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ENGINEERING TESTS FOR ENERGY STORAGE CARS AT THE TRANSPORTATION TEST CENTER
Volume IV - Ride Roughness Tests

William T. Curran

AiResearch Manufacturing Company
2525 West 190th Street
Torrance CA 90509

MAY 1977
FINAL REPORT

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16. Abstract

The primary purpose of the tests documented herein was to demonstrate the principles and feasibility of an energy storage type propulsion system, and its adaptability to an existing car design. The test program comprised four phases of tests on two New York City Transit Authority R-32 cars where the conventional propulsion system was replaced by an energy storage system. The four test phases were: verification of safe arrival, debugging procedures, performance verification tests, and expanded test program. This report contains test data collected during the performance verification and expanded test program phases. Testing was conducted at the DOT Transportation Test Center, Pueblo, Colorado. The data was collected and processed in accordance with the General Vehicle Test Plan for Urban Rail Testing.

Volume I of this report covers the Program Description and Test Summary; Volume II, Performance, Power Consumption, and Radio Frequency Interference Tests; Volume III, Noise Tests.

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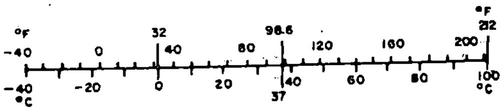
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

METRIC CONVERSION FACTORS

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (CONTINUED)

ILLUSTRATIONS (CONTINUED)

1. INTRODUCTION

1.1 GENERAL

The test report on energy storage cars is presented in four volumes.

Volume I	Program Description and Test Summary
Volume II	Performance, Power Consumption and Radio Frequency Interference Tests
Volume III	Noise Tests
Volume IV	Ride Roughness Tests

The information contained in this volume is related to the ride roughness tests which include: vertical, lateral and longitudinal dynamic shake tests, component induced vibration, worst speed and the acceleration/deceleration tests.

These tests were performed by AiResearch at the Transportation Test Center in Pueblo, Colorado. The tests were conducted in accordance with AiResearch Test Program, 73-9373 and Expanded Test Procedures, 74-10441 to comply with Transportation System Center General Vehicle Test Plan, GSP-064.

1.2 SCOPE

Each section of this volume is devoted to the tests covered by a specific GSP-064 Test Set. The test procedures for each test set and a description of the AiResearch tests are also included.

1.3 INSTRUMENTATION

The instrumentation required for the data acquisition system is shown in figure 1-1, the data recovery system instrumentation in figure 1-2. Figures 1-3 and 1-4 show in detail the specific instrumentation required for each of the tests included in this volume of the report.

1.4 TEST SET SUMMARY SHEETS

A summary sheet of each GSP-064 Test Set related to the tests covered by this volume is provided in this section as a convenience for the reader.

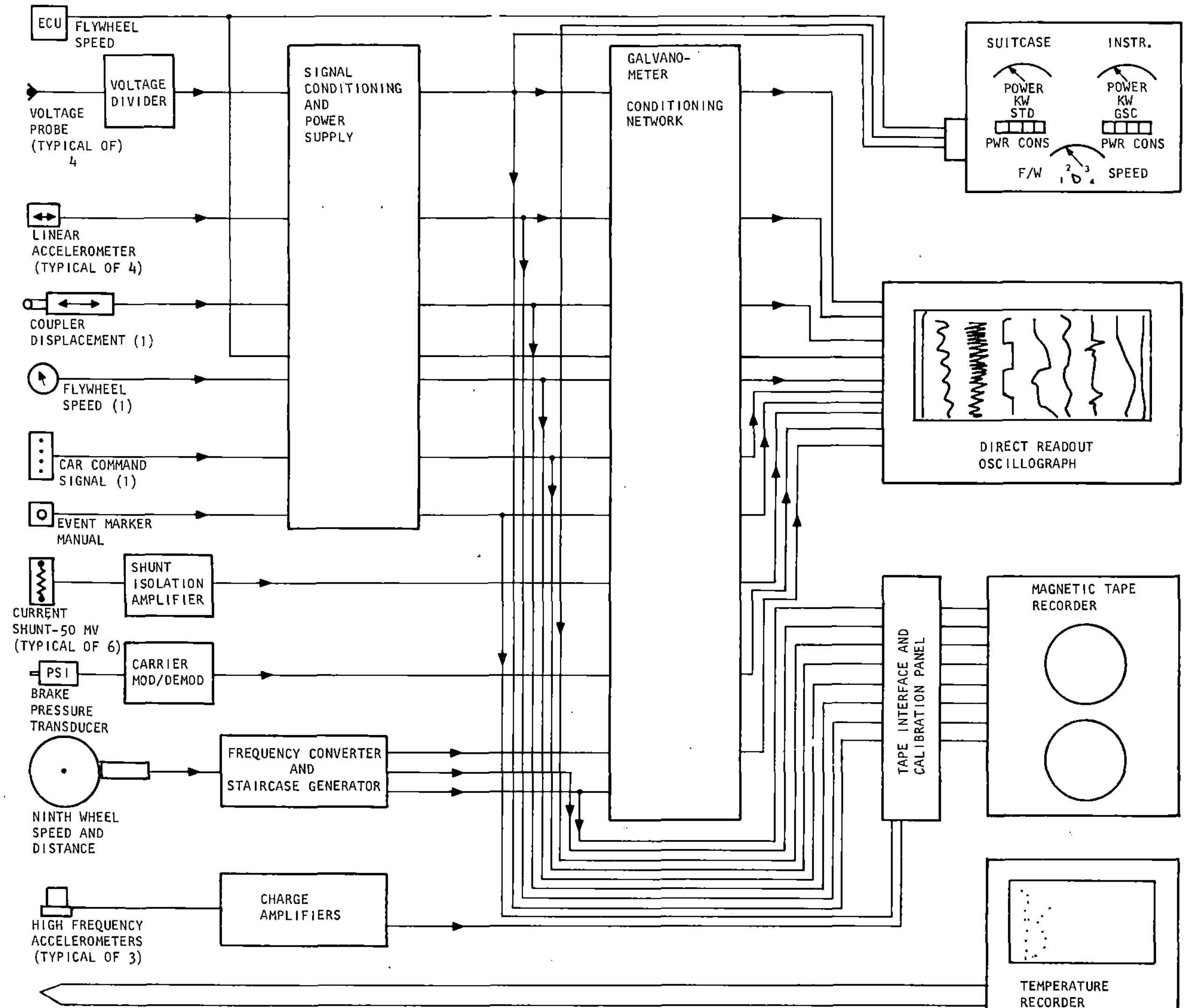


Figure 1-1. Data Acquisition System

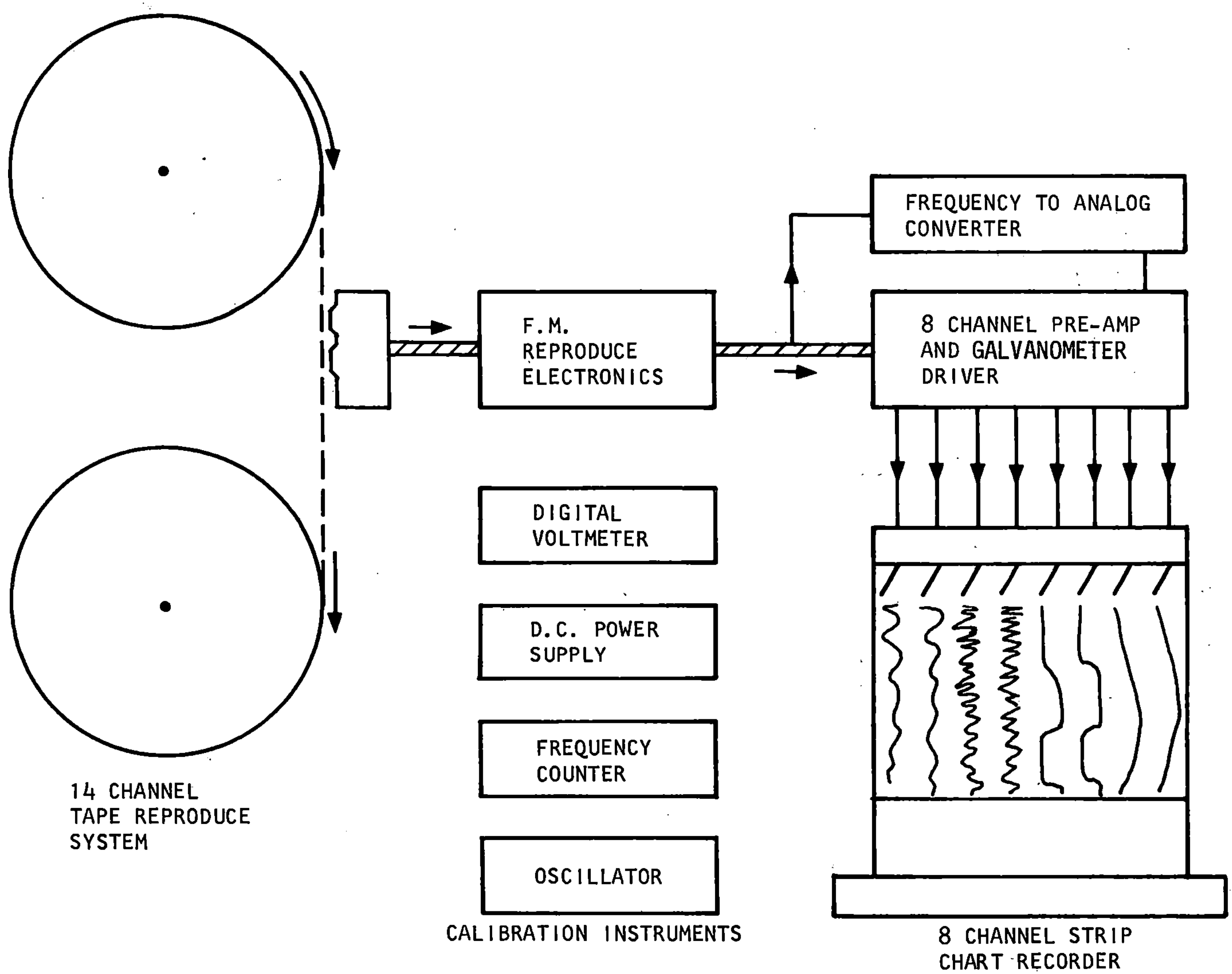


Figure 1-2. Data Recovery System

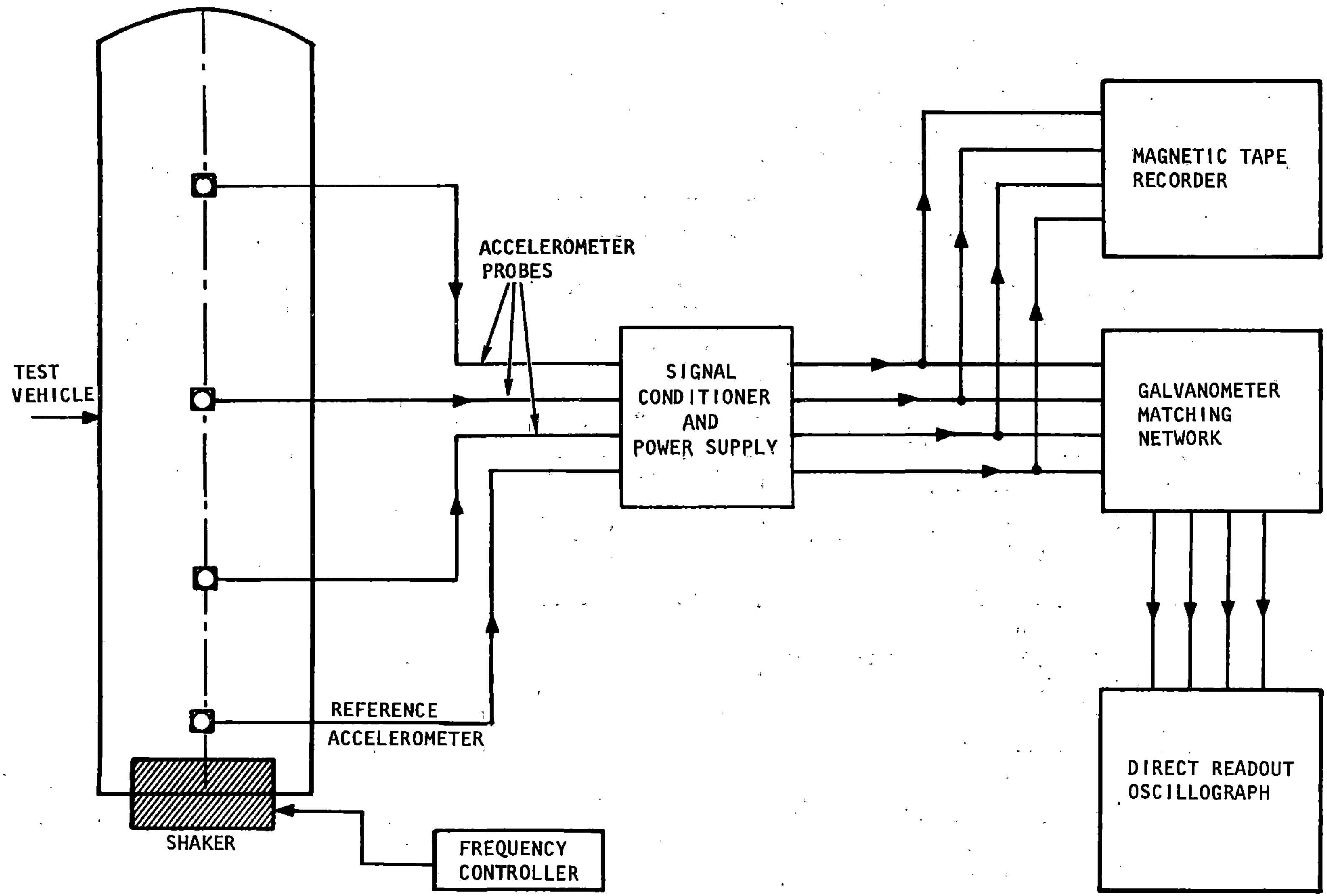


Figure 1-3. Dynamic Shake Test Instrumentation

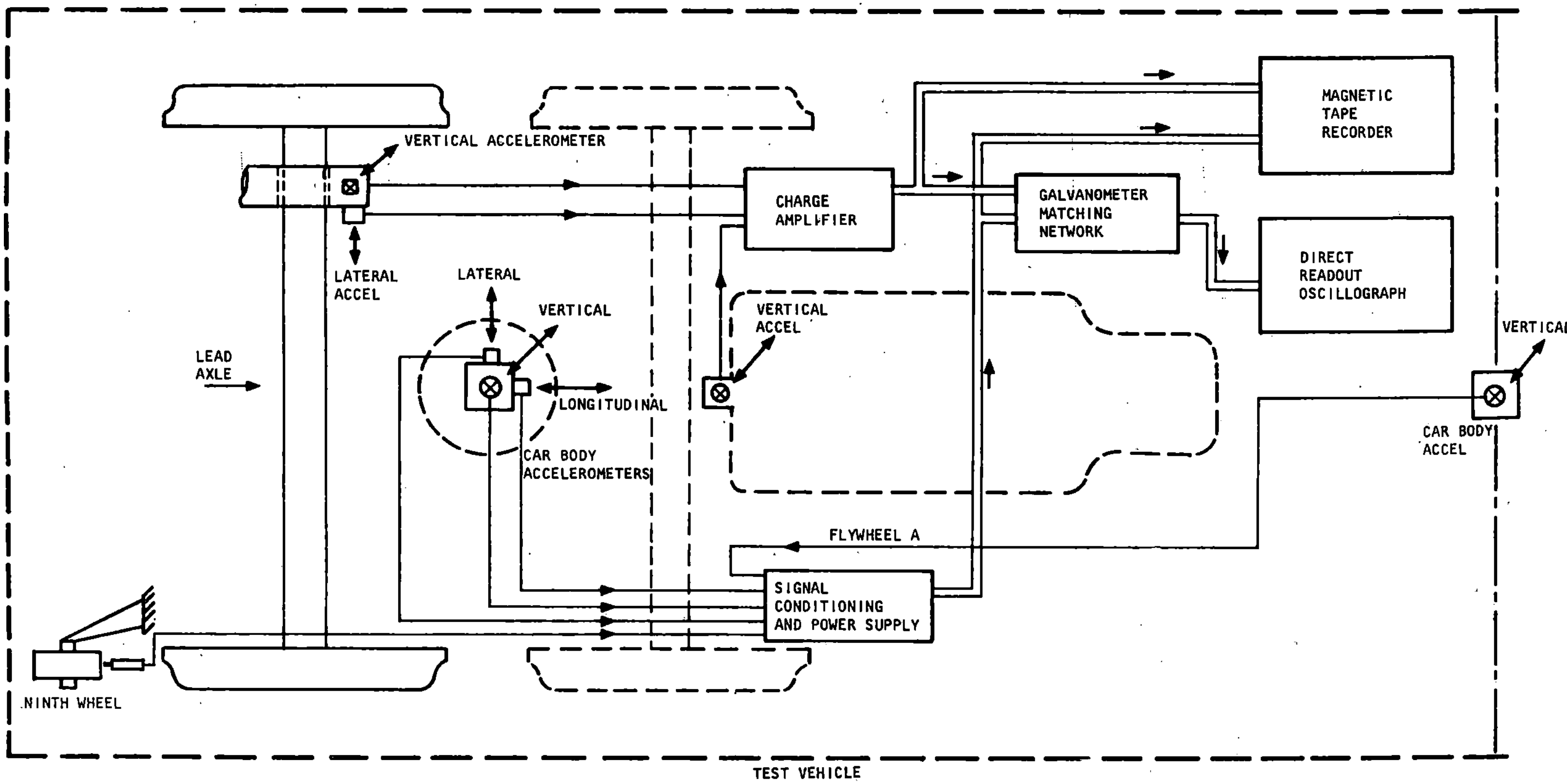


Figure 1-4. Ride Roughness Test Instrumentation

TEST TITLE: DYNAMIC SHAKE TEST - VERTICAL

TEST SET NUMBER: ESC-R-0001-XX

TEST OBJECTIVE:

To determine the vehicle vertical natural modes and frequencies.

TEST DESCRIPTION:

This test will include performing frequency sweeps of the vehicle by using a shaker to provide excitation forces. These sweeps will be generated for selected locations of the vehicle to determine the natural frequencies. At these natural frequencies detailed probes of the vehicle are necessary to determine the associated mode shapes. The test will be performed at vehicle weights of AW0, AW2 and AW3.

STATUS:

The energy storage cars successfully completed the vertical shake tests as prescribed by the conditions specified in paragraph 2.1.2. Refer to test log runs 83 through 86 presented in Volume I, Appendix C of this report.

TEST TITLE: DYNAMIC SHAKE TEST - LATERAL

TEST SET NUMBER: ESC-R-0002-XX

TEST OBJECTIVE:

To determine the vehicle lateral natural modes and frequencies.

TEST DESCRIPTION:

This test will include performing frequency sweeps of the vehicle by using a shaker to provide excitation forces. These sweeps will be generated for selected locations of the vehicle to determine the natural frequencies. At these natural frequencies detail probes of the vehicle are necessary to determine the associated mode shapes. The test will be performed at vehicle weights of AW0, AW2 and AW3.

STATUS:

The lateral shake tests could not be performed due to the lack of a mounting fixture. Refer to test log run 83 (Volume I, Appendix C).

TEST TITLE: DYNAMIC SHAKE TEST - LONGITUDINAL

TEST SET NUMBER: ESC-R-0003-XX

TEST OBJECTIVE:

To determine the vehicle longitudinal natural modes and freuqencies.

TEST DESCRIPTION:

This test will include performing frequency sweeps of the vehicle by using a shaker to provide excitation forces. These sweeps will be generated for selected locations of the vehicle to determine the natural frequencies. At these natural frequencies detailed probes of the vehicle are necessary to determine the associated mode shapes. The test will be performed at vehicle weights of AW0, AW2 and AW3.

STATUS:

No test data or results could be obtained for the longitudinal shake tests because the output of the shaker was not able to produce a measurable effect on the car body. Refer to test log runs 83 through 86 (Volume I, Appendix C).

TEST TITLE: COMPONENT INDUCED VIBRATION

TEST SET NUMBER: ESC-R-0010-TT

TEST OBJECTIVE:

To determine the vibration levels of the test vehicle components while stationary on the UMTA Test Track.

TEST DESCRIPTION:

This test will be performed on a stationary car at a known level section of track.

STATUS:

The energy storage cars successfully completed the component induced vibration tests as prescribed by the conditions specified in paragraph 5.1.2. Refer to test log run 73 presented in Volume I, Appendix C of this report.

TEST TITLE: RIDE ROUGHNESS - WORST SPEEDS

TEST SET NUMBER: ESC-R-1101-TT

TEST OBJECTIVE:

To determine worst steady vibration levels of the test vehicle on the UMTA test track.

TEST DESCRIPTION:

The following configurations will be tested:

(a) Vehicle weights of AW0, AW2, AW3.
(b) All track sections including grade crossings and switches as required to simulate revenue service.
(c) Select discrete vehicle speeds simulating revenue service and include V (max).
(d) Select other speeds as required to identify known or suspected acute vibration levels associated with carbody characteristics.

STATUS:

The energy storage cars successfully completed the worst speeds tests as prescribed by the conditions specified in paragraph 6.1.2. Refer to test log runs 73 through 75 presented in Volume I, Appendix C of this report.

TEST TITLE: RIDE ROUGHNESS - ACCELERATION

TEST SET NUMBER: ESC-R-2001-TT

TEST OBJECTIVE:

To determine the most severe vibration levels encountered during car acceleration

TEST DESCRIPTION:

This test is to be performed on track section I 24 vehicle weights of AW0, AW2 and AW3

STATUS:

The energy storage cars successfully completed the acceleration tests as prescribed by the conditions specified in paragraph 7.1.2 Refer to test log runs 73, 78 and 79 presented in Volume I, Appendix C of this report.

TEST TITLE: RIDE ROUGHNESS - DECELERATION

TEST SET NUMBER: ESC-R-3001-TT

TEST OBJECTIVE:

To determine the most severe vibration levels encountered during car deceleration.

TEST DESCRIPTION:

This test to be performed on track section I at vehicle weights of AW0, AW2, AW3

STATUS:

The energy storage cars successfully completed the deceleration tests as prescribed by the conditions specified in paragraph 8.1.2. Refer to test log runs 73, 78 and 79 presented in Volume I, Appendix C of this report.

2. DYNAMIC SHAKE TEST - VERTICAL (ESC-R-0001-XX)

2.1 SUMMARY

The dynamic vertical shake test was conducted in compliance with Test Set Number ESC-R-0001-XX of the TSC General Vehicle Test Plan GSP-064. Requirements and procedures covered by the test set are defined in paragraphs 2.1.1 through 2.2.2. Refer to paragraph 2.3 for a description of the test, instrumentation used, and for the test results.

2.1.1 TEST OBJECTIVE

To determine the vehicle vertical natural modes and frequencies.

2.1.2 TEST DESCRIPTION

This test will include performing frequency sweeps of the vehicle by using a shaker to provide excitation forces. These sweeps will be generated for selected locations of the vehicle to determine the natural frequencies. At these natural frequencies detailed probes of the vehicle are necessary to determine the associated mode shapes. The test will be performed at car weights of AW0, AW2 and AW3.

2.1.3 STATUS

The energy storage cars successfully completed the vertical shake tests as prescribed by the conditions specified in paragraph 2.1.2. Refer to test log runs 83 through 86 presented in Volume I, Appendix C of this report.

2.2 PROCEDURES

The following test procedures are included as part of the ESC-R-0001-XX Test Set. The ESC tests were performed generally in accordance with these procedures and any procedural differences are reflected in paragraph 2.3.

2.2.1 PRETEST PROCEDURE

(a) Install the required equipment and instrumentation. Shaker should be oriented to apply a vertical excitation force.

(b) Locate one sensor on the car body structure adjacent to the shaker location to determine amplitude and phase at the input source.

(c) In addition to the accelerometer located adjacent to the shaker position, at least one more accelerometer is required to determine frequency response curves. It is highly recommended that a sufficient number of additional accelerometers be used during the test to be compatible with the recording device utilized so as to be able to determine more expediently, and with a minimum of error, the vehicle mode shapes. Three portable accelerometers and one reference accelerometer was used for the ESC tests.

(d) Record vehicle weight.

(e) Calibrate system

2.2.2 TEST PROCEDURE

(a) The shaker will be located at the longitudinal centerline (C/L) of the car body at a car end.

(b) Orient reference probe and portable probe in the vertical direction.

(c) Utilize a continuous sweep oscillator to control the shaker frequency.

(d) Perform frequency sweeps of the vehicle (1 Hz - 30 Hz). Simultaneously obtain accelerometer output, amplitude and phase as a function of frequency and automatically record these data with an X-Y plotter.

(e) Move a portable probe to another position and repeat step d until a sufficient number of car, truck and component locations have been surveyed to determine the vehicle mode shapes and frequencies.

(f) Repeat steps a and e with portable probe oriented in the lateral direction.

(g) Repeat steps a through f with shaker mounted off the longitudinal centerline of the car body at the car end.

2.3 TEST DESCRIPTION AND RESULTS

The energy storage car (ESC) vertical shake tests were conducted in accordance with AiResearch Document 74-10441 as defined in paragraph 2.3.1 and in compliance with GSP-064 Test Set ESC-R-0001-XX, described in paragraphs 2.1.1 and 2.1.2.

2.3.1 DESCRIPTION

In addition to the instrumentation noted in paragraph 2.3.2, a G.S.I. Force Generator was required to perform the shake tests. See figure 2-1 for a description of the generator and to figure 2-2 for the adjustment curve.

The shaker and controls, provided by TSC was mounted in the ESC with accelerometers located as shown in figure 2-3. The vertical shake test was performed at AW0, AW2 and AW3 car weights using the procedures described in paragraph 2.2.

FORCE GENERATOR
LAZAN MODEL LA-1

POWERED BY G.E. THY-MO-TROL SYSTEM FOR PRECISE SPEED CONTROL.
THEORY - ECCENTRICS EXIST IN PAIRS AND ROTATE IN OPPOSITE DIRECTIONS EXCEPT THE DESIRED ONE.
± FORCE OUTPUT IS A FUNCTION OF BOTH THE SQUARE OF THE SPEED OF ROTATION AND THE AMOUNT OF UNBALANCE OF THE ECCENTRICS.

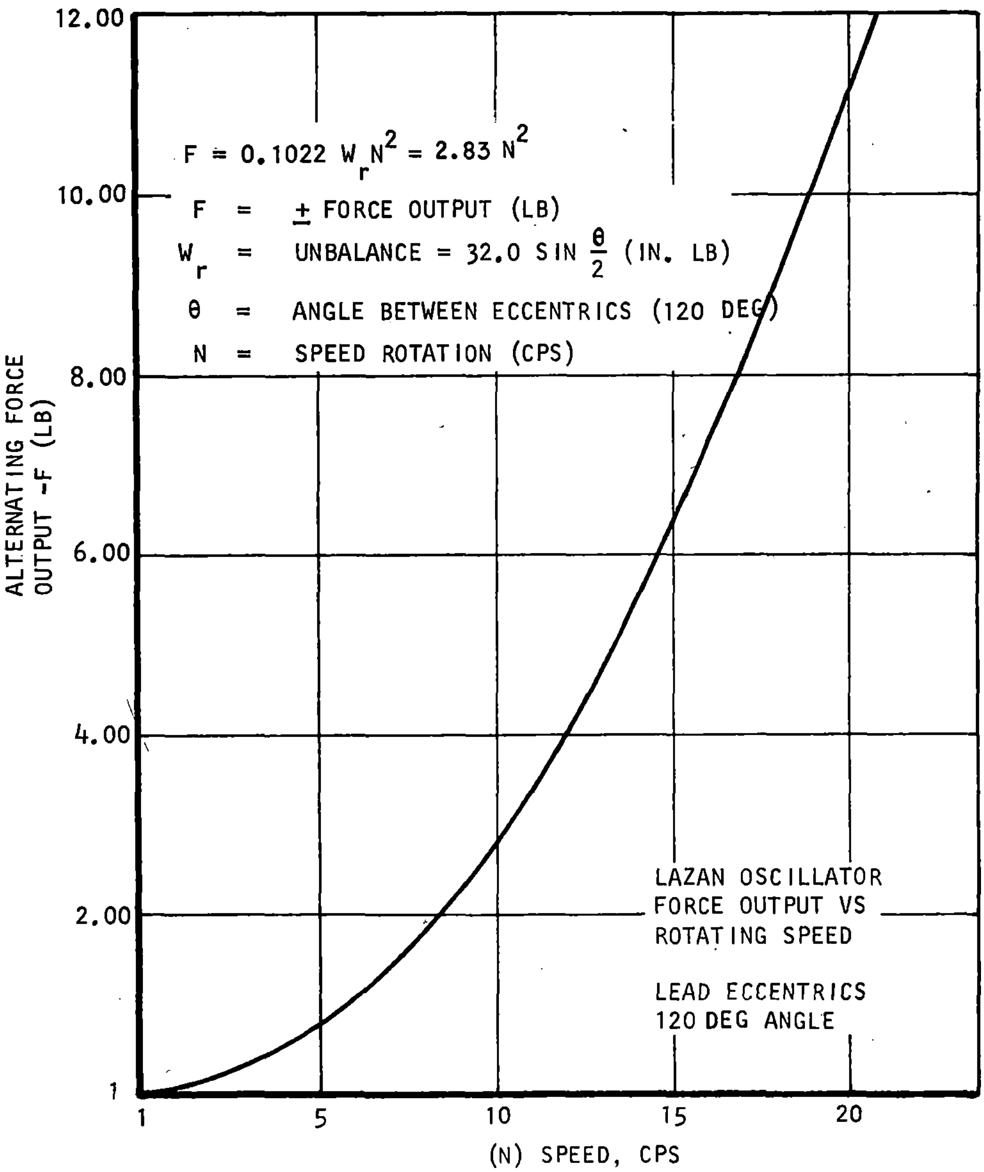


Figure 2-1. Description of G.S.I. Force Generator

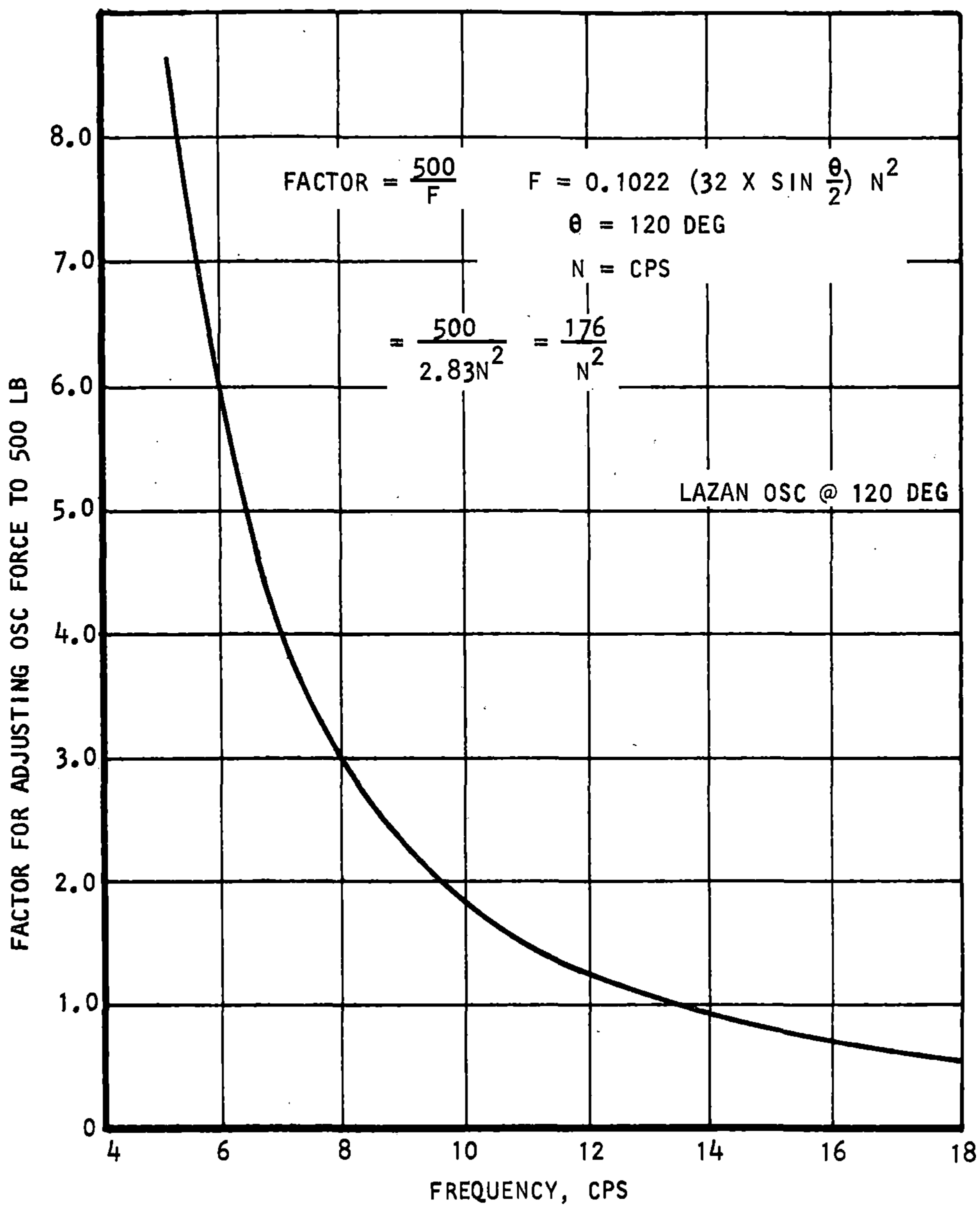


Figure 2-2. Adjustment Curve for G.S.I. Force Generator

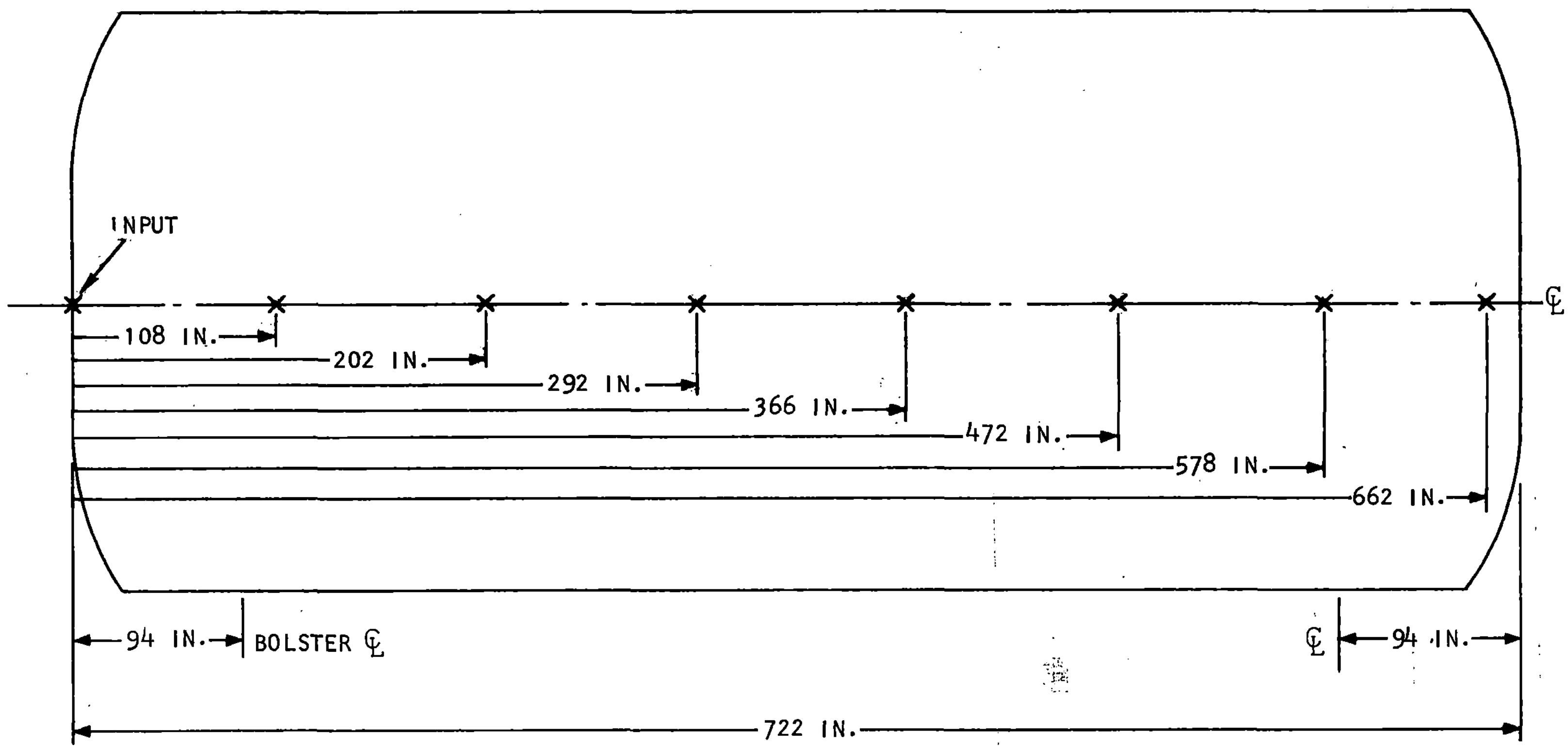


Figure 2-3. Vertical Dynamic Shake Test Accelerometer Location Description

2.3.2 INSTRUMENTATION

Block diagrams of the data acquisition system and the data recovery system are provided in figures 1-1 and 1-2. Details of instrumentation related to the vertical shake tests is shown in figure 1-3. Information concerning instrumentation for overall data acquisition for the energy storage car tests is described in Volume I of this report.

2.3.3 RESULTS

Representative samples of the shake test results are presented in figures 2-4 through 2-6. Vertical shake test plots for each car weight recorded at different locations are shown in figure 2-4, sheets 1 through 5. The steady state frequency tests did not contain enough test points for continuity of a phase shift plot. The best data appeared to be the frequency scans where the in-phase and 180 degree phase points could be more easily identified and correlated with frequency. Dynamic torsional test results are shown in figure 2-5 and the static torsional test results in figure 2-6.

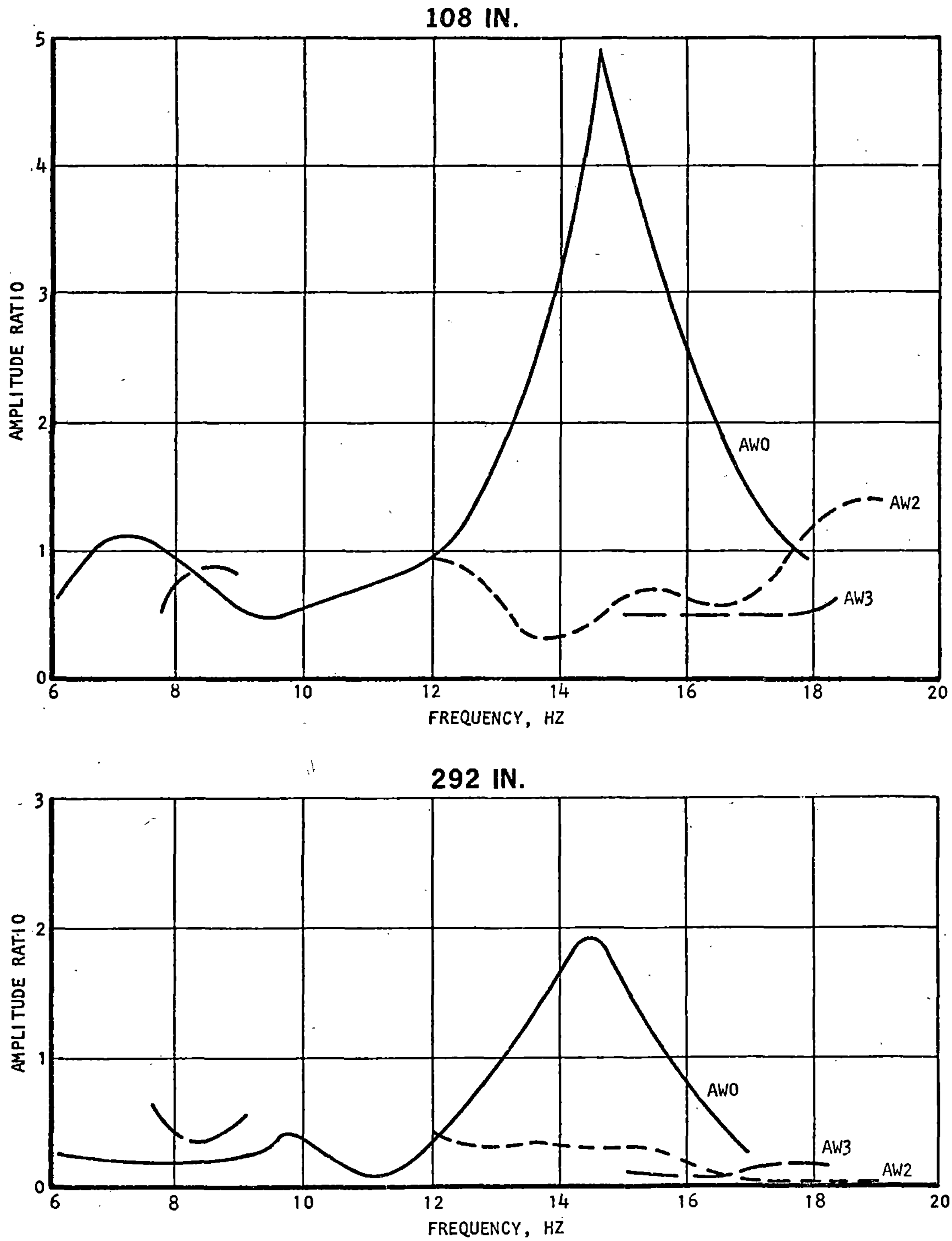


Figure 2-4. Vertical Dynamic Shake Test (Sheet 1)

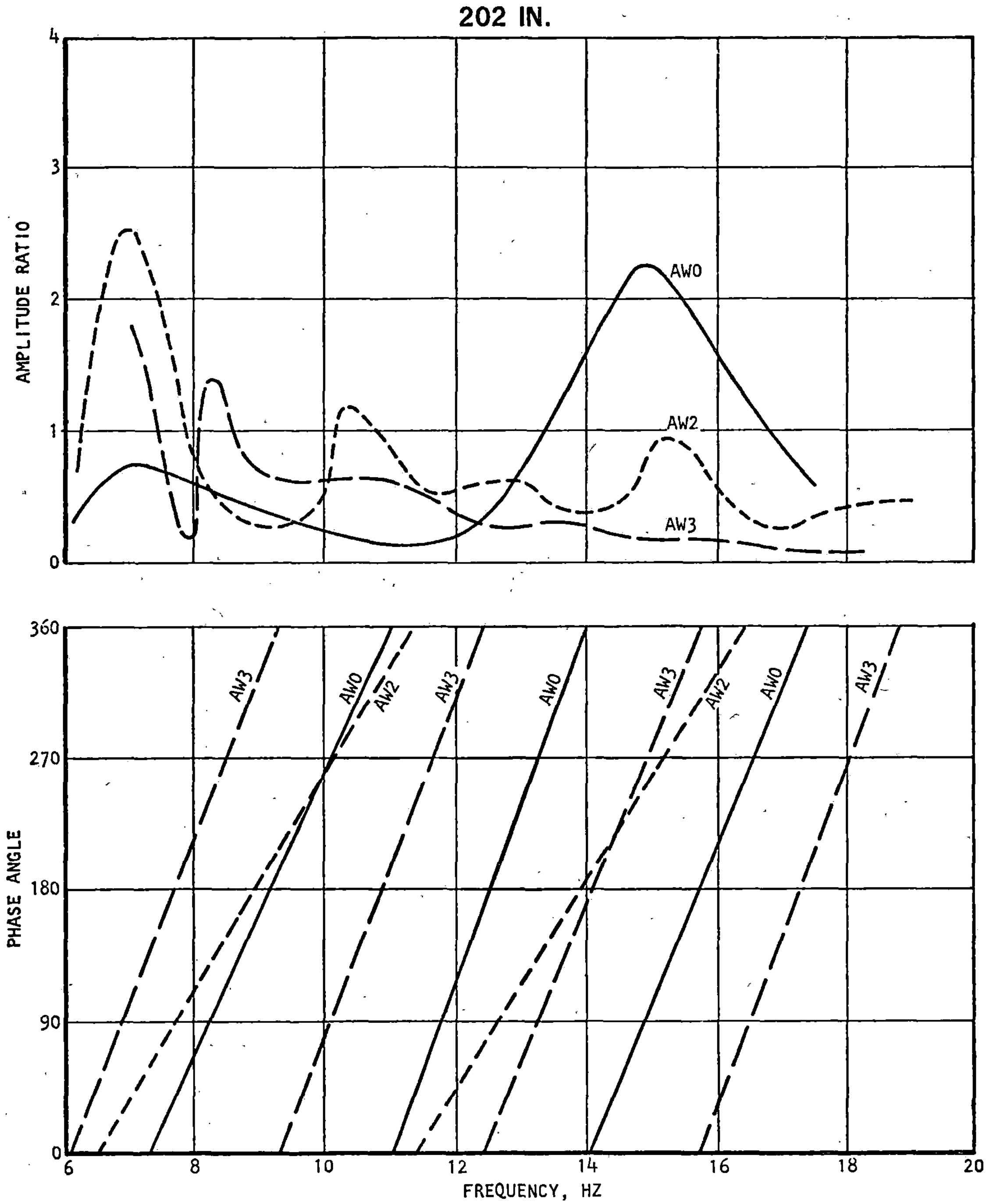


Figure 2-4. Vertical Dynamic Shake Test (Sheet 2)

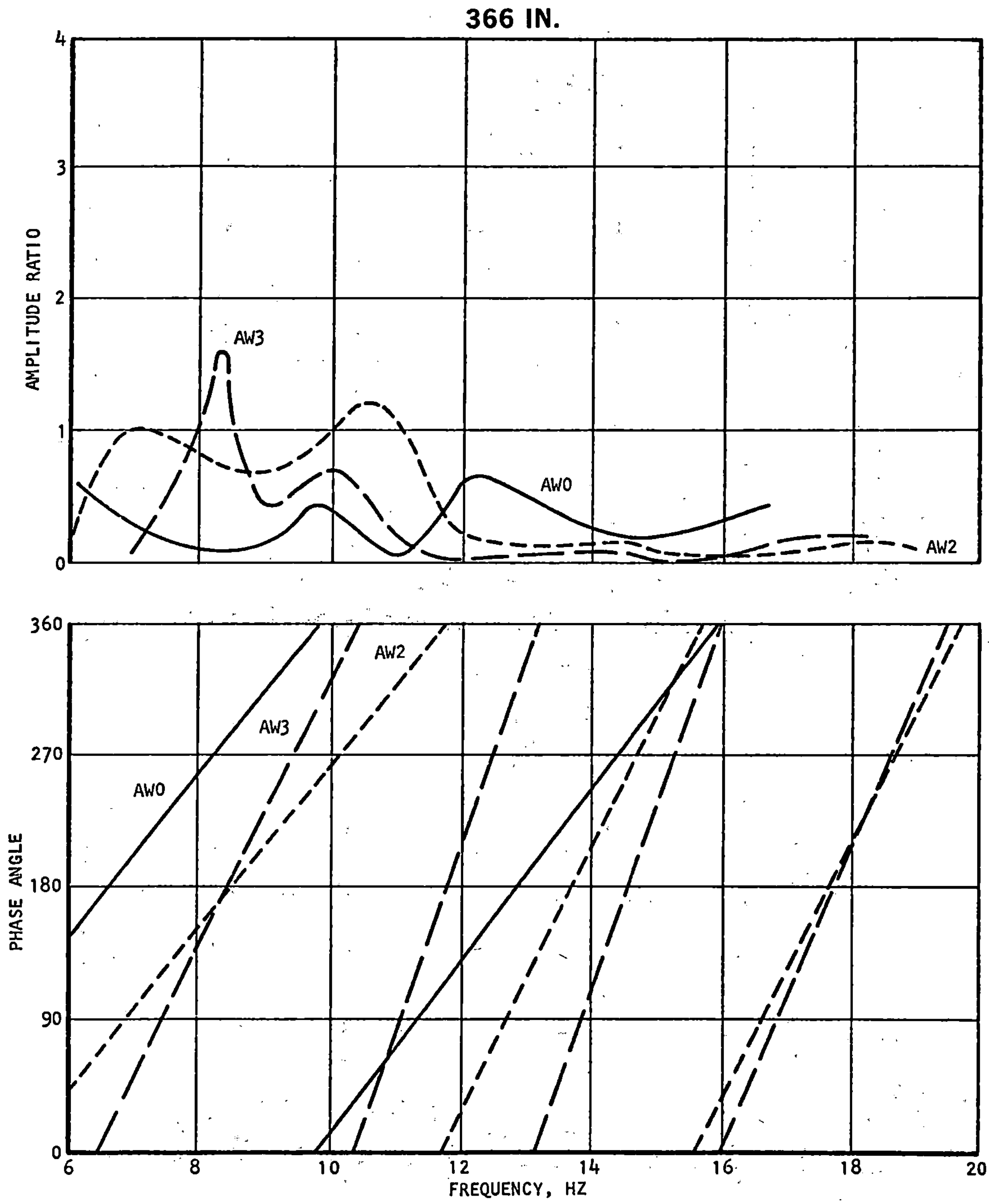
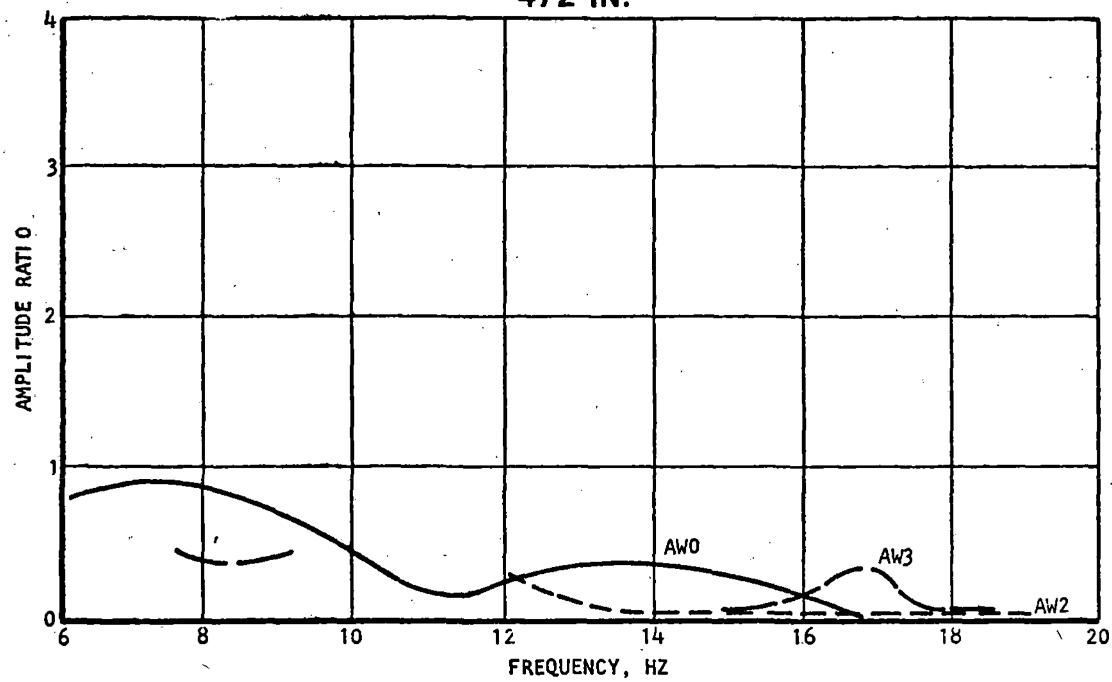


Figure 2-4. Vertical Dynamic Shake Test (Sheet 3)

472 IN.



578 IN.

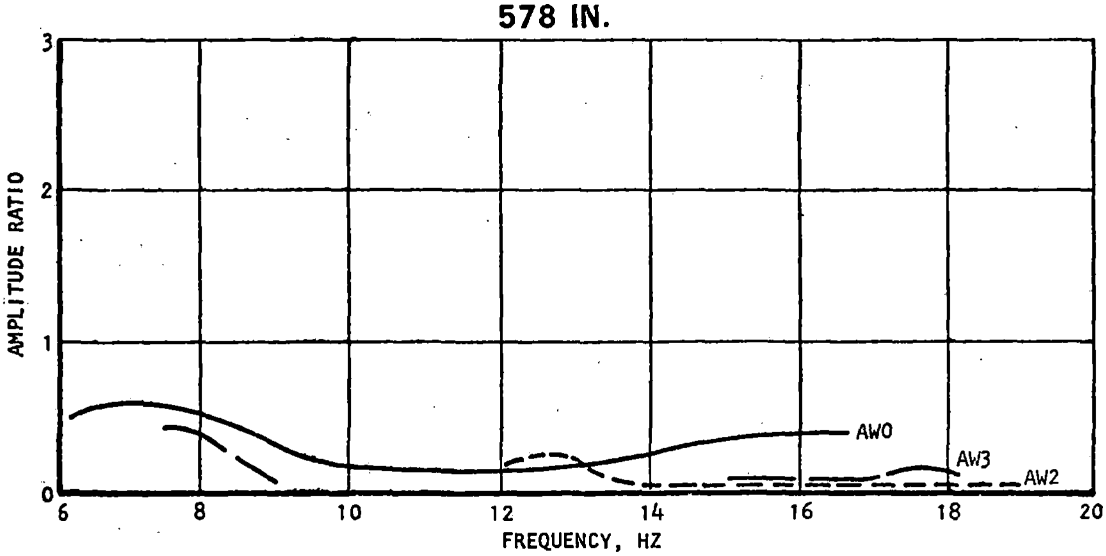


Figure 2-4. Vertical Dynamic Shake Test (Sheet 4)

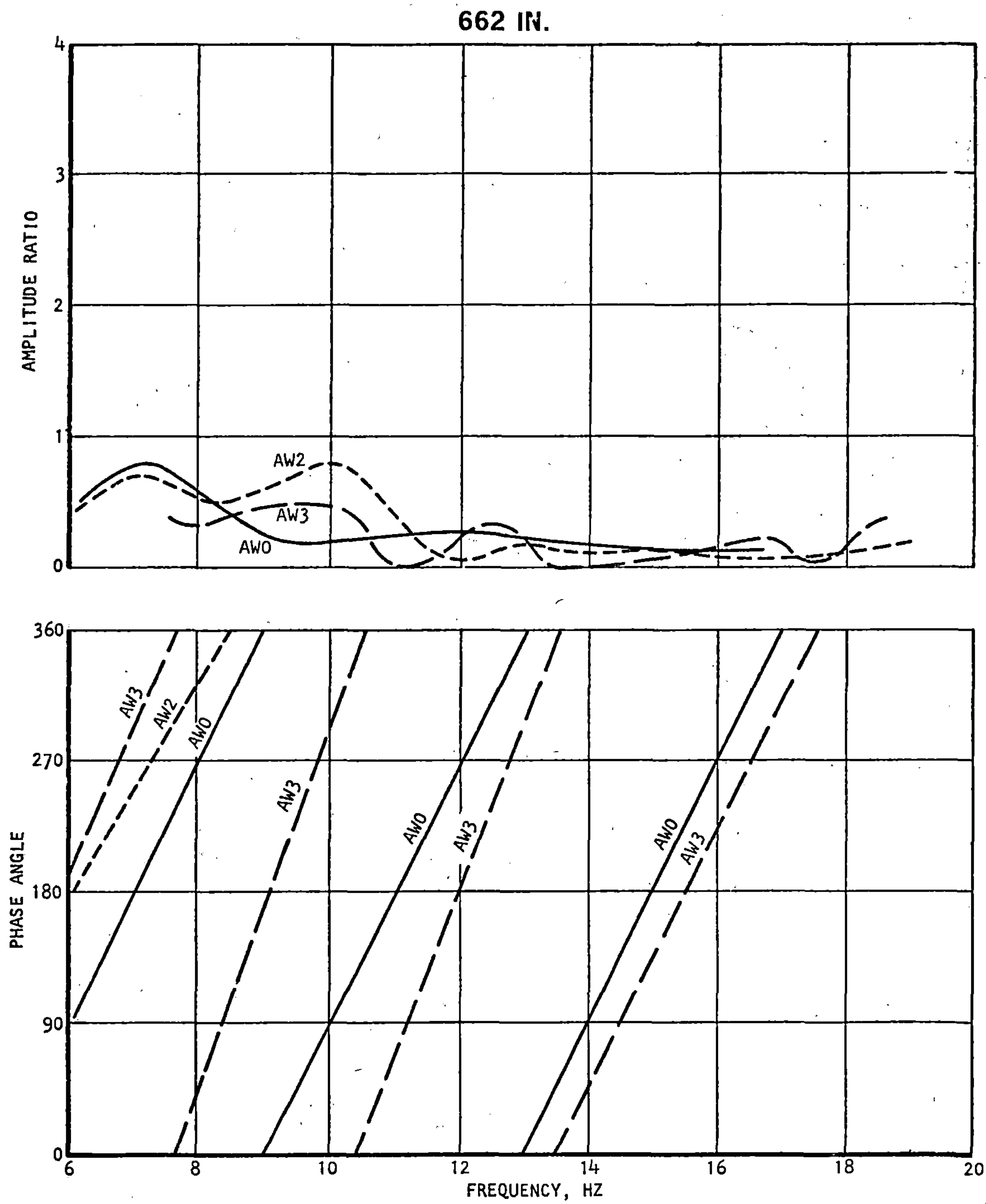


Figure 2-4. Vertical Dynamic Shake Test (Sheet 5)

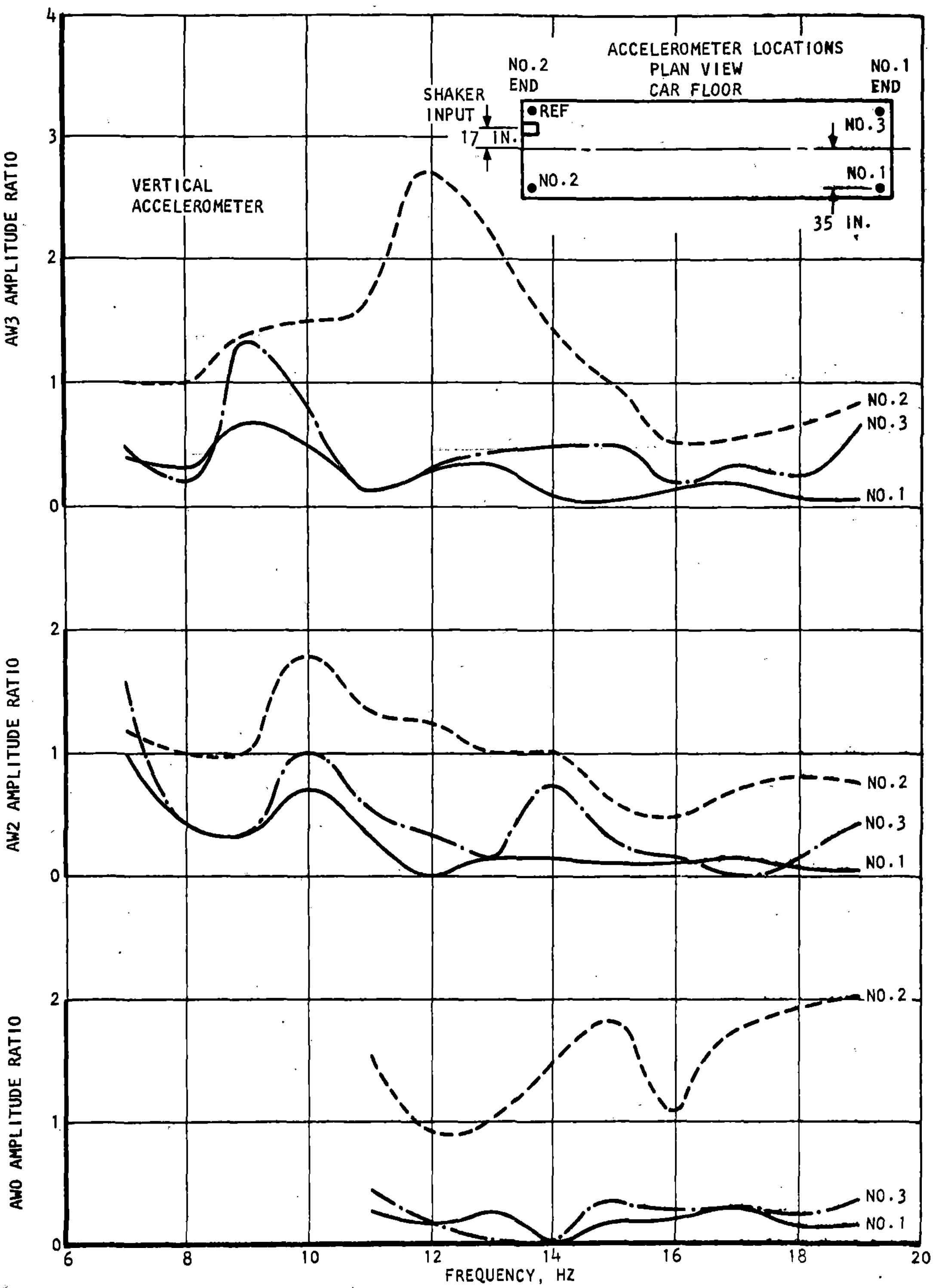


Figure 2-5. Dynamic Vertical Torsional Shake Test

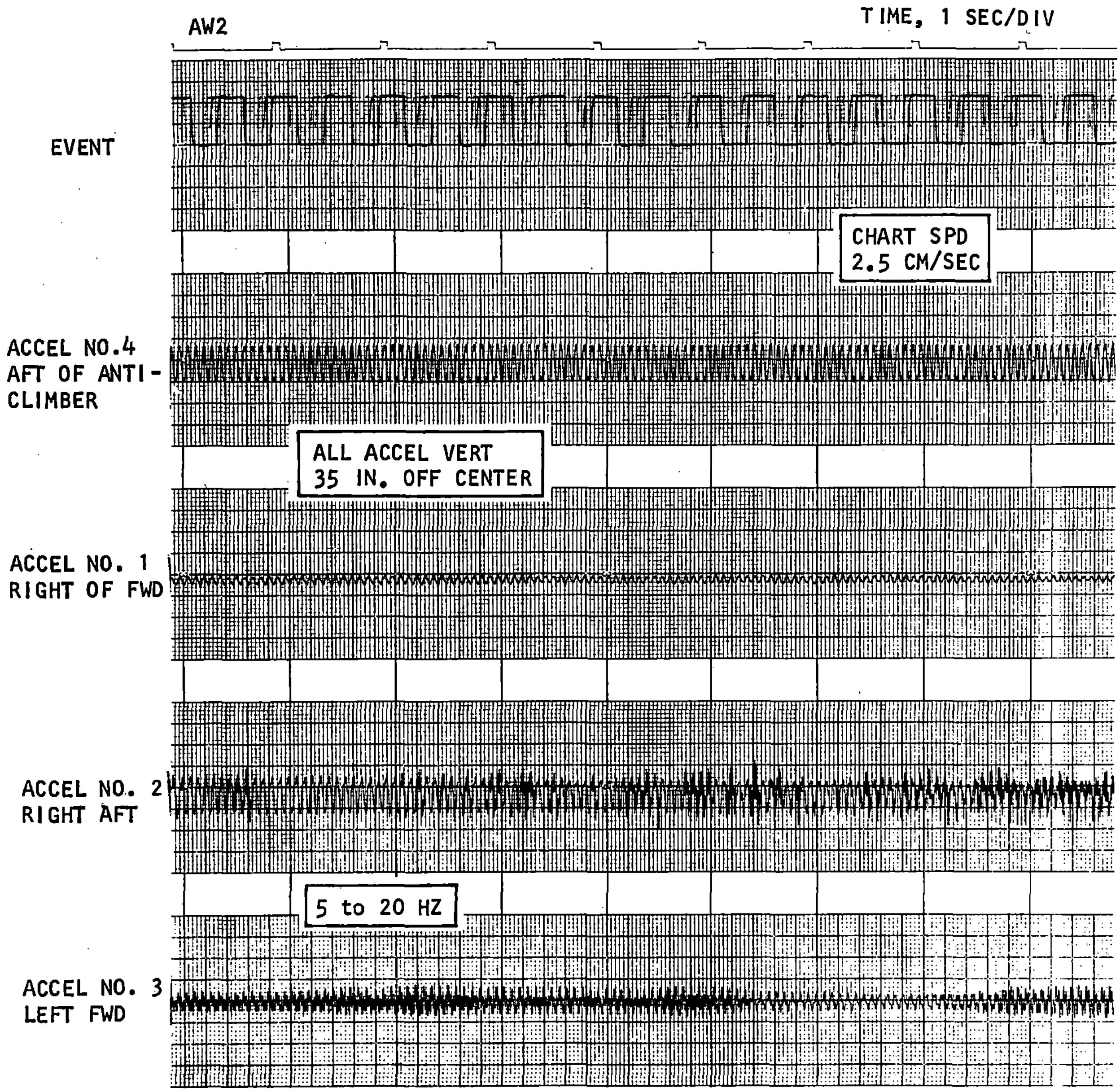


Figure 2-6. Static Vertical Torsional Vibration Scan (Sheet 1)

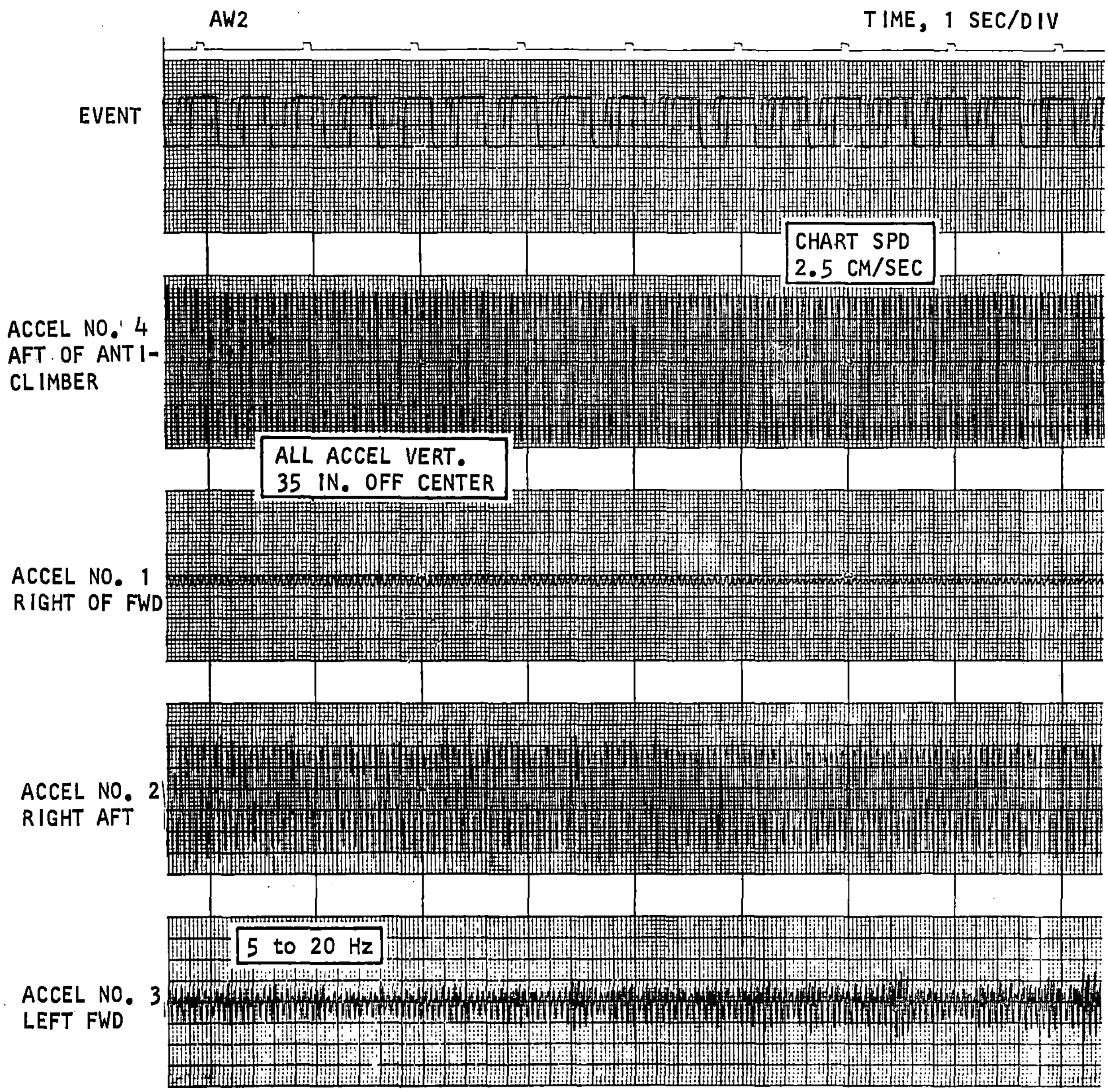


Figure 2-6. Static Vertical Torsional Vibration Scan (Sheet 2)

3. DYNAMIC SHAKE TEST - LATERAL (ESC-R-0002-XX)

3.1 SUMMARY

NOTE

Due to mechanical problems, the dynamic lateral shake test could not be performed. The following is included in this report for information only.

