



U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

Heavy Truck Pilot Crash Test Rollover

Roy S. Rice

Calspan Corporation
Advanced Technology Center
Post Box 400
Buffalo, New York 14225

Contract No. DTNH22-80-C-07537
Contract Amount \$76,395

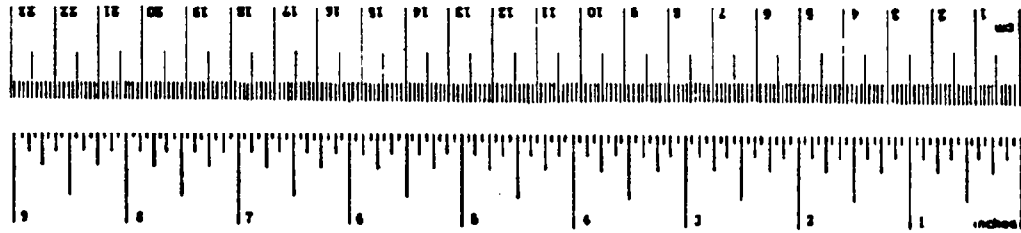
This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. DOT-HS-805 978		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle HEAVY TRUCK PILOT CRASH TEST ROLLOVER				5. Report Date July 1981	
				6. Performing Organization Code 92325	
7. Author(s) Roy S. Rice				8. Performing Organization Report No. 6748-V-4	
9. Performing Organization Name and Address Calspan Corporation Advanced Technology Center P.O. Box 400 Buffalo, New York 14225				10. Work Unit No. E28 Series	
				11. Contract or Grant No. DTNH22-80-C-07537	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590				13. Type of Report and Period Covered Test Report January-February 1981	
				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract <p>A ninety-degree rollover of a tractor-trailer on its left side was accomplished. This test was performed at an approach speed of 35 mph by directing the vehicle from a straight-ahead level path onto a side slope with a nominal inclination angle to the horizontal of 55 degrees. The test vehicle, which was operated at a total weight of 35,000 pounds, carried two 50th percentile Part 572 anthropometric test devices - one unrestrained at the driver position and the other, restrained by a lap belt, at the co-driver position. Test instrumentation consisted of 33 data channels to measure vehicle accelerations, dummy acceleration and force data, and vehicle roll rate. Photographic coverage of the event was provided by one real time and eight high speed motion picture cameras. This report contains information on all aspects of the test - physical characteristics of the vehicle and dummies, photographic and kinematic instrumentation, and data reduction methods. Still photographs of pre-test and post-test scenes as well as time histories of all measured vehicle and dummy responses are included.</p>					
17. Key Words: Heavy Vehicle Crash Test Articulated Vehicle Test Rollover Crash Tests			18. Distribution Statement : Unlimited. Available to the public through the National Technical Information Service, Springfield, Va. 22161		
19. Security Classif. (of this report)		20. Security Classif. (of this page)		21. No. of Pages 78	22. Price

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures				Approximate Conversions from Metric Measures			
Symbol	When You Know	Multiply by	To find	Symbol	When You Know	Multiply by	To find
LENGTH							
in	inches	2.5	centimeters	cm	centimeters	0.4	inches
ft	feet	30	centimeters	cm	centimeters	0.4	inches
yd	yards	0.9	meters	m	meters	3.3	yards
mi	miles	1.6	kilometers	km	kilometers	0.6	miles
AREA							
sq in	square inches	6.5	square centimeters	cm ²	square centimeters	0.16	square inches
sq ft	square feet	0.09	square meters	m ²	square meters	1.2	square yards
sq yd	square yards	0.8	square meters	m ²	square kilometers	0.4	square miles
ac	acres	2.5	hectares	ha	hectares (10,000 m ²)	2.6	acres
MASS (weight)							
oz	ounces	28	grams	g	grams	0.035	ounces
lb	pounds	0.45	kilograms	kg	kilograms	2.2	pounds
	short tons (2000 lb)	0.9	tonnes	t	tonnes (1000 kg)	1.1	short tons
VOLUME							
teaspoon	teaspoons	5	milliliters	ml	milliliters	0.03	fluid ounces
tablespoon	tablespoons	15	milliliters	ml	liters	2.1	pints
fluid ounce	fluid ounces	30	milliliters	ml	liters	1.06	quarts
cup	cups	0.24	liters	l	liters	0.26	gallons
quart	quarts	0.97	liters	l	liters	0.76	cubic feet
gallon	gallons	3.8	liters	l	liters	36	cubic meters
cubic foot	cubic feet	0.03	cubic meters	m ³	cubic meters	1.3	cubic yards
yd ³	cubic yards	0.76	cubic meters	m ³			
TEMPERATURE (Celsius)							
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature



* 1 in = 2.54 exactly. For other exact conversions and more detailed tables, see NBS Mon. Publ. 750, Units of Weight and Measures, Price \$2.25, SO Catalog No. C13.10 Z06.

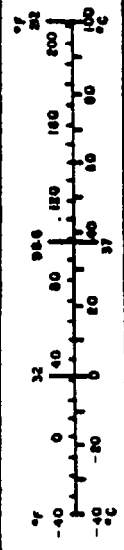


TABLE OF CONTENTS

	<u>Page No.</u>
I. INTRODUCTION	1
II. SUMMARY OF TEST	2
III. DESCRIPTIONS OF TEST CONDITIONS AND EQUIPMENT	5
IV. DISCUSSION OF RESULTS	18
APPENDIX A - PHOTOGRAPHS	A-1
APPENDIX B - VEHICLE AND DUMMY RESPONSE DATA	B-1

I. INTRODUCTION

This report describes a ninety-degree rollover test of a heavy-duty vehicle that was performed at the Advanced Technology Center of Calspan Corporation on 13 January 1981. The purpose of this test was to obtain baseline information relative to test procedures, instrumentation and variables of interest that are appropriate for crashes of vehicles of this type. Of special interest in this test were: (1) definition of the essential characteristics of a facility to produce a one-quarter roll, (2) requirements on photographic operations to provide adequate coverage of a relatively long-time crash event, and (3) information on vehicle damage and occupant motions in this type of crash.

This test was part of the Heavy Truck Pilot Crash Test program sponsored by the National Highway Traffic Safety Administration (NHTSA) under Contract No. DTNH22-80-C-07537. It was the second of two tests, the first of which was a frontal impact with a crushable barrier (Reference 1).

In addition to this test report, full photographic documentation of the crash event as well as pre-test and post-test scenes have been provided in a film containing all coverage from the several cameras used in the program. Background information for the test is contained in Reference 2.

II. SUMMARY OF TEST

This test was intended to produce a ninety-degree rollover of the tractor-trailer combination. This condition was chosen as an initial or base-line test since it was reasoned to be representative of many rollover crashes involving tractor/van semi-trailer combination unit vehicles. This configuration is the most prevalent combination unit in use. In order to accomplish the rollover a special excavation was prepared at Calspan's Vehicle Experimental Test Facility (VERF) (see Figure 5 on page 15).

For this test, precautions were taken to avoid potentially complicating factors, since the purpose was to study cab structural response as well as occupant responses, to rollover impact loadings. These included:

- (1) Addition of a trailer side curtain. A steel frame assembly, to which were attached hardboard panels, was installed at the forward left side of the trailer. This assembly was supported by transverse diagonal spars welded to the trailer frame to provide rigidity. The purpose of this unit was to simulate the side of a van semi-trailer. See Figure A-1 for views of the assembly.
- (2) Addition of a steering constraint. The test facility geometry was such that the vehicle had to traverse the length of the face of the side slope in order to achieve rollover. To avoid steering down the face of the side slope towards the bottom of the pit, the wheels were locked into the straight-ahead position by a clamping device. This device was a simple bar arrangement mounted to the tractor frame that prevented counterclockwise (left turn) displacement of the wheel. Figure A-3 is a photograph of this installation.

- (3) Articulation angle constraint. It was considered essential that the combination not articulate during the test in order to avoid an unintended jackknife type of crash. A cabling arrangement linking tractor and trailer, which had been used in the earlier frontal impact test, was therefore cinched tighter to prevent any articulation. Figure A-4 on page A-5 illustrates this arrangement.

- (4) Shortened wheelbase. The trailer wheel assembly was moved to its most forward position to assure that the unit's entire wheelbase would be accommodated on the side slope. This resulted in an overall unit wheelbase of 391 inches (as compared to the value of 466 inches for the unit in frontal impact test.

The rollover event was filmed by nine cameras, including one operating at real time from off-board and three high-speed units mounted on the vehicle to cover occupant motions. It has been found in the earlier frontal impact test that long-term crash events of this type require special considerations for lighting. Therefore, in the rollover test, six high-intensity quartz lamps were used for illuminating the cab interior. These lamps proved to be quite effective, but care must be exercised in their use because of the high heat they generate. In addition to the photographic coverage of the event (see Section III, page 5) the test was also videotaped from a single camera.

The specially-prepared site for this rollover test is shown diagrammatically in Figure 5 on page 15. Calculations based on estimates of the height of the center-of-gravity of the complete rig, coupled with measurements of the weight and planned weight distribution, indicated a static rollover angle for the unit of less than 50 degrees. To assure that rollover would occur, and recognizing that roll momentum would also contribute to the response, a side slope angle of 55 degrees was selected. The depth and length of the excavation were determined by a requirement that the complete vehicle could be accommodated on the slope, given the expected nose-down attitude it would have after path redirection and that the vehicle would slide some distance after touchdown. The depth was limited by a need to avoid reaching the 1/4 roll orientation much before contact with the base of the pit. The width of the base was selected to be somewhat greater than cab height in order to avoid unwanted contact of the cab with the far-side pit wall.

The vehicle was accelerated to approximately 35 mph along the guide rail parallel to the excavation and was then redirected through six degrees of counterclockwise heading change before reaching the pit area. At this point, the vehicle was released from tow. This redirection produced a lateral acceleration of about 1/4 g. This caused the occupants to rotate toward the right prior to the start of the vehicle's rollover motion. The six degree approach angle brought the vehicle onto the slope at a slightly nose-down attitude. As the vehicle proceeded along this path, the cab rolled to the left and, when the center-of-gravity of the complete unit passed over the edge of the pit, the left side wheels of the tractor contacted the sloped pit face. Continuing forward motion along the wall produced a roll angle exceeding that at which the vehicle is statically stable and rollover proceeded to the 1/4 roll attitude. The tractor left front wheel contacted the base of the pit during this transition and therefore absorbed most of kinetic energy of the forward motion. The vehicle slid on its side for a distance of 25 ft. after the rollover was completed.

III. DESCRIPTIONS OF TEST CONDITIONS AND EQUIPMENT

This section contains information about the test conditions, equipment, and facilities used for this test. It includes:

- vehicle measurements and specifications (Figures 1 and 2 and Tables 1-3).
- vehicle accelerometer locations (Figure 3 and Table 4).
- camera locations (Figure 4 and Table 5).
- test pit specifications (Figure 5).
- dummy location information and injury criteria values (Figure 6 and Table 6).

TABLE 1
CRASH TEST SUMMARY

TEST NO. 2 PROJECT: Heavy Truck Pilot Rollover Test
DATE: January 13, 1981 TIME: 12:15 TEMP: 20°F.

VEHICLE GMC Astro 95 tandem axle Tractor/35 ft. Trailco flat
TEST WEIGHT (lbs) 35,000 bed trailer
IMPACT ANGLE (deg)* Not applicable; 90 degree rollover
IMPACT VELOCITY (mph)** 35.0 (initial speed)

DUMMIES

TYPE	<u>Part 572, 50th Percentile</u>	<u>Part 572, 50th Percentile</u>
LOCATION	<u>LF (1)</u>	<u>RF (2)</u>
RESTRAINT	<u>Unrestrained</u>	<u>Lap Belt</u>
I.D. NUMBER	<u>110</u>	<u>97</u>

CRASH FACILITY

TYPE Sloped sidewall pit

DIMENSIONS

Length (ft): 100 (25 ft. transition and 75 ft. full depth)
Width (ft): 16 (at base of pit)
Side Slope Angle (deg): 55 (nominal; measured from horizontal)
Slant Height of Side Slope (ft): 10 (Approx.)

SURFACE packed clay (lightly snow covered)

NOTE: See Figure A-6 for photograph of this facility: dimensions are
shown in Figure 5 of this section.

NUMBER OF DATA CHANNELS 33

NUMBER OF HIGH SPEED CAMERAS 10 + 1 real time

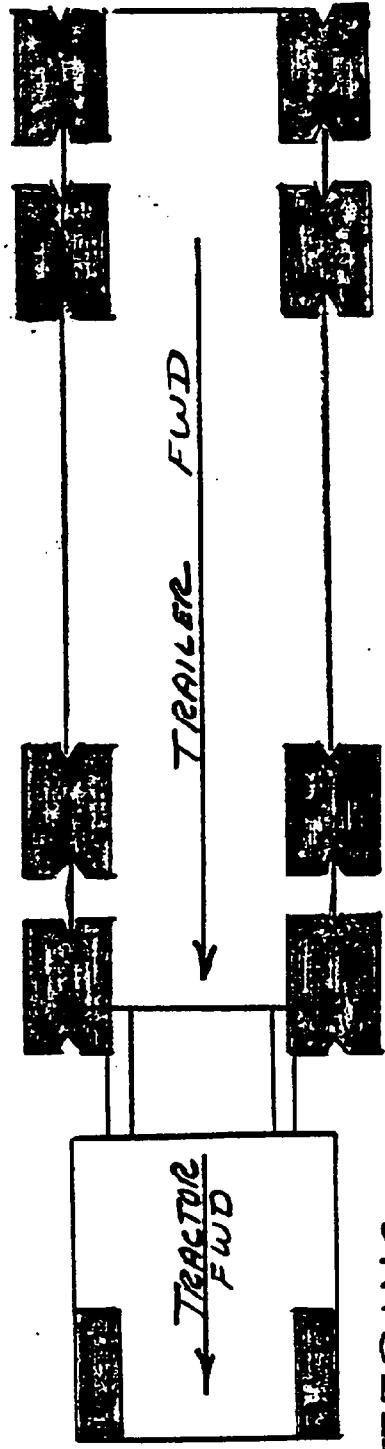
* With respect to two track Centerline

** Speed trap measurements (+ .05% accuracy)

TRACTOR MAKE GMC. ASTRO C.D.E.

TRAILER MAKE TRILCO

RF. 4150 RF. 4200 RR. 2850 RF. 3250 RR. 2500



STEERING

AXLE

L.F. 4900

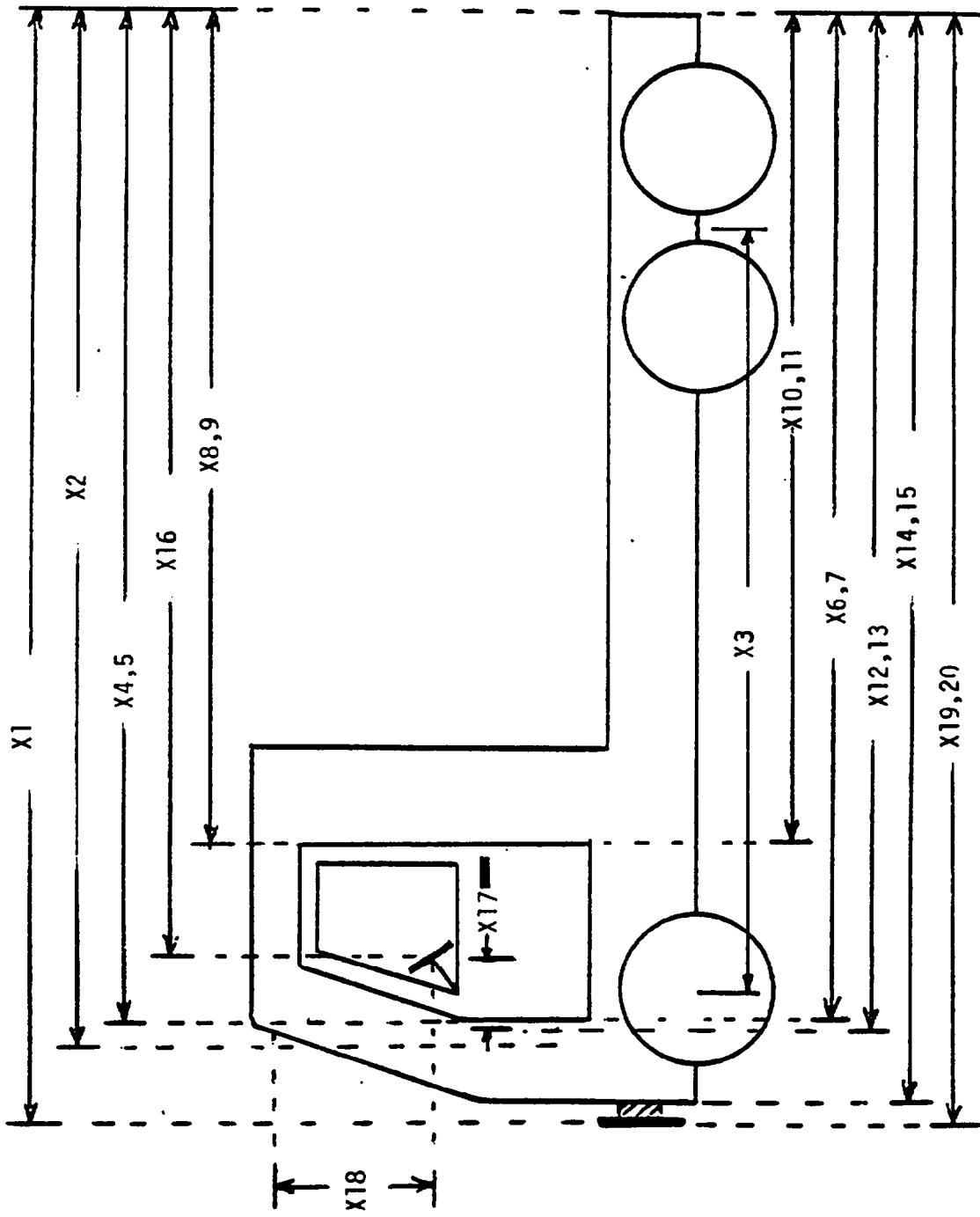
DRIVE AXLE

L.F. 4100 L.R. 3050

L.F. 3650 L.R. 2350

Total Weight: 35,000 lbs.

Figure 1 WEIGHT DISTRIBUTION



MEASUREMENT POINTS

FIGURE 2

TABLE 3
VEHICLE MEASUREMENTS

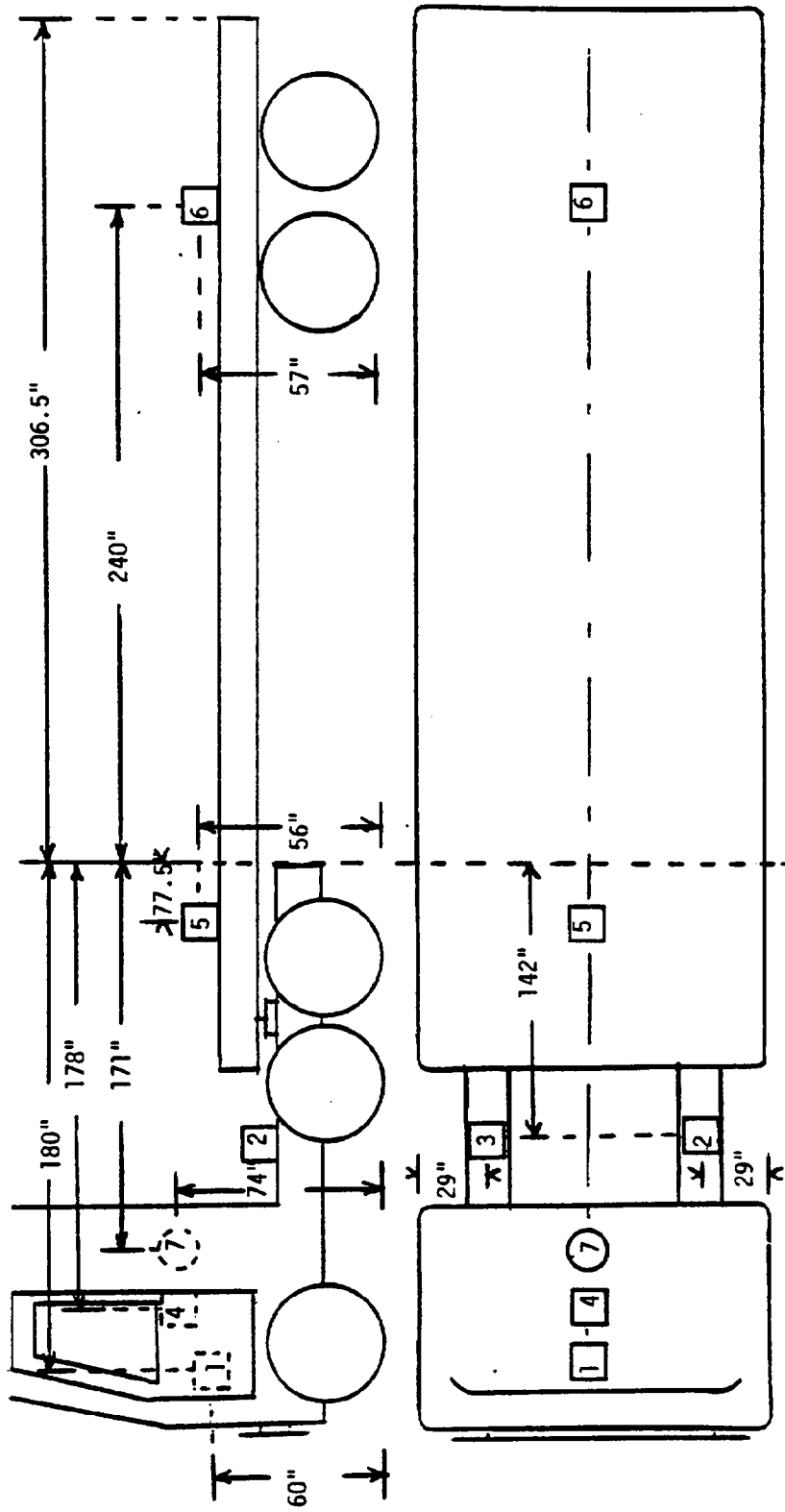
NO.		Pre-Test
X1	Total Length of Vehicle at Centerline	228.6
X2	Rear Surface of Vehicle to Front of Engine	208.2
X3	Wheelbase	140.0
X4	Rear Surface of Vehicle to Upper Leading Edge of Right Door	217.0
X5	Rear Surface of Vehicle to Upper Leading Edge of Left Door	217.1
X6	Rear Surface of Vehicle to Lower Leading Edge of Right Door	217.1
X7	Rear Surface of Vehicle to Lower Leading Edge of Left Door	217.0
X8	Rear Surface of Vehicle to Upper Trailing Edge of Right Door	182.8
X9	Rear Surface of Vehicle to Upper Trailing Edge of Left Door	182.8
X10	Rear Surface of Vehicle to Lower Trailing Edge of Right Door	182.8
X11	Rear Surface of Vehicle to Lower Trailing Edge of Left Door	183.0
X12	Rear Surface of Vehicle to Bottom of "A" Post of Right Side	212.4
X13	Rear Surface of Vehicle to Bottom of "A" Post of Left Side	212.5
X14	Rear Surface of Vehicle to Front Wall - Right Side	226.6
X15	Rear Surface of Vehicle to Front Wall - Left Side	226.5
X16	Rear Surface of Vehicle to Steering Column	209.0
X17	Center of Steering Column to "A" Post	15.2
X18	Center of Steering Column to Headliner	20.5
X19	Rear Surface of Vehicle to Right Side of Front Bumper	226.5
X20	Rear Surface of Vehicle to Left Side of Front Bumper	226.4

All Dimensions in inches

TABLE 4
ELECTRONIC INSTRUMENTATION TEST No. 2

TRANSDUCER DESCRIPTION OR ACCELEROMETER LOCATION *	DIRECTION OF PARAMETER BEING MEASURED	LOCATION ON VEHICLE	DESCRIPTION LISTED ON DATA PLOTS
<u>Vehicle Accelerometers</u> Engine Left Frame Rail Right Frame Rail Cab Center Line Trailer Front Trailer Rear Roll Rate Gyro	X, Y, Z X, Z X, Z X, Y, Z X, Y, Z X, Y, Z X	Top of Engine Left Tractor Frame Right Tractor Frame Inside Cab Compartment Front of Trailer Bed Rear of Trailer Bed Inside Cab Compartment	Engine Left Frame Rail Right Frame Rail Cab Centerline Trailer Front Trailer Rear Roll Rate
<u>Dummy</u> Driver Head Driver Chest Driver Femur Right Front Passenger Head Right Front Passenger Chest Right Front Passenger Femur	X, Y, Z X, Y, Z Left & Right Femur X, Y, Z X, Y, Z Left & Right Femur	Driver Position No. 1 Driver Position No. 1 Driver Position No. 1 RFP Position No. 2 RFP Position No. 2 RFP Position No. 2	Position No. 1 Head Position No. 1 Chest Position No. 1 Femur Position No. 2 Head Position No. 2 Chest Position No. 2 Femur

