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Development and Evaluation of a Belt Restraint System for Small Cars Using Force Limiting

Volume II

Michael J. Walsh
Barbara J. Kellerer

Calspan Corporation
4455 Genesee Street
Buffalo, NY 14225

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16. Abstract

Evaluation of the performance of a passive belt system designed to be force limiting and preloaded with regard to six-year-old sized anthropometric test devices (ATDs) is reported herein. The restraint system, including an energy managing knee bolster, was developed and demonstrated satisfactory performance when evaluated using adult sized ATDs in a small car (Chrysler L-body). This report addresses the special consideration of the problem of properly restraining the six-year-old sized ATD in a vehicle equipped with adult size restraint systems. In addition the results of sled tests of two prototype vest/belt restraint systems, one for handicapped occupants and one for the six-year-old size occupants, are presented.

This program was conducted under Modification No. 3 to the U.S. Department of Transportation, National Highway Traffic Safety Administration Contract No. DOT-HS-7-01679.

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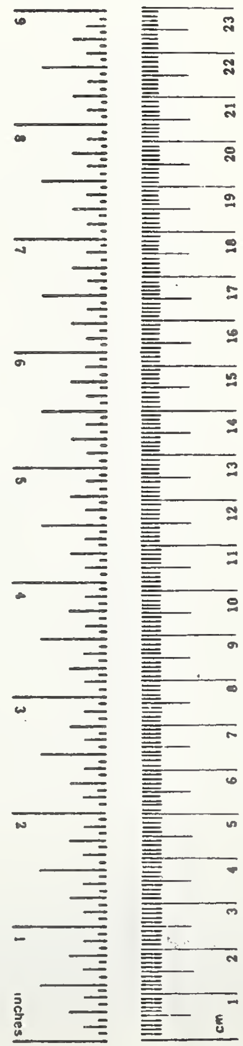
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

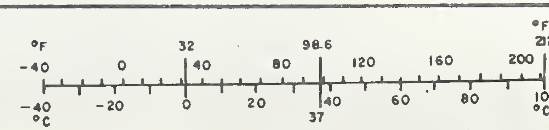
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	squsre kilometers	km^2
	acres	0.4	hectares	he
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnss	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	fset	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	milss	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	squars yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hecteres (10,000 m^2)	2.5	scres	
		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



FOREWORD

This report presents the results of an experimental program for the evaluation of the performance of a torso belt/knee bolster restraint system on six year old size occupants. It is the outgrowth of modification No. 3 to the U.S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA) Contract No. DOT-HS-7-01679 entitled "Development and Evaluation of a Belt Restraint System for Small Cars Using Force Limiting." Dr. Carl C. Clark was the Contract Technical Manager (CTM) for the NHTSA.

The objectives of this evaluation program modification were to address the special consideration of the problem of properly restraining the six year old size occupant in an adult restraint system, to identify the differences observed between six year old sized anthropometric test devices (ATDs) supplied by different manufacturers, and to evaluate two prototype vest/belt restraint systems, one for handicapped vehicle-occupants and one for children of sizes larger than can be accommodated by commercially available child restraint systems.

The prototype vest/belt restraint systems along with two types of bolster/belt restraint systems were supplied by the CTM. The authors acknowledge the many helpful suggestions and comments of Dr. Clark during the course of this program.

The opinions and findings expressed in this report are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

This report has been reviewed and is approved by:

Anthony L. Russo, Head
Transportation Research Department

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1.0 INTRODUCTION

Calspan Corporation completed a program for the National Highway Traffic Safety Administration (NHTSA) in September of 1979 entitled 'Development and Evaluation of a Belt Restraint System for Small Cars Using Force Limiting and Pretensioning'. This program consisted of 6 tasks which are described in detail in Reference 1.

The objectives of this program were:

(1) To develop a producible belt restraint system that, in addition to limiting the upper torso load applied to an anthropometric test device (ATD), would include; a capability for passivity, a capability for determining use of the belt under load after the crash, produce performance evaluation criteria data less than or equal to the limits prescribed in FMVSS 208 at speeds of 64 Km/hr (40 MPH) or higher in a small car (Chrysler L-Body) during frontal impact sled testing,

(2) To investigate the effects of pretensioning of the belt system,

(3) To compare the results of three dimensional computer simulations of the occupant with the results of sled tests and

(4) To compare the effect of pre-inflated energy distributing modules with no energy distribution in lateral sled tests.

Collision speeds (BEV) ranged from 55 Km/h (34 MPH) to 73 Km/h (45 MPH) and all ATD sizes from the 6-year old size through the 95th percentile male size were used in this study.

During the performance of sled tests to evaluate the effectiveness (with regard to child size ATDs) of the belt restraint system developed under this contract it was discovered that, not only did the 6-year-old size ATDs fail to comply with the FMVSS 208 performance evaluation criteria in a passive torso belt, a three point belt or a three point belt plus a styrofoam bolster seat, but that there was also a significant variability in ATDs from different manufacturers. The NHTSA decided to further investigate these problems under the optional Task 7 of the contract. This report documents these investigations.

This task was defined as consisting of several subtasks including anthropometry measurements, certification testing and sled testing in both front seat and rear seat configurations using four different types of 6-year-old size ATDs. Section 2.0 of this report discusses ATDs, anthropometry measurements and certification procedures, Section 3.0 describes the sled tests, Section 4.0 discusses the results obtained from the sled tests, and Section 5.0 presents concluding remarks. Relevant reference material is furnished in Section 6.0. The experimental data traces and pre- and post-test photographs can be found in Appendix A.

2.0 SIX-YEAR-OLD SIZE ANTHROPOMETRIC TEST DEVICES (ATDs)

It was determined, in consultation with the CTM that four types of 6-year-old size ATDs would undergo anthropometry measurements, certification testing and sled tests. The four ATDs selected were:

- Sierra Products Model 492-06
- Alderson Research Laboratory (ARL) Model VIP-6C
- Instituut Voor Wegtransportmiddelen (TNO) Model P6
- Humanoid Systems Incorporated experimental 6-year-old (under development).

The Sierra and ARL dummies were at Calspan and had been used in the original contract tasks. The TNO P6 dummy was delivered to NHTSA and subsequently to Calspan. This dummy is described in Reference 2, but for the sake of completeness a brief description is presented here.

The TNO P6 head is made of Poly Urethane Rubber (PUR) reinforced with a steel strip. The neck is built from a core of Poly Amide (PA) elements, a PA atlas-axis block on which the head is mounted and a series of PUR outer rings to give it the required support. A spine cable runs through the neck elements. The spine cable is a steel core cable with four terminals attaching the head, neck, upper torso, lower torso and lumbar vertebrae. The upper torso is made of PUR with a T-shaped tubular frame. The lower torso consists mainly of Glassfiber Reinforced Polyester coated with PUR. The lumbar vertebrae allow the dummy to flex forward only, limiting sideward and backward motion. The arms and legs consist of aluminum tubing and joints covered with PUR.

The experimental dummy being developed by Humanoid Systems was to be shipped to Calspan from Dynamic Sciences Inc. Instead of the Humanoid Systems dummy, an Alderson 6-year-old, S/N 049 which is owned by Dynamic Sciences was sent to Calspan. This error was not discovered until late in the program when the dummies were disassembled for certification testing.

The government-owned Alderson ATD at Calspan, S/N 048, has an older design head than the Alderson ATD that was sent from Dynamic Sciences. The change in head design from S/N 48 to S/N 49 came about as a result of conversations between ARL and NHTSA concerning excessive ringing experienced by the older style head (Reference 3). The basic difference in head design is in the construction of the shell and the addition of glass beads to the urethane head shell for S/N 049. Figure 2-1 presents a comparison of the two head designs.

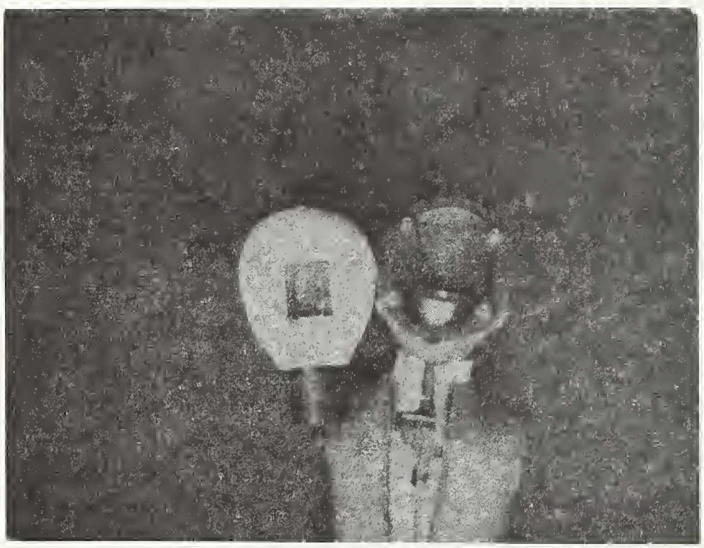


Figure 2-1 ALDERSON ATD HEAD DESIGN COMPARISON

S/N 49 S/N 48

Anthropometry measurements were taken only from the Alderson ATD S/N 49 due to the fact that the exteriors of S/N 48 and S/N 49 were alike. Both of these dummies were subjected to the certification procedures and the sled tests.

2.1 Anthropometry

The three following six-year-old anthropometric test devices were measured for the purpose of determining the anthropometric differences between them: Sierra 492-06, Alderson VIP-6C and TNO P6. The measurements of the Alderson VIP-6C dummy were obtained from the S/N 049 ATD.

The CTM had suggested that a recent study conducted by Snyder, et al (Reference 4) be used as a basis for selecting significant anthropometric measurements and that the child measurement from this study be included for comparative purposes. Therefore, Table 2-1 contains the anthropometric measurements of the three dummies along with the averaged measurements found in Snyder's work for 50th percentile 6-year-old children of both sexes.

2.2 Certification Procedures

It was planned that each of the surrogates would undergo one exposure to each of the four standard certification tests specified for the 3-year-old size ATD in the proposed rules of 49 CFR, Part 572, Subpart C, November 1, 1979 (Reference 5). The purpose of these exposures was to determine the response differences between the ATDs, and is not regarded as a certification of them.

Only three of these certification procedures were performed. They were the head impact, thorax impact and lumbar spine flexion tests. The fourth specified certification procedure, the head/neck pendulum test, was deleted in agreement with NHTSA personnel (Reference 6). This procedure was deleted because the structure of the spine cable in the TNO dummy, as described previously, precluded the use of the existing pendulum structure. Either the dummy or the pendulum would have required extensive revisions and this was considered beyond the scope of the program. Because the reason for executing these certification tests was for ATD response comparison, it was decided to delete the head/neck pendulum test on all surrogates.

Table 2-1

ANTHROPOMETRY MEASUREMENTS

	TNO	ALDERSON	SIERRA	CHILD
Weight	22.0 Kg (48.4) lb.	21.5 Kg (47.3) lb.	21.4 Kg (47.2) lb.	20.1 Kg (44.4) lb.
Stature	117.3 cm (46.2) in.	122.0 cm (48.0) in.	122.0 cm (48.0) in.	113.6 cm (44.7) in.
Sitting Height	63.0 cm (24.8) in.	65.5 cm (25.8) in.	66.8 cm (26.3) in.	61.8 cm (24.3) in.
Sitting Mid-Shoulder Height	39.9 cm (15.7) in.	41.1 cm (16.2) in.	40.6 cm (16.0) in.	38.7 cm (15.2) in.
Crotch Height	54.6 cm (21.5) in.	57.2 cm (22.5) in.	52.1 cm (20.5) in.	50.8 cm (20.0) in.
Buttock-Knee Length	34.3 cm (13.5) in.	27.9 cm (11.0) in.	25.4 cm (10.0) in.	35.0 cm (13.8) in.
Knee Height	31.8 cm (12.5) in.	33.0 cm (13.0) in.	30.5 cm (12.0) in.	33.9 cm (13.3) in.
Shoulder-Elbow Length	18.3 cm (7.2) in.	17.0 cm (6.7) in.	17.8 cm (7.0) in.	23.4 cm (9.2) in.
Lower Arm Length	23.4 cm (9.2) in.	30.5 cm (12.0) in.	27.9 cm (11.0) in.	29.8 cm (11.7) in.
Head Circumference	52.1 cm (20.5) in.	54.6 cm (21.5) in.	55.1 cm (21.7) in.	51.5 cm (20.3) in.
Neck Circumference	25.4 cm (10.0) in.	28.4 cm (11.2) in.	25.9 cm (10.2) in.	26.4 cm (10.4) in.
Chest Circumference	57.2 cm (22.5) in.	60.2 cm (23.7) in.	58.4 cm (23.0) in.	55.1 cm (21.7) in.
Forearm Circumference	16.5 cm (6.5) in.	15.2 cm (6.0) in.	16.5 cm (6.5) in.	16.4 cm (6.5) in.
Upper Arm Circumference	19.6 cm (7.7) in.	17.8 cm (7.0) in.	18.3 cm (7.2) in.	16.4 cm (6.5) in.
Mid-Thigh Circumference	30.5 cm (12.0) in.	33.5 cm (13.2) in.	28.4 cm (11.2) in.	30.4 cm (12.0) in.
Max. Calf Circumference	24.6 cm (9.7) in.	23.4 cm (9.2) in.	25.4 cm (10.0) in.	22.2 cm (8.7) in.
Ankle Circumference	16.5 cm (6.5) in.	19.1 cm (7.5) in.	19.1 cm (7.5) in.	15.0 cm (5.9) in.

The certification procedures, as specified in 49 CFR, Part 572, Subpart C, are defined for 3-year-old size ATDs. As can be seen in Figure 2-2, the seated heights of the 6-year-old size surrogates is significantly different than that of the SA103C 3-year-old size ATD [(57.2 cm) (22.5 inches)]. Therefore, impact points for both the head impact test and the chest impact test had to be defined for these surrogates. A scale factor was derived by ratioing seated heights of the 6-year-old ATDs and the seated height of the 3-year-old ATD and impact points were determined. These impact points, measured from the seated surface, were:

	TNO	Sierra	Alderson
Scale Factor	1.10	1.17	1.15
Chest	31.5 cm (12.4 in.)	33.3 cm (13.1 in.)	32.8 cm (12.9 in.)
Head	54.6 cm (21.5 in.)	58.2 cm (22.9 in.)	56.9 cm (22.4 in.)

All of these impact points were marked on the dummies and, with the exception of the Alderson ATD head impact point, the markings were at the approximate level of head and chest accelerometer placement. The Alderson dummy head impact point was considered too low (between the eyes) and therefore was raised to 59.7 cm (23.5 in.) to create a better alignment with accelerometer placement.

The following sections contain a brief description of the test apparatus and procedures concerning each certification procedure and the data generated by each of the surrogates.

2.2.1 Head Impact Tests

The six-year old size surrogates were positioned as specified for the three-year-old size ATD in 49 CFR, Part 572, Subpart C as of November 1979 (Figure 2-3). They were seated on a horizontal surface of teflon sheeting with a vertical back support which has been raised to a level coinciding with that specified for the three-year-old size dummy. The scale factors of 1.10 for

SA103C - 3-YEAR-OLD SIZE TNO-P6 - 6-YEAR-OLD SIZE

SA103C - 3-YEAR-OLD SIZE ATD - SIERRA 492-06 - 6-YEAR-OLD SIZE ATD

SA103C - 3-YEAR-OLD SIZE ATD - ALDERSON VIP-6C - 6-YEAR-OLD SIZE ATD S/N 49

Figure 2-2 COMPARISON OF 3-YEAR-OLD SIZE AND 6-YEAR-OLD SIZE ATD SEATING HEIGHTS

6174-V-4

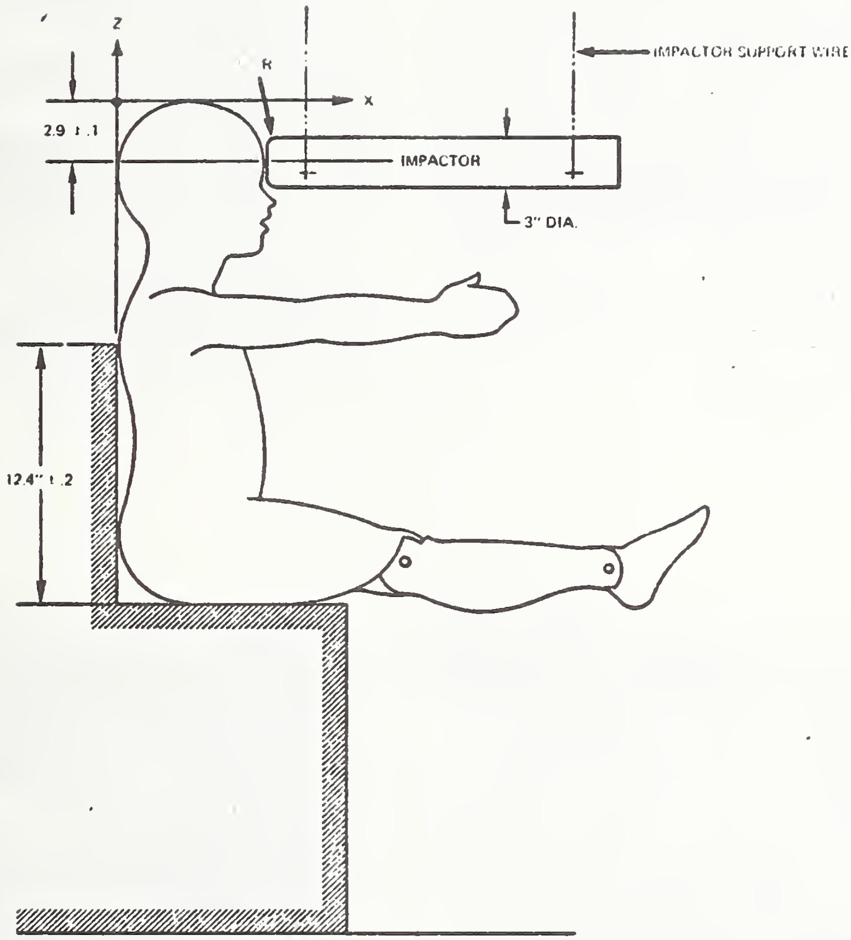


FIGURE NO. 16
HEAD IMPACT TEST

Figure 2-3 HEAD IMPACT CERTIFICATION TEST SEATING SPECIFICATION FOR THREE-YEAR-OLD SIZE ATD the TNO, 1.17 for the Sierra and 1.15 for the Alderson ATDs were again used to specify back-rest height. A head impact configuration photo for each of the 6-year-old size surrogates is found in Figure 2-4.

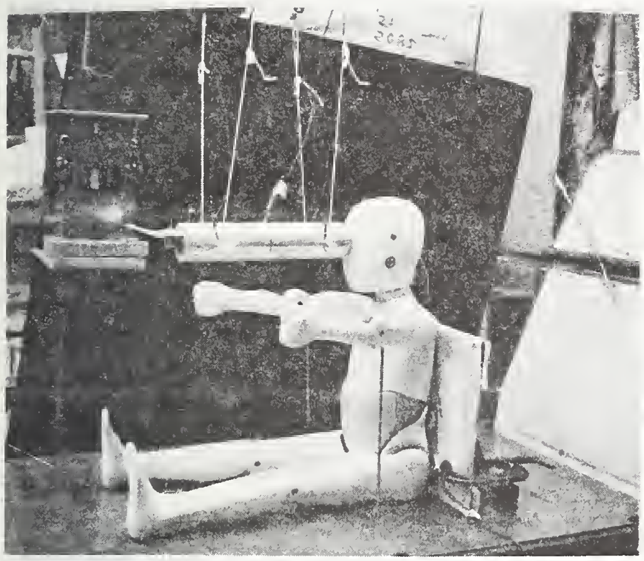
The dummies were impacted at the pre-determined head impact points with an aluminum pendulum weighing 4.7 kg (10.3 lbs.) at a velocity of [(2.1 m/sec) (7 ft/sec)]. The pendulum conforms dimensionally to the requirements of Part 572, Subpart C, is fabricated from aluminum and equipped with an accelerometer mounted on the rear side. Impact velocity is monitored by a light beam velocity trap that can be seen in Figure 2-4.

Figures 2-5 through 2-8 provide the time history data traces generated by the TNO, Sierra, Alderson S/N 48 and Alderson S/N 49 ATDs, respectively. A summary of head impact test data is presented in Table 2-2.

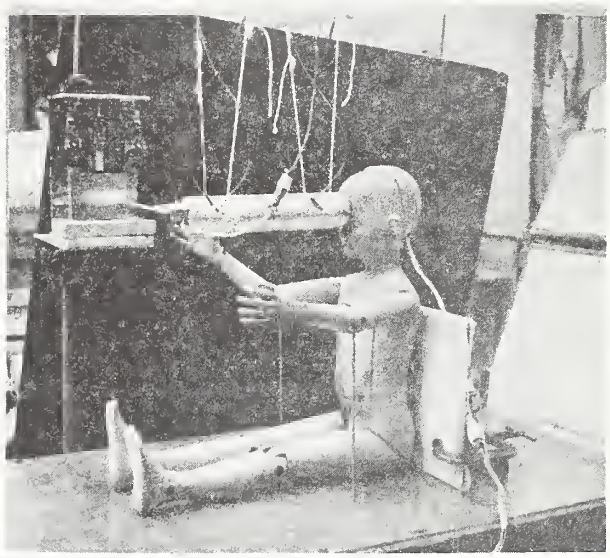
Table 2-2

SUMMARY OF HEAD IMPACT TEST DATA

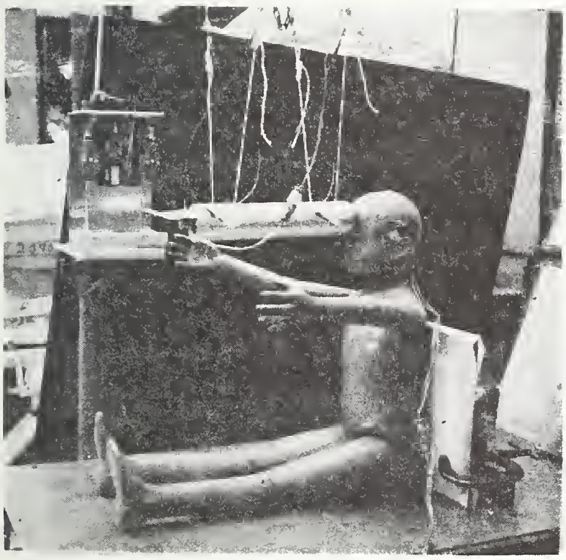
MEASUREMENT	DUMMY			
	TNO	Sierra	Alderson S/N 48	Alderson S/N 49
Pendulum Impact Velocity m/sec (ft/sec)	2.11 (6.92)	2.09 (6.85)	2.18 (7.16)	2.20 (7.22)
Peak Head Resultant Acceleration - G_R	35	200	47	113
Peak Head Lateral Acceleration - G_Y	5	17	7	12
Pulse Δ Time at 50 g - msec	0	1.2	0	2



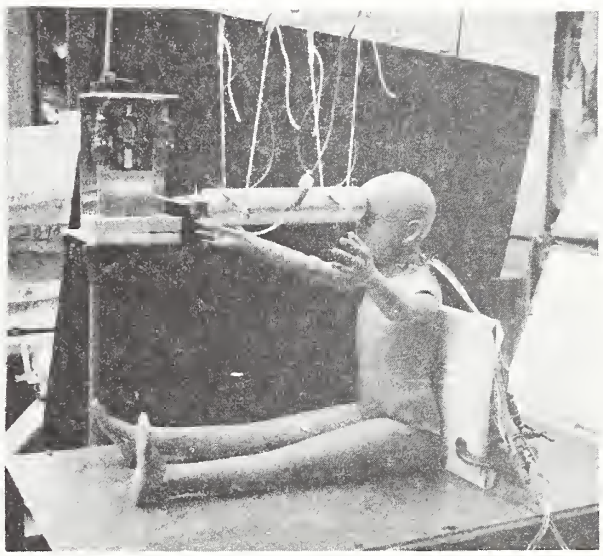
TNO - P6



SIERRA 492-06



ALDERSON VIP-6C S/N 48



ALDERSON VIP-6C S/N 49

Figure 2-4 SIX-YEAR-OLD SIZE ATDs - HEAD IMPACT CERTIFICATION TESTS

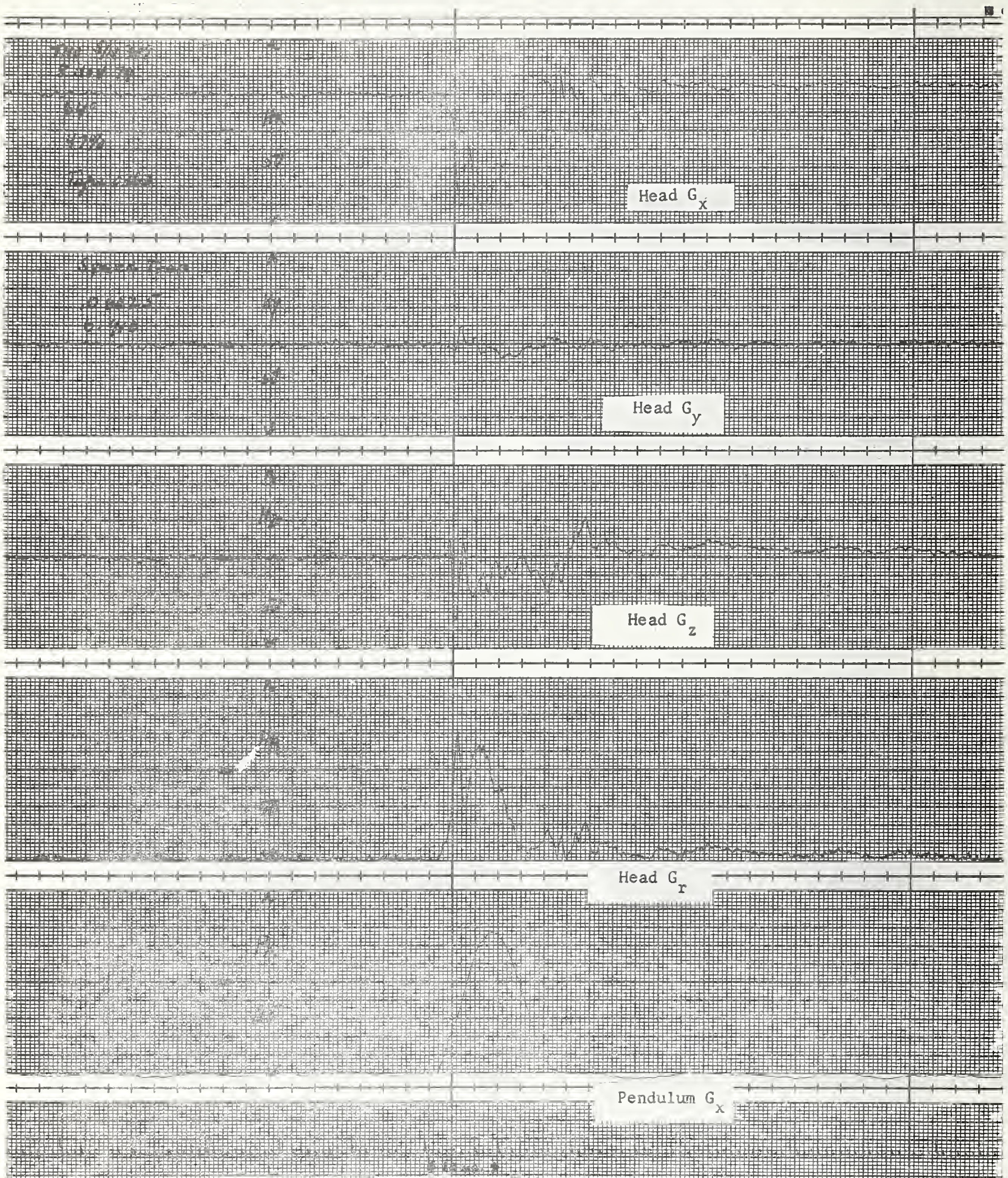


Figure 2-5 TNO S/N 309 DUMMY HEAD IMPACT TEST DATA

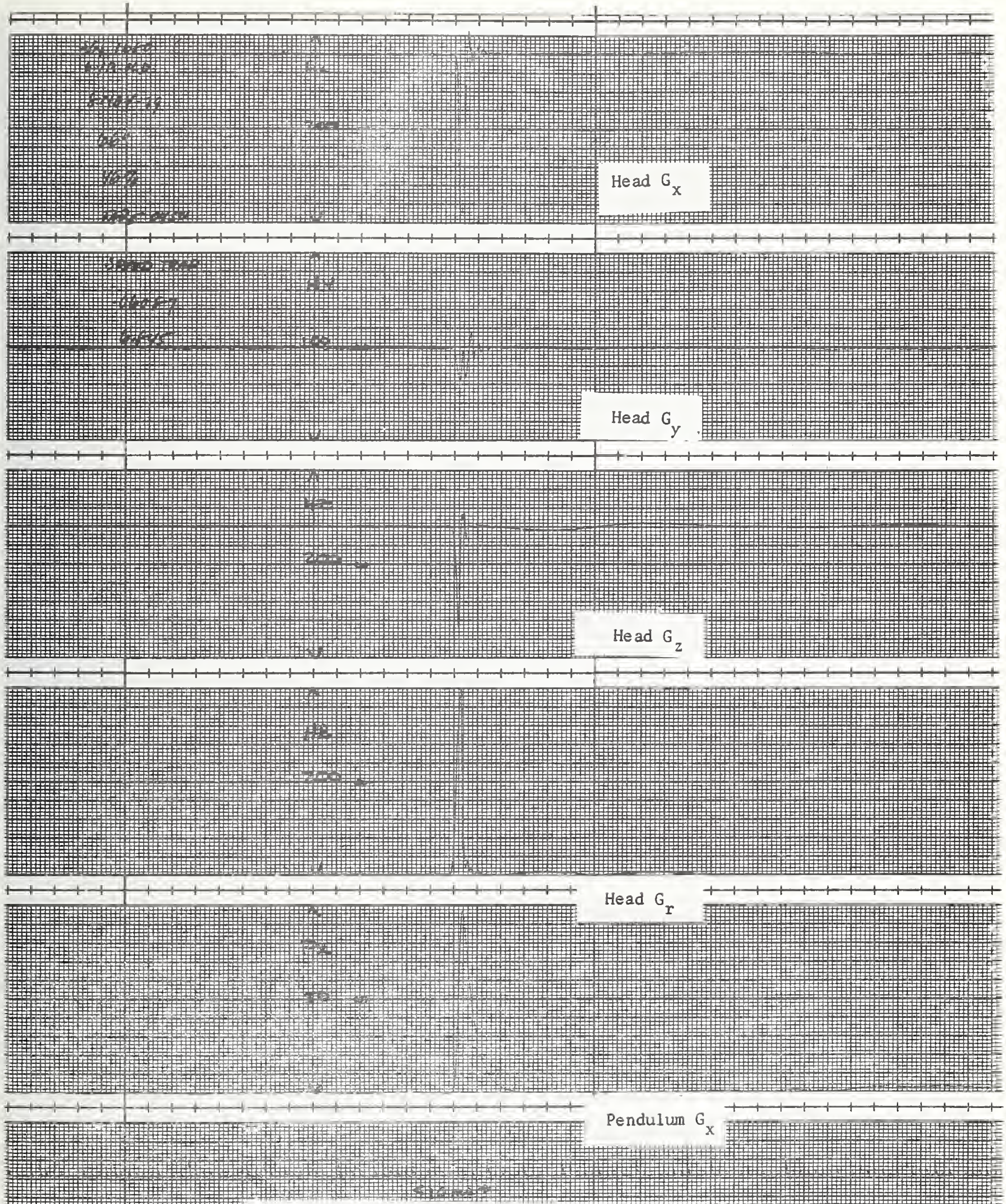


Figure 2-6 SIERRA DUMMY HEAD IMPACT TEST DATA

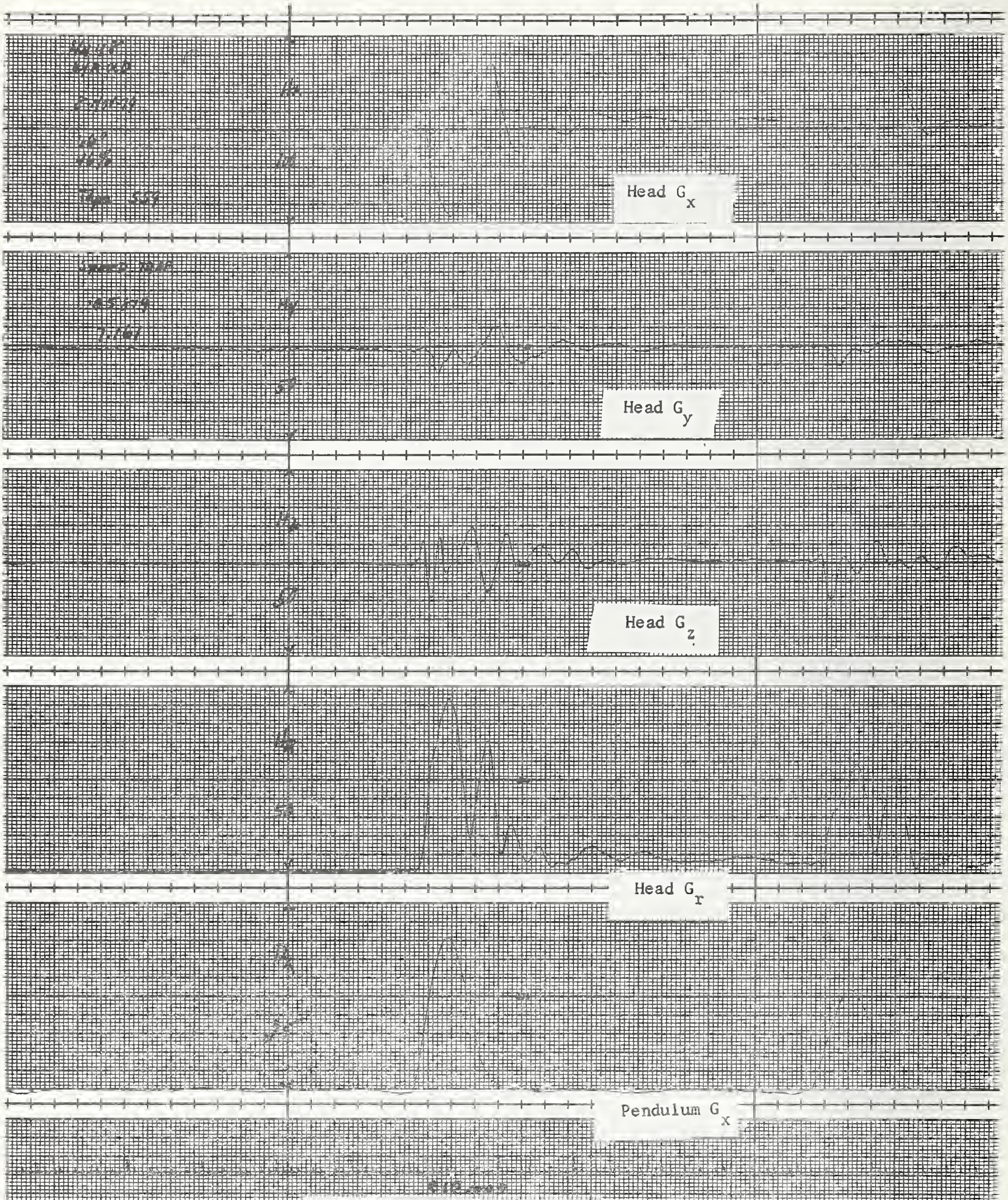


Figure 2-7 ALDERSON S/N 48 DUMMY HEAD IMPACT TEST DATA

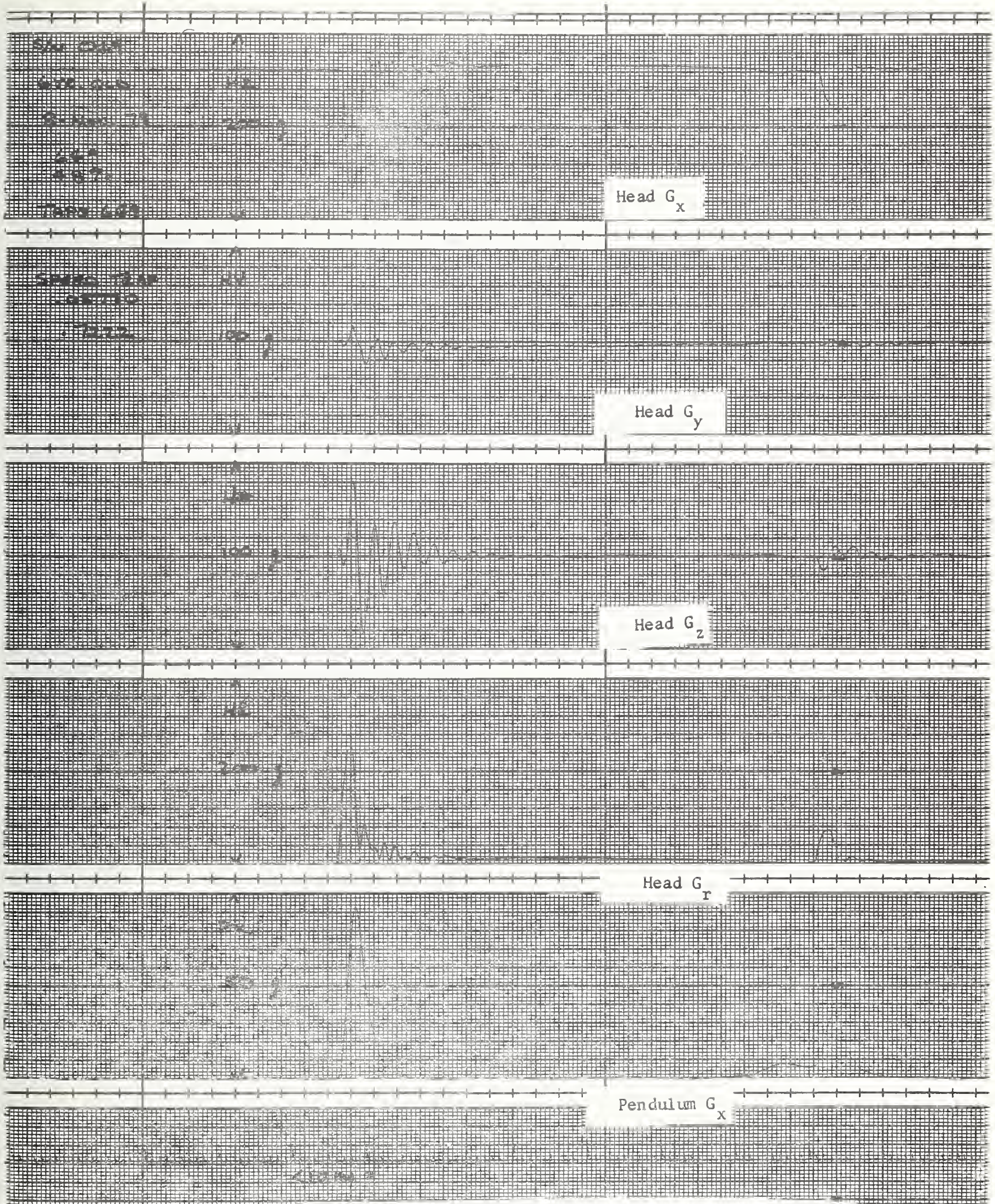


Figure 2-8 ALDERSON S/N 49 DUMMY HEAD IMPACT TEST DATA

2.2.2 Thorax Impact Tests

Seating specifications for the 3-year-old size dummy thorax certification test is found in Figure 2-9.

The six-year-old size surrogates were seated in a like manner on a horizontal surface of teflon sheeting with no back support. The positions of the four dummies can be seen in Figure 2-10. They were impacted at the pre-determined thorax position with the 4.7 kg (10.3 lb.) test pendulum at a velocity of 4 m/sec (13 ft/sec). The same pendulum is used for head and thorax impact certification tests. Pendulum impact velocity is measured by a light beam velocity trap. The time history data traces are presented in Figures 2-11 through 2-14 for the TNO, Sierra, Alderson S/N 48 and Alderson S/N 49 dummies, respectively. A summary of test data is provided in Table 2-3.

Table 2-3

SUMMARY OF THORAX IMPACT TEST DATA

MEASUREMENT	DUMMY			
	TNO	Sierra	Alderson S/N 48	Alderson S/N 49
Pendulum Impact Velocity m/sec (ft/sec)	3.95 (12.95)	3.94 (12.94)	3.96 (12.99)	3.95 (12.95)
Peak Chest Resultant Acceleration - G_R	58	93	60	64
Peak Chest Lateral Acceleration - G_Y	4	12	8	6
Pulse Δ Time at 30 g - msec	4	2	3	3

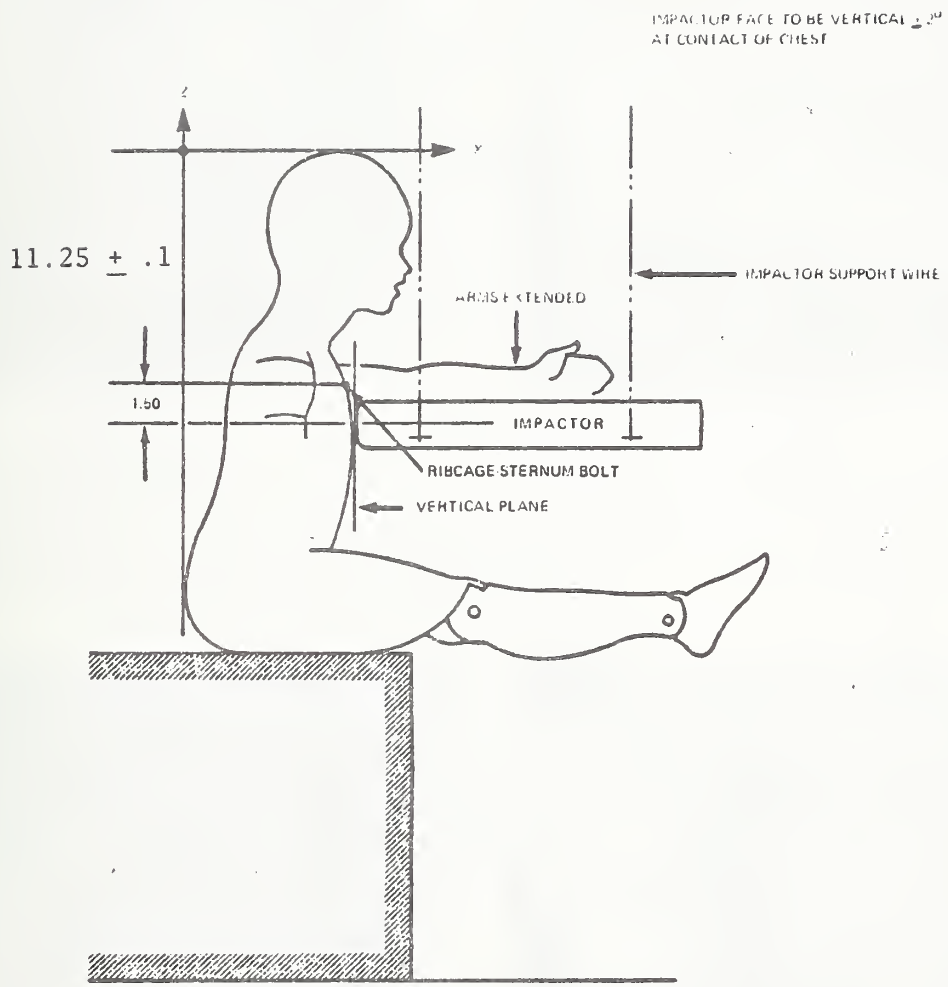
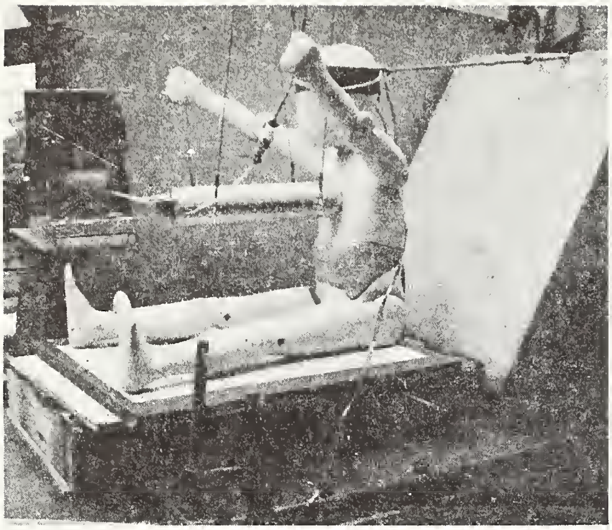


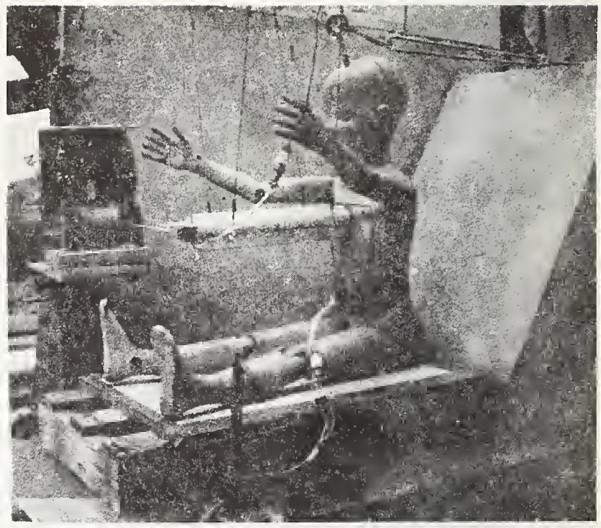
FIGURE NO. 17
CHEST IMPACT TEST

BILLING CODE 4910-59-C

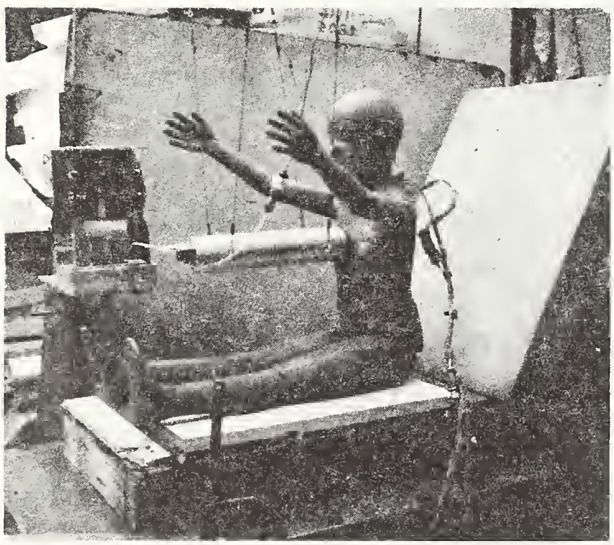
Figure 2-9 CHEST IMPACT CERTIFICATION TEST SEATING SPECIFICATION FOR THREE-YEAR-OLD SIZE ATD



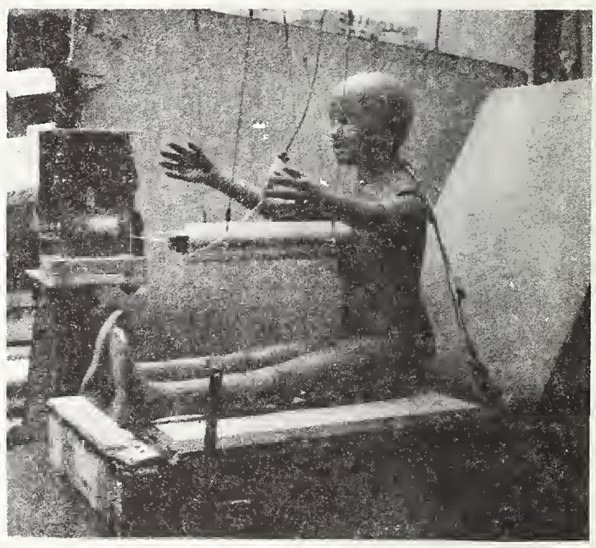
TNO - P6



SIERRA 492-06



ALDERSON VIP-6C S/N 48



ALDERSON VIP-6C S/N 49

Figure 2-10 SIX-YEAR-OLD SIZE ATDs - THORAX IMPACT CERTIFICATION TESTS

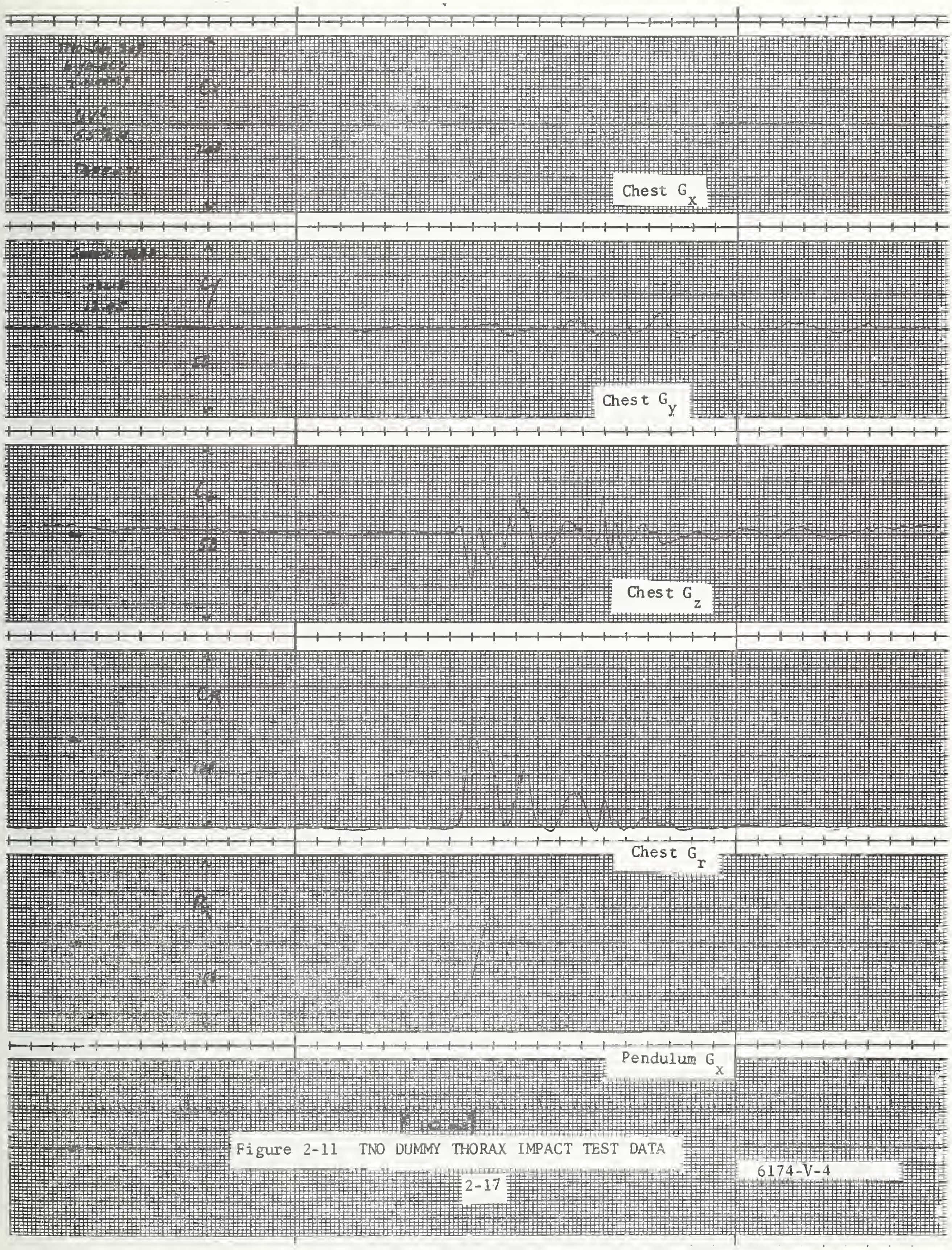


Figure 2-11 TNO DUMMY THORAX IMPACT TEST DATA

6174-V-4

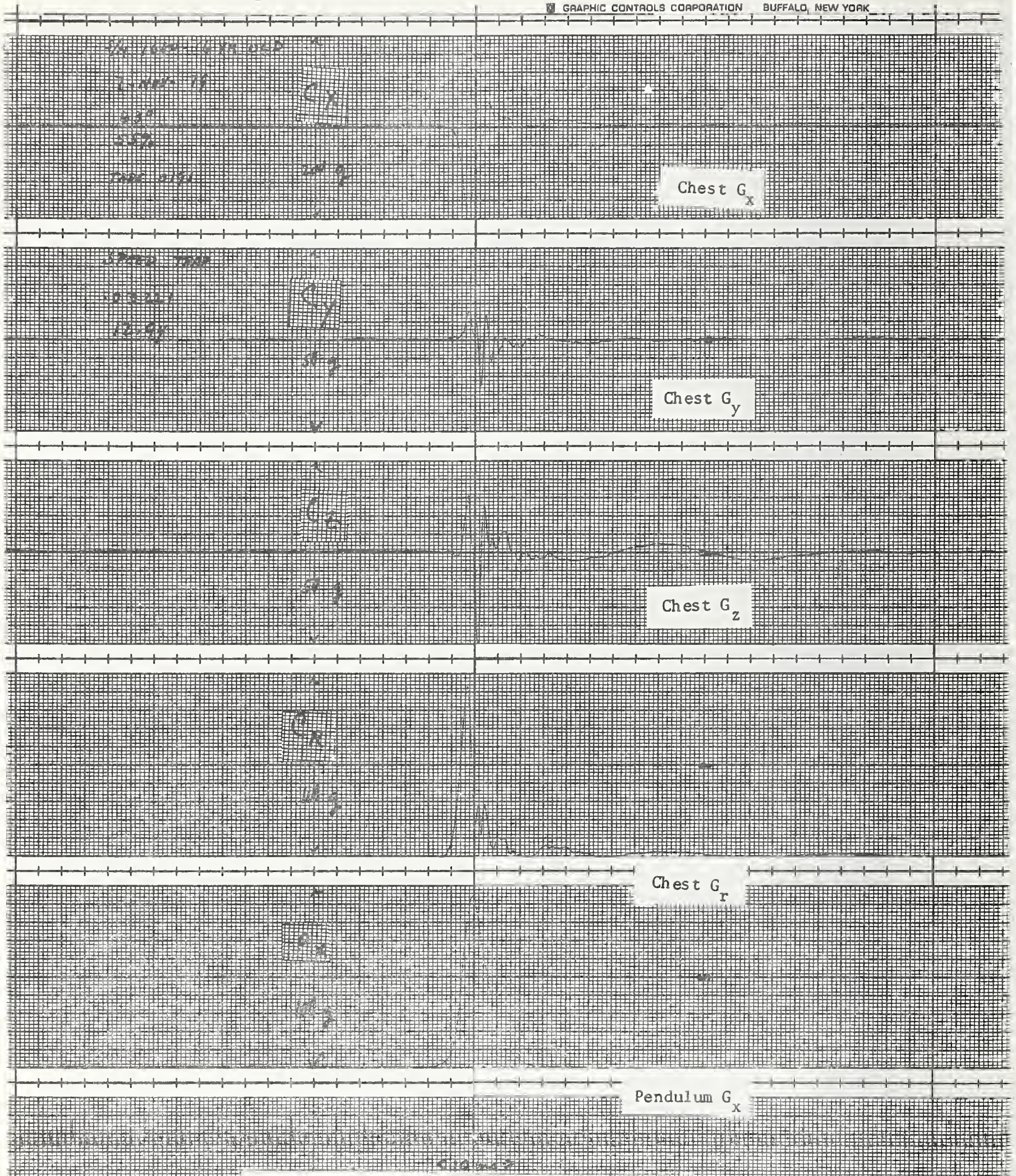


Figure 2-12 SIERRA DUMMY THORAX IMPACT TEST DATA

6174-V-4

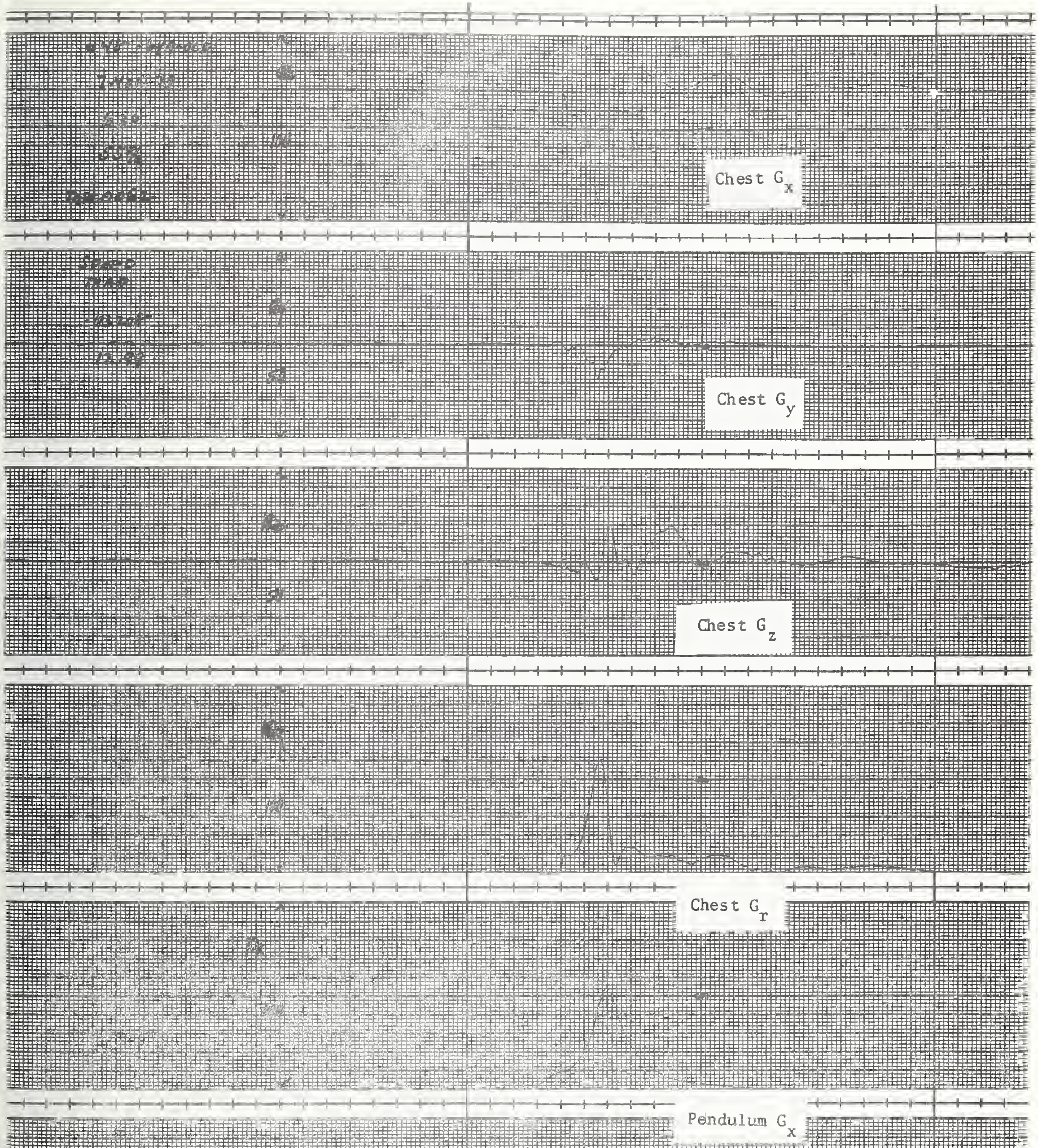


Figure 2-13 ALDERSON S/N 48 DUMMY THORAX IMPACT TEST DATA

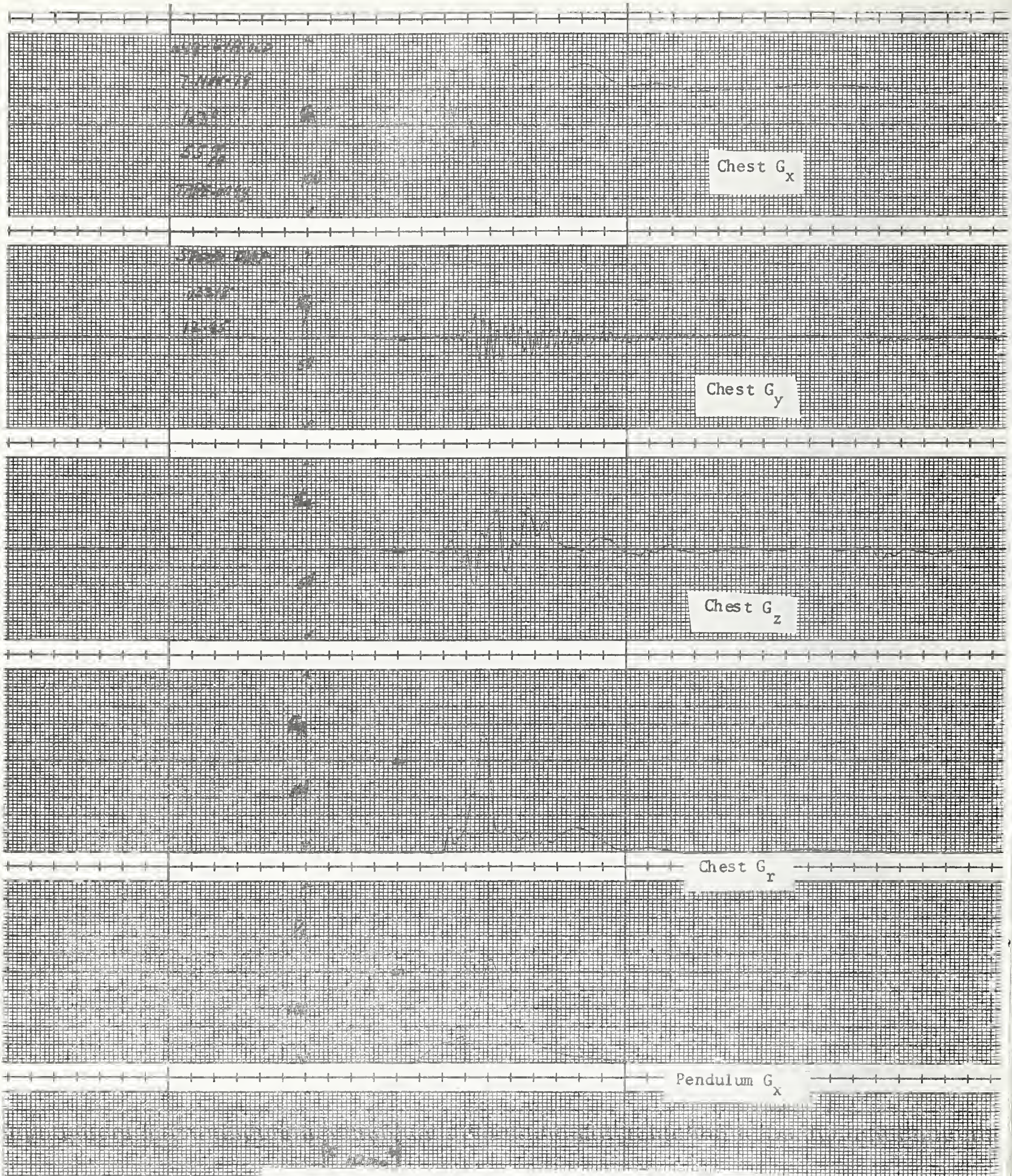


Figure 2-14 ALDERSON S/N 49 DUMMY THORAX IMPACT TEST DATA

2.2.3 Lumbar Spine Flexion Tests

The lumbar spine flexion test, as specified in 49 CFR, Part 572, Subpart C for the three-year-old dummy is pictured in Figure 2-15. The six-year-old surrogates were positioned as closely as possible to this specification.

Figure 2-16 depicts all four surrogates. The TNO-P6 ATD (Figure 2-16(a)) was rigidly attached to the table by inserting a metal block into the pelvic cavity which was then bolted onto the spine cable. This metal block was secured to the table by means of a C-clamp.

The Sierra and Alderson dummies are pictured in Figure 2-16 (b), (c) and (d), respectively. They were rigidly secured by bolting the pelvic area to the seating surface as specified for the three-year-old.

The lower legs of the Sierra dummy cannot be removed, and therefore, for comparative purposes, the legs of all of the surrogates were left intact for these tests. The upper legs at the knee axial rotation joints were attached to the mounting structure.

Force was applied to the upper thorax through an aluminum neck adapter and mounting plate. A hand-held load cell (BLH model U3G1) was used to apply force to the rear plate. The flexion angle of the upper torso was measured by a rotary potentiometer attached to a bracket on the side. A small pendulum arm, attached to this potentiometer, provided a constant vertical reference. The force and angle transducer signals were amplified and plotted simultaneously on an X-Y plotter. During application of force the load cell was kept perpendicular to the loading plate as the upper torso rotated.

The data traces generated by the lumbar spine flexion tests are presented in Figures 2-17 through 2-24. These plots include the torso deflection rate vs. time and flexion angle vs. force. These data are summarized in Table 2-4.

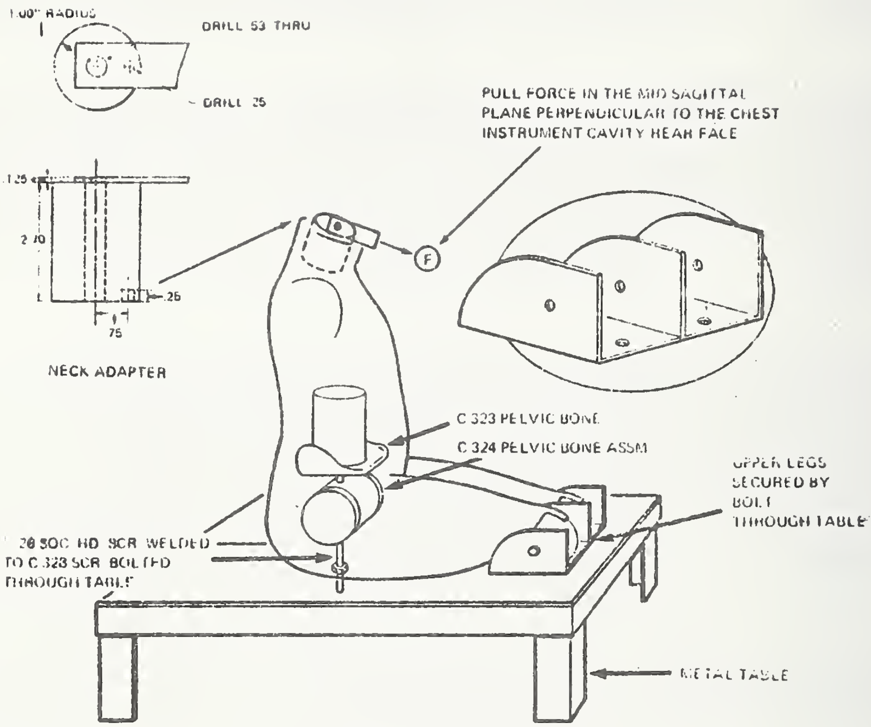
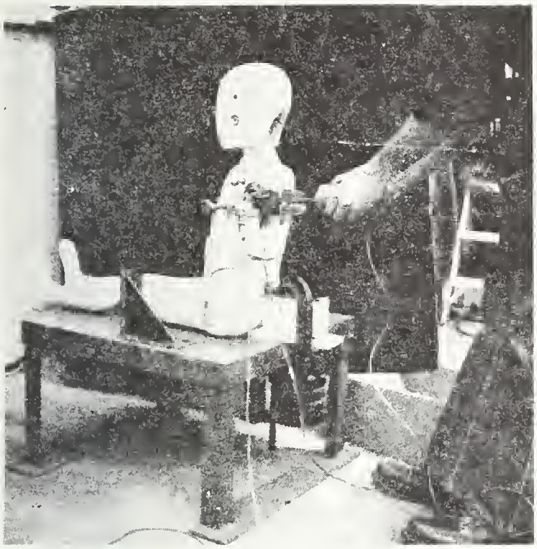
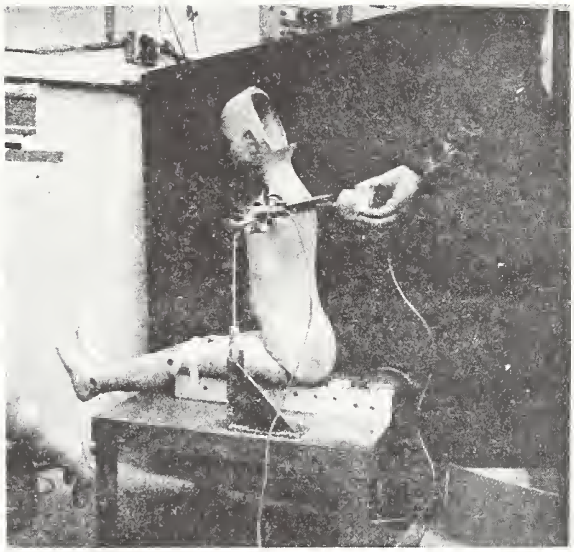


FIGURE NO. 18
LUMBAR SPINE FLEXION TEST

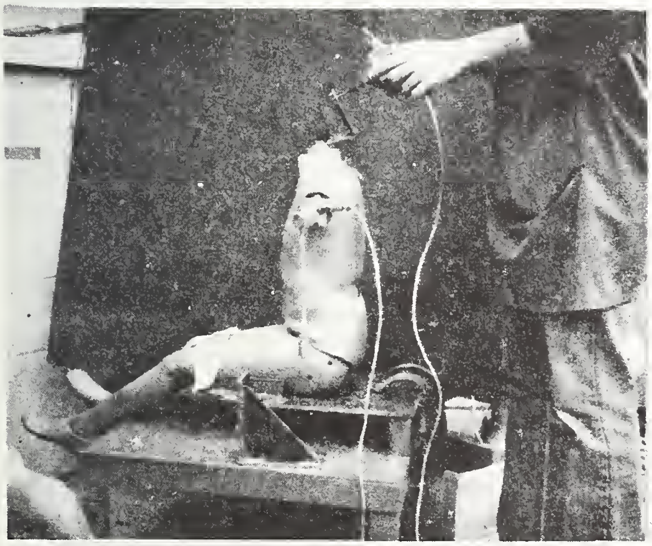
Figure 2-15 LUMBAR SPINE FLEXION CERTIFICATION TEST SEATING SPECIFICATIONS FOR THREE-YEAR-OLD SIZE ATD