The ESC dynamic lateral shake test was to be conducted in compliance with Test Set Number ECS-R-0002-XX of the TSC General Vehicle Test Plan GSP-064. Requirements and procedures covered by the test set are defined in paragraphs 3.1.1 through 3.2.2.

3.1.1 TEST OBJECTIVE

To determine the vehicle lateral natural modes and frequencies.

3.1.2 TEST DESCRIPTION

This test will include performing frequency sweeps of the vehicle by using a shaker to provide excitation forces. These sweeps will be generated for selected locations of the vehicle to determine the natural frequencies. At these natural frequencies detail probes of the vehicle are necessary to determine the associated mode shapes. The test will be performed at car weights of AWO, AW2 and AW3.

3.1.3 STATUS

The lateral shake tests could not be performed due to the lack of a mounting fixture. Refer to test log run 83 (Volume I, Appendix C).

3.2 PROCEDURES

The following test procedures are included as part of the ECS-R-0002-XX Test Set. The ESC tests were not performed due to the lack of a mounting fixture, therefore, the procedures below are provided for information only.

3.2.1 PRETEST PROCEDURE

(a) Install the required equipment and instrumentation. Shaker should be oriented to apply a lateral excitation force.

(b) Locate one sensor on the car body structure adjacent to the shaker location to determine amplitude and phase at the input source.

(c) In addition to the accelerometer located adjacent to the shaker position, at least one more accelerometer is required to determine frequency response curves. It is highly recommended that a sufficient number of additional accelerometers be used during the test to be compatible with the recording device utilized so as to be able to determine more expendiently and with a minimum or error the vehicle mode shapes.

(d) Record vehicle weight.

(e) Calibrate system.

(f) Operate the shaker throughout the range of frequencies to be tested and ascertain that no flexible equipment mounts are bottoming and that the vehicle is in a suitable test configuration.

3.2.2 TEST PROCEDURE

(a) The shaker will be located at the longitudinal centerline (C/L) of the car body at a car end.

(b) Orient reference probe and portable probe in the lateral direction.

(c) Utilize a continuous sweep oscillator to control the shaker frequency.

(d) Perform frequency sweeps of the vehicle (1 Hz - 30 Hz). Simultaneously obtain accelerometer output, amplitude and phase as a function of frequency and automatically record these data with an X-Y plotter.

(e) Move portable probe to another position and repeat step d until a sufficient number of car, truck and component locations have been surveyed to determ,ine the vehicle mode shapes and frequencies.

(f) Repeat steps a through e with portable probe oriented in the vertical direction.

3.3 TEST DESCRIPTION AND RESULTS

No test data or results are shown for the lateral shake test because no mounting fixture was available and the tests were not performed.

4. DYNAMIC SHAKE TEST-LONGITUDINAL (ESC-R-0003-XX)

4.1 SUMMARY

The ESC dynamic longitudinal shake test was conducted in compliance with Test Set Number ESC-R-0003-XX of the TSC General Vehicle Test Plan GSP-064. Requirements and procedures covered by the test set are defined in paragraphs 4.1.1 through 4.2.2. Refer to paragraph 4.3 for a description of the test, instrumentation used, and for the test results.

4.1.1 TEST OBJECTIVE

To determine the vehicle longitudinal natural modes and frequencies.

4.1.2 TEST DESCRIPTION

This test will include performing frequency sweeps of the vehicle by using a shaker to provide excitation forces. These sweeps will be generated for selected locations of the vehicle to determine the natural frequencies. At these natural frequencies detailed probes of the vehicle are necessary to determine the associated mode shapes. The test will be performed at car weights of AW0, AW2 and AW3.

4.1.3 STATUS

No test data or results could be obtained for the longitudinal shake tests because the output of the shaker was not able to produce a measurable effect on the car body. Refer to test log runs 83 through 86 (Volume I, Appendix C).

4.2 PROCEDURES

The following test procedures are included as part of the ESC-R-0003-XX Test Set. The ESC tests were performed generally in accordance with these procedures and any procedural differences are reflected in paragraph 4.3.

4.2.1 PRETEST PROCEDURE

(a) Install the required equipment and instrumentation. Shaker should be oriented to apply a longitudinal excitation force.

(b) Locate one sensor on the car body structure adjacent to the shaker location to determine amplitude and phase at the input source.

(c) In addition to the accelerometer located adjacent to the shaker position, at least one more accelerometer is required to determine frequency response curves. It is highly recommended that a sufficient number of additional accelerometers be used during the test to be compatible with the recording device utilized so as to be able to determine more expediently and with a minimum of error the vehicle mode shapes.

(d) Record vehicle weight.

(e) Calibrate system.

(f) Operate the shaker throughout the range of frequencies to be tested and ascertain that no flexible mounts are bottoming and that the vehicle is in a suitable test configuration.

4.2.2 TEST PROCEDURE

(a) The shaker will be located at the longitudinal centerline (C/L) of the car body at a car end.

(b) Orient reference probe and portable probe in the longitudinal direction.

(c) Utilize a continuous sweep oscillator to control the shaker frequency.

(d) Perform frequency sweeps of the vehicle (1 Hz - 30 Hz). Simultaneously obtain accelerometer output, amplitude and phase as a function of frequency and automatically record these data with an X-Y plotter.

(e) Move protable probe to another position and repeat step d until a sufficient number of car, truck and component locations have been surveyed to determine the vehicle mode shapes and frequencies.

4.3 TEST DESCRIPTION AND RESULTS

No test data or results are shown for the longitudinal shake test because the shaker was unable to provide sufficient output to produce a measurable effect on the car body.

5. COMPONENT INDUCED VIBRATION (ESC-R-0010-TT)

5.1 SUMMARY

The component induced vibration test was conducted in compliance with Test Set Number ESC-R-0010-TT of the TSC General Vehicle Test Plan, GSP-064. Requirements and procedures covered by the test set are defined in paragraphs 5.1.1 through 5.2.2. Refer to paragraph 5.3 for a description of the test, instrumentation used, and for the test results.

5.1.1 TEST OBJECTIVE

To determine the vibration levels of the test vehicle components while stationary on the UMTA test track.

5.1.2 TEST DESCRIPTION

This test will be performed on a stationary car at a known level section of track.

5.1.3 STATUS

The energy storage cars successfully completed the component induced vibration tests as prescribed by the conditions specified in paragraph 5.1.2. Refer to test log run 73 presented in Volume I, Appendix C of this report.

5.2 PROCEDURES

The following test procedures are included as part of the ESC-R-0010-TT Test Set. The ESC tests were performed generally in accordance with these procedures and any procedural differences are reflected in paragraph 5.3.

5.2.1 PRETEST PROCEDURE

(a) Install and check out required equipment.

(b) Photograph placement of sensors.

(c) Calibrate all instrumentation, data acquisition and processing equipment.

5.2.2 TEST PROCEDURE

(a) Position test vehicle at track section 300.

(b) Shut down all car equipment.

(c) Start recorder and provide record number.

(d) Turn on car equipment, one system at a time, and identify that item for the record.

(e) Record 15 to 20 seconds of data for each car equipment. Repeat Step d for all equipment which may be cycled.

(f) Stop recorder.

5.3 TEST DESCRIPTION AND RESULTS

The energy storage car (ESC) component induced vibration tests were conducted in accordance with AiResearch Documents 73-9373 and 74-10441 as defined in paragraph 5.3.1 and in compliance with GSP-064 Test Set ESC-R-0010-TT, described in paragraphs 5.1.1 through 5.1.2.

5.3.1 DESCRIPTION

The ESC component induced vibration tests were performed in a manner similar to that used for the noise survey tests described in Volume III of this report. However, for these tests additional vibration accelerometers were installed in the car body, the lead axle and at the flywheel. Seven vibration channels were recorded from sensors located as follows:

(a) Forward car body - vertical

(b) Forward car body - lateral

(c) Forward car body - longitudinal

(d) Mid car body - vertical

(e) Lead axle - vertical

(f) Lead axle - lateral

(g) Flywheel - vertical

The test was performed using the procedures described in paragraph 5.2.

5.3.2 INSTRUMENTATION

Block diagrams of the data acquisition system and the data recovery system are provided in figures 1-1 and 1-2. Details of the instrumentation related to the component induced vibration tests is shown in figure 1-4. Information concerning instrumentation for overall data acquisition for the energy storage car tests is described in Volume I of this report.

5.3.3 RESULTS

The results of the component induced vibration tests are shown in amplitude versus frequency plots for each of the components listed in table 5-1. The plots are grouped in sets of responses for each component, in the order listed in the table. Each plot is identified by a label stating the location and type of sensor and has a reference number (circled number on plot) keyed to the table.

Table 5-1. Component Induced Vibration Plot Index

Figure Number	Component	Sensor Location and Plot Reference Number						
		FWD CB VERT.	FWD CB LAT.	FWD CB LONG.	MID CB VERT.	LEAD AXLE VERT.	LEAD AXLE LAT.	F/W VERT.
5-1	Gas Generator	1	2	3	4	5	6	7
5-2	Air Compressor	8	9	10	11	12	13	14
5-3	Motor/Generator Set	15	16	17	18	19	20	21
5-4	Ventilation Fan	22	23	24	25	26	27	28
5-5	Flywheel (at 70%)	29	30	31	32	33	34	35
5-6	Flywheel (at 82%)	36	37	38	39	40	41	42

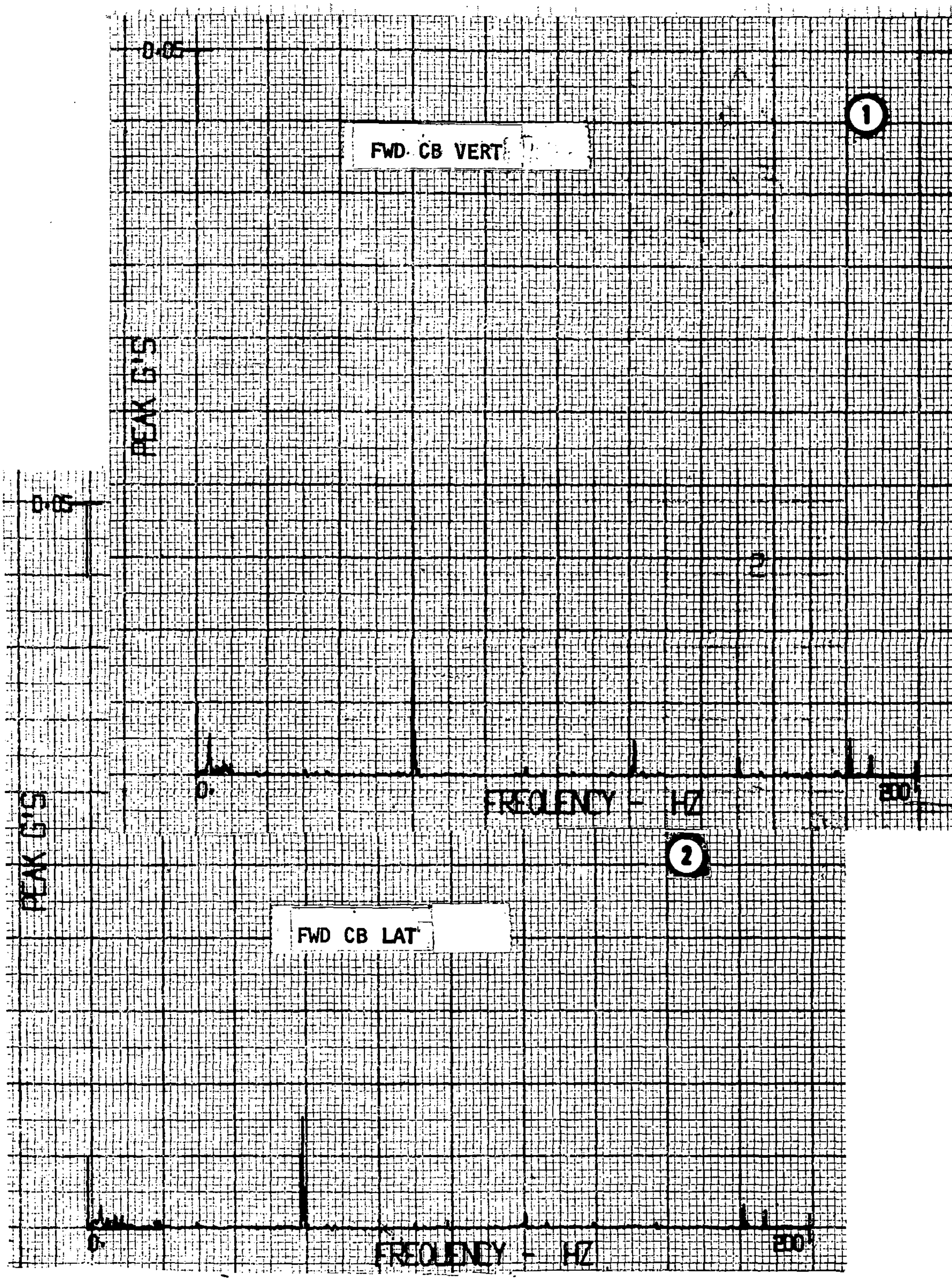


Figure 5-1. Gas Generator Induced Vibration (Sheet 1)

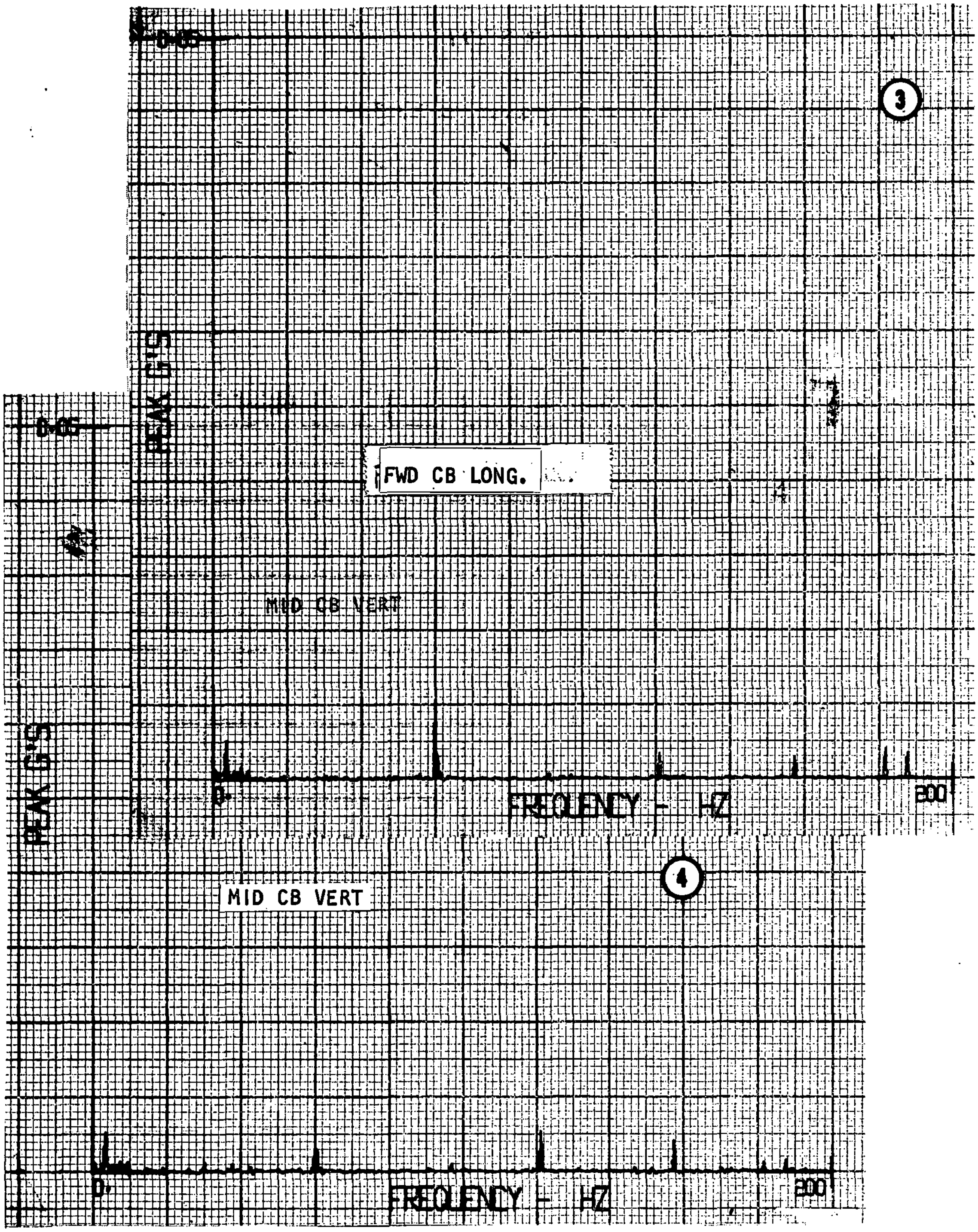


Figure 5-1. Gas Generator Induced Vibration (Sheet 2)

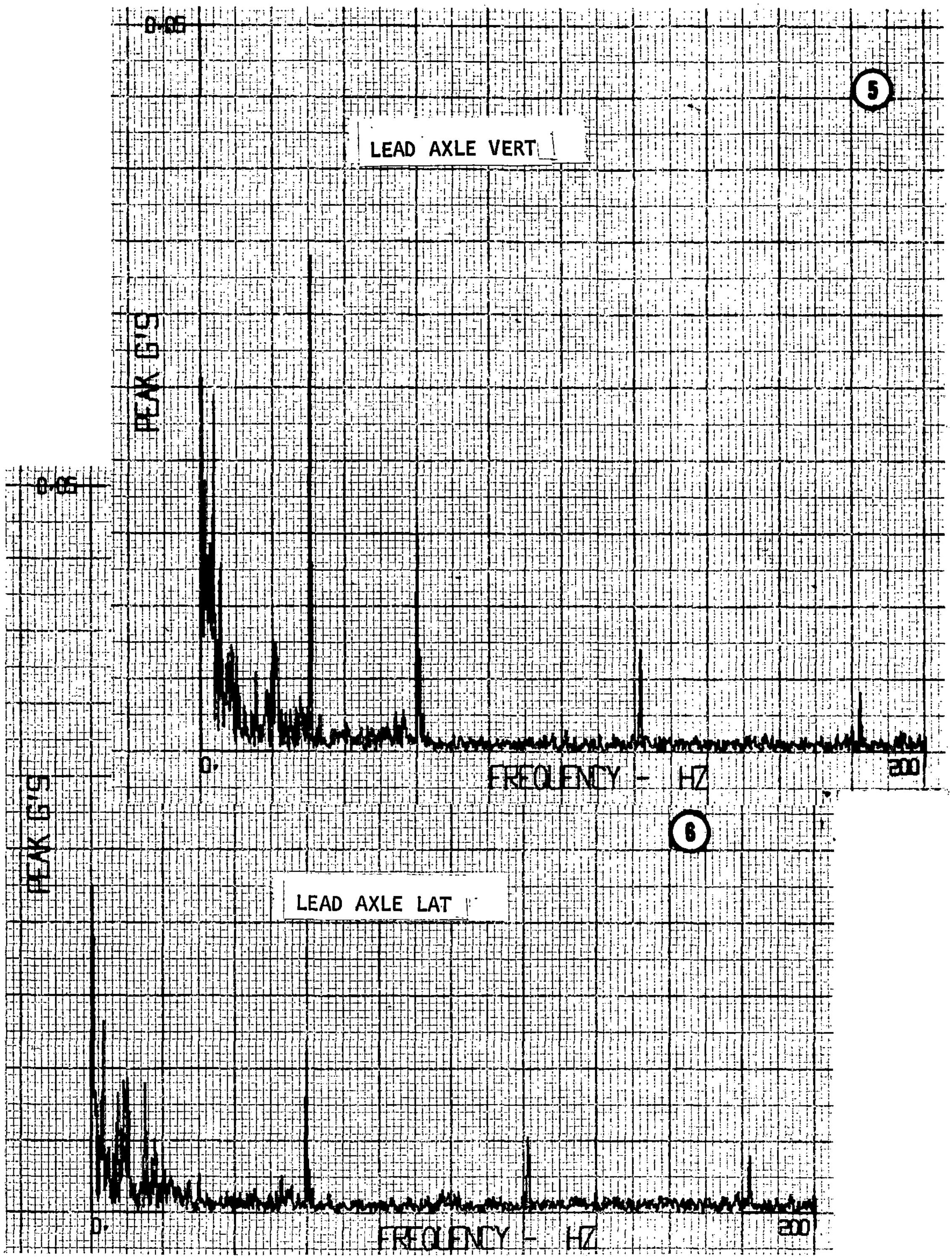


Figure 5-1. Gas Generator Induced Vibration (Sheet 3)

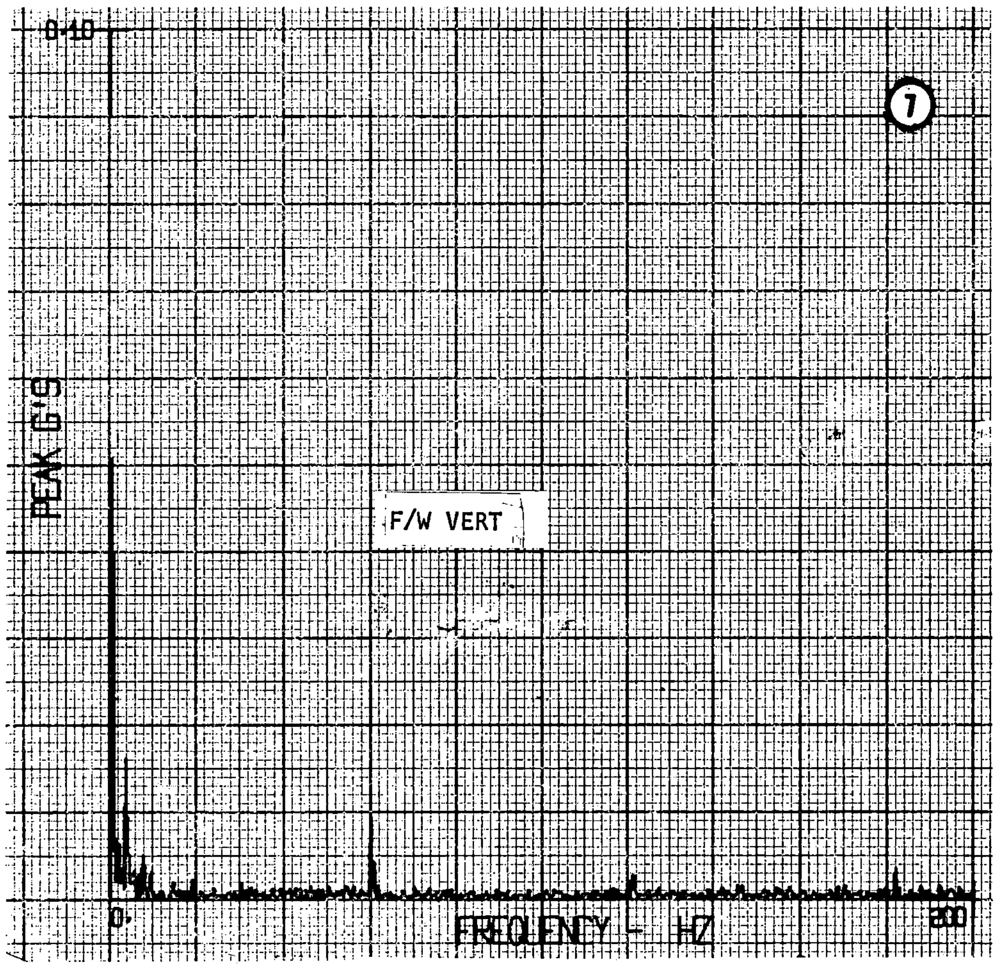


Figure 5-1. Gas Generator Induced Vibration (Sheet 4)

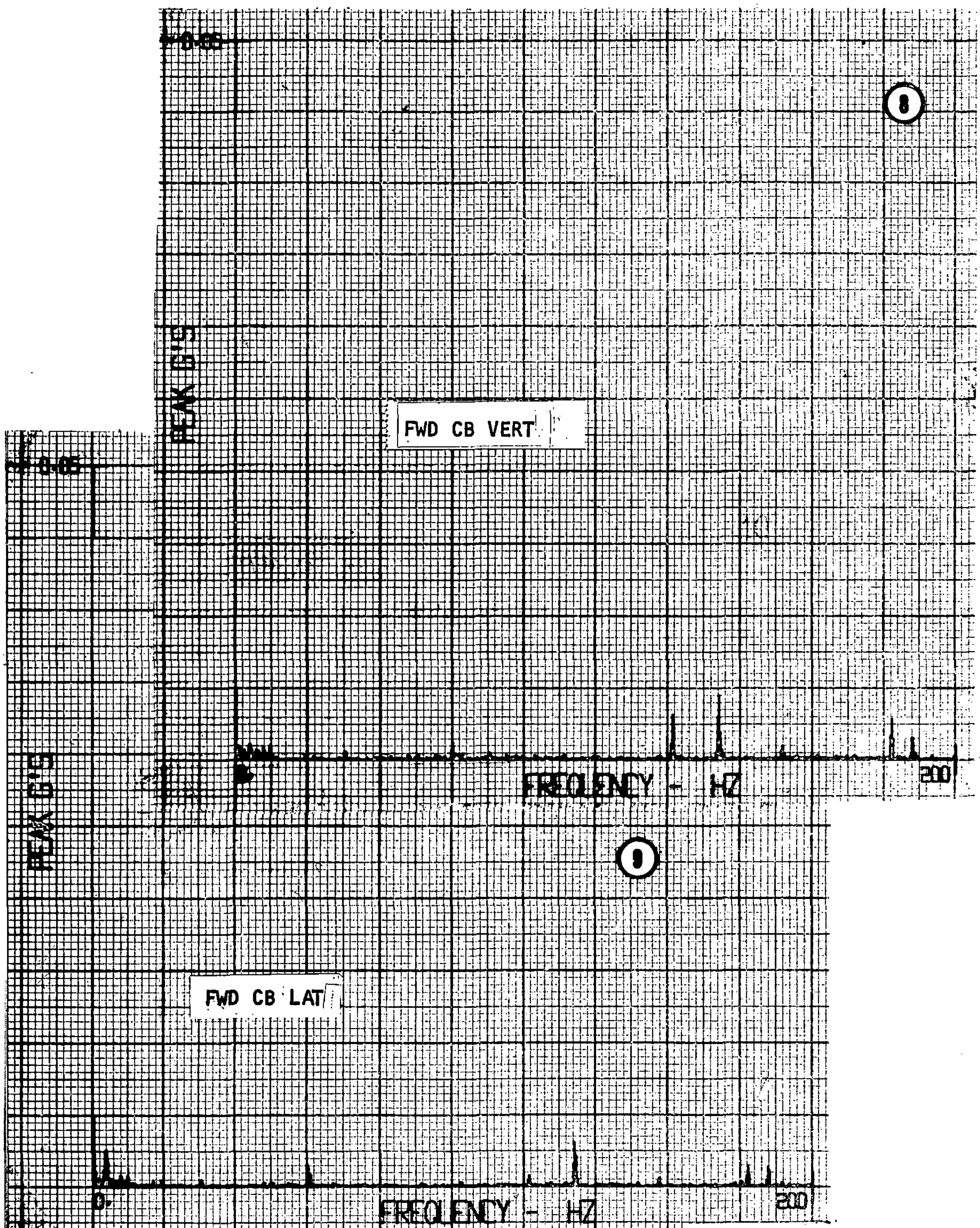


Figure 5-2. Air Compressor Induced Vibration (Sheet 1)

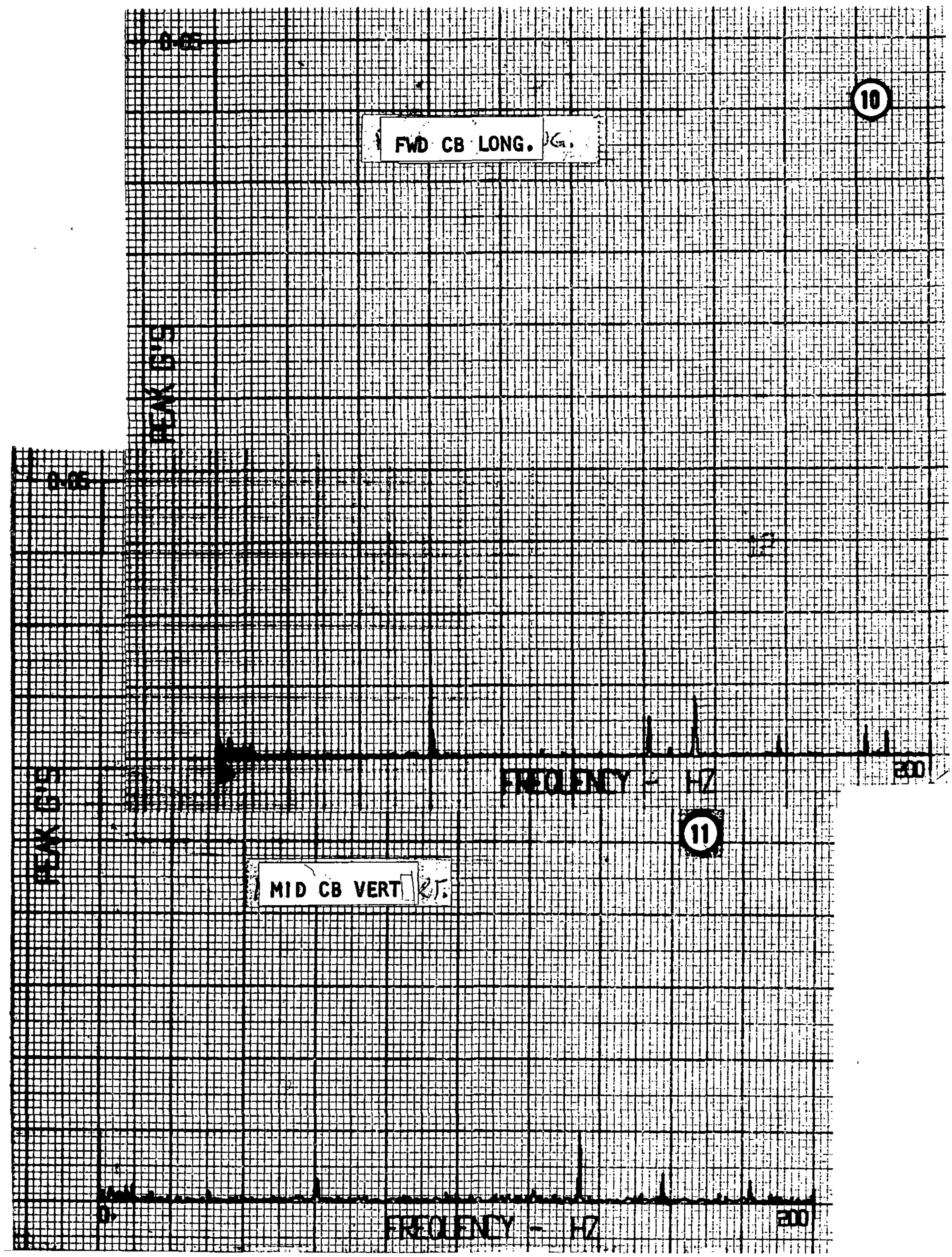


Figure 5-2. Air Compressor Induced Vibration (Sheet 2)

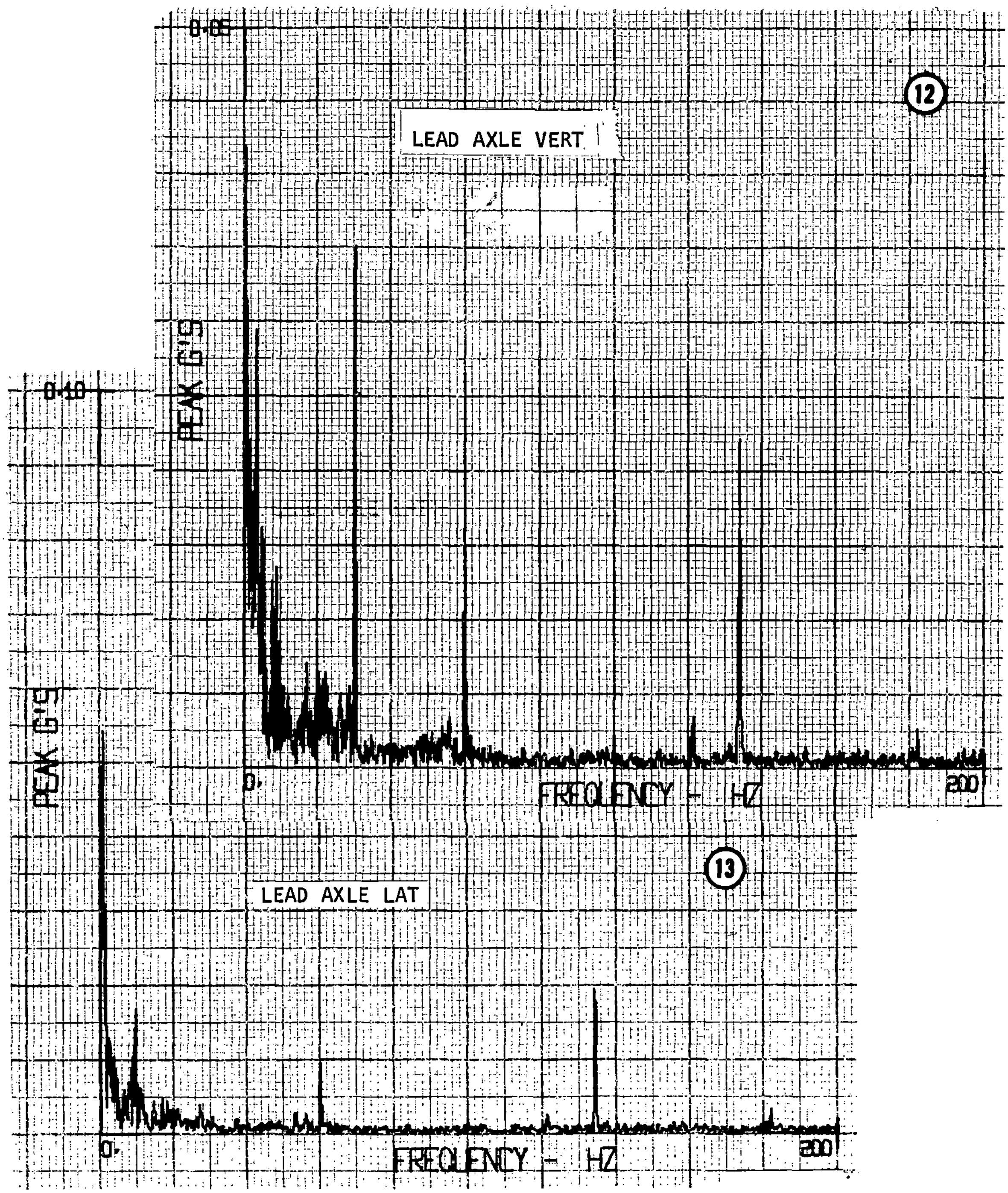


Figure 5-2. Air Compressor Induced Vibration (Sheet 3)

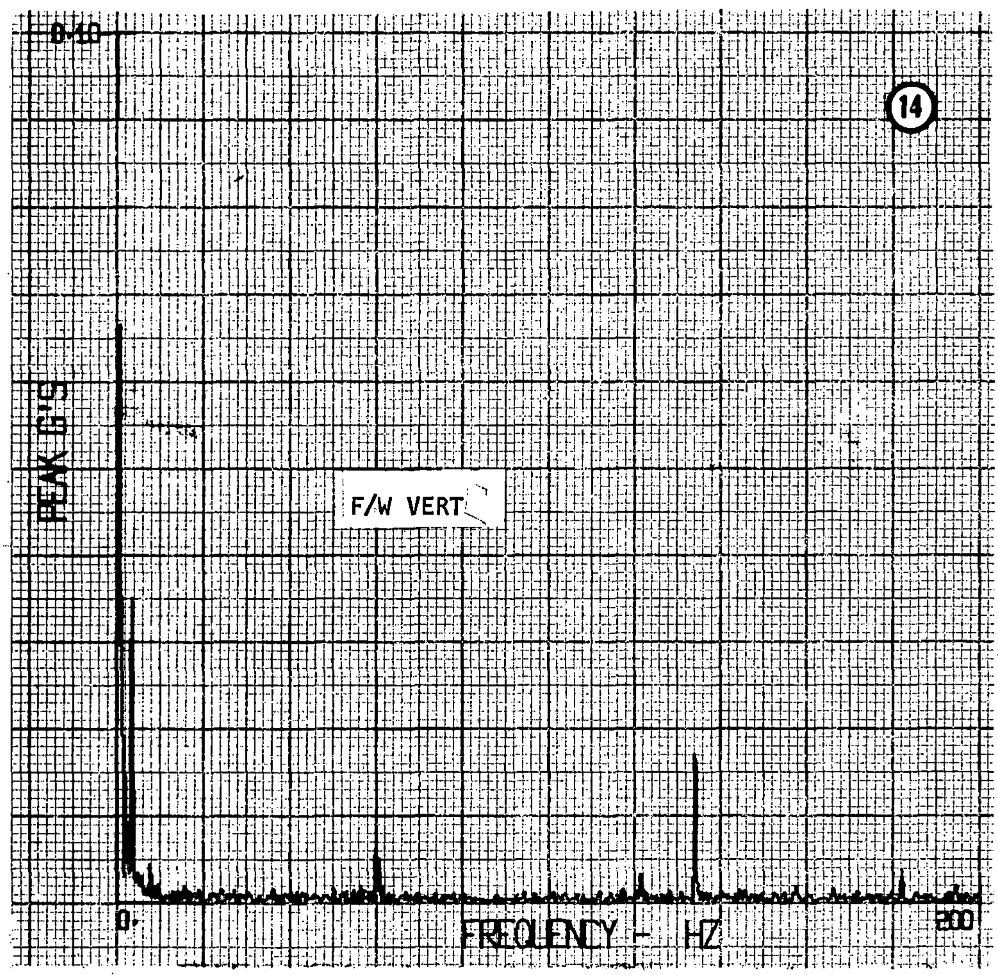


Figure 5-2. Air Compressor Induced Vibration (Sheet 4)

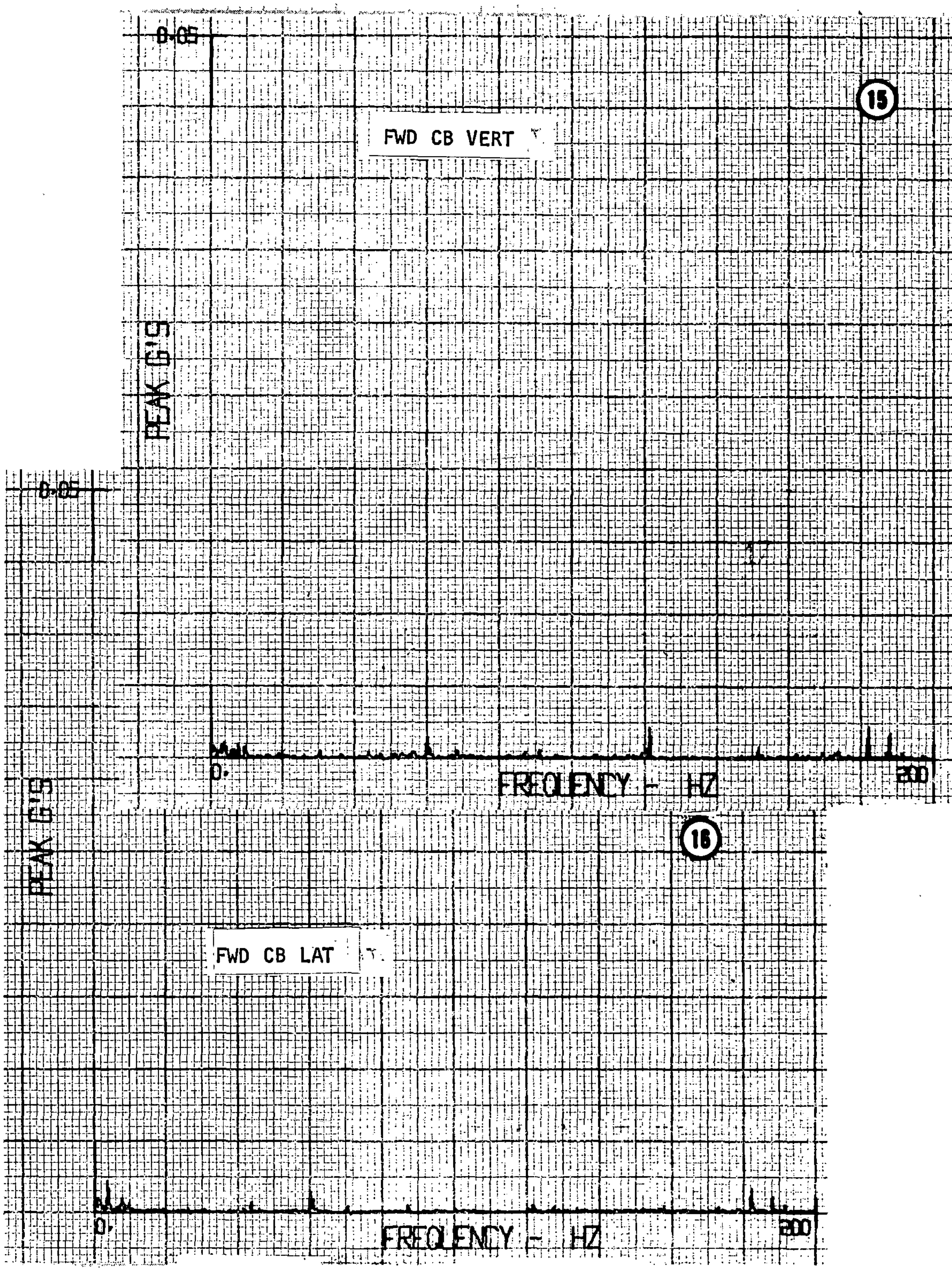


Figure 5-3. Motor/Generator Set Induced Vibration (Sheet 1)

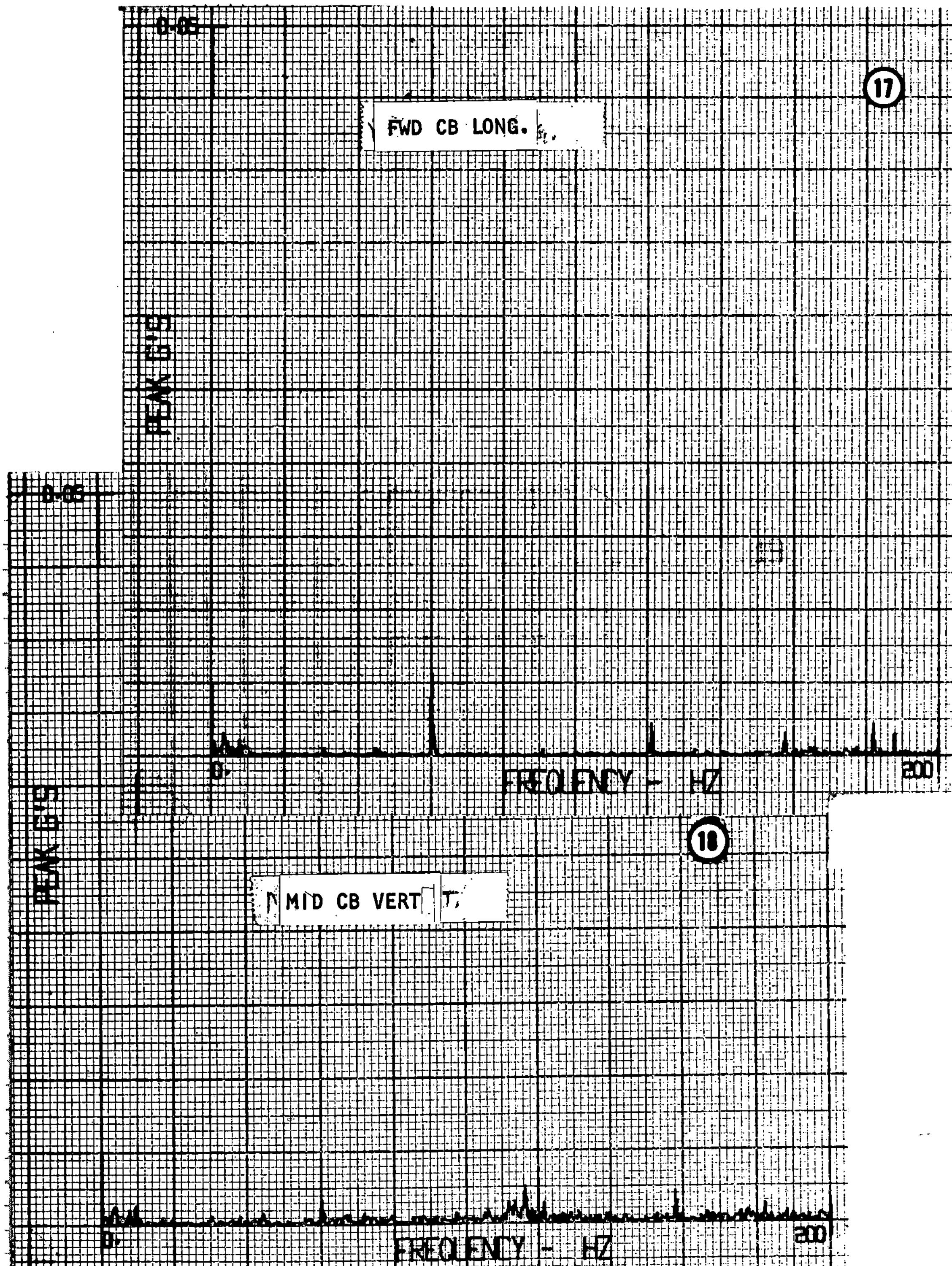


Figure 5-3. Motor/Generator Set Induced Vibration (Sheet 2)

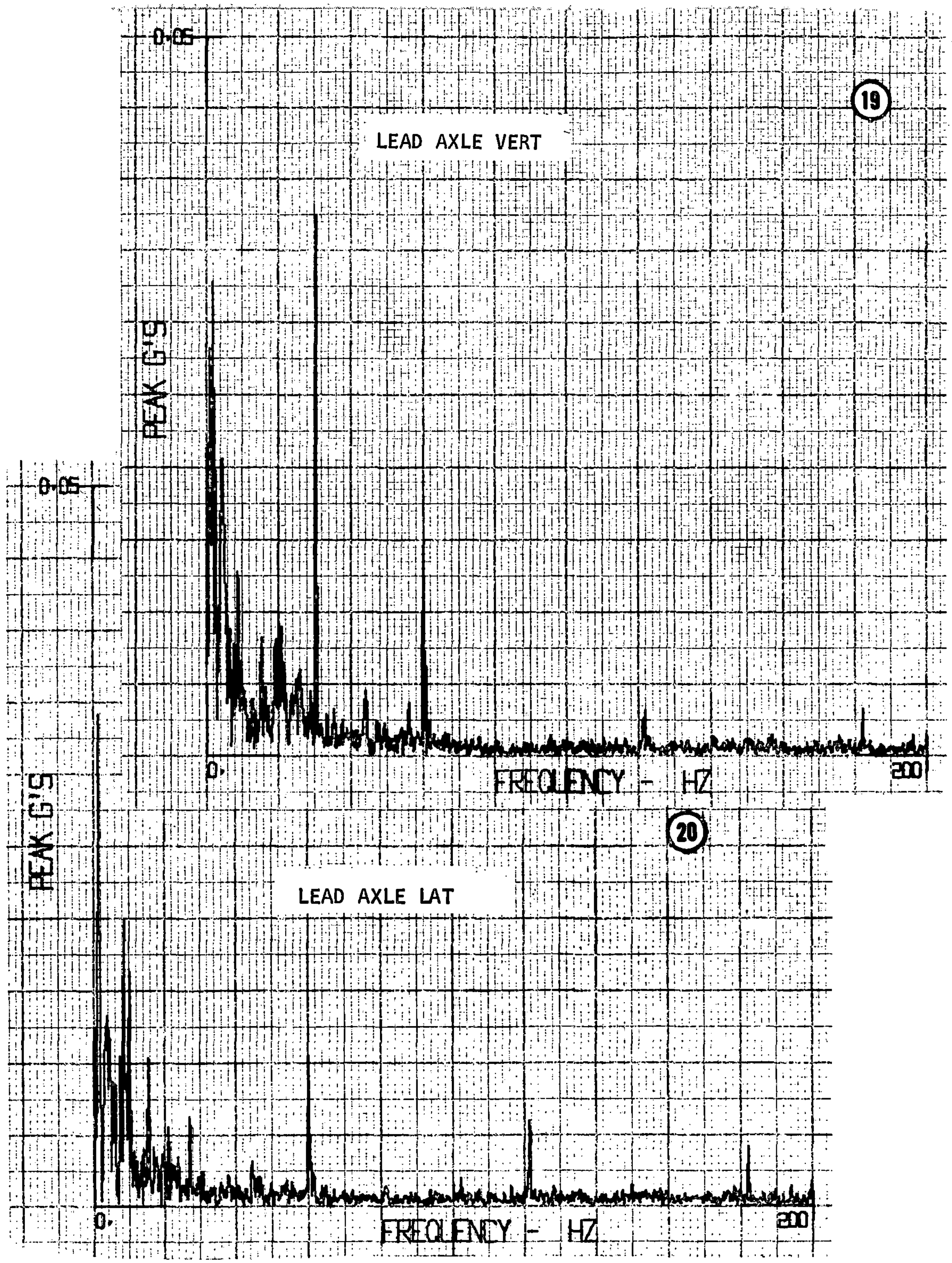


Figure 5-3. Motor/Generator Set Induced Vibration (Sheet 3)

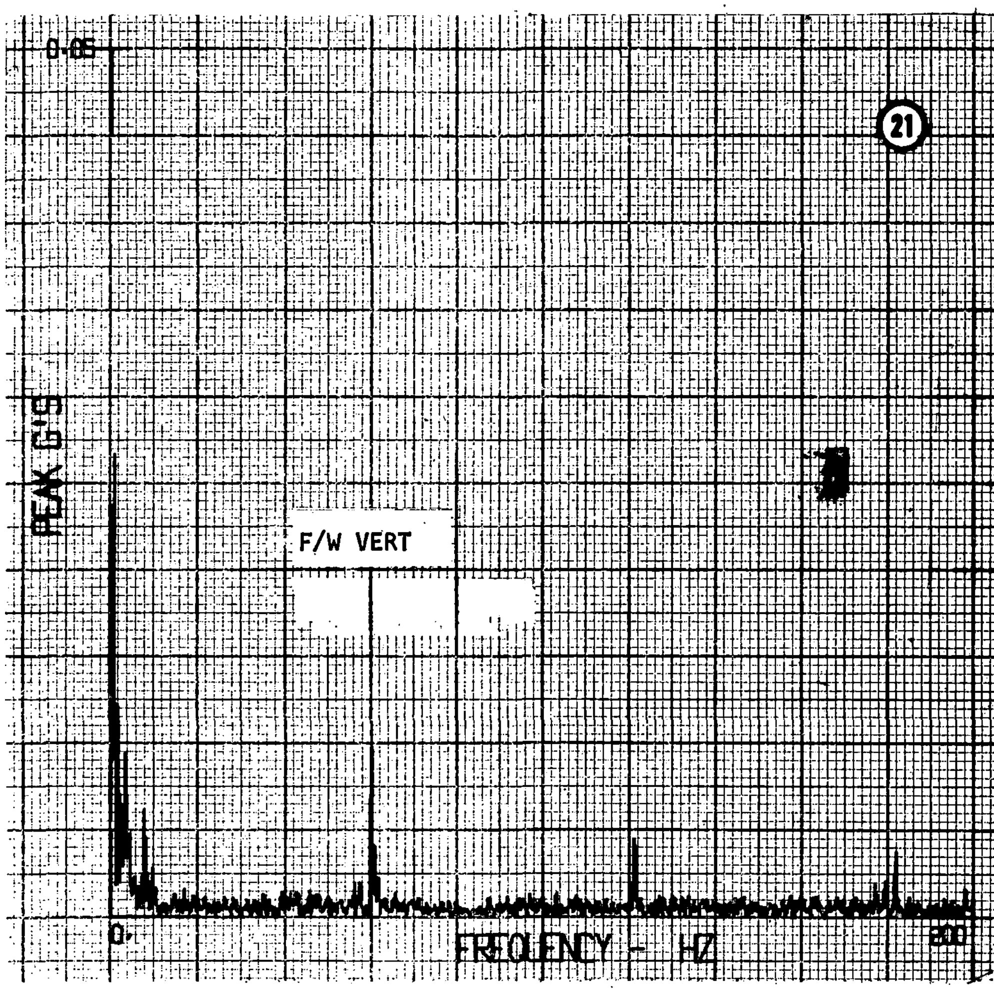


Figure 5-3. Motor/Generator Set Induced Vibration (Sheet 4)

