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Traffic Safety
Administration**

Improved Performance of Production Belt System Assembly for the Plymouth Horizon and Plymouth Reliant

Robert A. Galganski

Calspan Corporation Advanced Technology Center
P. O. Box 400
Buffalo, New York 14225

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16. Abstract

This report summarizes the findings of an experimental research program intended to improve the front-seat occupant protection potential provided by two current-production Chrysler Corporation automobiles in nominal 35 mph frontal impact exposures. It was demonstrated conclusively in both developmental sled testing and in full-scale evaluation crash testing that this capability can be significantly enhanced by making relatively simple, production-type changes to selected occupant compartment interior systems, i.e., the standard-equipment belt restraint system, seats and steering column. Overall occupant performance as measured by FMVSS 208 injury criteria and dummy kinematic response was upgraded from highly unacceptable in baseline New Car Assessment crash tests to very acceptable in similar Belt System Assembly program tests.

It is postulated that the same basic modification concepts successfully applied herein could also be effectively utilized in other selected vehicles which exhibit good front structure energy management and compartment integrity characteristics but still fail to provide satisfactory frontal impact occupant protection.

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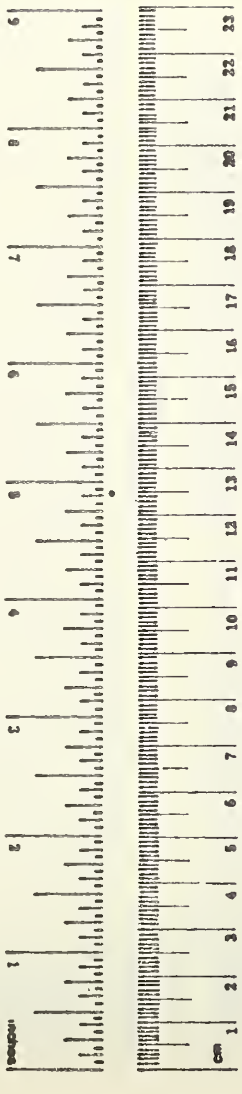
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

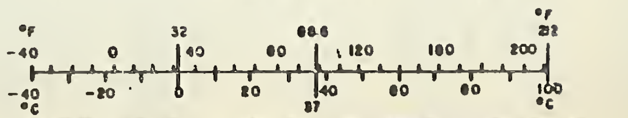
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	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		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

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



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PREFACE

This final report is submitted in partial fulfillment of the documentation requirements of Contract No. DTNH22-81-C-07111. It presents an overview of the research effort previously documented in technical reports 6829-V-1 through V-7 and in eighteen progress reports.

The author gratefully acknowledges the contributions of Messrs. Sheridan Smith and Saverio Pugliese, both of Calspan ATC. Mr. Smith supervised the construction of the Reliant sled body buck and was responsible for the detail design and preparation of engineering drawings of mounting hardware for the Takata Kojyo webbing clamp assembly and the Calspan-developed breakaway steering shaft used in the compartment-modified Reliant and Horizon, respectively. He also assisted in high-speed film data analysis of the two New Car Assessment crash tests and the Phase I and Phase II Reliant sled test series. In addition to providing valuable advice and constructive review of all technical reports, Mr. Pugliese suggested that the author investigate the concept of seat cushion stiffening to help control occupant head rotation/acceleration. This concept proved to be instrumental in the successful completion of this program.

The author would also like to thank the following individuals for their help during the program: Mr. T. Albert Yamada of Mike Masaoka Associates, Mr. David J. Romeo of Romeo Kojyo Co., Inc., and Mr. Robert Simpson of the Chrysler Corporation. Messrs. Yamada and Romeo provided reliable Takata Kojyo restraint system hardware used in developmental and evaluation testing while Mr. Simpson supplied the author with essential information regarding production Chrysler belt restraint system design.

The NHTSA Contract Technical Monitor for this program was Mr. Lee Stucki of the Occupant Packaging Branch of the Vehicle Engineering Research Division. Mr. Stucki's interest in the program and willingness to accommodate several changes in the original work plans were an integral part of this highly successful program.

The opinions, findings, and conclusions expressed in this publication are those of this author and not necessarily those of the National Highway Traffic Safety Administration.

This report has been reviewed and approved by:

Anthony L. Russo

Anthony L. Russo, Head
Transportation Research Department
Calspan Advanced Technology Center

1.0 INTRODUCTION

Many different small domestic and foreign cars have been evaluated in nominal 35 mph frontal impact crash tests as part of the NHTSA's ongoing New Car Assessment (NCA) program. Test results have indicated that while many of these cars provide generally satisfactory crash energy management and occupant compartment integrity, they still fail to offer adequate protection from injury to one or both of their front-seated occupants. This unsatisfactory performance can be attributed, at least in part, to inherent deficiencies in the vehicle standard-equipment belt restraint system, seat, steering column or dashboard design. In such cases, the application of straightforward, relatively minor modifications to one or more of these systems may offer the potential for full compliance with all FMVSS 208 occupant injury criteria.

Consistent with the above observation and hypothesis, the NHTSA selected two current-production Chrysler Corporation automobiles as the basis for the research program described in this report. The vehicles selected, a Plymouth Horizon TC-3 2-door hatchback (L-body car) and a Plymouth Reliant 2-door sedan (K-car), each were subjected to nominal 35 mph flat frontal barrier crash tests in the NCA program.* In addition, 1980 model year Horizons were also tested in nominal 70 mph closing speed,** colinear, car-to-car impacts against a 1980 Chevrolet Citation 2-door sedan and a 1980 Ford Mustang 2-door sedan in the same program. Occupant performance data were obtained for Part 572 50th percentile male anthropomorphic test devices (ATDs) placed in the driver and right-front seating positions of each vehicle.

Although both occupants of the barrier-tested Horizon (Reference 1) satisfied all FMVSS 208 occupant injury criteria, their counterparts in the car-to-car exposures each failed to comply with one or more of these requirements. Of these two tests, the Mustang impact (Reference 2) generated a more severe

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*Vehicle model years 1979 and 1981, respectively.

**Impact speed 35 mph, each car.

collision environment for the Horizon occupants than the Citation exposure (Reference 3). In the Reliant barrier test (Reference 4), the driver occupant alone complied fully with all injury criteria.

The original objectives of the subject research program entitled "Improved Performance of Production Belt System Assembly for the Plymouth Horizon and Plymouth Reliant," hereafter referred to as the BSA program, are delineated below:

- Horizon: (1) identify areas of the seat belt assembly, steering column and occupant compartment design which could be improved to enhance driver and right-front passenger performance in nominal 35 mph frontal impact exposures; and (2) make minor, readily producible modifications to one or more of the above systems which will insure compliance with FMVSS 208 occupant injury criteria in colinear, car-to-car frontal crash tests at a nominal 70 mph closing speed.

- Reliant: (1) identify those belt restraint system design characteristics which permit excessive front seat passenger excursion during a nominal 35 mph flat frontal barrier collision exposure; and (2) improve the production belt restraint system to insure that the occupant complies fully with all FMVSS 208 injury criteria in such a crash test.

On the basis of information which became available during the course of the program, the Ford Mustang was selected as the opposition vehicle for the demonstration of improved Horizon occupant performance in the car-to-car impact test mode. Also, satisfaction of program objectives for the Reliant required modification of more than just its production belt restraint system.

The BSA program, which was initially formulated for the Plymouth Horizon only, was subsequently expanded early in the original effort to include the Plymouth Reliant. The latter work was assigned higher priority by the NHTSA and thus was completed before the Horizon part of the program.

Implementation of the above program objectives commenced with a detailed data review/evaluation of baseline Horizon and Reliant occupant protection performance in each of the four, previously mentioned NCA crash tests. Knowledge obtained from these studies, discussed in Section 2.0, was instrumental in the formulation of our initial planned technical approach to vehicle occupant compartment interior systems redesign.

Subsequent validation and developmental sled testing provided essential additional insight into this process. Systems were developed which provided improved (relative to their production counterparts) occupant performance in appropriate simulated collision environments. These efforts are summarized in Section 3.0.

The same (or similar) substitute/modified compartment interior systems were employed in a production 1981 Reliant and evaluated under the corresponding NCA frontal barrier crash test condition. Also, a production 1982 Horizon was equipped with alternate occupant compartment systems and similarly evaluated in a car-to-car head-on impact against a 1982 Ford Mustang. Both modified vehicles afforded their occupants significantly improved crash protection relative to their baseline counterparts. The comparison of critical Head Injury Criterion (HIC) and maximum resultant chest acceleration (C_R) responses listed in Table 1 vividly typifies this improved overall performance. Complete summaries of these highly successful tests are presented in Section 4.0.

The last section, 5.0, outlines the significant conclusions drawn from the BSA research effort. Recommendations for additional, future work of a similar nature are also presented therein.

Table 1

PLYMOUTH RELIANT AND PLYMOUTH HORIZON OCCUPANT PERFORMANCE IN NOMINAL 35 MPH FRONTAL CRASH TESTS

TEST CONFIGURATION	VEHICLE	OCCUPANT LOCATION	INJURY RESPONSES BEFORE COMPT. SYSTEMS MOD.		INJURY RESPONSES AFTER COMPT. SYSTEMS MOD.[1]	
			HIC	$C_R \sim$ g's	HIC	$C_R \sim$ g's
FLAT FRONTAL BARRIER	PLYMOUTH RELIANT	DRIVER	605	52	367 (391)	33 (34)
		PASSENGER	1731	59	NA[2] (296)	38 (37)
HEAD-ON IMPACT WITH FORD MUSTANG	PLYMOUTH HORIZON TC-3	DRIVER	1817	61	727	44
		PASSENGER	2096	52	510	38

[1]NUMBERS IN PARENTHESES REFLECT RESULTS OBTAINED BY AN INDEPENDENT CONTRACTOR.

[2]PRODUCTION BUCKLE ASSEMBLY WEBBING FAILED. HEAD Z ACCELERATION DATA CONTAMINATED BY ANOMALOUS NOISE SPIKES.

2.0 PRODUCTION VEHICLE CRASHWORTHINESS DATA REVIEW AND EVALUATION

All available data generated during the conduct of the five pertinent NCA crash tests noted in Section 1.0 were first analyzed in an attempt to assess the crashworthiness performance of the production Horizon and Reliant in these 35 mph frontal crash test exposures. Consistent with the scope of the BSA program, attention was focused primarily on the occupant compartment interior systems and components directly affecting occupant performance.

This section summarizes the major conclusions reached during the Horizon and Reliant evaluation studies. They are presented in the proper chronological order, i.e., Horizon first, followed by Reliant-related observations. The reader is referred to References 5 and 6, respectively, for a detailed discussion of these findings.

2.1 Plymouth Horizon Responses

(1) The car-to-car collision mode is more severe than the flat barrier impact configuration with respect to both Horizon structural and occupant responses.

(2) The head-on impact configuration places greater kinetic energy dissipation demands on the Horizon (and opposing vehicle) front structure.

(3) Horizon underride of the opposing vehicle front end in the car-to-car exposures resulted in the generation of greater occupant compartment pitch and velocity change than that produced in the barrier impact. The car-to-car tests also caused larger steering column/wheel and fire wall intrusions than the barrier test configuration.

(4) Vehicle whole-body pitch is an inherent characteristic of the Horizon collision response. This action is more pronounced in the car-to-car impact configuration than in the flat barrier exposure. It also contributes to pitching of the seats themselves relative to the occupant compartment.

(5) In the head-on impact mode the front seats are prone to relative forward motion along their respective seat tracks.

(6) Within the car-to-car test mode itself, the Mustang impact exposure generated a more severe collision environment for the Horizon structure and occupants than the corresponding Citation exposure.

(7) Excessive steering column/wheel intrusion and subsequent head-wheel contacts in the head-on crash tests is the overriding cause for Horizon driver noncompliance with the FMVSS 208 HIC requirement.

(8) Rigid coupling of the upper steering column to the lower portion of the dashboard contributes to the vertical displacement component of steering system motion upon driver dummy knee contact with the dashboard and/or steering column shroud.

(9) The passenger dummy in both the flat barrier and car-to-car impact configuration undergoes excessive forward motion relative to the passenger compartment. Passenger noncompliance with the HIC requirement in the latter test mode occurs as a result of head contact with a hard surface (dashboard or dummy knee).

(10) The standard 3-point Horizon belt restraint system permits excessive webbing spool-off from the retractor.

(11) The occupants in all three tests have a tendency to submarine to some degree. This motion is attributable to occupant compartment/seat pitching, inadequate dummy lower torso/extremity restraint from the dashboard, seat relative forward motion and perhaps seat design.*

(12) Substantial passenger-side retractor housing deformation occurred in all three tests.

2.2 Plymouth Reliant Responses

(1) Right-front passenger noncompliance with the HIC requirement of FMVSS 208 stemmed directly from head impact with the unpadded metal dashboard top cover.

(2) Excessive fore-aft occupant stroke (relative to the passenger compartment), combined with substantial upward/rearward dashboard intrusion, permitted the above contact to occur.

(3) The Plymouth Reliant has a relatively limited amount of available passenger compartment stroking distance (e.g., as provided by a dummy chest-to-dash measurement) compared to other cars in its size/weight class.

*Developmental sled testing later showed that seat cushion design constitutes a critical factor in occupant submarining response.

(4) The aforementioned dashboard intrusion seriously compromised the (somewhat limited) space available for the occupant to ride down the crash.

(5) Belt spool-off from the retractor is the principal mechanism responsible for excessive occupant stroking. Significant belt playout and head motion, at relatively low torso belt loadings, occur early in the event.

3.0 VALIDATION AND DEVELOPMENTAL SLED TESTING

Three separate series of sled tests were performed during the BSA program; these efforts are outlined in the ensuing subsections. Consistent with the prudent use of program monetary resources, no attempt is made to describe these activities in complete detail. Rather, the reader is referred to the original test reports which provide excellent, comprehensive documentation of all individual tests. Included therein are test objectives, a description of the occupant compartment interior systems configuration evaluated, electronic data, photographs, analyses and visual observations. High-speed movies of each event are in the possession of the NHTSA.

This final report presents a summary of significant sled test results, including FMVSS 208 occupant injury indicator information, in tabular format. The "best fix" occupant compartment interior systems modification concepts uncovered during each of the three series are also briefly discussed herein.

3.1 Phase I Plymouth Reliant Developmental Sled Tests

Ten (10) single-occupant (right-front passenger) sled tests were performed in this initial (Phase I) series of developmental testing. Complete results are documented in Reference 7.

As indicated in Table 2, the Phase I test series explored a number of different restraint system-related modifications/concepts in an effort to improve the unsatisfactory right-front passenger performance provided by this vehicle in a New Car Assessment (NCA) 35 mph flat frontal barrier crash test (Reference 4). The most promising of these consisted of a simple, 12-inch length reduction of its standard unibelt (Tests 2749 and 2755). This change substantially reduced the head stroke, belt spool-off from the retractor and HIC number relative to results generated in two replicate baseline (zero belt reduction)

Table 2

PHASE I PLYMOUTH RELIANT DEVELOPMENTAL SLED TEST RESULTS

RUN NO.	ΔV, TOTAL VELOCITY CHANGE (mph)	RESTRAINT SYSTEM CONFIGURATION	DUMMY DATA: H_R, MAX RESULTANT HEAD ACCELERATION		HIC, HEAD INJURY CRITERION			C_R[1], MAX. RESULTANT CHEST ACCELERATION		MAX. COMPRESSIVE FEMUR LOADS (lbs.)		MAX. HEAD DISPLACEMENT[3] (in.)	RESTRAINT SYSTEM DATA: MAXIMUM BELT SPOOL-OFF[4] (in.)	MAX. TORSO BELT LOAD (lbs.)	MAX. LAP BELT LOAD (lbs.)	REMARKS
			MAGN. (g's)	TIME (ms.)	MAGN.	TIMING ~ ms. t_1	TIMING ~ ms. t_2	MAGN. (g's)	TIME[2] (ms.)	LEFT	RIGHT					
2748	39.7	STANDARD	116	97	974	83	111	44	65/99[5]	190	90	21.0	4.4	1910	NA[6]	TOP OF HEAD GRAZED RIM OF METAL DASHBOARD TOP COVER.
2749	39.8	BELT SHORTENED 12 INCHES	82	86	778	77	115	47	61/74	220	80	19.3	2.8	2100	980	
2750	39.7	RETRACTOR SPOOL DIAMETER INCREASED 5/8 INCHES.	98	93	1130	72	119	50	65/78	160	110	20.7	4.6	2130	1570	
2751	39.7	RETRACTOR SPOOL DIAMETER INCREASED 5/8 INCHES; BELT SHORTENED 20 INCHES	79	89	992	65	112	49	62/80	410	540	17.5	2.3	2110	1180	
2752	40.0	IRVIN INDUSTRIES WEBBING CLAMP MOUNTED ON B-PILLAR IN PLACE OF D-RING	-	-	-	-	-	-	-	-	-	-	-	2200[7]	-	BELT FAILURE AT WEBBING CLAMP CAUSED UNRESTRAINED OCCUPANT MOTION
2753	39.8	RETRACTOR LOCKED UP PRE-TEST TO SIMULATE IDEALIZED WEBBING CLAMP.	95	92	1092	72	118	50	63/79	140	70	19.8	4.1	2080	1620	LOCK-UP ACTION NOT TOTALLY EFFECTIVE; BELT SPOOLED OFF RETRACTOR AFTER AN INITIAL 11 ms. DELAY.
2754	39.7	BELT SHORTENED 8 INCHES.	-	-	-	-	-	54	65/80	130	60	-	3.4	2180	1760	NECK FAILED IN TENSION/HEAD BROKE LOOSE (CRACK IN NECK OPENED UP AT ABOUT 73 ms.).
2755	39.7	BELT SHORTENED 12 INCHES. (REPEAT OF RUN 2749)	76	86	964	65	116	46	62/75	390	410	18.1	2.6	2170	1120	
2756	39.7	STANDARD. PADDING FROM PRODUCTION DASH TOP ADDED TO PROJECTING DASHBOARD RIM.	88	92	1341	70	113	54	62/81	420	650	20.8	4.7	2520	1160	NO HEAD-DASH CONTACT OCCURRED; EFFECTS OF PADDING ON HEAD RESPONSES NOT ASCERTAINED.
2757	39.7	BELT SHORTENED 8 INCHES. (REPEAT OF RUN 2754)	100	90	1492	68	145	50	64/79	160	60	20.2	4.0	2200	1600	

[1] EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2] THESE RESPONSES ALL EXHIBIT AT LEAST TWO COMPARABLE RELATIVE MAXIMUM VALUES. THE TIMES LISTED HEREIN REFLECT THE TIMING OF THE INITIAL PEAK ACCELERATION AND THE NEXT-HIGHEST VALUE.

[3] HORIZONTAL COMPONENT AT CLOSEST APPROACH TO DASHBOARD FRONT SURFACE.

[4] AT CLOSEST HEAD-DASH APPROACH.

[5] LOWER, INTERMEDIATE PEAK AT 81 ms.

[6] LEBOW LOAD CELL JAMMED AGAINST SEAT FRAME DURING EVENT, PRODUCING AN UNREALISTICALLY HIGH LOAD READING.

[7] BELT FAILURE LOAD.

configuration runs (Nos. 2748 and 2756).* However, in Calspan's opinion, the HIC numbers obtained in the belt-shortened Tests 2749 and 2755 (779 and 964, respectively) did not provide an adequate margin to assure successful occupant performance during the final Reliant crash test. Accordingly, we recommended that an additional (Phase II) series of developmental sled testing be performed (see Section 3.2).

It should be noted that the 12-inch belt-shortening modification also failed to prevent the passenger occupant from submarining during forward excursion in the compartment. This motion resulted in highly undesirable lap belt roping and associated penetration of the dummy's abdomen.

3.2 Phase II Plymouth Reliant Developmental Sled Tests

Although Phase II testing was specifically undertaken in an attempt to decrease the above-noted marginally satisfactory occupant HIC response, this effort also addressed other (interrelated) aspects of occupant performance: (1) further reduction of retractor belt spool-off and head displacement magnitudes and (2) minimization/elimination of occupant submarining and consequent lap belt roping/abdominal penetration. The results of this effort are documented in Reference 8.

As indicated in Table 3, Phase II testing demonstrated that the Reliant's right-front passenger performance could be considerably enhanced by employing two basic modifications: (1) addition of a Takata Kojyo webbing clamp mounted near the intersection of the B-pillar and roof header and substitution of 8%-elongation Takata Kojyo webbing for the production belt material in the standard Reliant restraint system; (2) stiffening the front portion of the Reliant's relatively "soft" bench seat cushion. In the three tests which utilized these system changes (Nos. 2844, 2846 and 2847), the modified restraint system limited

*A slight improvement in maximum resultant chest acceleration was also noted.

Table 3

PHASE II PLYMOUTH RELIANT DEVELOPMENTAL SLED TEST RESULTS

RUN NO.	ΔV, TOTAL VELOCITY CHANGE (mph)	CONFIGURATION		DUMMY DATA													RESTRAINT SYSTEM DATA			REMARKS
		RESTRAINT SYSTEM	SEAT	H_R, MAX. RESULTANT HEAD ACCELERATION		HIC, HEAD INJURY CRITERION			C_R[1], MAX. RESULTANT CHEST ACCELERATION		MAX. COMPRESSIVE FEMUR LOADS (lbs.)		MAX. PELVIC ACCELERATION (g's)		MAX. HEAD DISPLACEMENT[3] (in.)	MAX. PELVIC DISPLACEMENT[4] (in.)	MAXIMUM BELT SPOOL-OFF (in.)	MAX. TORSO BELT LOAD (lbs.)	MAX. LAP BELT LOAD (lbs.)	
				MAGN. (g's)	TIME (ms.)	MAGN.	TIMING ~ ms. t_1	TIMING ~ ms. t_2	MAGN. (g's)	TIME[2] (ms.)	LEFT	RIGHT	HORIZ. COMP.	VERT. COMP.						
2843	40.3	BELT SHORTENED 12 INCHES	STIFFENED (MOD. 1)	77	95	795	68	127	45	66/83	260[5]	100	50	55	21.3	9.6	2.1	2130	1730	
2844	40.0	TAKATA KOJYO WEBBING/ WEBBING CLAMP; CLAMP MOUNTED ON B-PILLAR AFT AND ABOVE D-RING POSITION	STIFFENED (MOD. 1)	70	89	531	61	126	42	62/78	250[5]	50	44	52	16.7	8.3	0.5	2120	1750	
2845	40.5	AS PER 2844.	STANDARD	78 84[6]	89 165	1042 1489[7]	59 57	119 174	43	61/85[8]	320	670	19	50	16.0	14.7	0.5	2340	1630	OCCUPANT SUBMARINED/LAP BELT ROPED AND PENETRATED THE ABDOMINAL REGION. SMALL CRACK OPENED UP NEAR BASE OF DUMMY'S NECK. (NEW NECK INSTALLED FOR SUBSEQUENT RUNS)
2846	40.6	AS PER 2844.	STIFFENED (MOD. 2)	51	89	562	60	127	41	81/80	40	80	33	34	15.8	8.9	0.2	2380	1610	
2847	40.5	AS PER 2844.	STIFFENED (MOD. 2)	59	89	634	64	126	43	63/78	60	50	33	35	16.7	7.6	0.1	2550	1730	REPEAT OF RUN 2846.

[1] EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2] THESE RESPONSES ALL EXHIBIT AT LEAST TWO COMPARABLE RELATIVE MAXIMUM VALUES. THE TIMES LISTED HEREIN REFLECT THE TIMING OF THE INITIAL PEAK ACCELERATION AND THE NEXT-HIGHEST VALUE.

[3] HORIZONTAL COMPONENT AT CLOSEST APPROACH TO DASHBOARD FRONT SURFACE.

[4] HORIZONTAL COMPONENT.

[5] ESTIMATED VALUE: DATA TRACE CONTAMINATED BY NOISE SPIKES.

[6] CAUSED BY HEAD CONTACT WITH TOP OF SEAT BACK/END OF HEADREST ON REBOUND.

[7] INCLUDES THE EFFECTS OF HEAD-SEAT BACK/HEADREST CONTACT.

[8] LOWER, INTERMEDIATE PEAK AT 71 ms.

belt spool-off to minimal levels, provided early occupant upper torso restraint and significantly reduced occupant head excursion, insuring avoidance of head contact with an intruding dashboard surface in an actual 35 mph flat frontal barrier crash test. The stiffened seat cushion provided badly needed pelvic restraint to prevent occupant submarining motion and associated lap belt roping/abdominal penetration. All occupant injury indicator parameters obtained in these three tests were all well below FMVSS 208-stipulated limits.

3.3 Plymouth Horizon Validation and Developmental Sled Tests

A total of seven (7) double-occupant validation and developmental sled tests of the Plymouth Horizon were performed to simulate the 70 mph closing speed, NCA car-to-car head-on impact with a Ford Mustang (Reference 2). This effort was completed in two stages: (1) a combination validation/developmental series consisting of four tests performed in August 1981 (Nos. 2807-2810) and (2) a strictly developmental series of three tests performed in March 1982 (Nos. 2953-2955). Results from all seven tests are documented in Reference 9.

The initial test series basically provided occupant and restraint/occupant compartment interior systems performance data for the baseline Horizon configuration. All four tests utilized production bucket seats on both the driver-side and right-front passenger side. Both production and modified unibelt restraint systems were employed in this series. In addition, the steering wheel position was adjusted to simulate various degrees of column/wheel intrusion in the passenger compartment.

Table 4 presents a summary of the results obtained from the driver-side exposures of Tests 2807-2810. The first three validation runs led to the selection of Test 2808 as the baseline Horizon driver configuration.* Developmental Test 2810, which used a separate Takata Kojyo webbing clamp assembly behind a reverse-mounted production Horizon retractor, showed that this clamp

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*None of these runs provided an entirely satisfactory overall simulation of the driver HIC response, resultant chest acceleration or kinematics/body contacts exhibited in the NCA Horizon-Mustang crash test. Test 2808 was, however, so selected because its zero-intruded steering wheel position allowed for the generation of the highest occupant velocity change during crash ride down.

Table 4

PLYMOUTH HORIZON SLED TEST RESULTS: DRIVER OCCUPANT
SLED TESTS 2807-2810

RUN NO.	ΔV, TOTAL VELOCITY CHANGE (mph)	CONFIGURATION			DUMMY DATA													RESTRAINT SYSTEM DATA			REMARKS
		RESTRAINT SYSTEM	SEAT	STEERING WHEEL POSITION	H_R, MAX. RESULTANT HEAD ACCELERATION		HIC, HEAD INJURY CRITERION			C_R[1], MAX. RESULTANT CHEST ACCELERATION		MAX. COMPRESSIVE FEMUR LOADS (lbs.)		MAX. PELVIC ACCELERATION (g's)		VISIBLE BODY CONTACTS		MAXIMUM BELT SPOOL-OFF (in.)	MAX TORSO BELT LOAD (lbs.)	MAX LAP BELT LOAD (lbs.)	
					MAGN. (g's)	TIME (ms.)	MAGN. (g's)	TIMING~ms. t_1	t_2	MAGN. (g's)	TIME (ms.)	LEFT	RIGHT	HORIZ. COMP.	VERT. COMP.	HEAD	CHEST/ ABDOMEN				
2807	42.3	PRODUCTION	PRODUCTION	MAXIMUM INTRUSION	140[2] (126)	77	1525	65	85	54	62	300	420	20	9	FOREHEAD WITH UPPER STEERING WHEEL RIM.	UPPER CHEST WITH LOWER WHEEL RIM.	3.5	1410	1850	
2808	42.6	PRODUCTION	PRODUCTION	ZERO INTRUSION	270[2] (160)	90	2350	83	93	60	79[3]	110	420	21	9	FOREHEAD WITH UPPER WHEEL RIM. FACE WITH WHEEL HUB.	LOWER CHEST WITH LOWER WHEEL RIM.	4.0	1850	1980	
2809	42.5	PRODUCTION	PRODUCTION	ONE-THIRD MAXIMUM INTRUSION	240[2] (183)	85	2400	82	87	65	63	720	280	19	10	GRAZING CONTACT WITH UPPER WHEEL RIM, FACE WITH WHEEL HUB	LOWER CHEST WITH LOWER WHEEL RIM.	4.5	1610	1920	
2810	42.2	PRODUCTION RETRACTOR AND TAKATA KOJYO WEBBING CLAMP	PRODUCTION	MAXIMUM INTRUSION	–		–			–		–	–	–	–	–	–	–	–	–	DATA NOT VALID ROOF RAIL MOUNT FOR RESTRAINT SYSTEM BENT DURING TEST.

[1]EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2]SHORT-DURATION SPIKE CAUSED BY HEAD CONTACT WITH THE STEERING WHEEL THREE-MILLISECOND CUTOFF VALUE SHOWN IN PARENTHESIS.

[3]SLIGHTLY LOWER PEAK AT 64 ms.

was capable of substantially reducing belt spool-off and limiting occupant head displacement. Early upper-body restraint, however, failed to prevent the dummy from submarining during its forward excursion. This clearly indicated the need for increased occupant pelvic restraint.

Passenger-side results from the initial Horizon sled test series are shown in Table 5. Unfortunately, valid, incontrovertible data was obtained in only one of the four tests. The results of the other three tests were invalid because of a belt system integrity failure. In the latter tests, the production seat belt buckle assembly unlatched during occupant forward excursion, resulting in various degrees of partial (or nonexistent) occupant restraint at different event times. This problem, together with buck structural failures in Test 2810 and a higher priority placed in the Reliant part of the program by the NHTSA, caused the Horizon sled test effort to be postponed until March 1982.

The only valid passenger-side exposure (Test 2808) employed a production restraint system with its overall belt length shortened 6 inches. Because of program economy considerations and since results obtained with a full-length belt would not be expected to differ significantly from that generated in this run,* no further validation-type tests were performed when testing resumed. Thus Test 2808 was selected as the baseline Horizon passenger configuration. Clearly, if occupant performance were improved relative to Test 2808, it follows that the true baseline configuration (i.e., a full-length belt) would be similarly improved.

Test 2808 results clearly indicated the need for occupant compartment interior systems which could simultaneously (1) limit head and pelvic excursions, (2) prevent excessive head acceleration and HIC responses and (3) reduce or at least maintain the present, acceptable chest acceleration response level.

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*Occupant stroke and head acceleration responses would probably be higher in such a test.

Table 5

PLYMOUTH HORIZON SLED TEST RESULTS: PASSENGER OCCUPANT SLED TESTS 2807-2810

RUN NO.	ΔV, TOTAL VELOCITY CHANGE (mph)	CONFIGURATION		DUMMY DATA													RESTRAINT SYSTEM DATA			REMARKS
		RESTRAINT SYSTEM	SEAT	H_R, MAX. RESULTANT HEAD ACCELERATION		HIC, HEAD INJURY CRITERION			C_R[1], MAX. RESULTANT CHEST ACCELERATION		MAX. COMPRESSIVE FEMUR LOADS (lbs.)		MAX. PELVIC ACCELERATION (g's)		MAX. HEAD DISPLACEMENT[2] (in.)	MAX. PELVIC DISPLACEMENT[3] (in.)	MAXIMUM BELT SPOOL-OFF (in.)	MAX. TORSO BELT LOAD (lbs.)	MAX. LAP BELT LOAD (lbs.)	
				MAGN. (g's)	TIME (ms.)	MAGN. (g's)	TIMING ~ ms. t_1	TIMING ~ ms. t_2	MAGN. (g's)	TIME (ms).	LEFT	RIGHT	HORIZ. COMP.	VERT. COMP.						
2807	42.3	PRODUCTION	PRODUCTION	–		–			–		–	–	–	–	–	–	–	–	–	DATA NOT VALID BELT BUCKLE UNLATCHED DURING OCCUPANT FORWARD MOTION.
2808	42.6	PRODUCTION. BELT LENGTH SHORTENED 6 INCHES	PRODUCTION	93 (106)[4]	95 (166)	1711 (2198)[5]	68 (68)	150 (183)	52	66	150	390	28	13	21.6	13.9	3.8	2540	1610	OCCUPANT SUBMARINED: LAP BELT ROPED AND PENETRATED ABDOMINAL REGION. BACK OF OCCUPANT'S HEAD CONTACTED THE TOP OF THE SEAT BACK/END OF THE HEADREST ON REBOUND.
2809	42.5	PRODUCTION: RETRACTOR REPOSITIONED 3 INCHES REARWARD	PRODUCTION	–		–			–		–	–	–	–	–	–	–	–	–	DATA NOT VALID BELT BUCKLE UNLATCHED DURING OCCUPANT FORWARD MOTION.
2810	42.2	PRODUCTION RETRACTOR AND TAKATA KOJYO WEBBING CLAMP	PRODUCTION	–		–			–		–	–	–	–	–	–	–	–	–	DATA NOT VALID BELT BUCKLE UNLATCHED DURING OCCUPANT FORWARD MOTION.

[1] EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2] HORIZONTAL COMPONENT AT CLOSEST APPROACH TO DASHBOARD FRONT SURFACE.

[3] HORIZONTAL COMPONENT.

[4] CAUSED BY HEAD CONTACT WITH THE SEAT BACK/END OF HEADREST ON REBOUND.

[5] INCLUDES THE EFFECTS OF HEAD-SEAT BACK/HEADREST CONTACT.

The final three Horizon sled tests (Nos. 2853-2855) utilized restraint system/occupant compartment modifications similar to those employed in the highly successful Phase II Reliant sled test series. In the Horizon effort, a Takata Kojyo combination retractor/webbing clamp device, including 8%-elongation Takata Kojyo webbing, was substituted for the standard Horizon belt restraint system in order to limit occupant upper-body stroke. Also, the front portion of both bucket seat cushions were stiffened in an attempt to minimize occupant pelvic displacement. Two seat cushion modifications were evaluated; the second one (Mod. 2) provided the desired pelvic restraint.

Tables 6 and 7 present the results of these tests. Examination of these tables shows that occupant injury indicator parameters obtained in those tests which featured the Takata Kojyo restraint system and the Mod. 2 seat cushion were all well within FMVSS 208-stipulated limits.* Moreover, these changes also eliminated the inherent tendency for both occupants to submarine and the lap belt to rope by limiting forward pelvic excursion. Furthermore, occupant head excursion was well controlled, insuring avoidance of head contact with an intruding dashboard or steering wheel surface in an actual 35 mph car-to-car head-on collision. The kinematics of both occupants were also excellent during forward excursion and rebound motion. The unsatisfactory HIC results from driver-side Test 2955 (steering wheel in its two-thirds intruded position), however, indicated that successful driver occupant performance in such a collision environment mandates that steering wheel intrusion into the occupant compartment be minimized to the greatest extent feasible.

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*Tests 2954 and 2955 for the passenger-side exposure; Test 2954 (steering wheel in unintruded position) for the driver-side exposure.

Table 6

PLYMOUTH HORIZON SLED TEST RESULTS: DRIVER OCCUPANT SLED TESTS 2953-2955

RUN NO.	Δv, TOTAL VELOCITY CHANGE (mph)	CONFIGURATION: RESTRAINT SYSTEM	CONFIGURATION: SEAT	CONFIGURATION: STEERING WHEEL POSITION	DUMMY DATA: H_R, MAX. RESULTANT HEAD ACCELERATION: MAGN. (g's)	H_R: TIME (ms.)	HIC, HEAD INJURY CRITERION: MAGN. (g's)	HIC: TIMING ~ ms. t_1	HIC: TIMING ~ ms. t_2	C_R[1], MAX. RESULTANT CHEST ACCELERATION: MAGN. (g's)	C_R: TIME (ms.)	MAX. COMPRESSIVE FEMUR LOADS (lbs.): LEFT	FEMUR: RIGHT	MAX. PELVIC ACCELERATION (g's): HORIZ. COMP.	PELVIC: VERT. COMP.	VISIBLE BODY CONTACTS: HEAD	VISIBLE BODY CONTACTS: CHEST/ ABDOMEN	RESTRAINT SYSTEM DATA: MAXIMUM BELT SPOOL-OFF (in.)	MAX. TORSO BELT LOAD (lbs.)	MAX. LAP BELT LOAD (lbs.)	REMARKS
2953	42.2	TAKATA KOJYO RETRACTOR/ WEBBING CLAMP ASSEMBLY	STIFFENED (MOD. 1)	ZERO INTRUSION	–		–			–		–	–	–	–	–	–	–	–	–	RETRACTOR CLAMP HOUSING SEPARATED FROM MOUNTING PLATE, RESULTING IN UNRESTRAINED OCCUPANT MOTION.
2954	42.5	AS PER 2953	STIFFENED (MOD. 2)	ZERO INTRUSION	≈ 62[2]	≈90	619	47	121	46	54	80	60	29	39	NONE	NONE	0.5	1770	1270	
2955	42.5	AS PER 2953	STIFFENED (MOD. 2)	TWO-THIRDS MAX. INTRUSION	146[3] (128)	88	1230	86	91	49	60	90	20	30	38	FACE WITH STEERING WHEEL HUB	UPPER CHEST WITH LOWER STEERING WHEEL RIM	0.5	1880	1200	LOWER STEERING WHEEL RIM SUSTAINED MINIMAL PERMANENT BENDING DEFORMATION

[1] EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2] VALUE QUOTED EXCLUDES AN ANOMALOUS NOISE SPIKE PRESENT IN THE HEAD Z ACCELERATION DATA.

[3] SHORT-DURATION SPIKE CAUSED BY HEAD CONTACT WITH THE WHEEL HUB. THREE MILLISECOND CUTOFF VALUE SHOWN IN PARENTHESIS.

Table 7

PLYMOUTH HORIZON SLED TEST RESULTS: PASSENGER OCCUPANT SLED TESTS 2953-2955

RUN NO.	ΔV, TOTAL VELOCITY CHANGE (mph)	CONFIGURATION		DUMMY DATA													RESTRAINT SYSTEM DATA			REMARKS
		RESTRAINT SYSTEM	SEAT	H_R, MAX. RESULTANT HEAD ACCELERATION		HIC, HEAD INJURY CRITERION			C_R[1], MAX. RESULTANT CHEST ACCELERATION		MAX. COMPRESSIVE FEMUR LOADS (lbs.)		MAX. PELVIC ACCELERATION (g's)		MAX. HEAD DISPLACEMENT[2] (in.)	MAX. PELVIC DISPLACEMENT[3] (in.)	MAXIMUM BELT SPOOL-OFF (in.)	MAX. TORSO BELT LOAD (lbs.)	MAX LAP BELT LOAD (lbs.)	
				MAGN. (g's)	TIME (ms.)	MAGN. (g's)	TIMING ~ ms. t_1	TIMING ~ ms. t_2	MAGN. (g's)	TIME (ms).	LEFT	RIGHT	HORIZ. COMP.	VERT. COMP.						
2953	42.2	TAKATA KOJYO RETRACTOR/ WEBBING CLAMP ASSEMBLY	STIFFENED (MOD 1)	NA[4]		NA[4]			44	59	220	220[5]	24	37	15.6	12.0	1.0	1990	1680	OCCUPANT SUBMARINED LAP BELT ROPED AND PENETRATED ABDOMINAL REGION. BACK OF OCCUPANT'S HEAD CONTACTED THE TOP OF THE SEAT BACK/ END OF THE HEAD REST ON REBOUND, PRODUCING A HIGH, SECONDARY ACCELERATION PEAK.
2954	42.5	AS PER 2953	STIFFENED (MOD. 2)	56	90	616	53	126	43	59	160	220[5]	31	46	16.4	5.5	0.5	2150	1650	
2955	42.5	AS PER 2953	STIFFENED (MOD. 2)	65	91	677	57	121	43	58	80	210[5]	22	53	14.9	6.0	0.5	2020	1050	REPEAT OF RUN 2954

[1]EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2]HORIZONTAL COMPONENT AT CLOSEST APPROACH TO DASHBOARD FRONT SURFACE.

[3]HORIZONTAL COMPONENT.

[4]H_R AND HIC RESULTS ARE QUESTIONABLE: HEAD X ACCELERATION DATA CONTAIN SEVERAL DISCONTINUITIES/SPIKES CAUSED BY INTERMITTENT GROUNDING OF AN ACCELEROMETER WIRE DURING THE EVENT.

[5]VALUE QUOTED DISCOUNTS ANOMALOUS NOISE SPIKES PRESENT IN THE DATA.

4.0 FULL-SCALE CRASH TESTING

A 1982 Plymouth Horizon TC-3 2-door hatchback and a 1981 Plymouth Reliant 2-door sedan were each subjected to nominal 35 mph frontal crash tests in order to evaluate the effectiveness of selected occupant compartment interio system changes developed during previous sled testing in an actual collision environment. Calspan attempted to duplicate, to the extent feasible, the test conditions for the corresponding original NCA crash test. Occupant performance data were obtained for two Part 572 50th percentile male anthropomorphic test devices (ATDs) placed in the driver and right-front seating positions of the test vehicles. All seats were in the mid-position on their respective seat tracks.

The following two subsections briefly summarize, in tabular format, the occupant-related results obtained for the compartment-modified vehicles in the two BSA program crash tests. Identical information generated in the corresponding NCA tests is also presented in these tables, enabling a direct comparison of occupant protection provided by both the baseline (NCA) and compartment-modified (BSA) cars.

Complete tests results, including written and pictorial descriptions of the modified compartment systems, electronic data, photographs, pre- and post-test measurements, analyses, and visual observations are documented in two separate test reports. High-speed movies of both crash tests are in the posses of the NHTSA.

4.1 Plymouth Reliant Flat Frontal Barrier Crash Test

A production 1981 Plymouth Reliant 2-door sedan was subjected to a 35.3 mph flat frontal barrier crash test on October 19, 1981. The Reliant was equipped with a Calspan-developed, modified front bench seat cushion and 3-point belt restraint systems.* A complete description of these systems, as well as all test results, is provided in Reference 10. For the convenience of the reader, however, the above modifications are described briefly in the ensuing three paragraphs. Also, electronic data recorded during this test are presented in Appendices A, B and C of this report.

The Reliant's production unibelt restraint system was modified by (1) the installation of a Takata Kojyo webbing clamp and conventional belt guide loop near the B-pillar; (2) removal of the standard-equipment, B-pillar-mounted D-ring; and (3) substitution of 8%-elongation Takata Kojyo webbing for the thinner, 7%-elongation production Reliant webbing. Photographs of the production and Reliant-adapted versions of the Takata Kojyo webbing clamp are presented in Figure 1.

The clamp and a conventional belt guide loop were mounted on a specially-designed bracket, depicted in Figure 2. The bracket was bolted in three places to locally reinforced regions of the B-pillar and side roof rail (see Figure 3). Various views of the passenger-side webbing clamp system and resulting belt configuration are depicted in Figure 4. It can be seen that the belt guide loop serves to remove an inherent belt twist between the production retractor (mounted at the base of the B-pillar) and the webbing clamp. Pre-test photographs of the modified restraint system belt configuration in place around the driver and passenger occupants are presented in Figure 5.

The production Reliant front bench seat cushion was stiffened along its front edge in a rather straightforward manner. Four mild steel angle sections were welded to the underside of the existing cushion frame and the space between it and the cushion springs filled with a single, 3-inch thick shaped piece of closed-cell polystyrene insulation board;** this fill material

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*Both the driver and the right-front passenger were restrained with the same modified belt systems.

**Dow Chemical Styrofoam SM, with a density of 2.1 $lbs./ft.^3$, was used.

PRODUCTION VERSION

MODIFIED VERSION USED IN PLYMOUTH RELIANT

Figure 1 TAKATA KOJYO WEBBING CLAMP

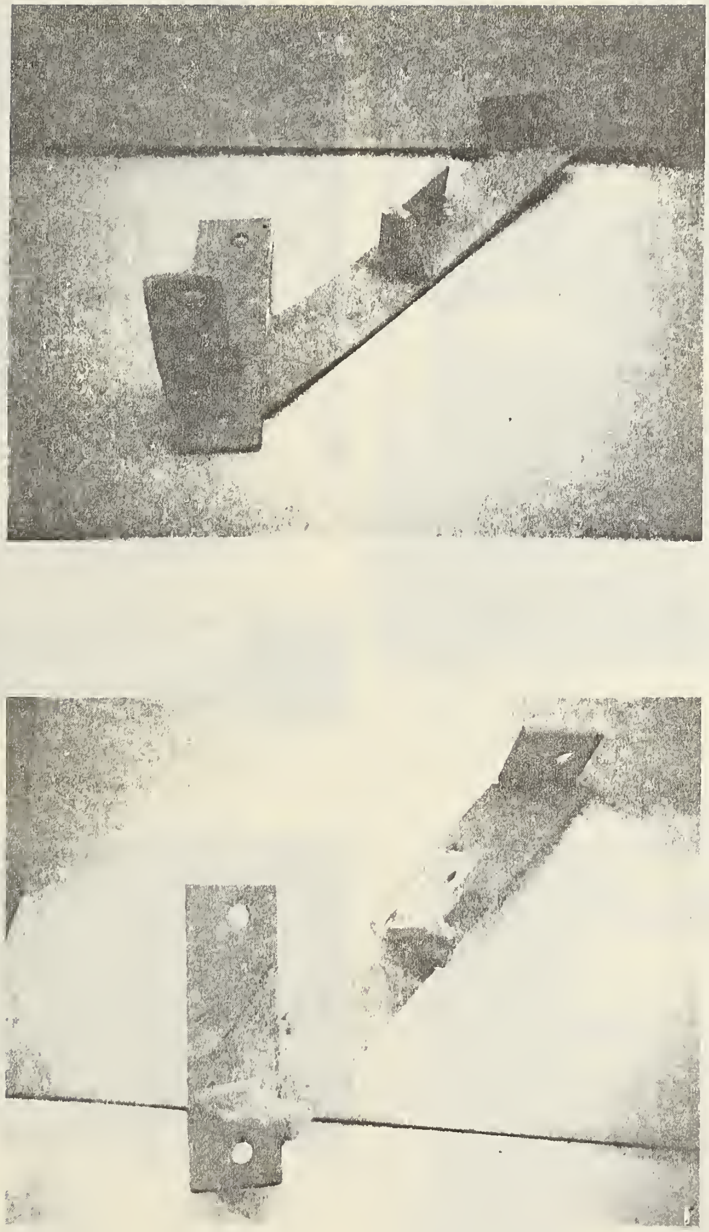
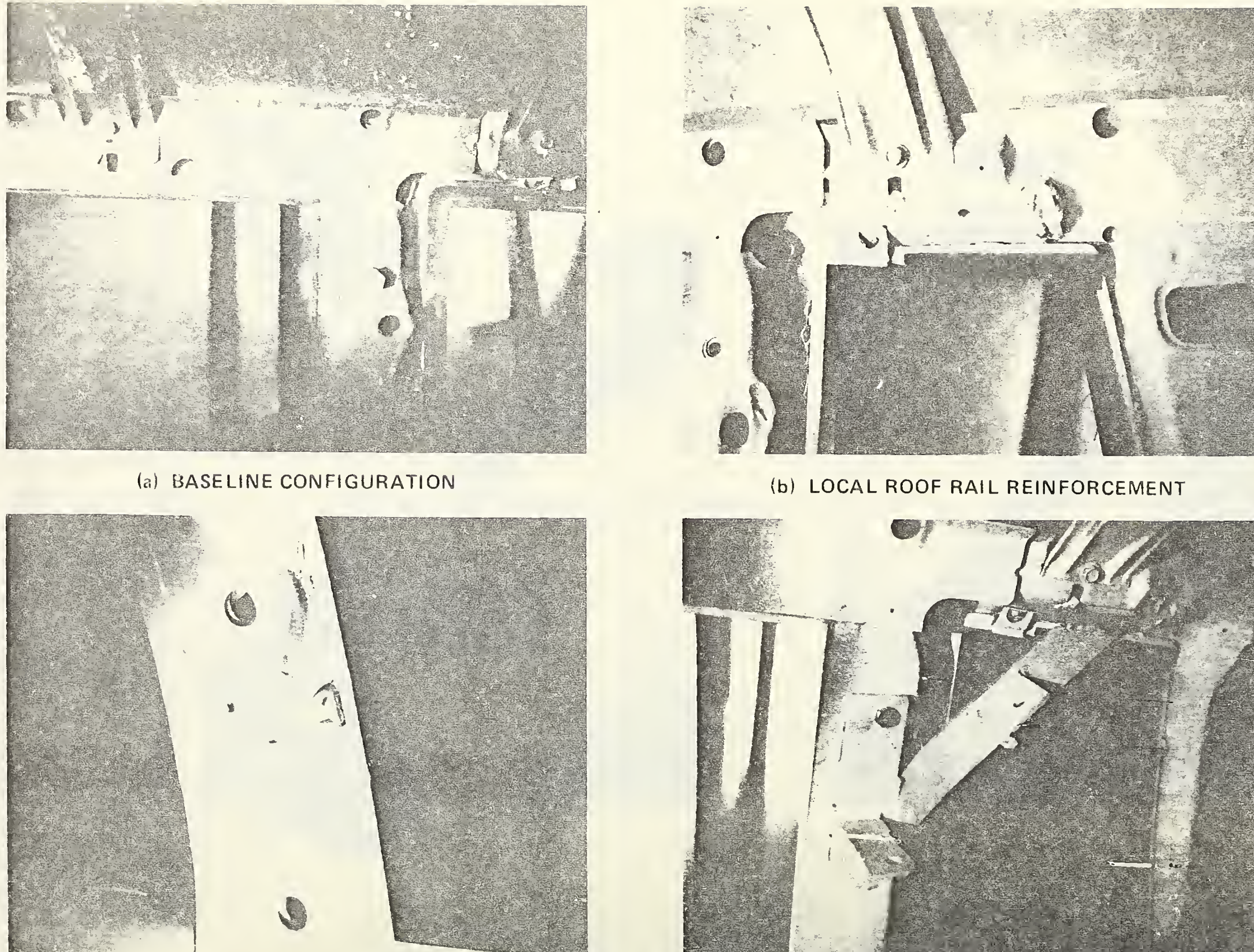


Figure 2 PLYMOUTH RELIANT WEBBING CLAMP MOUNTING BRACKET



(a) BASELINE CONFIGURATION

(b) LOCAL ROOF RAIL REINFORCEMENT

(c) LOCAL B-PILLAR REINFORCEMENT

(d) WEBBING CLAMP MOUNTING BRACKET INSTALLATION

Figure 3 PLYMOUTH RELIANT B-PILLAR/ROOF RAIL MODIFICATIONS

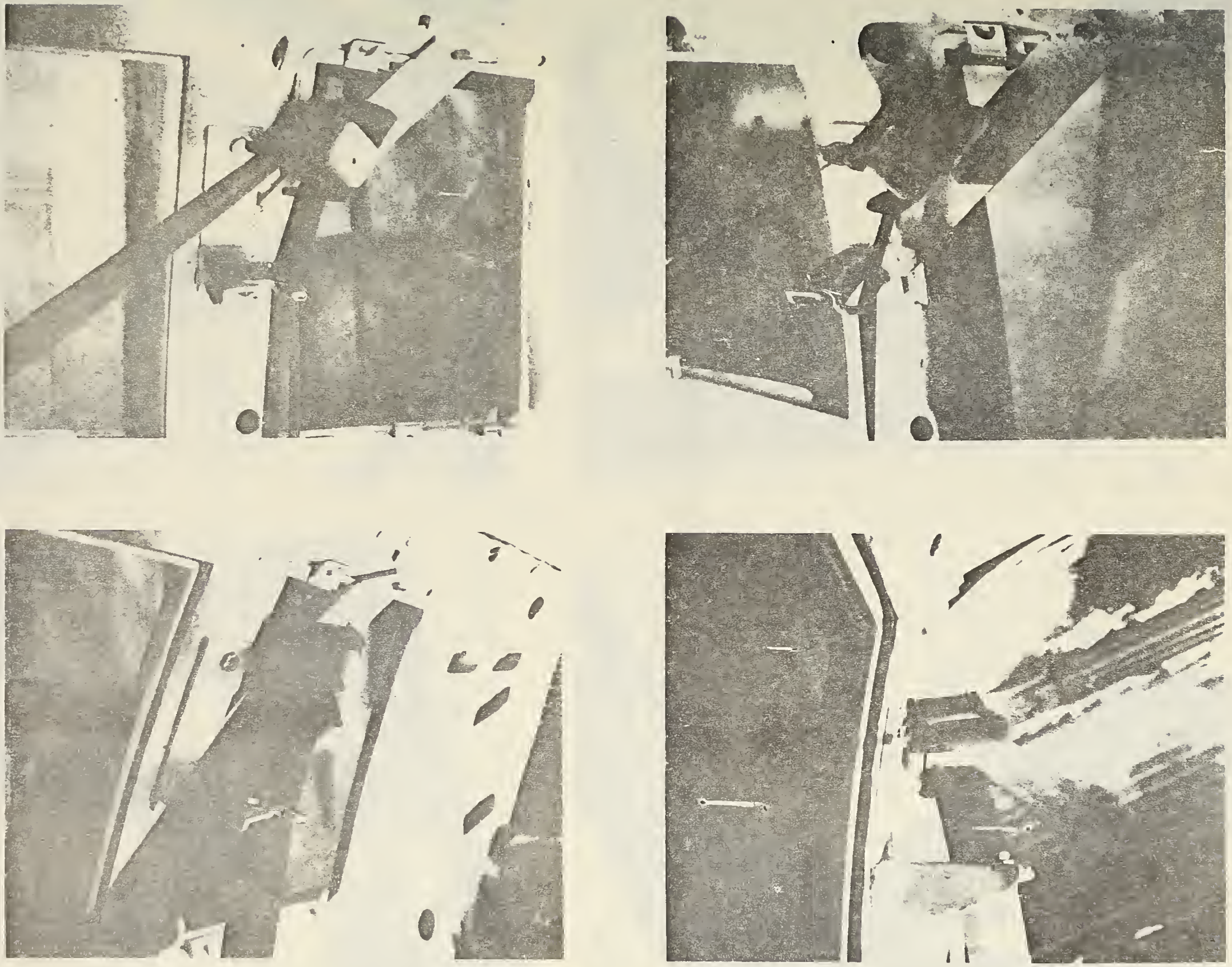
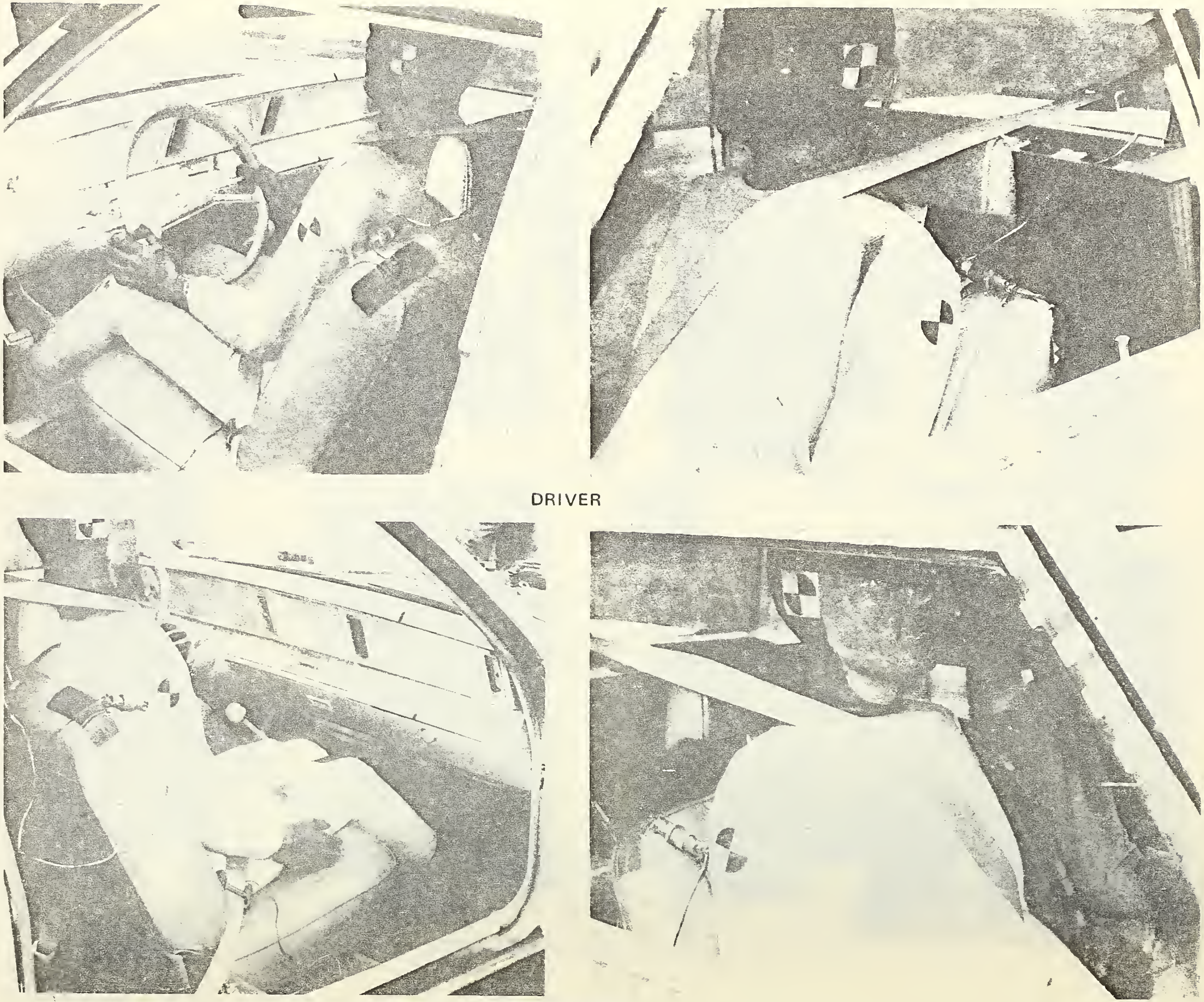


Figure 4 PLYMOUTH RELIANT WEBBING CLAMP SYSTEM/BELT CONFIGURATION



DRIVER

PASSENGER

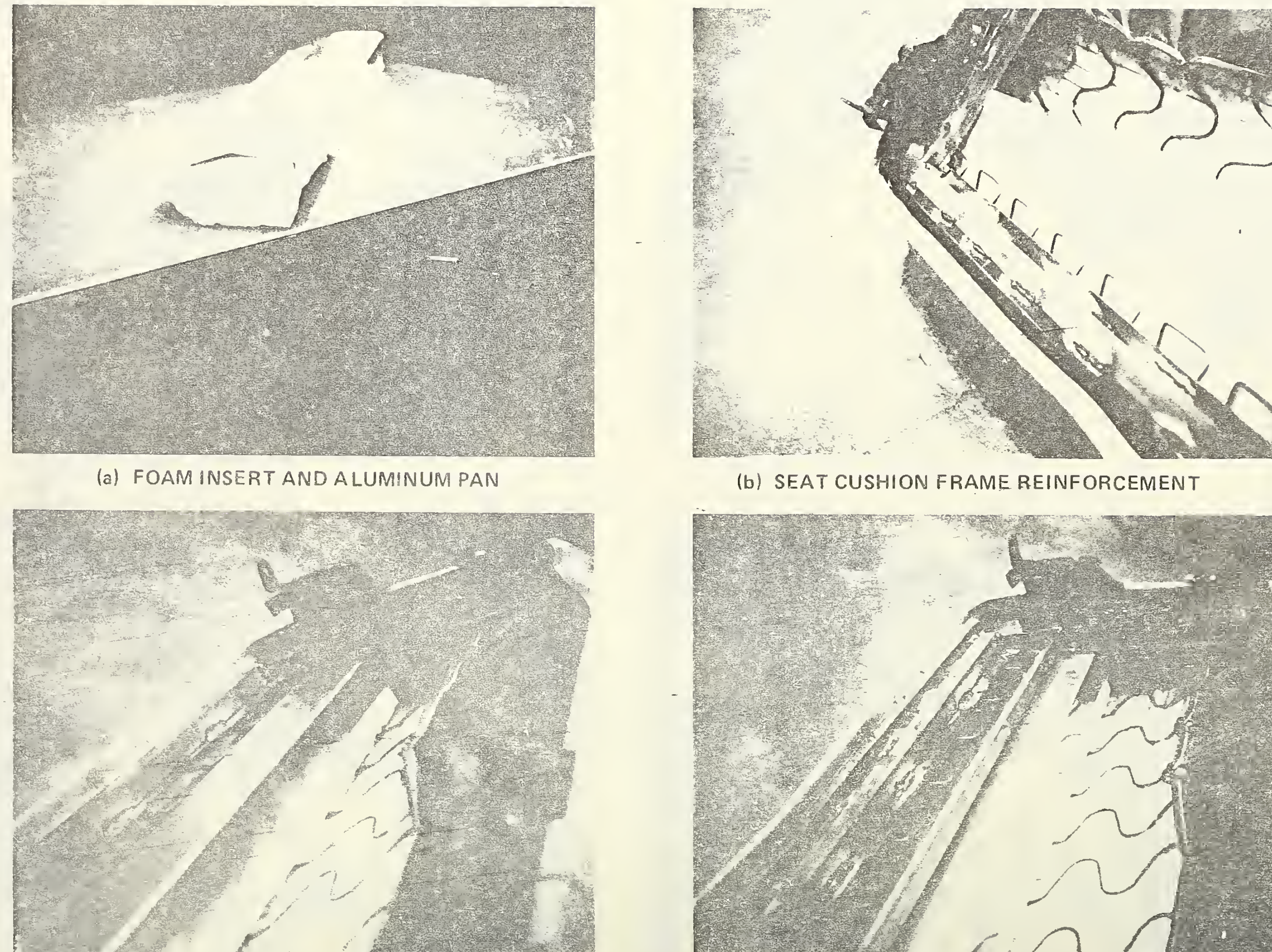
Figure 5 PRE-TEST BELT CONFIGURATION: MODIFIED PLYMOUTH RELIANT RESTRAINT SYSTEM extended about 8 inches back from the inner cushion front end. Covering the foam over most of its lower surface was a contoured, 0.040-inch thick sheet of 2024 aluminum. Figure 6 depicts the components and various stages of construction of the cushion assembly used in the crash-tested Reliant.

Table 8 presents a summary of Reliant driver responses in both the BSA and NCA barrier impacts. With the possible exception of a low-severity head contact with the upper steering wheel rim,* the driver in the BSA test exhibited excellent responses in all aspects of occupant performance. Occupant injury indicators were all well below the allowable values stipulated by FMVSS 208. Moreover, the maximum resultant head and chest accelerations (i.e., H_R and C_R, respectively) and HIC number were substantially lower than the already satisfactory magnitudes recorded in the NCA test. On a percentage basis, the BSA HIC and C_R were 63 percent and 45 percent below their allowable limits while their NCA counterparts were 40 percent and 13 percent below these same respective values. Left and right BSA femur loads were respectively 24 percent and 56 percent below the maximum allowable loading compared to 56 percent and 72 percent below for the corresponding NCA magnitudes.

High-speed films and post-test inspection of the dummy and belt configuration disclosed the absence of lap belt roping/penetration of the driver dummy's abdominal region. The films also showed a maximum retractor belt spool-off of less than 1/4 inch for the BSA test, appreciably less than the approximate 3 inch belt playout recorded in the NCA test at the time of initial head-wheel rim contact.

Unfortunately, an incontrovertible assessment of the Reliant right-front passenger performance in the subject crash test could not be made because of the occurrence of a bizarre restraint system component failure and an unrelated critical head accelerometer malfunction. The production webbing

*As borne out by the head acceleration and HIC number values, driver head contact with the steering wheel was more severe in the NCA test than in its BSA counterpart.



(a) FOAM INSERT AND ALUMINUM PAN

(b) SEAT CUSHION FRAME REINFORCEMENT

(c) FOAM AND PAN INSTALLED BETWEEN CUSHION SPRINGS AND REINFORCED FRAME

(d) COMPLETED CUSHION MODIFICATION: ADDITIONAL CROSSMEMBER INSTALLED

Figure 6 PLYMOUTH RELIANT MODIFIED SEAT CUSHION ASSEMBLY

Table 8

PLYMOUTH RELIANT DRIVER RESPONSES IN 35 MPH FLAT FRONTAL BARRIER CRASH TESTS

TEST & VEHICLE IMPACT VELOCITY	MAX. RESULTANT HEAD ACCELERATION		HIC, HEAD INJURY CRITERION			MAX. RESULTANT CHEST ACCELERATION[1]		MAX. FEMUR LOADS (lbs)		VISIBLE BODY CONTACTS		BELT SPOOL-OFF AT INITIAL HEAD WHEEL RIM CONTACT (in)	REMARKS
	MAGN. (g's)	TIME (ms)	MAGN.	TIMING~ms t_1	TIMING~ms t_2	MAGN (g's)	TIME[3] (ms)	LEFT	RIGHT	HEAD	CHEST/ABDOMEN		
NEW CAR ASSESSMENT (34.8 mph)	86[2] (70)	65	605	65	104	52	60/86	1000	640	FOREHEAD WITH UPPER STEERING WHEEL RIM. SLIGHT HEAD CONTACT WITH TOP OF UPPER DASHBOARD FOLLOWING STEERING WHEEL/COLUMN COLLAPSE.	ABDOMEN INTO LOWER STEERING WHEEL RIM. CHEST INTO WHEEL HUB	≈ 3	EXTENSIVE BENDING OF LOWER STEERING WHEEL RIM. INERTIA-SENSITIVE SEAT BACK FAILED TO LOCK UP.
PRODUCTION BELT SYSTEM ASSEMBLY (35.3 mph)	71[2] (53)	93	367	53	115	33	72/96	1720	980	LOWER FOREHEAD WITH UPPER STEERING WHEEL RIM	ABDOMEN INTO LOWER STEERING WHEEL RIM	$< 1/4$	NEGLIGIBLE STEERING WHEEL RIM DEFORMATION. SEAT MOVED FORWARD RELATIVE TO TRACK

[1] EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2] SHORT-DURATION SPIKE (LESS THAN 2 MILLISECONDS WIDE) CAUSED BY IMPACT WITH STEERING WHEEL RIM. APPROXIMATE THREE MILLISECOND CUTOFF MAGNITUDES SHOWN IN PARENTHESES.

[3] THESE RESPONSES EXHIBIT TWO COMPARABLE RELATIVE MAXIMUM VALUES. THE TIMES LISTED HEREIN REFLECT THE TIMING OF THE INITIAL PEAK ACCELERATION AND THE NEXT HIGHEST VALUE

of the tunnel-mounted unibelt buckle assembly was cut by the edge of the back, transverse production seat cushion frame member,* causing the belt to break at about 75 milliseconds into the impact. As a result, restraint system integrity was lost and the occupant subsequently experienced head contact with the unpadded metal rim of the dashboard top cover.

Compounding this problem, the passenger head Z acceleration-time history (H_Z) was contaminated by inexplicable noise spikes over the entire length of the data trace,** precluding the calculation of a HIC number from all three head acceleration components.

As discussed in Reference 10, Calspan believes, based on the arguments presented therein, that the passenger occupant complied with the HIC requirements of FMVSS 208. This contention is based on a combination of evidence comprised of both high-speed film and electronic data, physical mechanics principles and sound engineering judgment.

The belt failure was also unfortunate in that the full stroke-limiting capabilities of the modified restraint system could not be demonstrated completely for the passenger occupant. Fortunately, this feature was fully evident in the driver's excellent kinematics and injury indicator responses.

Inspection of Table 9 shows that the BSA test passenger dummy experienced a maximum resultant chest acceleration of only 38 g's, considerably lower than the marginally acceptable 59 g magnitude sustained by the NCA test occupant. The former value reflects the effects of two events which occurred

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*The protective plastic sheath enclosing the webbing between its anchorage point and the buckle was removed, as per standard practice, to enable the attachment of a Lebow load cell to obtain the inboard-side lap belt load-time history.

**Subsequent investigation traced this problem to a defective accelerometer. This sensor did, however, check out OK both before and immediately after impact.

Table 9

PLYMOUTH RELIANT PASSENGER RESPONSES IN 35 MPH FLAT FRONTAL BARRIER CRASH TESTS

TEST & VEHICLE IMPACT VELOCITY	MAX. HEAD ACCELERATION AND TIMING								HIC, HEAD INJURY CRITERION			MAX. RESULTANT CHEST ACCELERATION[1]		MAX. FEMUR LOADS (lbs)		VISIBLE BODY CONTACTS	BELT SPOOL-OFF AT INITIAL HEAD-DASH CONTACT (in)	REMARKS
	H_X (g's)	t_X (ms)	H_Y (g's)	t_Y (ms)	H_Z (g's)	t_Z (ms)	H_R (g's)	t_R (ms)	MAGN.	TIMING ~ms t_1	TIMING ~ms t_2	MAGN. (g's)	TIME (ms)	LEFT	RIGHT			
NEW CAR ASSESSMENT (34.8 mph)	133[2] (100)	94	34[2] (25)	97	122[2] (80)	91	182[2] (118)	91	1731	89	99	59	97	720	800	TOP OF HEAD WITH RIM OF METAL OASHBOARD TOP COVER, FOLLOWED BY FOREHEAD CDNTACT WITH PLASTIC OASH-BOARD FRDNT SURFACE.	4.1	NO BELT SYSTEM FAILURES DETECTED. INERTIA SENSITIVE SEAT BACK FAILEO TO LOCK UP.
PRODUCTION BELT SYSTEM ASSEMBLY (35.3 mph)	30	120	9	123	NA[3]	–	31[4]	121	113[4]	50	128	38	85	980	420	UPPER FOREHEAO WITH RIM OF METAL DASH-BOARD TOP COVER.	< 1/4	BELT SYSTEM INTEGRITY LOST AT ABOUT 75 ms AFTER IMPACT,[5] ALLOWING THE OCCUPANT TD UNDERGO ABNORMAL (BASED ON SLED TEST PERFDRMANCE WITH MDOIFIED SEAT RESTRAINT SYSTEMS) EXCESSIVE EXCURSION SEAT MOVED FORWARD RELATIVE TO SEAT TRACK INERTIA SENSITIVE SEAT BACK FAILED TO LOCK UP.

[1] EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2] SHORT-DURATION SPIKE (LESS THAN 2 MILLISECONDS WIDE) CAUSED BY HEAO IMPACT WITH OASHBOARD. APPRDXIMATE THREE MILLISECOND CUTOFF VALUES SHOWN IN PARENTHESES.

[3] ENTIRE DATA TRACE CONTAMINATED BY NOISE FROM UNKNOWN SOURCE; NOT POSSIBLE TO EXTRACT TRUE H_Z RESPDNSE FROM THIS SIGNAL.

[4] REFLECTS X AND Y ACCELERATIDN COMPONENTS ONLY (SEE NOTE 3).

[5] STANDARO WEBBING OF BUCKLE ASSEMBLY ABOVE INBDARD LAP BELT ANCHOR POINT WAS CUT BY THE EDGE OF THE PRODUCTION DESIGN TRANSVERSE SEAT CUSHIDN FRAME MEMBER.

during dummy crash ride down: (1) loss of belt restraint system integrity and (2) 1-3/8 inches of forward seat translation (post-test measurement) relative to the seat track. The extent to which these factors contributed to the BSA test C_R cannot be ascertained.

Table 9 also shows that the BSA test maximum femur loads were essentially the same acceptable order of magnitude as those developed in the NCA test. However, the former values were also influenced to some unknown degree by the aforementioned belt failure and seat translation mechanisms. Had these two events not occurred, it is probable that the BSA test loads would have been even smaller.

Analysis of high-speed films showed that the BSA test passenger demonstrated excellent kinematics prior to the buckle-part lap belt failure. No tendency to submarine was evident in the films of the event.

Finally, it should be noted that another compartment-modified Reliant was recently subjected to a nearly identical, 34.8 mph flat barrier crash test by an independent contractor.* The Reliant's modified compartment system successfully prevented passenger head-dash contact and produced a HIC of only 296. (The C_R was 37 g's while left and right femur loads were 780 lbs. and 1290 lbs., respectively.) These results dramatically support our previously mentioned belief that the BSA Reliant passenger would have complied easily with the HIC requirements of FMVSS 208 had the buckle webbing remained intact.

As a matter of interest, corresponding driver occupant parameters in the above test were as follows: HIC = 391, C_R = 34 g's, F_L = 1130 lbs., F_R = 840 lbs.

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*Test SRL 53 performed on 7 July 1982 by the Vehicle Research and Test Center (TRC) in East Liberty, Ohio. See Reference 11.

4.2 Plymouth Horizon - Ford Mustang Car-to-Car Head-On Crash Test

A production 1982 Plymouth Horizon TC-3 2-door hatchback was subjected to a 70.6 mph closing speed, colinear, car-to-car frontal crash test with a 1982 Ford Mustang 2-door sedan. The Horizon was equipped with Calspan-developed, modified front bucket seat cushions and breakaway-type steering shaft assembly and production Takata Kojyo belt restraint systems. The Mustang was tested in its baseline (i.e., standard-equipment) condition. A complete description of these systems, as well as all test results, is provided in Reference 12. For the convenience of the reader, however, the above modifications are described briefly in the ensuing six paragraphs. Also, electronic data recorded in this test are presented in Appendices D through G of this report.

Both Horizon production front seat belt restraint systems were replaced by a Takata Kojyo combination retractor/webbing clamp assembly, including 8%-elongation Takata Kojyo webbing. This device, shown in Figure 7a, is a variation of a production version used in the 1982 Honda Accord (4-door model). As such, it features the same, proven retractor lock-up/belt gripping mechanism. Only the inclination (26° relative to the horizontal instead of a vertical orientation) is different. Thus with the Takata Kojyo unit mounted near the Horizon's zero-inclination (horizontal) side roof rail, the retractor was effectively locked up prior to the test. While this pre-locked condition certainly provided an advantage for the Horizon occupants during collision ride down, it is highly probable that essentially similar belt spool-off would have occurred if a hypothetical production Takata Kojyo unit designed for horizontal roof rail mounting were employed in this test.*

The Takata Kojyo unit was adapted for bolt mounting to the roof rail as shown in Figure 7b. Passenger-side views of both the production and substitute

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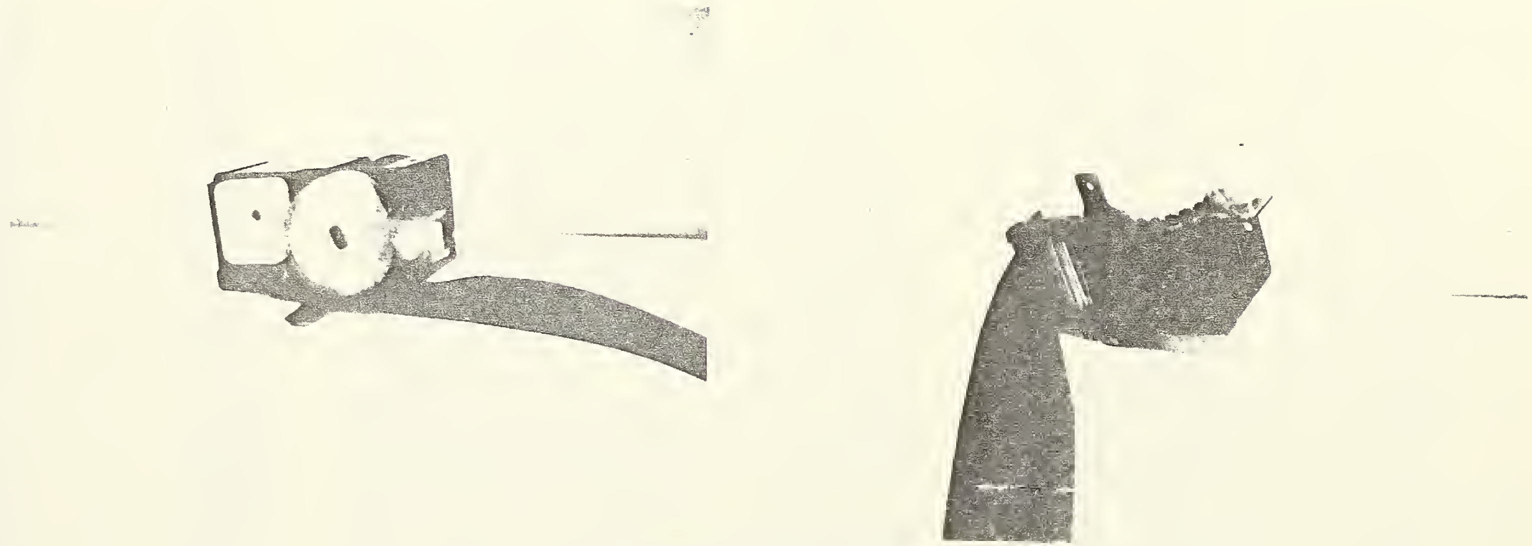
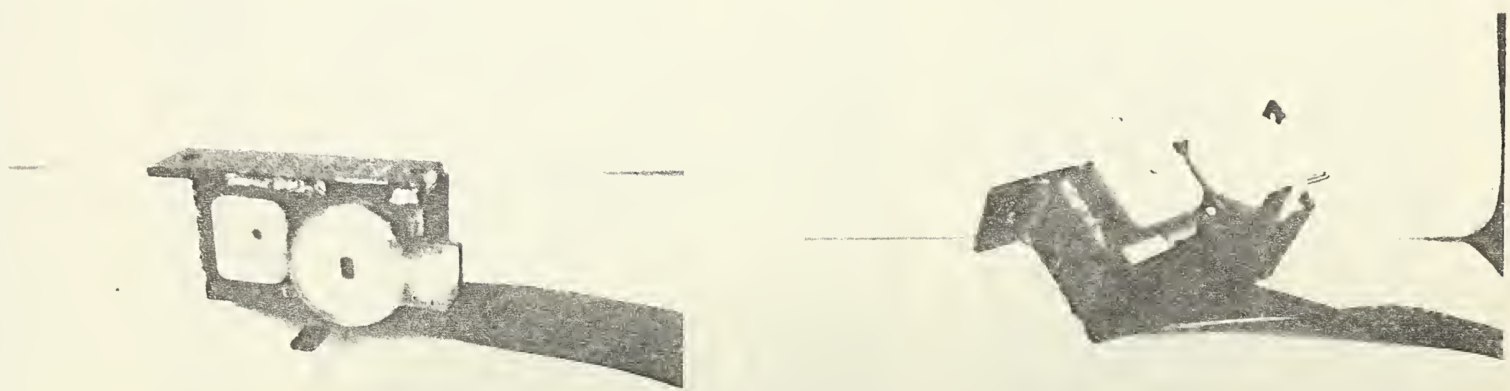
*Supporting arguments for this contention are presented in Section 2.2 of Reference 9.



(a) PRODUCTION VERSION



(b) MODIFIED VERSION

Figure 7 TAKATA KOJYO RETRACTOR/WEBBING CLAMP ASSEMBLY retractor units at the common side roof rail mounting location are depicted in Figure 8. Figure 9 displays pre-test photographs of the Takata Kojyo restraint system belt configuration in place around the driver and passenger occupants.

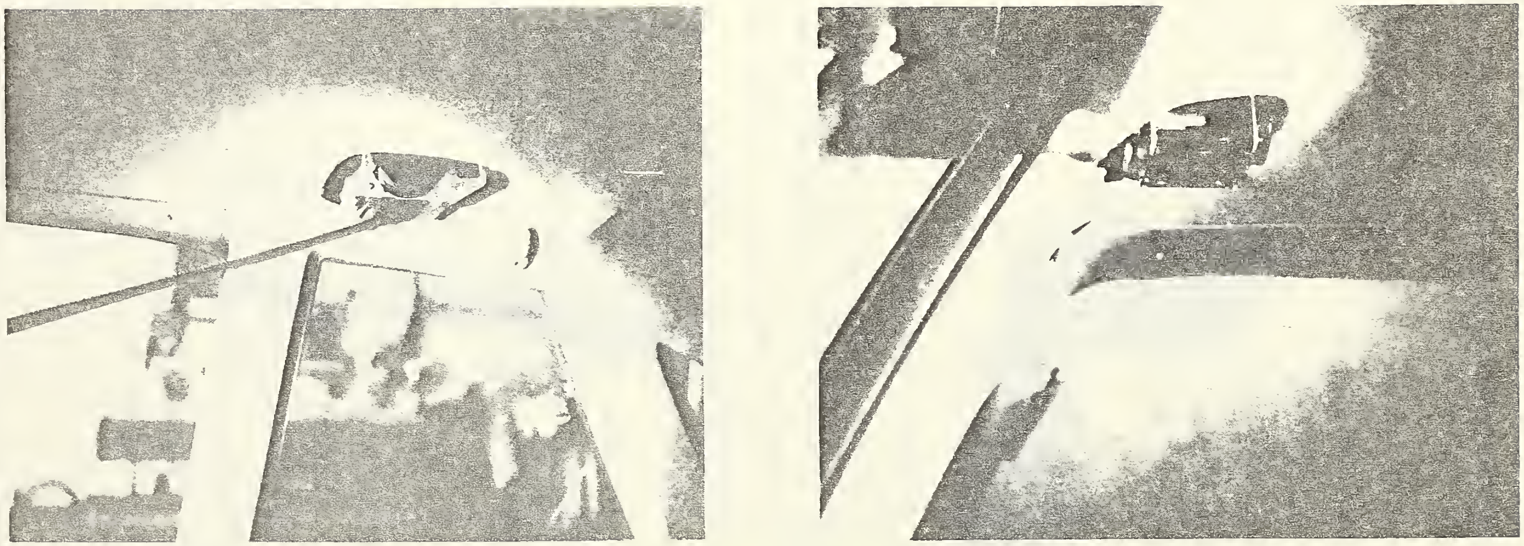
In the production Horizon, the retractor is bolted in place using two studs projecting from a cantilevered sheet metal pan (see Figure 10a) which can be pulled downward (elastically) under the action of a small, hand-applied force. In an effort to eliminate the possibility of undesired increased occupant stroke (via extensive permanent pan distortion) during occupant loading, the free edges of the cantilevered pan were pop-riveted to the exterior roof sheet metal as depicted in Figure 10b.

Both production Horizon front bucket seat cushions were stiffened along the front edge in a manner somewhat analogous to the Reliant cushion modification. As shown in Figure 11, mild steel angle sections, polystyrene insulation board and aluminum sheet stock were utilized in the construction of this assembly. As was the case with the stiffened Reliant seat cushion, the added, higher-density foam at the front of the cushion traps the dummy's buttocks in the softer portion of the seat during collision ride down, limiting pelvic excursion.

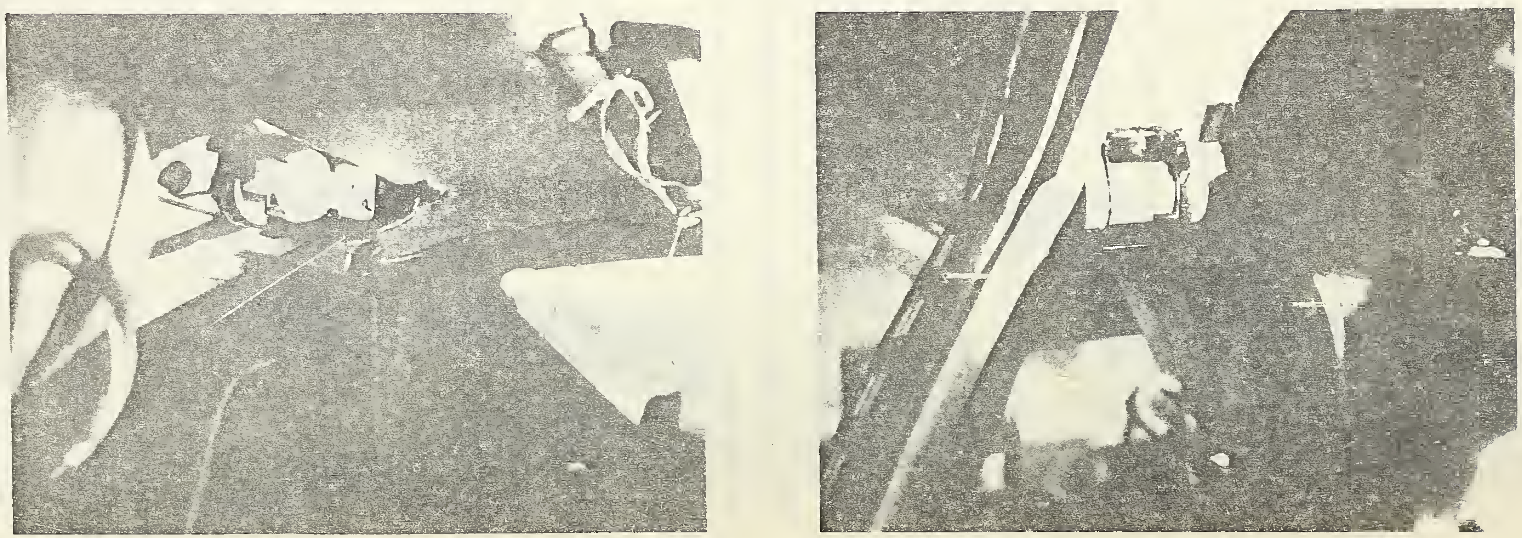
In an effort to prevent the seats from translating forward relative to their respective seat tracks under occupant loading during the test,* the upper and lower portions of all four production seat track assemblies were tack-welded together at four locations.

As mentioned in Section 3.3, successful driver occupant performance in an actual 35 mph frontal collision environment required, in addition to the restraint system and seat modifications described above, that steering wheel intrusion be kept to a minimum. In an attempt to accomplish this objective, the solid, production lower steering shaft assembly was modified to form a breakaway-type joint between the upper steering shaft and the short shaft projecting from the steering rack. Photographs of the production and modified

*As noted in Reference 5, the production Horizon bucket seats have a tendency to move forward relative to the seat track assemblies.

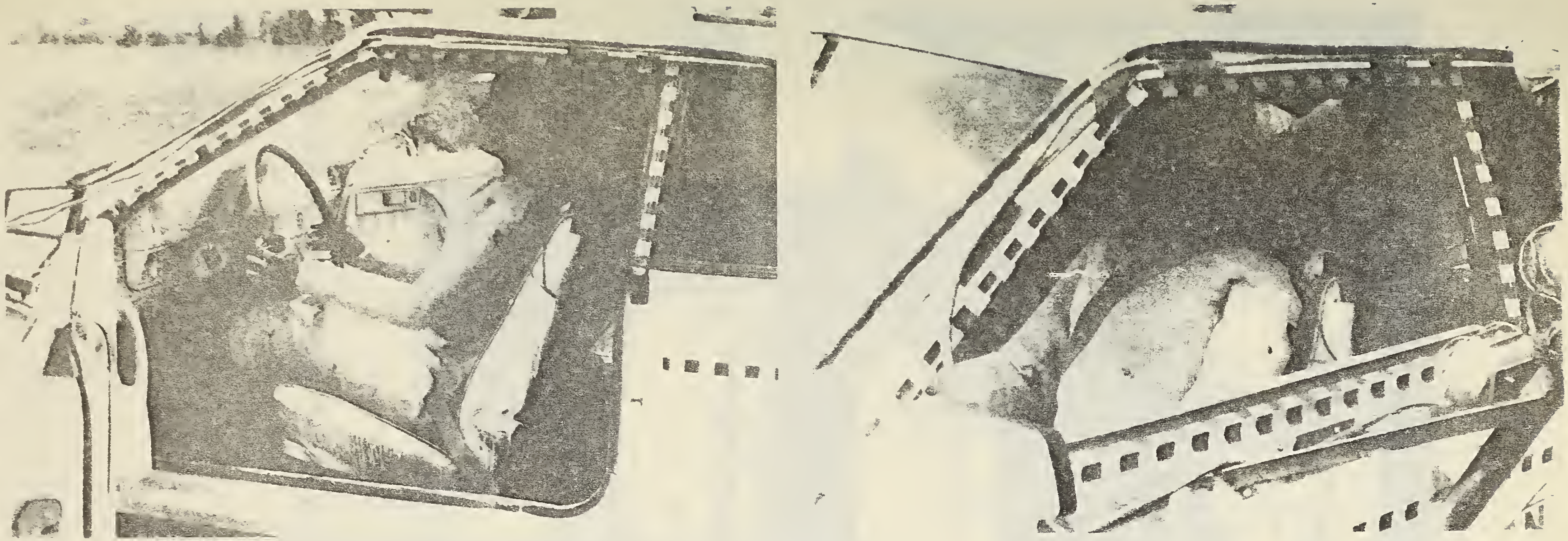


(a) PRODUCTION SYSTEM

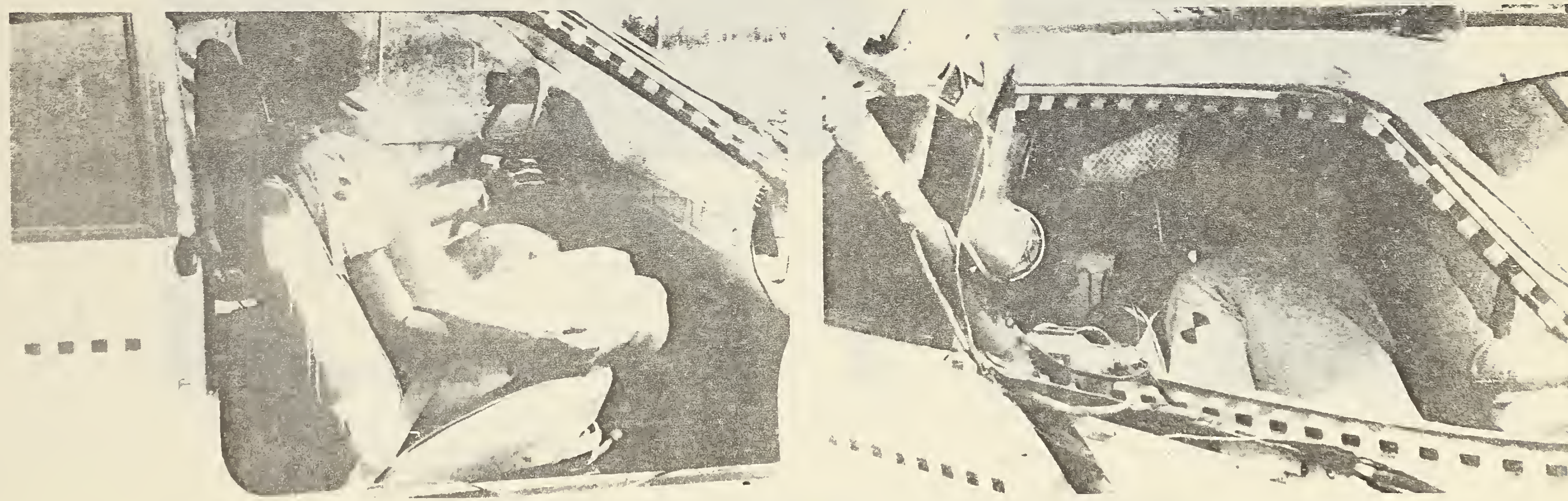


(b) TAKATA KOJYO SYSTEM USED IN CRASH TEST

Figure 8 PLYMOUTH HORIZON RETRACTOR AT ROOF RAIL MOUNTING LOCATION

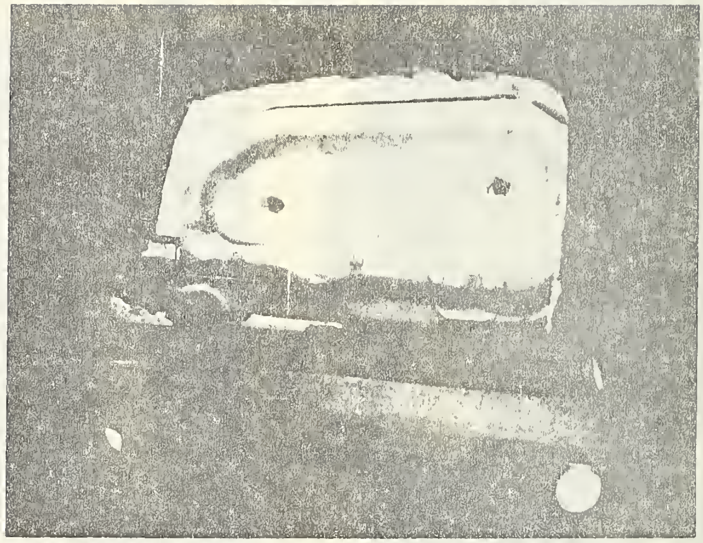


DRIVER

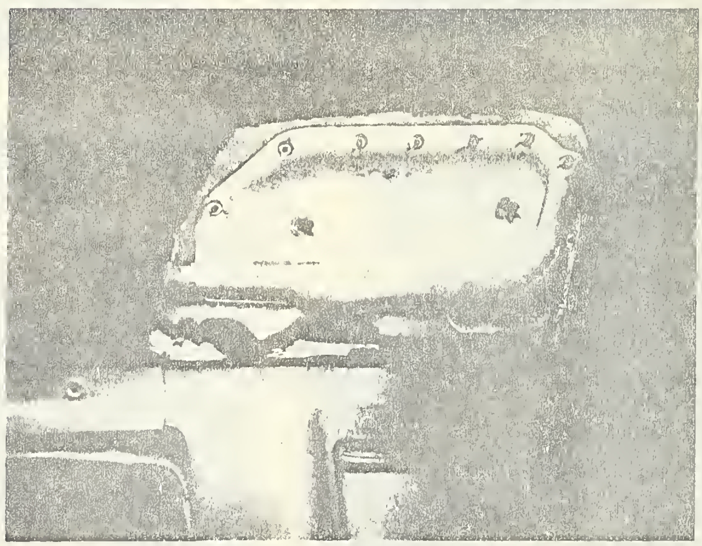


PASSENGER

Figure 9 PLYMOUTH HORIZON TEST VEHICLE: TAKATA KOJYO RESTRAINT SYSTEM BELT CONFIGURATION

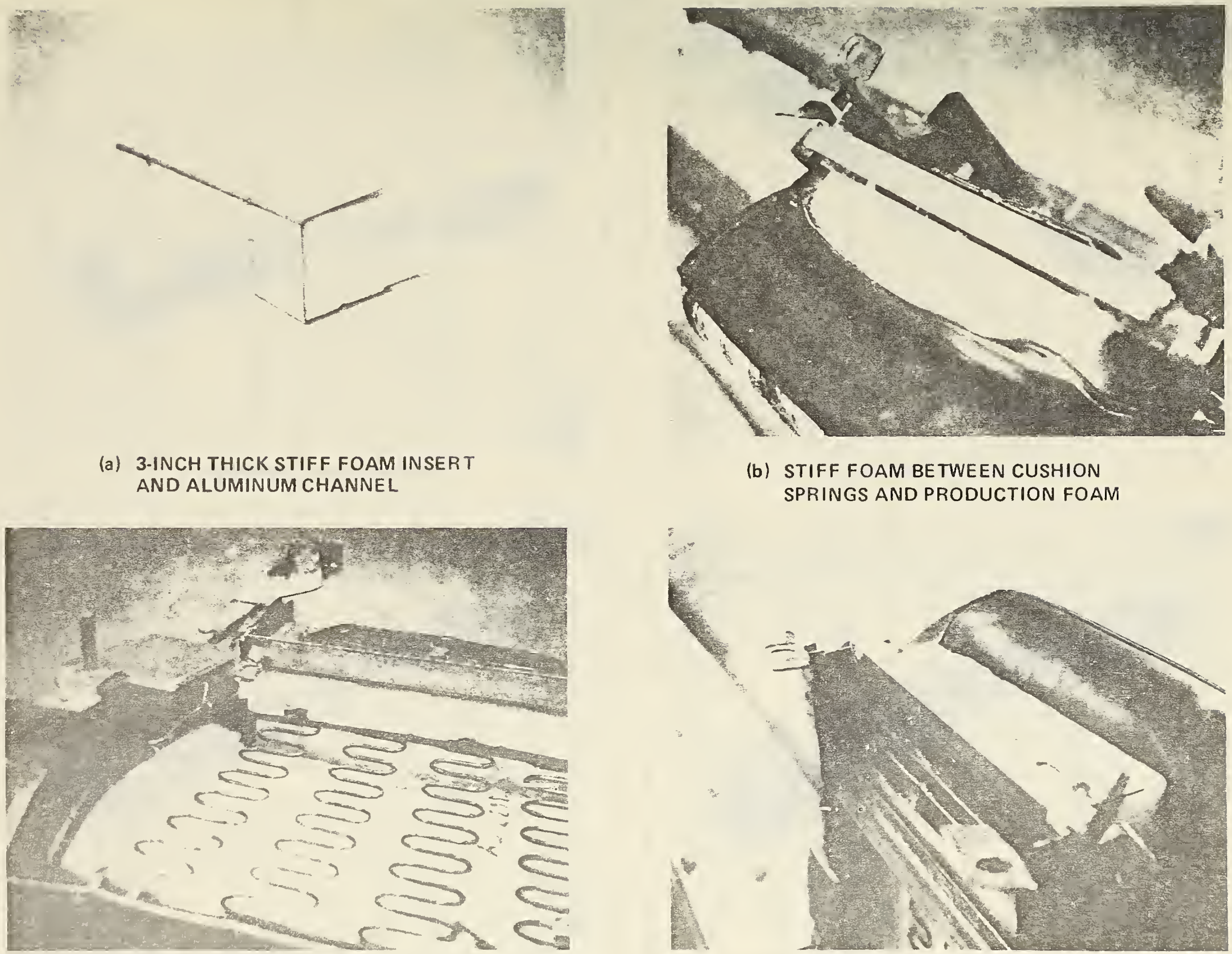


(a) PRODUCTION SYSTEM



(b) REINFORCED SYSTEM

Figure 10 PLYMOUTH HORIZON RETRACTOR MOUNT STRUCTURE



(a) 3-INCH THICK STIFF FOAM INSERT AND ALUMINUM CHANNEL

(b) STIFF FOAM BETWEEN CUSHION SPRINGS AND PRODUCTION FOAM

(c) ADDITIONAL FOAM/PAN INSTALLED BETWEEN SPRINGS AND FRAME REINFORCEMENT MEMBER

(d) FOAM RETENTION PLATE

Figure 11 MODIFIED PLYMOUTH HORIZON SEAT CUSHION ASSEMBLY shafts are presented in Figures 12a and 12b, respectively, while Figures 13a and 13b show these two assemblies in place in the vehicle.

Examination of Table 10 shows that with the possible exception of a low-severity head contact with the upper steering wheel rim,* the driver in the BSA test exhibited excellent responses in all aspects of occupant performance. Occupant injury indicators were all well below the allowable limits stipulated by FMVSS 208. Moreover, the HIC number and maximum resultant accelerations C_R and H_R were all substantially lower than their unsatisfactory counterparts in the NCA collision.** On a percentage basis, the BSA HIC and C_R were both 27 percent below their allowable limits while their NCA counterparts were 82 percent and 2 percent above these same respective levels. Left and right BSA femur loads were respectively 72 percent and 18 percent below the maximum allowable loading compared to 24 percent and 38 percent below for the corresponding NCA magnitudes.

Despite significant seat pitching motion arising from extensive vehicle floor pan/sill deformation, relative seat translation was prevented and overall driver occupant kinematics were excellent. Submarining motion and lap belt roping were nonexistent and rebound was straight back into the seat back/headrest. Belt spool-off was confined to less than 1/2 inch.

The BSA test passenger displayed outstanding performance relative to both FMVSS 208 occupant injury criteria and kinematic response. With respect to occupant injury indicators, inspection of Table 11 reveals that the HIC number and resultant chest acceleration were both well below the FMVSS 208 tolerance levels and substantially lower than the corresponding values generated in the NCA test. Indeed, the BSA HIC and C_R were 49 percent and 37 percent lower, respectively, than their allowable limits. Conversely, the same NCA

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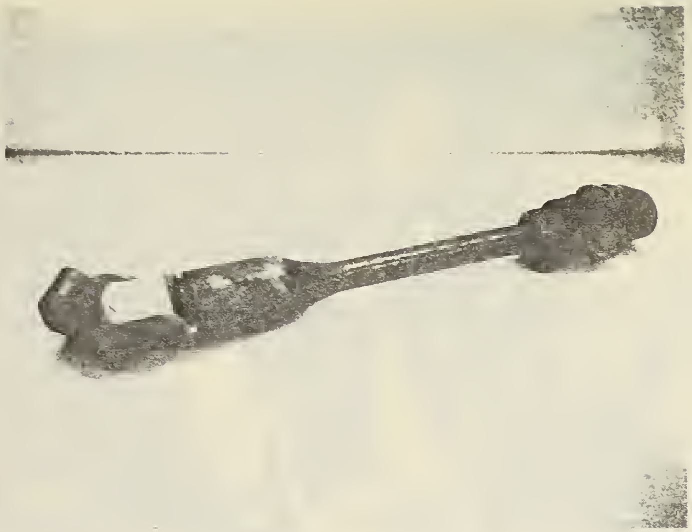
*As borne out by the head acceleration and HIC number values, driver head contact with the steering wheel was more severe in the NCA test than in its BSA counterpart.

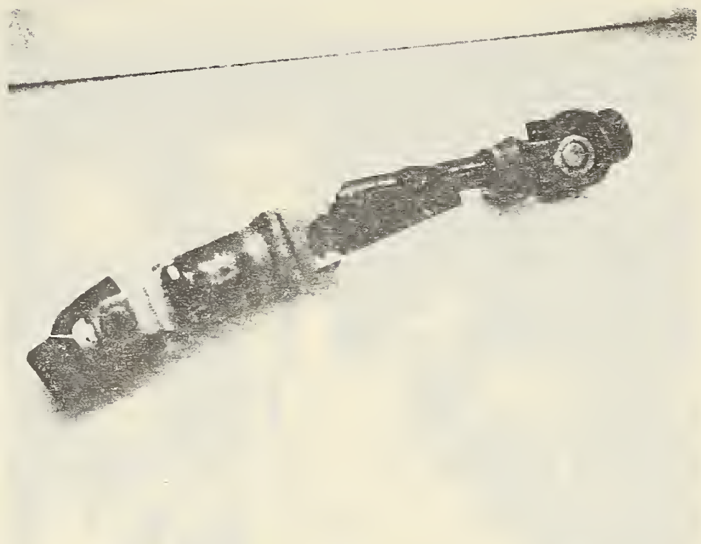
**The driver's 1817 HIC and 61 g C_R exceeded FMVSS 208 tolerance levels in the NCA test.