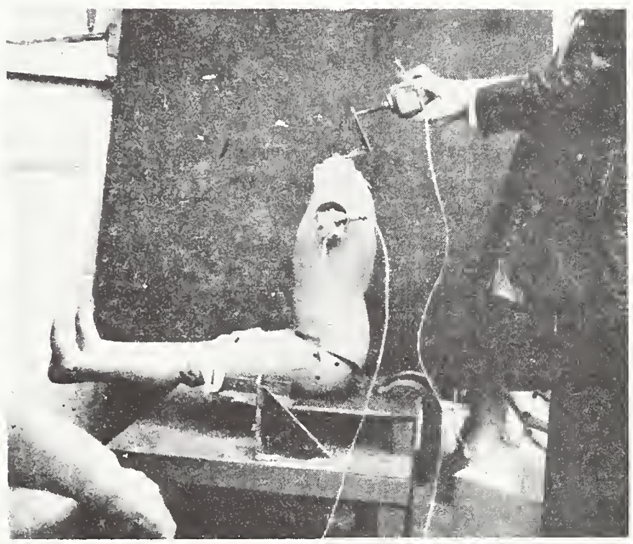
(a) TNO-P6



(b) Sierra 492-06



(c) Alderson VIP-6C S/N 48



(d) Alderson VIP-6C S/N 49

Figure 2-16 SIX-YEAR-OLD SIZE SURROGATES - LUMBAR SPINE FLEXION CERTIFICATION TEST

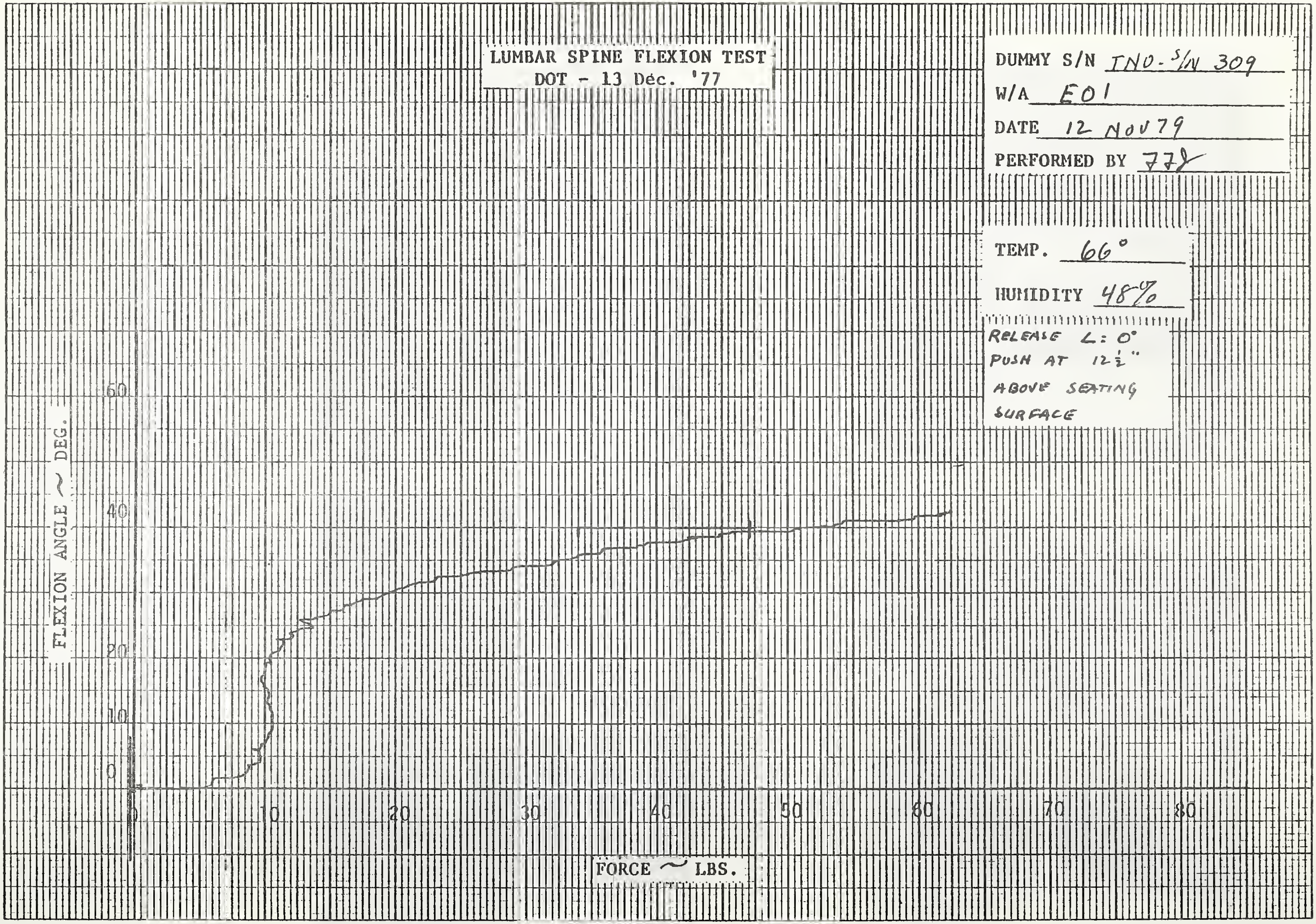


Figure 2-17 TNO DUMMY LUMBAR SPINE FLEXION TEST DATA

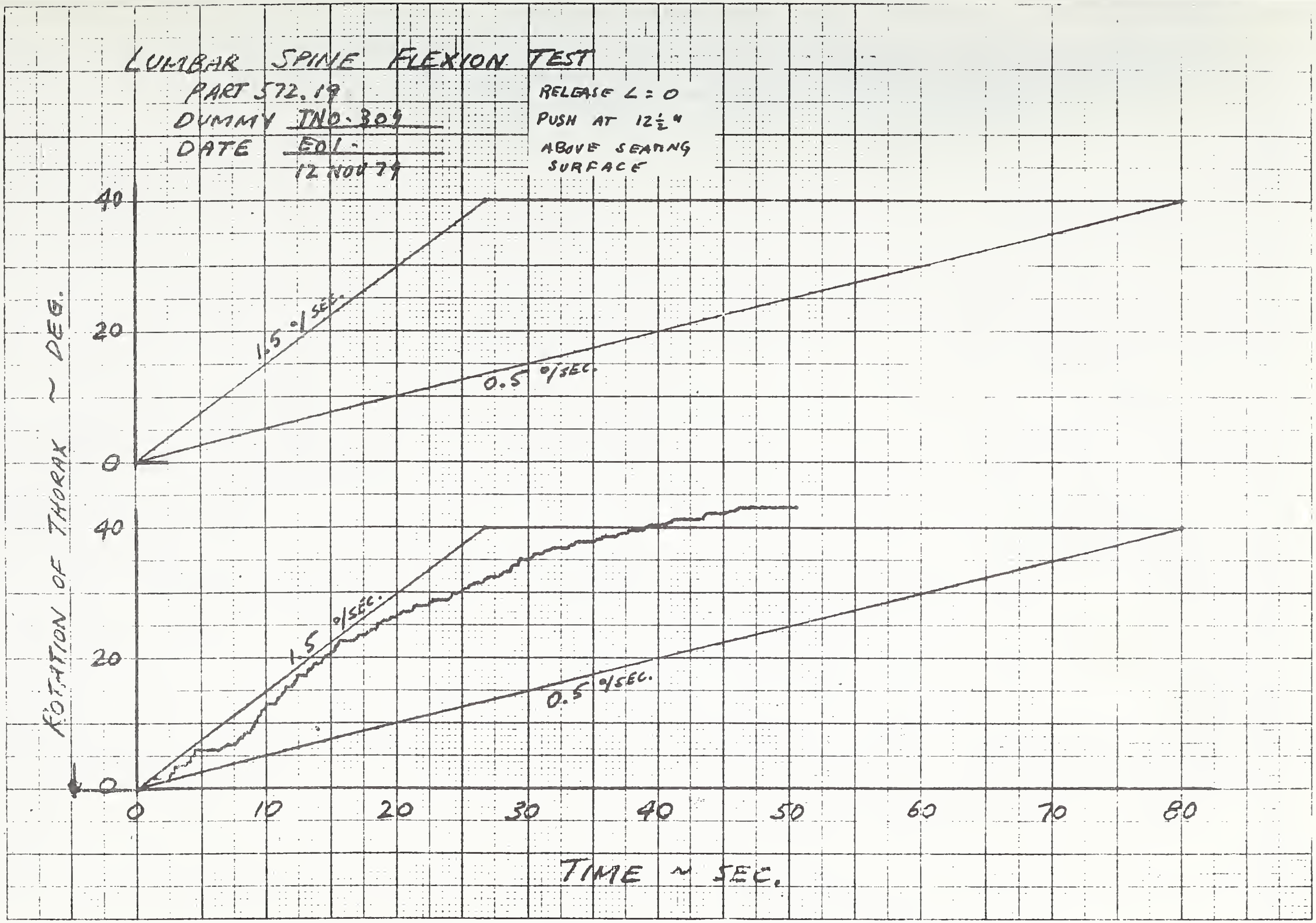


Figure 2-18 TNO DUMMY LUMBAR SPINE FLEXION TEST DATA

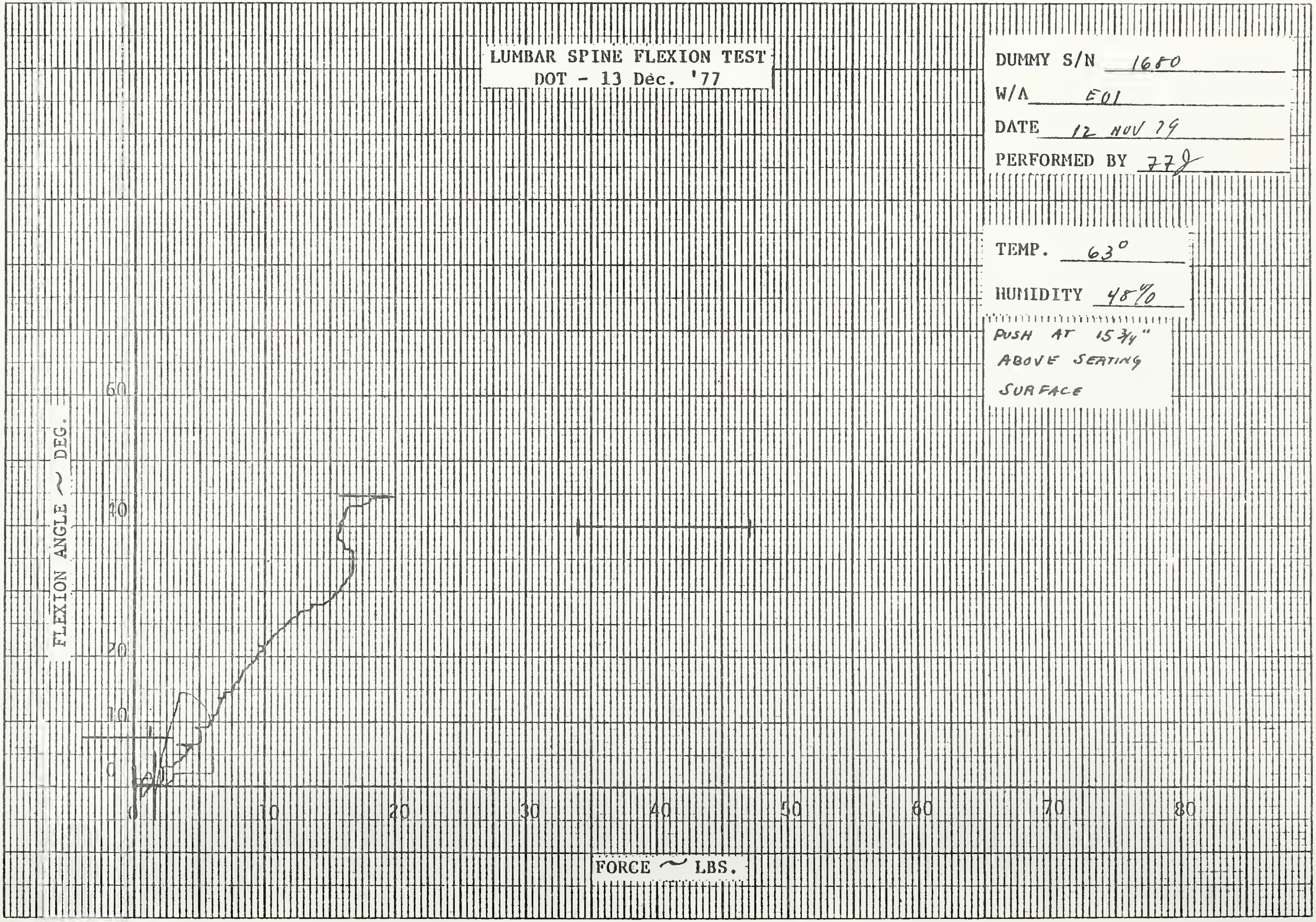


Figure 2-19 SIERRA DUMMY LUMBAR SPINE FLEXION TEST DATA

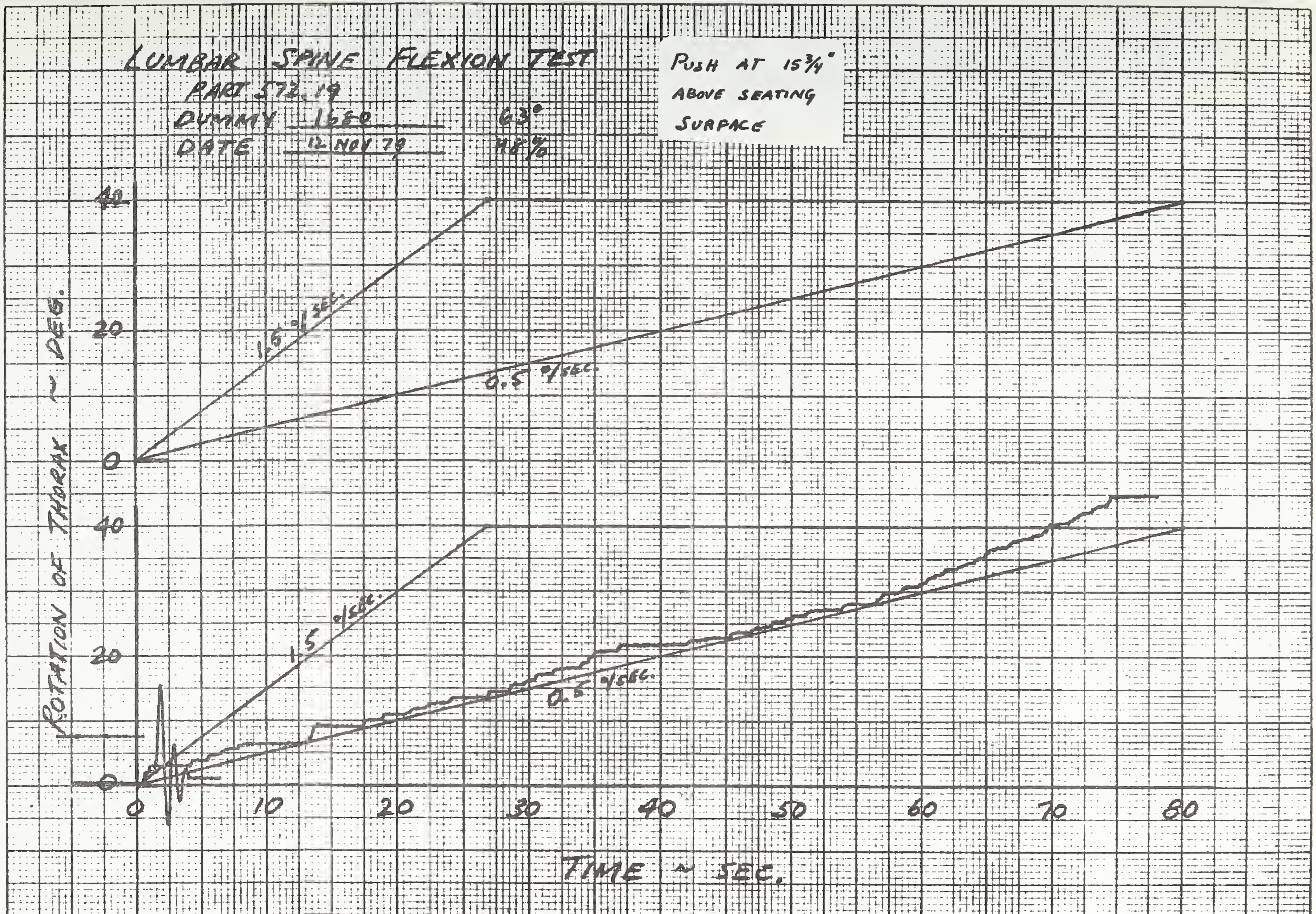


Figure 2-20 SIERRA DUMMY LUMBAR SPINE FLEXION TEST DATA

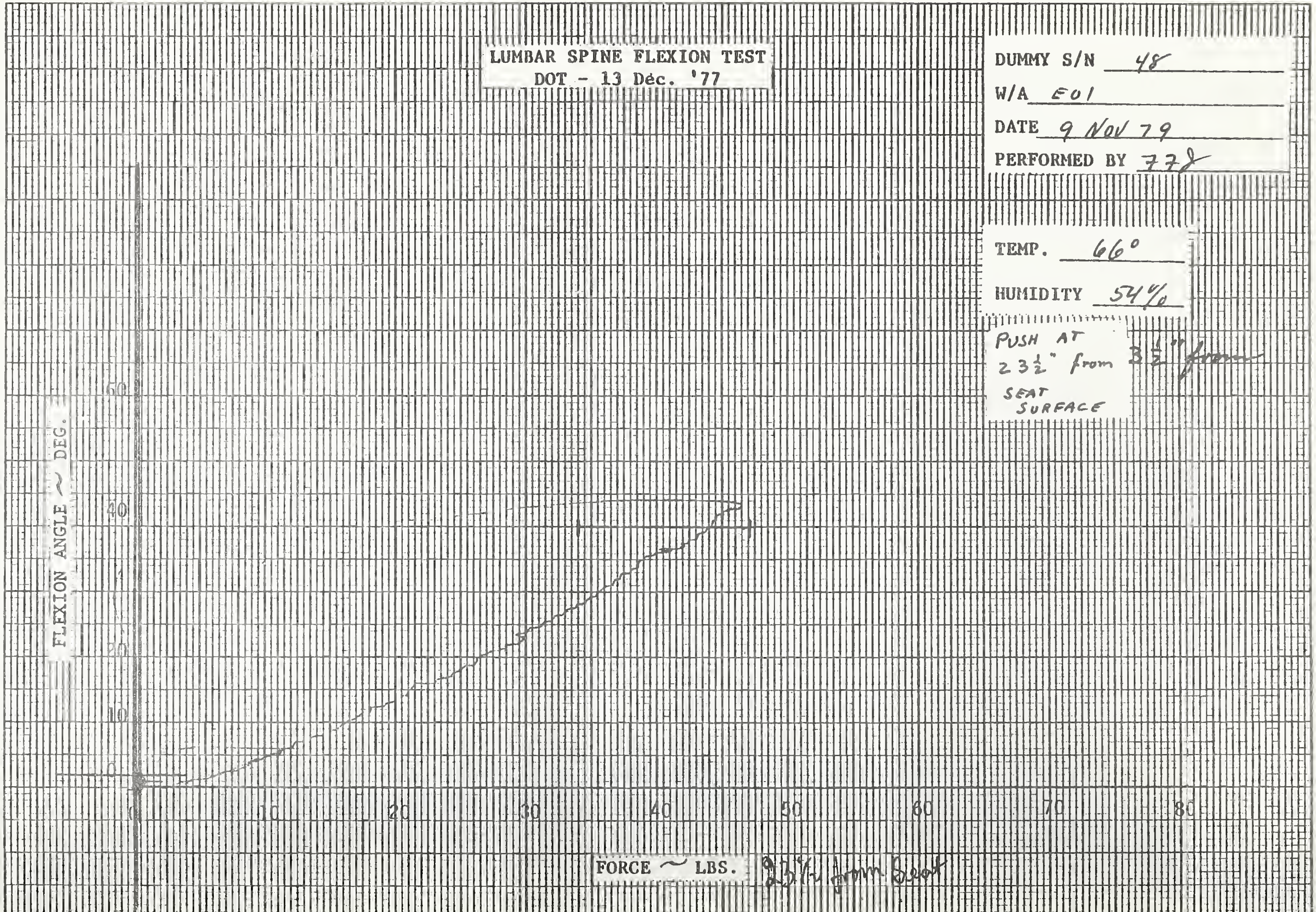


Figure 2-21 ALDERSON S/N 48 DUMMY LUMBAR SPINE FLEXION TEST DATA

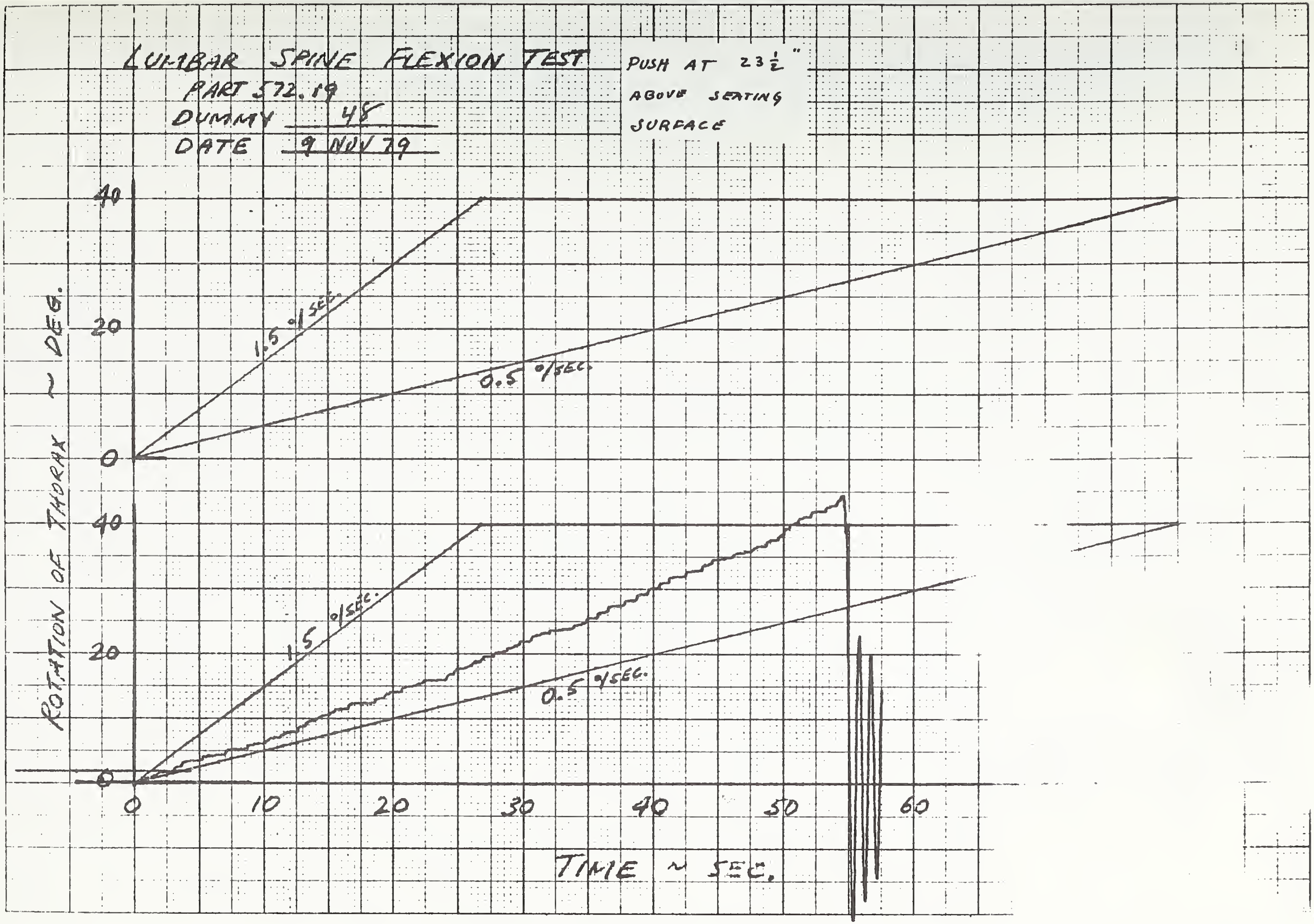


Figure 2-22 ALDERSON S/N 48 DUMMY LUMBAR SPINE FLEXION TEST DATA

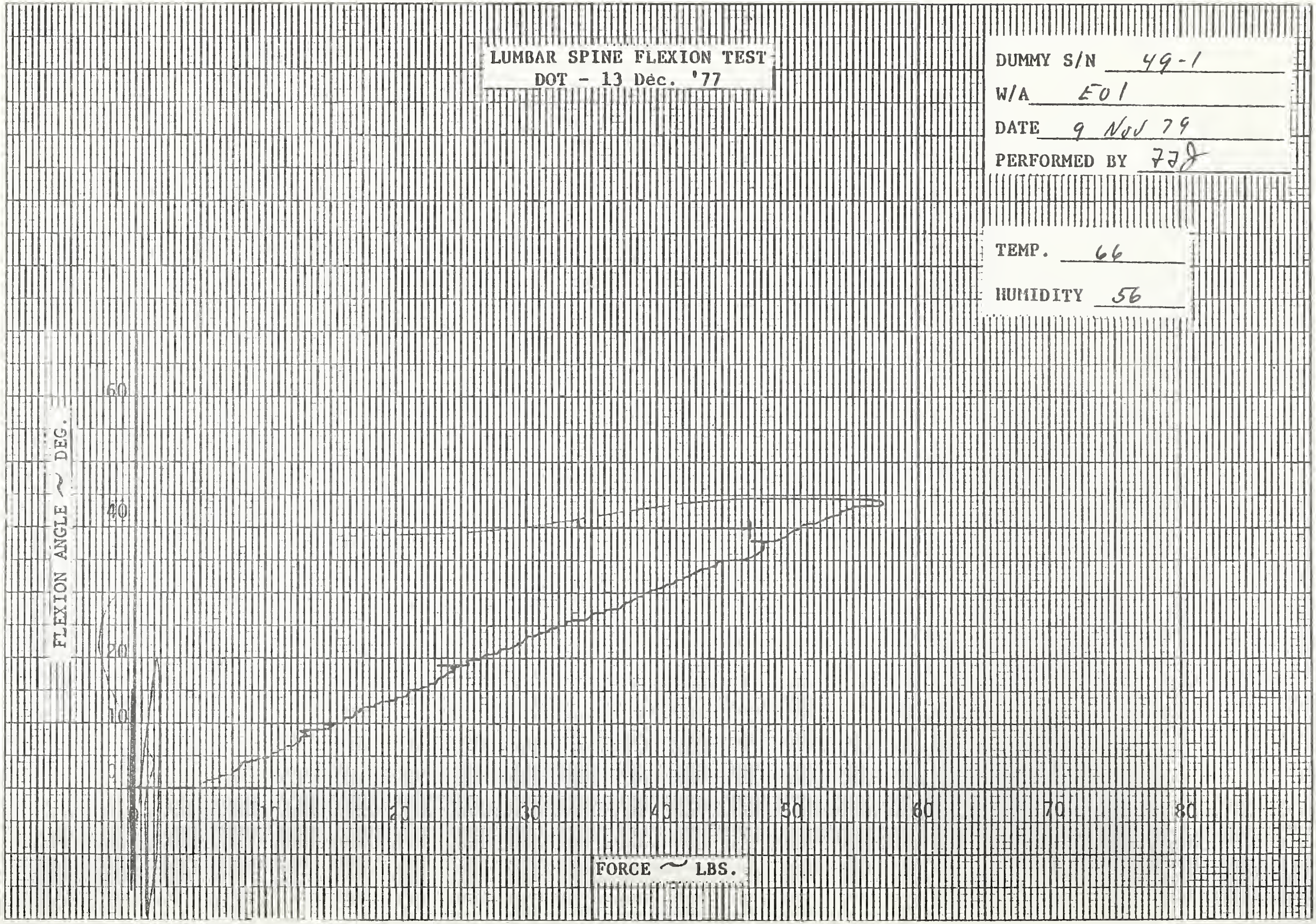


Figure 2-23 ALDERSON S/N 49 DUMMY LUMBAR SPINE FLEXION TEST DATA

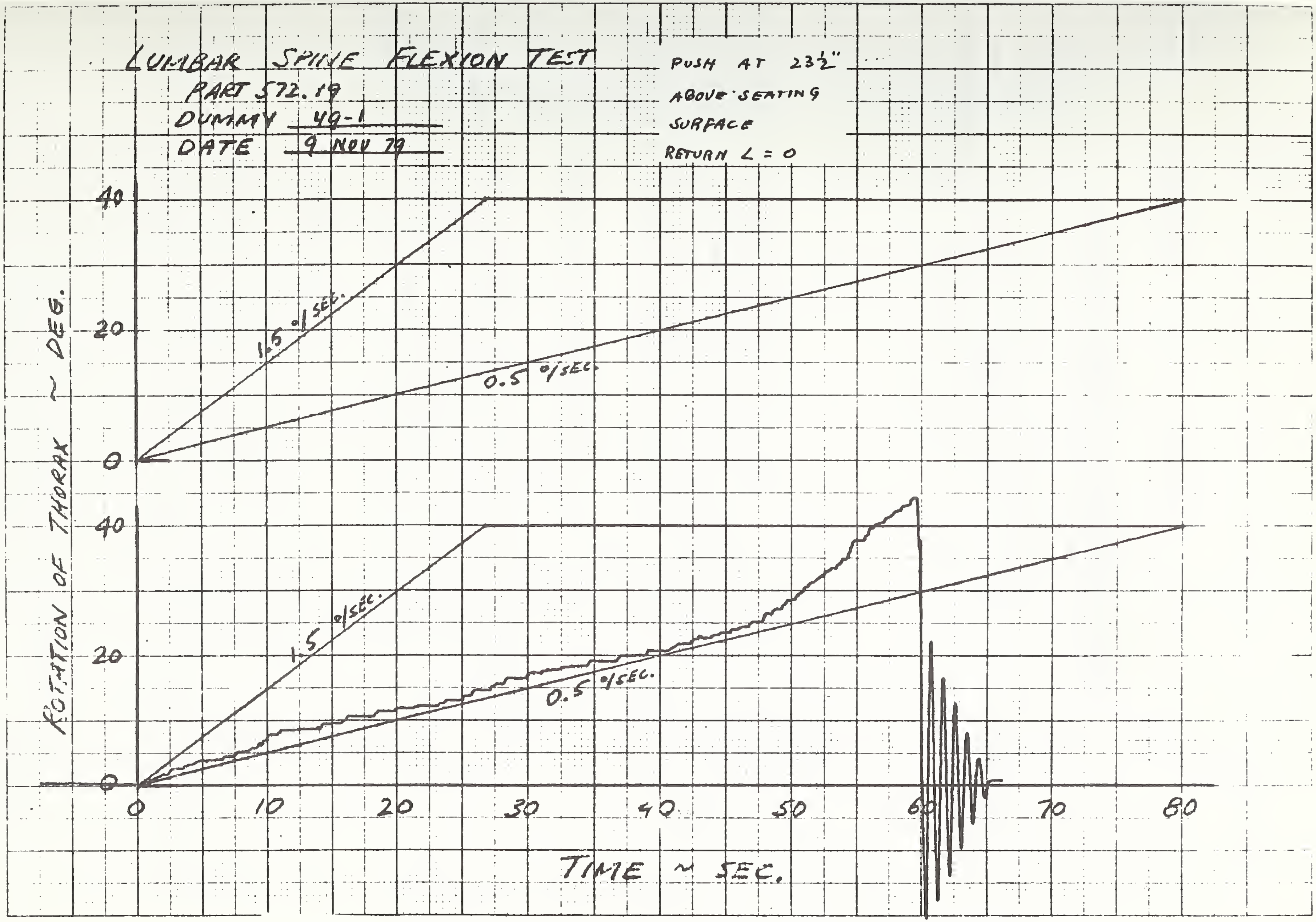


Figure 2-24 ALDERSON S/N 49 DUMMY LUMBAR SPINE FLEXION TEST DATA

Table 2-4

SUMMARY OF LUMBAR SPINE FLEXION TEST DATA

MEASUREMENT	DUMMY			
	TNO	Sierra	Alderson S/N 48	Alderson S/N 49
Force at 40° Flexion Angle - N (lbs.)	227.2 (51)	71.3 (16)	196.0 (44)	227.2 (51)
Spinal Column Angle at 3 Min. Post Test - deg.	0	7.5	2	0

3.0 SLED TESTS

The sled testing for this task was divided into two phases: front seat simulations and rear seat simulations. All four ATDs were used during the front seat simulations which were performed in the Omni sled buck. Only the TNO-P6 and the ARL S/N 49 ATDs were used in the rear seat configurations which were performed in an open sled buck. All sled tests were performed using two ATDs seated side-by-side.

Crash Pulse

All of the six-year-old size ATD sled testing was performed using the barrier crash pulse supplied by Chrysler for the L-body (Omni). The metering pin designed to simulate this pulse had been developed during the original program, and the design is described in Reference 1. A typical sled pulse is presented in Figure 3-1. Sled test conditions can be found in Table 3-1.

Recording Instrumentation

Dummy kinematics were measured by high-speed movie cameras which were mounted on the sled and operated at a nominal 1000 frames per second. All four ATDs were equipped with accelerometers in the head and chest regions. Table 3-2 presents the instrumentation employed for these tests.

Test Conditions

Front seat simulations were performed with two ATDs positioned in the front bucket seats of the Omni sled buck. This sled buck had been fabricated for the original program (Reference 1). The steering column was removed for this series of tests so that both ATDs would simulate front seat passengers.

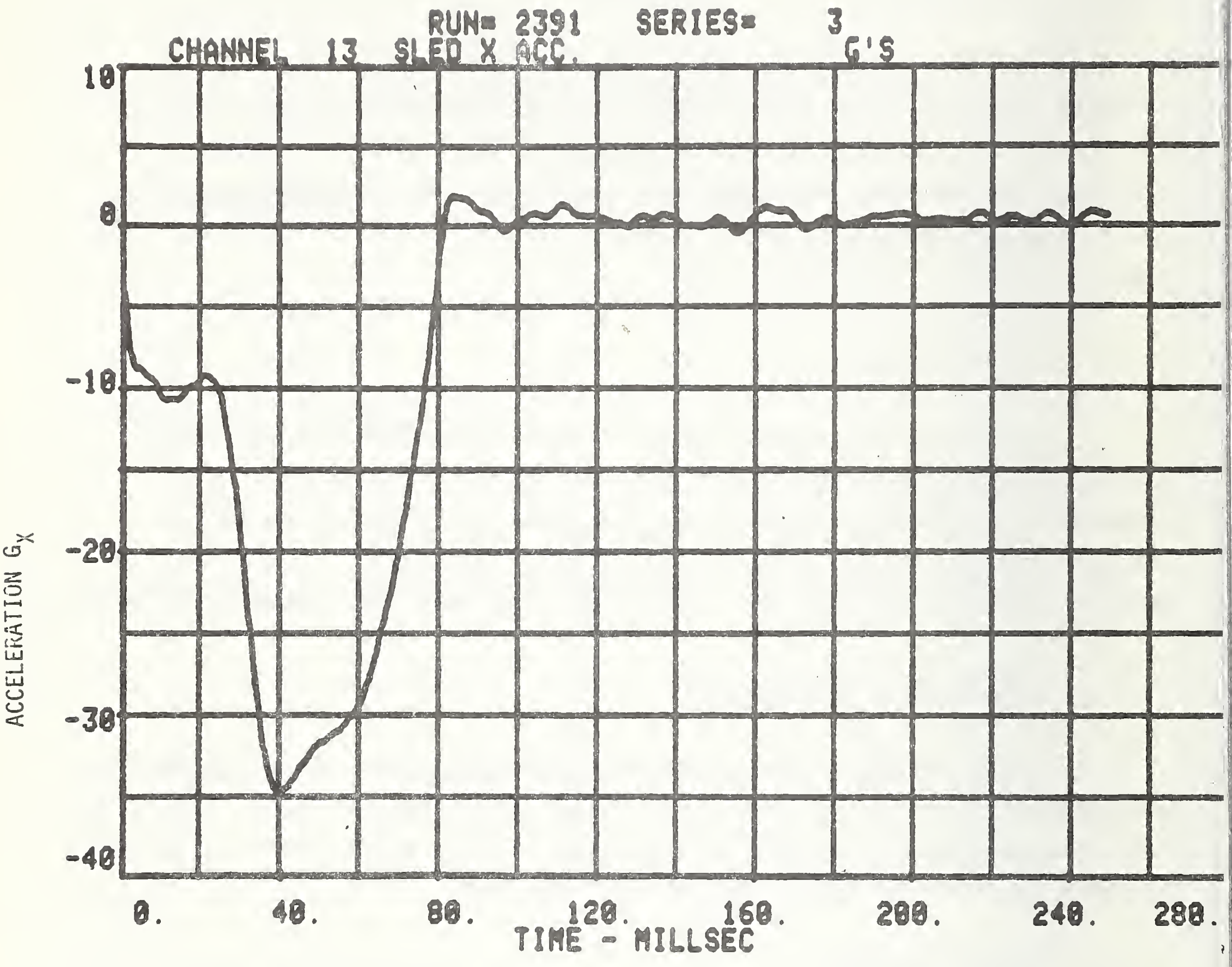


Figure 3-1 TYPICAL ACTUAL SLED PULSE

Table 3-1

SLED TEST DATA

Front Seat Simulations

Test ID	Velocity Change Km/h (mph)	Peak Acceleration G_X	Sled Stroke cm (in)	Pulse Time ms.
2343	53.6 (33.3)	32.0	55.9 (22.0)	83.6
2344	53.4 (33.2	31.5	55.1 (21.7)	83.3
2345	53.4 (33.2)	31.8	55.4 (21.8)	83.8
2346	53.6 (33.3)	31.7	55.1 (21.7)	83.3
2347	53.4 (33.2)	31.6	55.4 (21.8)	83.4
2348	53.4 (33.2)	31.7	54.9 (21.6)	82.8

Rear Seat Simulations

Run No.	Velocity Change Km/h (mph)	Peak Acceleration G_X	Sled Stroke cm (in)	Pulse Time ms.
2389	55.2 (34.3)	35.0	55.9 (22.0)	81.7
2390	55.0 (34.2)	34.6	55.9 (22.0)	81.8
2391	55.5 (34.5)	34.7	55.6 (21.9)	81.2
2392	54.9 (34.1)	34.7	55.9 (22.0)	81.6
2393	55.3 (34.4)	34.6	55.6 (21.9)	81.3

Table 3-2

TEST INSTRUMENTATION

Dummy	Location	Instrumentation
TNO	Head	Triaxial Endevco 7267C-750
TNO	Chest	Triaxial Endevco 7267C-750
Sierra	Head	3 - CEC Type 202-250G
Sierra	Chest	3 - CEC Type 202-250G
Alderson (S/N 48, S/N 49)	Head	3 - Endevco 7231C-750
Alderson (S/N 48, S/N 49)	Chest	3 - Endevco 7231C-750
All	Belt Loads	Lebow Cells, Model 3371

An open buck was fabricated for this series of tests to represent the rear seat of a contemporary small car. Measurements were taken in an Omni of the rear seat angle and position relevant to the front bucket seats in the mid-seating position. The Omni front bucket seats were removed from the sled buck and attached to the open test rig. A Volkswagen Rabbit rear seat, which was immediately available, was positioned on the rig according to the Omni rear seat measurements. Figure 3-2 presents photographs of both test buck configurations.

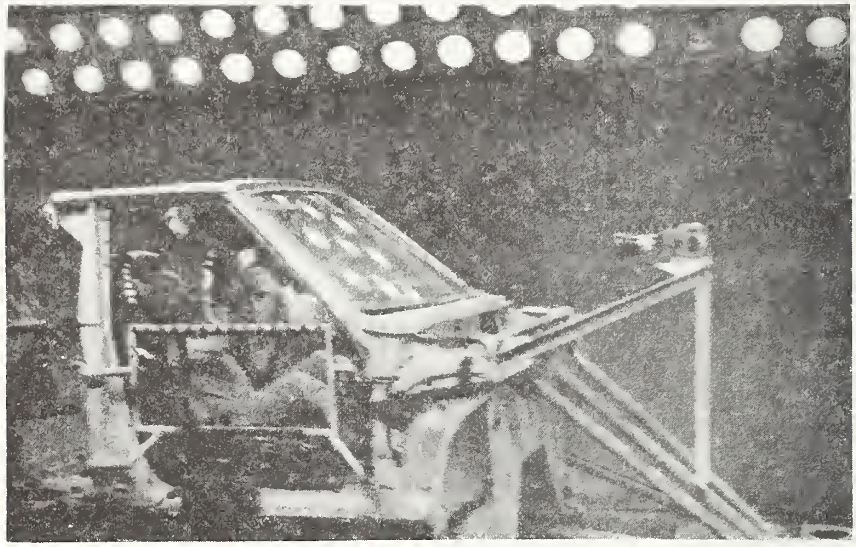
3.1 Front Seat Simulations

A total of six front seat sled tests were performed. Pre- and post-test photographs and dummy response data traces can be found in Appendix A.

Four runs were performed with each of the four ATDs restrained by standard webbing in both two-point passive torso belt and three-point torso and lap belt configurations. Two runs utilized only the TNO P6 restrained with 3-point belts made of standard webbing during run 2347 and seated on the same bolsters restrained with force-limiting webbing (4.4 kN (1000 lb.) - torso belt, 2.2 kN (500 lb.) - lap belt) during run 2348. Bolster size was determined by the best torso belt deployment across the ATD (see Appendix A, Figure A-99). The TNO dummy was seated on a 11.4 cm (4.5 in.) bolster, and the Alderson was on a 6.4 cm (2.5 in.) bolster, both made of commercial styrofoam 22.9 cm x 33.0 cm x 5.1 cm (9 in. x 13 in. x 2 in.) with 1/2 inch (1.3 cm) of ensolite on the seating surface. A detailed description of sled seating configurations and results is presented in Section 4.1.

3.2 Rear Seat Simulations

Five rear seat simulation sled tests were performed utilizing the TNO-P6 and the Alderson VIP-6C S/N 49 dummies. Appendix A contains pre- and post-test photographs and dummy response data traces.



CHRYSLER OMNI SLED BUCK USED FOR FRONT SEAT SLED TESTS

Figure 3-2 SLED BUCK CONFIGURATIONS

As was mentioned previously, only the TNO P6 and the Alderson VIP-6C S/N 49 were tested in the rear seat. The only comparison run in this series was performed with both ATDs restrained with only a lap belt. The other rear seat tests were performed mainly to evaluate alternative means of restraining this size ATD with the intention of improving upon the results of the "lap belt only" restrained ATD.

A brief description of the various restraint systems used is presented below:

Alderson VIP-6C S/N 49 Right Rear Passenger:

Run 1 The ATD was restrained with a lap belt.

Run 2 The ATD was seated on a 10.2 cm (4 in.) bolster of Ethafoam and restrained with a lap belt. The bolster was not attached to the seat.

Run 3 The ATD was seated on a molded seat made of styrofoam and covered with a terrycloth cover (seat supplied by NHTSA). The dummy/seat complex was secured with a three-point belt system. The torso belt passed through a notch on the inboard side of the molded seat.

Run 4 The ATD was restrained with a 4-point Rebco harness attached to the lap belt and fastened with a top tether.

Run 5 The ATD was seated on the Rebco booster seat plus elevator and restrained with the 4-point Rebco harness attached to the seat belt and fastened with a top tether.

TNO-P6 Left Rear Passenger:

Run 1 The ATD was restrained with a lap belt.

Run 2 The ATD was restrained in a vest designed for handicapped children which was supplied by NHTSA (Vest #1). The rear attachment consisted of two double clasps attached to the floor with a top tether strap and one end of the lap belt in each clasp.

Run 3 The ATD was restrained with a modified design of Vest #1 having a different rear attachement (a 5-point airplane locking device hooked to both top tethers, both ends of the lap belt and the floor).

Run 4 The ATD was restrained in a vest designed for the 6-year-old size child which was supplied by NHTSA (Vest #2).

Run 5 The ATD was restrained with a modified version of Vest #2. Webbing was removed from the neck area, the neck was cut lower and straps around the thighs were added.

All dummy response data traces are available in Appendix A. Sled test results are presented and discussed in Section 4.2.

4.0 DISCUSSION

Several serious problems exist in the area of defining proper protection for children. Human injury tolerance data for children is essentially non-existent and, therefore, it is impossible to set meaningful performance evaluation criteria upper limits. Adding to this dilemma is the fact that there is a wide disparity in the response data of the available six-year-old sized surrogates, both in measured accelerations and kinematics.

For the sake of expediency, the following discussion of the sled runs will consider pass/fail performance evaluation criteria for the six-year-old ATDs to be the same as that specified for the adult sized ATDs (i.e., HIC = 1000 and C_R = 60).

4.1 Front Seat Sled Tests

The front seat sled tests were performed for two reasons: first, for comparative purposes with the six-year-old sized surrogates placed in identical restraint systems and, second, to determine if the level of protection afforded this size child surrogate by adult restraint systems could be improved upon. These restraint systems will be discussed as they are tabulated in Table 4-1.

Two-Point Passive Belt

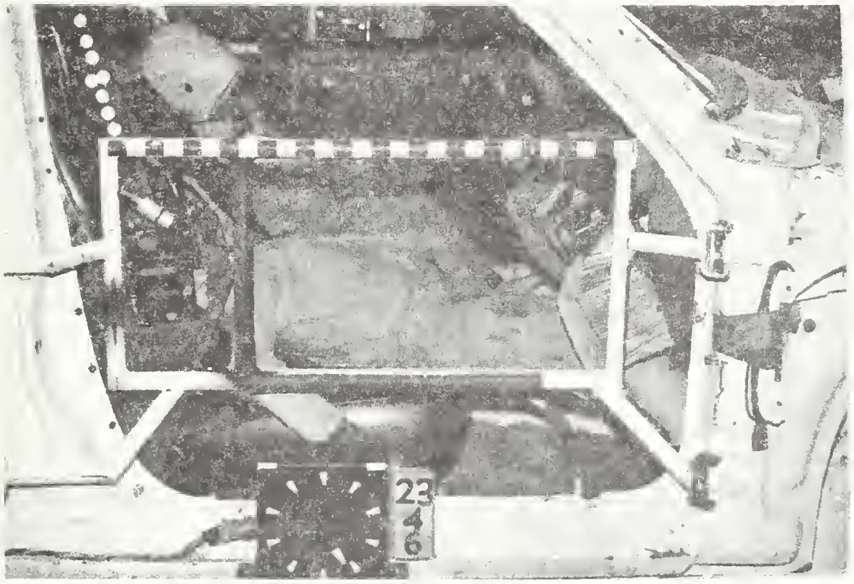
Figure 4-1 provides post-test photographs of sled runs in which the ATDs were restrained by passive torso belts and kneebars. The kneebar (designed for adult size ATDs) was ineffective in restraining the lower torso of all the child size surrogates. The legs of the dummies underrode the kneebar, and the torso belt loaded the neck and left axilla in all cases. In the post-test photographs of the Sierra, Alderson S/N 48 and Alderson S/N 49 the underriding of the kneebar is obvious. The TNO dummy rebounded and appears to be sitting in the seat. Analysis of high-speed movies indicates that the

Table 4-1

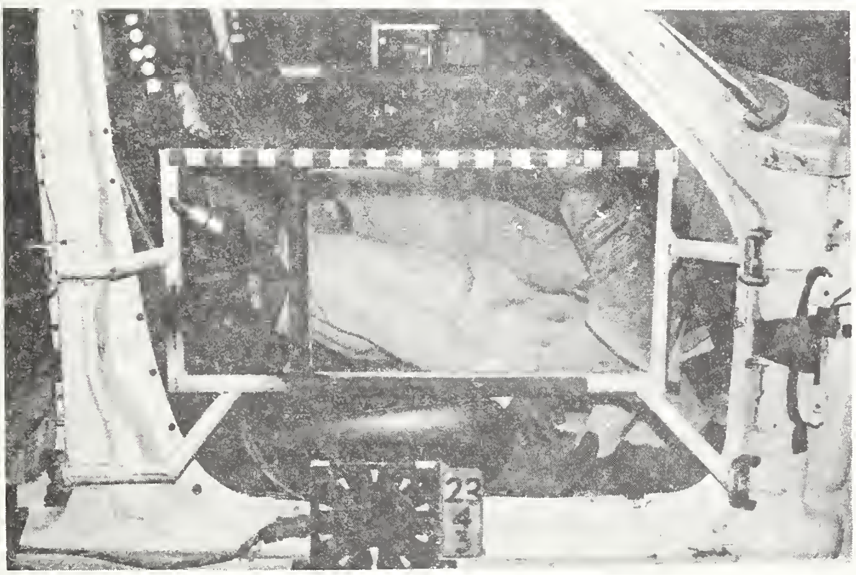
FRONT SEAT TESTS

PERFORMANCE EVALUATION CRITERIA

ATD	C_R (g)	Head Excursion cm	(in.)	HIC	Test ID
Two-Point Passive Belt					
Sierra	65	35.6	(14.0)	2256	2343
Alderson S/N 48	107	27.9	(11.0)	1150	2343
TNO	55	24.1	(9.5)	1859	2346
Alderson S/N 49	63	23.4	(9.2)	977	2346
Three-Point Belt					
Sierra	59	34.3	(13.5)	2765	2344
Alderson S/N 48	69	29.2	(11.5)	1377	2344
TNO	73	30.5	(12.0)	2643	2345
Alderson S/N 49	62	26.7	(10.5)	876	2345
Bolster, Three-Point Belt - Standard Webbing					
TNO	55	30.5	(12.0)	1533	2347
Alderson S/N 49	63	31.8	(12.5)	977	2347
Bolster, Three-Point Belt - Force Limited Webbing					
TNO	45	41.9	(16.5)	1315	2348
Alderson S/N 49	46	36.8	(14.5)	898	2348



(a) Alderson S/N 49, TNO



(b) Alderson S/N 48, Sierra

Figure 4-1 POST-TEST POSITIONS OF ATDs RESTRAINED BY PASSIVE TORSO BELT AND KNEEBAR

TNO dummy rotated around the torso belt in the neck area, the lower torso came completely off of the seat, and his legs went under the kneebar causing the thighs and lower abdomen to load the kneebar. The top of the abdominal insert popped out, and small rips were evident in the two lower neck rings.

Although the HIC numbers generated by all four dummies were above the FMVSS 208 limits, and chest resultant accelerations on all but the TNO ATD exceeded 60 g, the most serious injury producing mechanism in these runs appears to be the severe loading of the neck area by the torso belt.

Three-Point Belt

It was decided to test all four ATDs in 3-point belt systems. The kinematics were improved in all cases in that the lap belt restrained the lower torso which the kneebar had failed to do. However, the Sierra and TNO ATDs, both of which have quite flexible necks, appeared to have contact between the head and chest thus generating HIC numbers of 2765 and 2643, respectively. Both of the Alderson ATDs, S/N 48 and S/N 49, received lower HIC numbers (1377 and 876, respectively) but the torso belt loaded the neck area in both cases. This neck loading can be seen in the post-test photographs found on Page A-24 and A-50. These results indicate that the adult three point belt system may not be optimum for protecting this size child surrogate.

The Sierra 492-06 and Alderson VIP-6C, S/N 48, because they are obsolete designs, were dropped from the test schedule at this point.

Bolster, Three-Point Belt - Standard Webbing

The suggestion has been made that seating a child size ATD on a firm bolster and securing him with a three-point adult belt system may afford an increased level of protection. A styrofoam bolster was made for each dummy, taking into consideration the belt deployment across the dummy chest. This belt deployment can be seen in the pre-test photographs found on Page A-99.

Neither dummy showed any indication of neck loading during the test. The Alderson dummy's HIC number was degraded somewhat from run 2345 but was still within the FMVSS 208 limit. The TNO dummy's HIC number and chest resultant were improved significantly. The bolster slipped out from under this dummy on rebound.

Bolster, Three-Point Belt, Force-Limited Webbing

The previous tests, wherein the six-year-old size ATDs were seated on proper size bolsters and restrained with standard three-point belt systems, showed an improvement in both performance evaluation criteria values and ATD kinematics. Due to the fact that the use of force-limited webbing in place of standard nylon and polyester webbing caused a marked improvement in performance evaluation criteria values for adult ATDs during the initial phase of this program (Reference 1), it was decided to test the six-year-old sized ATDs seated on the same bolsters restrained with force-limited three-point belt systems.

Referring to Table 4-1 it can be seen that HIC numbers and chest resultant acceleration values were lower for both surrogates in the force-limited system than the previous standard webbing test. The increase in head excursion due to increased webbing stretch is well within the allowable occupant compartment space and does not present any danger of head contact with interior vehicular surfaces.

4.2 Rear Seat Sled Tests

The rear seat sled tests utilized the Alderson VIP-6C S/N 49 as the right rear passenger and the TNO-P6 as the left rear passenger in all of the following tests.

The rationale behind these tests was to determine the responses of both dummies restrained by only a lap belt and then to attempt to improve on these responses by the use of a simple, homemade bolster seat, two developmental vests and two bolster devices which are commercially available in foreign countries.

The scope of this program did not allow for testing both dummies in all of these devices. The Alderson ATD was sled tested in the bolster seats, and the TNO ATD was tested with the developmental vests. This discussion of the rear seat sled tests will concern itself first with the Alderson dummy and then with the TNO dummy. The performance evaluation criteria values are available in Table 4-2.

Alderson ATD Sled Tests

The Alderson ATD, when restrained with a production type lap belt only (Run 1), struck his head on the back of the front seat generating a HIC number of 2681 and ripping the front seat upholstery. The lap belt roped and became imbedded in the dummy's adominal area as indicated in Figure 4-2.

During Run 2 the dummy was restrained by a lap belt while seated on a bolster constructed by taping two pieces of Ethafoam together. This simple bolster was designed as an example of a "quick fix" that parents might put together and use in their vehicle. The dummy struck his head on the back of the front seat and his HIC number was essentially the same as the lap belt alone test (HIC = 2626). Analysis of the high-speed movies indicates that the lap belt remained over the dummy's thighs during the run, and there was no evidence of abdominal loading.

Table 4-2

REAR SEAT TESTS
PERFORMANCE EVALUATION CRITERIA

ALDERSON VIP-6C S/N 49

Run No.	Configuration	C_R (g's)	Head Excursion cm	(in.)	HIC	Test ID
1	Lap Belt	54	79	(31)*	2681	2393
2	10.2 cm (4 in.) Ethafoam Booster w/Lap Belt	42	81	(32)*	2626	2389
3	Molded Seat w/Lap Belt and Torso Belt	59	46	(18)	965	2390
4	Rebco Harness w/Lap Belt	63	46	(18)	2892	2391
5	Rebco Booster Seat, Elevator, Harness w/Lap Belt	62	41	(16)	697	2392

TNO P6

Run No.	Configuration	C_R (g's)	Head Excursion cm	(in.)	HIC	Test ID
1	Lap Belt	65	79	(31)*	3348	2391
2	Proposed Vest For Handicapped (2 - 2-Point Releases)	46	58	(23)	1865	2389
3	Proposed Vest For Handicapped (Pilot 5-Point Release)	59	46	(18)	819	2392
4	Proposed Vest For 6-Year-Old	70	36	(14)	1104	2390
5	Proposed Vest For 6-Year-Old - Modified	54	48	(19)	583	2393

*Head contacted back of front seat.

Figure 4-2 POST-TEST VIEW OF ALDERSON ATD IN LAP BELT ONLY

The CTM supplied two production booster seats. The first was a styrofoam seat covered with a terrycloth cover and designed to accommodate a three-point belt system. This seat was tested in Run 3; and, as can be seen in Figure 4-3, the styrofoam was not strong enough to take the torso belt loading, and the seat broke on the inboard side causing the dummy to rotate inboard. HIC number and chest resultant acceleration were 965 and 59 respectively.

The second seat supplied by the CTM was a Rebco Hi-Rider, manufactured in Australia. A harness, designed with a top tether and lap belt attachment is supplied in conjunction with this seat, and a decision was made to test the Alderson ATD restrained by this harness alone. The results of this sled test were HIC number and chest resultant acceleration in excess of FMVSS 208 limits. The harness pulled the lap belt up across the upper abdominal area of the ATD causing severe loading which can be seen in Figure 4-4.

The Rebco booster seat with the elevator and harness was tested in Run 5. Dummy kinematics showed that, although the ATD was seated quite high, there was no hyperextension of the head on rebound, and a HIC number of 697 was generated. The chest resultant accelerations on both runs utilizing the Rebco harness were slightly greater than 60 g.

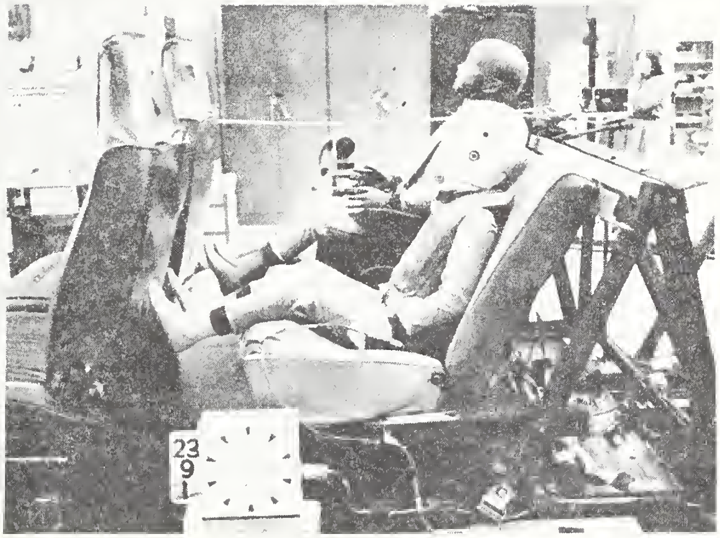
TNO ATD Sled Tests

The TNO dummy, when restrained by a production type lap belt only also struck his head on the back of the front seat with enough force to rip the upholstery. This ATD exceeded FMVSS 208 performance evaluation criteria on both the head and chest. The dummy contacted his knees with his chest, and there was hyperextension of the head on rebound.

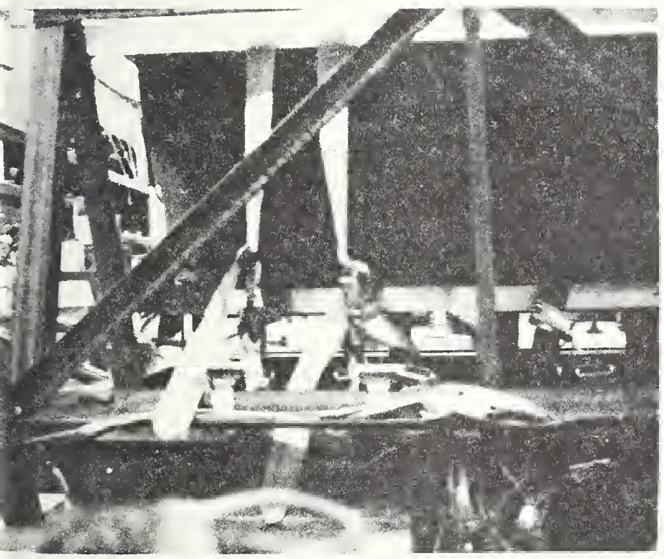
Two developmental vests were supplied by the CTM. The first, designed by Alice Chatham, was intended for handicapped children and was sled tested in runs 2 and 3 with different release mechanisms as can be seen in Figure 4-5.

Figure 4-3 BROKEN STYROFOAM BOOSTER SEAT

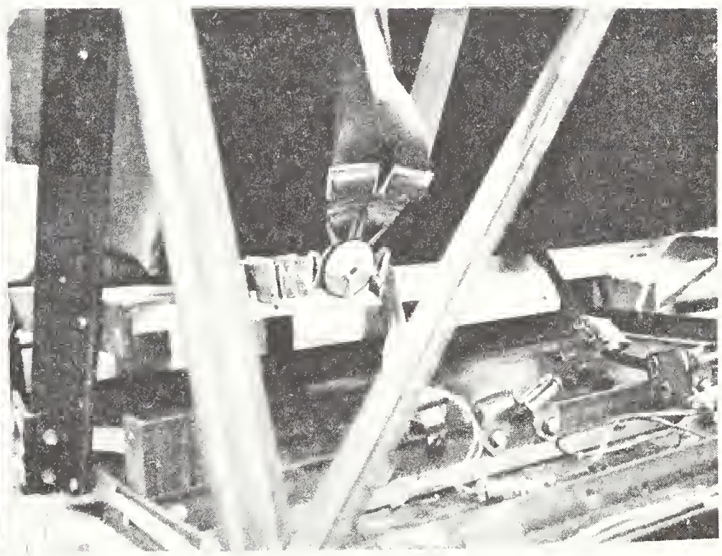
Figure 4-4 POST-TEST VIEW OF REBCO HARNESS



TNO ATD - VEST #1



RELEASE MECHANISM - RUN 2



RELEASE MECHANISM - RUN 3

Figure 4-5 PROPOSED VEST FOR HANDICAPPED

During the first run using this vest the ATD contacted his knee with his head, his body lifted up off the seat, and there was hyperextension of the neck over the seat back during rebound. The HIC number was 1865. The next run, using the 5-point release mechanism, kept the ATD more securely in the seat, and there was no hyperextension of the ATD neck. The HIC number was 819.

The second vest was designed for the six-year-old child by Suzanne Klick. Tests 4 and 5 utilized this vest.

Sled test 4 was performed with the vest as seen in Figure 4-6. Because the forward stroke of the ATD was somewhat restricted and the HIC and chest resultant acceleration exceeded FMVSS 208 limits, the designer made some modifications to the vest. Run 5 was performed with this modified vest which had been cut lower in the neck, some of the upper chest webbing removed and thigh straps added. Although the results of this test show that FMVSS 208 limits were not exceeded, the high-speed movie analysis indicates that the vest ripped apart and slipped down off the ATD shoulders restraining him primarily across the abdominal area.

Figure 4-6   PROPOSED VEST FOR SIX-YEAR-OLD

5.0 CONCLUDING REMARKS

Based upon the results of the limited numbers of tests, it is not appropriate that firm conclusions be drawn. This is so because there were no repeatability tests performed during this task that would indicate the possible variance inherent in a given ATD. It is appropriate, however, that concluding remarks, based upon the observations of the individual exposures, be made and this section of the report will document these findings.

With regard to the anthropometry efforts it is apparent that there is a wide variation between the sizes of Snyder's (Reference No. 4) average six-year-old and that of the various manufacturers of ATDs. The differences range from -28% to +27% in some instances. Of the 17 measurements obtained from the ATDs and compared with the work reported in Reference No. 4 (see Table 2-1, page 2-4 of this report) some are more critical to the field of occupant protection than others. For example, weight and seated height are, in general, considered to be more critical to test results than forearm and ankle circumference. This is not to imply that the circumferential measurements are insignificant since they may indicate segment mass differences that could have an effect on surrogate kinematics and thereby anatomical loading areas (e.g., a propensity for submarining in a belt restraint system).

All three ATDs are heavier than the 50th percentile child with a range of 9% for the TNO to 6% for the Sierra. They are taller (3%, TNO to 7% Alderson and Sierra) and the seated height is greater (2%, TNO to 8% Sierra). The buttock-knee length is shorter (-2%, TNO to -28%, Sierra) as is the knee height (-2%, Alderson to -10%, Sierra). The shoulder-elbow length is shorter (-22%, TNO to -27%, Alderson) and the lower arm length varies from +2% for the Alderson to -21% for the TNO. The variations in lengths of these anatomical component measurements (not only with regard to the 50th percentile child but also with regard to each other) could certainly produce significantly different results in replicate testing configurations. In overview, the TNO P-6 ATD appears to be closer (with the exception of the 9% higher weight) to the anthropometrical average of the six-year-old child than the other two ATDs tested.

The certification technique exposures that were performed on the ATDs (see Section 2, Table 2-2, Page 2-8, Table 2-3, Page 2-14, and Table 2-4, Page 2-32) indicate a wide variation in their responses to identical (within reasonable engineering tolerances) stimuli. The most notable are the total responses of the Sierra ATD when compared to the other three and the head responses of the two Alderson ATDs when compared to one another.

The head resultant acceleration of 200 G_R recorded during the pendulum impact (Table 2-2, Page 2-8) of the Sierra ATD is 571% of that recorded from the TNO P-6, 426% of that recorded for the Alderson S/N 48 and 177% of that recorded from the Alderson S/N 49. This is most likely attributable to the material from which the various heads were manufactured and the stiffness of the necks. The Sierra head is metal while the other heads are nonmetallic. The TNO and S/N 48 ATDs appeared (in the high-speed movies of the sled tests) to have necks that were less stiff than the S/N 49 ATD. No attempt was made during this program to quantify the neck stiffness of the four ATDs.

During the chest pendulum impact the Sierra ATD also recorded higher resultant accelerations than the other three (Table 2-3, Page 2-14). The 93 G_R is 60% higher than the TNO, 55% higher than S/N 48 and 45% higher than S/N 49. As was the case with the heads, the thorax of the Sierra ATD is metal while the thoraces of the other ATDs are nonmetallic. Furthermore, this phenomenon could be a function of dimensional and mass distribution difference, the determination of which were outside the scope of this small program. Table 2-4, Page 2-32, the torso flexion tests, indicates that in flexion the Sierra ATD lower spine is considerably softer and less resilient than the other three requiring 31% to 36% of the force to attain 40 degrees of flexion and remaining at an angle of 7.5 degrees 3 minutes after the removal of the force. While the TNO and S/N 49 ATDs indicated the same stiffness and resilience, S/N 48 was slightly softer and less resilient.

Because of the variability in the ATDs noted during the anthropometry efforts and the certification exposures, it is not surprising that the results of the single sled tests in identical restraint systems show a wide scatter from ATD to ATD. Therefore, only qualitative conclusions can be drawn from the results of these tests and they must be partially based upon the subjective evaluation of body segment loading by the restraint systems as observed from the high speed movie.

For front seat child-sized occupants it is apparent that (Table 4-1, Page 4-2):

1.) a two-point passive belt system provides restraint to motion by loading the neck and axilla areas of the ATDs

2.) a three-point belt system with standard webbing is preferable to the two-point passive system but still causes serious neck loading of the ATDs

3.) a three-point belt system with standard webbing and a bolster seat of a height to optimize the torso belt deployment over the shoulder can reduce neck loading and is preferable to the previous two systems

4.) a force limited three-point belt system with the same size bolster lowers chest acceleration and HIC values and increases head excursion to a nominally safe level.

For rear seat child-sized occupants it is apparent that (Table 4-2, Page 4-7):

1.) a lap belt only restrained occupant of this size will strike the back of the front seat in a small car in this crash environment whether or not the occupant is seated on a bolster. The contact will be at a velocity that could (based upon HIC value) be injurious.

2.) a booster seat with lap and shoulder strap or harness with back tether is probably sufficient for frontal impact protection of this sized occupant in a crash environment of 48 Km/h (30 mph). These reported tests were performed at approximately 55 Km/h (34.4 mph) and the results using the S/N 49 ATD were below the FMVSS 208 performance evaluation criteria with the exception of booster seat, harness and lap belt configuration that generated 62 G_R on the chest, 2 G_A over the limit.

3.) the type of harness with lap belt not only generated chest acceleration and HIC values above the FMVSS-208 limits but allowed submarining with subsequent heavy abdominal loading. This type of loading could cause severe abdominal injuries.

The two types of vests that were used in these tests were experimental and were modified by their designers between tests. All that can be concluded from these single exposure tests is that they are interesting concepts and with further development could provide a needed occupant protection capability to the handicapped and children in the intermediate sizes between child restraint systems and adult restraint systems.

The overall conclusion to be drawn from the results of this program is that at the present time there does not appear to exist a six-year-old size ATD that is anthropometrically 50th percentile (based upon Snyder's work) nor reproducible. Repeatability determinations were outside the scope of this program.

6.0 REFERENCES

1. Walsh, M. J. and Kelleher, B. J., "Development and Evaluation of a Belt Restraint System for Small Cars Using Force Limiting and Pretensioning," Final Report, September, 1979, Contract No. DOT-HS-7-01679.

2. "The TNO Child Dummies, P 3/4, P 3, P 6 and P 10," Research Institute for Road Vehicles, TNO-Complex Zuidpolder, Shoemakerstraat 97, Postbus 237, Delft, Holland, January, 1979.

3. Conversations with Mr. Joseph Smrcka, Alderson Research Labs., Stanford, Connecticut, November, 1979.

4. Snyder, R. G., Spencer, M. L. Owings, C. L. and Schneider, L. W., "Anthropometry of U. S. Infants and Children SP-394 SAE Paper No. 750423, February, 1975.

5. "Anthropomorphic Test Dummies Representing Six Month Old and Three Year Old Children," National Highway Traffic Safety Administration, Department of Transportation, Docket No. 78-09, Notice 1, proposed amendment in 49 CFR Part 572, Subpart C... Three Year Old Child and Subpart D... Six Month Old Infant, May 18, 1978.

6. Conversation with Mr. Vladislav Radovich, Office of Vehicle Safety Standards, NHTSA, November, 1979.

APPENDIX A

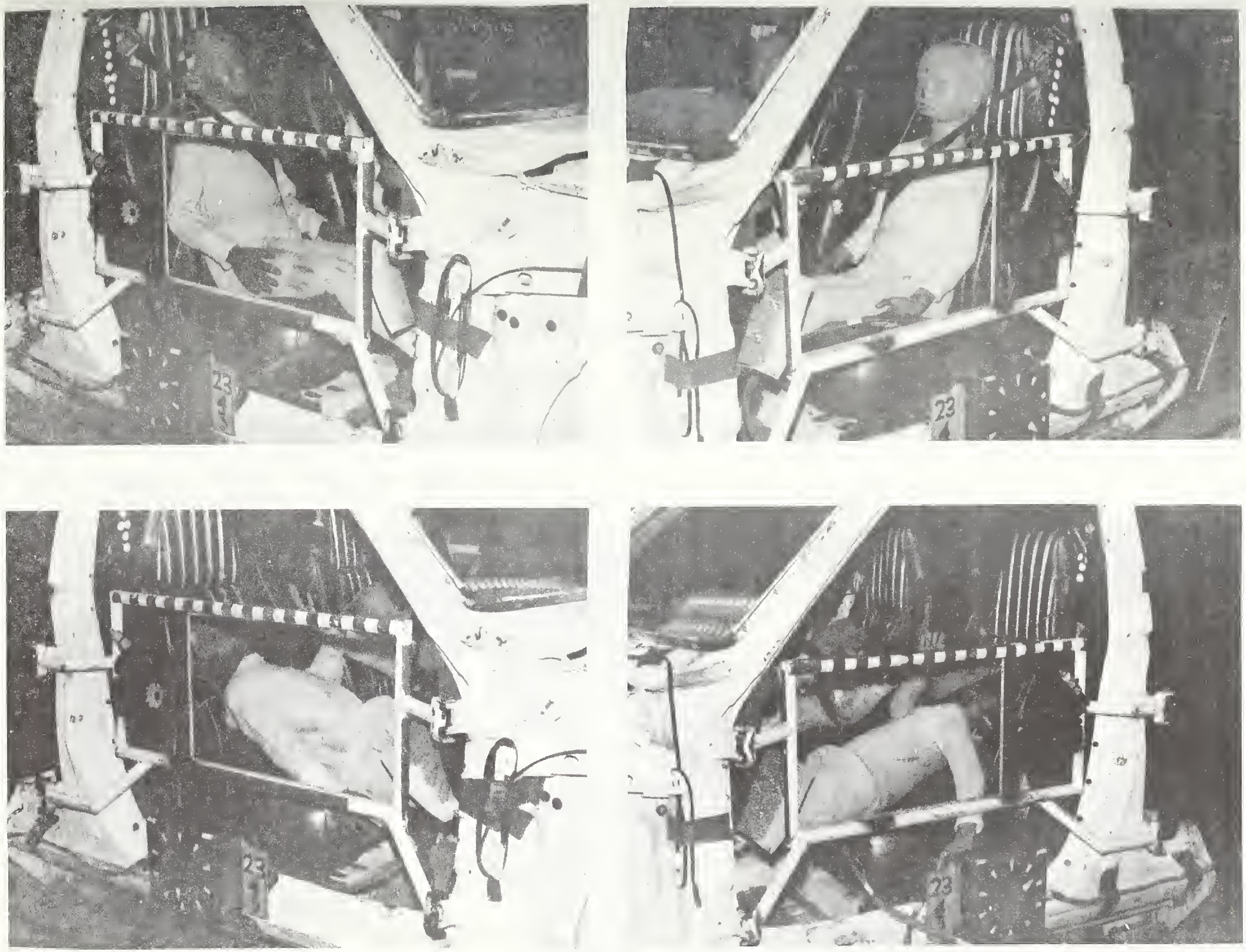
PRE- AND POST-TEST PHOTOGRAPHS
DATA TRACES

Index to Appendix A

Sled Test Photographs and Data Traces

Front Seat Sled Tests

Rear Seat Sled Tests

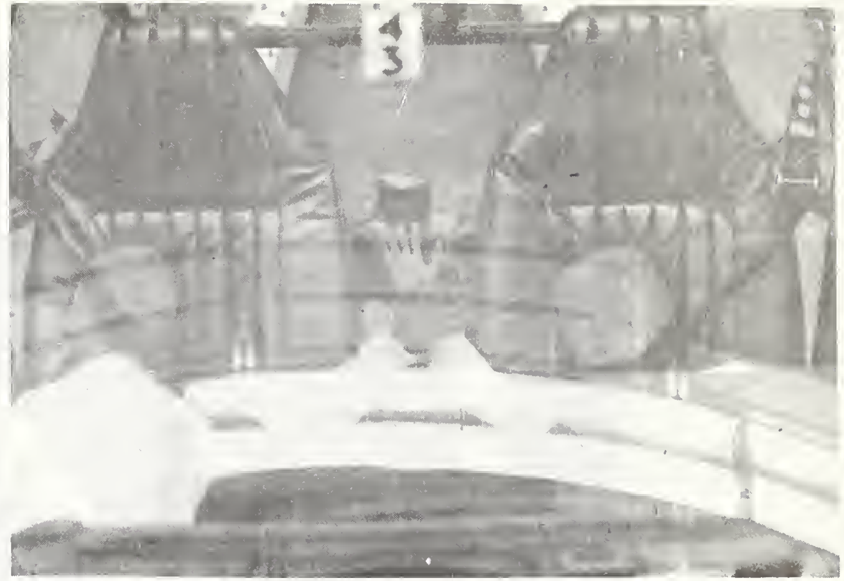


ALDERSON S/N 48 SIERRA

POST-TEST
RUN 2343

ALDERSON S/N 48 SIERRA

PRE-TEST



ALDERSON S/N 48 SIERRA

POST-TEST

RUN 2343

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2343

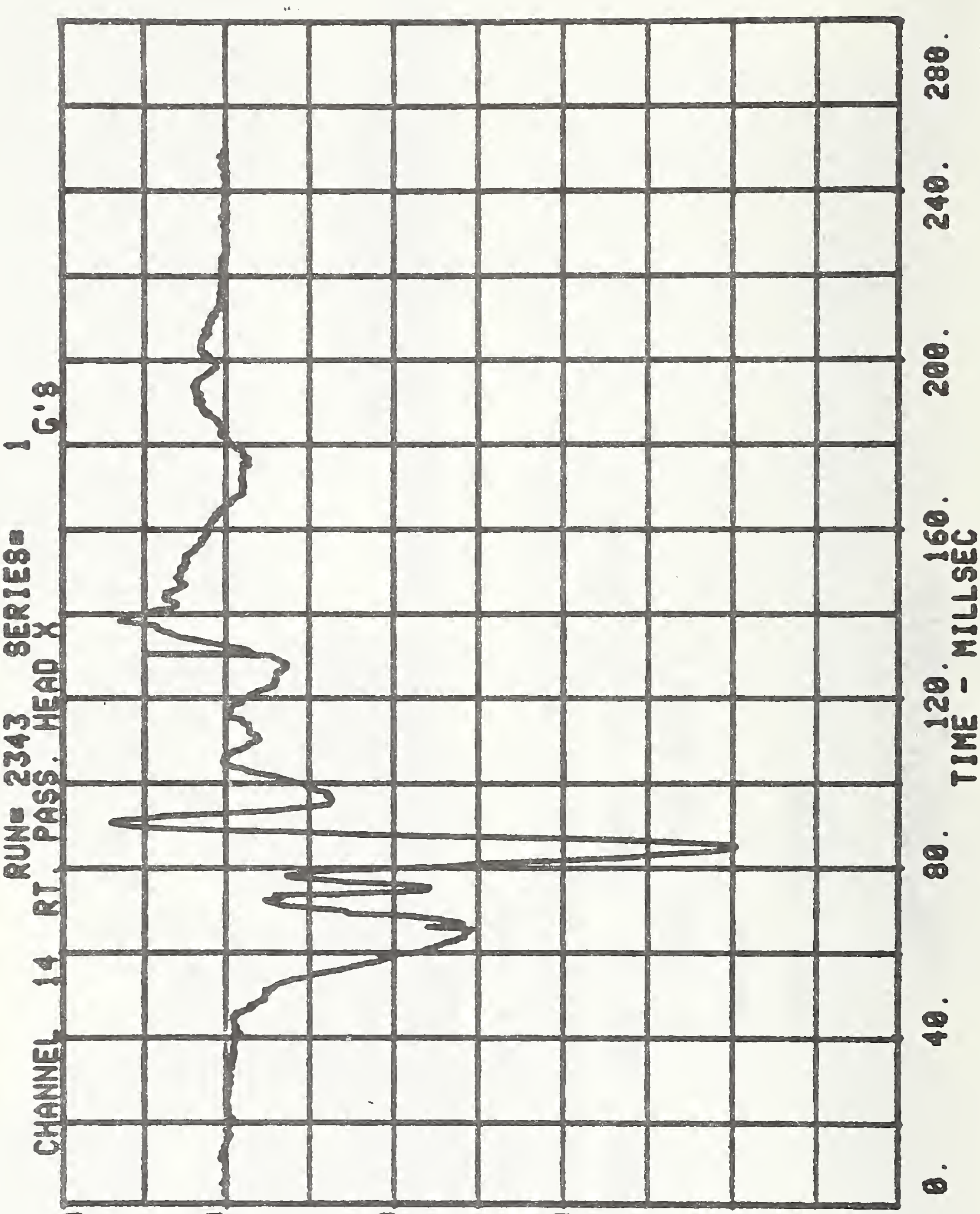
RT. PASS. HEAD RESULT.

HIC=1150.0 FROM T1= .05790 TO T2= .08790

AVERAGE ACCELERATION BETWEEN T1 AND T2= 68.2G'S

EVENT TIME= 250.0 MSEC

SEVERITY INDEX=1882.0



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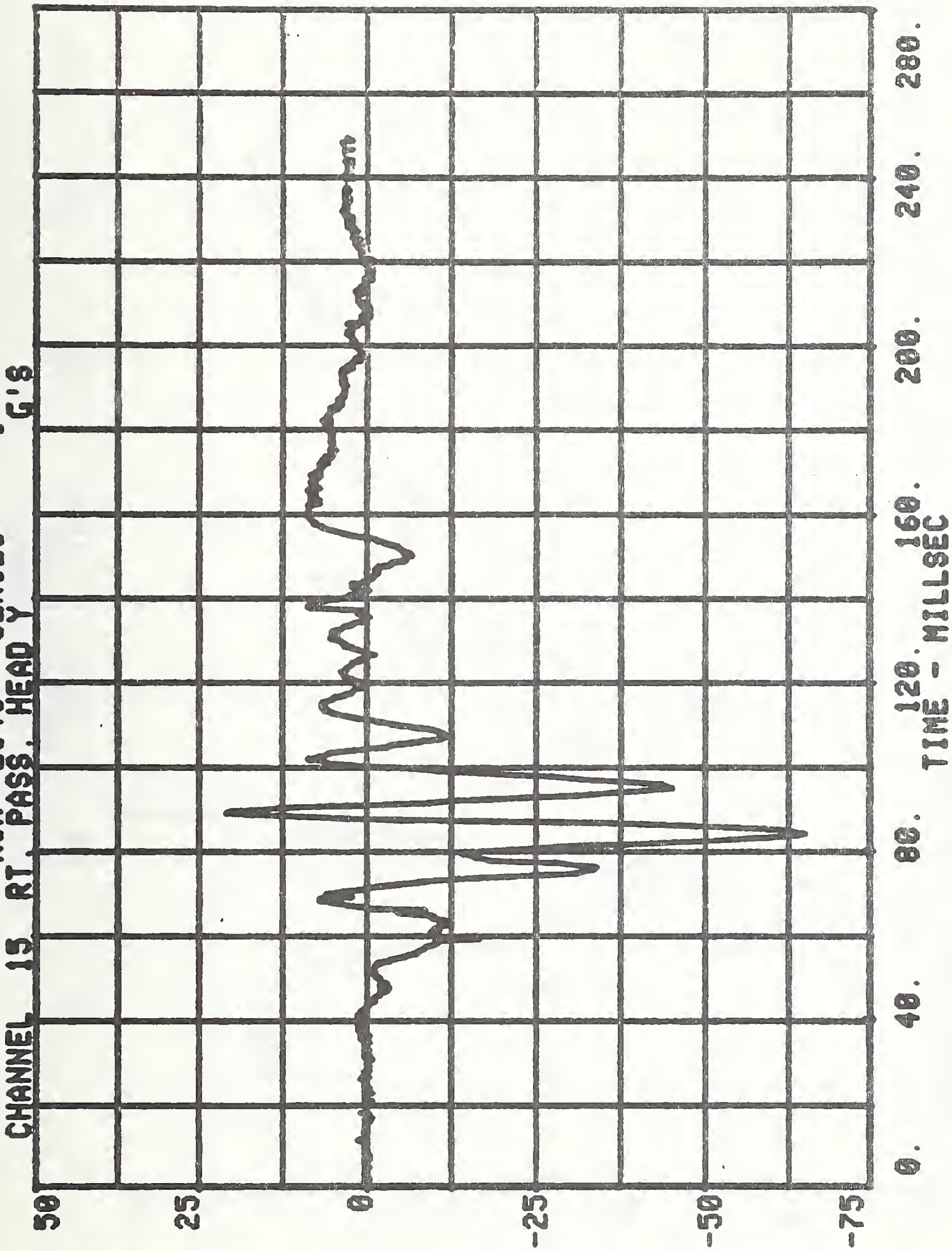
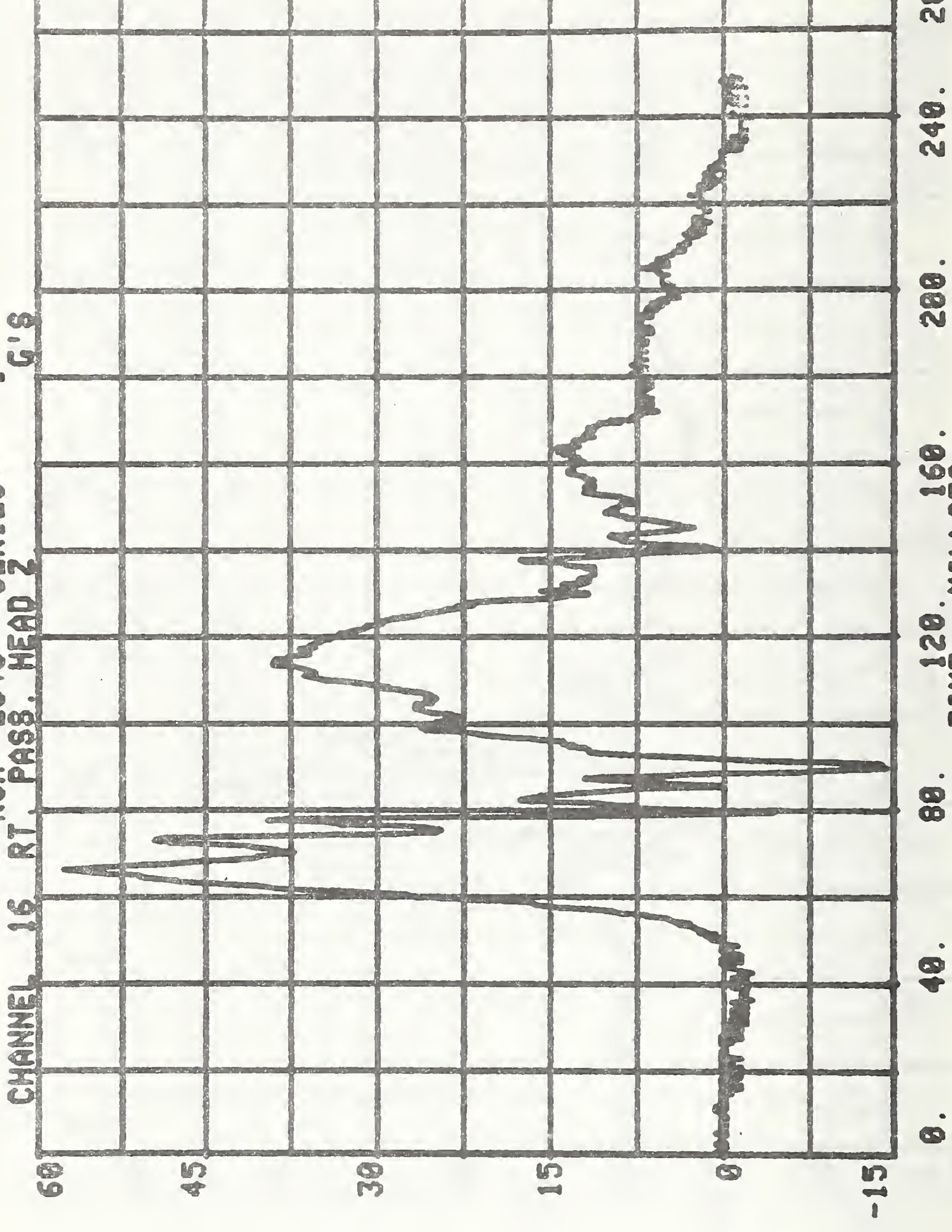

CHANNEL 15 RUN= 2343 SERIES= 1
RT. PASS. HEAD Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
50 25 0 -25 -50 -75


CHANNEL 16 RUN= 2343 SERIES= 1 G'S
RT. PASS. HEAD Z
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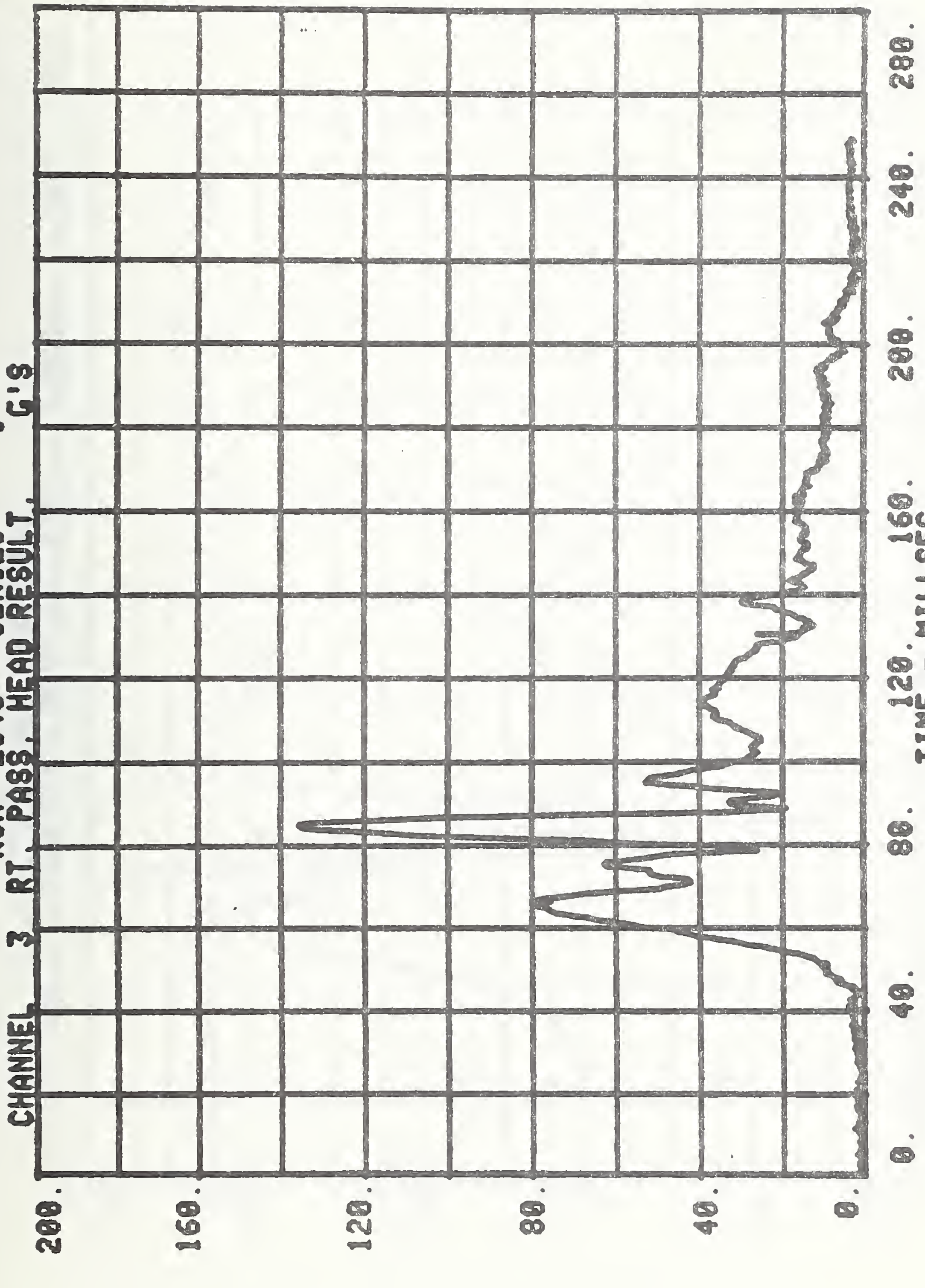
45
30
15
0
-15
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 3 RUN= 2343 SERIES= 1
RT. PASS. HEAD RESULT. G'S
TIME - MILLSEC
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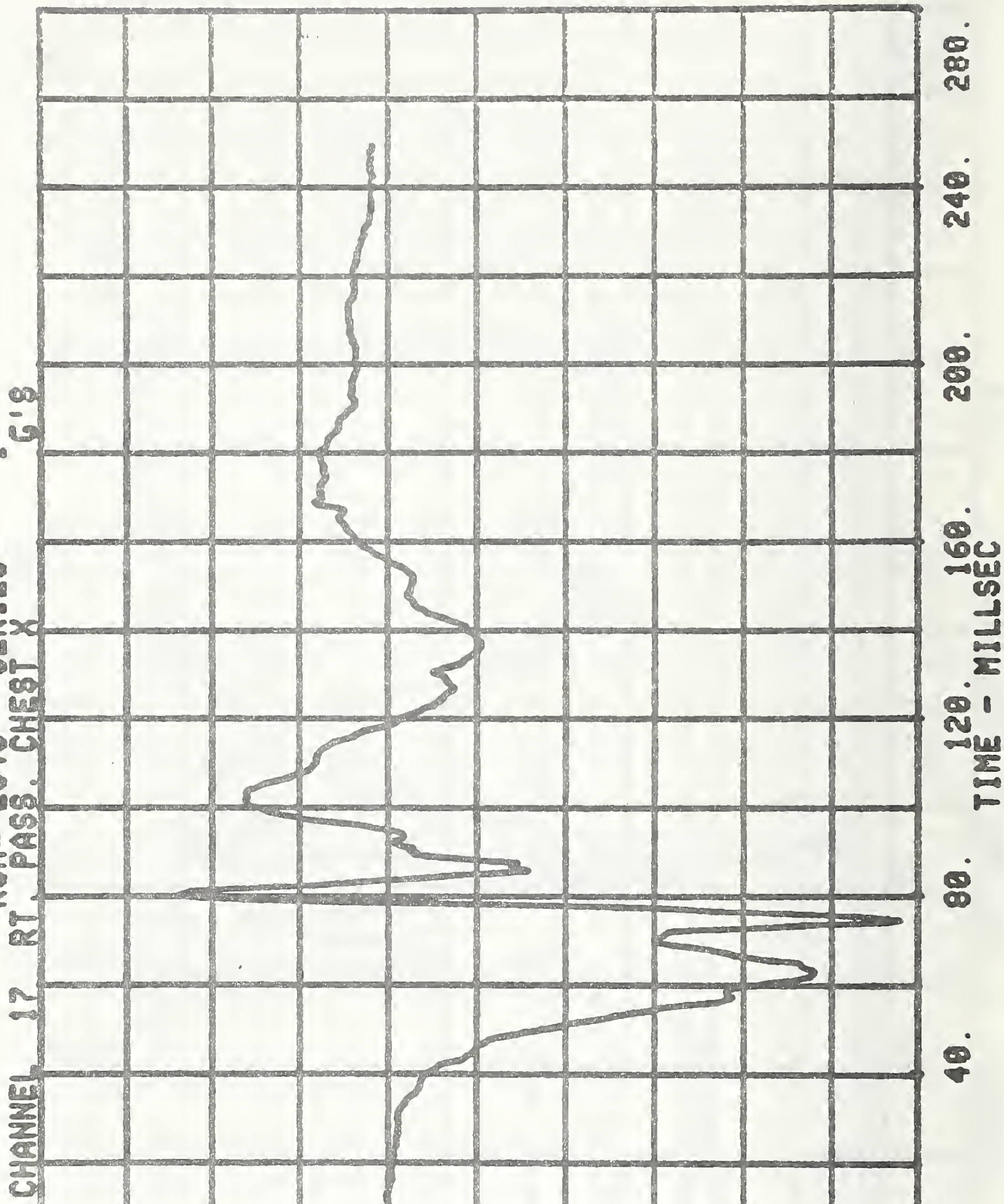
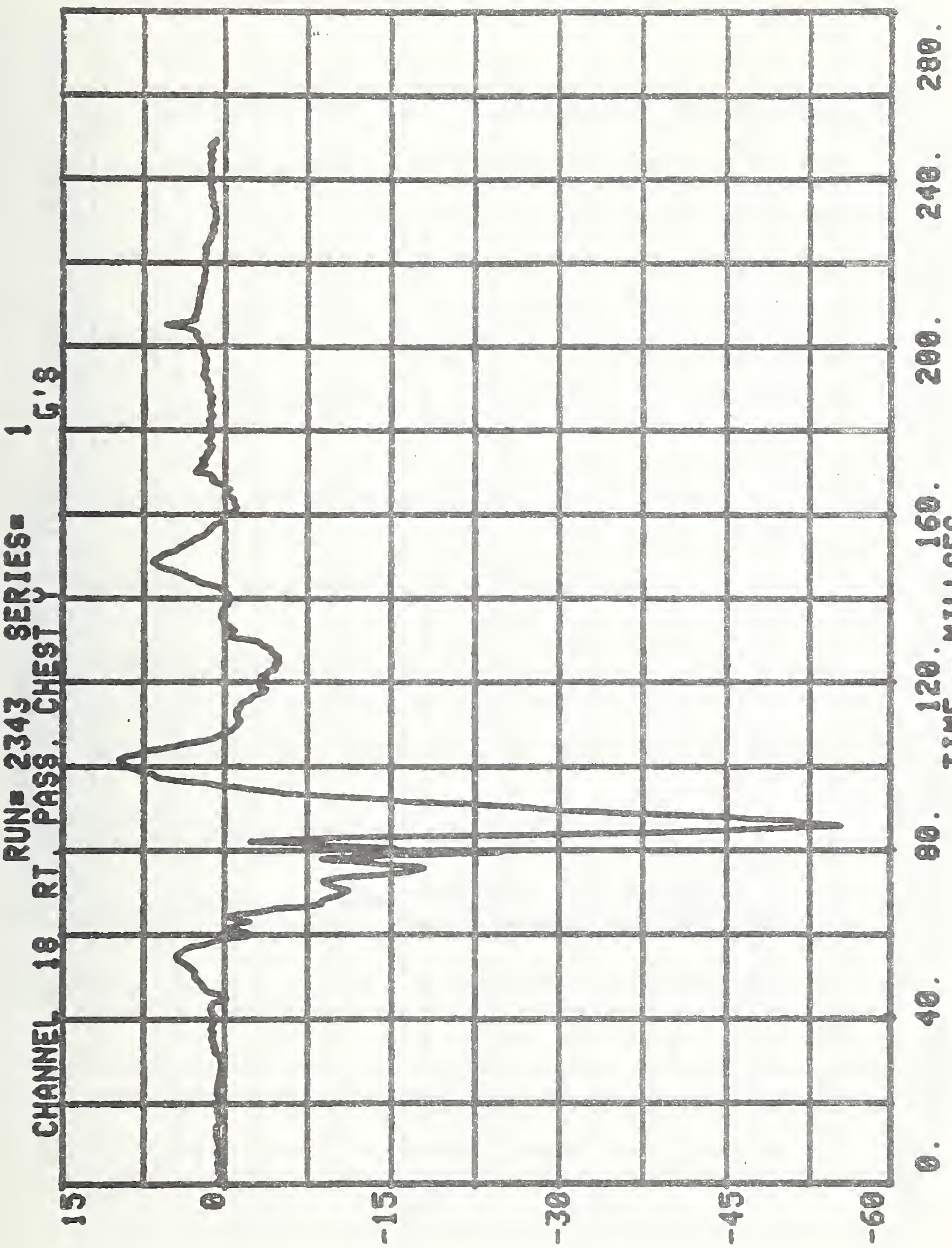
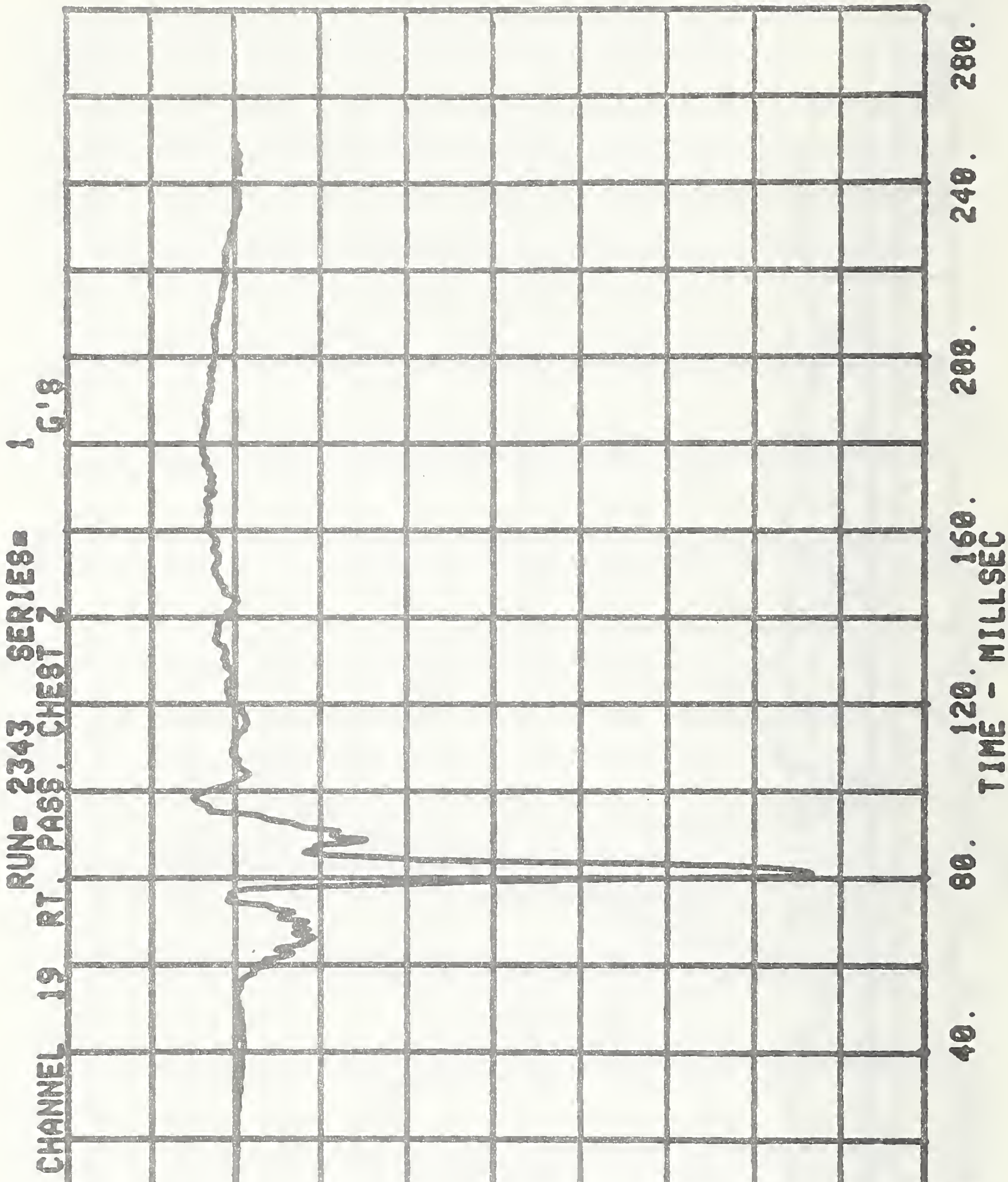
0. 40. 80. 120. 160. 200.


