

REPORT NO. FRA/ORD-76/303, III

TRAIN-TO-TRAIN REAR END
IMPACT TESTS
Volume III - Appendix A: Impact Test Data
Appendix B: Report of Inventions

R.L. Anderson
P.L. Cramer

ULTRASYSTEMS, INC.
The Dynamic Science Division
1850 West Pinnacle Peak Road
Phoenix AZ 85027



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FINAL REPORT

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PREFACE

This final report, Volume III, contains the original data of the train-to-train impact test program conducted by the Dynamic Science Division of Ultrasystems, Inc., for the Transportation Systems Center under direction of the Federal Railroad Administration; Contract DOT-TSC-840. The Contract Technical Managers for the program were Mr. Sam Polcari and Mr. How Wong who worked in conjunction with Dr. A. R. Raab, Program Manager, and Dr. Pin Tong, program consultant; all of Transportation Systems Center. Mr. Don Levine was the Federal Railroad Administration Sponsor.

The program was devoted to determining the dynamic response characteristics of a series of rear-end train collisions, ranging from 3 mph to 30 mph.

The opinions and findings expressed in this publication are those of the authors and not necessarily those of the Transportation Systems Center.

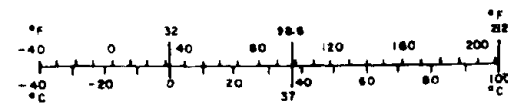
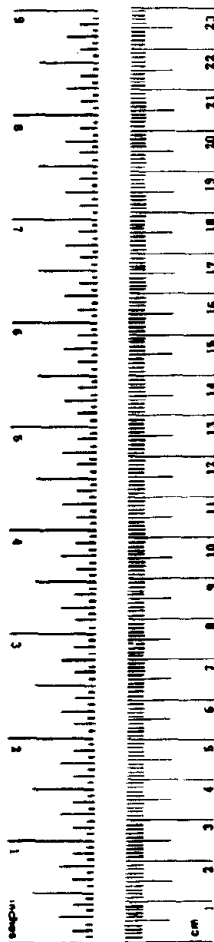
METRIC CONVERSION FACTORS

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				
teaspoon	teaspoons	5	milliliters	ml
Tablespoon	tablespoons	15	milliliters	ml
fluid ounce	fluid ounces	30	milliliters	ml
c	cup	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

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)	2.6	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	36	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



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APPENDIX A
IMPACT TEST DATA

A.1 INTRODUCTION

All nine impact tests described in this report were instrumented. This appendix describes the locations of the instruments and presents a complete set of time histories of the data.

All data processing was performed in accordance with SAE Recommended Practice J211a, entitled "Instrumentation for Impact Tests." The data are presented in the form of computer generated time histories. Two filtering frequencies were used to generate each plot. They are listed in each plot in the following manner:

- The first number denotes the cutoff frequency of the presampling analog filter (the 3-dB point).

If the analog data are not filtered with a low pass filter to eliminate the frequencies down to about one-half of the sample rate or lower, the higher frequencies may appear as an aliasing* error. For instance, if a high-frequency component occurs in the data which is exactly five times the sample rate, the sample will be taken at the same amplitude but on every fifth cycle. The digitized data will show this frequency as a constant DC level instead of varying at a high frequency. High frequency components must be removed to ensure an accurate representation of the data in digital form. A data sample must be taken at least every half cycle to detect a component of that frequency. Further filtering, if desired, is accomplished by applying a digital filter to the digitized data.

- The second number is the frequency at the break point in the ideal digital filter applied to the data prior to plotting. After the break point, the data were attenuated at 12 dB/octave. The digital filter utilizes a fast Fourier transformation of the data into the frequency domain, followed by an attenuation of the higher frequencies, and an inverse transformation back into the time domain.

*Bendat, J. S., and Piersol, A. G., "Measurement" and Analysis of Random Data, John Wiley and Sons, 1967.

A.2 NUMBERING SYSTEM FOR INSTRUMENT LOCATIONS

The instrument location numbers are made up of two alphabetic characters and one numeric character. The first alphabetic character is either "S" for stationary train or "M" for moving train. The second alphabetic character is one of four codes describing the type of instrument:

- A - Accelerometer
- S - Strain gauge
- D - Displacement transducer
- H - Swinghanger strain gauge sum

The numeric character defines the position of the instrument from the impact point; the larger the number, the farther the instrument is from impact. Example: "SA7" is the seventh accelerometer on the standing train away from impact.

Diagrams of instrument location are included with the graphs of each test. Location numbers appear on these diagrams to indicate the types and number of instruments. The location numbers also appear at the top of the computer-drawn time histories to identify the location where the data was obtained.

A.3 INSTRUMENT LOCATIONS

The accelerometers were bolted directly to the center sill of all cars except the locomotives. Figure A-1 is a diagram of the location of the accelerometers on the caboose, which were mounted on top of the sill through a hole in the floor. The front and rear accelerometers on the first hopper were attached to the top of the sill near the ends and all center accelerometers were mounted from underneath the cars. The locomotive front and rear triaxial accelerometers* were mounted on top of the draft gear assembly (see Figure A-2). The center accelerometer was mounted on the side frame rail (see Figure A-3). The

*A triaxial accelerometer has 3 accelerometers in one canister, giving acceleration in the longitudinal, lateral, and vertical directions.

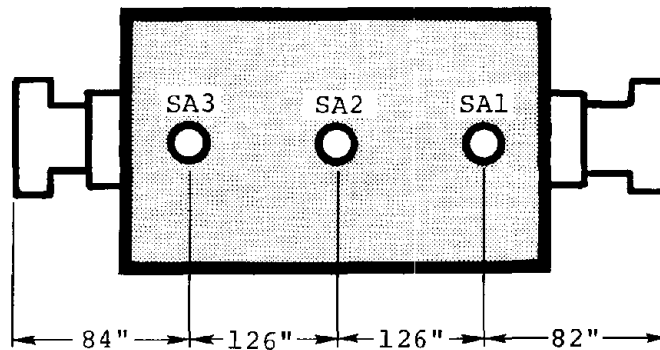


Figure A-1. Accelerometer Positioning on Caboose.

two longitudinal accelerometers in the cab were attached to the floor near the brakeman and engineer dummies.

The strain gauges mounted on the coupler shanks were attached about 3 inches behind the horn and centered vertically on the shank (see Figure A-4). A gauge was mounted on each side to cancel effects of lateral bending. Several couplers were calibrated prior to testing and data were converted to force before being plotted (see *Train-to-Train Impact Tests - Volume I, Pre-Impact Determination of Vehicle Properties*, for details). The center sill strain gauges were mounted vertically in the center of the sill sides and longitudinally between the attachments of the buffer casting and the draft gear (see Figure A-5). Again, one gauge was installed on each side to cancel signals due to bending. The caboose truck swinghangers were removed, strain gauges mounted, calibrated in a tensile tester, and reinstalled in the truck (see Figures A-6 and A-7). The four gauges on each truck were monitored separately, but added together prior to being plotted. The force thus represents the total force as seen on the truck during impact; with the static load of the caboose equal to zero. The swinghangers were inclined 8 degrees from the vertical, but the $\cos(8^\circ)$ is almost 1 and the change in force due to the angle was assumed to be negligible.

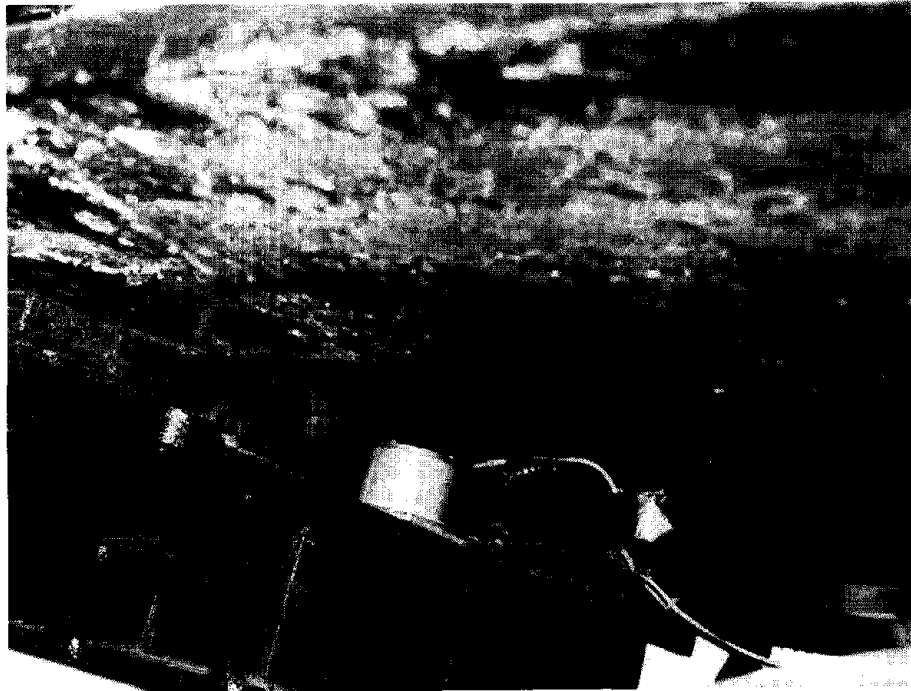


Figure A-2. Front and Rear Triaxial Accelerometer Location on the Locomotive.

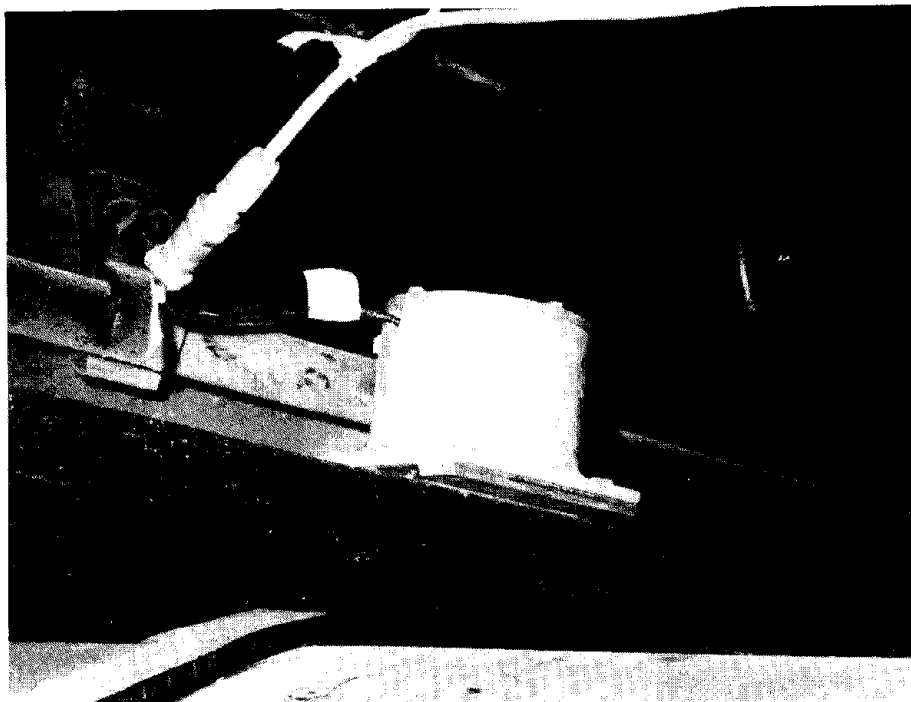


Figure A-3. Center Vertical Accelerometer Location on the Locomotive.

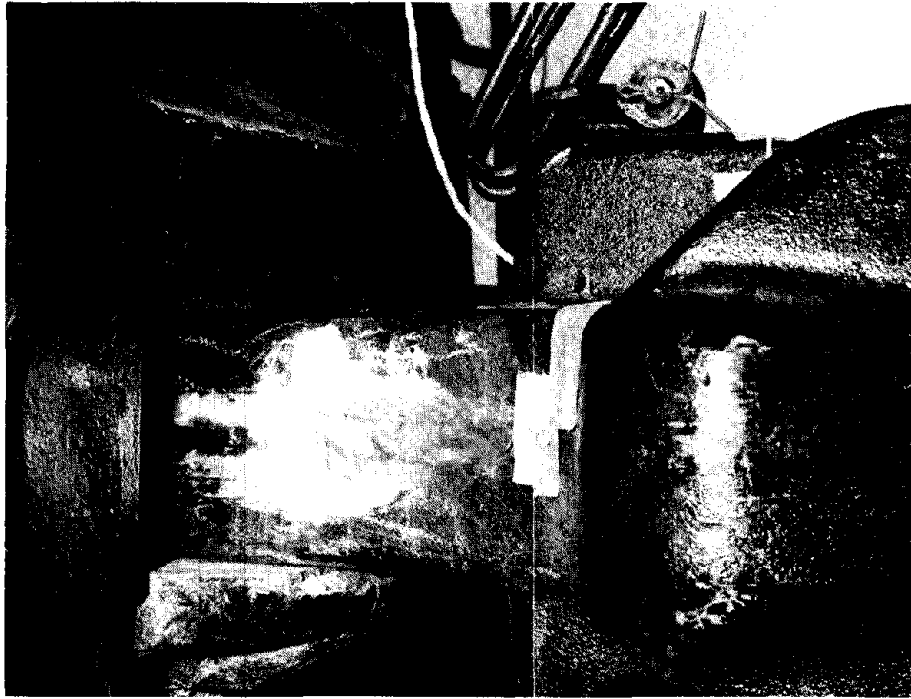


Figure A-4. Strain Gauge Location on the Couplers.

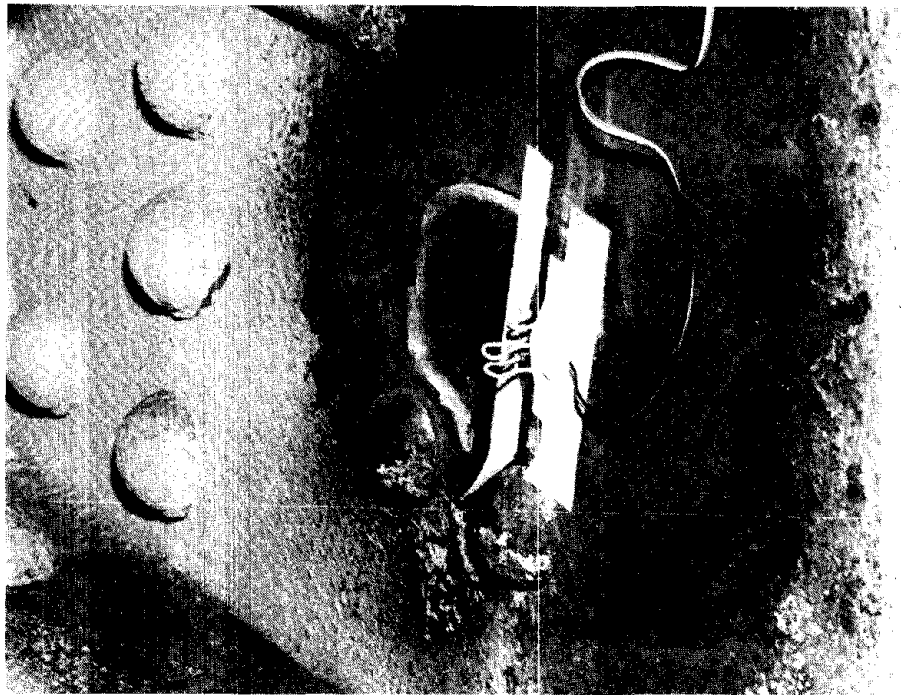


Figure A-5. Center Sill Strain Gauge Location.

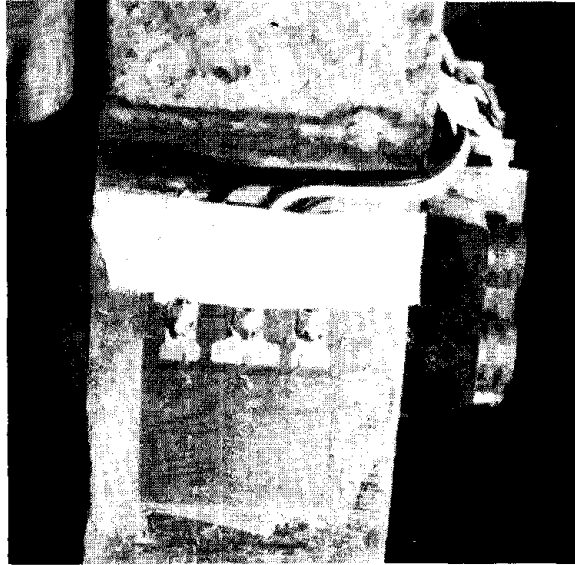


Figure A-6. Strain Gauge Location on Caboose Swinghangers.

Four displacement transducers were mounted on the caboose cross braces and a wire attached to the truck side frame (see Figure A-8). Any vertical motion was measured by extension or retraction of the wire. A fifth displacement transducer was mounted on the end of the hopper center sill and the wire attached to the caboose, measuring longitudinal motion between the caboose and hopper (see Figure A-9).

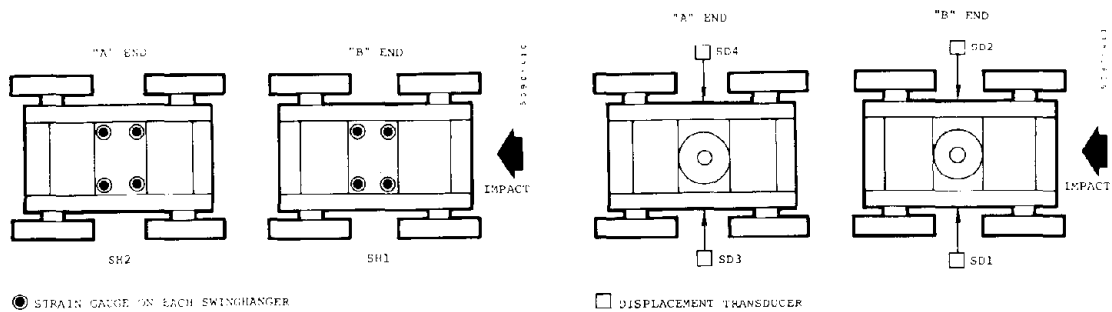


Figure A-7. Caboose Truck Swinghanger Strain Gauge Locations.

Figure A-8. Caboose Displacement Transducer Locations.

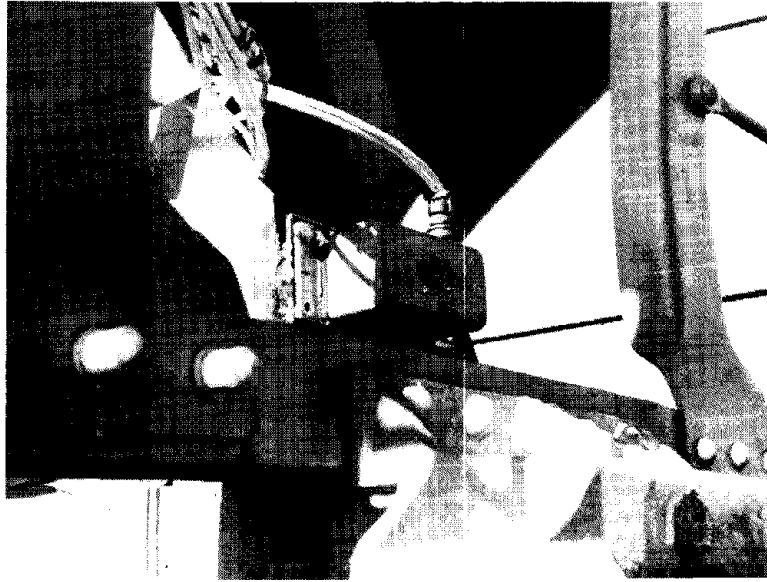


Figure A-9. Displacement Transducer Between the Hopper and Caboose.

A.4 INSTRUMENT SIGN CONVENTION

The positive sense for the data is defined by a coordinate system fixed to the caboose as shown in Figure A-10. A corresponding coordinate system is applied to the locomotive. The positive direction, with respect to the vehicle, is taken as forward, to the right and down for the X, Y, and Z axes, respectively.

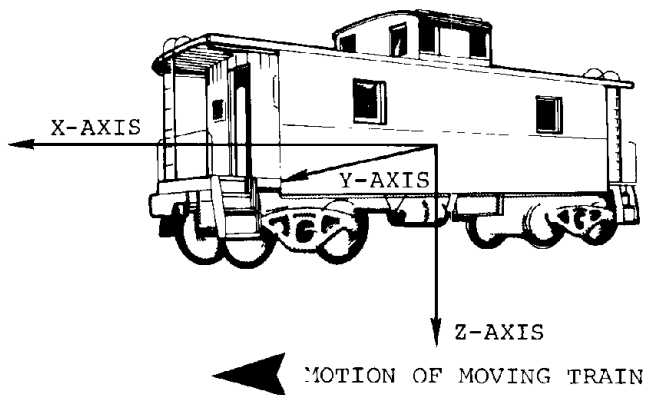


Figure A-10. Vehicle Coordinate System.

The proper definition of positive and negative for the data graphs is as follows:

A. Acceleration

Longitudinal: Positive is in the direction of initial locomotive velocity

Negative is toward impact from stationary train

Vertical: Positive is down

Negative is up

Lateral: Positive is right*

Negative is left

B. Displacement

Displacement Transducers

Longitudinal: Positive is extension or separation of the caboose and hopper

Negative is retraction

Vertical: Positive is upward lift of the caboose

Negative is downward motion of the caboose

C. Force

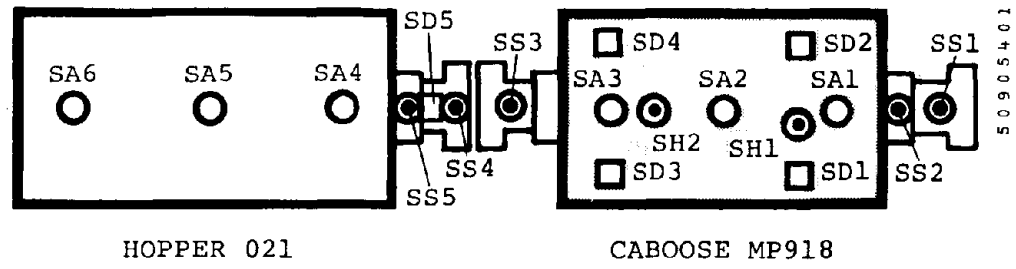
Positive is tension

Negative is compression (for swing-hangers, negative is less tension)

A.5 DATA FROM TESTS 1 THROUGH 9

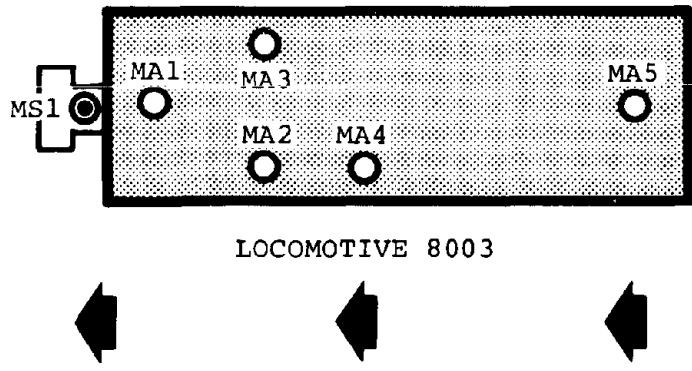
This section contains a schematic of the instrument locations and plots of the data from the instruments for each test. Sometimes the data from an instrument were of an extremely short duration because the impact destroyed the instrument or a part of the data transmission system before a significant amount of usable data were recorded. For these cases, the data plots were omitted.

*Right and left are defined as normal when facing in the direction of initial velocity of the moving train.



- HOPPER EMPTY
 - TRAIN IN DRAFT
- STANDING TRAIN

A-9



- IMPACT VELOCITY = 3.4 MPH
- MOVING TRAIN

Figure A-11. Instrument Locations - Test 1.

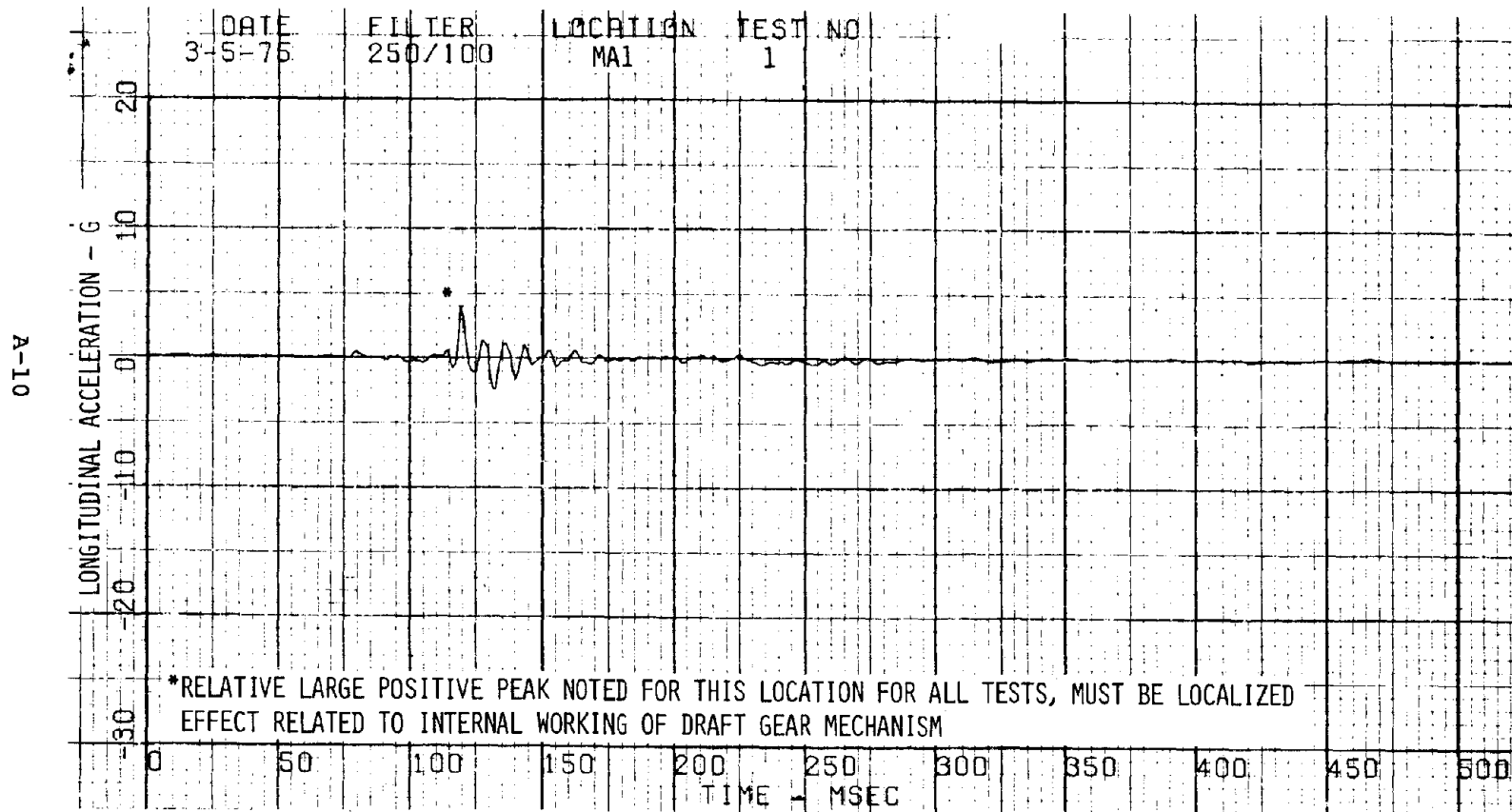


Figure A-12. Locomotive Rear Triaxial Accelerometer (X) - Test 1.

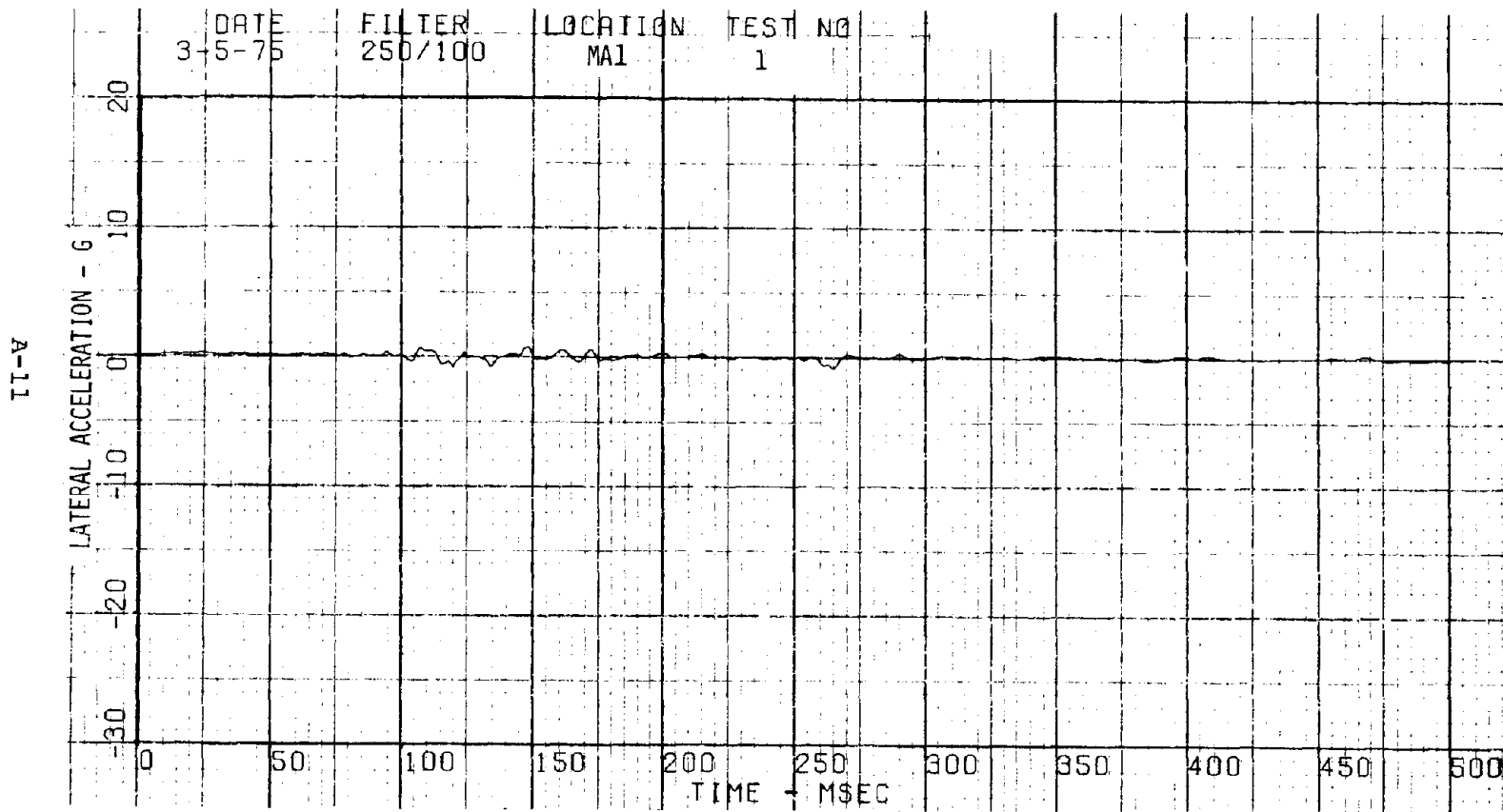


Figure A-13. Locomotive Rear Triaxial Accelerometer (Y) - Test 1.

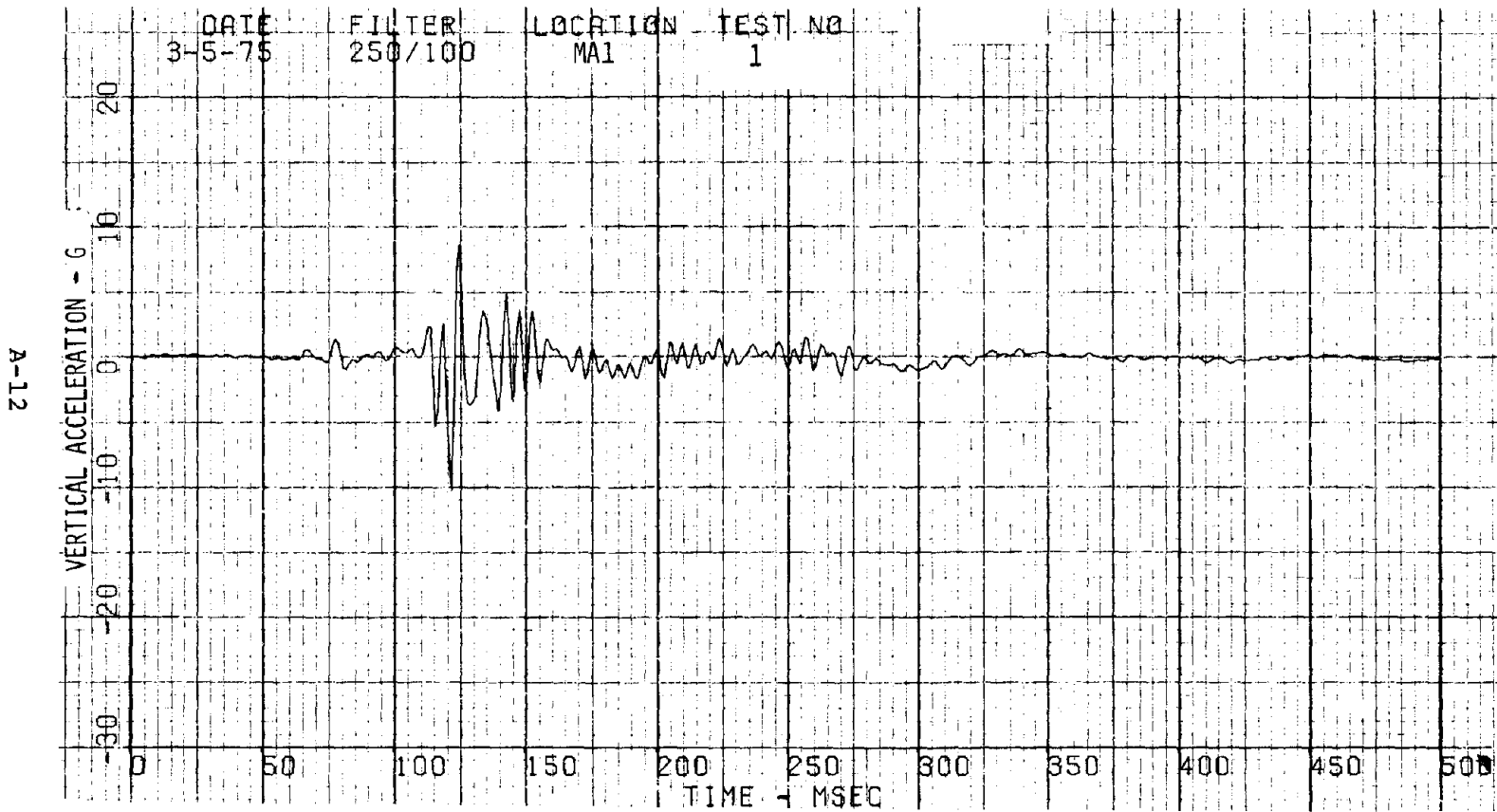


Figure A-14. Locomotive Rear Triaxial Accelerometer (Z) - Test 1.

A-13

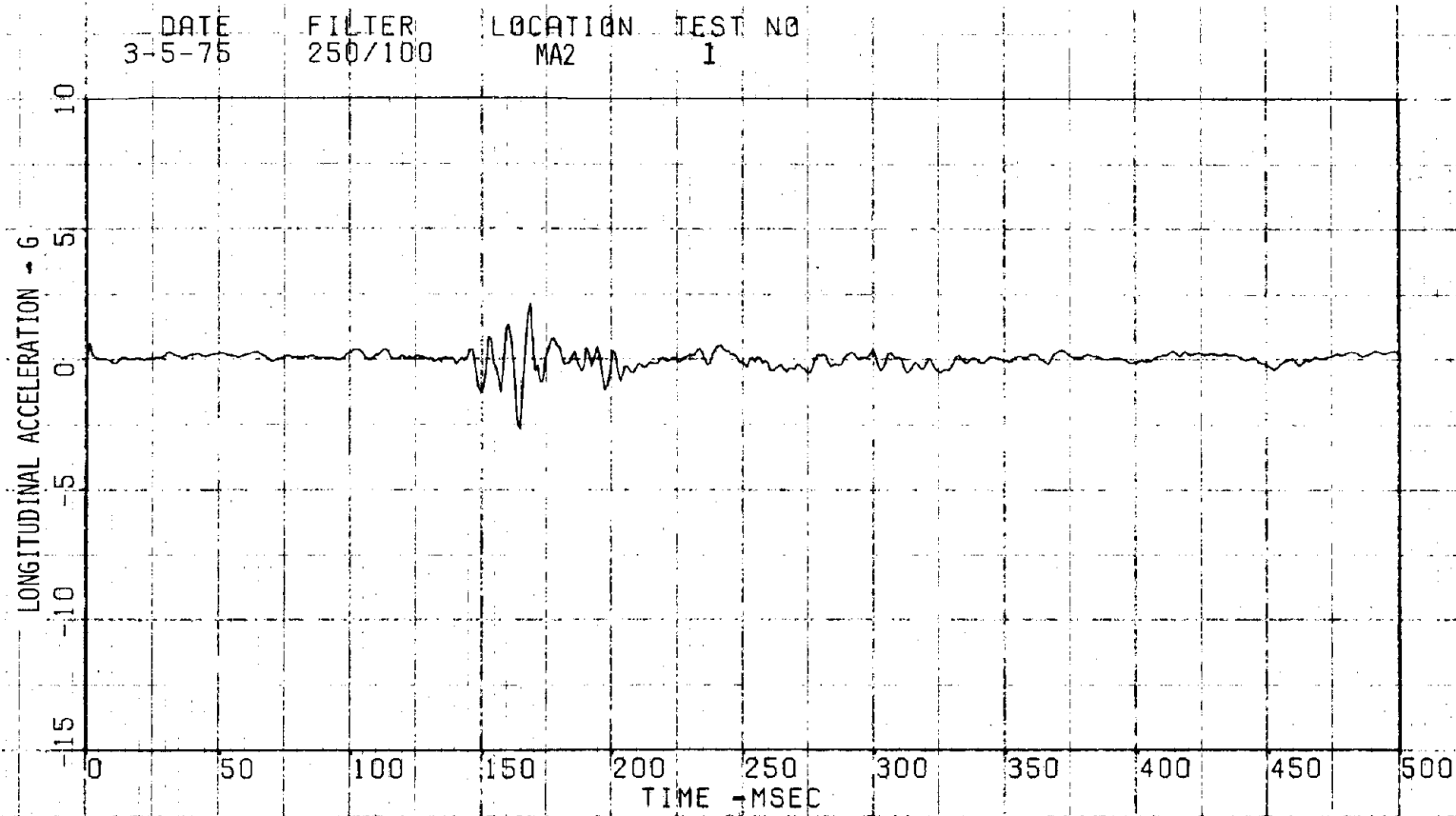


Figure A-15. Locomotive Left Cab Accelerometer - Test 1.

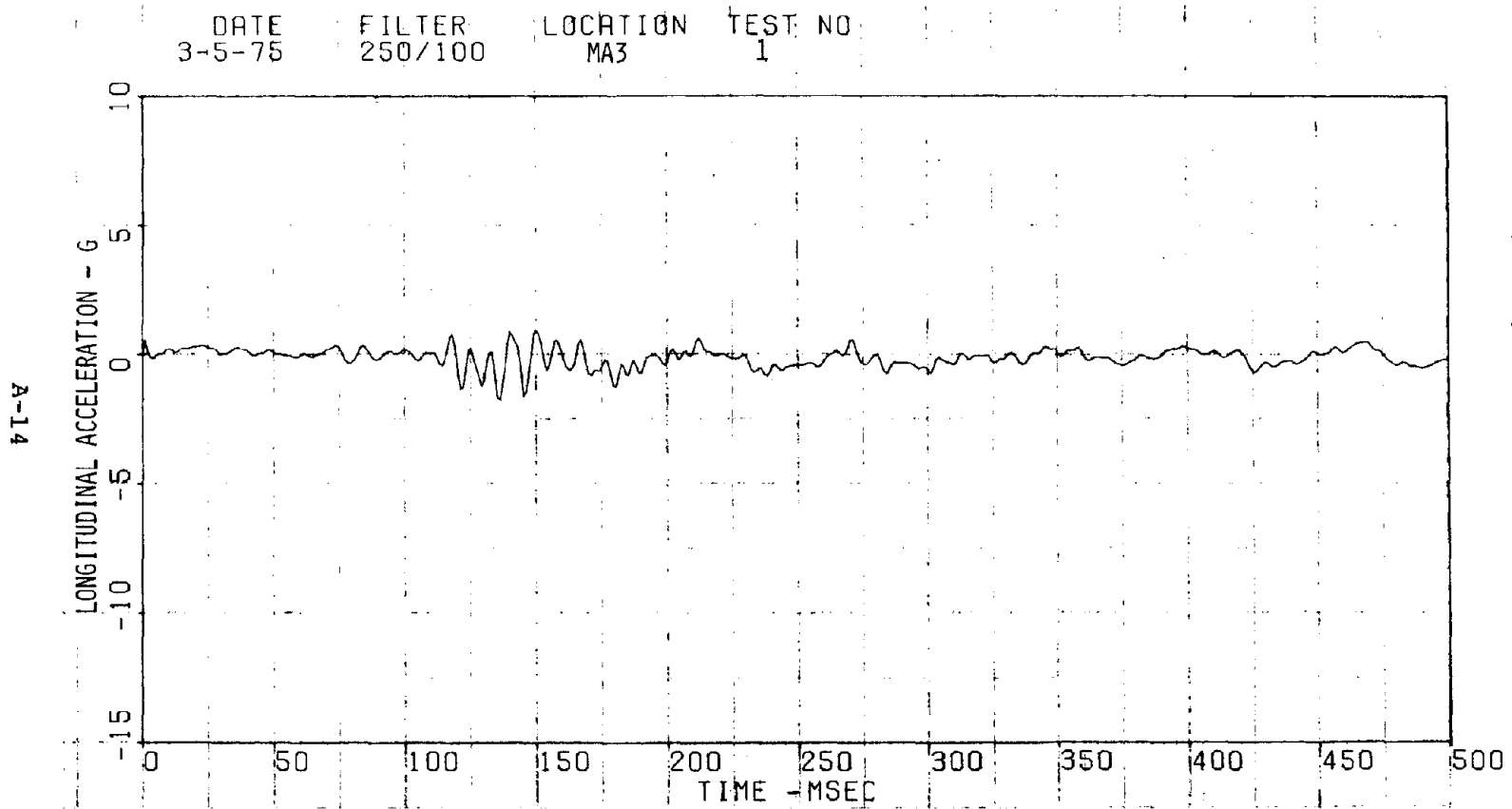


Figure A-16. Locomotive Right Cab Accelerometer - Test 1.

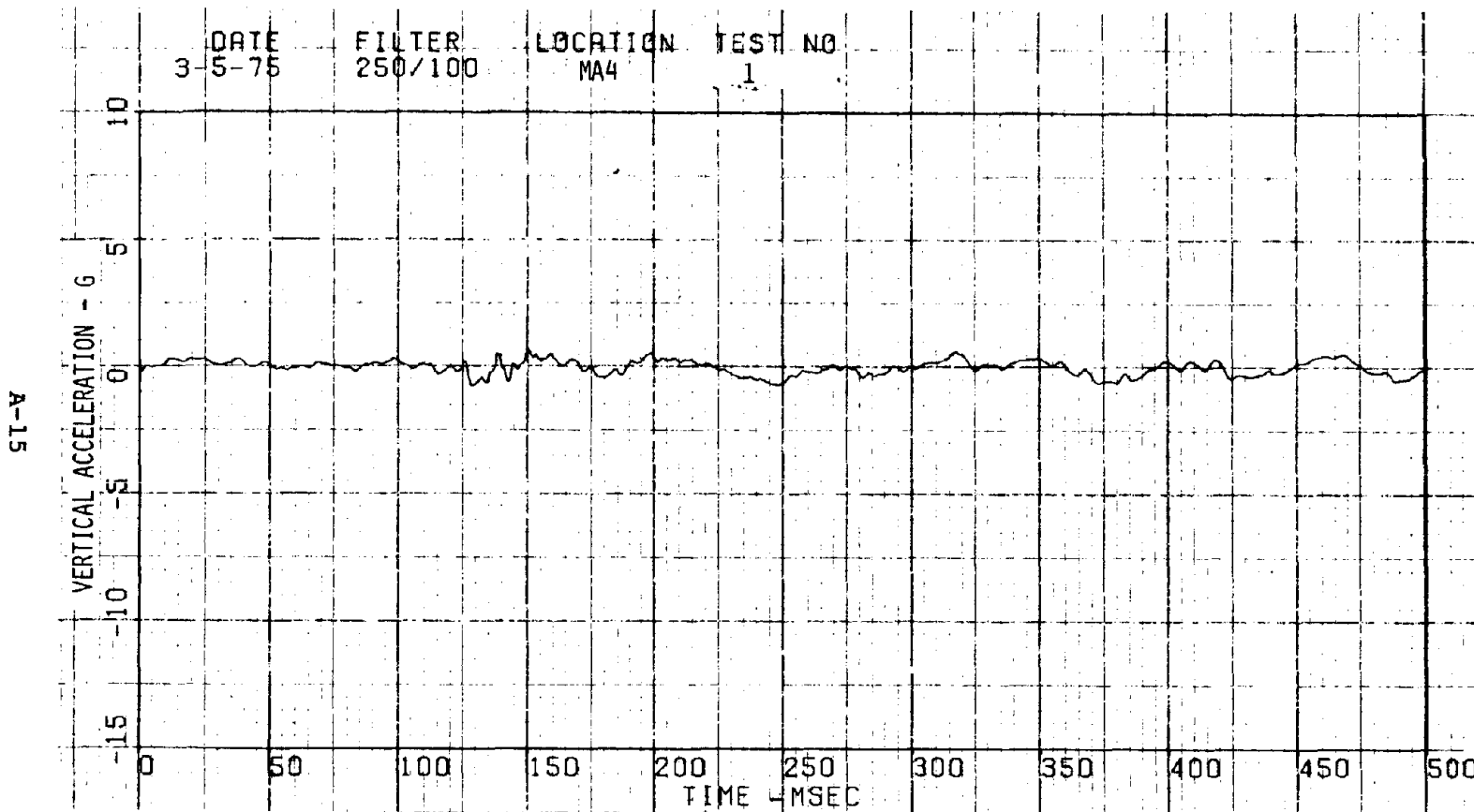


Figure A-17. Locomotive Center Vertical Acceleration - Test 1.

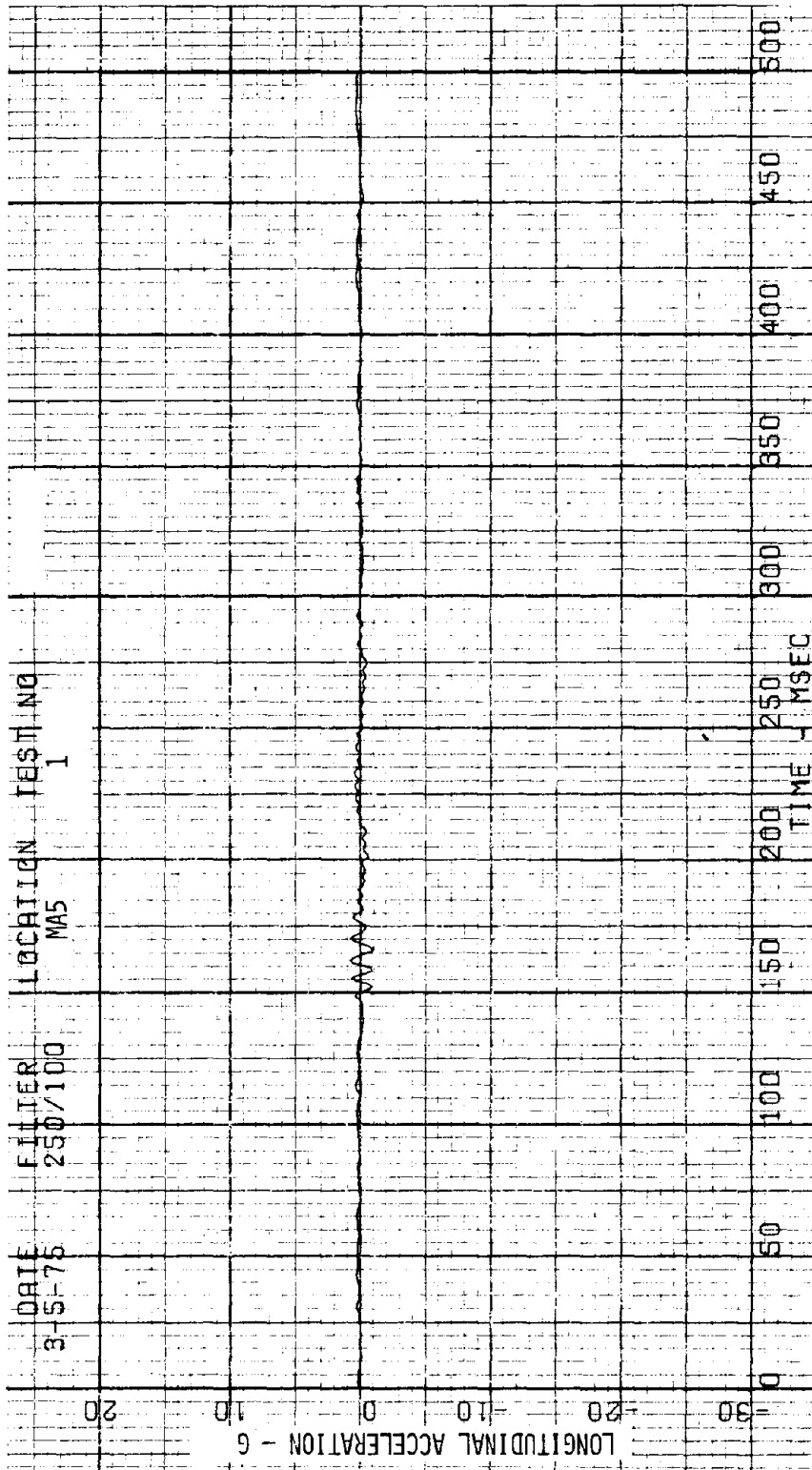


Figure A-18. Locomotive Front Triaxial Accelerometer (X) - Test 1.

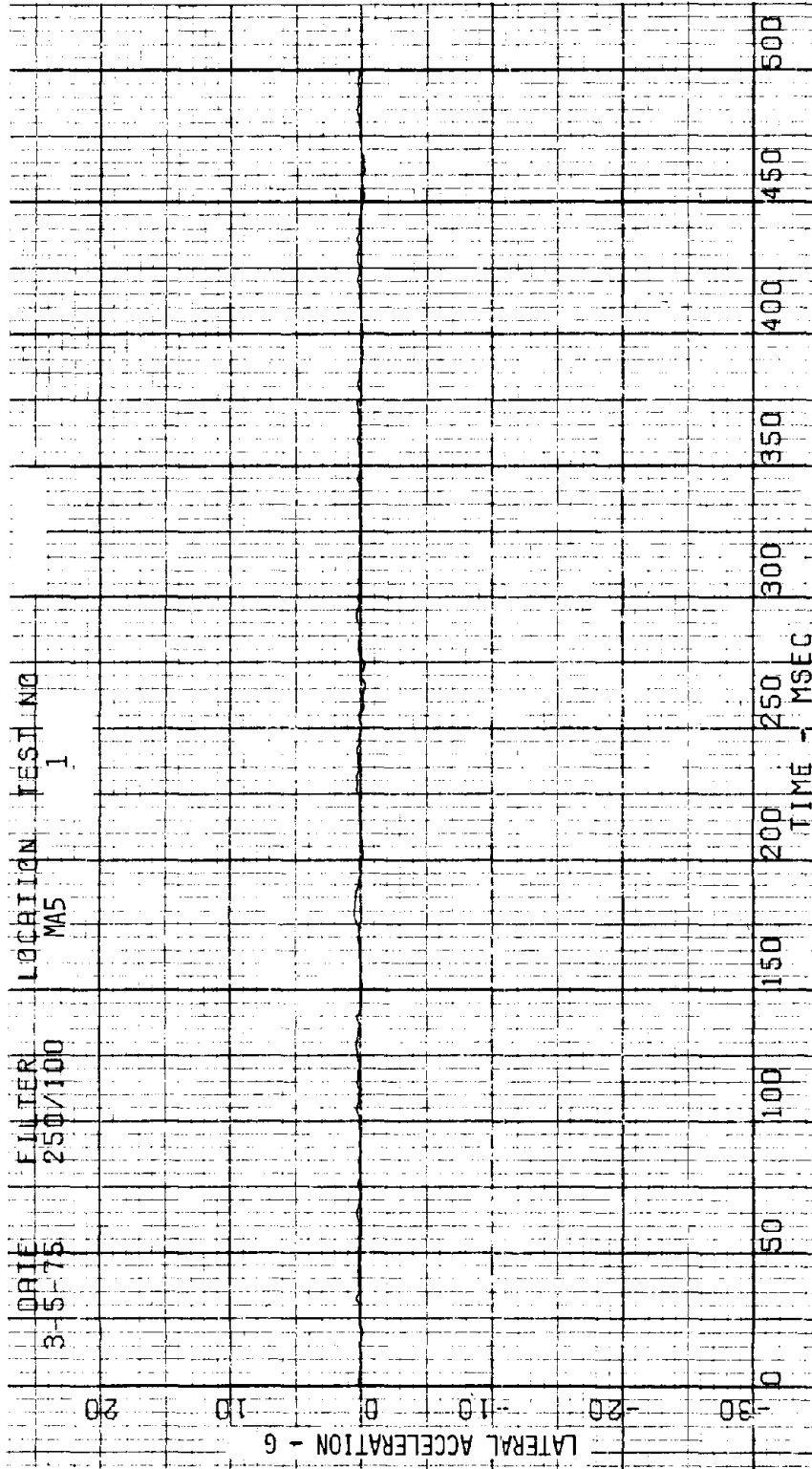


Figure A-19. Locomotive Front Triaxial Accelerometer (Y) - Test 1.

A-18

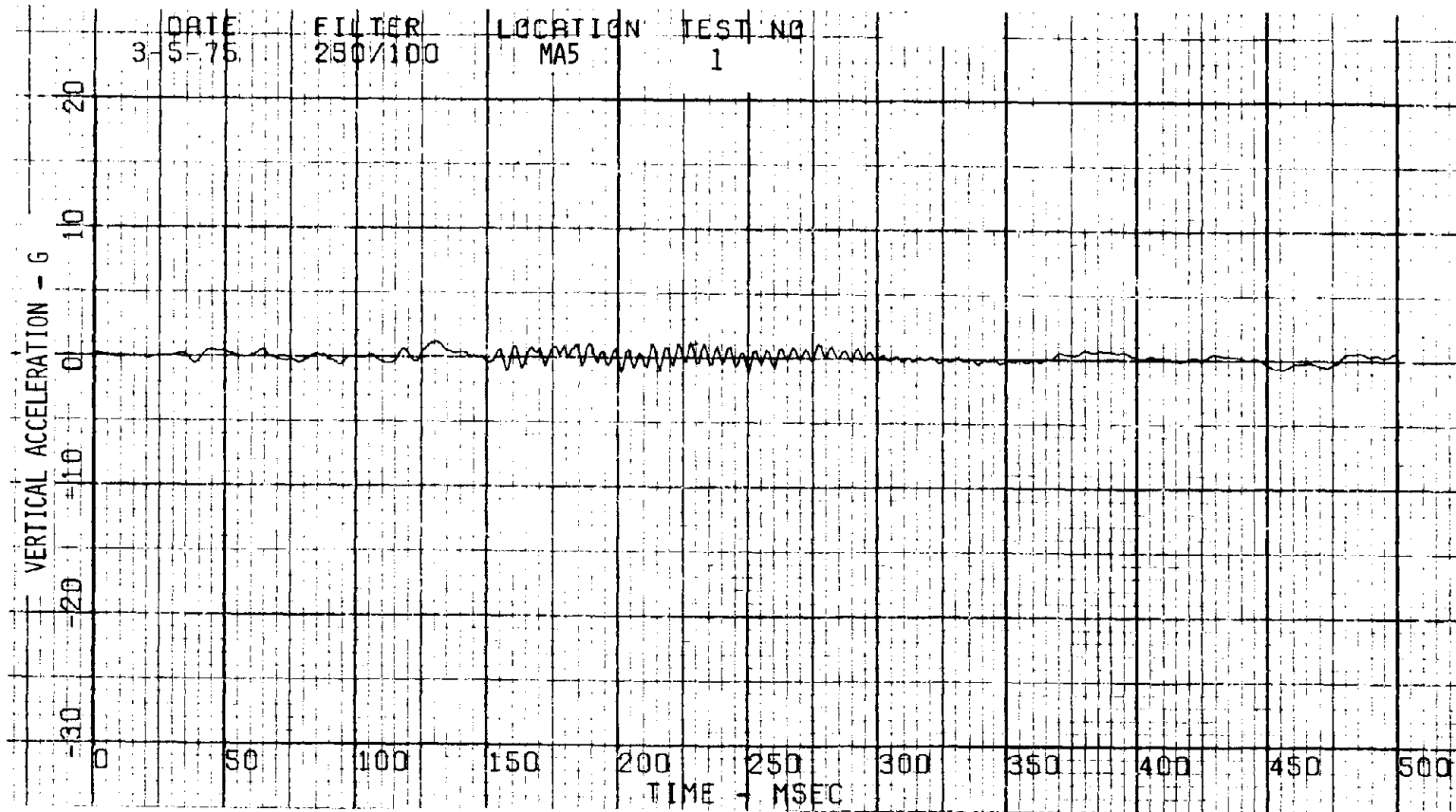


Figure A-20. Locomotive Front Triaxial Accelerometer (Z) - Test 1.

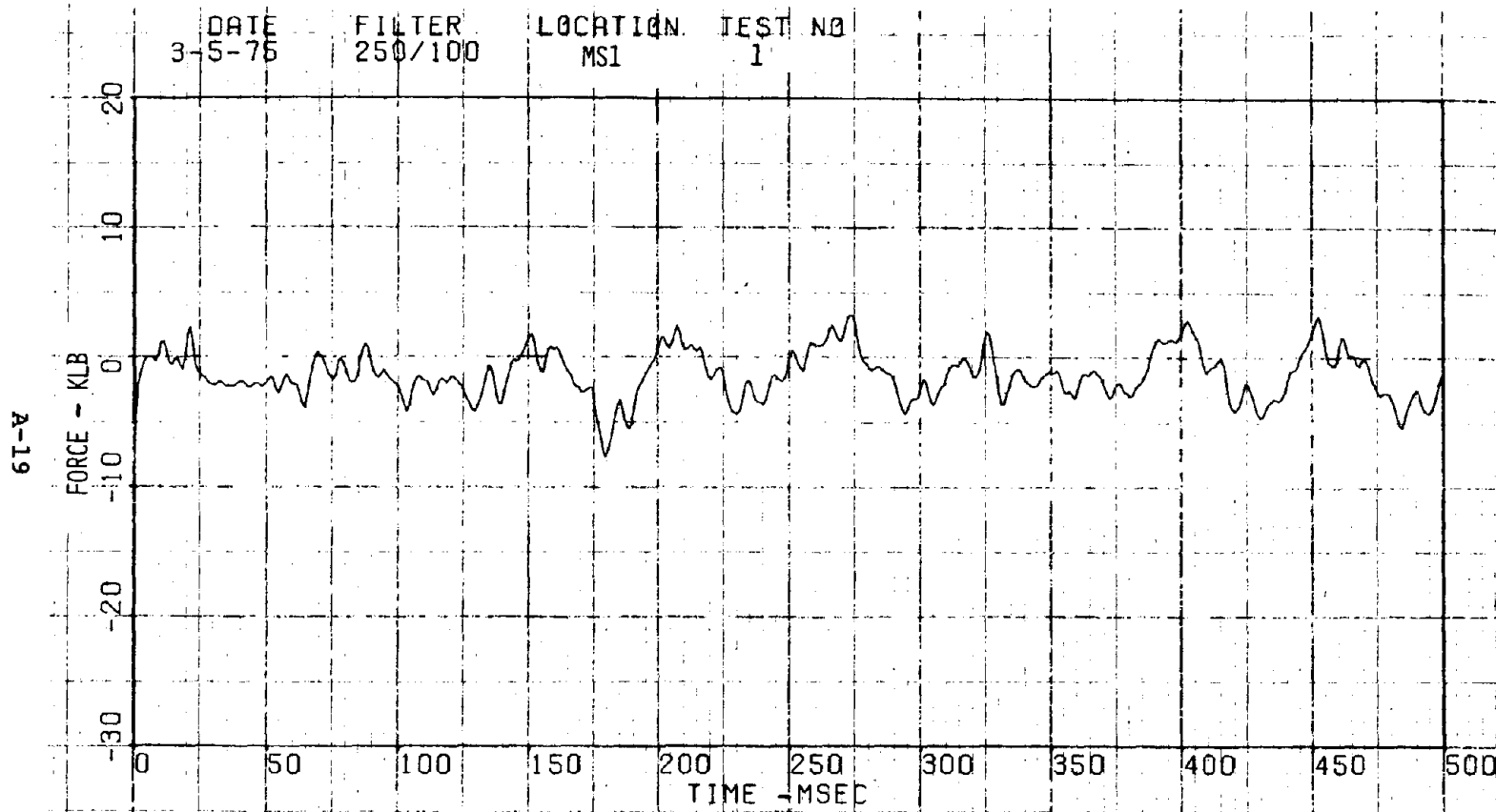


Figure A-21. Locomotive Rear Coupler Strain Gauge - Test 1.

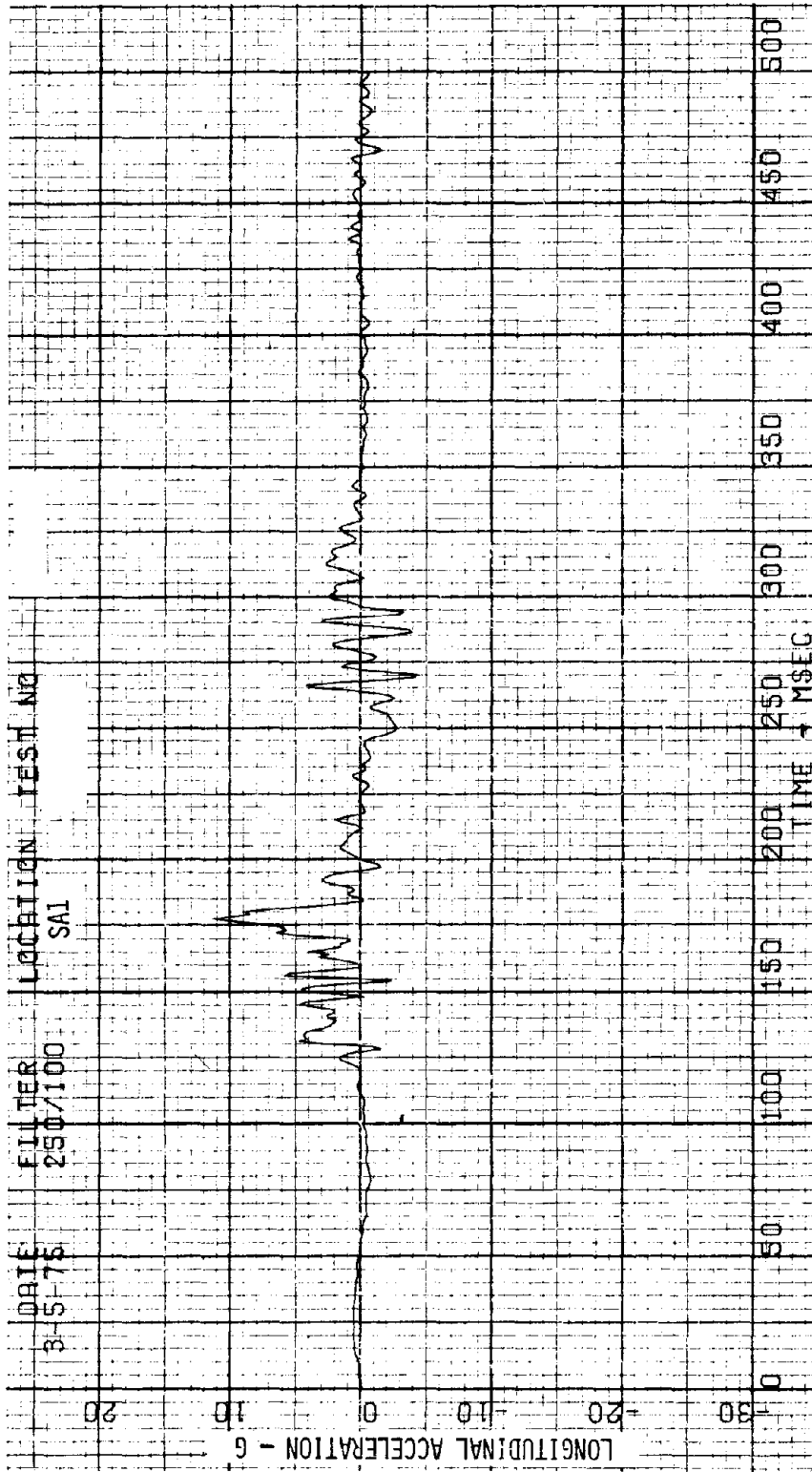


Figure A-22. Caboose Rear Triaxial Accelerometer (X) - Test 1.

A-21

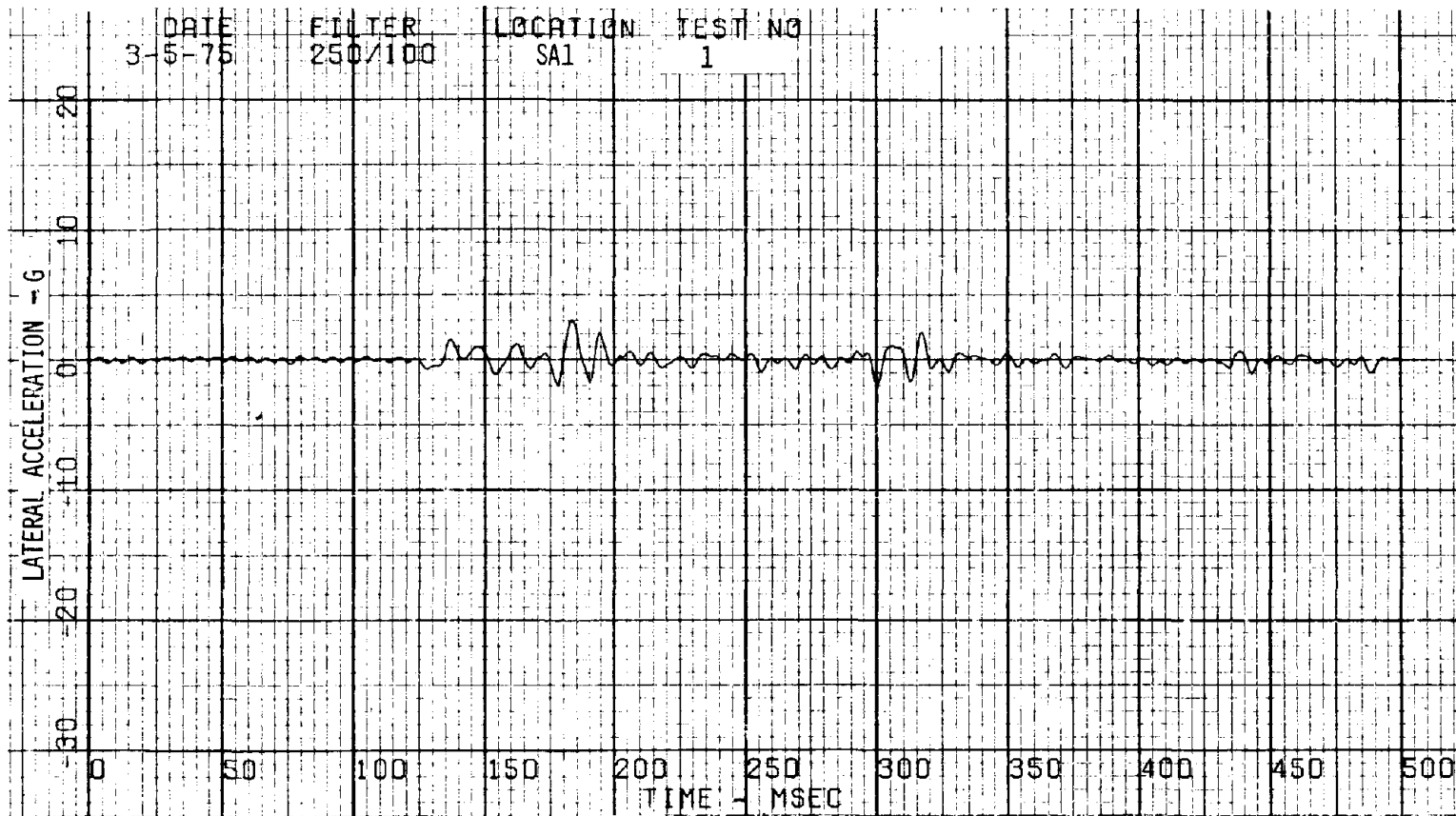


Figure A-23. Caboose Rear Triaxial Accelerometer (Y) - Test 1.

A-22

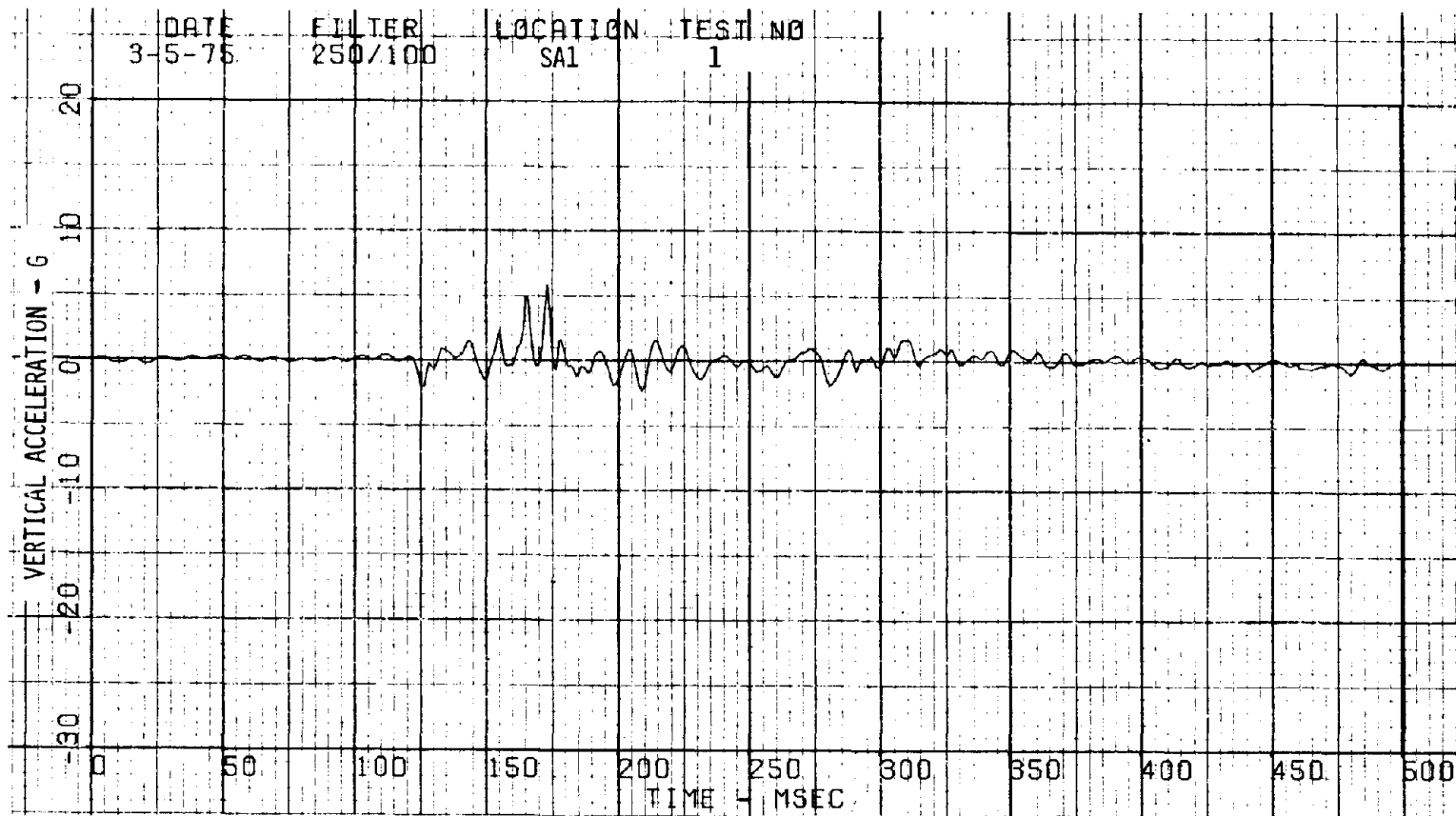


Figure A-24. Caboose Rear Triaxial Accelerometer (Z) - Test 1.

A-23

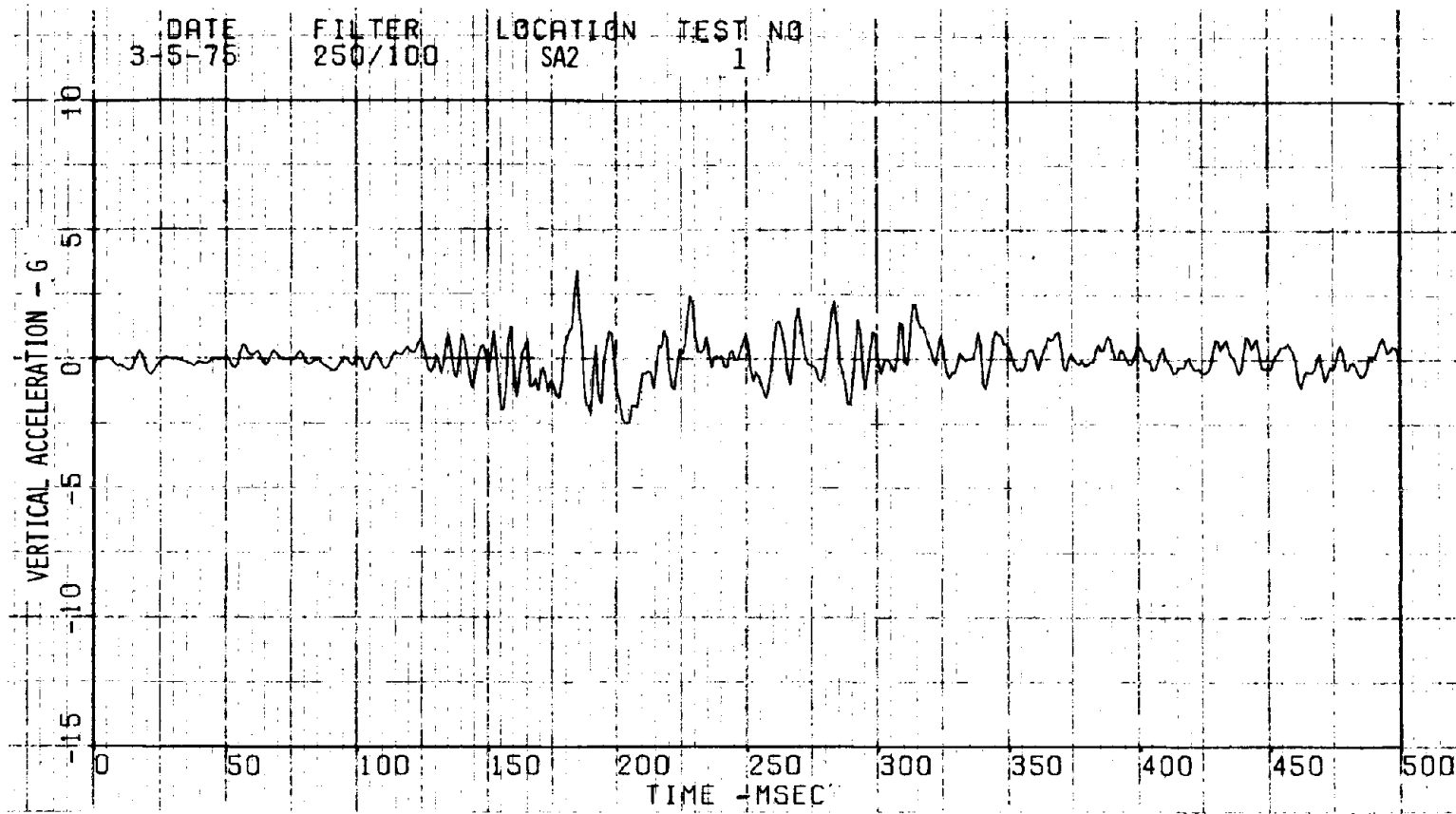


Figure A-25. Caboose Center Vertical Accelerometer - Test 1.

A-24

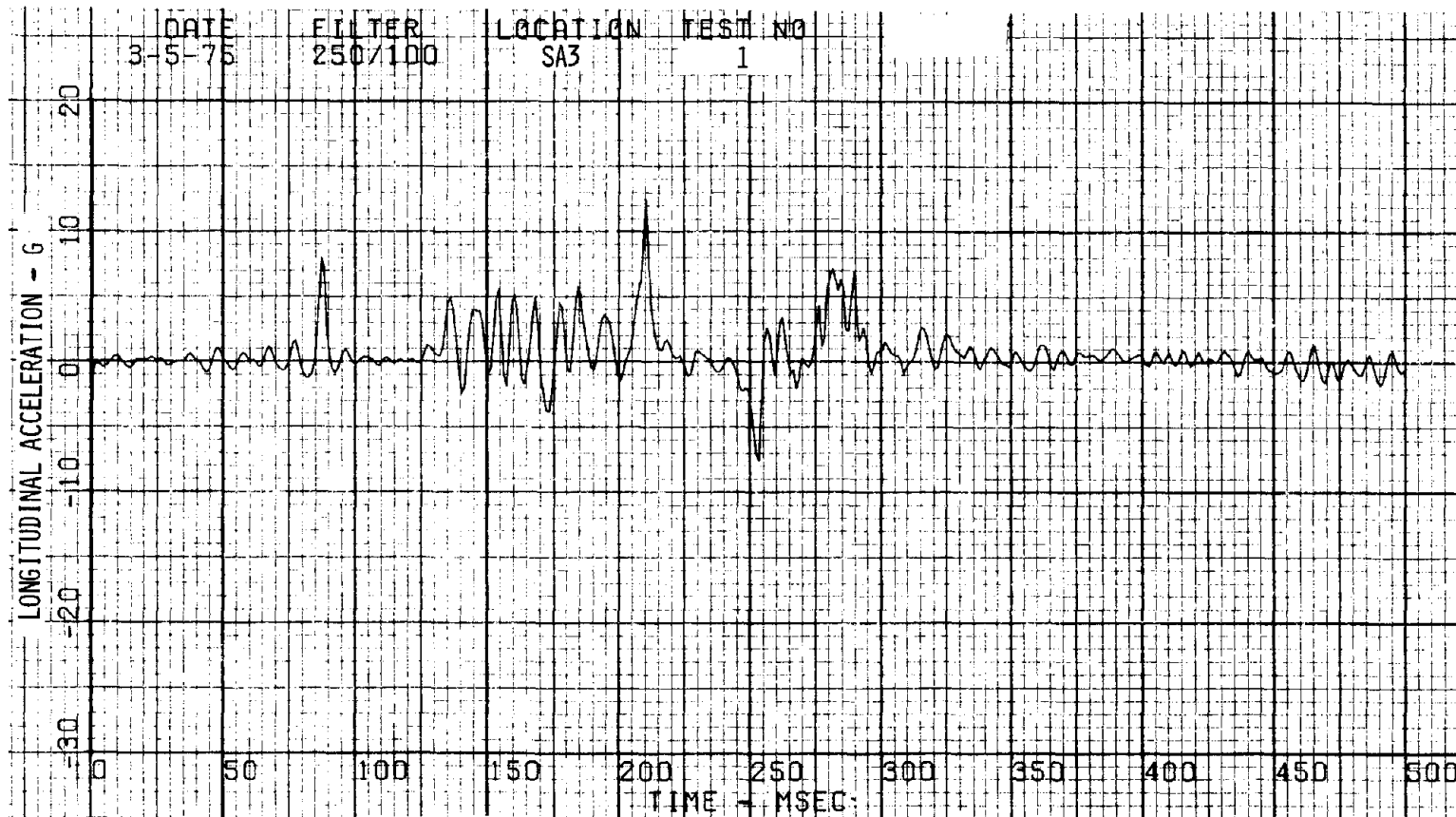


Figure A-26. Caboose Front Triaxial Accelerometer (X) - Test 1.

A-25

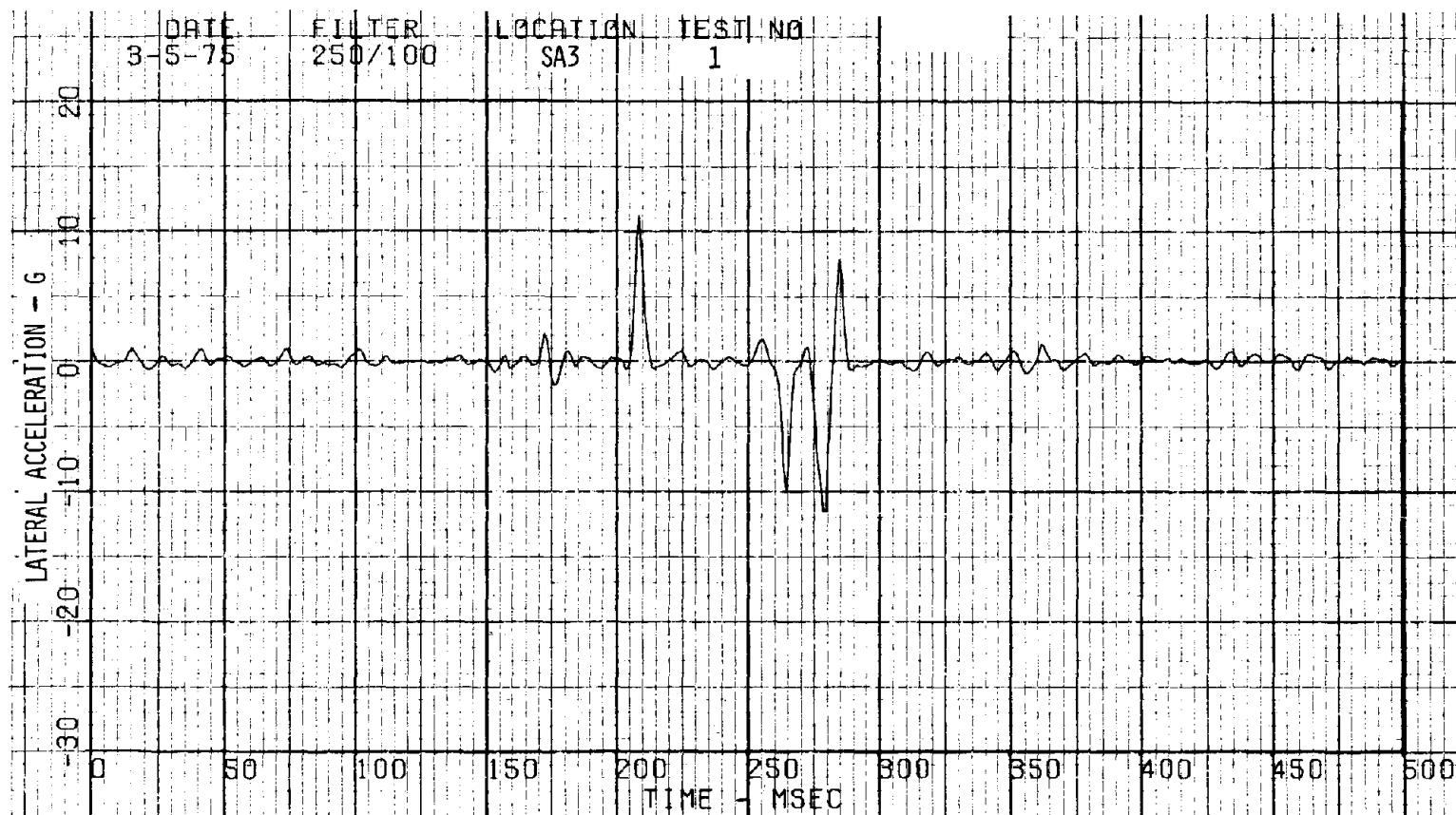


Figure A-27. Caboose Front Triaxial Accelerometer (Y) - Test 1.

A-26

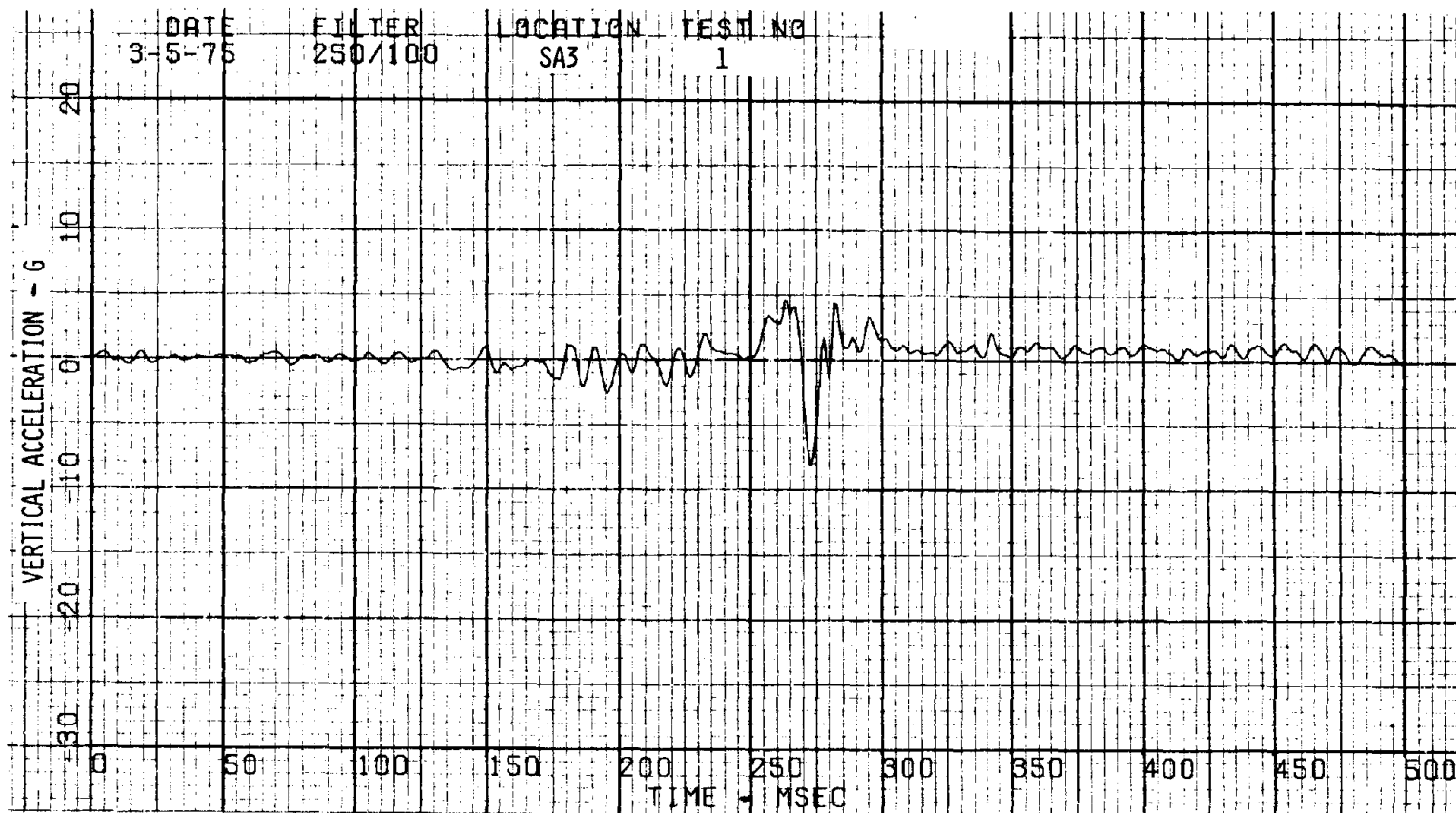


Figure A-28. Caboose Front Triaxial Accelerometer (Z) - Test 1.

A-27

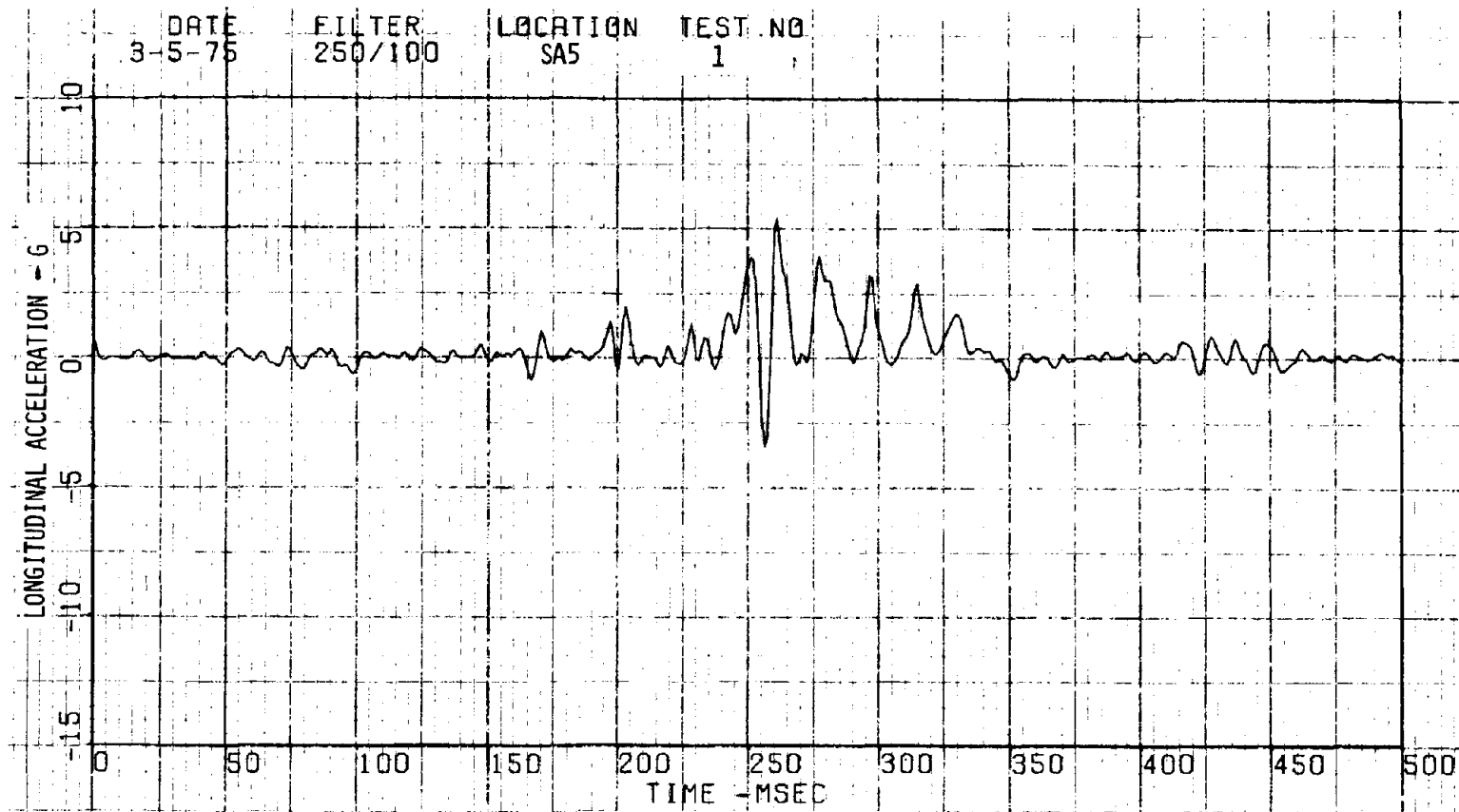


Figure A-29. Hopper 021 Center Longitudinal Accelerometer - Test 1.

A-28

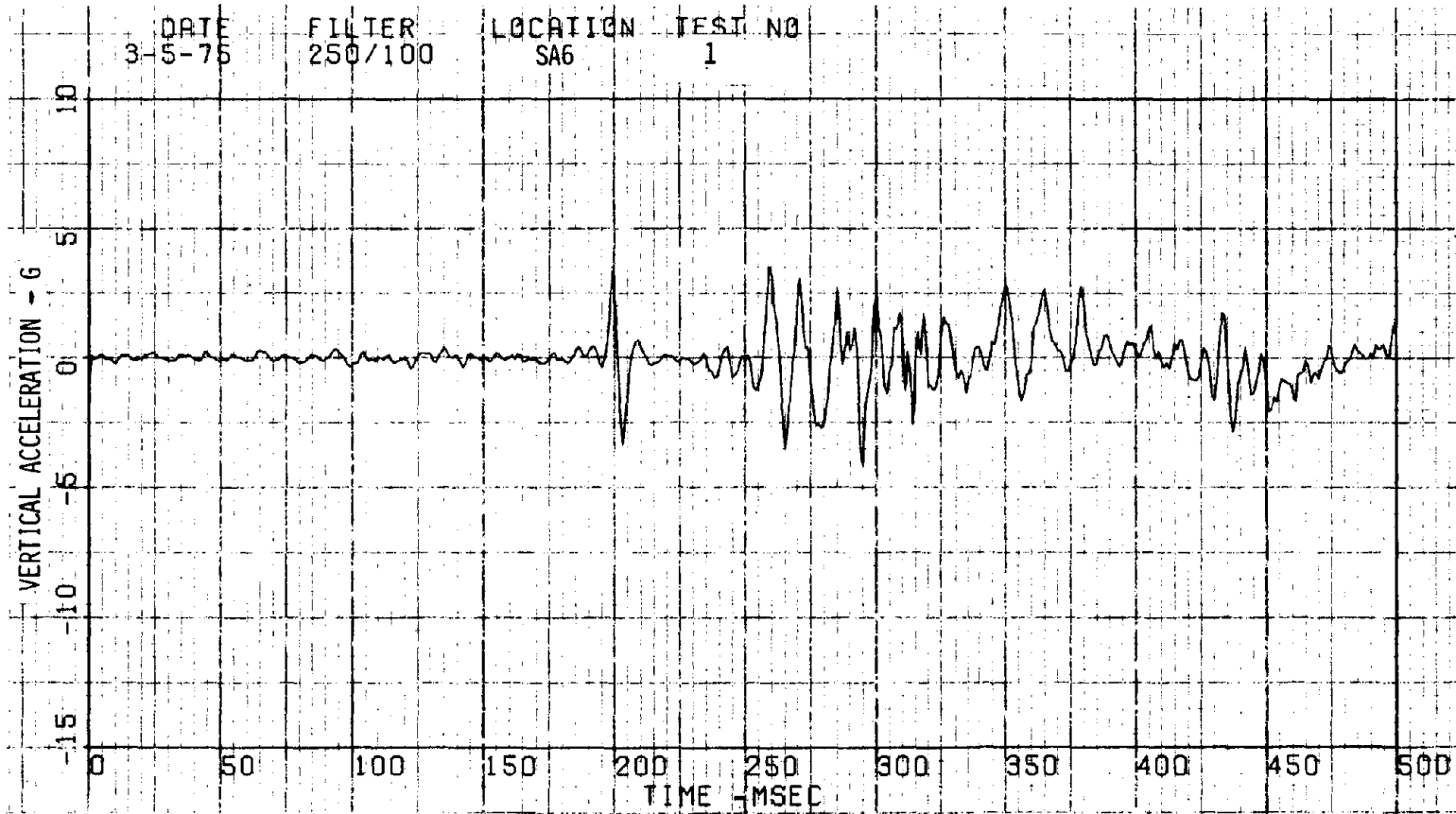


Figure A-30. Hopper 021 Front Vertical Accelerometer - Test 1.

A-29

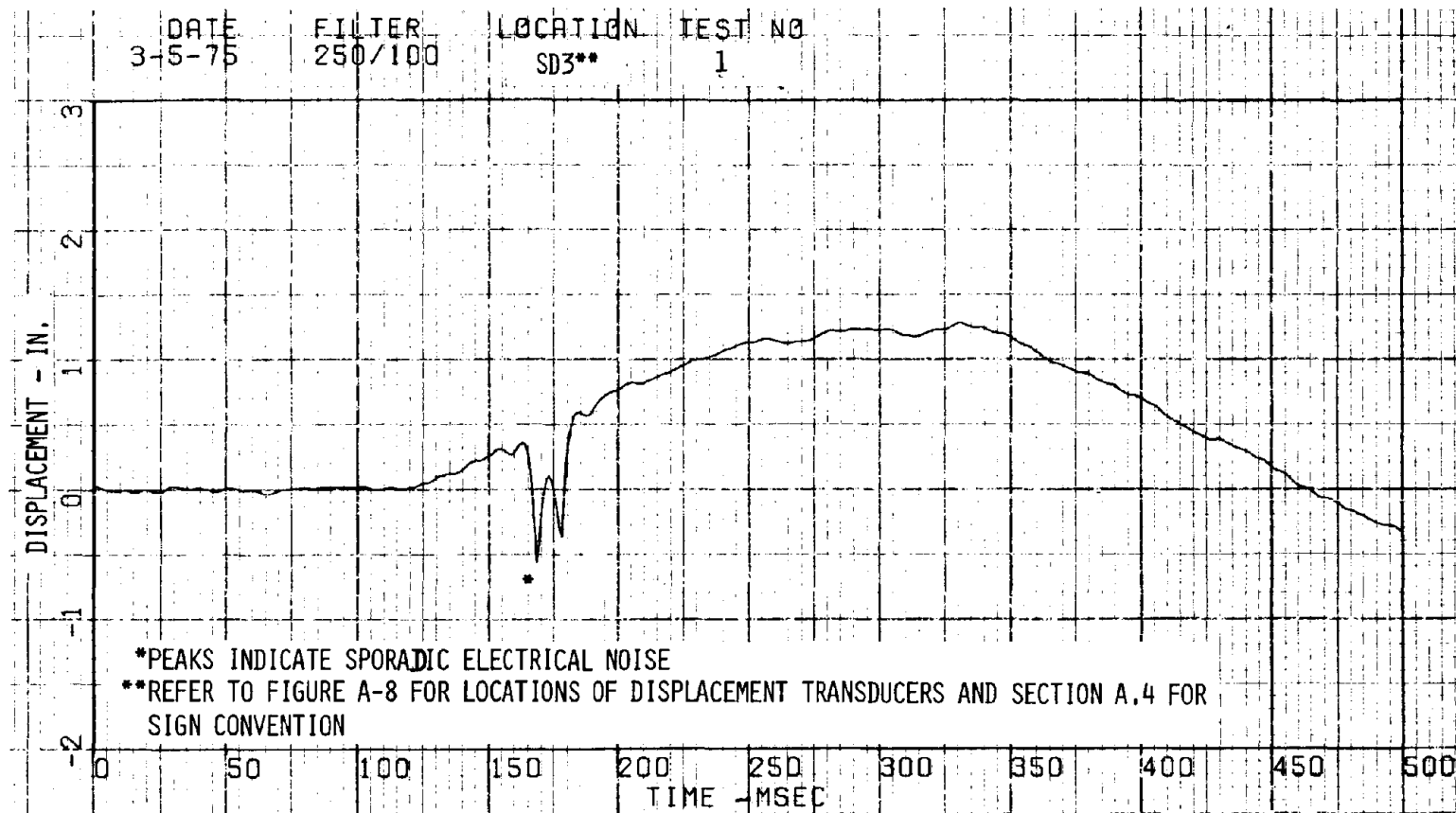


Figure A-31. Caboose Left Front Displacement Transducer - Test 1.

A-30

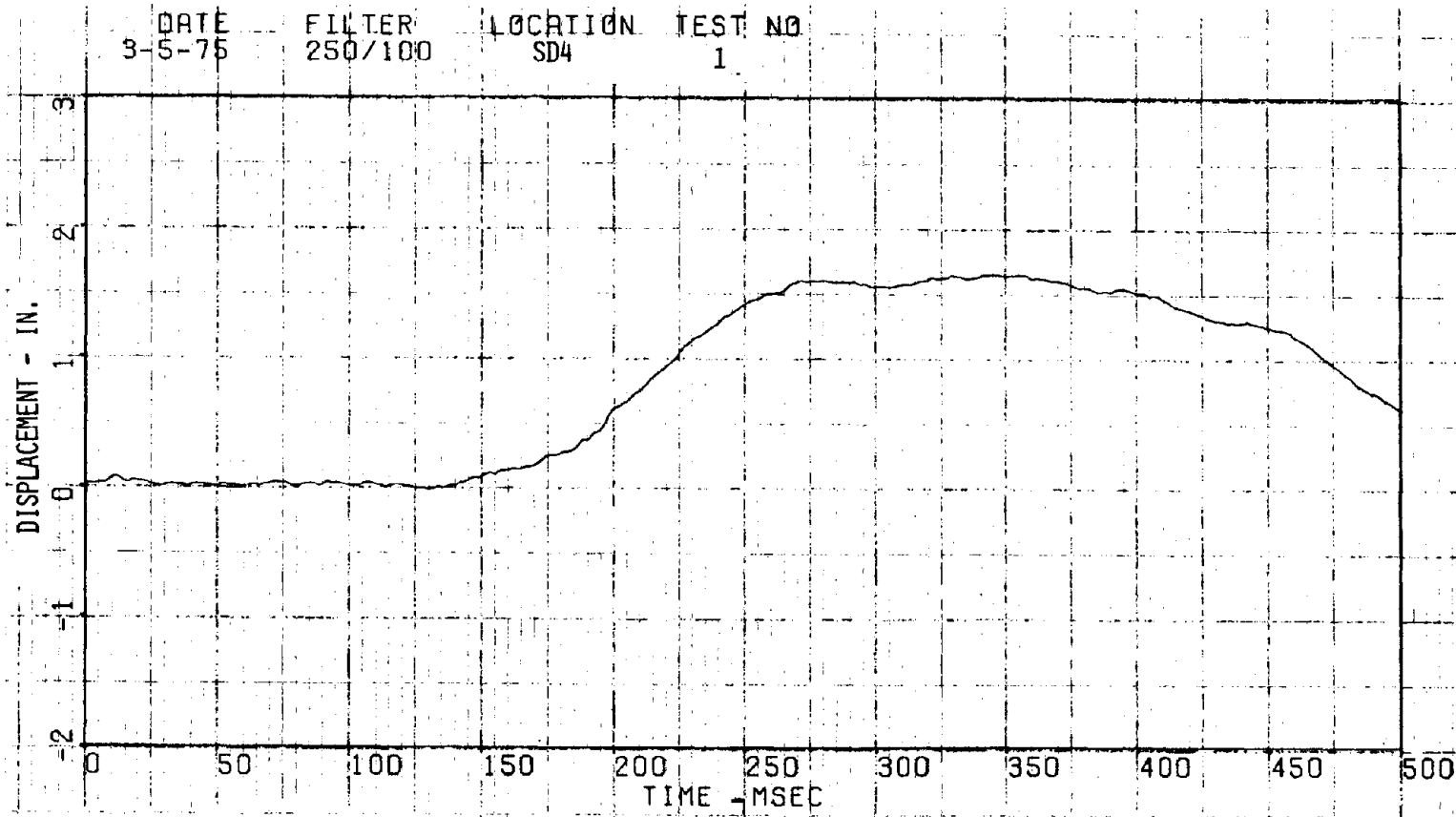


Figure A-32. Caboose Right Front Displacement Transducer - Test 1.

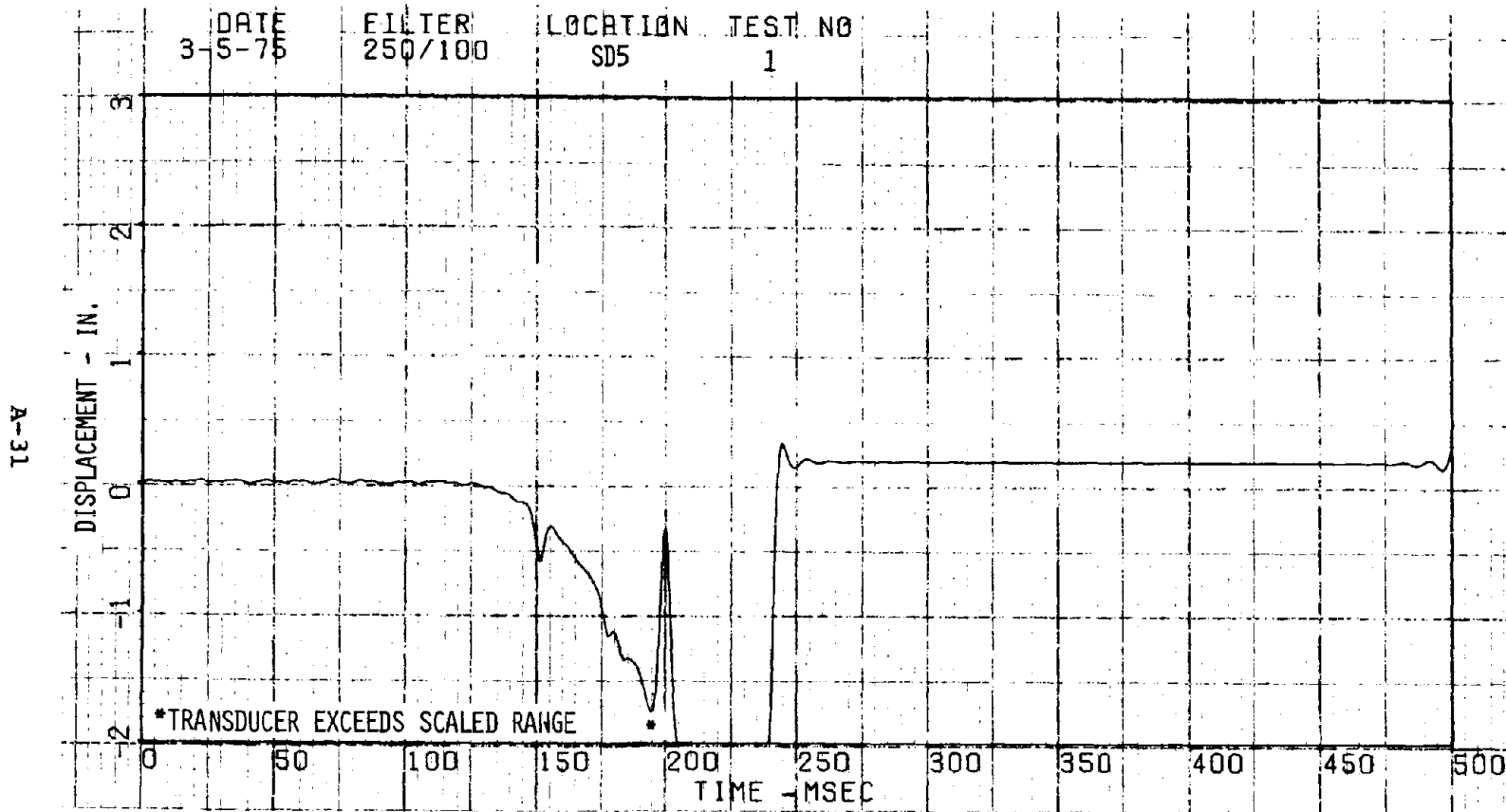


Figure A-33. Caboose to Hopper Displacement Transducer - Test 1.

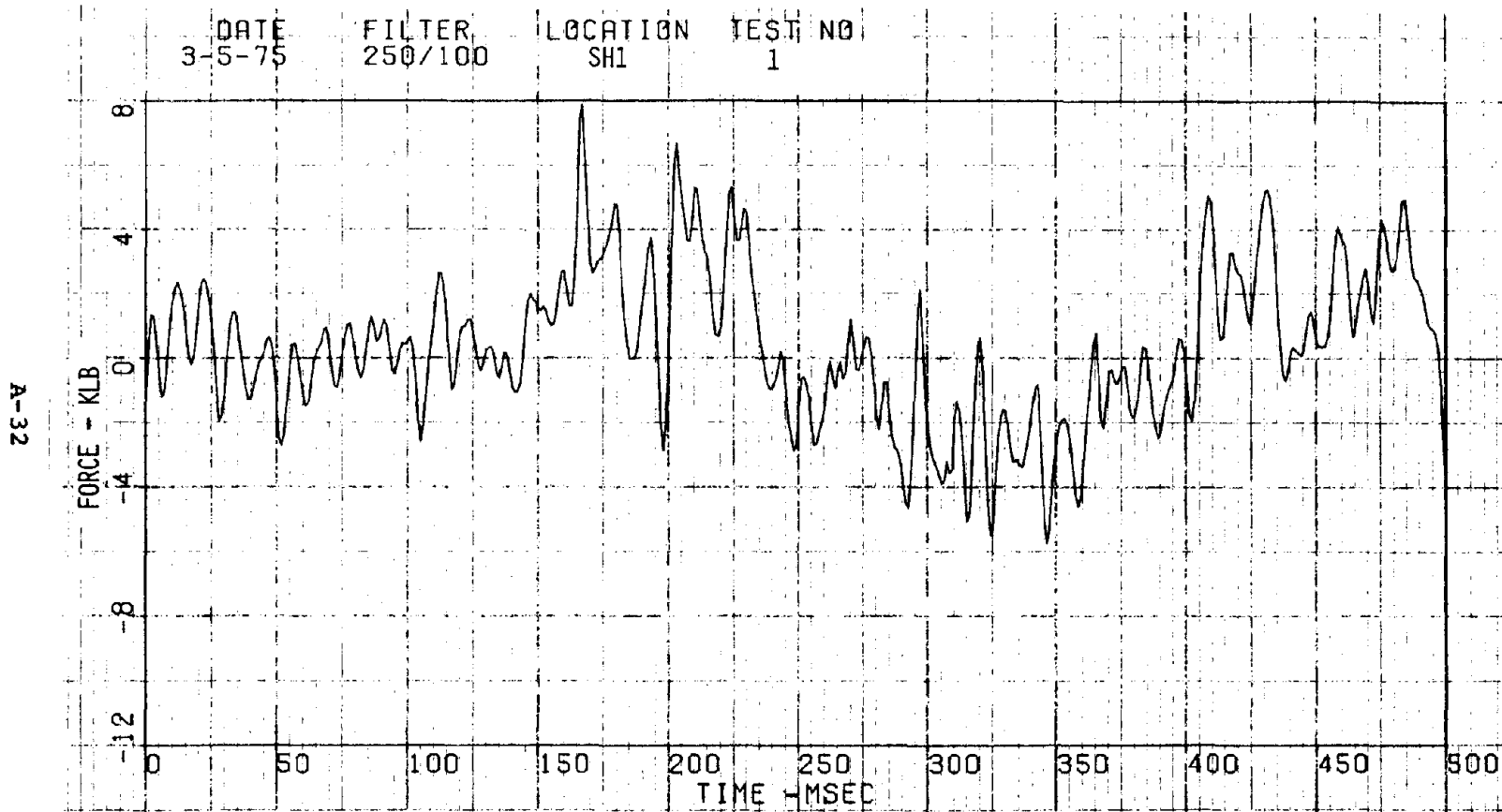


Figure A-34. Caboose Rear Swinghanger Strain Gauge - Test 1.

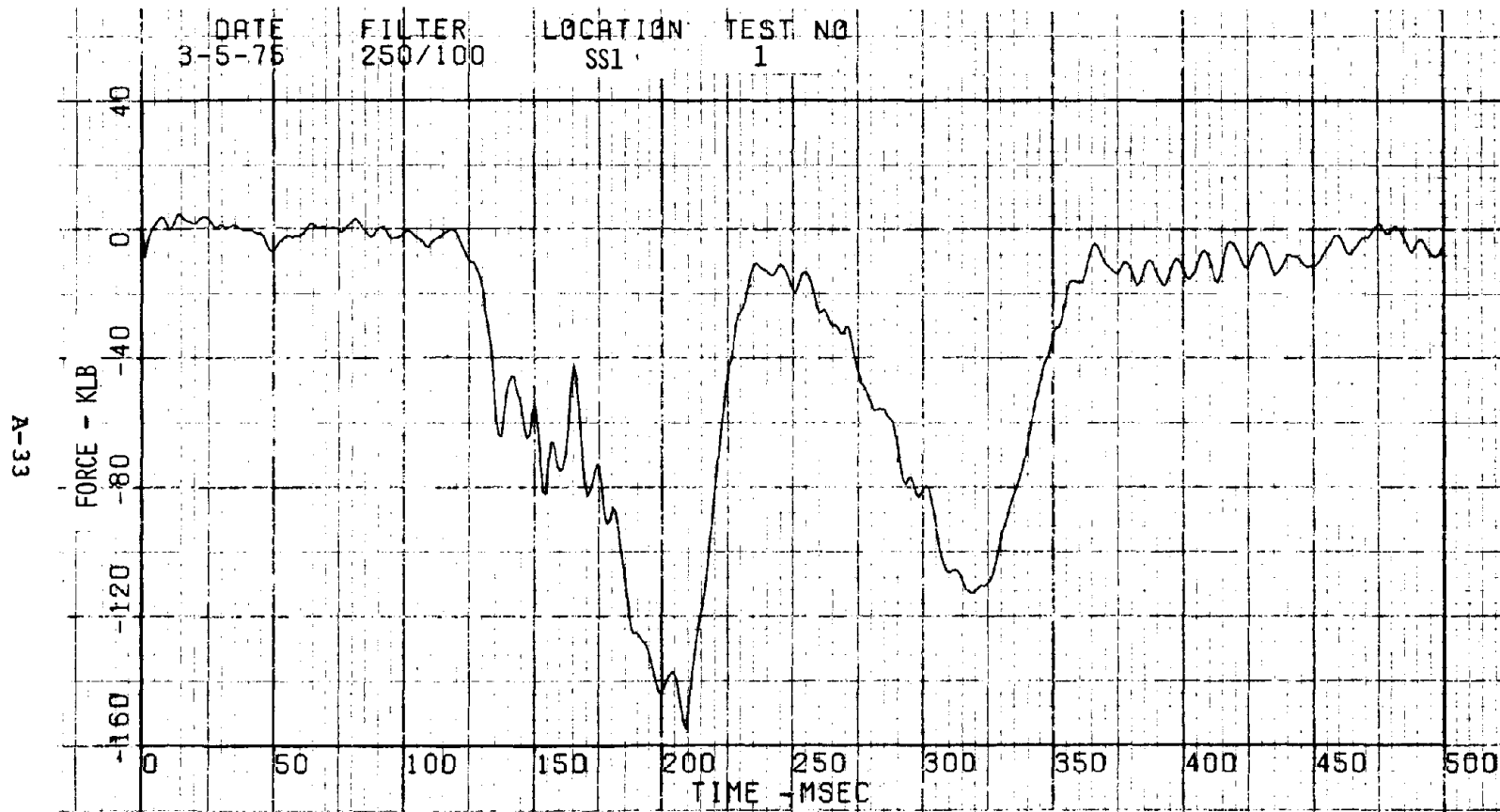


Figure A-35. Caboose Rear Coupler Strain Gauge - Test 1.

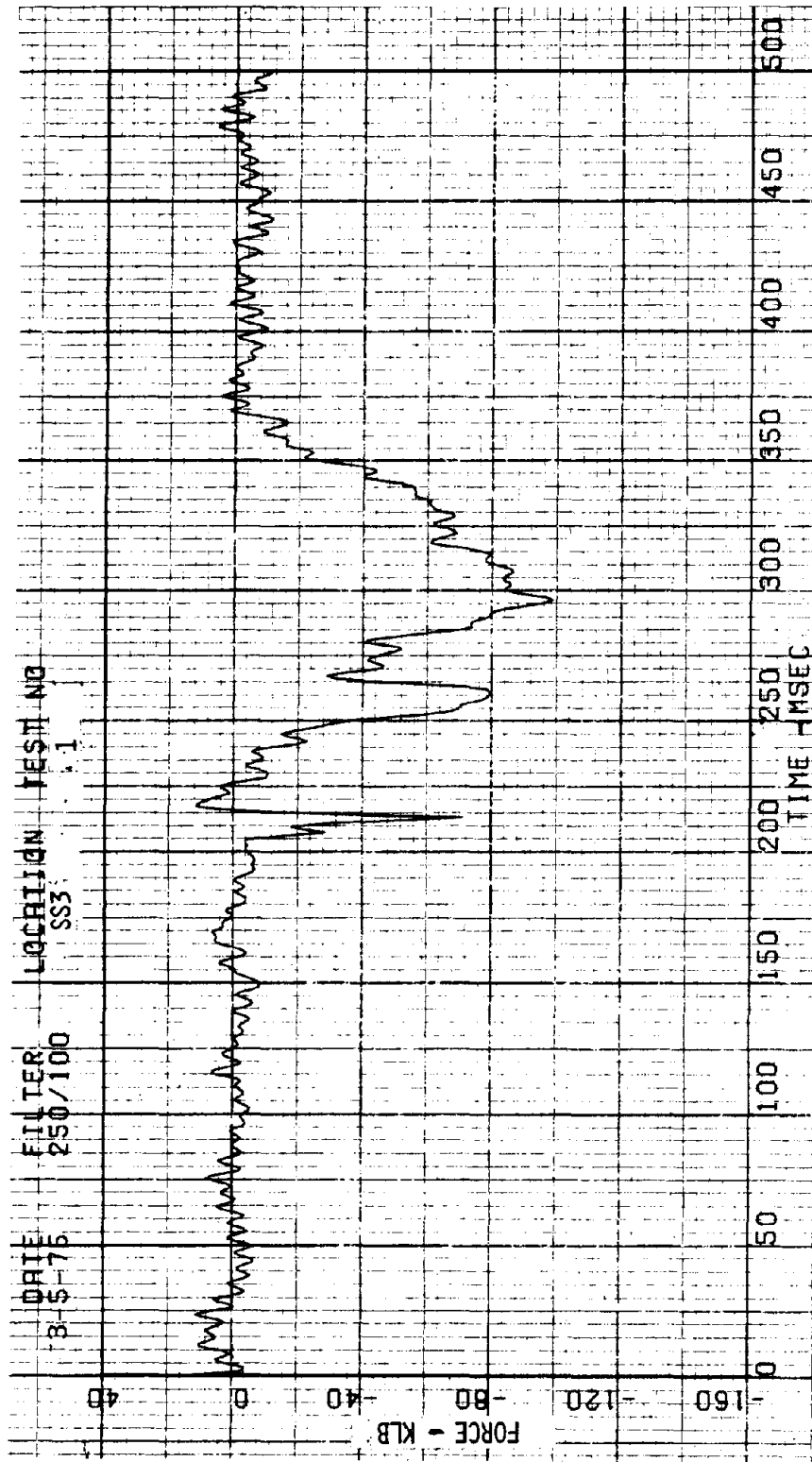


Figure A-36. Caboose Front Coupler Strain Gauge - Test 1.

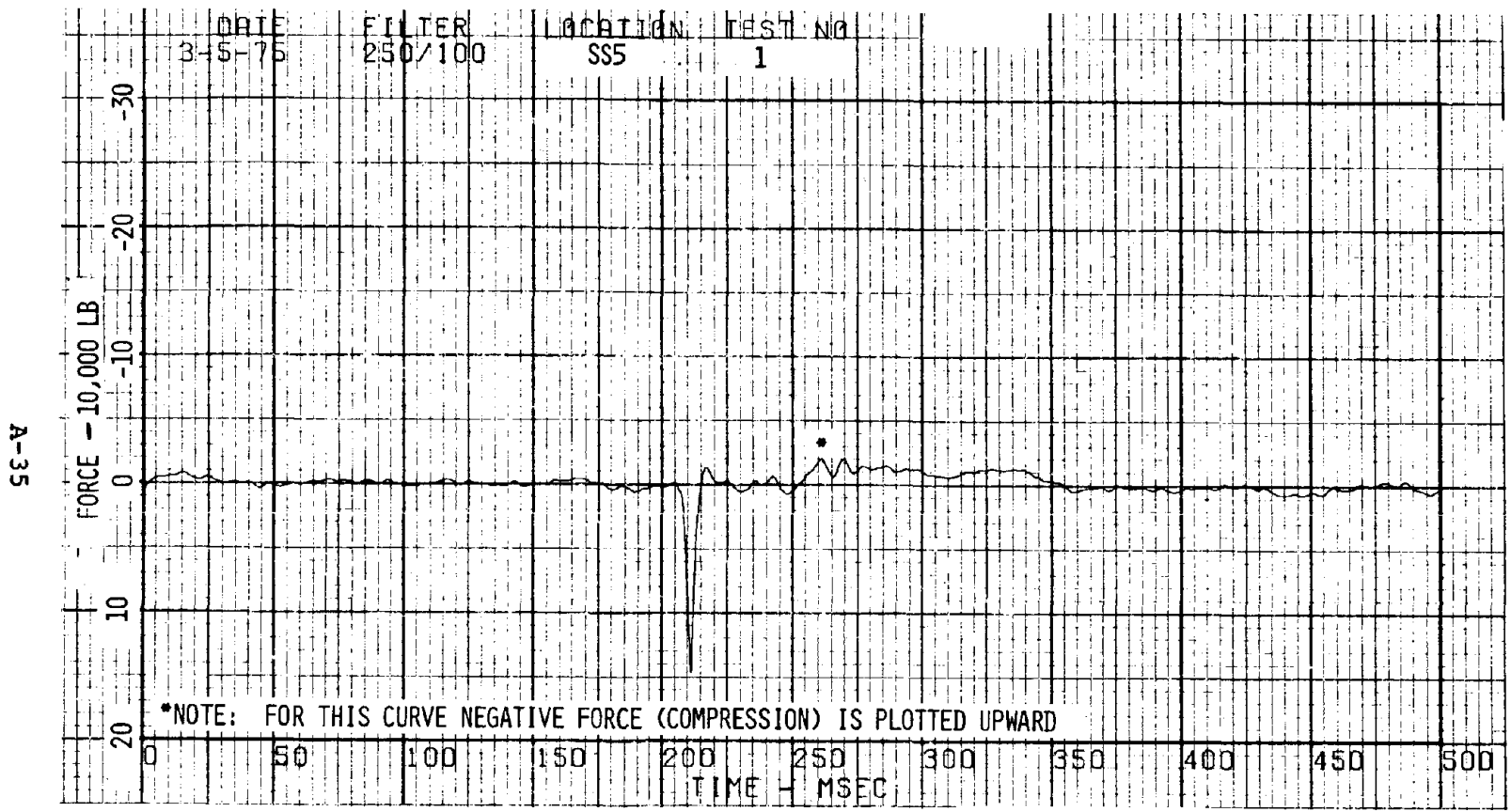
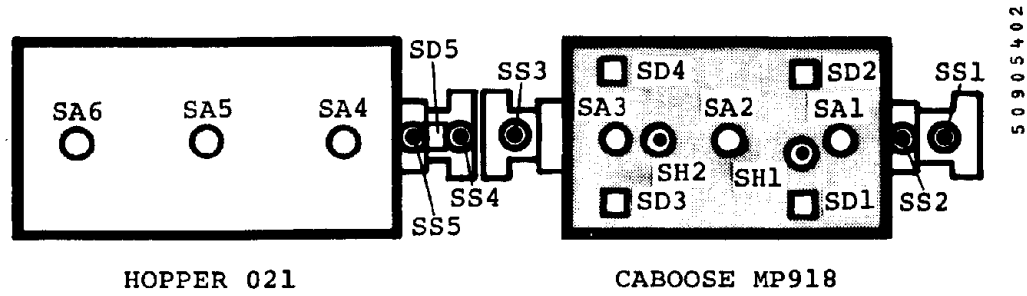
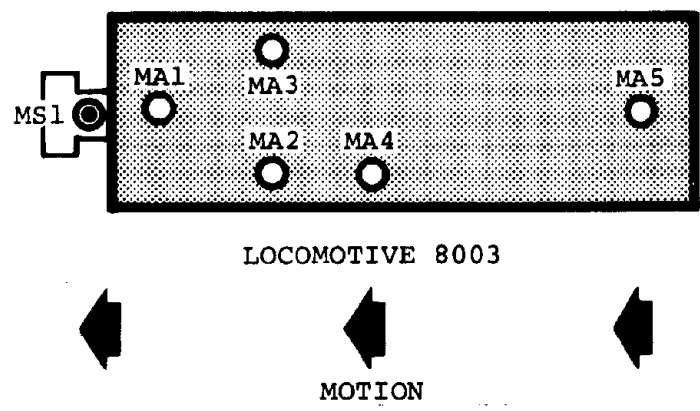


Figure A-37. Hopper Center Sill Strain Gauge - Test 1.



- HOPPER EMPTY
 - TRAIN IN DRAFT
- STANDING TRAIN

A-36



- IMPACT VELOCITY = 5.2 MPH
- MOVING TRAIN

Figure A-38. Instrument Locations - Test 2.

A-37

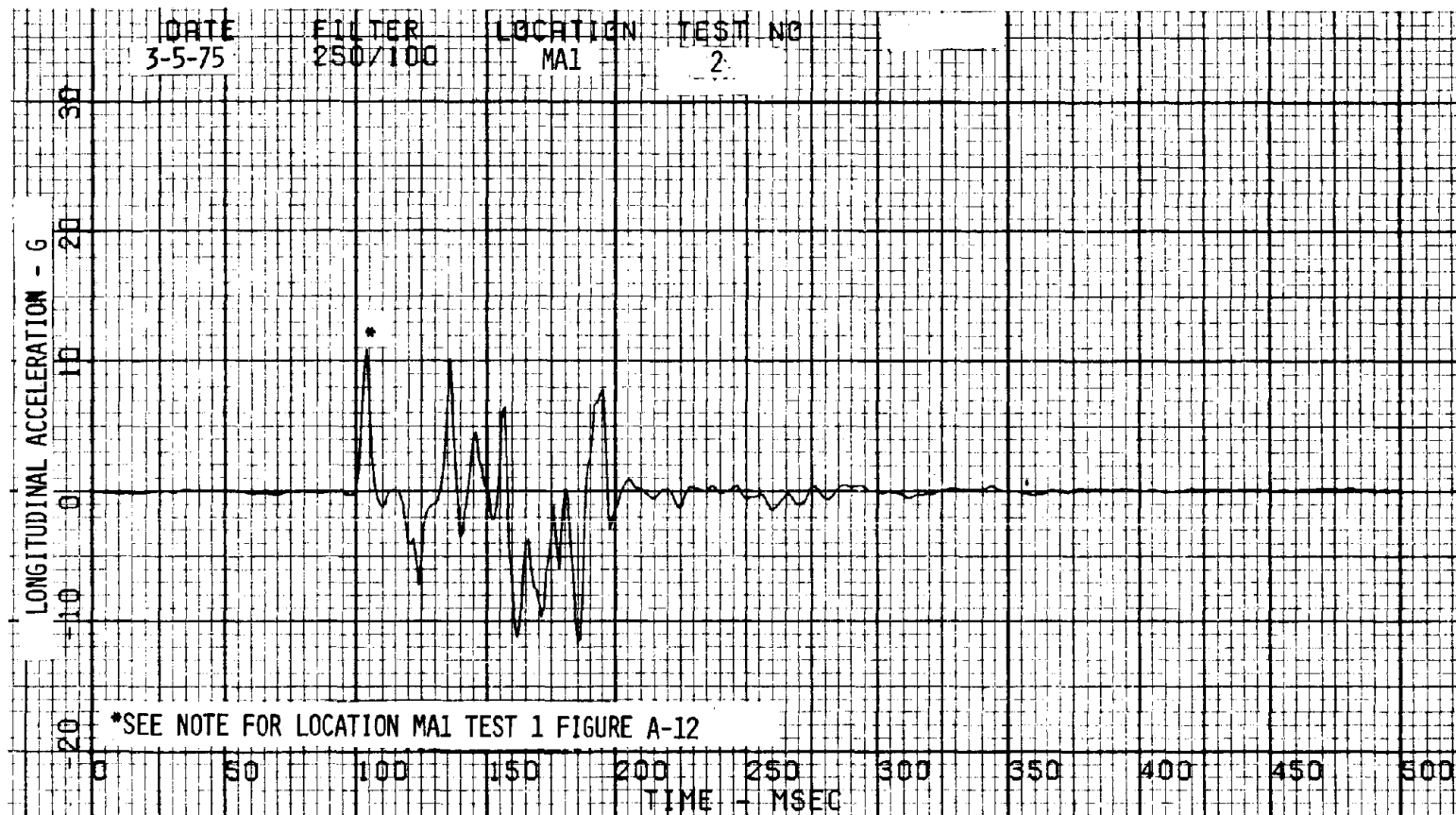


Figure A-39. Locomotive Rear Triaxial Accelerometer (X) - Test 2.

A-38

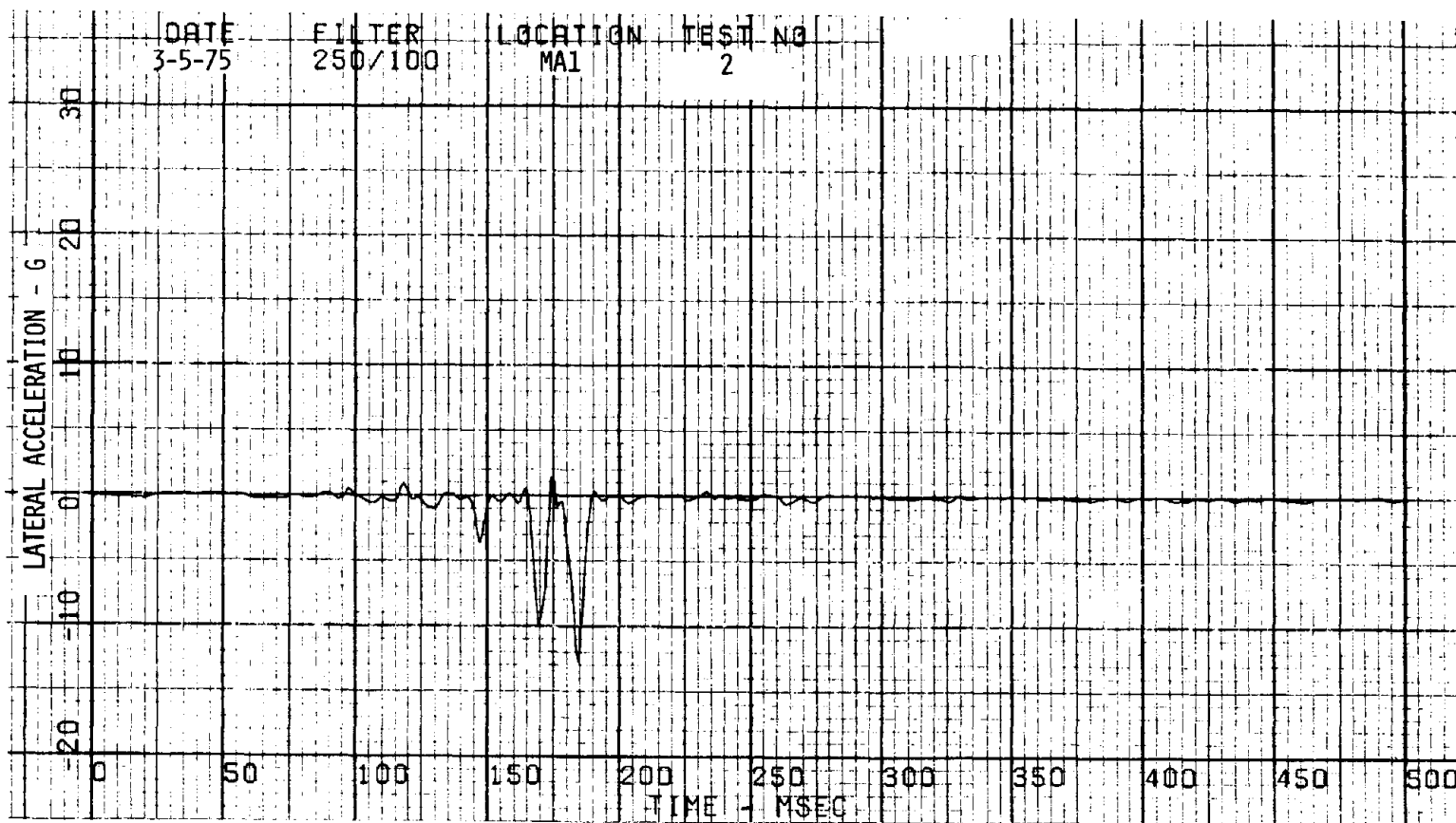


Figure A-40. Locomotive Rear Triaxial Accelerometer (Y) - Test 2.

A-39

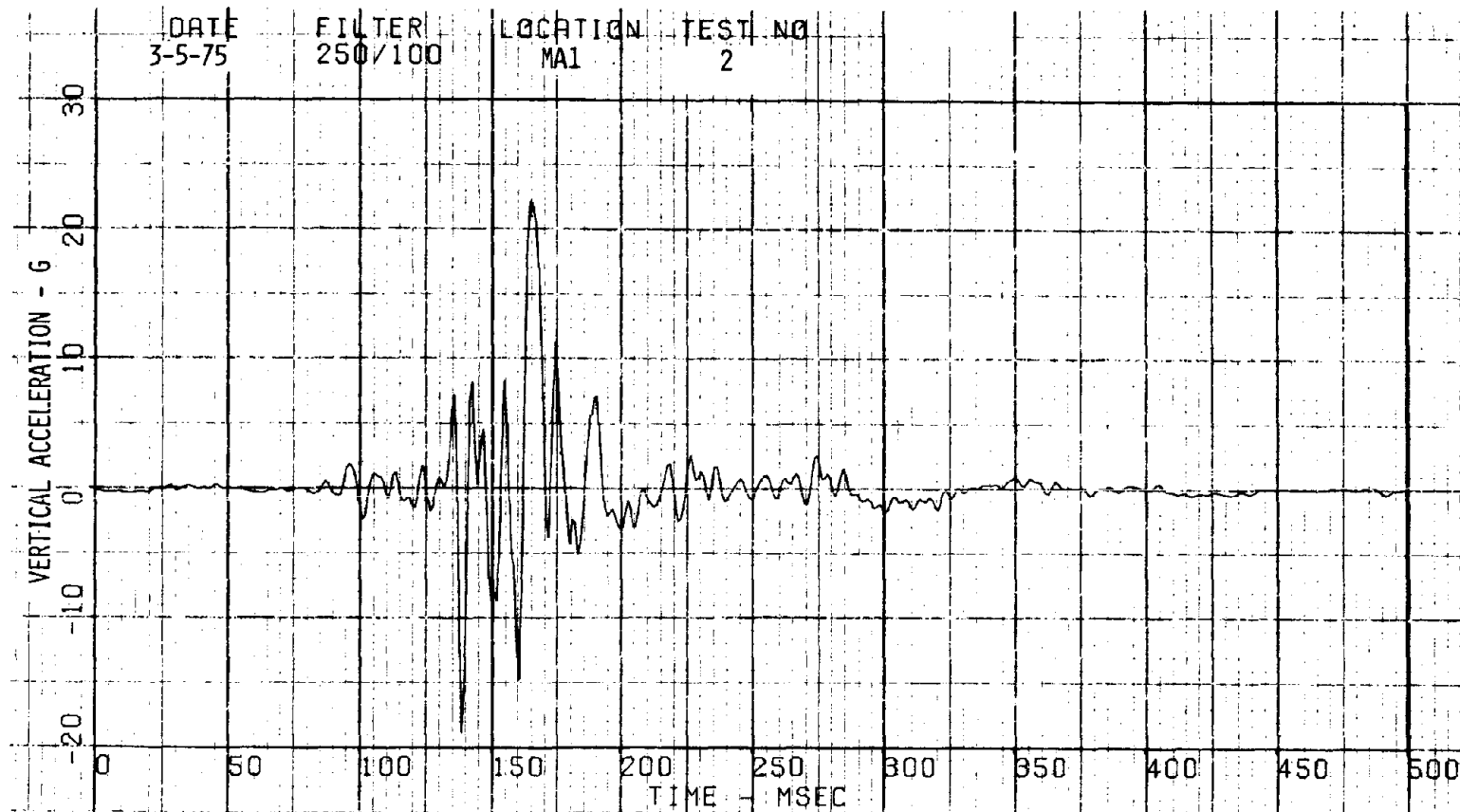


Figure A-41. Locomotive Rear Triaxial Accelerometer (Z) - Test 2.

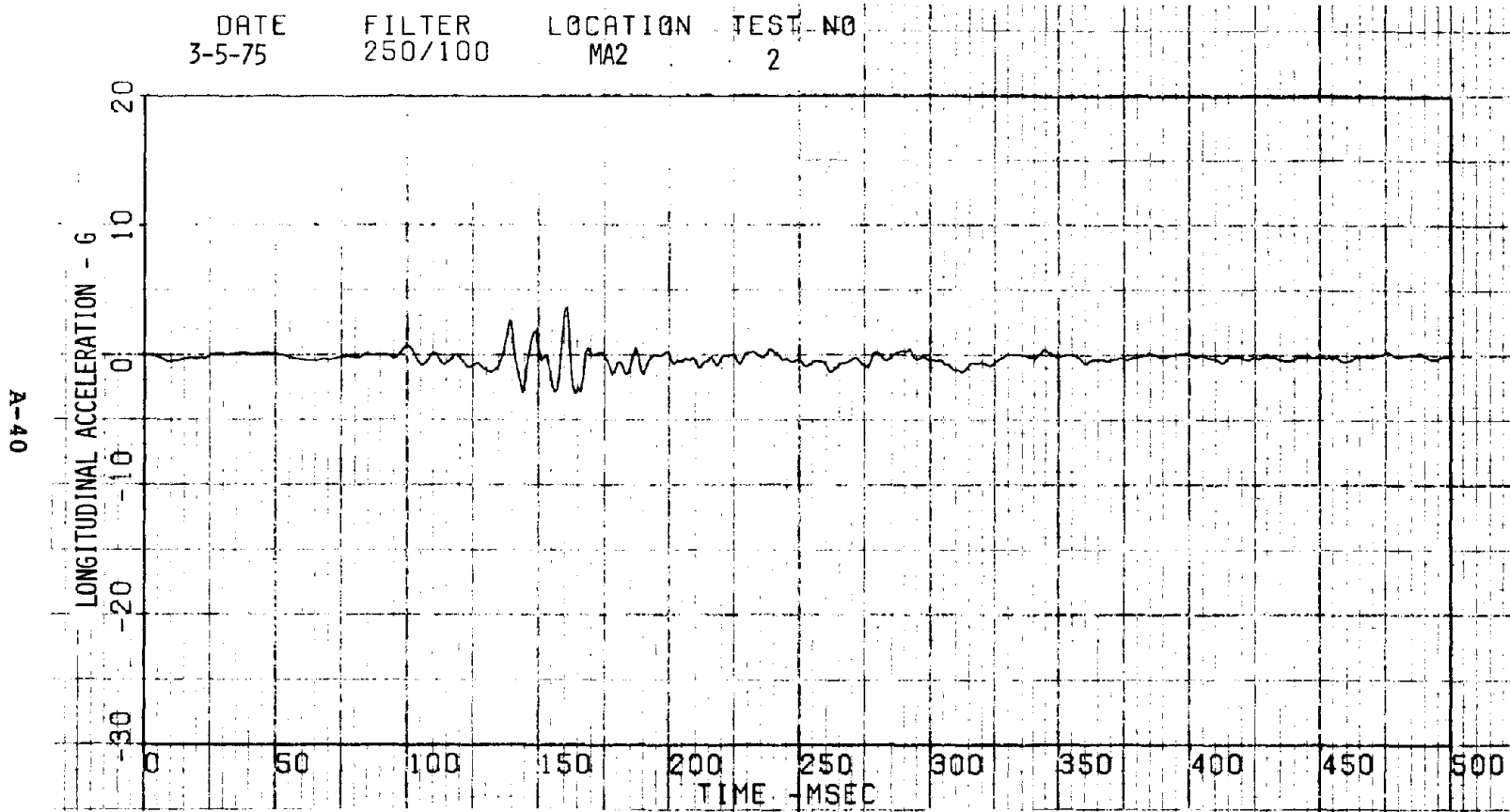


Figure A-42. Locomotive Left Cab Accelerometer - Test 2.

DATE 3-5-75 FILTER 250/100 LOCATION MA3 TEST NO 2

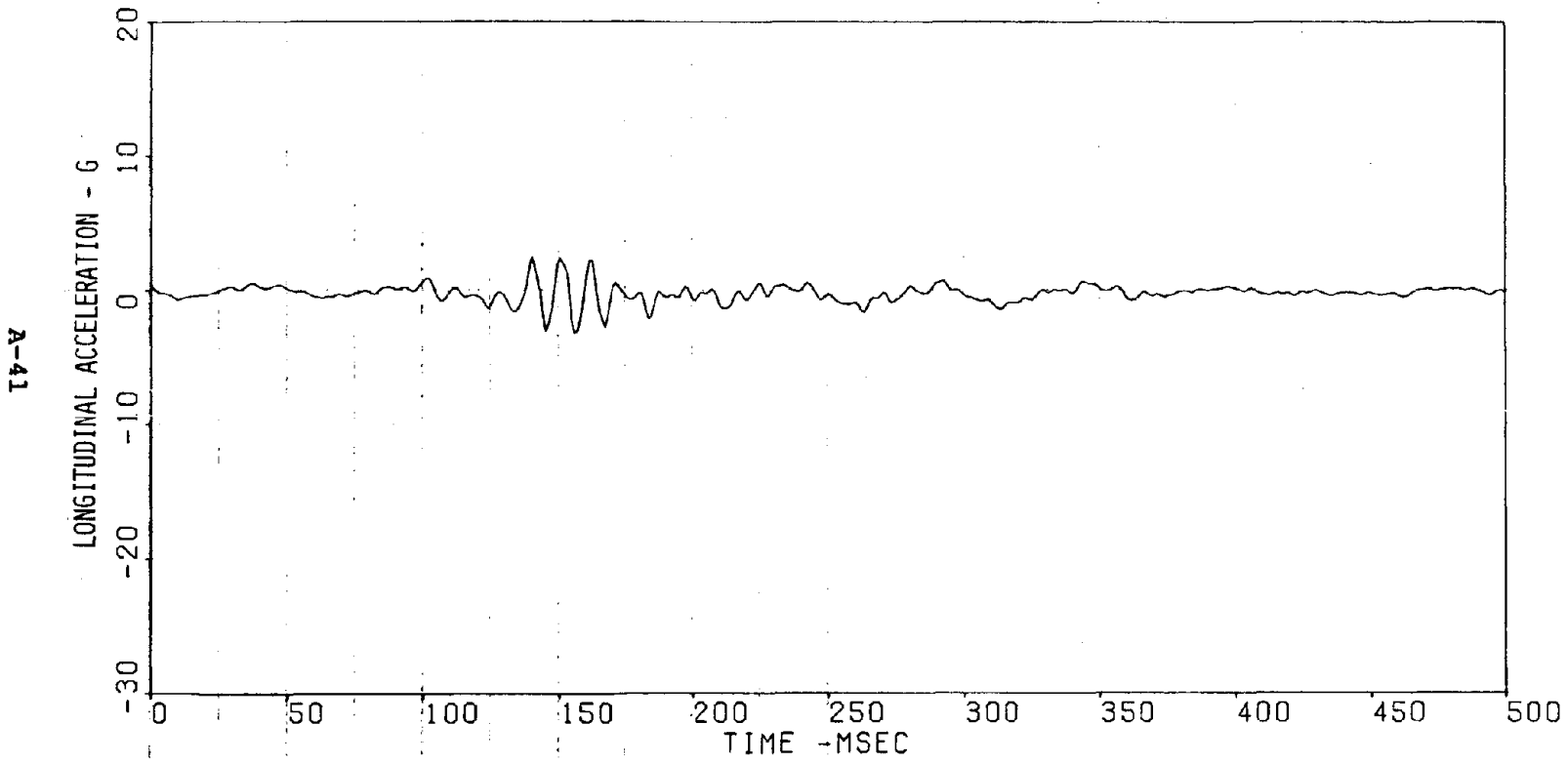


Figure A-43. Locomotive Right Cab Accelerometer - Test 2.

DATE 3-5-75 FILTER 250/100 LOCATION MA4 TEST NO 2

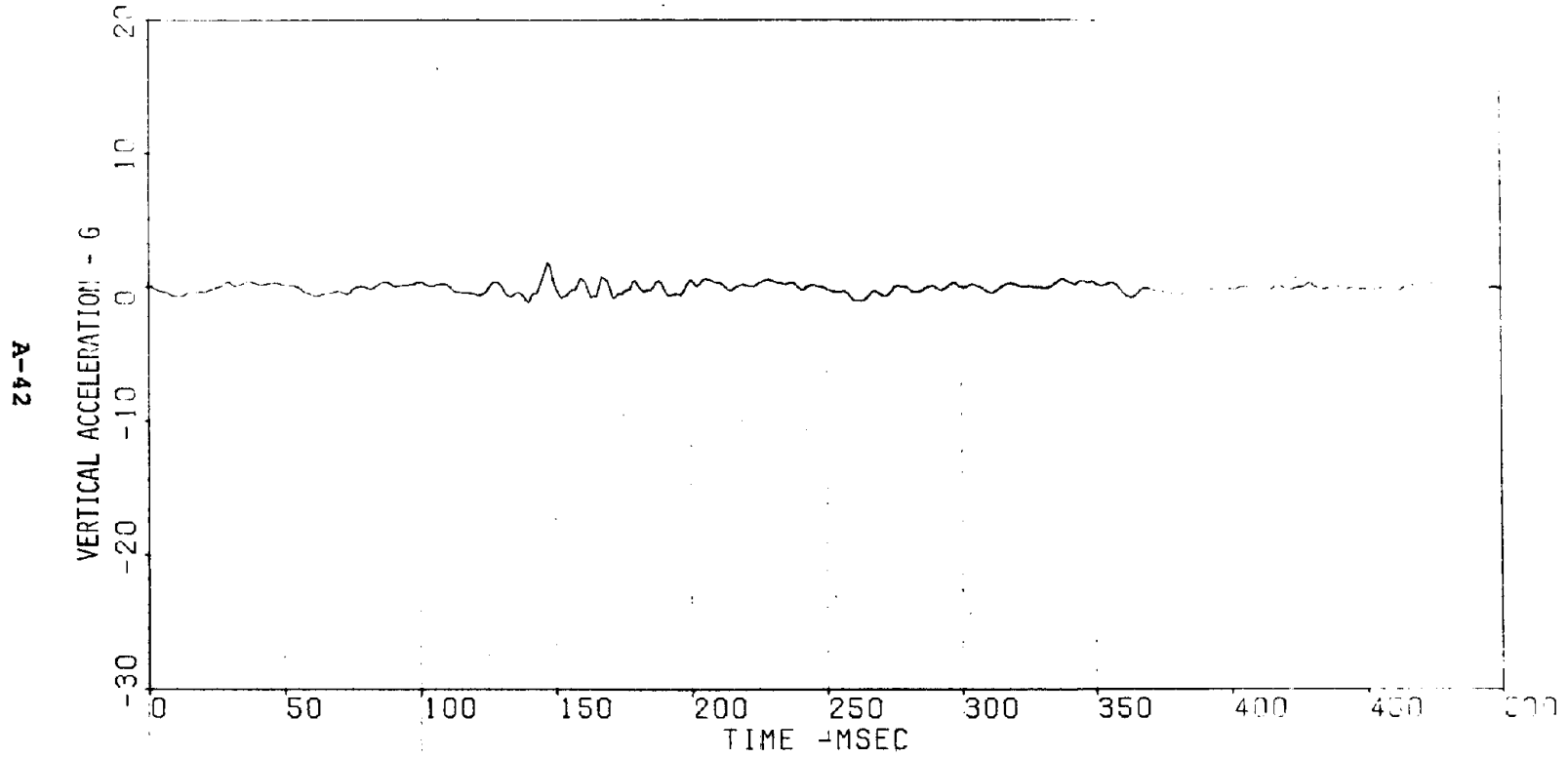


Figure A-44. Locomotive Center Vertical Accelerometer - Test 2.