(a) PRODUCTION VERSION

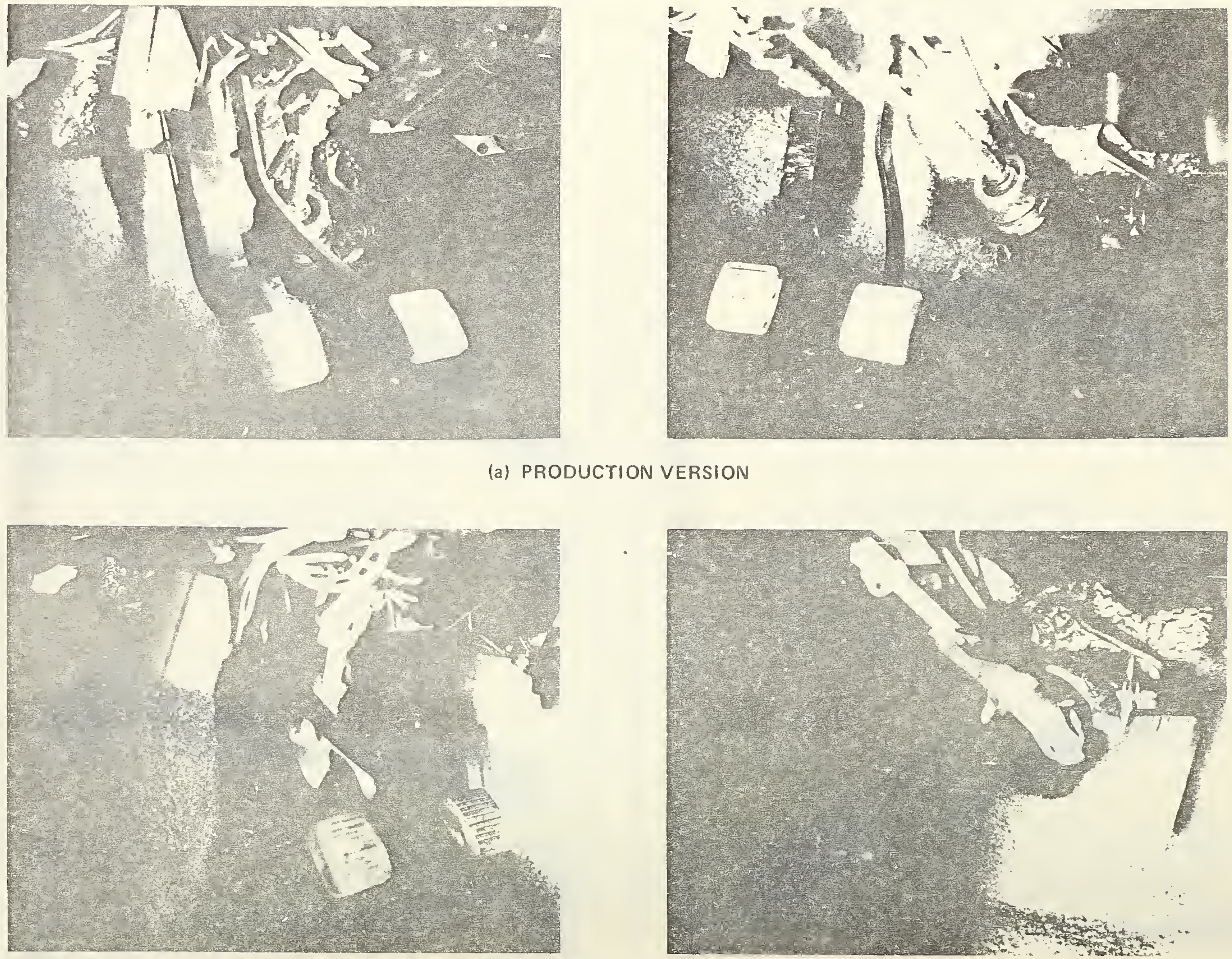
(b) MODIFIED VERSION

(c) MODIFIED VERSION: COUPLED CONDITION



(d) MODIFIED VERSION: SEPARATION CONDITION

Figure 12 PLYMOUTH HORIZON LOWER STEERING SHAFT ASSEMBLY



(a) PRODUCTION VERSION

(b) MODIFIED VERSION

Figure 13 PLYMOUTH HORIZON LOWER STEERING SHAFT CONFIGURATION

Table 10
PLYMOUTH HORIZON DRIVER RESPONSES IN 70 MPH CLOSING SPEED HEAD-ON FRONTAL IMPACTS WITH A FORD MUSTANG

TEST & CLOSING VELOCITY AT IMPACT	H_R, MAX. RESULTANT HEAD ACCELERATION		HIC, HEAD INJURY CRITERION			C_R[1], MAX. RESULTANT CHEST ACCELERATION		MAX. COMPRESSIVE FEMUR LOADS (lbs.)		VISIBLE BODY CONTACTS		REMARKS
	MAGN. (g's)	TIME (ms.)	MAGN. (g's)	TIMING~ms. t_1	TIMING~ms. t_2	MAGN. (g's)	TIME (ms.)	LEFT	RIGHT	HEAD	CHEST/ABDOMEN	
NEW CAR ASSESSMENT (70.2 mph)	184[2] (129)	70	1817	69	85	61	76	1700	1400	EYES/BRIDGE OF NOSE WITH UPPER STEERING RIM, FOLLOWED BY FACIAL CONTACT WITH WHEEL HUB.	ABDOMEN WITH LOWER STEERING WHEEL RIM.	SEAT MOVED FORWARD RELATIVE TO SEAT TRACK. FLOOR PAN ROTATION (PRIMARILY) CAUSED MODERATE SEAT FORWARD PITCH. OCCUPANT SUBMARINED
PRODUCTION BELT SYSTEM ASSEMBLY (70.6 mph)	153[2] (89)	83	727	83	97	44	77	630	1850	BRIDGE OF NOSE WITH UPPER STEERING WHEEL RIM.	ABDOMEN WITH LOWER STEERING WHEEL RIM.	EXTENSIVE FLOOR PAN DEFORMATION/ROTATION CAUSED THE ENTIRE SEAT TO UNDERGO CONSIDERABLE PITCHING MOTION.

[1]EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2]SHORT-DURATION SPIKE CAUSED BY HEAD CONTACT WITH THE STEERING WHEEL. THREE-MILLISECOND CUTOFF VALUE SHOWN IN PARENTHESIS.

Table 11
PLYMOUTH HORIZON PASSENGER RESPONSES IN 70 MPH CLOSING SPEED HEAD-ON FRONTAL IMPACTS WITH A FORD MUSTANG

TEST & CLOSING VELOCITY AT IMPACT	H_R, MAX. RESULTANT HEAD ACCELERATION		HIC, HEAD INJURY CRITERION			C_R[1], MAX. RESULTANT CHEST ACCELERATION		MAX. COMPRESSIVE FEMUR LOADS (lbs.)		VISIBLE BODY CONTACTS		REMARKS
	MAGN. (g's)	TIME (ms.)	MAGN. (g's)	TIMING~ms. t_1	TIMING~ms. t_2	MAGN. (g's)	TIME (ms.)	LEFT	RIGHT	HEAD	CHEST/ABDOMEN	
NEW CAR ASSESSMENT (70.2 mph)	288[2] (120)	98	2096	96	101	52	100	1330	710	TOP OF HEAD WITH UPPER FRONT SURFACE OF DASHBOARD	NONE	SEAT MOVED FORWARD RELATIVE TO SEAT TRACK. FLOOR PAN ROTATION (PRIMARILY) CAUSED MODERATE SEAT FORWARD PITCH. OCCUPANT SUBMARINED.
PRODUCTION BELT SYSTEM ASSEMBLY (70.6 mph)	52	97	510	86	136	38	85	NA[3]	740	NONE	NONE	EXTENSIVE FLOOR PAN DEFORMATION/ROTATION CAUSED THE ENTIRE SEAT TO UNDERGO CONSIDERABLE PITCHING MOTION

[1] EXCEEDING A CUMULATIVE DURATION OF 3 MILLISECONDS.

[2] SHORT-DURATION SPIKE CAUSED BY HEAD CONTACT WITH THE DASHBOARD. THREE-MILLISECOND CUTOFF VALUE SHOWN IN PARENTHESIS.

[3] NOT AVAILABLE: WIRES PULLED OUT OF LOAD CELL.

parameters were 110 percent above and 15 percent below these limiting values. Peak right femur loadings were comparable in both tests, considerably lower (67 percent and 68 percent less for the BSA and NCA test exposures, respectively) than the maximum allowable loading. A data loss precluded a definitive assessment of corresponding maximum left femur load magnitudes. However, it can be reasonably assumed that this value would not have been significantly different from the acceptable magnitude (1330 lbs.) registered during the NCA collision.

The stroke-limiting features of the BSA vehicle restraint system and seat modifications prevented the life-threatening NCA test head-dashboard contact with margin to spare. Again, occupant submarining and lap belt roping/abdominal penetration was prevented and rebound was straight back into the seat back/headrest.

As was the case for the driver occupant, the passenger-side restraint system permitted minimal spool-off (<1/2 inch), significantly less than the approximate maximum 5 inches of belt playout noted in the NCA test. Also (as expected), no seat translation relative to the seat tracks occurred during the test.

5.0 CONCLUDING REMARKS AND RECOMMENDATIONS

The research program "Improved Performance of Production Belt System Assembly for the Plymouth Horizon and Plymouth Reliant" (i.e., the BSA program), examined the occupant protection potential provided by two current-production, small domestic automobiles in nominal 35 mph frontal impact exposures. It was demonstrated conclusively that this capability can be significantly enhanced by making relatively simple, production-type modifications to the standard-equipment belt restraint system, seats and steering column. As a result of these changes, overall occupant performance as measured by FMVSS 208 injury criteria and dummy kinematic response was upgraded from highly unacceptable in baseline New Car Assessment (NCA) crash tests to very acceptable in corresponding BSA program tests.

Calspan believes that the same basic concepts successfully employed herein could also be effectively utilized in other domestic and foreign automobiles. The NCA frontal impact test series would provide a relatively large sample of candidate vehicles for this purpose. As was the case with the Horizon and Reliant, the vehicle(s) selected for occupant compartment modification would possess good front structure energy management and compartment integrity characteristics but still fail to provide satisfactory frontal impact occupant injury protection.

Because of the knowledge acquired during the BSA effort, the proposed additional effort could be accomplished for perhaps a number of different production vehicles at relatively little expense. Such research could lead to a new generation of safer passenger cars without involving expensive vehicle structure redesign. Also, 40 mph frontal impact occupant protection could be achieved by some of these compartment-modified automobiles.

6.0 REFERENCES

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2. Levan, W. E. and Kelleher, B. J., "New Car Assessment and Standards Enforcement Indicant Testing - Ford Mustang to Plymouth Horizon Frontal Impact, 70 mph Closing Speed - NHTSA 308-34-492," Calspan Report No. 6525-V-34, June 18, 1980.

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5. Galganski, R. A., "Improved Performance of Production Belt System Assembly for the Plymouth Horizon, First Progress Report," Contract No. DTNH22-81-C-07111, 1 January to 31 January 1981.

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7. Galganski, R. A., "Improved Performance of Production Belt System Assembly for the Plymouth Reliant, Sled Test Report, Phase I Developmental Testing," Calspan Report No. 6829-V-3, July 1981.

8. Galganski, R. A., "Improved Performance of Production Belt System Assembly for the Plymouth Reliant, Sled Test Report, Phase II Developmental Testing," Calspan Report No. 6829-V-4, November 1981.

9. Galganski, R. A., "Improved Performance of Production Belt System Assembly for the Plymouth Horizon, Sled Test Report, Validation and Developmental Testing," Calspan Report No. 6829-V-6, April 1982.

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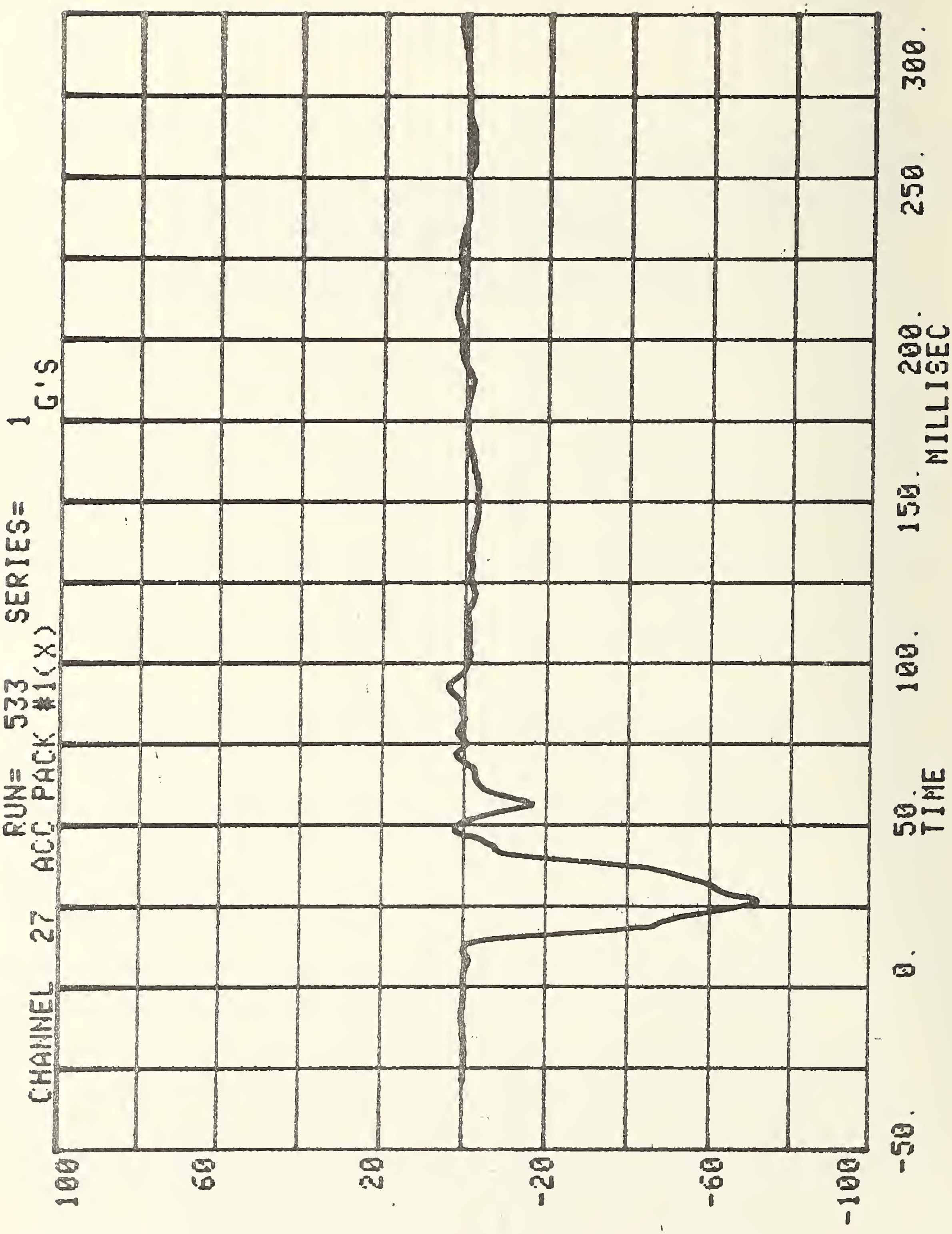
11. Favors, J., "Restraint System Test, Modified Reliant K," Vehicle Research and Test Center Report No. SRL 53, to be published.

12. Galganski, R. A., "Improved Performance of Production Belt System Assembly for the Plymouth Horizon, Crash Test Report, Car-to-Car Frontal Impact, Plymouth Horizon into Ford Mustang, 70 mph Closing Speed," Calspan Report No. 6829-V-7, July 1982.

APPENDIX A

ELECTRONIC CRASH TEST DATA:

PLYMOUTH RELIANT VEHICLE-MOUNTED SENSORS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ACC PACK #1(X)
G'S
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60
20
-20
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-100
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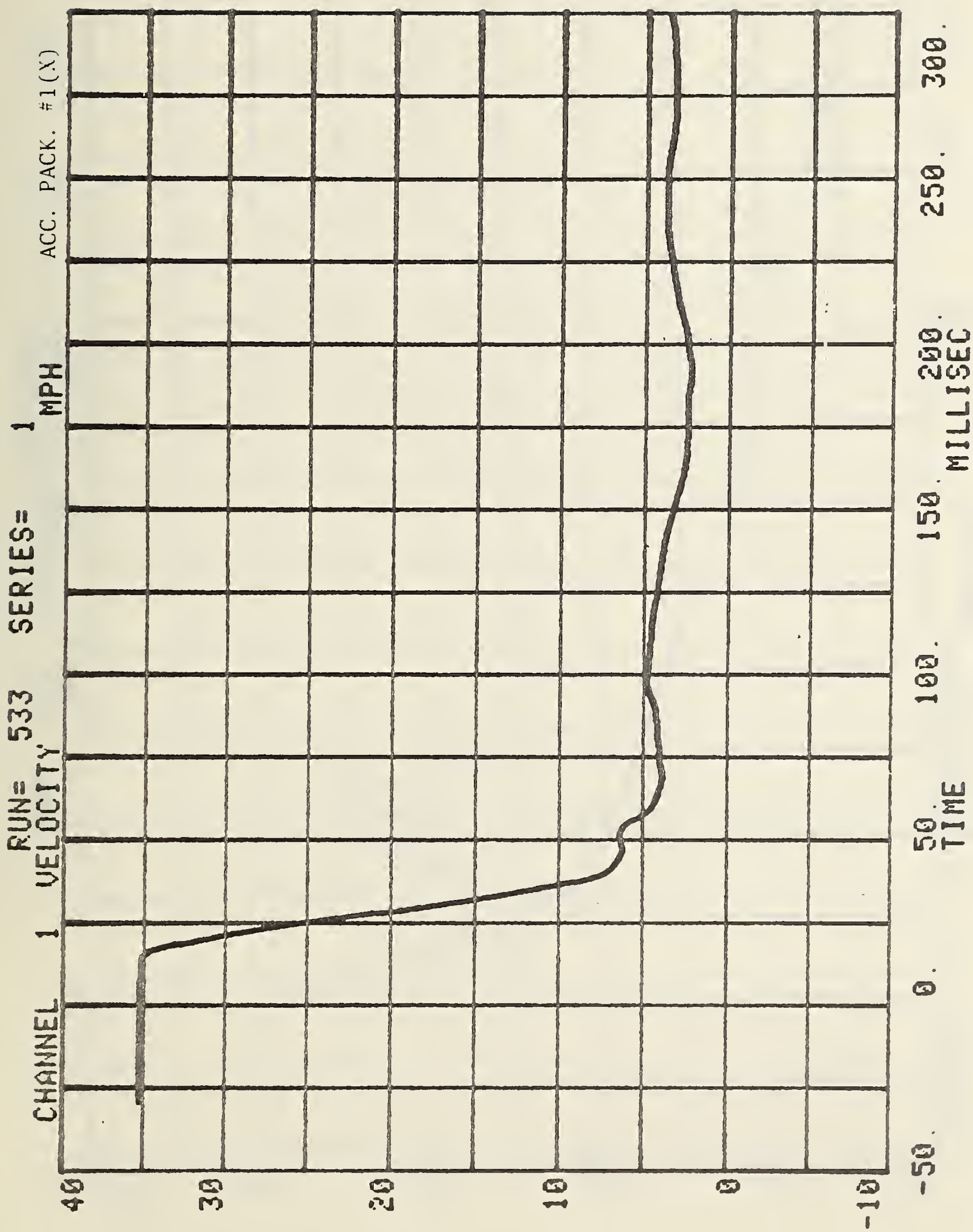
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC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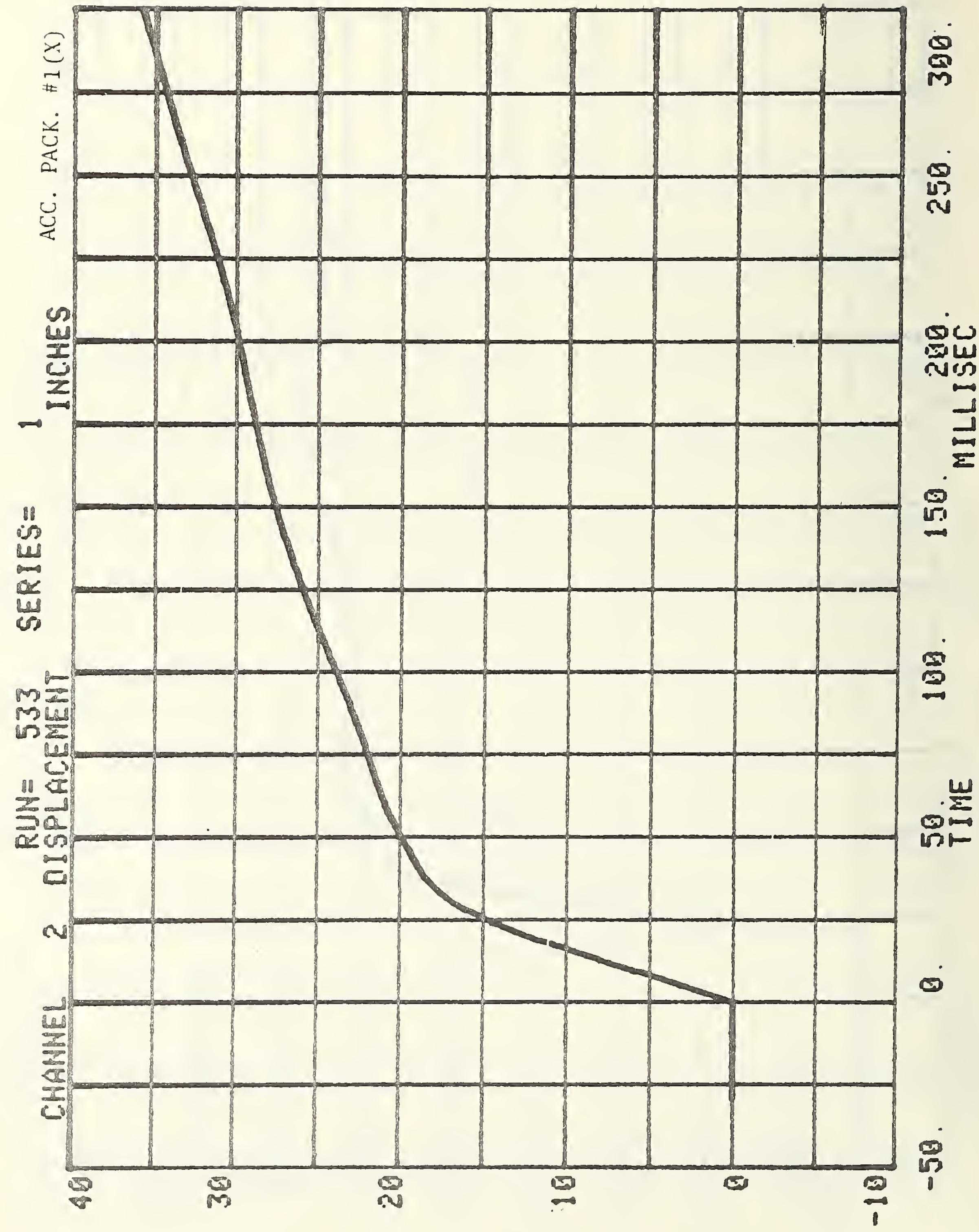
50.
100.
150.
200.
250.
300.
TIME MILLISEC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DISPLACEMENT INCHES
ACC. PACK. #1(X)
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0
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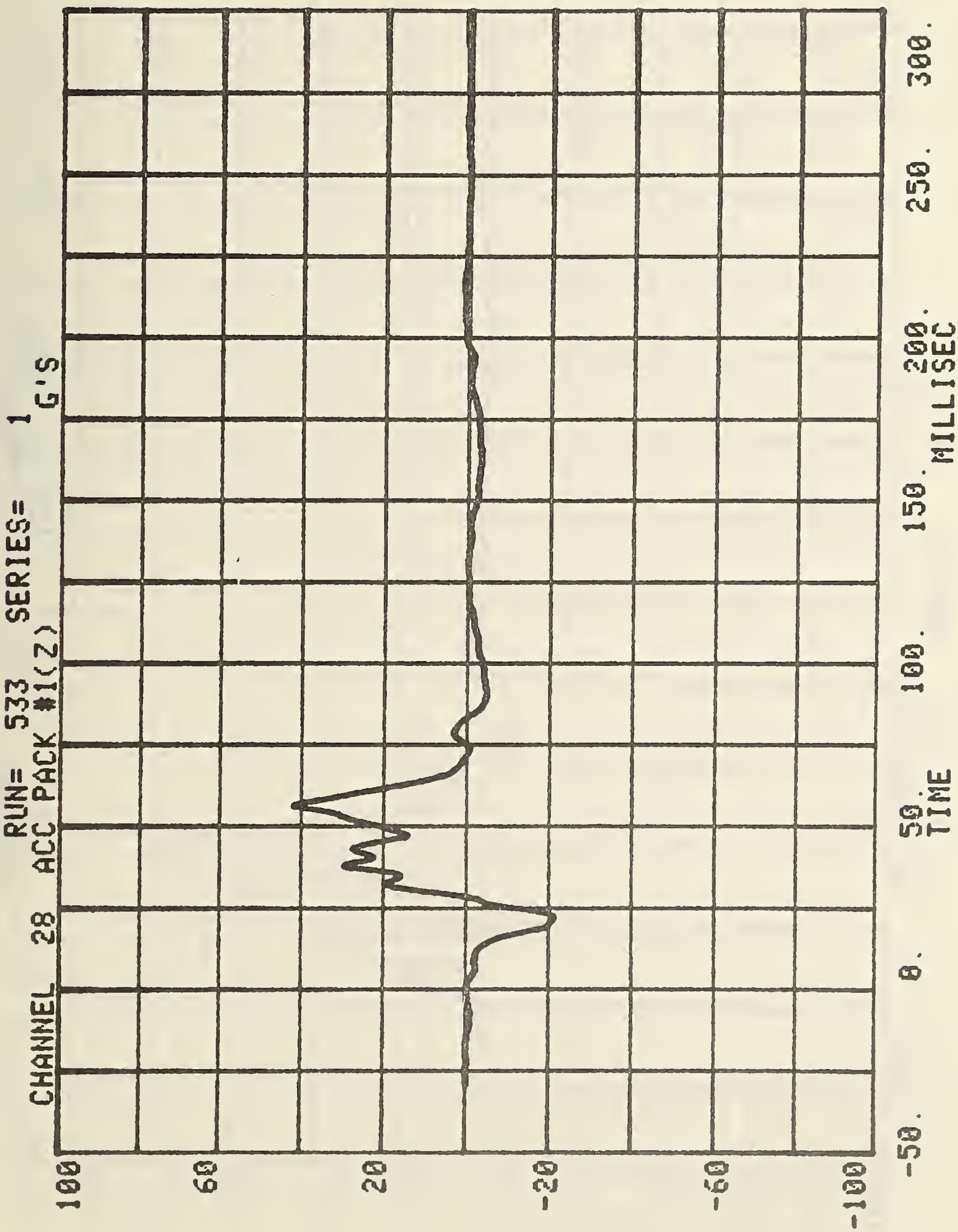
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC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ACC PACK #1(Z) G'S
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-100
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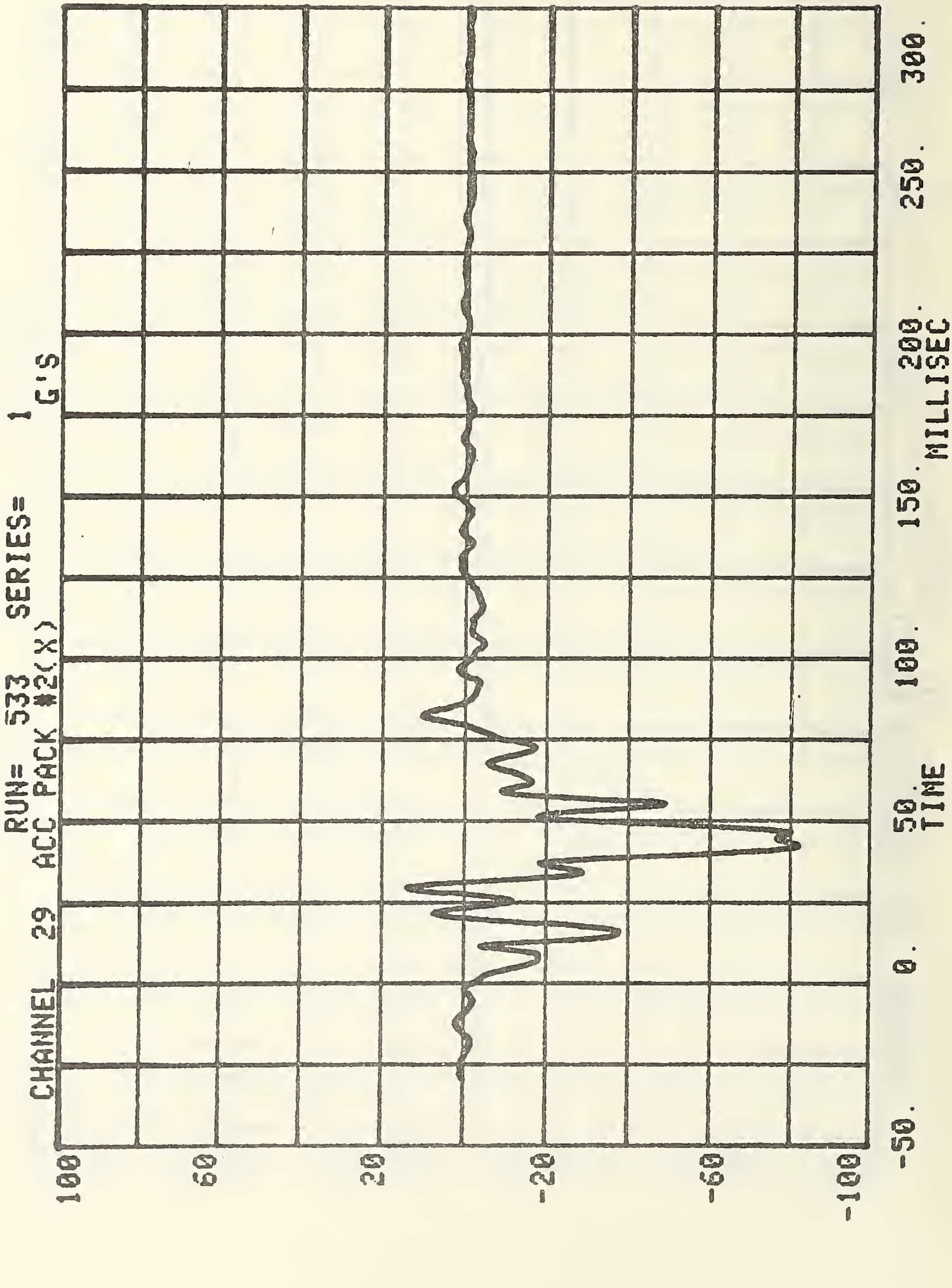
50.
100.
150.
200.
250.
300.
TIME MILLISEC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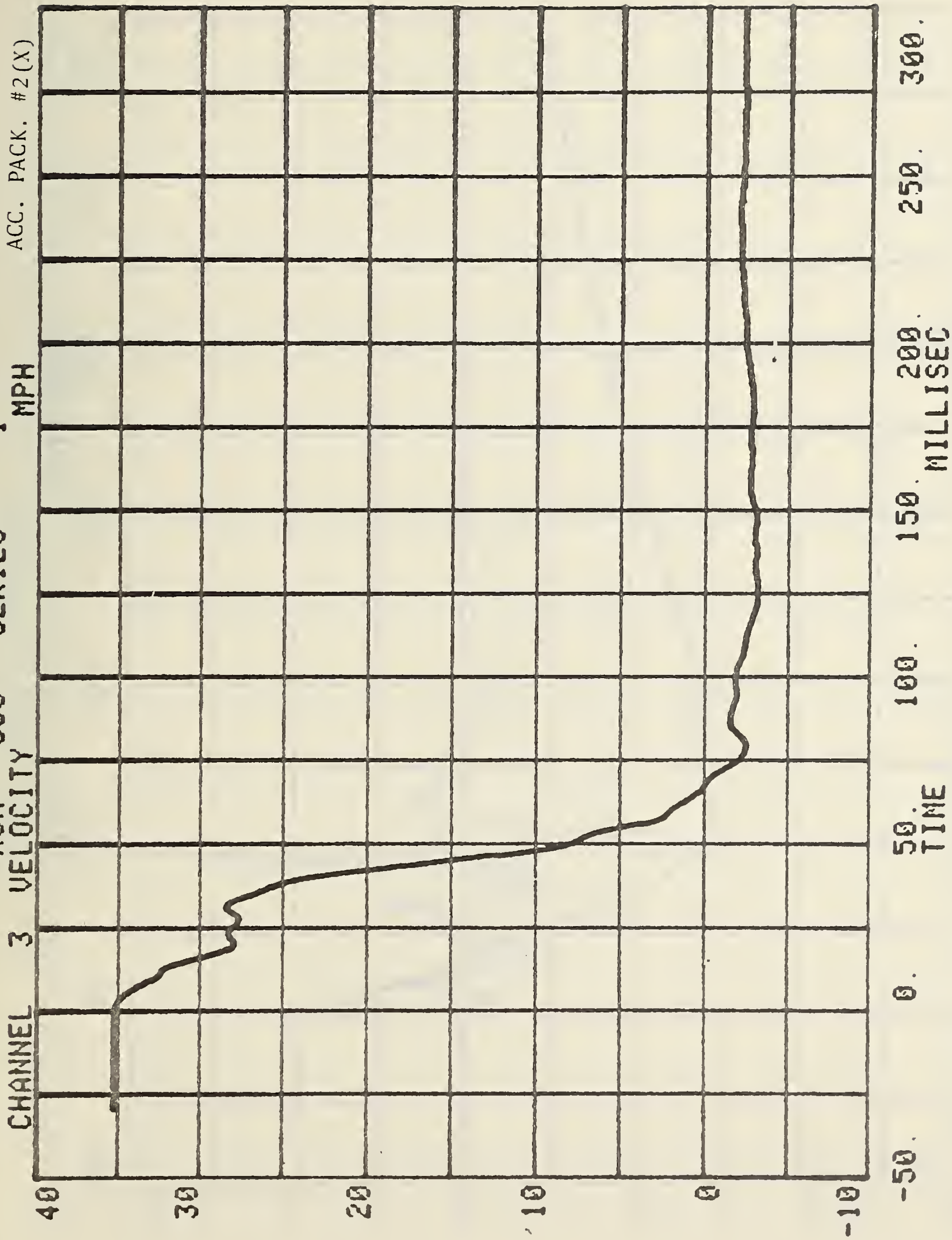
150.
200.
250.
300.
TIME MILLISEC



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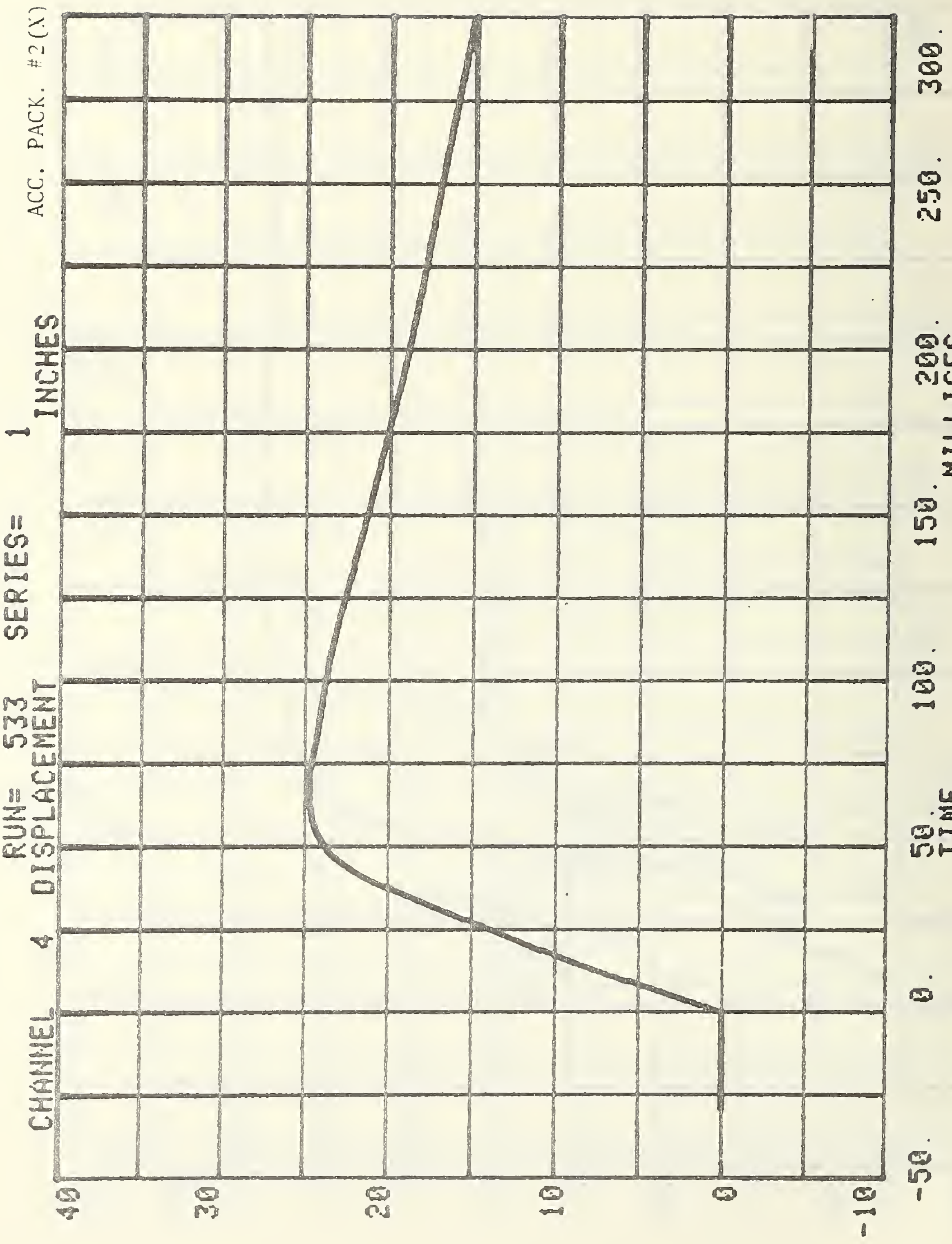
50.
100.
150.
200.
250.
300.
TIME MILLISEC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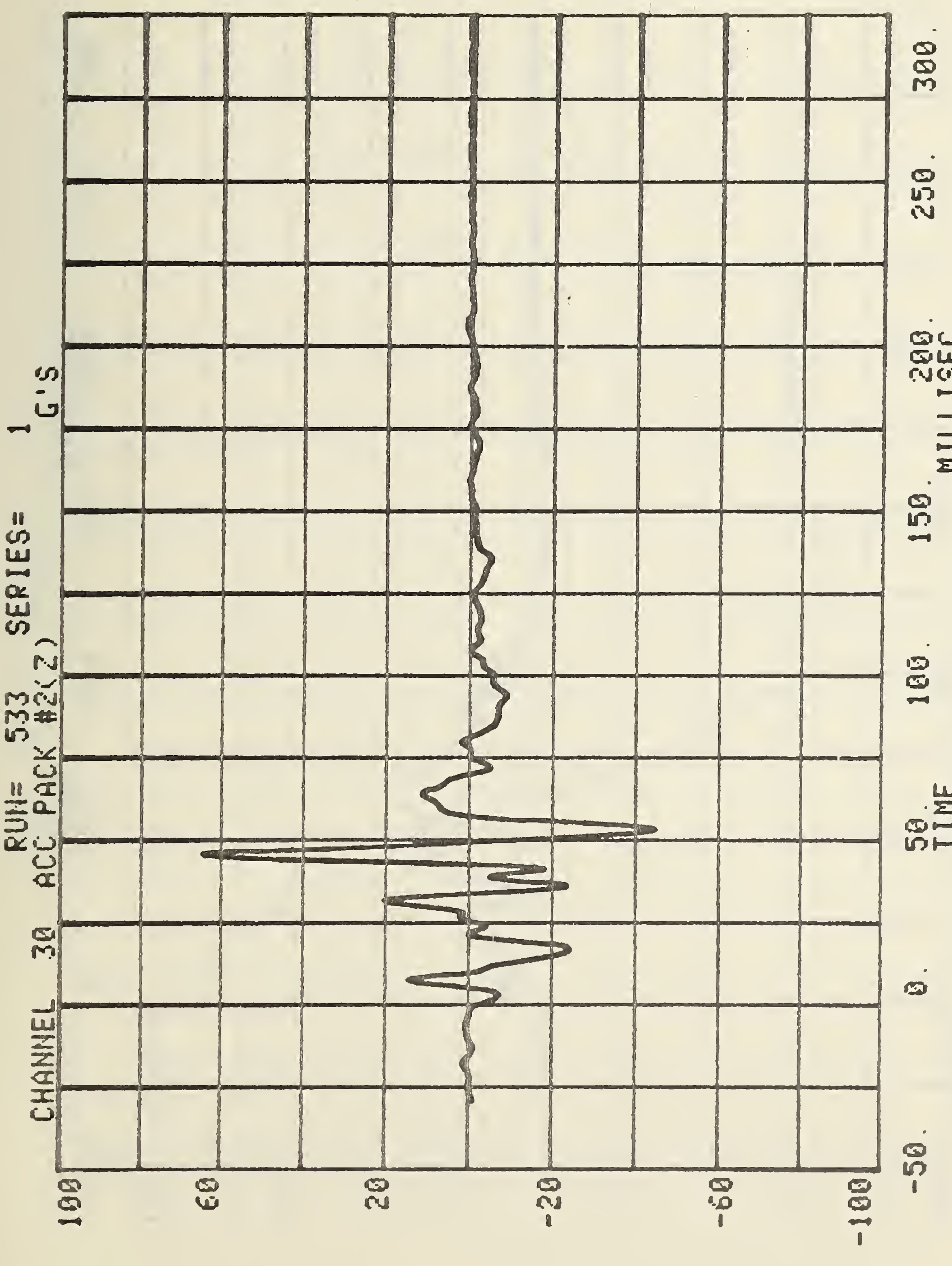
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50.
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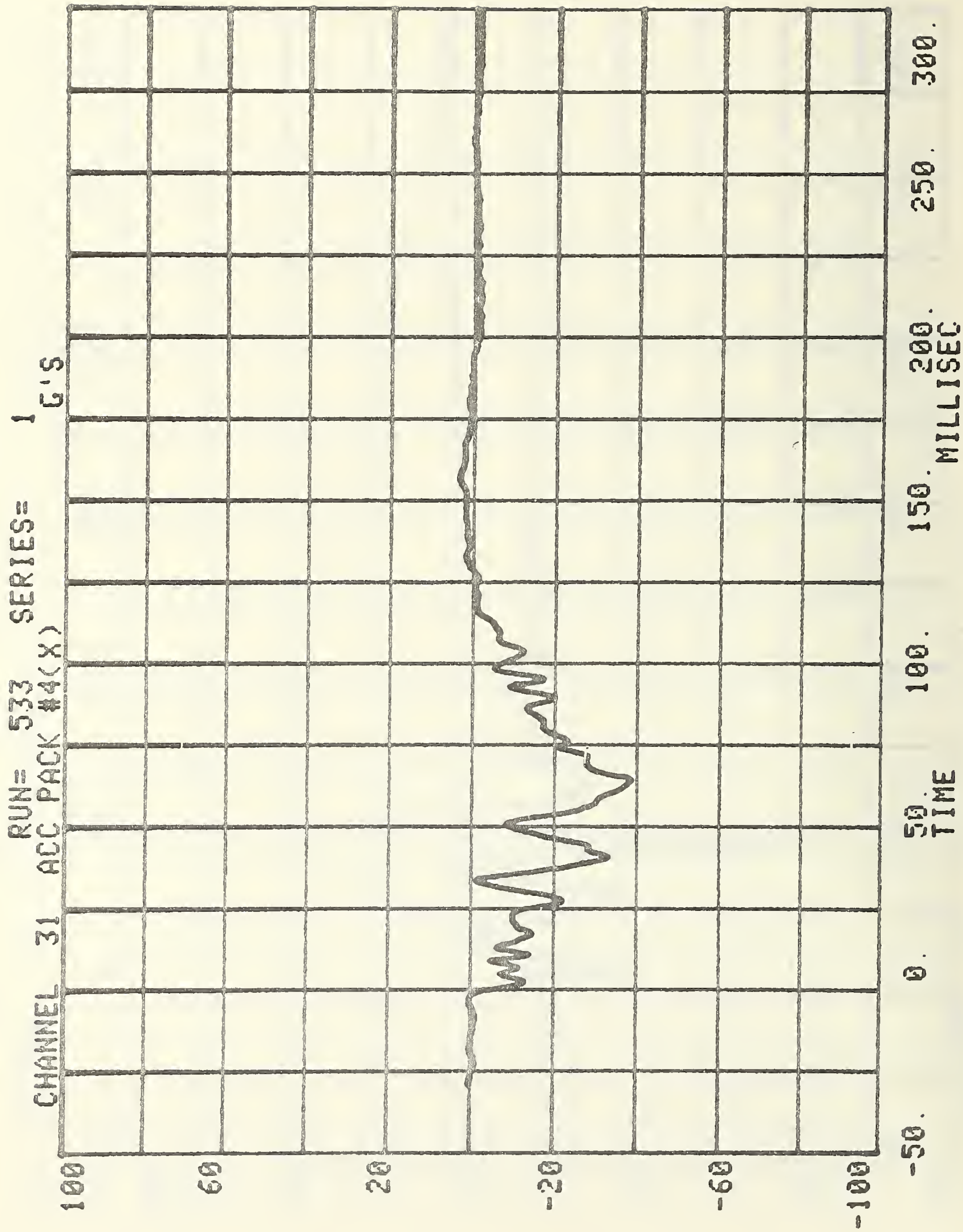
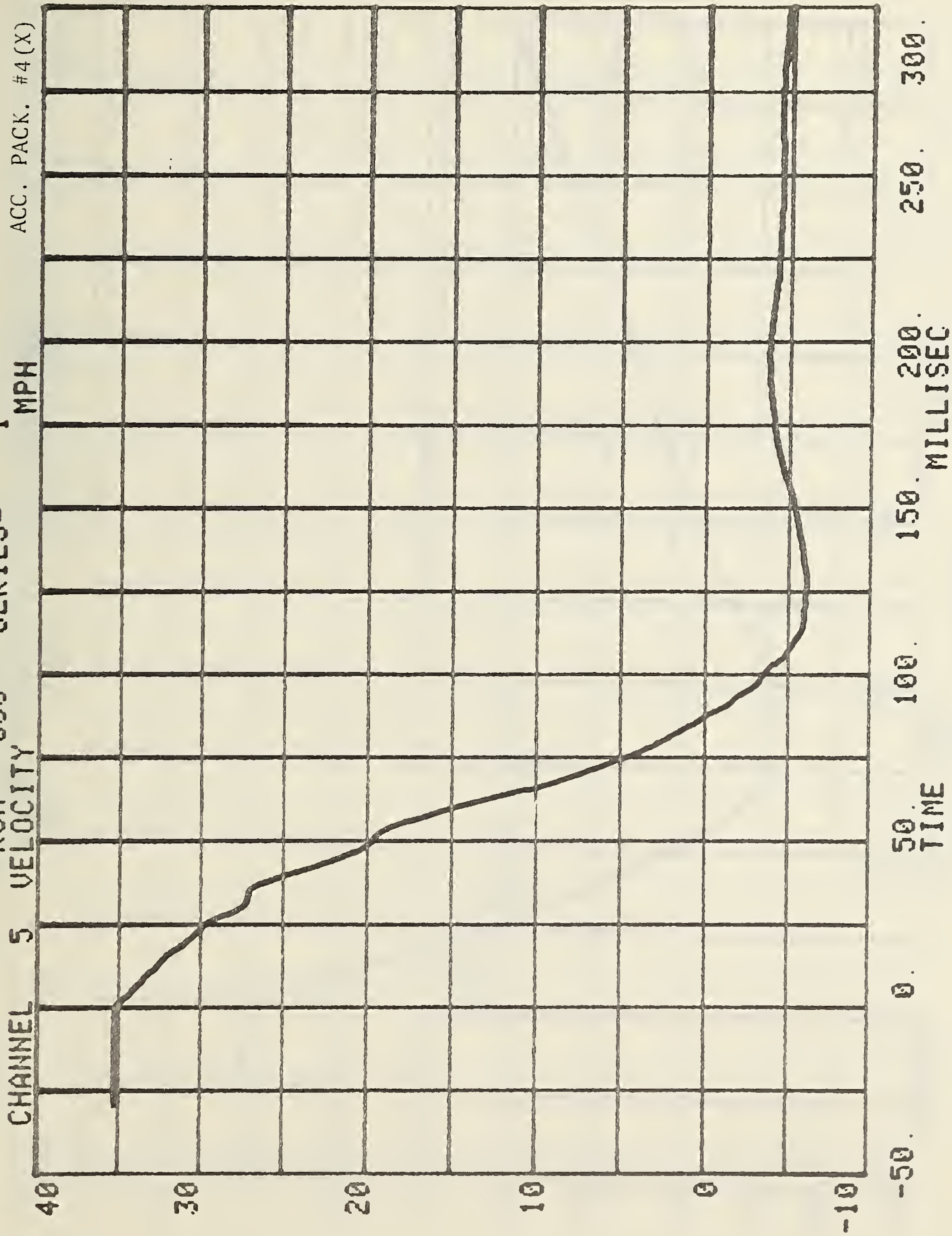
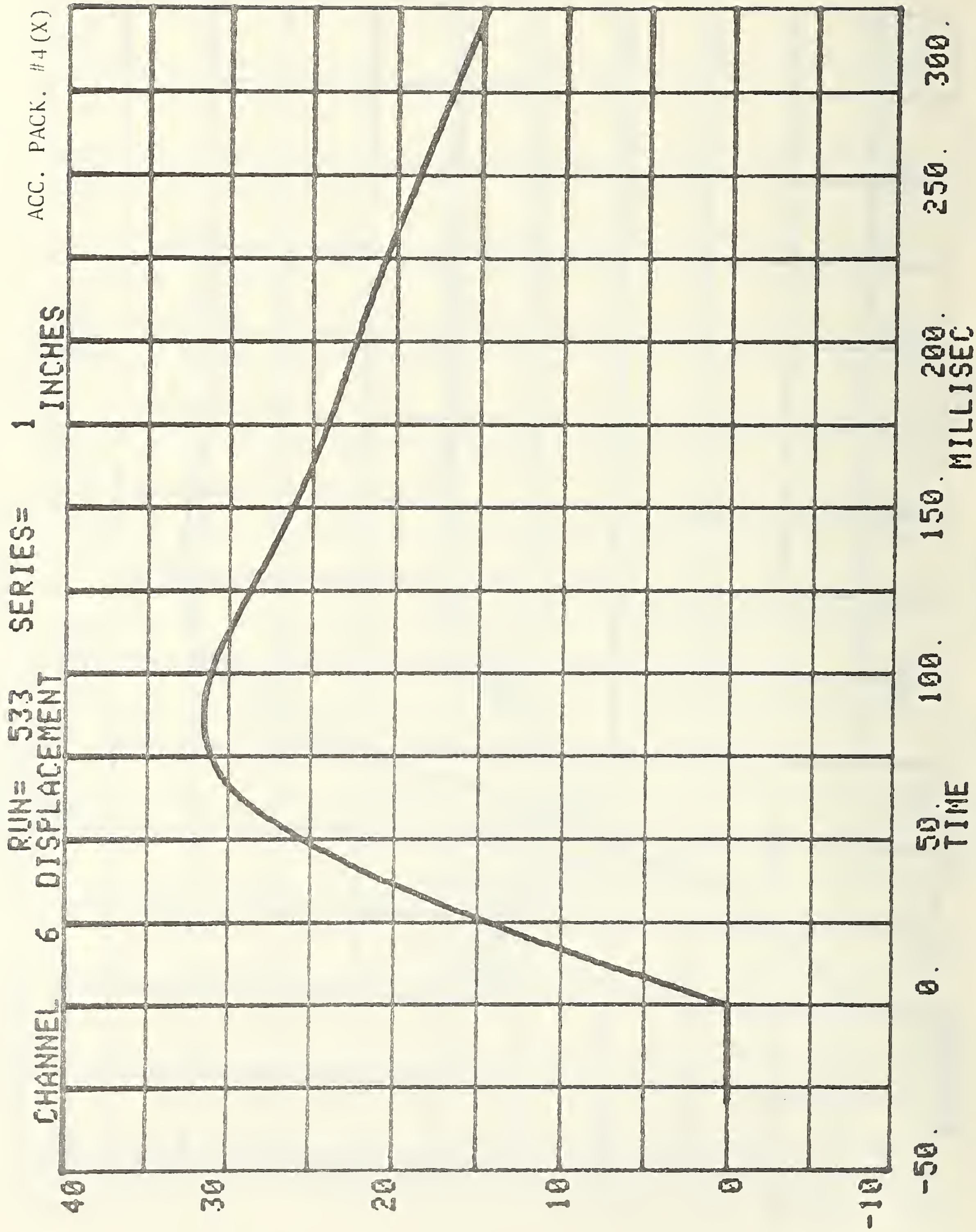
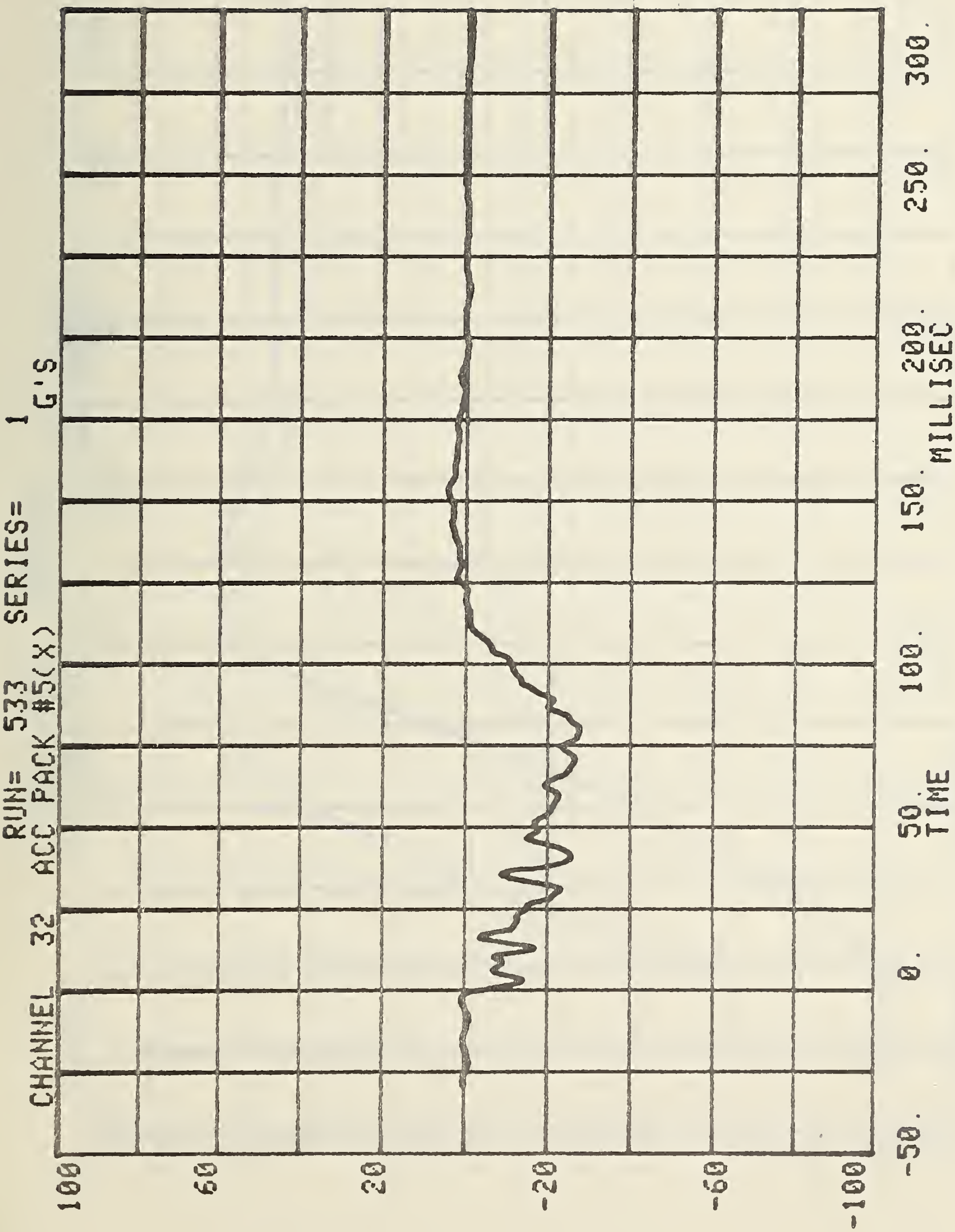
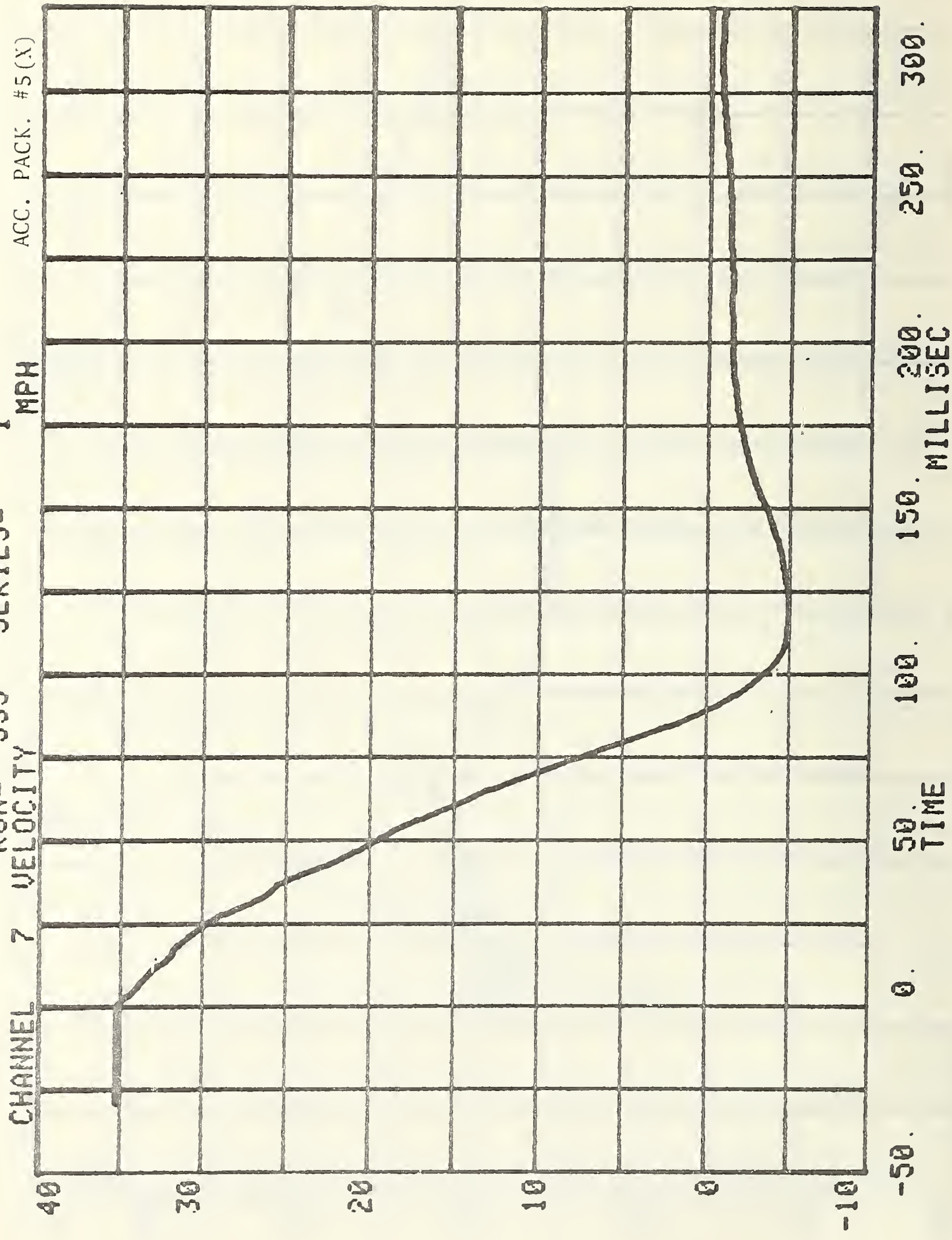
200.
250.
300.
TIME MILLISEC

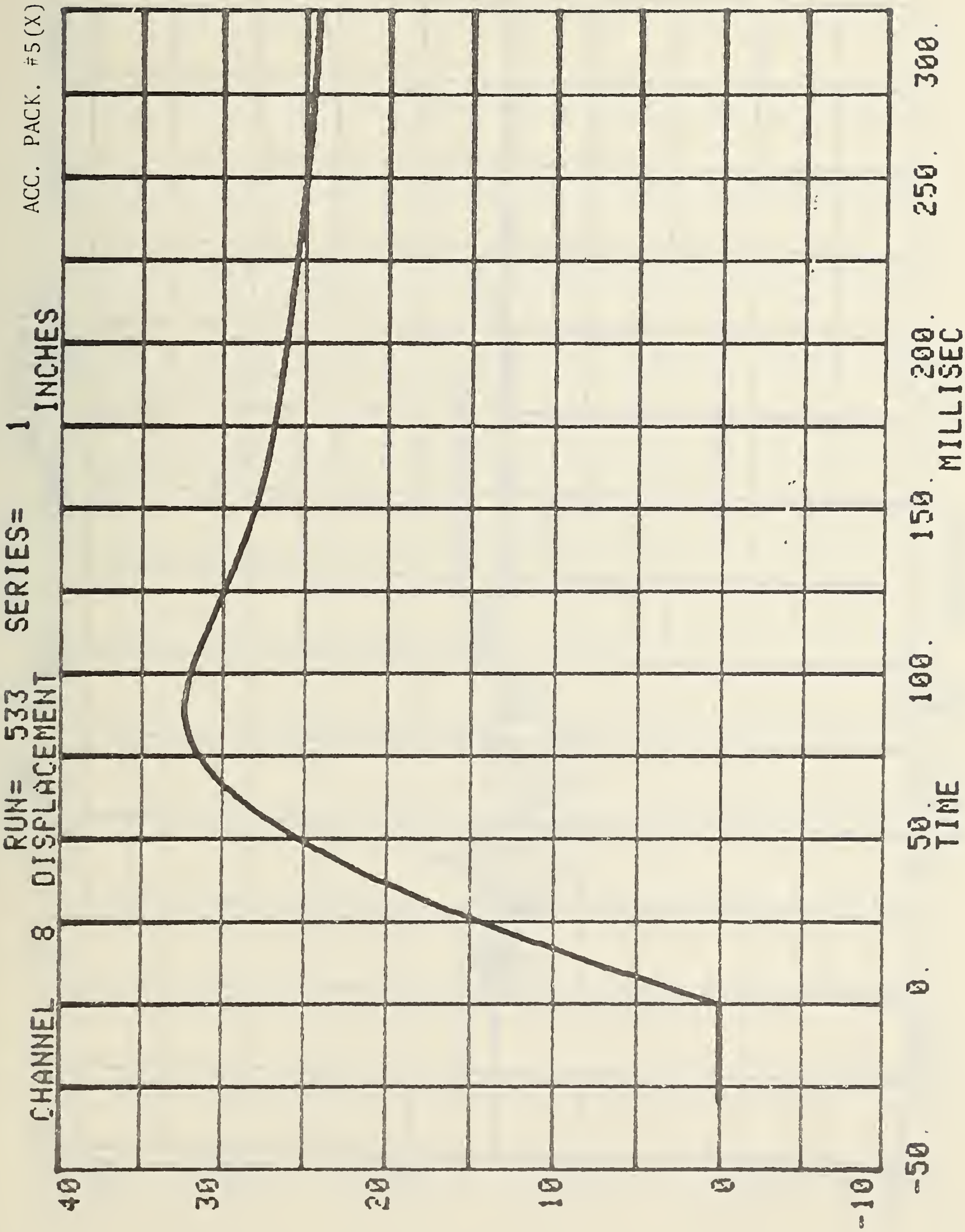

CHANNEL 31 RUN= 533 SERIES= 1
ACC PACK #4(X) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 5 RUN= 533 SERIES= 1
VELOCITY MPH
ACC. PACK. #4(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

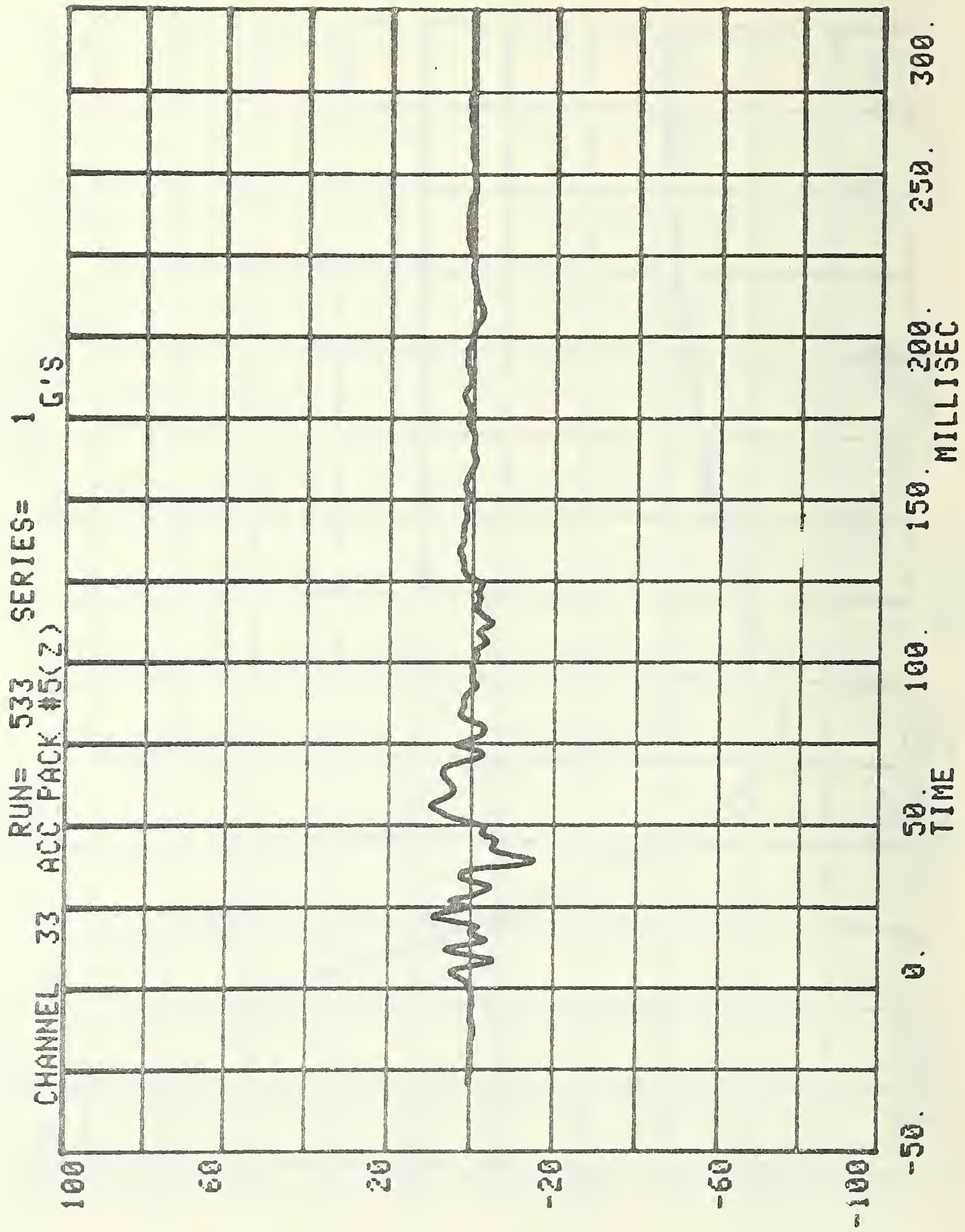

CHANNEL 6 RUN= 533 SERIES= 1
DISPLACEMENT INCHES
ACC. PACK. #4(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

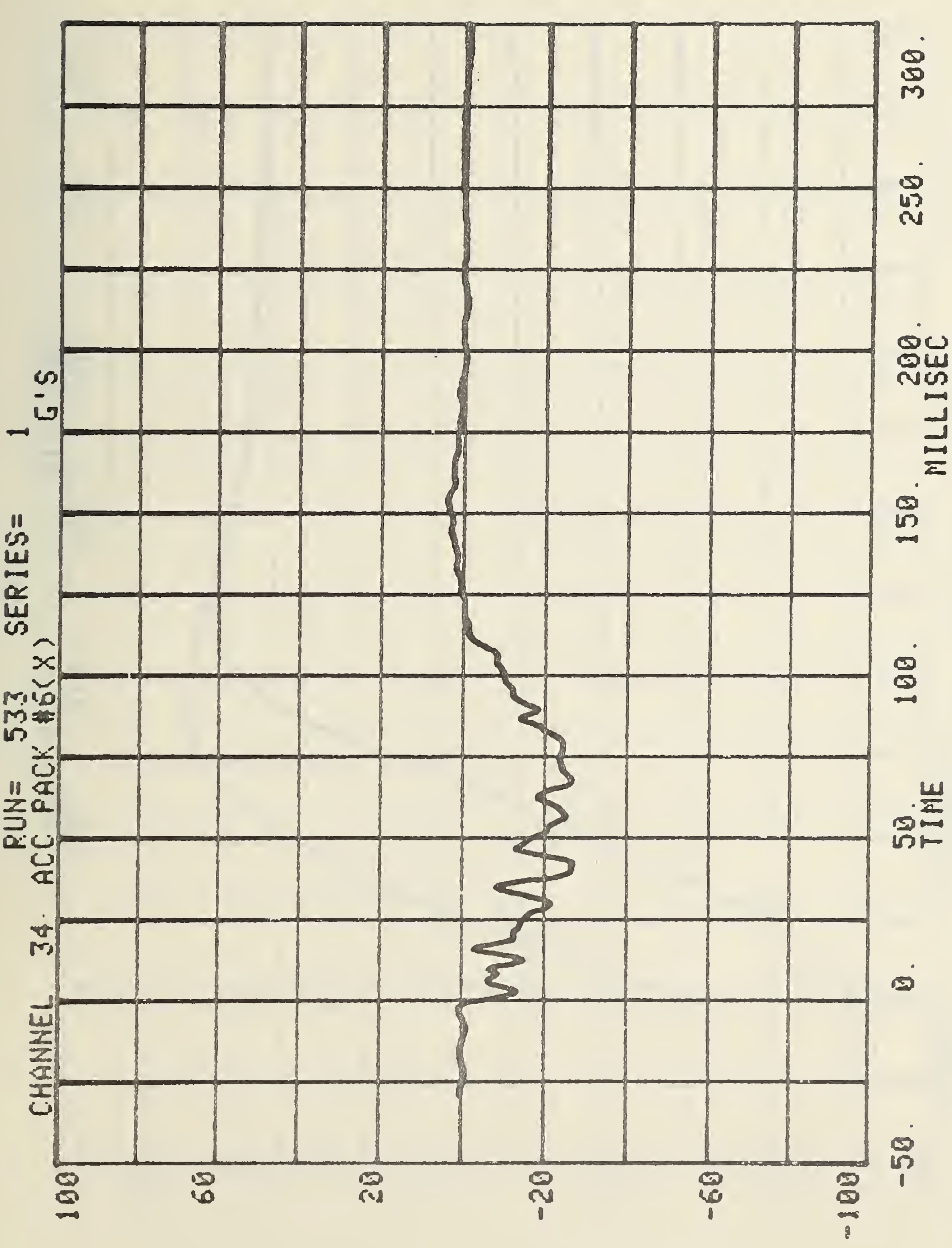

CHANNEL 32 RUN= 533 SERIES= 1
ACC PACK #5(X)
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

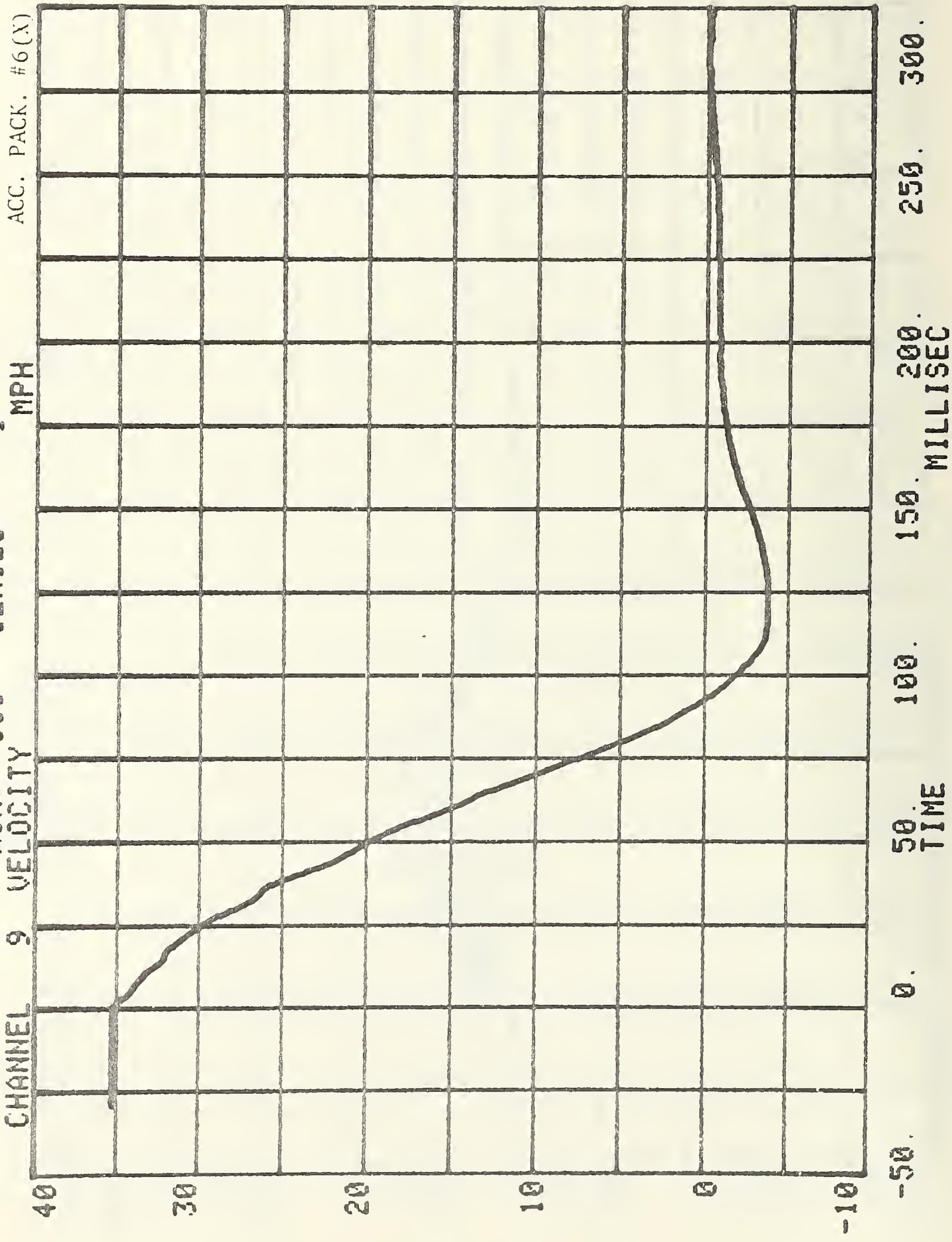

CHANNEL 7 RUN= 533 SERIES= 1
ACC. PACK. #5(X)
VELOCITY MPH
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
40 30 20 10 0 -10

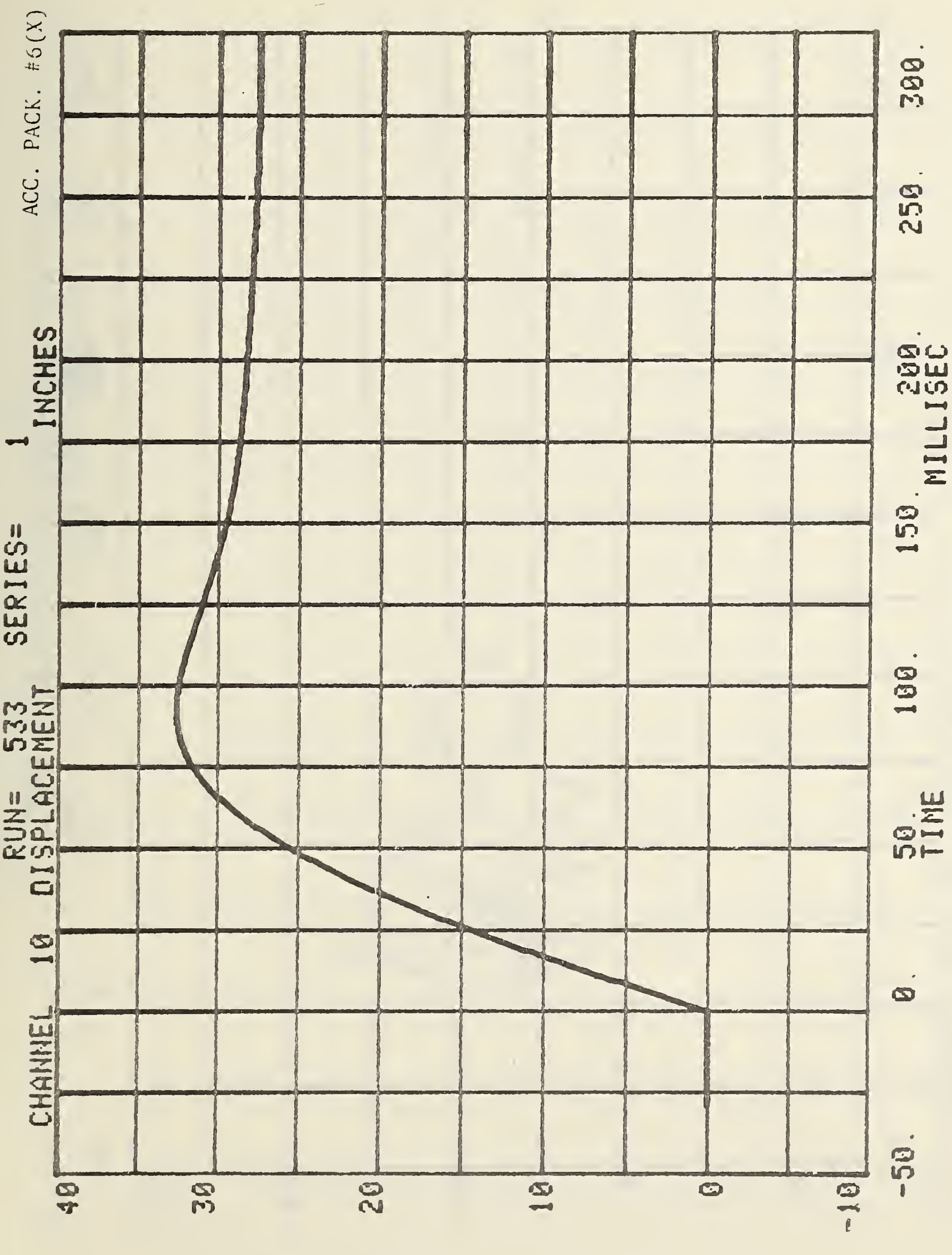


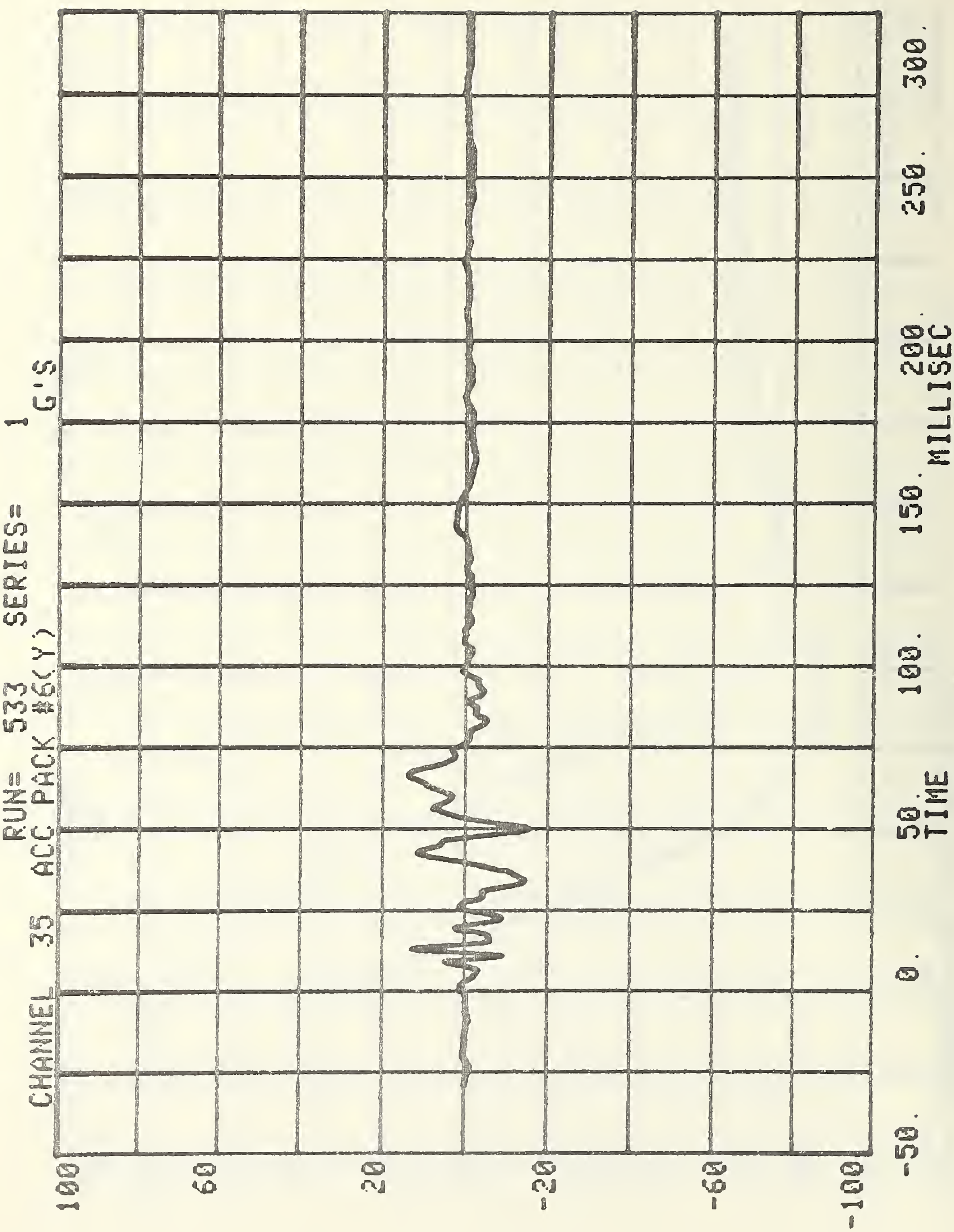
CHANNEL 8 DISPLACEMENT
RUN= 533 SERIES= 1
INCHES
ACC. PACK. #5(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

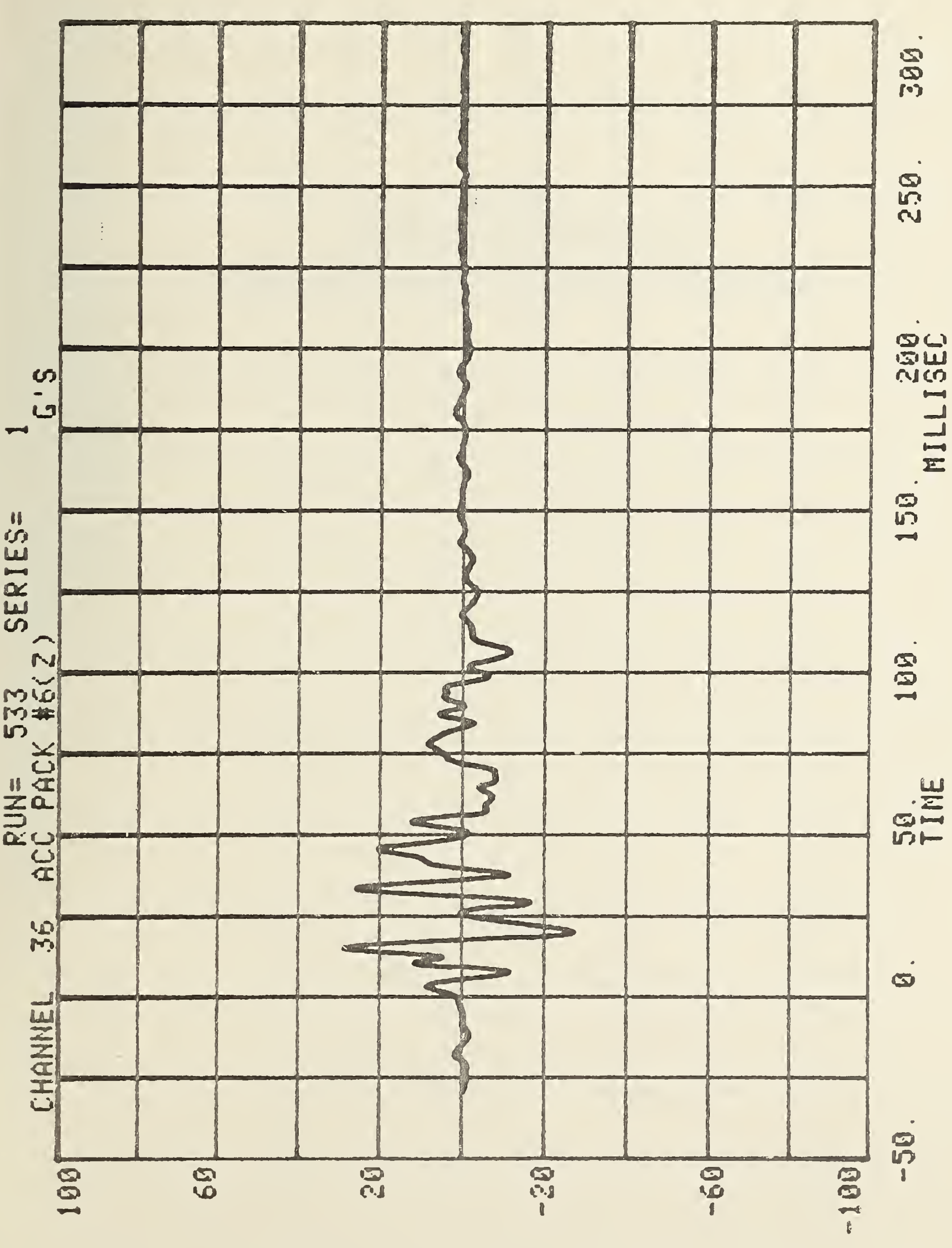

CHANNEL 33 RUN= 533 SERIES= 1
ACC PACK #5(Z) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


RUN= 533 SERIES= 1
CHANNEL 34 ACC PACK #6(X)
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC


CHANNEL 9 RUN= 533 SERIES= 1
VELOCITY MPH
ACC. PACK. #6(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 10 RUN= 533 SERIES= 1
DISPLACEMENT INCHES
ACC. PACK. #5(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

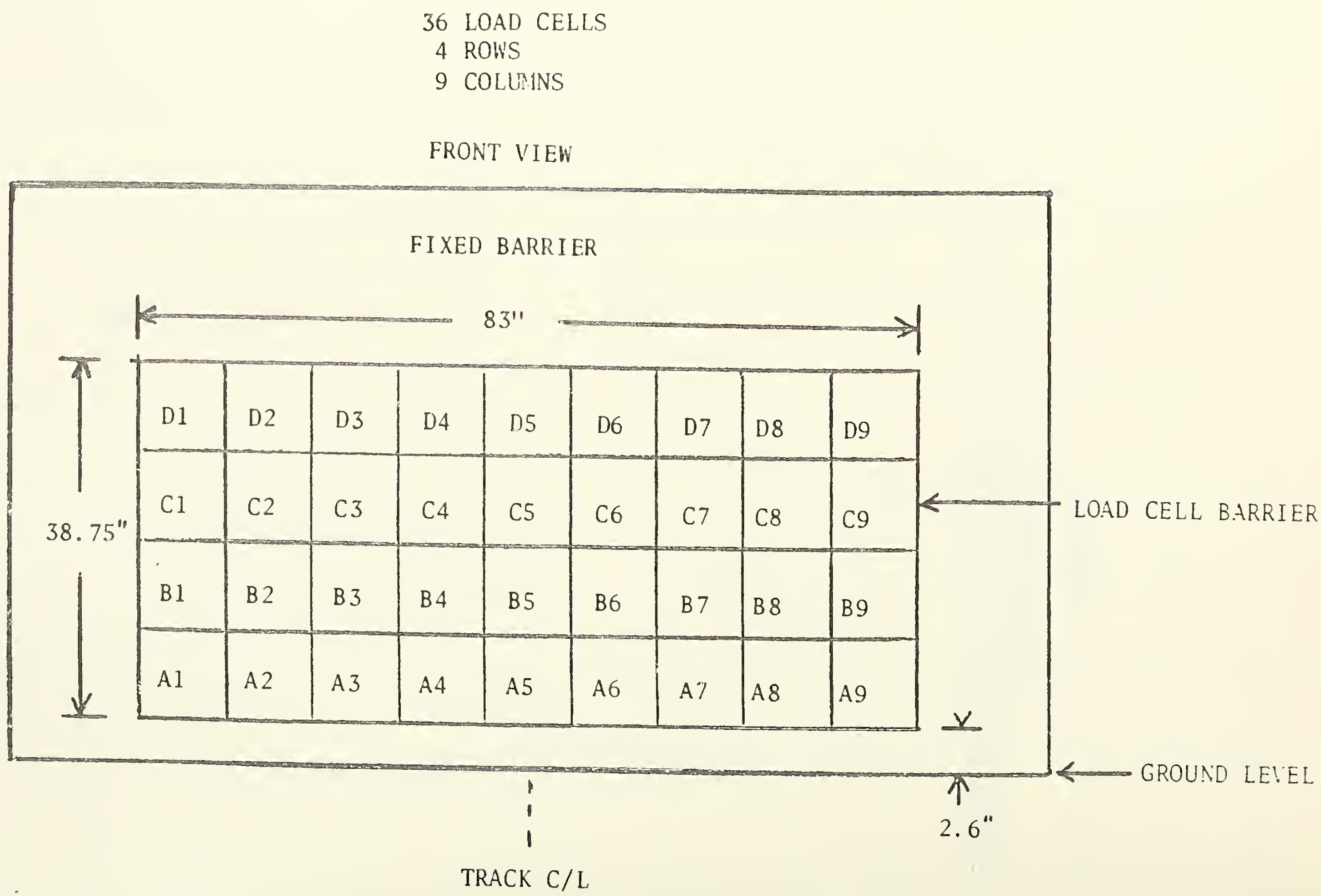

CHANNEL 35 RUN= 533 SERIES= 1
ACC PACK #6(Y) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 36 RUN= 533 SERIES= 1
ACC PACK #6(Z)
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

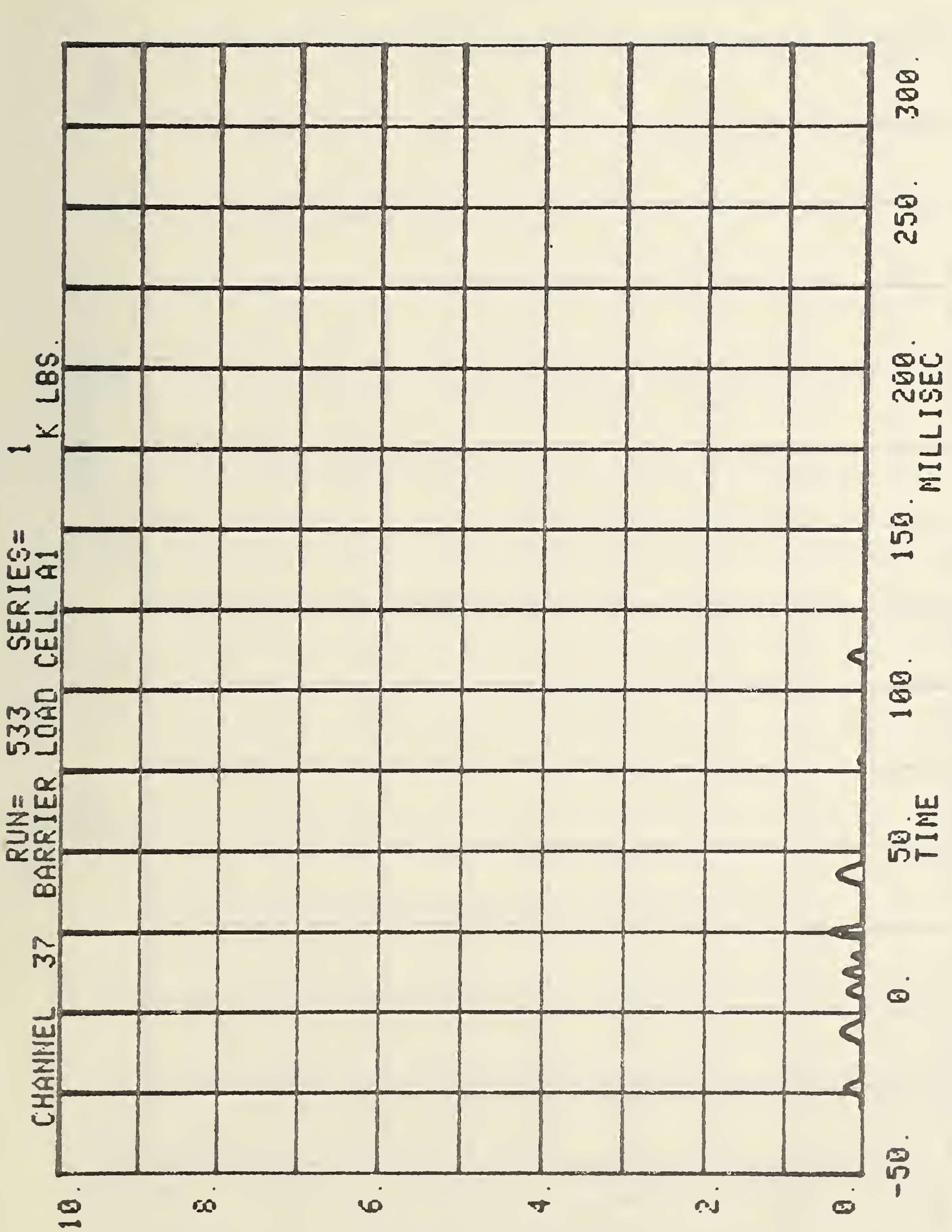
APPENDIX B

ELECTRONIC CRASH TEST DATA:

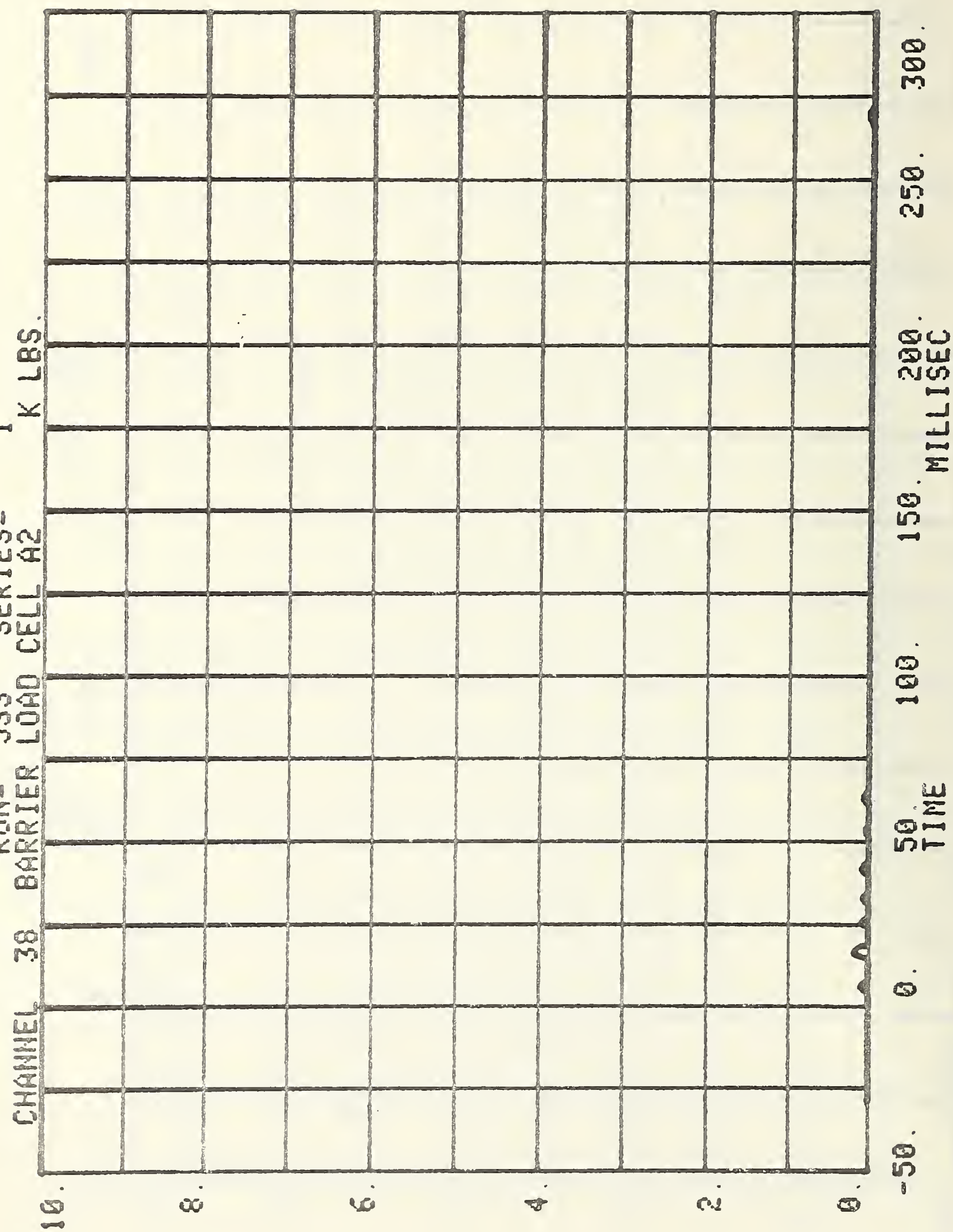
BARRIER LOAD CELL FROM PLYMOUTH RELIANT IMPACT

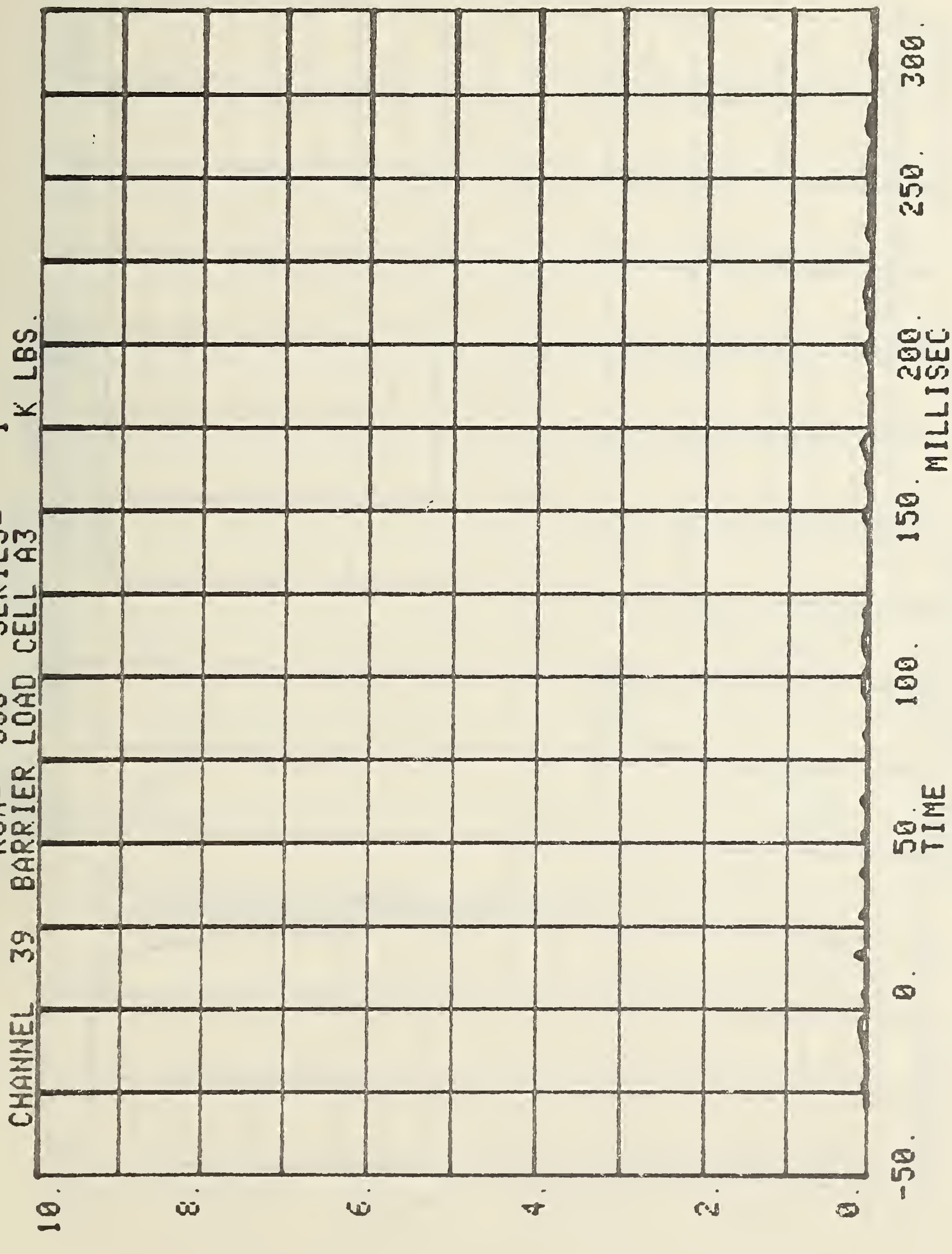


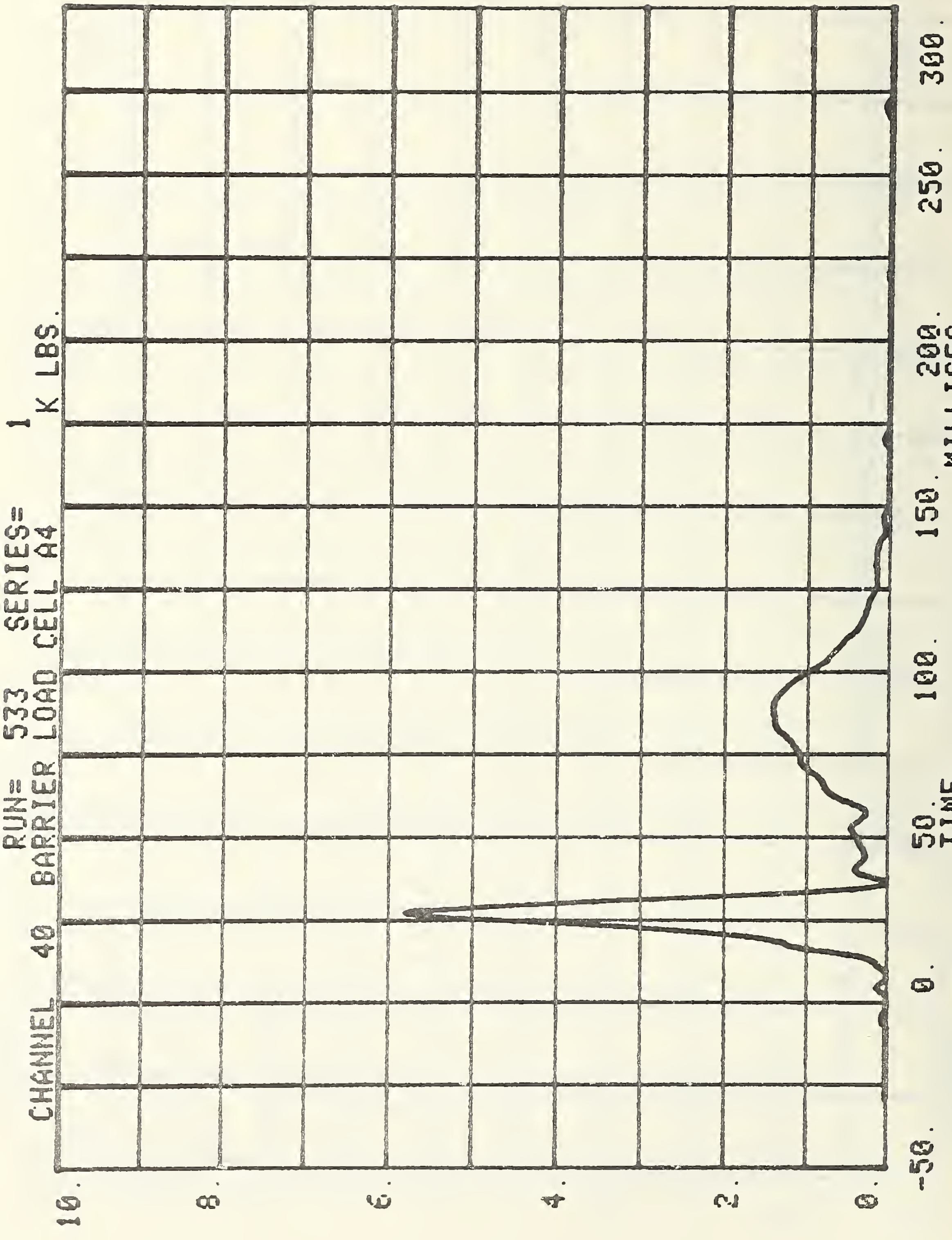
BARRIER LOAD CELL CONFIGURATION

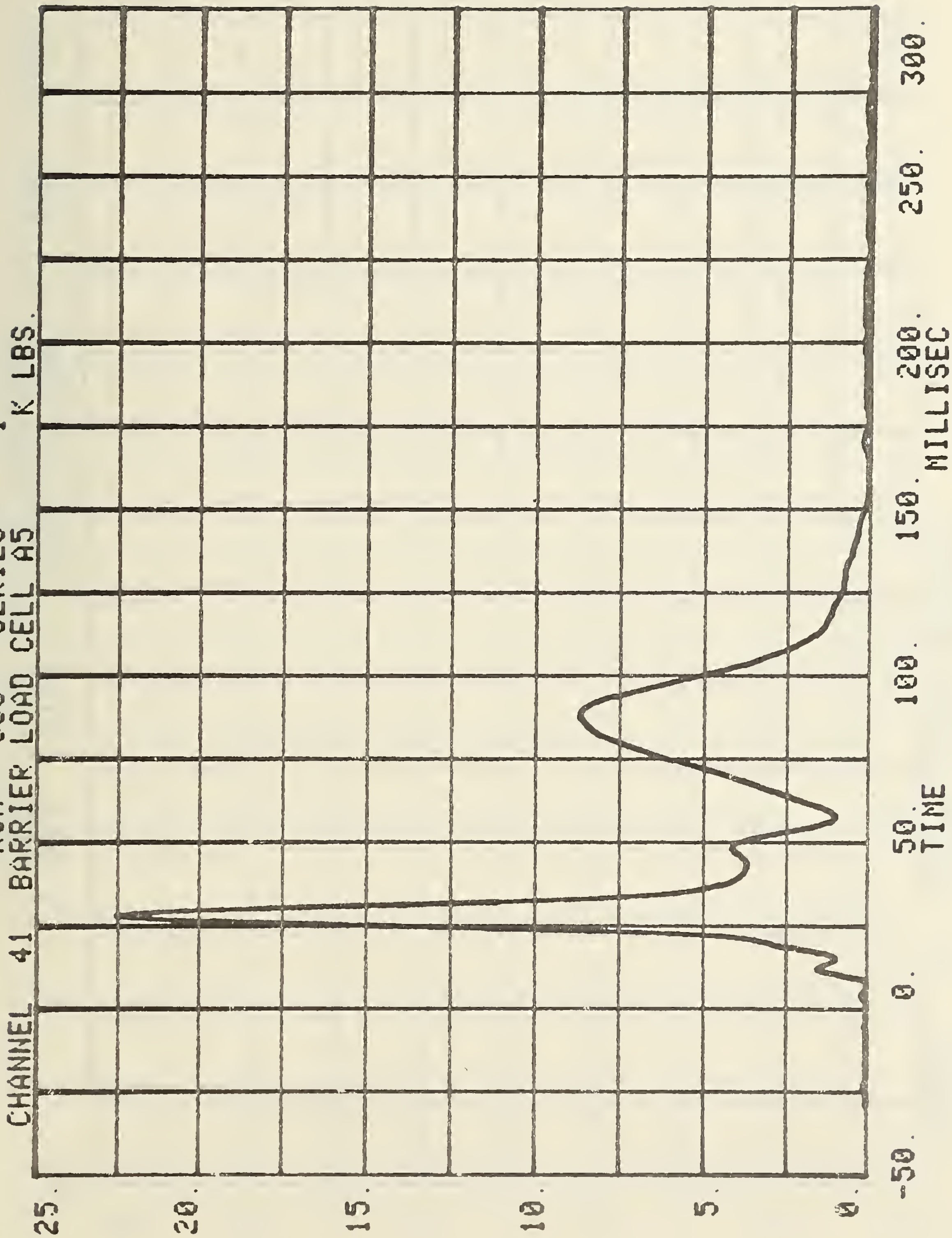


CHANNEL 37 RUN= 533 SERIES= 1
BARRIER LOAD CELL A1 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

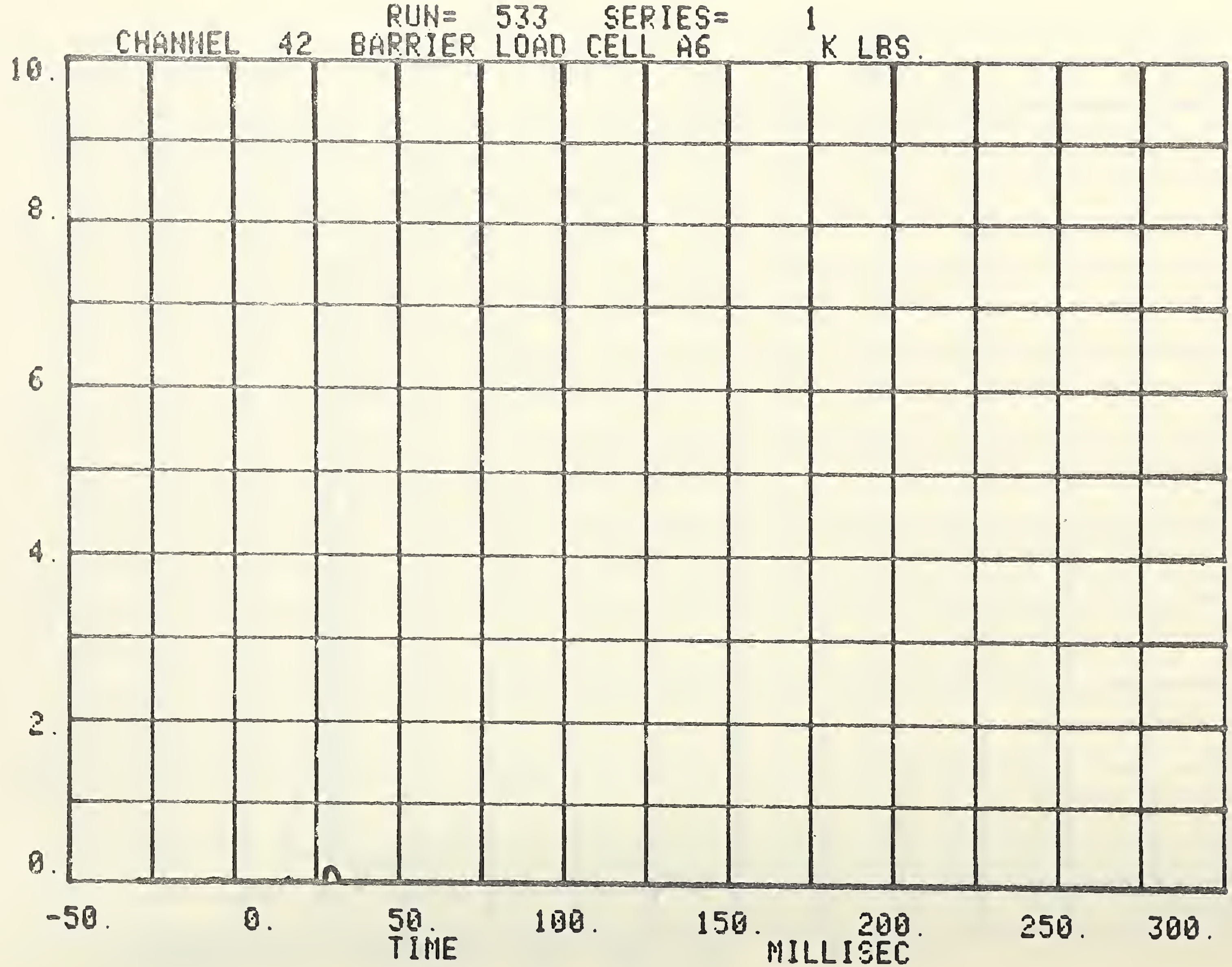

CHANNEL 38 RUN= 533 SERIES= 1
BARRIER LOAD CELL A2 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

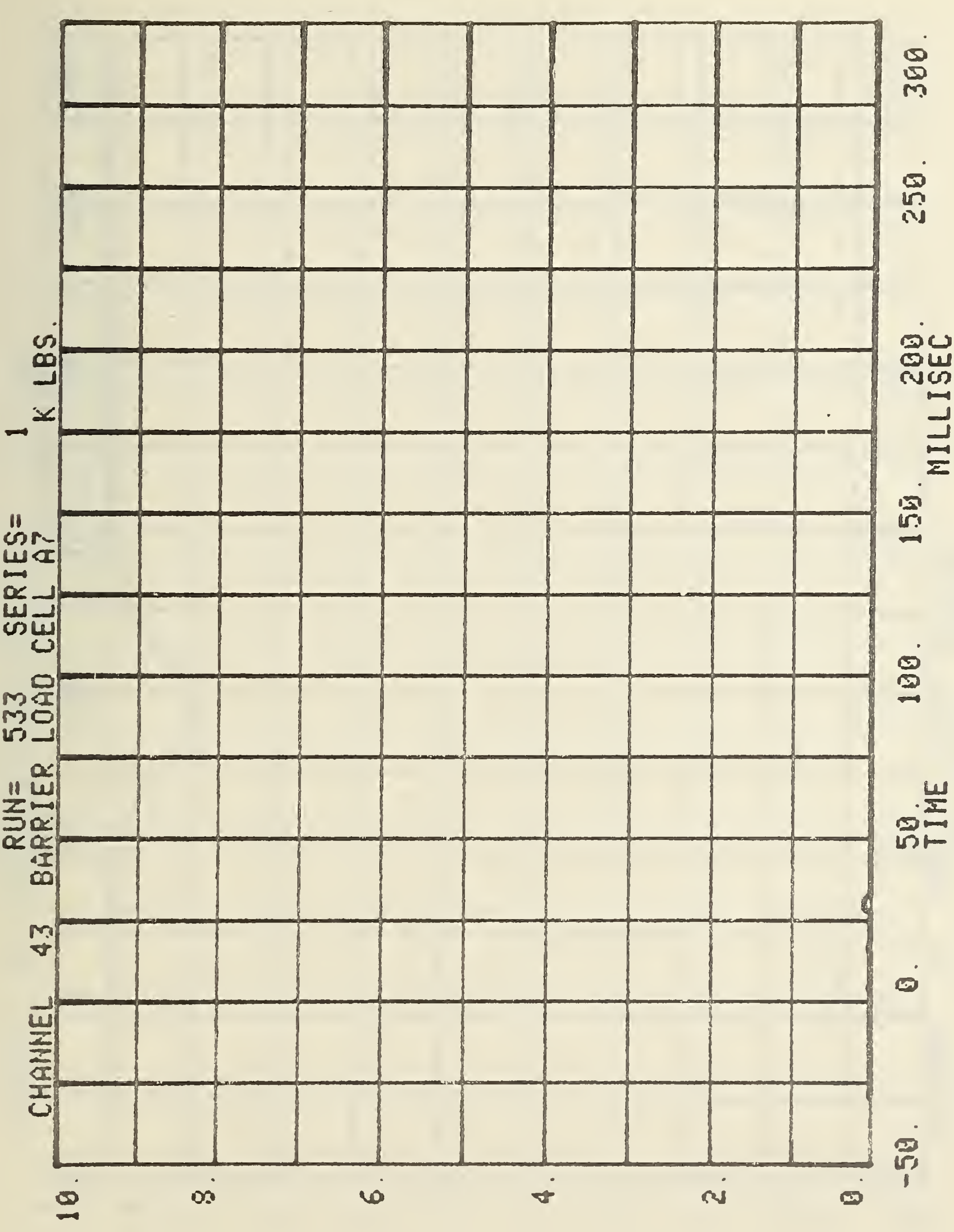

CHANNEL 39 RUN= 533 SERIES= 1
BARRIER LOAD CELL A3 K LBS.
TIME MILLISEC
-50.
0.
50.
100.
150.
200.
250.
300.
0.
2.
4.
6.
8.
10.