CHANNEL 17 RUN= 2343 SERIES= 1
RT. PASS. CHEST X G'S
40
20
0
-20
-40
-60
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 18 RUN= 2343 SERIES= 1
RT. PASS. CHEST Y G'S
15
0
-15
-30
-45
-60
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC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RT. PASS. CHEST Z G'S
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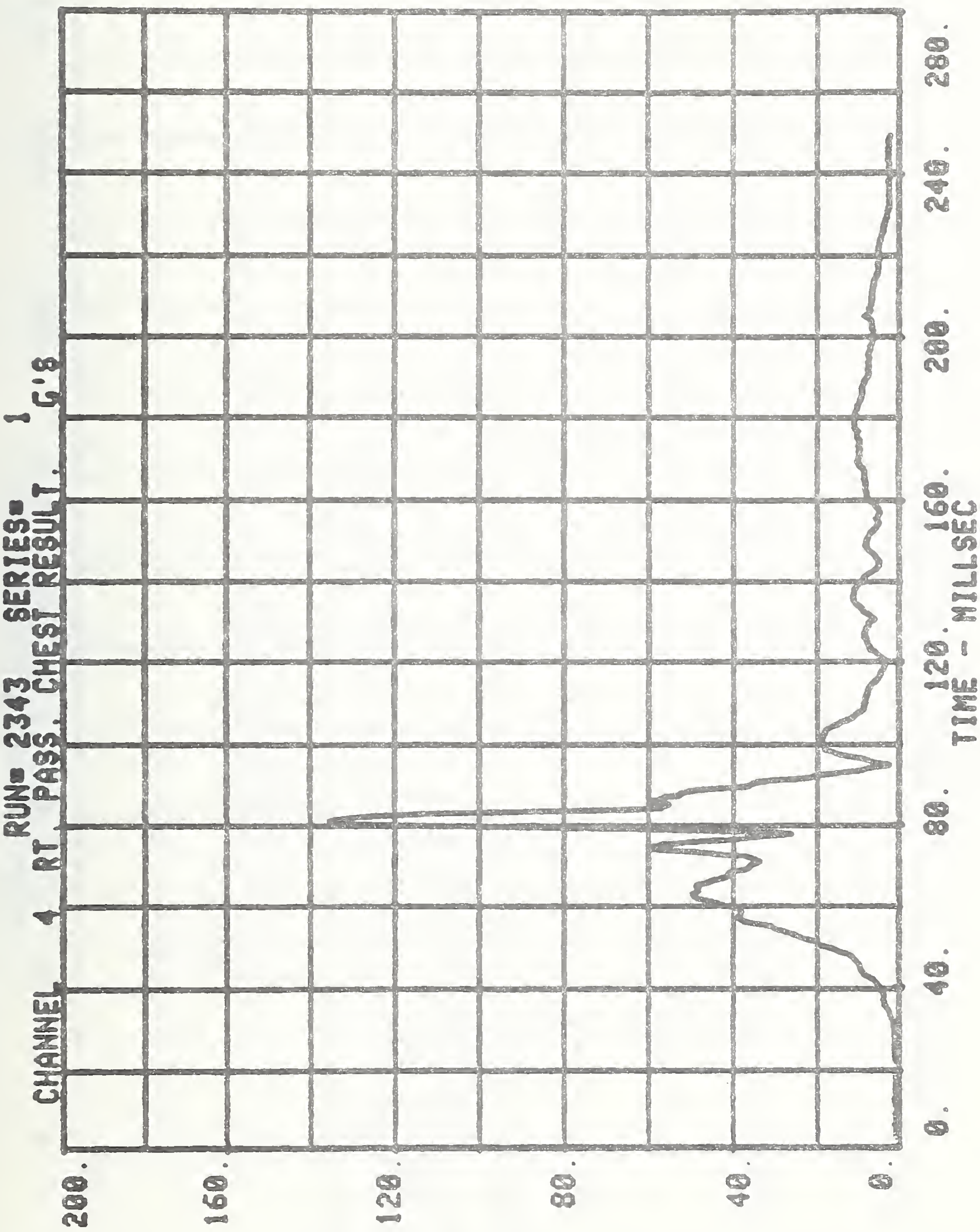
0
-40
-80
-120
-160
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


RUN= 2343 SERIES= 1
CHANNEL 4 RT. PASS. CHEST RESULT. G'S
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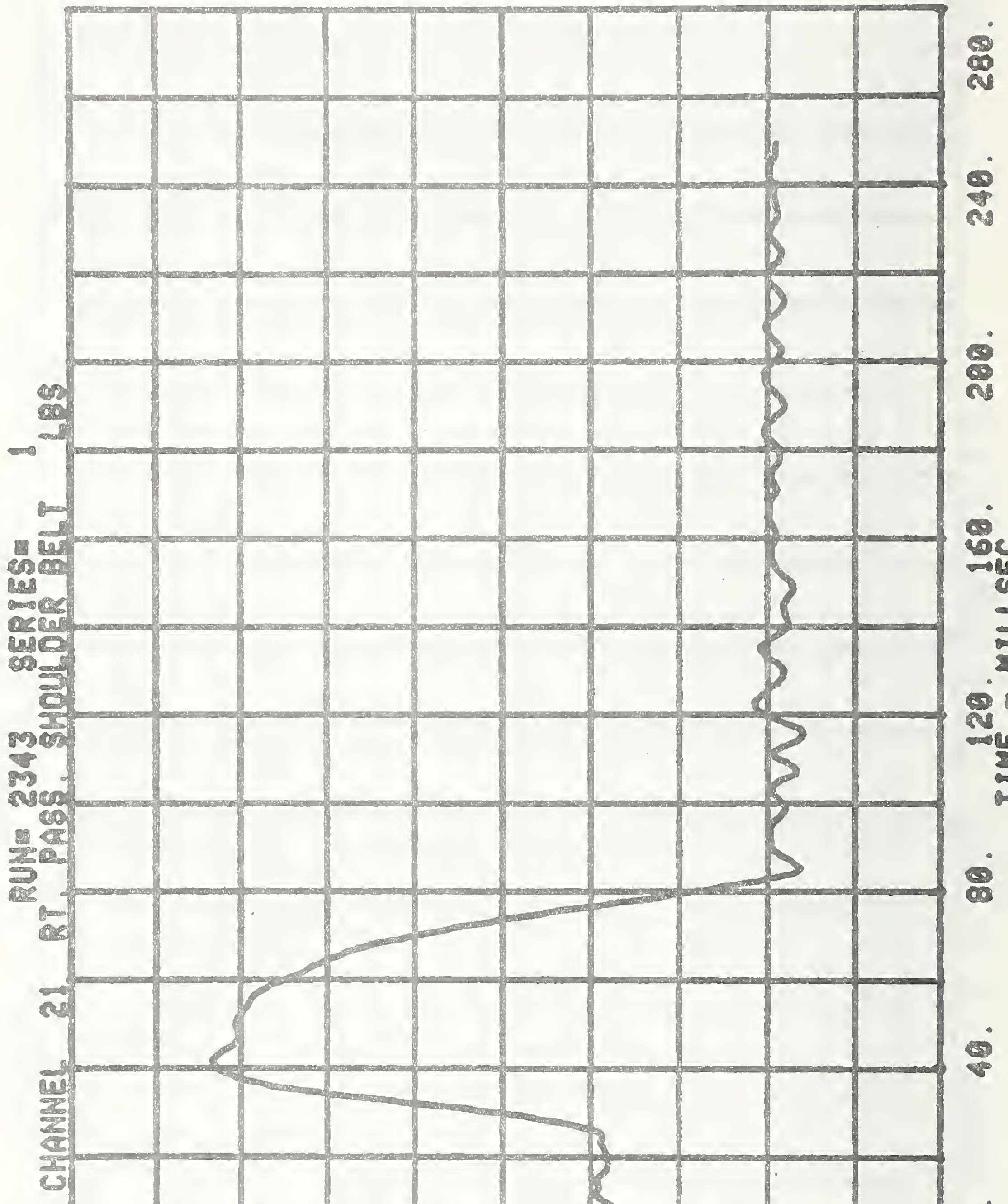
0. 40. 80. 120. 160. 200.


CHANNEL 21 RUN= 2343 SERIES= 1
RT. PASS. SHOULDER BELT LBS
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2343

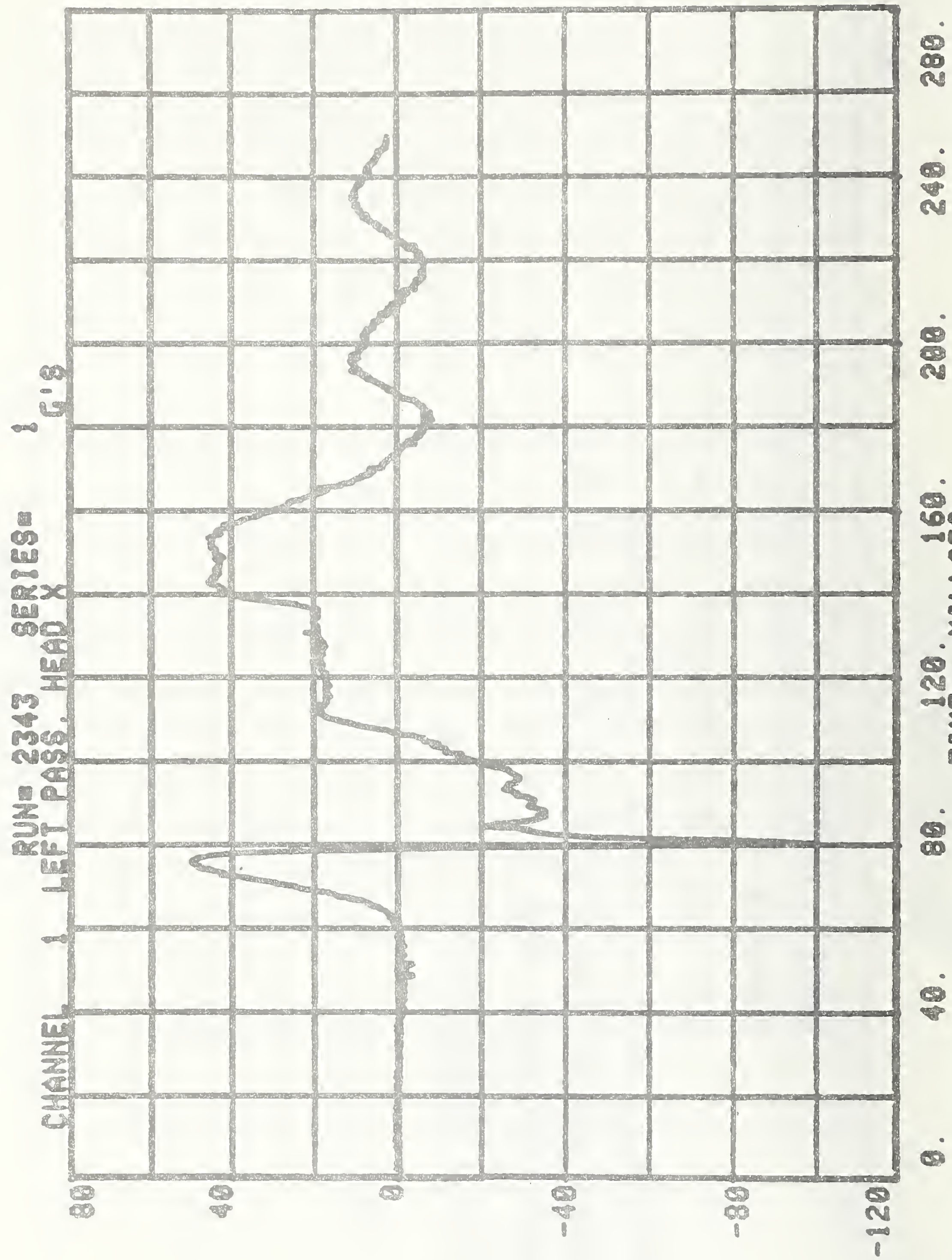
LEFT PASS. HEAD RESULT.

HIC=2255.6   FROM T1= .07230   TO T2= .09690

AVERAGE ACCELERATION BETWEEN T1 AND T2= 96.6G'S

EVENT TIME= 250.0 MSEC

SEVERITY INDEX=3115.0


CHANNEL 1 RUN= 2343 SERIES= 1
LEFT PASS. HEAD X G'S
TIME - MILLSEC
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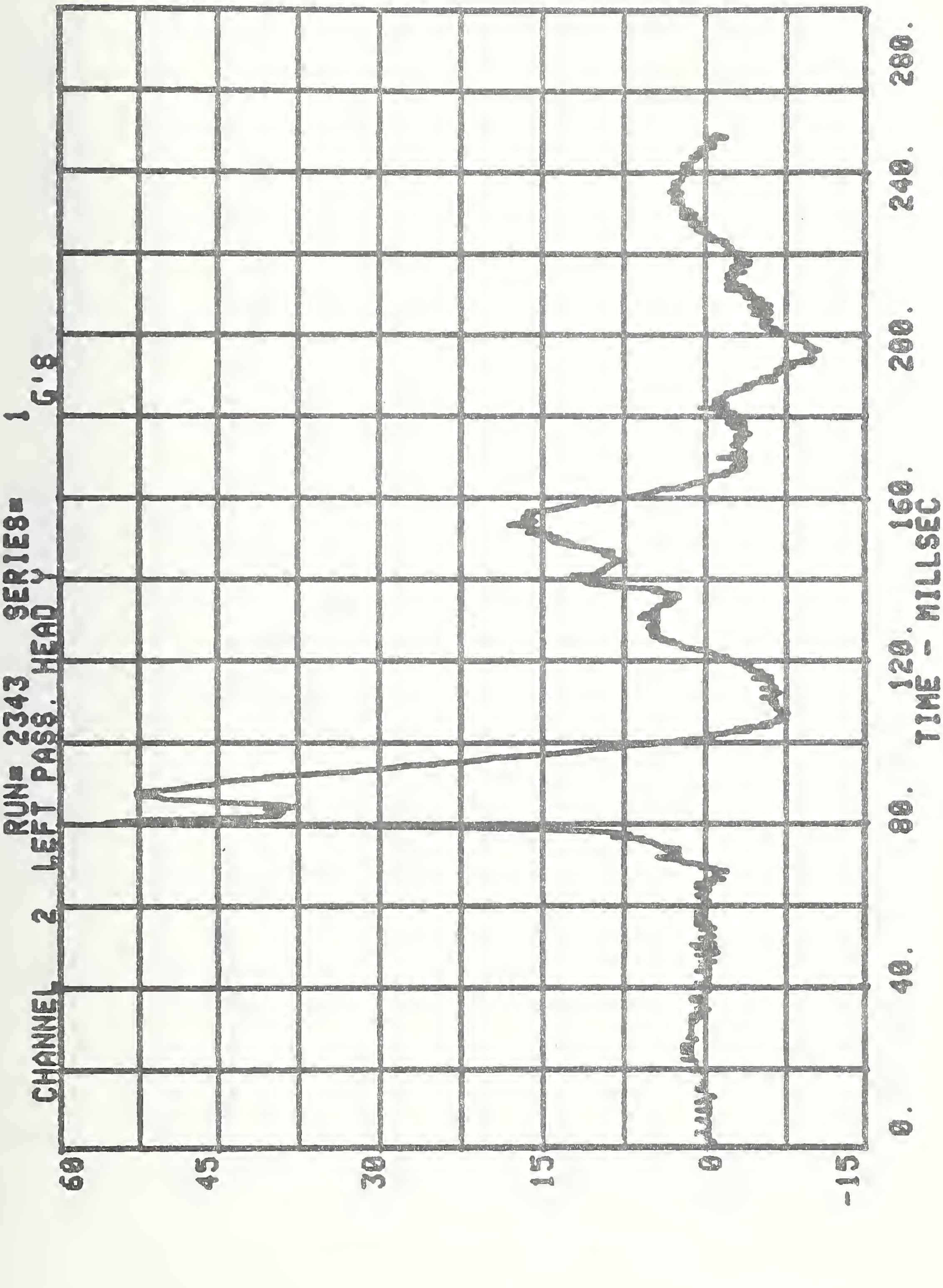
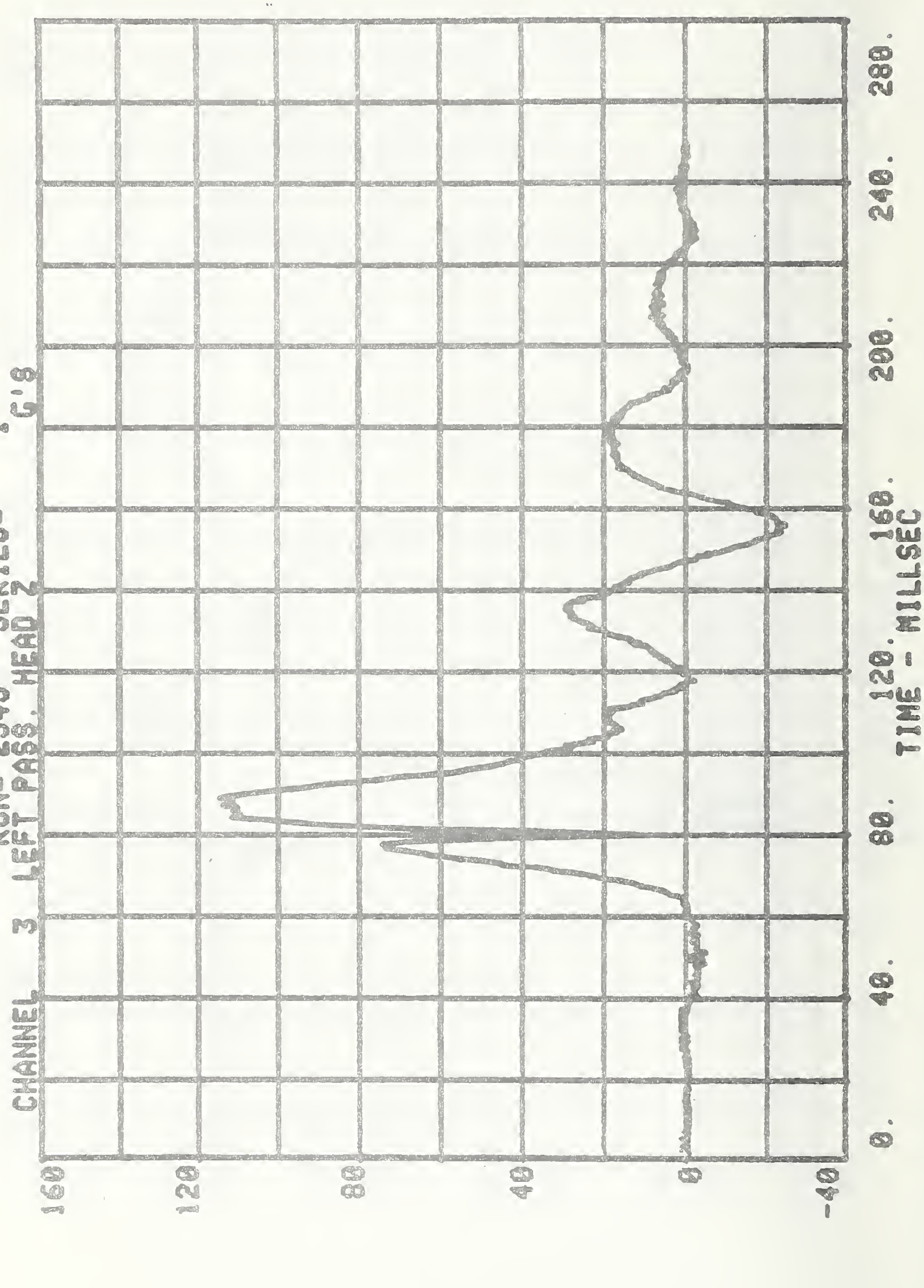
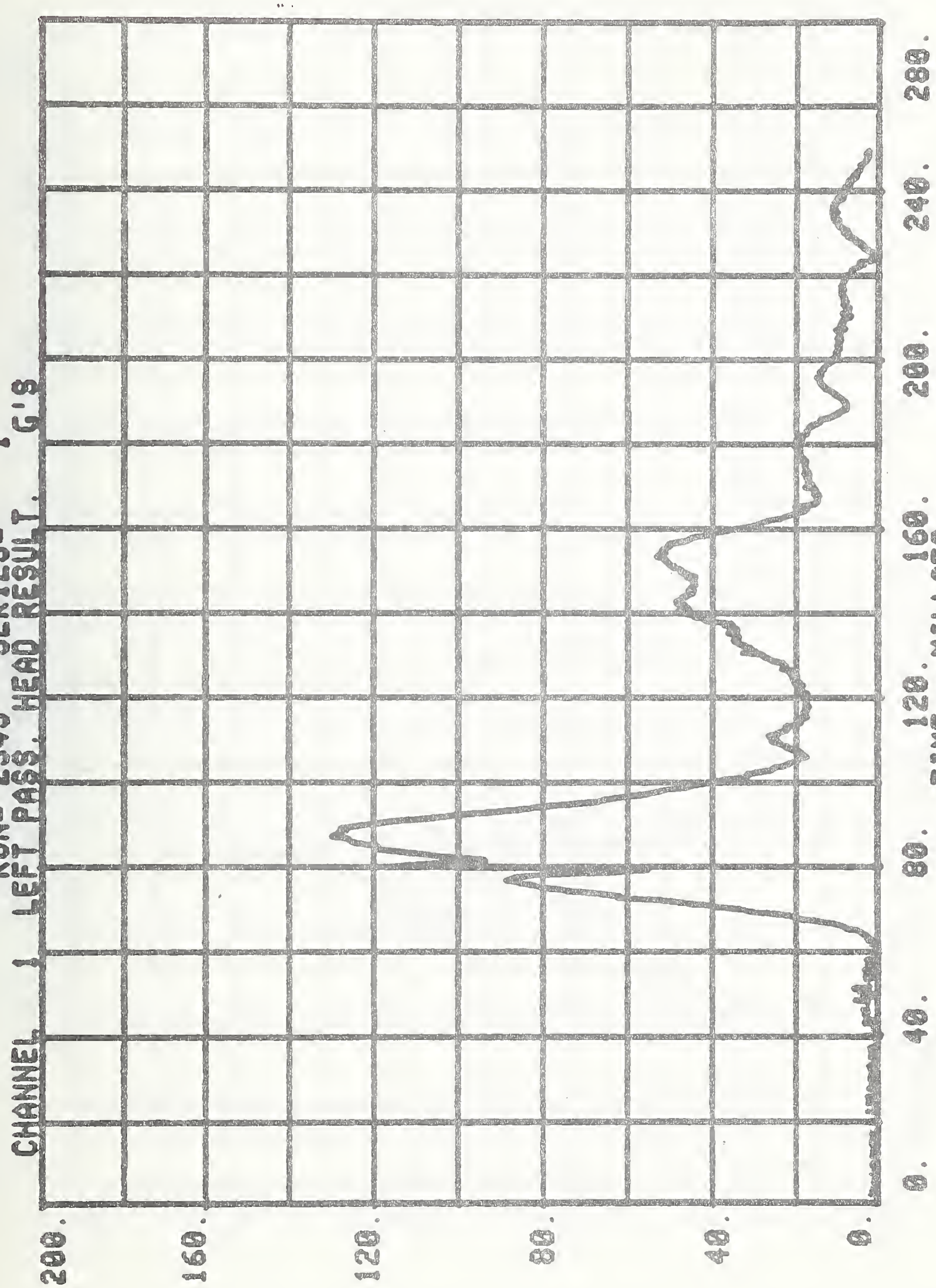
80 40 0 -40 -80 -120


CHANNEL 2 RUN= 2343 SERIES= 1
LEFT PASS. HEAD Y G'S
60
45
30
15
0
-15
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 3 RUN= 2343 SERIES= 1
LEFT PASS. HEAD Z G'S
160
120
80
40
0
-40
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 1 RUN= 2343 SERIES= 1
LEFT PASS. HEAD RESULT. G'S
TIME - MILLSEC
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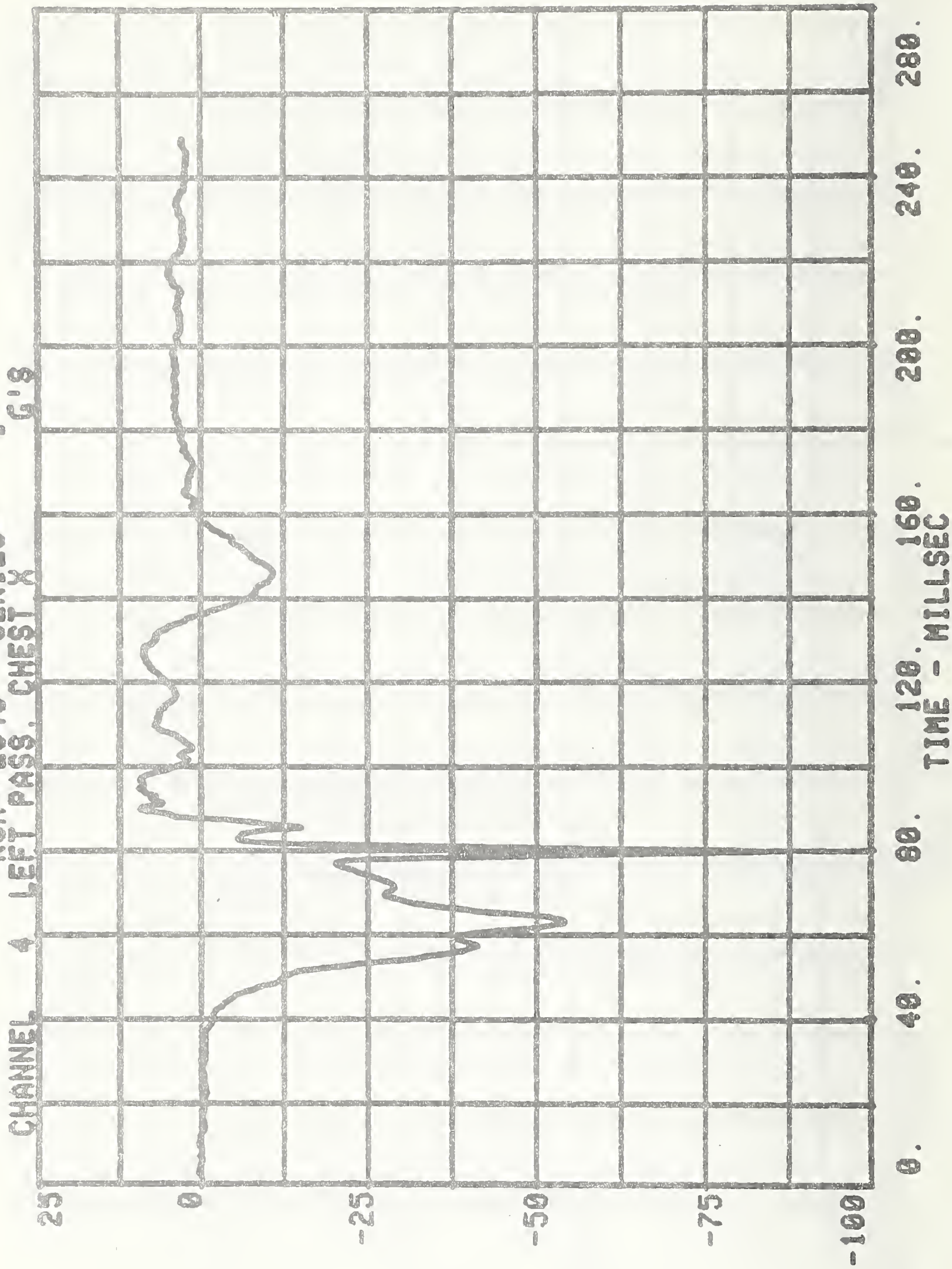
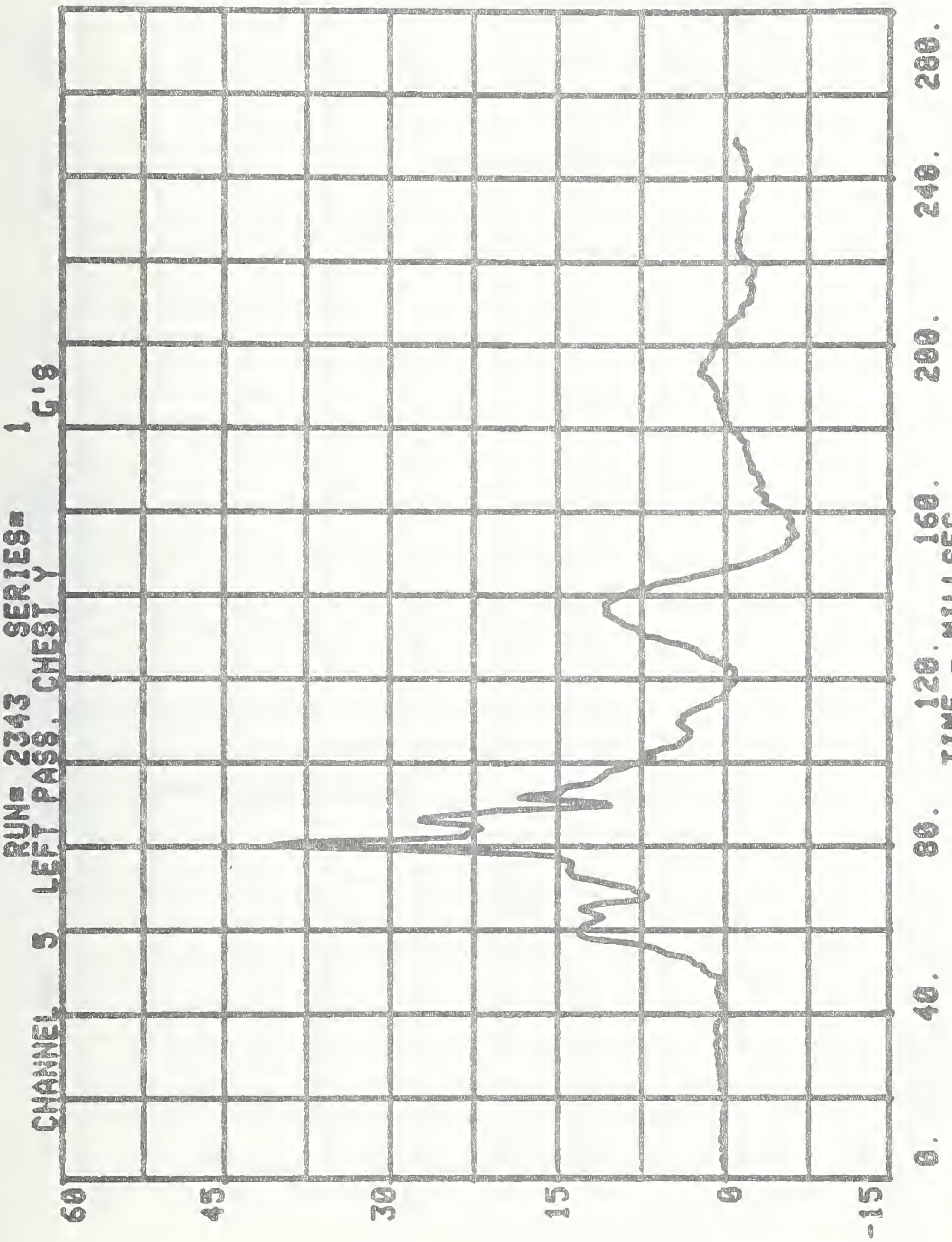
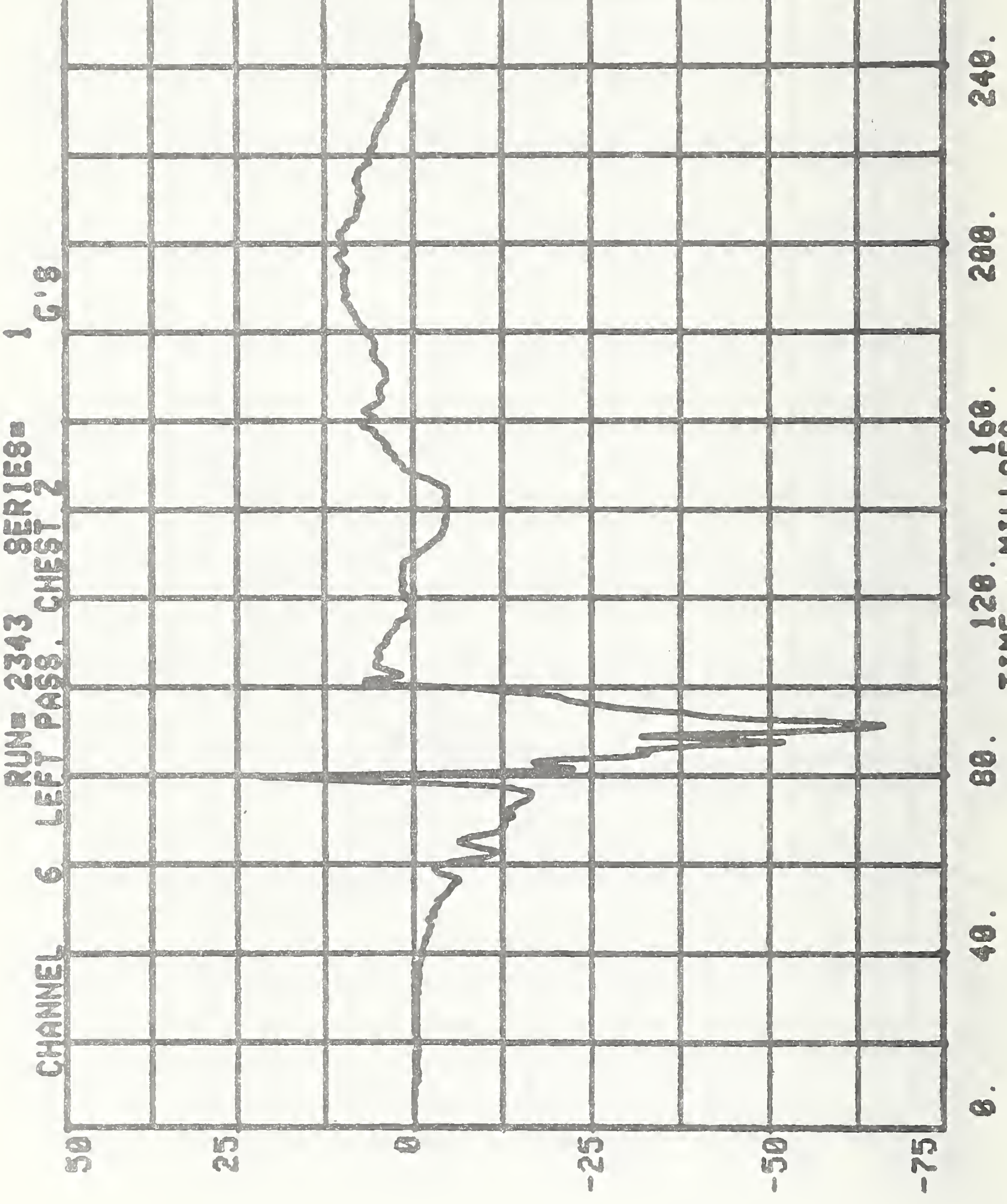
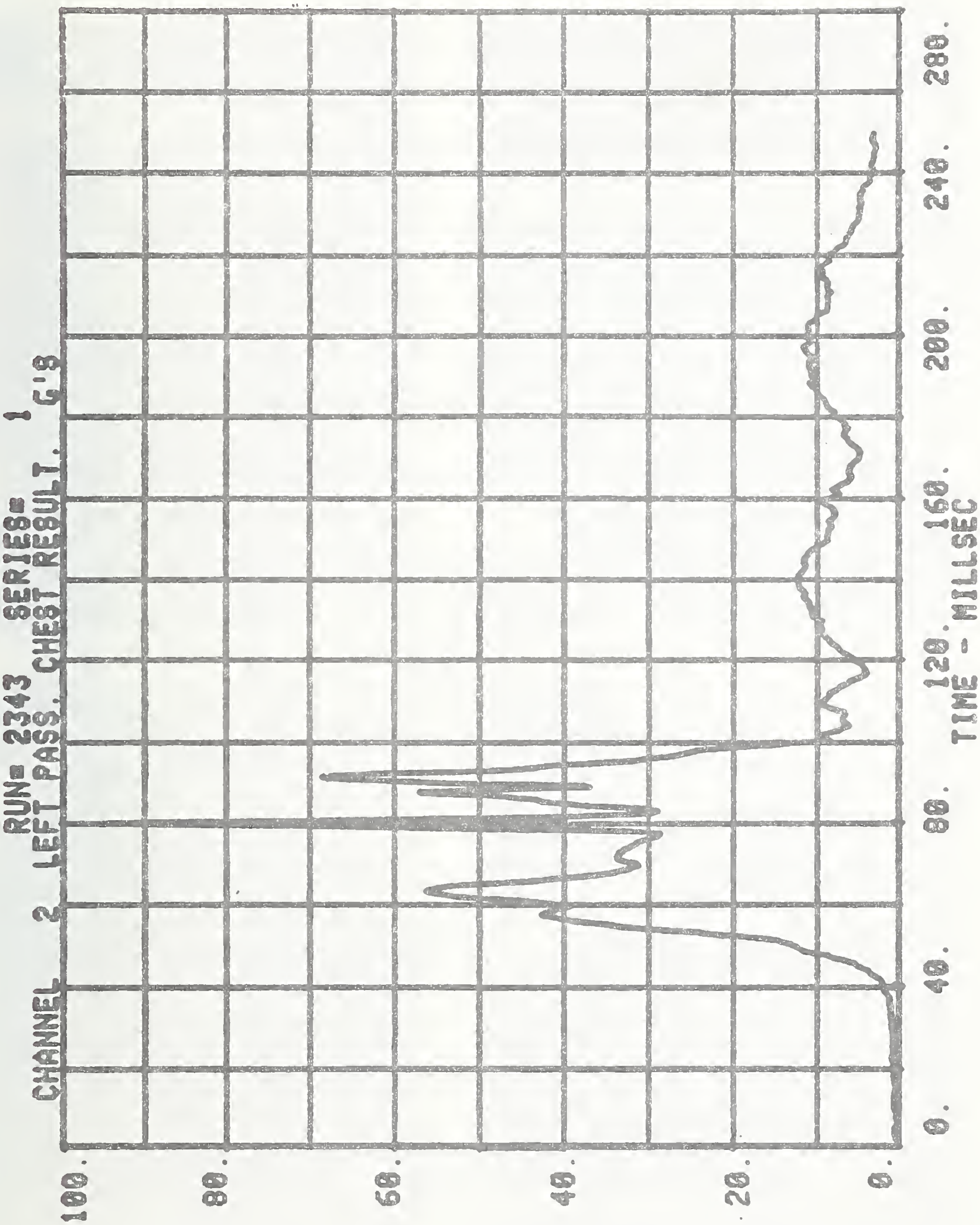
40.
80.
120.
160.
200.
240.
280.
0.
40.
80.
120.
160.
200.

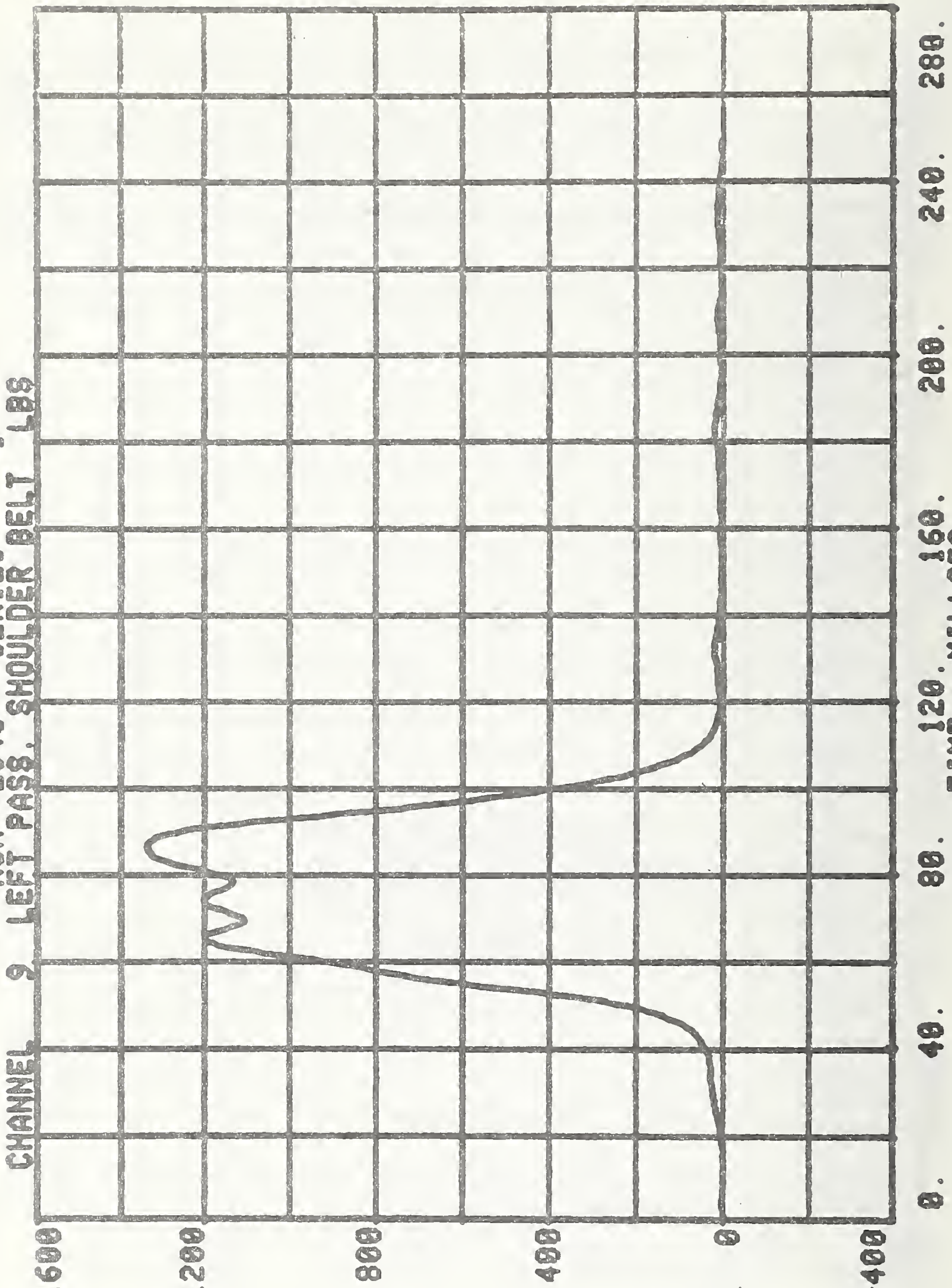

RUN= 2343 SERIES= 1
CHANNEL 4 LEFT PASS. CHEST X G'S
25
0
-25
-50
-75
-100
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

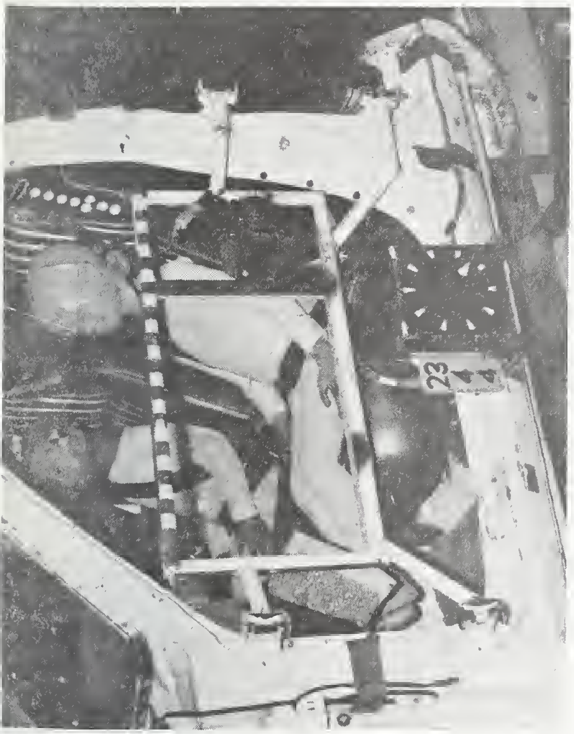


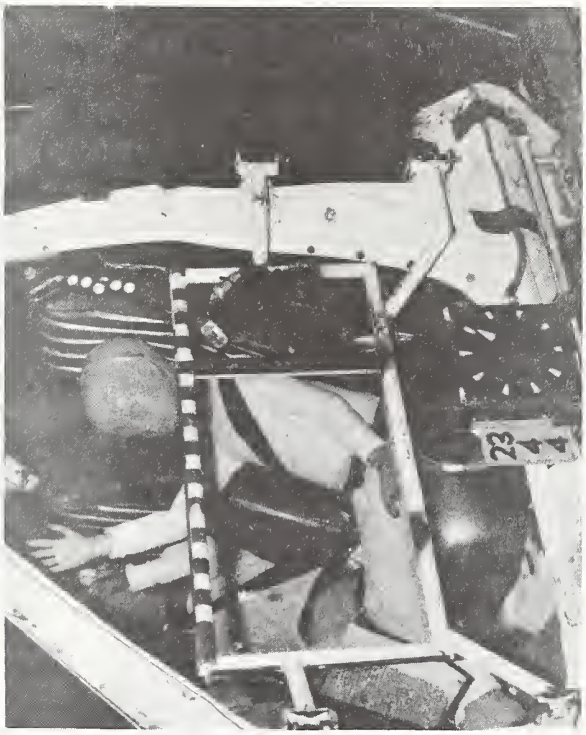
CHANNEL 5 RUN= 2343 SERIES= 1
LEFT PASS. CHEST Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
60 45 30 15 0 -15

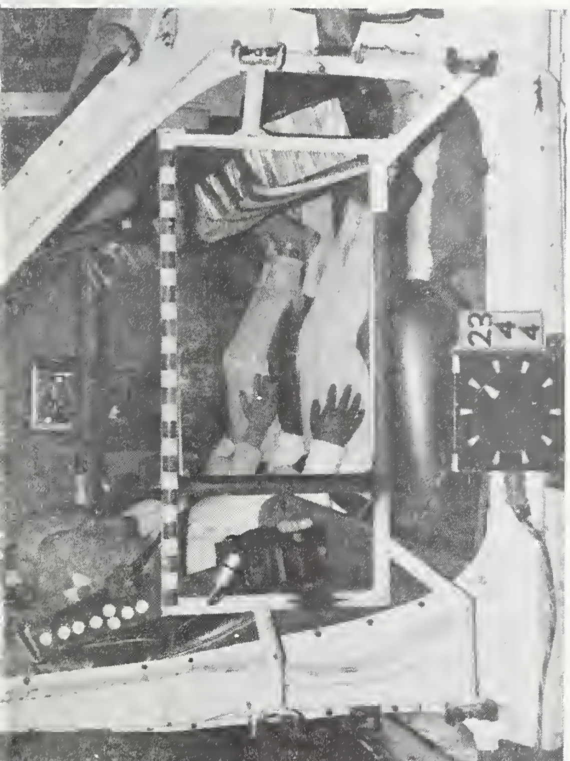

CHANNEL 6 RUN= 2343 SERIES= 1
LEFT PASS. CHEST 2 G'S
50
25
0
-25
-50
-75
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

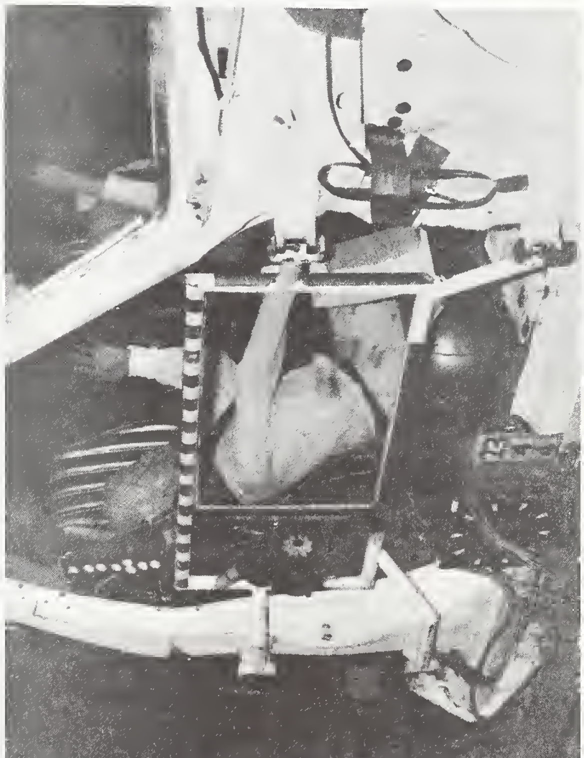

CHANNEL 2 RUN= 2343 SERIES= 1
LEFT PASS. CHEST RESULT. G'S
100.
80.
60.
40.
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 9 RUN= 2343 SERIES= 1
LEFT PASS. SHOULDER BELT LBS
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC









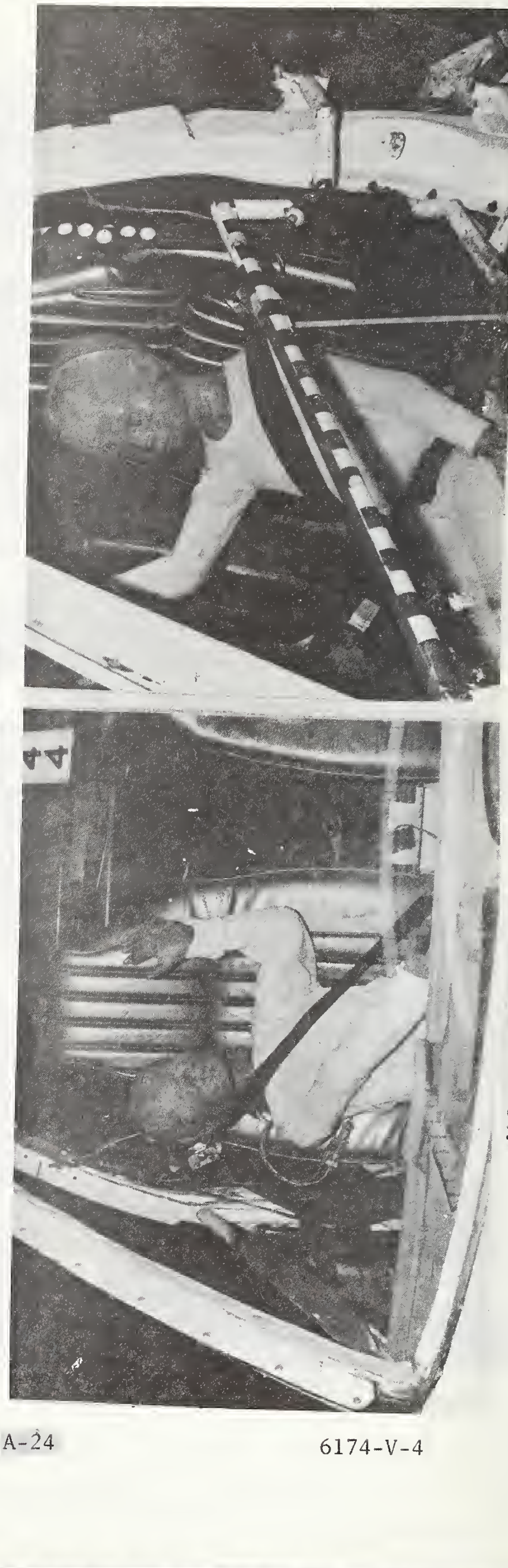
PRE-TEST

POST-TEST
RUN 2344

SIERRA

ALDERSON S/N 48

PRE-TEST



SIERRA

ALDERSON S/N 48

POST-TEST
RUN 2344

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2344

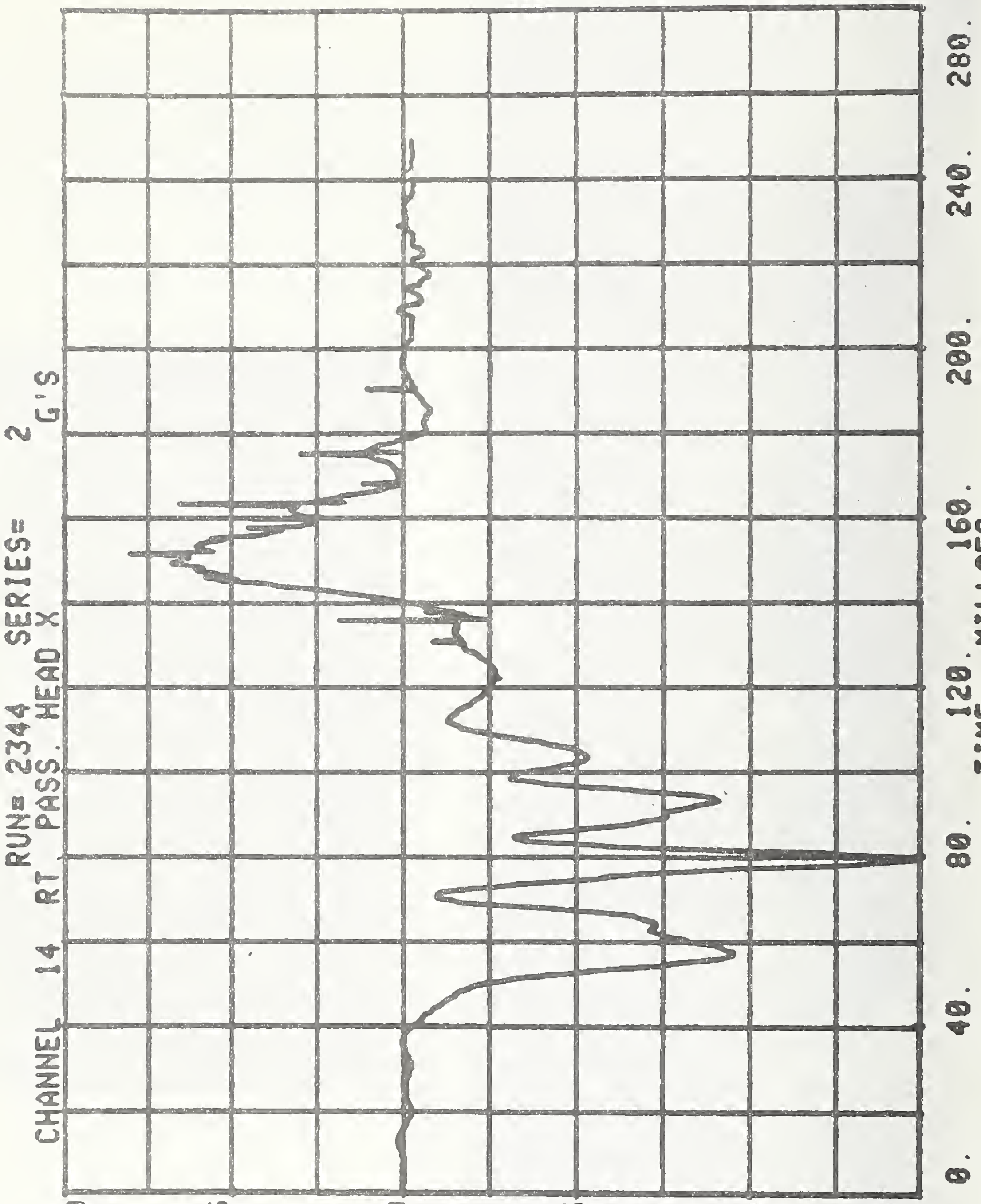
RT. PASS. HEAD RESULT.

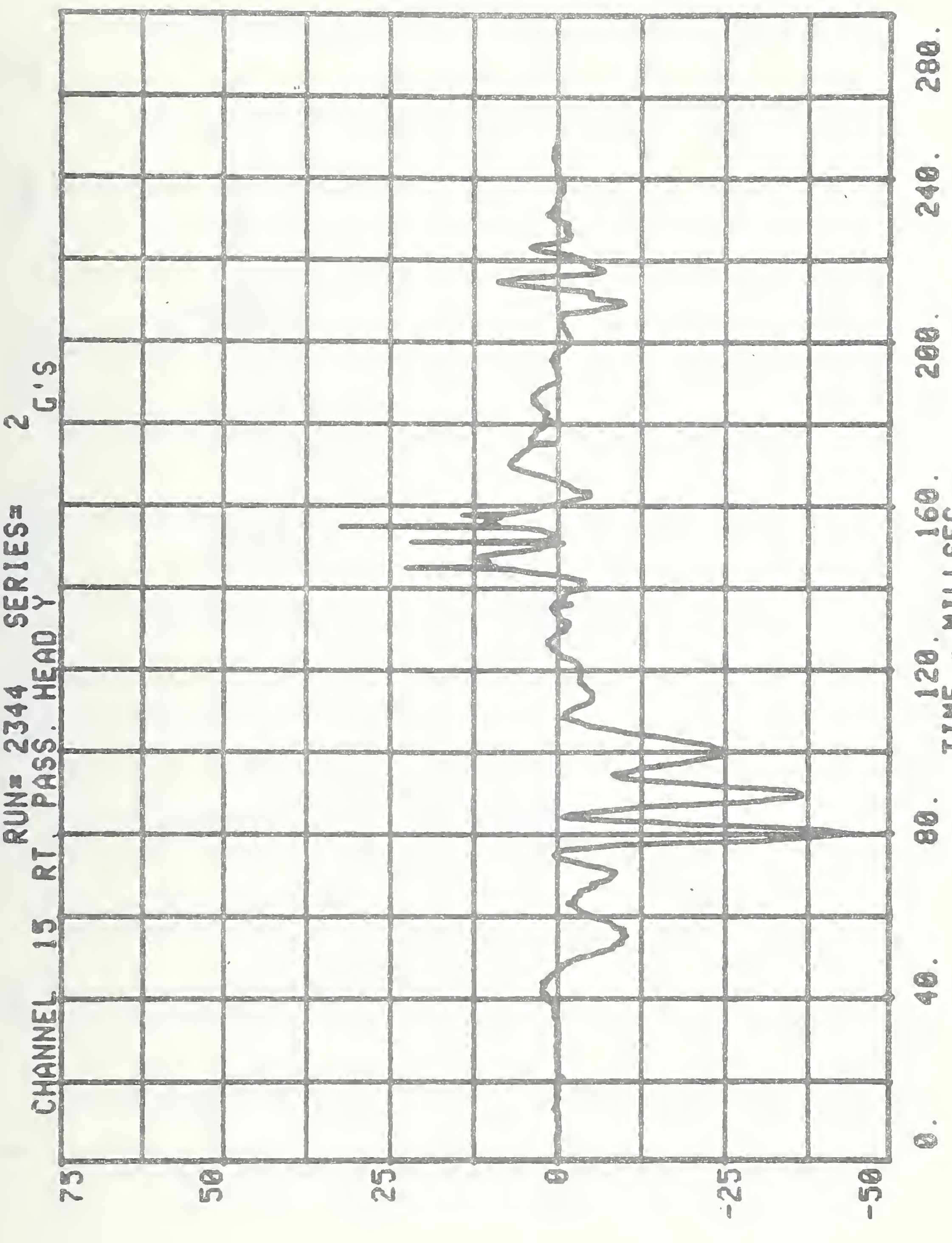
HIC=1376.5 FROM T1= .05100 TO T2= .15570

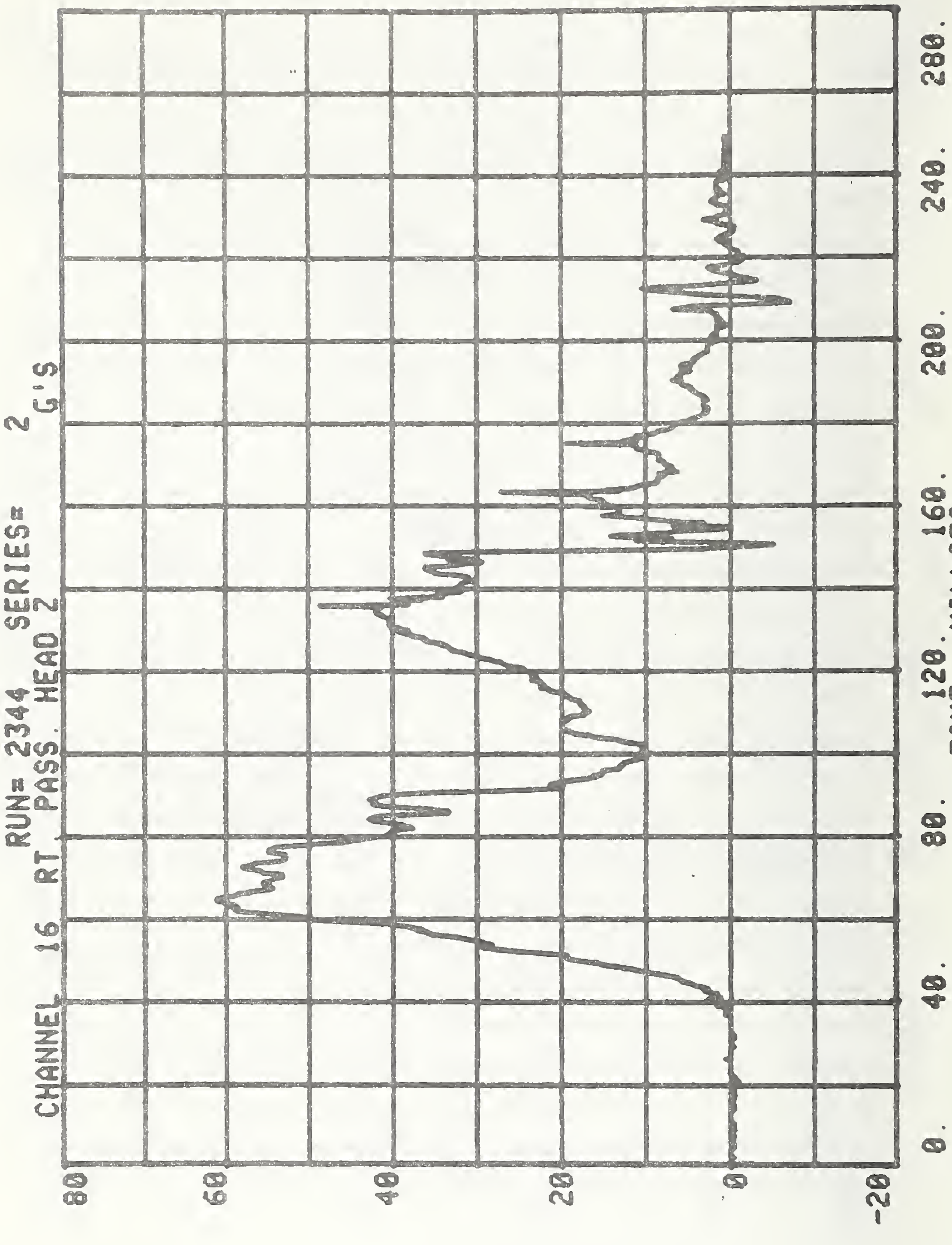
AVERAGE ACCELERATION BETWEEN T1 AND T2= 44.4G'S

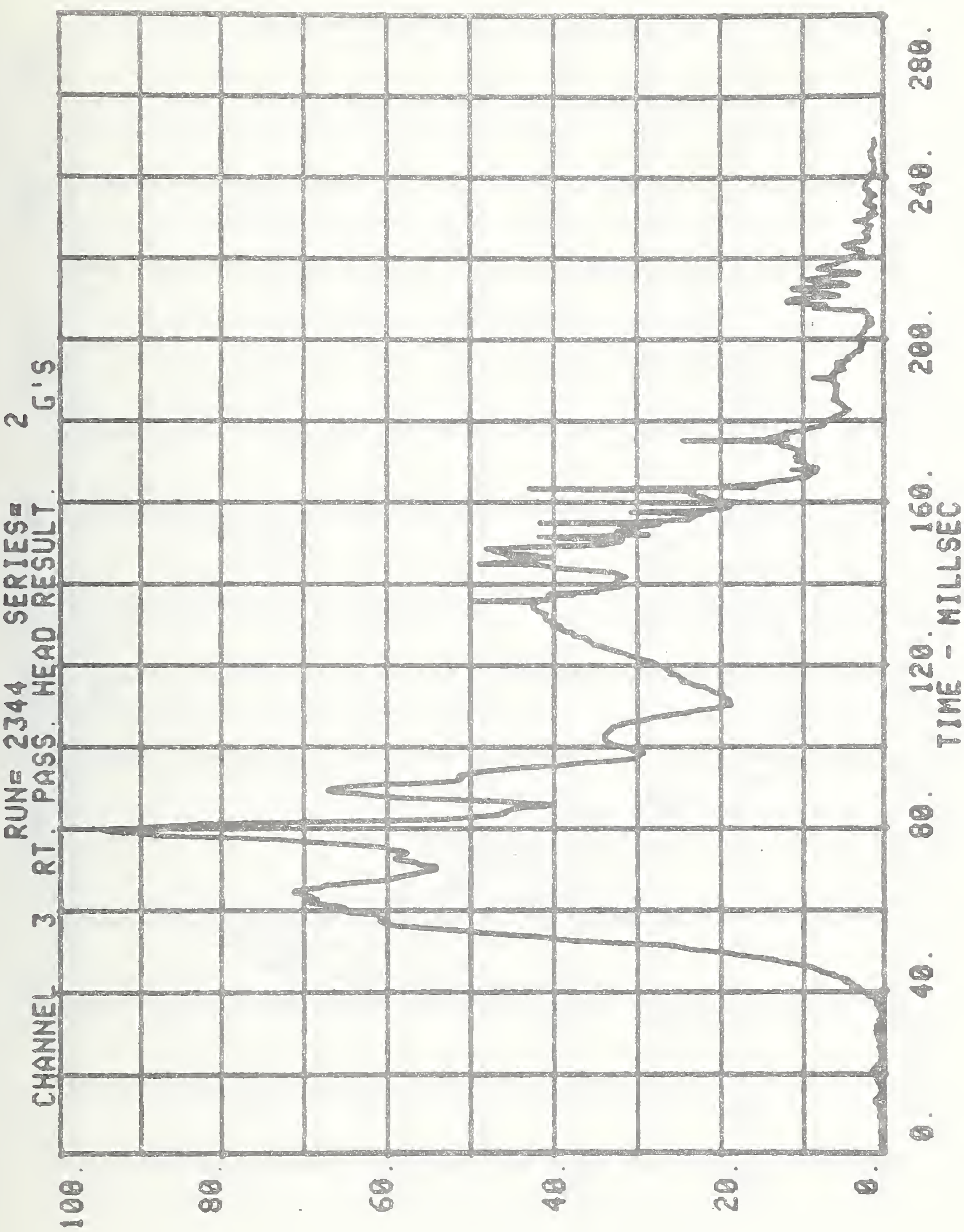
EVENT TIME= 250.0 MSEC

SEVERITY INDEX=1799.2


CHANNEL 14 RUN= 2344 SERIES= 2
RT PASS. HEAD X G'S
50
25
0
-25
-50
-75
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


RUN= 2344 SERIES= 2
CHANNEL 15 RT. PASS. HEAD Y
G'S
75
50
25
0
-25
-50
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 16 RUN= 2344 SERIES= 2
RT PASS HEAD 2
G'S
80
60
40
20
0
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 3 RUN= 2344 SERIES= 2
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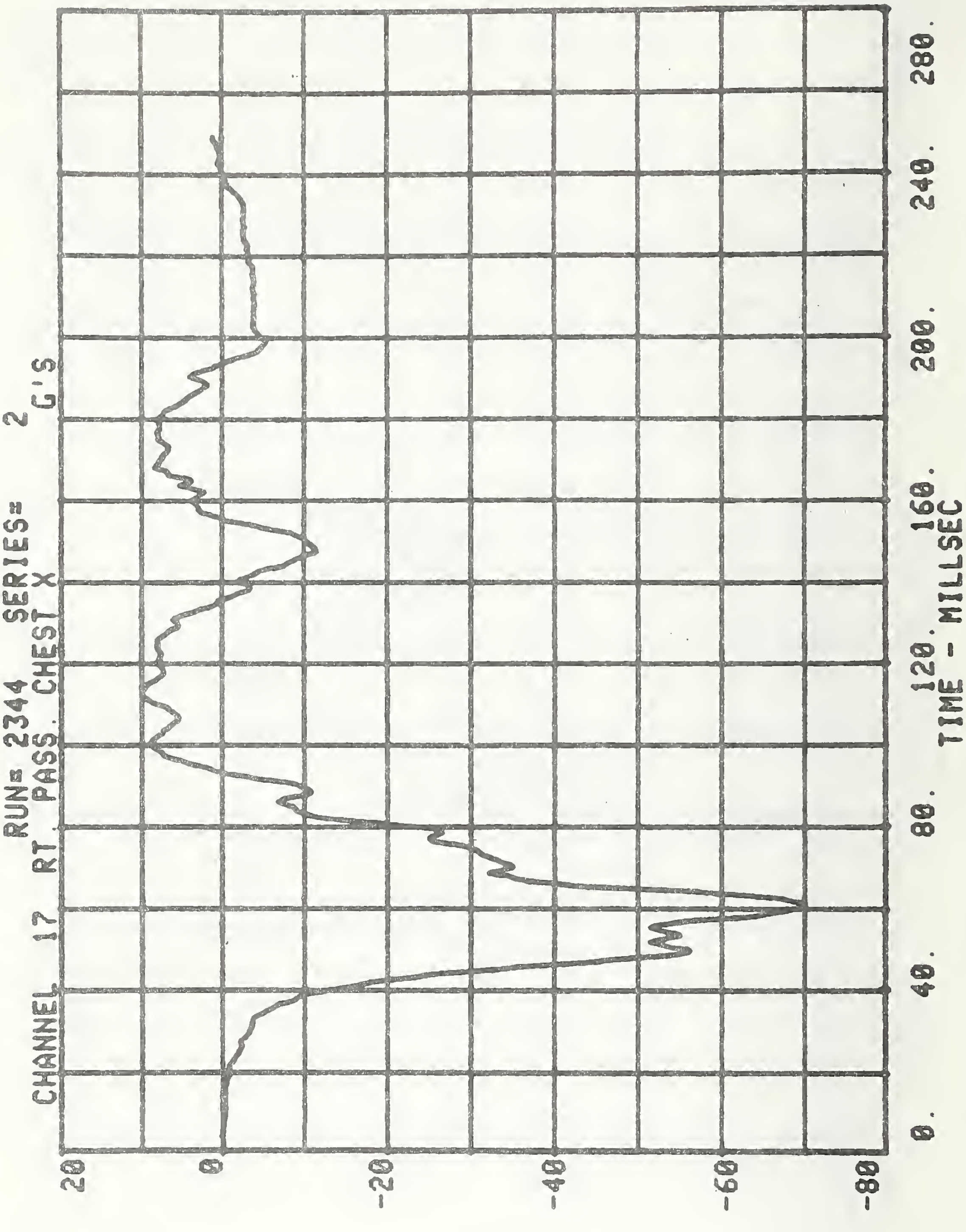
0. 20. 40. 60. 80. 100.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G'S
TIME - MILLSEC
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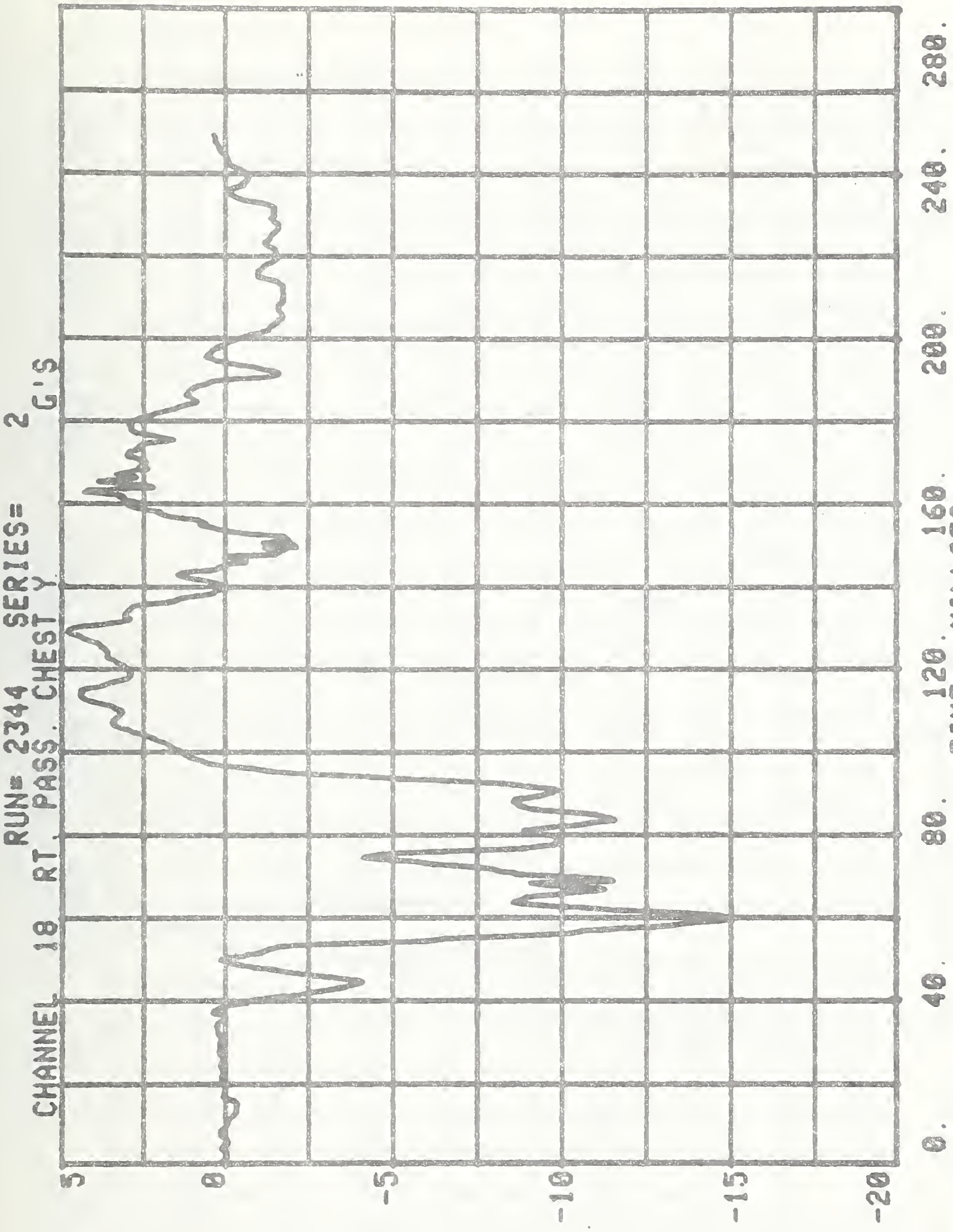
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RT. PASS. CHEST Y G'S
TIME - MILLSEC
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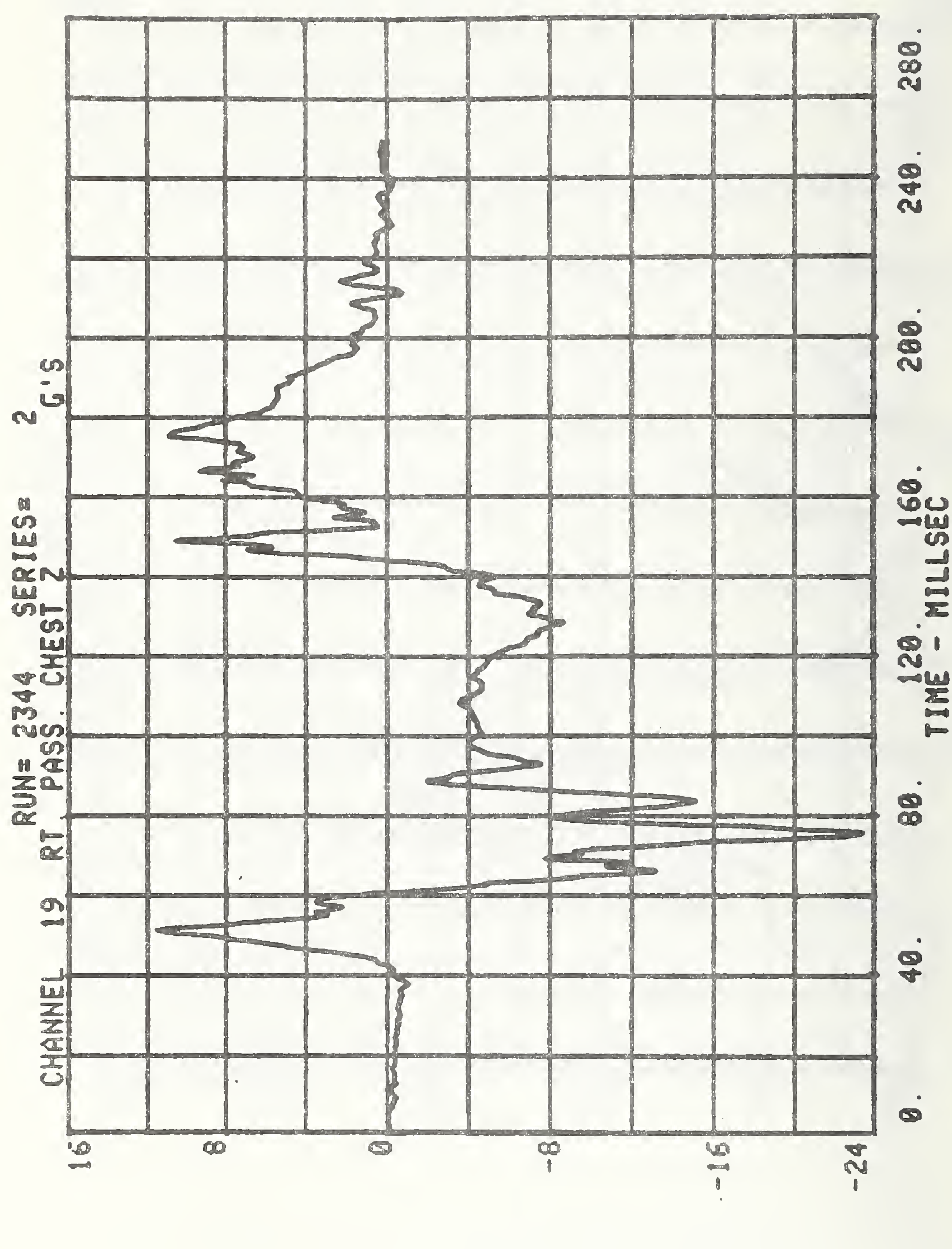
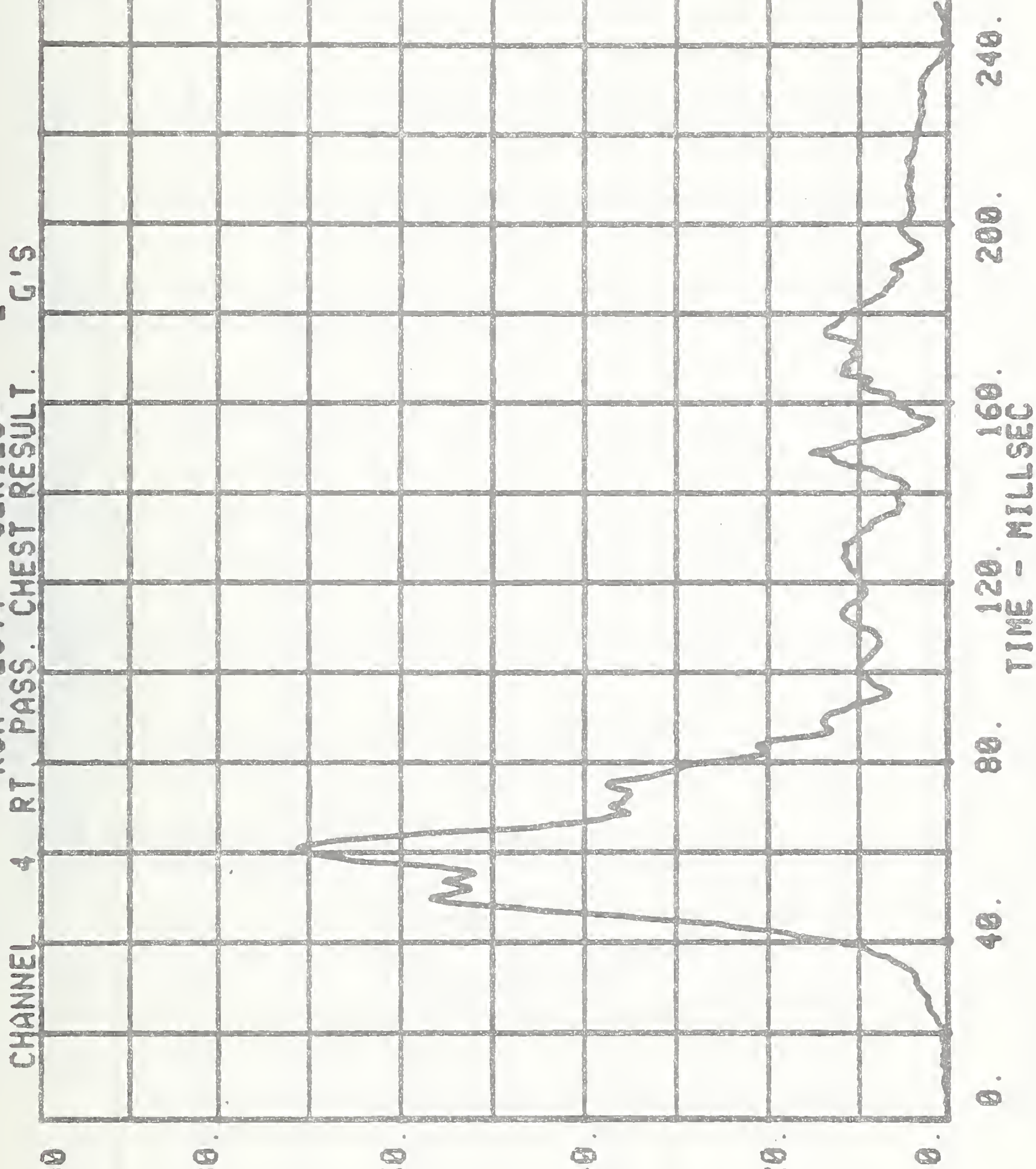
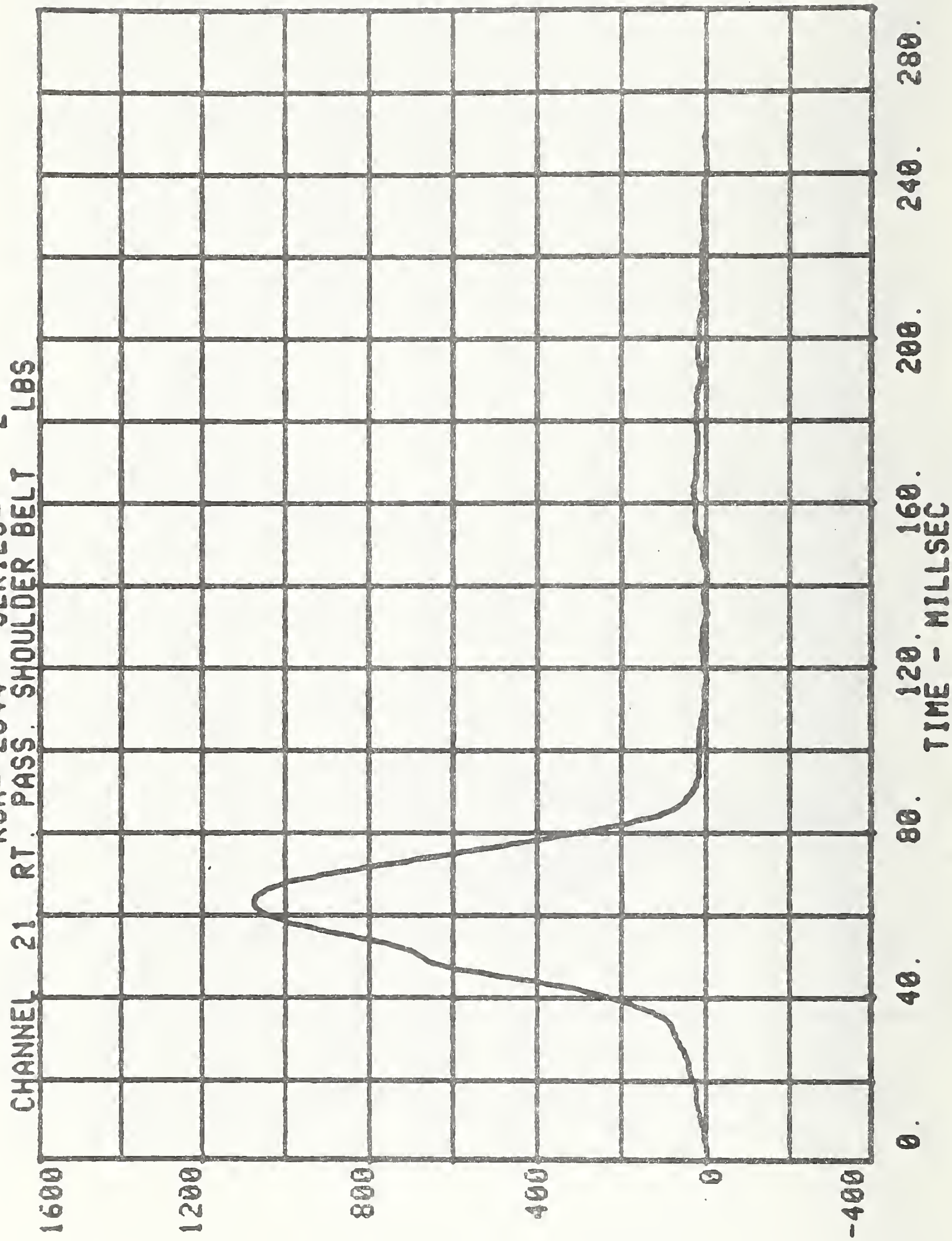
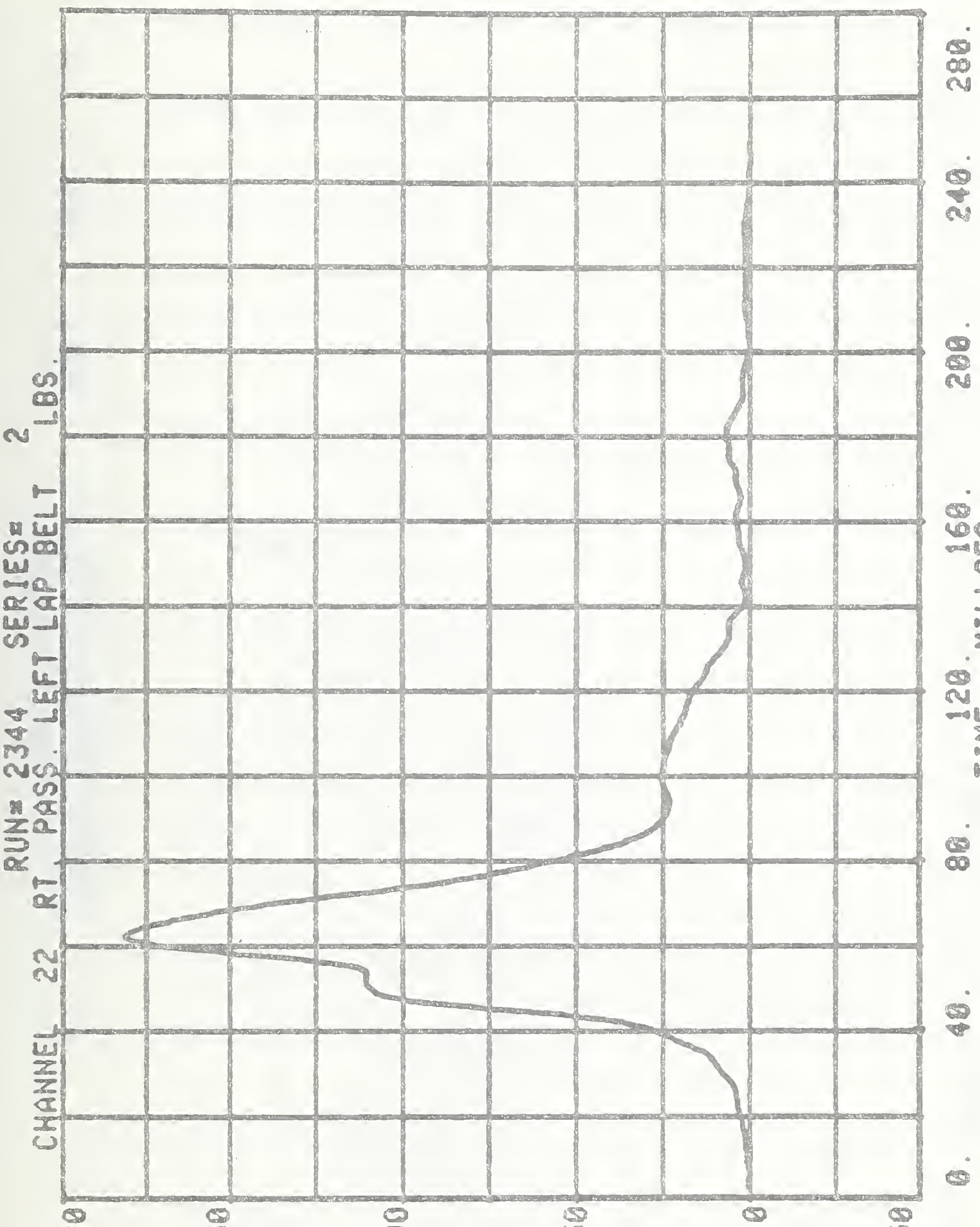
5 0 -5 -10 -15 -20

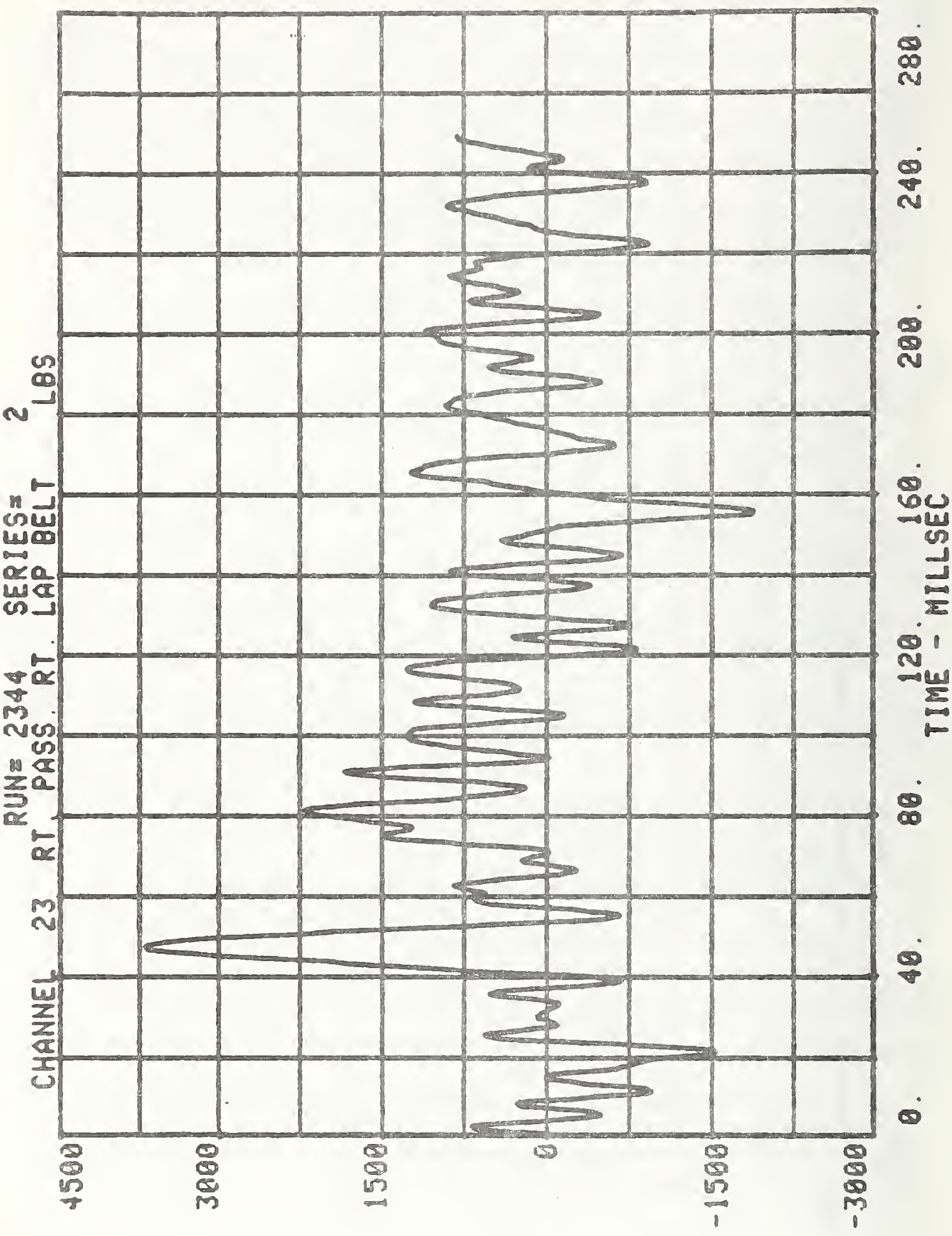

CHANNEL 19 RUN= 2344 SERIES= 2
RT PASS. CHEST Z G'S
16
8
0
-8
-16
-24
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


RUN= 2344 SERIES= 2
CHANNEL 4 RT PASS. CHEST RESULT. G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100


CHANNEL 21 RUN= 2344 SERIES= 2
RT. PASS. SHOULDER BELT LBS
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 22 RUN= 2344 SERIES= 2
RT. PASS. LEFT LAP BELT LBS.
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
1000 750 500 250 0 -250



CHANNEL 23 RUN= 2344 SERIES= 2
RT PASS. RT. LAP BELT LBS
4500
3000
1500
0
-1500
-3000
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2344

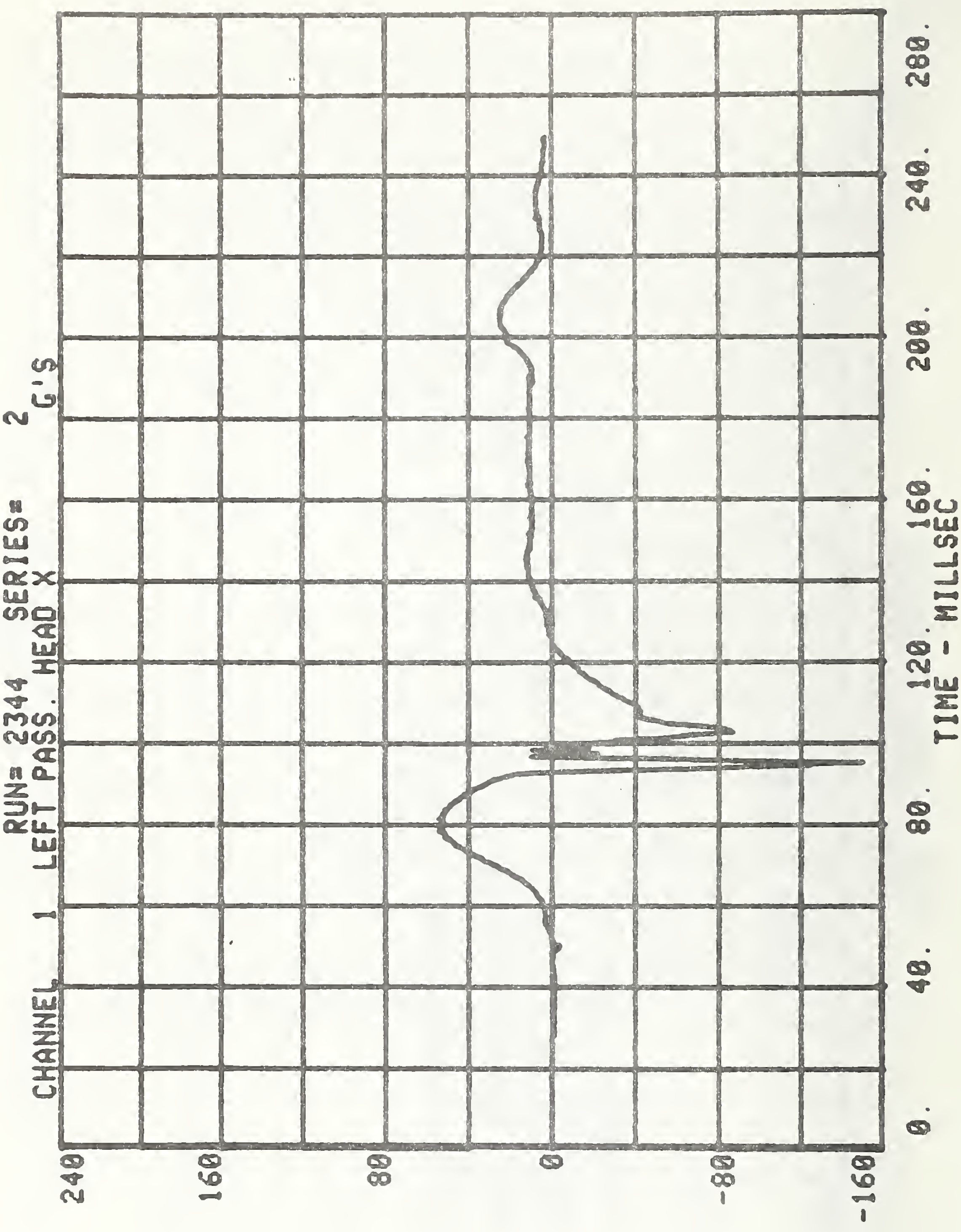
LEFT PASS. HEAD RESULT.

