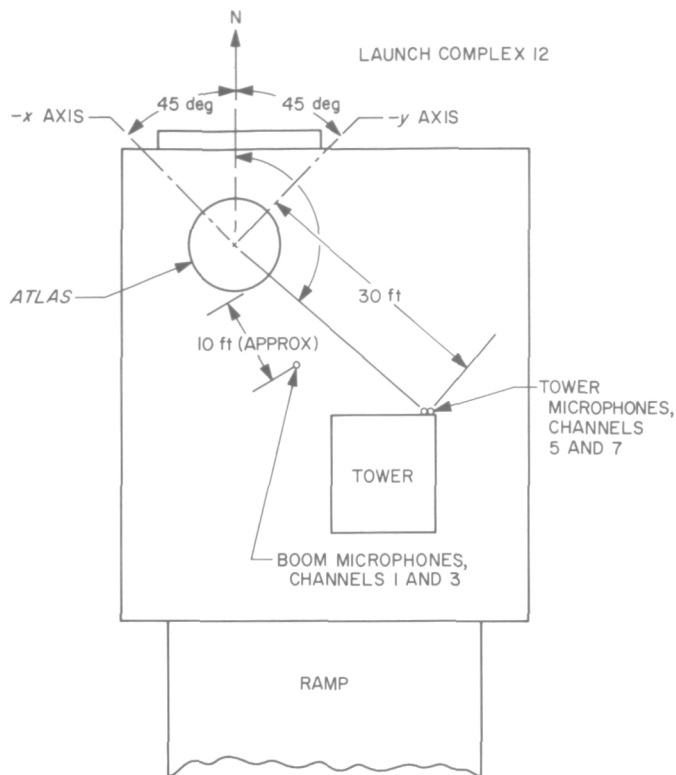


Fig. 10. Mariner V acoustic instrumentation (detail)

III. Analysis Techniques

The methods used in data reduction are presented in this section and brief comments are made concerning limitations and error sources.

A. Oscillograph Records

The oscillograph records present all of the data in detail in the time domain and provide excellent data for a "quick look" analysis. The approximate magnitudes and exact time for all dynamic events can be derived from this type of data. These records are limited by the frequency response of the system and the band limits of the particular channels.

An oscillogram was made of the instantaneous and the rms values of channels 17 and 18, the AMR-D5 time code, and the carrier signal strength from shortly before lift-off until after spacecraft separation. Portions of this record presenting transients and all pertinent events are presented in Section IV.²

²Figure 13 is an example of this type of data and shows the lift-off period for Mariner V.

B. Power Spectral Density

The power spectral density (PSD) analyses for vibration and acoustic data presented in this report were derived with a digital analysis technique. The analog signal was digitized and the resulting digital data were processed on the IBM 7094 computer with JPL program 5599. Typical analysis parameters for flight vibration data were the following:

Resolution	20 Hz
Data sample length	2.5 s
Aliasing filter	2500 Hz
Digitizing sample rate	10,000 samples/s

These parameters were used for analysis of all random data with the exception of additional analysis of the transonic vibration where higher frequencies and longer sample lengths were examined. These exceptions are discussed further in Section IV.

C. Shock Spectra

Transient events that displayed a rapid time rate of change of acceleration with a short duration were analyzed by the shock spectrum method.

The shock spectrum analysis is accomplished digitally following analog-to-digital conversion of the data. The computation of the shock spectrum is performed on an IBM 7094 computer with JPL program 5628. The end data are presented as plots of peak response to the transient (applied as a base acceleration) of a single-degree-of-freedom spring mass-damper system as a function of the system's natural frequency and damping. The data are also stored on cards for later manipulation.

All shock spectra data presented herein were derived using a Q of 20 ($Q = 1/[2\zeta]$), where ζ is the percent of critical damping. Additional spectra were calculated with $Q = 10$ and $Q = 10^6$ but are not included in this report.

IV. Mariner V Data

The data in this section are arranged by type: oscillograms (Figs. 11-26), acceleration and sound pressure spectral density curves (Figs. 27-52), and shock spectra (Figs. 53-78), in that order. Each type of data is arranged in the chronological sequence in which the events occurred. The oscillograms display the real-time signal of each pertinent event. A more detailed analysis of the various events is provided by the ASD curves or by the shock spectrum.

In general, the telemetry coverage was good, inasmuch as there was no loss of data. The quality of the data, however, could have been improved. Specifically, the low-frequency (below 150 Hz) noise level was quite high as indicated by data recorded prior to lift-off and during coast times. The ASD plots for the pre-lift-off quiet times indicate a background level between -28 and -40 dB in the area up to 150 Hz and -40 to -50 dB above 150 Hz, as may be seen in Figs. 35 and 36. The rms values for the pre-lift-off quiet times were 0.43 g for B3 and 0.596 for F4.

A. Oscillogram Data

The oscillograms of all channels for all pertinent events are arranged in chronological sequence and shown in Figs. 11–26. Some time transients are included in this memorandum as oscillograms only, with no corresponding shock spectra plots. These were events with small amplitudes or slow time rate of change that did not qualify as meaningful environmental transients. Examples of data in this category are the *Agna* second ignition (Fig. 24), the *Agna* first cutoff, and the *Agna* second cutoff.

During some transient events, out-of-band conditions existed on both data channels. The F4 channel experienced a sizable out-of-band signal during shroud jettison (Fig. 19), *Atlas/Agna* separation (Fig. 20), and *Agna* sustainer first ignition (Fig. 21). Channel B3 experienced a minor out-of-band condition during shroud jettison and spacecraft separation (Figs. 19 and 26, respectively). During the shroud jettison event, channel F4 (Fig. 19) also recorded approximately a 10-g dc offset. This offset should not be considered real data as it is probably the result of an overdriven amplifier. The accuracy of the data associated with the out-of-band conditions cannot be assured and the amplitudes should be considered minimum values.

The slow-speed oscillogram of rms values for B3 and F4 for lift-off and the transonic period (Fig. 11) requires some explanation. In comparing the amplitude of the F4 data in Fig. 11 with the rms values indicated in the ASD for the same event (Fig. 40), there is a discrepancy. The maximum F4 rms value in Fig. 11 is approximately 130% of the rms value indicated in the ASD for the same event. This discrepancy resulted from using different filters to reduce the two sets of data. The rms oscillogram data were conditioned through discriminator filters of 2100 Hz for B3 and 3000 Hz for F4. As mentioned previously, the PSD data were conditioned through the filters above

plus a 2500-Hz low-pass aliasing filter. To evaluate the high-frequency data, an ASD plot was generated by removing the aliasing low-pass filter. The results are shown as the upper curve in Fig. 42, with an rms value of 3.43 g. This compares favorably with the rms value of 3.5 g as indicated for F4 in Fig. 11.

B. Acceleration Spectral Density

The ASD plots are presented in the chronological order in which the events occurred and include sound pressure spectrum level (SPSL) plots for the four ground instrumentation microphones. Both ASD and SPSL plots present spectrum levels within a 1-Hz bandwidth.

The maximum random vibration occurred during the transonic period, as indicated in Figs. 39–46. Figures 39 and 40 display ASDs of a 10-s time sample during the transonic period. Figures 41–46 display ASDs for 2.5-s time samples within the 10-s period. Figures 41 and 42 show two traces in the high-frequency area. The upper trace was obtained using only the discriminator low-pass filter during data reduction, and the lower trace resulted from use of the standard 2500-Hz aliasing filter in addition to the discriminator filter. The resulting rms levels with and without the aliasing filter were 0.65 and 0.74 g rms for B3 and 2.7 and 3.4 g rms for F4.

V. Comparison of *Mariner V* Data With Data From Previous *Mariners* and With Ground Test Data

The data in this section are presented in order to simplify the comparison with counterpart data for different missions (Ref. 2) and, where possible, with ground test data.

A. Random Vibration

The wideband vibration vs time for the lift-off and transonic flight periods from *Mariners IV* and *V* is compared and shown in Fig. 79 for accelerometers B3 and F4. The *Mariner IV* data for B3 and F4 were taken from wideband (0 to 2000 Hz) average data. The *Mariner V* B3 data were filtered with only the 2100-Hz low-pass discriminator filter, and the F4 data were filtered with only the 3000-Hz low-pass discriminator filter. Because of the dissimilar filter characteristics, the amplitudes of the two sets of data cannot be accurately compared. Therefore, only the general shape of the data will be discussed. Both channels for each mission indicate a notch characteristic during the transonic period. This notch occurs at approximately 53 s on the *Mariner IV* data and

approximately 46.5 s on the *Mariner V* data. Launch time meteorological data were used to generate a post-flight trajectory for this portion of the flight. Results indicated Mach 1 occurring at 47 to 47.2 s. Localized spacecraft aerodynamics and other nonstandard conditions could account for the approximately 0.5-s deviation from the nominal time. Therefore, it could be assumed that the "notch" resulted from a condition associated with the Mach 1 transition.

The ASDs for *Mariner IV* and *V* for lift-off are shown in Figs. 80 and 81 for accelerometers B3 and F4, respectively. The similarity in the shape of the curves for the two flights and the minor differences in the rms values (within 6.5%) indicate that the lift-off environment was approximately the same for the two missions.

ASD data for *Mariners IV* and *V* at transonic velocity are shown in Figs. 82 and 83 for accelerometers B3 and F4, respectively. *Mariner IV* data were conditioned through a 4-kHz low-pass aliasing filter and sampled for 2 s, whereas no aliasing filter was used for the *Mariner V* data. The B3 data (Fig. 82) indicate that the *Mariner IV* level is lower around 450 Hz and higher above 1500 Hz than the *Mariner V* data. The overall level for *Mariner IV* is 0.801 g rms compared with 0.742 g rms for *Mariner V*. The F4 data (Fig. 83) indicate good similarity in curve shape, with the *Mariner IV* level somewhat lower than that for *Mariner V* except at the upper frequencies. The overall level for *Mariner IV* was 3.80 g rms compared with 3.43 g rms for *Mariner V*.

Results from the random vibration ground tests are compared with *Mariner V* flight results in Figs. 84 and 85 for accelerometers B3 and F4, respectively. However, before discussing the results, a brief description of the conditions and configuration of the ground test is in order. The test configuration for the thrust-axis flight-acceptance random vibration test was as shown in Fig. 86. The wideband ground vibration test input level was 9.7 g rms with an ASD of $0.07 \text{ g}^2/\text{Hz}$ between 1000 and 2000 Hz. The roll-off was 6 dB/octave below 1000 Hz and 48 dB/octave above 2000 Hz. This input level was monitored and controlled by six control accelerometers, as indicated in Fig. 86. The outputs of the six control accelerometers were averaged and used as feedback to control the input.

Comparative results for accelerometer B3 data (Fig. 84) indicate the ground test level to be adequate inasmuch as the test environment is more severe at all frequencies. The flight data below 50 Hz are essentially all system

noise, as indicated in the B3 quiet-time data in Fig. 35, and should be ignored. The F4 data in Fig. 85 indicate the ground test level to be adequate up to 1500 Hz. Between 1500 and 2000 Hz, the flight environment is as much as 5 dB above the ground test level over narrow frequency ranges. Investigation of this apparent test inadequacy revealed the following information: (1) inspection of the ASDs for the six circumferential control accelerometers on the vibration test fixture indicated that the two accelerometers adjacent to F4 were from 5 to 15 dB below the average input levels at certain frequencies between 1500 and 2000 Hz; (2) the characteristics of the vibration test configuration could be expected to result in additional high-frequency attenuation between the control points and F4. Therefore, the recorded value at F4 was below the average input level on the adapter ring and did not provide a true representation of the actual input to the spacecraft. A substantiating fact is that on the same test the B3 vibration level exceeded the flight vibration level by a reasonable margin at all frequencies. Since the vibration energy imparted in the spacecraft is more accurately represented by the B3 measurement, the ground test levels are considered adequate in this frequency range as well as below 1500 Hz.

B. Transient Vibration

The shock spectra maximum and minimum envelopes for the B3 accelerometers for *Mariners III*, *IV*, and *V* are presented in Fig. 87, which indicates reasonable similarity between the three sets of data. In the area between 100 and 800 Hz, the *Mariner V* data are greater than those of either *Mariner III* or *IV*. The predominant events in various portions of the *Mariner V* maximum curve indicate that the maximum in the area of 250 to 600 Hz resulted from spacecraft separation. The 1-kHz peak resulted from *Atlas/Agenda* separation, and the 1600-Hz peak resulted from spacecraft separation.

Similar data for the *Mariner V* accelerometer F4 are presented in Fig. 88. Comparative data for *Mariner IV* are not available, because of "out-of-band" condition during most events. The maximum curve in Fig. 88 in the area up to 1400 Hz resulted from shroud jettison. The peak at 1600 Hz resulted from *Atlas/Agenda* separation.

A comparison of flight shock spectra and ground test shock spectra is presented in Figs. 89 and 90 for accelerometers B3 and F4, respectively. Results presented in these two figures indicate the ground test response exceeds the flight response at frequencies above 250 Hz. Examination of the conditions of the ground pyrotechnic

tests revealed that for both the spacecraft V-band and the shroud V-band test, the spacecraft (in flight configuration) was secured atop the spacecraft adapter and an *Agenda* forward equipment rack. The rack, in turn, was bolted to and rested upon a 2-in.-thick steel plate. It is believed that the more rigid ground test configuration restricted the low-frequency response of the system during the ground pyrotechnic tests.

C. Acoustic Data

Mariners IV and *V* were both launched from launch complex 12, which utilizes a "wet" flame bucket. *Mariner III* was launched from launch complex 13, which has a "dry" flame bucket and a blast deflection wall which could cause reflections back upon the spacecraft.

Acoustic data presented in Fig. 91 indicate that the tower microphone acoustic levels for *Mariners IV* and *V* were very similar and that both were approximately 6 dB below the overall level of 147.1 dB for *Mariner III*. These data indicate that the acoustical characteristics of the "wet" flame bucket of launch complex 12 near the spacecraft shroud, from an environmental point of view, are superior to the "dry" flame bucket utilized for the launch of *Mariner III*.

VI. Conclusions

This report has presented a complete data reduction of the *Mariner V* dynamic instrumentation, including four ground acoustic measurements of the external acoustic field at lift-off and two spacecraft vibration measurements from before lift-off through spacecraft separation. The data have been presented as direct-write time histories, rms time histories, SPSLs, ASDs, or shock spectra, as appropriate. The data acquisition systems and the various data reduction systems have been described in sufficient detail to permit proper interpretation of the results.

While the quantity of dynamic data available from the *Mariner V* flight is not sufficient to present a complete survey of the dynamic environment of the spacecraft or its assemblies, the data are valuable as a measure of the *Mariner V* flight for comparison with previous *Mariner* flights and with ground vibration tests, and to assist in estimating the flight dynamic environment on future spacecraft.

To define the spacecraft's dynamic environment in more complete terms on future flights, the addition of other dynamic transducers at several other meaningful locations is necessary.

Comparisons of *Mariner V* flight random vibration data with the equivalent *Mariner IV* data indicated the lift-off environments to be approximately equivalent. During the transonic period, the *Mariner IV* random level exceeded that for *Mariner V* in the high-frequency area.

The maximum transient response for *Mariner V* resulted from shroud jettison on accelerometer F4 and *Atlas/Agenda* separation on accelerometer B3. Comparisons indicated *Mariner IV* and *V* levels to be comparable and both to be less than those for *Mariner III* between 800 and 1500 Hz. In the area below 800 Hz, the *Mariner V* shock spectra exceeded those of *Mariners III* and *IV*.

Comparing *Mariner V* flight random vibration levels with equivalent ground test data indicated the ground test levels to be deficient in the area above 1500 Hz when compared by response at the F4 location. However, at the B3 location (representing spacecraft vibration), the ground test greatly exceeds flight measurements. The shock spectra from ground pyrotechnic tests are less than flight shock spectra in the low-frequency area. This is believed to be due in part to the method of supporting the spacecraft during the ground pyrotechnic tests. It may be advisable to perform future ground pyrotechnic tests with the equipment not firmly attached to the 2-in.-thick steel base plate.

References

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2. Randolph, J. E., *Mariner Mars 1964 Flight Dynamic Data*, Technical Memorandum 33-278, Rev. 1. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 15, 1966.

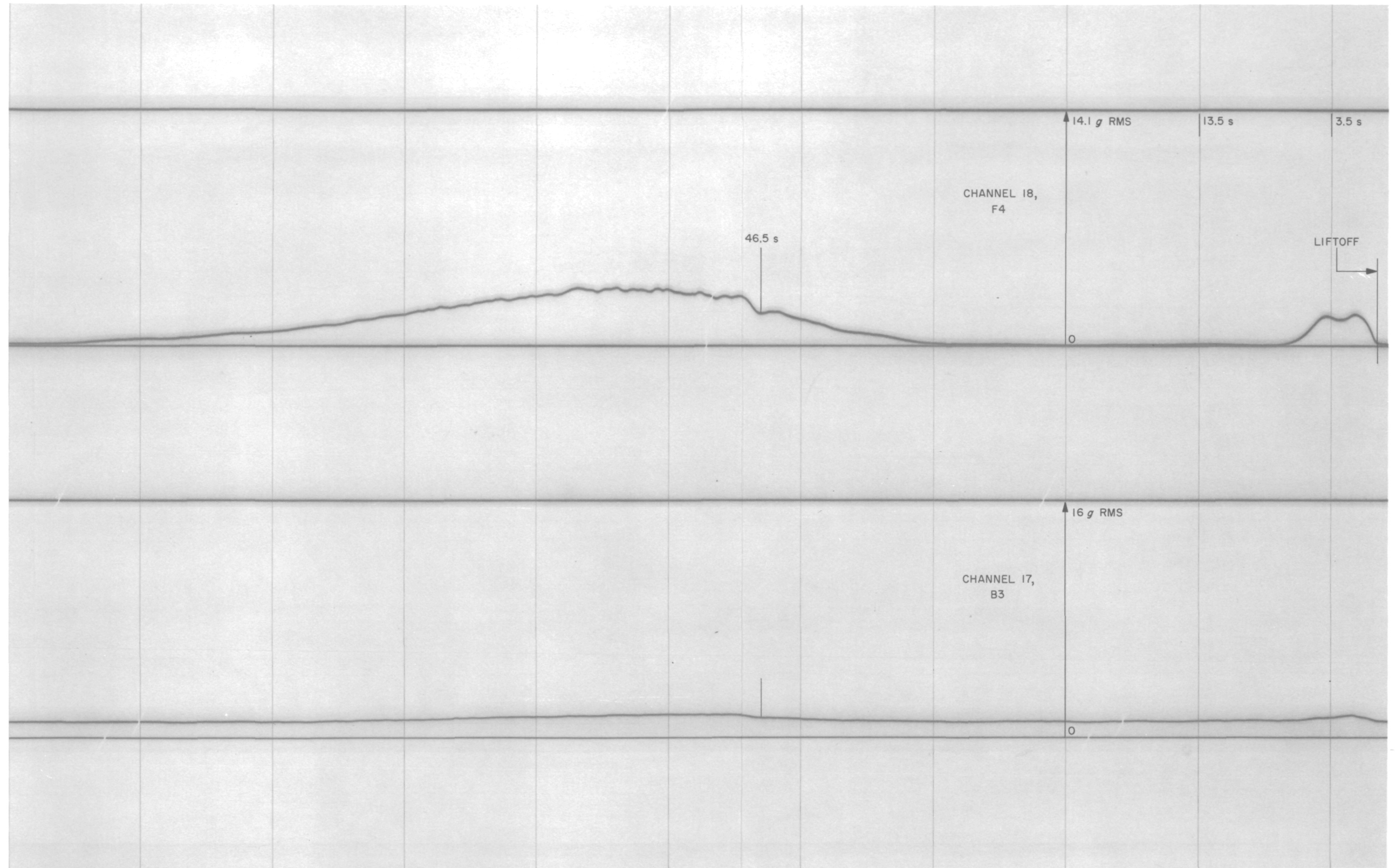


Fig. 11. Oscillogram, Mariner V slow-speed rms, lift-off and transonic period, AFETR tape