A-43

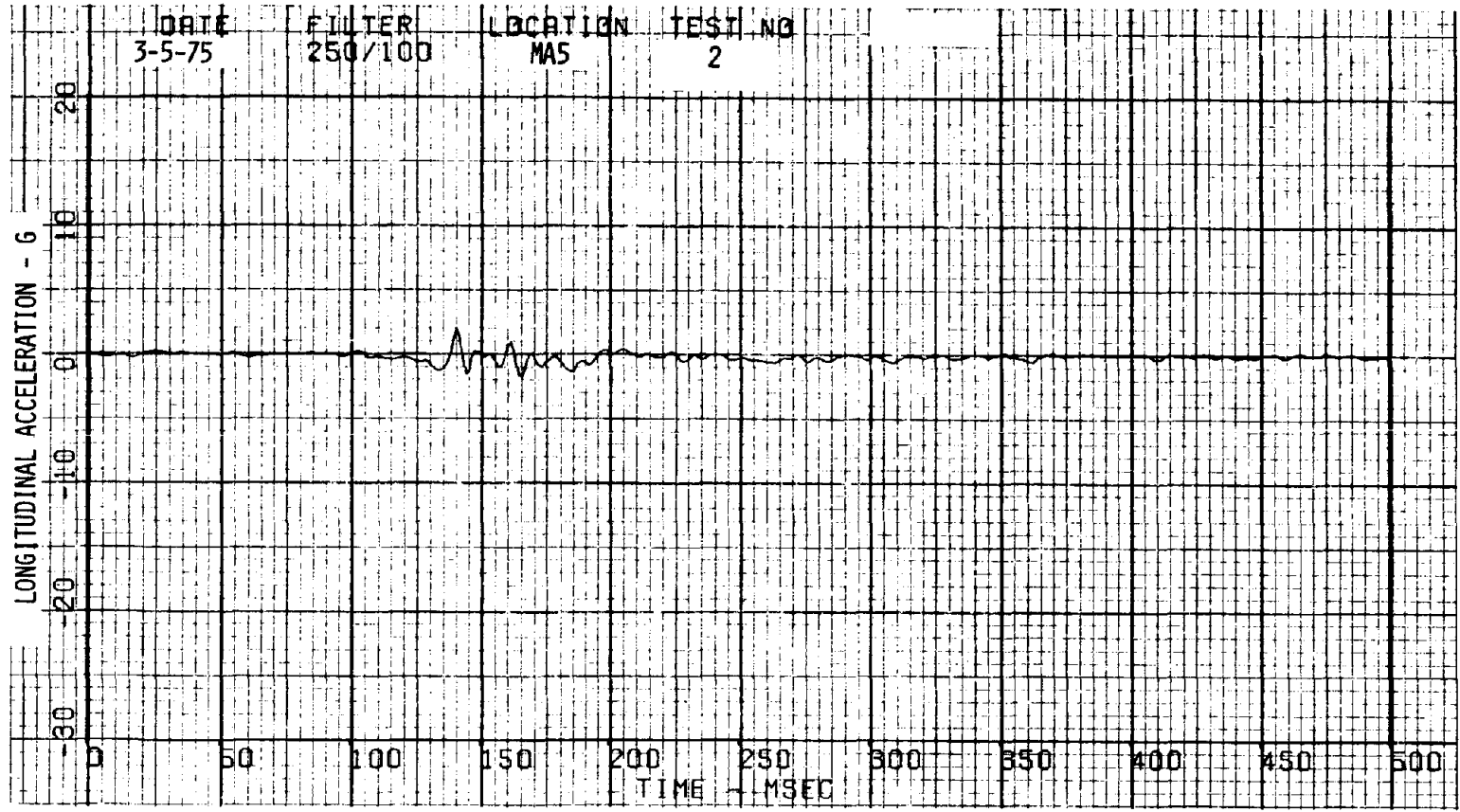


Figure A-45. Locomotive Front Triaxial Accelerometer (X) - Test 2.

A-44

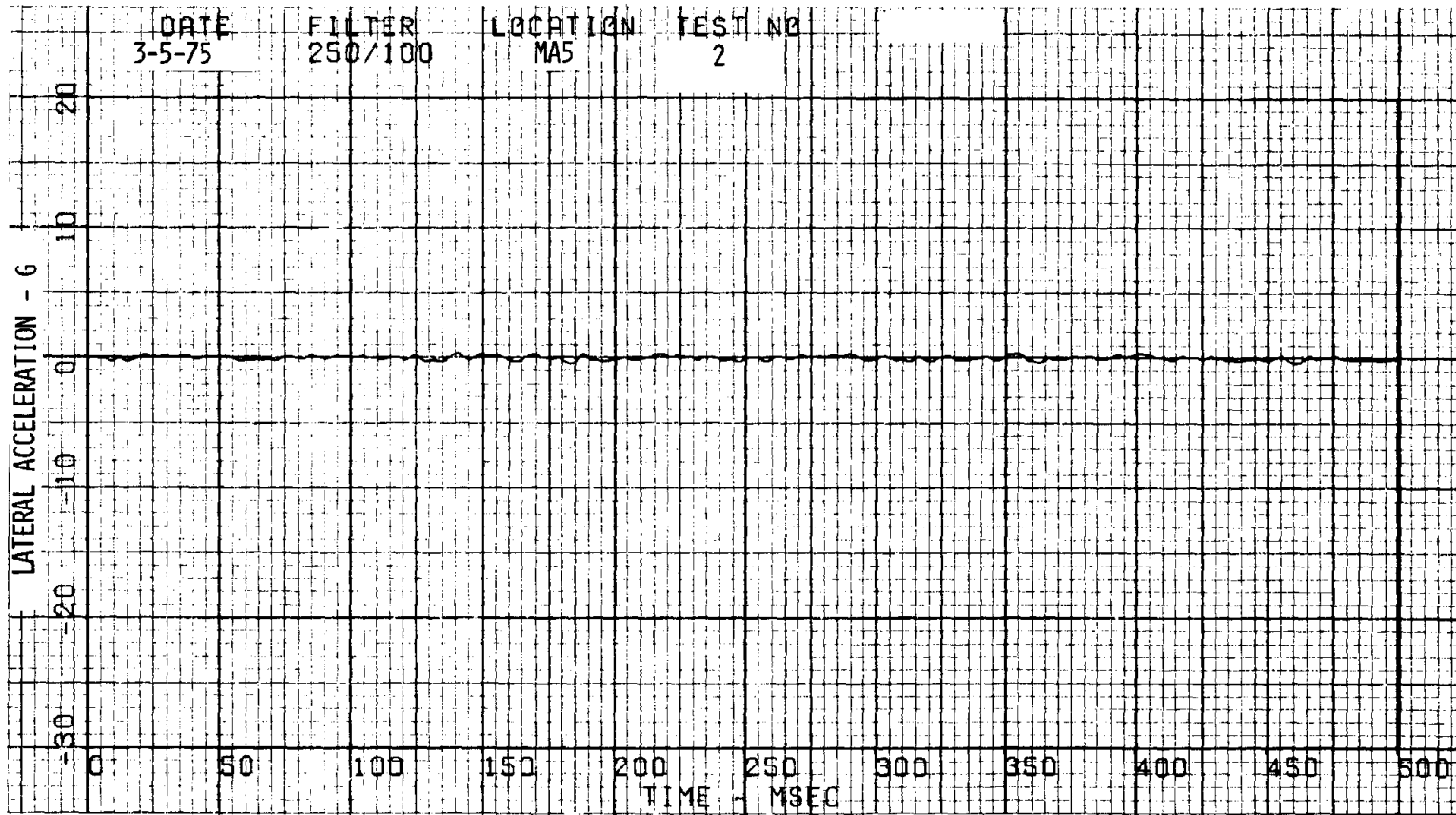


Figure A-46. Locomotive Front Triaxial Accelerometer (Y) - Test 2.

A-45

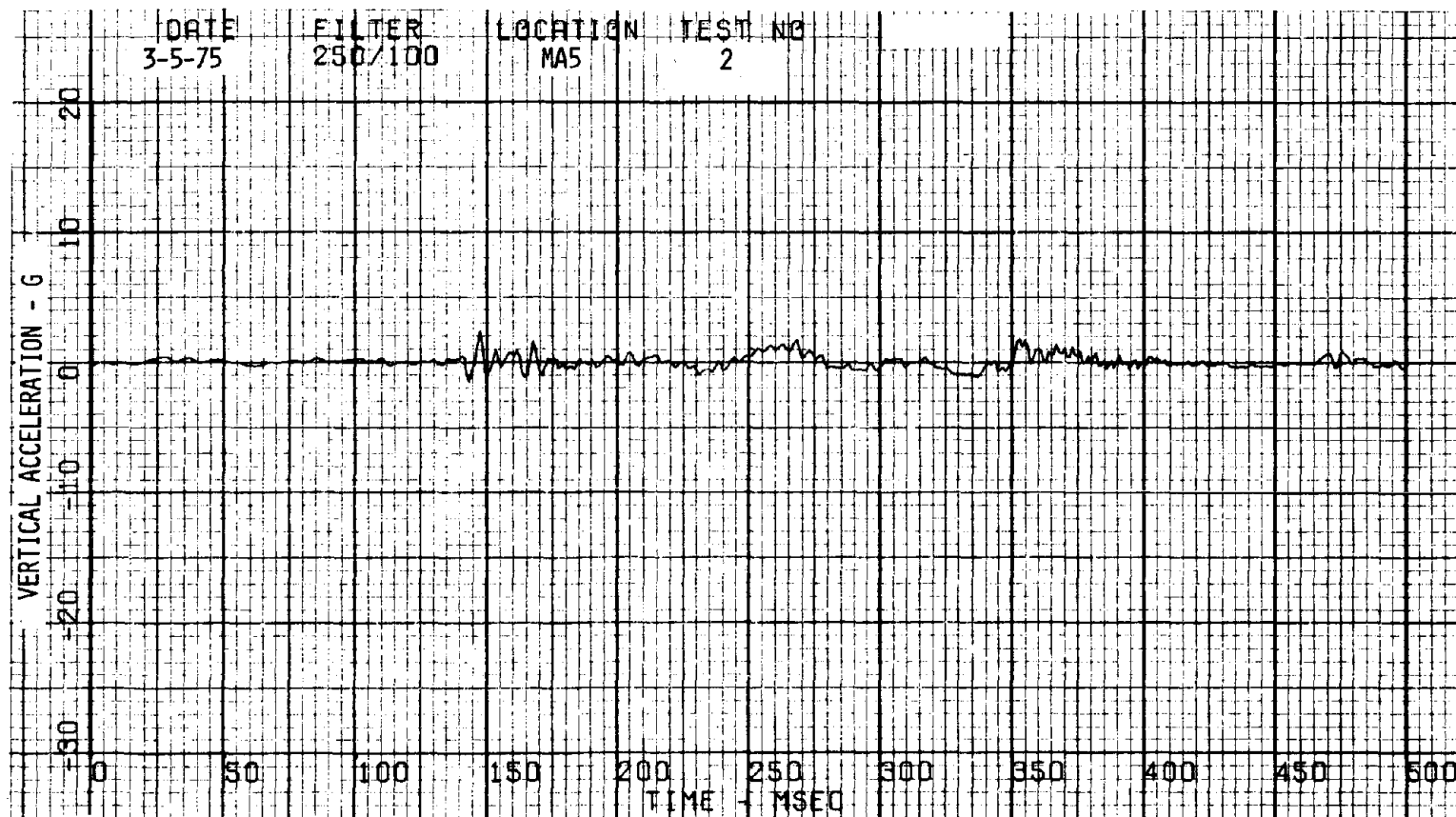


Figure A-47. Locomotive Front Triaxial Accelerometer (Z) - Test 2.

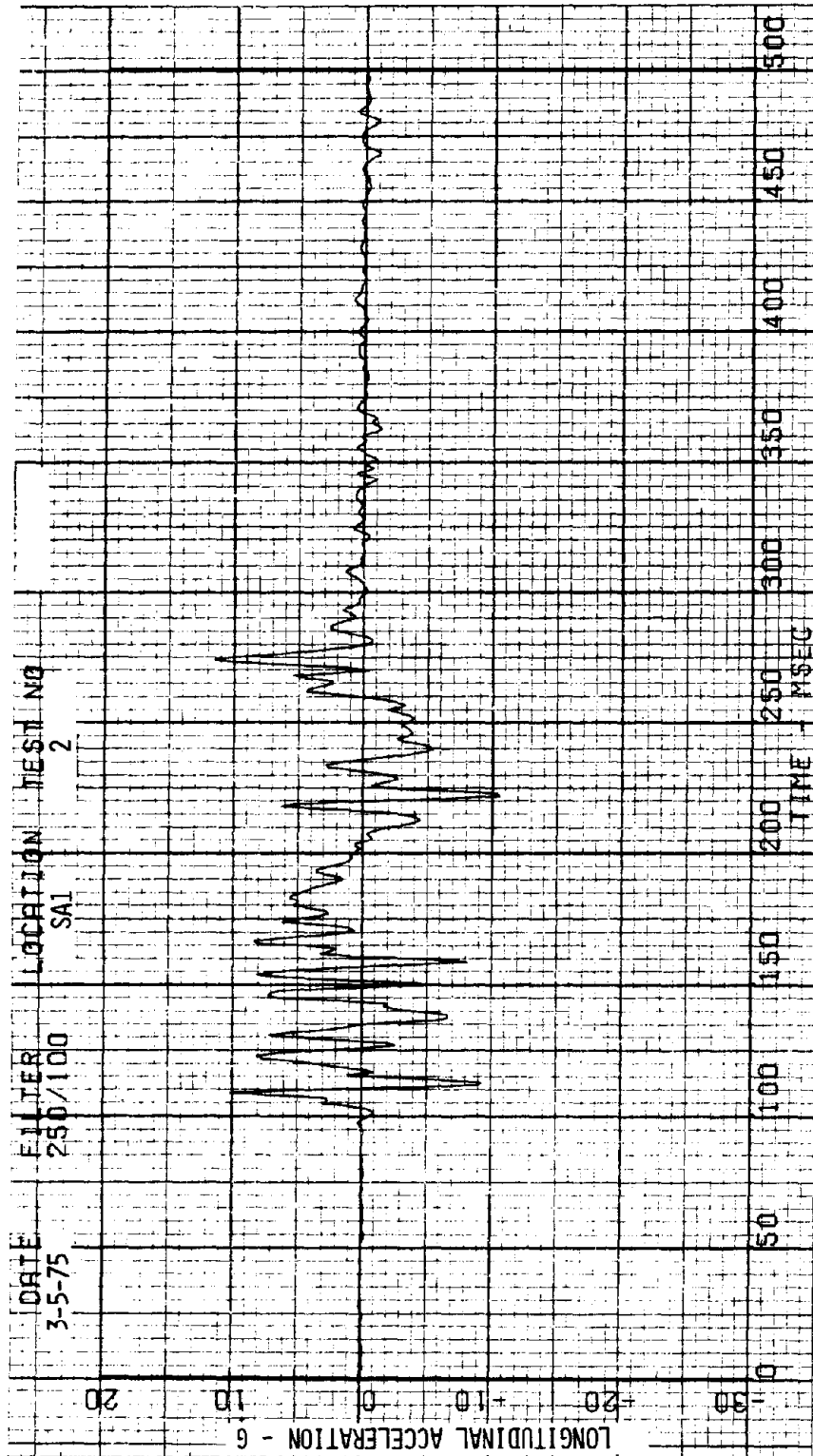


Figure A-48. Caboose Rear Triaxial Accelerometer (X) - Test 2.

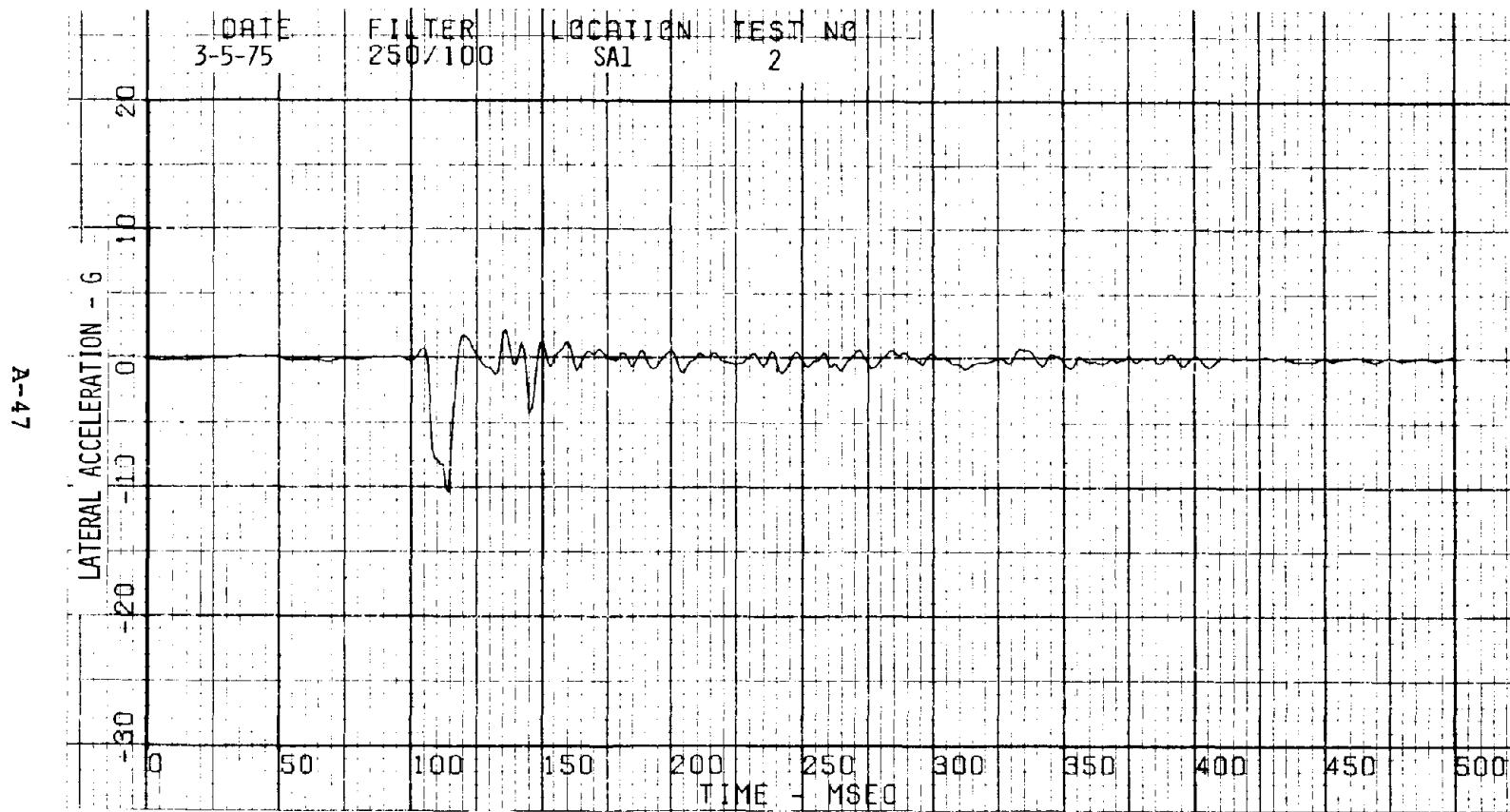


Figure A-49. Caboose Rear Triaxial Accelerometer (Y) - Test 2.

A-48

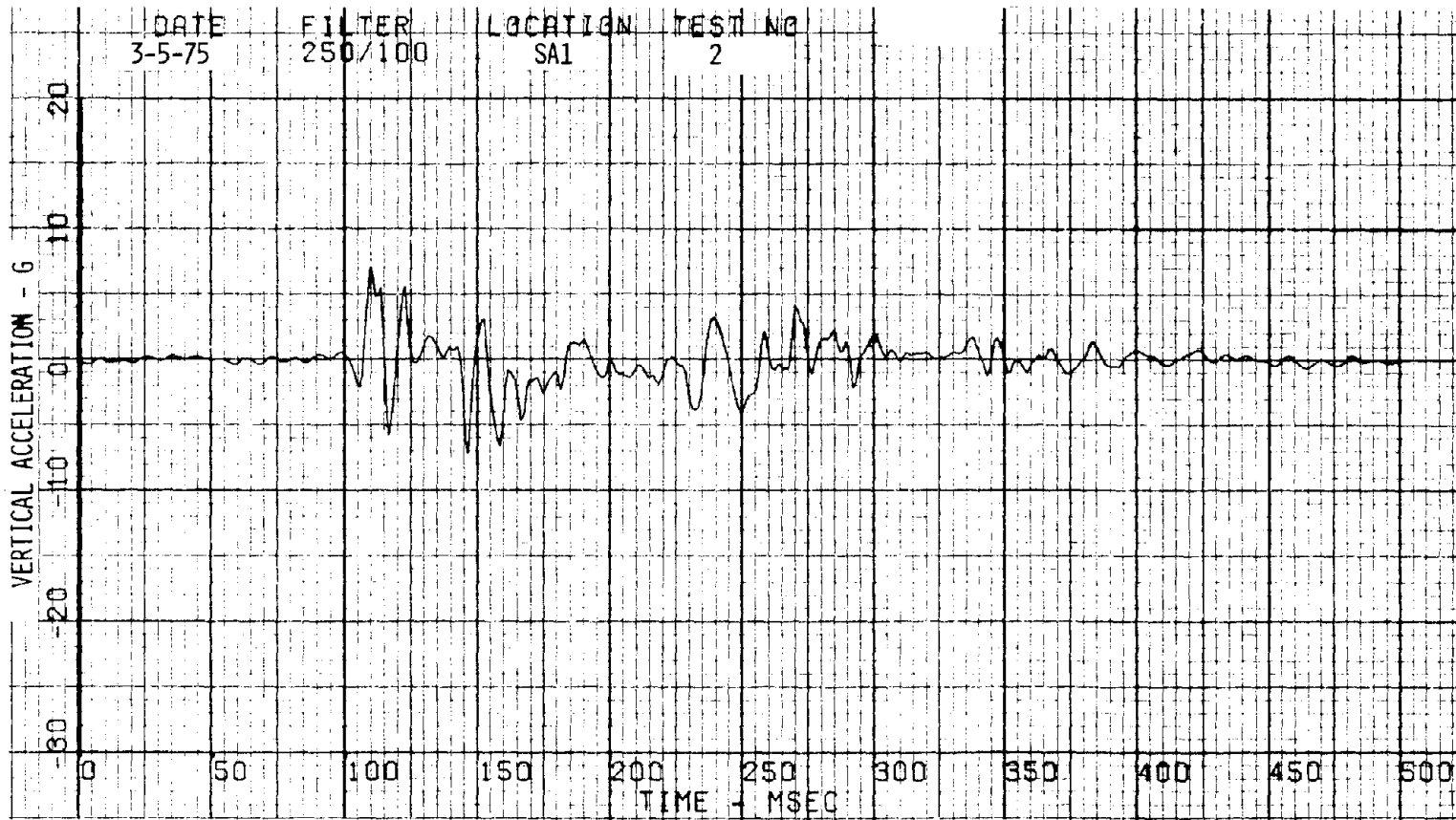


Figure A-50. Caboose Rear Triaxial Accelerometer (Z) - Test 2.

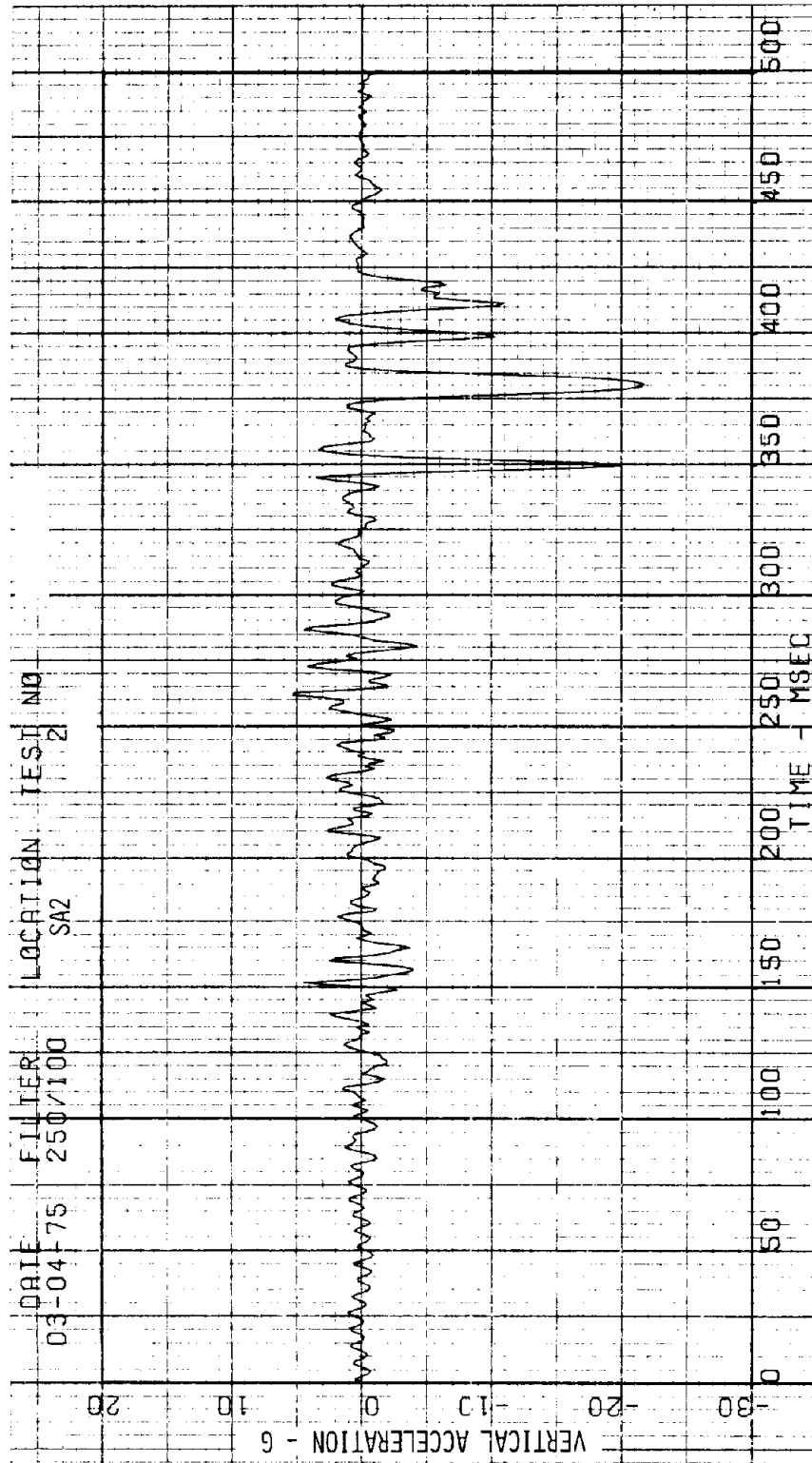


Figure A-51. Caboose Center Vertical Accelerometer - Test 2.

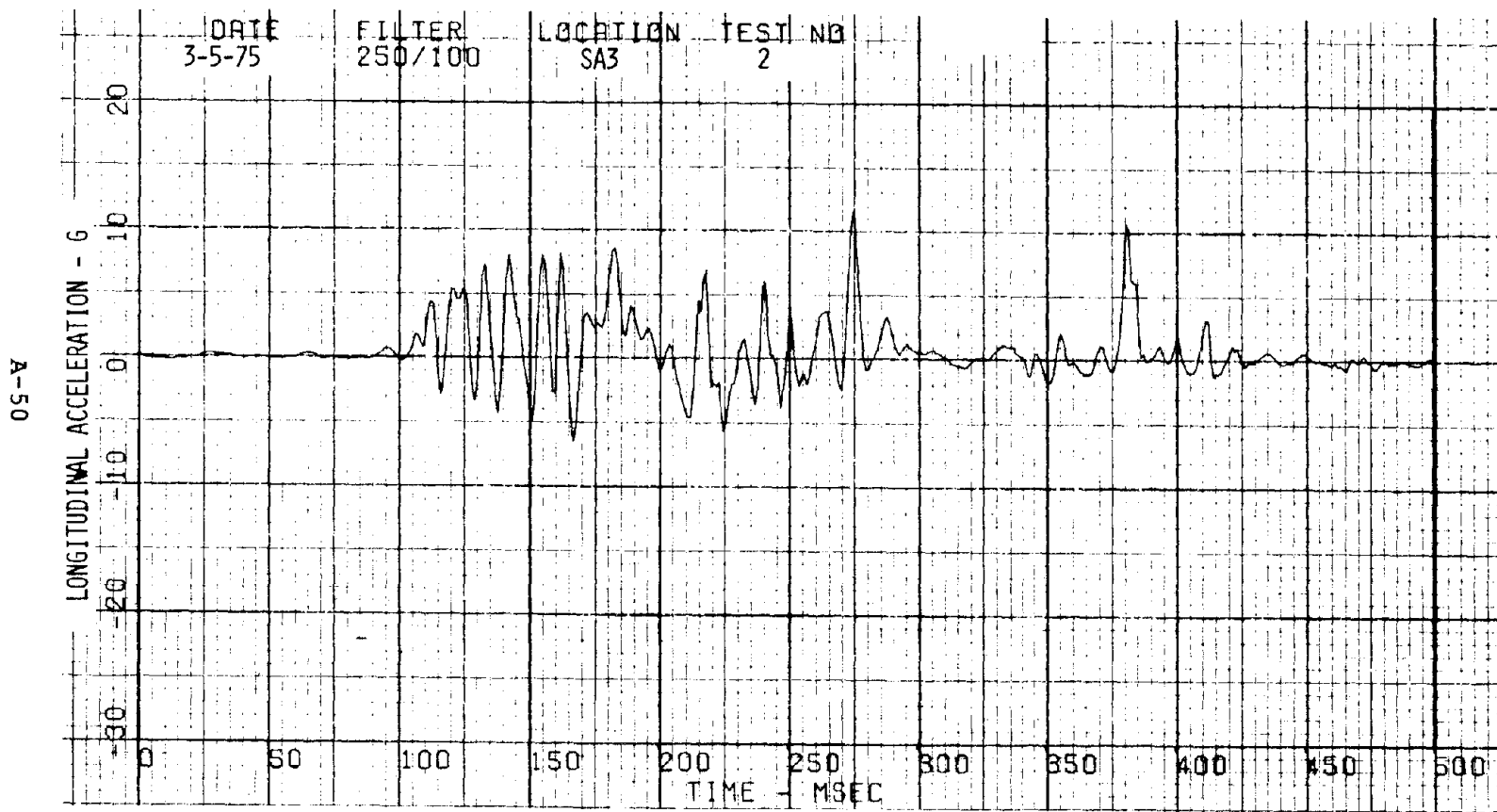


Figure A-52. Caboose Front Triaxial Accelerometer (X) - Test 2.

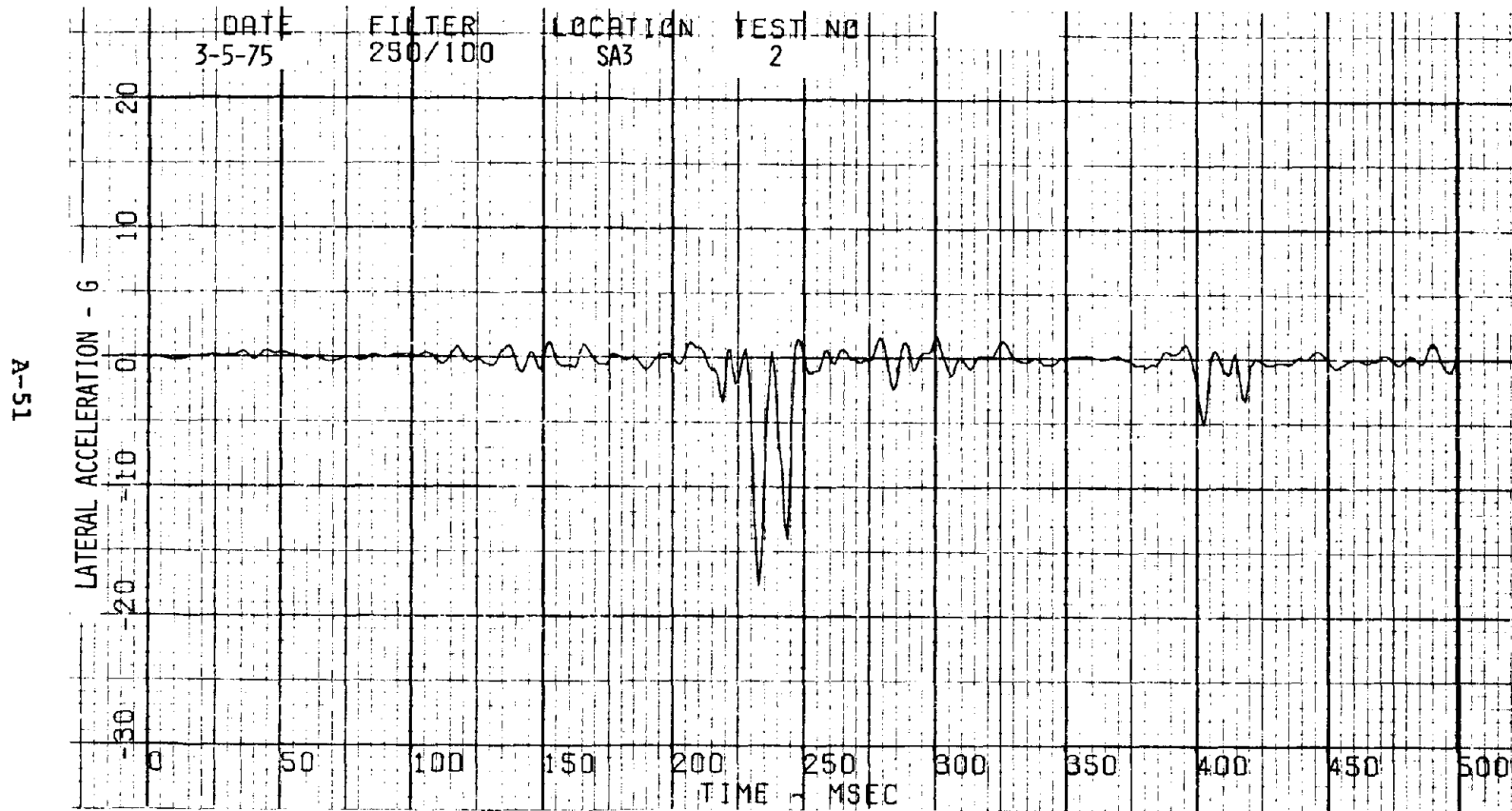


Figure A-53. Caboose Front Triaxial Accelerometer (Y) - Test 2.

A-52

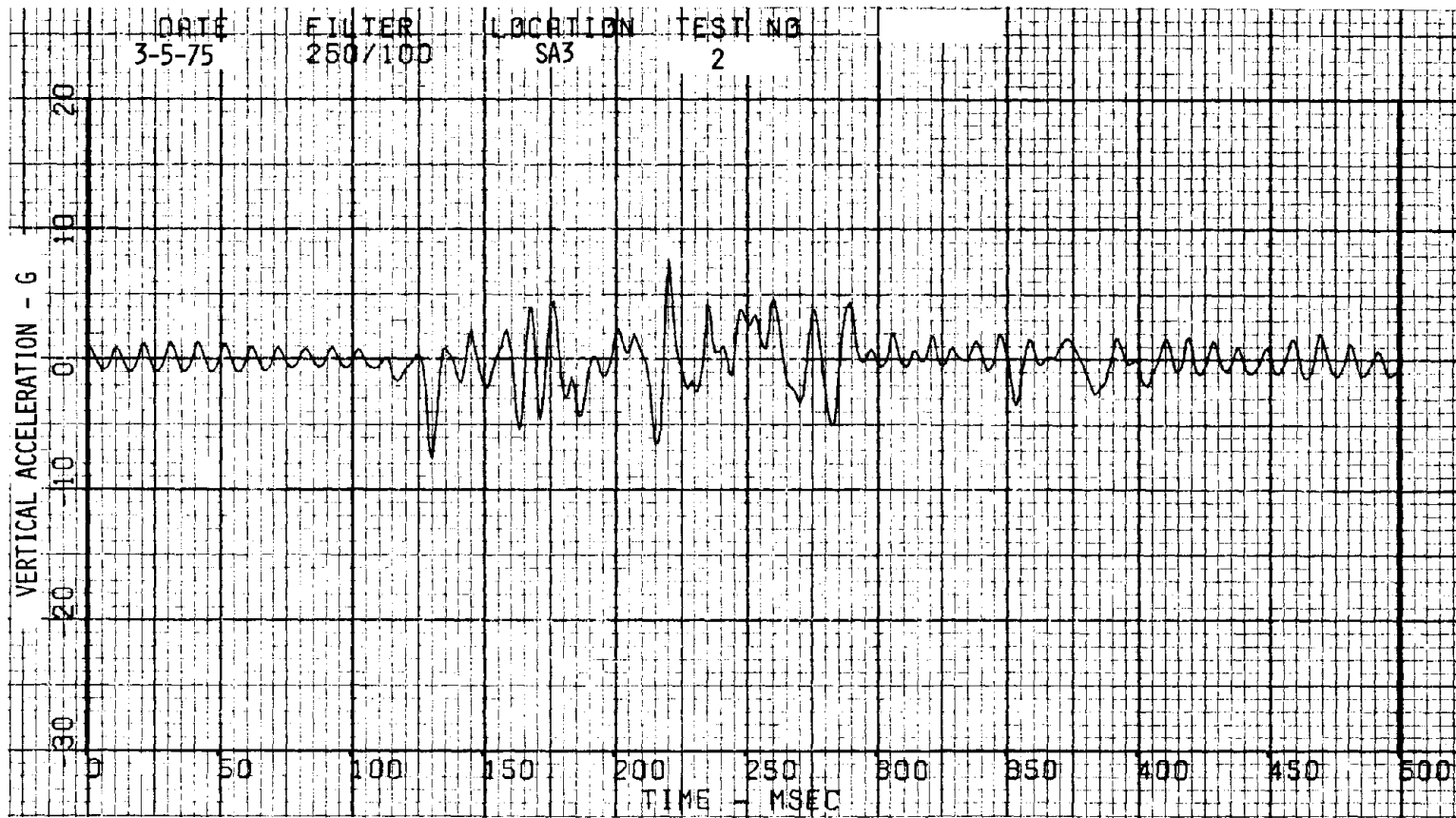


Figure A-54. Caboose Front Triaxial Accelerometer (Z) - Test 2.

A-53

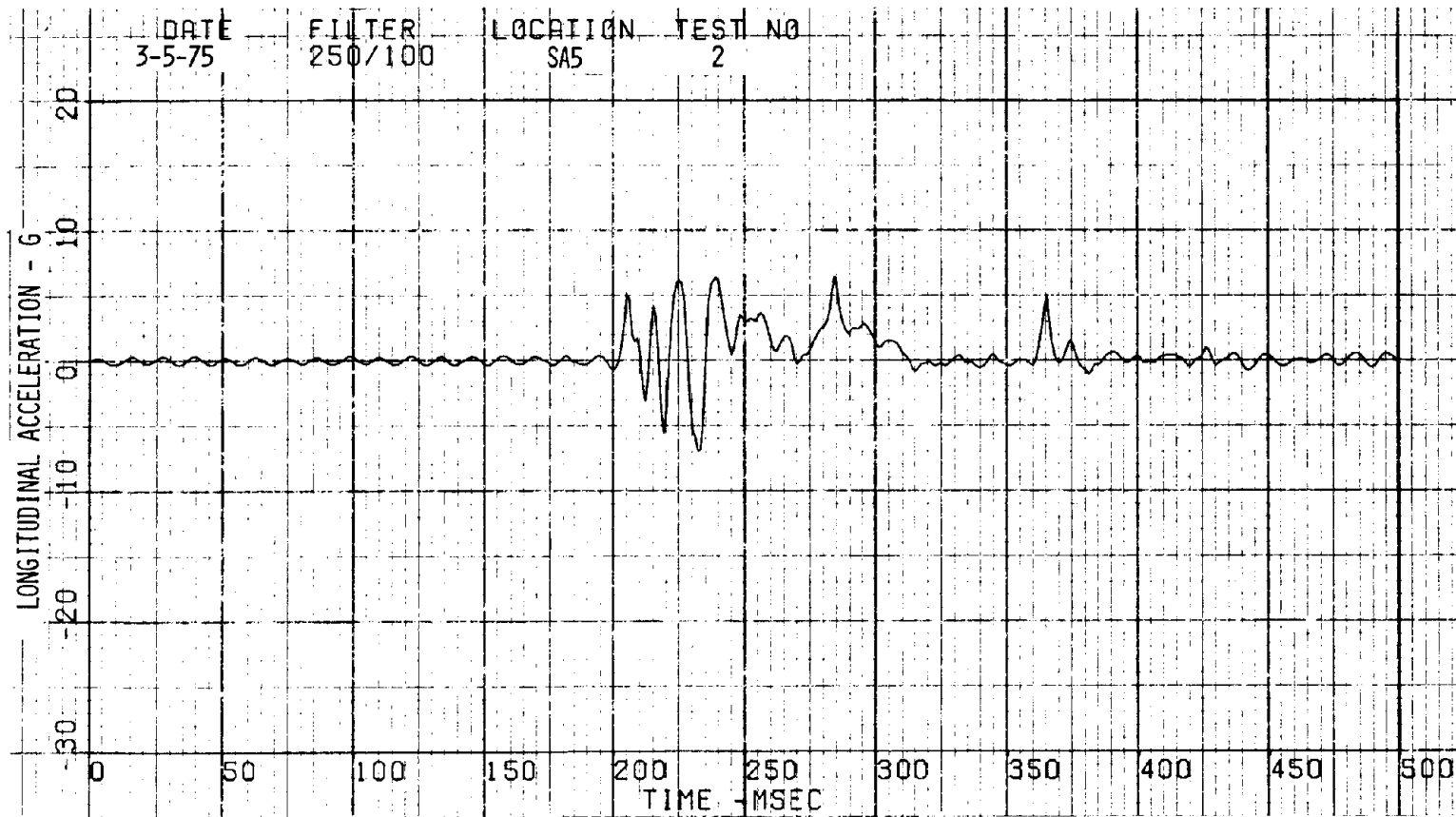


Figure A-55. Hopper 021 Center Longitudinal Accelerometer - Test 2.

A-54

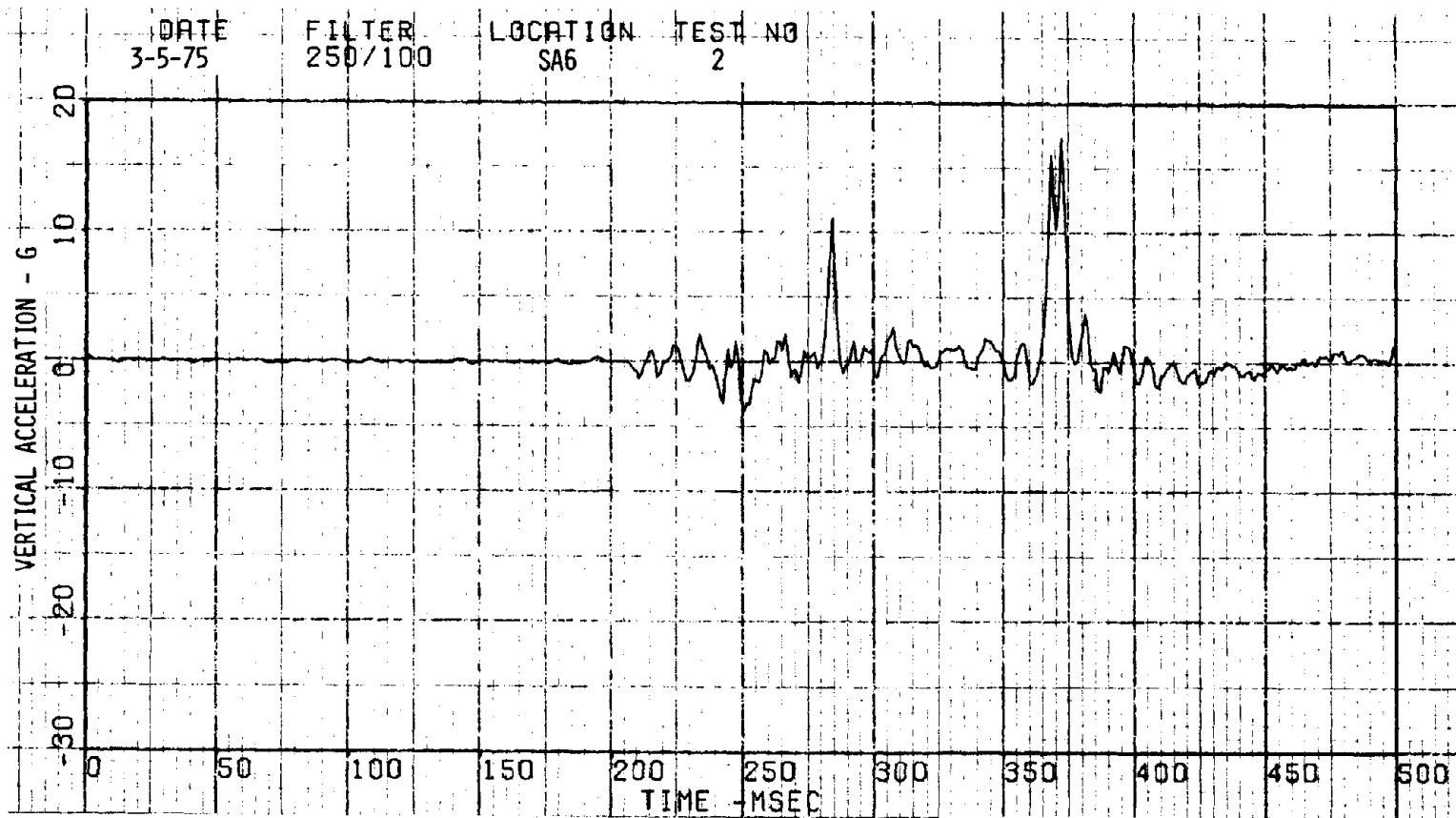


Figure A-56. Hopper 021 Front Vertical Accelerometer - Test 2.

A-55

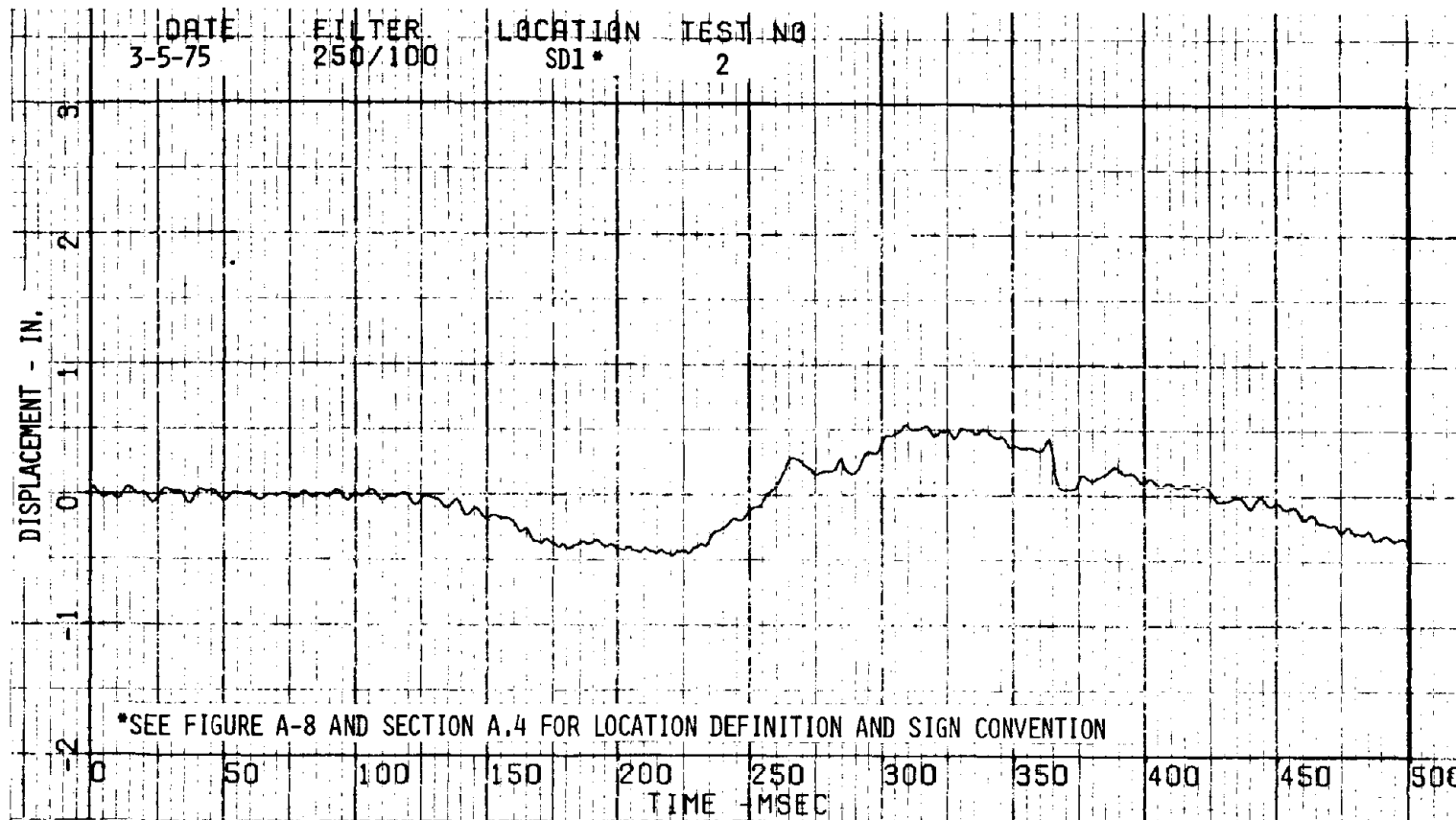


Figure A-57. Caboose Left Rear Displacement Transducer - Test 2.

A-56

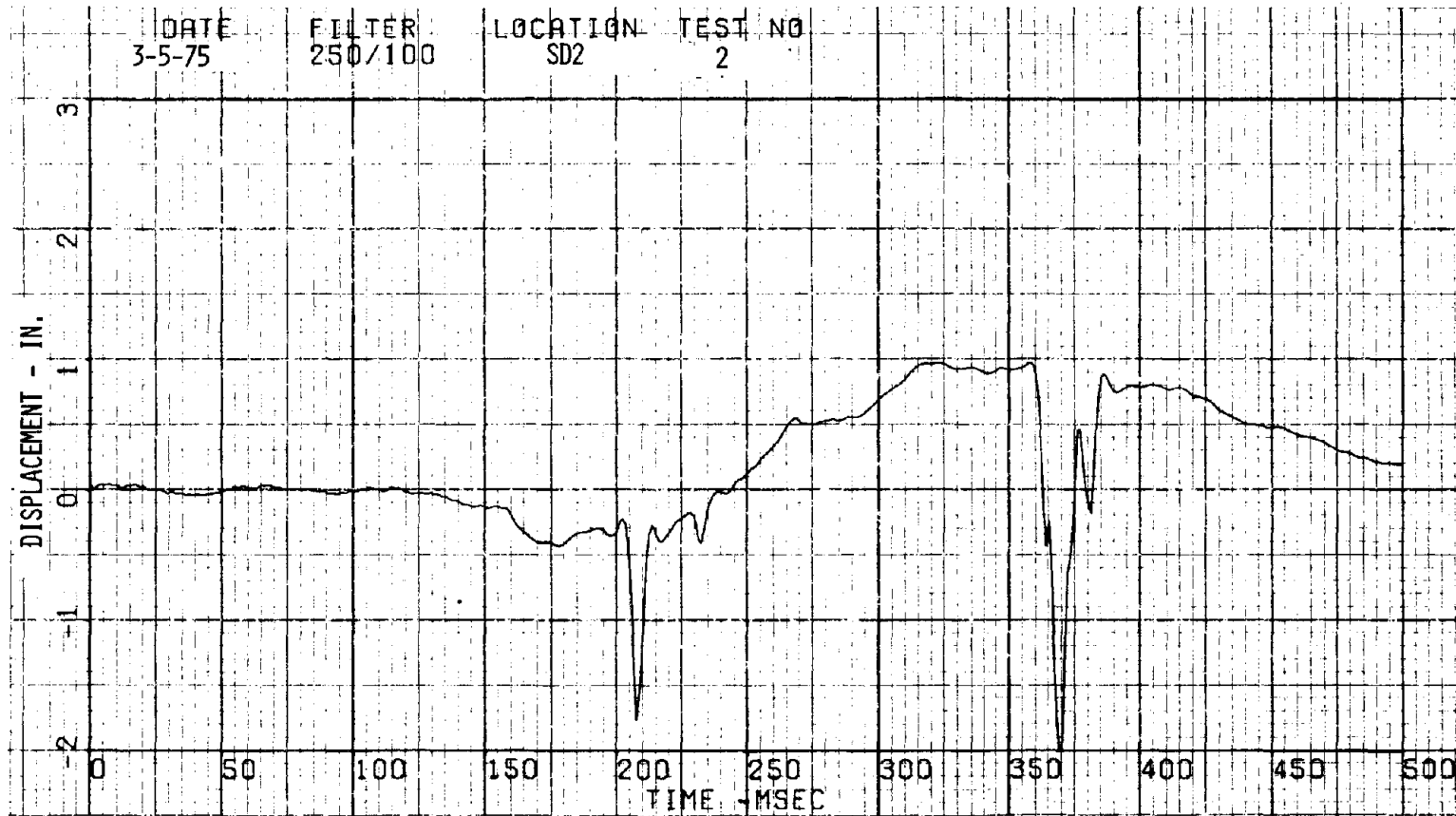


Figure A-58. Caboose Right Rear Displacement Transducer - Test 2.

A-57

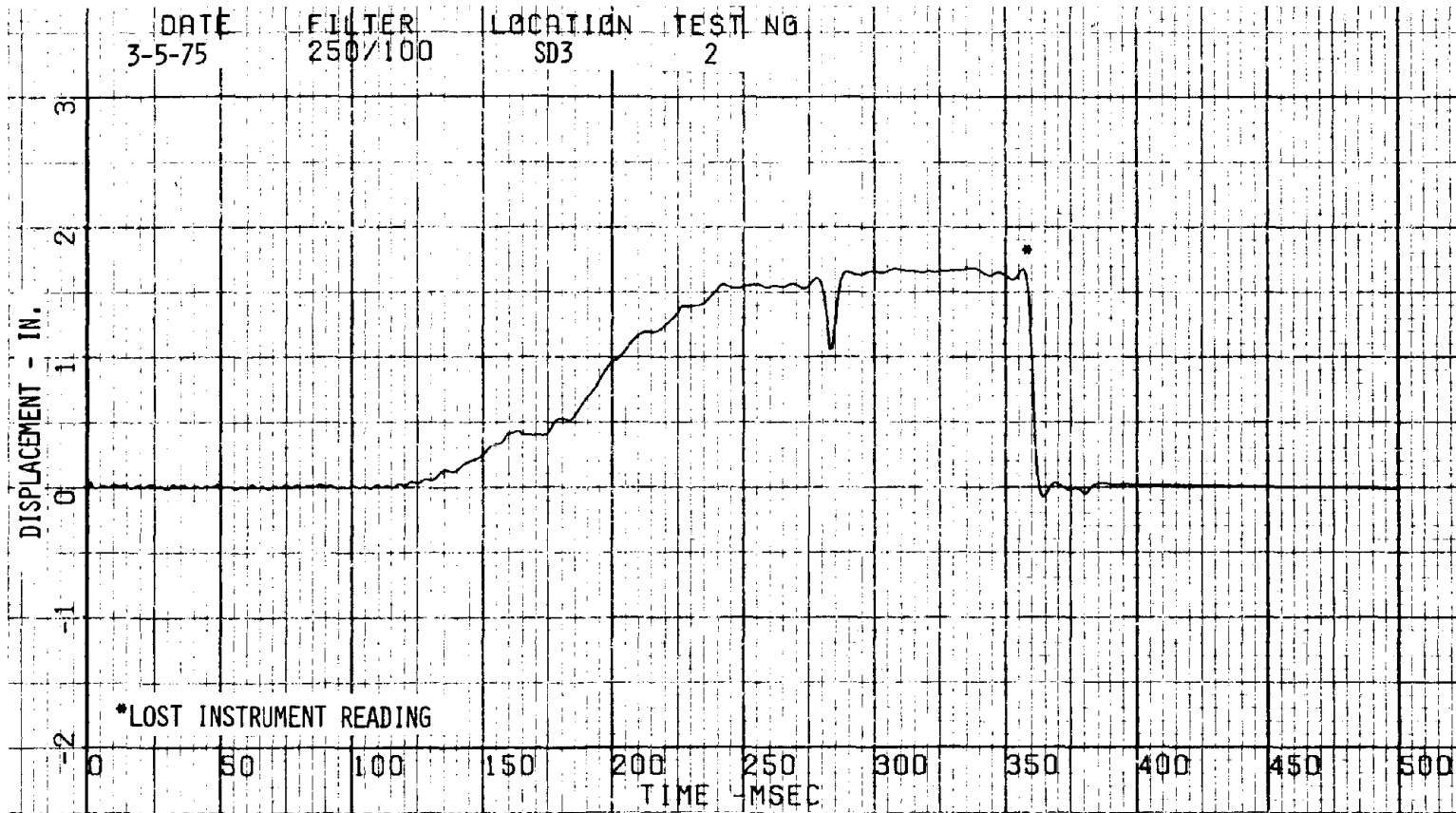


Figure A-59. Caboose Left Front Displacement Transducer - Test 2.

A-58

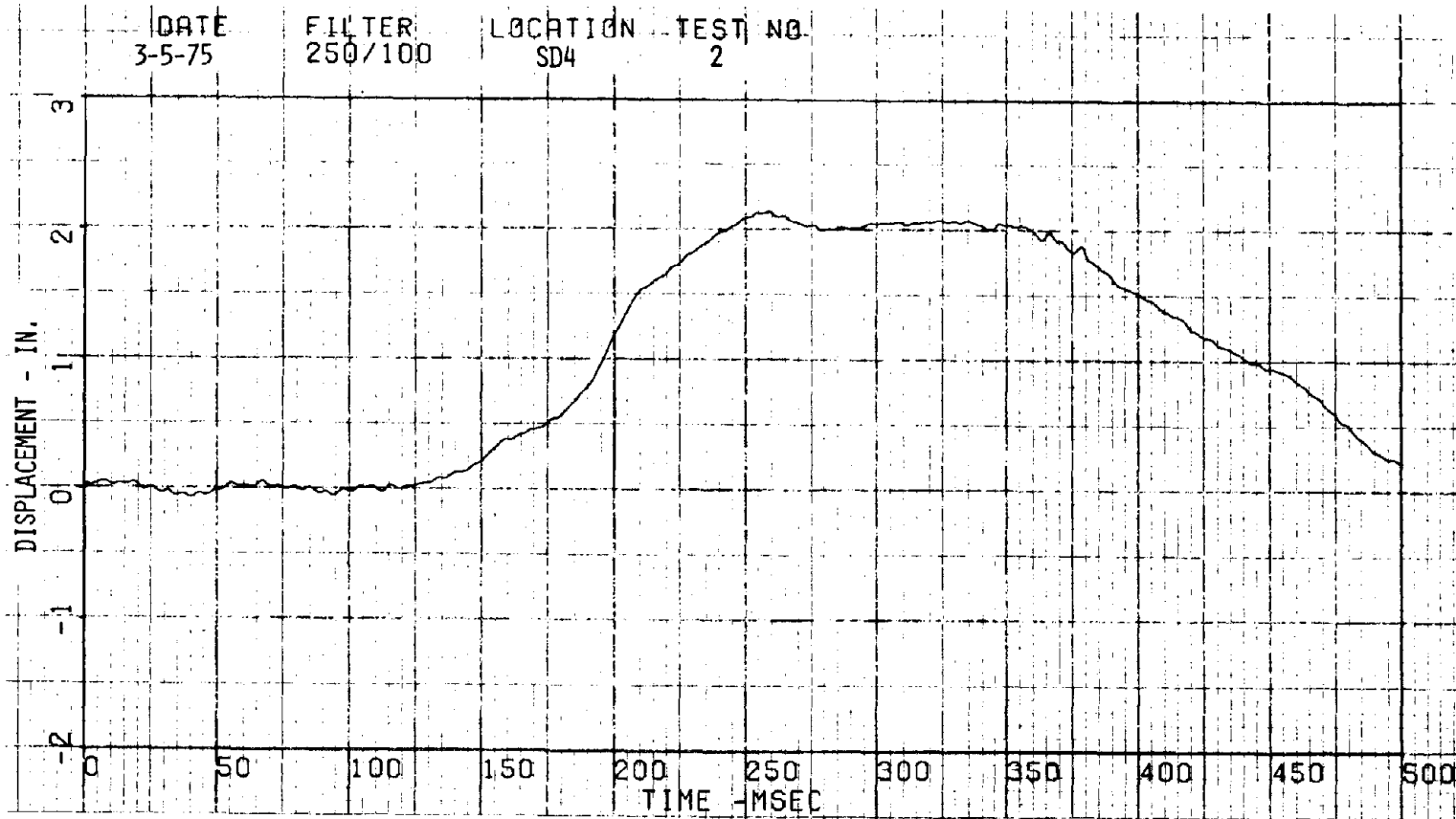


Figure A-60. Caboose Right Front Displacement Transducer - Test 2.

A-59

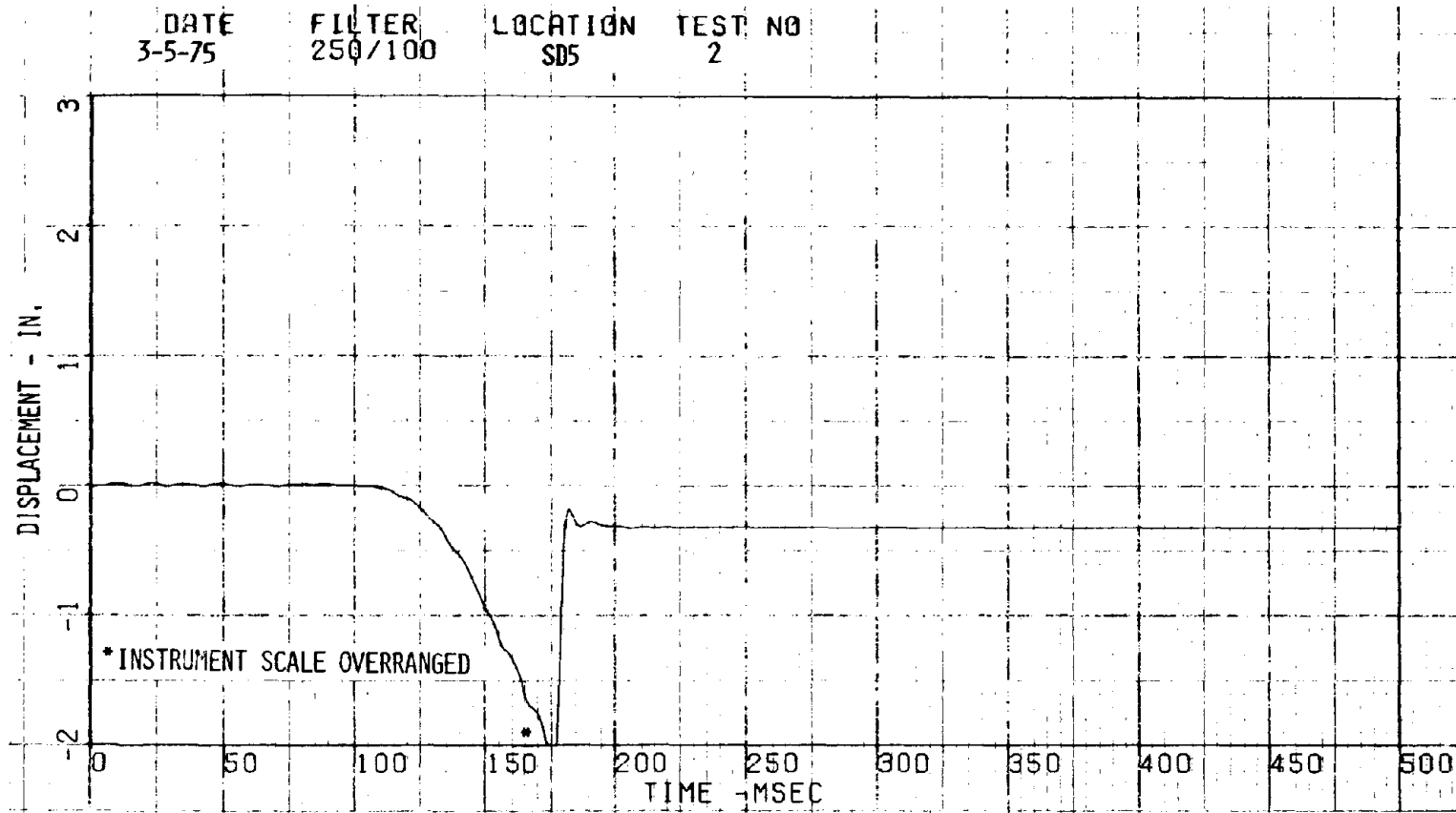


Figure A-61. Caboose to Hopper Displacement Transducer - Test 2.

A-60

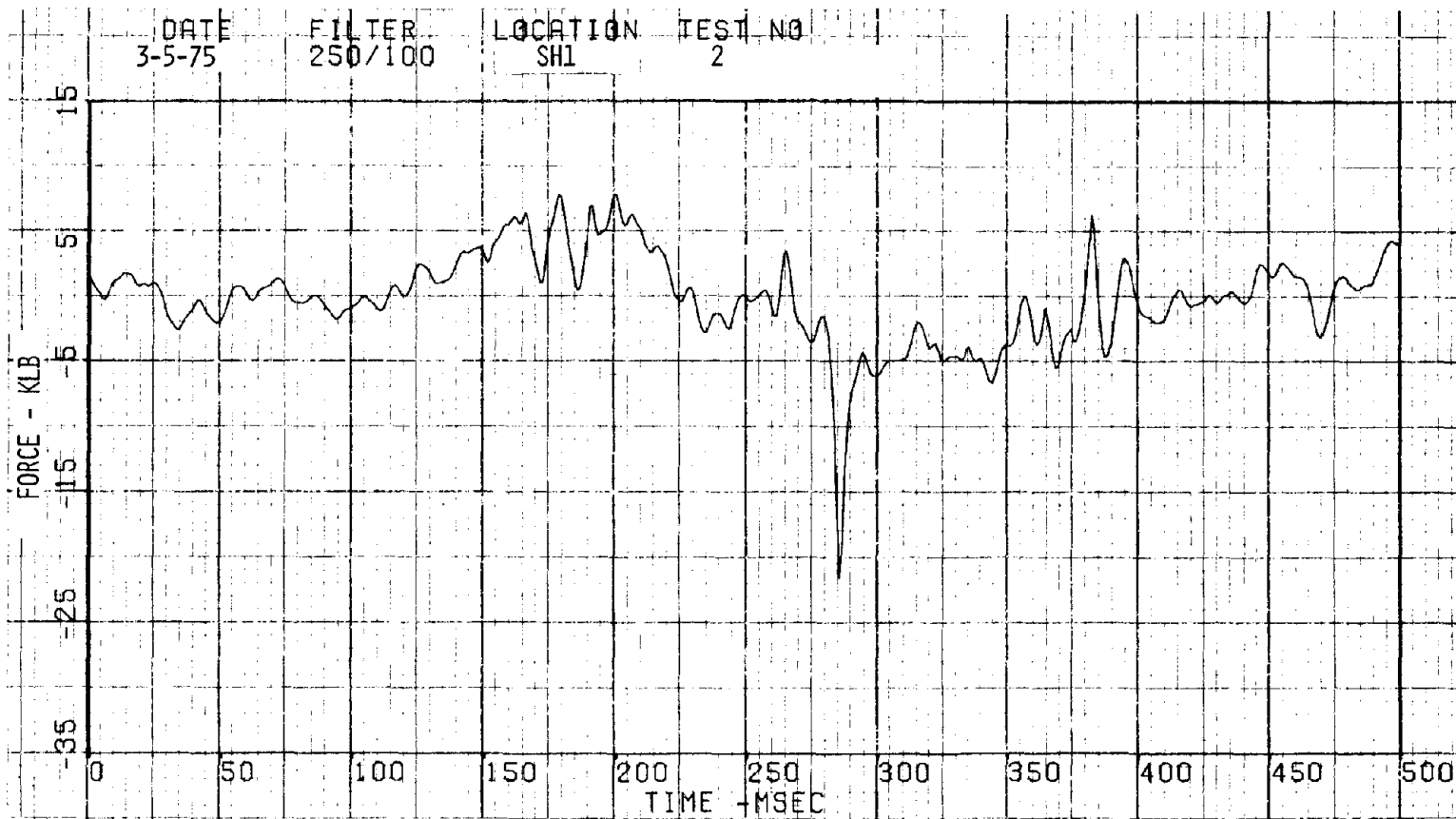


Figure A-62. Caboose Rear Swinghanger Strain Gauge - Test 2.

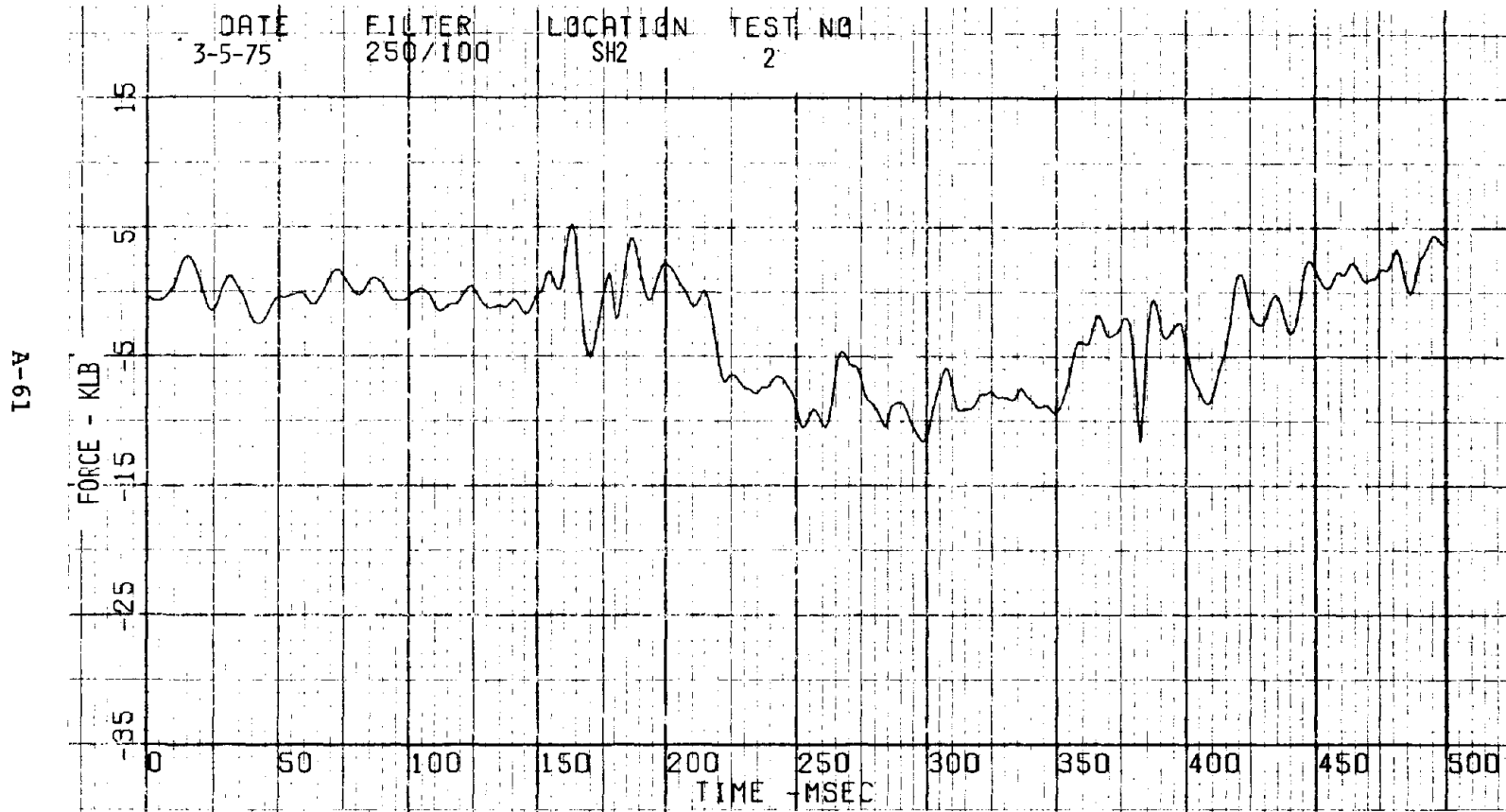


Figure A-63. Caboose Front Swinghanger Strain Gauge - Test 2.

A-62

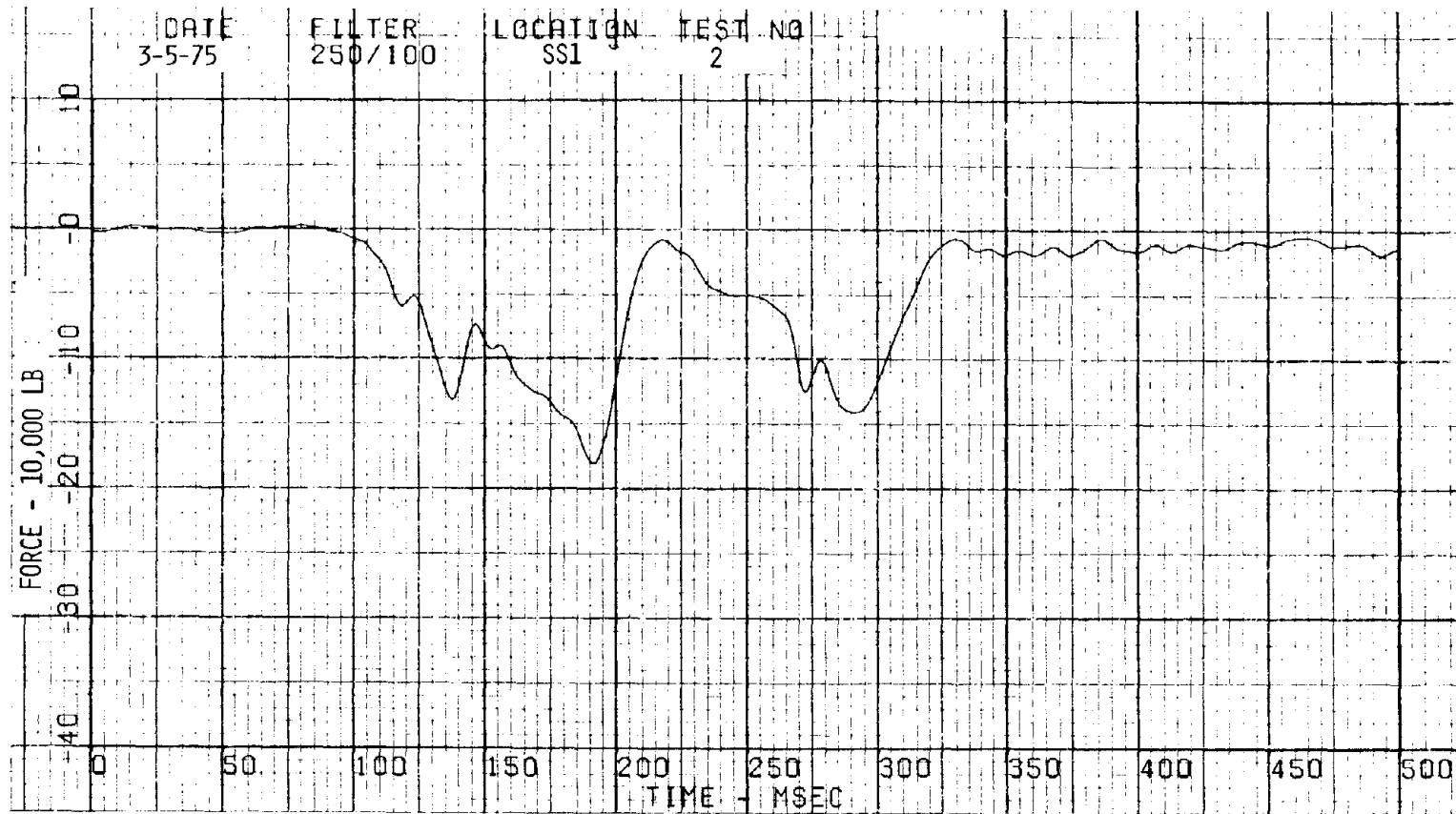


Figure A-64. Caboose Rear Coupler Strain Gauge - Test 2.

A-63

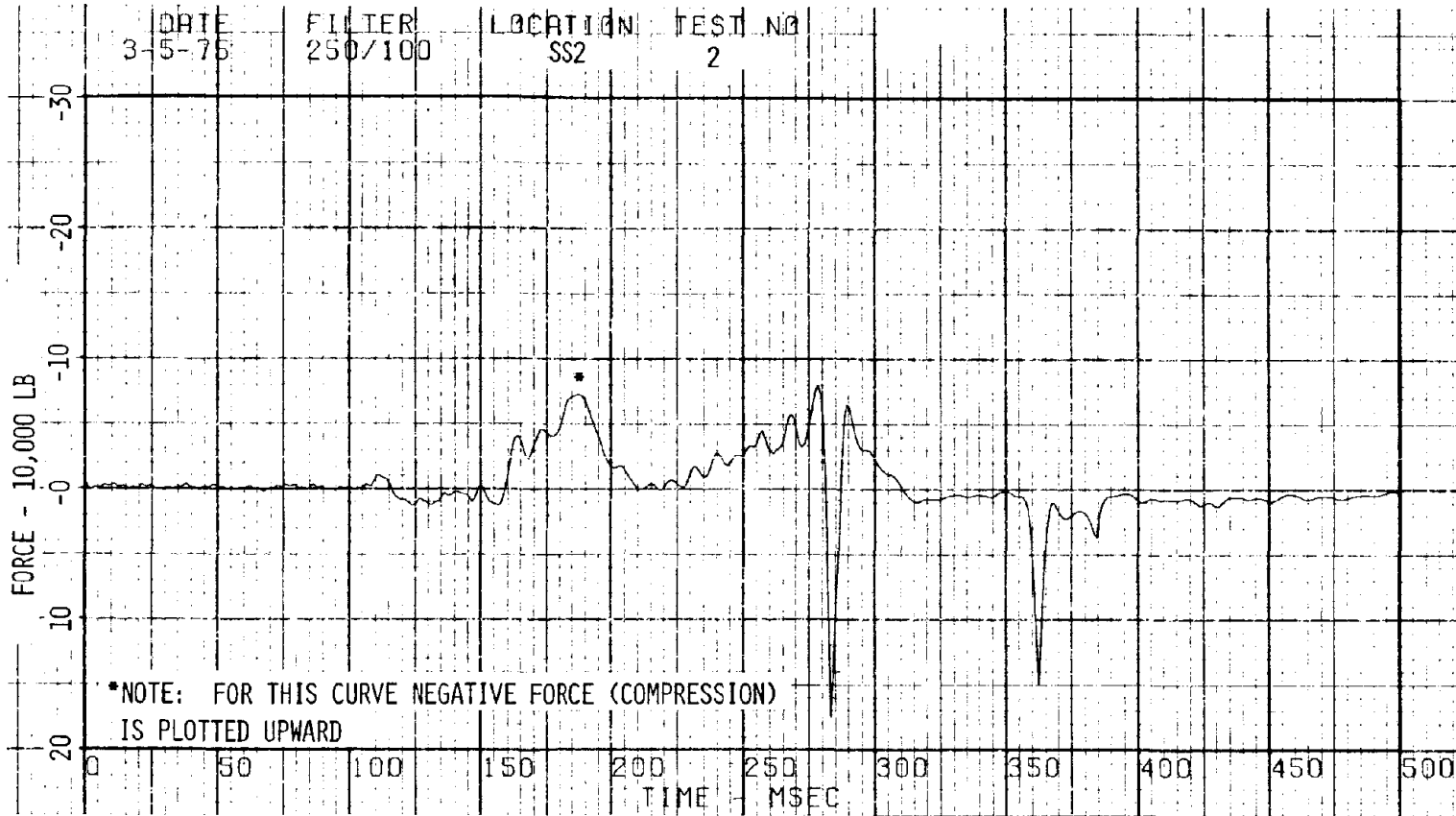


Figure A-65. Caboose Center Sill Strain Gauge - Test 2.

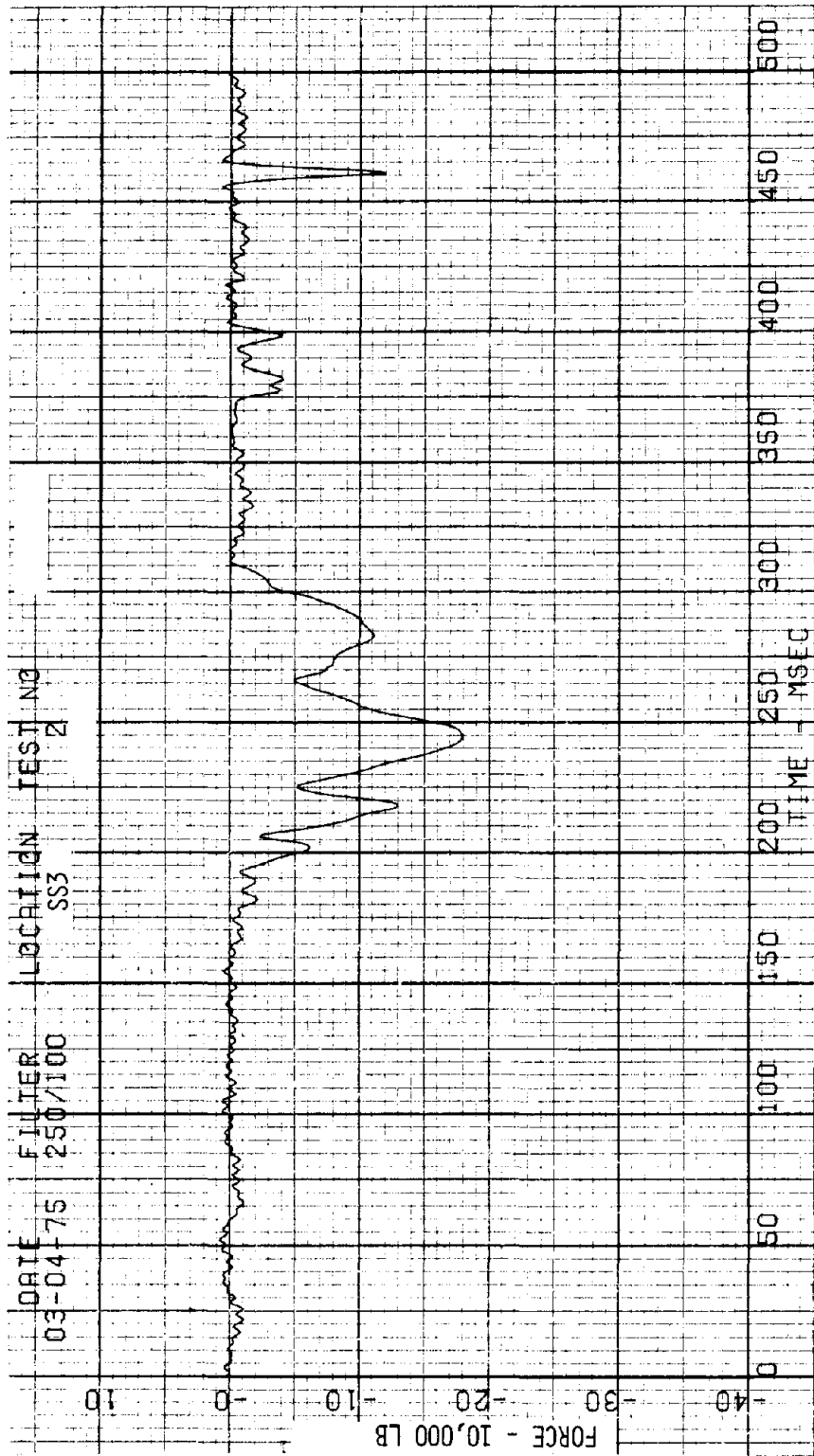


Figure A-66. Caboose Front Coupler Strain Gauge - Test 2.

A-65

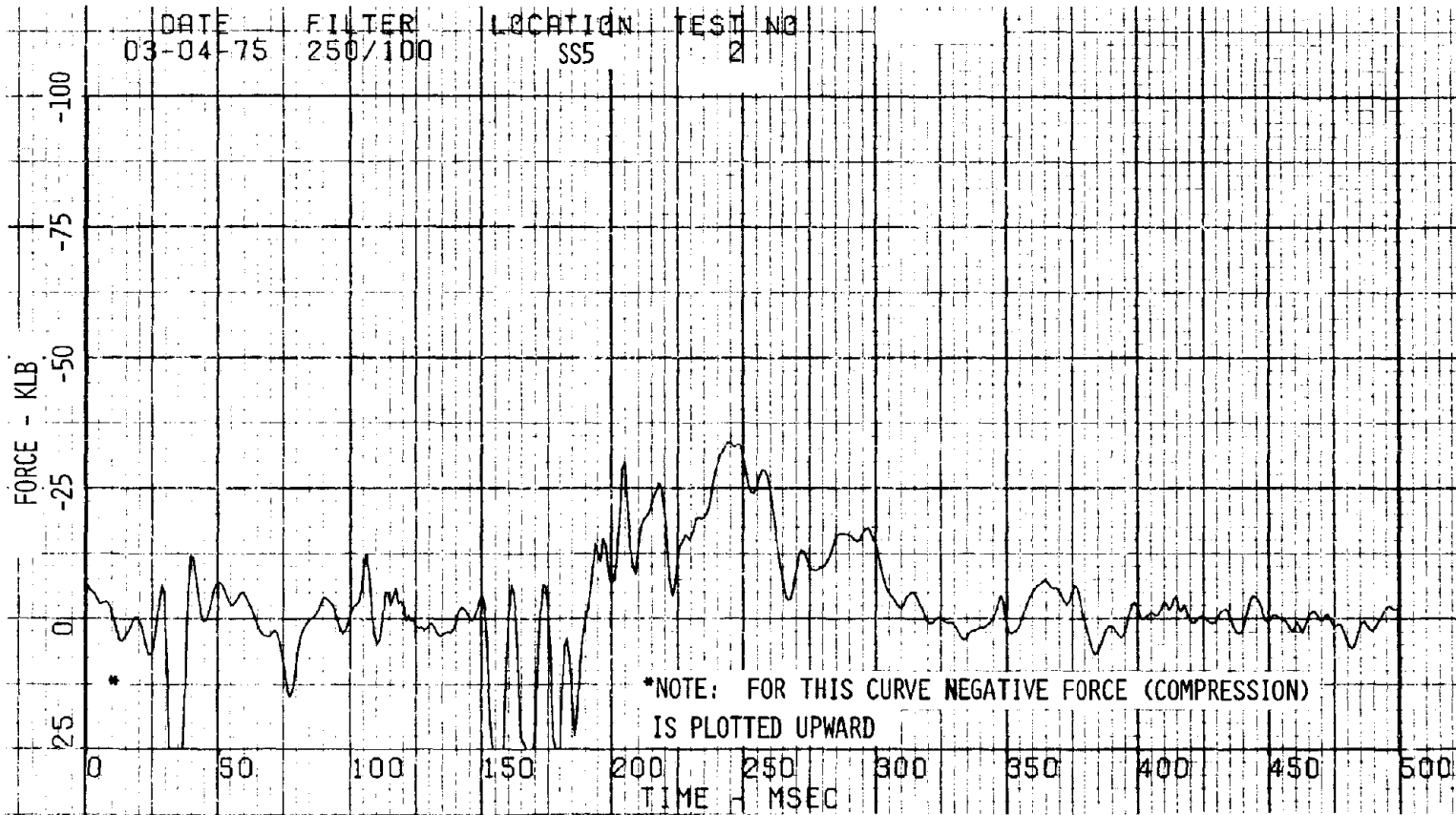
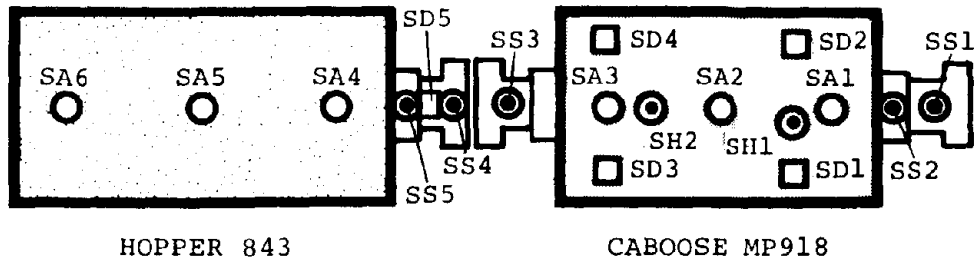
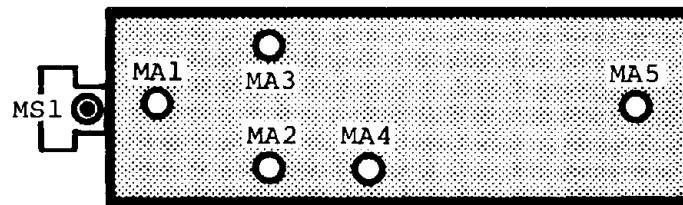


Figure A-67. Hopper 021 Center Sill Strain Gauge - Test 2.



- HOPPER LOADED
 - TRAIN IN DRAFT
- STANDING TRAIN



- MOTION
- IMPACT VELOCITY = 3.3 MPH
- MOVING TRAIN

A-66

Figure A-68. Instrument Locations - Test 3.

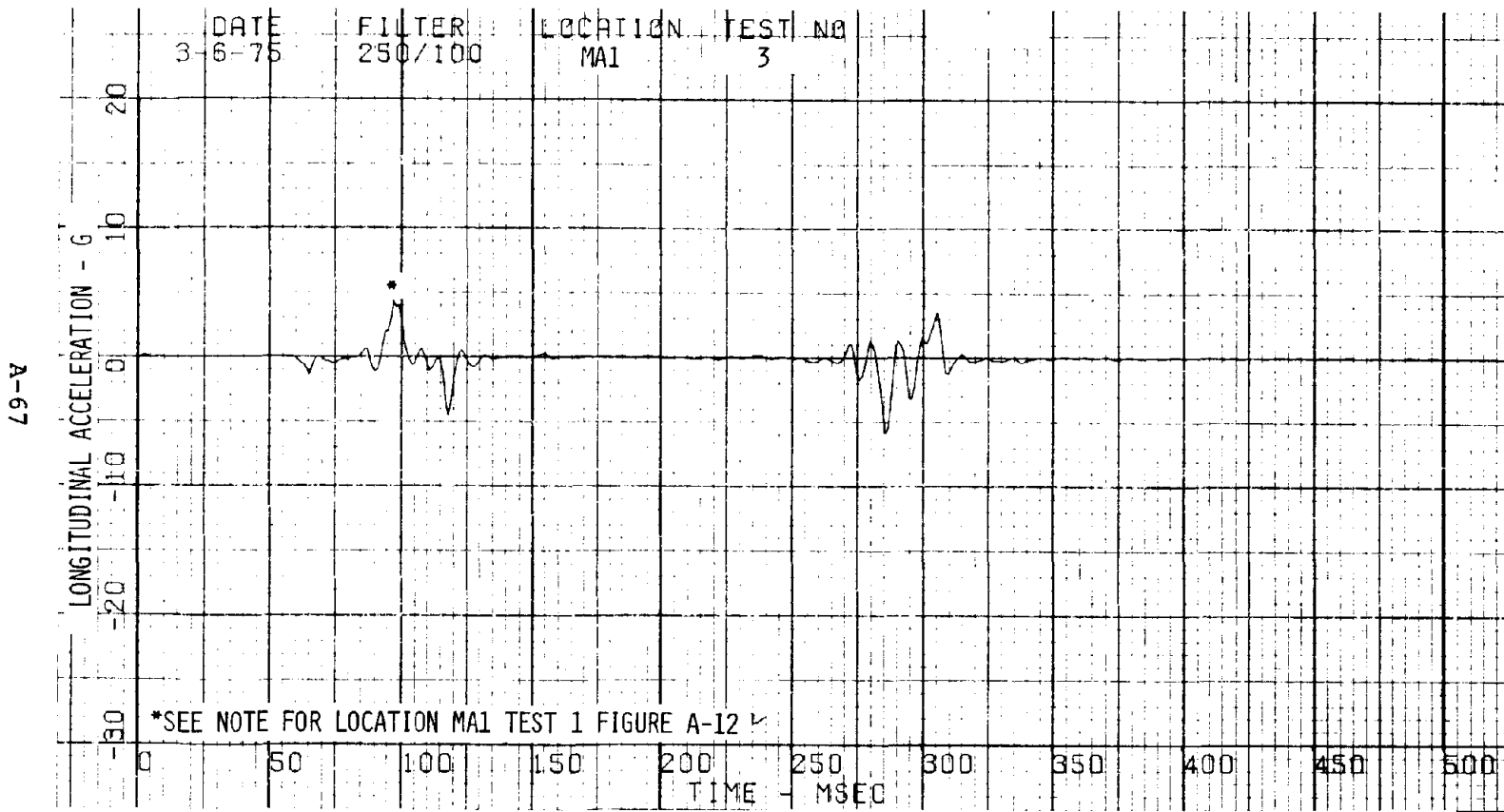


Figure A-69. Locomotive Rear Triaxial Accelerometer (X) - Test 3.

89-A

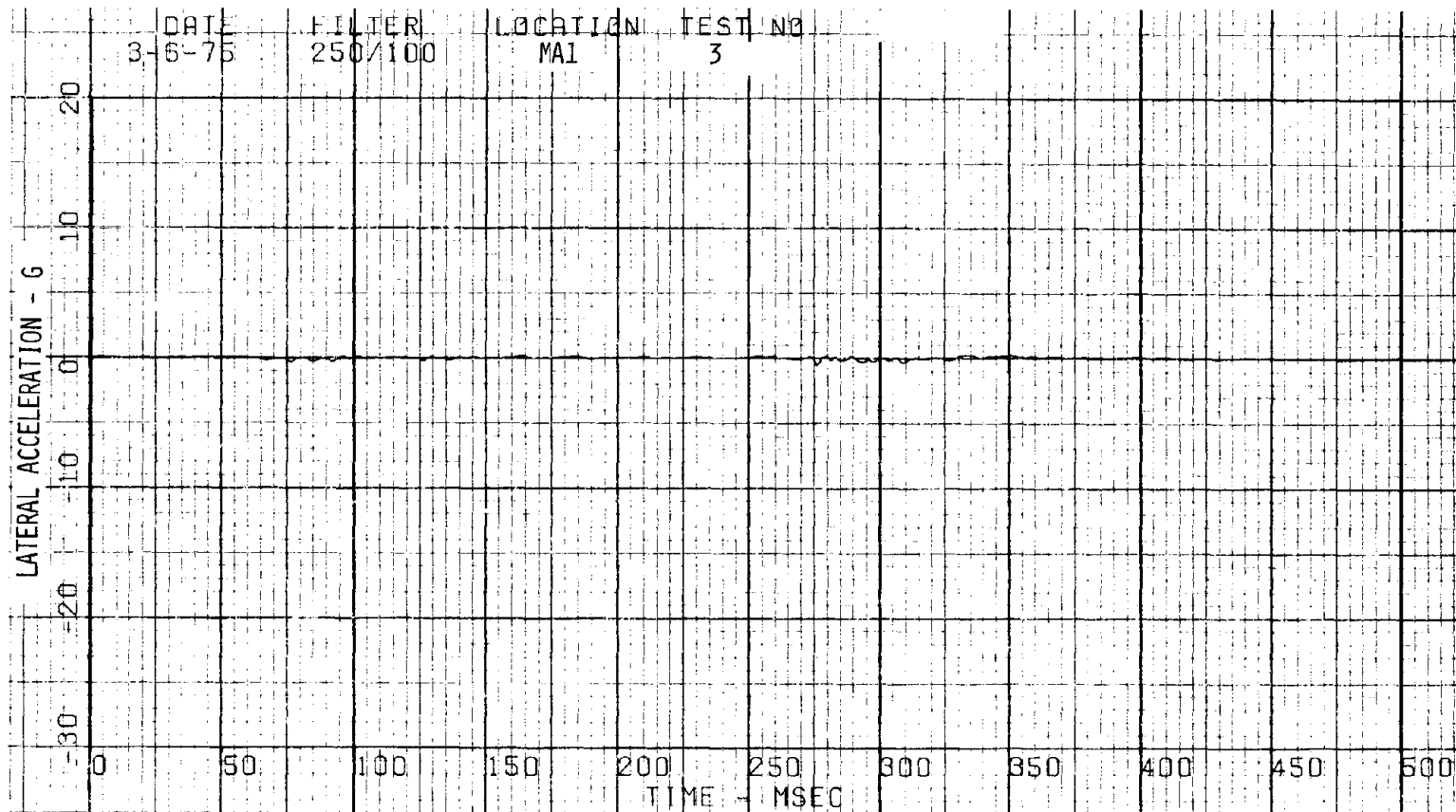


Figure A-70. Locomotive Rear Triaxial Accelerometer (Y) - Test 3.

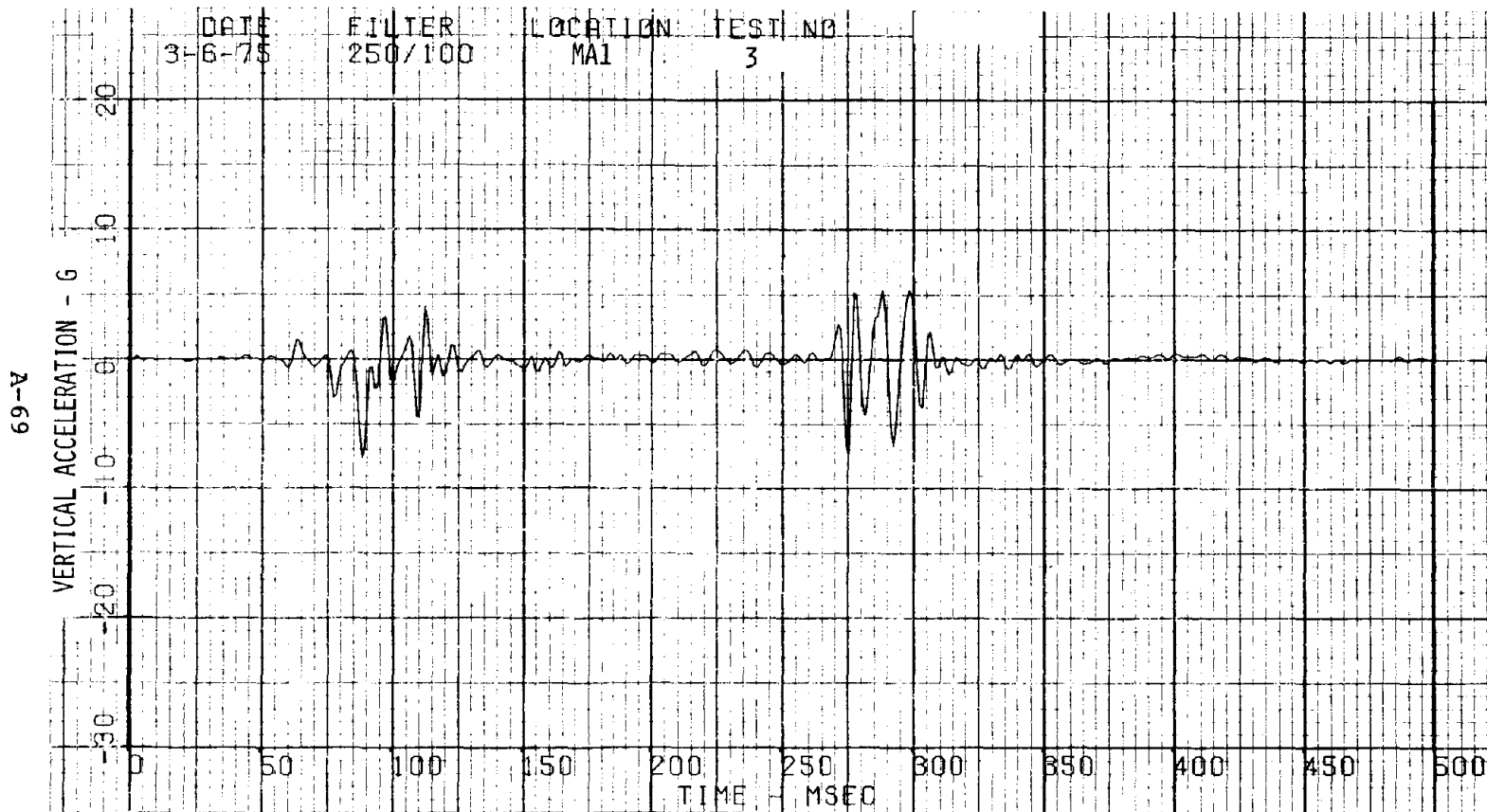


Figure A-71. Locomotive Rear Triaxial Accelerometer (Z) - Test 3.

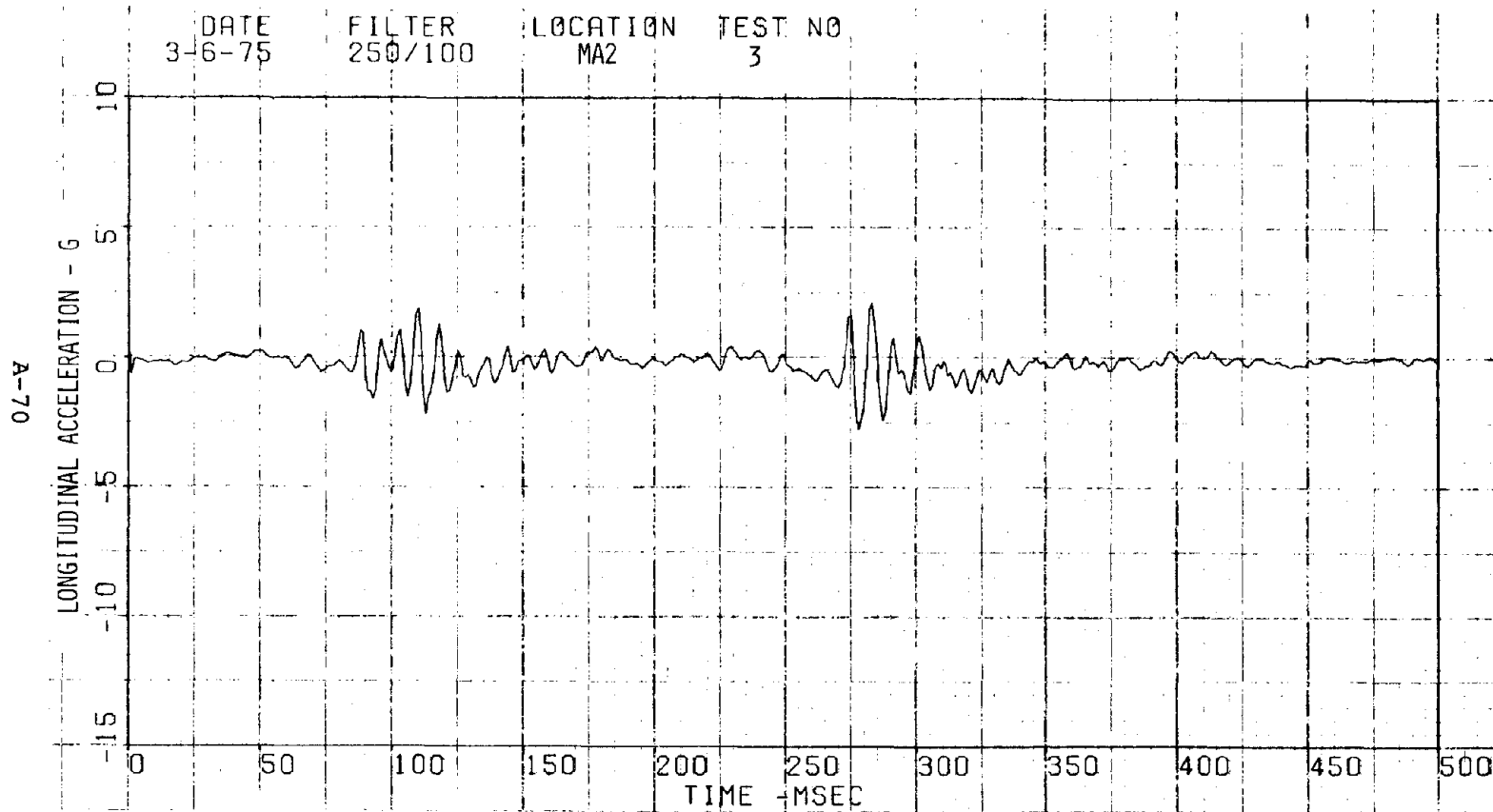


Figure A-72. Locomotive Left Cab Accelerometer - Test 3.

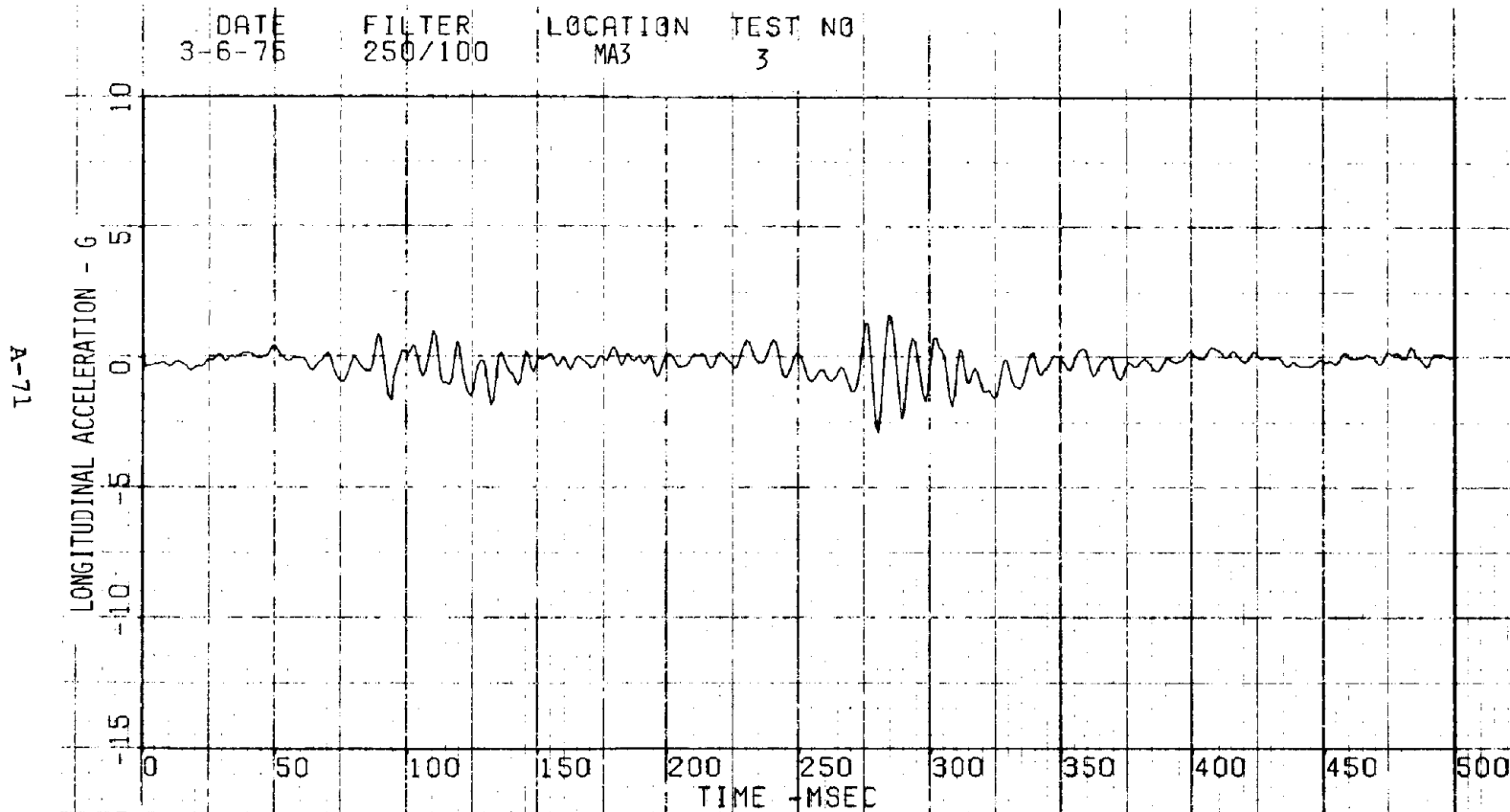


Figure A-73. Locomotive Right Cab Accelerometer - Test 3.

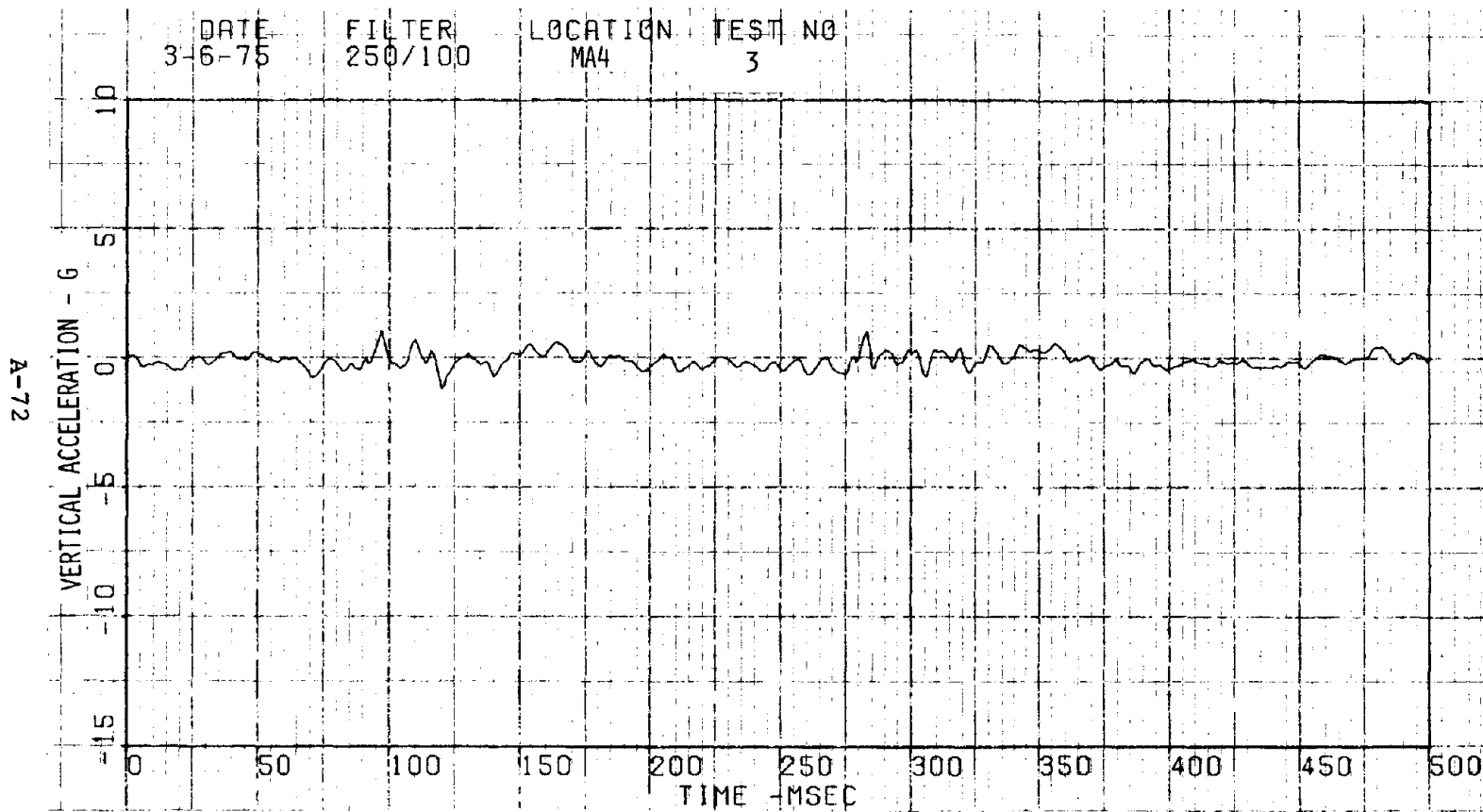


Figure A-74. Locomotive Center Vertical Accelerometer - Test 3.

A-73

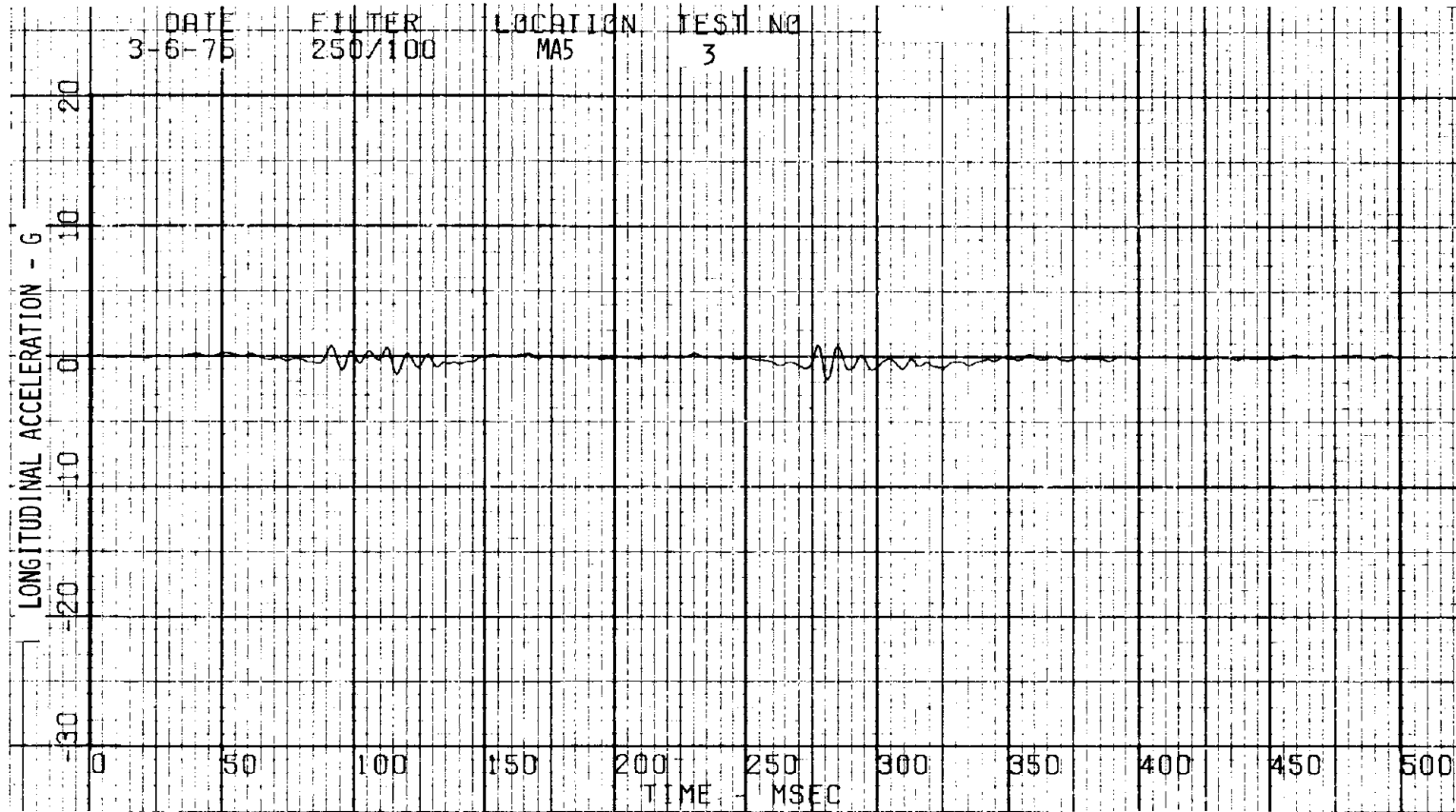


Figure A-75. Locomotive Front Triaxial Accelerometer (X) - Test 3.

A-74

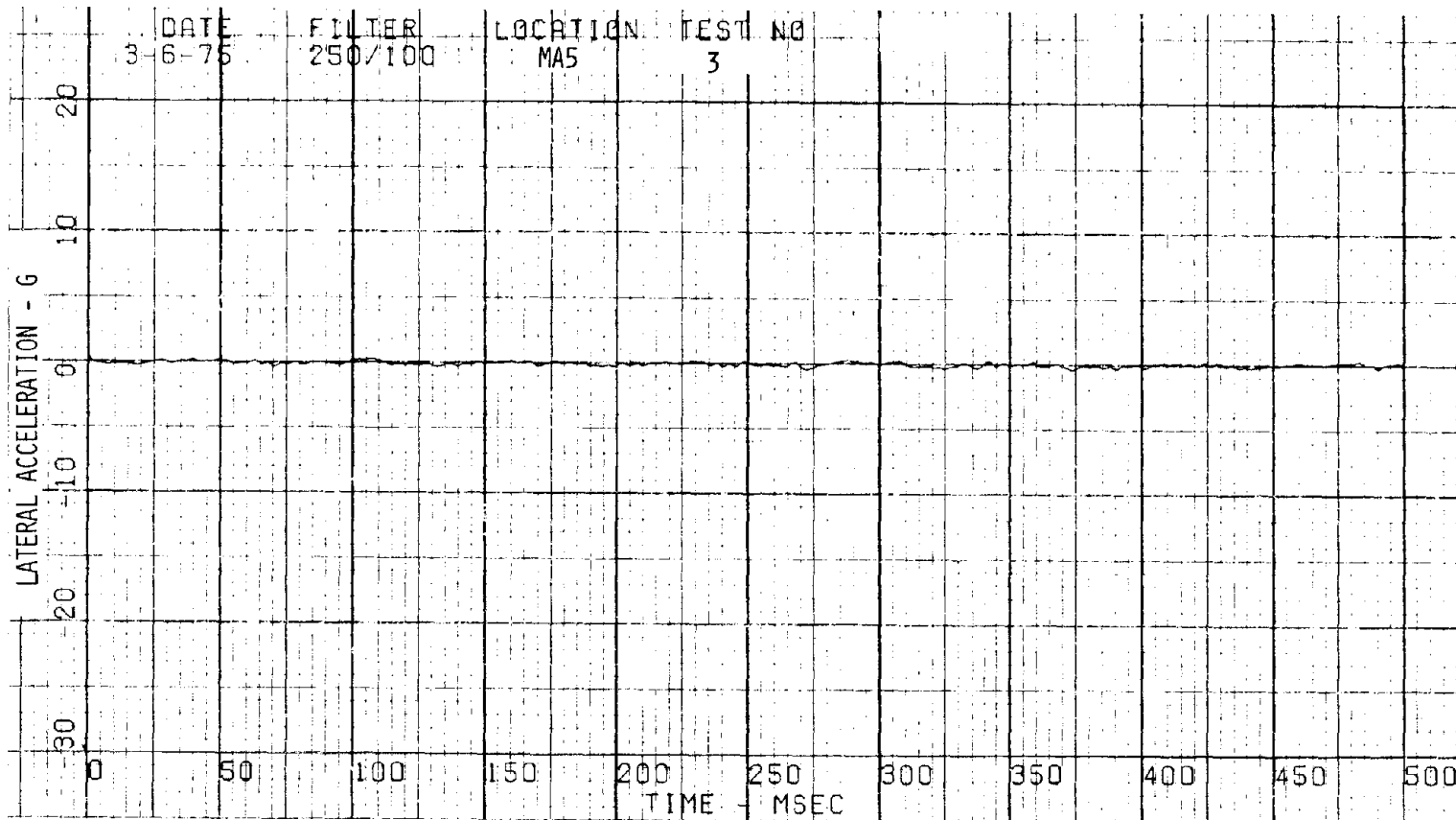


Figure A-76. Locomotive Front Triaxial Accelerometer (Y) - Test 3.

A-75

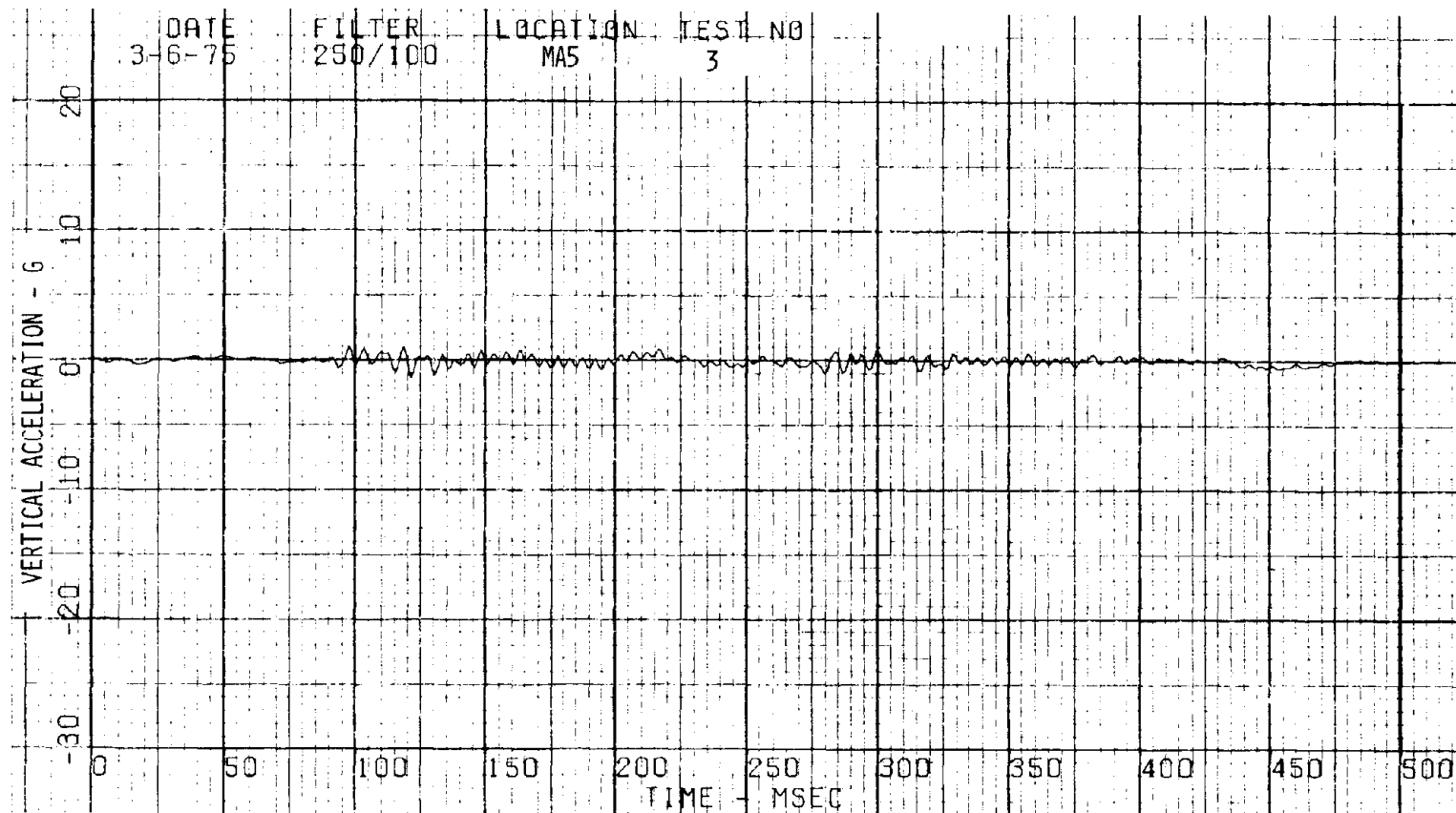


Figure A-77. Locomotive Front Triaxial Accelerometer (Z) - Test 3.

A-76

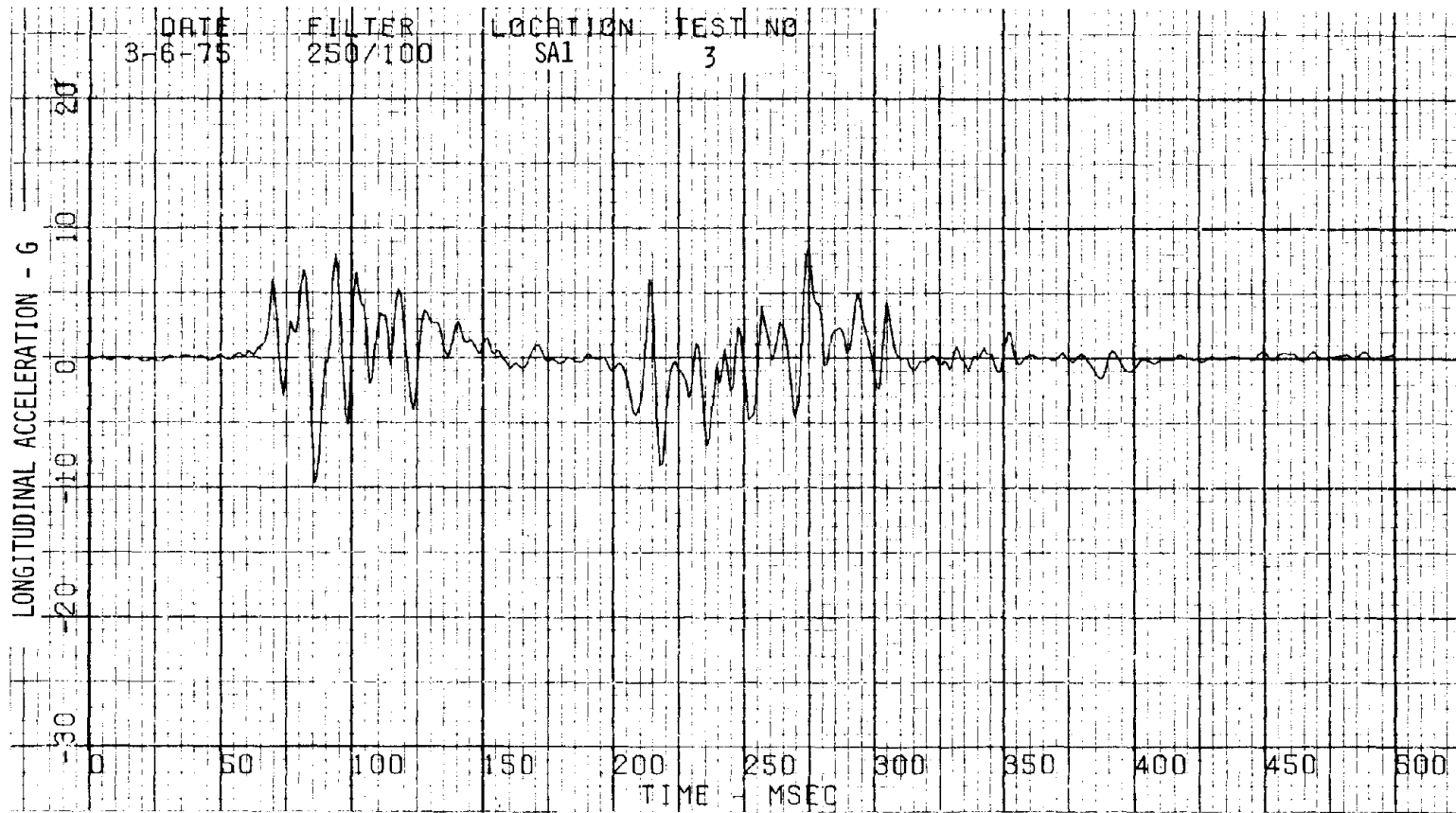
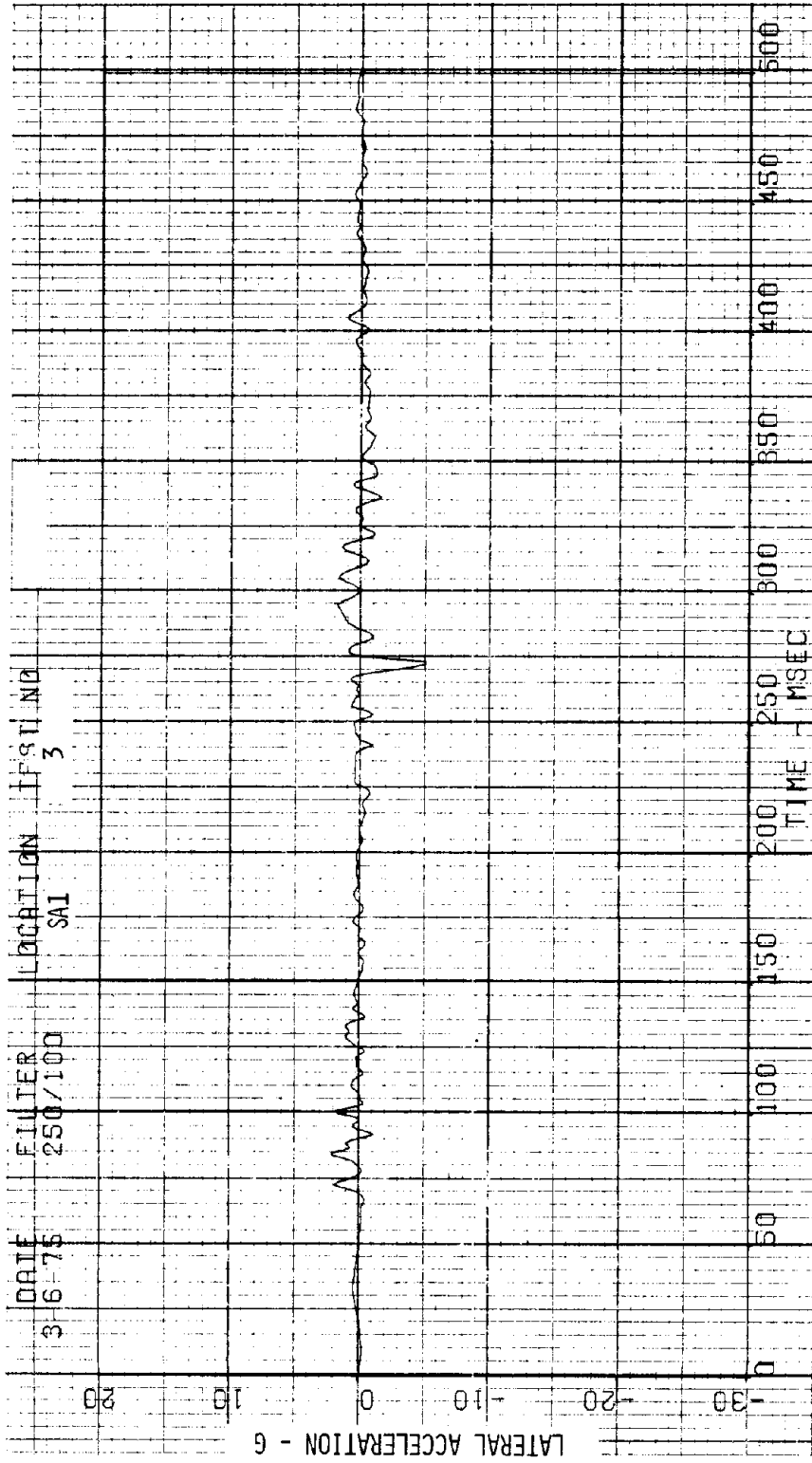


Figure A-78. Caboose Rear Triaxial Accelerometer (X) - Test 3.



A-77

Figure A-79. Caboose Rear Triaxial Accelerometer (Y) - Test 3.

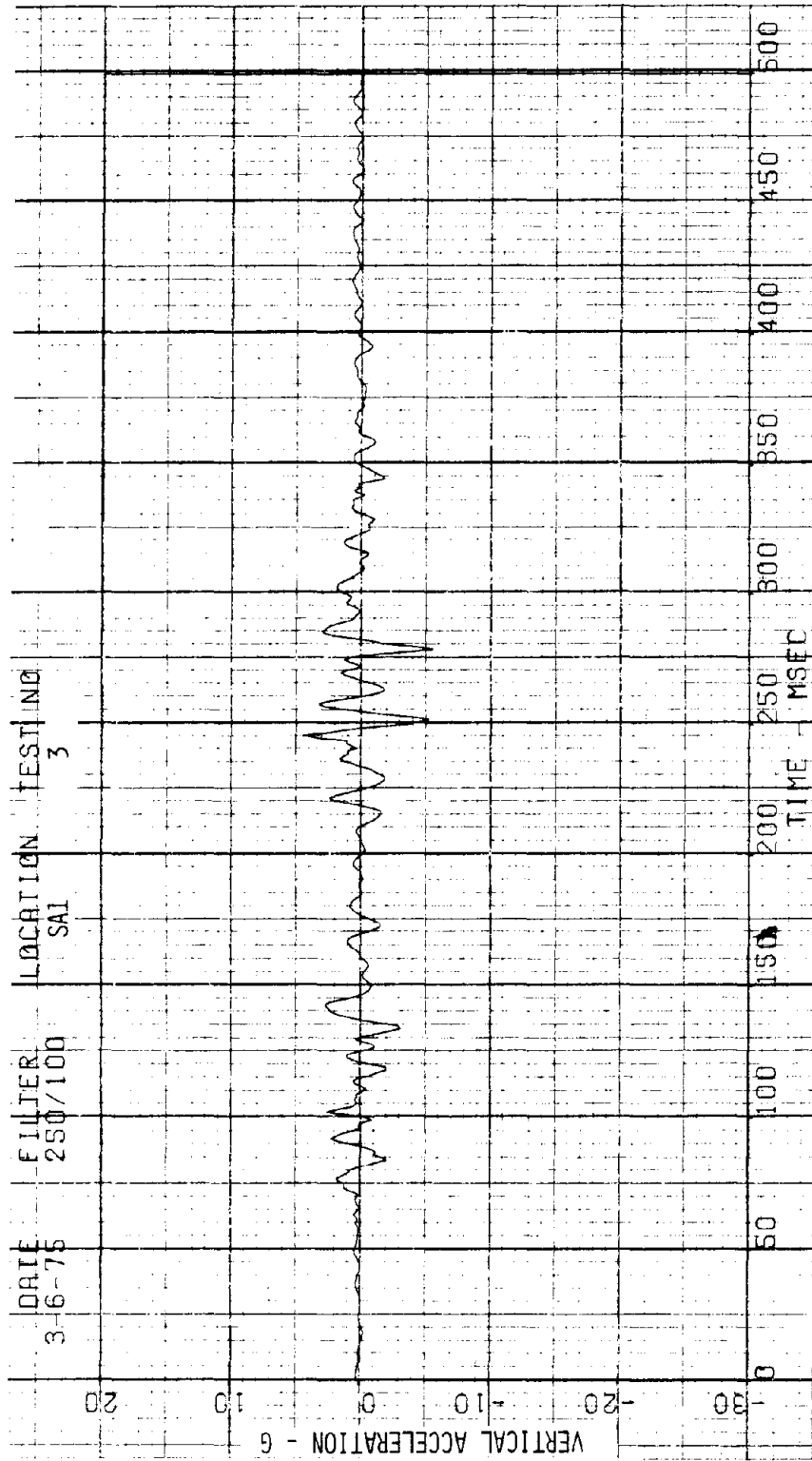


Figure A-80. Caboose Rear Triaxial Accelerometer (Z) - Test 3.

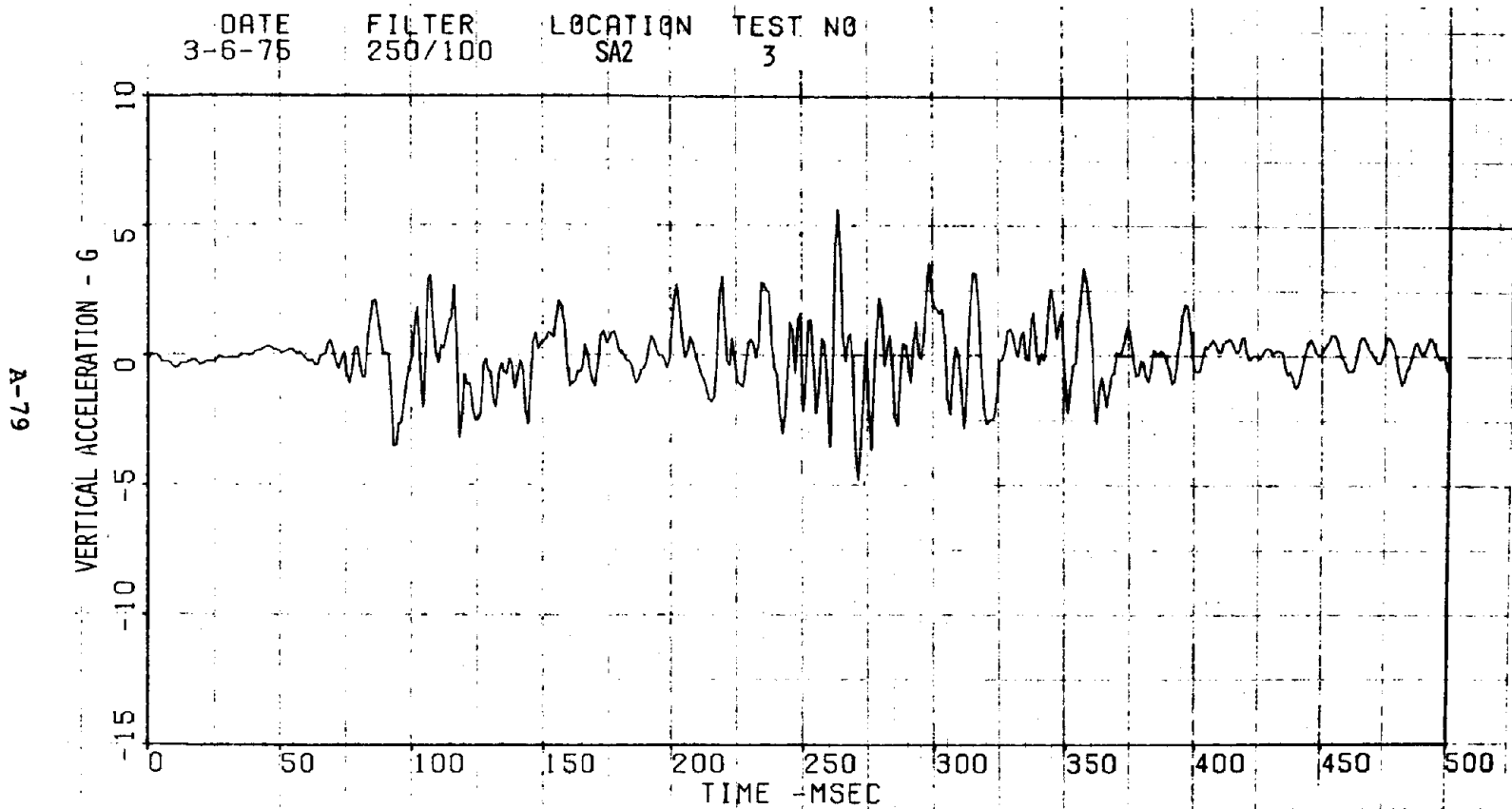


Figure A-81. Caboose Center Vertical Accelerometer - Test 3.

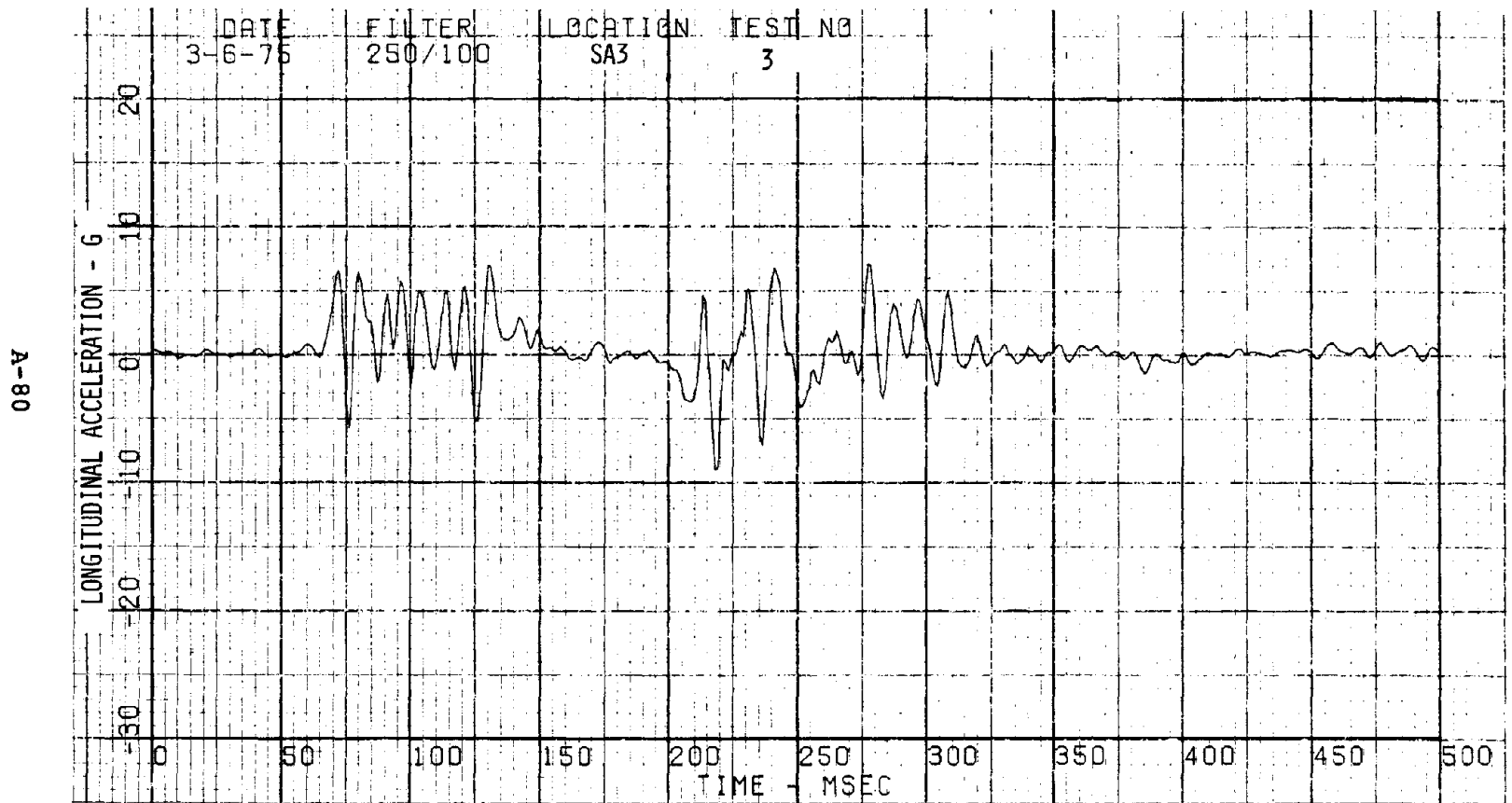


Figure A-82. Caboose Front Triaxial Accelerometer (X) - Test 3.

A-81

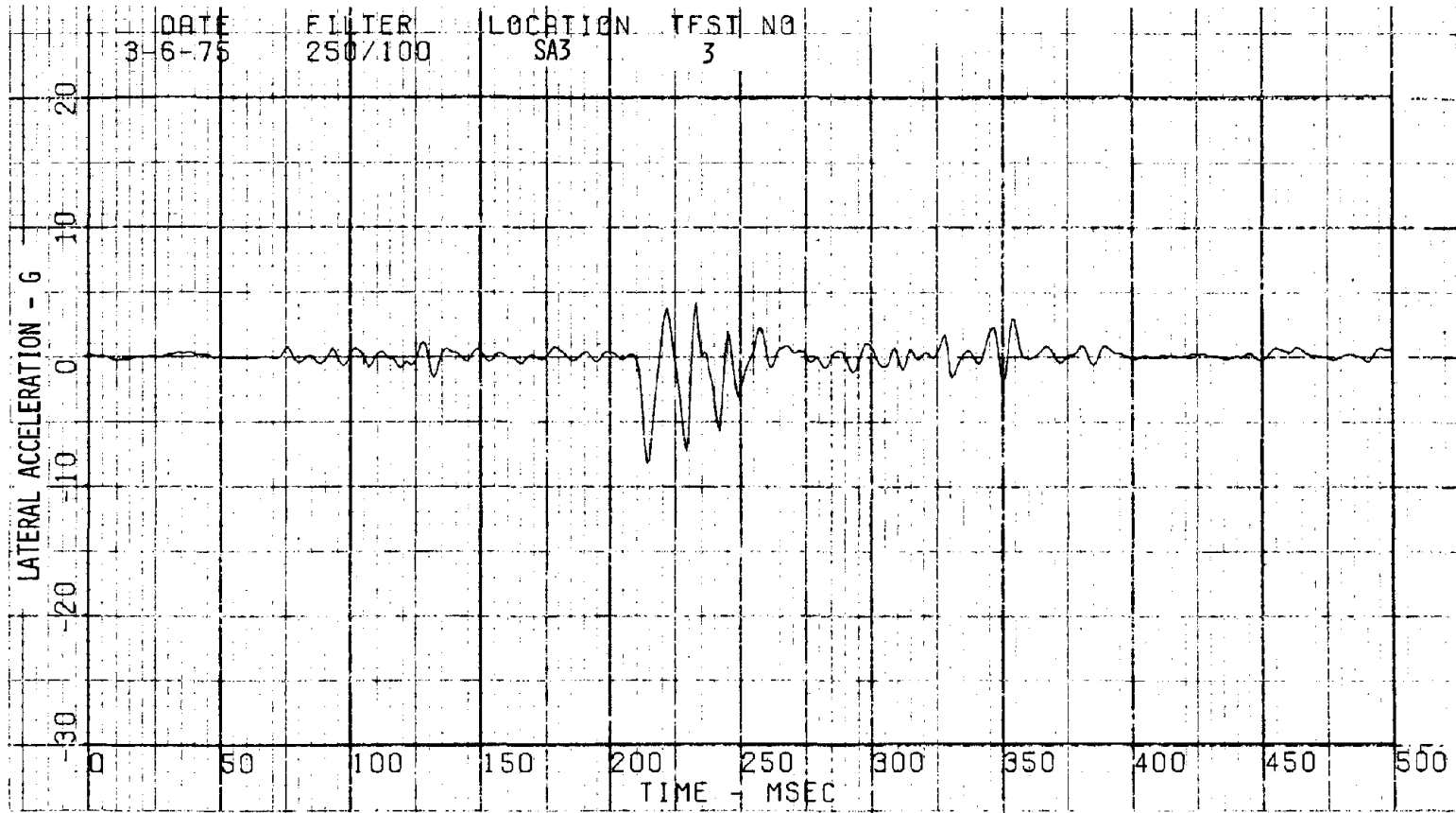


Figure A-83. Caboose Front Triaxial Accelerometer (Y) - Test 3.

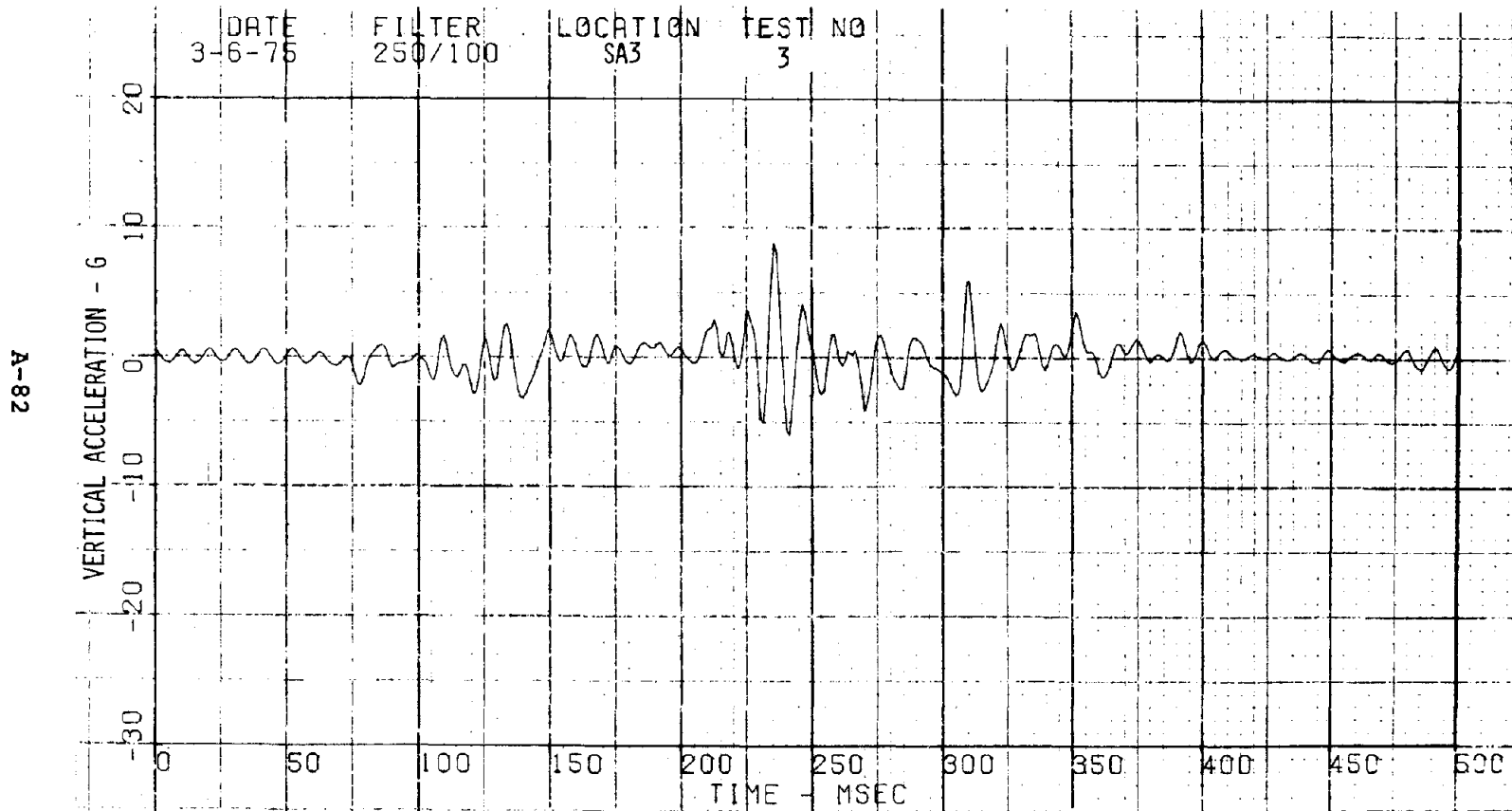


Figure A-84. Caboose Front Triaxial Accelerometer (Z) - Test 3.