*SEE ACCELEROMETER LAYOUT DIAGRAM FIGURE 3



ACCELEROMETER NUMBER	ACCELEROMETER LOCATION	DIRECTION		
		X	Y	Z
1	Engine	x	x	x
2	Left Frame Rail	x		x
3	Right Frame Rail	x		x
4	Cab C/L	x	x	x
5	Trailer Front	x	x	x
6	Trailer Rear	x		x
7	Roll Rate Gyro	x		

FIGURE 3 VEHICLE ACCELEROMETER LOCATIONS

NOTE: Camera Information Shown on Table 5

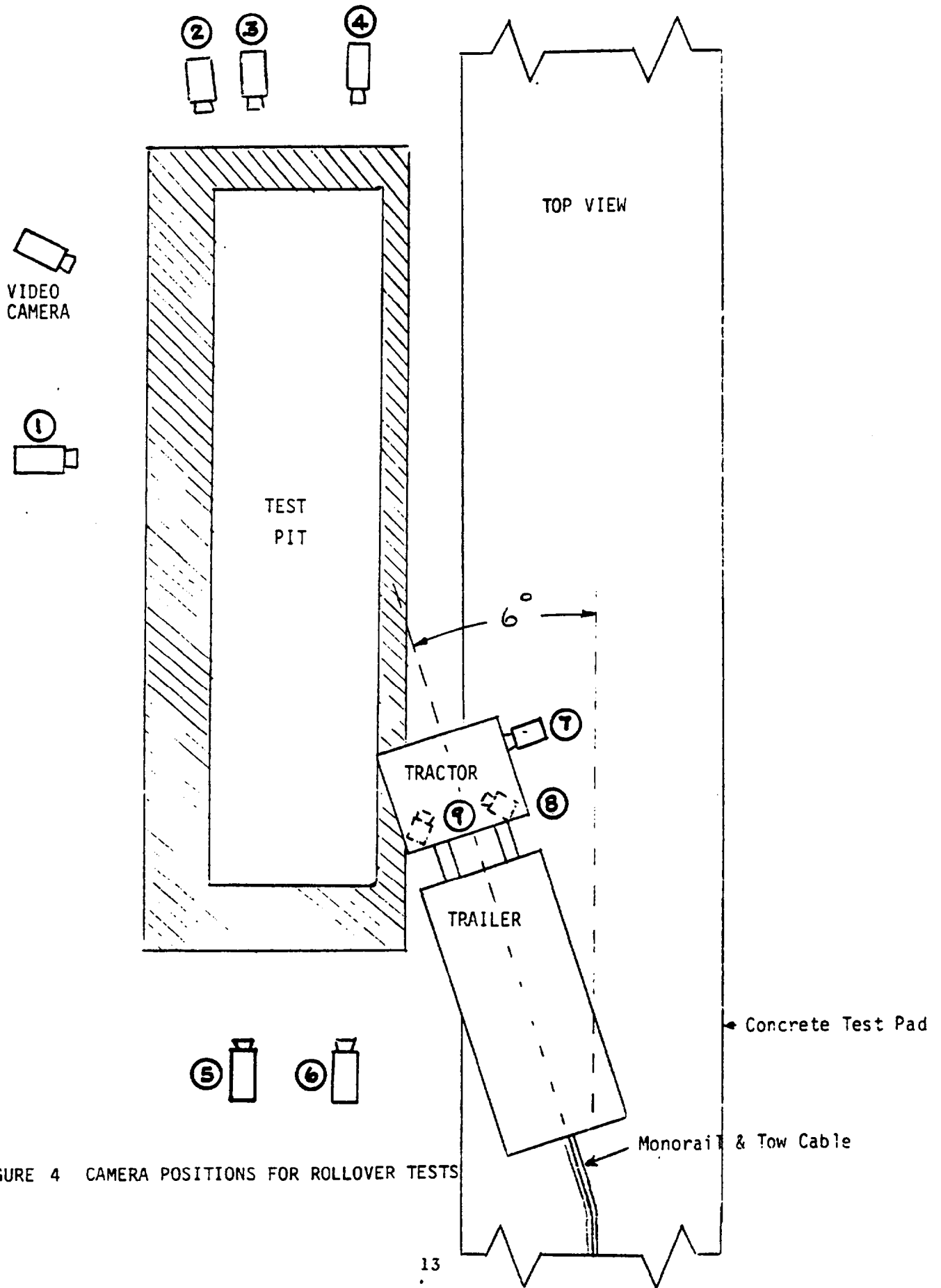


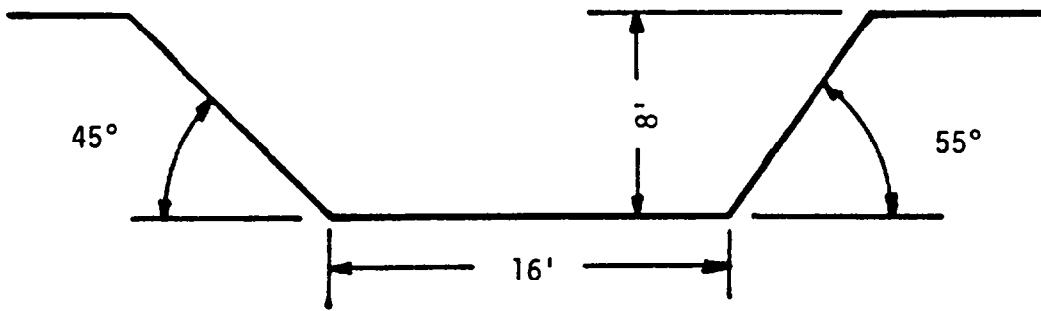
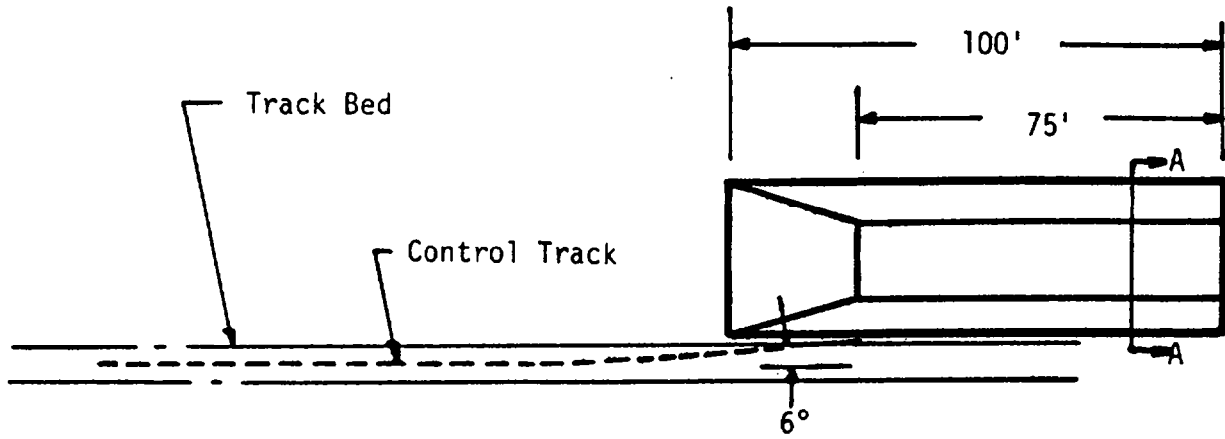
FIGURE 4 CAMERA POSITIONS FOR ROLLOVER TESTS

Table 5
CAMERA INFORMATION

CAMERA NO.	LOCATION	TYPE	LENS (mm)	SPEED (fps)
1	Tower (south side of facility)	Aeroflex	8	24
2	Ground level	Photosonic	13	900
3	(west end	Photosonic	25	900
4	of facility)	Photosonic	13	900
5	Ground level	Photosonic	13	500
6	(east end of facility)	Photosonic	25	500
7	Vehicle-Mounted	Stalex	8	1400
8	(right side,	Stalex	8	1400
9	left side)	Stalex	8	1400

NOTE: CAMERAS ARE NUMBERED ACCORDING TO SPLICING SEQUENCE OF FILM.

(24 fps) REAL TIME MOVIE FILM COVERAGE OF PRE-CRASH, POST-CRASH AND CRASH EVENT SPLICED AT START AND END OF FILM.

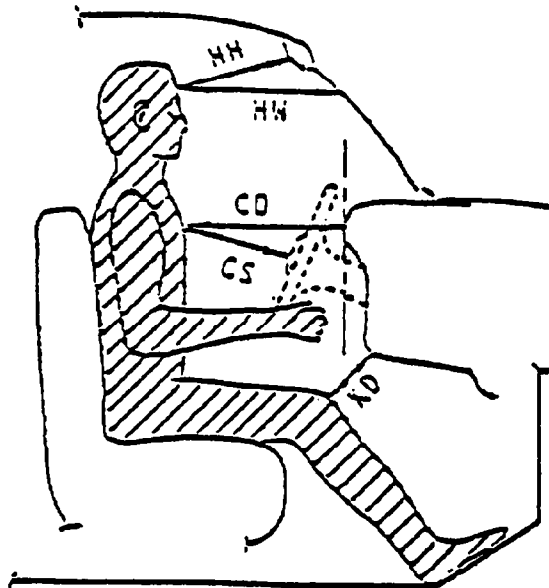


Section A-A

FIGURE 5: ROLLOVER FACILITY DIMENSIONS

	<u>DRIVER</u>	<u>PASS</u>
HH	27	25
HW	31	29.5
CD	31.5	29.5
CS	18.5	-
KDL	7.2	8.5
KDR	5.7	8.7

NOTE: KDL and KDR indicate left and right knee clearances, respectively.



HR	9.5	9.5
HS	9.5	9.5
AD	2.5	3.2
HD	3.0	3.0

NOTE: All dimensions in inches.

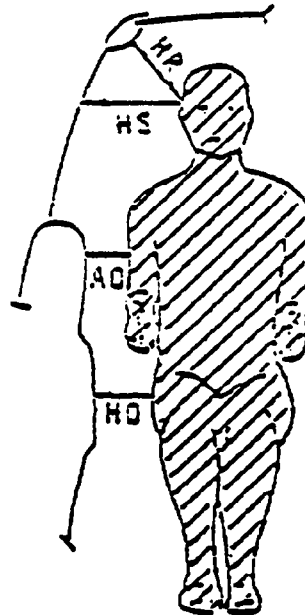


Figure 6 OCCUPANT CLEARANCE DIMENSIONS

Table 6

DUMMY INJURY CRITERIA VALUES

	MAXIMUM ACCELERATION ("G") *							
	HEAD				CHEST			
	X	Y	Z	R	X	Y	Z	R
DUMMY (1)	+77	+60	+59	+79	-18	+30	-24	+42
DUMMY (2)	-5	+9	+11	+13	-4	+15	+7	+15

	MAXIMUM FORCE-FEMUR LOAD (LBS)	
	RIGHT FEMUR	LEFT FEMUR
DUMMY (1)	500	220
DUMMY (2)	310	270

					SEVERITY
	HEAD INJURY CRITERIA**				INDEX
	HIC	t ₁ (SEC)	t ₂ (SEC)	AVE. ACC. (g) t ₁ TO t ₂	HEAD
DUMMY (1)	369	.192	.207	57.1	716
DUMMY (2)	60	.1287	.6081	6.0	91

*DEFINED AS EXCEEDING 0.003 SEC. DURATION

**AS DEFINED IN FMVSS NO. 208

Note: Values for maximum resultant accelerations (R) are determined from continuous computations of instantaneous R values throughout the event. See Figures B4, B8, B14, and B18.

IV. DISCUSSION OF RESULTS

Results of this test, as reflected in the measurements of occupant accelerations and loads (see Appendix B), imply survivability of both occupants. The cab structure maintained its integrity, with only minor external damage (See Figure A-14), and both occupants remained in the cab during the whole of the event. The lap belt restraint used with the dummy in the co-driver seat was very effective in preventing contact with internal surfaces. Although the unrestrained occupant at the driver position contacted both the windshield and left header, HIC number computations show sub-critical values (see Tables B-2 and B-3).

These results must be considered in light of the manner in which the vehicle's kinetic energy was dissipated in the event. The left side of the tractor front axle absorbed much of this energy when it struck the bottom of the pit and, as a consequence, was sheared from the frame. (This condition is shown in Figures A-7 and A-8.) The significant cab structure (i.e., the front left pillar) was therefore exposed to only the energy of the rollover in contacting the ground. This caused the cab damage which is evident in Figure A-14.

The major shocks experienced by the driver position dummy occur in the neighborhood of 0.2 seconds after the point at which data reduction is initiated (i.e., the $t = 0$ point on the data traces of Appendix B; see Figure B-4, for example). That time corresponds to a point approximately 1.4 seconds into the total event (which is referenced to the start of vehicle rollover. See Figure B-38) and is consistent with the time of high cab accelerations although integration of the rate gyro indicates that the vehicle has not yet reached ninety degrees of roll. Examination of the pertinent vehicle motion data traces in Appendix B shows that these secondary impacts follow closely in time after the major decelerations measured by the engine and cab centerline sensors. Thus, the occupant contacts can be associated with the point at which the tractor left front wheel reached the base of the slope.

The results further suggest that new test protocols are needed for

full-scale rollover testing. Because of the rotation of the vehicle and the large motions of unbelted occupants, integrations of the acceleration data do not provide meaningful velocity and position (displacement) information. The test of standard reference dimensions (Table 3), which has been successfully employed in horizontal crash testing, needs to be reviewed so that it is more useful for assessing crash damage. Methods for preventing unwanted articulation and heading angle changes that can be ambiguously specified must be devised in order to achieve high probabilities of test reproducibility.

Although the vehicle's rollover response followed predictions reasonably well in this test, the general use of a fixed-geometry facility of this type for a range of heavy vehicle physical characteristics would not be recommended. Each vehicle configuration, particularly those involving a trailer, would have to be investigated in order to develop high confidence in the definitions of approach angle, departure point, and speed needed for specifying test operations. The configurational factors of most importance include vehicle wheelbase, load distribution, and effective center-of-gravity location. A given individual test would require careful and extensive preparation, which, coupled with the expense of the test units, indicates high cost. The principal use of such tests would therefore appear to be as validation for other kinds of crashworthiness evaluation approaches: pendulum tests, static structural loading, and mathematical modelling. These approaches do not directly treat the question of occupant protection, except as implied by demonstration of cab integrity, and the potential of sled-testing for this purpose should be considered. NHTSA, under separate contract (DTNH22-80-C-07547), is sponsoring investigations of these approaches. A portion of this follow-on study is devoted to in-depth analyses of accident data. Results from that investigation are expected to provide a better understanding of real-life rollovers - structural damage, occupant injury patterns, critical elements. From such results, the usefulness of rollover crash testing can be better evaluated.

V.

REFERENCES

1. Rice, R. S. and Shoemaker, N. E., Heavy Truck Pilot Crash Test - Frontal Impact. Calspan Report No. 6748-V-2. June 1981. (Under Contract No. DTNH22-80-C-07537.)
2. Rice, R. S., Test Plan for Heavy Truck Pilot Crash Test. Calspan Report No. 6748-V-1. (Under Contract No. DTNH22-80-C-07537.)

APPENDIX A

PHOTOGRAPHS

This appendix contains still photographs of various facets of the test. Both pre-test and post-test photographs are included. Attention is called to the following -

- Figure A-1, showing the trailer side curtain and structure used to simulate the side of a van trailer and thus to limit roll angle to one-quarter turn.
- Figure A-3, illustrating the clamping device used to prevent front wheel rotation during the test event.
- Figure A-6, views of the rollover test facility.
- Figures A-9 and A-10, indicating the post-test rest positions of the occupants.

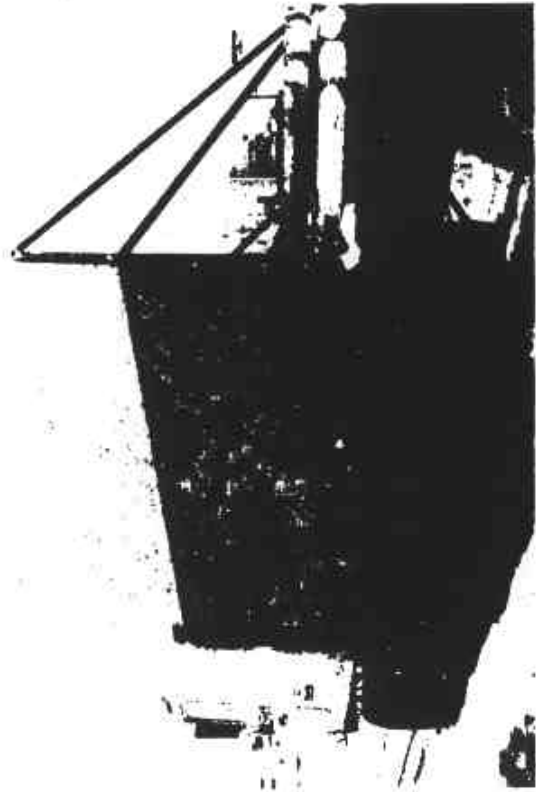
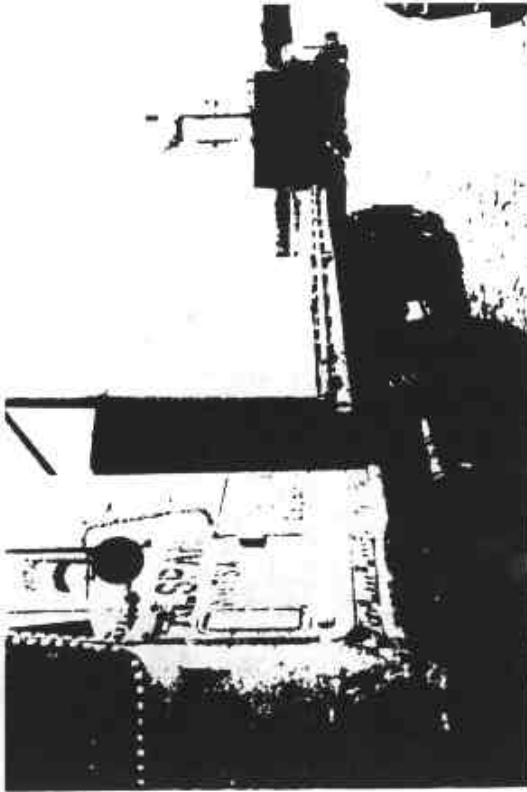
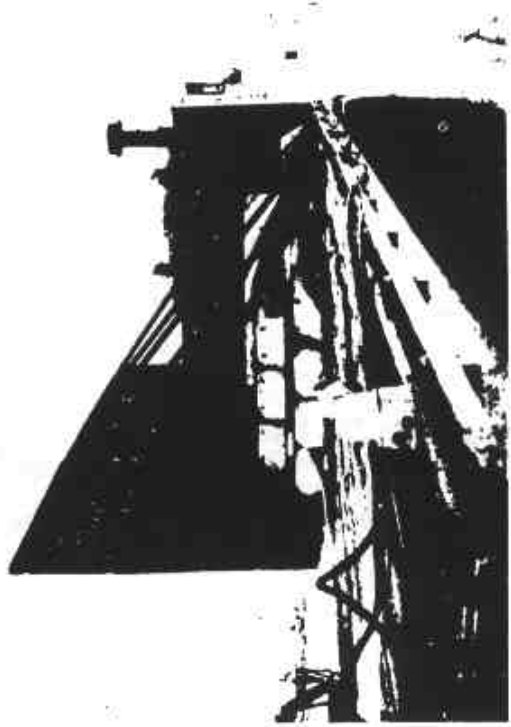


FIGURE A-1 PRE-TEST VIEWS OF VEHICLE

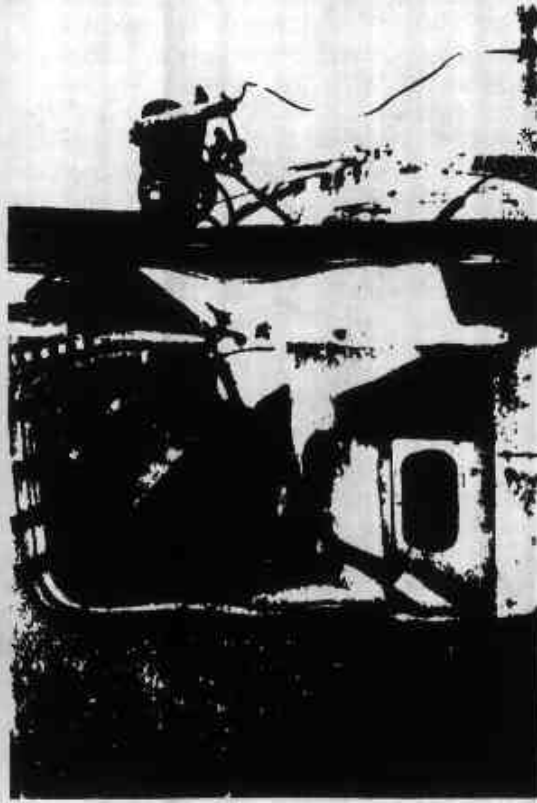
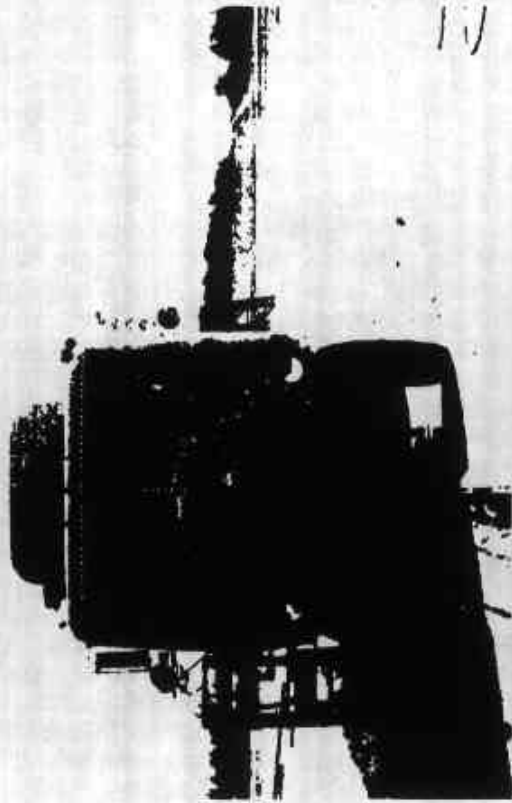
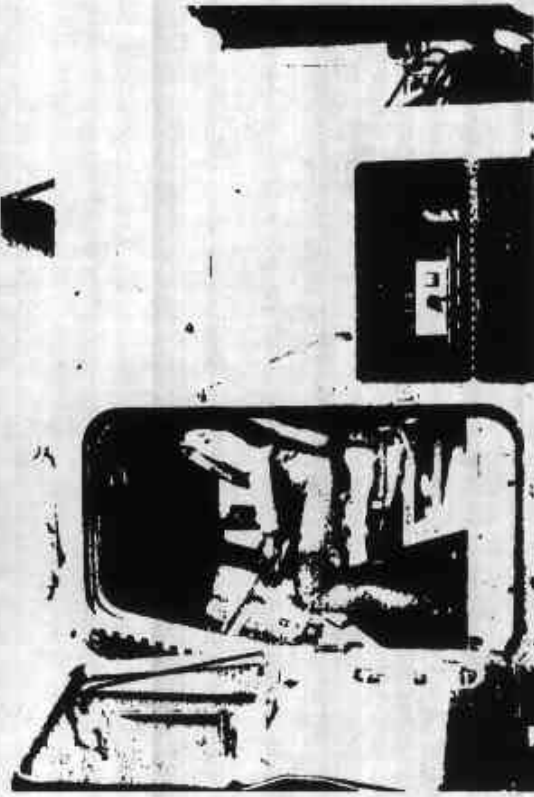
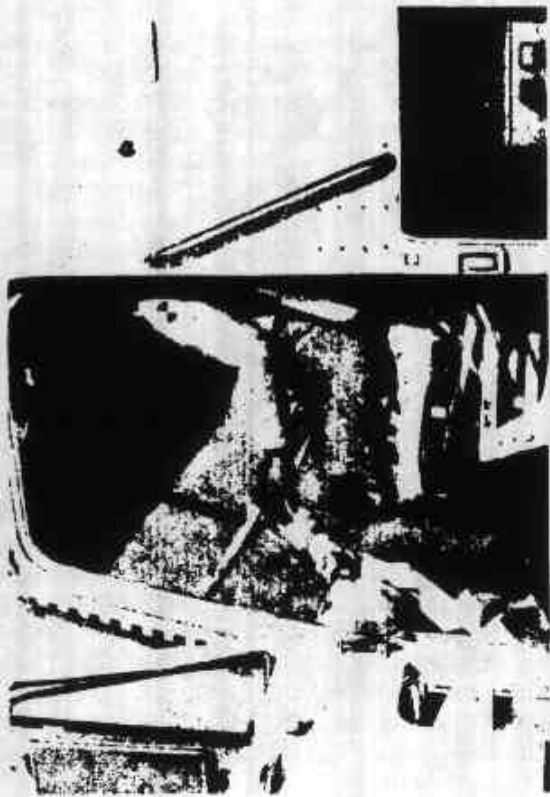