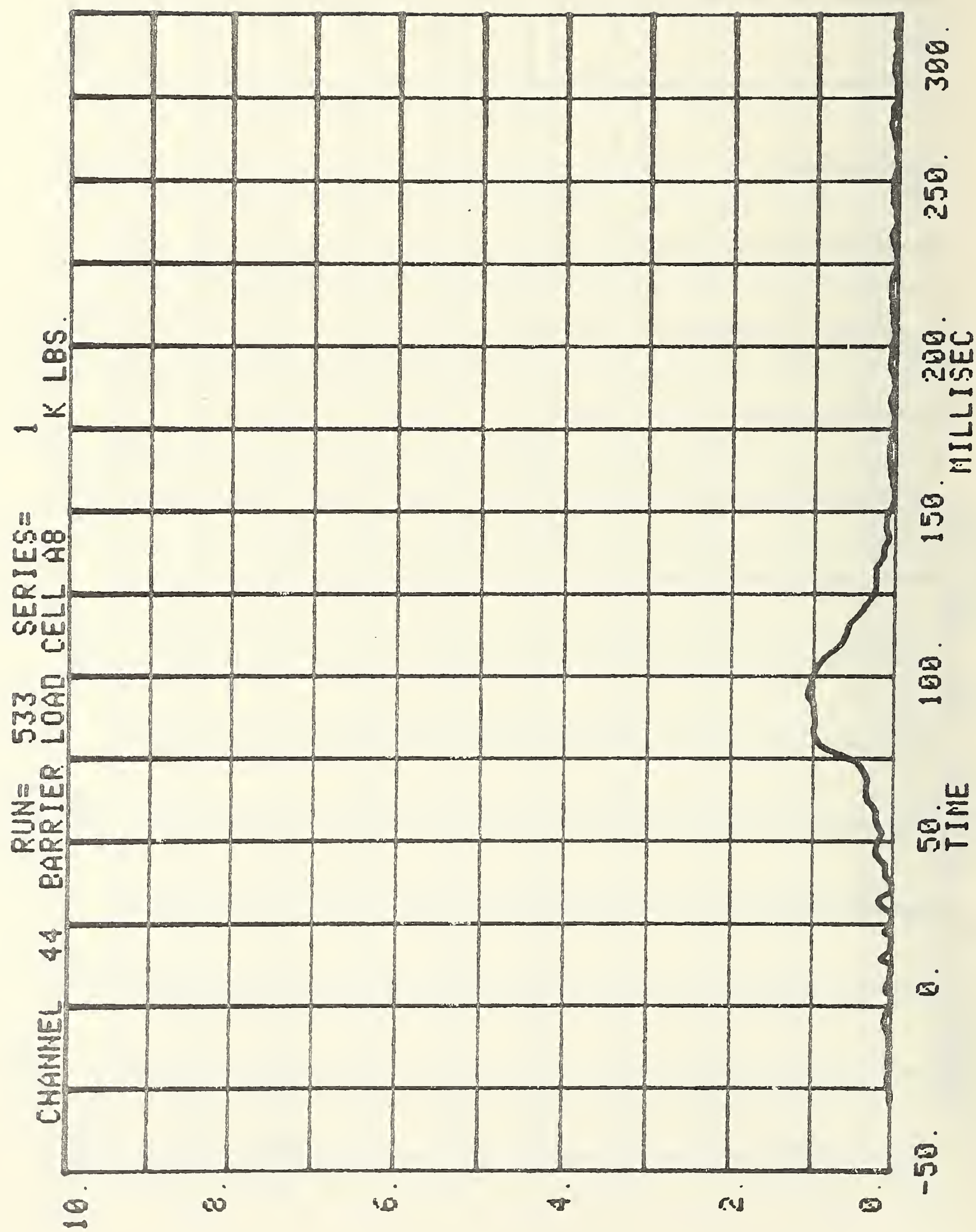

CHANNEL 40 RUN= 533 SERIES= 1
BARRIER LOAD CELL A4 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

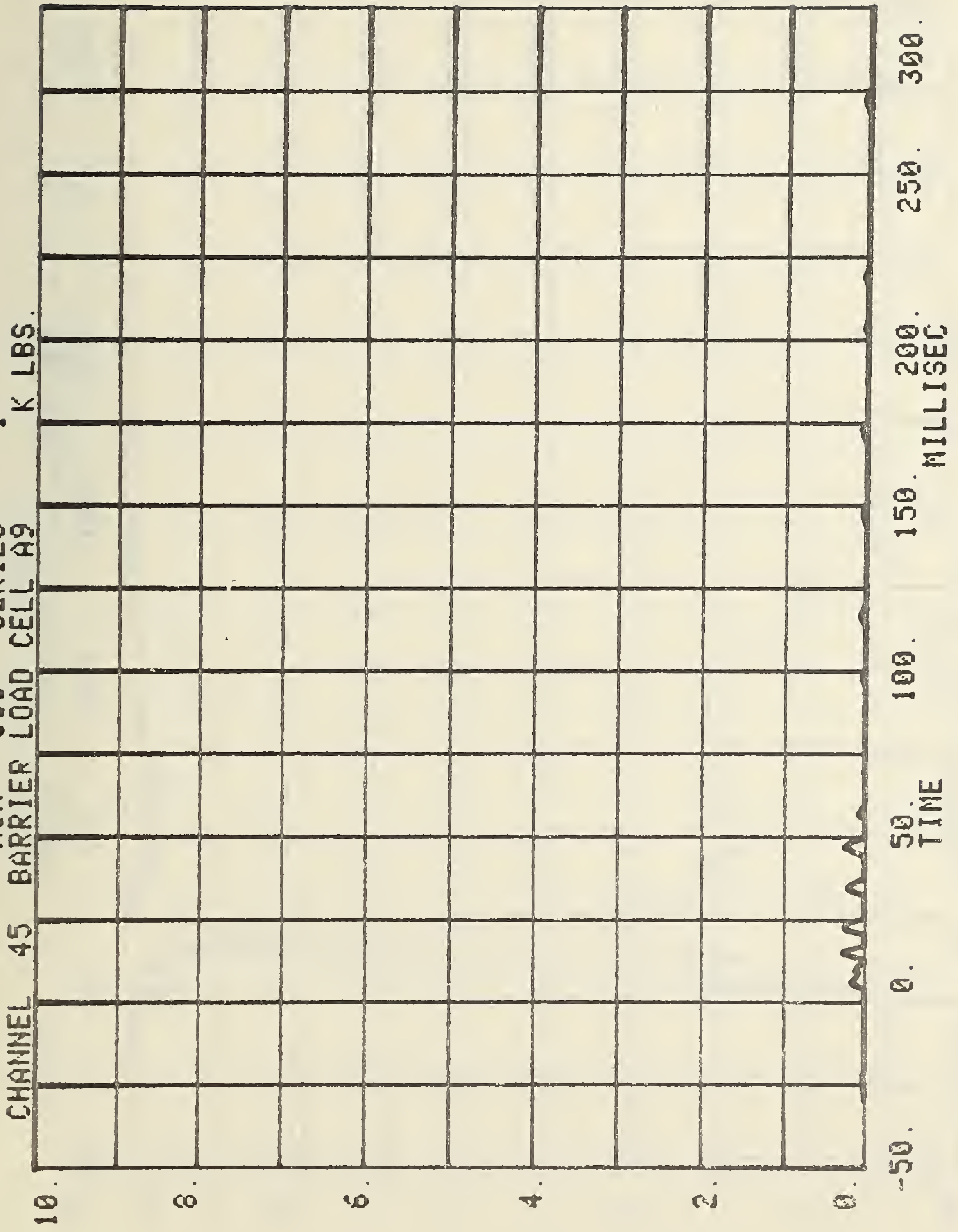


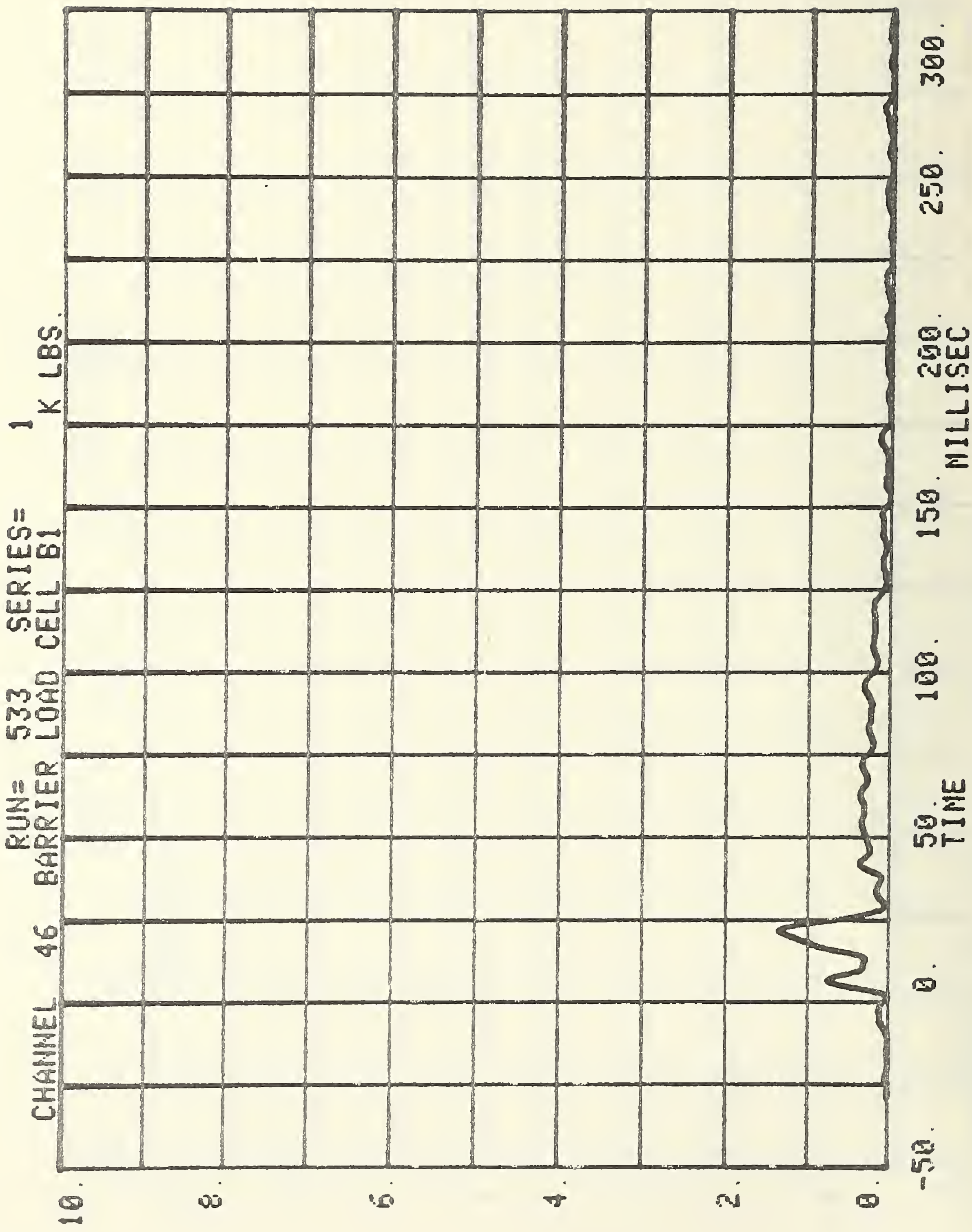
CHANNEL 41 RUN= 533 SERIES= 1
BARRIER LOAD CELL A5 K LBS.
25.
20.
15.
10.
5.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


RUN= 533 SERIES= 1
CHANNEL 42 BARRIER LOAD CELL A6 K LBS.
10.
8.
6
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

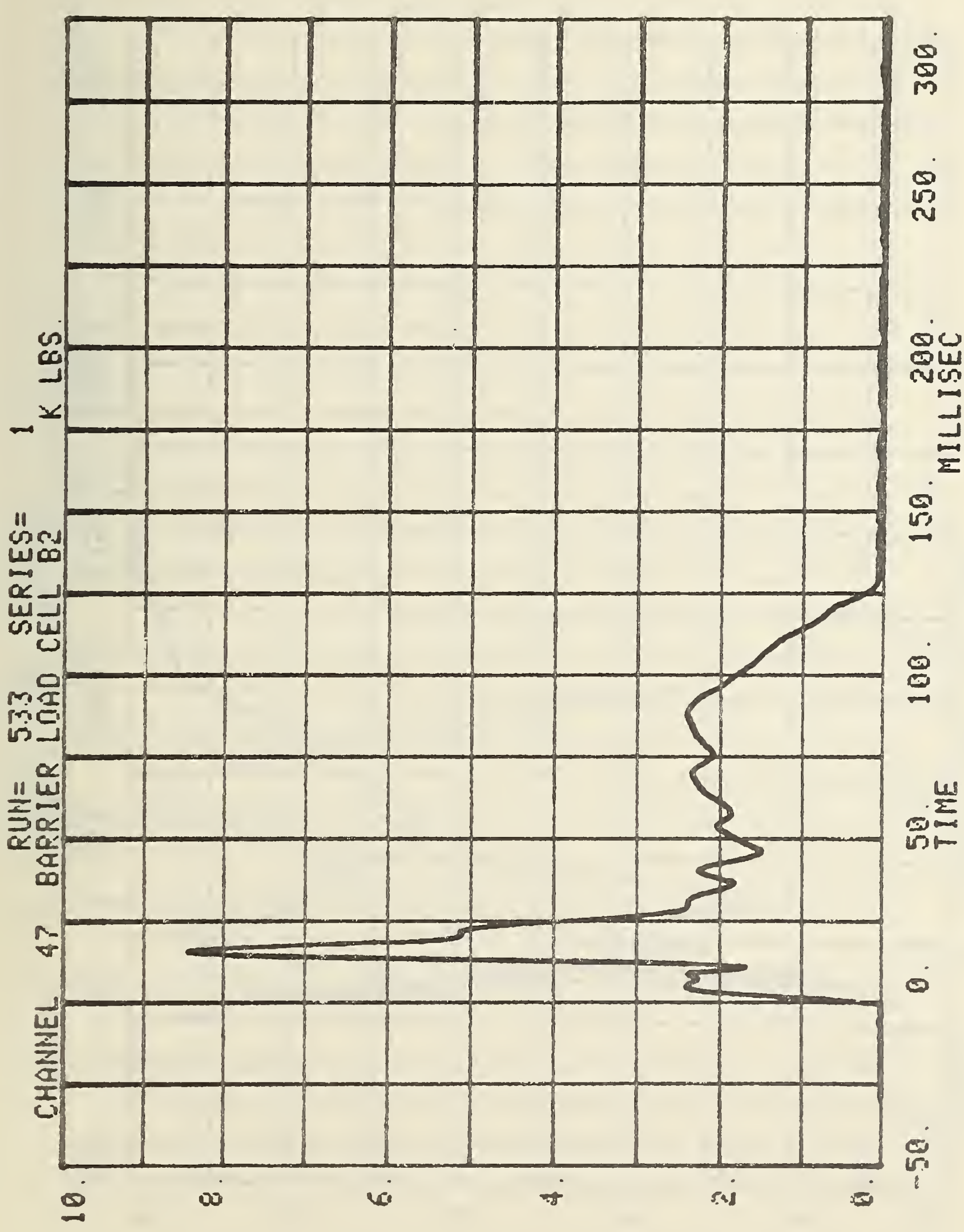

CHANNEL 43 RUN= 533 SERIES= 1
BARRIER LOAD CELL A7 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

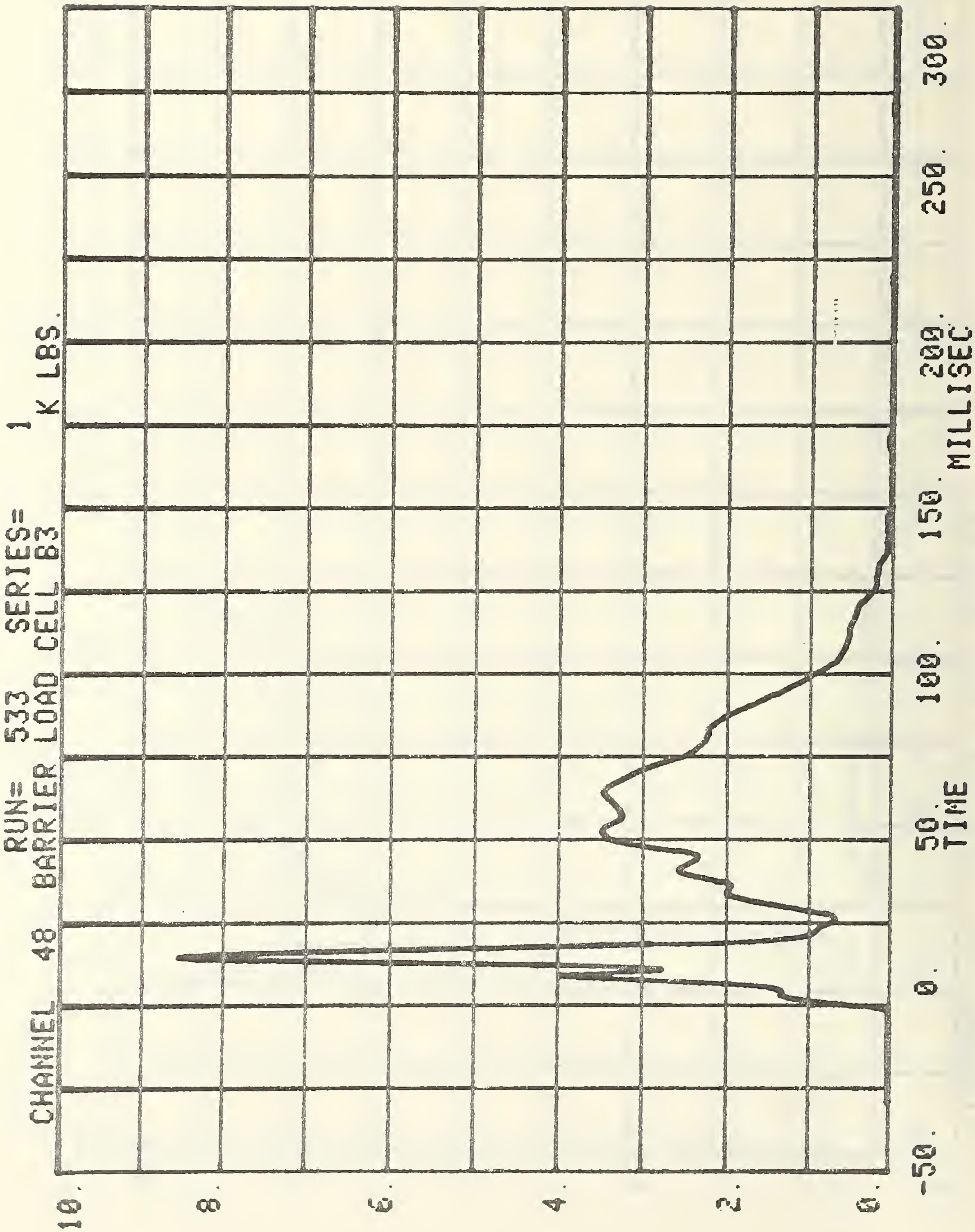

CHANNEL 44 RUN= 533 SERIES= 1
BARRIER LOAD CELL AB K LBS.
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
0. 2. 4. 6. 8. 10.

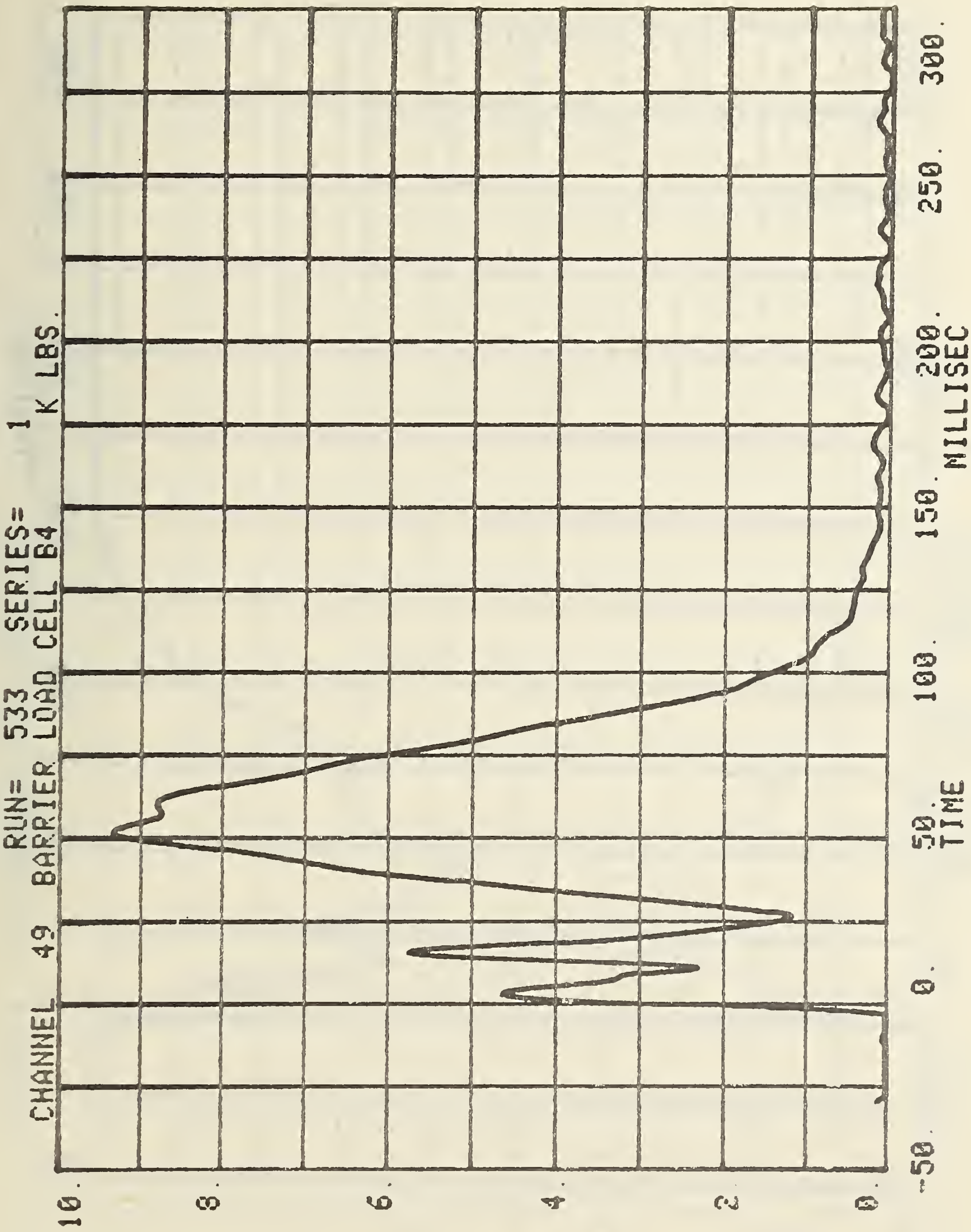

CHANNEL 45 RUN= 533 SERIES= 1
BARRIER LOAD CELL A9 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

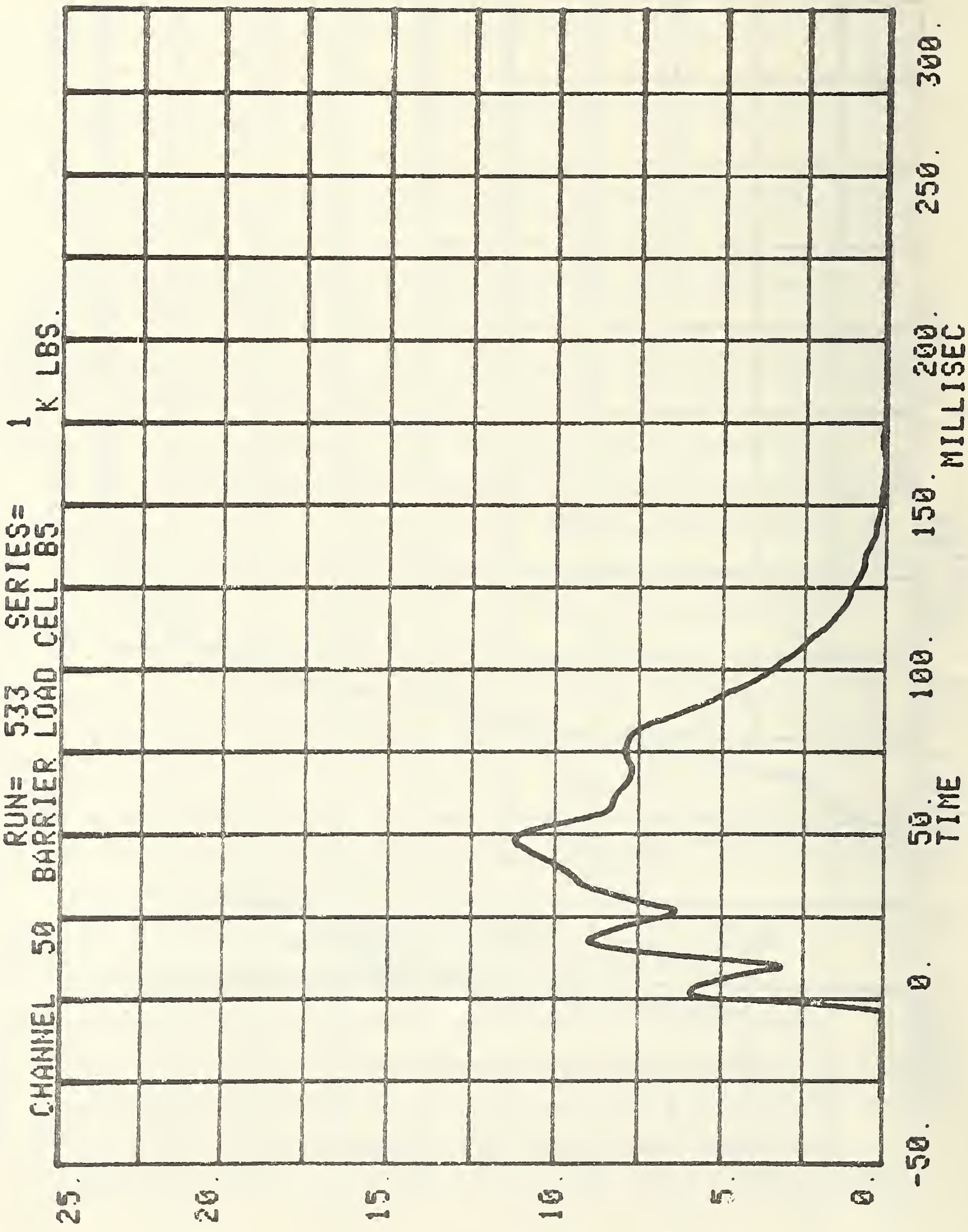


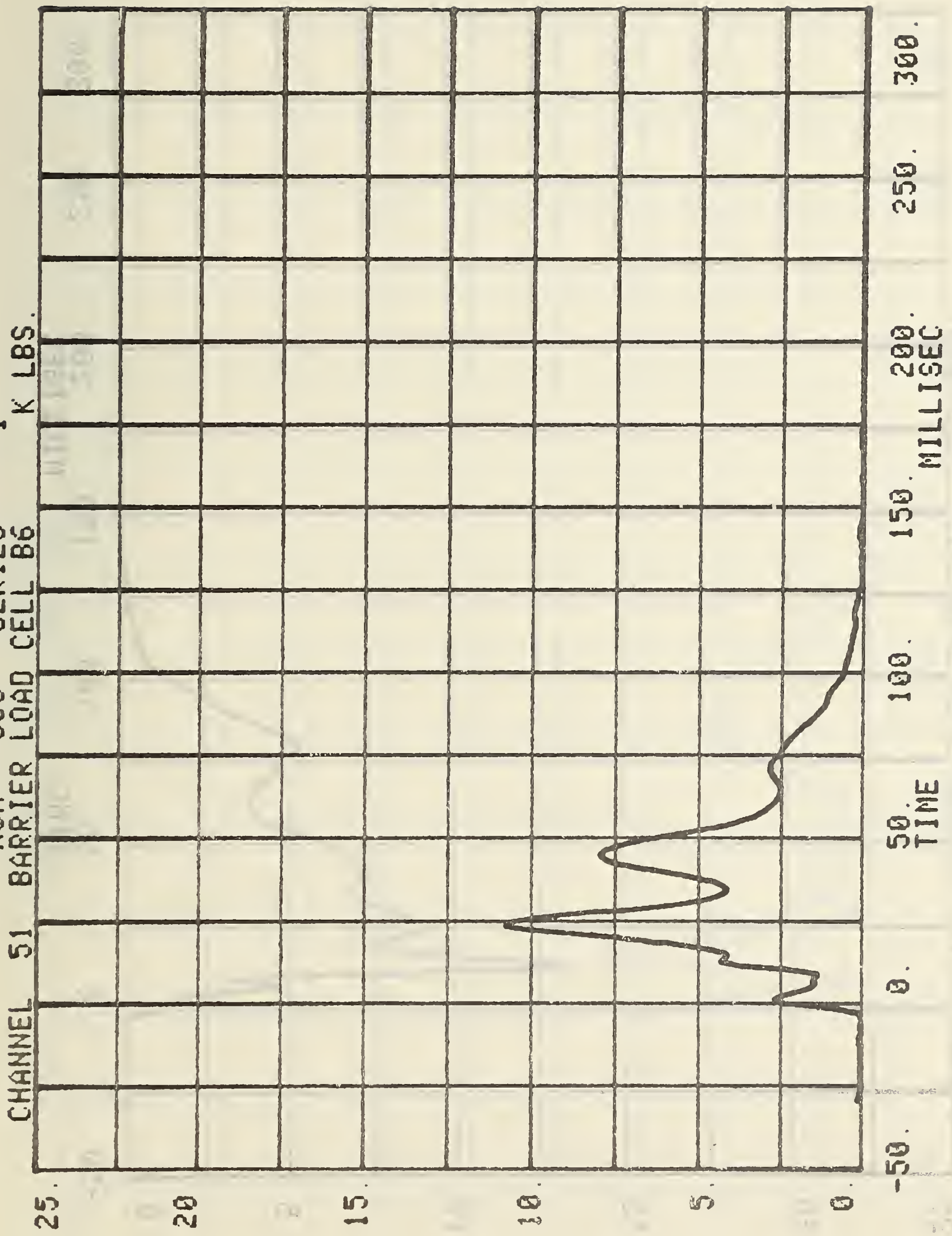
CHANNEL 46 RUN= 533 SERIES= 1
BARRIER LOAD CELL B1 K LBS.
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
0. 2. 4. 6. 8. 10.

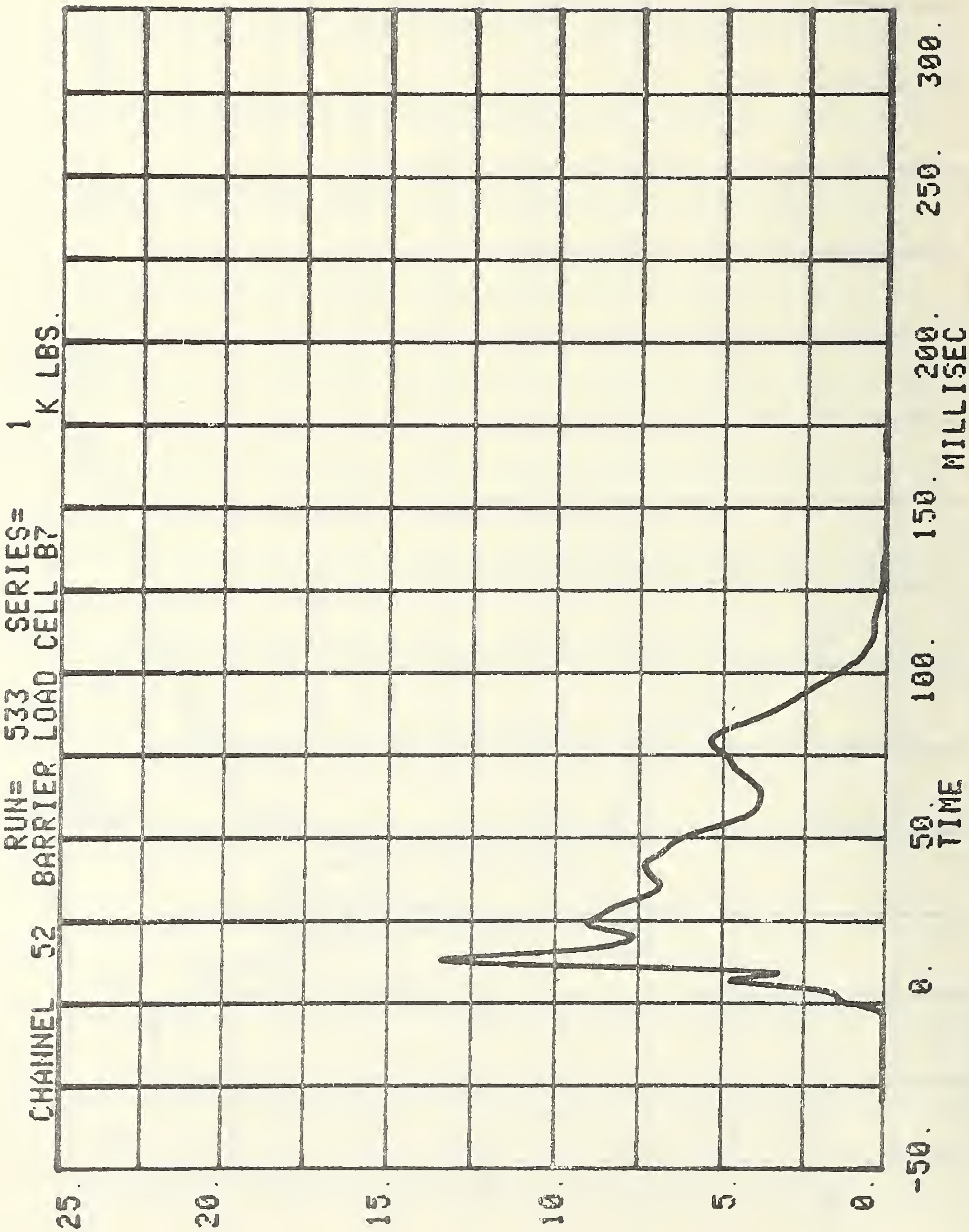

CHANNEL 47 RUN= 533 SERIES= 1
BARRIER LOAD CELL B2 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

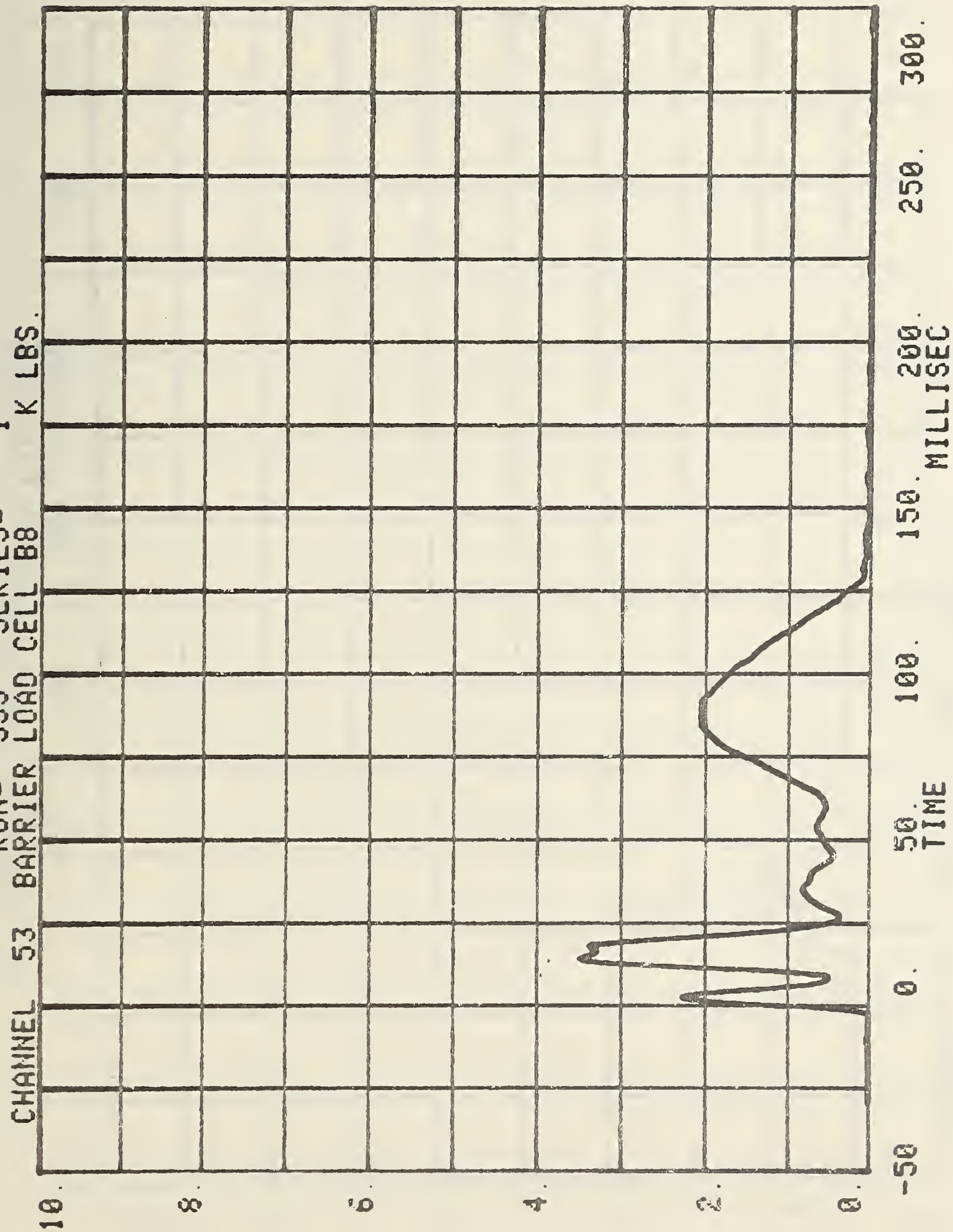

CHANNEL 48 RUN= 533 SERIES= 1
BARRIER LOAD CELL B3 K LBS
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

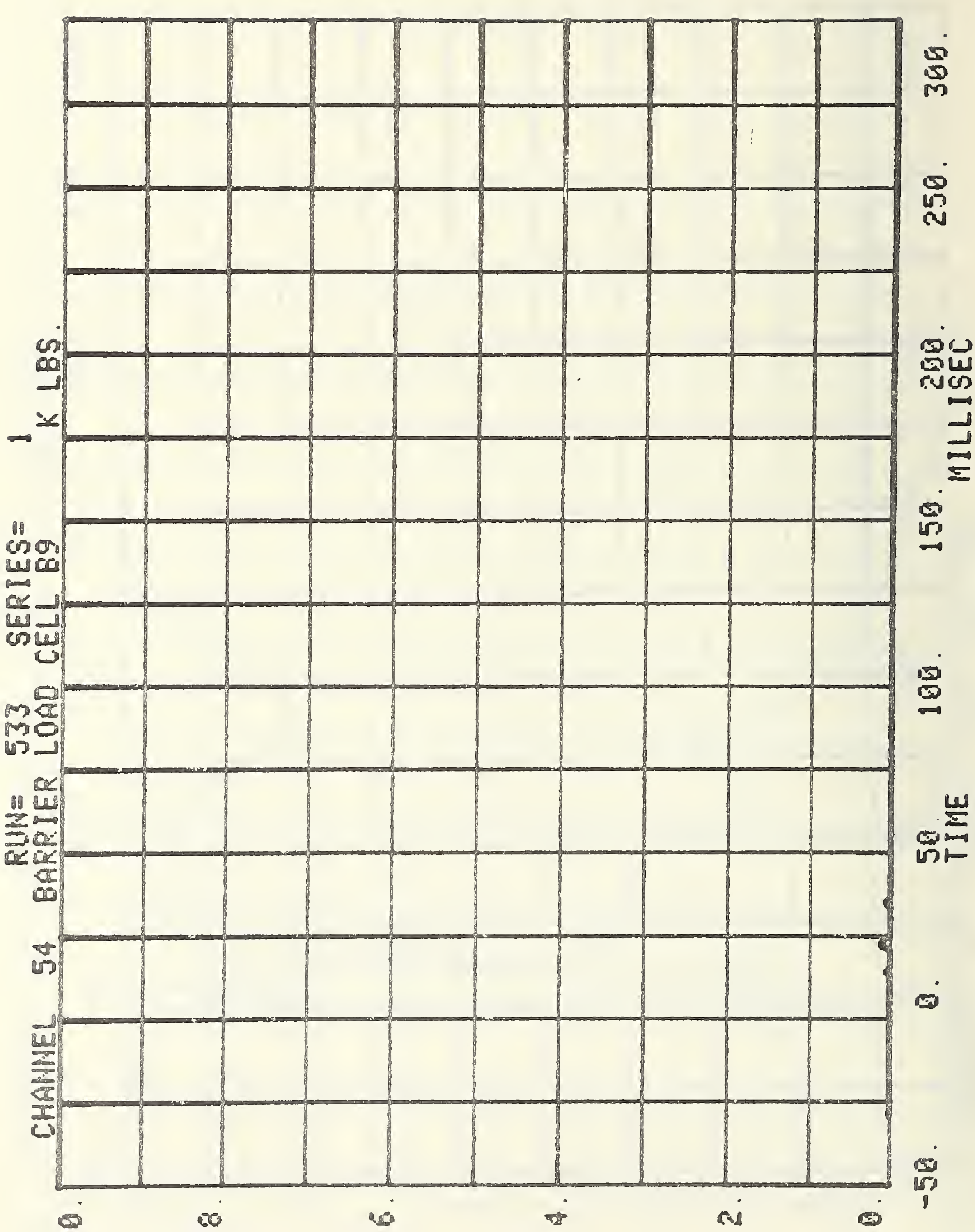

CHANNEL 49 RUN= 533 SERIES= 1
BARRIER LOAD CELL B4 K LBS.
TIME MILLISEC
-50.
0.
50.
100.
150.
200.
250.
300.
0.
2.
4.
6.
8.
10.

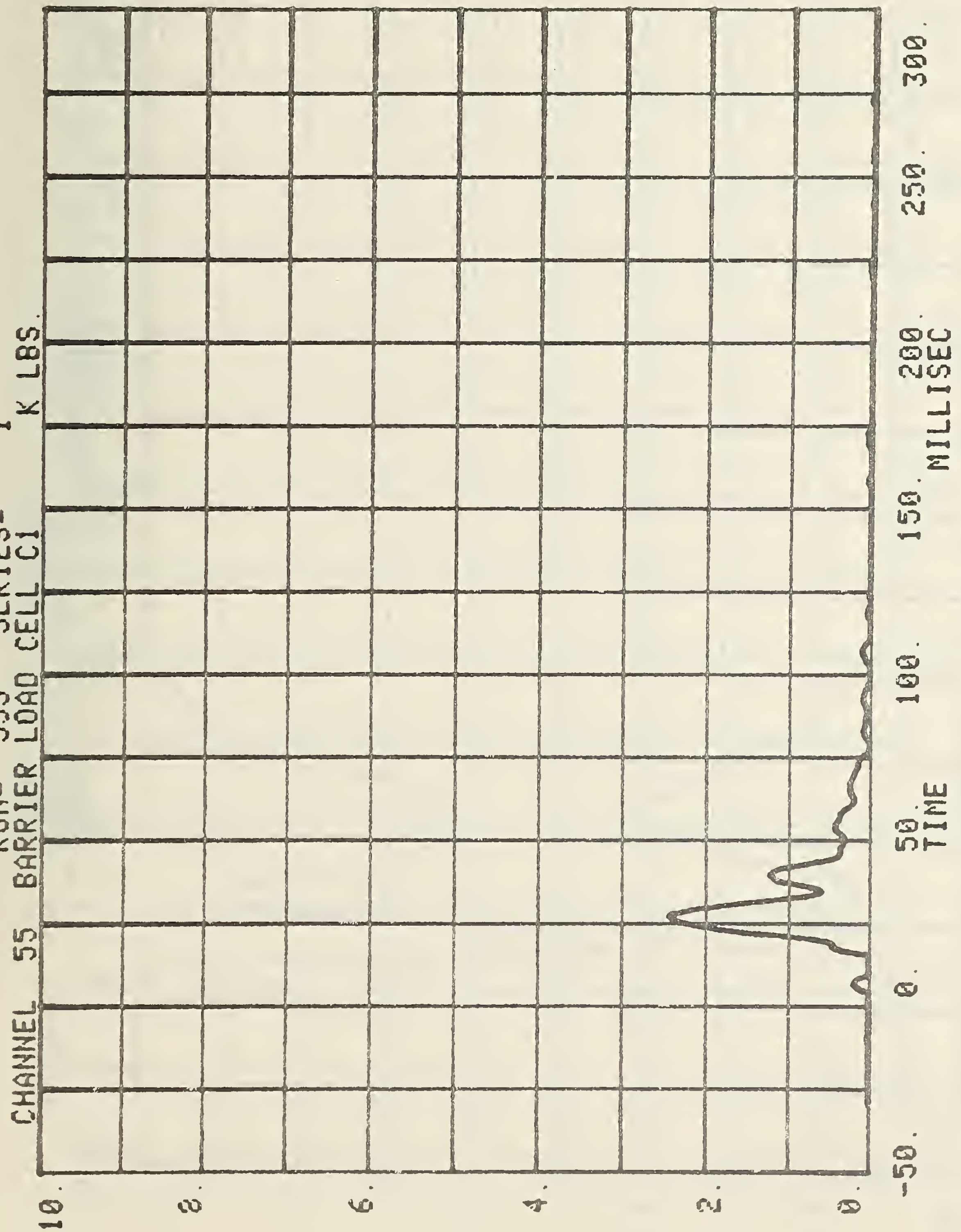

CHANNEL 50 RUN= 533 SERIES= 1
BARRIER LOAD CELL B5 K LBS.
25.
20.
15.
10.
5.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

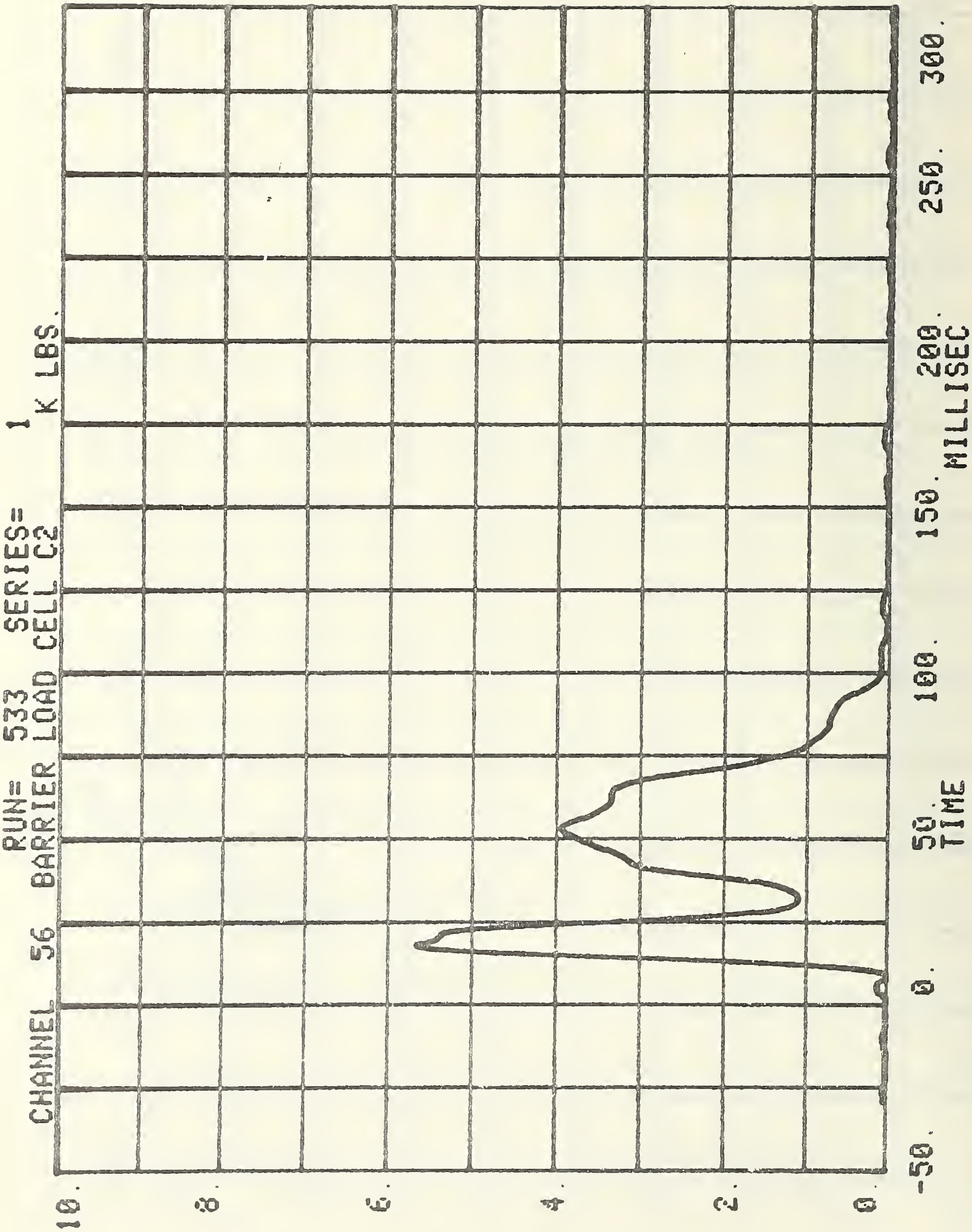

CHANNEL 51 RUN= 533 SERIES= 1
BARRIER LOAD CELL B6 K LBS.
TIME MILLISEC
-50.
0.
50.
100.
150.
200.
250.
300.
0.
5.
10.
15.
20.
25.


CHANNEL 52 RUN= 533 SERIES= 1
BARRIER LOAD CELL B7 K LBS.
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
0. 5. 10. 15. 20. 25.

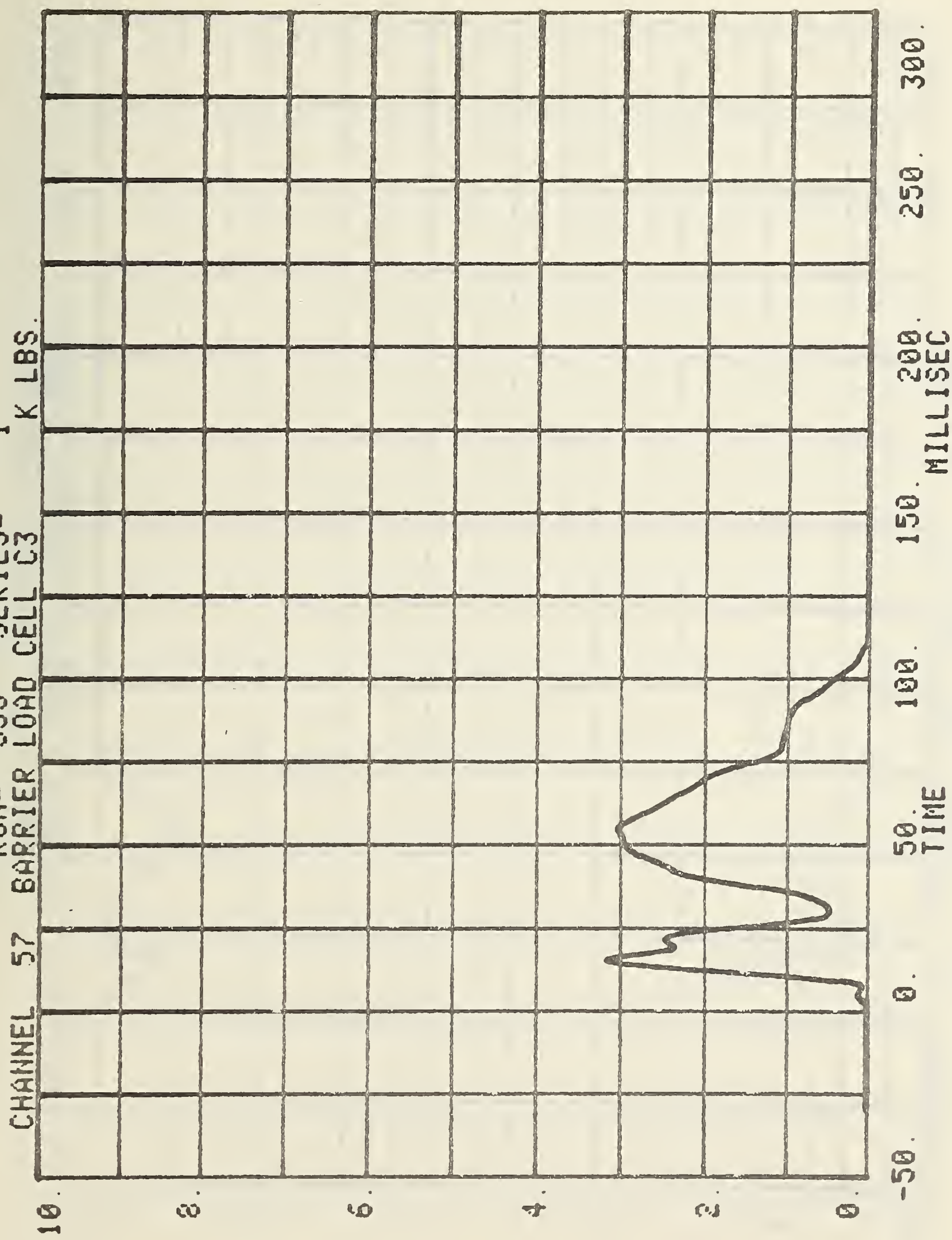

CHANNEL 53 RUN= 533 SERIES= 1
BARRIER LOAD CELL B8 K LBS.
-50 0. 50. 100. 150. 200. 250. 300.
TIME MILLISEC
0. 2. 4. 6. 8. 10.

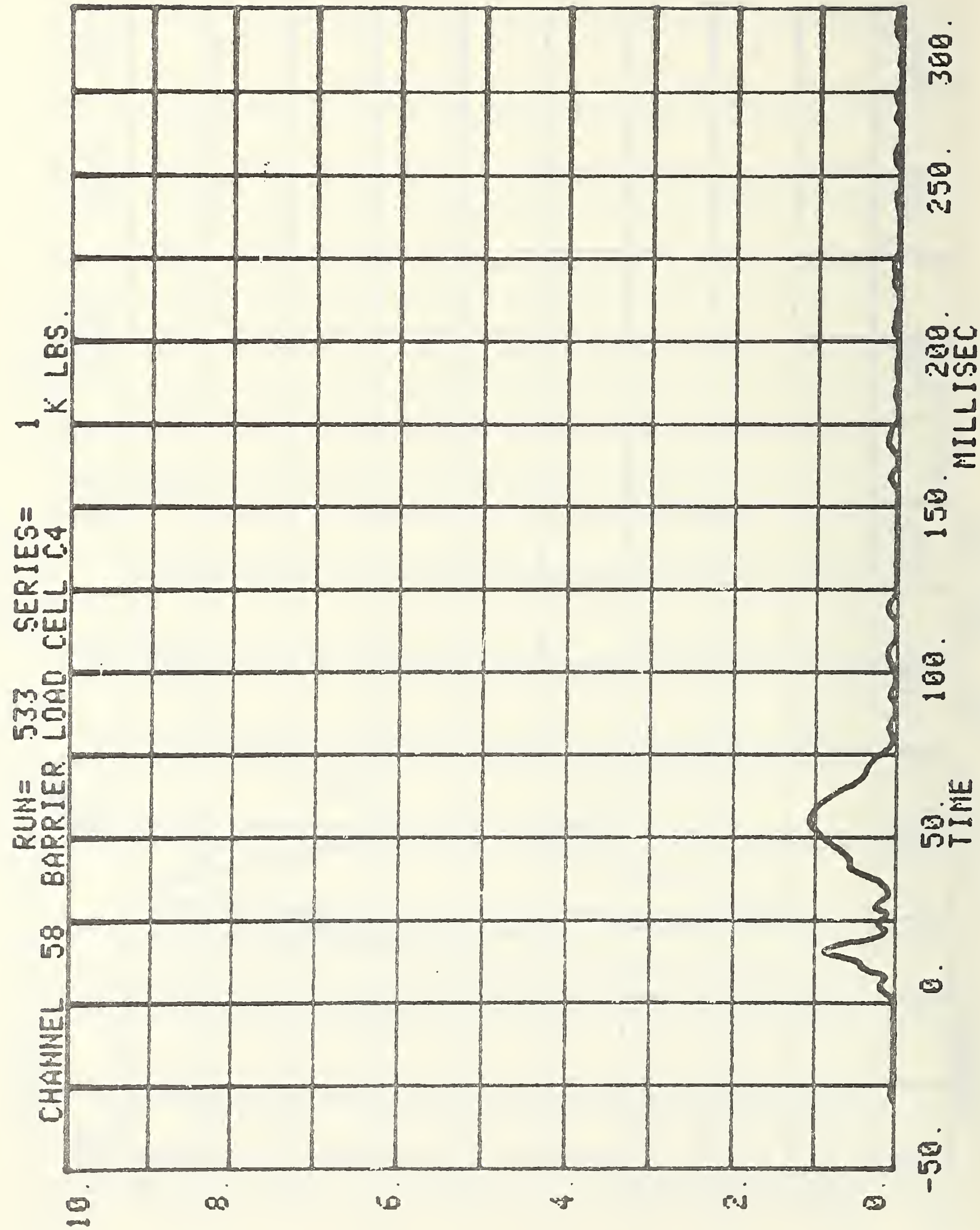

CHANNEL 54 RUN= 533 SERIES= 1
BARRIER LOAD CELL B9 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

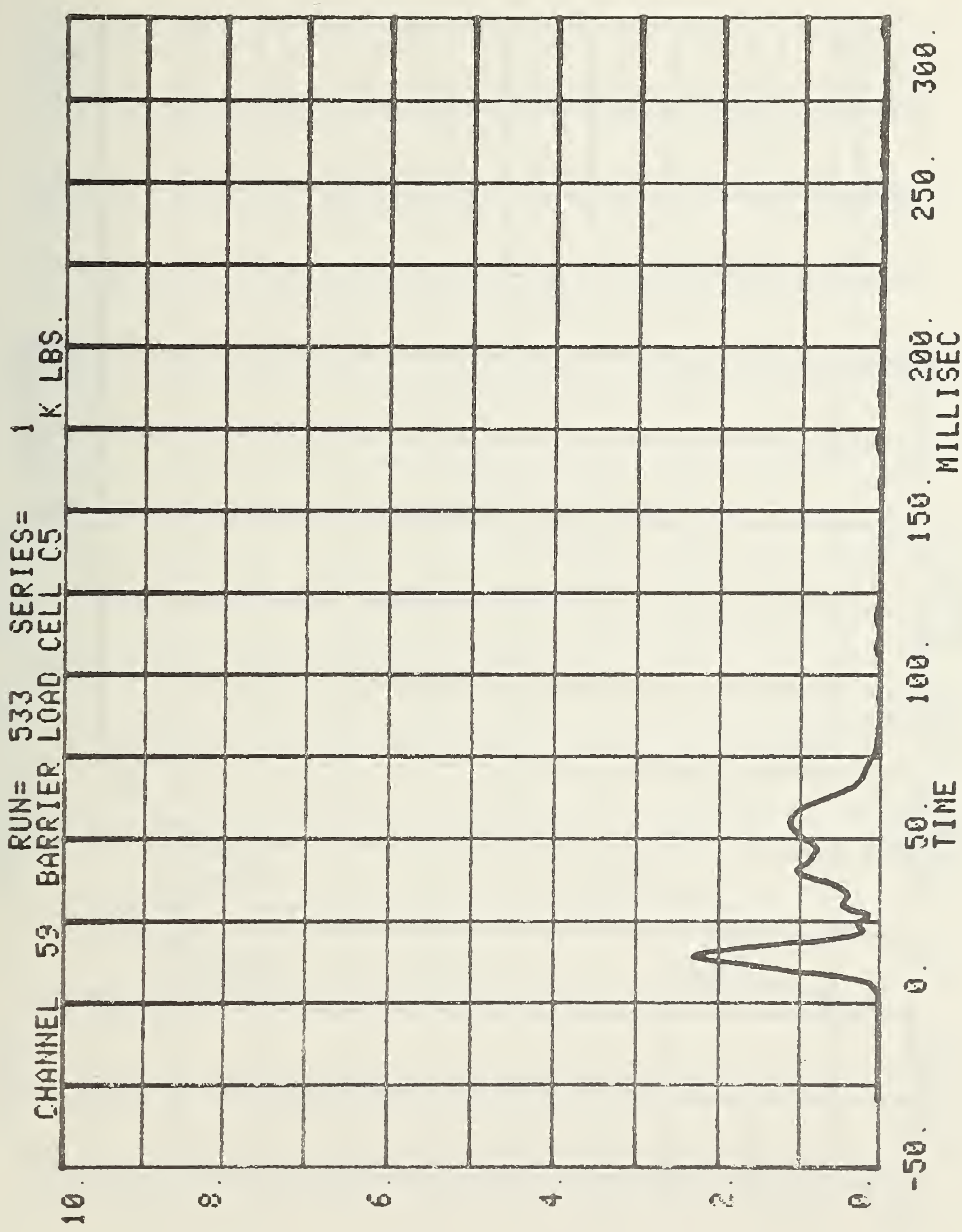

CHANNEL 55 RUN= 533 SERIES= 1
BARRIER LOAD CELL C1 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

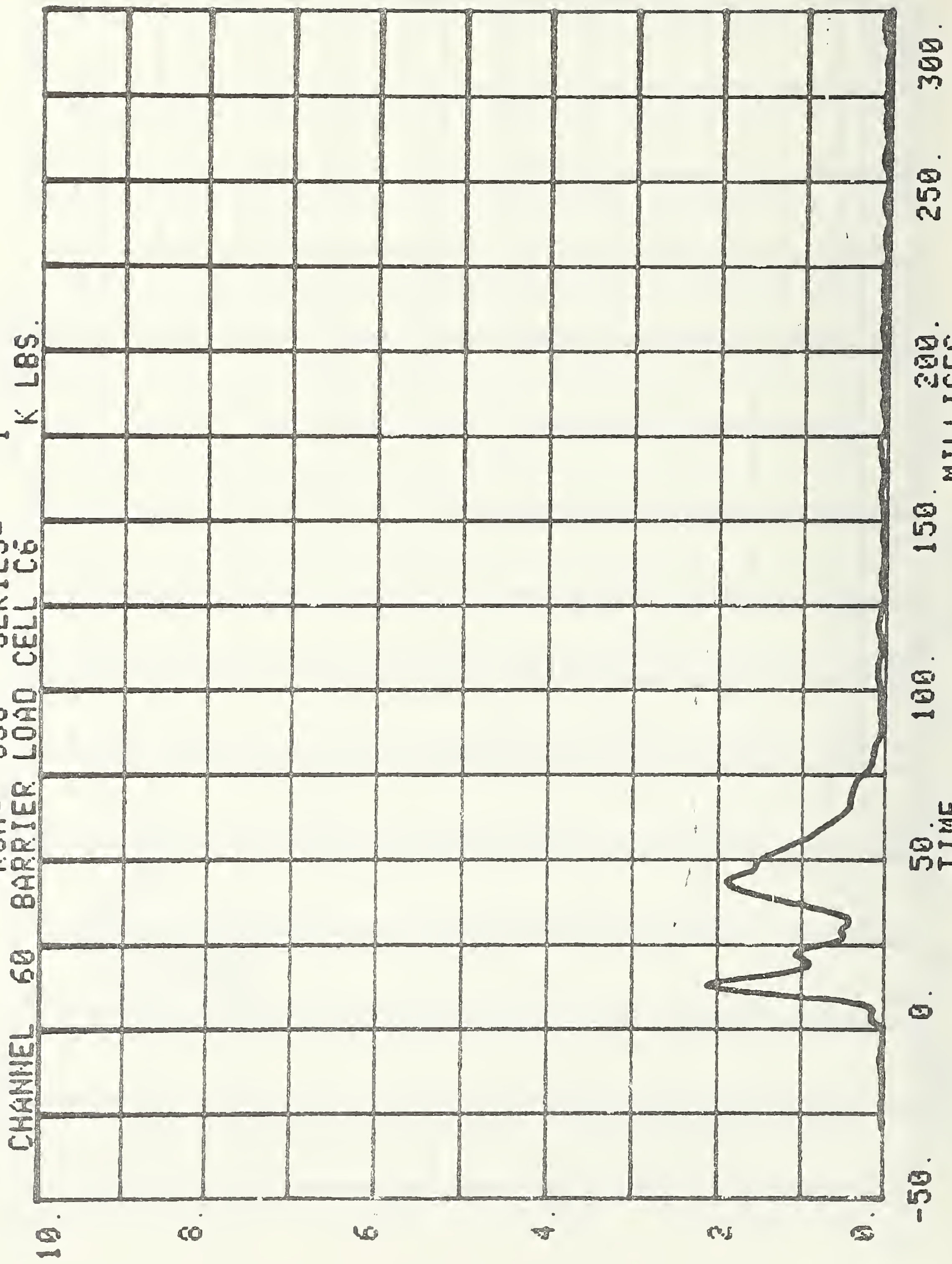


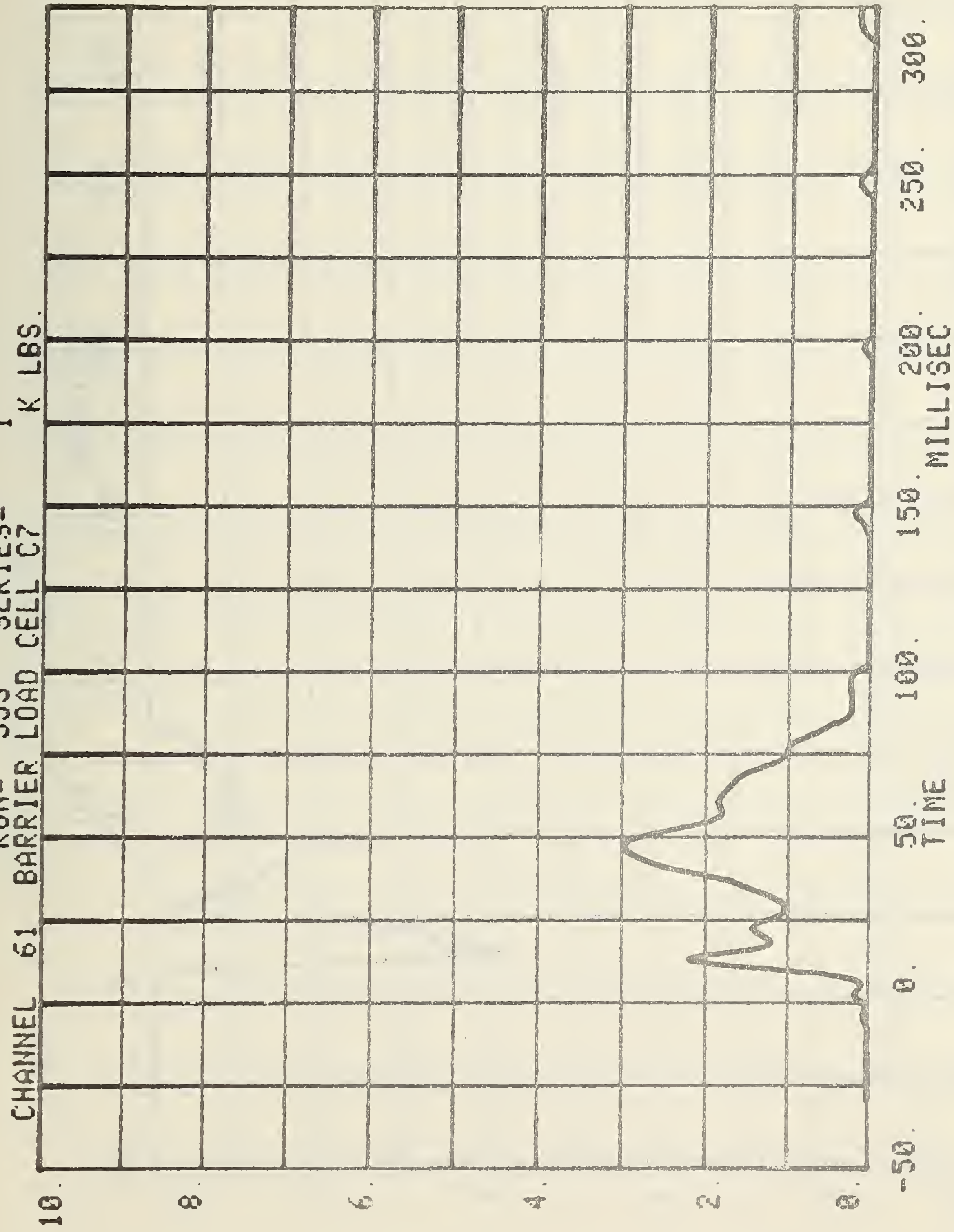
CHANNEL 56 RUN= 533 SERIES= 1
BARRIER LOAD CELL C2 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

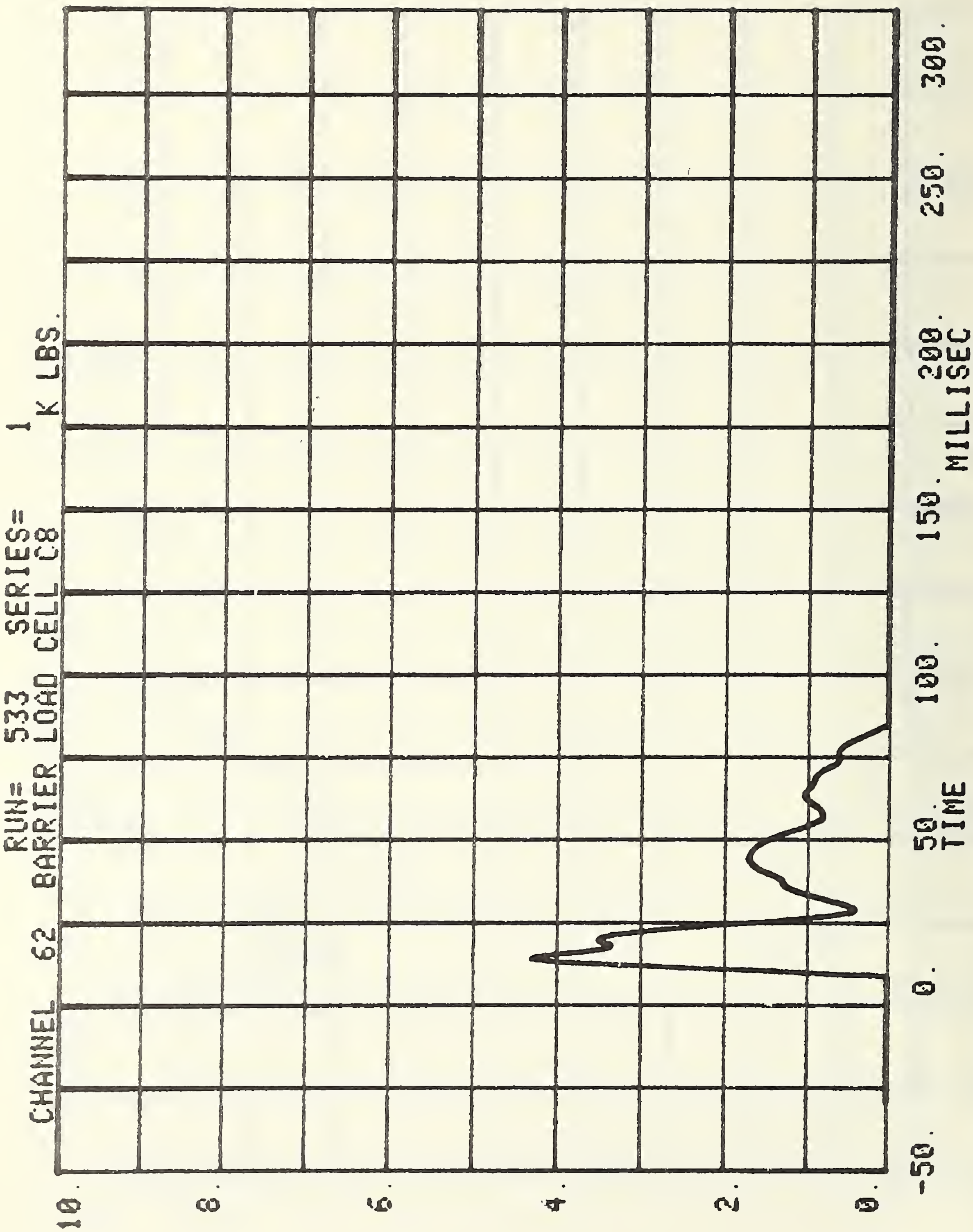

CHANNEL 57 RUN= 533 SERIES= 1
BARRIER LOAD CELL C3 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

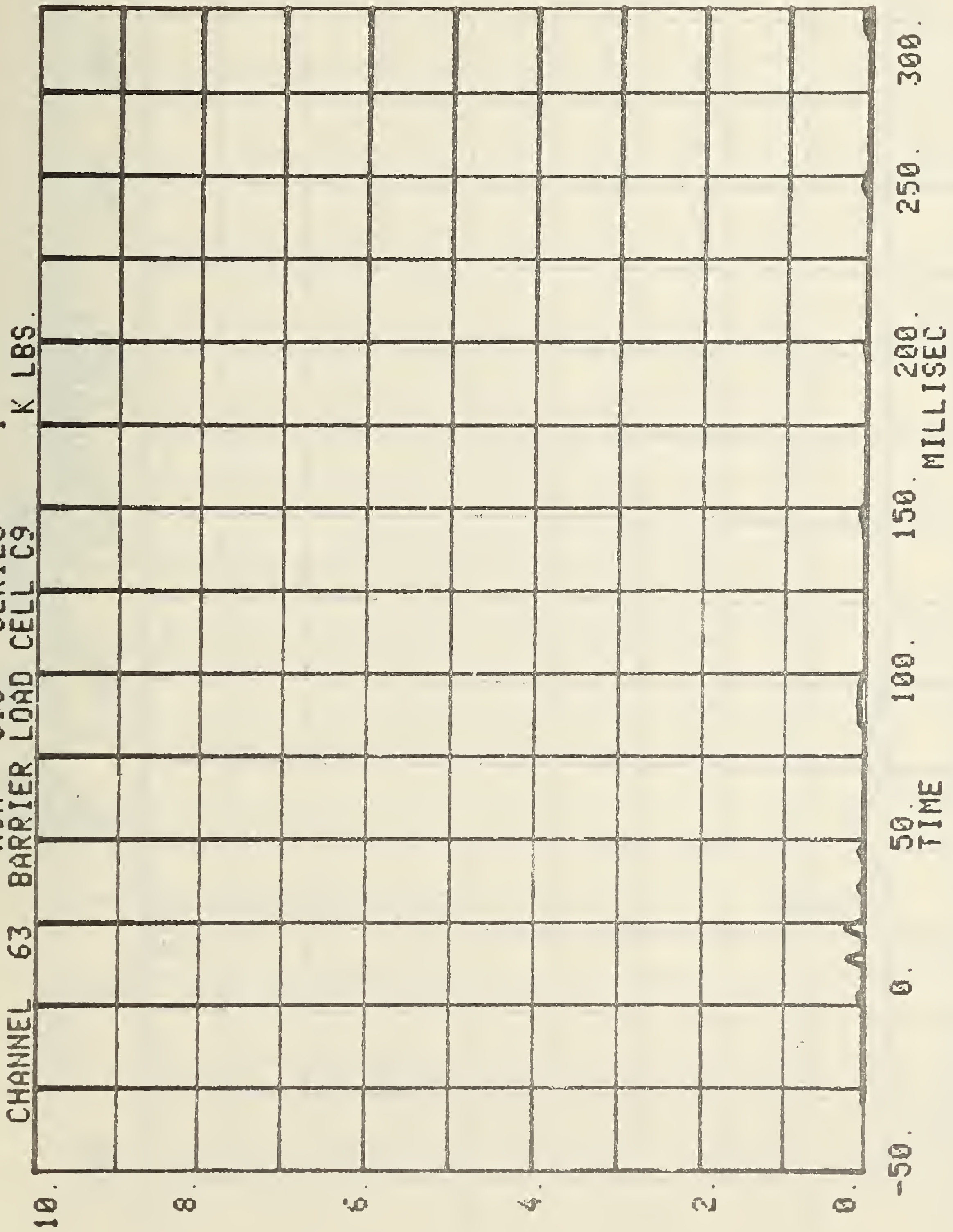

CHANNEL 58 RUN= 533 SERIES= 1
BARRIER LOAD CELL C4 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 59 RUN= 533 SERIES= 1
BARRIER LOAD CELL C5 K LBS.
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
0. 2. 4. 6. 8. 10.