A-84

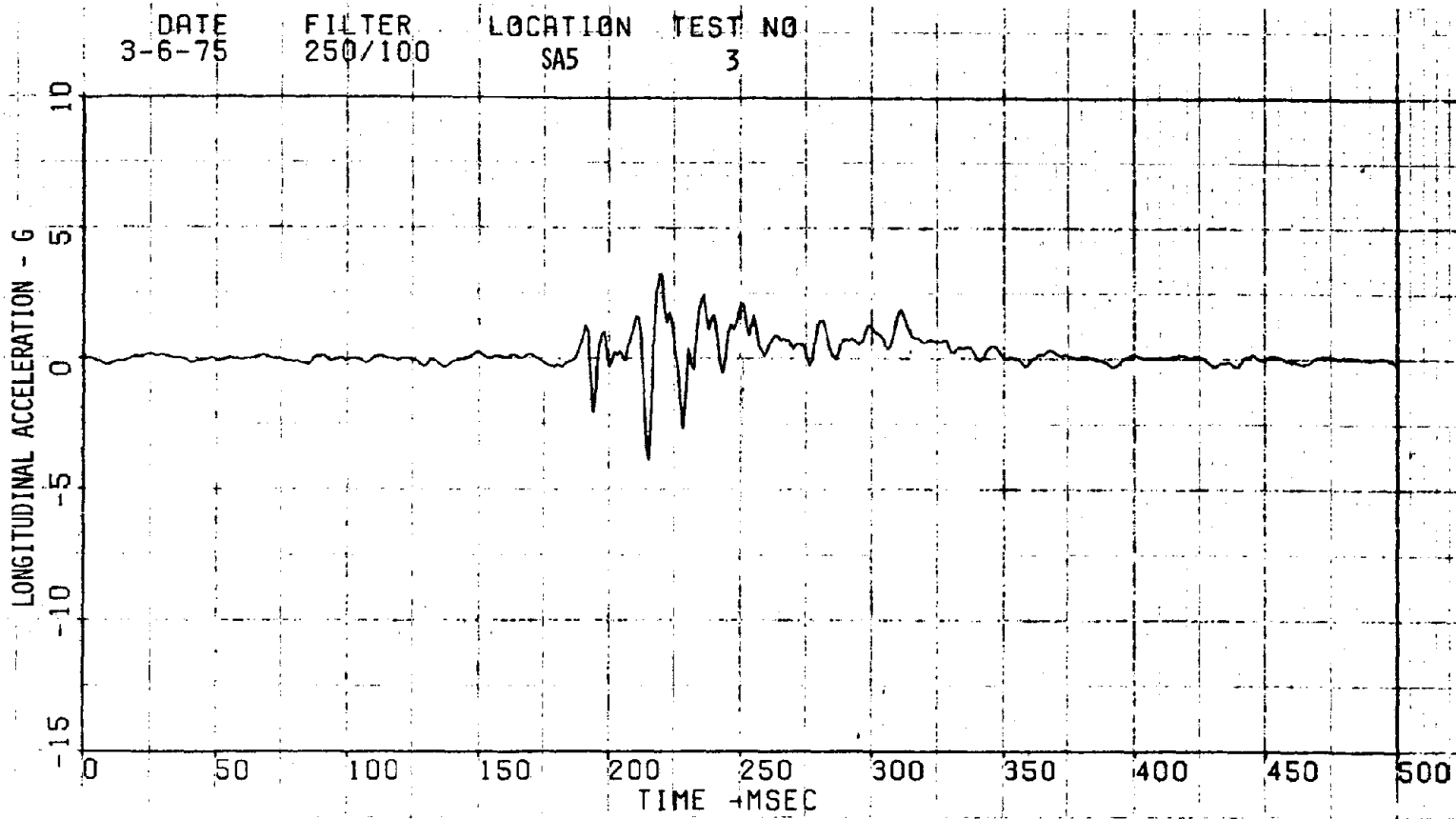


Figure A-86. Hopper 843 Center Longitudinal Accelerometer - Test 3.

A-83

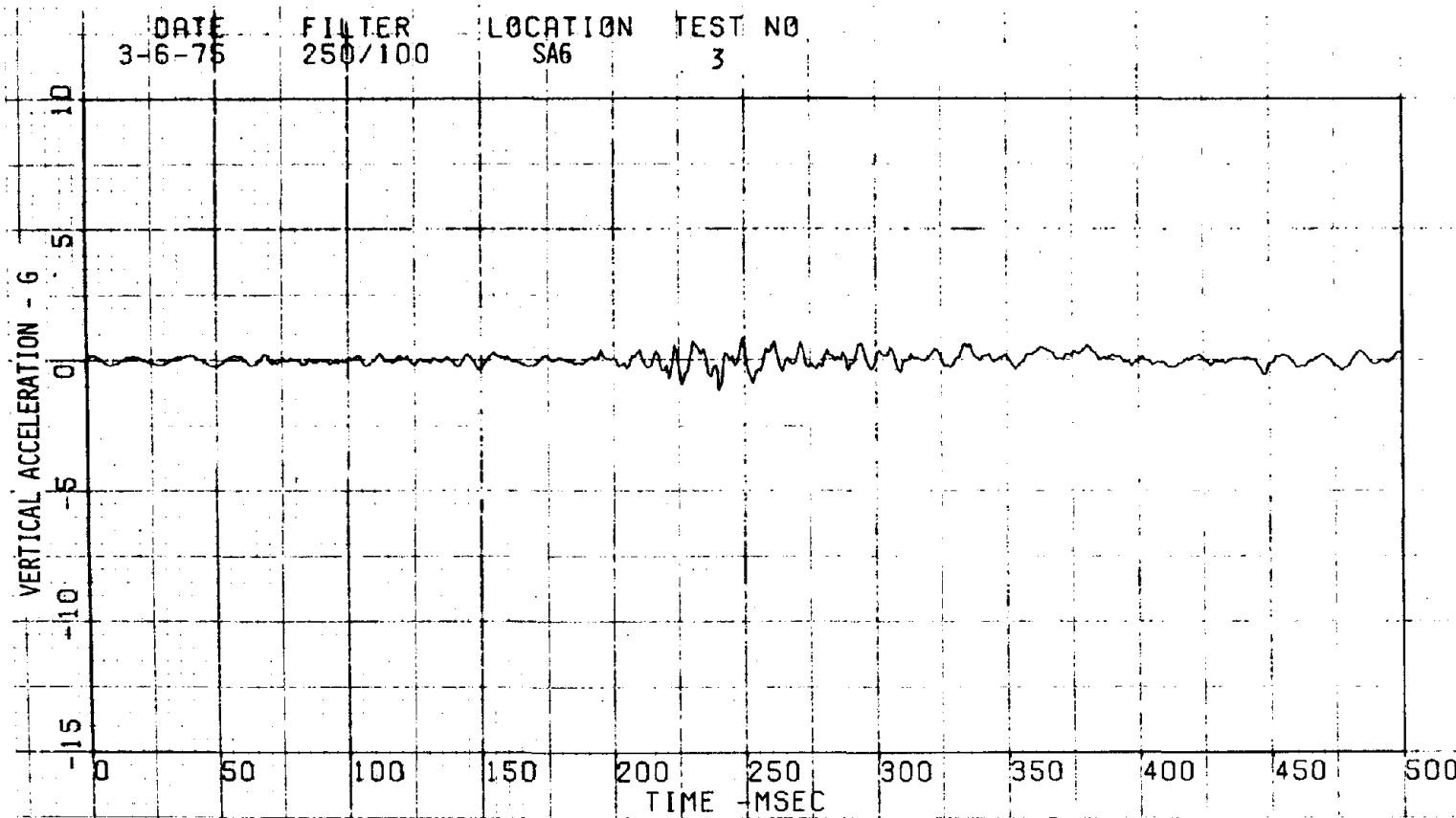


Figure A-85. Hopper 843 Front Vertical Accelerometer - Test 3.

A-85

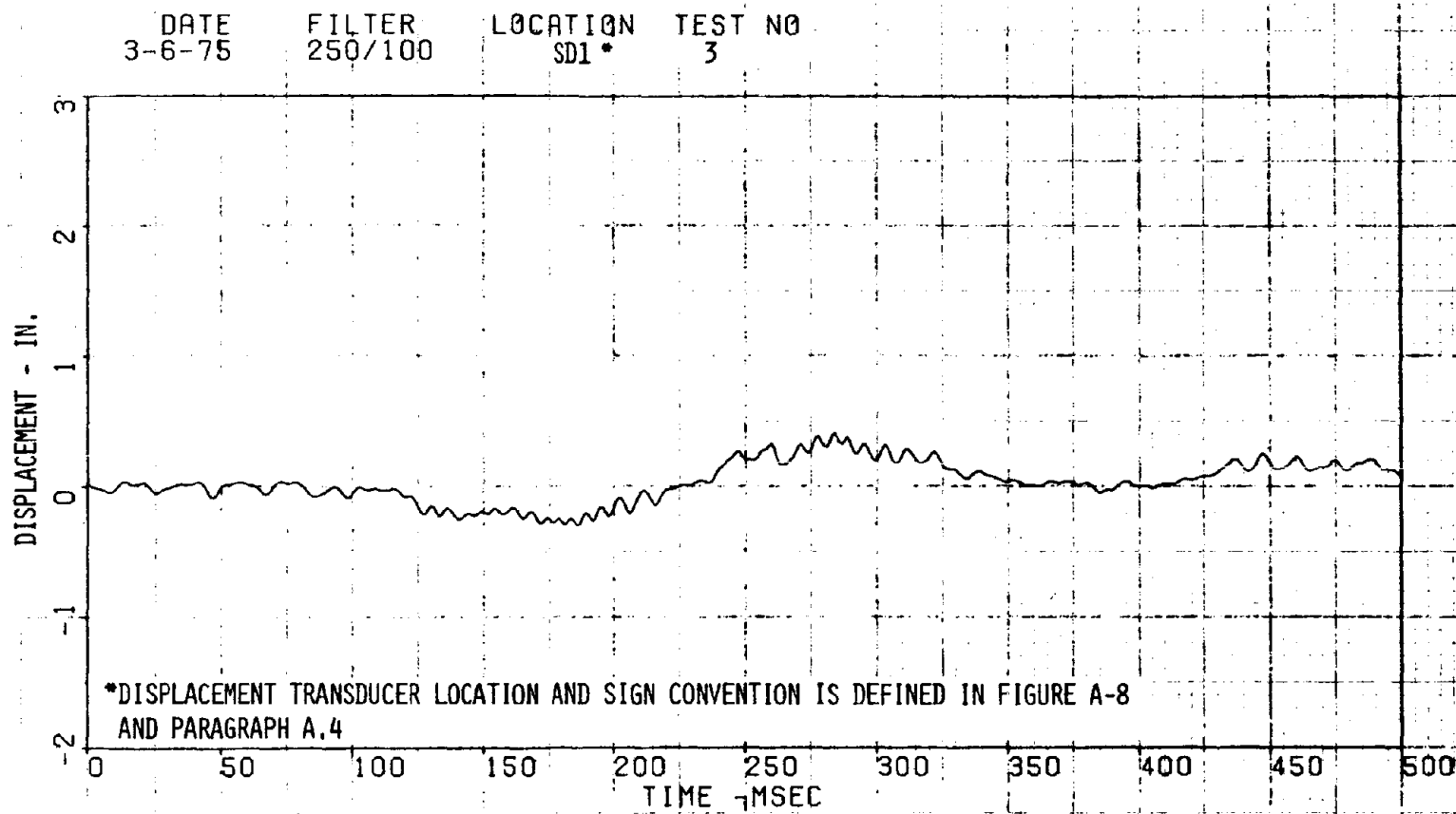


Figure A-87. Caboose Left Rear Displacement Transducer - Test 3.

A-86

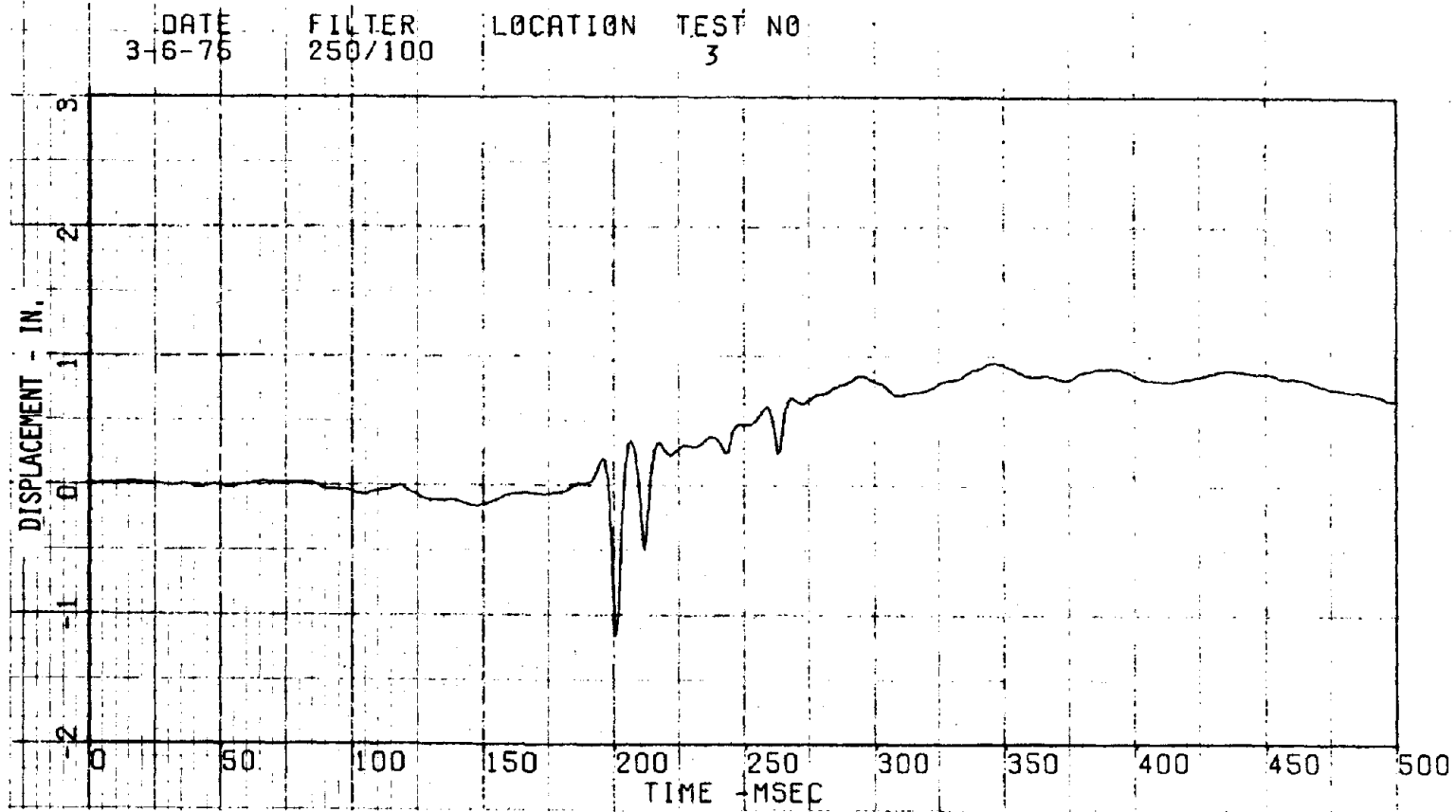


Figure A-88. Caboose Right Rear Displacement Transducer - Test 3.

A-87

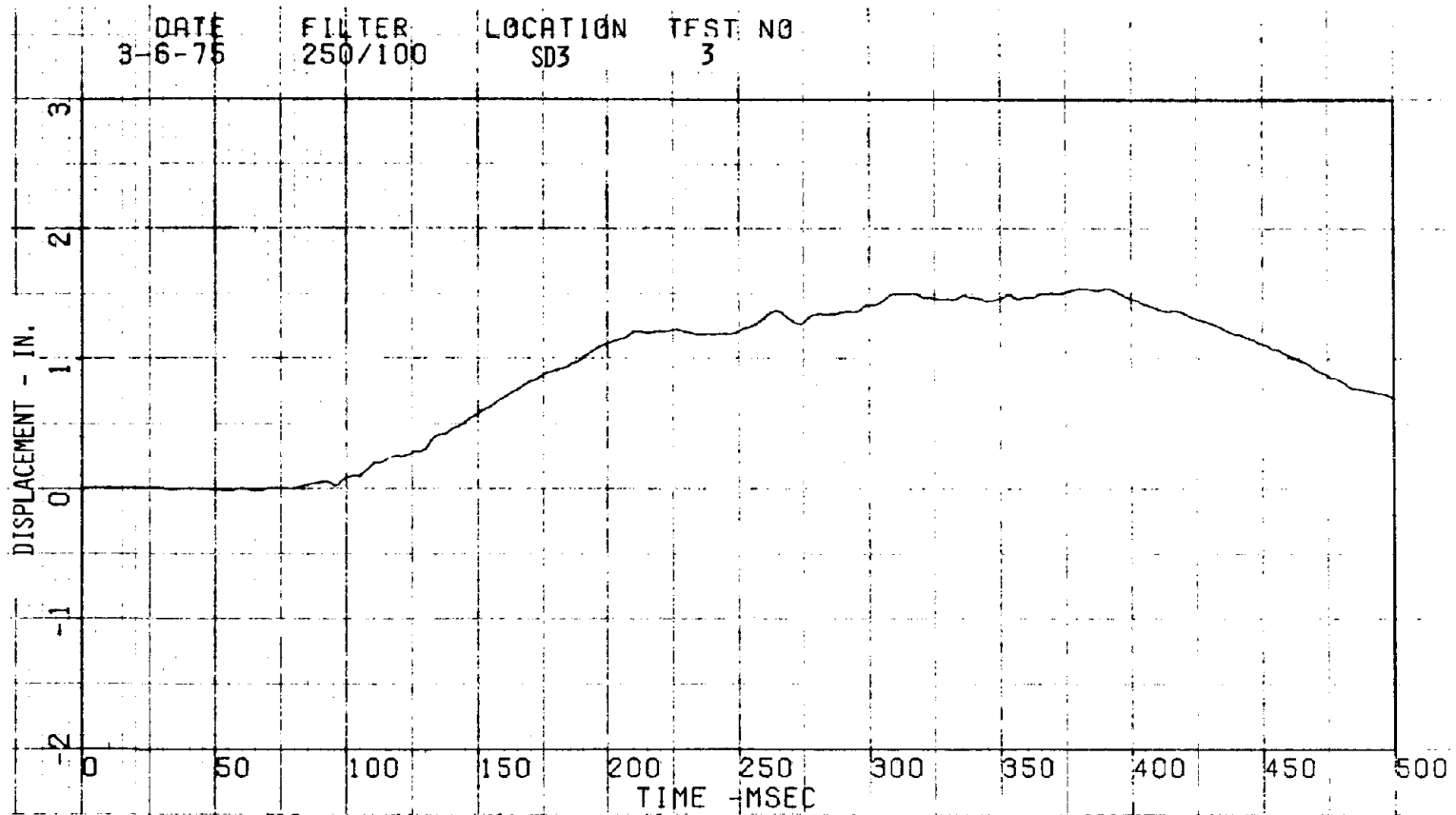


Figure A-89. Caboose Left Front Displacement Transducer - Test 3.

A-88

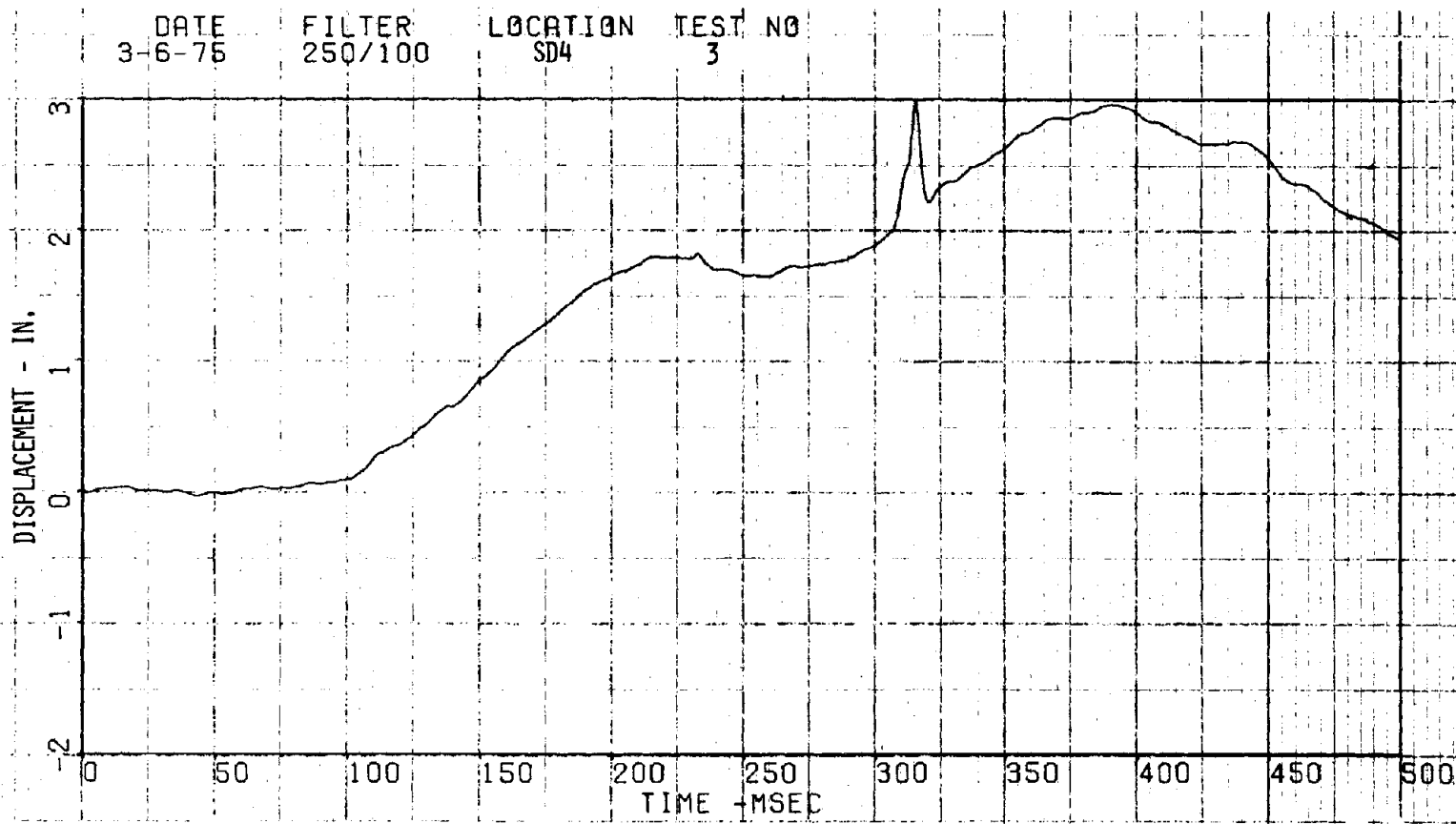


Figure A-90. Caboose Right Front Displacement Transducer - Test 3.

A-89

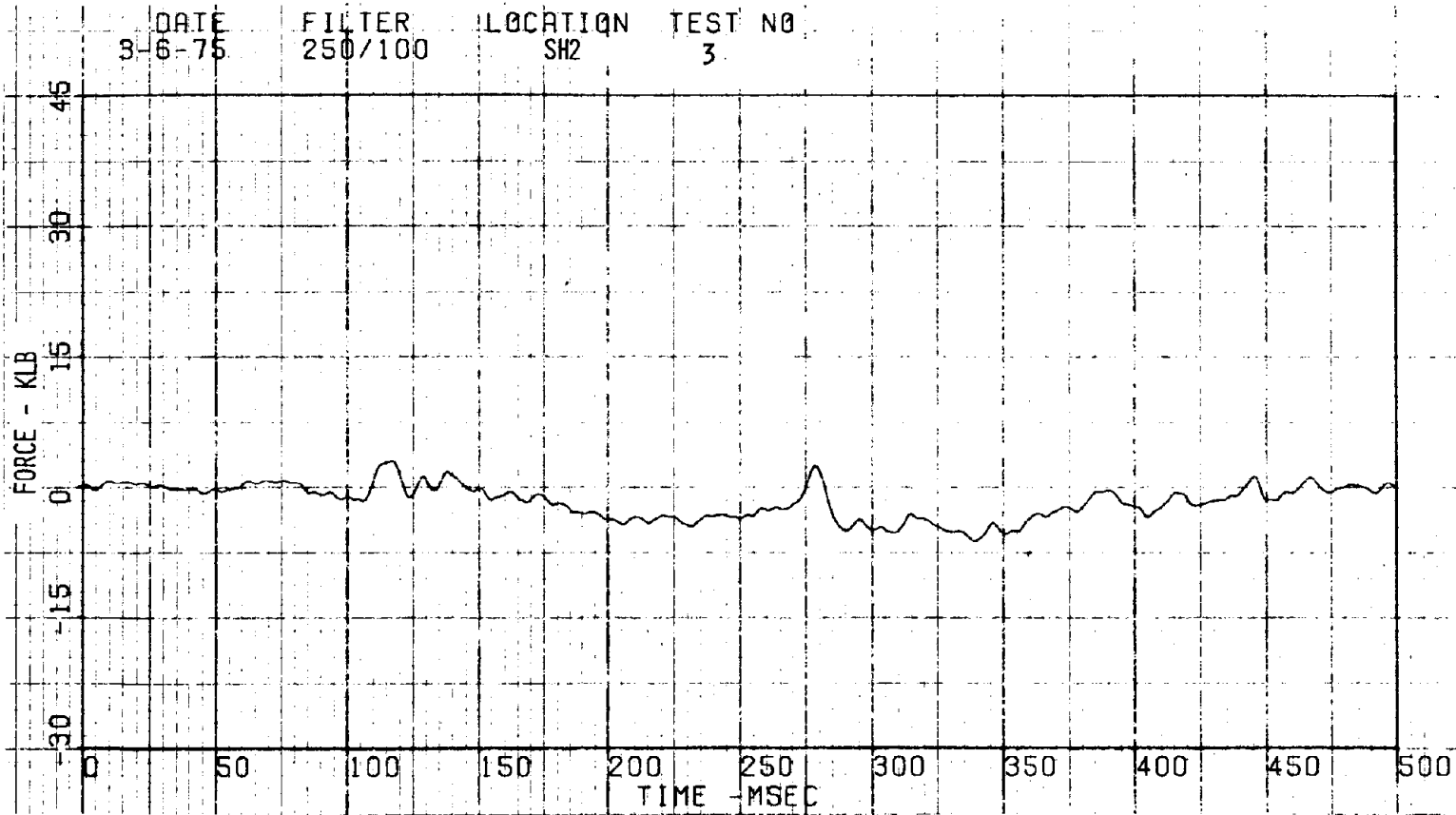


Figure A-91. Caboose Front Swinghanger Strain Gauge - Test 3.

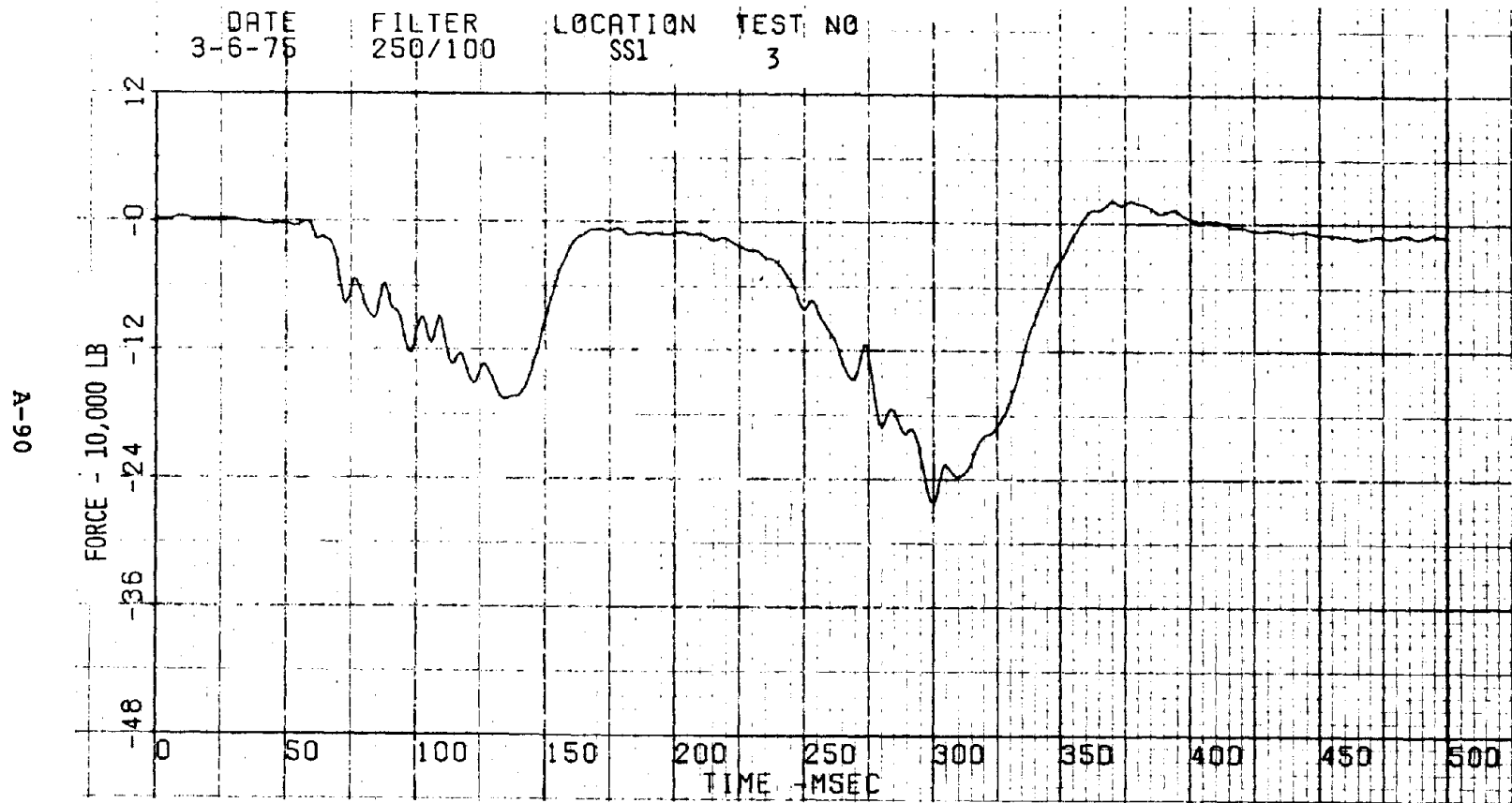


Figure A-92. Caboose Rear Coupler Strain Gauge - Test 3.

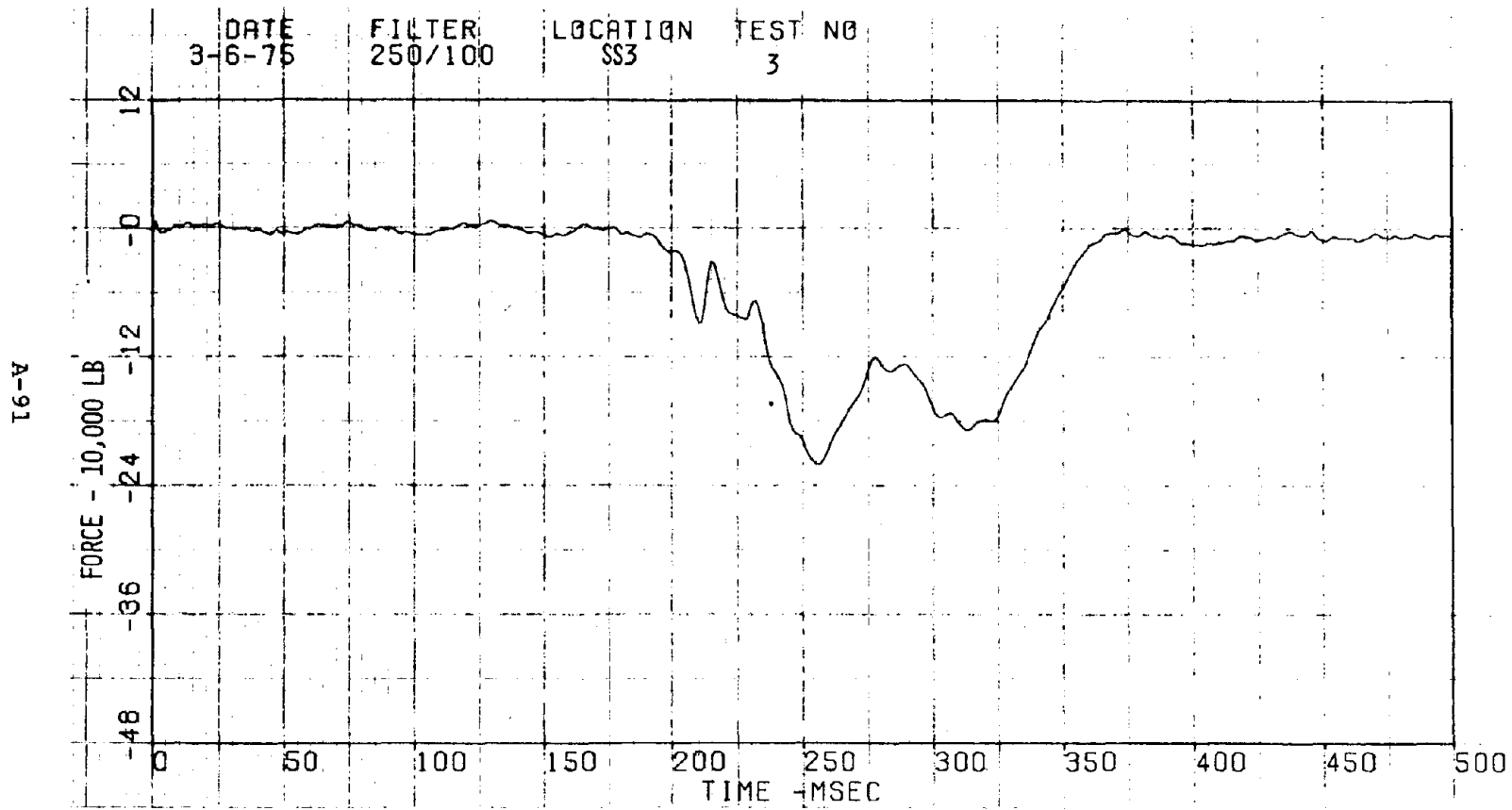
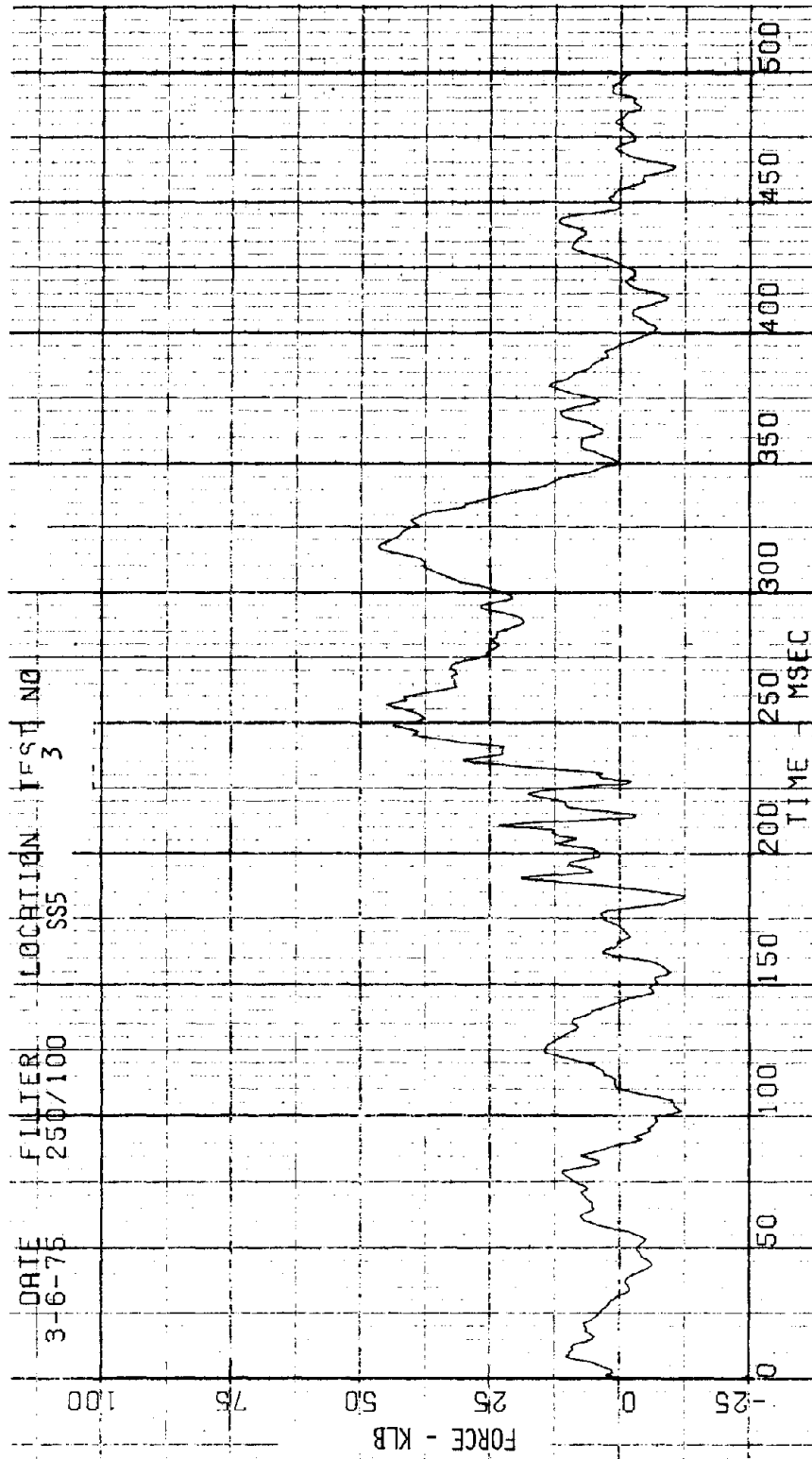
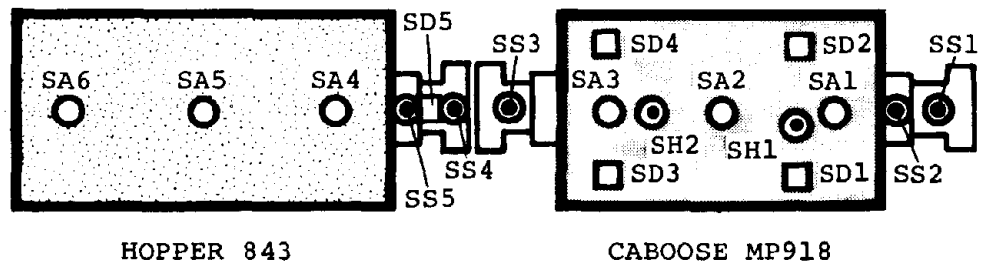


Figure A-93. Caboose Front Coupler Strain Gauge - Test 3.



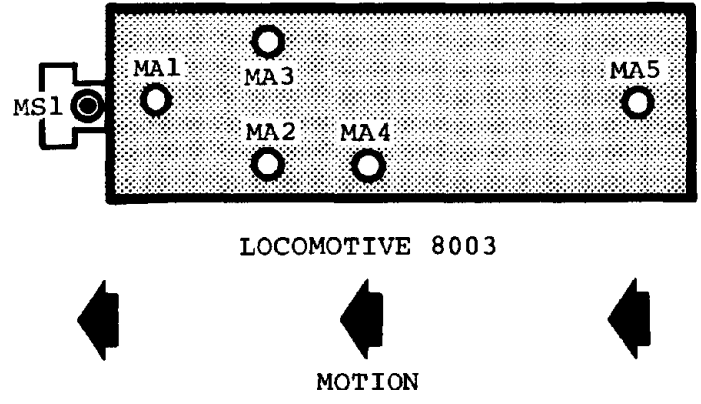
A-92

Figure A-94. Hopper 843 Center Sill Strain Gauge - Test 3.



- HOPPER LOADED
 - TRAIN IN DRAFT
- STANDING TRAIN

A-93



- IMPACT VELOCITY = 8.8 MPH
- MOVING TRAIN

Figure A-95. Instrument Locations - Test 4.

A-94

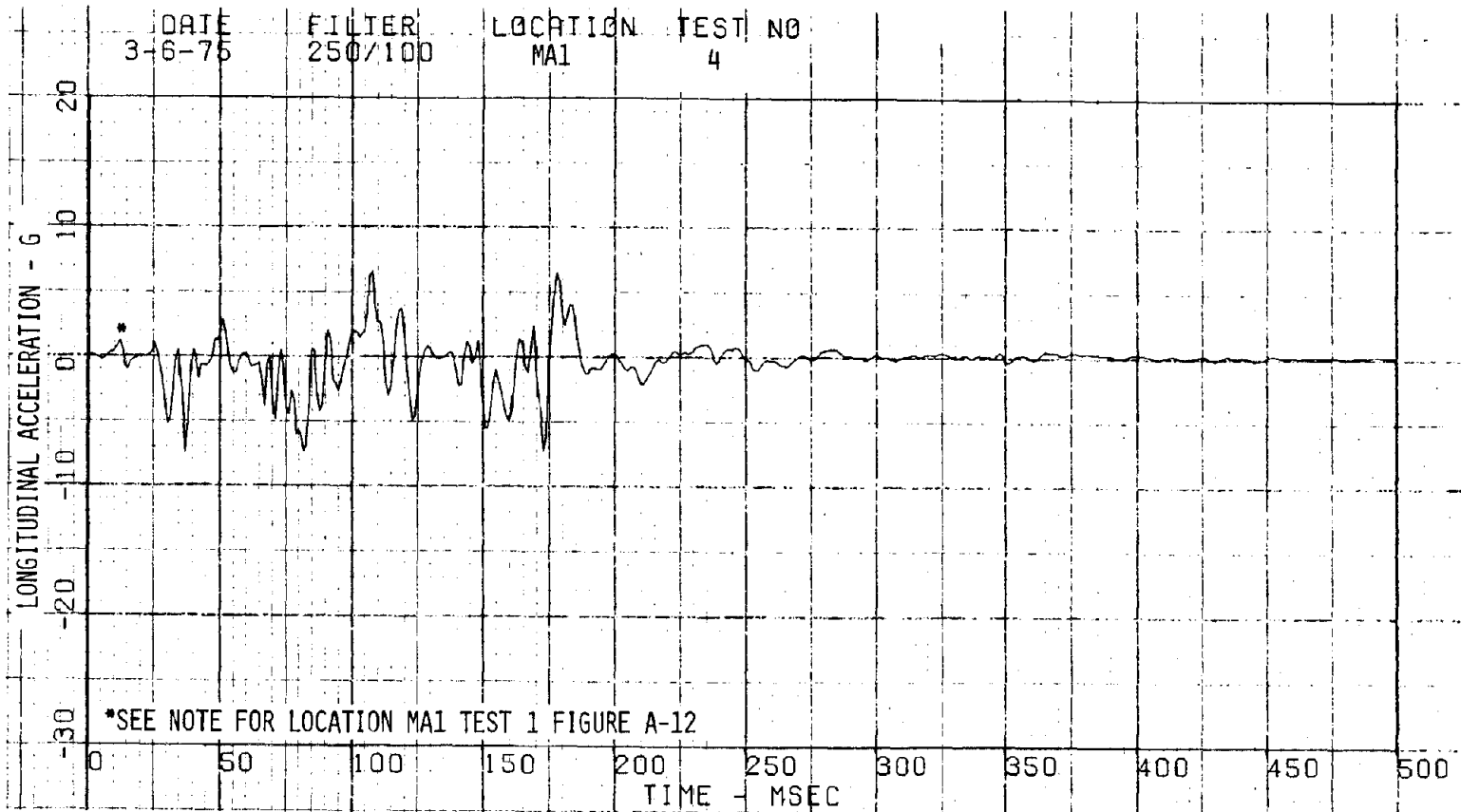


Figure A-96. Locomotive Rear Triaxial Accelerometer (X) - Test 4.

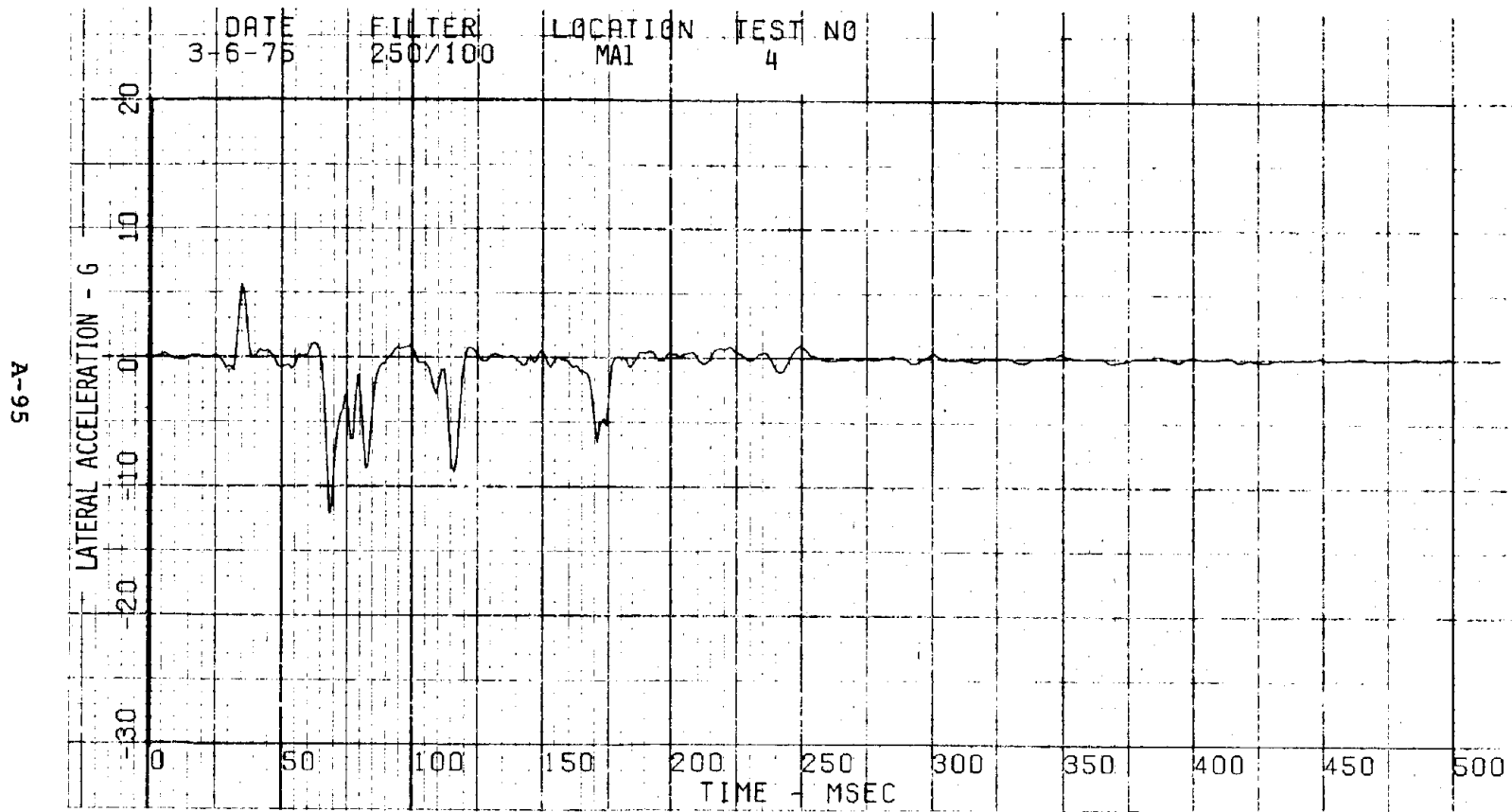


Figure A-97. Locomotive Rear Triaxial Accelerometer (Y) - Test 4.

A-96

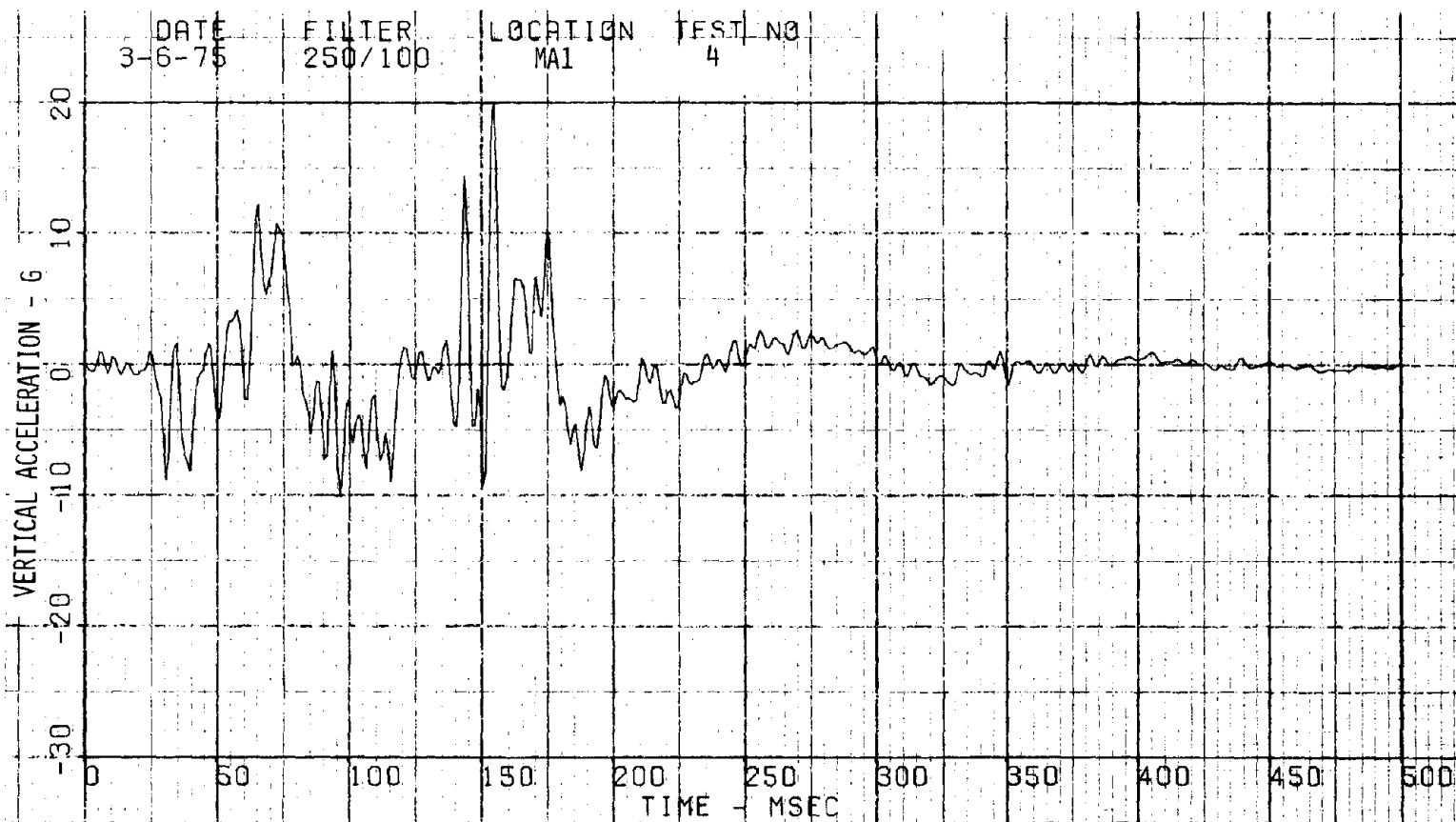


Figure A-98. Locomotive Rear Triaxial Accelerometer (Z) - Test 4.

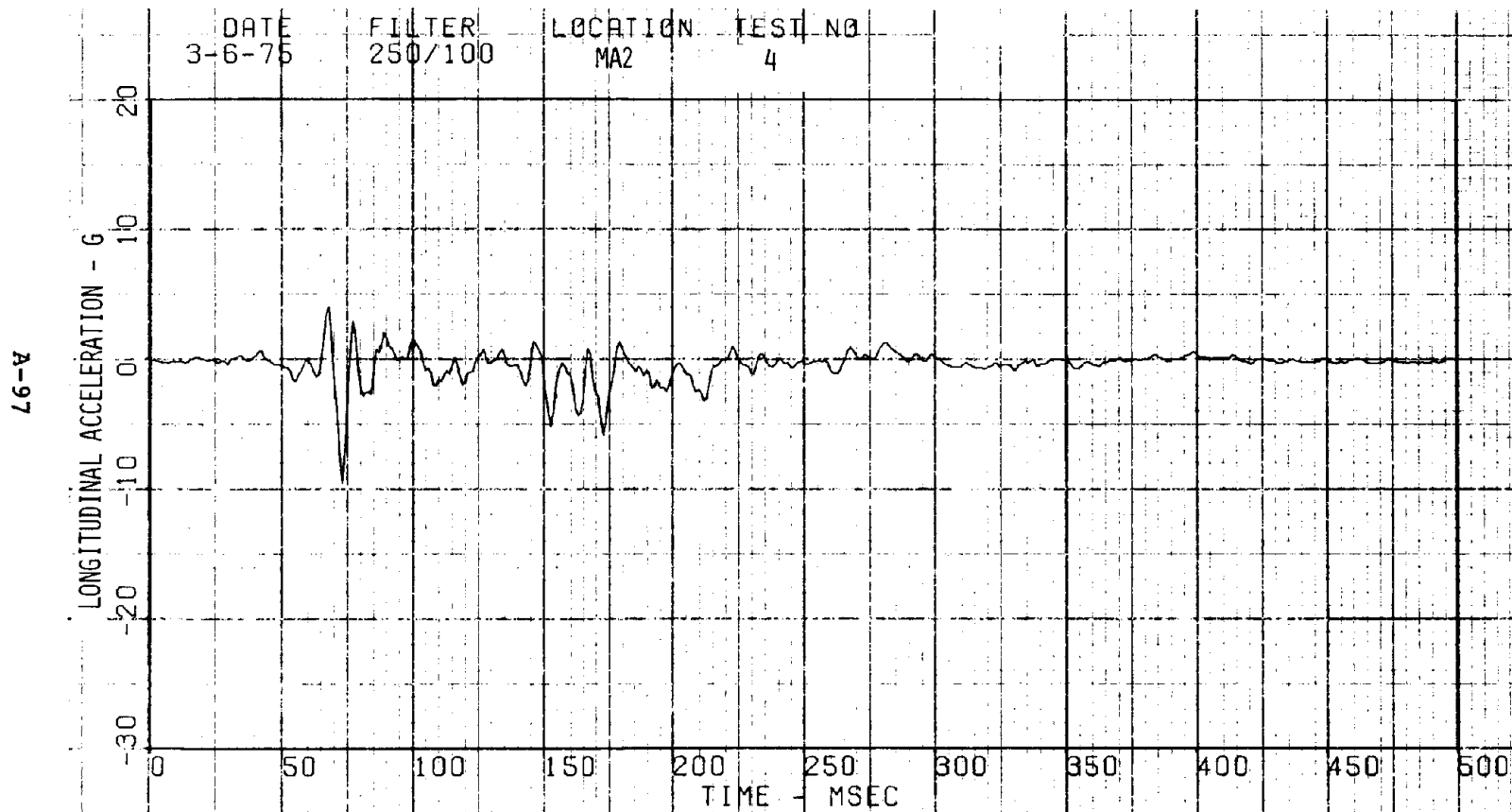


Figure A-99. Locomotive Left Cab Accelerometer - Test 4.

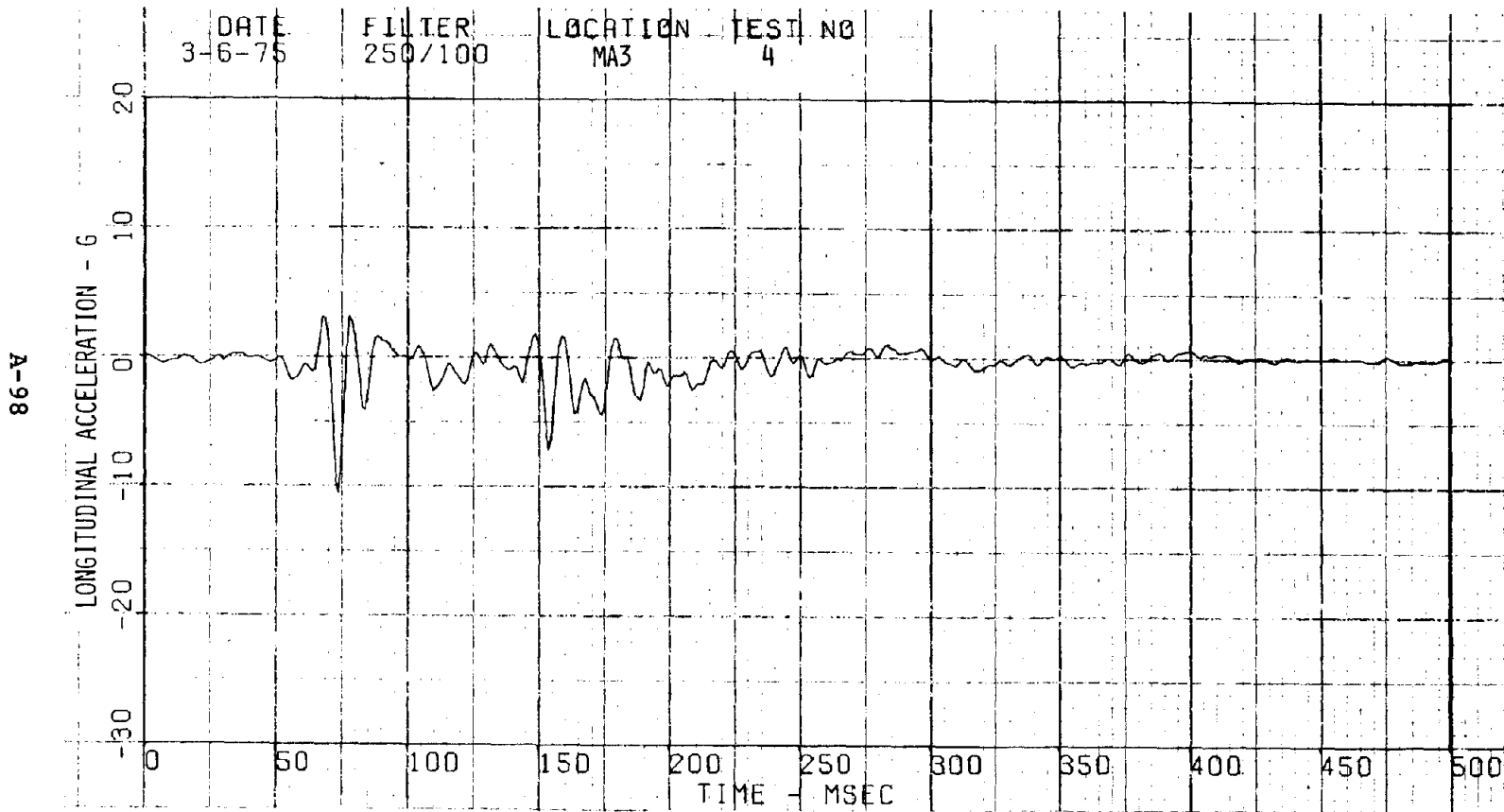


Figure A-100. Locomotive Right Cab Accelerometer - Test 4.

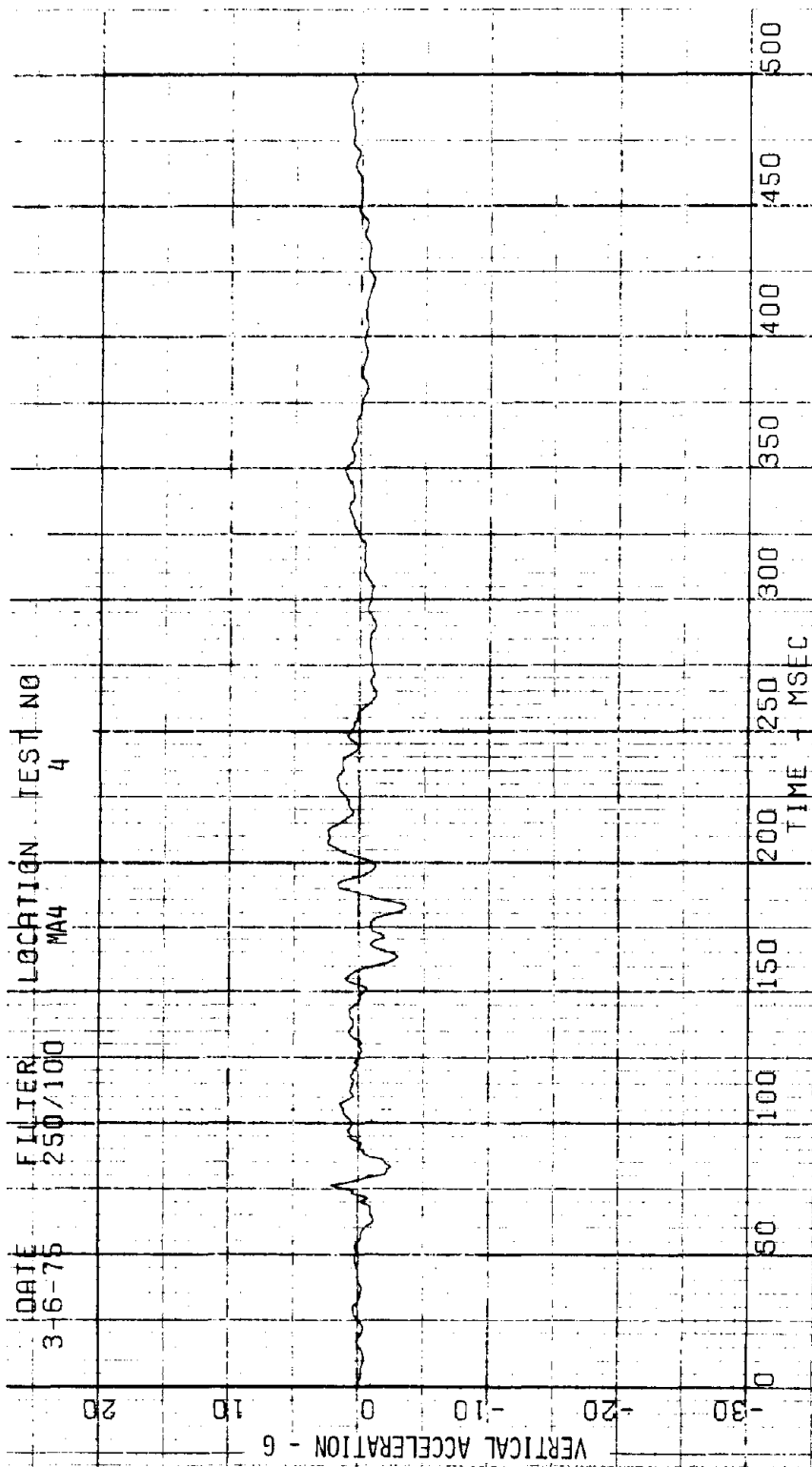


Figure A-101. Locomotive Center Vertical Accelerometer - Test 4.

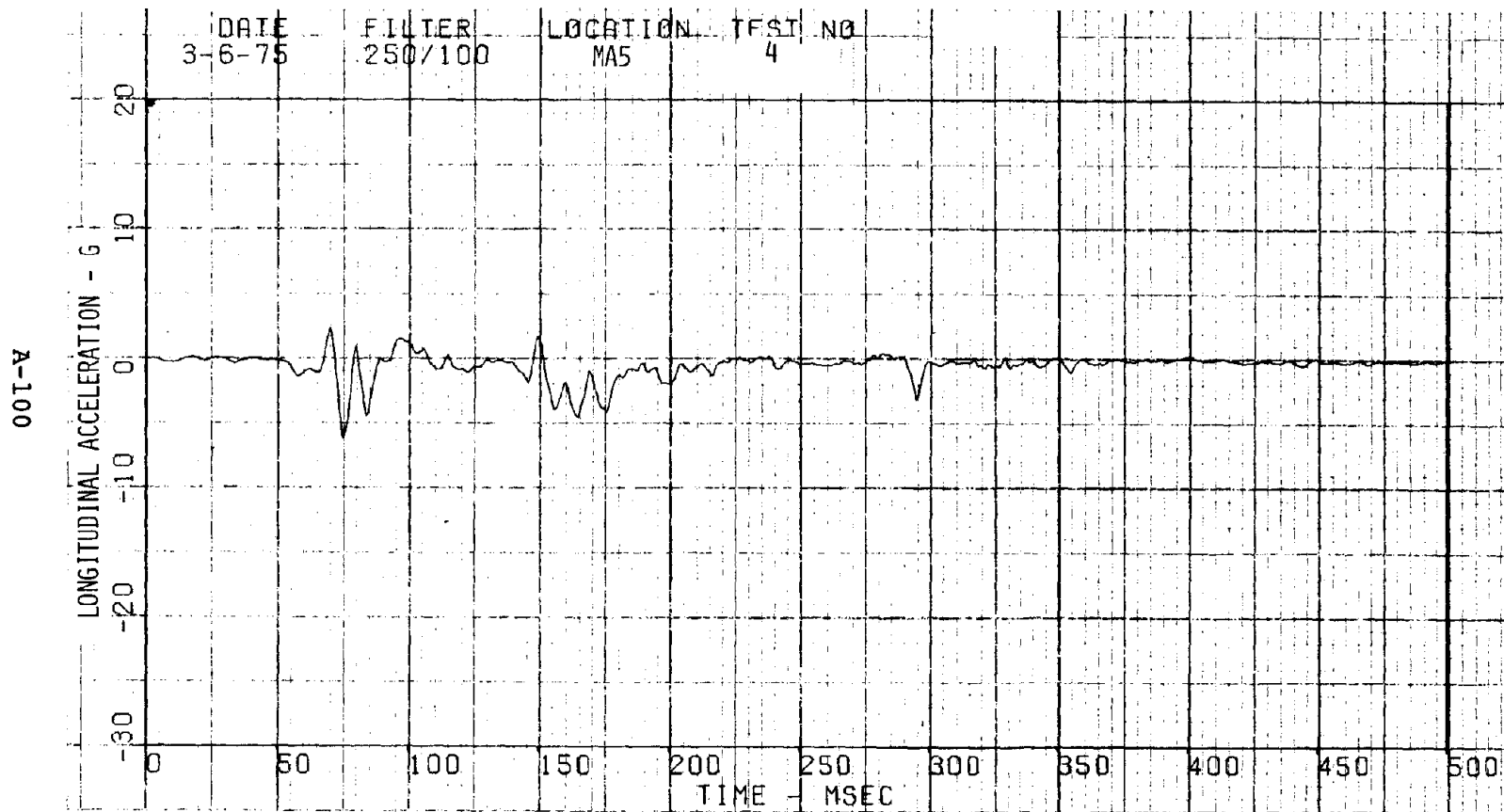


Figure A-102. Locomotive Front Triaxial Accelerometer (X) - Test 4.

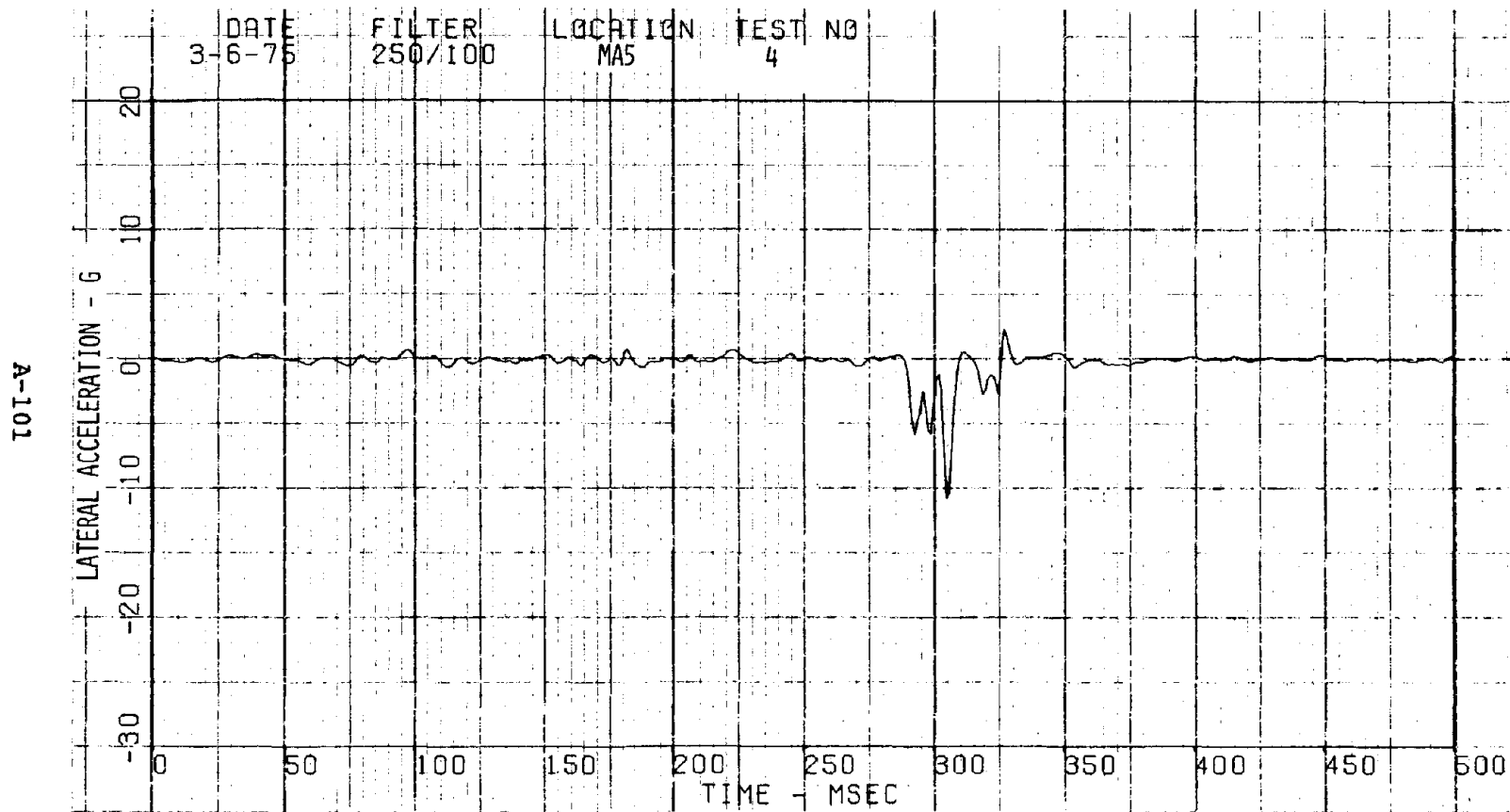


Figure A-103. Locomotive Front Triaxial Accelerometer (Y) - Test 4.

A-102

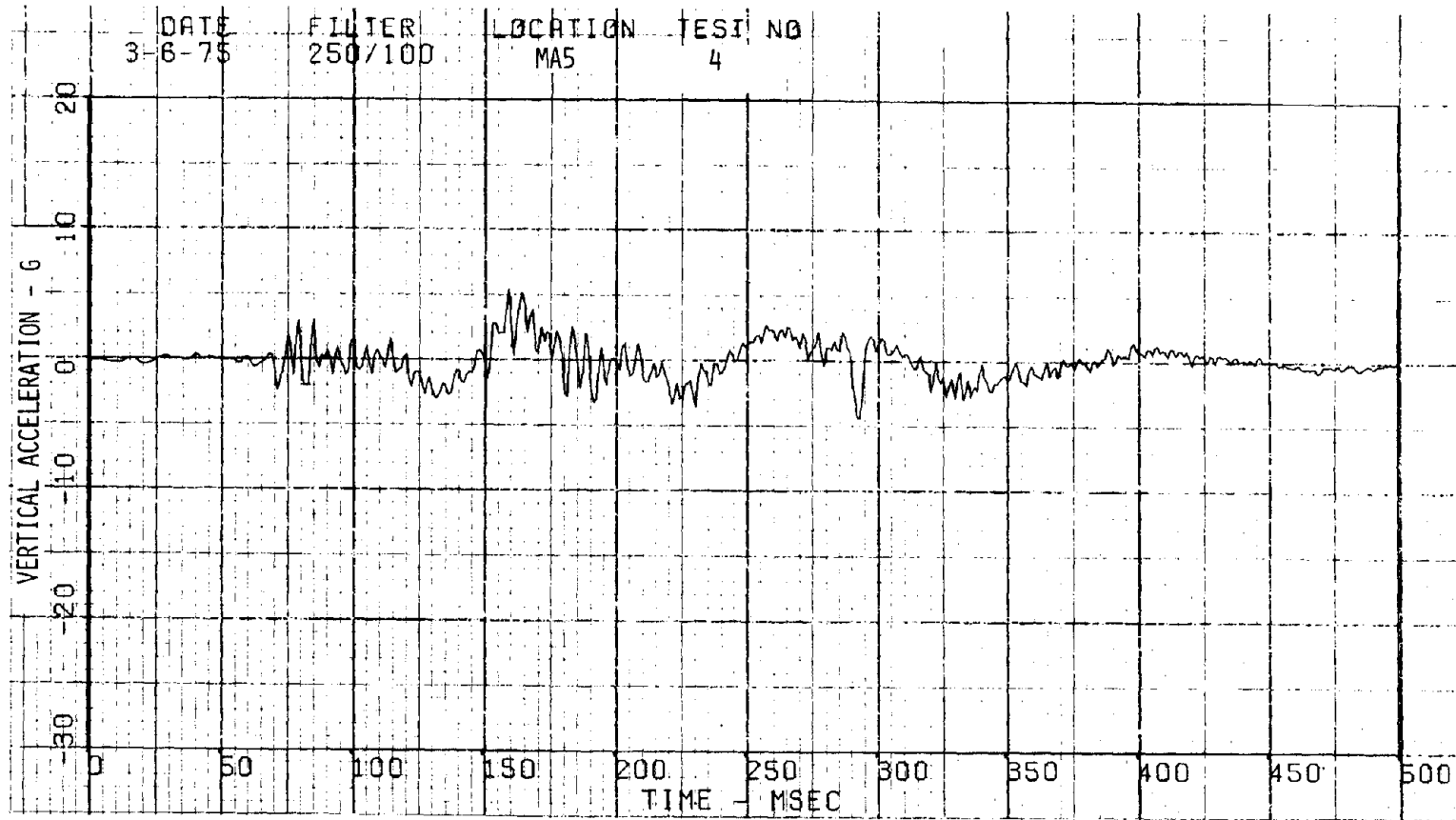


Figure A-104. Locomotive Front Triaxial Accelerometer (Z) - Test 4.

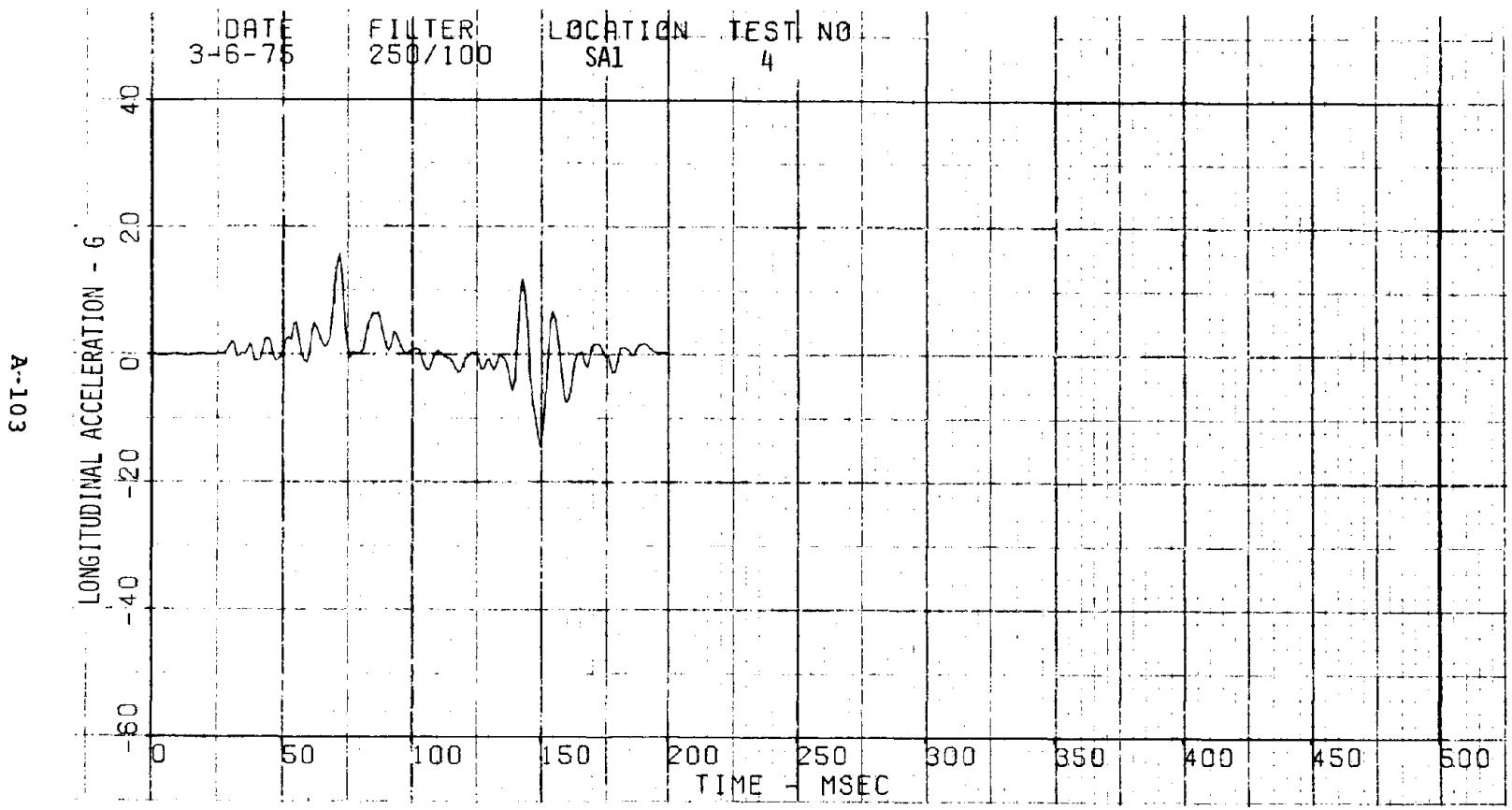


Figure A-105. Caboose Rear Triaxial Accelerometer (X) - Test 4.

A-104

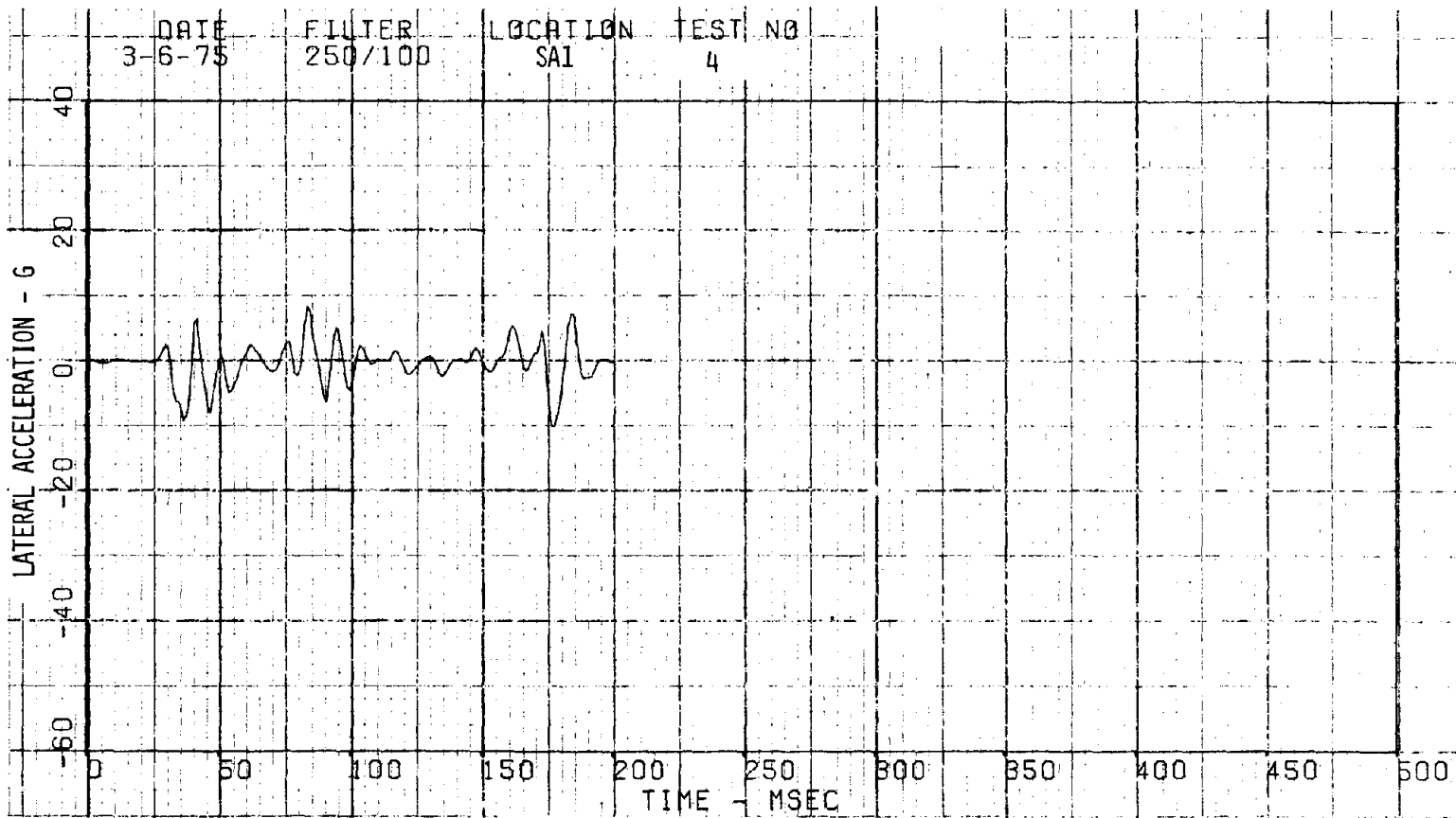


Figure A-106. Caboose Rear Triaxial Accelerometer (Y) - Test 4.

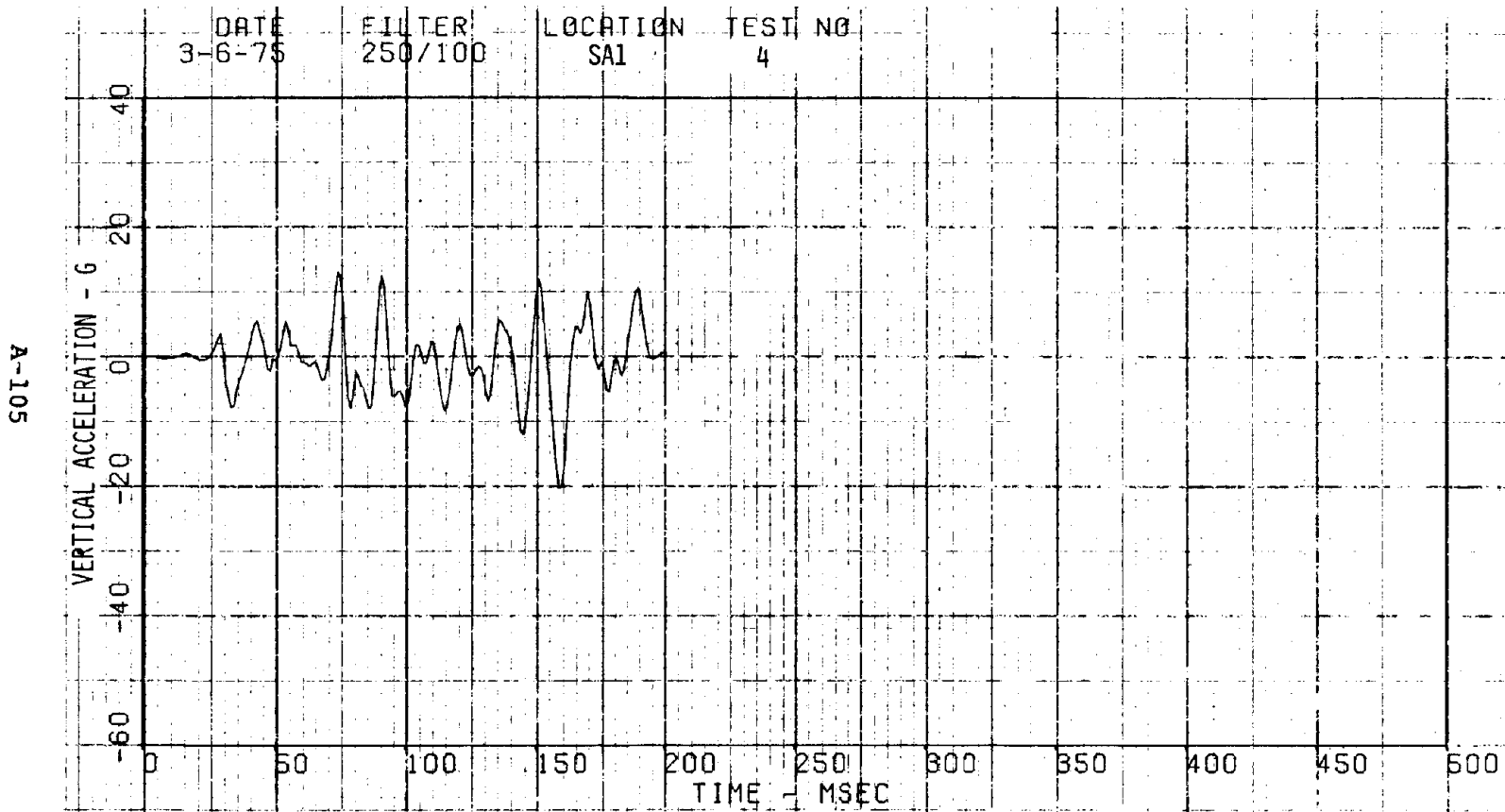


Figure A-107. Caboose Rear Triaxial Accelerometer (Z) - Test 4.

A-106

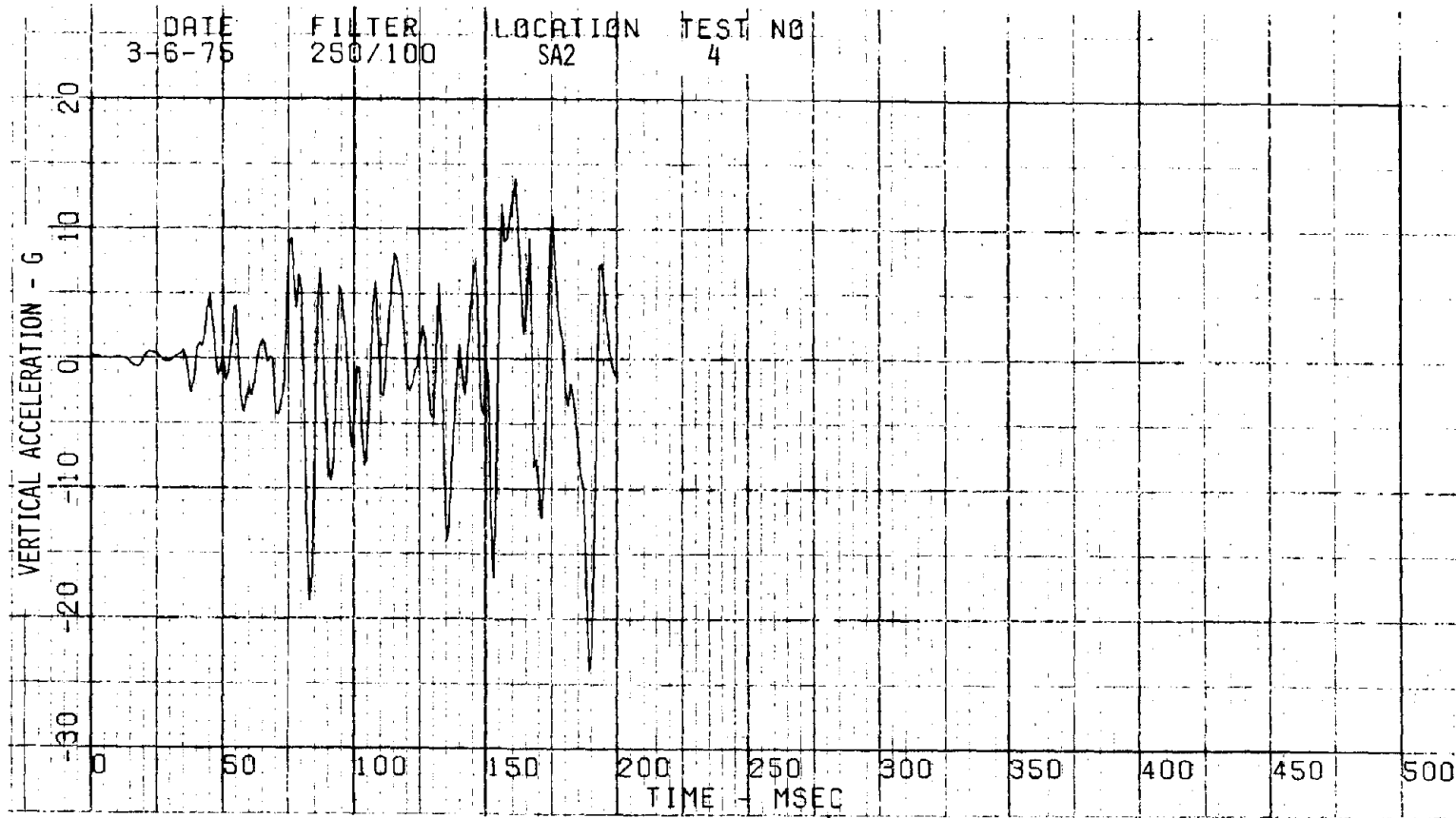


Figure A-108. Caboose Center Vertical Accelerometer - Test 4.

A-107

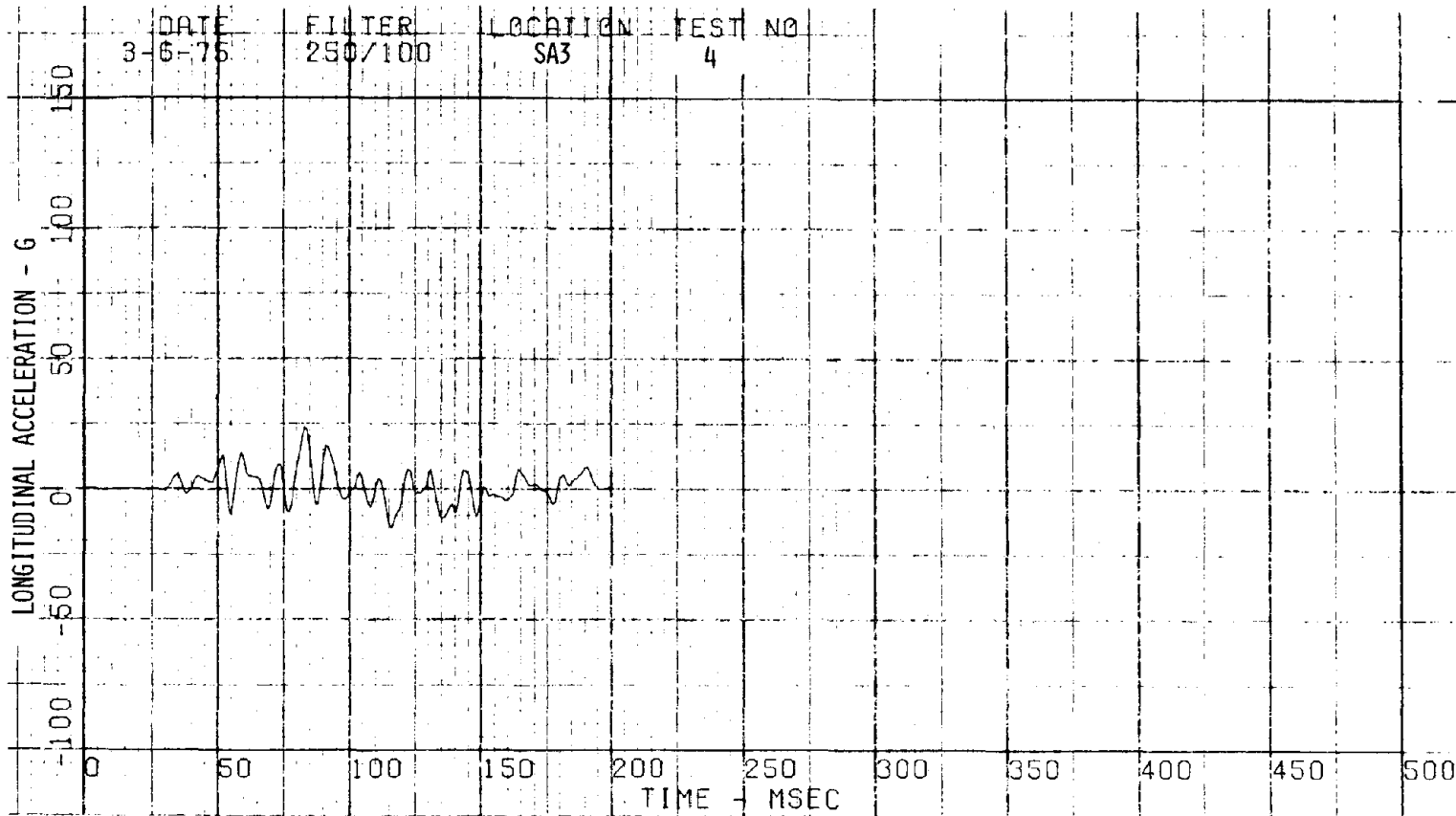


Figure A-109. Caboose Front Triaxial Accelerometer (X) - Test 4.

A-108

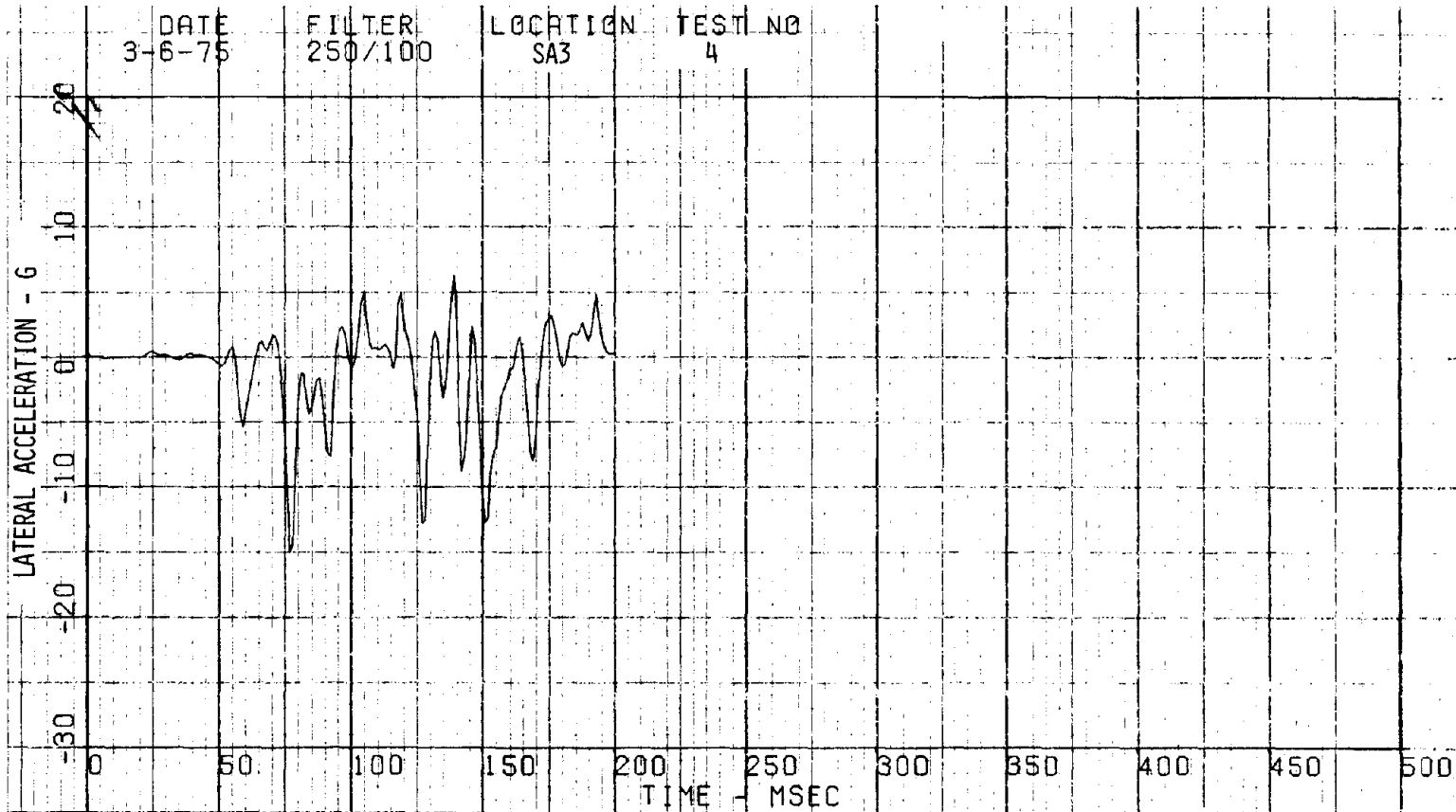


Figure A-110. Caboose Front Triaxial Accelerometer (Y) - Test 4.

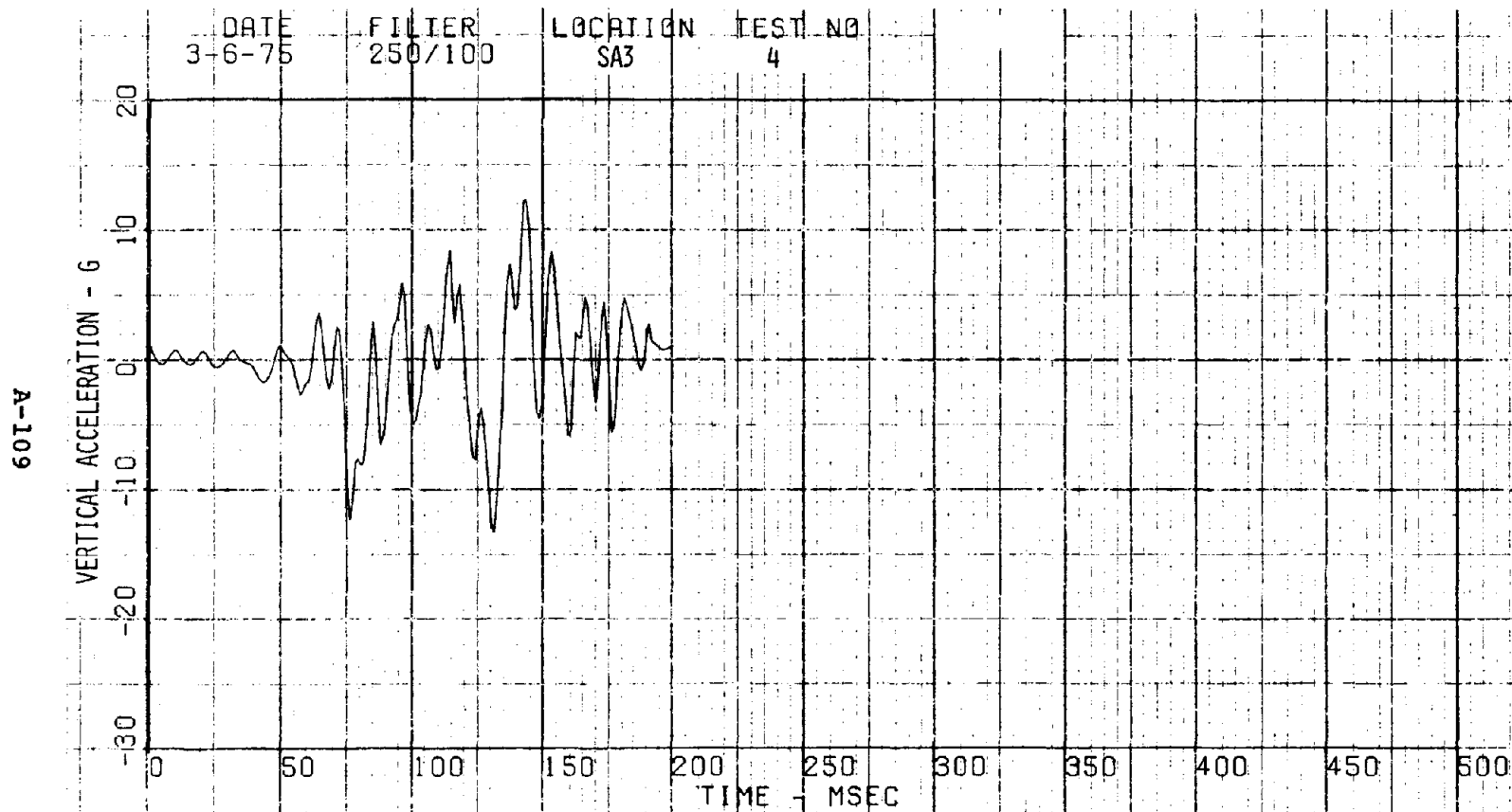


Figure A-111. Caboose Front Triaxial Accelerometer (Z) - Test 4.

A-110

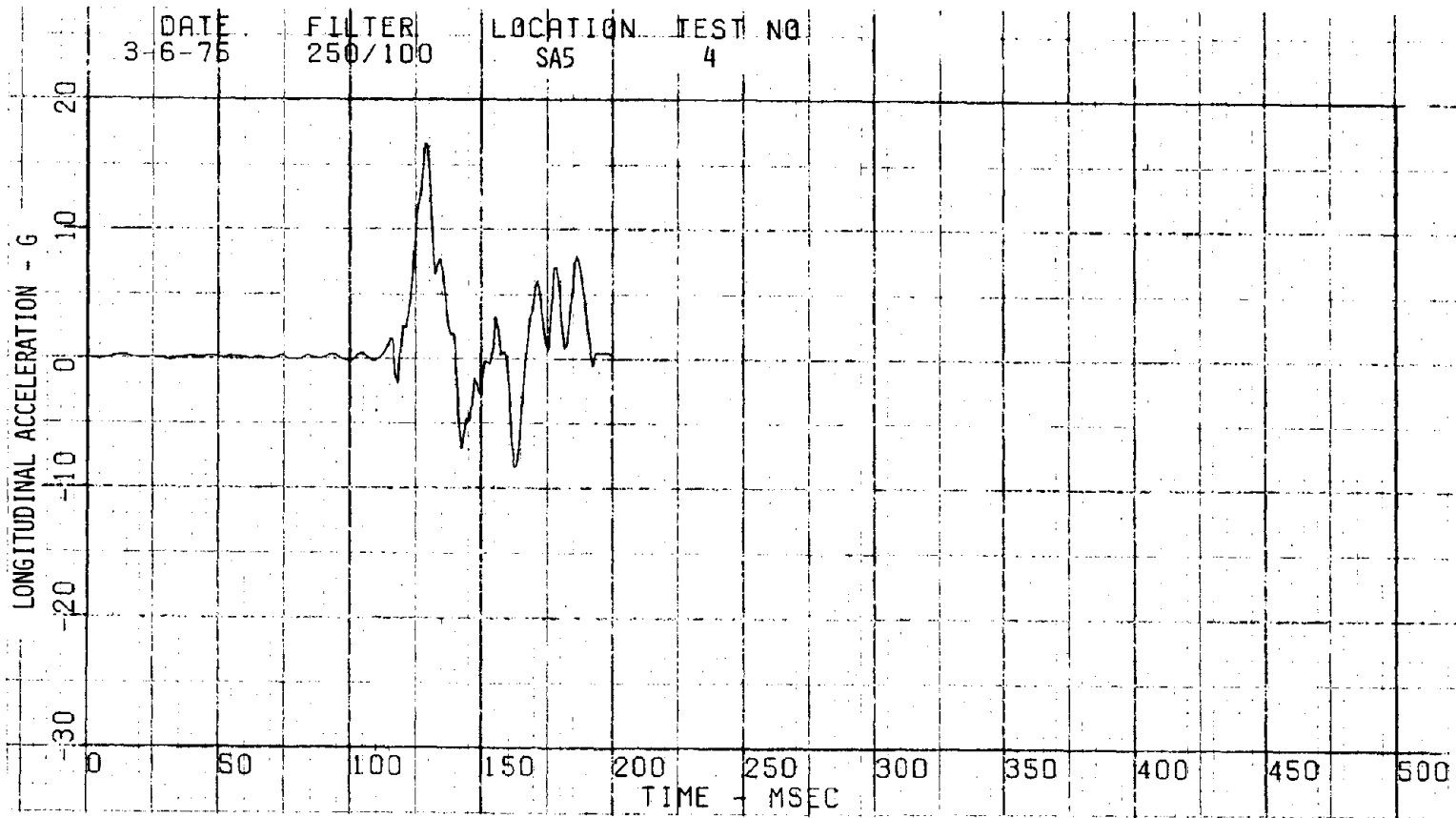


Figure A-112. Hopper 843 Center Longitudinal Accelerometer - Test 4.

A-111

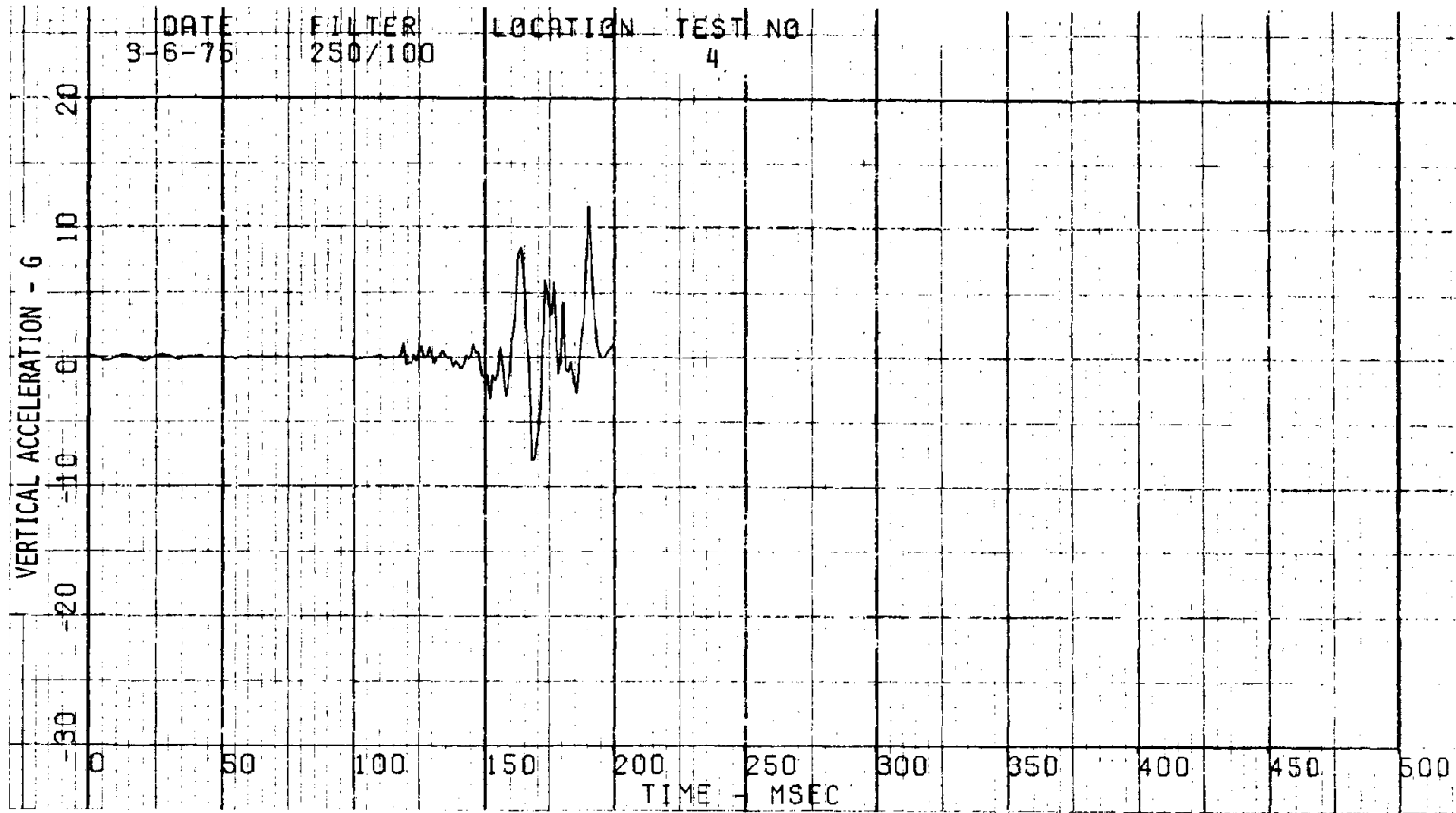


Figure A-113. Hopper 843 Front Vertical Accelerometer - Test 4.

A-112

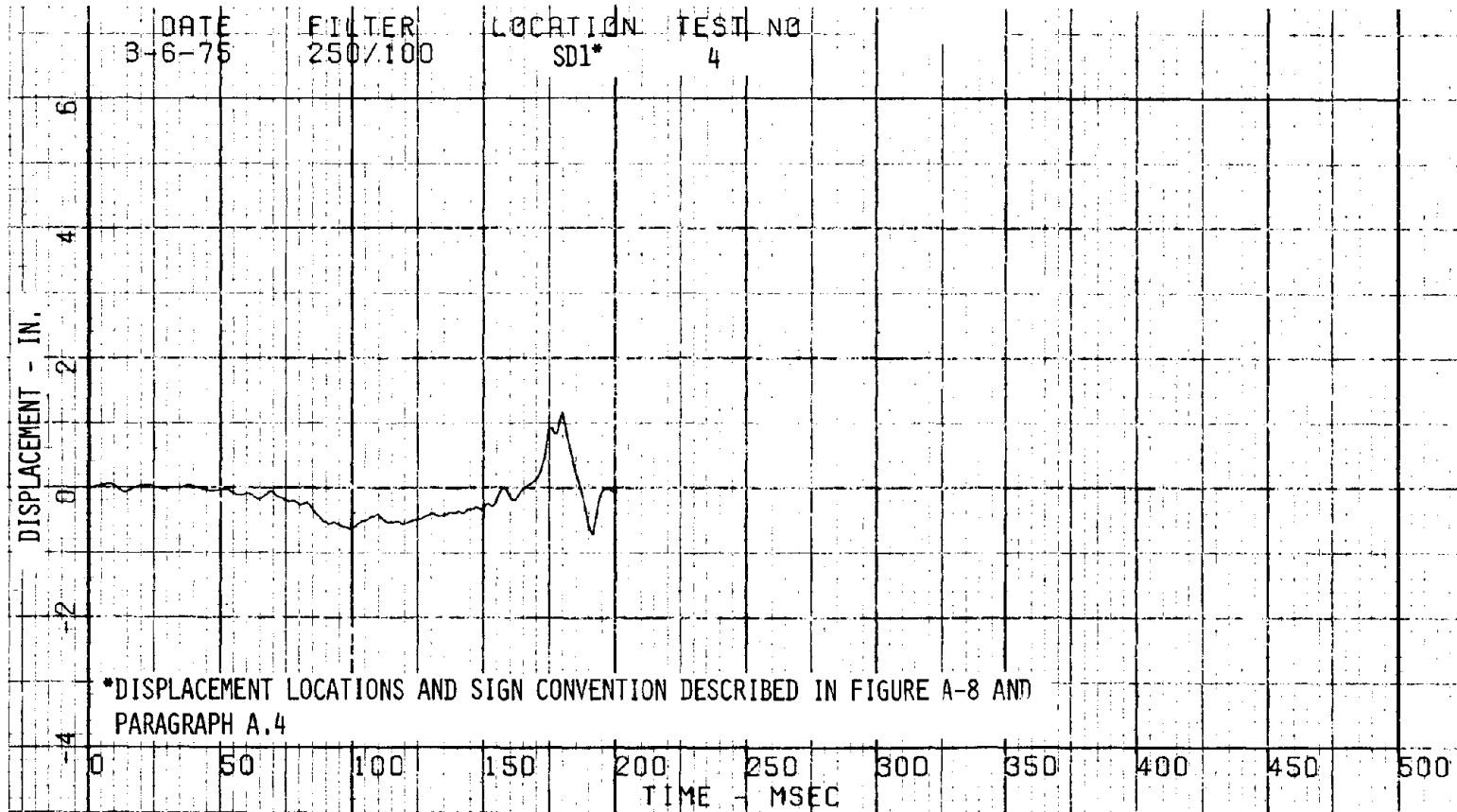


Figure A-114. Caboose Left Rear Displacement Transducer - Test 4.

A-113

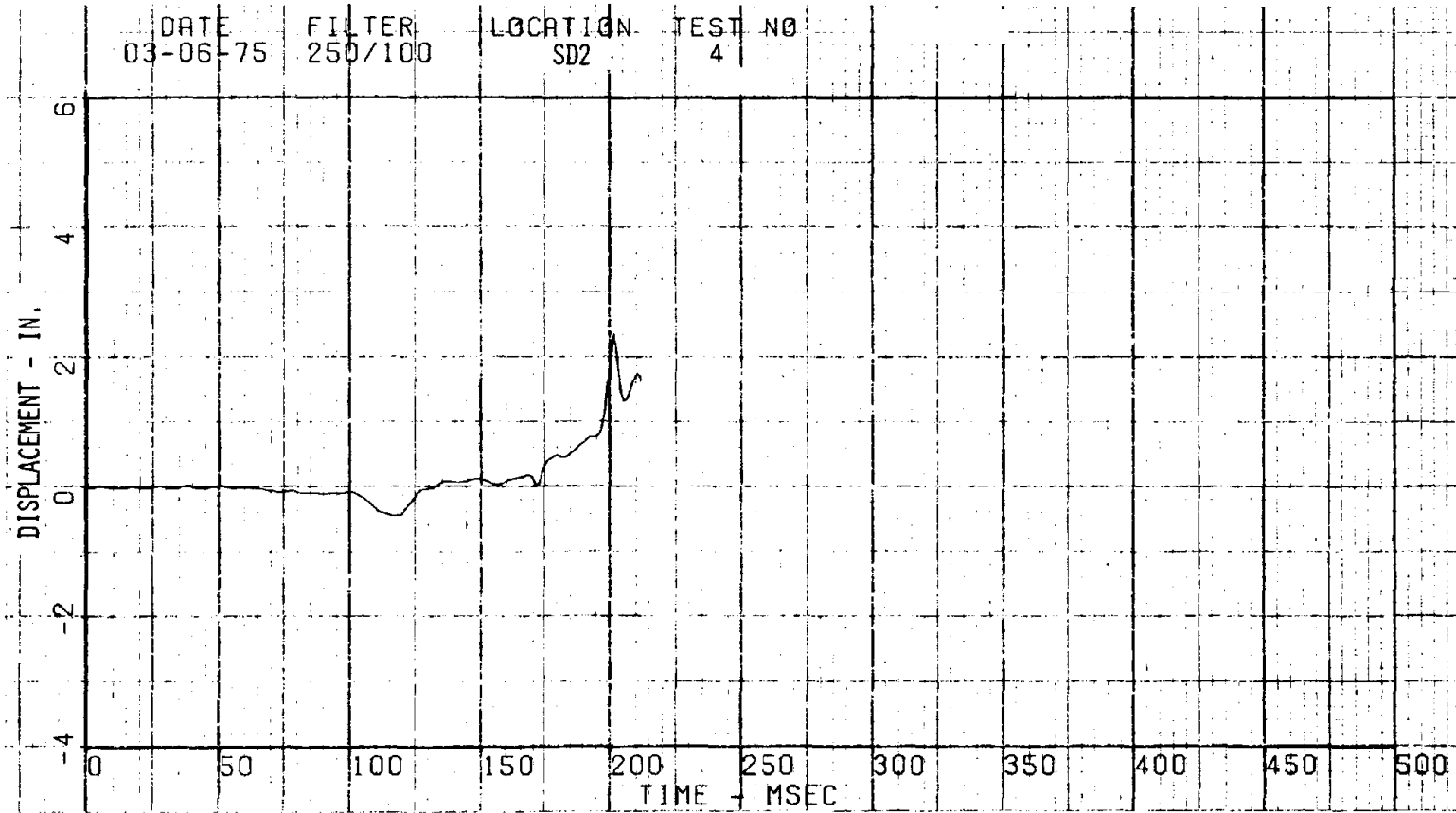


Figure A-115. Caboose Right Rear Displacement Transducer - Test 4.

A-114

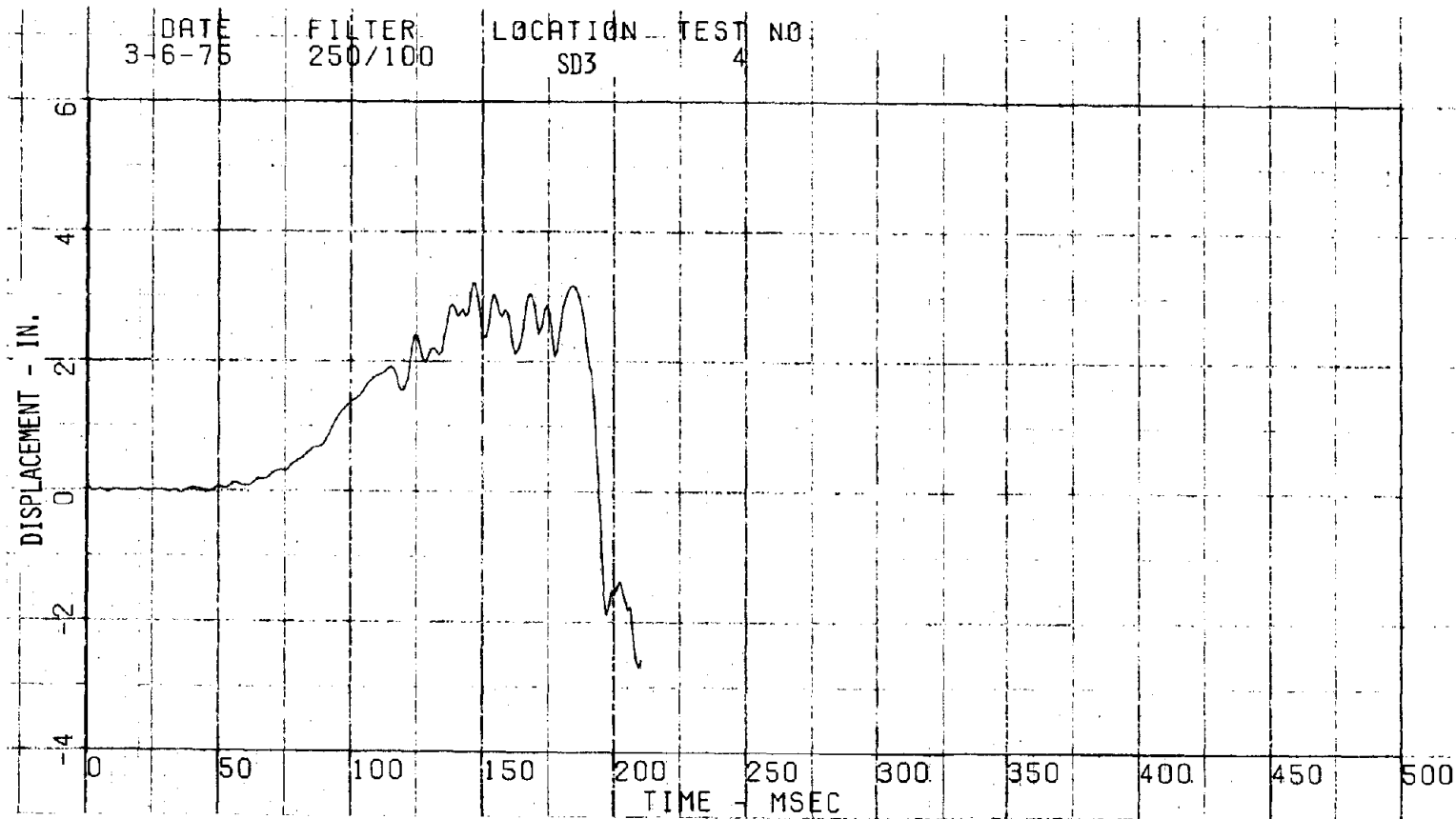


Figure A-116. Caboose Left Front Displacement Transducer - Test 4.

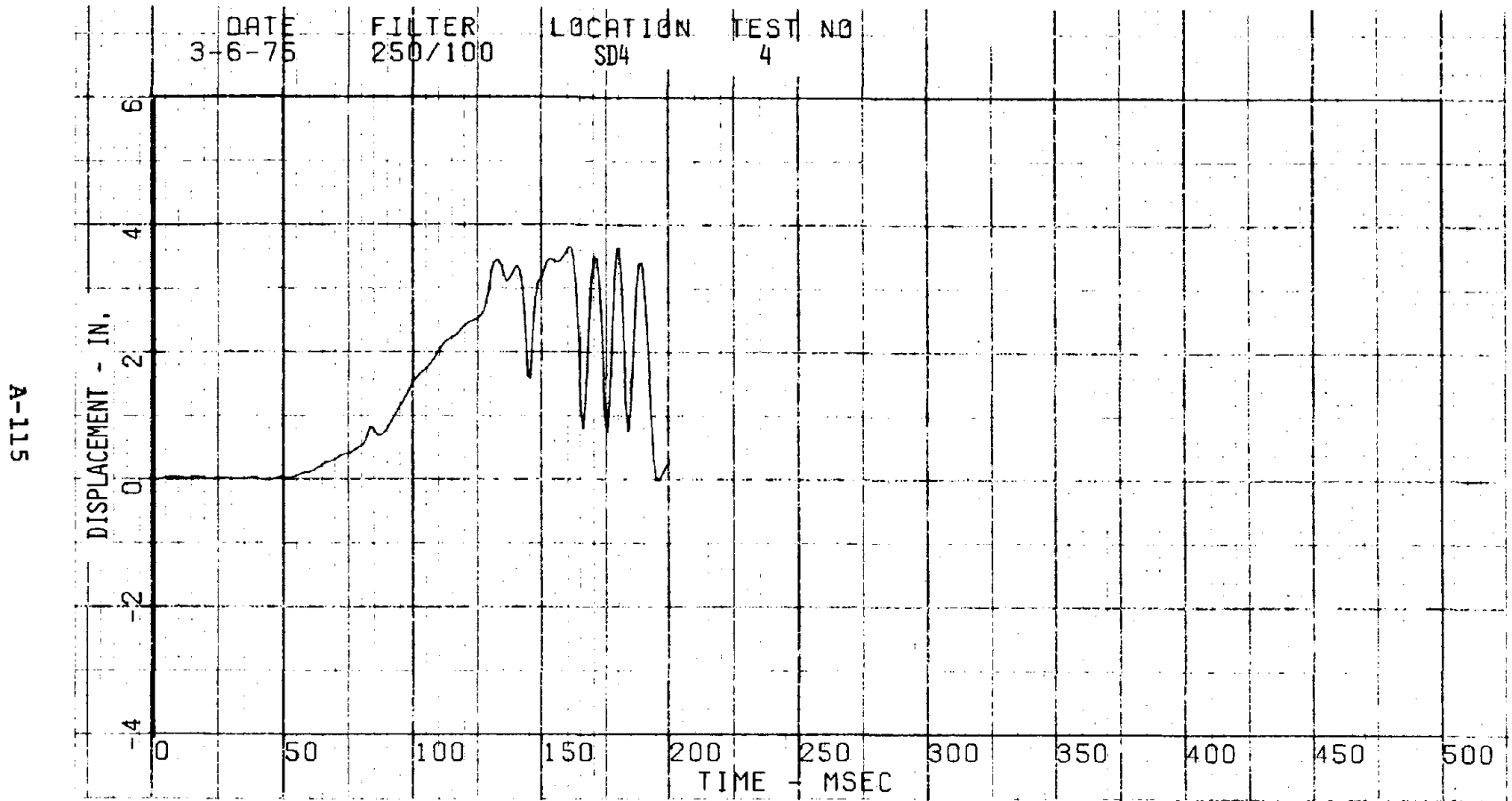


Figure A-117. Caboose Right Front Displacement Transducer - Test 4.

A-116

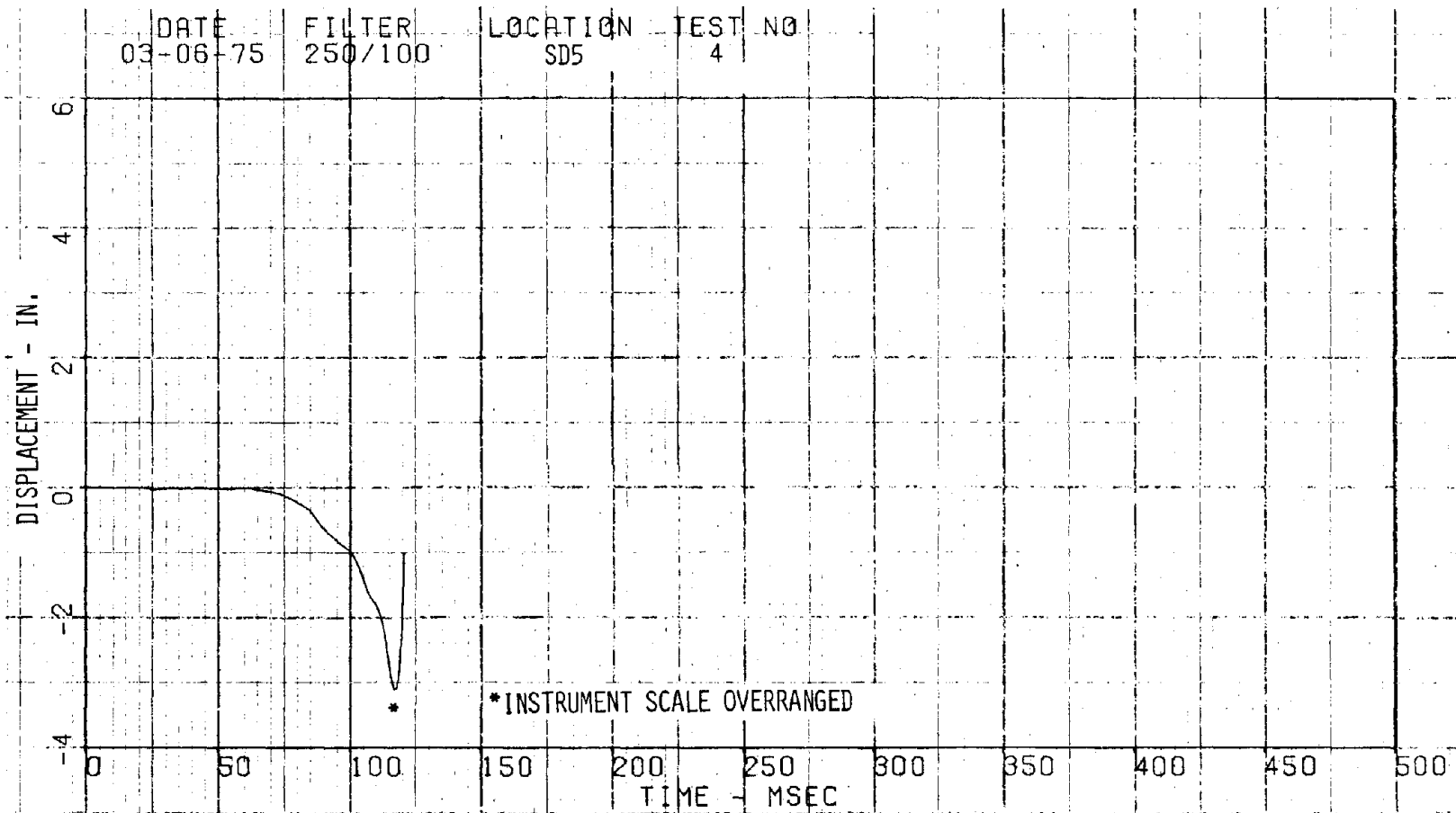


Figure A-118. Caboose to Hopper Displacement Transducer - Test 4.

A-117

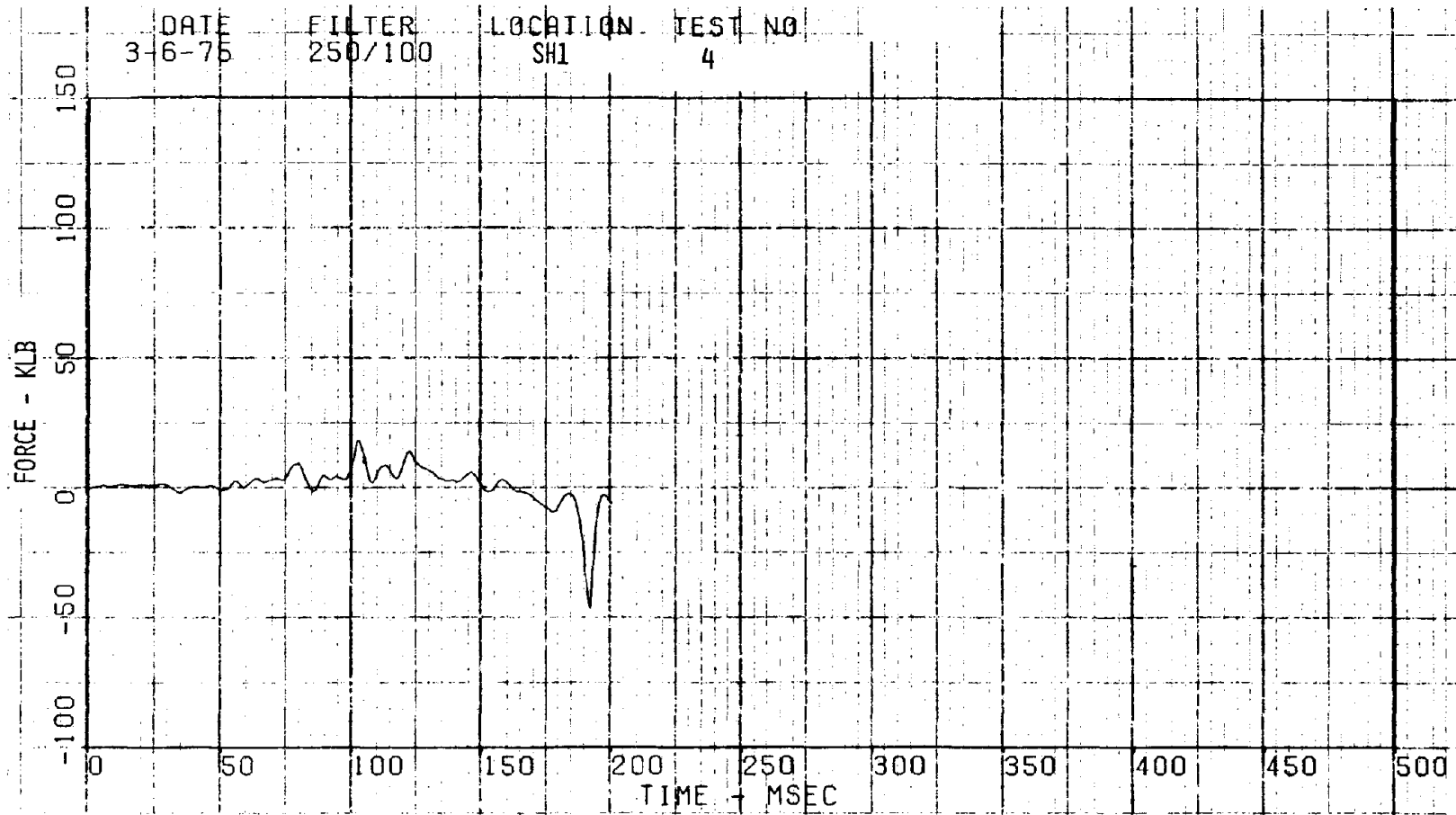


Figure A-119. Caboose Rear Swinghanger Strain Gauge - Test 4.

A-118

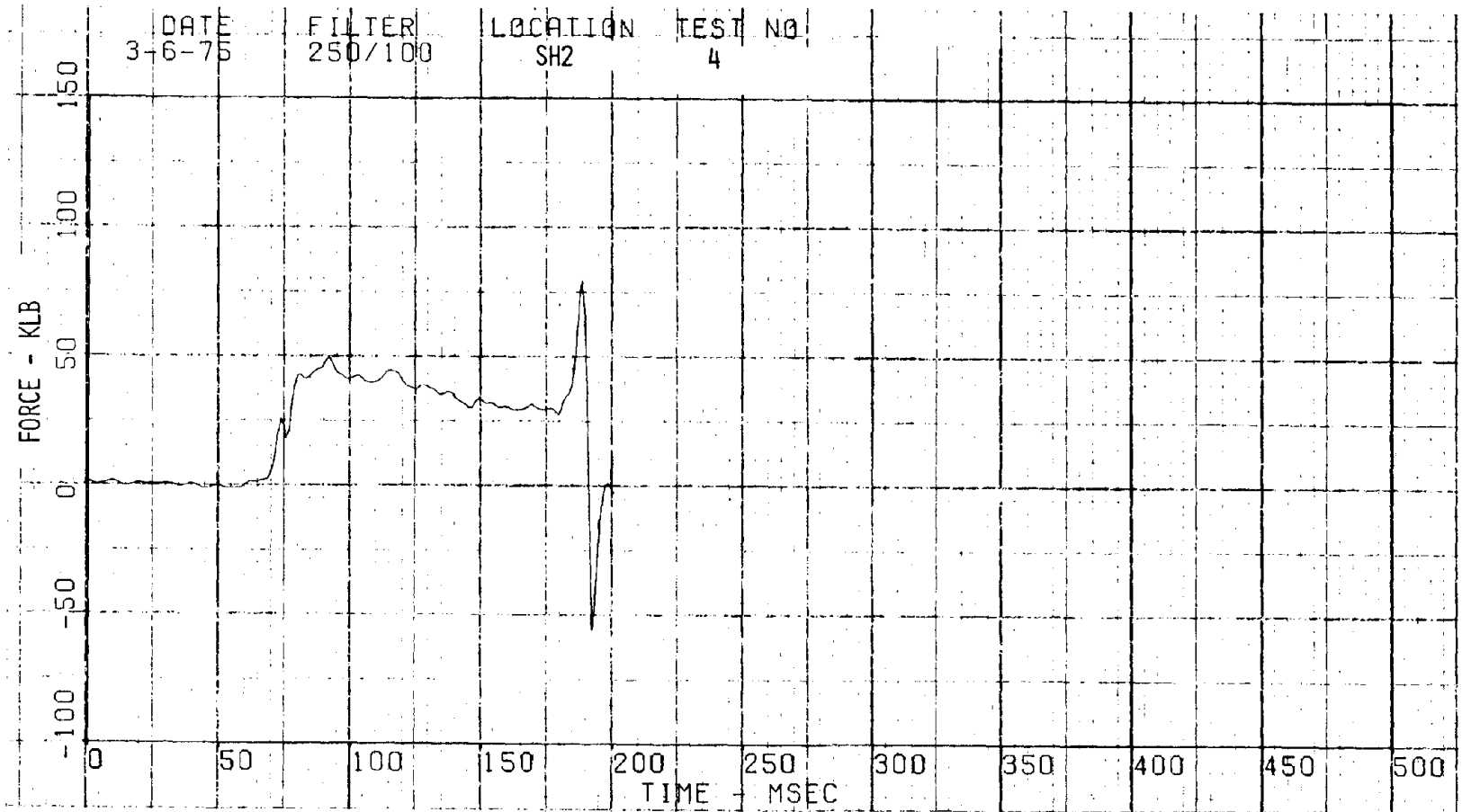


Figure A-120. Caboose Front Swinghanger Strain Gauge - Test 4.

A-119

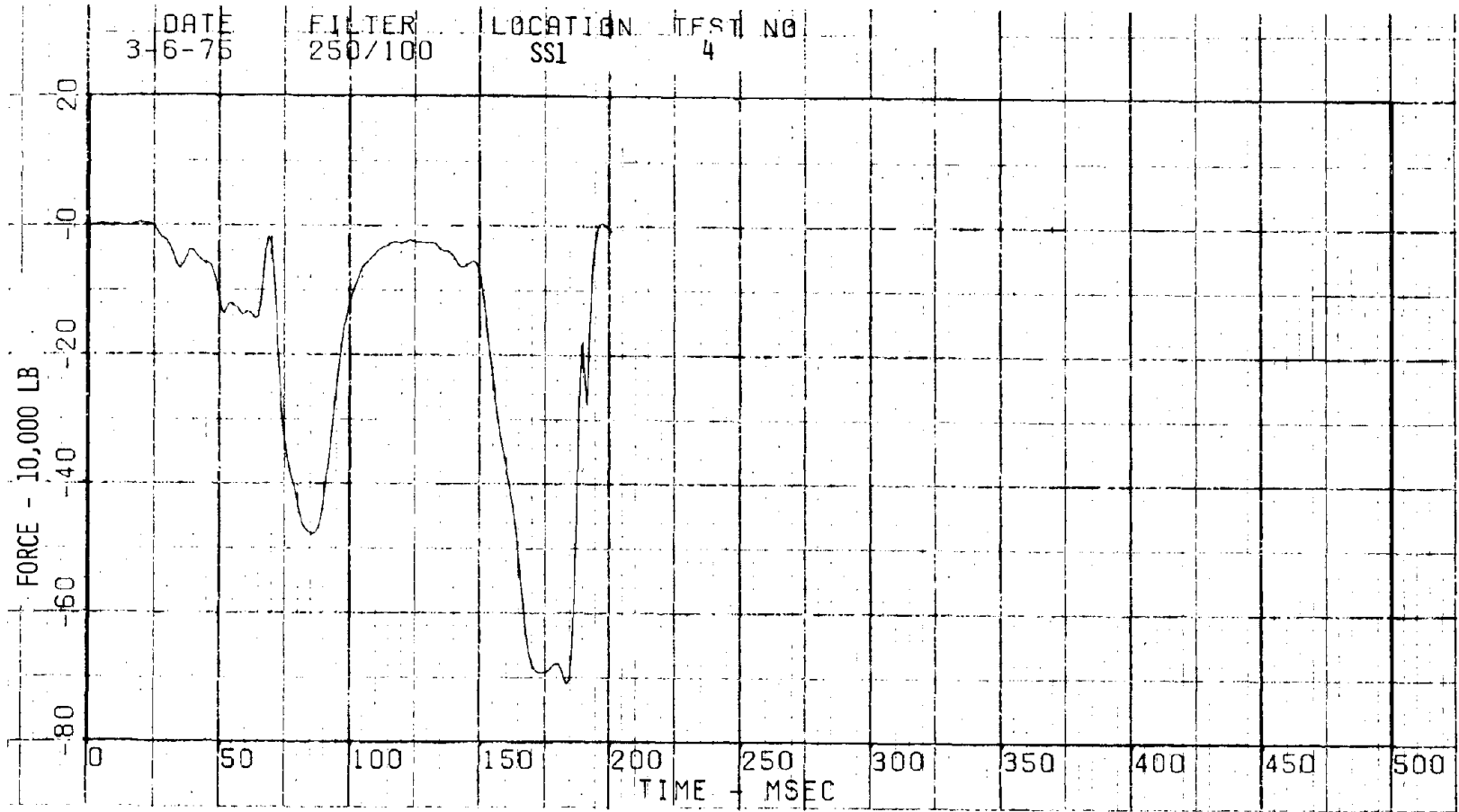


Figure A-121. Caboose Rear Coupler Strain Gauge - Test 4.

A-120

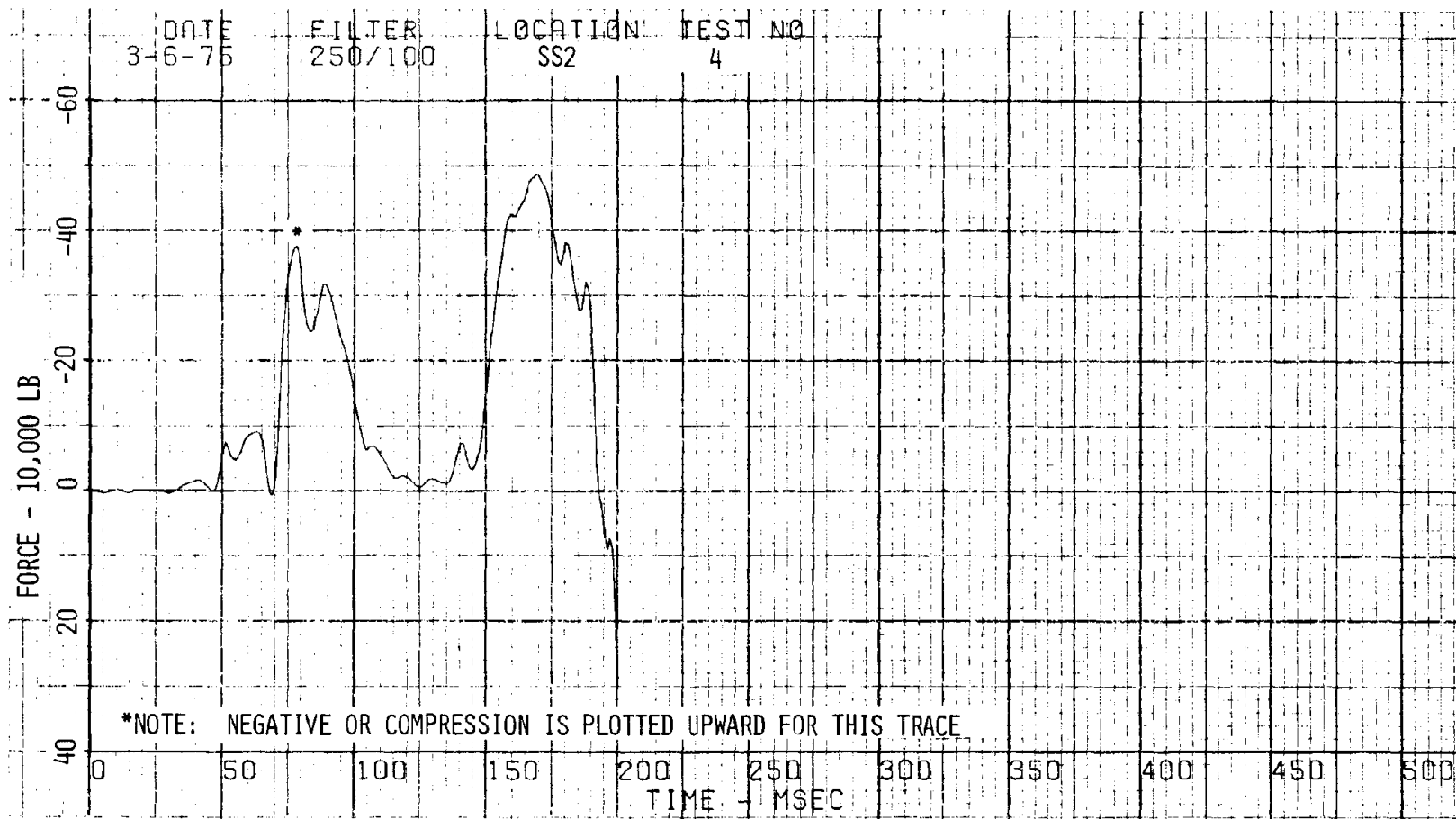


Figure A-122. Caboose Center Sill Strain Gauge - Test 4.

A-121

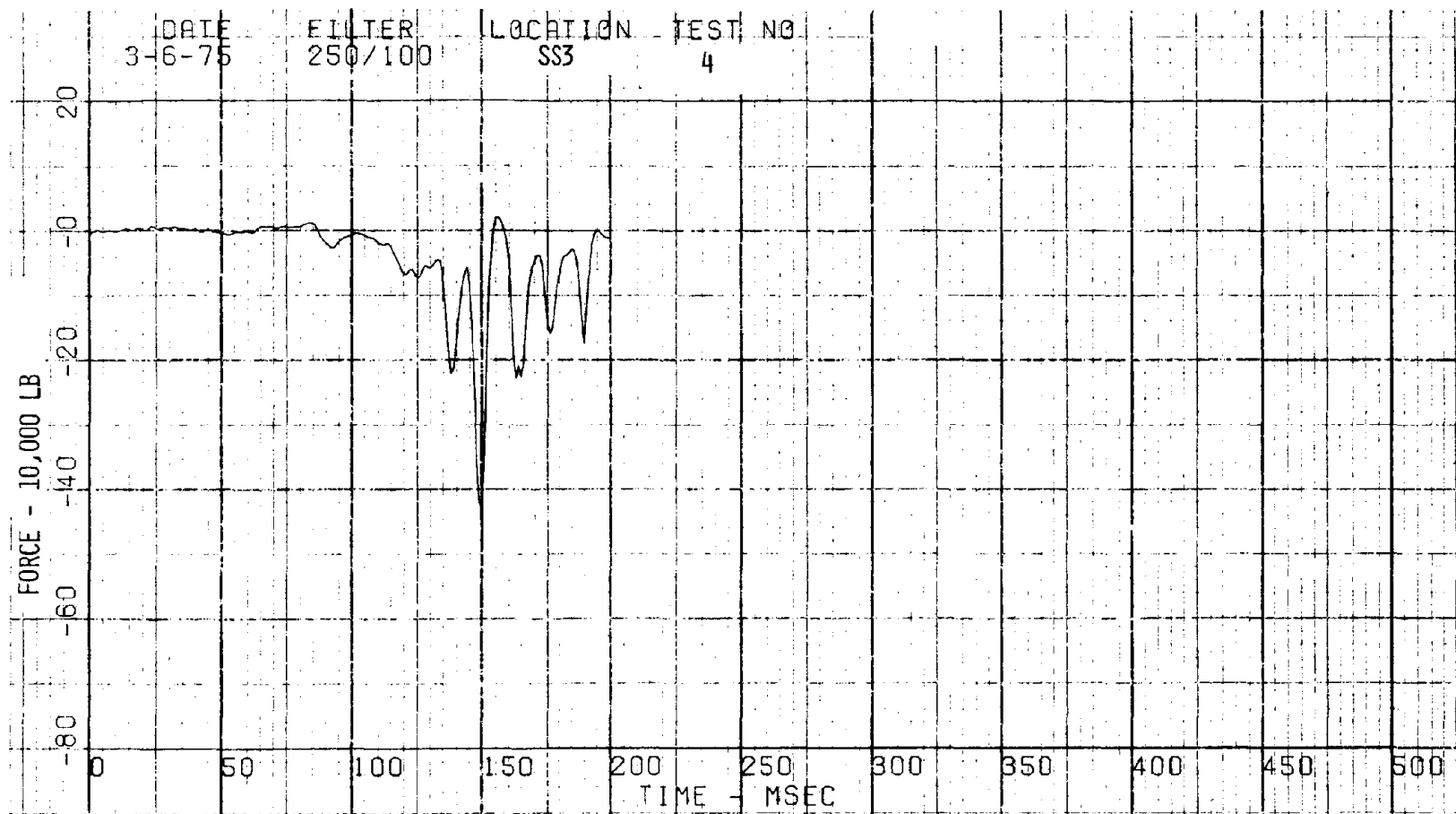


Figure A-123. Caboose Front Coupler Strain Gauge - Test 4.