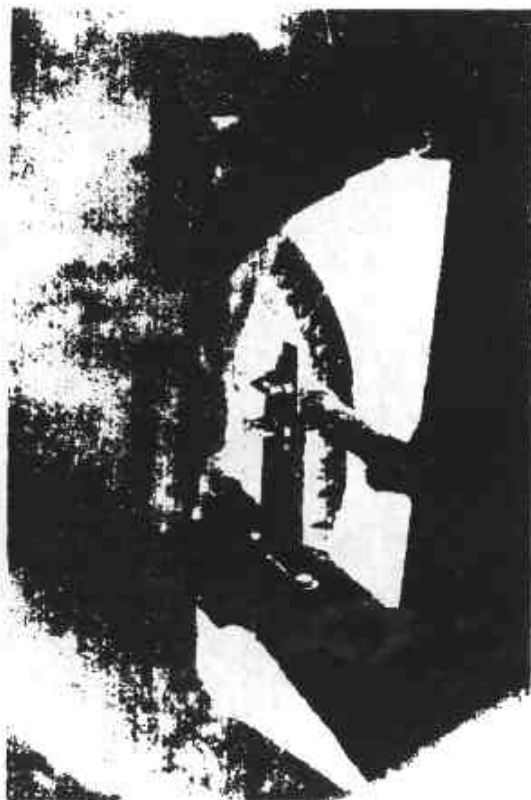
FIGURE A-2 PRE-TEST VIEWS OF OCCUPANTS



FIGURE A-3 WHEEL-LOCKING DEVICE



FIGURE A-4 ANTI-ARTICULATION CABLING



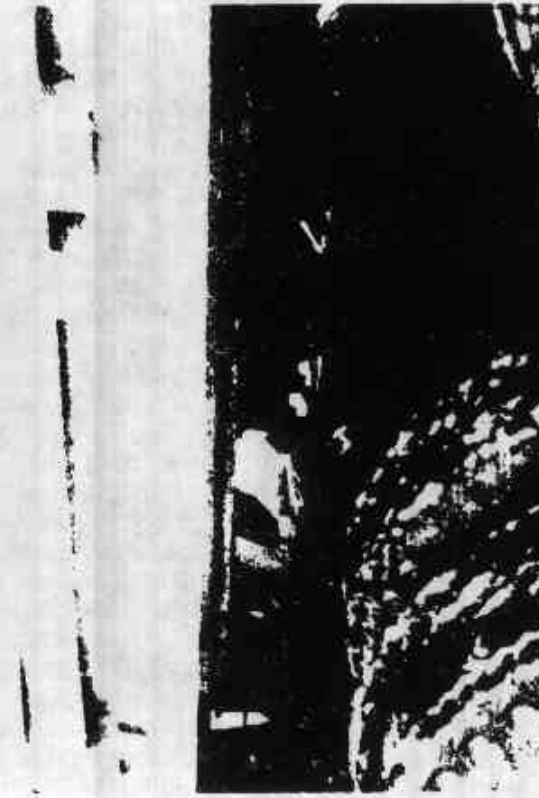
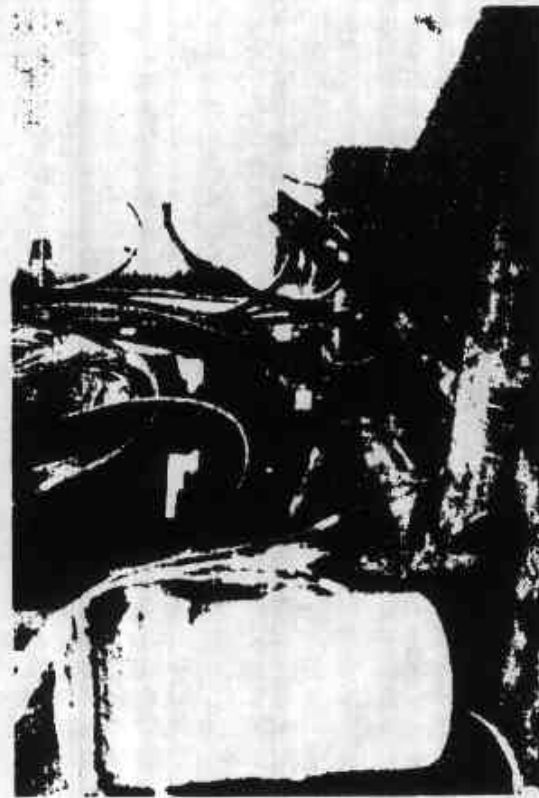


FIGURE A-5 DETAILS OF TEST EQUIPMENT

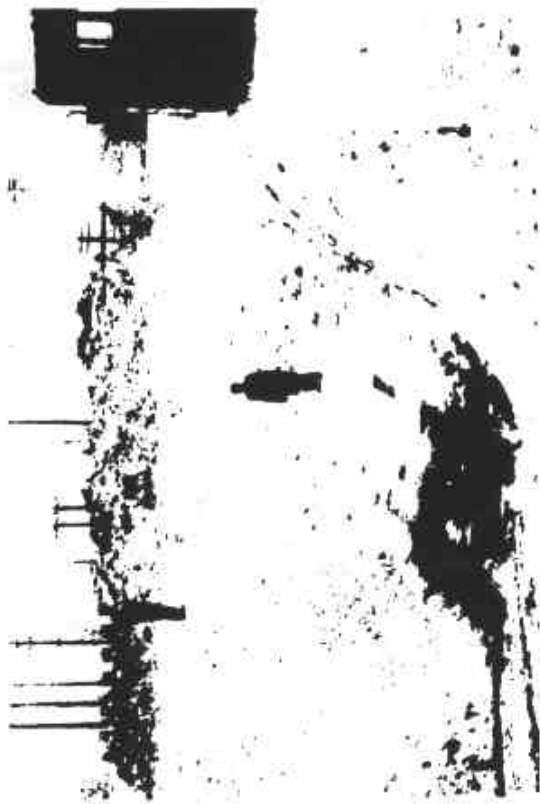


FIGURE A-6 PRE-TEST AND POST-TEST VIEW OF FACILITY

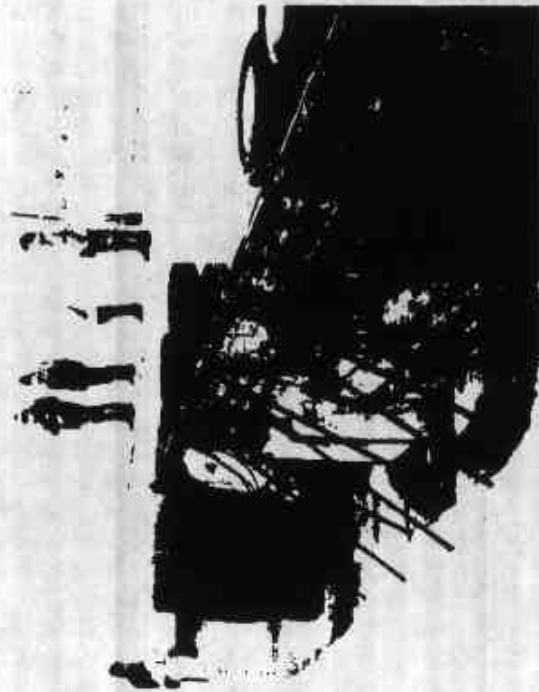


FIGURE A-7 OVERALL POST-TEST VIEW OF VEHICLE

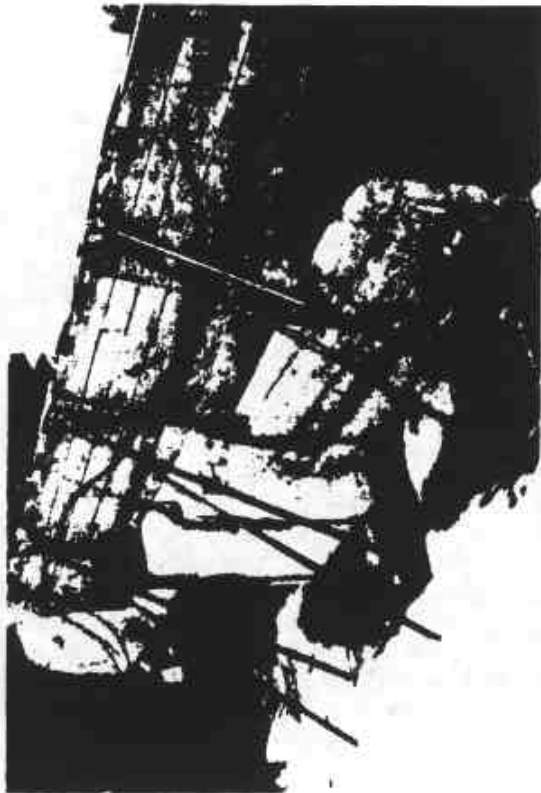


FIGURE A-8 CLOSE POST-TEST VIEWS OF VEHICLE



FIGURE A-9 POST-TEST VIEWS OF DRIVER OCCUPANT

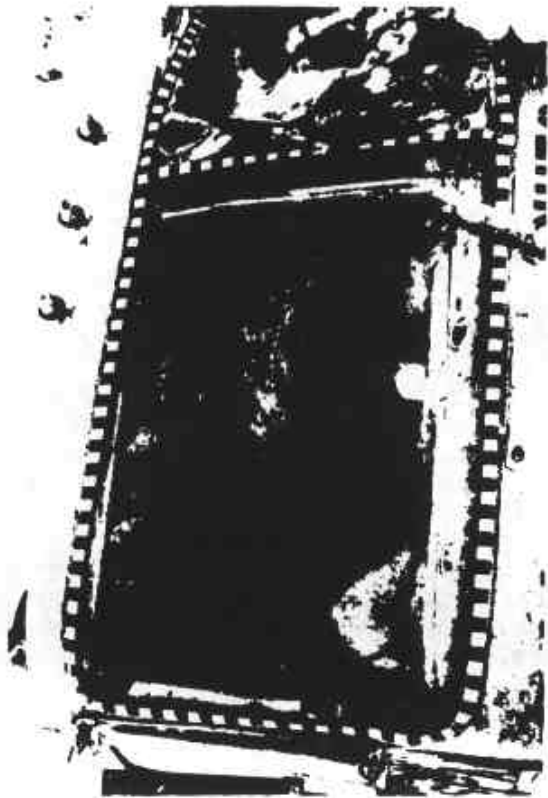


FIGURE A-10 POST-TEST VIEWS OF CO-DRIVER OCCUPANT

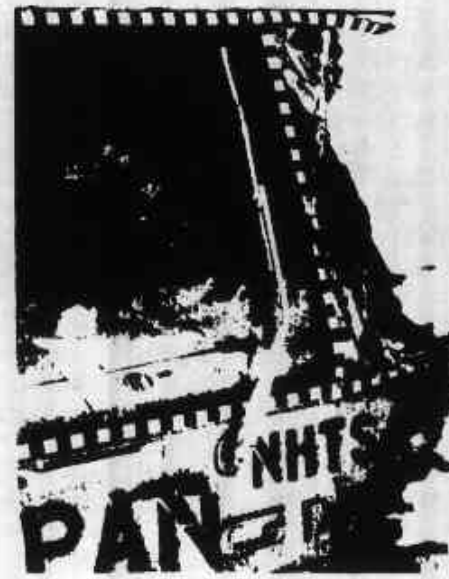


FIGURE A-11 POST-TEST VIEWS OF CAB DAMAGE



FIGURE A-12 POST-TEST VIEW OF SUSPENSION DAMAGE



FIGURE A-13 POST-TEST VIEWS OF TIRE DAMAGE

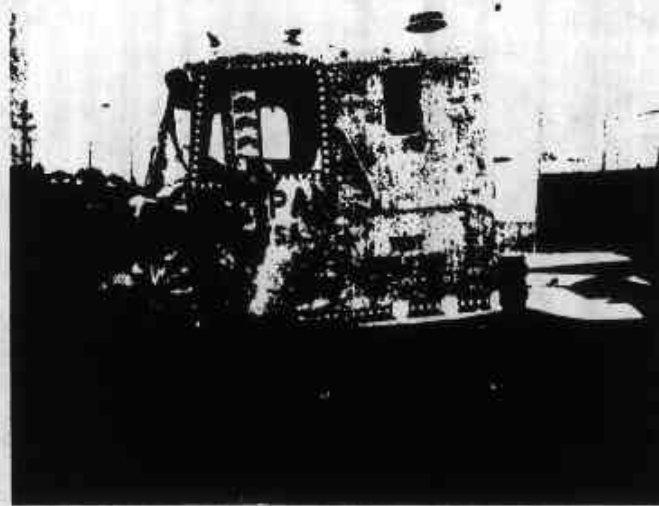
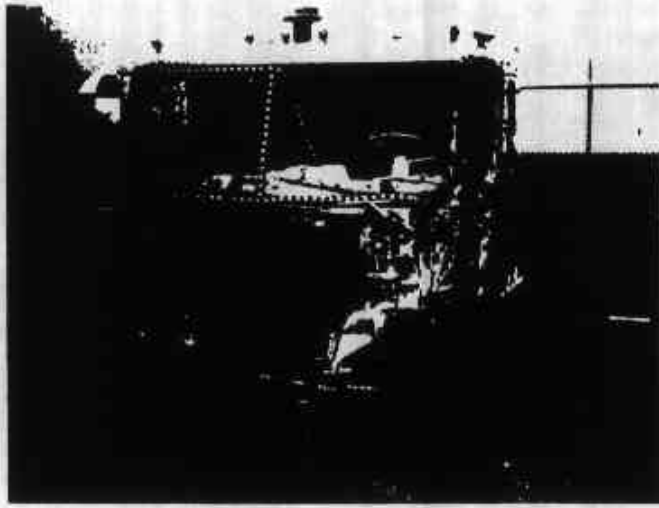


Figure A-14: POST-TEST VIEWS OF TRACTOR
(AFTER REMOVAL FROM PIT)

APPENDIX B

VEHICLE AND DUMMY RESPONSE DATA

This appendix contains processed time histories for each of the data channels that were utilized in the test. All data have been filtered through specified filters defined in the following list -

Occupant head accelerometer data:	1000 Hz
Occupant chest accelerometer data:	180 Hz
Occupant femur load data:	600 Hz
Vehicle acceleration data:	60 Hz

Each of the thirty-three data measurement channels used in the test is identified in Table B-1. Tables B-2 and B-3 contain computed injury index values for the driver seat occupant (Position 1) and the co-driver seat dummy (Position 2), respectively. In addition to the individual sensor output time histories, computed resultant accelerations at the heads and chests of the two occupants are given in Figures B-4, B-8, B-14, and B-18. Figures B-37 and B-38 show the output of the roll rate gyro that was mounted in the tractor cab. In the first of these, the time frame is consistent with that for all previous figures of this section. This figure is actually a section of Figure B-39, representing the 800 millisecond span from approximately 1.22 seconds to about 2.02 seconds in Figure B-39. Since the data processing equipment limited the sampling time to this 800 millisecond value, the segment was selected to cover the period of the significant vehicle and dummy responses; the longer period of time during which the vehicle rotated in roll from the horizontal to the final angle of ninety degrees required separate processing. Figure B-39 shows this complete time history. An approximate integration of this trace indicates roll angles of about 50 degrees after 1.2 seconds (when the tractor is fully on the slope) and about 55 degrees at 1.5 seconds (when the complete unit is on the slope), after which the vehicle rolls to touchdown.

TABLE B-1
ACTIVE CHANNELS

<u>Channel</u>	<u>Description</u>
1	Position No. 1, Head X
2	Position No. 1, Head Y
3	Position No. 1, Head Z
4	Position No. 1, Chest X
5	Position No. 1, Chest Y
6	Position No. 1, Chest Z
7	Position No. 2, Head X
8	Position No. 2, Head Y
9	Position No. 2, Head Z
10	Position No. 2, Chest X
11	Position No. 2, Chest Y
12	Position No. 2, Chest Z
13	Position No. 1, Right Femur 38
14	Position No. 1, Left Femur 19
15	Position No. 2, Right Femur 50
16	Position No. 2, Left Femur 3
17	(Not Used)
18	Roll Rate Gyro

TABLE B-1 (Cont'd)
ACTIVE CHANNELS

<u>Channel</u>	<u>Description</u>
19	Engine X
20	Engine Y
21	Engine Z
22	Left Frame Rail X
23	Left Frame Rail Z
24	Right Frame Rail X
25	Right Frame Z
26	Cab C X
27	Cab C Y
28	Cab C Z
29	Trailer Front X
30	Trailer Front Y
31	Trailer Front Z
32	Trailer Rear X
33	Trailer Rear Y
34	Trailer Rear Z

TABLE B-2

**HEAD INJURY CRITERION
HEAD SEVERITY INDEX**

GMC HEAVY TRUCK ROLLOVER TEST

RUN= 509

POS#1 HEAD RESULTANT

**HIC= 368.8 FROM T1= .19200 TO T2= .20700
AVERAGE ACCELERATION BETWEEN T1 AND T2= 57.1G'S
EVENT TIME= 800.0 MSEC
SEVERITY INDEX= 715.9**