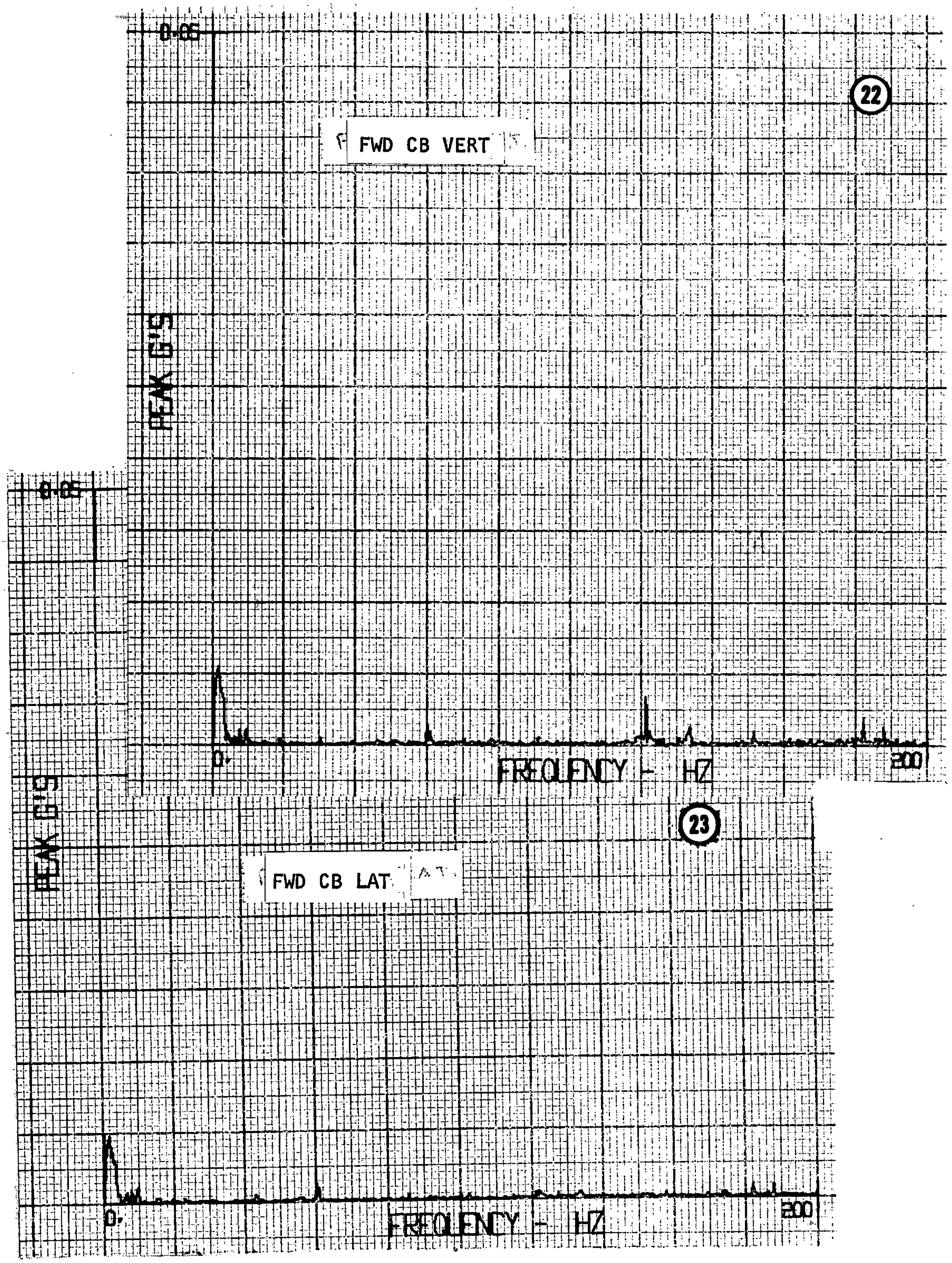


Figure 5-4. Ventilation Fan Induced Vibration (Sheet 1)

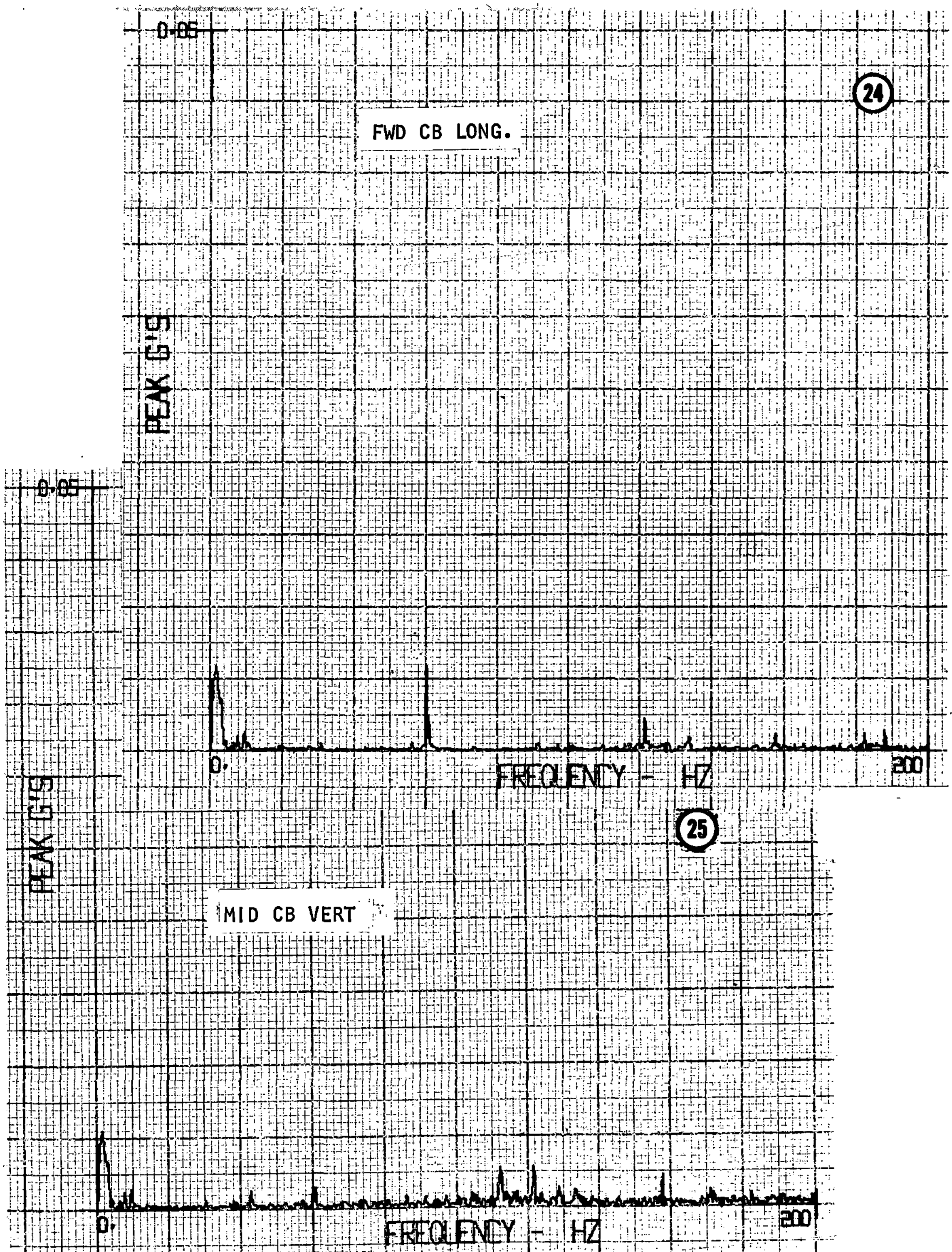


Figure 5-4. Ventilation Fan Induced Vibration (Sheet 2)

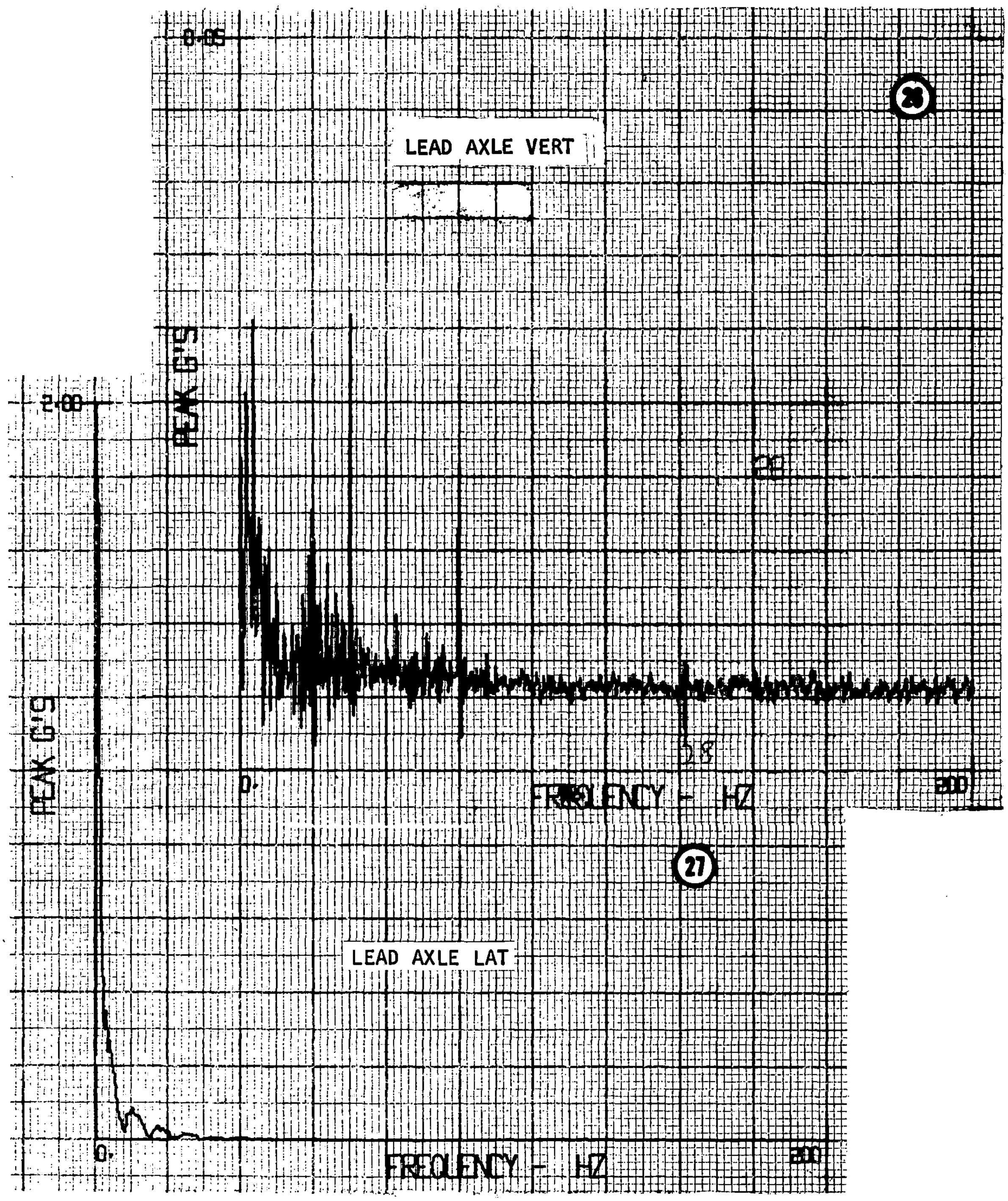


Figure 5-4. Ventilation Fan Induced Vibration (Sheet 3)

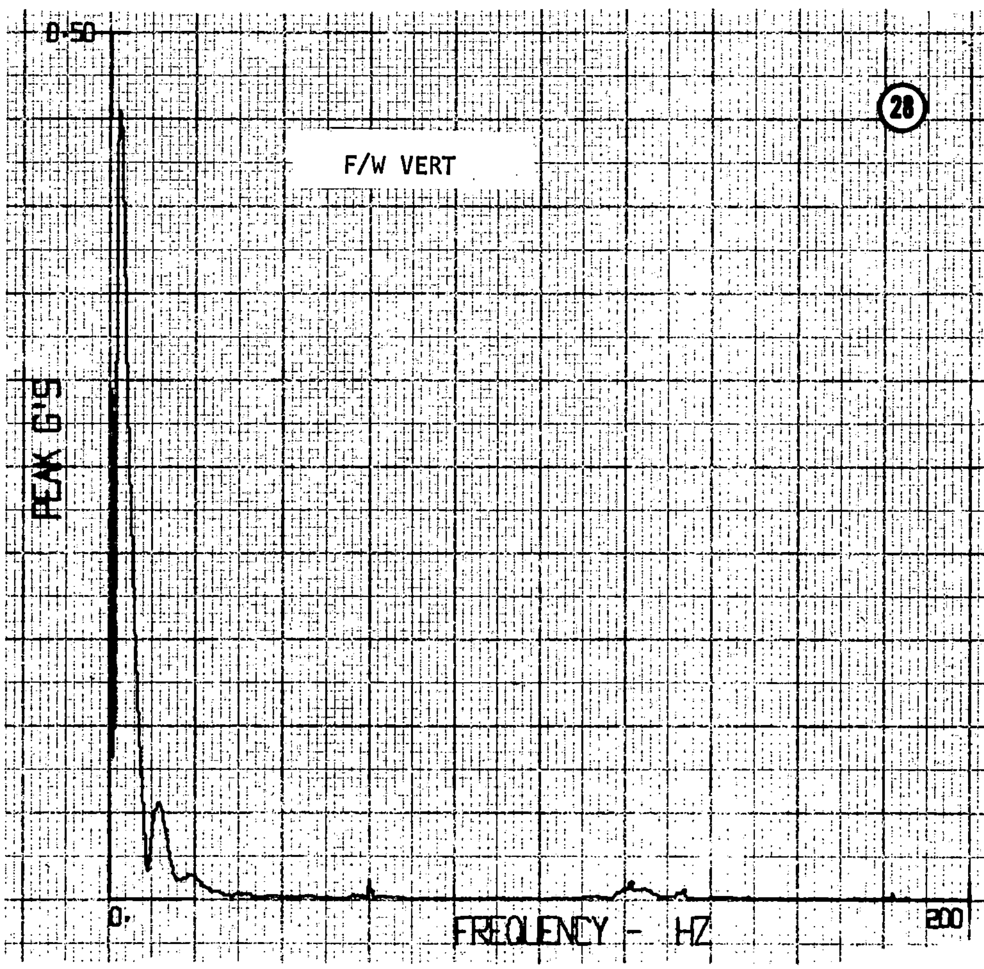


Figure 5-4. Ventilation Fan Induced Vibration (Sheet 4)

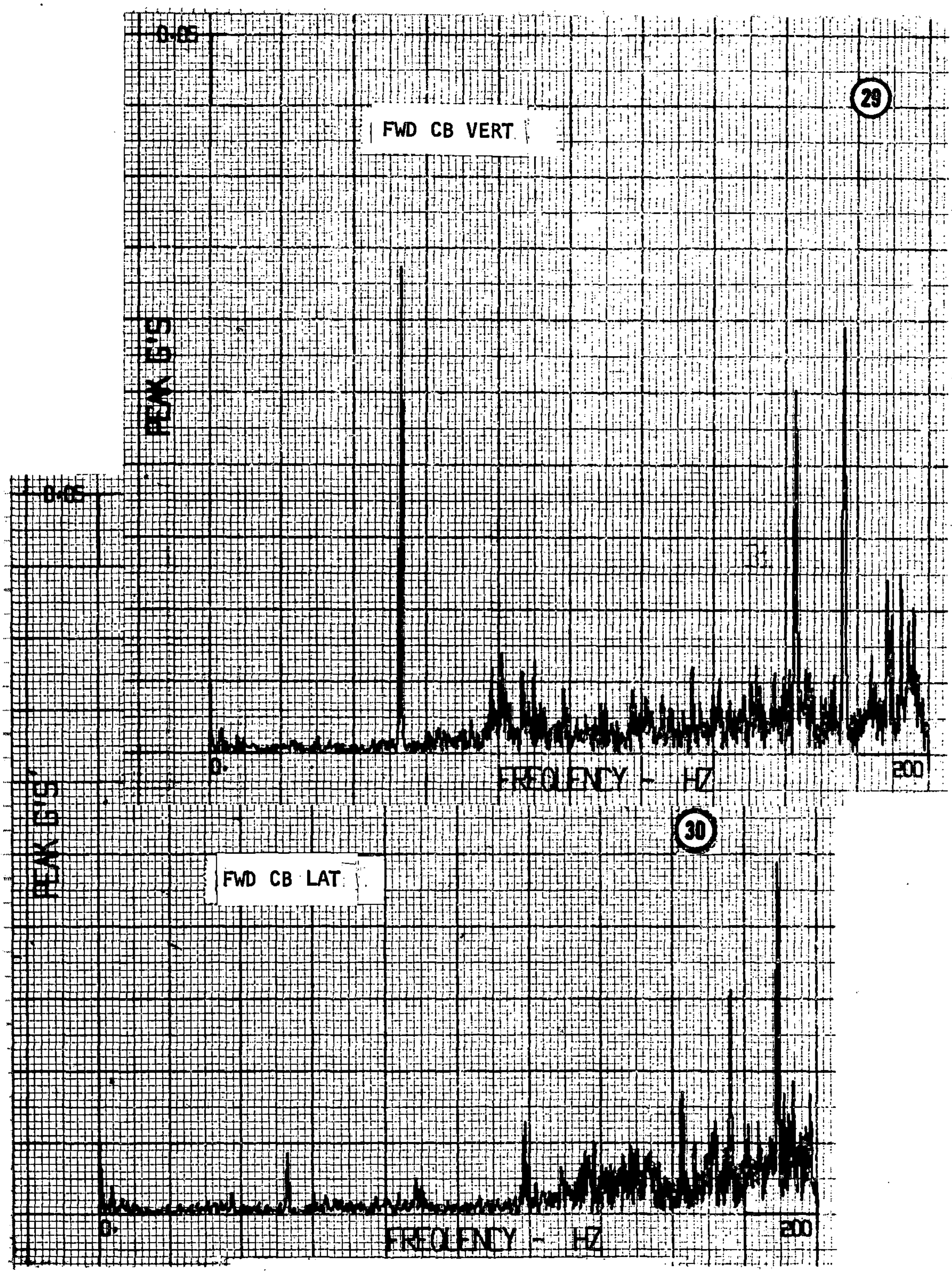


Figure 5-5. Flywheel 70 Percent Speed Induced Vibration (Sheet 1)

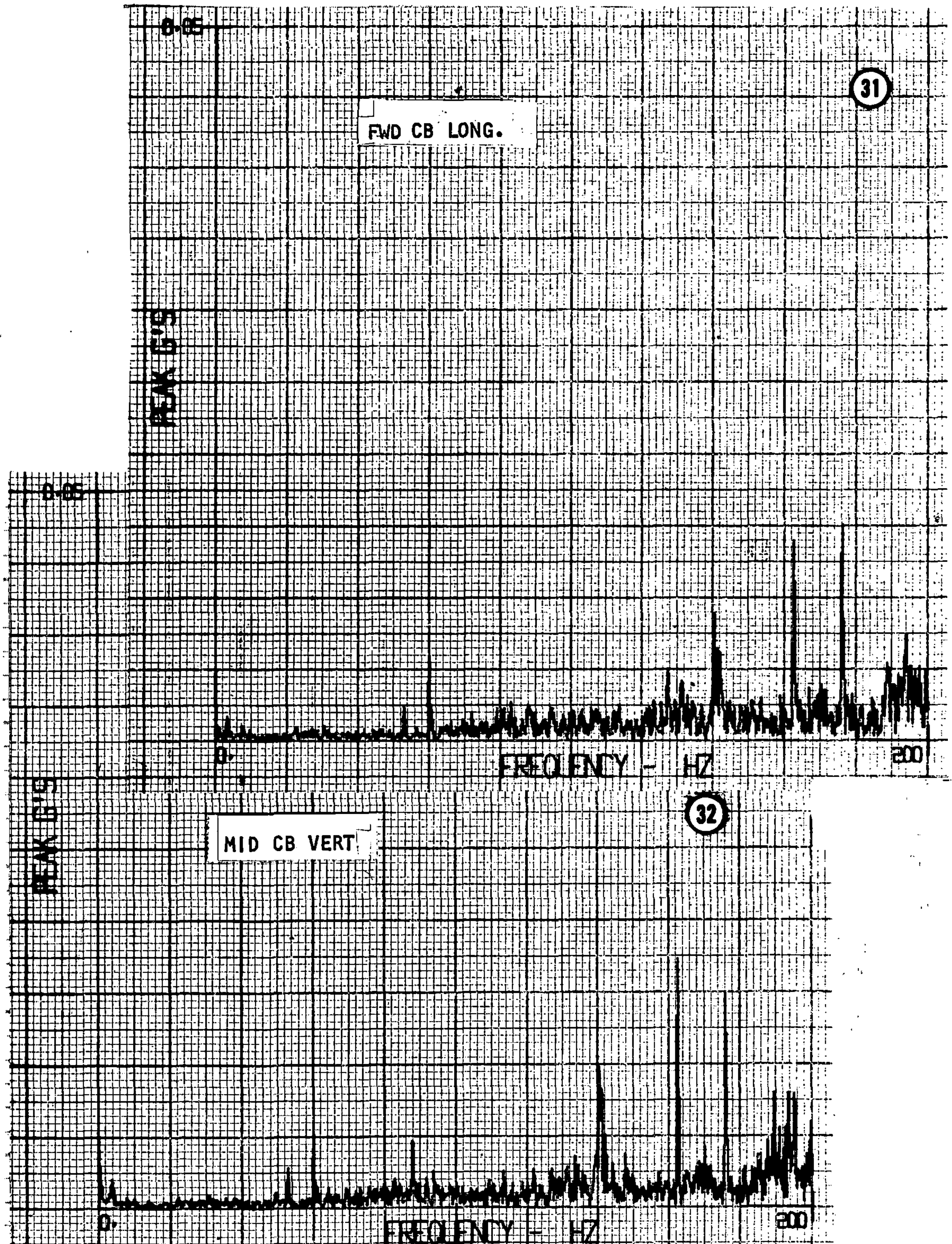
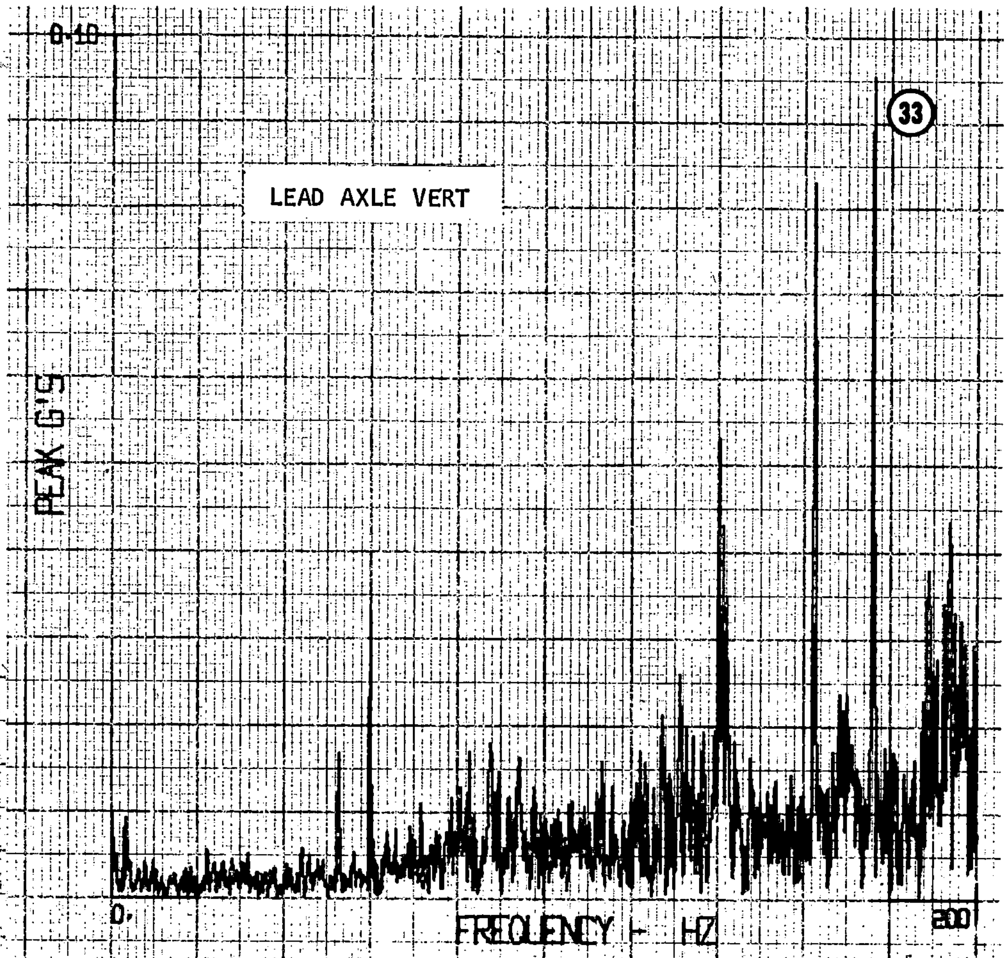


Figure 5-5. Flywheel 70 Percent Speed Induced Vibration (Sheet 2)



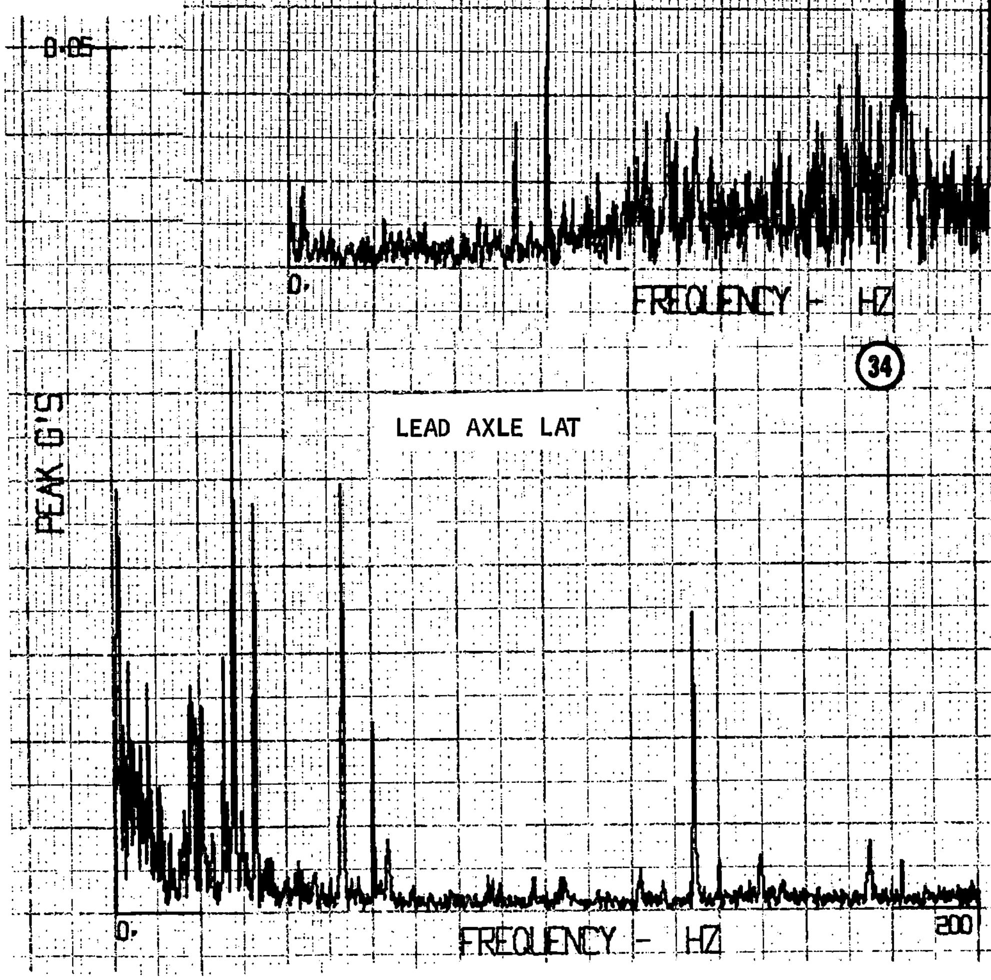


Figure 5-5. Flywheel 70 Percent Speed Induced Vibration (Sheet 3)

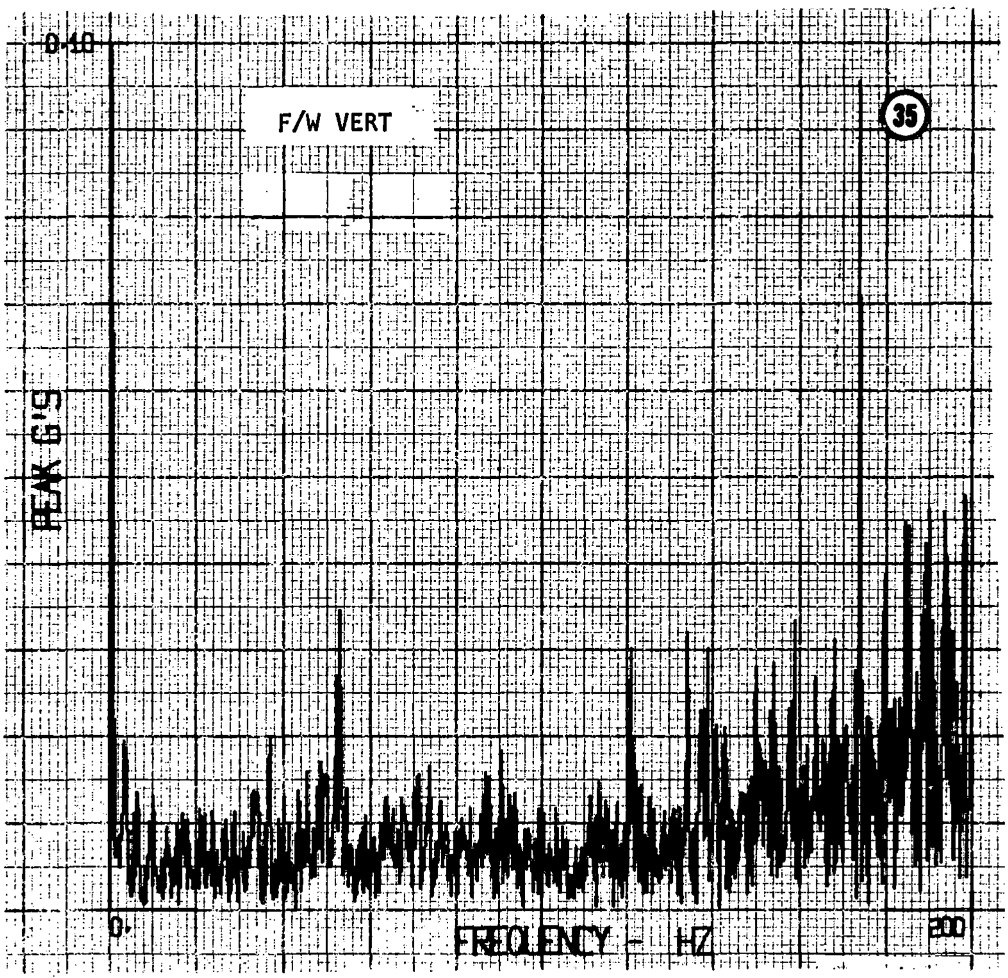


Figure 5-5. Flywheel 70 Percent Speed Induced Vibration (Sheet 4)

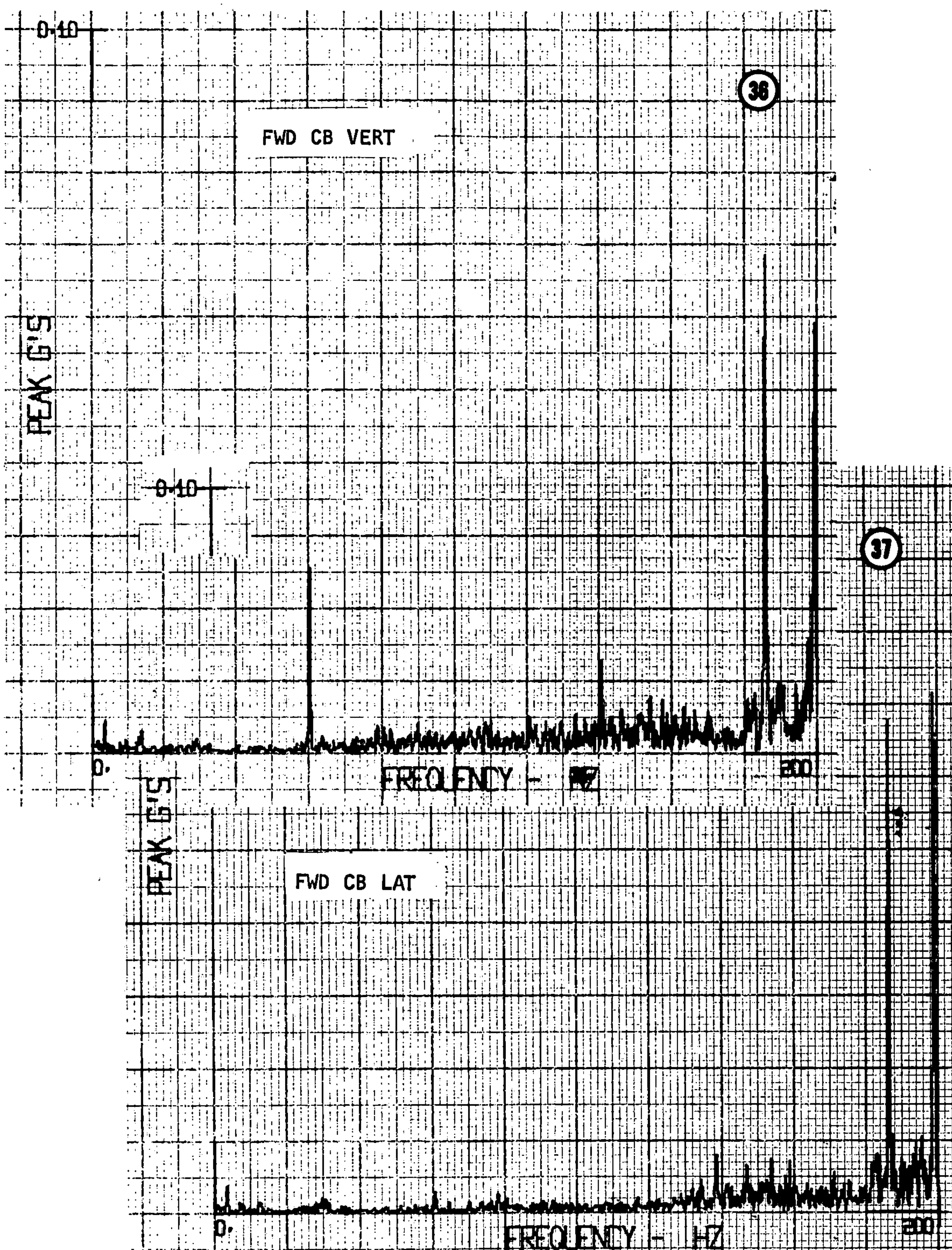


Figure 5-6. Flywheel 82 Percent Speed Induced Vibration (Sheet 1)

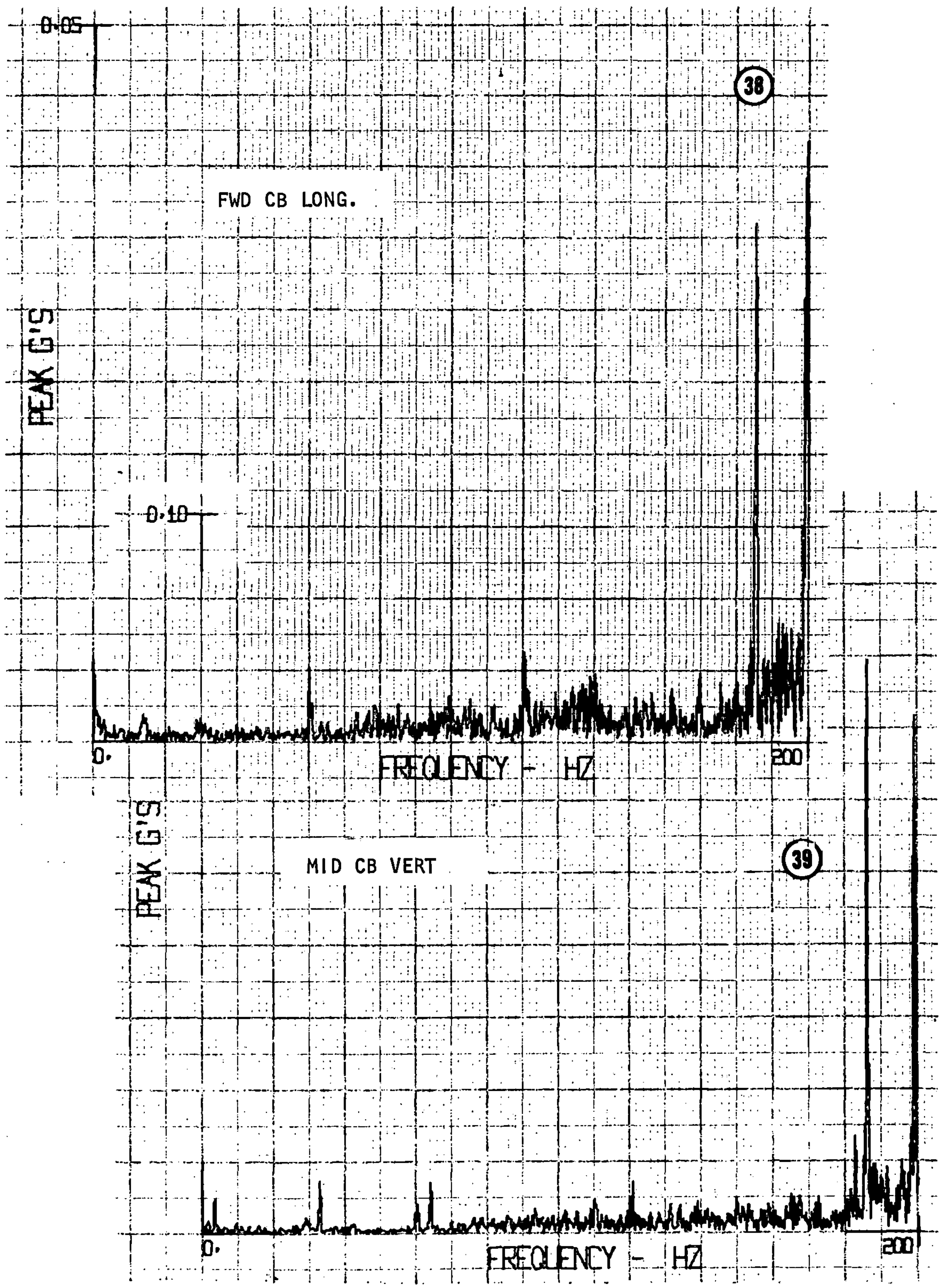


Figure 5-6. Flywheel 82 Percent Speed Induced Vibration (Sheet 2)

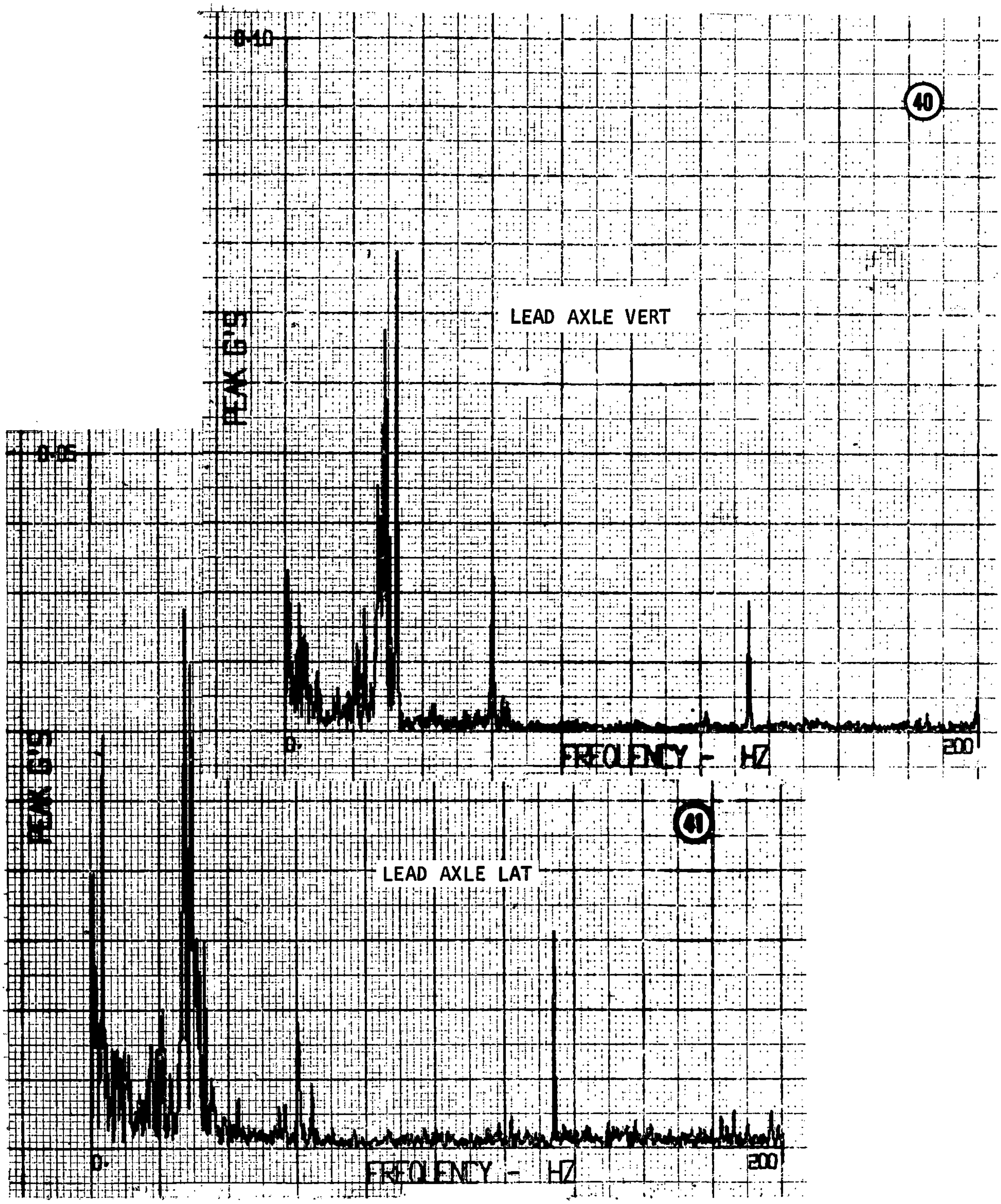


Figure 5-6. Flywheel 82 Percent Speed Induced Vibration (Sheet 3)

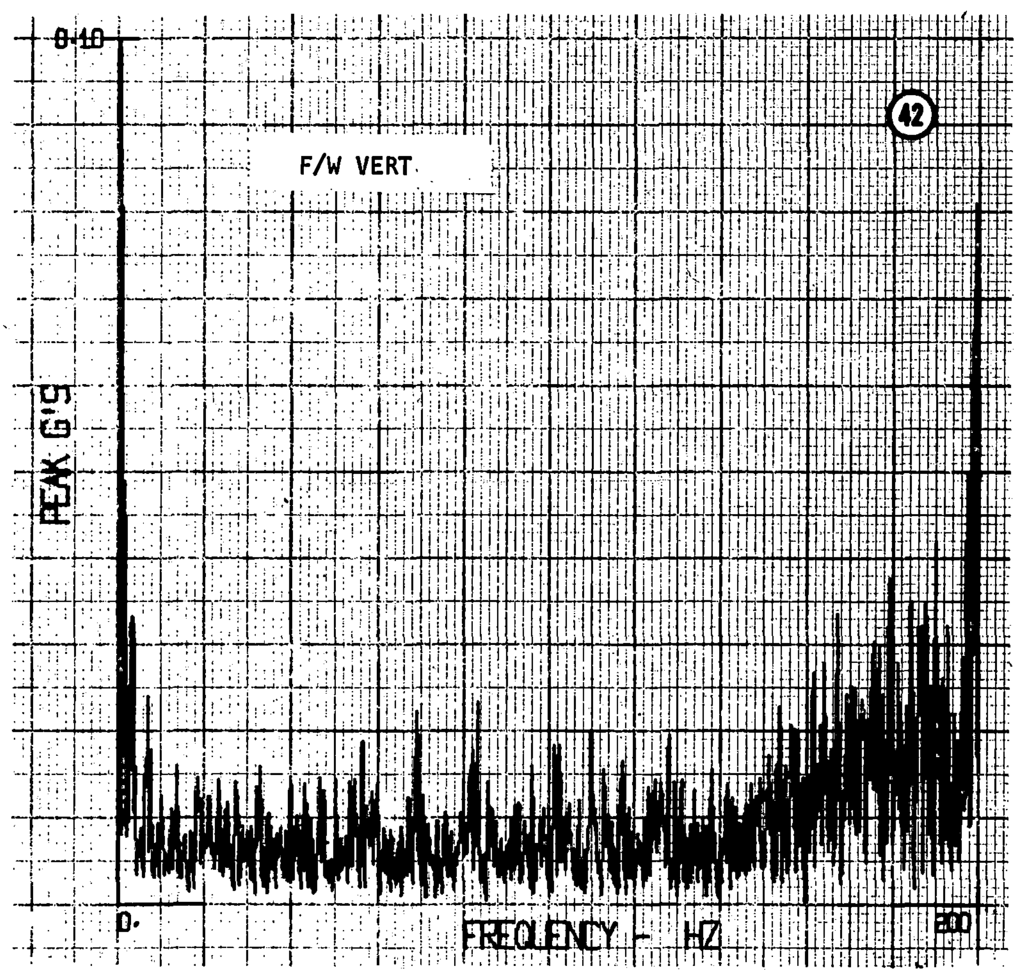


Figure 5-6. Flywheel 82 Percent Speed Induced Vibration (Sheet 4)

6. RIDE ROUGHNESS - WORST SPEEDS (ESC-R-1101-TT)

6.1 SUMMARY

The worst Speeds Test was conducted in compliance with Test Set Number ESC-R-1101-TT of the TSC General Vehicle Test Plan, GSP-064. Requirements and procedures covered by this test set are defined in paragraphs 6.1.1 through 6.2.2. Refer to paragraph 6.3 for a description of the test, instrumentation used, and for the test results.

6.1.1 TEST OBJECTIVE

To determine worst steady vibration levels of the test vehicle on the UMTA test track.

6.1.2 TEST DESCRIPTION

The following configurations will be tested:

(a) Vehicle weights of AWO, AW2 and AW3

(b) All track sections including grade crossings and switches as required to simulate revenue service

(c) Select discrete vehicle speeds simulating revenue service and include V (max)

(d) Select other speeds as required to identify known or suspected acute vibration levels associated with car body characteristics

6.1.3 STATUS

The energy storage cars successfully completed the worst speeds tests as prescribed by the conditions specified in paragraph 6.1.2. Refer to test log runs 73 through 75 presented in Volume I, Appendix C of this report.

6.2 PROCEDURES

The following test procedures are included as part of the ESC-R-1101-TT Test Set. The ESC tests were performed generally in accordance with these procedures and any procedural differences are reflected in paragraph 6.3.

6.2.1 PRETEST PROCEDURE

(a) Install and photograph required equipment and instrumentation

(b) Manually record vehicle weight and passenger weight

(c) Calibrate all instrumentation, data acquisition and processing equipment

6.2.2 TEST PROCEDURE

(a) Turn on all car auxiliary equipment and note equipment operation

(b) Accelerate to and maintain test point speed

(c) Prior to entering a test section, start recorders and mark tapes and data sheets with a record number

(d) Provide an event mark on tape record at beginning of test section (See Table 6-1 and Figure 6-1.)

(e) Provide an event mark at the end of 20 seconds on data

(f) Stop recorders

(g) Proceed to next section or speed and repeat the above

6.3 TEST DESCRIPTION AND RESULTS

The energy storage car (ESC) worst speed tests were conducted in accordance with AiResearch Document 74-10441 as defined in paragraph 6.3.1 and in compliance with GSP-064 Test Set ESC-R-1101-TT, described in paragraphs 6.1.1 and 6.1.2.

6.3.1 DESCRIPTION

The worst speed tests were performed at car weights of AW0, AW2 and AW3 to determine the speed at which the worst steady vibration levels occurred. Tests were run at selected speeds of 20, 35, and 45 mph. During the test runs, no noticeable worst-speed condition was encountered, and therefore, all recorded tests were run at 35 mph. This speed was selected because it was a speed that could be duplicated and maintained on each track section. Six vibration channels were recorded from sensors located as follows:

(a) Forward car body - vertical

(b) Forward car body - lateral

(c) Forward car body - longitudinal

(d) Mid car body - vertical

(e) Lead axle - vertical

(f) Lead axle - lateral

The tests were performed using the procedures described in paragraph 6.2. The test track layout is shown in figure 6-1 and track section beginning locations listed in table 6-1.

Table 6-1. Track Test Section Beginning Locations

Section	Begin CW	Begin CCW
I	120	150
II	215	240
III	255	280
IV	360	385
V	450	480
VI	480	510
Switch	520	50

6.3.2 INSTRUMENTATION

Block diagrams of the data acquisition system and the data recovery system are provided in figures 1-1 and 1-2. Details of the instrumentation related to the worst speeds tests is shown in figure 1-4. Information concerning instrumentation for overall data acquisition for the energy storage car tests is described in Volume I of this report.

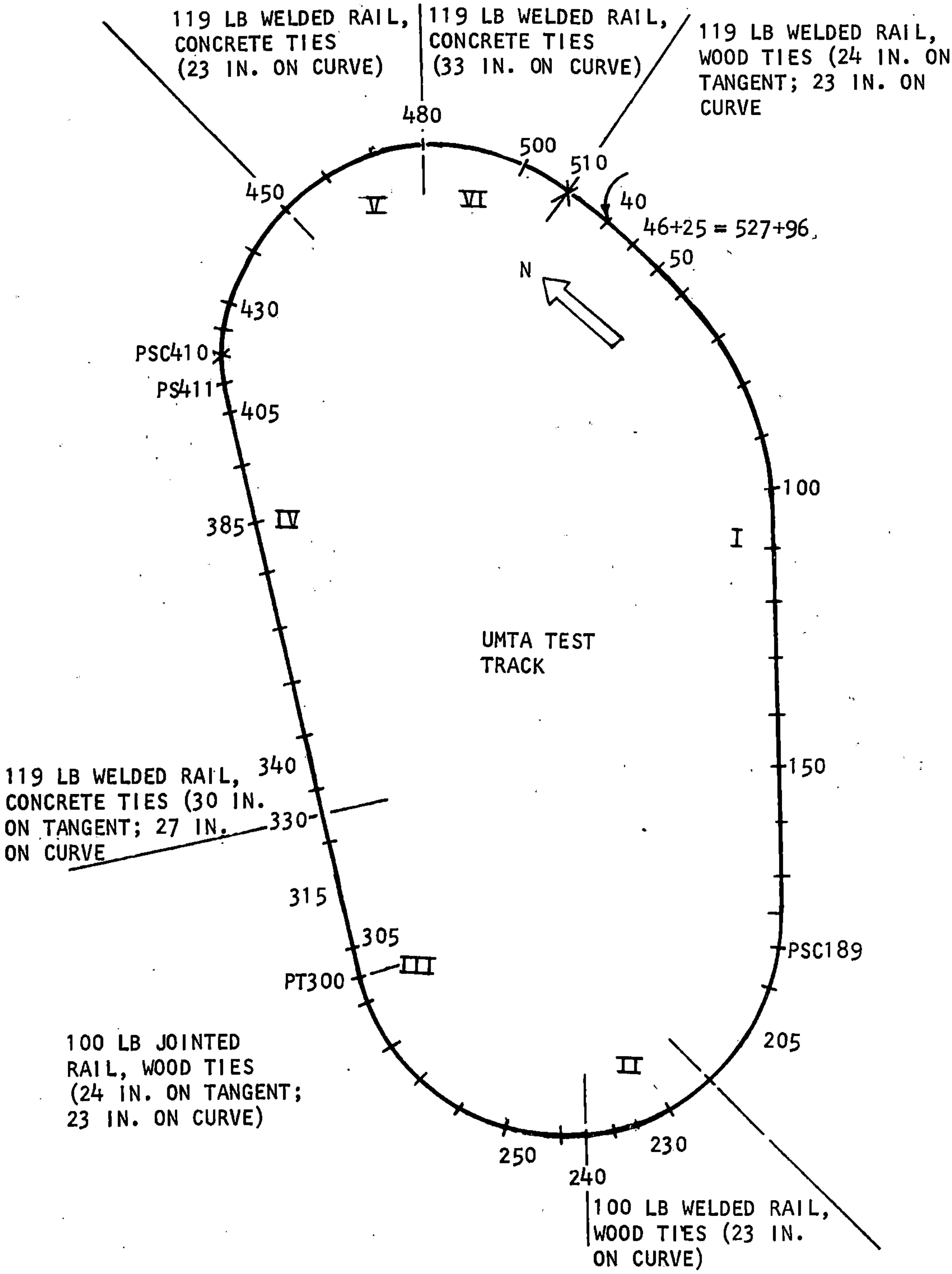


Figure 6-1. Test Track Layout

6.3.3 RESULTS

The results of the AWO car weight worst speed tests are shown in amplitude versus frequency plots, figures 6-2 through 6-7. The plots are grouped in sets of responses for each track section according to the location and type of sensor listed in table 6-2. Each plot is identified by a label stating the track section and a reference number (circled number on plot) keyed to the table.