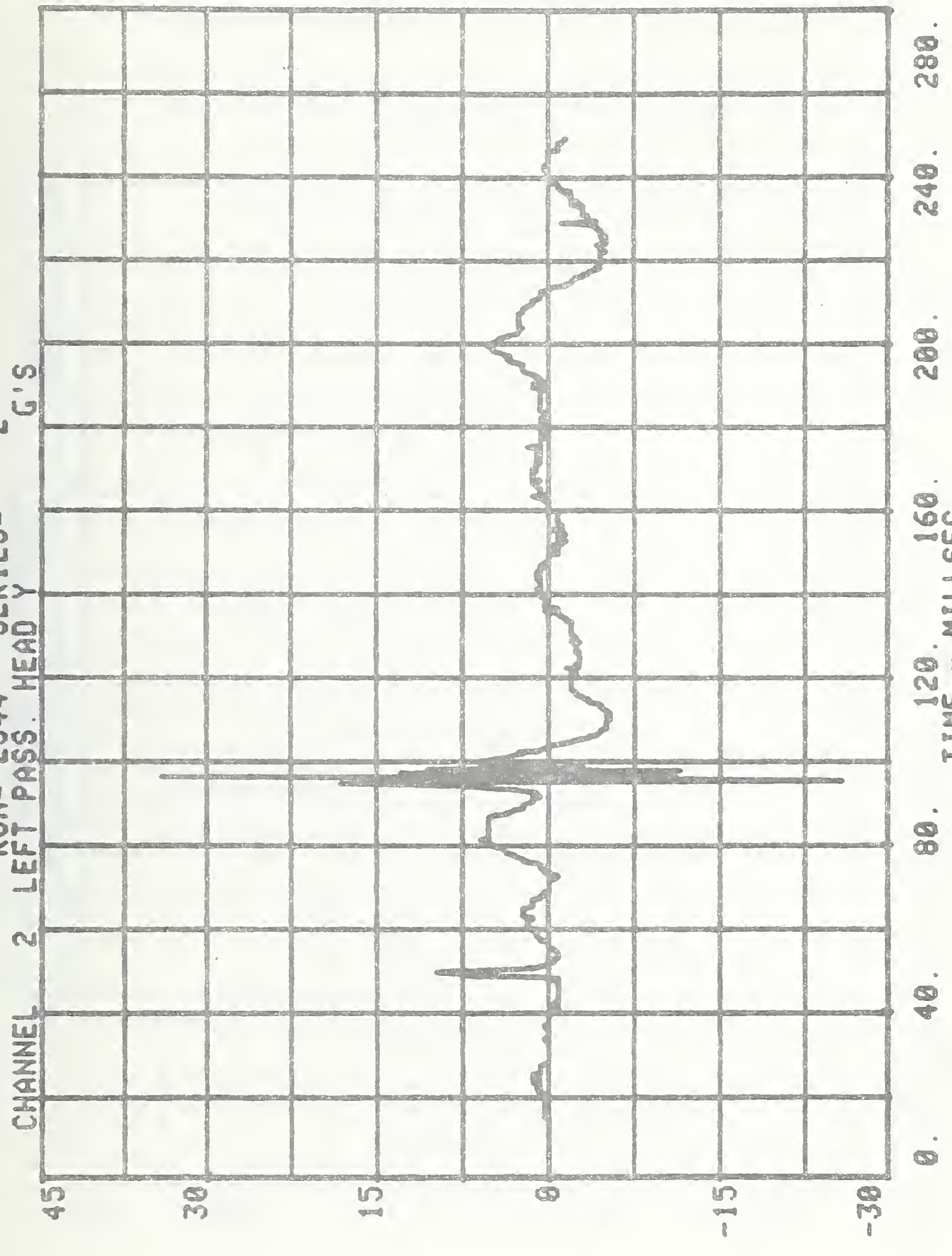
HIC=2765.3   FROM T1= .07230   TO T2= .11250

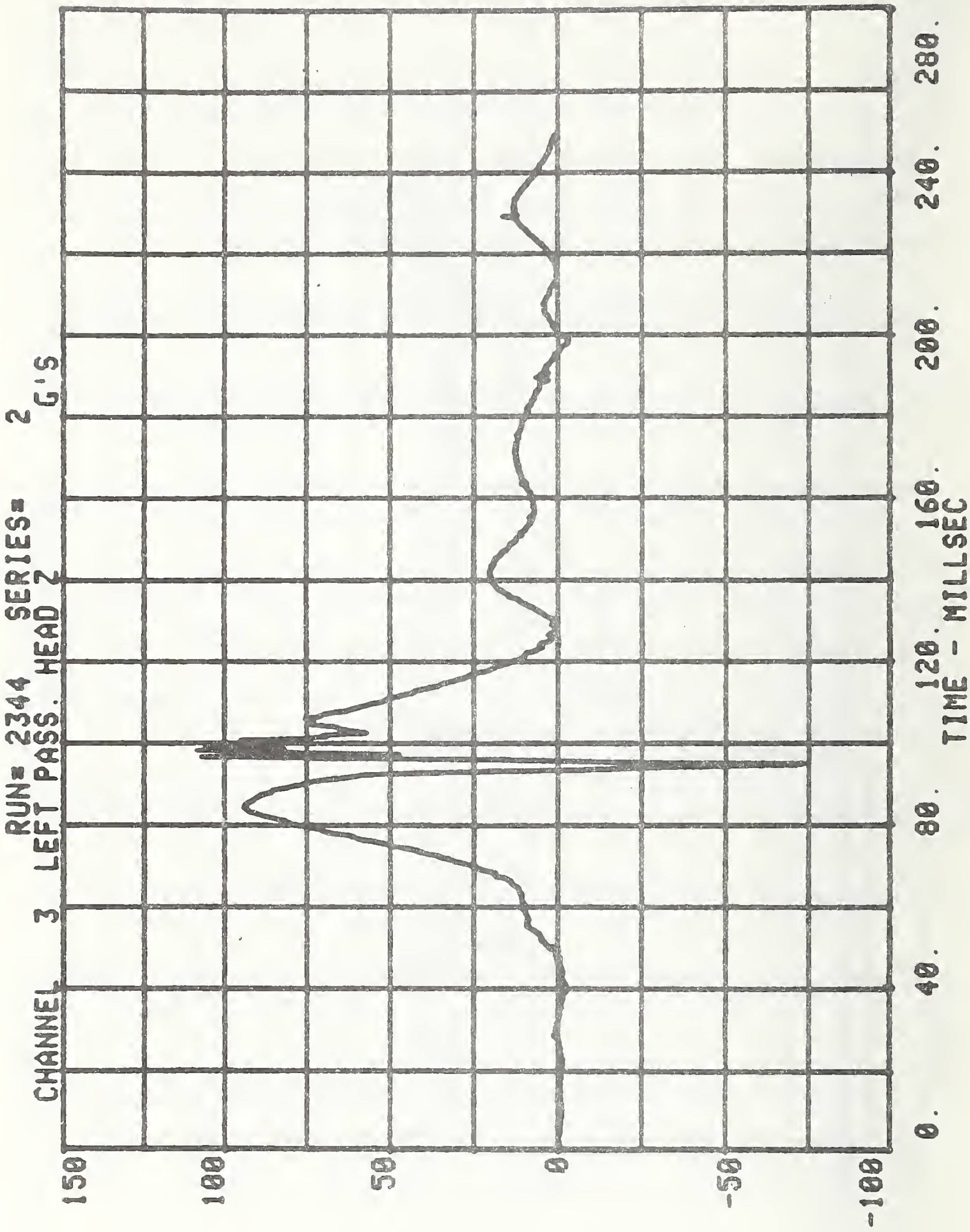
AVERAGE ACCELERATION BETWEEN T1 AND T2= 86.1G'S

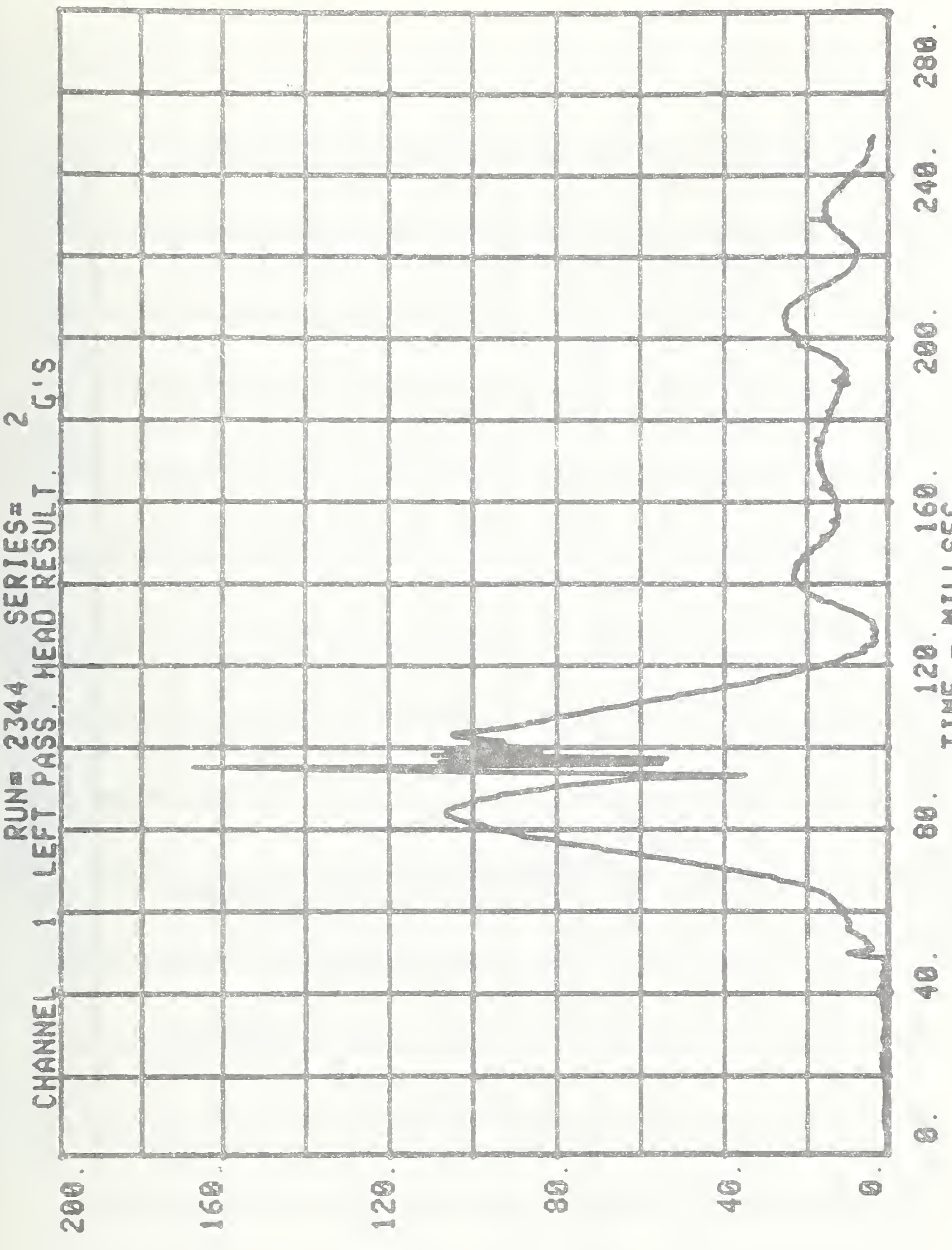
EVENT TIME= 250.0 MSEC

SEVERITY INDEX=3312.5

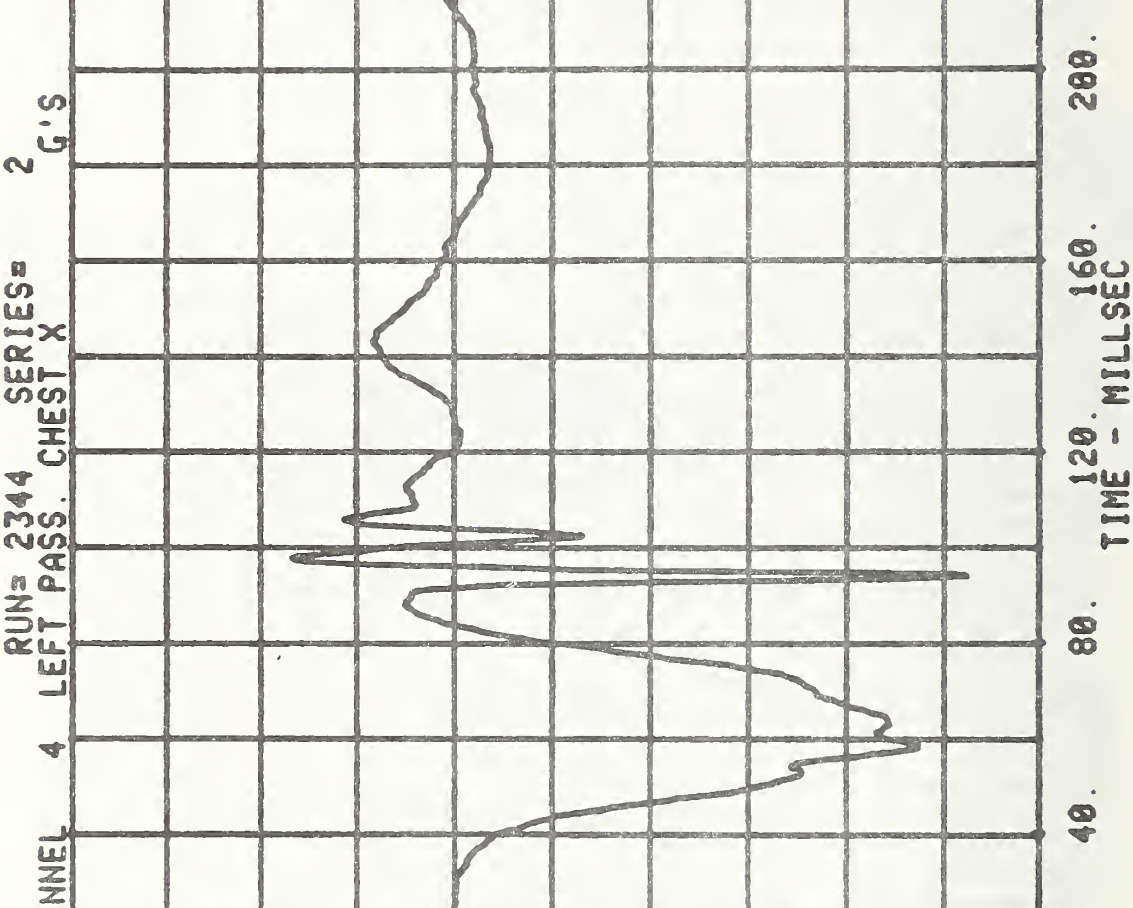

CHANNEL 1 RUN= 2344 SERIES= 2
LEFT PASS. HEAD X G'S
240
160
80
0
-80
-160
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 2 RUN= 2344 SERIES= 2
LEFT PASS. HEAD Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
45 30 15 0 -15 -30

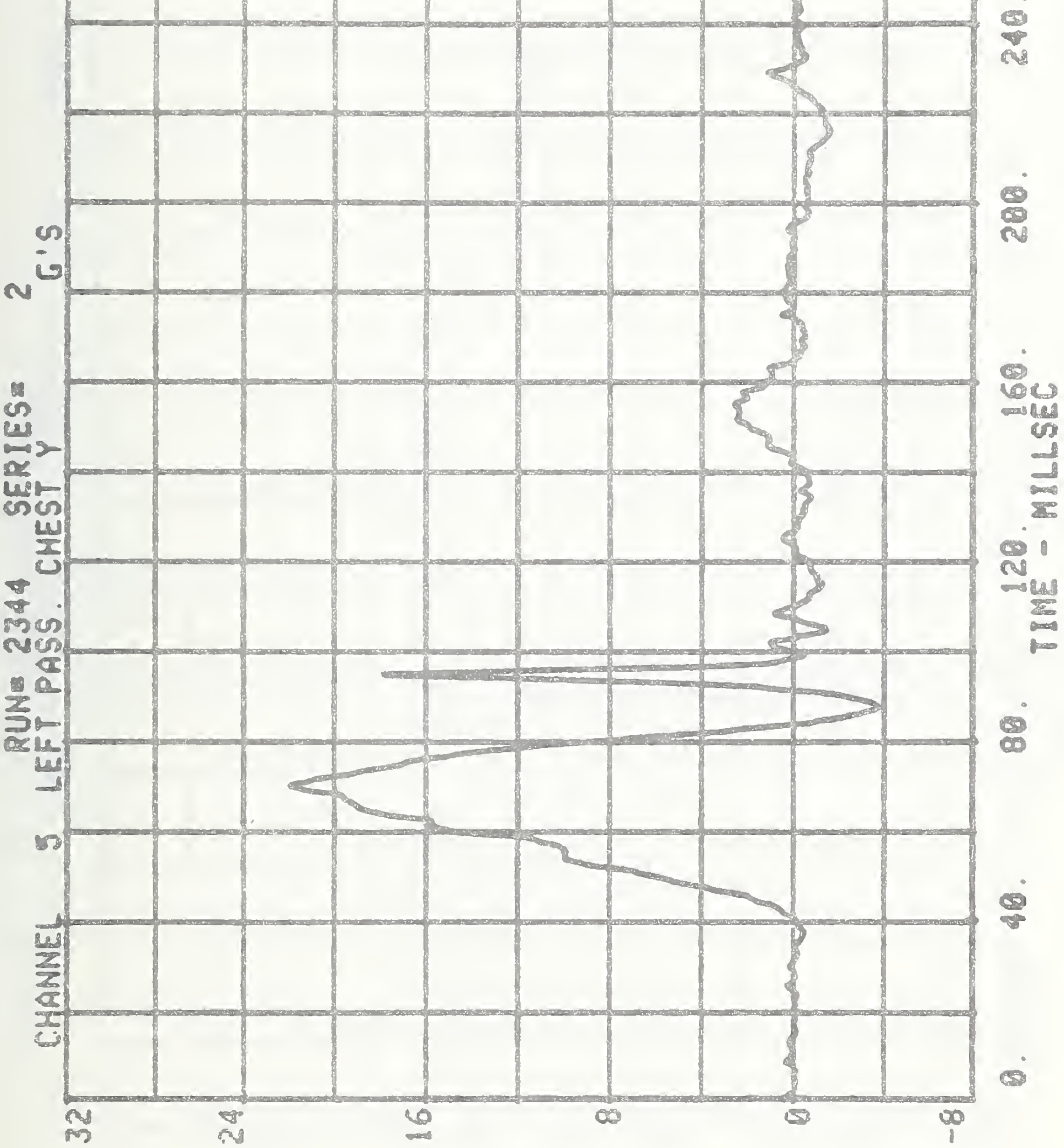

CHANNEL 3 RUN= 2344 SERIES= 2
LEFT PASS. HEAD Z G'S
150
100
50
0
-50
-100
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

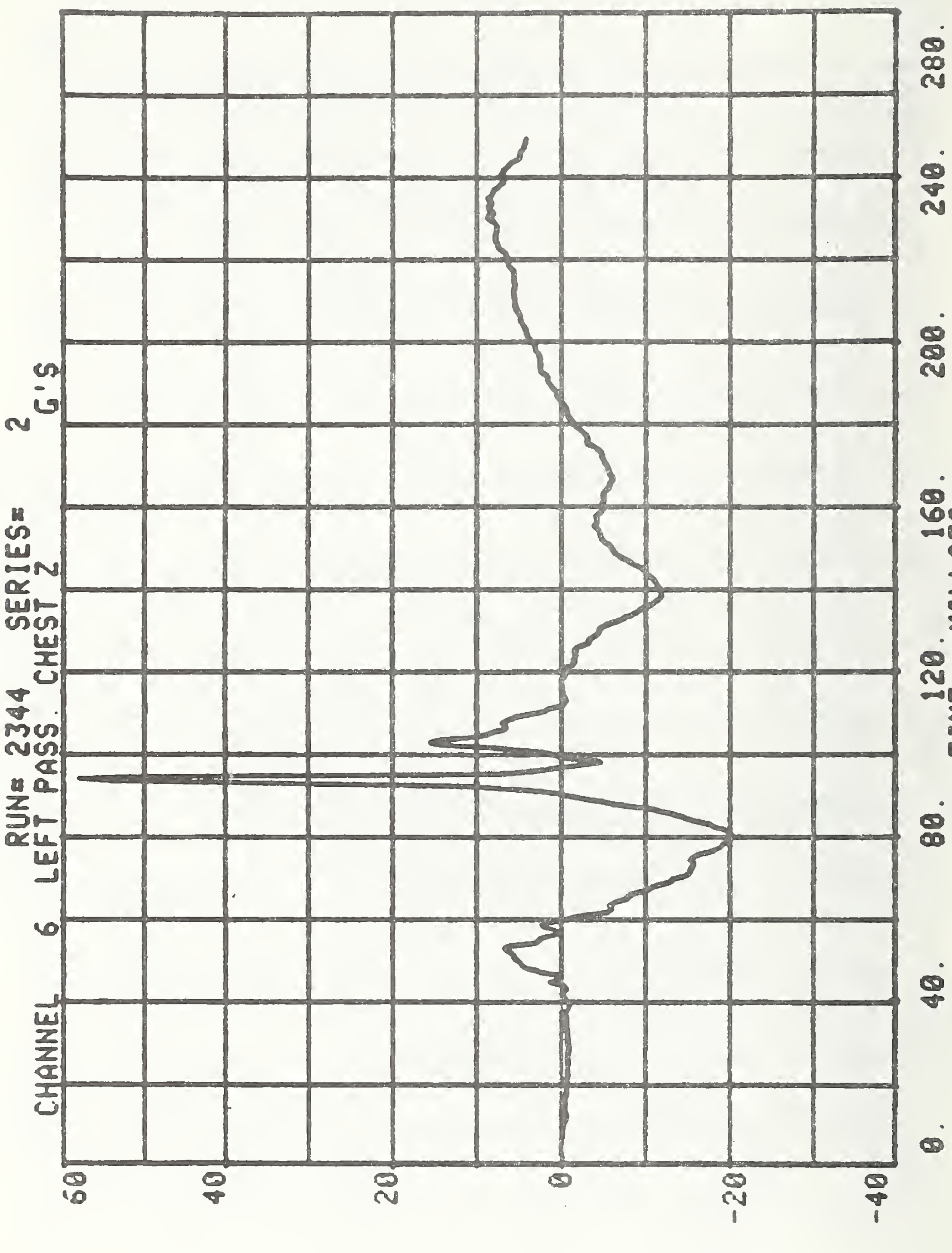


CHANNEL 1 RUN= 2344 SERIES= 2
LEFT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
0.
40.
80.
120.
160.
200.

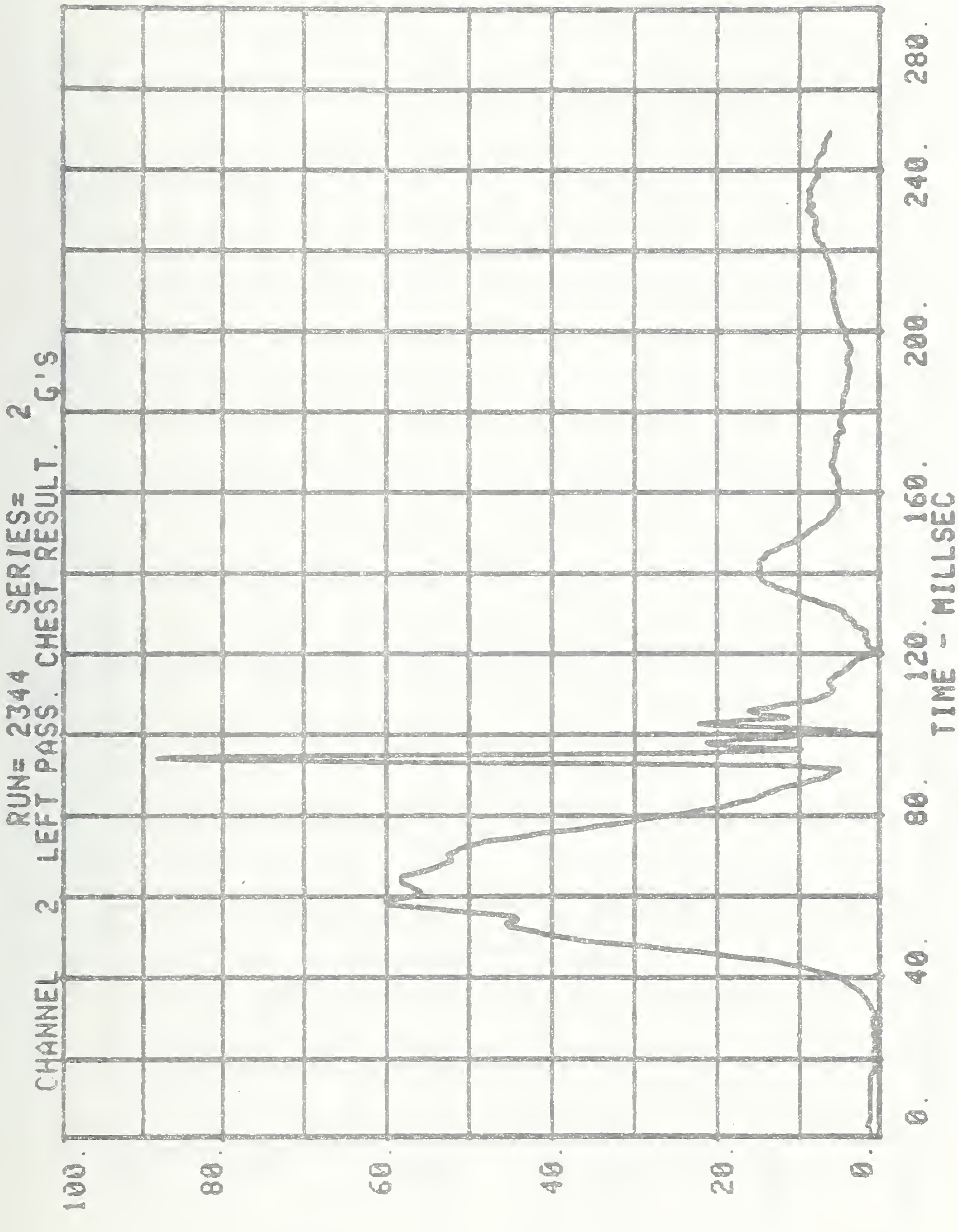


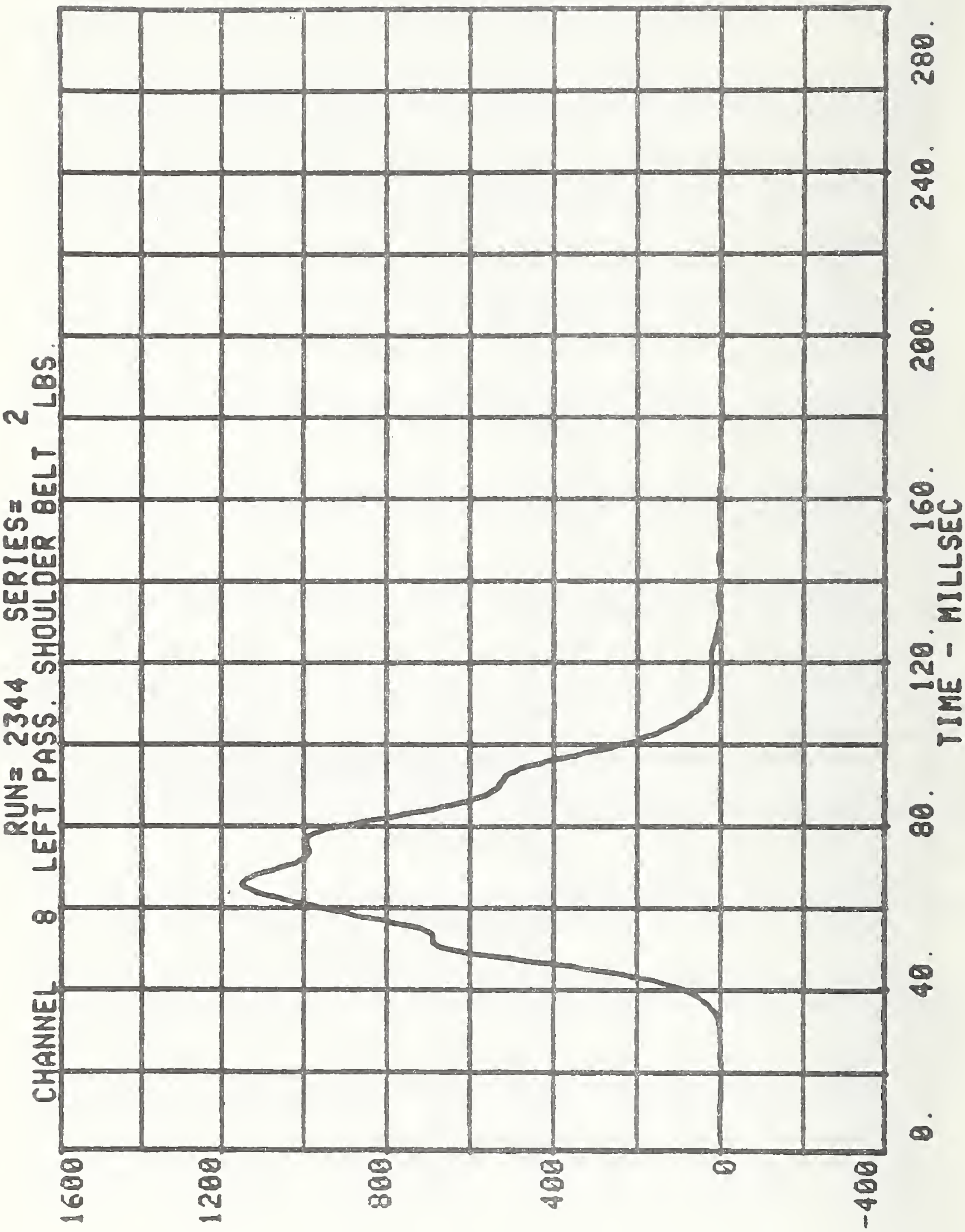
CHANNEL 4 RUN= 2344 SERIES= 2
LEFT PASS. CHEST X G'S
50
25
0
-25
-50
-75
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

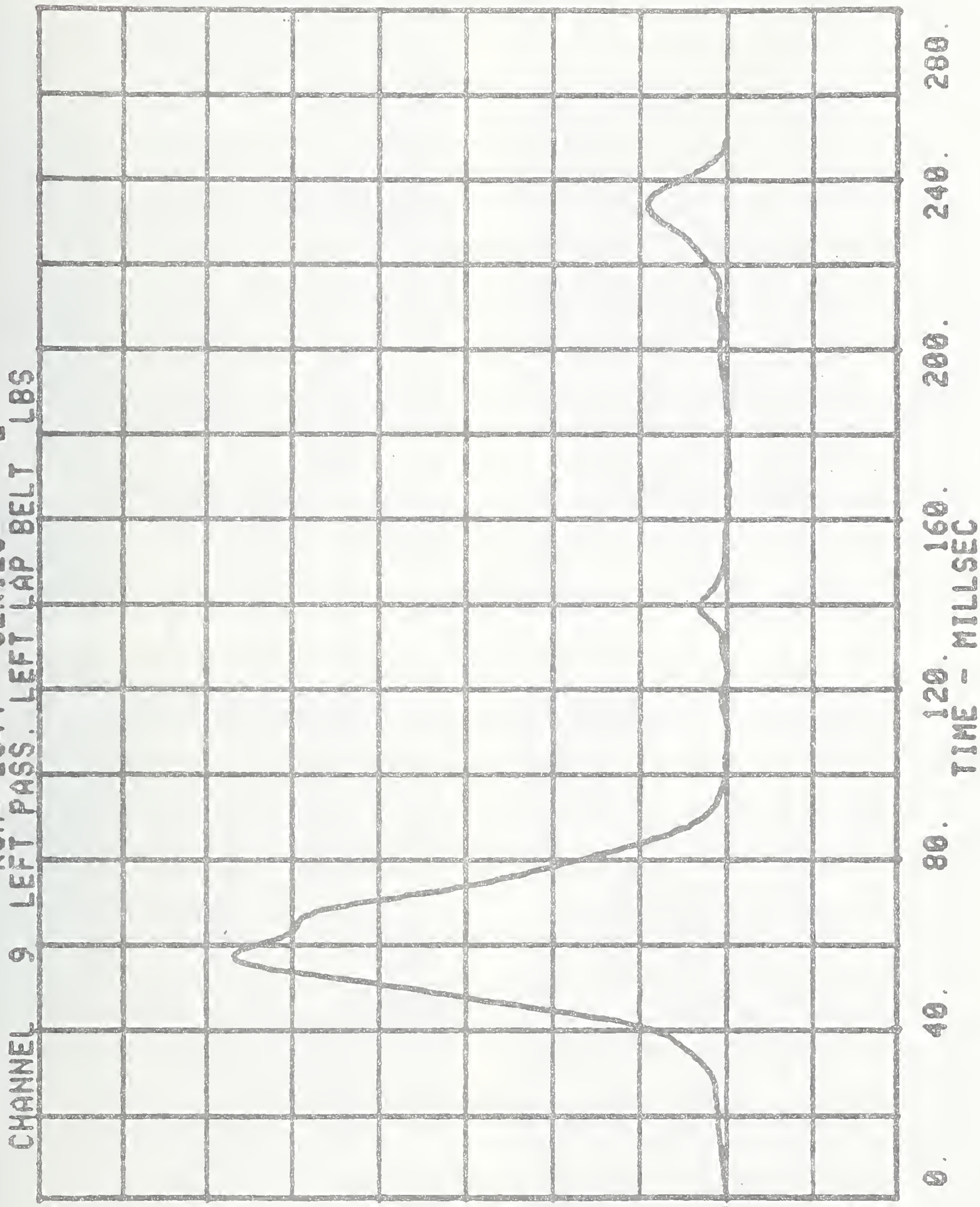

CHANNEL 5 RUN= 2344 SERIES= 2
LEFT PASS. CHEST Y G'S
TIME - MILLSEC
32
24
16
8
0
-8
0.
40.
80.
120.
160.
200.
240.
280.

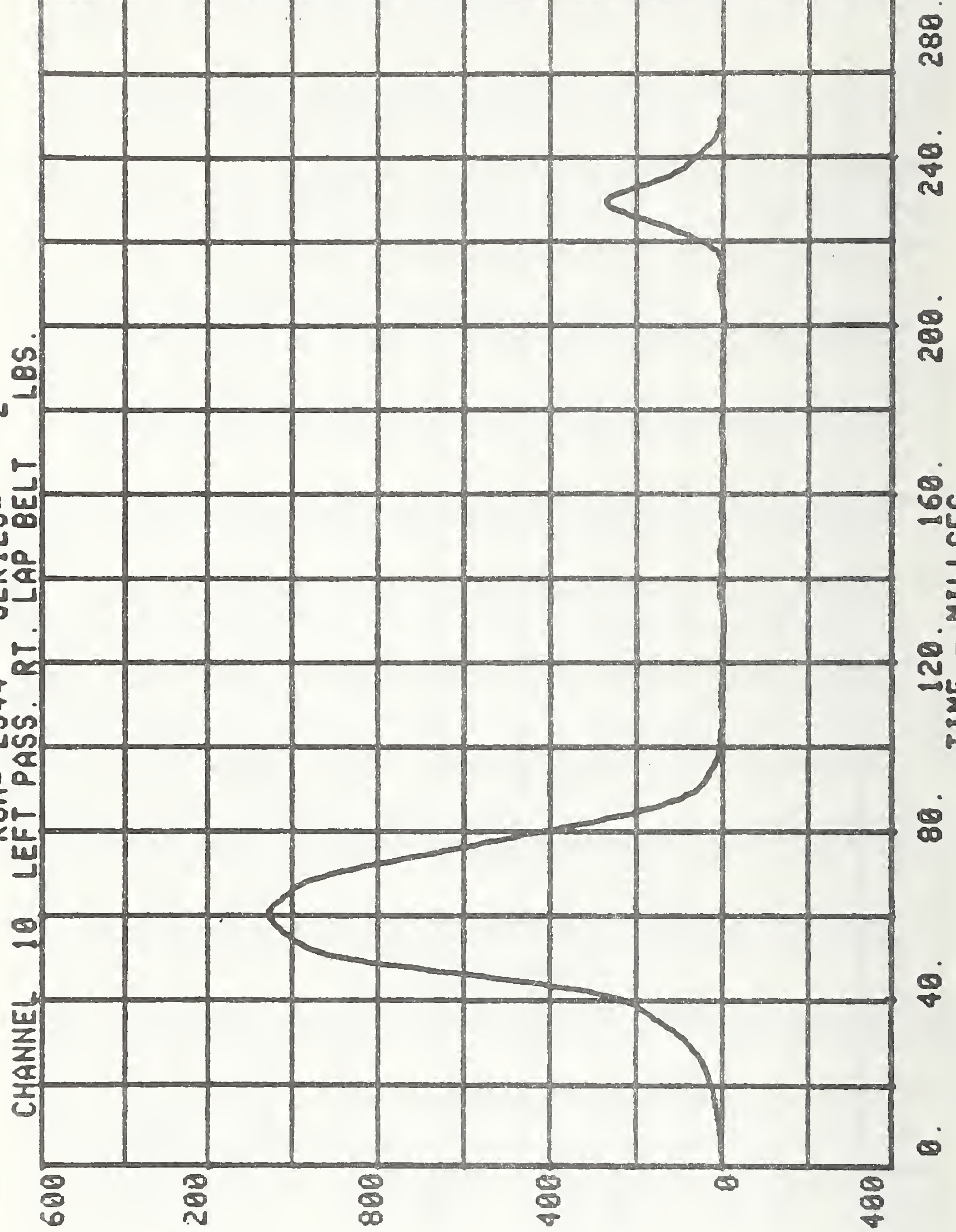


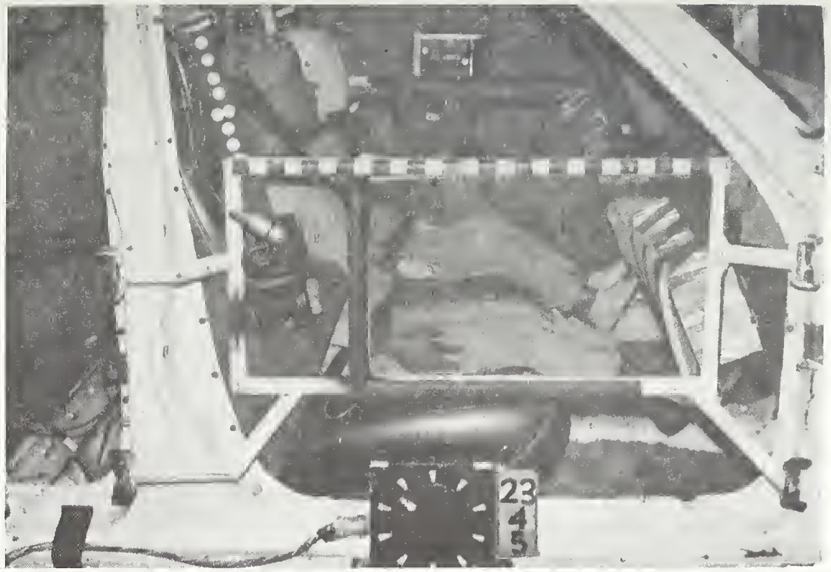
CHANNEL 6 RUN= 2344 SERIES= 2
LEFT PASS. CHEST Z G'S
60
40
20
0
-20
-40
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

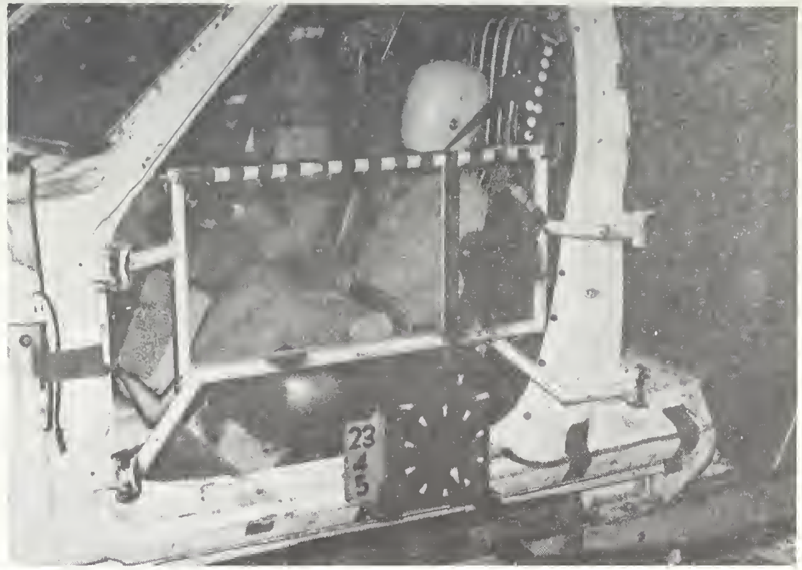

CHANNEL 2 RUN= 2344 SERIES= 2
LEFT PASS. CHEST RESULT. G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100.


CHANNEL 8 RUN= 2344 SERIES= 2
LEFT PASS. SHOULDER BELT LBS.
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

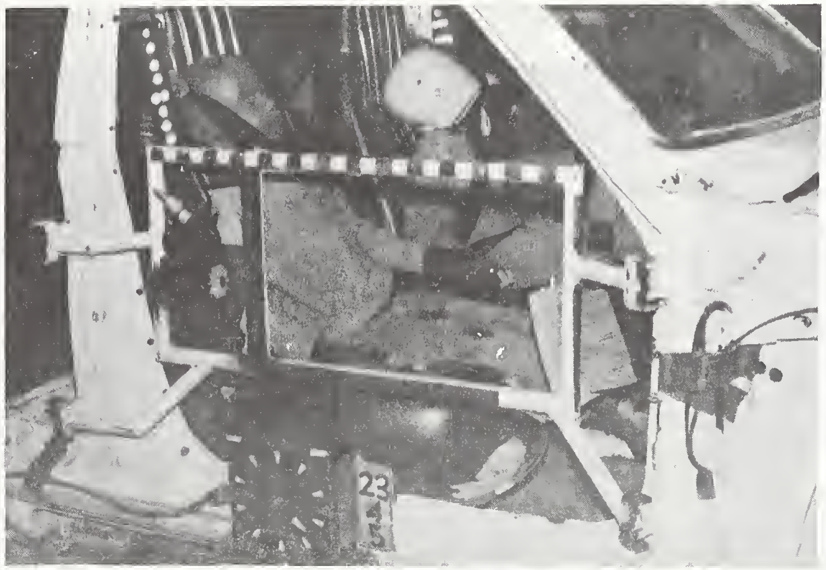

CHANNEL 9 RUN= 2344 SERIES= 2
LEFT PASS. LEFT LAP BELT LBS
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

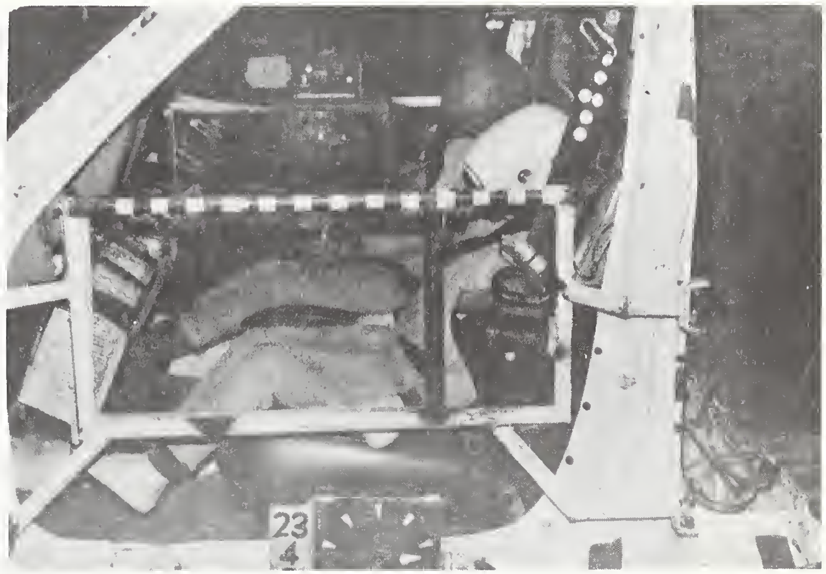

CHANNEL 10 RUN= 2344 SERIES= 2
LEFT PASS. RT. LAP BELT LBS.
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC





PRE-TEST





ALDERSON S/N 49

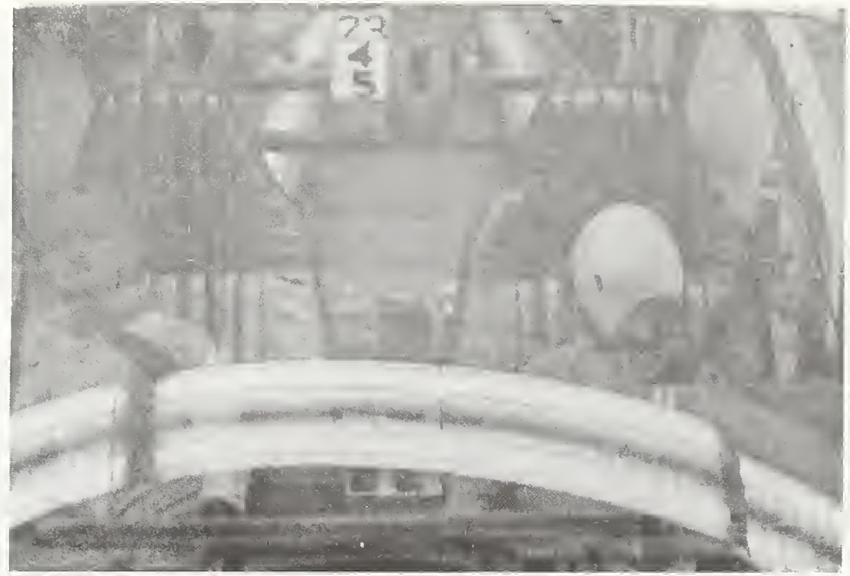
TNO

POST-TEST

RUN 2345

ALDERSON S/N 49 TNO

PRE-TEST



ALDERSON S/N 49 TNO

POST-TEST

RUN 2345

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCED LIMITER

RUN=2345

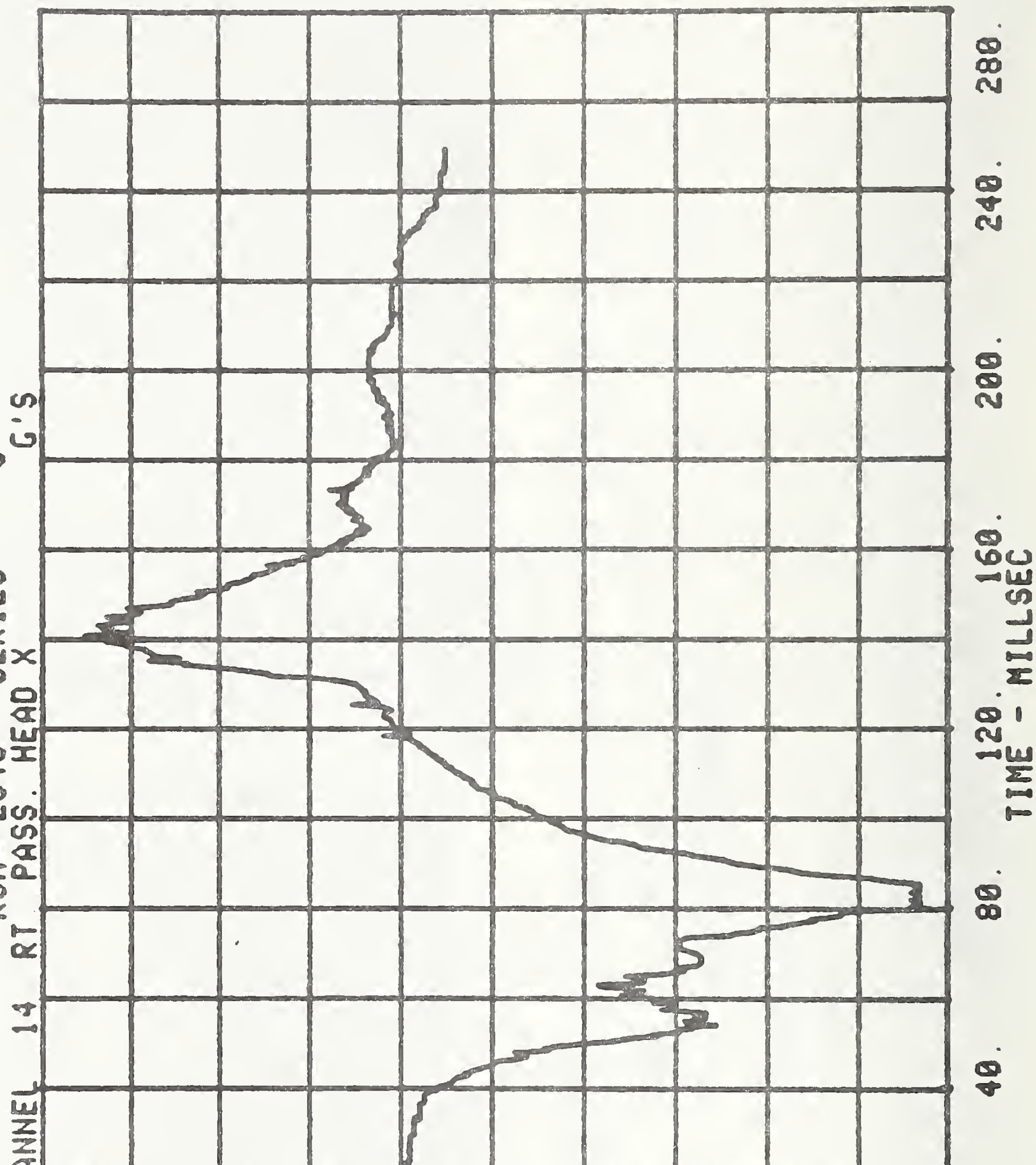
RT. PASS. HEAD RESULT.

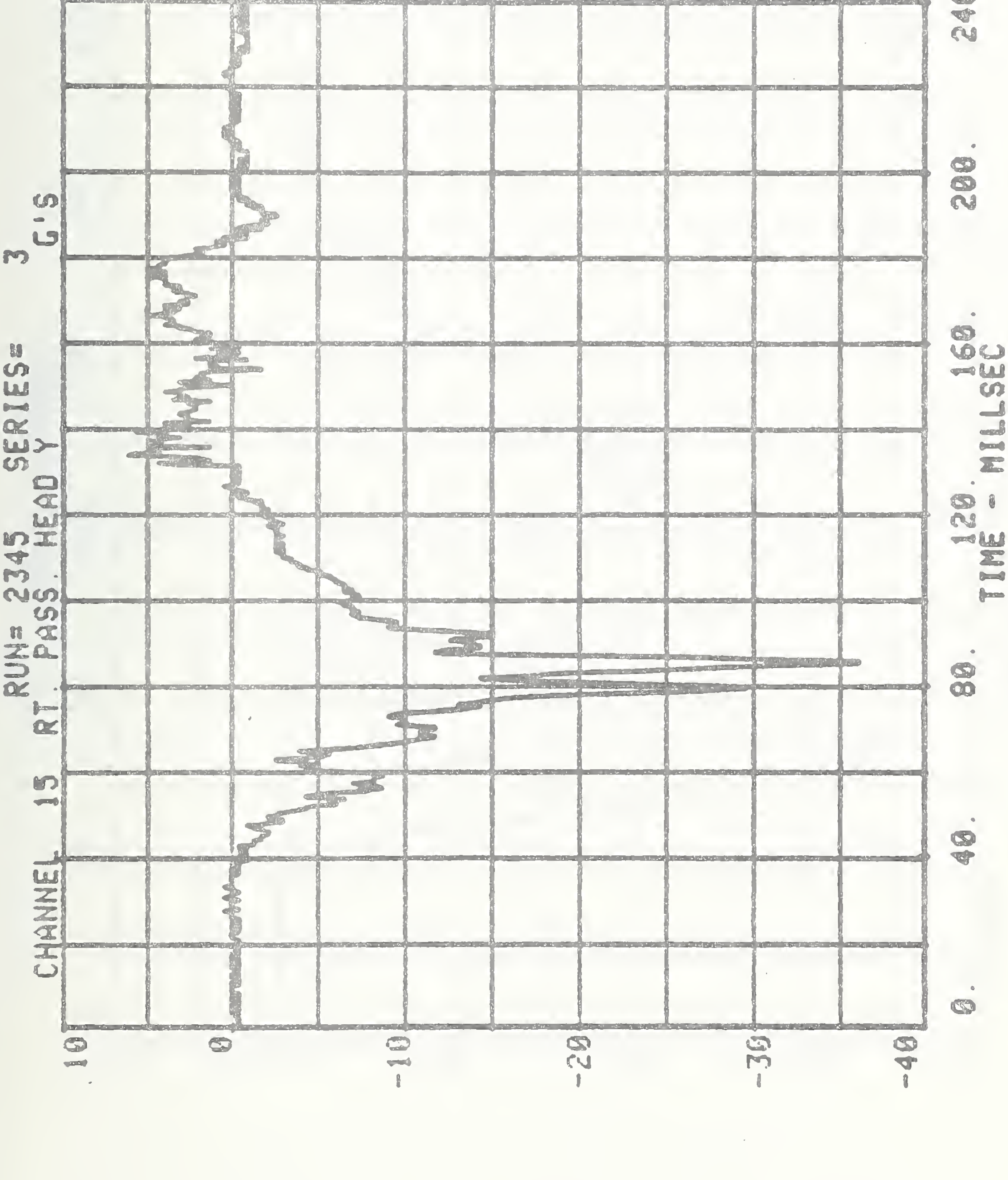
HIC= 875.7   FROM T1= .05130   TO T2= .09330

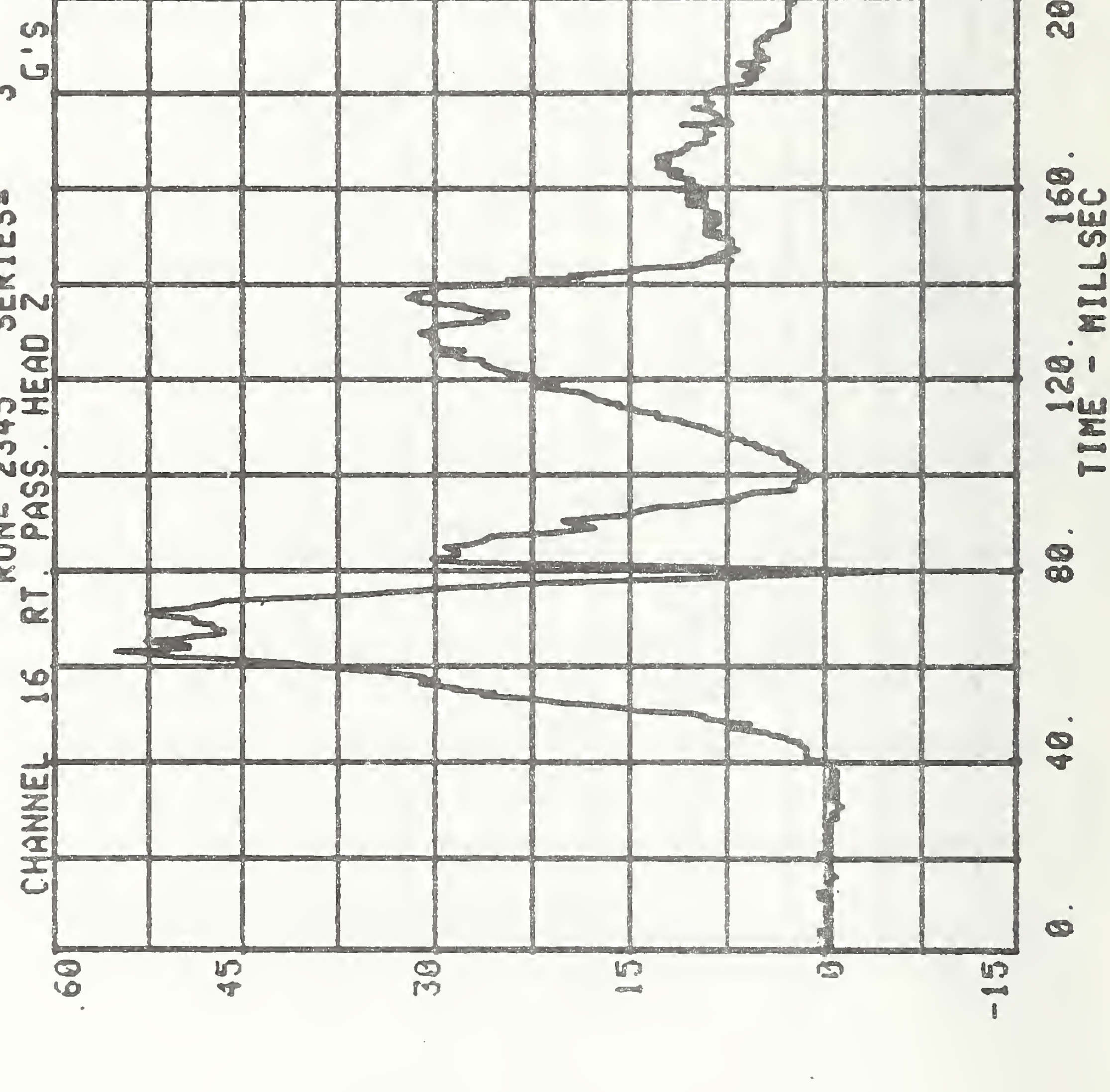
AVERAGE ACCELERATION BETWEEN T1 AND T2= 53.4G'S

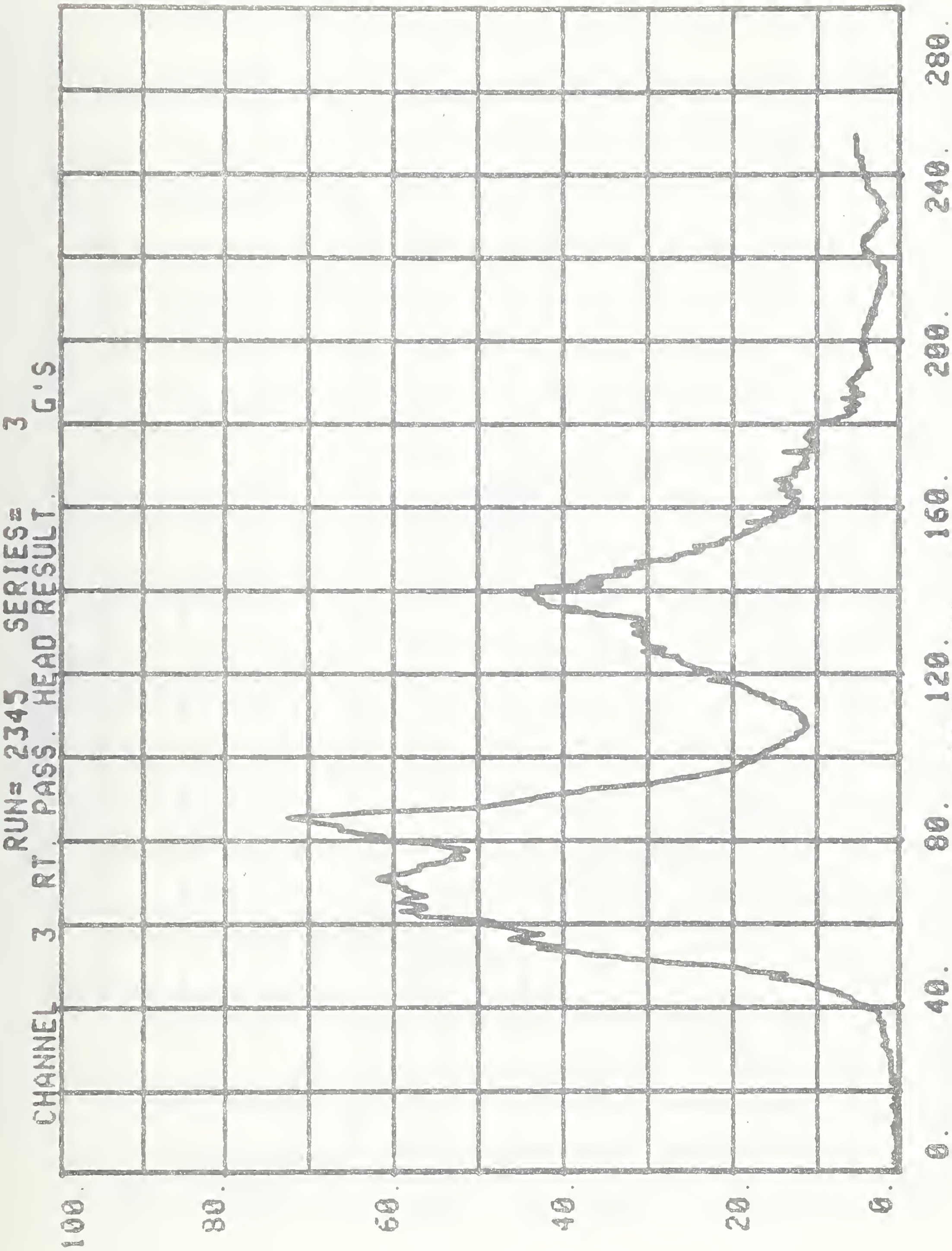
EVENT TIME= 250.0 MSEC

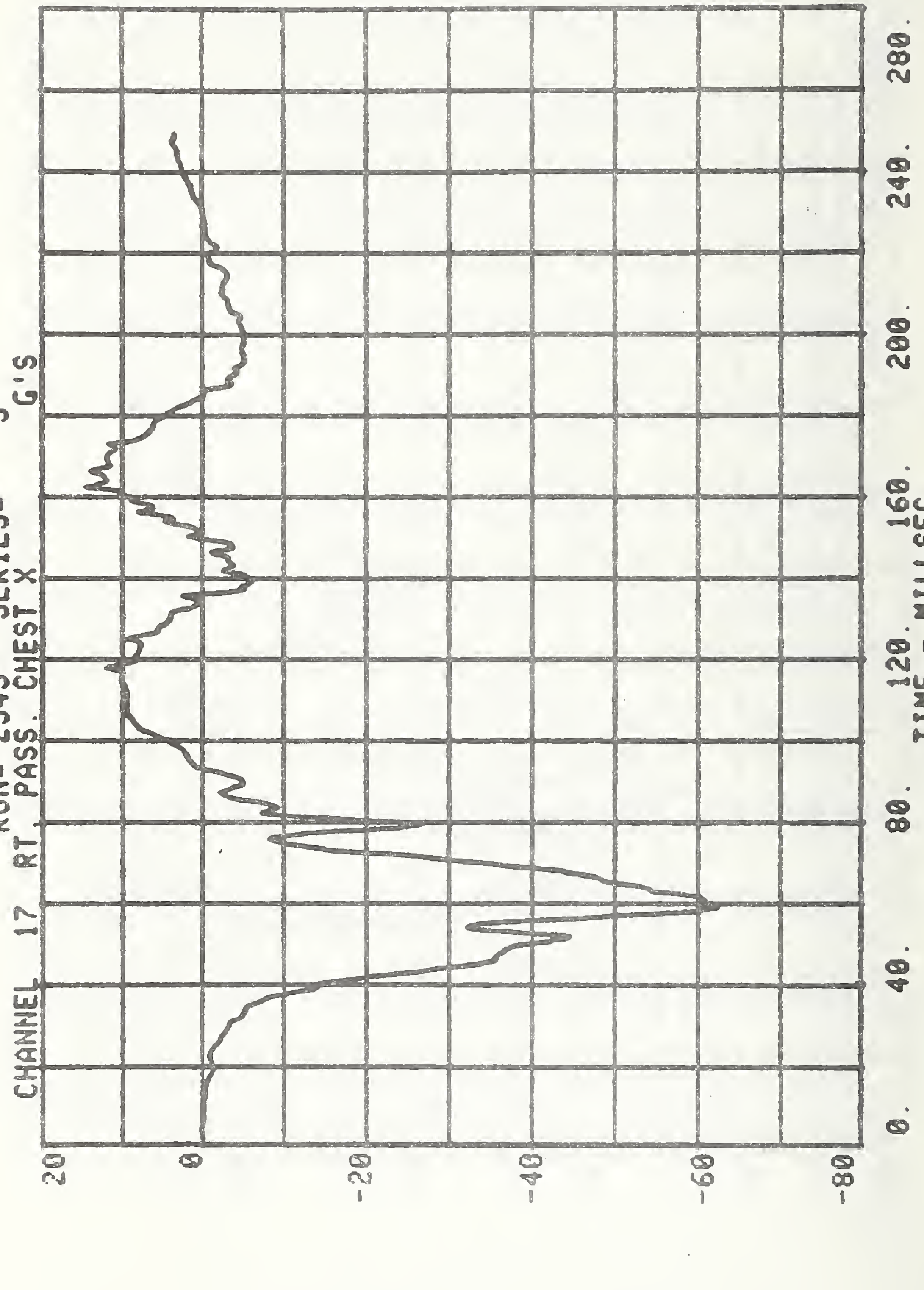
SEVERITY INDEX=1192.8

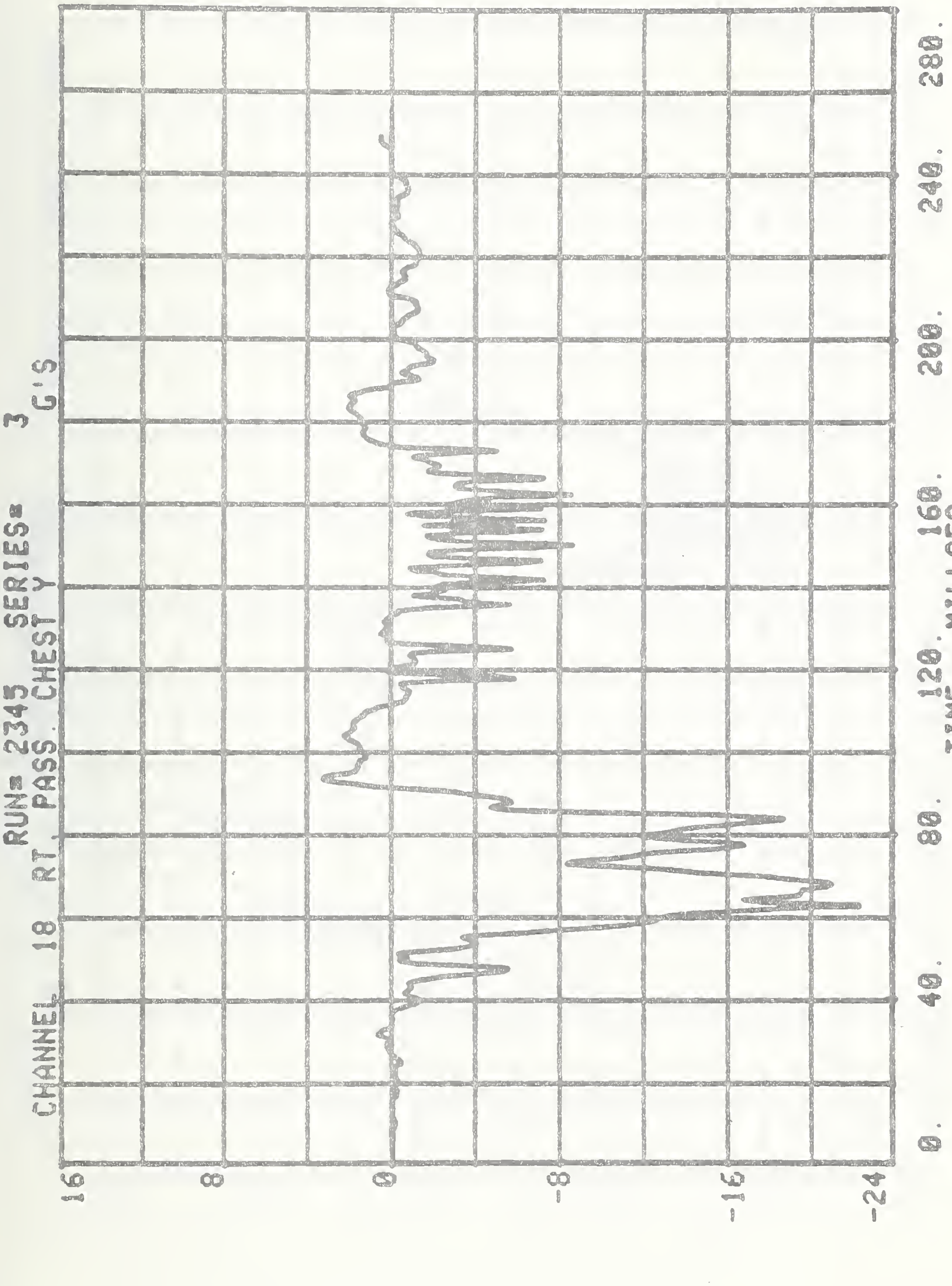

CHANNEL 14 RUN= 2345 SERIES= 3
RT PASS. HEAD X G'S
40
20
0
-20
-40
-60
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 15 RUN= 2345 SERIES= 3
RT. PASS. HEAD Y G'S
10
0
-10
-20
-30
-40
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

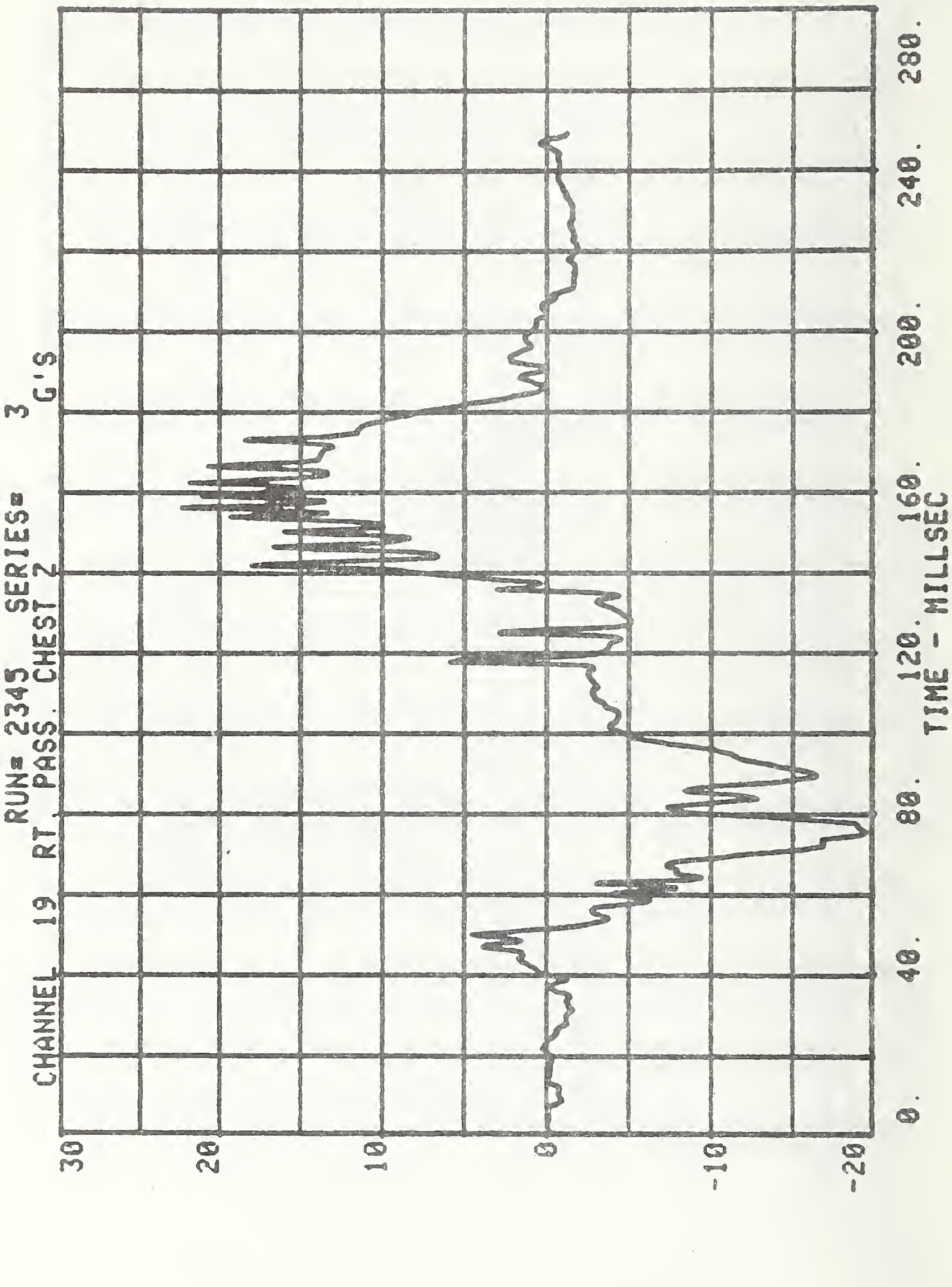

CHANNEL 16 RUN= 2345 SERIES= 3
RT. PASS. HEAD Z G'S
60
45
30
15
0
-15
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

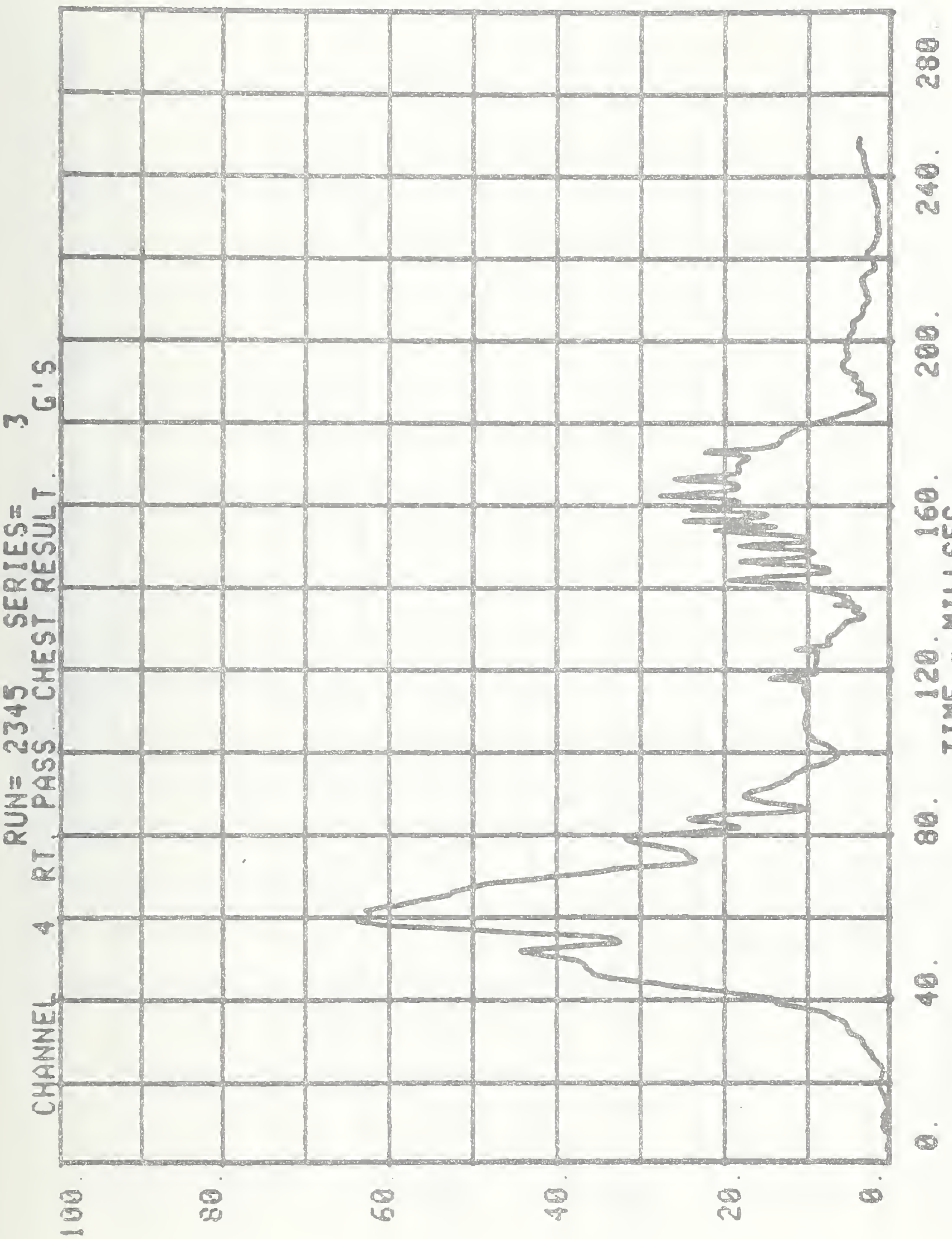

CHANNEL 3 RUN= 2345 SERIES= 3
RT. PASS. HEAD RESULT G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100

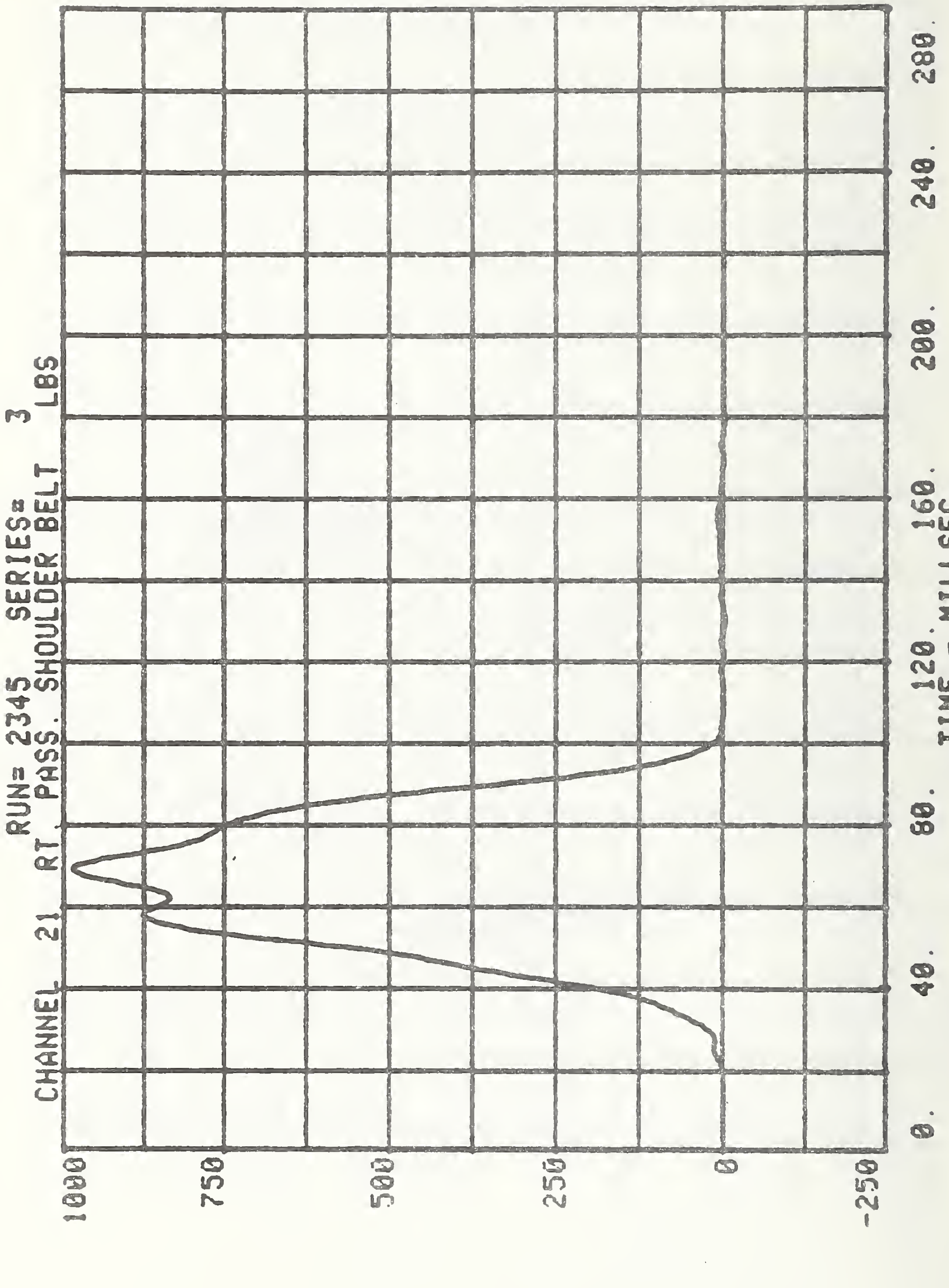

CHANNEL 17 RUN= 2345 SERIES= 3
RT. PASS. CHEST X G'S
20
0
-20
-40
-60
-80
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



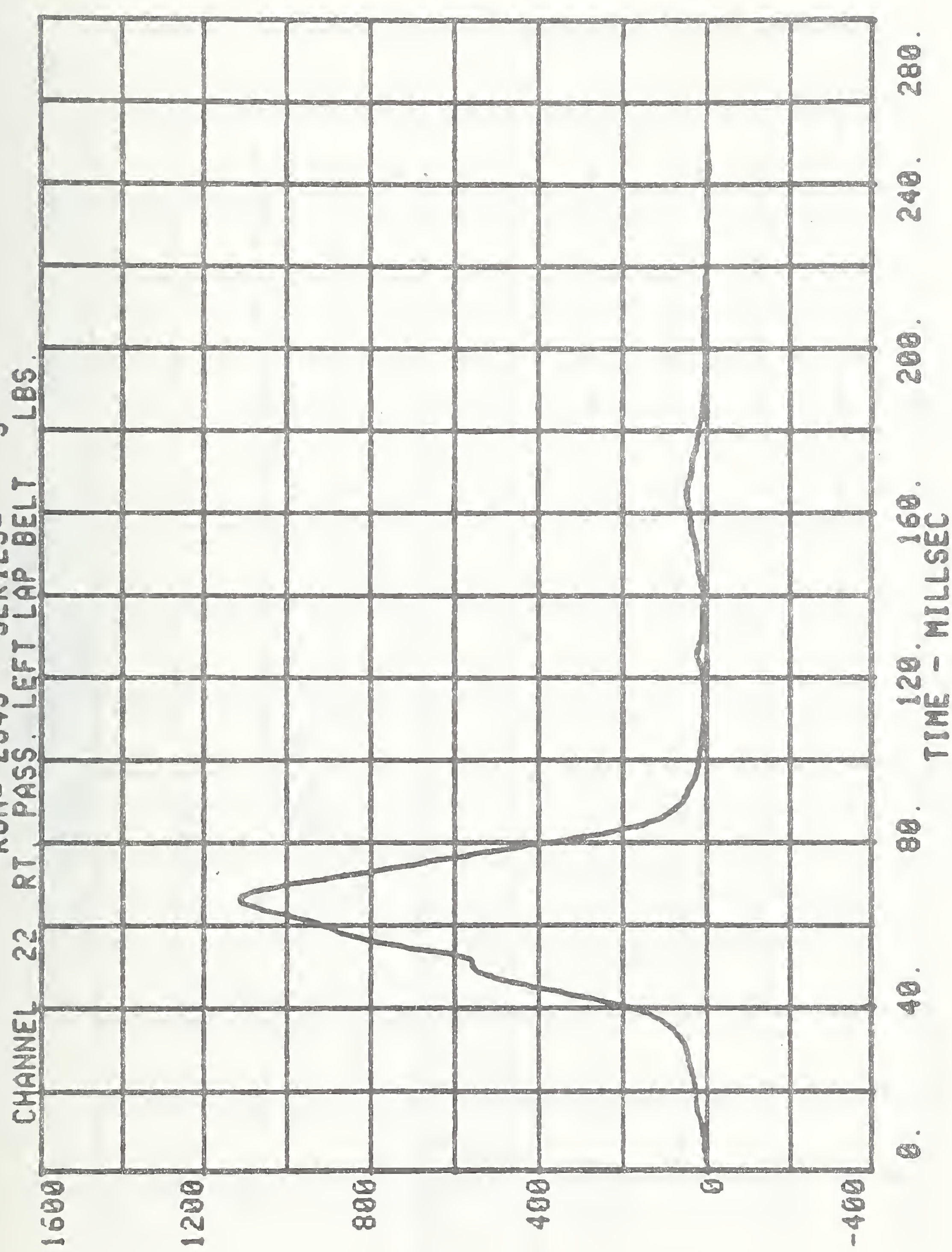
CHANNEL 18 RUN= 2345 SERIES= 3
RT. PASS. CHEST Y G'S
16
8
0
-8
-16
-24
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

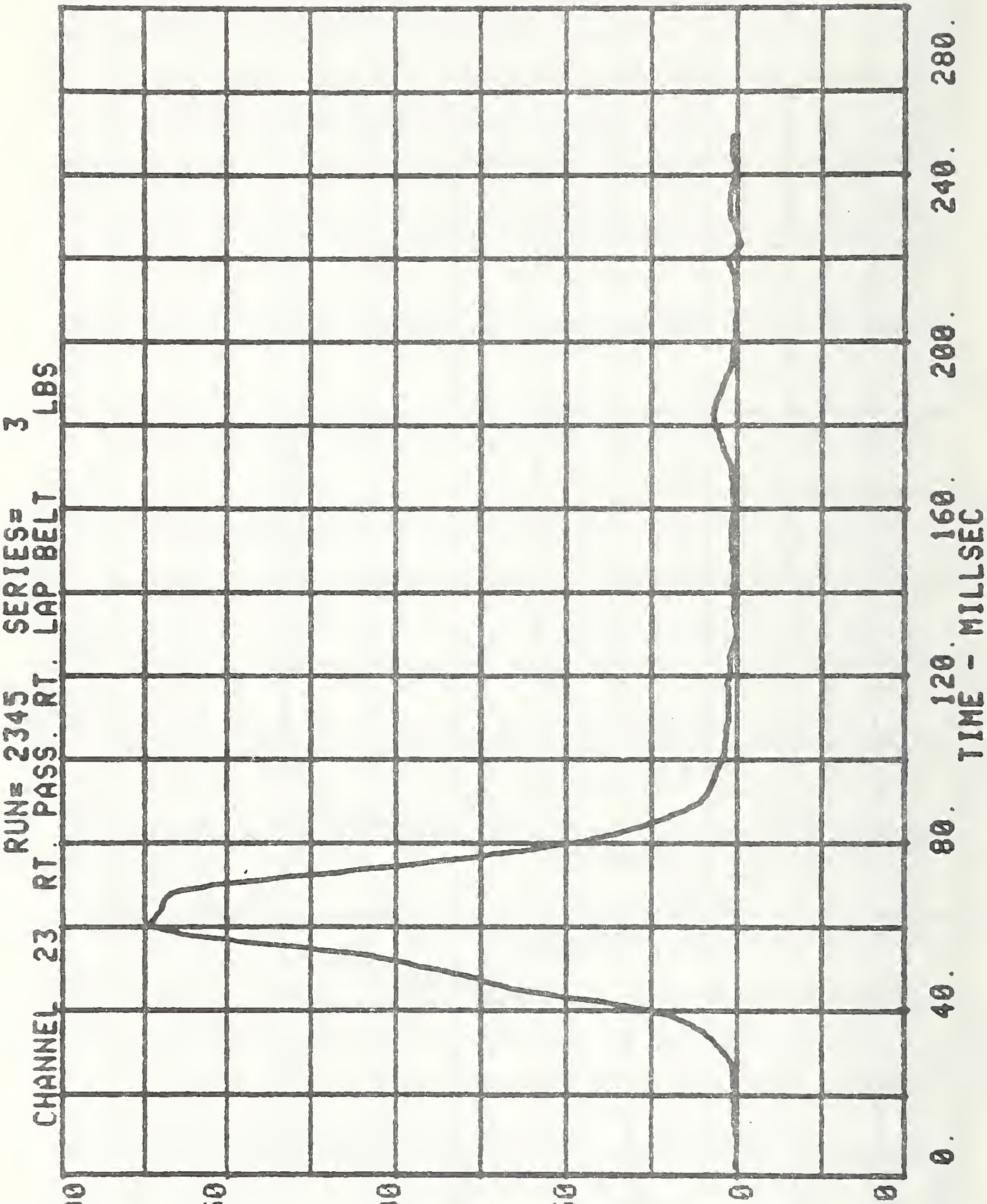

CHANNEL 19 RUN= 2345 SERIES= 3
RT. PASS. CHEST Z G'S
30
20
10
0
-10
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 4 RUN= 2345 SERIES= 3
RT. PASS CHEST RESULT G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100.