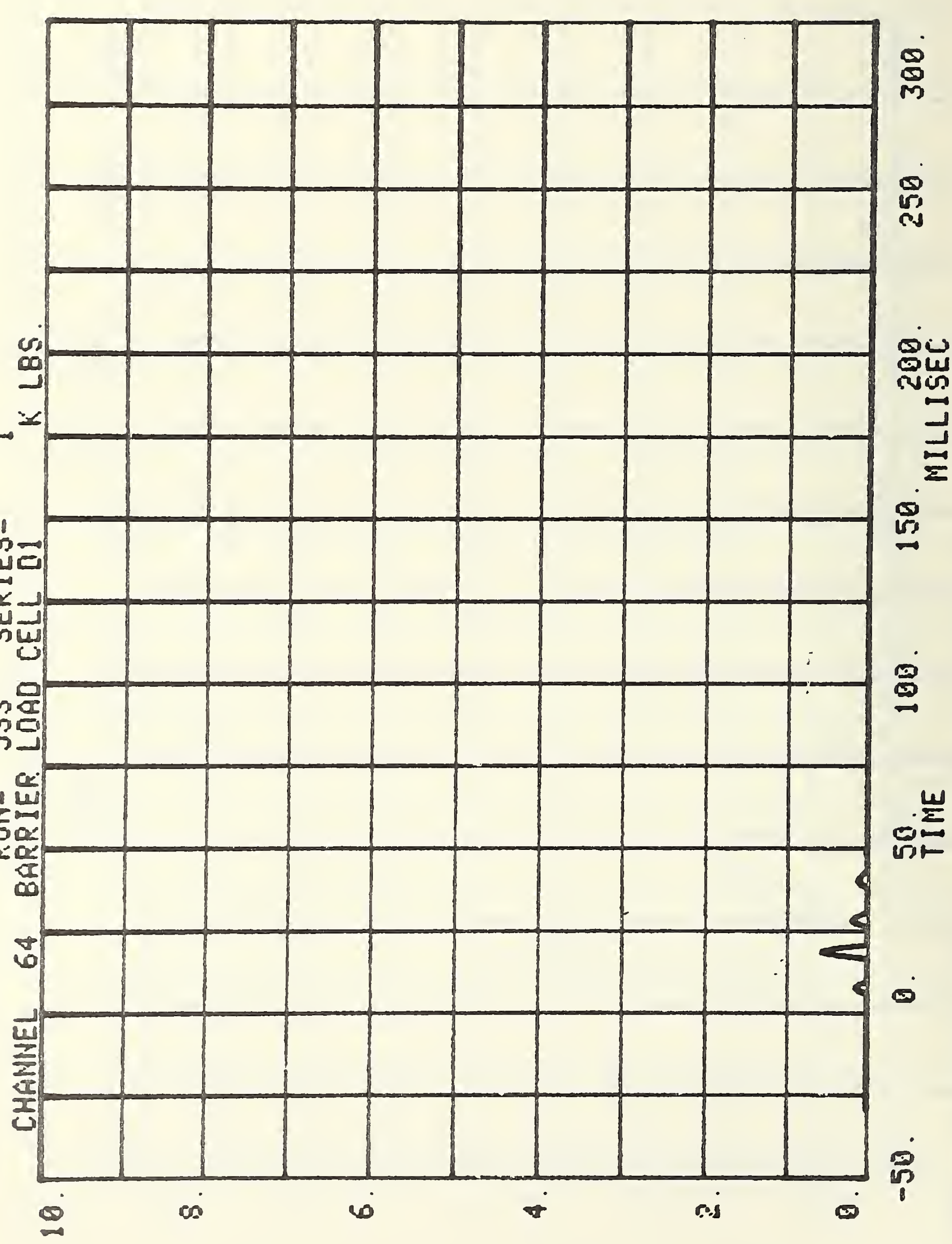

CHANNEL 60 RUN= 533 SERIES= 1
BARRIER LOAD CELL C6 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

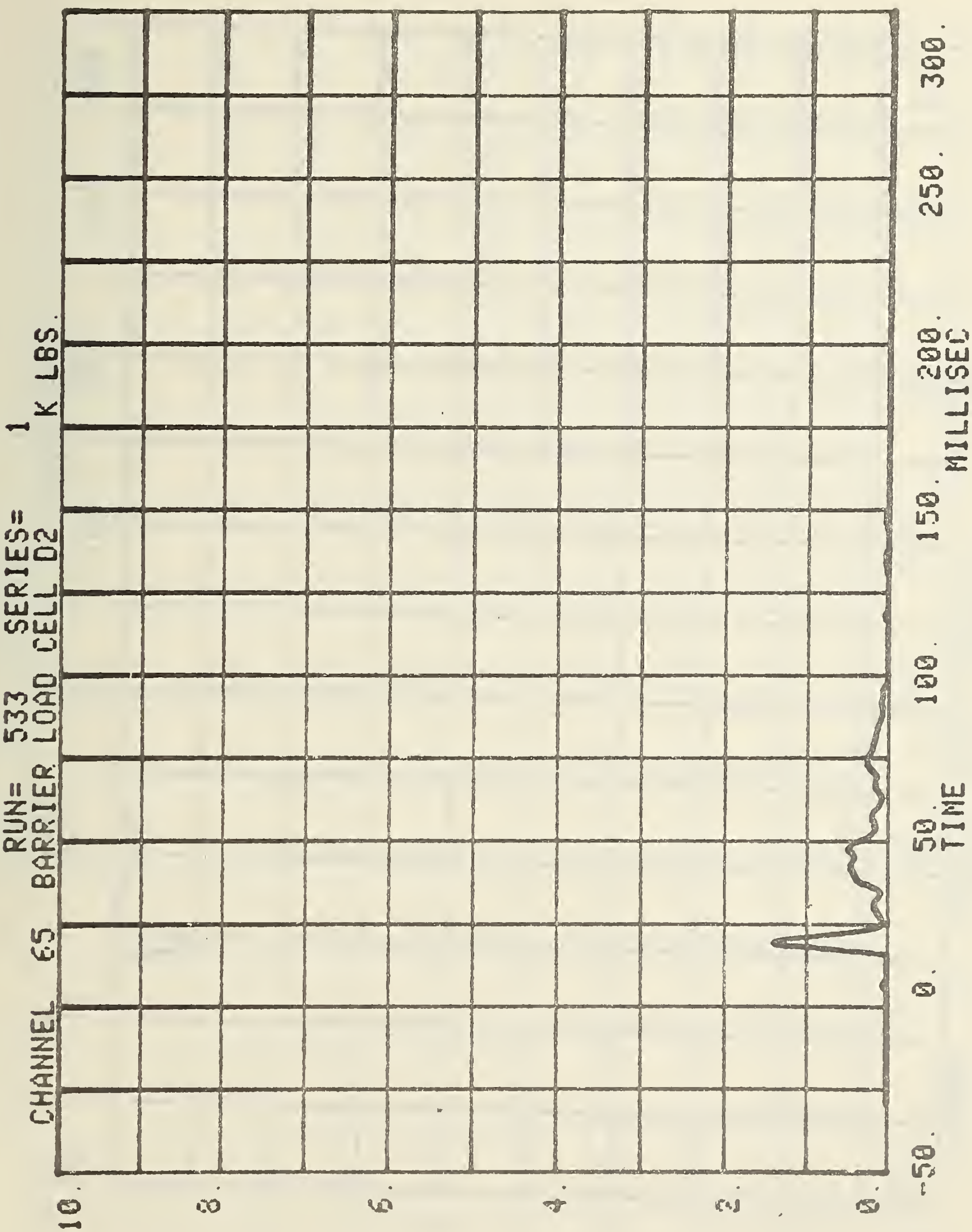

CHANNEL 61 RUN= 533 SERIES= 1
BARRIER LOAD CELL C7 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

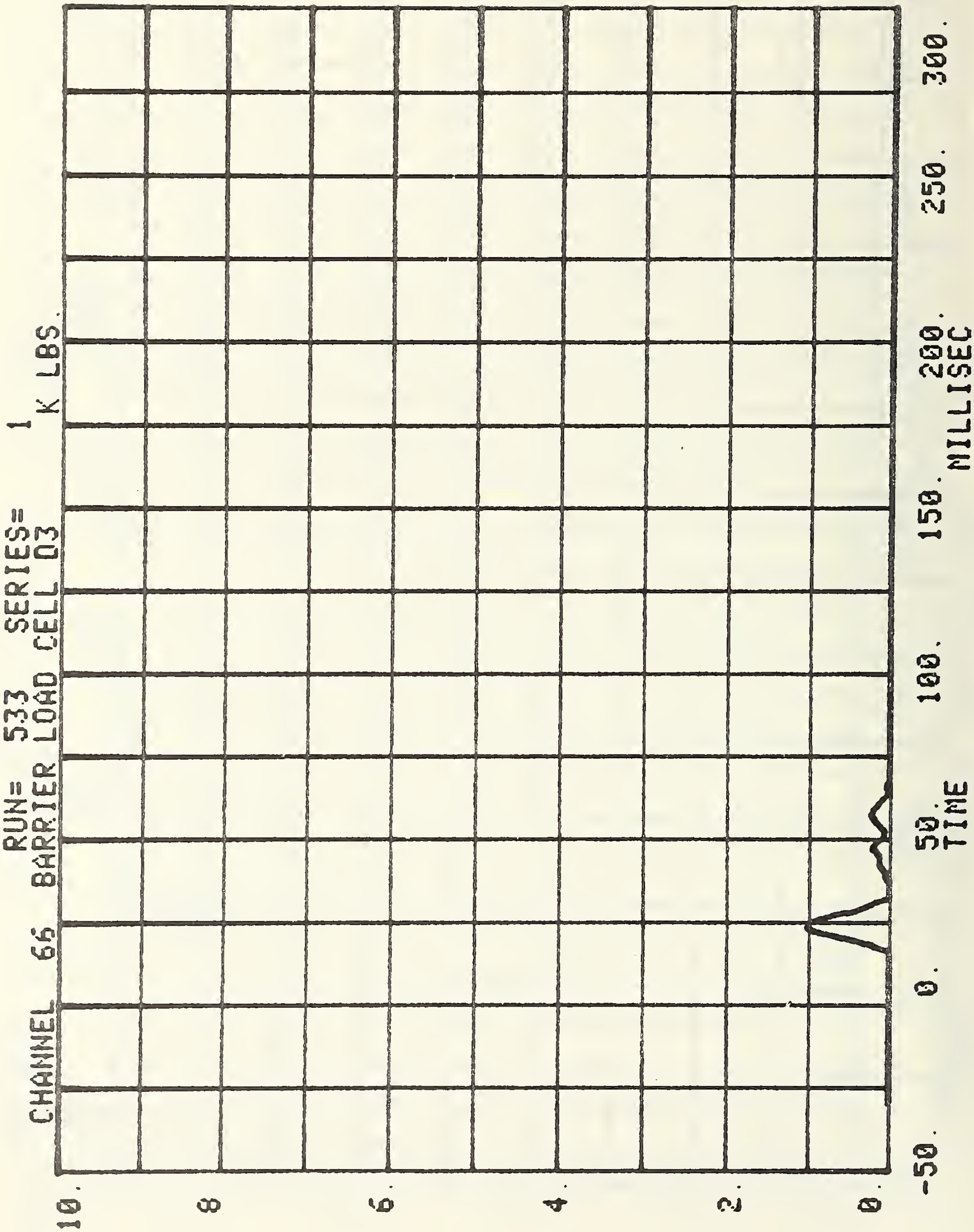

CHANNEL 62 RUN= 533 SERIES= 1
BARRIER LOAD CELL C8 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

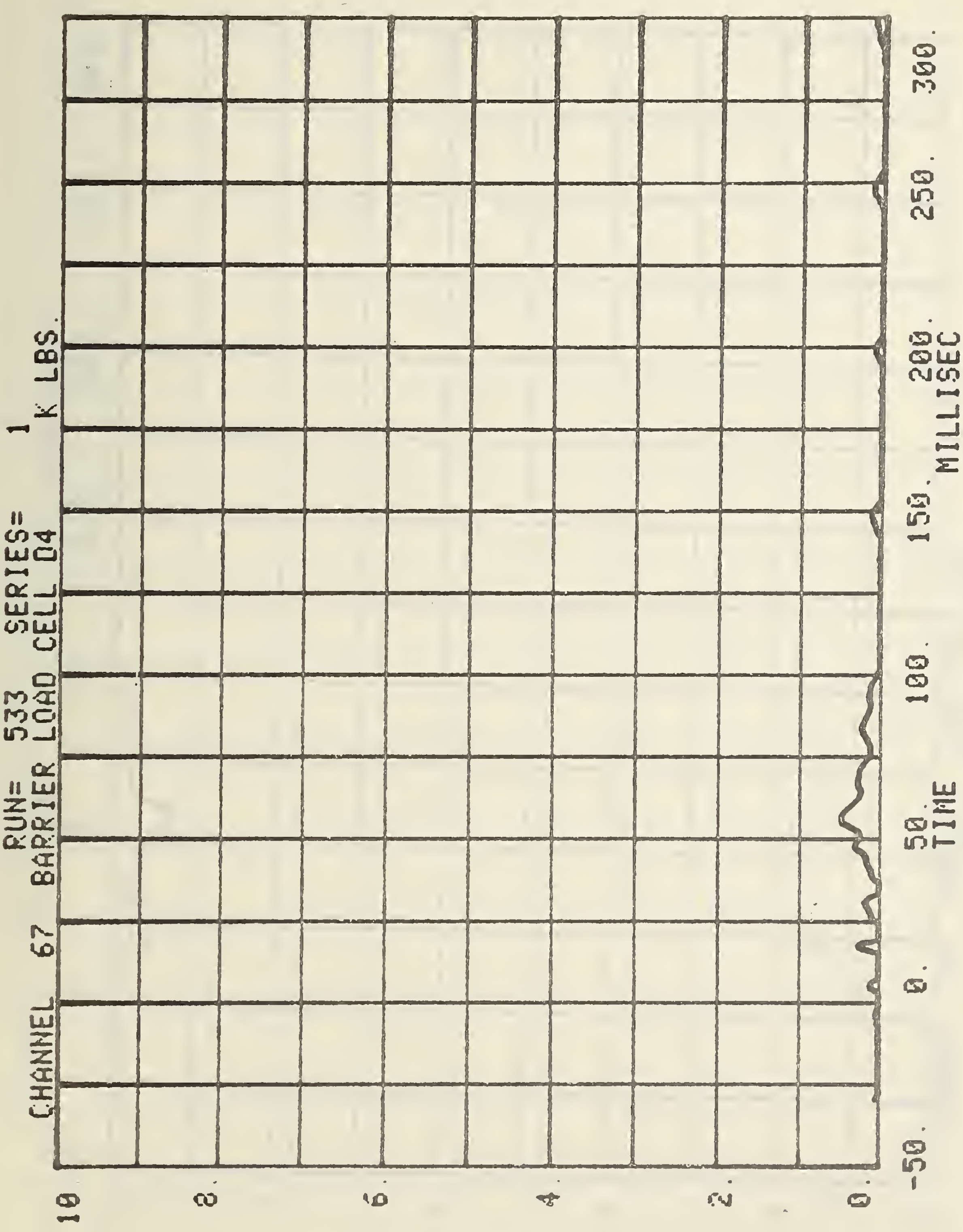


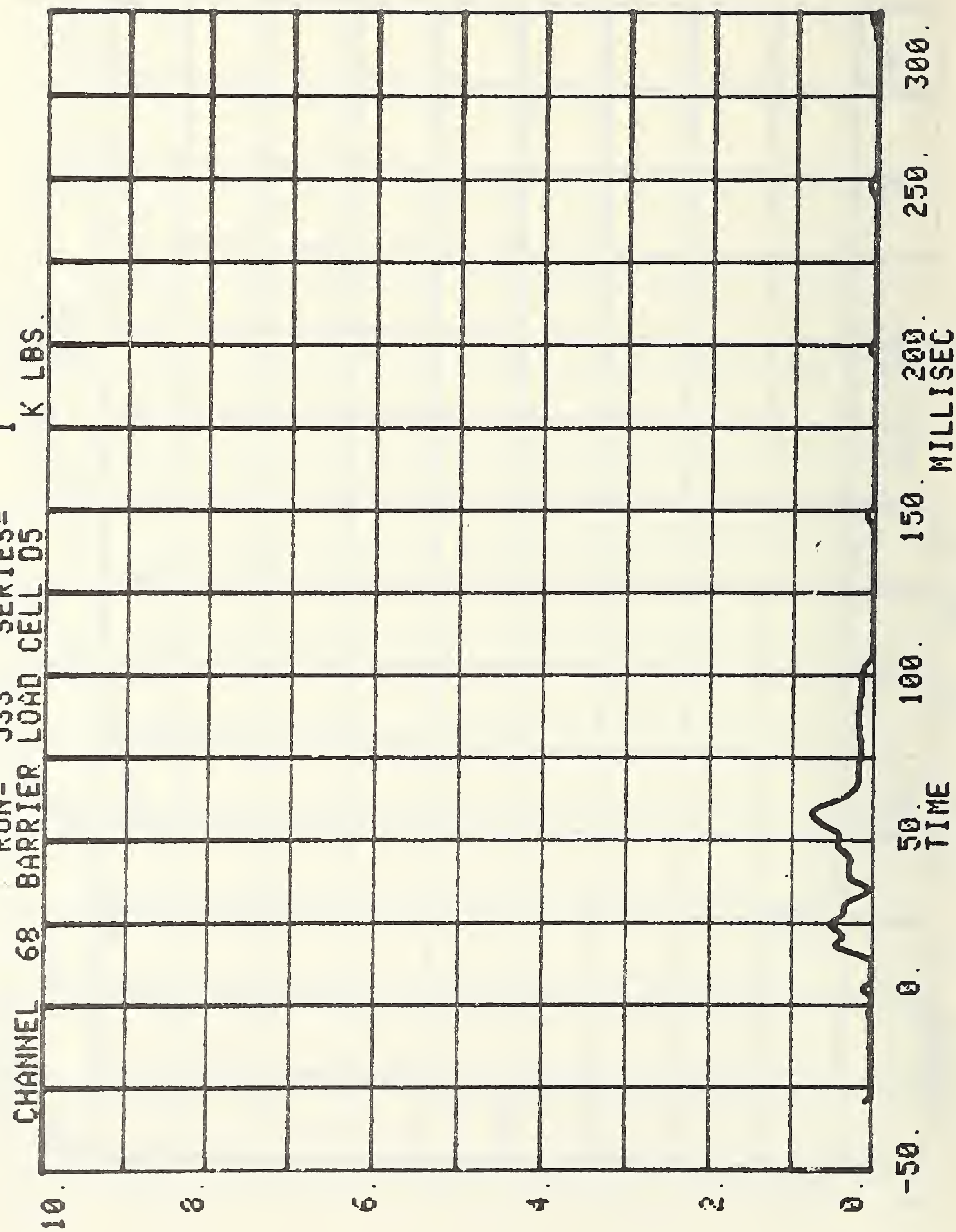
CHANNEL 63 RUN= 533 SERIES= 1
BARRIER LOAD CELL C9 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

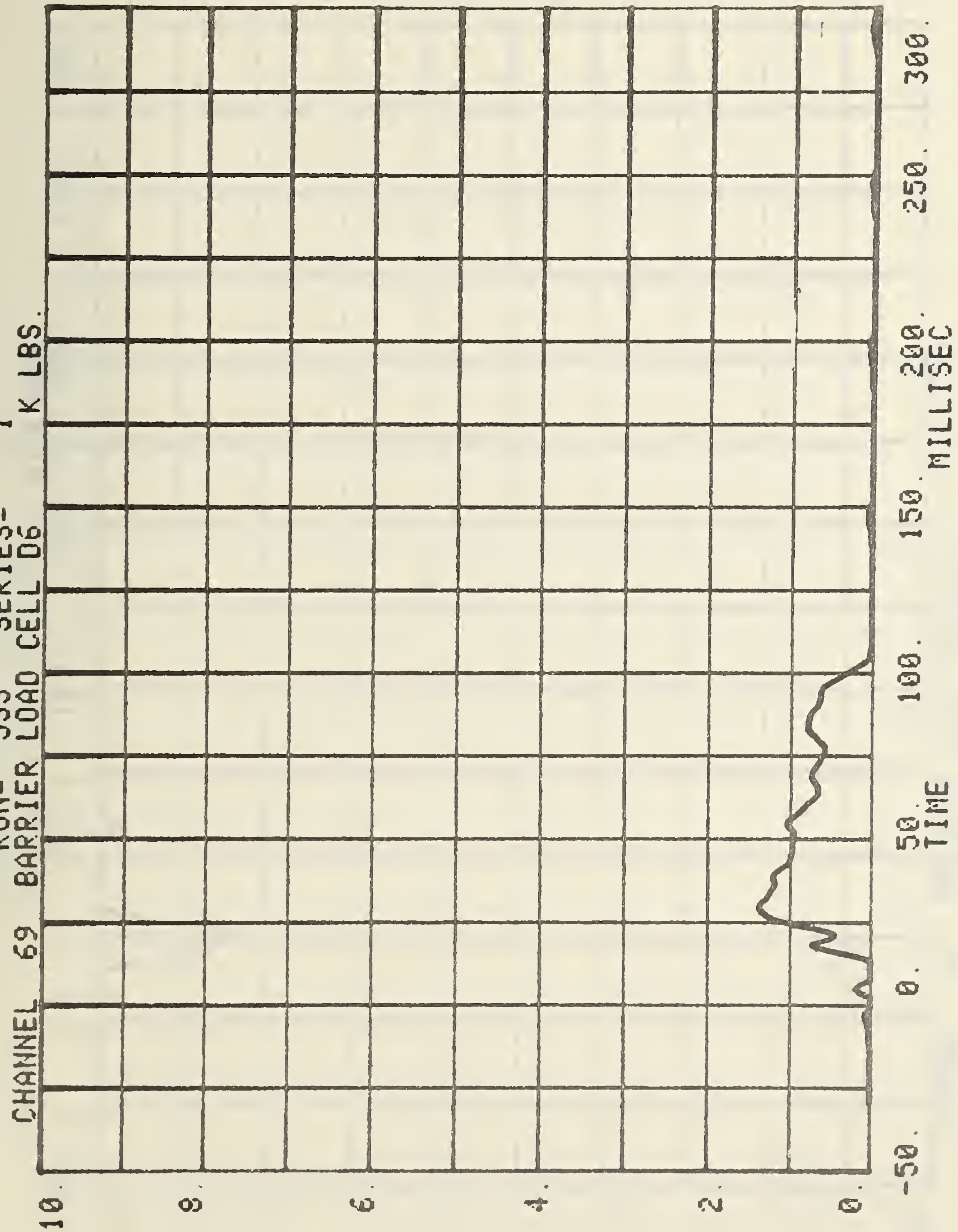

CHANNEL 64 RUN= 533 SERIES= 1
BARRIER LOAD CELL D1 K LBS
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

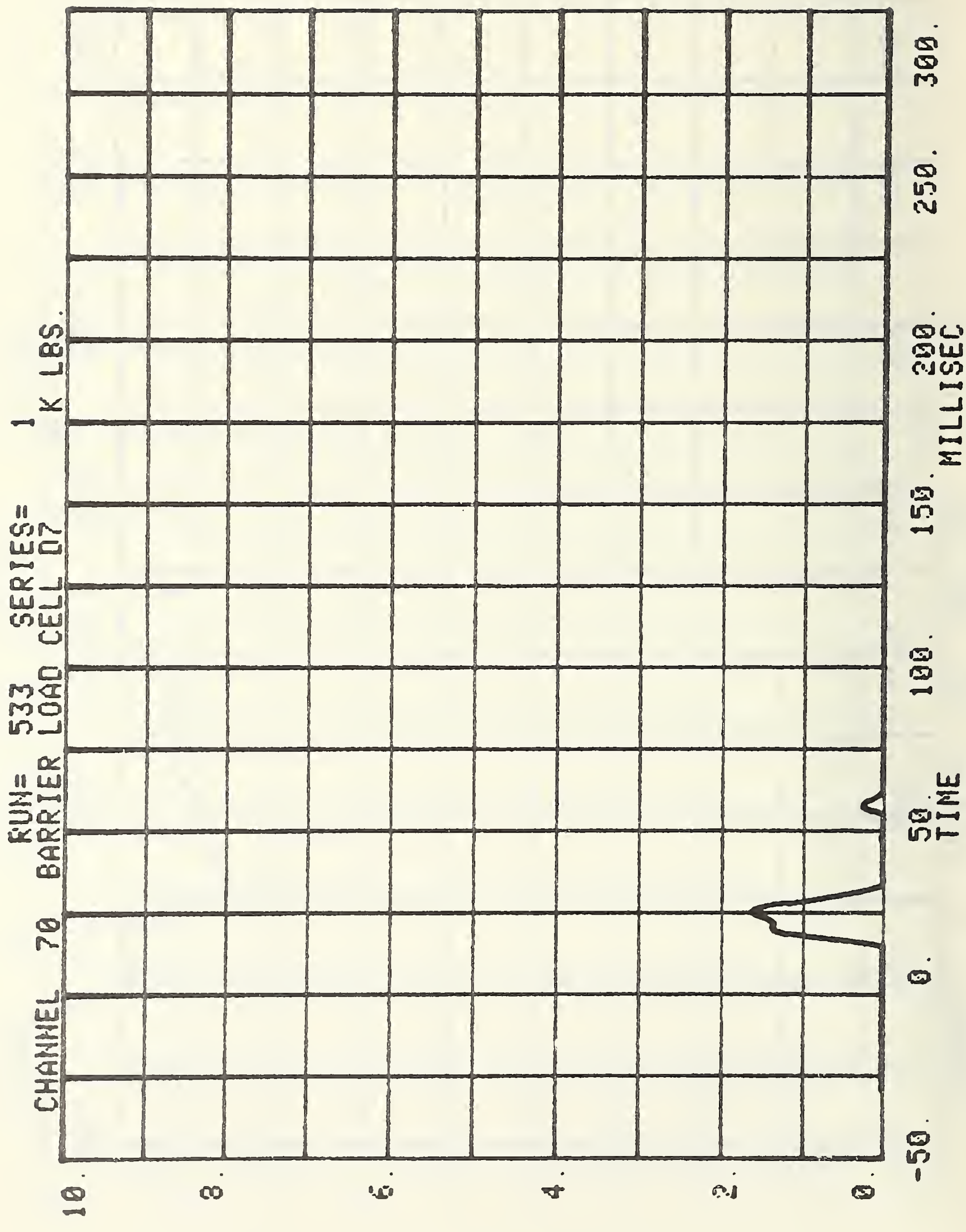

CHANNEL 65 RUN= 533 SERIES= 1
BARRIER LOAD CELL D2 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

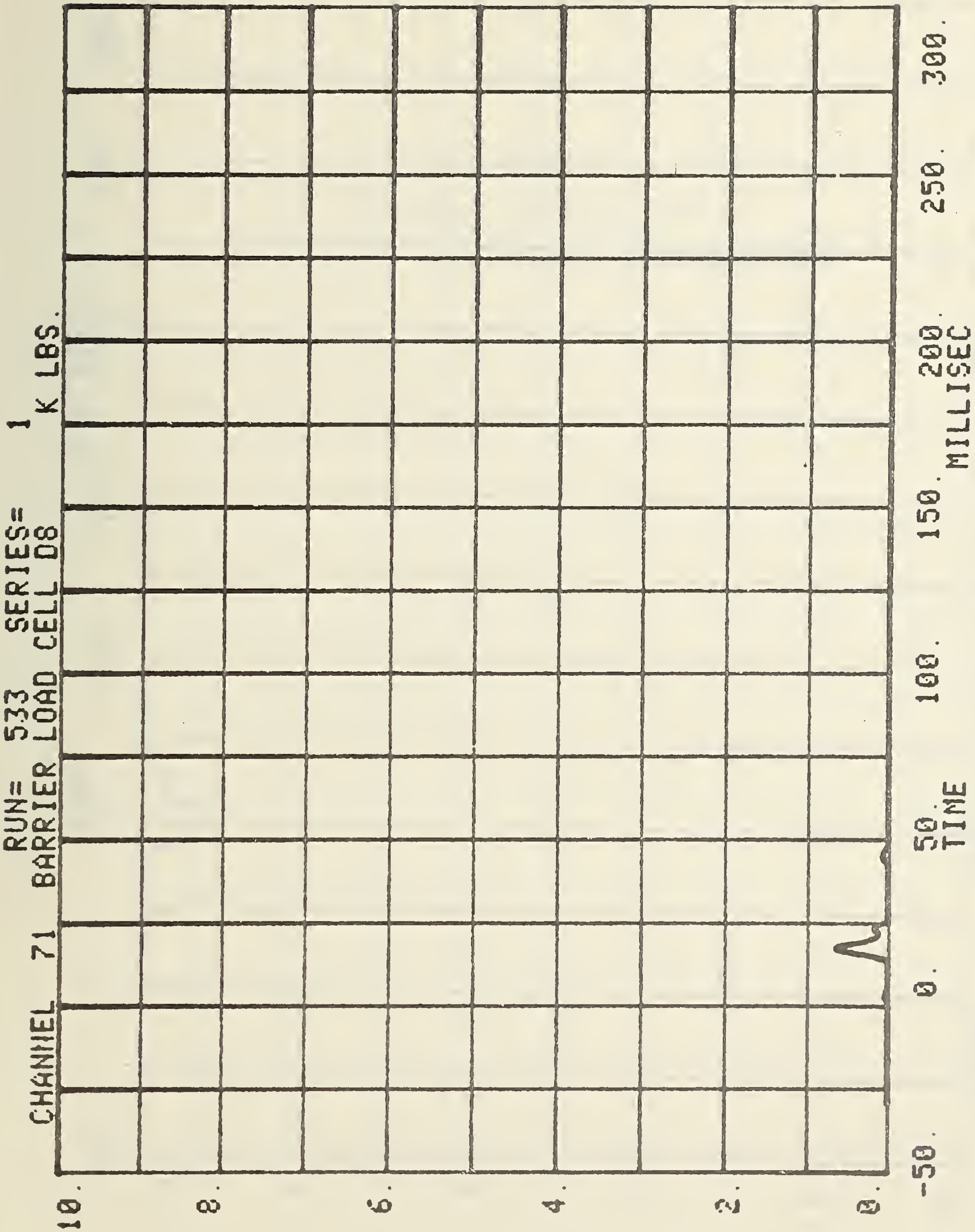

CHANNEL 66 RUN= 533 SERIES= 1
BARRIER LOAD CELL D3 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

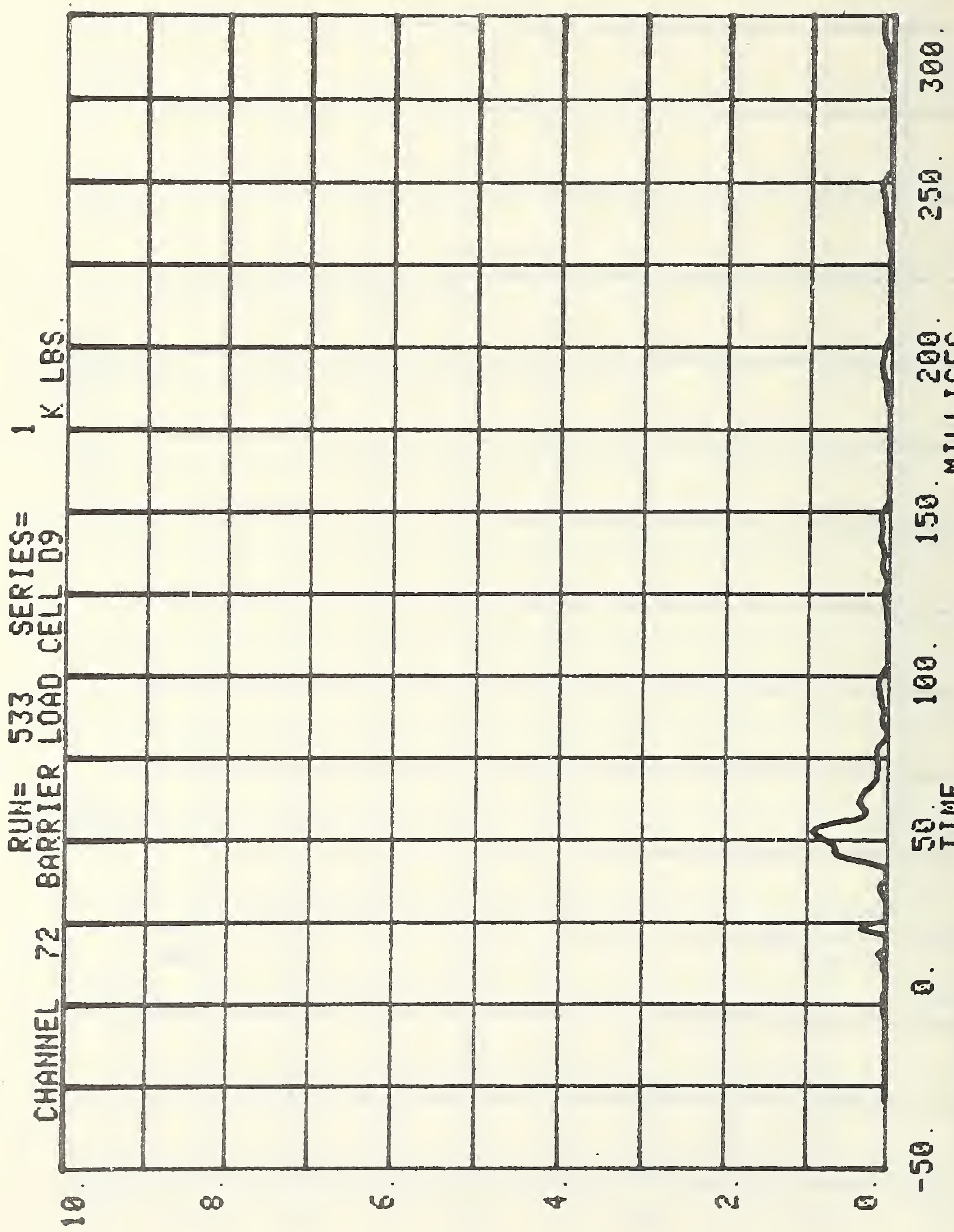

CHANNEL 67 RUN= 533 SERIES= 1
BARRIER LOAD CELL D4 K LBS.
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
0. 2. 4. 6. 8. 10


CHANNEL 68 RUN= 533 SERIES= 1
BARRIER LOAD CELL D5 K LBS
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 69 RUN= 533 SERIES= 1
BARRIER LOAD CELL D6 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 70 RUN= 533 SERIES= 1
BARRIER LOAD CELL D7 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 71 RUN= 533 SERIES= 1
BARRIER LOAD CELL D8 K LBS.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC
0.
2.
4.
6.
8.
10.


CHANNEL 72 RUN= 533 SERIES= 1
BARRIER LOAD CELL D9 K LBS.
10.
8.
6.
4.
2.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

APPENDIX C

ELECTRONIC CRASH TEST DATA:

PLYMOUTH RELIANT OCCUPANT AND RESTRAINT SYSTEM

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

CAR TO LOAD CELL BARRIER

RUN= 533

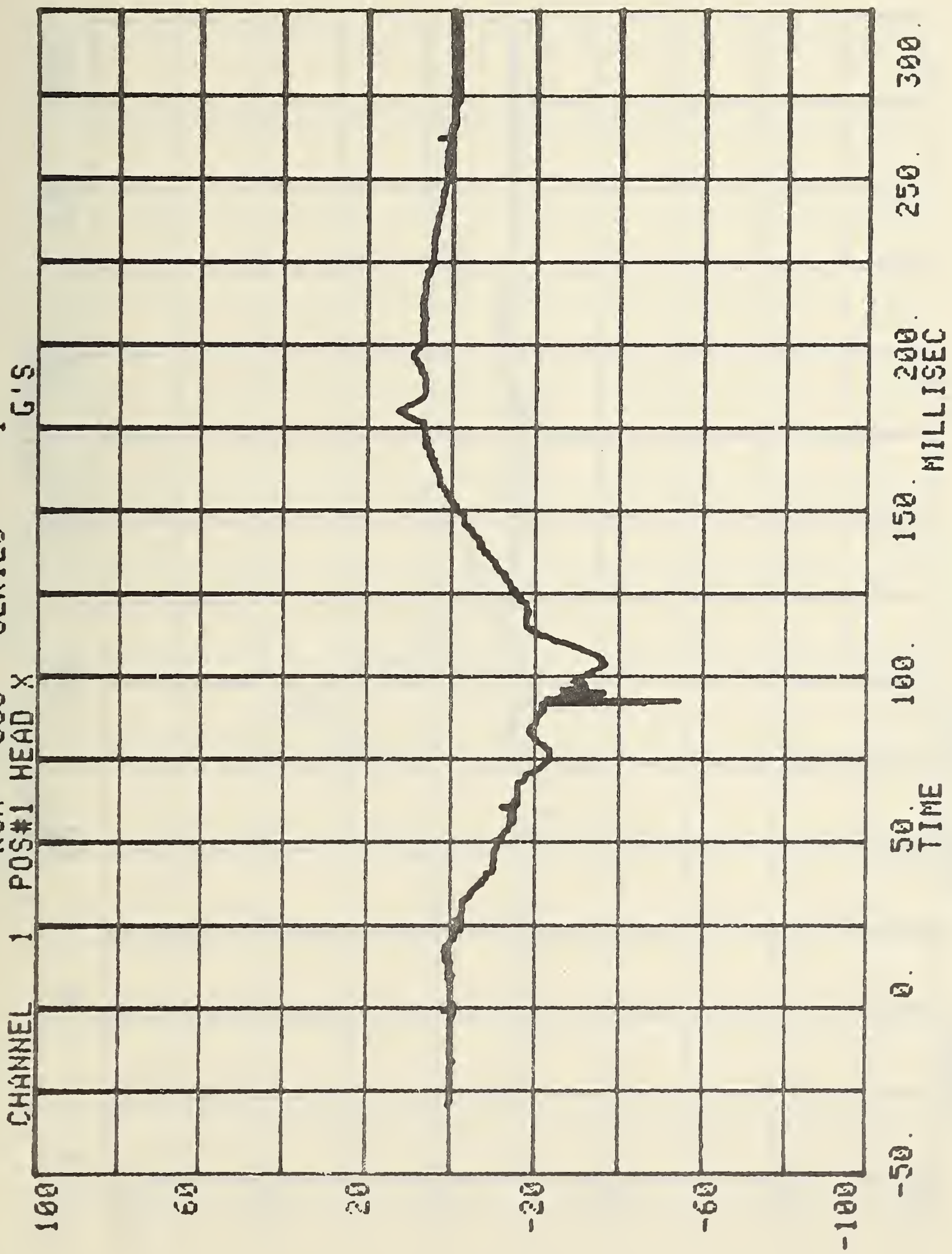
POS#1 HEAD RESULTANT

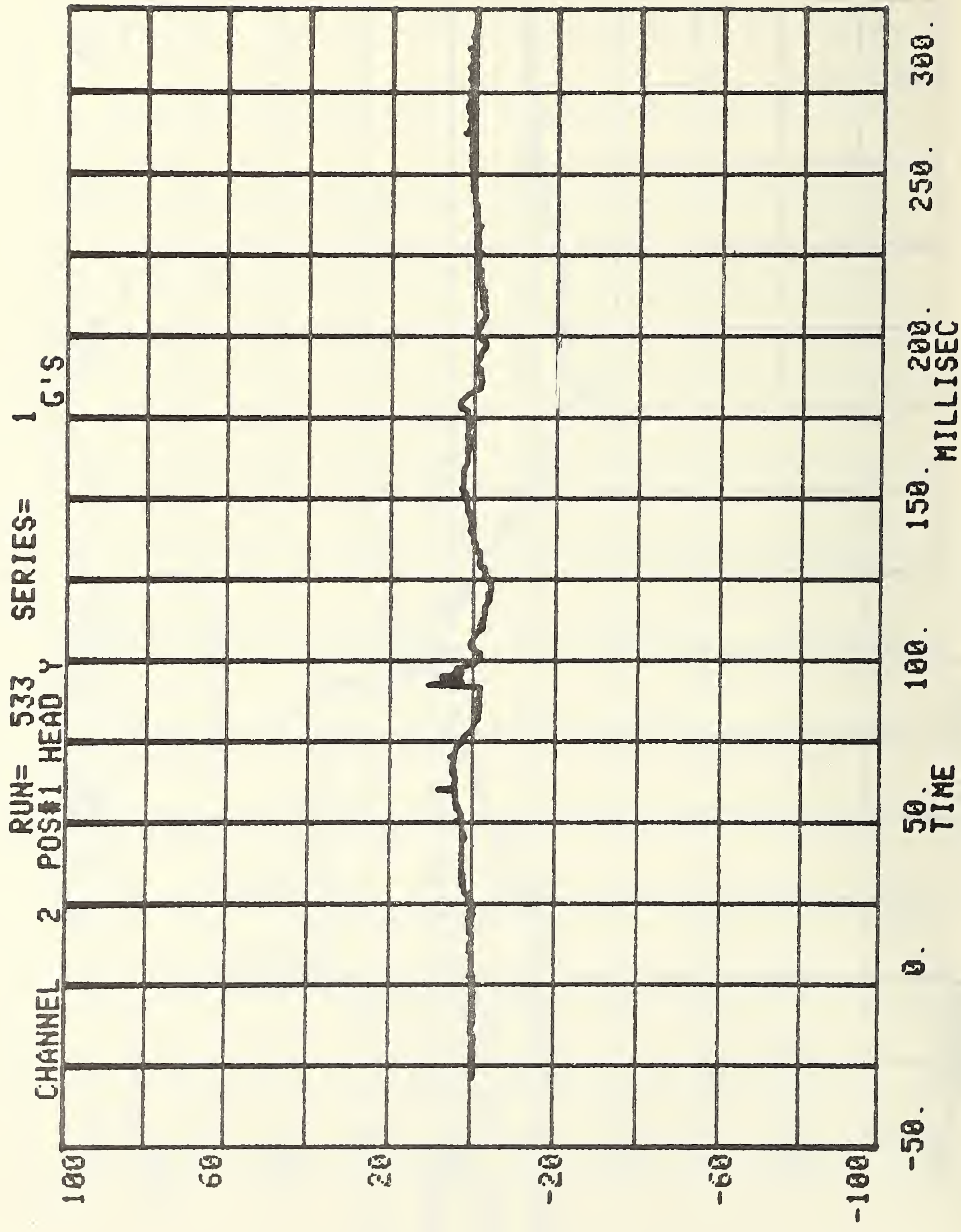
HIC= 367.3   FROM T1= .05280   TO T2= .11520

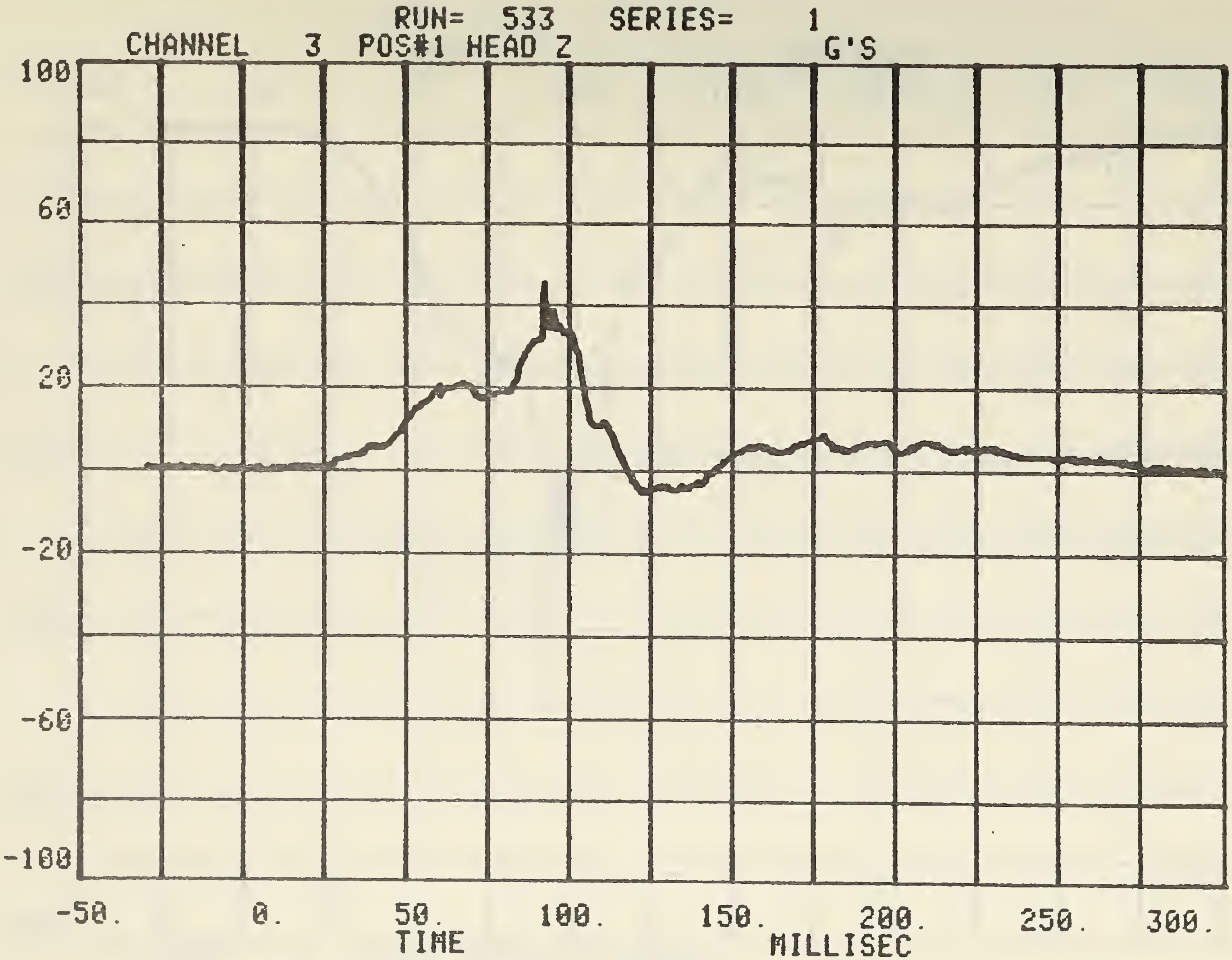
AVERAGE ACCELERATION BETWEEN T1 AND T2= 32.2G'S

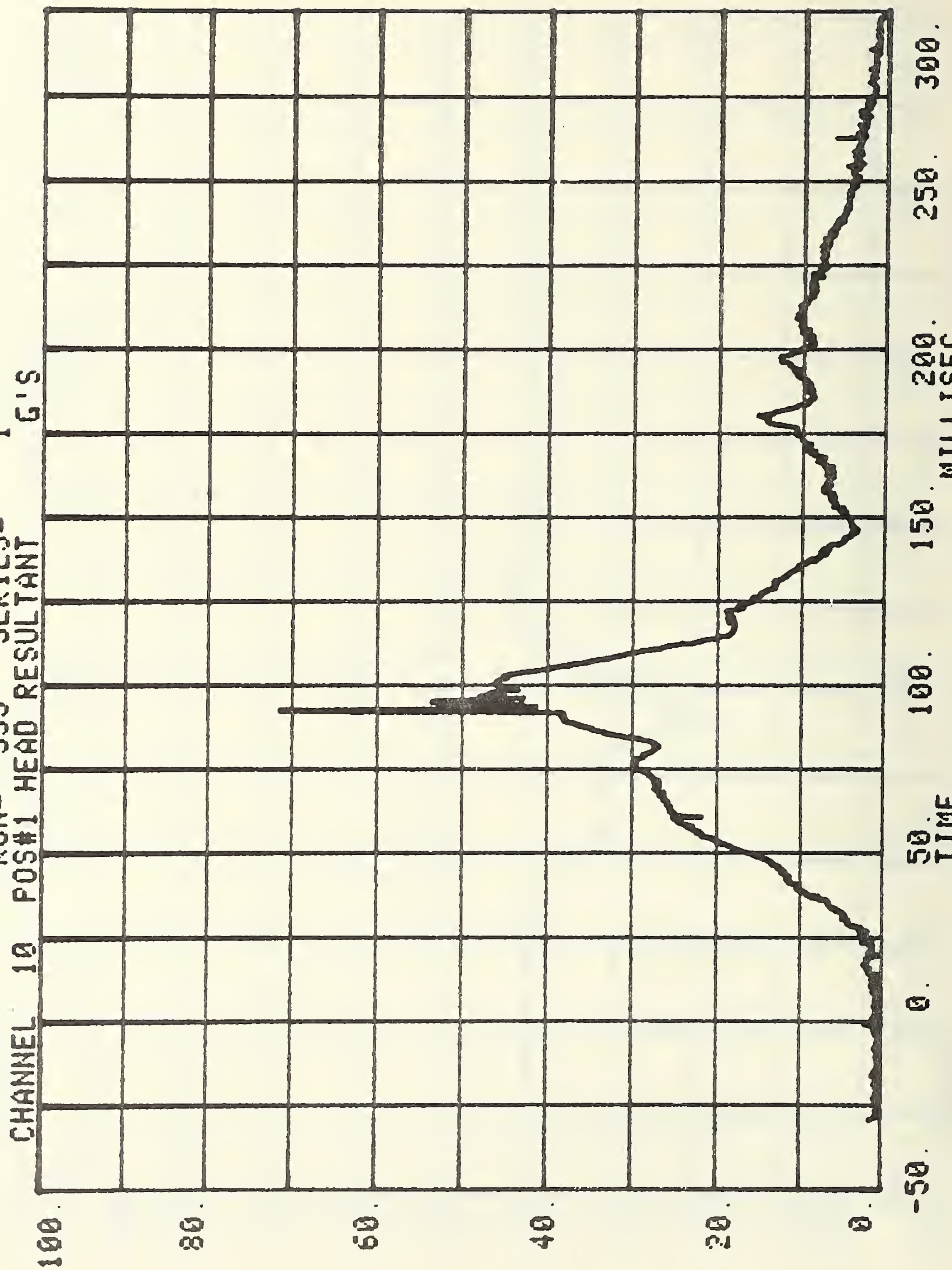
EVENT TIME= 300.0 MSEC

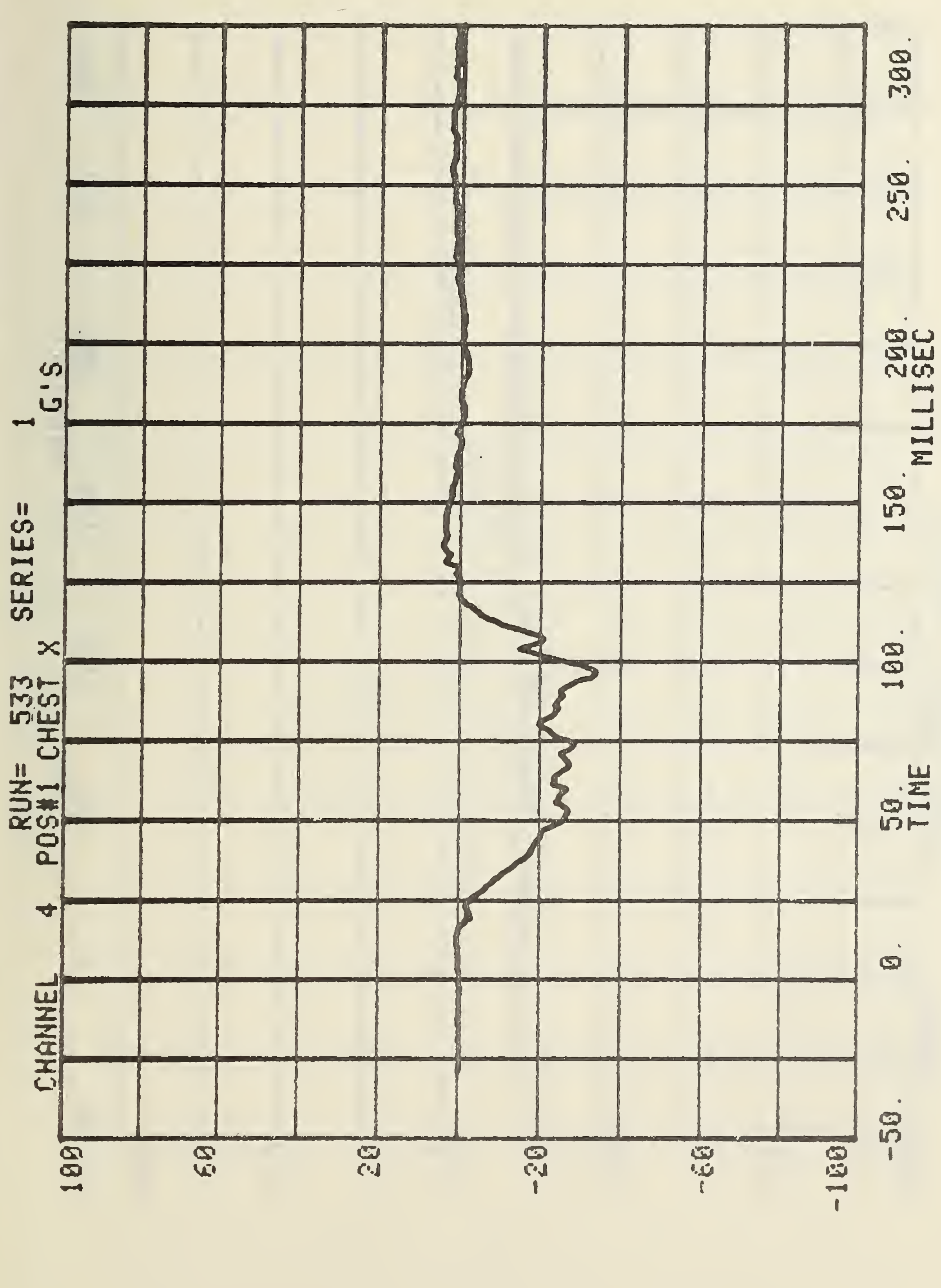
SEVERITY INDEX= 486.9

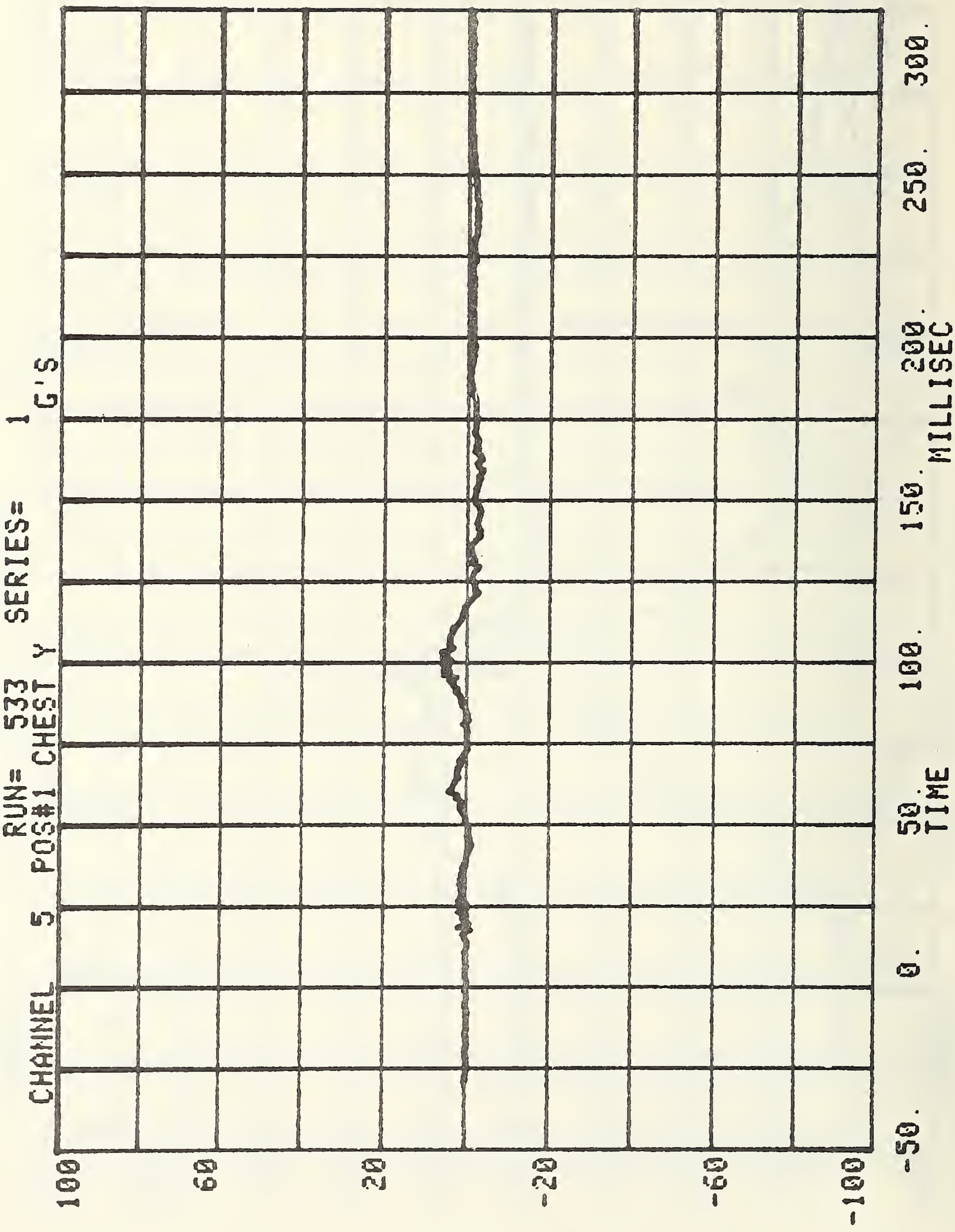

CHANNEL 1 RUN= 533 SERIES= 1
POS#1 HEAD X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

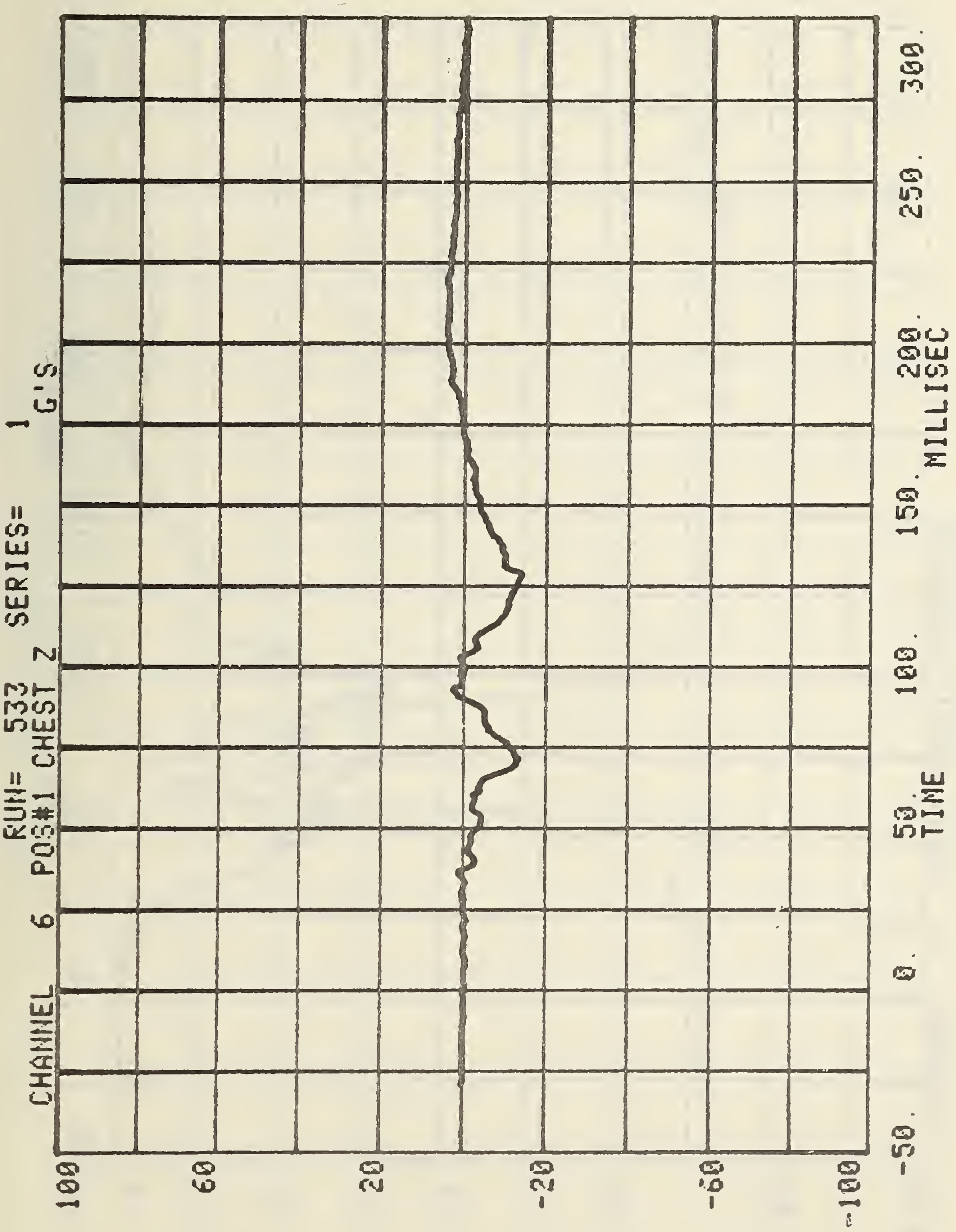

CHANNEL 2 RUN= 533 SERIES= 1
POS#1 HEAD Y
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

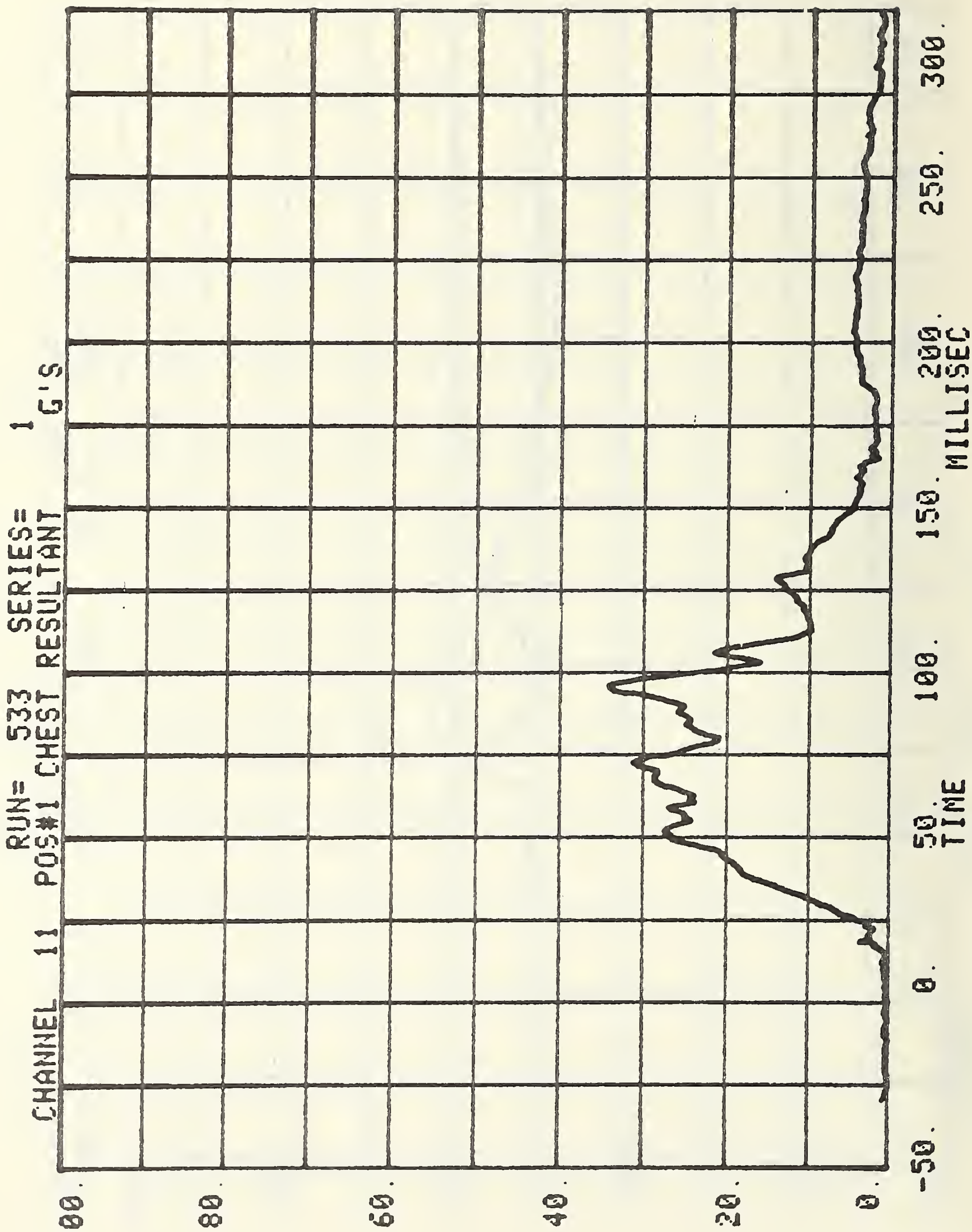

RUN= 533 SERIES= 1
CHANNEL 3 POS#1 HEAD Z
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

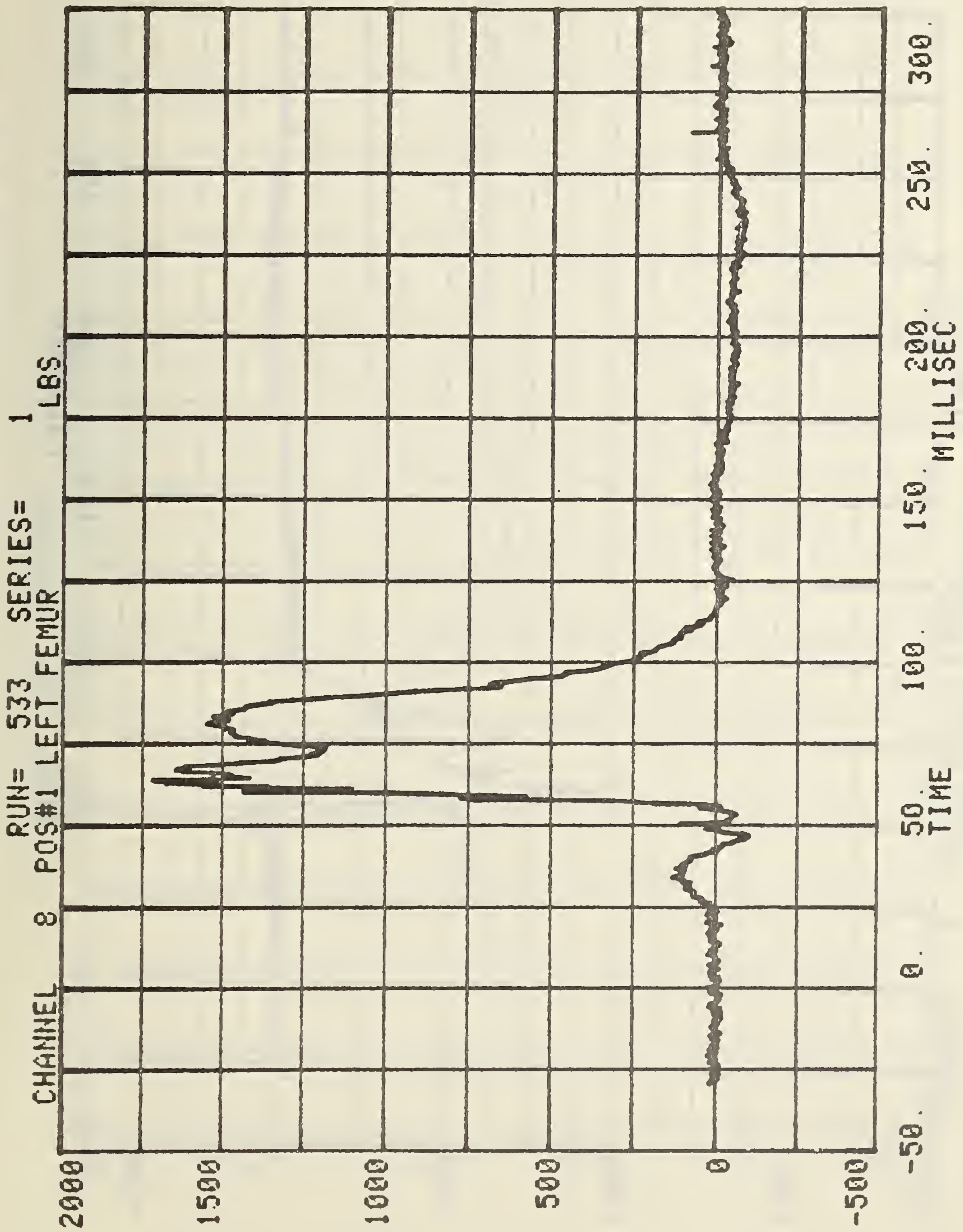

CHANNEL 10 RUN= 533 SERIES= 1
POS#1 HEAD RESULTANT G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

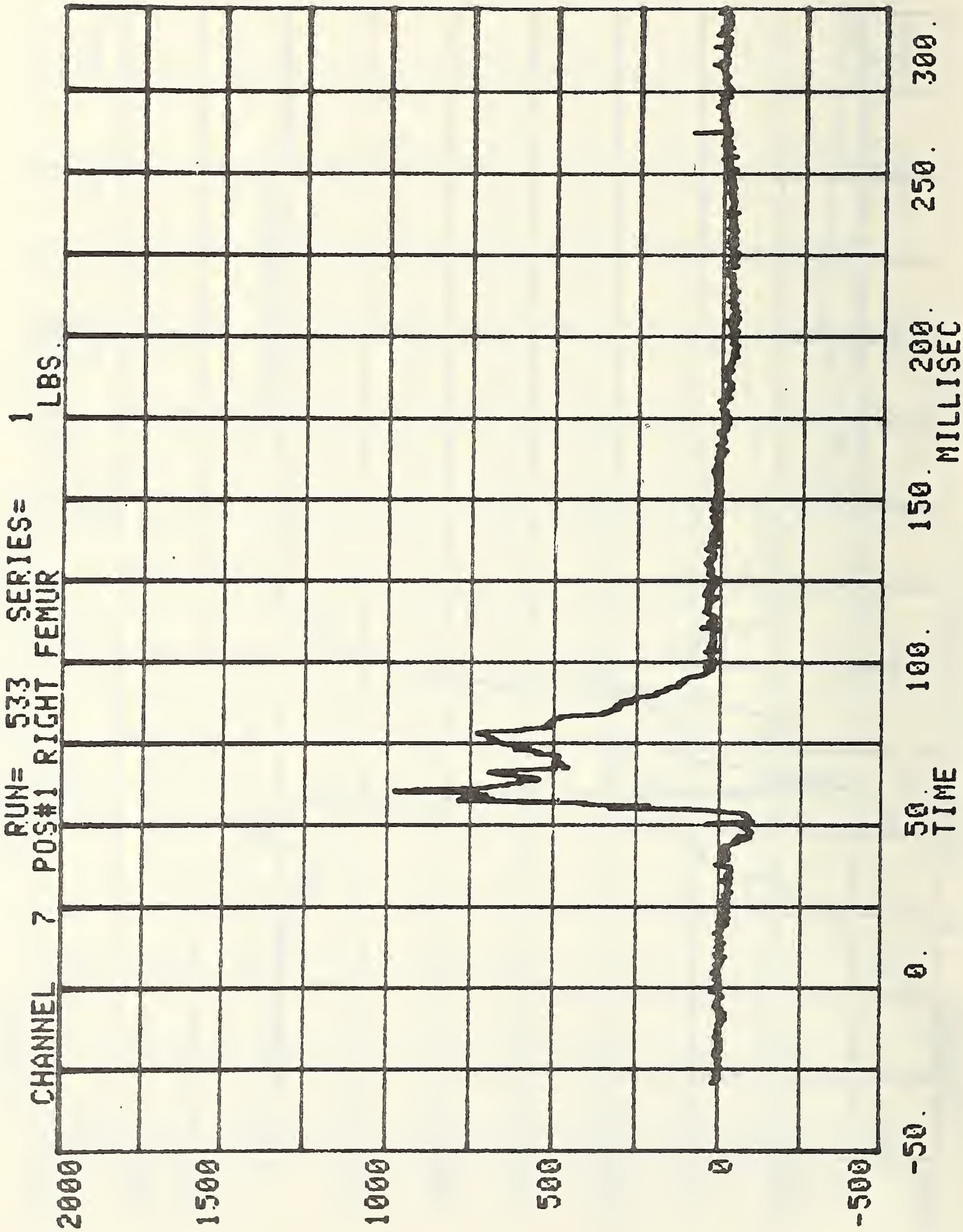

CHANNEL 4 RUN= 533 SERIES= 1
POS#1 CHEST X
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC


CHANNEL 5 RUN= 533 SERIES= 1
POS#1 CHEST Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

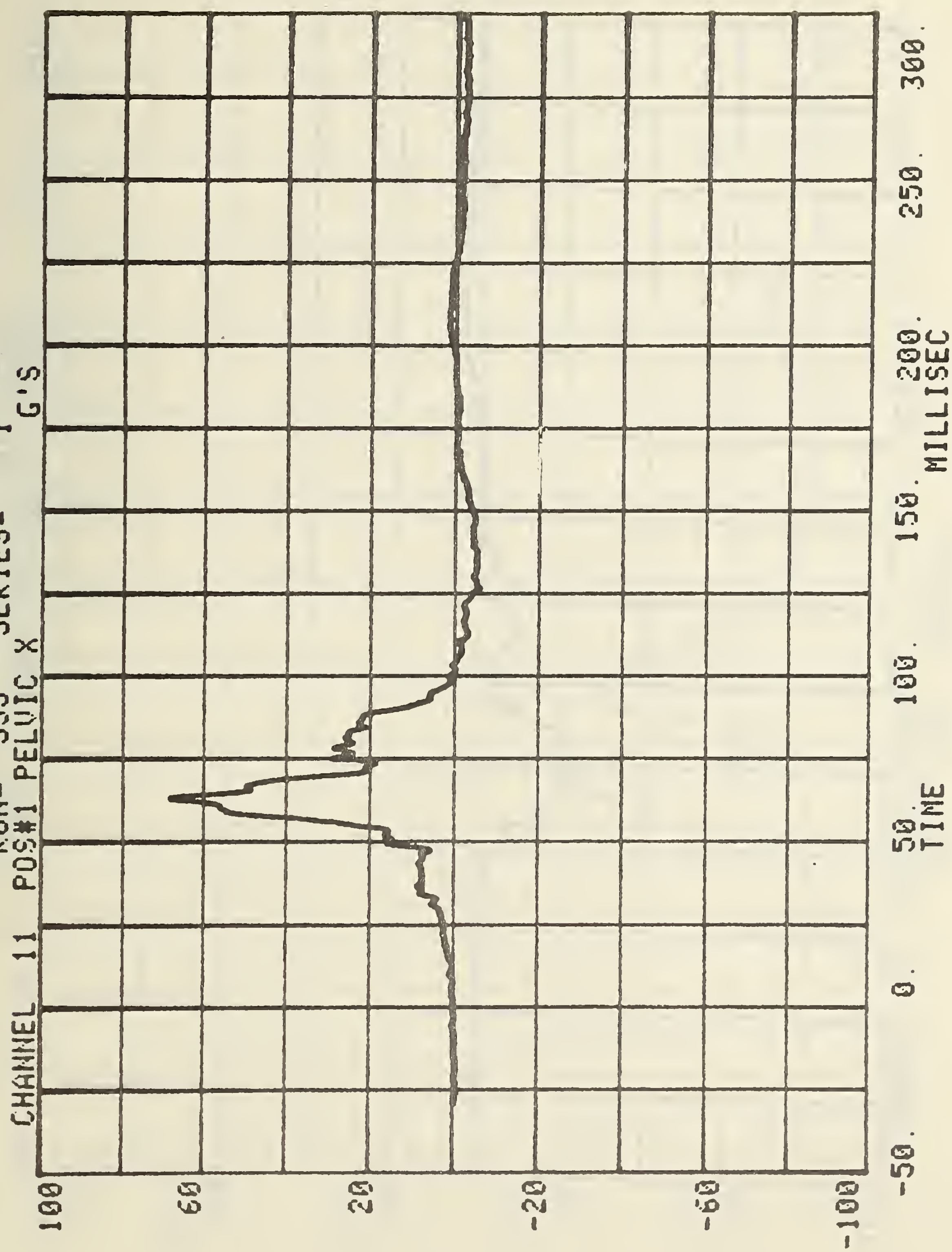

CHANNEL 6 RUN= 533 SERIES= 1
POS#1 CHEST Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

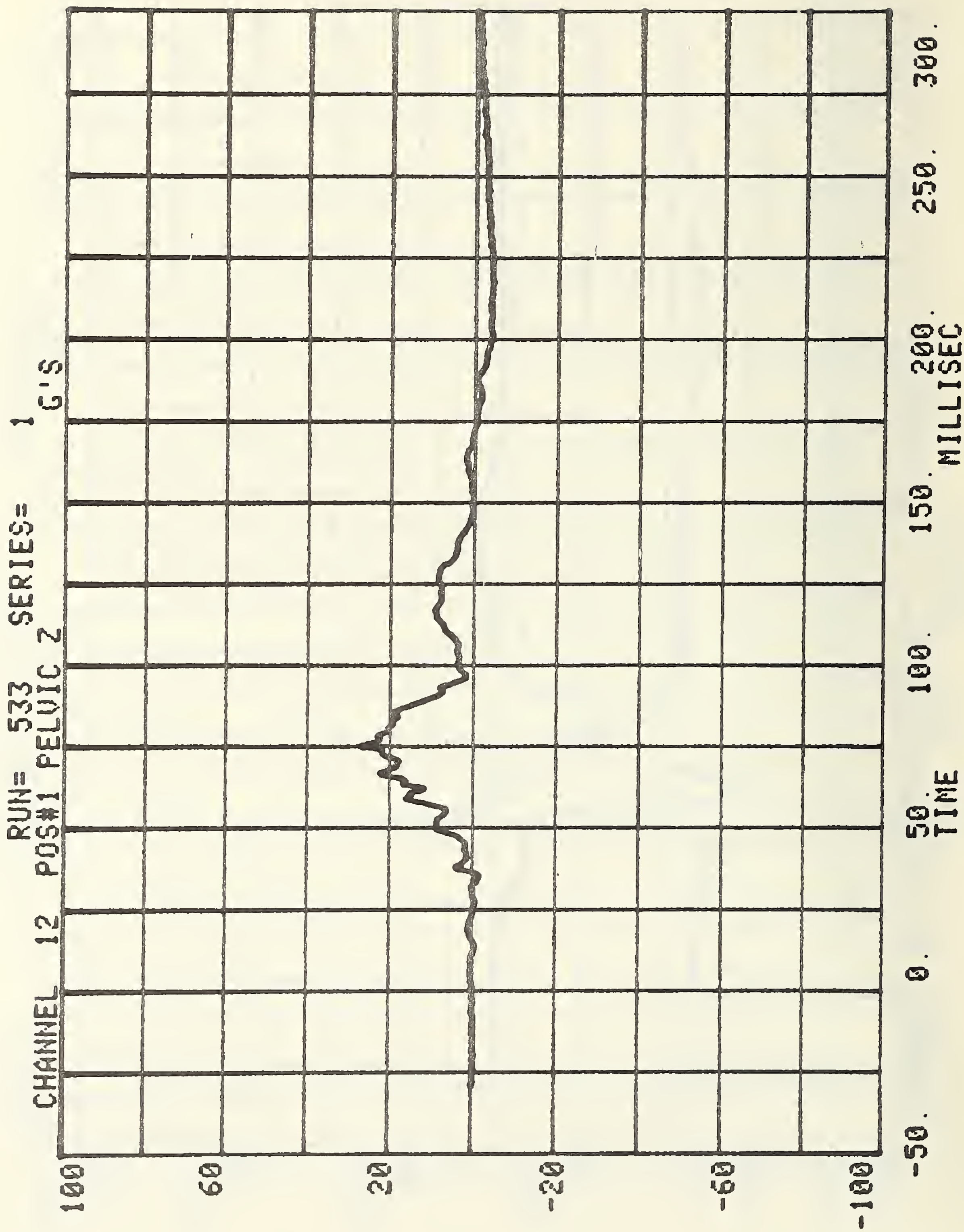

CHANNEL 11 RUN= 533 SERIES= 1
POS#1 CHEST RESULTANT G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

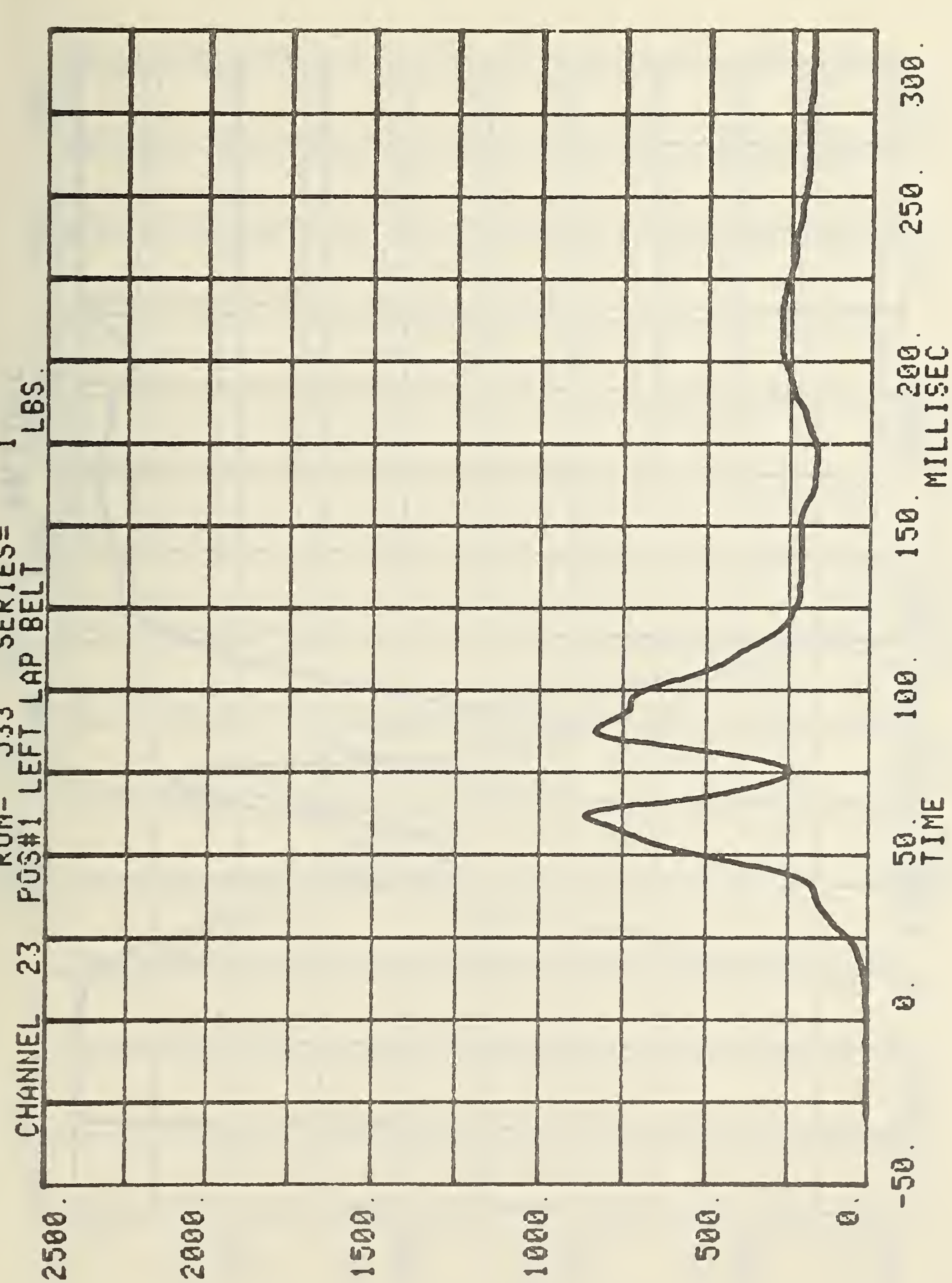

CHANNEL 8 RUN= 533 SERIES= 1
POS#1 LEFT FEMUR LBS
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

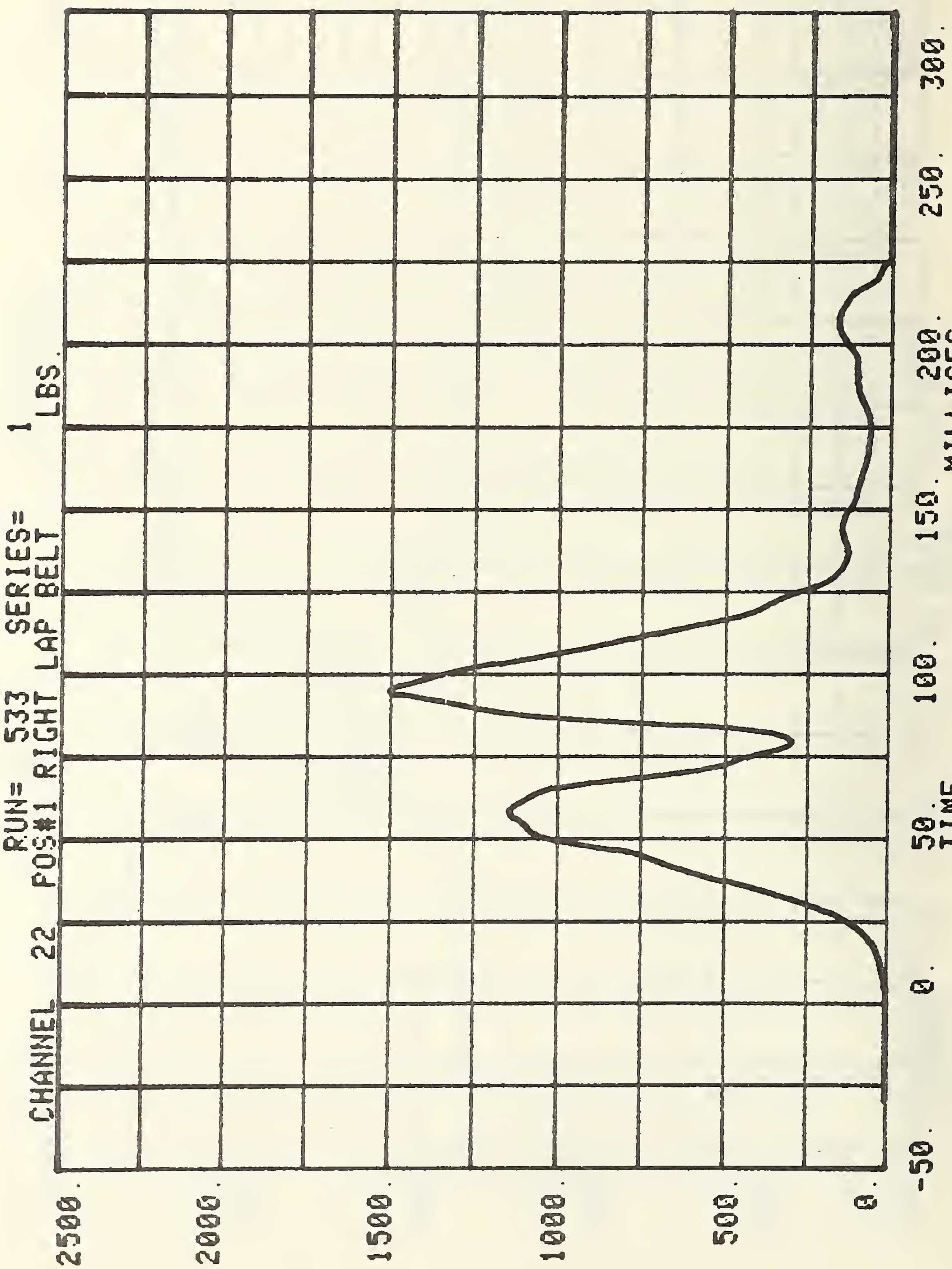


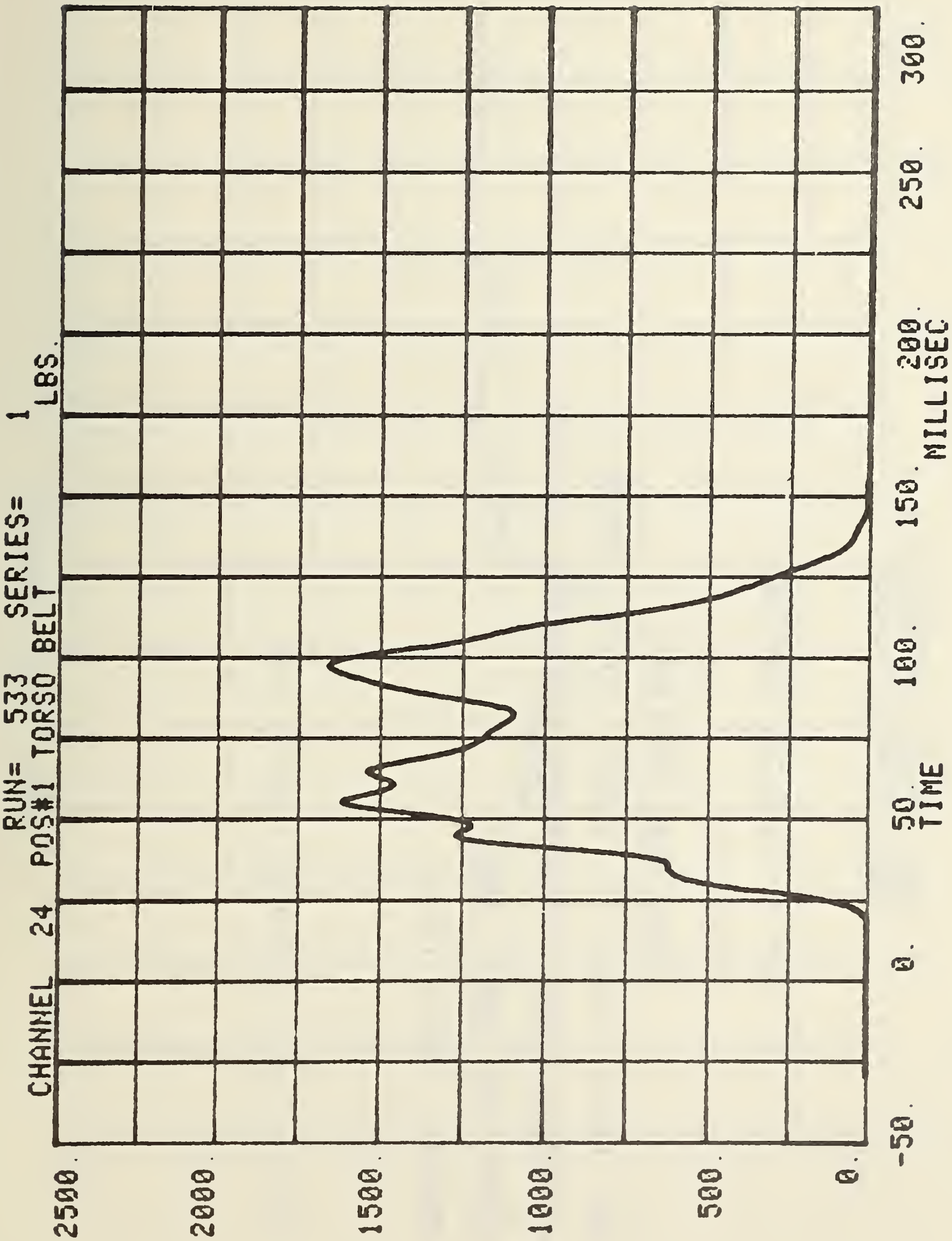
CHANNEL 7 RUN= 533 SERIES= 1
POS#1 RIGHT FEMUR LBS.
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 11 RUN= 533 SERIES= 1
POS#1 PELVIC X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 12 RUN= 533 SERIES= 1
POS#1 PELVIC Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 23
RUN= 533 SERIES= 1
POS#1 LEFT LAP BELT
LBS
2500.
2000.
1500.
1000.
500.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC


CHANNEL 22 RUN= 533 SERIES= 1
POS#1 RIGHT LAP BELT LBS.
2500.
2000.
1500.
1000.
500.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 24 RUN= 533 SERIES= 1
POS#1 TORSO BELT LBS.
2500.
2000.
1500.
1000.
500.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

CAR TO LOAD CELL BARRIER

RUN= 533

POS#2 HEAD RESULTANT*

HIC= 112.5   FROM T1= .05010   TO T2= .12840

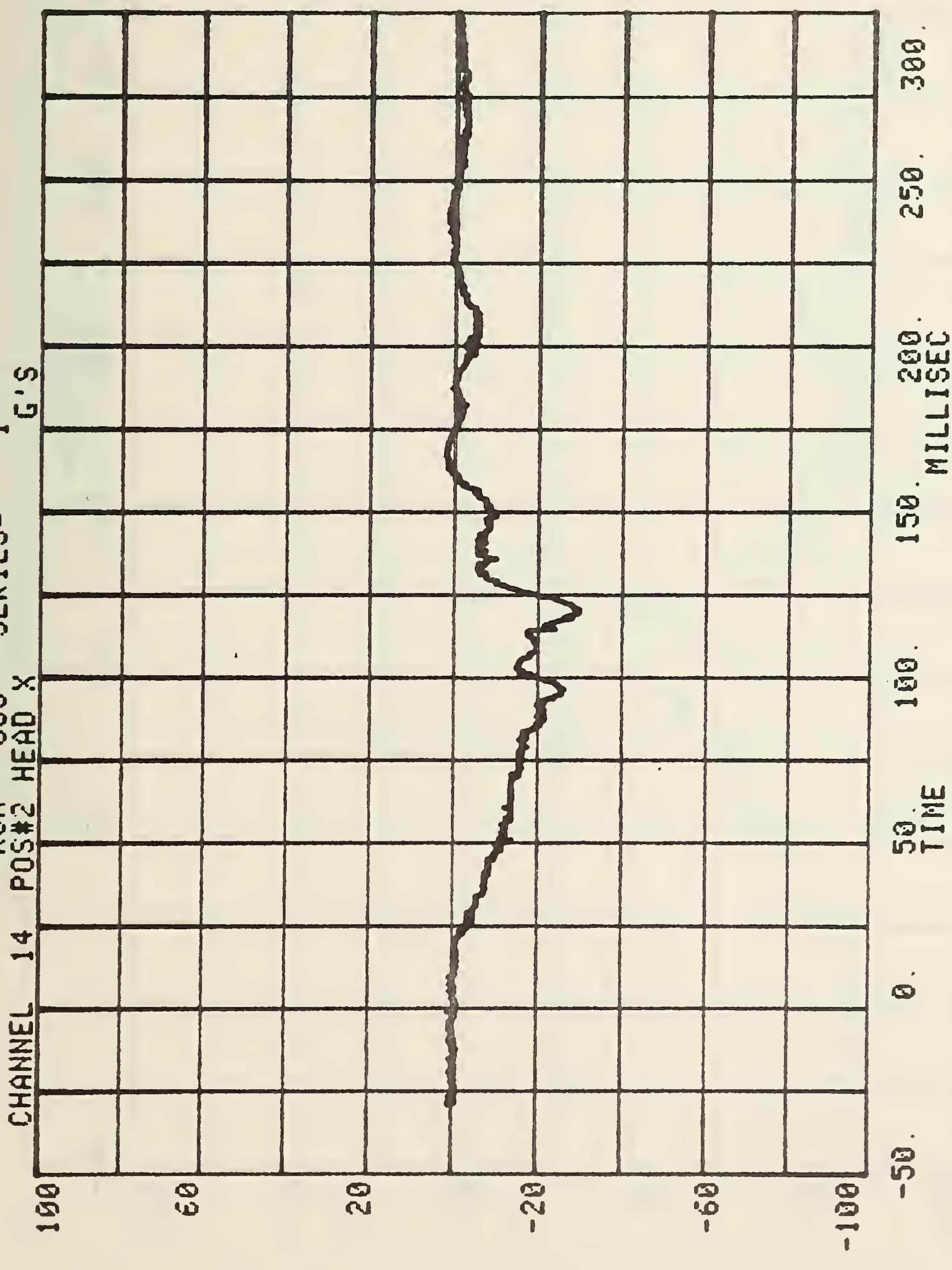
AVERAGE ACCELERATION BETWEEN T1 AND T2= 18.3G'S

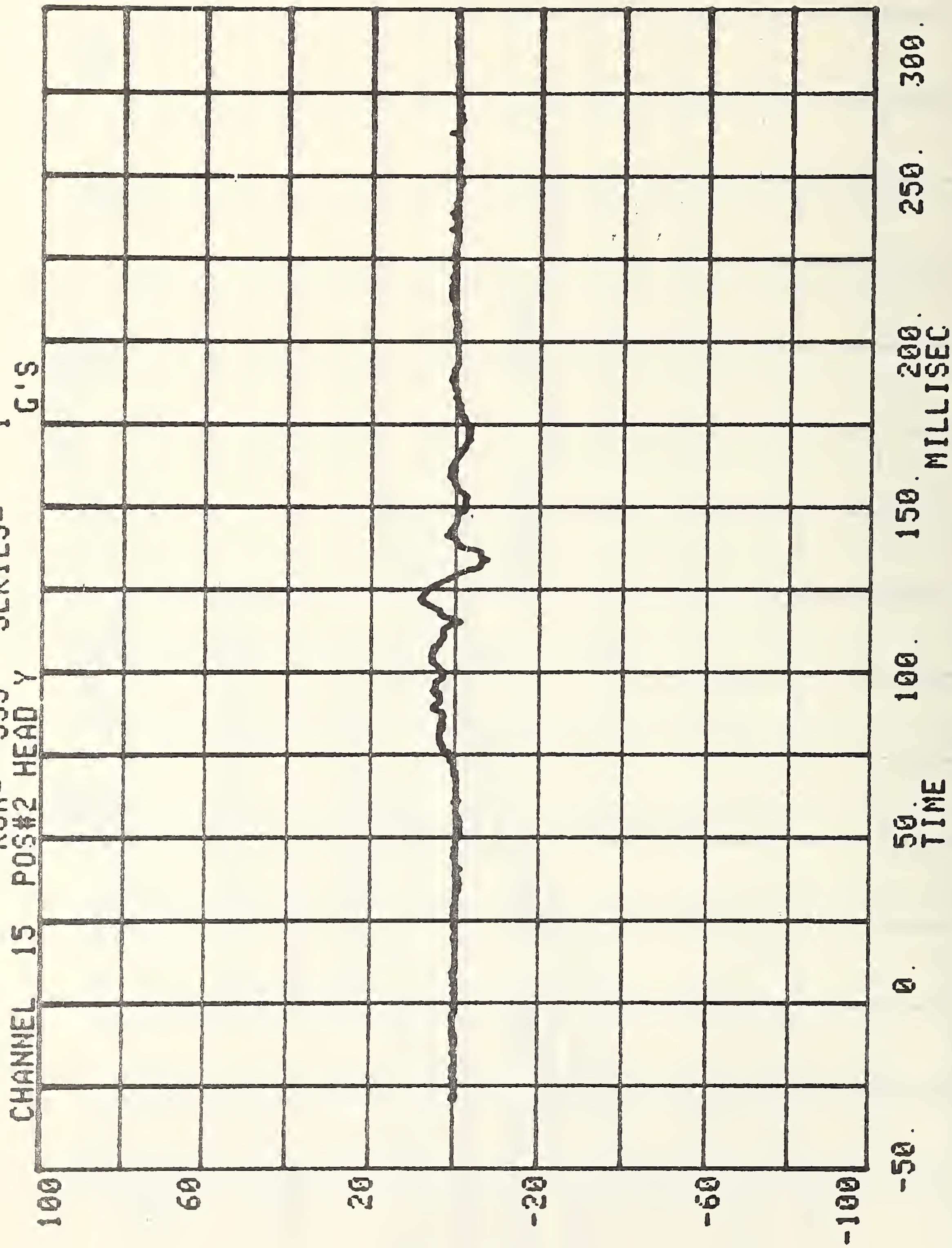
EVENT TIME= 300.0 MSEC

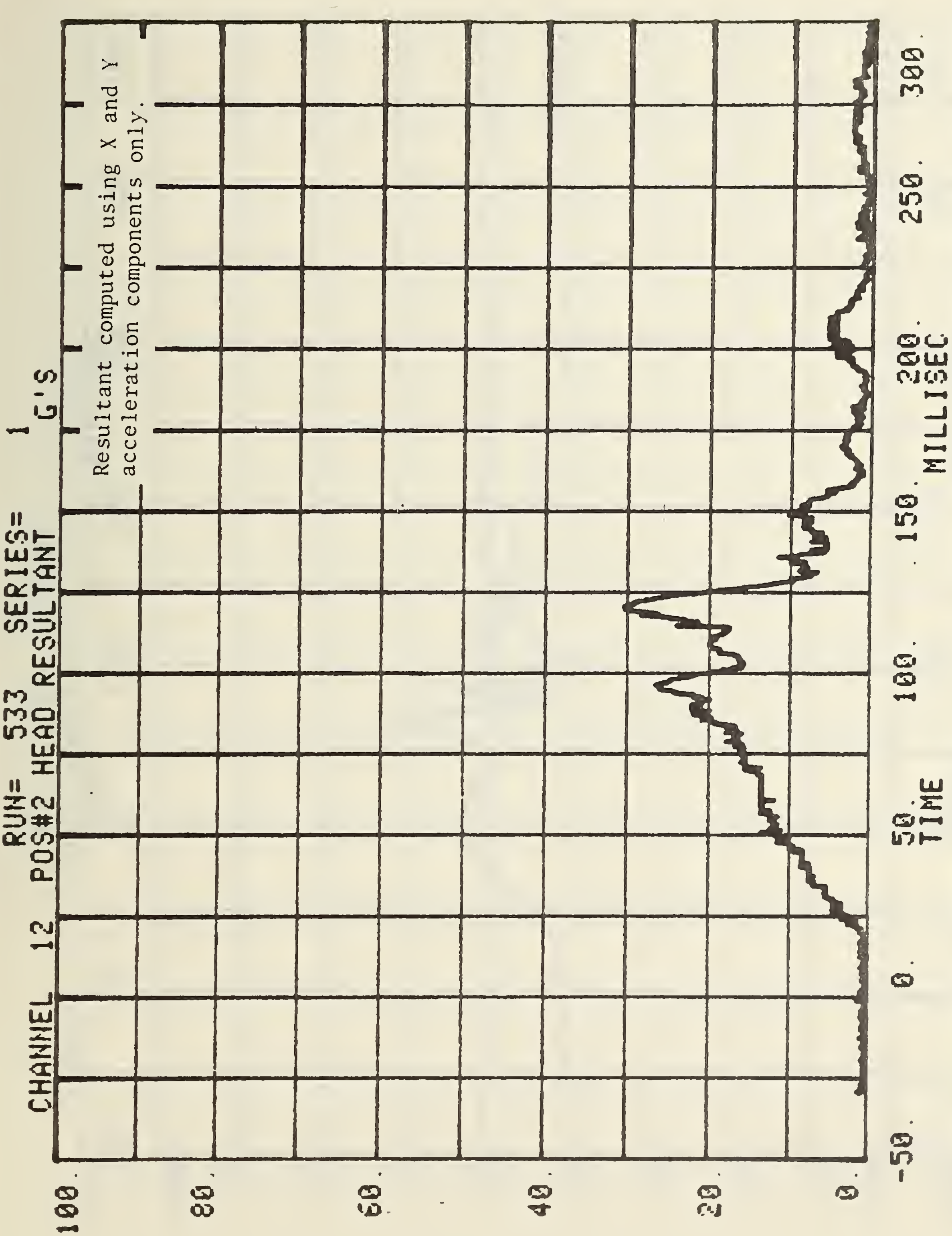
SEVERITY INDEX= 137.8

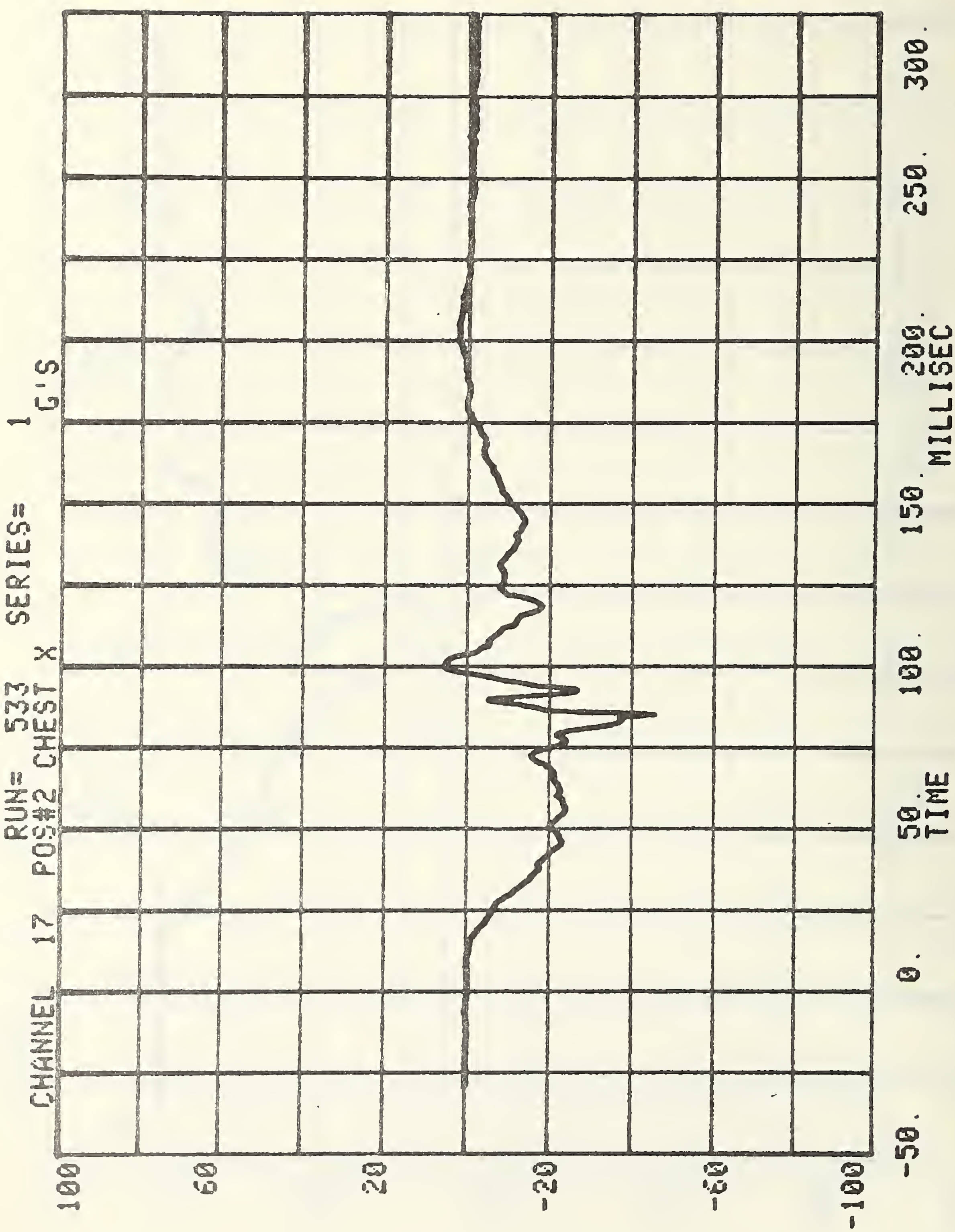
---

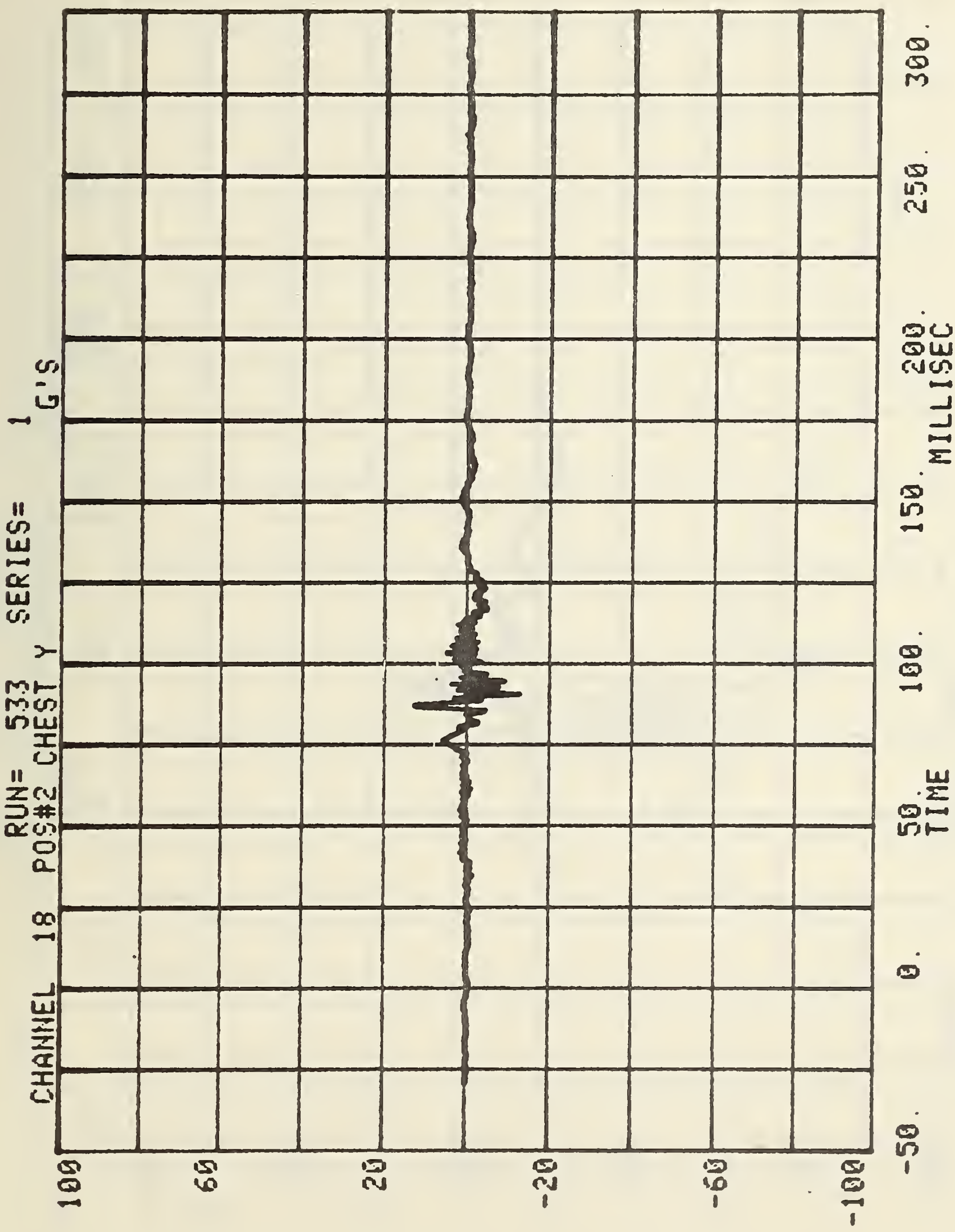
*Reflects X and Y acceleration components only.