FIGURE B-1

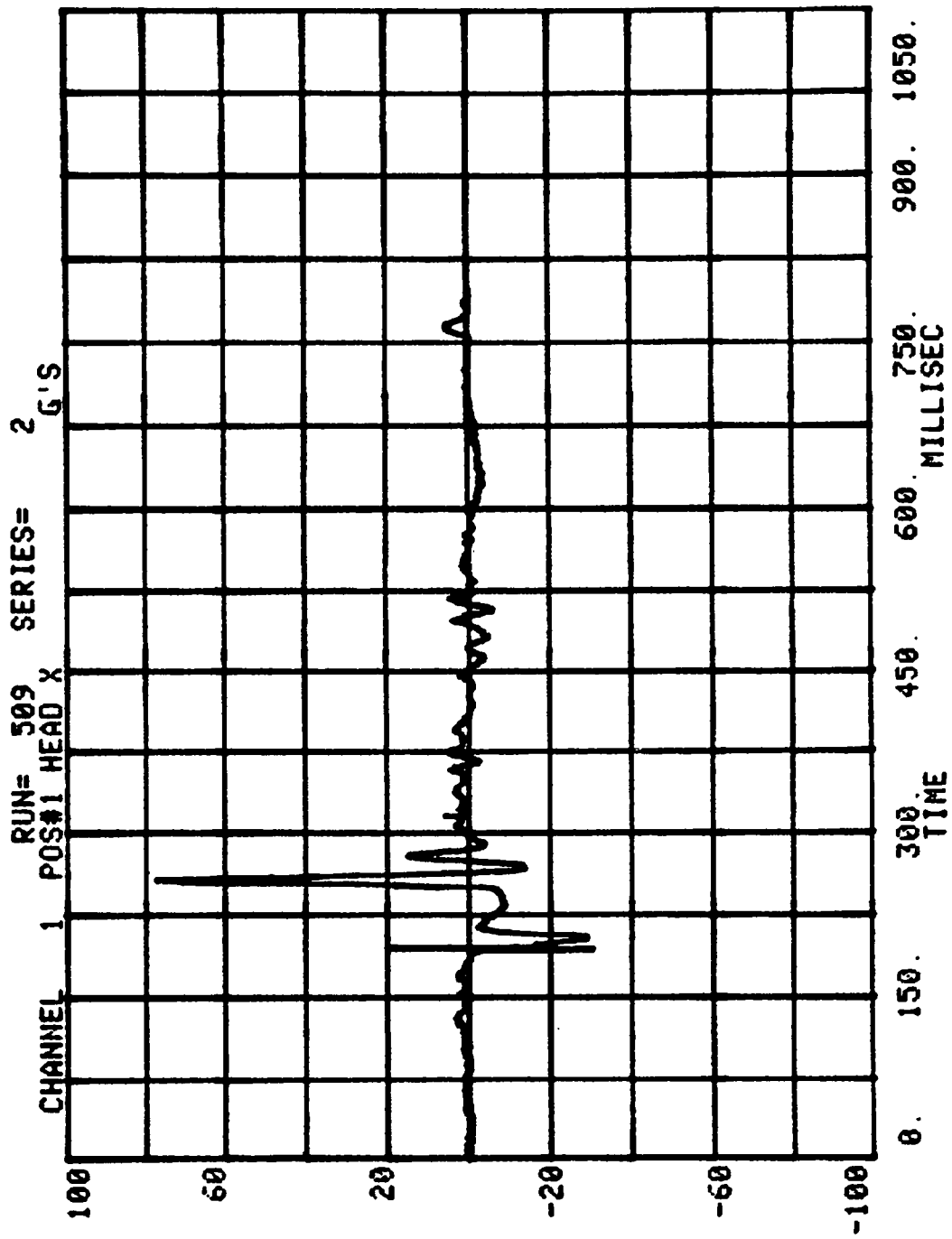


FIGURE B-2

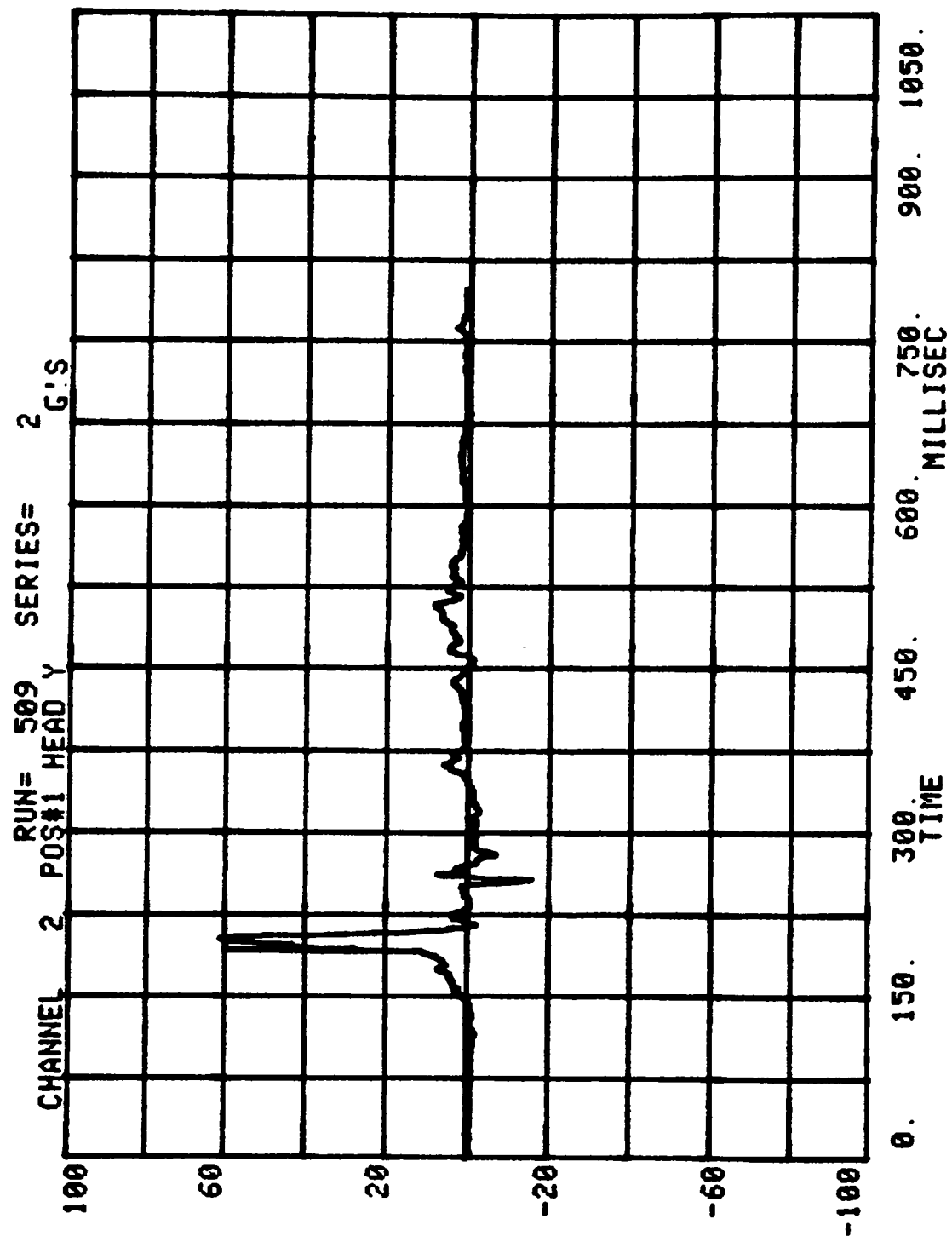


FIGURE B-3

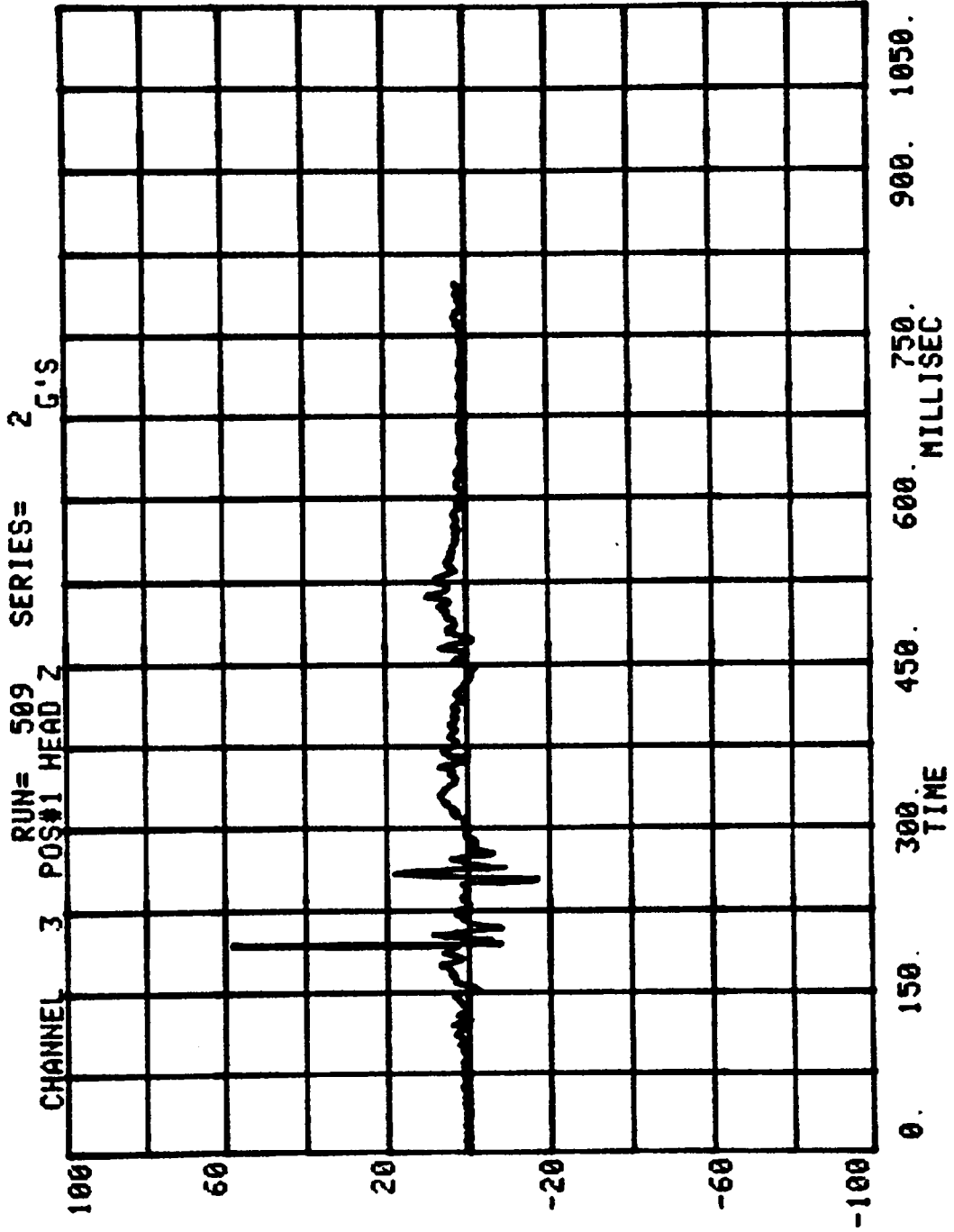


FIGURE B-4

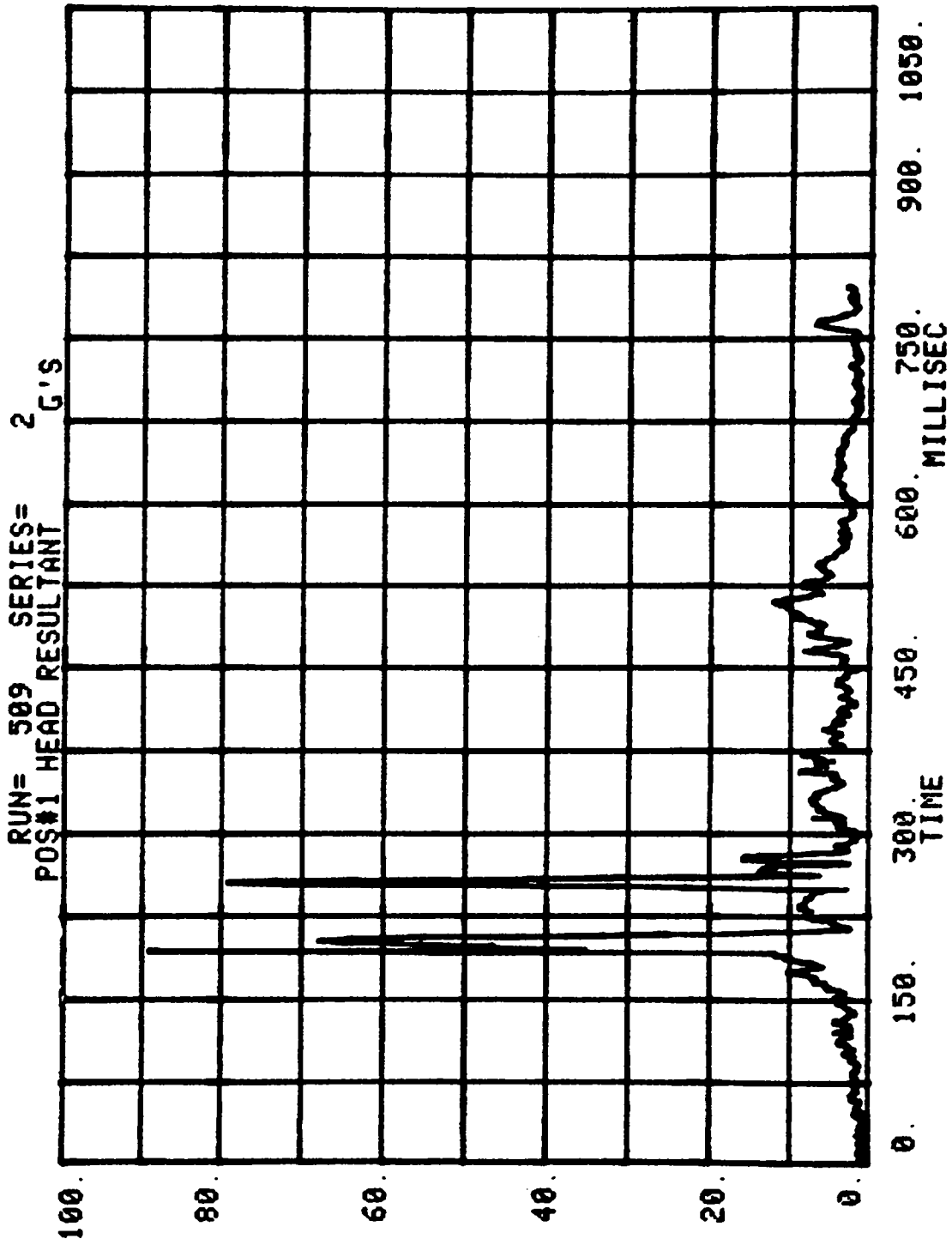


FIGURE B-5

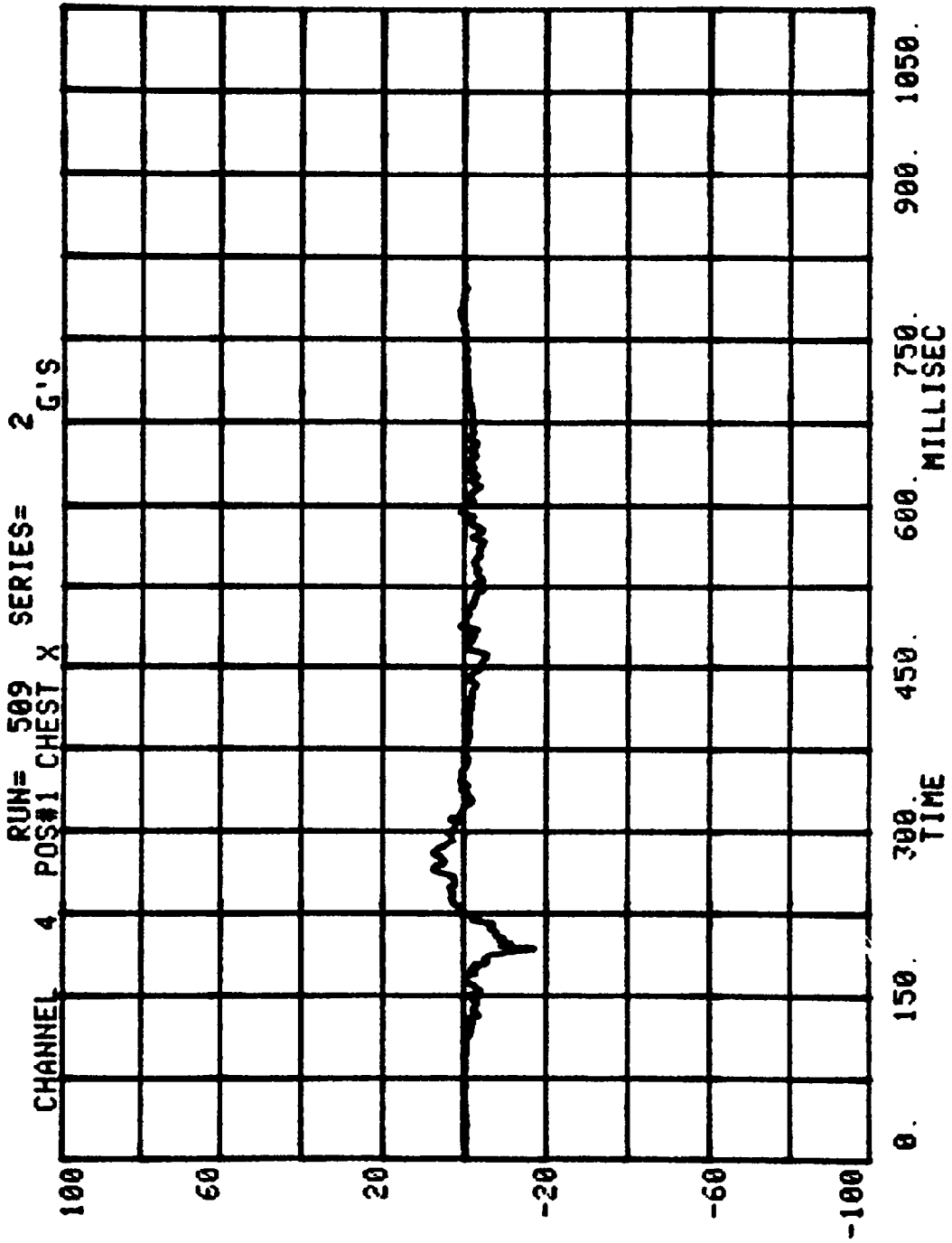


FIGURE B-6

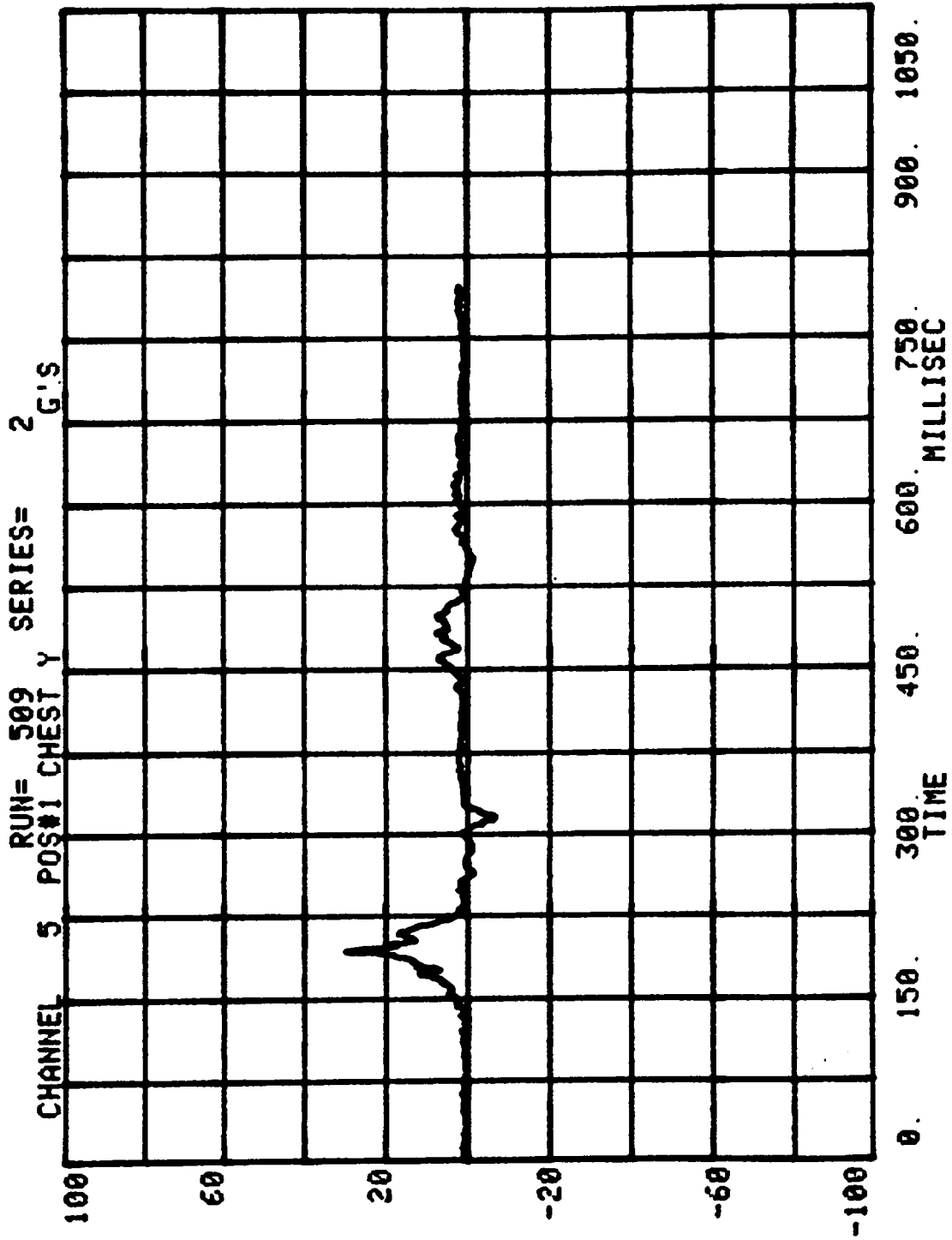


FIGURE B-7

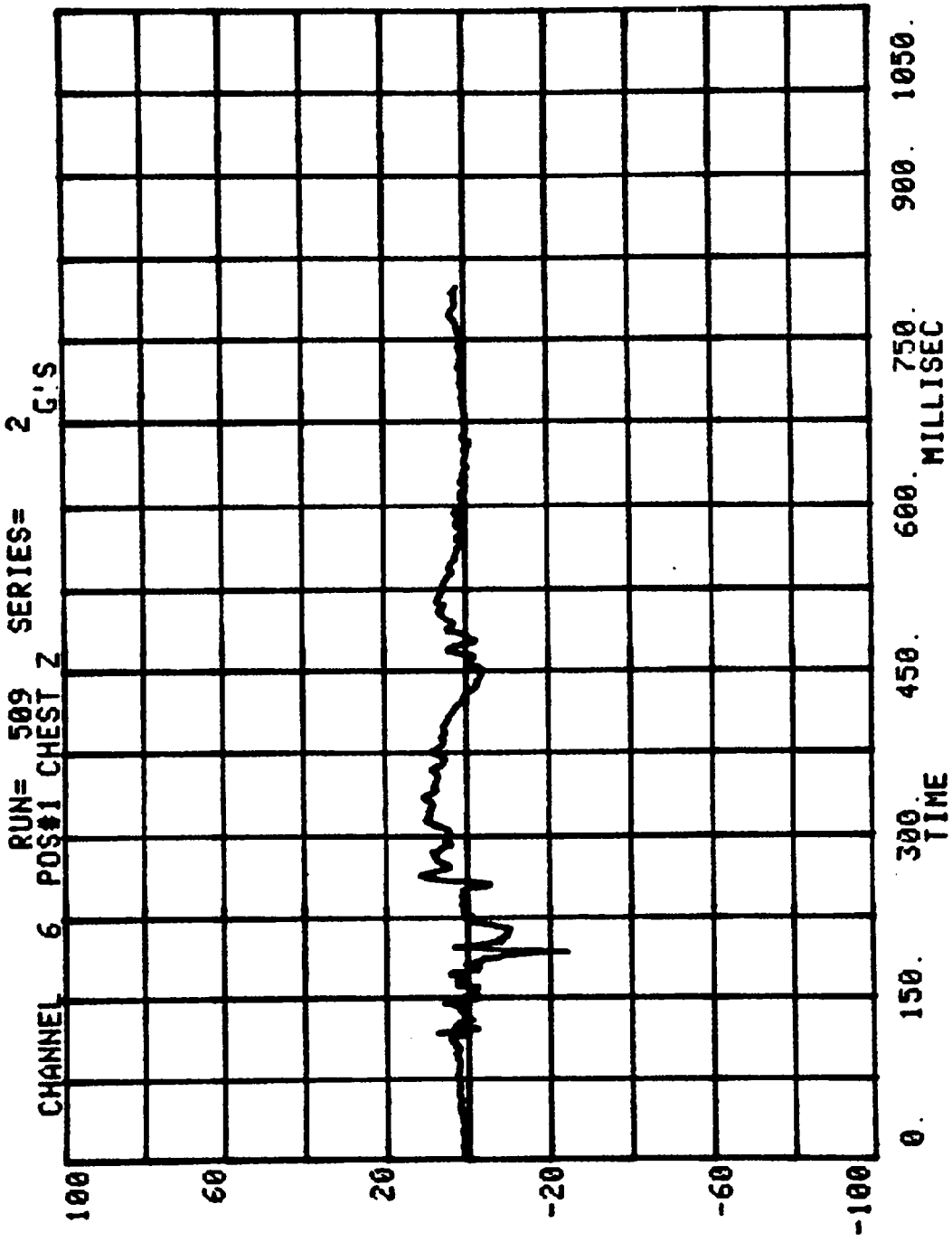


FIGURE B-8

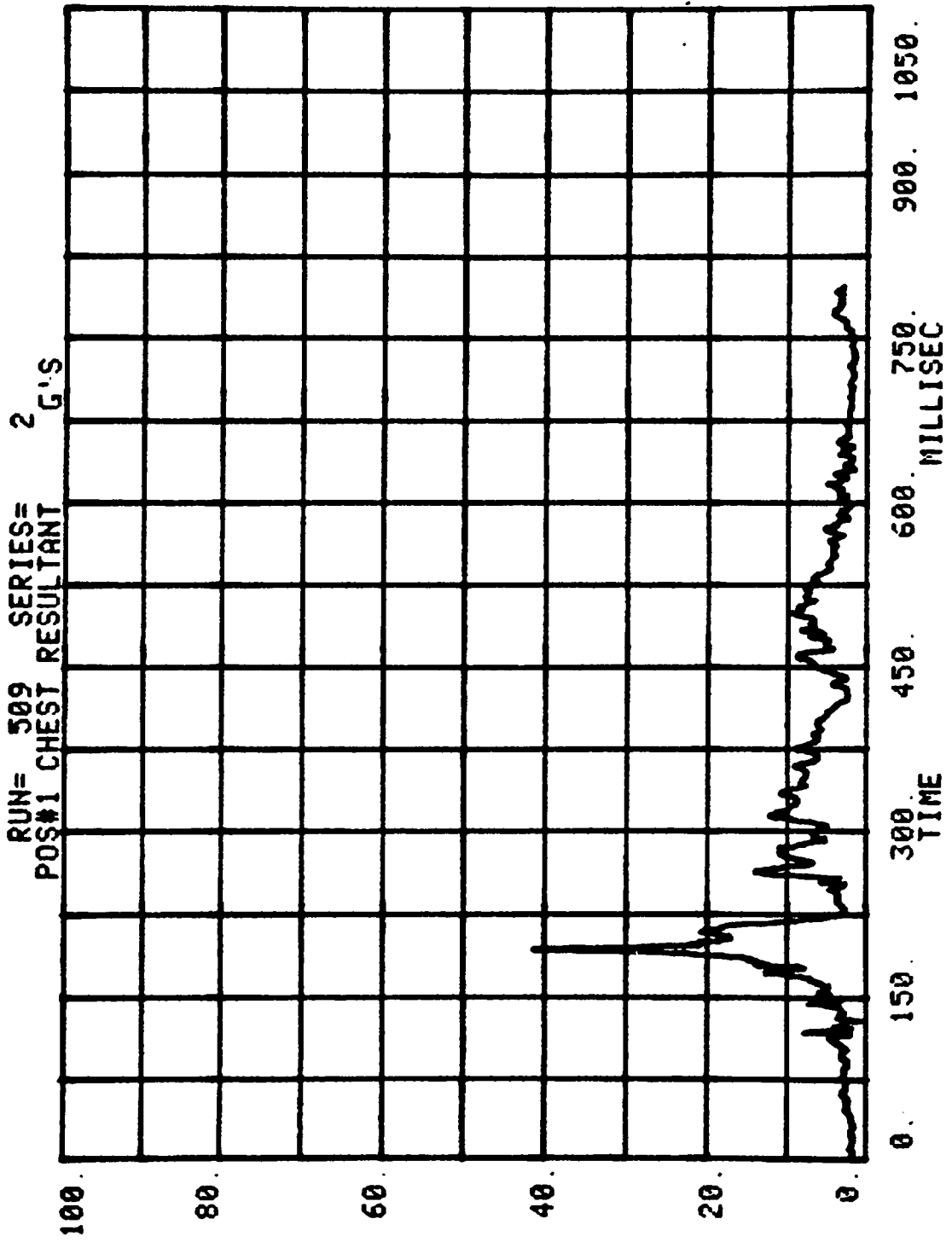


FIGURE B-9