CHANNEL 21 RUN= 2345 SERIES= 3
RT PASS. SHOULDER BELT LBS
1000
750
500
250
0
-250
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 22 RUN= 2345 SERIES= 3
RT. PASS. LEFT LAP BELT LBS.
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 23 RUN= 2345 SERIES= 3
RT. PASS. RT. LAP BELT LBS
1000
750
500
250
0
-250
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2345

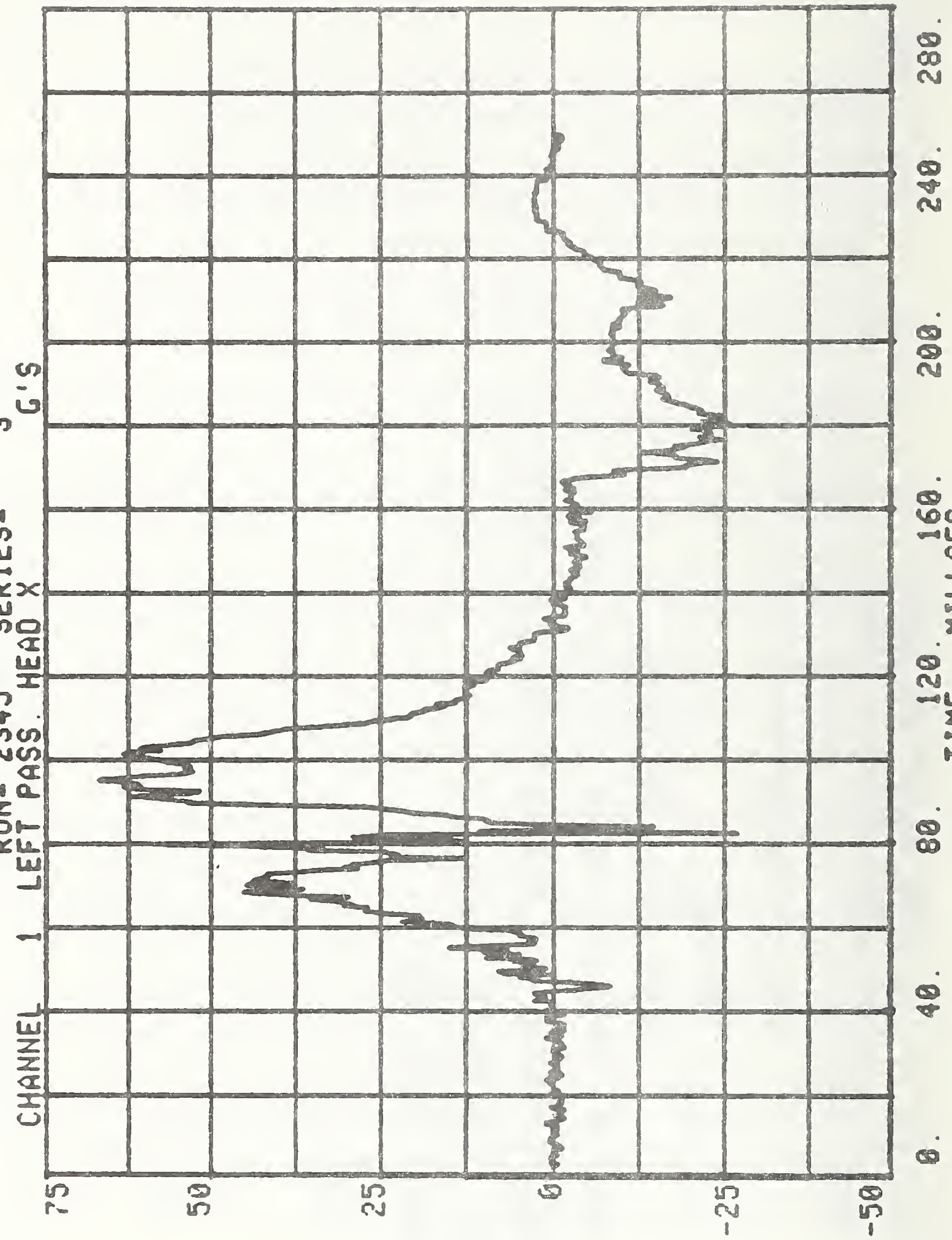
LEFT PASS. HEAD RESULT.

HIC=2642.9   FROM T1= .06150   TO T2= .10710

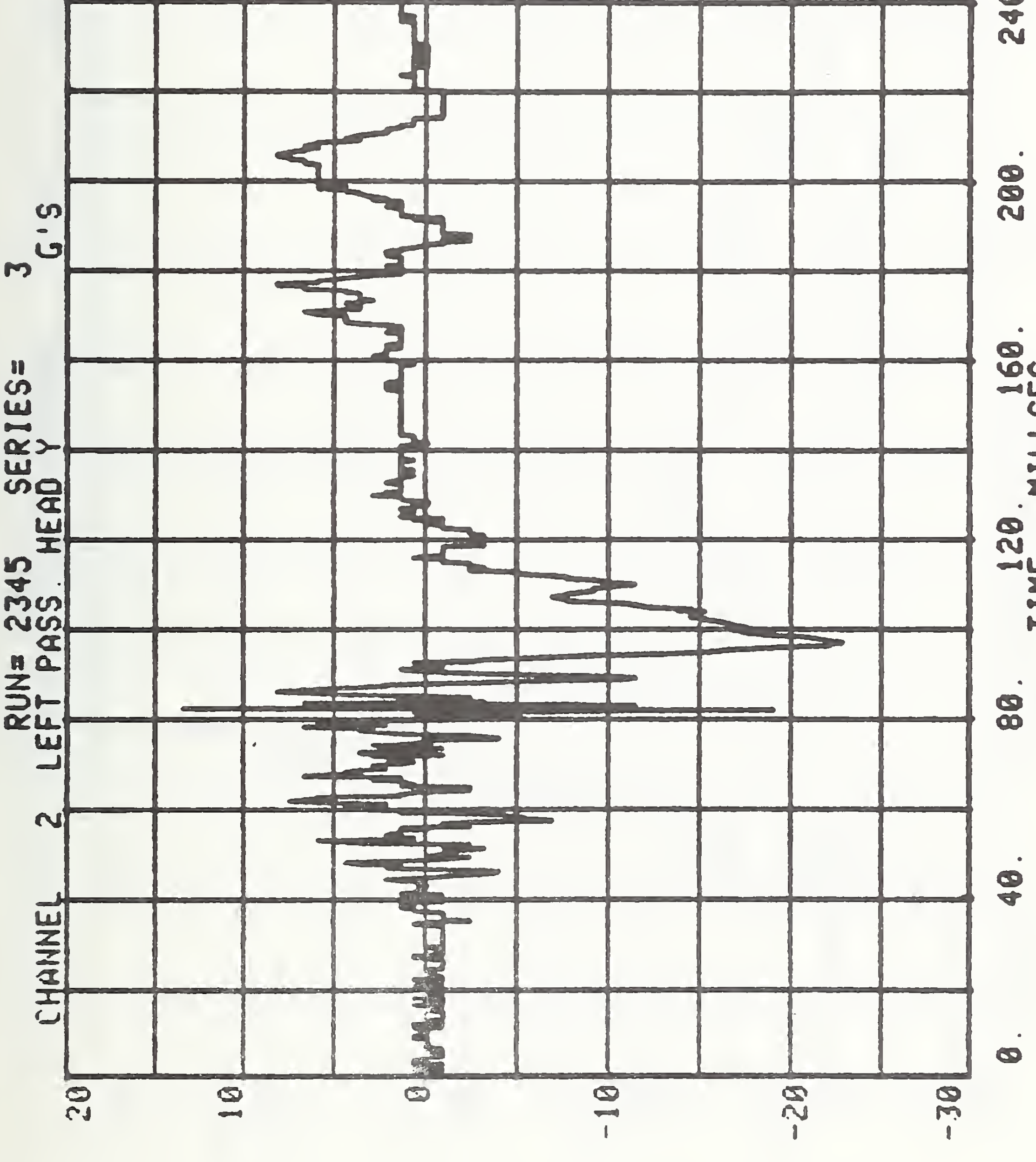
AVERAGE ACCELERATION BETWEEN T1 AND T2= 80.4G'S

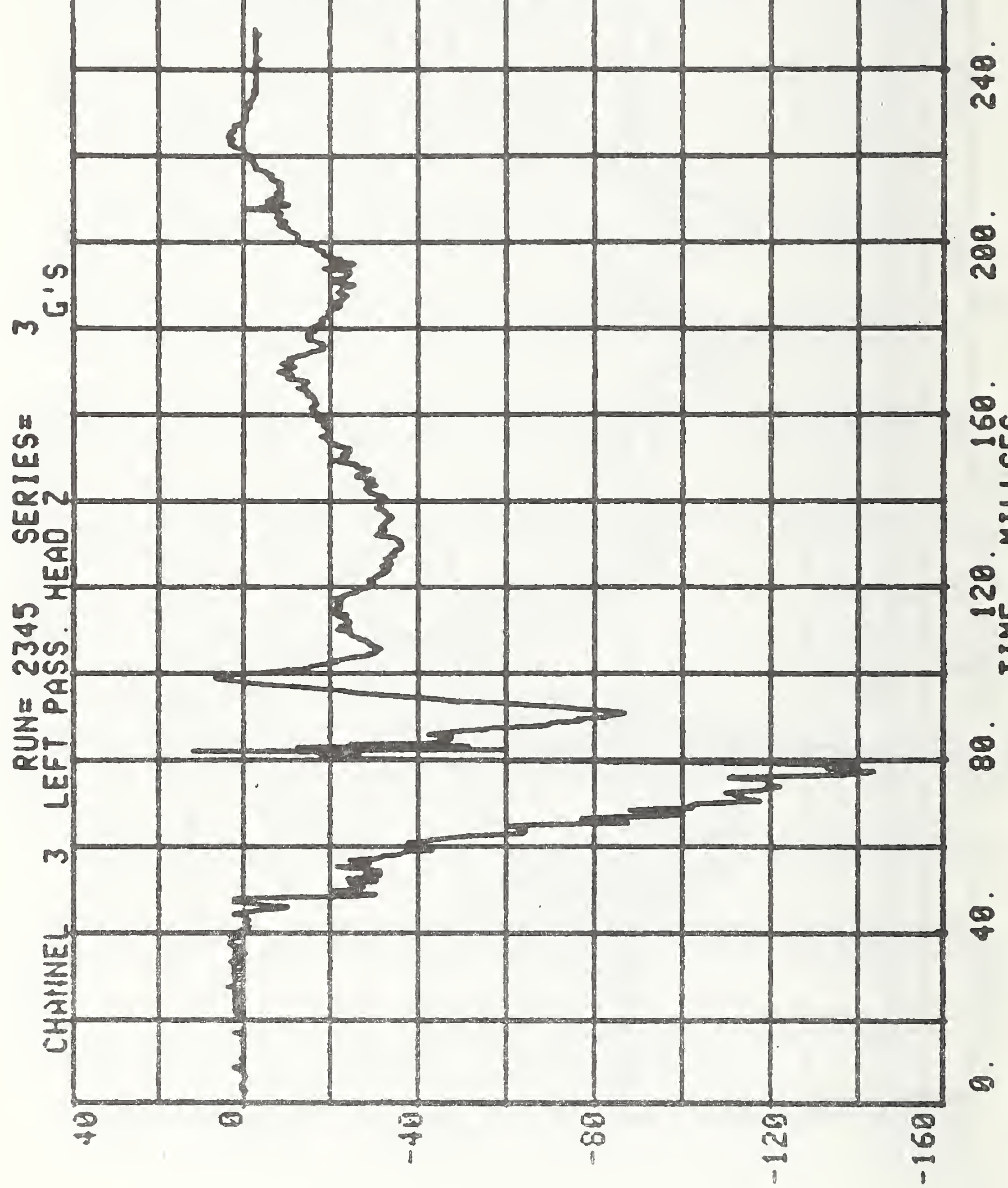
EVENT TIME= 250.0 MSEC

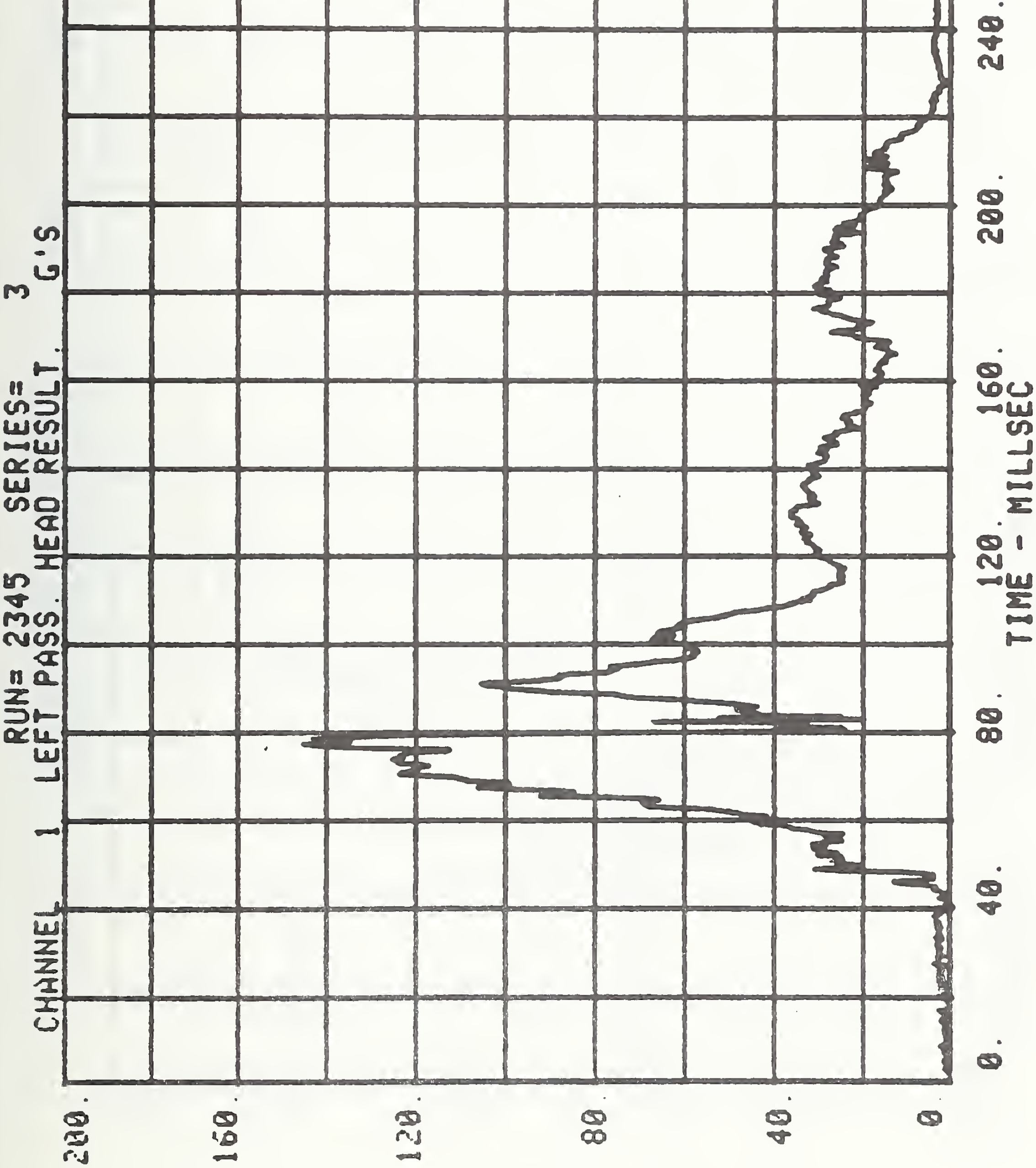
SEVERITY INDEX=3830.1



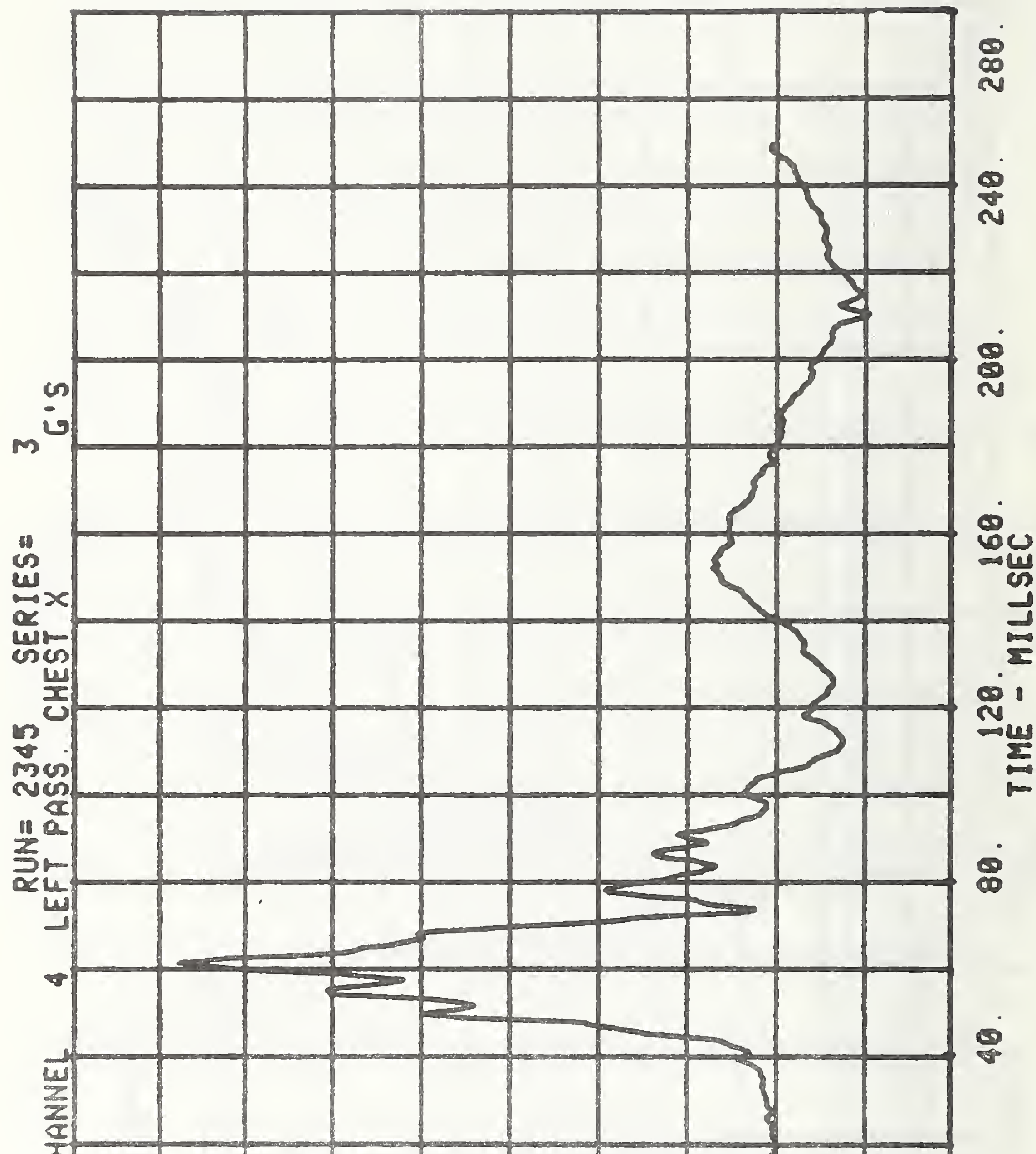
CHANNEL 1 RUN= 2345 SERIES= 3
LEFT PASS. HEAD X G'S
75
50
25
0
-25
-50
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 2 RUN= 2345 SERIES= 3
LEFT PASS. HEAD Y
G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
20 10 0 -10 -20 -30

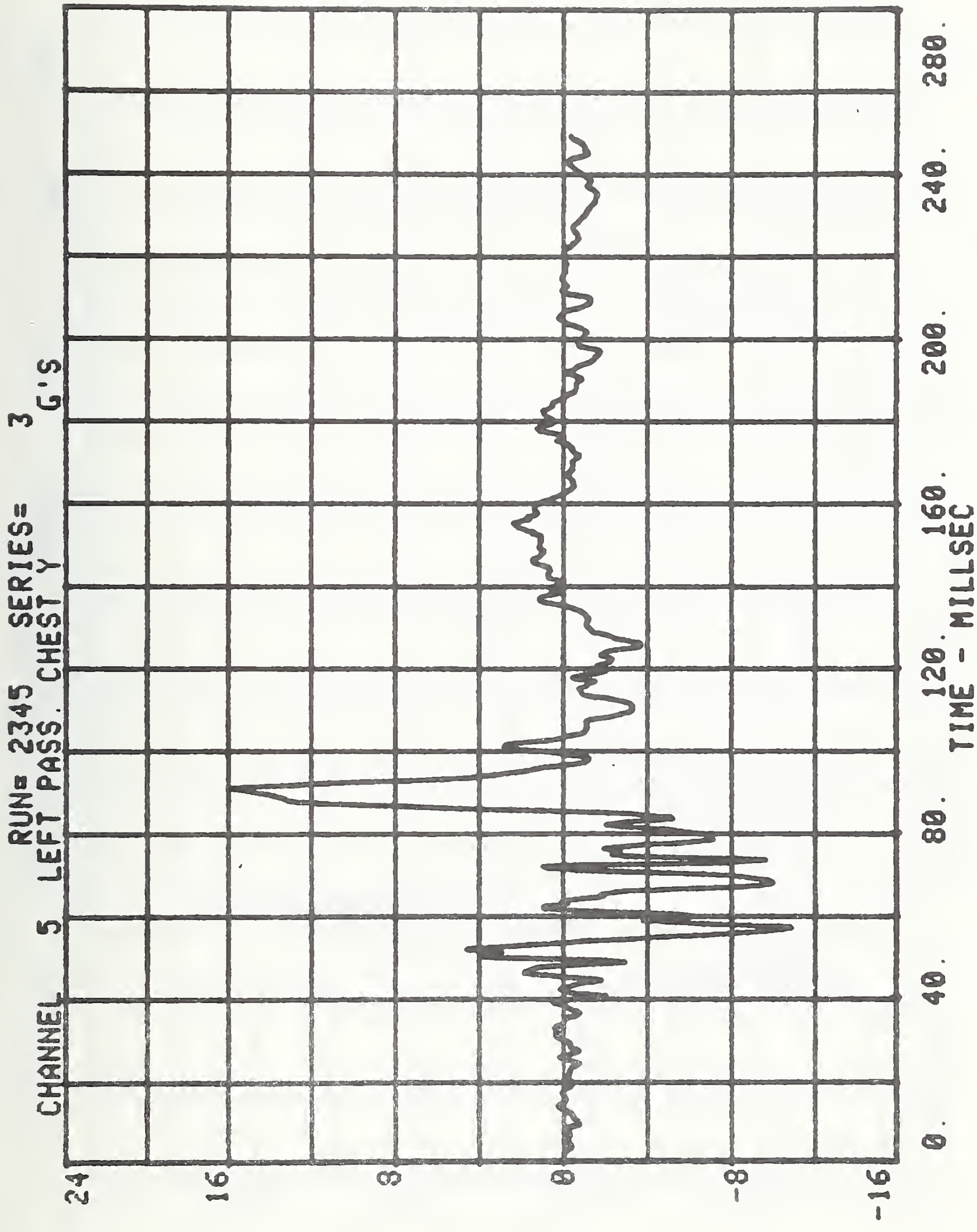

CHANNEL 3 RUN= 2345 SERIES= 3
LEFT PASS. HEAD Z G'S
40
0
-40
-80
-120
-160
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

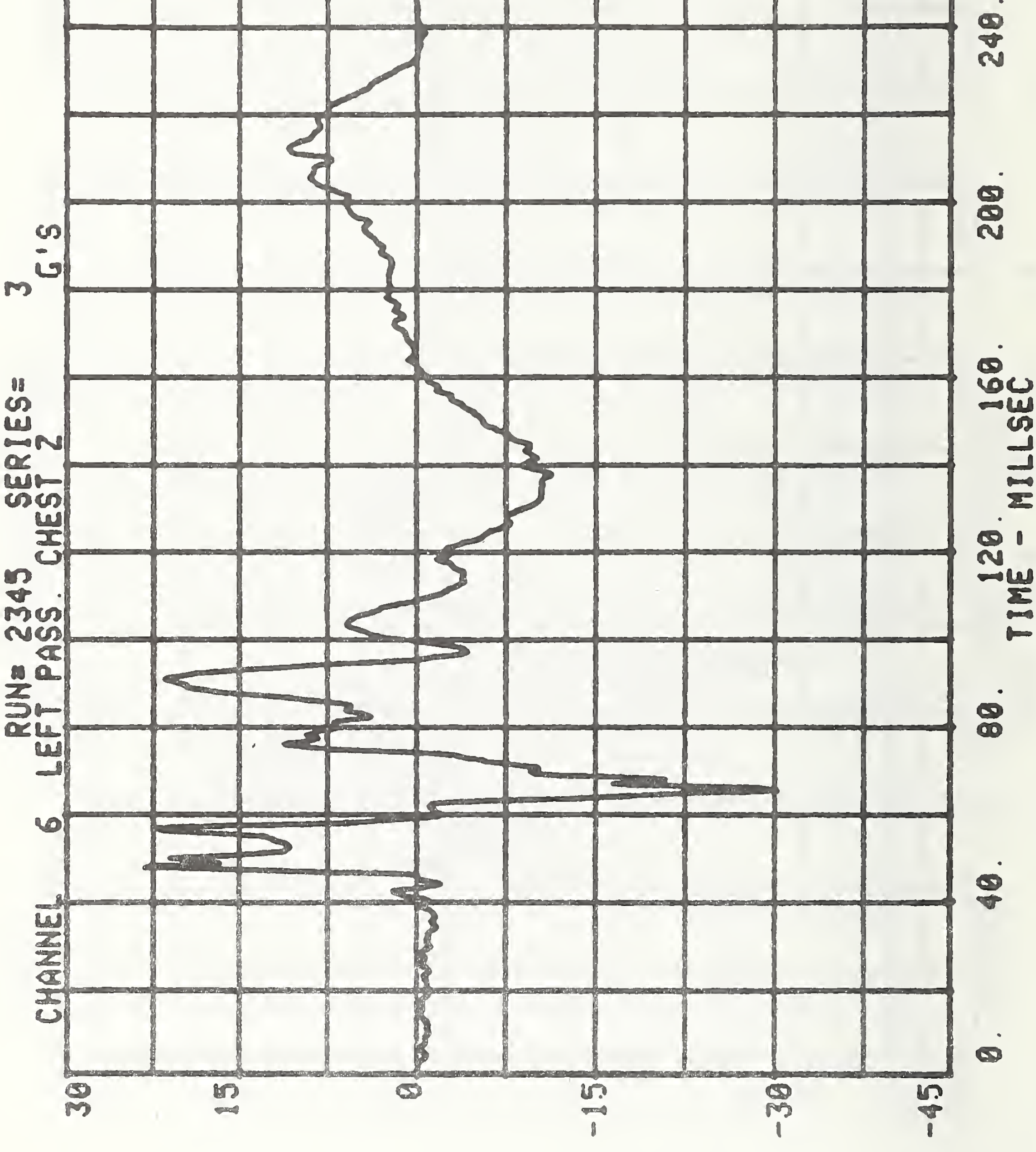


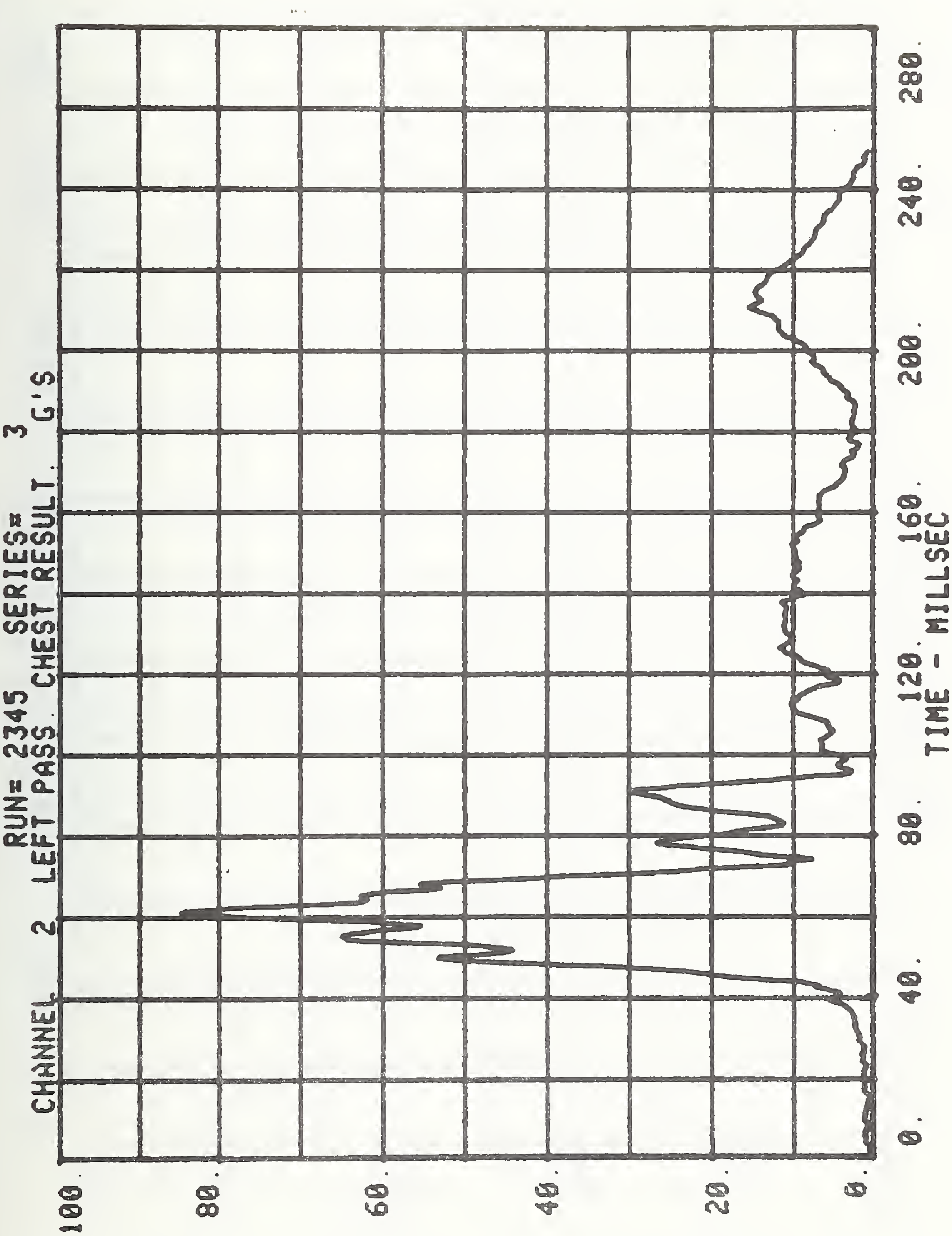
CHANNEL 1 RUN= 2345 SERIES= 3
LEFT PASS. HEAD RESULT. G'S
200.
160.
120.
80.
40.
0
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



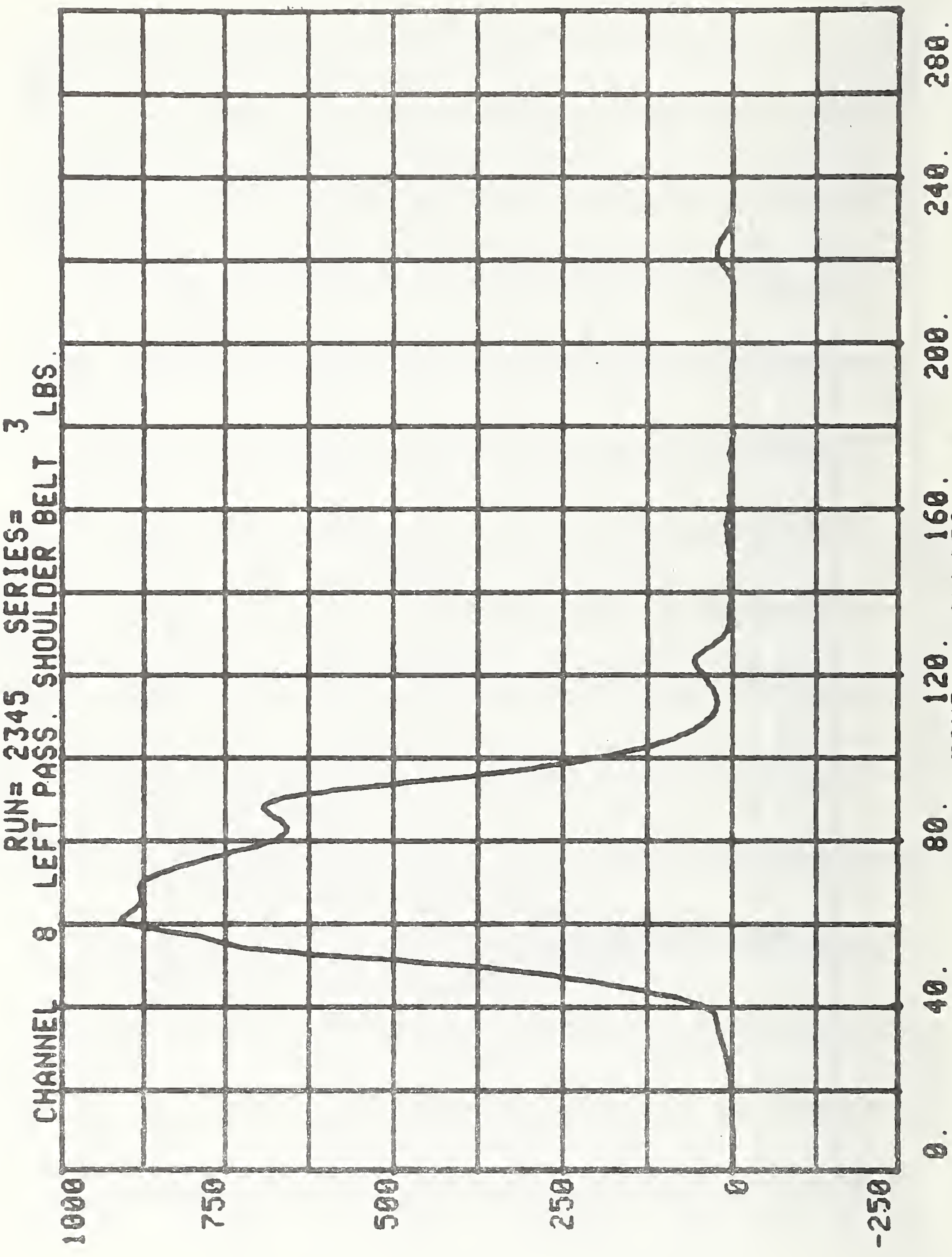
CHANNEL 4 RUN= 2345 SERIES= 3
LEFT PASS. CHEST X G'S
100
75
50
25
0
-25
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

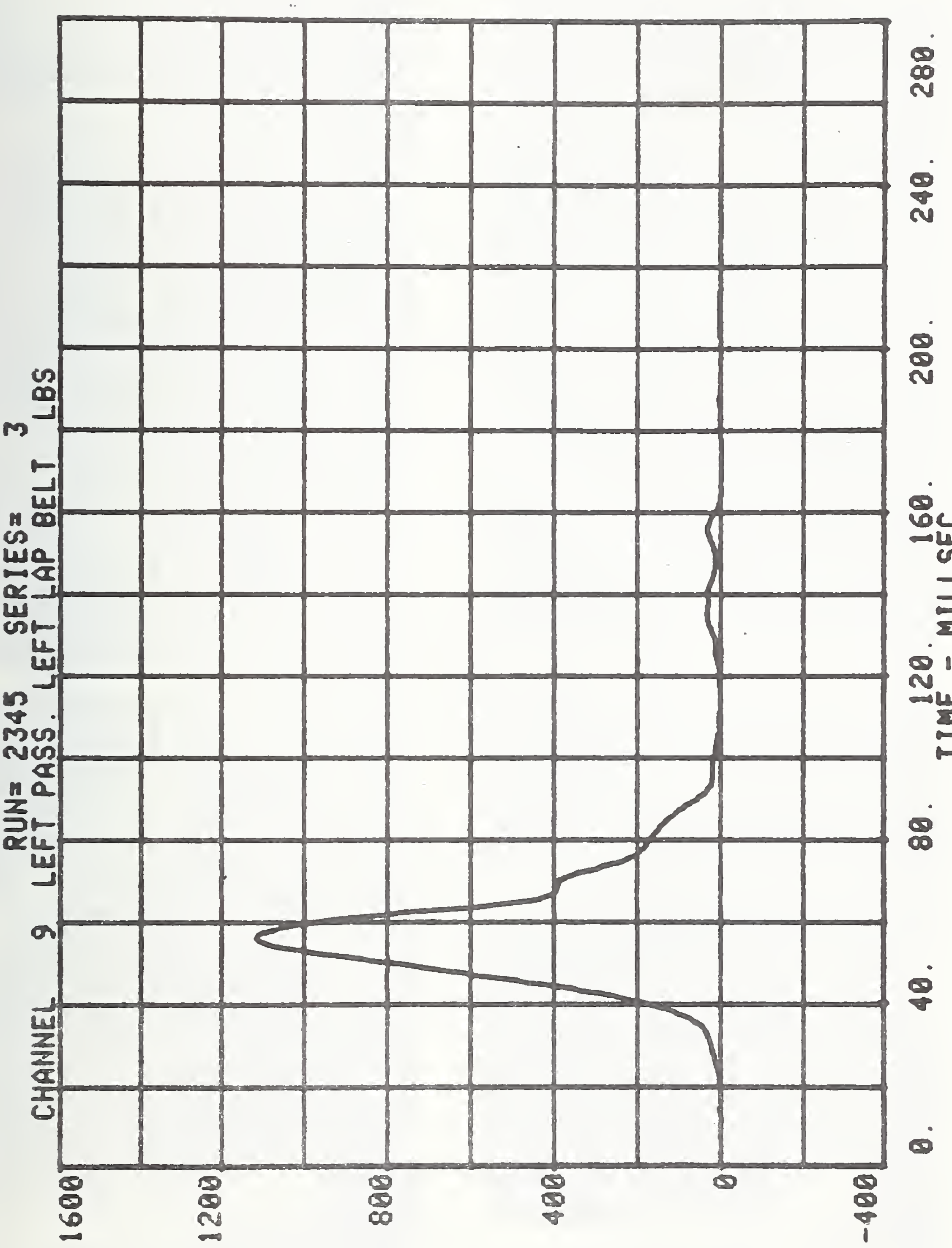

CHANNEL 5 RUN= 2345 SERIES= 3
LEFT PASS. CHEST Y G'S
24
16
8
0
-8
-16
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

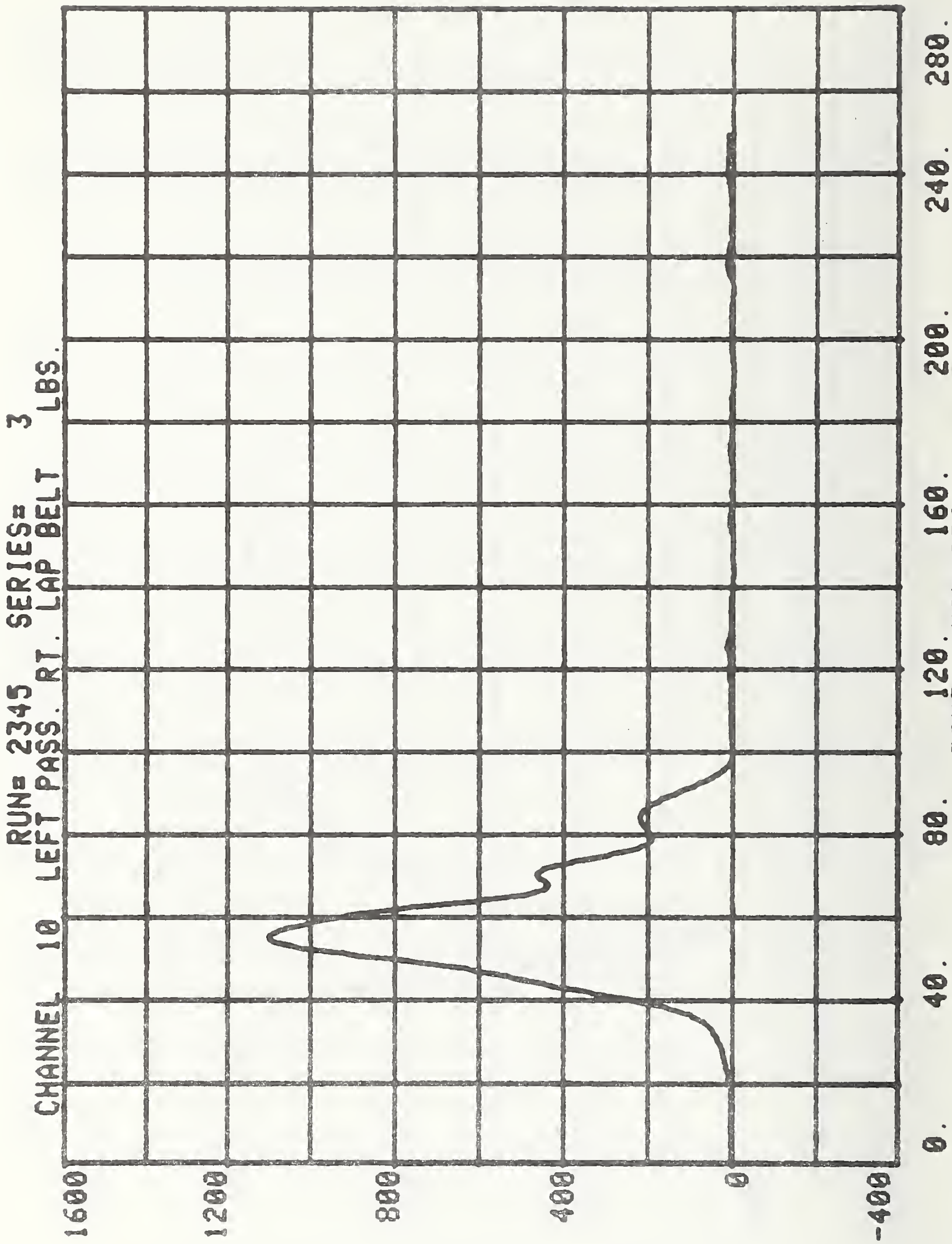

CHANNEL 6 RUN= 2345 SERIES= 3
LEFT PASS. CHEST 2 G'S
30
15
0
-15
-30
-45
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

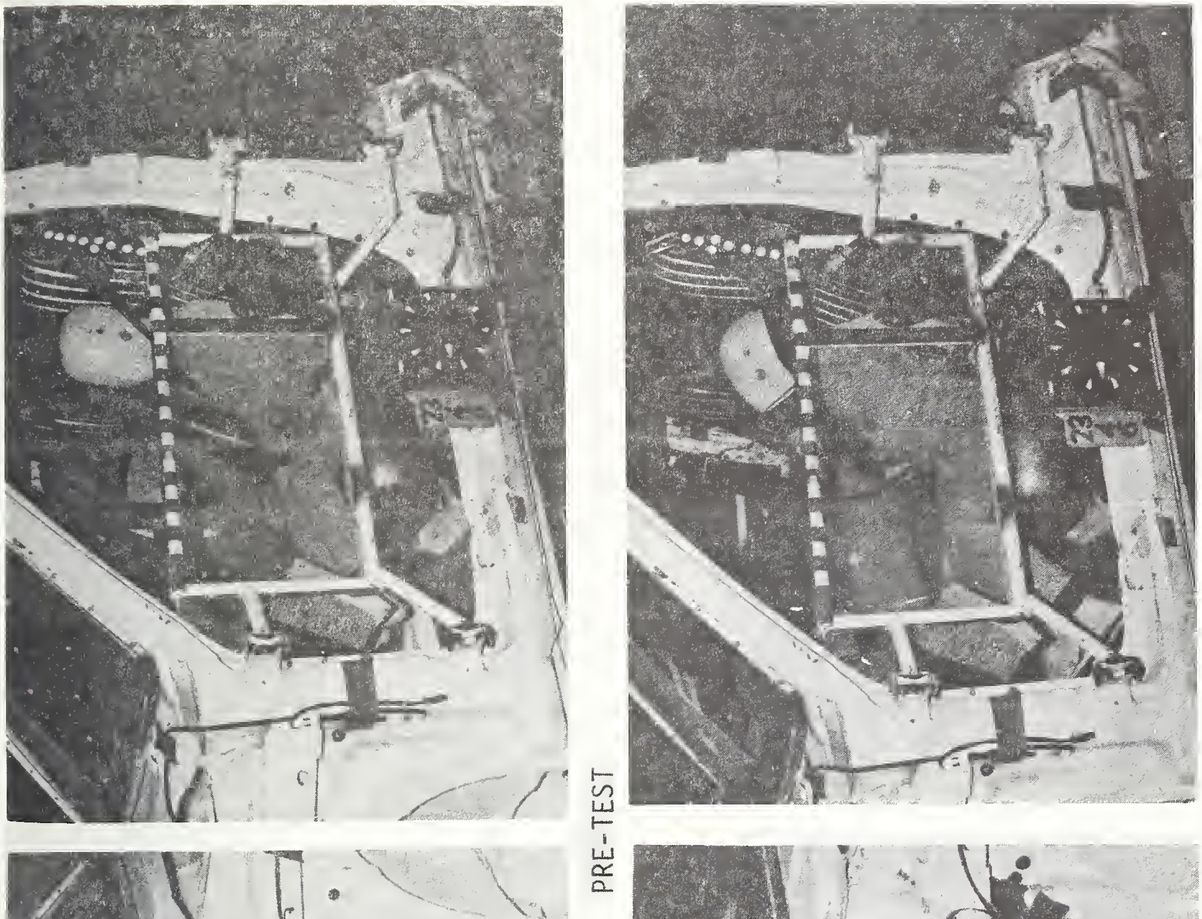


CHANNEL 2 RUN= 2345 SERIES= 3
LEFT PASS CHEST RESULT. G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100.


CHANNEL 8 RUN= 2345 SERIES= 3
LEFT PASS. SHOULDER BELT LBS.
1000
750
500
250
0
-250
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 9 RUN= 2345 SERIES= 3
LEFT PASS. LEFT LAP BELT LBS
TIME - MILLSEC
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.


CHANNEL 10 RUN= 2345 SERIES= 3
LEFT PASS. RT. LAP BELT LBS.
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
1600 1200 800 400 0 -400



PRE-TEST

POST-TEST
RUN 2346

ALDERSON S/N 49

TNO

ALDERSON S/N 49 TNO

PRE-TEST

ALDERSON S/N 49 TNO

POST-TEST

RUN 2346

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2346

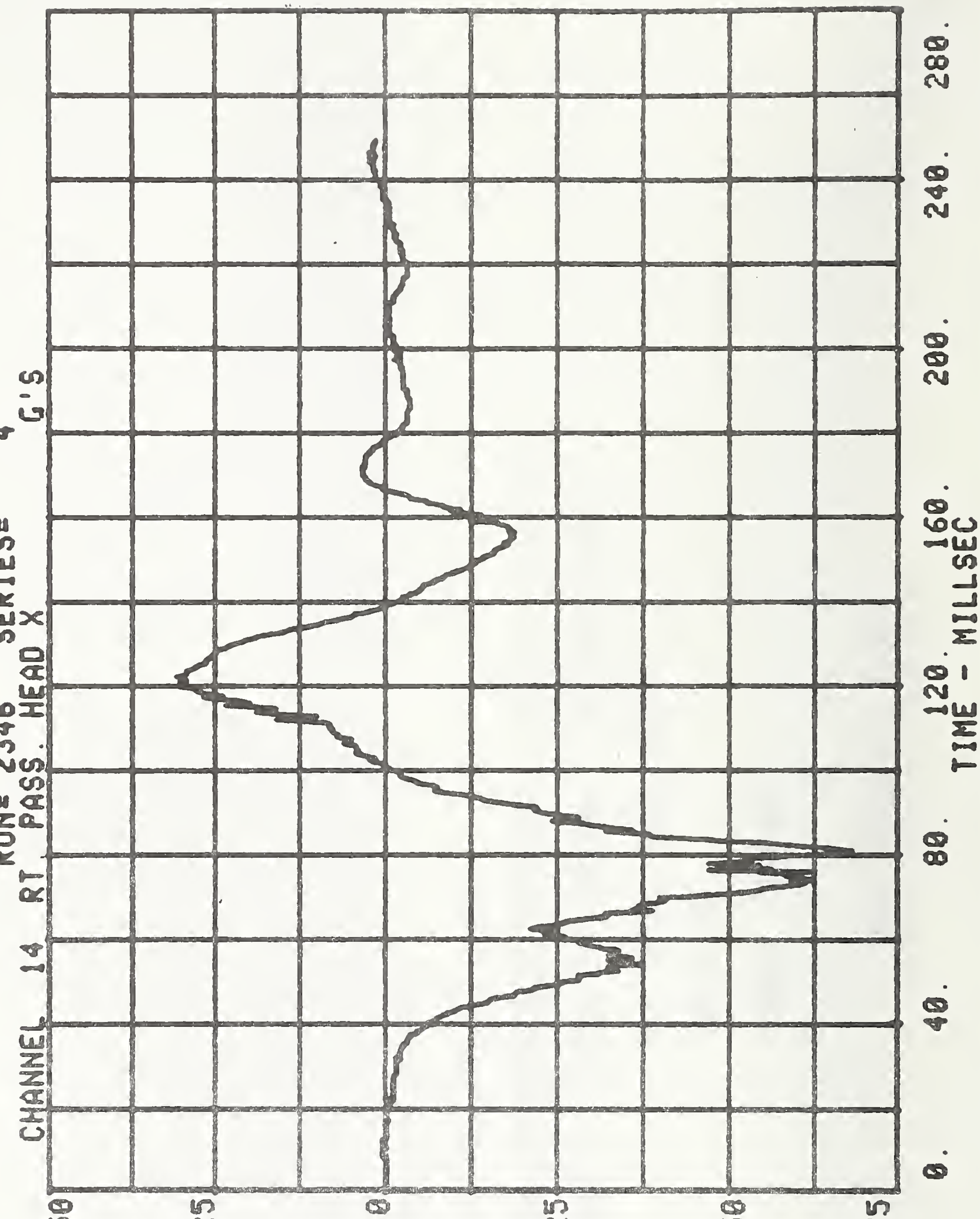
RT. PASS. HEAD RESULT.

HIC=1096.7   FROM T1= .04980   TO T2= .12990

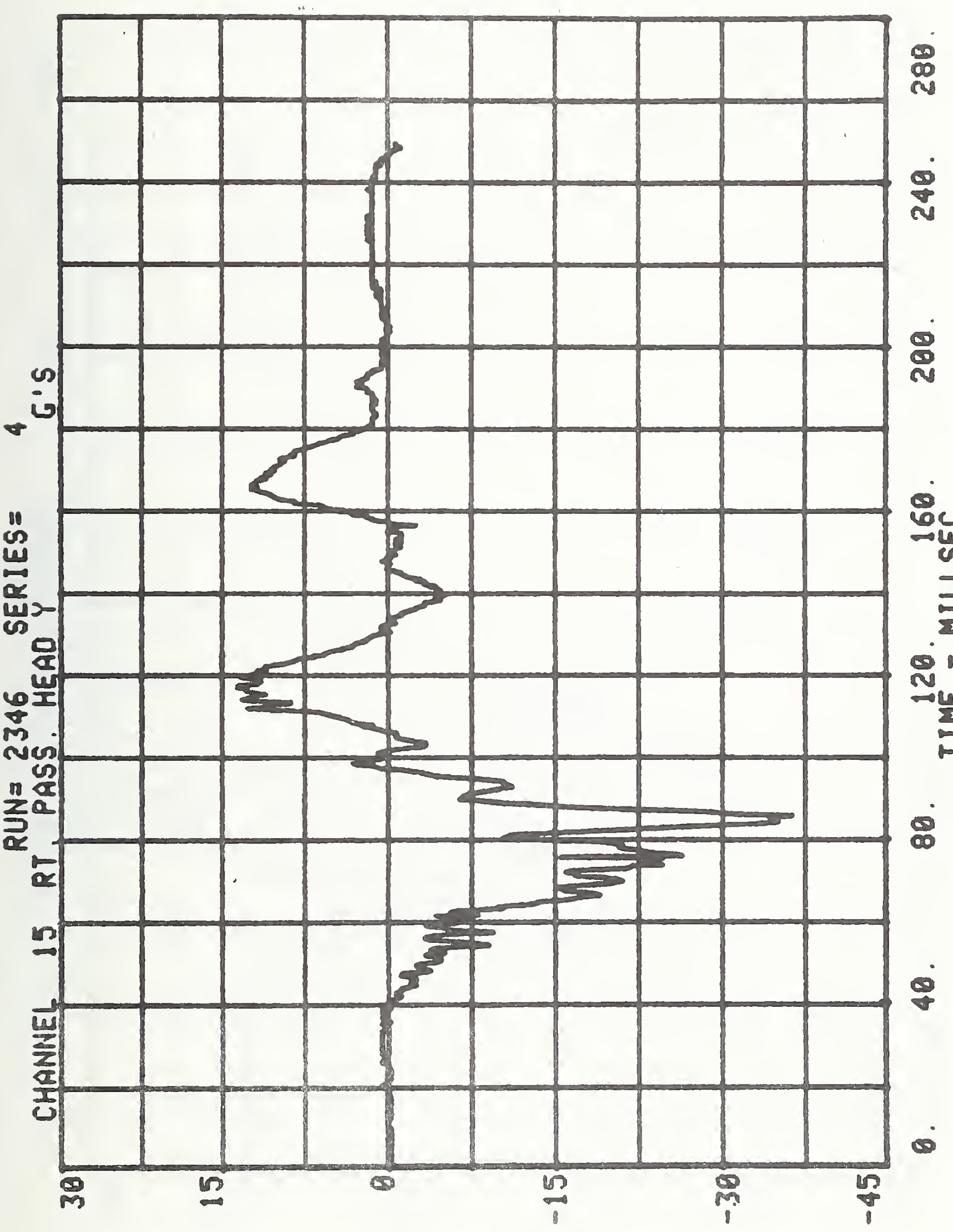
AVERAGE ACCELERATION BETWEEN T1 AND T2= 45.1G'S

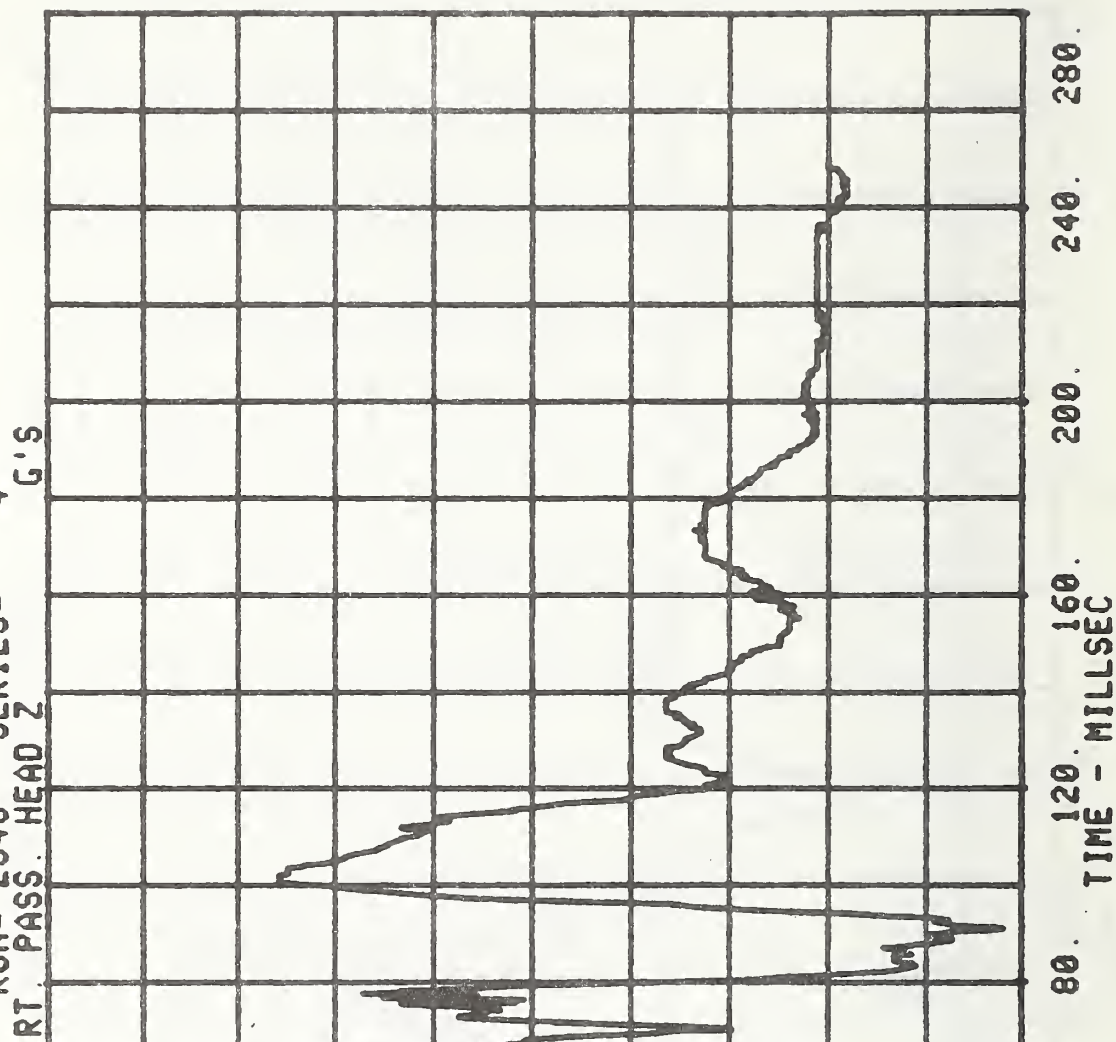
EVENT TIME= 250.0 MSEC

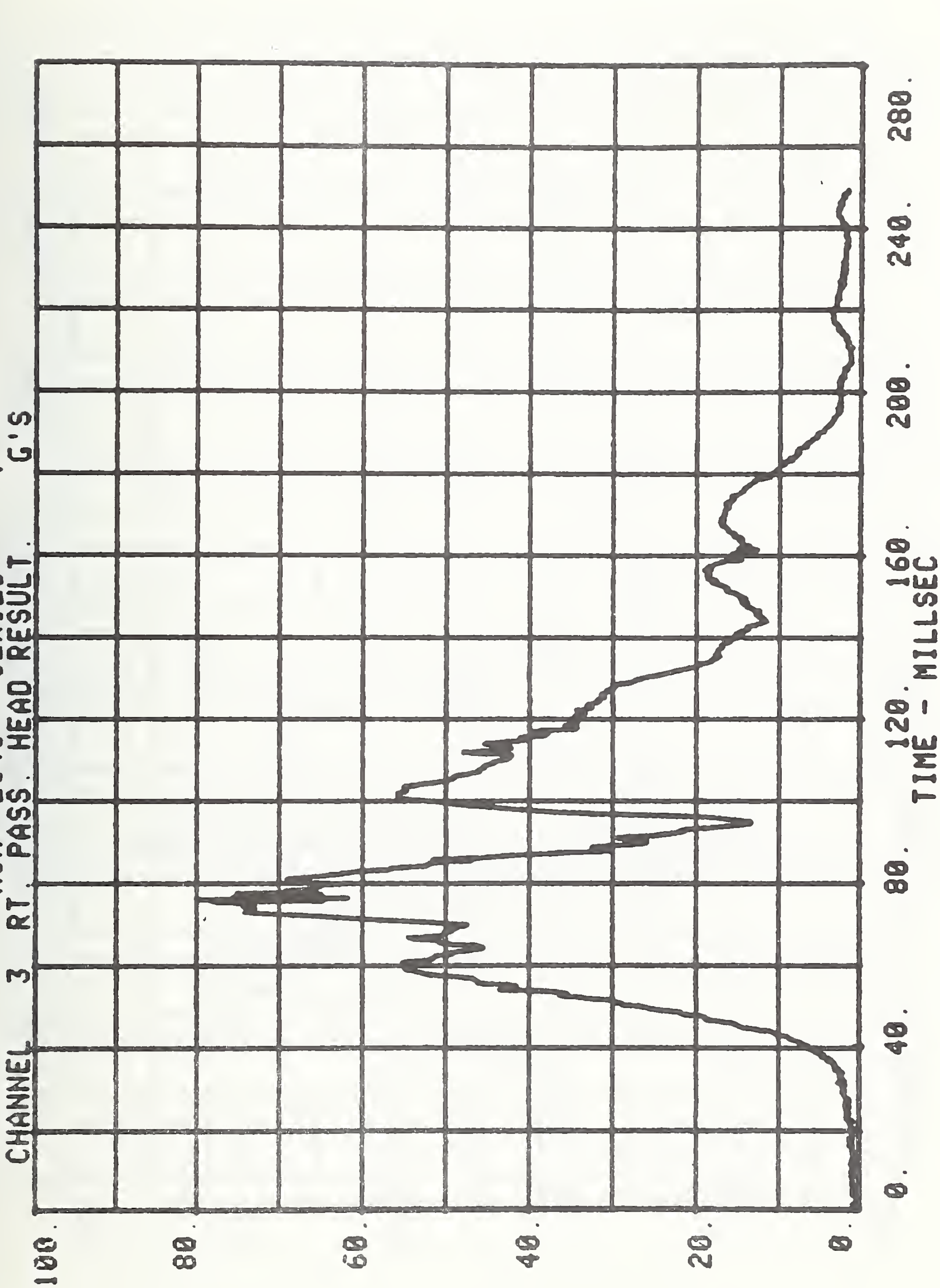
SEVERITY INDEX=1366.7

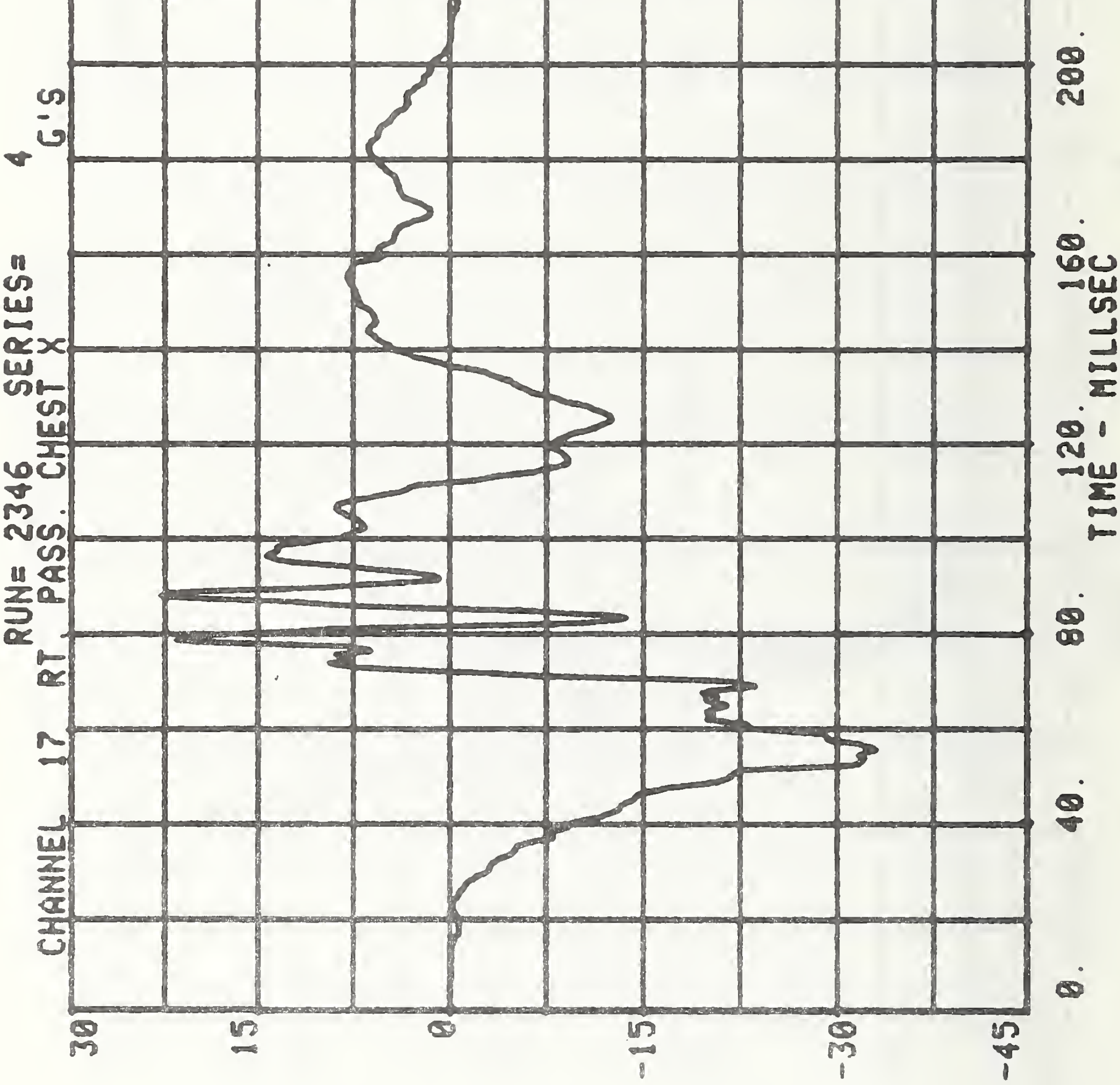


CHANNEL 14 RT PASS. HEAD X
RUN= 2346 SERIES= 4
G'S
50
25
0
-25
-50
-75
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

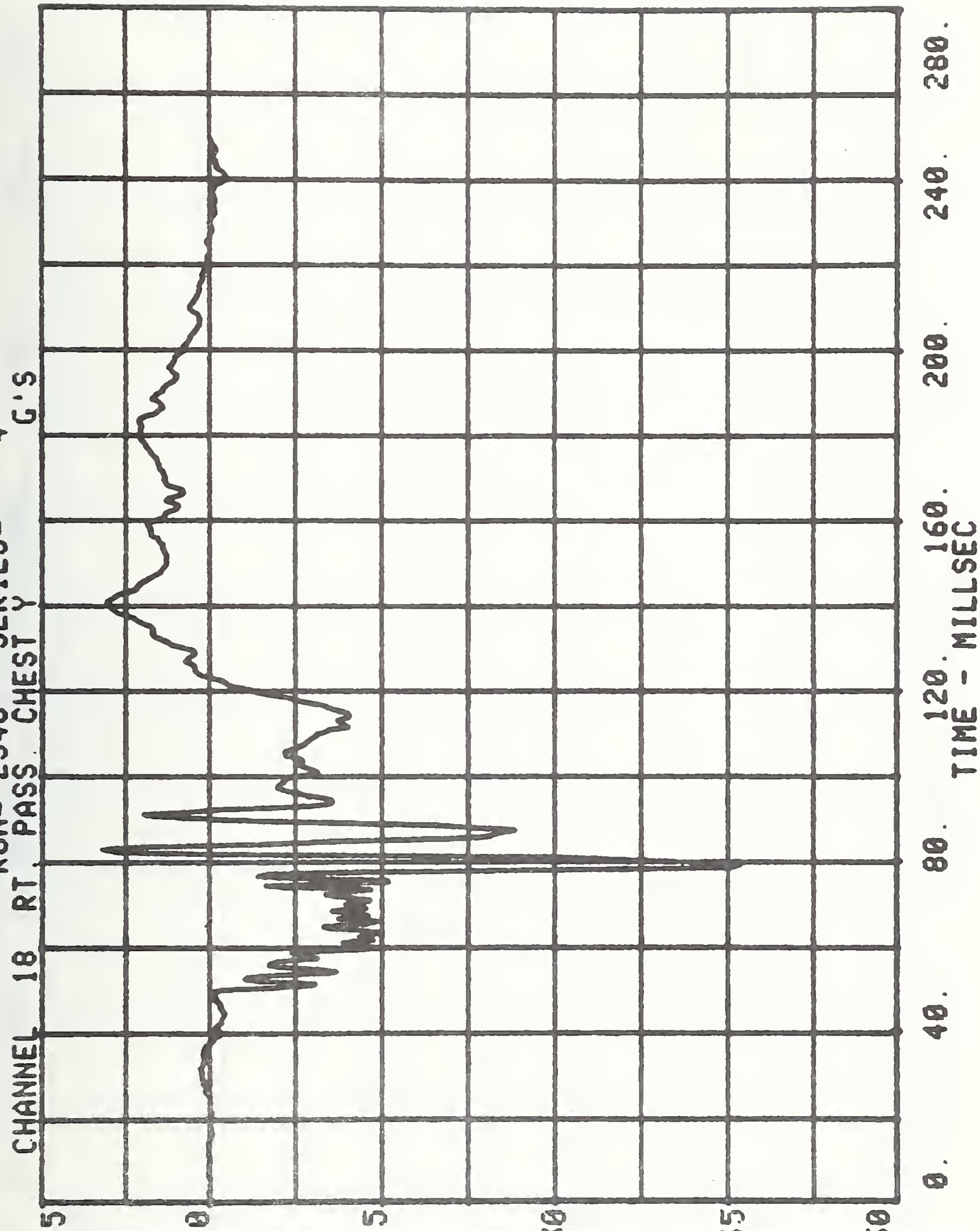

CHANNEL 15 RT. PASS. HEAD Y
RUN= 2346 SERIES= 4
G'S
30
15
0
-15
-30
-45
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

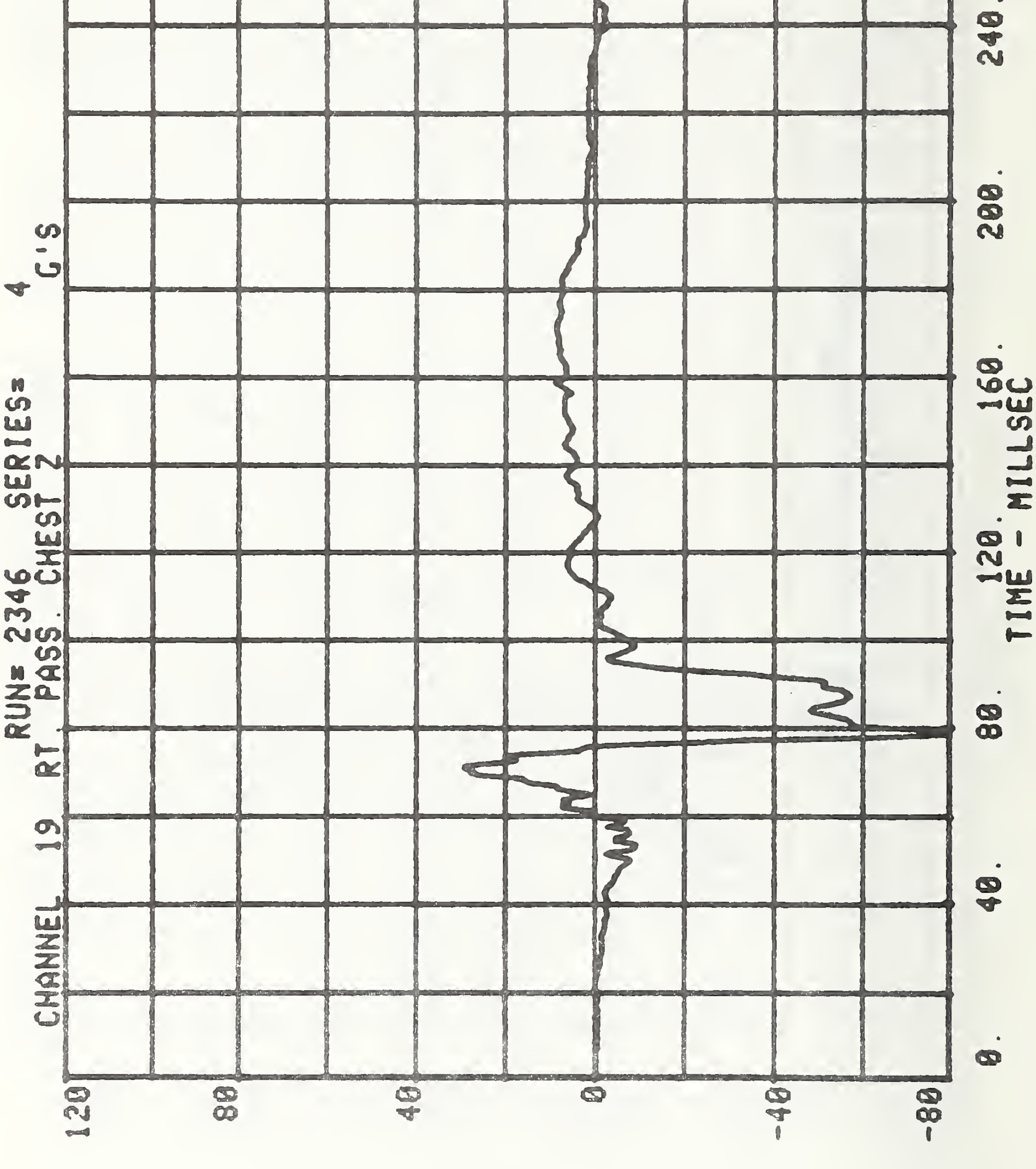

RUN= 2346 SERIES= 4
CHANNEL 16 RT. PASS. HEAD Z G'S
80
60
40
20
0
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 3 RUN= 2346 SERIES= 4
RT. PASS. HEAD RESULT G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100.