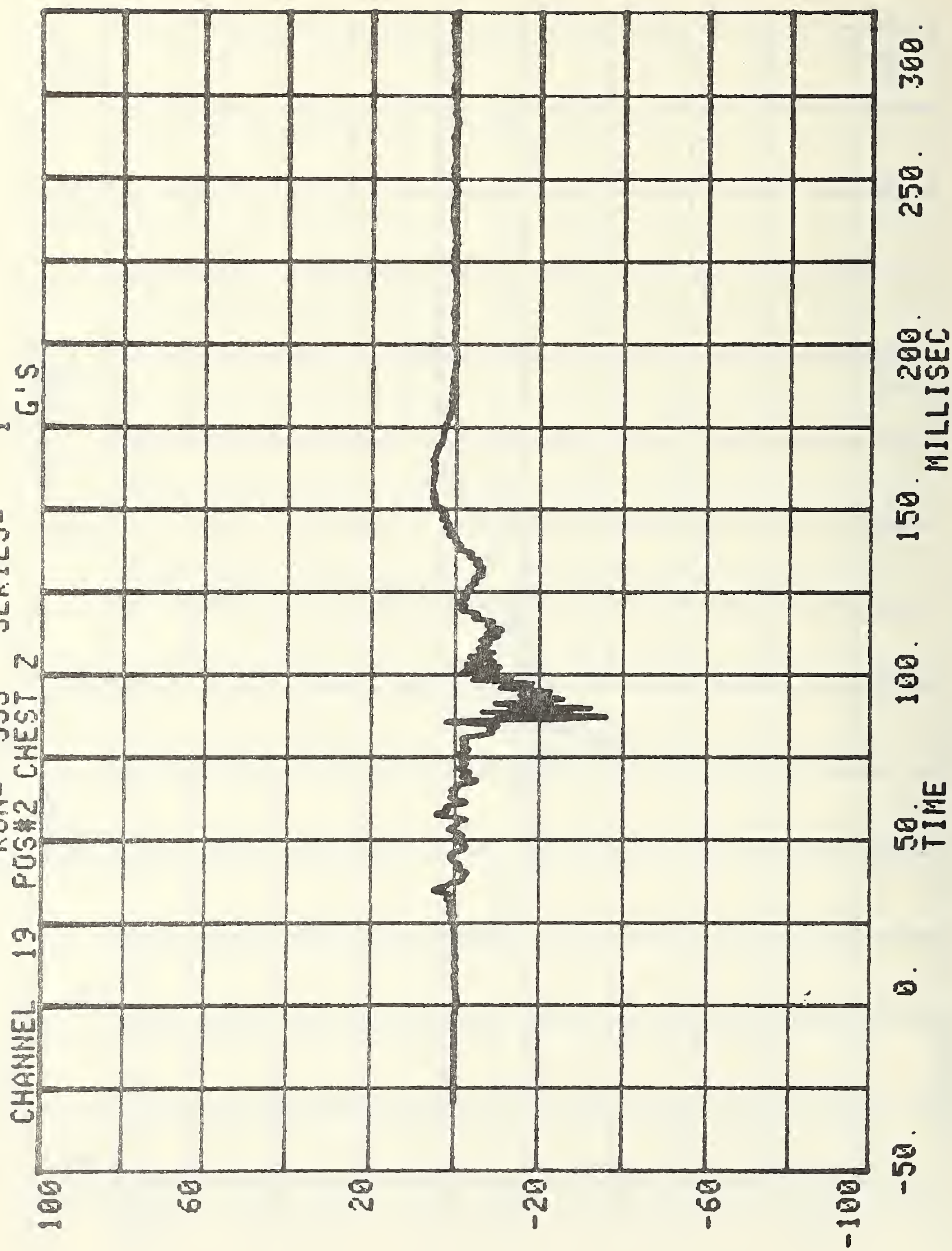

CHANNEL 14 RUN= 533 SERIES= 1
POS#2 HEAD X
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

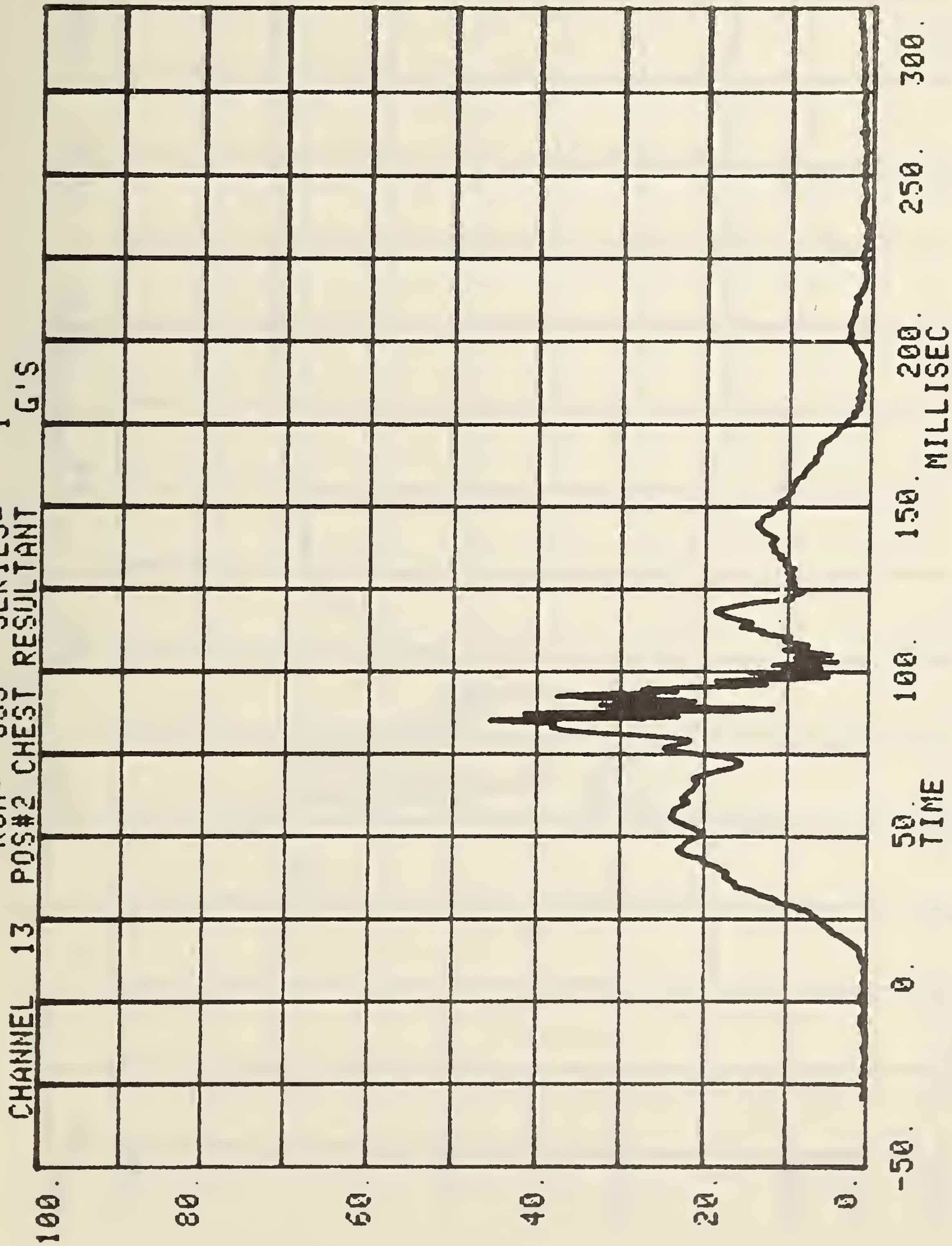

CHANNEL 15 RUN= 533 SERIES= 1
POS#2 HEAD Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

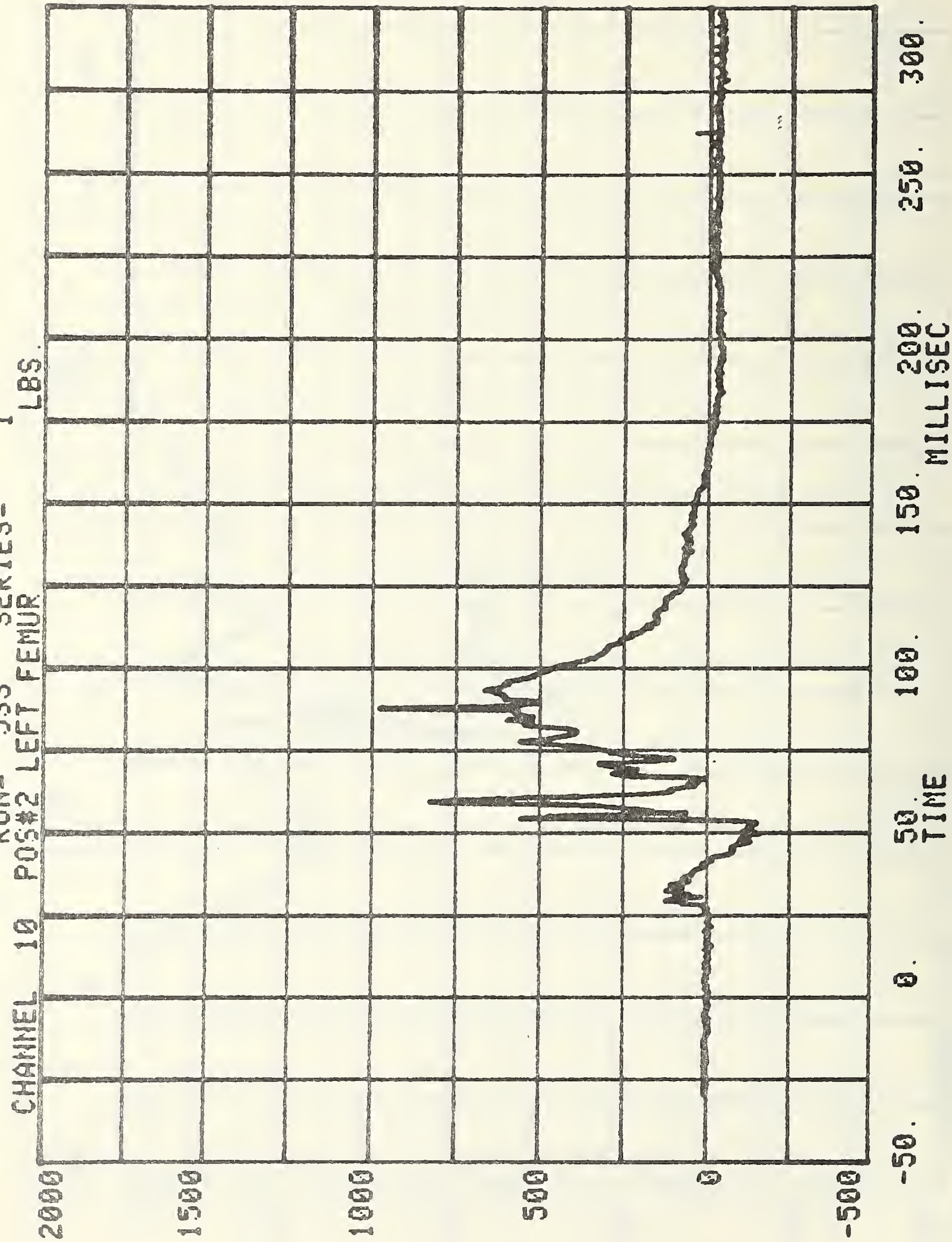

CHANNEL 12 RUN= 533 SERIES= 1
POS#2 HEAD RESULTANT G'S
Resultant computed using X and Y
acceleration components only.
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

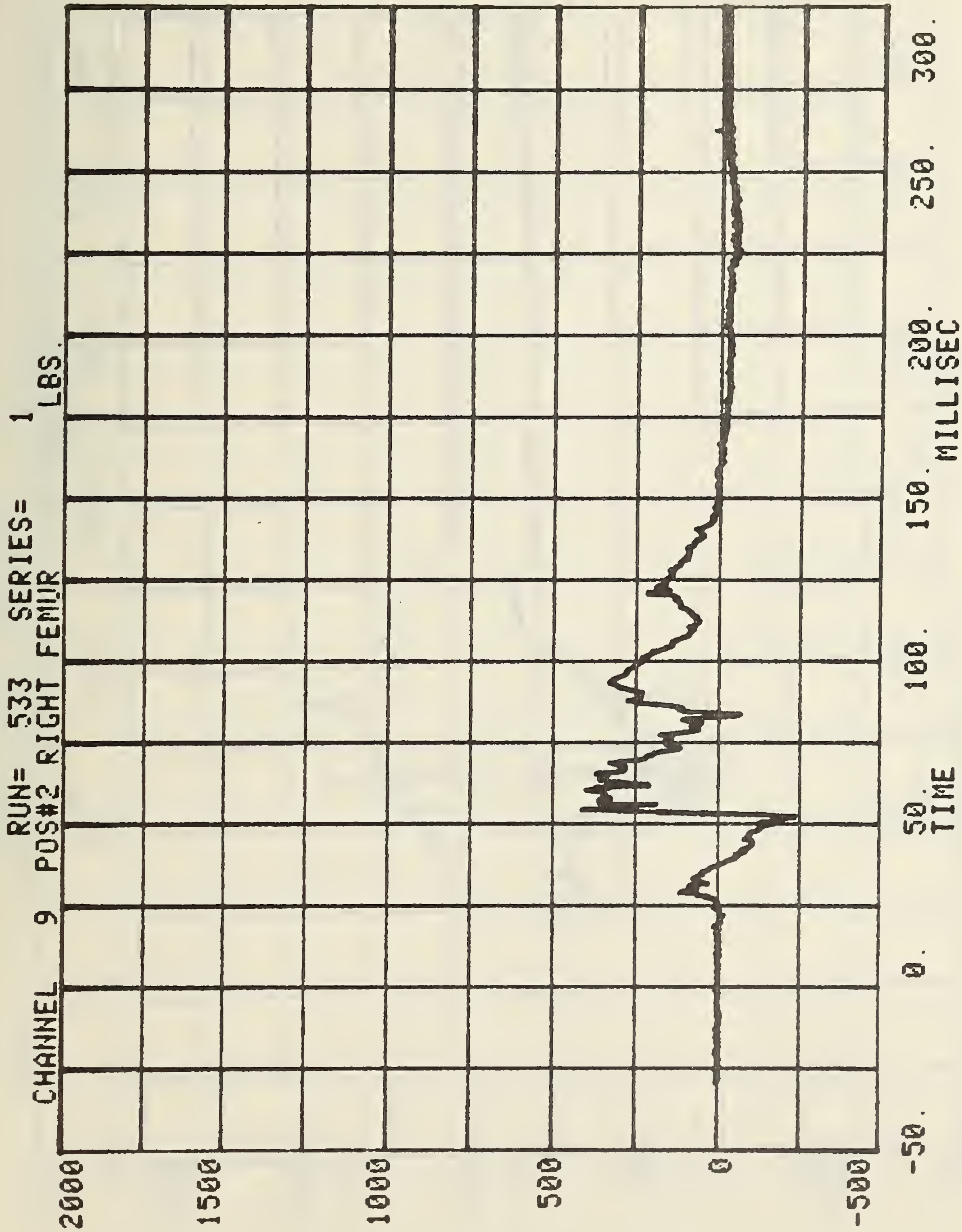

CHANNEL 17 RUN= 533 SERIES= 1
POS#2 CHEST X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

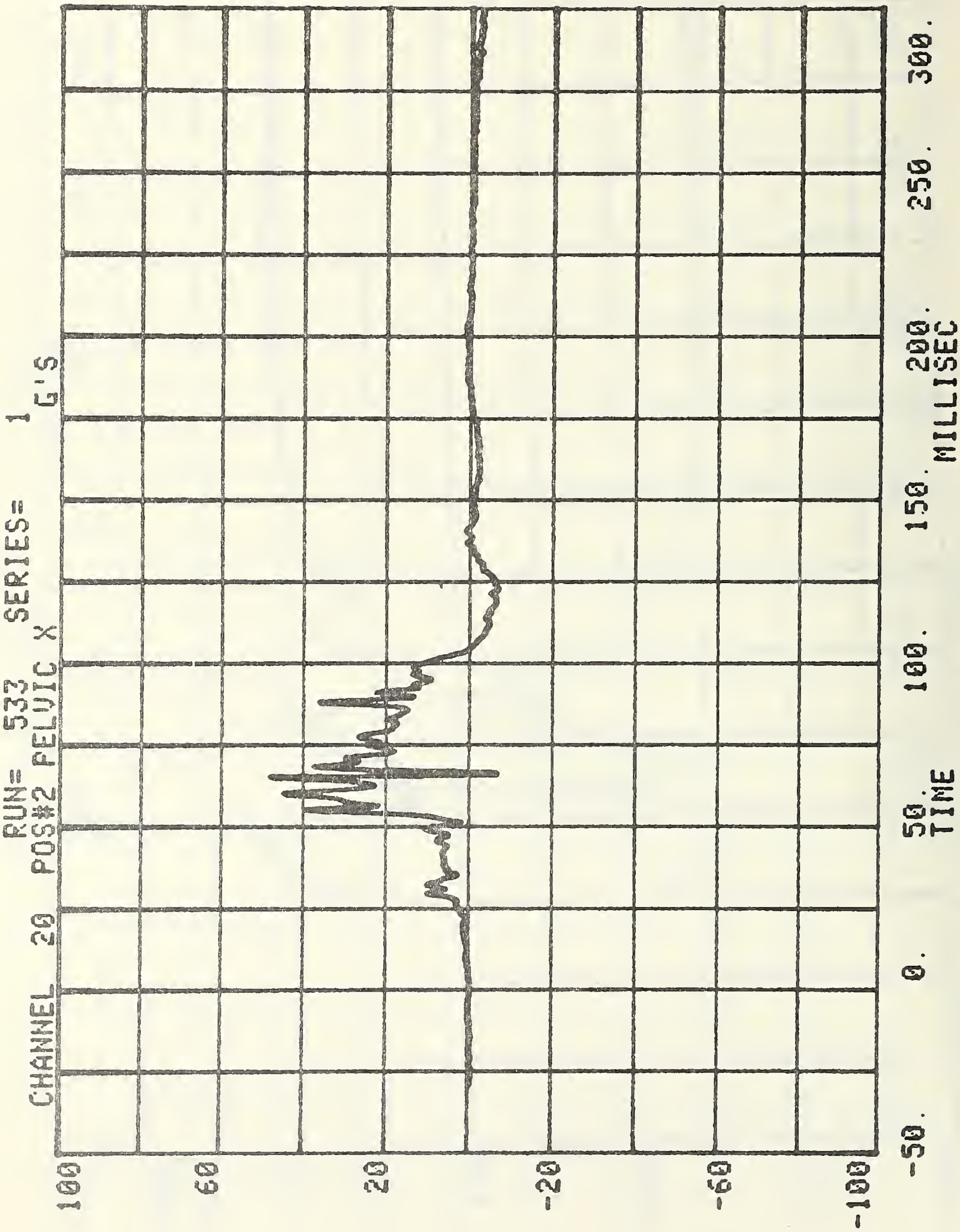

CHANNEL 18 RUN= 533 SERIES= 1
POS#2 CHEST Y
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

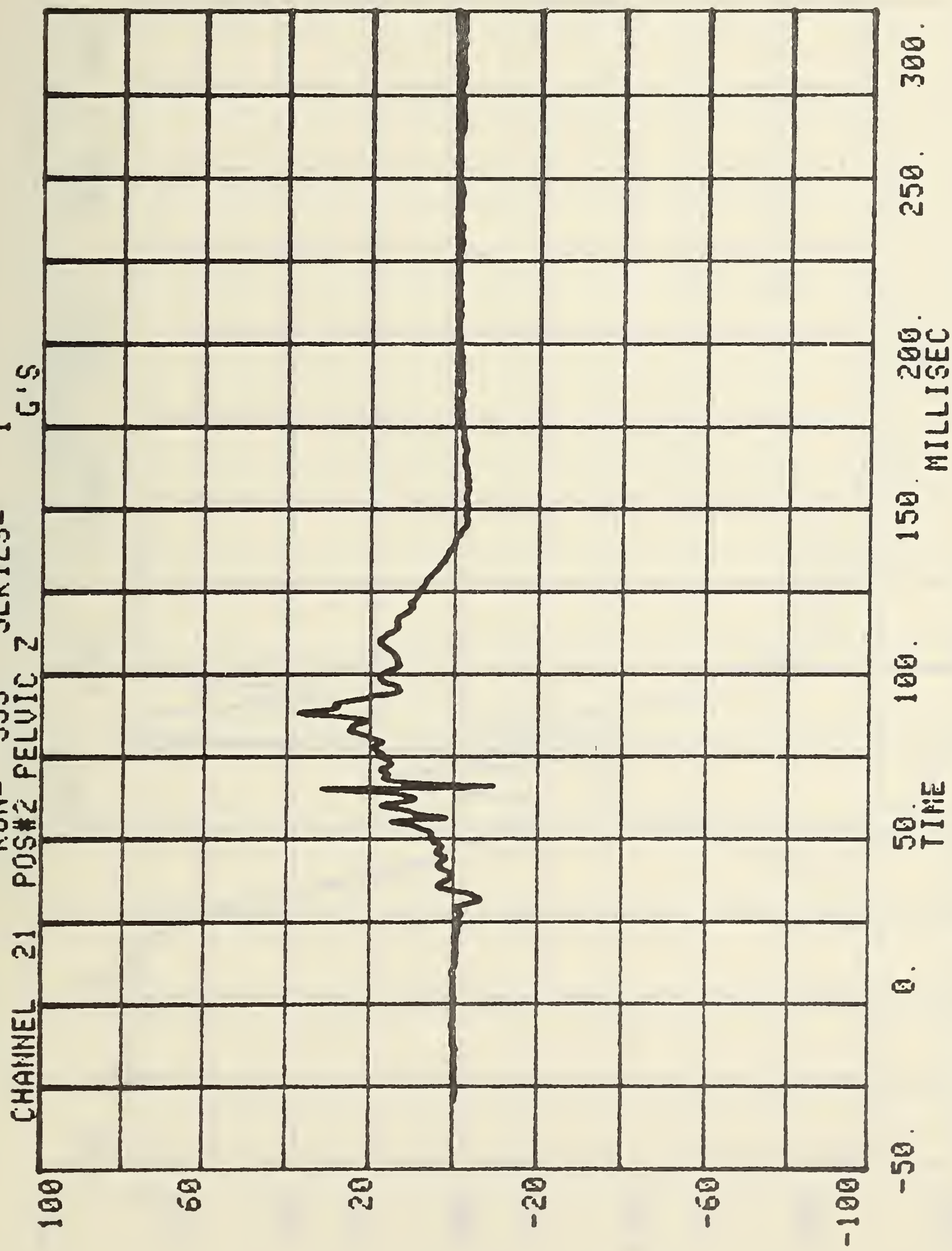

CHANNEL 19 RUN= 533 SERIES= 1
POS#2 CHEST Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

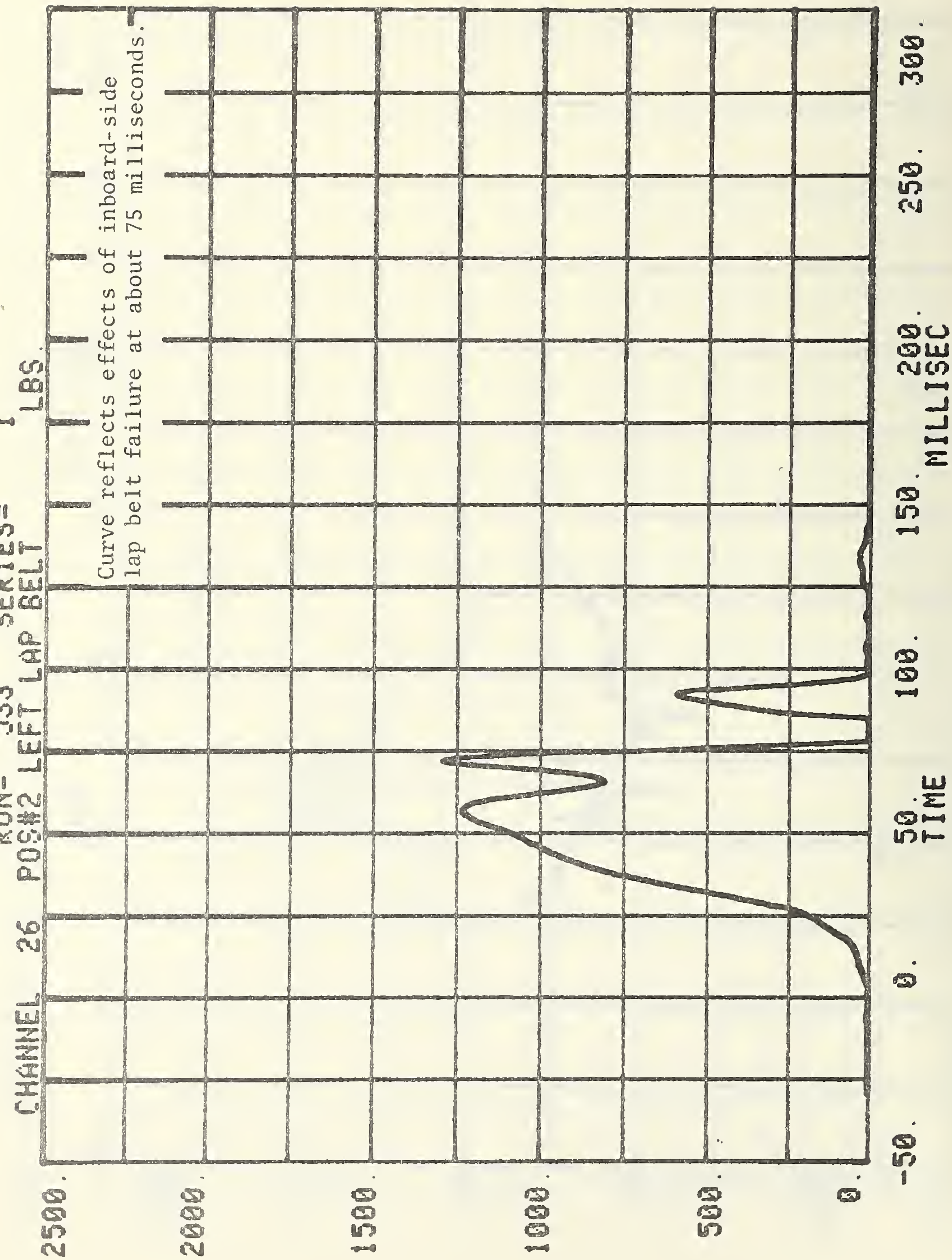

CHANNEL 13 RUN= 533 SERIES= 1
POS#2 CHEST RESULTANT G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

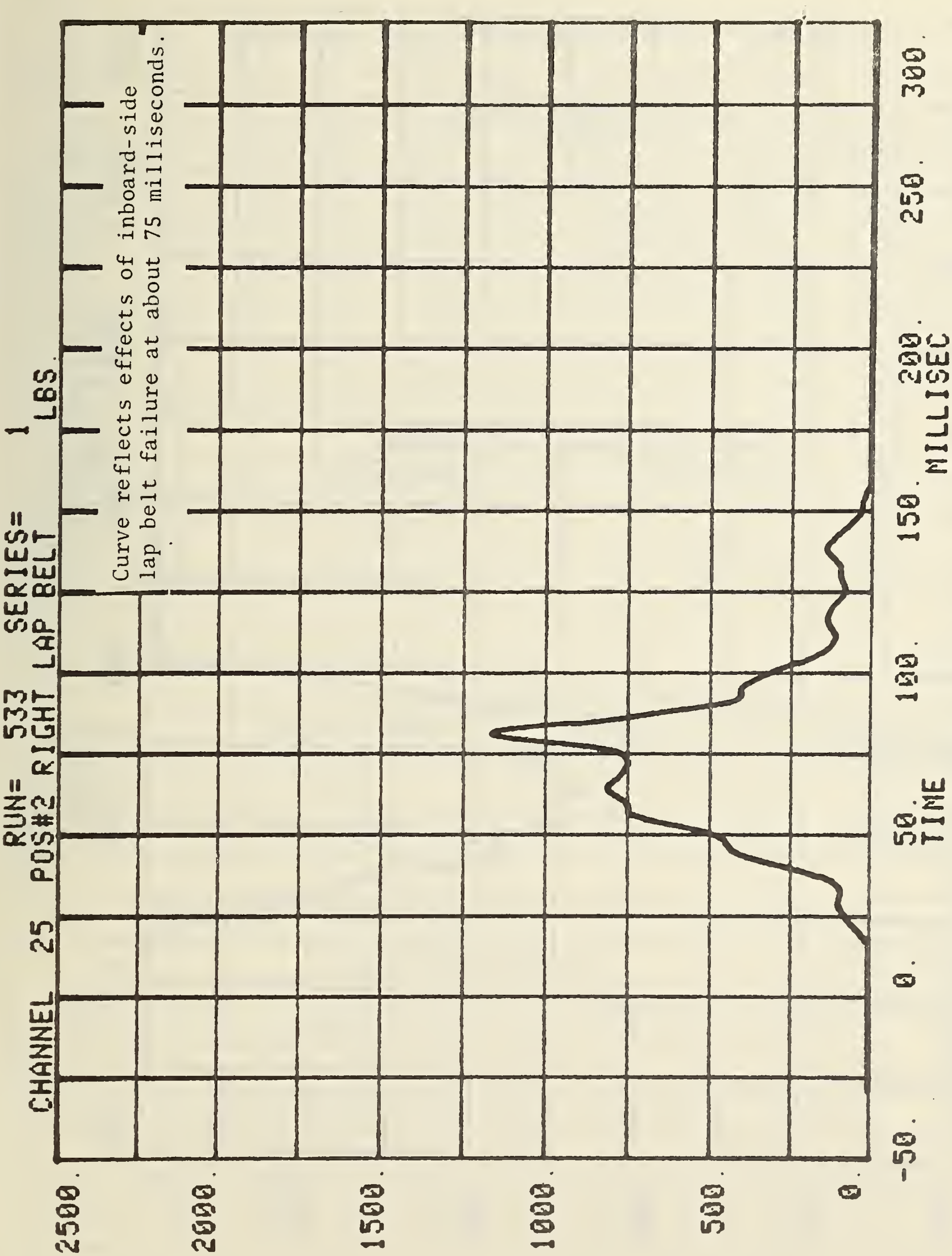

CHANNEL 10 RUN= 533 SERIES= 1
POS#2 LEFT FEMUR LBS.
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

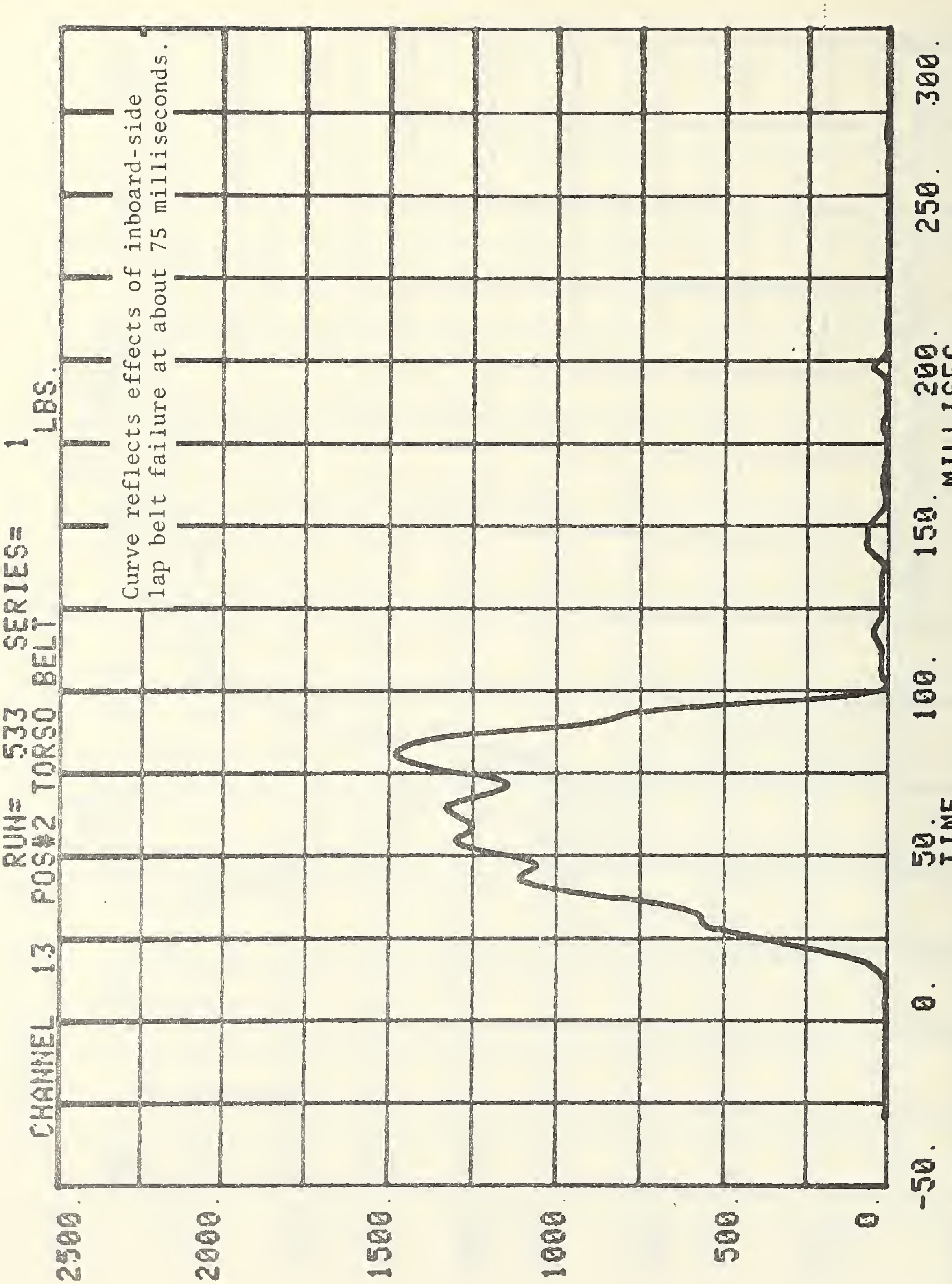

CHANNEL 9 RUN= 533 SERIES= 1
POS#2 RIGHT FEMUR LBS.
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 20 RUN= 533 SERIES= 1
POS#2 PELVIC X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 21 RUN= 533 SERIES= 1
POS#2 PELVIC Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 26 RUN= 533 SERIES= 1
POS#2 LEFT LAP BELT LBS
Curve reflects effects of inboard-side
lap belt failure at about 75 milliseconds.
2500.
2000.
1500.
1000.
500.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 25 RUN= 533 SERIES= 1
POS#2 RIGHT LAP BELT LBS
Curve reflects effects of inboard-side lap belt failure at about 75 milliseconds.
2500.
2000.
1500.
1000.
500.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 13 RUN= 533 SERIES= 1
POS#2 TORSO BELT LBS.
Curve reflects effects of inboard-side
lap belt failure at about 75 milliseconds.
2500.
2000.
1500.
1000.
500.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

OCCUPANT AND RESTRAINT SYSTEM DATA SUMMARY

DUMMY POSITION	MAXIMUM ACCELERATION (g)											
	HEAD				CHEST[1]				PELVIS			
	X	Y	Z	R	X	Y	Z	R	X	Y	Z	R
Driver (1)	-55	11	45	71	-32	6	-14	33	68	--	27	--
Pass. (2)	-30	9	NA	30[3]	-37	-8	-28	38	48	--	37	--

DUMMY POSITION	MAXIMUM FORCE-FEMUR LOAD (LBS)	
	RIGHT FEMUR	LEFT FEMUR
Driver (1)	980	1720
Pass. (2)	420	980

DUMMY POSITION	MAXIMUM FORCE-SEAT BELT LOADS (LBS)		
	SHOULDER STRAP UPPER BELT LOAD	LAP STRAP RIGHT BELT LOAD	LAP STRAP LEFT BELT LOAD
Driver (1)	1660	1500	860
Pass. (2)	1480[4]	1170[4]	1280[4]

DUMMY POSITION	HEAD INJURY CRITERIA[2]				SEVERITY INDEX	
	HIC	t_1 (SEC)	t_2 (SEC)	AVE. ACC. (g) t_1 TO t_2	HEAD	CHEST
Driver (1)	367	0.053	0.115	32	487	--
Pass. (2)	113[3]	0.050	0.128	18[3]	138[3]	--

[1]DEFINED AS EXCEEDING 0.003 SEC. DURATION

[2]AS DEFINED IN FMVSS NO. 208

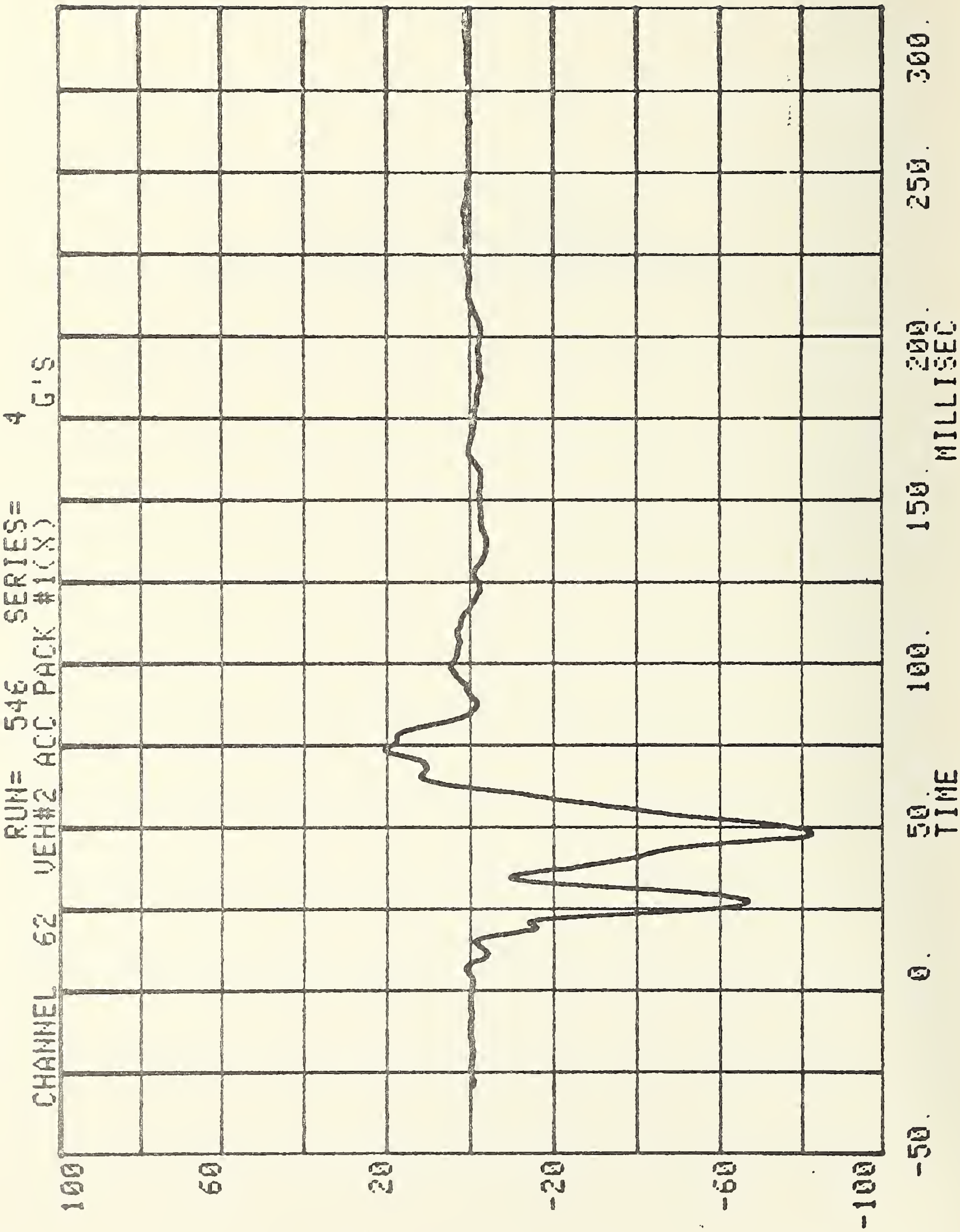
[3]COMPUTED USING X AND Y ACCELERATION COMPONENTS ONLY

[4]MAXIMUM LOADING PRIOR TO LEFT LAP BELT WEBBING FAILURE

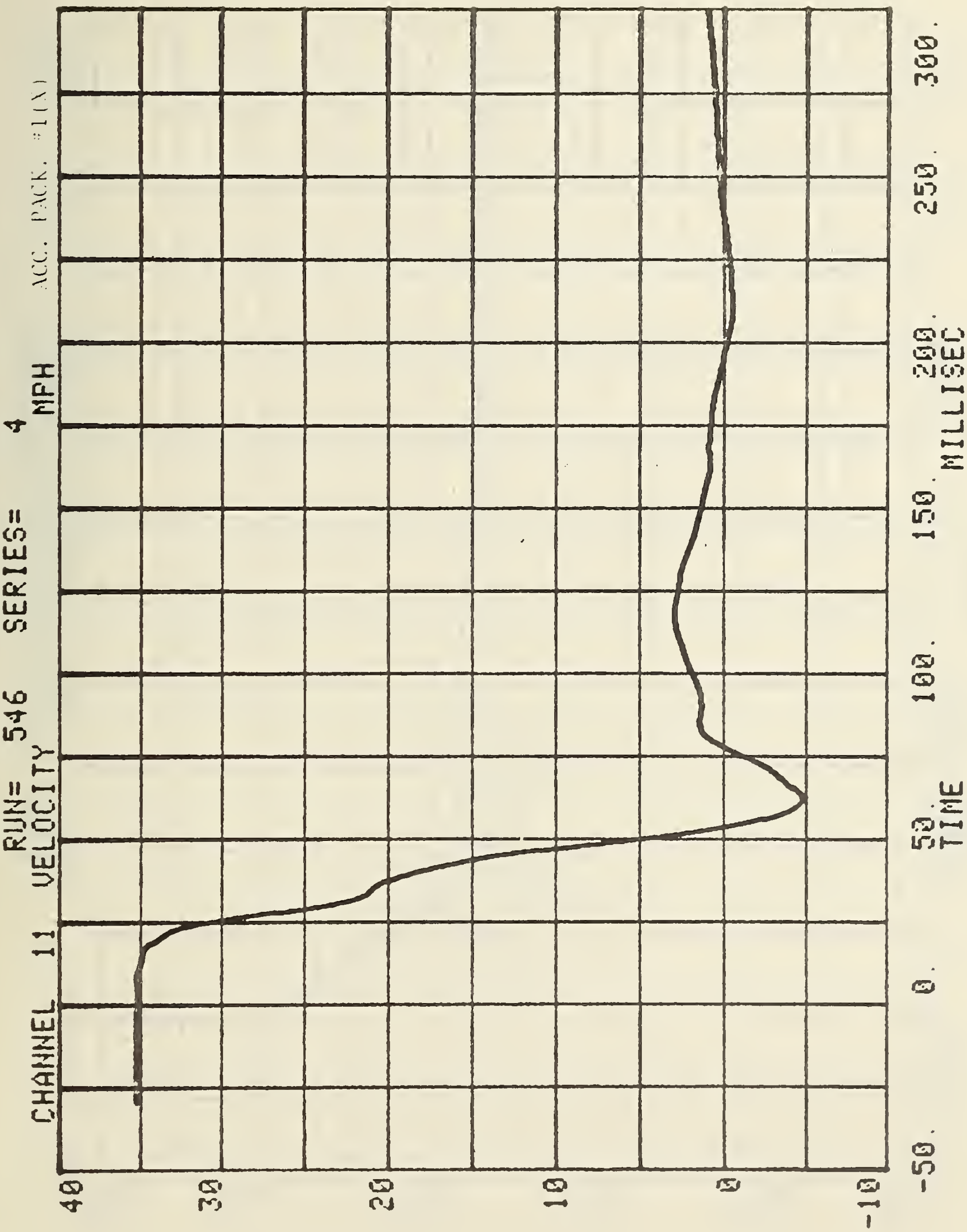
APPENDIX D

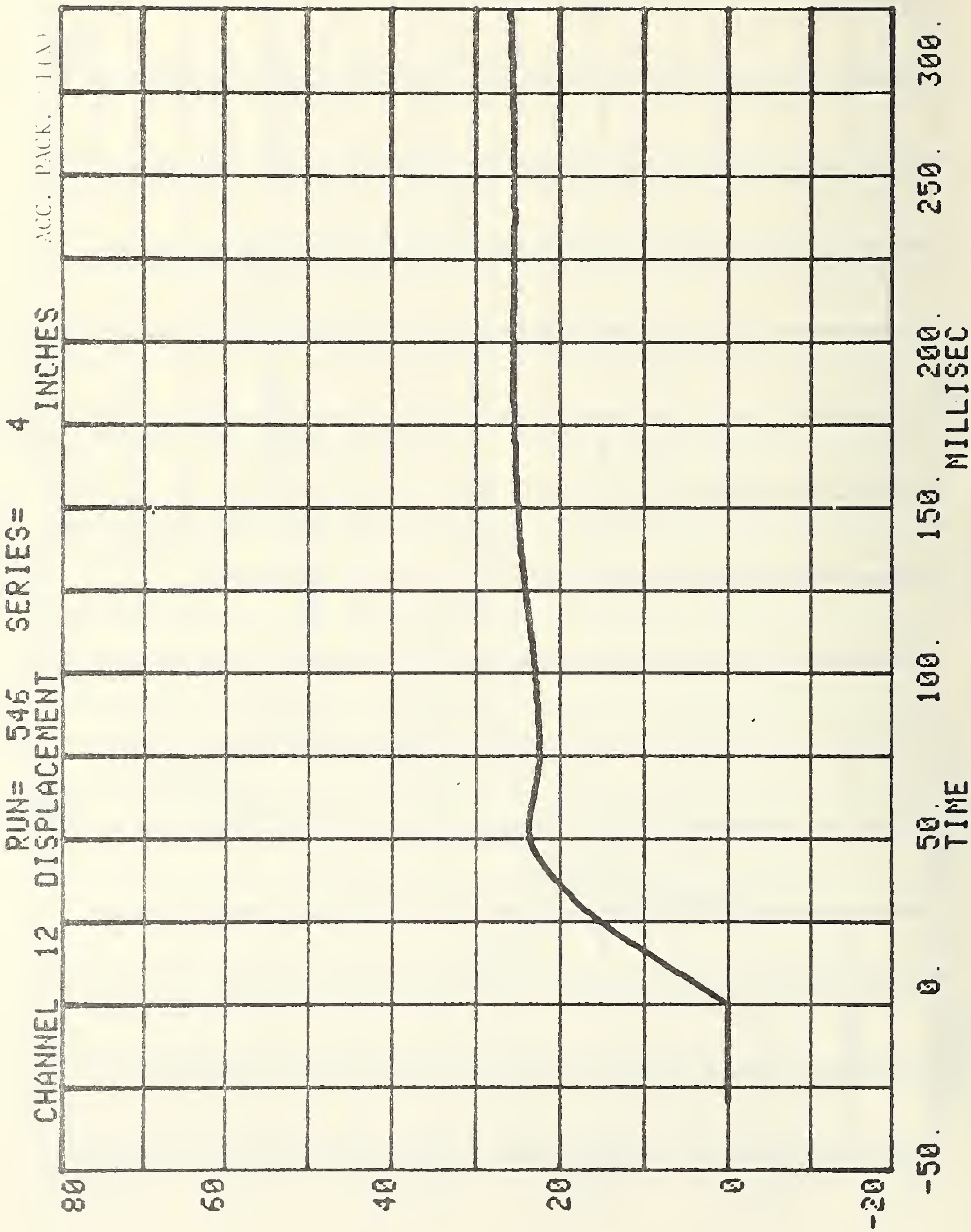
ELECTRONIC CRASH TEST DATA:

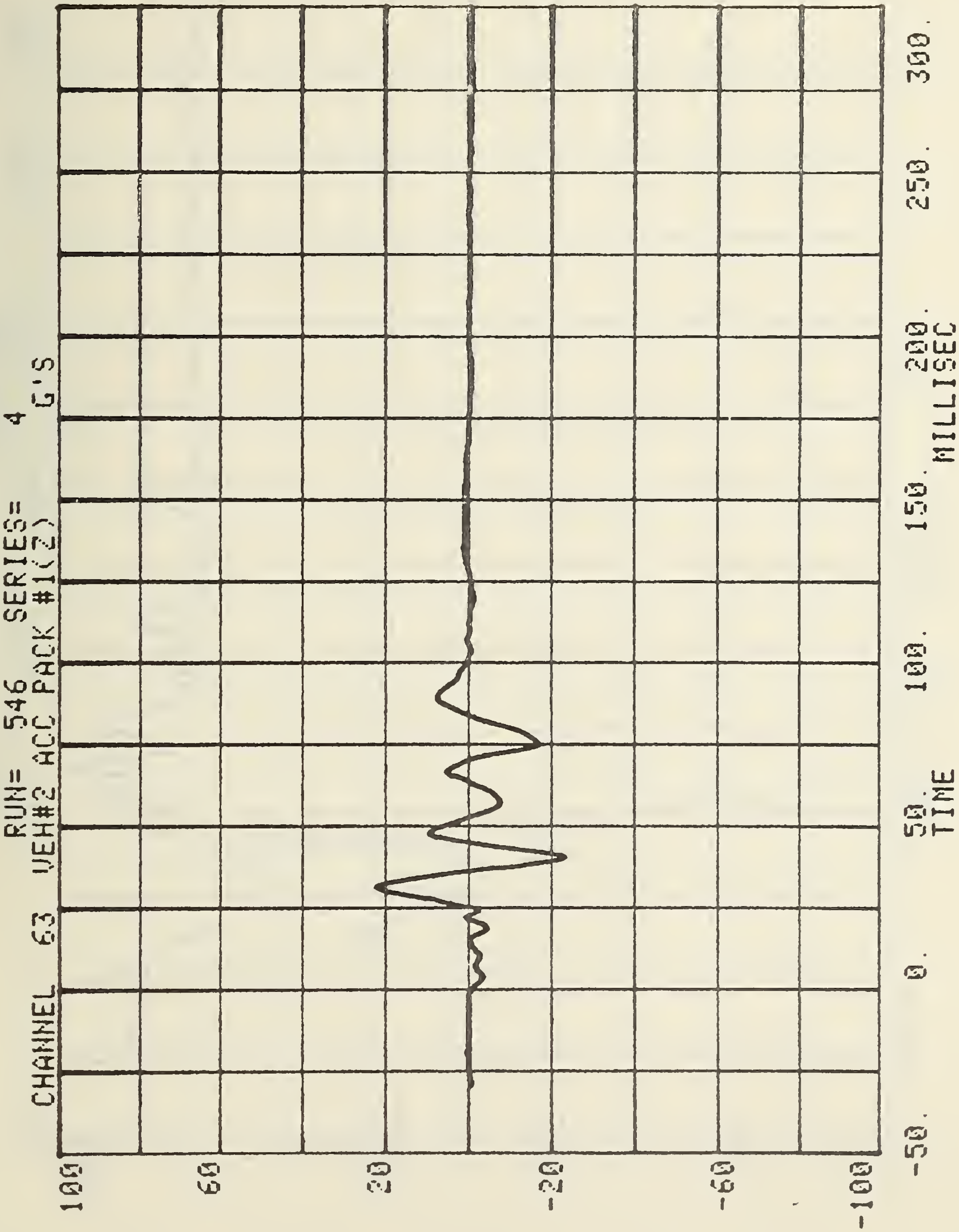
PLYMOUTH HORIZON VEHICLE-MOUNTED SENSORS

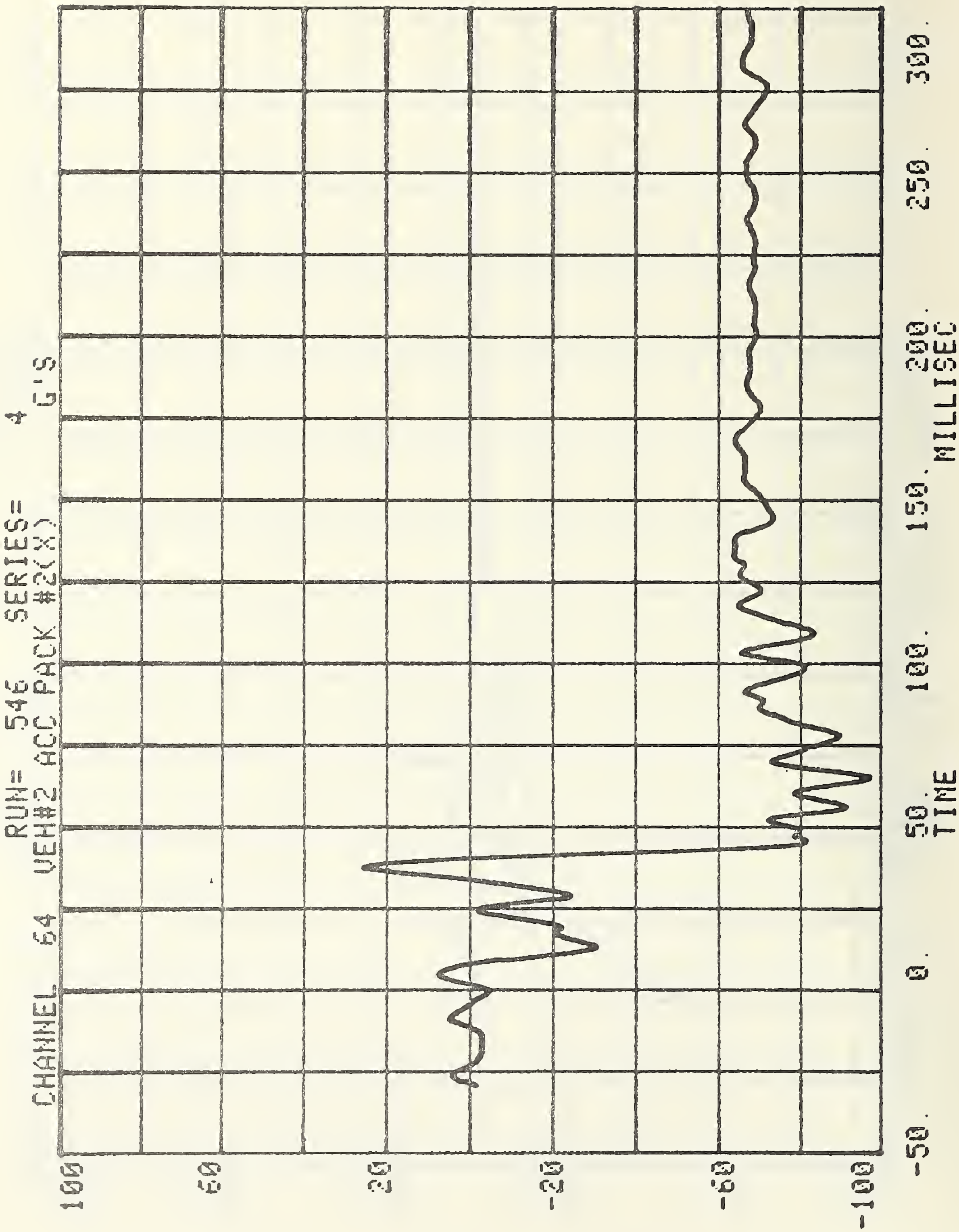


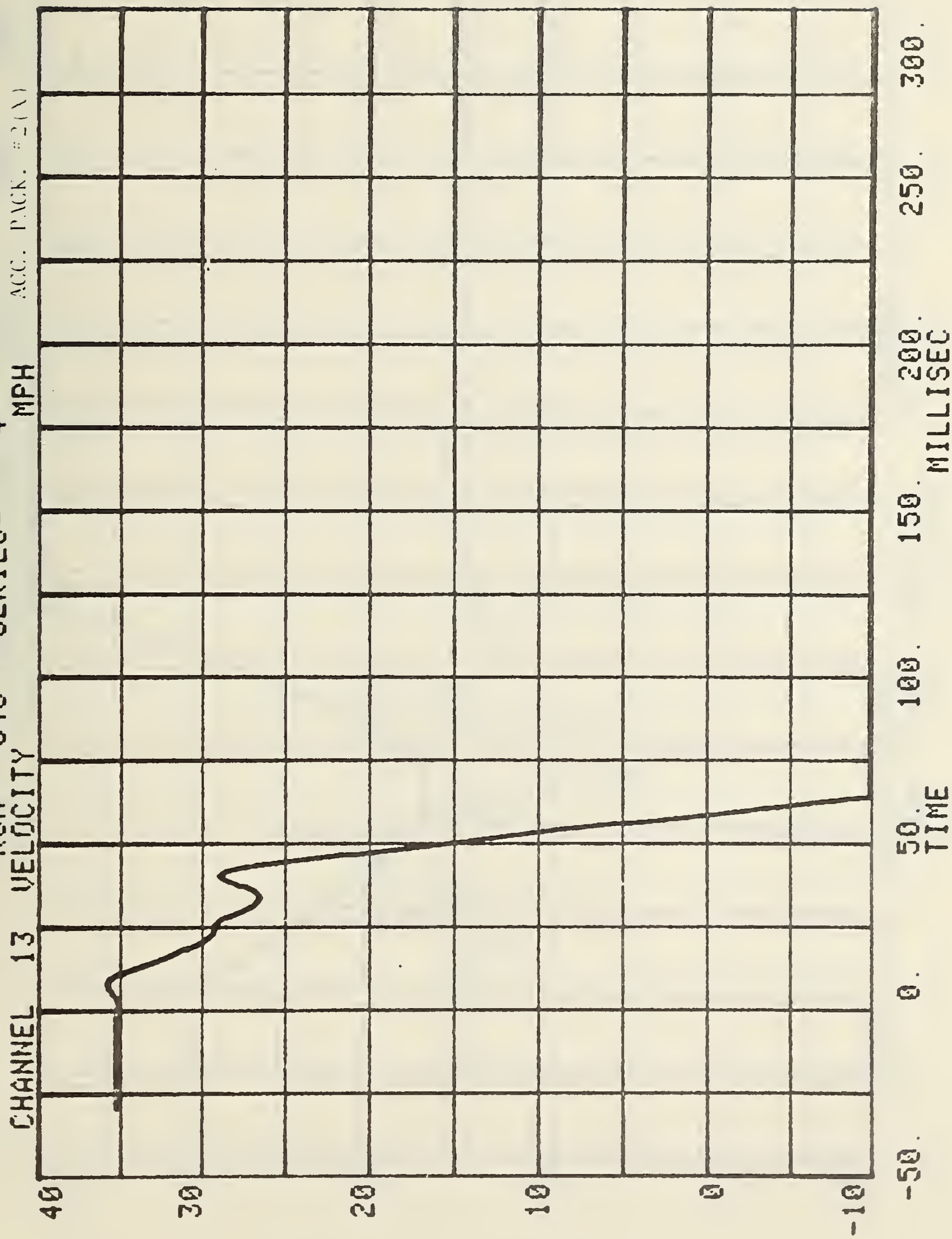
CHANNEL 62 RUN= 546 SERIES= 4
VEH#2 ACC PACK #1(X) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

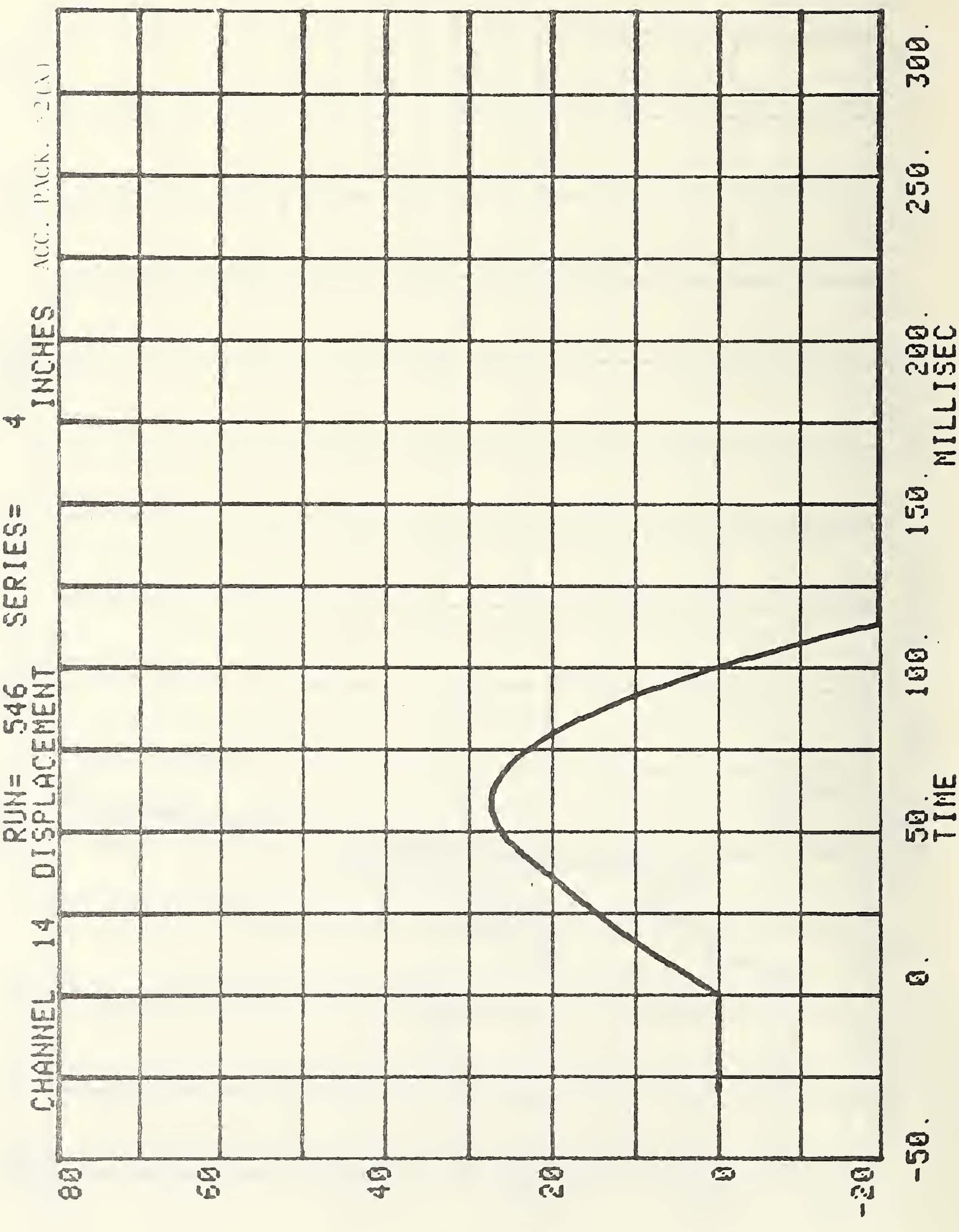

CHANNEL 11 RUN= 546 SERIES= 4
VELOCITY
MPH
ACC. PACK. #1(X)
TIME
MILLISEC
-50.
0.
50.
100.
150.
200.
250.
300.
40
30
20
10
0
-10

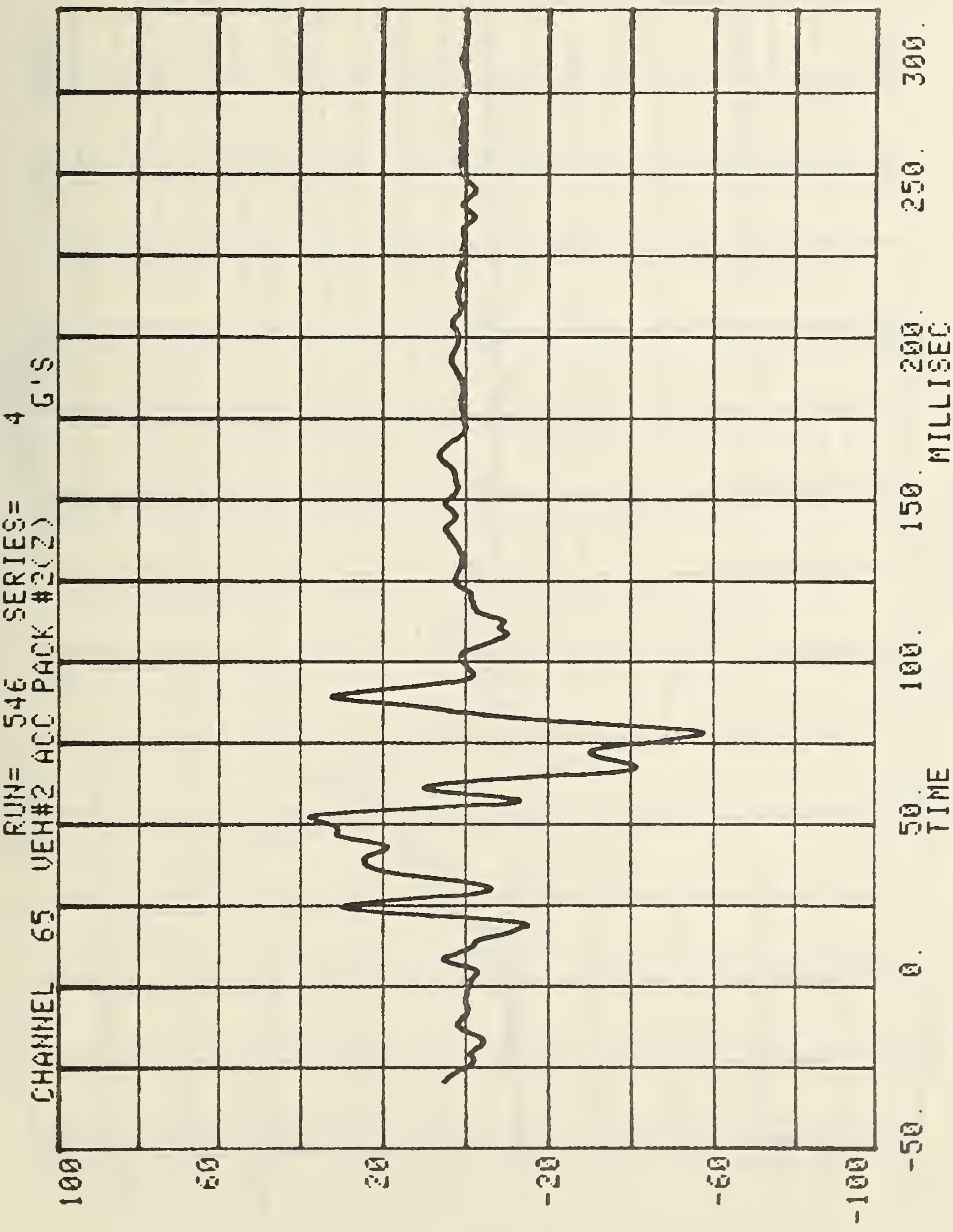

CHANNEL 12 RUN= 545 SERIES= 4
DISPLACEMENT INCHES
ACC. PACK.
80
60
40
20
0
-20
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

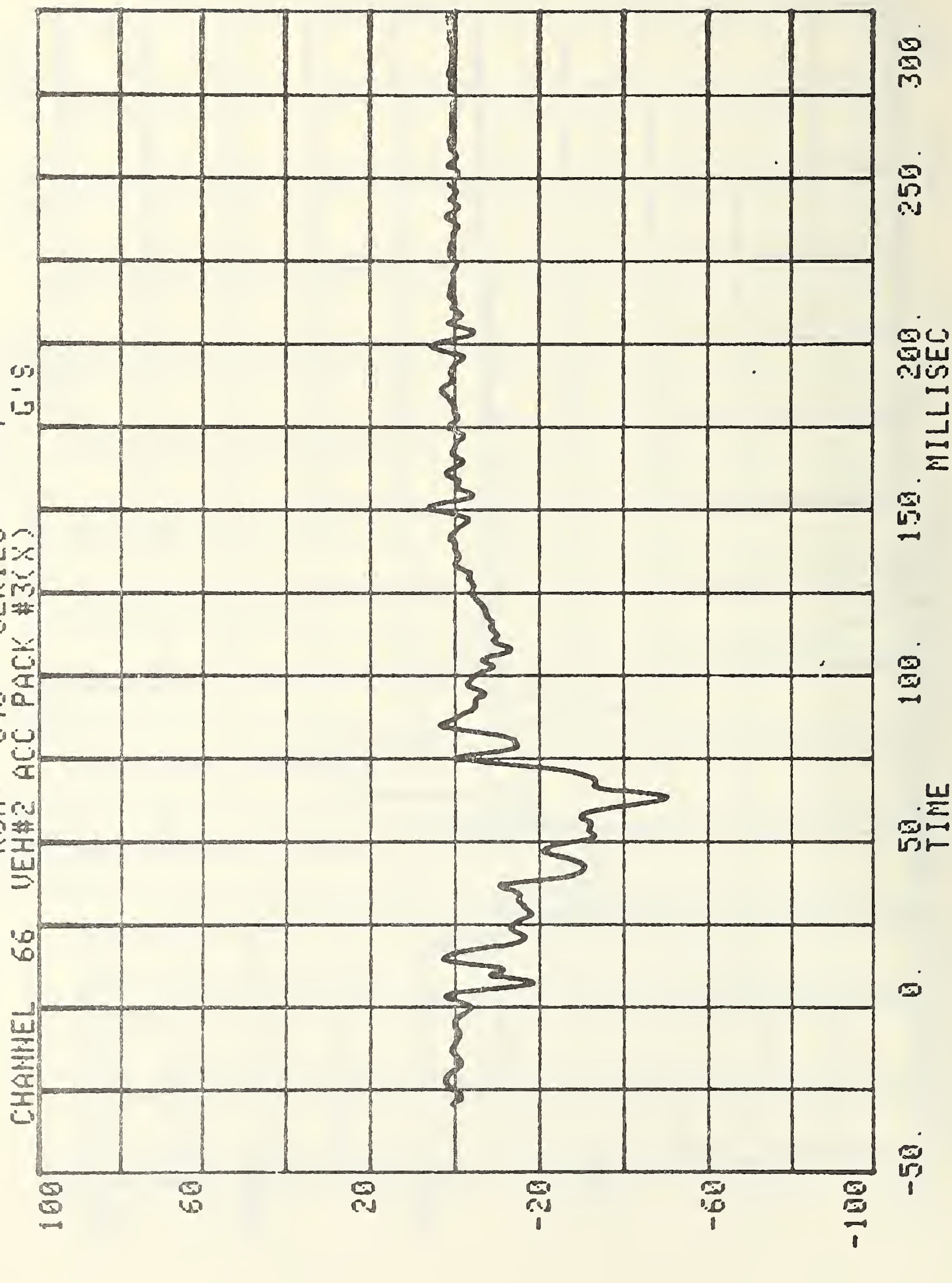

CHANNEL 63 RUN= 546 SERIES= 4
VEH#2 ACC PACK #1(Z) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

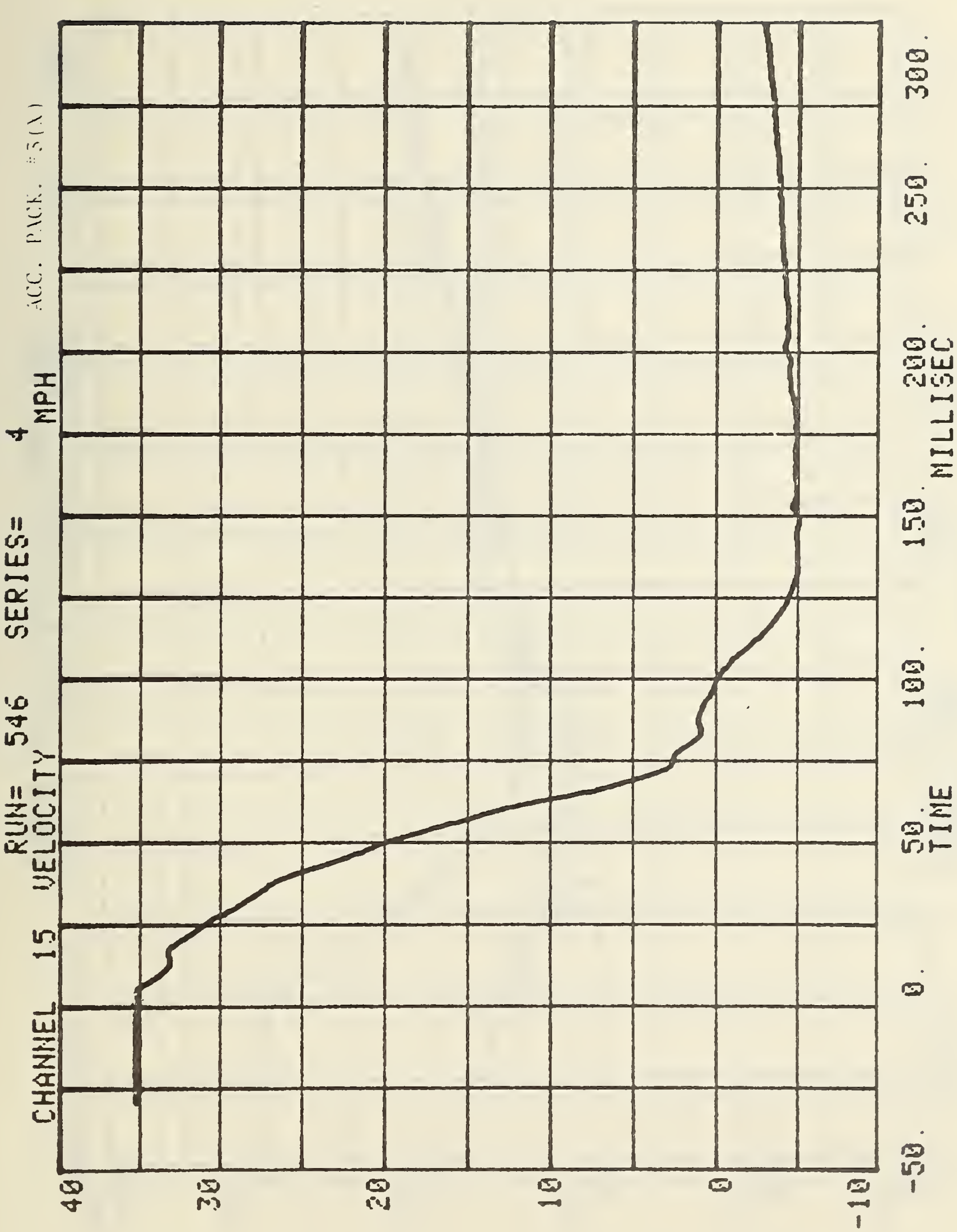

CHANNEL 64 RUN= 546 SERIES= 4
VEH#2 ACC PACK #2(X)
G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

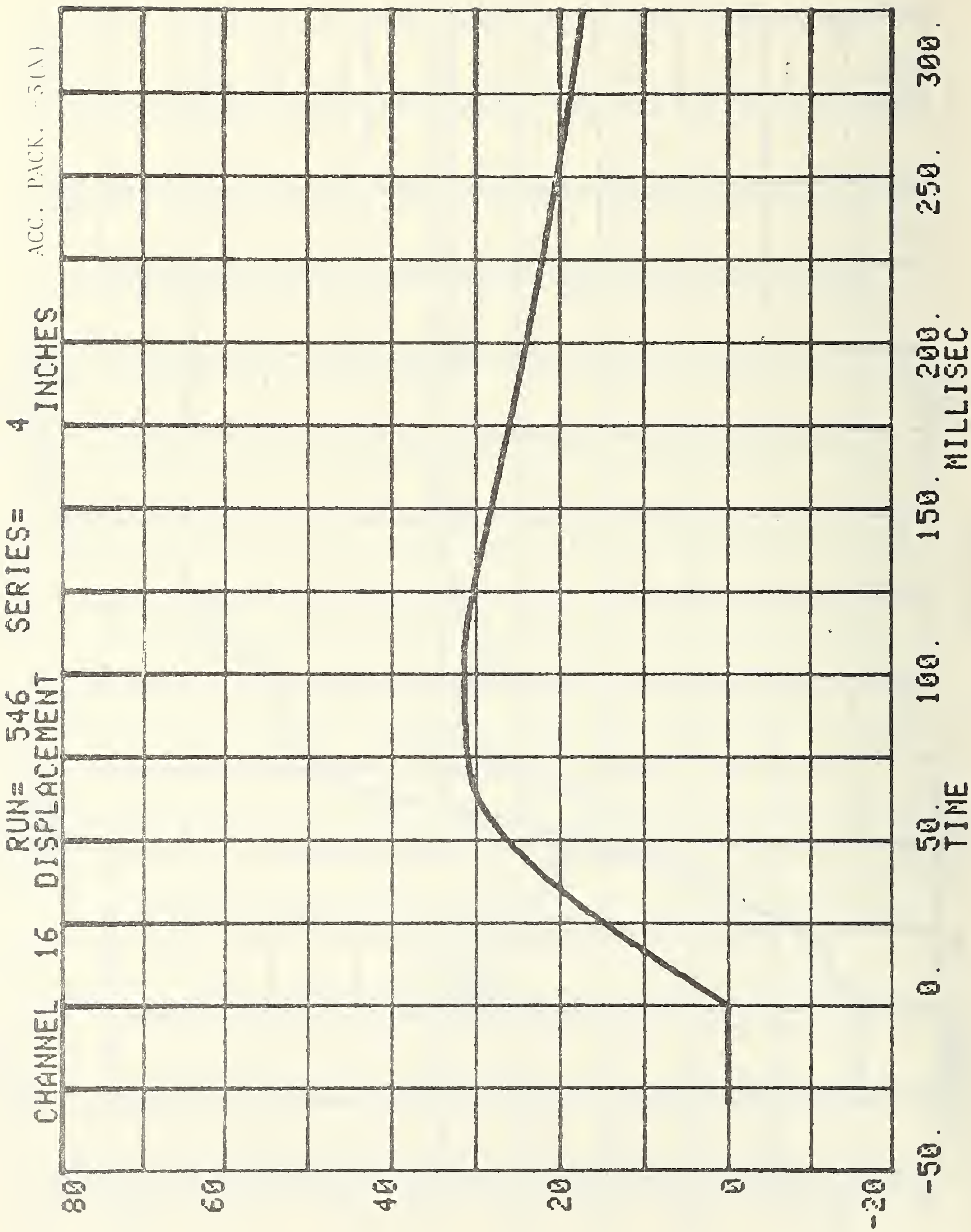

CHANNEL 13 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK. #2(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

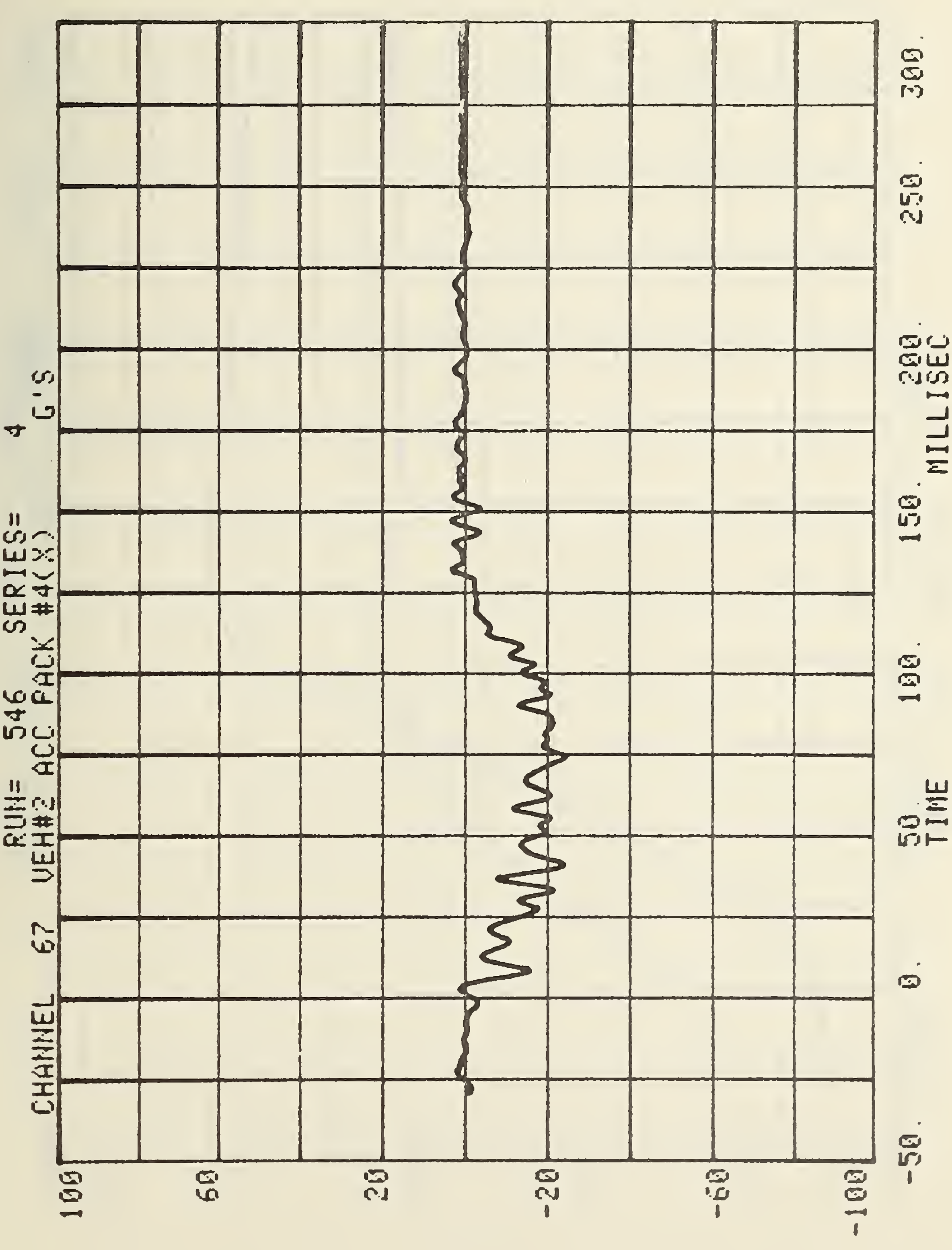

CHANNEL 14 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
80
60
40
20
0
-20
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

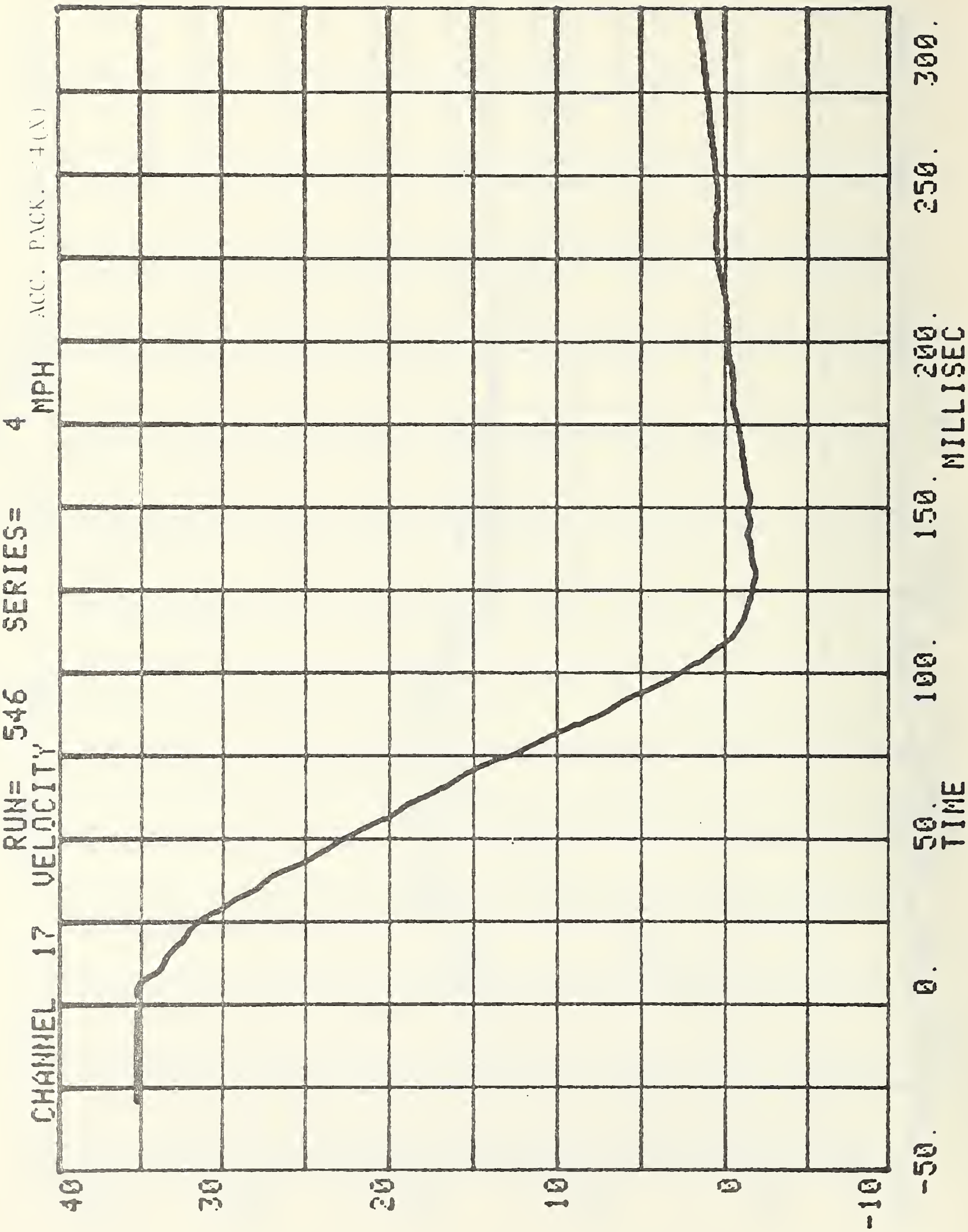

CHANNEL 65 RUN= 546 SERIES= 4
VEH#2 ACC PACK #2(Z) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

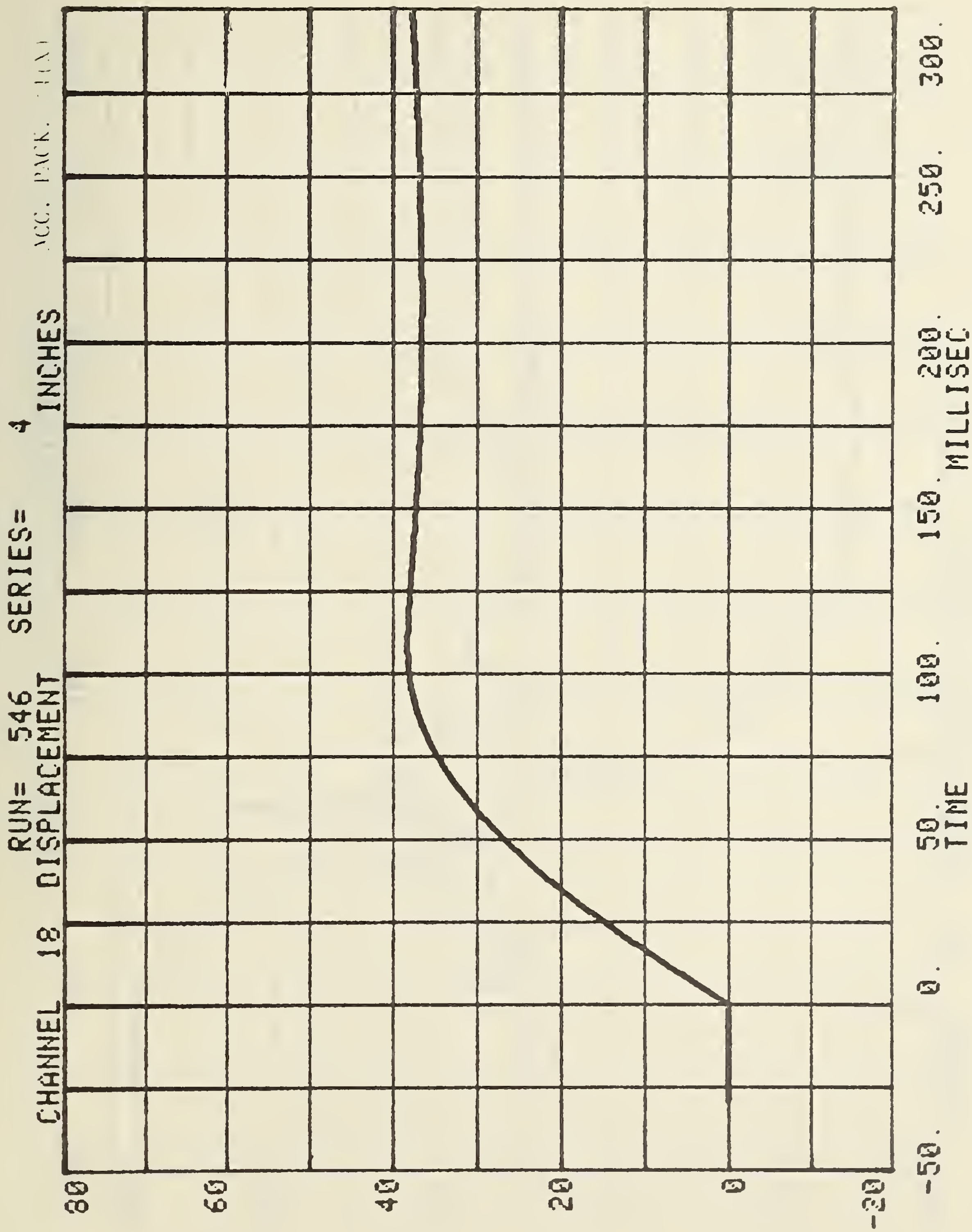

CHANNEL 66 RUN= 546 SERIES= 4
VEH#2 ACC PACK #3(X) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

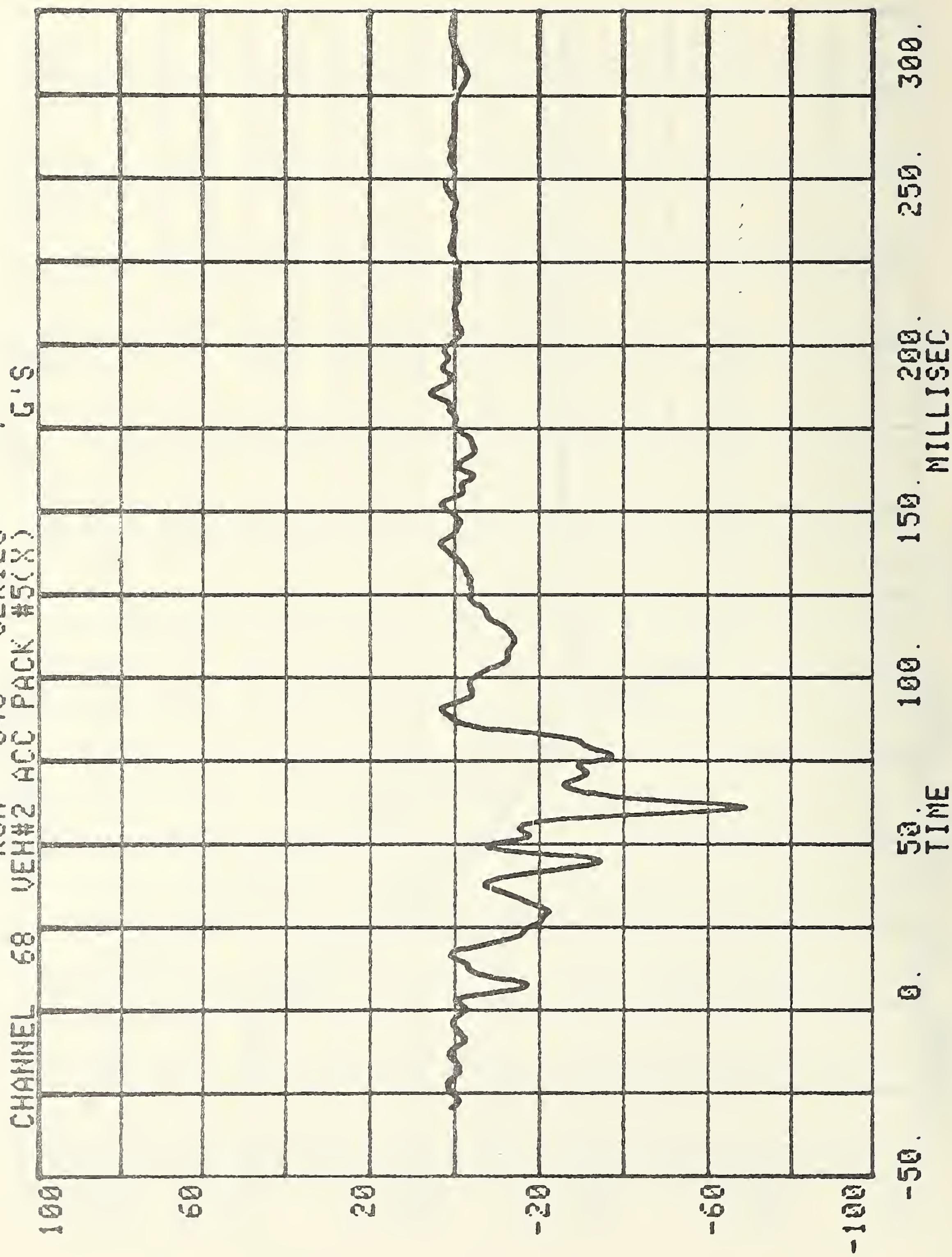

CHANNEL 15 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK. #3(X)
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
40 30 20 10 0 -10

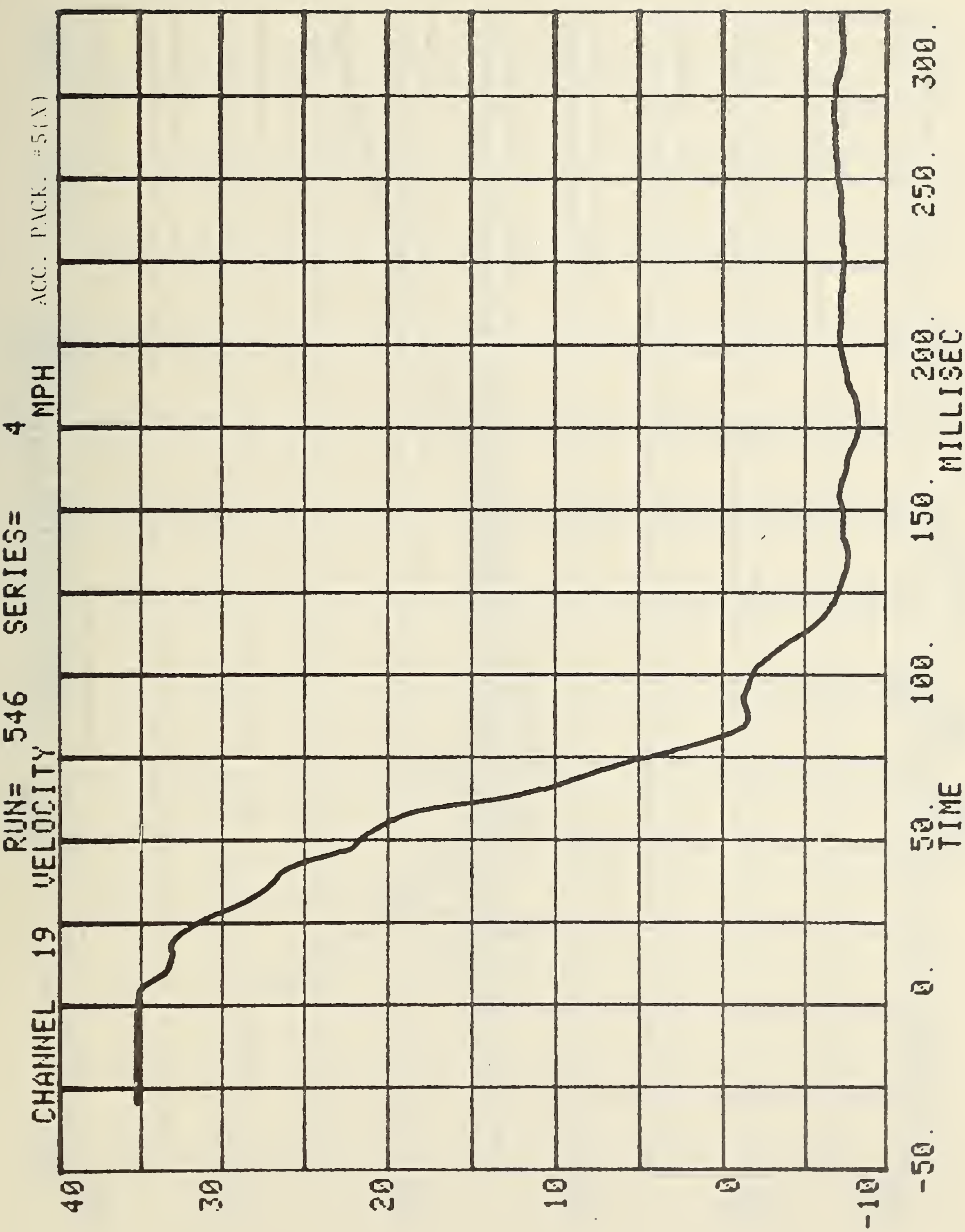

CHANNEL 16 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
ACC. PACK.
80
60
40
20
0
-20
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

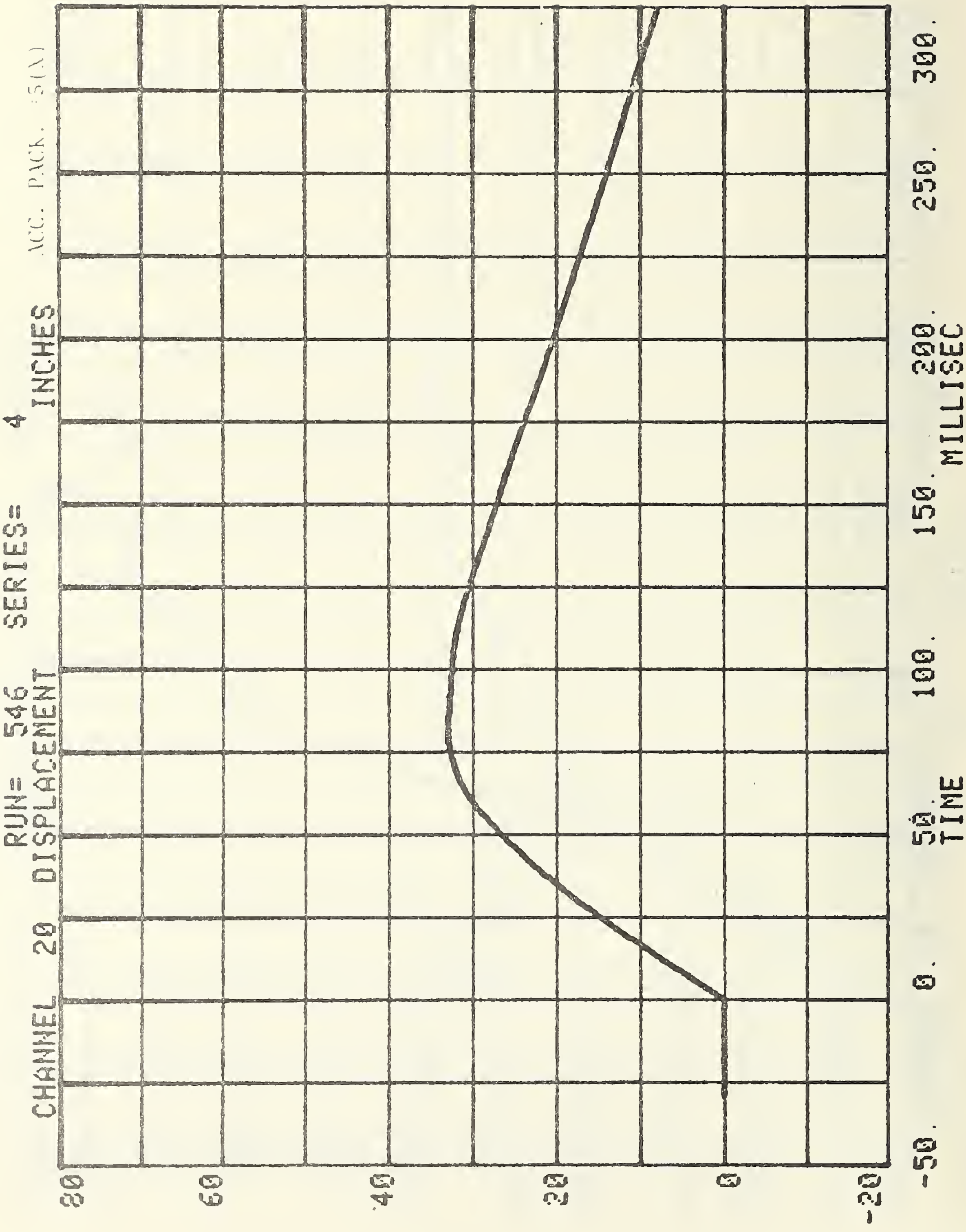

CHANNEL 67 RUN= 546 SERIES= 4
VEH#2 ACC PACK #4(X) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

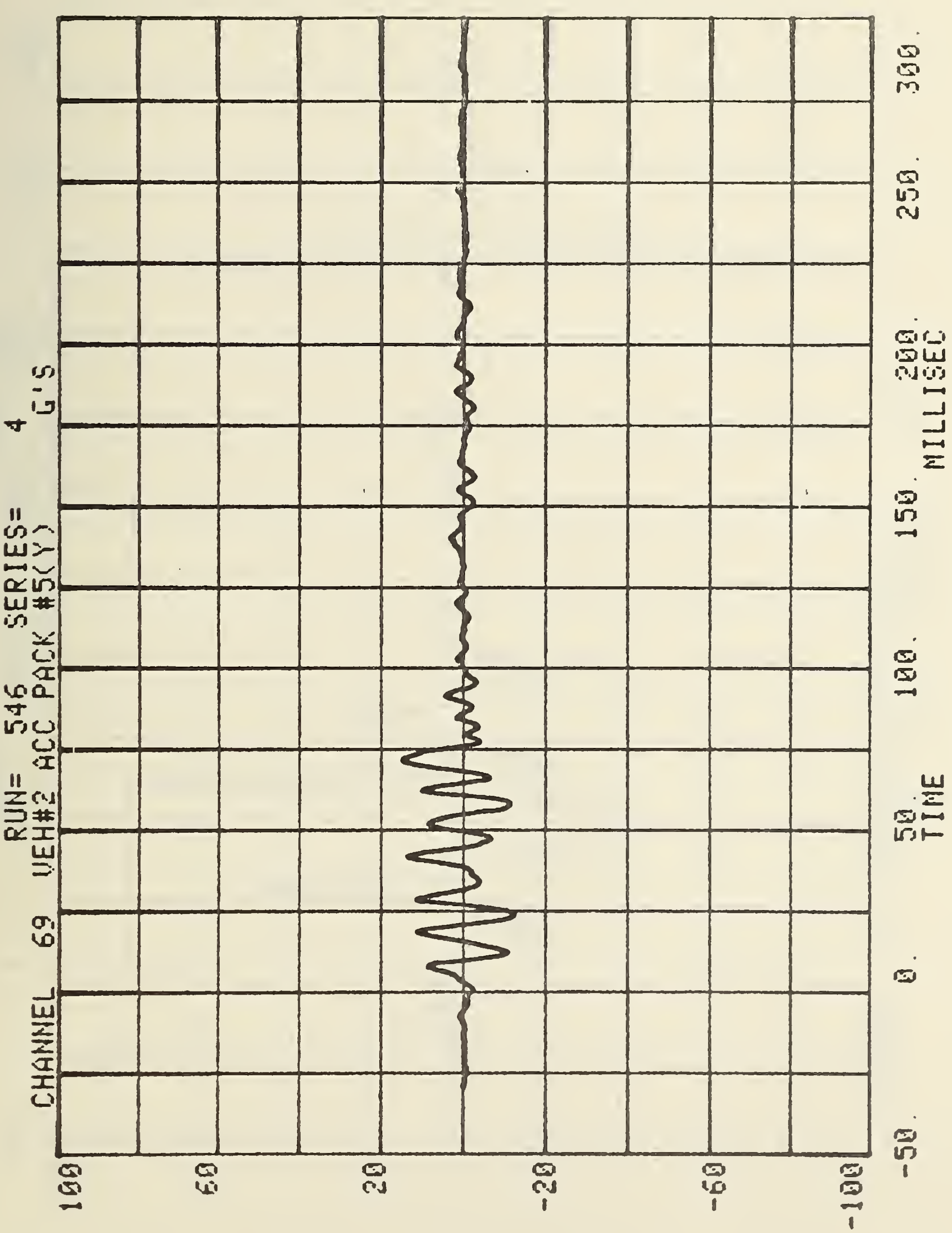

CHANNEL 17 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK.
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

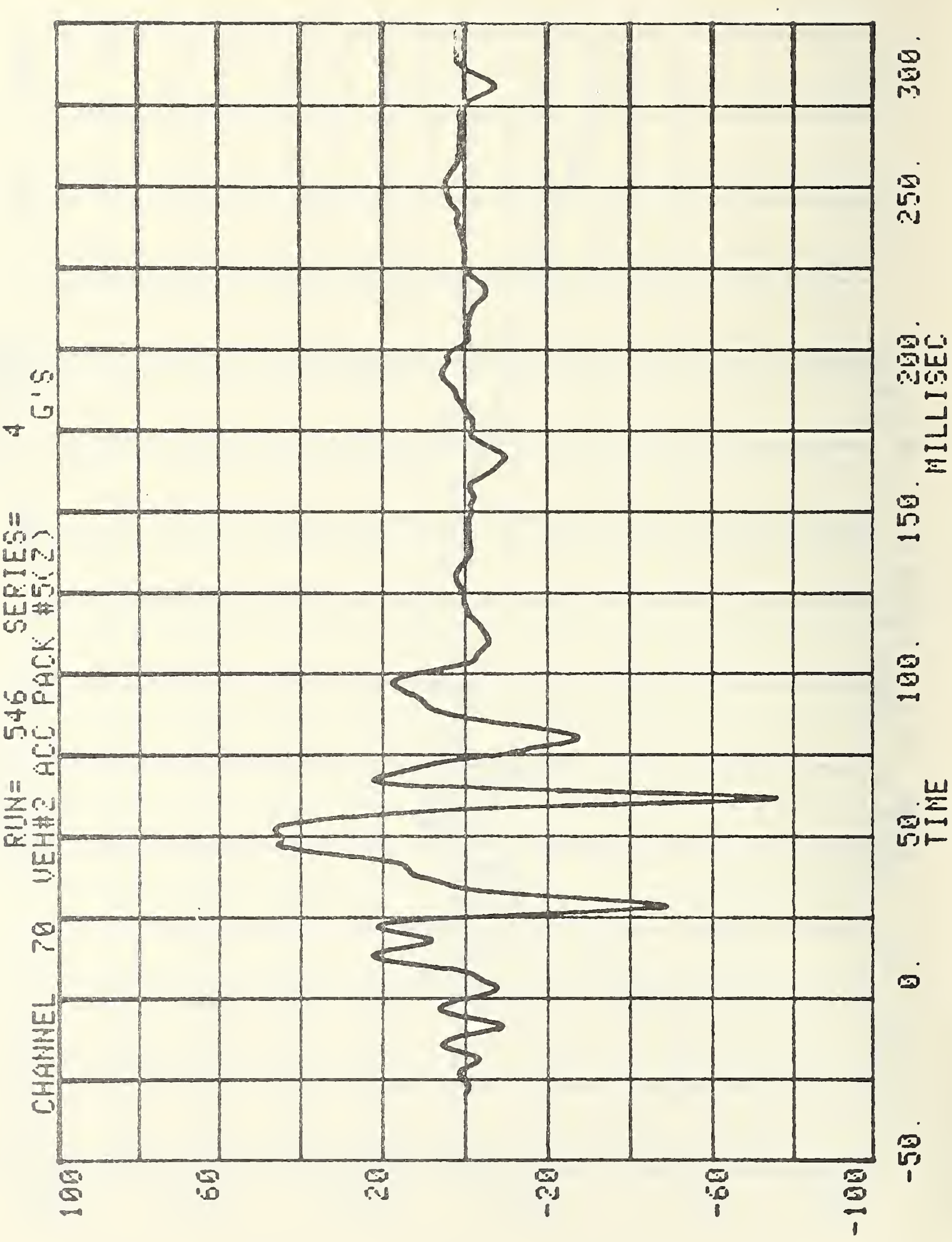

CHANNEL 18 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
80
60
40
20
0
-20


CHANNEL 68 RUN= 546 SERIES= 4
VEH#2 ACC PACK #5(X) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 19 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK. #5(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 20 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
ACC. PACK.
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
80
60
40
20
0
-20


CHANNEL 69 RUN= 546 SERIES= 4
VEH#2 ACC PACK #5(Y) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 70 RUN= 546 SERIES= 4
VEH#2 ACC PACK #5(Z) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

APPENDIX E

ELECTRONIC CRASH TEST DATA:

PLYMOUTH HORIZON OCCUPANT AND RESTRAINT SYSTEM

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

IBSA CAR-TO-CAR TEST #4

RUN= 546

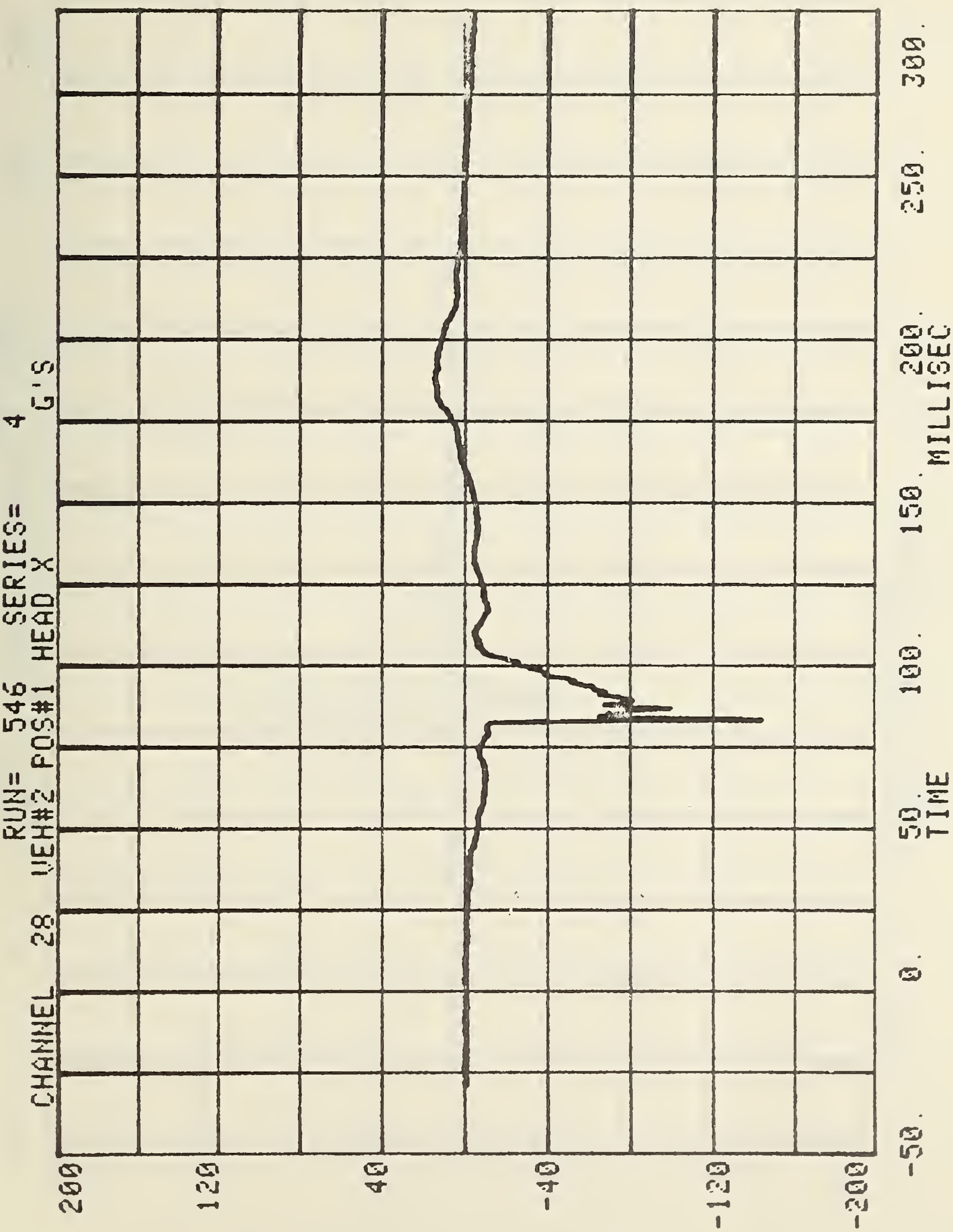
VEH#2 POS#1 HEAD R

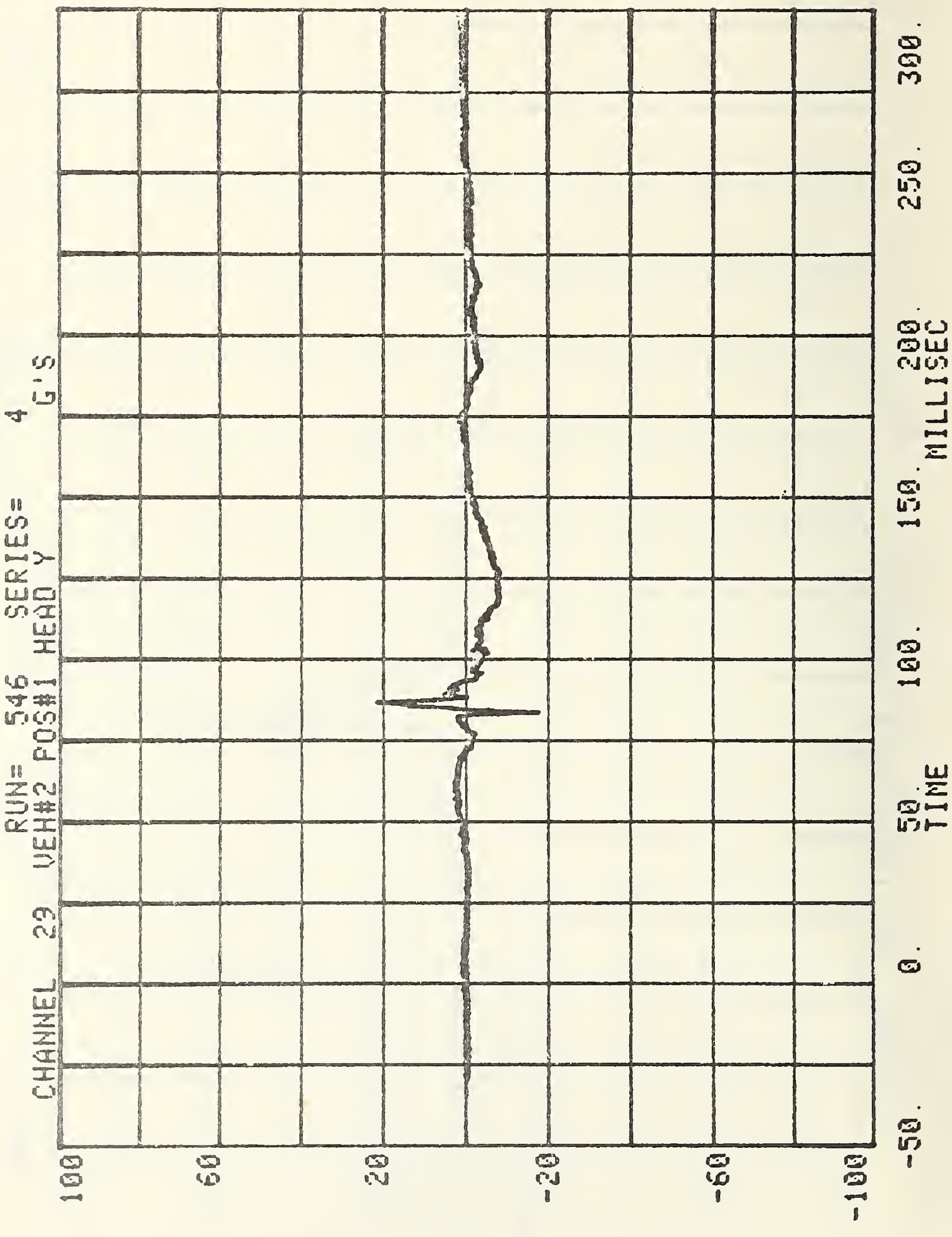
HIC= 727.1   FROM T1= .08310   TO T2= .09690

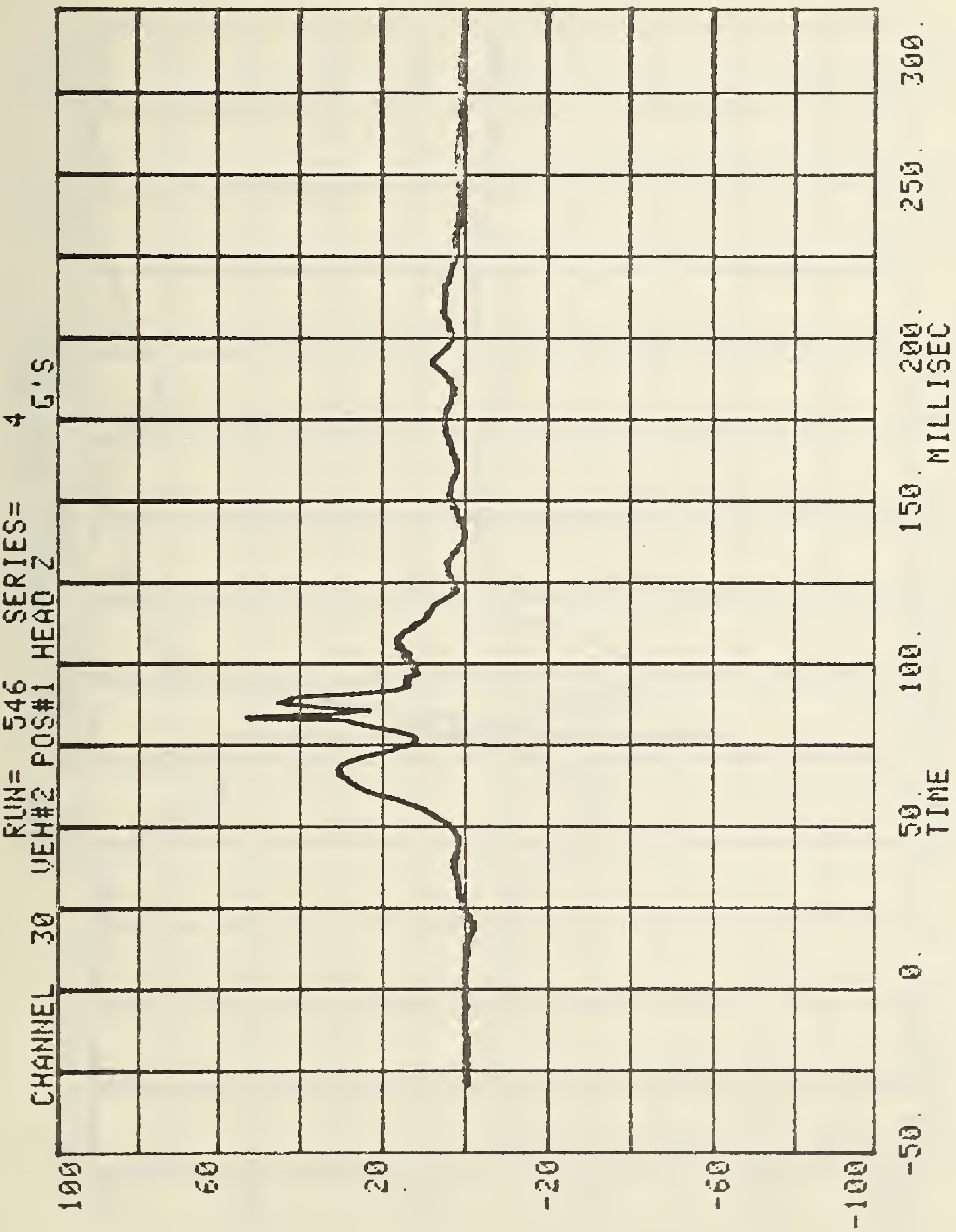
AVERAGE ACCELERATION BETWEEN T1 AND T2= 77.4G'S

EVENT TIME= 300.0 MSEC

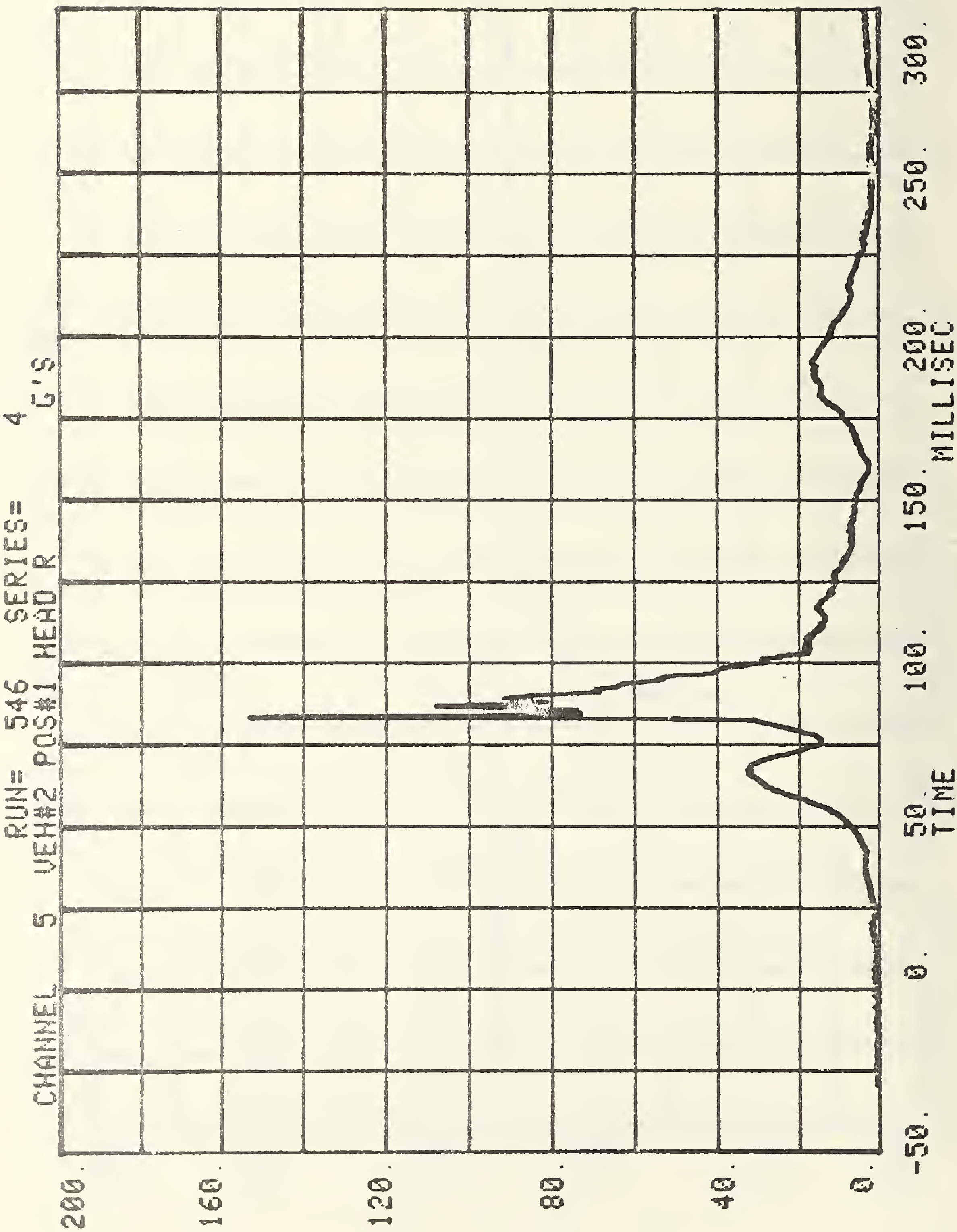
SEVERITY INDEX=1031.1

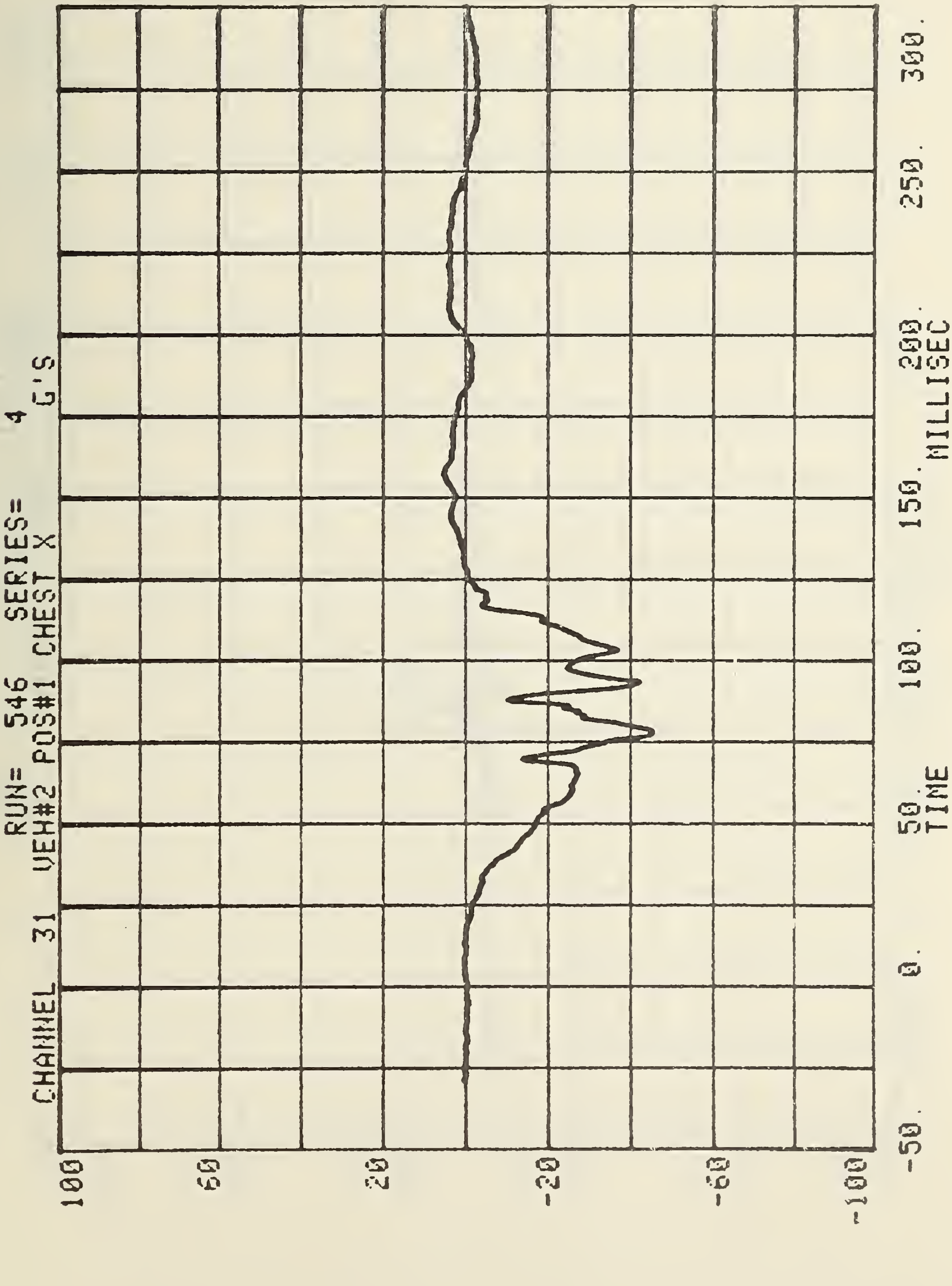

CHANNEL 28 RUN= 546 SERIES= 4
VEH#2 POS#1 HEAD X G'S
200
120
40
-40
-120
-200
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

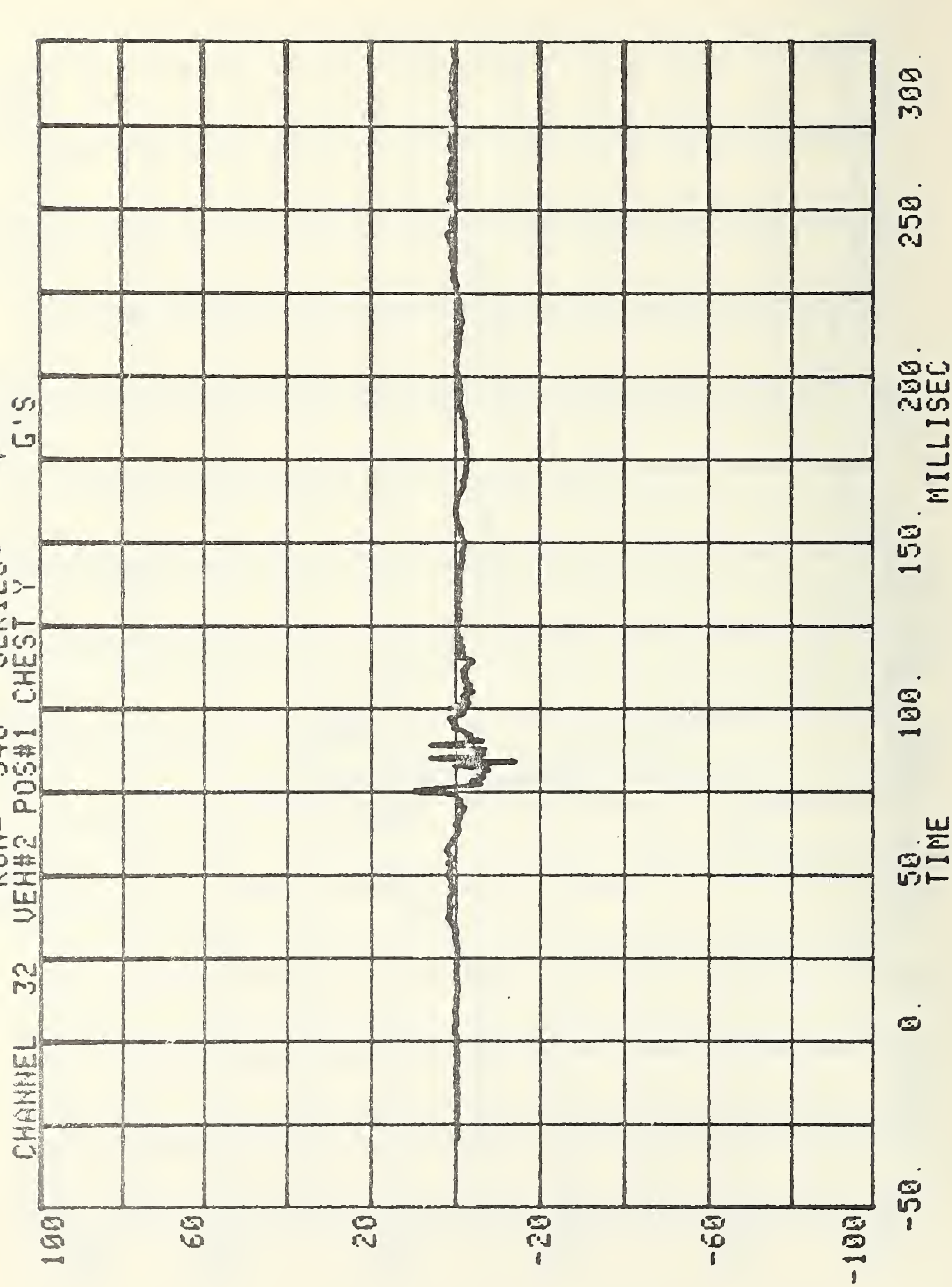

CHANNEL 23 RUN= 546 SERIES= 4
VEH#2 POS#1 HEAD Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

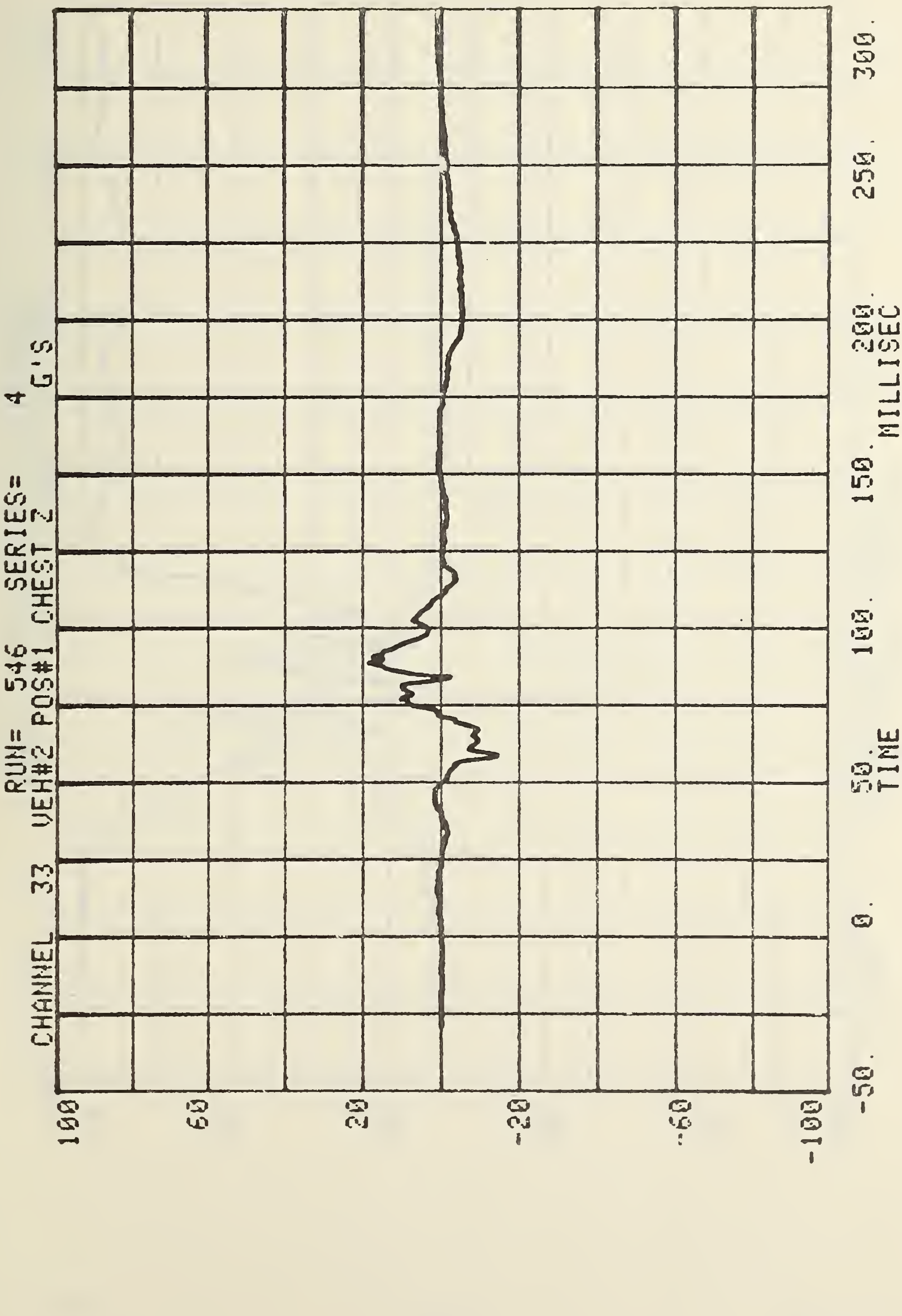


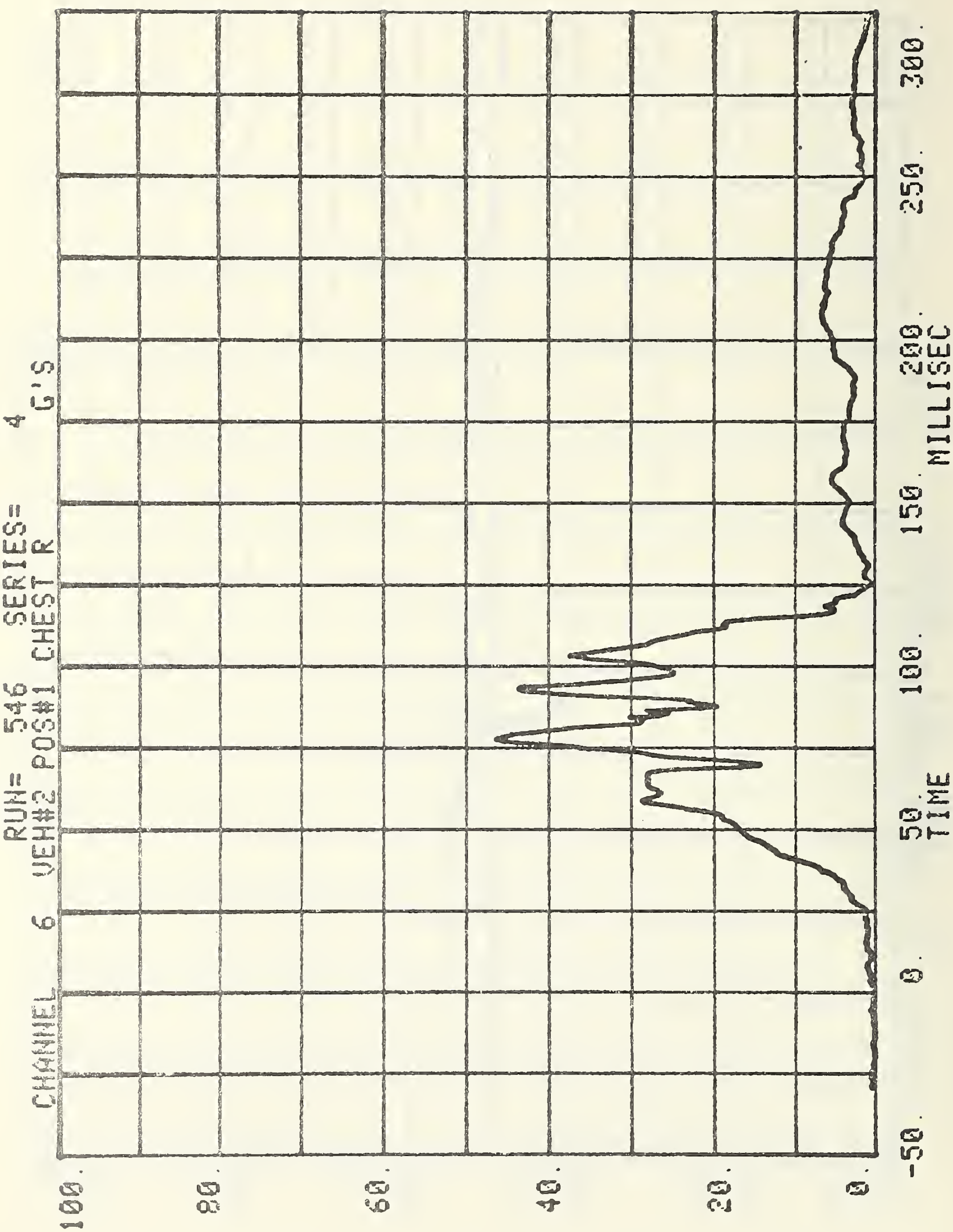
CHANNEL 30 RUN= 546 SERIES= 4
VEH#2 POS#1 HEAD Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

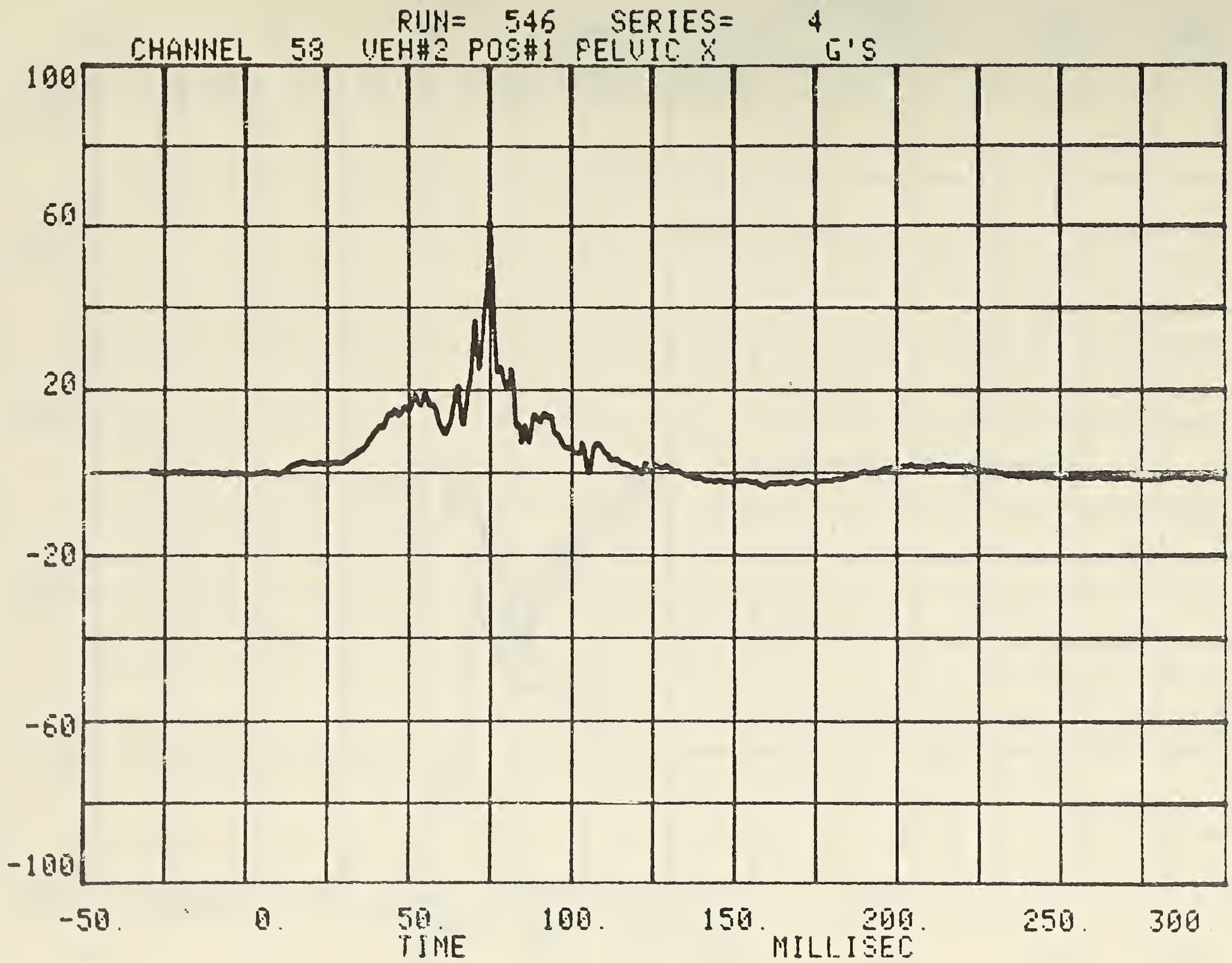

CHANNEL 5 RUN= 546 SERIES= 4
VEH#2 POS#1 HEAD R G'S
200.
160.
120.
80.
40.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

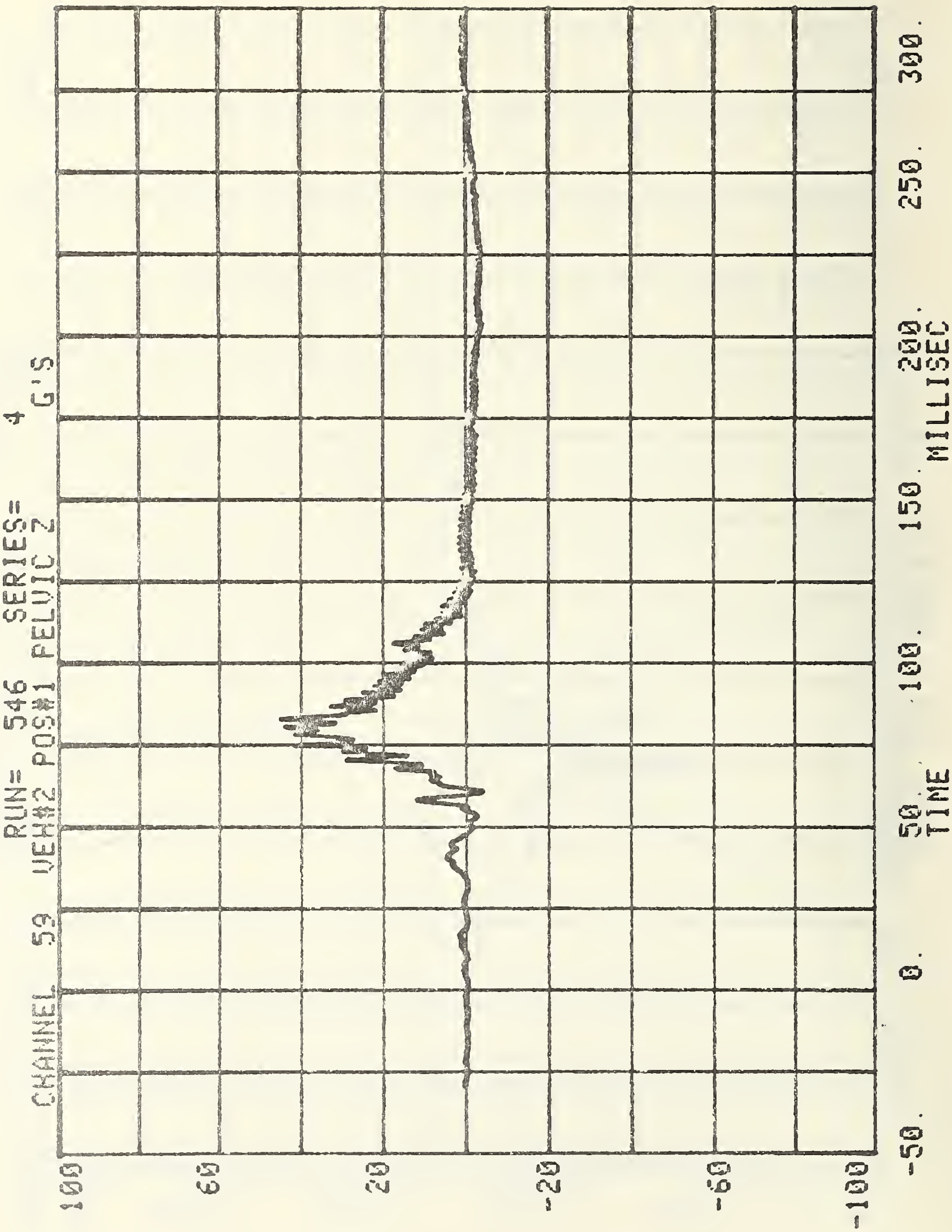

CHANNEL 31 RUN= 546 SERIES= 4
VEH#2 POS#1 CHEST X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

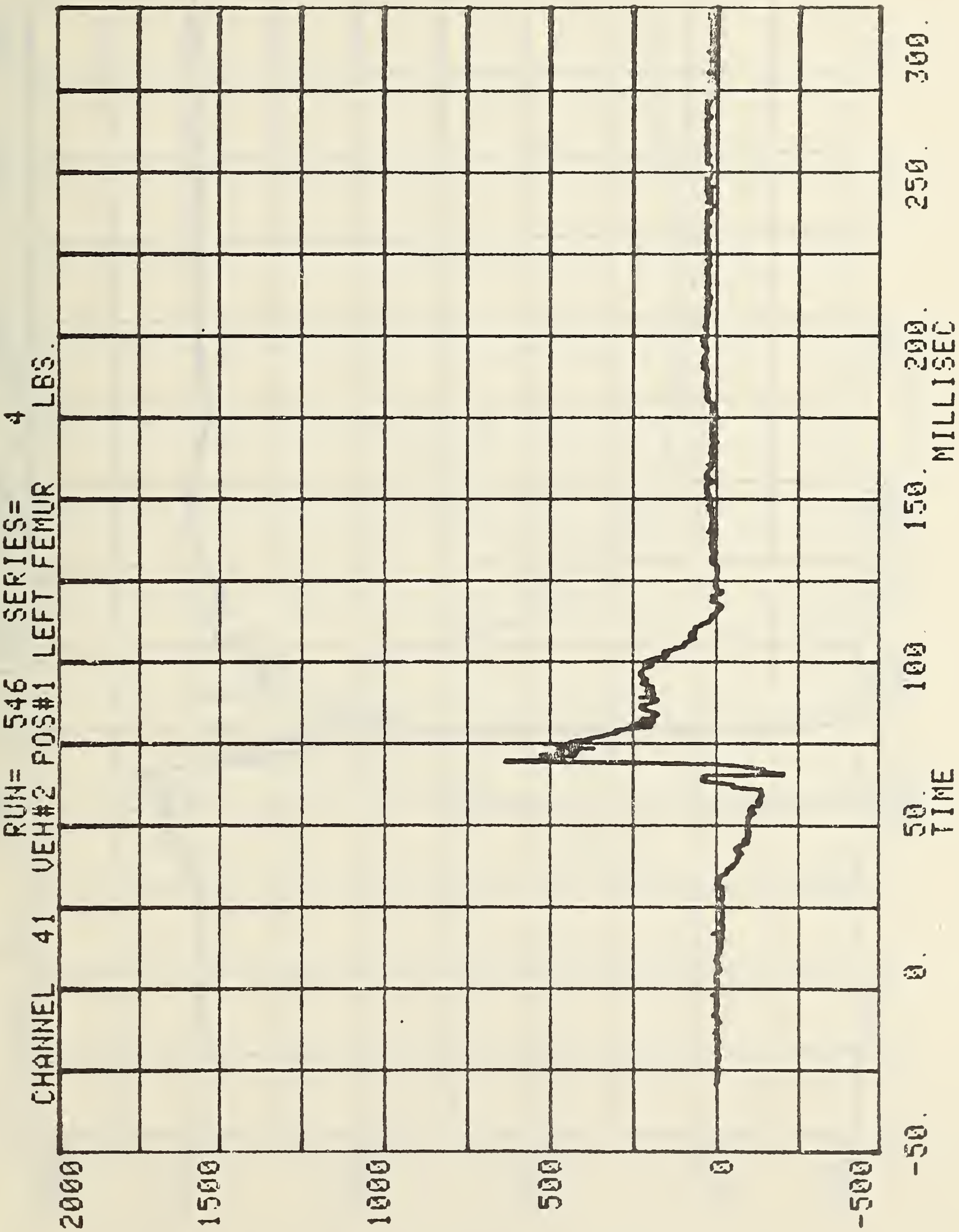

CHANNEL 32 RUN= 546 SERIES= 4
VEH#2 POS#1 CHEST Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

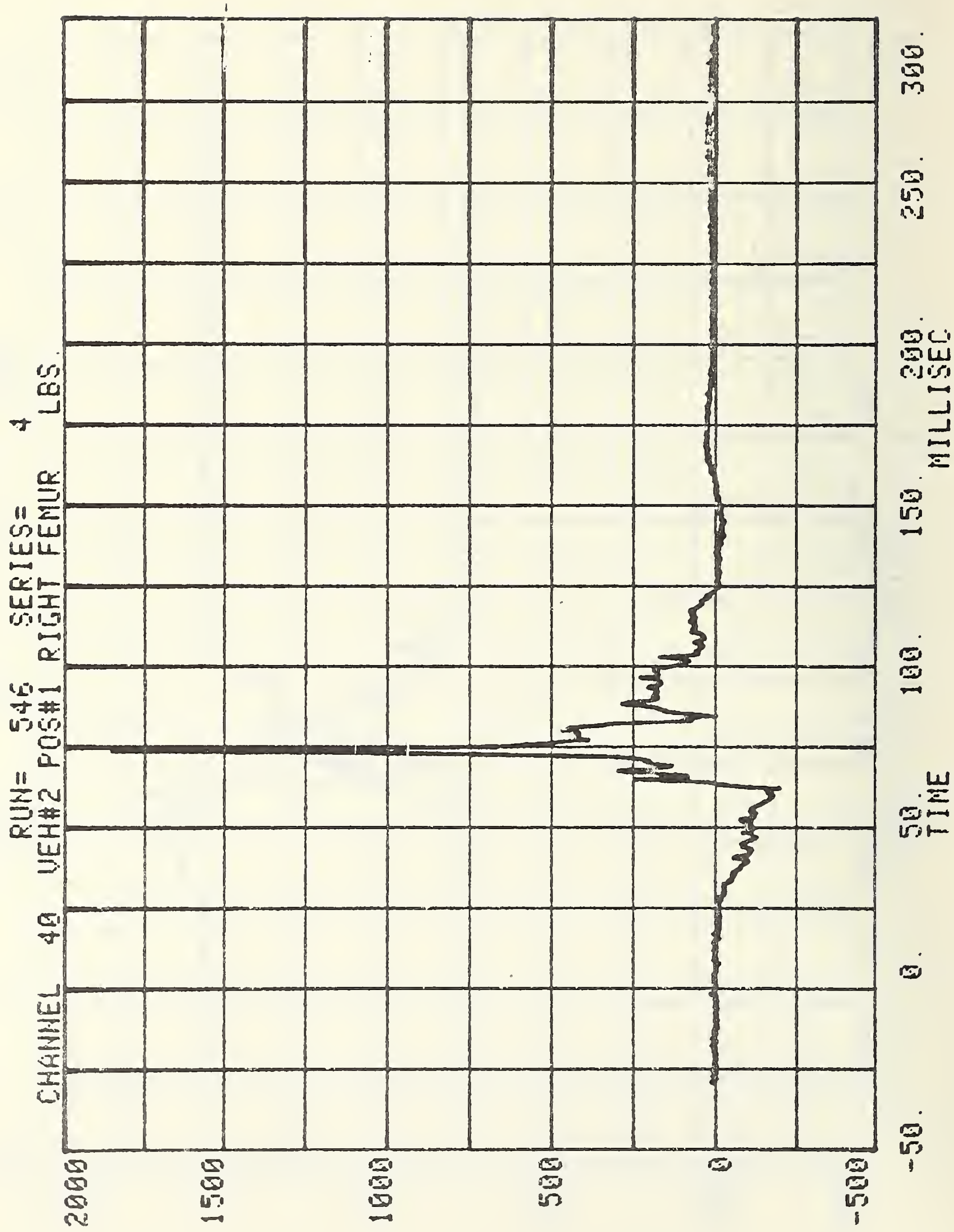

CHANNEL 33 RUN= 546 SERIES= 4
VEH#2 POS#1 CHEST Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

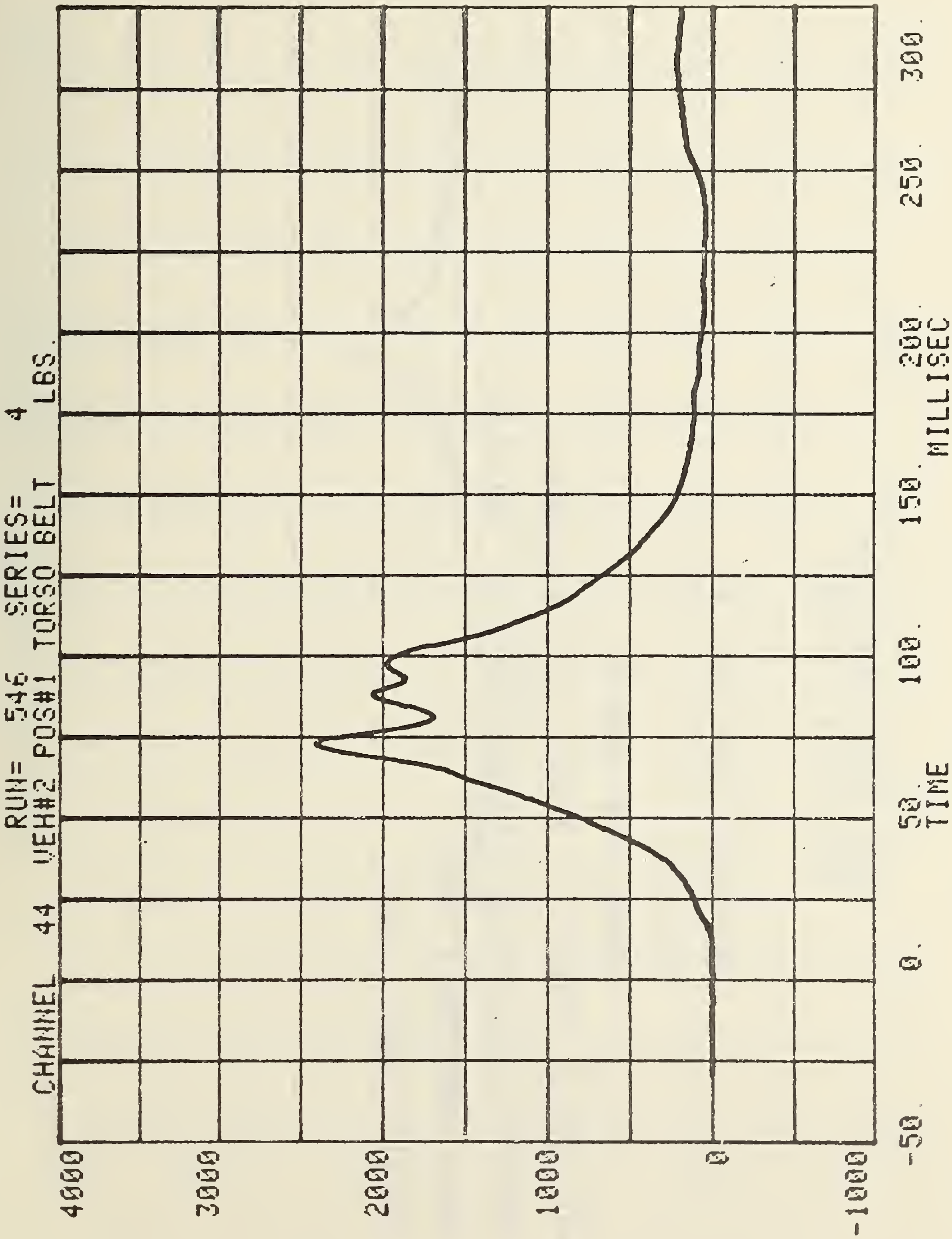

CHANNEL 6 RUN= 546 SERIES= 4
VEH#2 POS#1 CHEST R G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


RUN= 546 SERIES= 4
CHANNEL 58 VEH#2 POS#1 PELVIC X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300
TIME
MILLISEC


CHANNEL 59 RUN= 546 SERIES= 4
VEH#2 POS#1 PELVIC Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 41 RUN= 546 SERIES= 4
VEH#2 POS#1 LEFT FEMUR LBS.
2000
1500
1000
500
0
-500
-50.
0.
50.
100
150.
200.
250.
300.
TIME
MILLISEC


CHANNEL 40 RUN= 546 SERIES= 4
VEH#2 POS#1 RIGHT FEMUR LBS
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 44 RUN= 546 SERIES= 4
VEH#2 POS#1 TORSO BELT LBS.
4000
3000
2000
1000
0
-1000
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

IBSA CAR-TO-CAR TEST #4

RUN= 546

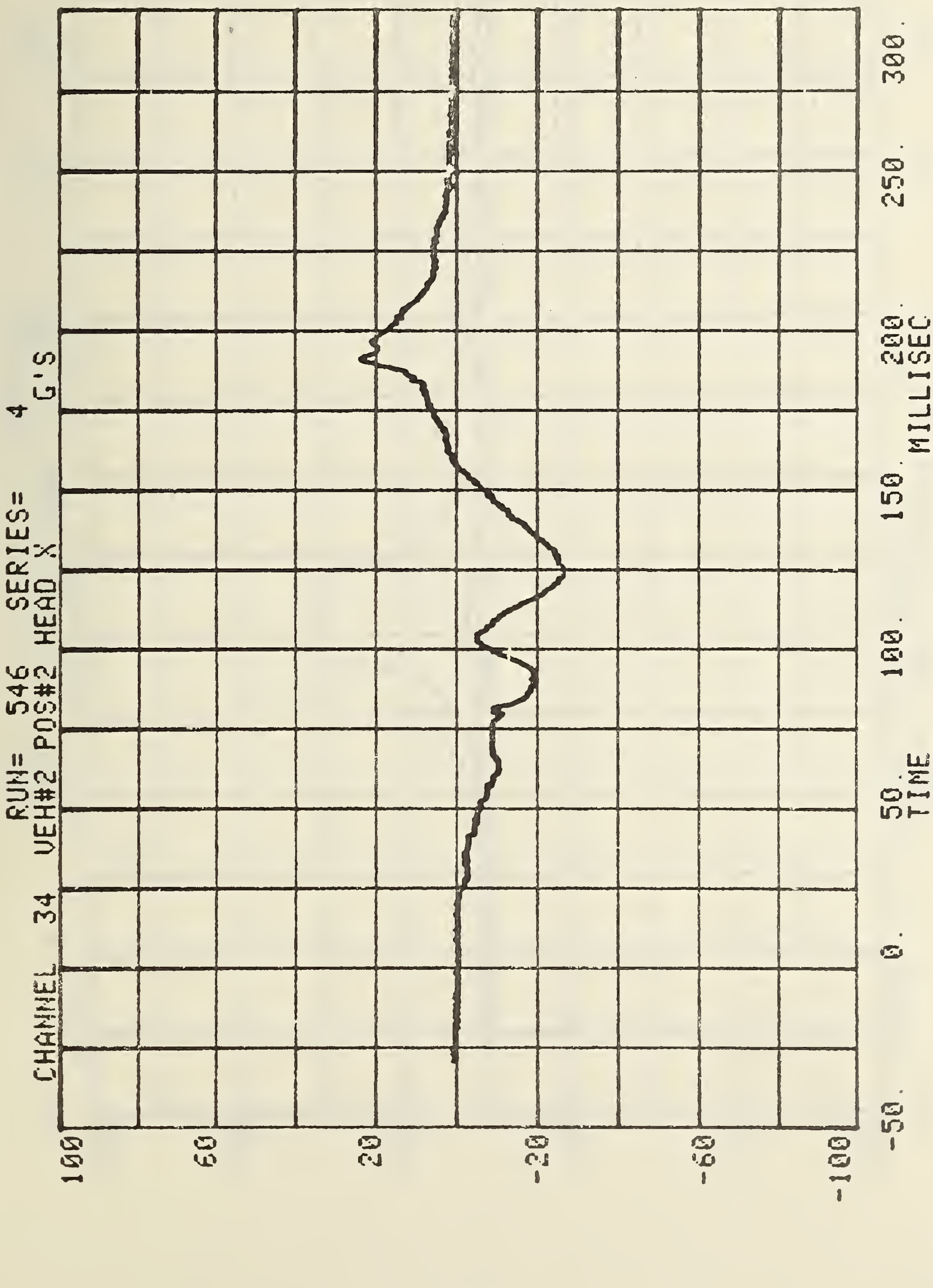
VEH#2 POS#2 HEAD R

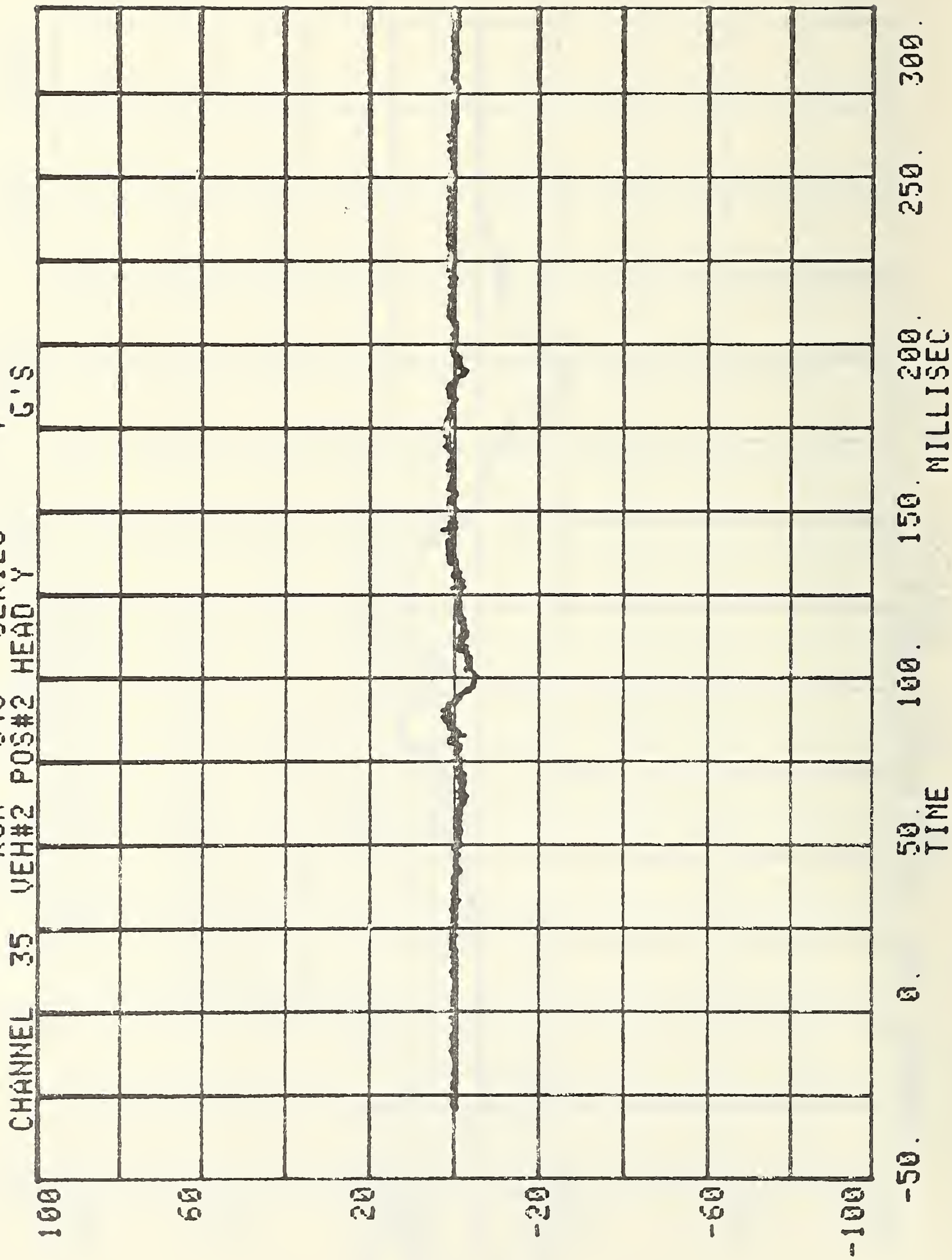
HIC= 510.4   FROM T1= .08550   TO T2= .13560

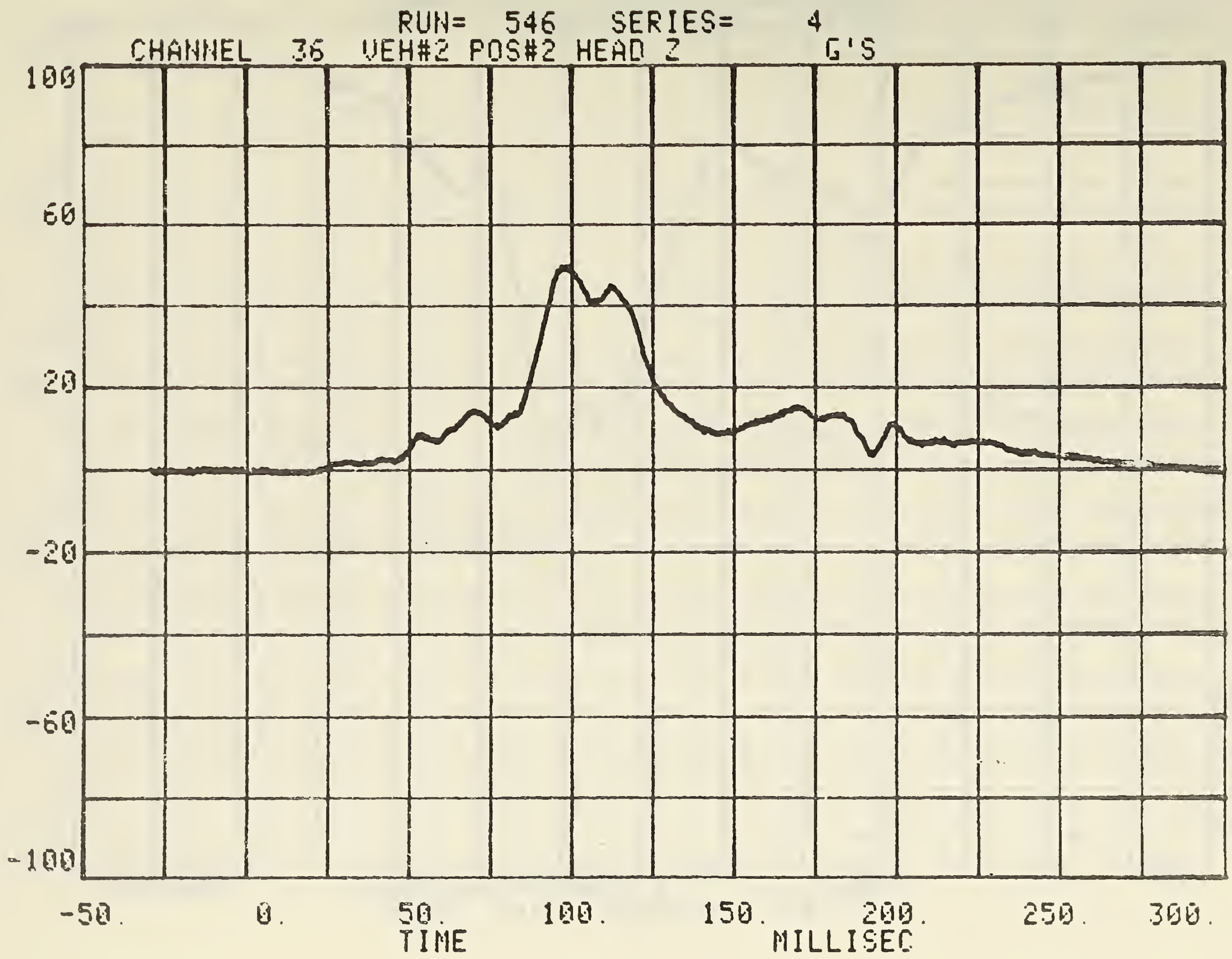
AVERAGE ACCELERATION BETWEEN T1 AND T2= 40.1G'S

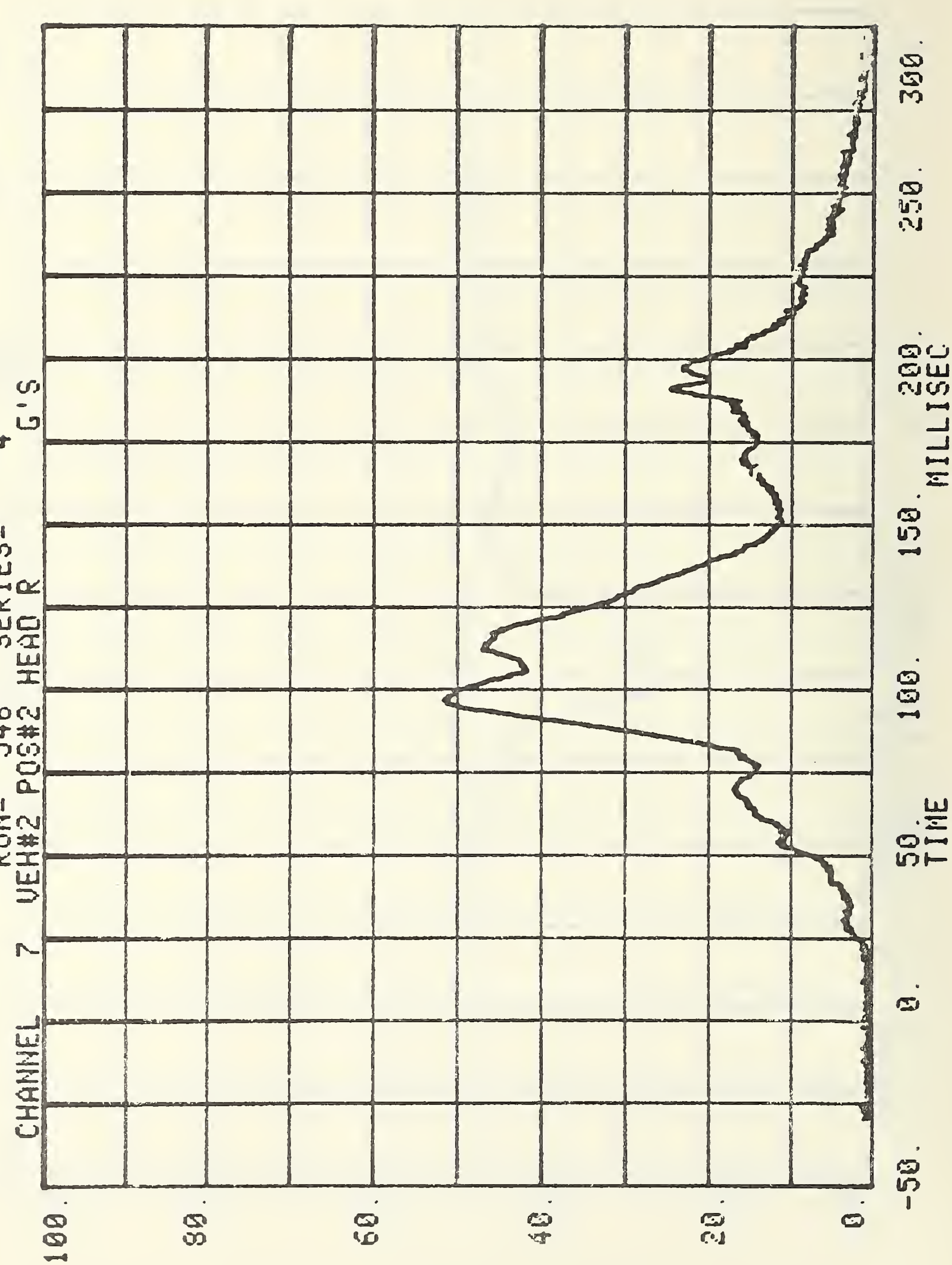
EVENT TIME= 300.0 MSEC

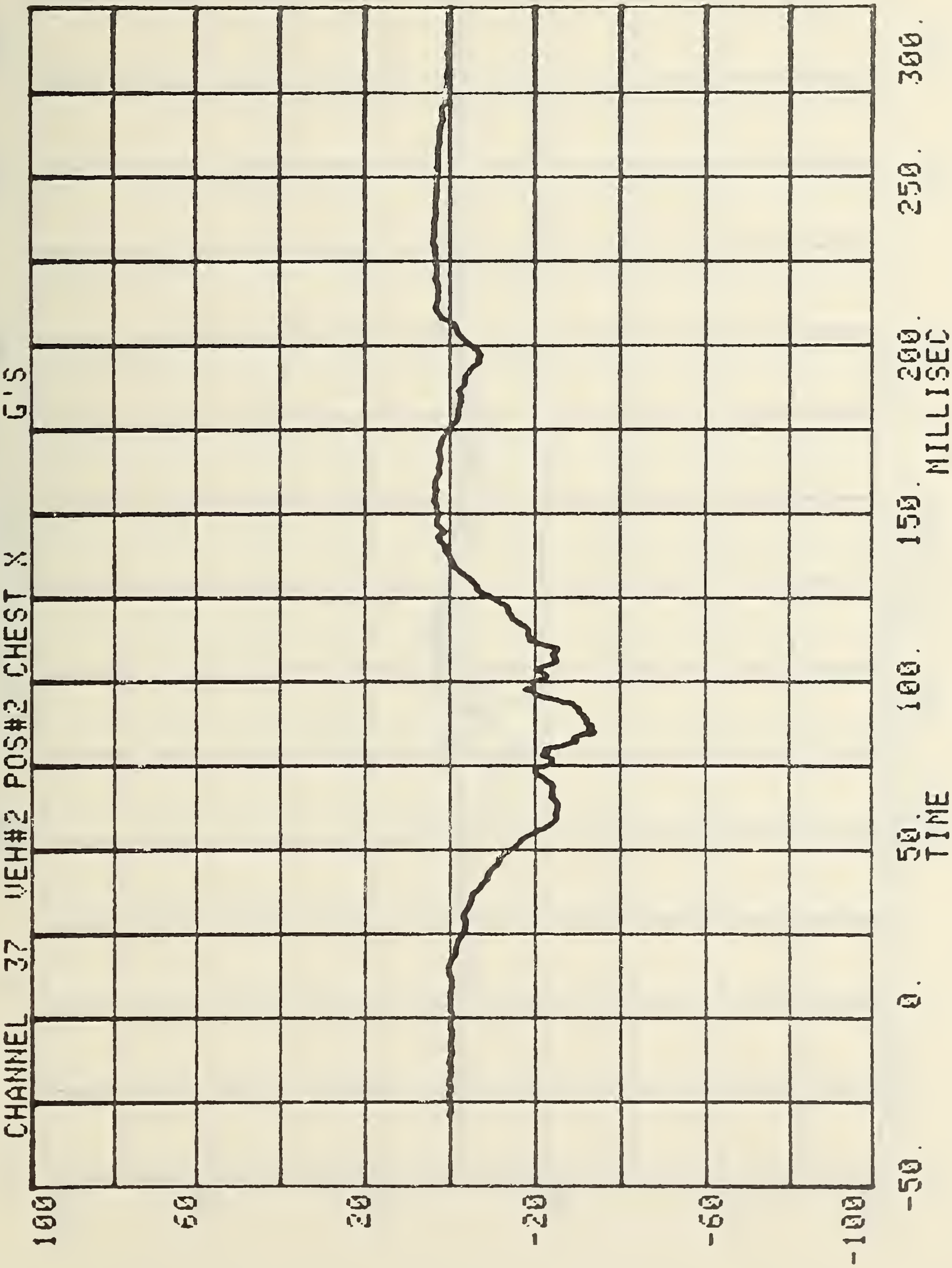
SEVERITY INDEX= 673.2


CHANNEL 34 RUN= 546 SERIES= 4
VEH#2 POS#2 HEAD X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

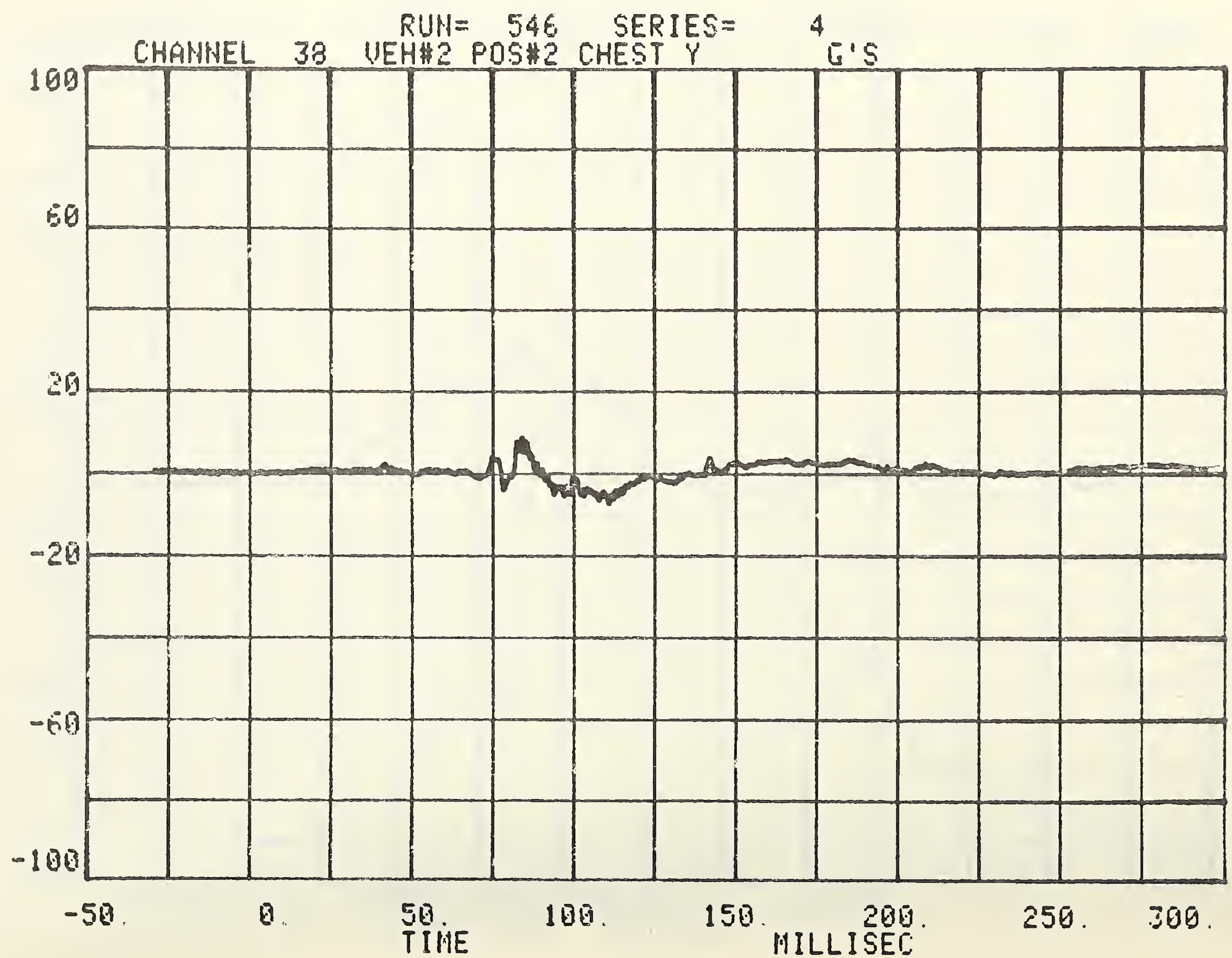

CHANNEL 35 RUN= 546 SERIES= 4
VEH#2 POS#2 HEAD Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

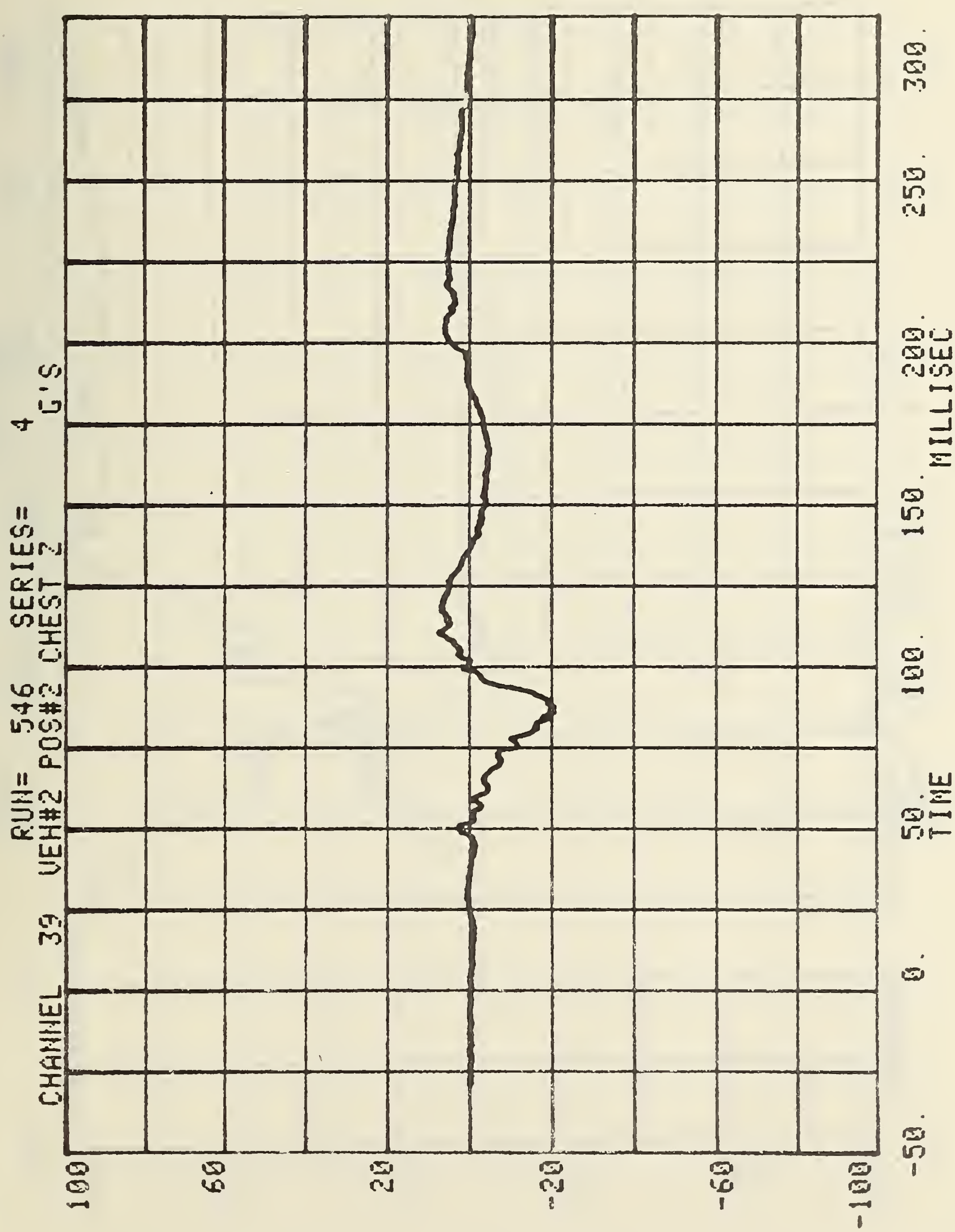

RUN= 546 SERIES= 4
CHANNEL 36 VEH#2 POS#2 HEAD Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

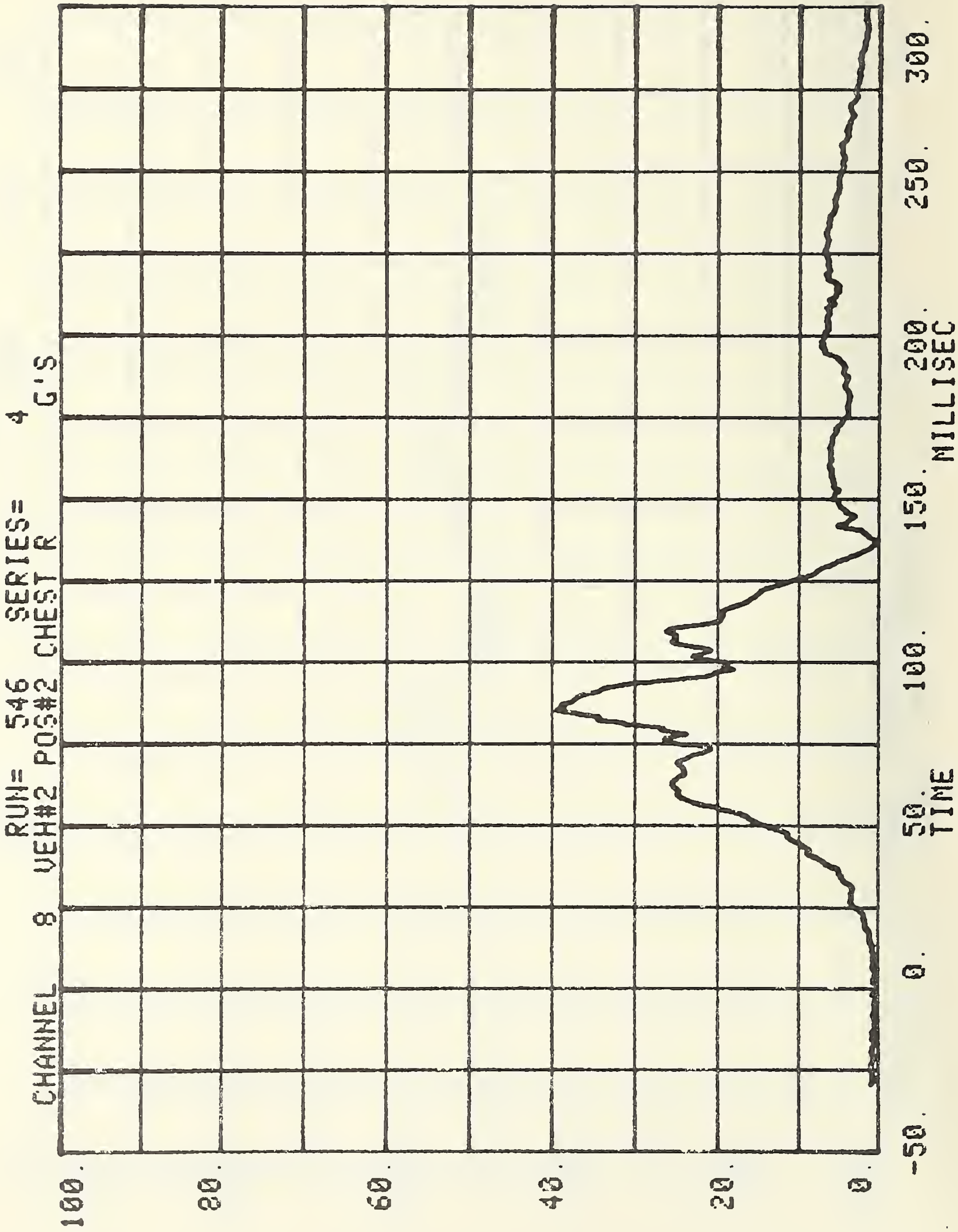

CHANNEL 7 RUN= 546 SERIES= 4
VEH#2 POS#2 HEAD R G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

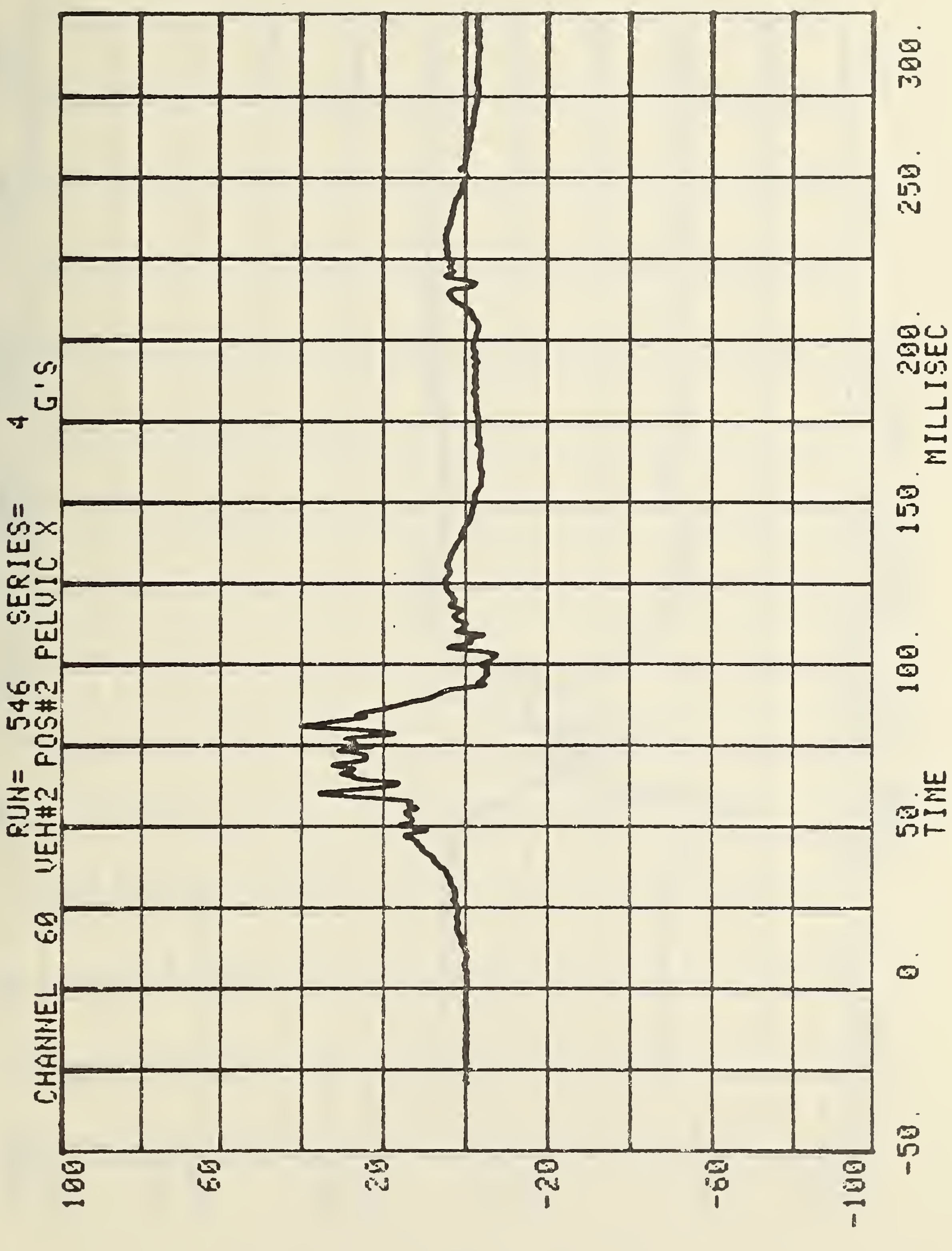


CHANNEL 37 RUN= 546 SERIES= 4
VEH#2 POS#2 CHEST X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

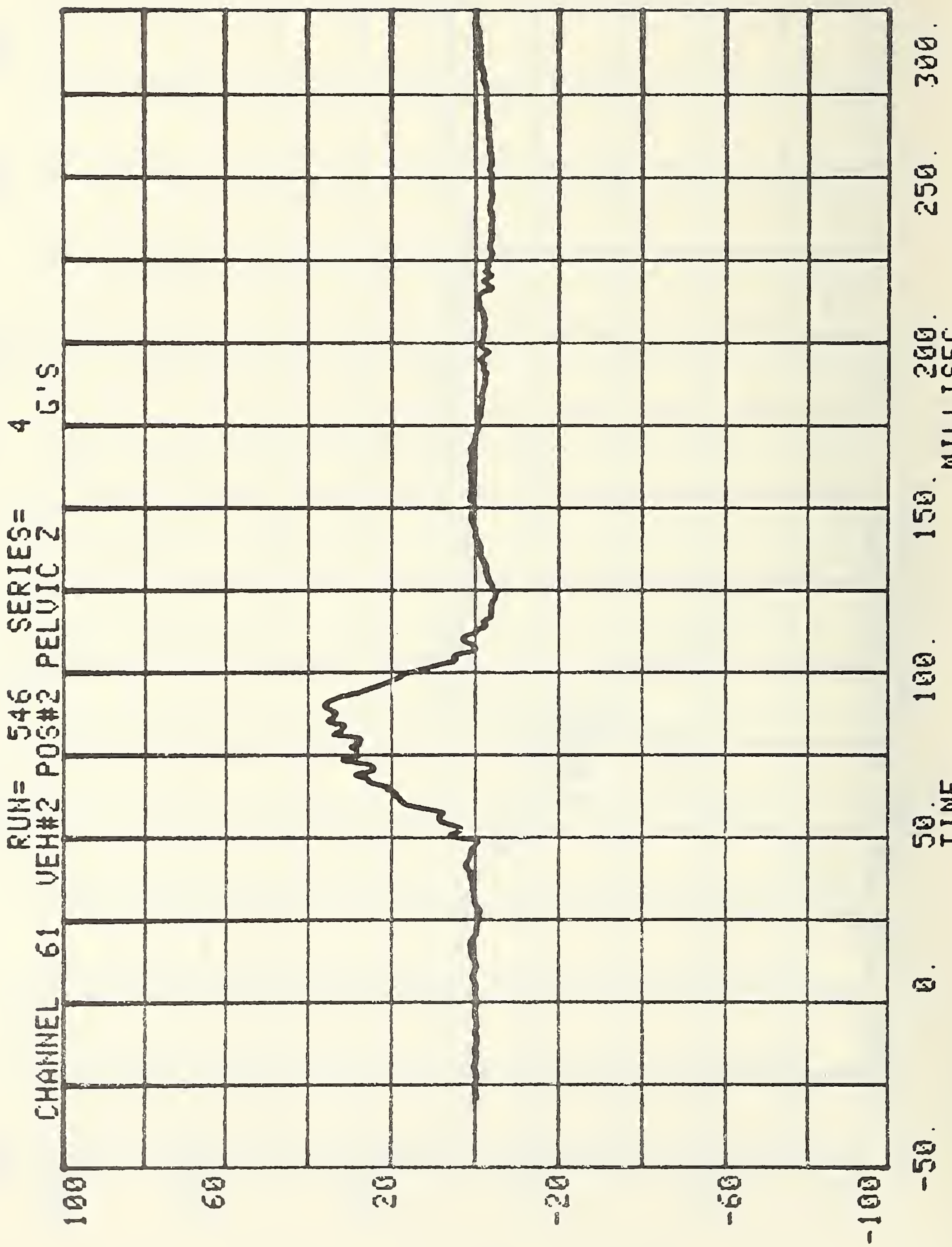

RUN= 546 SERIES= 4
CHANNEL 38 VEH#2 POS#2 CHEST Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

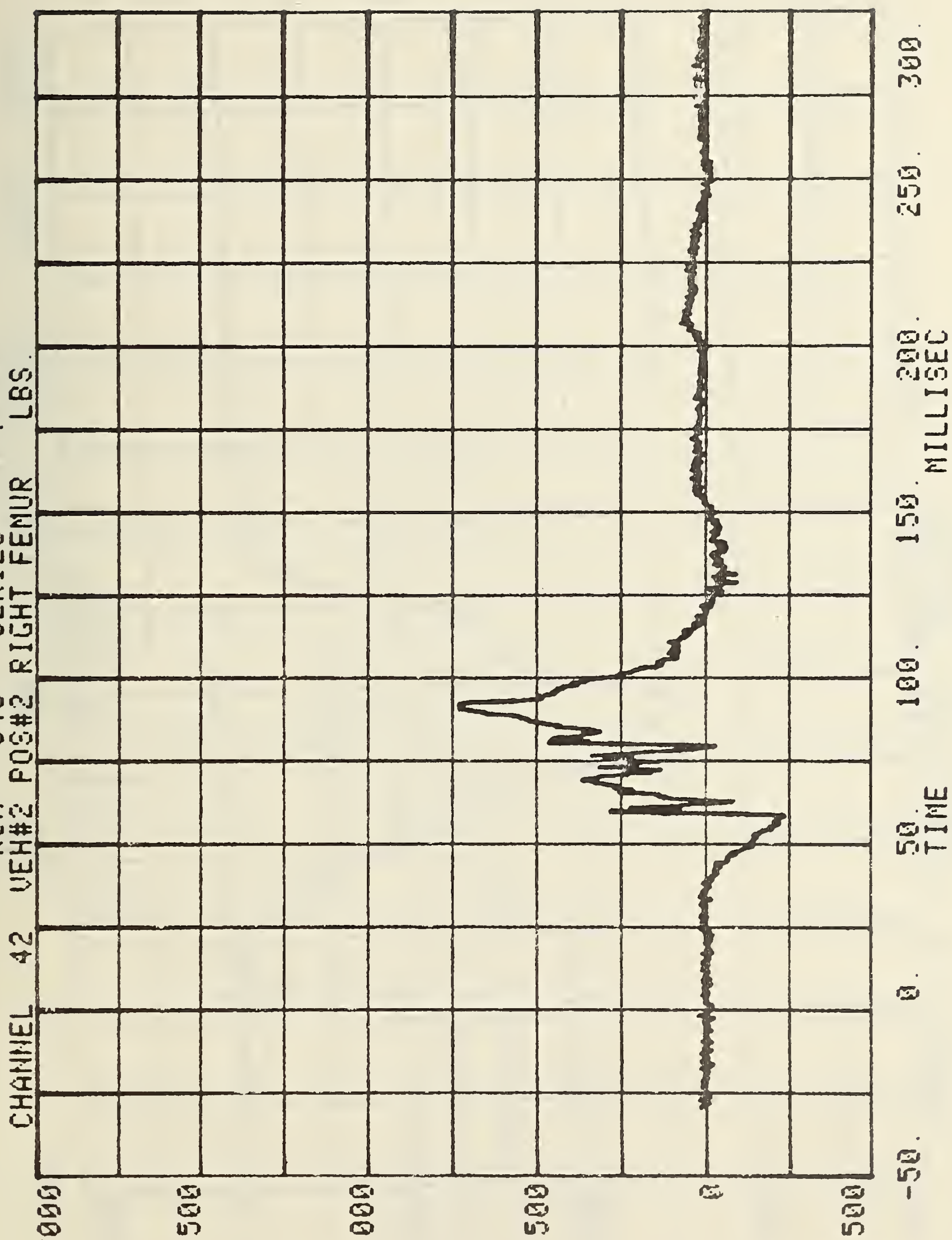

CHANNEL 39 RUN= 546 SERIES= 4
VEH#2 POS#2 CHEST Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

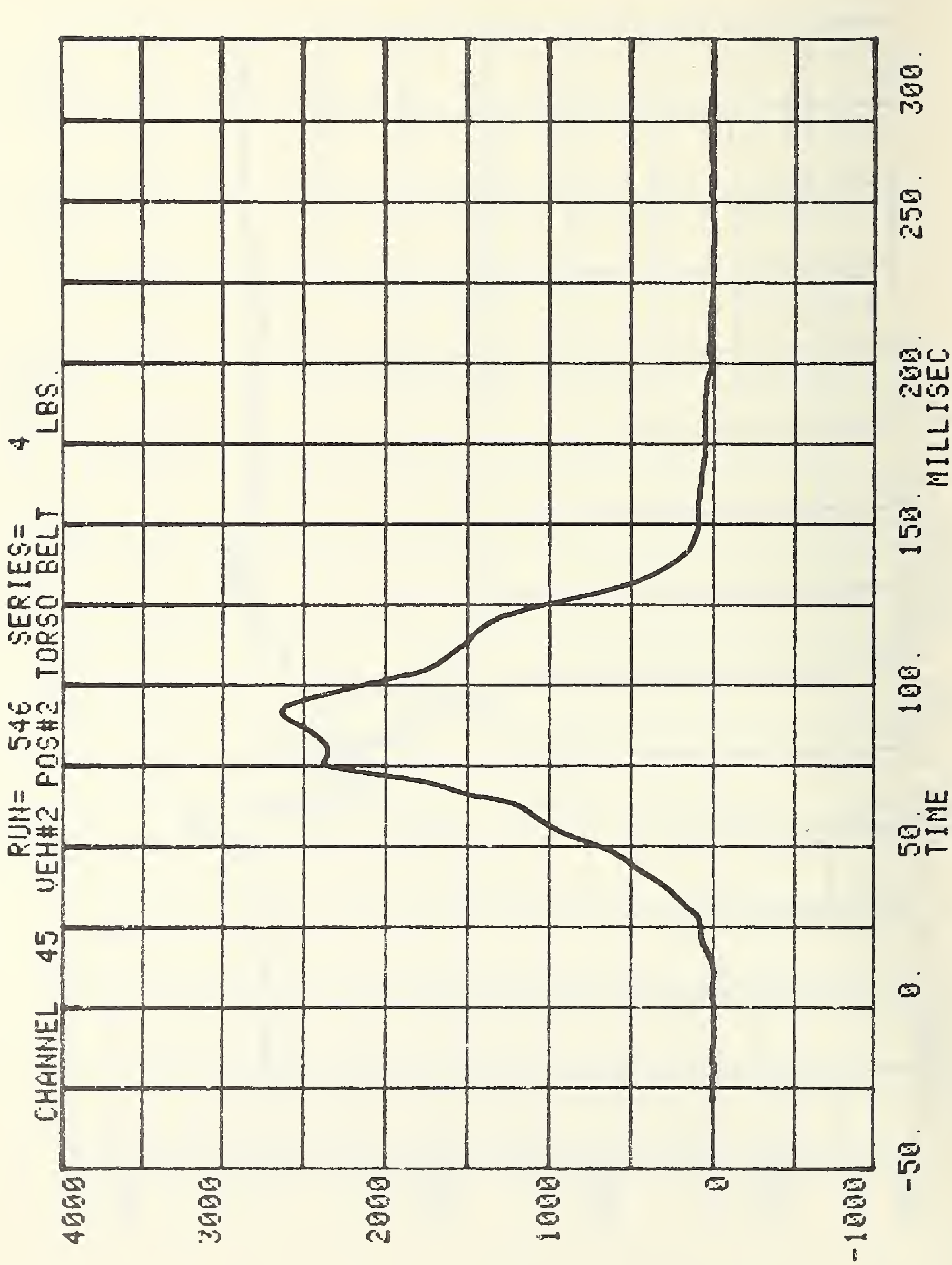

CHANNEL 8 RUN= 546 SERIES= 4
VEH#2 POS#2 CHEST R G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 60 RUN= 546 SERIES= 4
VEH#2 POS#2 PELVIC X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 61 RUN= 546 SERIES= 4
VEH#2 POS#2 PELVIC Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 42 RUN= 546 SERIES= 4
VEH#2 POS#2 RIGHT FEMUR LBS
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 45 RUN= 546 SERIES= 4
VEH#2 POS#2 TORSO BELT LBS.
4000
3000
2000
1000
0
-1000
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

IBSA CAR-TO-CAR TEST #4

RUN= 546

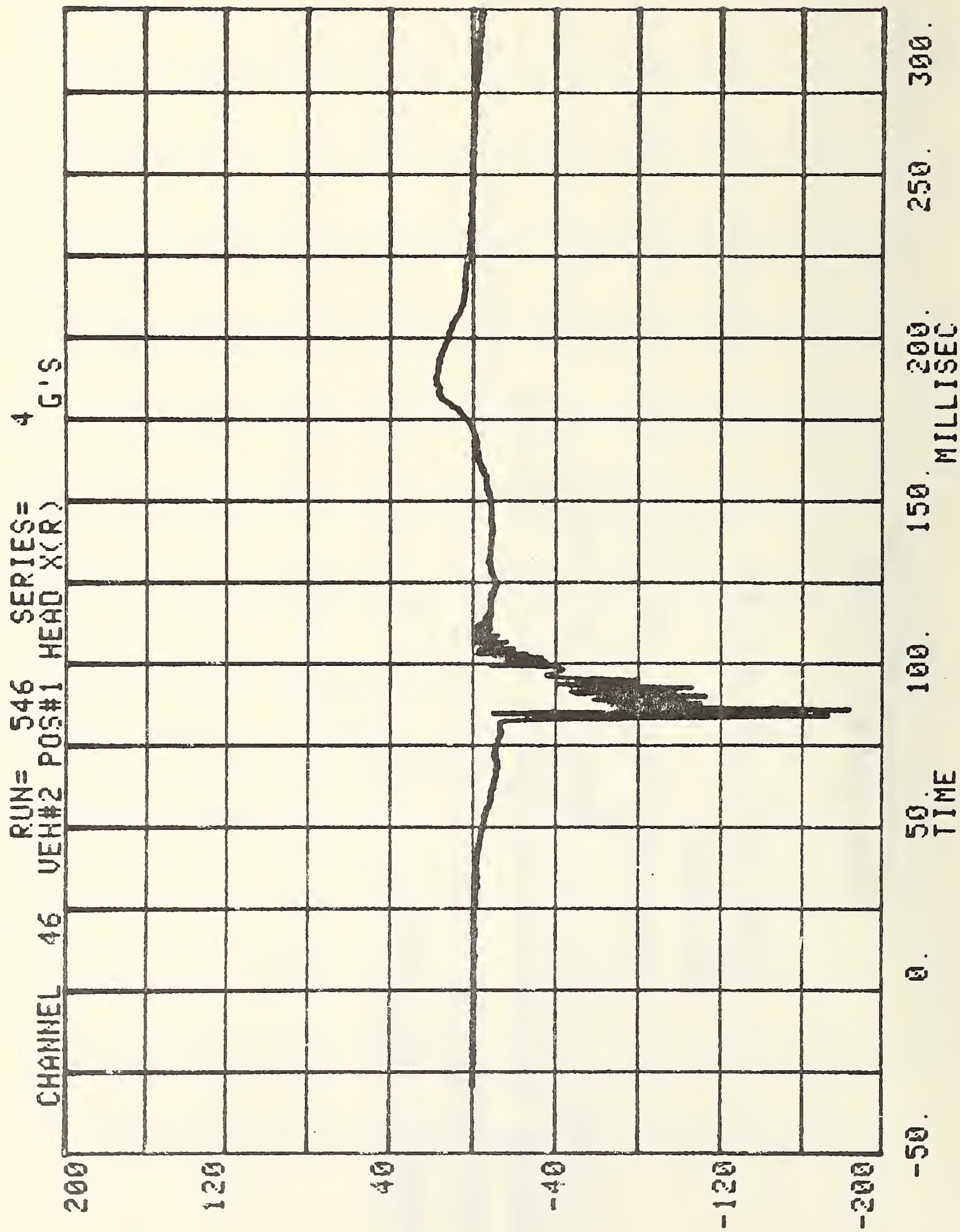
VEH#2 POS#1 HEAD R(R)

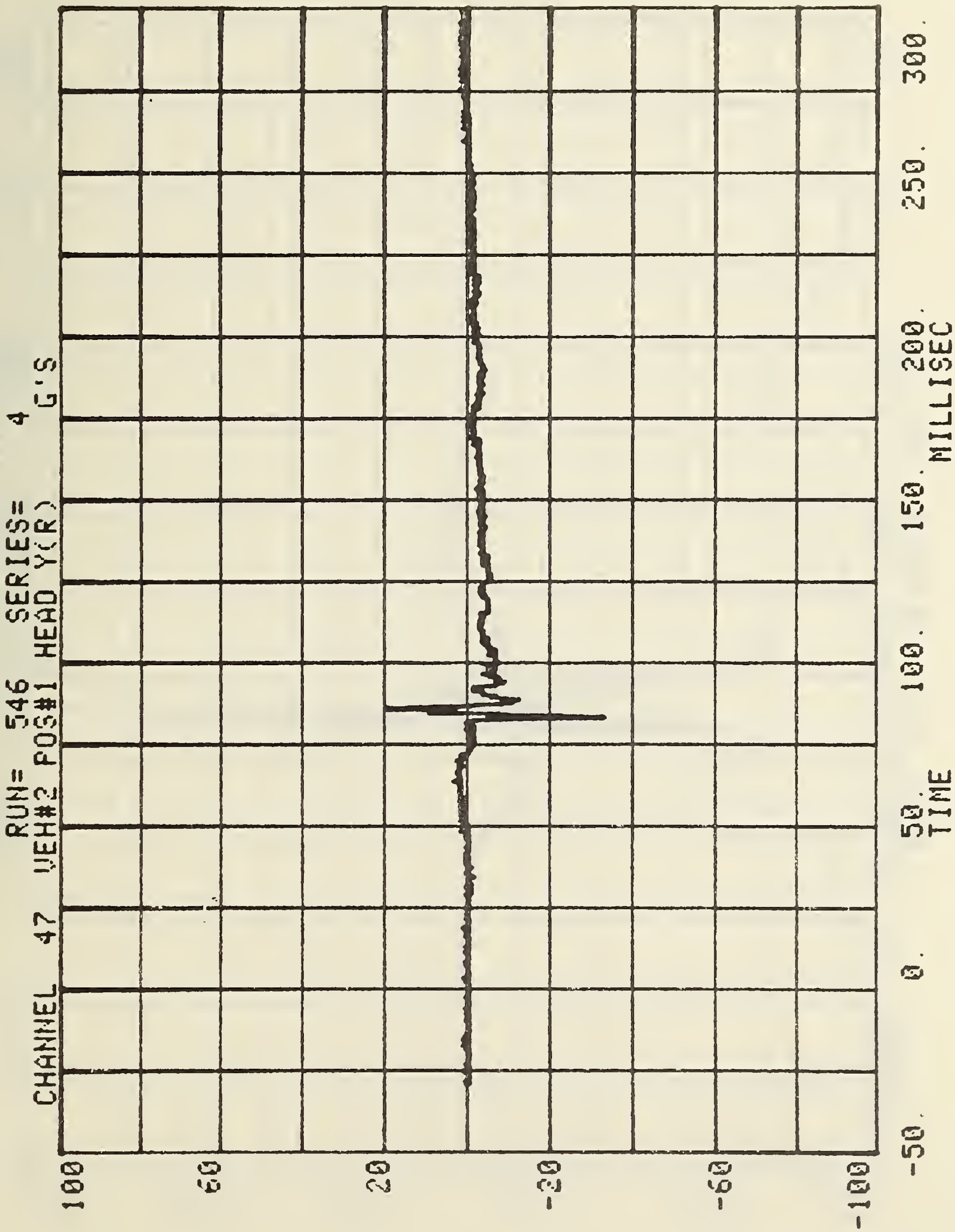
HIC= 952.6   FROM T1= .08280   TO T2= .09600