Table 6-2. AWO Worst Speed Plot Index

Figure Number	Sensor Location and Type	Track Section and Plot Reference Numbers						
		VI	V	IV	III	II	I	Switch Section
6-2	Forward Car Body - Vertical	1	2	3	4	5	6	7
6-3	Forward Car Body - Lateral	8	9	10	11	12	13	14
6-4	Forward Car Body - Longitudinal	15	16	17	18	19	20	21
6-5	Mid Car Body - Vertical	22	23	24	25	26	27	28
6-6	Lead Axle - Vertical	29	30	31	32	33	34	35
6-7	Lead Axle - Lateral	36	37	38	39	40	41	42

<u>NOTES</u>: Car speed, 35 mph for all tests
Car body sensors, ±5.0 vdc = ±0.5 G
Axle sensors, ±5.0 vdc = ±3.0 G

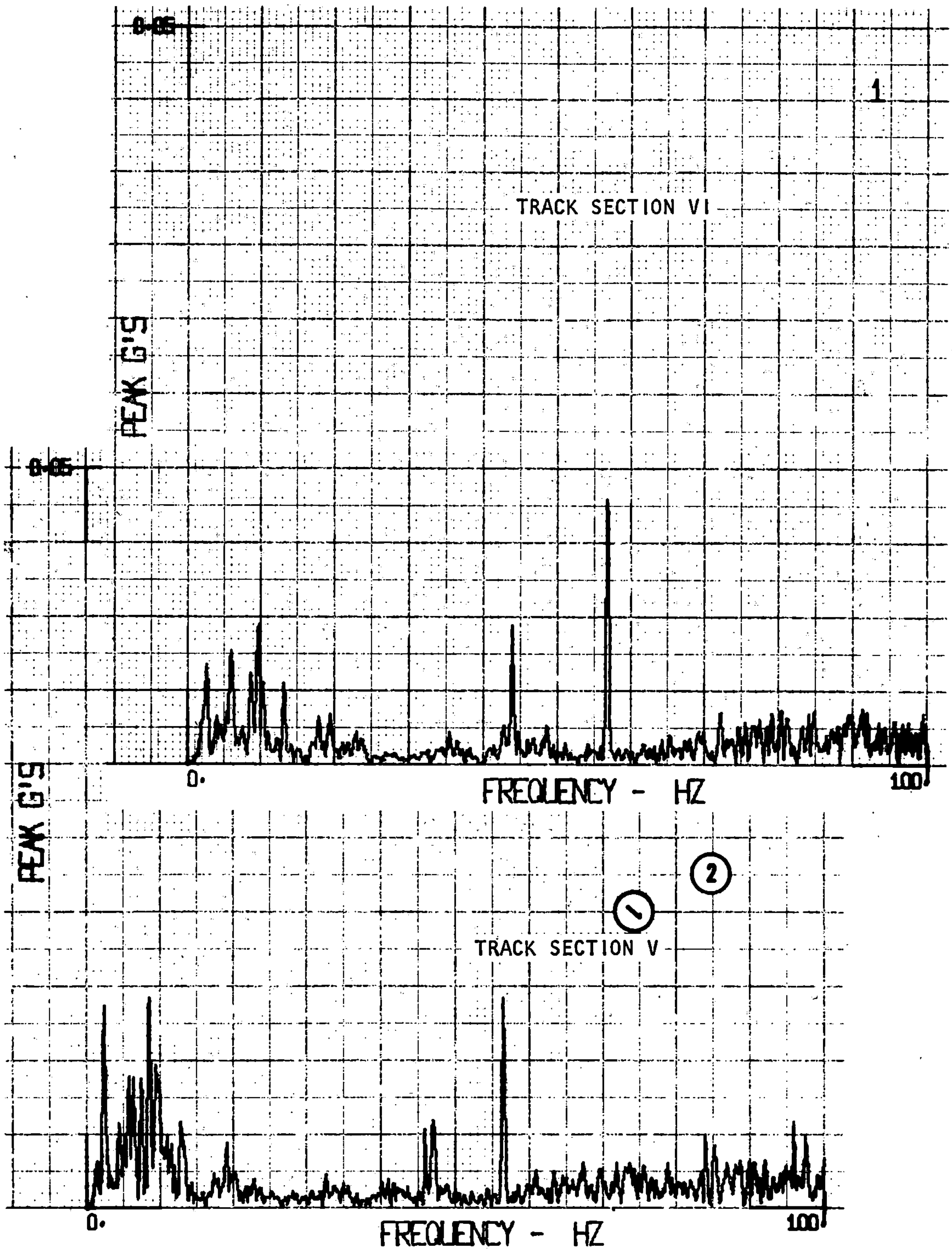


Figure 6-2. Forward Car Body Vertical Vibration - AWO (Sheet 1)

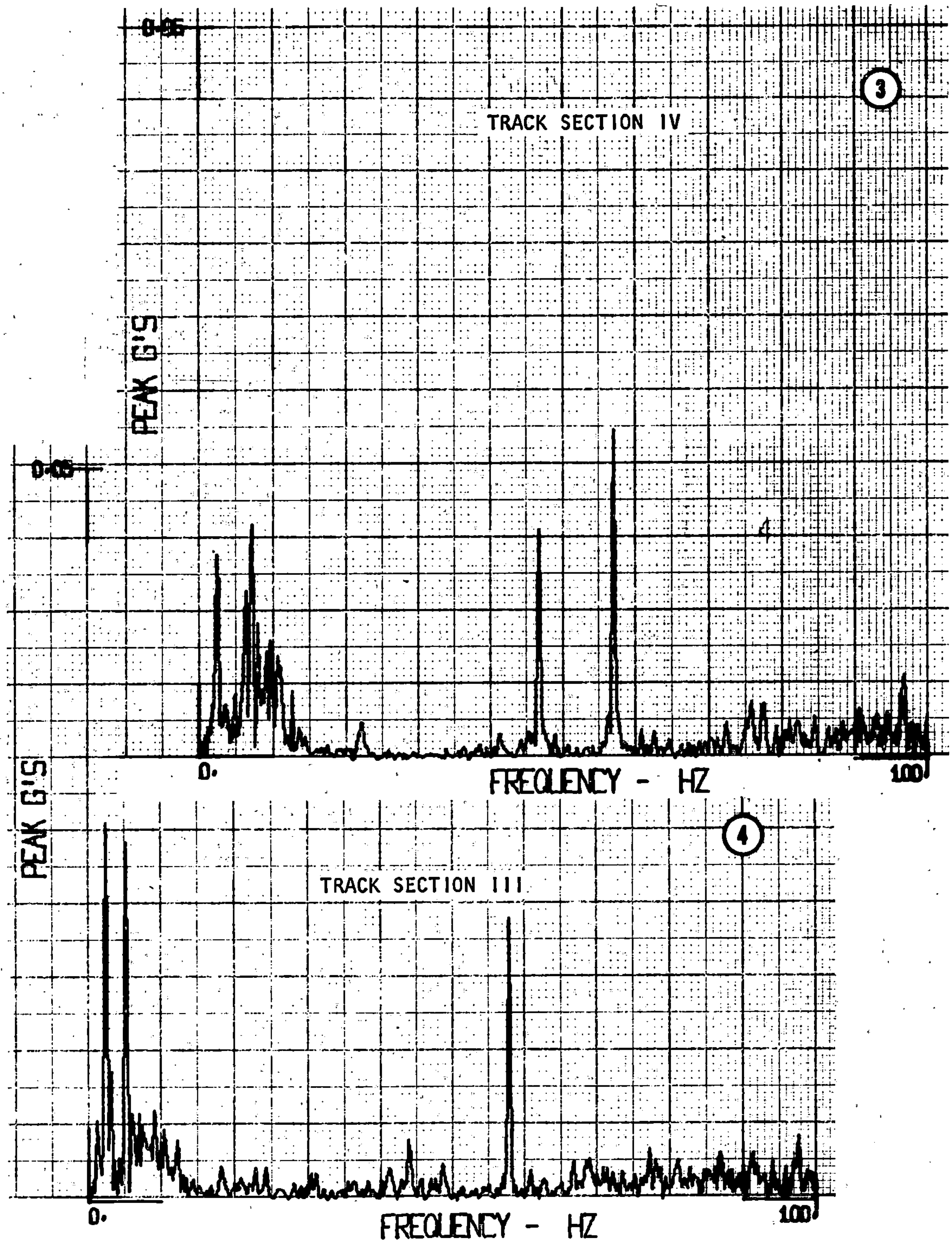


Figure 6-2. Forward Car Body Vertical Vibration - AWO (Sheet 2)

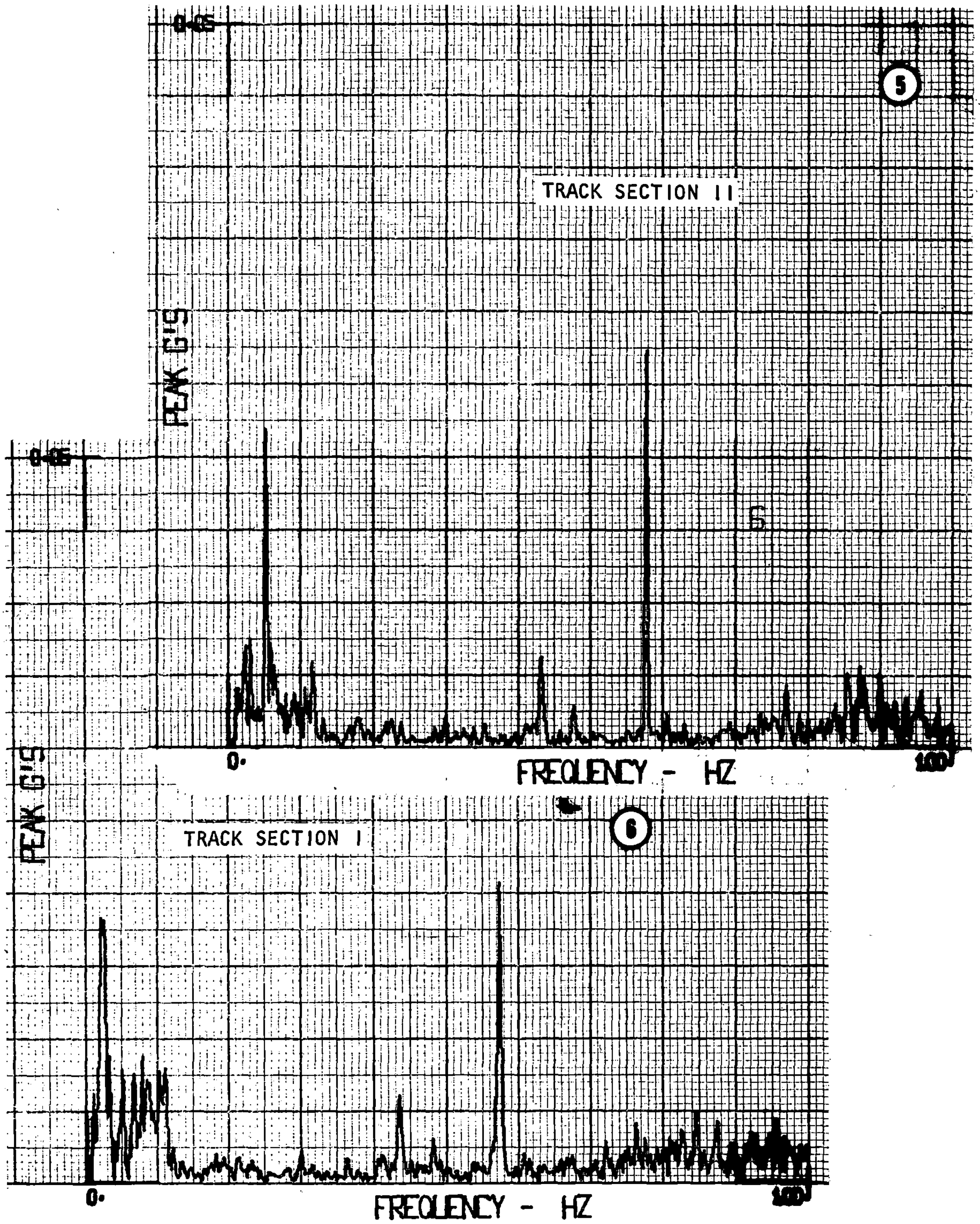


Figure 6-2. Forward Car Body Vertical Vibration - AWO (Sheet 3)

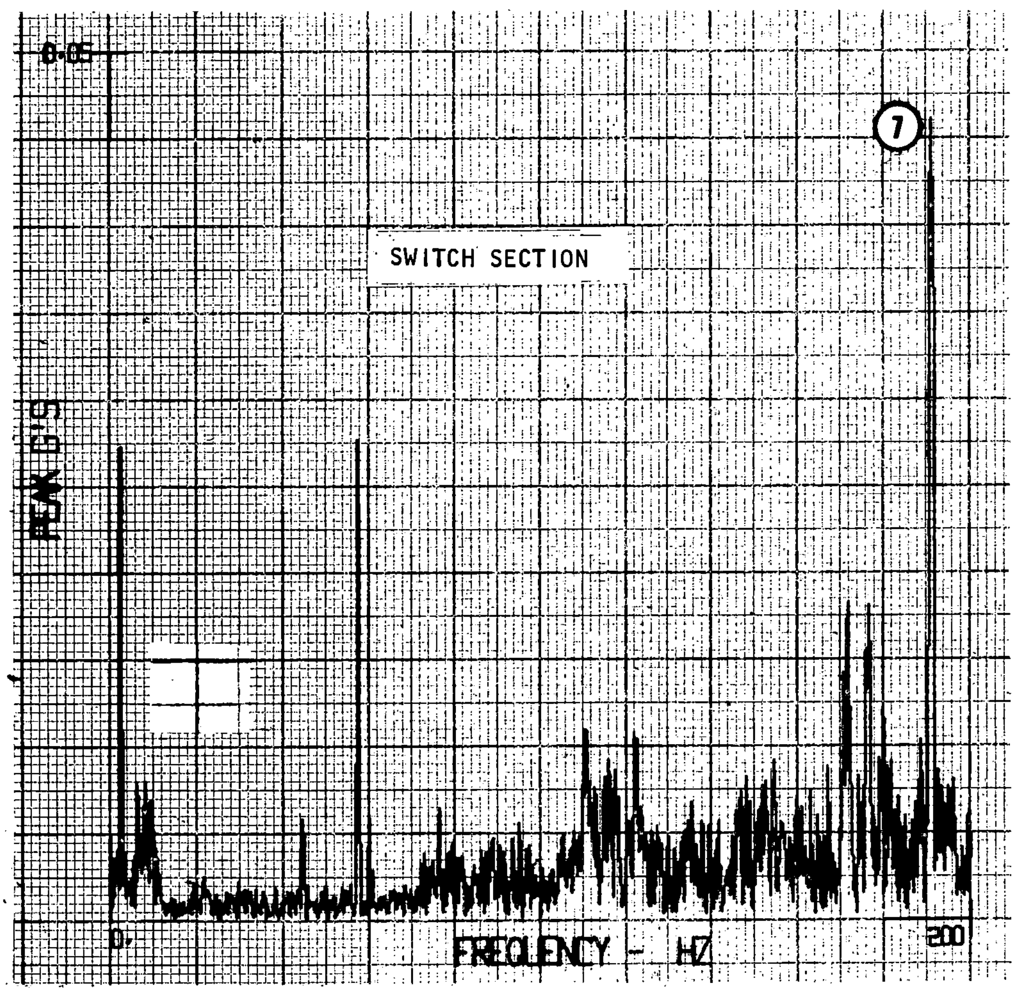


Figure 6-2. Forward Car Body Vertical Vibration - AWO (Sheet 4)

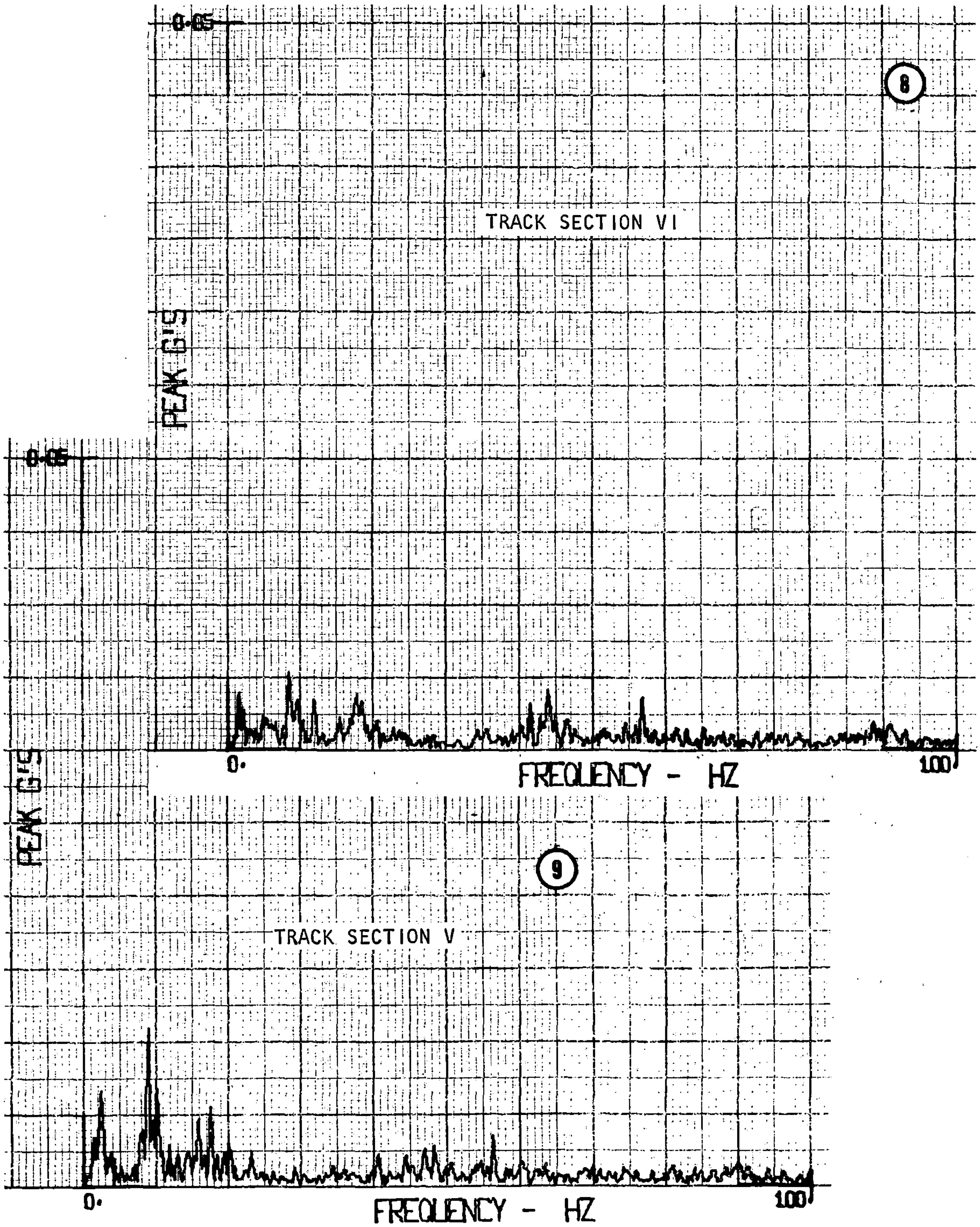


Figure 6-3. Forward Car Body Lateral Vibration - AWO (Sheet 1)

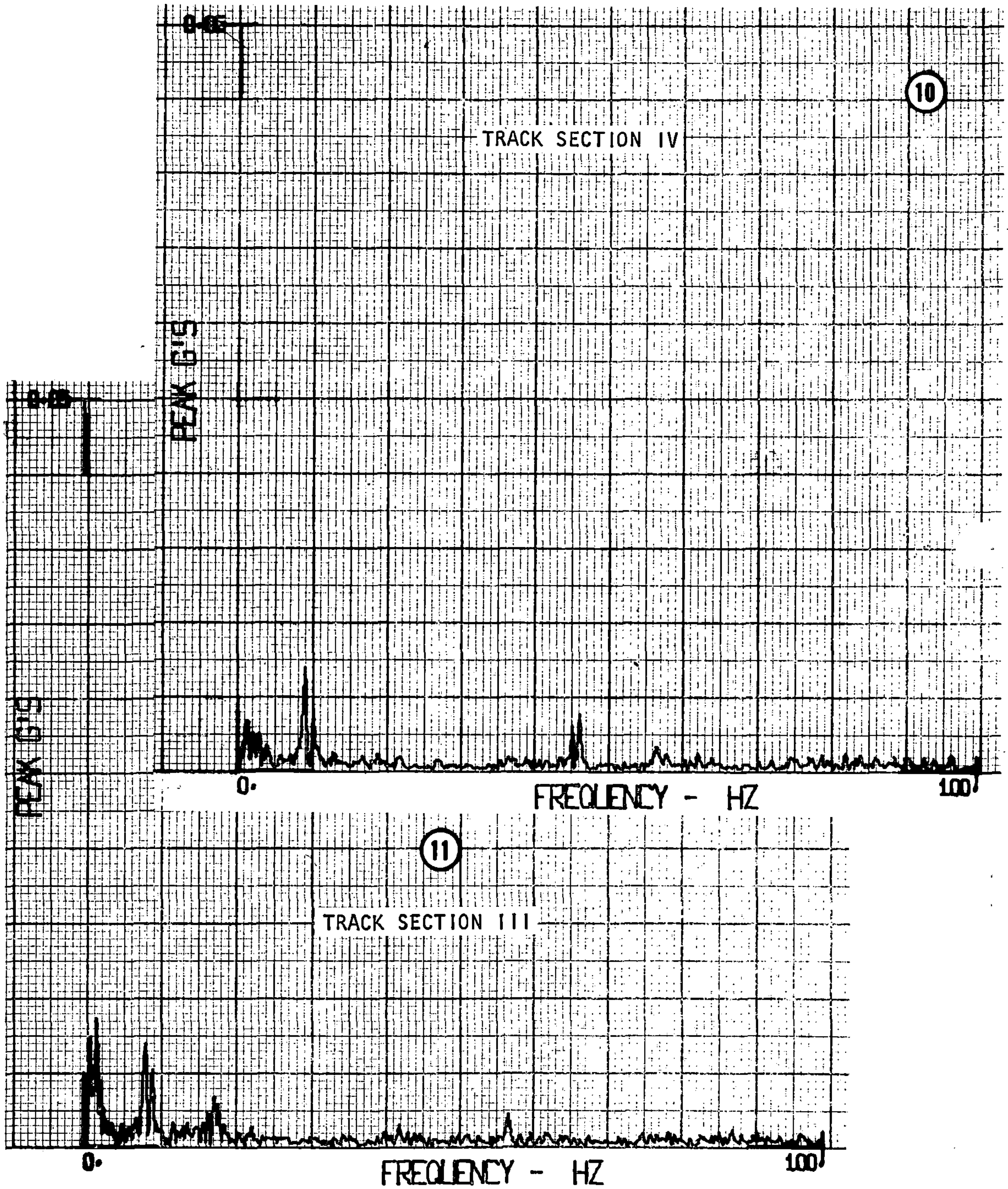


Figure 6-3. Forward Car Body Lateral Vibration - AWO (Sheet 2)

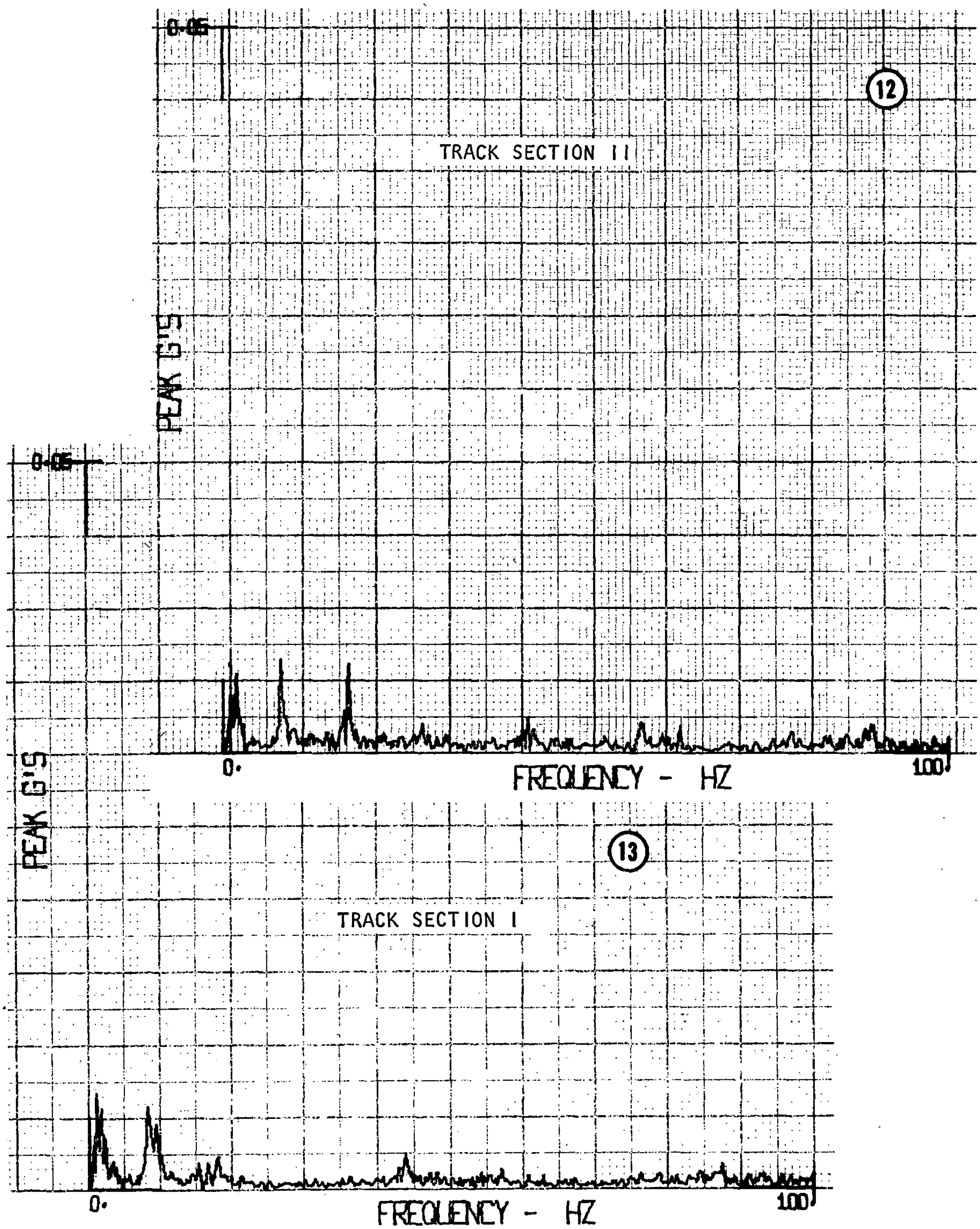


Figure 6-3. Forward Car Body Lateral Vibration - AWO (Sheet 3)

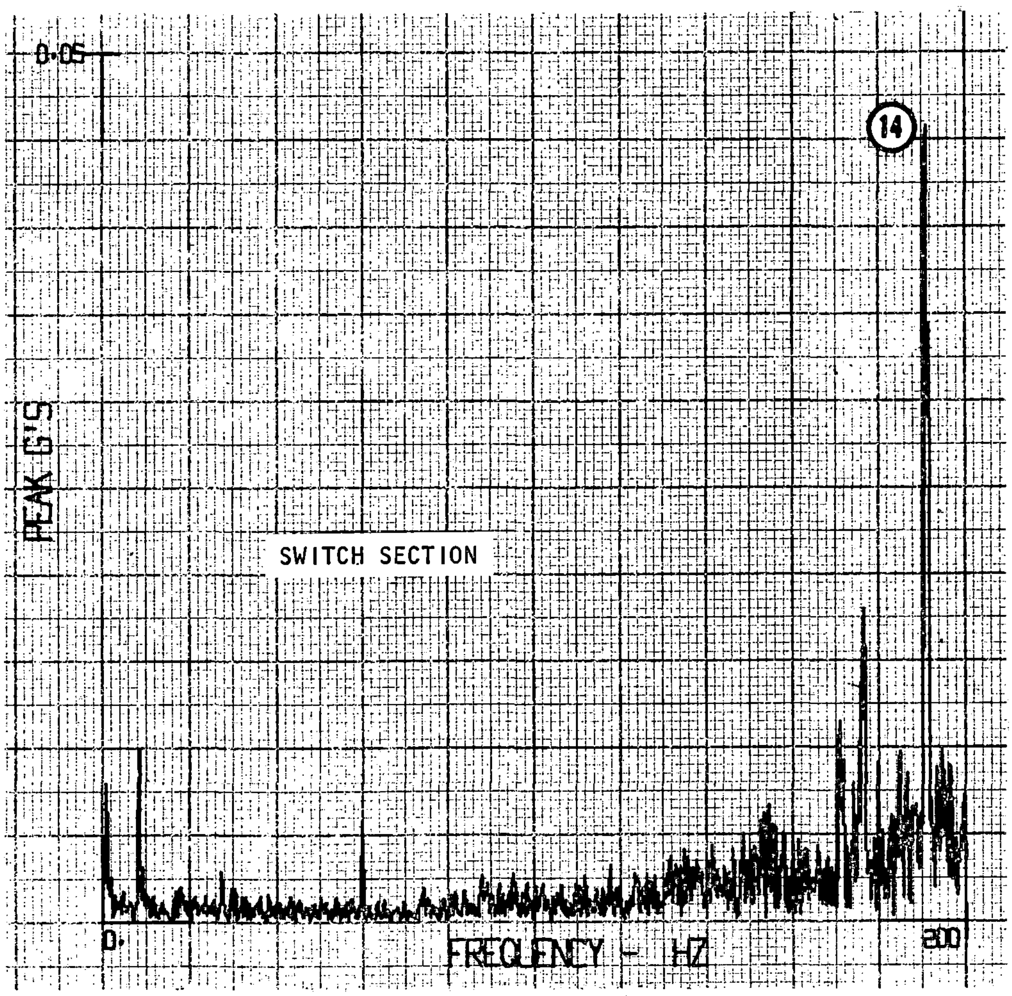


Figure 6-3. Forward Car Body Lateral Vibration - AWO (Sheet 4)

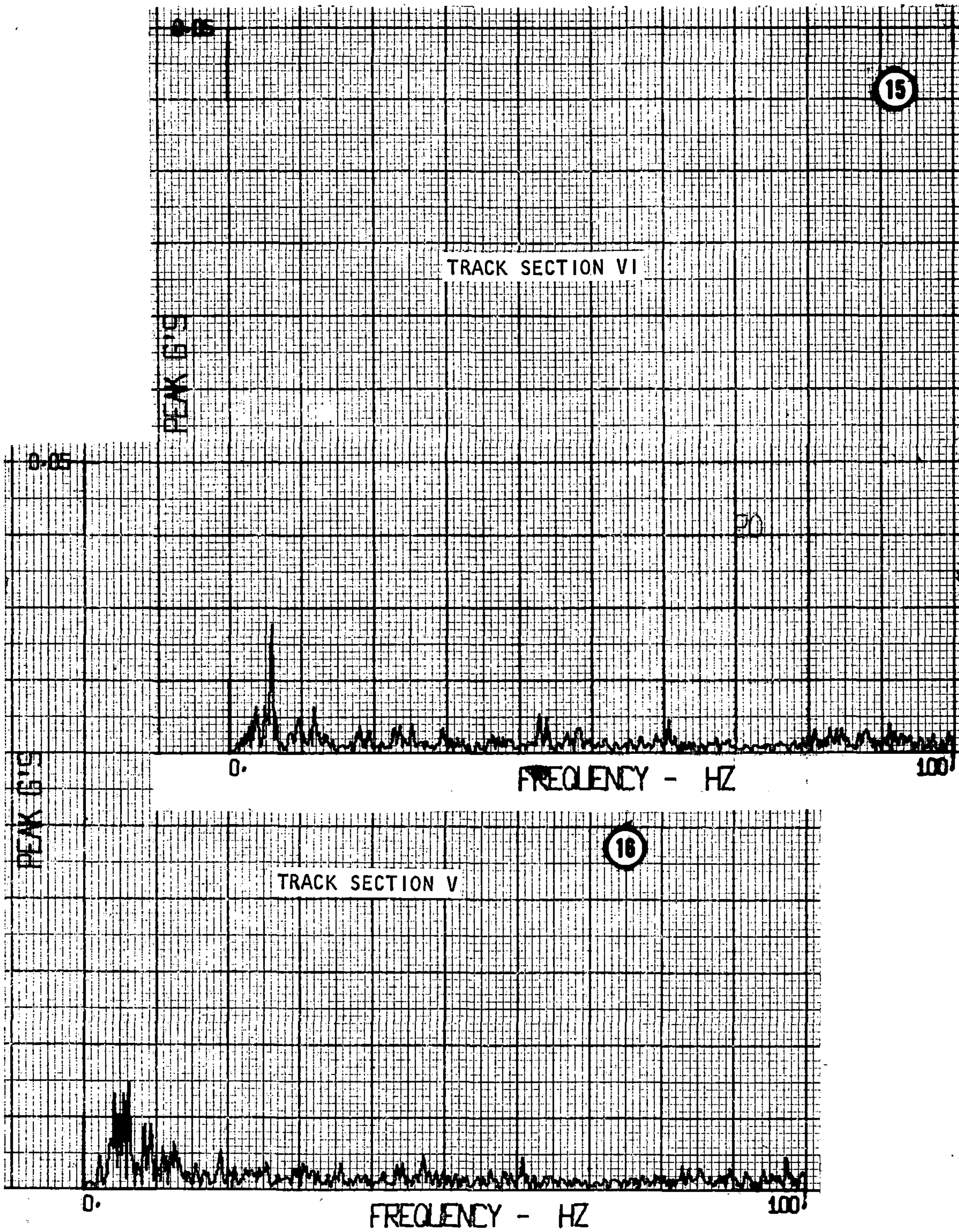


Figure 6-4. Forward Car Body Longitudinal Vibration - AWO (Sheet 1)

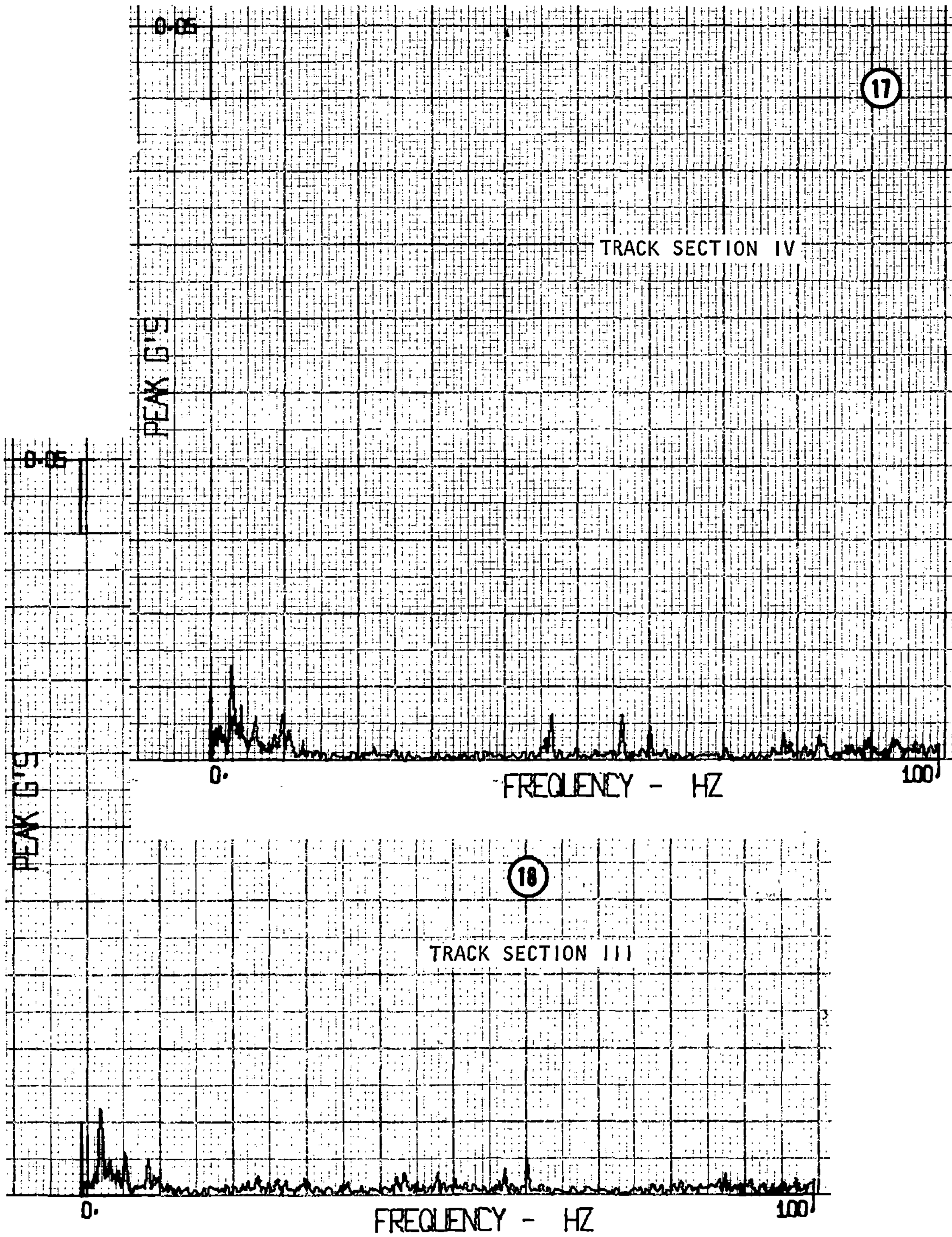


Figure 6-4. Forward Car Body Longitudinal Vibration - AWU (Sheet 2)

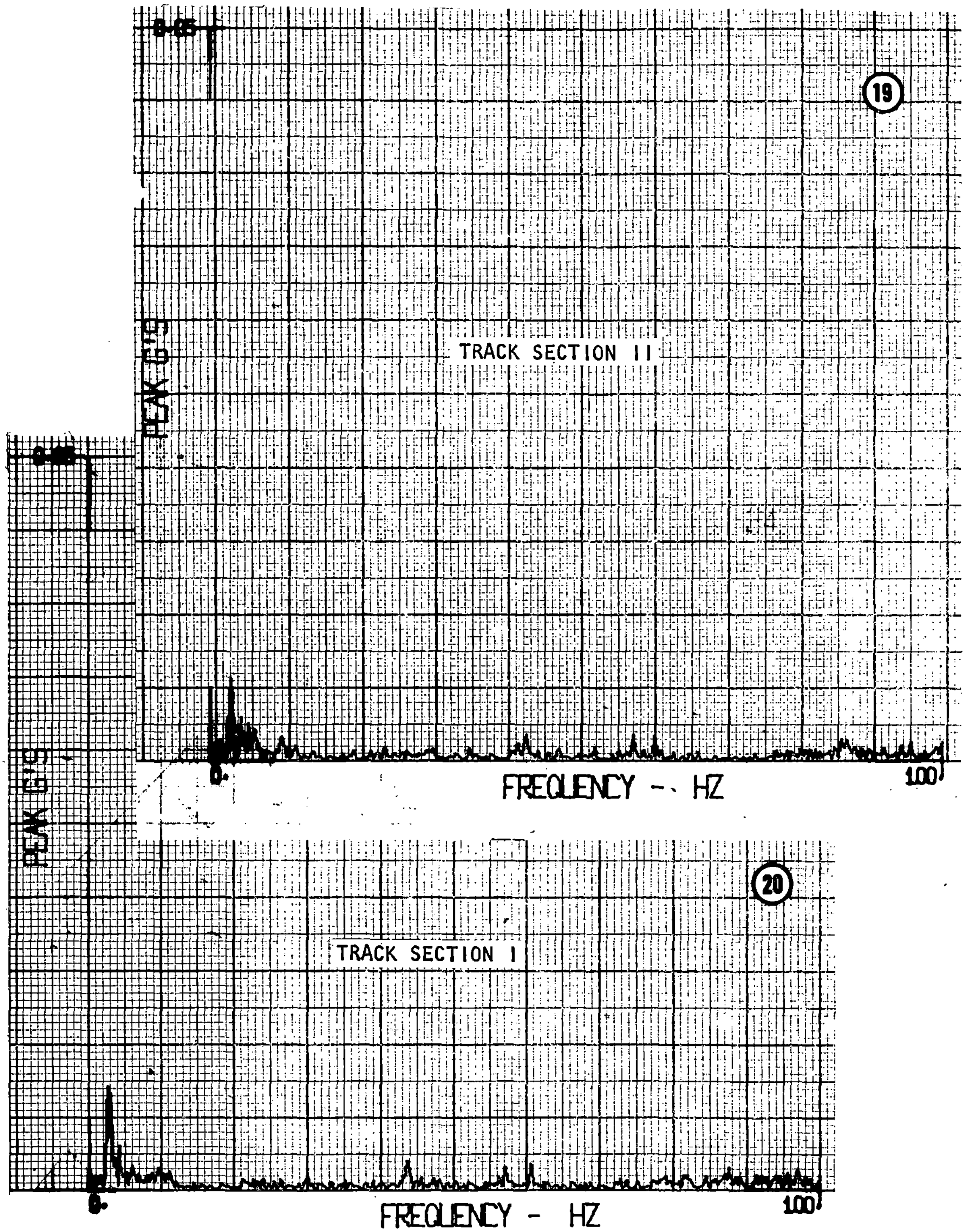


Figure 6-4. Forward Car Body Longitudinal Vibration - AWO (Sheet 3)

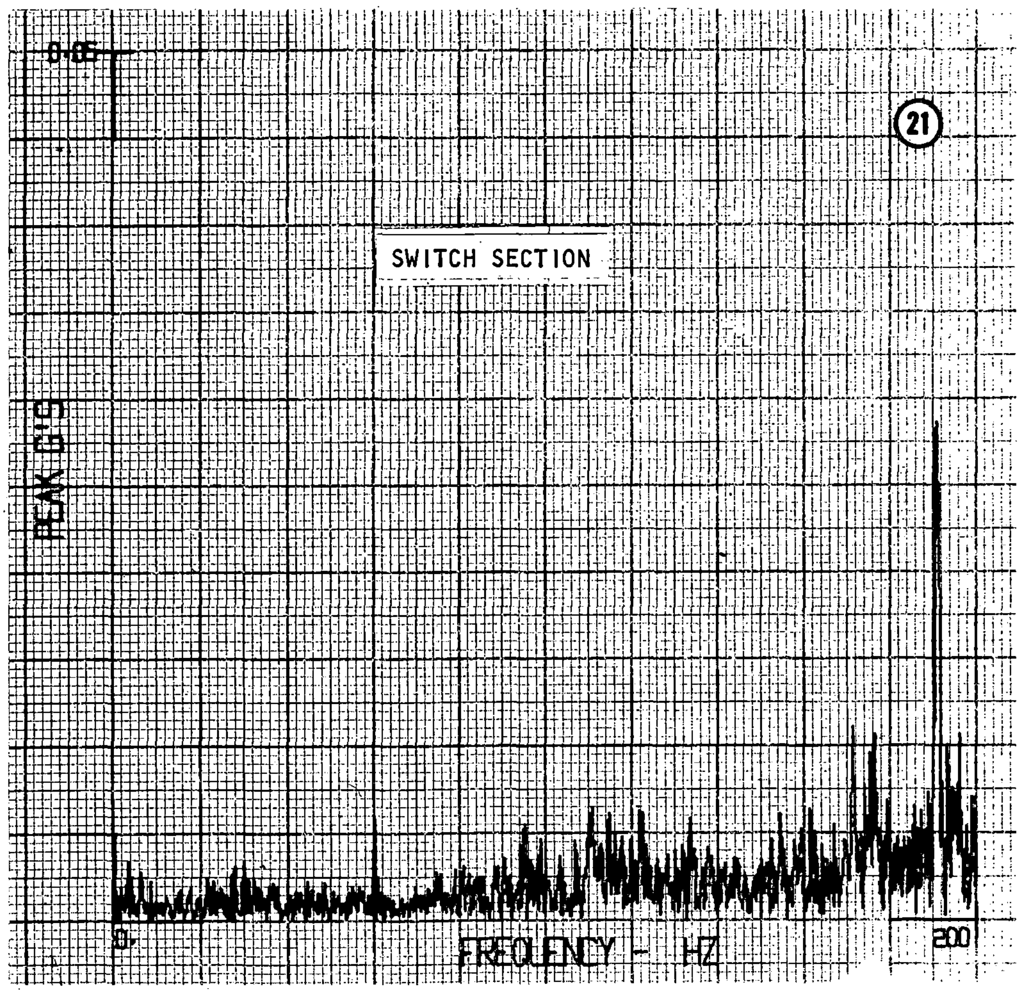


Figure 6-4. Forward Car Body Longitudinal Vibration - AWO (Sheet 4)

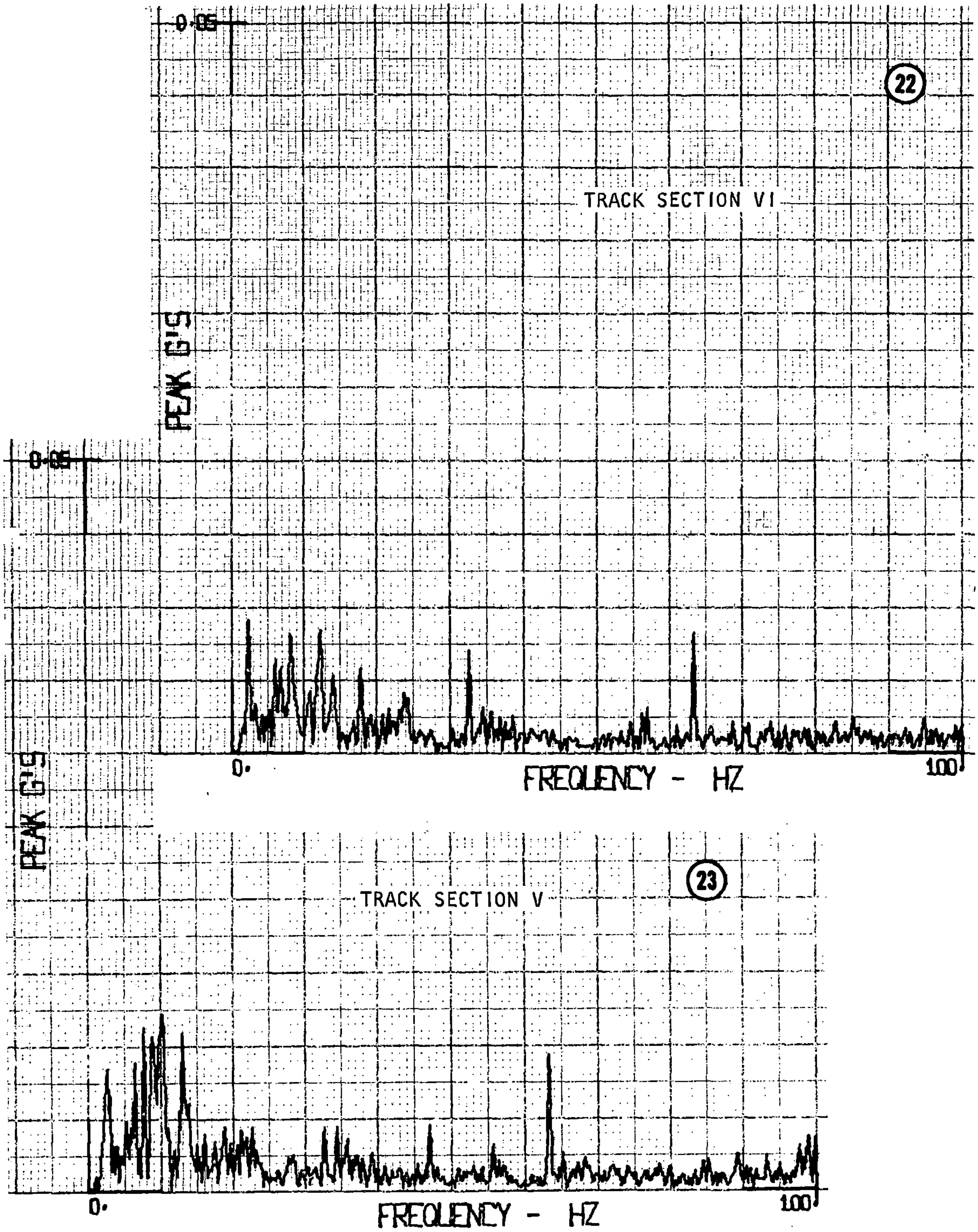


Figure 6-5. Mid Car Body Vertical Vibration - AWO (Sheet 1)

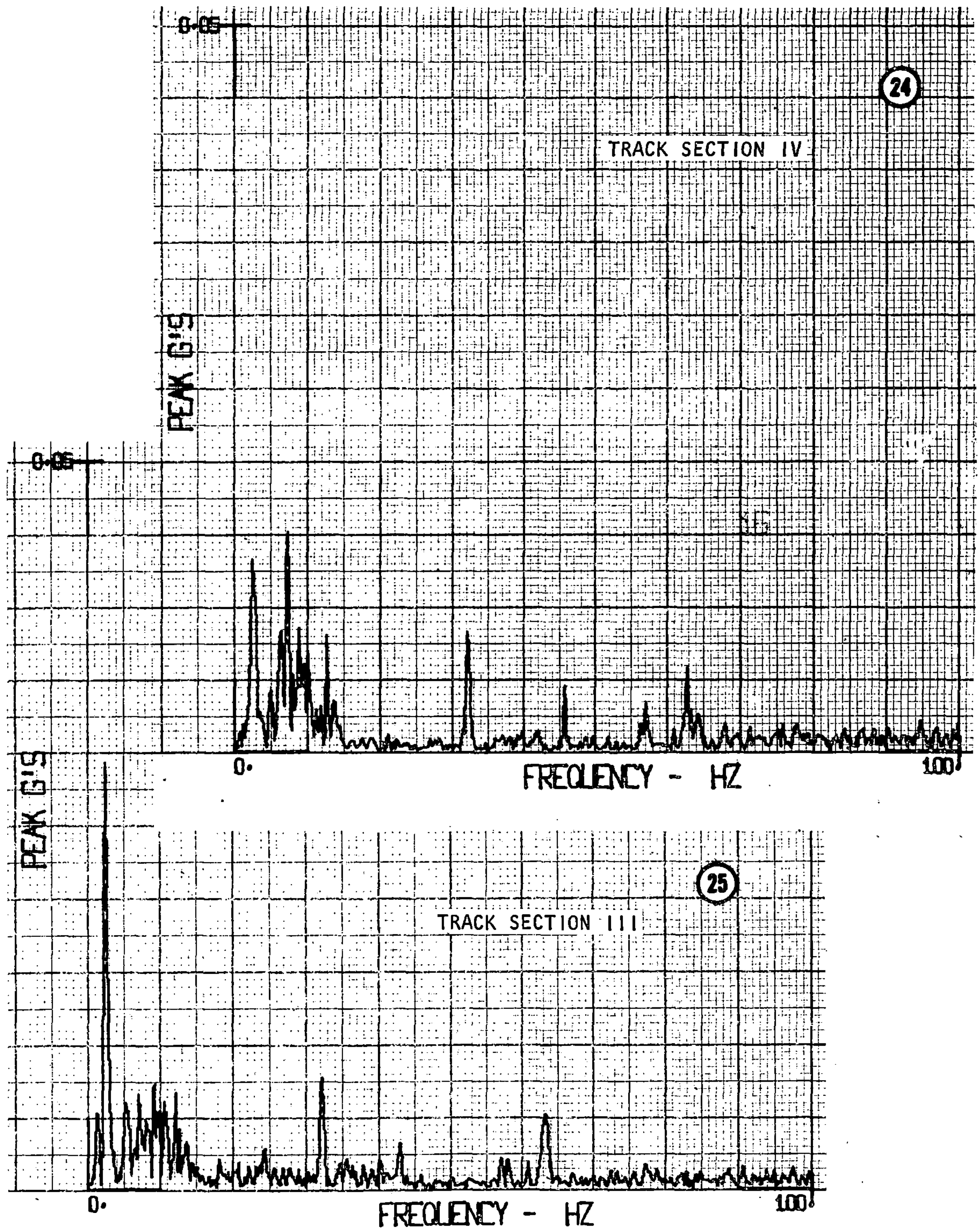


Figure 6-5. Mid Car Body Vertical Vibration - AWO (Sheet 2)

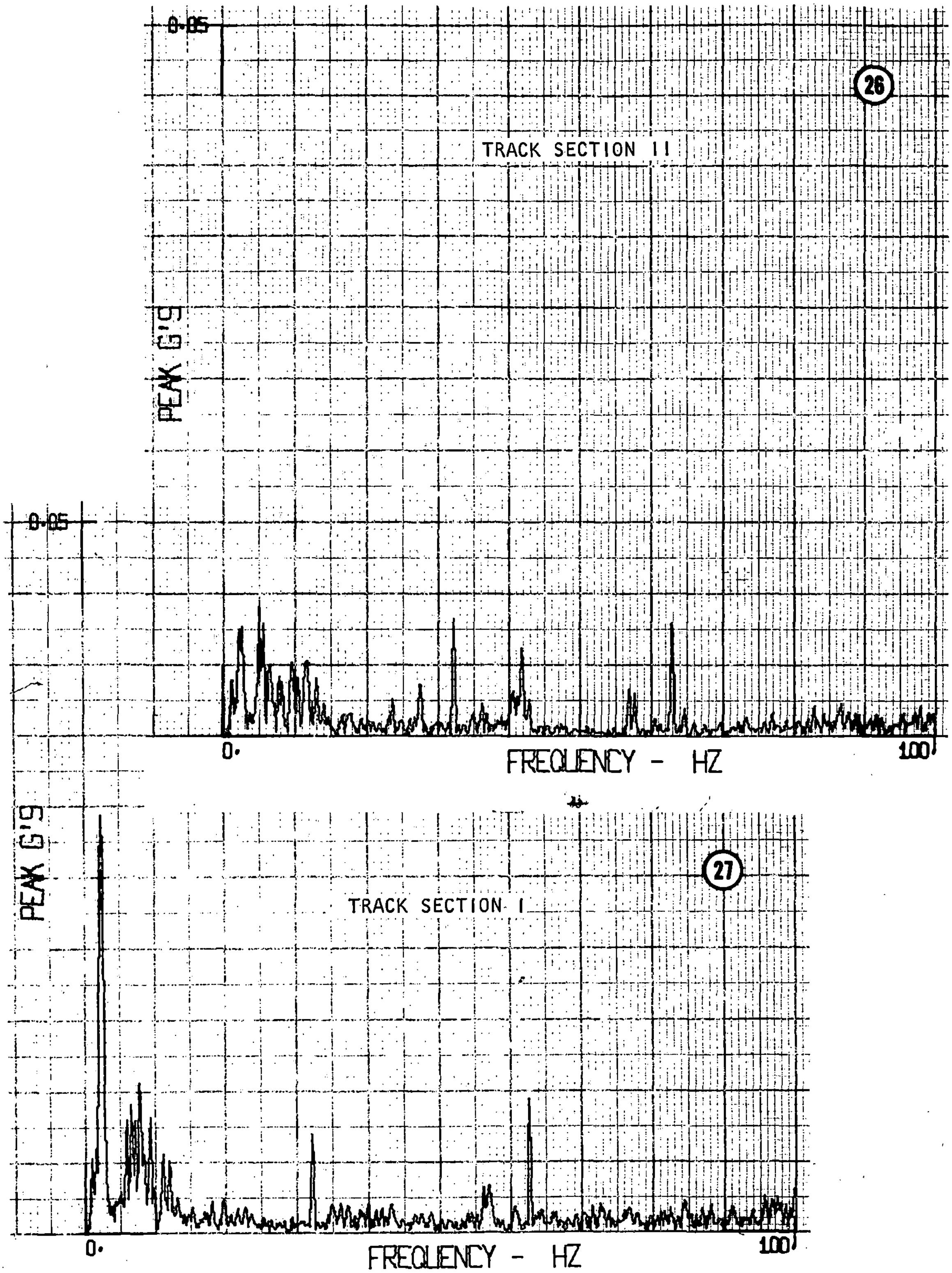


Figure 6-5. Mid Car Body Vertical Vibration - AWO (Sheet 3)

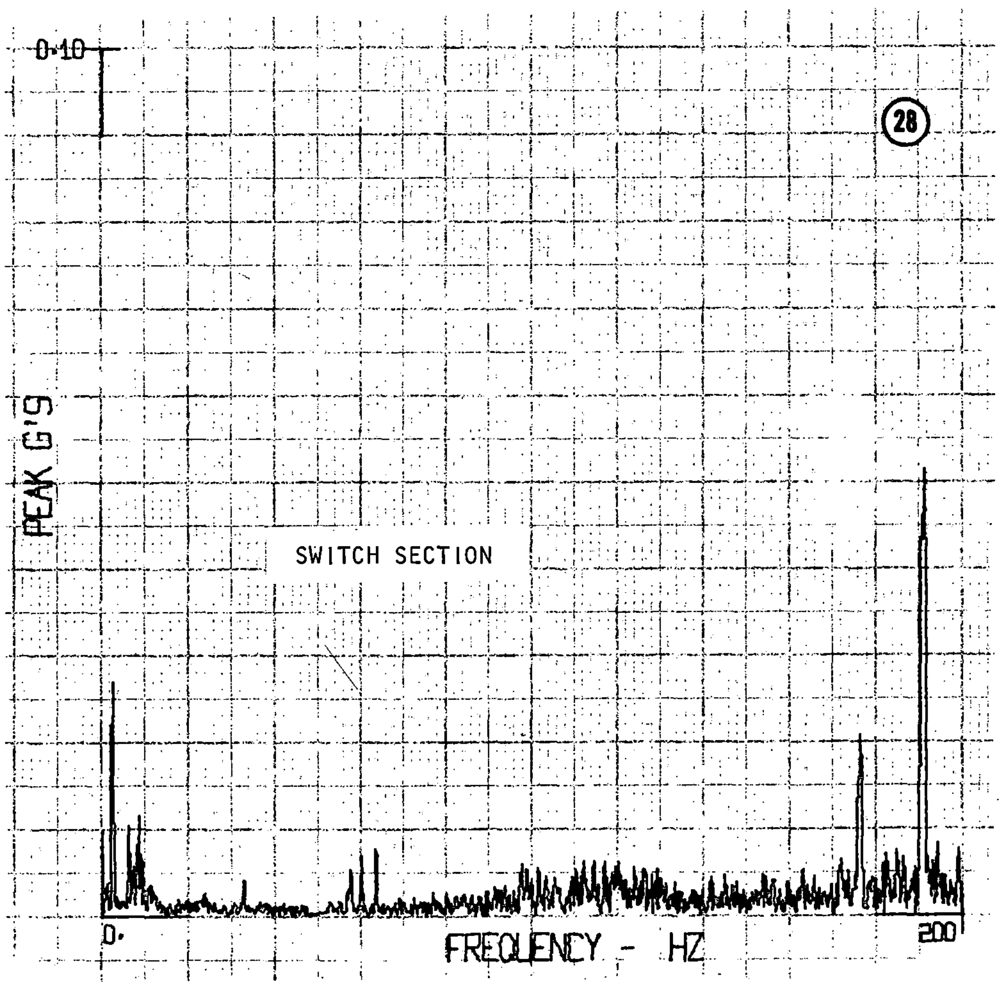


Figure 6-5. Mid Car Body Vertical Vibration - AWO (Sheet 4)

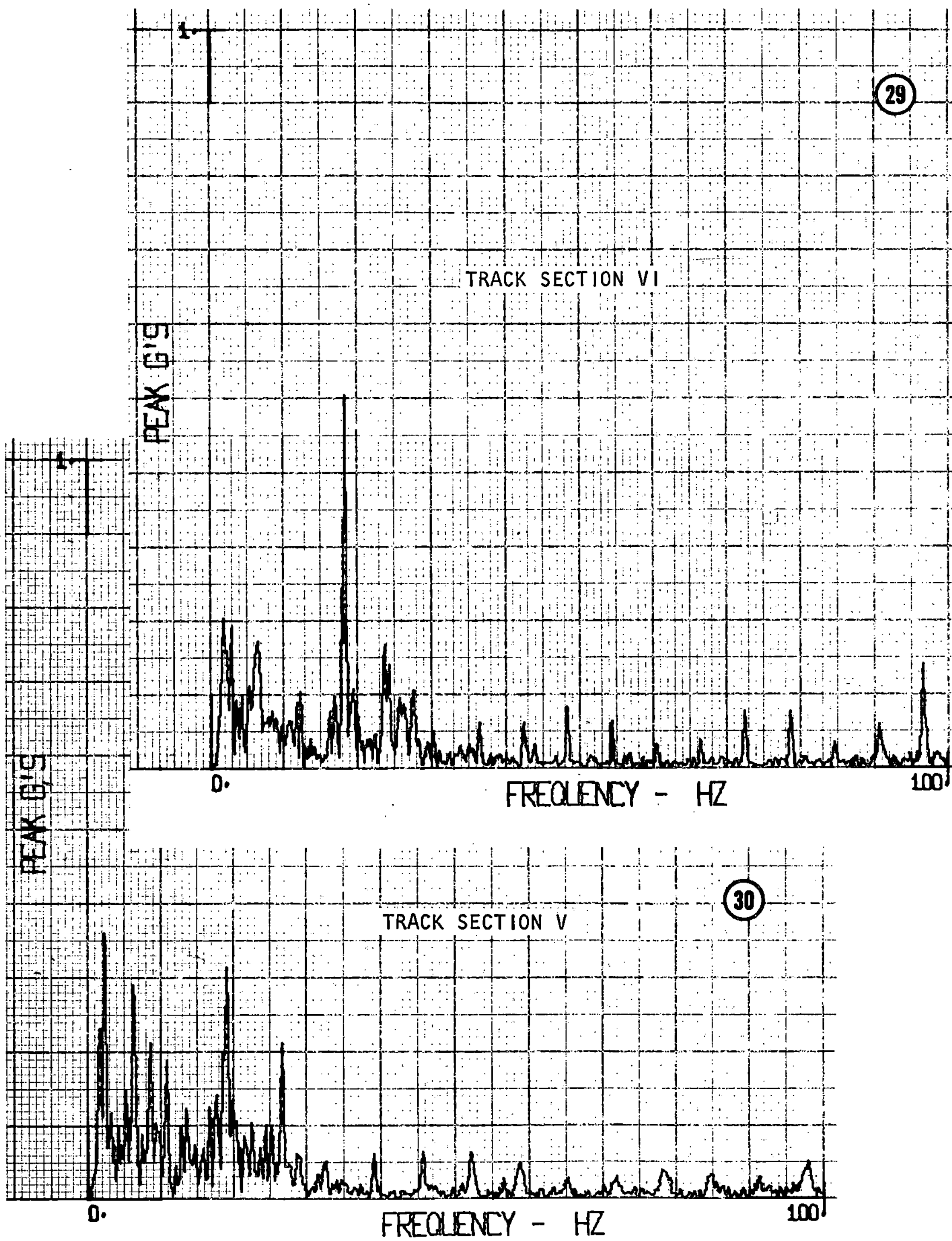


Figure 6-6. Lead Axle Vertical Vibration - AWO (Sheet 1)

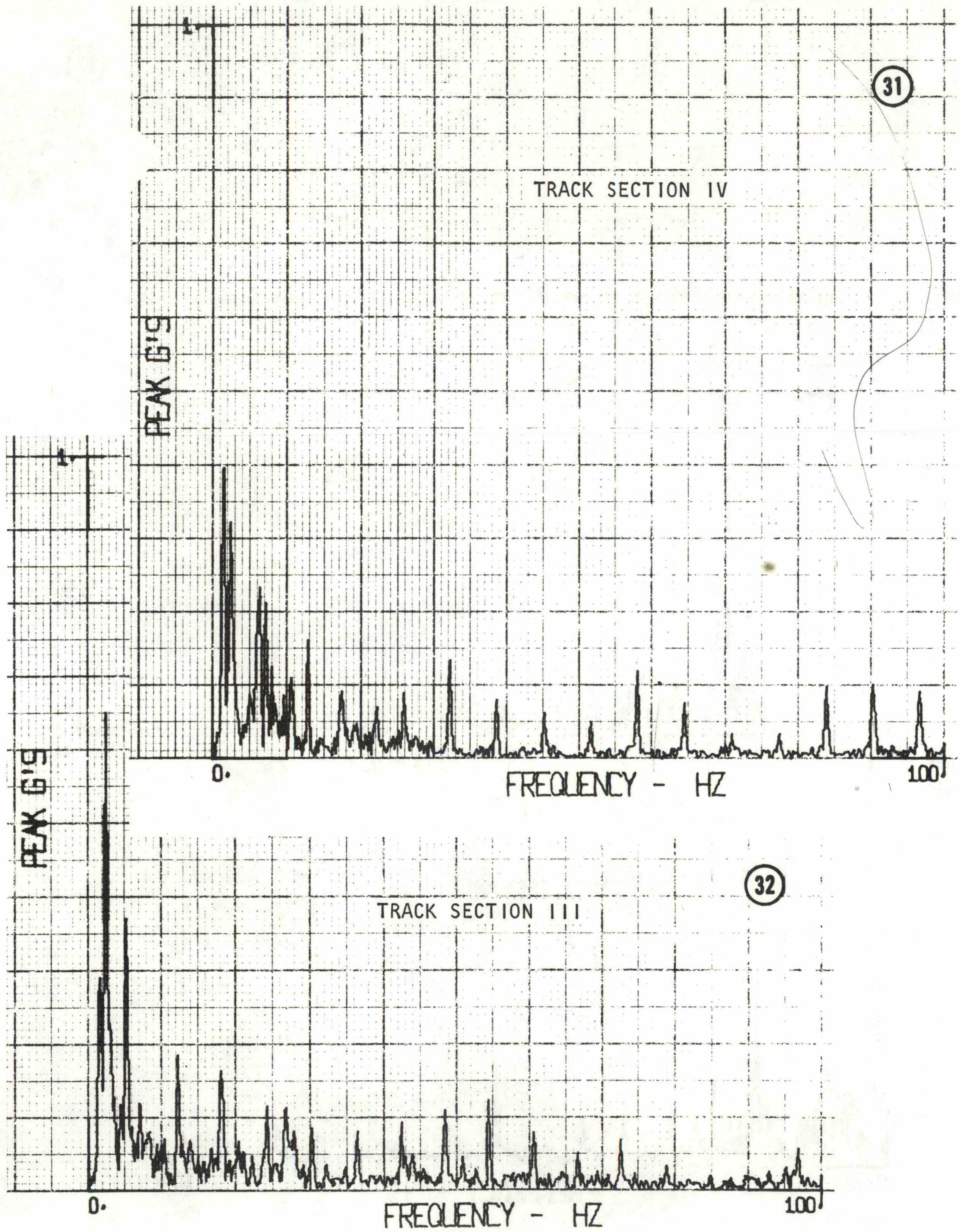


Figure 6-6. Lead Axle Vertical Vibration - AWO (Sheet 2)