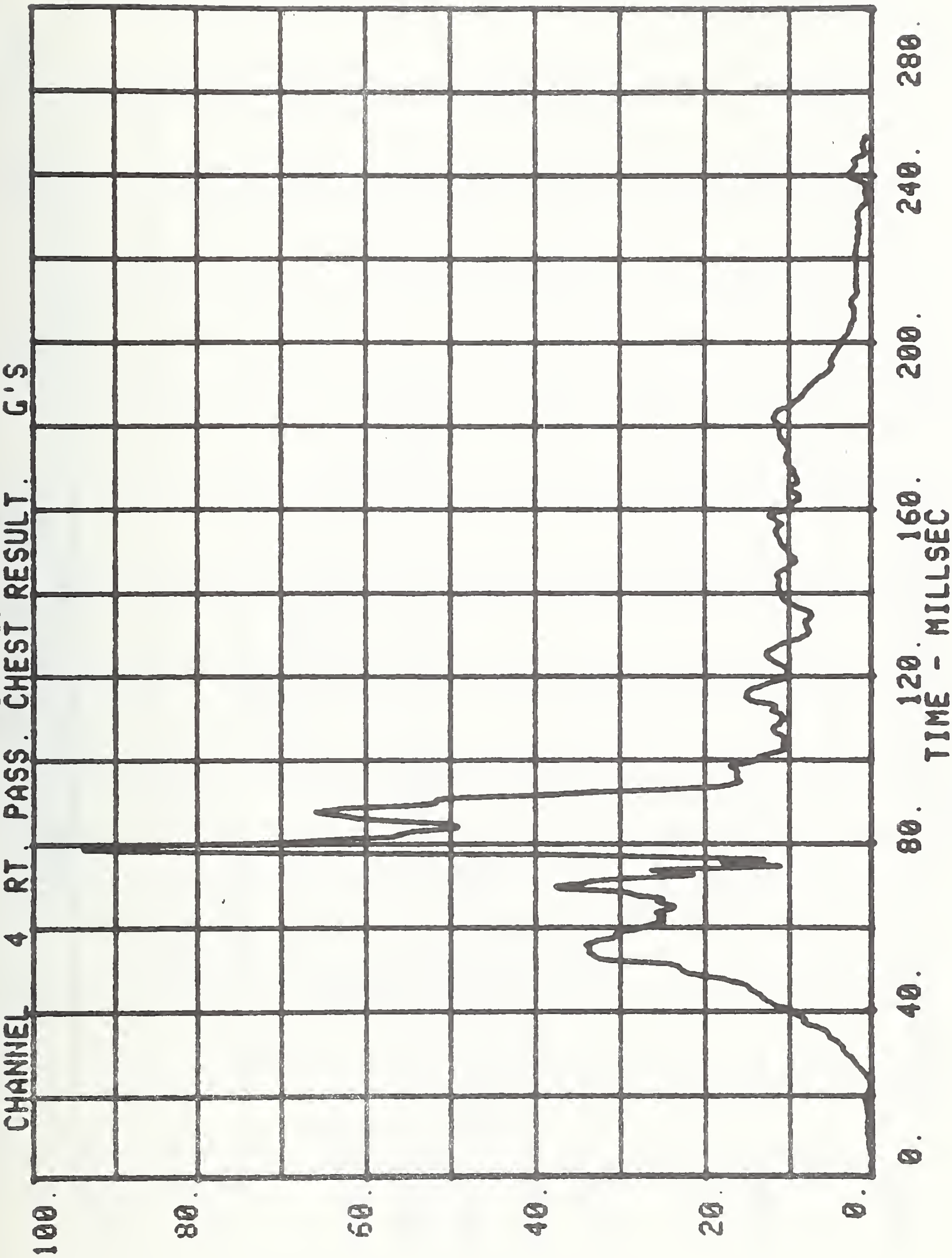


CHANNEL 17 RUN= 2346 SERIES= 4
RT PASS. CHEST X G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
30 15 0 -15 -30 -45

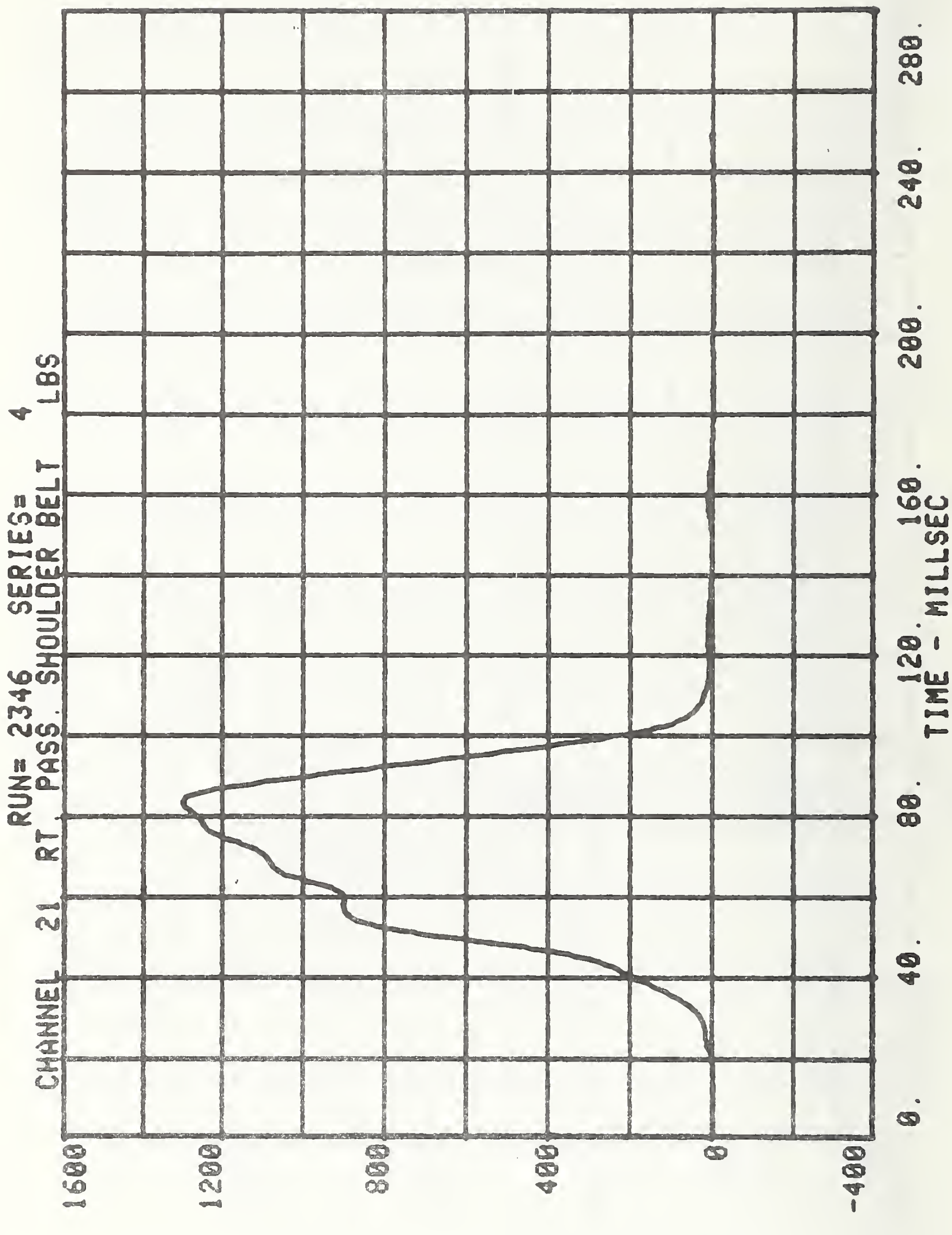

CHANNEL 18 RUN= 2346 SERIES= 4
RT. PASS. CHEST Y G'S
15
0
-15
-30
-45
-60
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 19 RUN= 2346 SERIES= 4
RT. PASS. CHEST Z G'S
120
80
40
0
-40
-80
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 4 RUN= 2346 SERIES= 4
RT. PASS. CHEST RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
100.
80.
60.
40.
20.
0.


CHANNEL 21 RUN= 2346 SERIES= 4
RT. PASS. SHOULDER BELT LBS
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2346

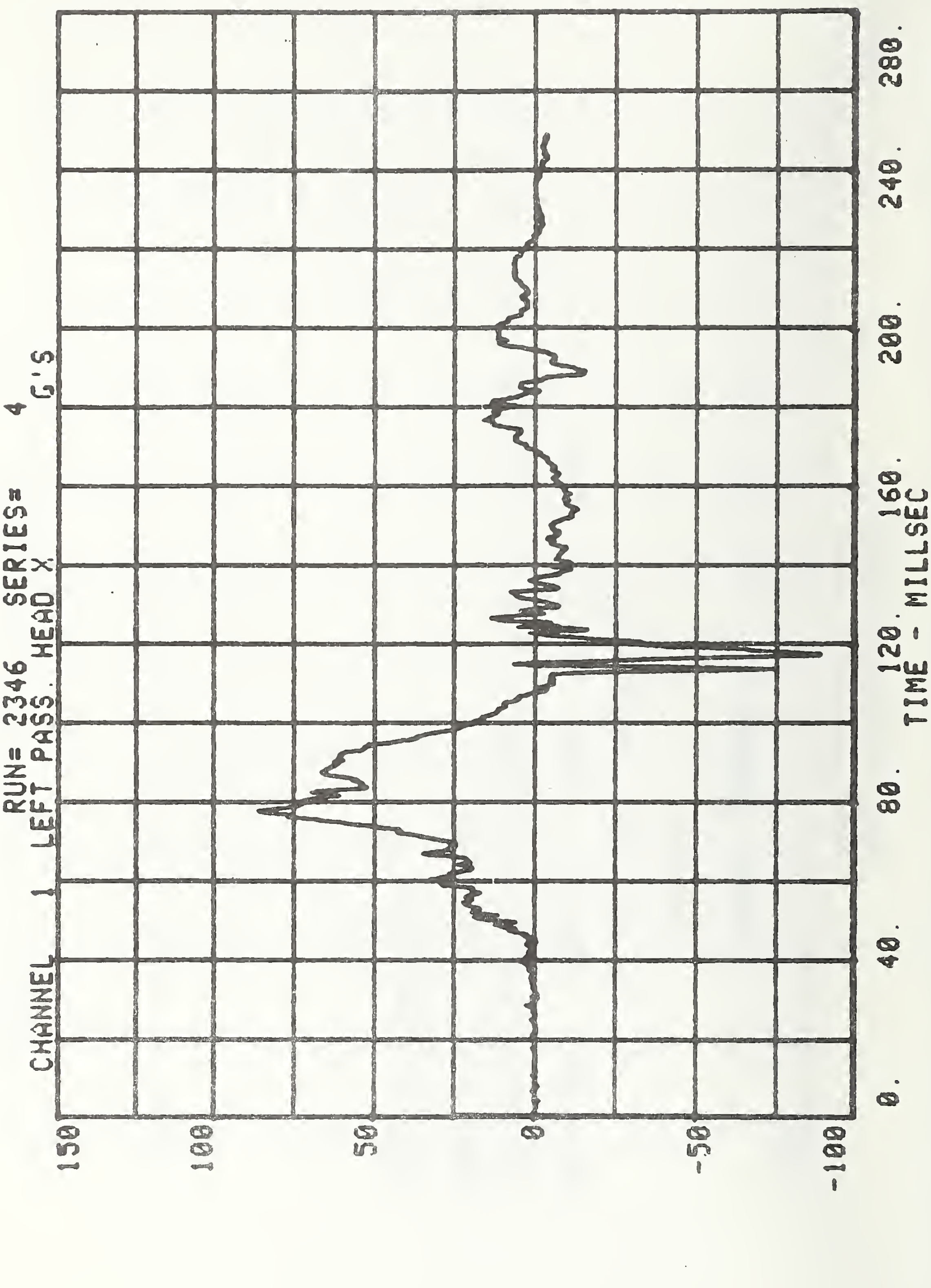
LEFT PASS. HEAD RESULT.

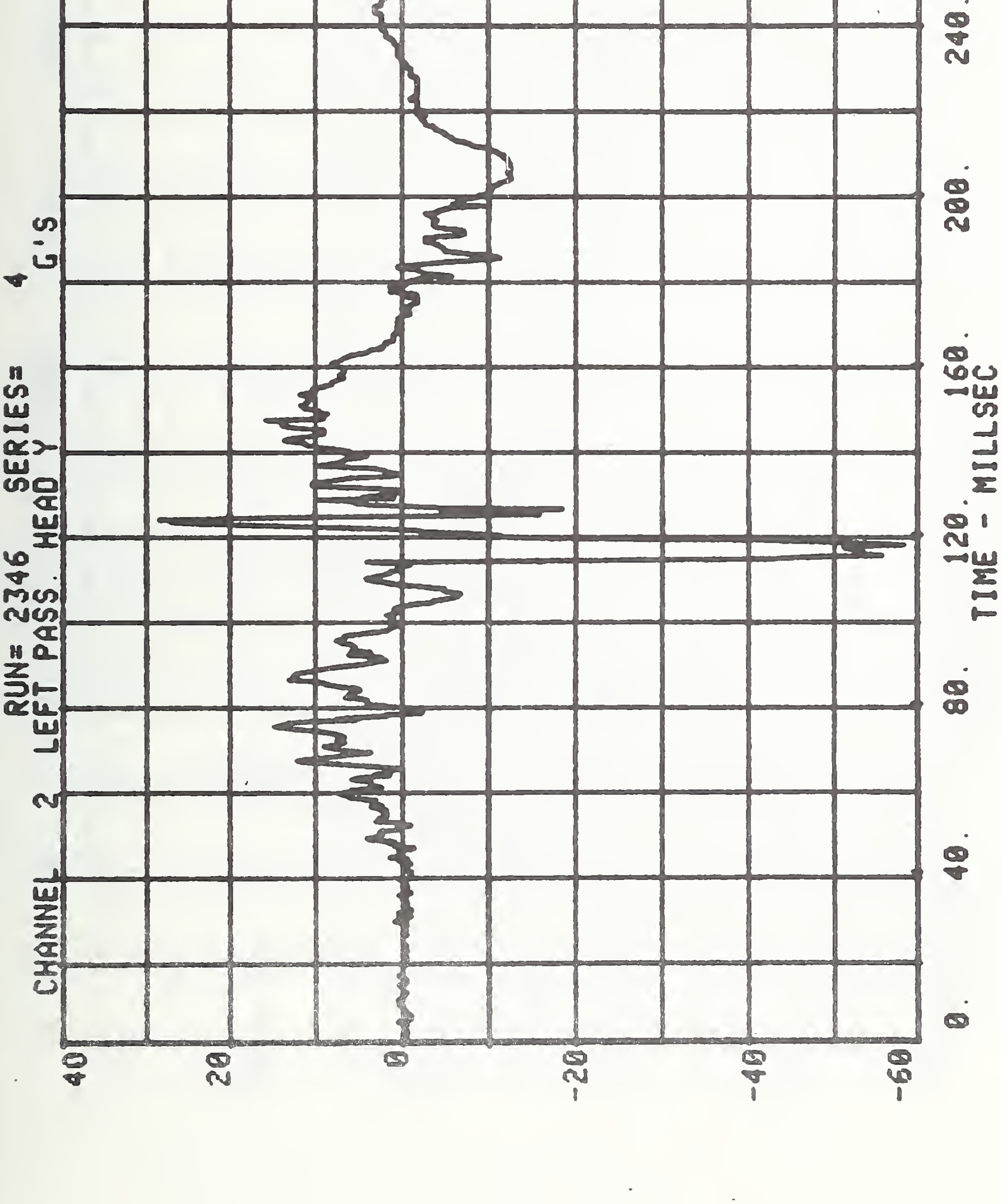
HIC=1859.3   FROM T1= .05160   TO T2= .12420

AVERAGE ACCELERATION BETWEEN T1 AND T2= 58.0G'S

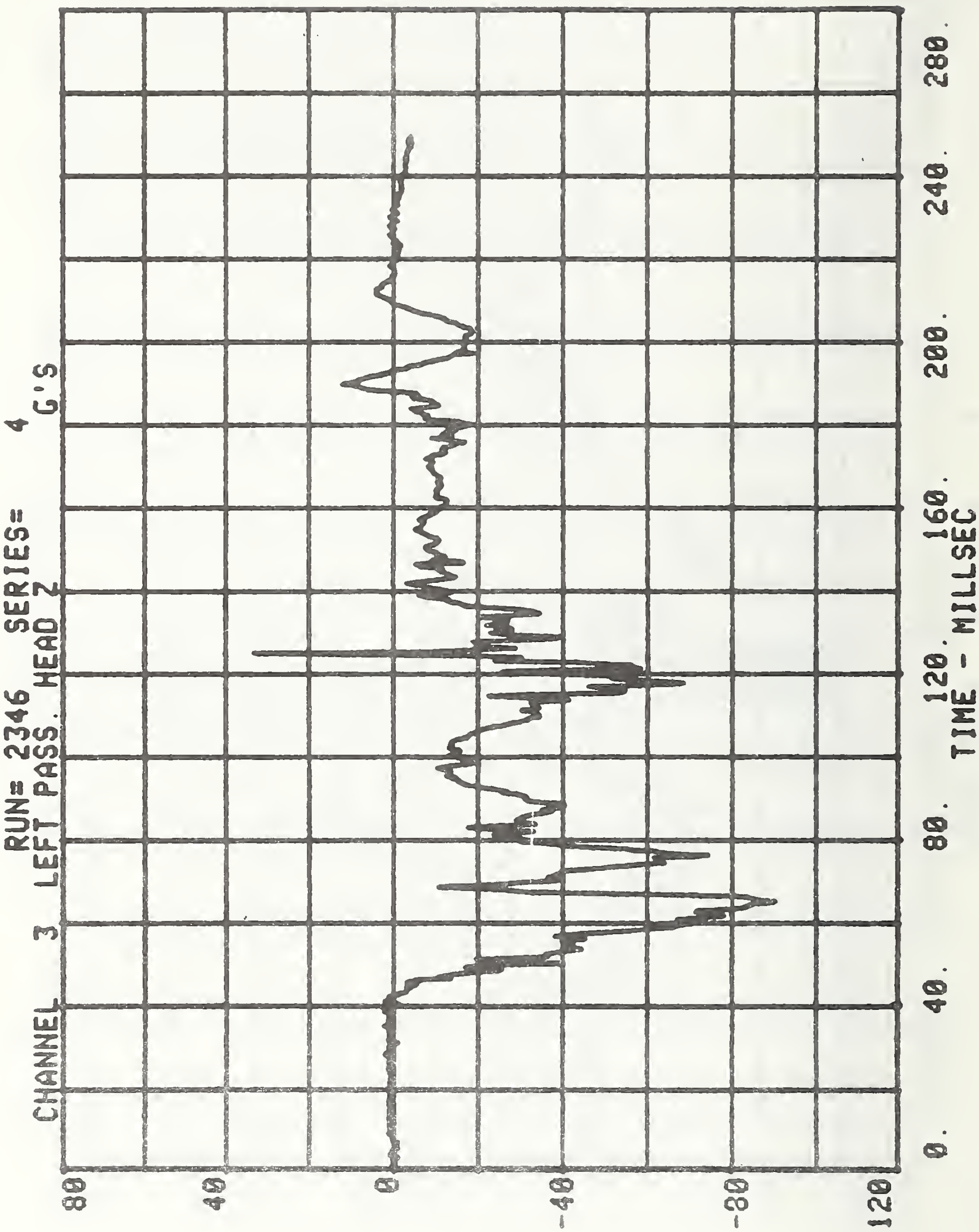
EVENT TIME= 250.0 MSEC

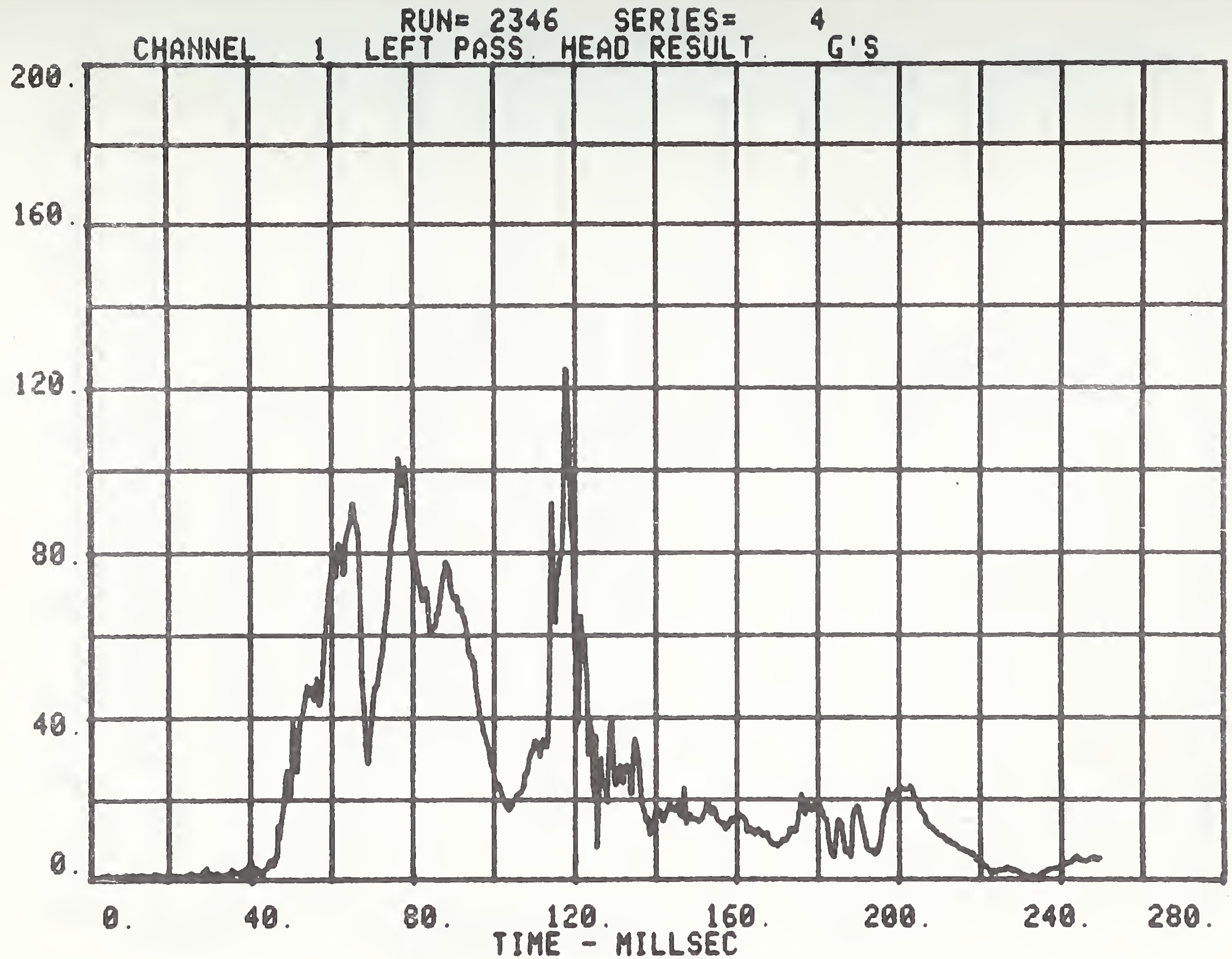
SEVERITY INDEX=2598.7

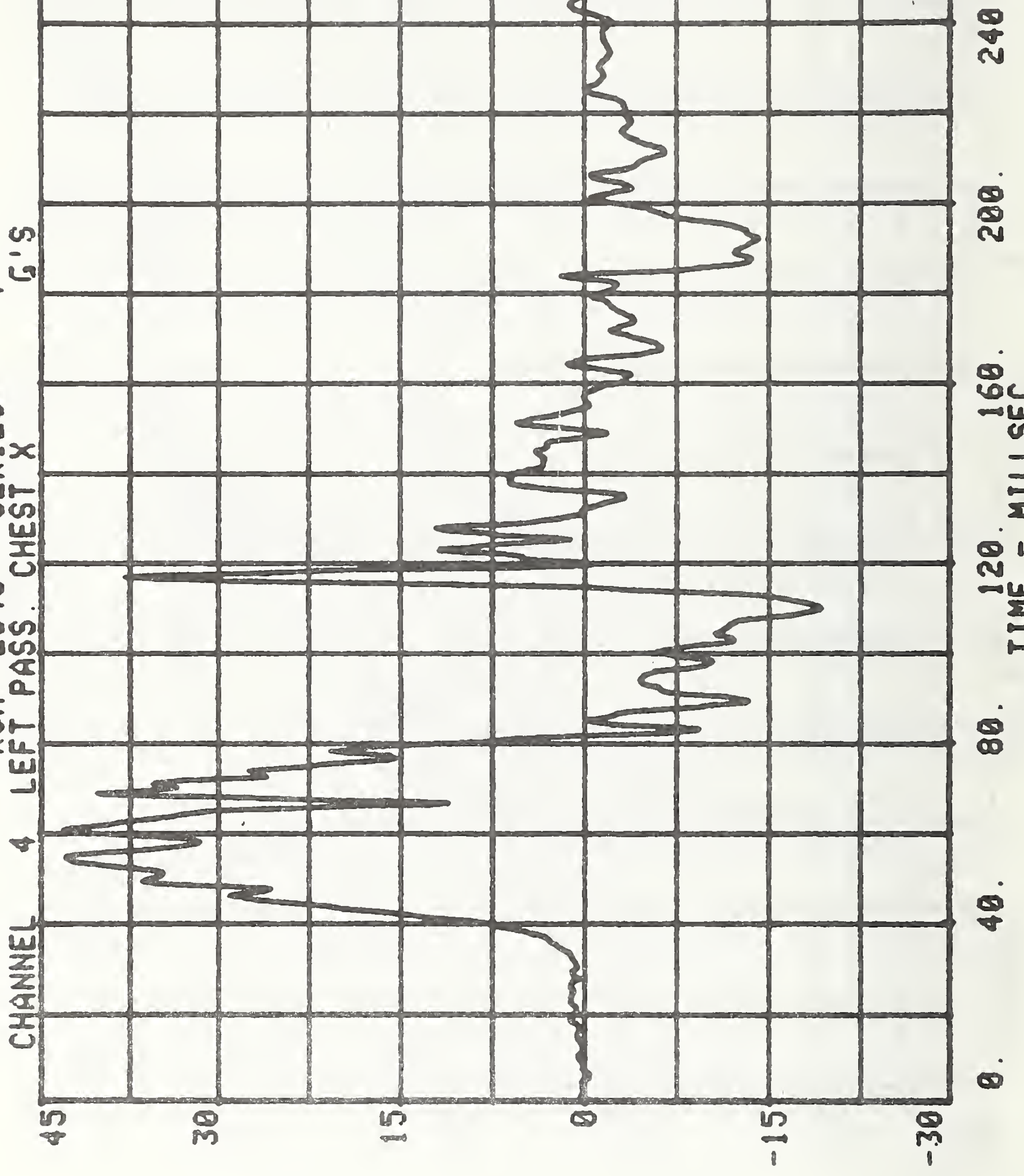

CHANNEL 1 RUN= 2346 SERIES= 4
LEFT PASS. HEAD X G'S
150
100
50
0
-50
-100
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



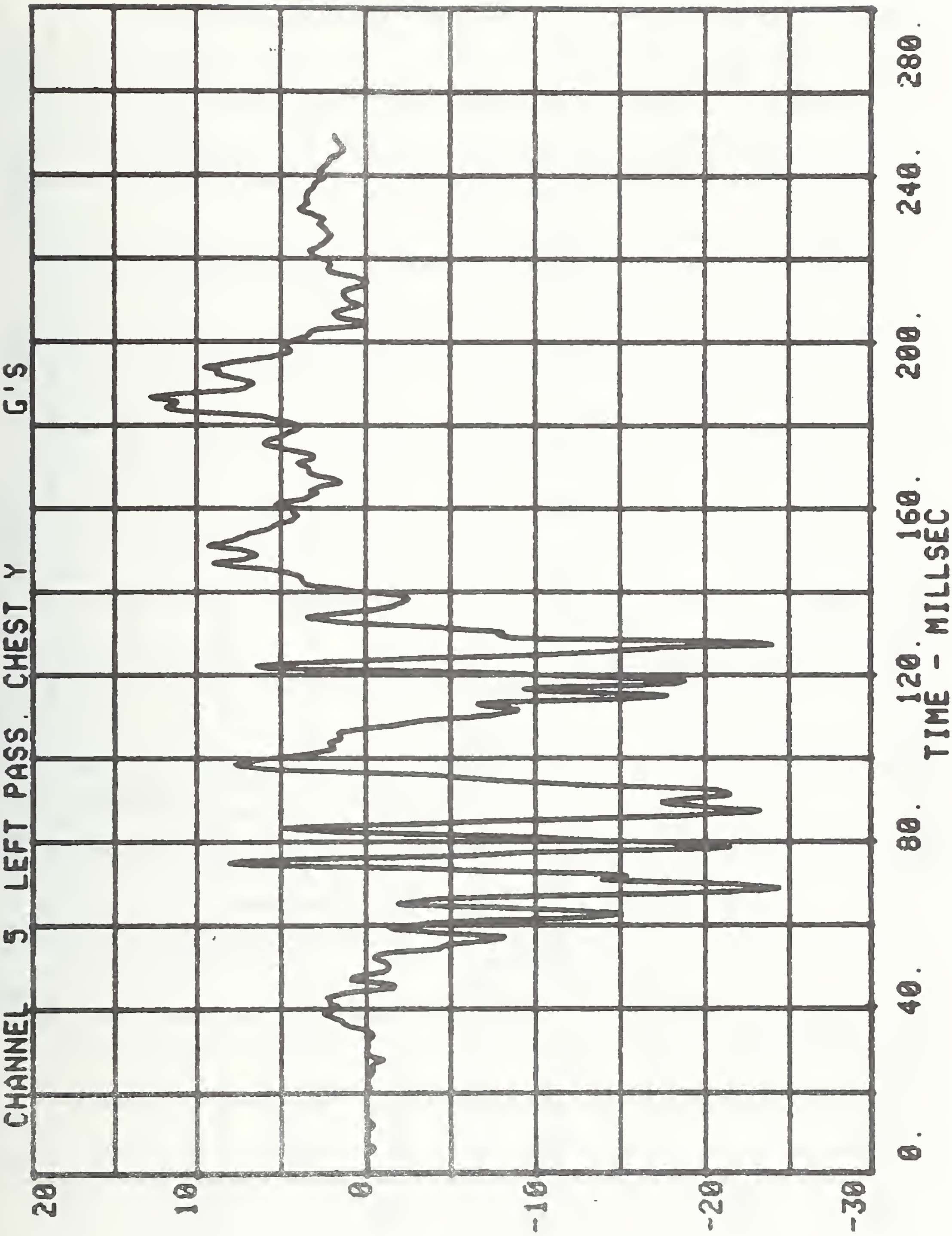
CHANNEL 2 RUN= 2346 SERIES= 4
LEFT PASS. HEAD Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
40 20 0 -20 -40 -60

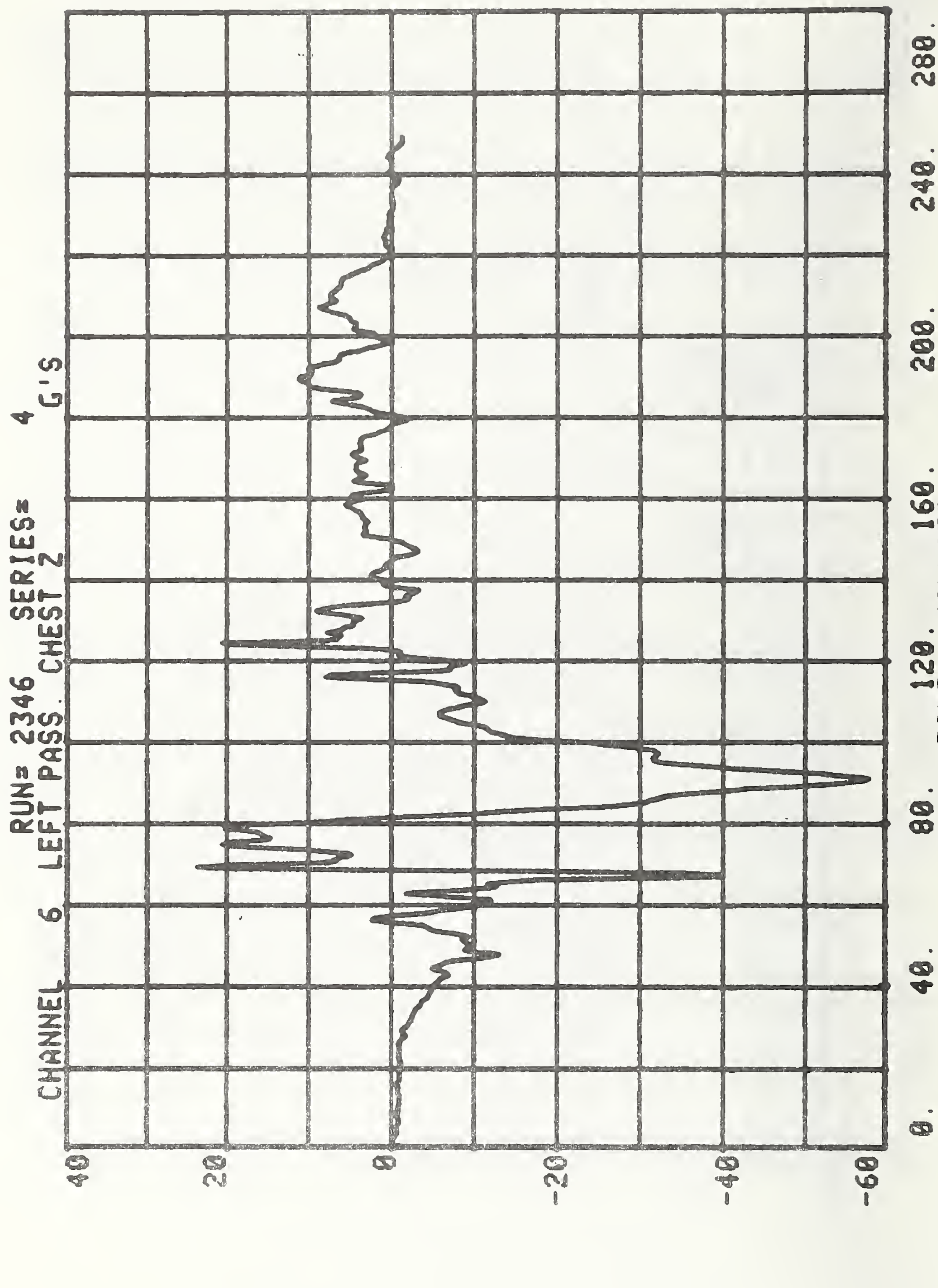

CHANNEL 3 RUN= 2346 SERIES= 4
LEFT PASS. HEAD Z G'S
80
40
0
-40
-80
-120
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

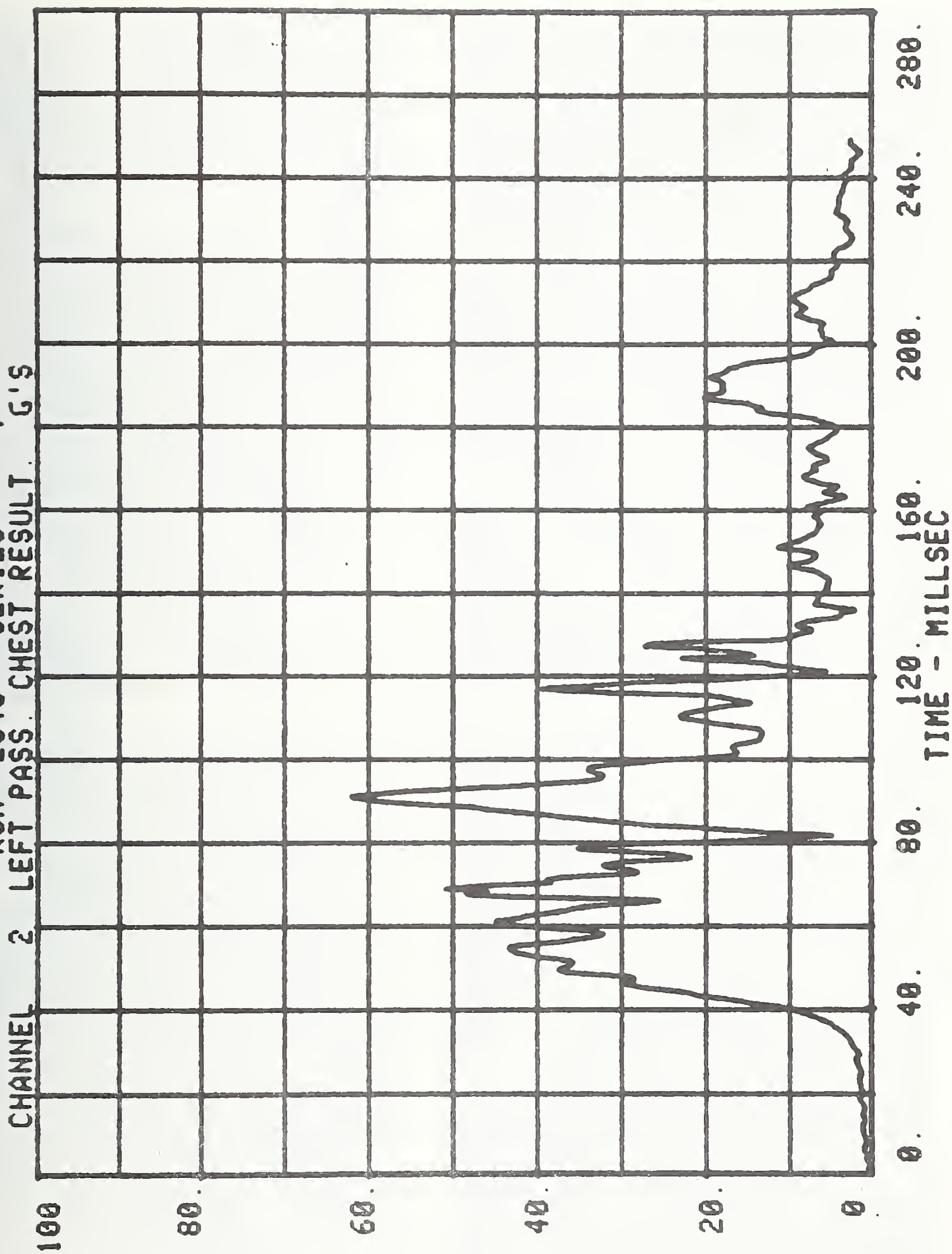

RUN= 2346 SERIES= 4
CHANNEL 1 LEFT PASS. HEAD RESULT. G'S
200.
160.
120.
80.
40.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

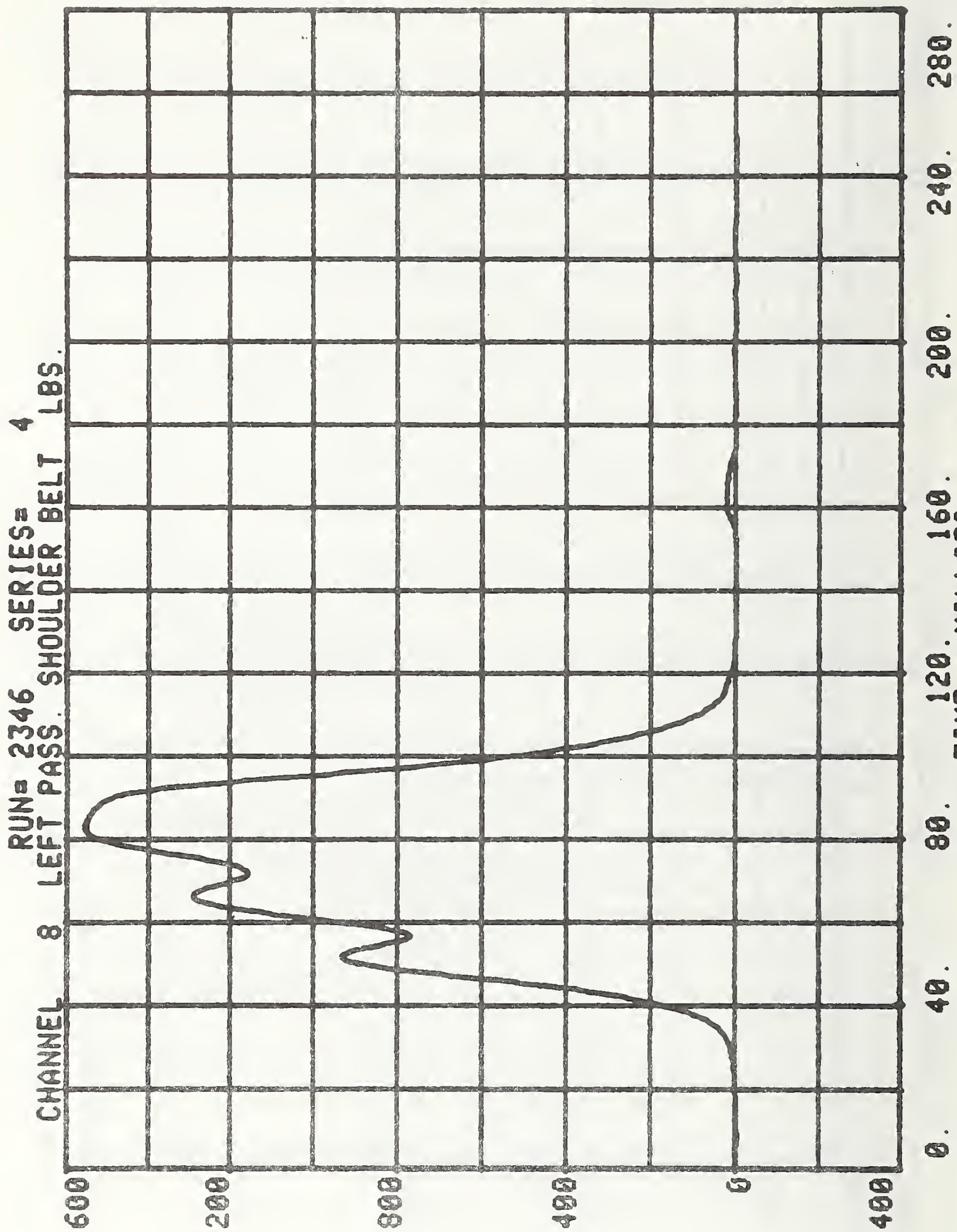


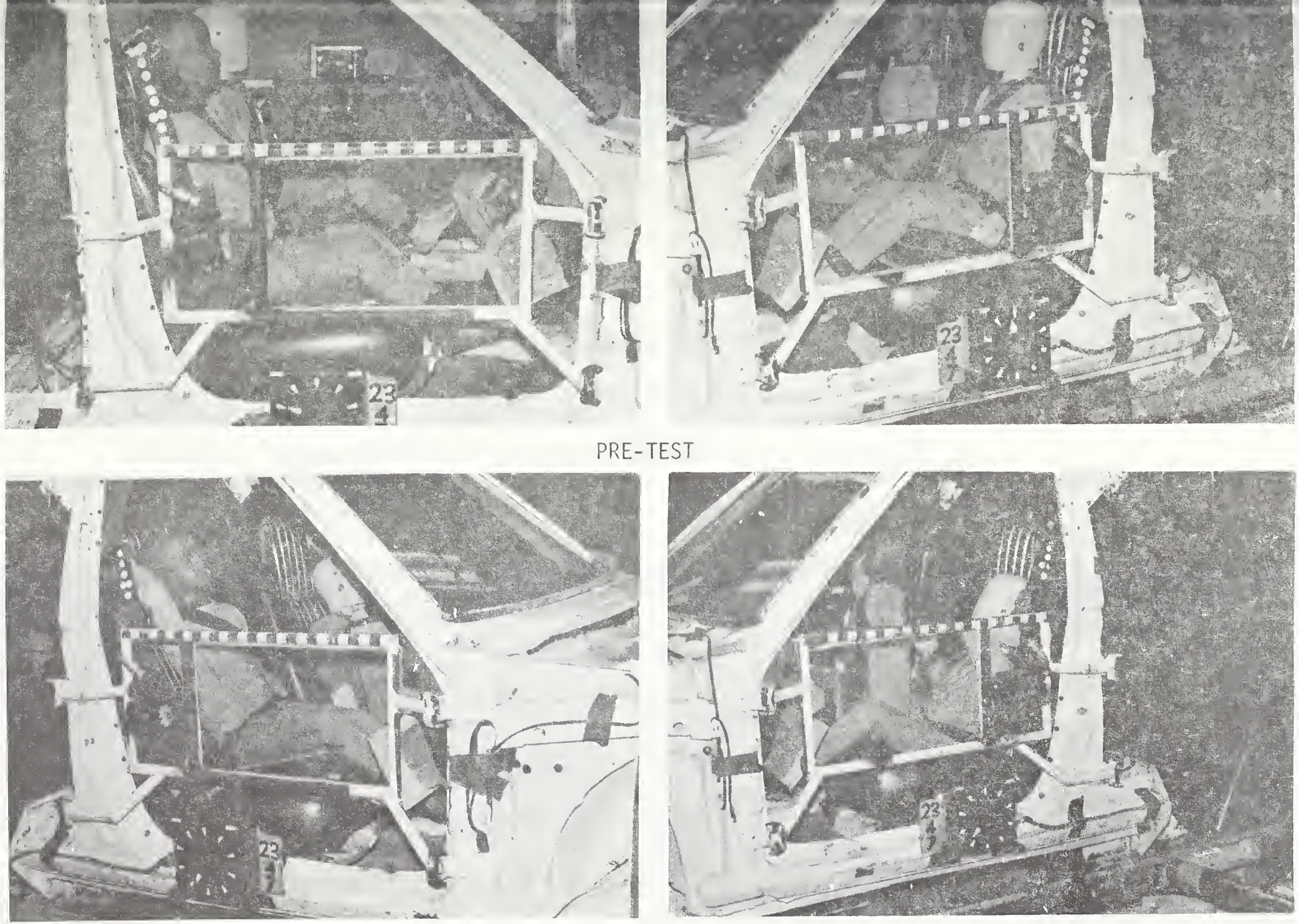
CHANNEL 4 RUN= 2346 SERIES= 4
LEFT PASS. CHEST X G'S
45
30
15
0
-15
-30
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 5 RUN= 2346 SERIES= 4
LEFT PASS. CHEST Y G'S
20
10
0
-10
-20
-30
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 6 RUN= 2346 SERIES= 4
LEFT PASS. CHEST Z G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
40 20 0 -20 -40 -60


CHANNEL 2 RUN= 2346 SERIES= 4
LEFT PASS. CHEST RESULT. G'S
0. 20. 40. 60. 80. 100
0. 40. 80. 120. 160. 200. 240. 280.
TIME - MILLSEC


CHANNEL 8 RUN= 2346 SERIES= 4
LEFT PASS. SHOULDER BELT LBS.
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

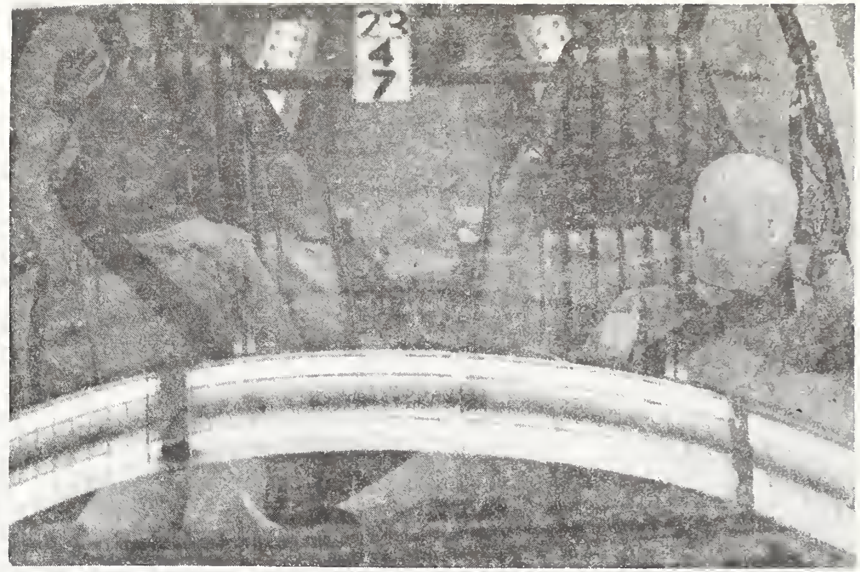


PRE-TEST

ALDERSON S/N 49

TNO

POST-TEST
RUN 2347



ALDERSON S/N 49 TNO

PRE-TEST

ALDERSON S/N 49 TNO

POST-TEST

RUN 2347

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2347

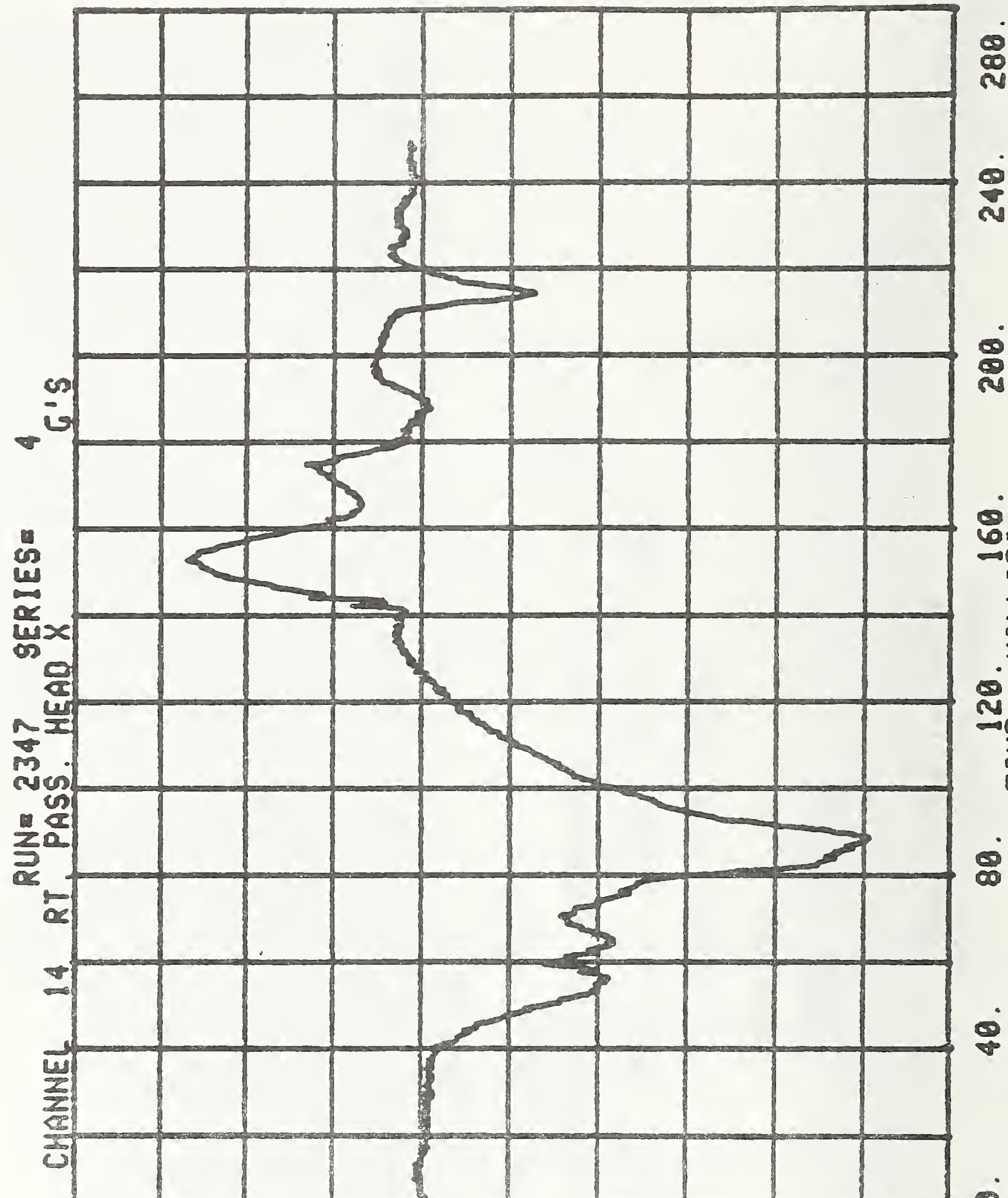
RT. PASS. HEAD RESULT.

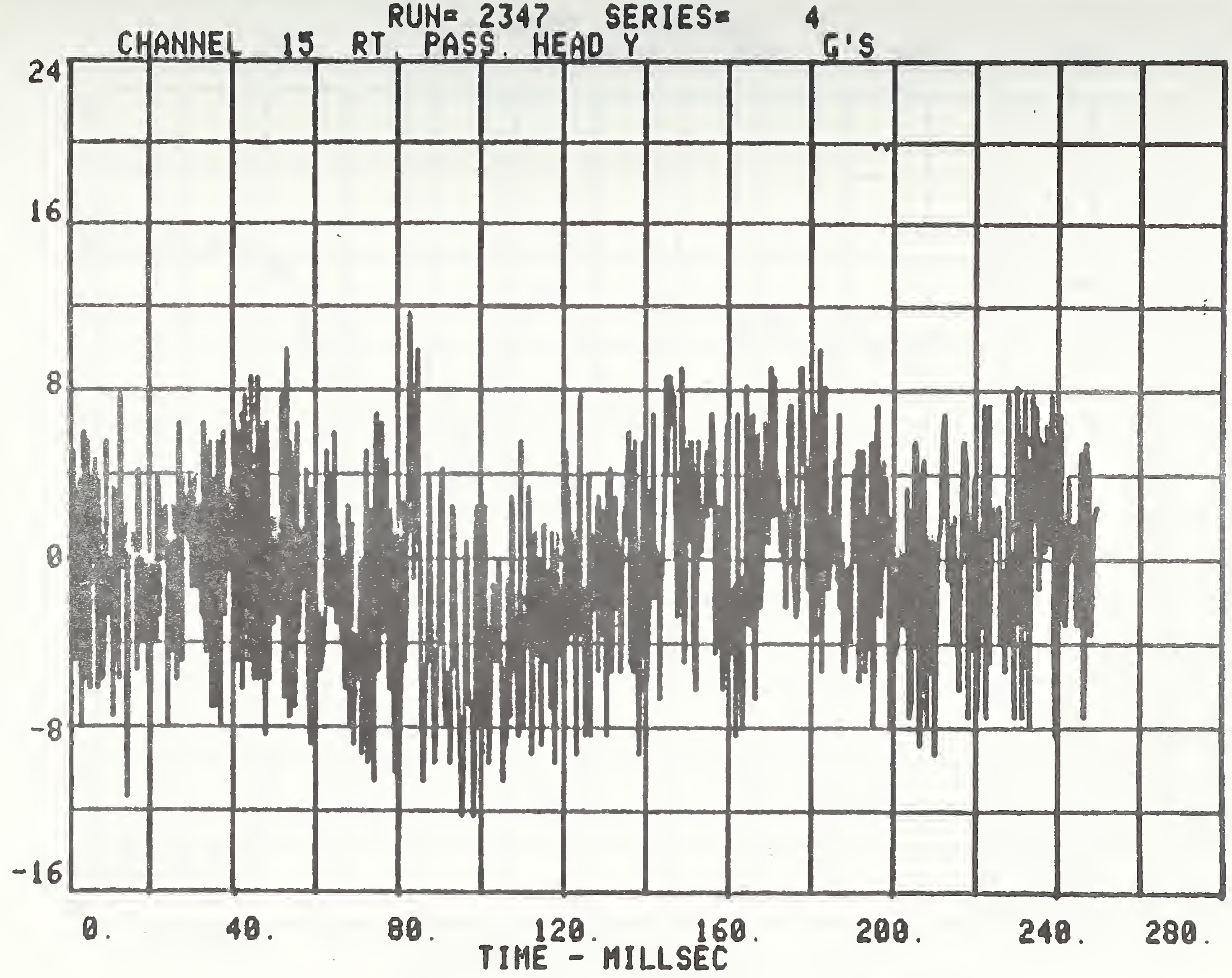
HIC= 976.8 FROM T1= .05280 TO T2= .09870

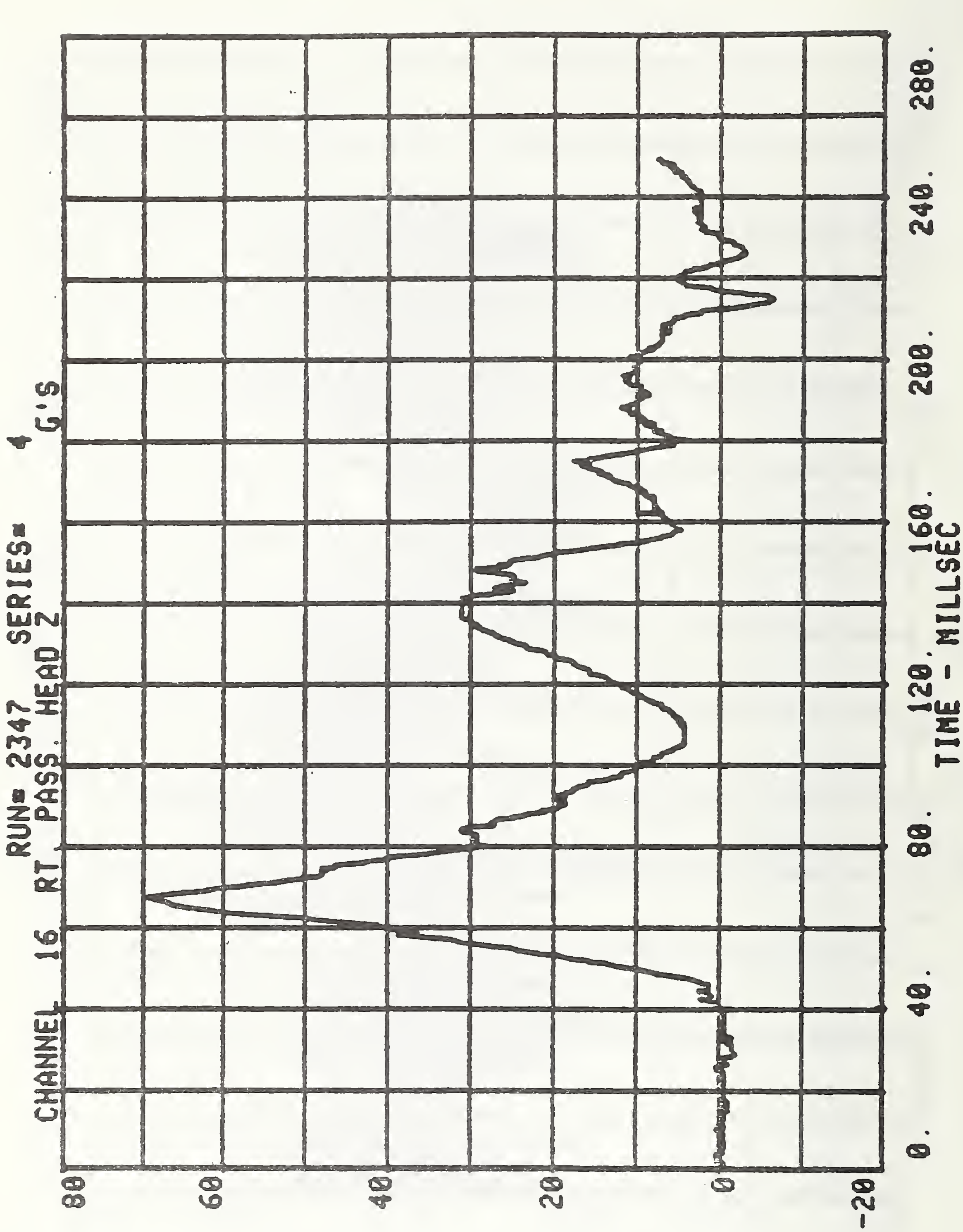
AVERAGE ACCELERATION BETWEEN T1 AND T2= 53.9G'S

EVENT TIME= 250.0 MSEC

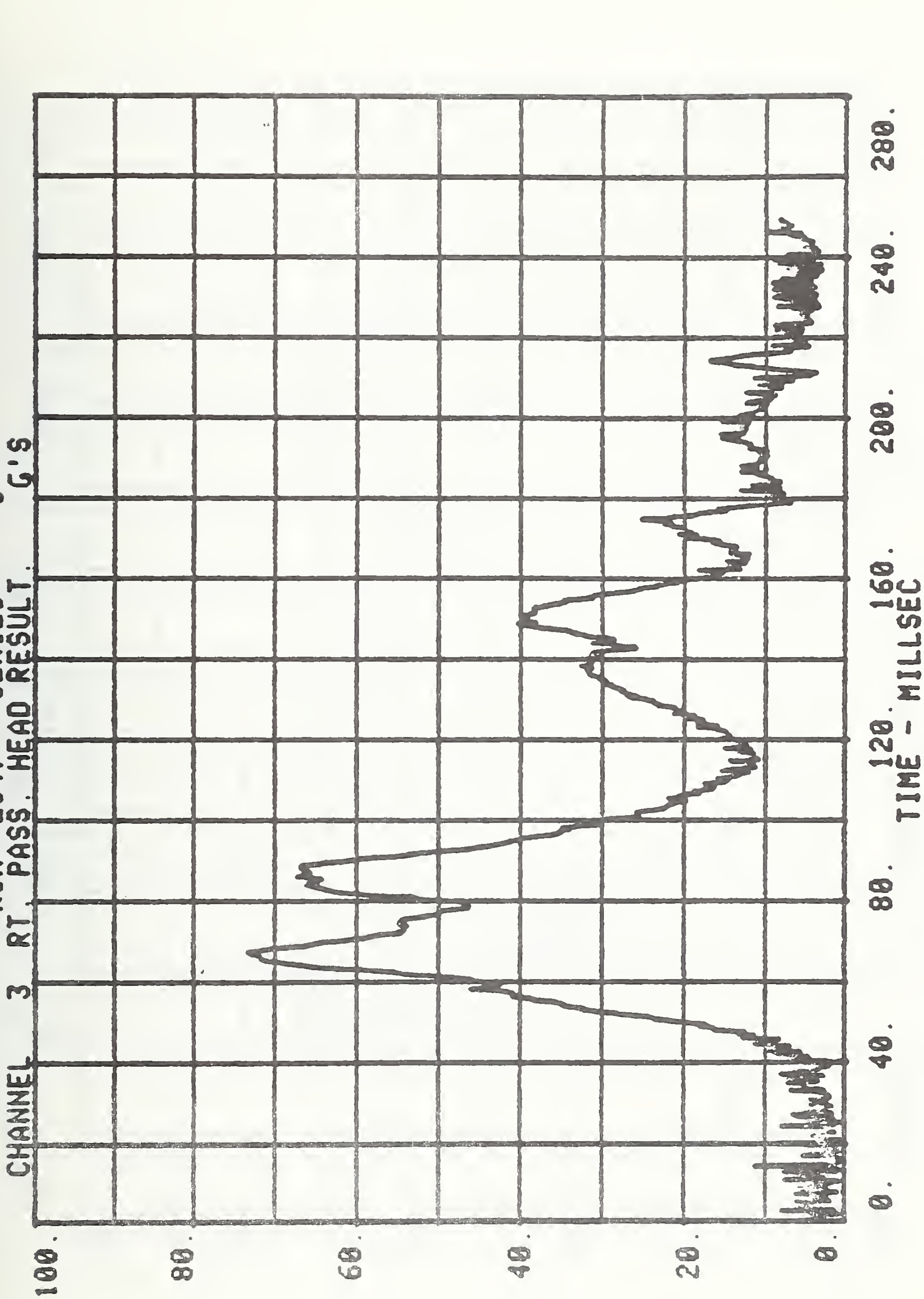
SEVERITY INDEX=1344.1


CHANNEL 14 RUN= 2347 SERIES= 4
RT PASS. HEAD X G'S
50
25
0
-25
-50
-75
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

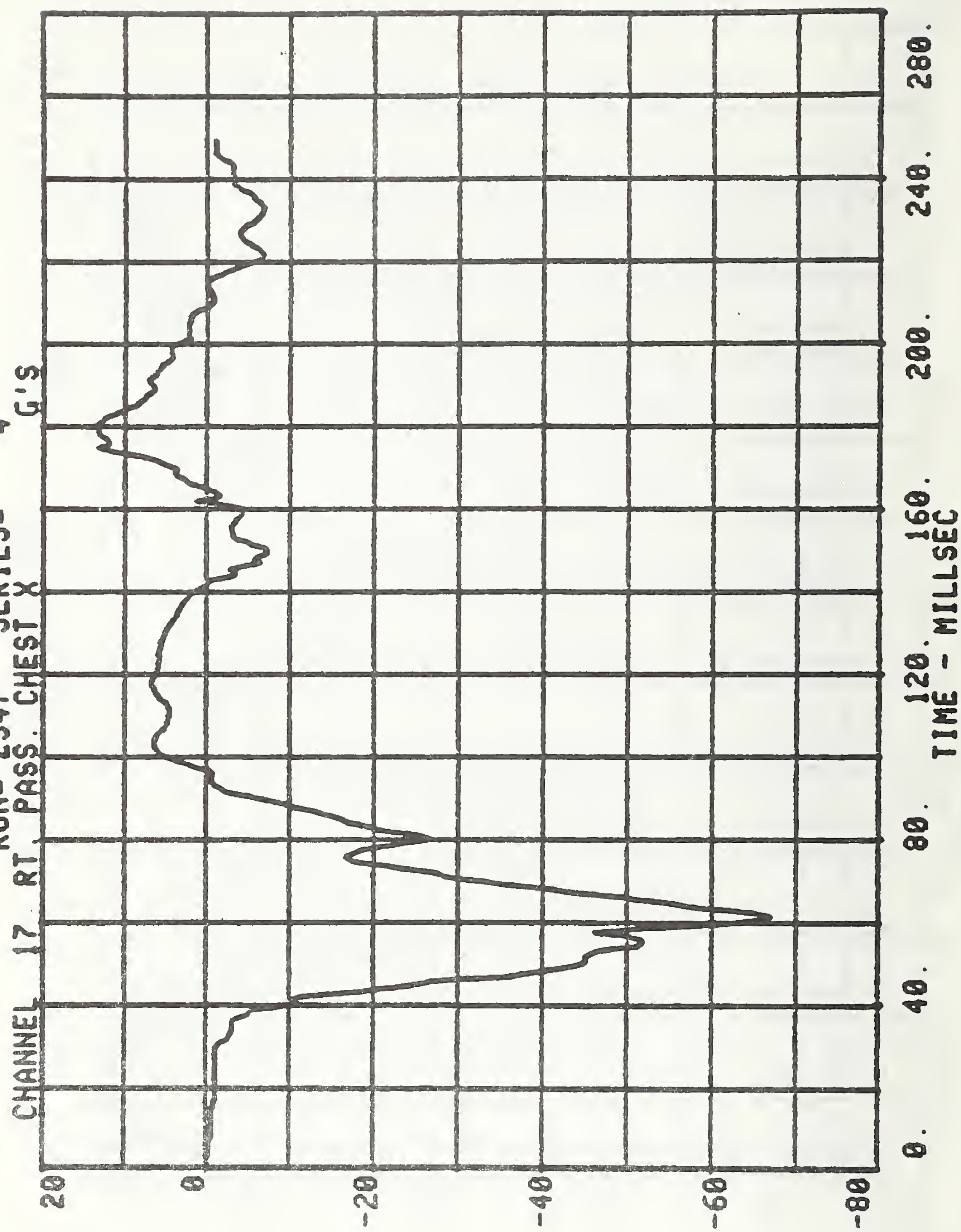

RUN= 2347 SERIES= 4
CHANNEL 15 RT. PASS. HEAD Y G'S
24
16
8
0
-8
-16
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

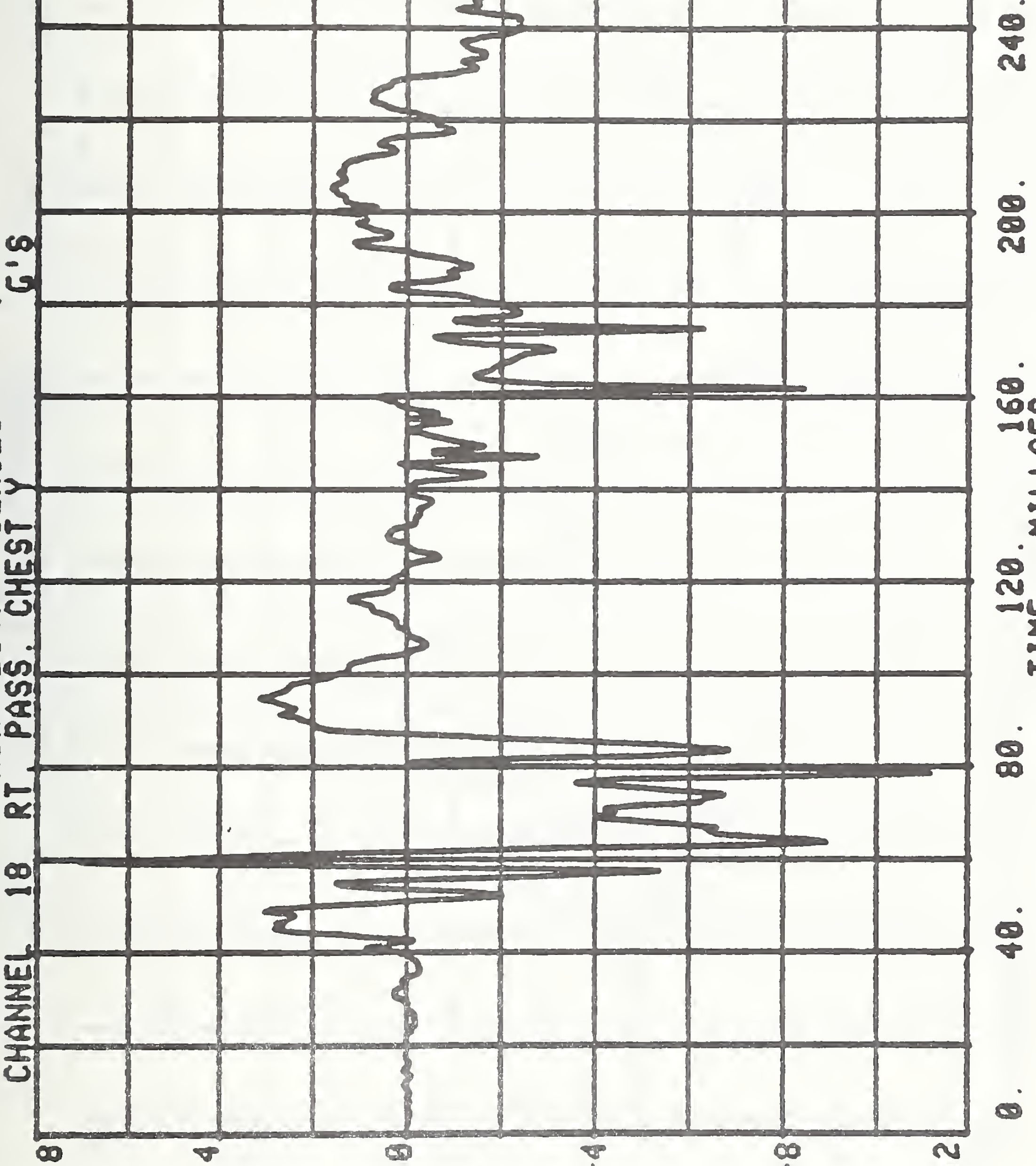


CHANNEL 16 RUN= 2347 SERIES= 4
RT. PASS. HEAD 2 G'S
80
60
40
20
0
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

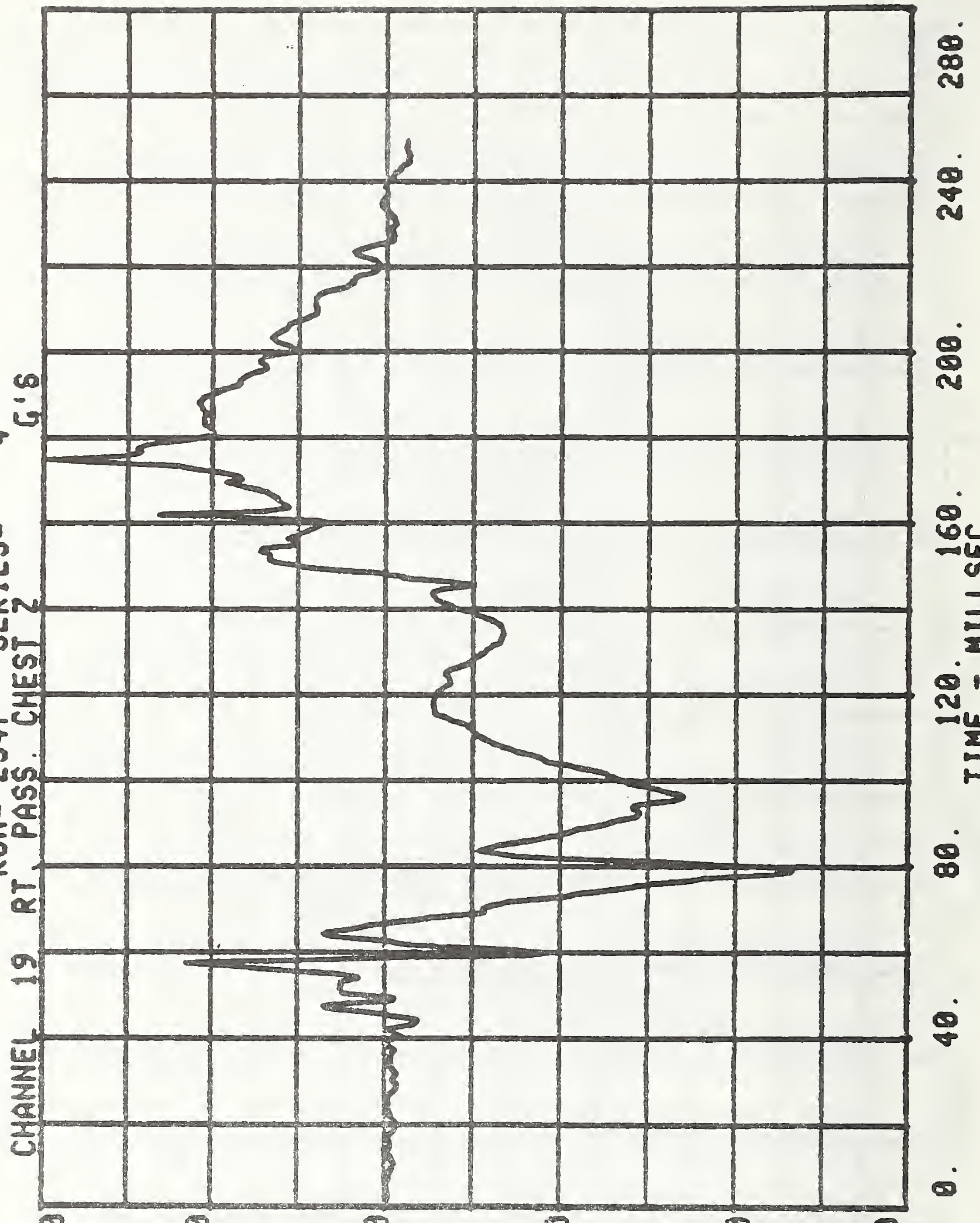


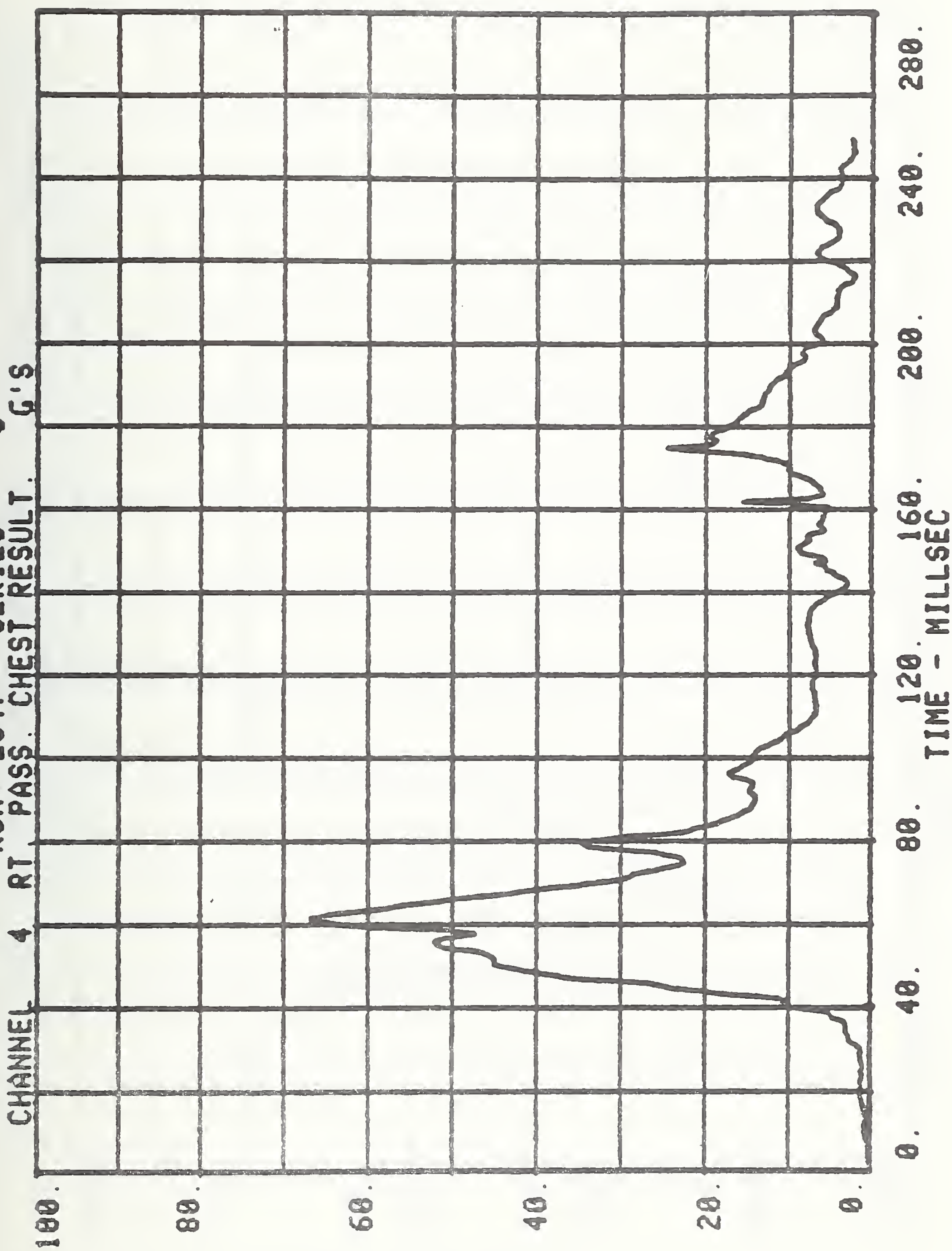
CHANNEL 3 RUN= 2347 SERIES= 5
RT. PASS. HEAD RESULT. G'S
100.
80.
60.
40.
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

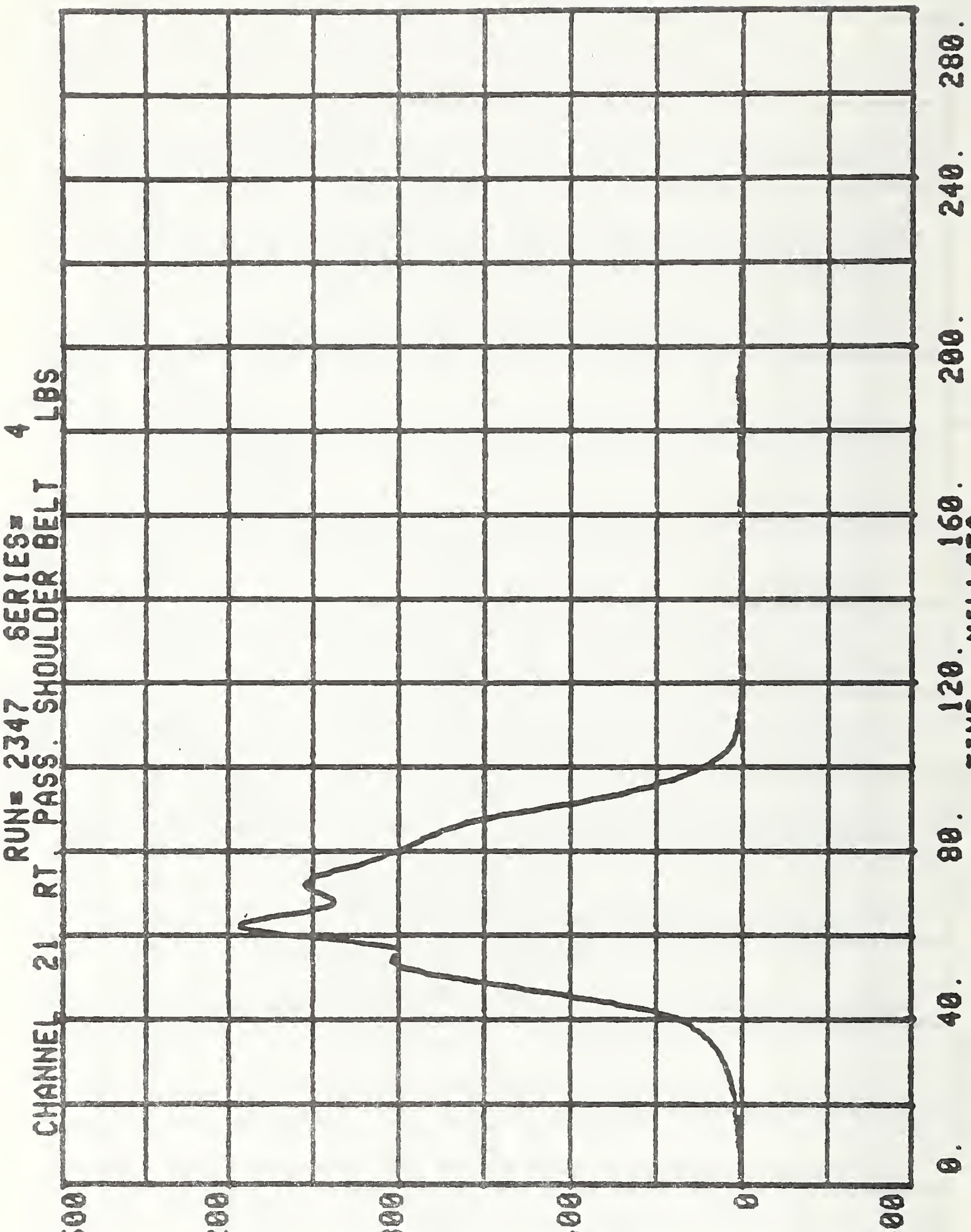

CHANNEL 17 RT. PASS. CHEST X
RUN= 2347 SERIES= 4
G'S
TIME - MILLSEC
20
0
-20
-40
-60
-80
0.
40.
80.
120.
160.
200.
240.
280.