A-122

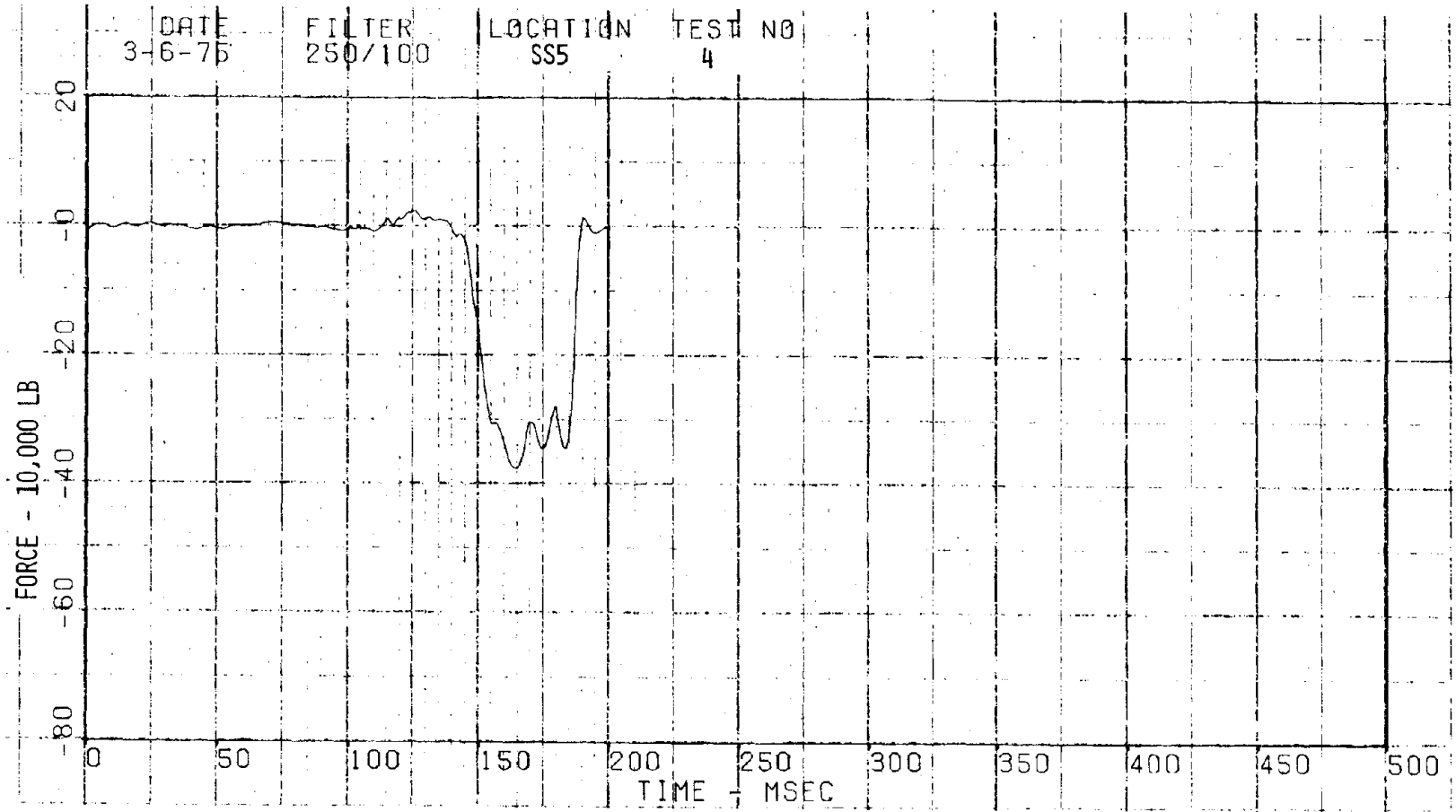
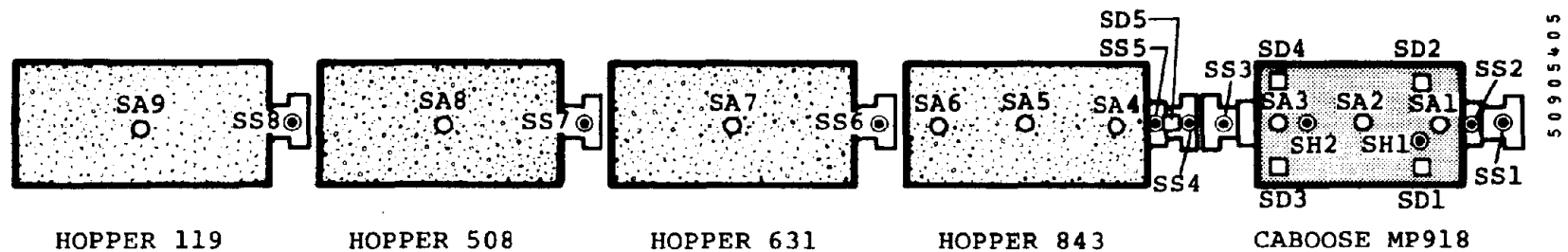
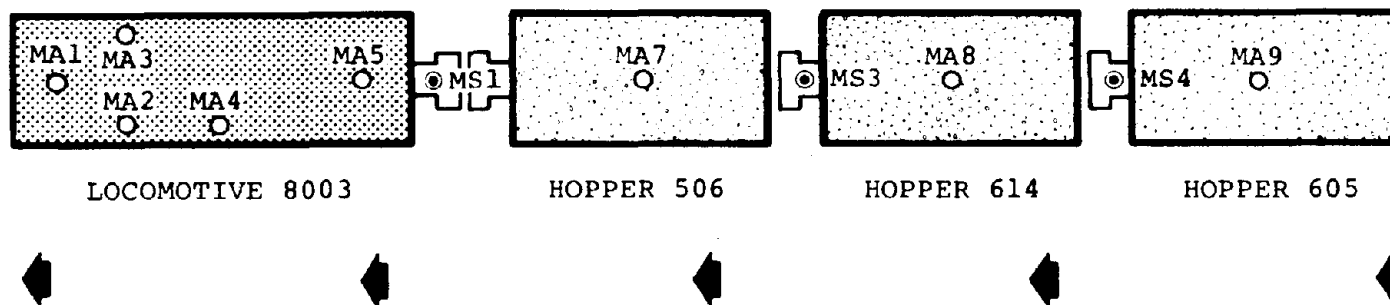


Figure A-124. Hopper 843 Center Sill Strain Gauge - Test 4.



- HOPPER LOADED
 - TRAIN IN DRAFT
- STANDING TRAIN

A-123



- MOTION
- IMPACT VELOCITY = 4.7 MPH
- MOVING TRAIN

Figure A-125. Instrument Locations - Test 5.

A-124

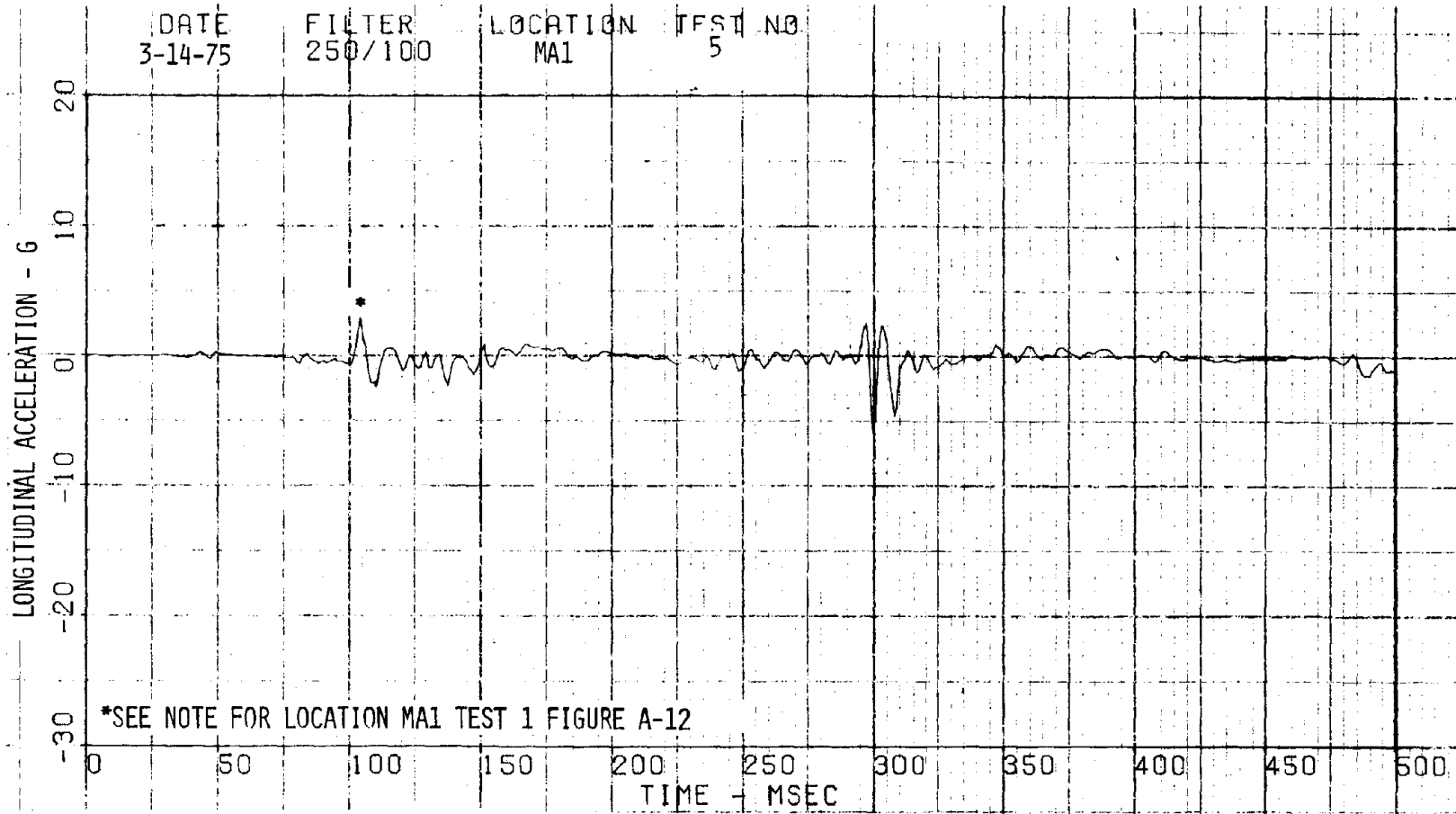


Figure A-126. Locomotive Rear Triaxial Accelerometer (X) - Test 5.

A-125

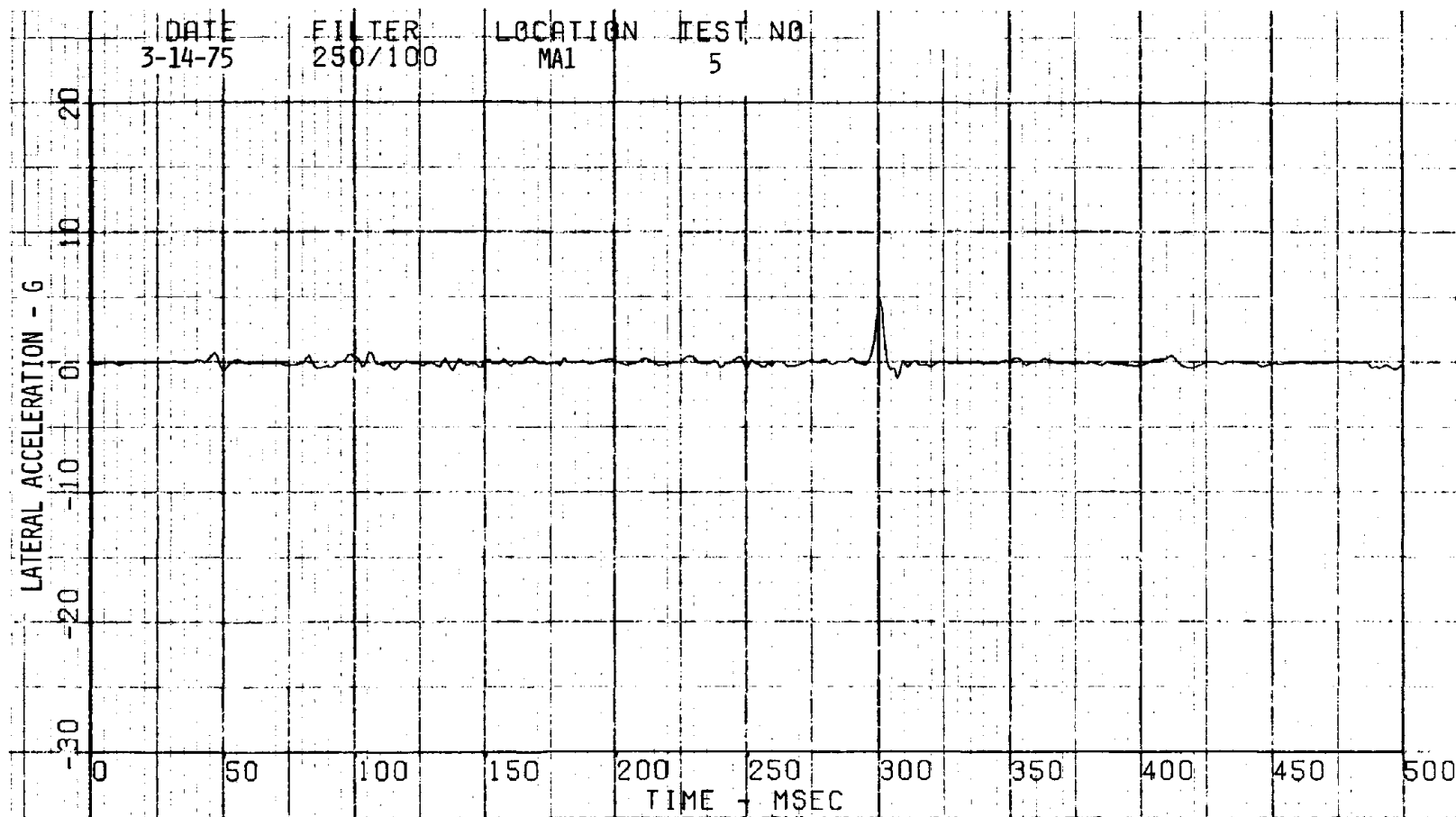


Figure A-127. Locomotive Rear Triaxial Accelerometer (Y) - Test 5.

A-126

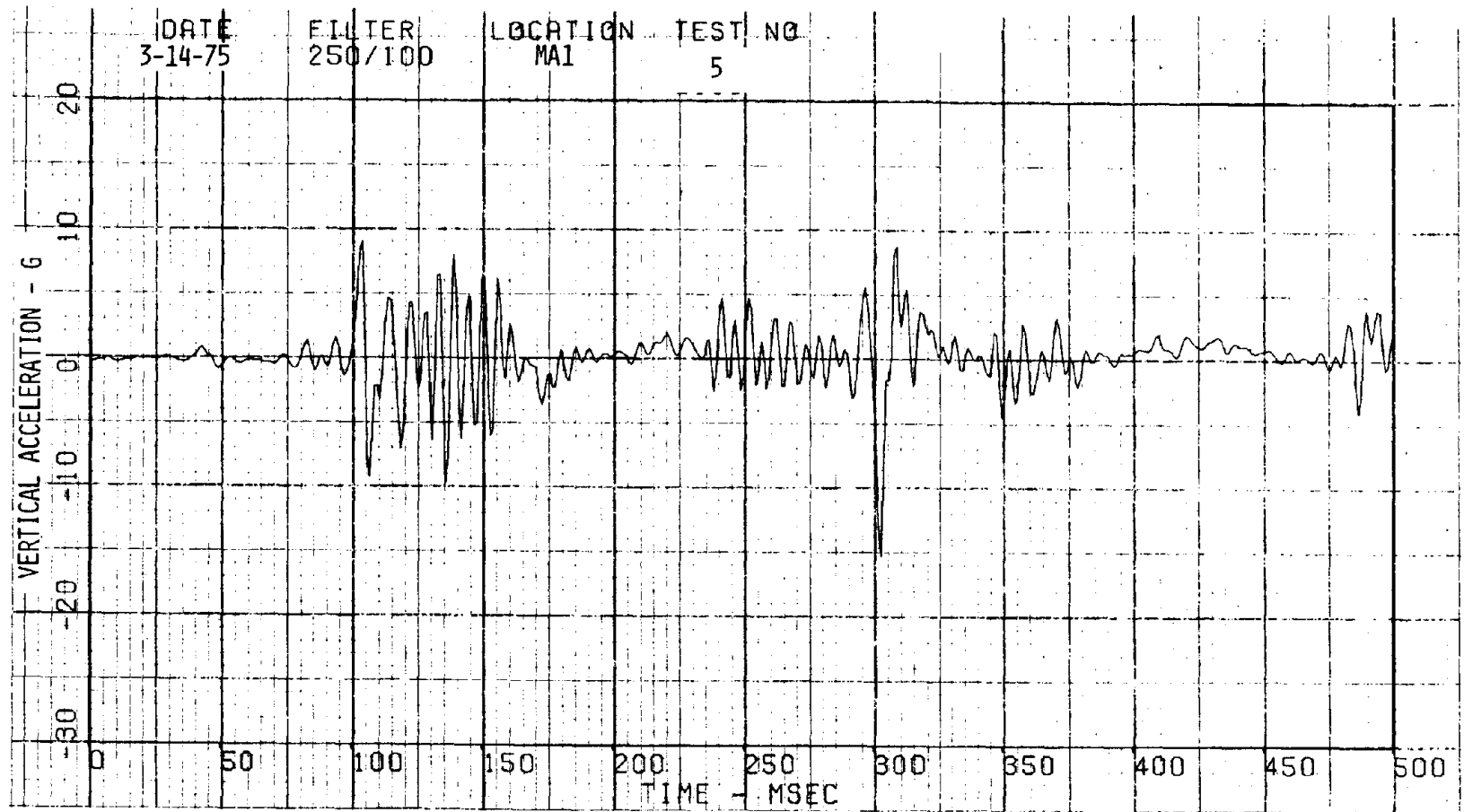


Figure A-128. Locomotive Rear Triaxial Accelerometer (Z) - Test 5.

A-127

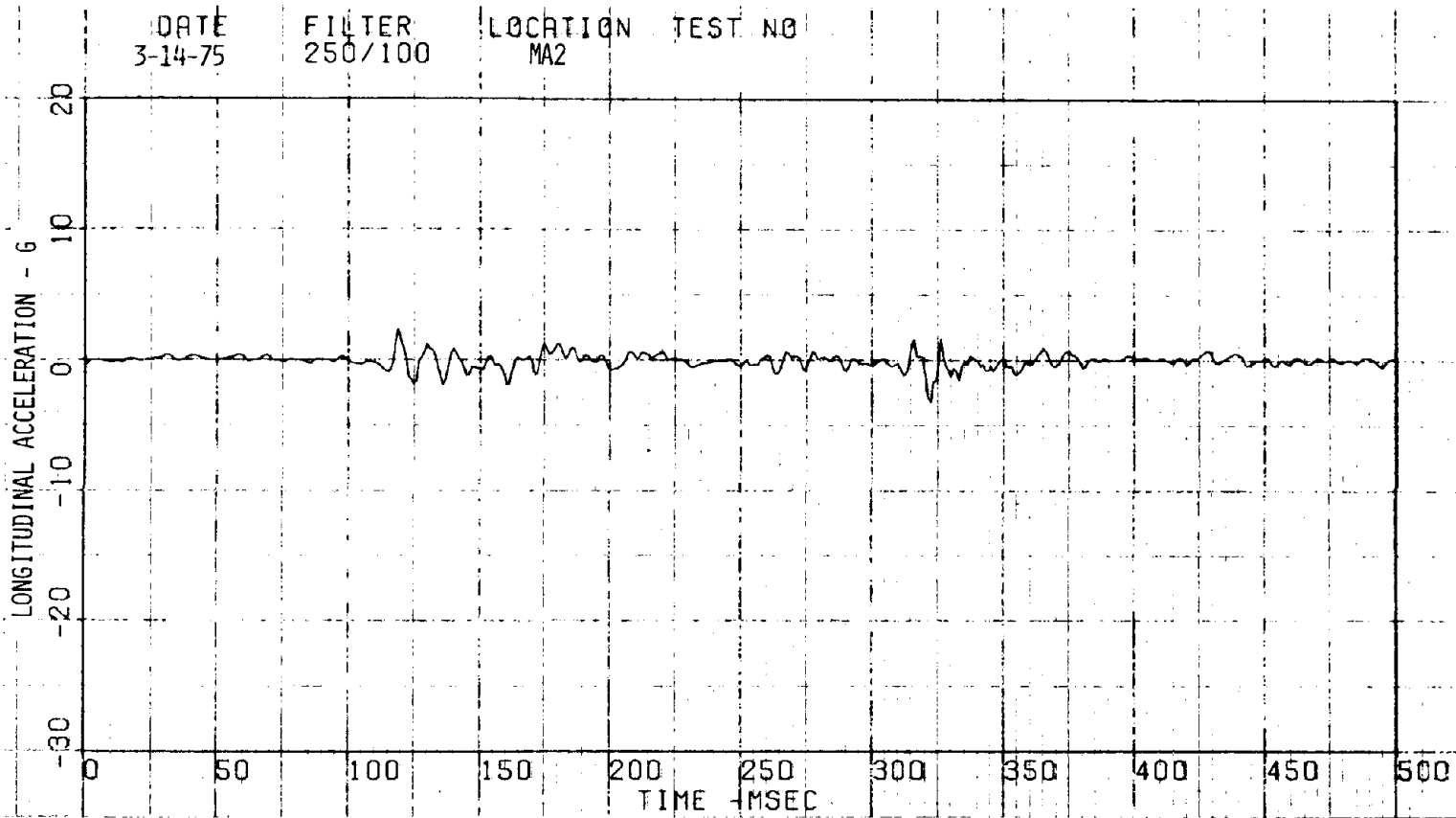


Figure A-129. Locomotive Left Cab Accelerometer - Test 5.

A-128

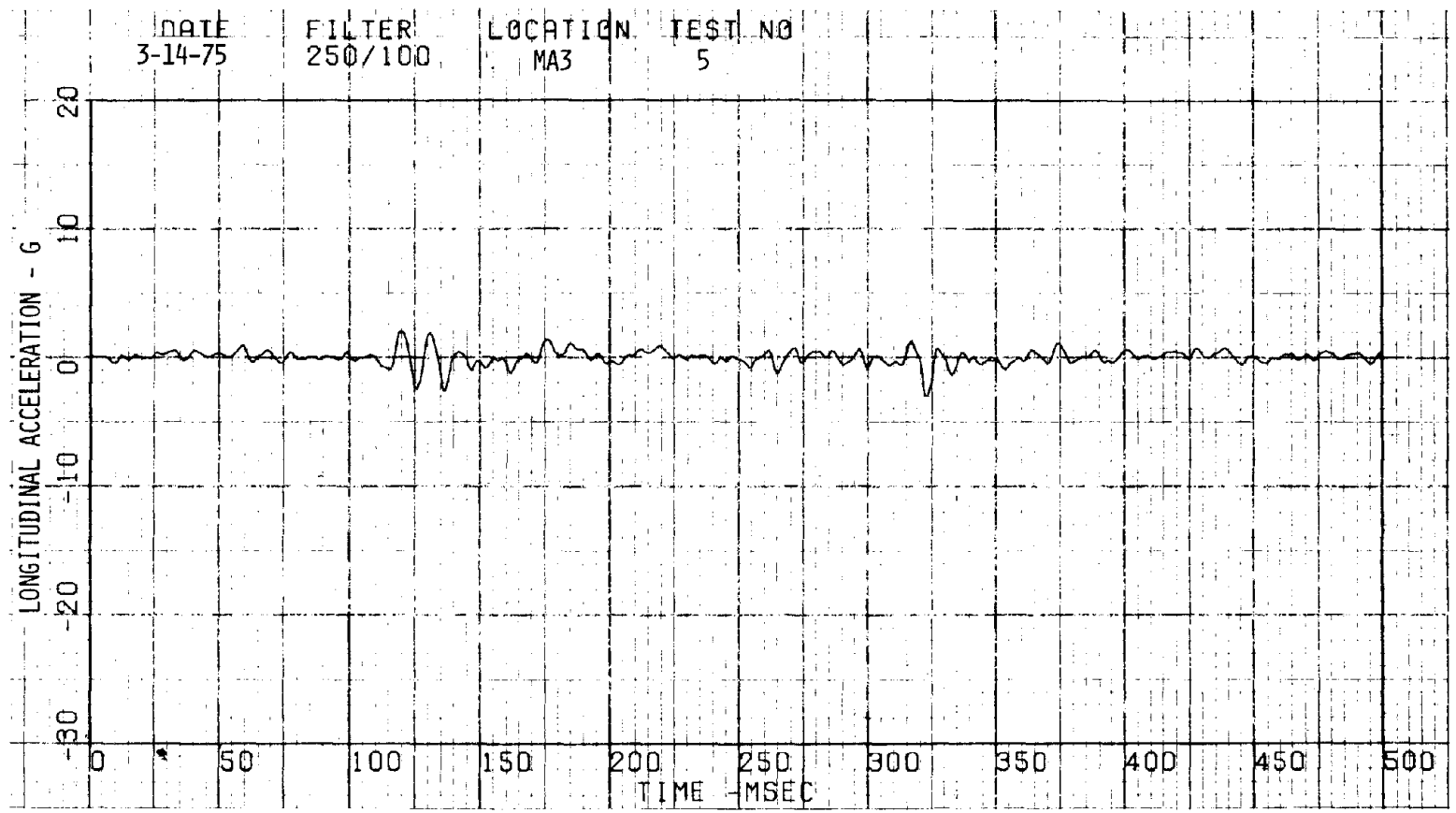


Figure A-130. Locomotive Right Cab Accelerometer - Test 5.

A-129

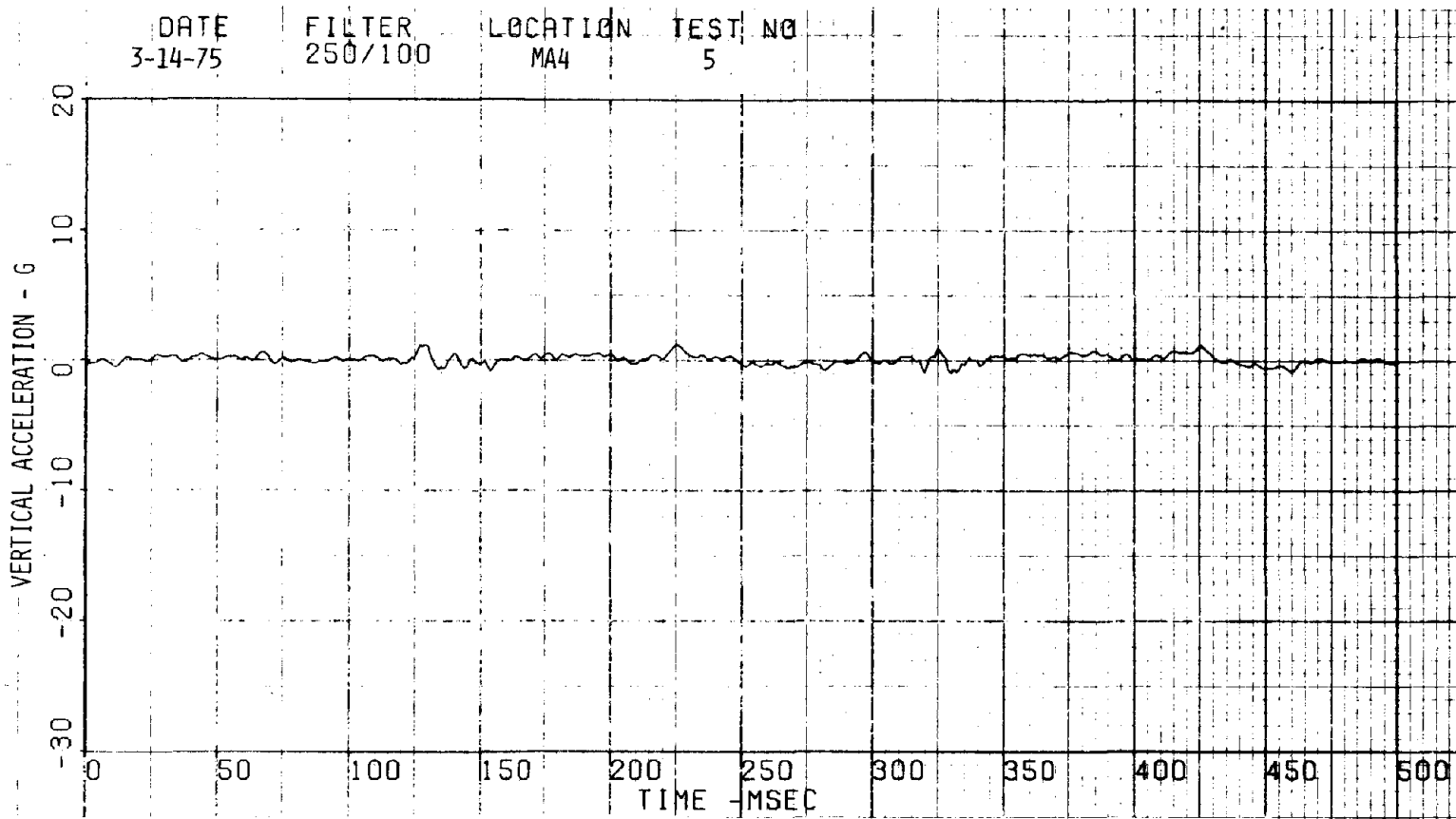


Figure A-131. Locomotive Center Vertical Accelerometer - Test 5.

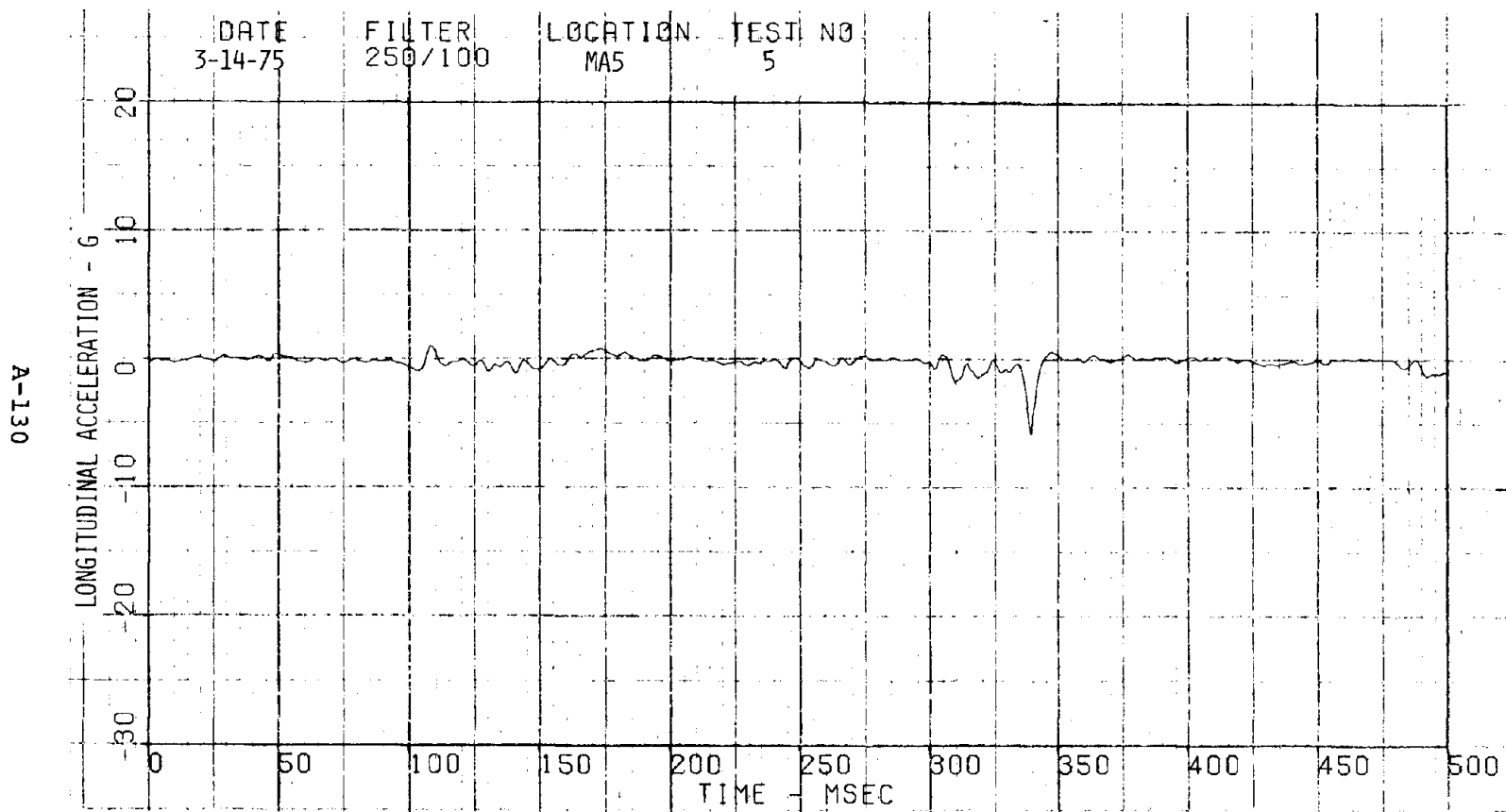


Figure A-132. Locomotive Front Triaxial Accelerometer (X) - Test 5.

A-131

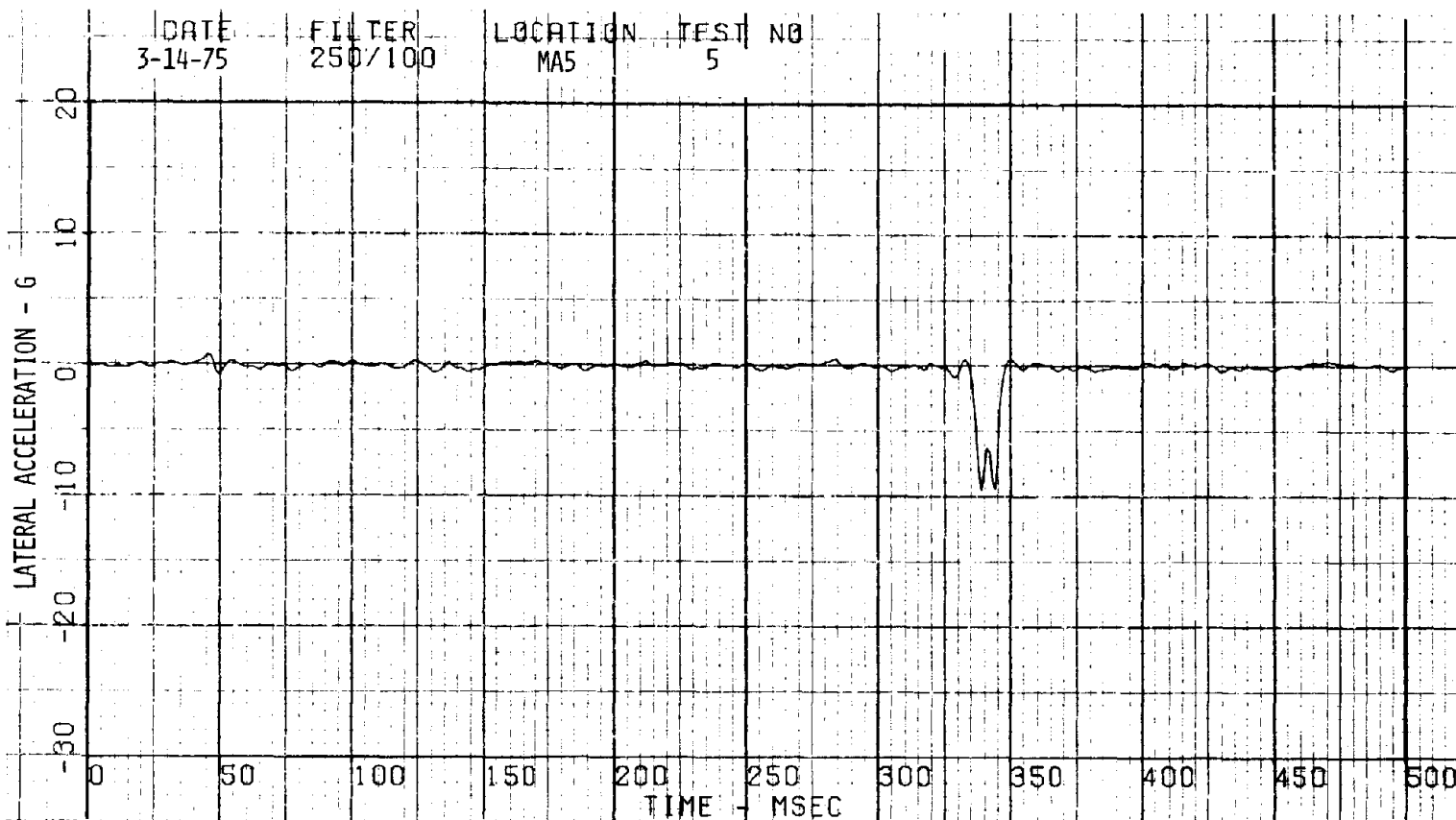


Figure A-133. Locomotive Front Triaxial Accelerometer (Y) - Test 5.

A-132

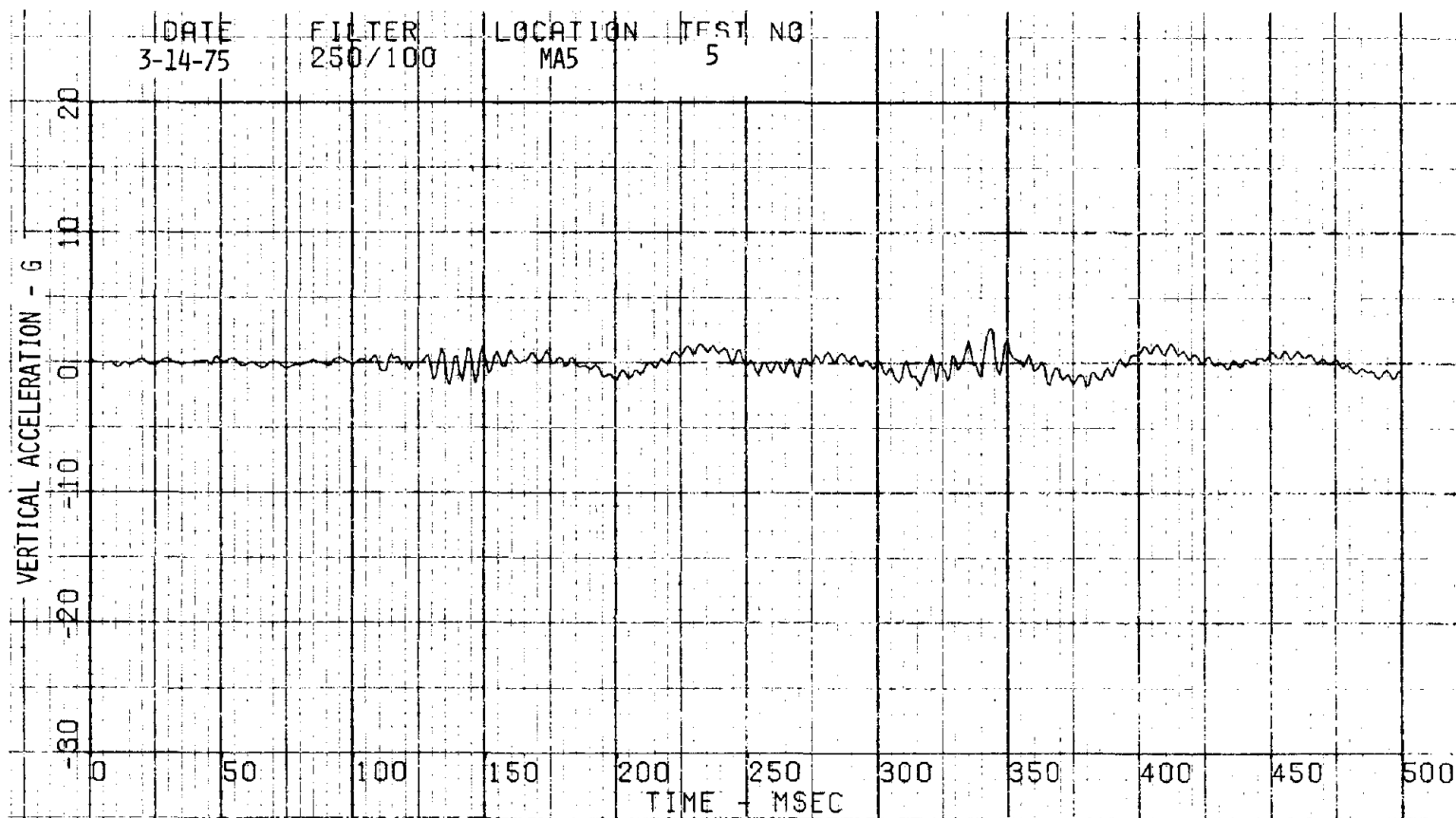


Figure A-134. Locomotive Front Triaxial Accelerometer (Z) - Test 5.

A-133

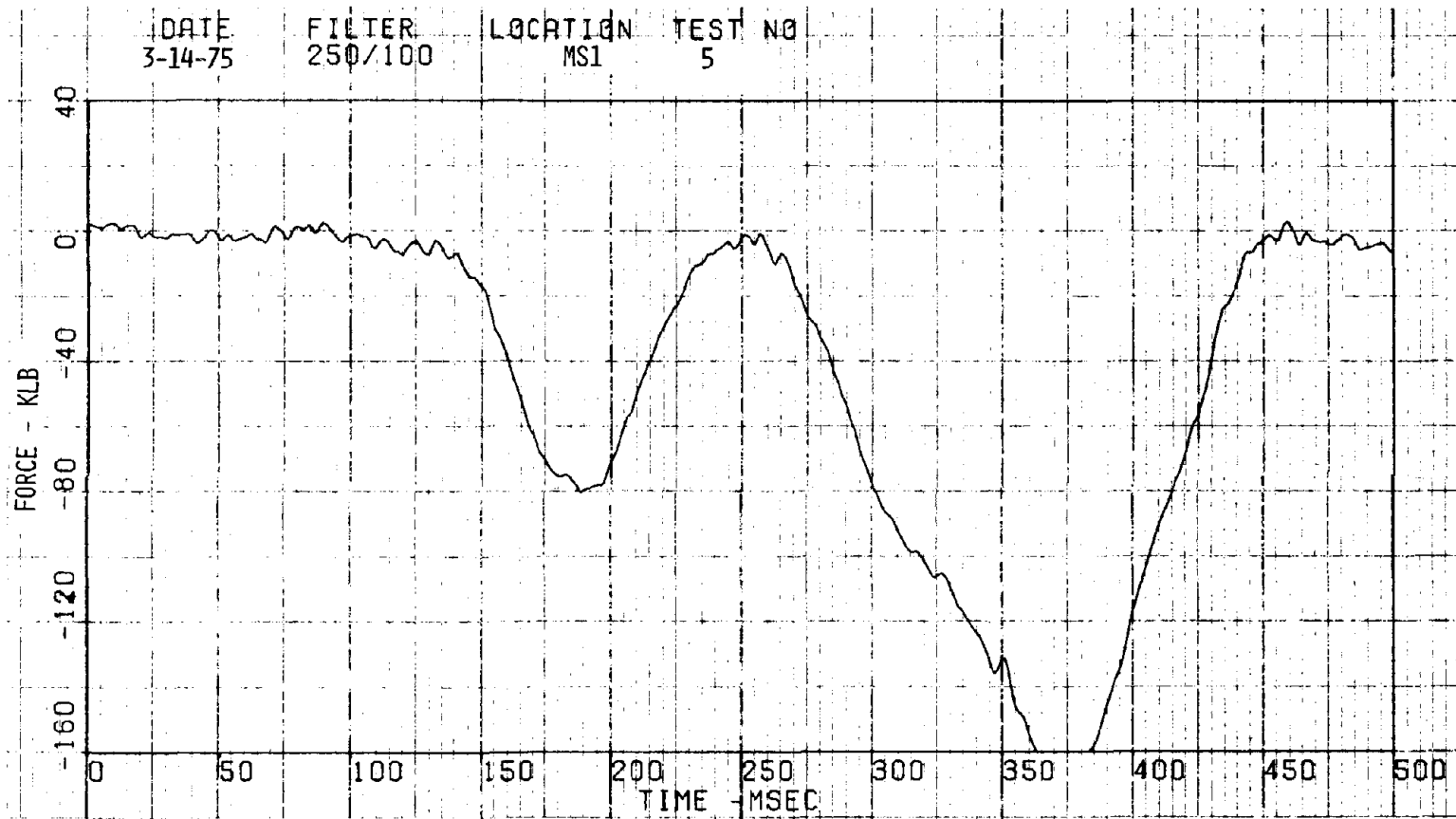


Figure A-135. Locomotive Front Coupler Strain Gauge - Test 5.

A-134

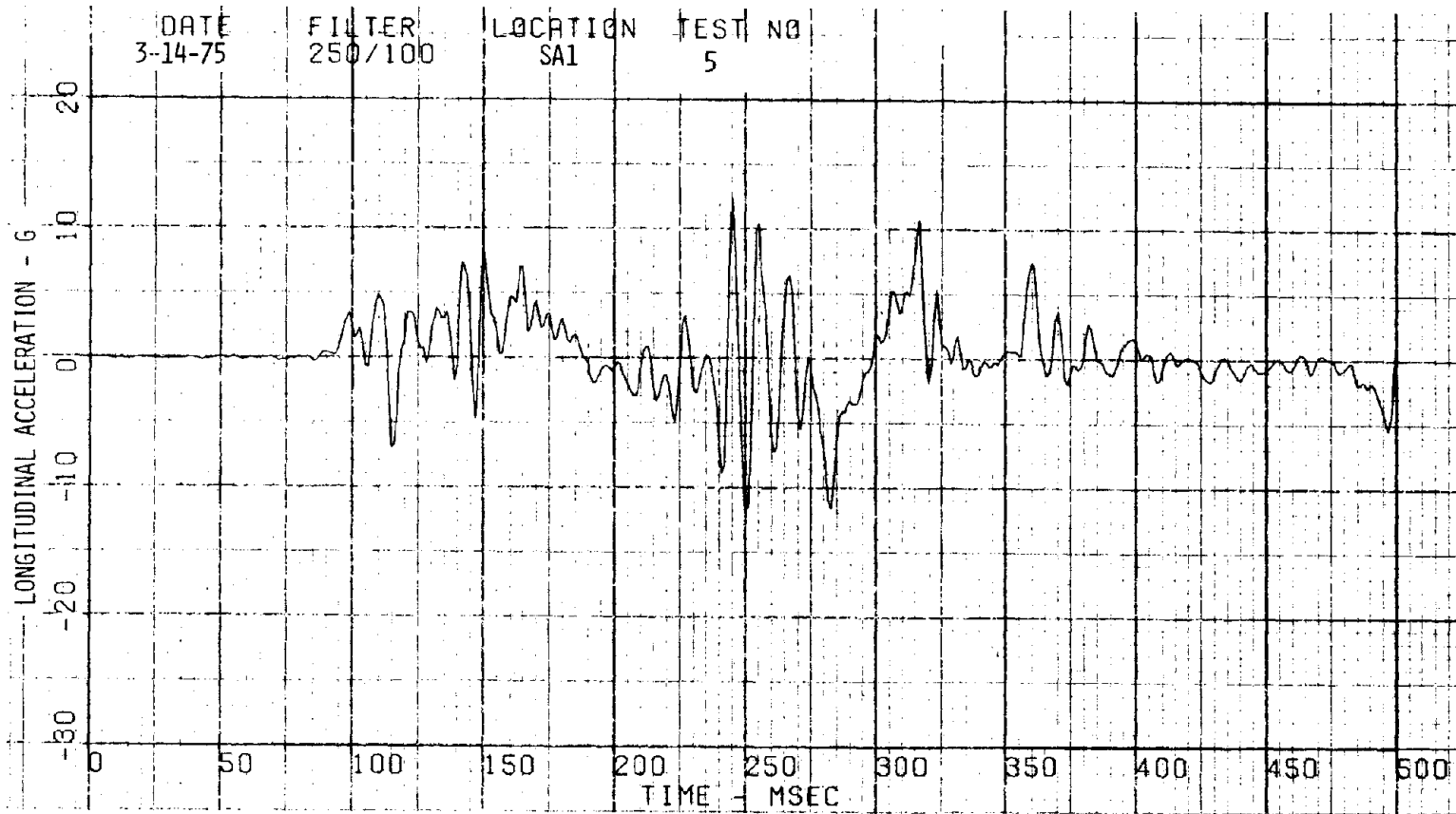


Figure A-136. Caboose Rear Triaxial Accelerometer (X) - Test 5.

A-135

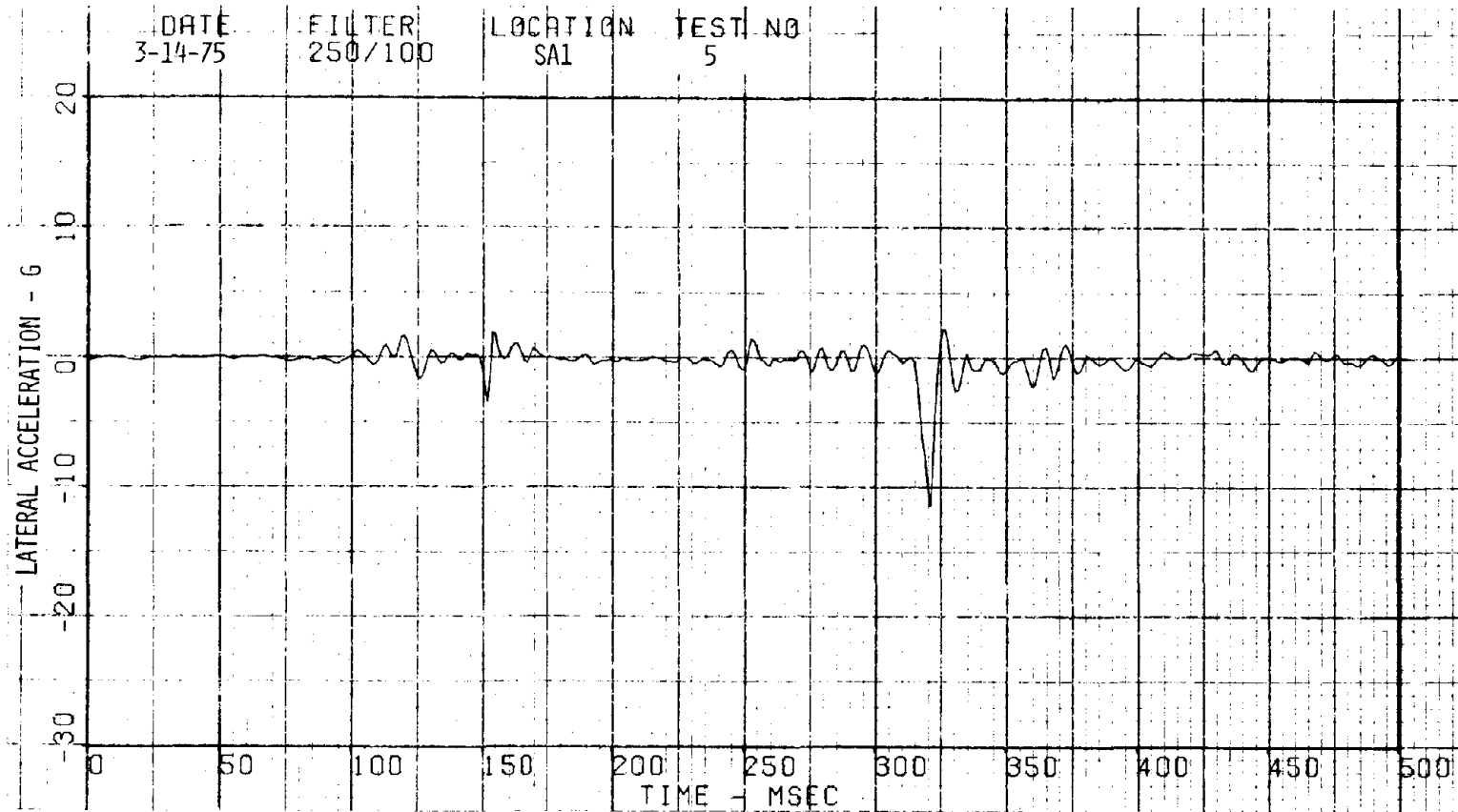


Figure A-137. Caboose Rear Triaxial Accelerometer (Y) - Test 5.

A-136

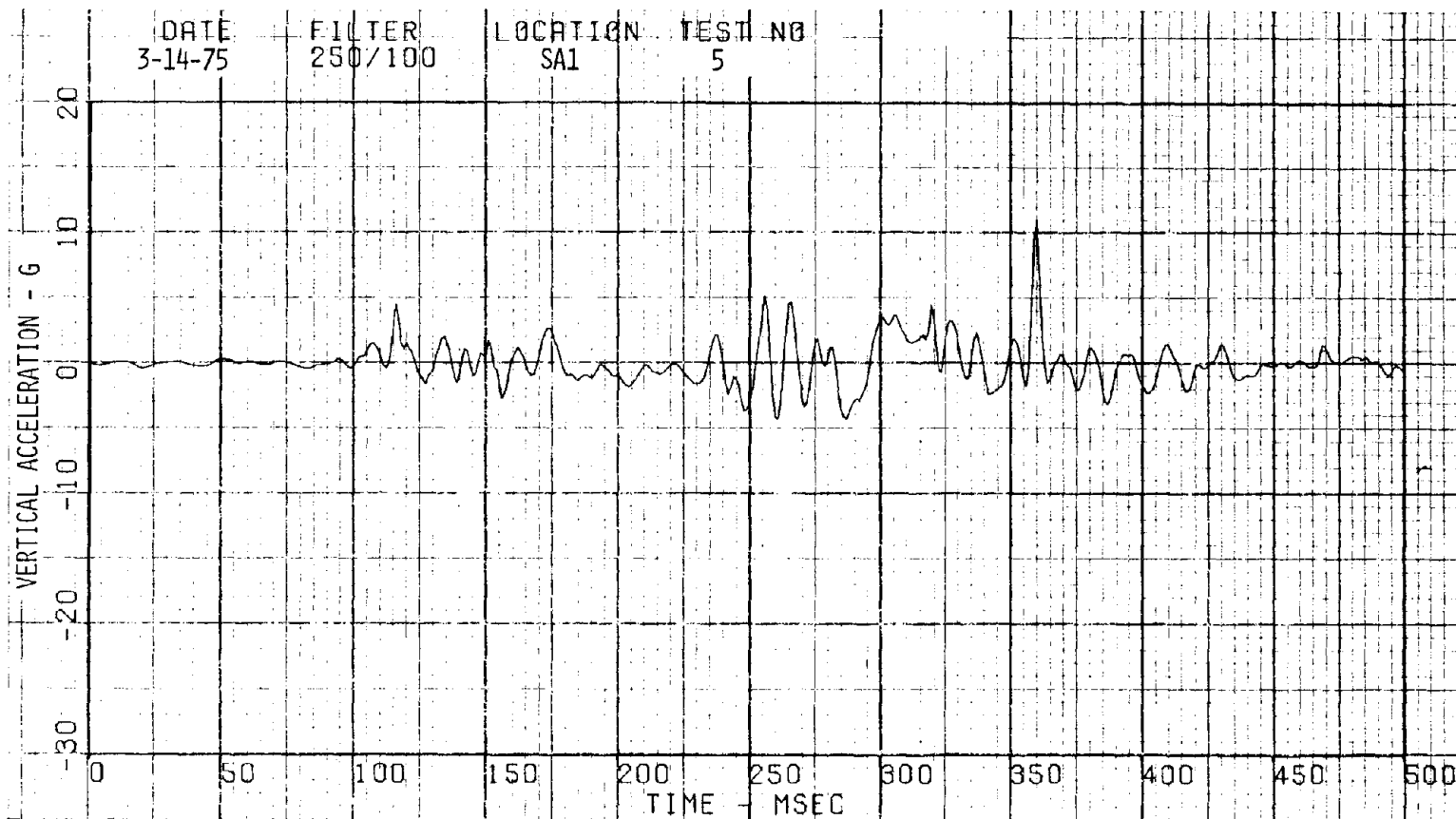


Figure A-138. Caboose Rear Triaxial Accelerometer (Z) - Test 5.

A-137

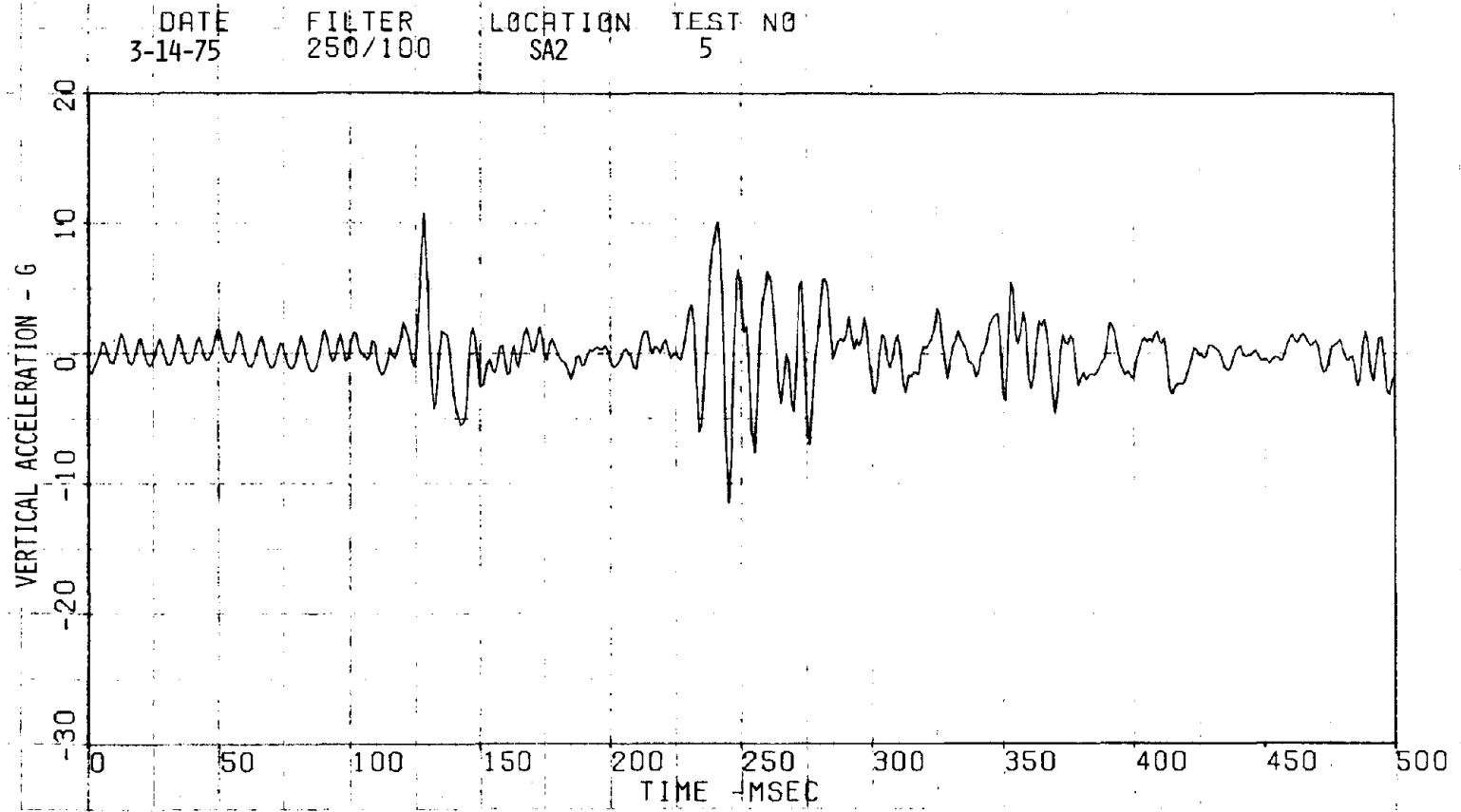


Figure A-139. Caboose Center Vertical Accelerometer - Test 5.

A-138

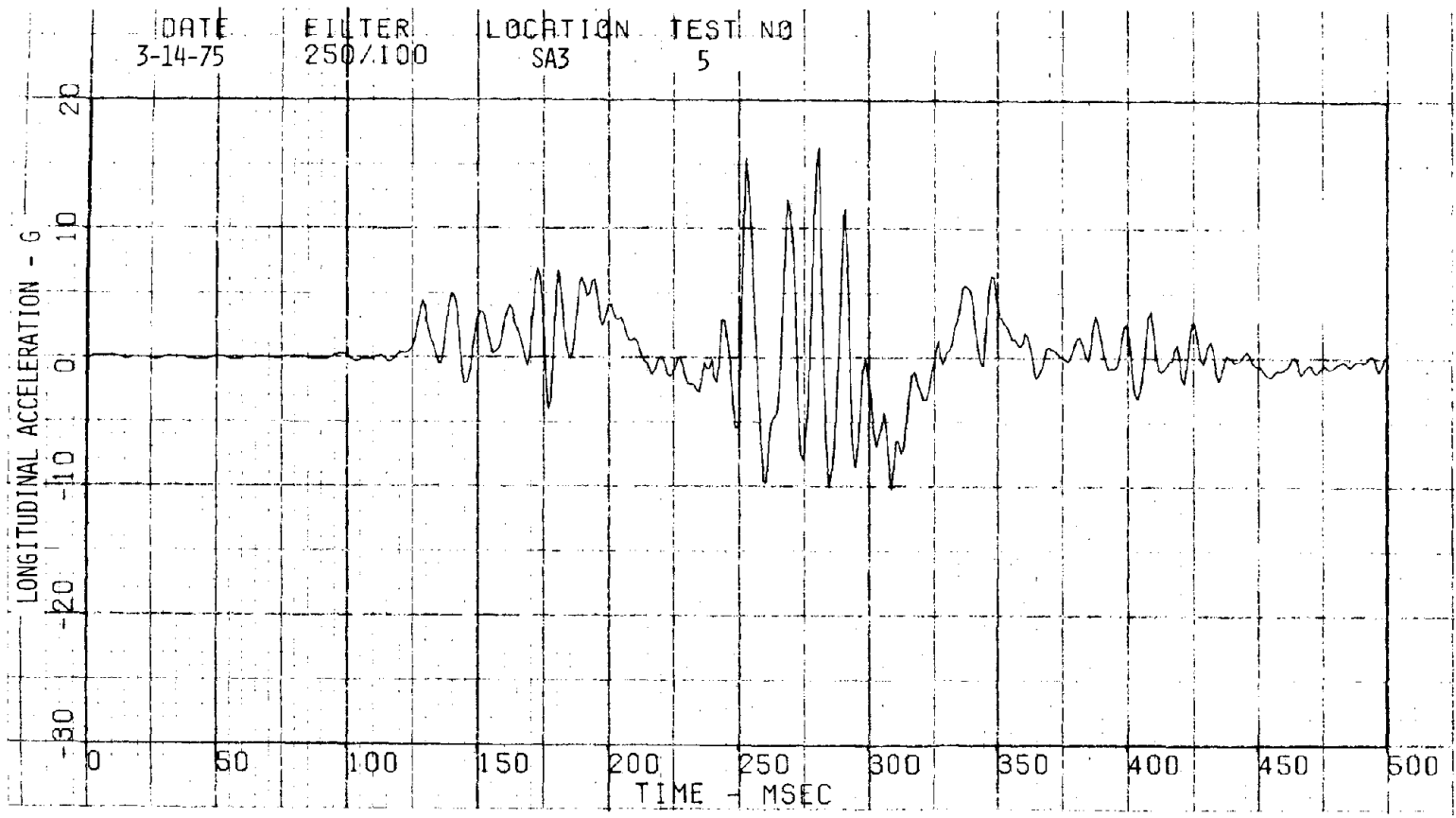


Figure A-140. Caboose Front Triaxial Accelerometer (X) - Test 5.

A-139

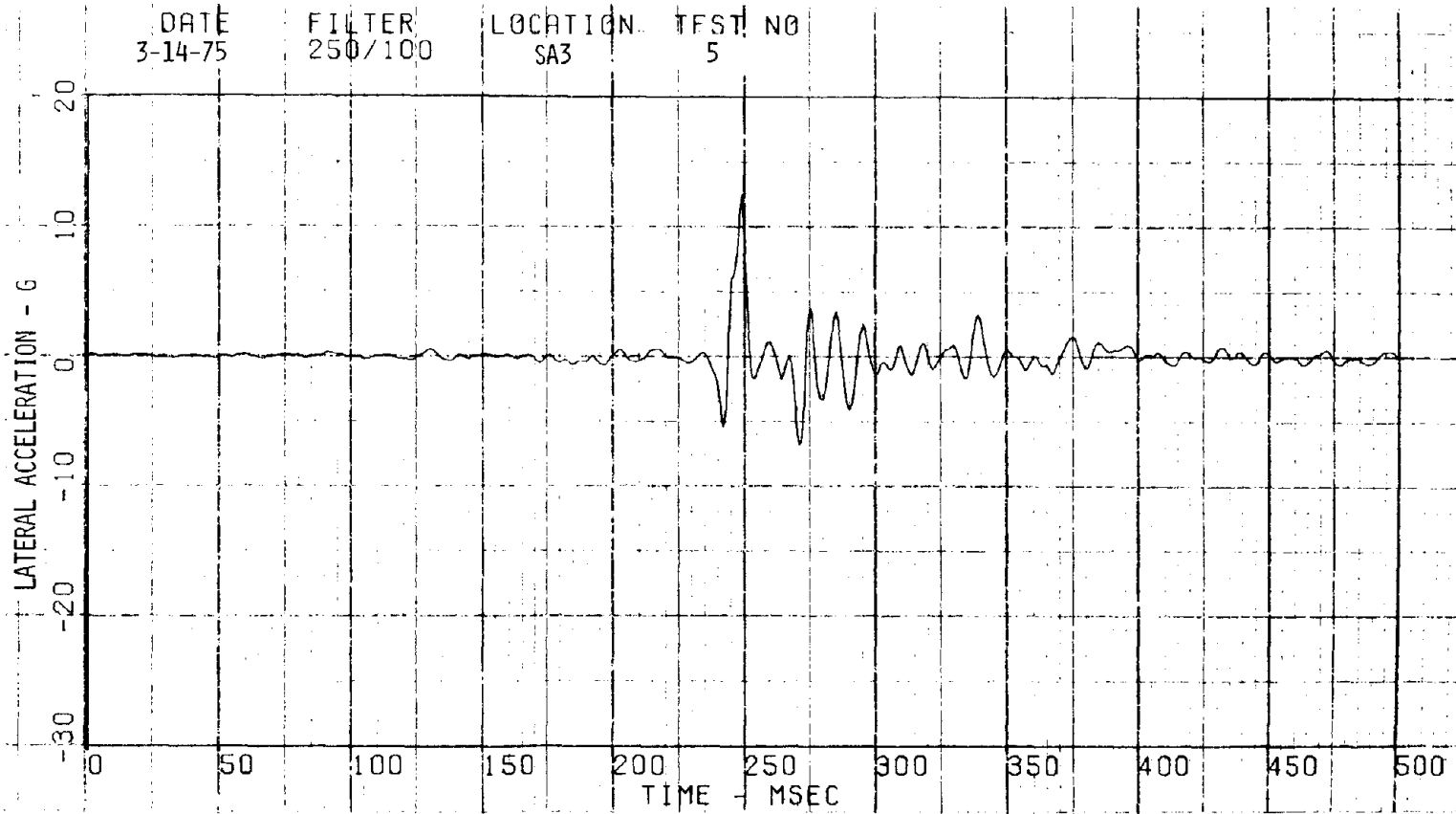


Figure A-141. Caboose Front Triaxial Accelerometer (Y) - Test 5.

A-140

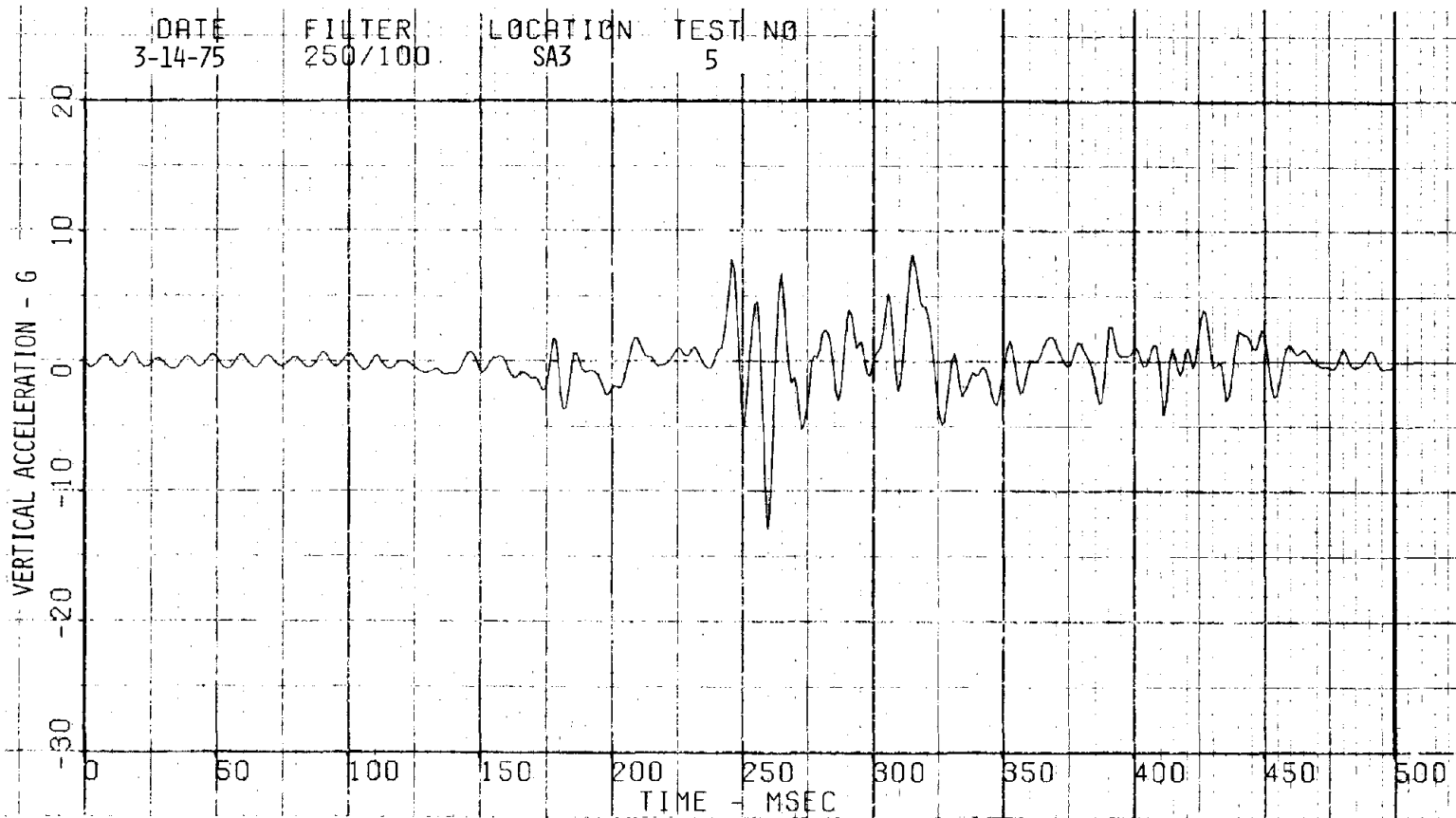


Figure A-142. Caboose Front Triaxial Accelerometer (Z) - Test 5.

A-141

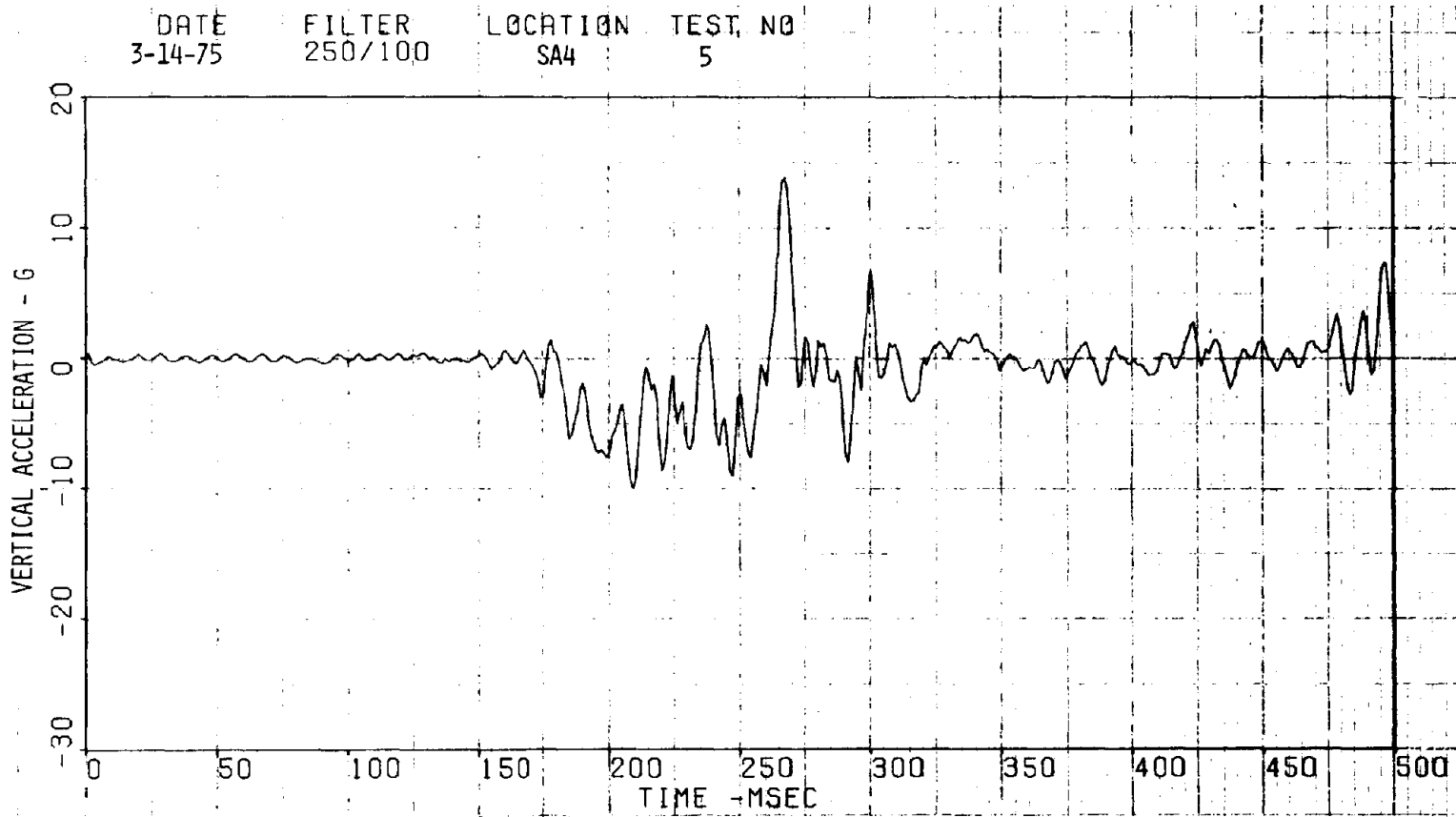


Figure A-143. Hopper 843 Rear Vertical Accelerometer - Test 5.

A-142

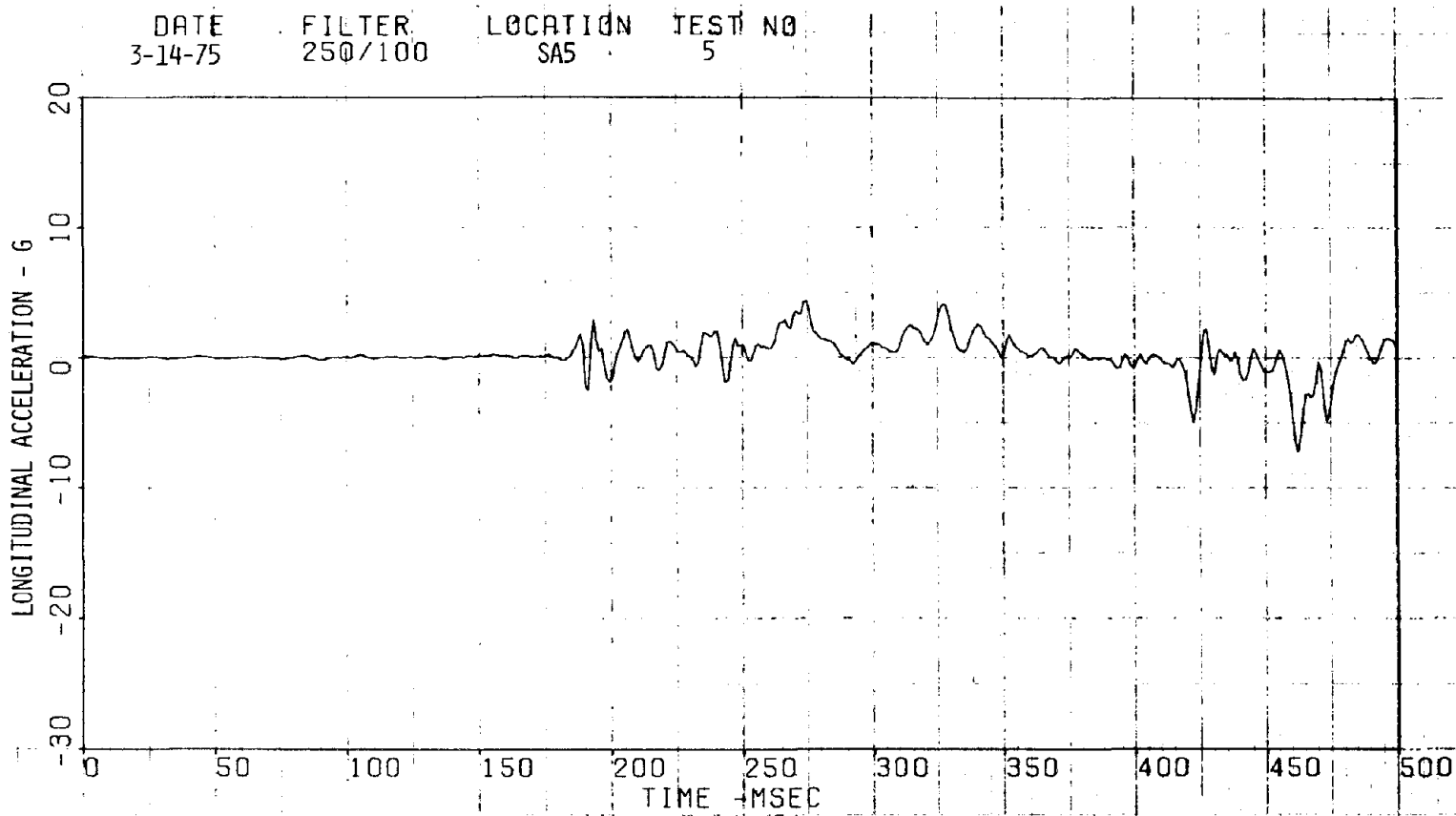


Figure A-144. Hopper 843 Center Longitudinal Accelerometer - Test 5.

A-143

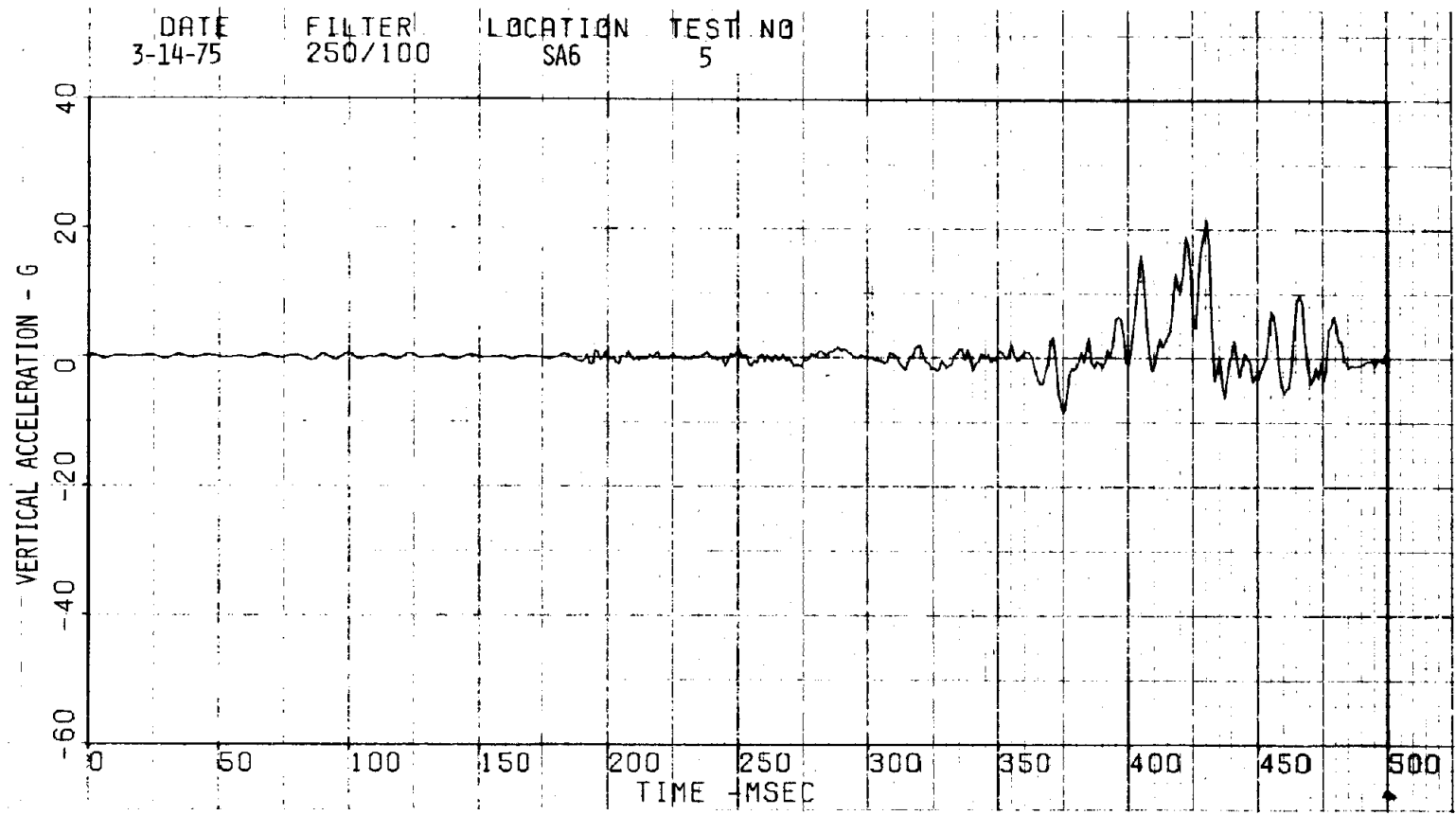


Figure A-145. Hopper 843 Front Vertical Accelerometer - Test 5.

A-144

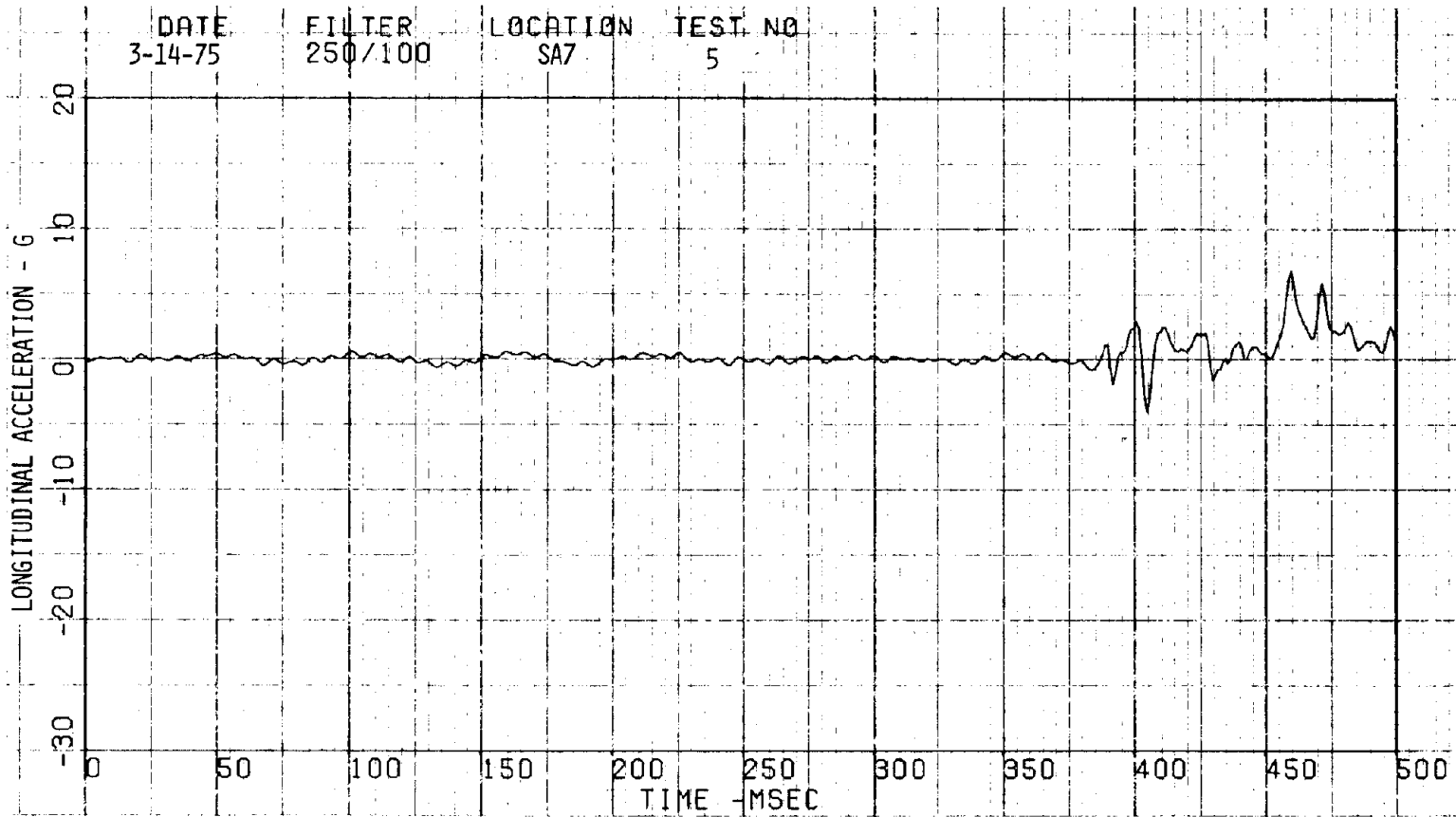


Figure A-146. Hopper 631 Center Longitudinal Accelerometer - Test 5.

A-145

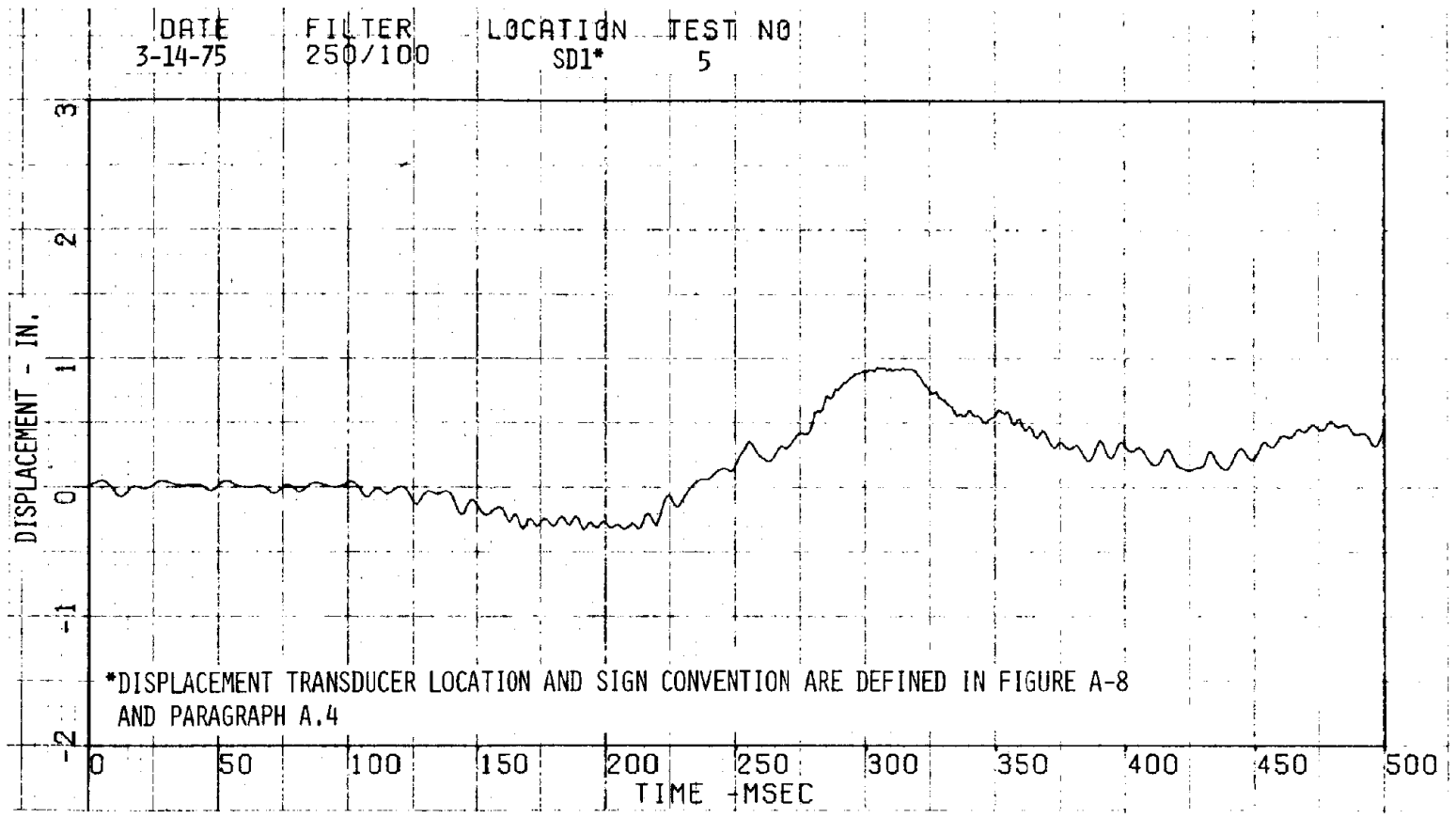


Figure A-147. Caboose Left Rear Displacement Transducer - Test 5.

A-146

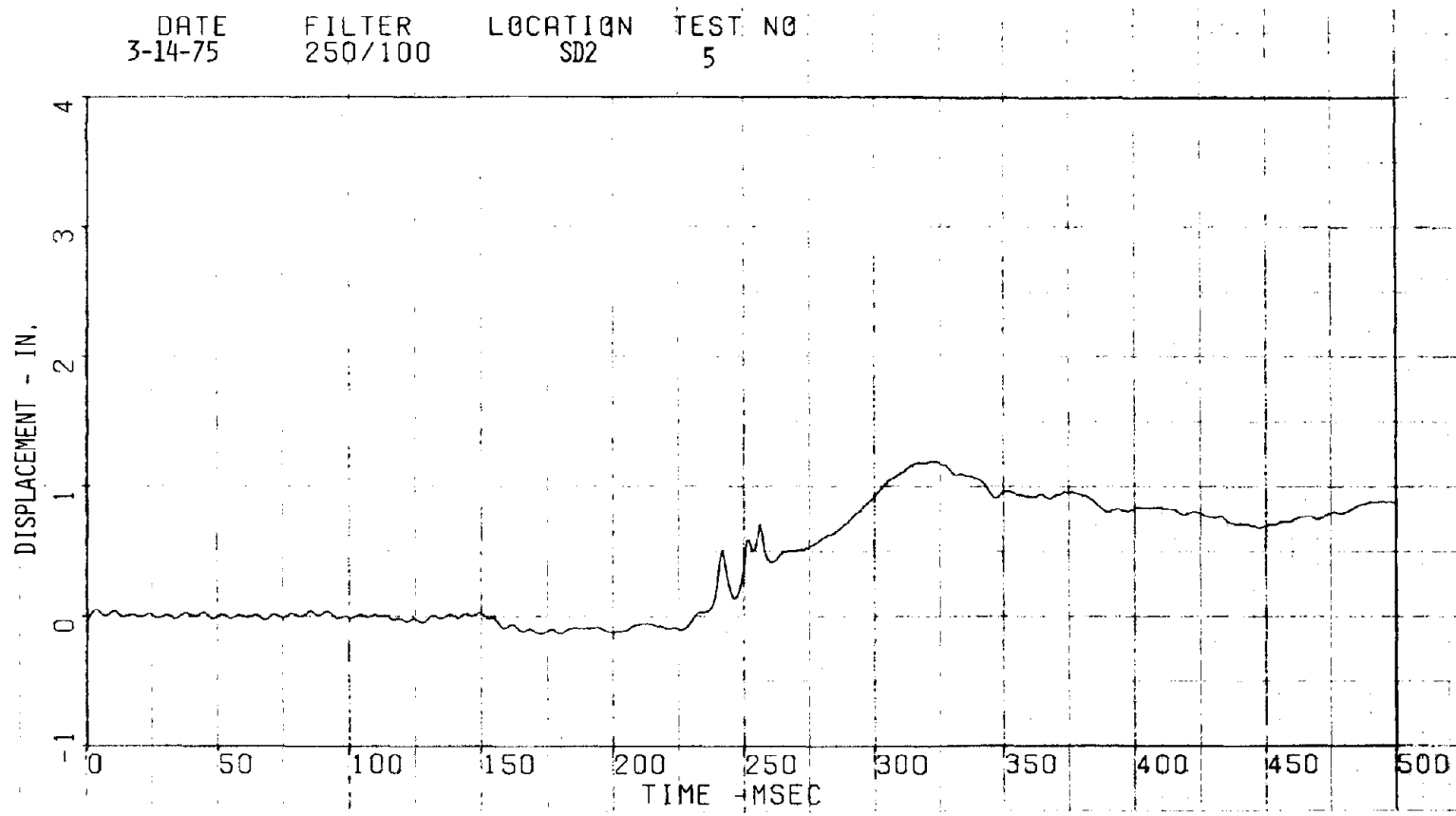


Figure A-148. Caboose Right Rear Displacement Transducer - Test 5.

DATE 3-14-75 FILTER 250/100 LOCATION SD3 TEST NO 5

A-147

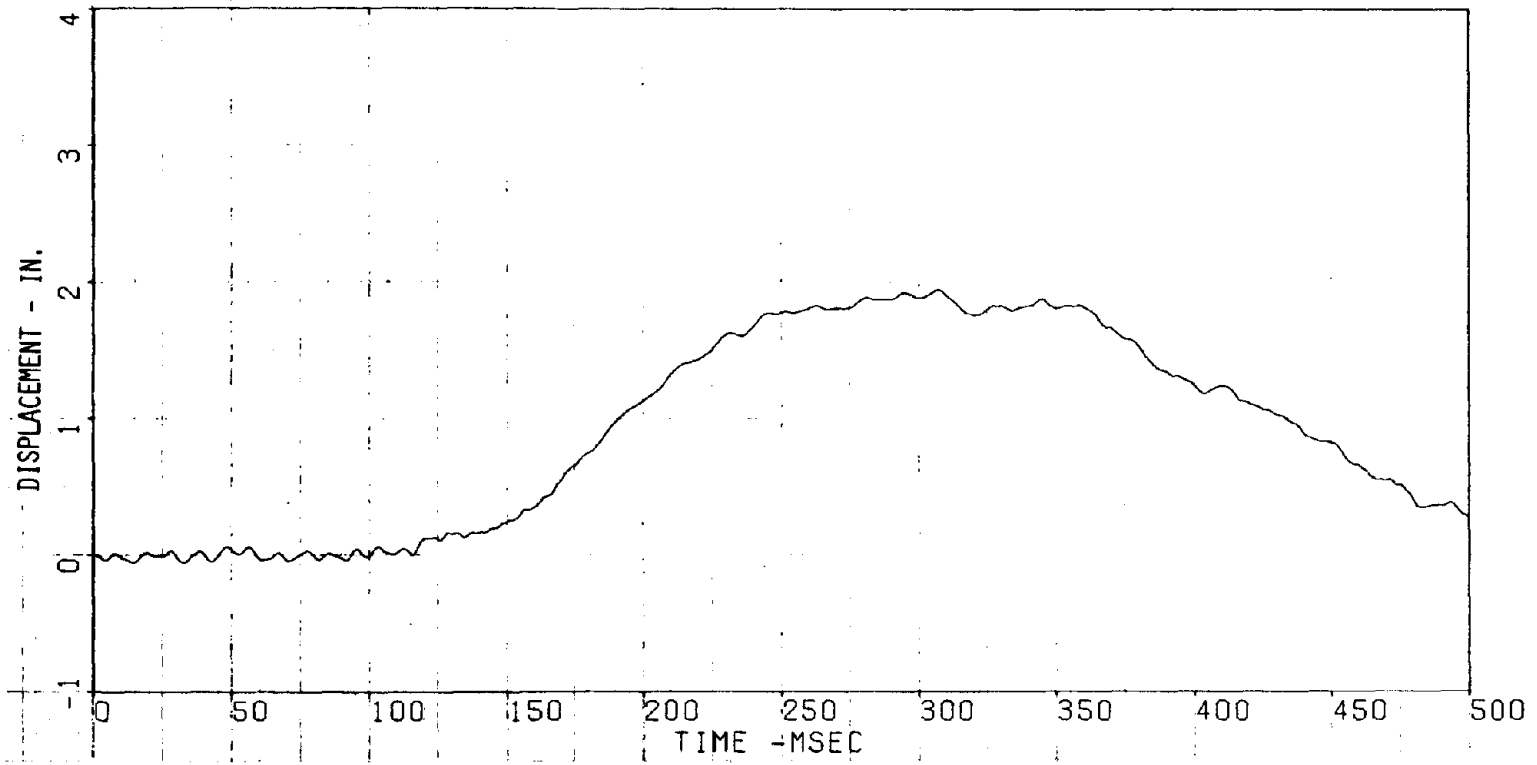


Figure A-149. Caboose Left Front Displacement Transducer - Test 5.

A-148

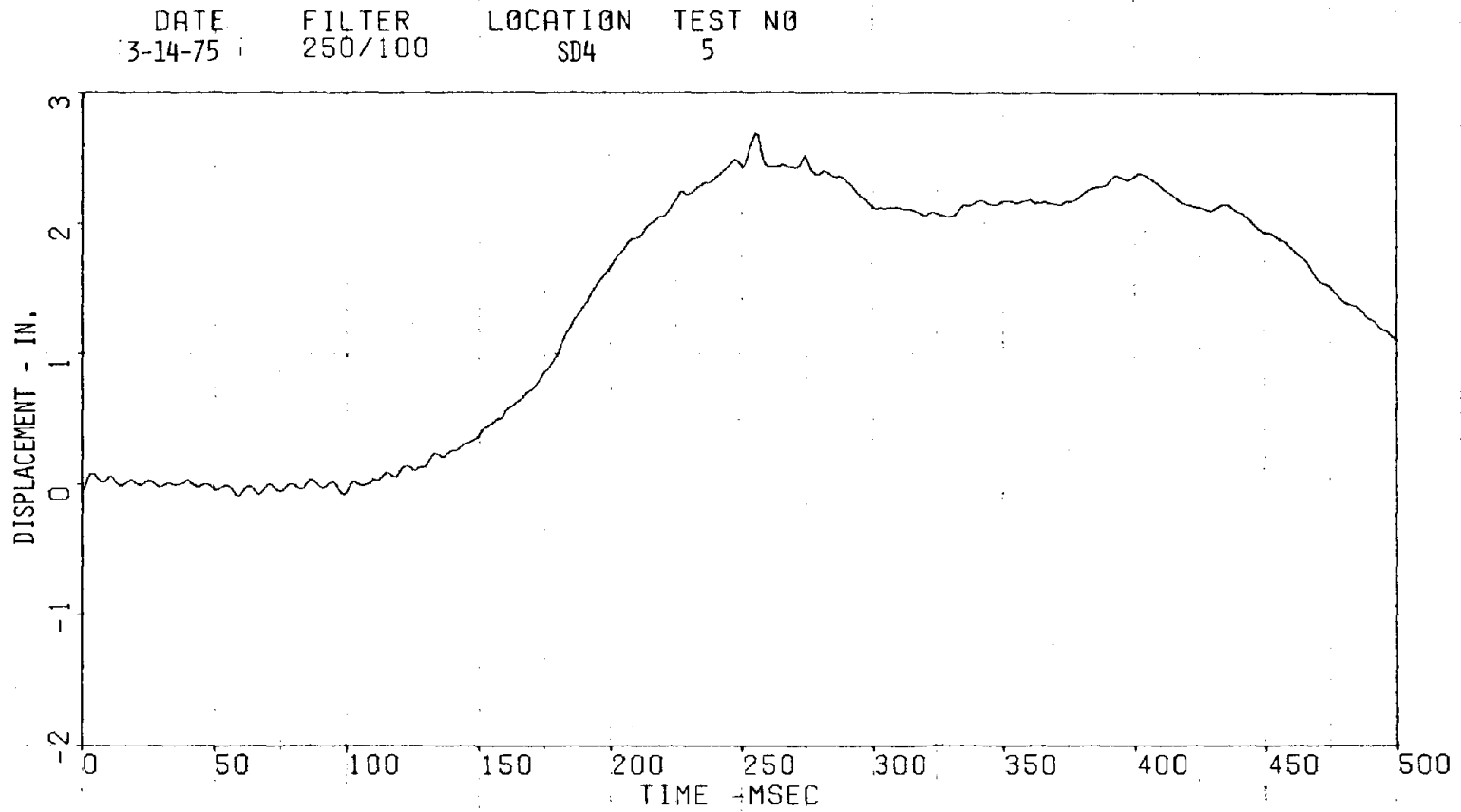


Figure A-150. Caboose Right Front Displacement Transducer - Test 5.

A-149

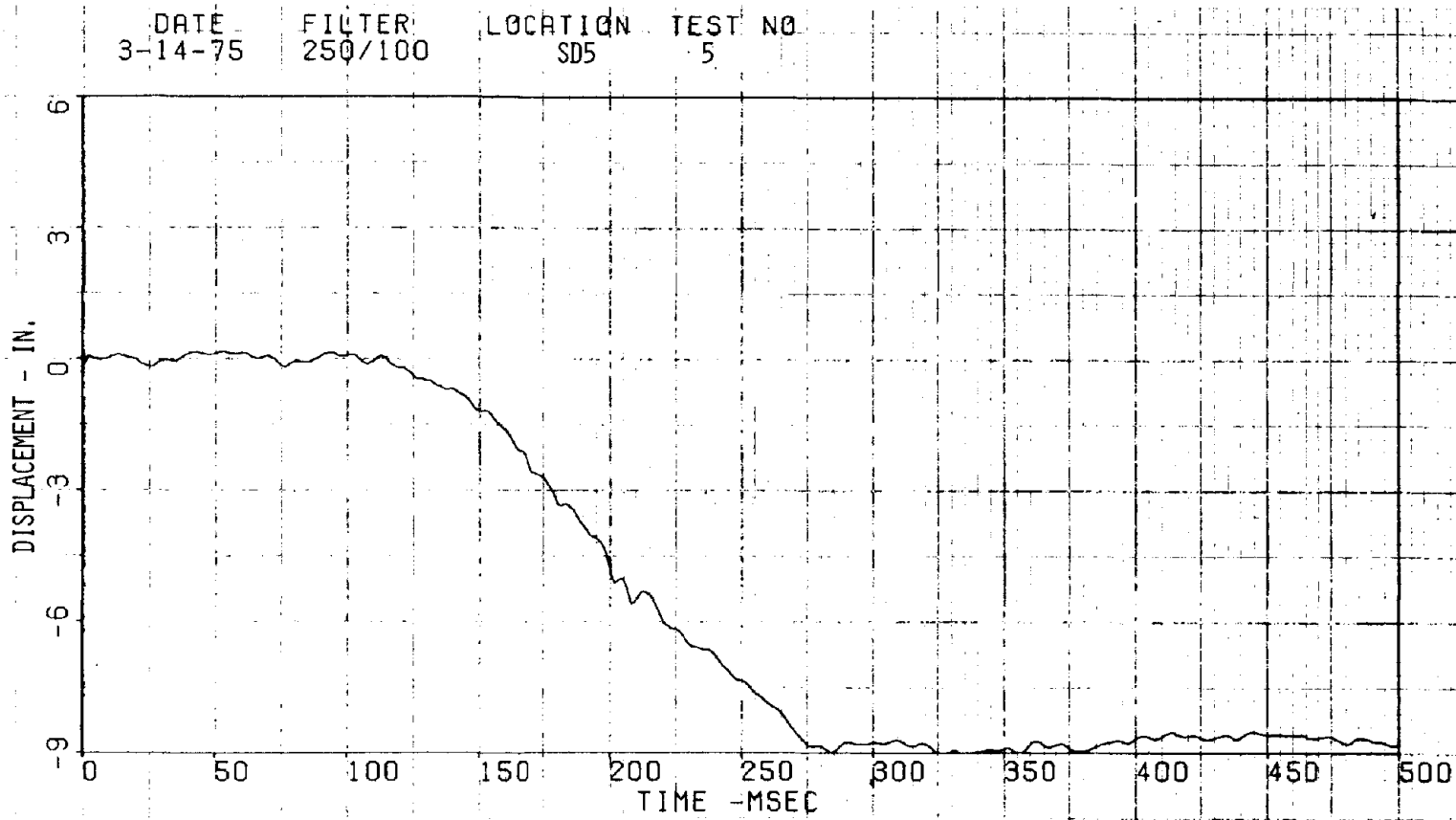


Figure A-151. Caboose to Hopper Displacement Transducer - Test 5.

A-150

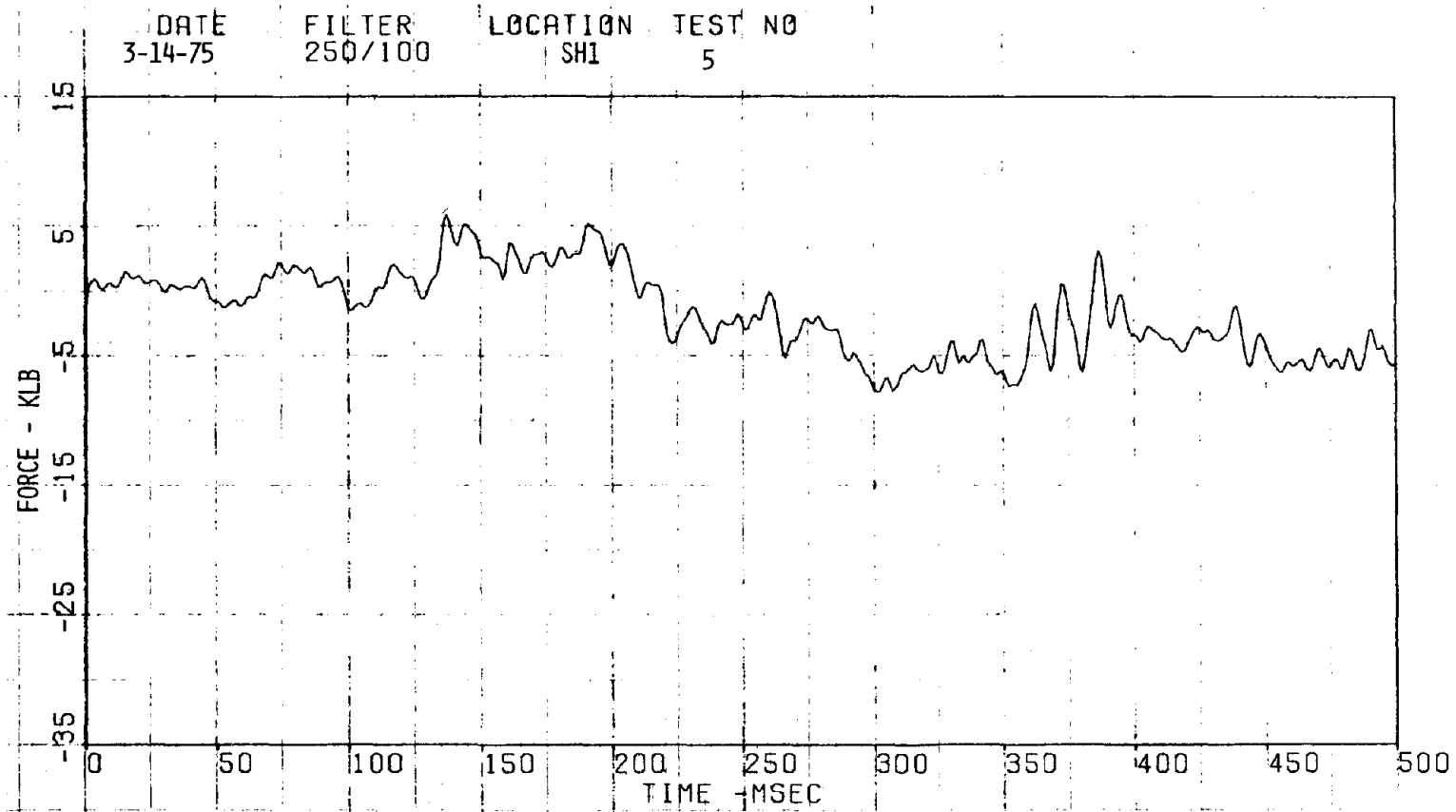


Figure A-152. Caboose Rear Swinghanger Strain Gauge - Test 5.

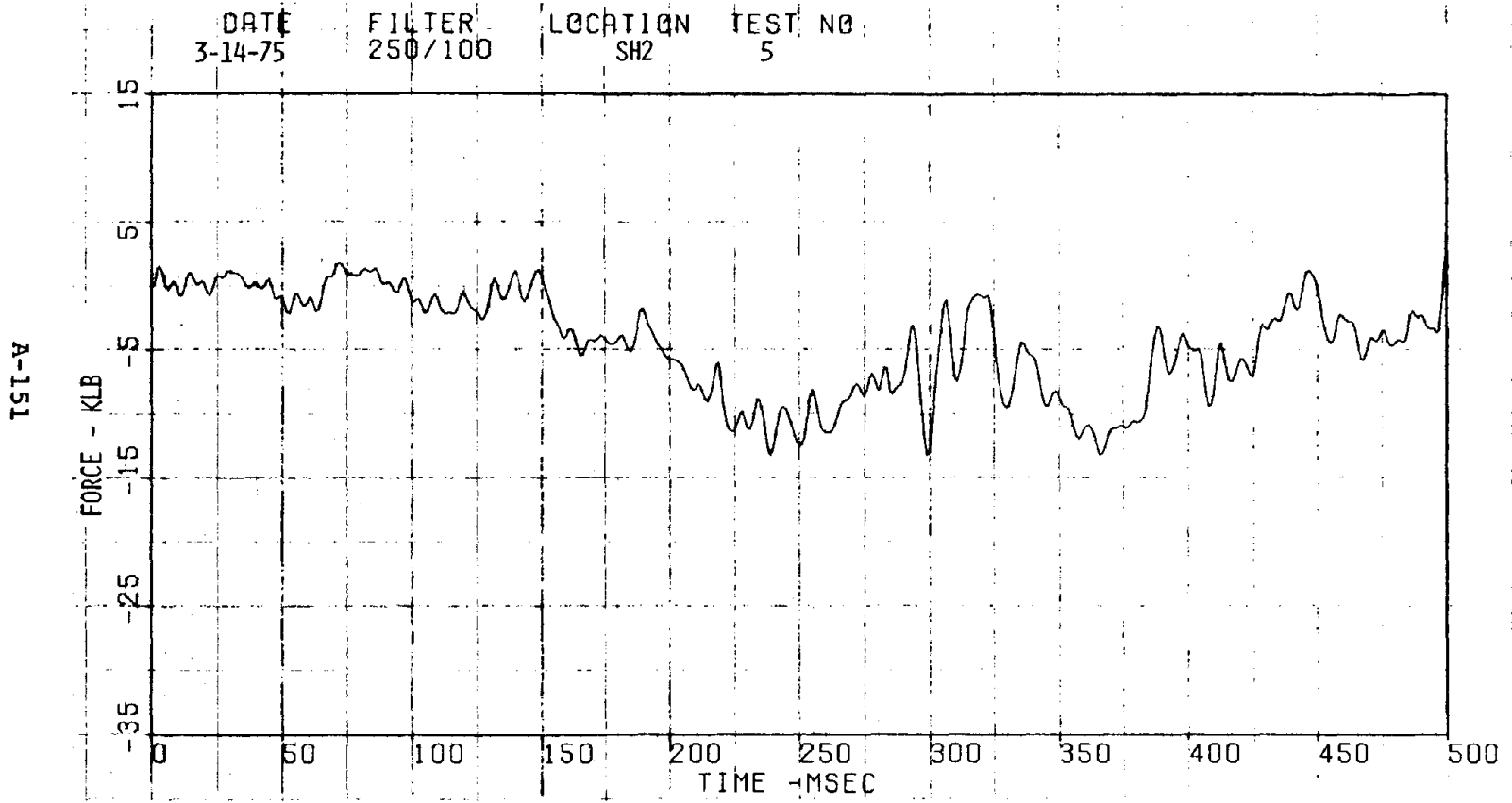


Figure A-153. Caboose Front Swinghanger Strain Gauge - Test 5.

A-152

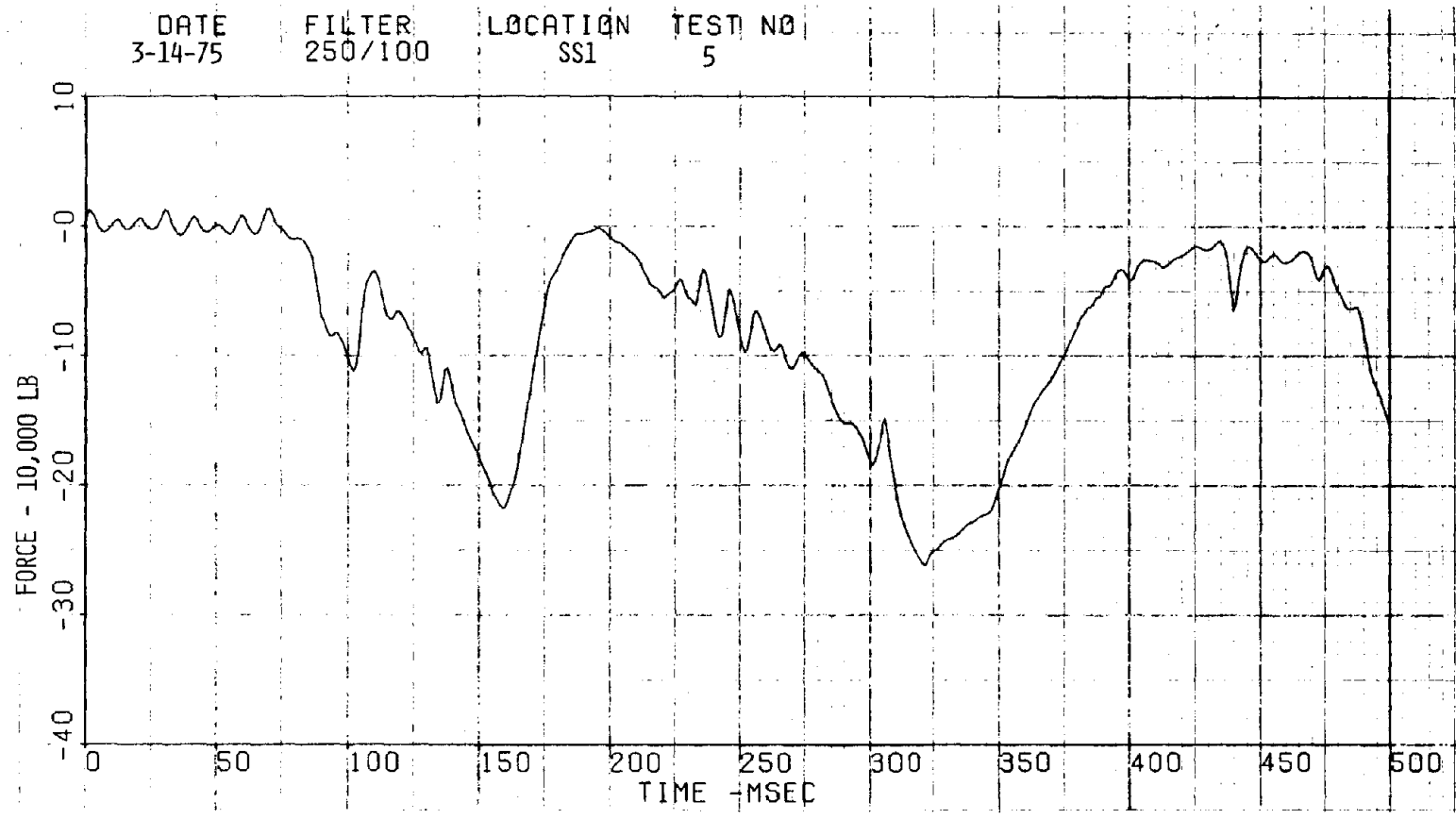


Figure A-154. Caboose Rear Coupler Strain Gauge - Test 5.

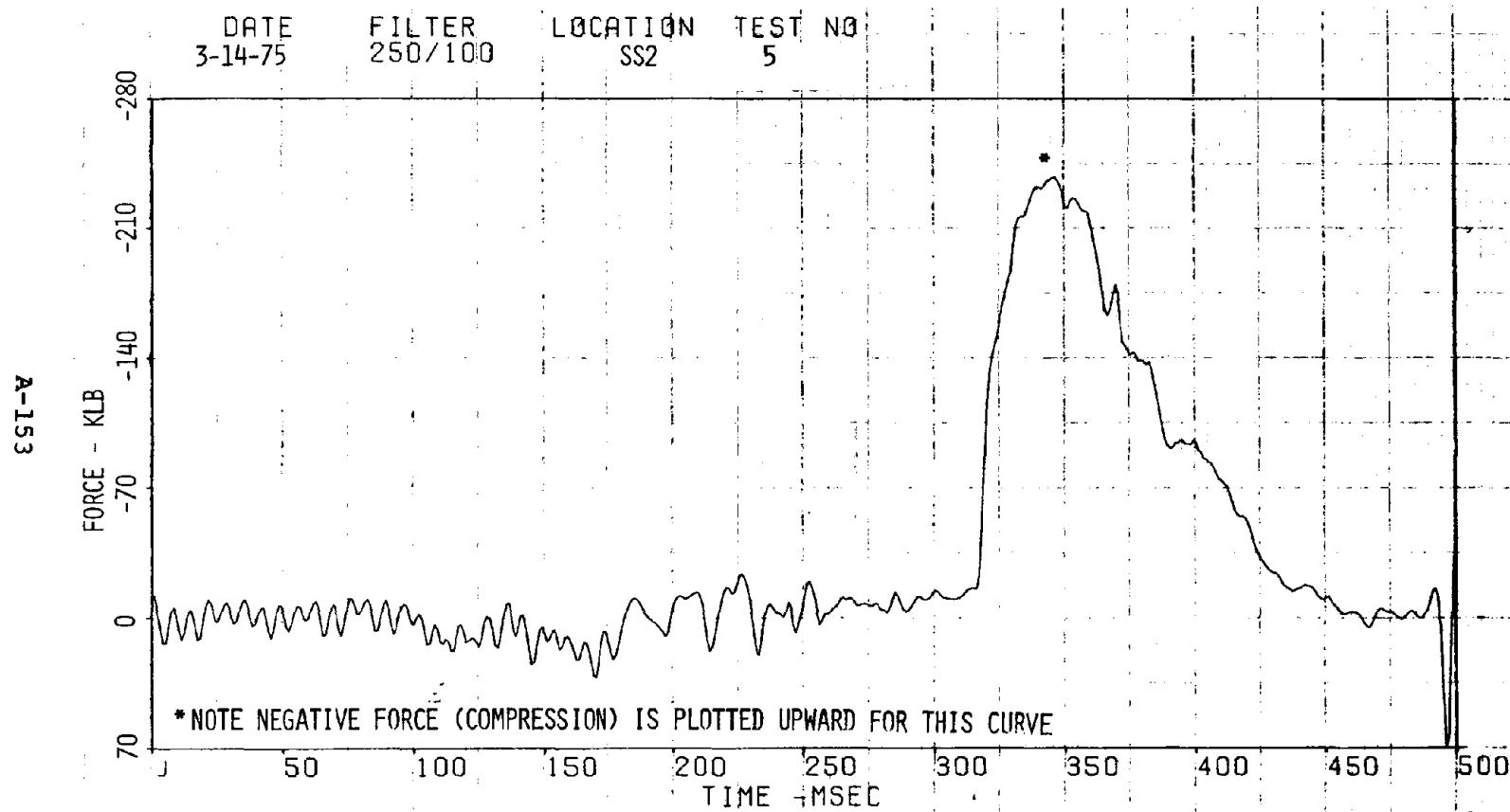


Figure A-155. Caboose Center Sill Strain Gauge - Test 5.

A-154

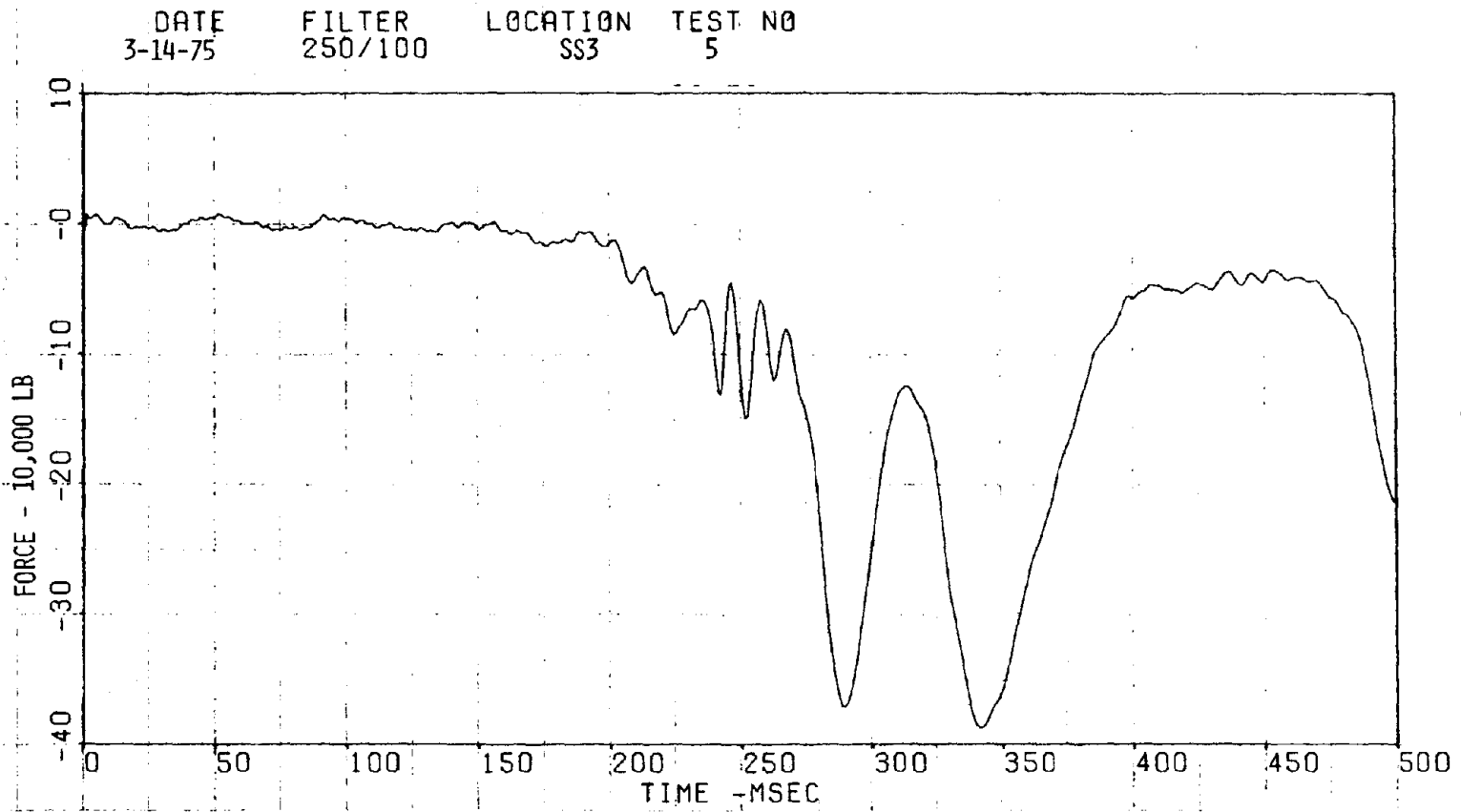


Figure A-156. Caboose Front Coupler Strain Gauge - Test 5.

A-155

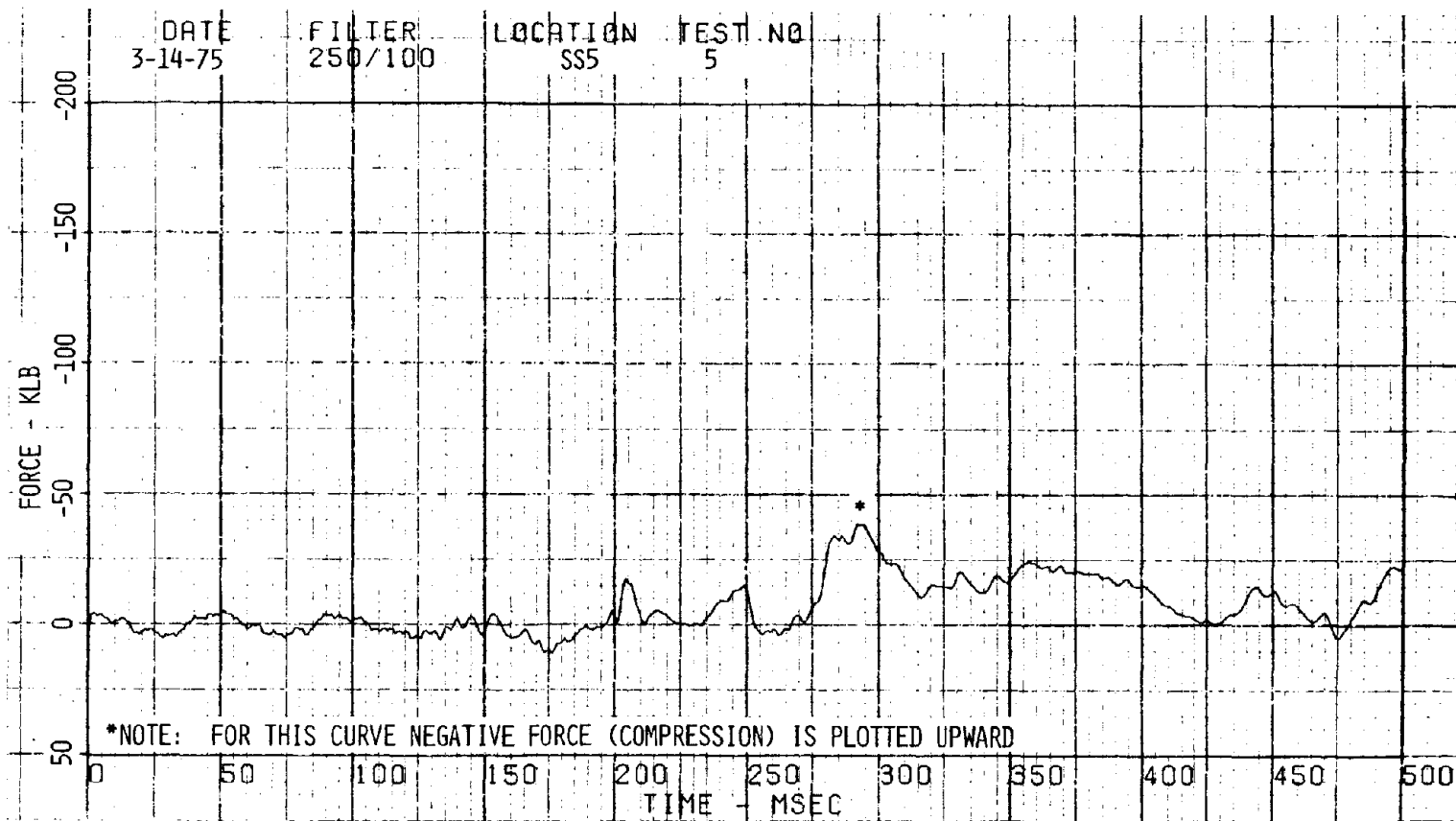


Figure A-157. Hopper 843 Center Sill Strain Gauge - Test 5.

A-156

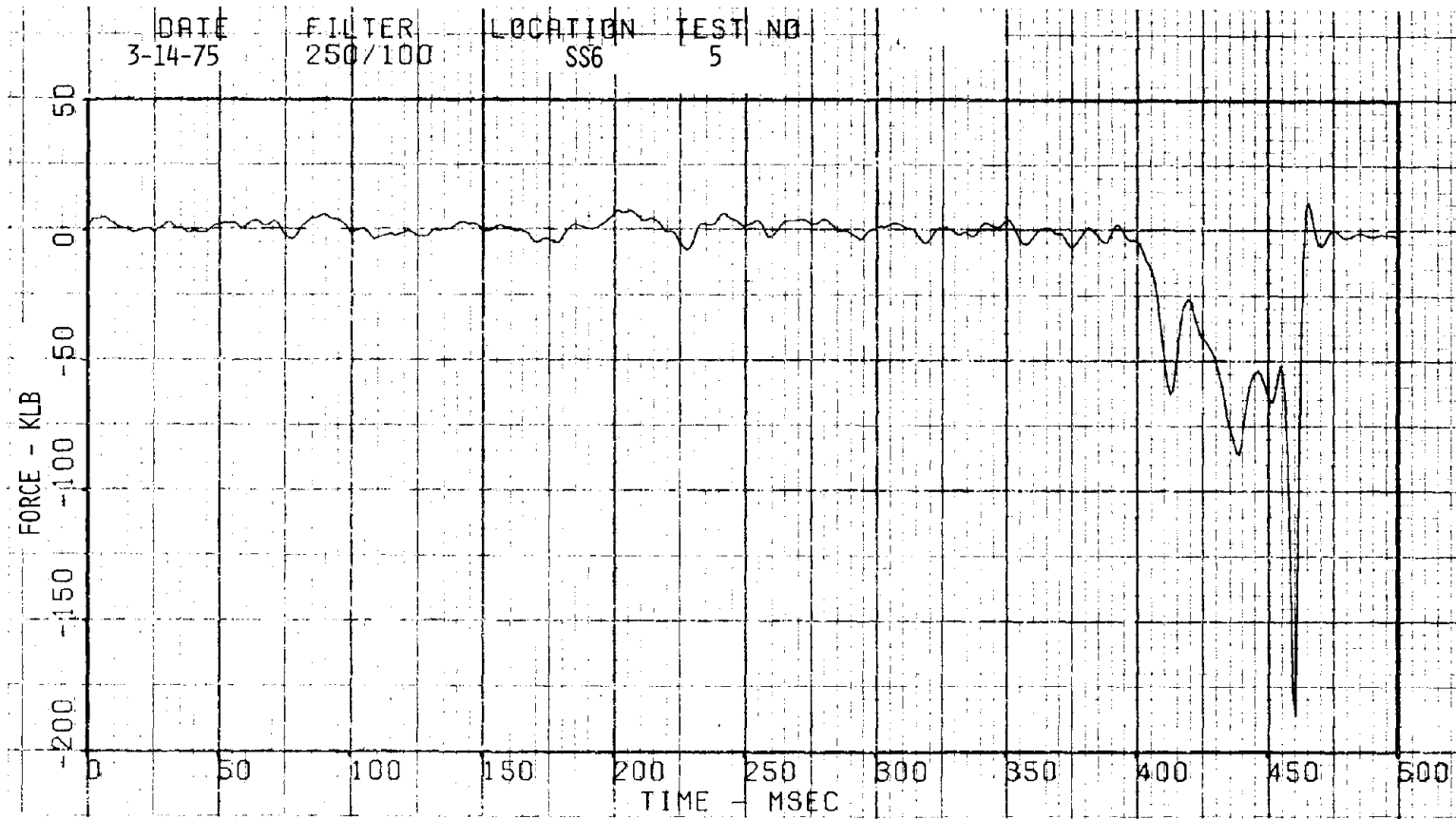
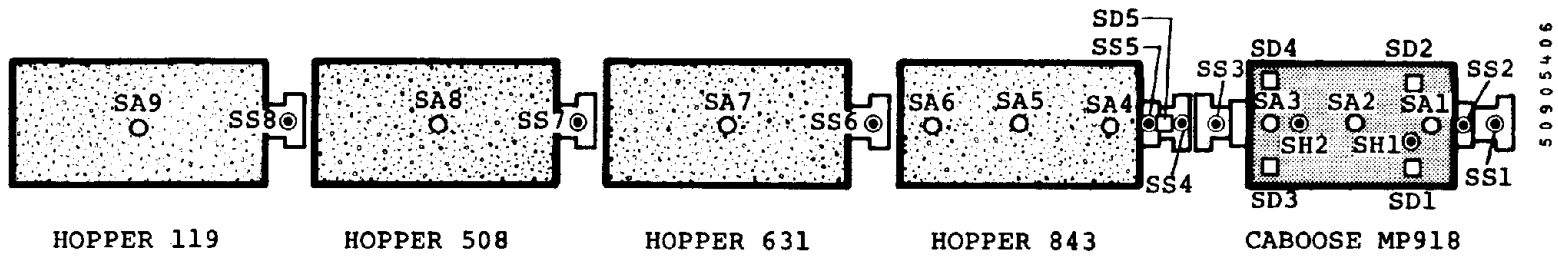
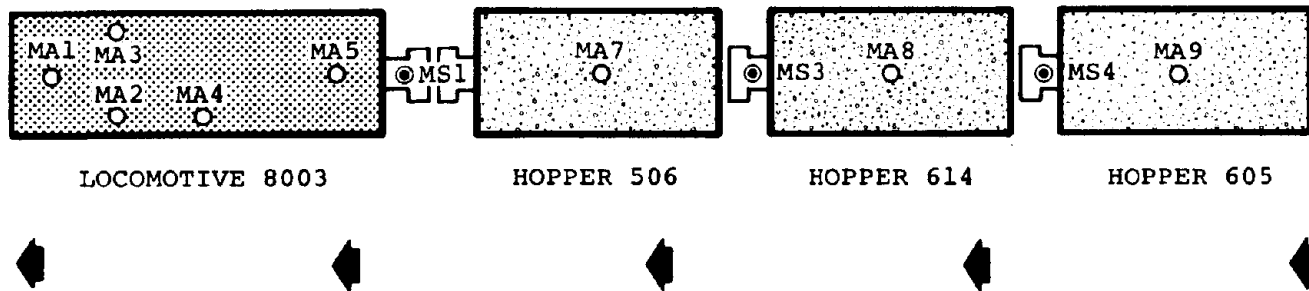


Figure A-158. Hopper 631 Rear Coupler Strain Gauge - Test 5.



- HOPPER LOADED
 - TRAIN IN BUFF
- STANDING TRAIN

A-157



MOTION

- IMPACT VELOCITY = 4.9 MPH
- MOVING TRAIN

Figure A-159. Instrument Locations - Test 6.

A-158

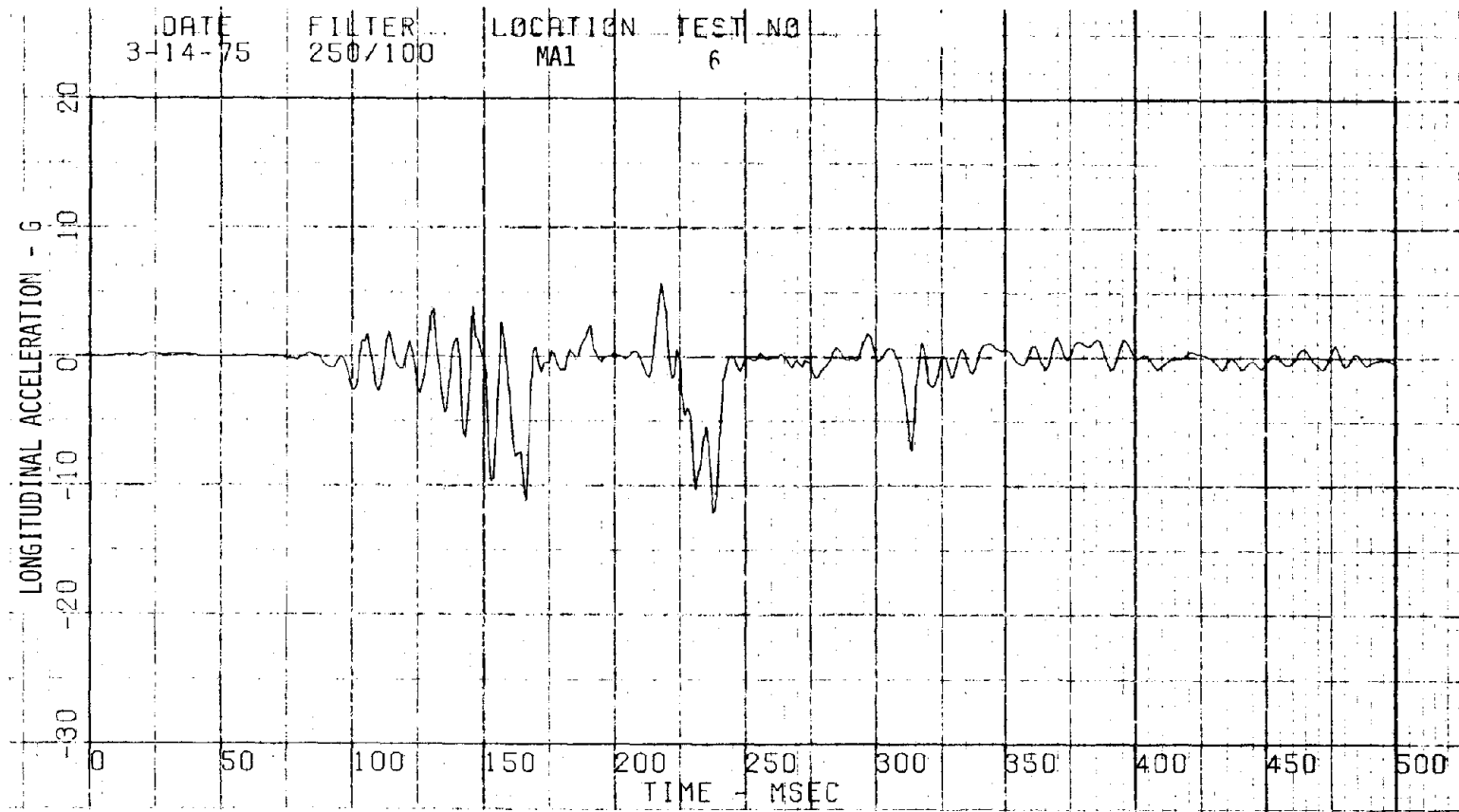


Figure A-160. Locomotive Rear Triaxial Accelerometer (X) - Test 6.

A-159

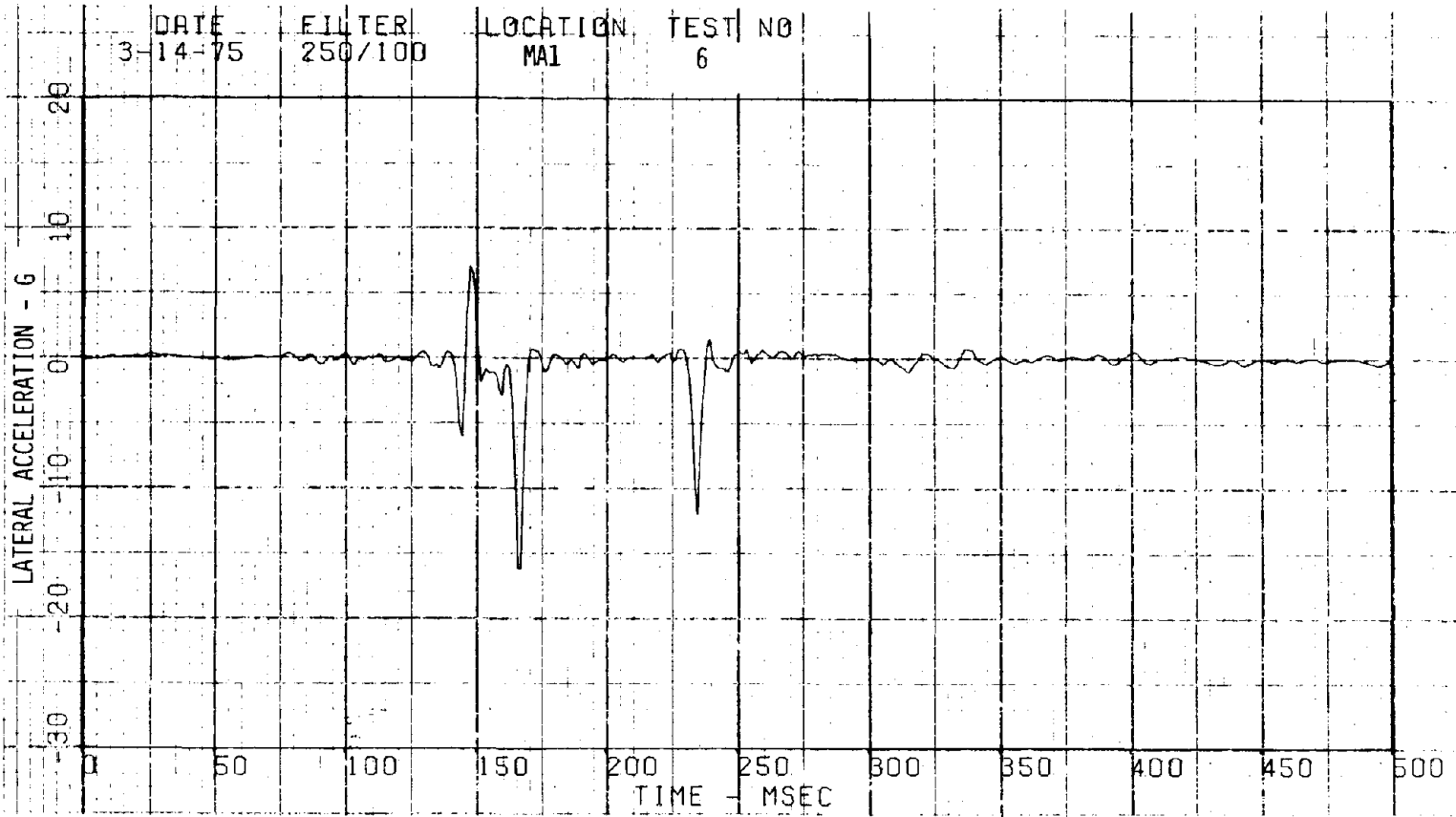


Figure A-161. Locomotive Rear Triaxial Accelerometer (Y) - Test 6.

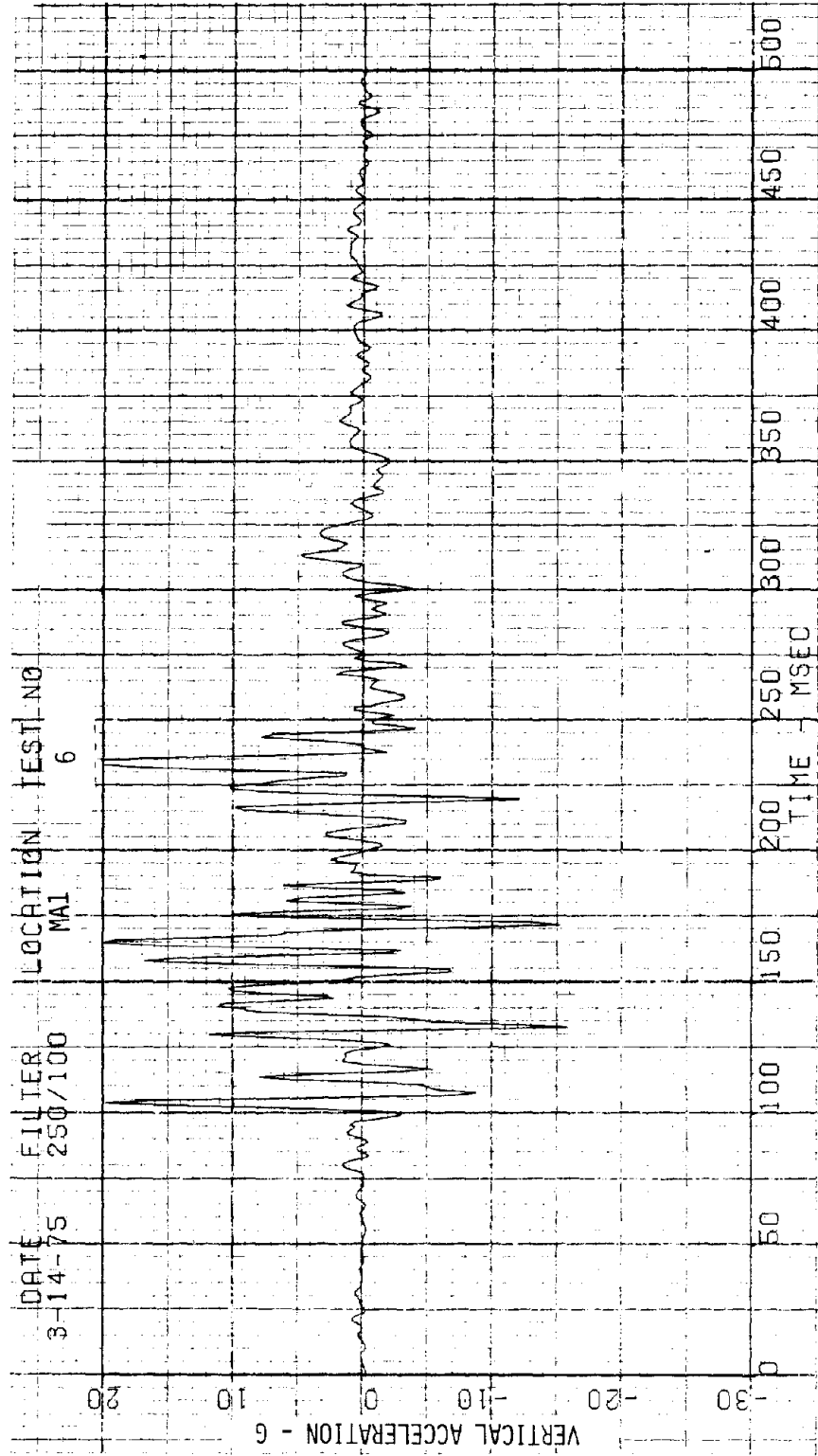


Figure A-162. Locomotive Rear Triaxial Accelerometer (Z) - Test 6.