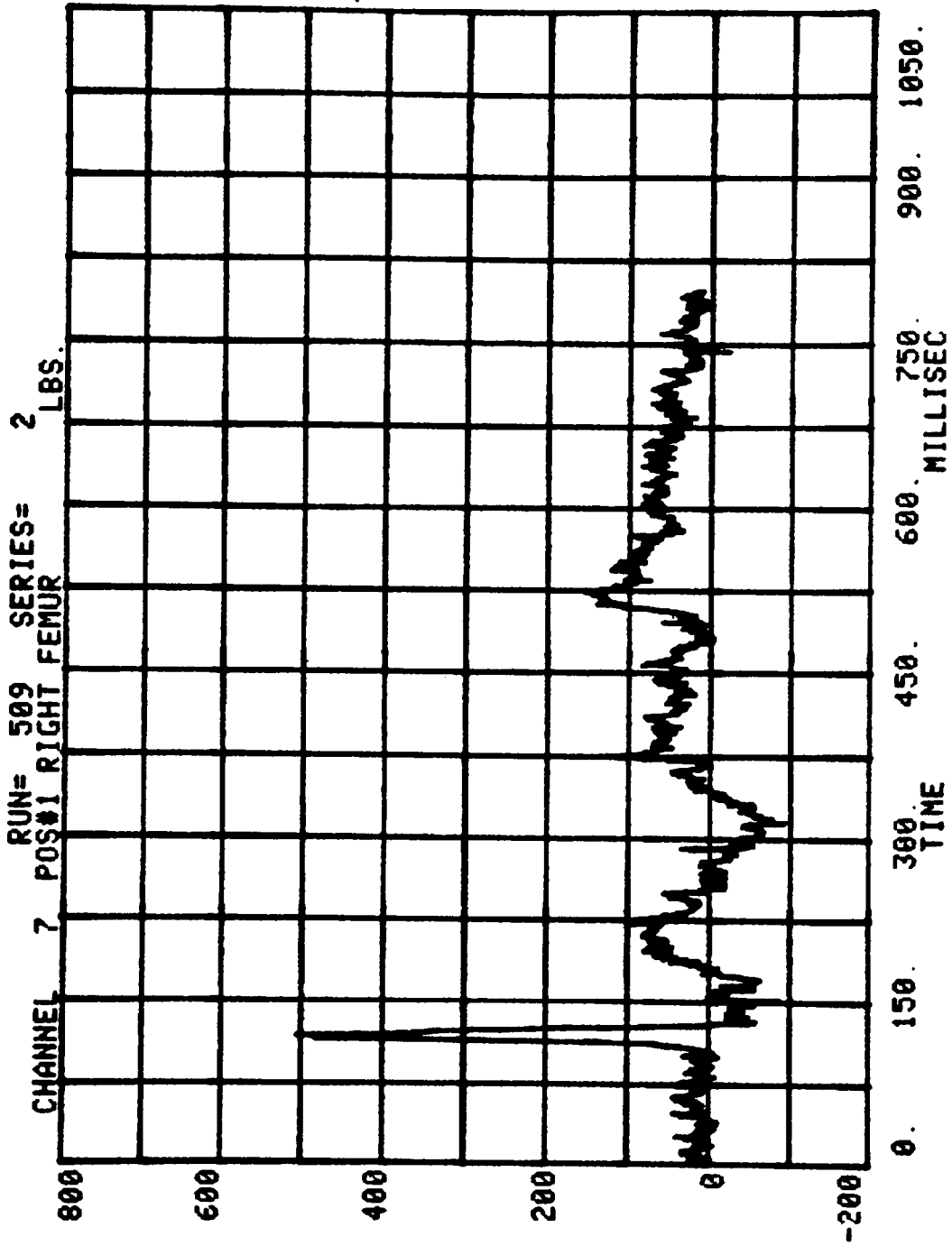


FIGURE B-10

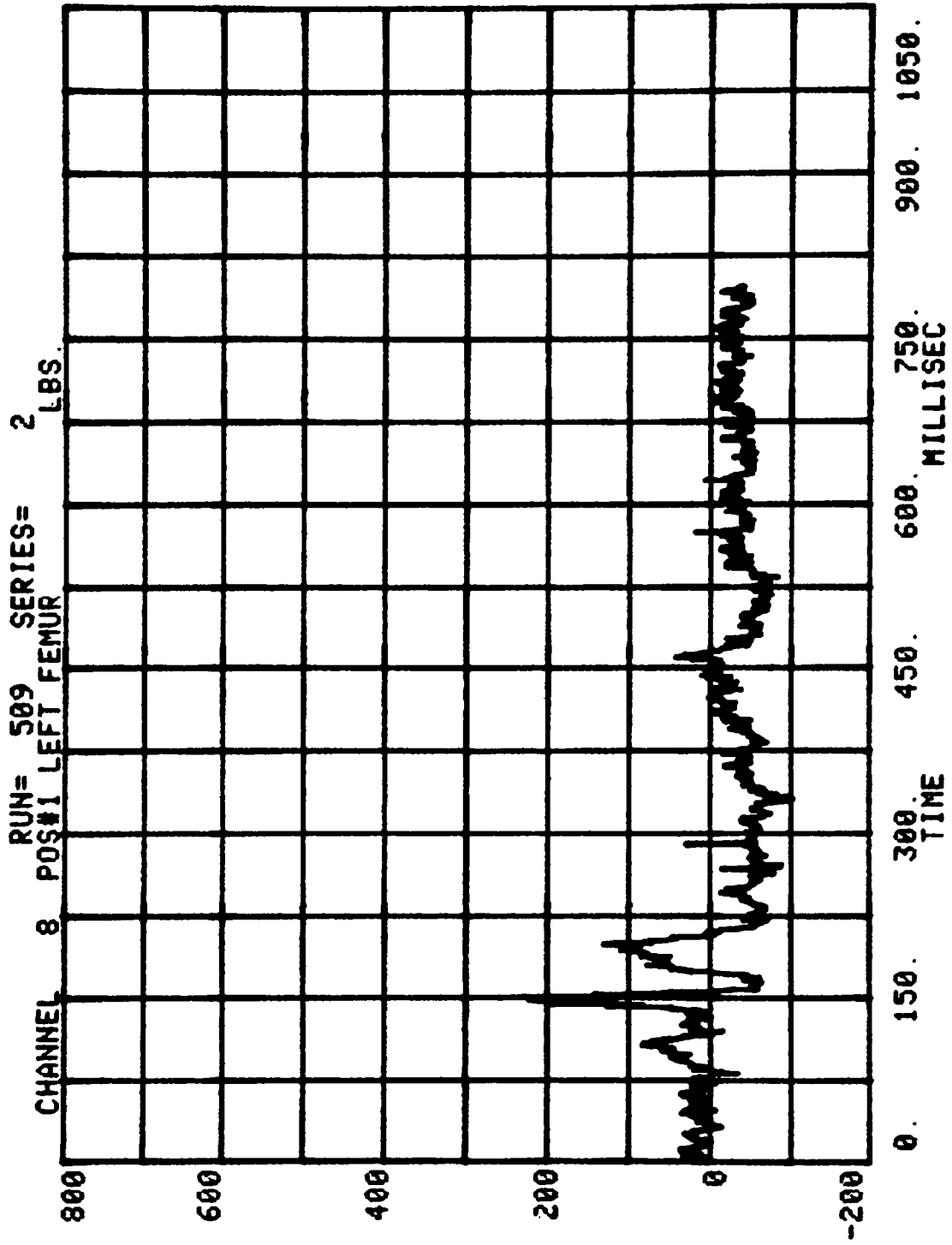


TABLE B-3

**HEAD INJURY CRITERION
HEAD SEVERITY INDEX**

GMC HEAVY TRUCK ROLLOVER TEST

RUN= 509

POS#2 HEAD RESULTANT

HIC= 59.6 FROM T1= .12870 TO T2= .60810

AVERAGE ACCELERATION BETWEEN T1 AND T2= 6.9G'S

EVENT TIME= 800.0 MSEC

SEVERITY INDEX= 90.8

FIGURE B-11

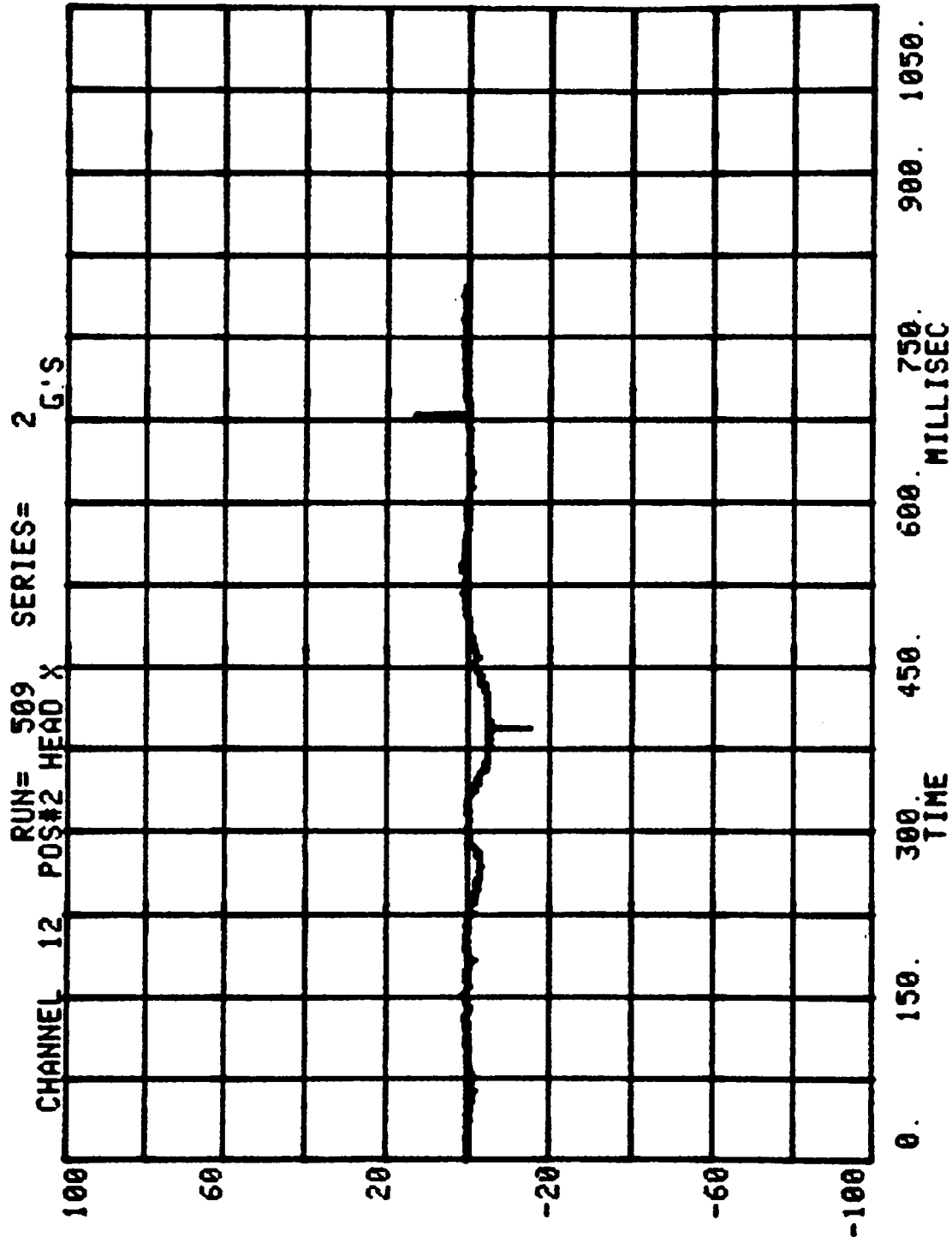


FIGURE B-12

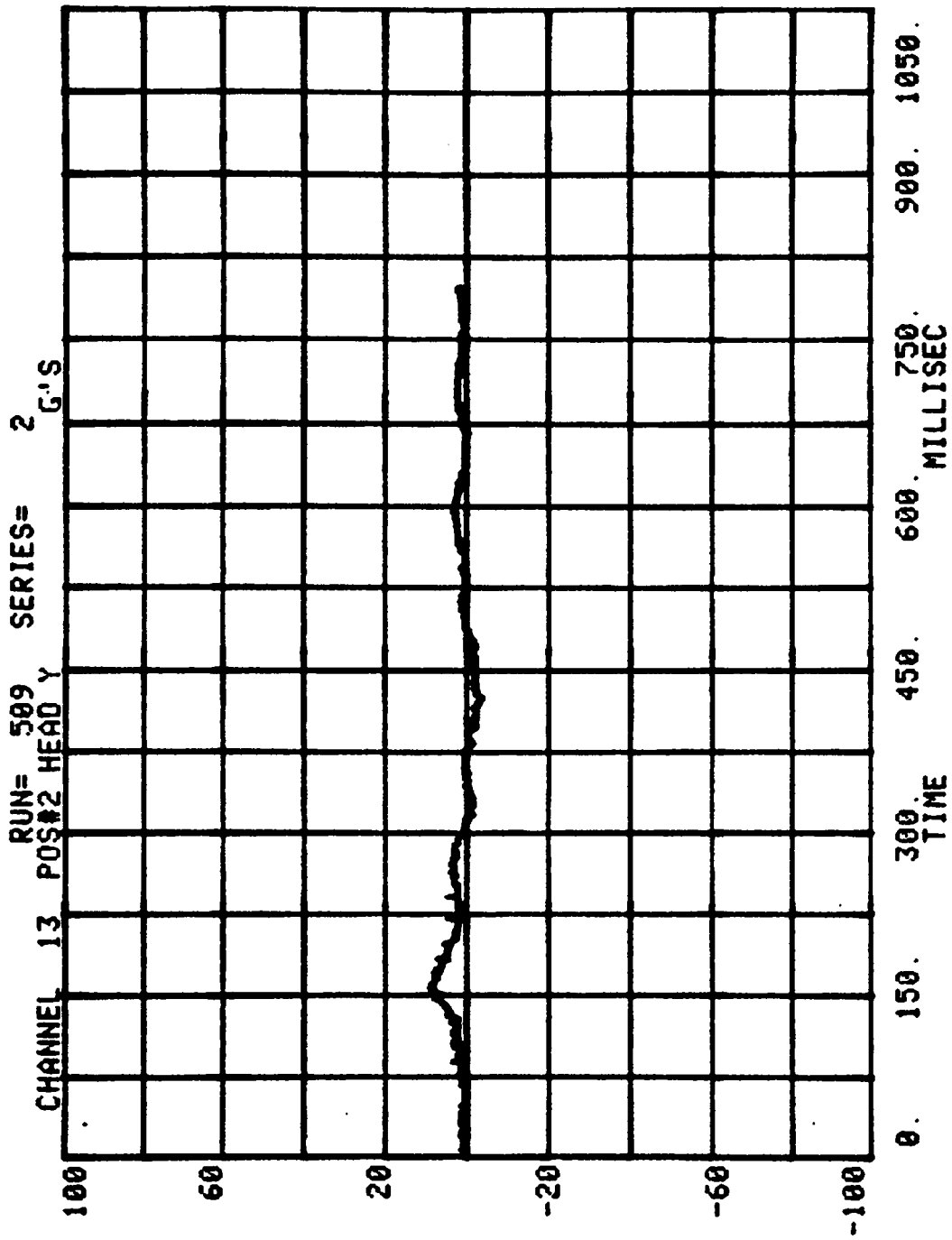