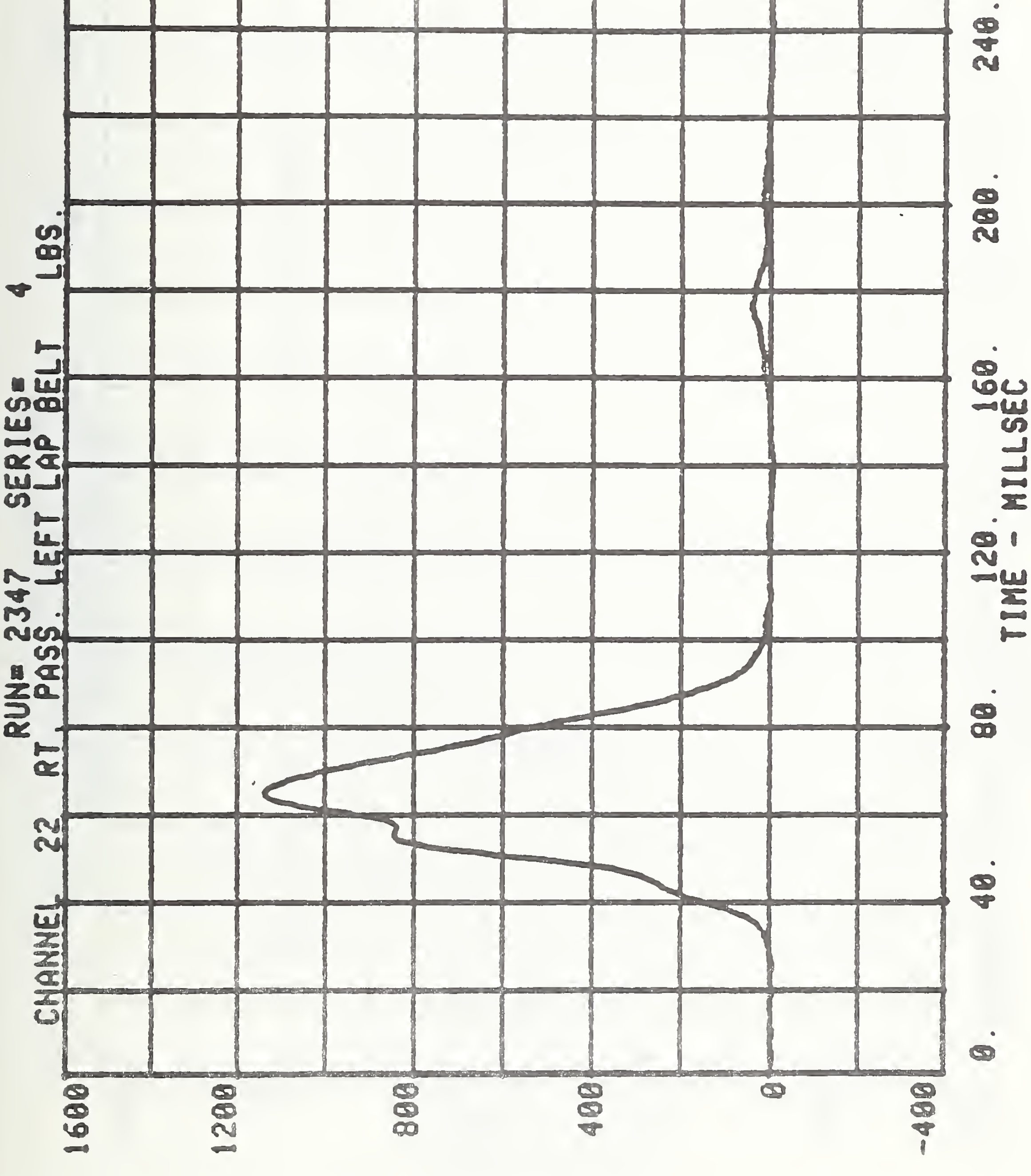


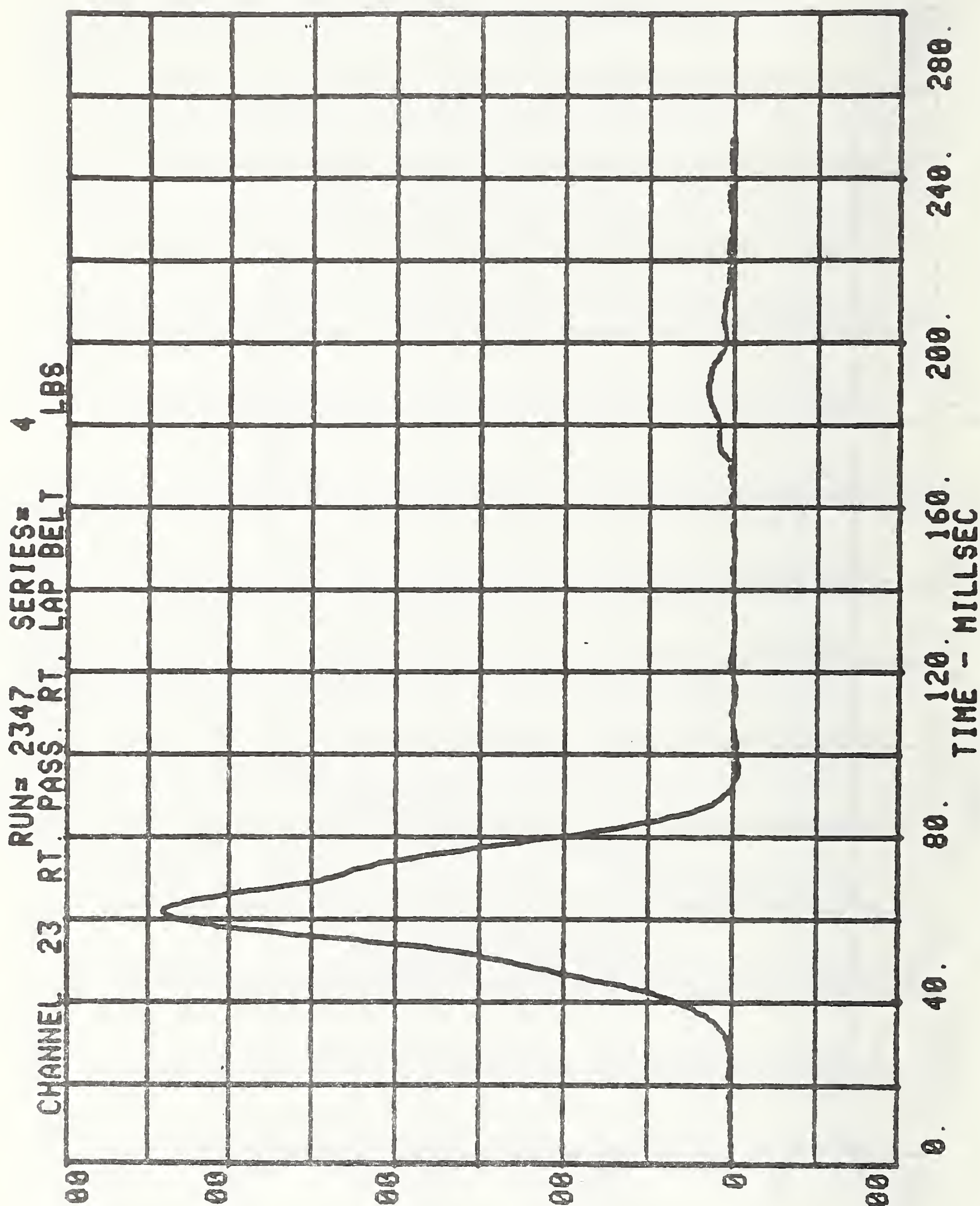
CHANNEL 18 RUN= 2347 SERIES= 4
RT. PASS. CHEST Y G'S
8
4
0
-4
-8
-12
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 19 RUN= 2347 SERIES= 4
RT PASS. CHEST Z G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
20
10
0
-10
-20
-30


CHANNEL 4 RUN= 2347 SERIES= 5
RT. PASS. CHEST RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
0.
20.
40.
60.
80.
100.


CHANNEL 21 RUN= 2347 SERIES= 4
RT. PASS. SHOULDER BELT LBS
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 22 RUN= 2347 SERIES= 4
RT. PASS. LEFT LAP BELT LBS.
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
1600 1200 800 400 0 -400



CHANNEL 23 RUN= 2347 SERIES= 4
RT. PASS. RT. LAP BELT LBS
800
600
400
200
0
-200
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2347

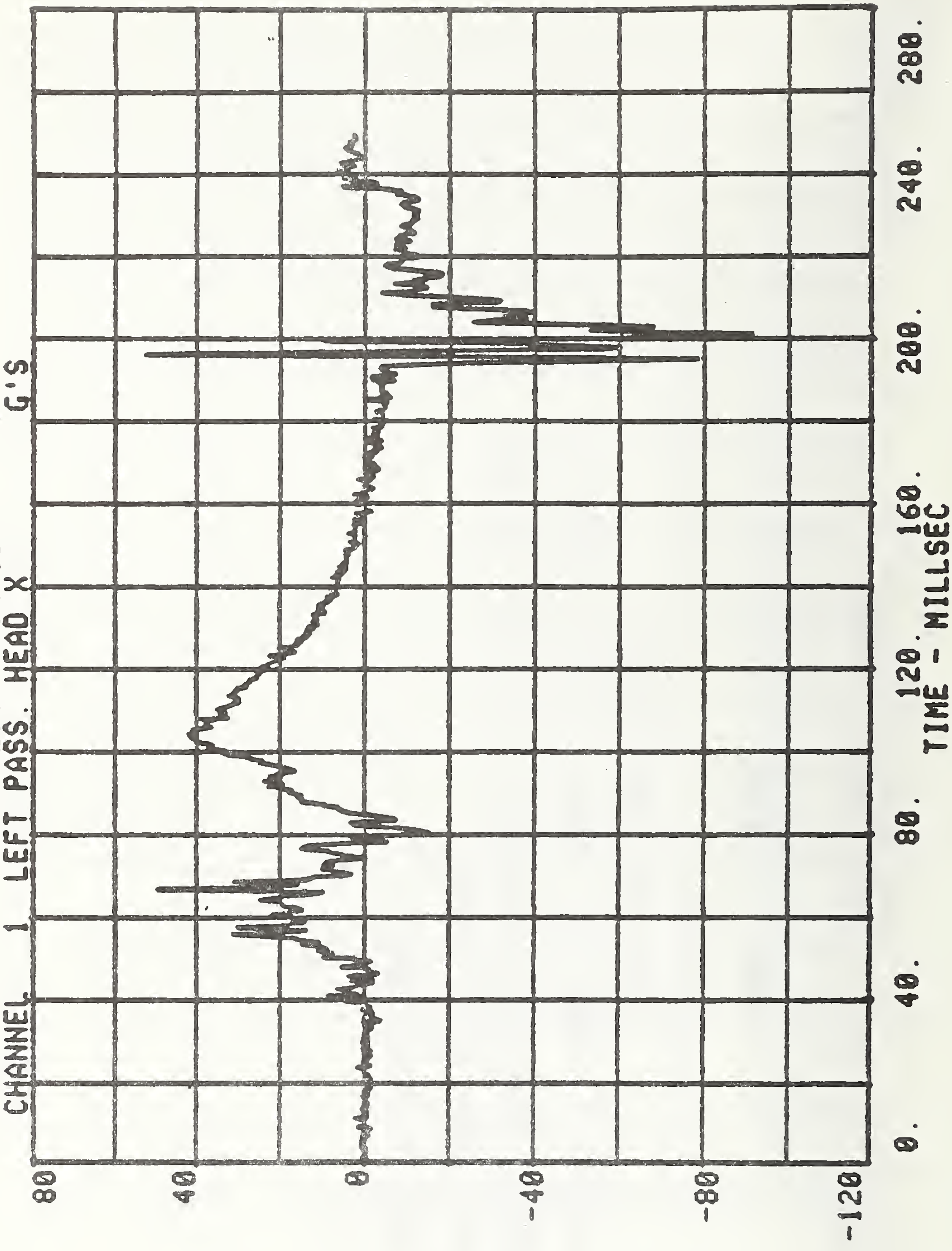
LEFT PASS. HEAD RESULT.

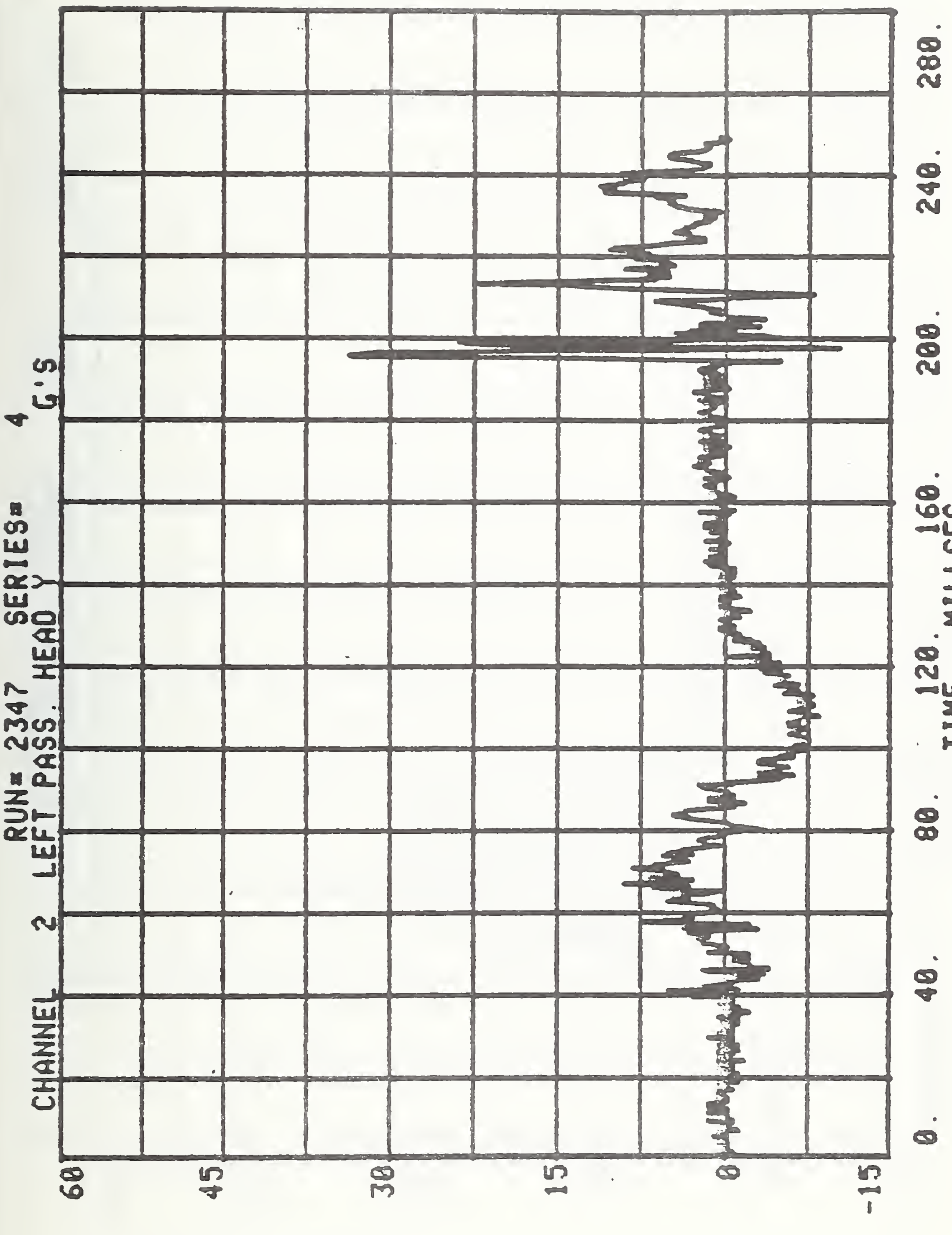
HIC=1533.3   FROM T1= .05220   TO T2= .11520

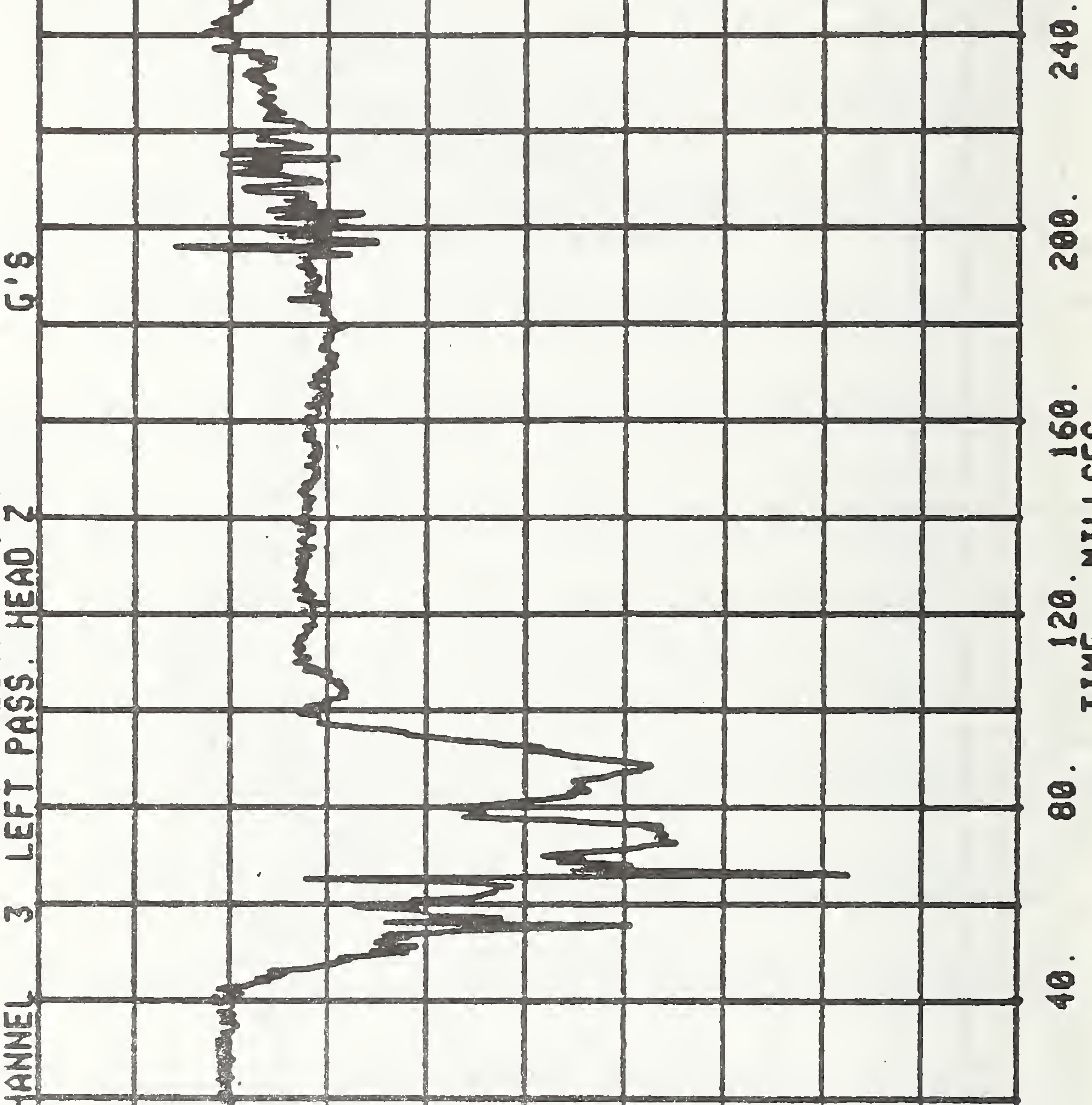
AVERAGE ACCELERATION BETWEEN T1 AND T2= 56.8G'S

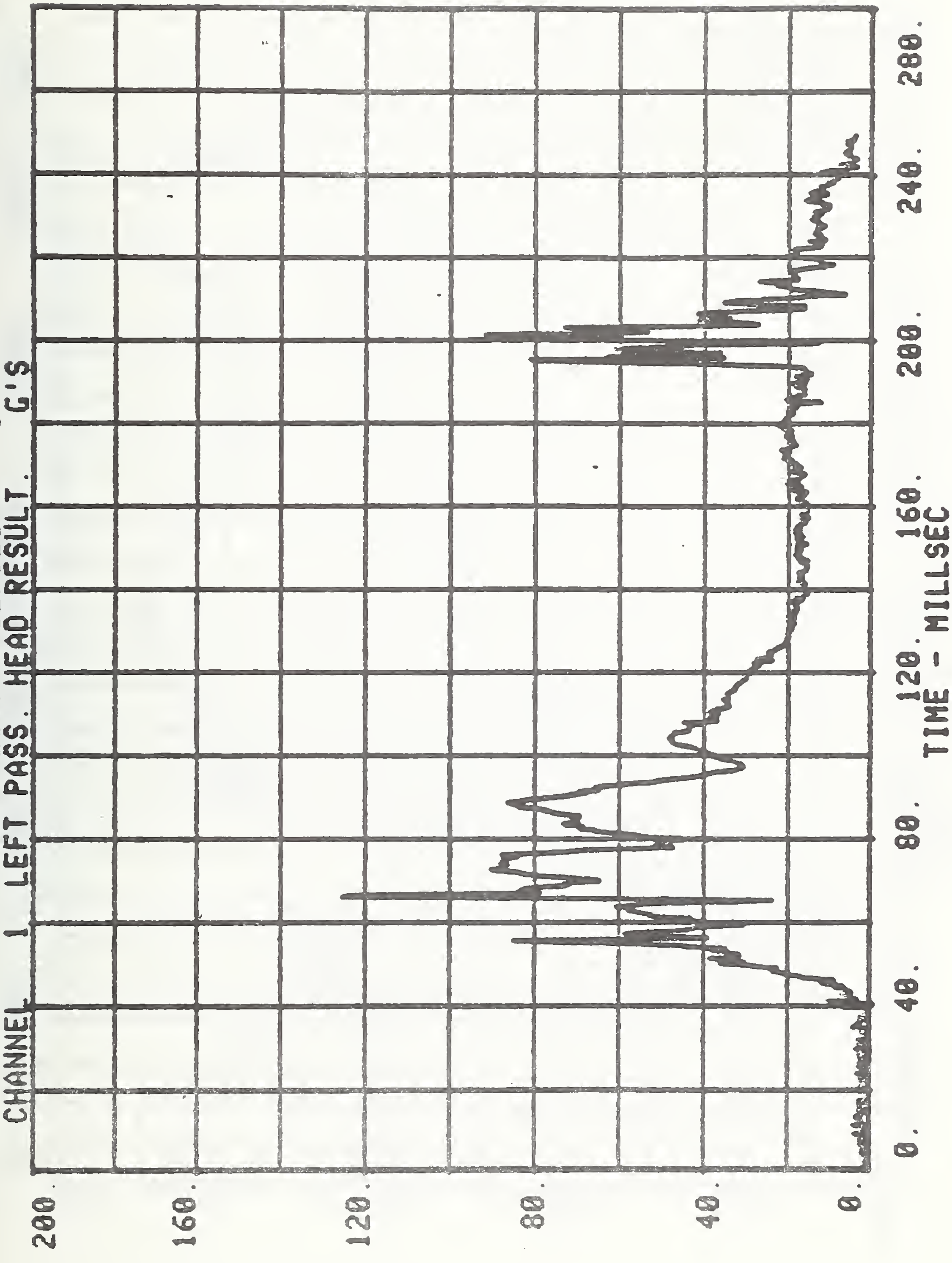
EVENT TIME= 250.0 MSEC

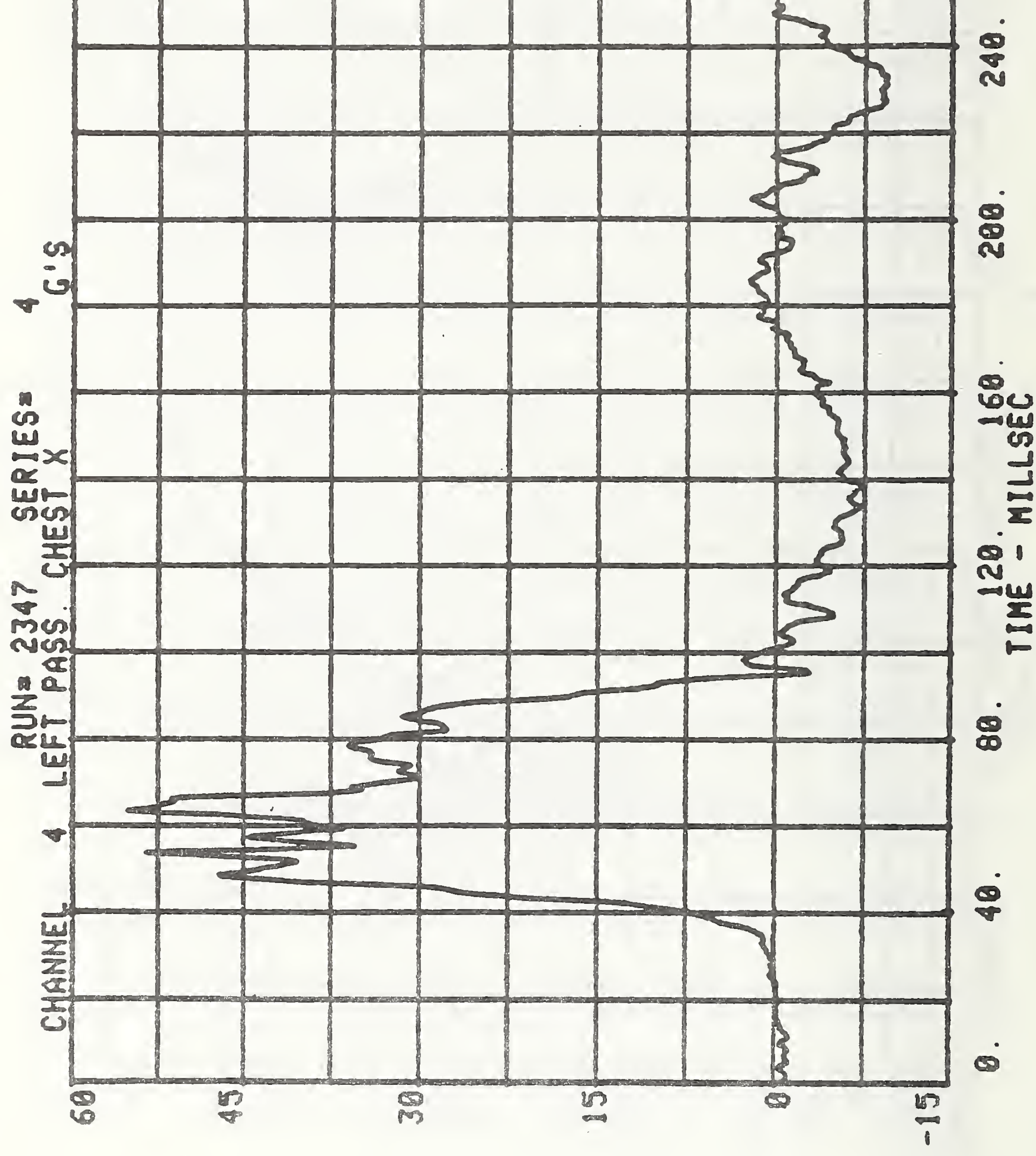
SEVERITY INDEX=2402.0

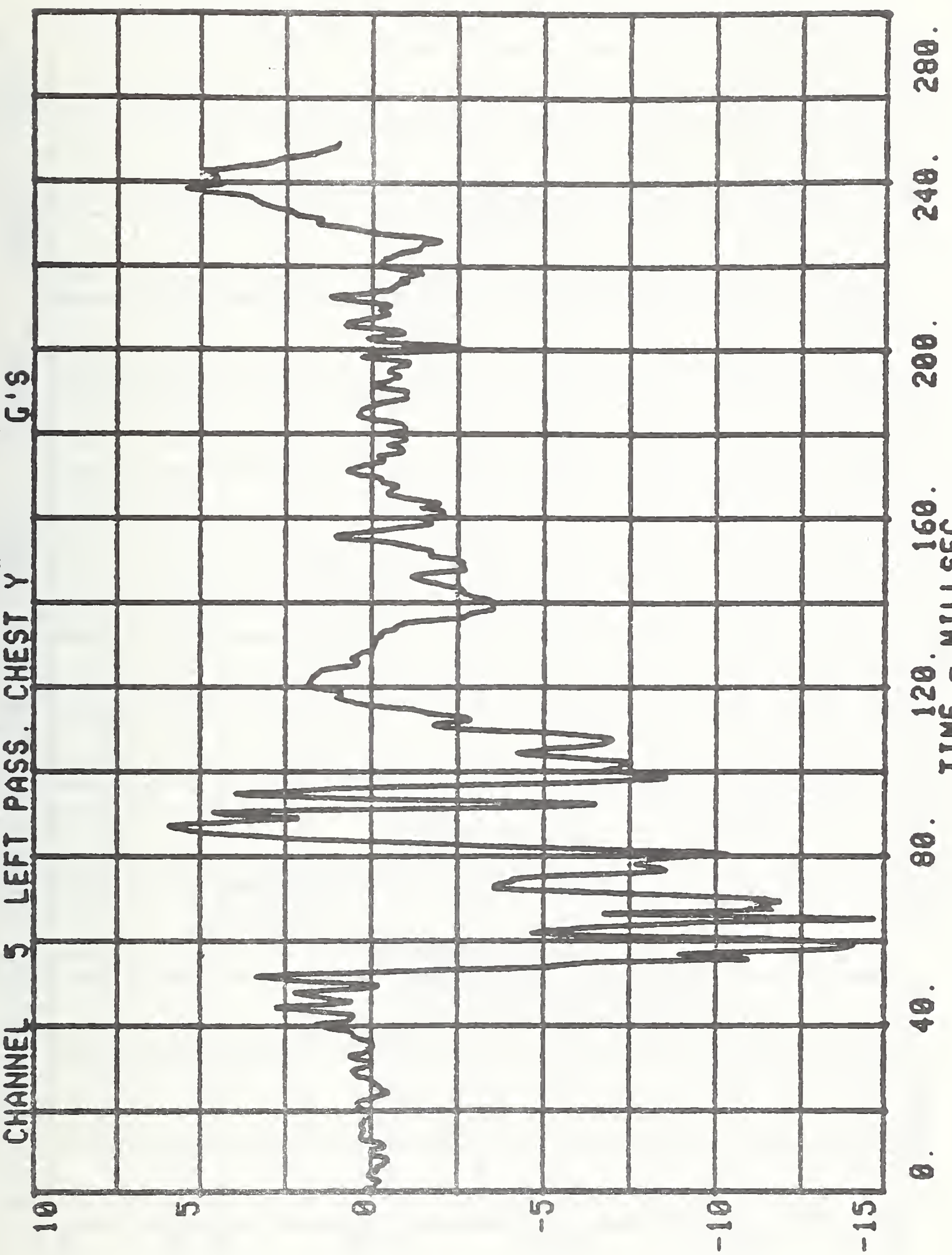

CHANNEL 1 RUN= 2347 SERIES= 4
LEFT PASS. HEAD X G'S
80
40
0
-40
-80
-120
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 2 RUN= 2347 SERIES= 4
LEFT PASS. HEAD Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
60 45 30 15 0 -15

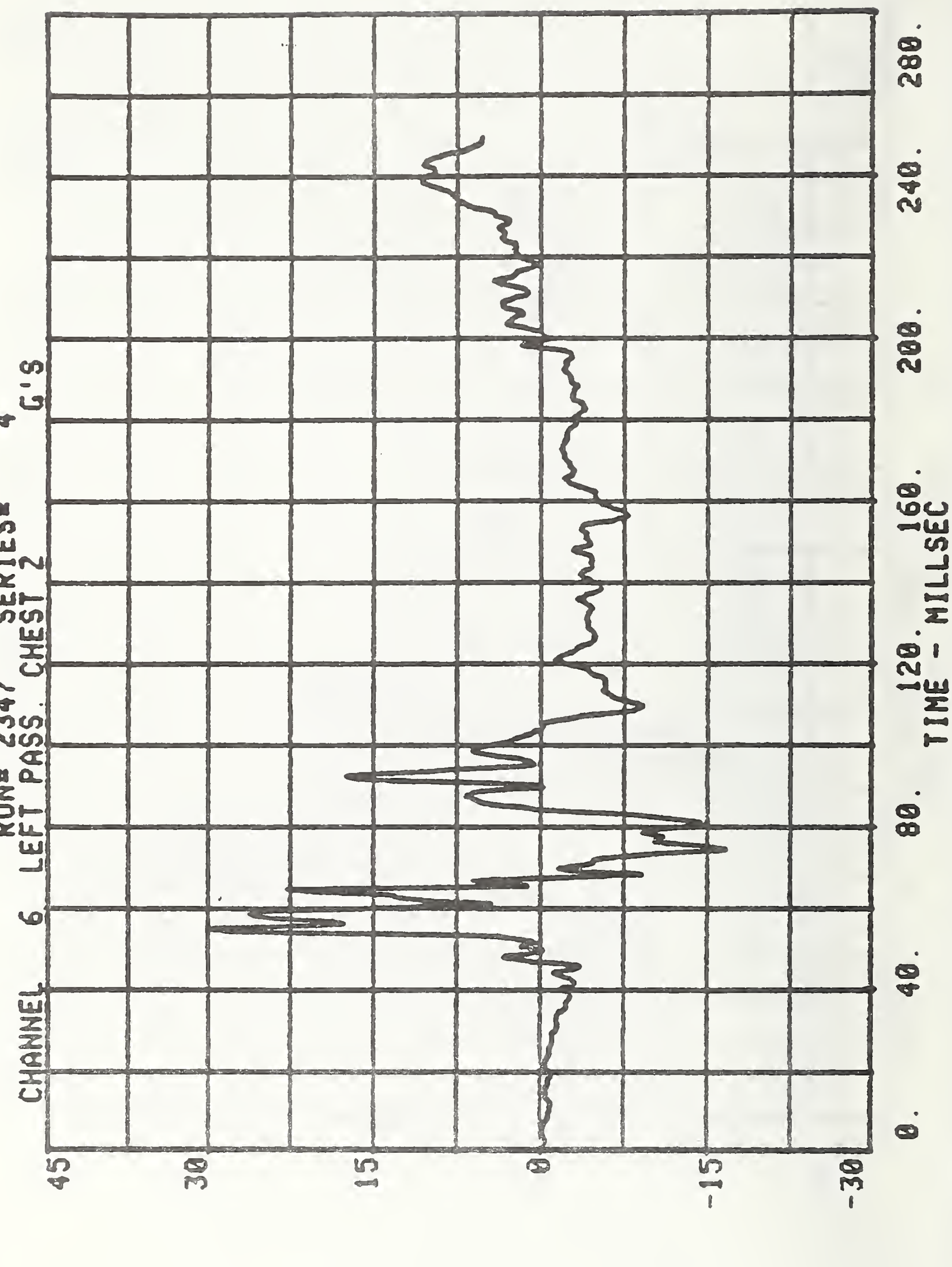

CHANNEL 3 RUN= 2347 SERIES= 4
LEFT PASS. HEAD Z G'S
40
0
-40
-80
-120
-160
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

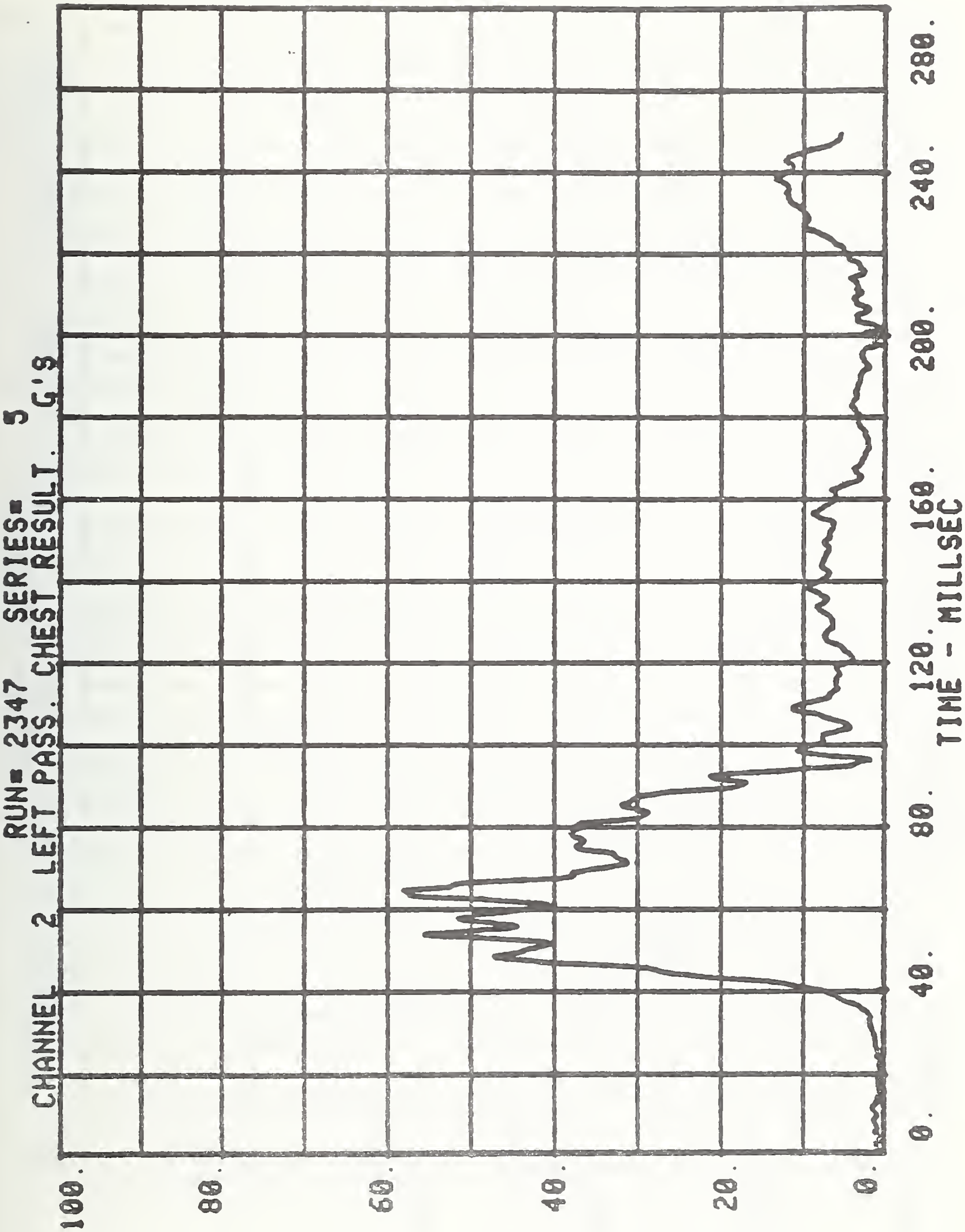

CHANNEL 1 RUN= 2347 SERIES= 5
LEFT PASS. HEAD RESULT. G'S
200.
160.
120.
80.
40.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

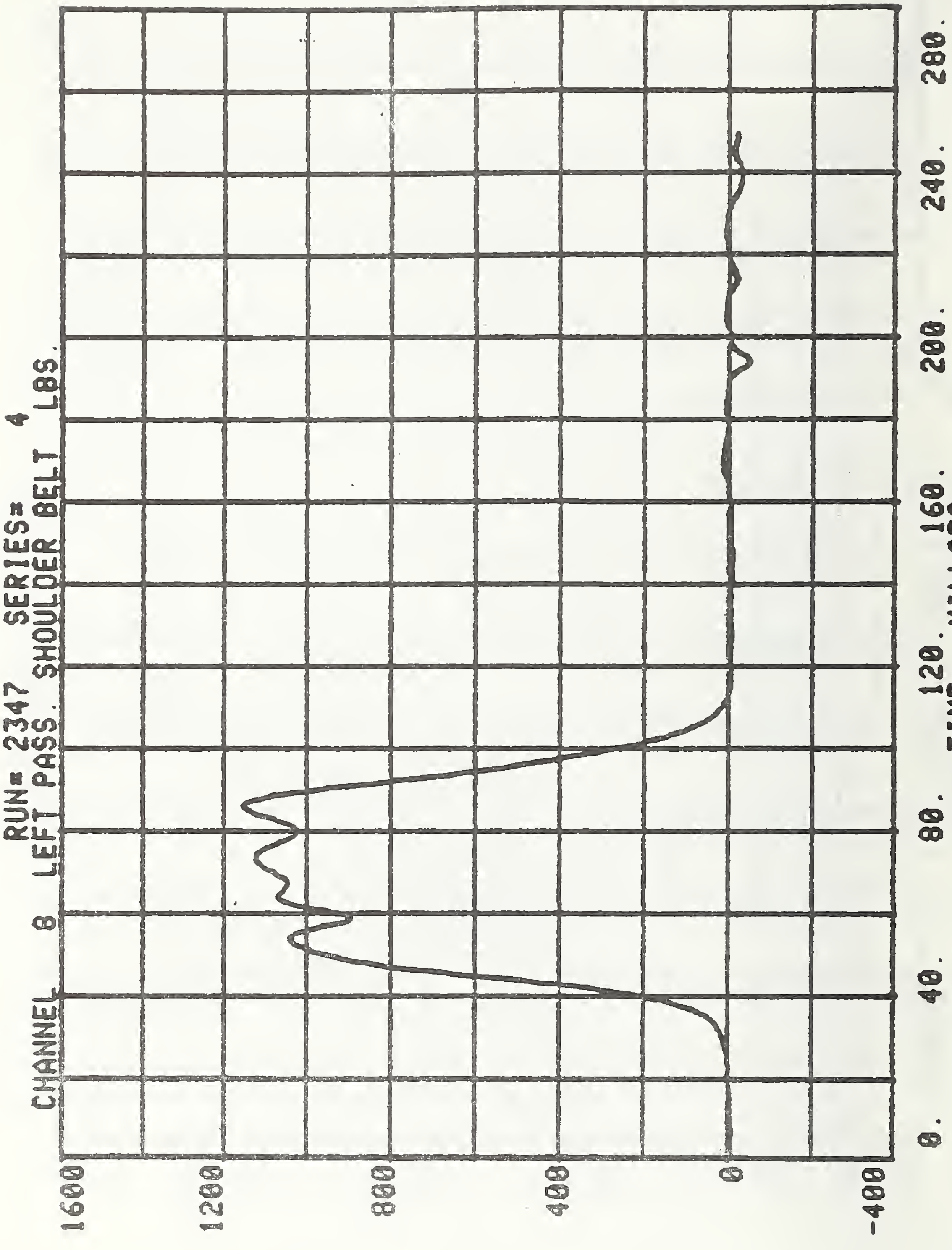

CHANNEL 4 RUN= 2347 SERIES= 4
LEFT PASS CHEST X G'S
60
45
30
15
0
-15
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

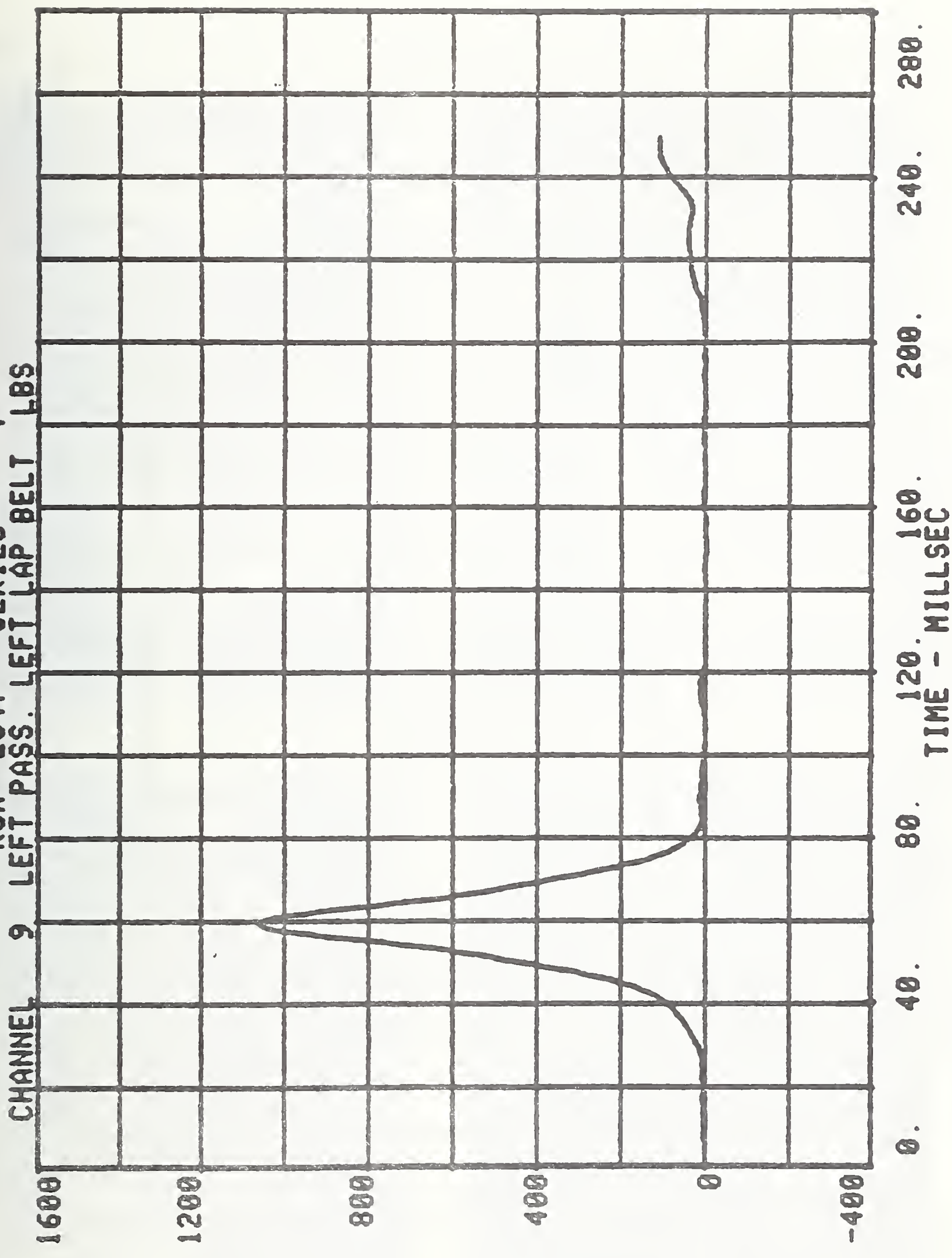


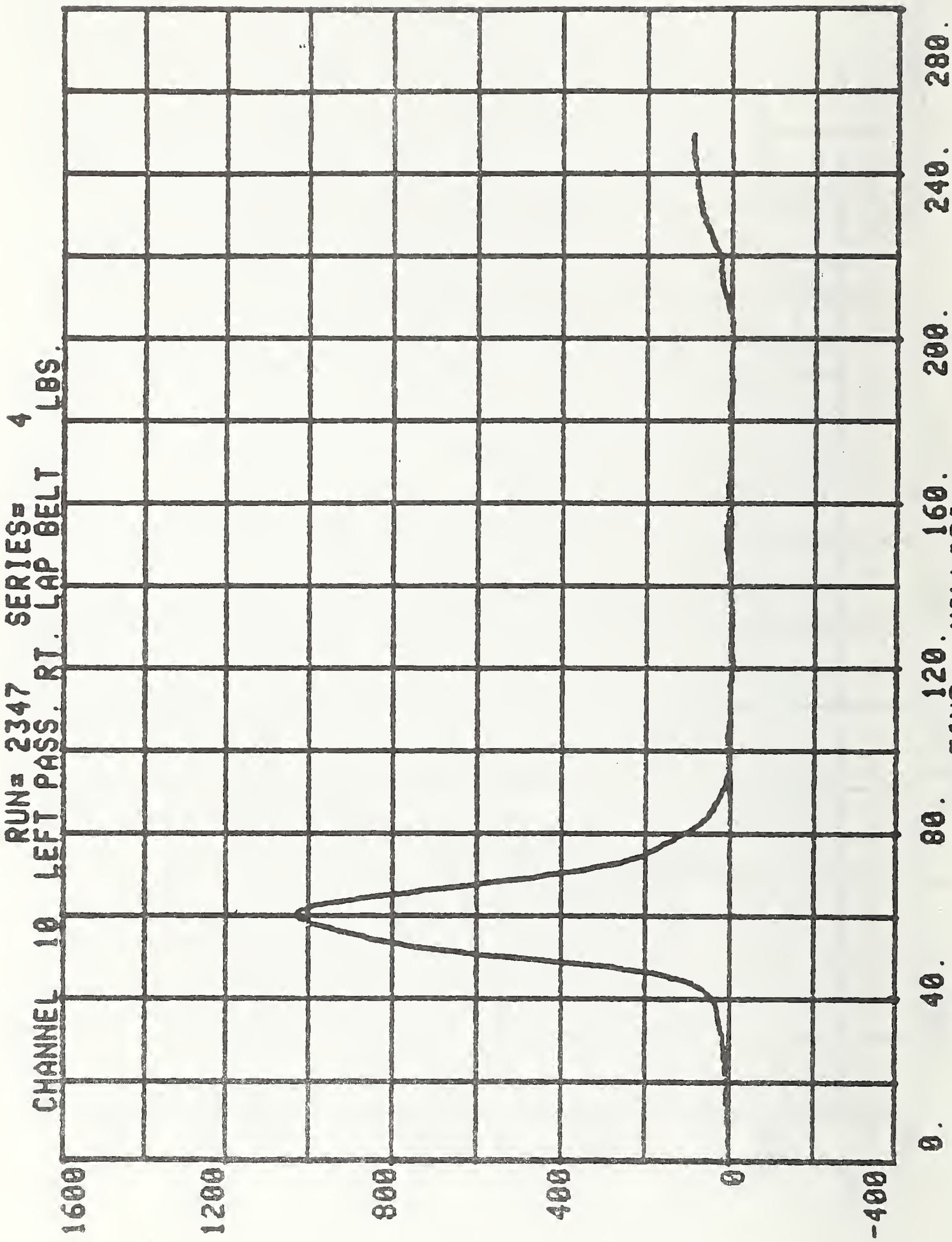
CHANNEL 5 RUN= 2347 SERIES= 4
LEFT PASS. CHEST Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
10 5 0 -5 -10 -15


CHANNEL 6 RUN= 2347 SERIES= 4
LEFT PASS. CHEST 2 G'S
45
30
15
0
-15
-30
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

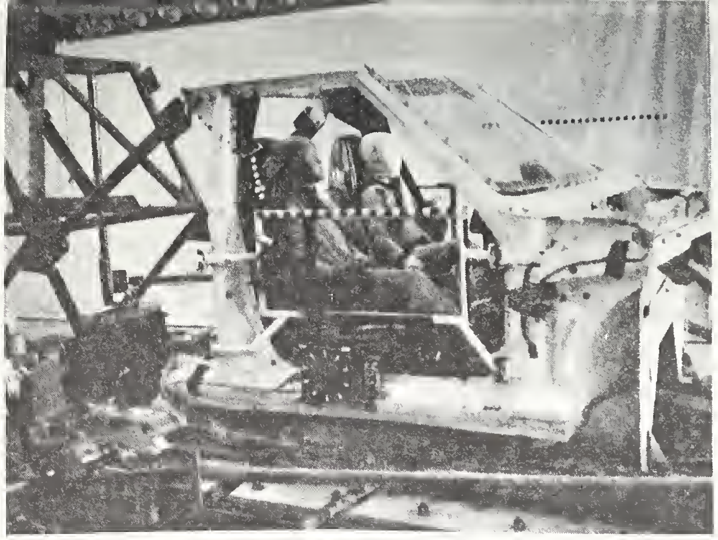

CHANNEL 2 RUN= 2347 SERIES= 5
LEFT PASS. CHEST RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
100.
80.
60.
40.
20.
0.

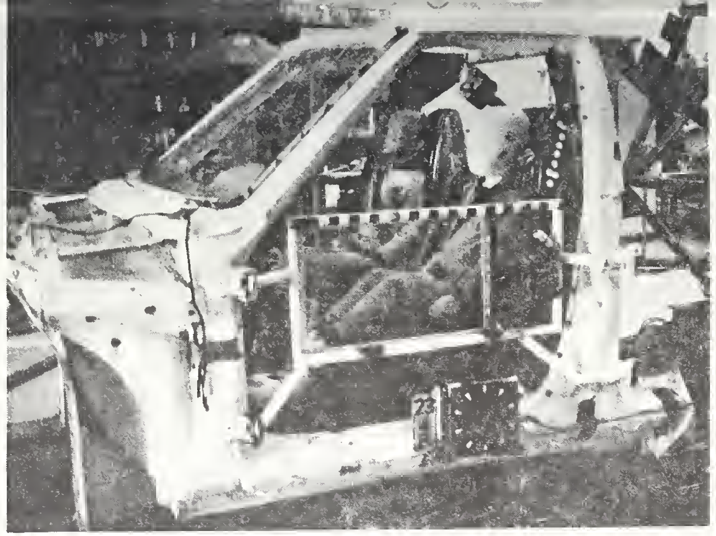

CHANNEL 8 RUN= 2347 SERIES= 4
LEFT PASS. SHOULDER BELT LBS.
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 9 RUN= 2347 SERIES= 4
LEFT PASS. LEFT LAP BELT LBS
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

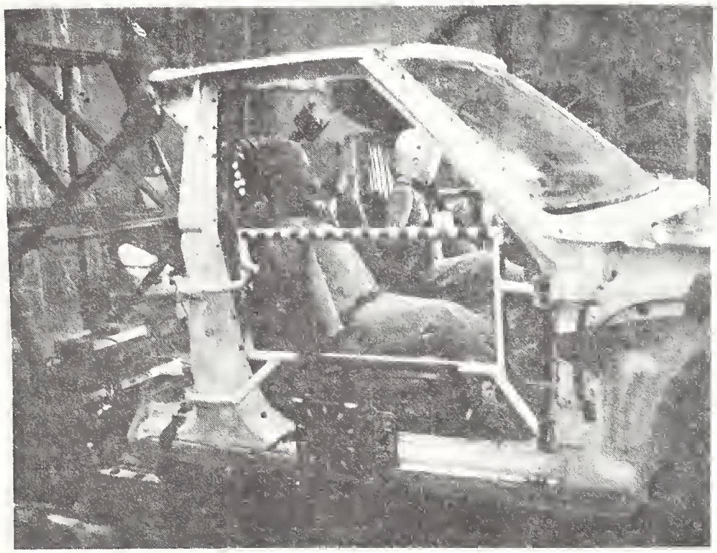


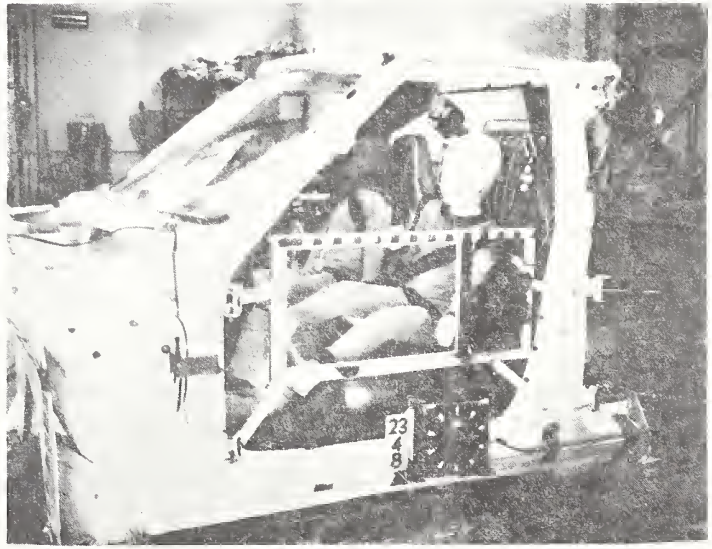
CHANNEL 10 RUN= 2347 SERIES= 4
LEFT PASS. RT. LAP BELT LBS.
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC





PRE-TEST





ALDERSON S/N 49

TNO

POST-TEST

RUN 2348

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2348

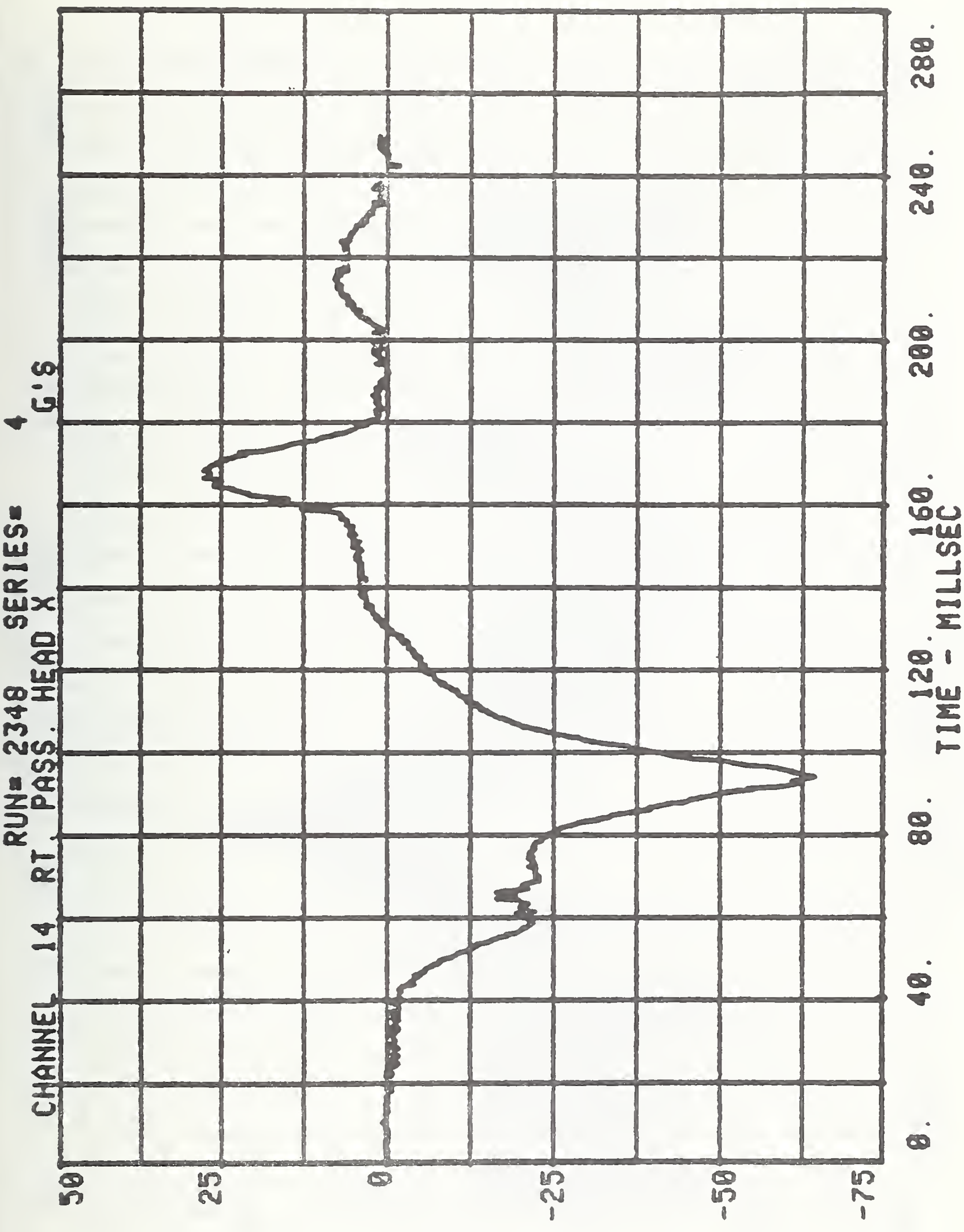
RT. PASS. HEAD RESULT.

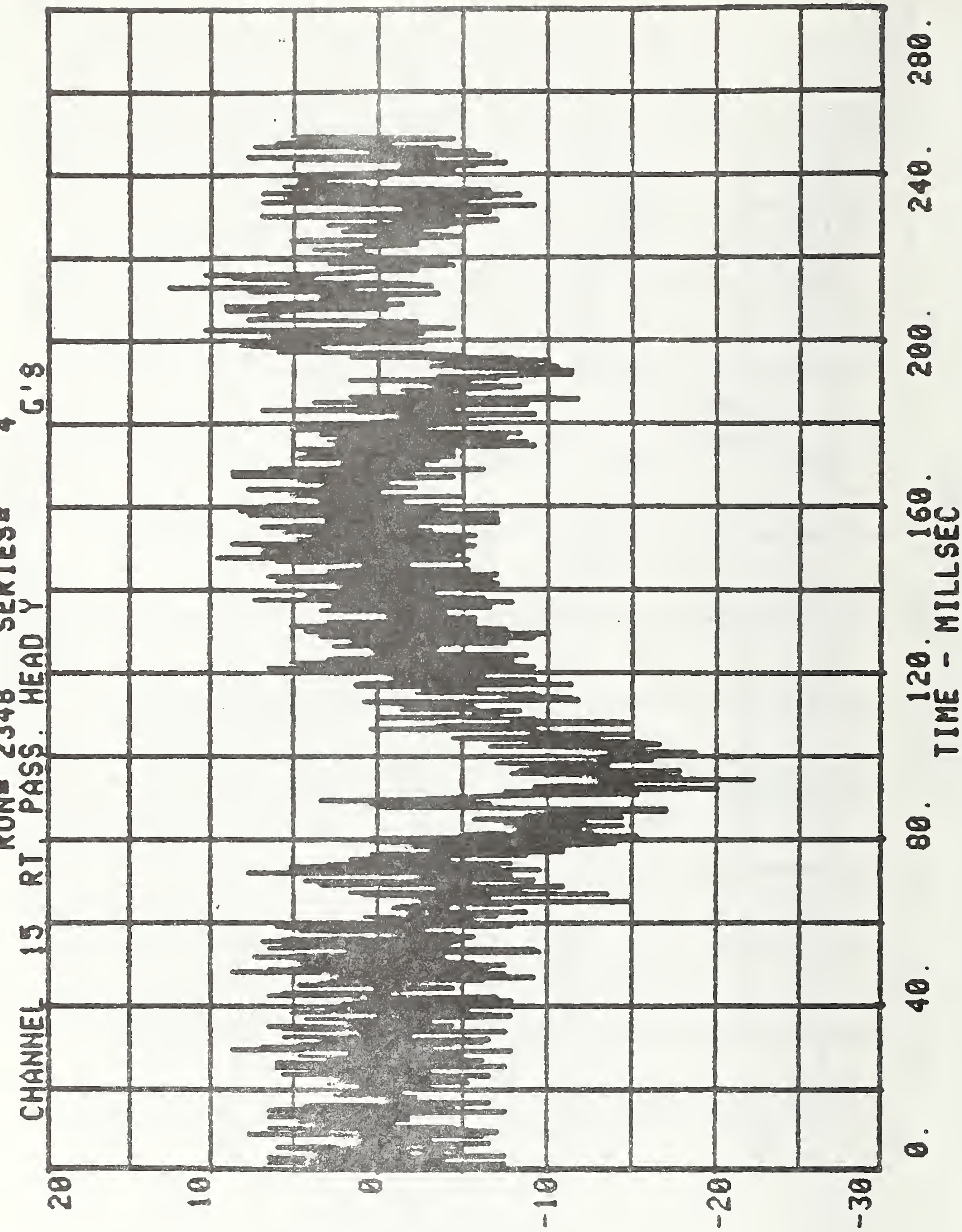
HIC= 898.1 FROM T1= .05970 TO T2= .10350

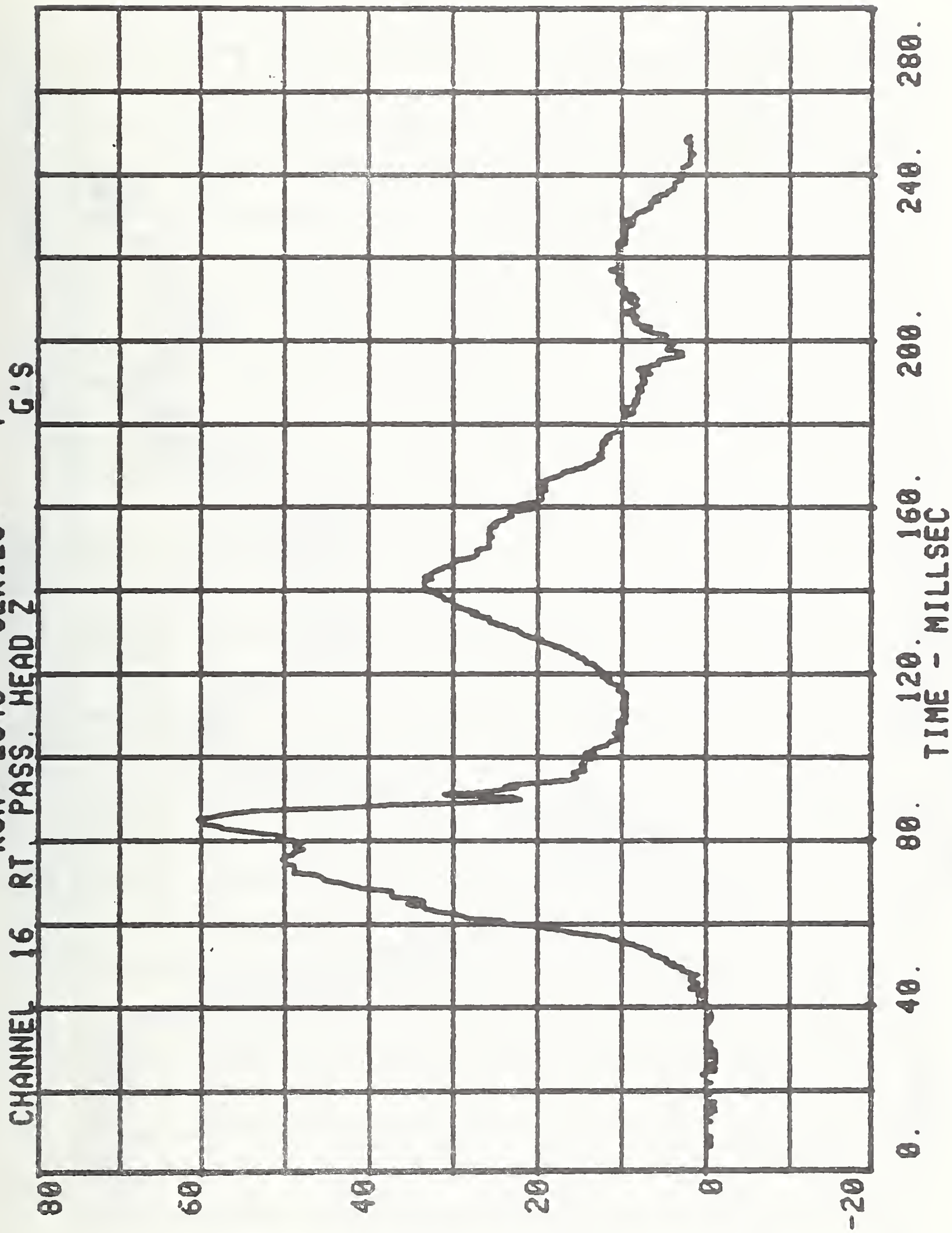
AVERAGE ACCELERATION BETWEEN T1 AND T2= 53.1G'S

EVENT TIME= 250.0 MSEC

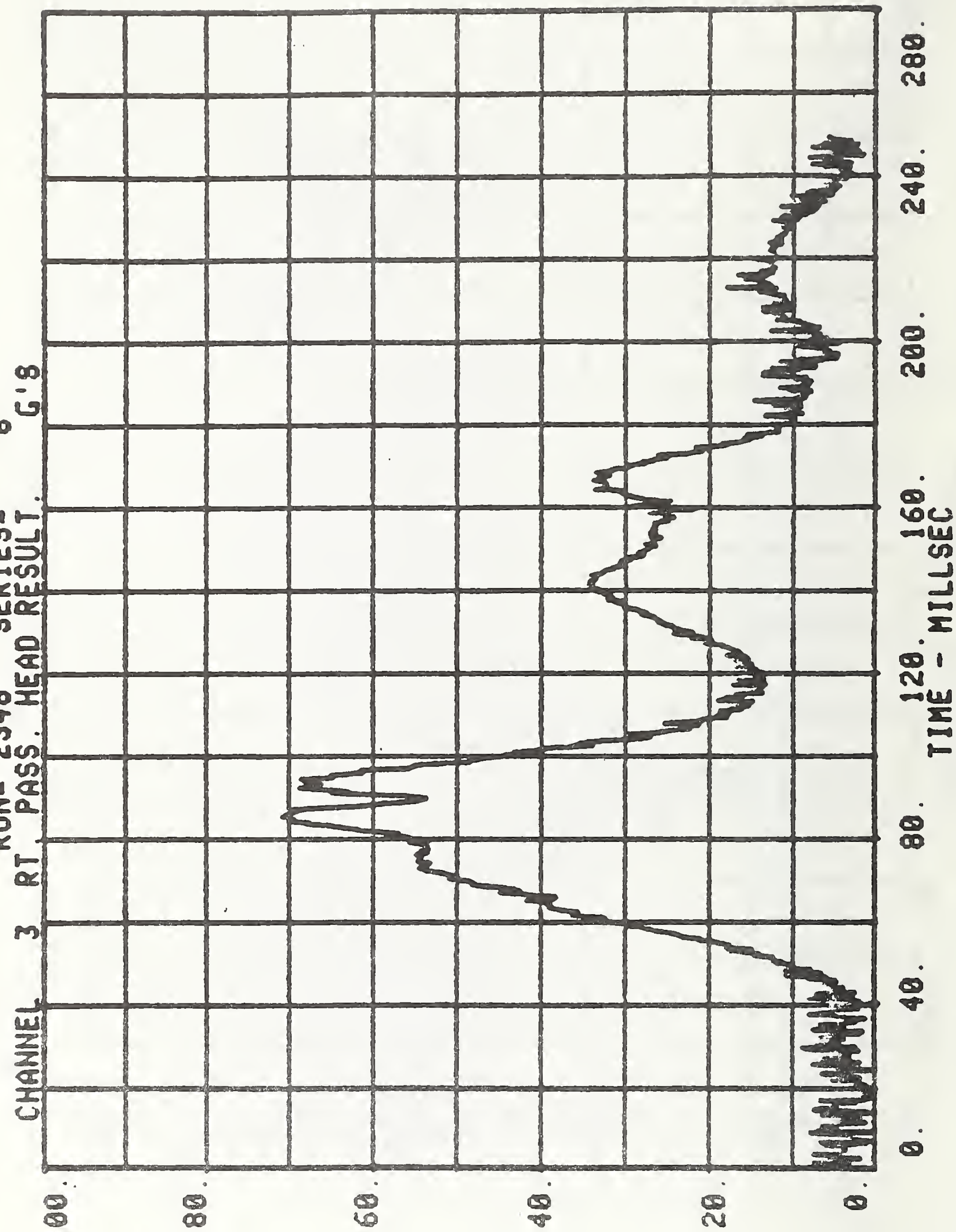
SEVERITY INDEX=1270.9

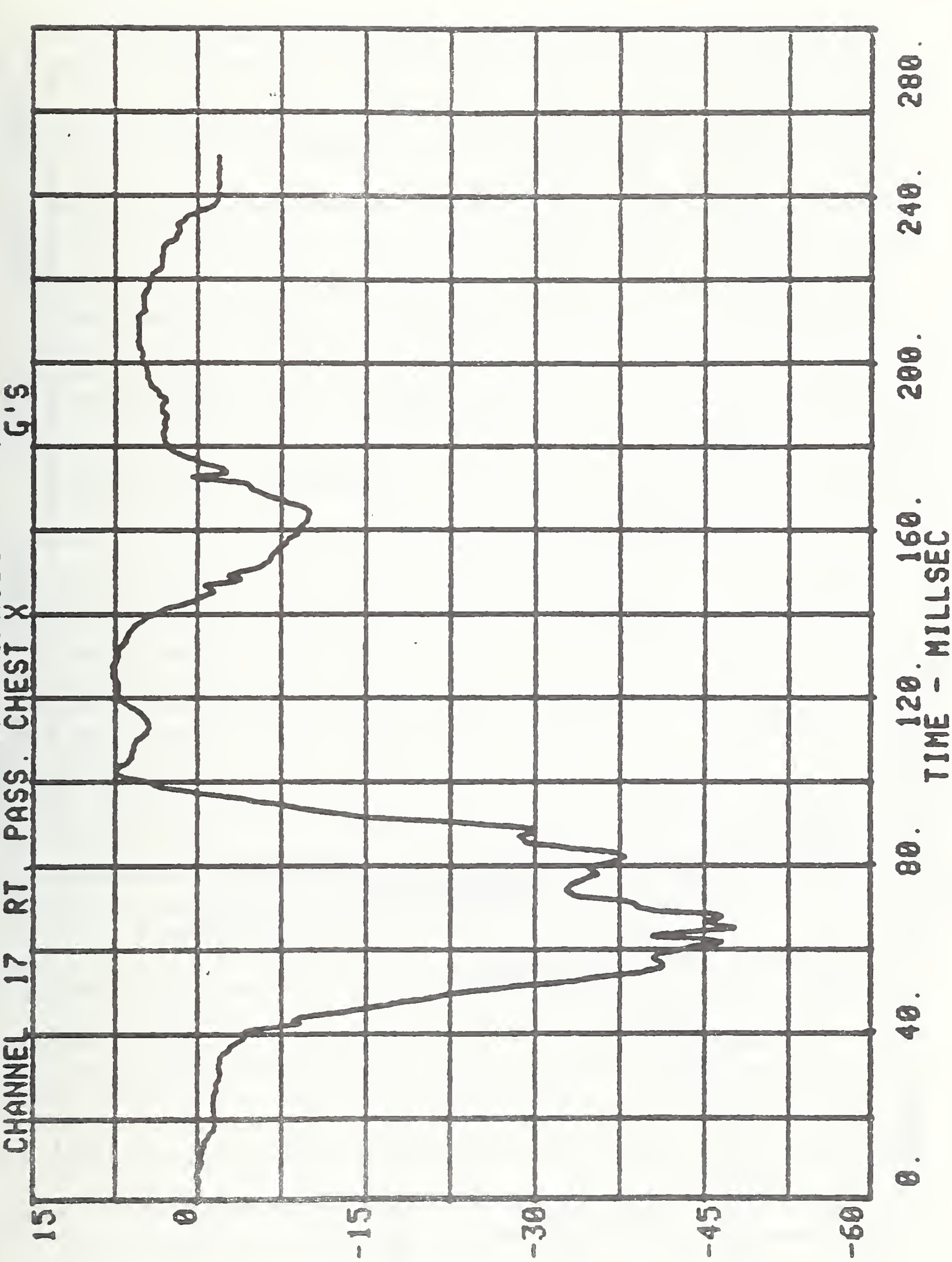

CHANNEL 14 RUN= 2348 SERIES= 4
RT. PASS. HEAD X G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
50 25 0 -25 -50 -75

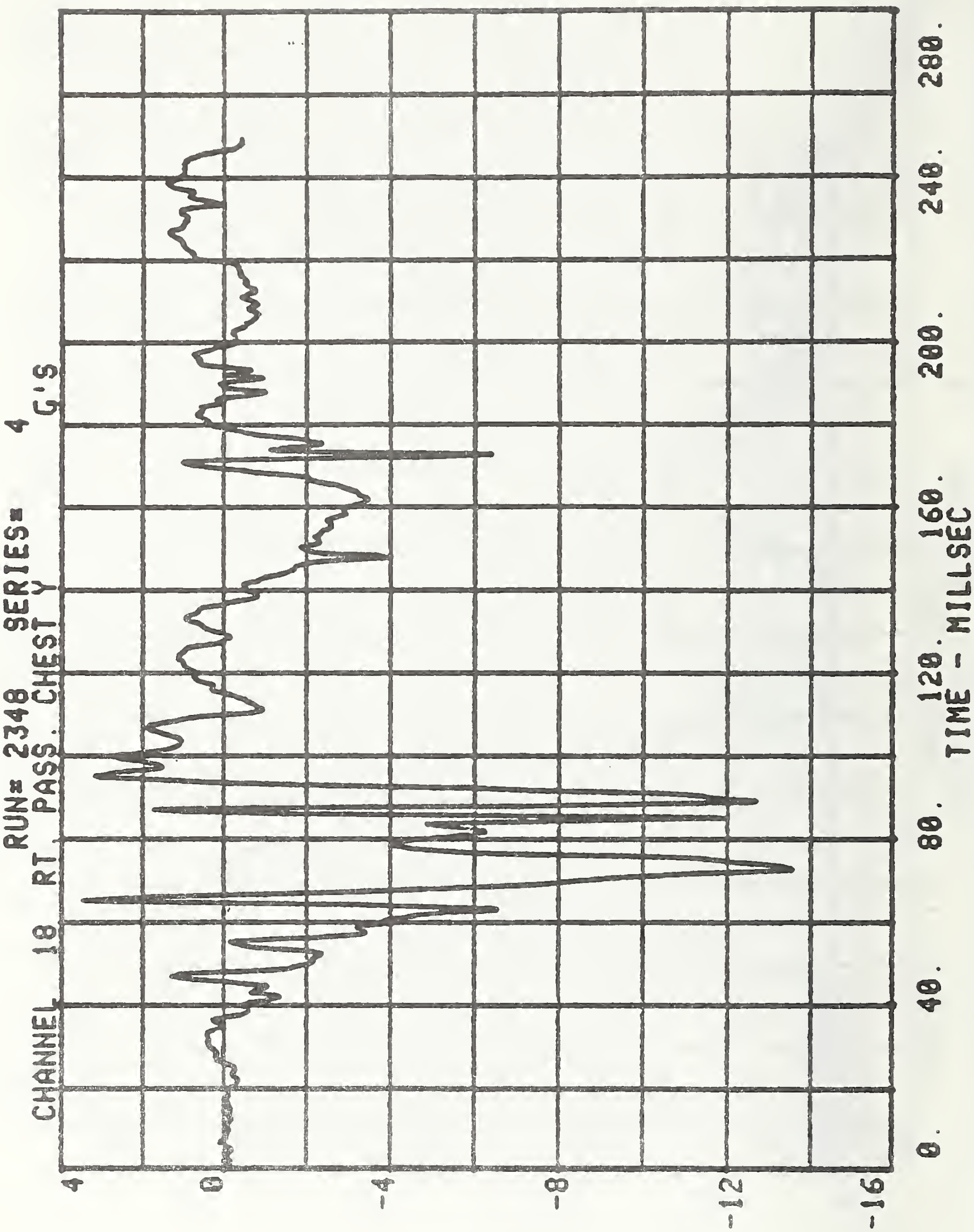

CHANNEL 15 RT PASS. HEAD Y
RUN= 2348 SERIES= 4
G'S
20
10
0
-10
-20
-30
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

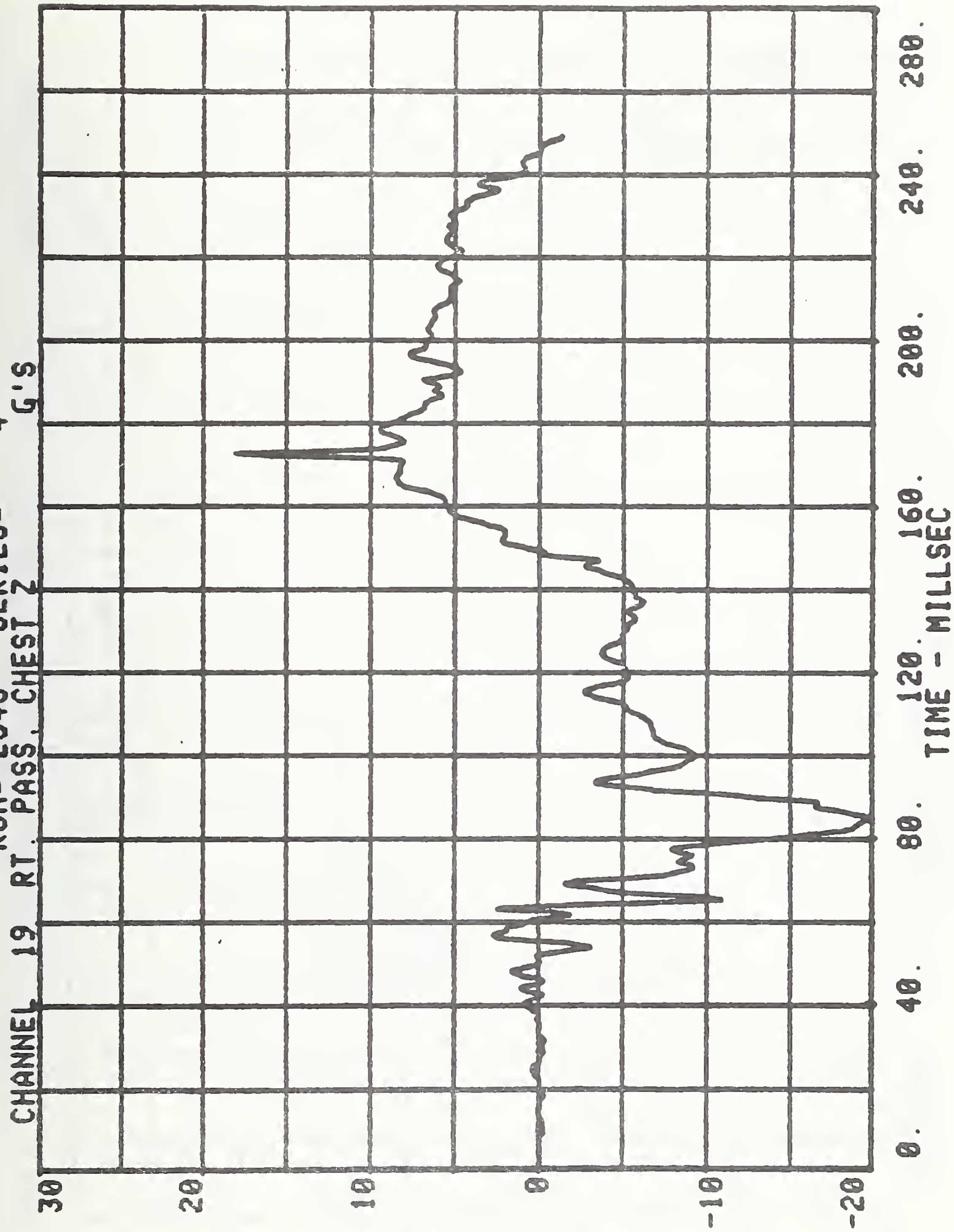


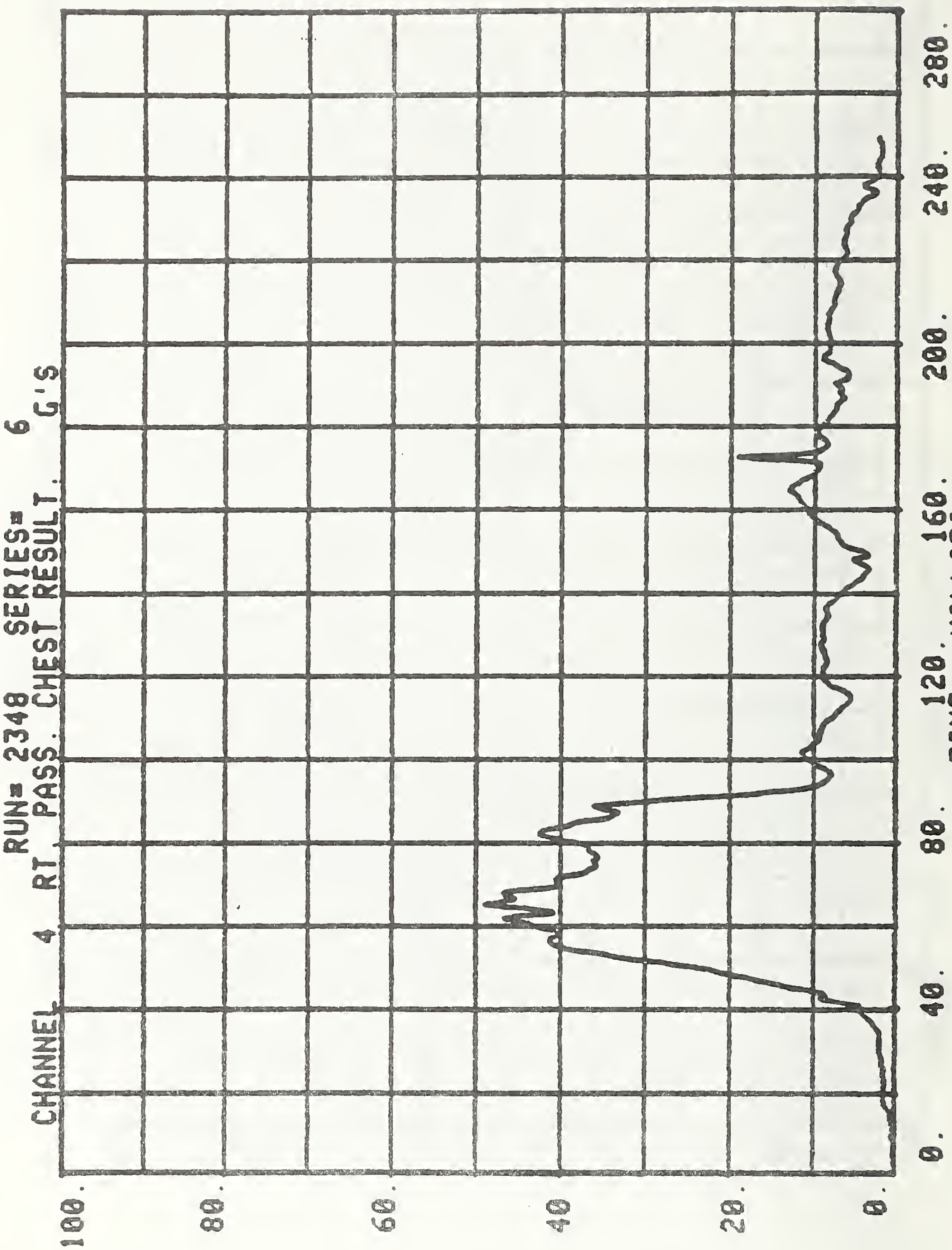
RUN= 2348 SERIES= 4
CHANNEL 16 RT PASS. HEAD Z
G'S
80
60
40
20
0
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

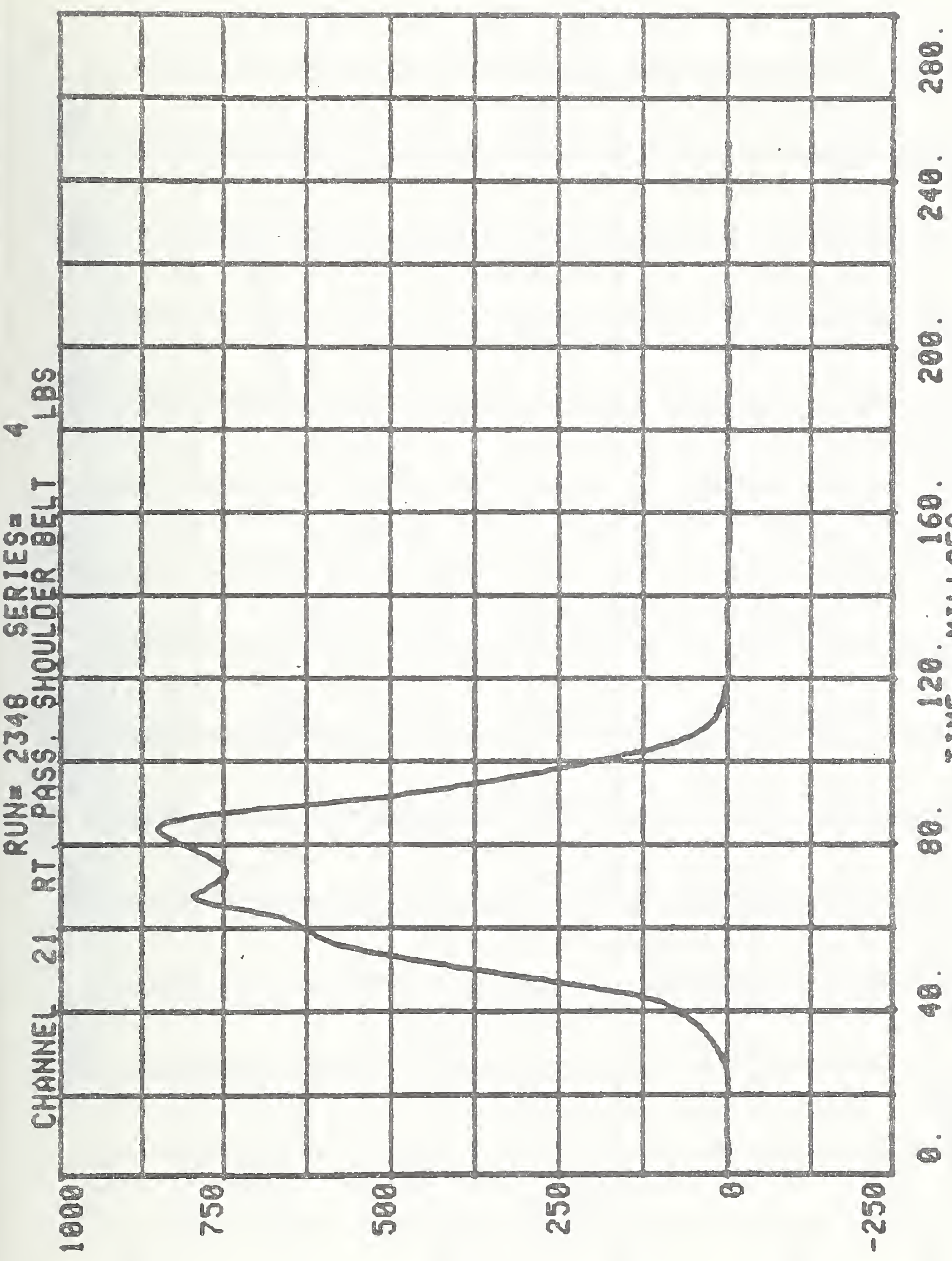

CHANNEL 3 RUN= 2348 SERIES= 6
RT. PASS. HEAD RESULT. G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100.