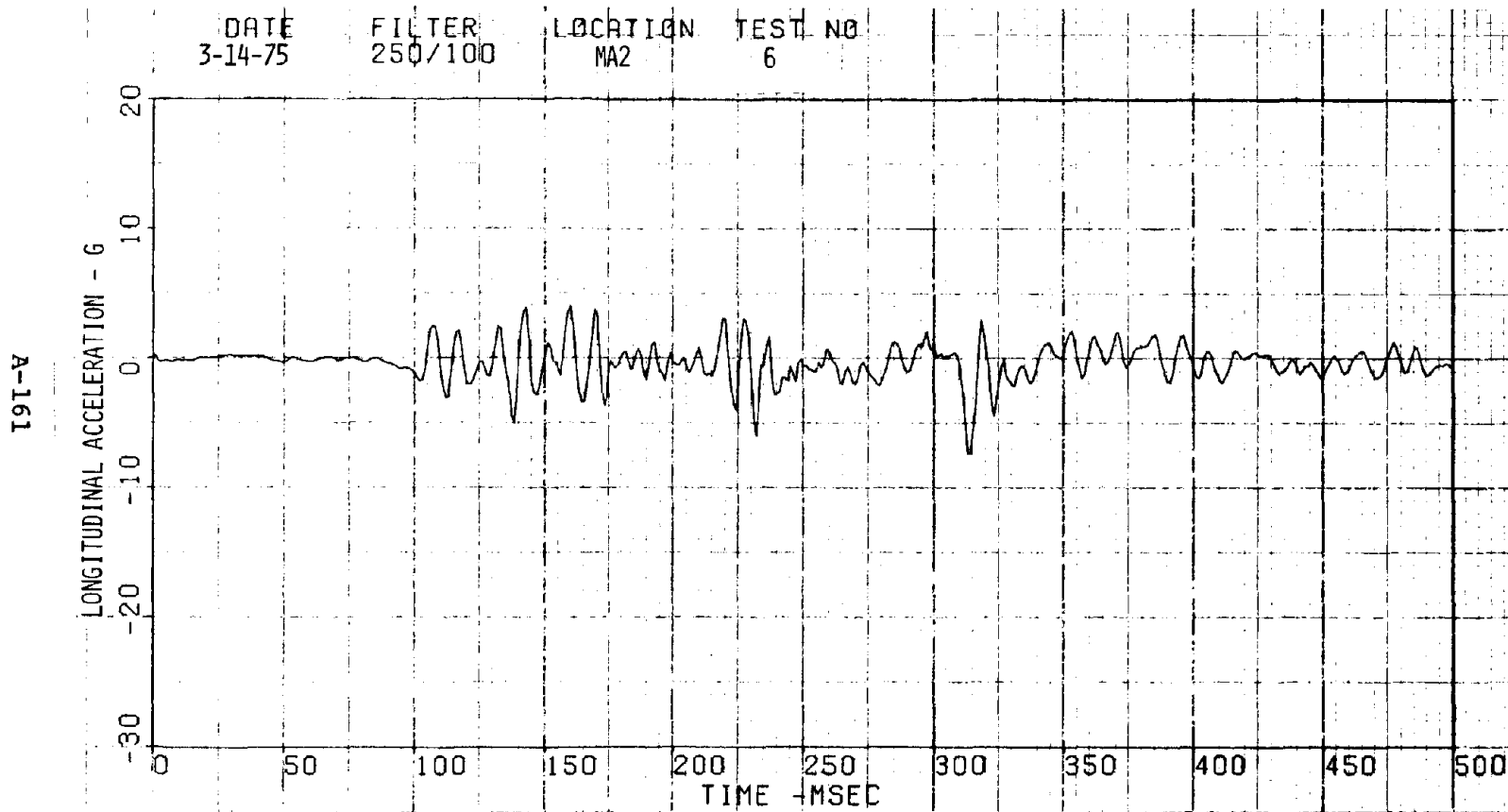


Figure A-163. Locomotive Left Cab Accelerometer - Test 6.

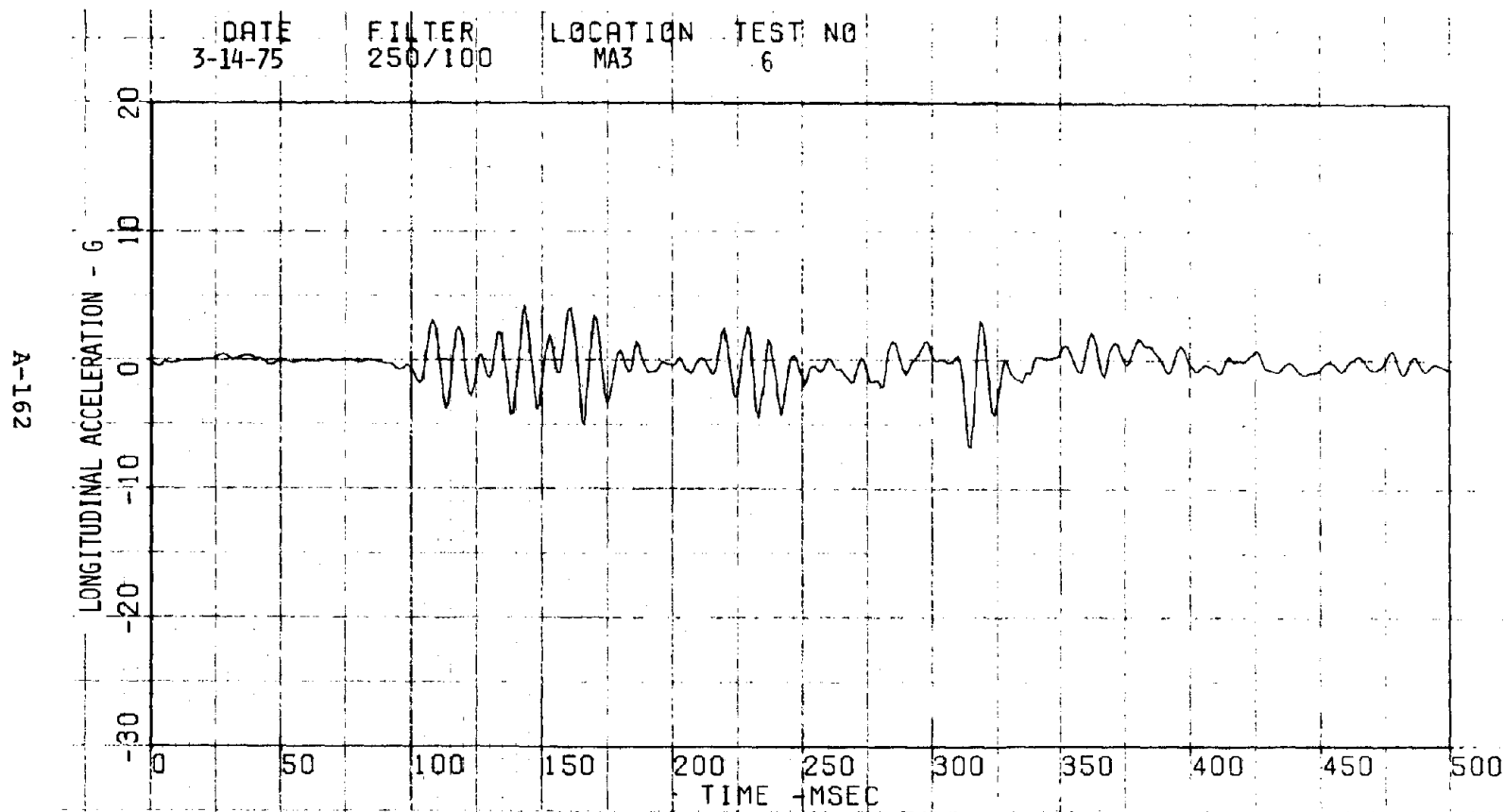


Figure A-164. Locomotive Right Cab Accelerometer - Test 6.

A-163

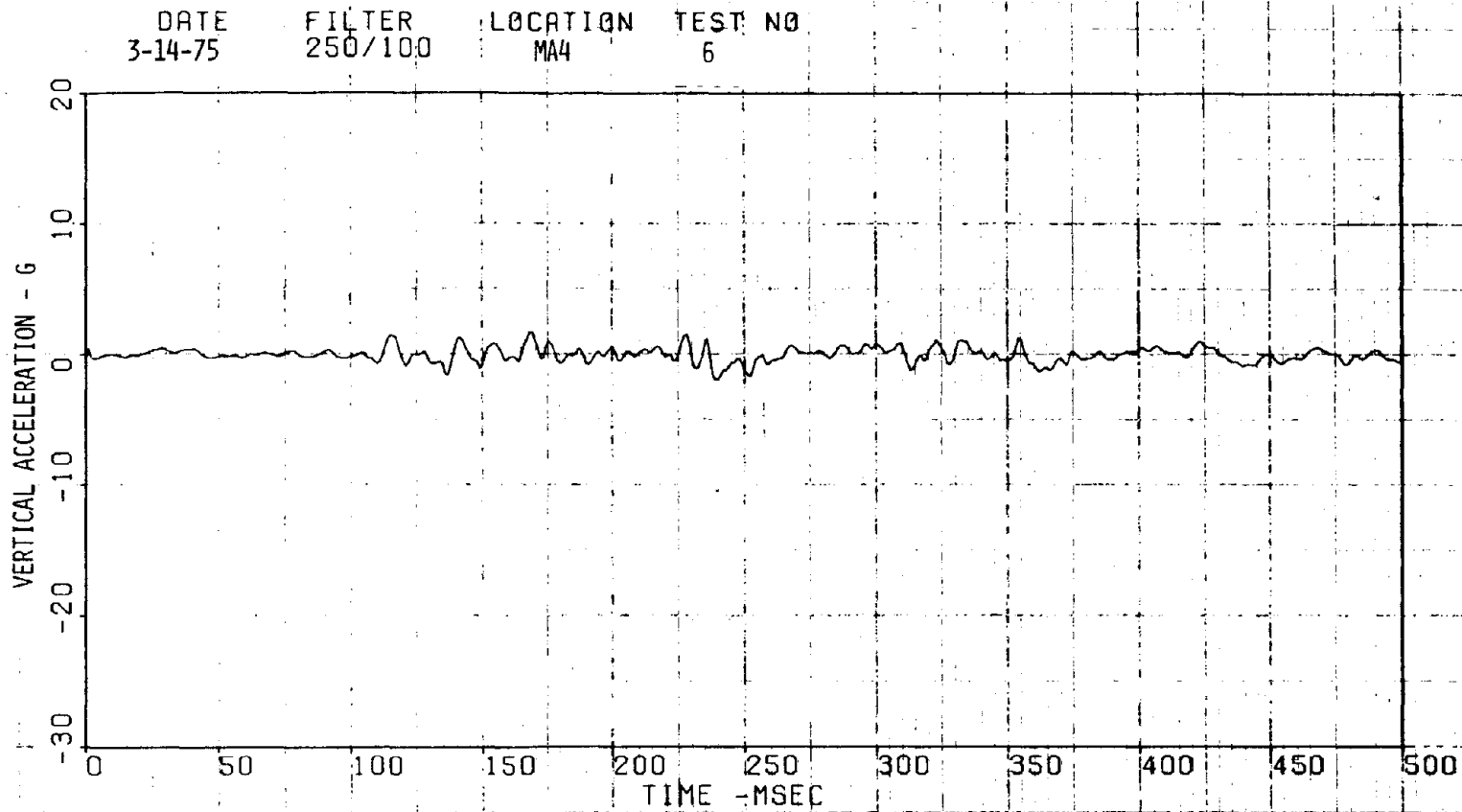


Figure A-165. Locomotive Center Vertical Accelerometer - Test 6.

A-164

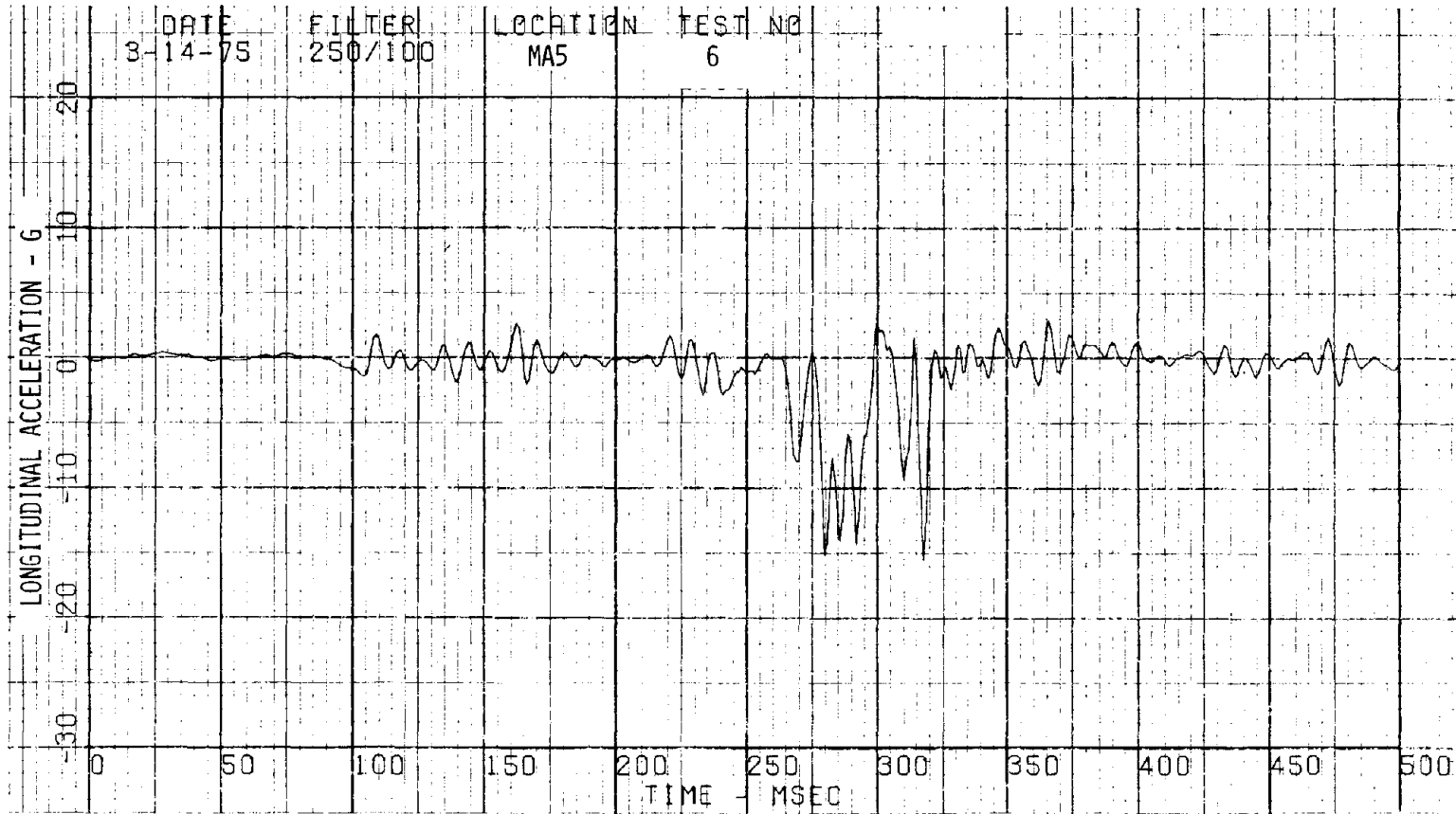


Figure A-166. Locomotive Front Triaxial Accelerometer (X) - Test 6.

A-165

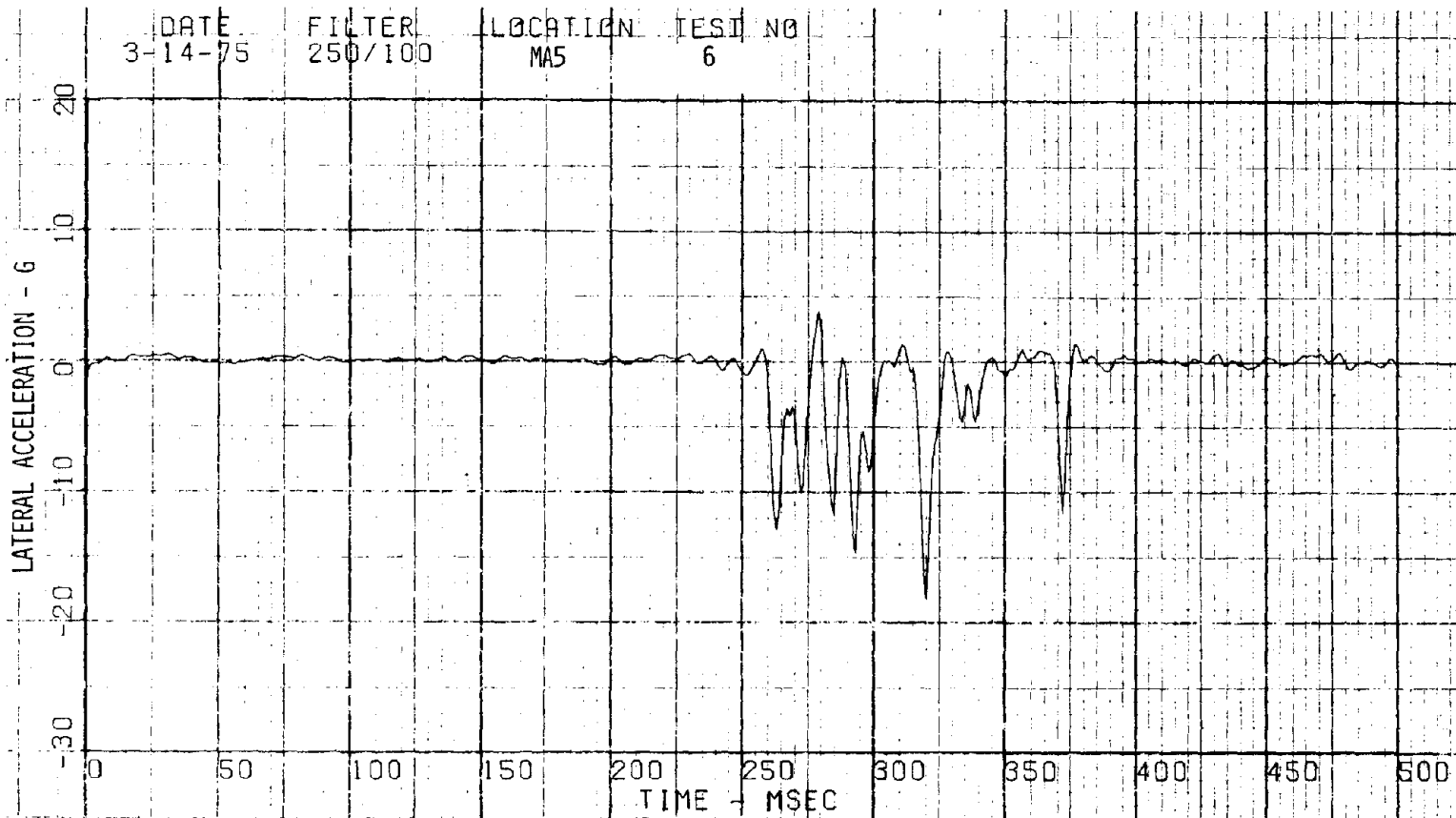


Figure A-167. Locomotive Front Triaxial Accelerometer (Y) - Test 6.

A-166

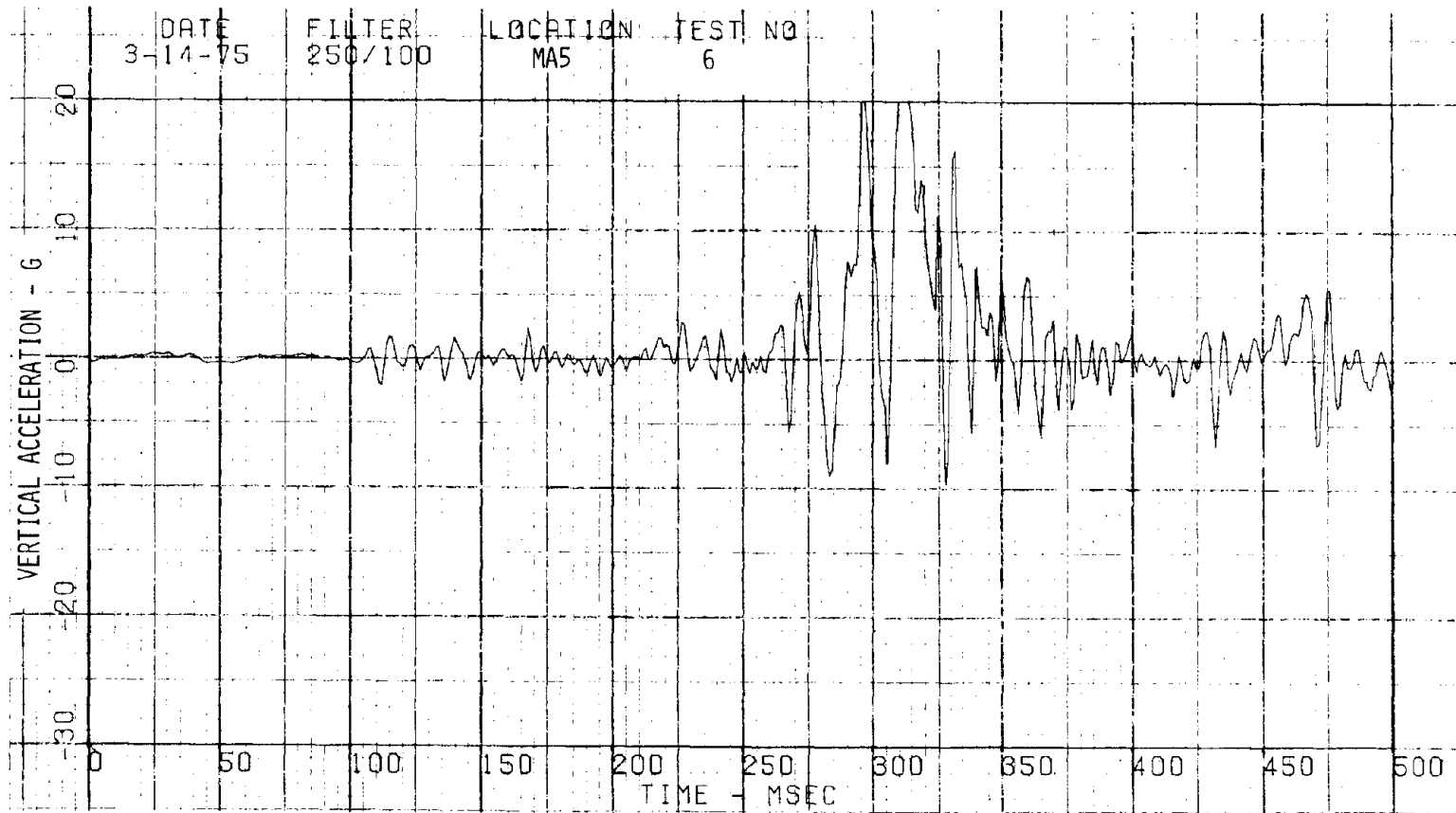


Figure A-168. Locomotive Front Triaxial Accelerometer (Z) - Test 6.

A-167

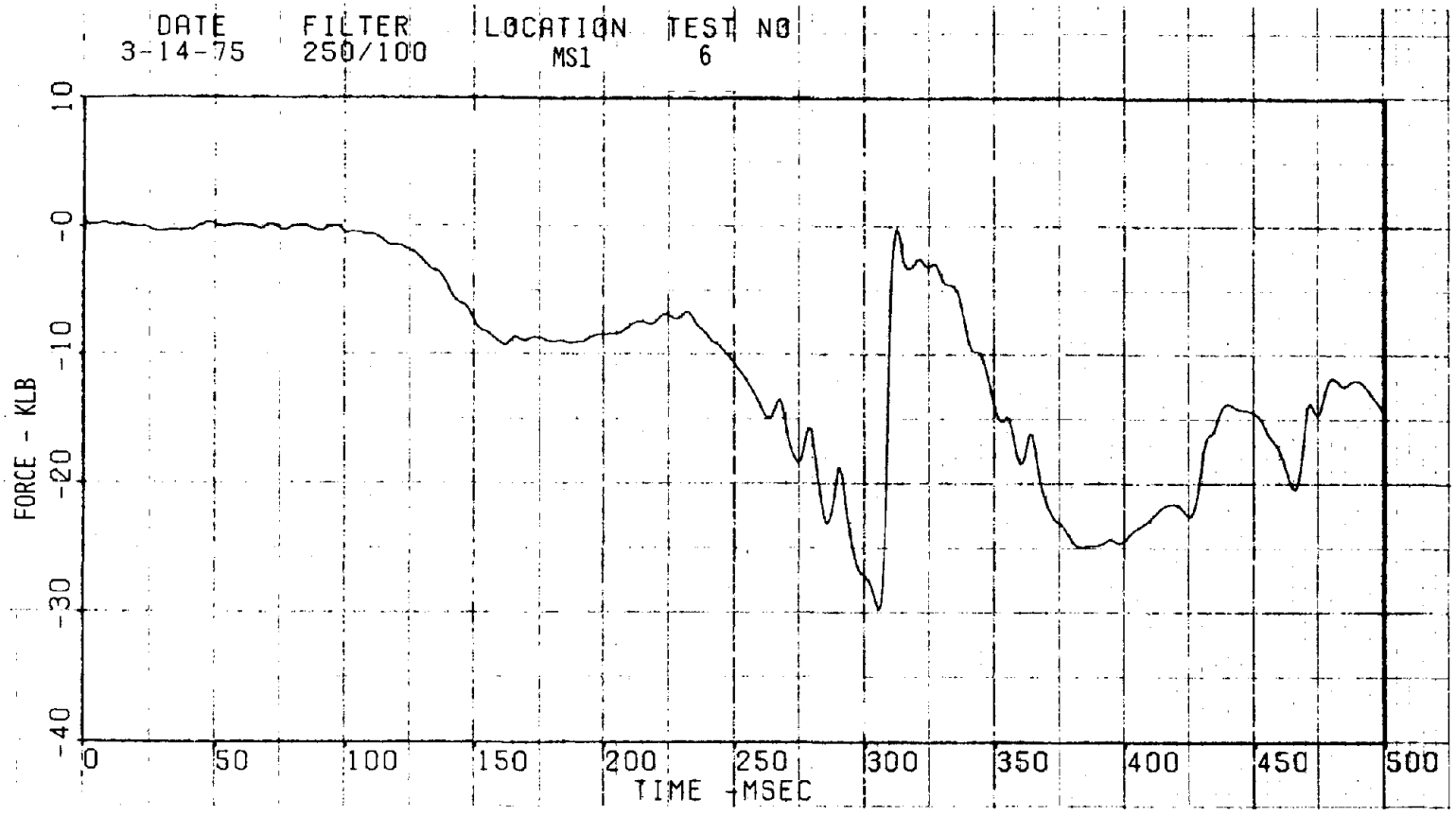


Figure A-169. Locomotive Front Coupler Strain Gauge - Test 6.

A-168

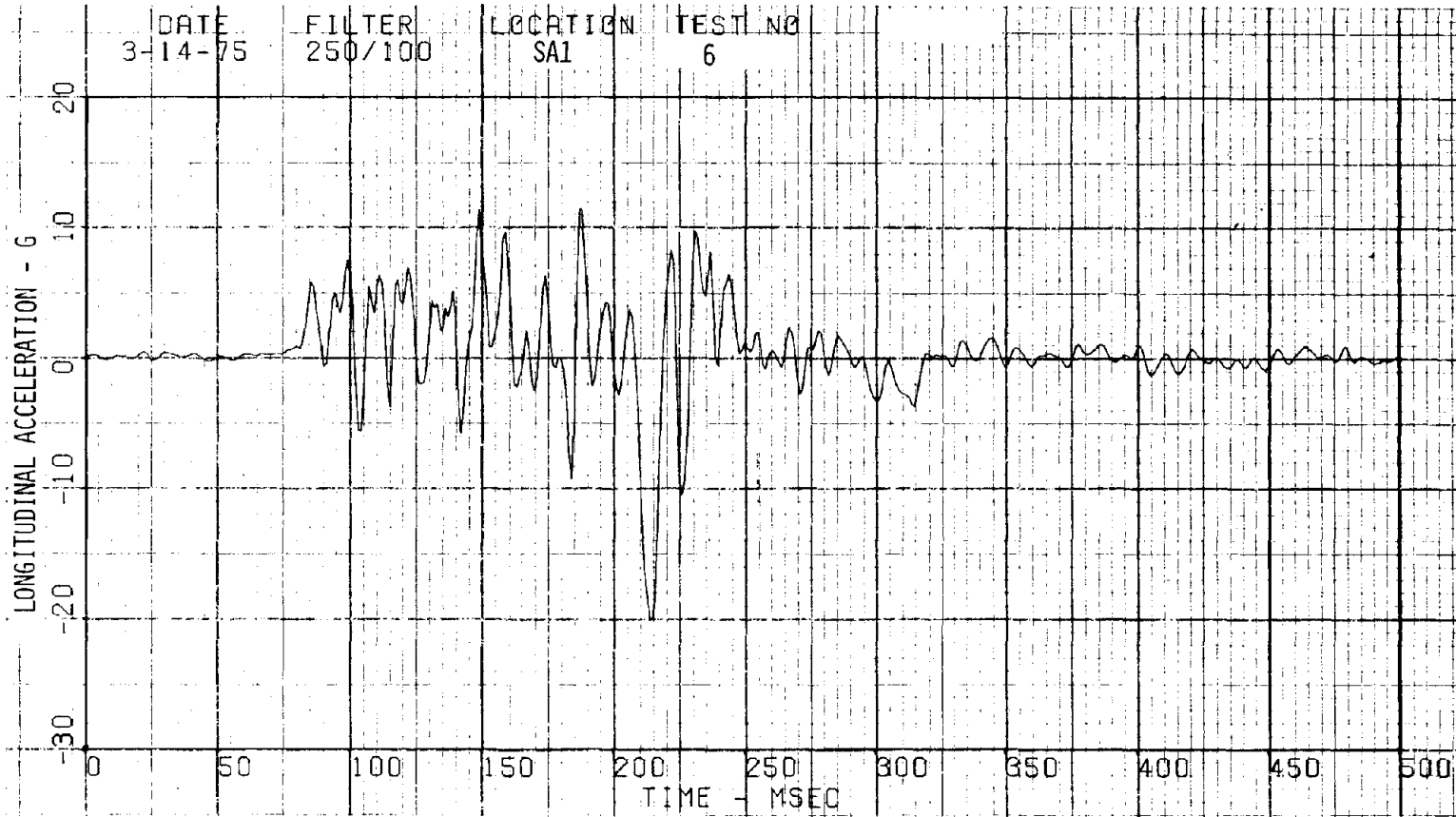


Figure A-170. Caboose Rear Triaxial Accelerometer (X) - Test 6.

A-169

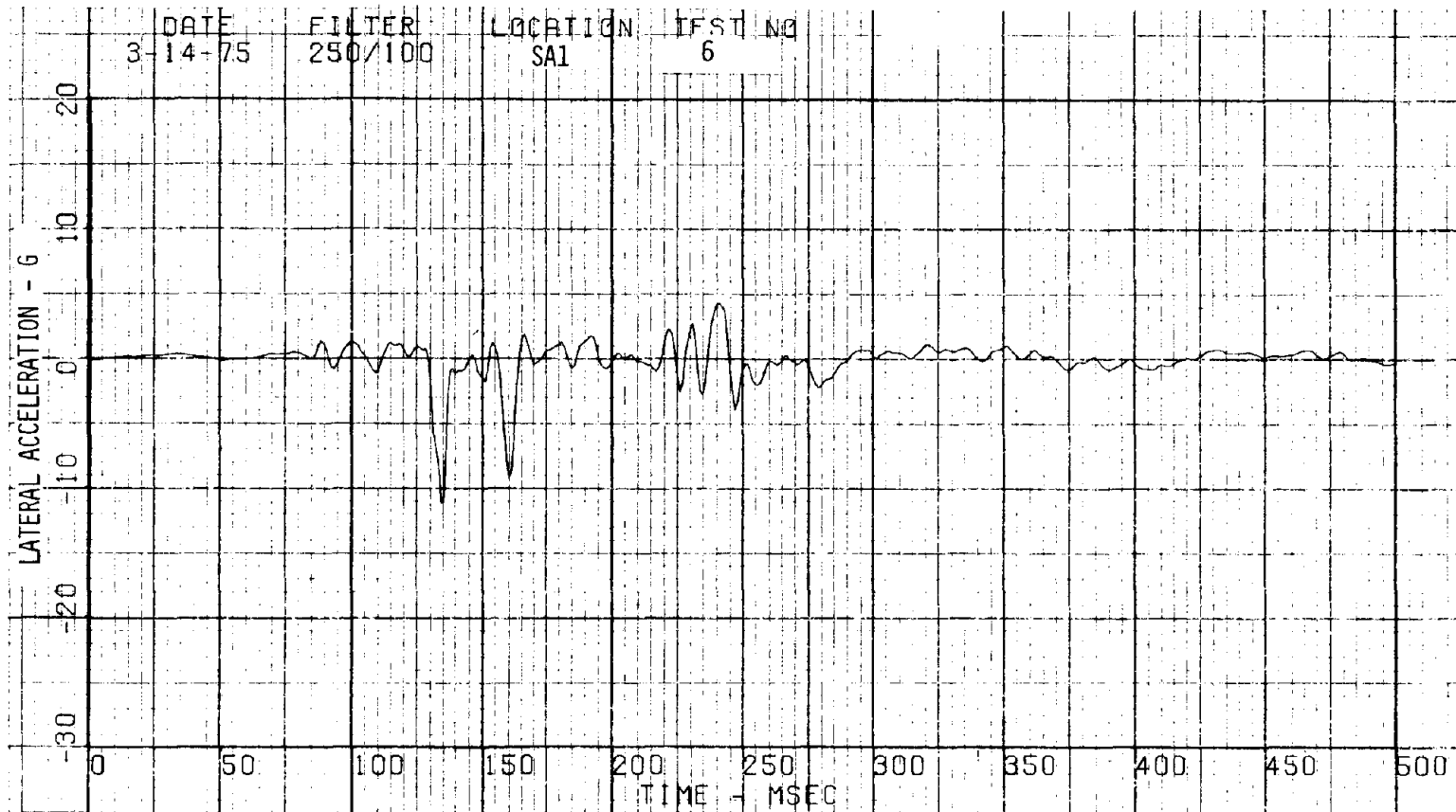


Figure A-171. Caboose Rear Triaxial Accelerometer (Y) - Test 6.

A-170

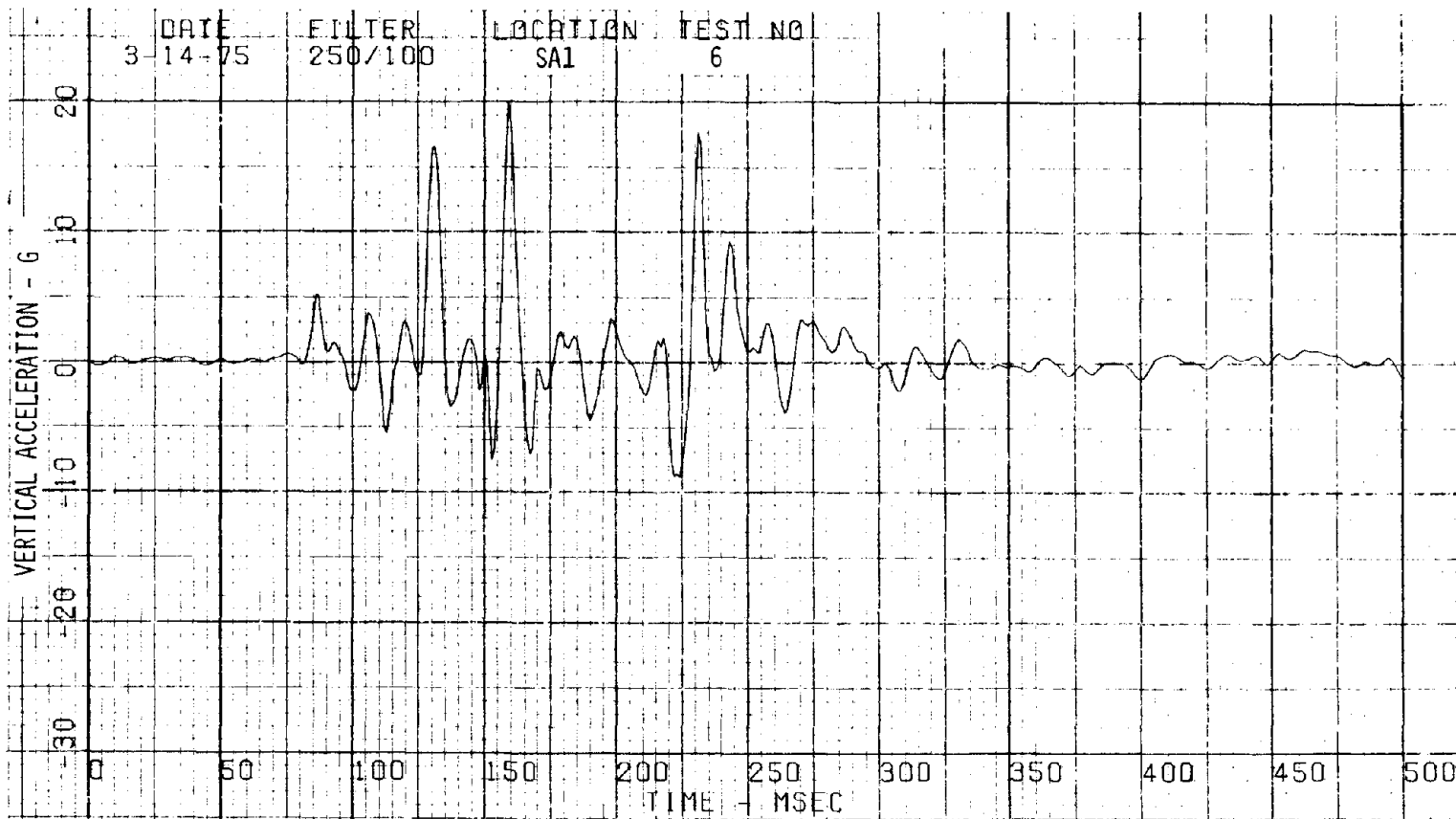


Figure A-172. Caboose Rear Triaxial Accelerometer (Z) - Test 6.

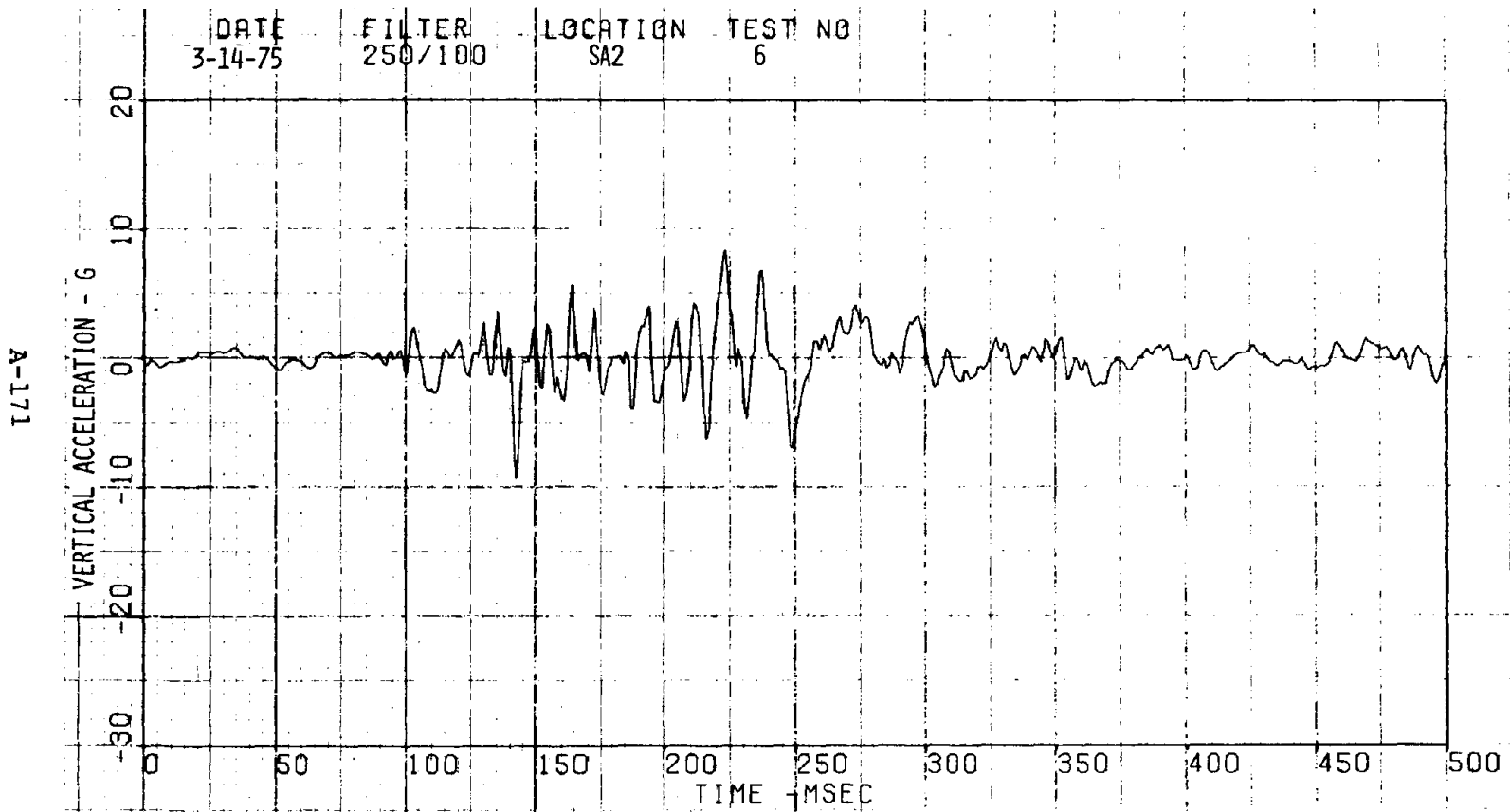


Figure A-173. Caboose Center Vertical Accelerometer - Test 6.

A-172

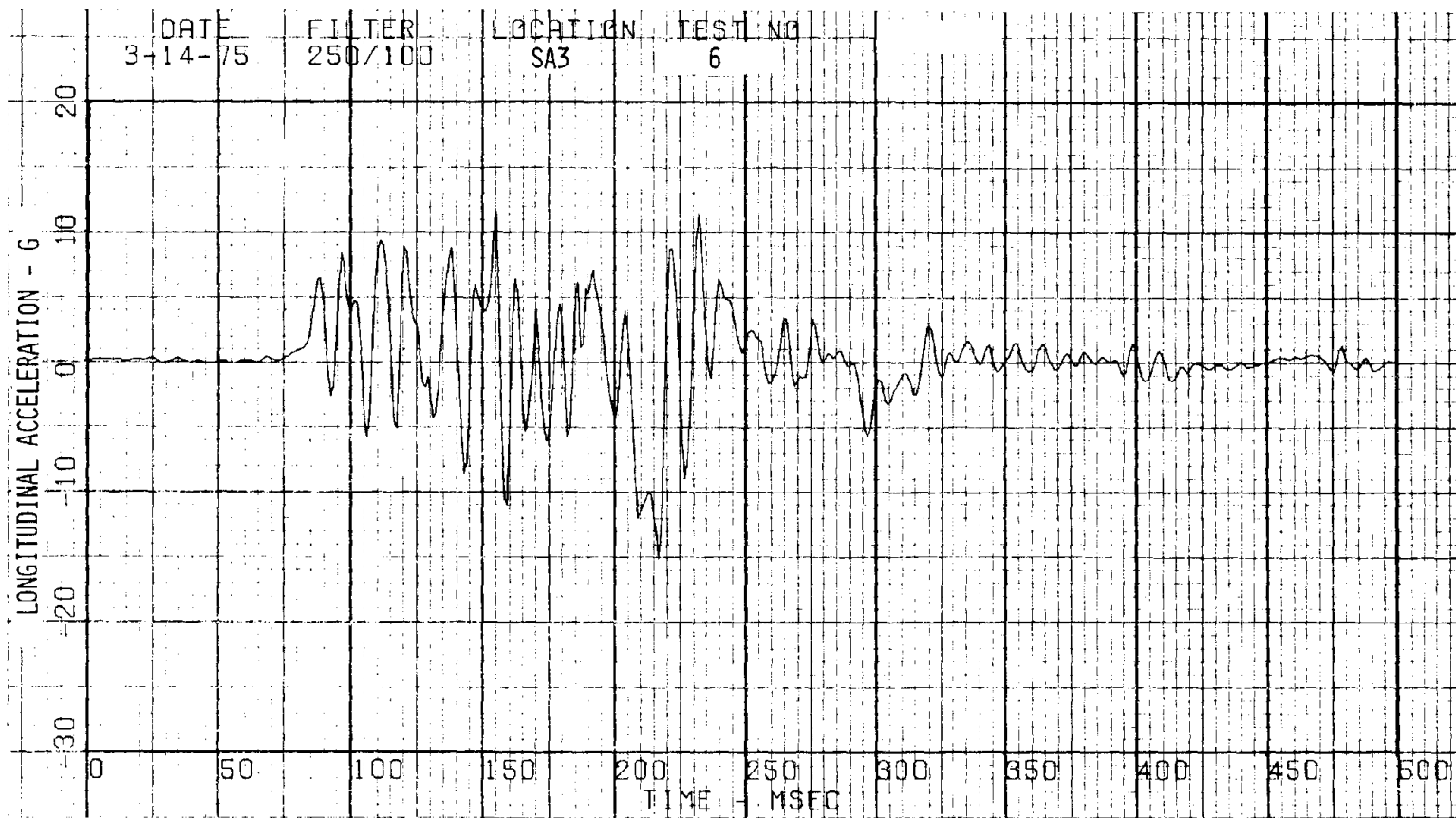


Figure A-174. Caboose Front Triaxial Accelerometer (X) - Test 6.

A-173

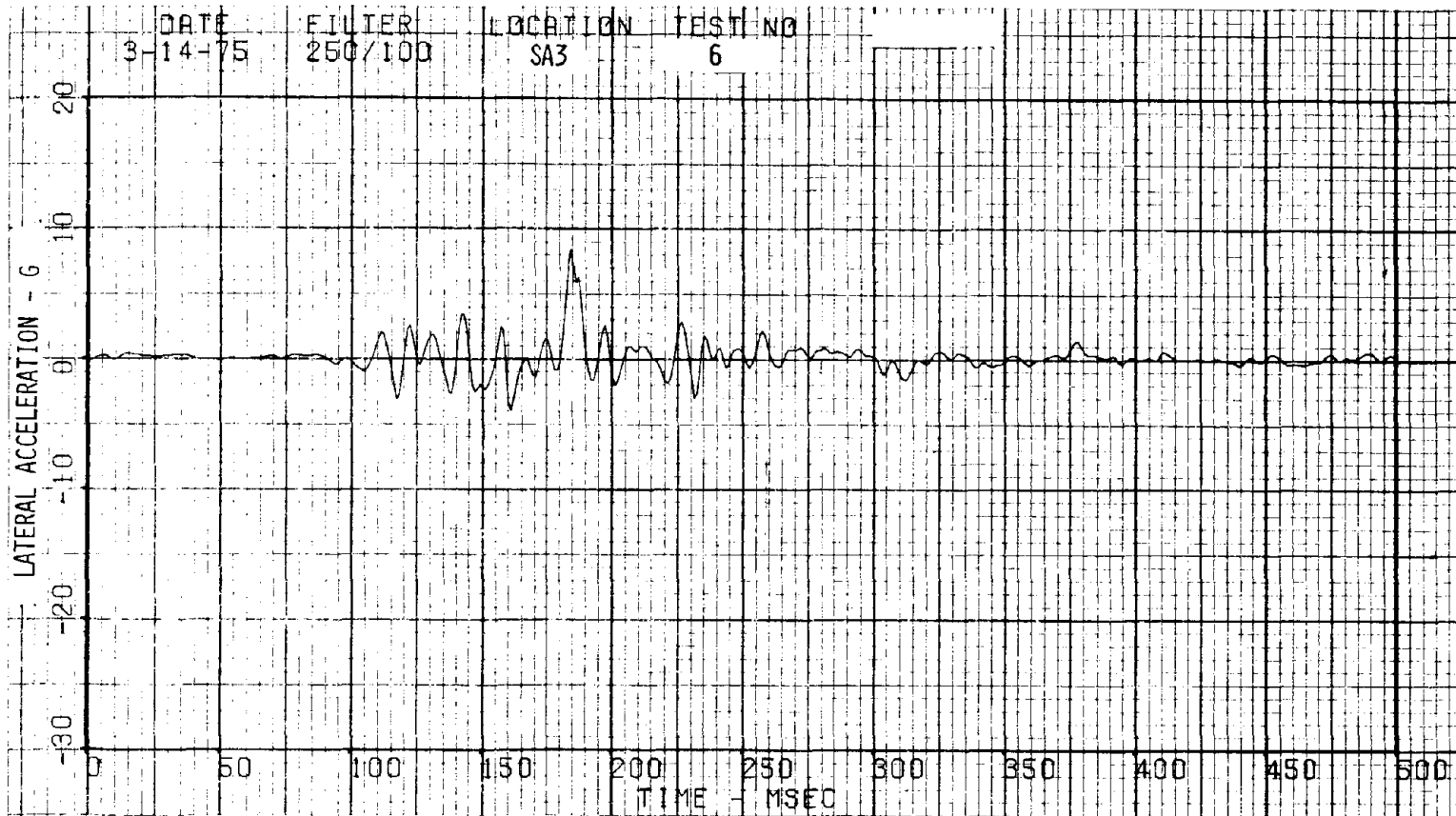


Figure A-175. Caboose Front Triaxial Accelerometer (Y) - Test 6.

A-174

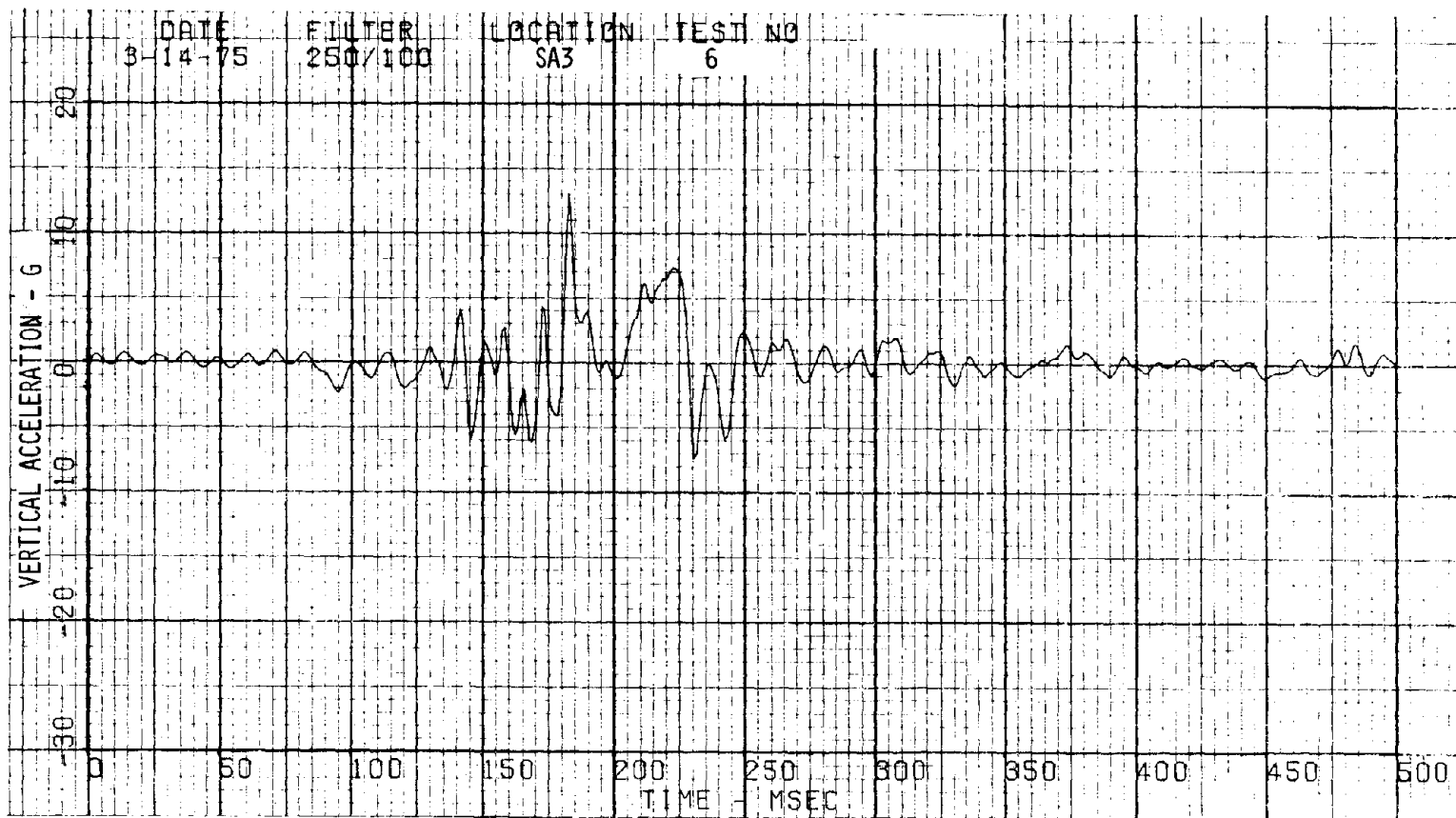


Figure A-176. Caboose Front Triaxial Accelerometer (Z) - Test 6.

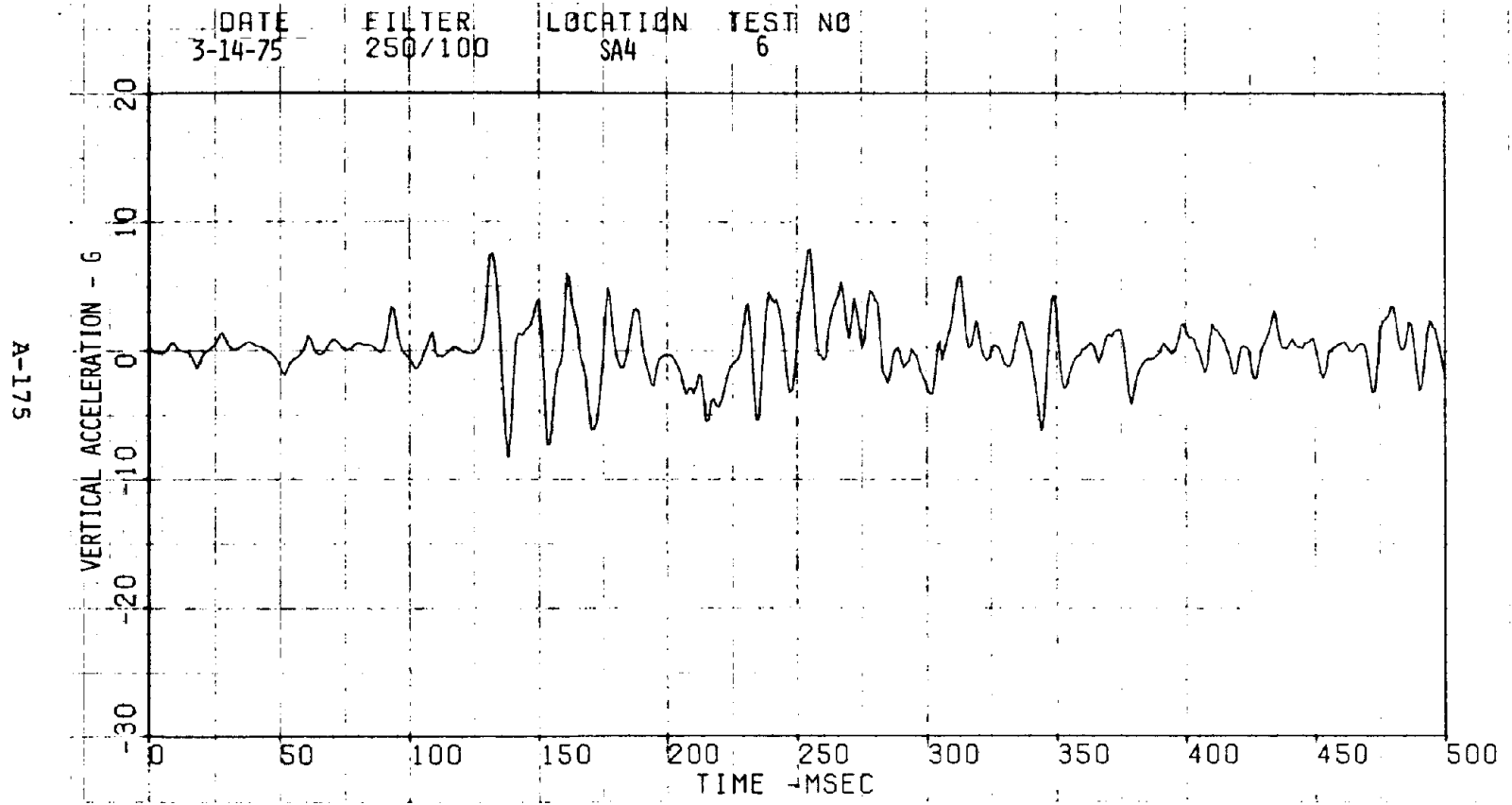


Figure A-177. Hopper 843 Rear Vertical Accelerometer - Test 6.

A-176

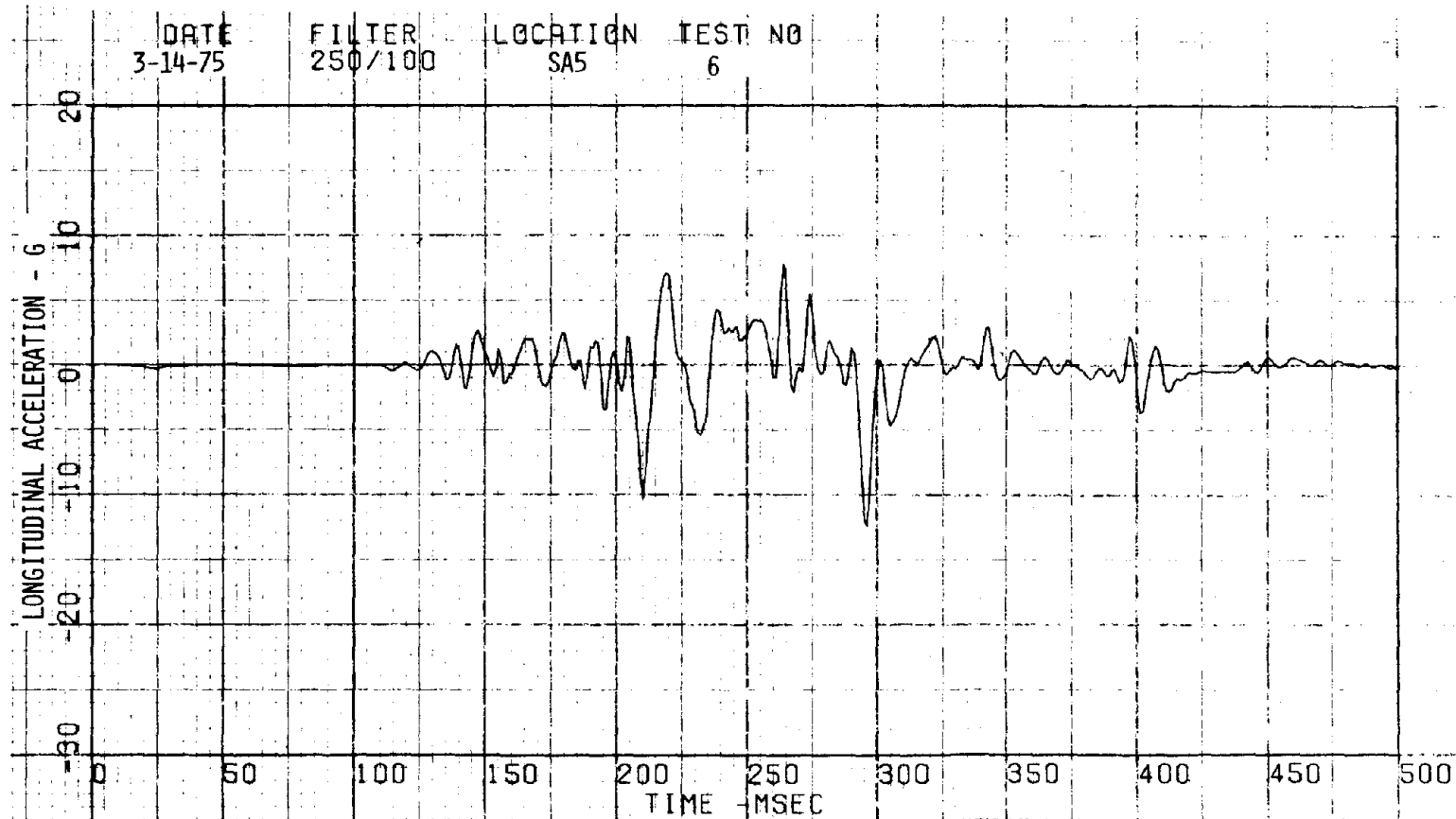


Figure A-178. Hopper 843 Center Longitudinal Accelerometer - Test 6.

A-177

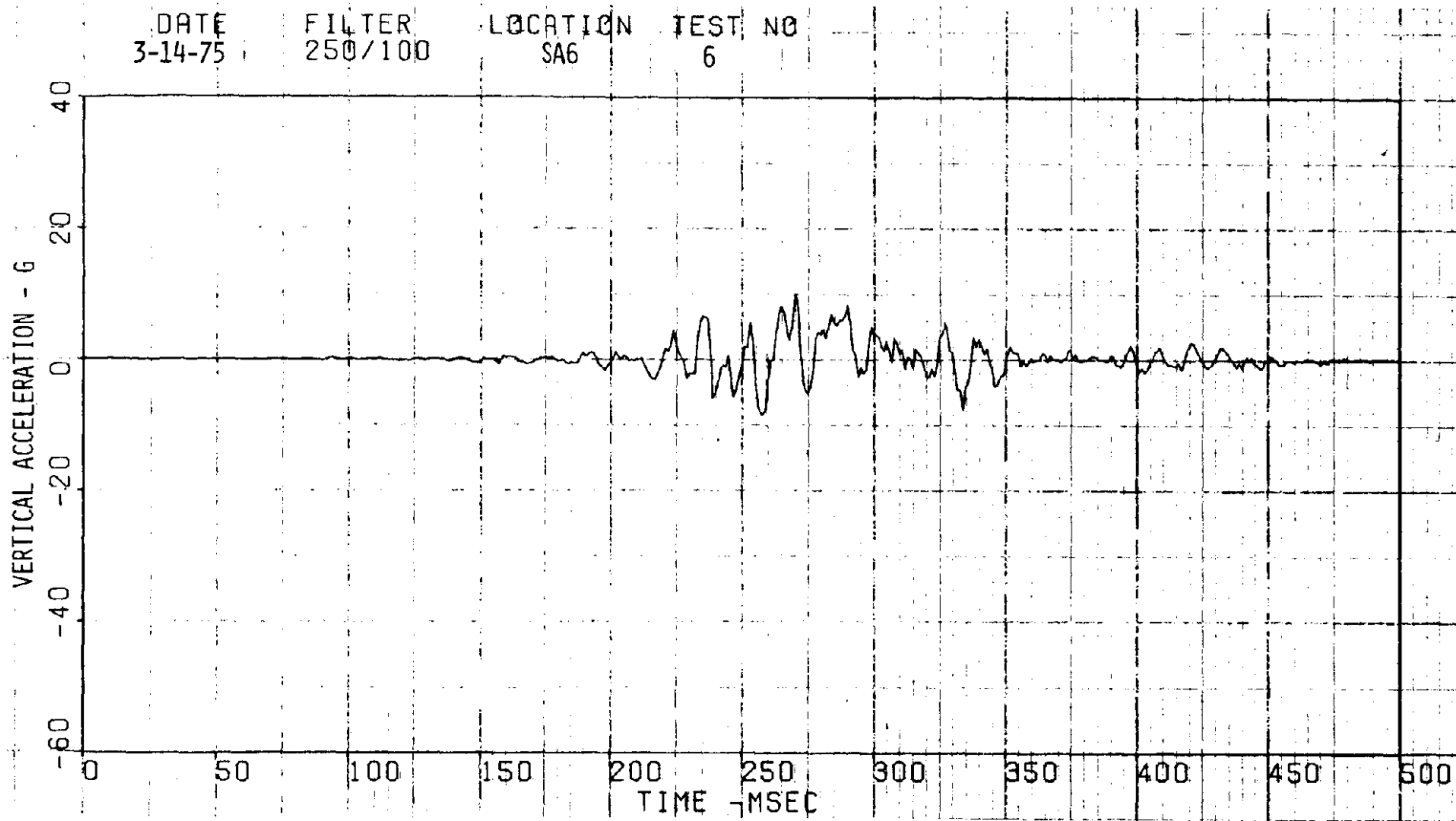


Figure A-179. Hopper 843 Front Vertical Accelerometer - Test 6.

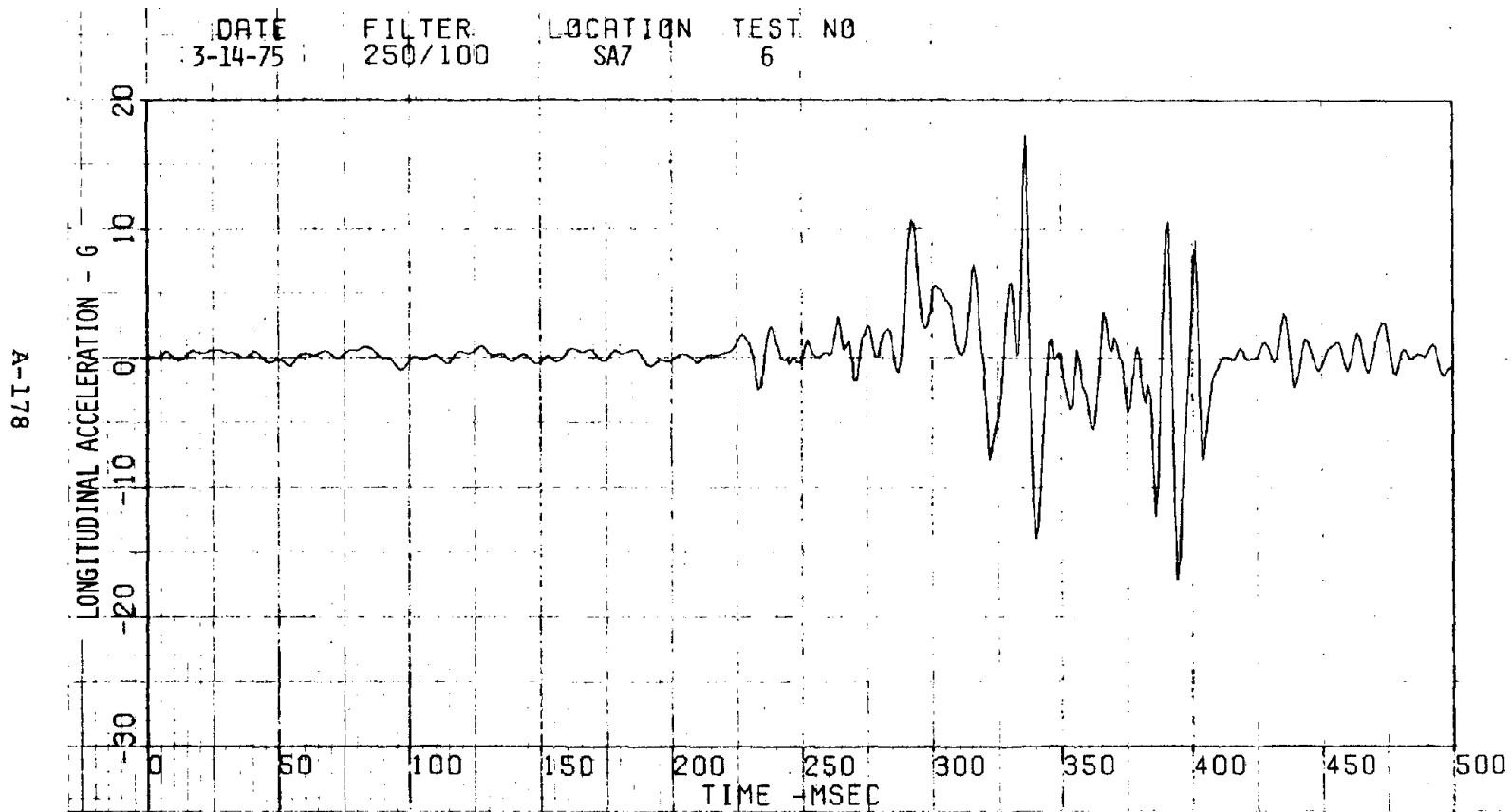


Figure A-180. Hopper 631 Center Longitudinal Accelerometer - Test 6.

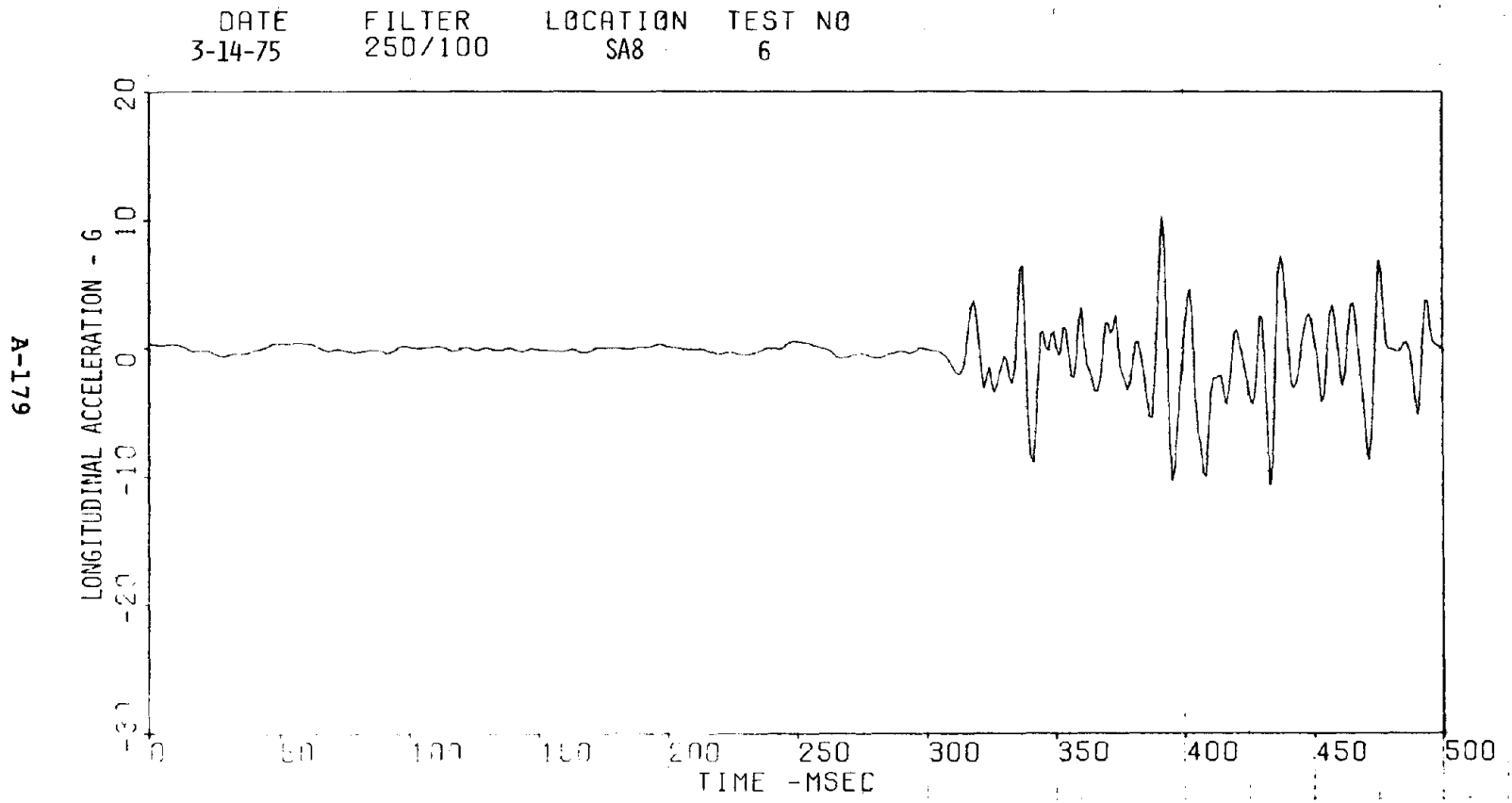


Figure A-181. Hopper 508 Center Longitudinal Accelerometer - Test 6.

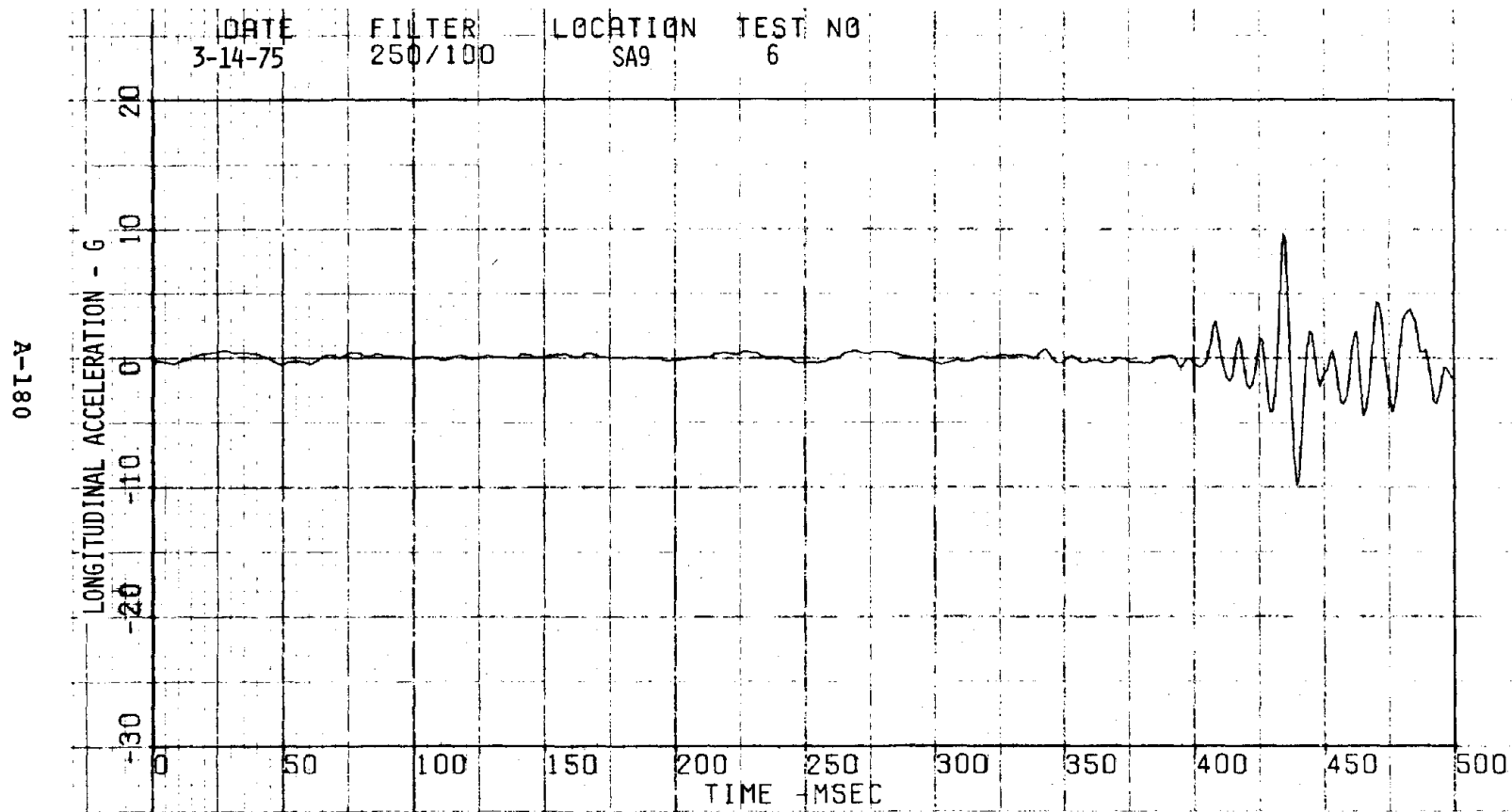


Figure A-182. Hopper 119 Center Longitudinal Accelerometer - Test 6.

A-181

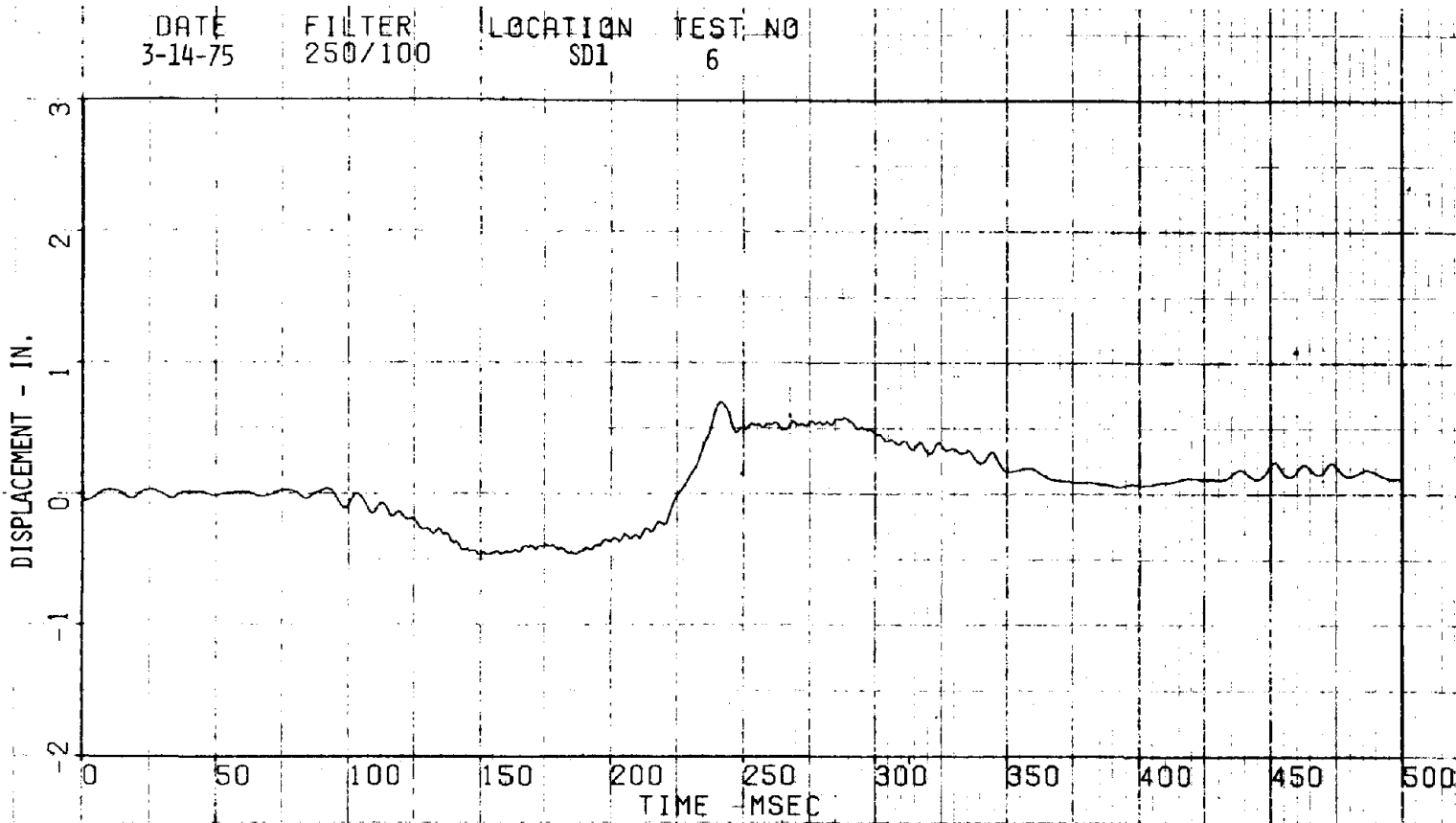


Figure A-183. Caboose Left Rear Displacement Transducer - Test 6.

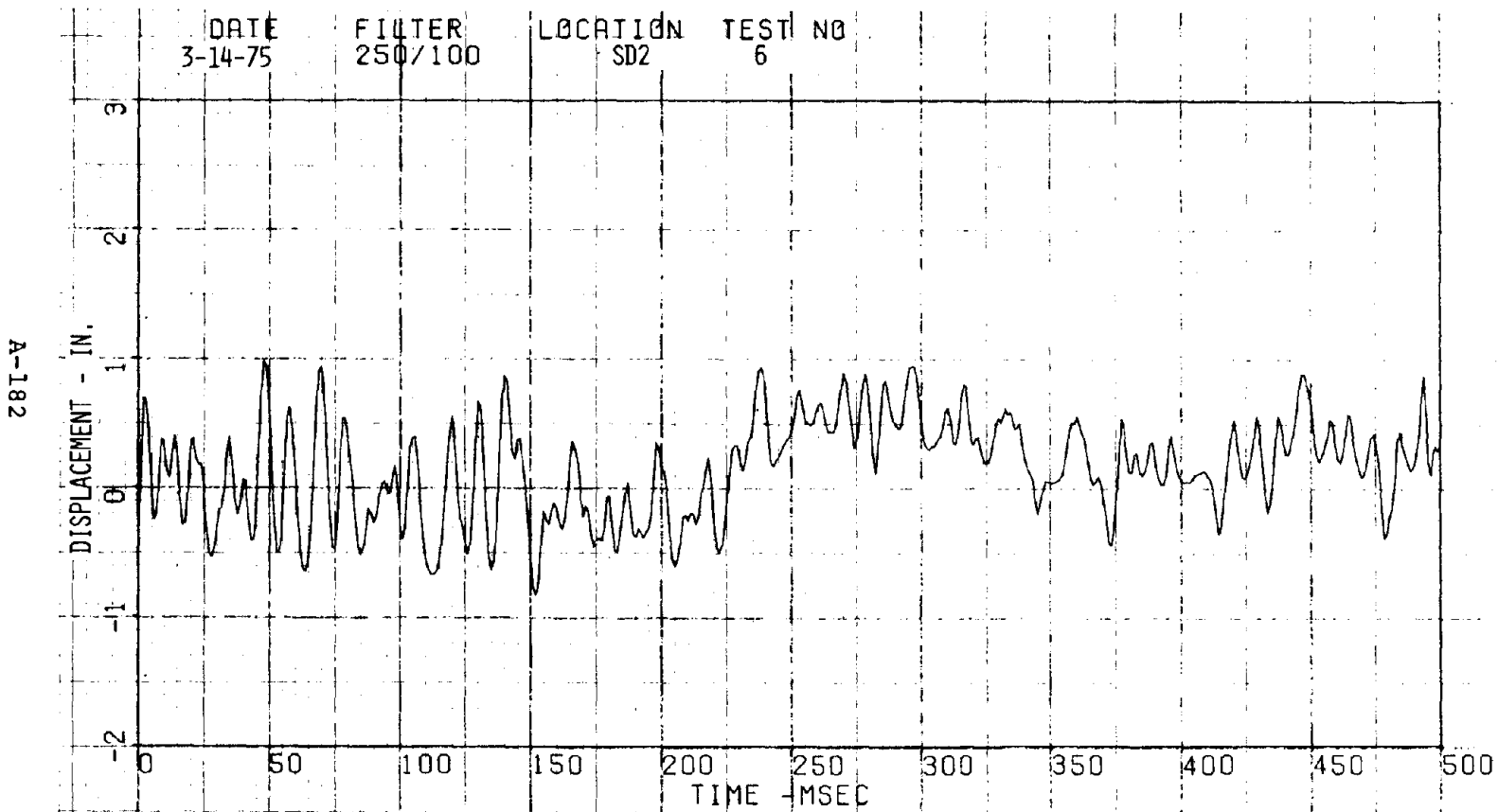


Figure A-184. Caboose Right Rear Displacement Transducer - Test 6.

A-183

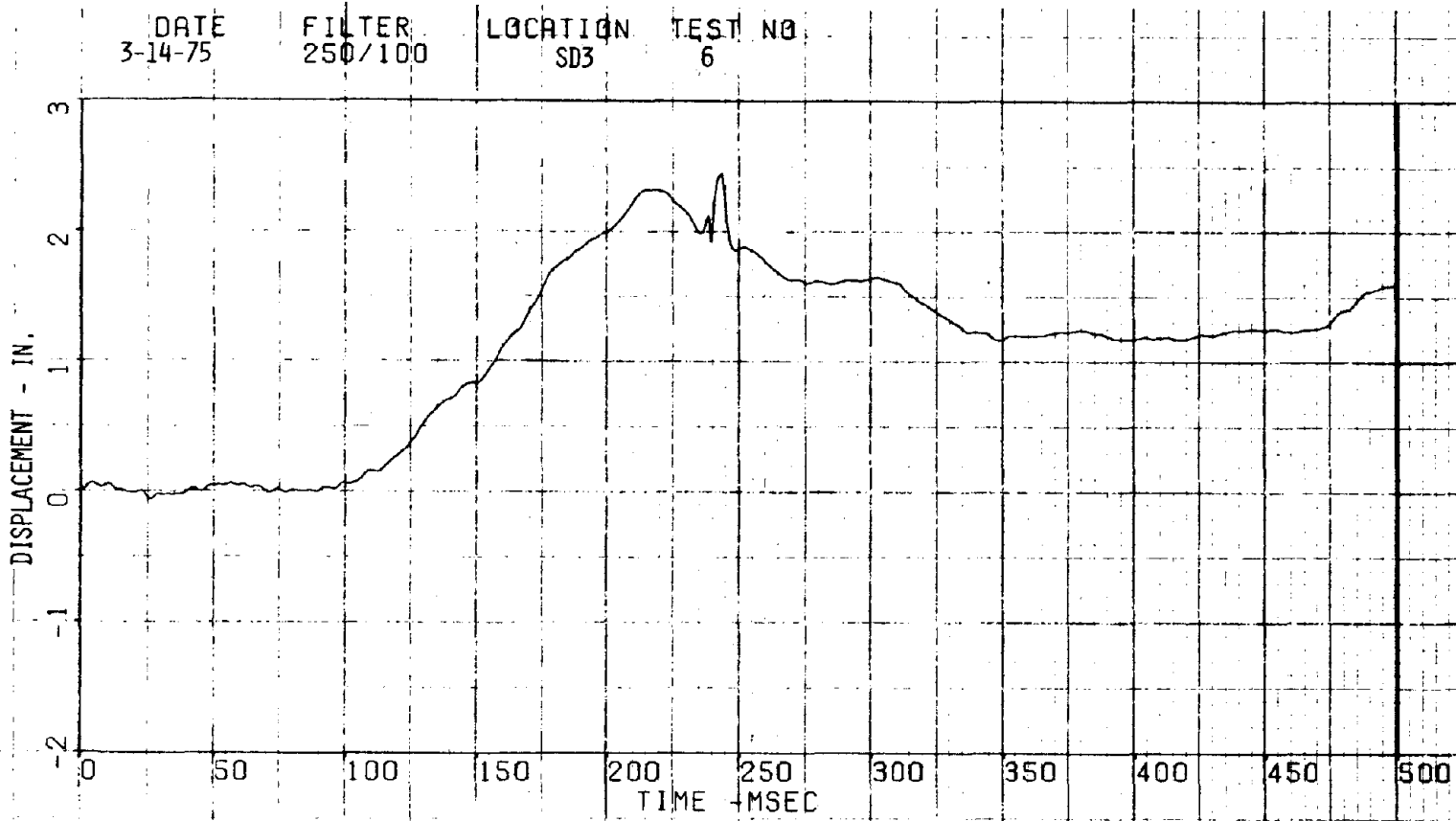


Figure A-185. Caboose Left Front Displacement Transducer - Test 6.

A-184

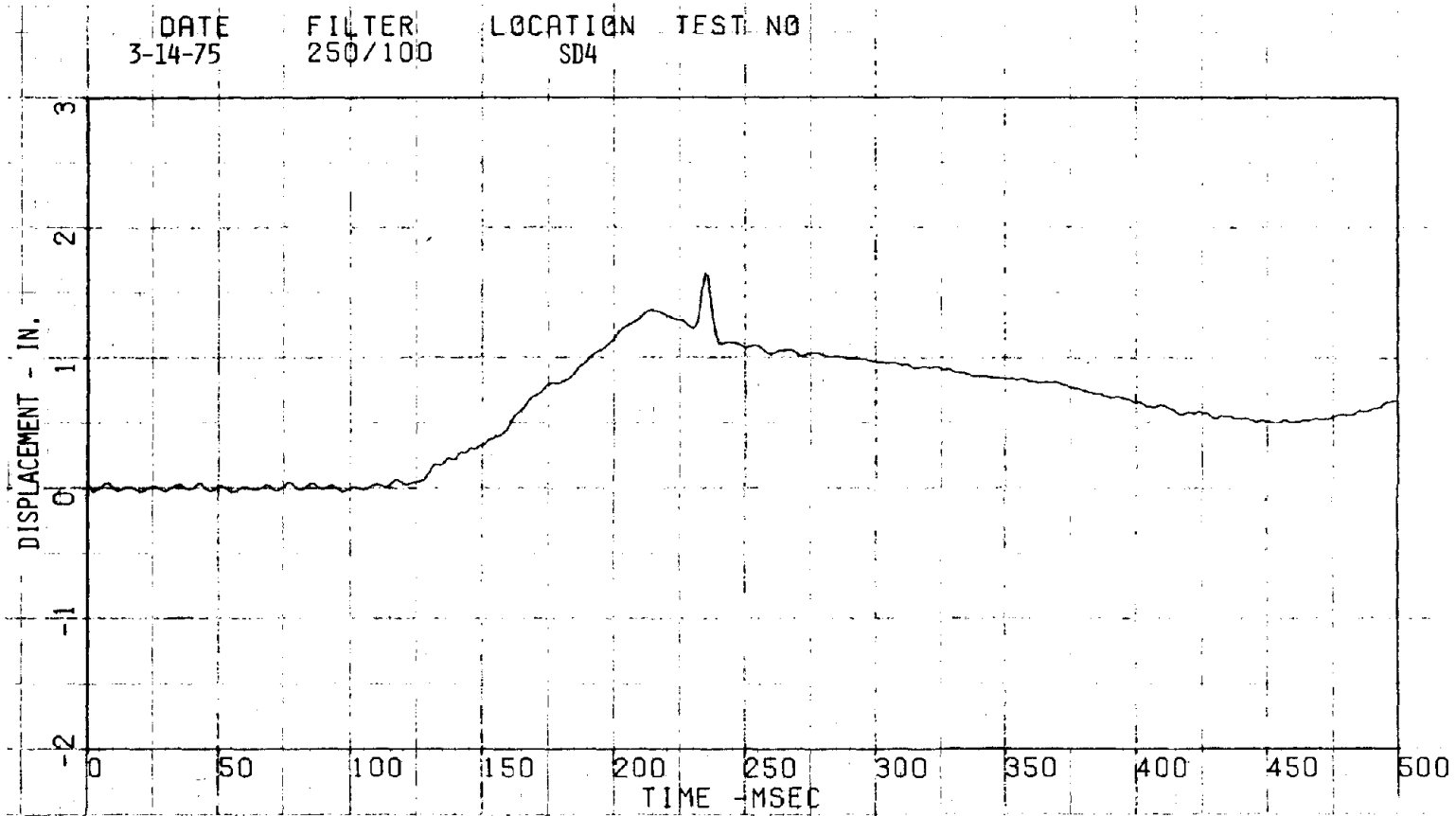


Figure A-186. Caboose Right Front Displacement Transducer - Test 6.

A-185

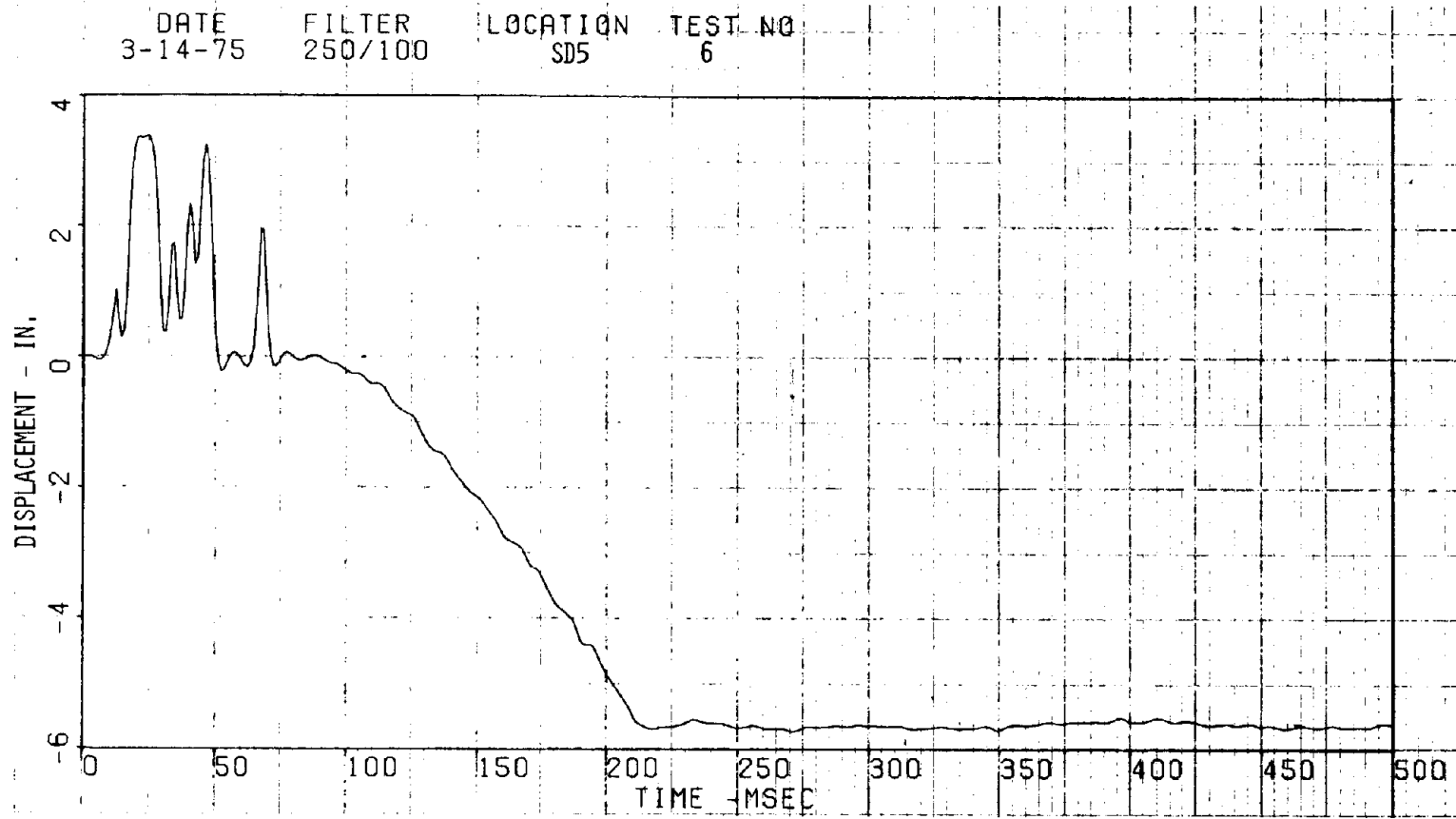


Figure A-187. Caboose to Hopper Displacement Transducer - Test 6.

A-186

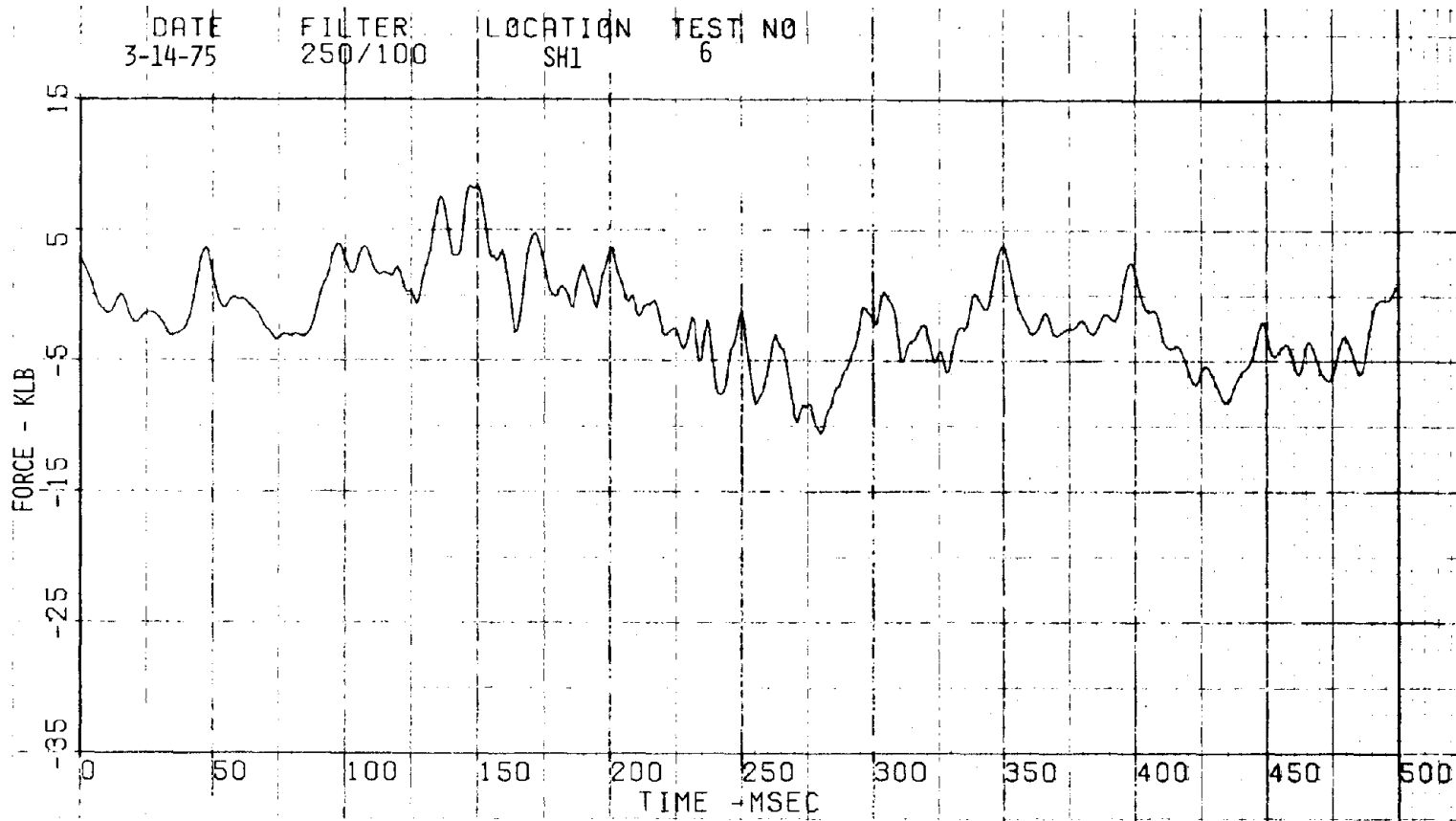


Figure A-188. Caboose Rear Swinghanger Strain Gauge - Test 6.

A-187

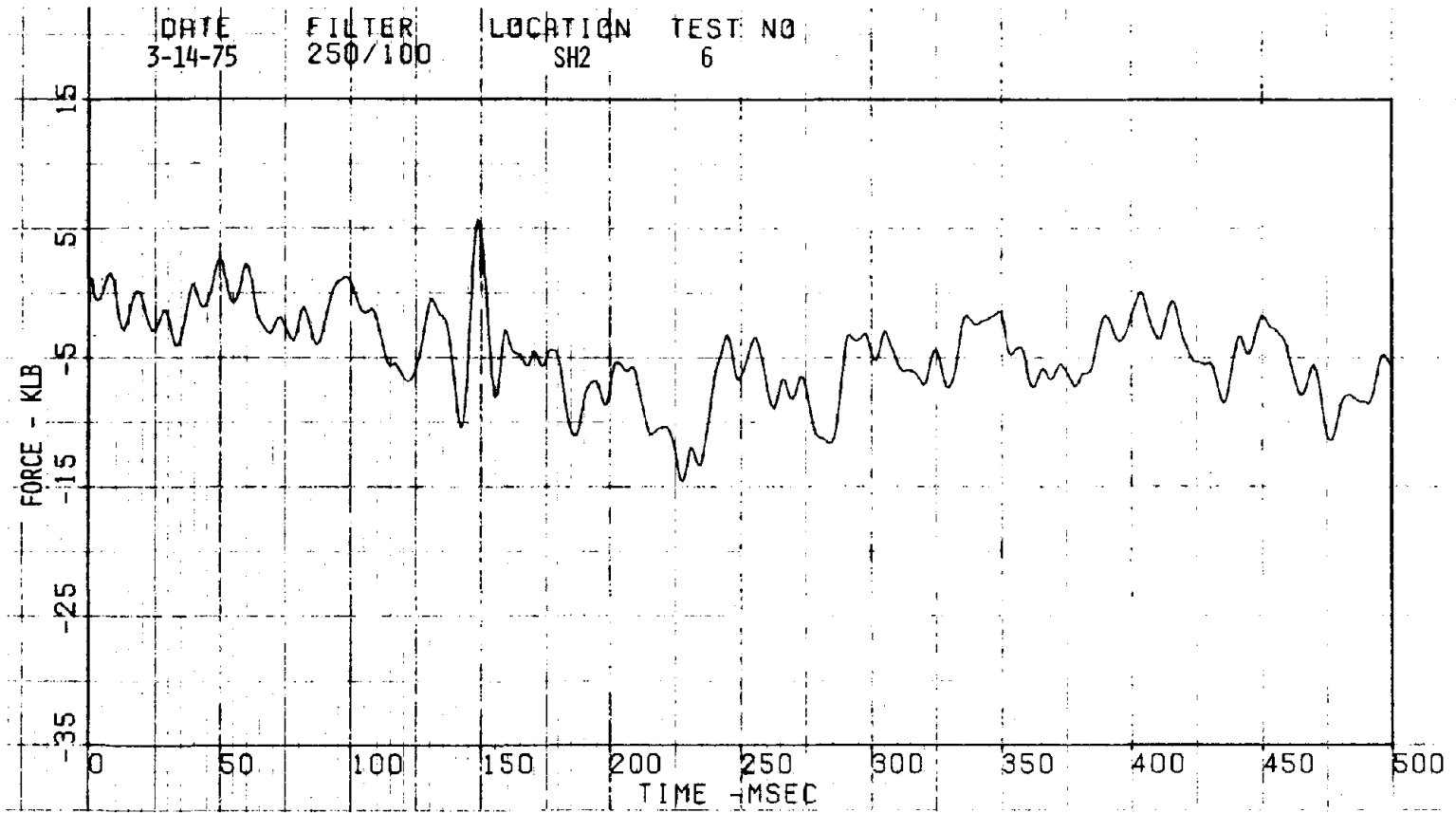


Figure A-189. Caboose Front Swinghanger Strain Gauge - Test 6.

A-188

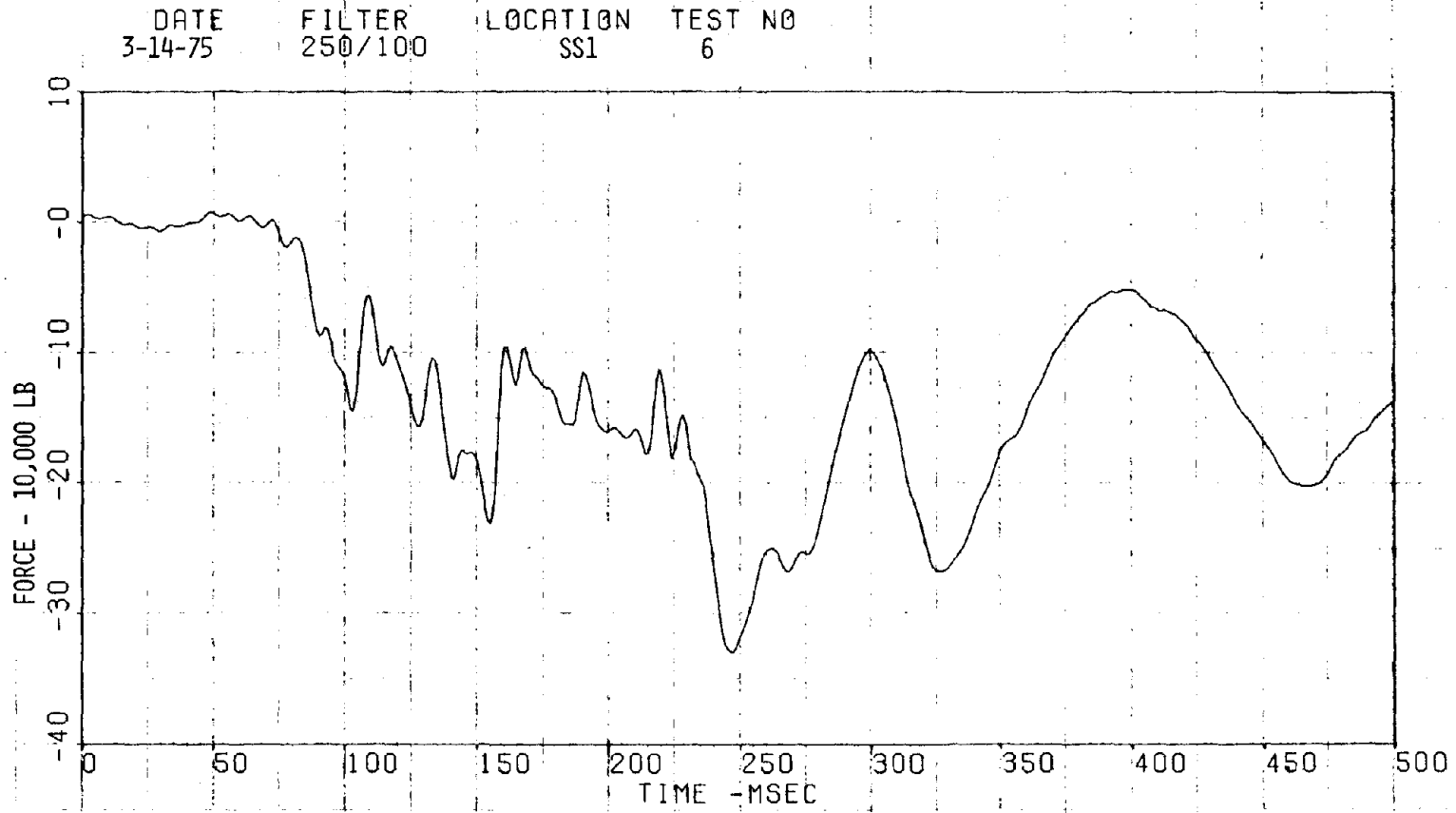


Figure A-190. Caboose Rear Coupler Strain Gauge - Test 6.

68T-V

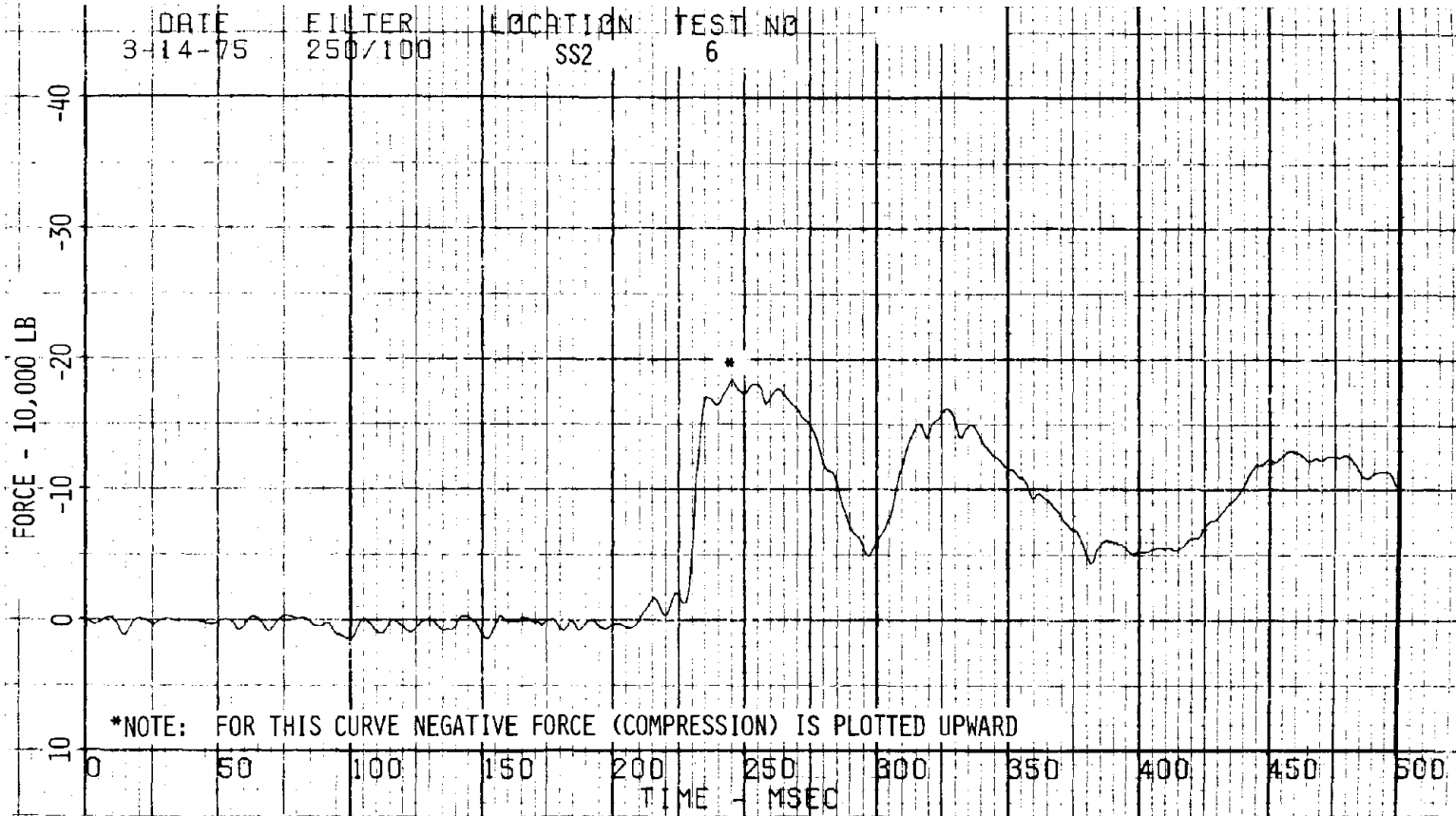


Figure A-191. Caboose Center Sill Strain Gauge - Test 6.

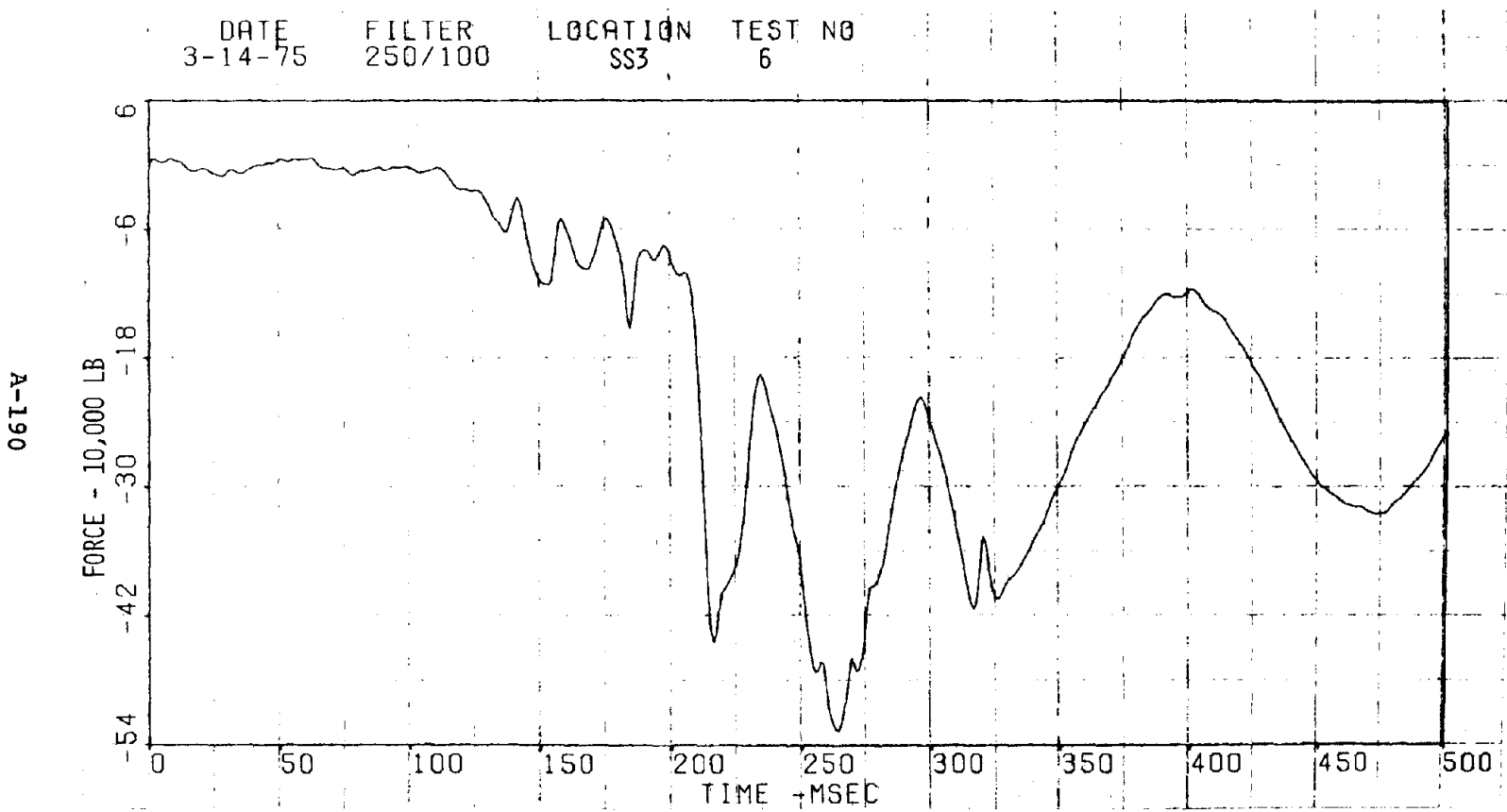


Figure A-192. Caboose Front Coupler Strain Gauge - Test 6.

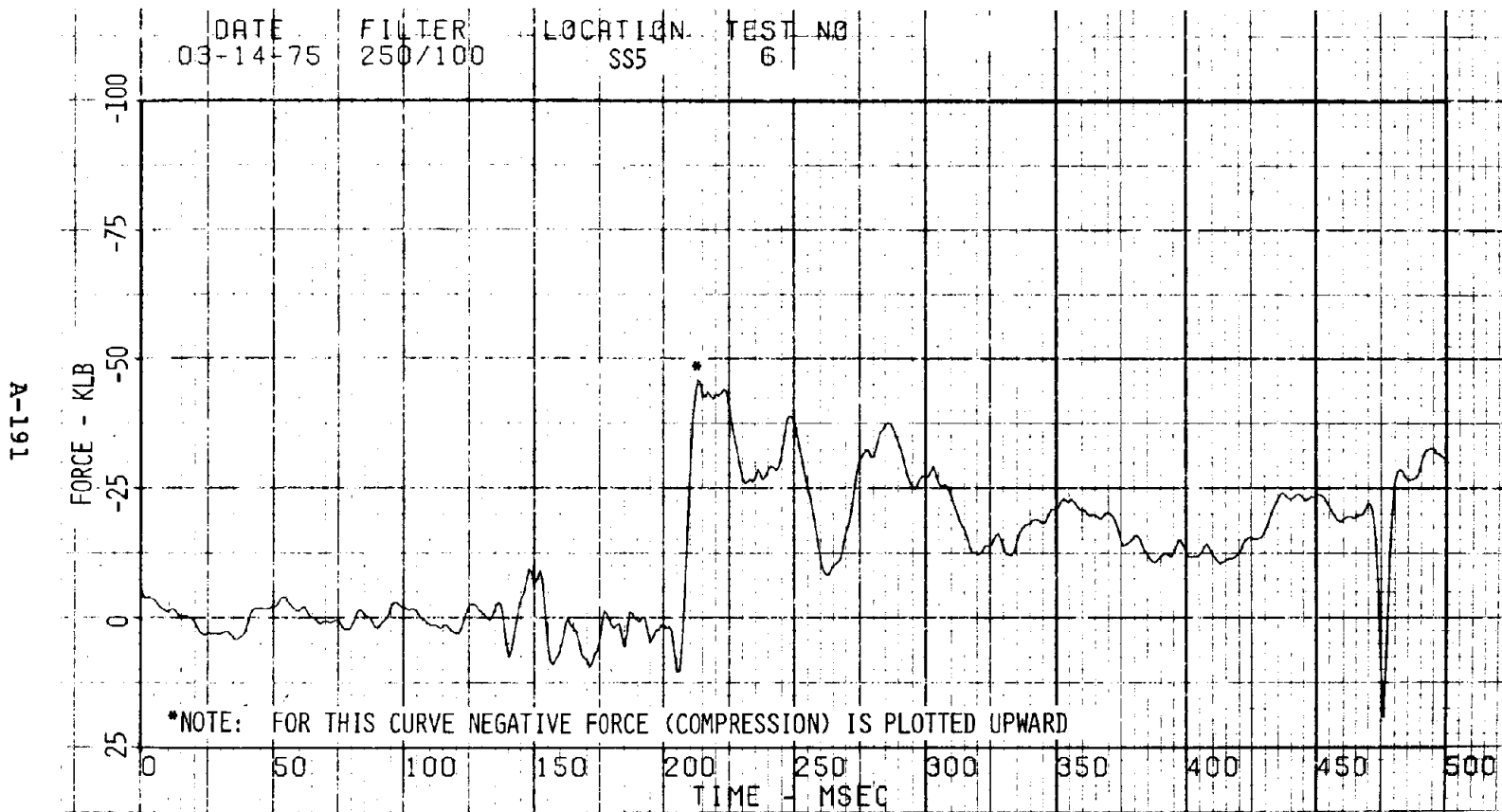


Figure A-193. Hopper Center Sill Strain Gauge - Test 6.

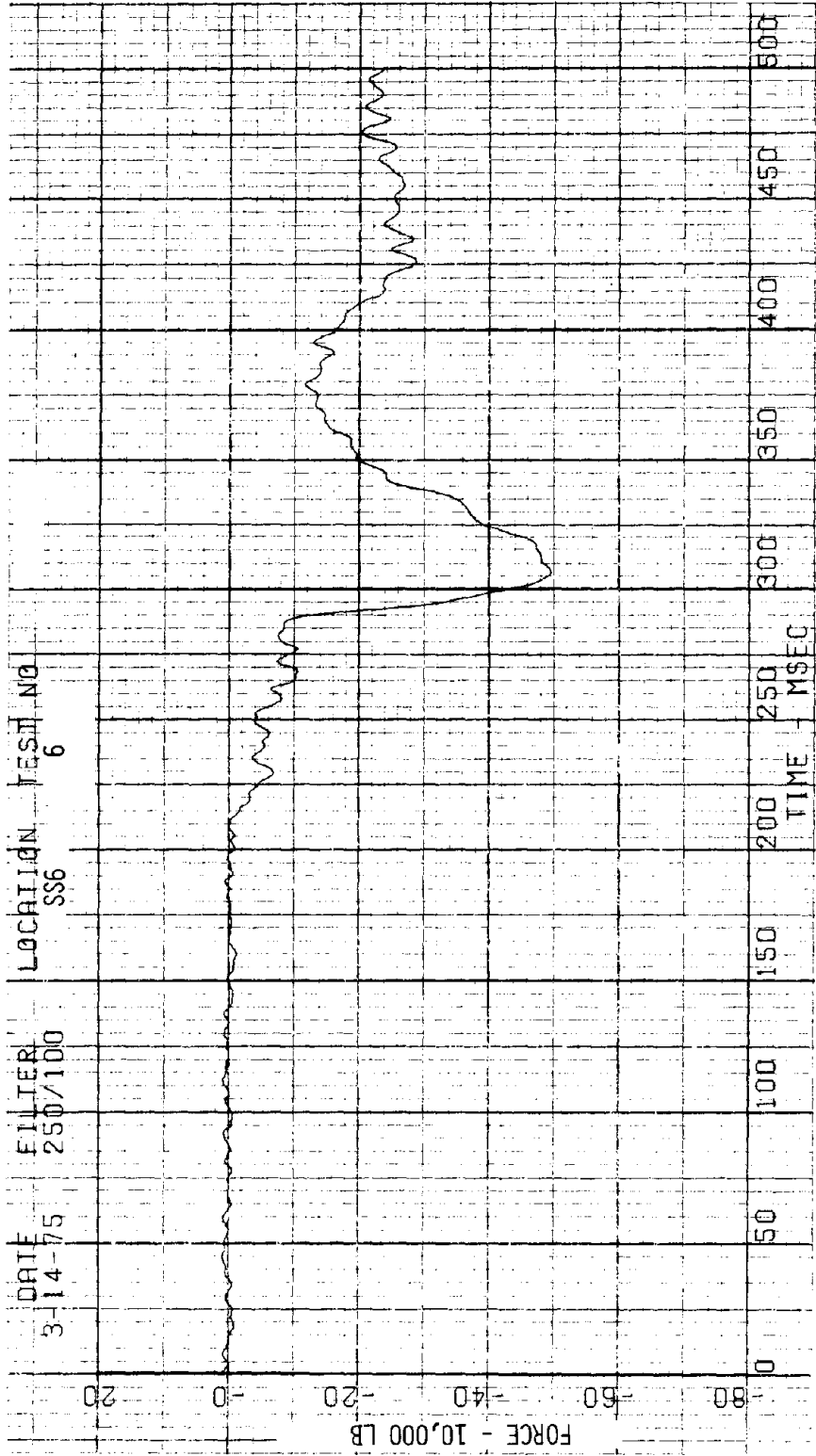


Figure A-194. Hopper 631 Rear Coupler Strain Gauge - Test 6.

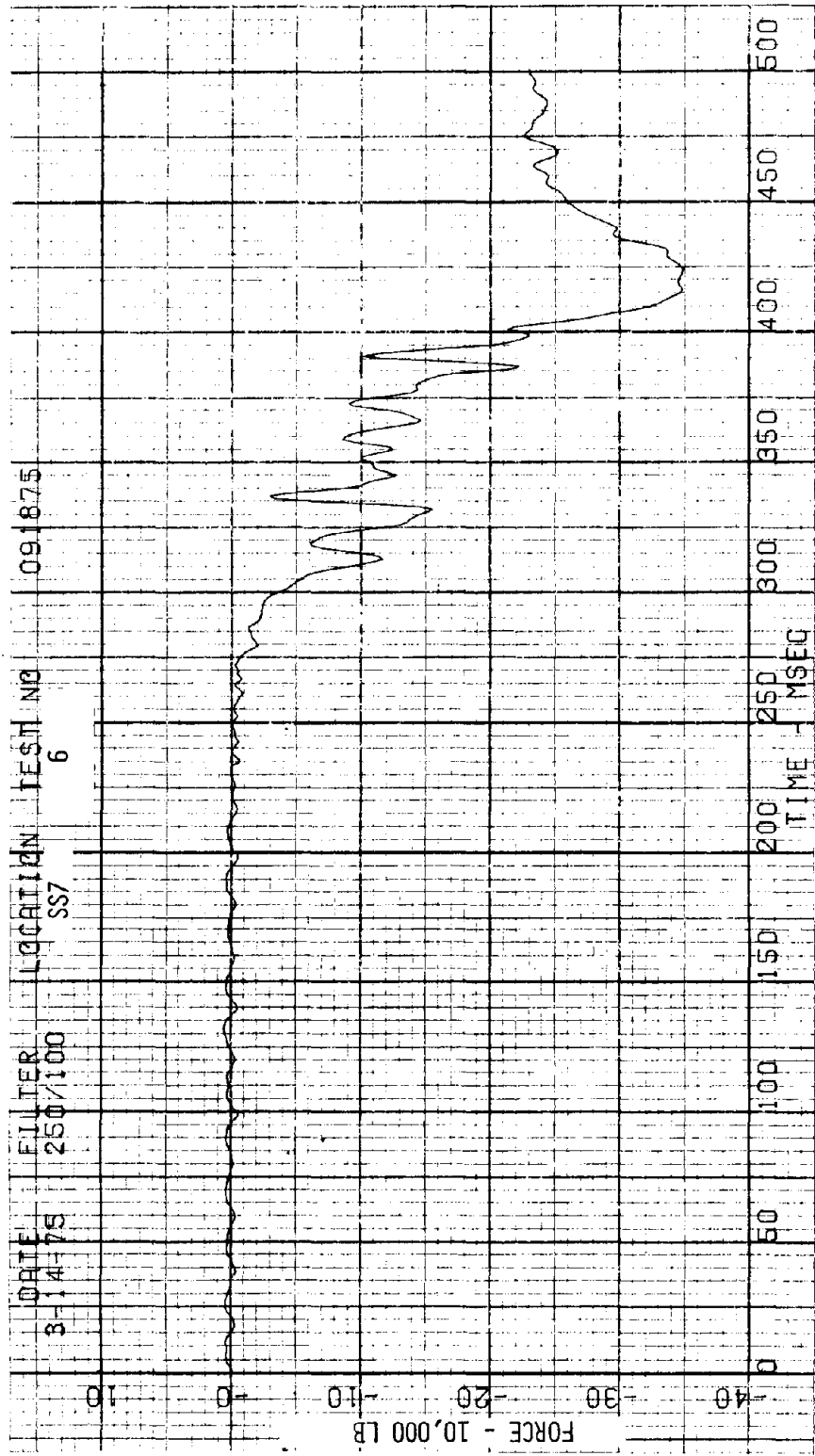
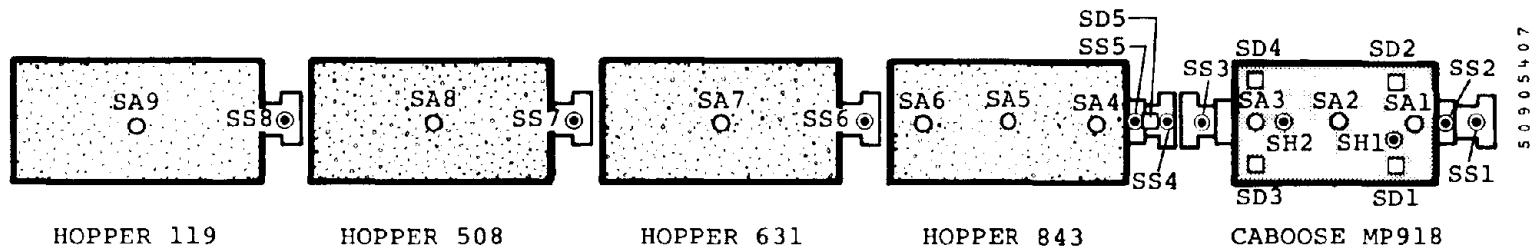
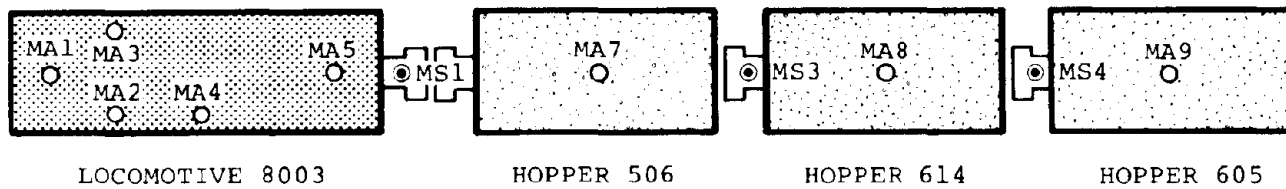


Figure A-195. Hopper 508 Rear Coupler Strain Gauge - Test 6.



- HOPPER LOADED
 - TRAIN IN BUFF
- STANDING TRAIN

A-194



MOTION

- IMPACT VELOCITY = 7.8 MPH

MOVING TRAIN

Figure A-196. Instrument Locations - Test 7.

A-195

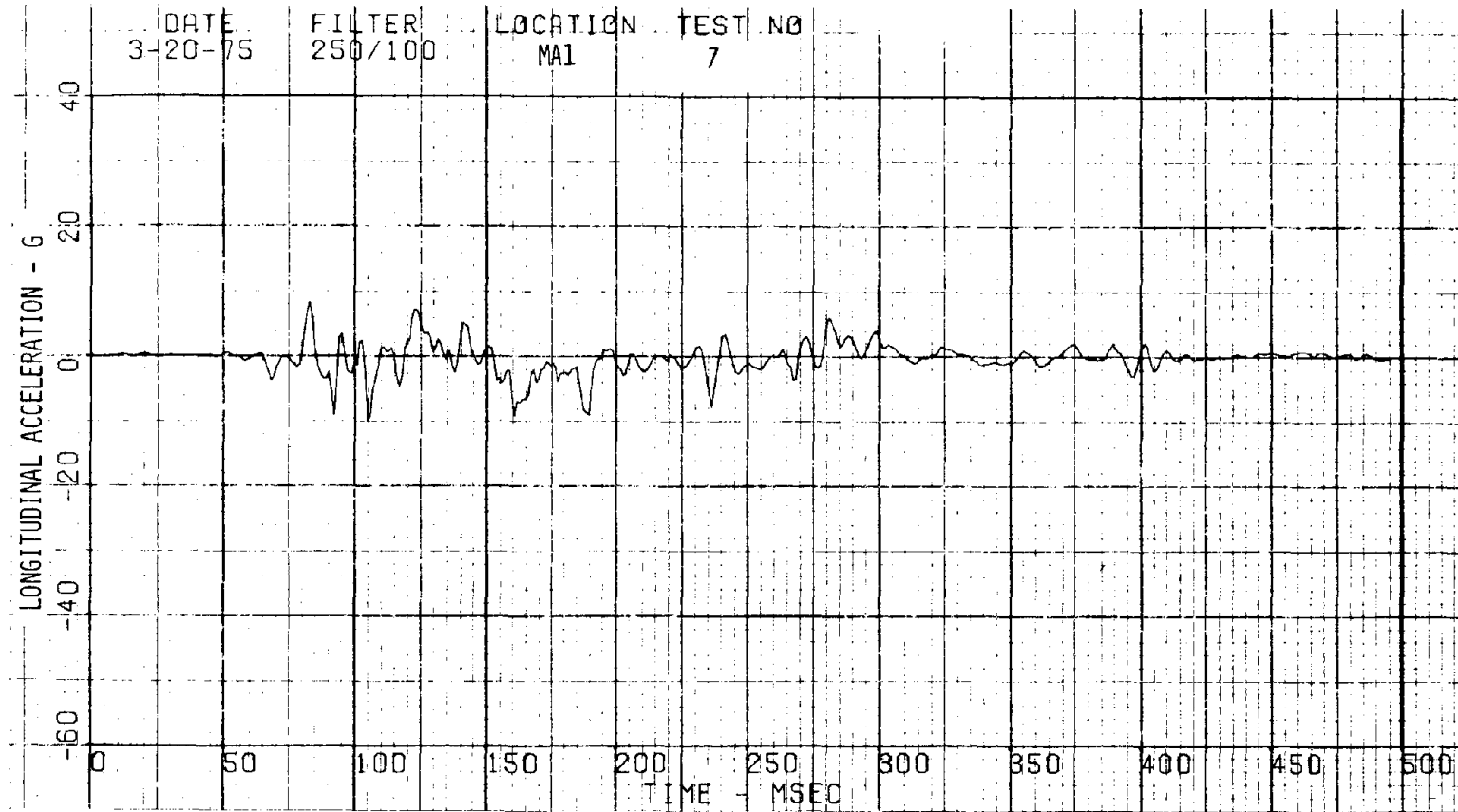


Figure A-197. Locomotive Rear Triaxial Accelerometer (X) - Test 7.

A-196

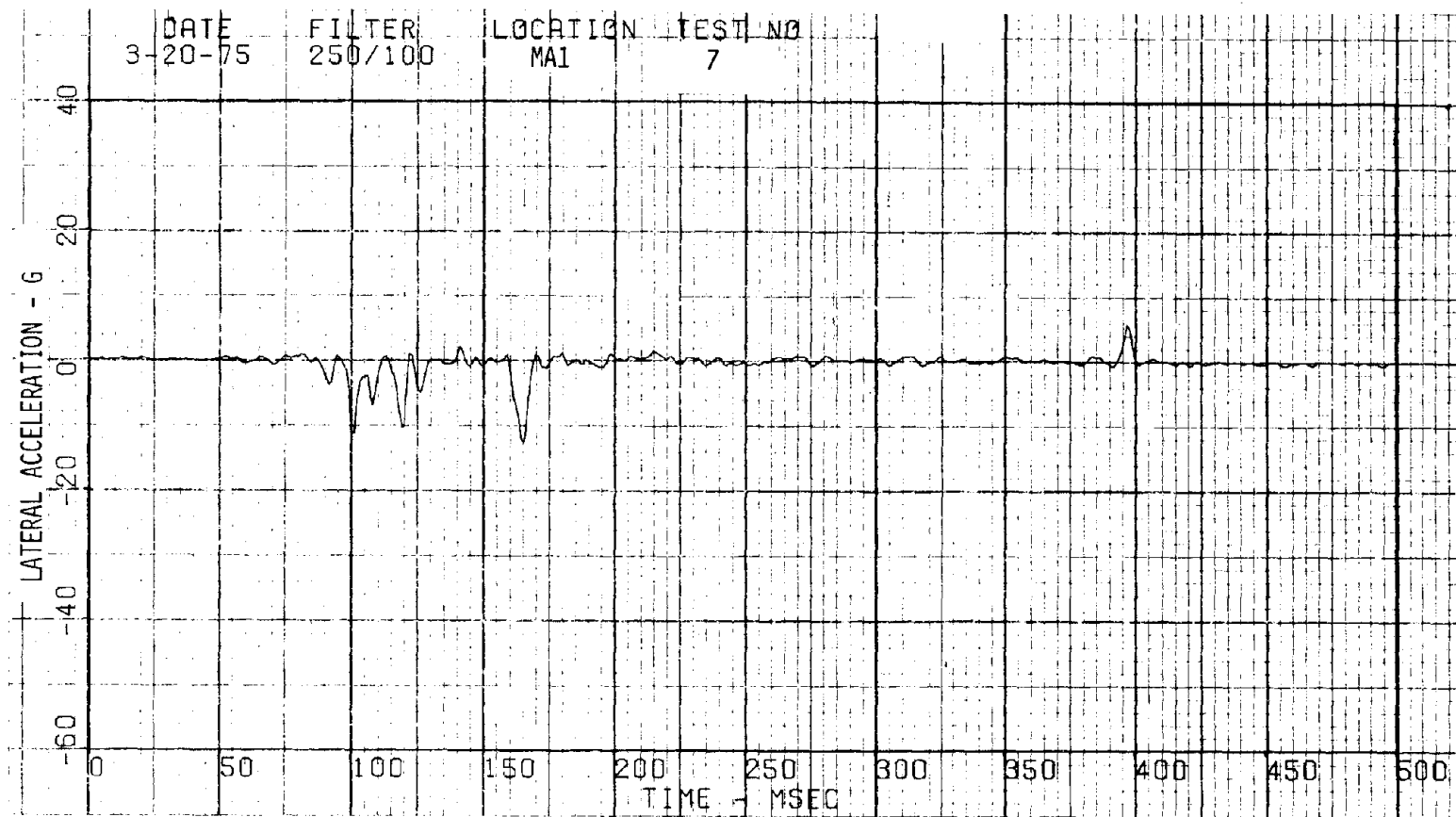


Figure A-198. Locomotive Rear Triaxial Accelerometer (Y) - Test 7.

A-197

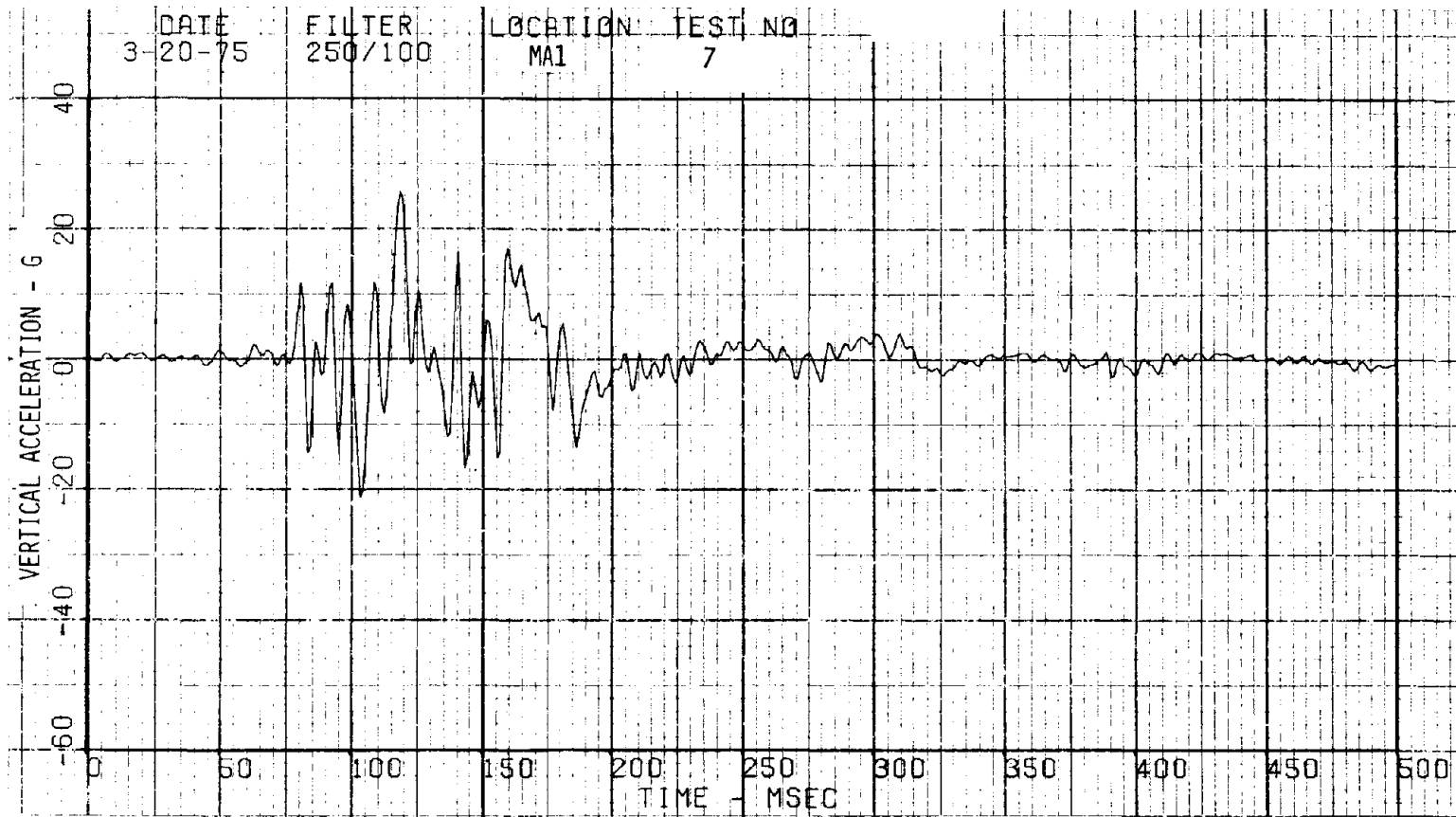


Figure A-199. Locomotive Rear Triaxial Accelerometer (Z) - Test 7.

86T-V

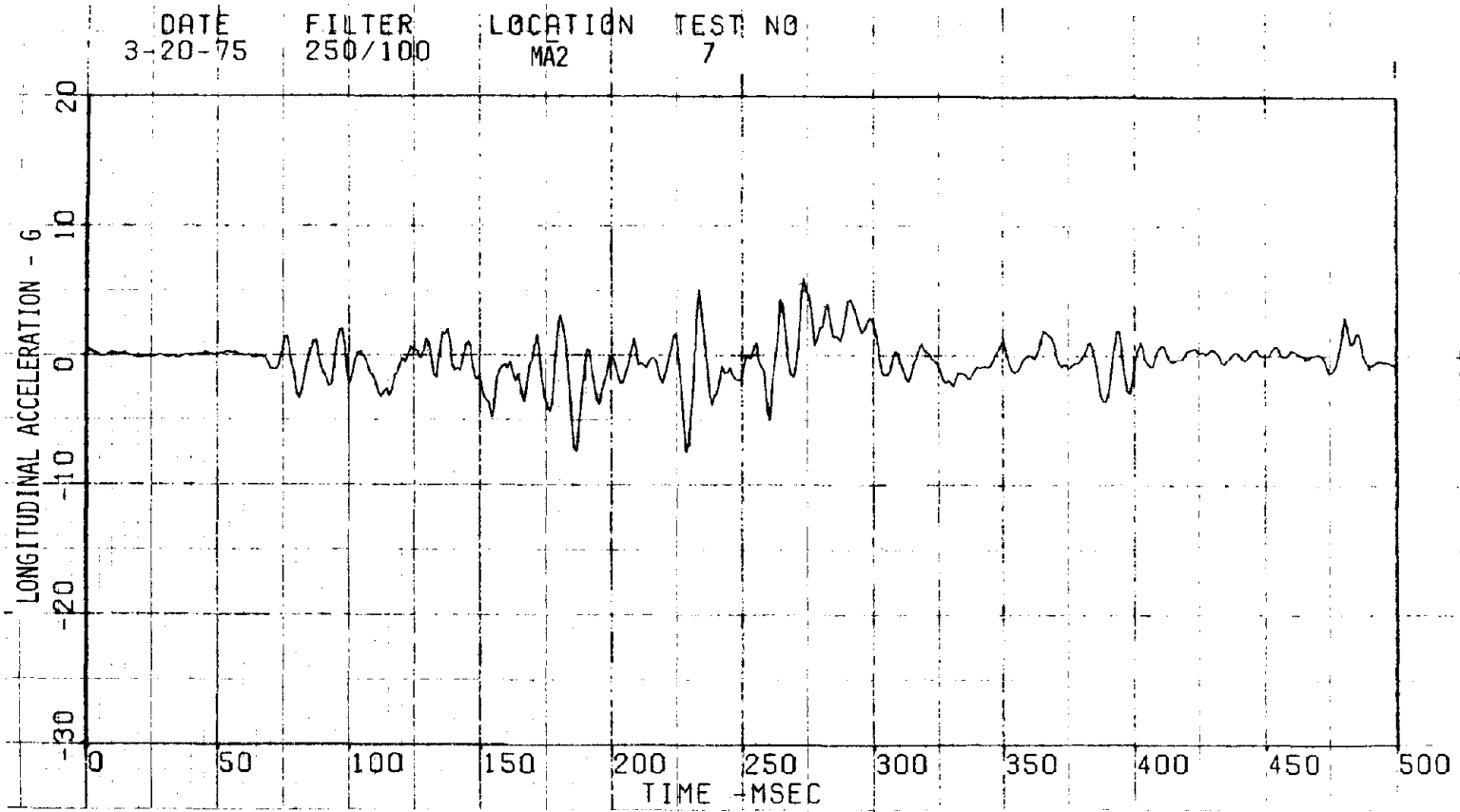


Figure A-200. Locomotive Left Cab Accelerometer - Test 7.

A-199

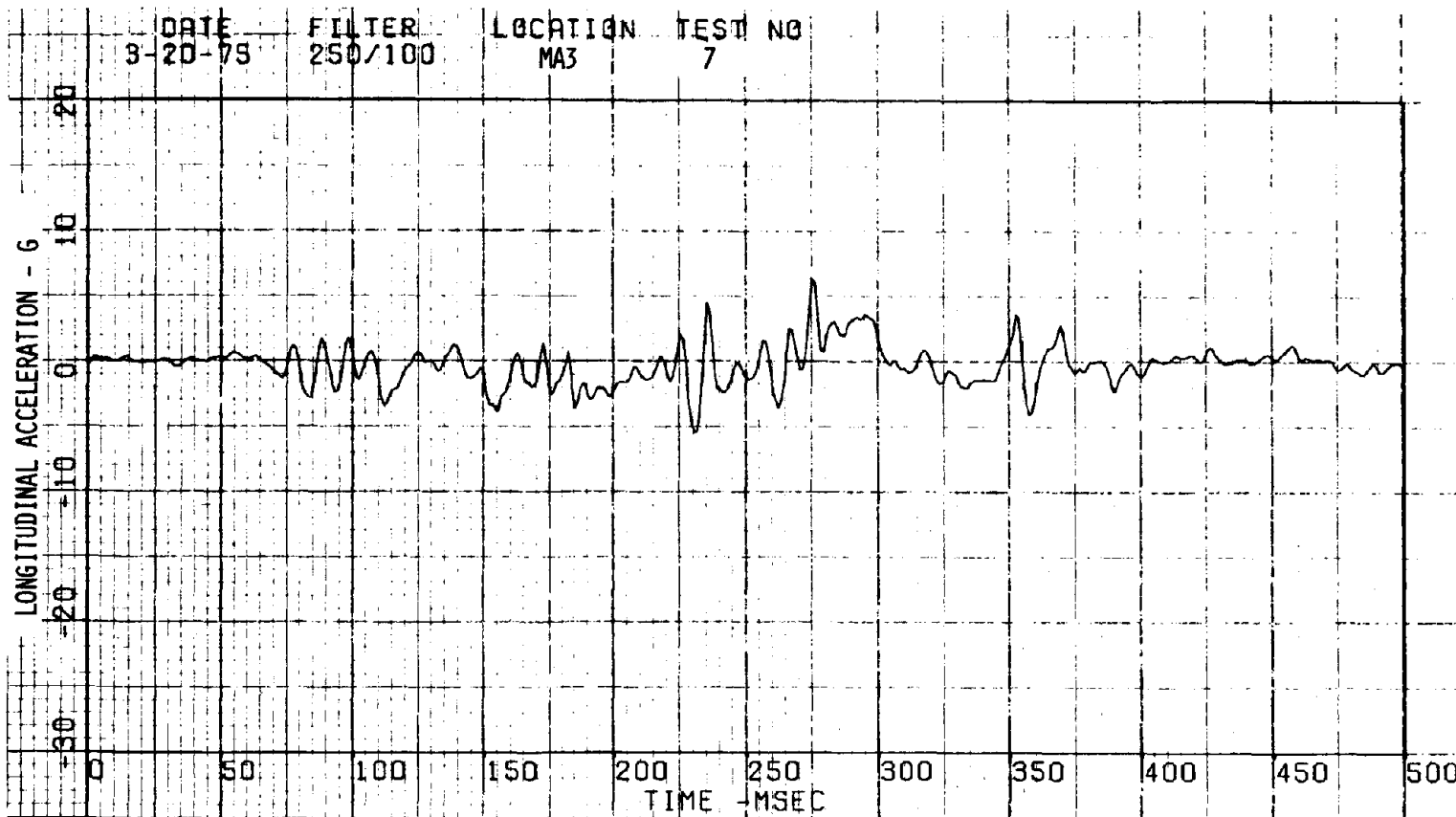


Figure A-201. Locomotive Right Cab Accelerometer - Test 7.