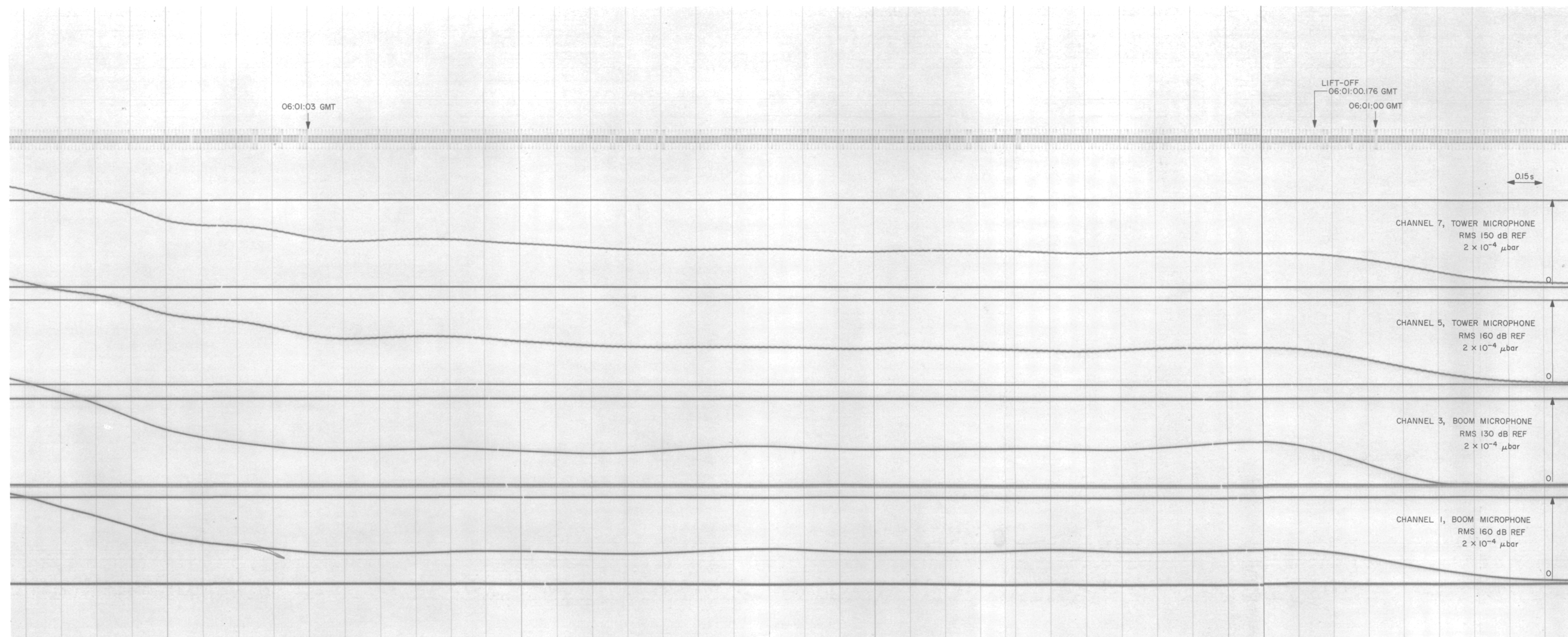


Fig. 12. Oscillogram, Mariner V rms acoustic data, lift-off period, AFETR tape

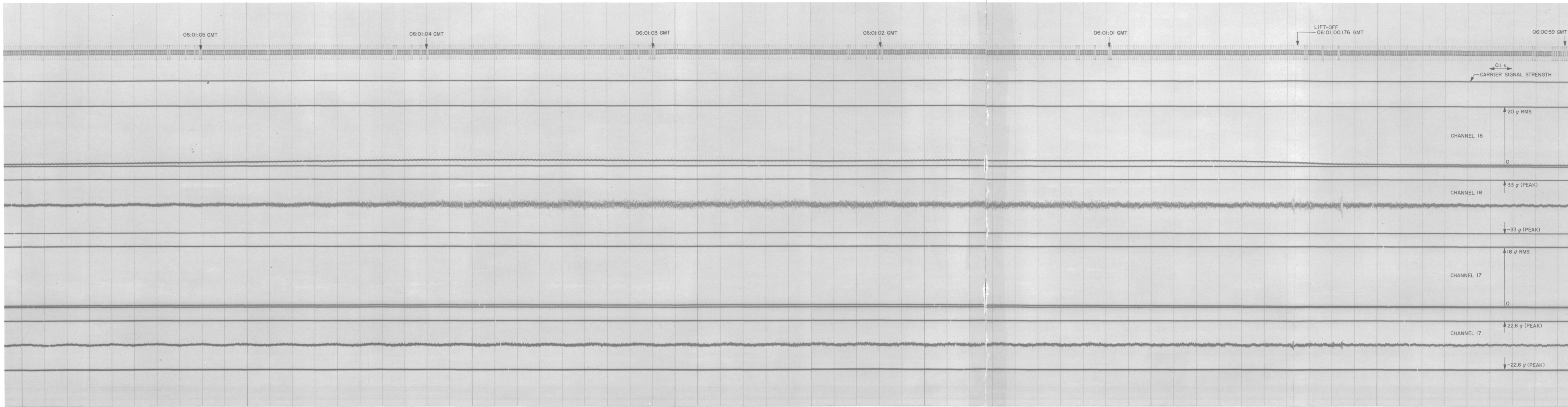


Fig. 13. Oscillogram, Mariner V lift-off, AFETR tape—all channels

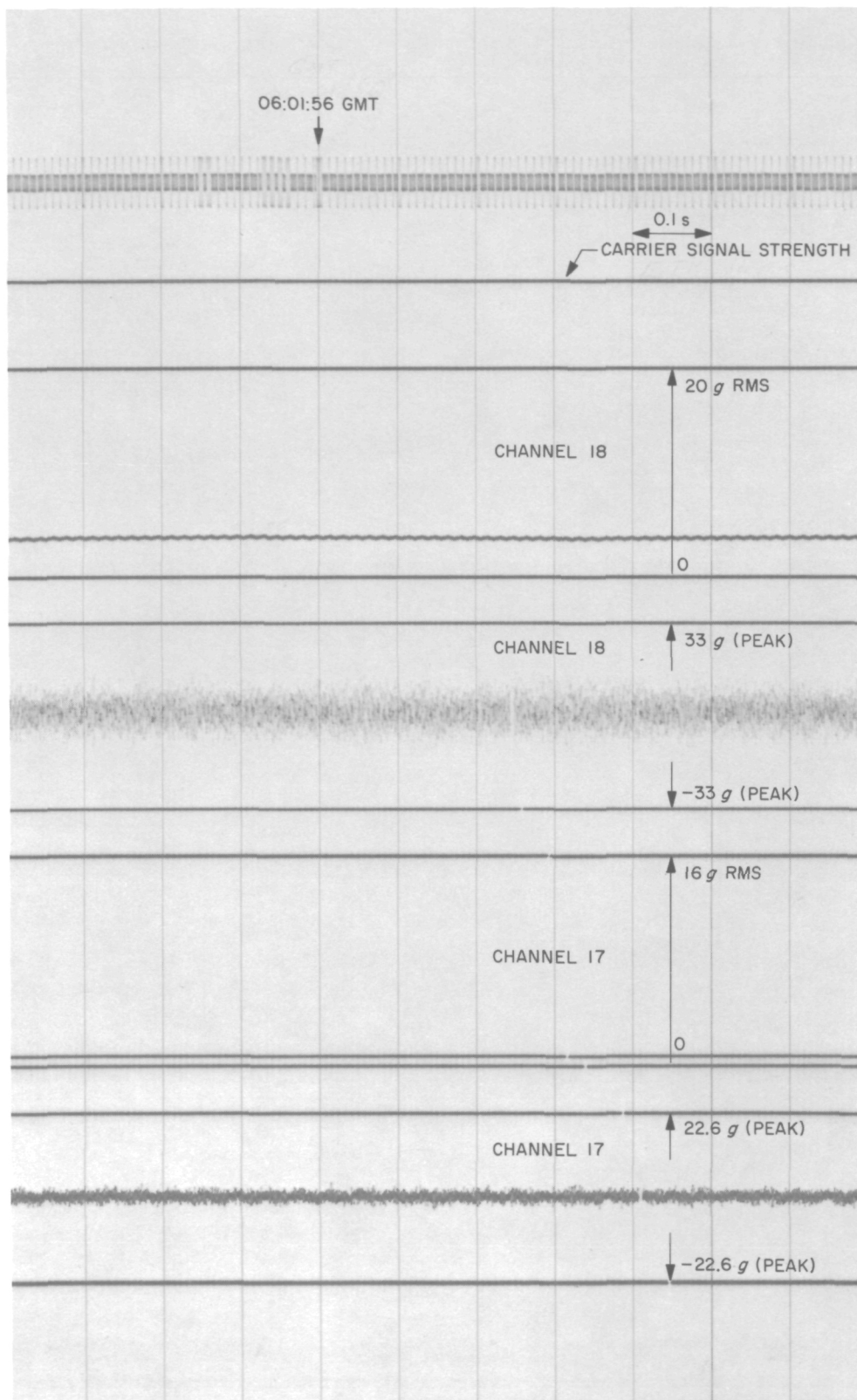


Fig. 14. Oscillogram, Mariner V transonic period, AFETR tape—all channels

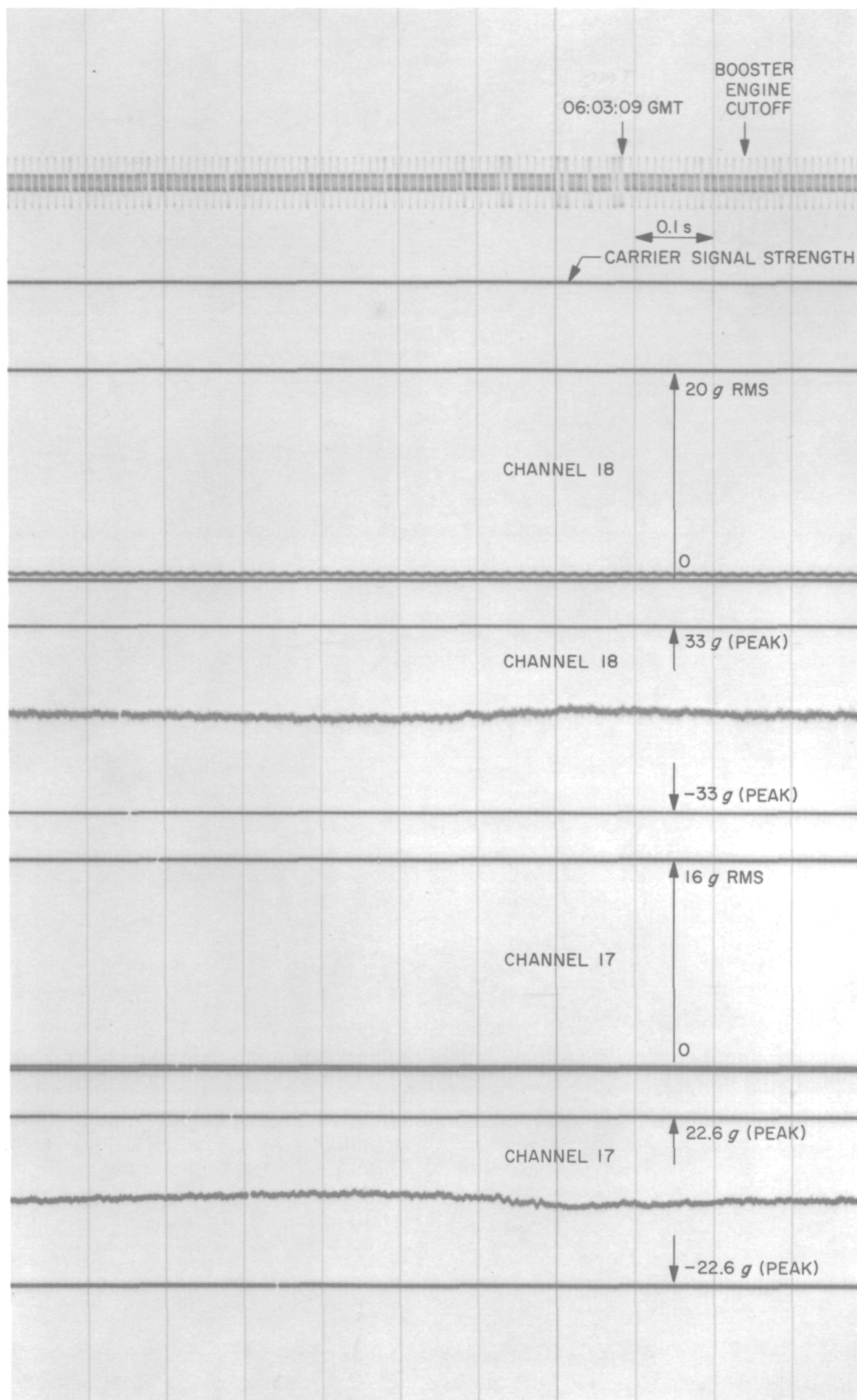


Fig. 15. Oscillogram, *Mariner V* booster engine cutoff, AFETR tape—all channels

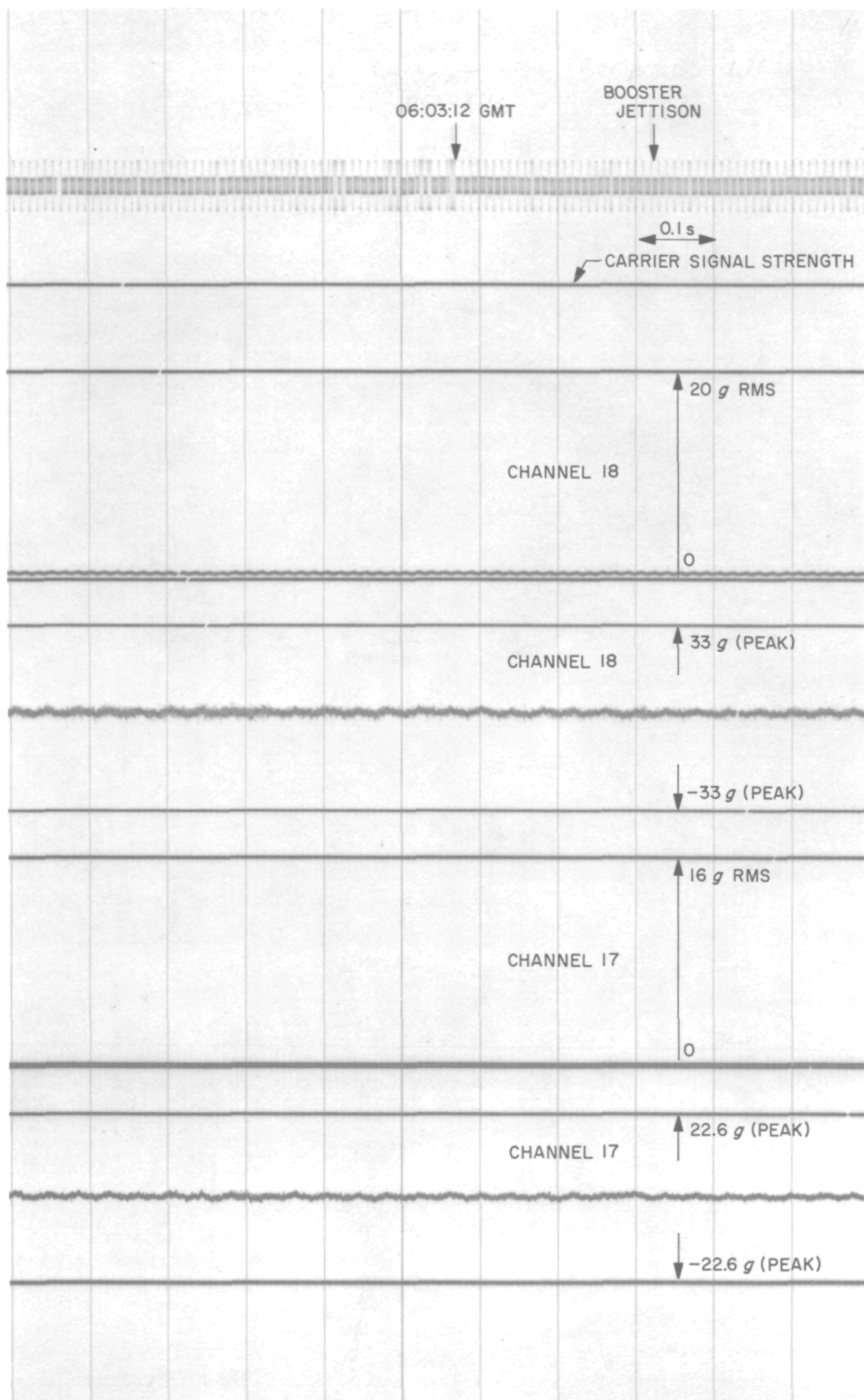


Fig. 16. Oscillogram, *Mariner V* booster jettison, AFETR tape—all channels

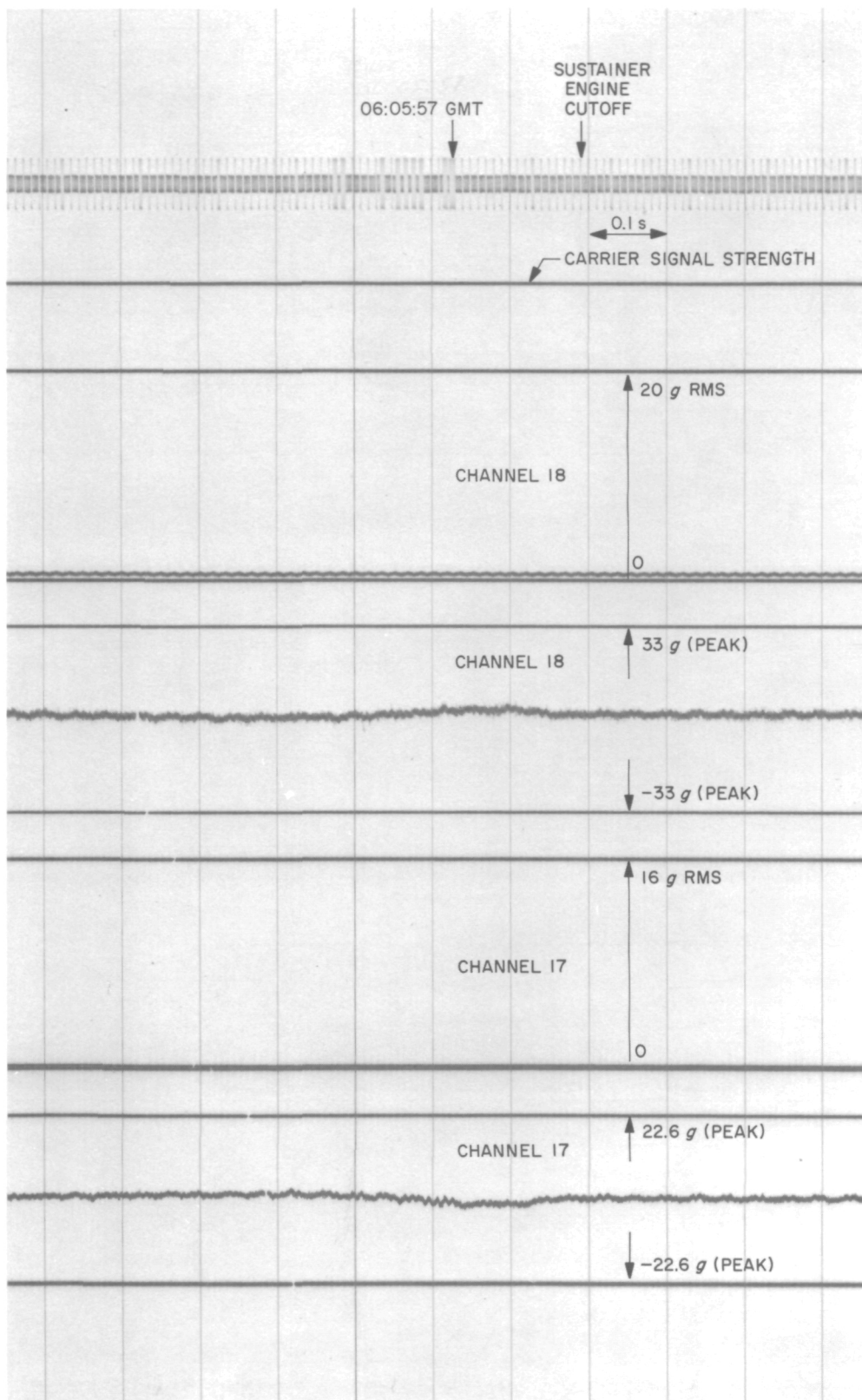


Fig. 17. Oscillogram, Mariner V sustainer engine cutoff, AFETR tape—all channels

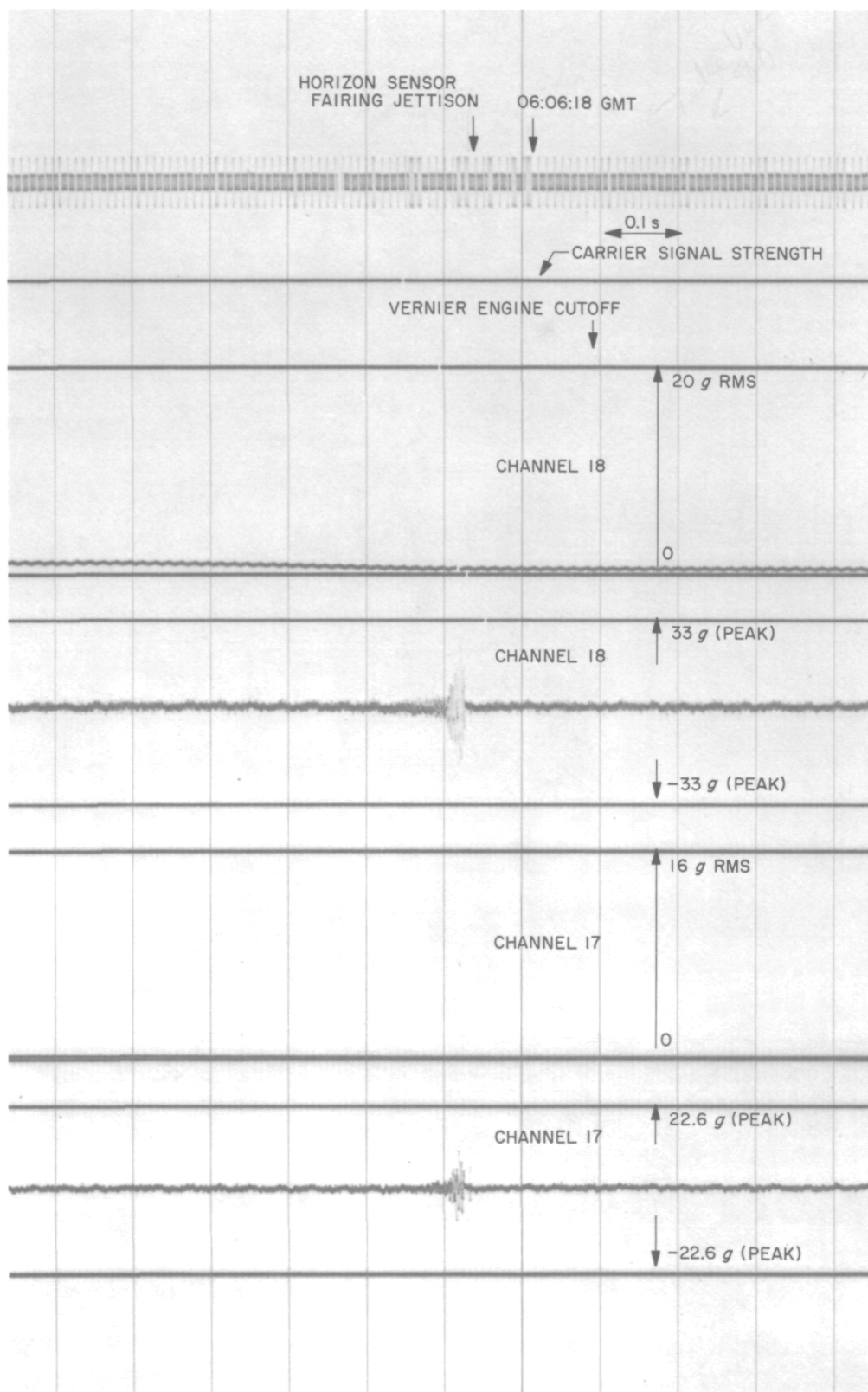


Fig. 18. Oscillogram, Mariner V horizon sensor fairing jettison, AFETR tape—all channels