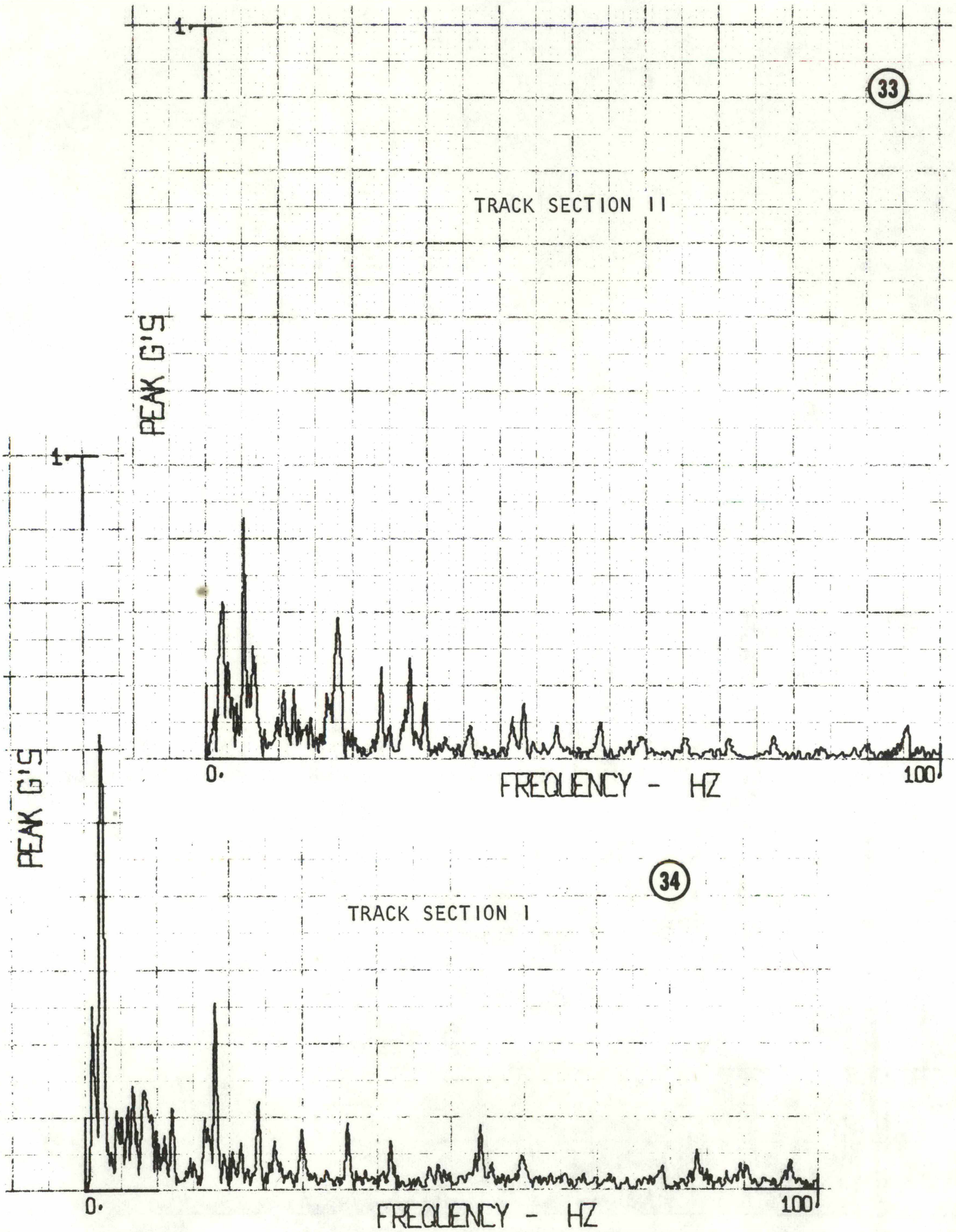


Figure 6-6. Lead Axle Vertical Vibration - AWO (Sheet 3)

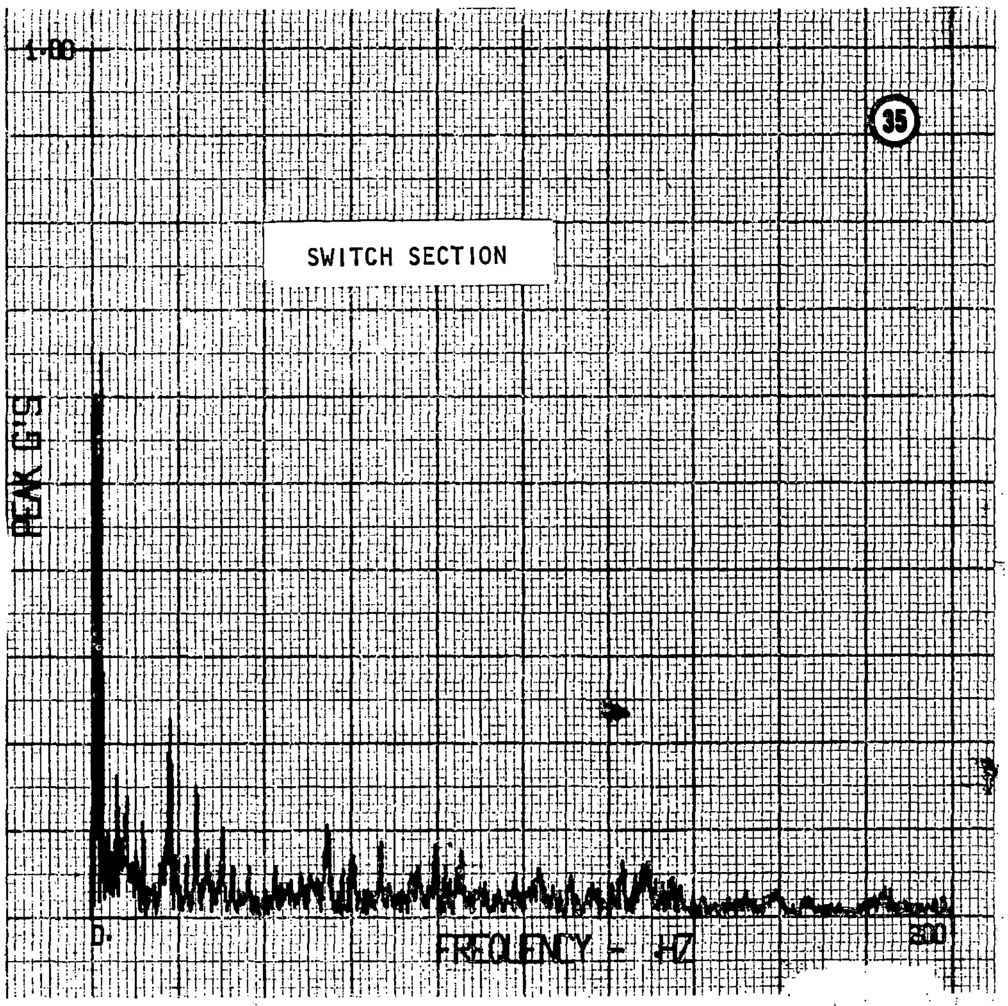


Figure 6-6. Lead Axle Vertical Vibration - AWO (Sheet 4)

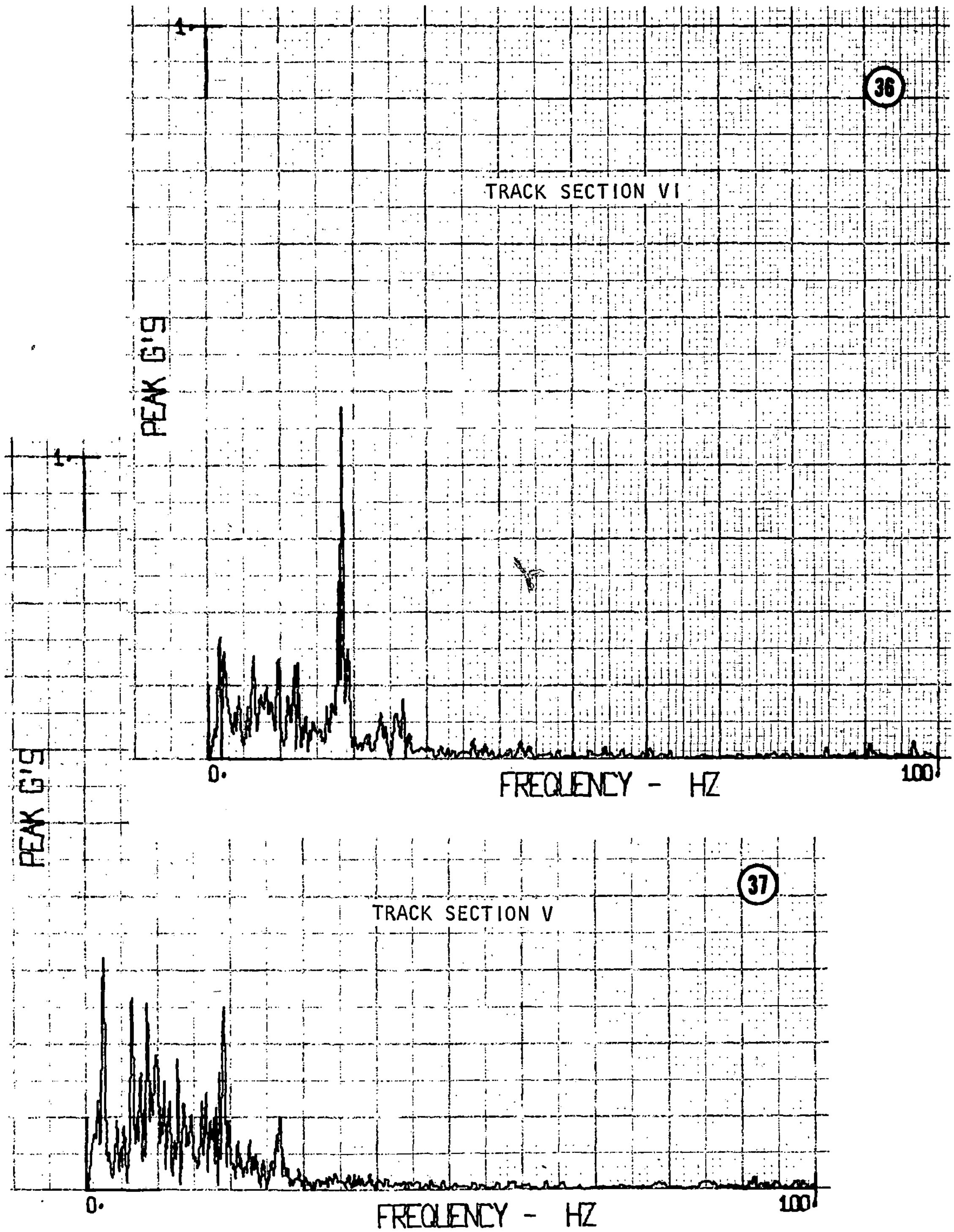
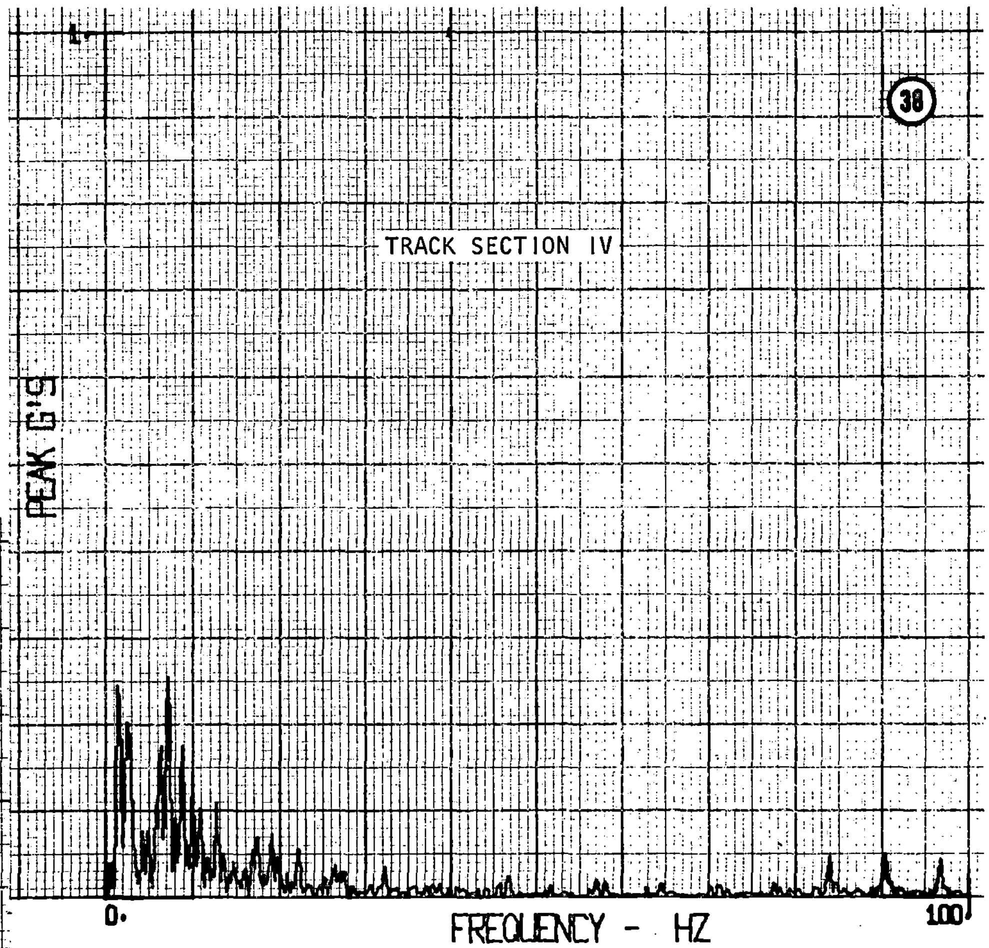


Figure 6-7. Lead Axle Lateral Vibration - AWO (Sheet 1)



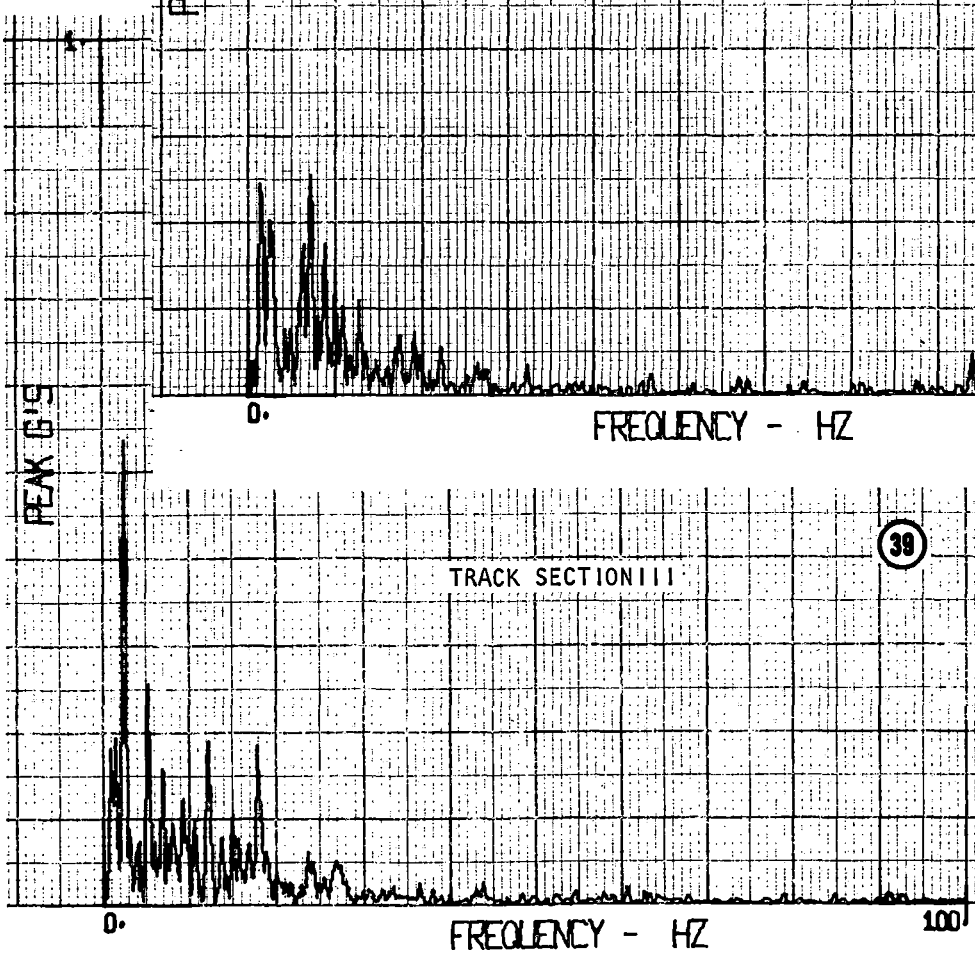


Figure 6-7. Lead Axle Lateral Vibration - AWO (Sheet 2)

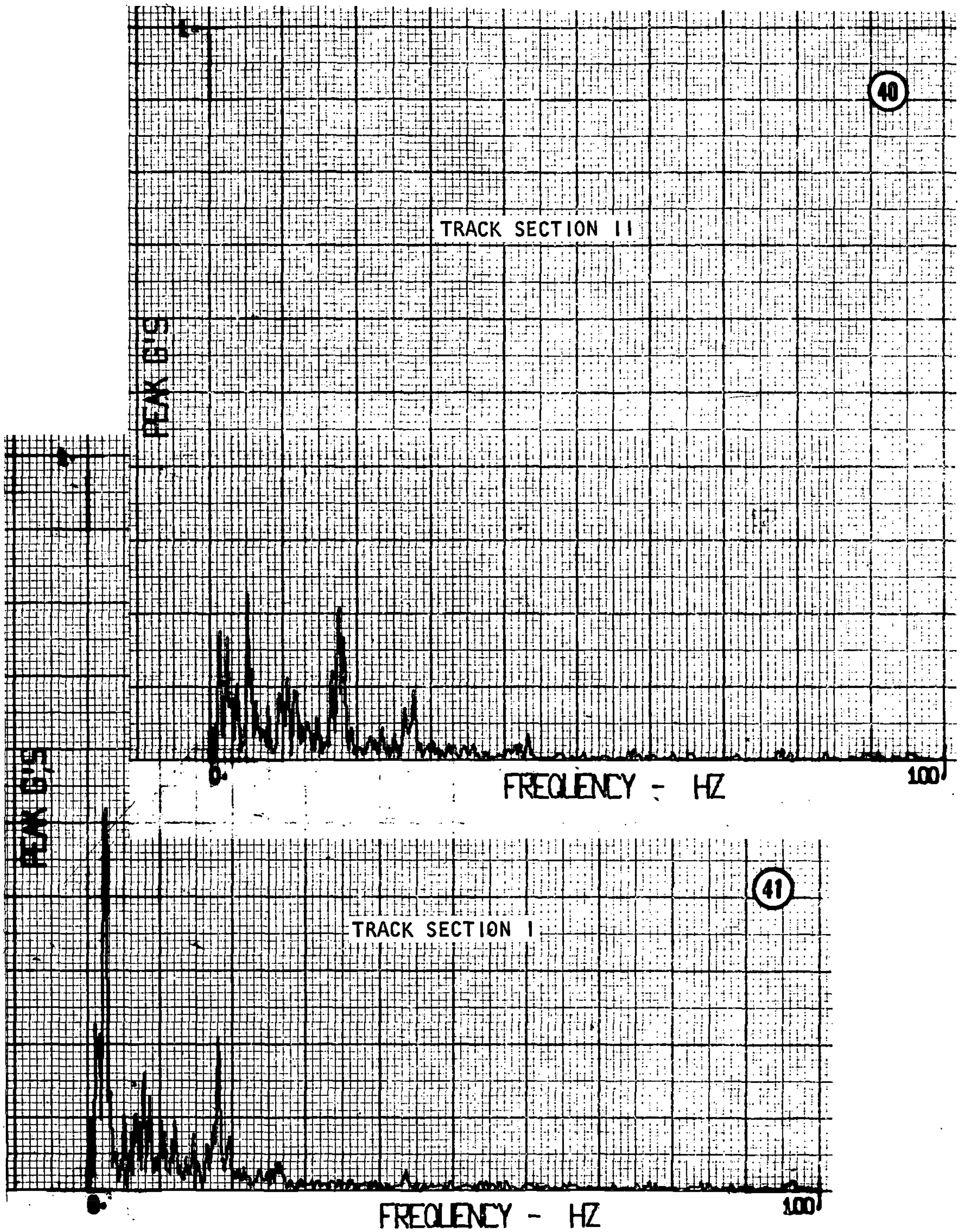


Figure 6-7. Lead Axle Lateral Vibration - AWO (Sheet 3)

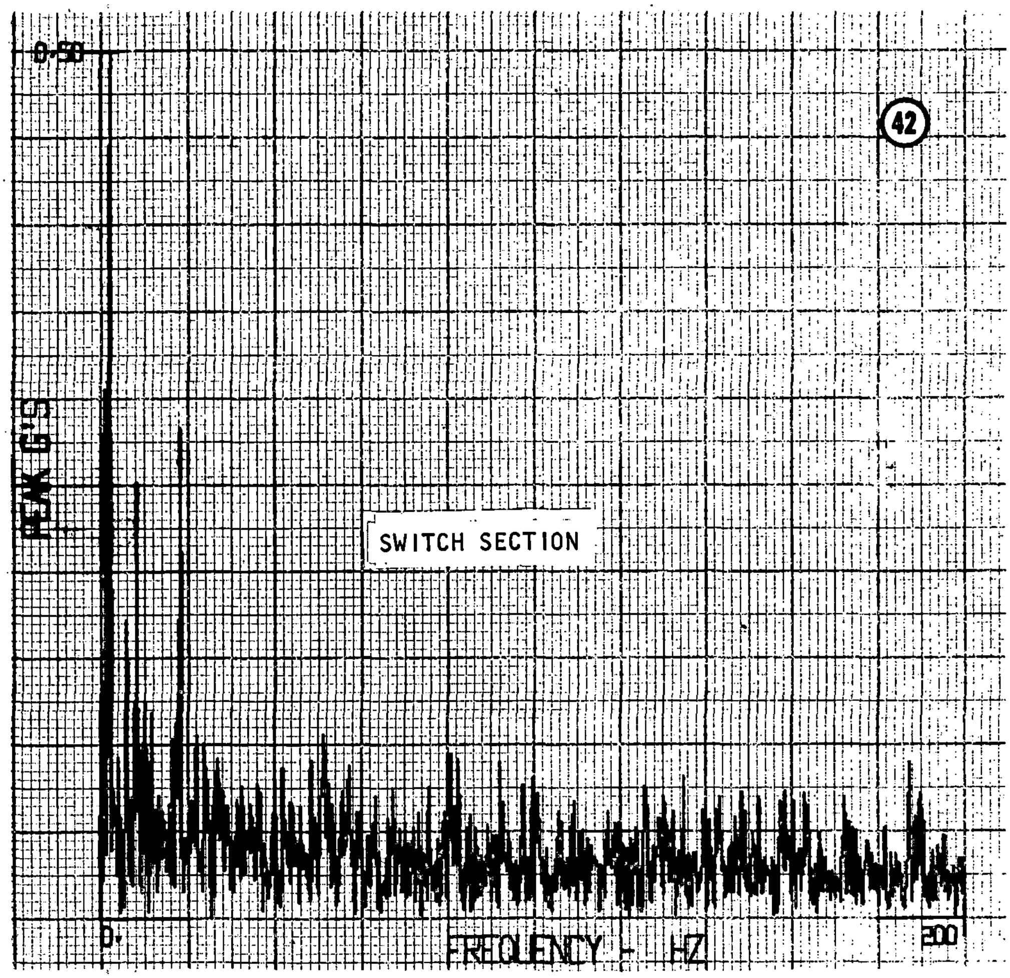


Figure 6-7. Lead Axle Lateral Vibration - AWO (Sheet 4)

The results of the AW2 car weight worst speed tests are shown in amplitude versus frequency plots, figures 6-8 through 6-13. The plots are grouped in sets of responses for each track section according to the location and type of sensor listed in table 6-3. Each plot is identified by a label stating the track section and a reference number (circled number on plot) keyed to the table.

Table 6-3. AW2 Worst Speed Plot Index

Figure Number	Sensor Location and Type	Track Section and Plot Reference Numbers						
		VI	V	IV	III	II	I	Switch Section
6-8	Forward Car Body - Vertical	43	44	45	46	47	48	49
6-9	Forward Car Body - Lateral	50	51	52	53	54	55	56
6-10	Forward Car Body - Longitudinal	57	58	59	60	61	62	63
6-11	Mid Car Body - Vertical	64	65	66	67	68	69	70
6-12	Lead Axle - Vertical	71	72	73	74	75	76	77
6-13	Lead Axle - Lateral	78	79	80	81	82	83	84

NOTES: Car speed, 35 mph for all tests
Car body sensors, ±5.0 vdc = ±0.5 G
Axle sensors, ±5.0 vdc = ±3.0 G

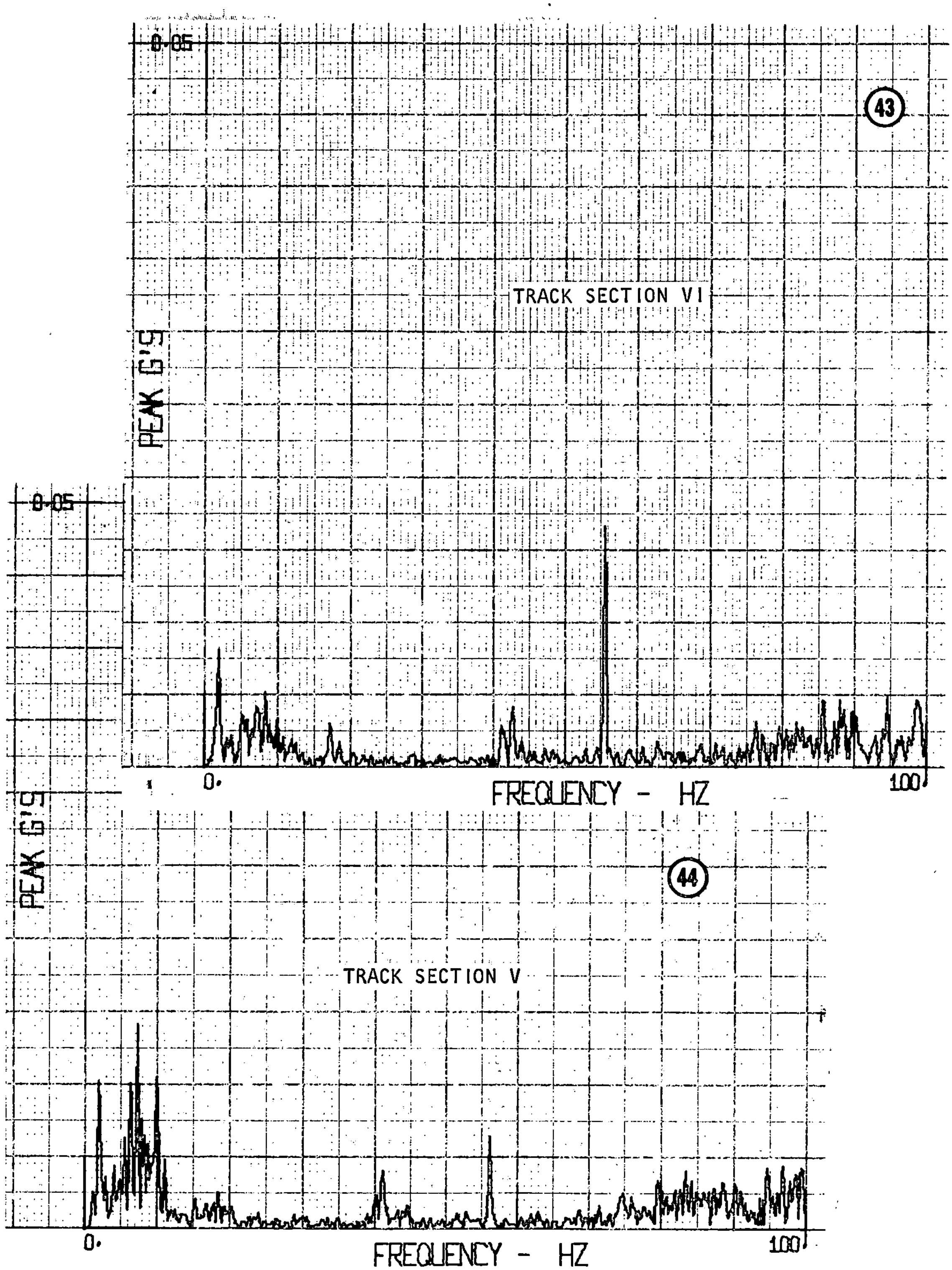


Figure 6-8. Forward Car Body Vertical Vibration - AW2 (Sheet 1)

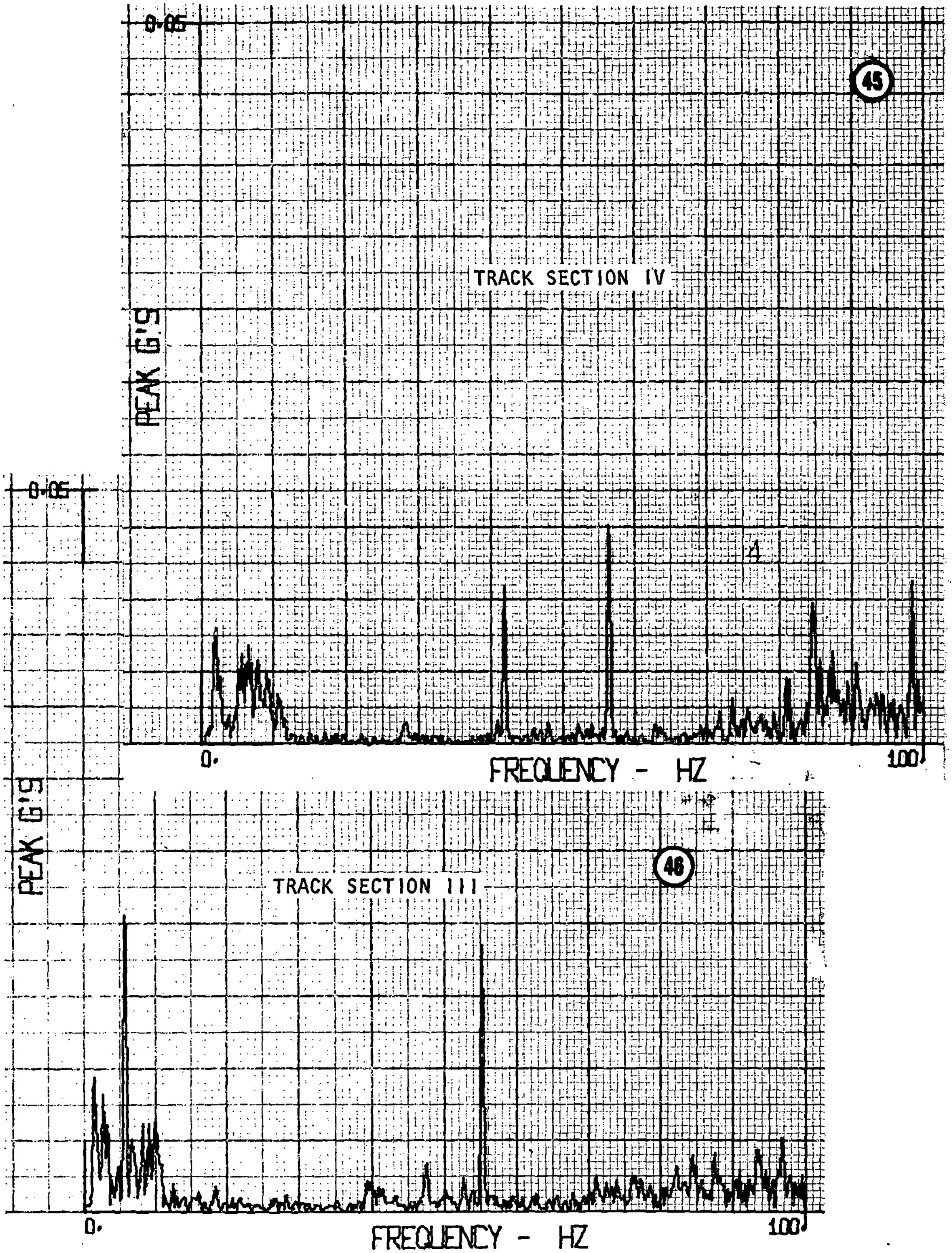


Figure 6-8. Forward Car Body Vertical Vibration - AW2 (Sheet 2)

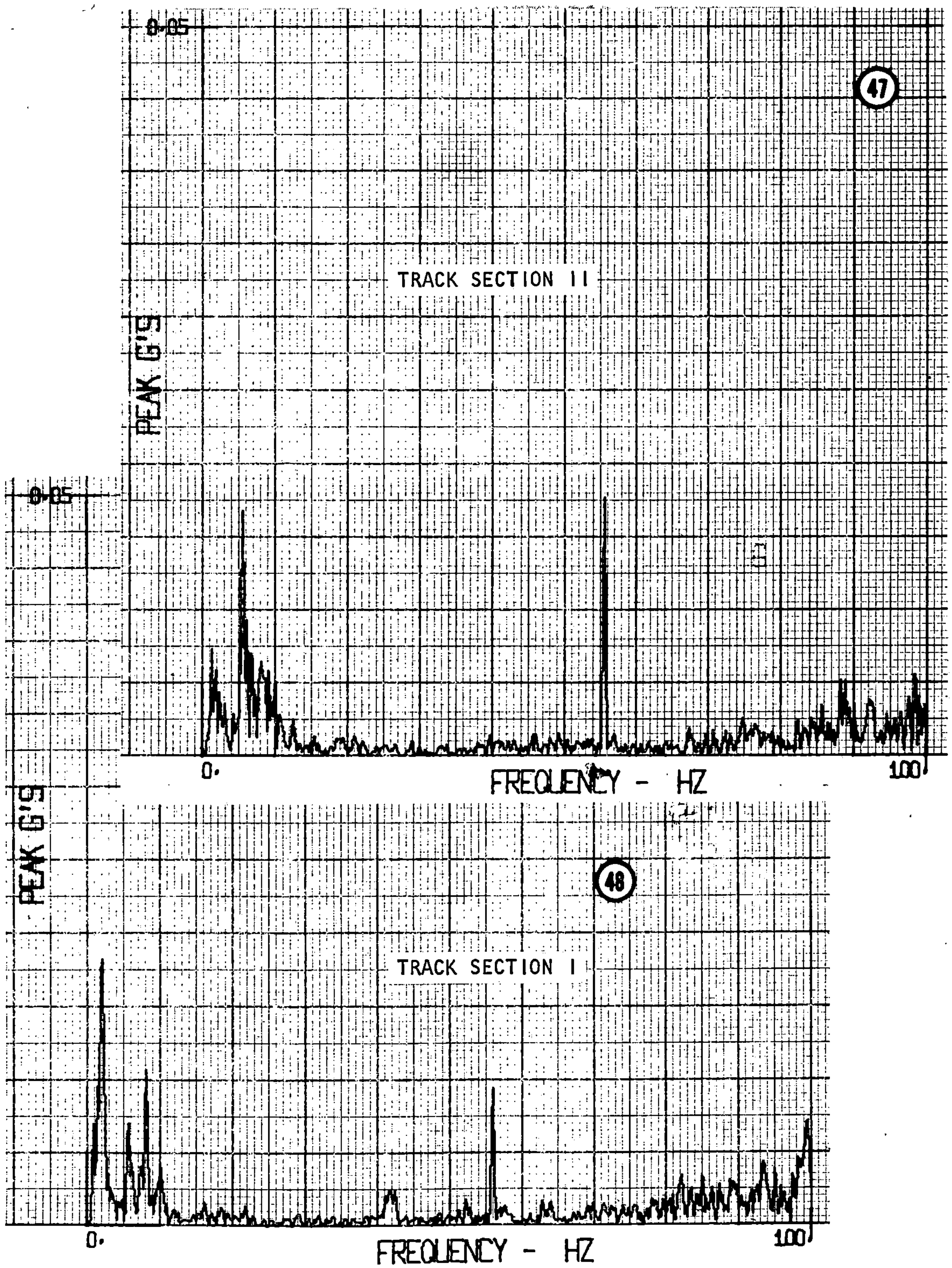


Figure 6-8. Forward Car Body Vertical Vibration - AW2 (Sheet 3)

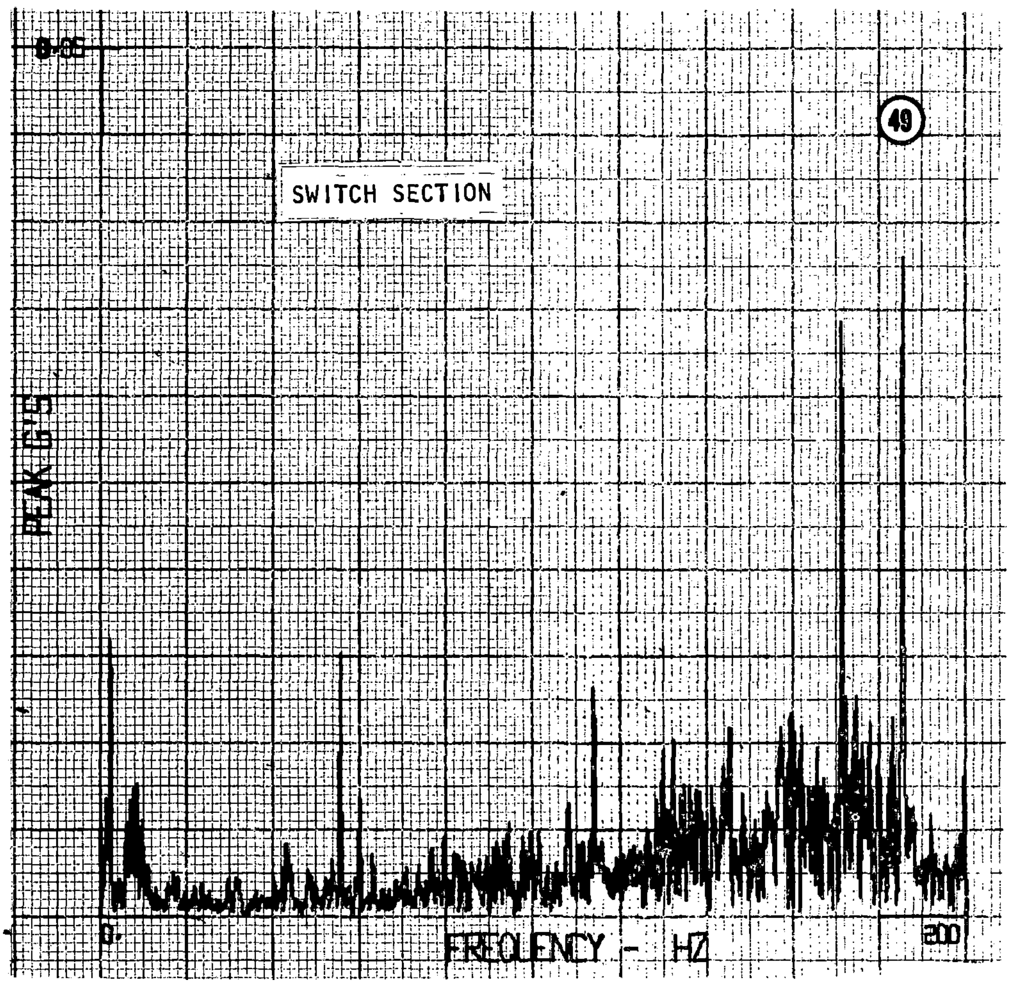


Figure 6-8. Forward Car Body Vertical Vibration - AW2 (Sheet 4)

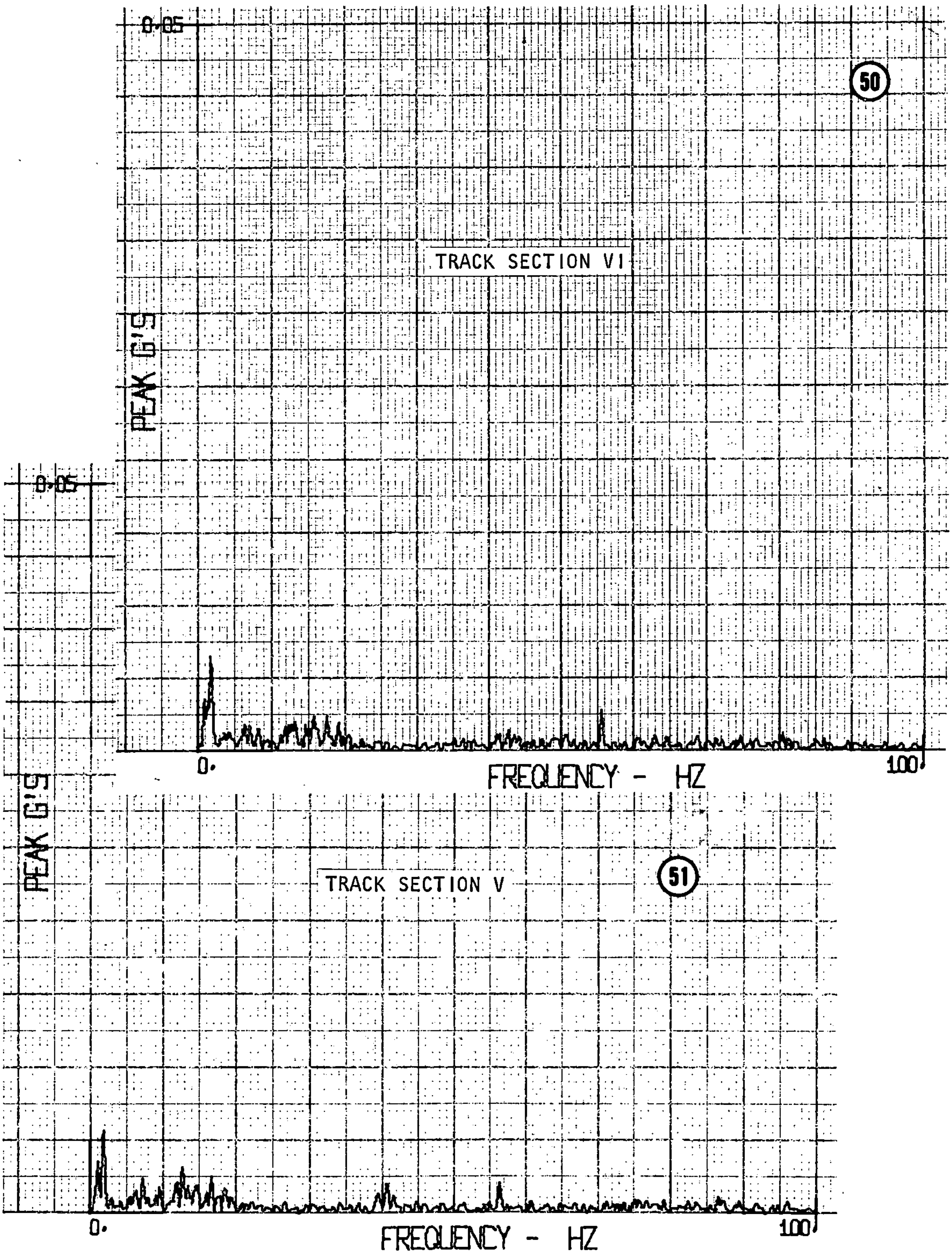


Figure 6-9. Forward Car Body Lateral Vibration - AW2 (Sheet 1)

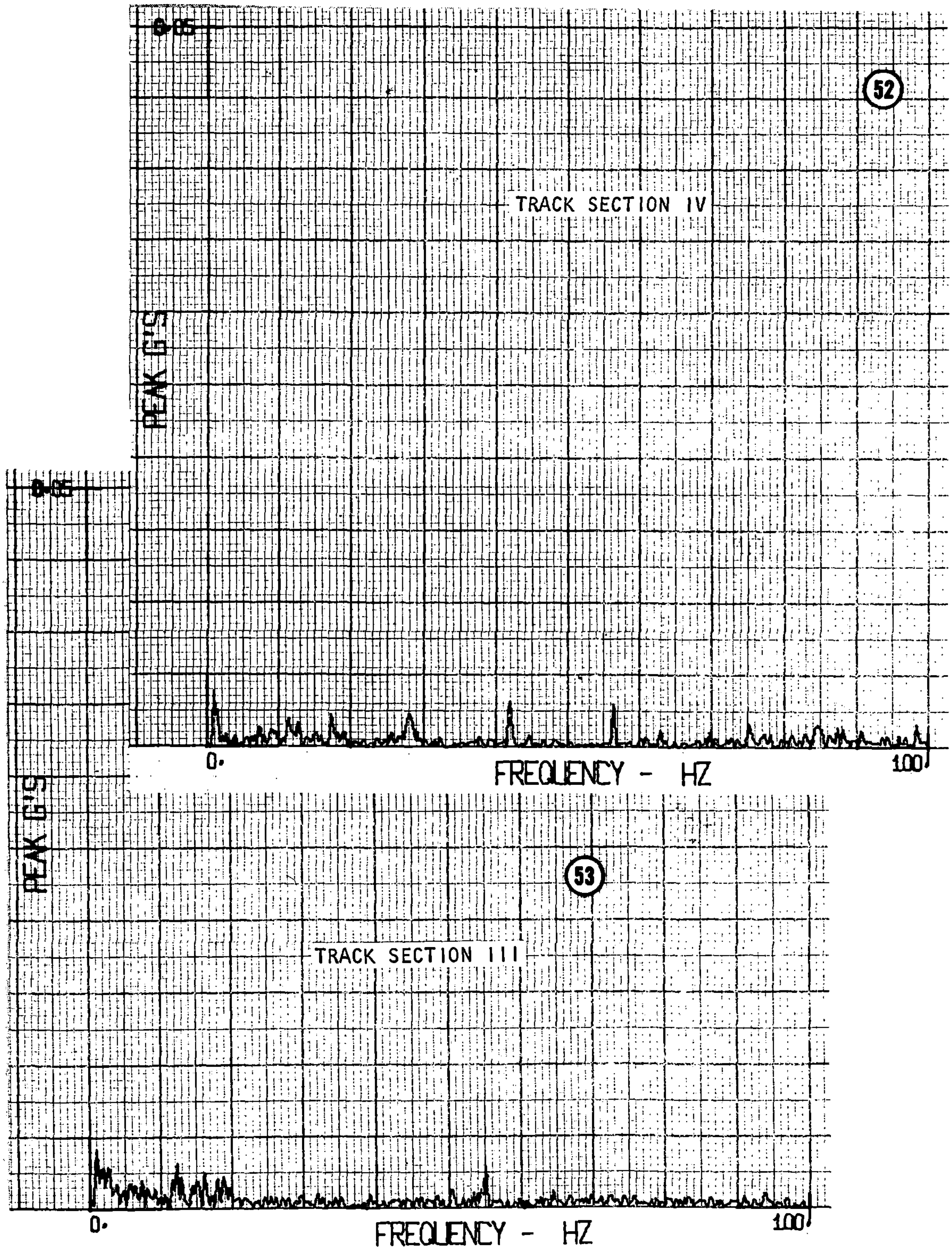


Figure 6-9. Forward Car Body Lateral Vibration - AW2 (Sheet 2)

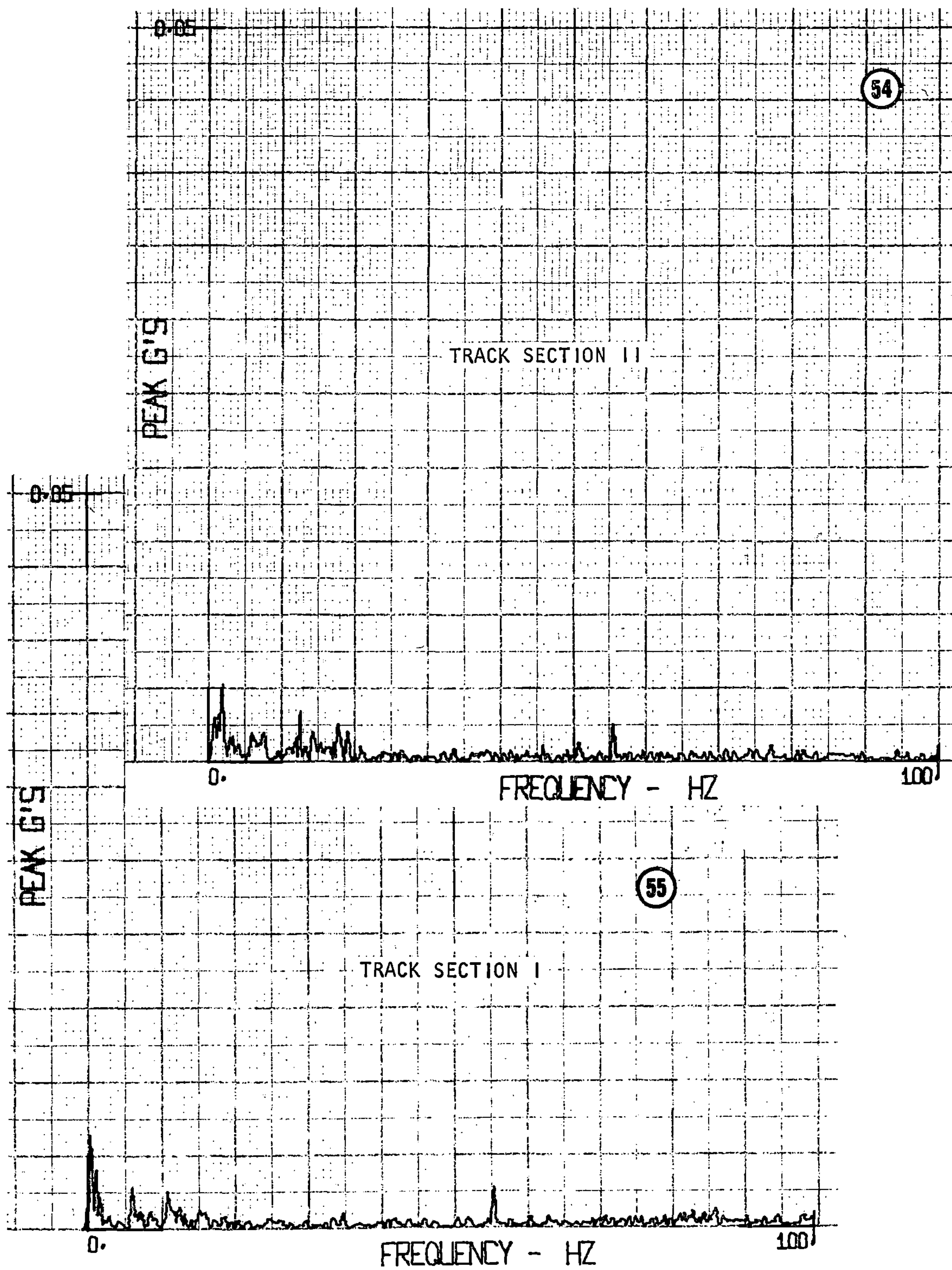


Figure 6-9. Forward Car Body Lateral Vibration - AW2 (Sheet 3)

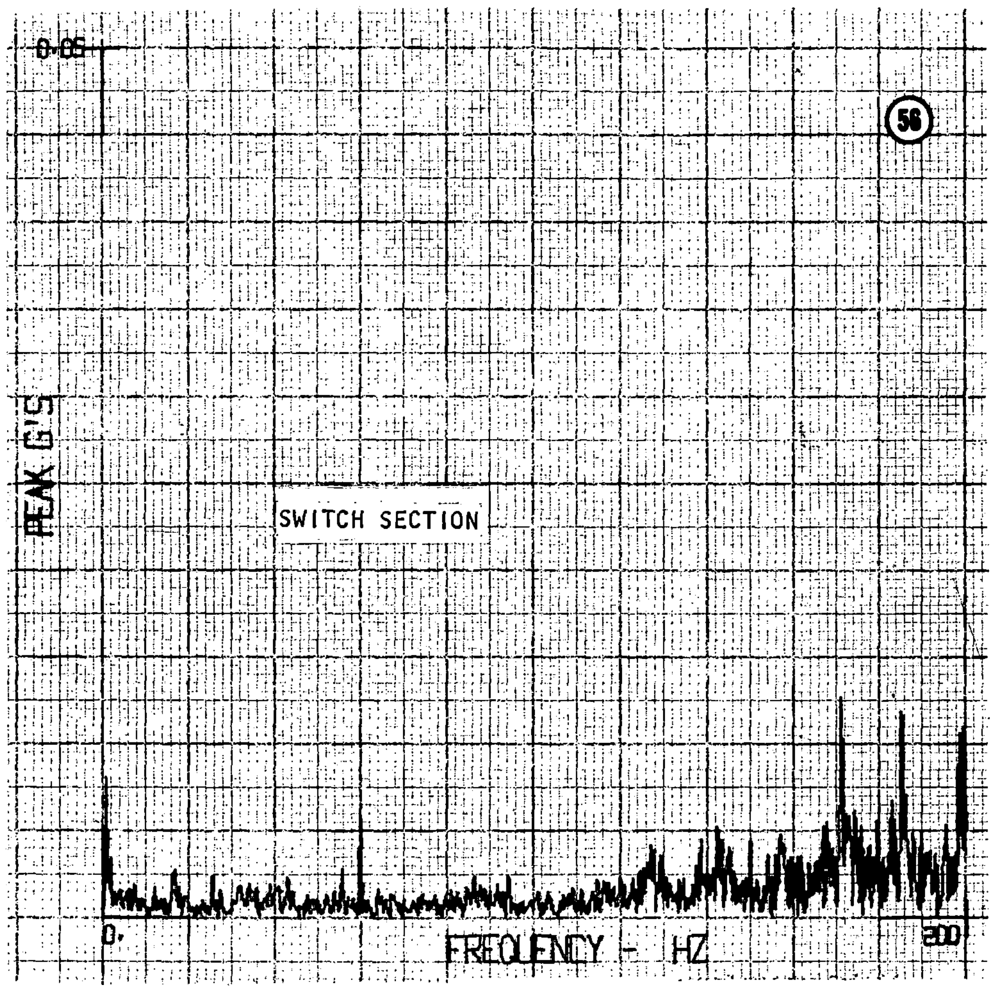


Figure 6-9. Forward Car Body Lateral Vibration - AW2 (Sheet 4)

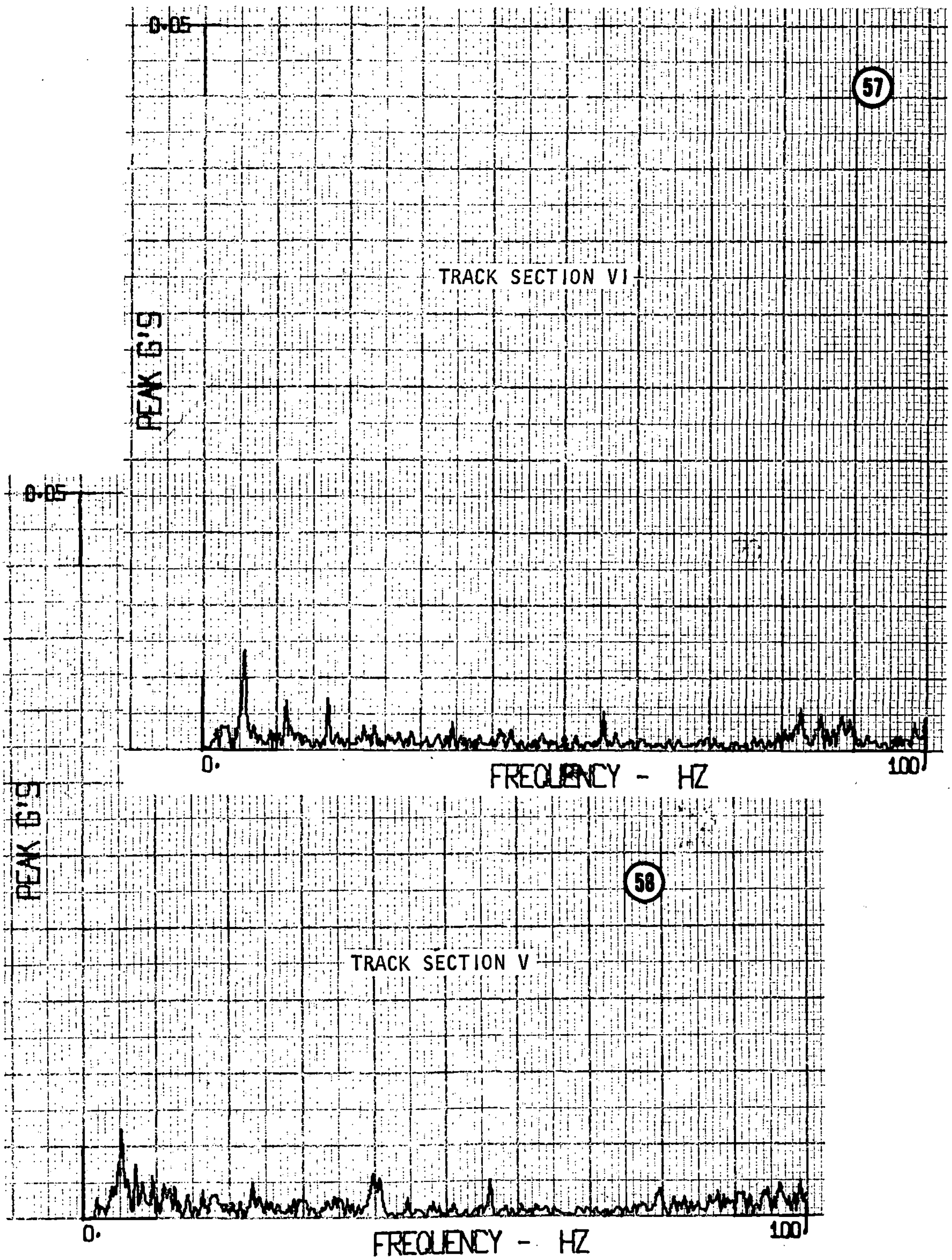


Figure 6-10. Forward Car Body Longitudinal Vibration - AW2 (Sheet 1)

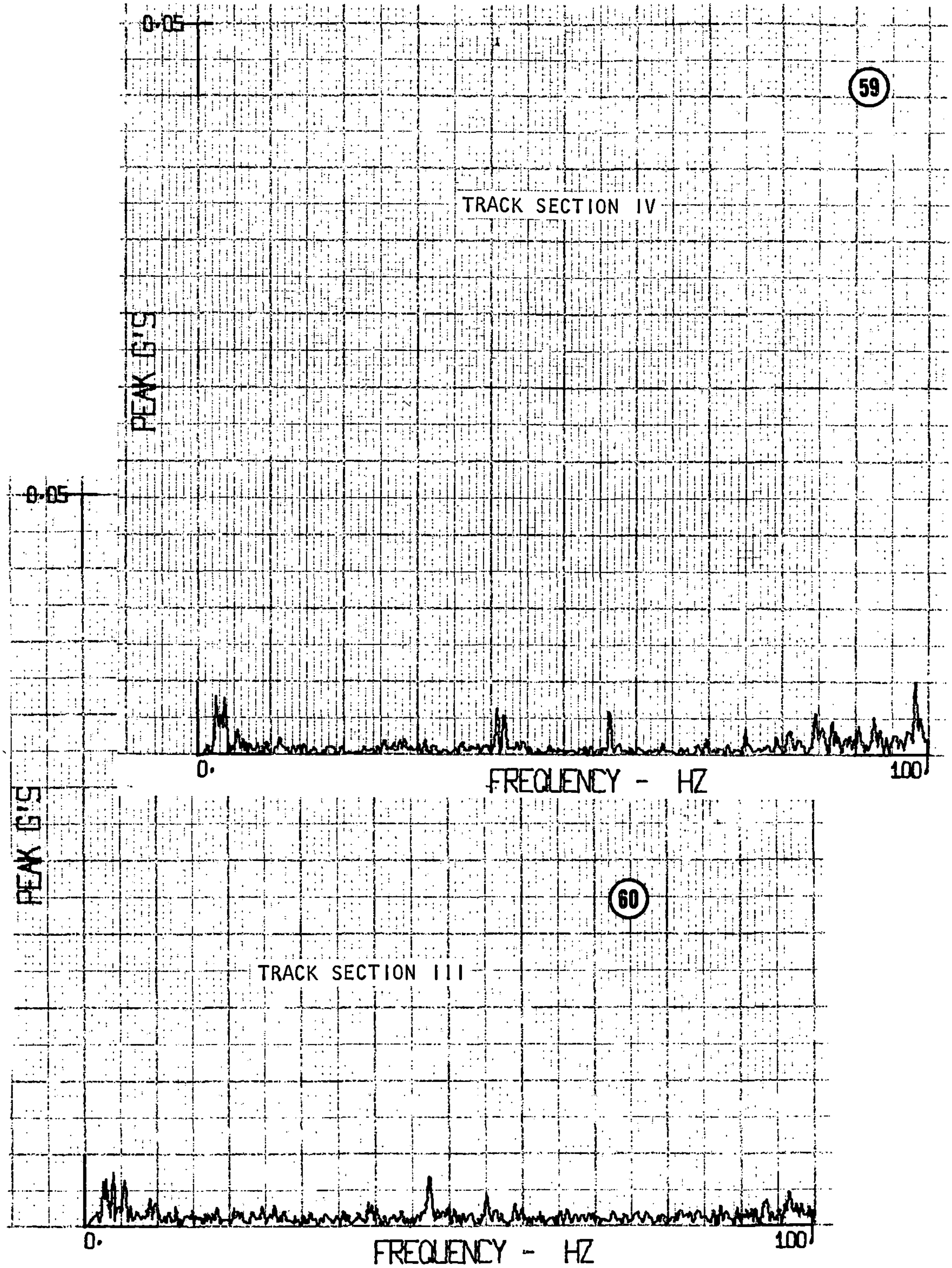


Figure 6-10. Forward Car Body Longitudinal Vibration - AW2 (Sheet 2)