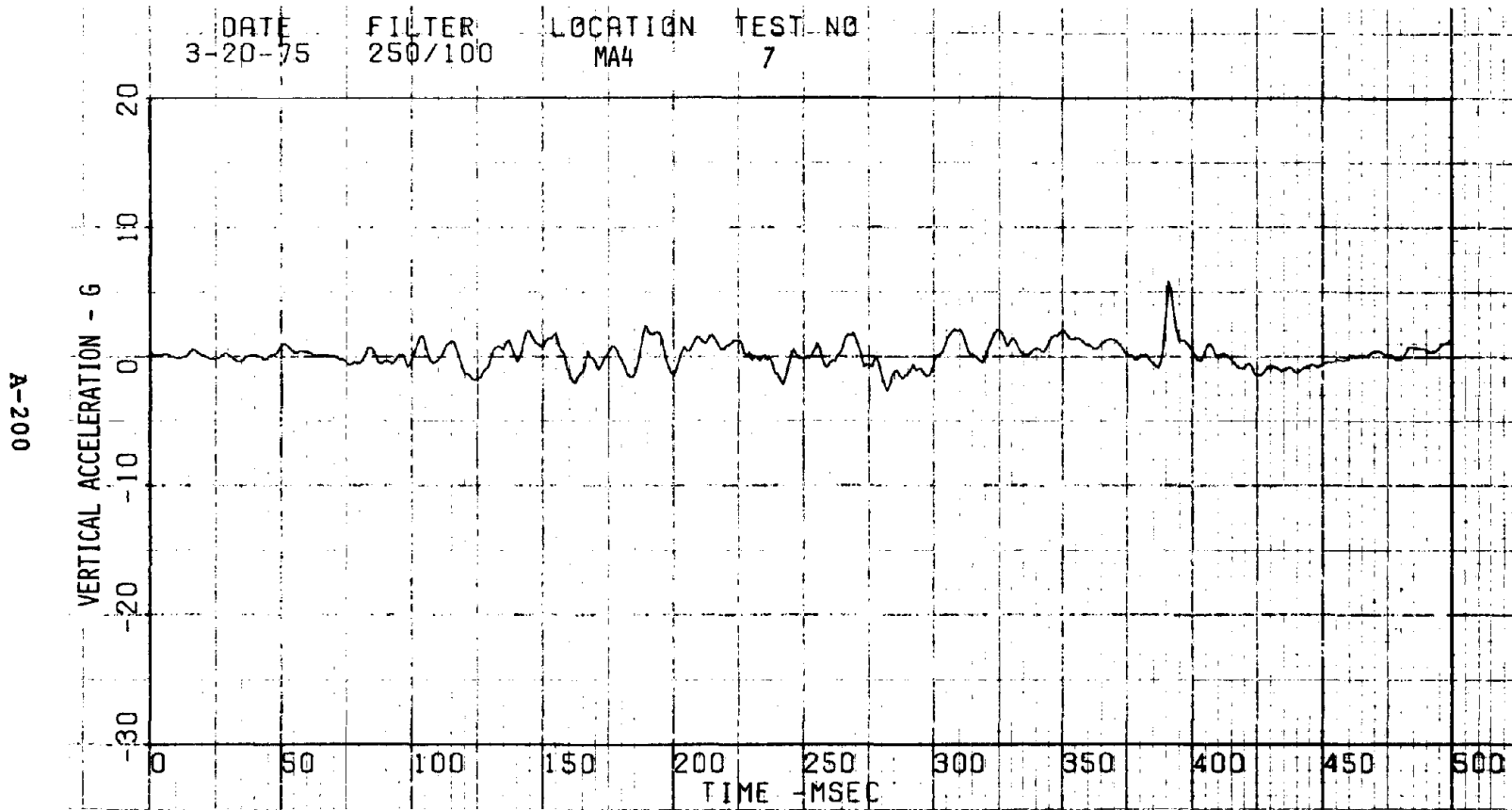


Figure A-202. Locomotive Center Vertical Accelerometer - Test 7.

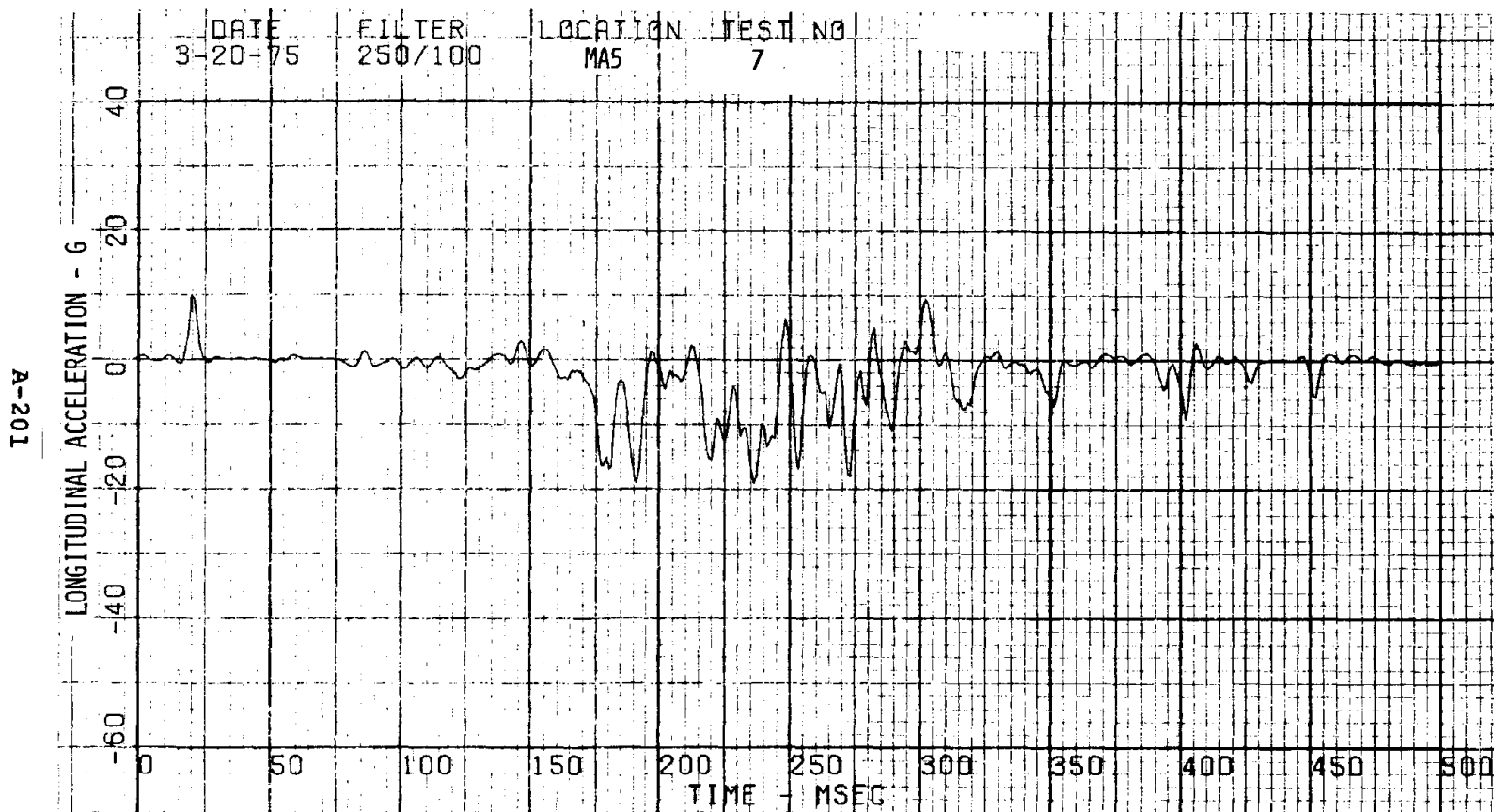


Figure A-203. Locomotive Front Triaxial Accelerometer (X) - Test 7.

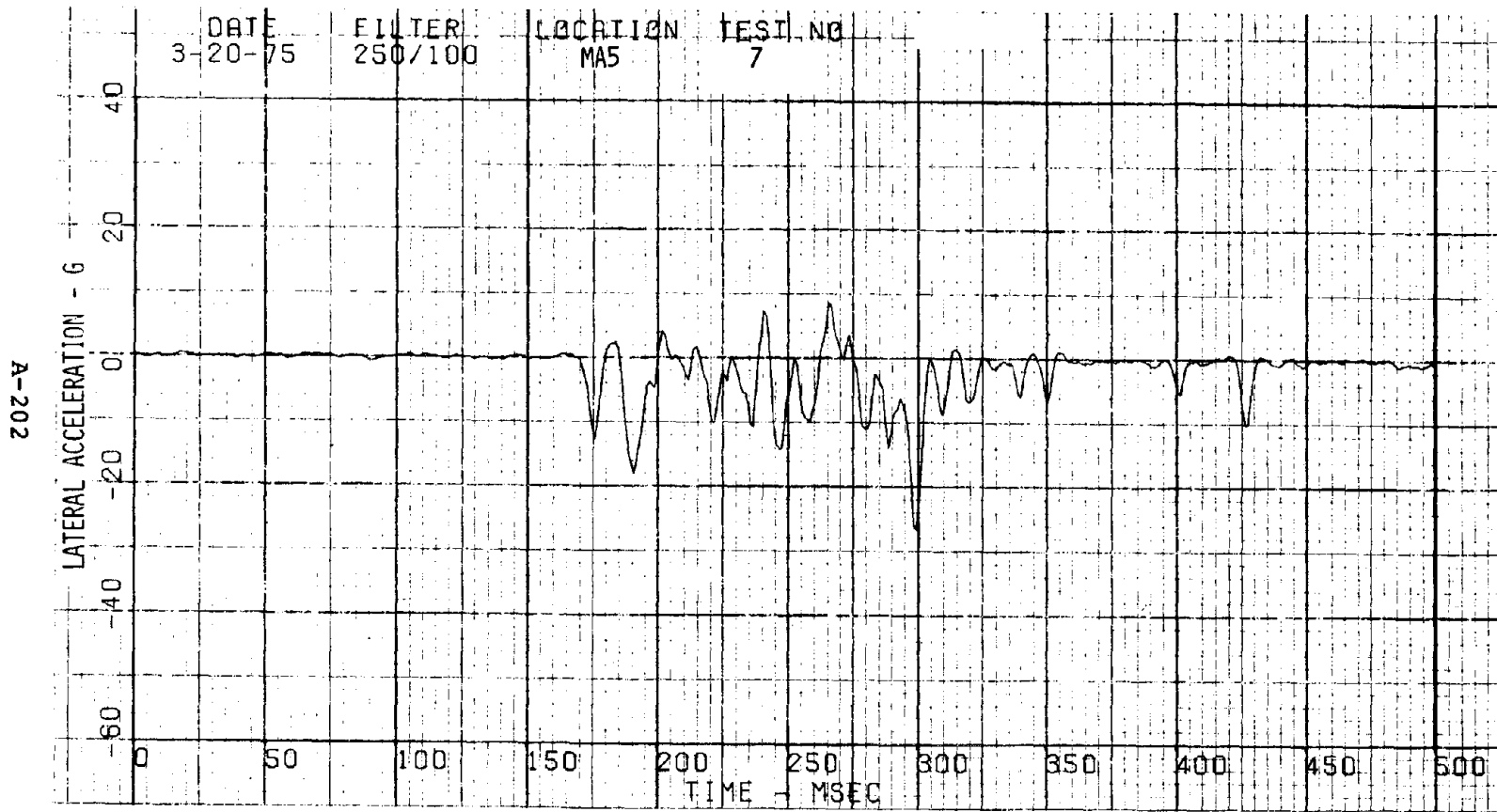


Figure A-204. Locomotive Front Triaxial Accelerometer (Y) - Test 7.

A-203

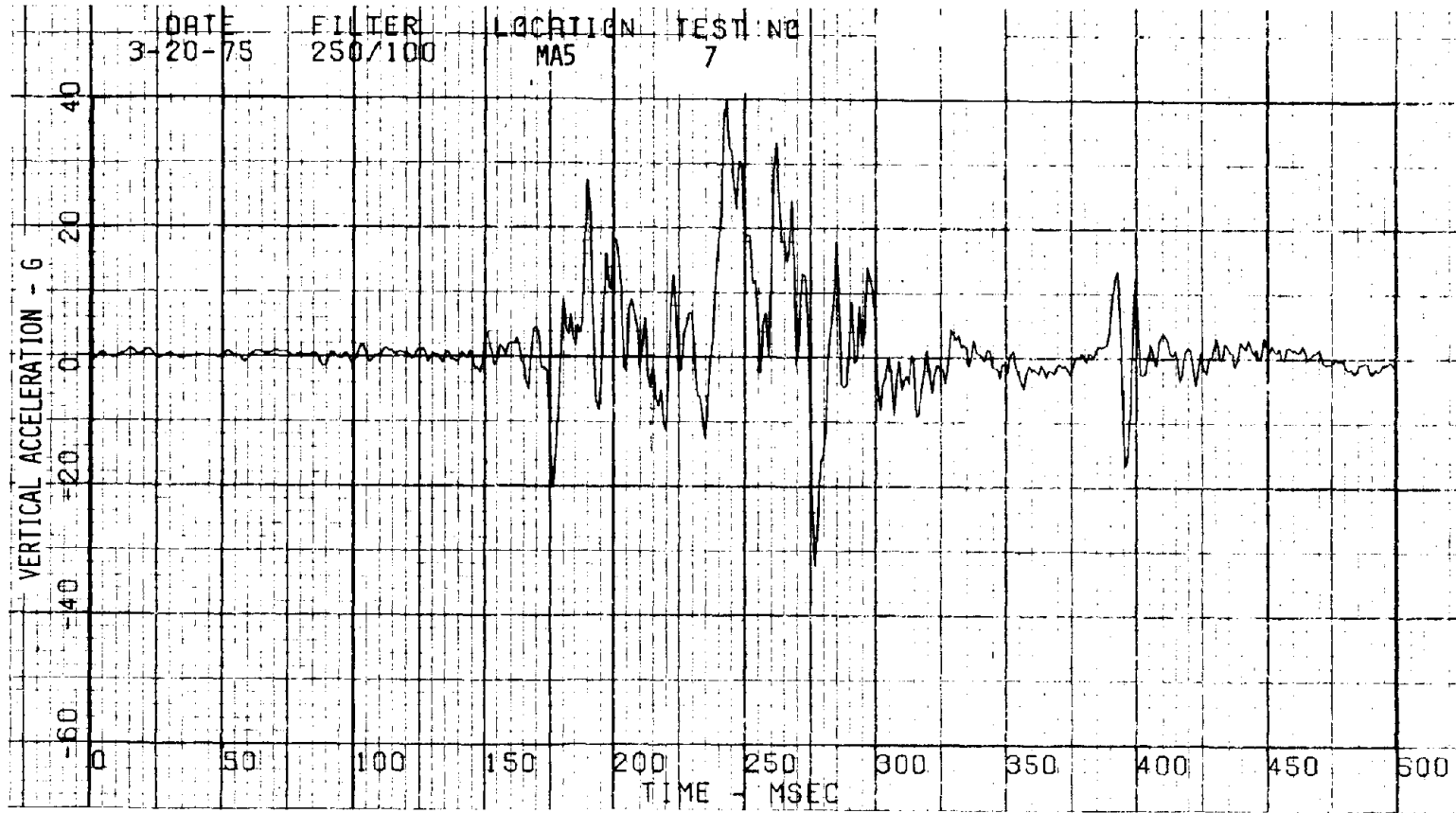


Figure A-205. Locomotive Front Triaxial Accelerometer (Z) - Test 7.

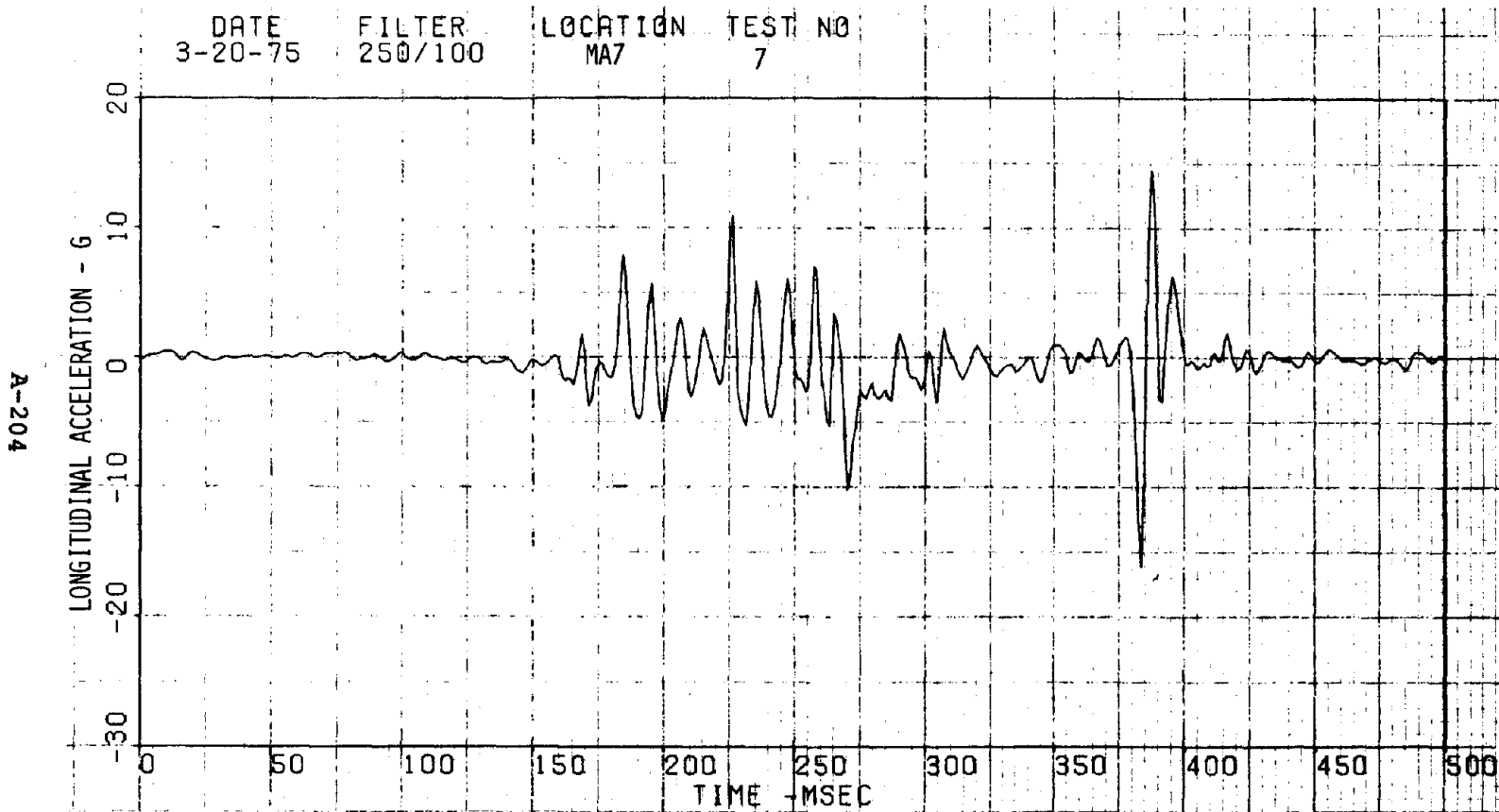


Figure A-206. Hopper 506 Center Longitudinal Accelerometer - Test 7.

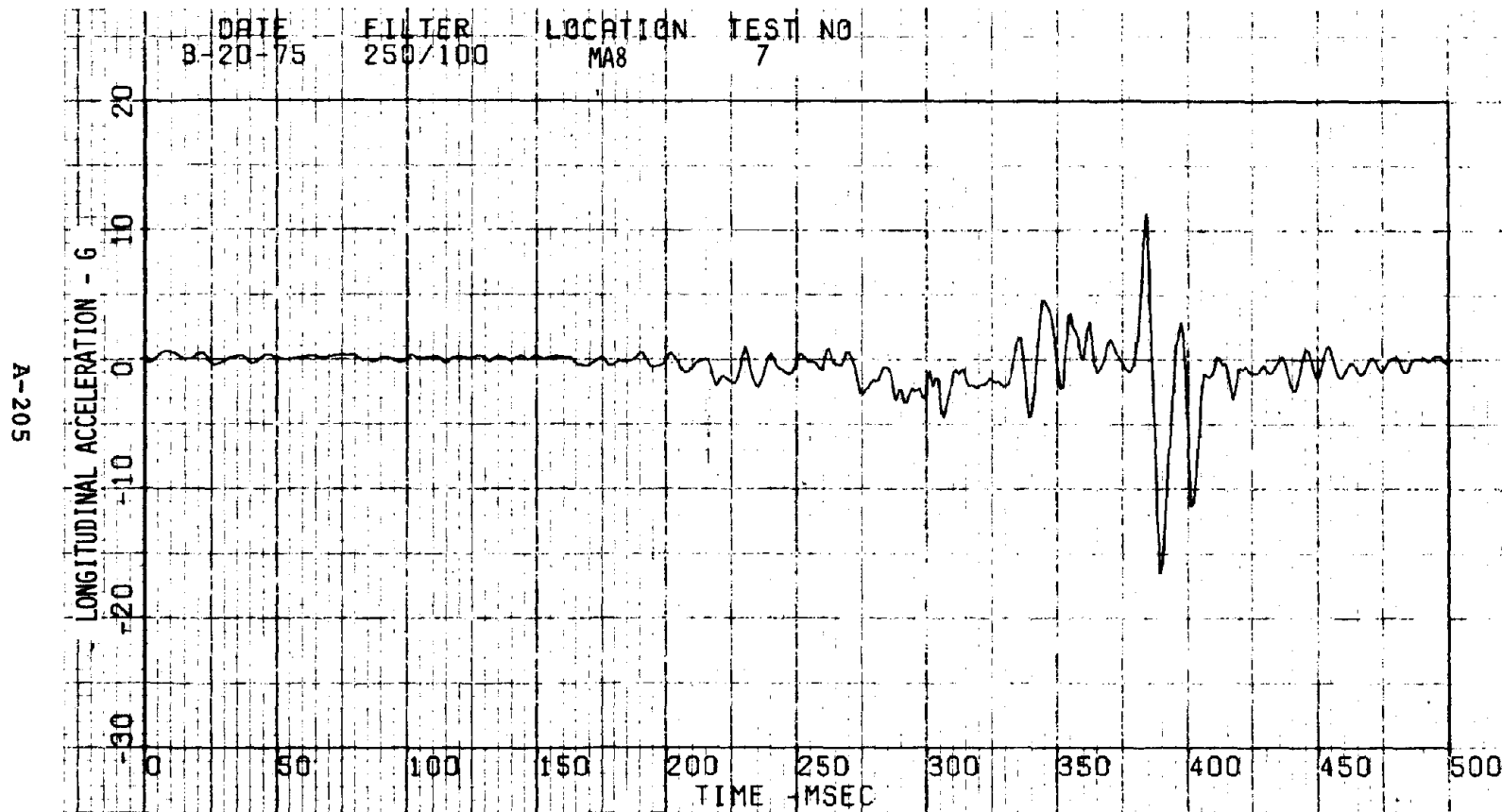


Figure A-207. Hopper 614 Center Longitudinal Accelerometer - Test 7.

A-206

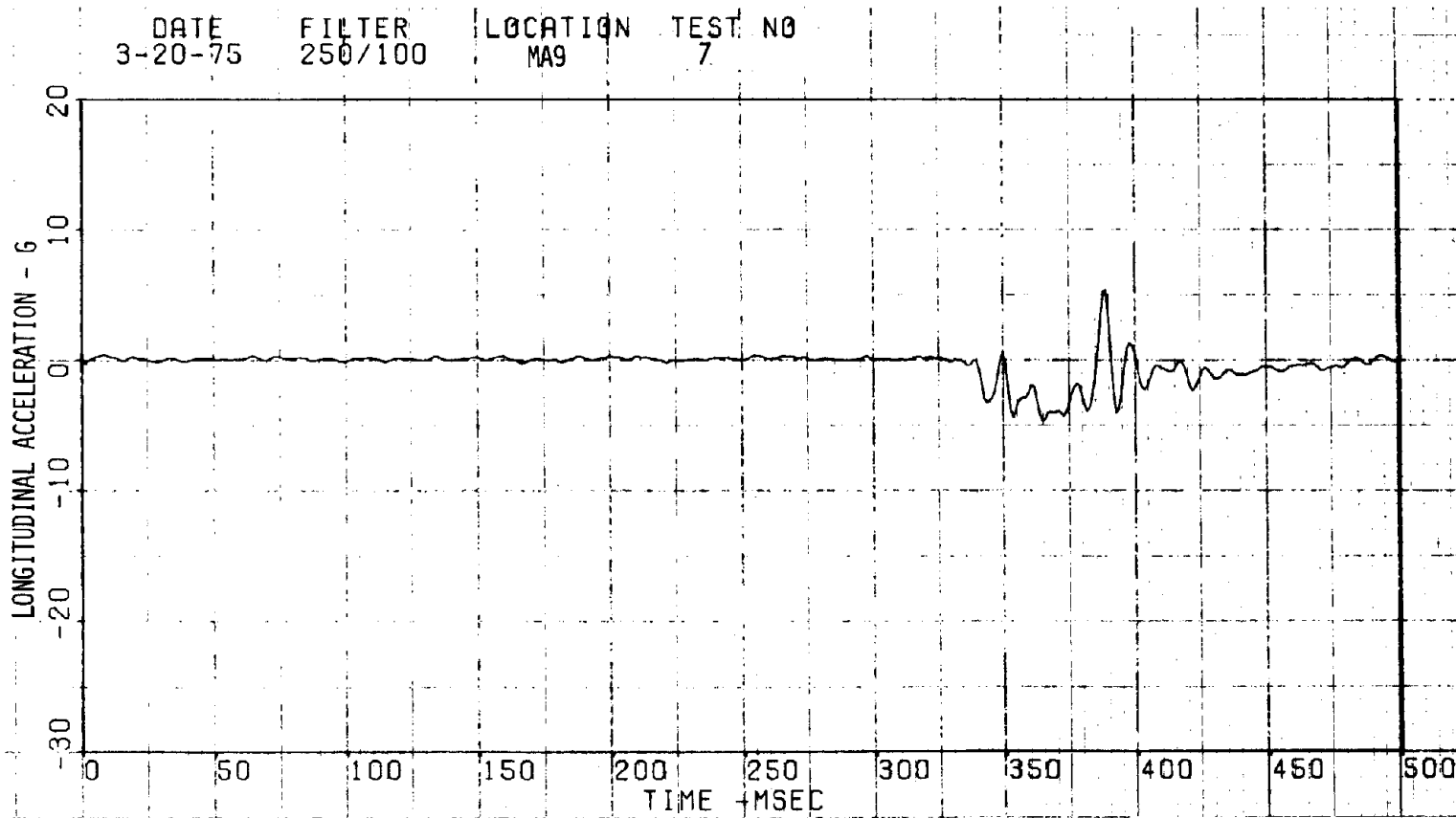


Figure A-208. Hopper 605 Center Longitudinal Accelerometer - Test 7.

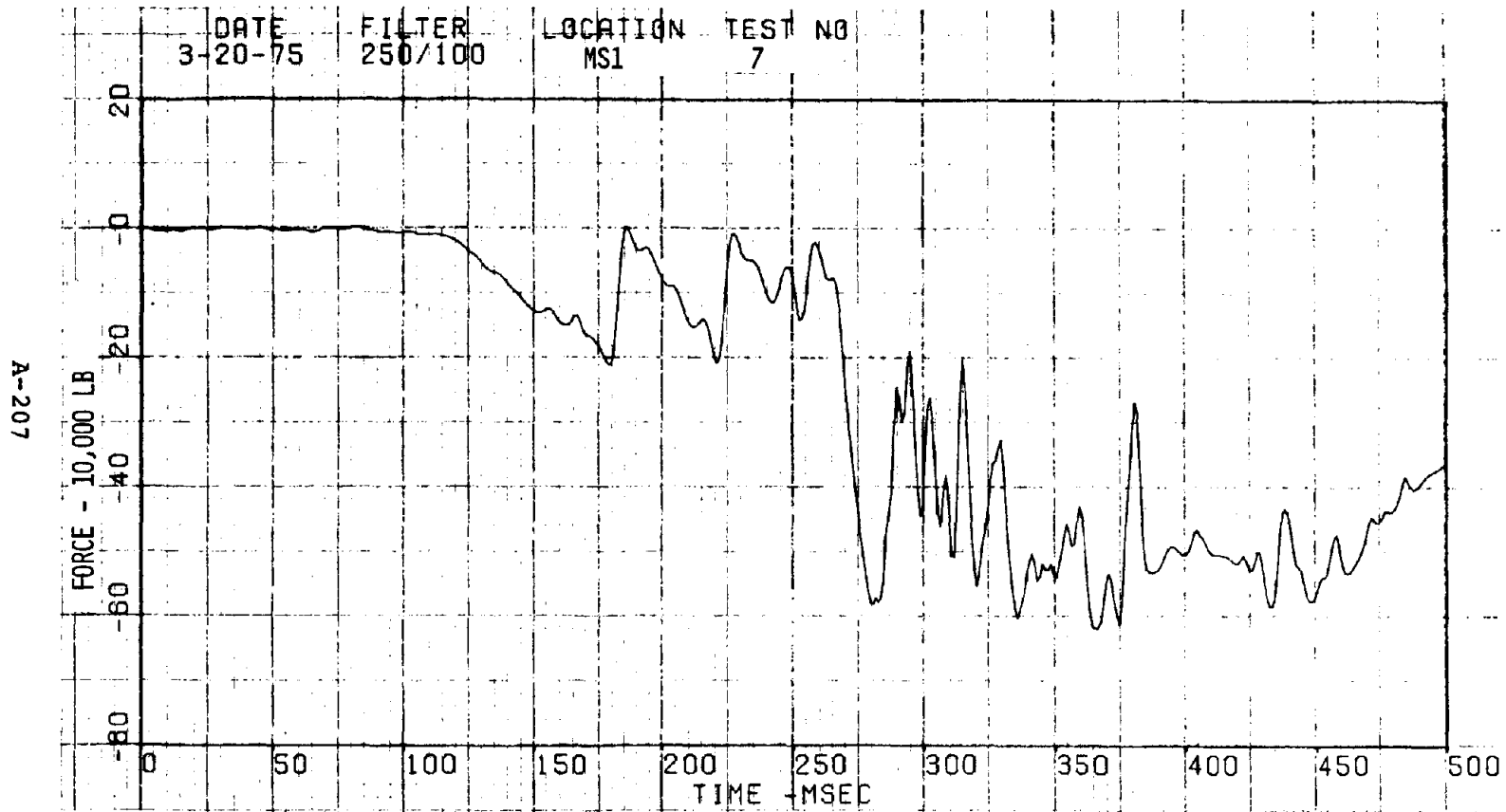


Figure A-209. Locomotive Front Coupler Strain Gauge - Test 7.

A-208

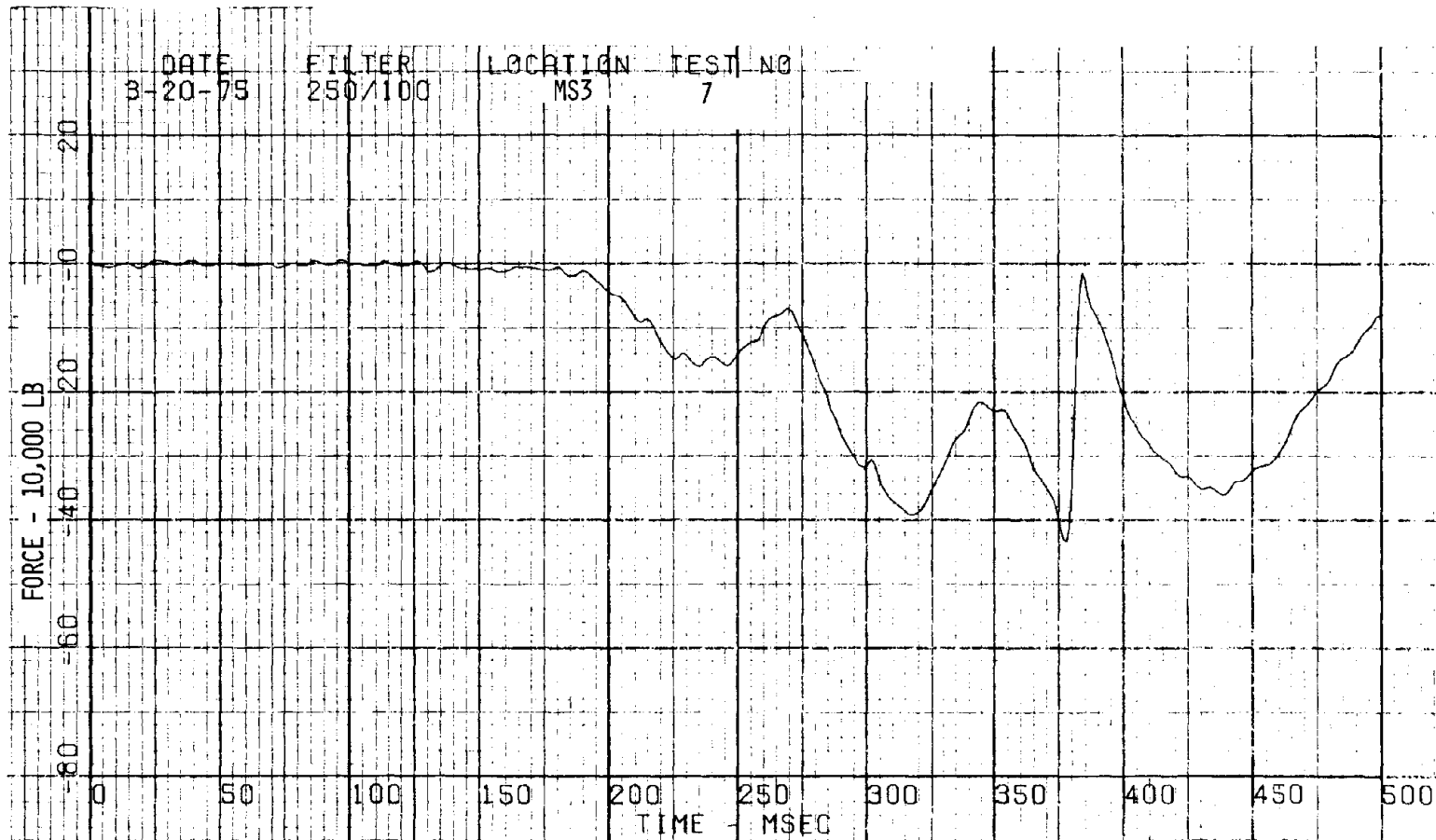


Figure A-210. Hopper 614 Rear Coupler Strain Gauge - Test 7.

A-209

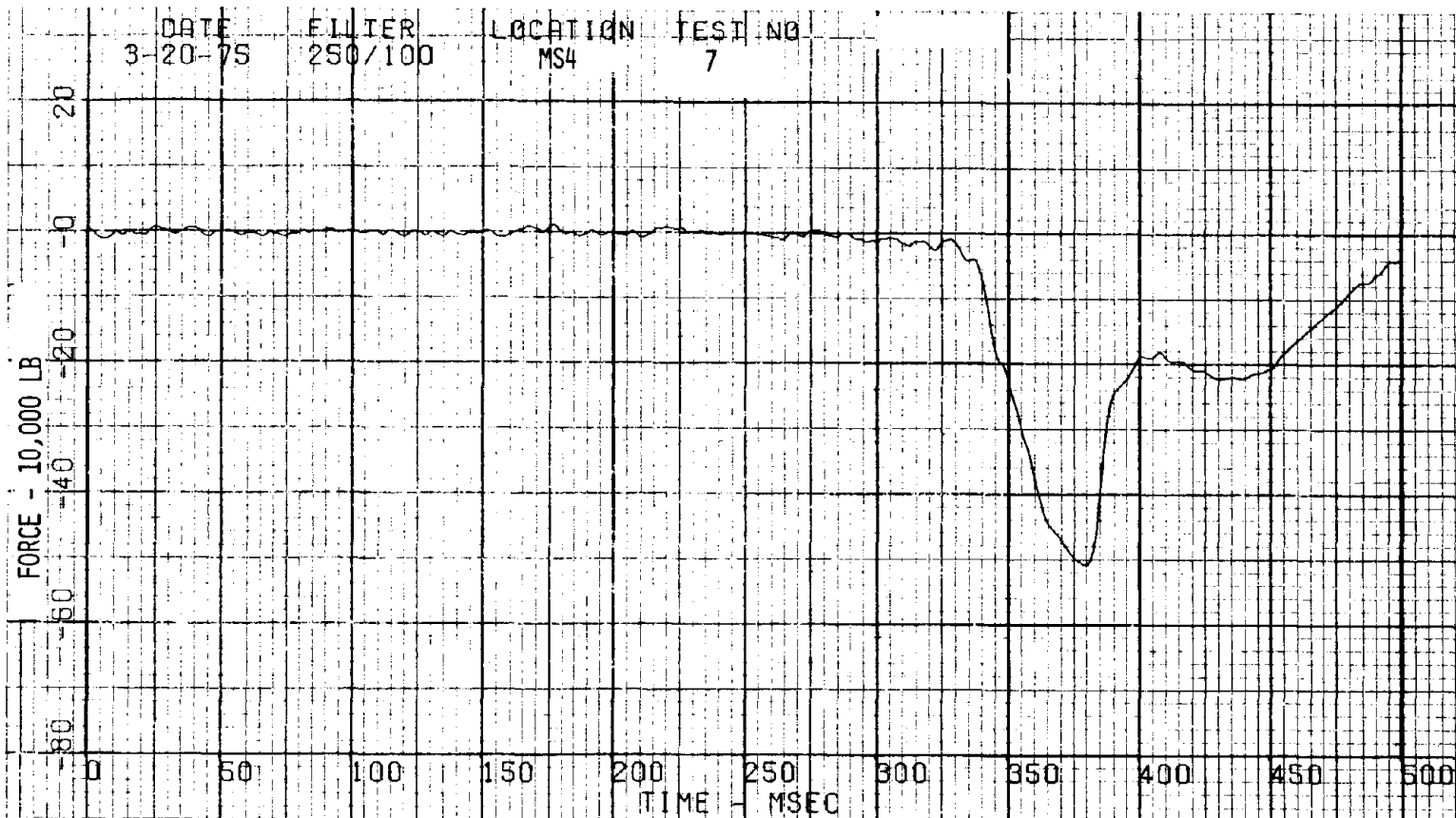


Figure A-211. Hopper 605 Rear Coupler Strain Gauge - Test 7.

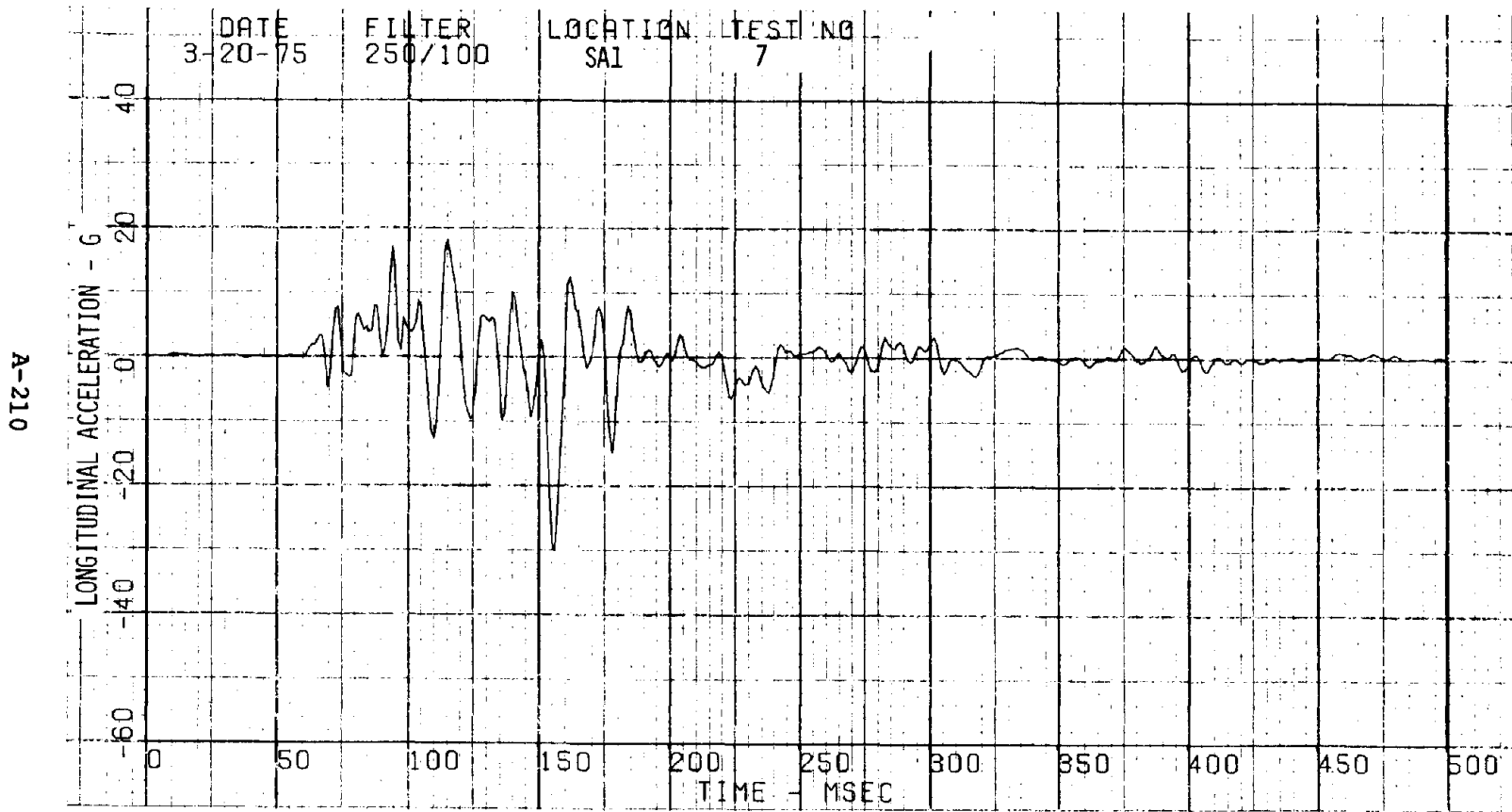


Figure A-212. Caboose Rear Triaxial Accelerometer (X) - Test 7.

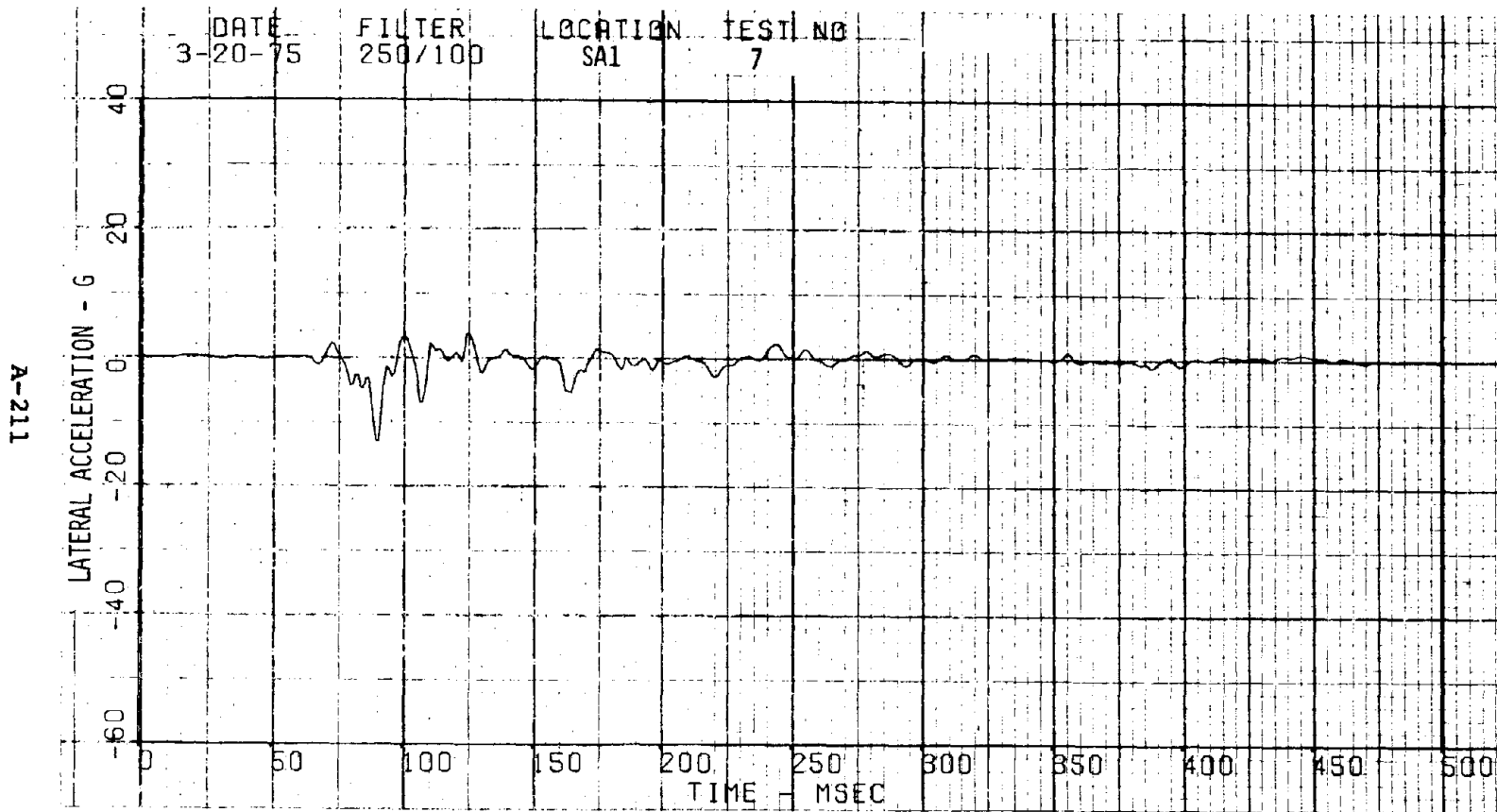


Figure A-213. Caboose Rear Triaxial Accelerometer (Y) - Test 7.

A-212

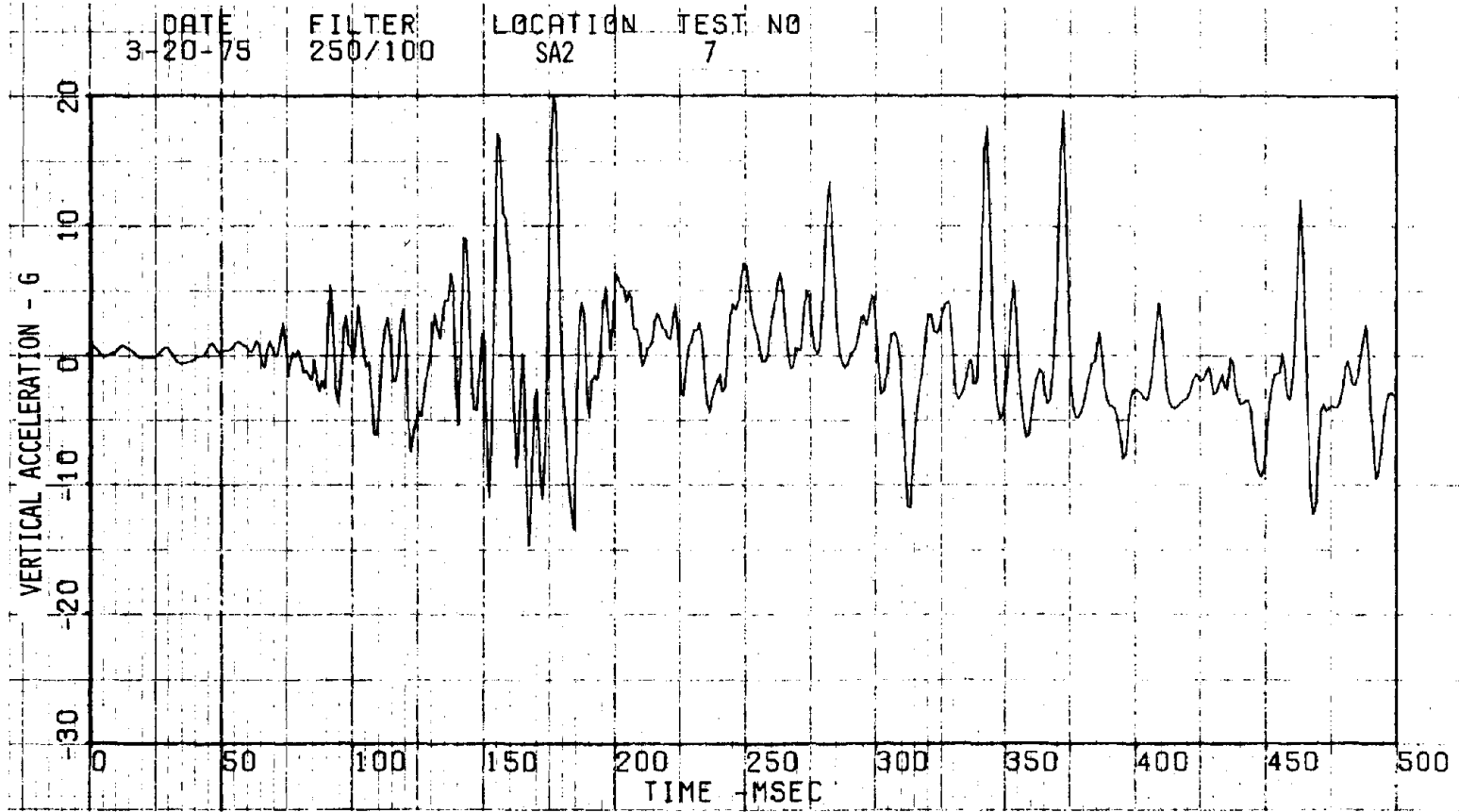


Figure A-214. Caboose Rear Triaxial Accelerometer (Z) - Test 7.

A-213

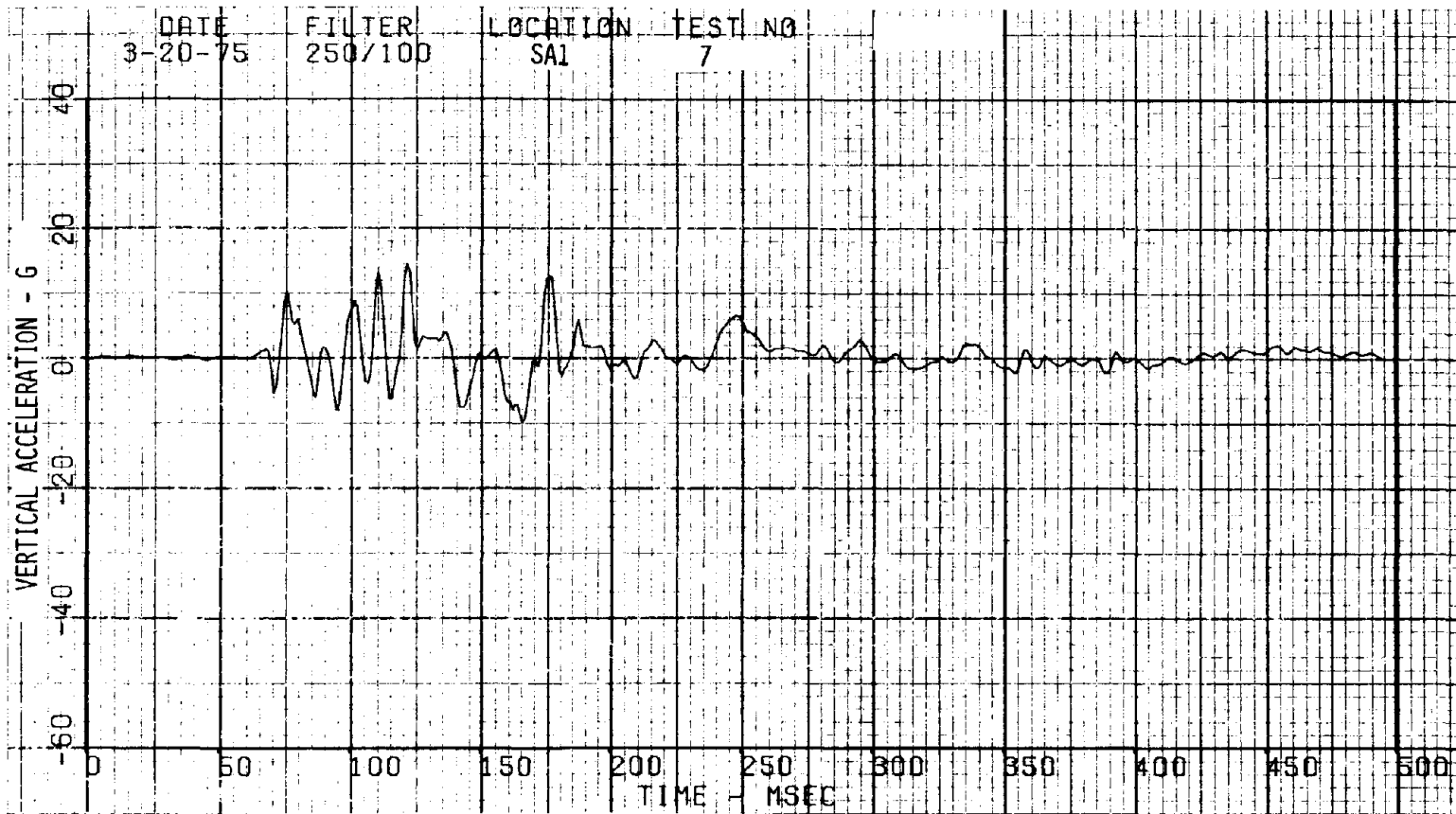


Figure A-215. Caboose Center Vertical Accelerometer - Test 7.

A-214

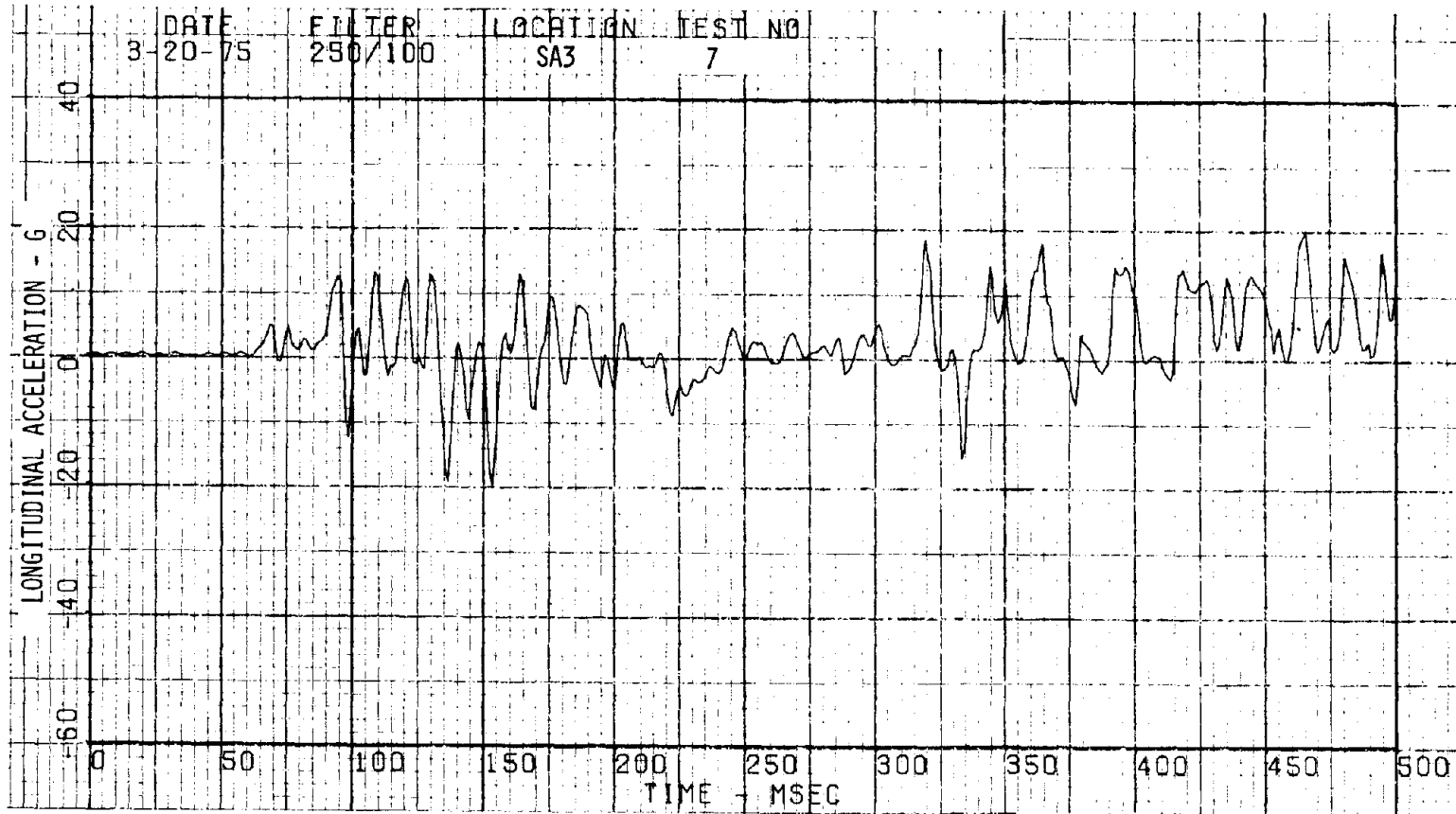


Figure A-216. Caboose Front Triaxial Accelerometer (X) - Test 7.

A-215

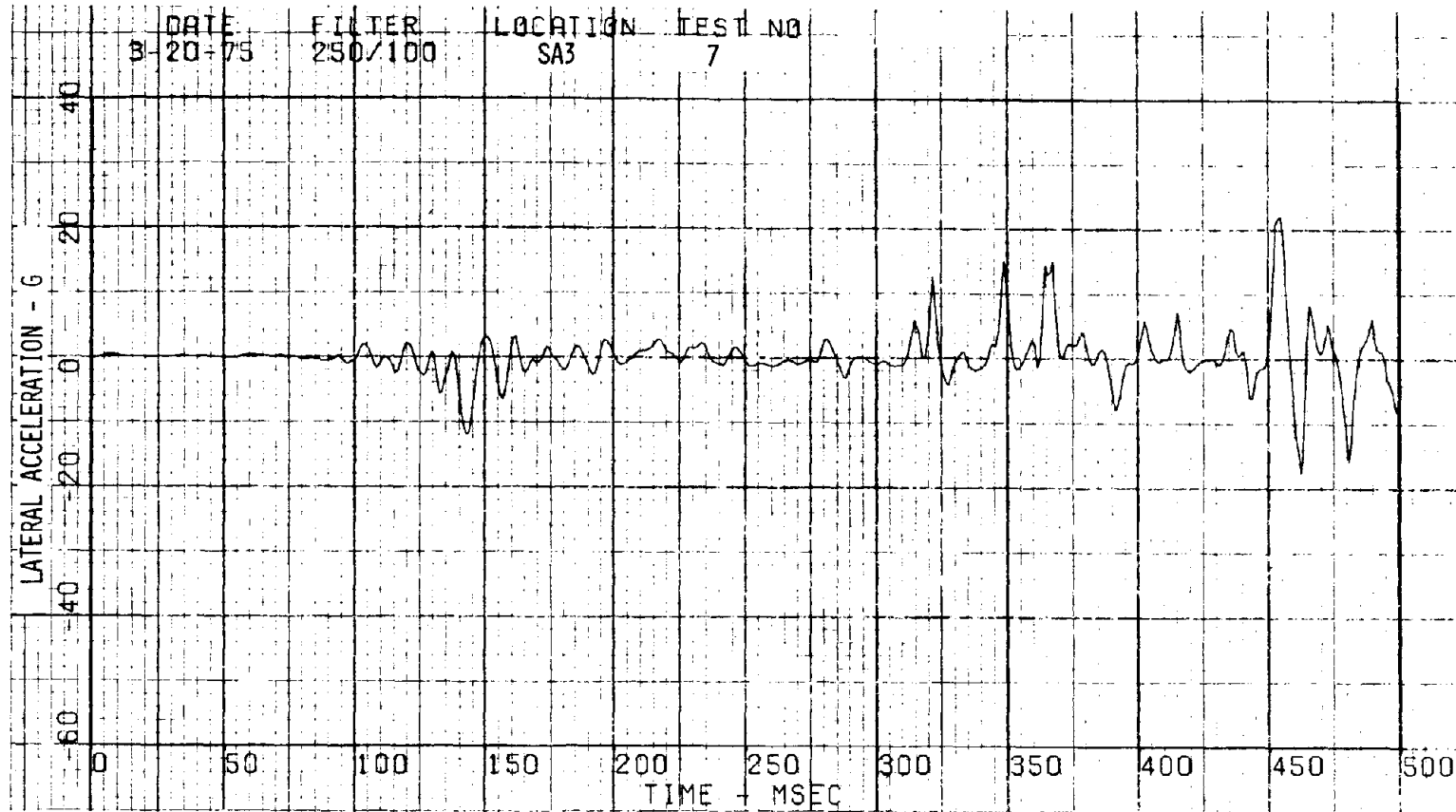


Figure A-217. Caboose Front Triaxial Accelerometer (Y) - Test 7.

A-216

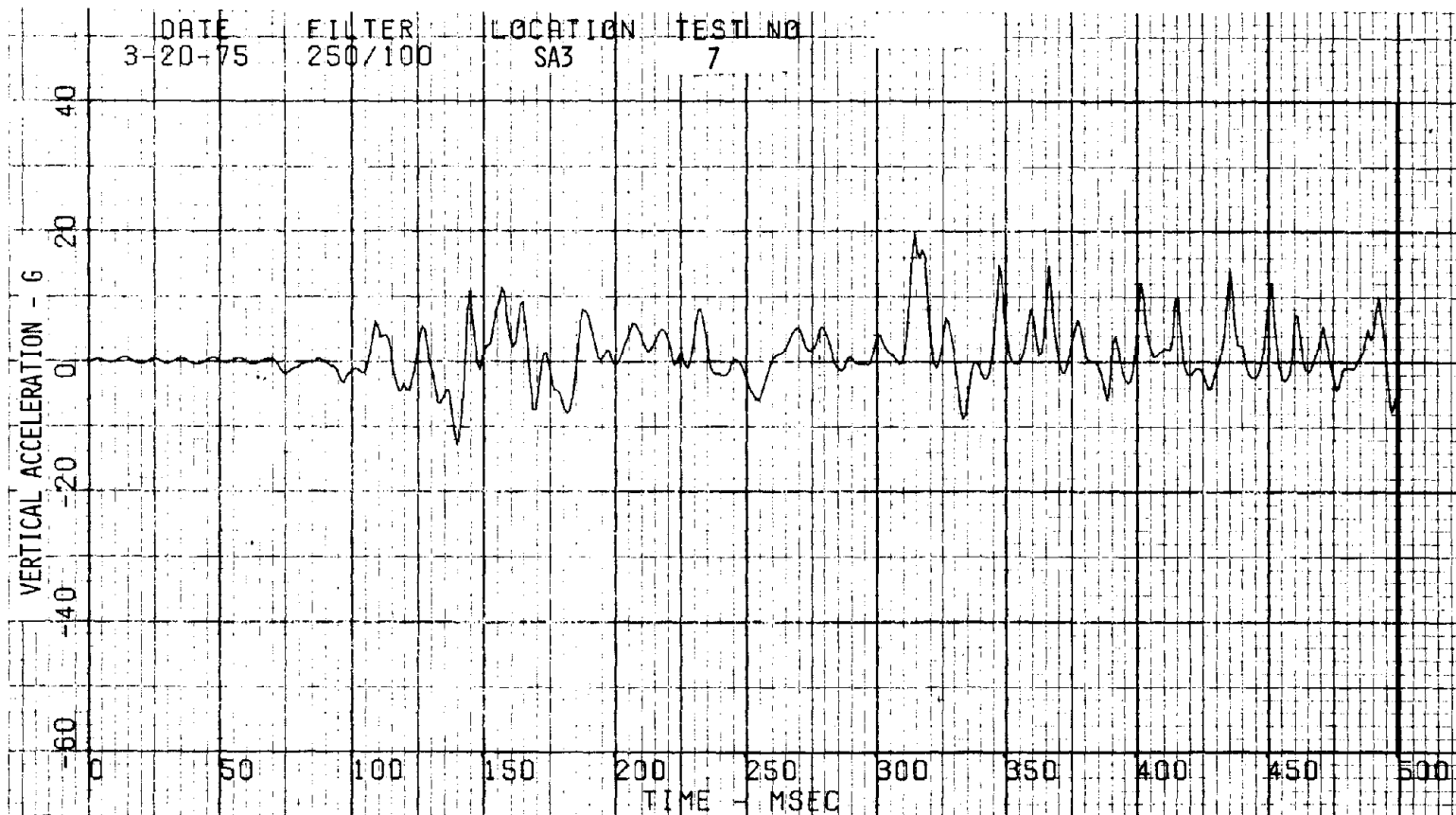


Figure A-218. Caboose Front Triaxial Accelerometer (Z) - Test 7.

A-217

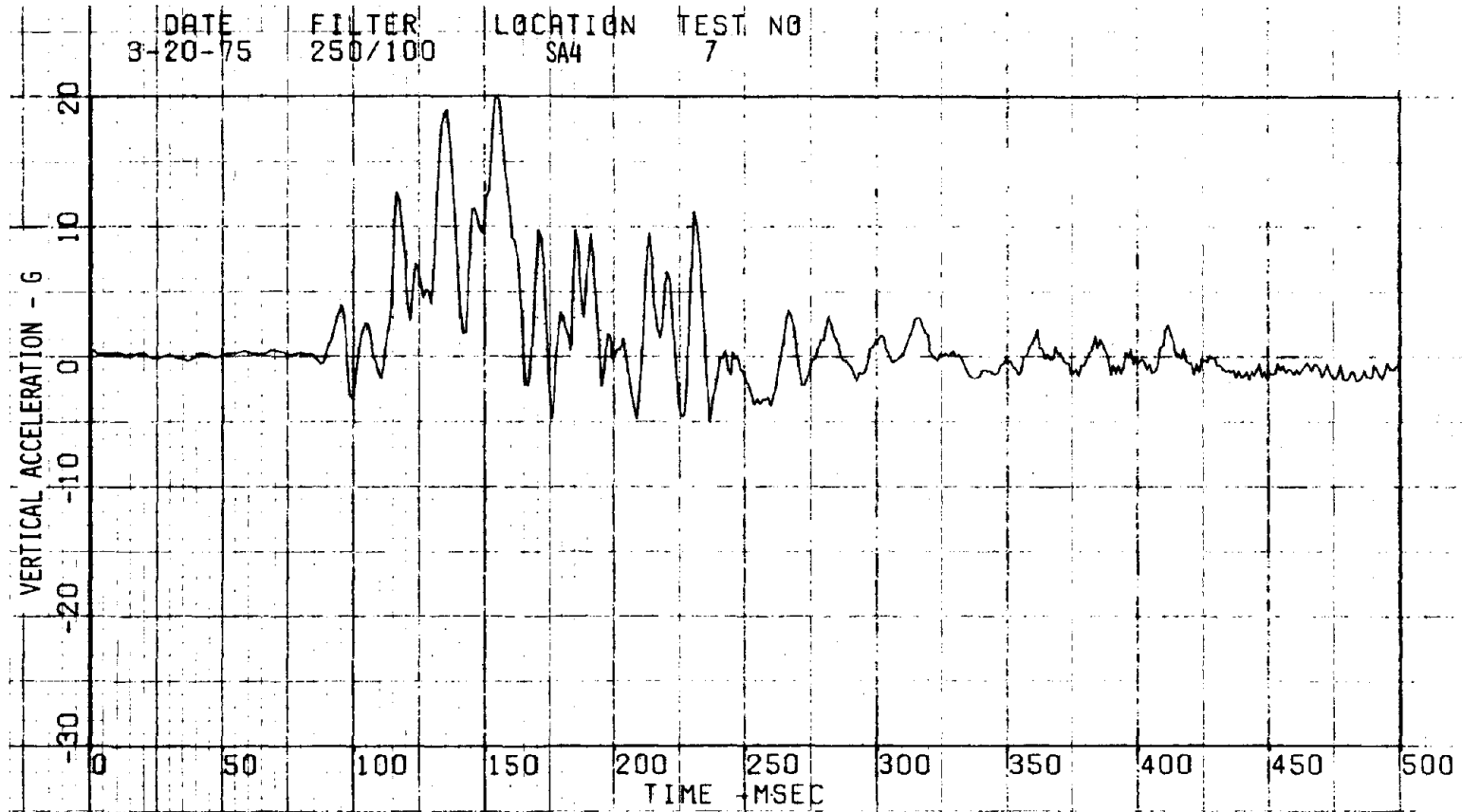


Figure A-219. Hopper 843 Rear Vertical Accelerometer - Test 7.

A-218

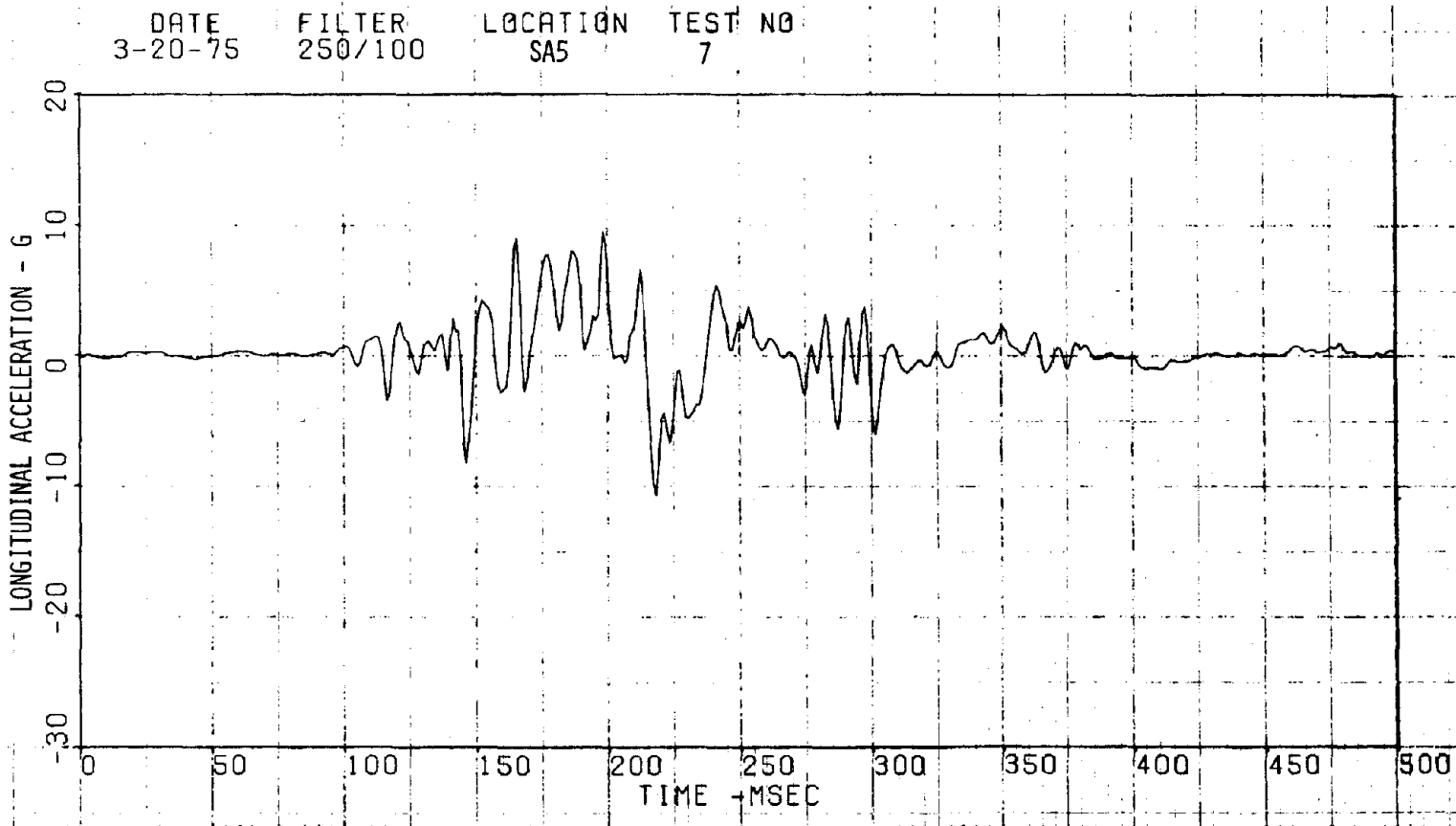


Figure A-220. Hopper 843 Center Longitudinal Accelerometer - Test 7.

A-219

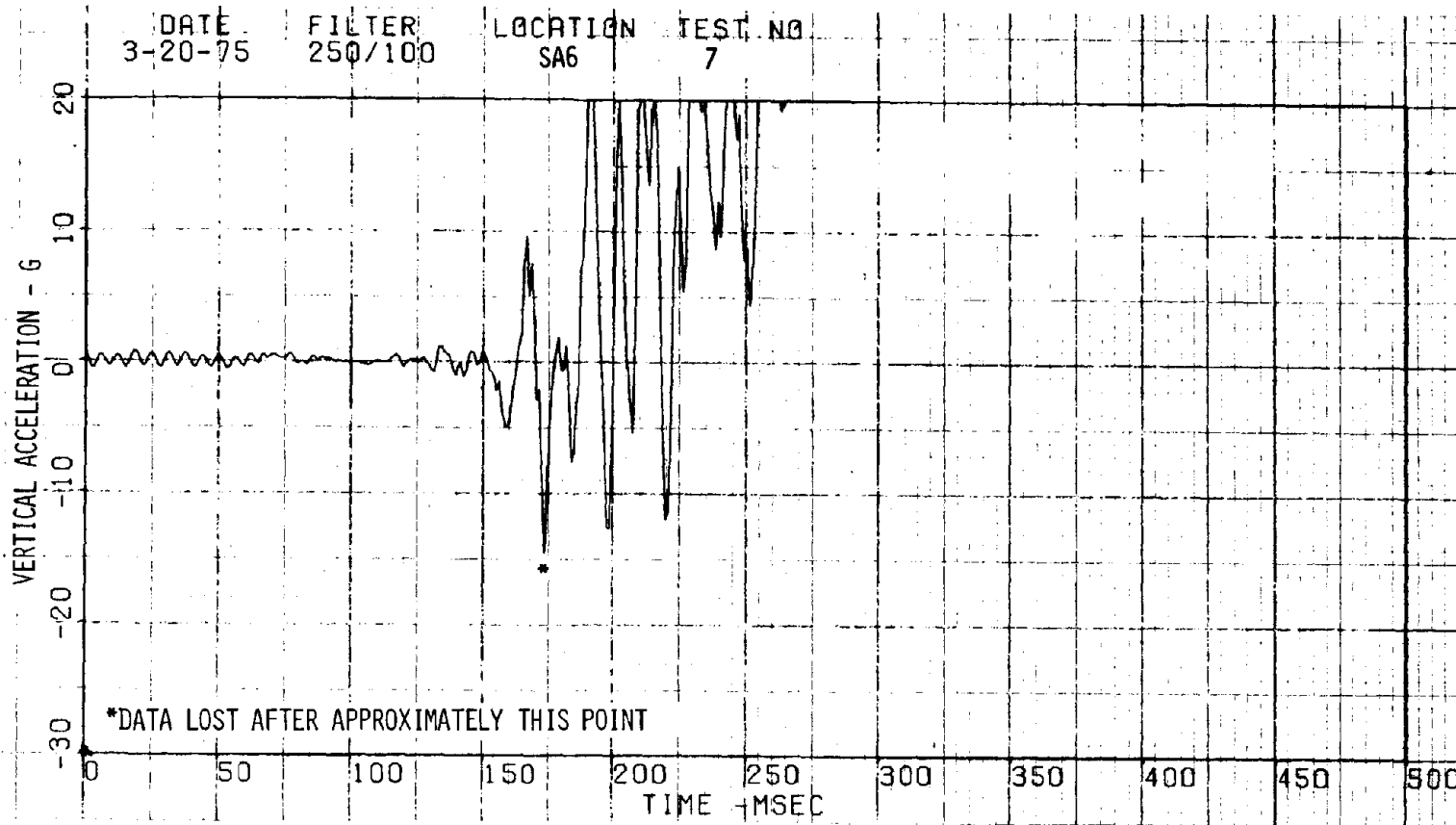


Figure A-221. Hopper 843 Front Vertical Accelerometer - Test 7.

A-220

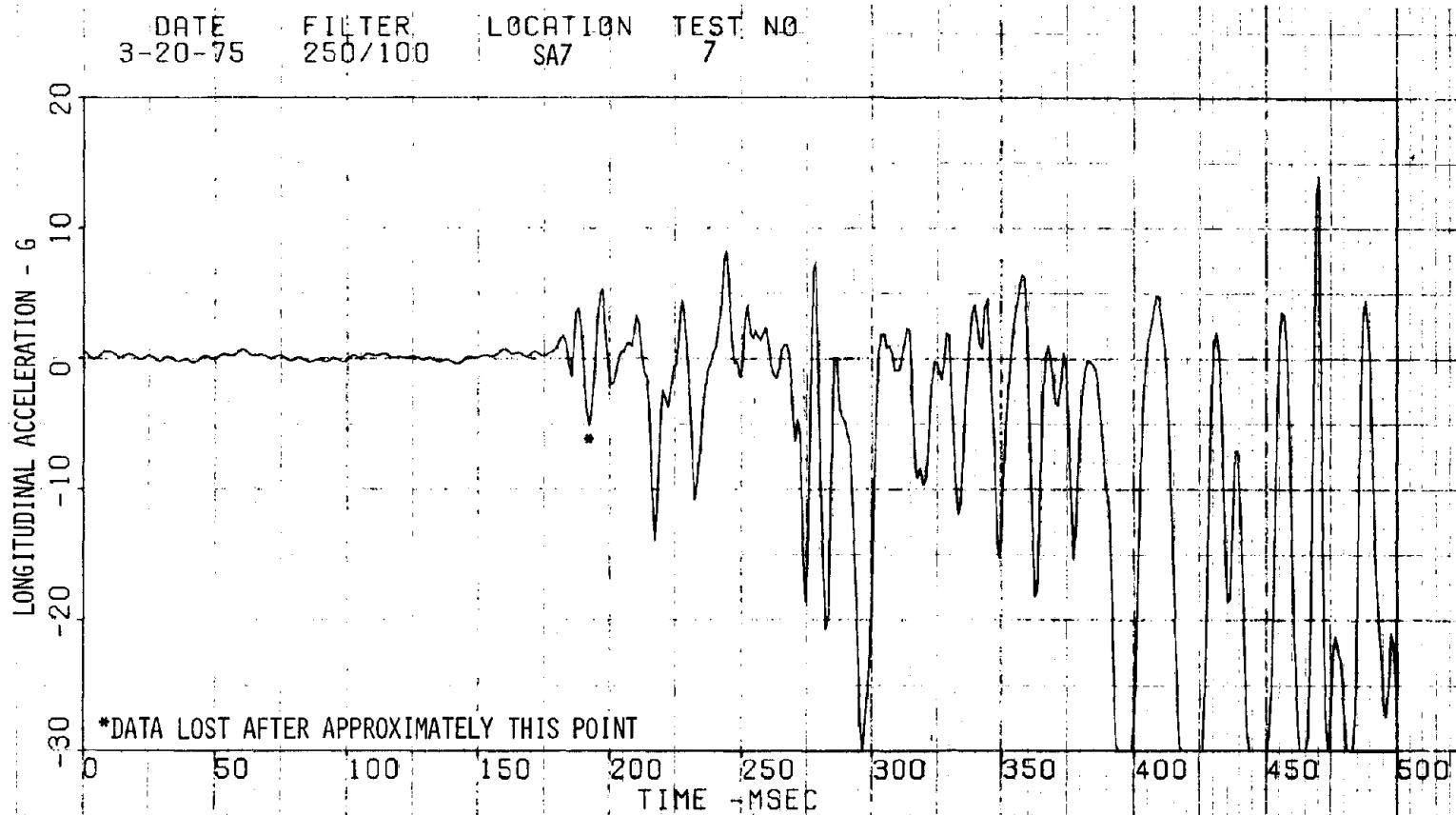


Figure A-222. Hopper 631 Center Longitudinal Accelerometer - Test 7.

A-221

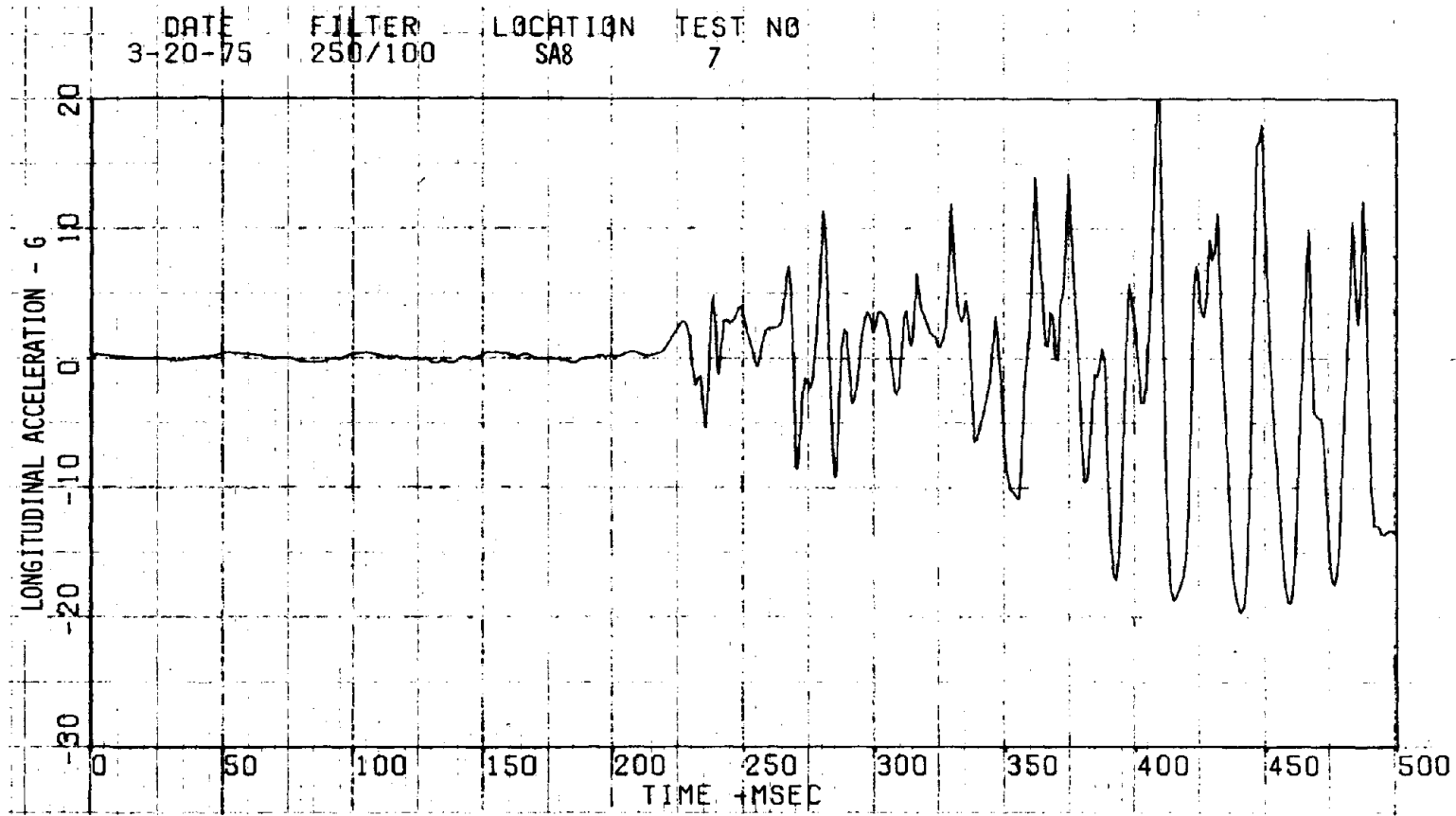


Figure A-223. Hopper 508 Center Longitudinal Accelerometer - Test 7.

A-222

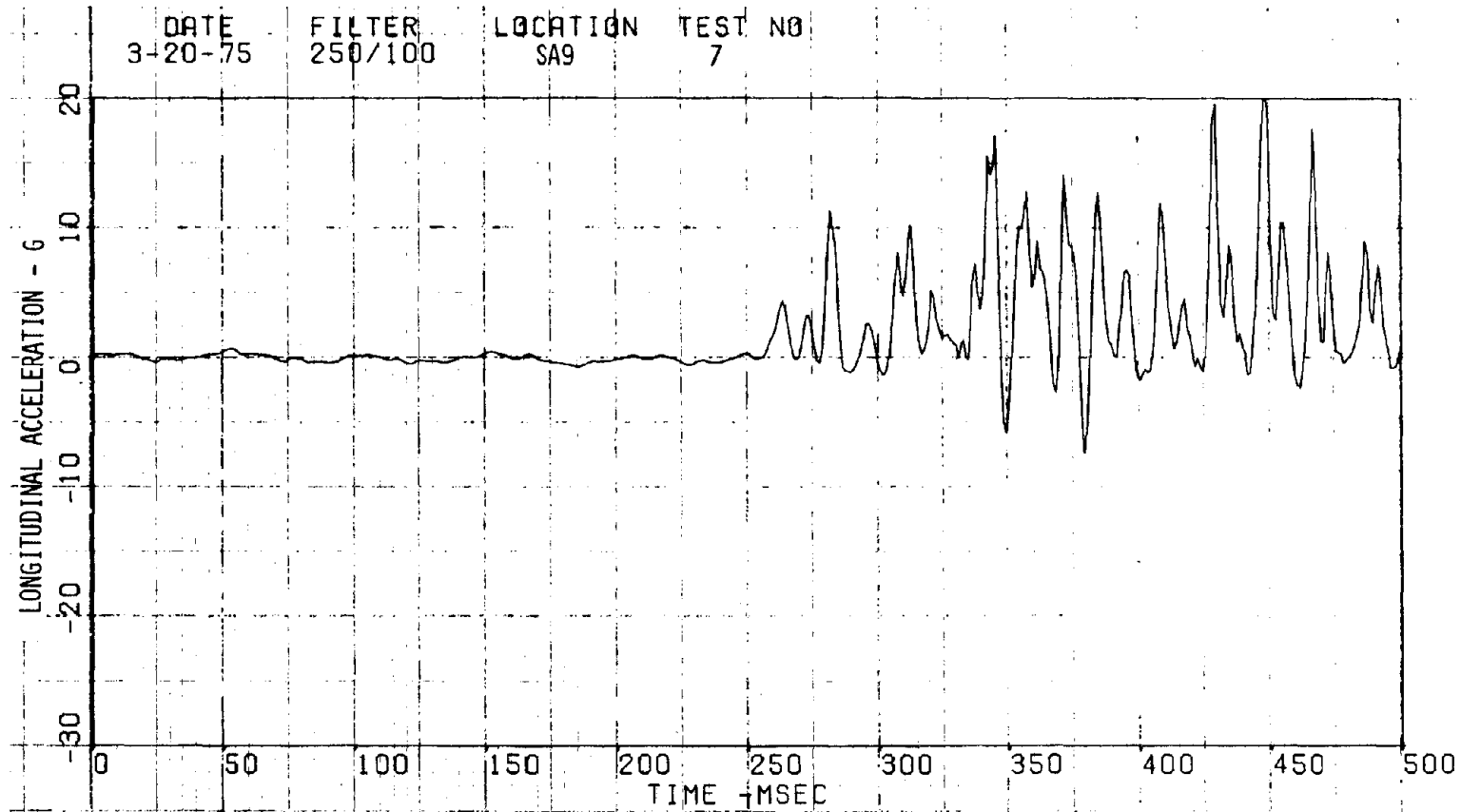


Figure A-224. Hopper 119 Center Longitudinal Accelerometer - Test 7.

A-223

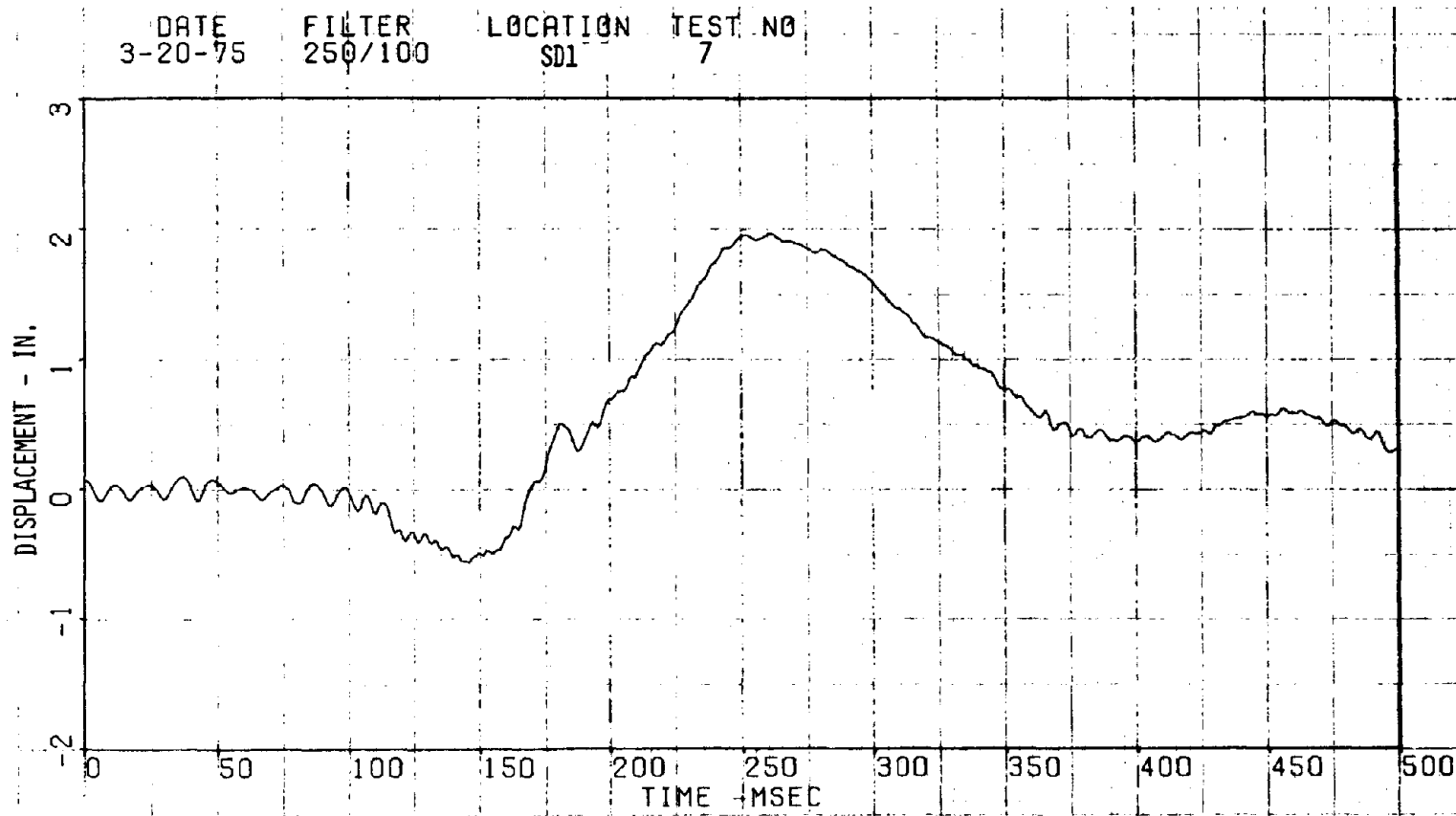


Figure A-225. Caboose Left Rear Displacement Transducer - Test 7.

A-224

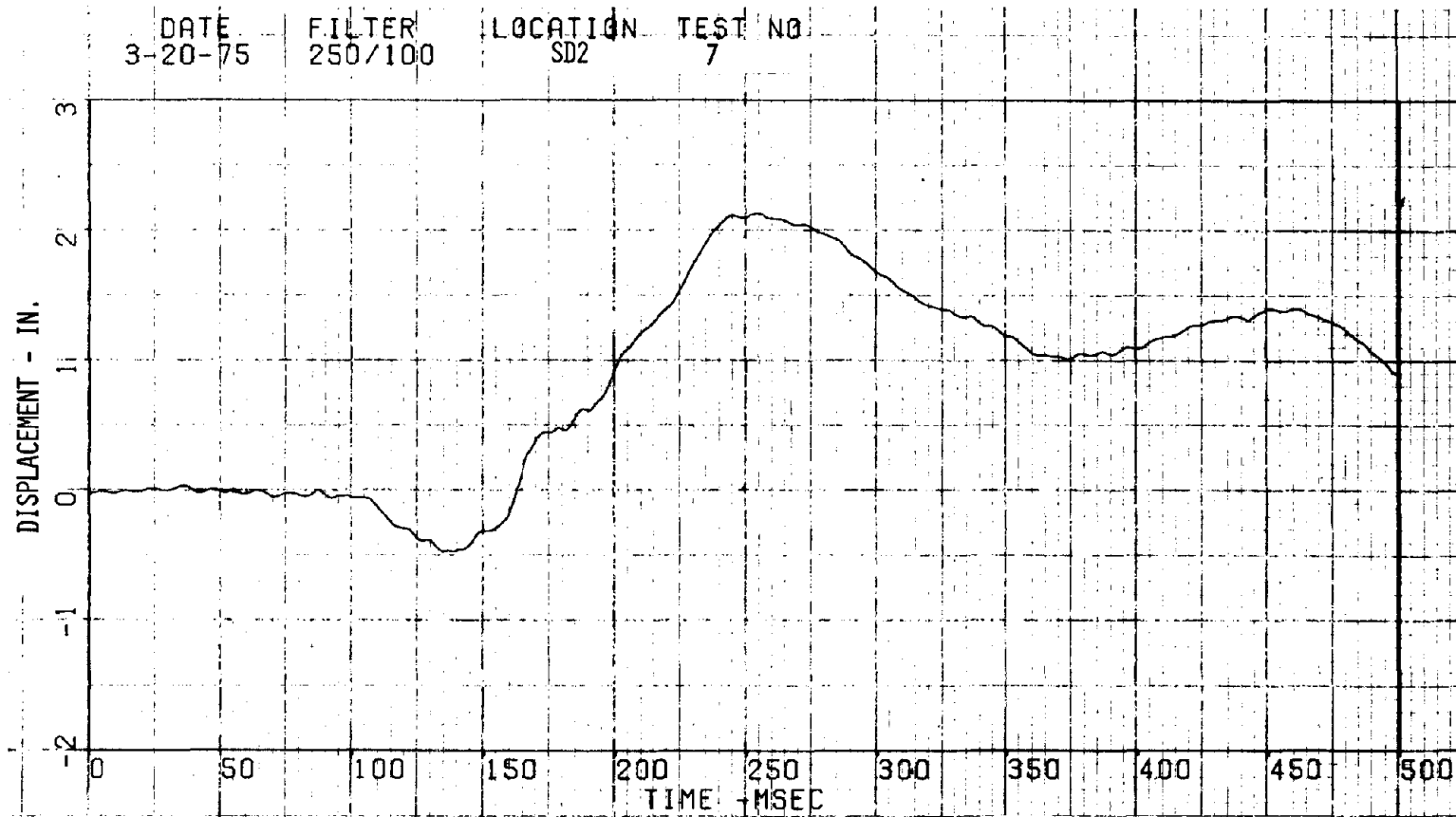


Figure A-226. Caboose Right Rear Displacement Transducer - Test 7.

A-225

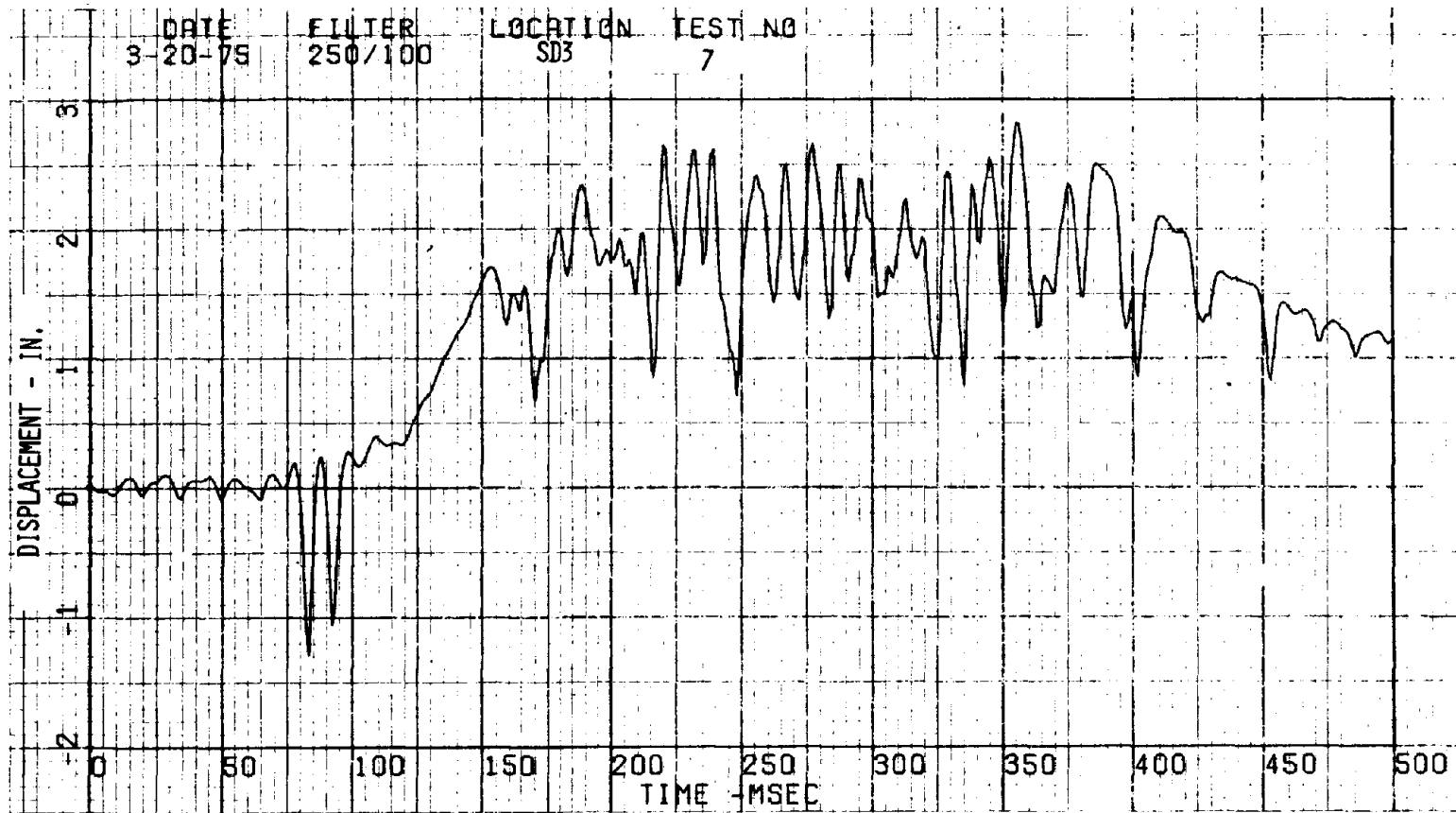


Figure A-227. Caboose Left Front Displacement Transducer - Test 7.

A-226

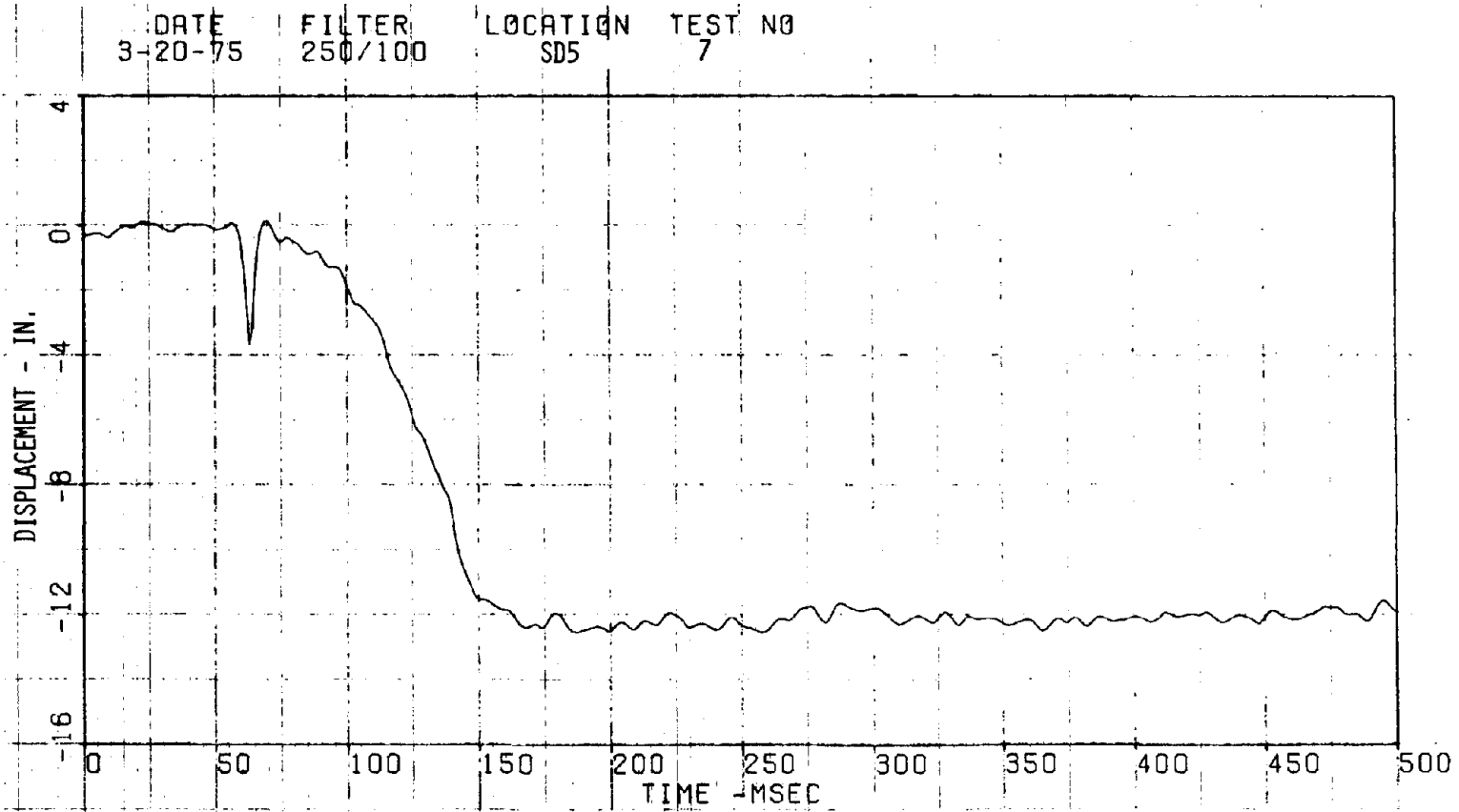


Figure A-228. Caboose to Hopper Displacement Transducer - Test 7.

A-227

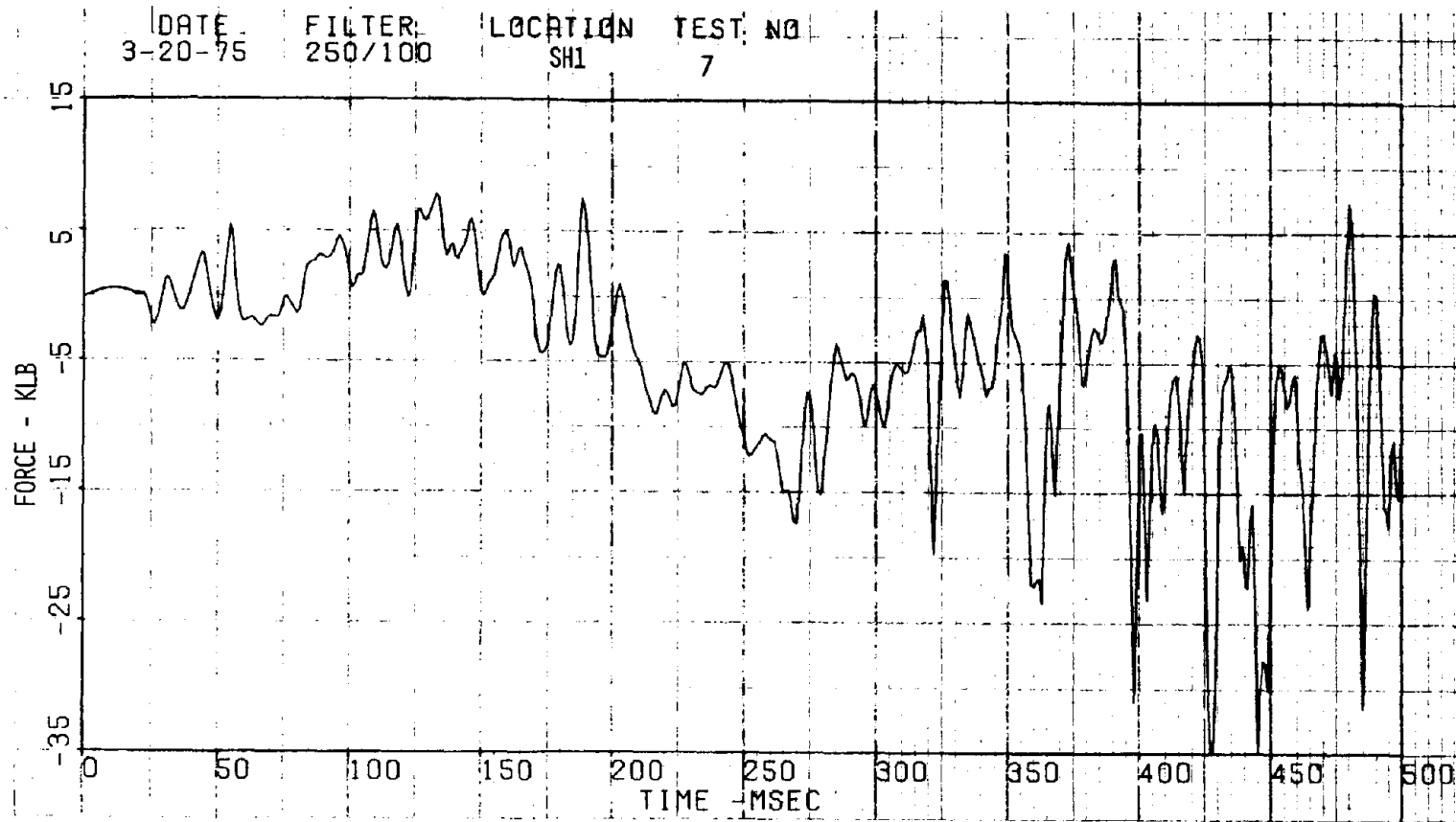


Figure A-229. Caboose Rear Swinghanger Strain Gauge - Test 7.

A-228

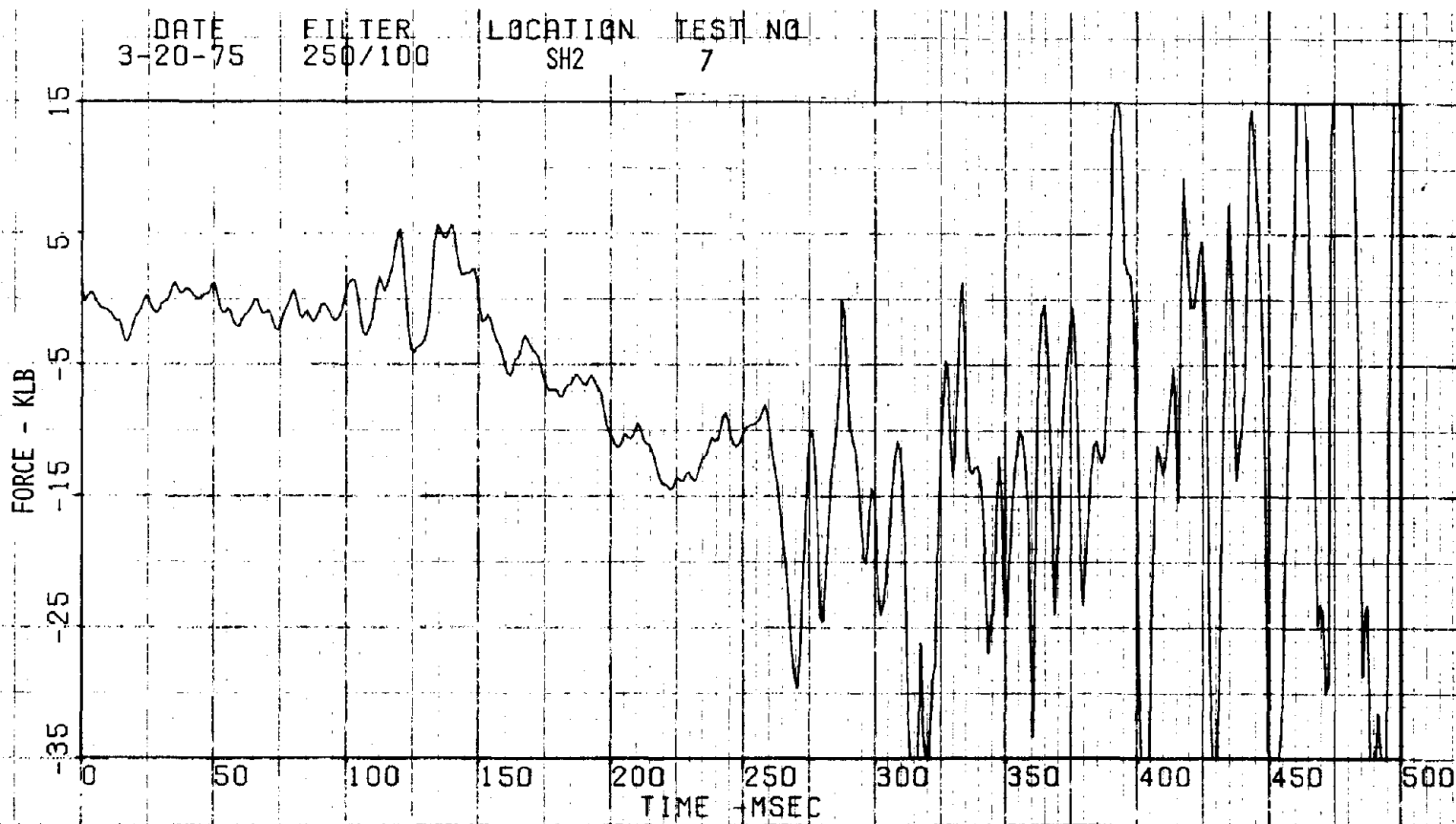


Figure A-230. Caboose Front Swinghanger Strain Gauge - Test 7.

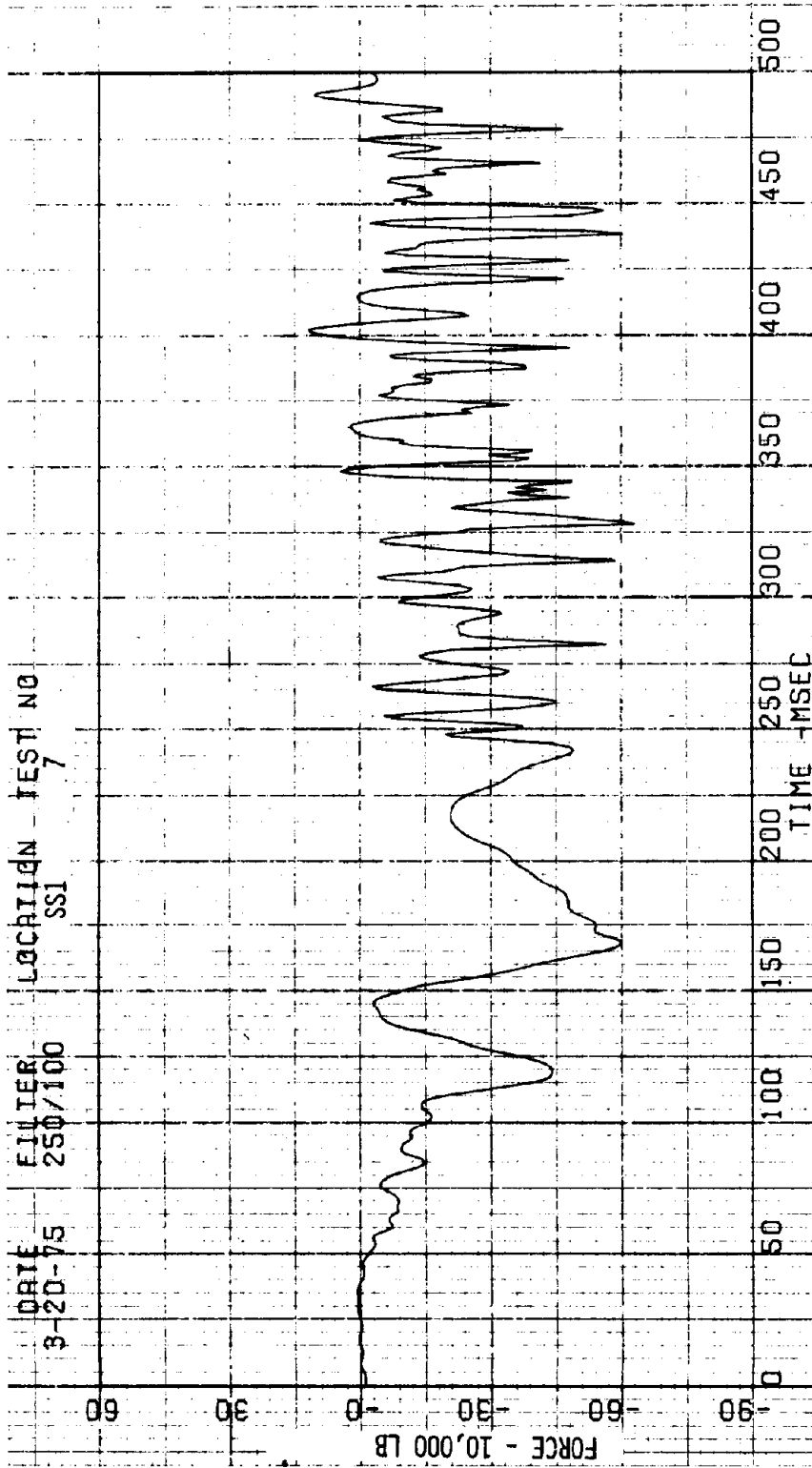


Figure A-231. Hopper 843 Rear Coupler Strain Gauge - Test 7.

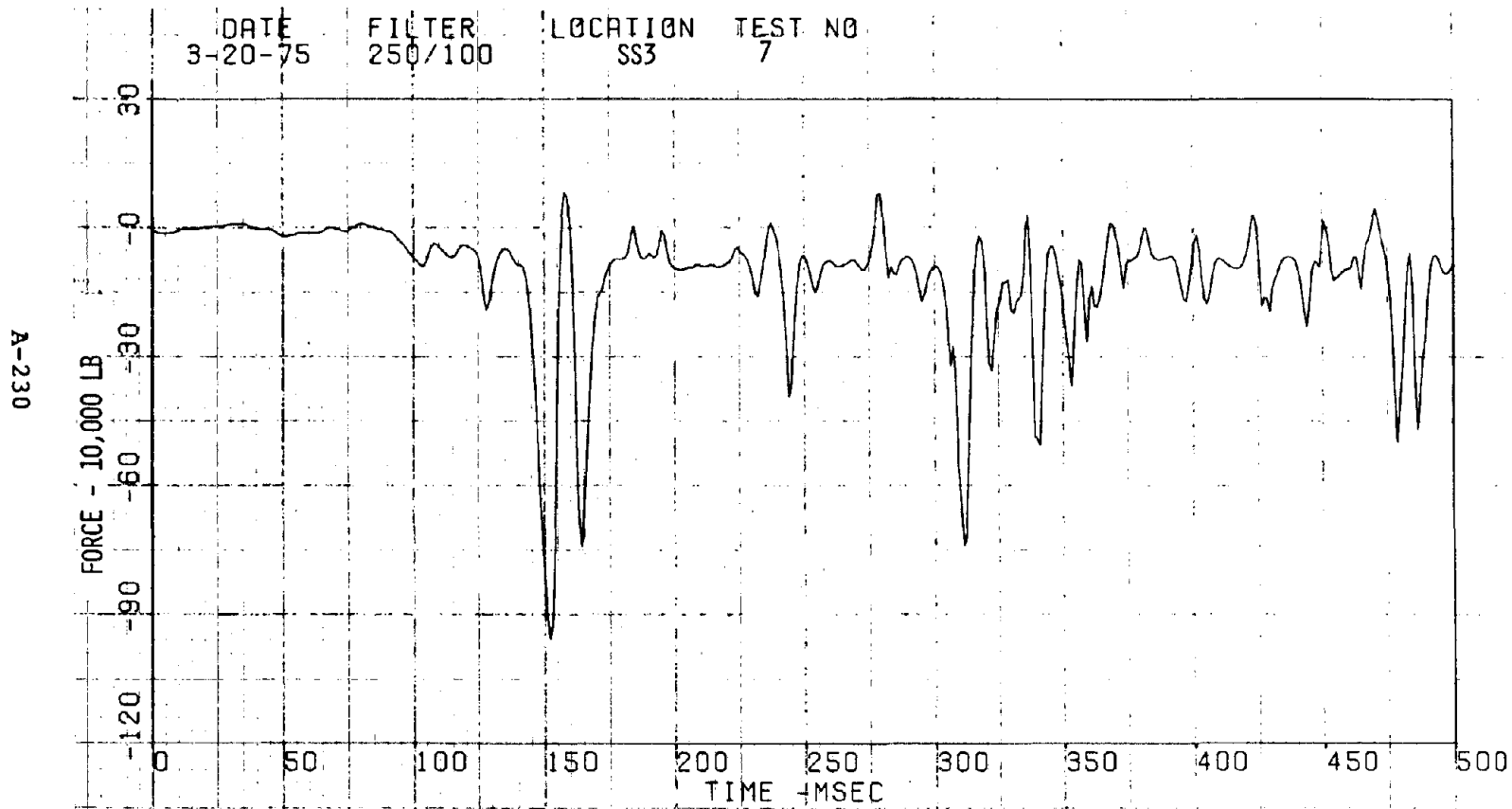


Figure A-232. Hopper 843 Center Sill Strain Gauge - Test 7.

A-231

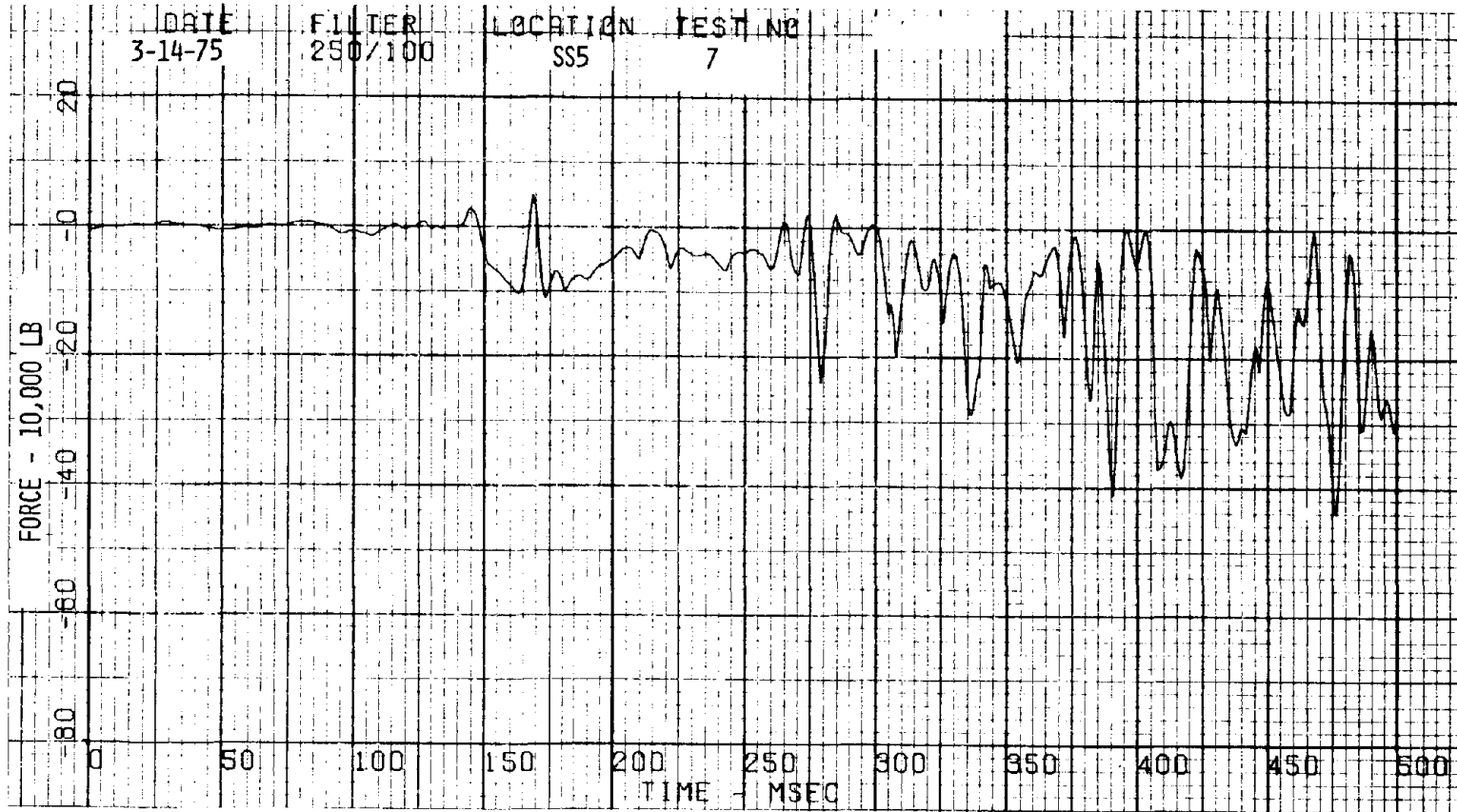


Figure A-233. Caboose Rear Coupler Strain Gauge - Test 7.

A-232

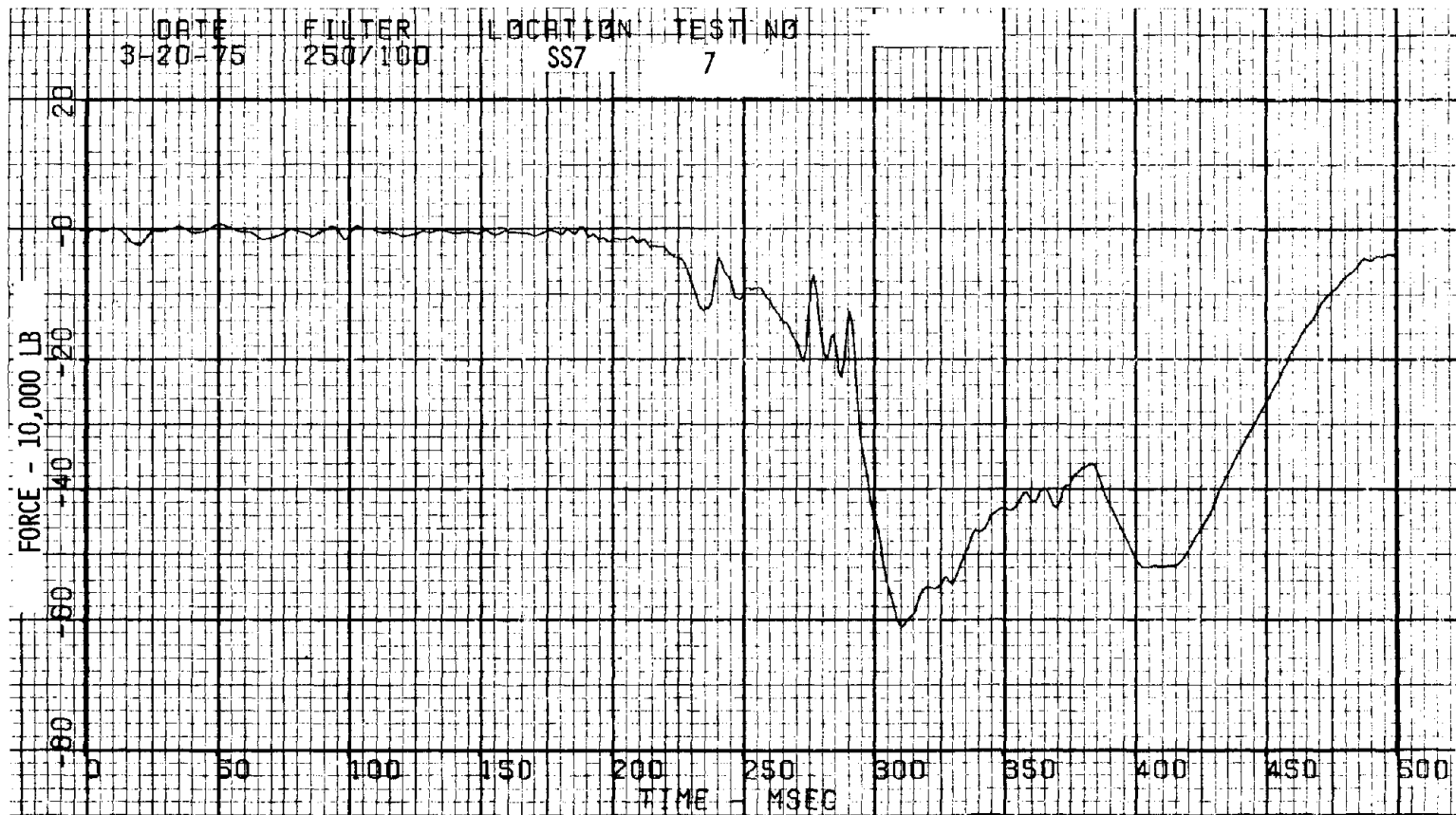
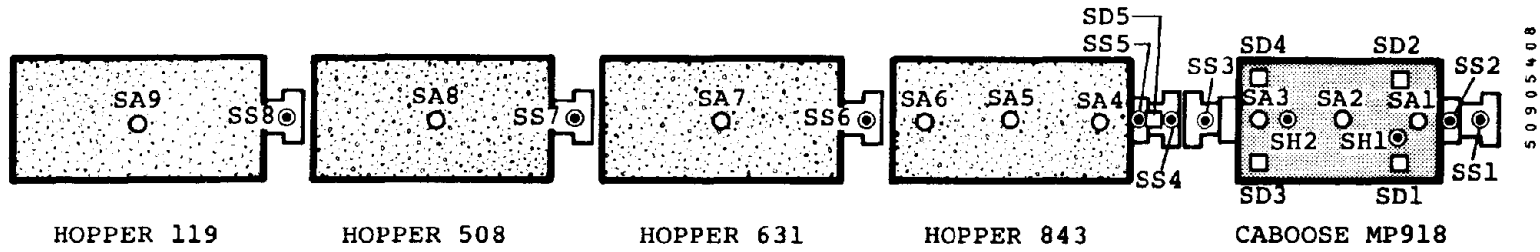
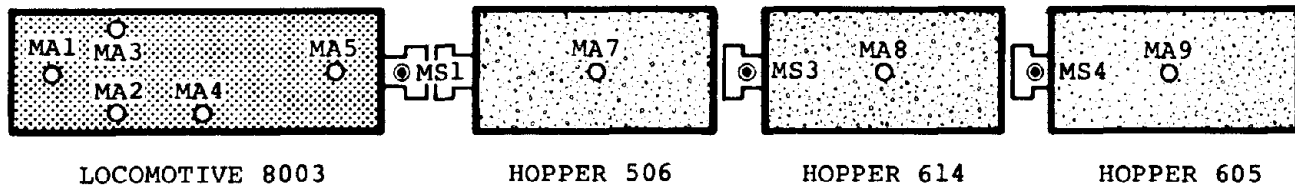


Figure A-234. Hopper 508 Rear Coupler Strain Gauge - Test 7.



- HOPPER LOADED
 - TRAIN IN BUFF
- STANDING TRAIN

A-233



MOTION

- IMPACT VELOCITY = 18.1 MPH

MOVING TRAIN

Figure A-235. Instrument Locations - Test 8.

A-234

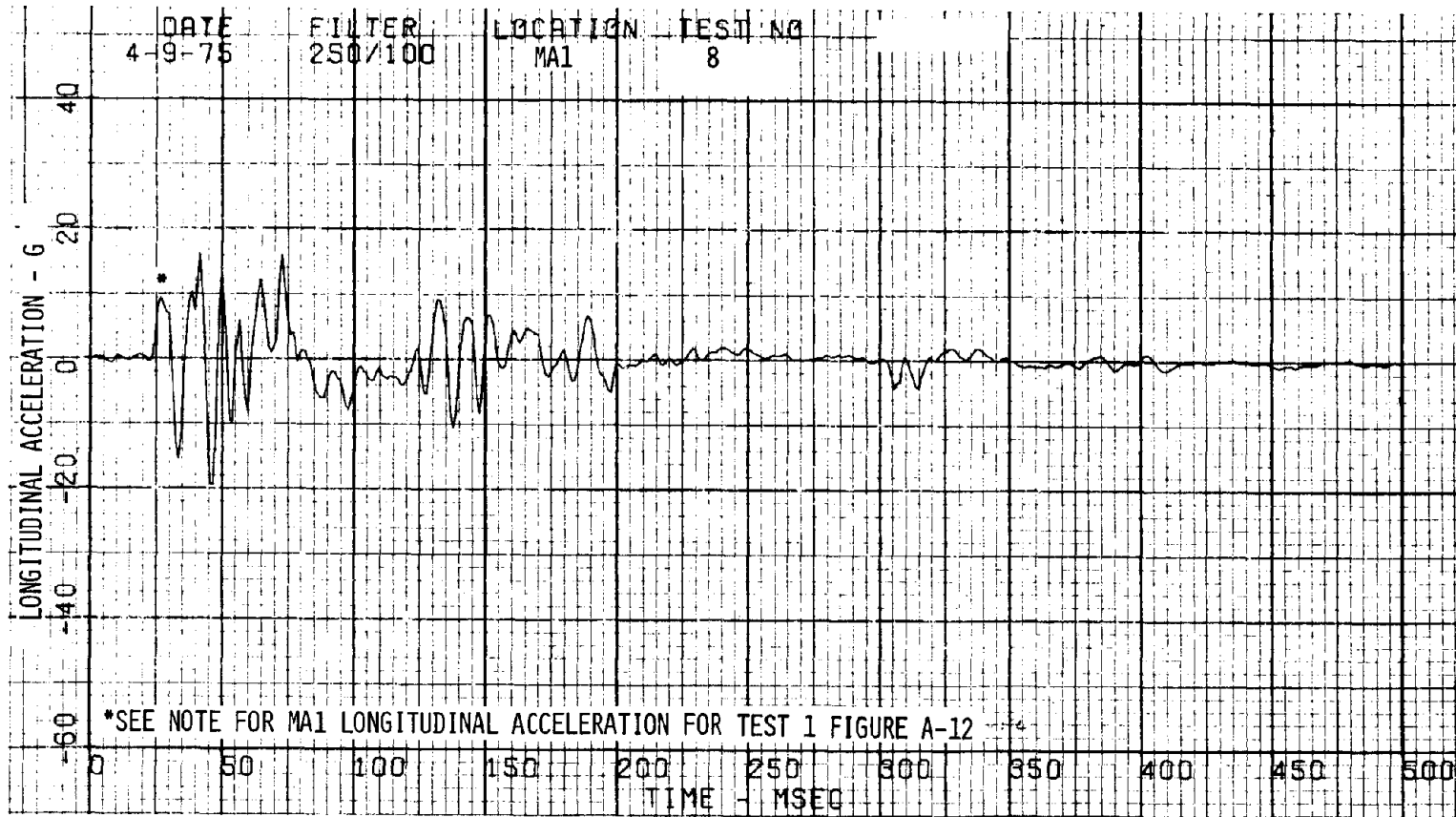


Figure A-236. Locomotive Rear Triaxial Accelerometer (X) - Test 8.

A-235

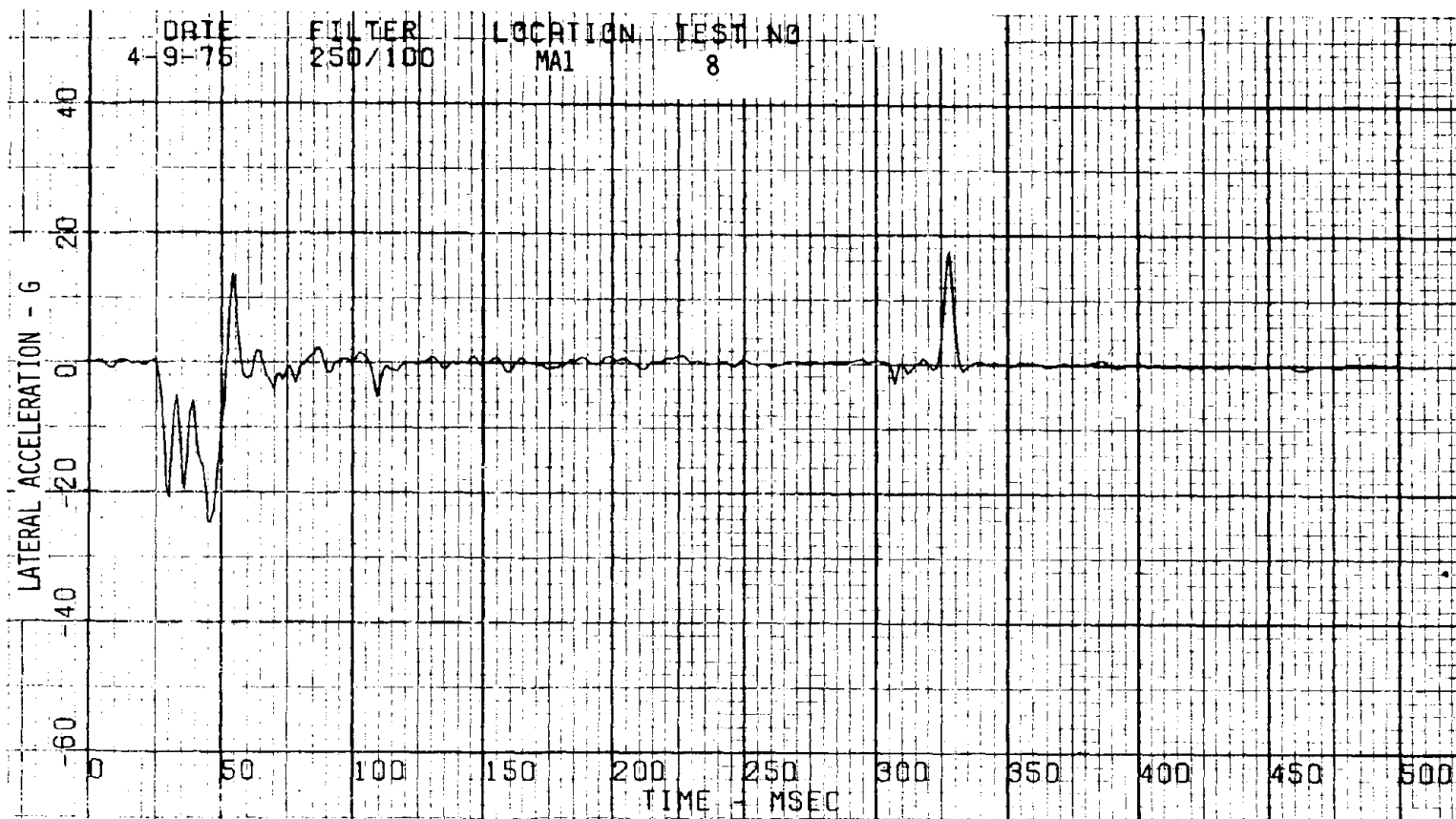


Figure A-237. Locomotive Rear Triaxial Accelerometer (Y) - Test 8.

A-236

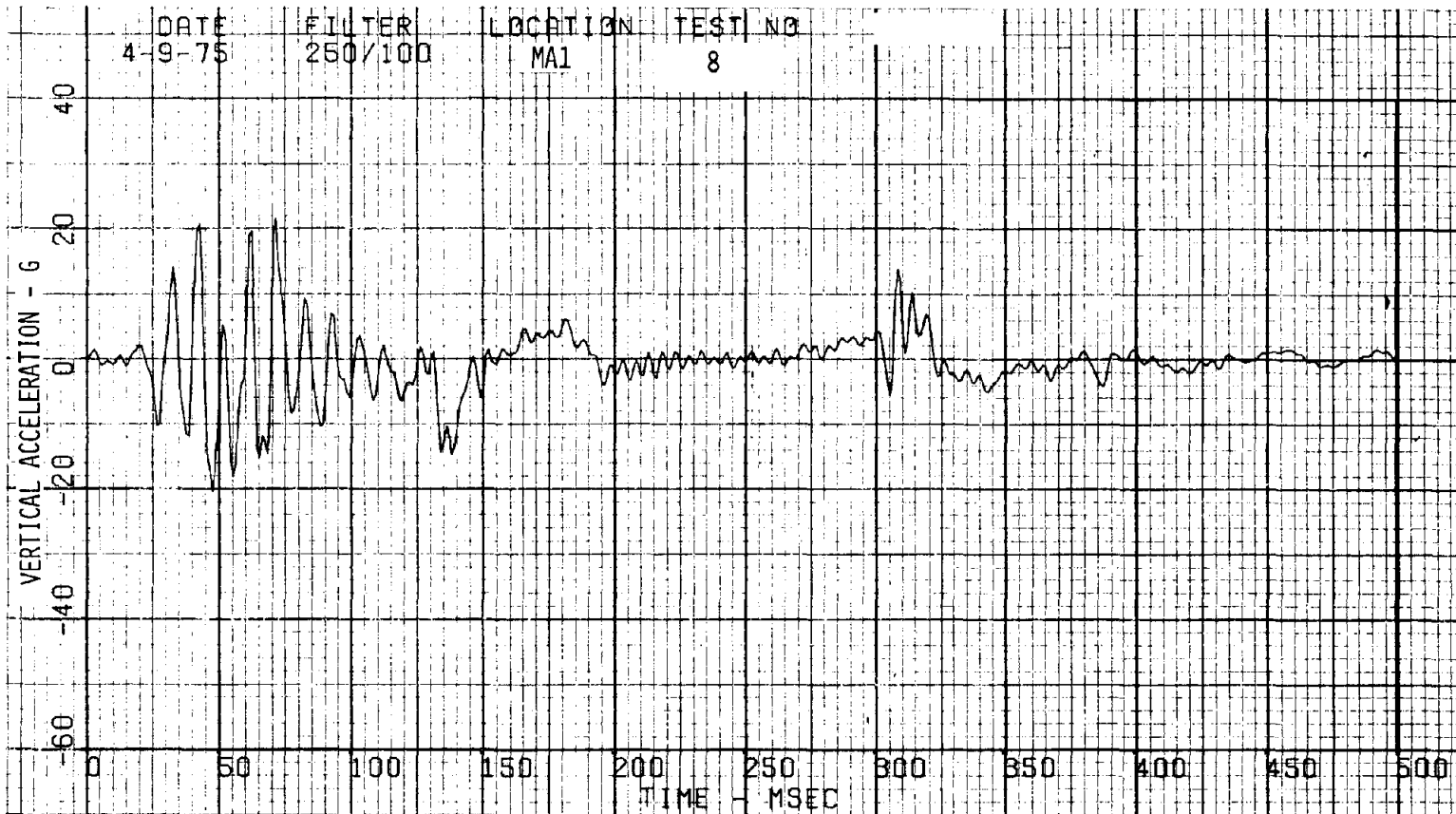


Figure A-238. Locomotive Rear Triaxial Accelerometer (Z) - Test 8.

A-237

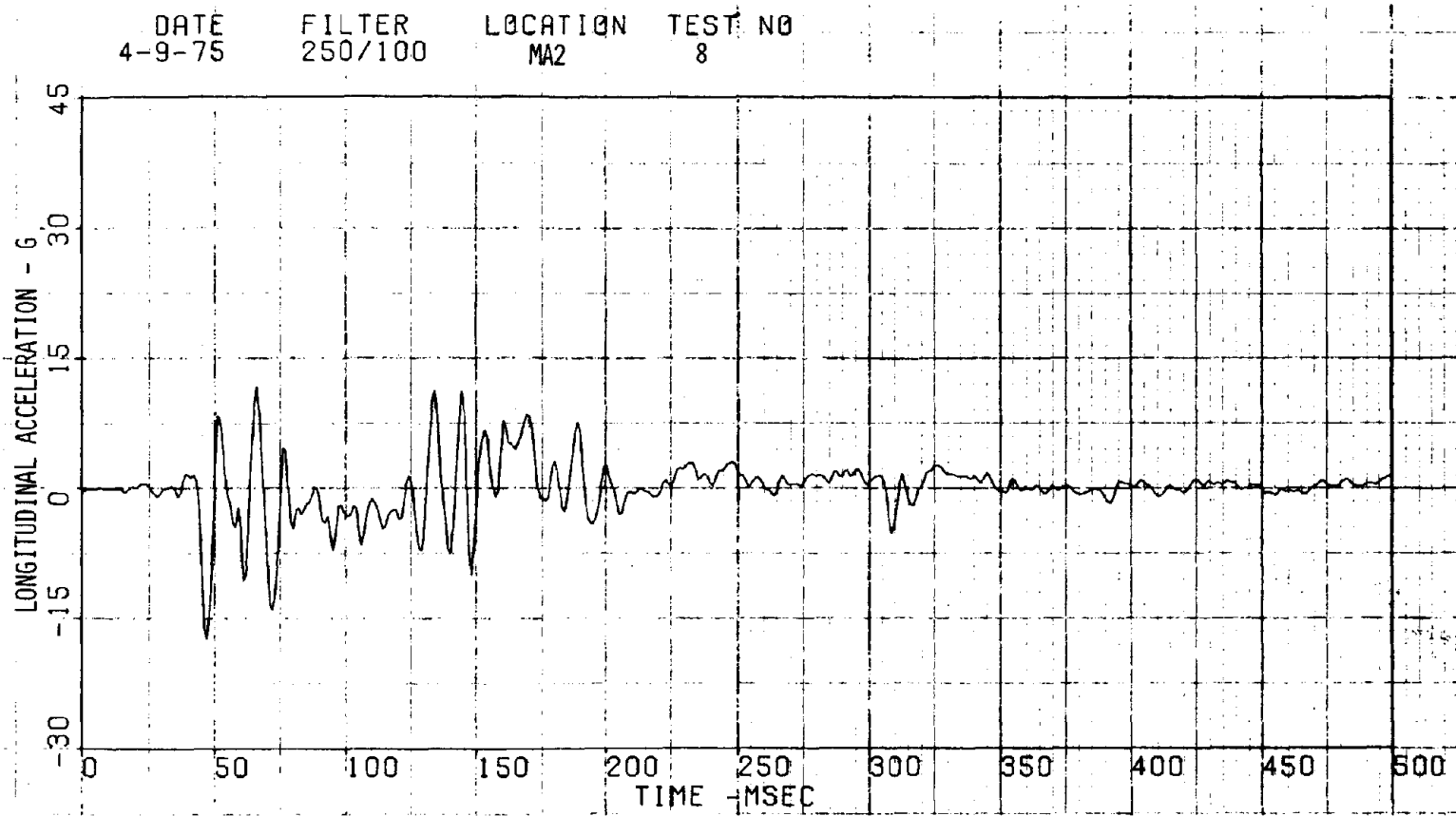


Figure A-239. Locomotive Left Cab Accelerometer - Test 8.

A-238

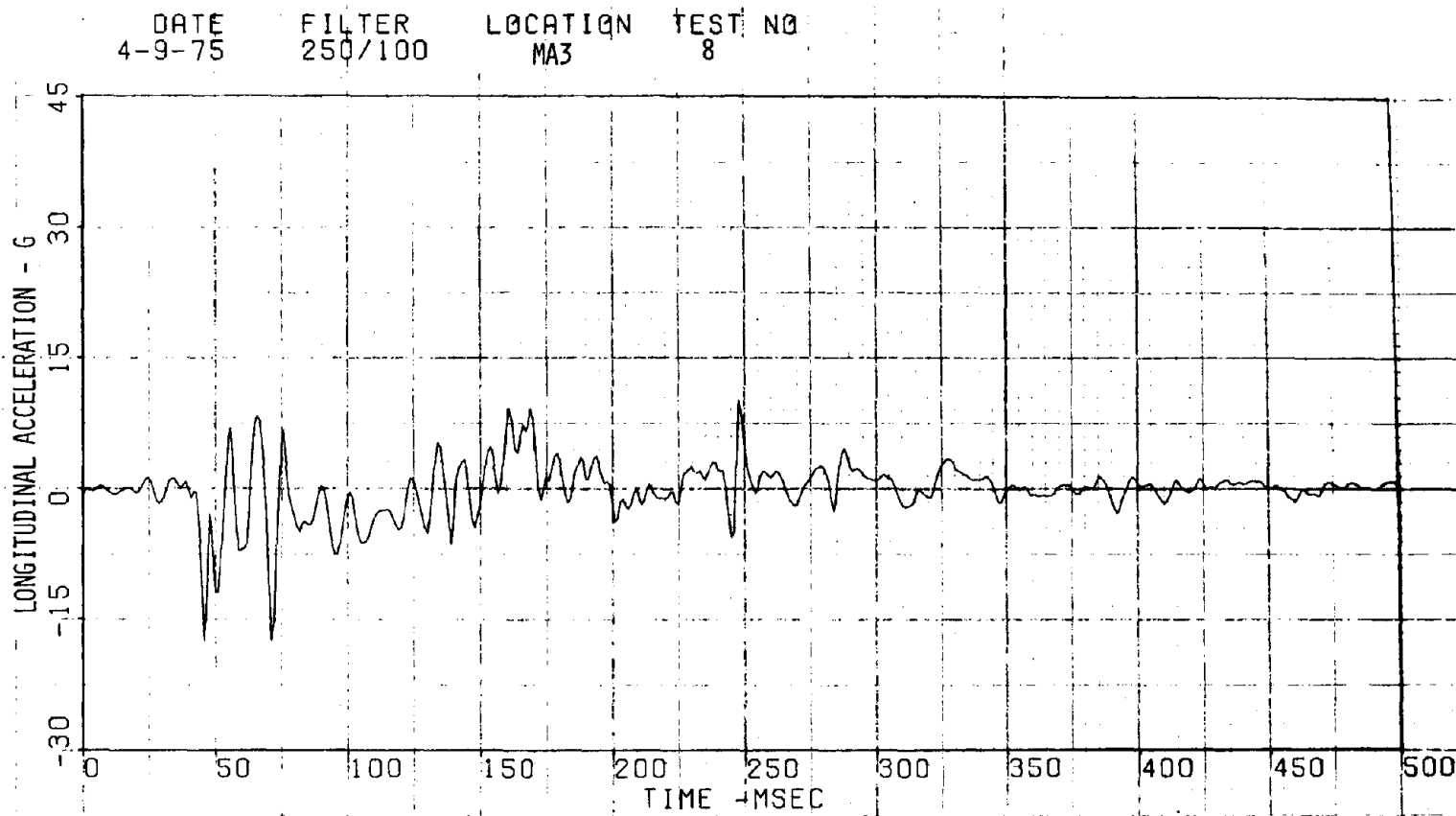


Figure A-240. Locomotive Right Cab Accelerometer - Test 8.

A-239

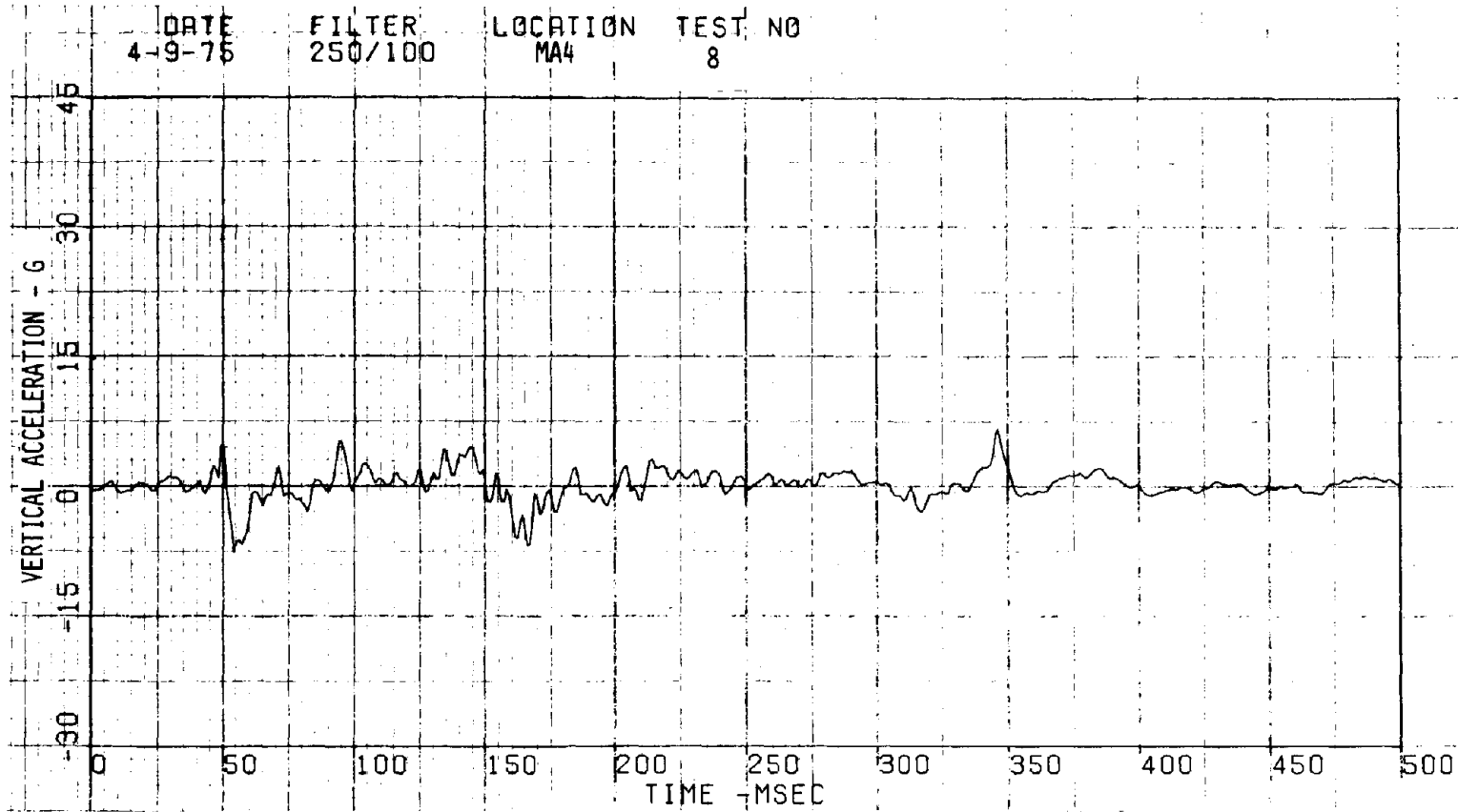


Figure A-241. Locomotive Center Vertical Accelerometer - Test 8.