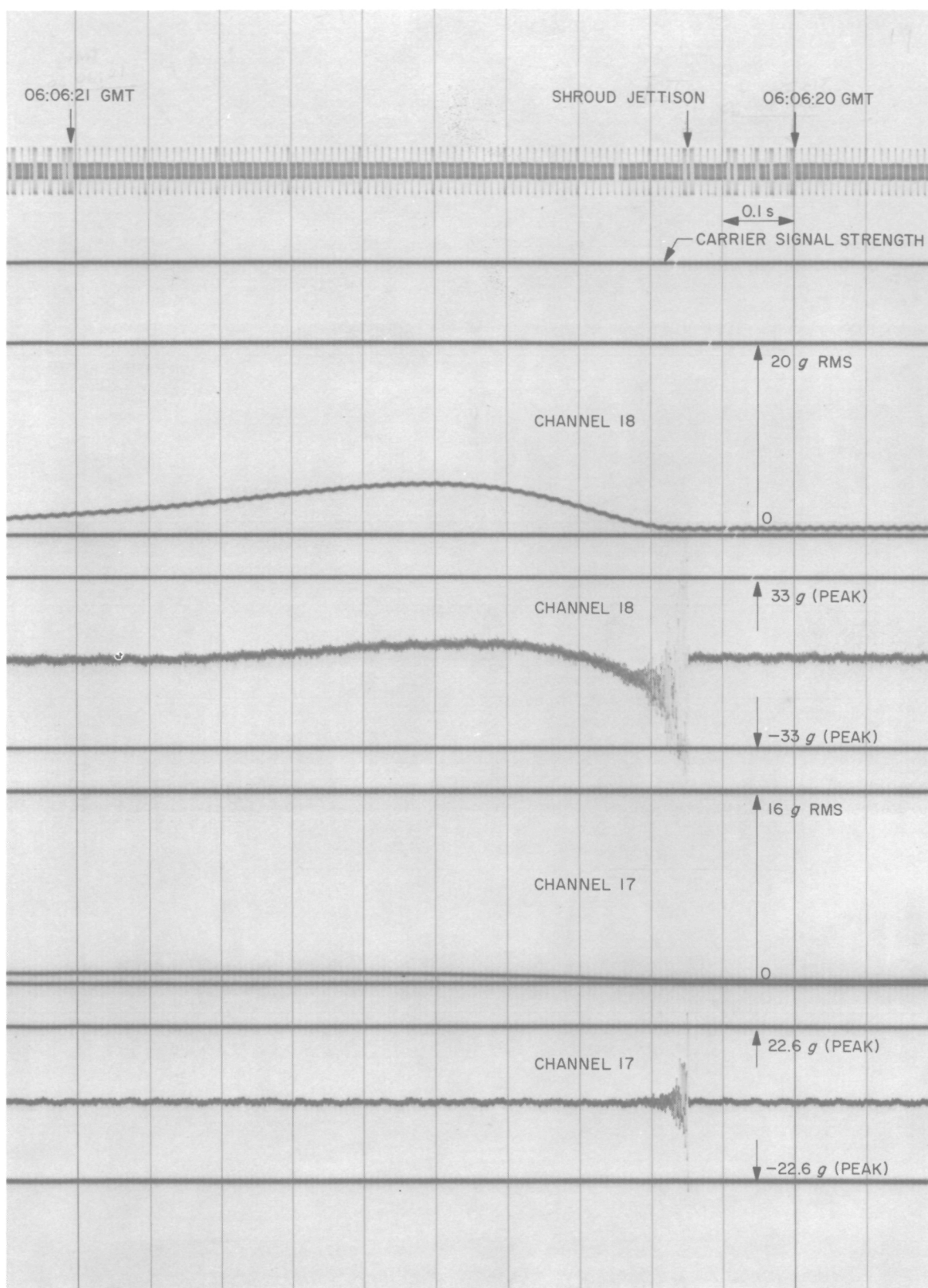


Fig. 19. Oscillogram, Mariner V shroud jettison, AFETR tape—all channels

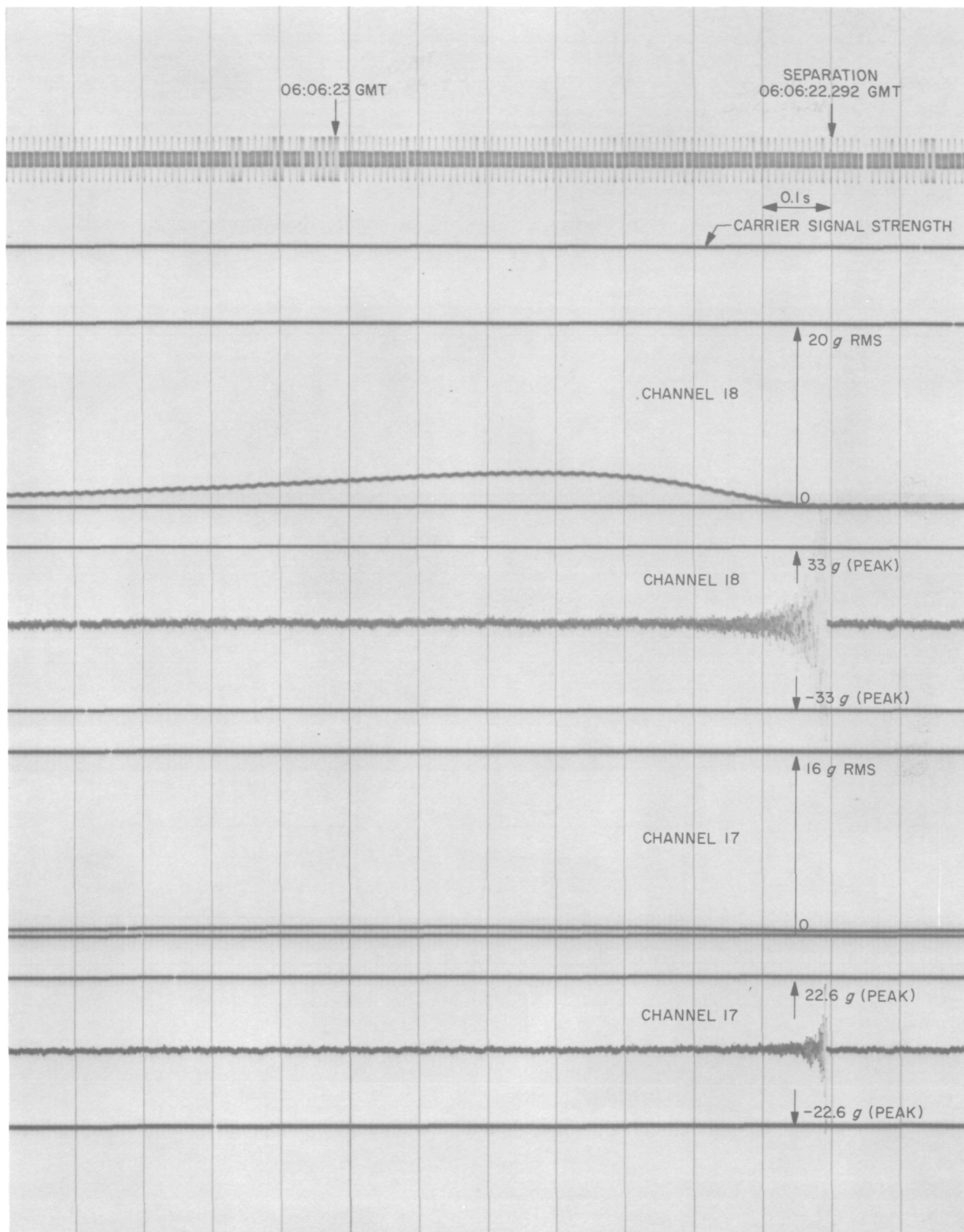


Fig. 20. Oscillogram, Mariner V Atlas/Agena separation, AFETR tape—all channels

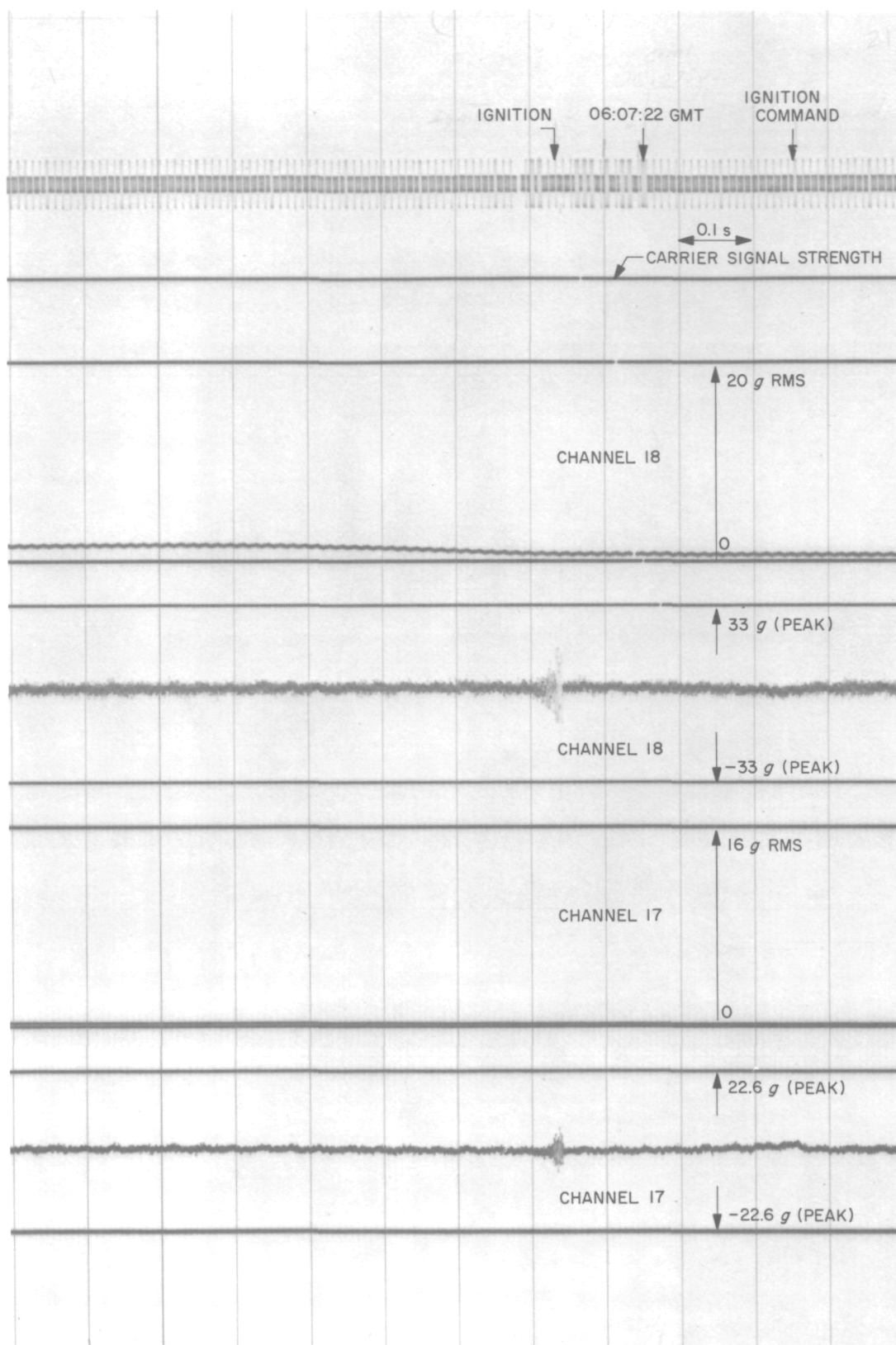


Fig. 21. Oscillogram, Mariner V Agena first ignition, AFETR tape—all channels

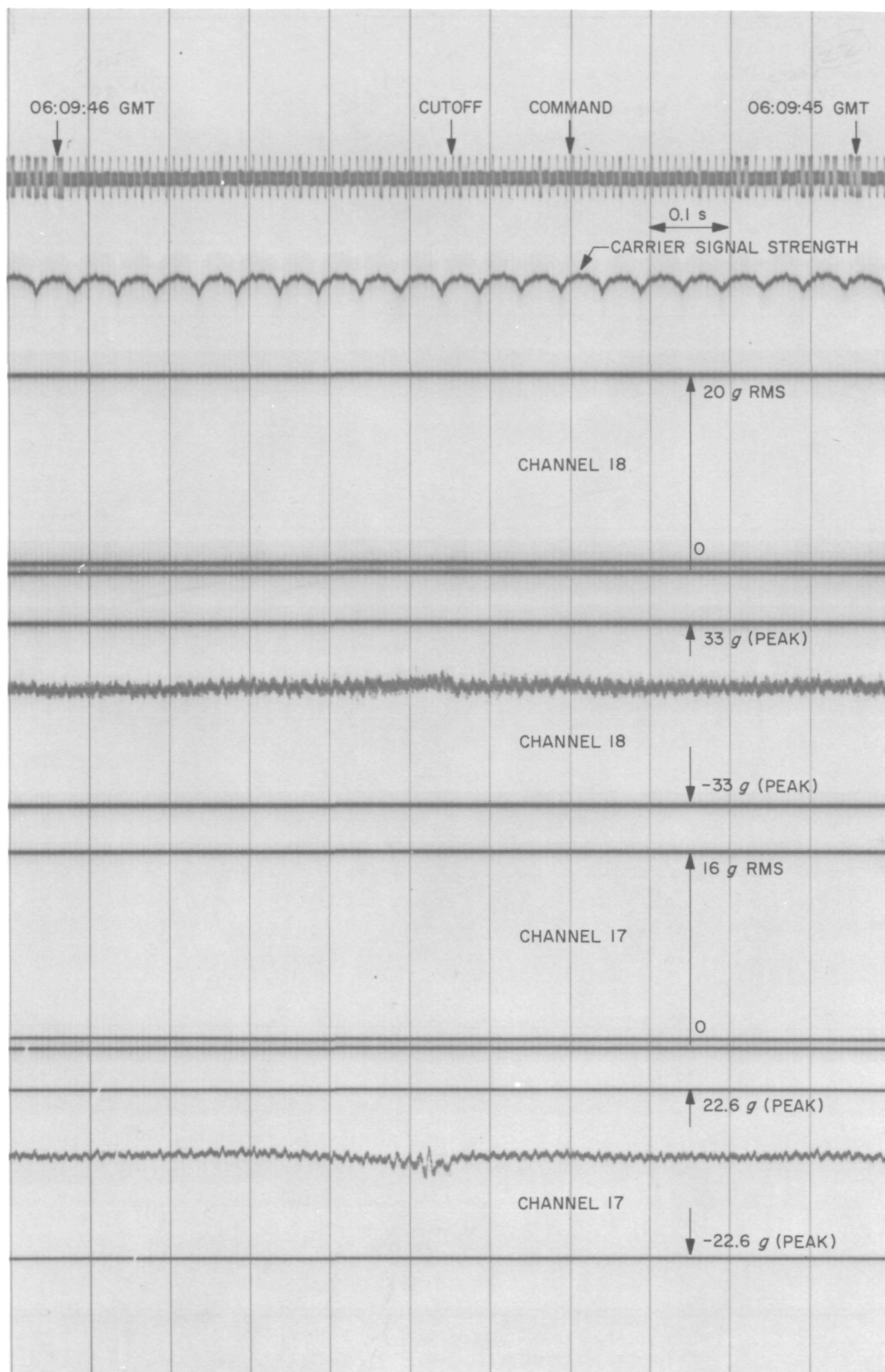


Fig. 22. Oscillogram, Mariner V Agena first cutoff, Antigua tape—all channels

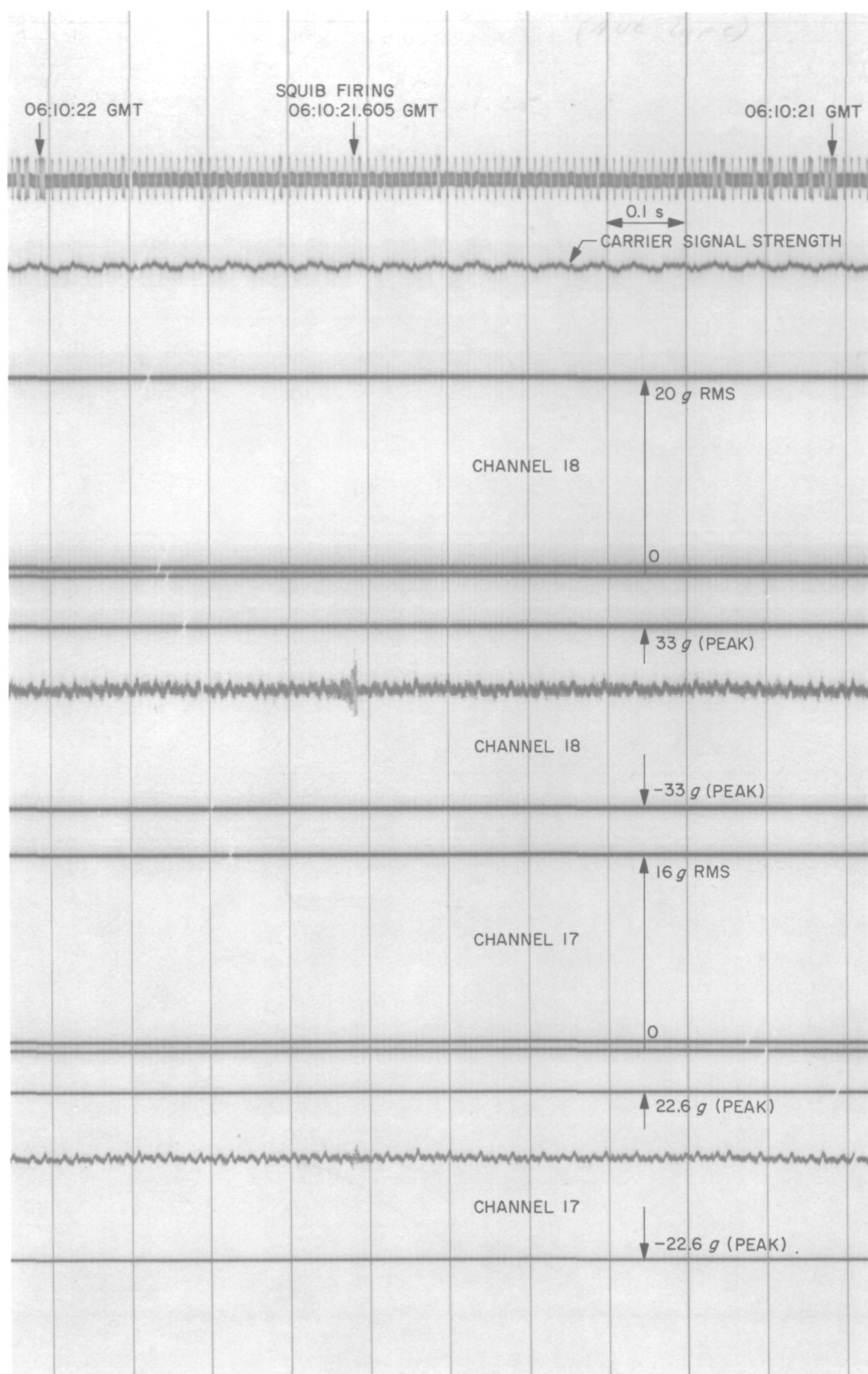


Fig. 23. Oscillogram, *Mariner V* firing of horizon sensor 0-deg position squib, Antigua tape—all channels

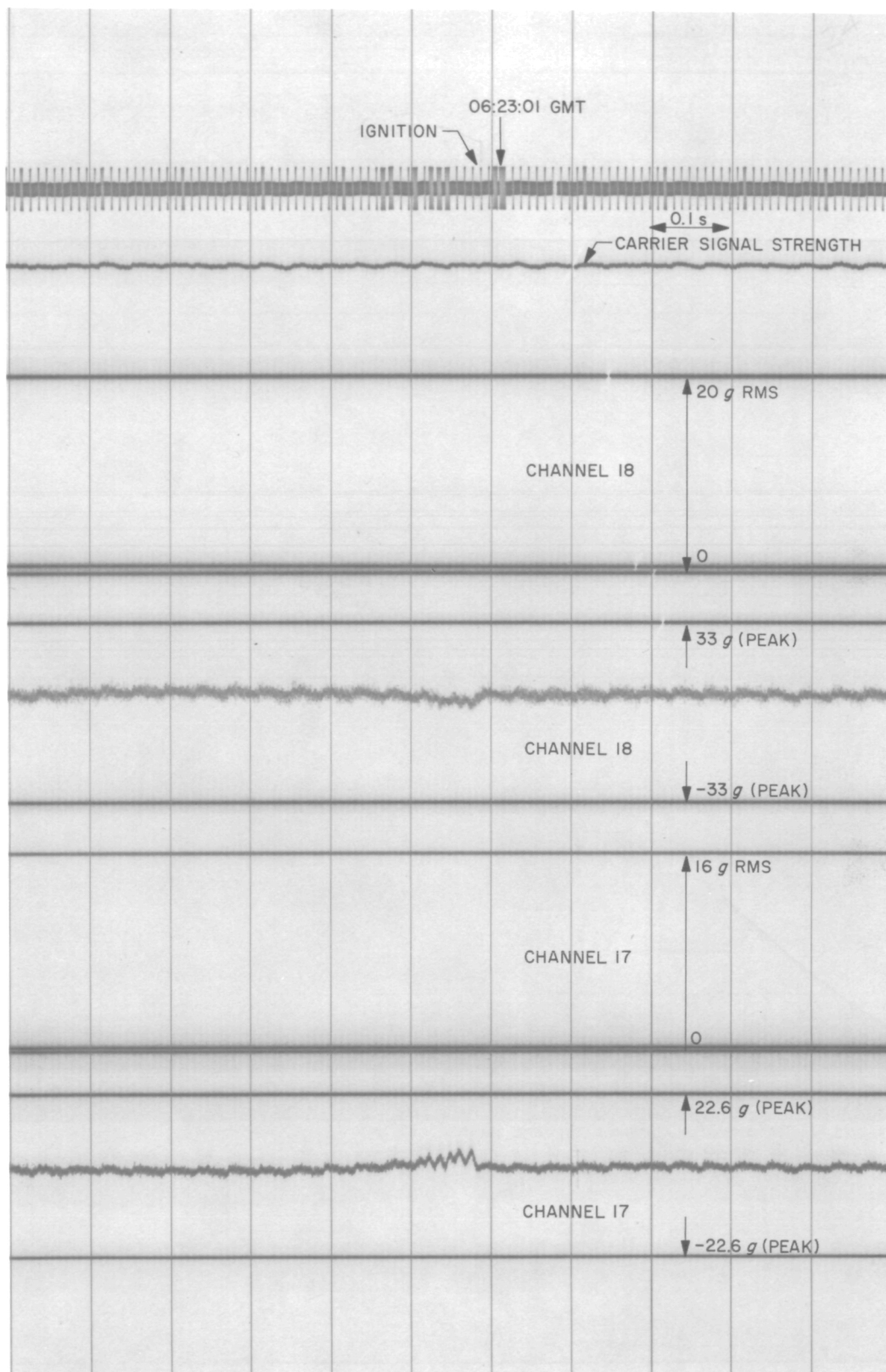


Fig. 24. Oscillogram, Mariner V Agena second ignition, Ascension tape—all channels

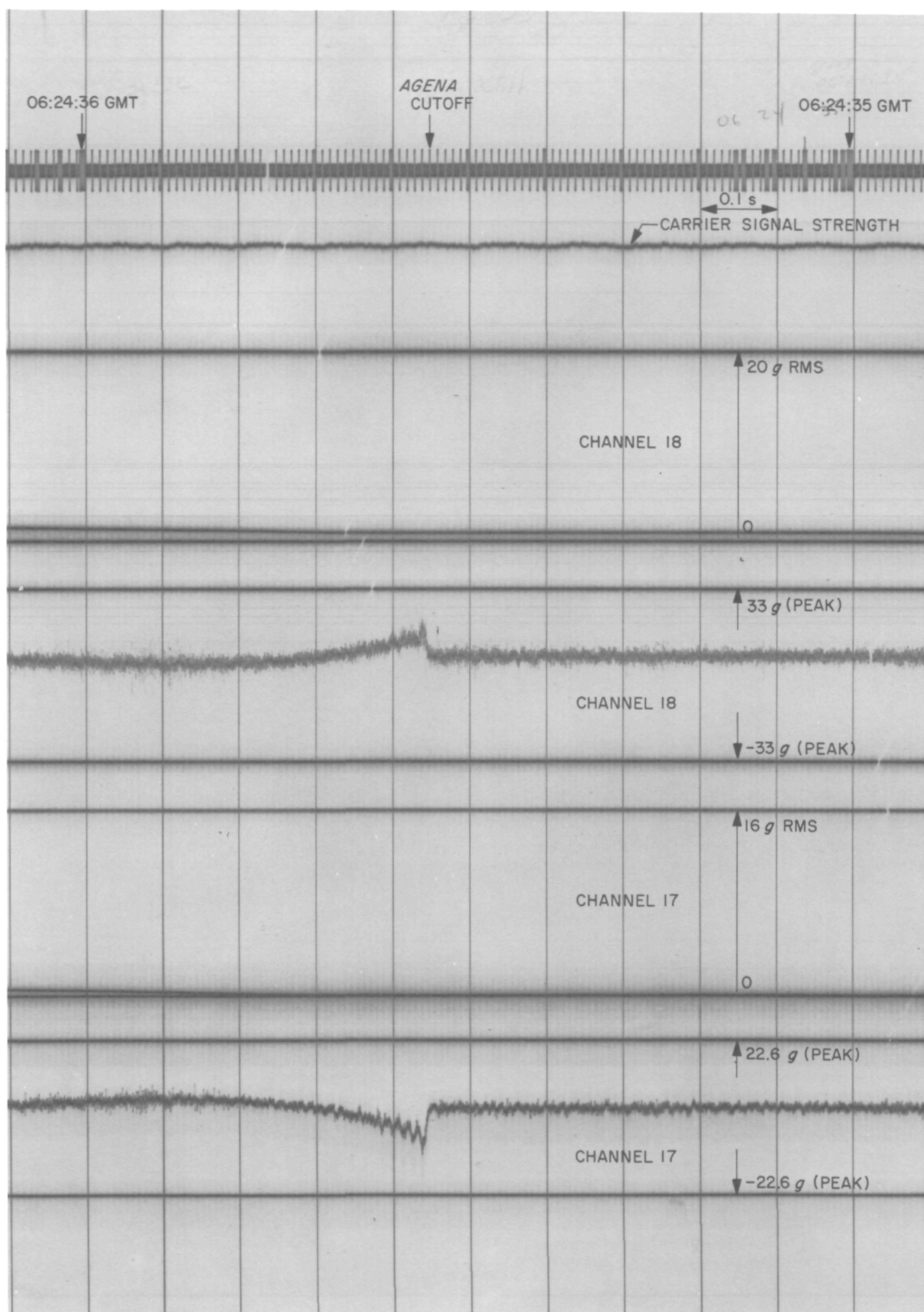


Fig. 25. Oscillogram, *Mariner V* Agena second cutoff, Ascension tape—all channels

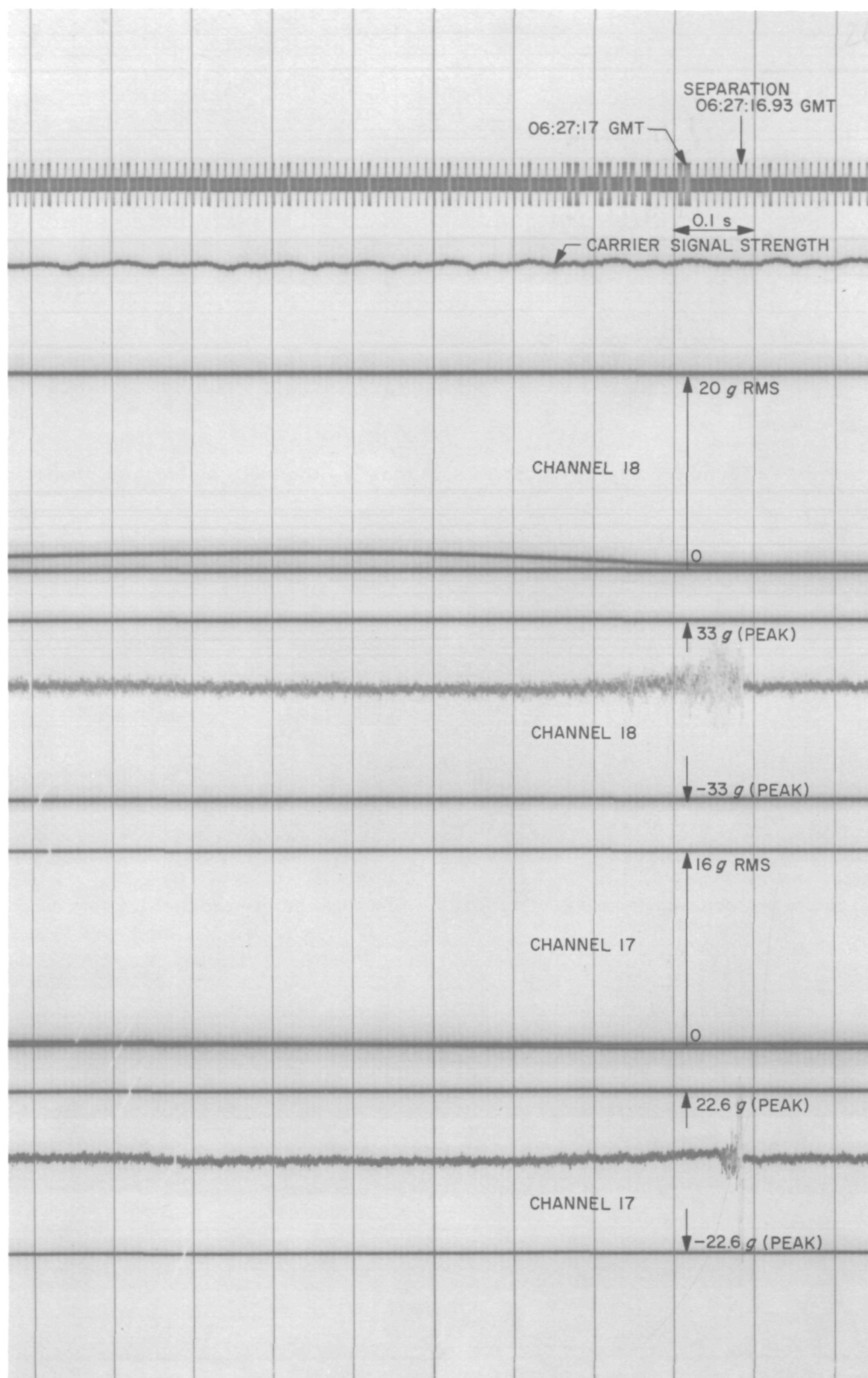


Fig. 26. Oscillogram, Mariner V spacecraft separation, Ascension tape—all channels

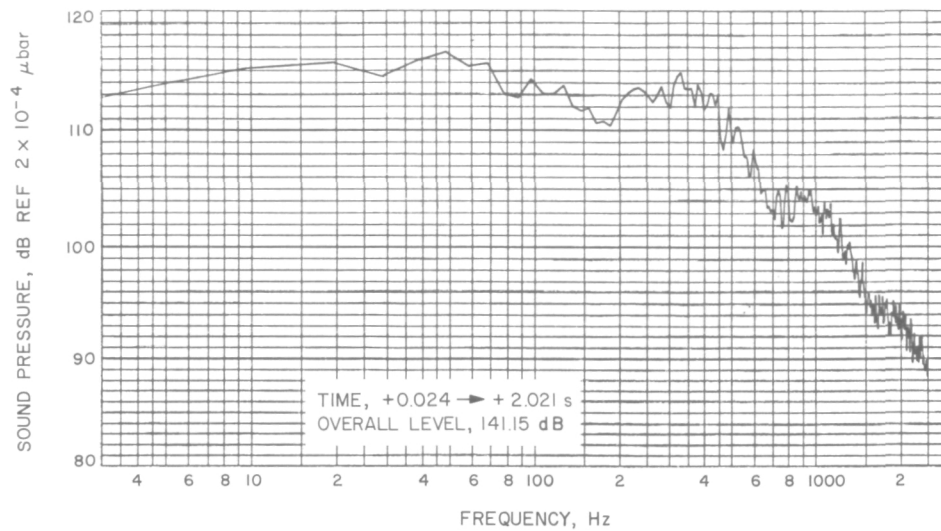


Fig. 27. Sound pressure spectrum level, *Mariner V*—channel 1, boom microphone

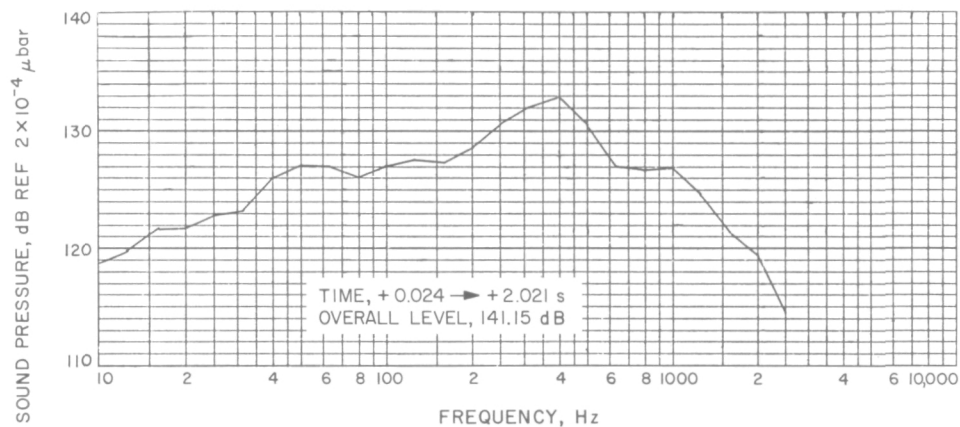


Fig. 28. Sound pressure spectrum level, *Mariner V* 1/3-octave band—channel 1, boom microphone