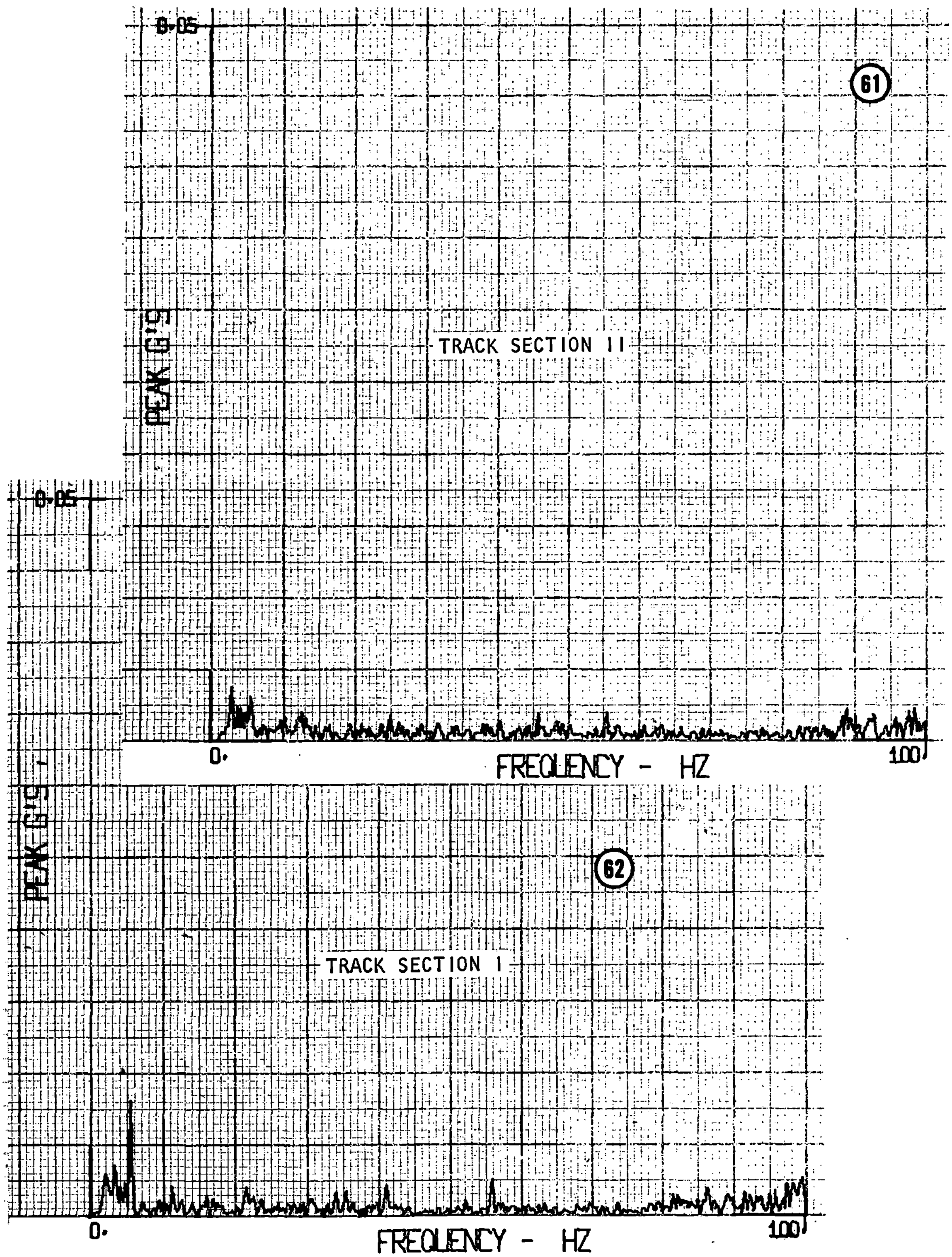


Figure 6-10. Forward Car Body Longitudinal Vibration - AW2 (Sheet 3)

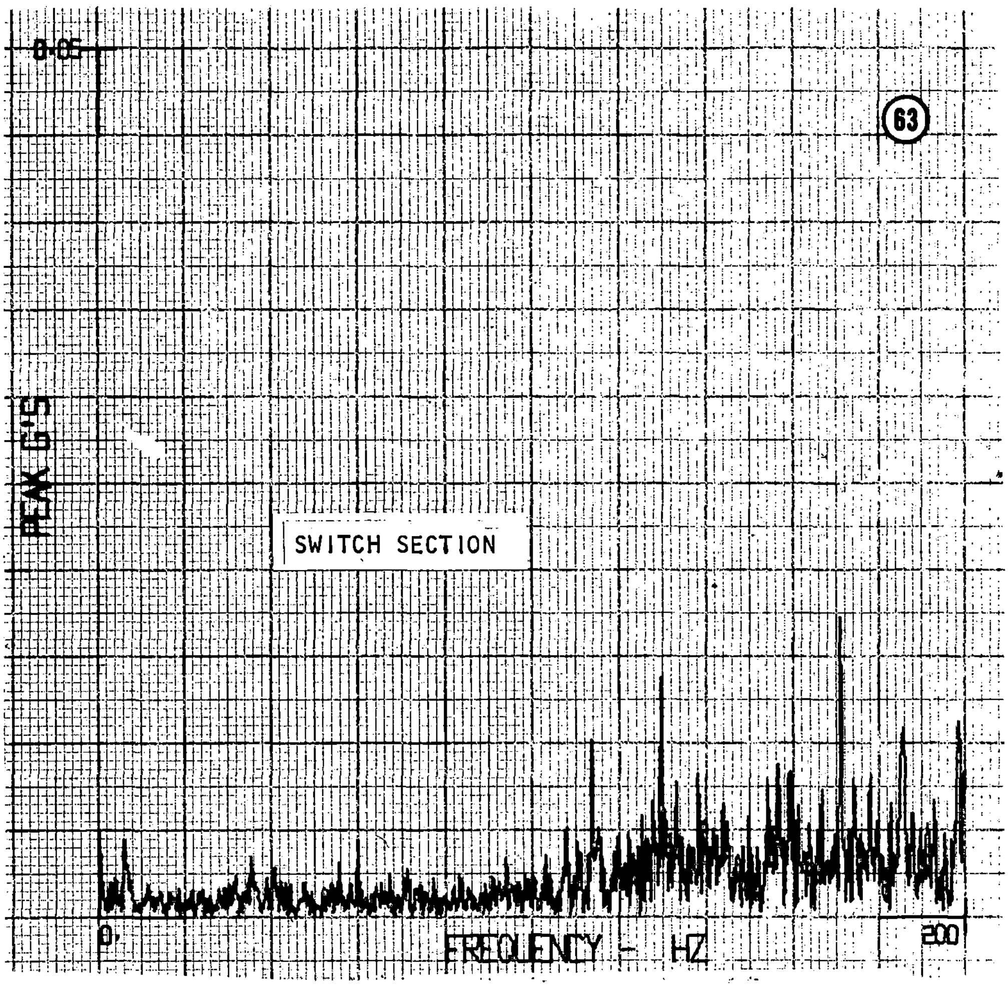


Figure 6-10. Forward Car Body Longitudinal Vibration - AW2 (Sheet 4)

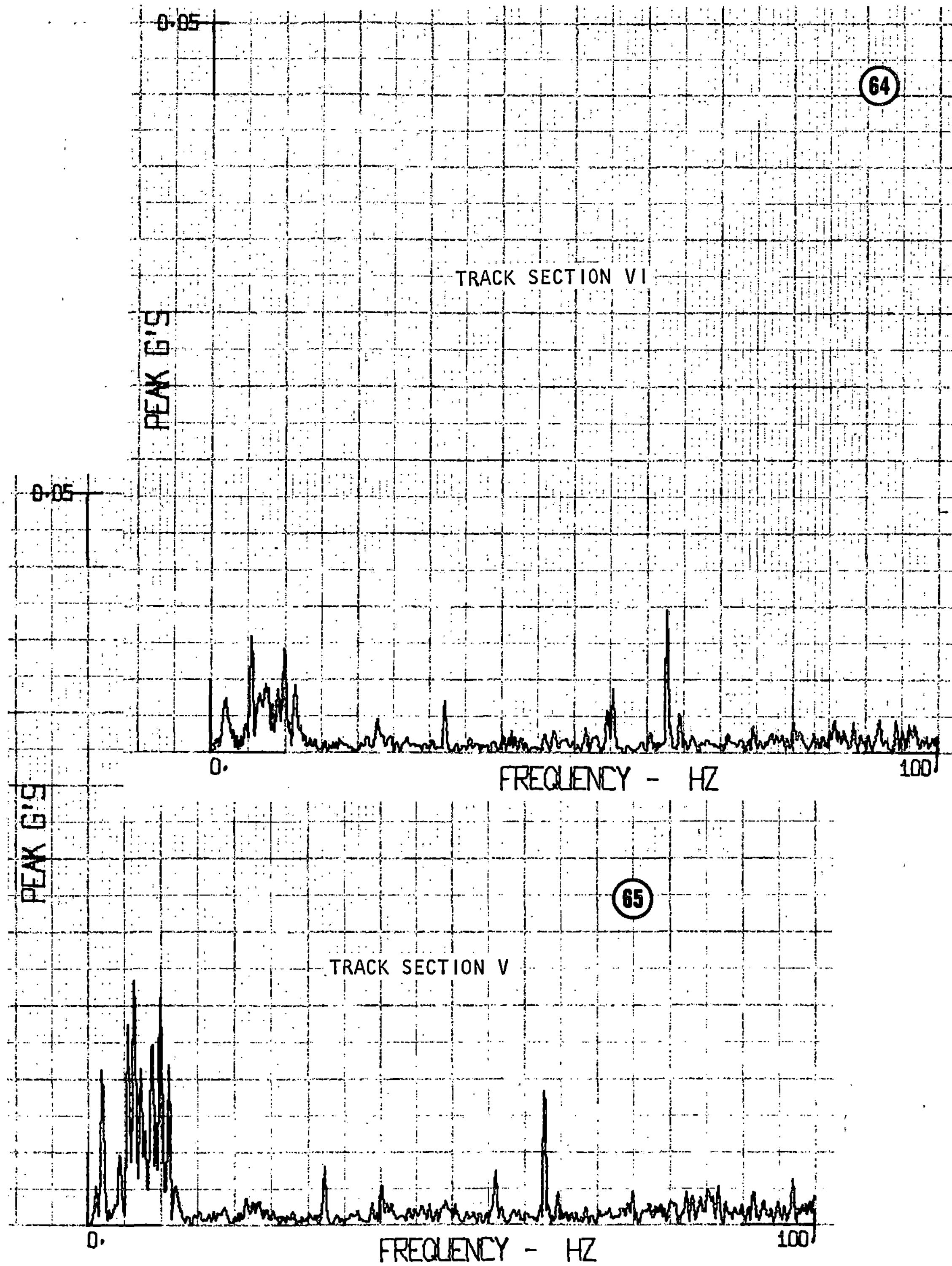


Figure 6-11. Mid Car Body Vertical Vibration - AW2 (Sheet 1)

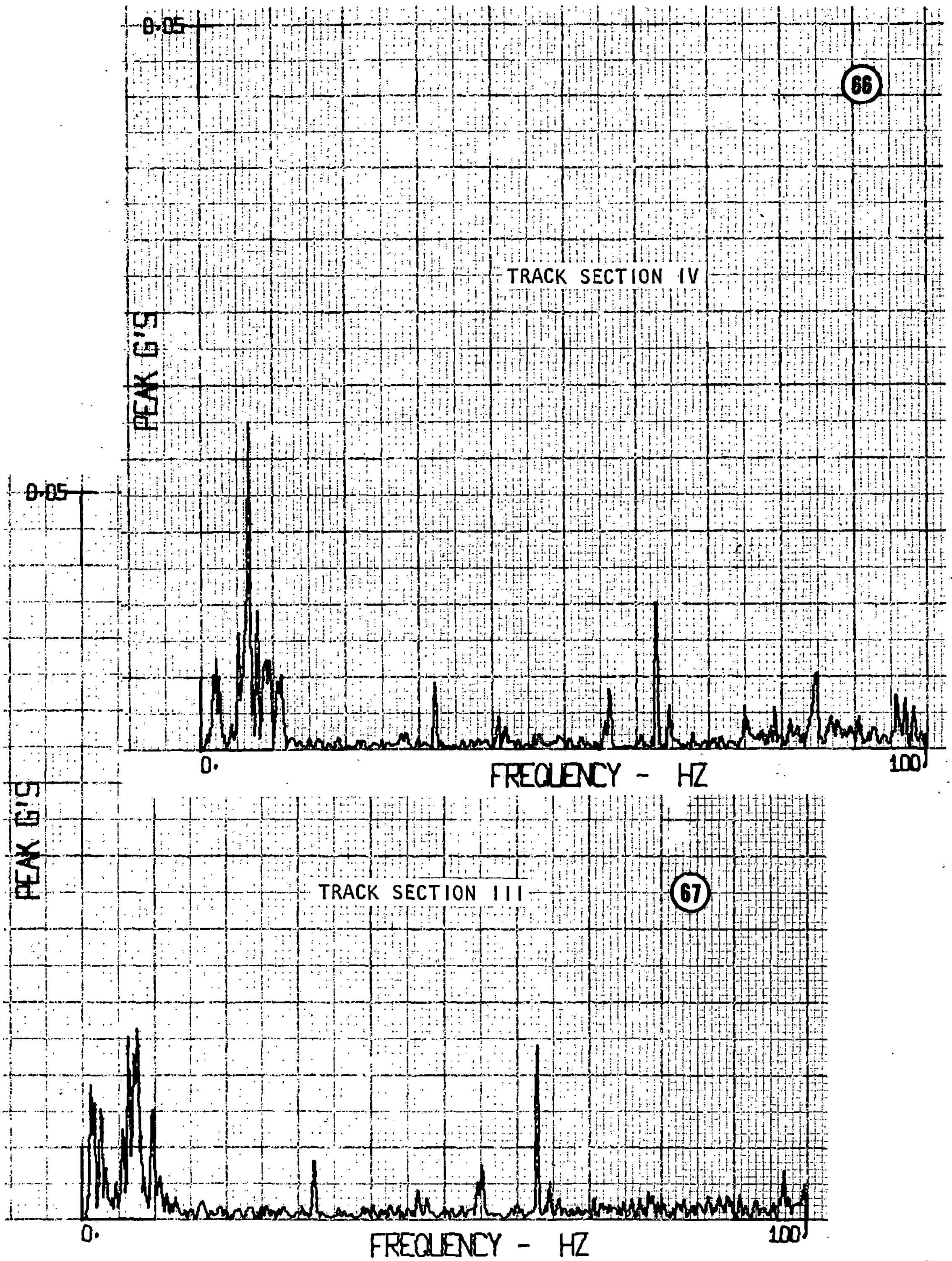


Figure 6-11. Mid Car Body Vertical Vibration - AW2 (Sheet 2)

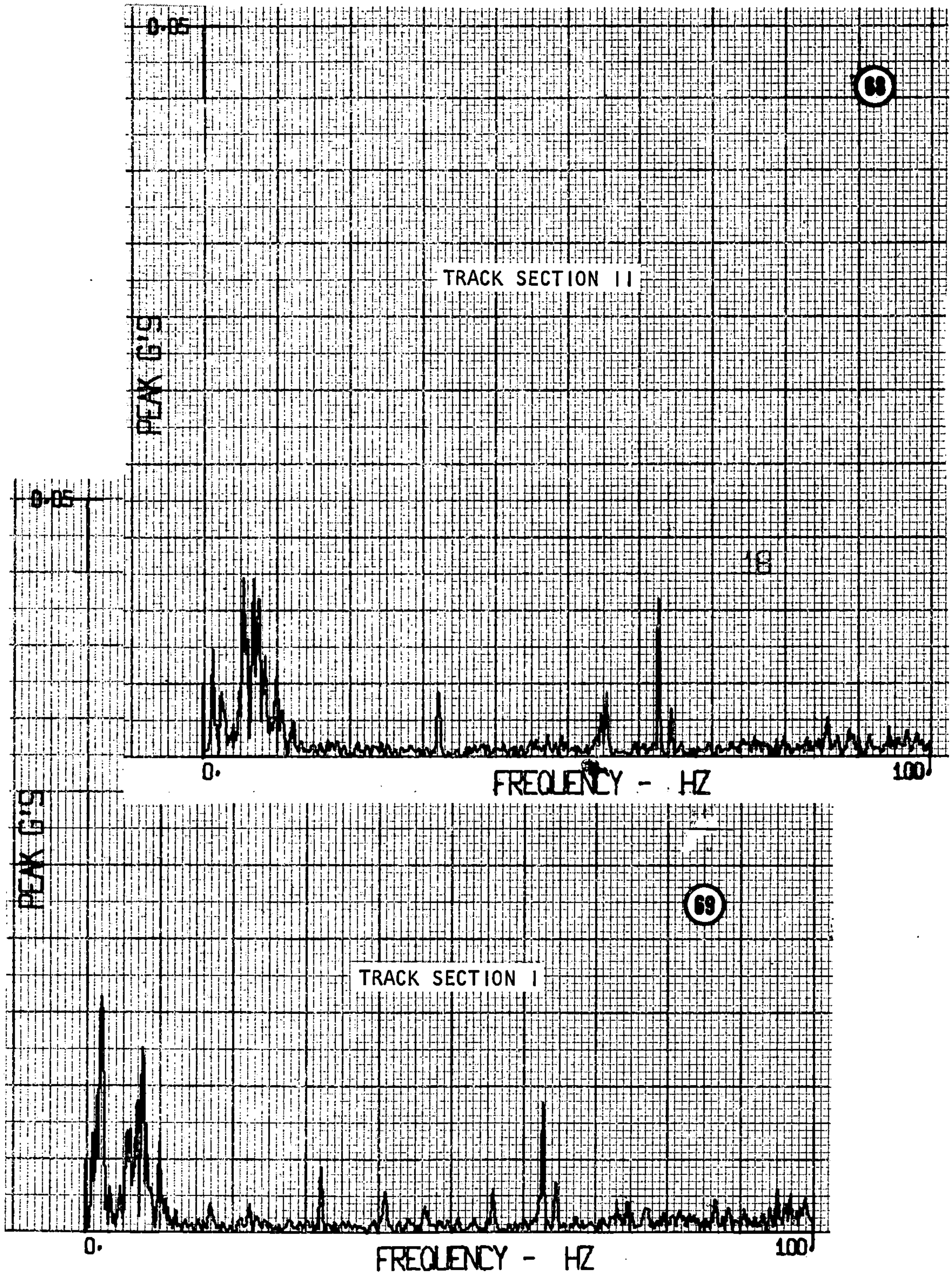


Figure 6-11. Mid Car Body Vertical Vibration - AW2 (Sheet 3)

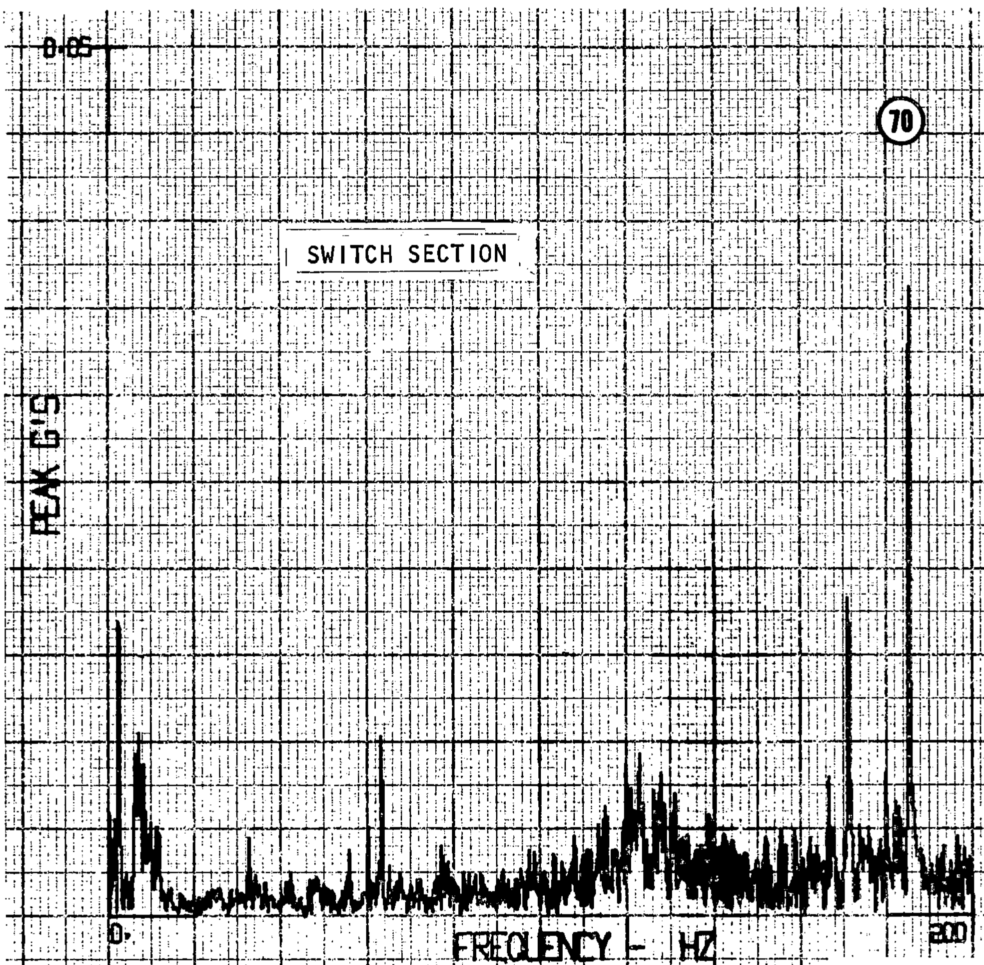


Figure 6-11. Mid Car Body Vertical Vibration - AW2 (Sheet 4)

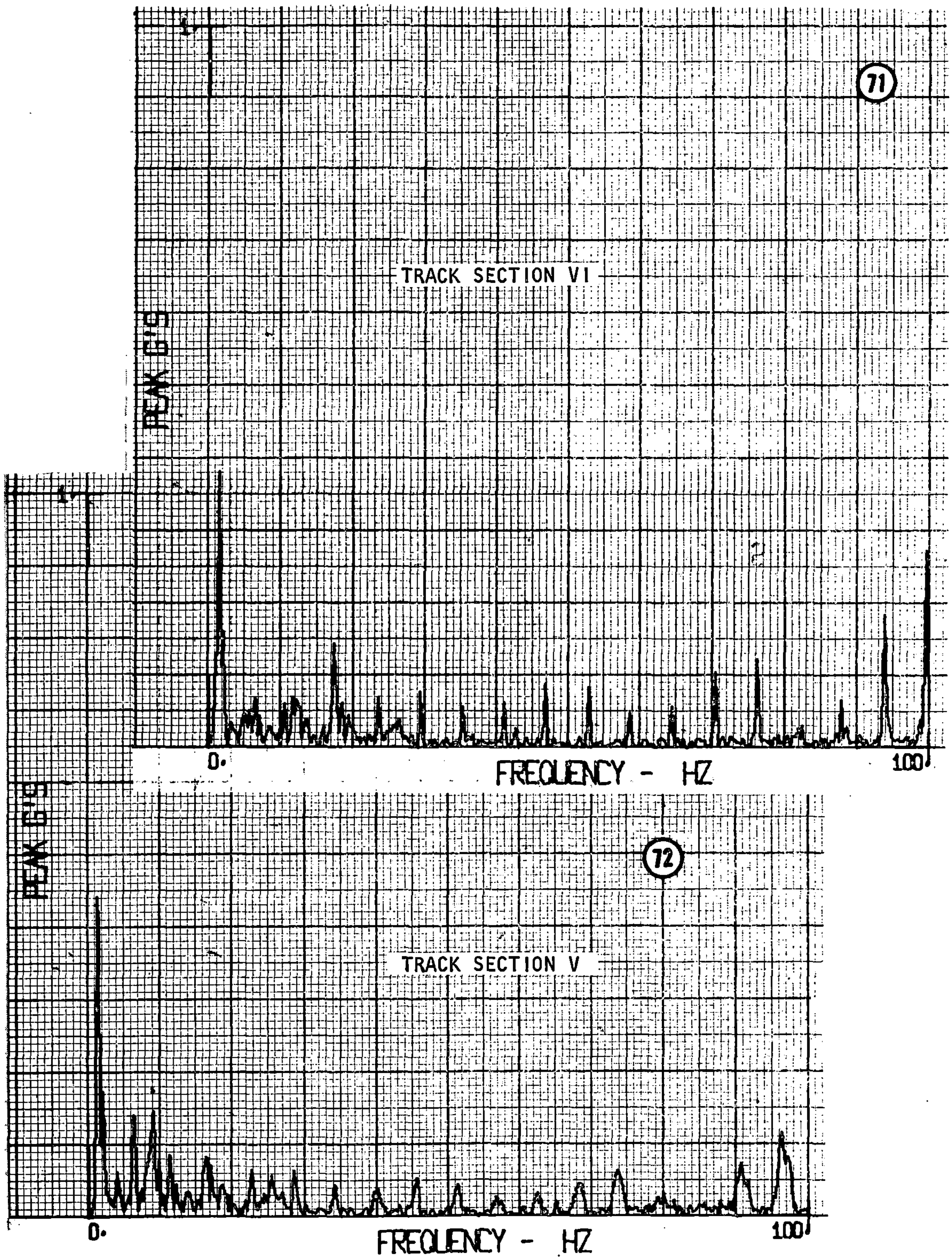


Figure 6-12. Lead Axle Vertical Vibration - AW2 (Sheet 1)

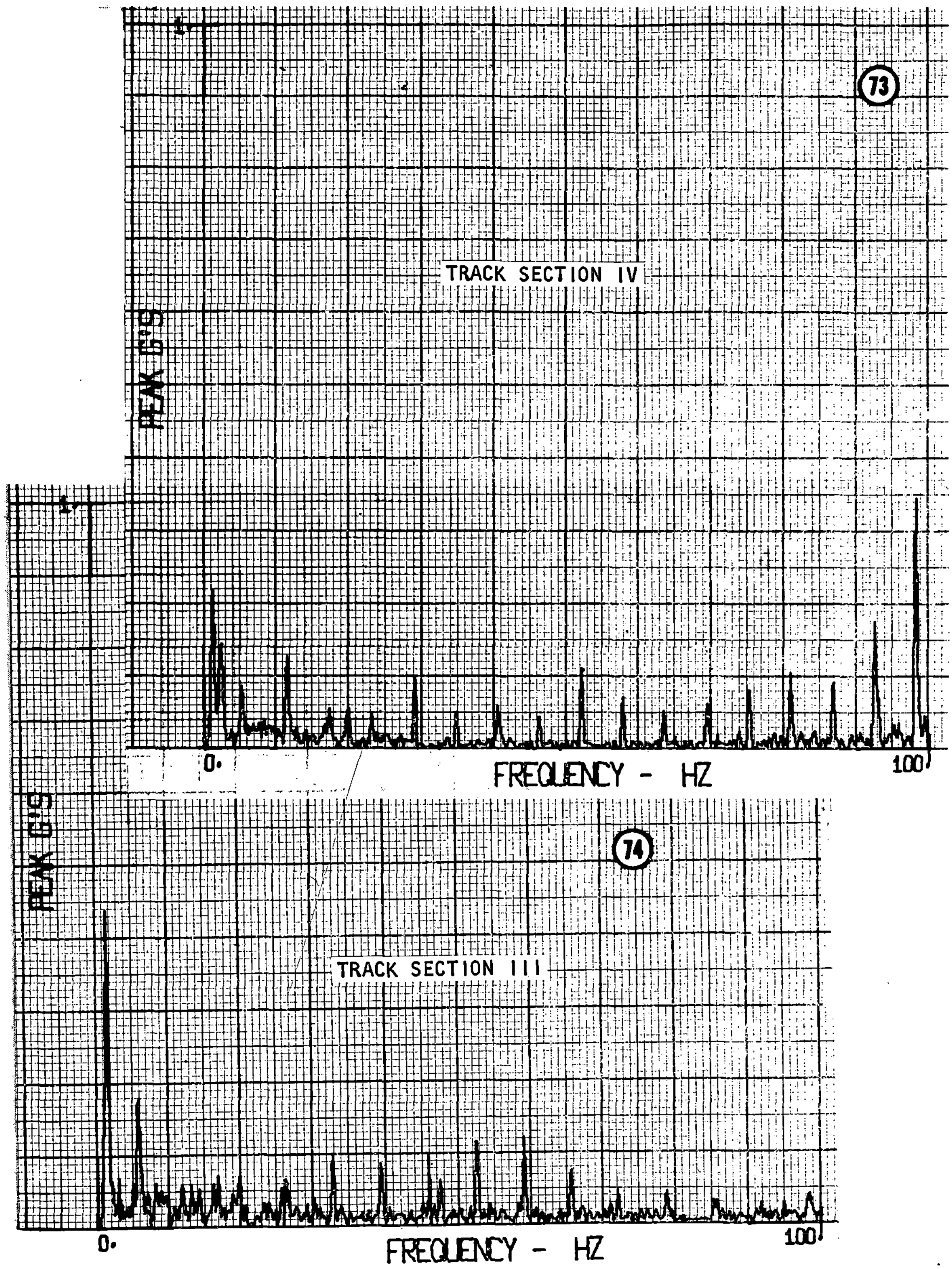


Figure 6-12. Lead Axle Vertical Vibration - AW2 (Sheet 2)

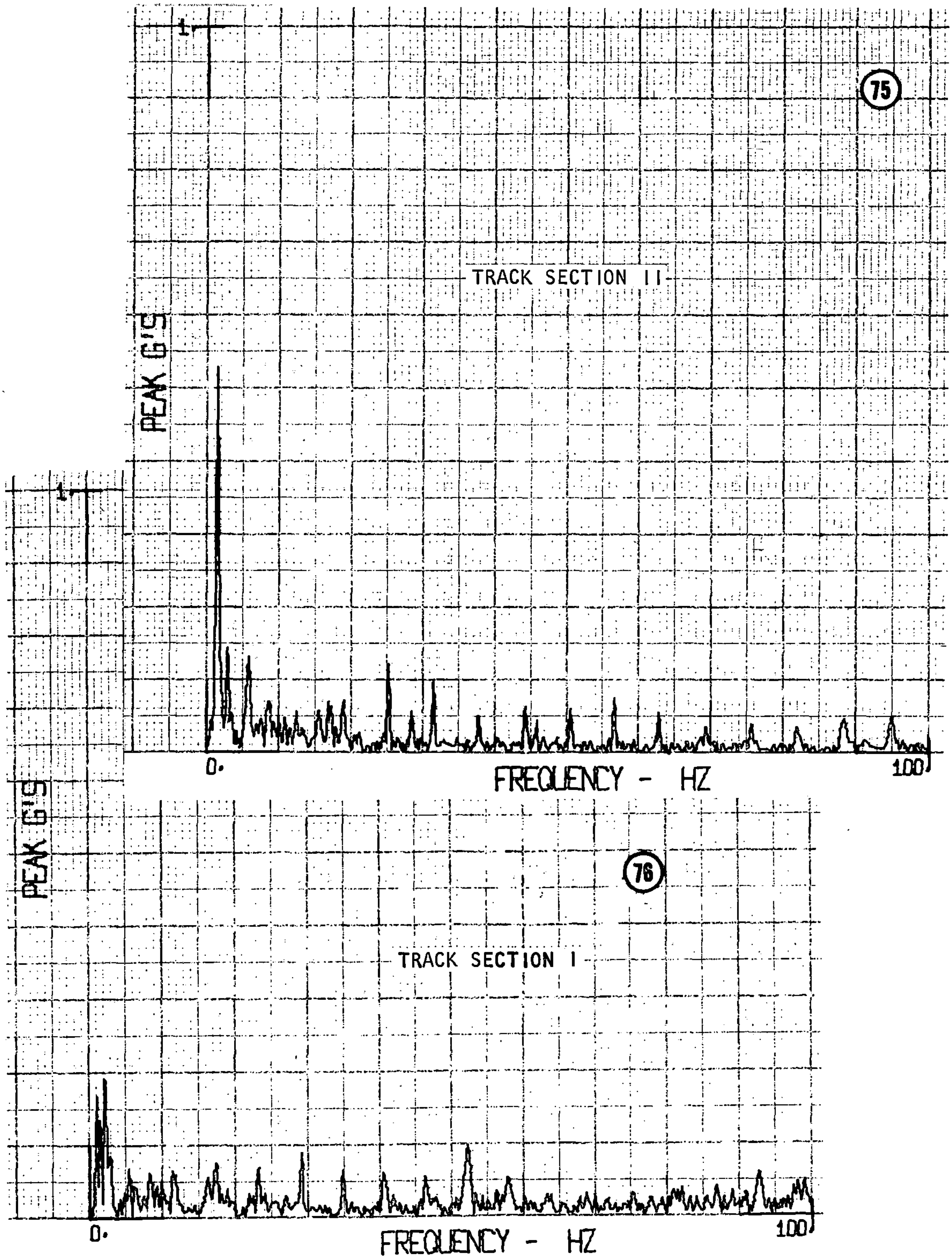


Figure 6-12. Lead Axle Vertical Vibration - AW2 (Sheet 3)

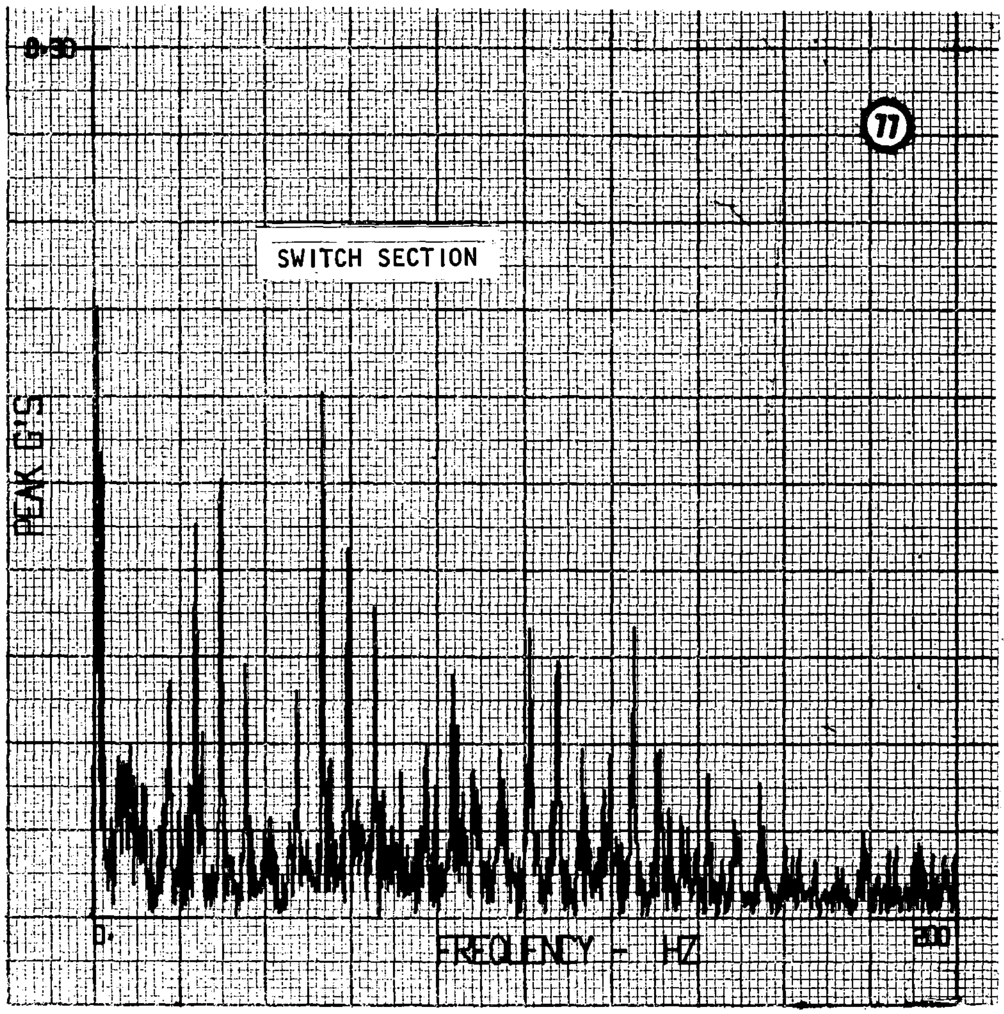


Figure 6-12. Lead Axle Vertical Vibration - AW2 (Sheet 4)

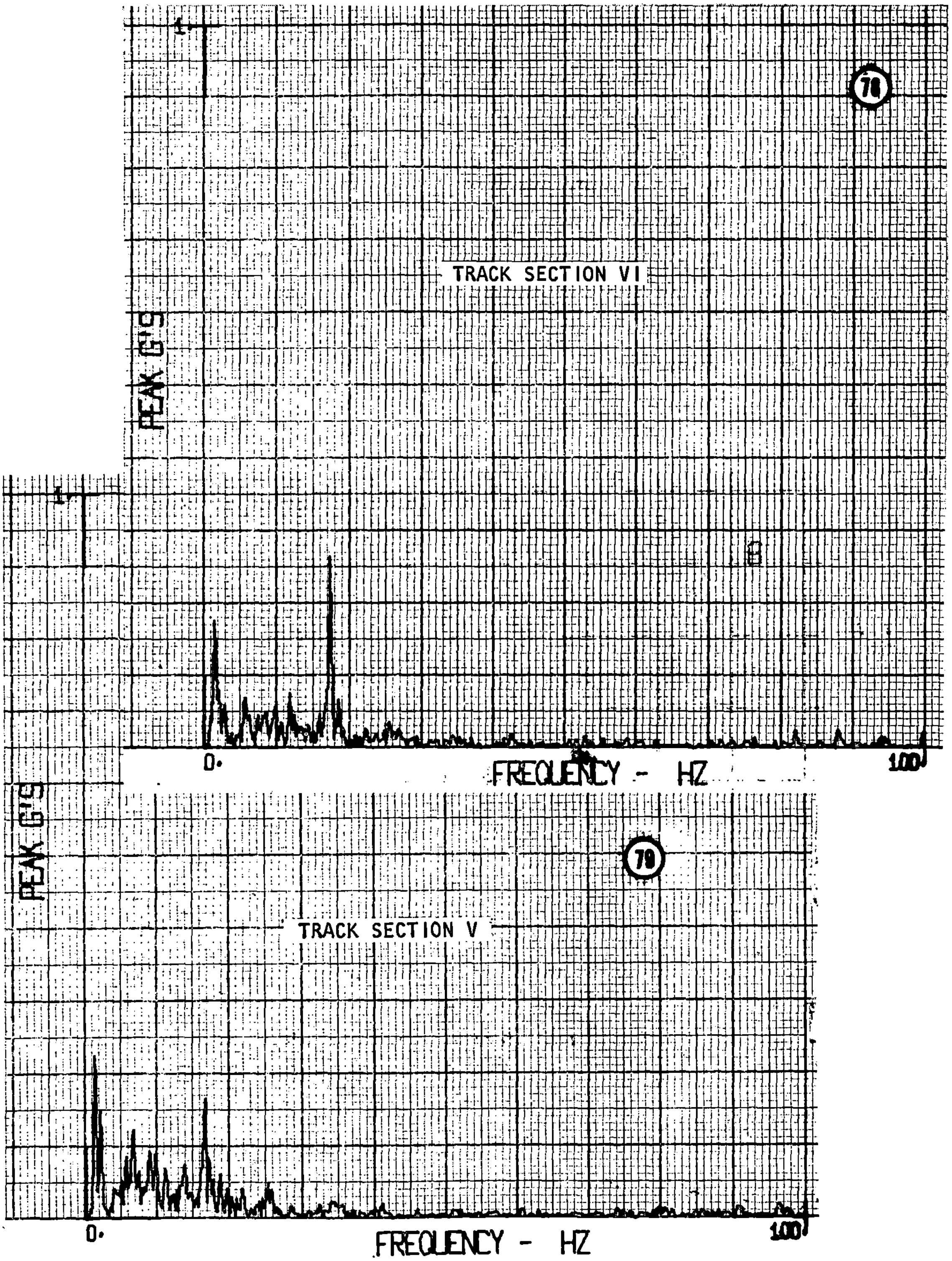


Figure 6-13. Lead Axle Lateral Vibration - AW2 (Sheet 1)

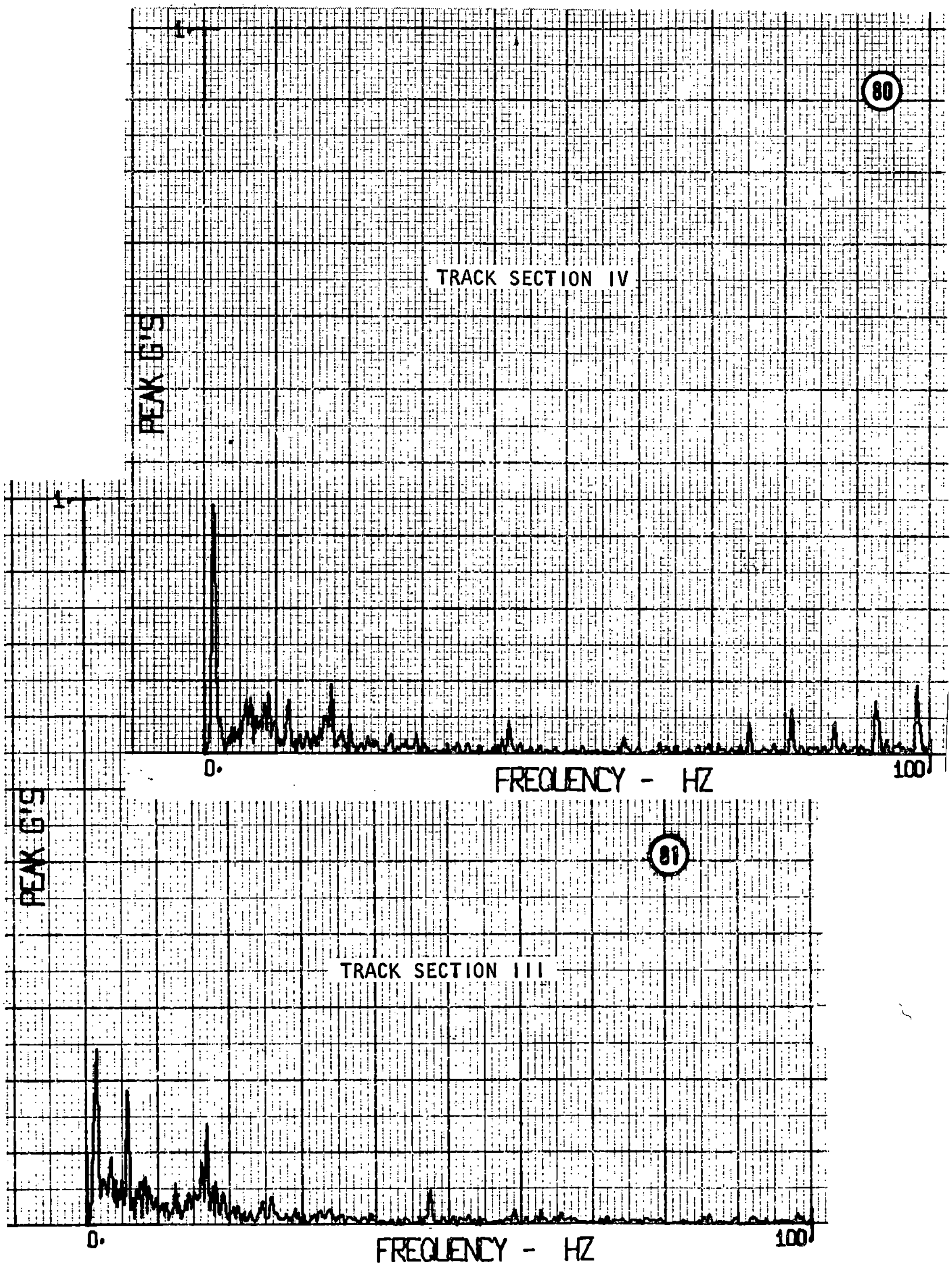


Figure 6-13. Lead Axle Lateral Vibration - AW2 (Sheet 2)

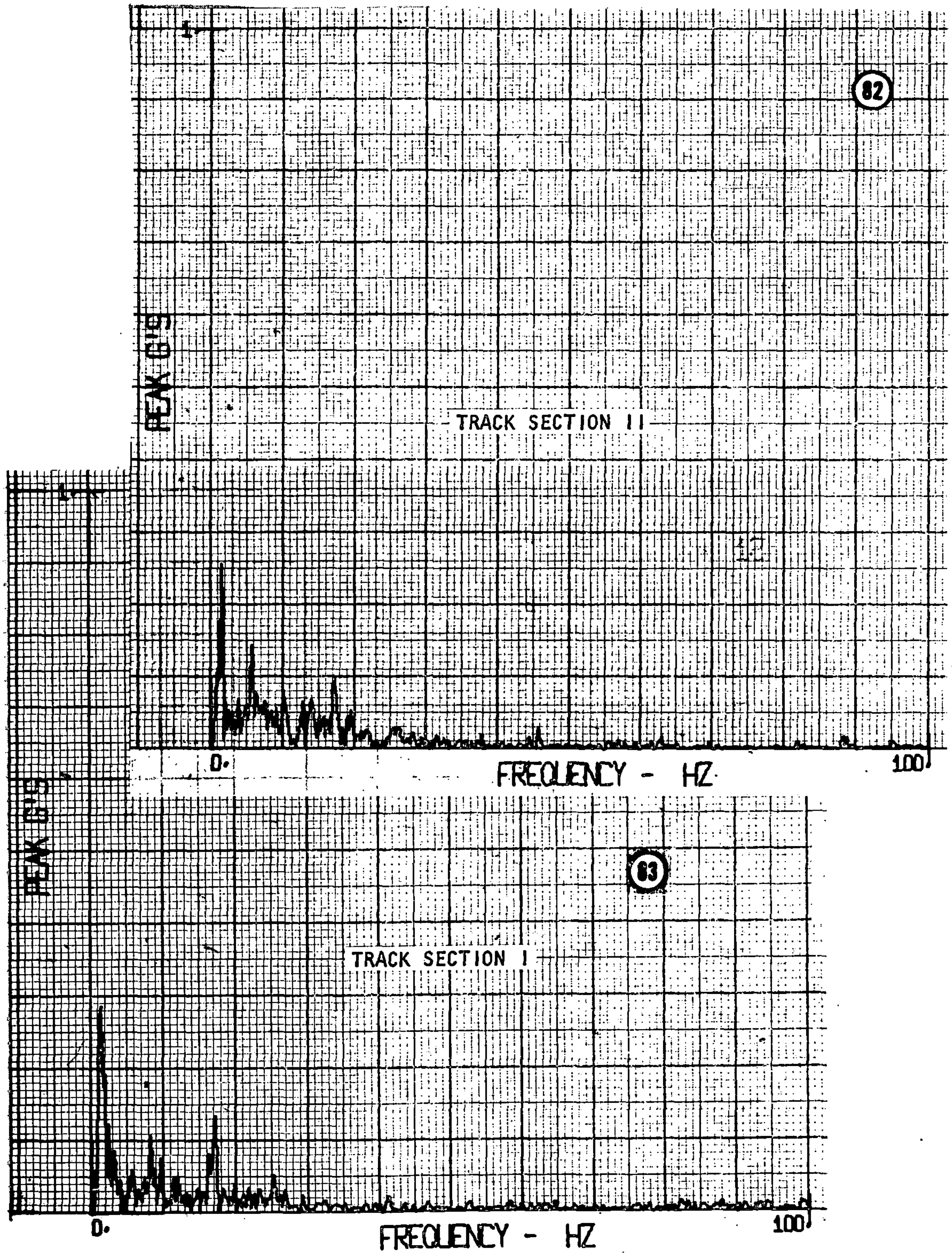


Figure 6-13. Lead Axle Lateral Vibration - AW2 (Sheet 3)

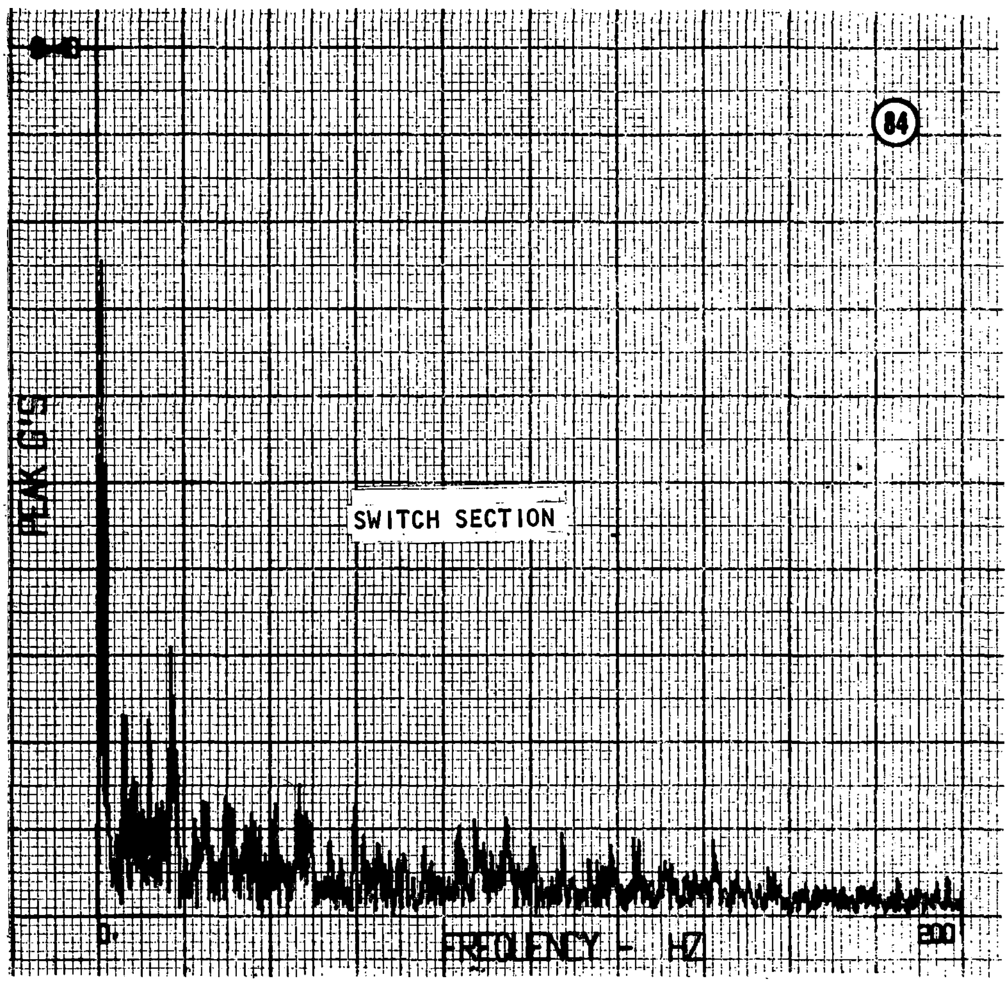


Figure 6-13. Lead Axle Lateral Vibration - AW2 (Sheet 4)

The results of the AW3 car weight worst speed tests are shown in amplitude versus frequency plots, figures 6-14 through 6-19. The plots are grouped in sets of responses for each track section according to the location and type of sensor listed in table 6-4. Each plot is identified by a label stating the track section and a reference number (circled number on plot (keyed to the table.