AVERAGE ACCELERATION BETWEEN T1 AND T2= 87.8G'S

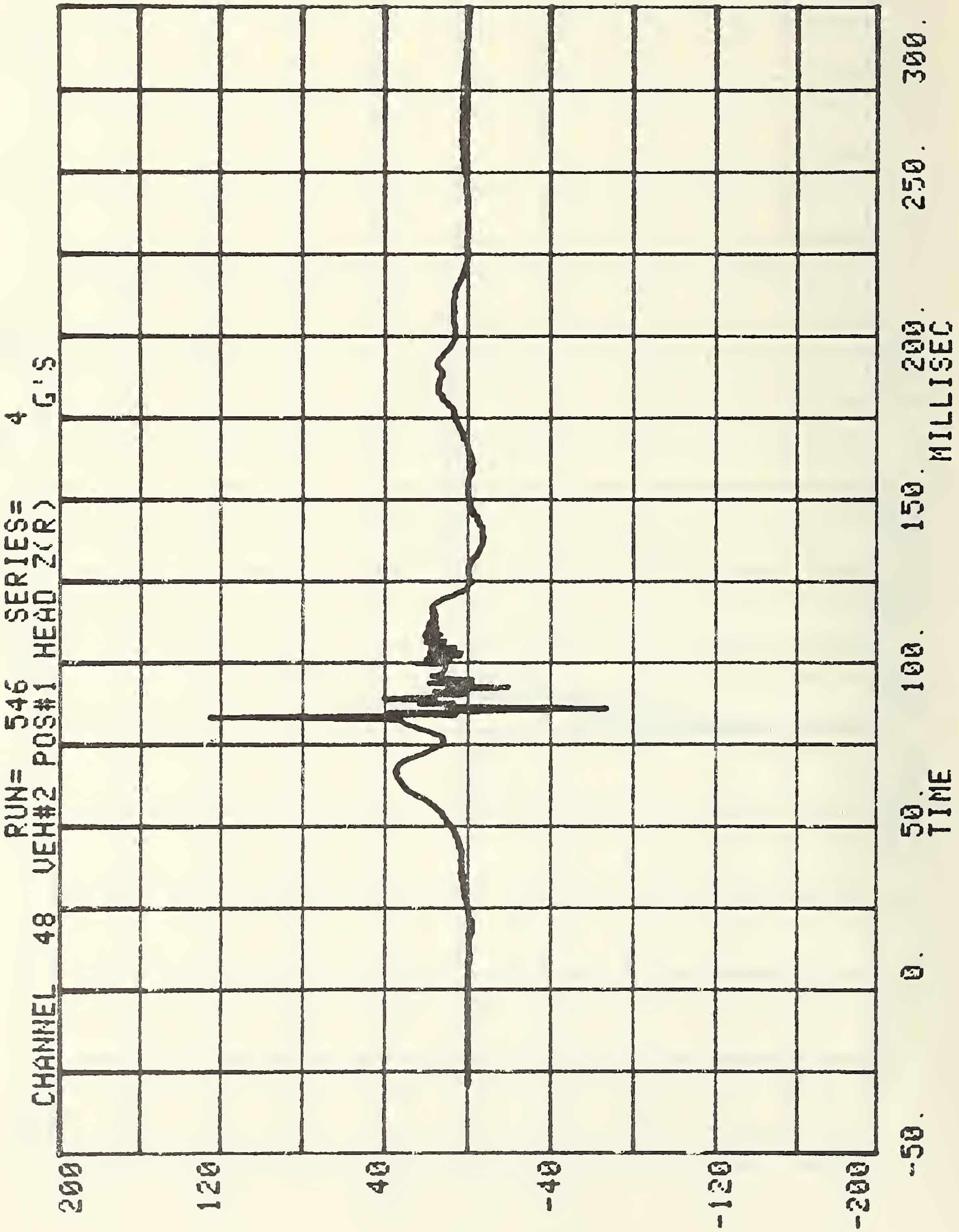
EVENT TIME= 300.0 MSEC

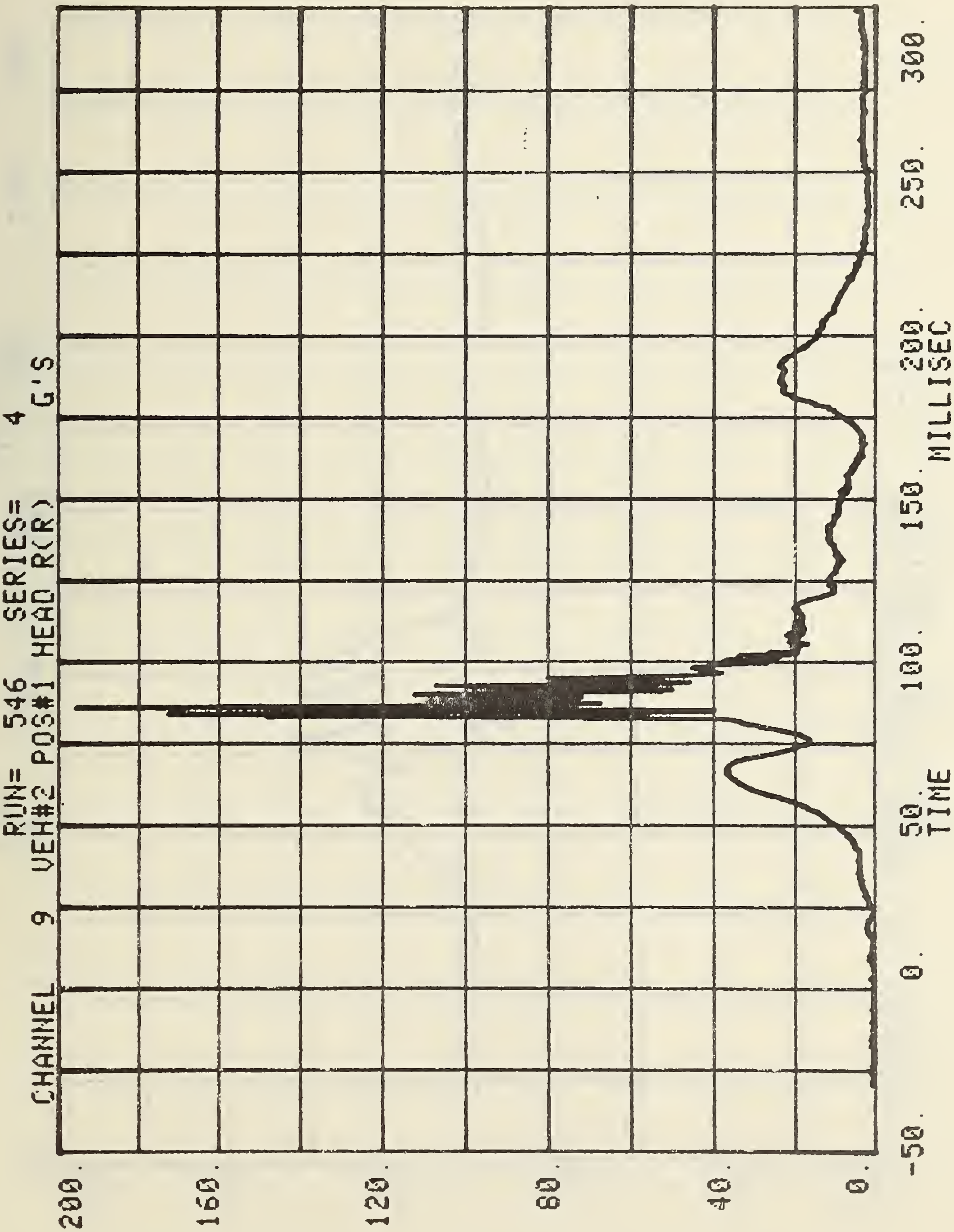
SEVERITY INDEX=1588.9


CHANNEL 46 RUN= 546 SERIES= 4
VEH#2 POS#1 HEAD X(R) G'S
200
120
40
-40
-120
-200
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

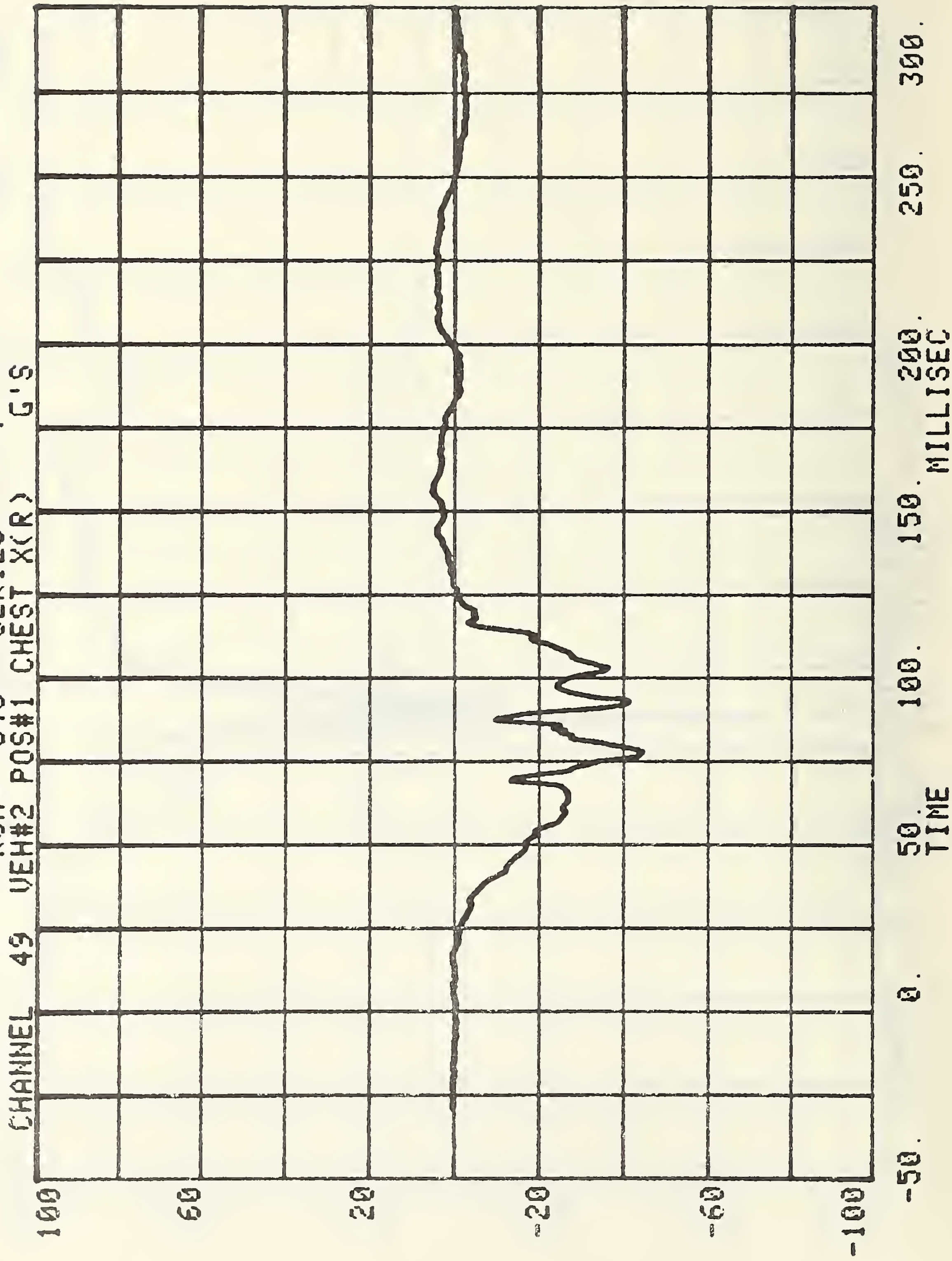


CHANNEL 47 RUN= 546 SERIES= 4
VEH#2 POS#1 HEAD Y(R) G'S
100
60
20
-30
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

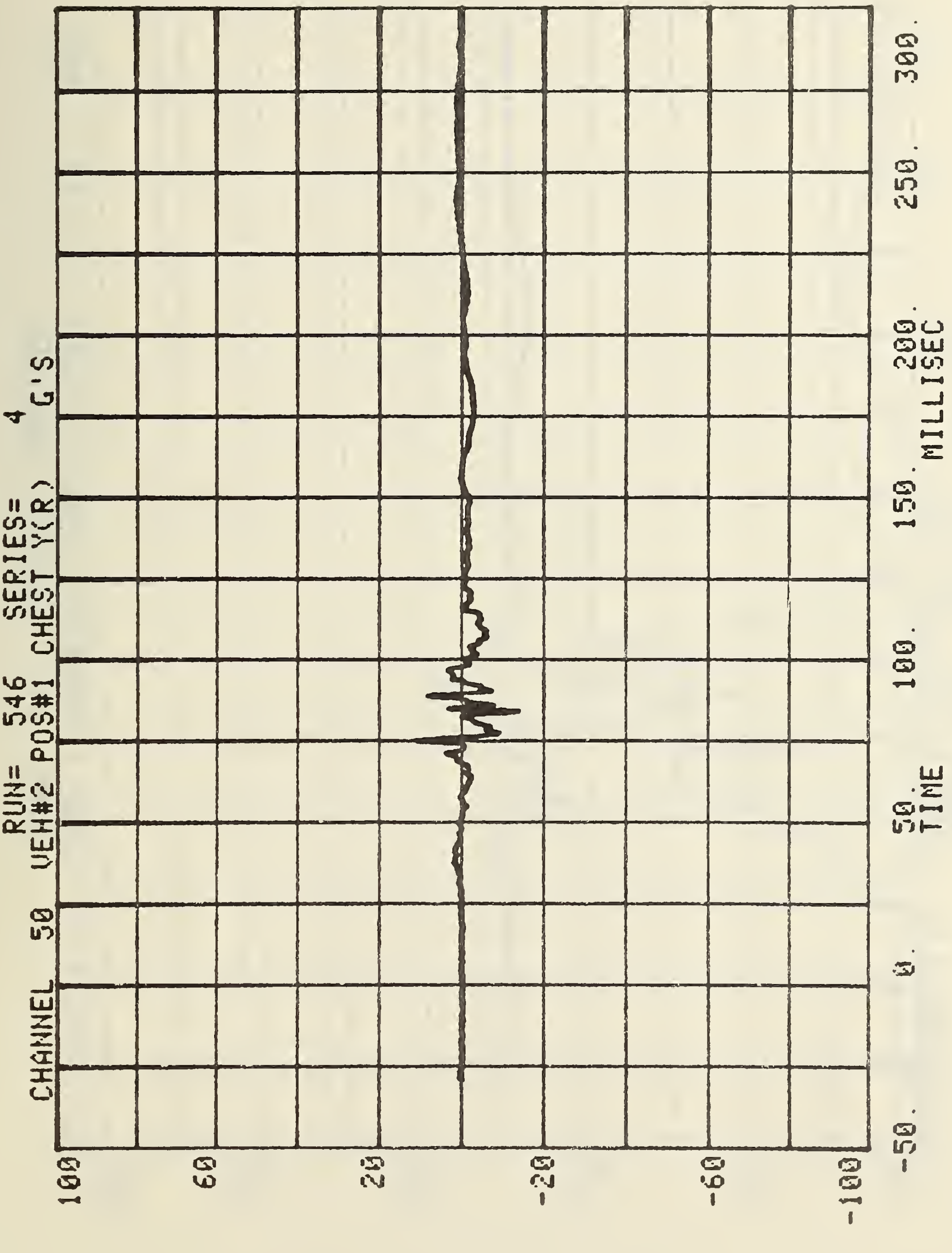

CHANNEL 48 RUN= 546 SERIES= 4
VEH#2 POS#1 HEAD Z(R) G'S
200
120
40
-40
-120
-200
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

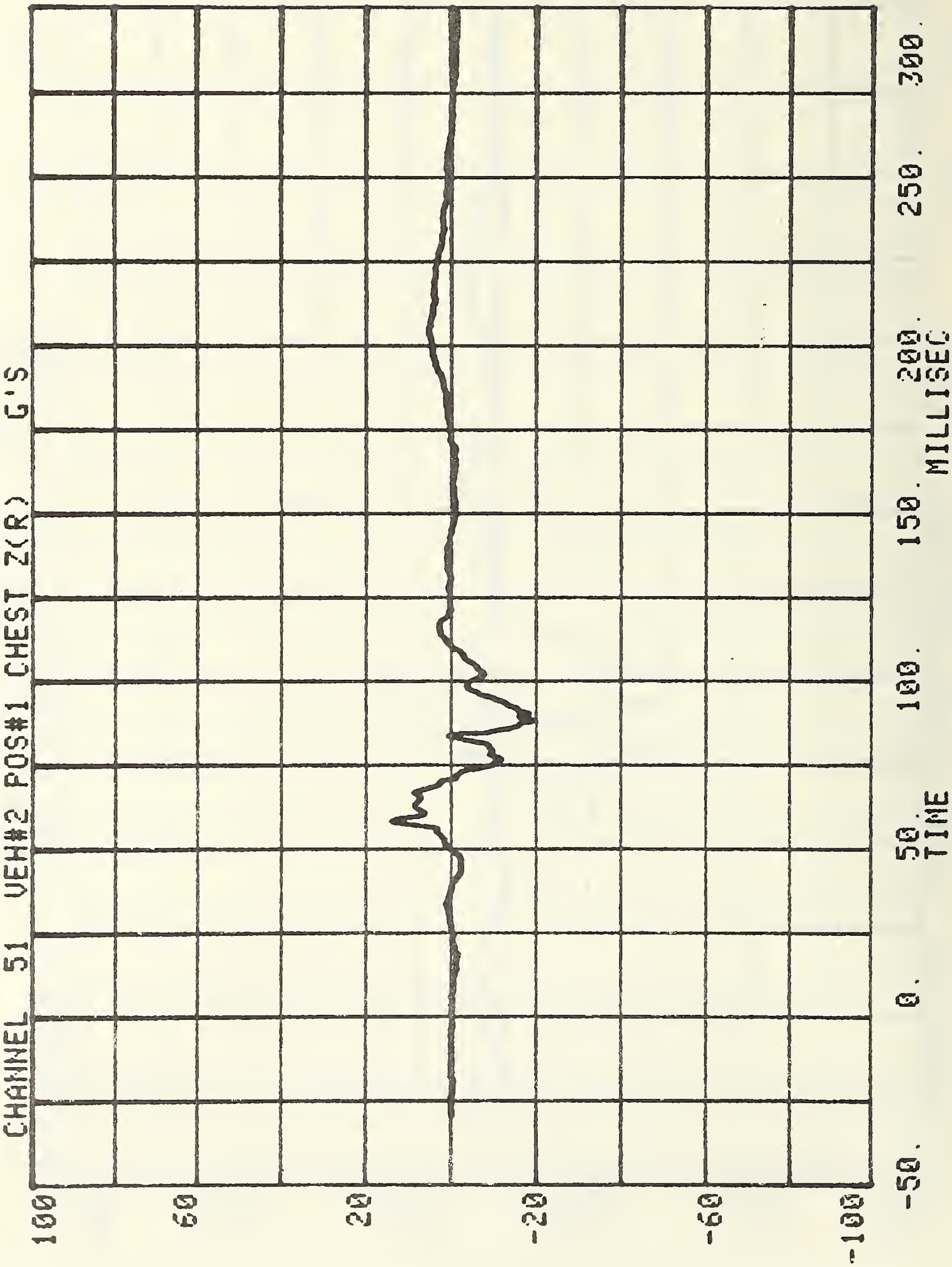


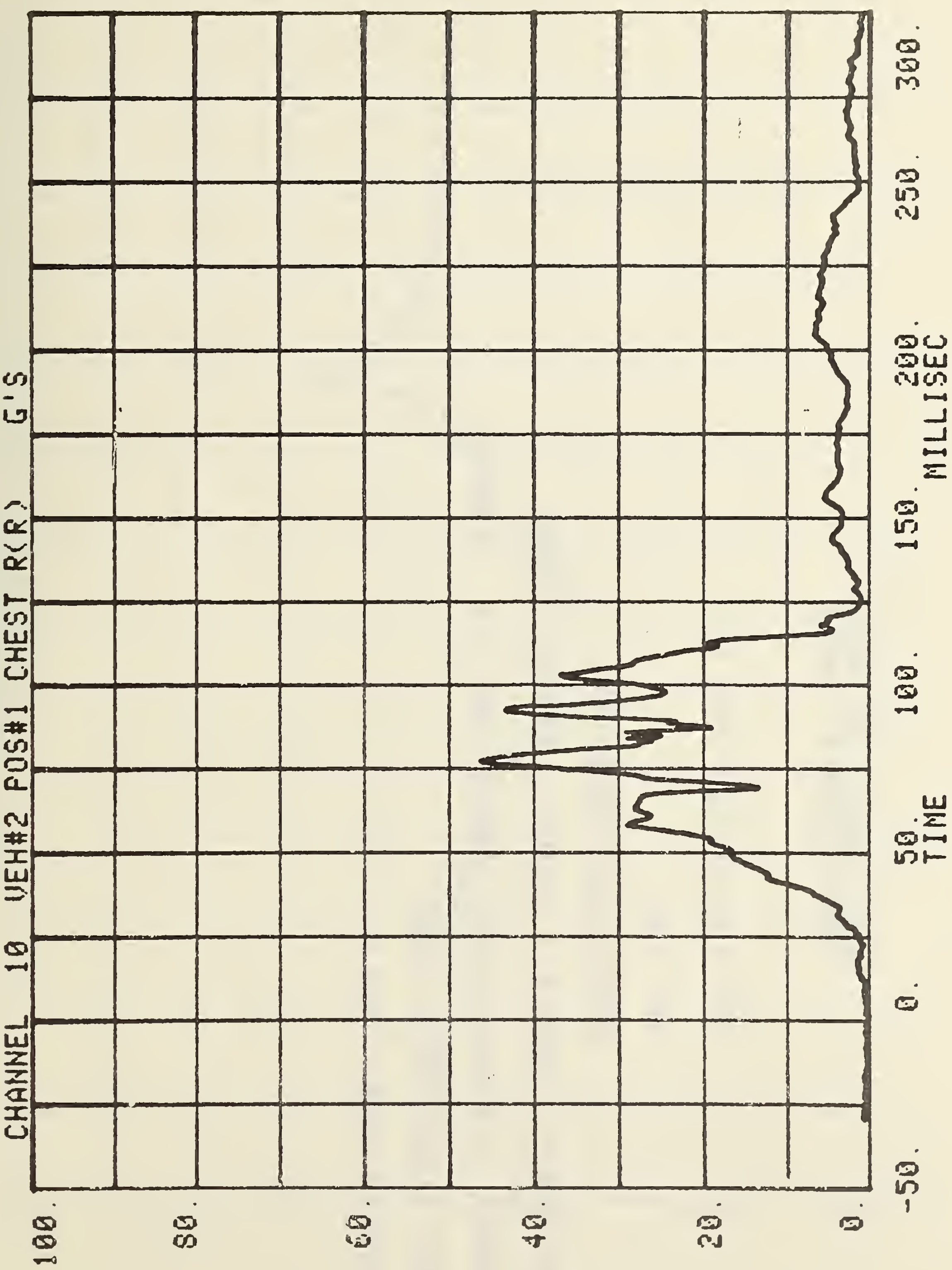
CHANNEL 9 RUN= 546 SERIES= 4
VEH#2 POS#1 HEAD R(R) G'S
200.
160.
120.
80.
40.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 49 RUN= 546 SERIES= 4
VEH#2 POS#1 CHEST X(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 50 RUN= 546 SERIES= 4
VEH#2 POS#1 CHEST Y(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 51 RUN= 546 SERIES= 4
VEH#2 POS#1 CHEST Z(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 10 RUN= 546 SERIES= 4
VEH#2 POS#1 CHEST R(R) G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

IBSA CAR-TO-CAR TEST #4

RUN= 546

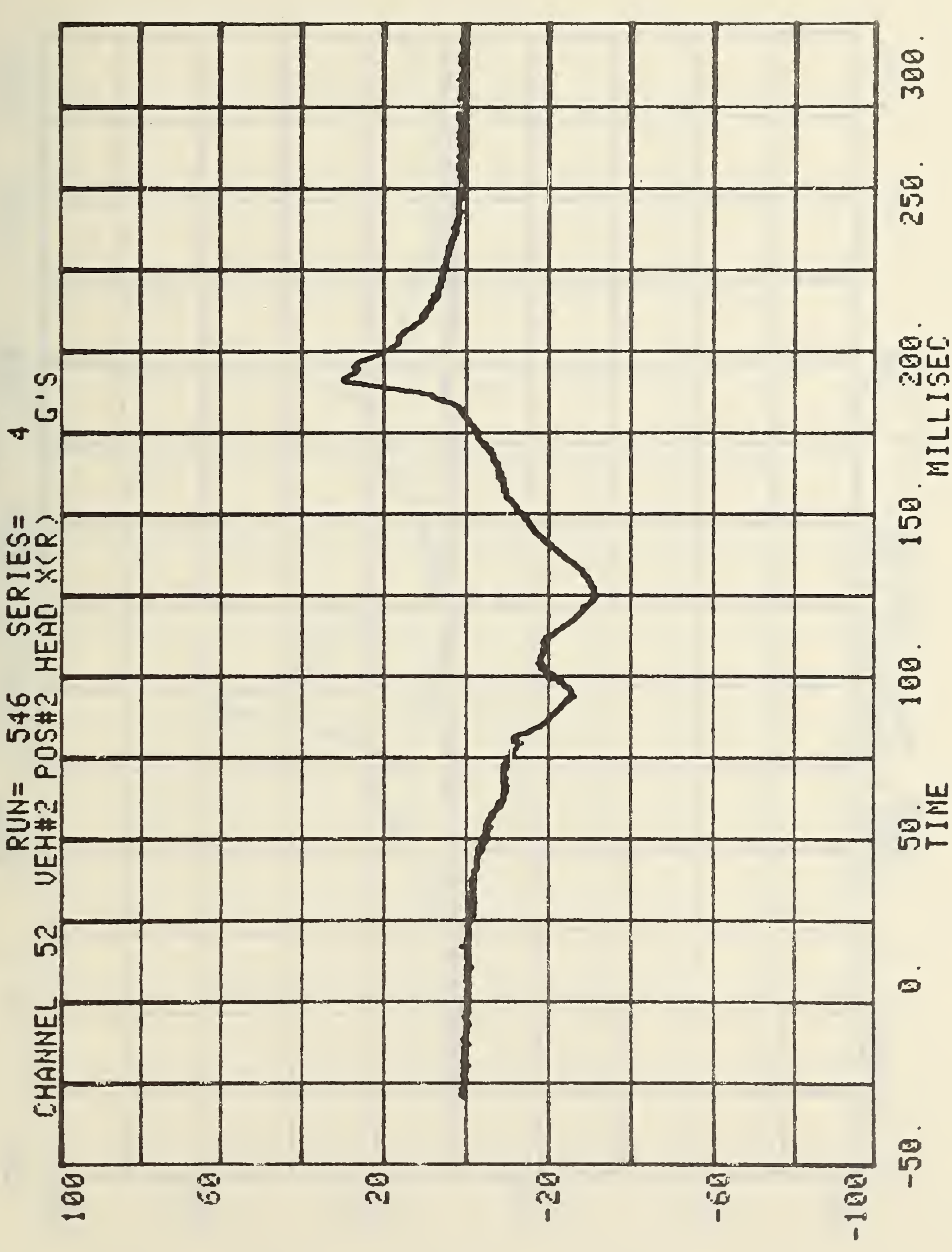
VEH#2 POS#2 HEAD R(R)

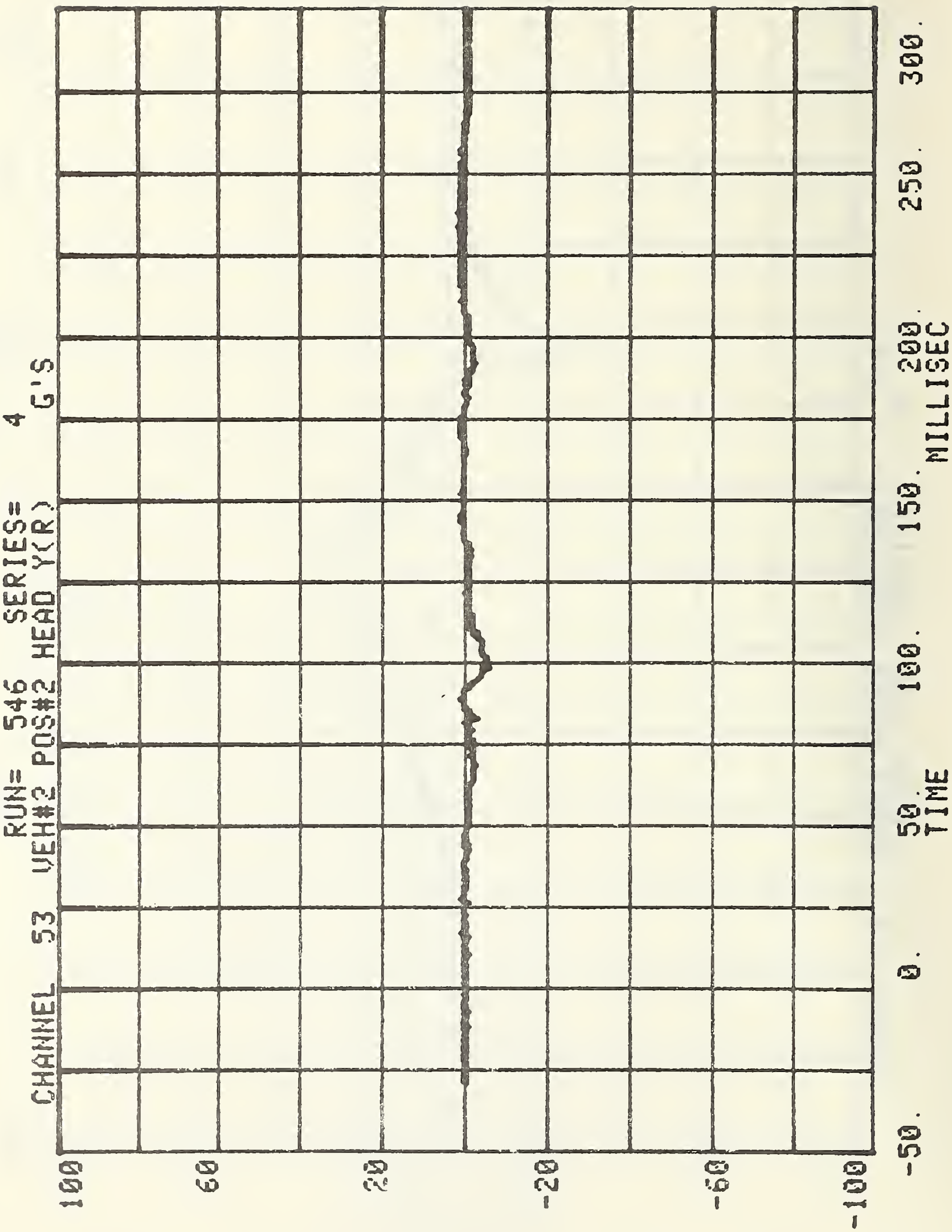
HIC= 540.5   FROM T1= .06030   TO T2= .20790

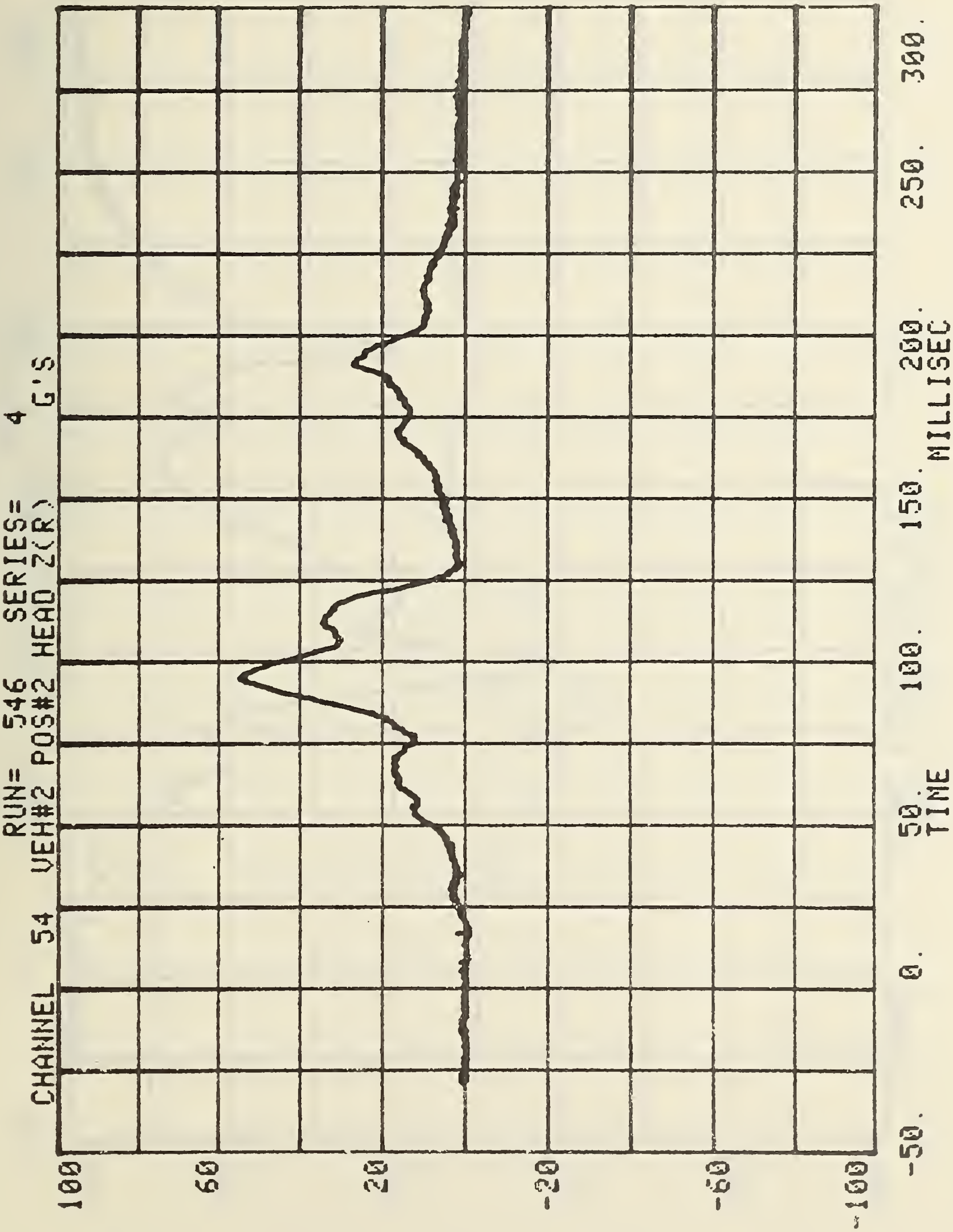
AVERAGE ACCELERATION BETWEEN T1 AND T2= 26.6G'S

EVENT TIME= 300.0 MSEC

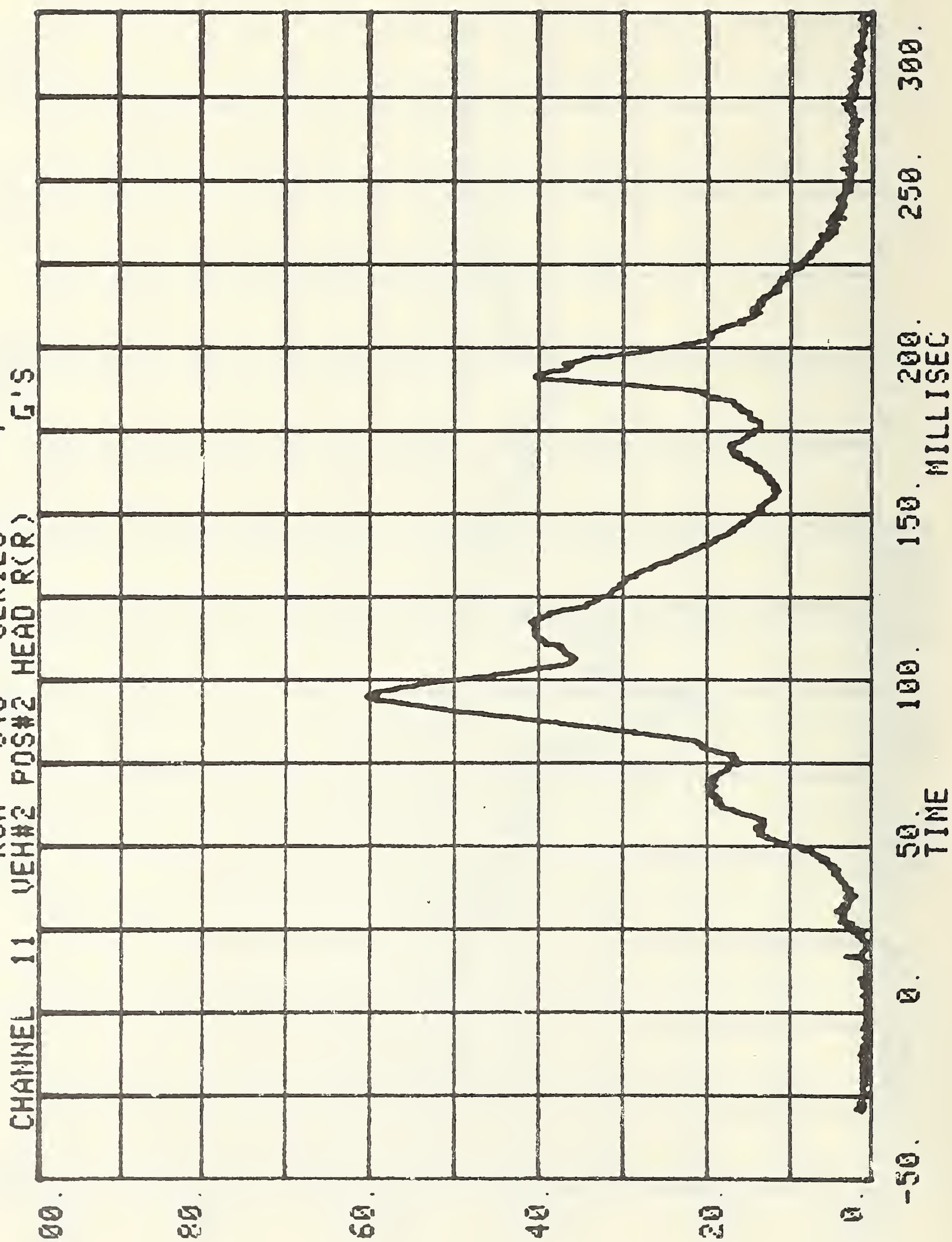
SEVERITY INDEX= 792.0

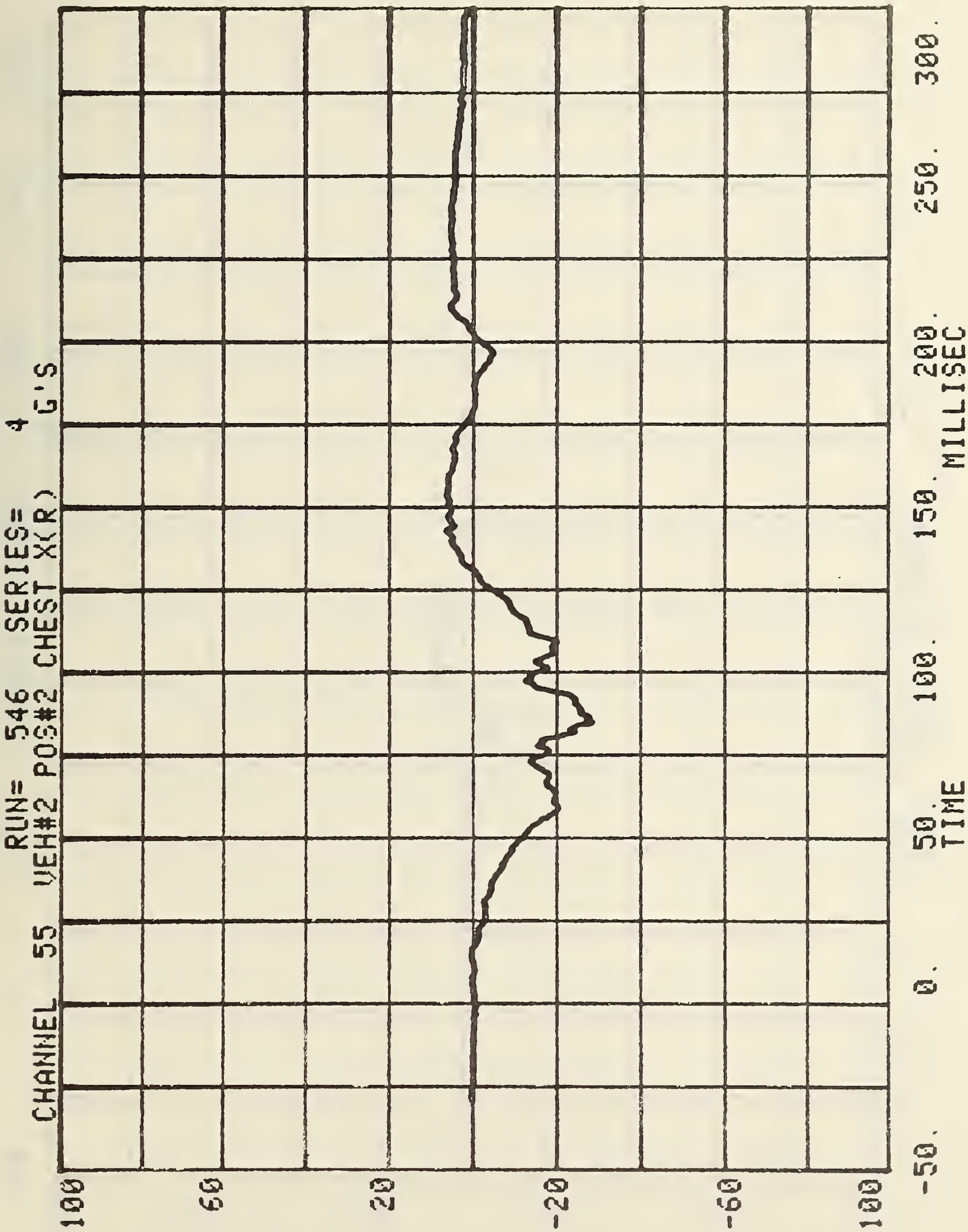

CHANNEL 52 RUN= 546 SERIES= 4
VEH#2 POS#2 HEAD X(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

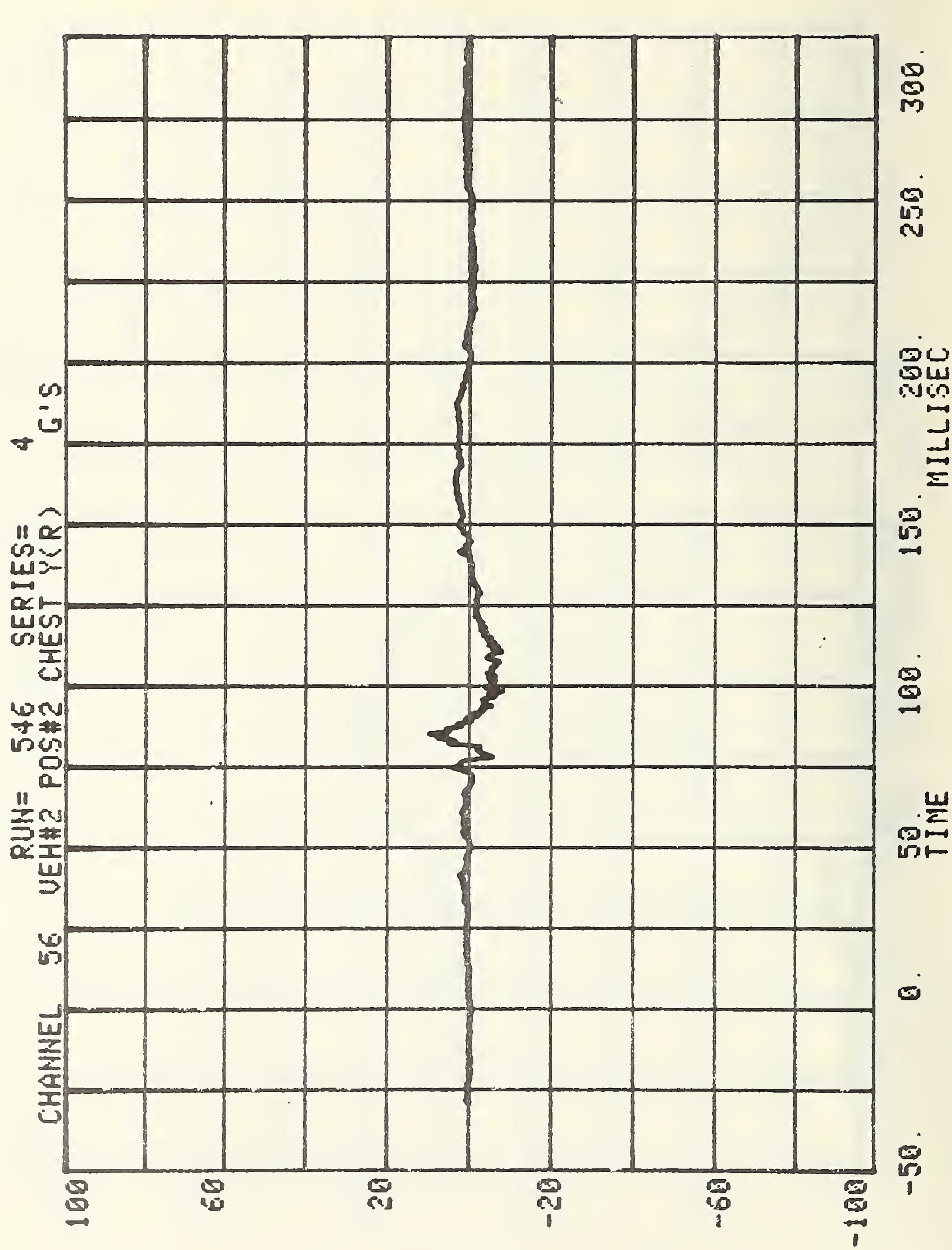

CHANNEL 53 RUN= 546 SERIES= 4
VEH#2 POS#2 HEAD Y(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

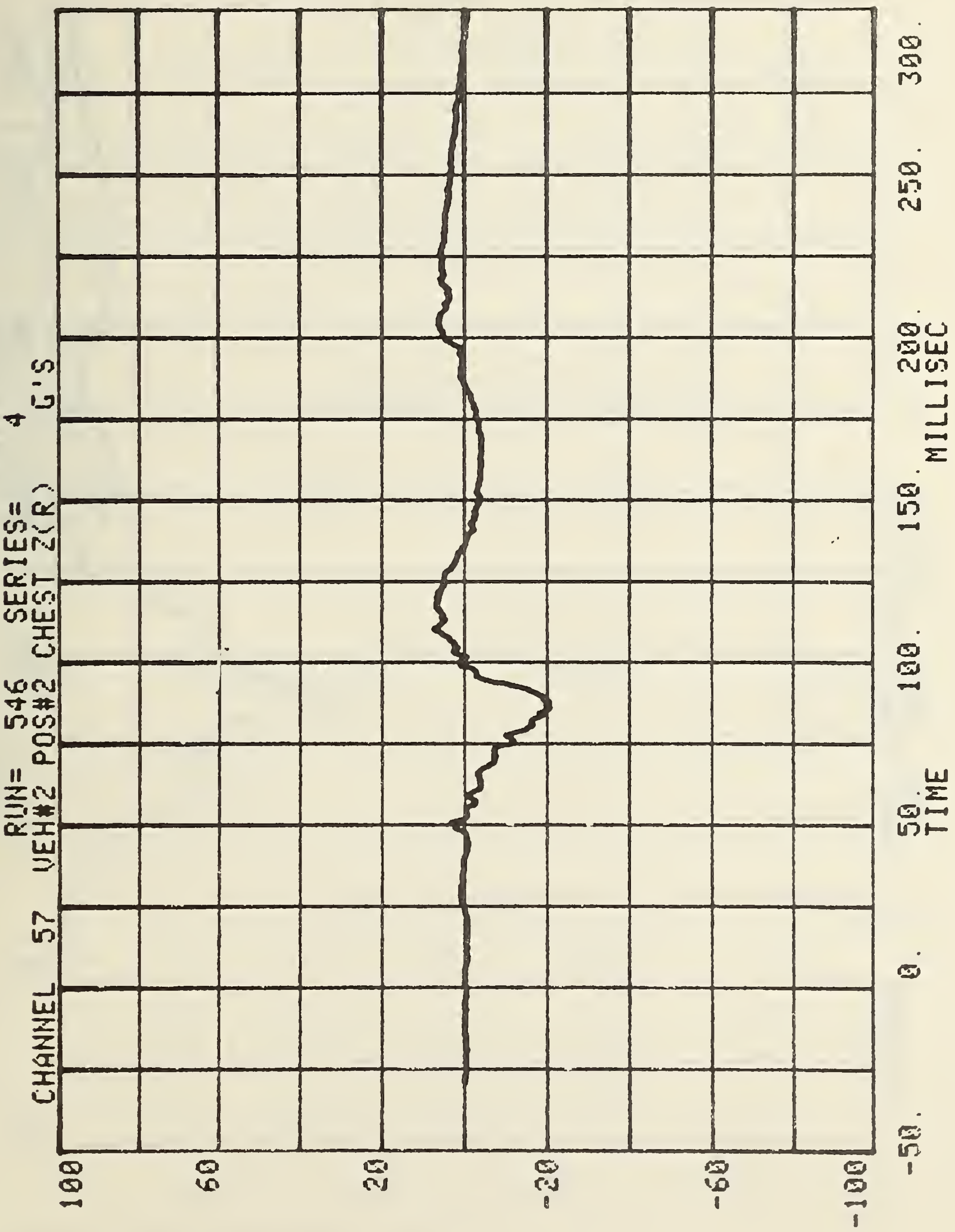


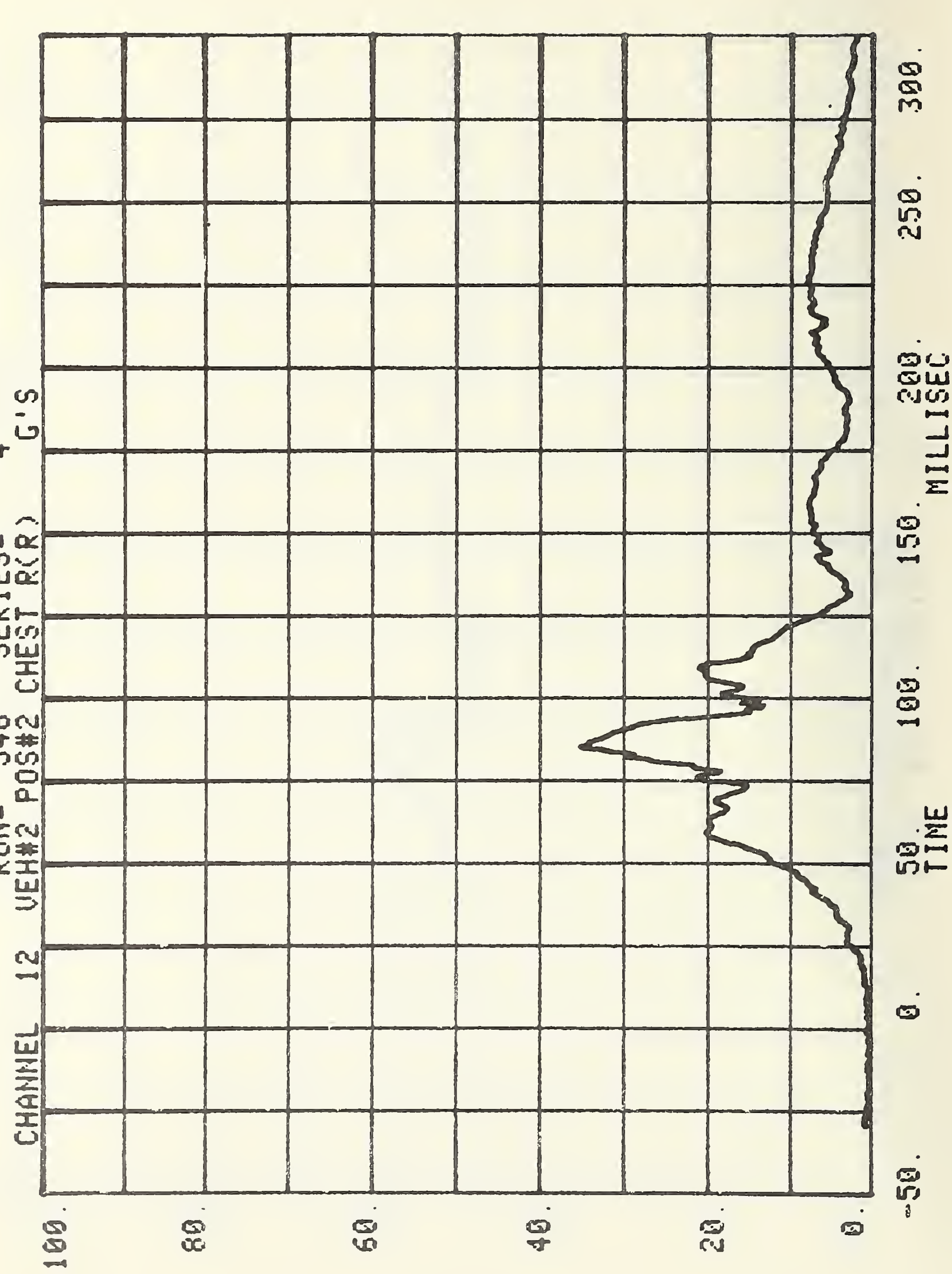
CHANNEL 54 RUN= 546 SERIES= 4
VEH#2 POS#2 HEAD Z(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 11 RUN= 546 SERIES= 4
VEH#2 POS#2 HEAD R(R) G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 55 RUN= 546 SERIES= 4
VEH#2 POS#2 CHEST X(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 56 RUN= 546 SERIES= 4
VEH#2 POS#2 CHEST Y(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 57 RUN= 546 SERIES= 4
VEH#2 POS#2 CHEST Z(R) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 12 RUN= 546 SERIES= 4
VEH#2 POS#2 CHEST R(R) G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

PLYMOUTH HORIZON OCCUPANT AND RESTRAINT SYSTEM DATA SUMMARY

DUMMY POSITION	MAXIMUM ACCELERATION (g)											
	HEAD				CHEST[1]				PELVIS			
	X	Y	Z	R	X	Y	Z	R	X	Y	Z	R
Driver[3] (1)	-144	21	53	153	-42	-7	15	44	60	-	45	-
	-184	-33	125	195	-42	-7	-16	43				
Passenger[3] (2)	-27	-5	49	52	-33	6	-20	38	40	-	36	-
	-31	-6	54	60	-26	-6	-20	33				

DUMMY POSITION	MAXIMUM FORCE-FEMUR LOAD (LBS)	
	RIGHT FEMUR	LEFT FEMUR
Driver (1)	1850	630
Passenger (1)	740	NA[4]

DUMMY POSITION	MAXIMUM FORCE-SEAT BELT LOADS (LBS)		
	SHOULDER STRAP UPPER BELT LOAD	LAP STRAP RIGHT BELT LOAD	LAP STRAP LEFT BELT LOAD
Driver (1)	2410	--	--
Passenger (2)	2630	--	--

DUMMY POSITION	HEAD INJURY CRITERIA[2]				SEVERITY INDEX	
	HIC	t_1 (SEC)	t_2 (SEC)	AVE. ACC. (g) t_1 TO t_2	HEAD	CHEST
Driver[3] (1)	727	0.083	0.097	77.4	1031	--
	953	0.083	0.096	87.8	1589	--
Passenger[3] (2)	510	0.086	0.136	40.1	673	--
	541	0.060	0.208	26.6	792	--

[1] DEFINED AS EXCEEDING 0.003 SEC. DURATION

[2] AS DEFINED IN FMVSS NO. 208

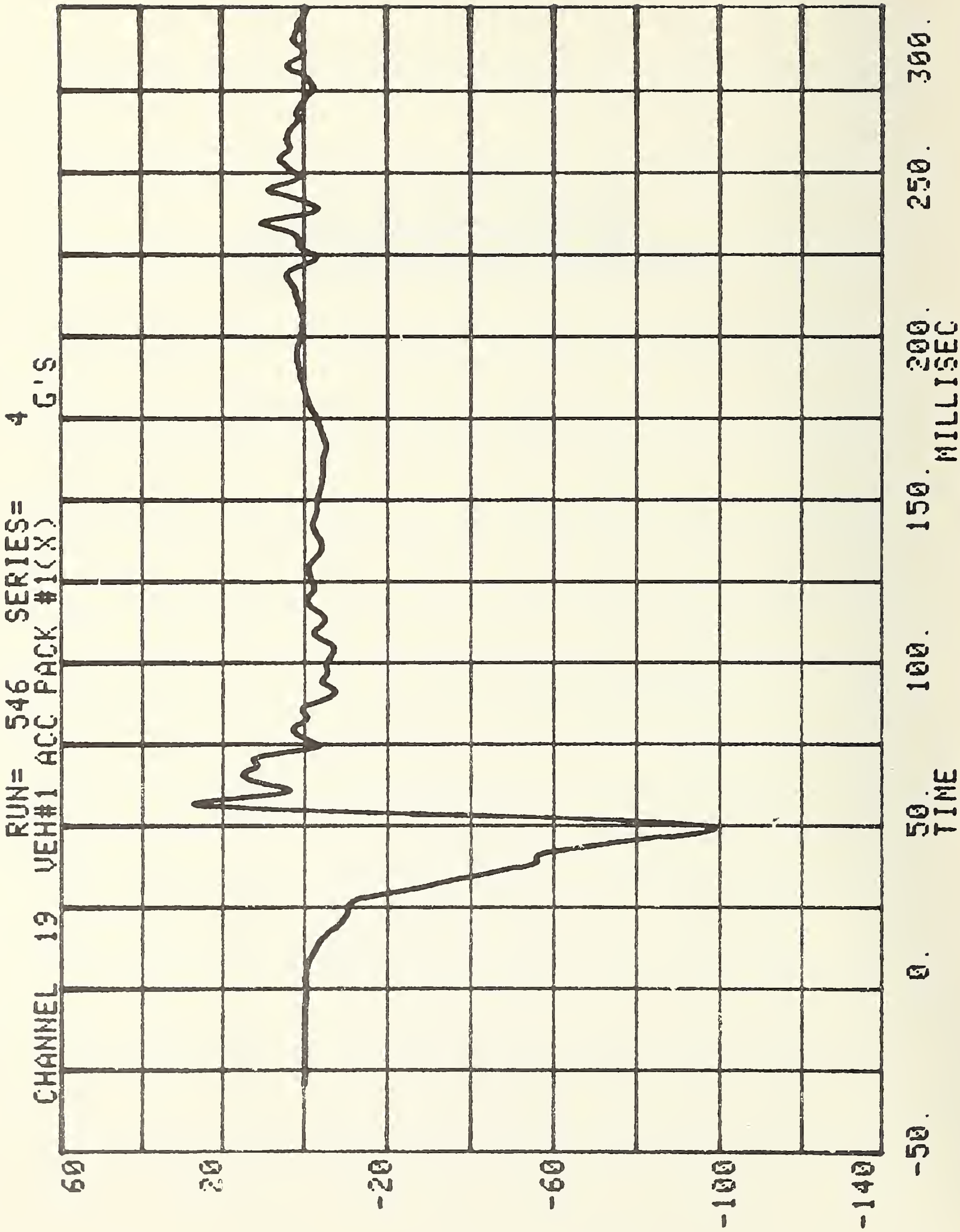
[3] VALUES ON FIRST AND SECOND LINES REFLECT PRIMARY AND REDUNDANT ACCELERATION MEASUREMENTS, RESPECTIVELY, FOR THE SAME DUMMY.

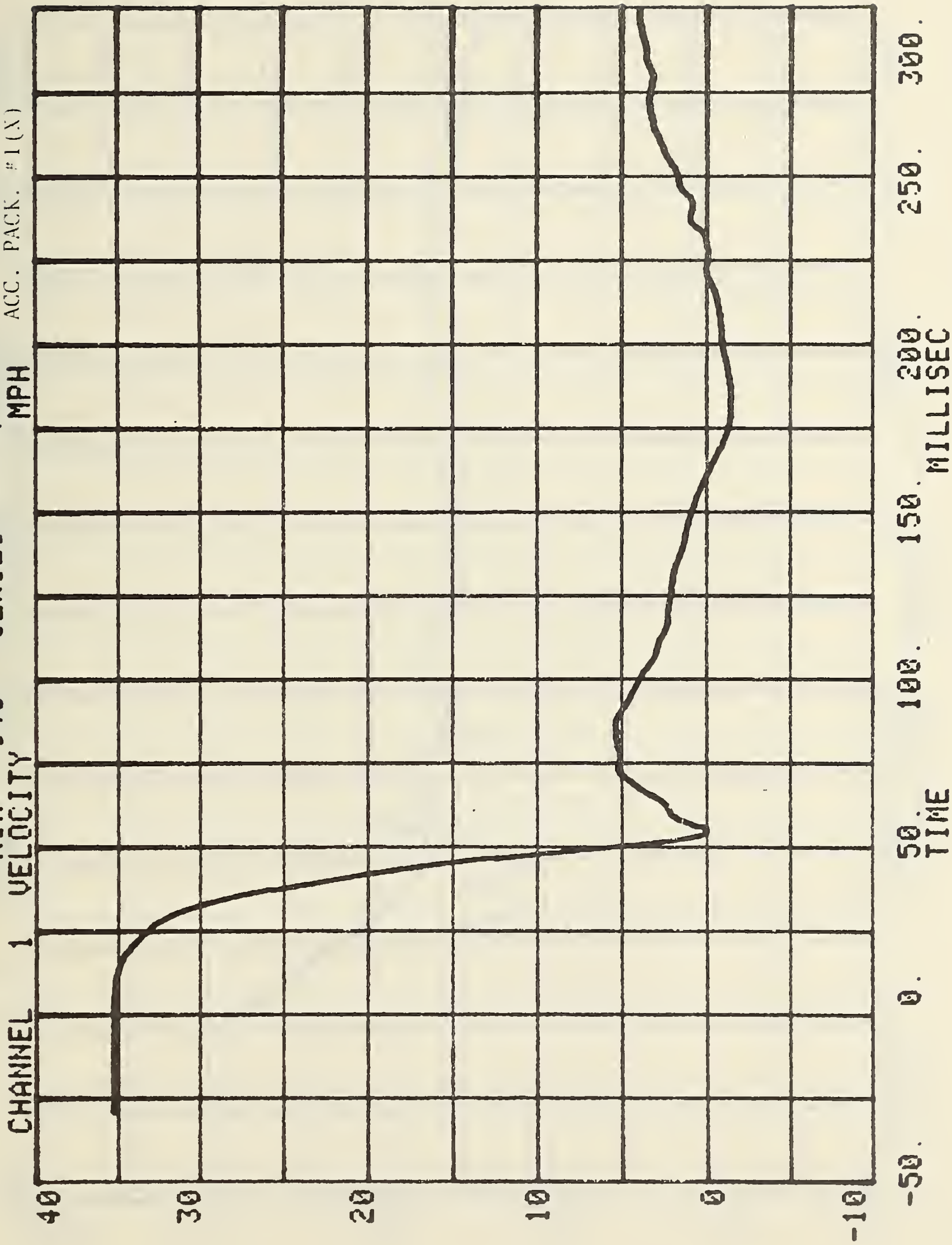
[4] NOT AVAILABLE: WIRES PULLED OUT OF LOAD CELL.

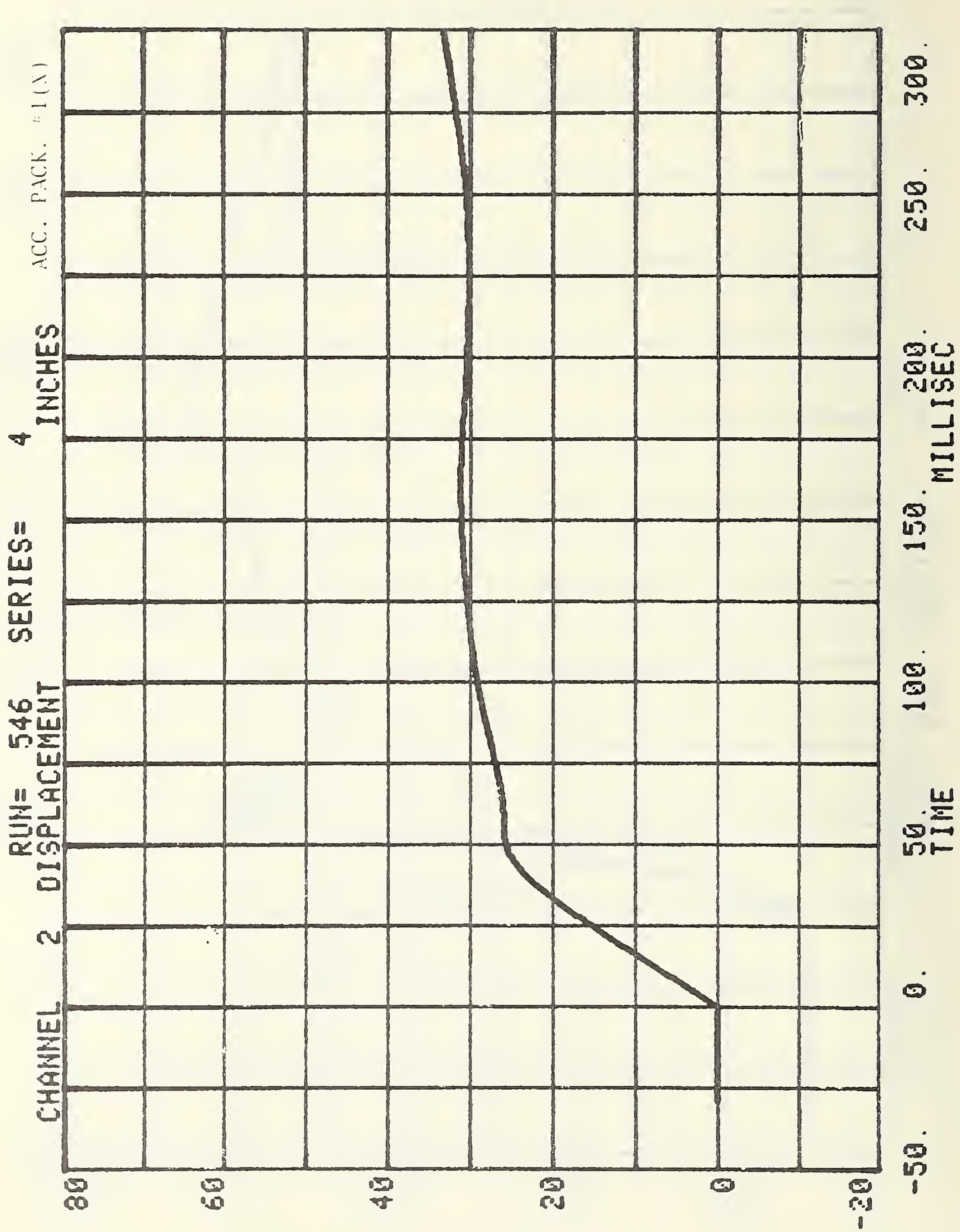
APPENDIX F

ELECTRONIC CRASH TEST DATA:

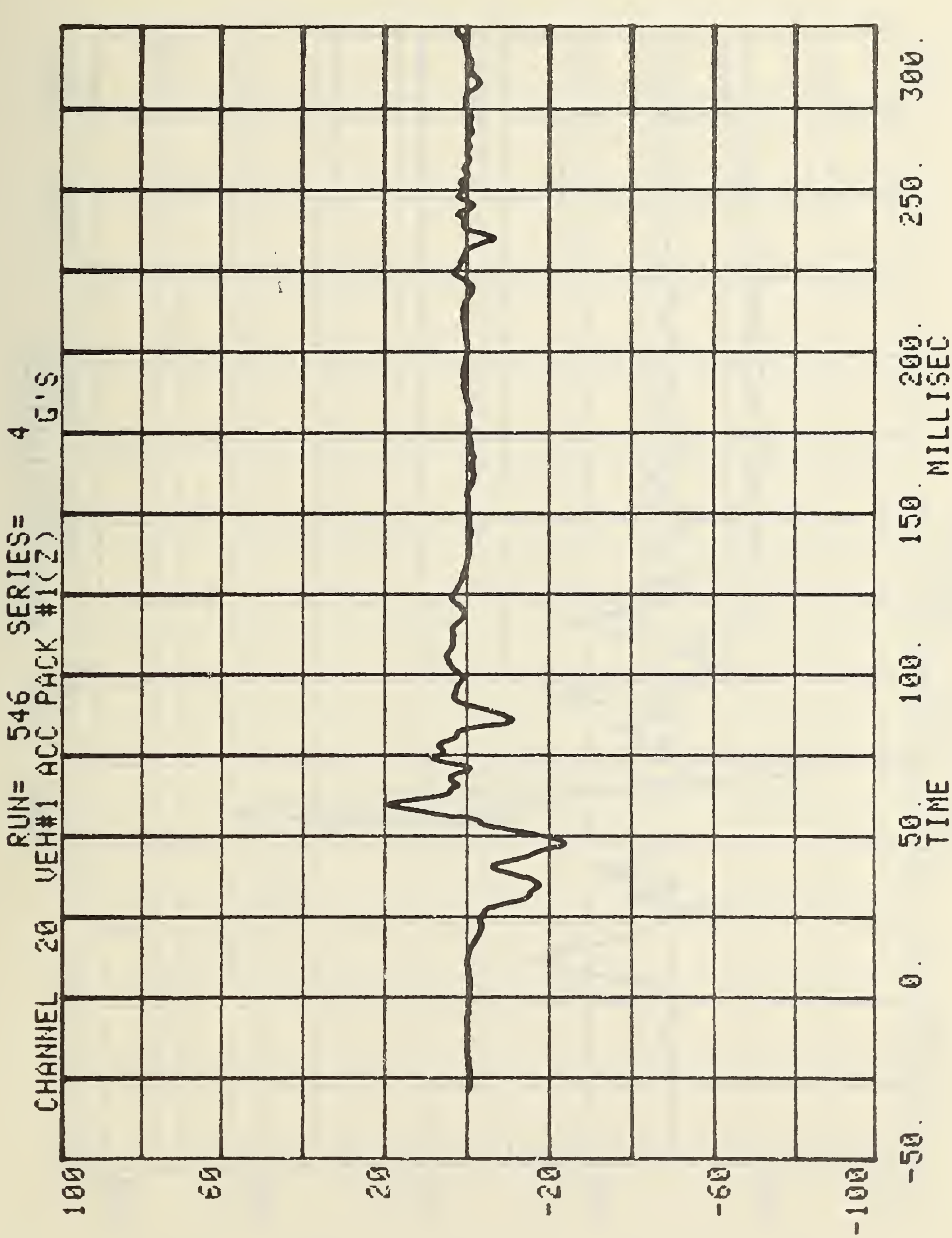
FORD MUSTANG VEHICLE-MOUNTED SENSORS

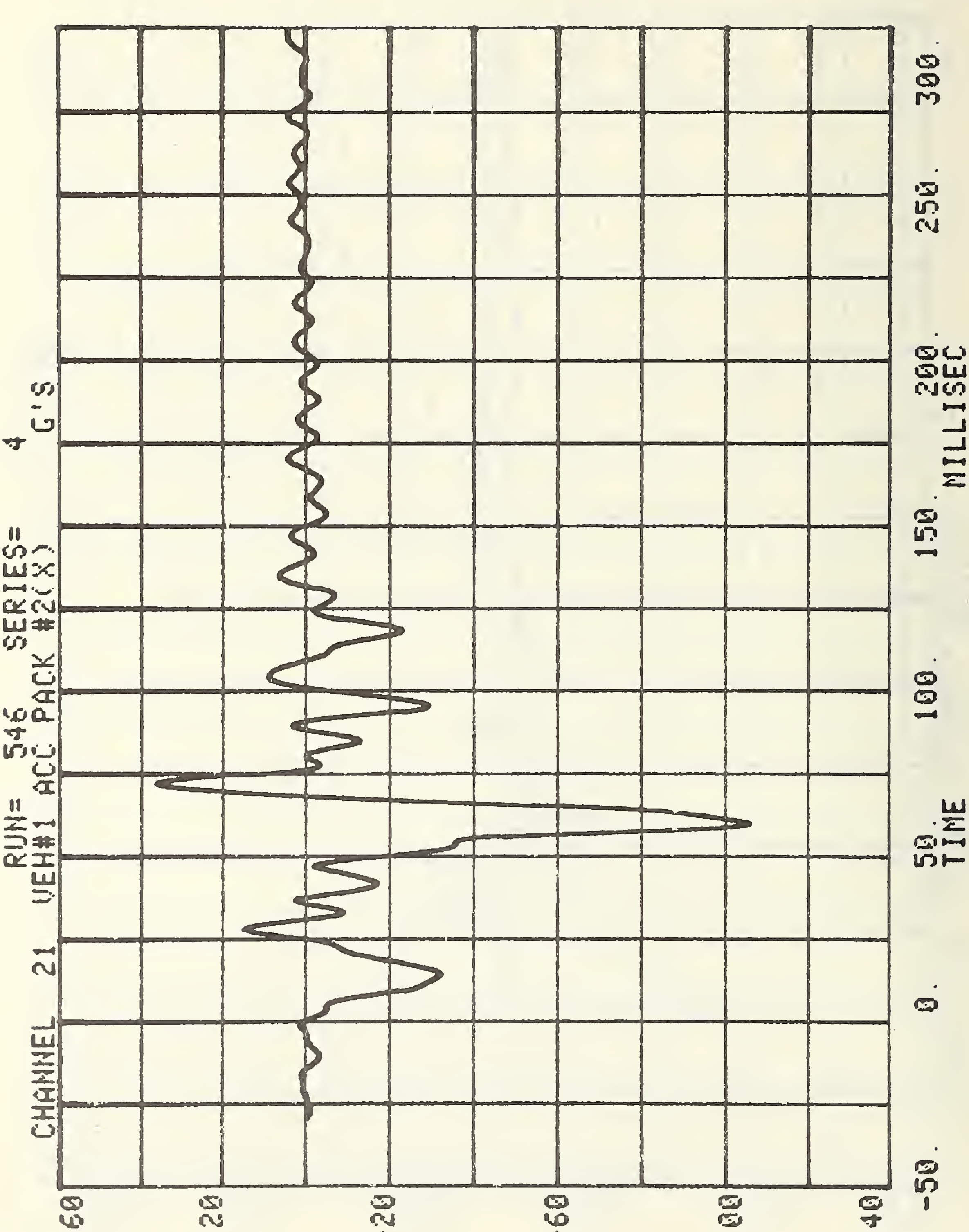

CHANNEL 19 RUN= 546 SERIES= 4
VEH#1 ACC PACK #1(X) G'S
60
20
-20
-60
-100
-140
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

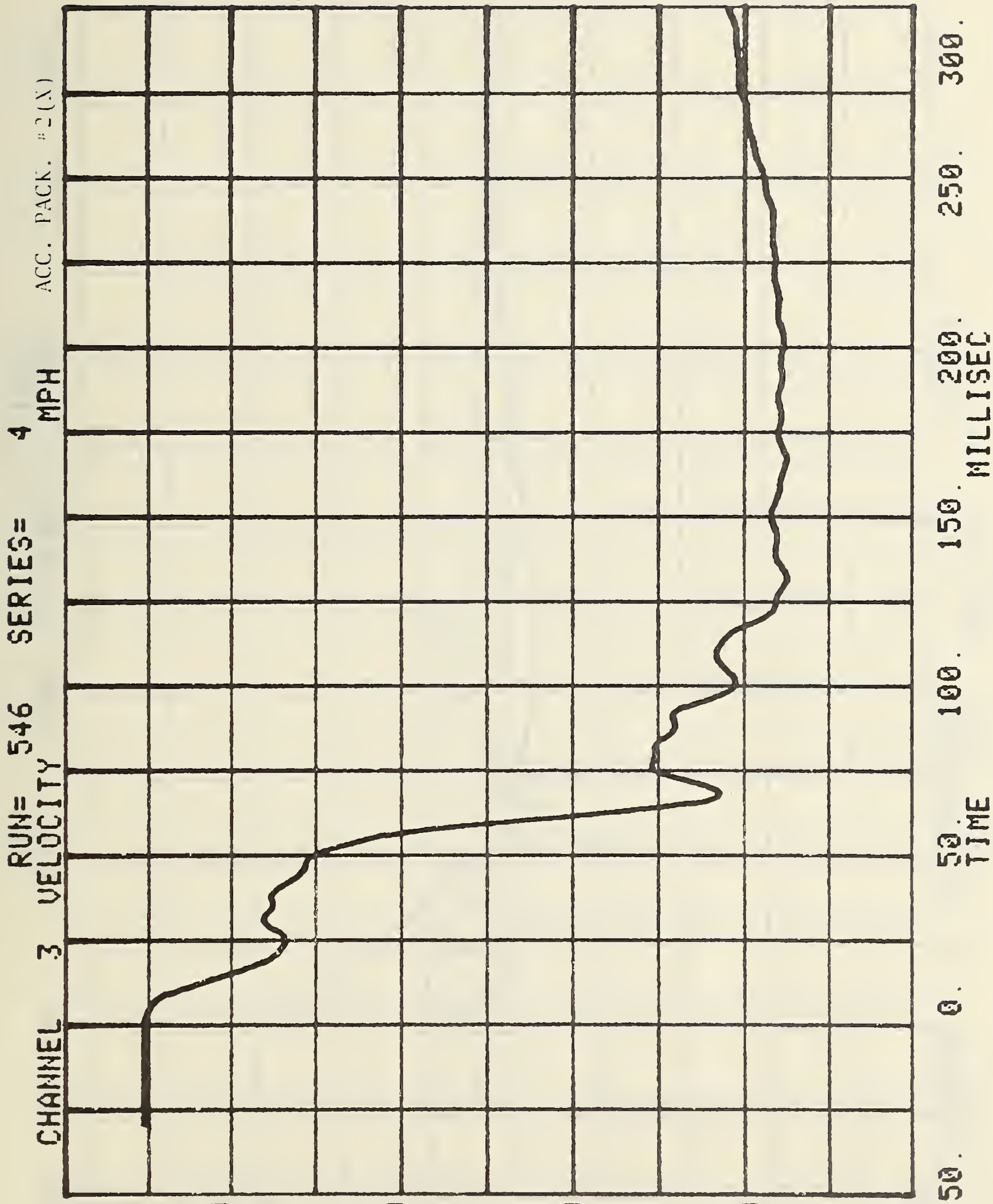

CHANNEL 1 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK. #1(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



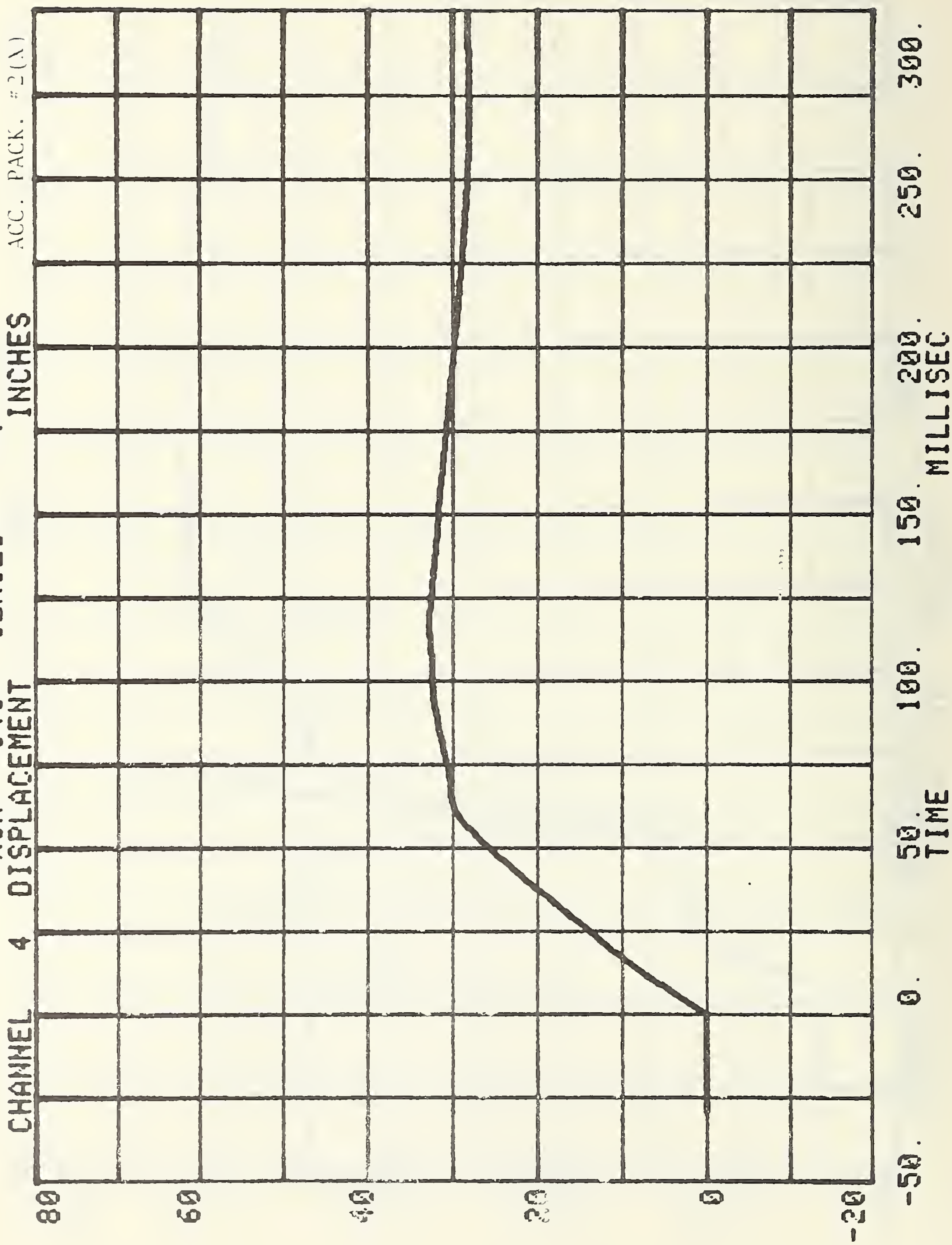
CHANNEL 2 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
ACC. PACK. #1(X)
80
60
40
20
0
-20
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

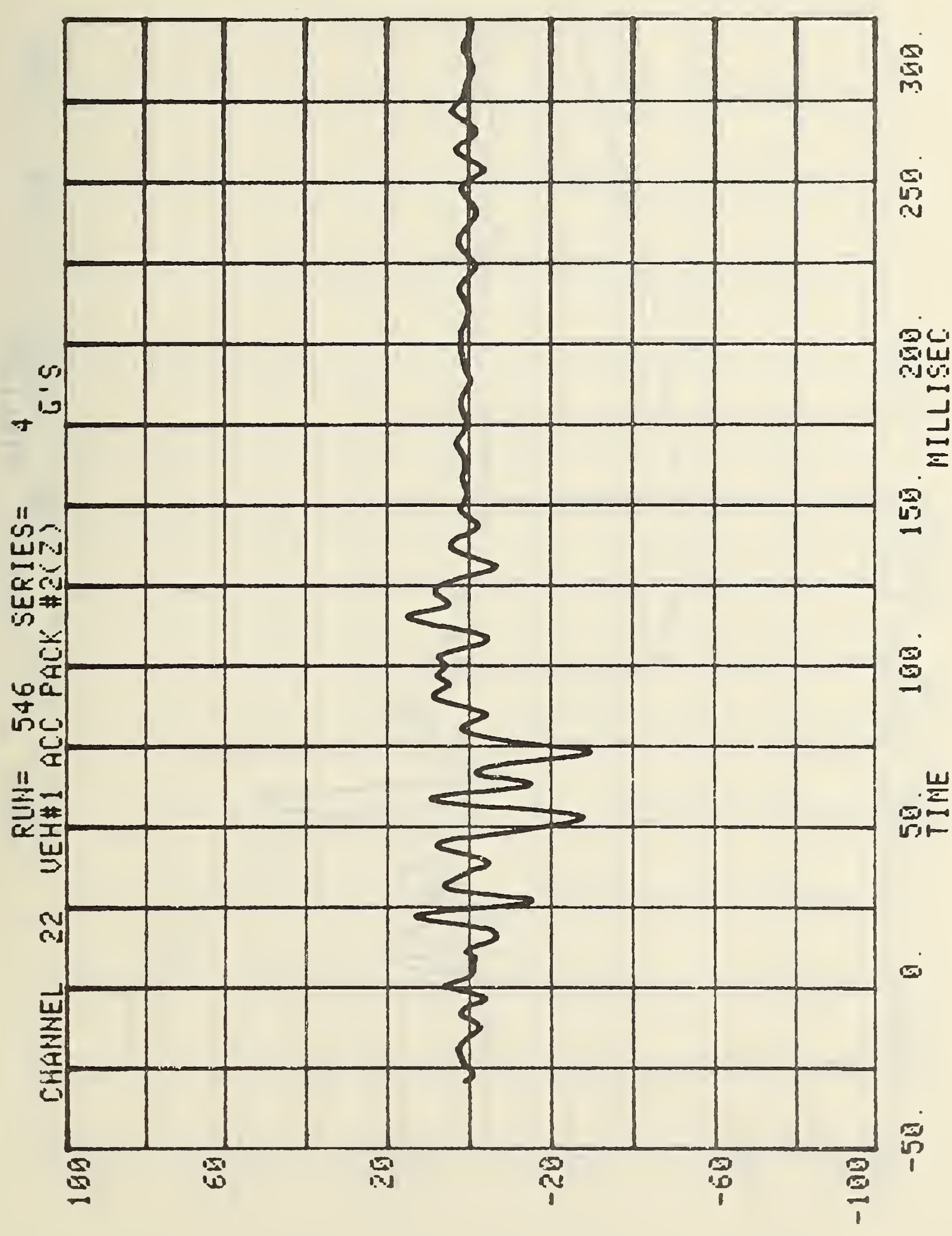

CHANNEL 20 RUN= 546 SERIES= 4
VEH#1 ACC PACK #1(Z) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

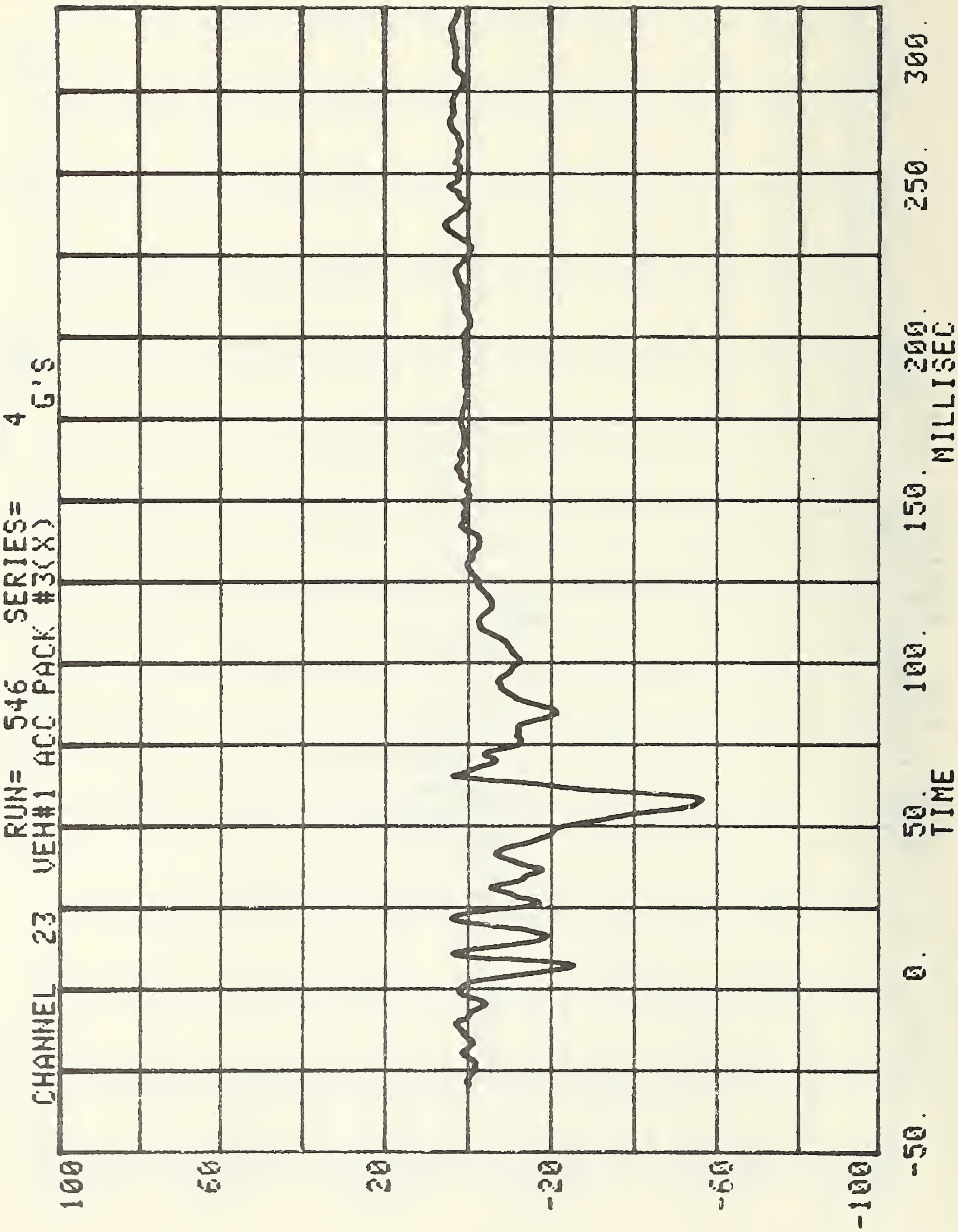

CHANNEL 21 RUN= 546 SERIES= 4
VEH#1 ACC PACK #2(X) G'S
60
20
-20
-60
-100
-140
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

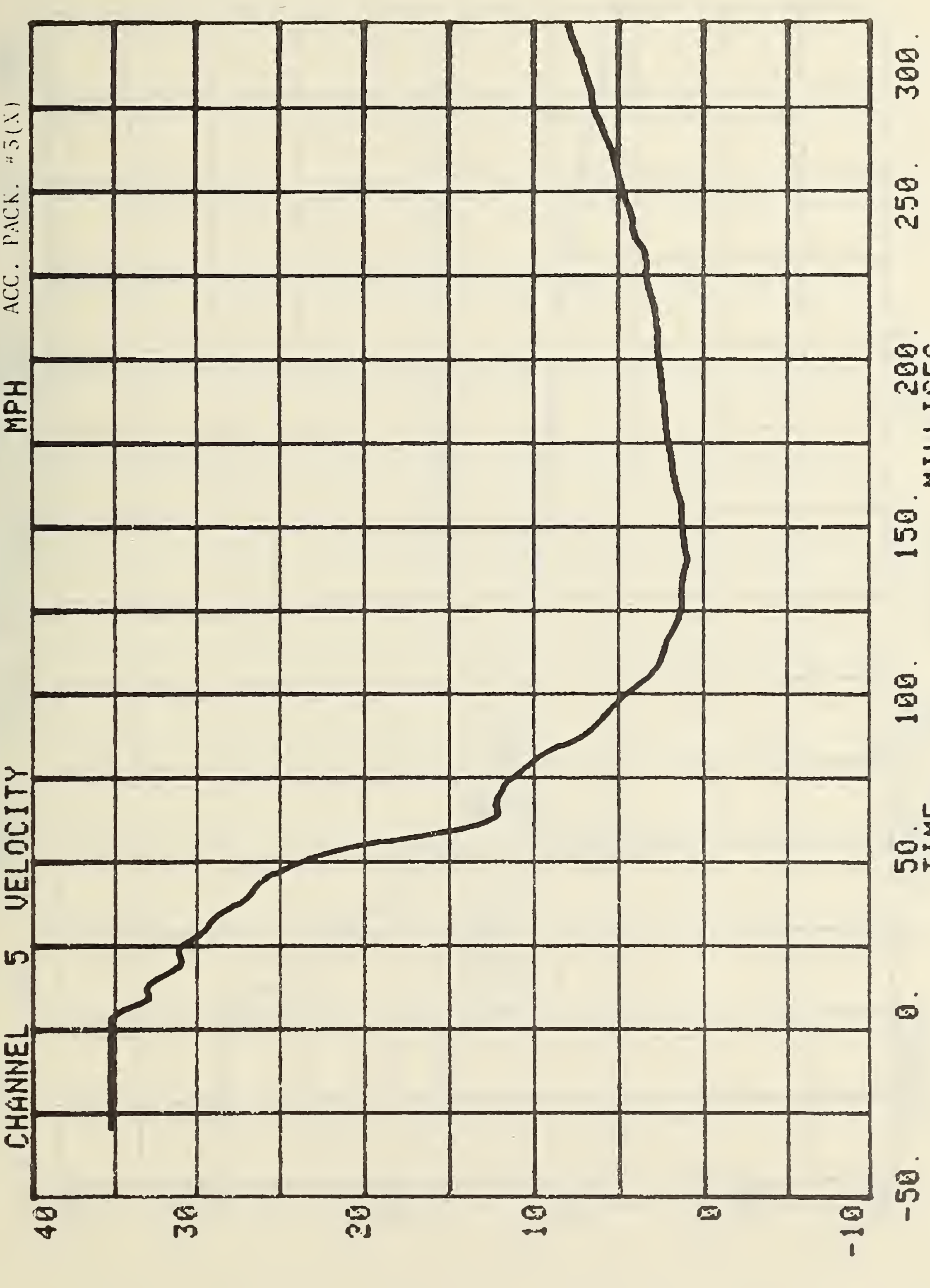


CHANNEL 3 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK. #2(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

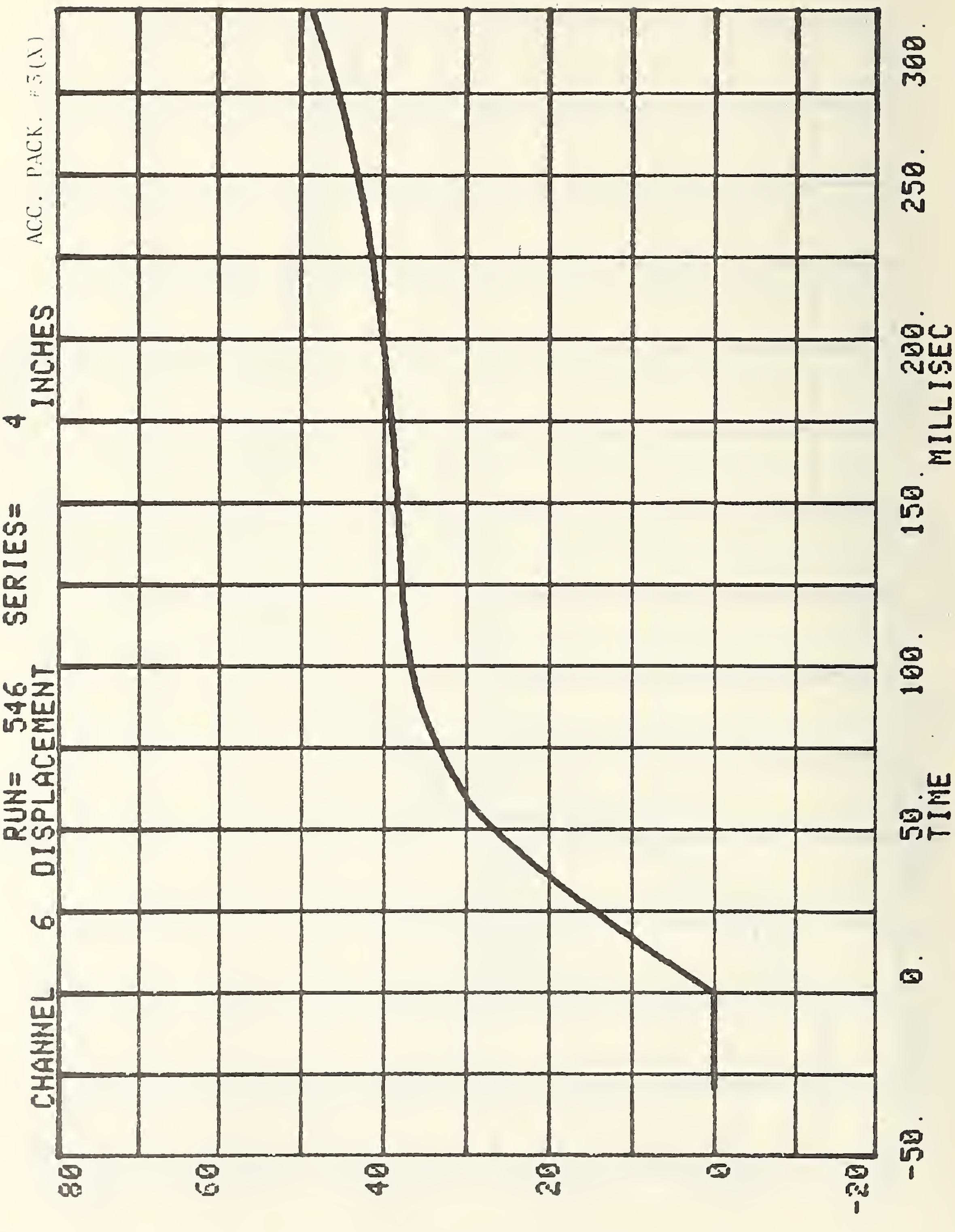

CHANNEL 4 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
ACC. PACK. #2(X)
80
60
40
20
0
-20
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

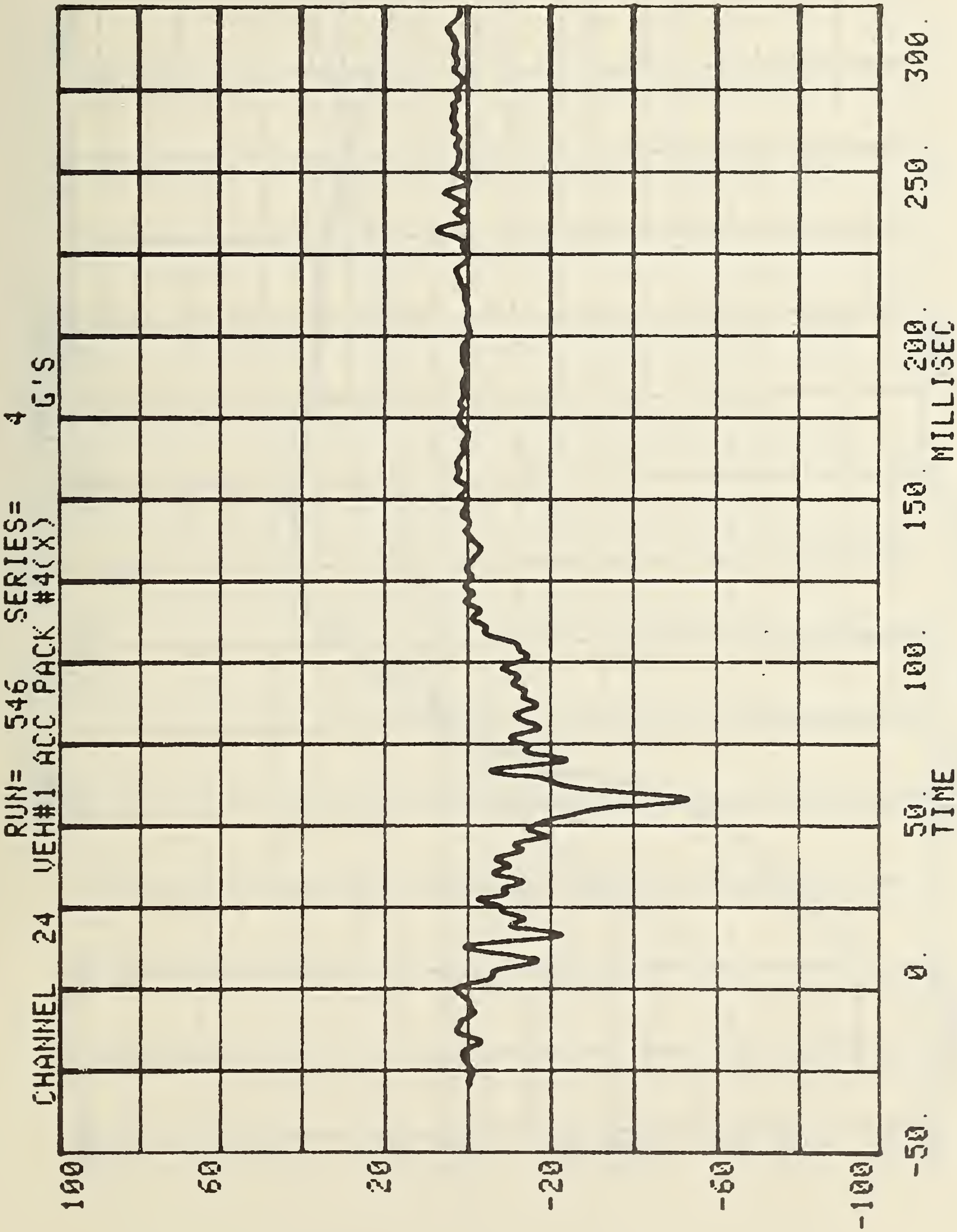

CHANNEL 22 RUN= 546 SERIES= 4
VEH#1 ACC PACK #2(Z) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 23 RUN= 546 SERIES= 4
VEH#1 ACC PACK #3(X) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

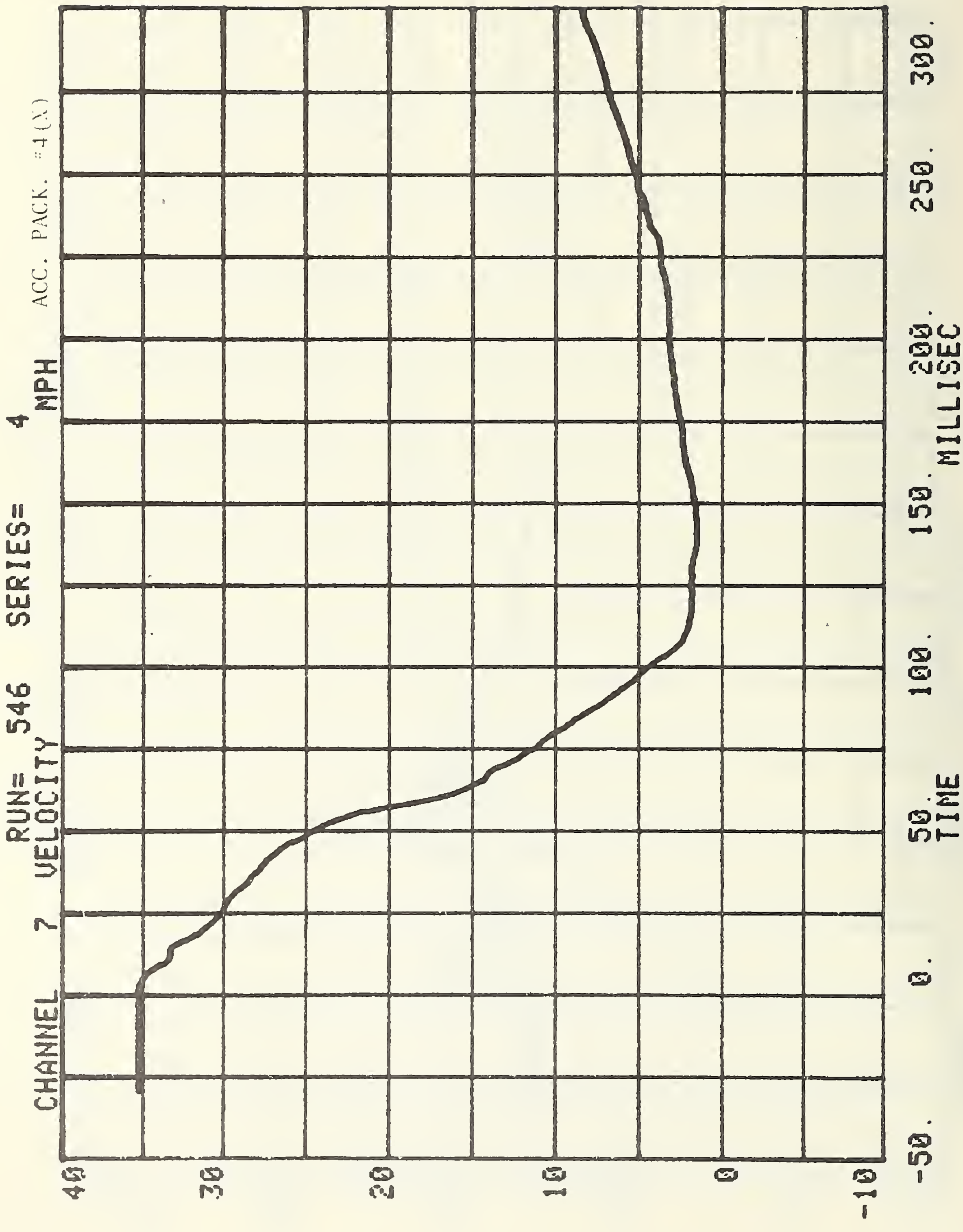


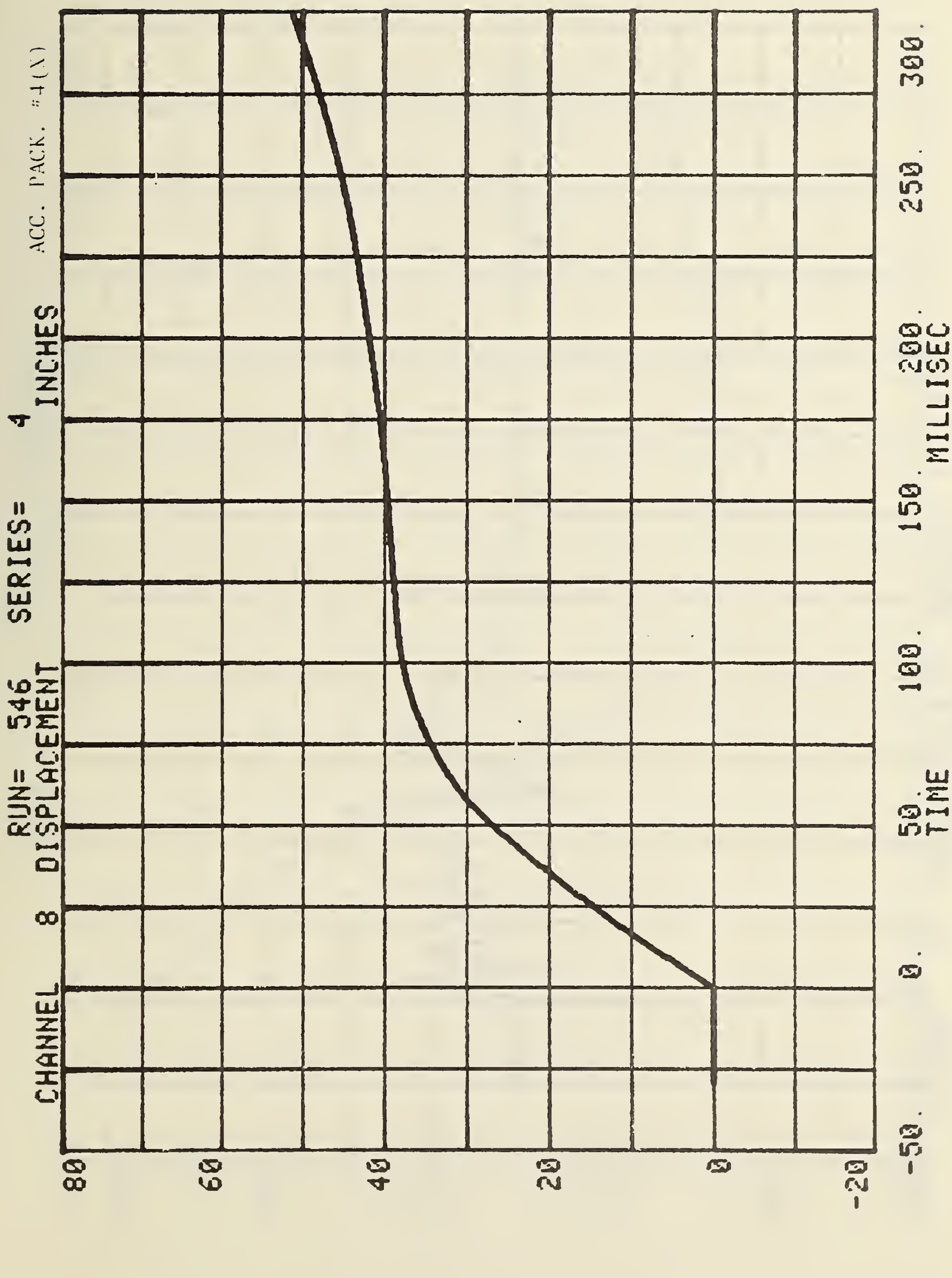
CHANNEL 5 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK. #3(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 6 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
ACC. PACK. #3(X)
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
80
60
40
20
0
-20