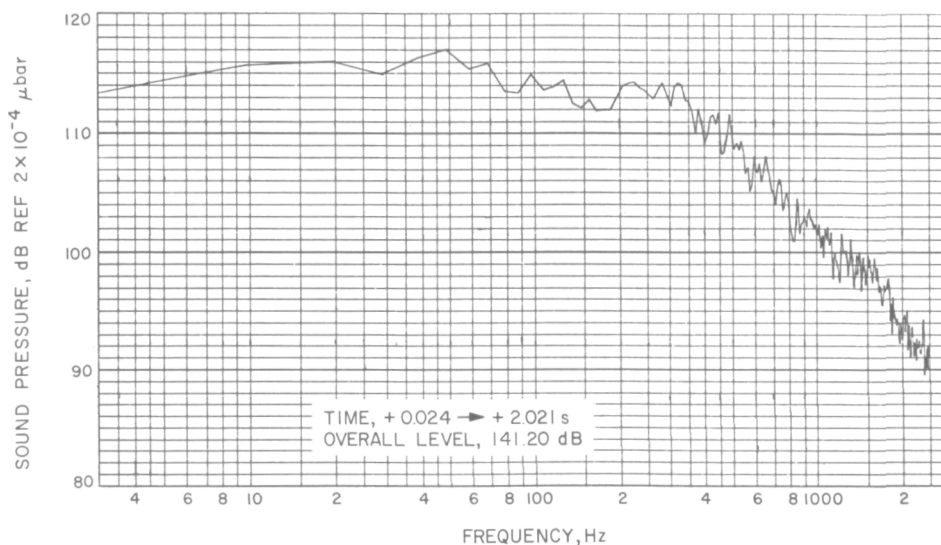


Fig. 29. Sound pressure spectrum level, *Mariner V*—channel 3, boom microphone

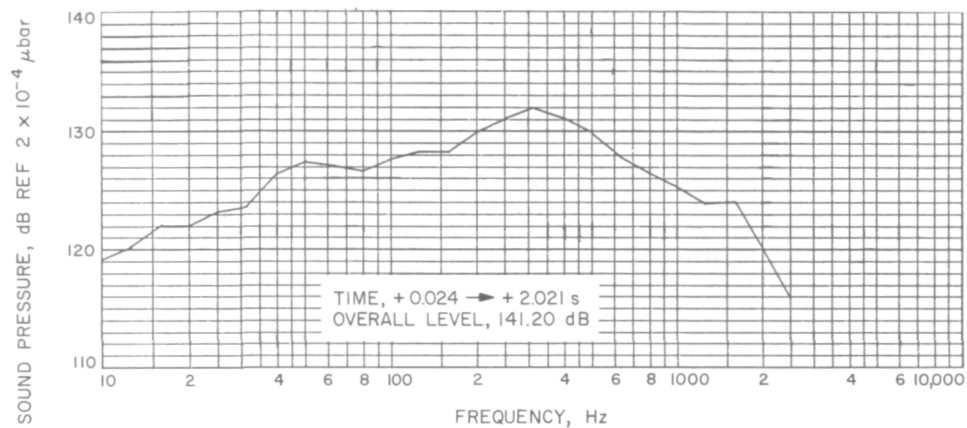


Fig. 30. Sound pressure spectrum level, *Mariner V* 1/3-octave band—channel 3, boom microphone

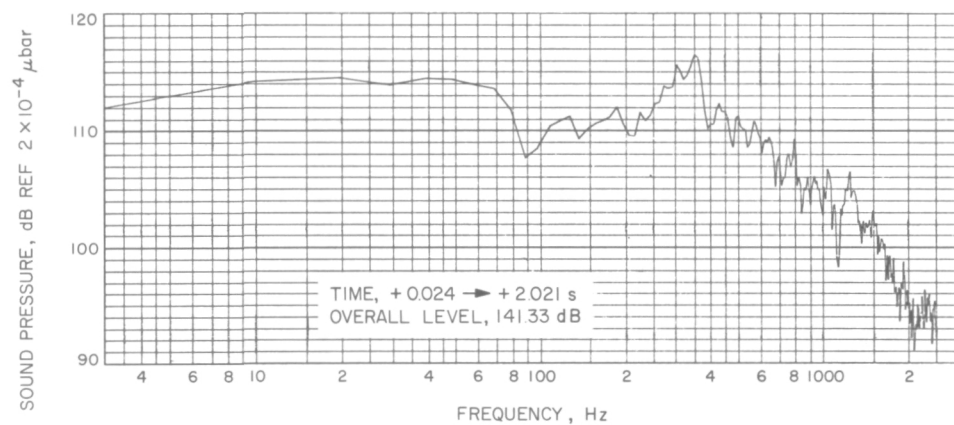


Fig. 31. Sound pressure spectrum level, *Mariner V*—channel 5, tower microphone

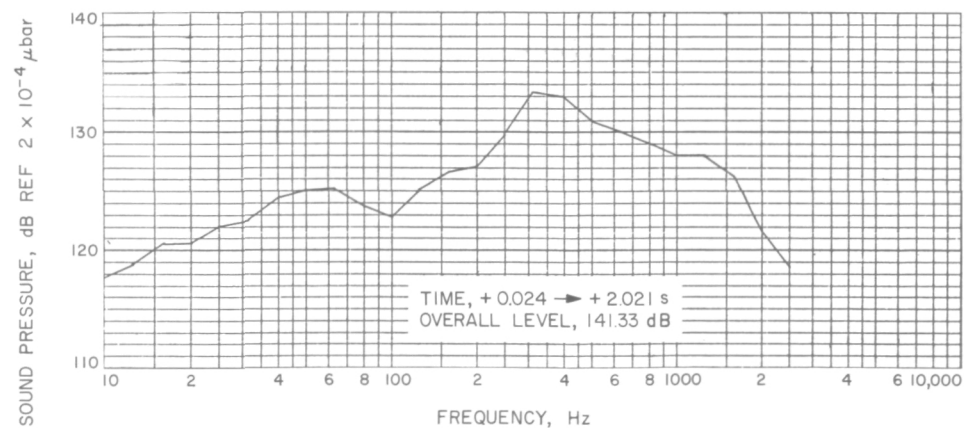


Fig. 32. Sound pressure spectrum level, *Mariner V* 1/3-octave band—channel 5, tower microphone

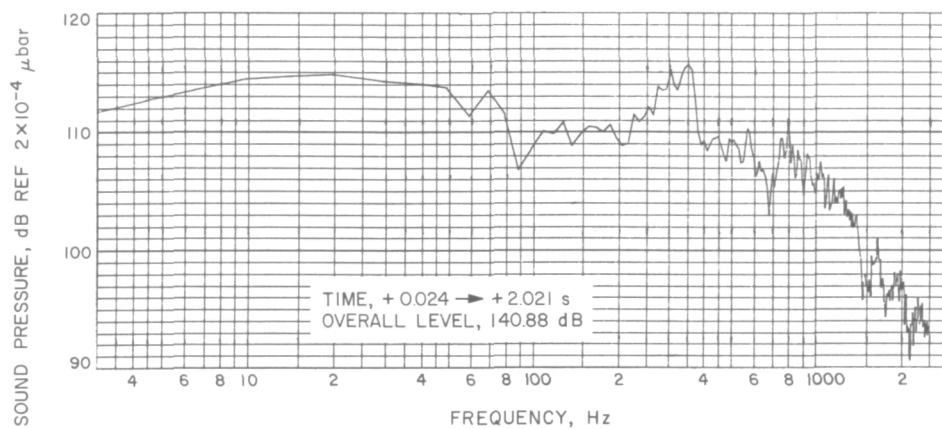


Fig. 33. Sound pressure spectrum level, *Mariner V*—channel 7, tower microphone

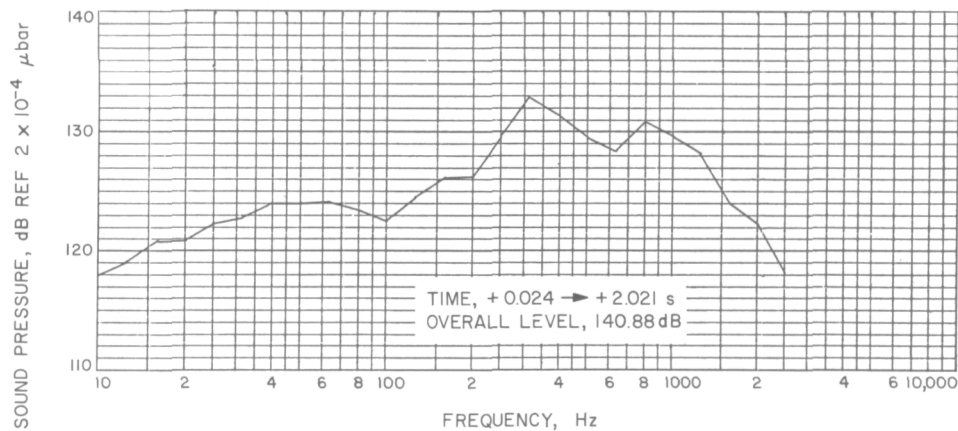


Fig. 34. Sound pressure spectrum level, *Mariner V* 1/3-octave band—channel 7, tower microphone

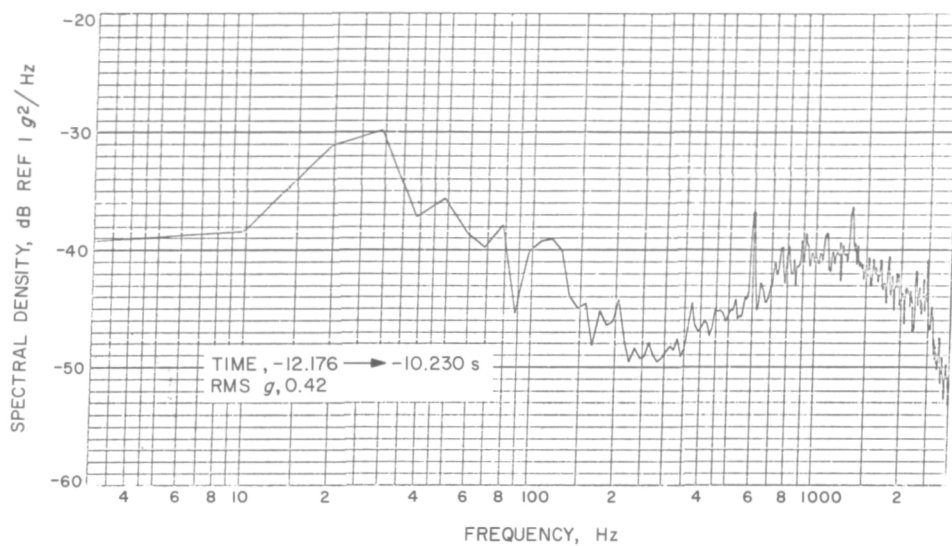


Fig. 35. Acceleration spectral density, Mariner V pre-lift-off quiet time, B3

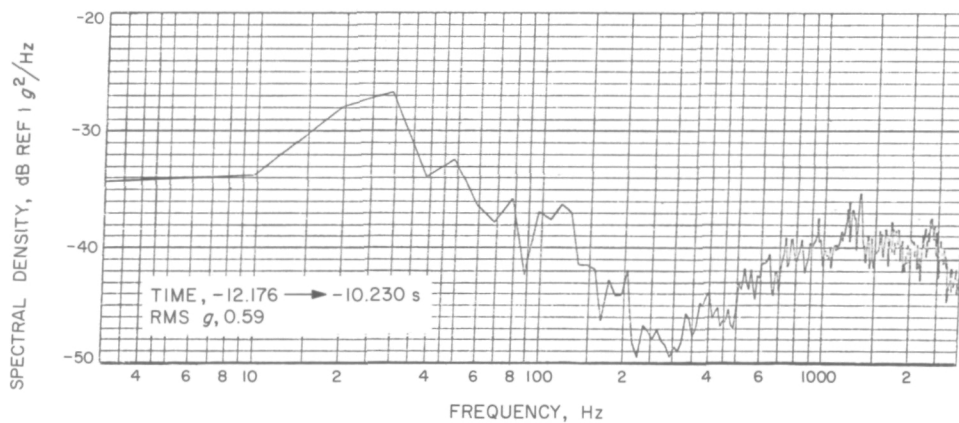


Fig. 36. Acceleration spectral density, Mariner V pre-lift-off quiet time, F4

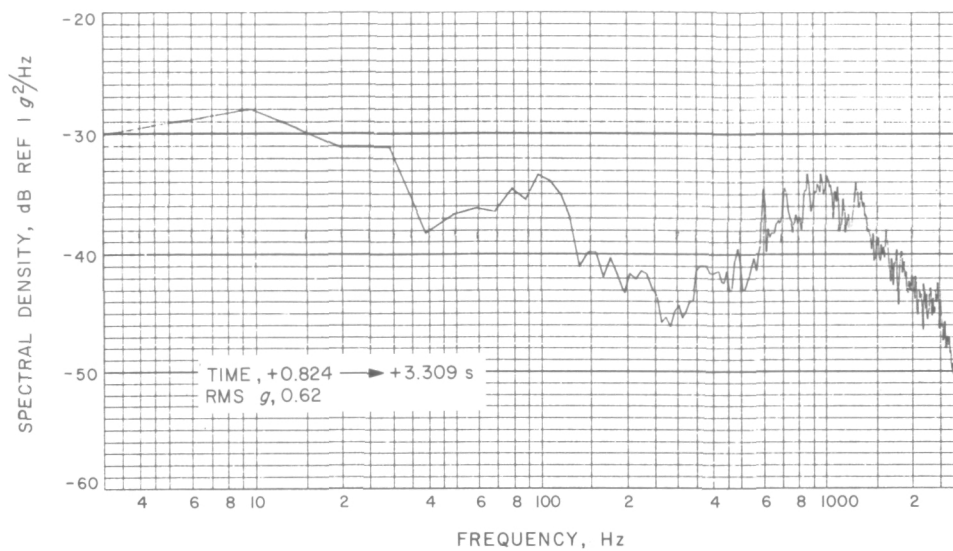


Fig. 37. Acceleration spectral density, Mariner V lift-off, B3

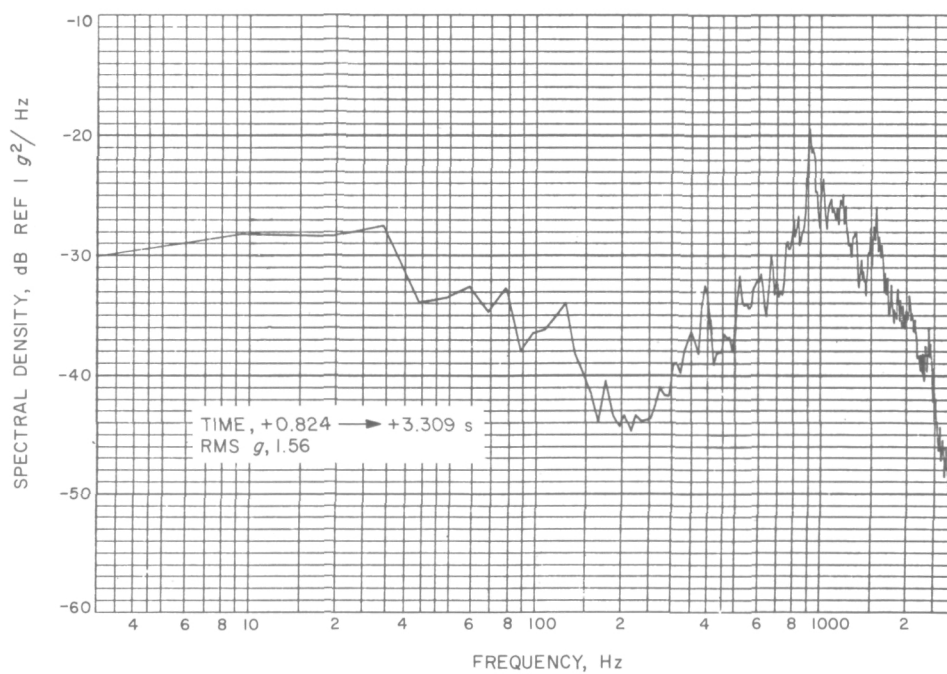


Fig. 38. Acceleration spectral density, Mariner V lift-off, F4

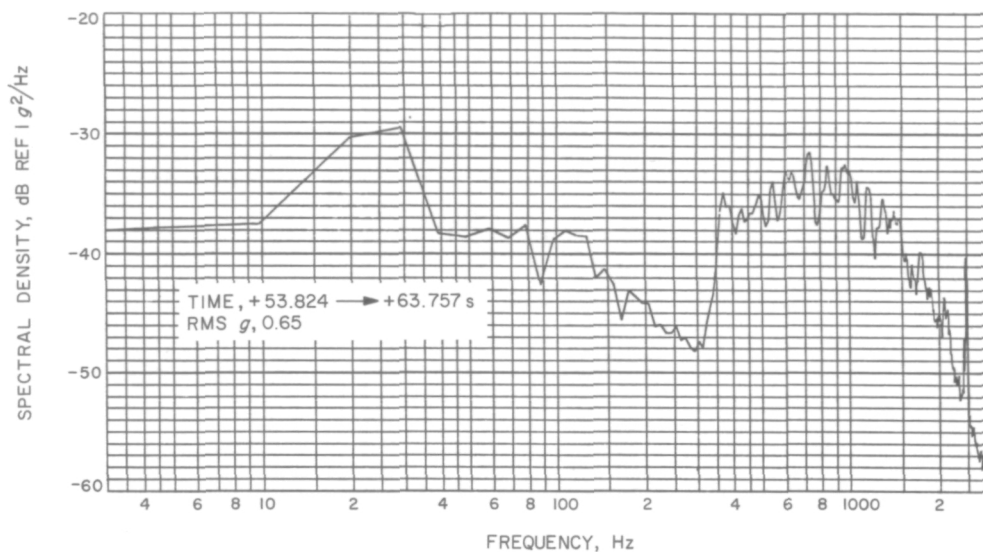


Fig. 39. Acceleration spectral density, *Mariner V* transonic period (10-s sample), B3

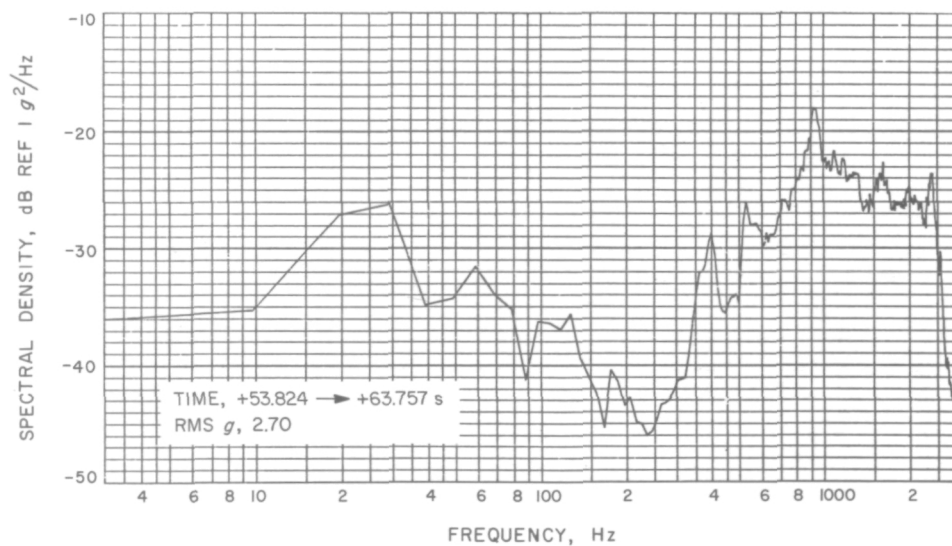


Fig. 40. Acceleration spectral density, *Mariner V* transonic period (10-s sample), F4

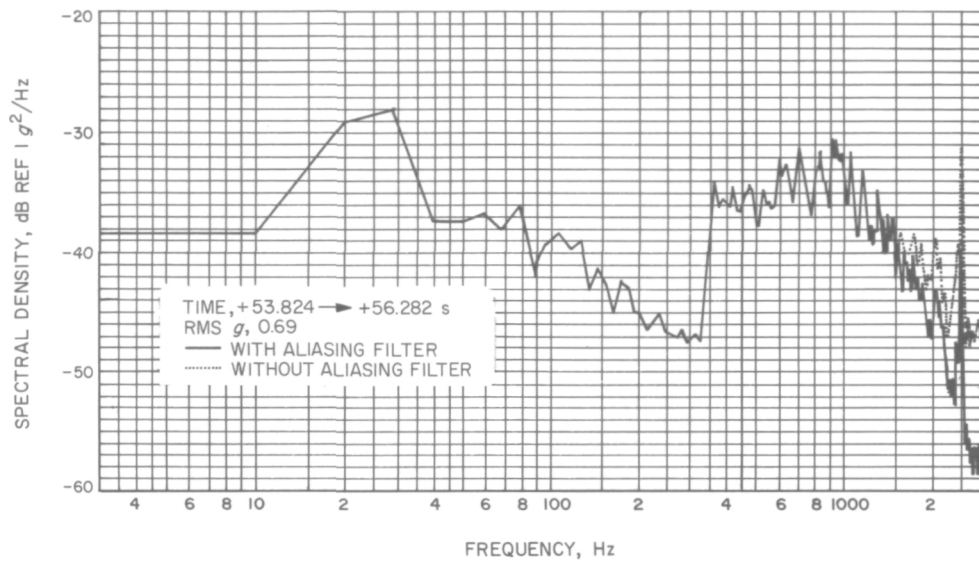


Fig. 41. Acceleration spectral density, *Mariner V* transonic period (53.824–56.282 s), B3

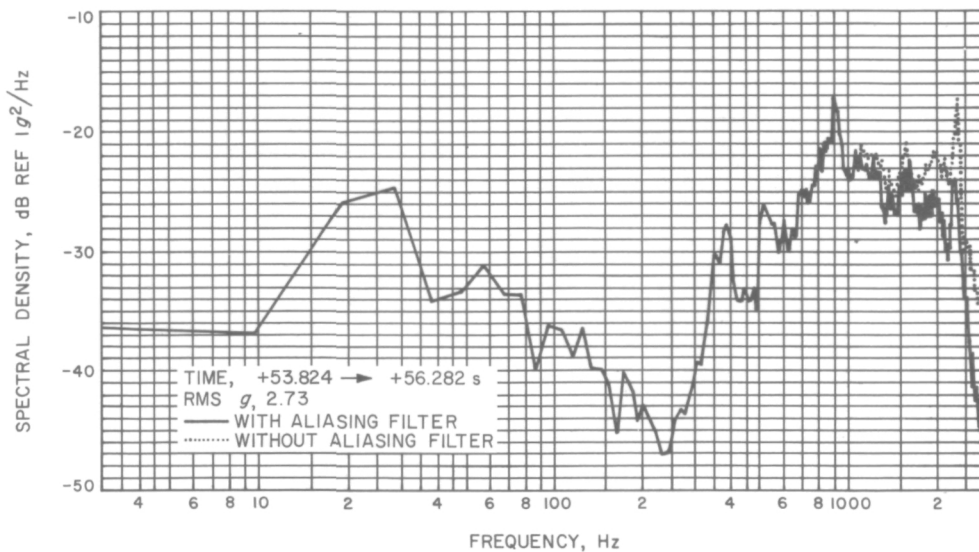


Fig. 42. Acceleration spectral density, *Mariner V* transonic period (53.824–56.282 s), F4

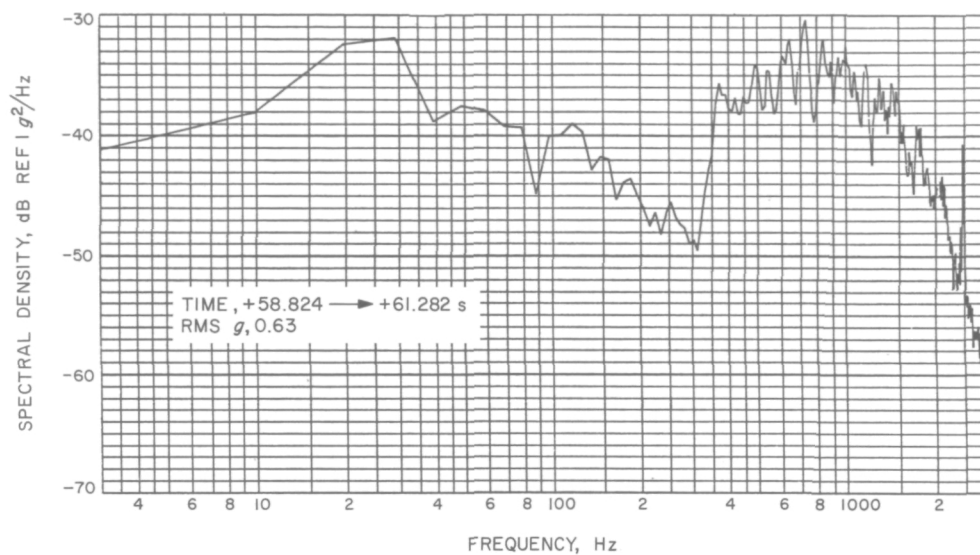


Fig. 43. Acceleration spectral density, Mariner V transonic period (58.824–61.282 s), B3