Table 6-4. AW3 Worst Speed Plot Index

Figure Number	Sensor Location and Type	Track Section and Plot Reference Numbers						
		VI	V	IV	III	II	I	Switch Section
6-14	Forward Car Body - Vertical	85	86	87	88	89	90	91
6-15	Forward Car Body - Lateral	92	93	94	95	96	97	98
6-16	Forward Car Body - Longitudinal	99	100	101	102	103	104	105
6-17	Mid Car Body - Vertical	106	107	108	109	110	111	112
6-18	Lead Axle - Vertical	113	114	115	116	117	118	119
6-19	Lead Axle - Lateral	120	121	122	123	124	125	126

NOTES: Car speed, 35 mph for all tests
Car body sensors, ±5.0 vdc = ±0.5 G
Axle sensors, ±5.0 vdc = ±3.0 G

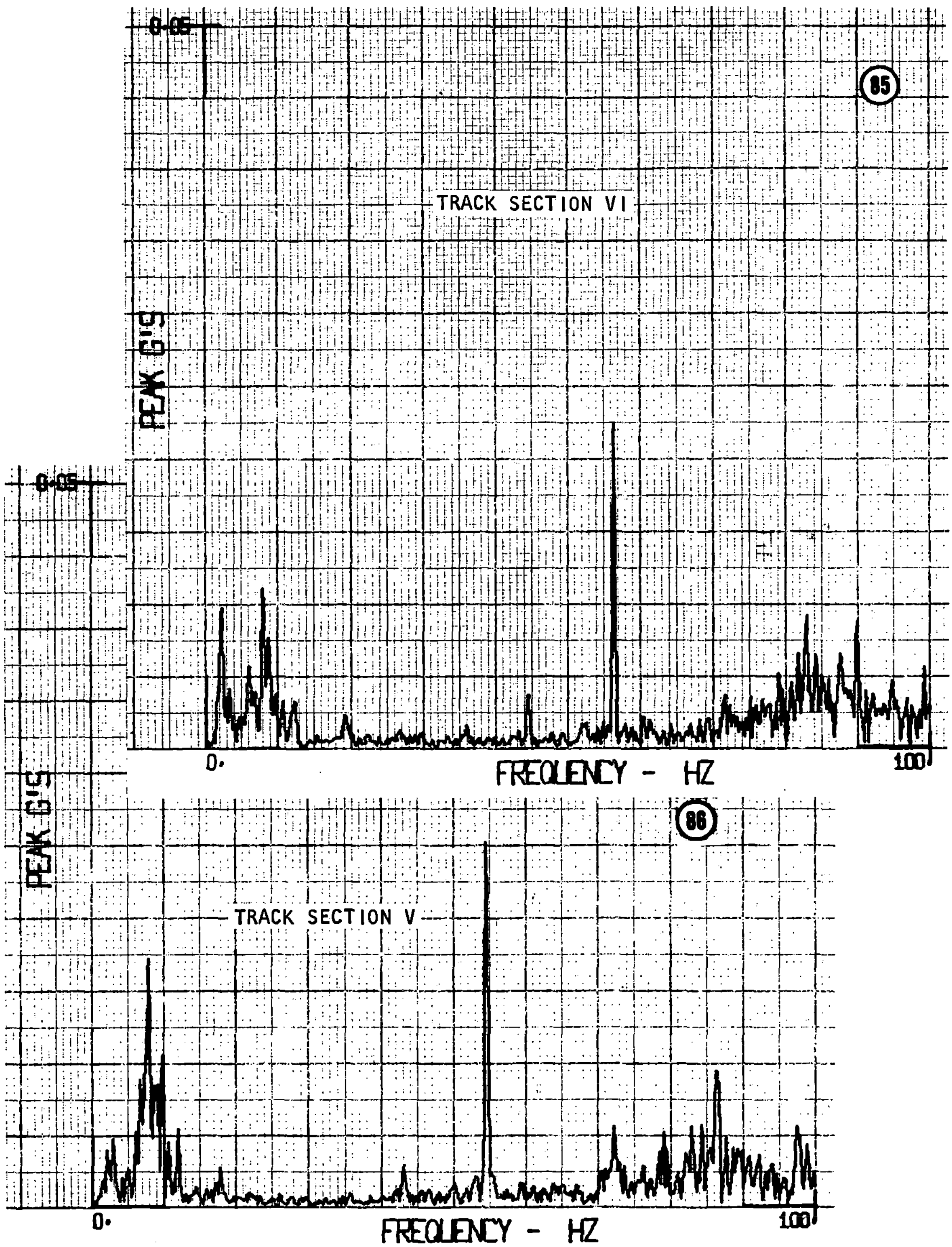


Figure 6-14. Forward Car Body Vertical Vibration - AW3 (Sheet 1)

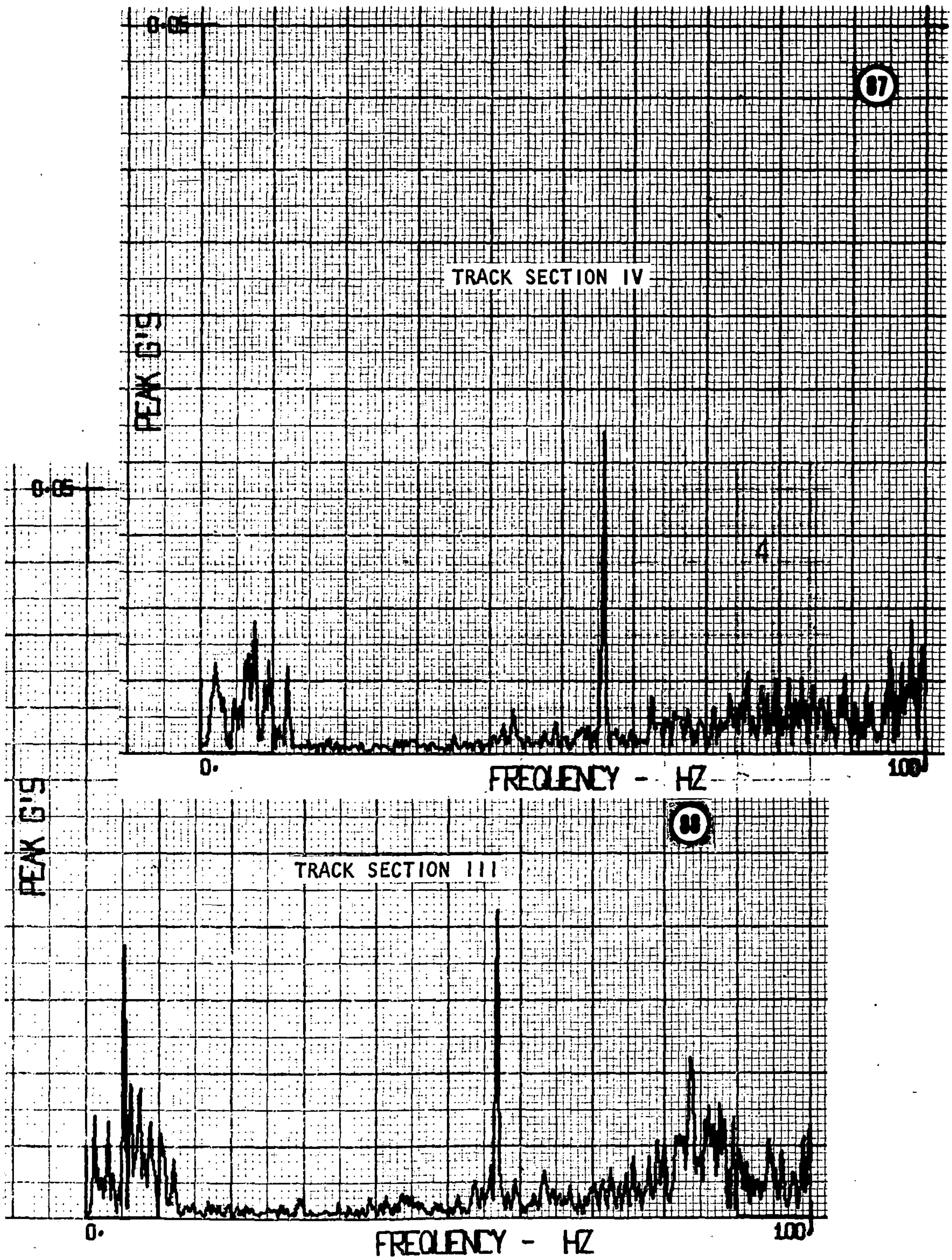


Figure 6-14. Forward Car Body Vertical Vibration - AW3 (Sheet 2)

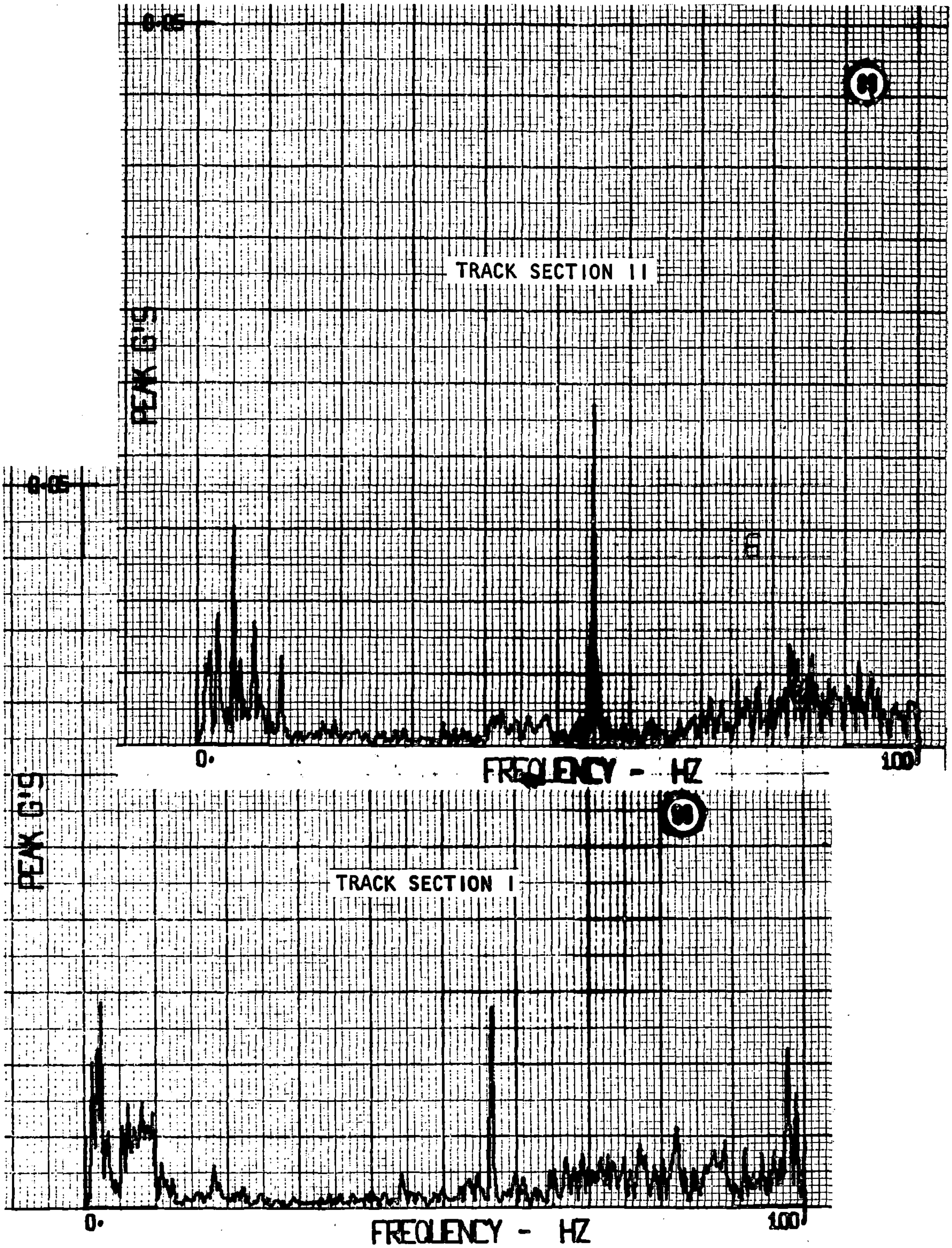


Figure 6-14. Forward Car Body Vertical Vibration - AW3 (Sheet 3)

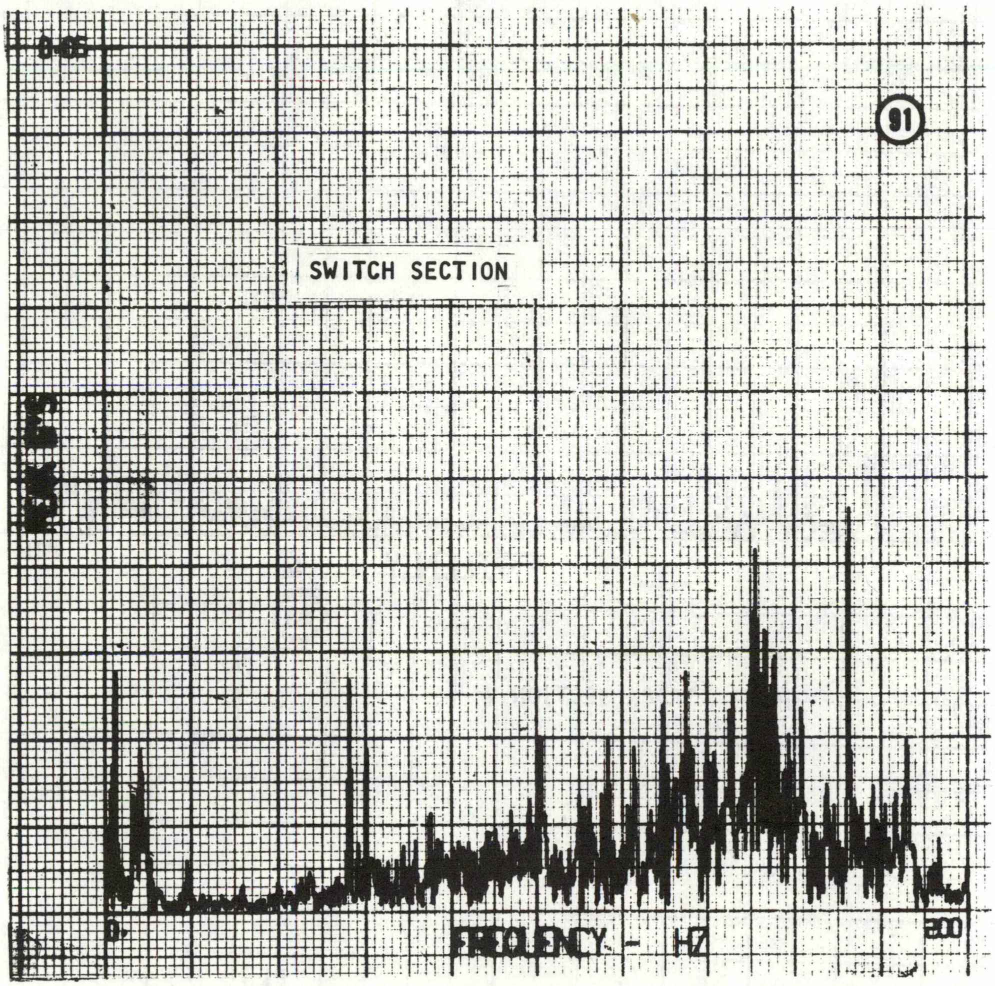


Figure 6-14. Forward Car Body Vertical Vibration - AW3 (Sheet 4)

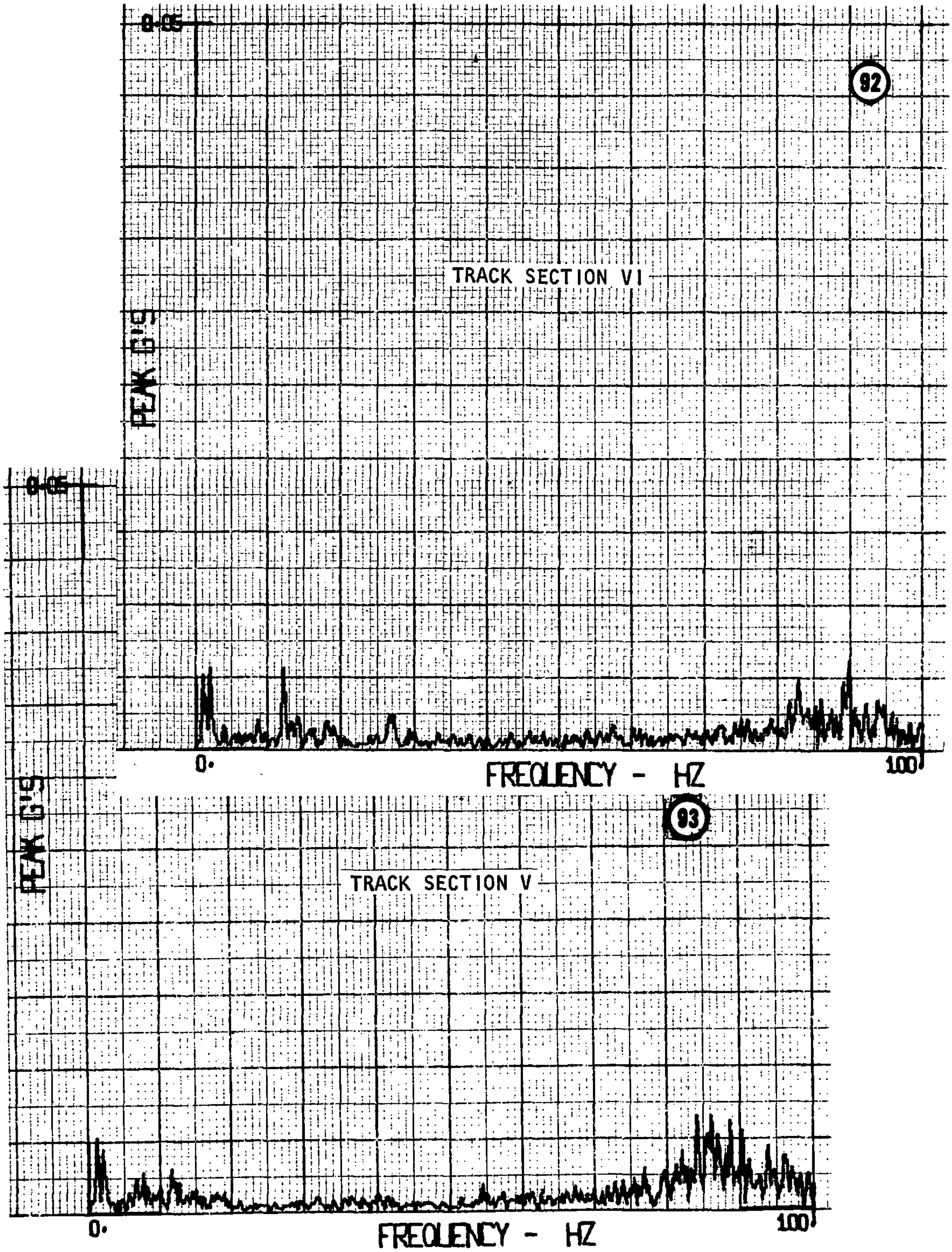


Figure 6-15. Forward Car Body Lateral Vibration - AW3 (Sheet 1)

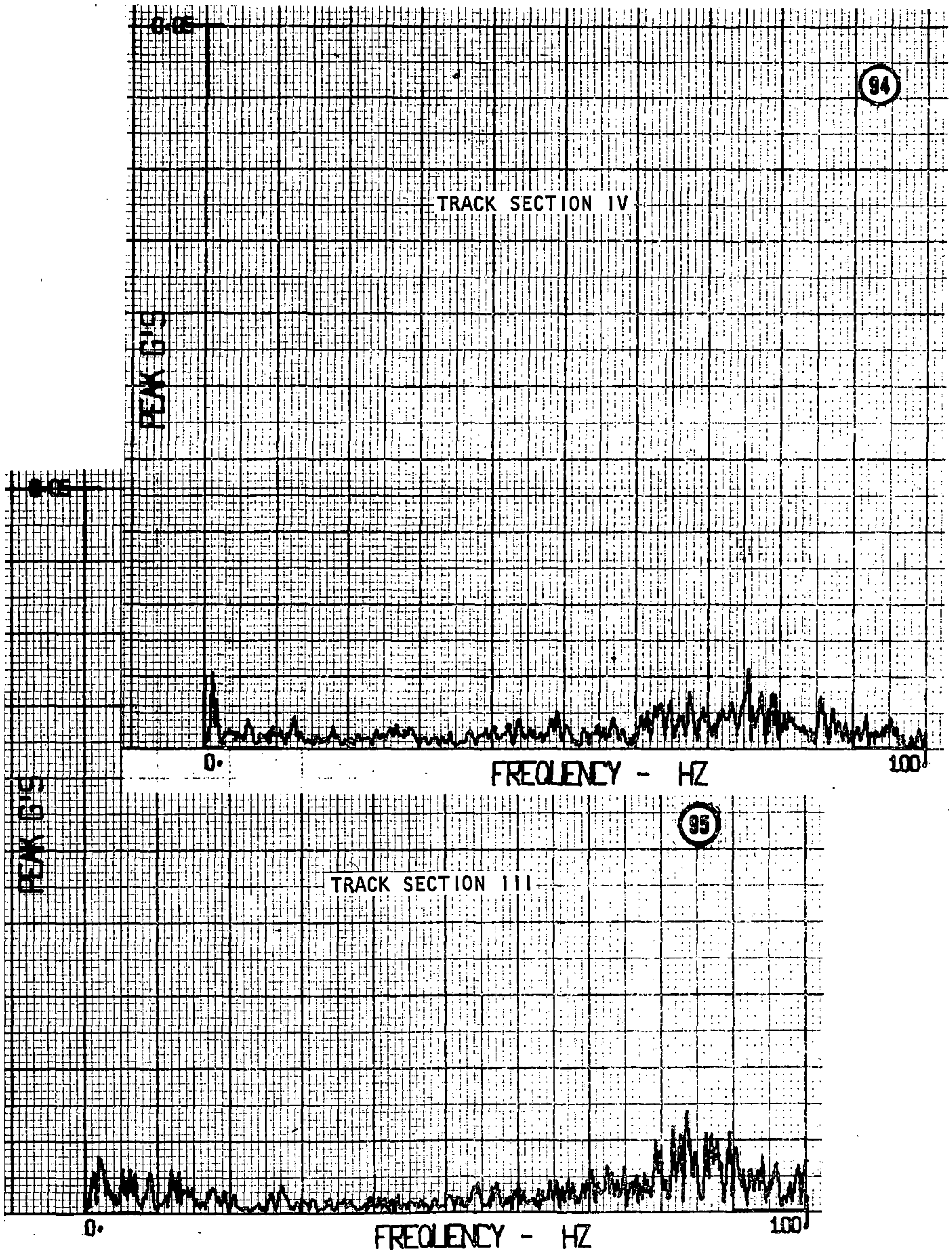


Figure 6-15. Forward Car Body Lateral Vibration - AW3 (Sheet 2)

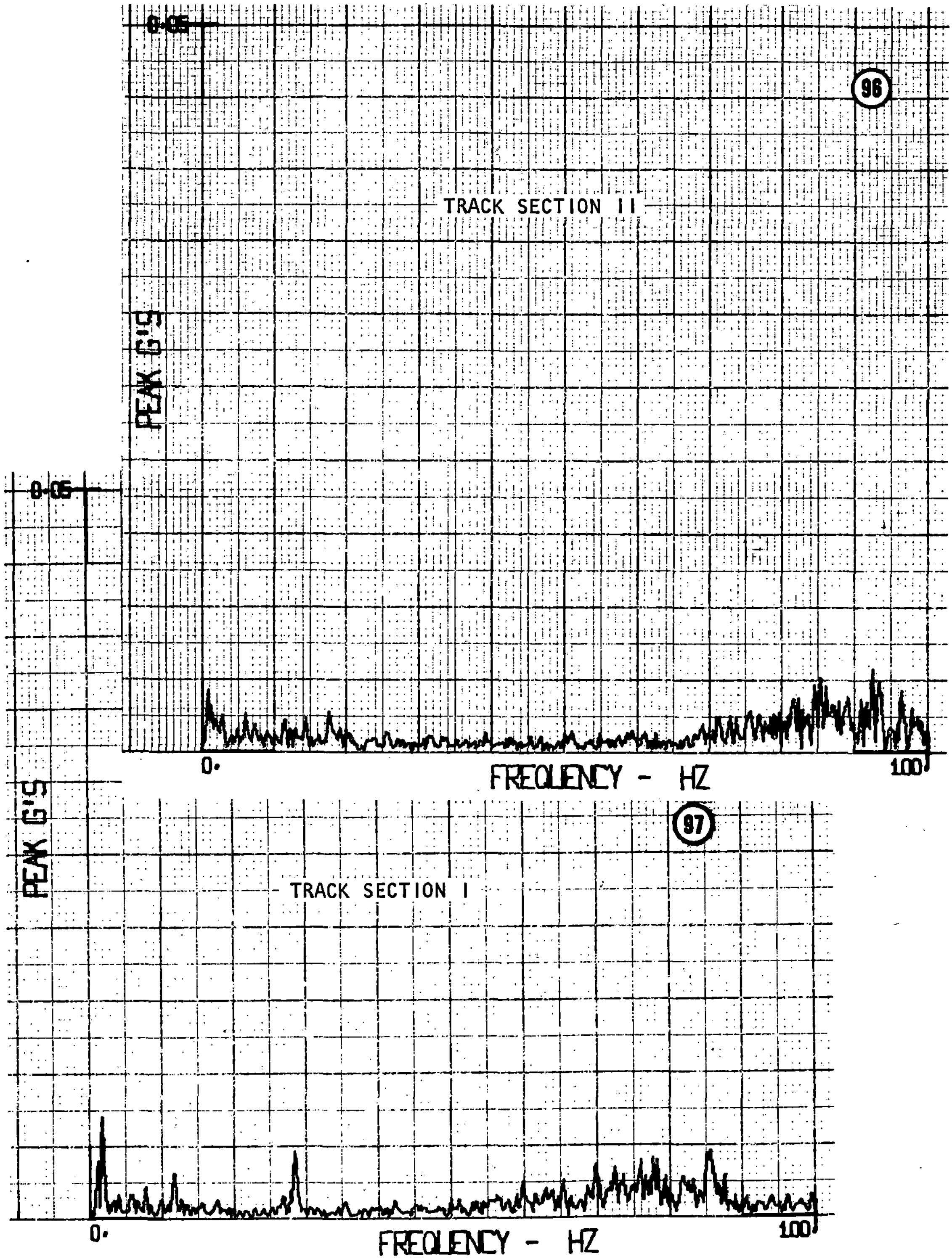


Figure 6-15. Forward Car Body Lateral Vibration - AW3 (Sheet 3)

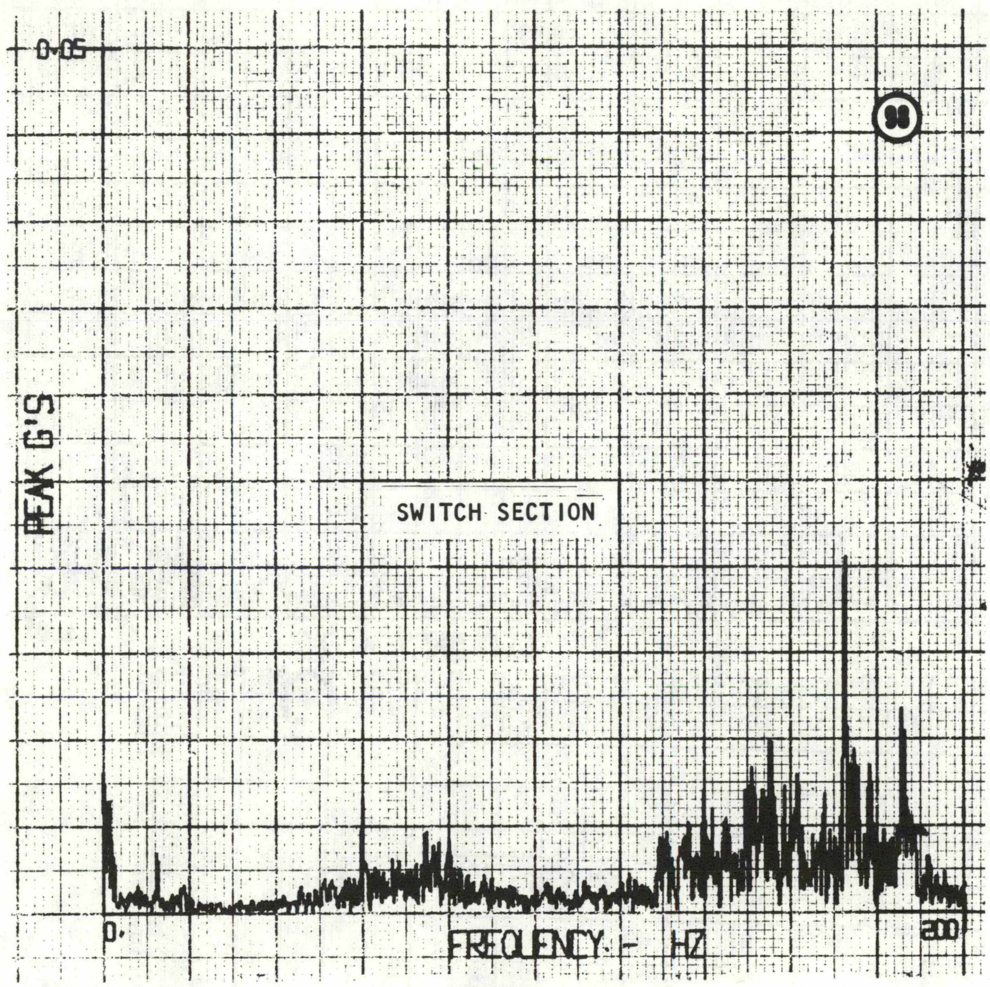


Figure 6-15. Forward Car Body Lateral Vibration - AW3 (Sheet 4)

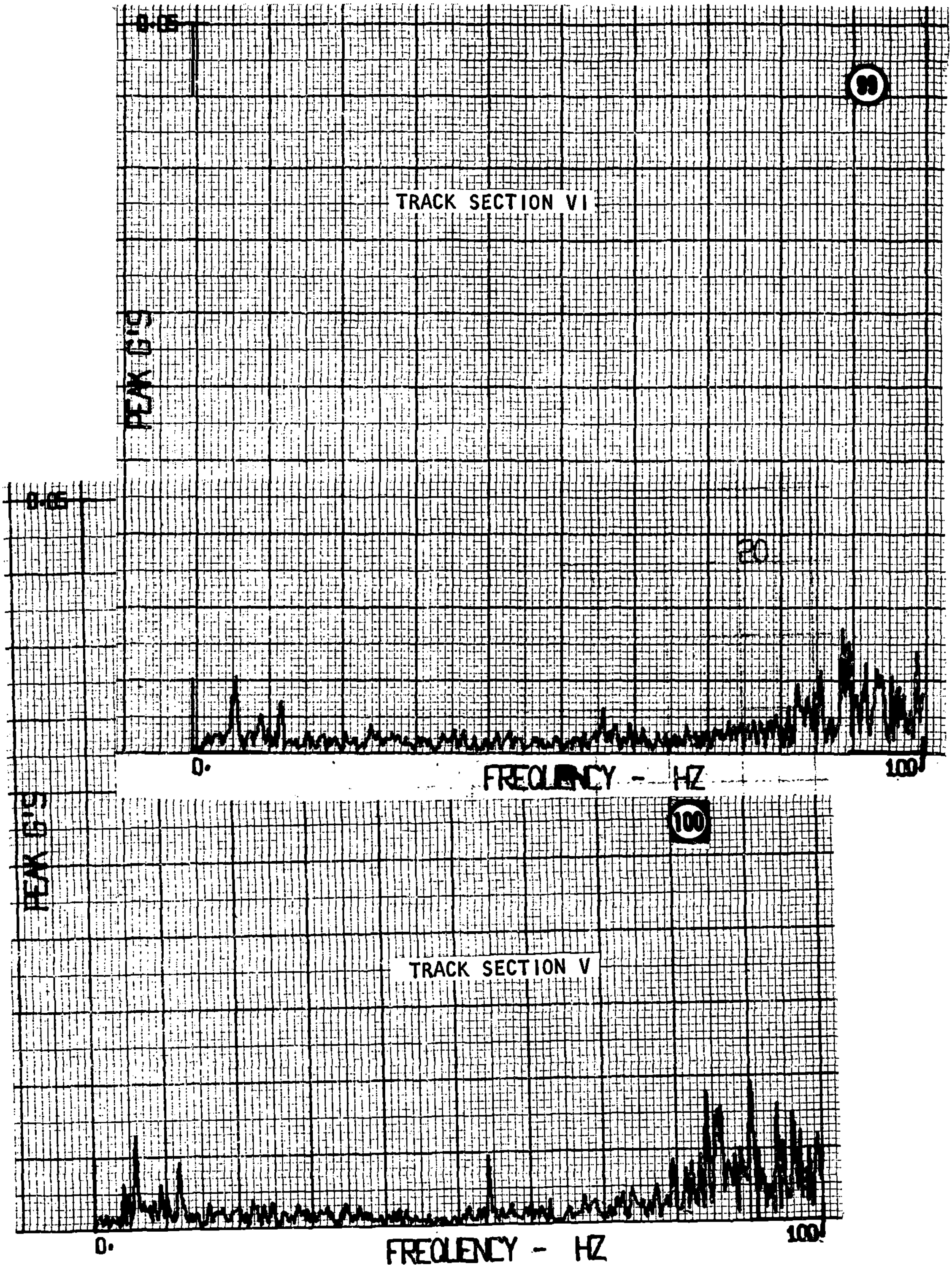


Figure 6-16. Forward Car Body Longitudinal Vibration - AW3 (Sheet 1)

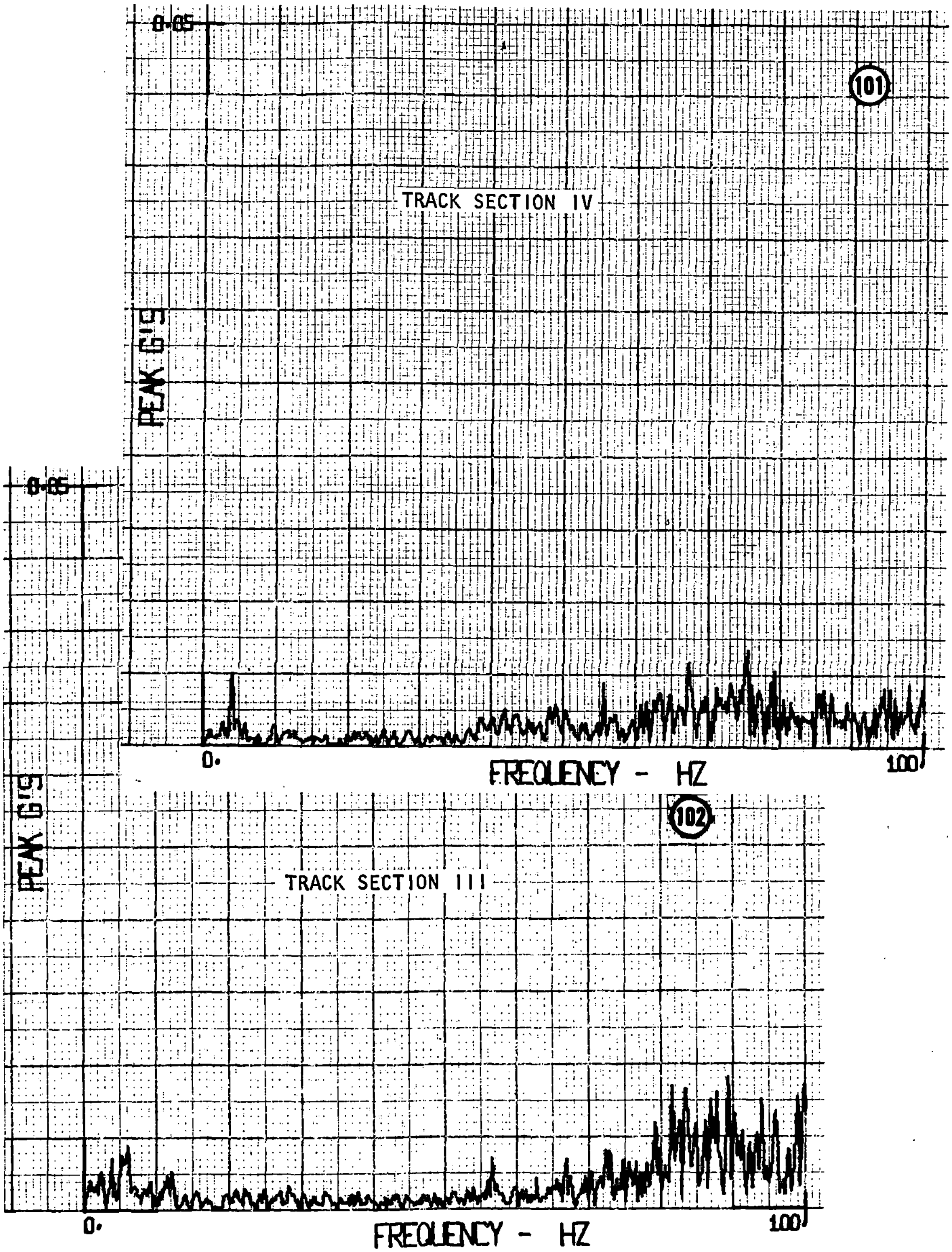


Figure 6-16. Forward Car Body Longitudinal Vibration - AW3 (Sheet 2)

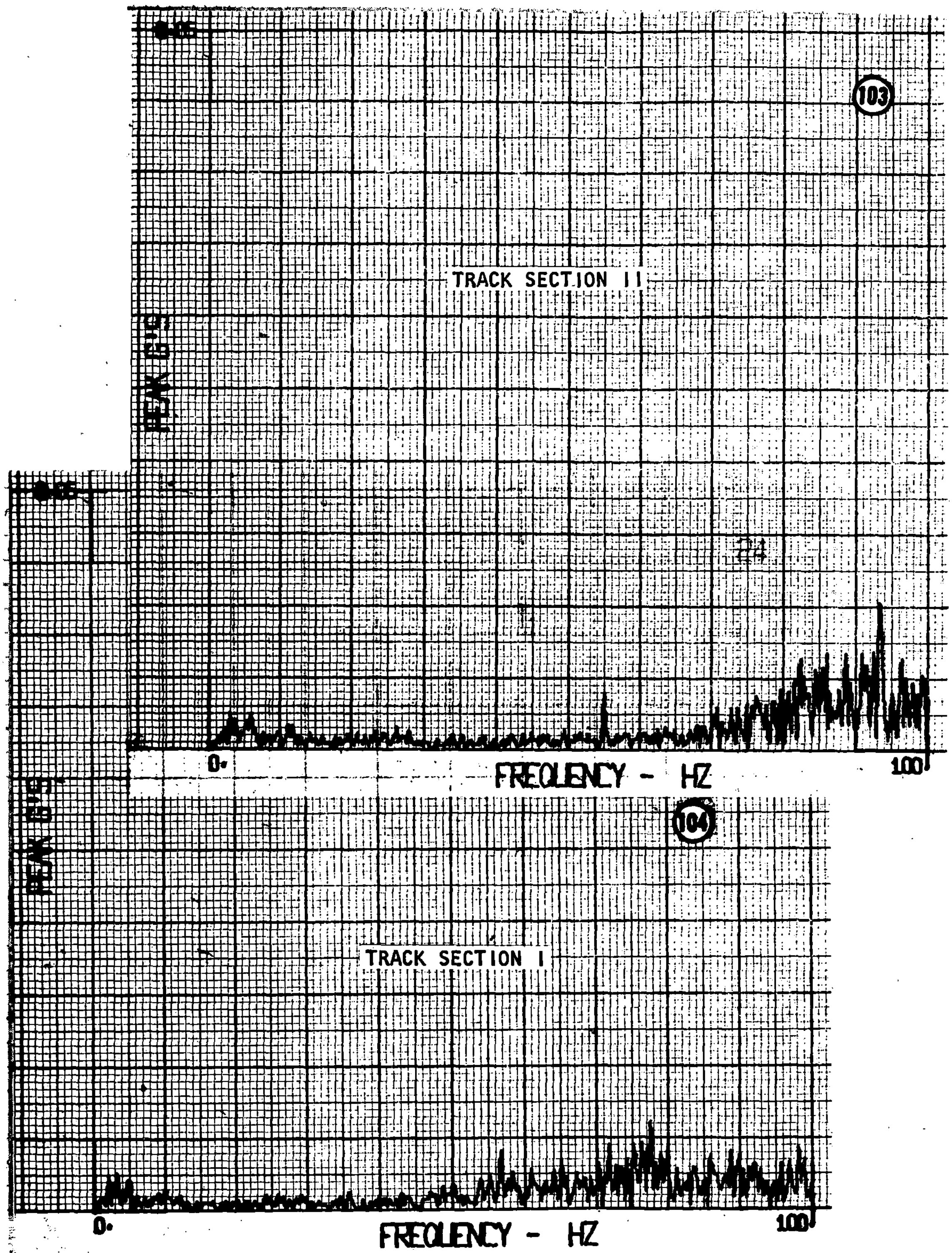


Figure 6-16. Forward Car Body Longitudinal Vibration - AW3 (Sheet 3)

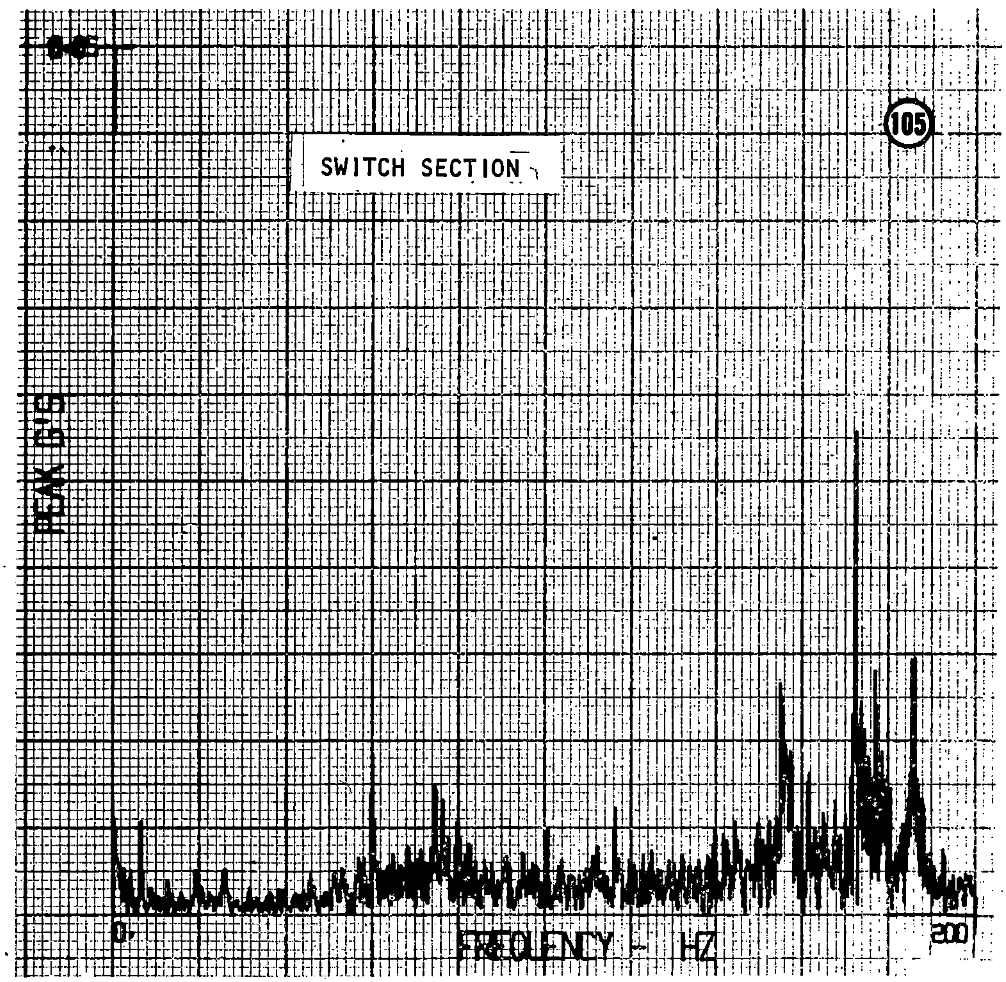


Figure 6-16. Forward Car Body Longitudinal Vibration - AW3 (Sheet 4)

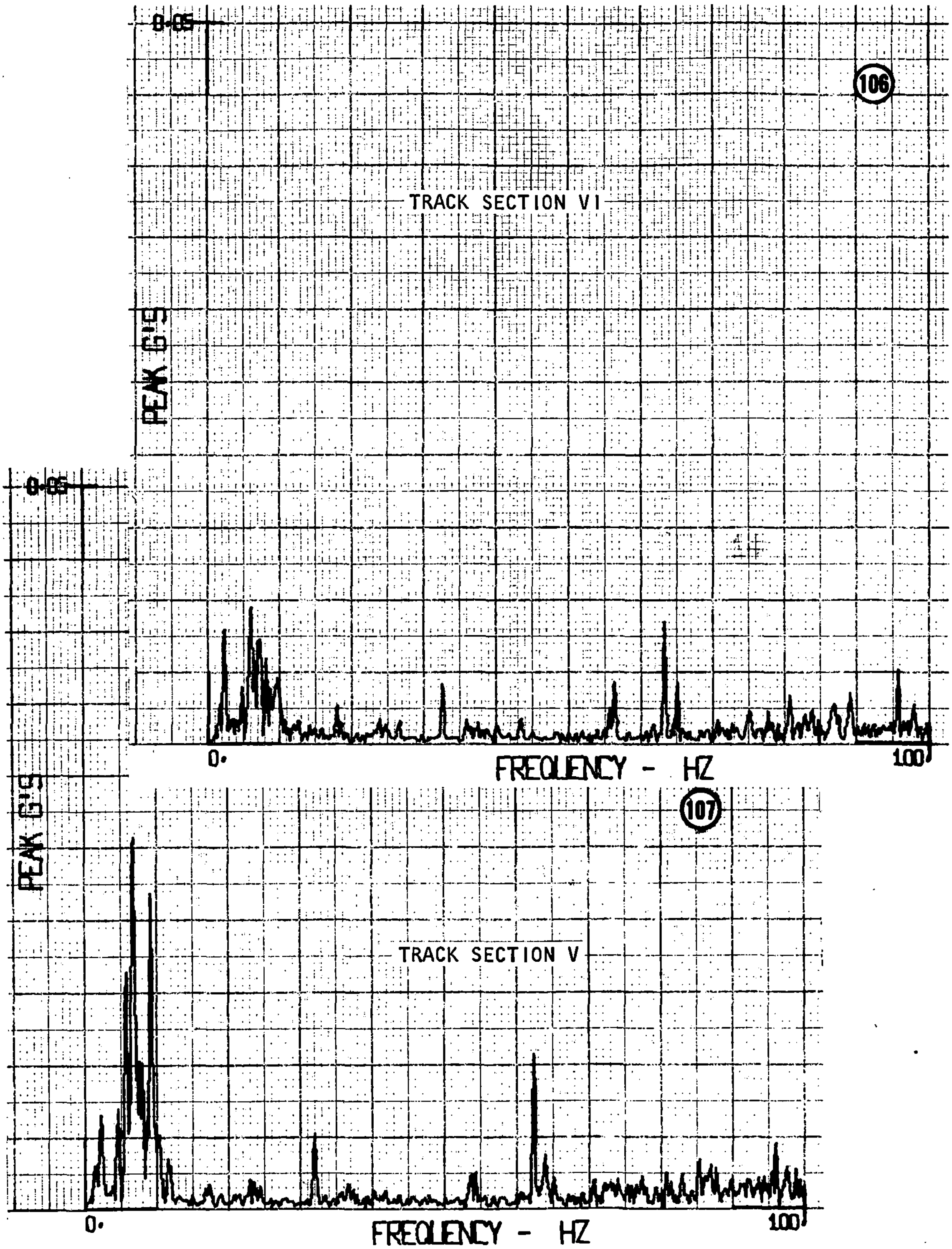
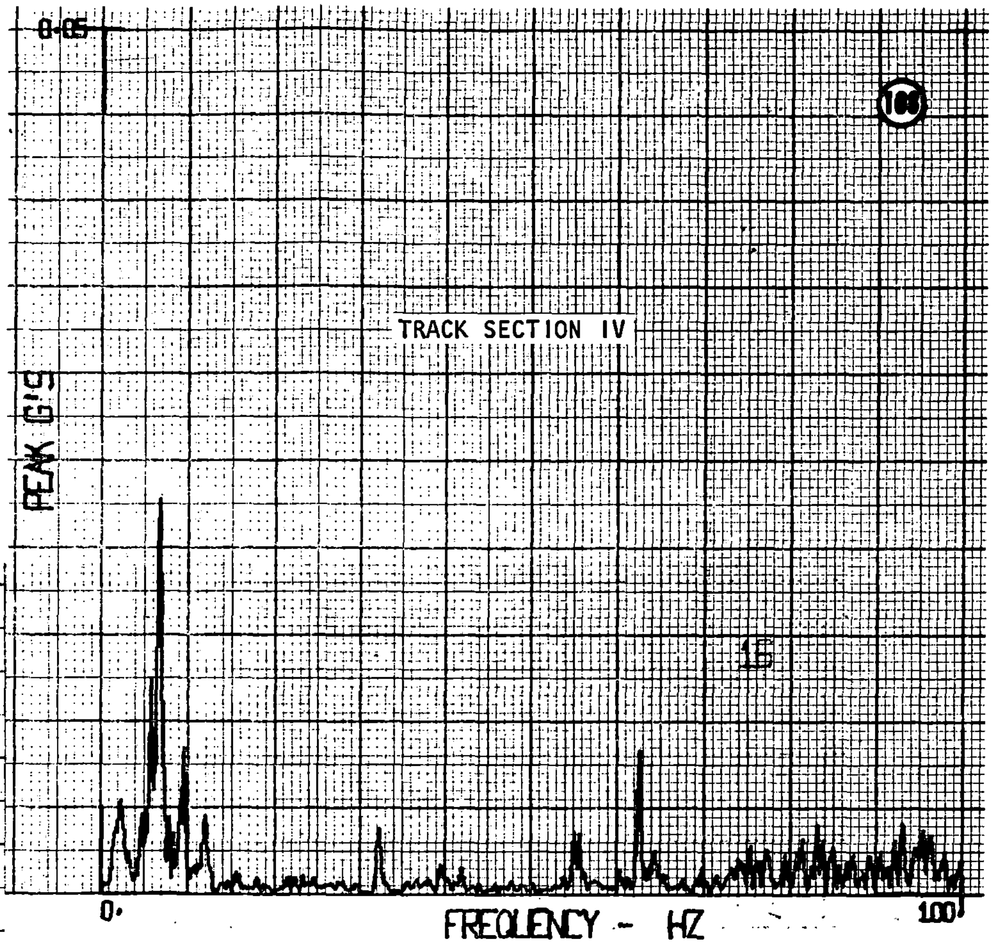


Figure 6-17. Mid Car Body Vertical Vibration - AW3 (Sheet 1)



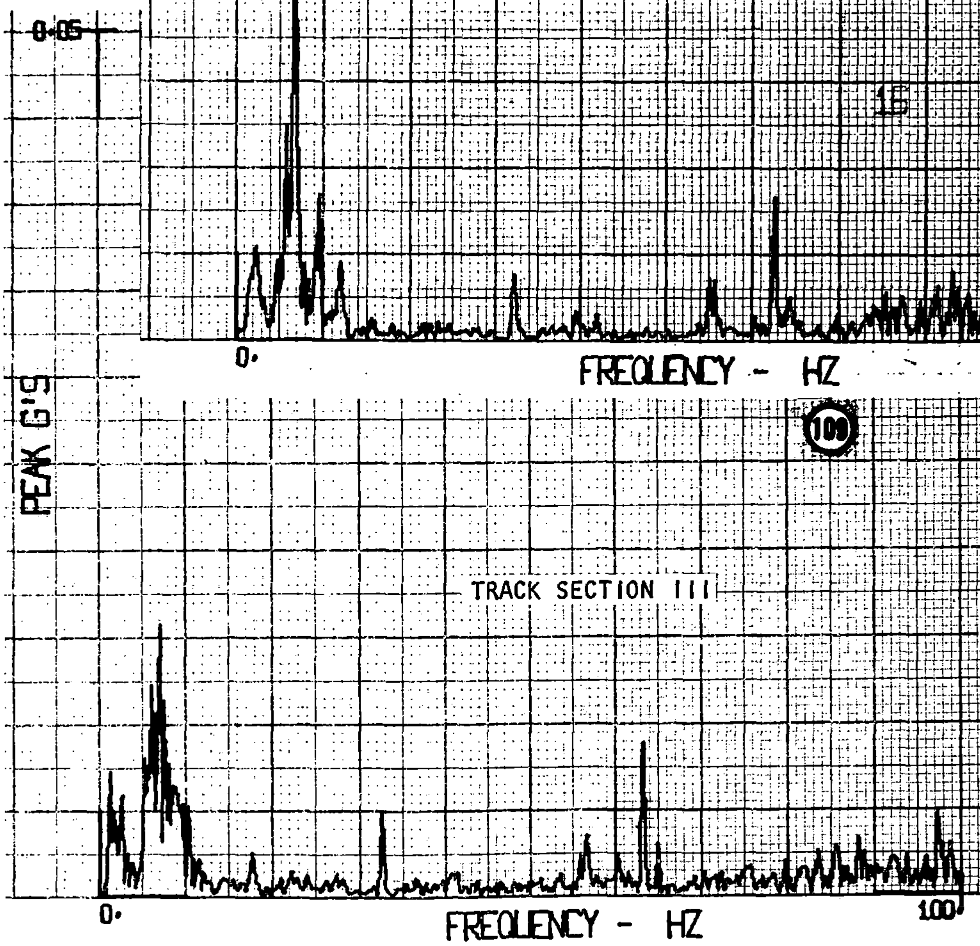


Figure 6-17. Mid Car Body Vertical Vibration - AW3 (Sheet 2)

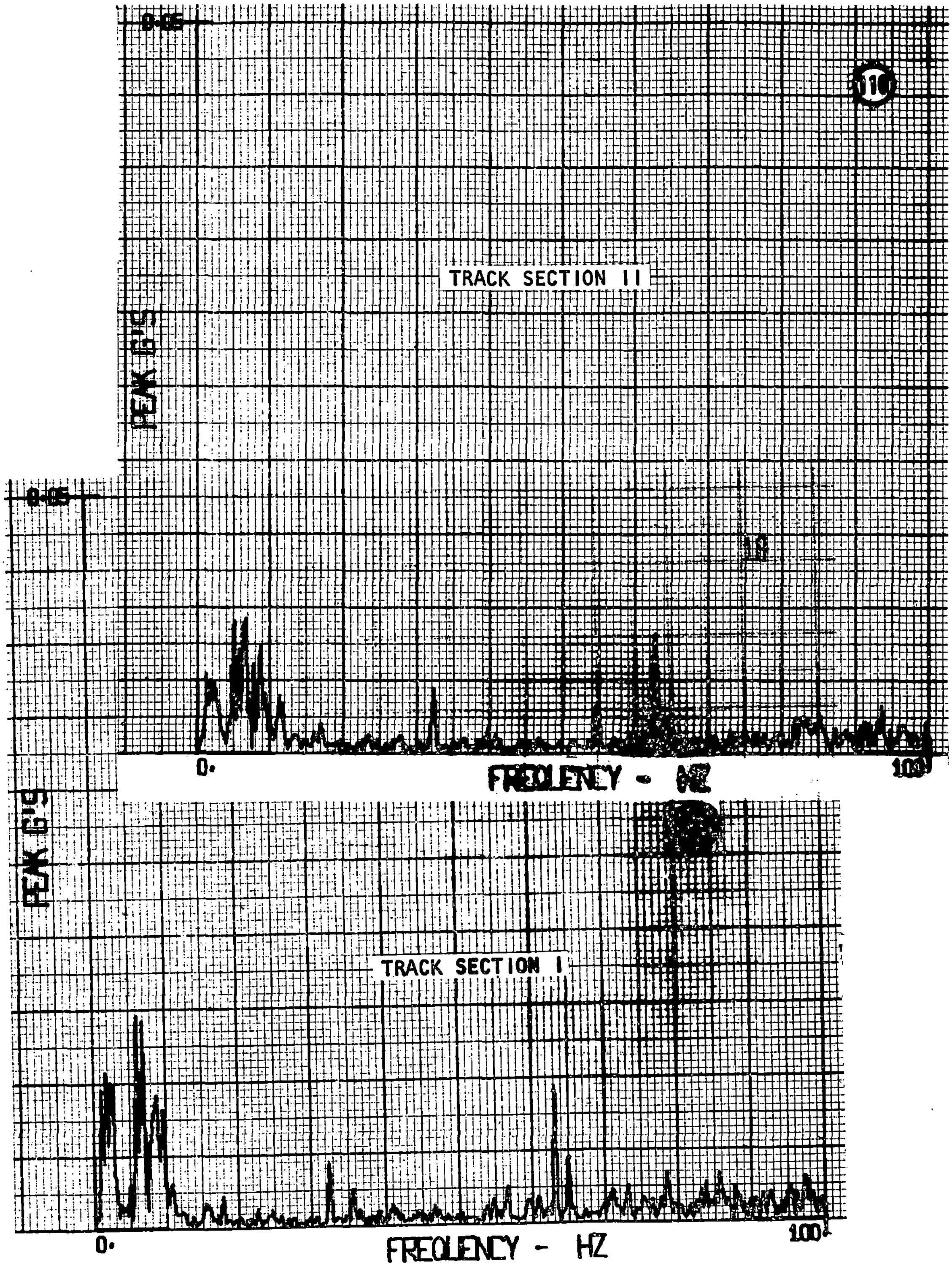


Figure 6-17. Mid Car Body Vertical Vibration - AW3 (Sheet 3)

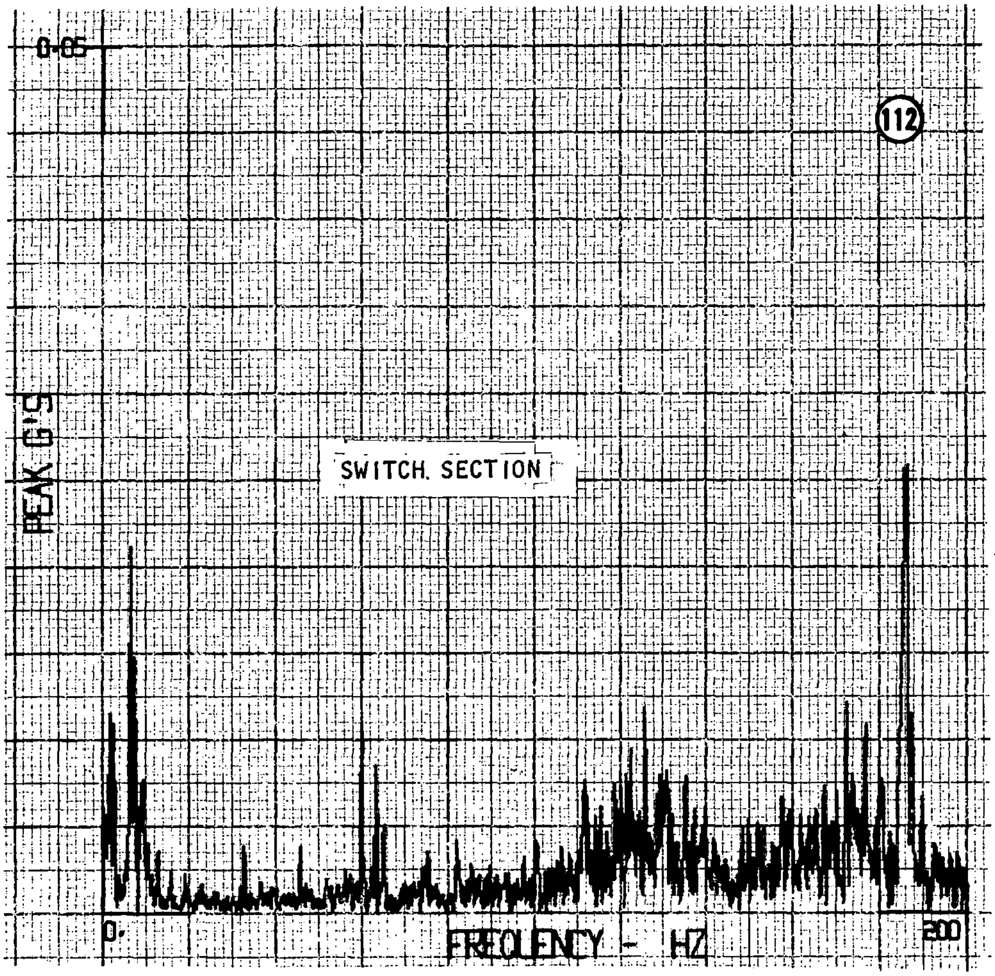


Figure 6-17. Mid Car Body Vertical Vibration - AW3 (Sheet 4)

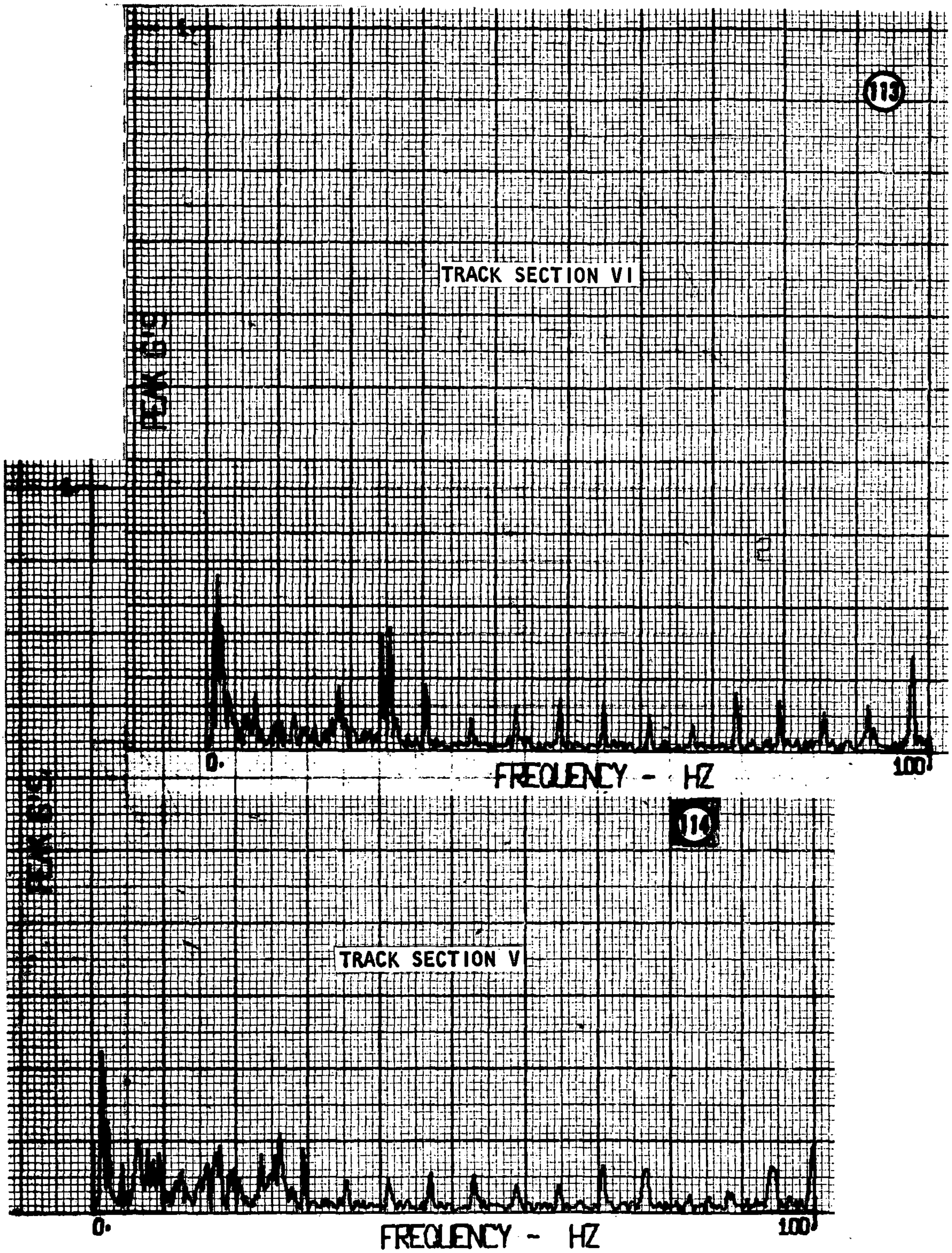


Figure 6-18. Lead Axle Vertical Vibration - AW3 (Sheet 1)

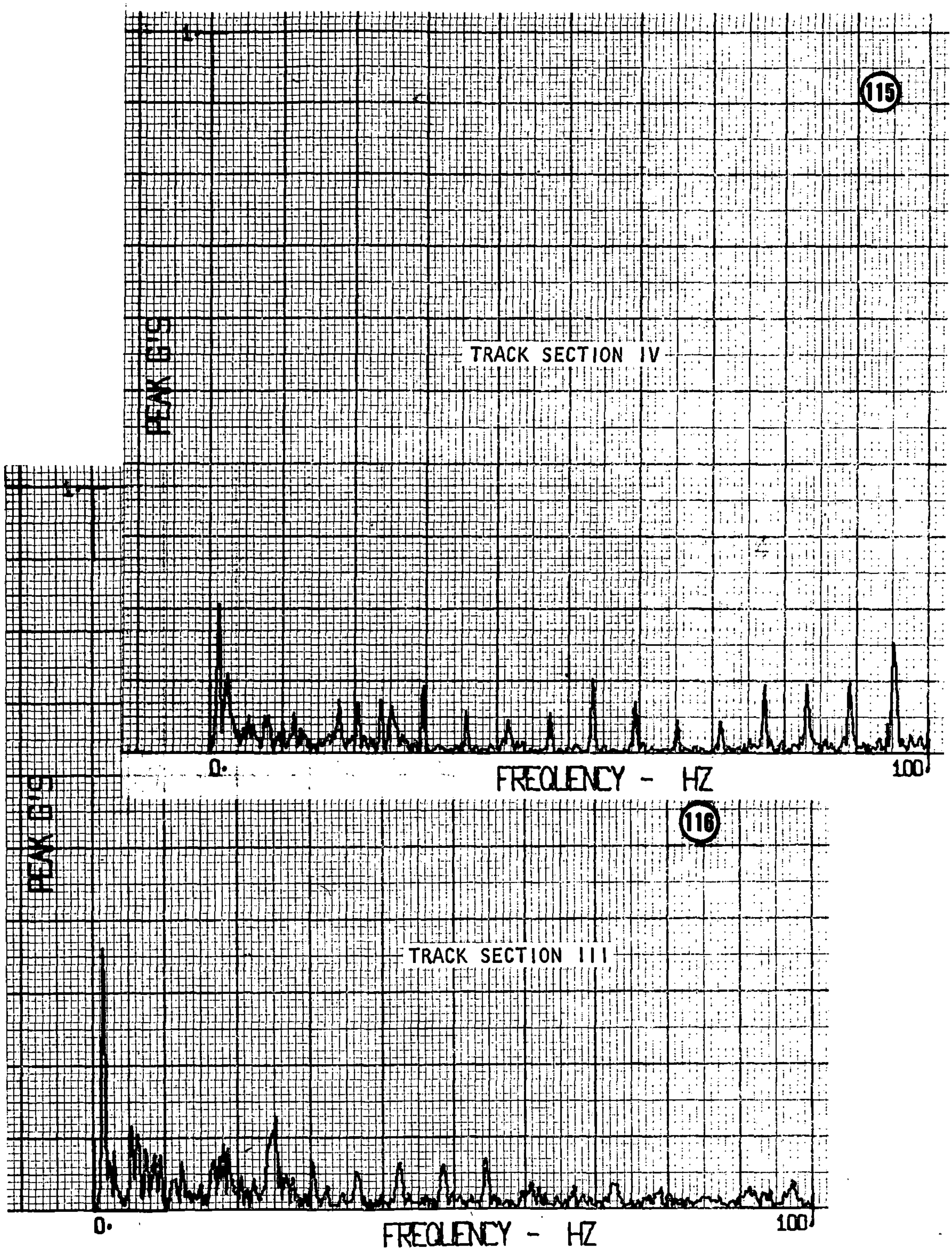
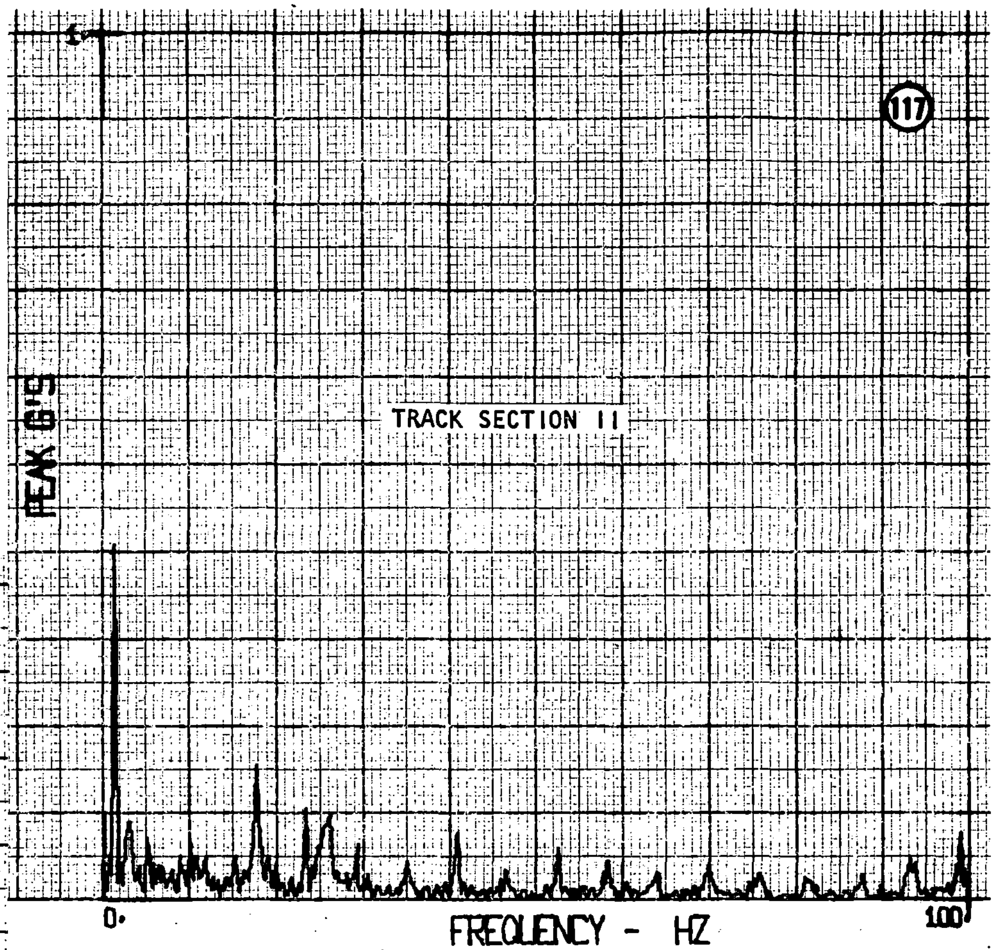