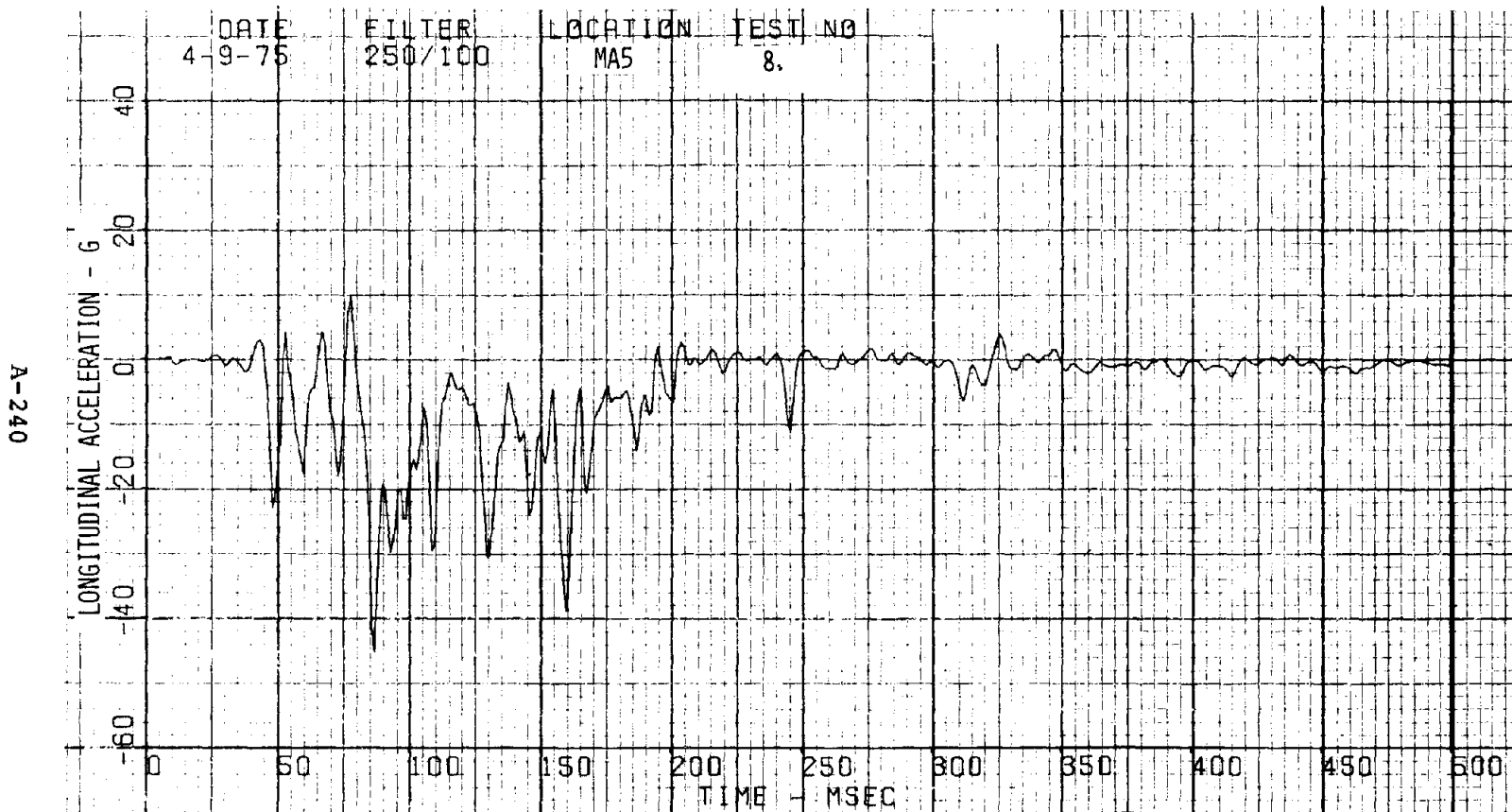


Figure A-242. Locomotive Front Triaxial Accelerometer (X) - Test 8.

A-241

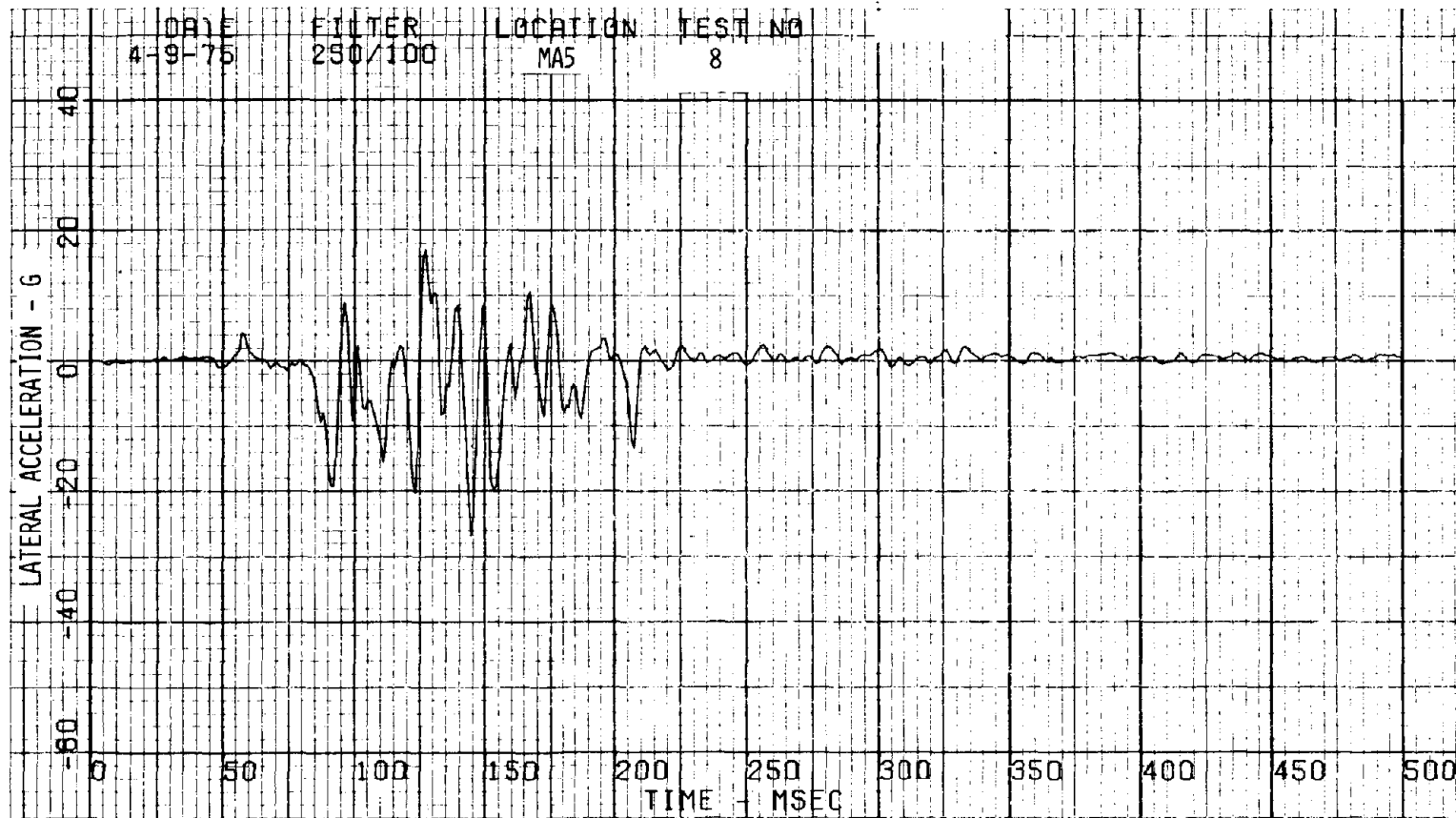


Figure A-243. Locomotive Front Triaxial Accelerometer (Y) - Test 8.

A-242

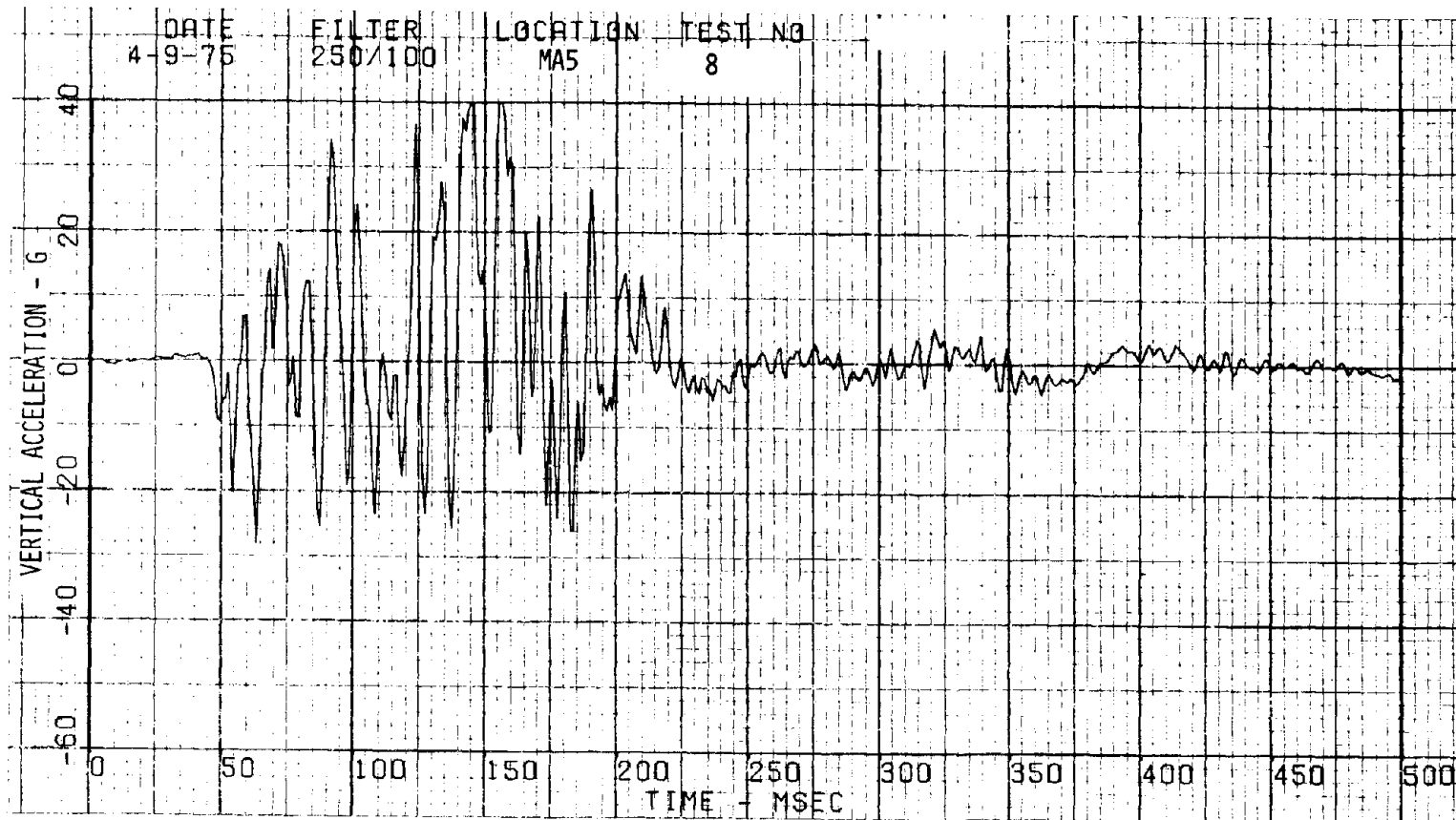


Figure A-244. Locomotive Front Triaxial Accelerometer (Z) - Test 8.

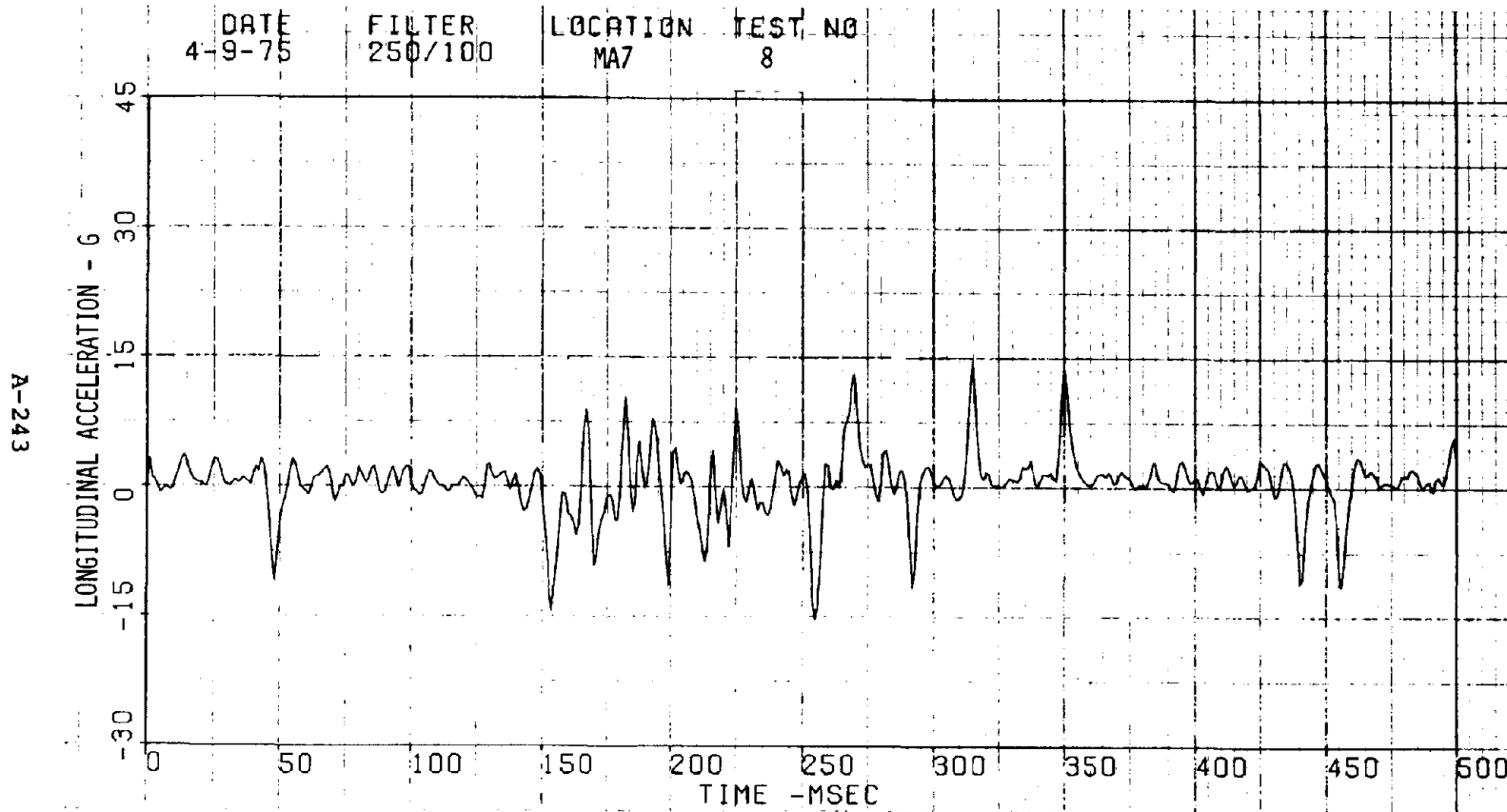


Figure A-245. Hopper 506 Center Longitudinal Accelerometer - Test 8.

A-244

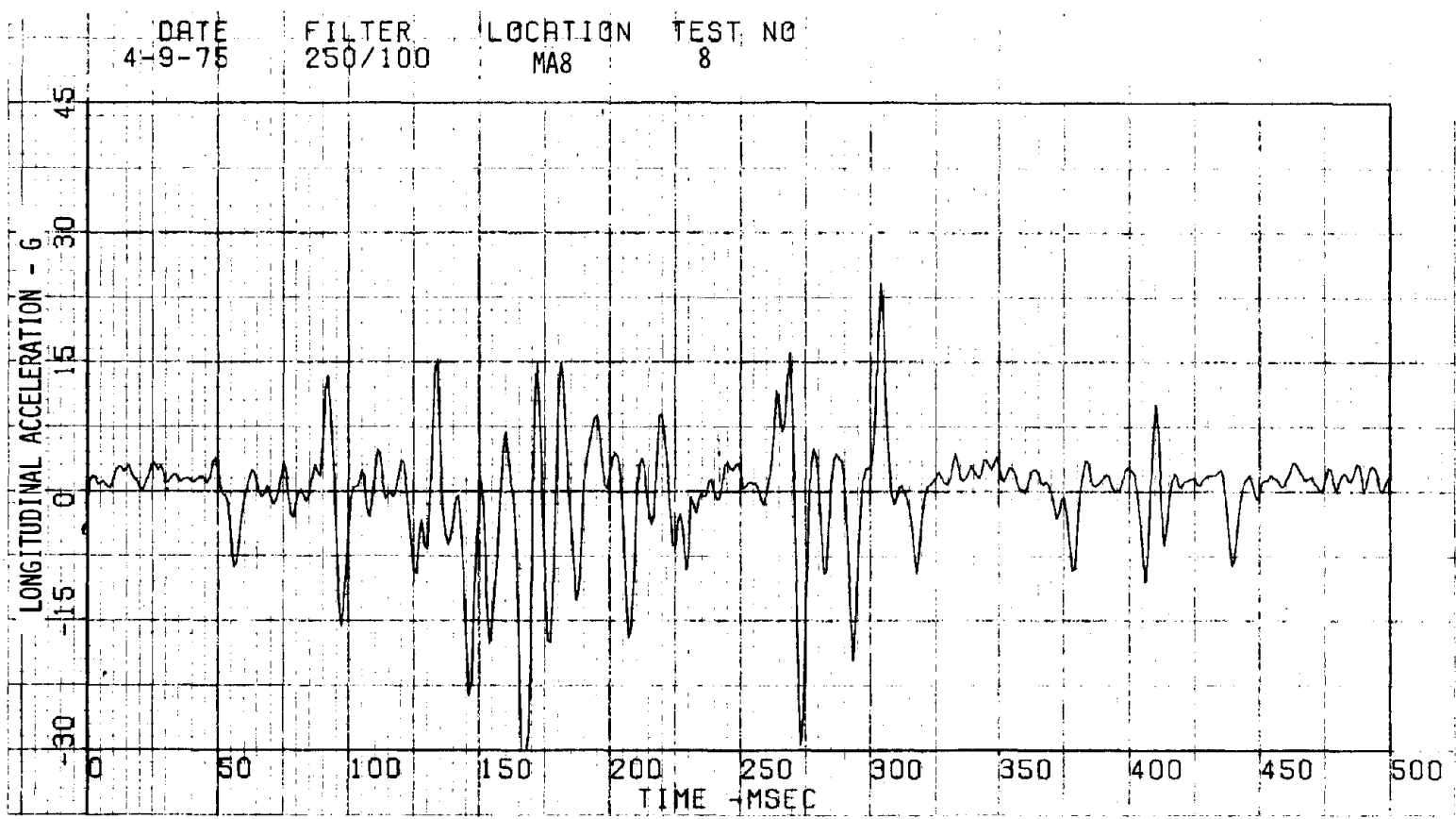


Figure A-246. Hopper 614 Center Longitudinal Accelerometer - Test 8.

A-245

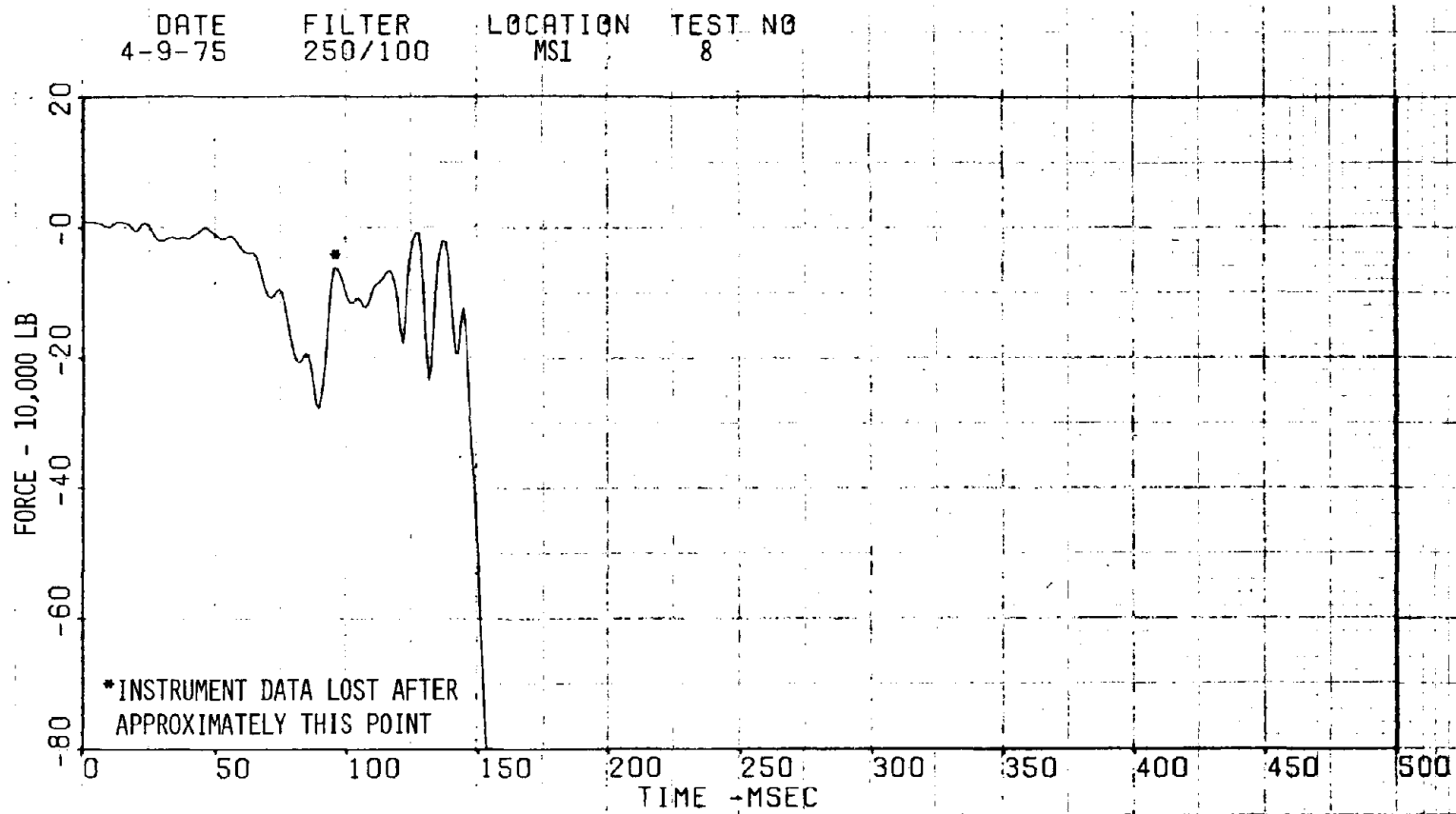
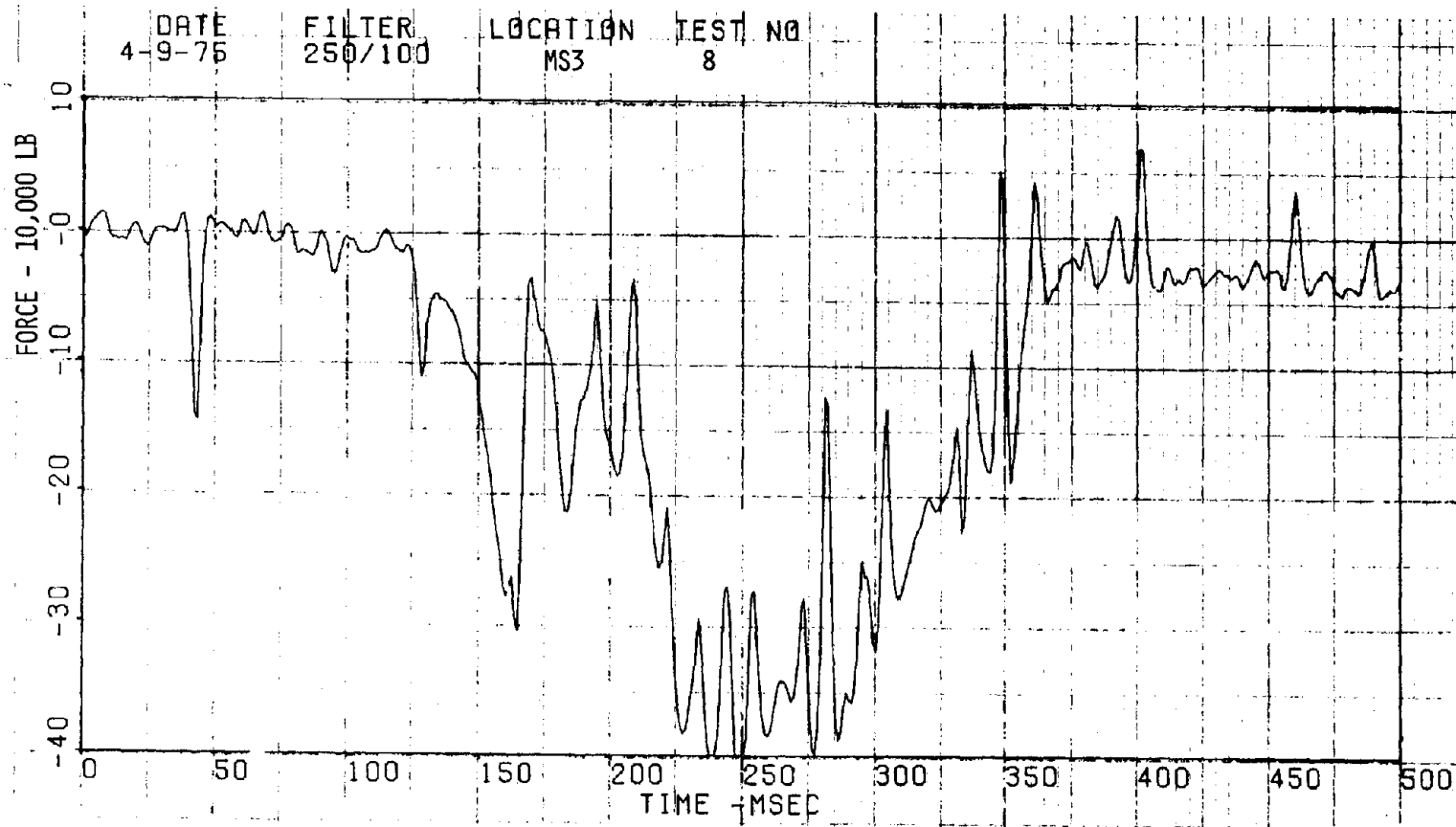


Figure A-247. Locomotive Front Coupler Strain Gauge - Test 8.



A-246

Figure A-248. Hopper 614 Rear Coupler Strain Gauge - Test 8.

A-247

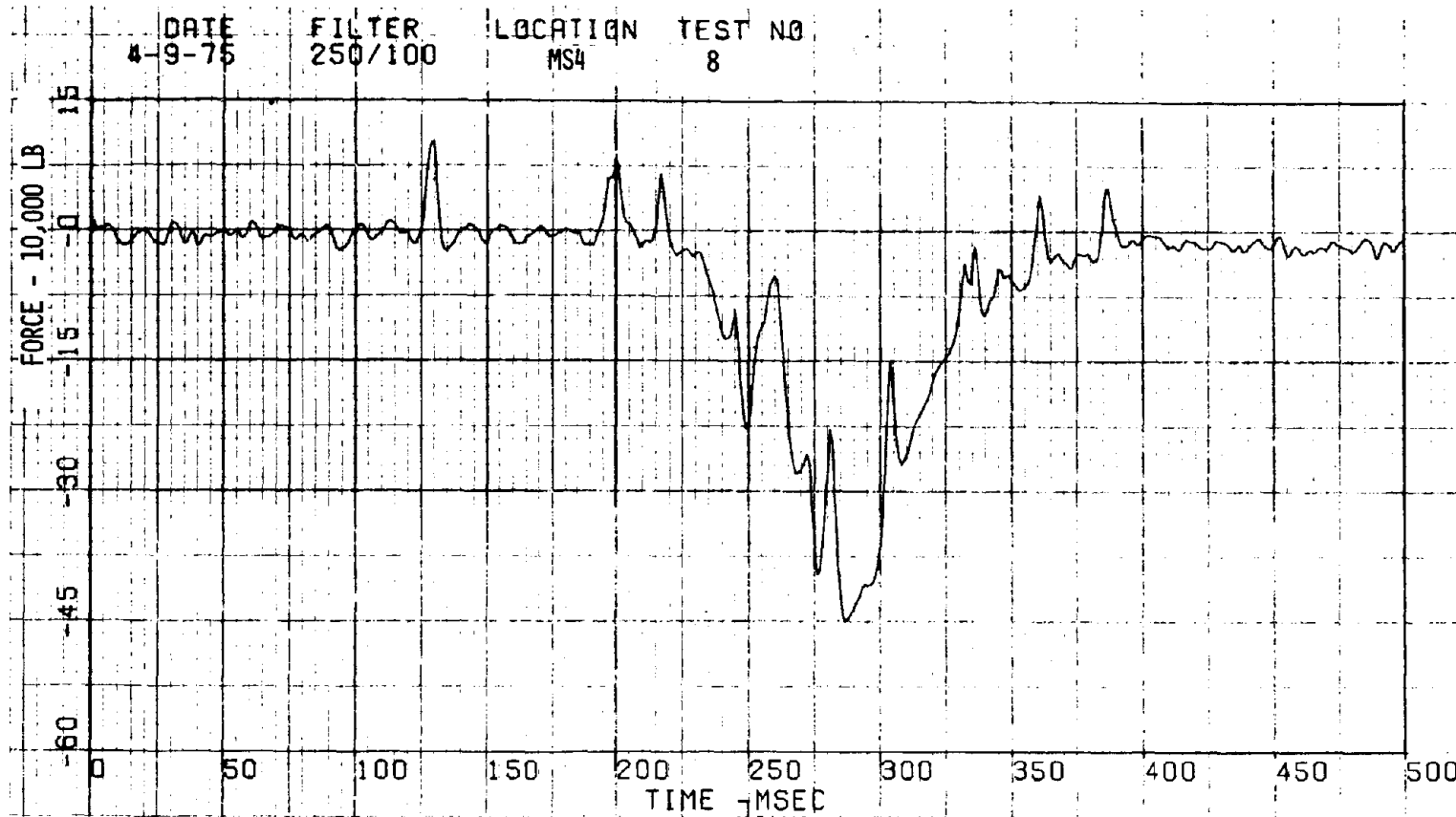


Figure A-249. Hopper 605 Rear Coupler Strain Gauge - Test 8.

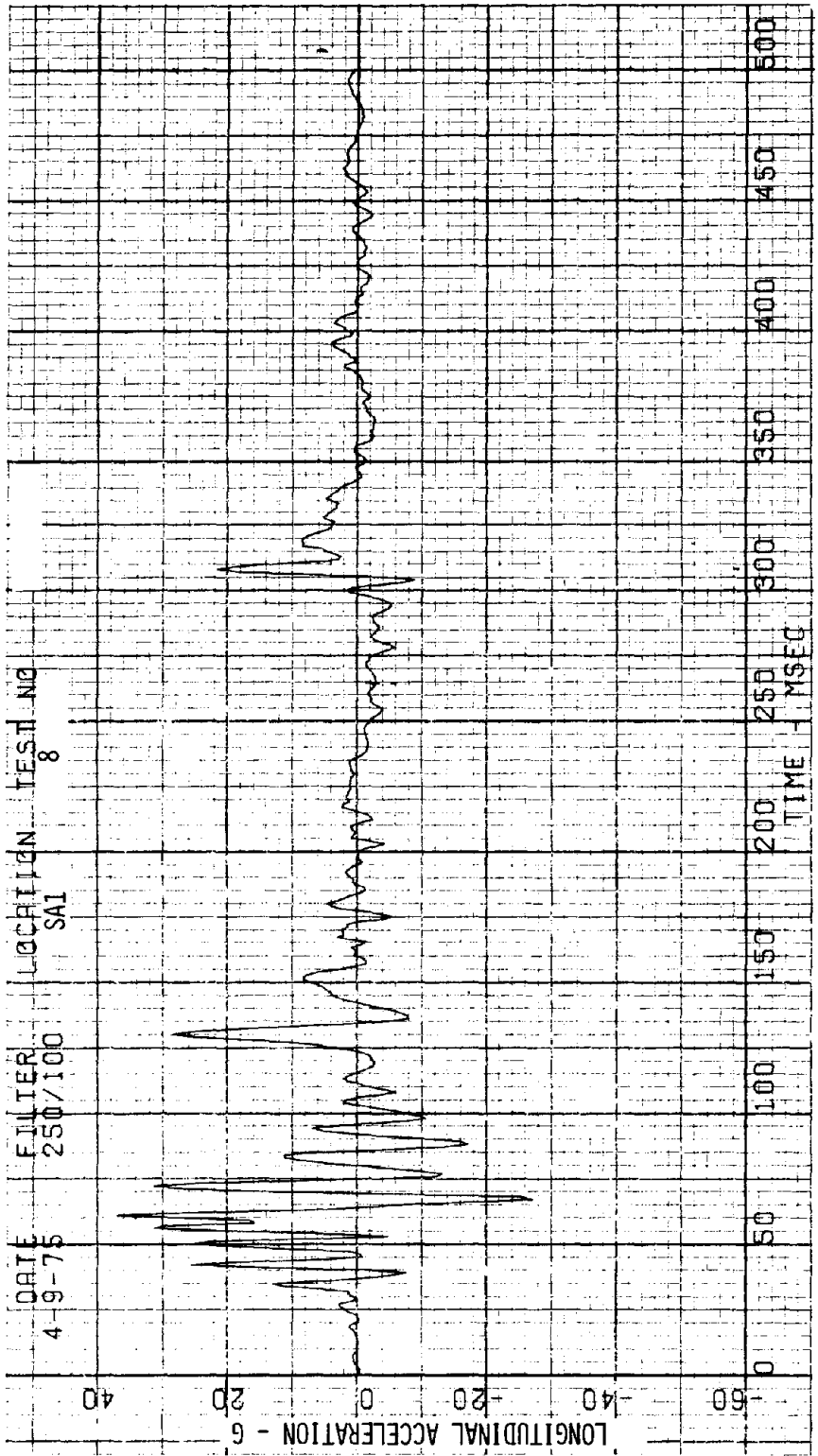


Figure A-250. Caboose Rear Triaxial Accelerometer (X) - Test 8.

A-249

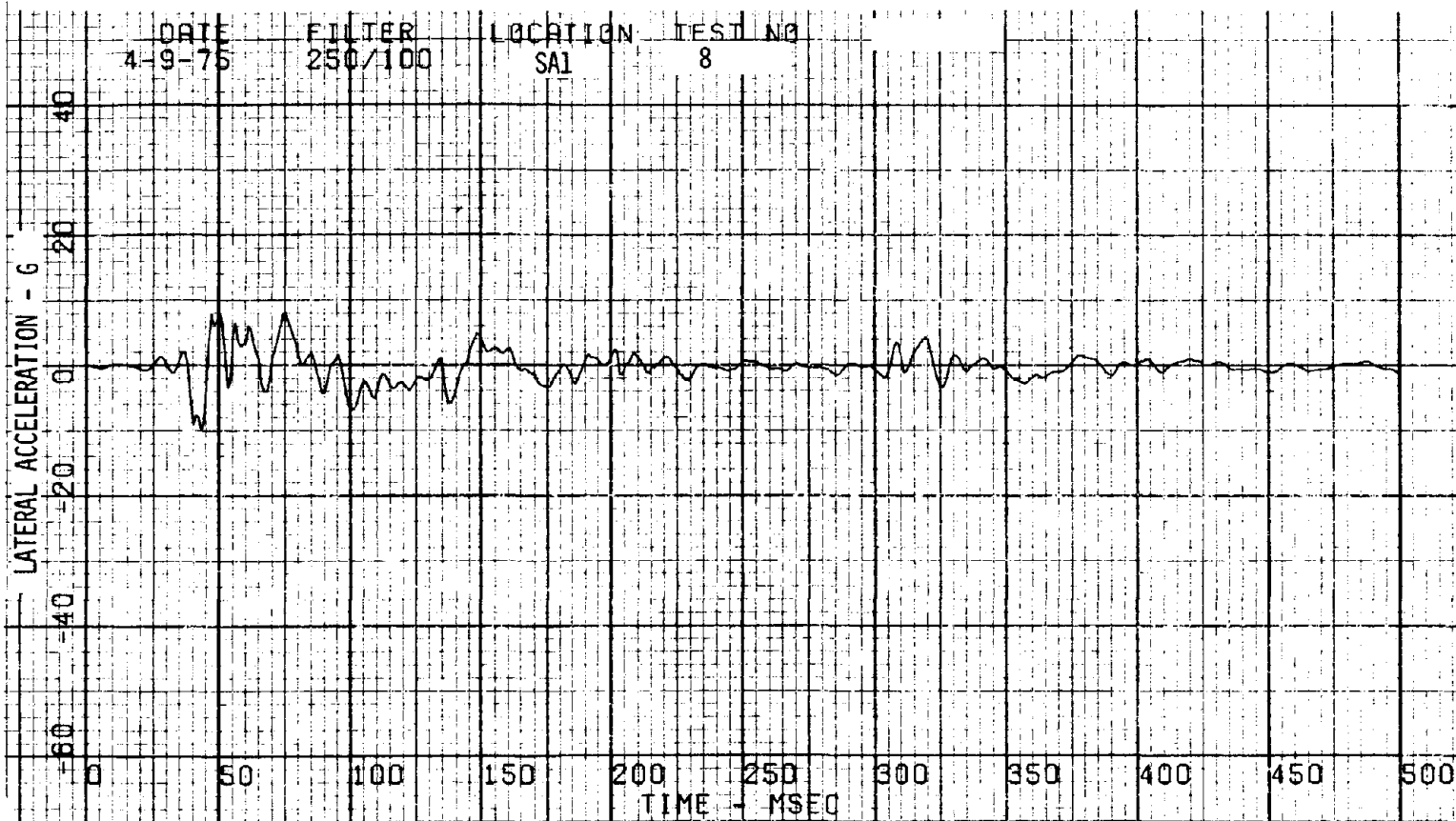


Figure A-251. Caboose Rear Triaxial Accelerometer (Y) - Test 8.

A-250

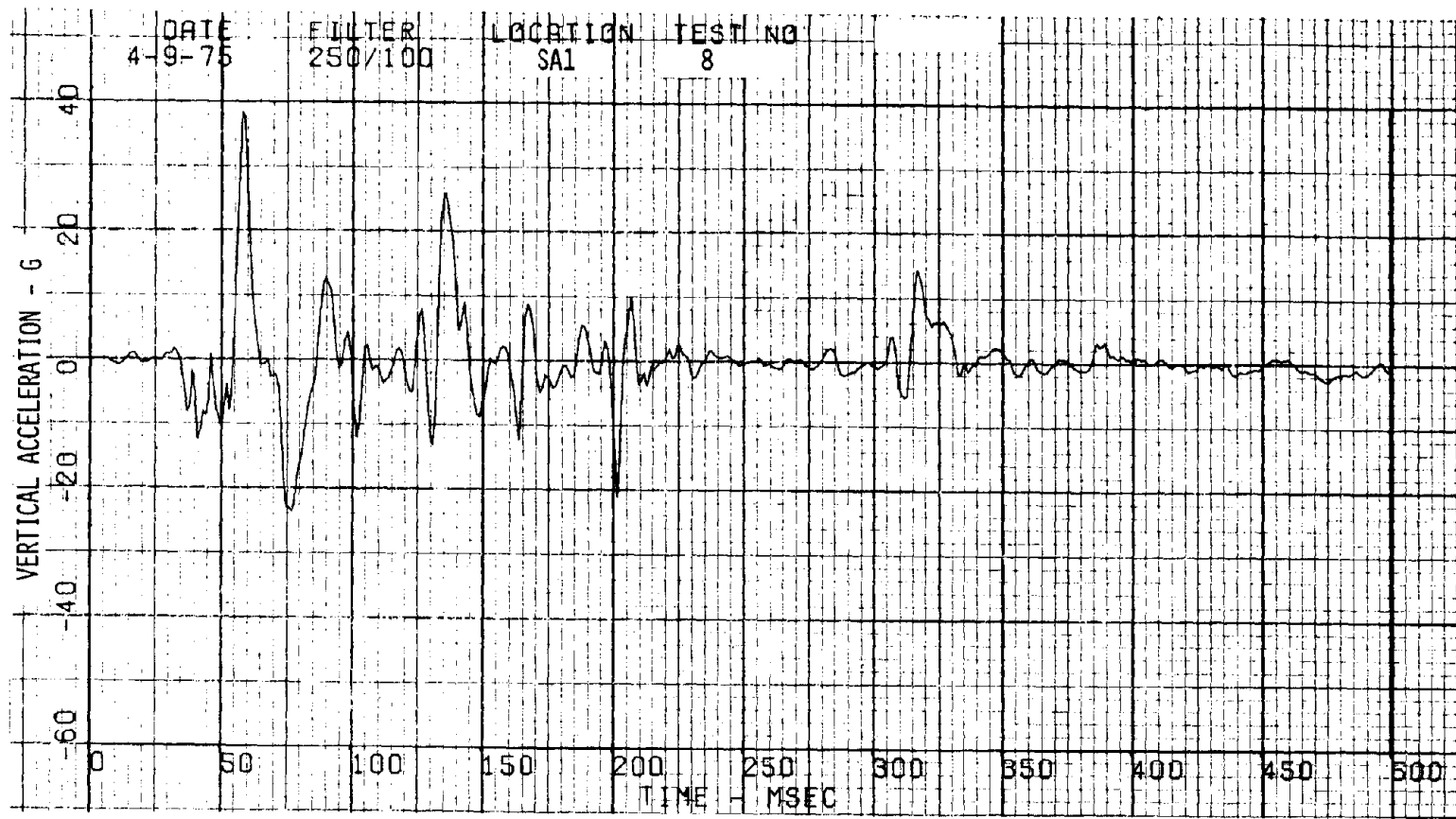


Figure A-252. Caboose Rear Triaxial Accelerometer (Z) - Test 8.

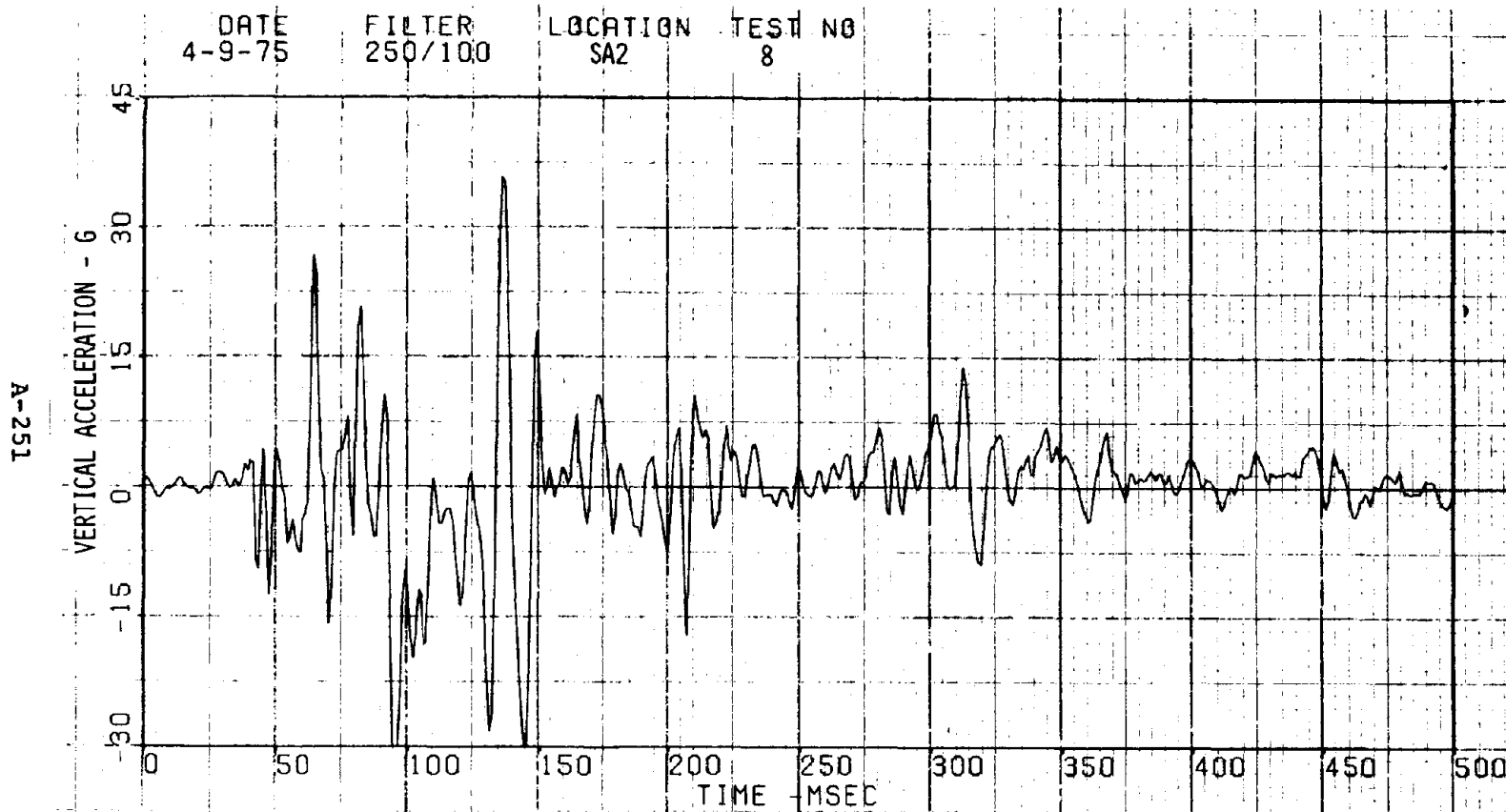


Figure A-253. Caboose Center Vertical Accelerometer - Test 8.

A-252

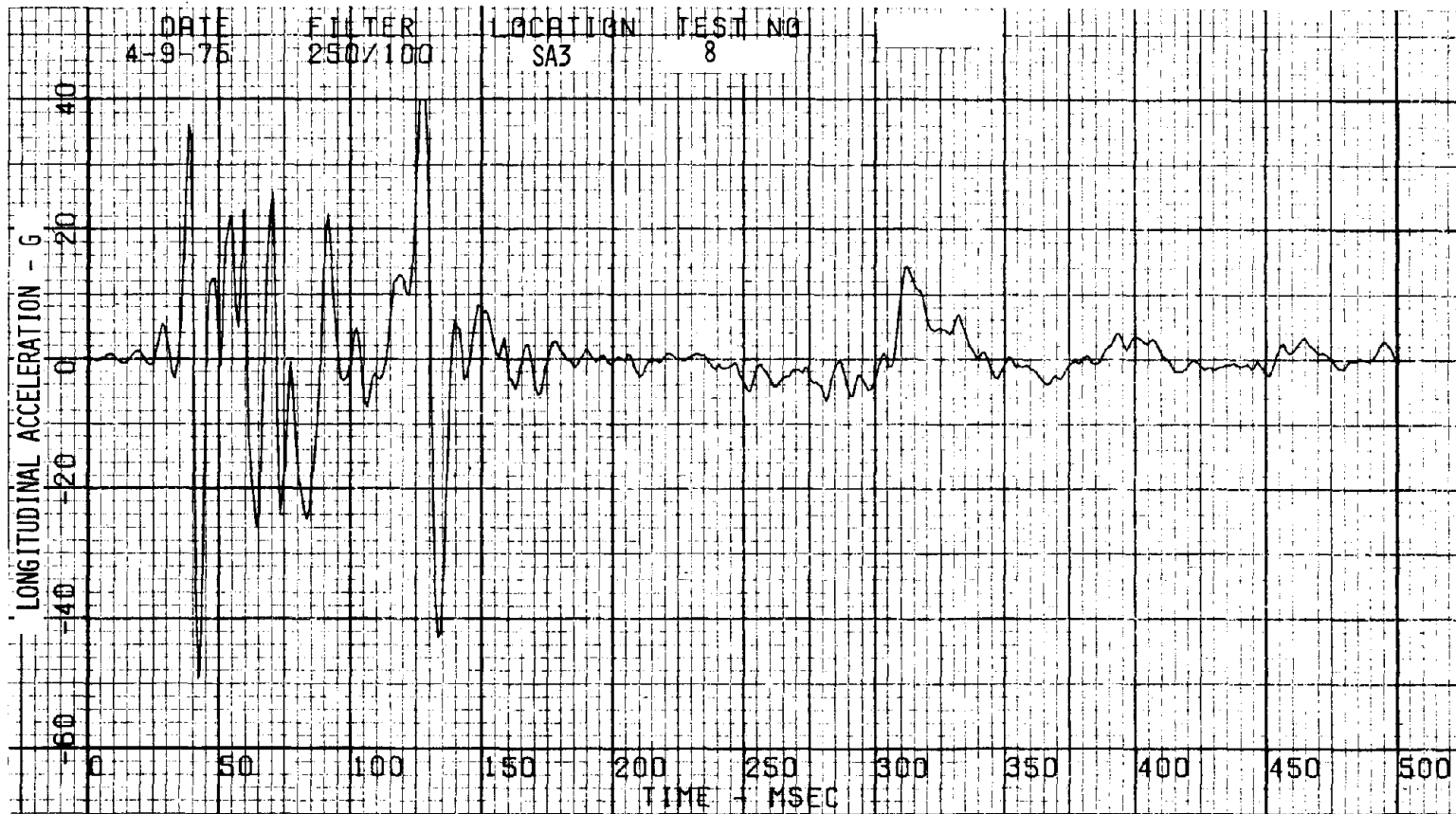


Figure A-254. Caboose Front Triaxial Accelerometer (X) - Test 8.

A-253

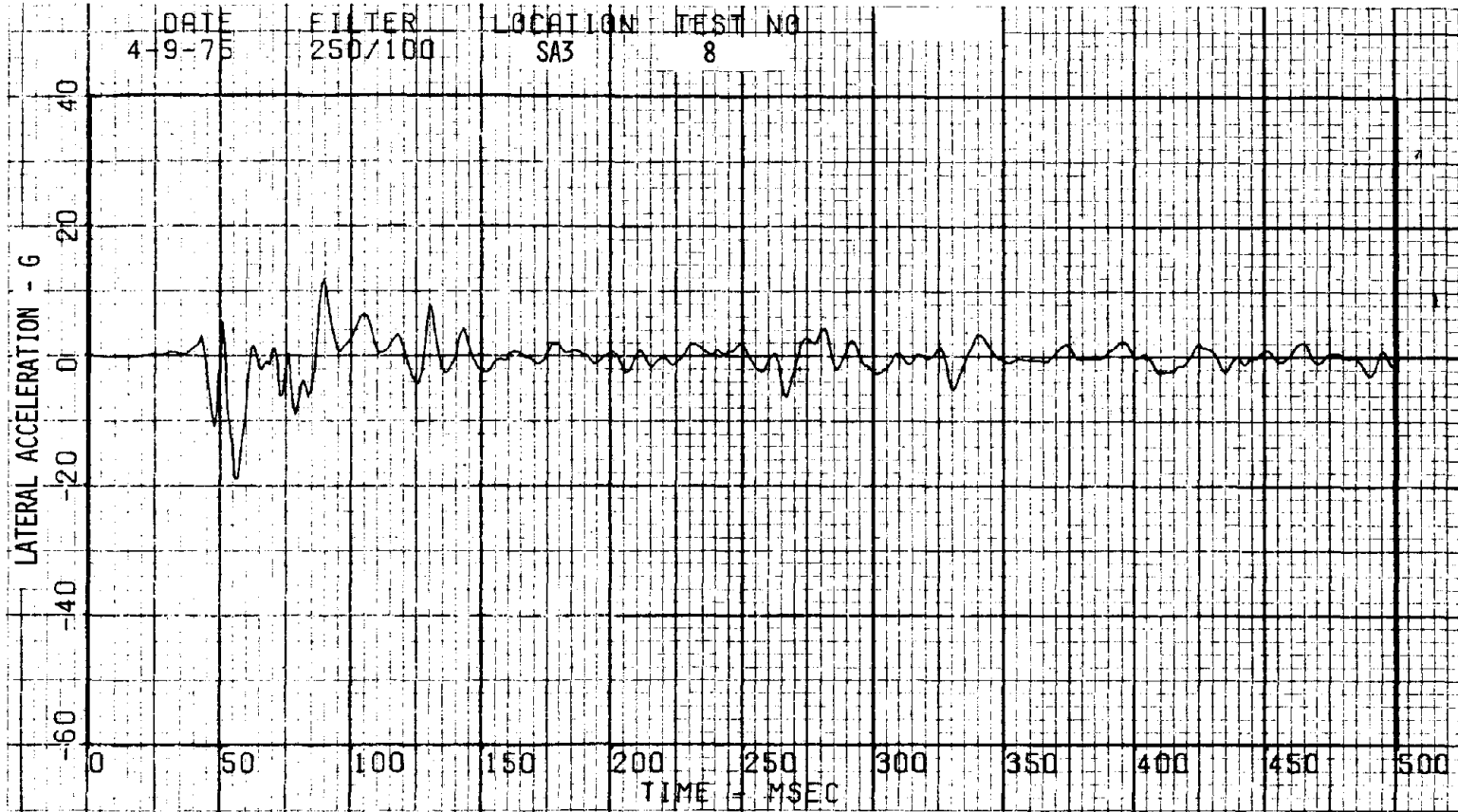


Figure A-255. Caboose Front Triaxial Accelerometer (Y) - Test 8.

A-254

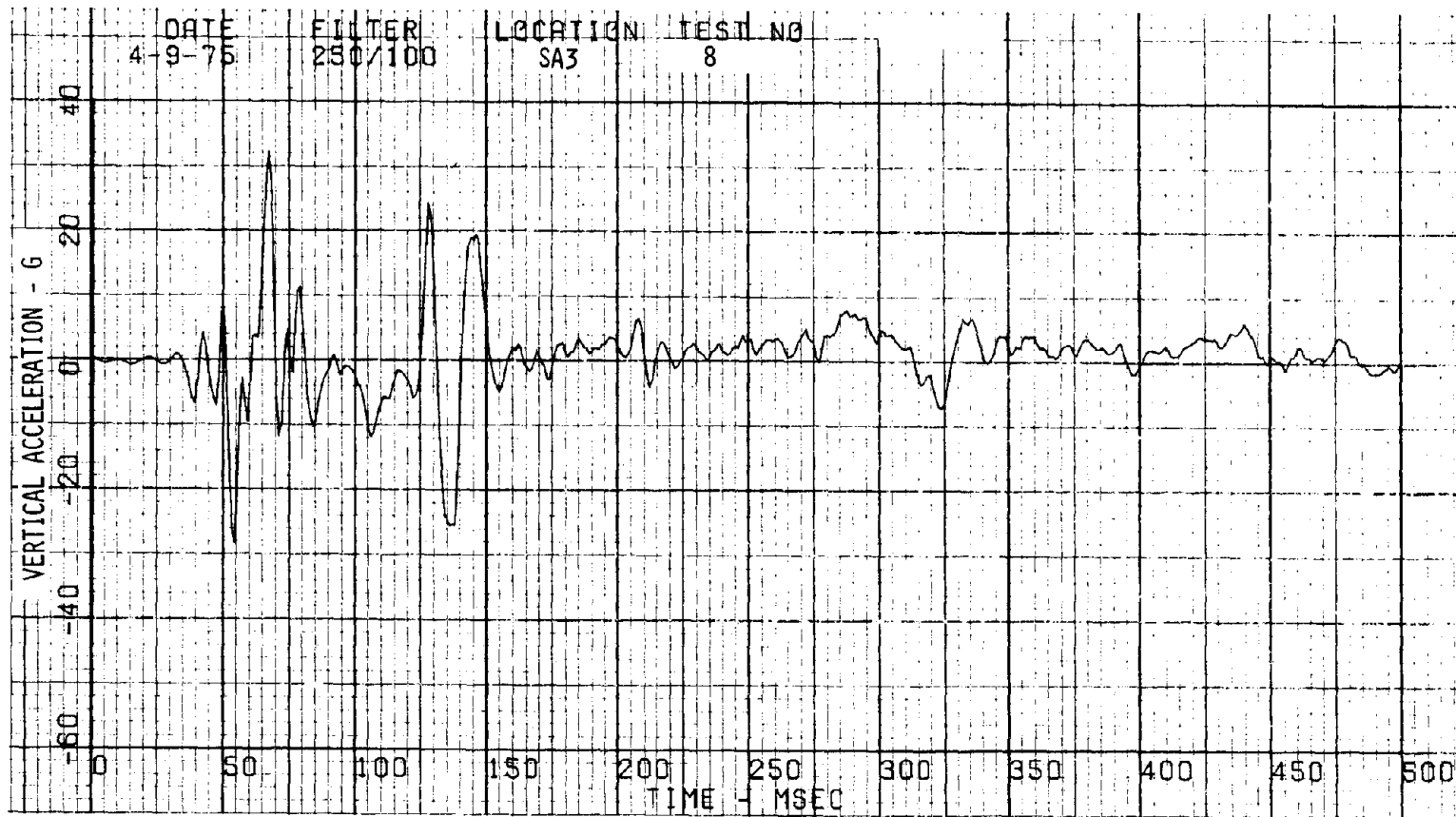


Figure A-256. Caboose Front Triaxial Accelerometer (Z) - Test 8.

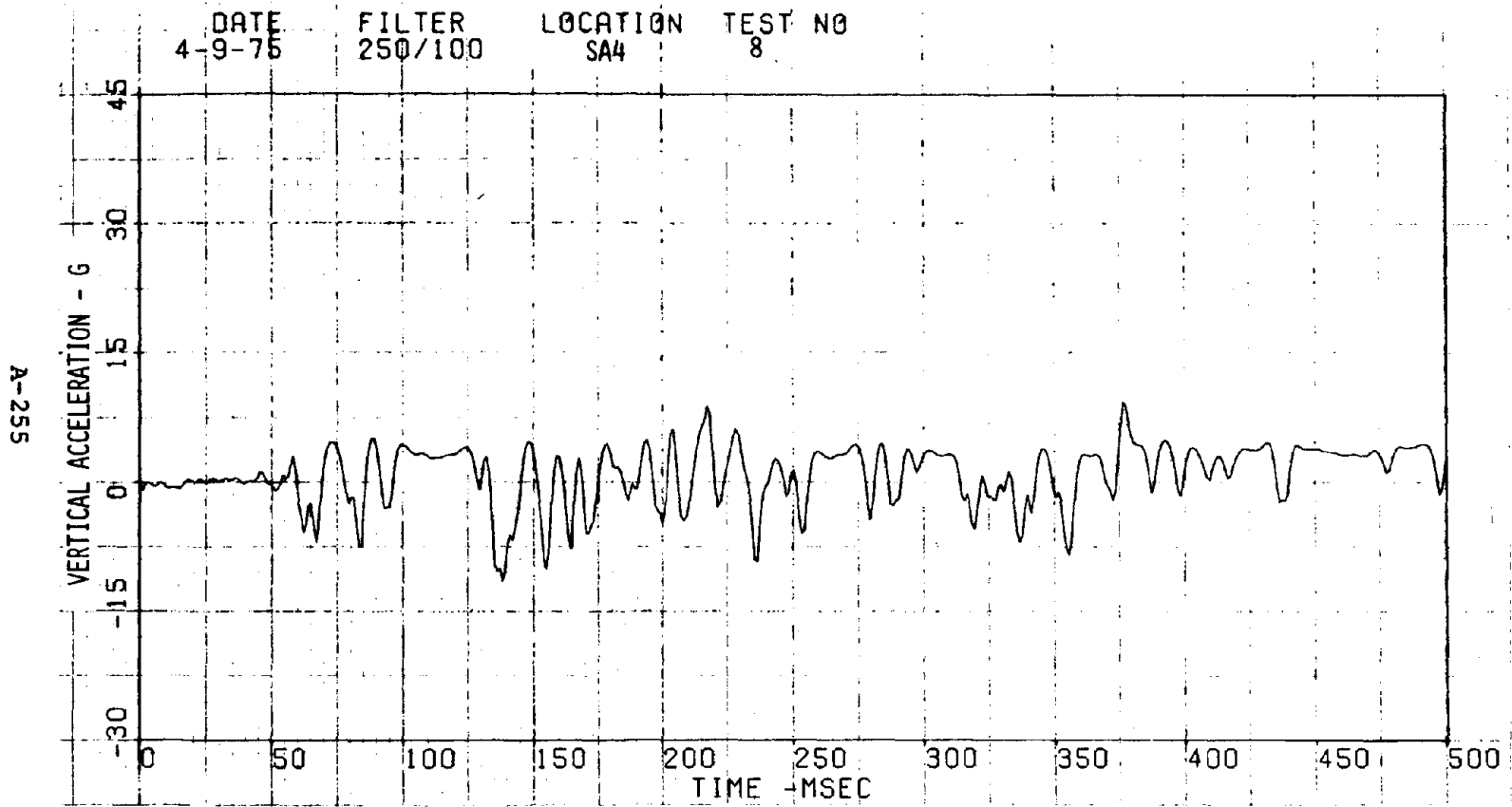


Figure A-257. Hopper 843 Rear Vertical Accelerometer - Test 8.

A-256

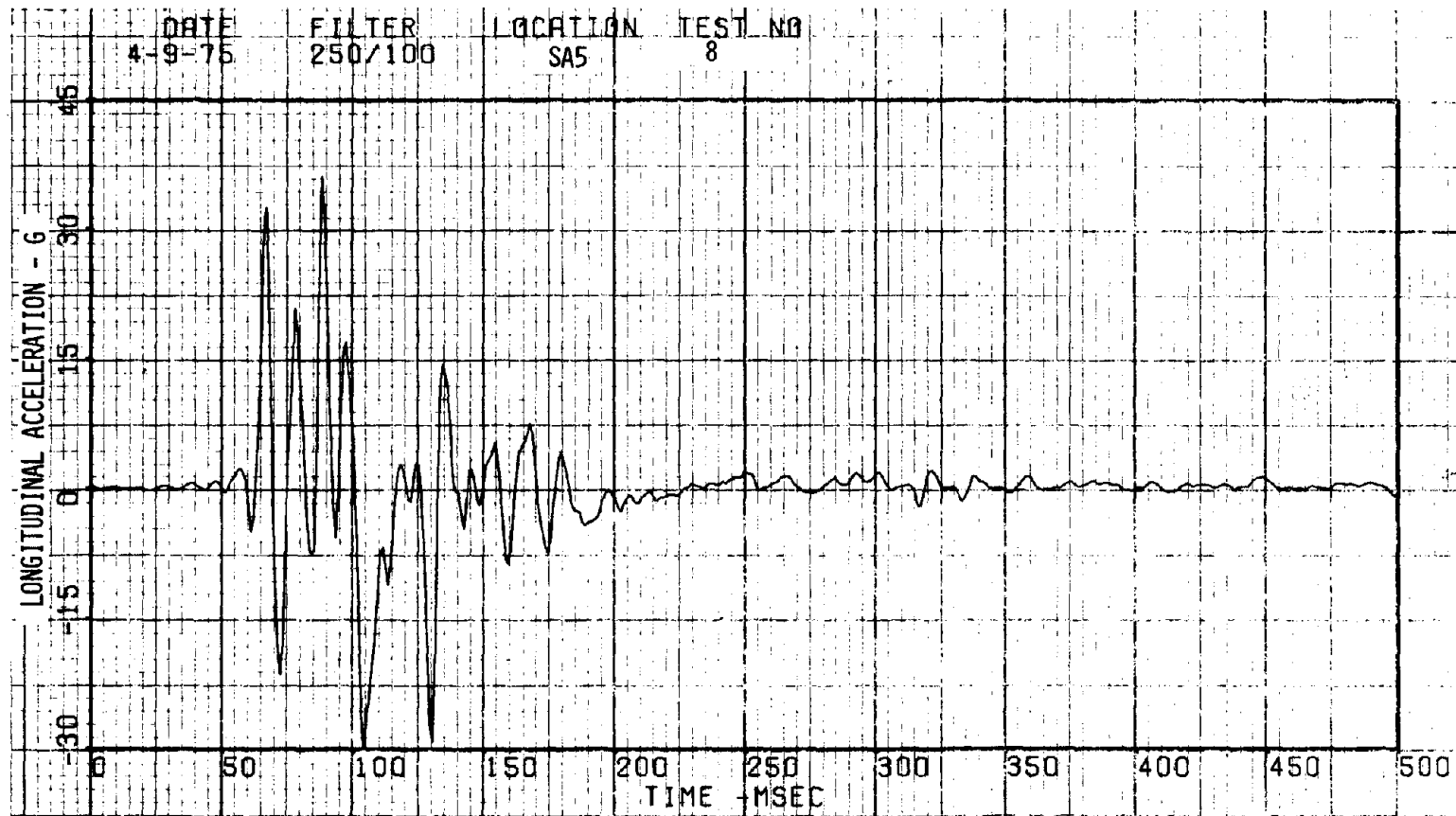


Figure A-258. Hopper 843 Center Longitudinal Accelerometer - Test 8.

A-257

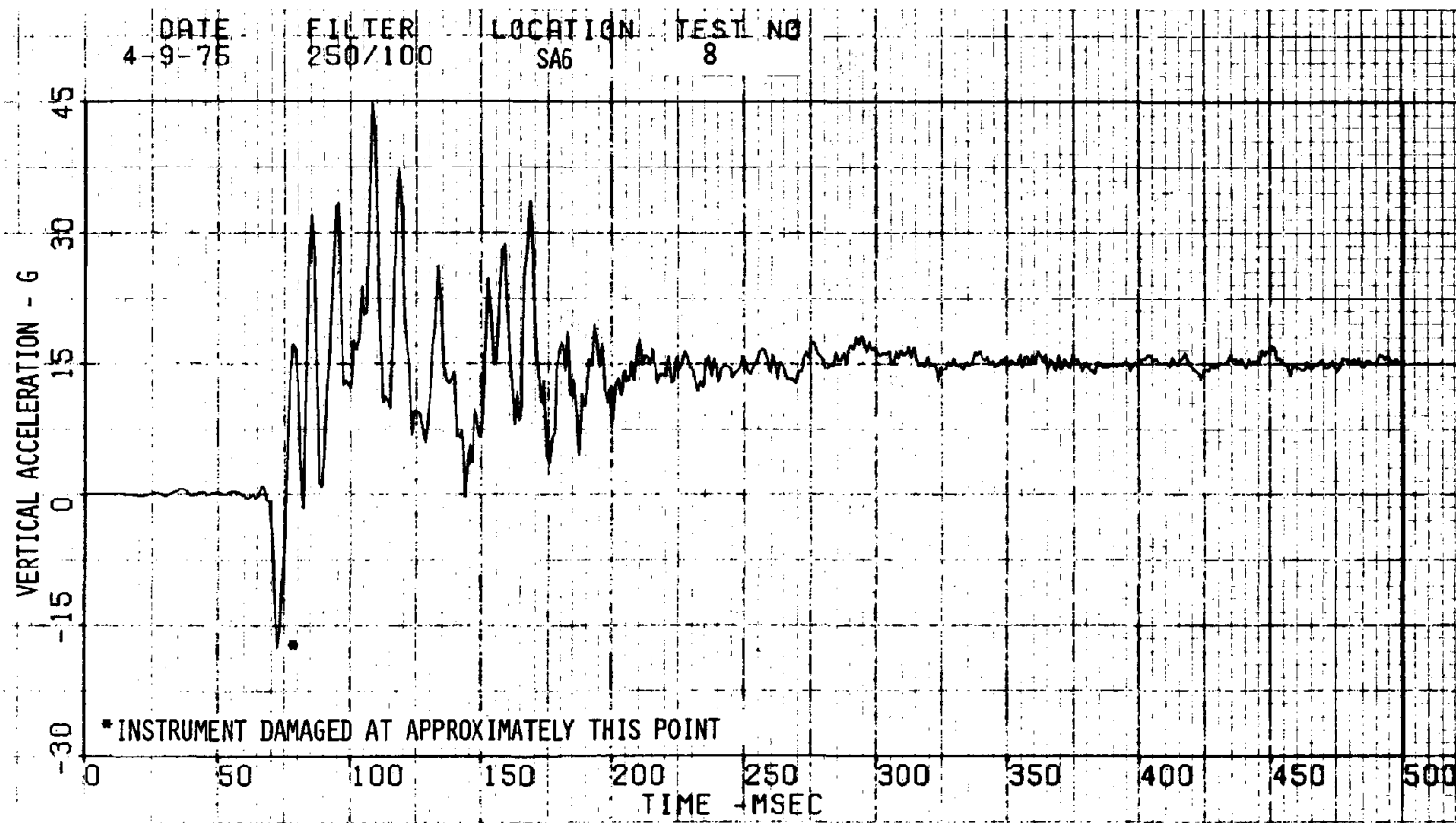


Figure A-259. Hopper 843 Front Vertical Accelerometer - Test 8.

A-258

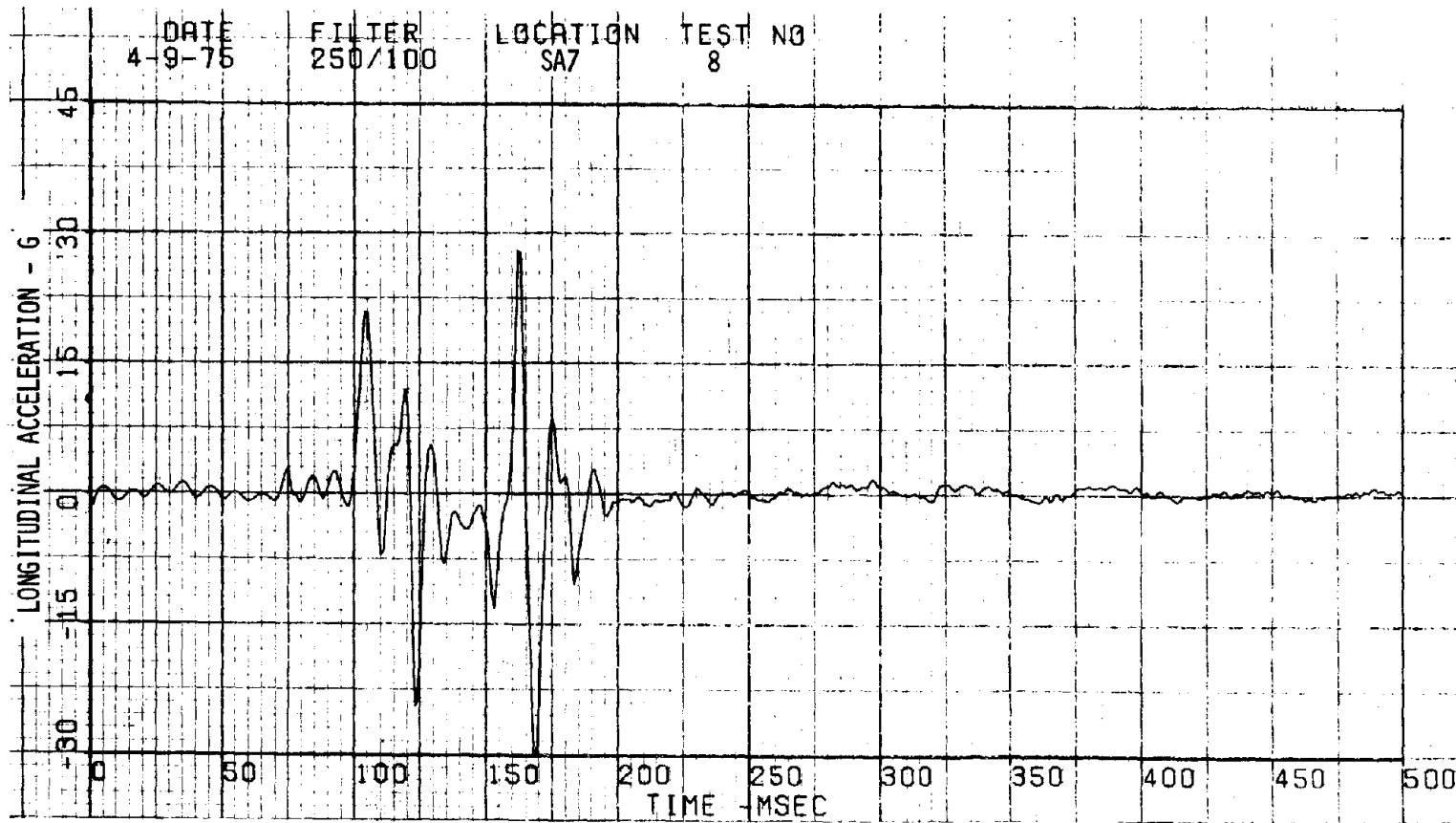


Figure A-260. Hopper 631 Center Longitudinal Accelerometer -- Test 8.

A-259

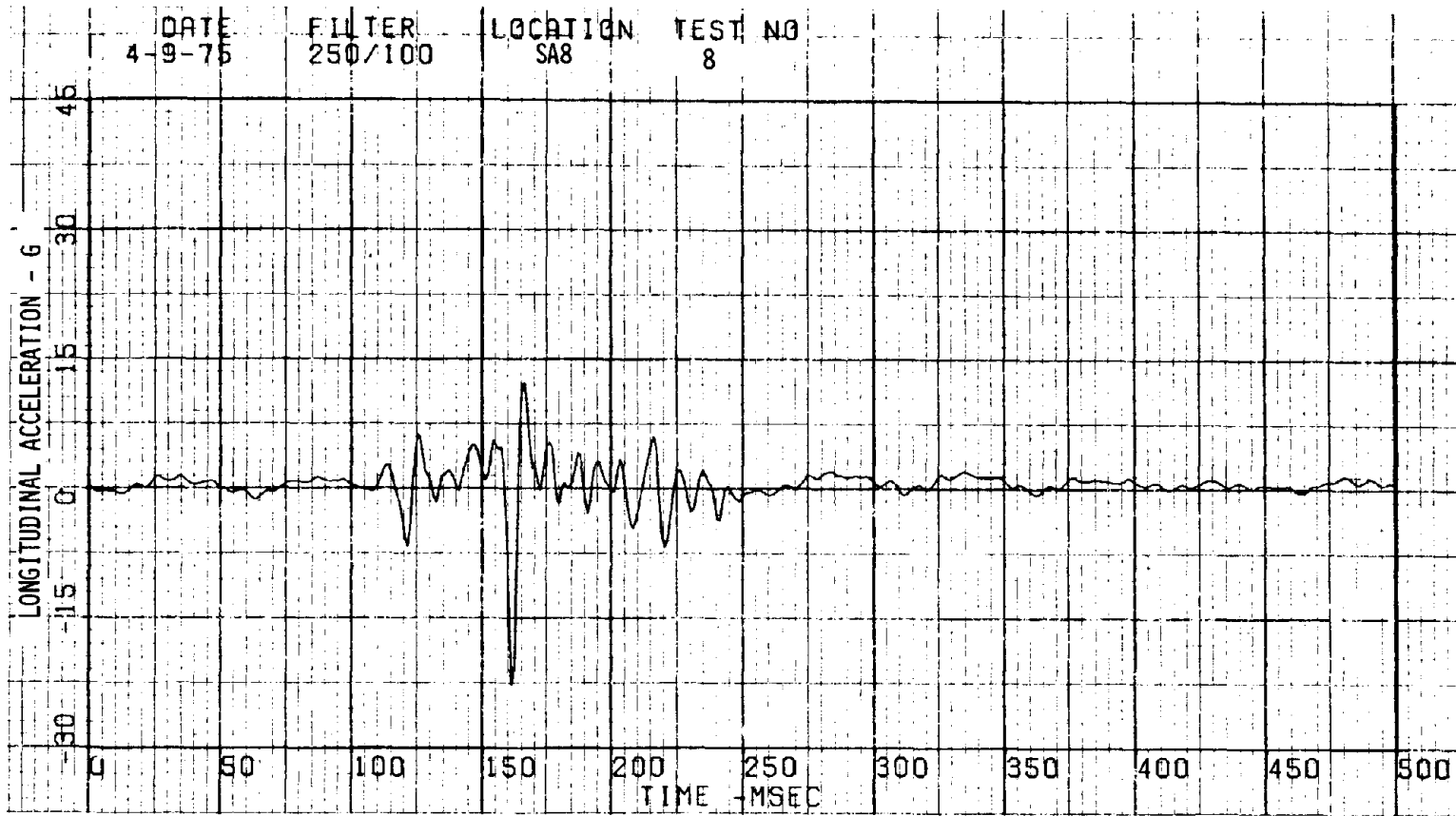


Figure A-261. Hopper 508 Center Longitudinal Accelerometer - Test 8.

A-260

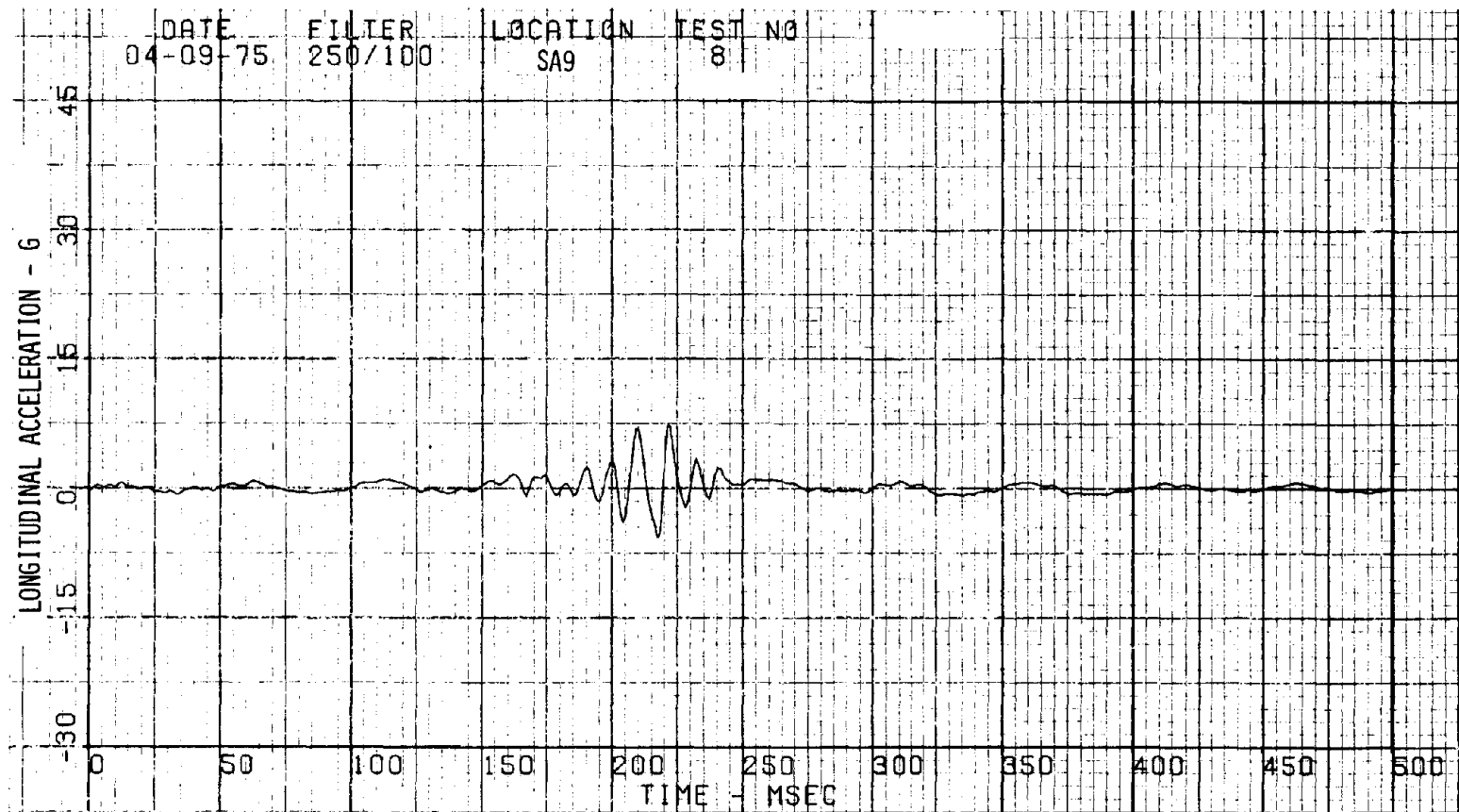


Figure A-262. Hopper 119 Center Longitudinal Accelerometer - Test 8.

A-261

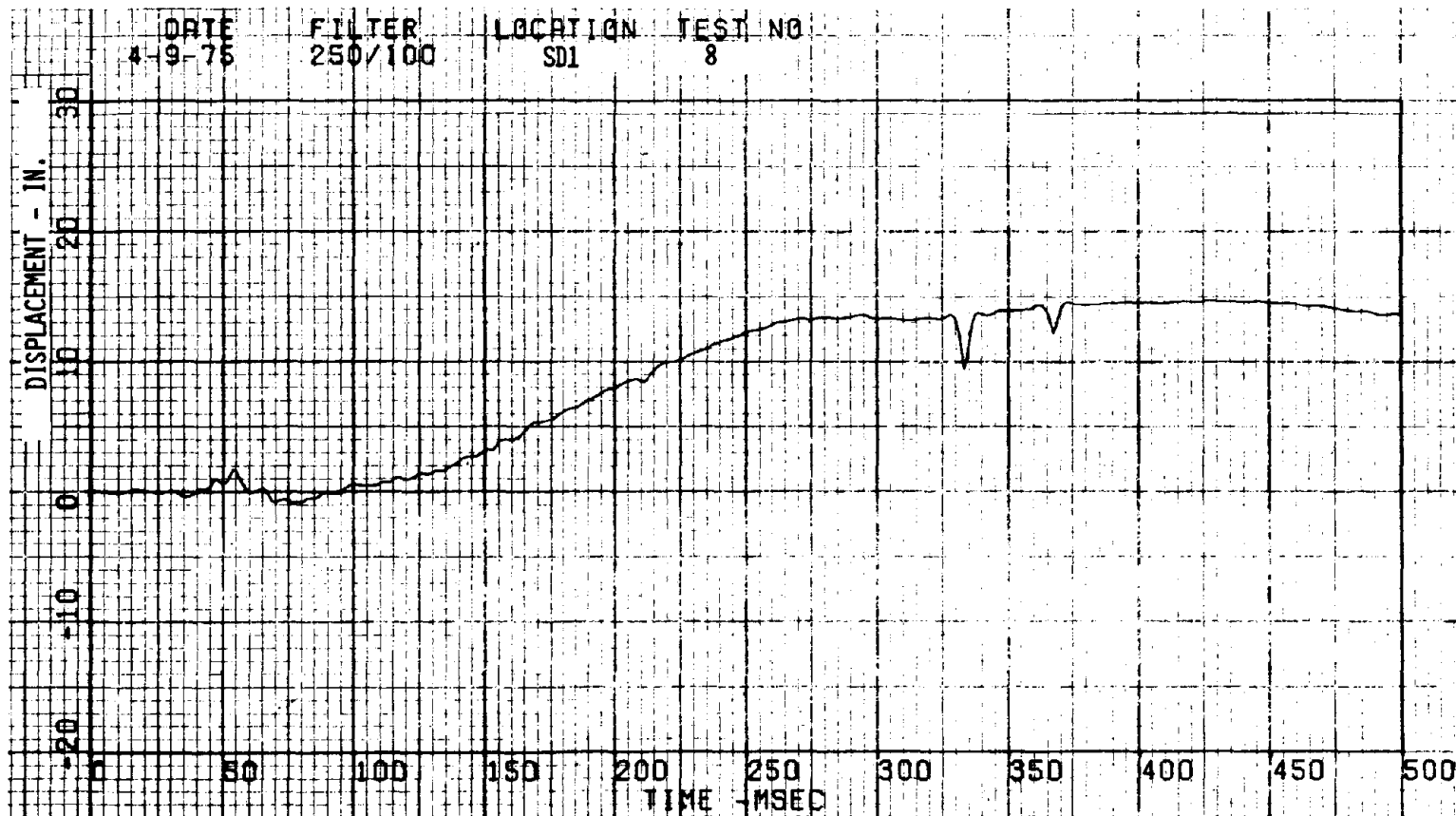


Figure A-263. Caboose Left Rear Displacement Transducer - Test 8.

A-262

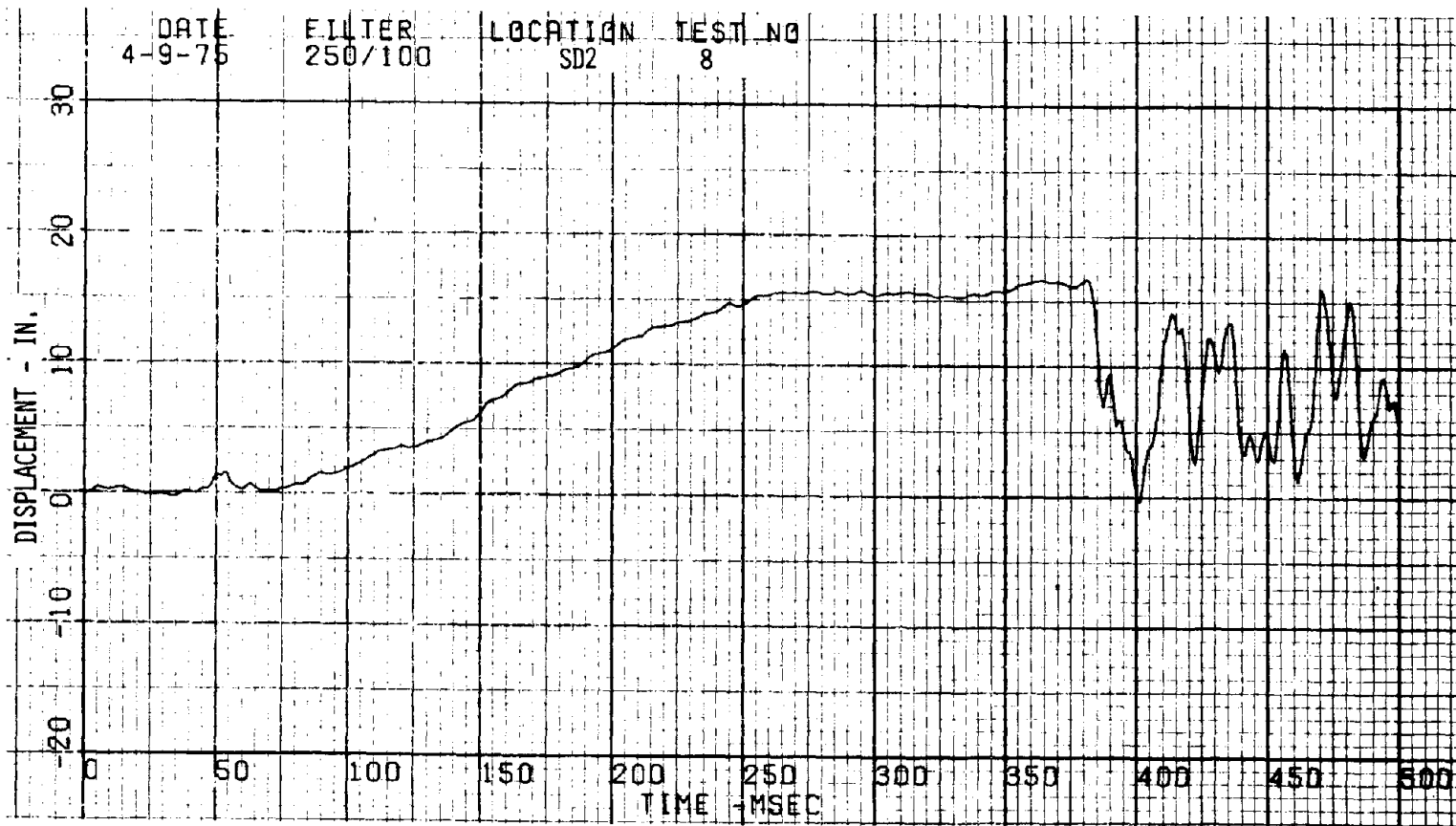


Figure A-264. Caboose Right Rear Displacement Transducer - Test 8.

A-263

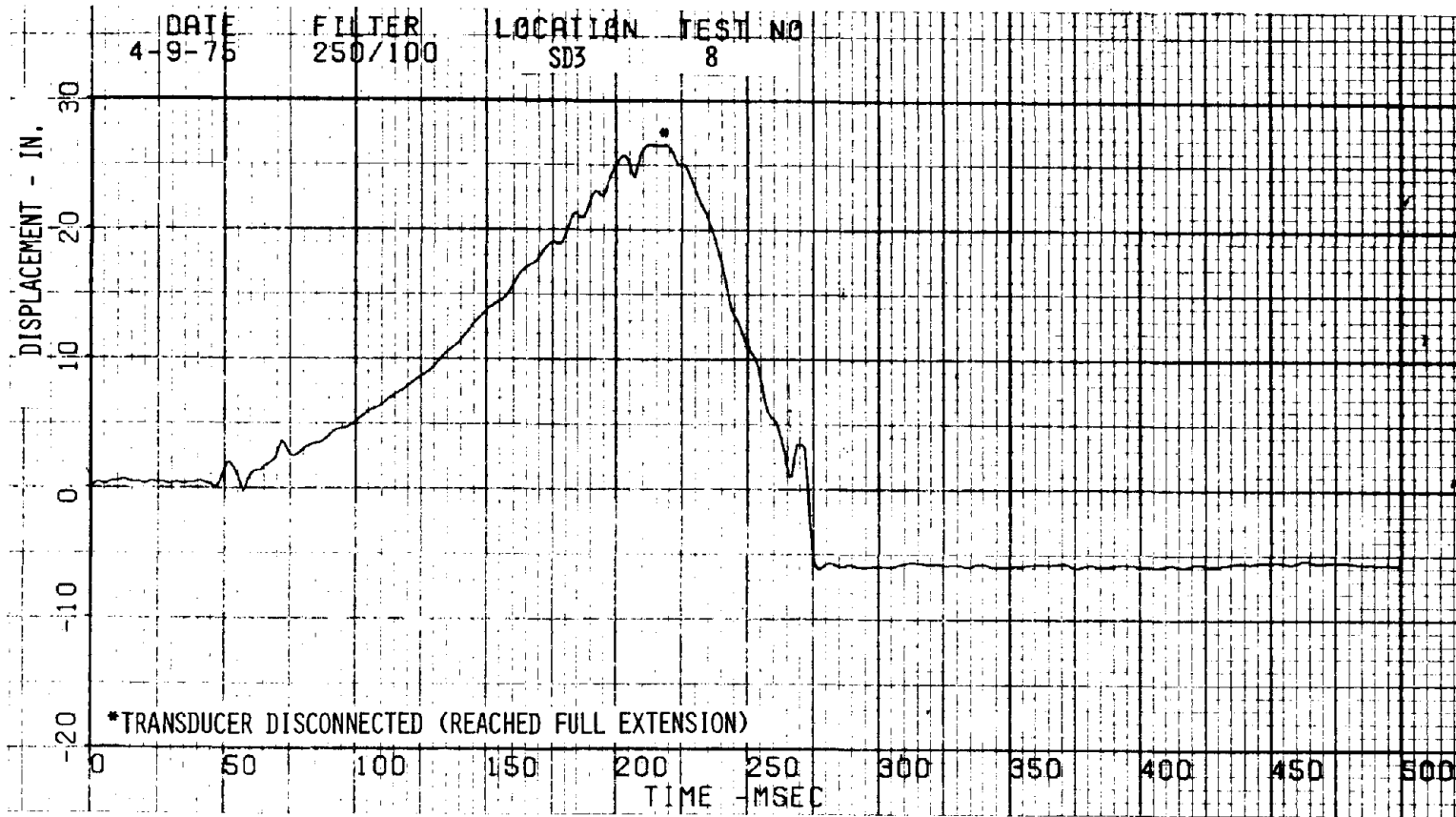


Figure A-265. Caboose Left Front Displacement Transducer - Test 8.

A-264

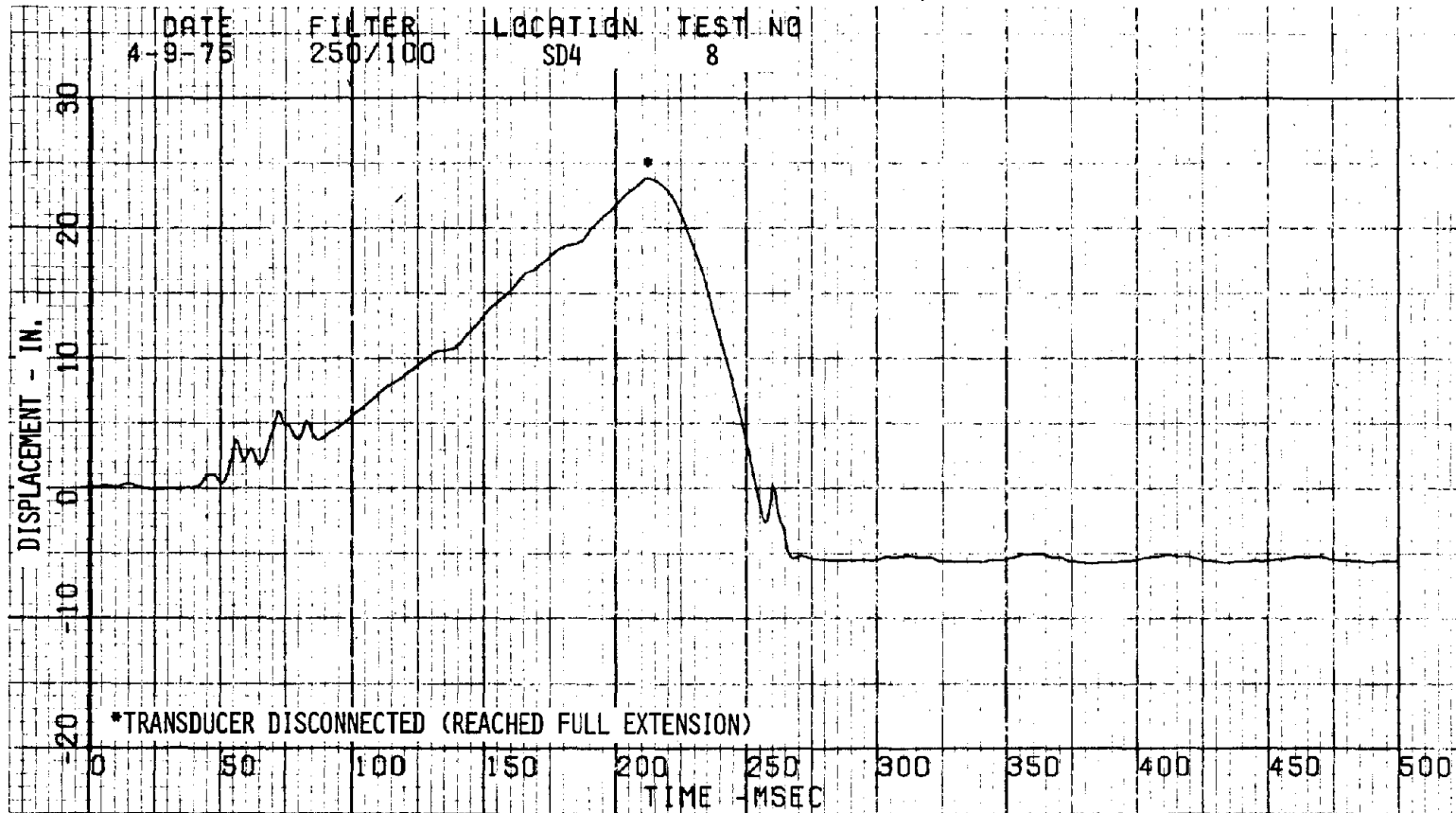


Figure A-266. Caboose Right Front Displacement Transducer - Test 8.

A-265

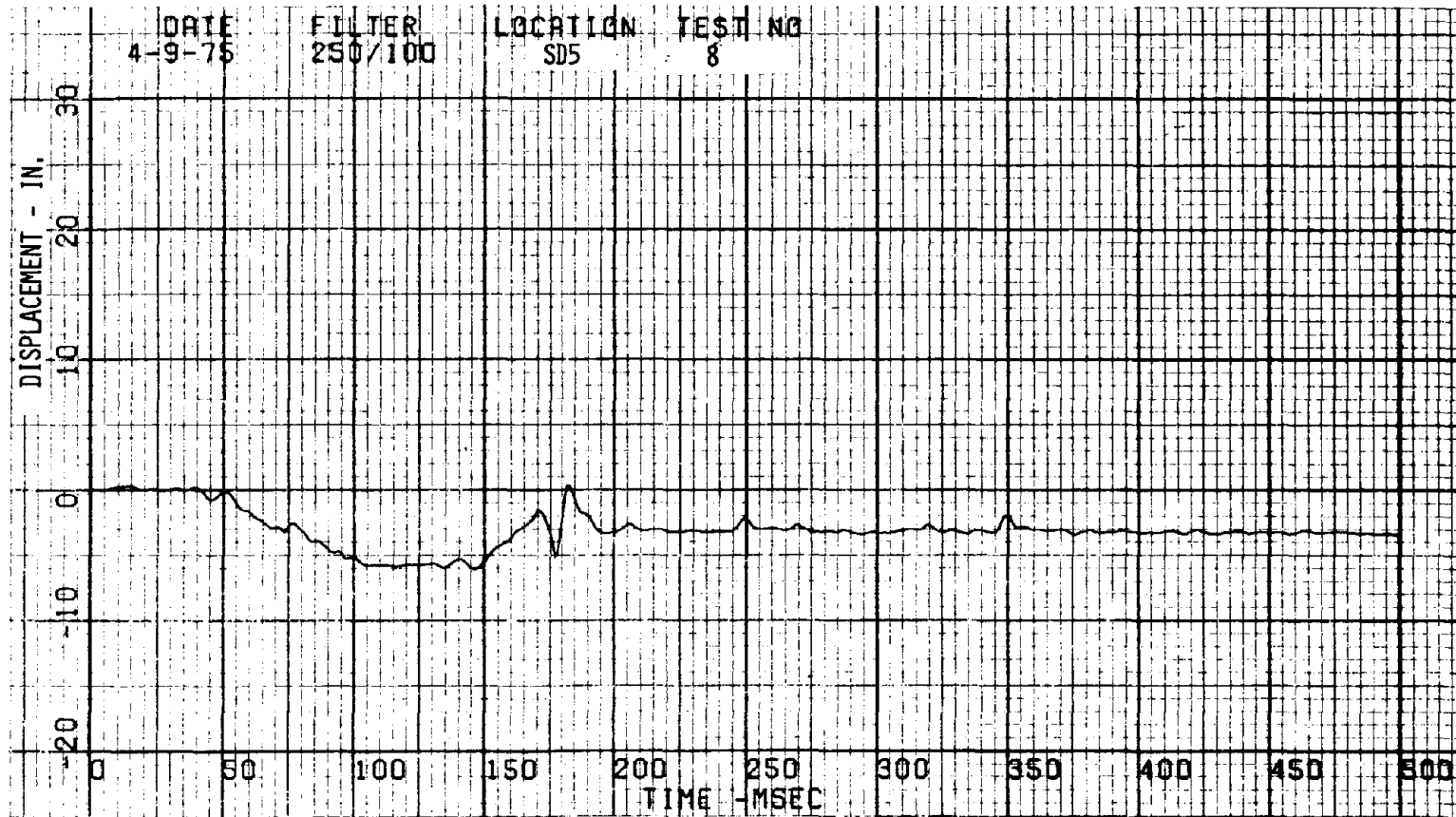


Figure A-267. Caboose to Hopper Displacement Transducer - Test 8.

A-266

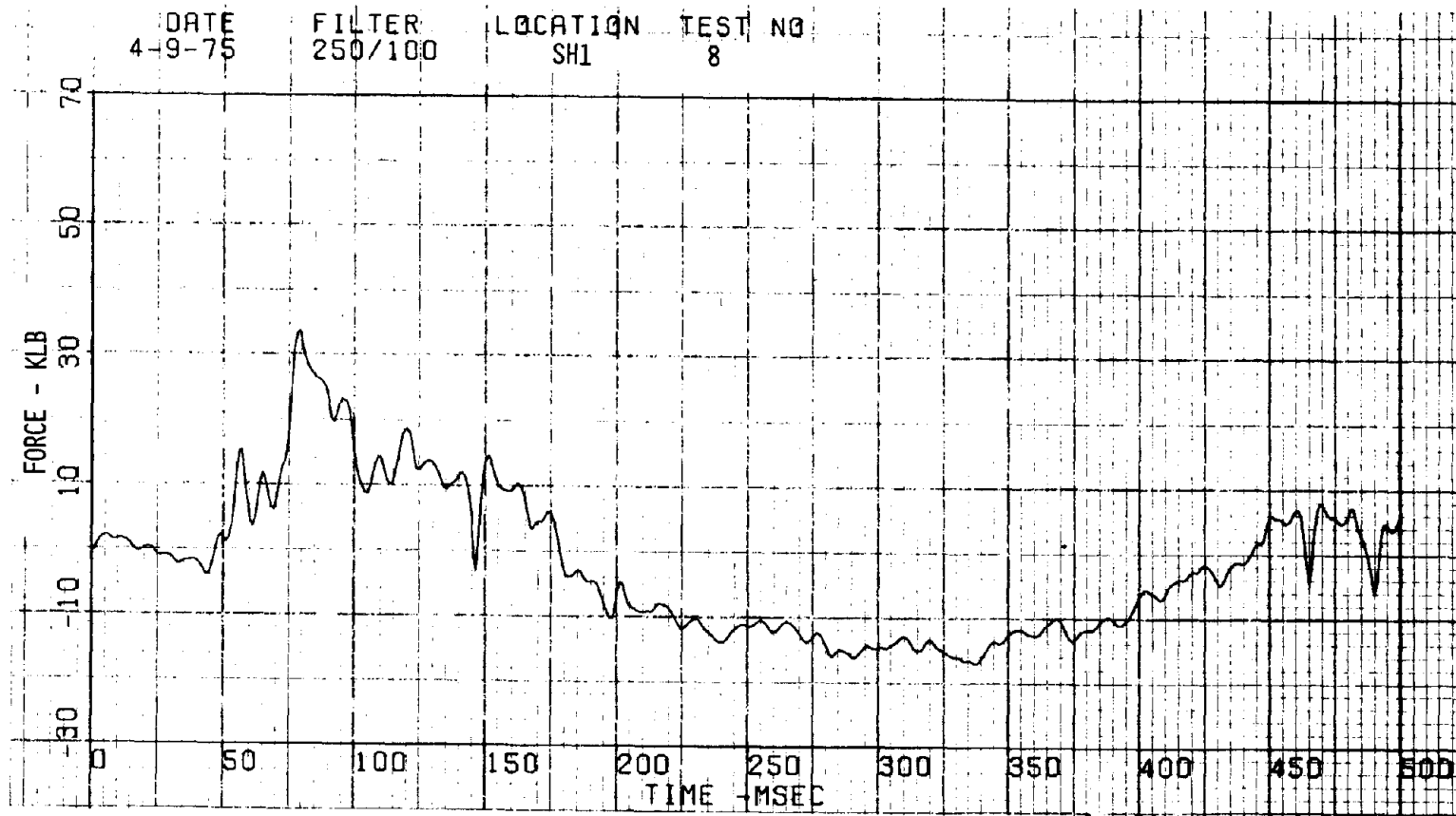


Figure A-268. Caboose Rear Swinghanger Strain Gauge - Test 8.

A-267

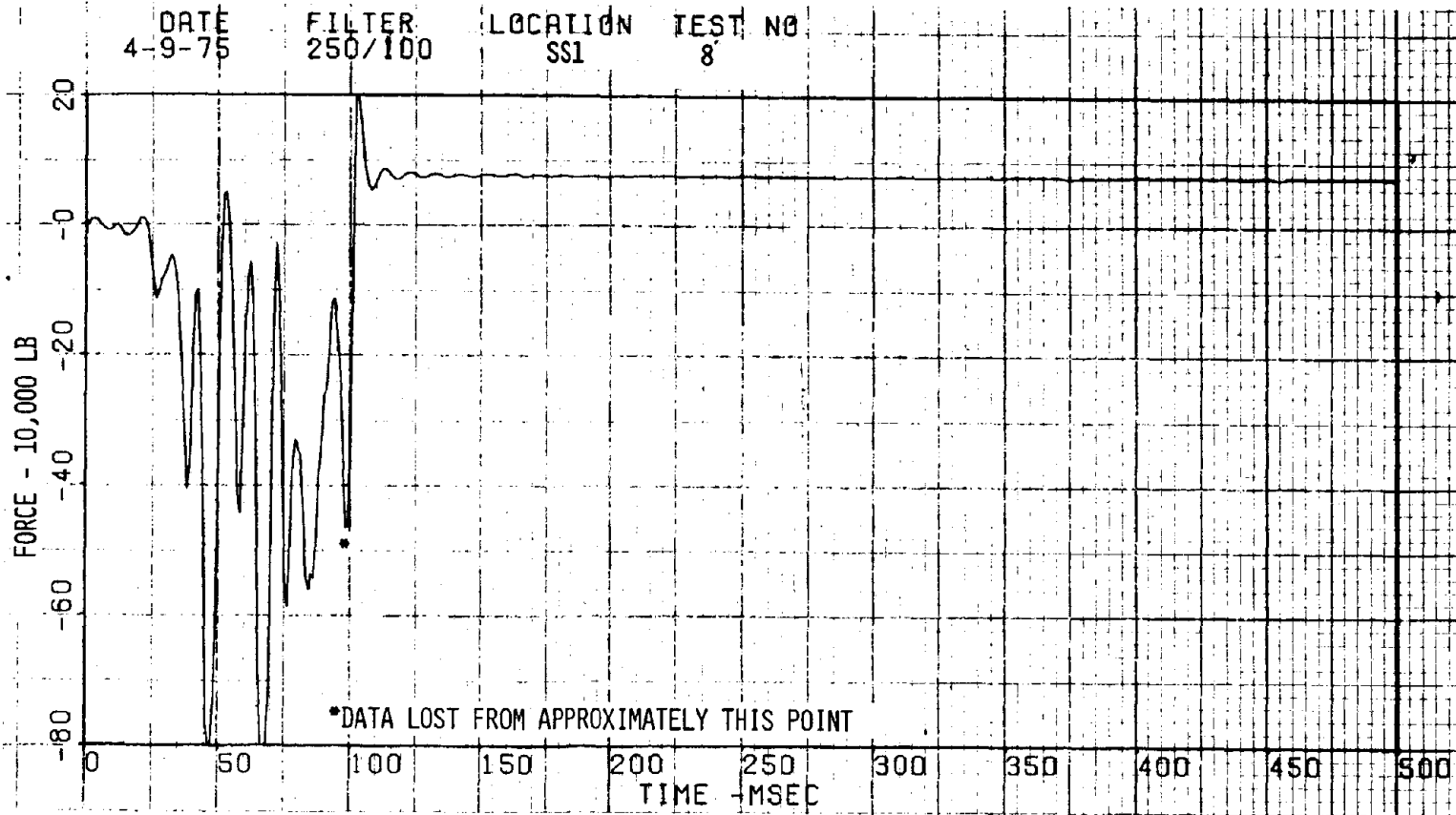


Figure A-269. Caboose Rear Coupler Strain Gauge - Test 8.

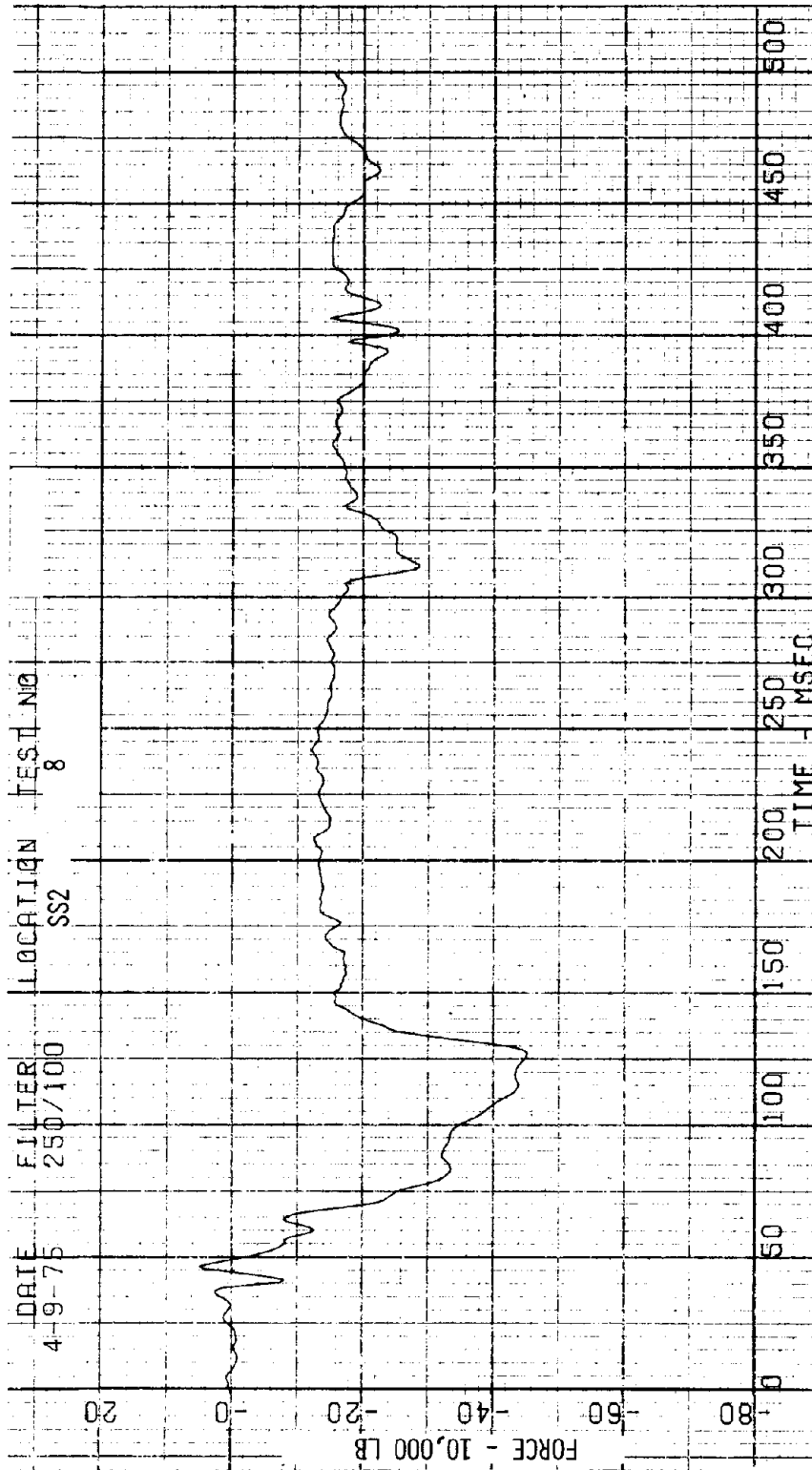


Figure A-270. Caboose Center Sill Strain Gauge - Test 8.

A-269

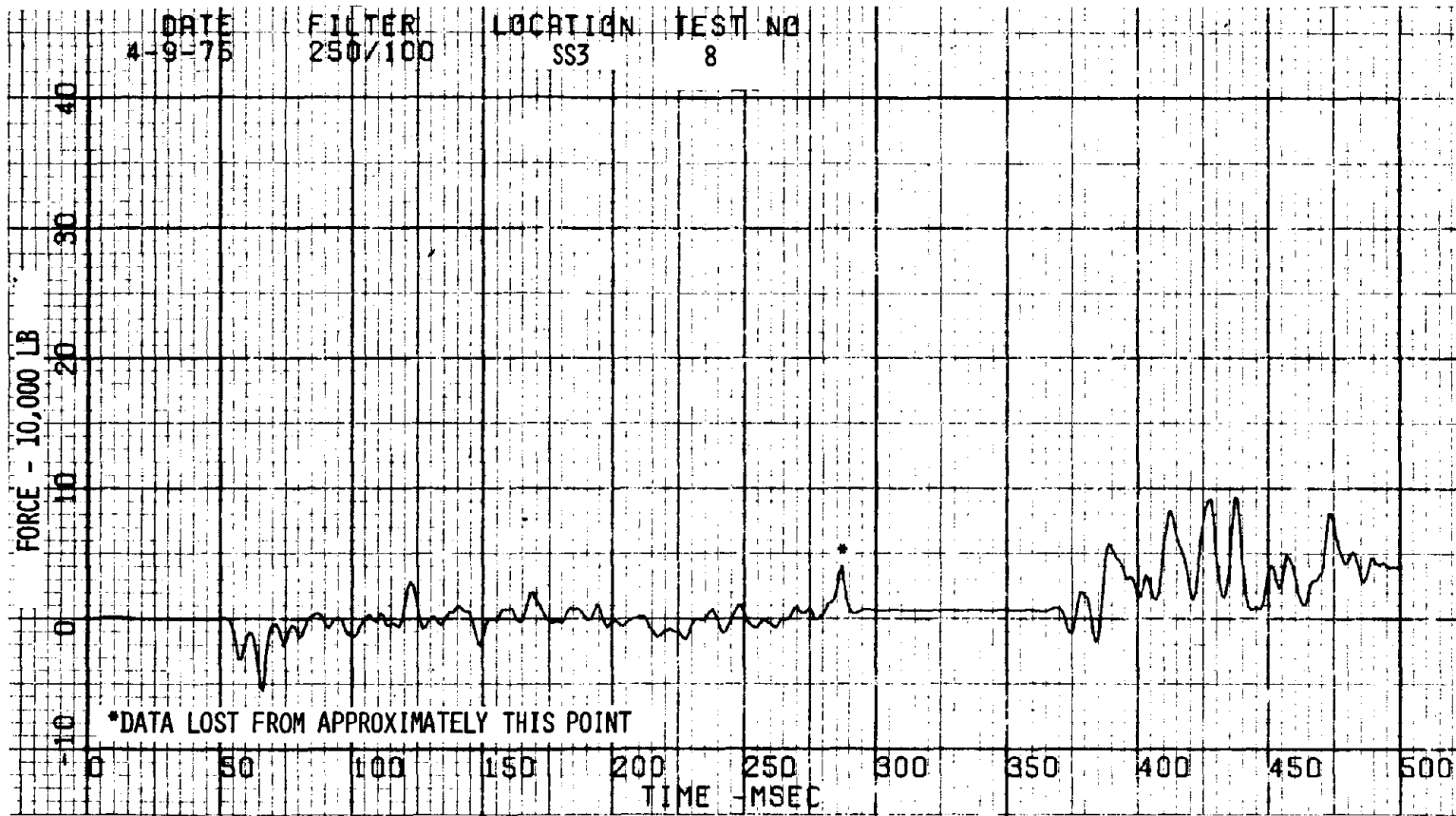


Figure A-271. Caboose Front Coupler Strain Gauge - Test 8.

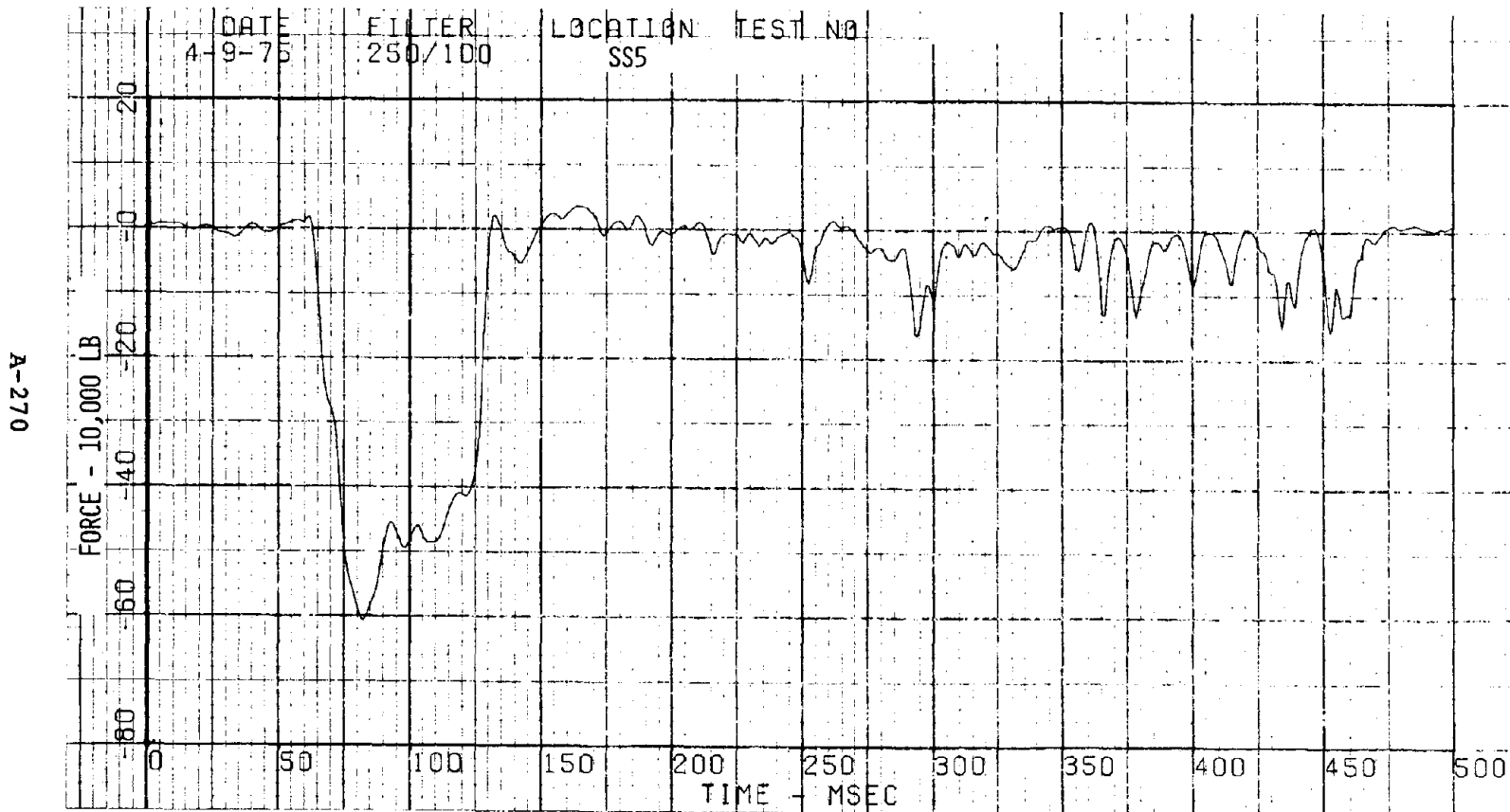


Figure A-272. Hopper 843 Center Sill Strain Gauge - Test 8.

A-271

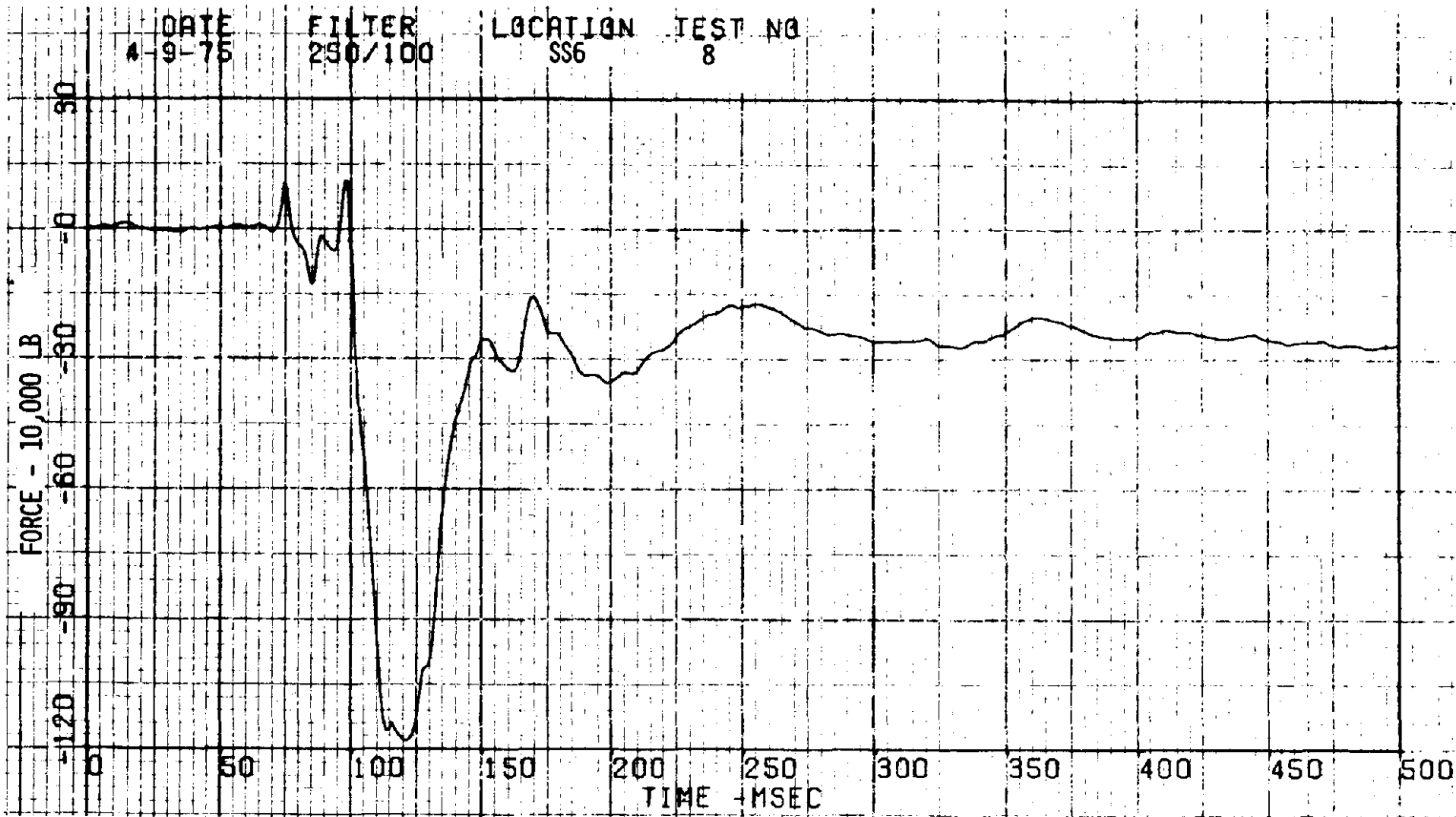


Figure A-273. Hopper 631 Rear Coupler Strain Gauge - Test 8.

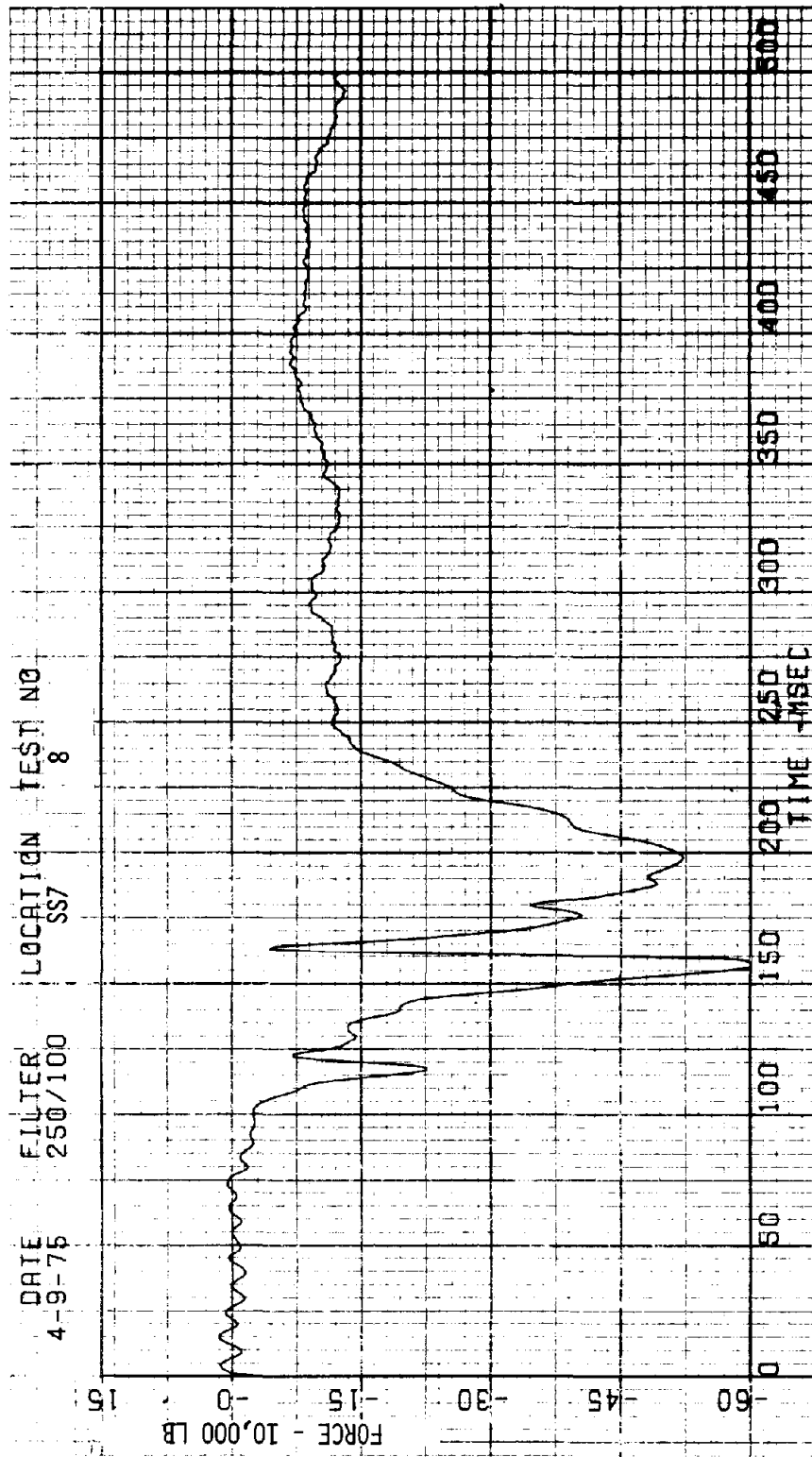
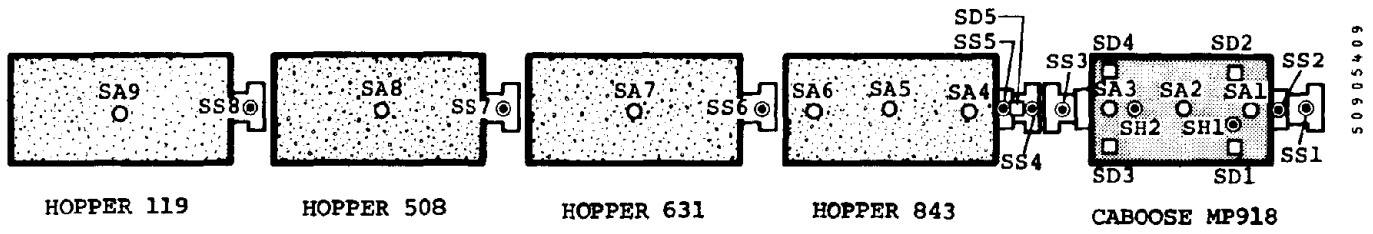
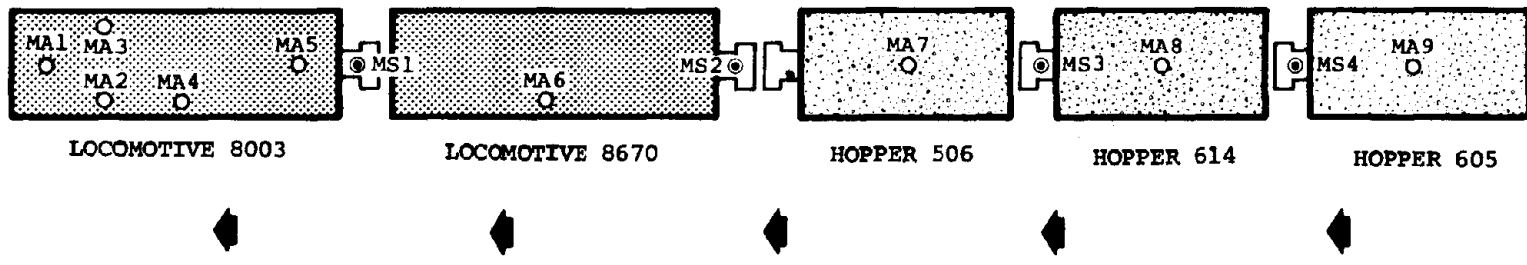


Figure A-274. Hopper 508 Rear Coupler Strain Gauge - Test 8.



- HOPPER LOADED
 - TRAIN IN BUFF
- STANDING TRAIN

A-273



- MOTION
- IMPACT VELOCITY = 30.3 MPH
- MOVING TRAIN

Figure A-275. Instrument Locations - Test 9.

A-274

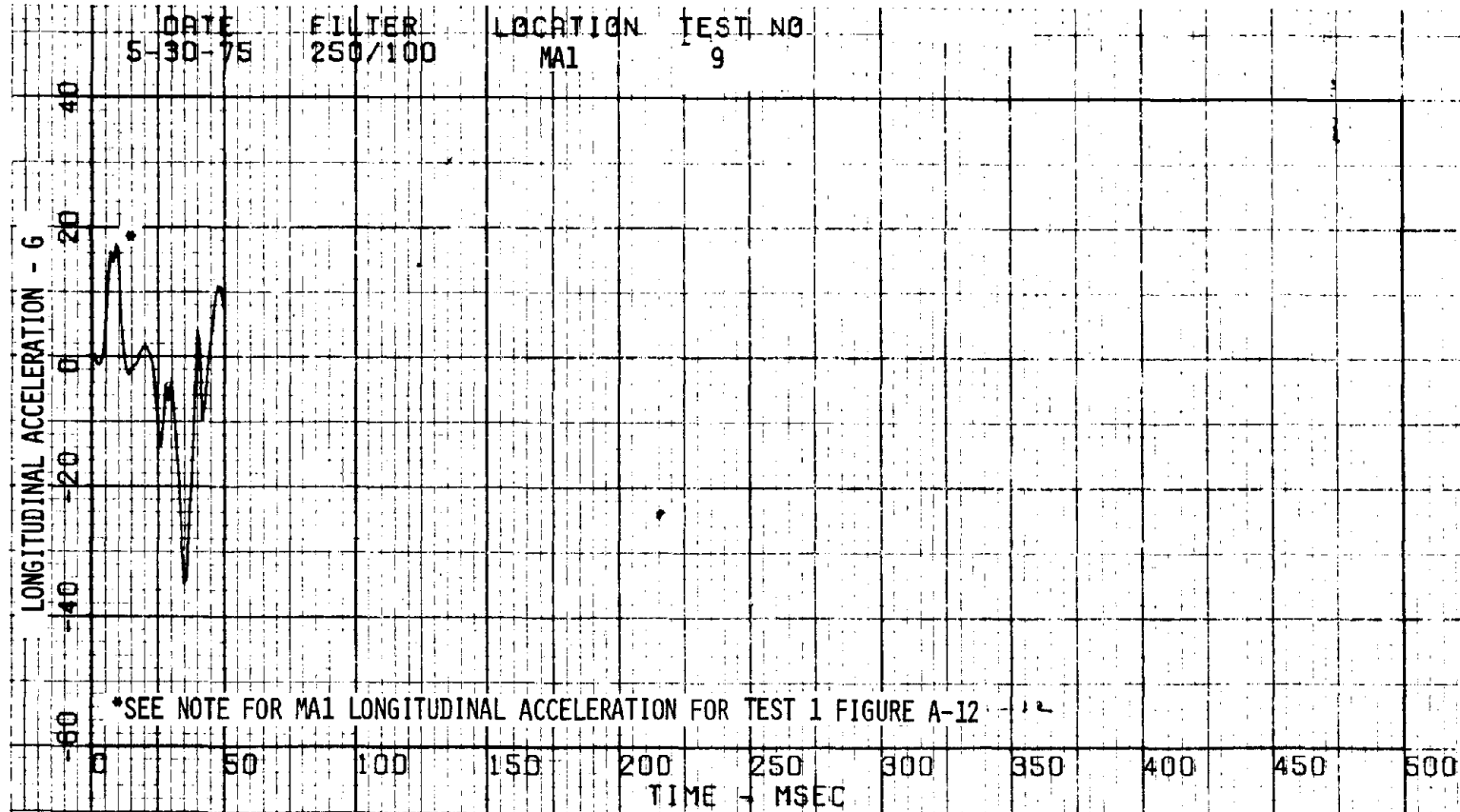


Figure A-276. Locomotive 8003 Rear Triaxial Accelerometer (X) - Test 9.

A-275

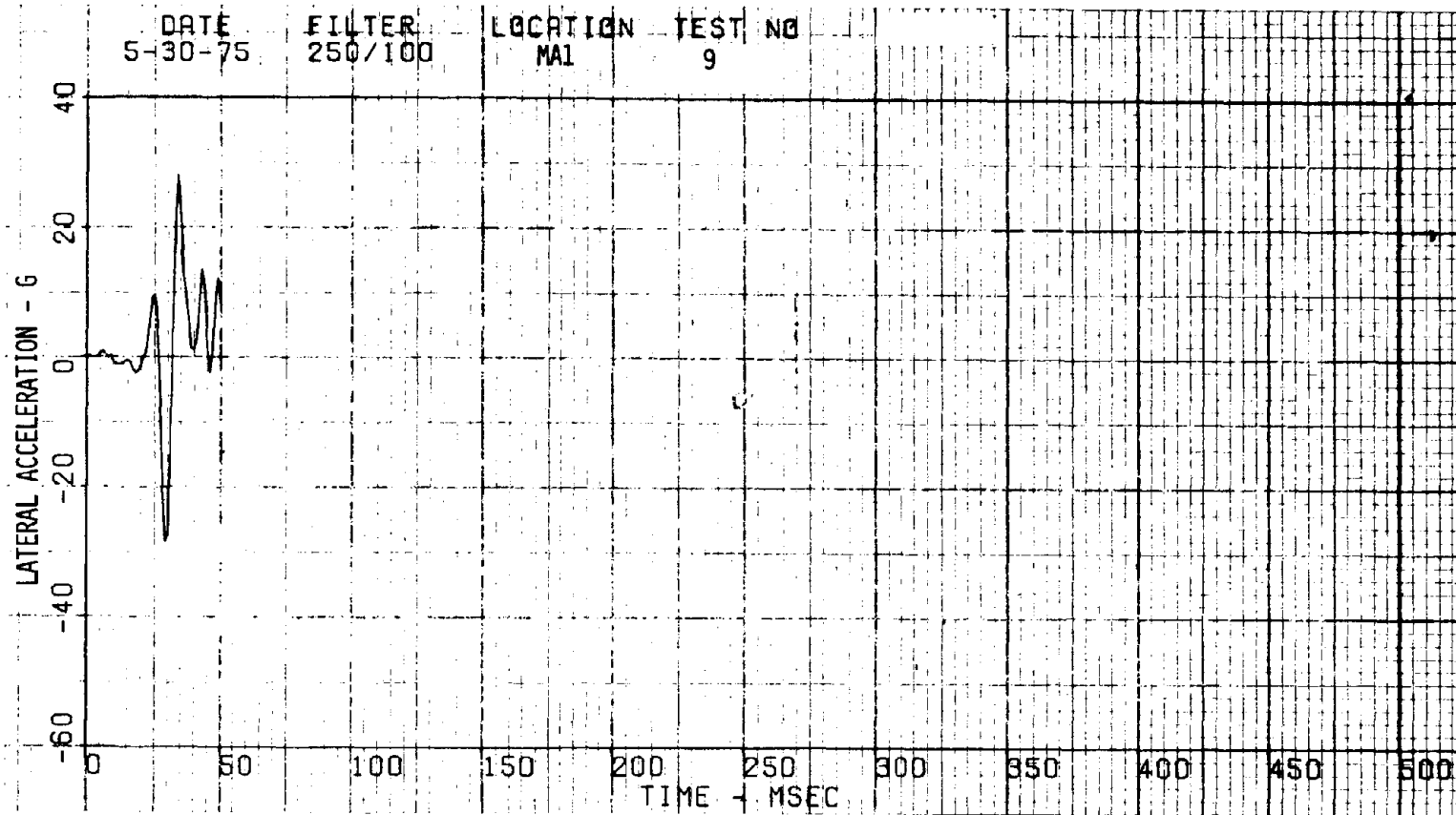


Figure A-277. Locomotive 8003 Rear Triaxial Accelerometer (Y) - Test 9.

A-276

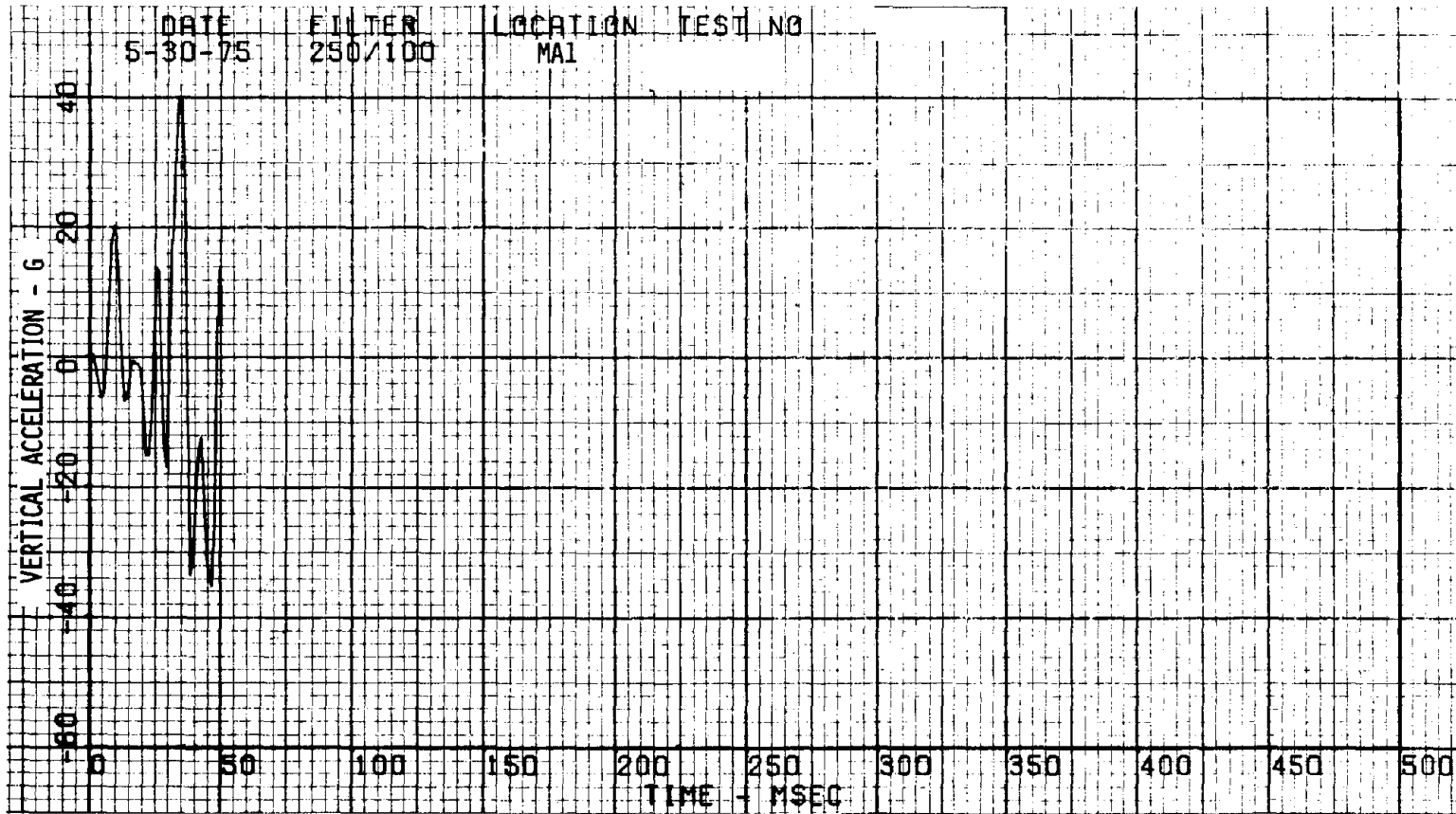


Figure A-278. Locomotive 8003 Rear Triaxial Accelerometer (Z) - Test 9.

A-277

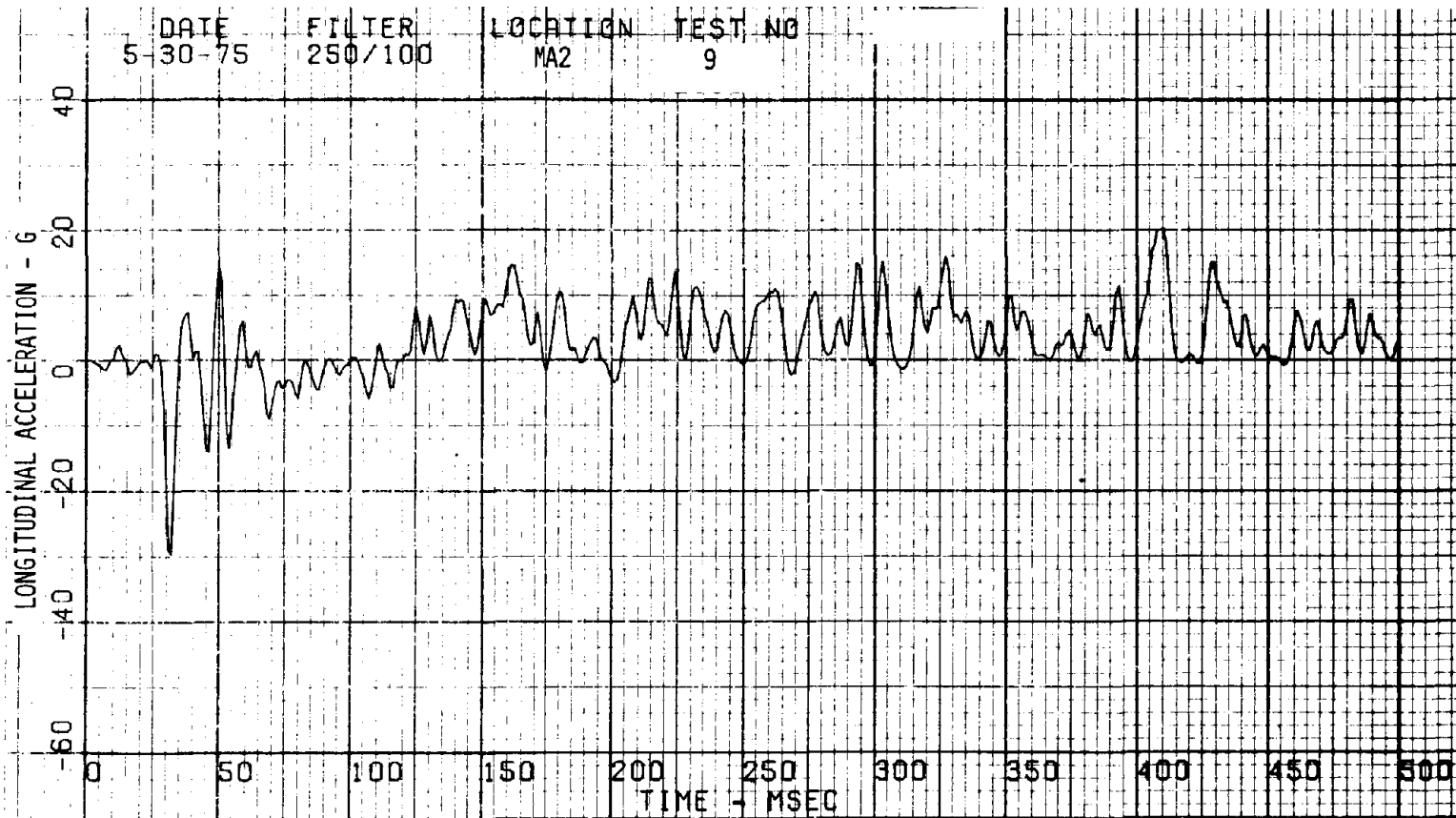


Figure A-279. Locomotive 8003 Left Cab Accelerometer - Test 9.

A-278

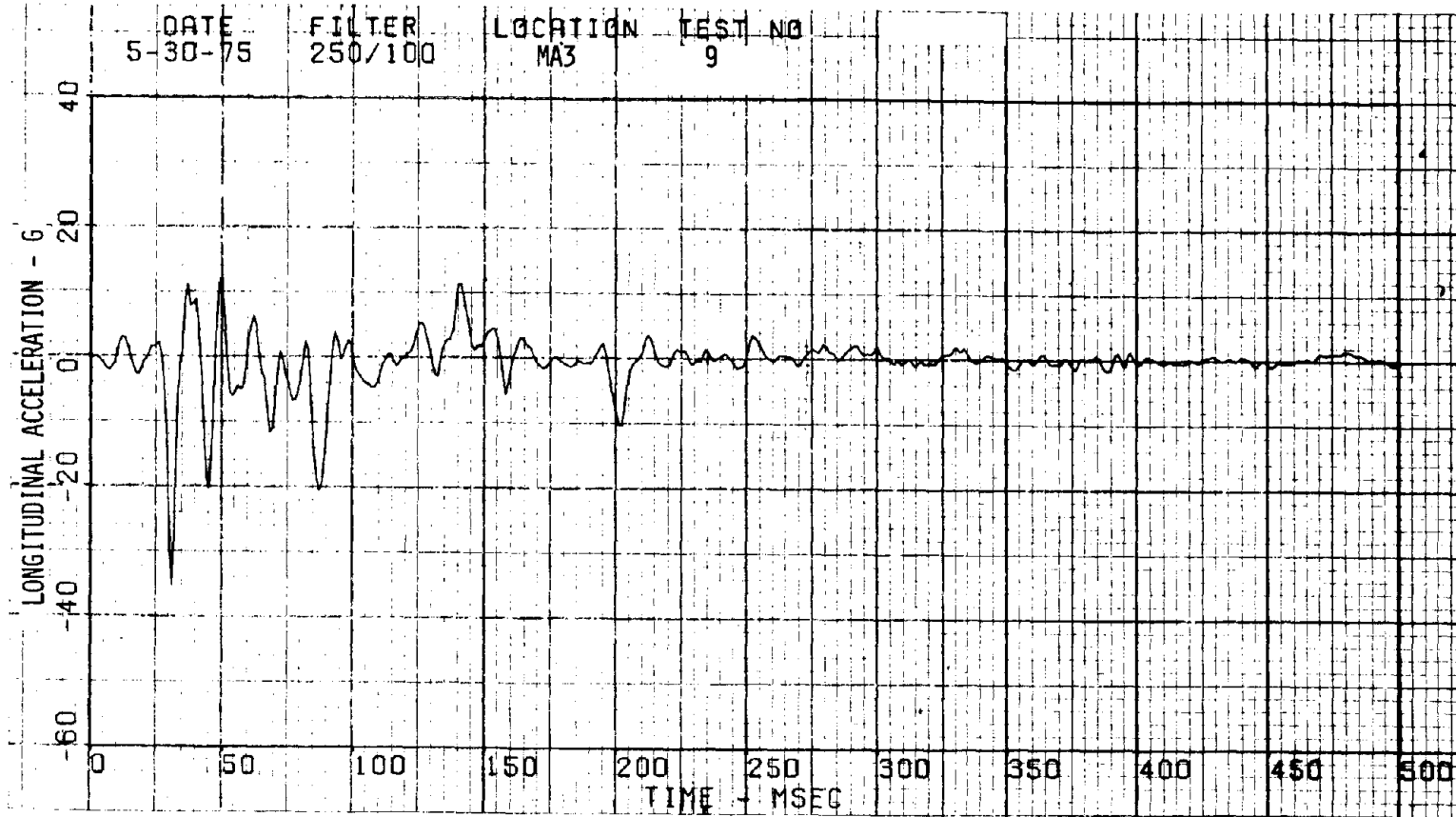


Figure A-280. Locomotive 8003 Right Cab Accelerometer - Test 9.