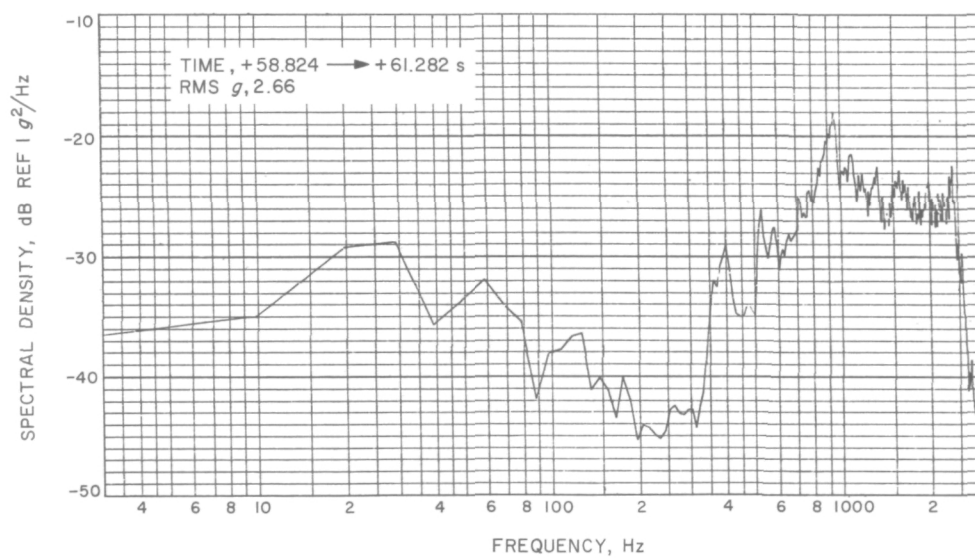


Fig. 44. Acceleration spectral density, Mariner V transonic period (58.824–61.282 s), F4

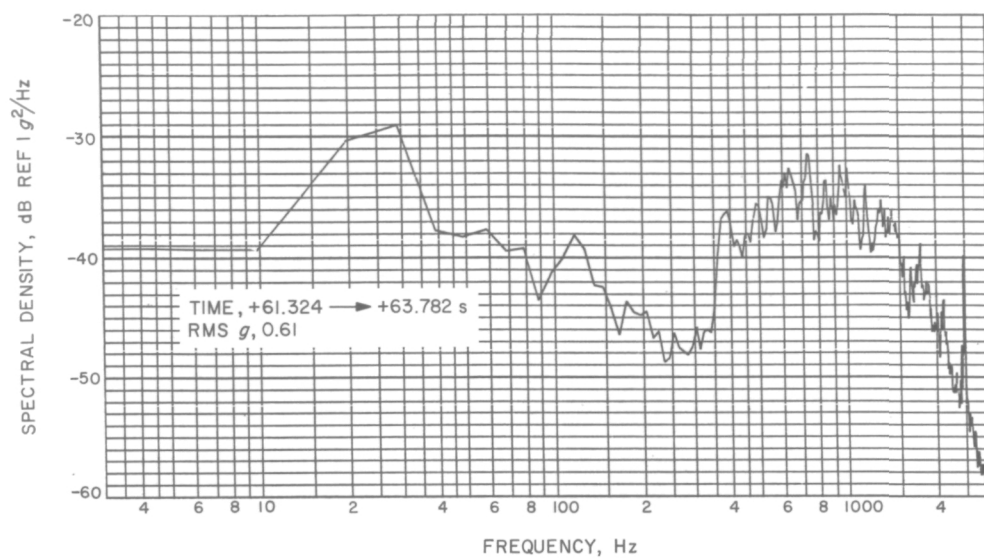


Fig. 45. Acceleration spectral density, *Mariner V* transonic period (61.324–63.782 s), B3

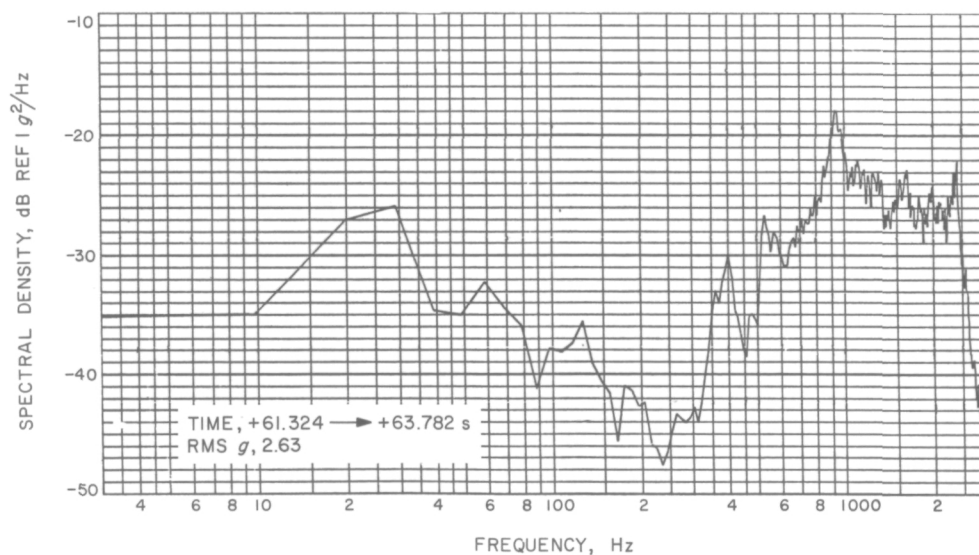


Fig. 46. Acceleration spectral density, *Mariner V* transonic period (61.324–63.782 s), F4

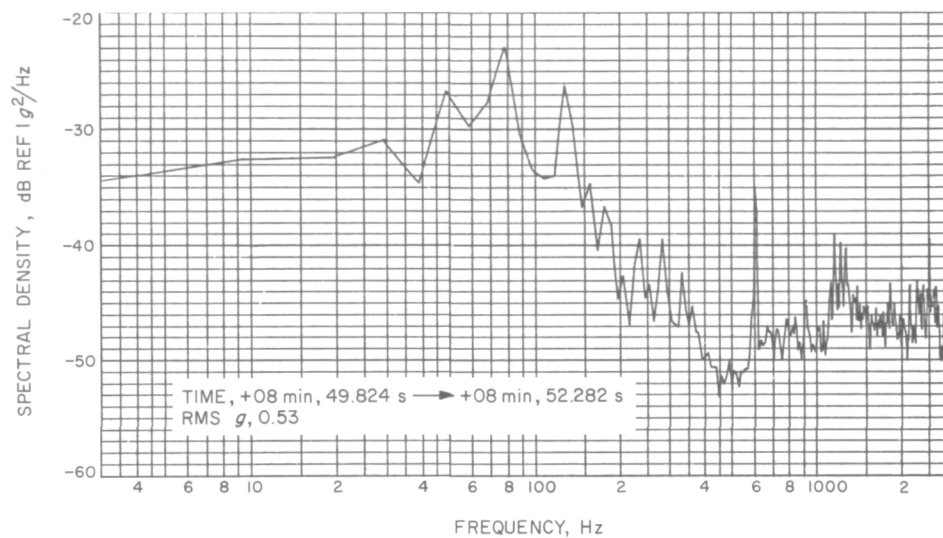


Fig. 47. Acceleration spectral density, *Mariner V* coast time, Antigua tape, B3

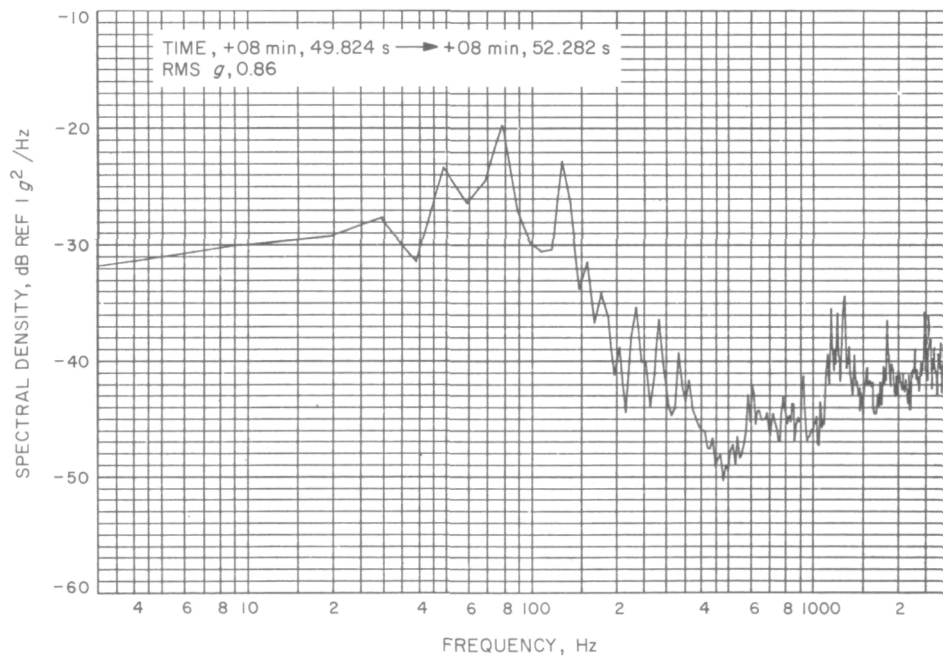


Fig. 48. Acceleration spectral density, *Mariner V* coast time, Antigua tape, F4

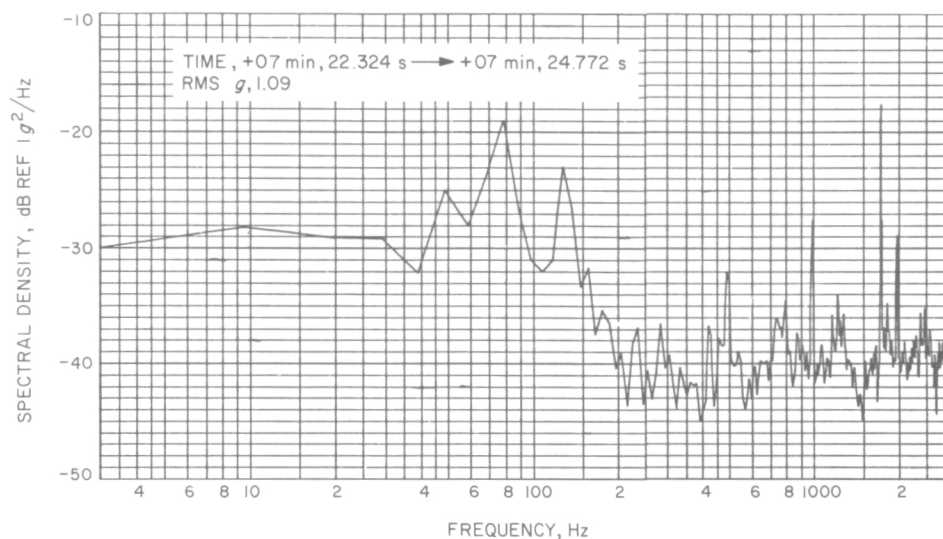


Fig. 49. Acceleration spectral density, *Mariner V* Agena first burn, Antigua tape, F4

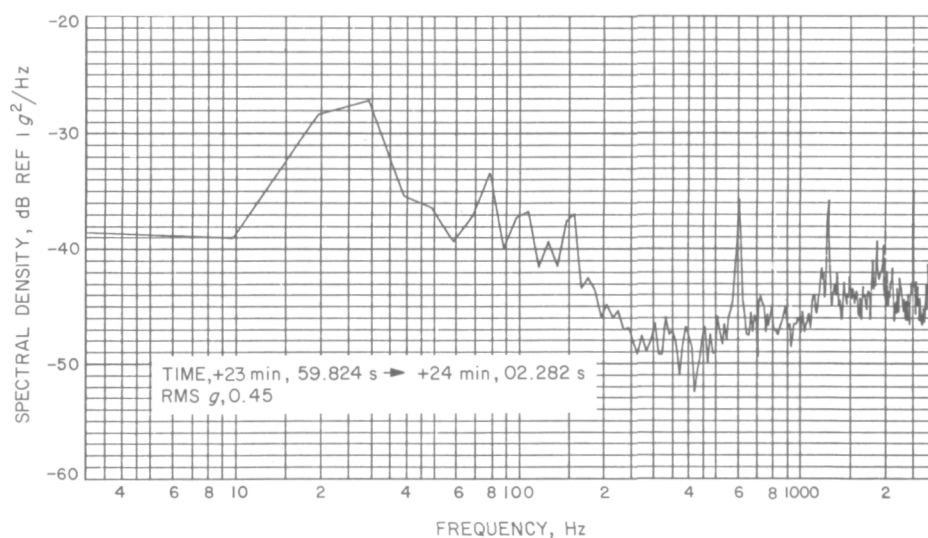


Fig. 50. Acceleration spectral density, *Mariner V* coast time, Ascension tape, B3

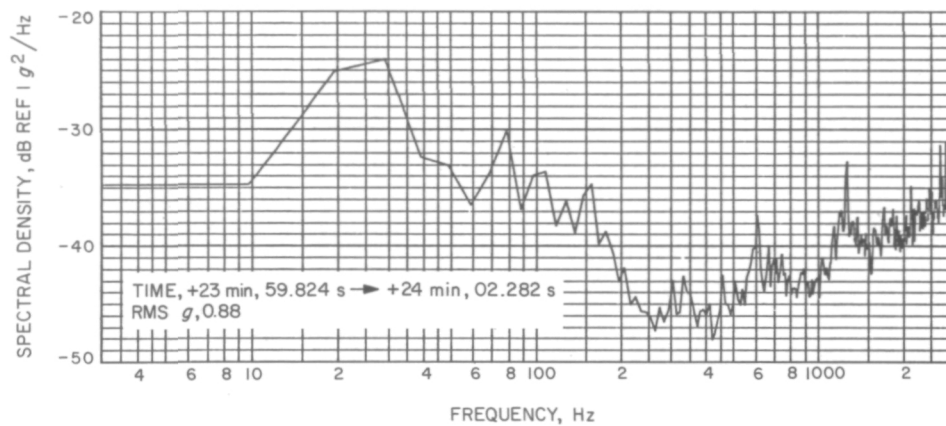


Fig. 51. Acceleration spectral density, Mariner V coast time, Ascension tape, F4

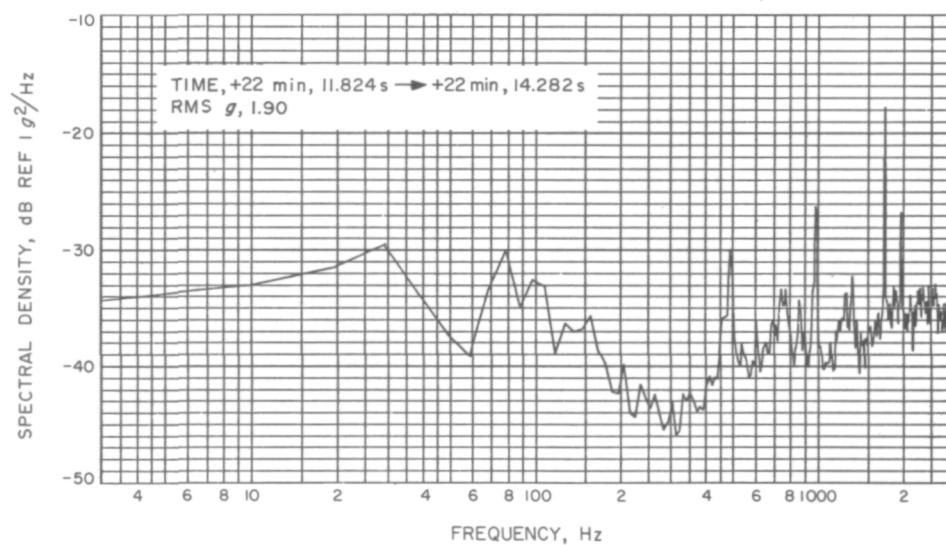


Fig. 52. Acceleration spectral density, Mariner V Agena second burn, Ascension tape, F4