FIGURE B-13

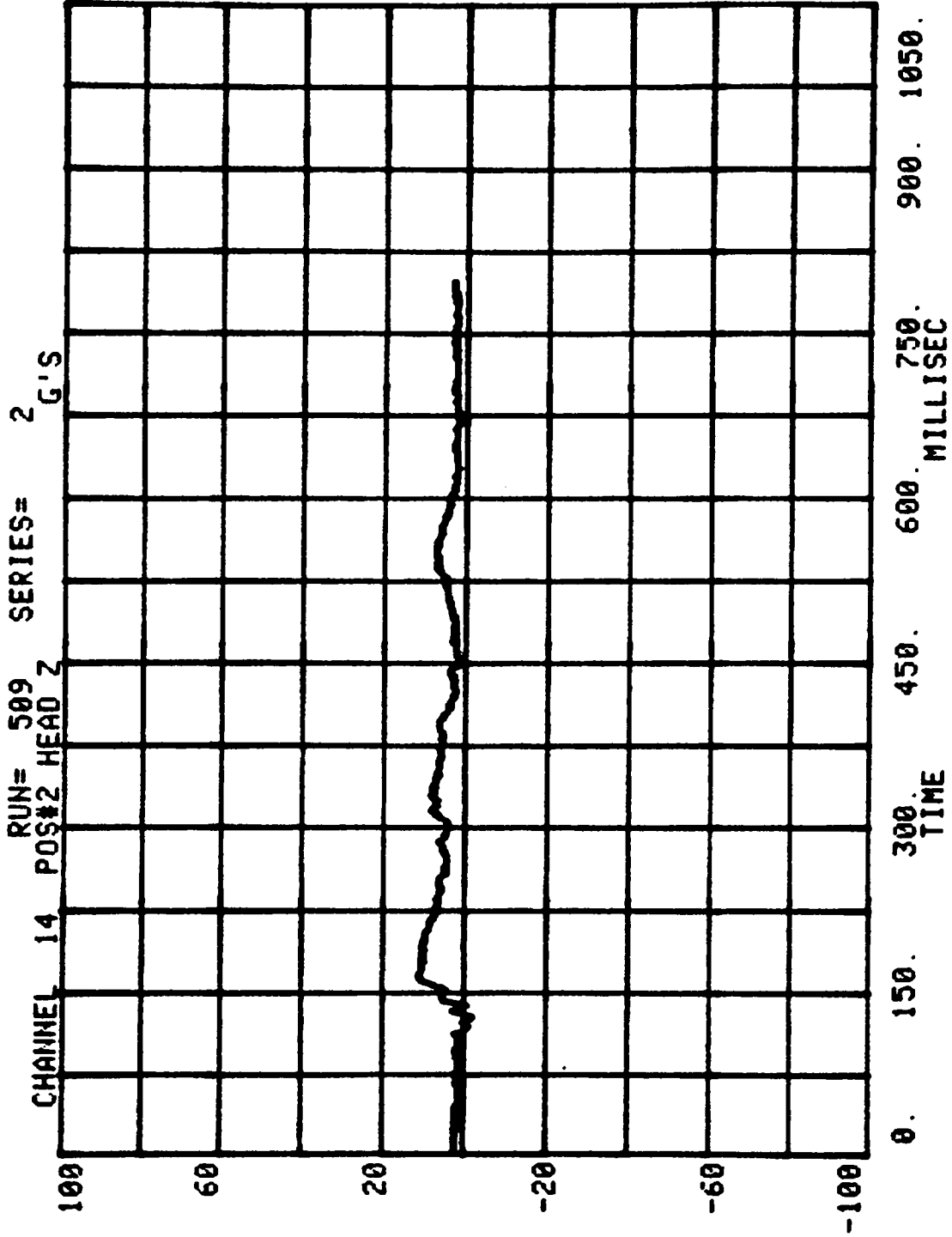


FIGURE B-14

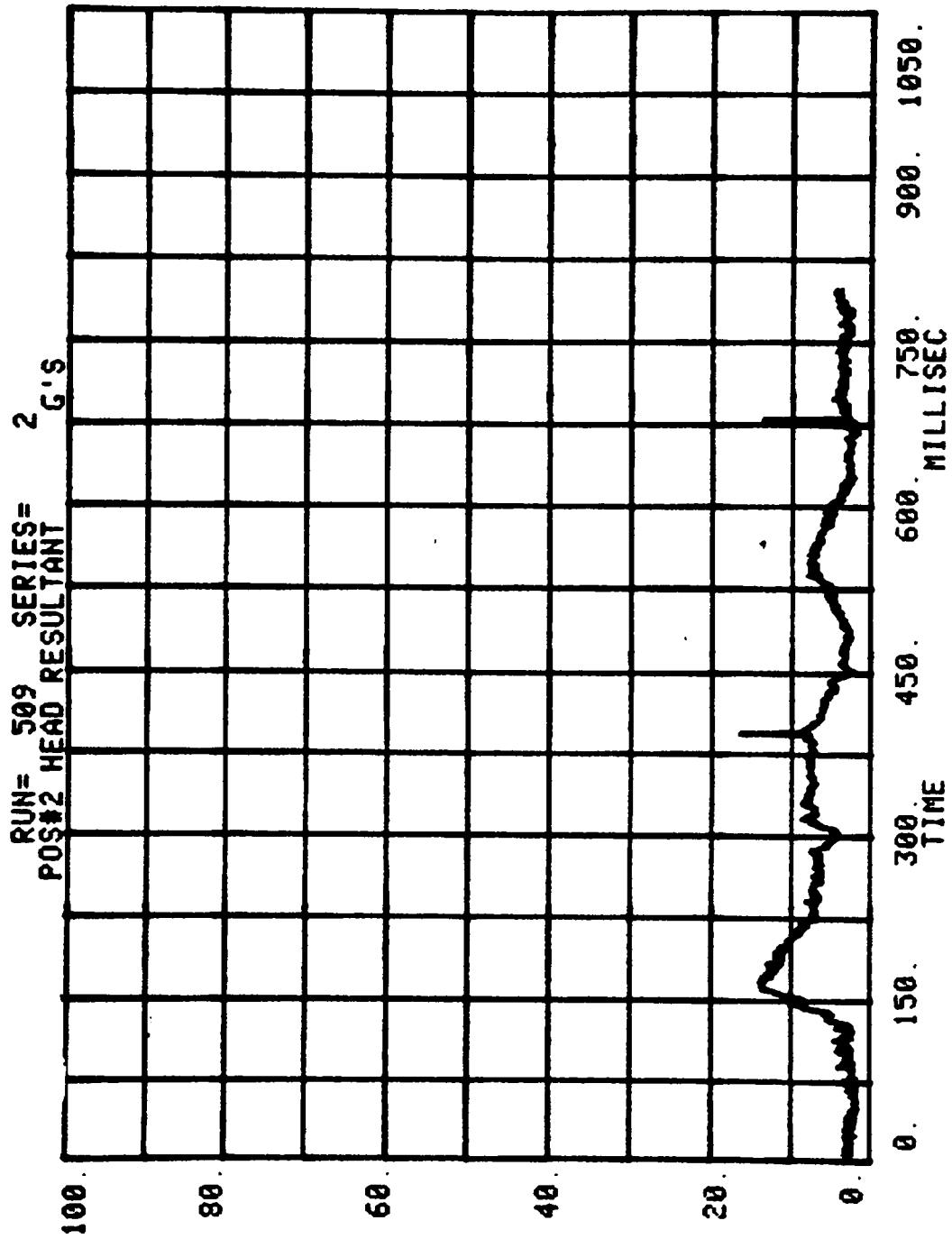


FIGURE B-15

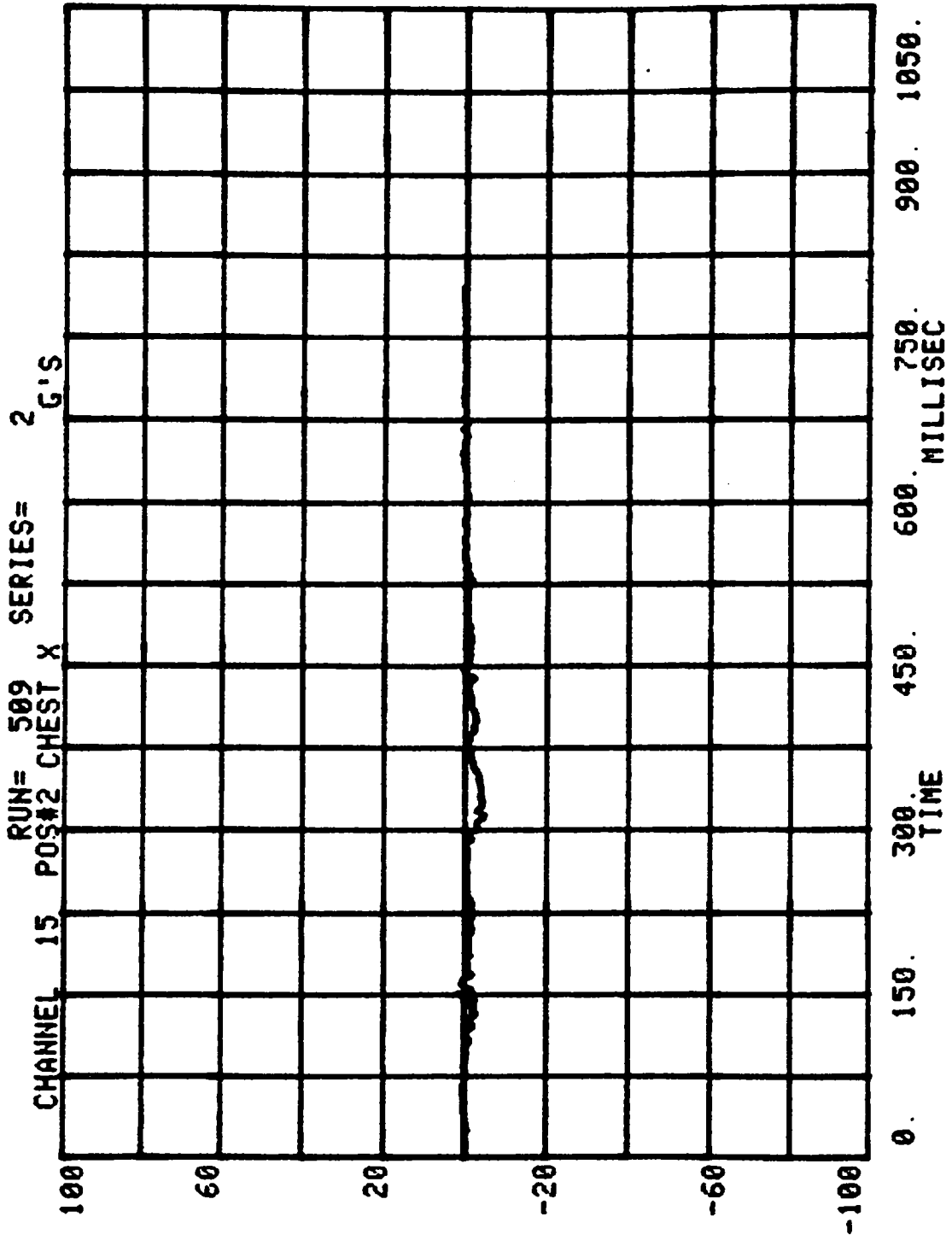


FIGURE B-16

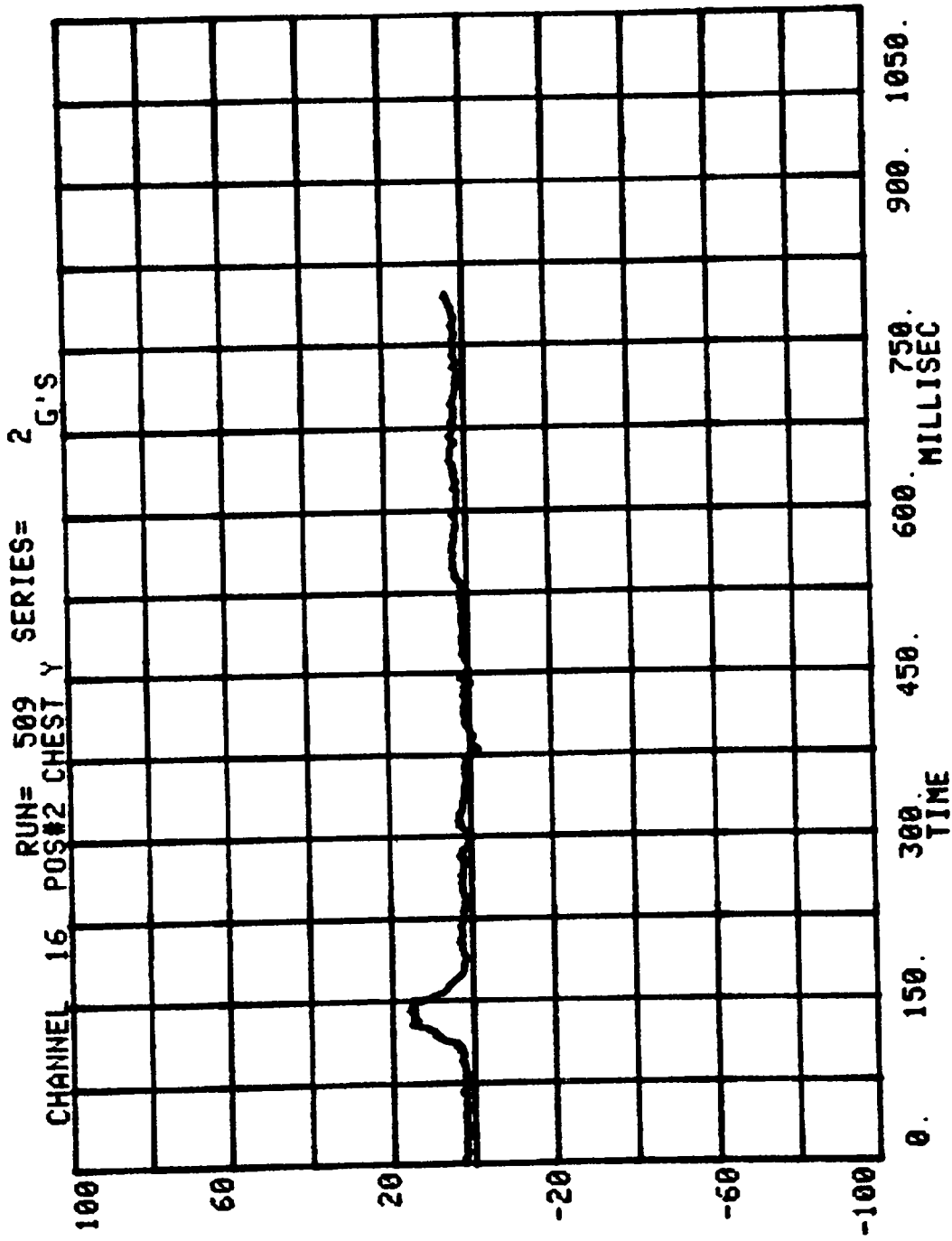


FIGURE B-17

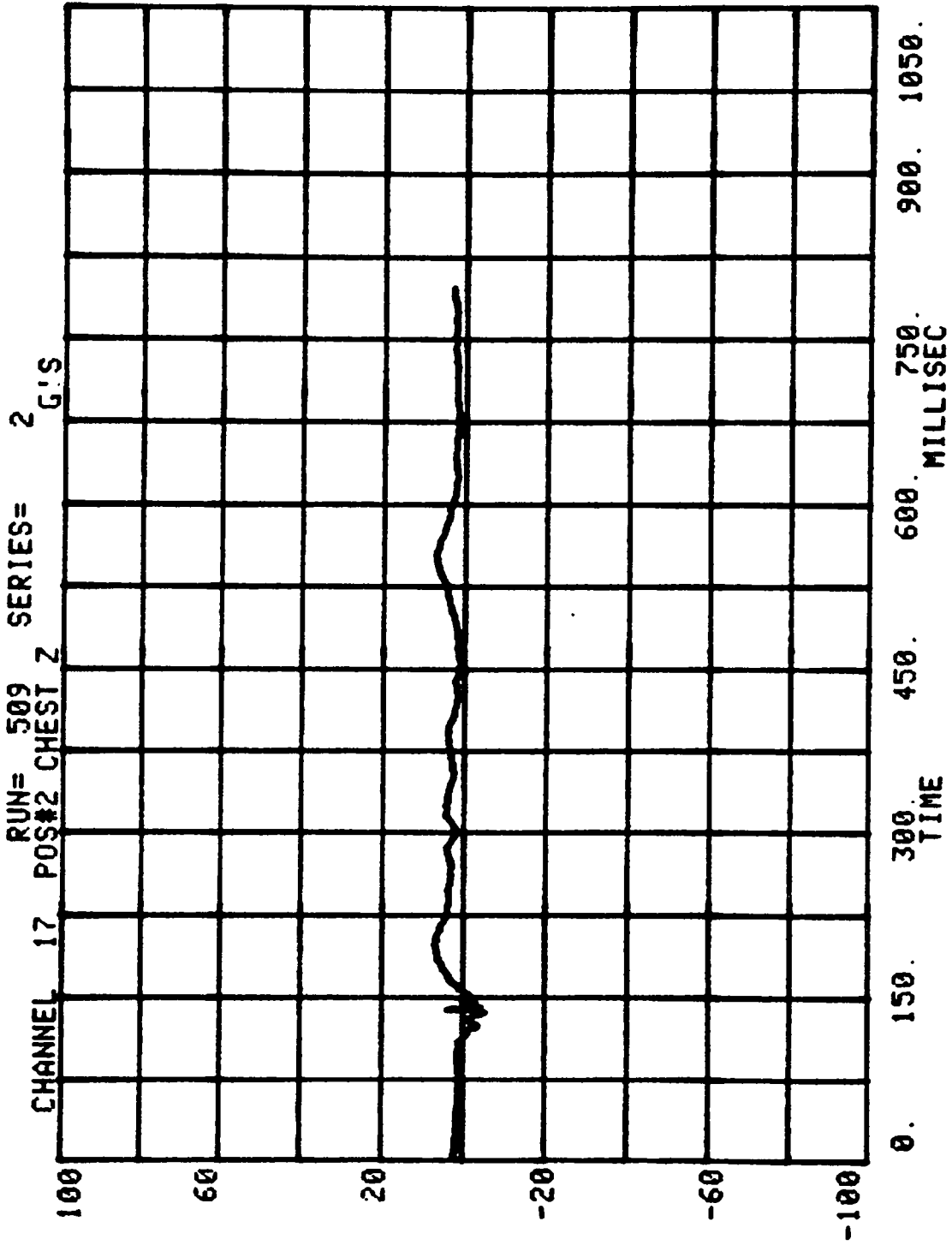


FIGURE B-18

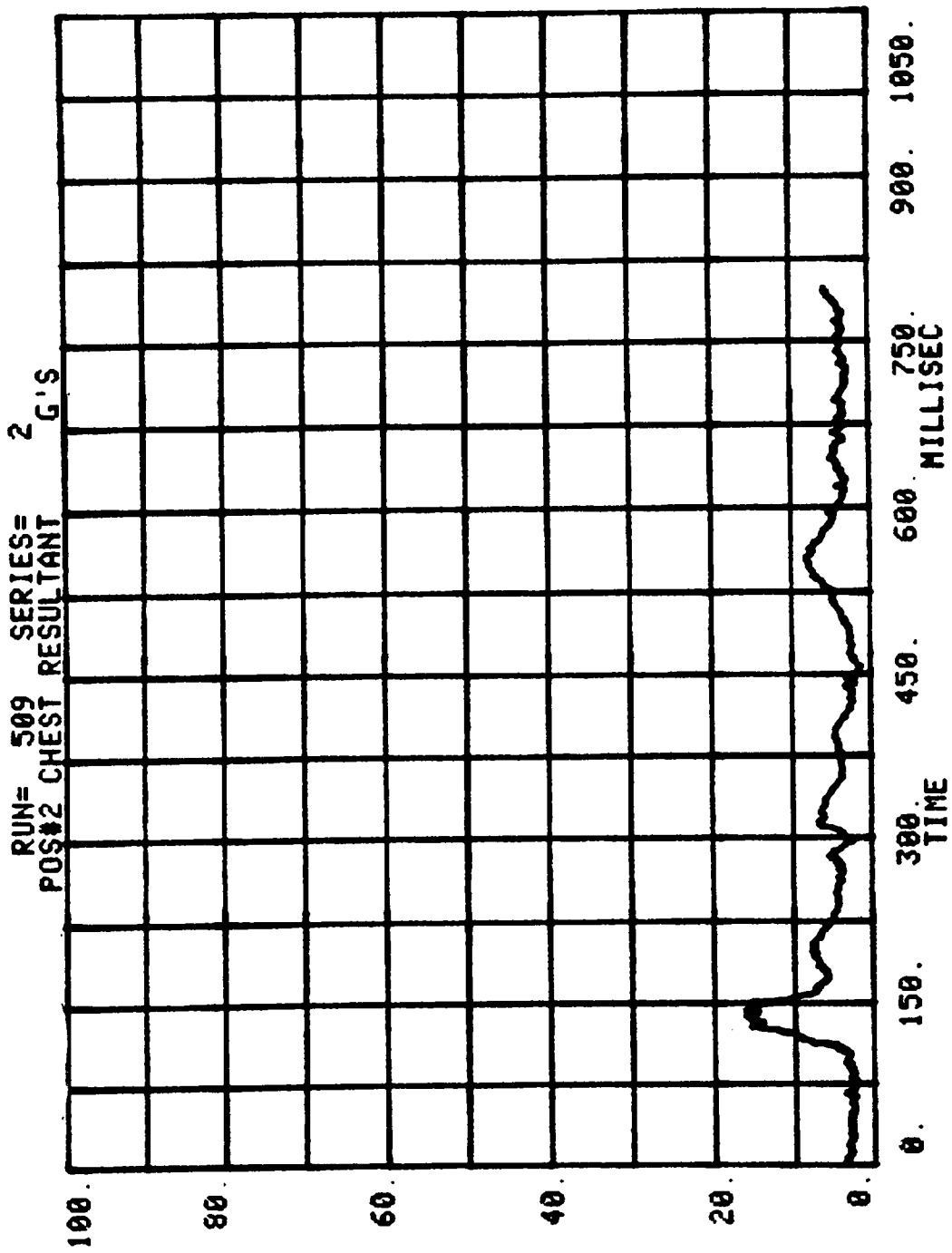


FIGURE B-19

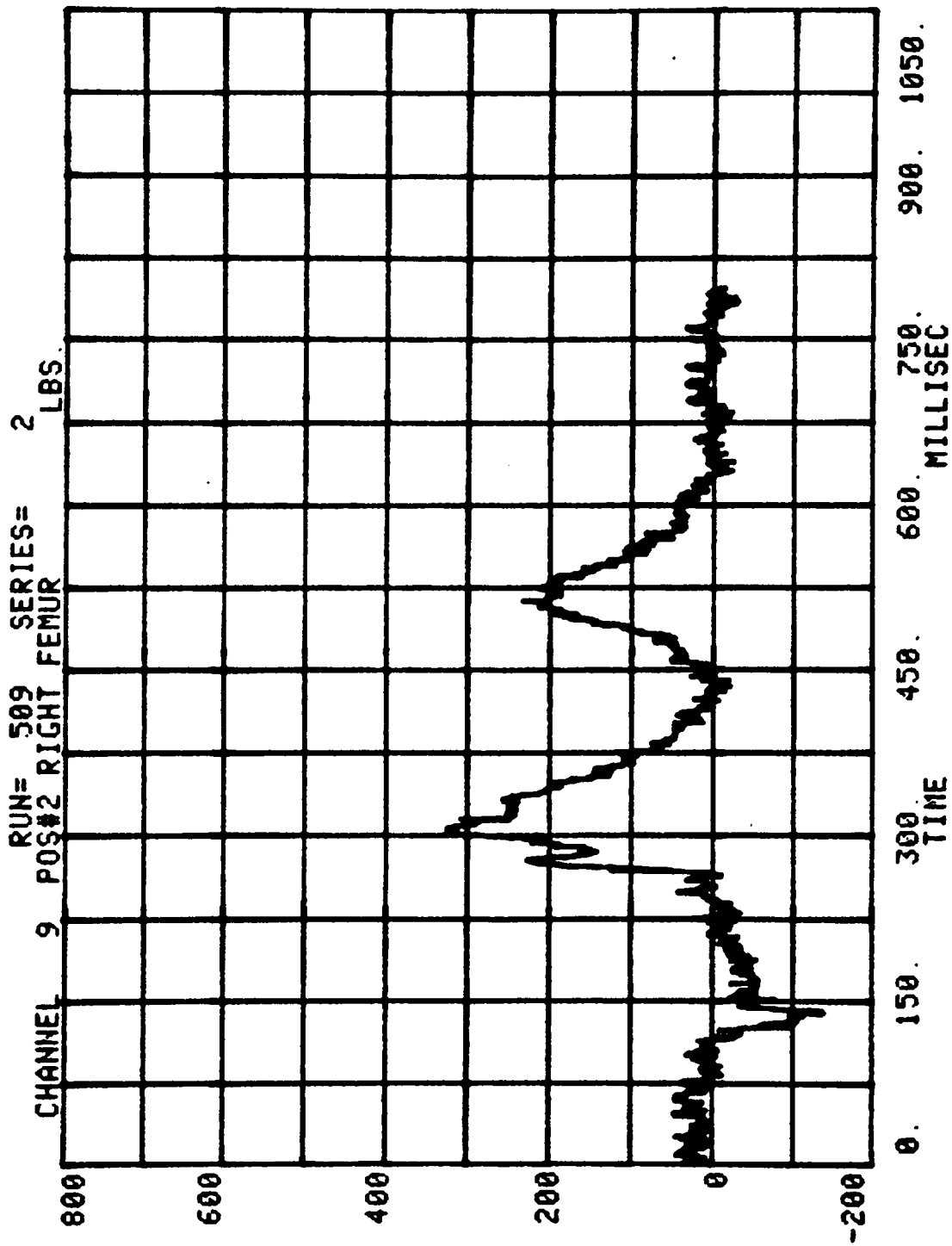


FIGURE B-20

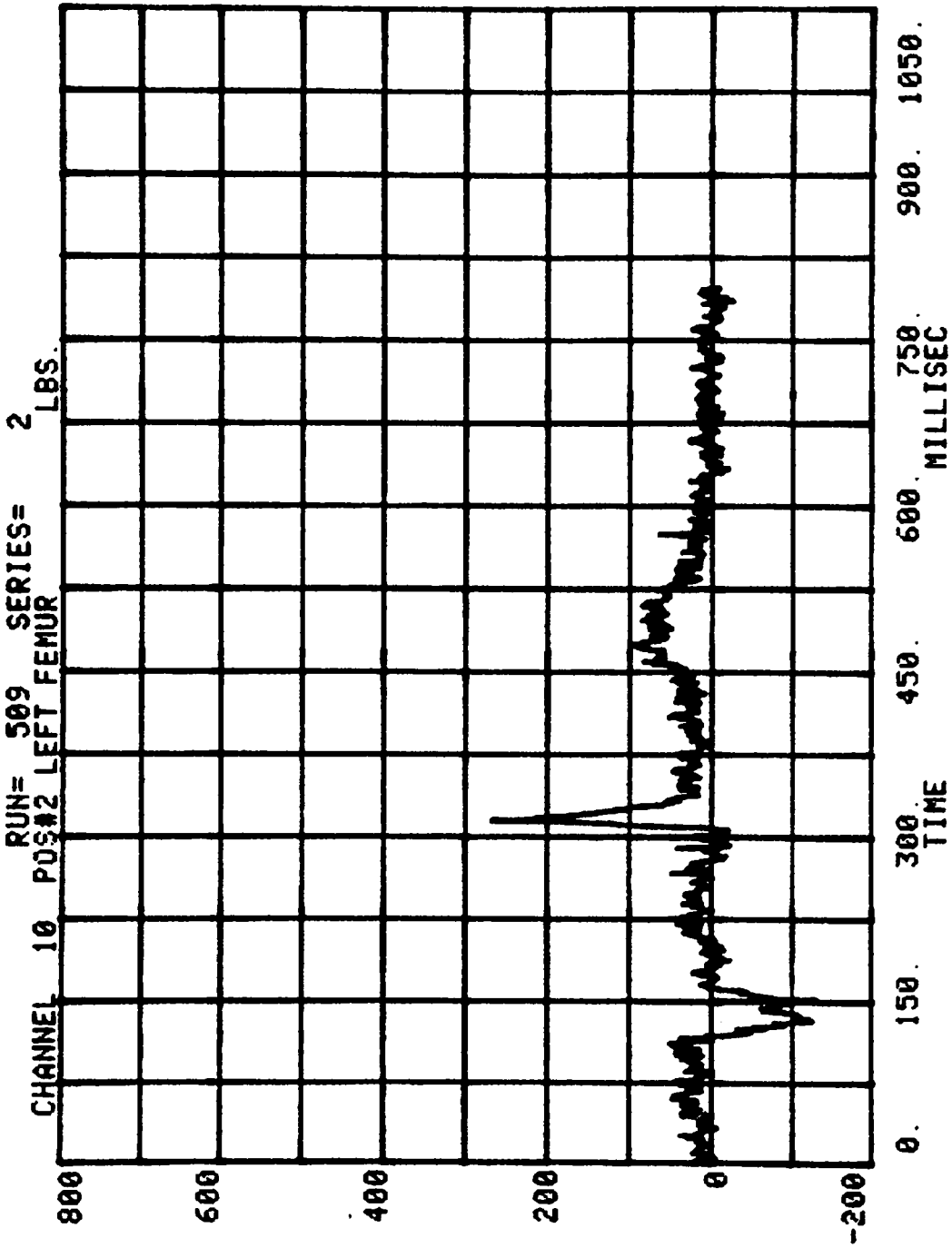