A-279

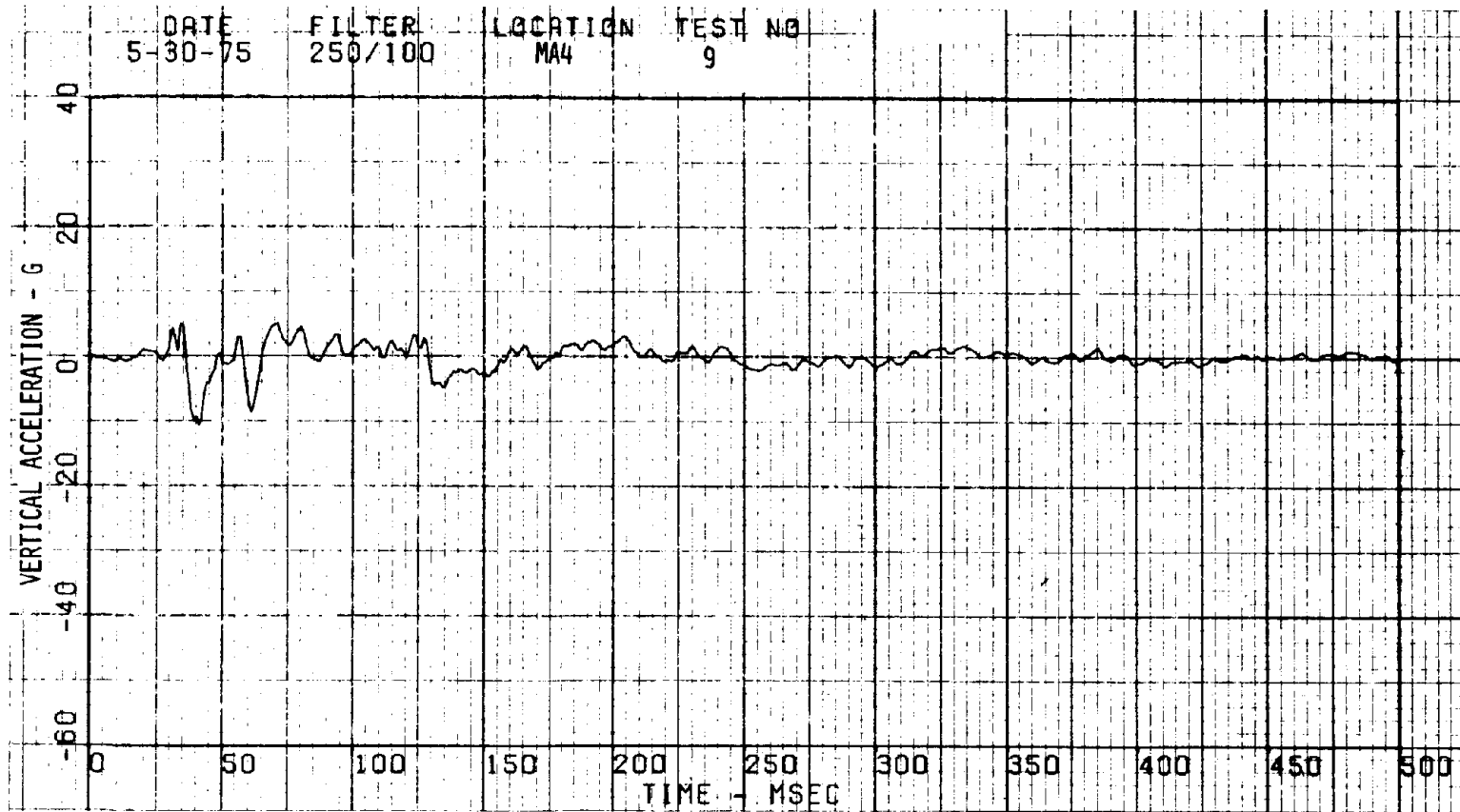


Figure A-281. Locomotive 8003 Center Vertical Accelerometer - Test 9.

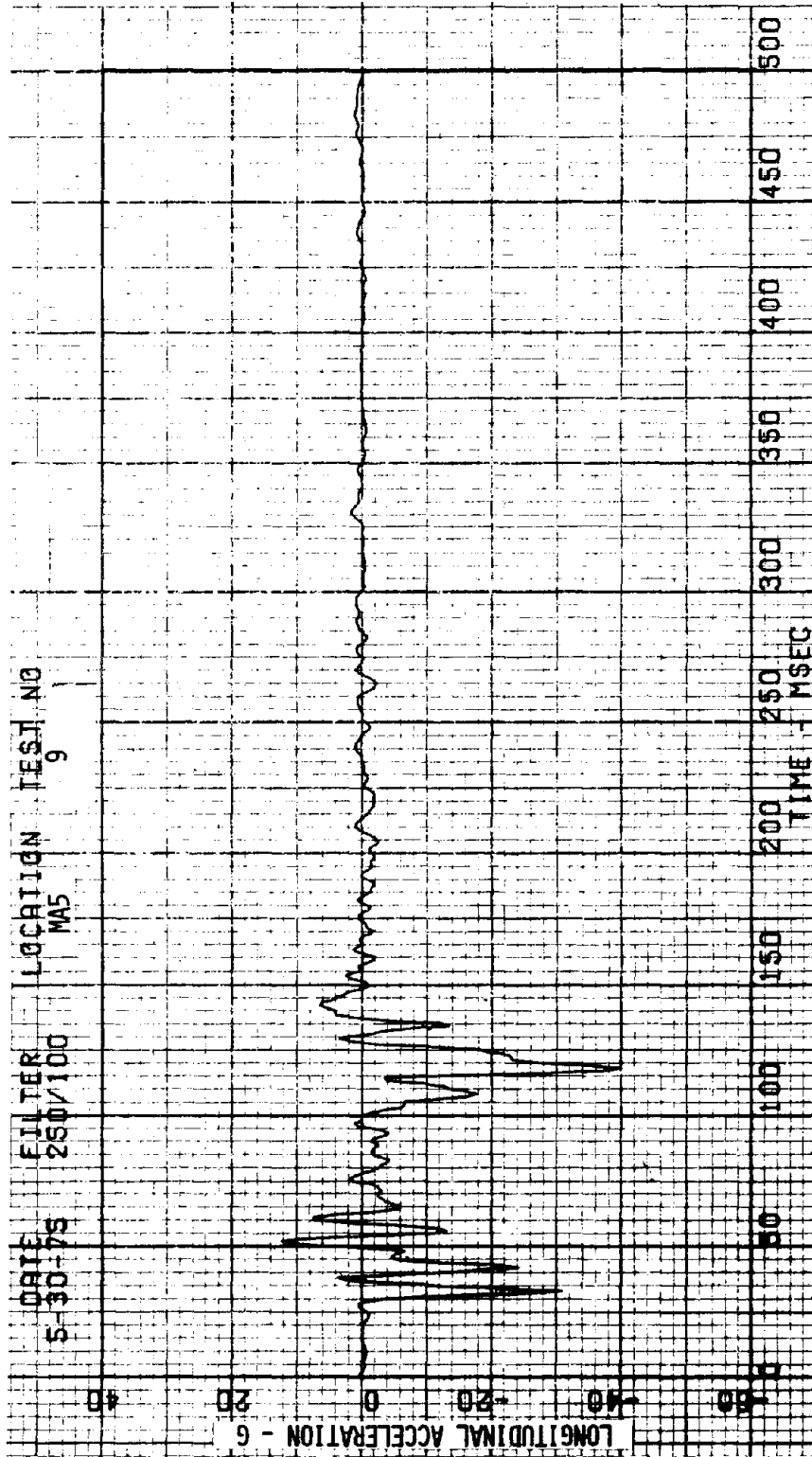


Figure A-282. Locomotive 8003 Front Triaxial Accelerometer (X) - Test 9.

A-281

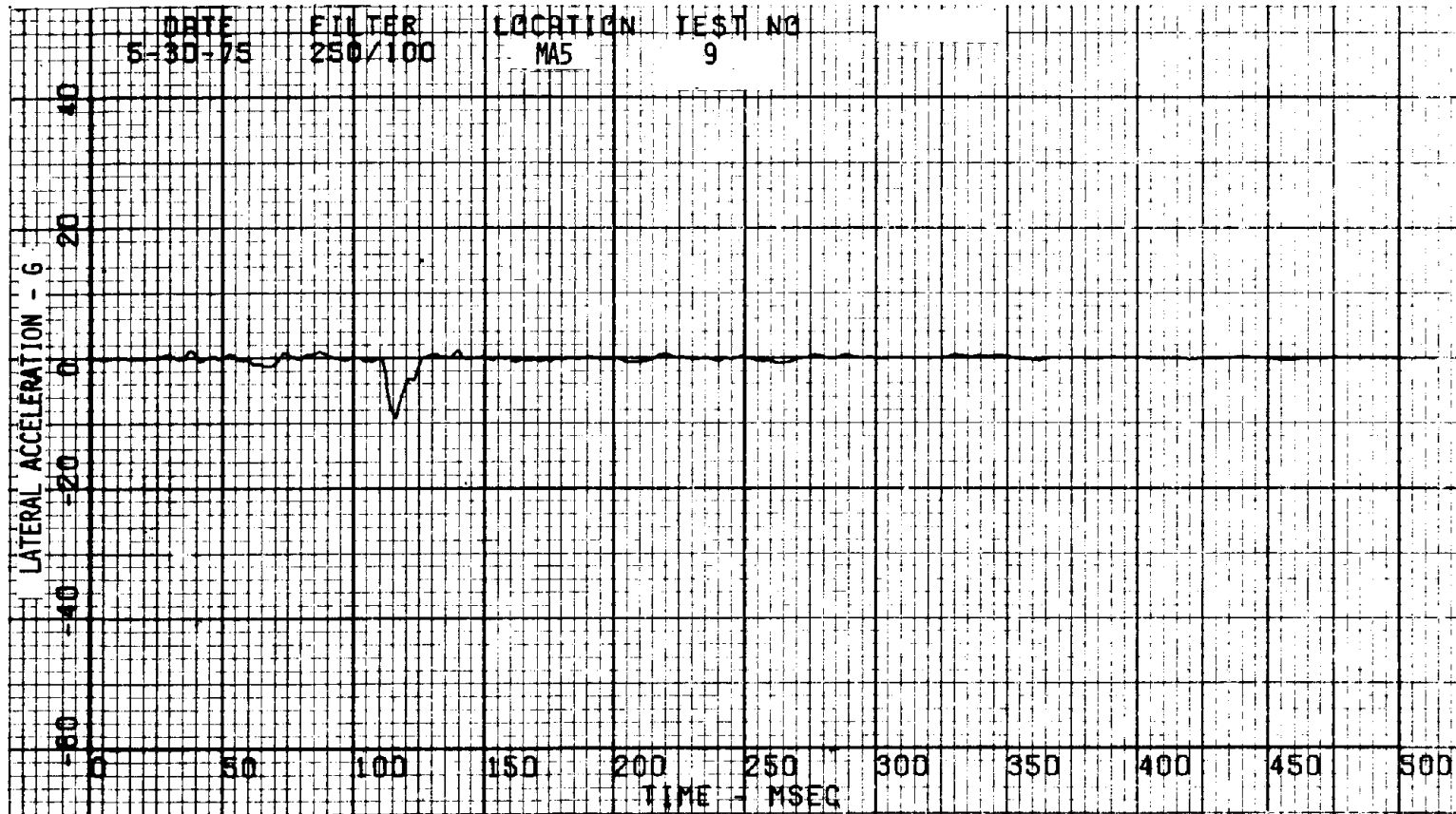


Figure A-283. Locomotive 8003 Front Triaxial Accelerometer (Y) - Test 9.

A-282

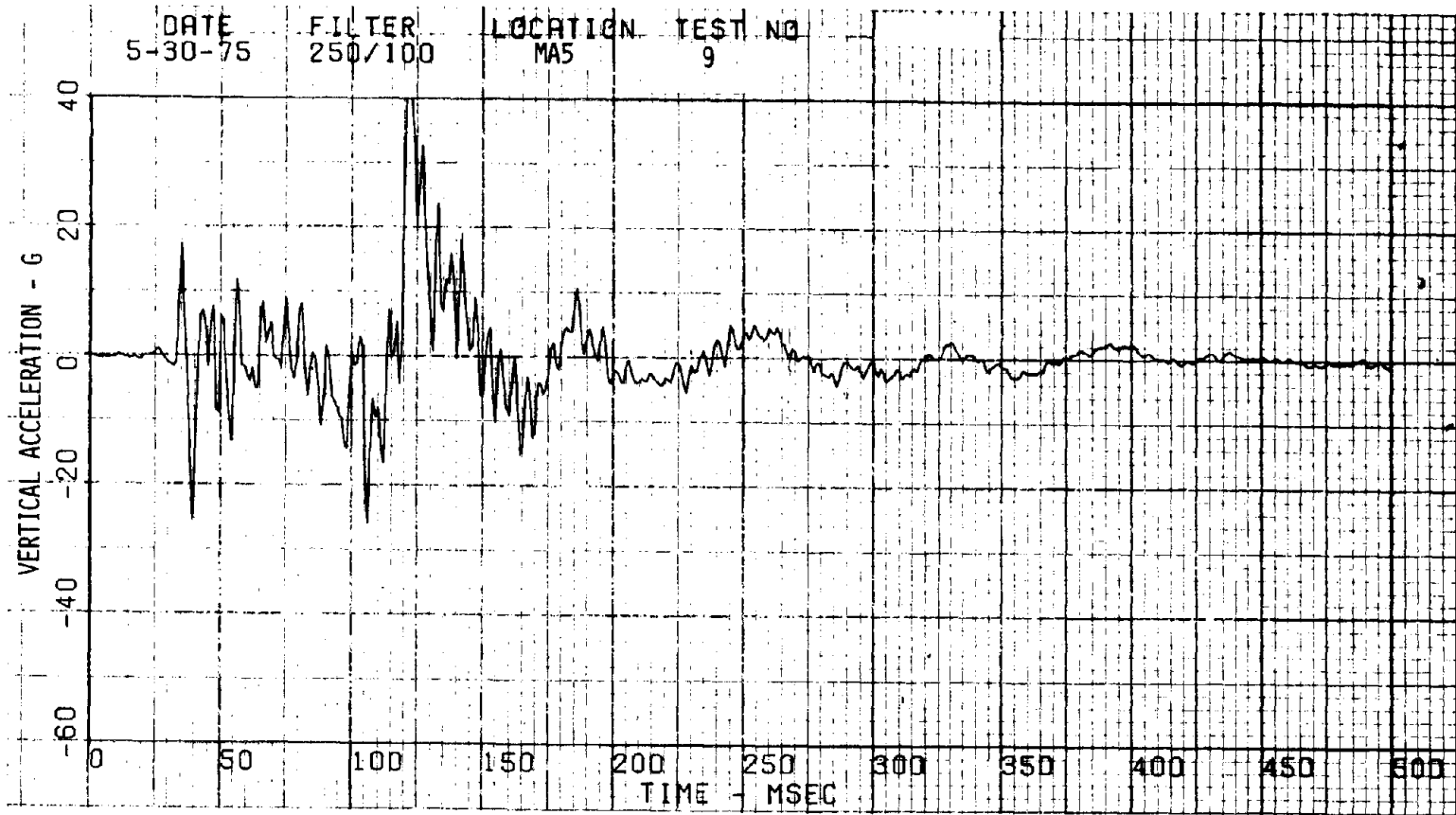


Figure A-284. Locomotive 8003 Front Triaxial Accelerometer (Z) - Test 9.

A-283

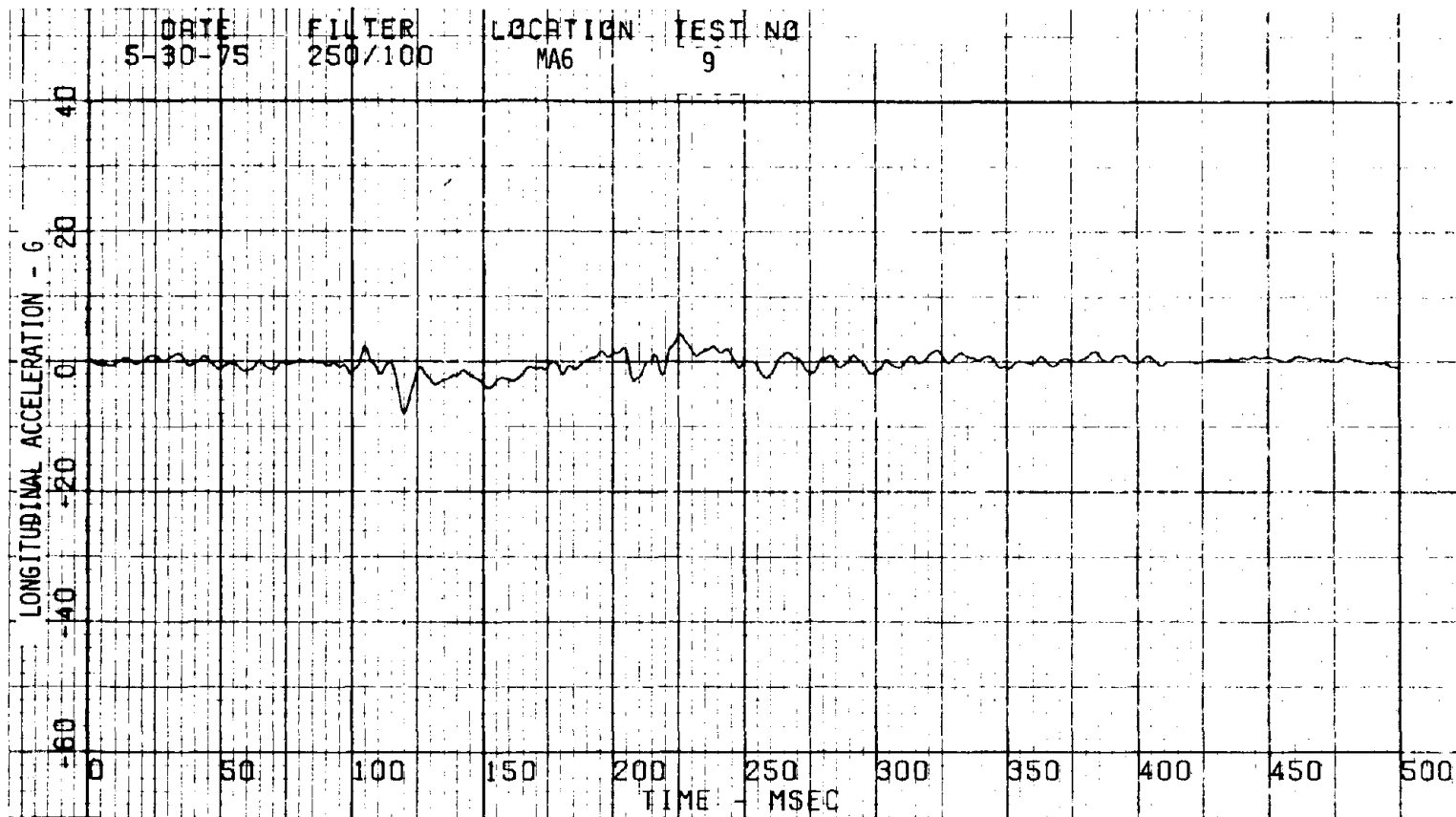


Figure A-285. Locomotive 8670 Center Longitudinal Accelerometer - Test 9.

A-284

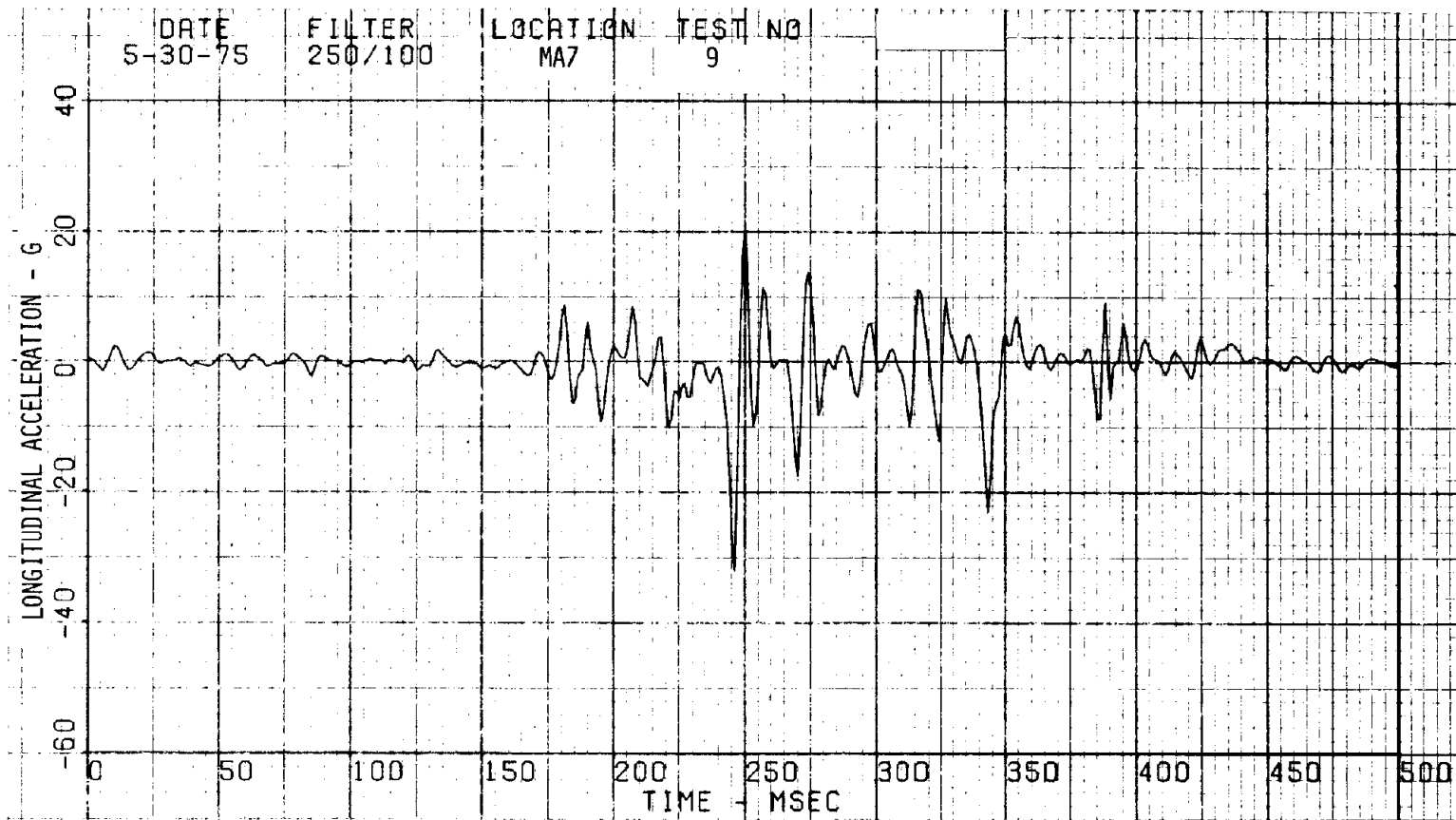


Figure A-286. Hopper 506 Center Longitudinal Accelerometer - Test 9.

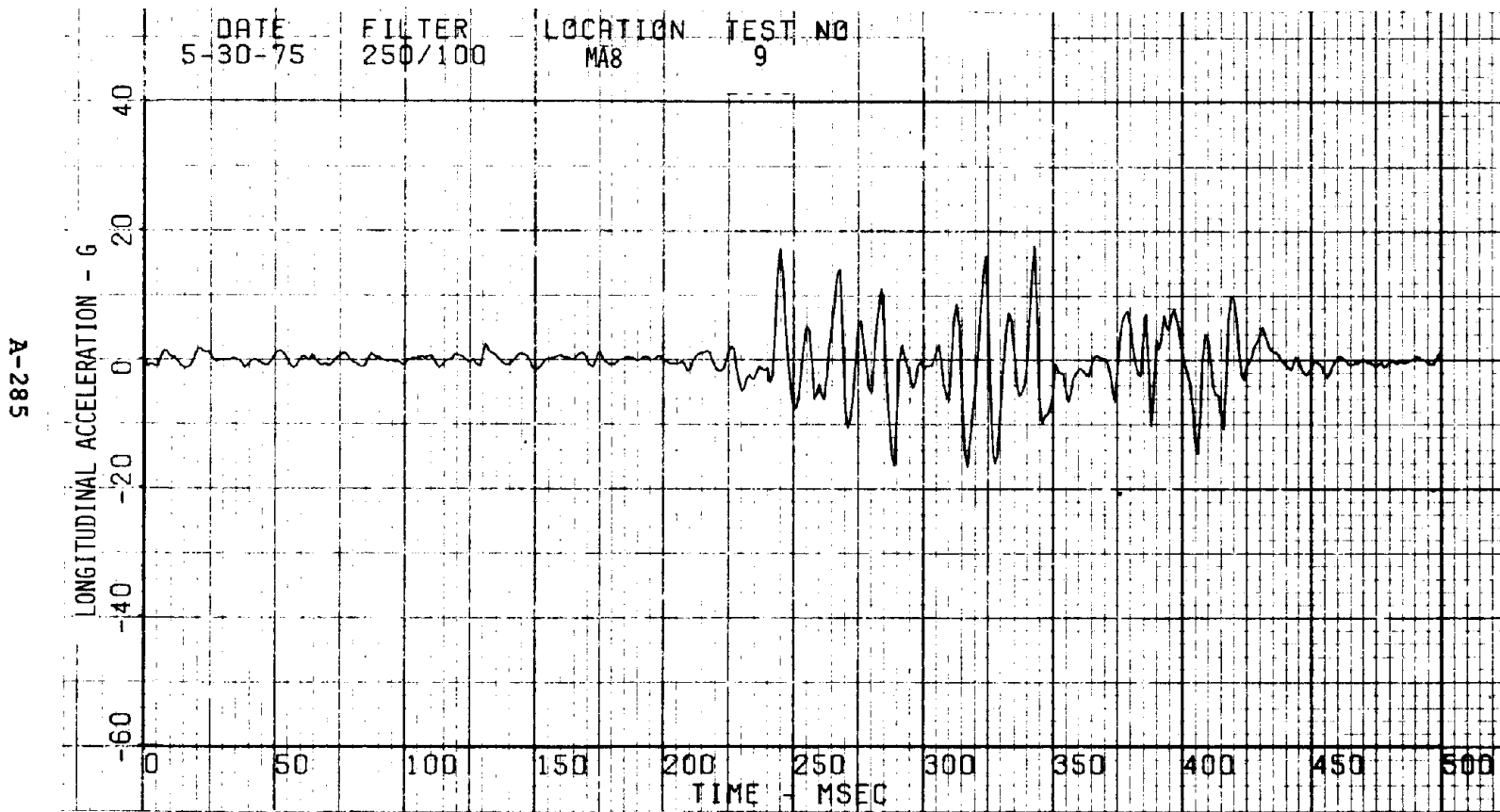


Figure A-287. Hopper 614 Center Longitudinal Accelerometer - Test 9.

A-286

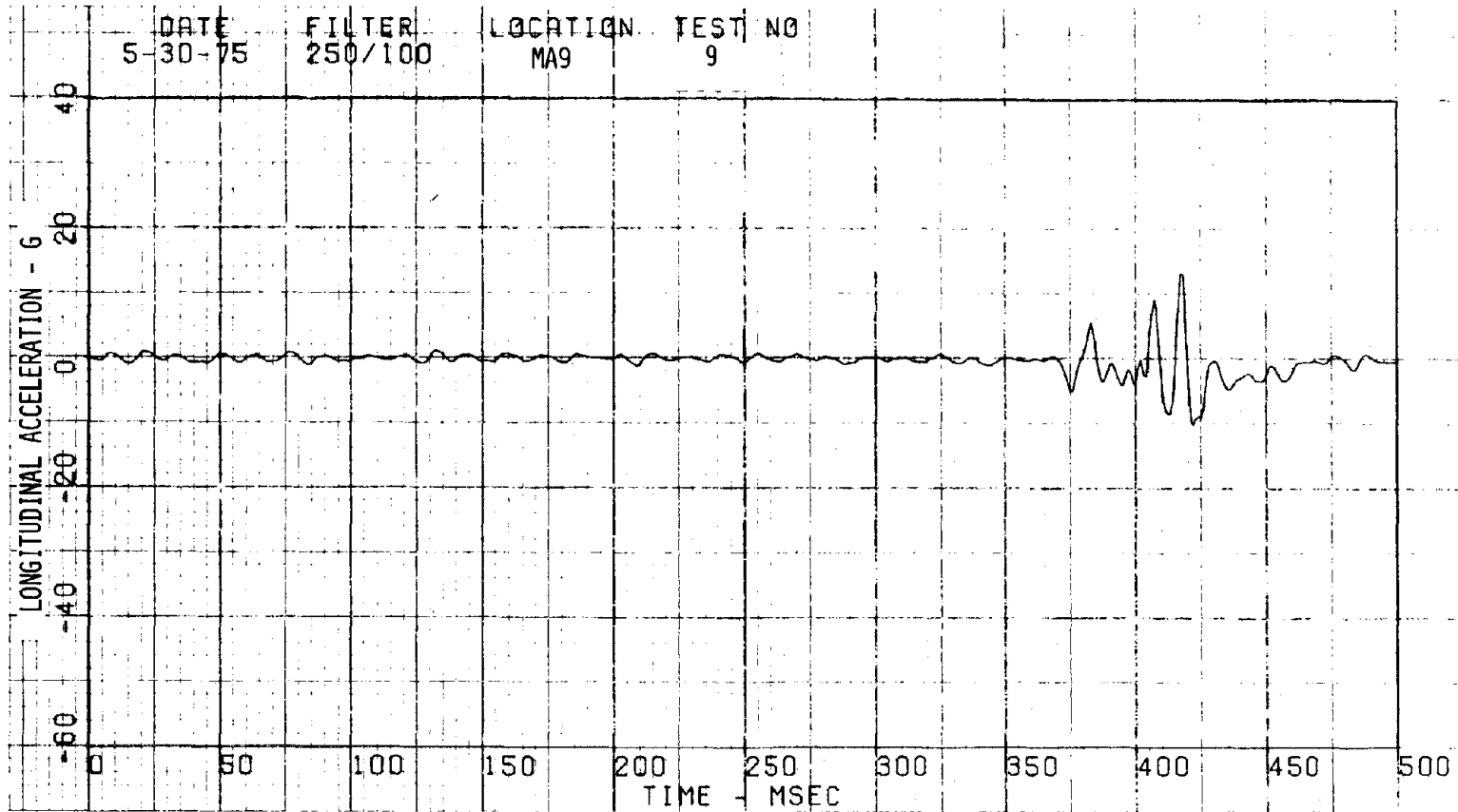


Figure A-288. Hopper 605 Center Longitudinal Accelerometer - Test 9.

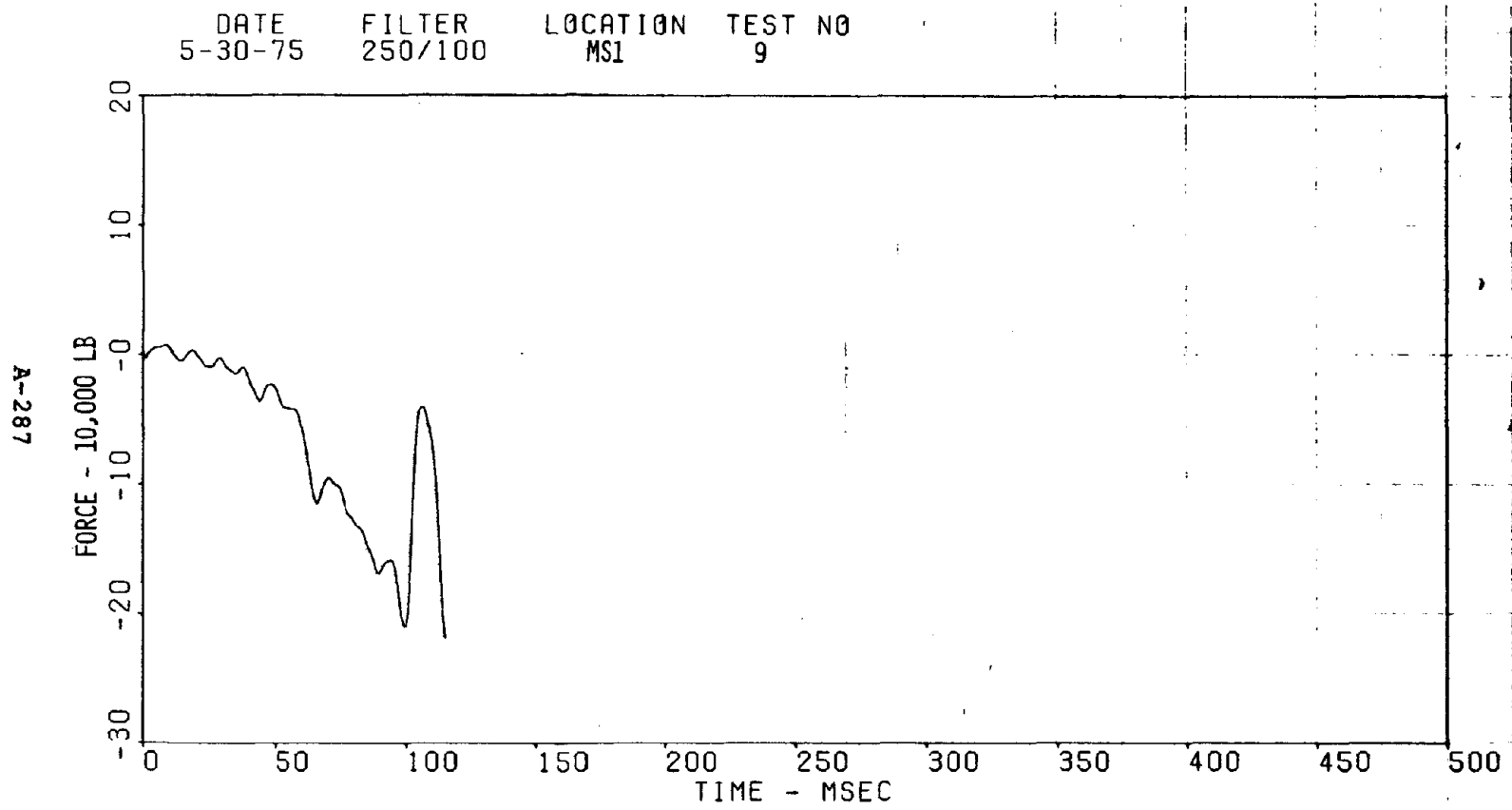


Figure A-289. Locomotive 8003 Front Coupler Strain Gauge - Test 9.

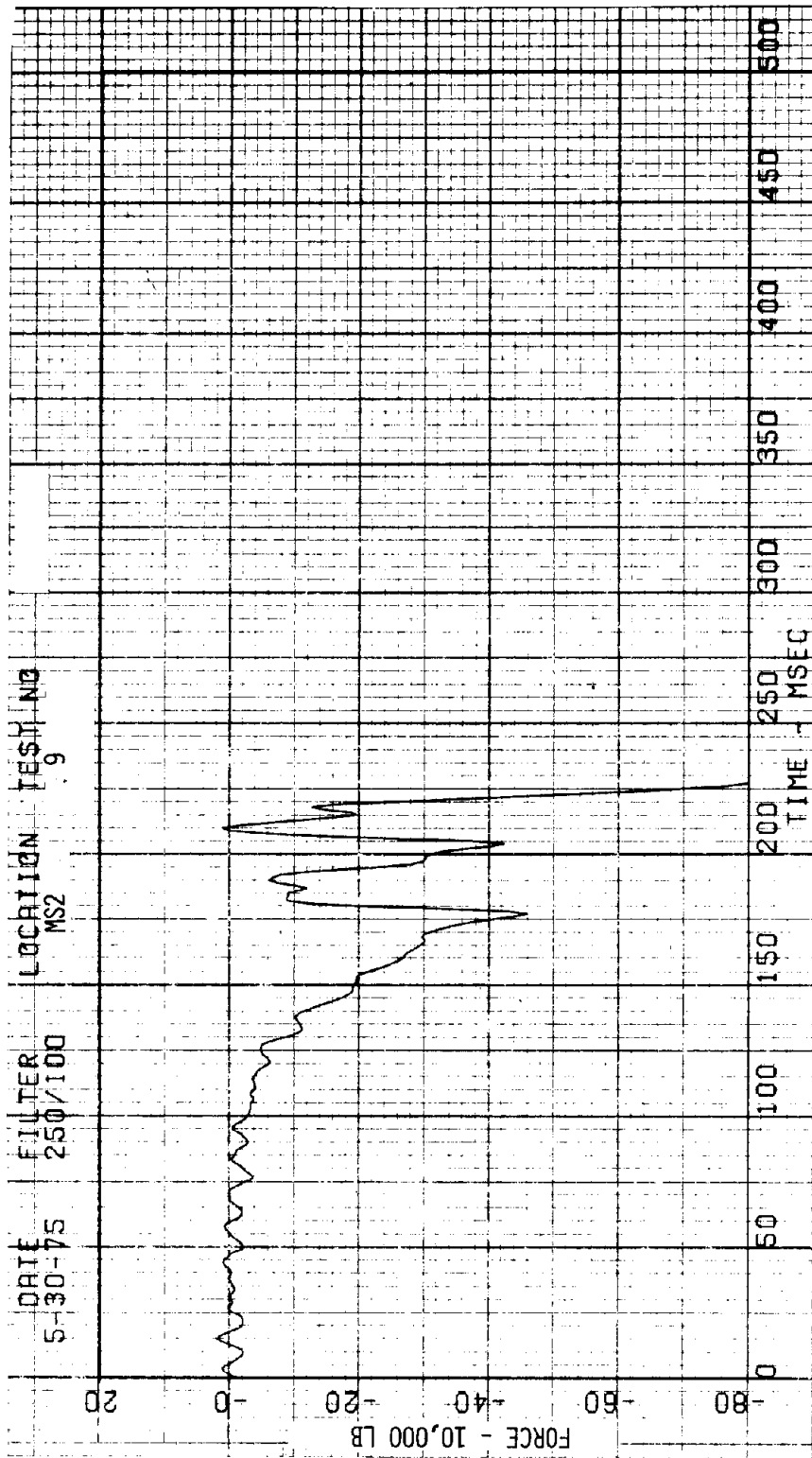


Figure A-290. Locomotive 8670 Front Coupler Strain Gauge - Test 9.

A-289

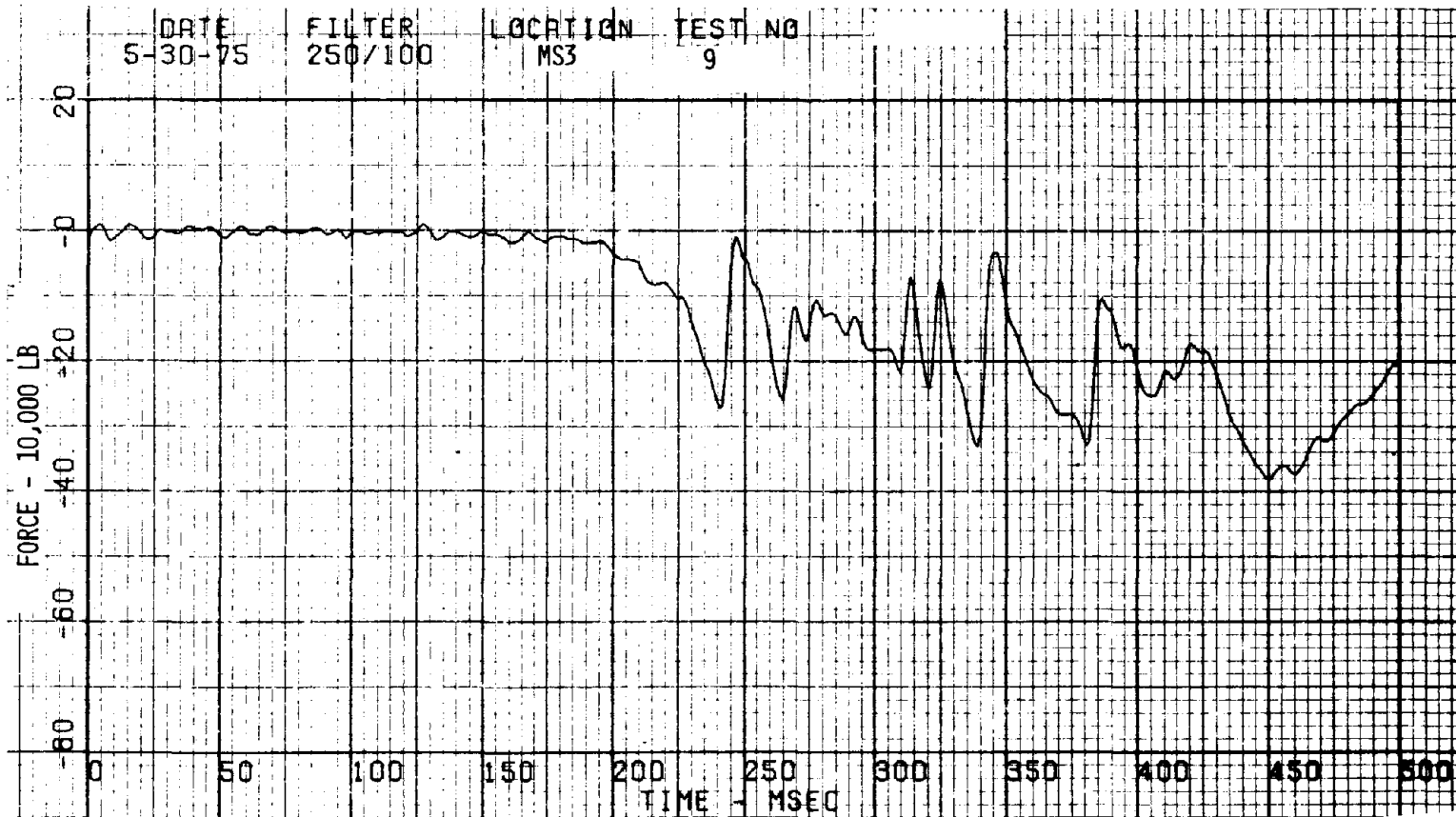


Figure A-291. Hopper 614 Rear Coupler Strain Gauge - Test 9.

A-290

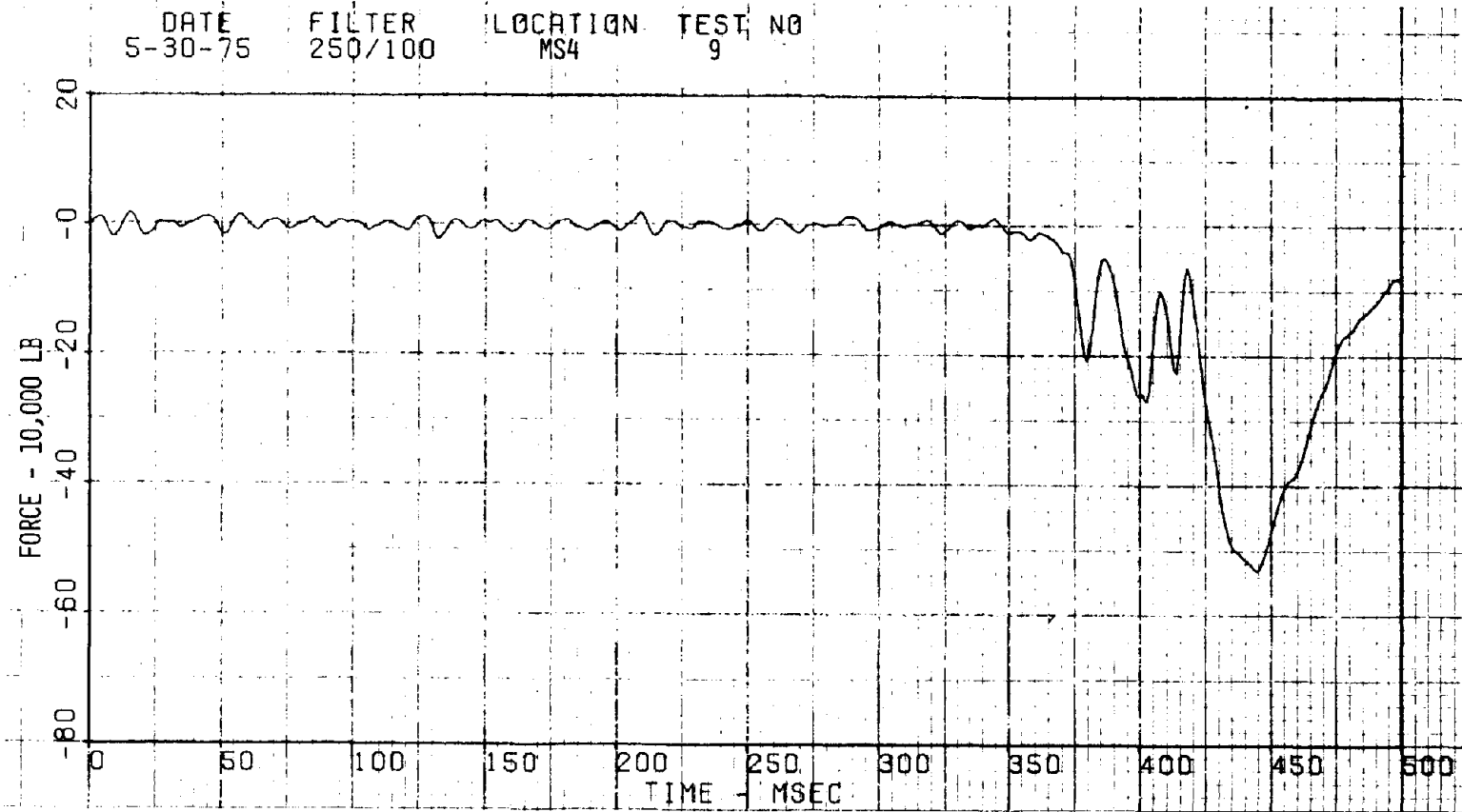


Figure A-292. Hopper 605 Rear Coupler Strain Gauge - Test 9.

A-291

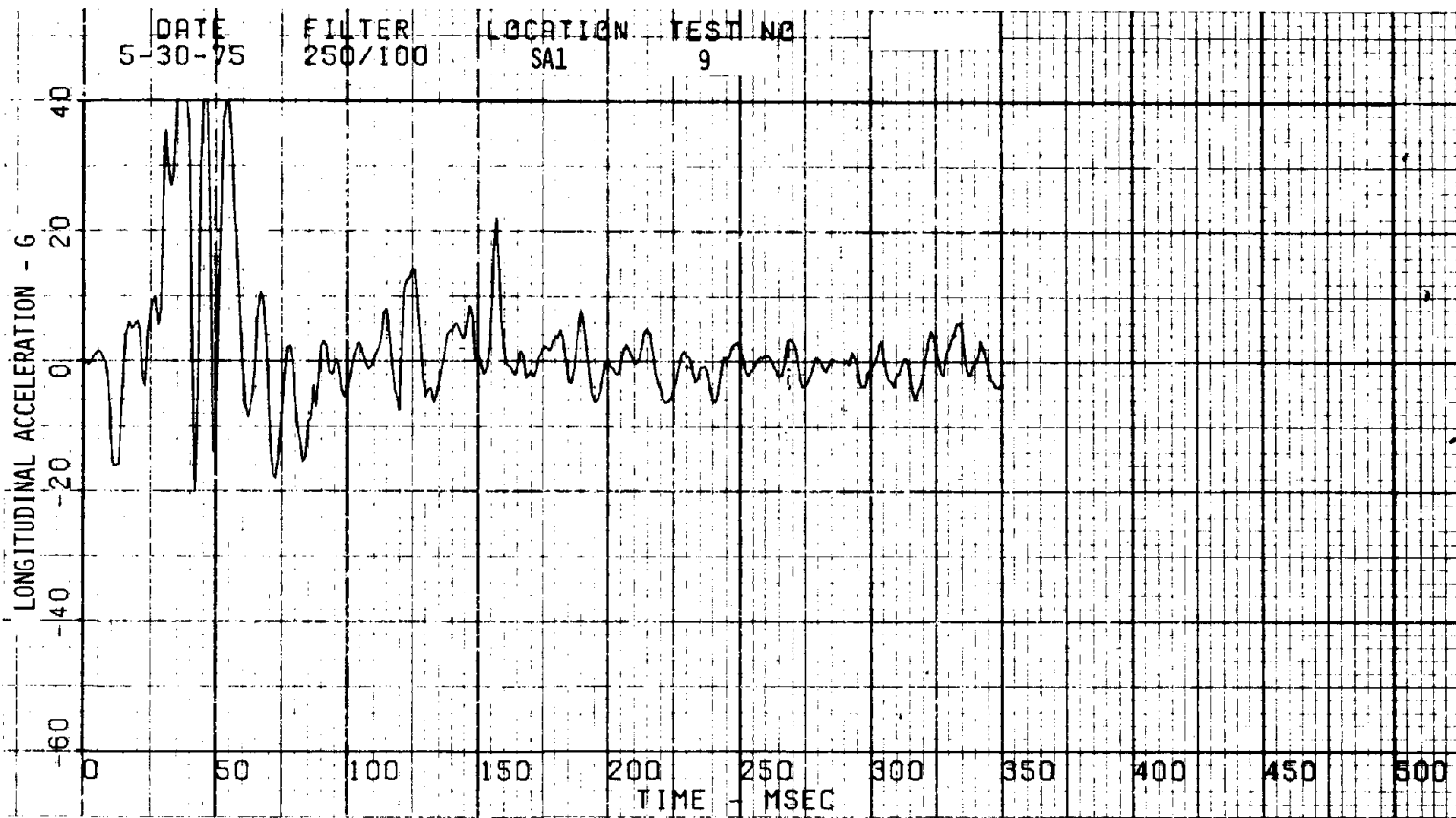


Figure A-293. Caboose Rear Triaxial Accelerometer (X) - Test 9.

A-292

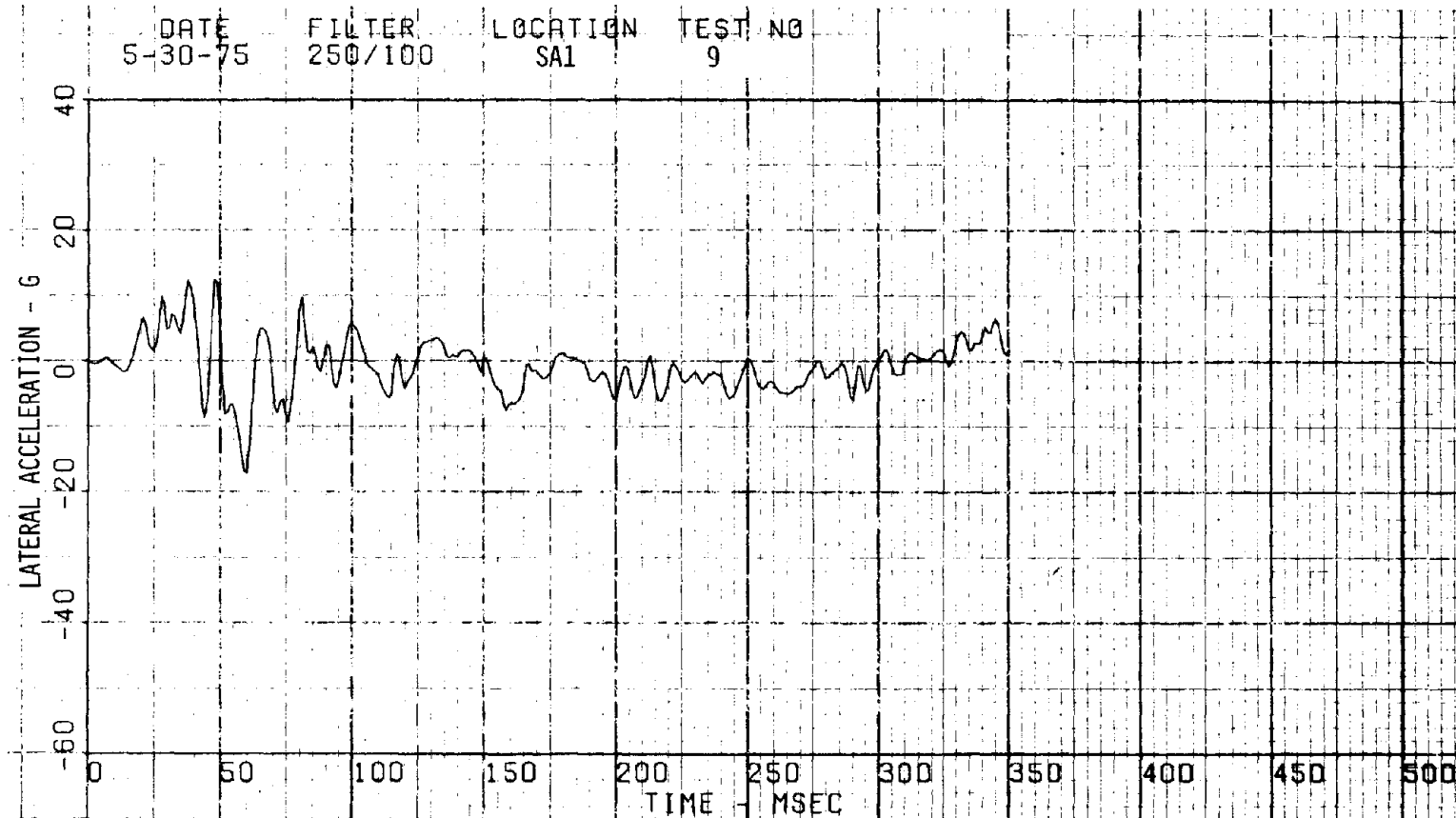


Figure A-294. Caboose Rear Triaxial Accelerometer (Y) - Test 9.

A-293

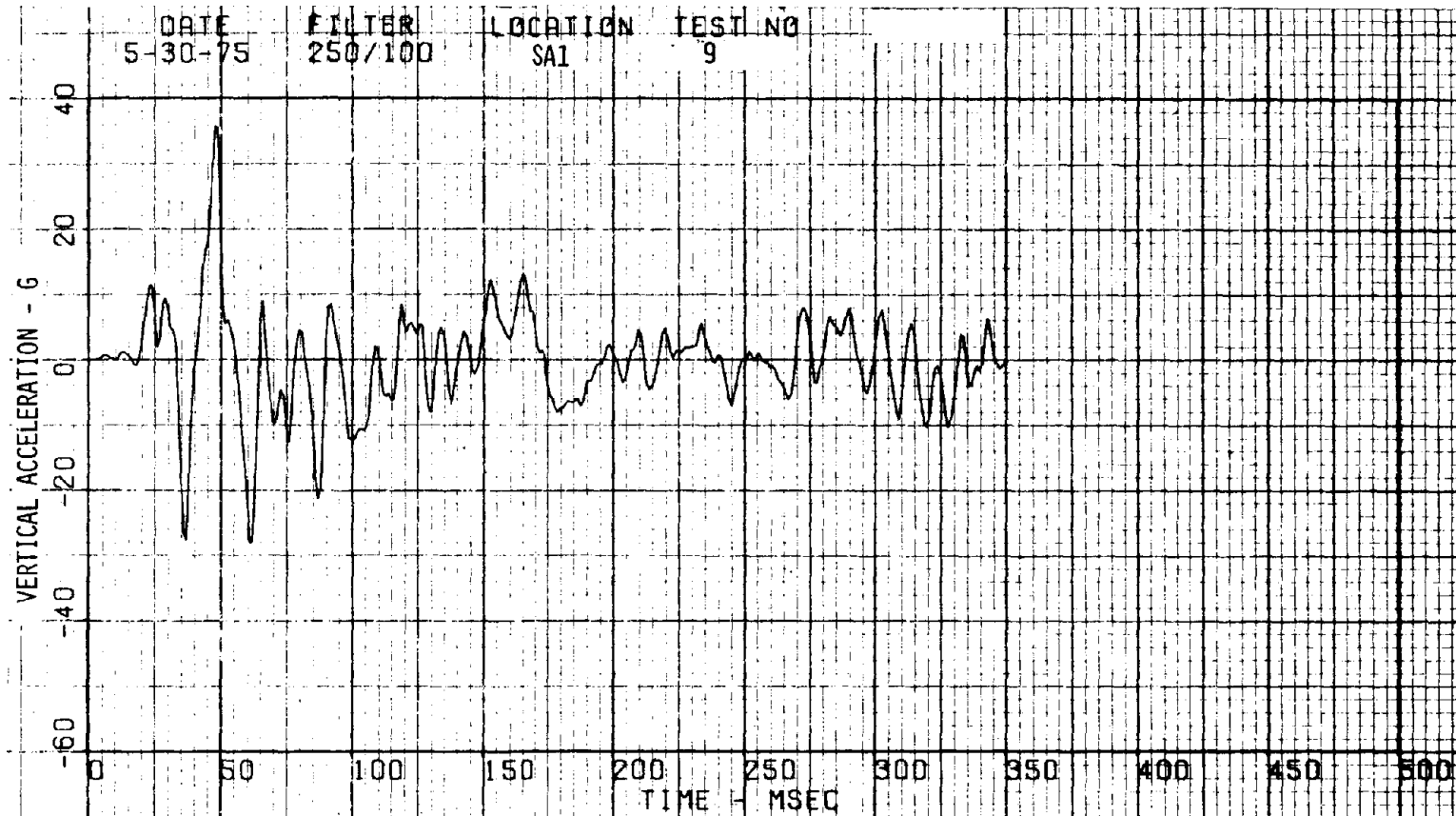


Figure A-295. Caboose Rear Triaxial Accelerometer (Z) - Test 9.

A-294

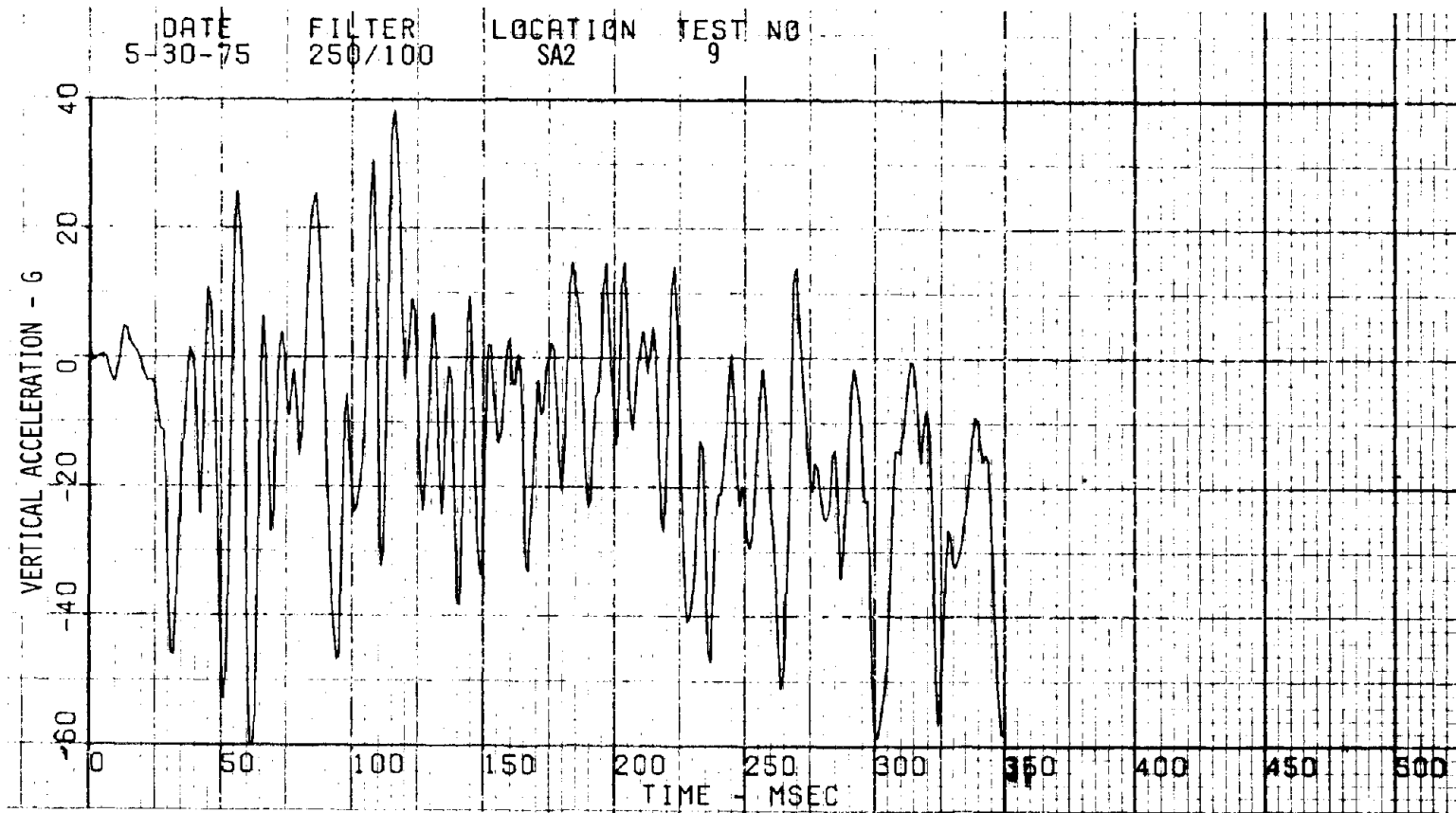


Figure A-296. Caboose Center Vertical Accelerometer - Test 9.

A-295

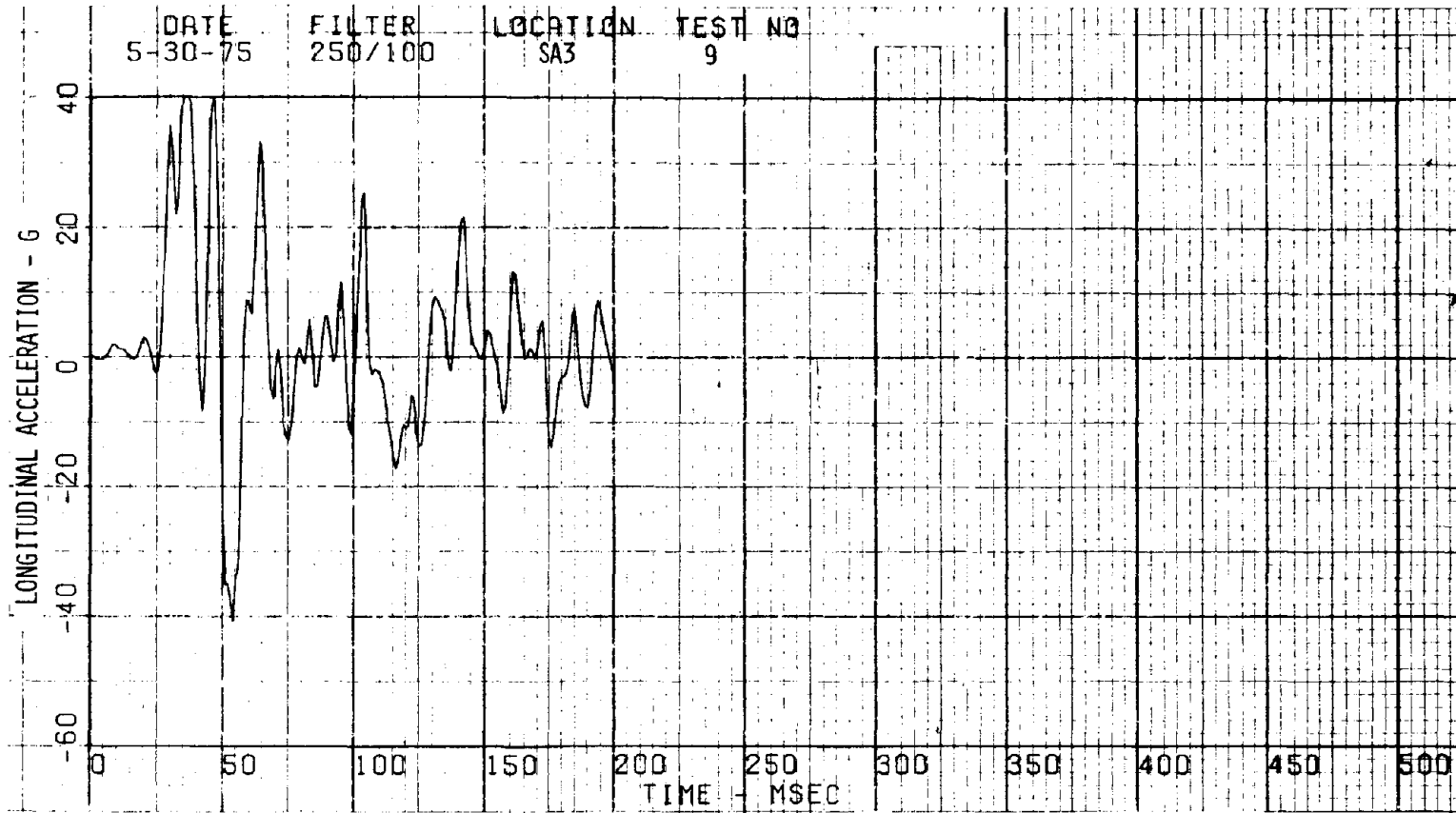


Figure A-297. Caboose Front Triaxial Accelerometer (X) - Test 9.

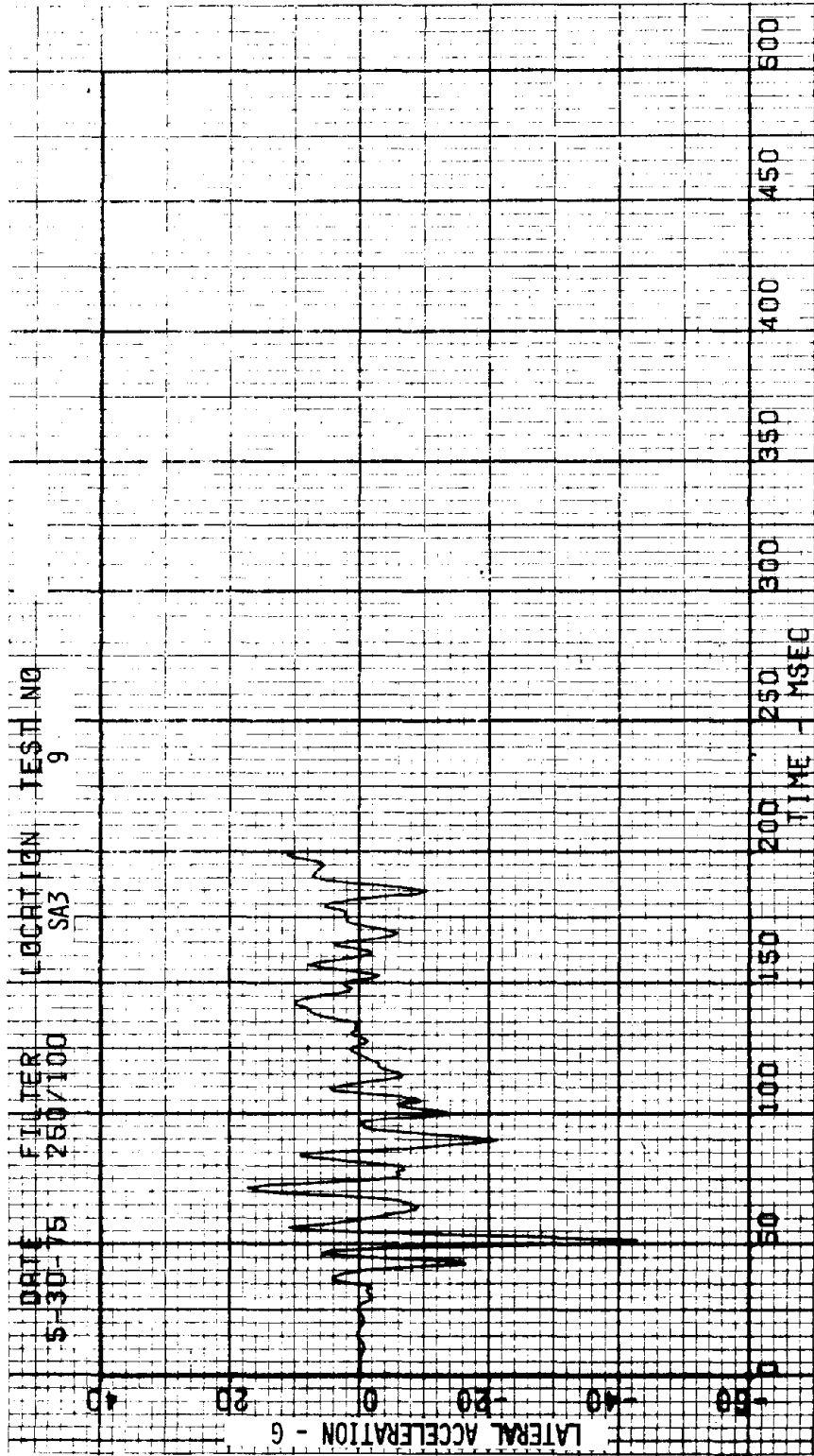


Figure A-298. Caboose Front Triaxial Accelerometer (Y) - Test 9.

A-297

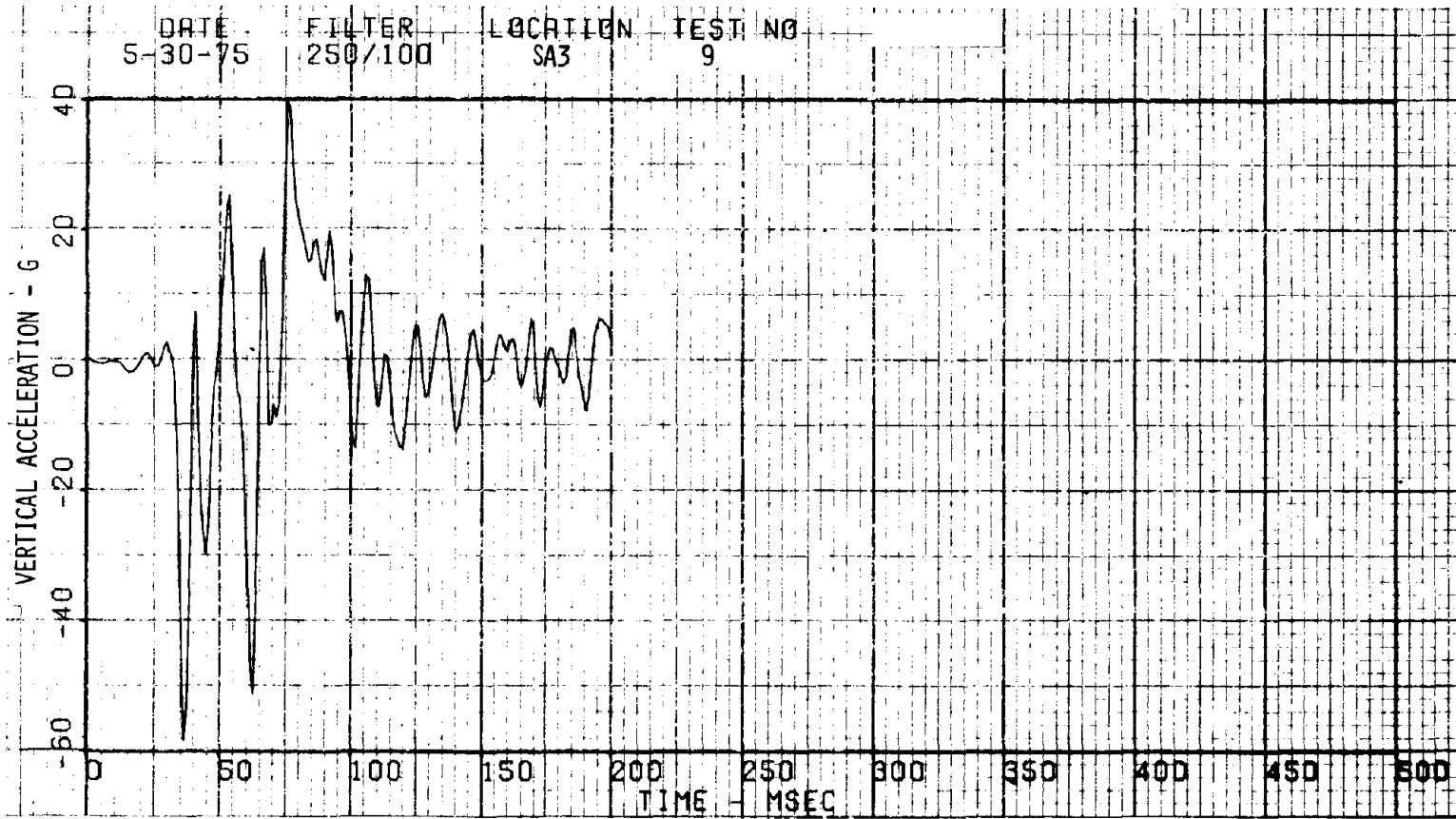


Figure A-299. Caboose Front Triaxial Accelerometer (Z) - Test 9.

A-298

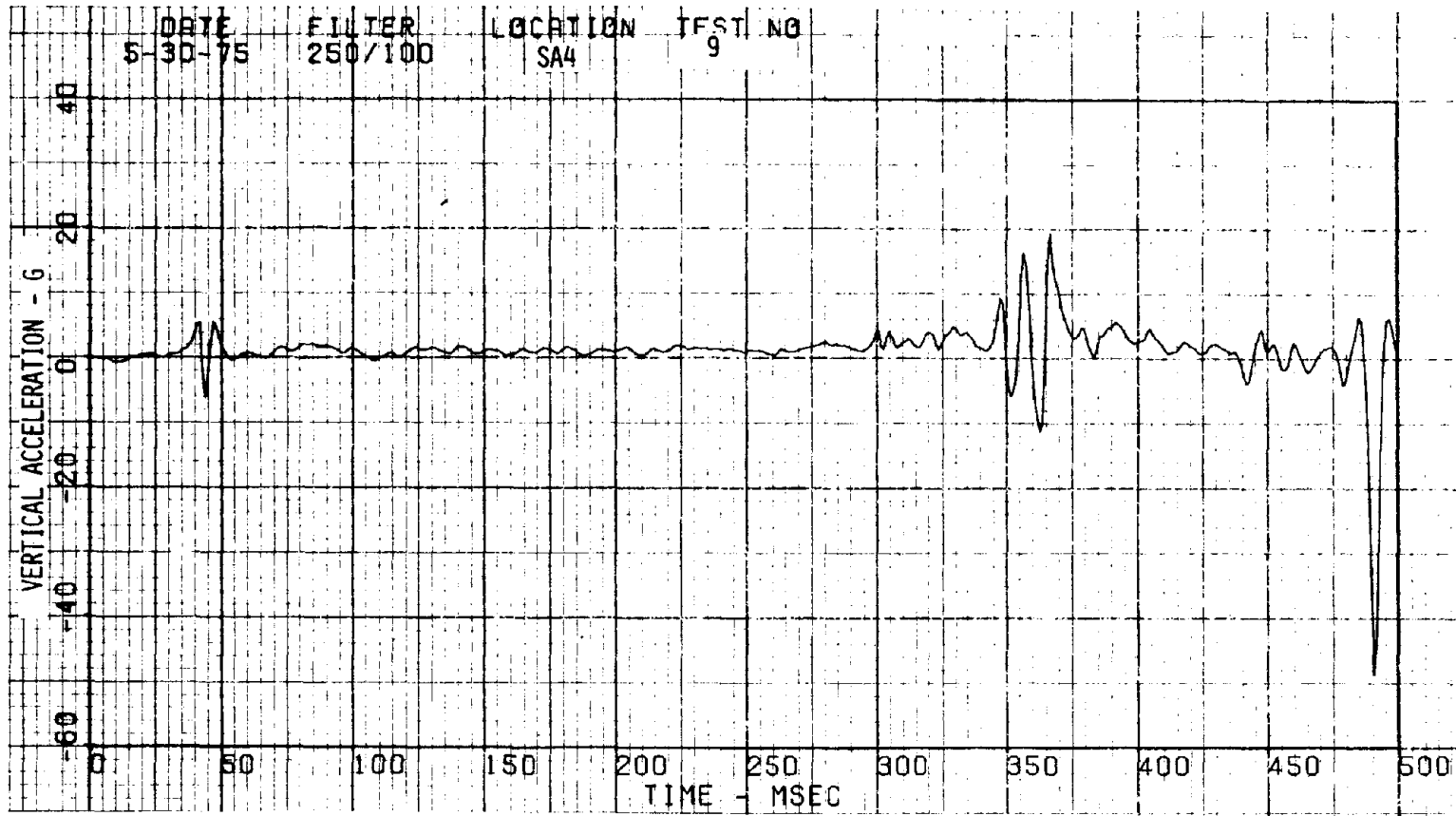


Figure A-300. Hopper 021 Rear Vertical Accelerometer - Test 9.

A-299

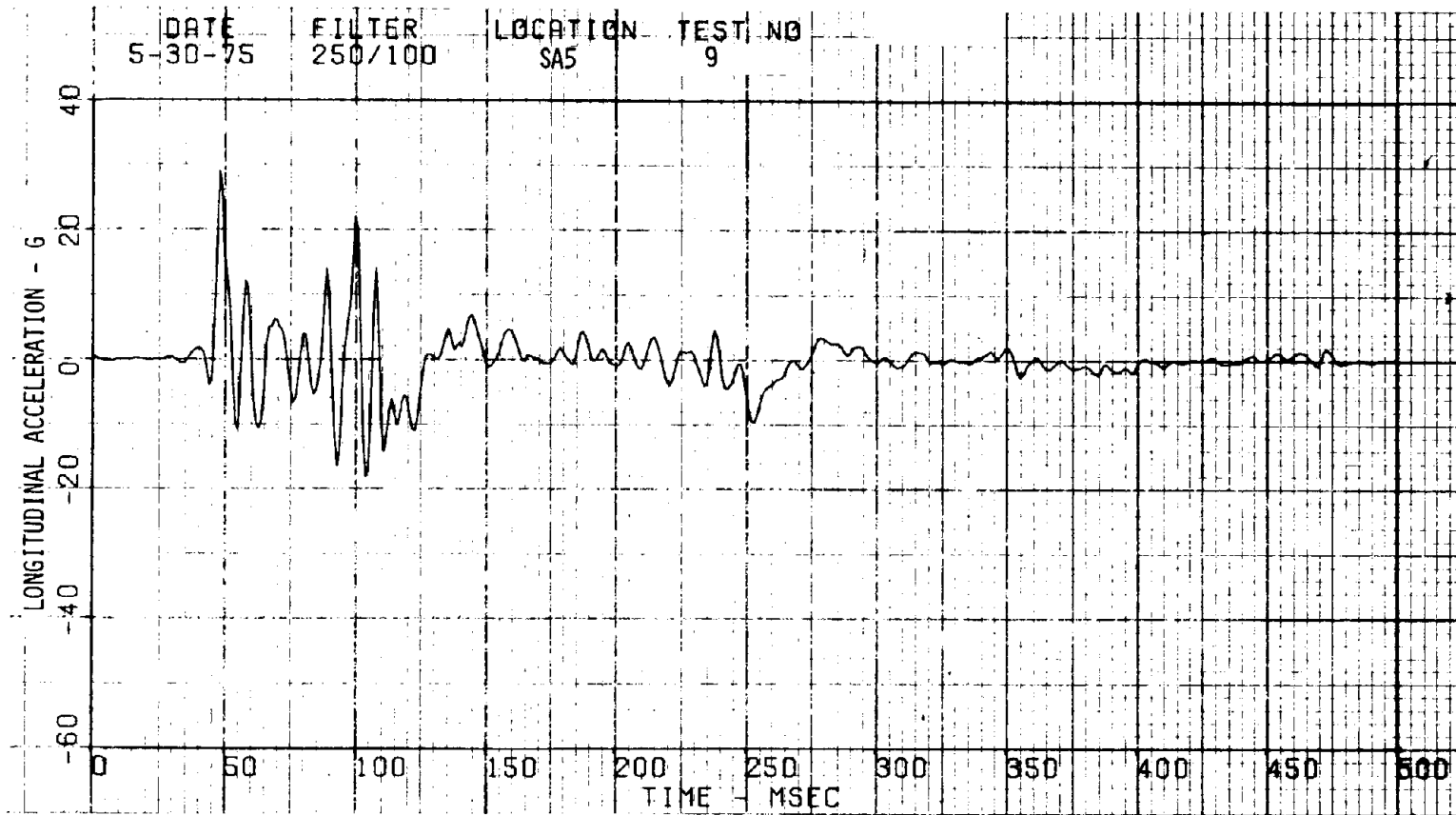


Figure A-301. Hopper 021 Center Longitudinal Accelerometer - Test 9.

A-300

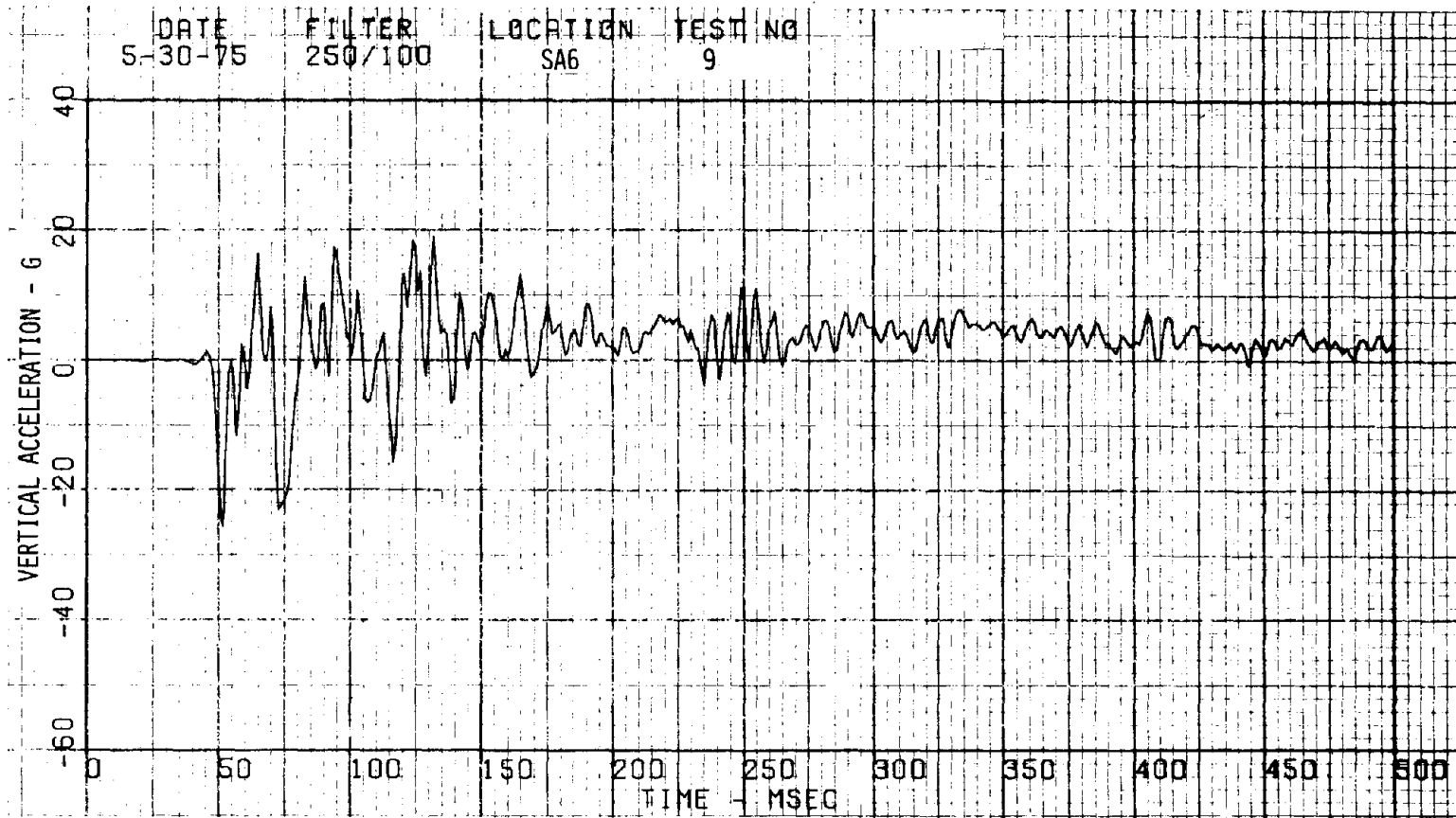


Figure A-302. Hopper 021 Front Vertical Accelerometer - Test 9.

A-301

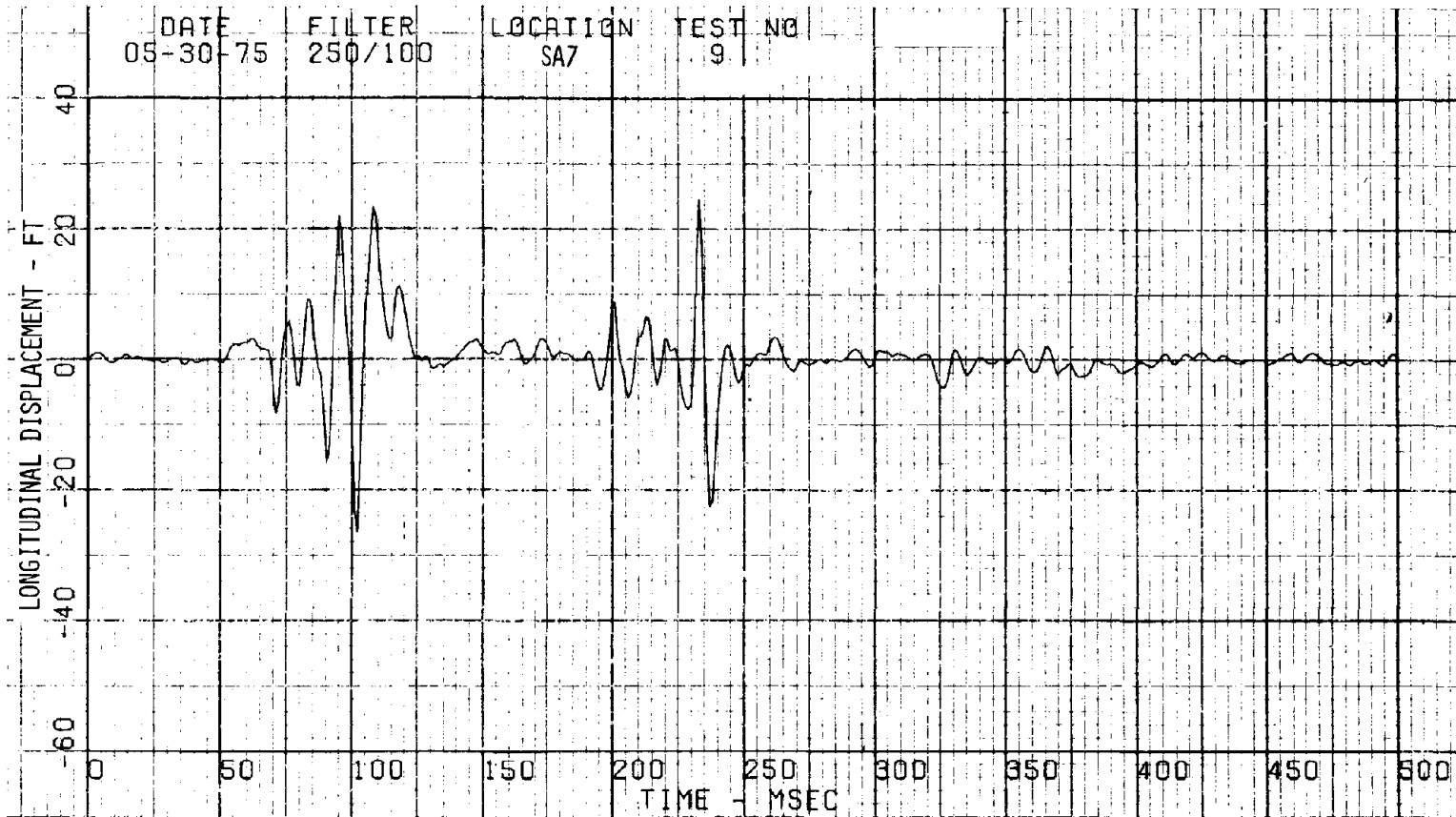


Figure A-303. Hopper 119 Center Longitudinal Accelerometer - Test 9.

A-302

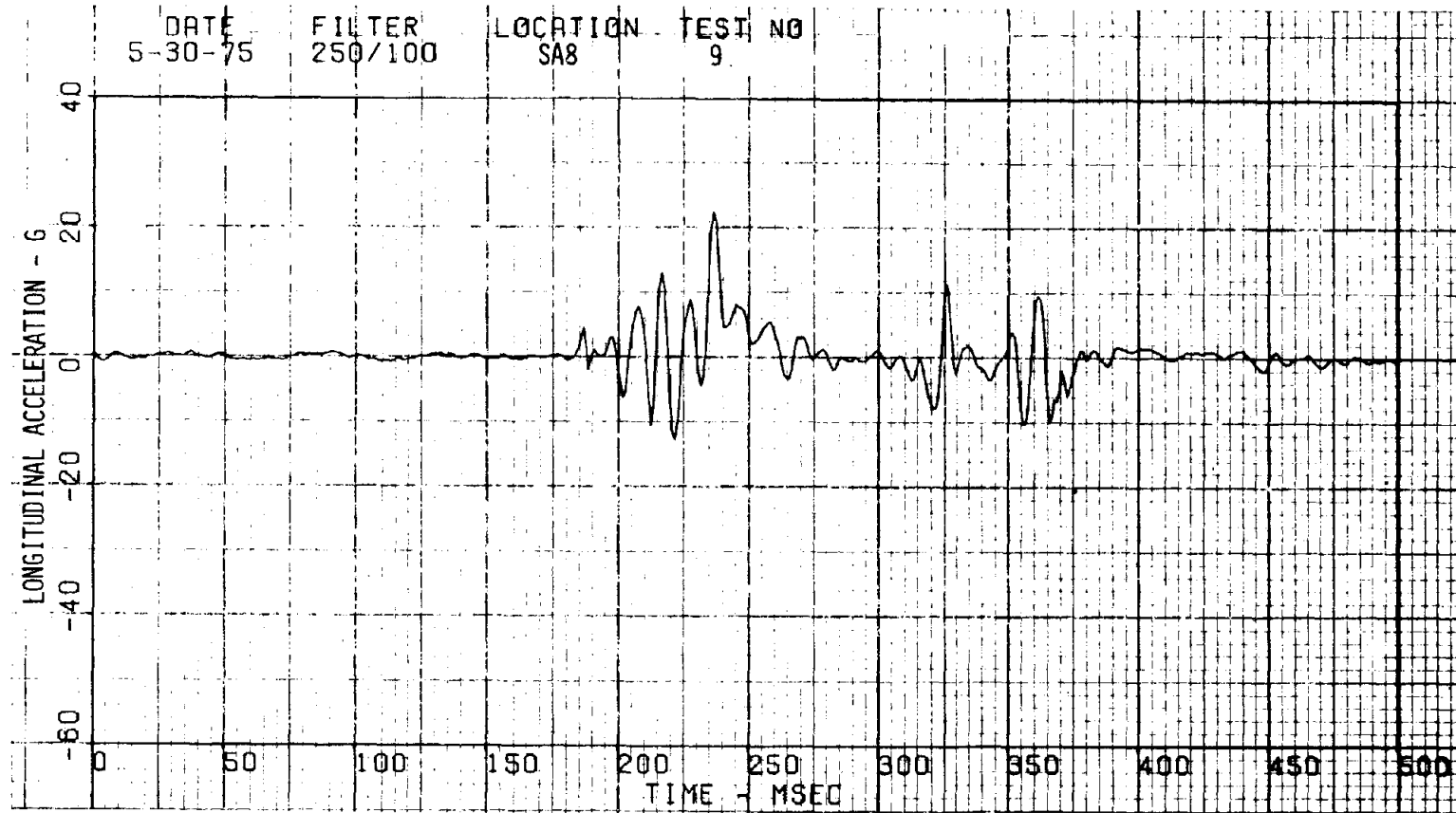


Figure A-304. Hopper 508 Center Longitudinal Accelerometer - Test 9.

A-303

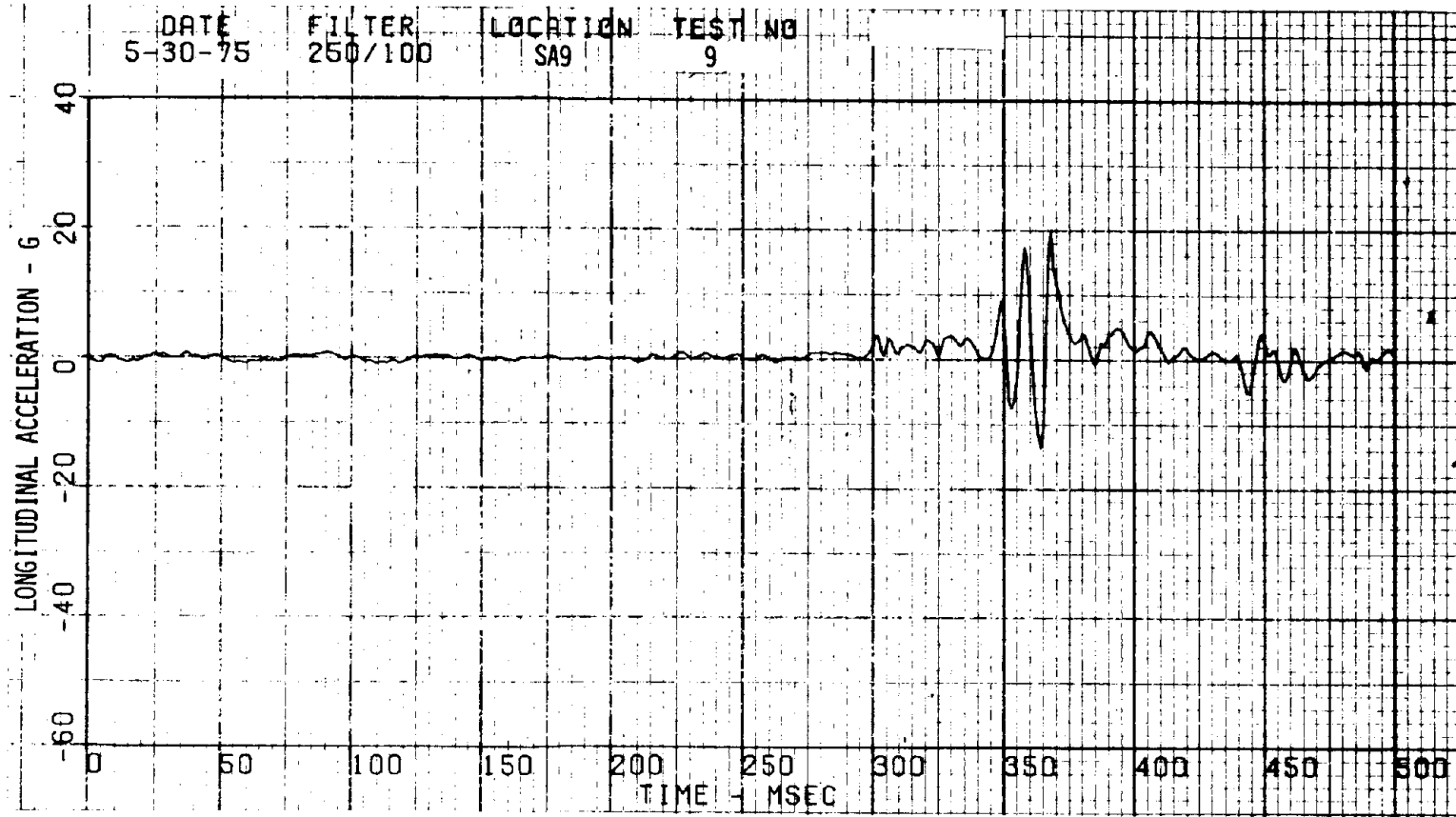


Figure A-305. Hopper 631 Center Longitudinal Accelerometer - Test 9.

A-304

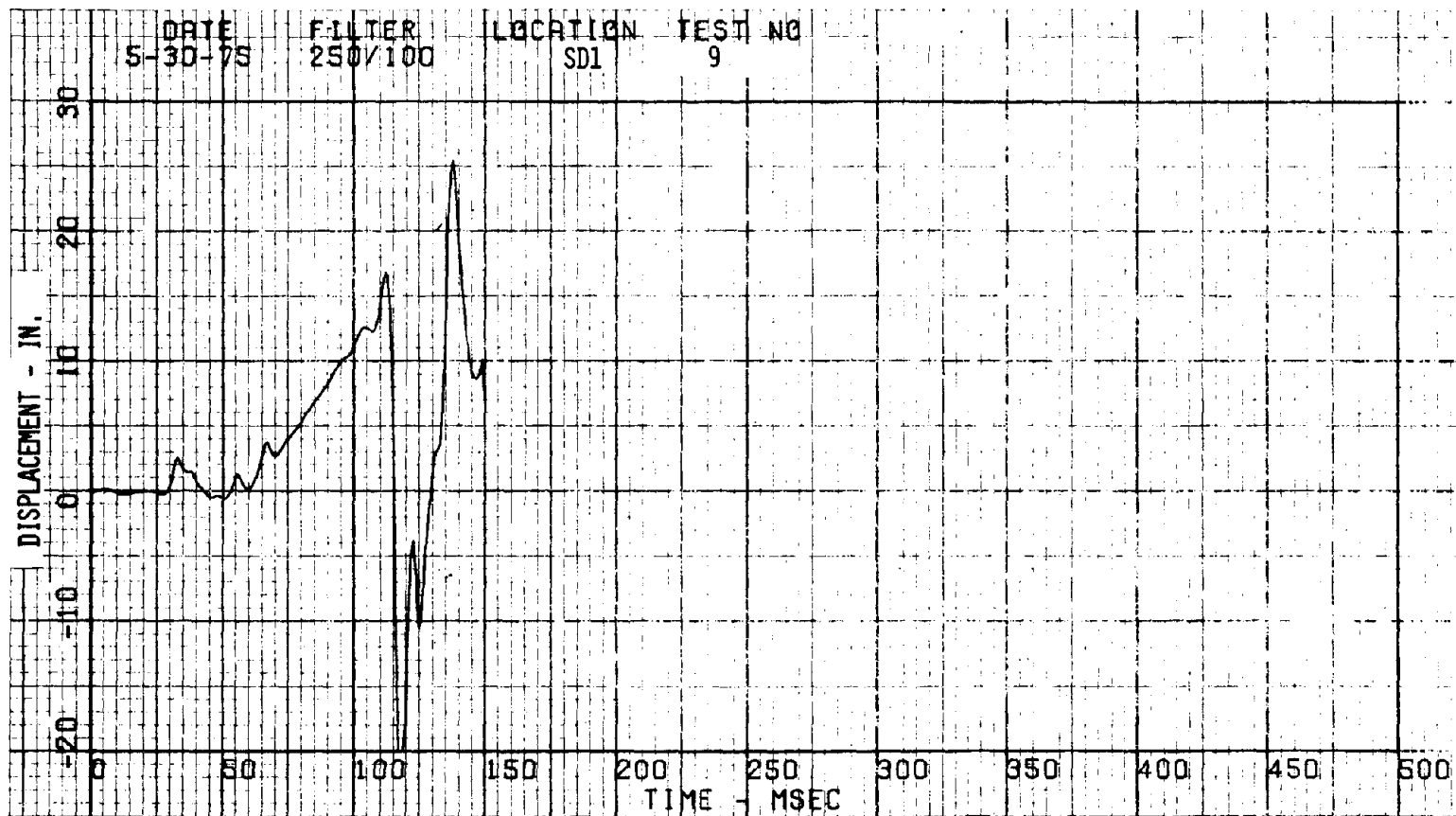


Figure A-306. Caboose Left Rear Displacement Transducer - Test 9.

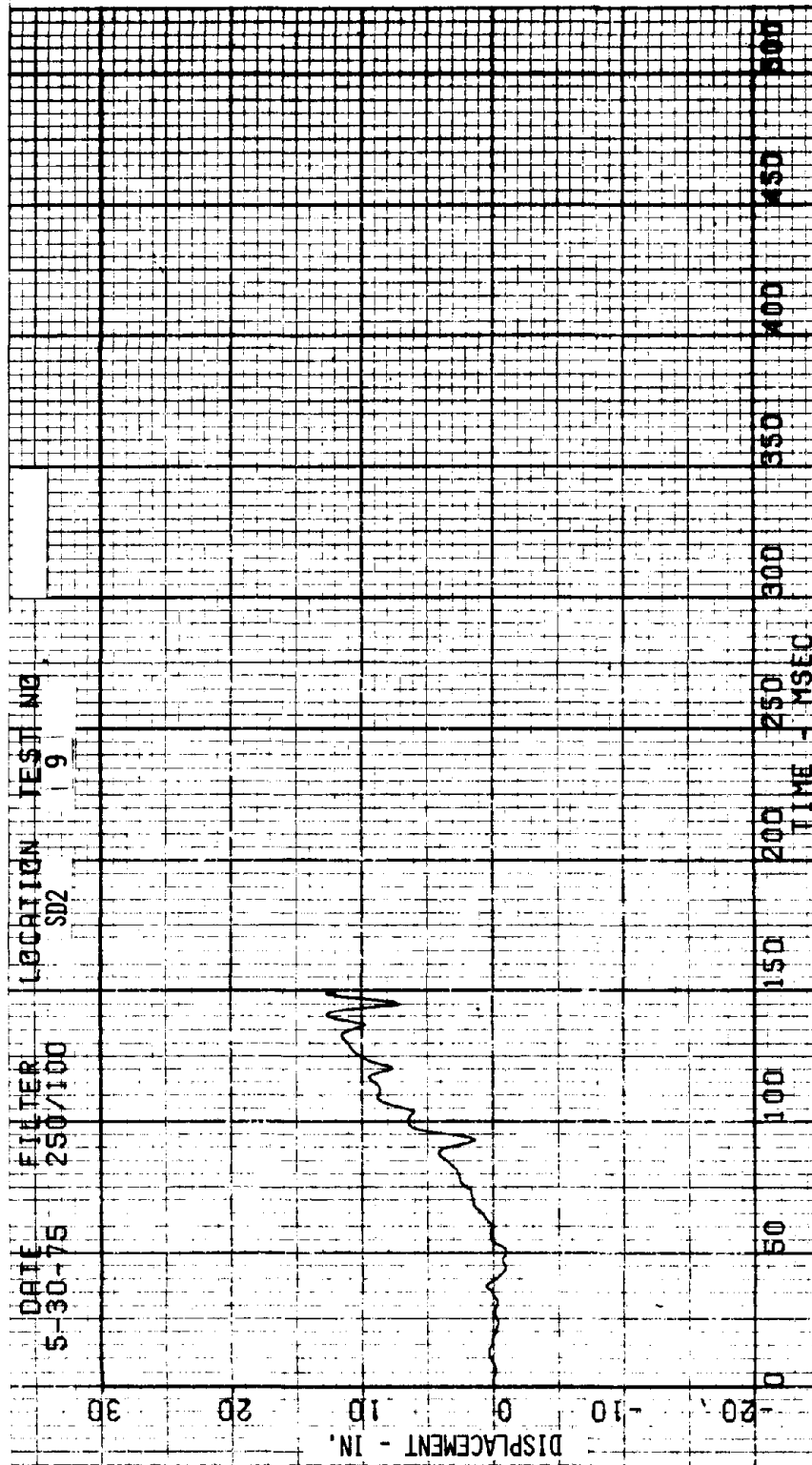


Figure A-307. Caboose Right Rear Displacement Transducer - Test 9.

A-306

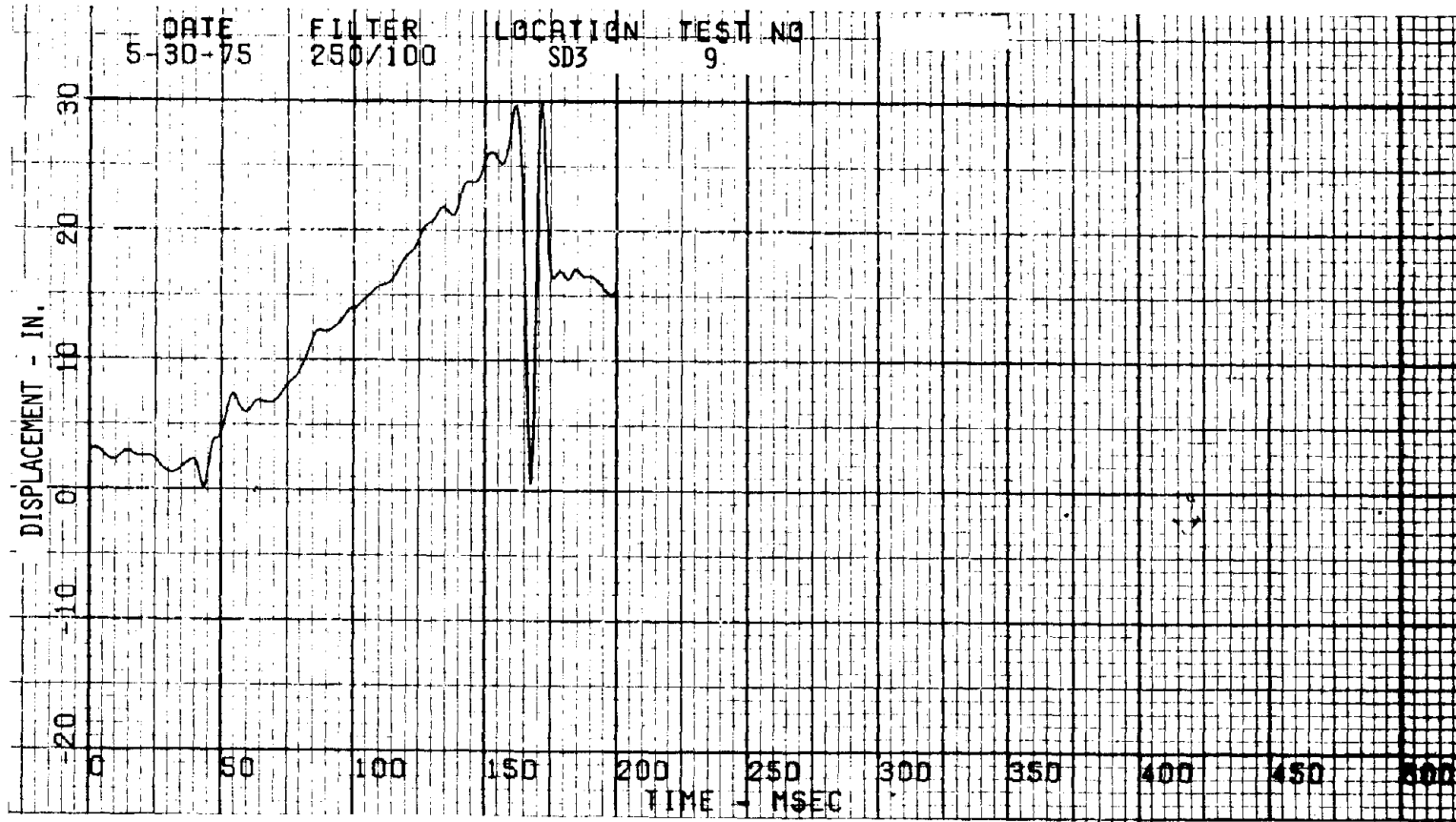


Figure A-308. Caboose Left Front Displacement Transducer - Test 9.

A-307

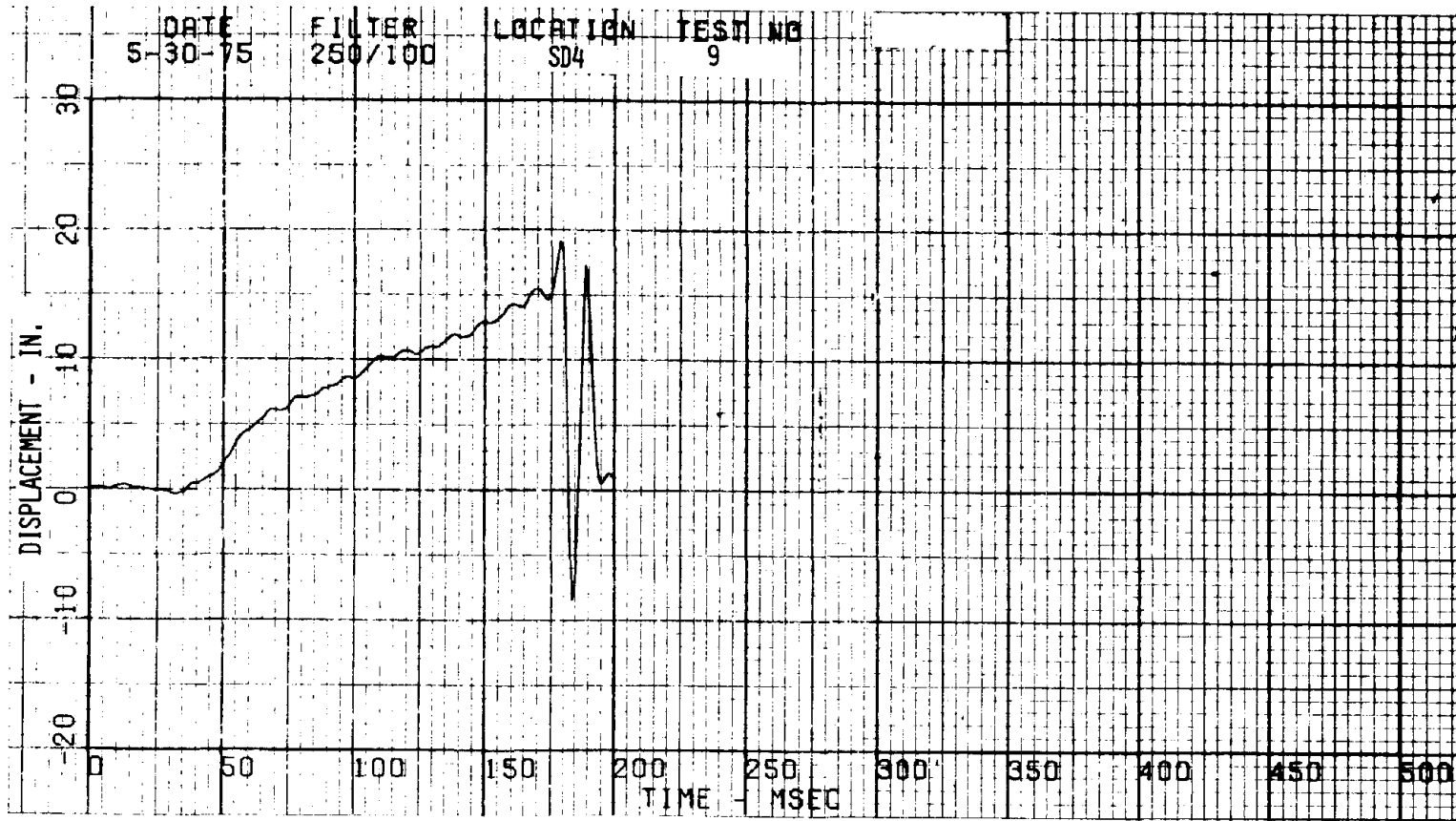


Figure A-309. Caboose Right Front Displacement Transducer - Test 9.

A-308

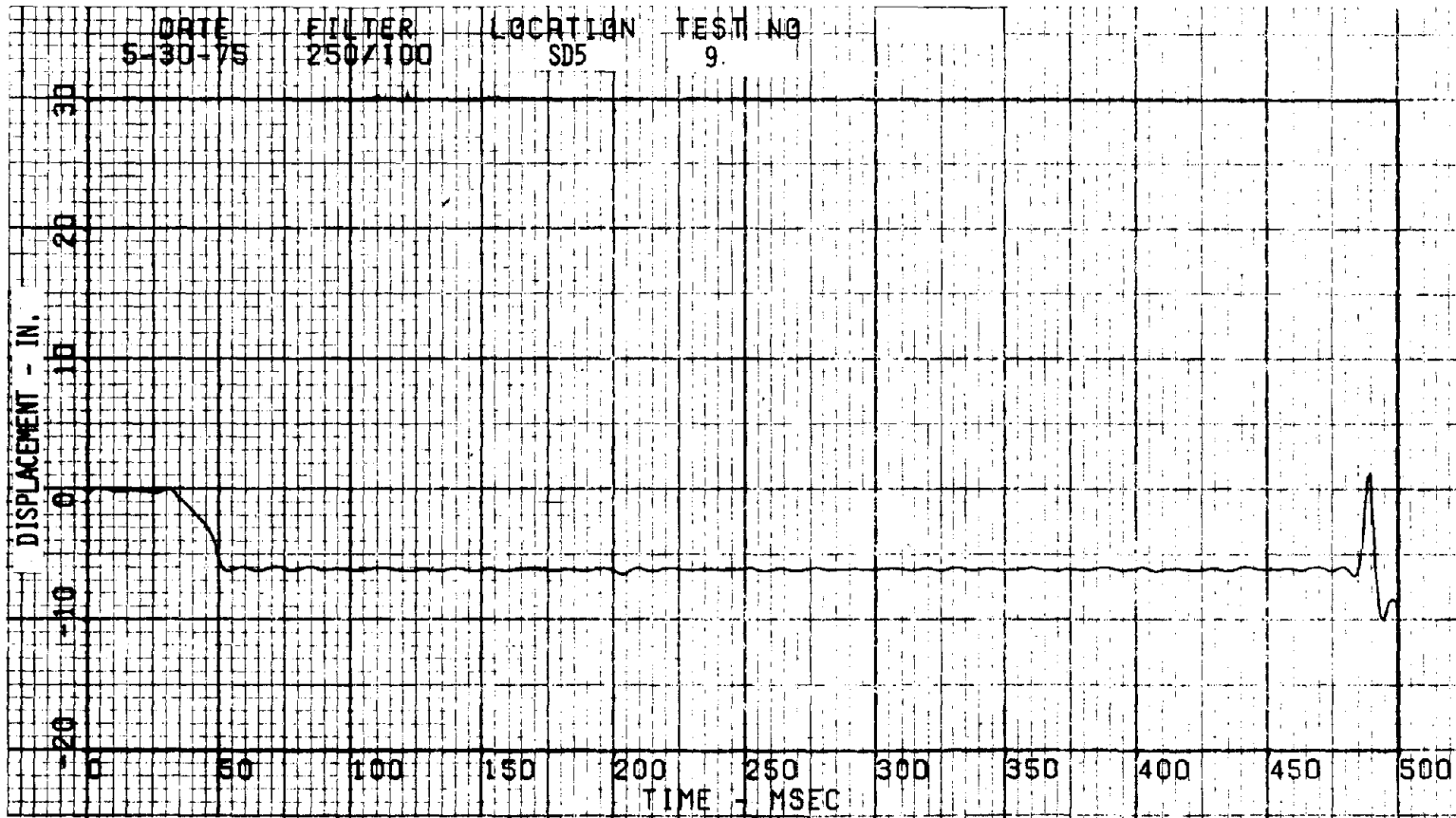


Figure A-310. Caboose to Hopper Displacement Transducer - Test 9.

A-309

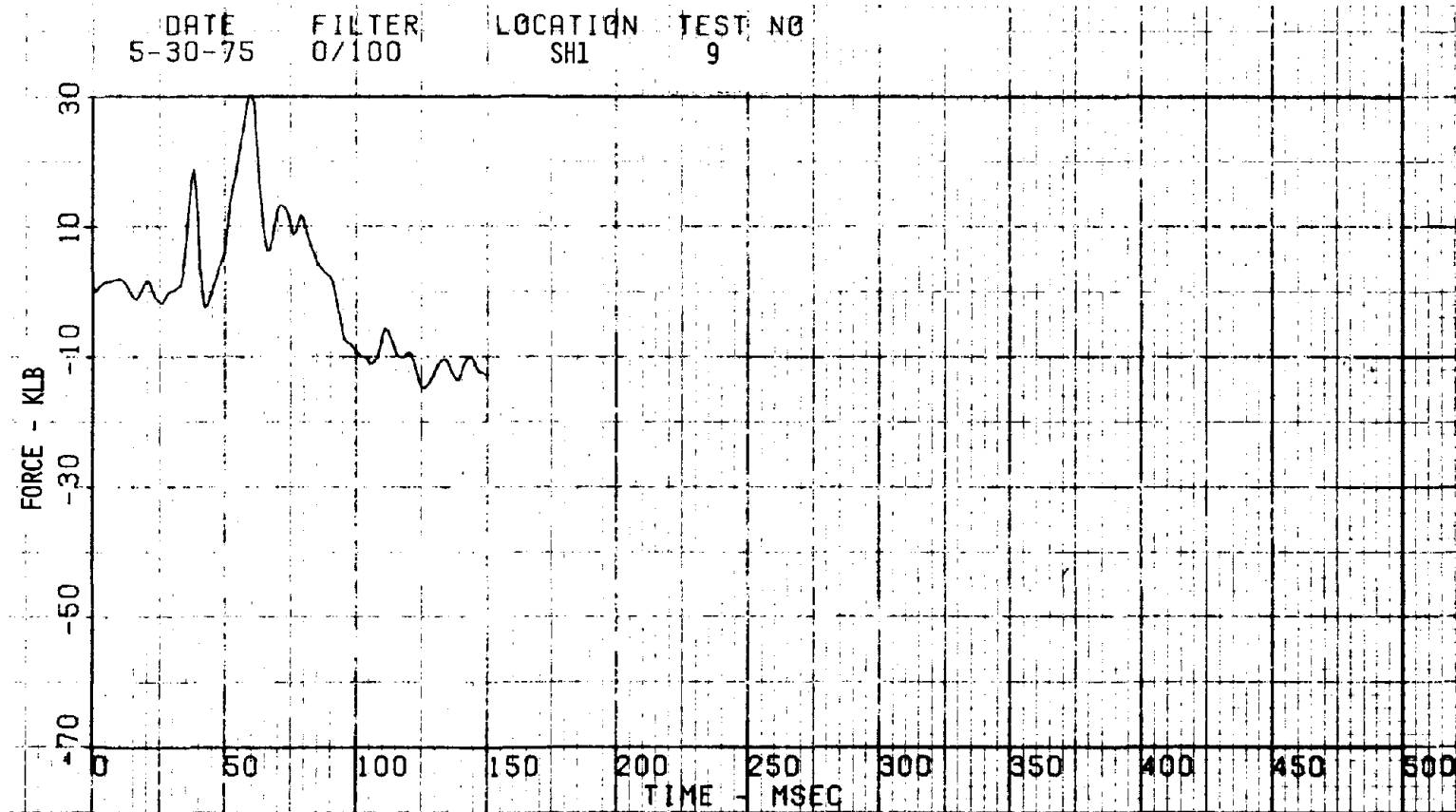


Figure A-311. Caboose Rear Swinghanger Strain Gauge - Test 9.

A-310

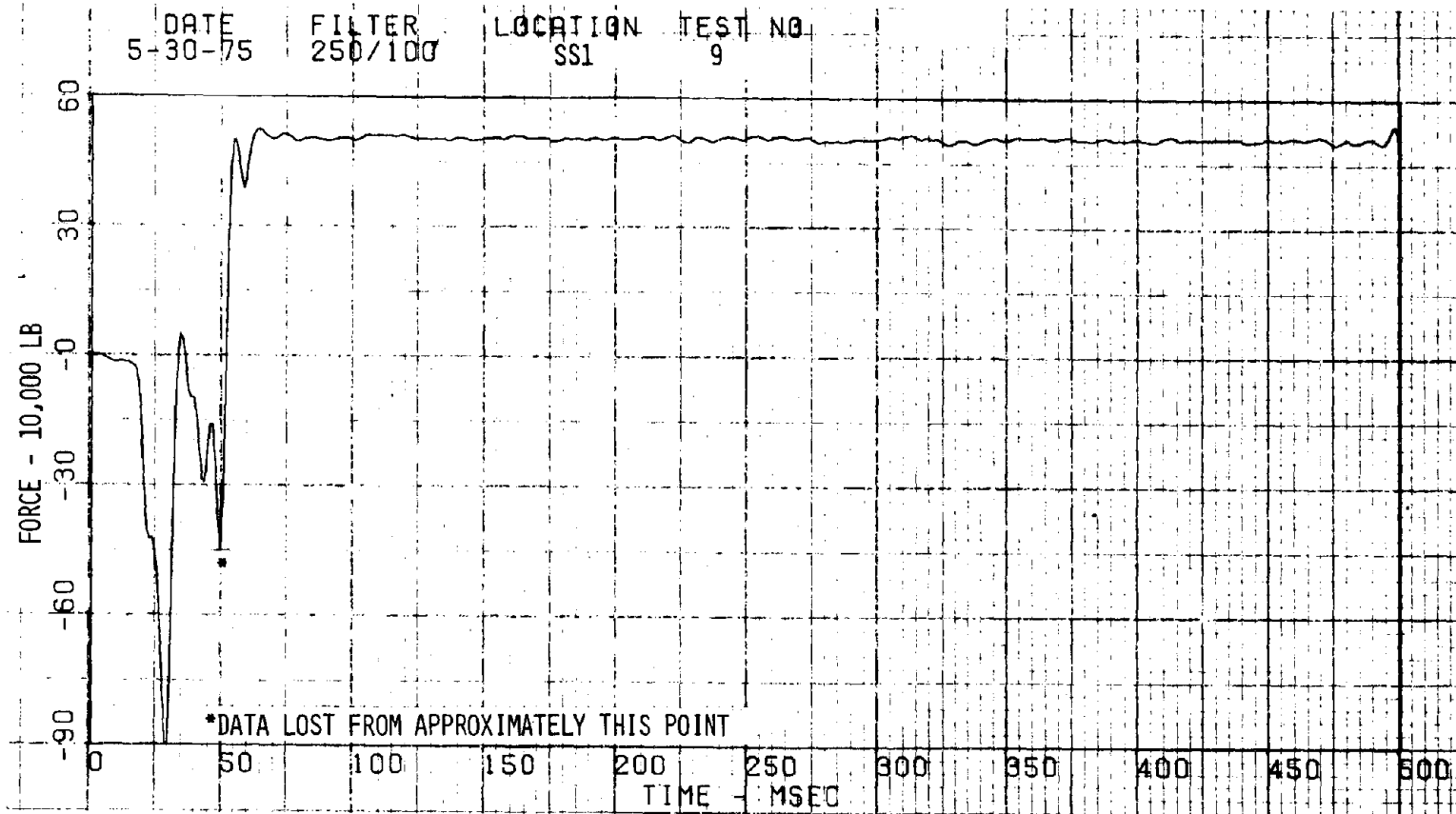


Figure A-312. Caboose Front Swinghanger Strain Gauge - Test 9.

A-311

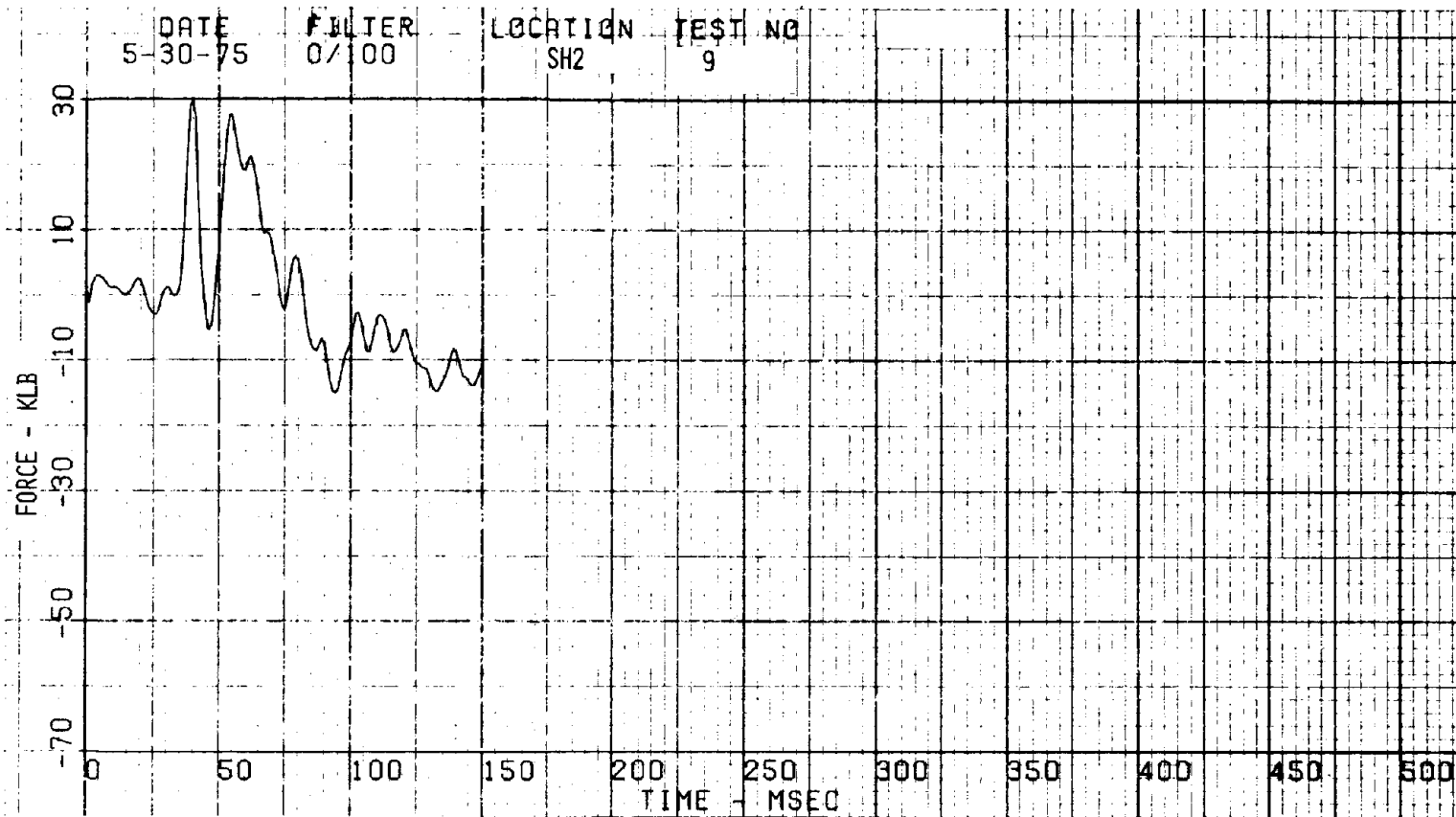


Figure A-313. Caboose Rear Coupler Strain Gauge - Test 9.

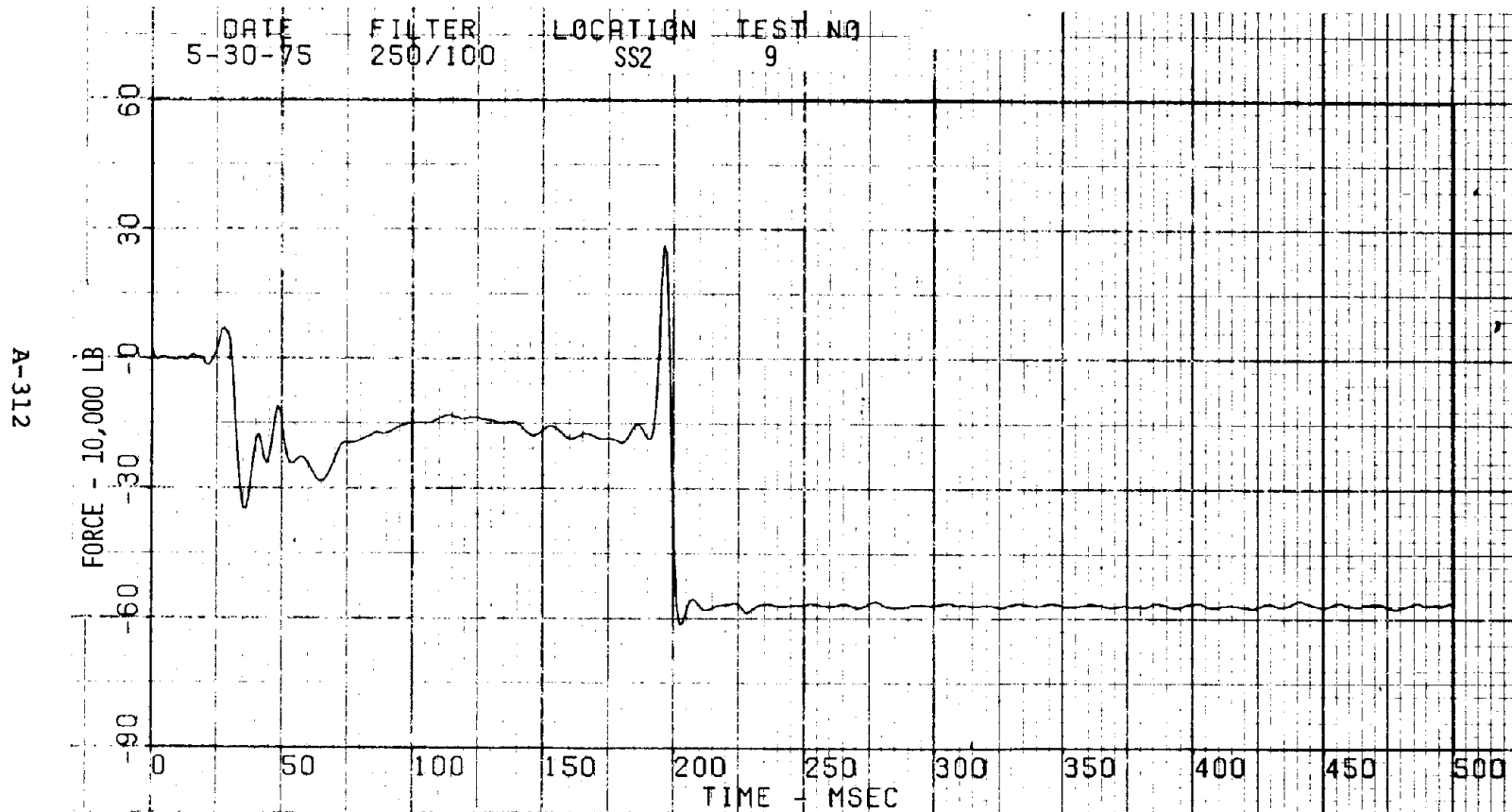


Figure A-314. Caboose Center Sill Strain Gauge - Test 9.

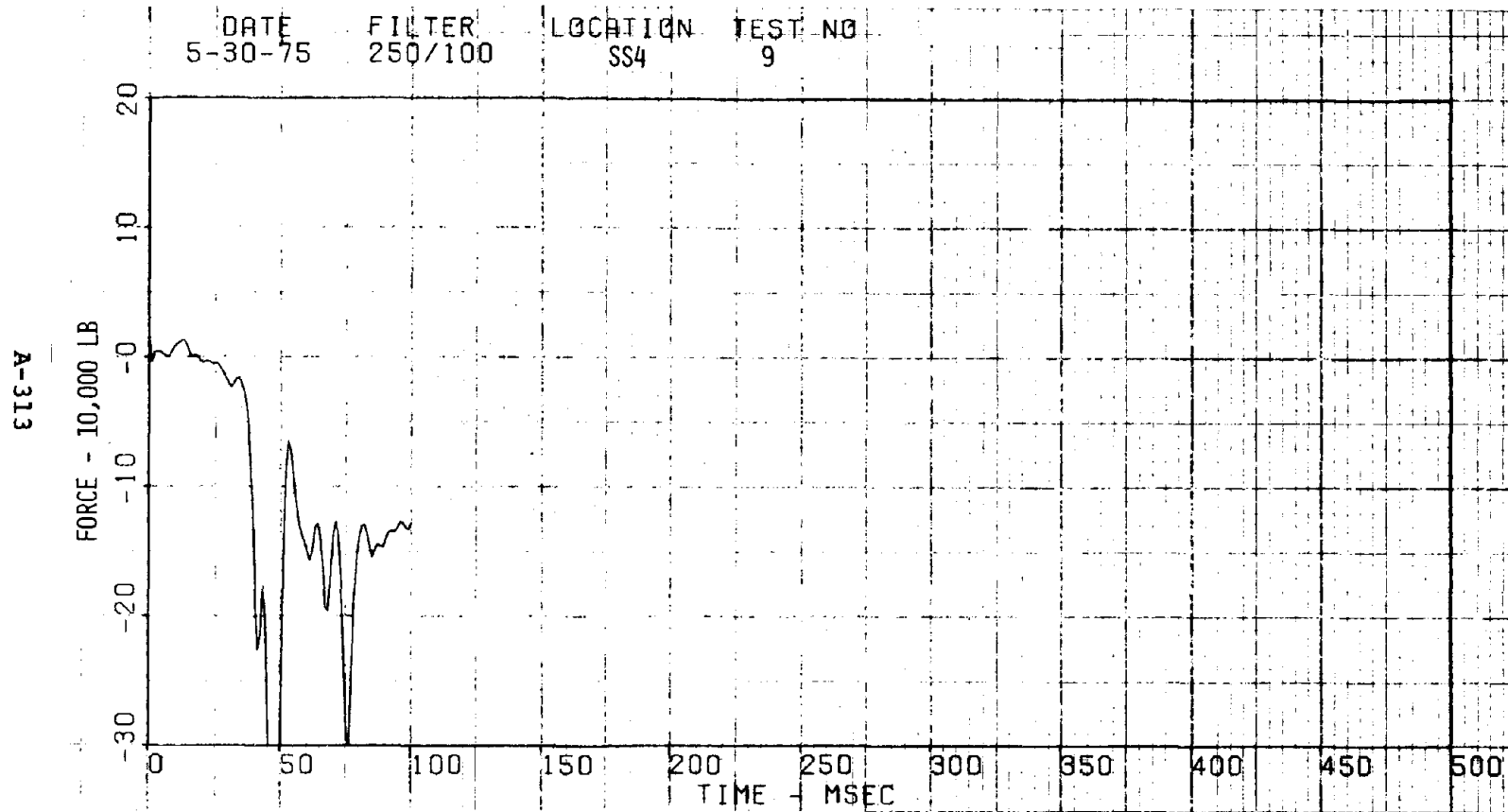


Figure A-315. Hopper 021 Rear Coupler Strain Gauge - Test 9.

DATE 5-30-75 FILTER 250/100 LOCATION SS5 TEST NO 9

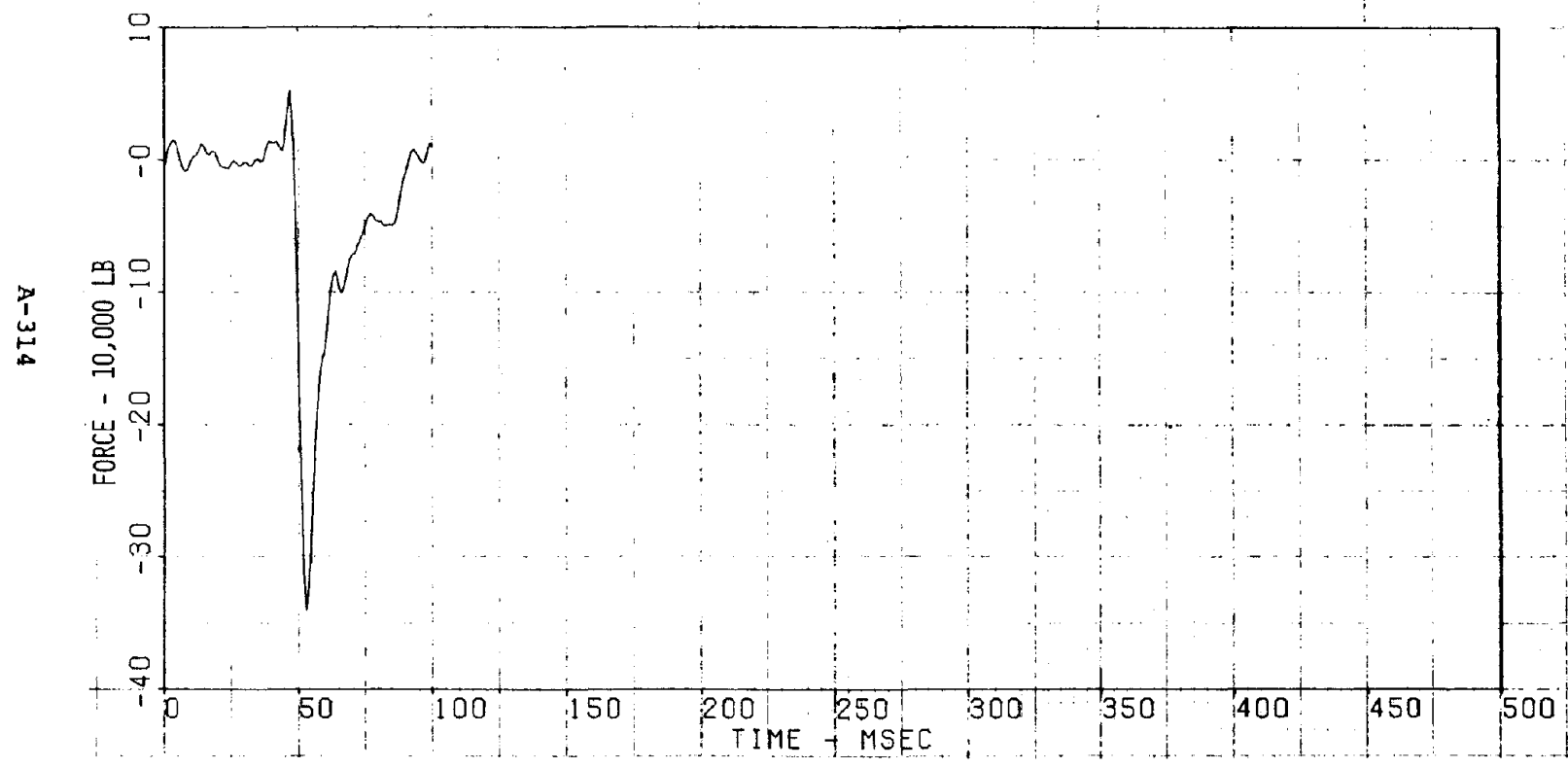


Figure A-316. Hopper 021 Center Sill Strain Gauge - Test 9.

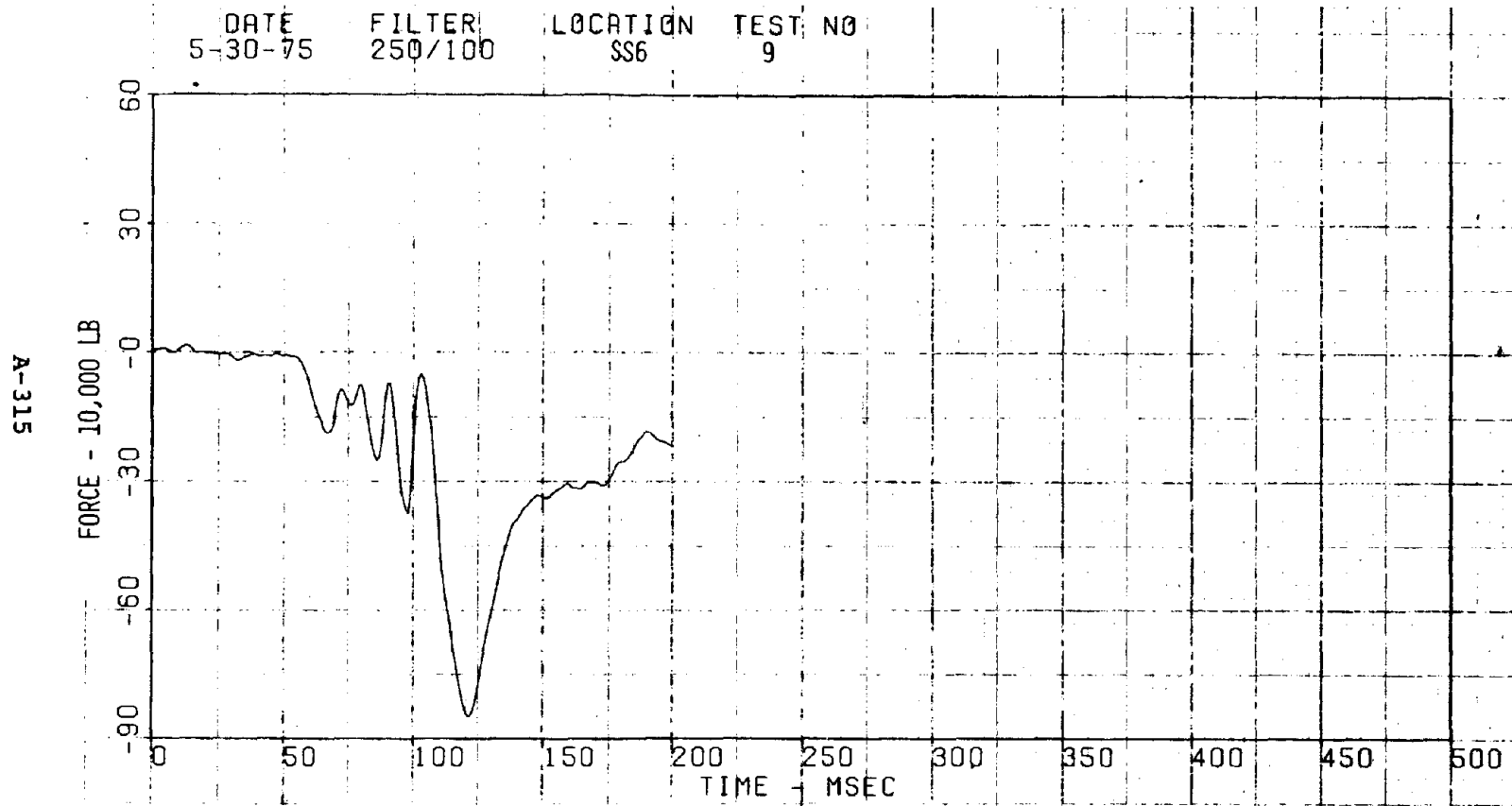


Figure A-317. Hopper 119 Rear Coupler Strain Gauge - Test 9.

A-316

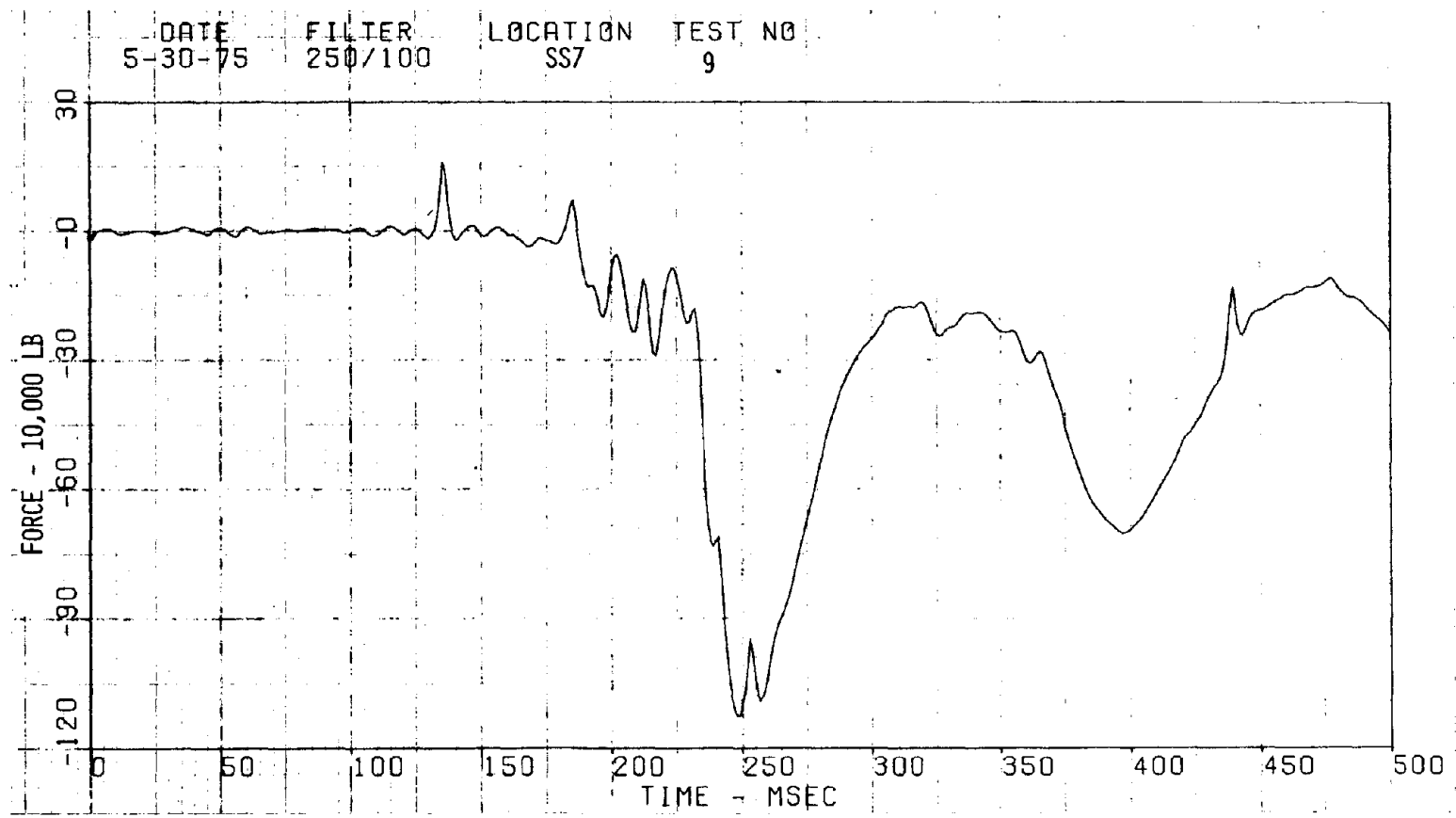


Figure A-318. Hopper 508 Rear Coupler Strain Gauge - Test 9.

APPENDIX B
REPORT OF INVENTIONS

This report contains no patentable innovation, discovery, improvement, or invention. It is a report on the collection of data concerning train-to train rear end collision. While the collection of this data used existing technology and techniques, the data itself is original.

380 copies

Technical Report Documentation Page

1. Report No. FRA/ORD-76/303,III		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle TRAIN-TO-TRAIN REAR END IMPACT TESTS - Volume III - Appendix A: Impact Test Data Appendix B: Report of Inventions				5. Report Date March 1977	
				6. Performing Organization Code	
7. Author(s) R. L. Anderson, P. L. Cramer				8. Performing Organization Report No. DOT-TSC-FRA-76-7,III	
9. Performing Organization Name and Address Ultrasystems, Inc.* The Dynamic Science Division 1850 West Pinnacle Peak Road Phoenix AZ 85027				10. Work Unit No. (TRAIS) RR628/R7323	
				11. Contract or Grant No. DOT-TSC-840-3	
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Railroad Administration Office of Research and Development Washington DC 20590				13. Type of Report and Period Covered Final Report June 1974 - Dec 1975	
				14. Sponsoring Agency Code	
15. Supplementary Notes *Under Contract to: U.S. Department of Transportation Transportation Systems Center Kendall Square Cambridge MA 02142					
16. Abstract <p>Nine train-to-train rear end impact tests were performed by the Dynamic Science Division of Ultrasystems, Inc., at DOT's Transportation Test Center under contract with the Transportation Test Center undercontract with the Transportation Systems Center which is conducting the program for the Federal Railroad Administration.</p> <p>This final report documents these none tests.</p> <p>Volume I, Pre-Impact Determination of Vehicle Properties, summarizes the vehicle properties obtained prior to the impact tests. These vehicle properties were used in computer simulation of the impact tests and included weights, pitch moments of inertia, force deflection characteristics, vertical center of gravity location, and linear dimensions.</p> <p>Volume II, Impact Test Summaries, describes the impact tests. The impact tests were remotely controlled with impact speeds ranging from 3 to 30 mph. An array of approximately 20 high-speed cameras and 50 channels of data, including accelerations, strains, and displacement, documented the impacts.</p> <p>Volume III, Impact Test Summaries Appendix, is an appendix to Volume II. It contains the original data of the impact test.</p>					
17. Key Words Train-to-Train Impact Tests, Impacts, Baseline Impact Tests, Impact Tests, Rear End Train Collisions			18. Distribution Statement DOCUMENT IS AVAILABLE TO THE U.S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161		
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