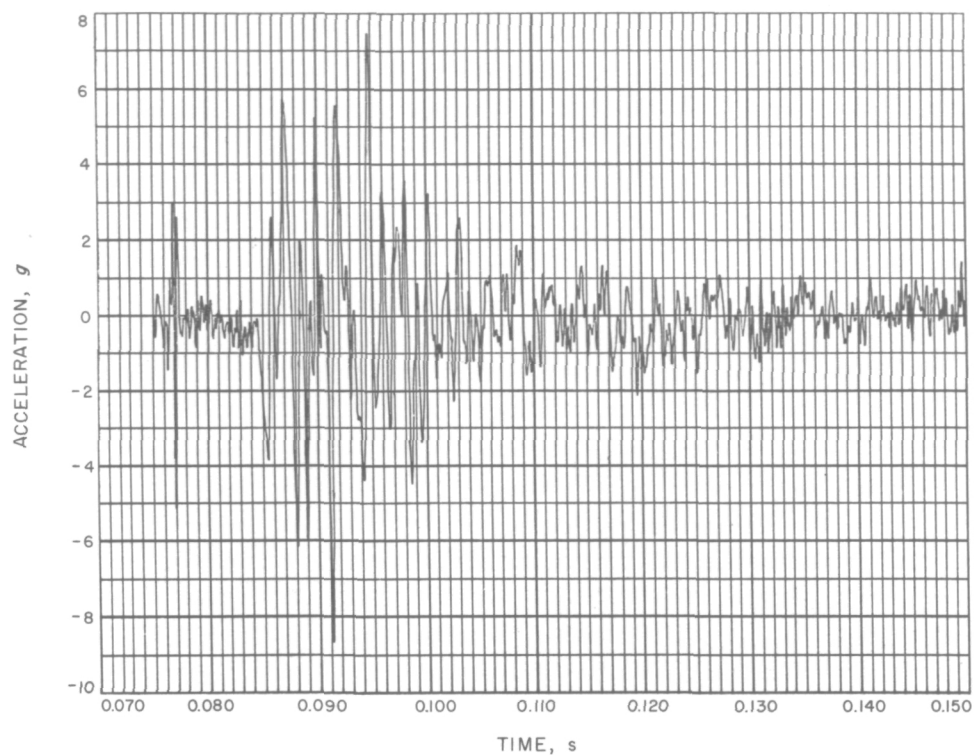


Fig. 53. Transient acceleration, Mariner V horizon sensor fairing jettison, B3

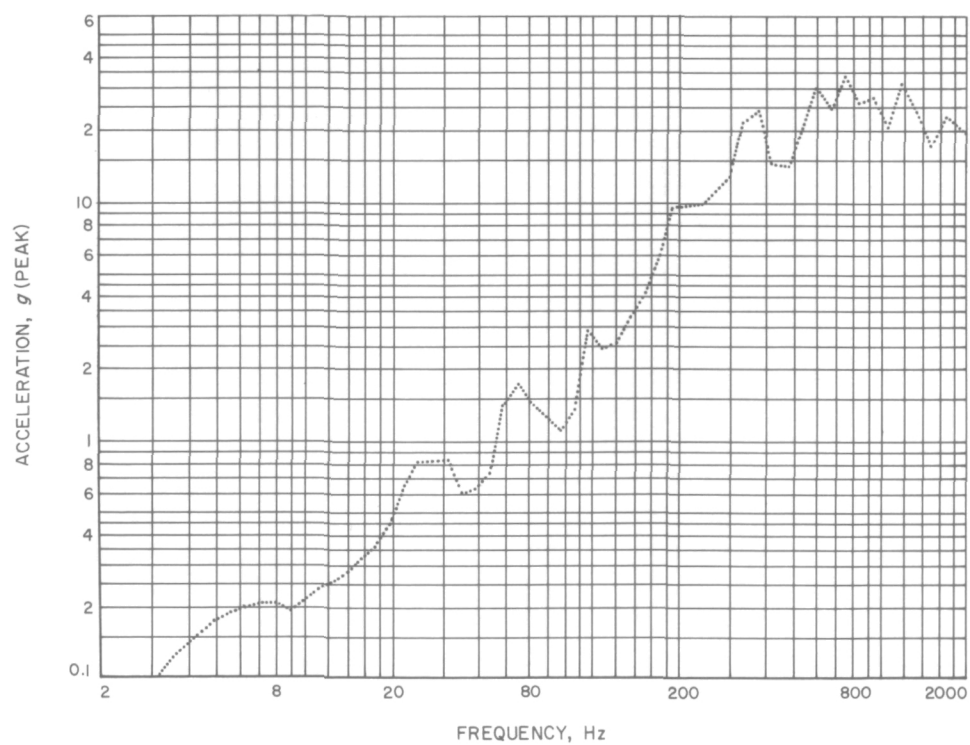


Fig. 54. Shock spectrum, Mariner V horizon sensor fairing jettison, B3

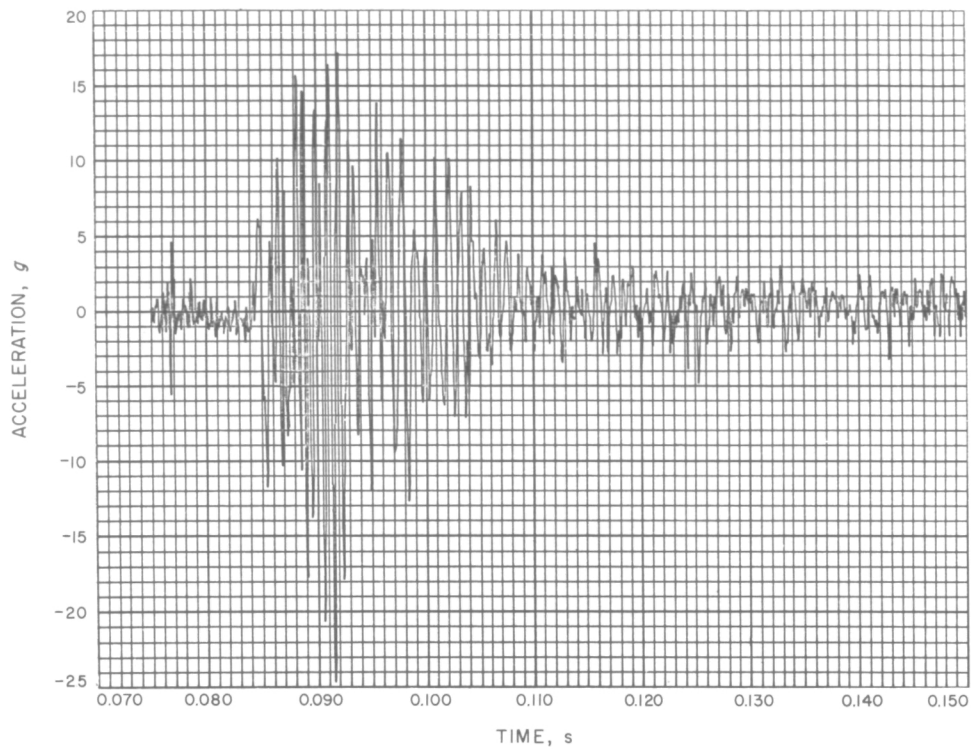


Fig. 55. Transient acceleration, Mariner V horizon sensor fairing jettison, F4

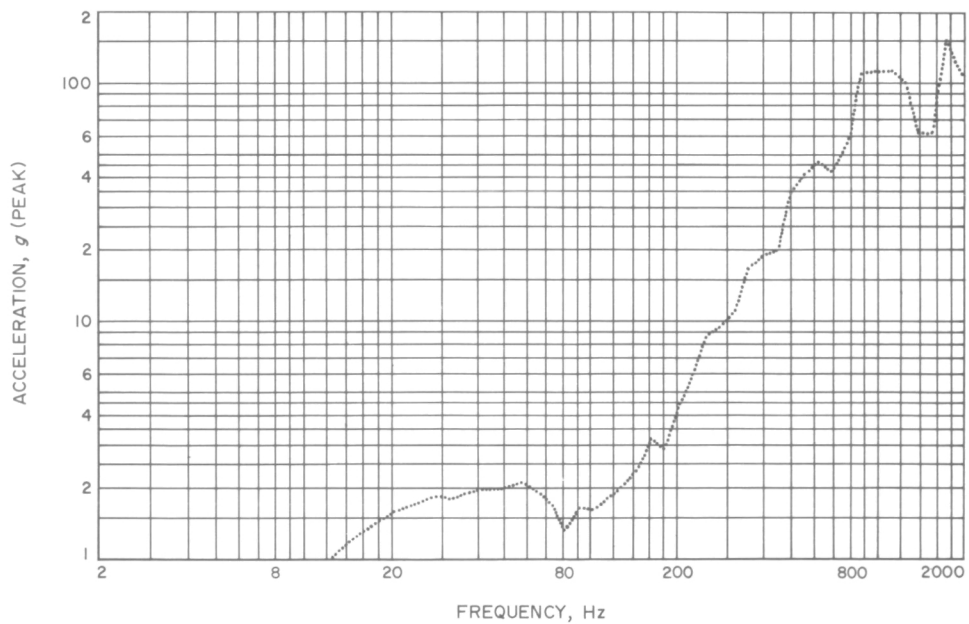


Fig. 56. Shock spectrum, Mariner V horizon sensor fairing jettison, F4

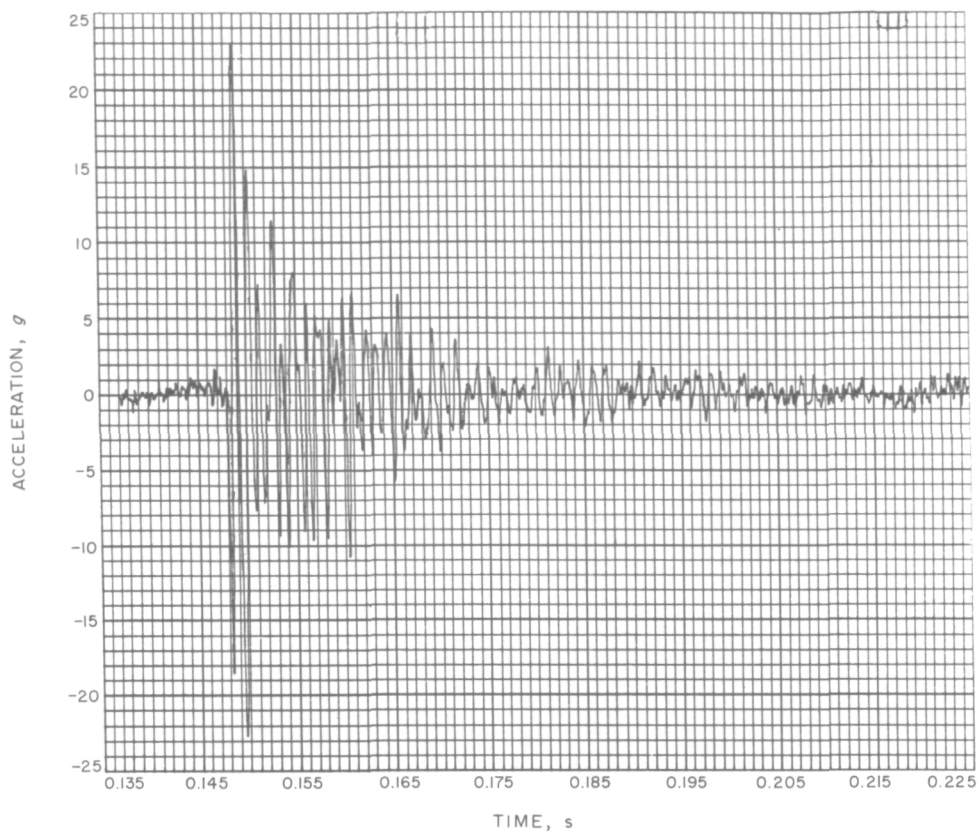


Fig. 57. Transient acceleration, *Mariner V* shroud jettison, B3

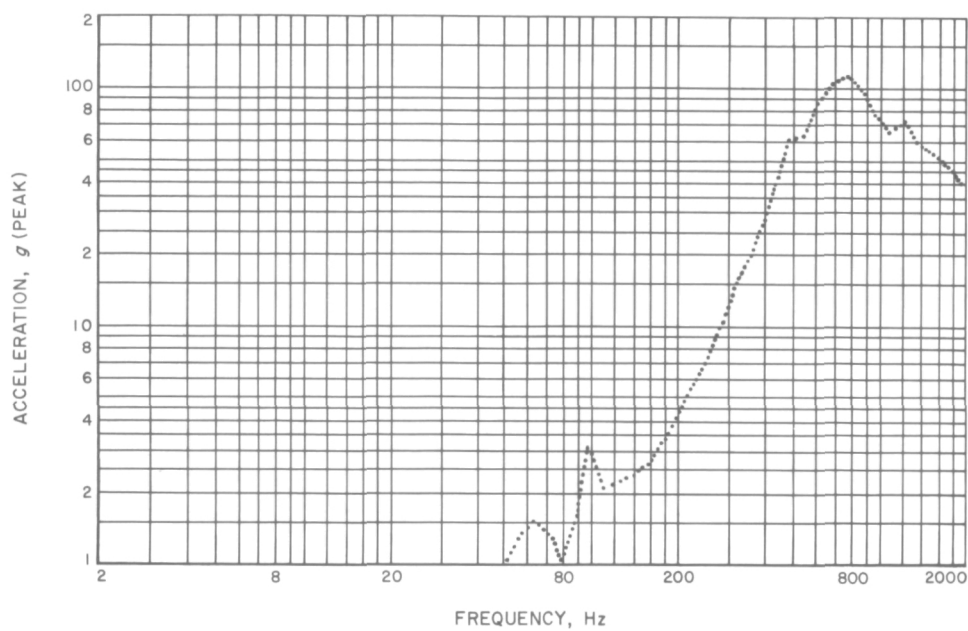
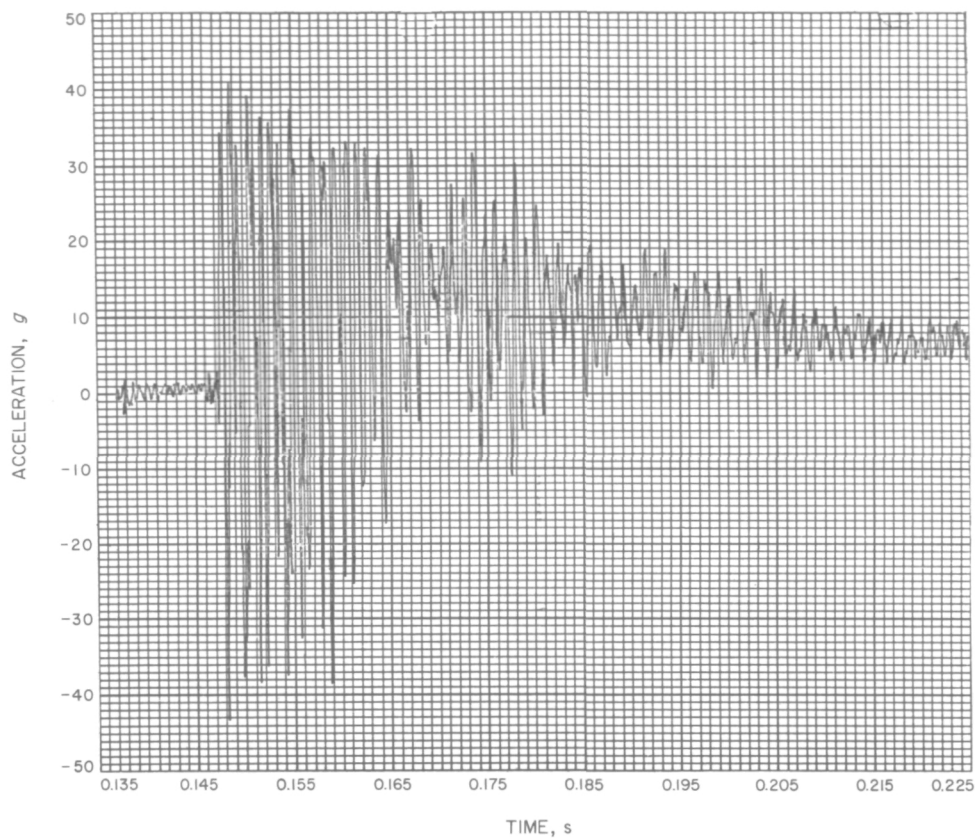
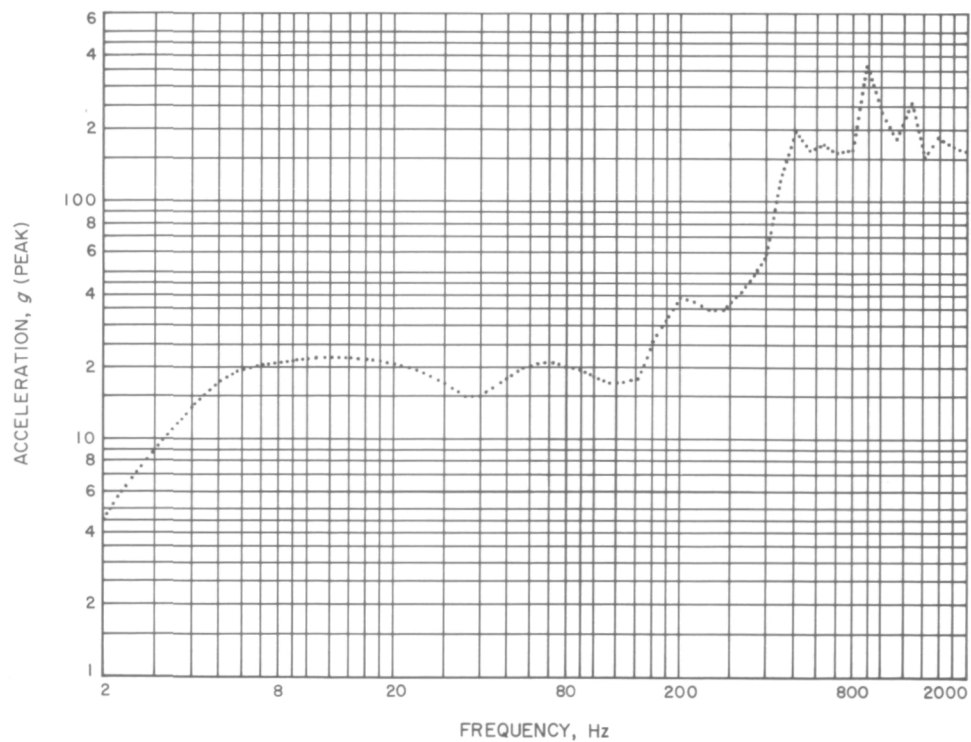