Figure 6-18. Lead Axle Vertical Vibration - AW3 (Sheet 2)



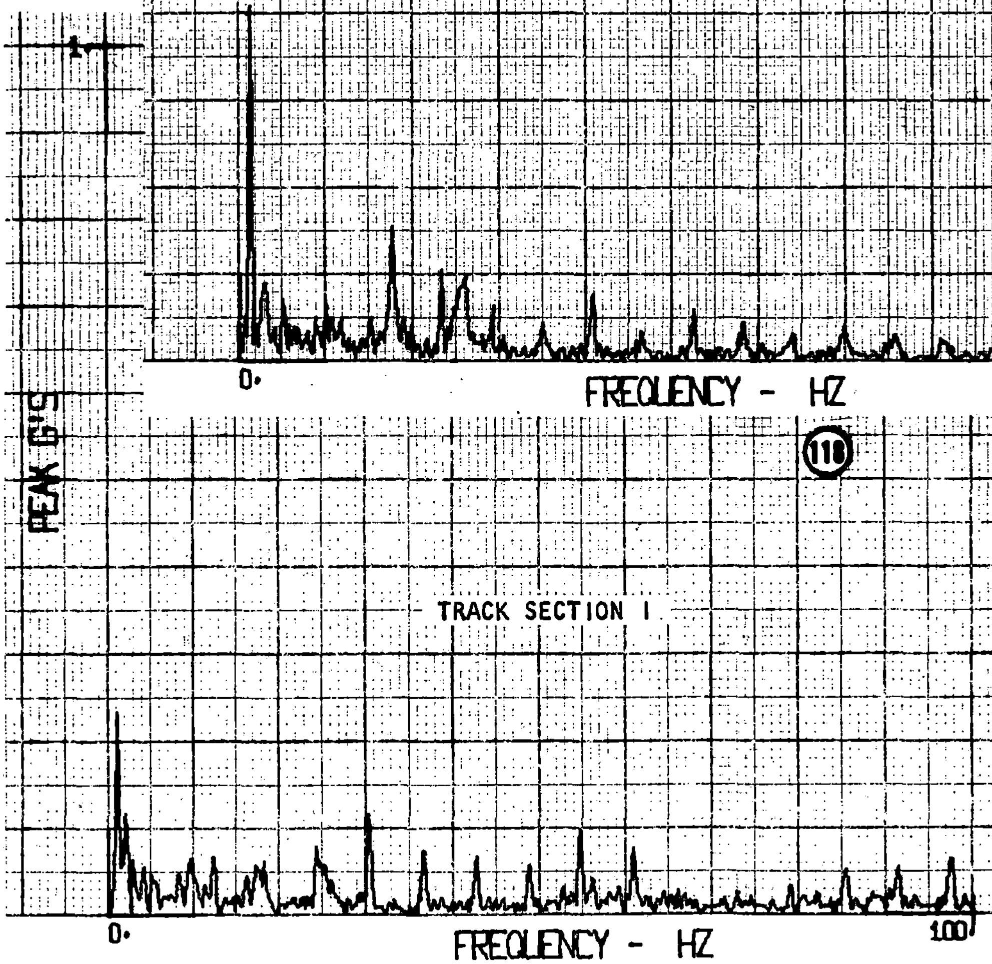


Figure 6-18. Lead Axle Vertical Vibration - AW3 (Sheet 3)

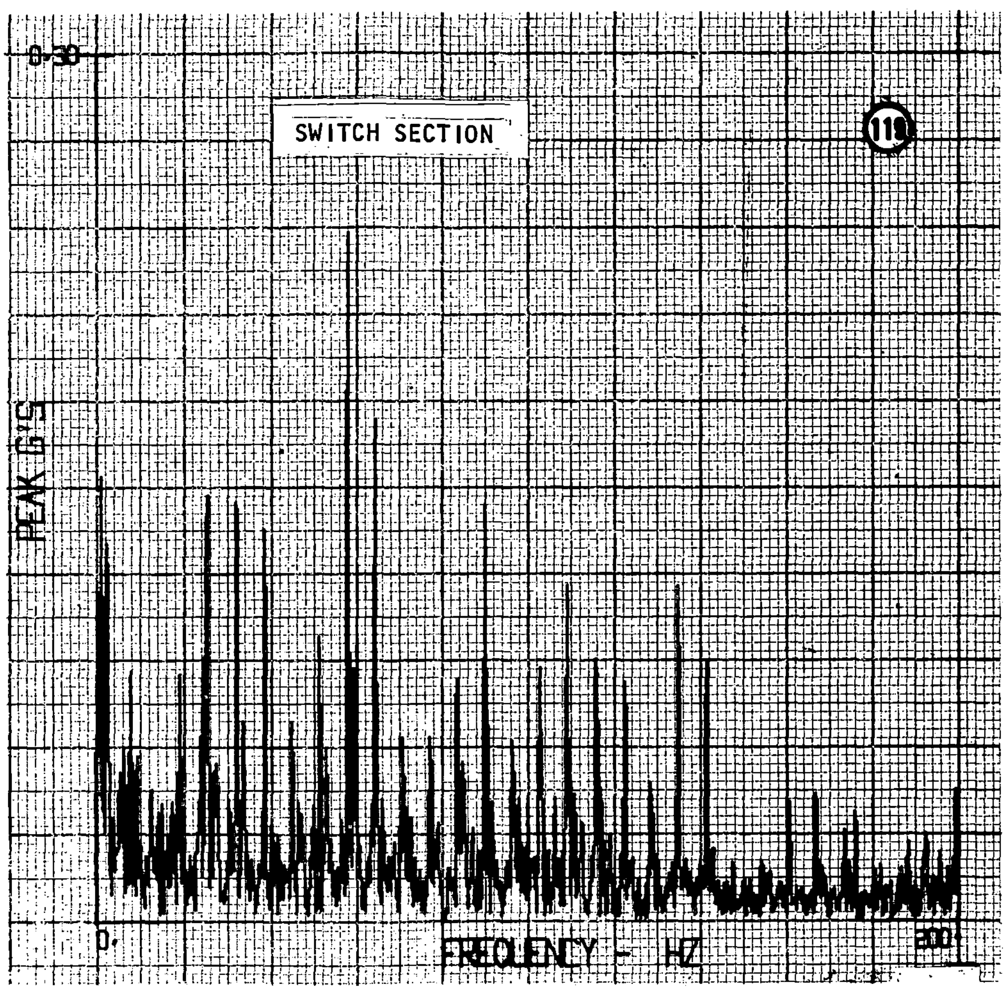


Figure 6-18. Lead Axle Vertical Vibration - AW3 (Sheet 4)

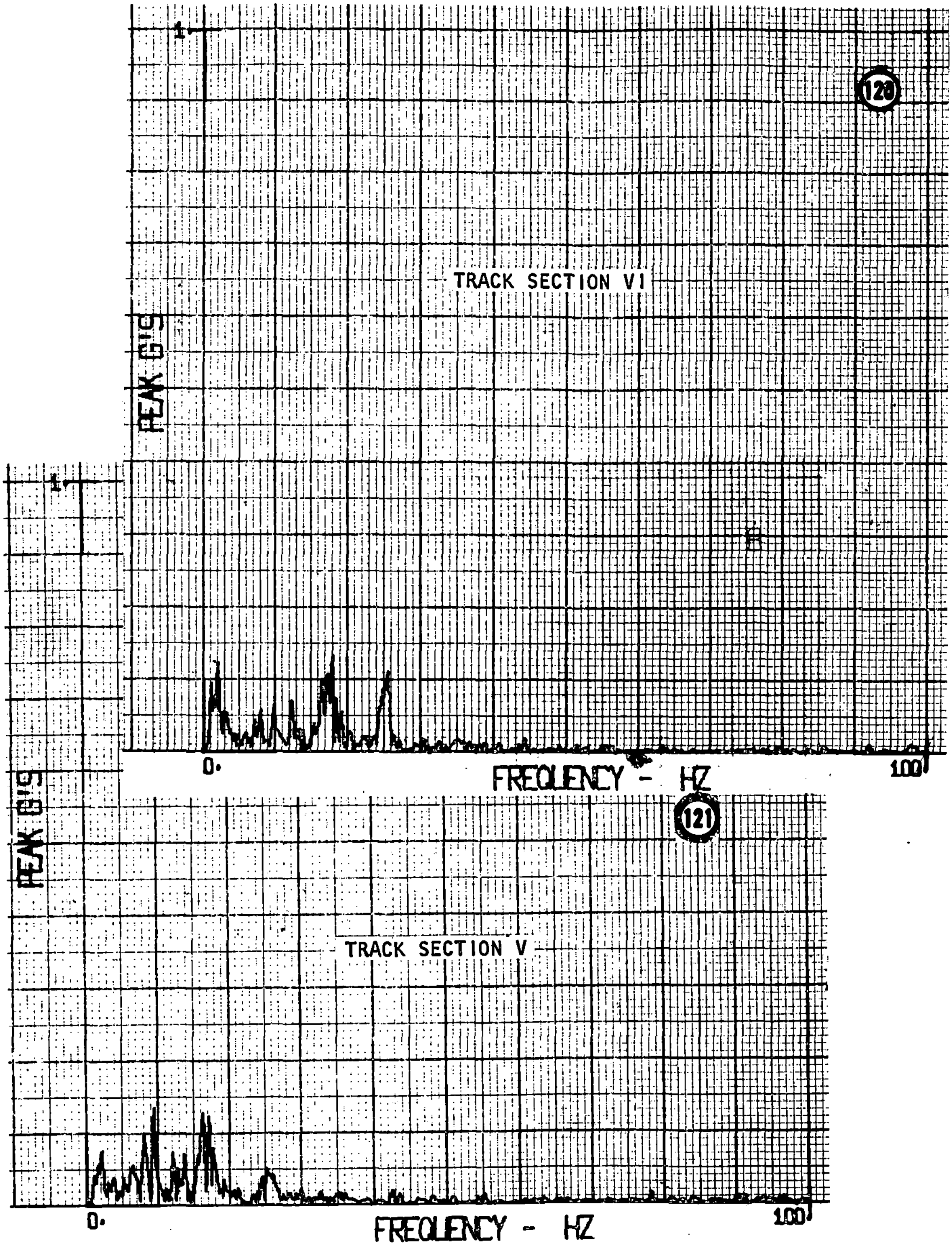


Figure 6-19. Lead Axle Lateral Vibration - AW3 (Sheet 1)

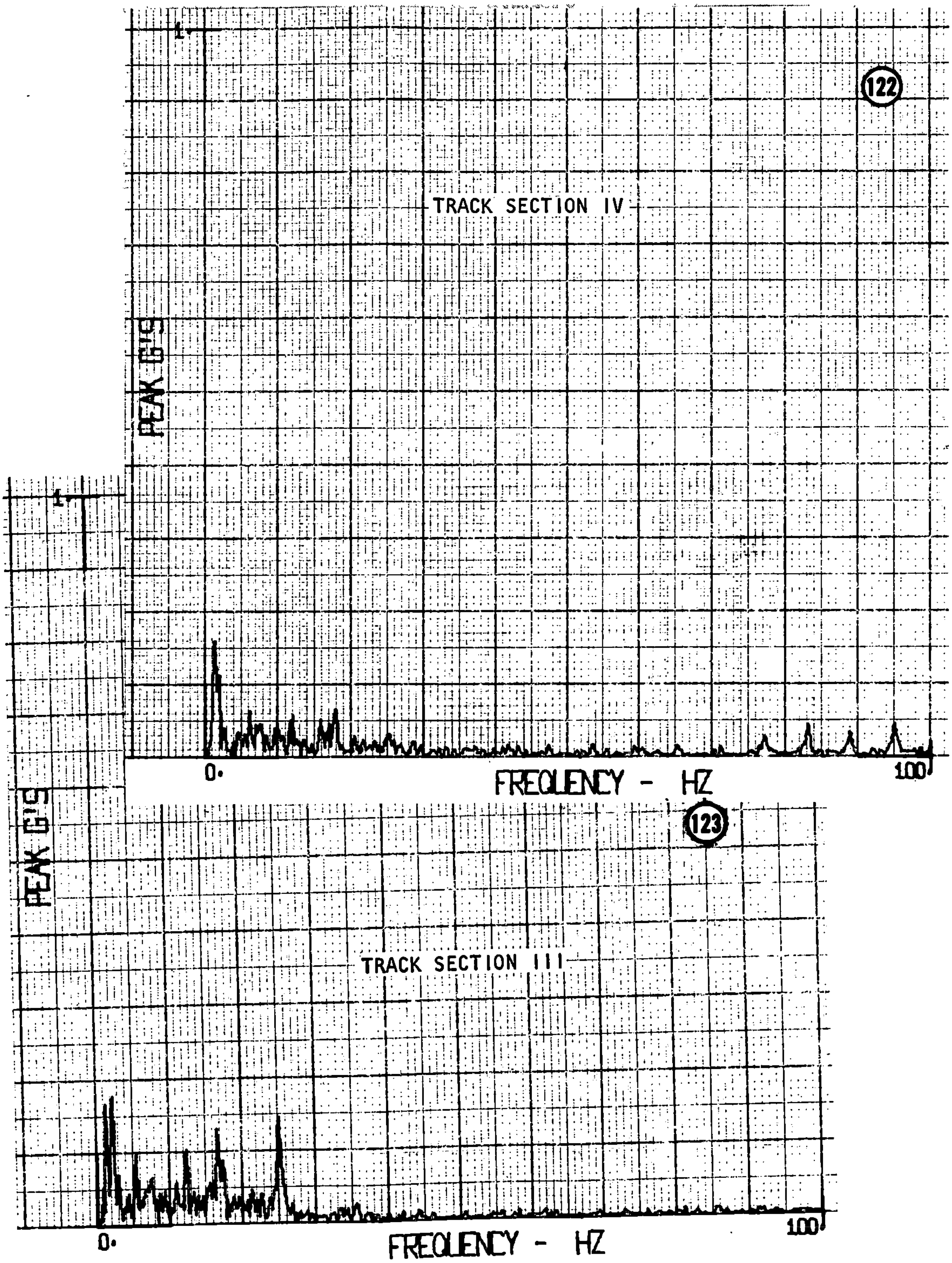


Figure 6-19. Lead Axle Lateral Vibration - AW3 (Sheet 2)

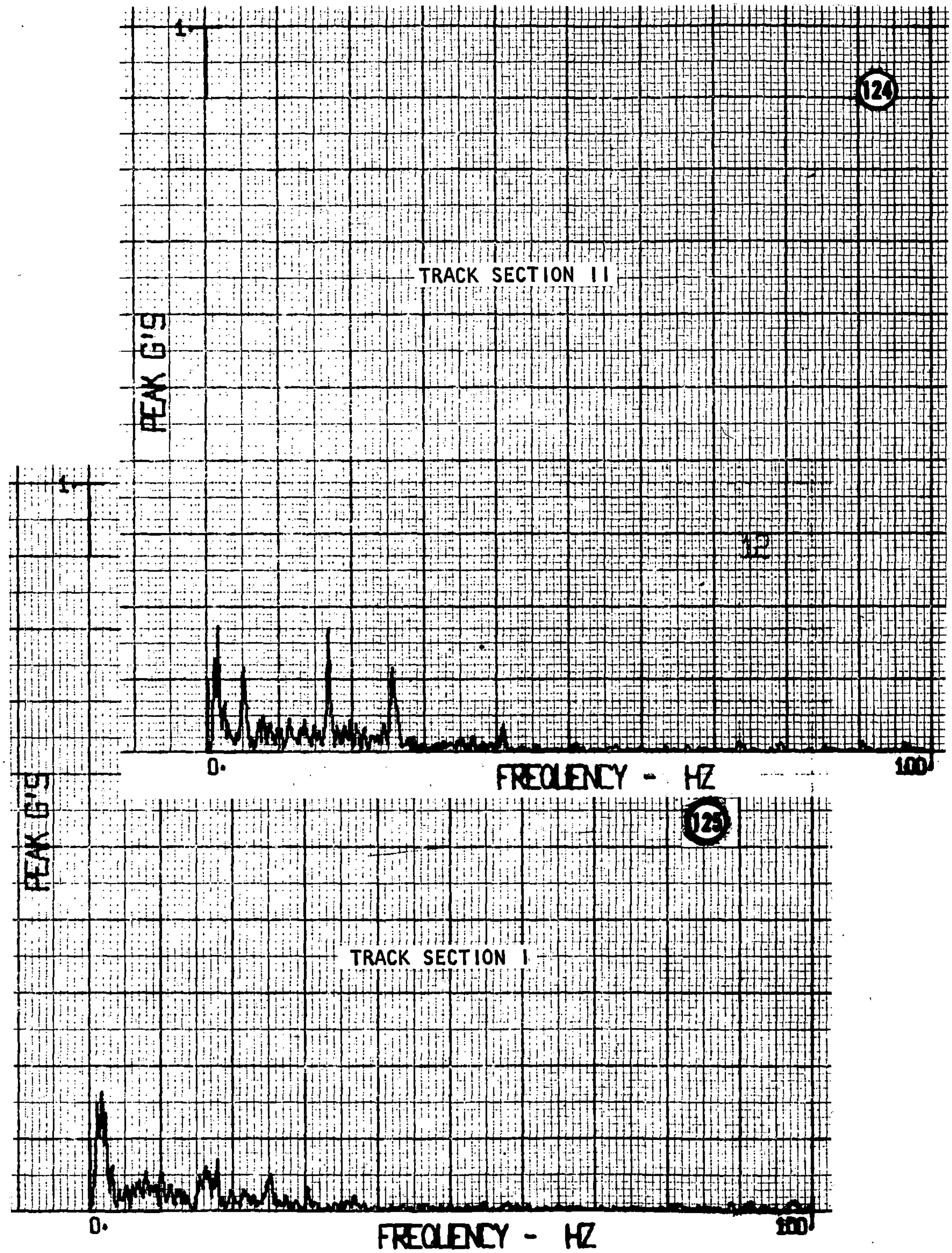


Figure 6-19. Lead Axle Lateral Vibration - AW3 (Sheet 3)

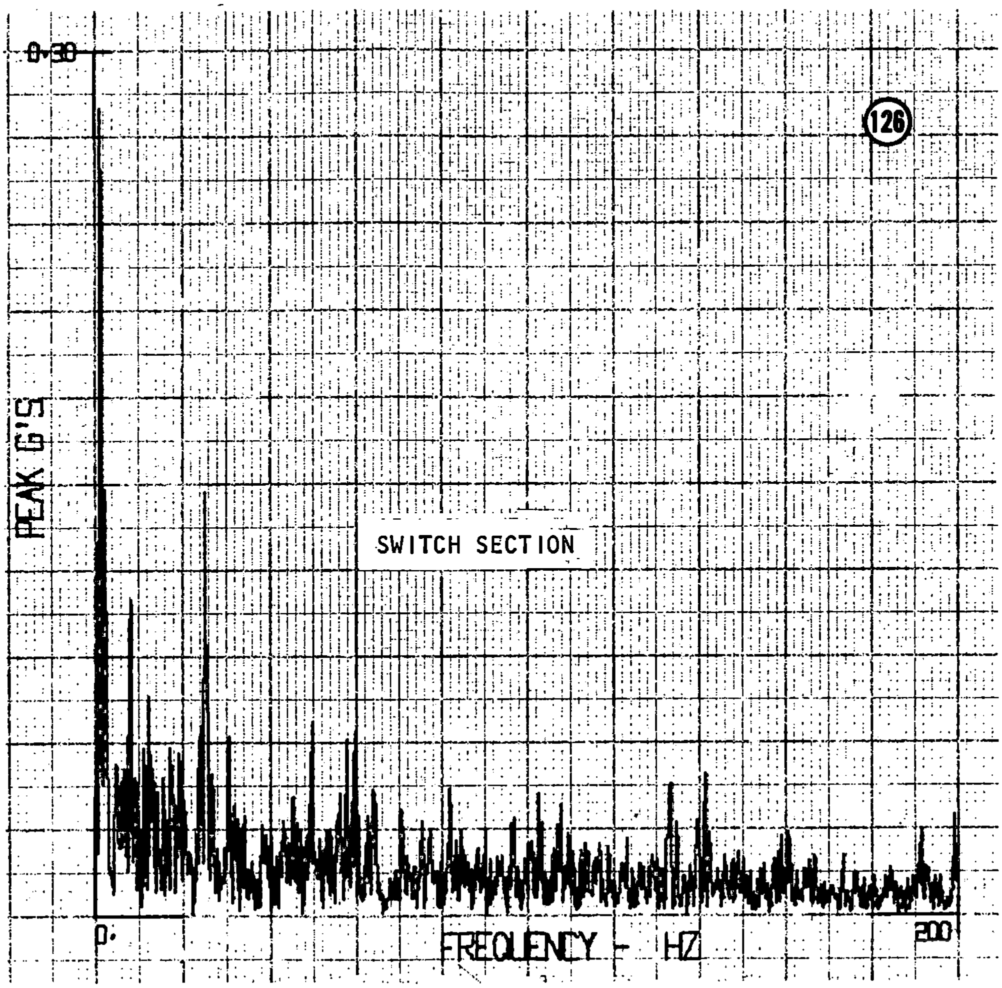


Figure 6-19. Lead Axle Lateral Vibration - AW3 (Sheet 4)

7. RIDE ROUGHNESS - ACCELERATION
(ESC-R-2001-TT)

7.1 SUMMARY

The ride roughness acceleration test was conducted in compliance with Test Set Number ESC-R-2001-TT of the TSC General Vehicle Test Plan, GSP-064. Requirements and procedures covered by this test set are defined in paragraphs 7.1.1 through 7.2.2. Refer to paragraph 7.3 for a description of the test, instrumentation used, and for the test results.

7.1.1 TEST OBJECTIVE

To determine the most severe vibration levels encountered during car acceleration.

7.1.2 TEST DESCRIPTION

This test will be performed on Track Section I and the test vehicle weights will be AW0, AW2 and AW3.

7.1.3 STATUS

The energy storage cars successfully completed the acceleration tests as prescribed by the conditions specified in paragraph 7.1.2. Refer to test log runs 73, 78 and 79 presented in Volume I, Appendix C of this report.

7.2 PROCEDURES

The following test procedures are included as part of the ESC-R-2001-TT Test Set. The ESC tests were performed generally in accordance with these procedures and any procedural differences are reflected in paragraph 7.3.

7.2.1 PRETEST PROCEDURE

(a) Install and check out required equipment

(b) Photograph placement of sensors

(c) Calibrate all instrumentation, data processing and acquisition equipment

7.2.2 TEST PROCEDURE

(a) Turn on all car auxiliary equipment and make note of equipment operation

(b) Proceed to start location and stop vehicles (Location 120 CW or Location 150 CCW)

(c) Start recorders and provide record number

(d) Initiate full acceleration and maintain

(e) Provide event mark at first motion

(f) Provide event marks at selected speeds and at maximum speed

(g) Stop recorder

(h) Stop vehicle

7.3 TEST DESCRIPTION AND RESULTS

The energy storage car (ESC) ride roughness acceleration tests were conducted in accordance with AiResearch Document 74-10441 as defined in paragraph 7.3.1 and in compliance with GSP-064 Test Set ESC-R-2001-TT, described in paragraphs 7.1.1 and 7.1.2.

7.3.1 DESCRIPTION

The ESC acceleation tests were performed in conjunction with the deceleration tests described in Section 8. The acceleration portion of the test was performed on Track Section I at vehicle test weight of AW0, AW2 and AW3 at the full acceleration rate. Six vibration channels were recorded from sensors located as follows:

(a) Forward car body - vertical

(b) Forward car body - lateral

(c) Forward car body - longitudinal

(d) Mid car body - vertical

(e) Lead axle - vertical

(f) lead axle - lateral

The test was performed using the procedures described in paragraph 7.2.

7.3.2 INSTRUMENTATION

Block diagrams of the data acquisition system and the data recovery system are provided in figures 1-1 and 1-2. Details of the instrumentation related to the acceleration tests is shown in figure 1-4. Information concerning instrumentation for overall data acquisition for the energy storage car tests is described in Volume I of this report.

7.3.3 RESULTS

Representative samples of the acceleration test results for AW0, AW2 and AW3 car weights are shown in figures 7-1, 7-2 and 7-3 respectively.

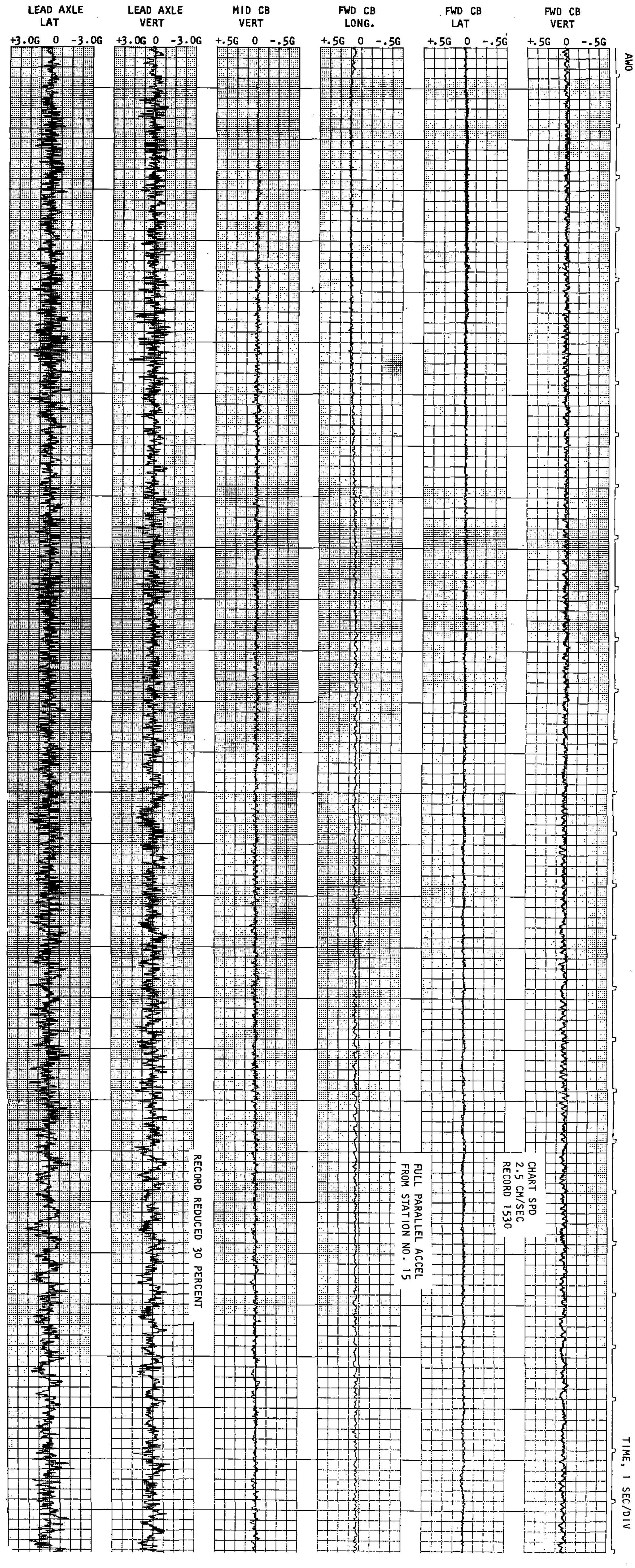


Figure 7-1. Ride Roughness Acceleration Test - AWO (Sheet 1)

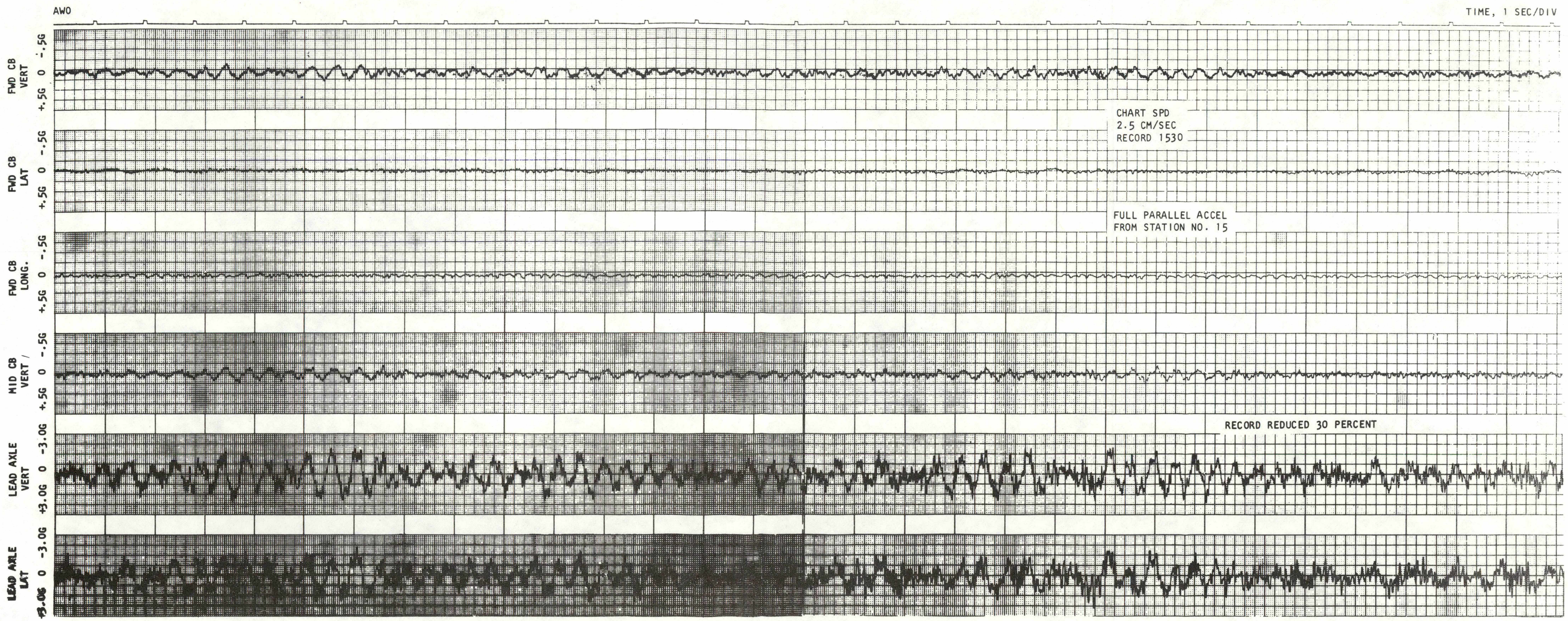


Figure 7-1. Ride Roughness Acceleration Test - AWO (Sheet 2)

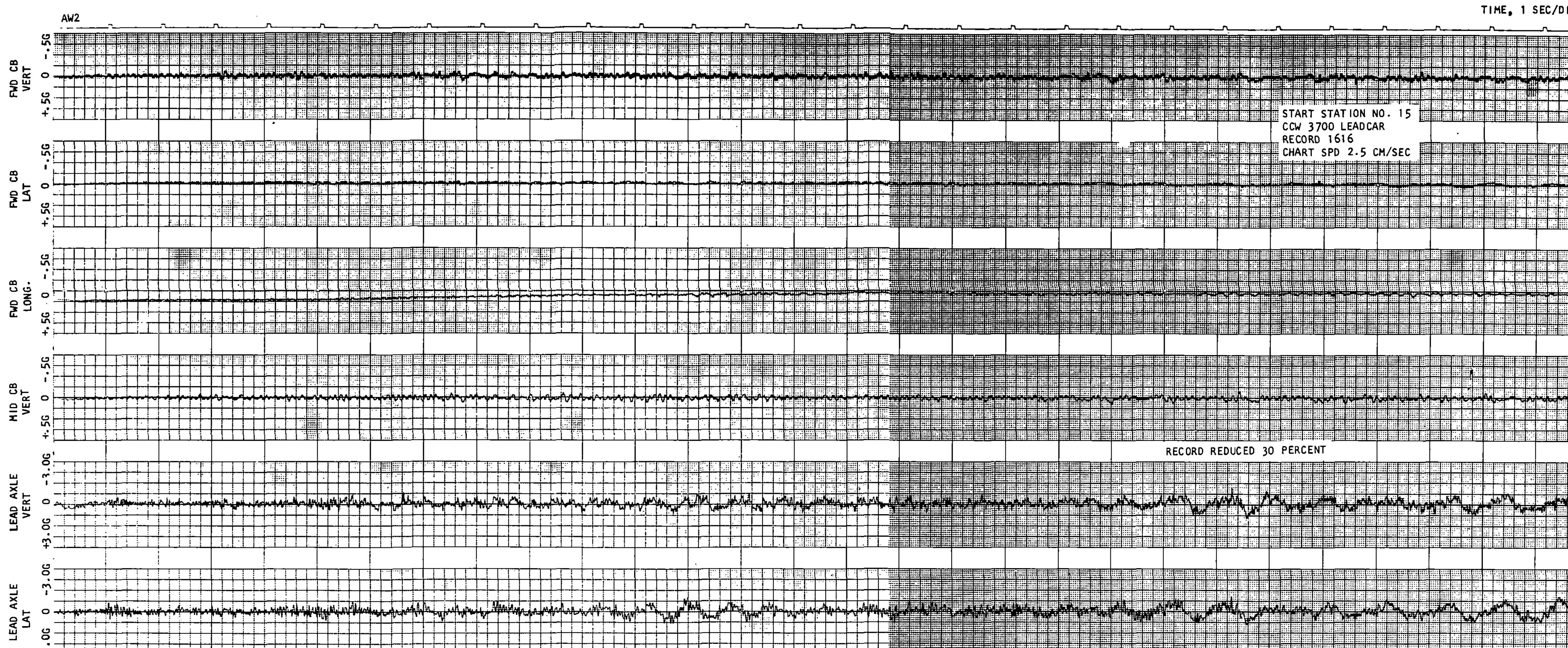


Figure 7-2. Ride Roughness Acceleration Test - AW2 (Sheet 1)

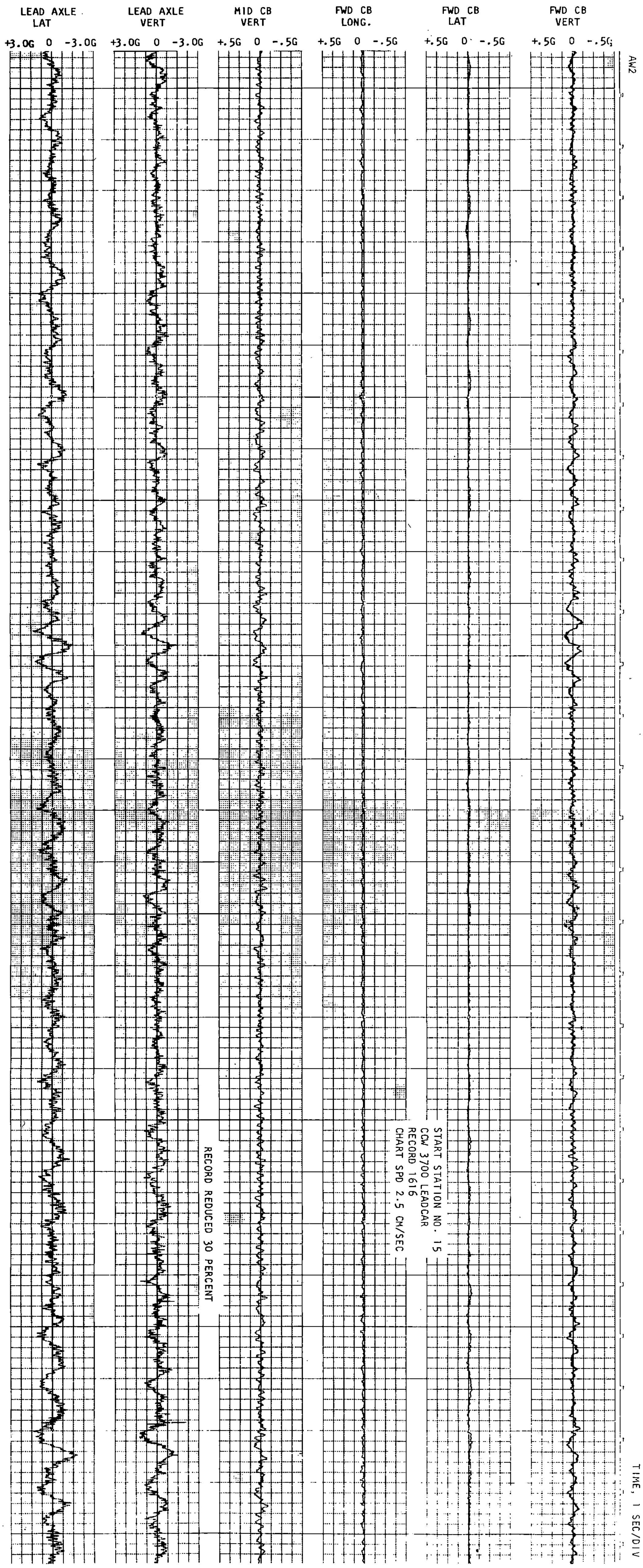


Figure 7-2. Ride Roughness Acceleration Test - AW2 (Sheet 2)

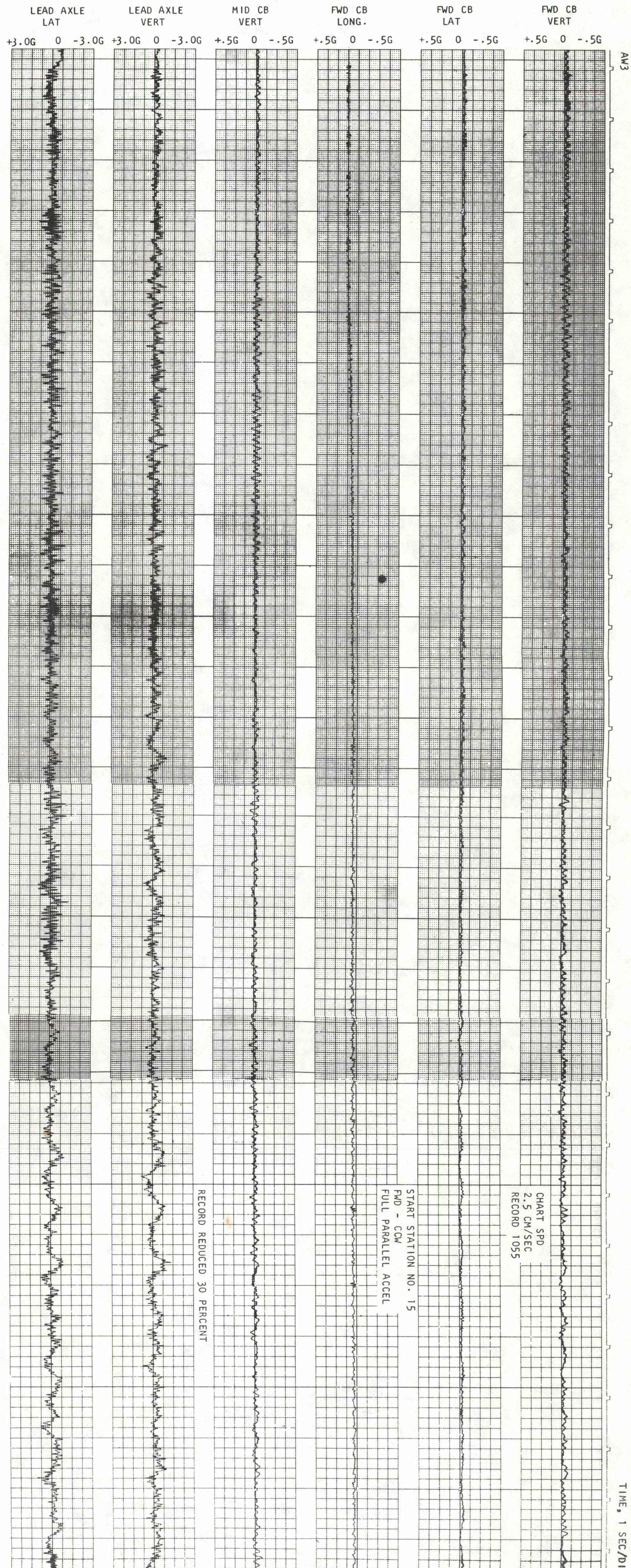


Figure 7-3. Ride Roughness Acceleration Test - AW3 (Sheet 1)

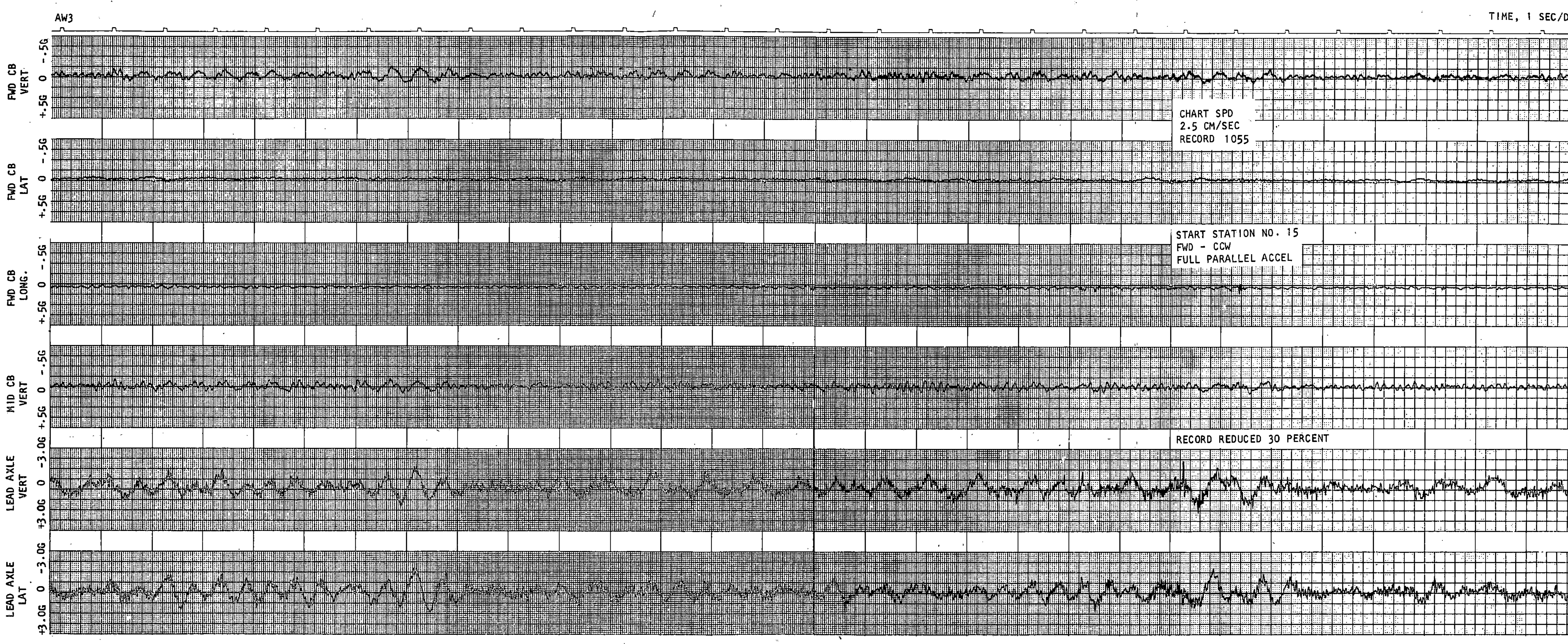


Figure 7-3. Ride Roughness Acceleration Test - AW3 (Sheet 2)

8. RIDE ROUGHNESS - DECELERATION (ESC-R-3001-TT)

8.1 SUMMARY

The ride roughness deceleration test was conducted in compliance with Test Set Number ESC-R-3001-TT of the TSC General Vehicle Test Plan, GSP-064. Requirements and procedures covered by the test set are defined in paragraphs 8.1.1 through 8.2.2. Refer to paragraph 8.3 for a description of the test, instrumentation used, and the test results.

8.1.1 TEST OBJECTIVE

To determine the most severe vibration levels encountered during car deceleration.

8.1.2 TEST DESCRIPTION

This test will be performed on Track Section I and the test vehicle weights will be AW0, AW2 and AW3.

8.1.3 STATUS

The energy storage cars successfully completed the deceleration tests as prescribed by the conditions specified in paragraph 8.1.2. Refer to test log runs 73, 78 and 79 presented in Volume I, Appendix C of this report.

8.2 PROCEDURES

The following test procedures are included as part of the ESC-R-3001-TT Test Set. The ESC tests were performed generally in accordance with these procedures and any procedural differences are reflected in paragraph 8.3.

8.2.1 PRETEST PROCEDURE

(a) Install and check out required equipment

(b) Photograph placement of sensors

(c) Calibrate all instrumentation, data acquisition and processing equipment

8.2.2 TEST PROCEDURE

(a) Turn on all car auxiliary equipment and make note of equipment operation

(b) Proceed to start location at maximum speed (Location 120 CW or 150 CCW)

(c) Start recorder and provide record number

(d) Initiate full service brake, blended or friction braking as required

(e) Provide an event mark at initiation of braking

(f) Provide an event mark at complete stop

(g) Stop recorder

8.3 TEST DESCRIPTION AND RESULTS

The energy storage car (ESC) ride roughness deceleration tests were conducted in accordance with AiResearch Document 74-10441 as defined in paragraph 8.3.1 and in compliance with GSP-064 Test SEt ESC-R-3001-TT, described in paragraphs 8.1.1 and 8.1.2.

8.3.1 DESCRIPTION

The ESC deceleration tests were performed in conjunction with the acceleration tests described in Section 7. The deceleration portion of the test was performed on Track Section I at vehicle test weight of AW0, AW2 and AW3 using the full service brake system for braking. Six vibration channels were recorded from sensors located as follows:

(a) Forward car body - vertical

(b) Forward car body - lateral

(c) Forward car body - longitudinal

(d) Mid car body - vertical

(e) Lead axle - vertical

(f) Lead axle - lateral

The test was performed using the procedures described in paragraph 8.2.

8.3.2 INSTRUMENTATION

Block diagrams of the data acquisition system and the data recovery system are provided in figures 1-1 and 1-2. Details of the instrumentation related to the acceleration tests is shown in figure 1-4. Information concerning instrumentation for overall data acquisition for the energy storage car tests is described in Volume I of this report.

8.3.3 RESULTS

Representative samples of the deceleration test results for AW0, AW2 and AW3 car weights are shown in figures 8-1, 8-2 and 8-3 respectively.

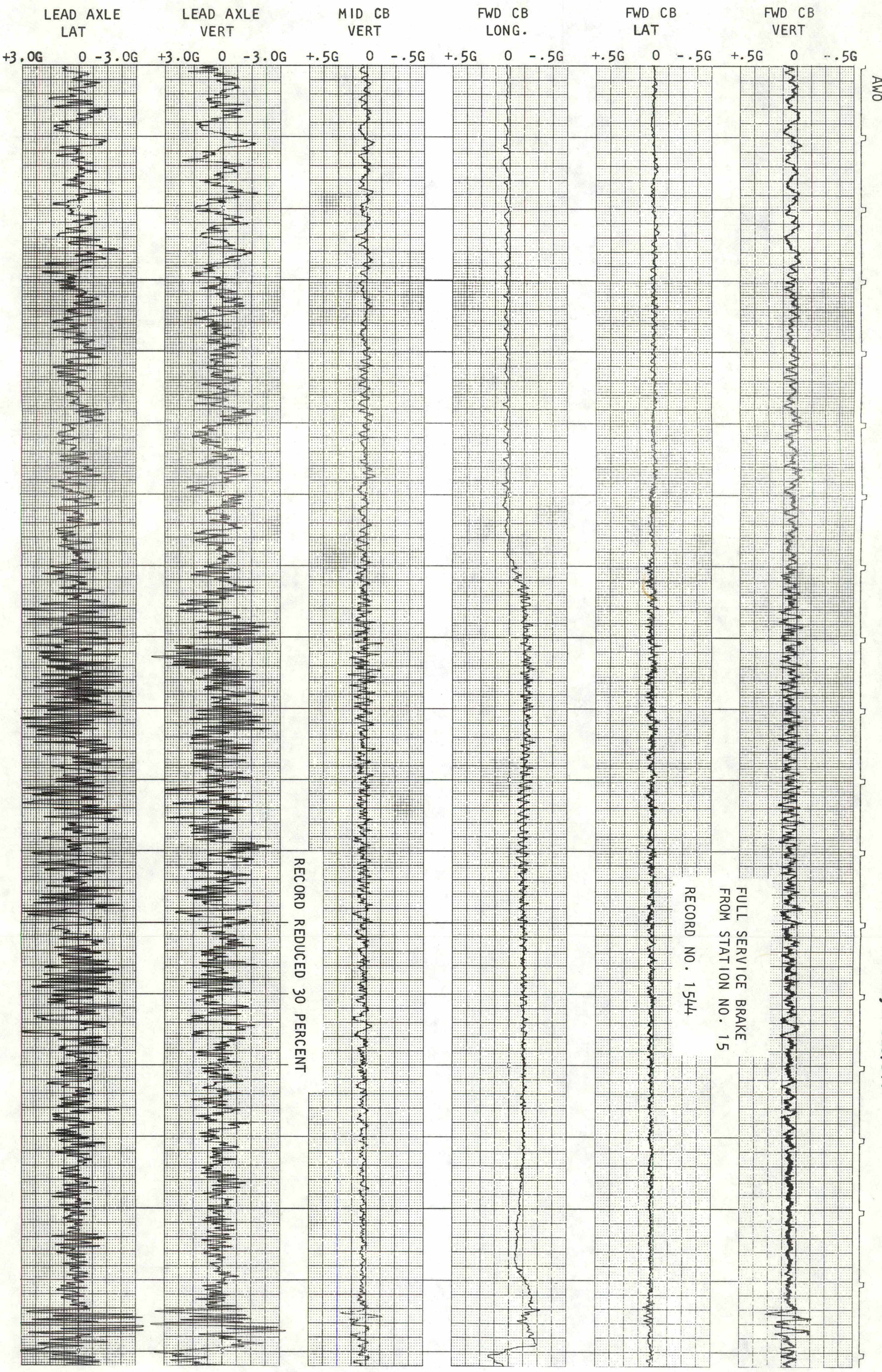


Figure 8-1. Ride Roughness Deceleration Test - AWO

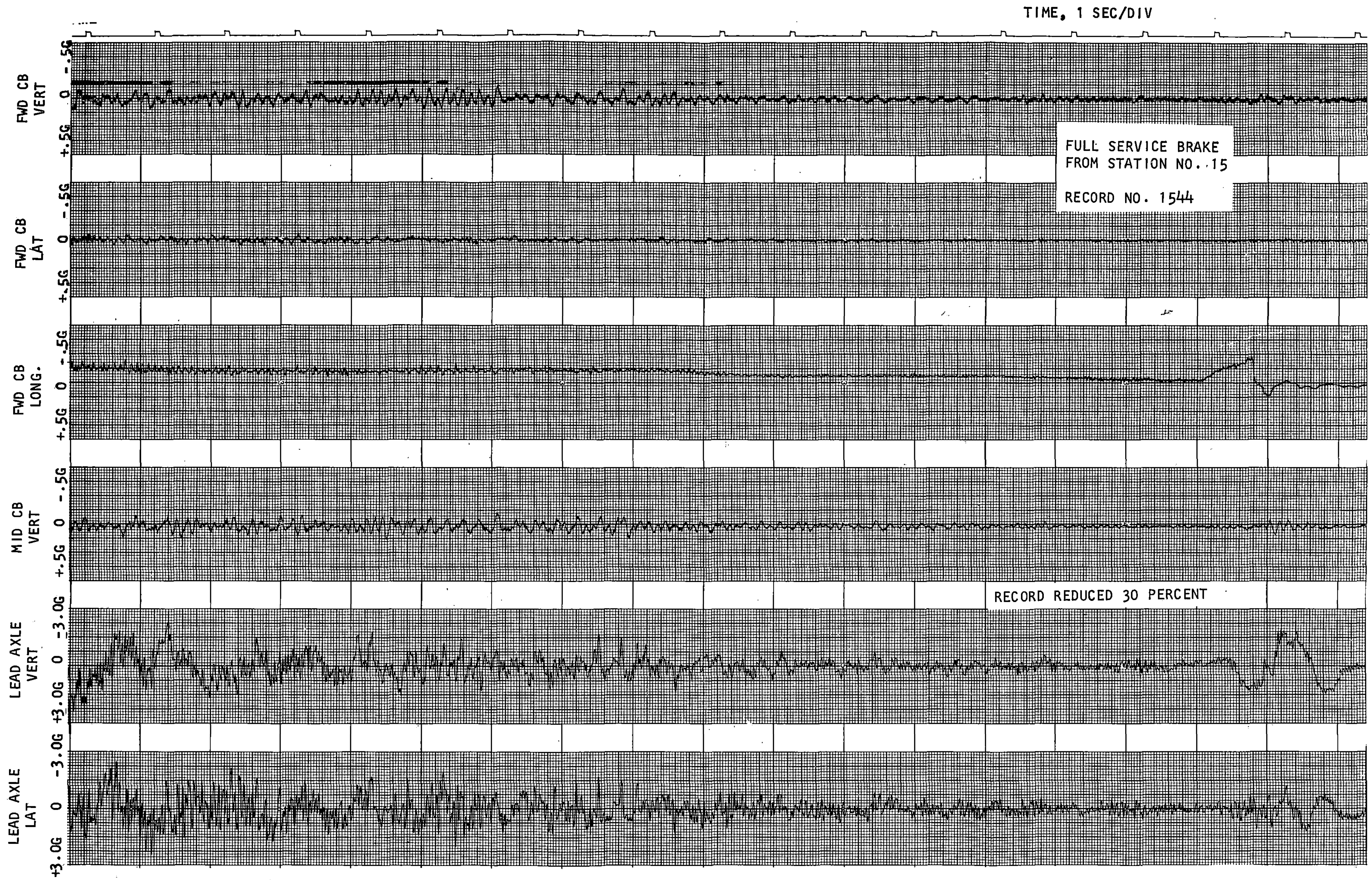


Figure 8-2. Ride Roughness Deceleration Test - AW2

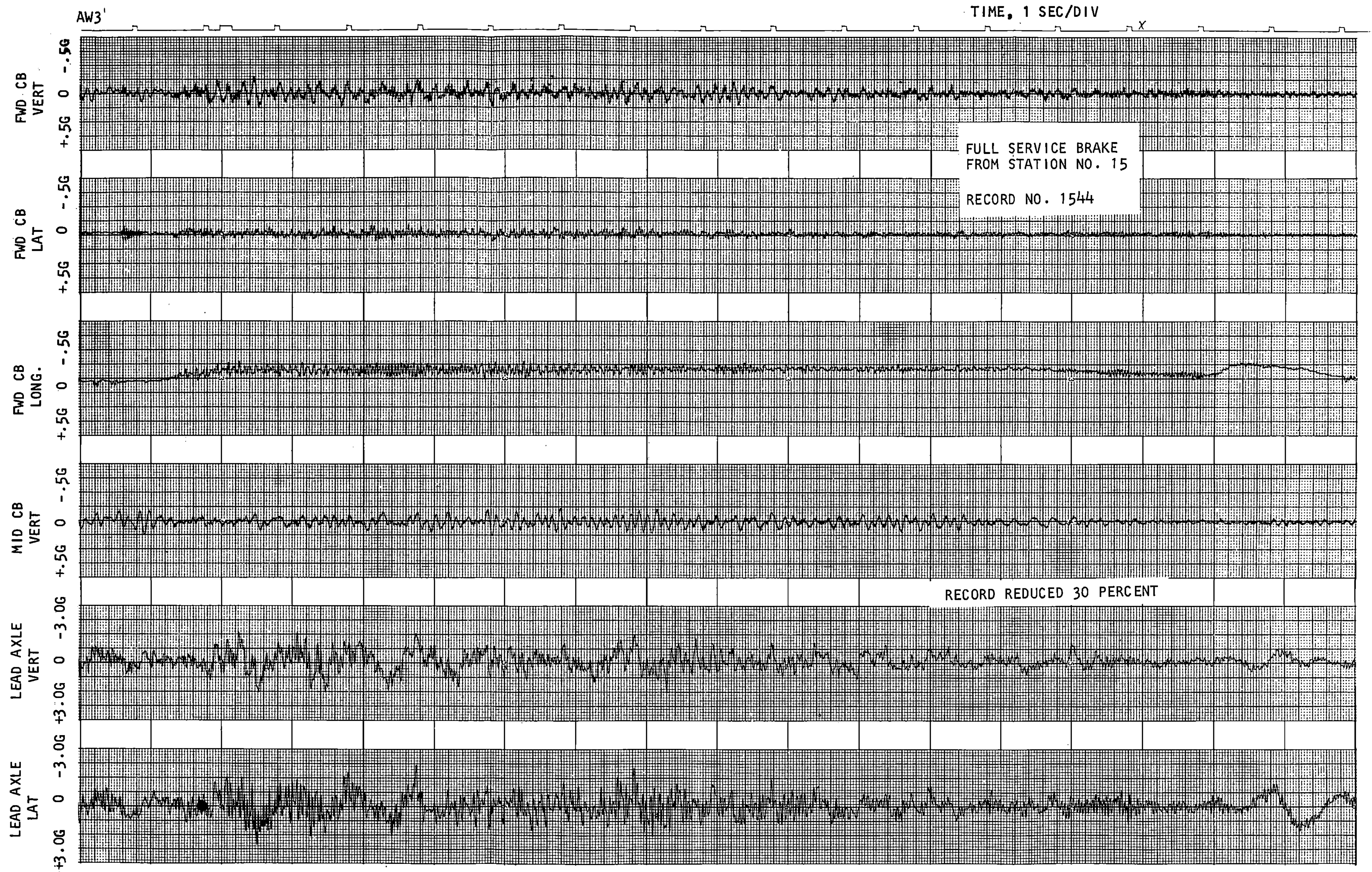


Figure 8-3. Ride Roughness Deceleration Test - AW3

9. GLOSSARY

Ampl vs Freq plot	Log-log plot or semi-log plot of data
AWO	Vehicle empty weight
AW2	Vehicle empty weight plus full load
AW3	Vehicle empty weight plus crush load
CB	Carbody
DOT	Department of Transportation
ESC	Energy storage car
ESS	Energy storage system
FWD	Forward
F.S.	Full scale
F/W	Flywheel
H.P.	Hewlett Packard
MTA	Metropolitan Transit Agency
NA	Not applicable
NYCTA	New York City Transit Authority
PAR	Parallel
QSD	Quick shutdown
REV	Reverse
RQD	Required
SER	Series
SW	Switch
TSC	Transportation Systems Center
TTC	Transportation Test Center
T/M	Traction motor
UMTA	Urban Mass Transportation Administration
X-Y Plot	Graphical data presention obtained by running analog magnetic tape into an X-Y plotter with minimum filtering.

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