FIGURE B-21

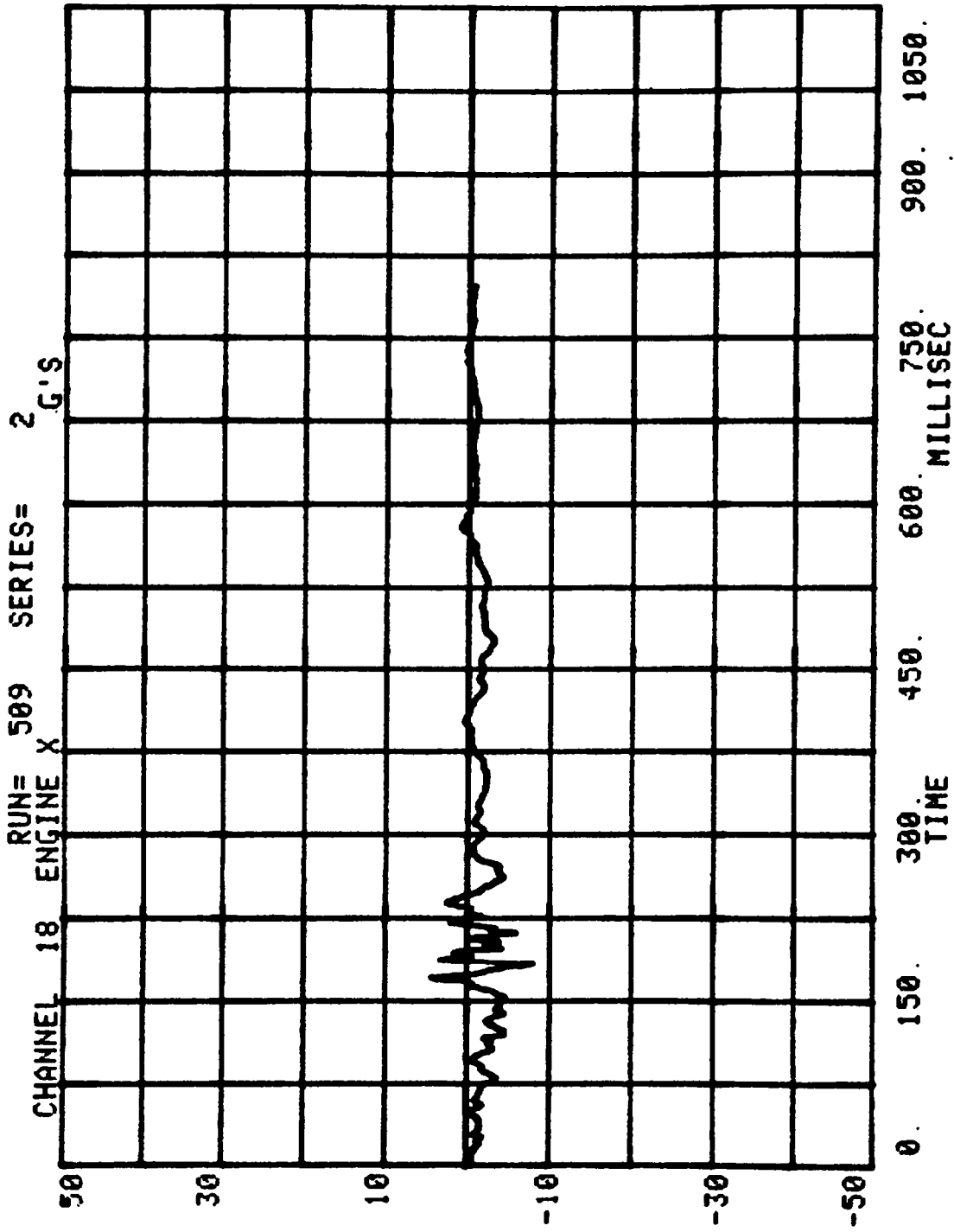


FIGURE B-22

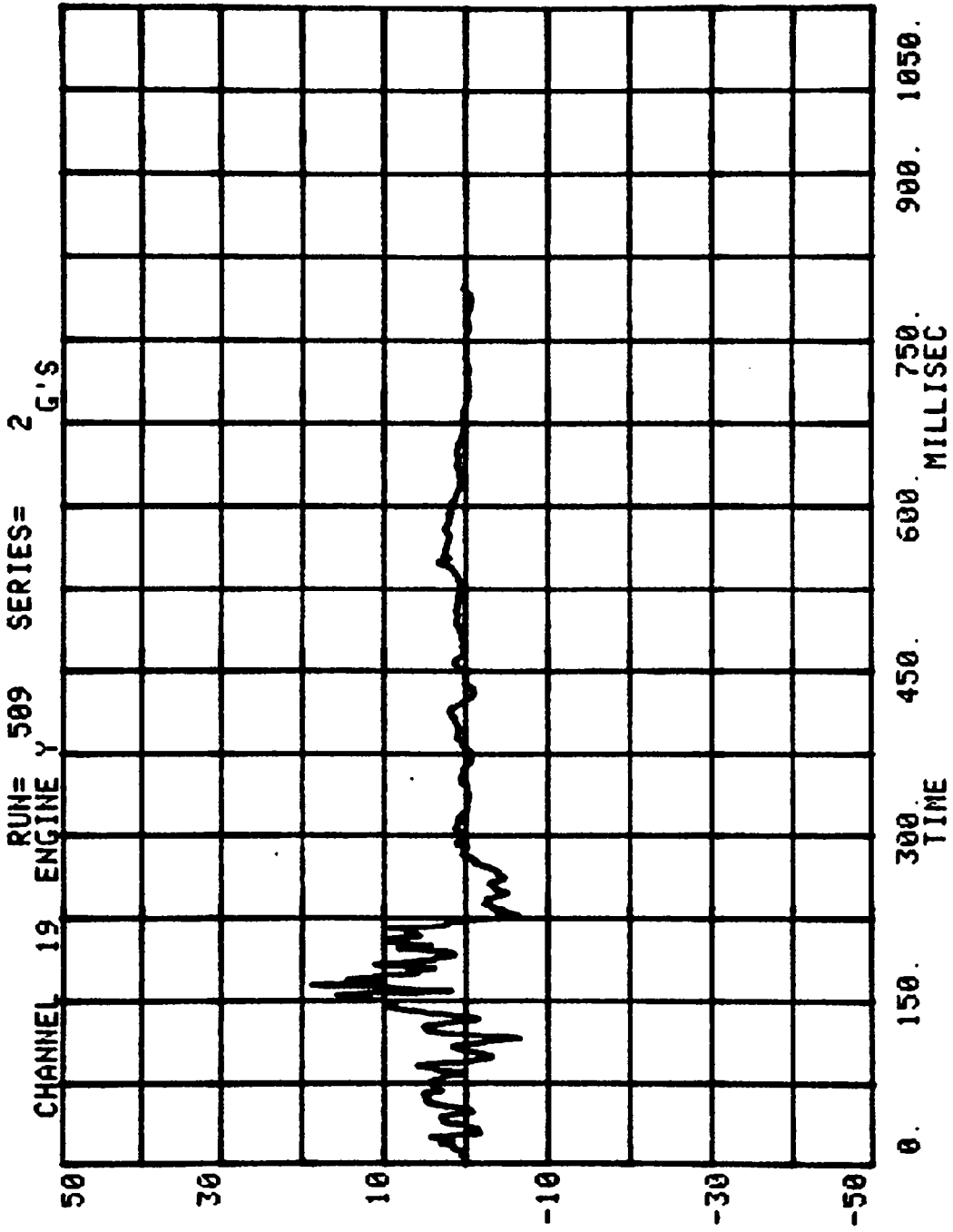


FIGURE B-23

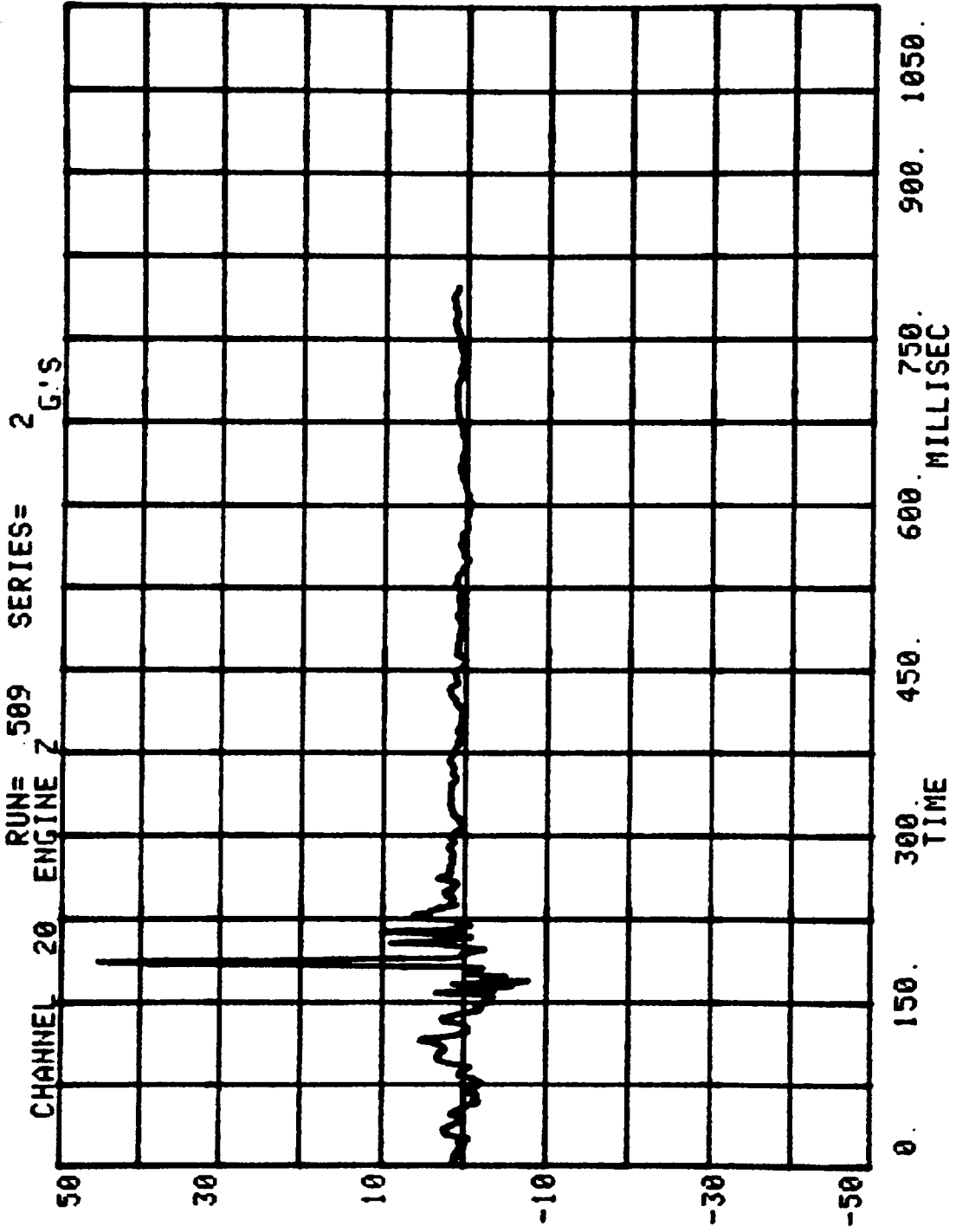


FIGURE B-24

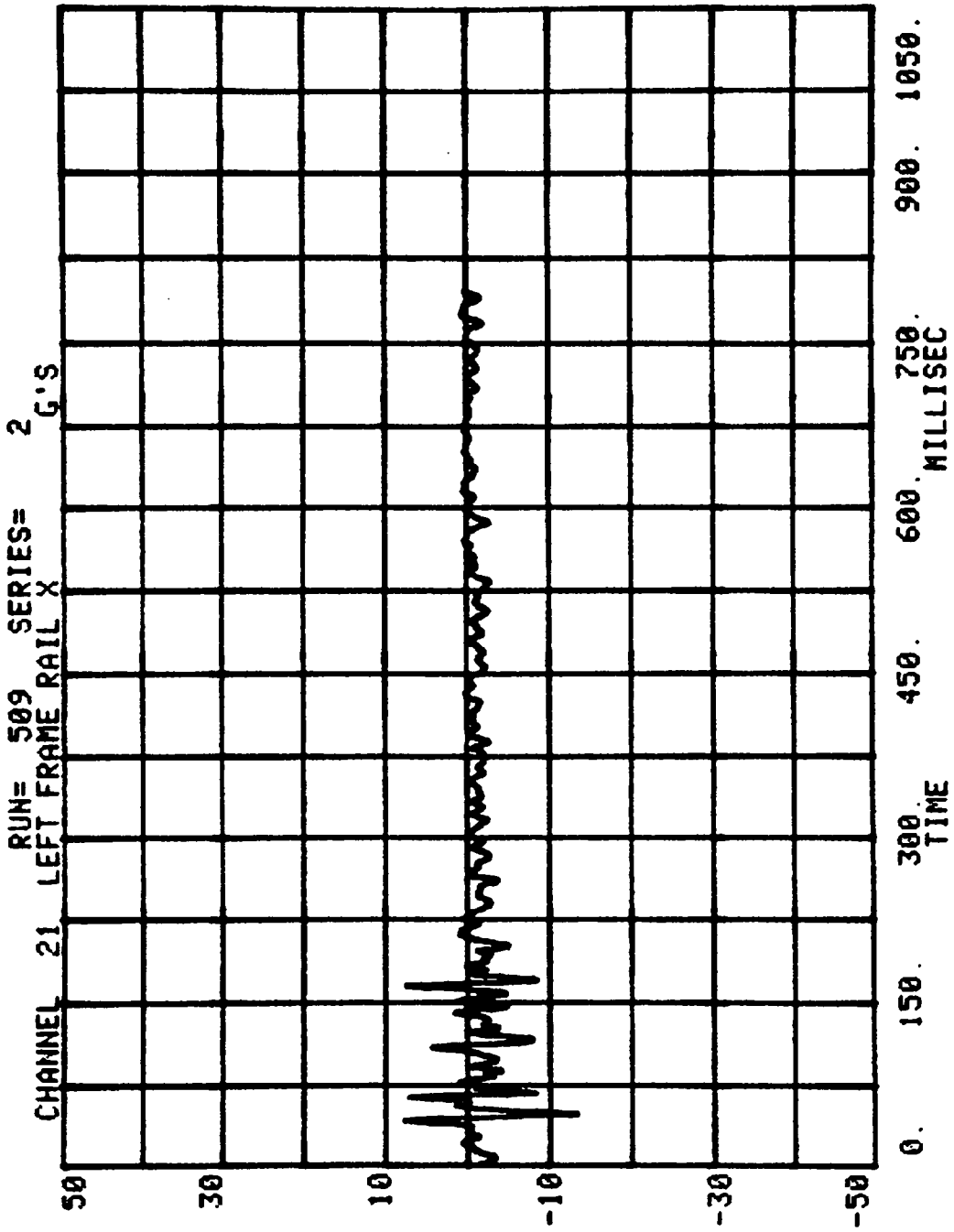


FIGURE B-25

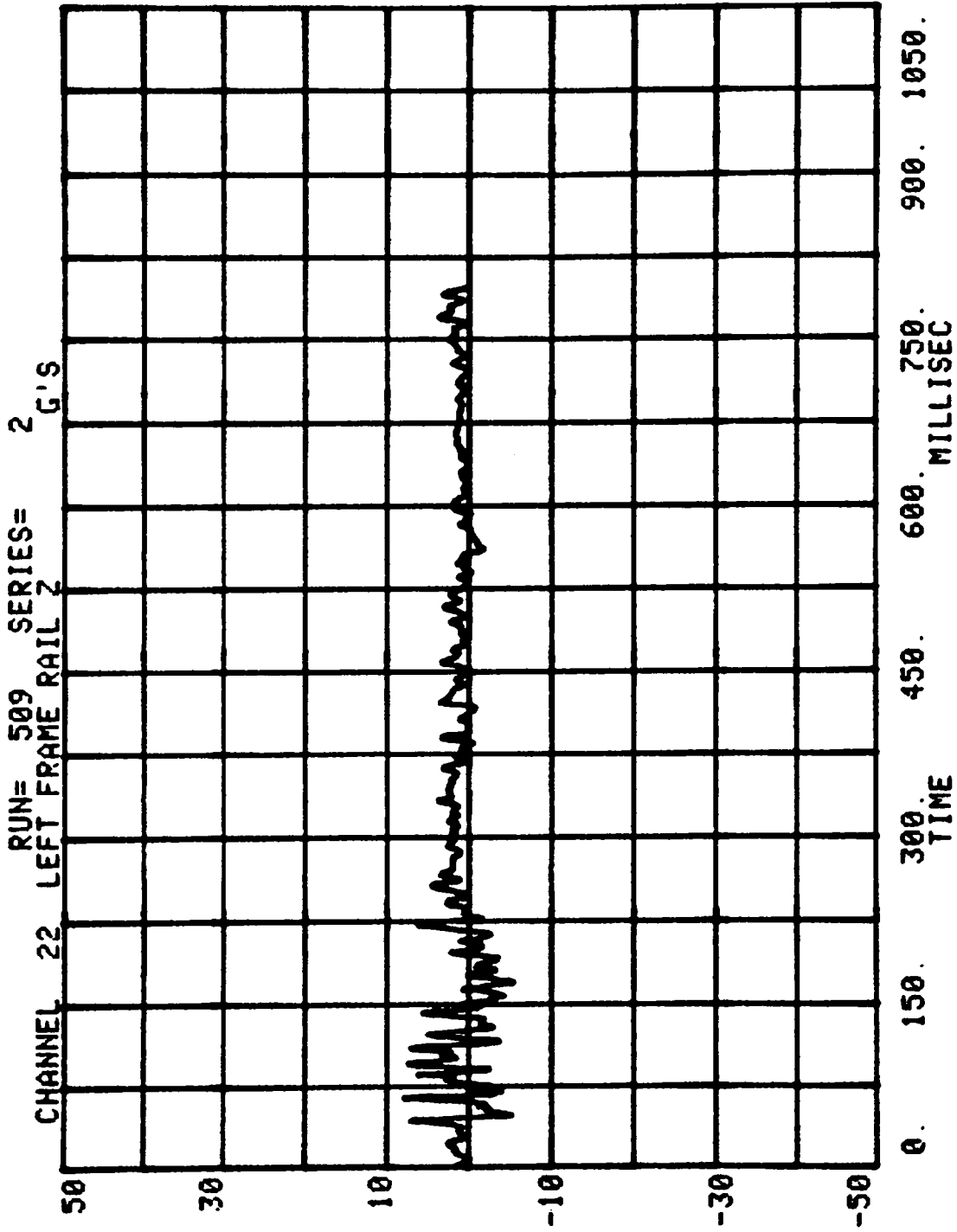


FIGURE B-26

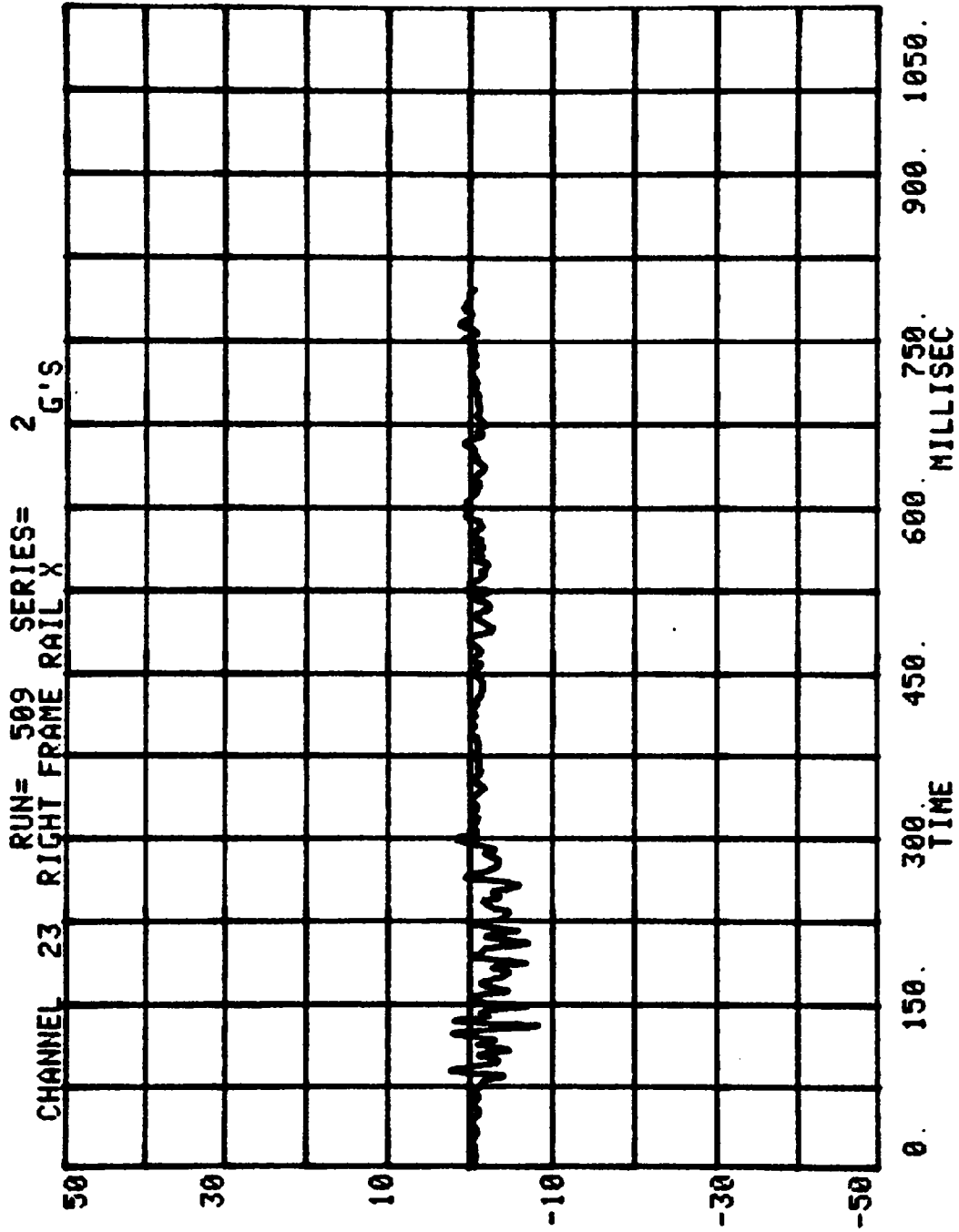


FIGURE B-27

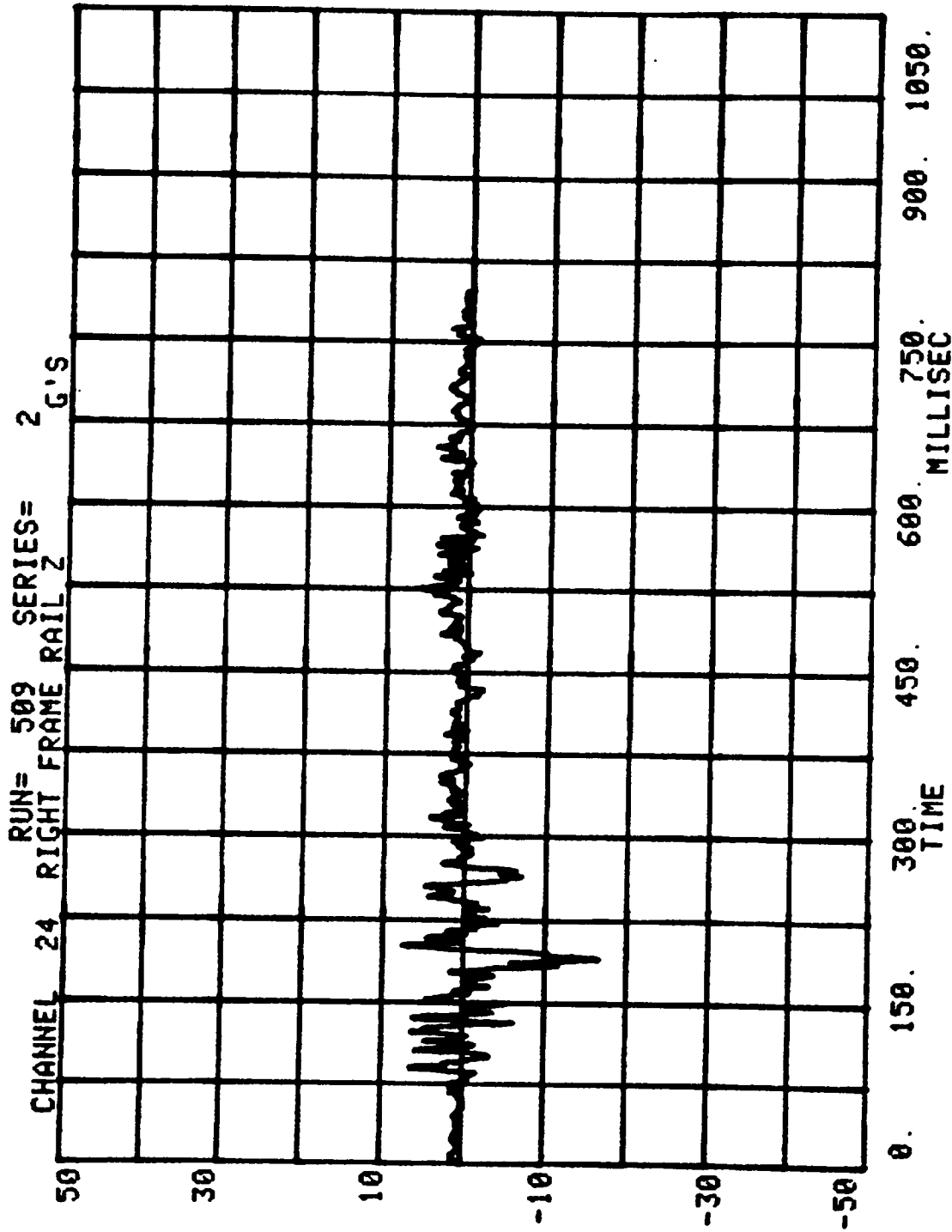


FIGURE B-28

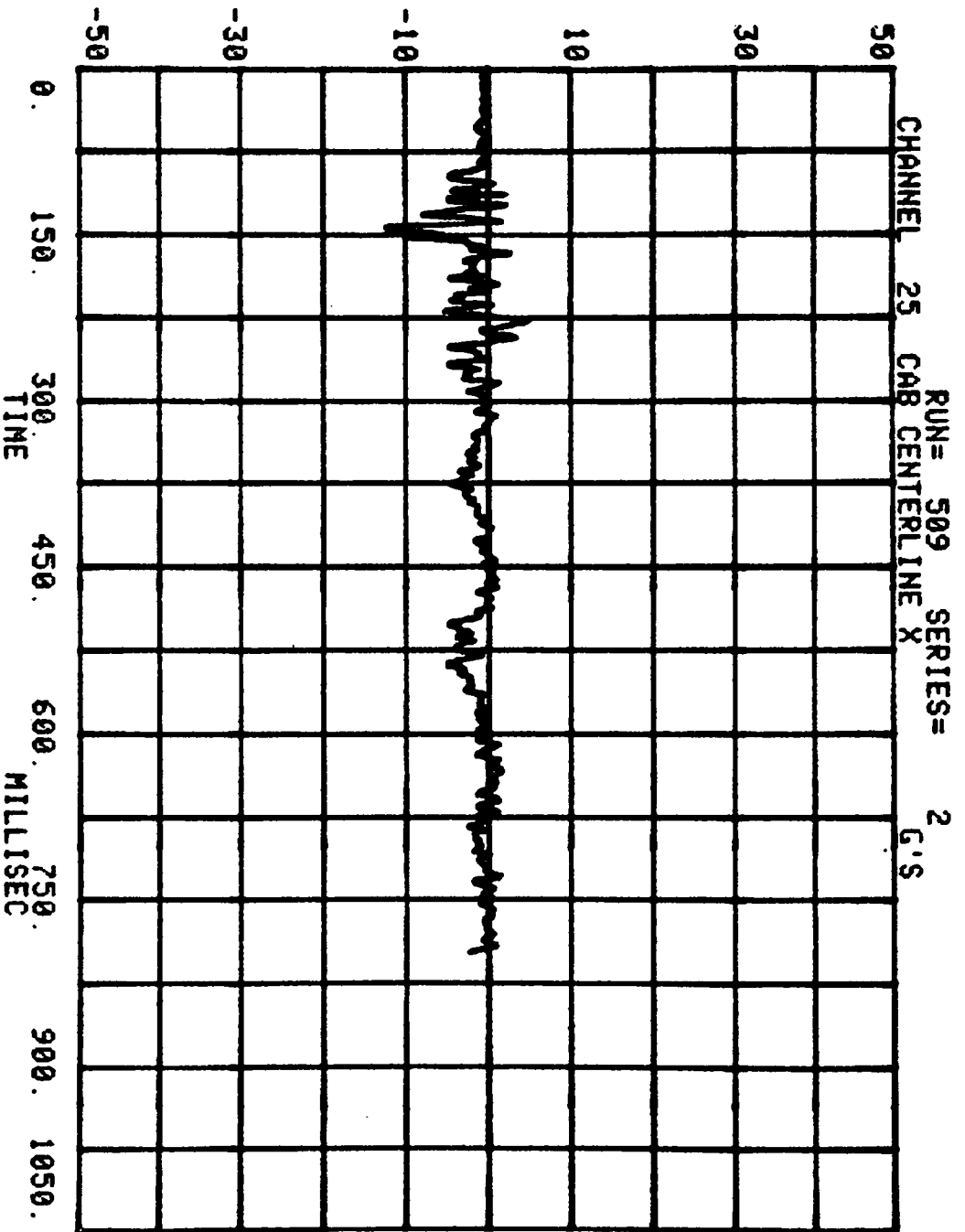