Fig. 58. Shock spectrum, *Mariner V* shroud jettison, B3



**Fig. 59. Transient acceleration,
Mariner V shroud jettison, F4**

**Fig. 60. Shock spectrum,
Mariner V shroud
jettison, F4**



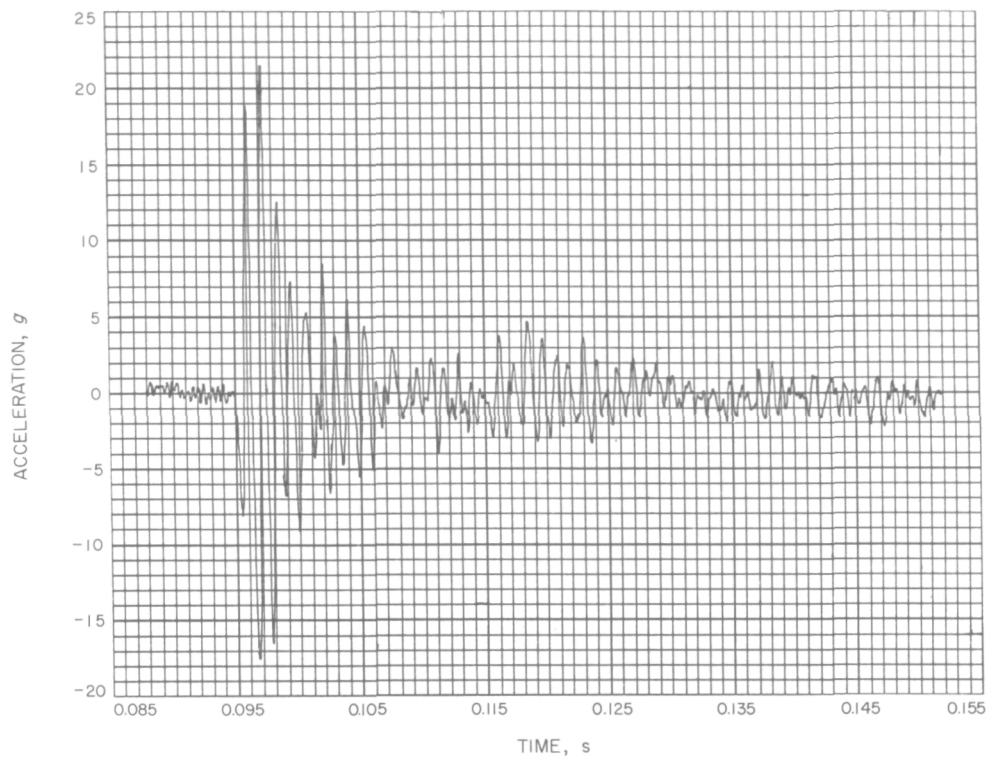


Fig. 61. Transient acceleration, *Mariner V Atlas/Agena separation, B3*

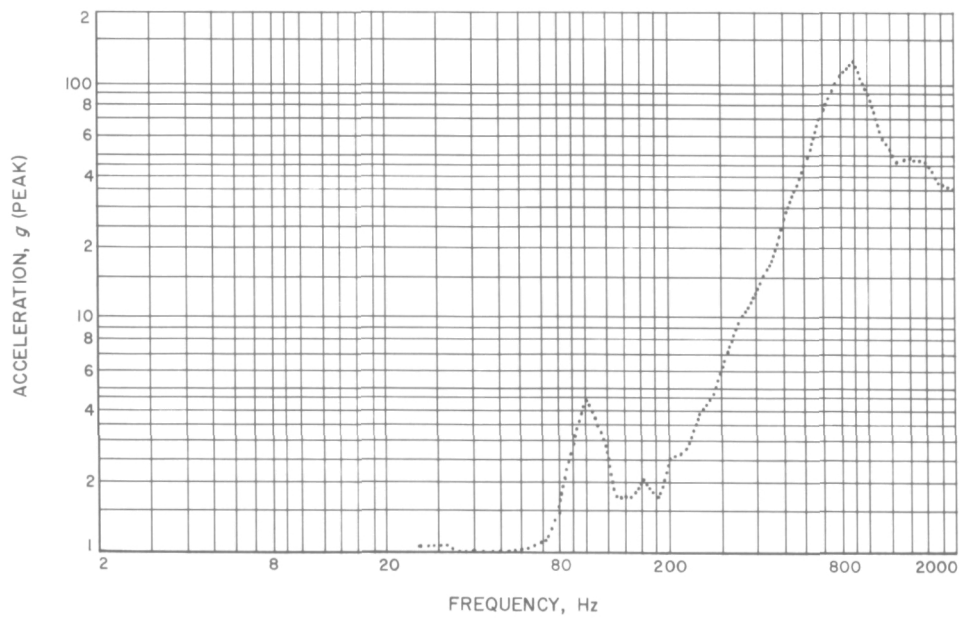


Fig. 62. Shock spectrum, *Mariner V Atlas/Agena separation, B3*

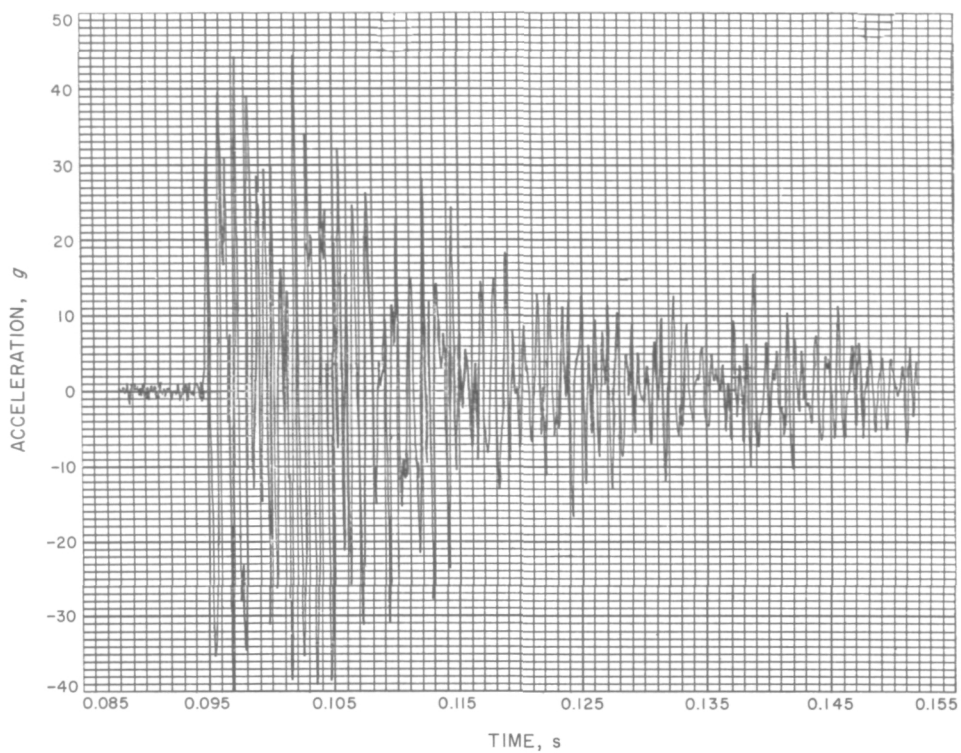


Fig. 63. Transient acceleration, *Mariner V Atlas/Agena* separation, F4

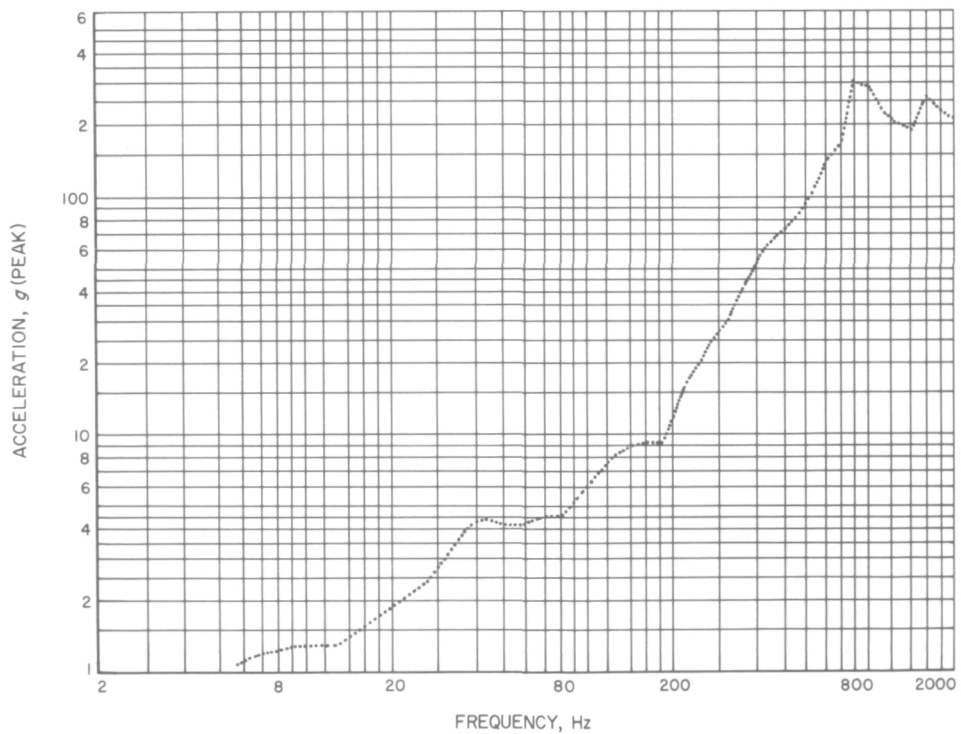


Fig. 64. Shock spectrum, *Mariner V Atlas/Agena* separation, F4

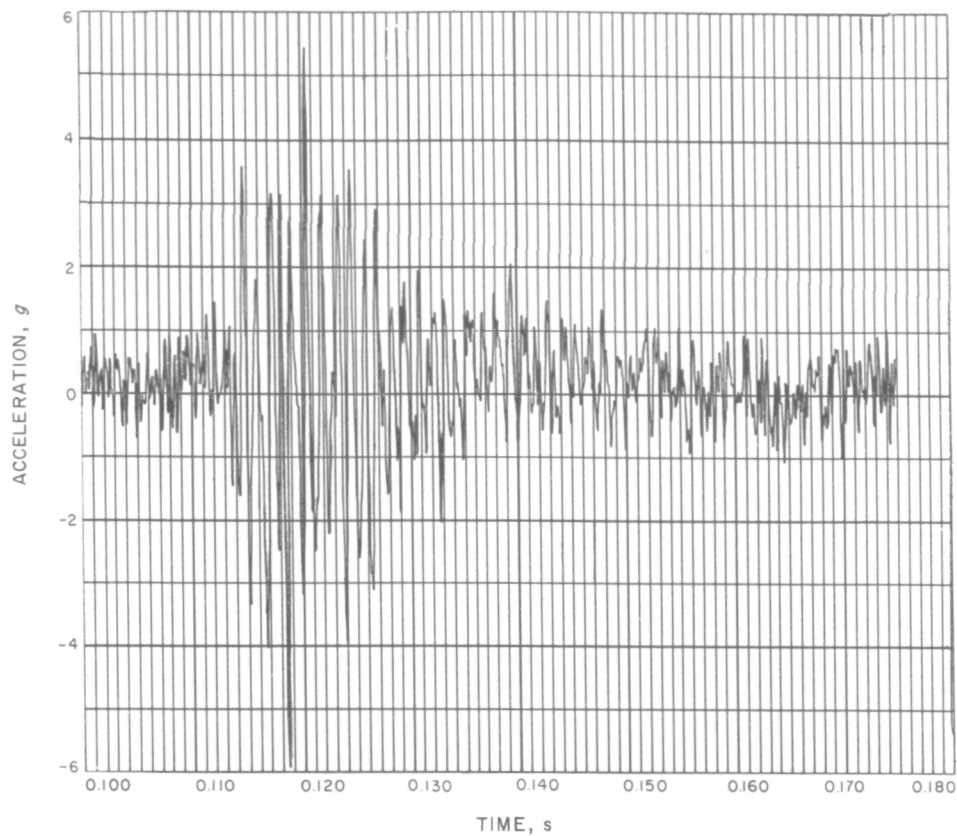


Fig. 65. Transient acceleration, *Mariner V Agena* first ignition, B3

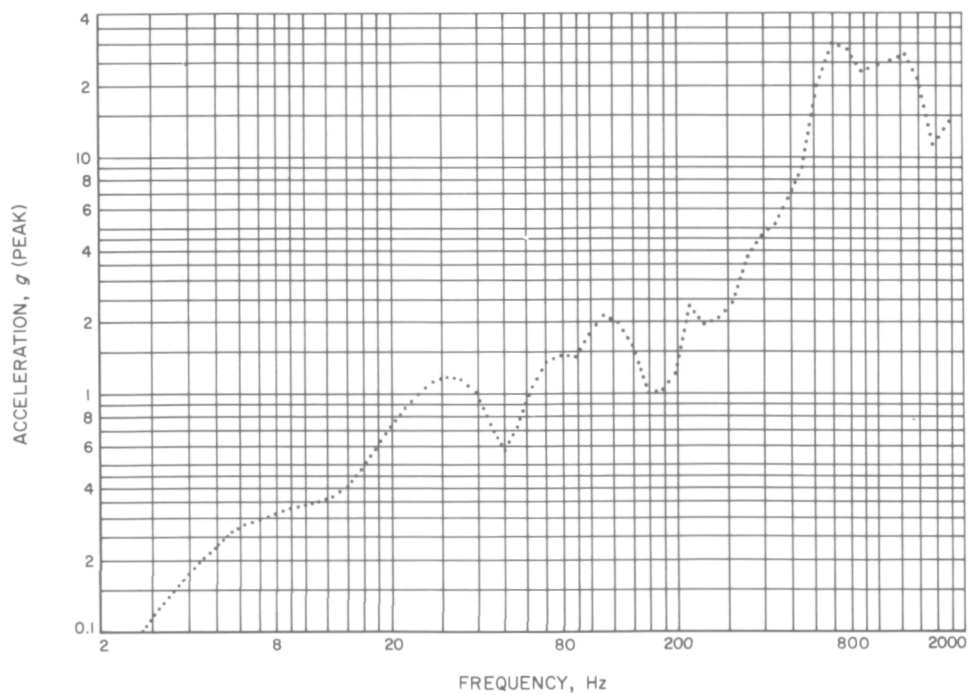


Fig. 66. Shock spectrum, *Mariner V Agena* first ignition, B3

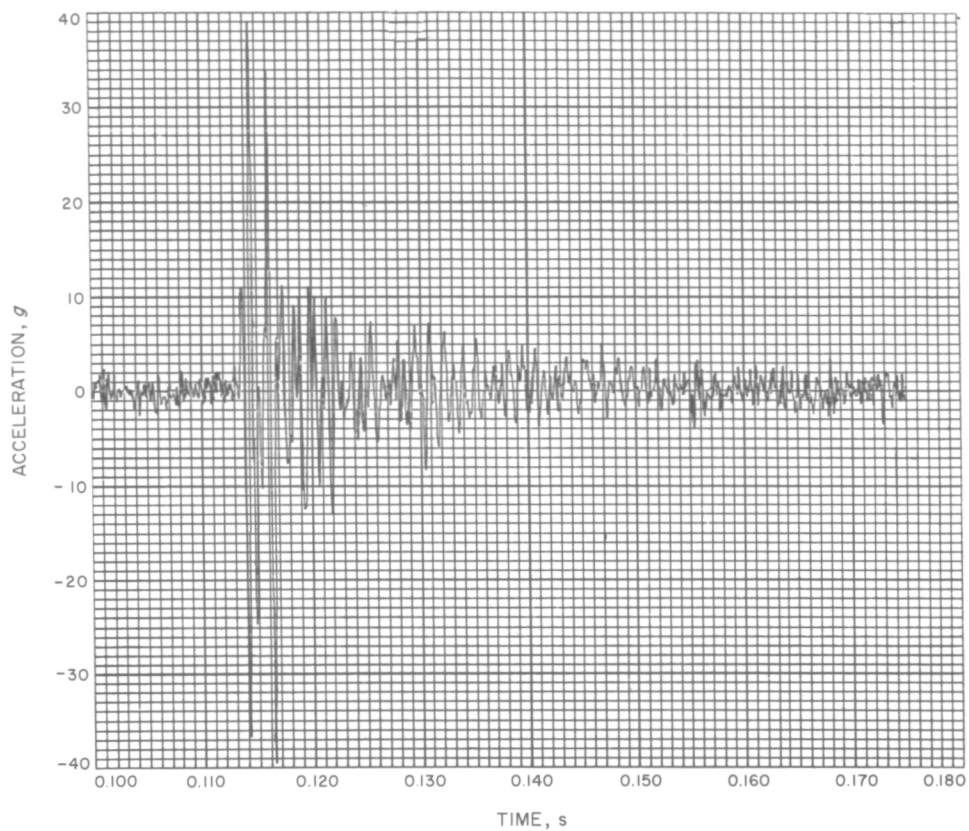


Fig. 67. Transient acceleration, *Mariner V* Agena first ignition, F4

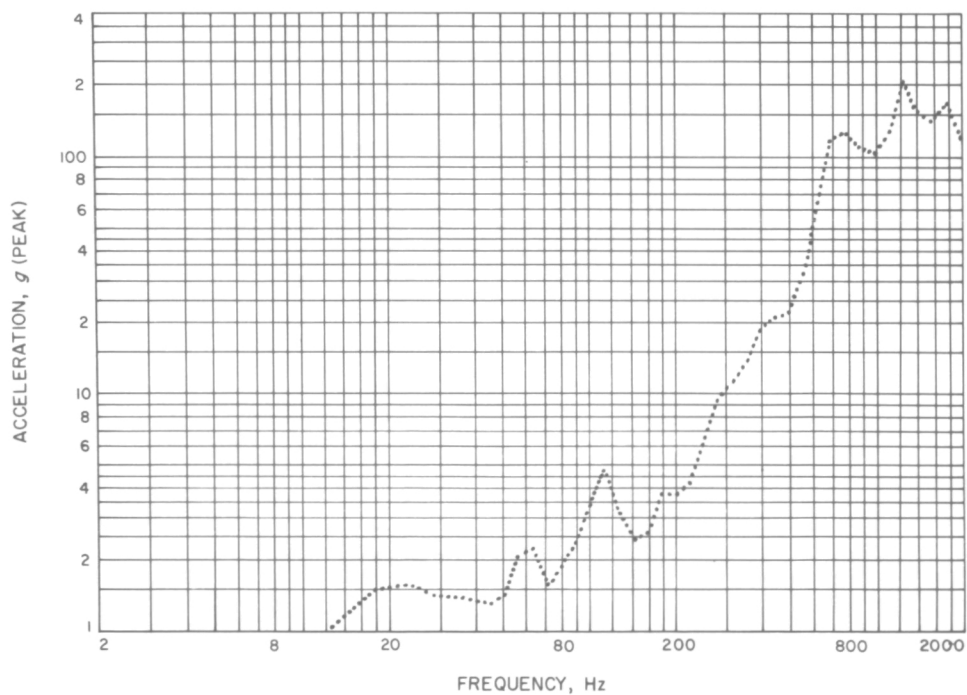


Fig. 68. Shock spectrum, *Mariner V* Agena first ignition, F4

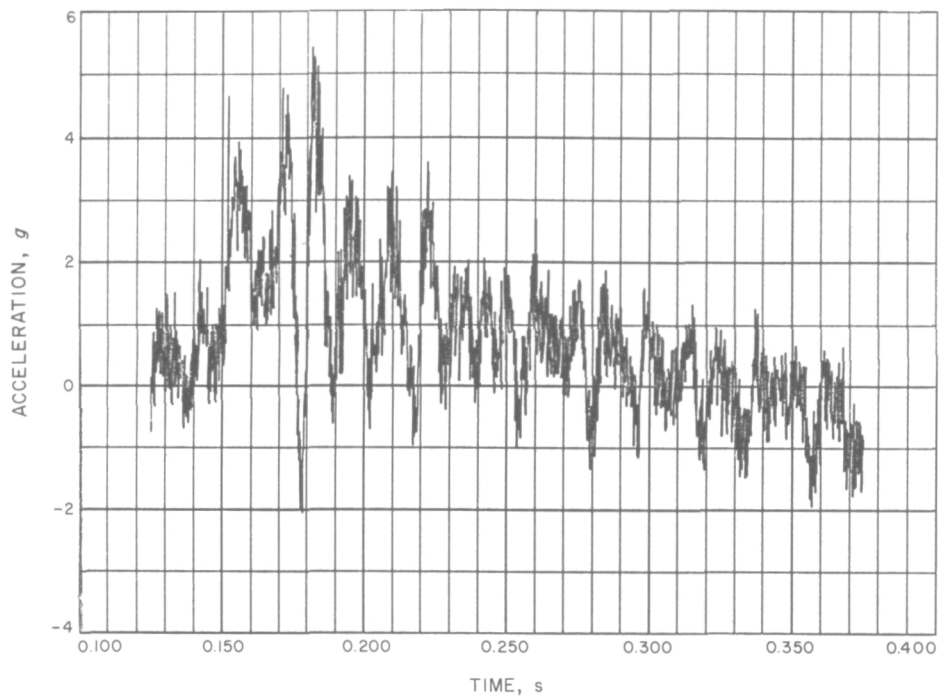


Fig. 69. Transient acceleration, *Mariner V* Agena first cutoff, B3

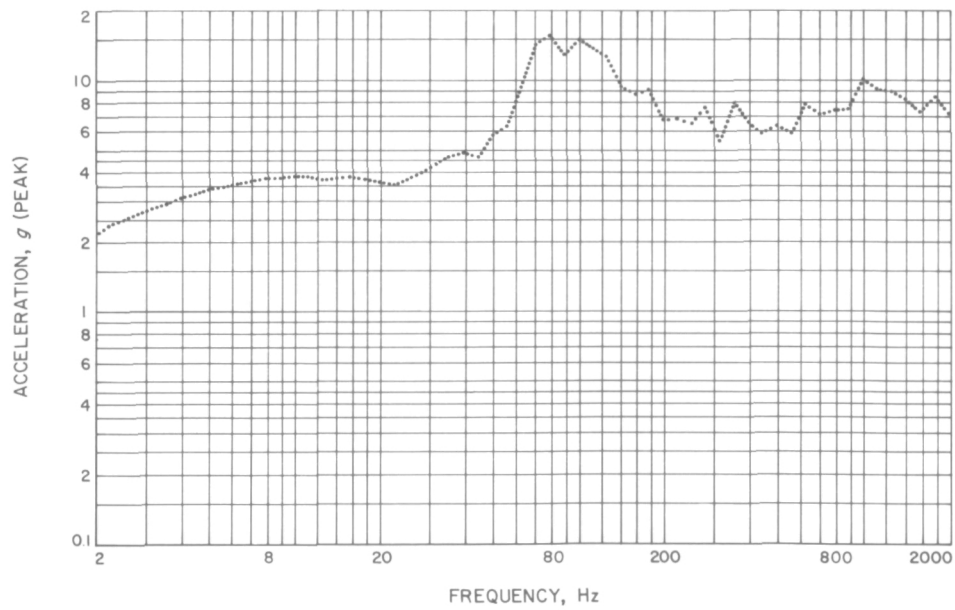


Fig. 70. Shock spectrum, *Mariner V* Agena first cutoff, B3

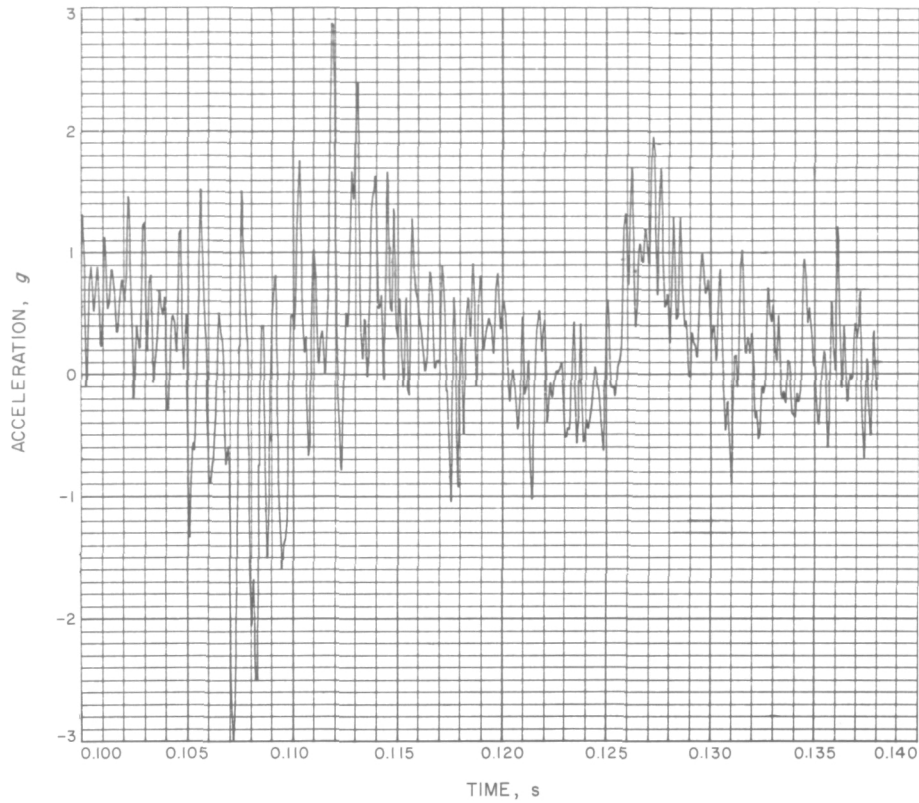


Fig. 71. Transient acceleration, Mariner V firing of horizon sensor 0-deg position squib, B3

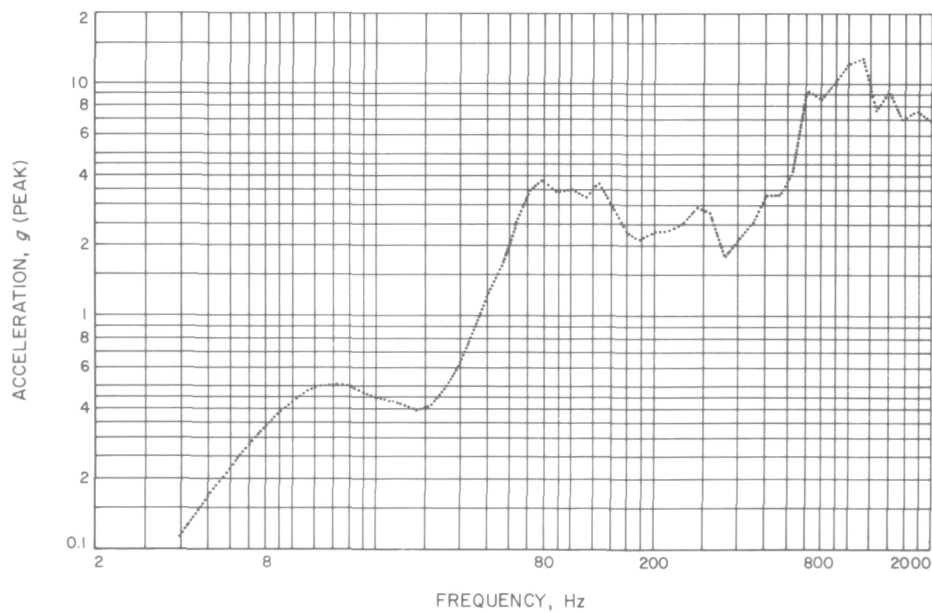


Fig. 72. Shock spectrum, Mariner V firing of horizon sensor 0-deg position squib, B3

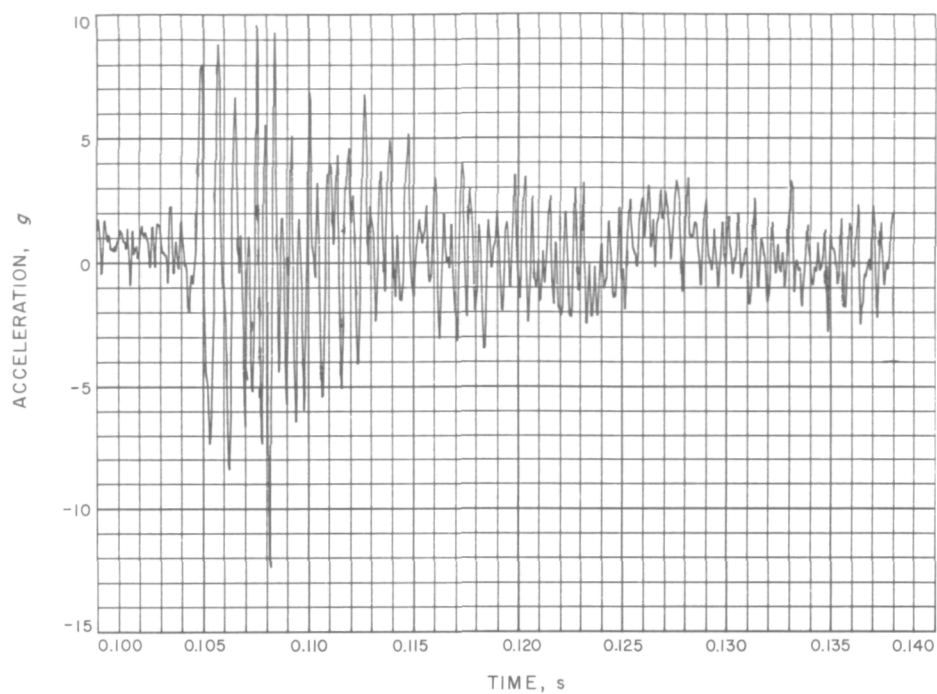


Fig. 73. Transient acceleration, Mariner V firing of horizon sensor 0-deg position squib, F4

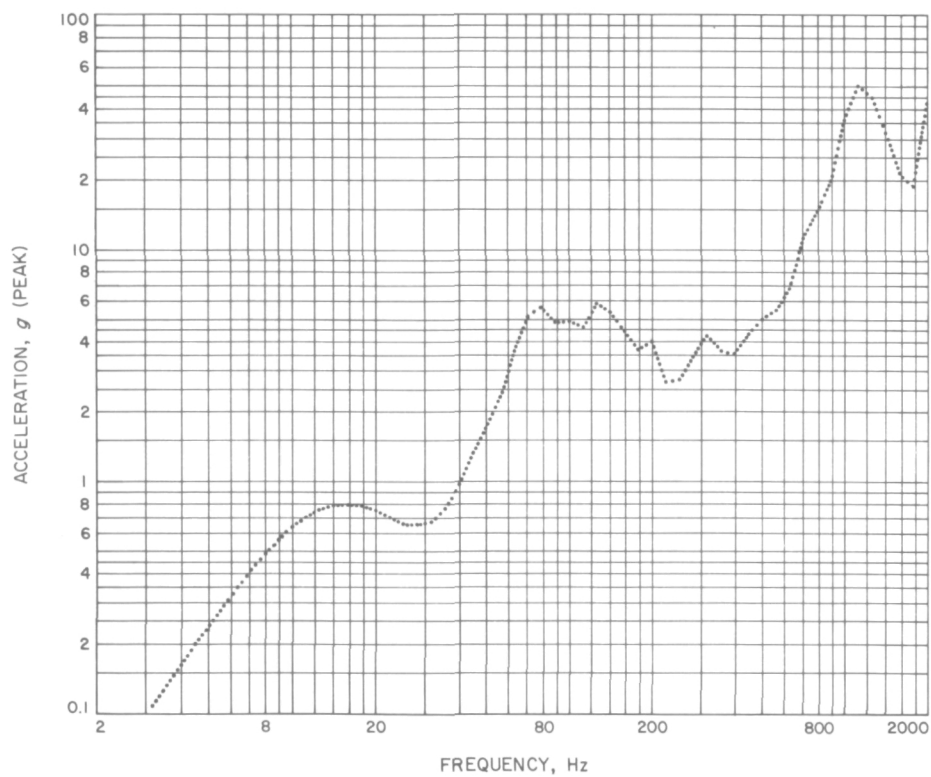


Fig. 74. Shock spectrum, Mariner V firing of horizon sensor 0-deg position squib, F4

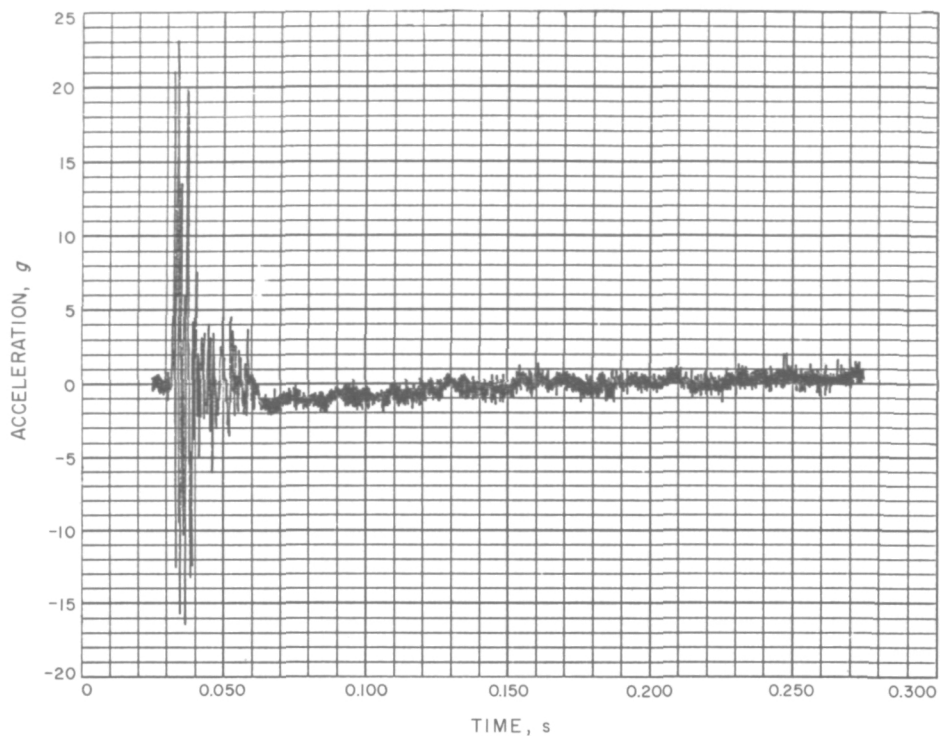


Fig. 75. Transient acceleration, Mariner V spacecraft separation, B3

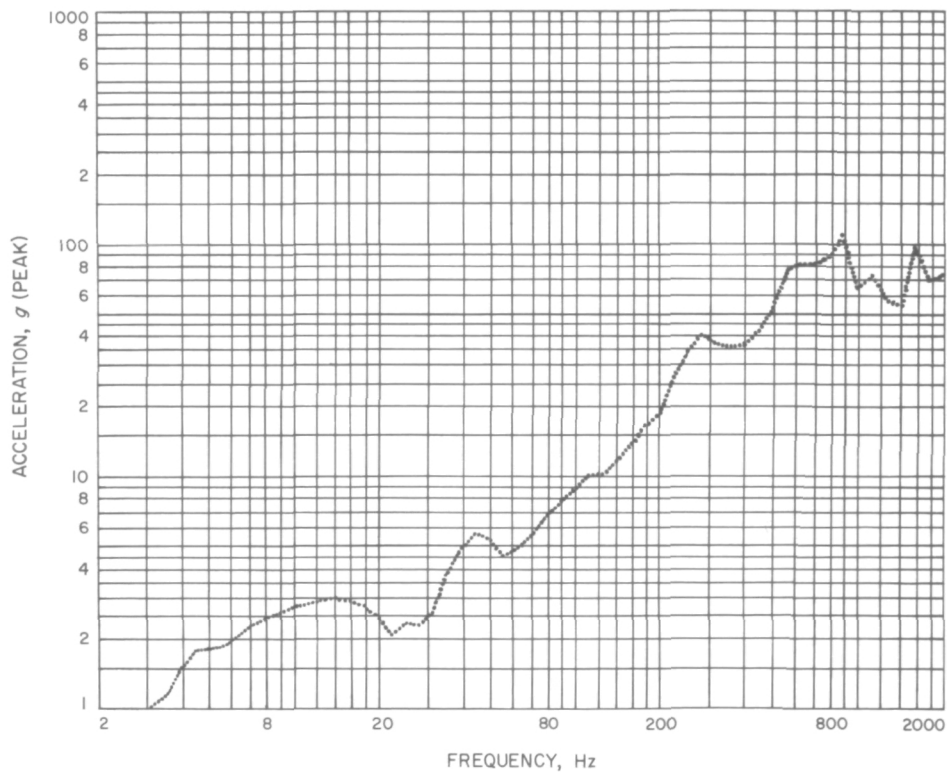


Fig. 76. Shock spectrum, Mariner V spacecraft separation, B3

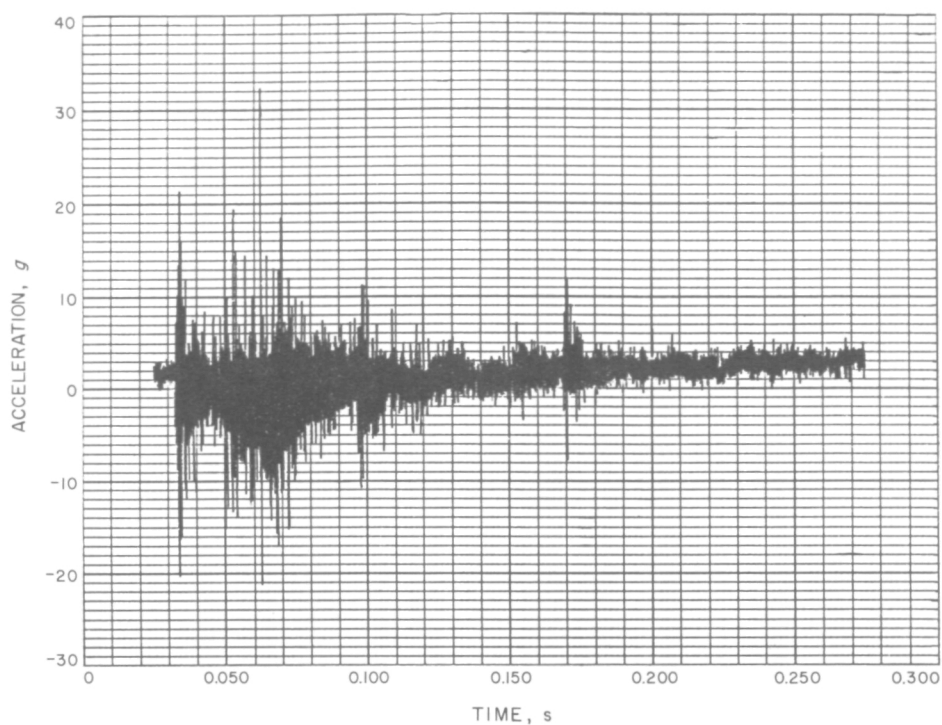


Fig. 77. Transient acceleration, *Mariner V* spacecraft separation, F4

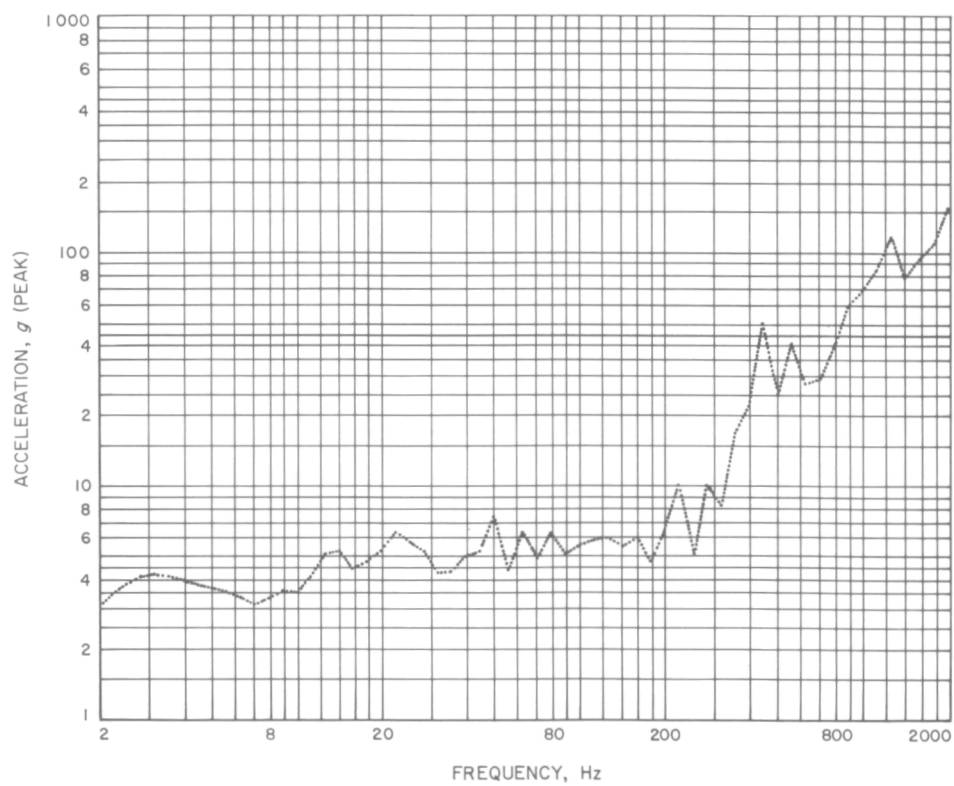


Fig. 78. Shock spectrum, *Mariner V* spacecraft separation, F4

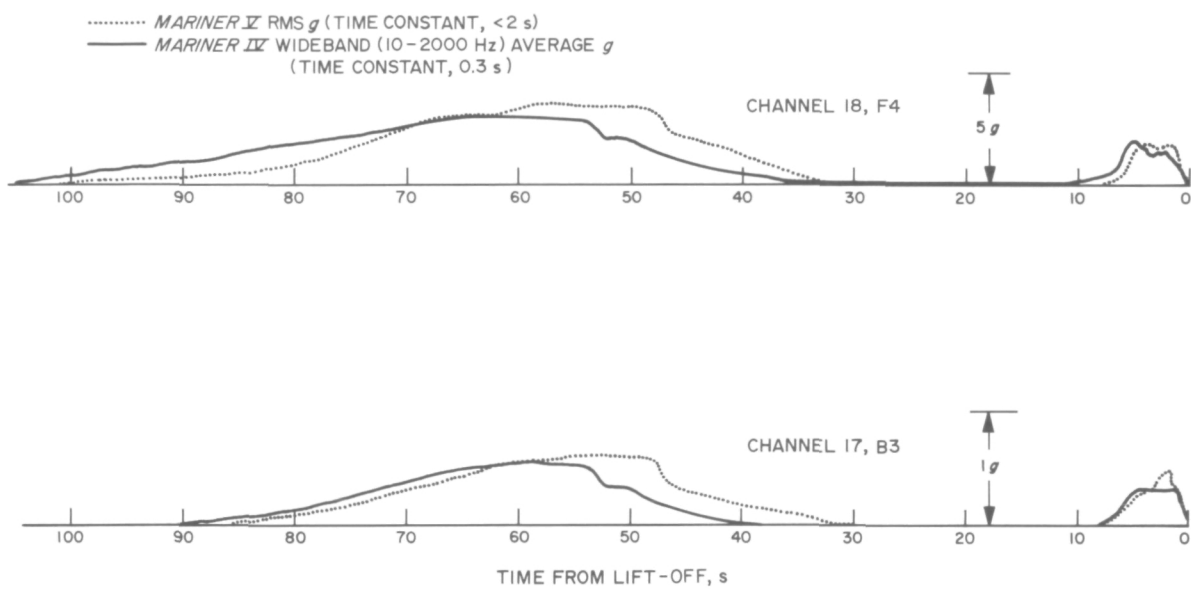


Fig. 79. Comparison of Mariner IV and V lift-off and transonic slow-speed rms values, B3 and F4