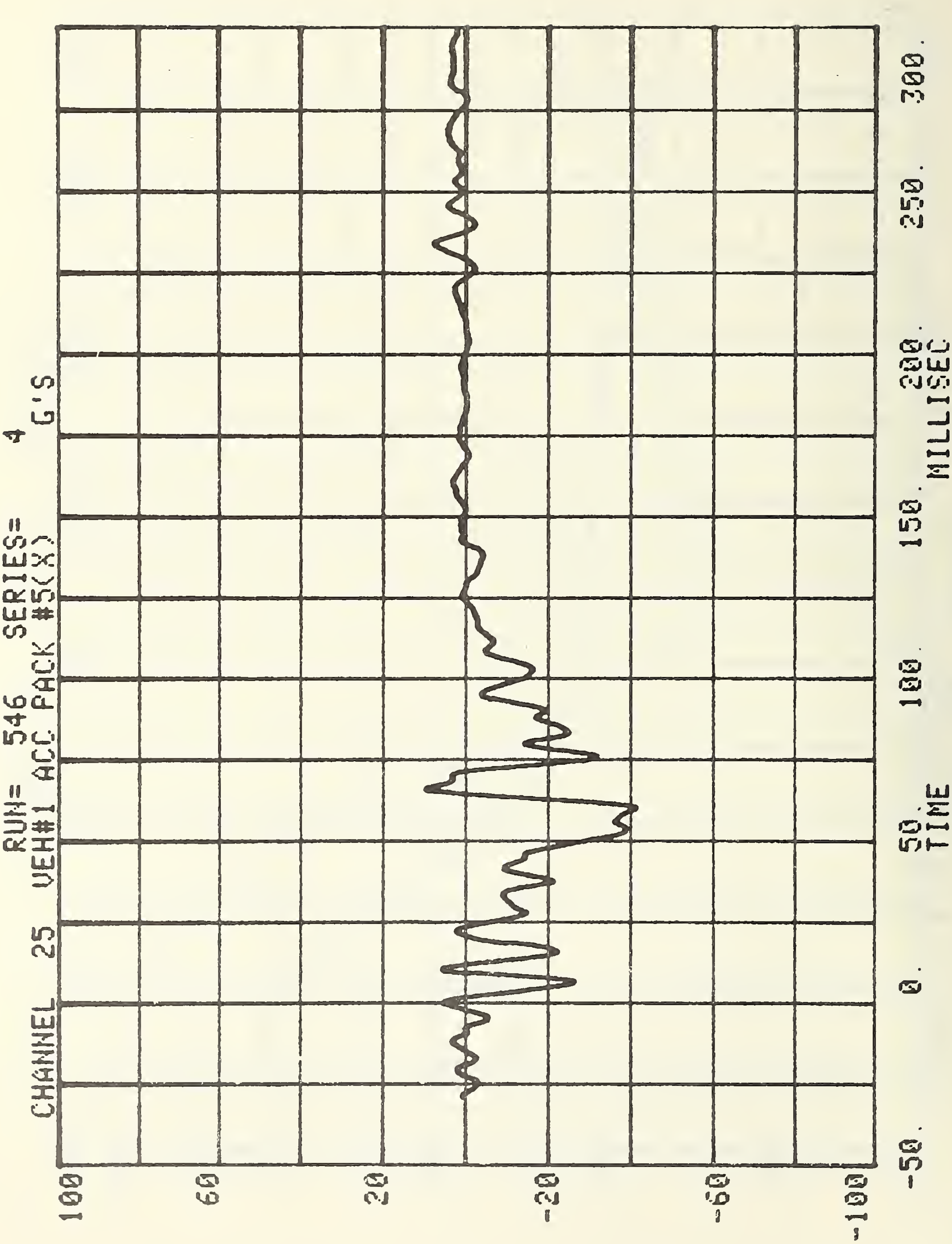


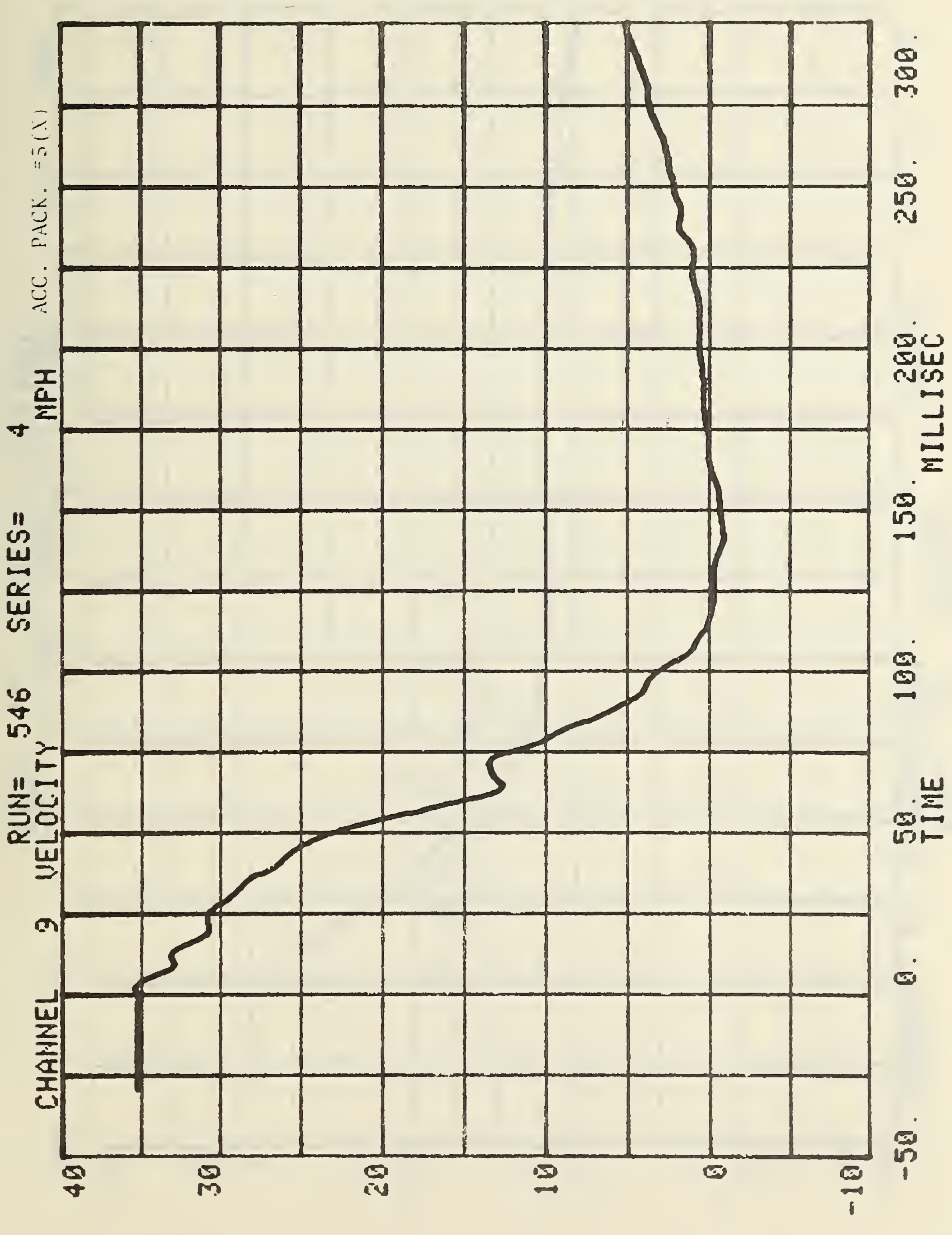
CHANNEL 24 RUN= 546 SERIES= 4
VEH#1 ACC PACK #4(X) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

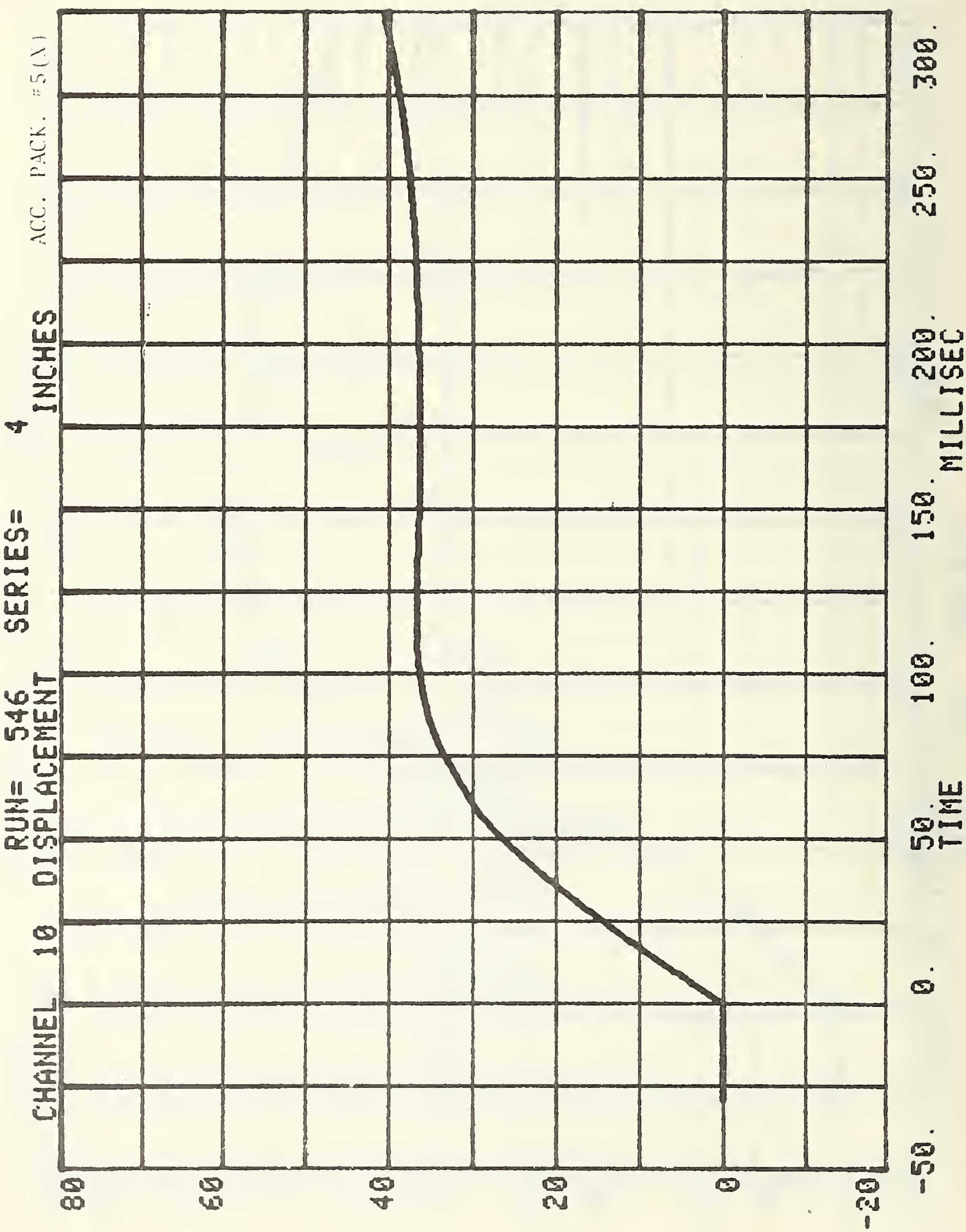

CHANNEL 7 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK. #4(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



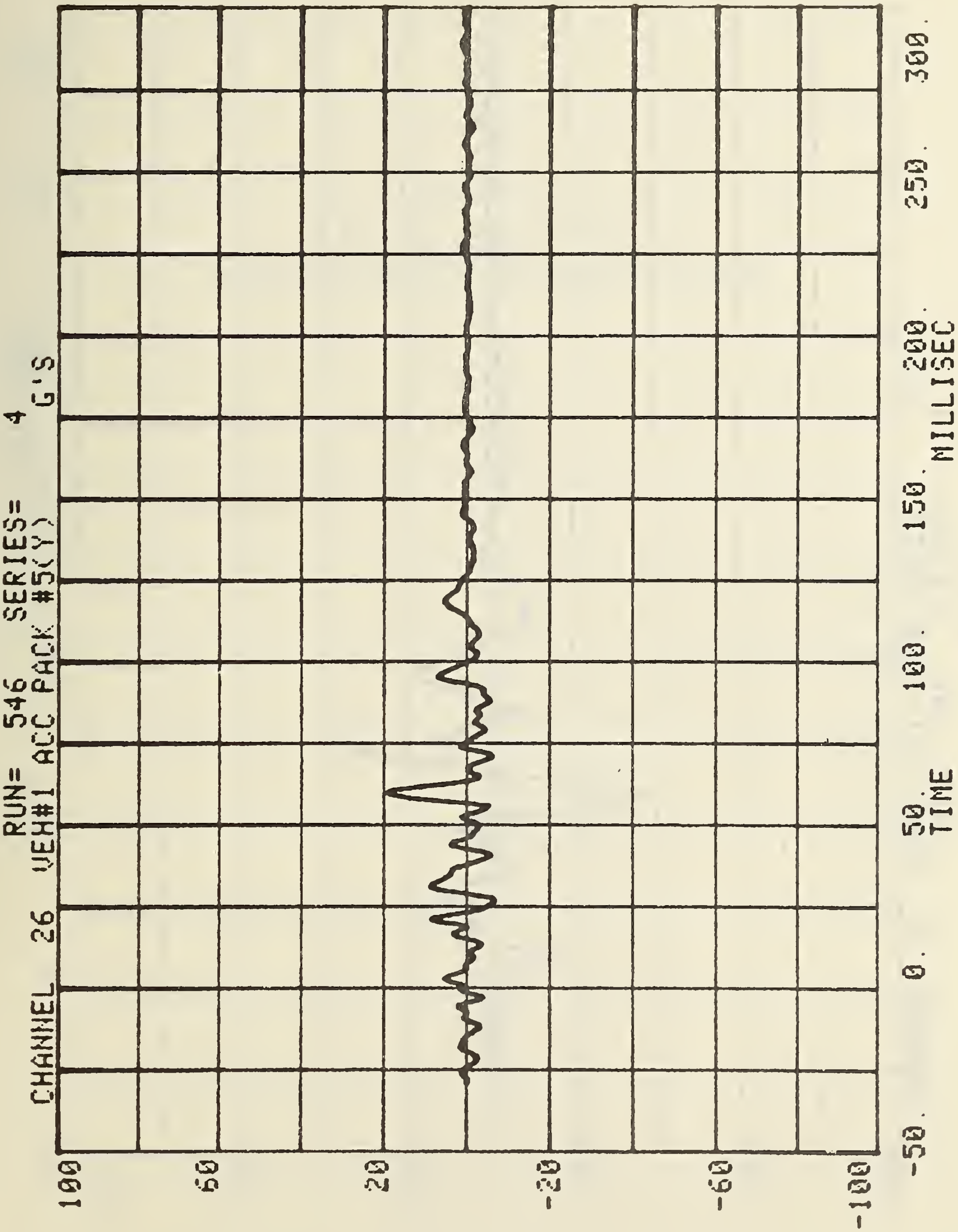
CHANNEL 8 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
ACC. PACK. #4(X)
80
60
40
20
0
-20
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 25 RUN= 546 SERIES= 4
VEH#1 ACC PACK #5(X) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

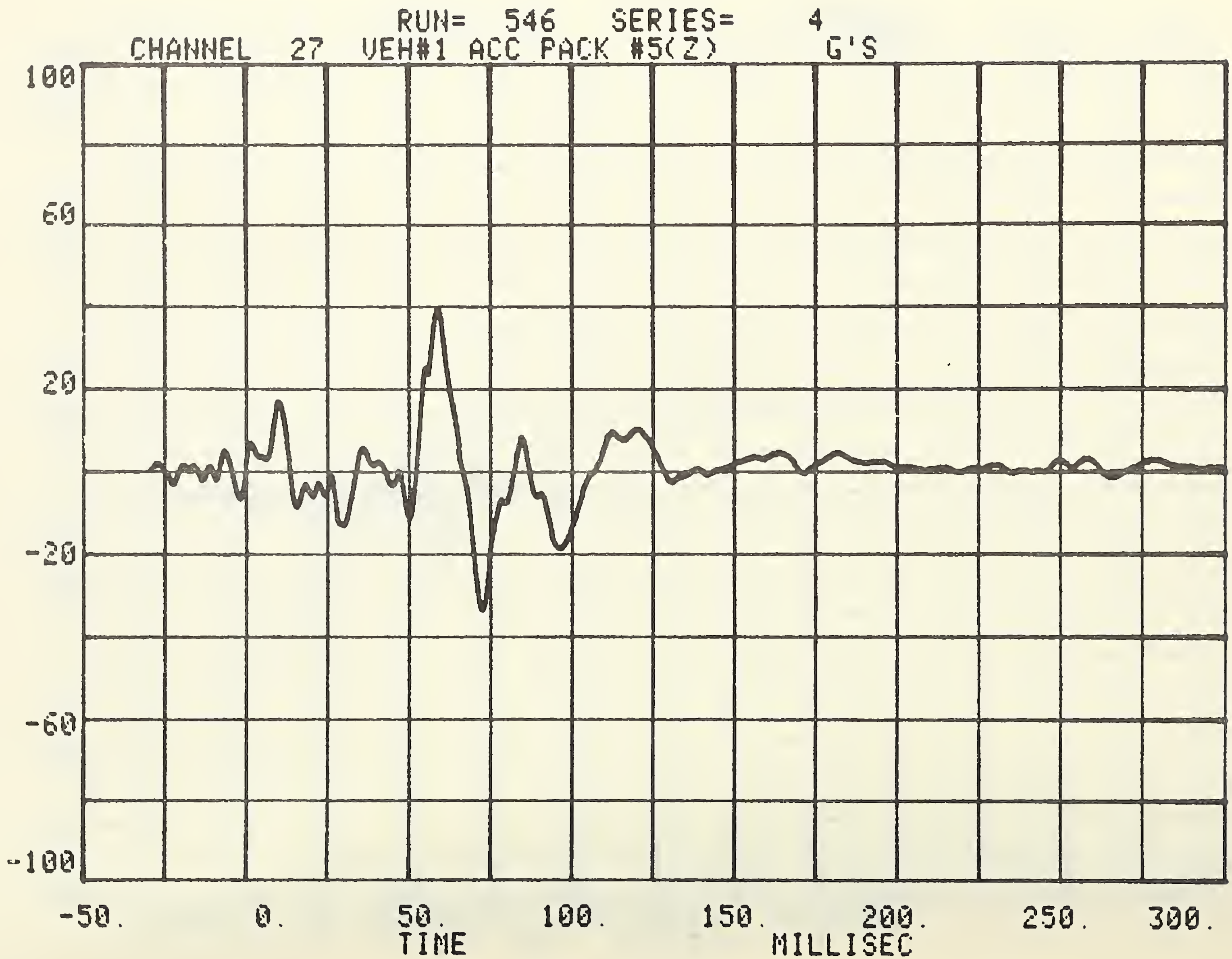

CHANNEL 9 RUN= 546 SERIES= 4
VELOCITY MPH
ACC. PACK. #5(X)
40
30
20
10
0
-10
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 10 RUN= 546 SERIES= 4
DISPLACEMENT INCHES
ACC. PACK. #5(X)
TIME MILLISEC
-50. 0. 50. 100. 150. 200. 250. 300.
80 60 40 20 0 -20

6829-V-8



CHANNEL 26 RUN= 546 SERIES= 4
VEH#1 ACC PACK #5(Y) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


RUN= 546 SERIES= 4
CHANNEL 27 VEH#1 ACC PACK #5(Z) G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC

APPENDIX G

ELECTRONIC CRASH TEST DATA:

FORD MUSTANG OCCUPANT AND RESTRAINT SYSTEM

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

IBSA CAR-TO-CAR TEST #4

RUN= 546

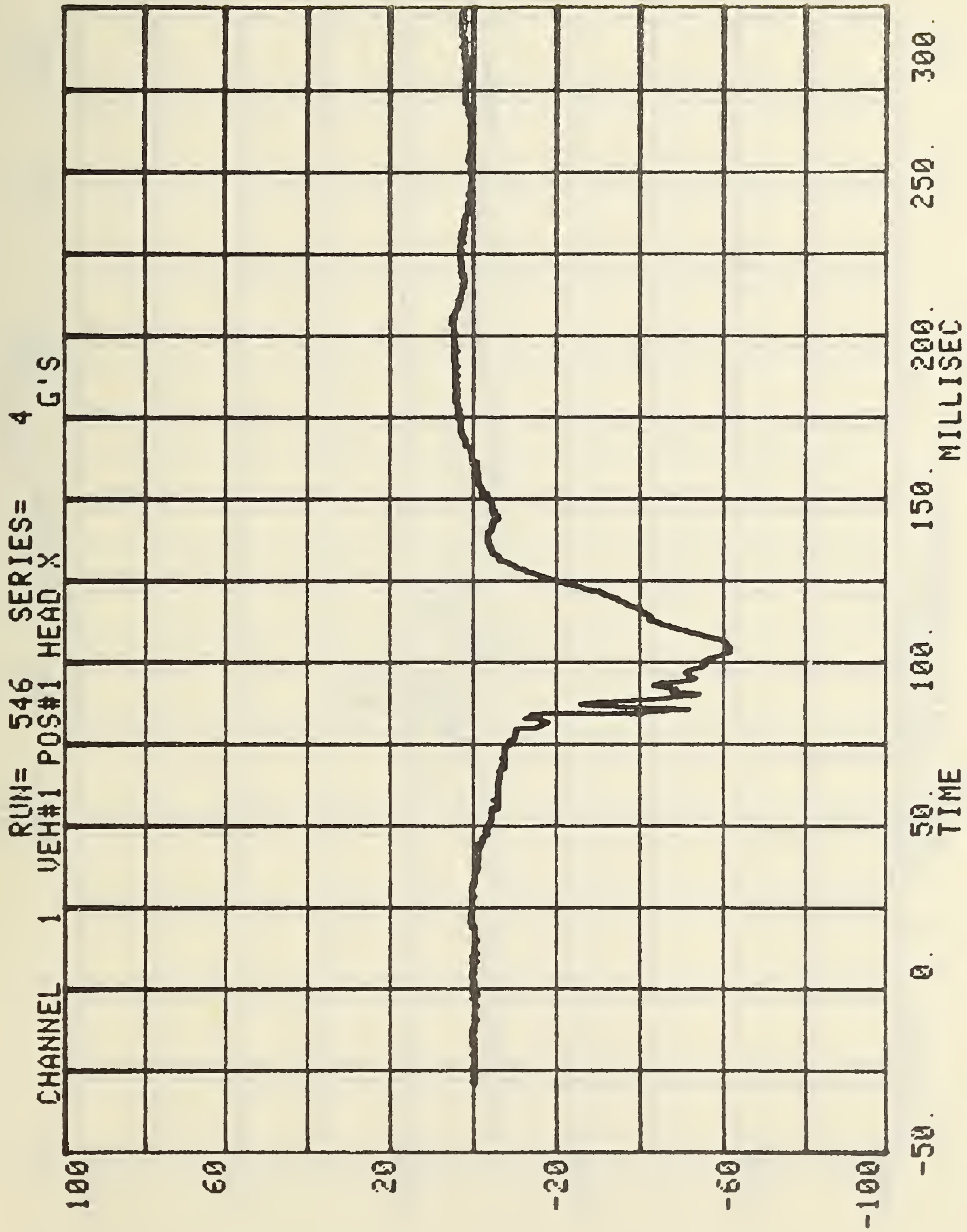
VEH#1 POS#1 HEAD R

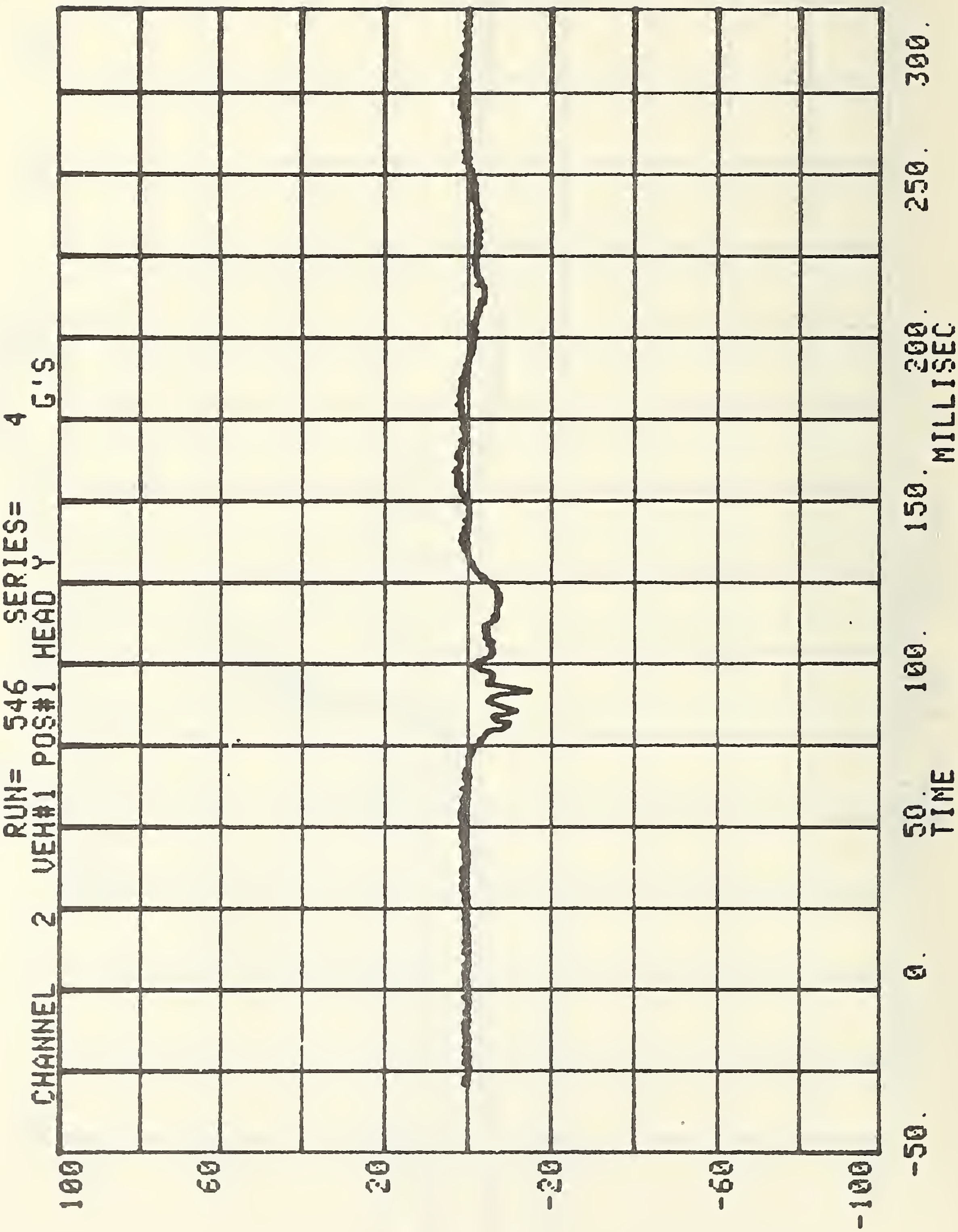
HIC= 709.3   FROM T1= .08400   TO T2= .12210

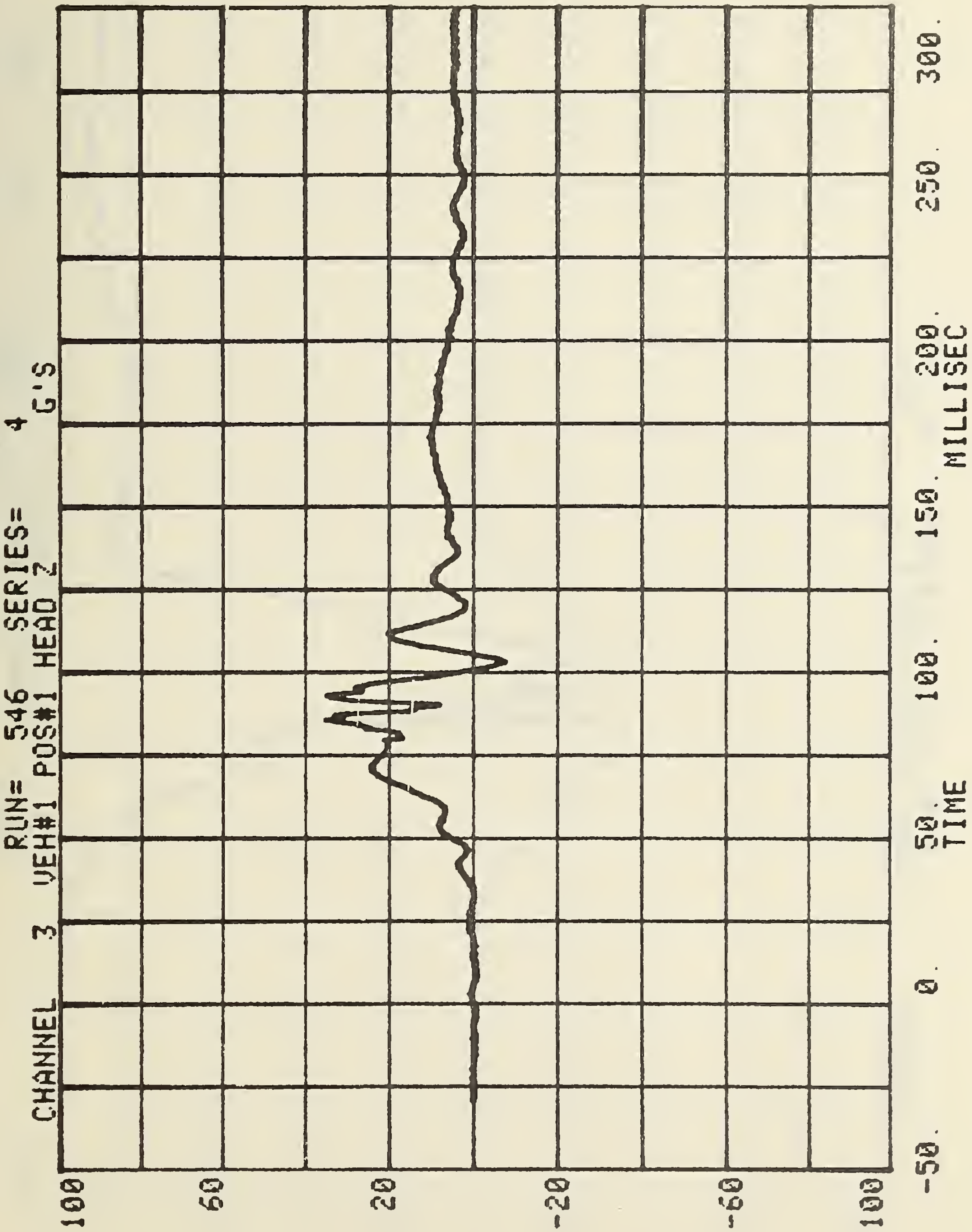
AVERAGE ACCELERATION BETWEEN T1 AND T2= 51.0G'S

EVENT TIME= 300.0 MSEC

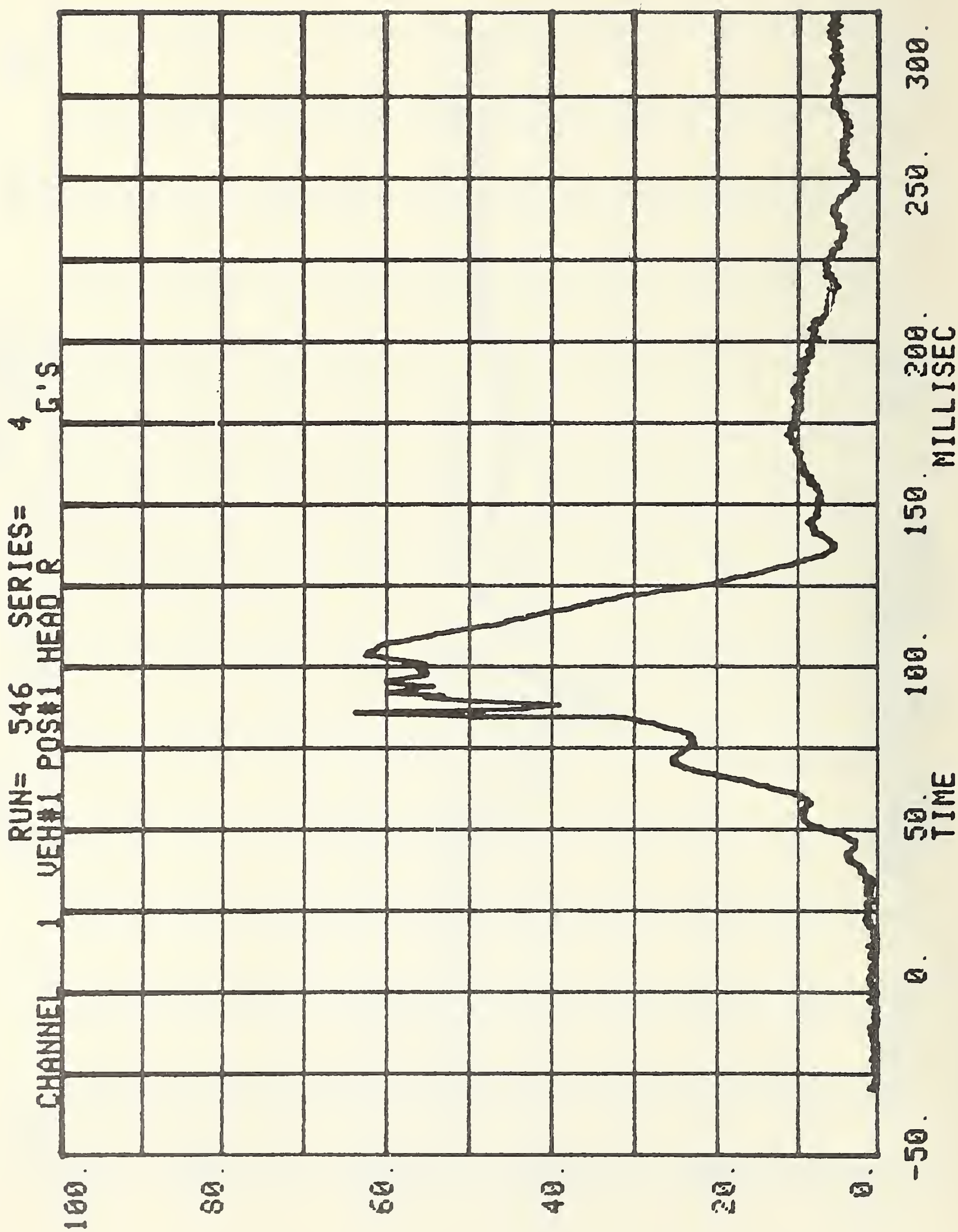
SEVERITY INDEX= 850.9

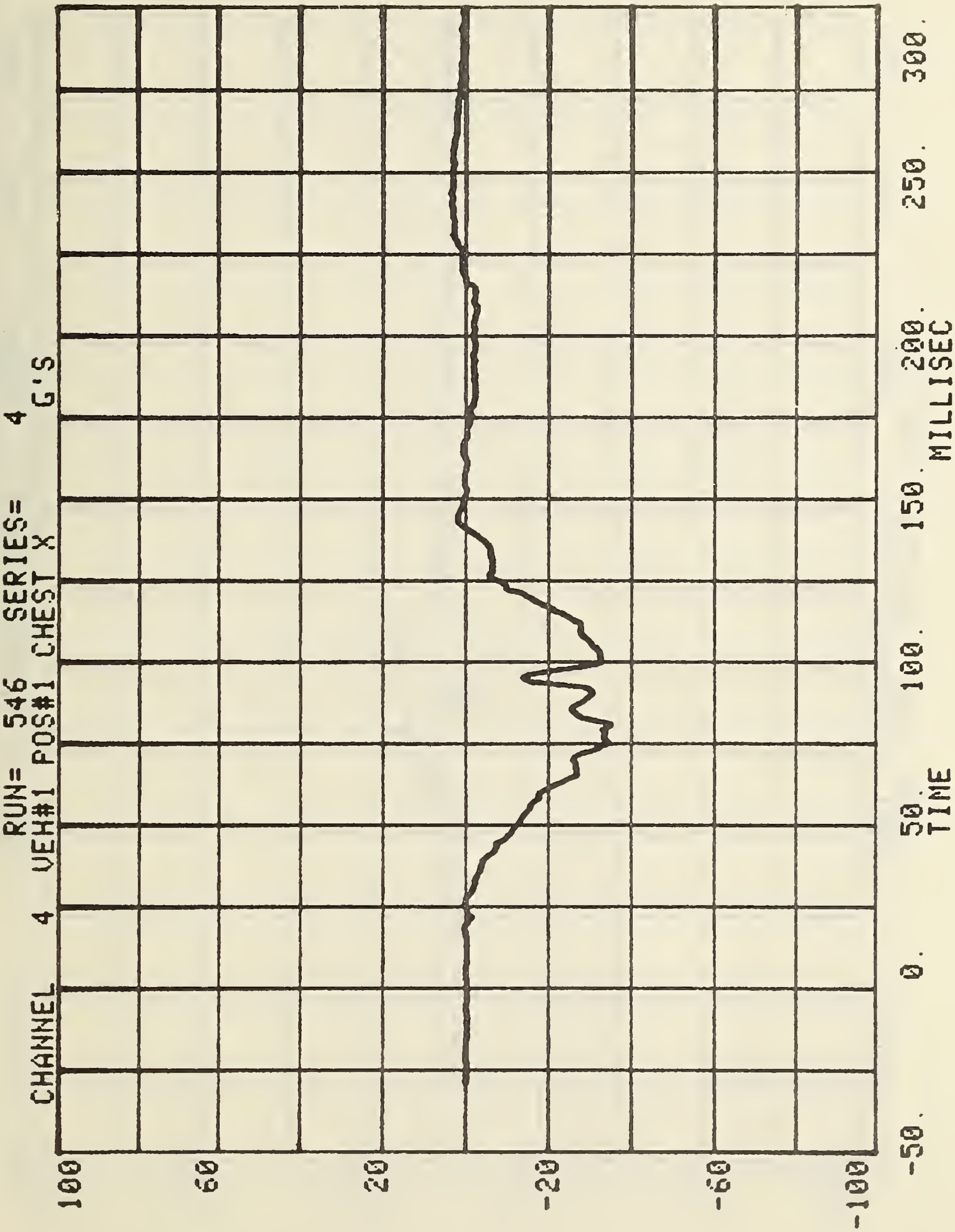

CHANNEL 1 RUN= 546 SERIES= 4
VEH#1 POS#1 HEAD X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

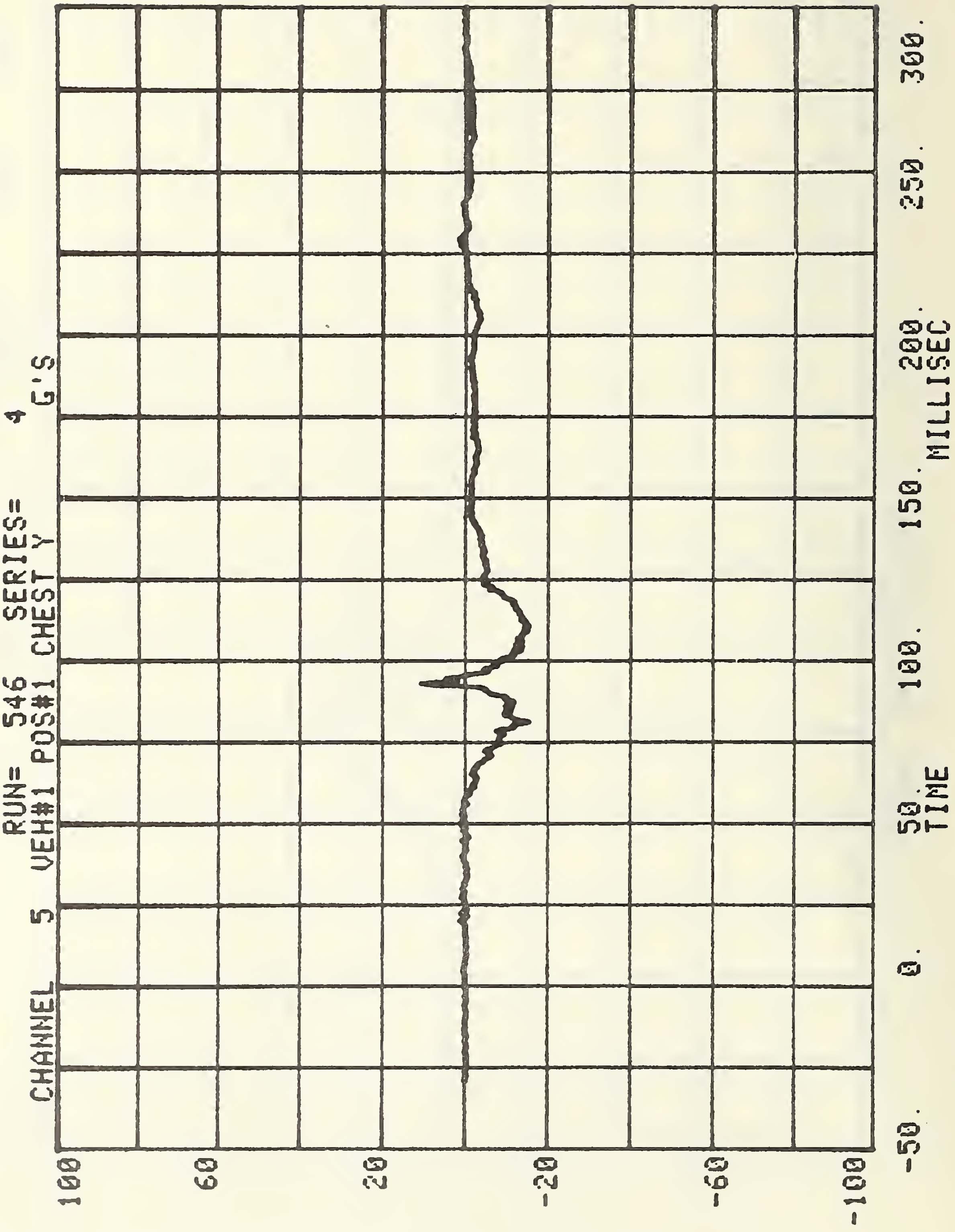

CHANNEL 2 RUN= 546 SERIES= 4
VEH#1 POS#1 HEAD Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

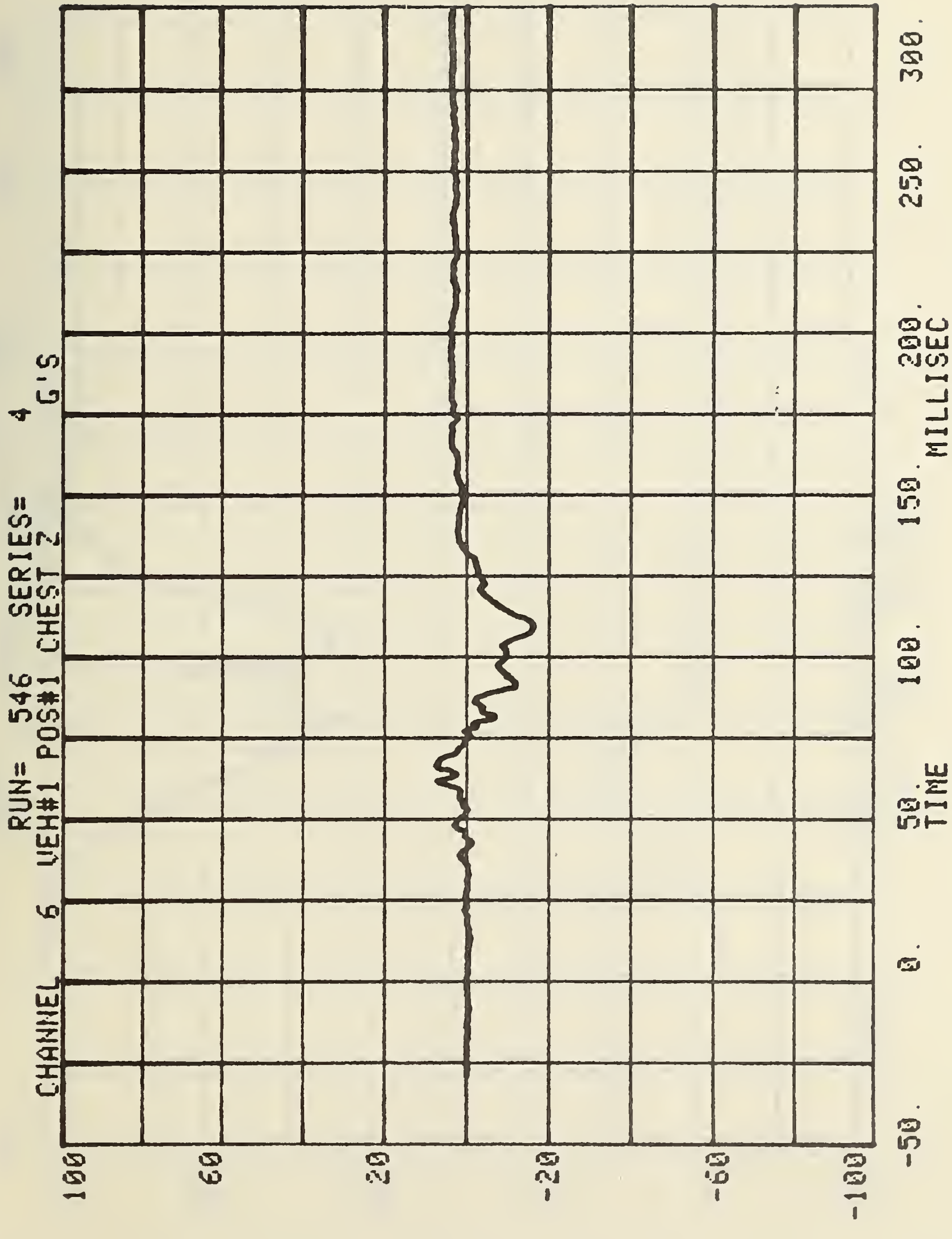


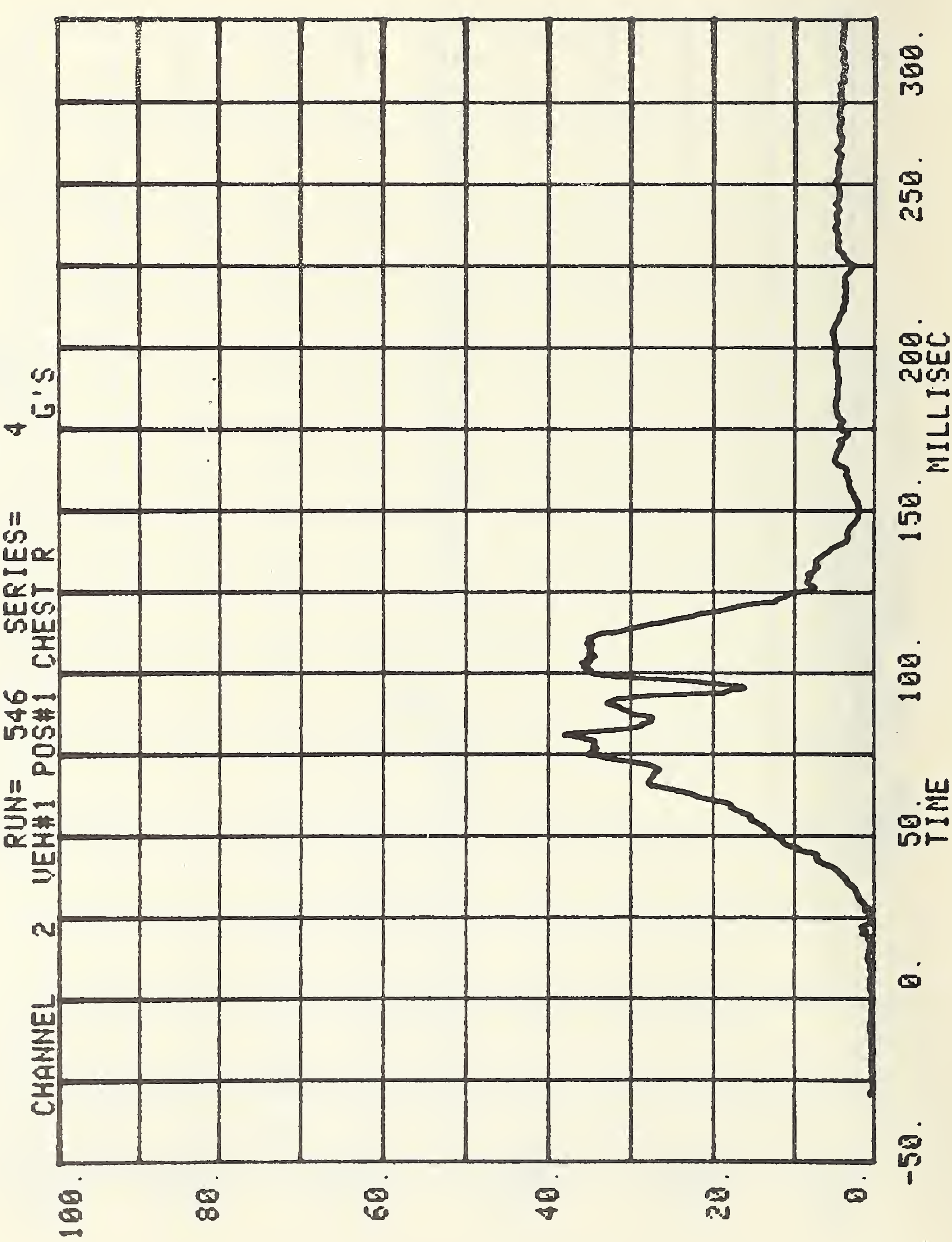
CHANNEL 3 RUN= 546 SERIES= 4
VEH#1 POS#1 HEAD Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

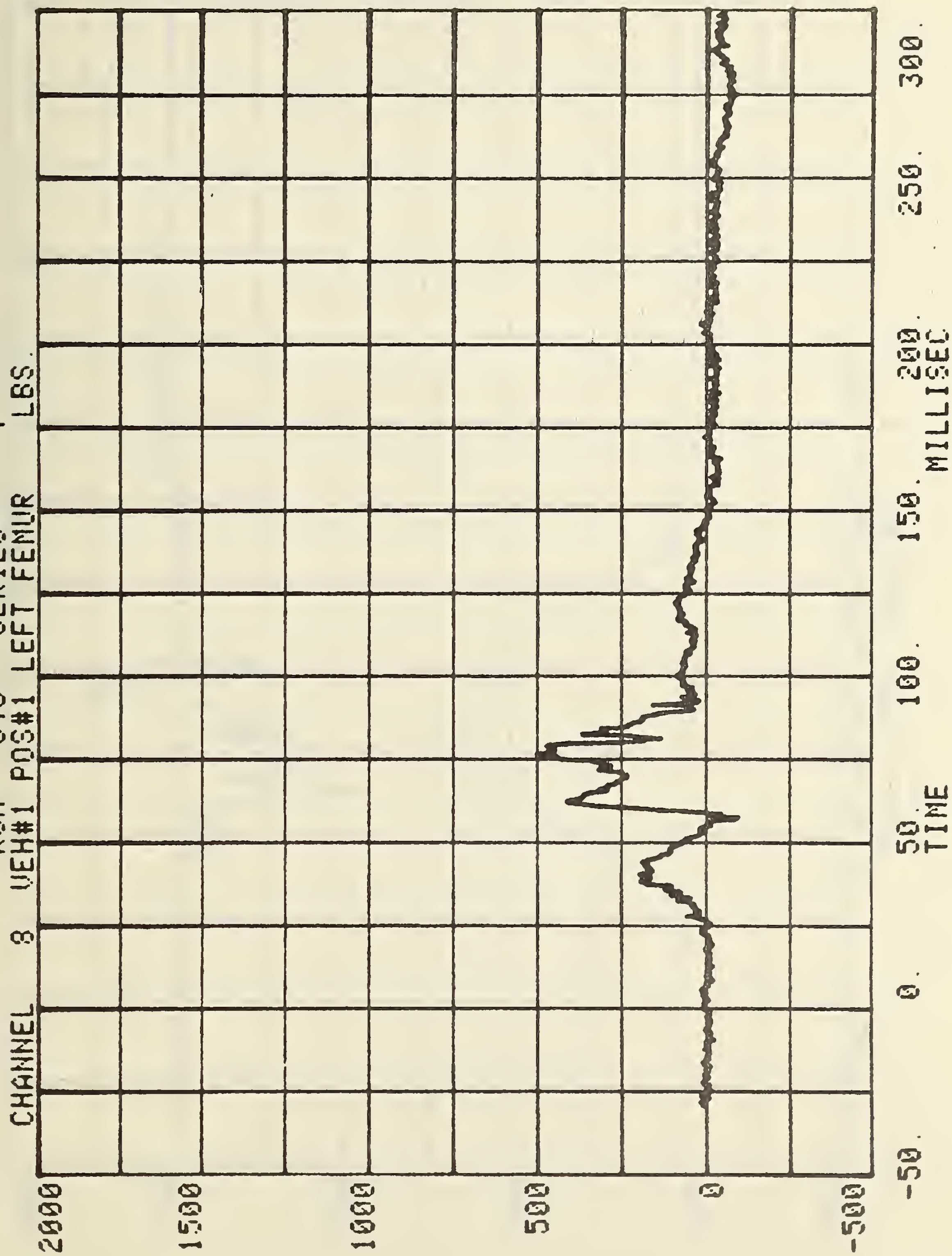

CHANNEL 1 RUN= 546 SERIES= 4
VEH#1 POS#1 HEAD R G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

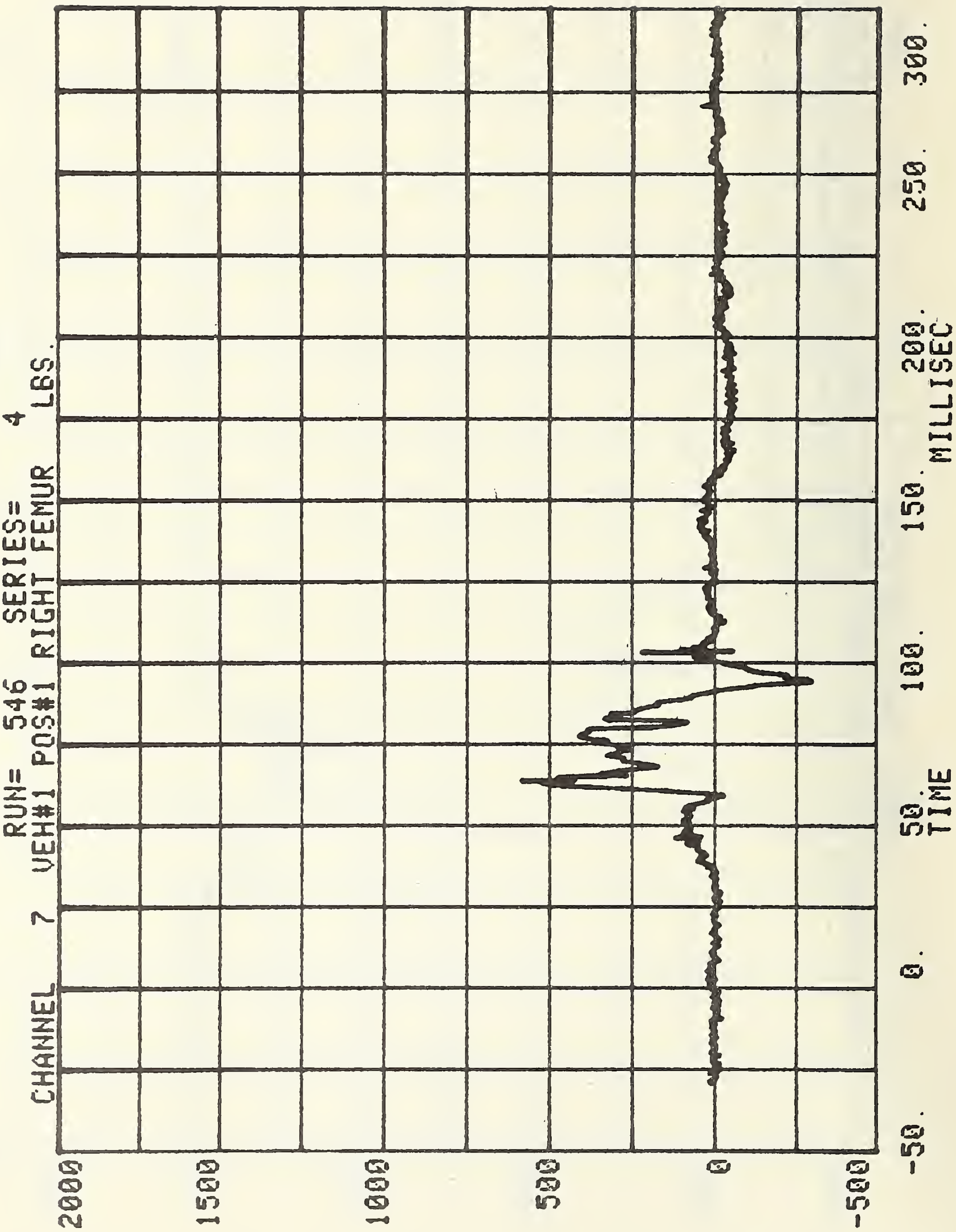

CHANNEL 4 RUN= 546 SERIES= 4
VEH#1 POS#1 CHEST X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 5 RUN= 546 SERIES= 4
VEH#1 POS#1 CHEST Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

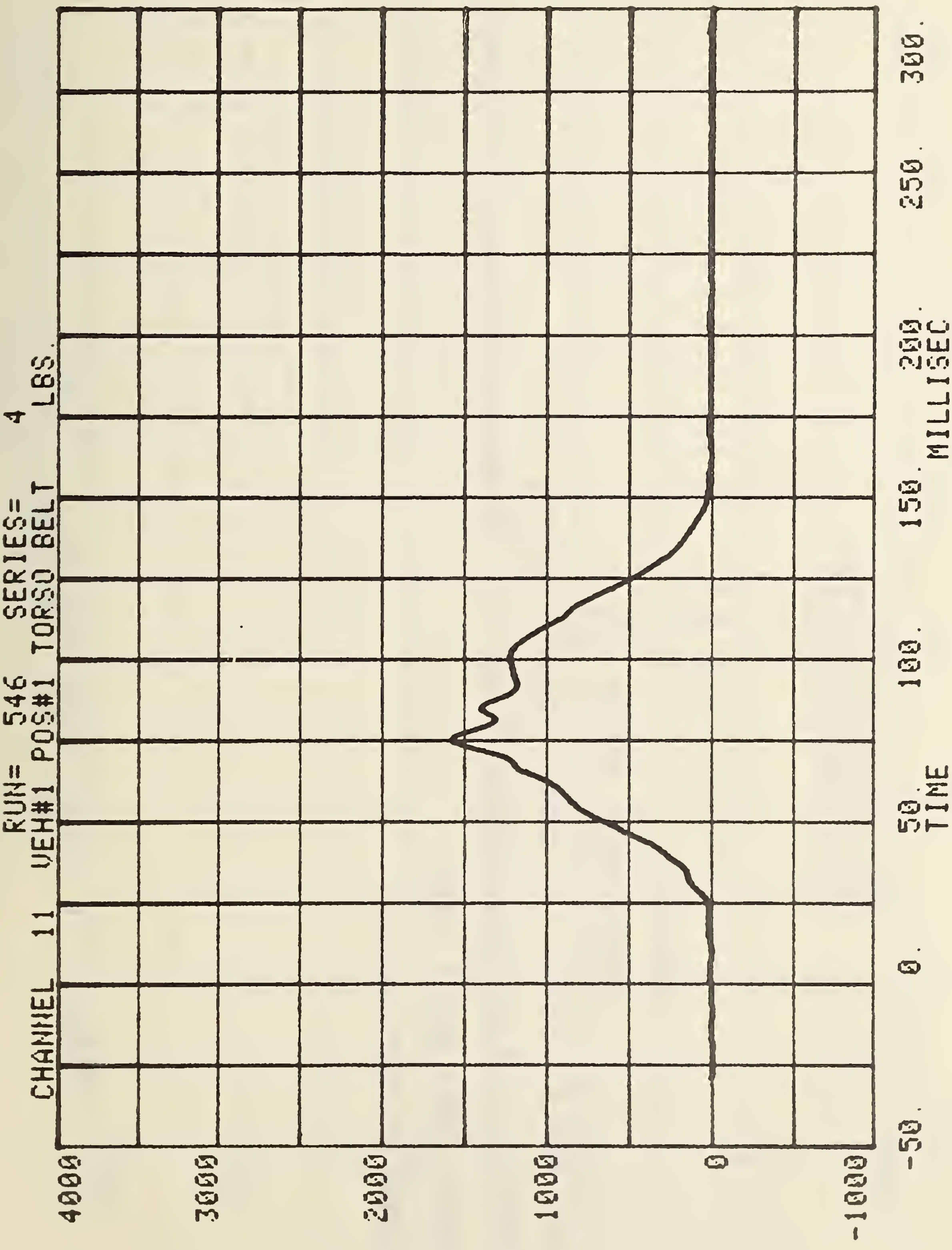

CHANNEL 6 RUN= 546 SERIES= 4
VEH#1 POS#1 CHEST Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 2 RUN= 546 SERIES= 4
VEH#1 POS#1 CHEST R G'S
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 8 RUN= 546 SERIES= 4
VEH#1 POS#1 LEFT FEMUR LBS.
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 7 RUN= 546 SERIES= 4
VEH#1 POS#1 RIGHT FEMUR LBS.
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 11 RUN= 546 SERIES= 4
VEH#1 POS#1 TORSO BELT LBS.
4000
3000
2000
1000
0
-1000
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

IBSA CAR-TO-CAR TEST #4

RUN= 546

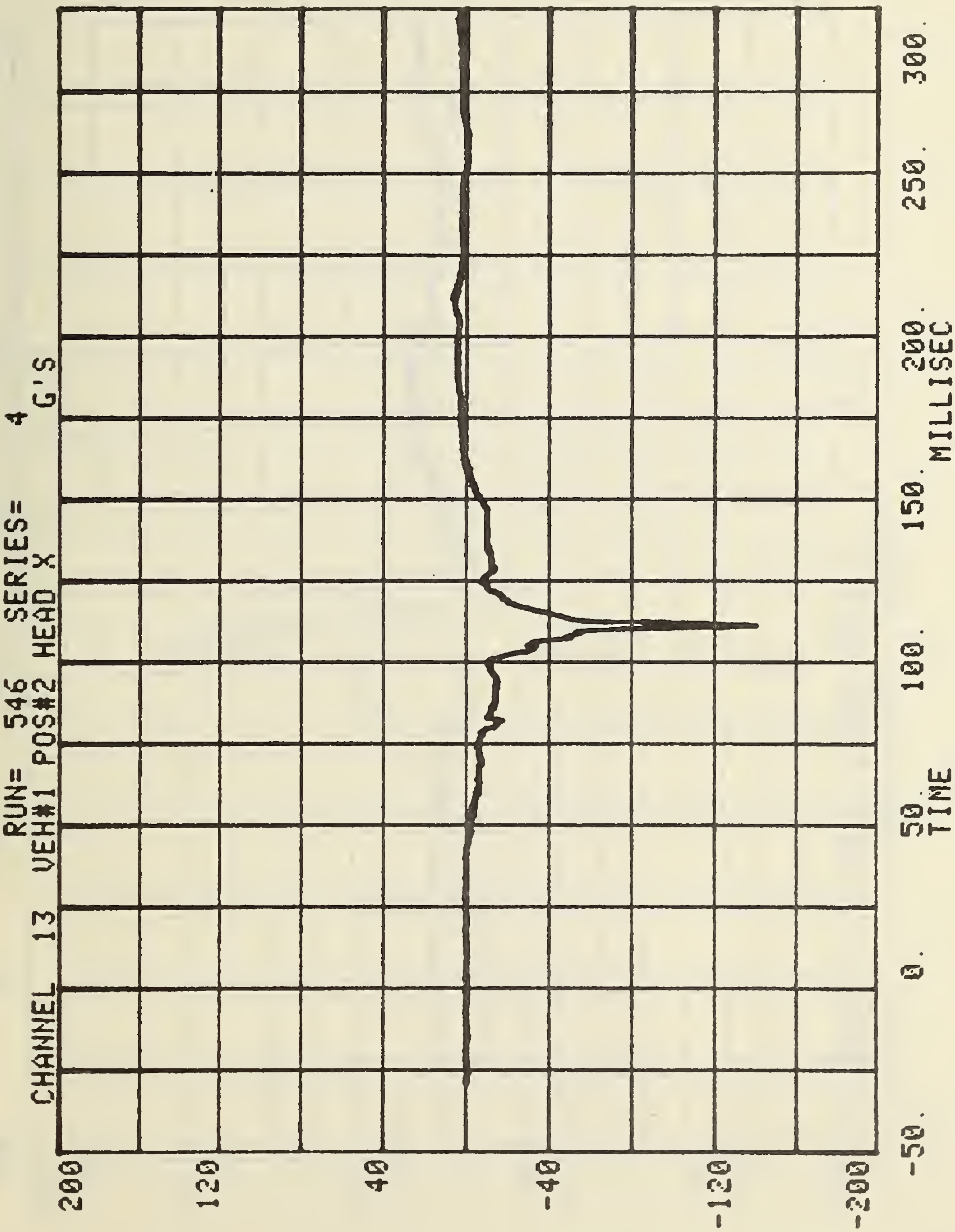
VEH#1 POS#2 HEAD R

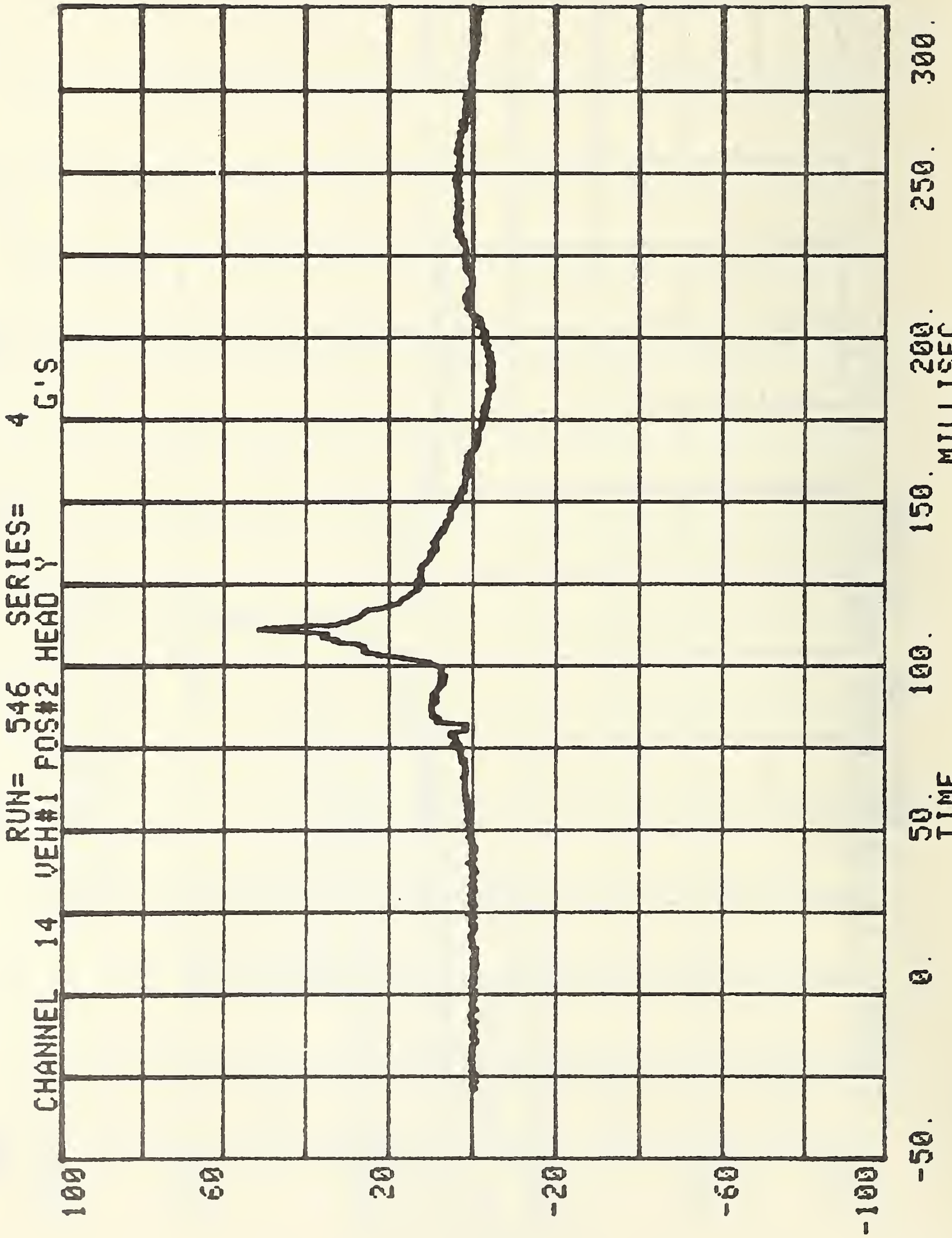
HIC= 896.0   FROM T1= .09510   TO T2= .12150

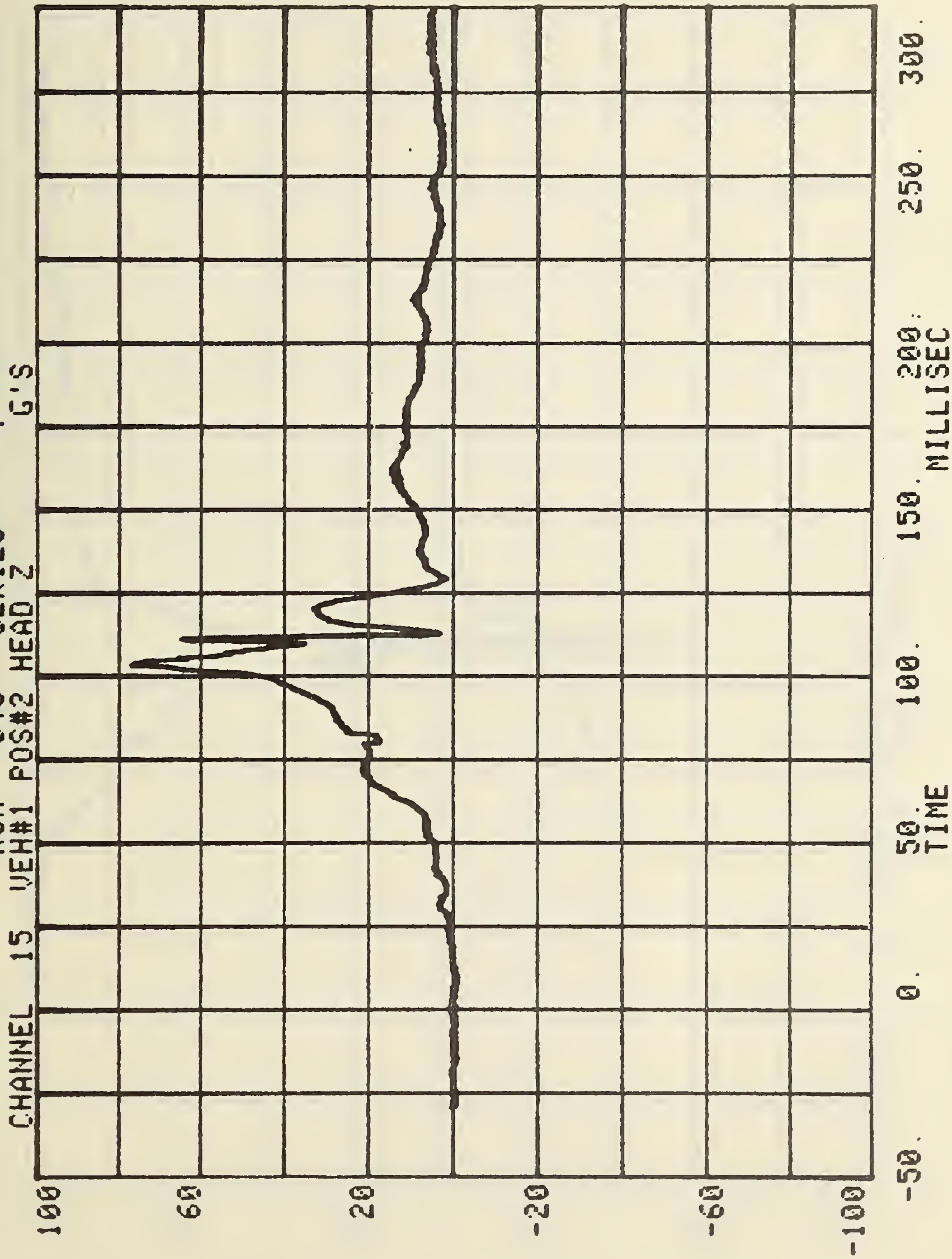
AVERAGE ACCELERATION BETWEEN T1 AND T2= 64.9G'S

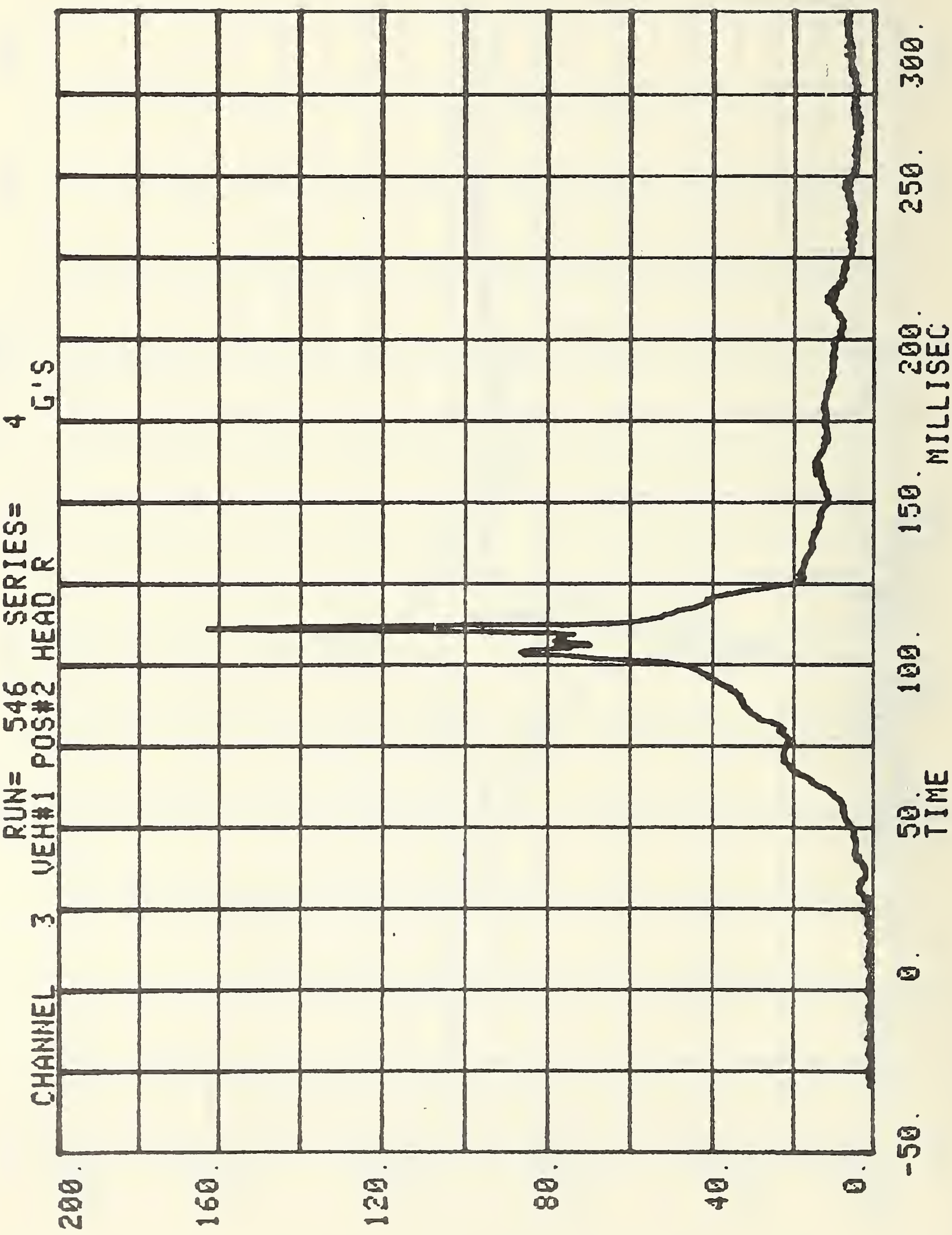
EVENT TIME= 300.0 MSEC

SEVERITY INDEX=1421.6

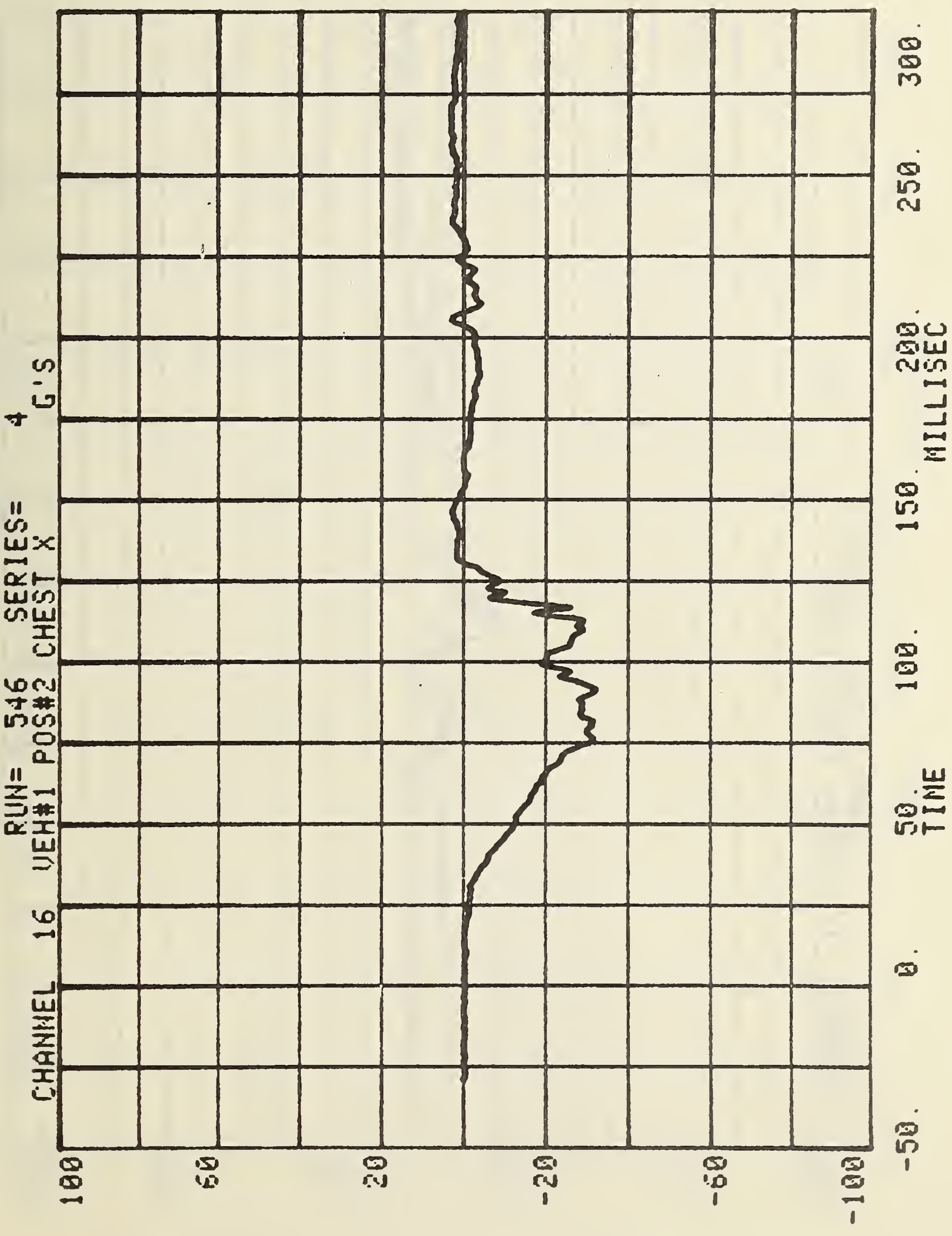

CHANNEL 13 RUN= 546 SERIES= 4
VEH#1 POS#2 HEAD X G'S
200
120
40
-40
-120
-200
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

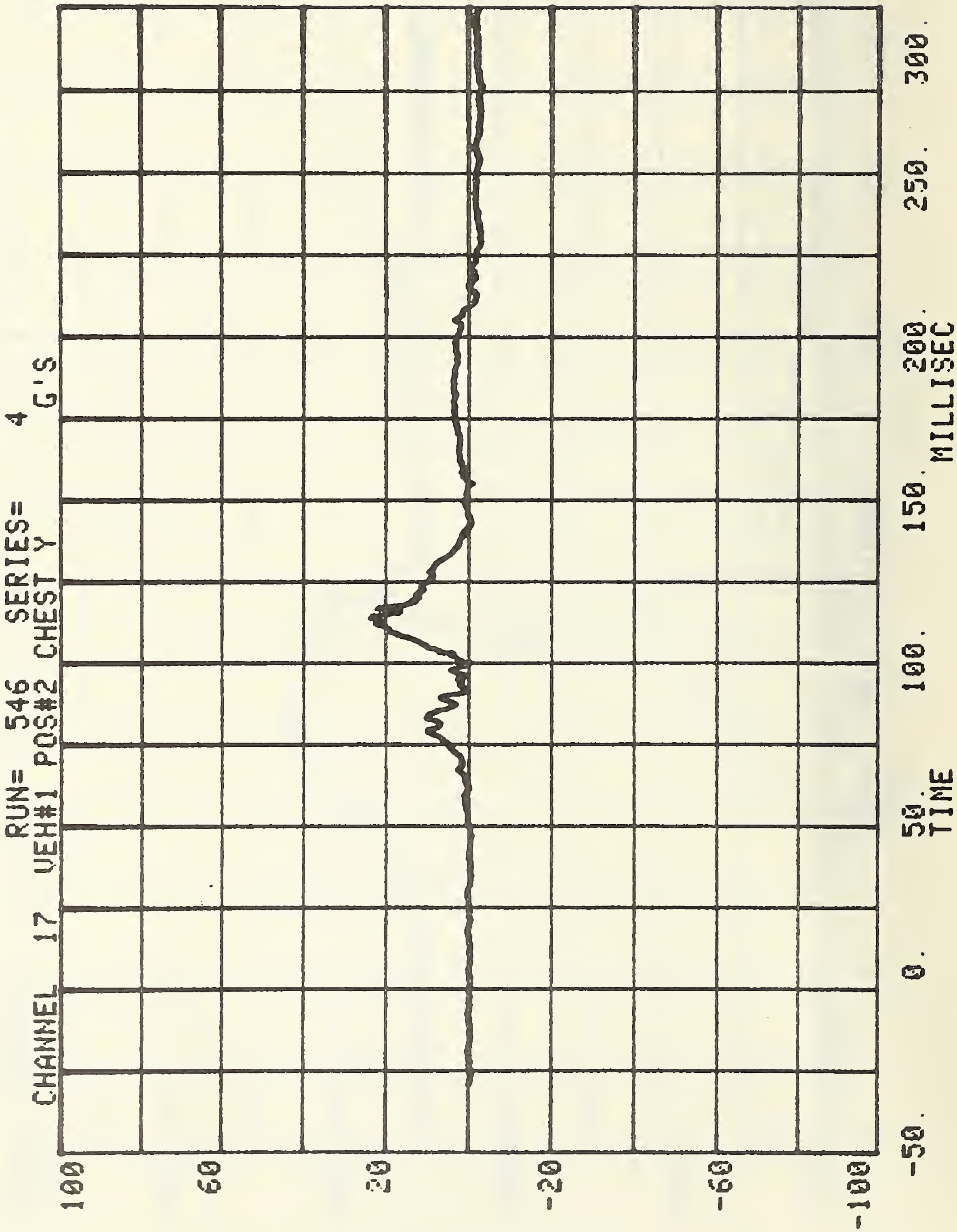

CHANNEL 14 RUN= 546 SERIES= 4
VEH#1 POS#2 HEAD Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

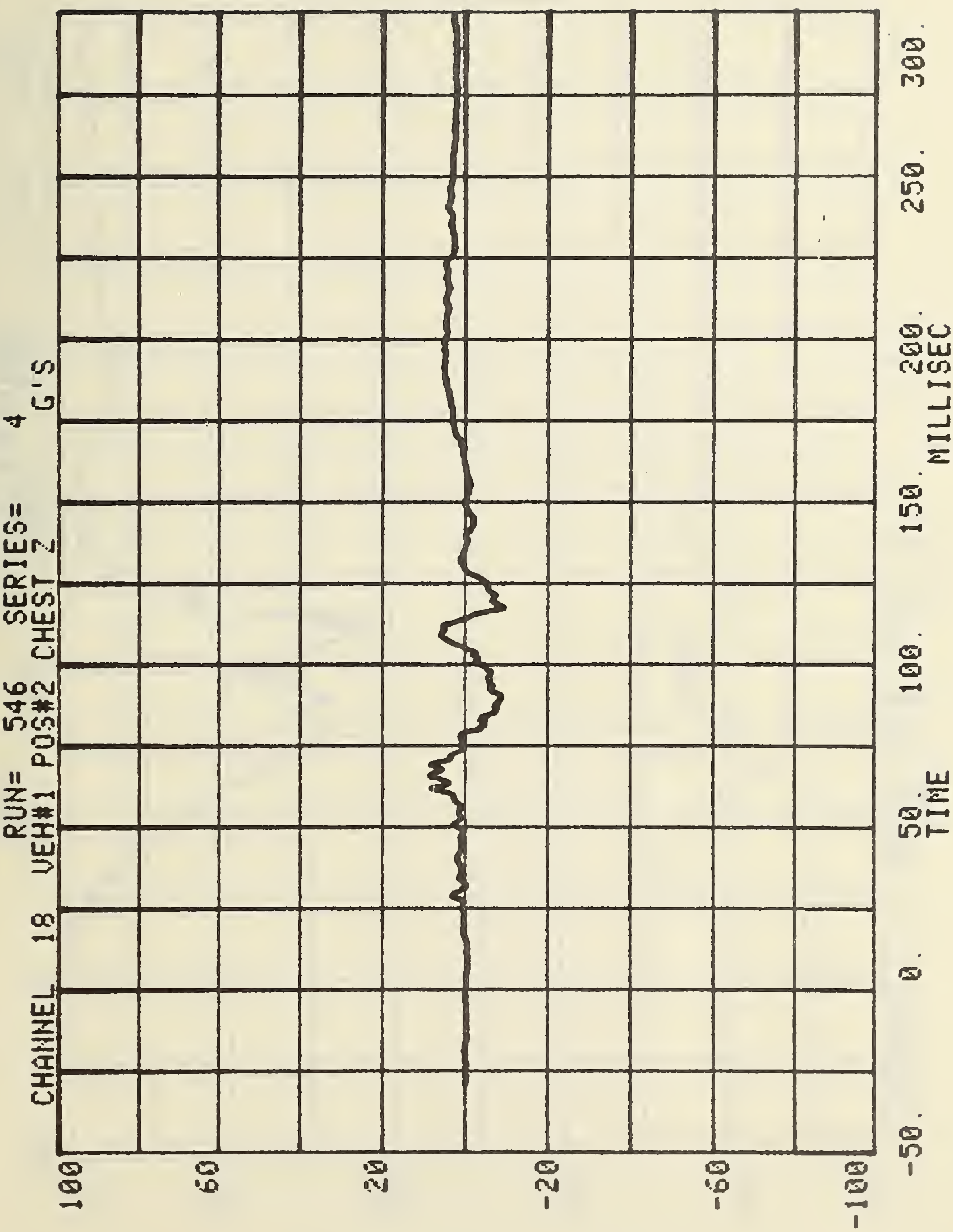

CHANNEL 15 RUN= 546 SERIES= 4
VEH#1 POS#2 HEAD Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

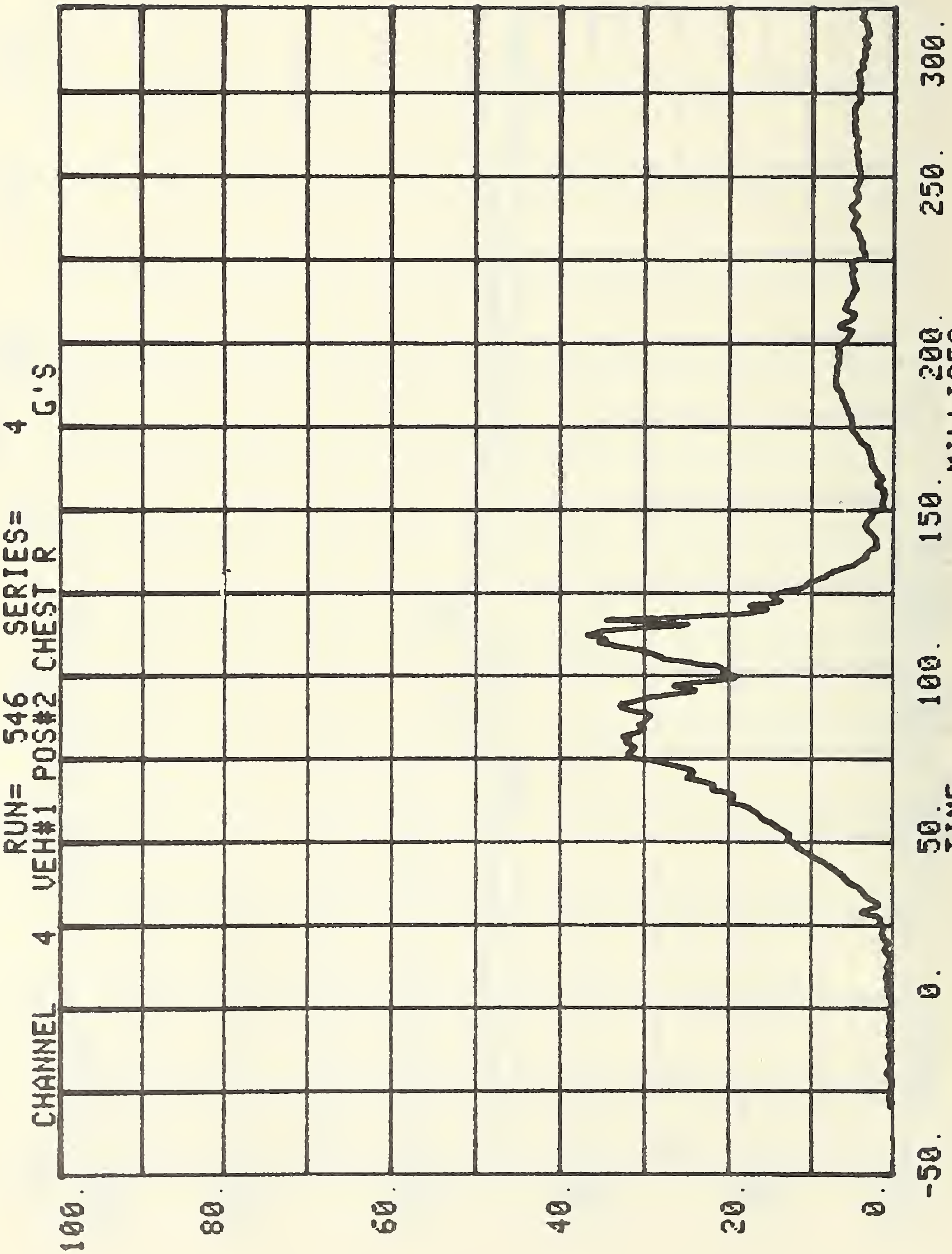


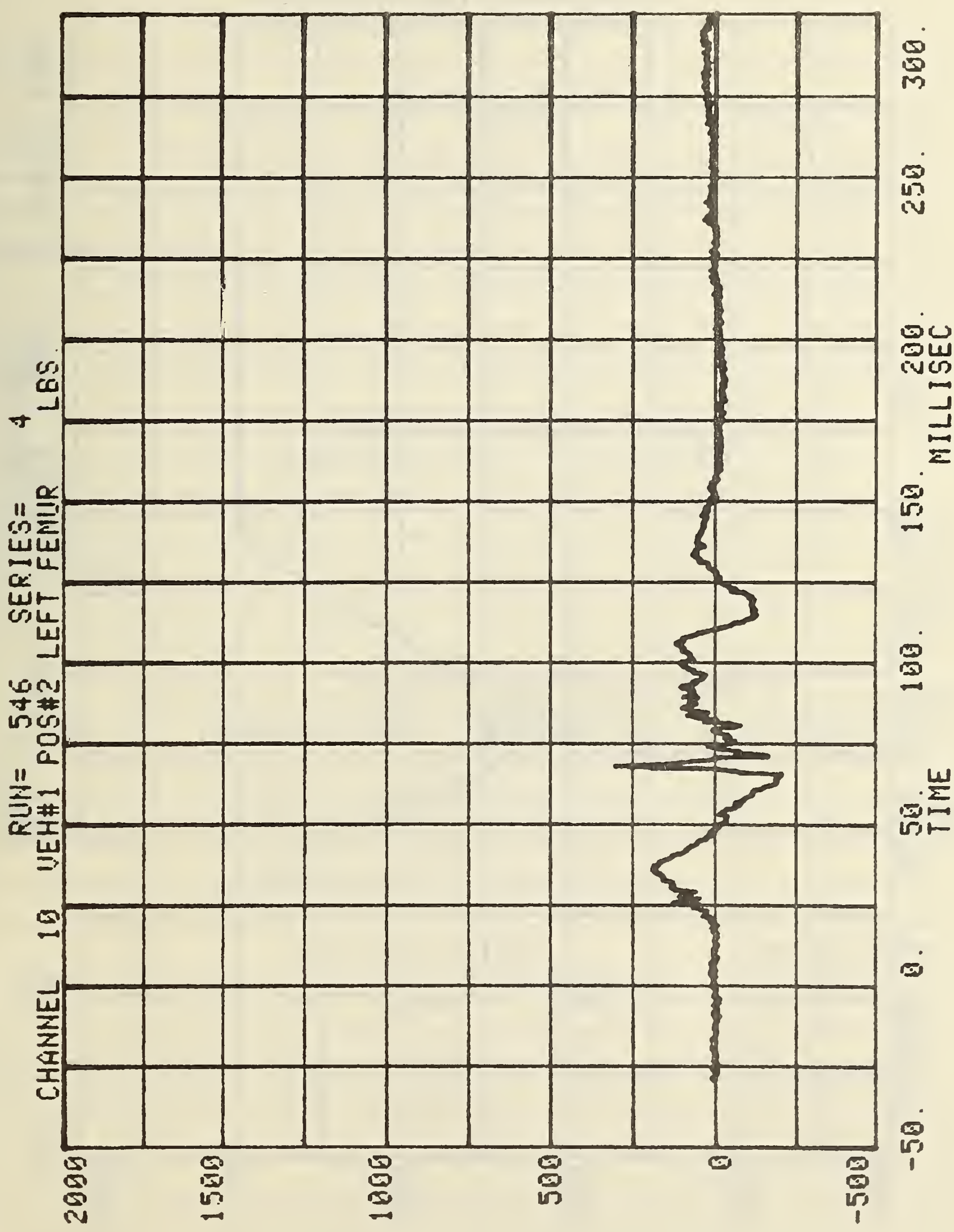
CHANNEL 3 RUN= 546 SERIES= 4
VEH#1 POS#2 HEAD R G'S
200.
160.
120.
80.
40.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 16 RUN= 546 SERIES= 4
VEH#1 POS#2 CHEST X G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

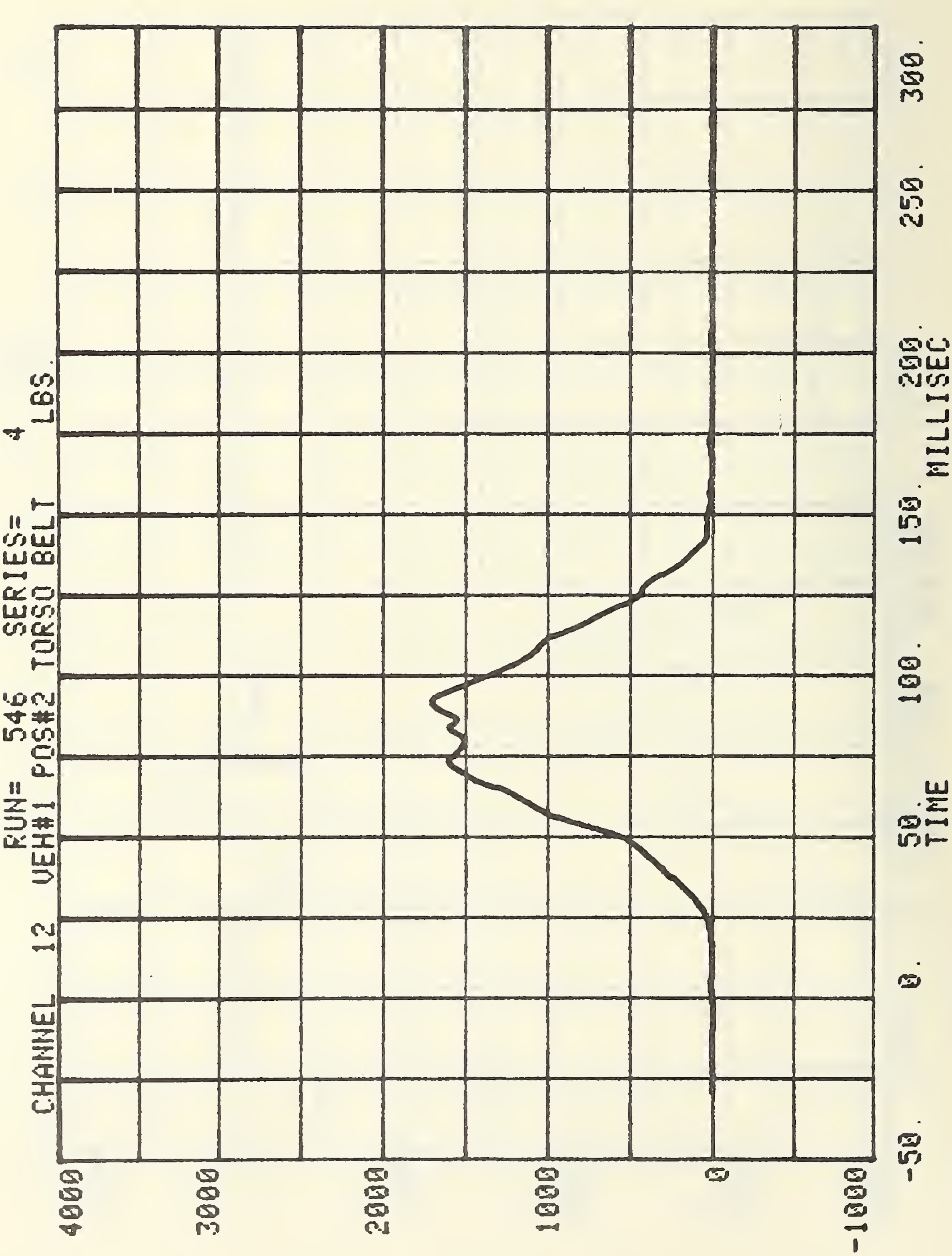

CHANNEL 17 RUN= 546 SERIES= 4
VEH#1 POS#2 CHEST Y G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME
MILLISEC


CHANNEL 18 RUN= 546 SERIES= 4
VEH#1 POS#2 CHEST Z G'S
100
60
20
-20
-60
-100
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 4 RUN= 546 SERIES= 4 G'S
VEH#1 POS#2 CHEST R
100.
80.
60.
40.
20.
0.
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC



CHANNEL 10 RUN= 546 SERIES= 4
VEH#1 POS#2 LEFT FEMUR LBS.
2000
1500
1000
500
0
-500
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC


CHANNEL 12 RUN= 546 SERIES= 4
VEH#1 POS#2 TORSO BELT LBS.
4000
3000
2000
1000
0
-1000
-50.
0.
50.
100.
150.
200.
250.
300.
TIME MILLISEC

FORD MUSTANG OCCUPANT AND
RESTRAINT SYSTEM DATA SUMMARY

DUMMY POSITION	MAXIMUM ACCELERATION (g)[1]											
	HEAD				CHEST				PELVIS			
	X	Y	Z	R	X	Y	Z	R	X	Y	Z	R
Driver (1)	-61	-15	35	62	-34	-15	-16	36	--	--	--	--
Passenger(2)	-140	51	77	163	-31	22	-8	35	--	--	--	--

DUMMY POSITION	MAXIMUM FORCE-FEMUR LOAD (LBS)	
	RIGHT FEMUR	LEFT FEMUR
Driver (1)	580	500
Passenger(2)	NA[3]	300

DUMMY POSITION	MAXIMUM FORCE-SEAT BELT LOADS (LBS)		
	SHOULDER STRAP UPPER BELT LOAD	LAP STRAP RIGHT BELT LOAD	LAP STRAP LEFT BELT LOAD
Driver (1)	1580	--	--
Passenger(2)	1700	--	--

DUMMY POSITION	HEAD INJURY CRITERIA[2]				SEVERITY INDEX	
	HIC	t_1 (SEC)	t_2 (SEC)	AVE. ACC. (g) t_1 TO t_2	HEAD	CHEST
Driver (1)	709	0.084	0.122	51.0	851	--
Passenger(2)	896	0.095	0.122	64.9	1422	--

[1]DEFINED AS EXCEEDING 0.003 SEC. DURATION

[2]AS DEFINED IN FMVSS NO. 208

[3]NOT AVAILABLE: WIRES PULLED OUT OF LOAD CELL