FIGURE B-29

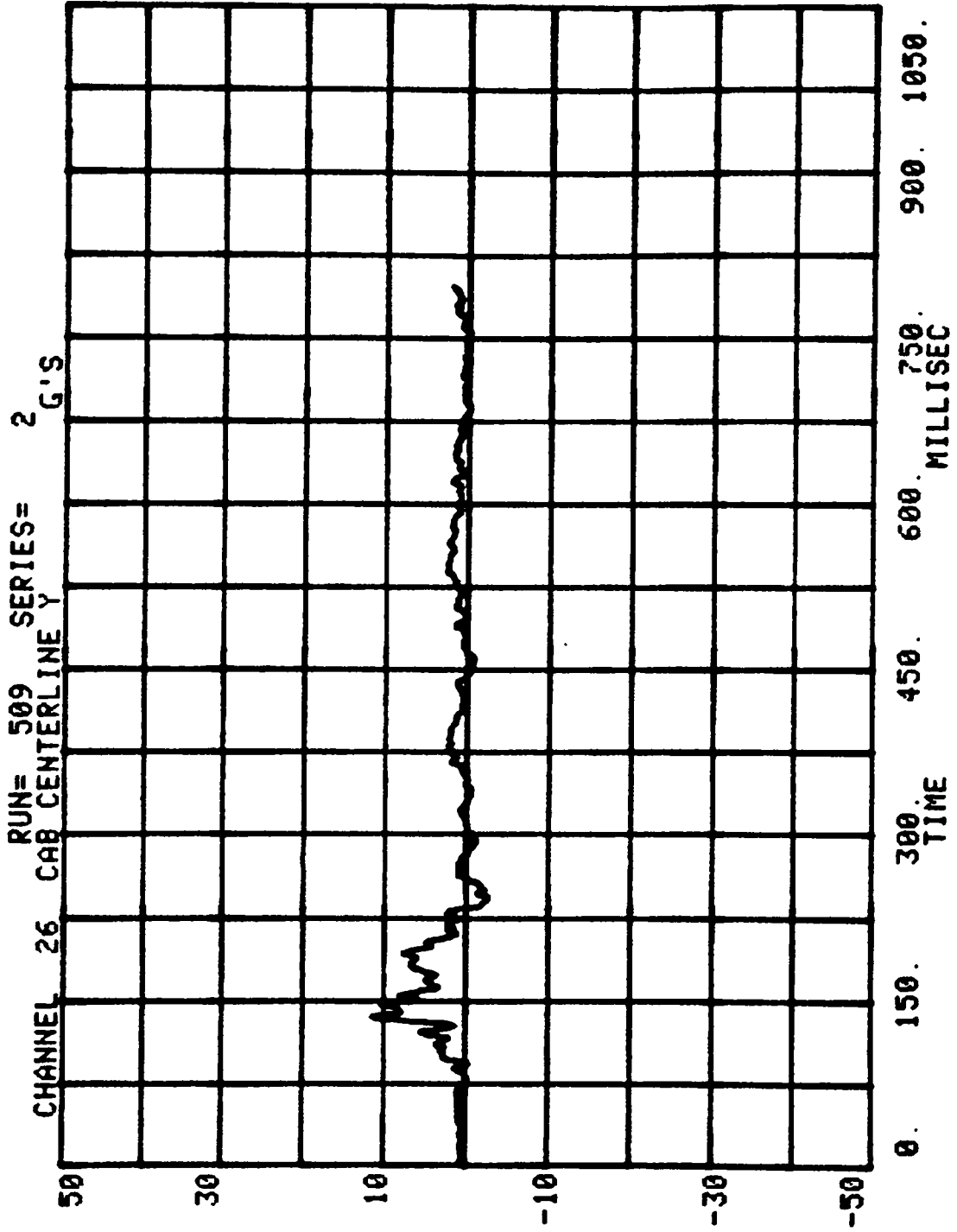


FIGURE B-30

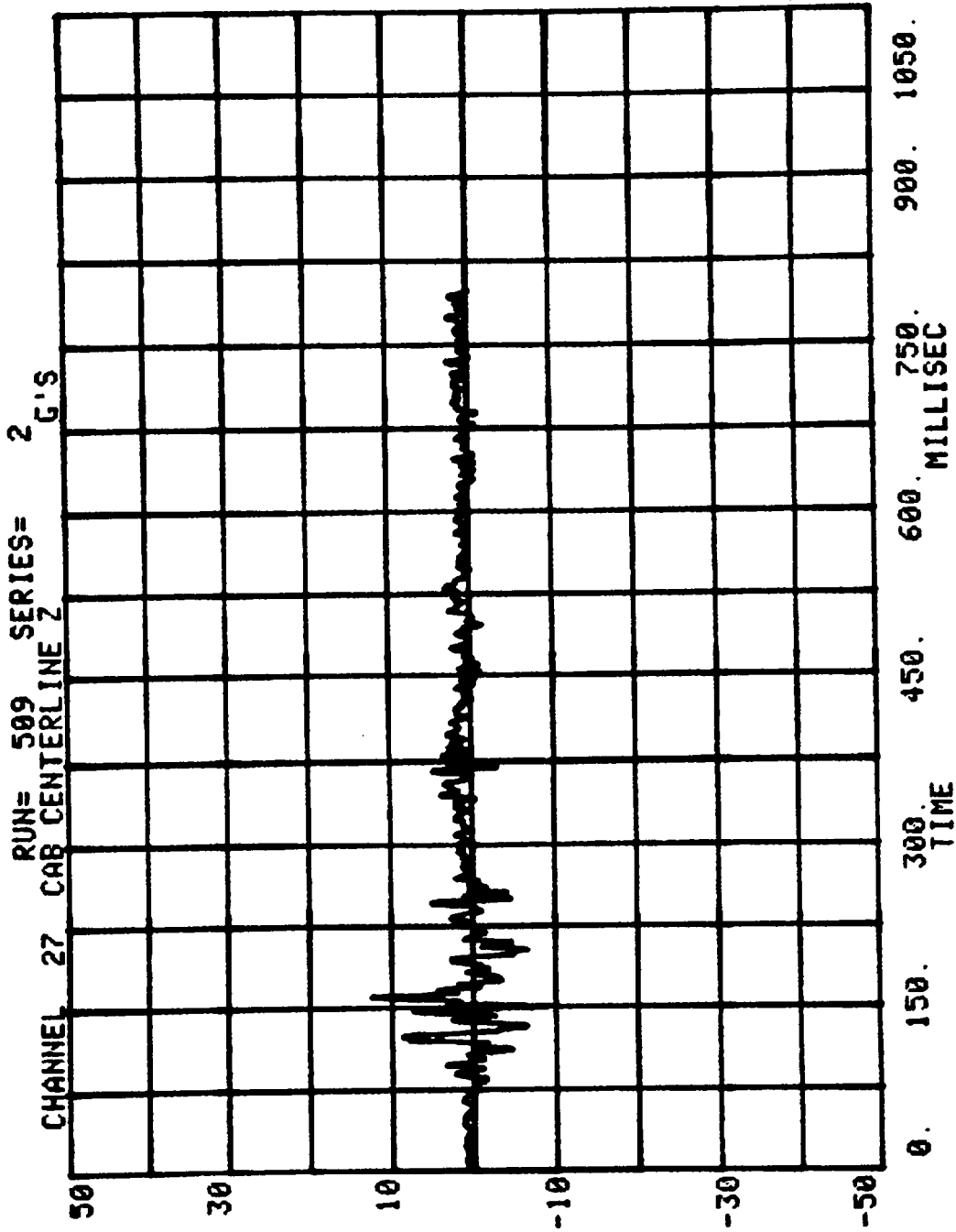


FIGURE B-31

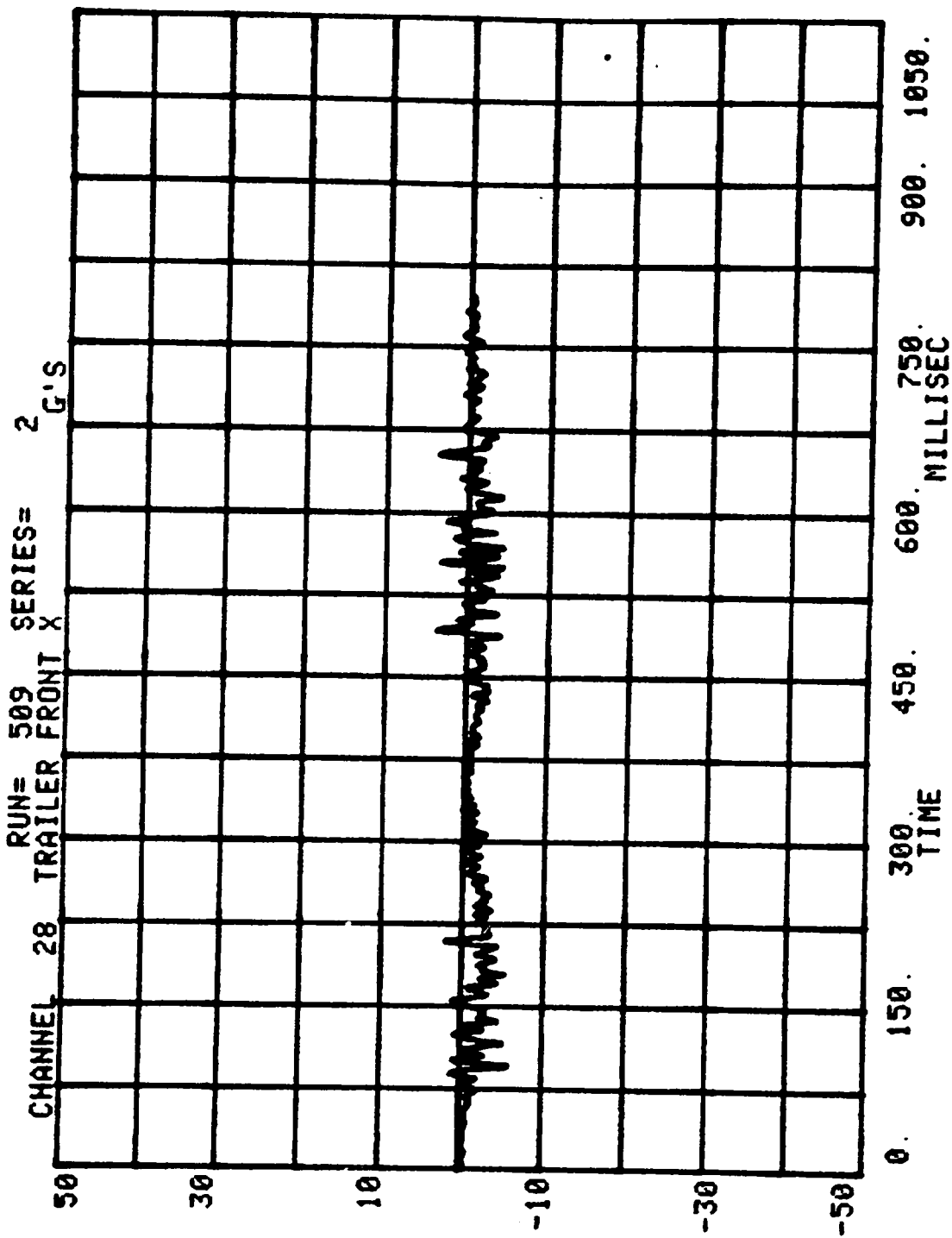


FIGURE B-32

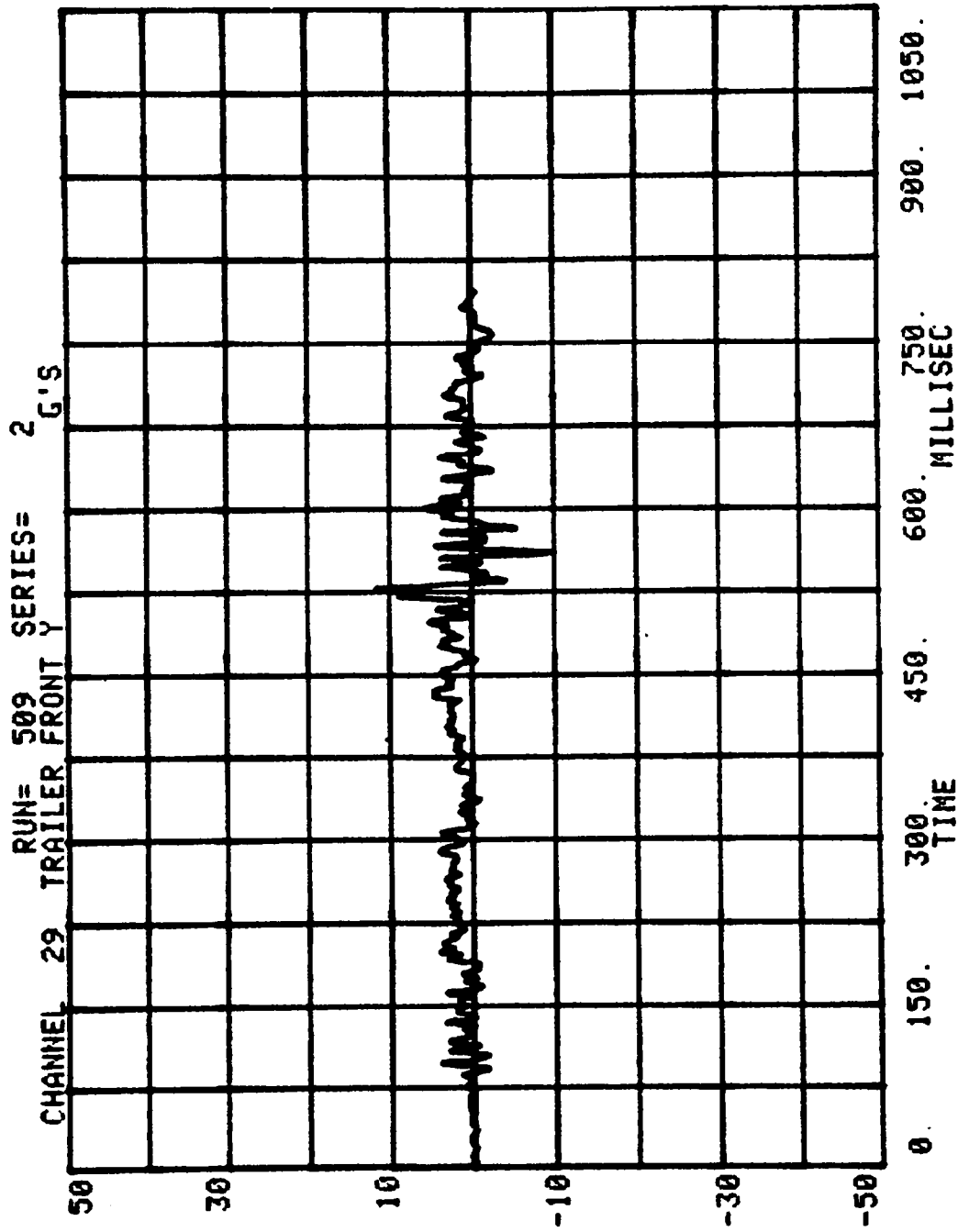


FIGURE B-33

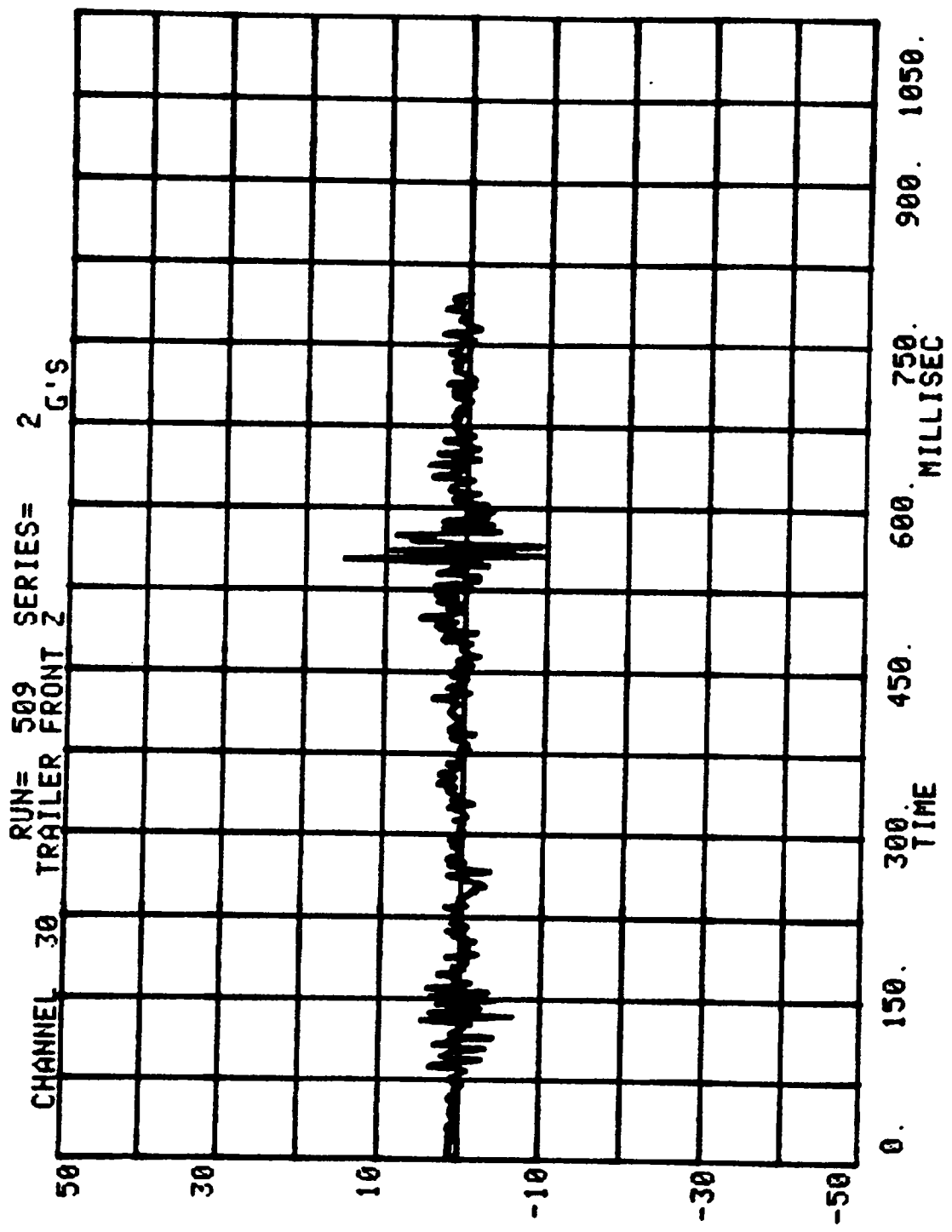


FIGURE B-34

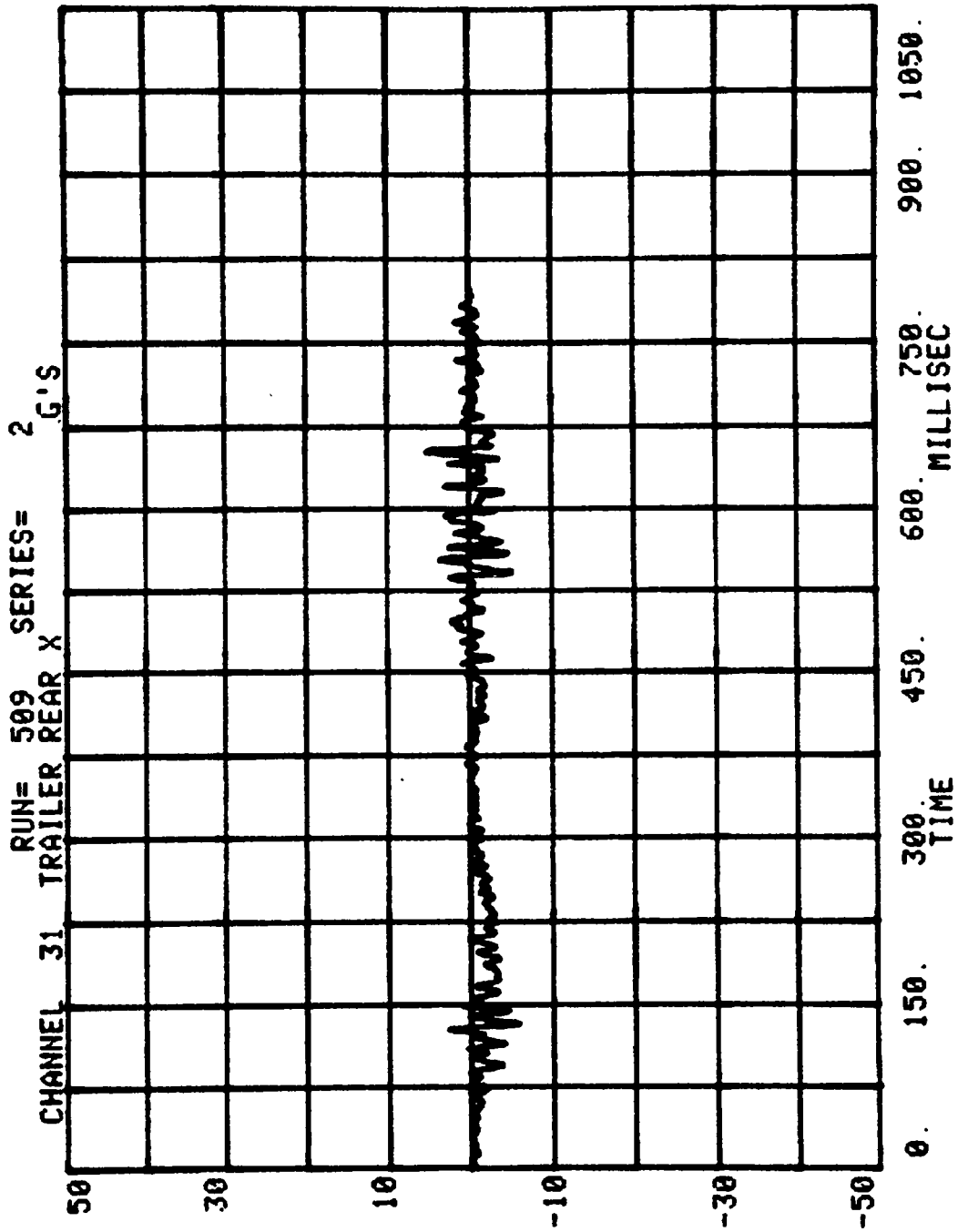


FIGURE B-35

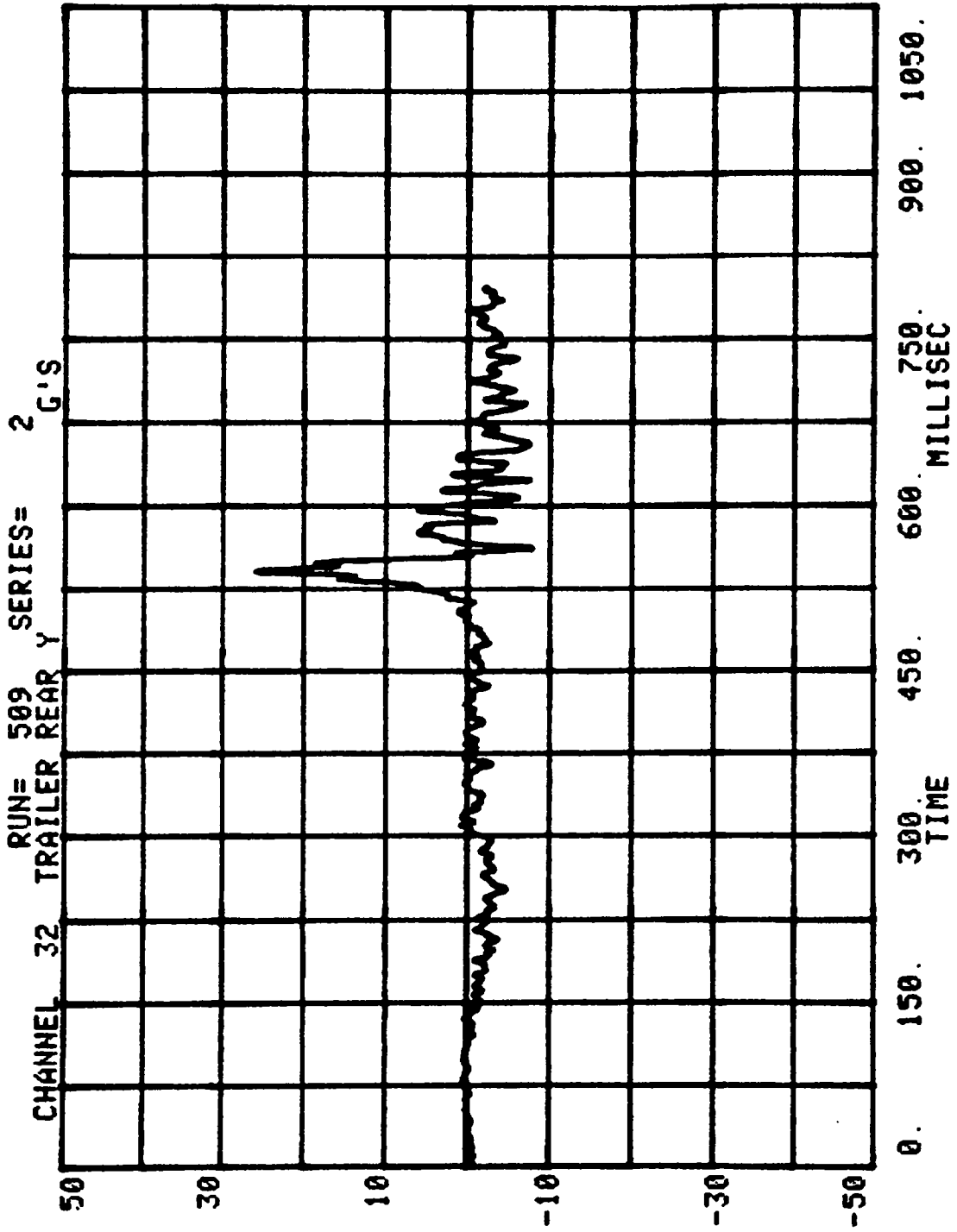


FIGURE B-36

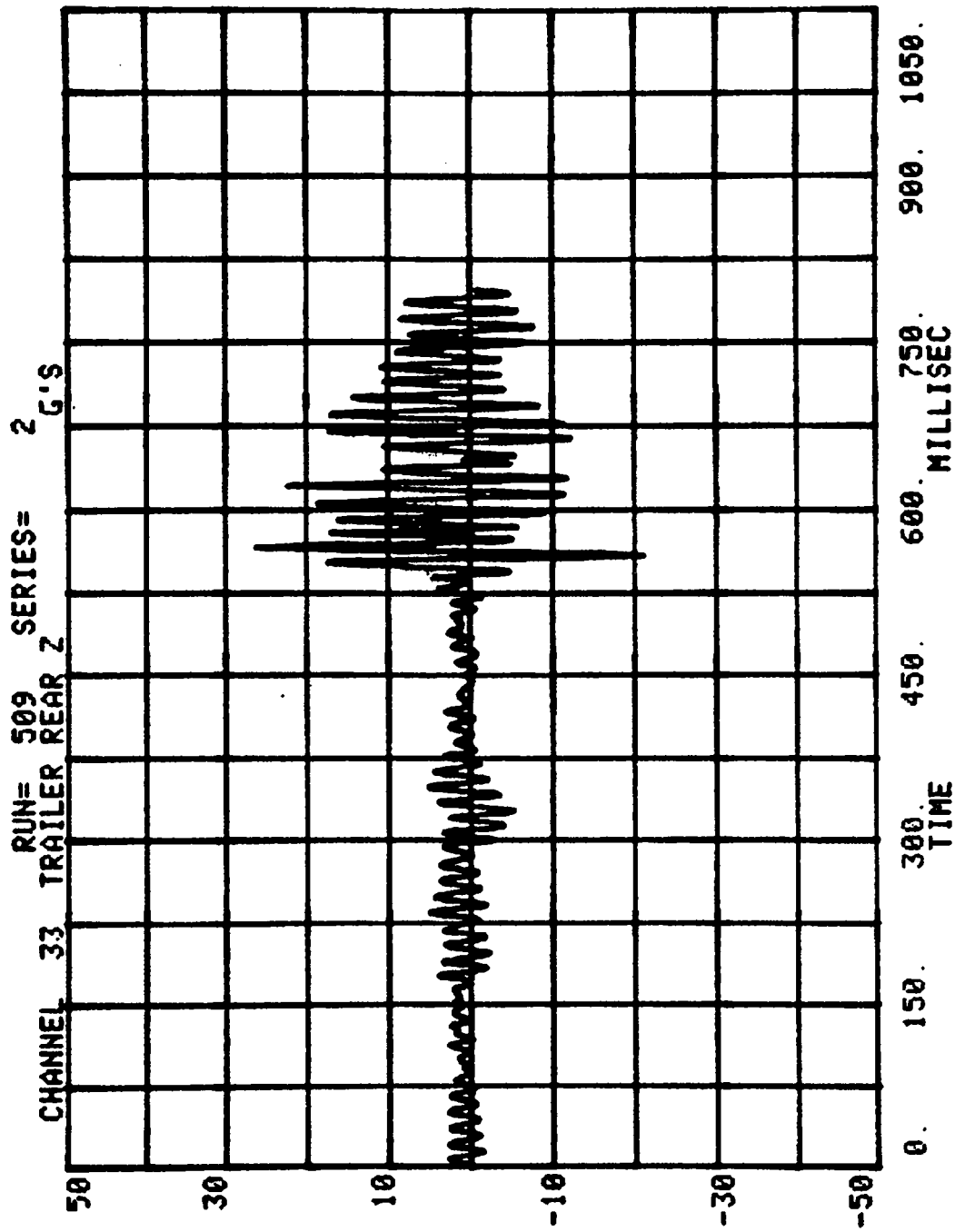


FIGURE B-37