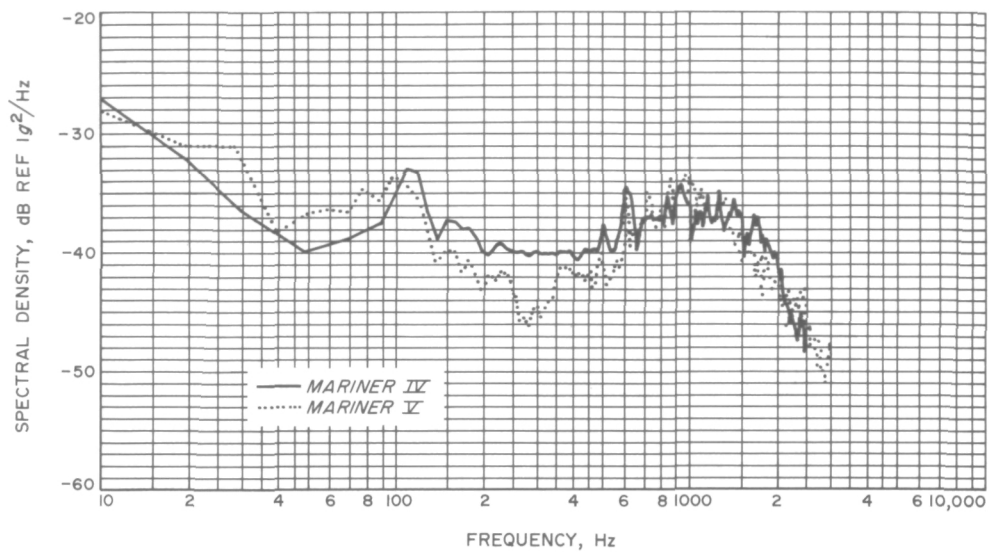


Fig. 80. Comparison of Mariner IV and V acceleration spectral density at lift-off, B3

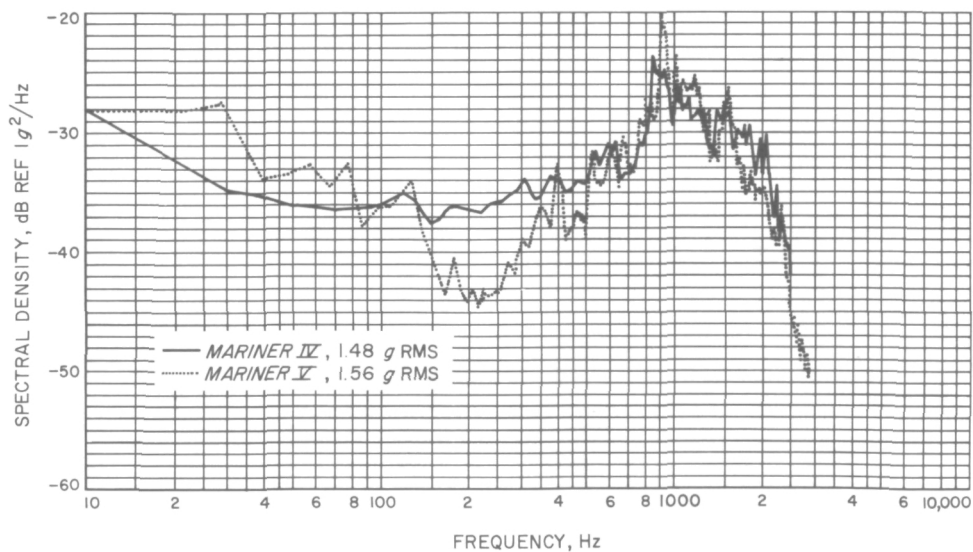


Fig. 81. Comparison of Mariner IV and V acceleration spectral density at lift-off, F4

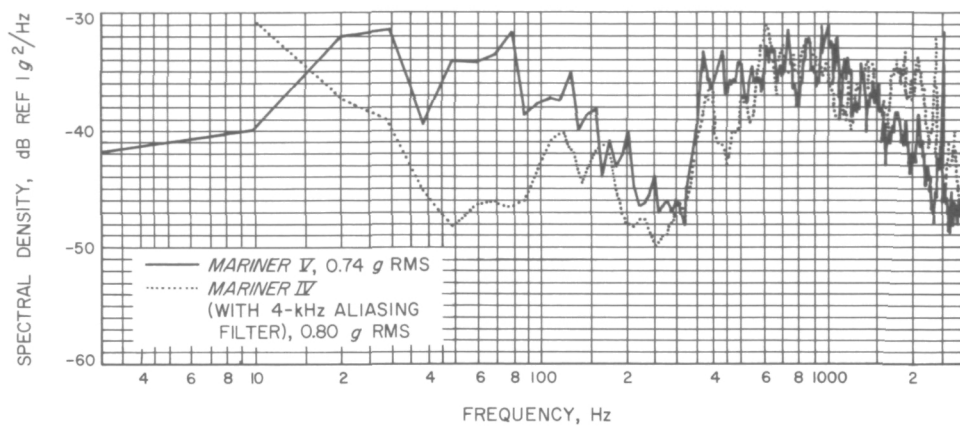


Fig. 82. Comparison of *Mariner IV* and *V* acceleration spectral density at transonic velocity, B3

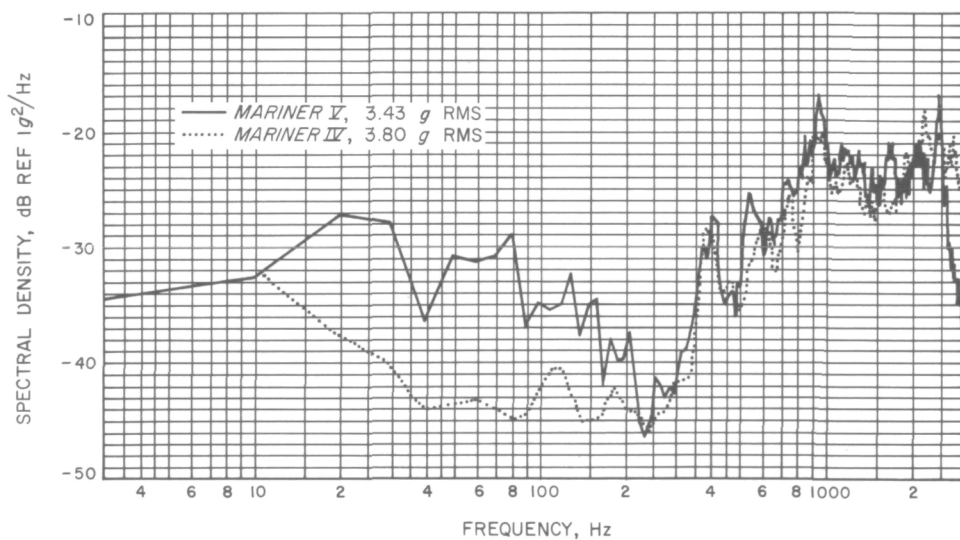


Fig. 83. Comparison of *Mariner IV* and *V* acceleration spectral density at transonic velocity, F4

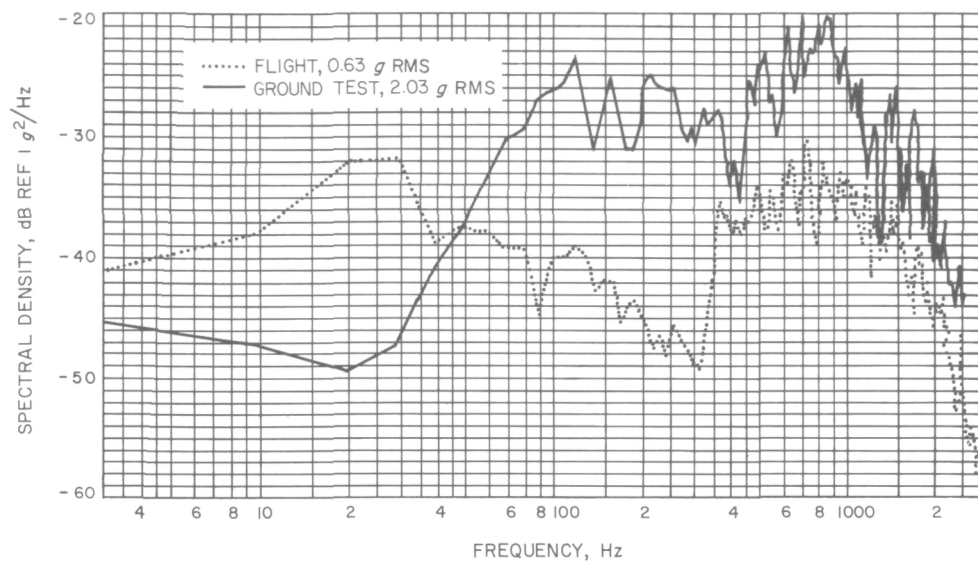


Fig. 84. Comparison of *Mariner V* acceleration spectral density at transonic velocity with the ground test level, B3

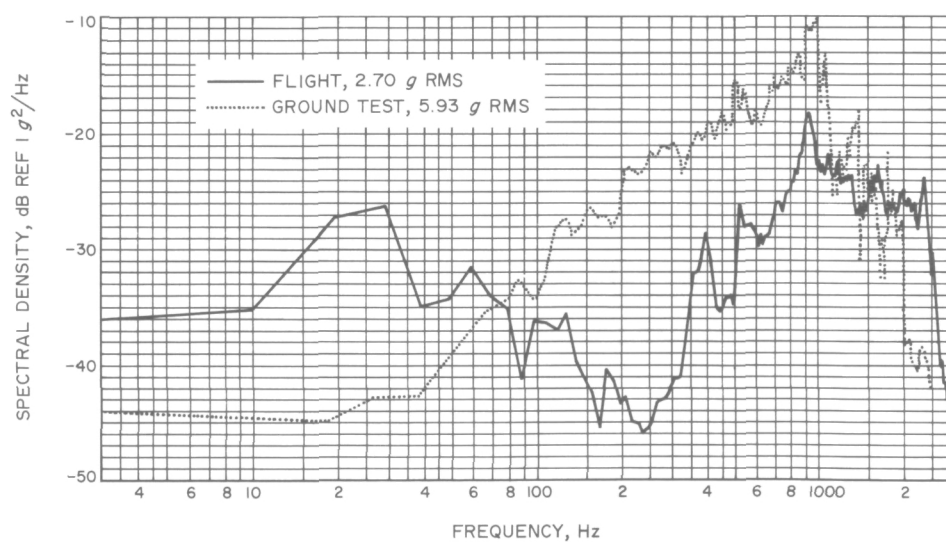


Fig. 85. Comparison of *Mariner V* acceleration spectral density at transonic velocity with the ground test level, F4

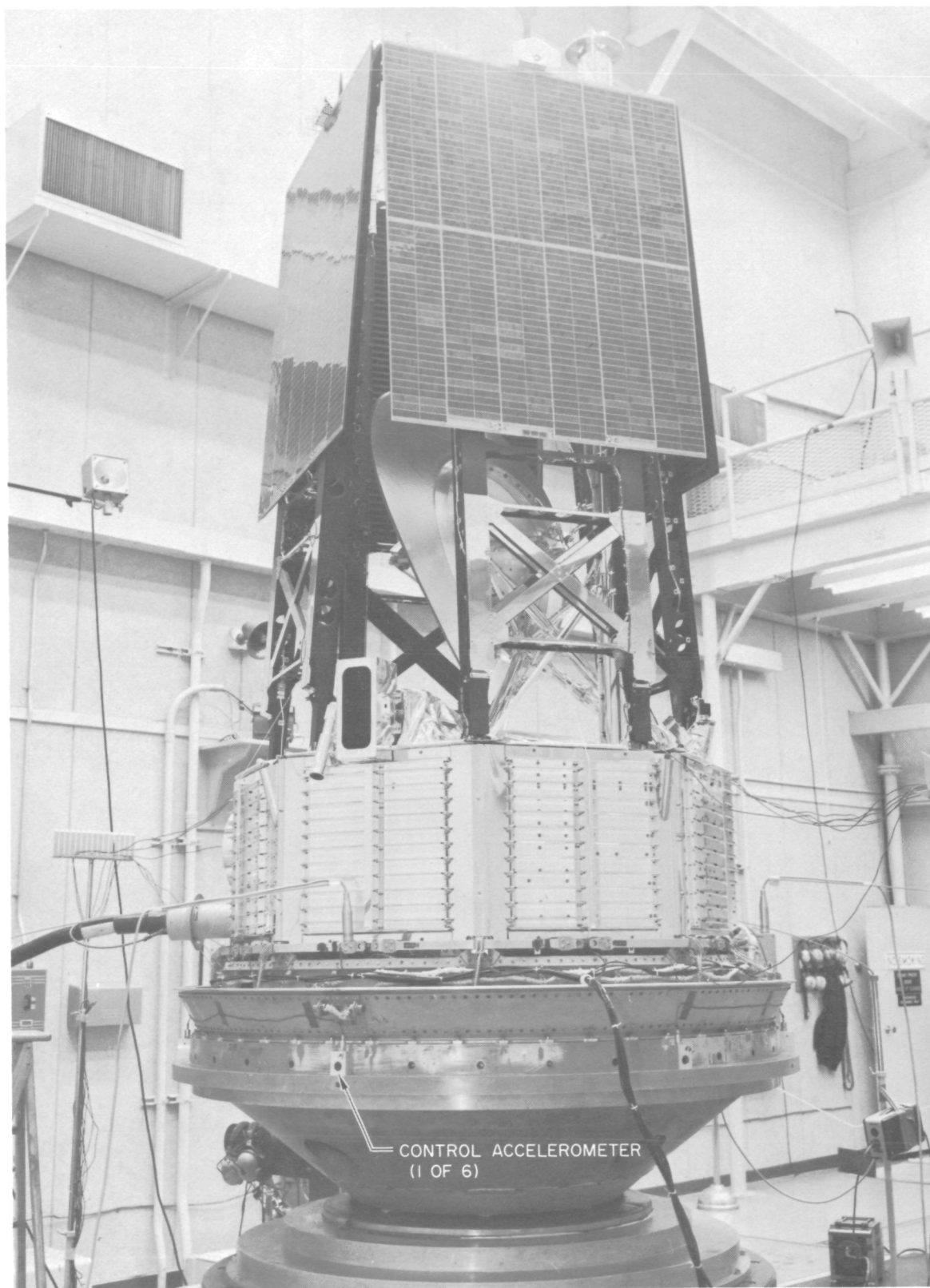


Fig. 86. *Mariner V* test configuration for random vibration

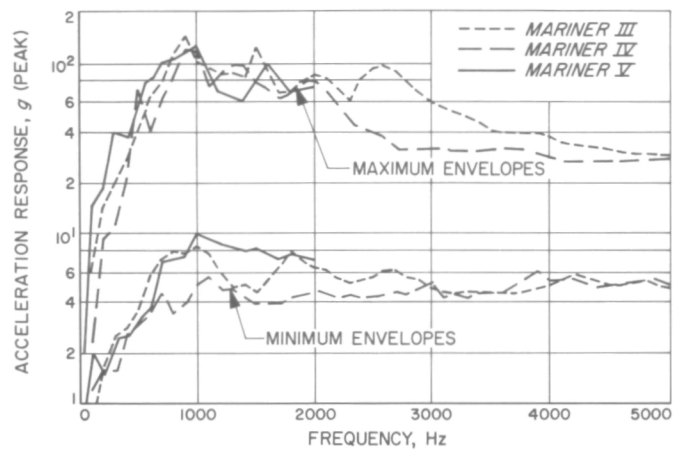


Fig. 87. Shock spectra, Mariner III, IV and V maximum and minimum envelopes, B3

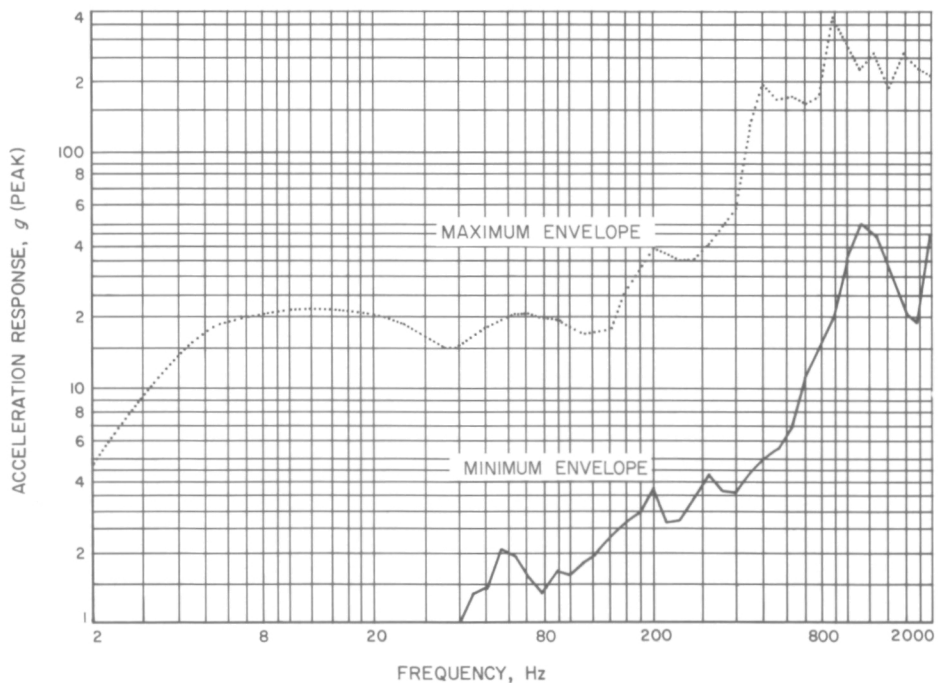


Fig. 88. Shock spectra, Mariner V maximum and minimum envelopes, F4

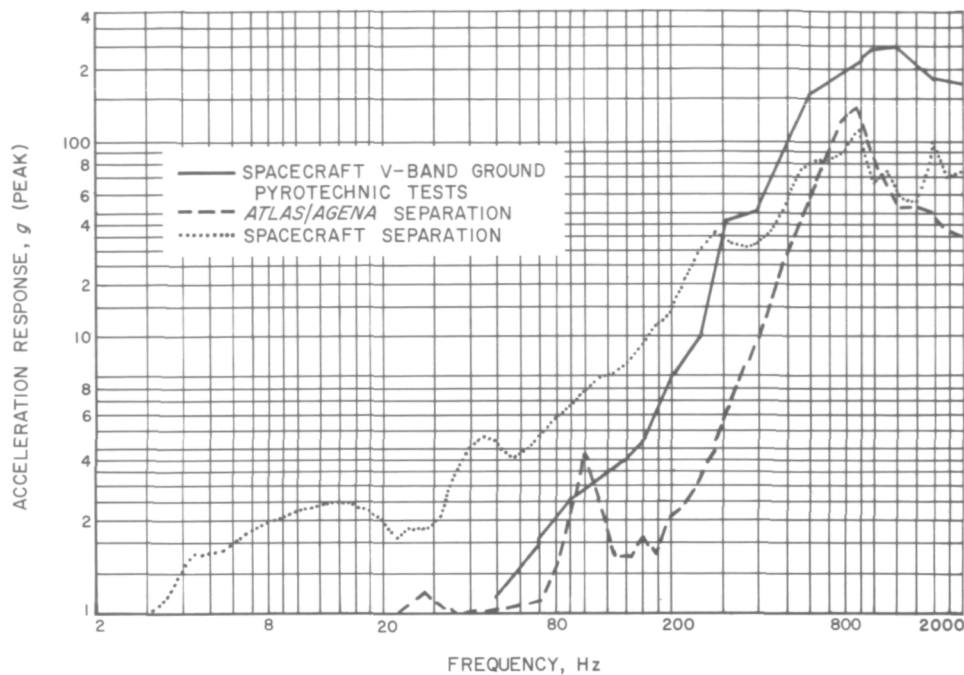


Fig. 89. Comparison of Mariner V shock spectra for Atlas/Agena separation and spacecraft separation with that for V-band pyrotechnic firing during flight acceptance tests, B3

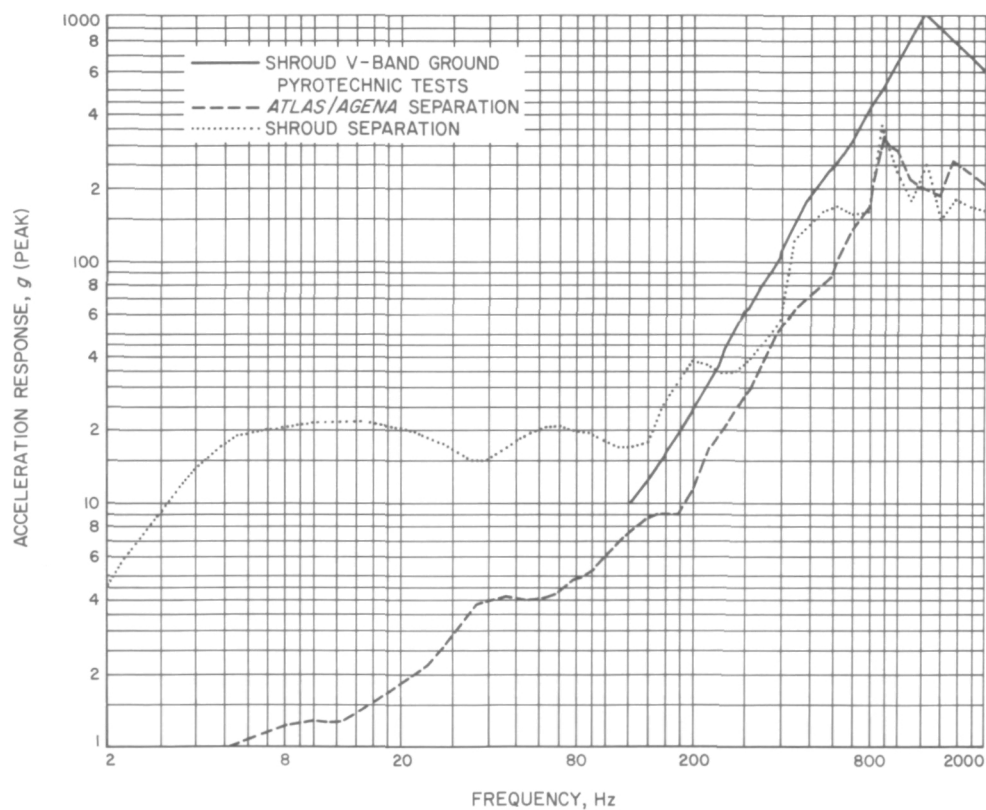


Fig. 90. Comparison of Mariner V shock spectra for Atlas/Agena separation and shroud jettison with that for shroud V-band pyrotechnic firing during flight acceptance tests, F4

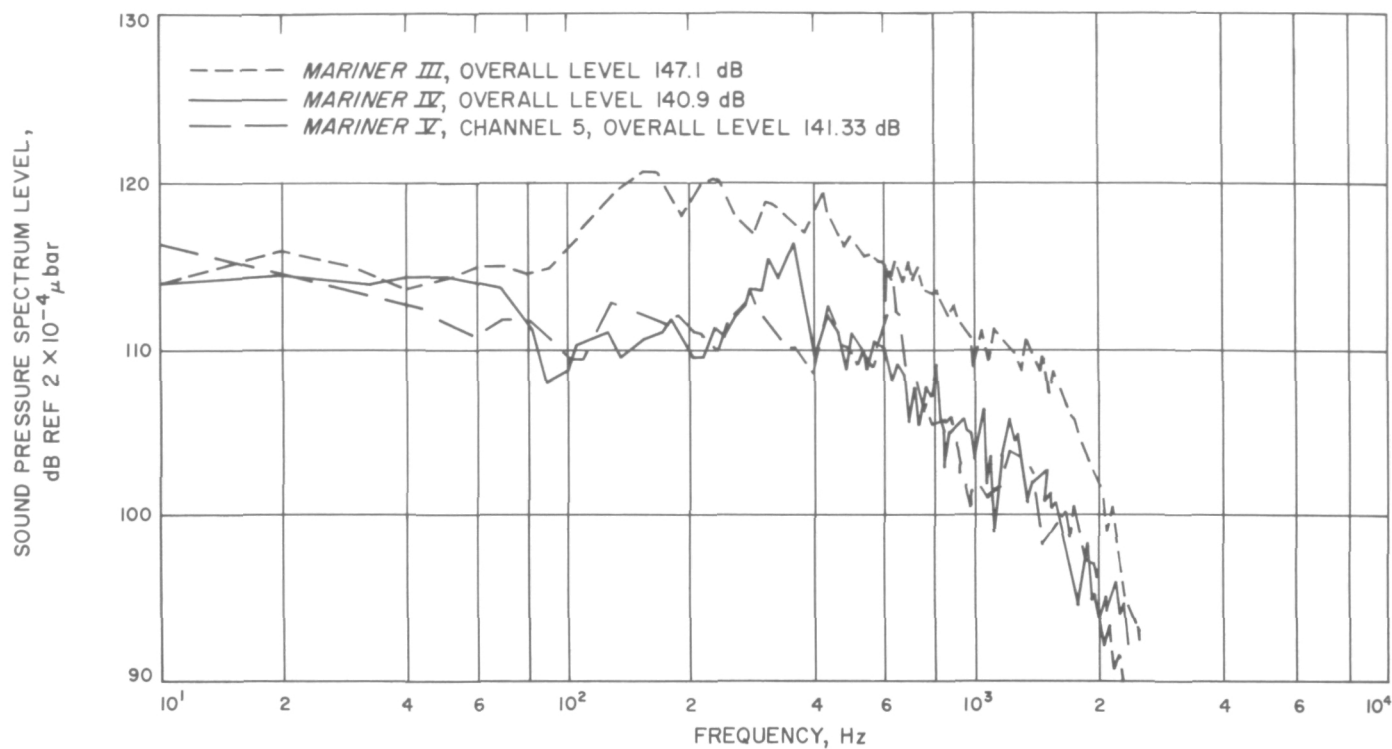


Fig. 91. Comparison of *Mariner III*, *IV* and *V* sound pressure spectrum levels, tower location