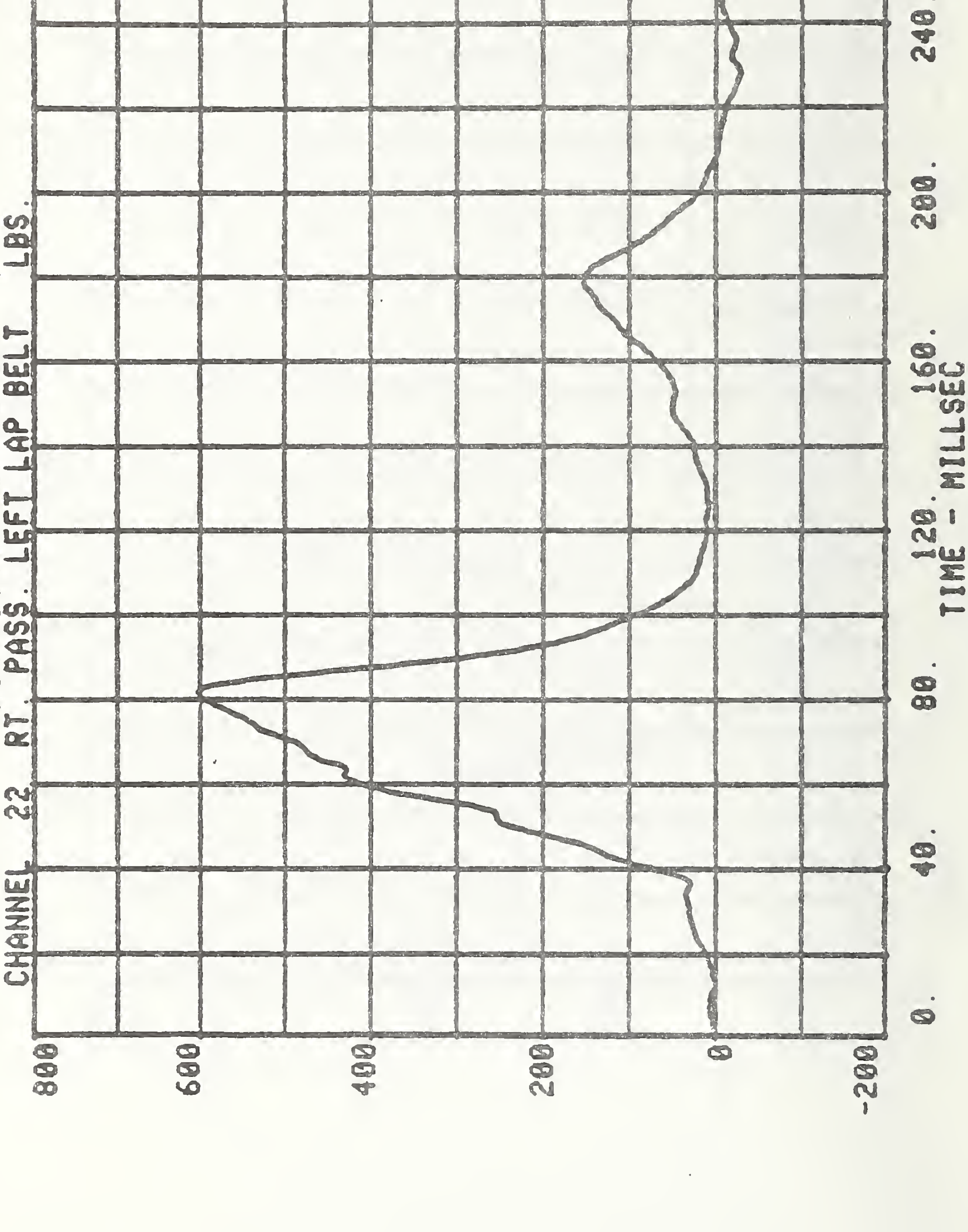

CHANNEL 17 RUN= 2348 SERIES= 4
RT PASS. CHEST X G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
15 0 -15 -30 -45 -60

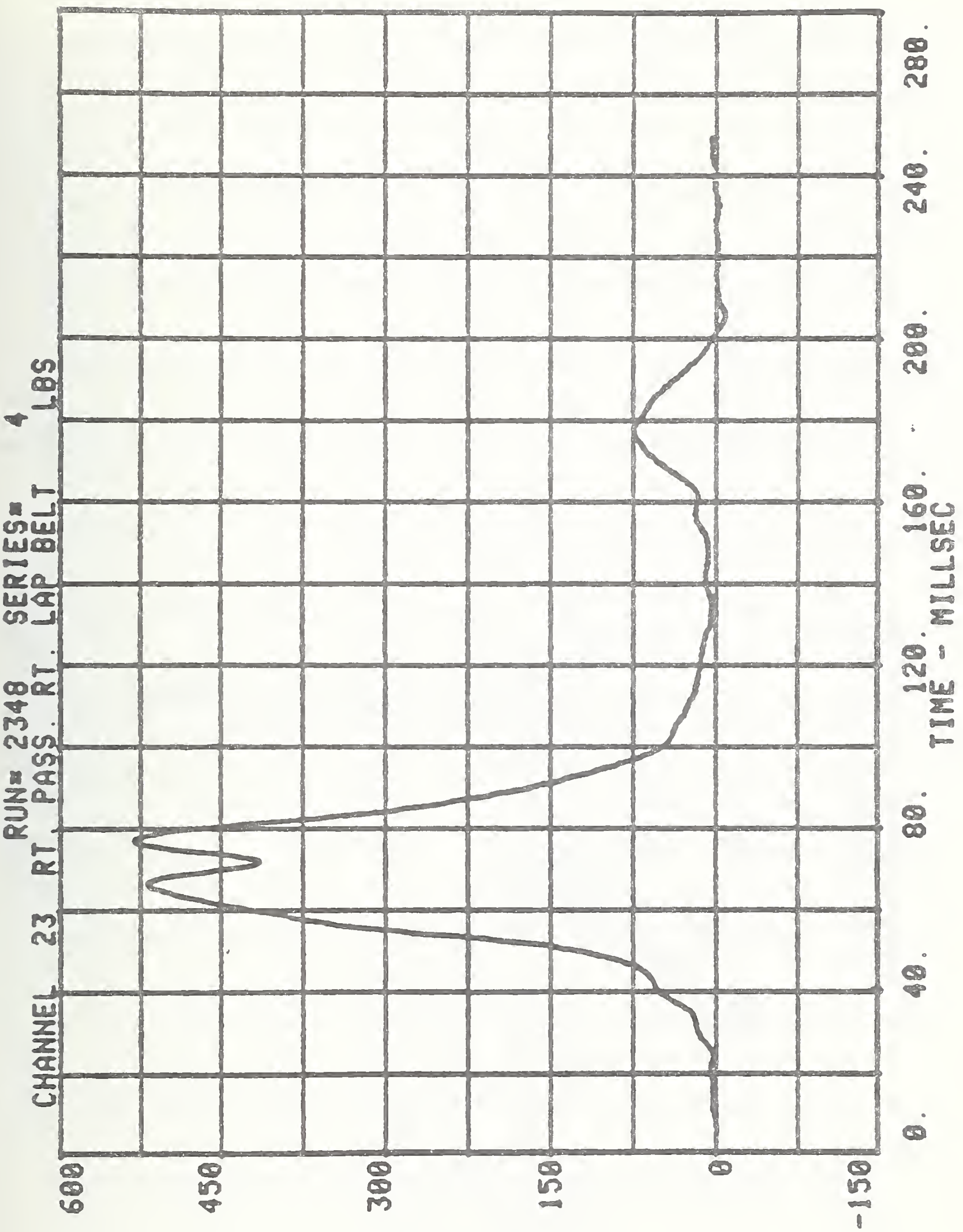

CHANNEL 18 RUN= 2348 SERIES= 4
RT. PASS. CHEST Y G'S
4
0
-4
-8
-12
-16
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 19 RUN= 2348 SERIES= 4
RT. PASS. CHEST Z G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
30 20 10 0 -10 -20


CHANNEL 4 RUN= 2348 SERIES= 6
RT. PASS. CHEST RESULT. G'S
100.
80.
60.
40
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 21 RUN= 2348 SERIES= 4
RT PASS. SHOULDER BELT LBS
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
1000 750 500 250 0 -250


CHANNEL 22 RUN= 234B SERIES= 4
RT. PASS. LEFT LAP BELT LBS.
800
600
400
200
0
-200
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 23 RUN= 2348 SERIES= 4
RT. PASS. RT. LAP BELT LBS
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER

RUN=2348

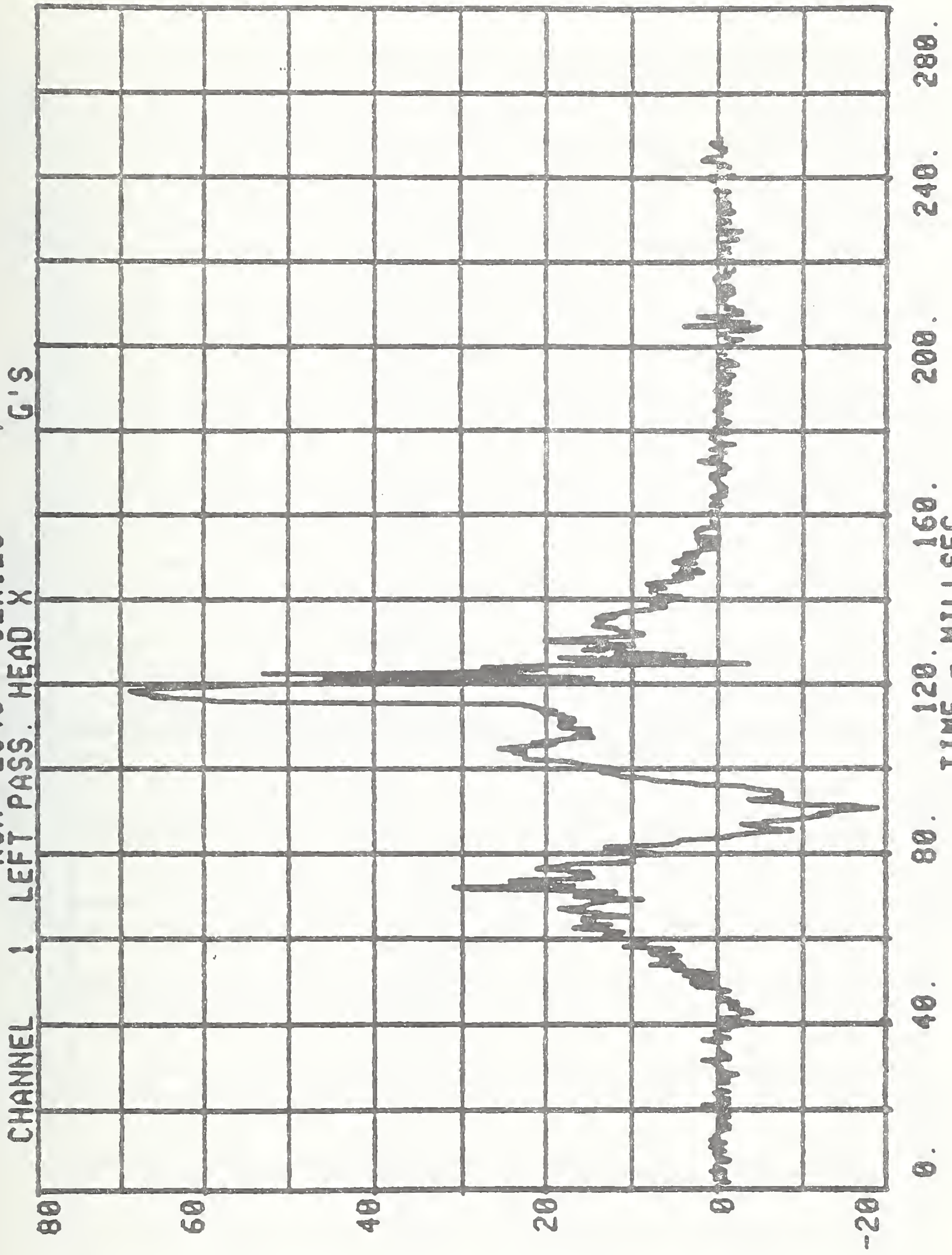
LEFT PASS. HEAD RESULT.

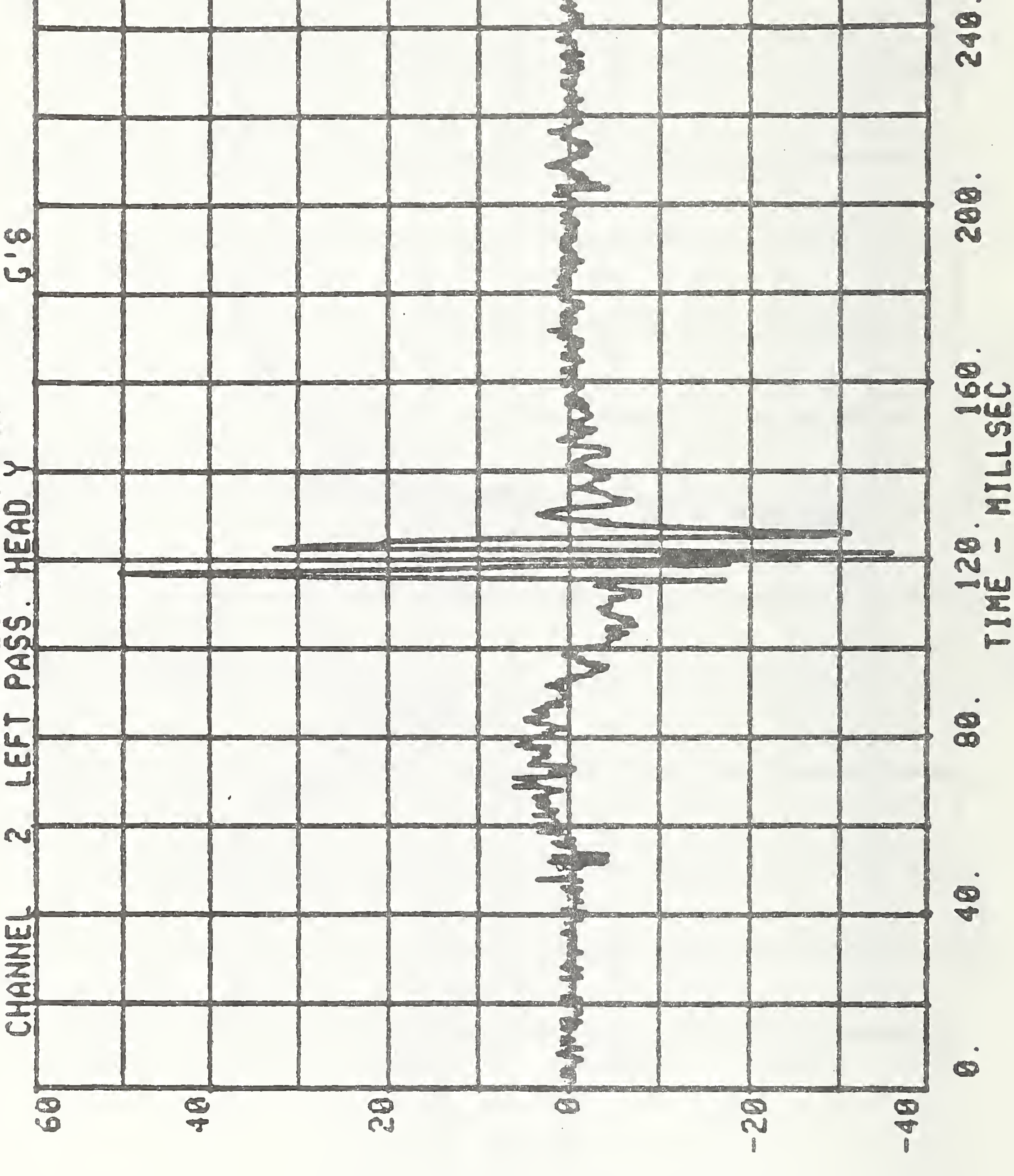
HIC=1314.9 FROM T1= .05730 TO T2= .12420

AVERAGE ACCELERATION BETWEEN T1 AND T2= 52.2G'S

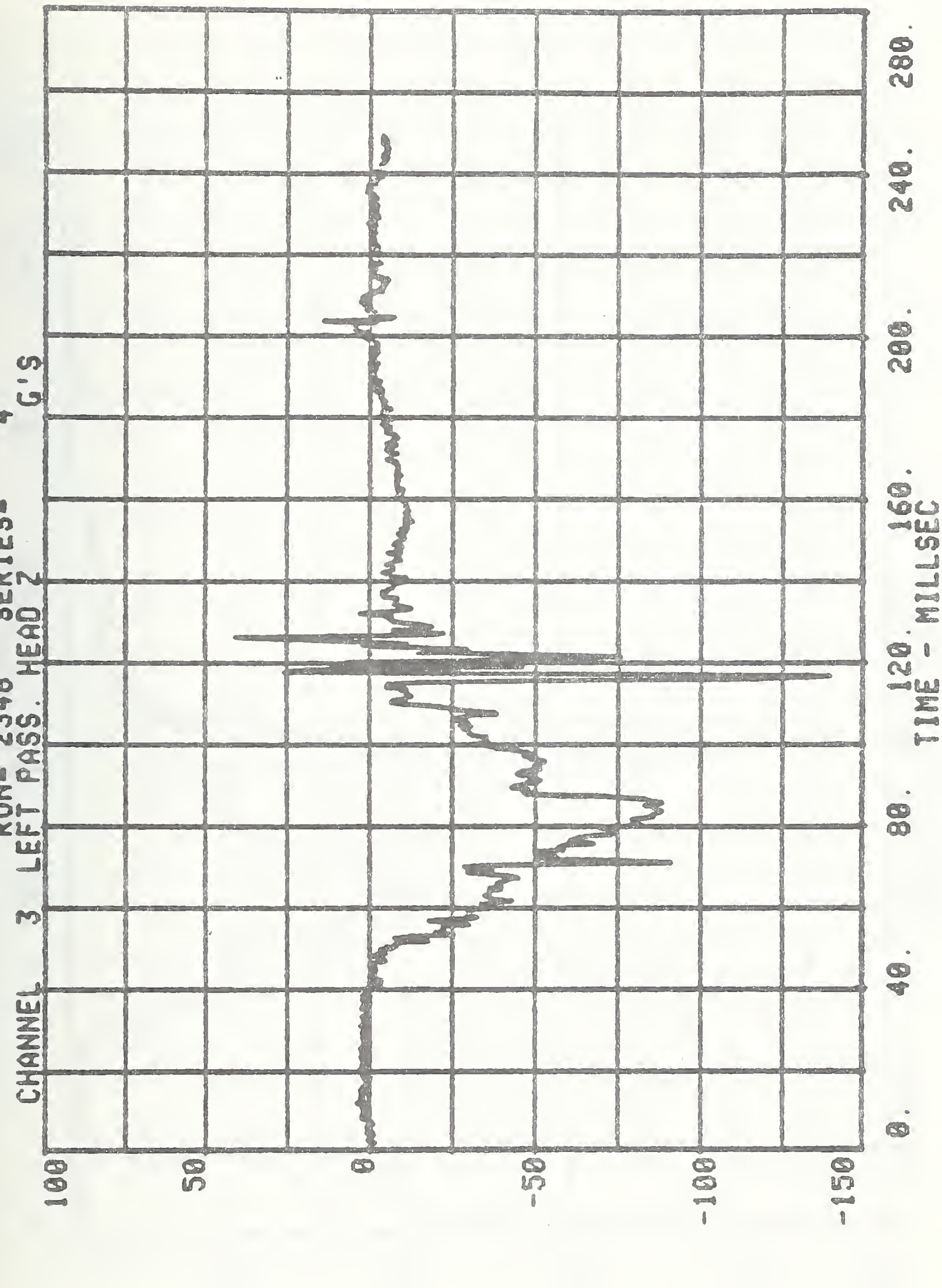
EVENT TIME= 250.0 MSEC

SEVERITY INDEX=1893.8

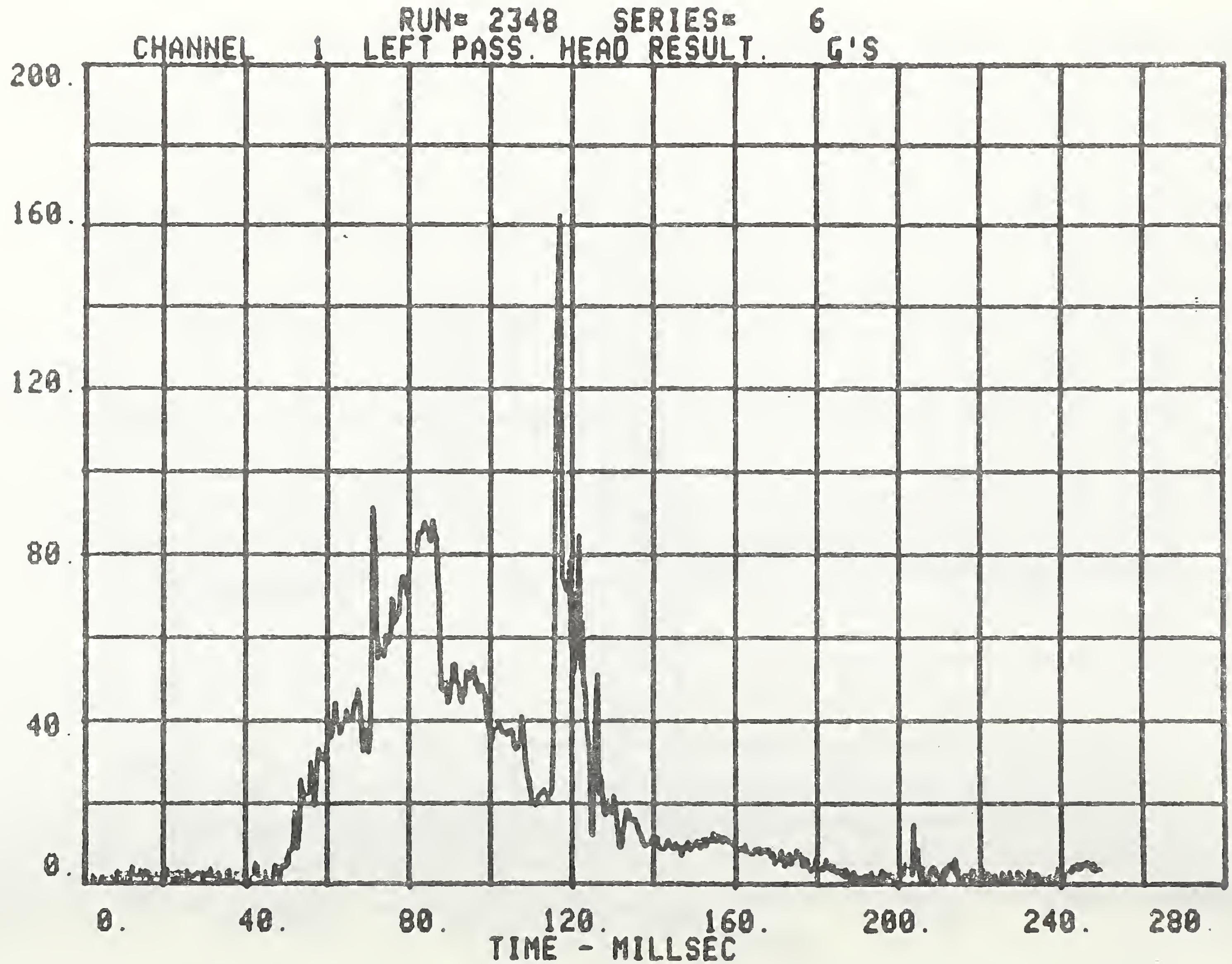

CHANNEL 1 RUN= 2348 SERIES= 4
LEFT PASS. HEAD X G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
80 60 40 20 0 -20

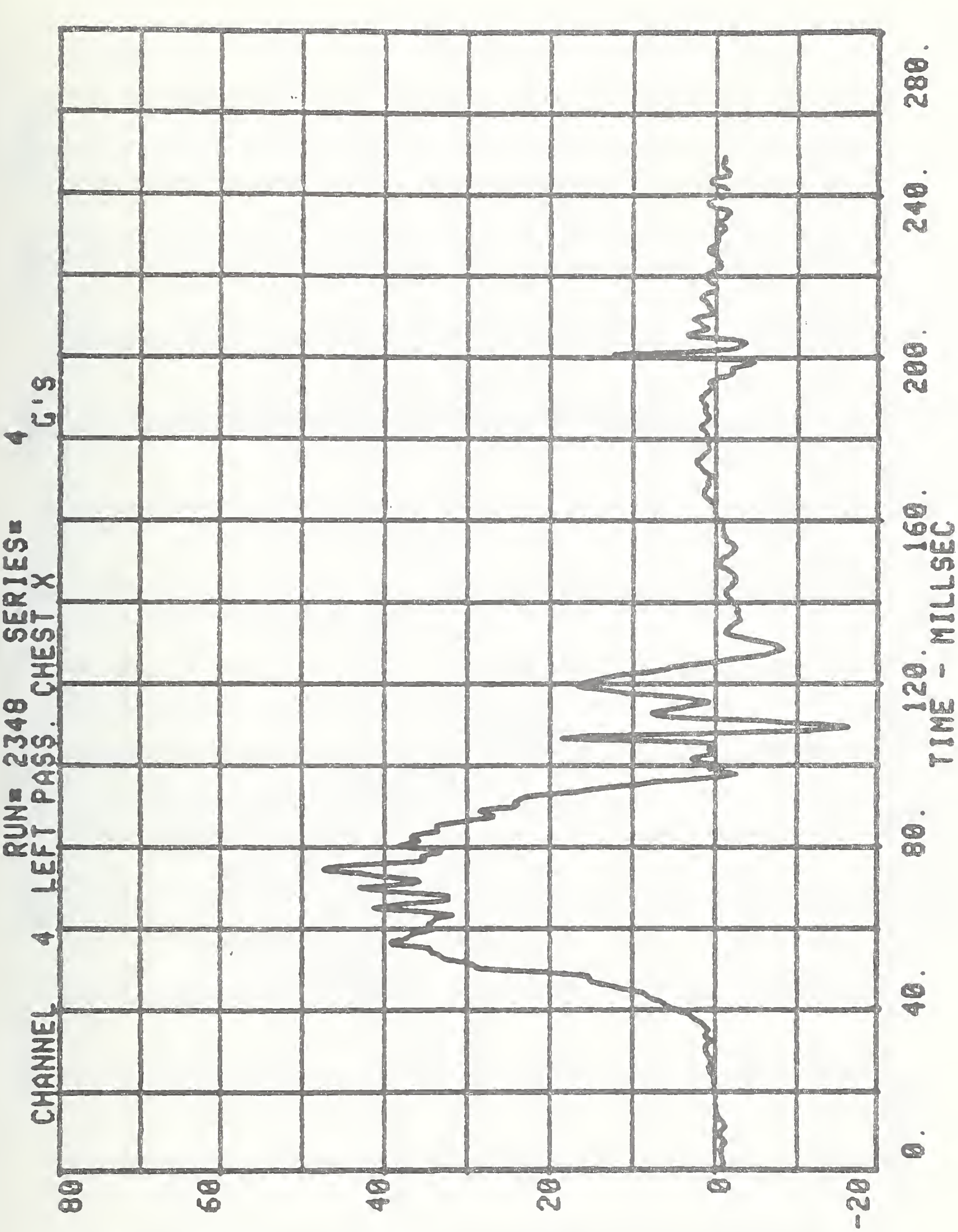


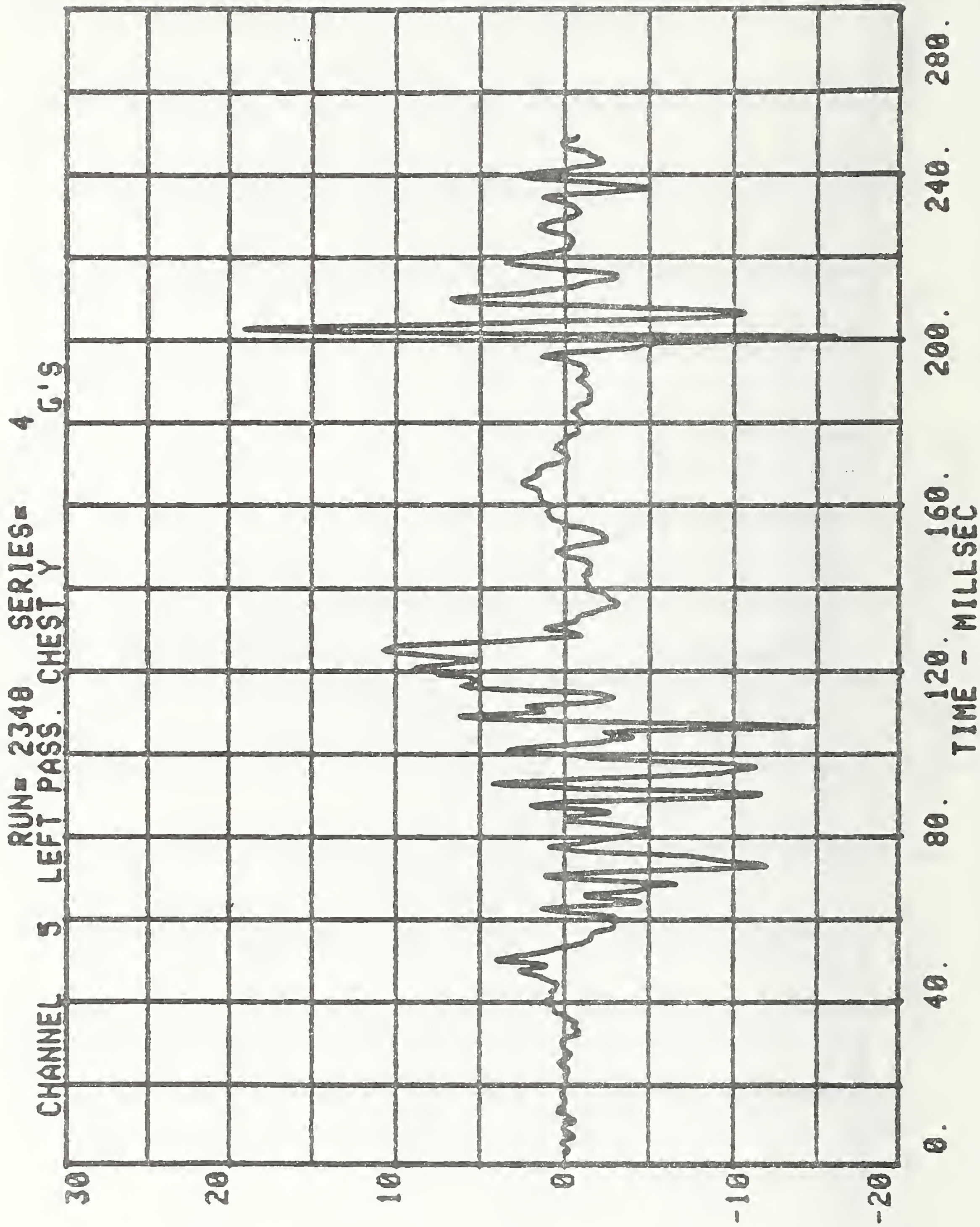
CHANNEL 2 RUN= 2348 SERIES= 4
LEFT PASS. HEAD Y G'S
60
40
20
0
-20
-40
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

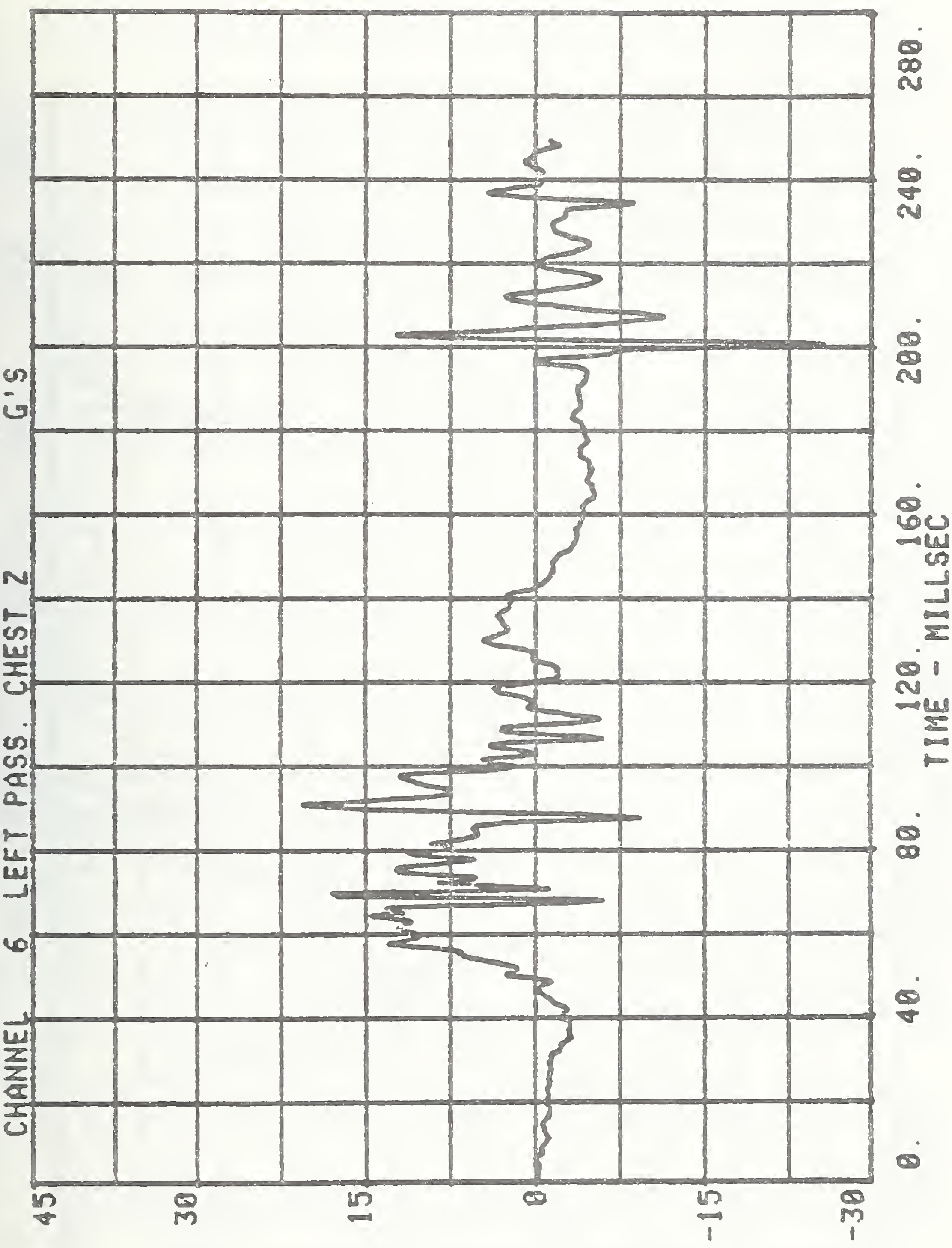


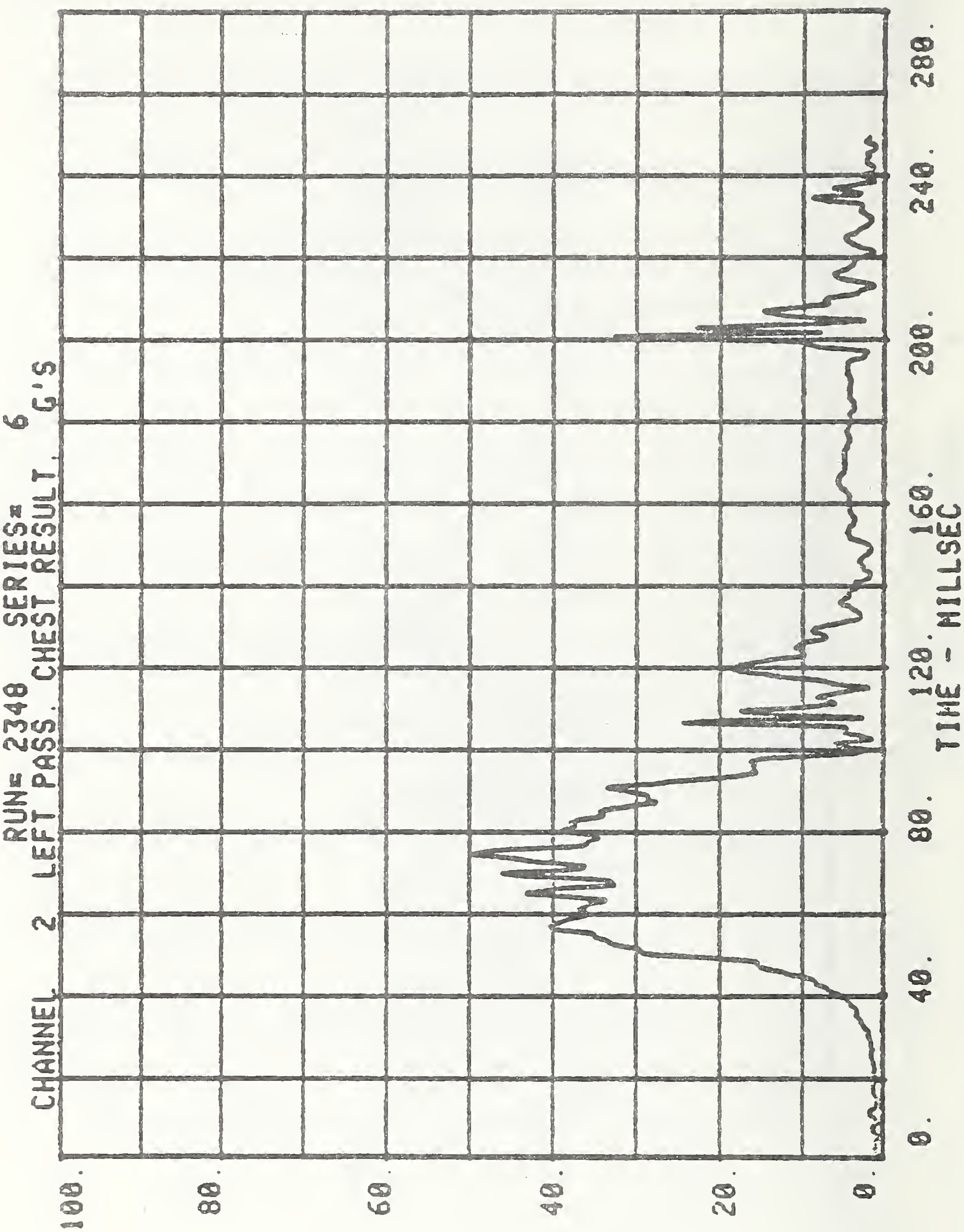
CHANNEL 3 RUN= 2340 SERIES= 4
LEFT PASS. HEAD Z G'S
100
50
0
-50
-100
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

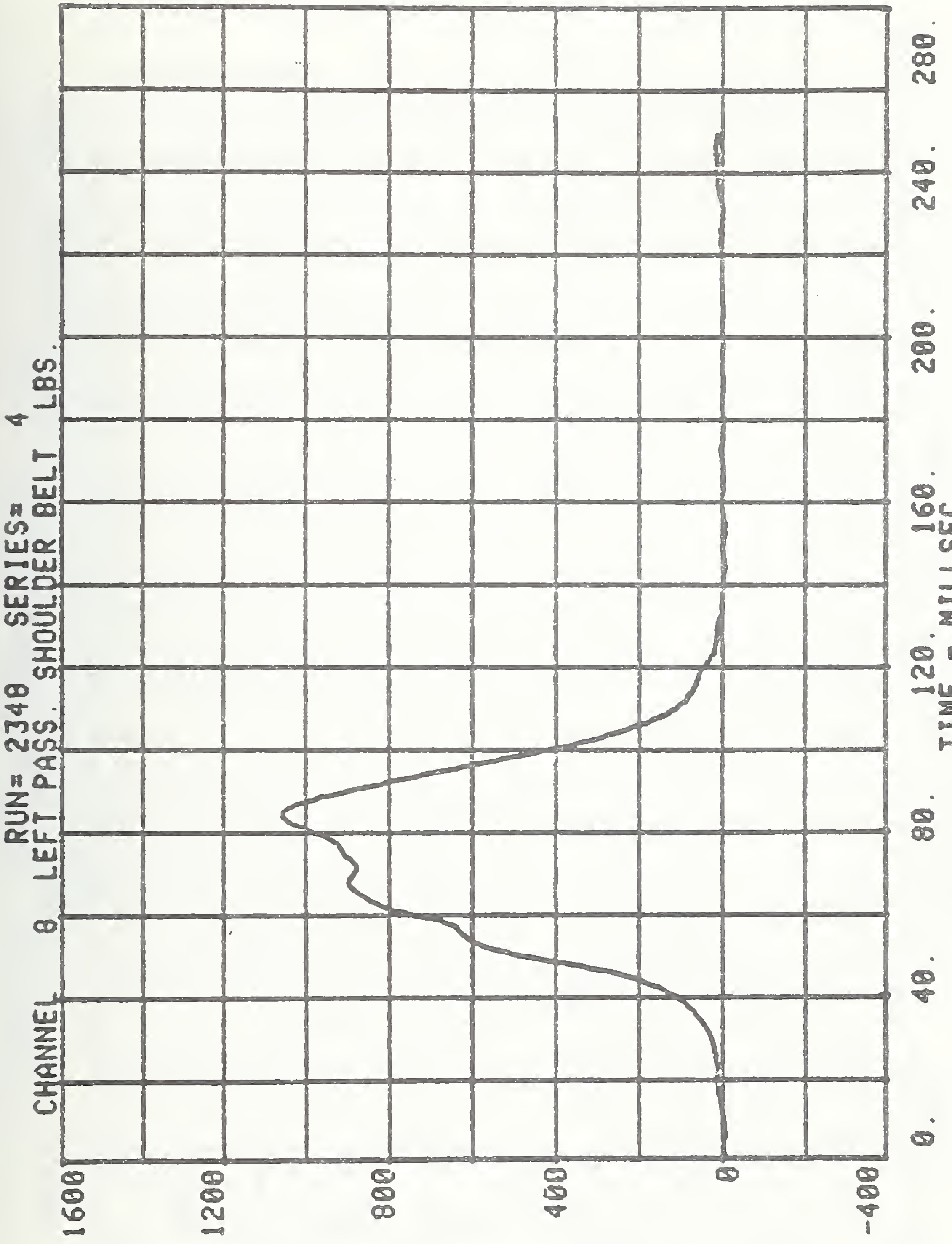

RUN= 2348 SERIES= 6
CHANNEL 1 LEFT PASS. HEAD RESULT. G'S
200.
160.
120.
80.
40.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

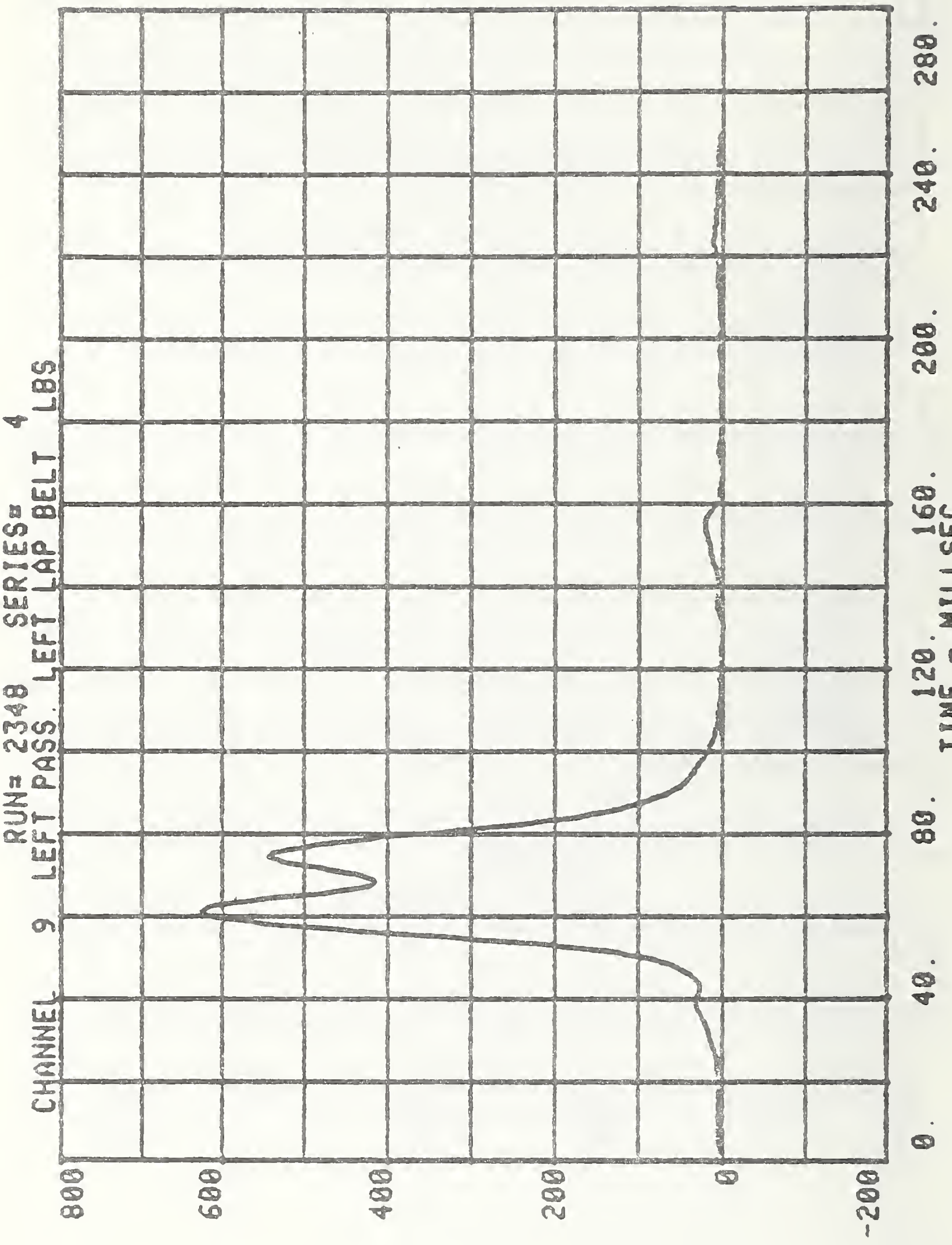

CHANNEL 4 RUN= 2348 SERIES= 4
LEFT PASS. CHEST X G'S
80
60
40
20
0
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

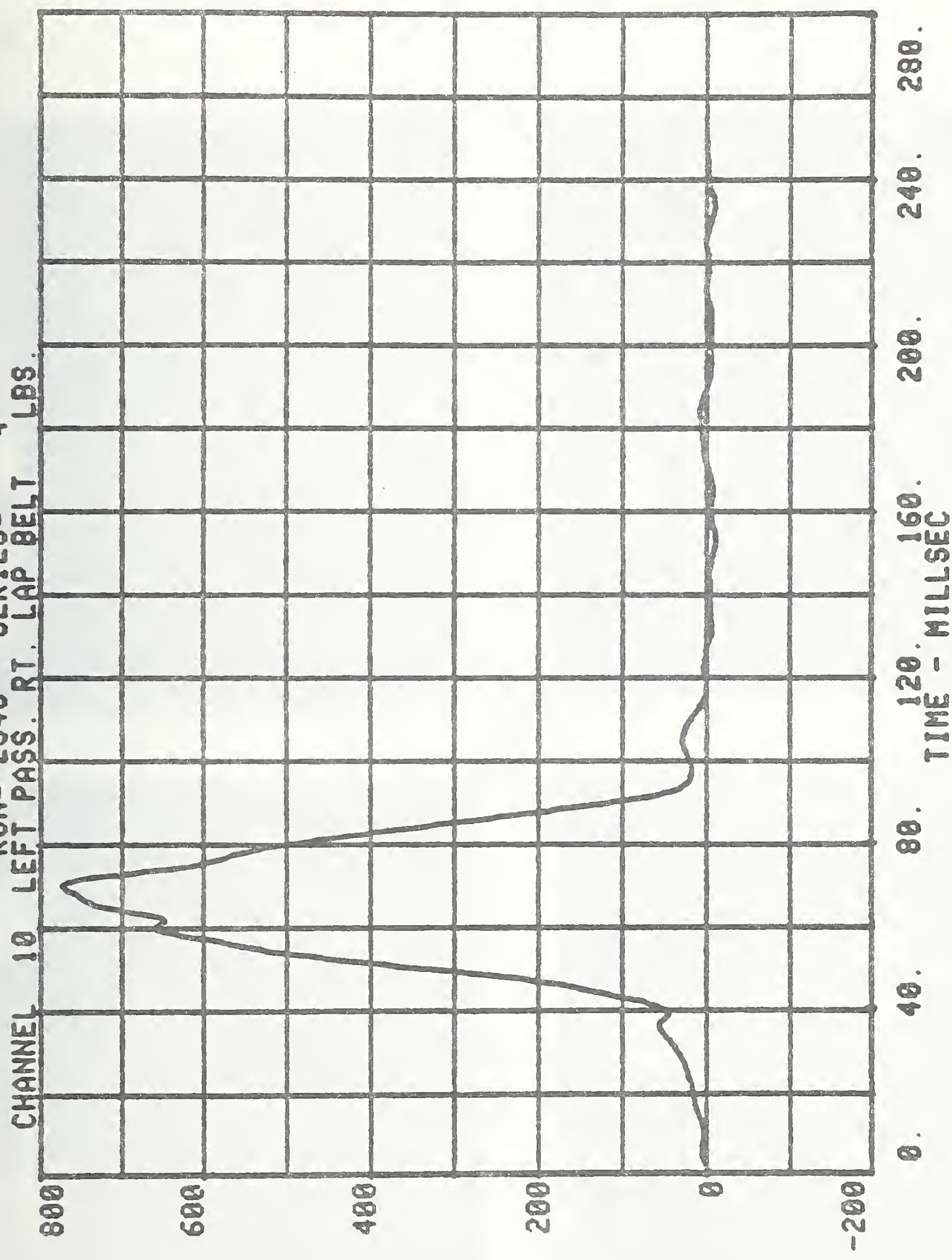

CHANNEL 5 RUN= 2340 SERIES= 4
LEFT PASS. CHEST Y G'S
30
20
10
0
-10
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 6 RUN= 2348 SERIES= 4
LEFT PASS. CHEST Z G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
45
30
15
0
-15
-30


CHANNEL 2 RUN= 2348 SERIES= 6
LEFT PASS. CHEST RESULT. G'S
100.
80.
60.
40.
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 8 RUN= 2348 SERIES= 4
LEFT PASS. SHOULDER BELT LBS.
1600
1200
800
400
0
-400
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

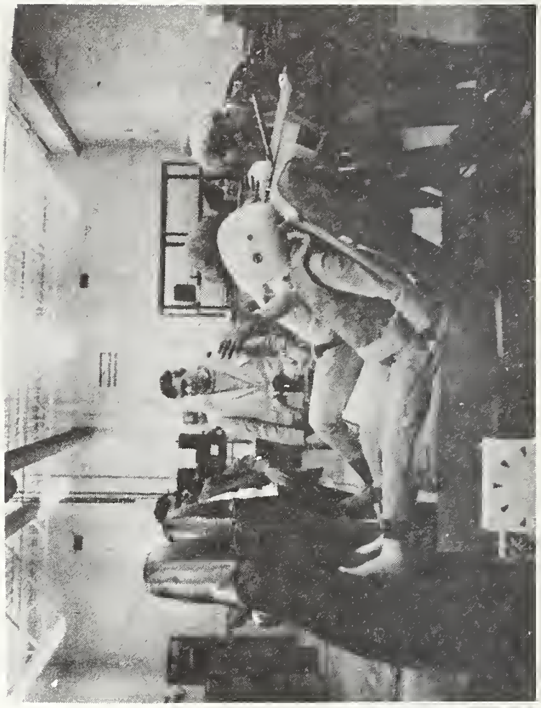

CHANNEL 9 RUN= 2340 SERIES= 4
LEFT PASS. LEFT LAP BELT LBS
800
600
400
200
0
-200
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

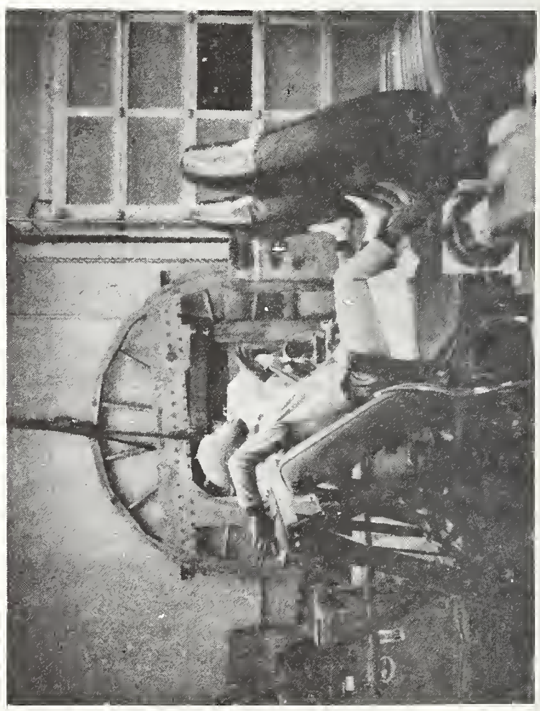


CHANNEL 10 RUN= 2348 SERIES= 4
LEFT PASS. RT. LAP BELT LBS.
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
800 600 400 200 0 -200

PRE-TEST

POST-TEST
RUN 2389



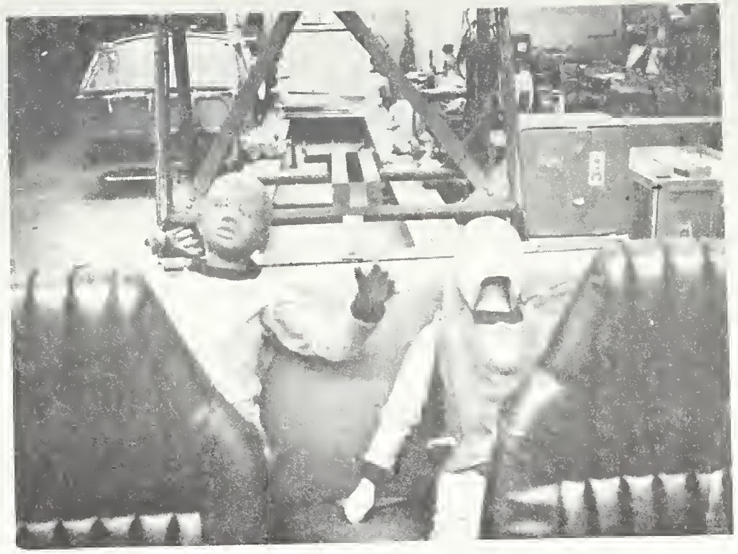


ALDERSON S/N 49

TNO

ALDERSON S/N 49 TNO

PRE-TEST



ALDERSON S/N 49 TNO

POST-TEST

RUN 2389

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #1

RUN=2389

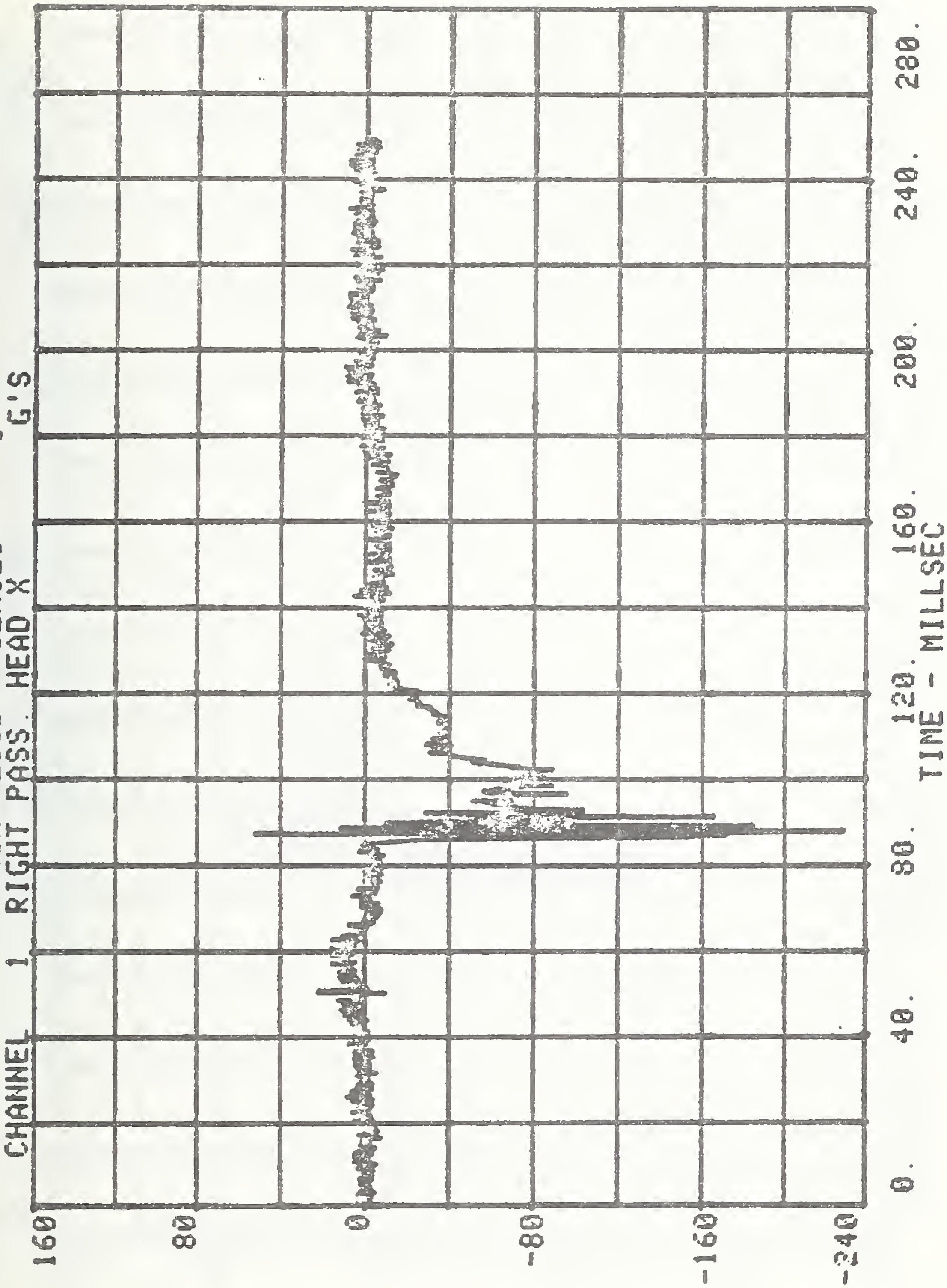
RIGHT PASS. HEAD RESULT.

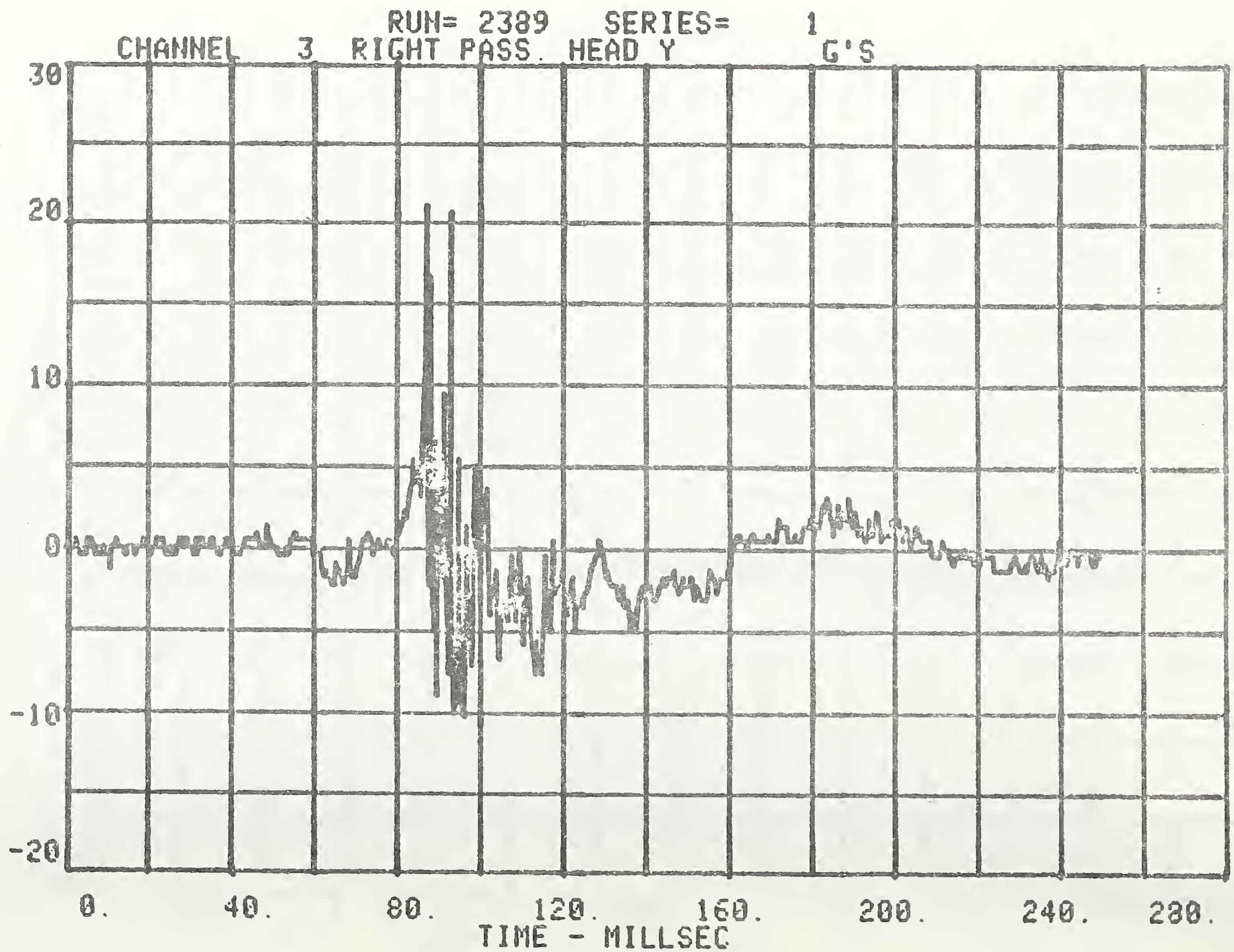
HIC=2625.6   FROM T1= .07650   TO T2= .10350

AVERAGE ACCELERATION BETWEEN T1 AND T2= 98.9G'S

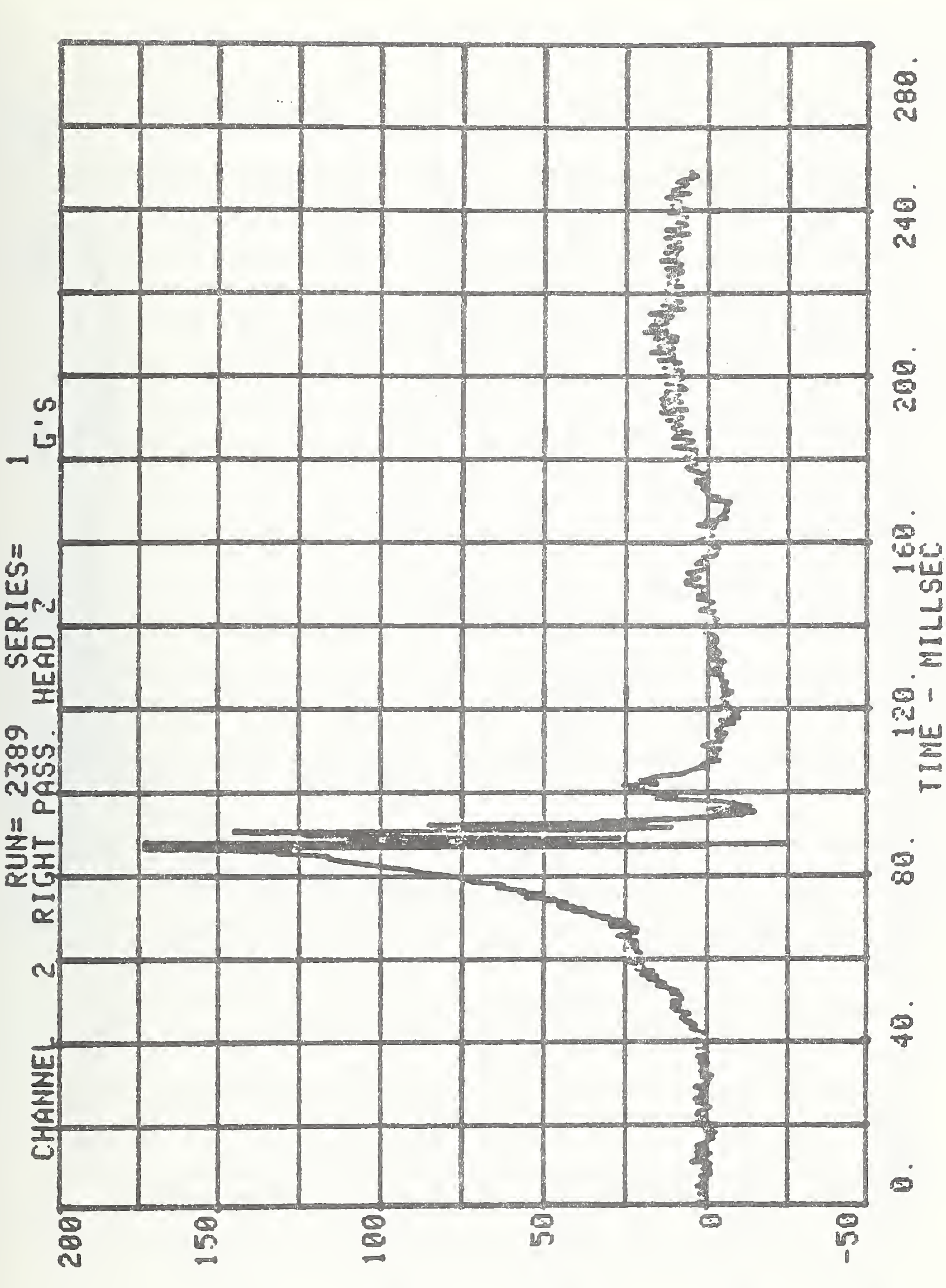
EVENT TIME= 250.0 MSEC

SEVERITY INDEX=4035.6

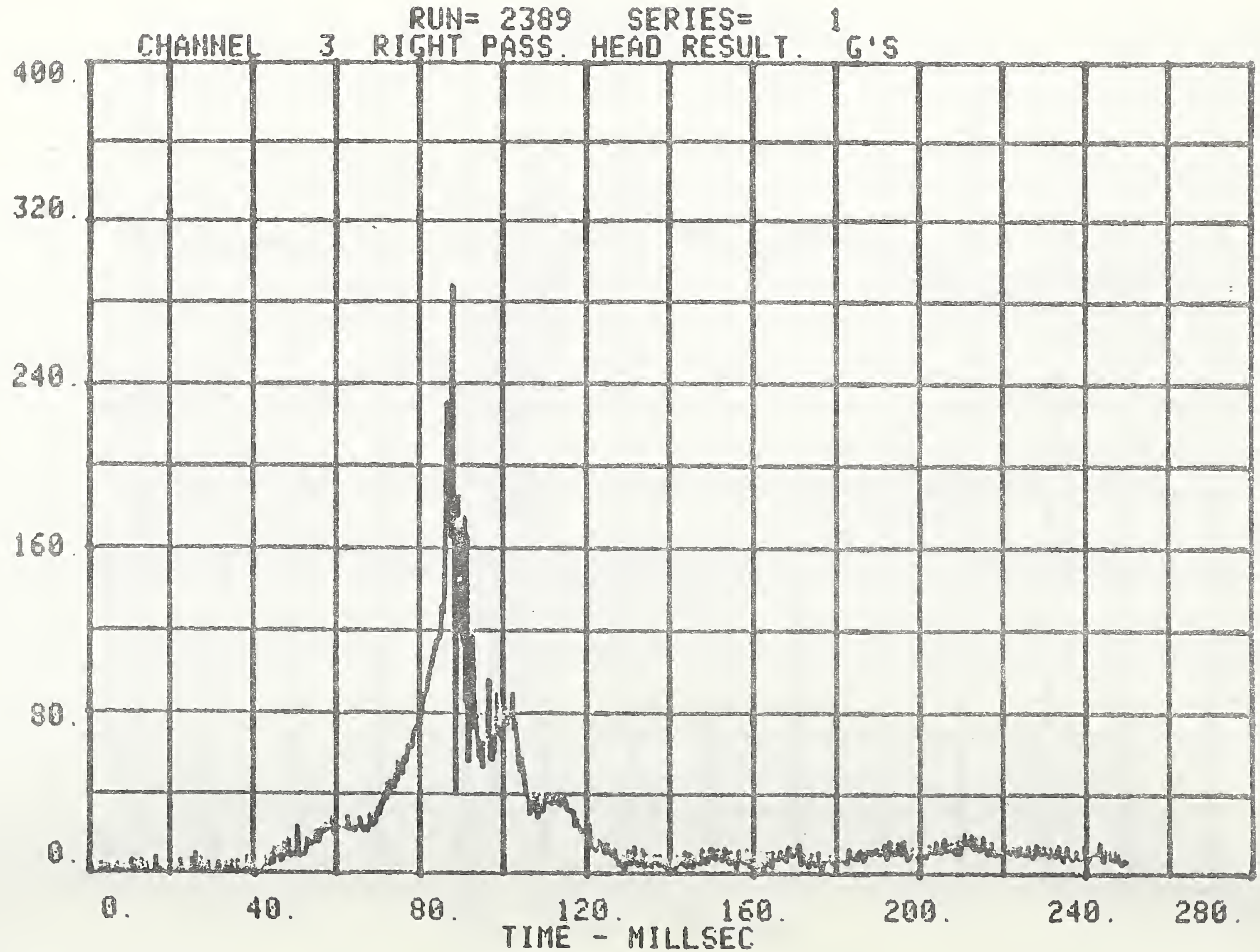

CHANNEL 1 RUN= 2389 SERIES= 1
RIGHT PASS. HEAD X G'S
160
80
0
-80
-160
-240
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

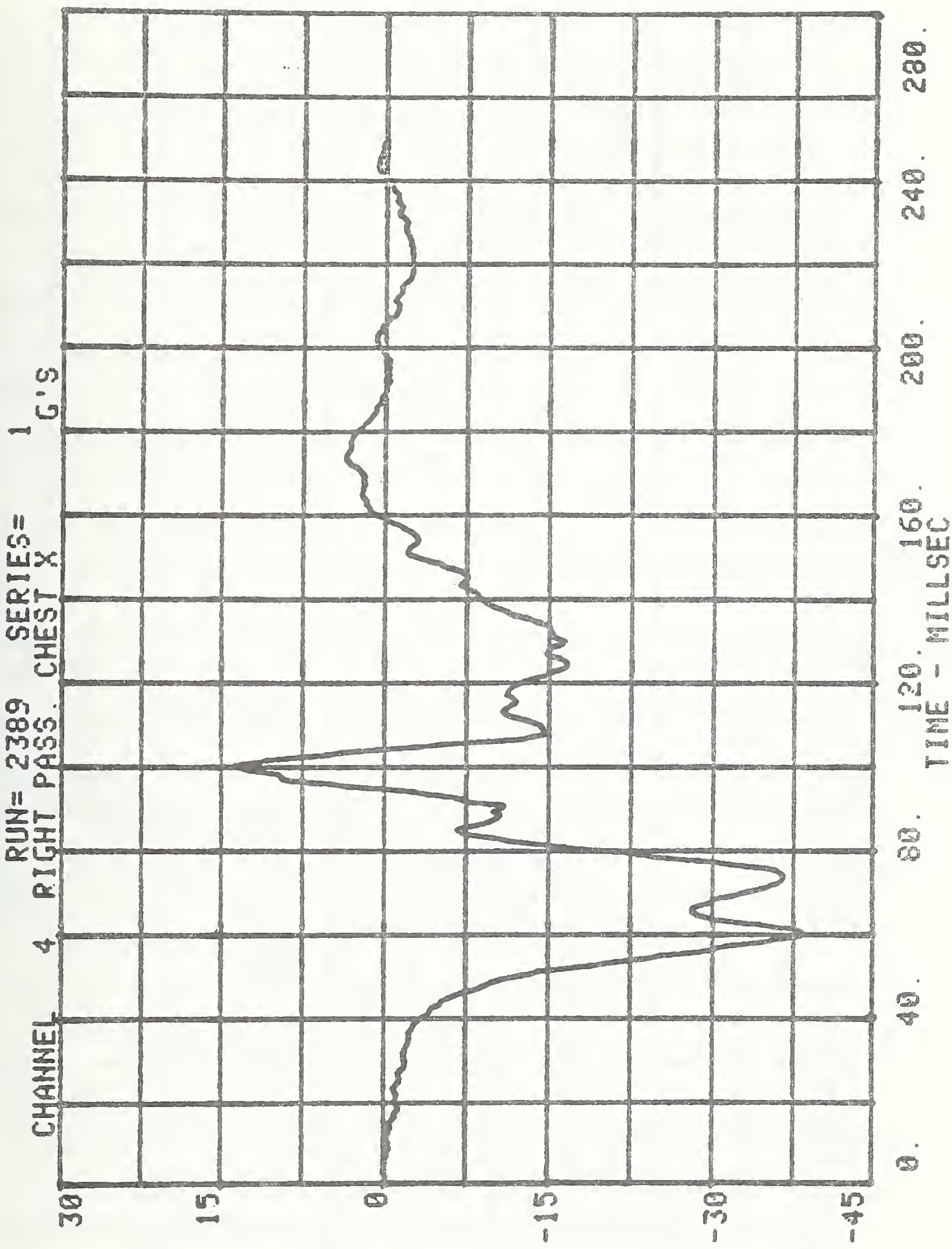


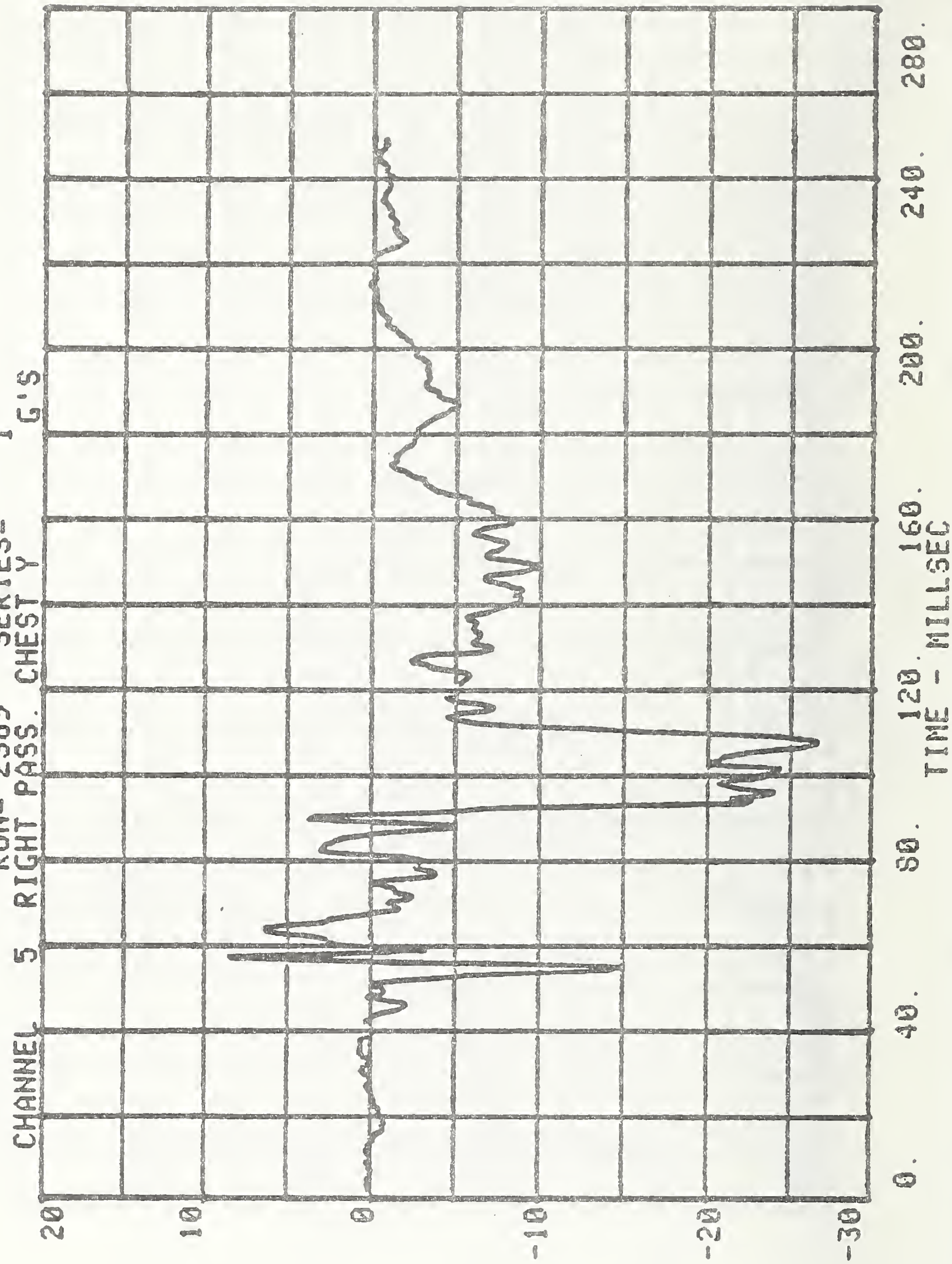
RUN= 2389 SERIES= 1
CHANNEL 3 RIGHT PASS. HEAD Y G'S
30
20
10
0
-10
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

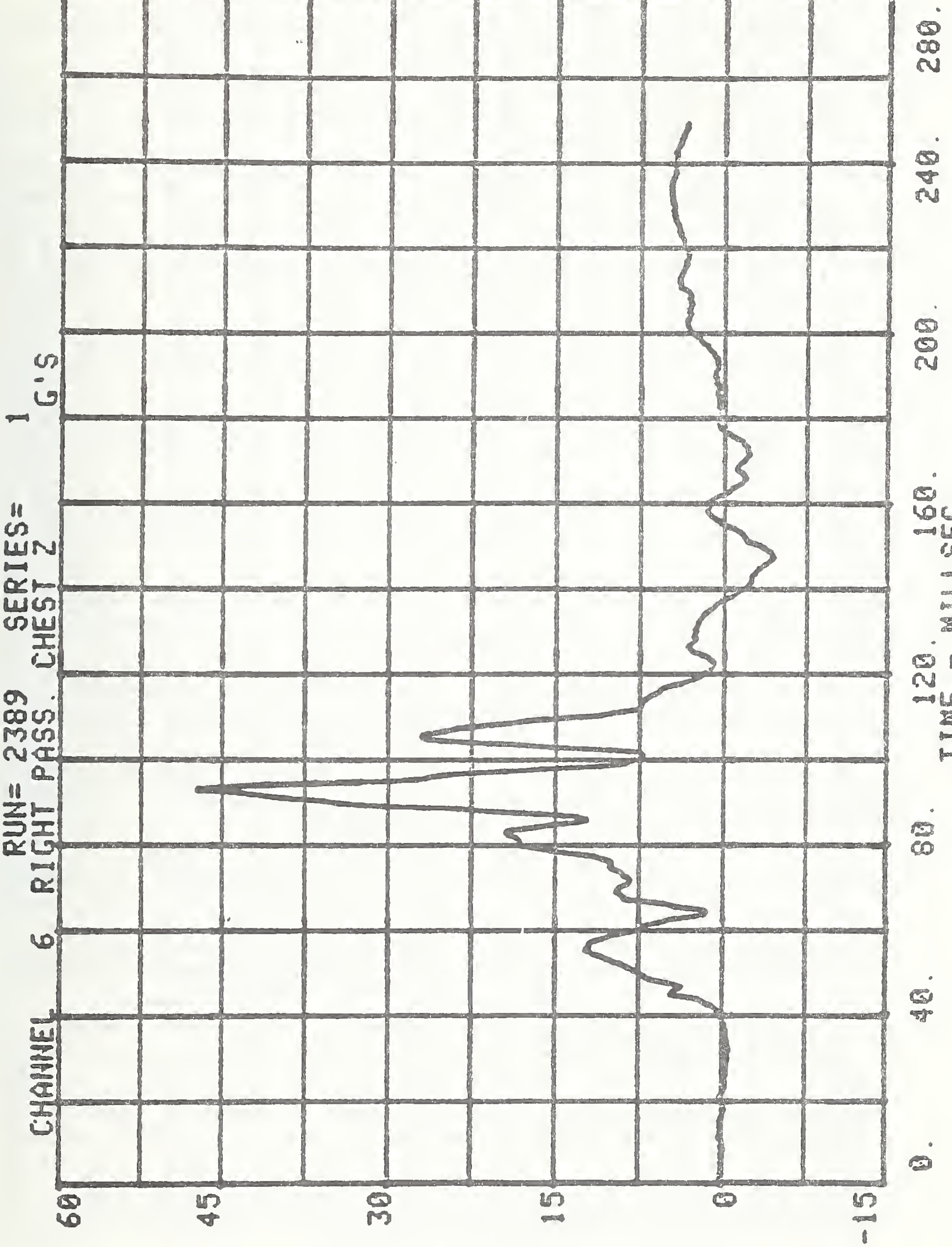


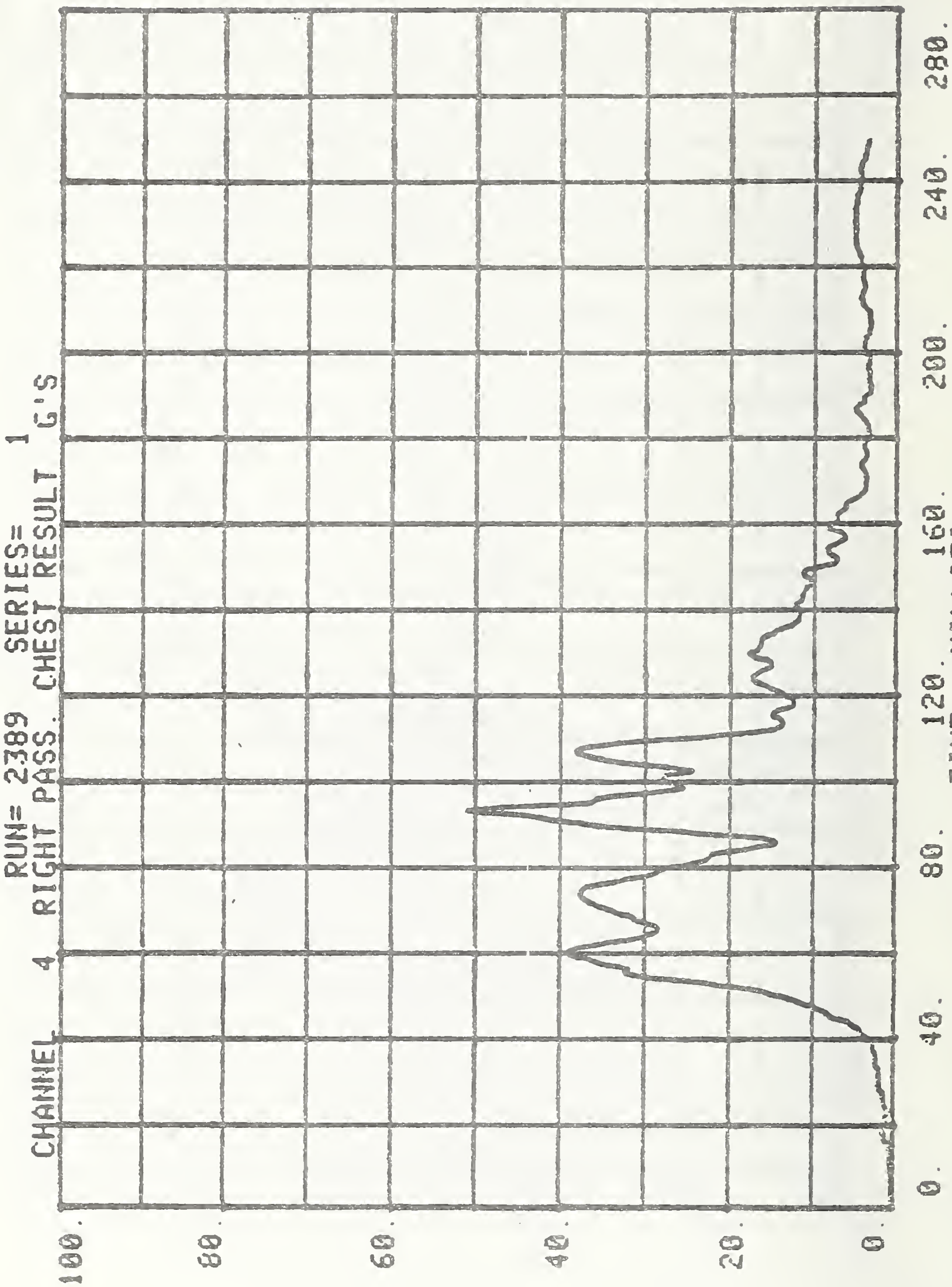
CHANNEL 2
RUN= 2389 SERIES= 1
RIGHT PASS. HEAD
G'S
200
150
100
50
0
-50
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

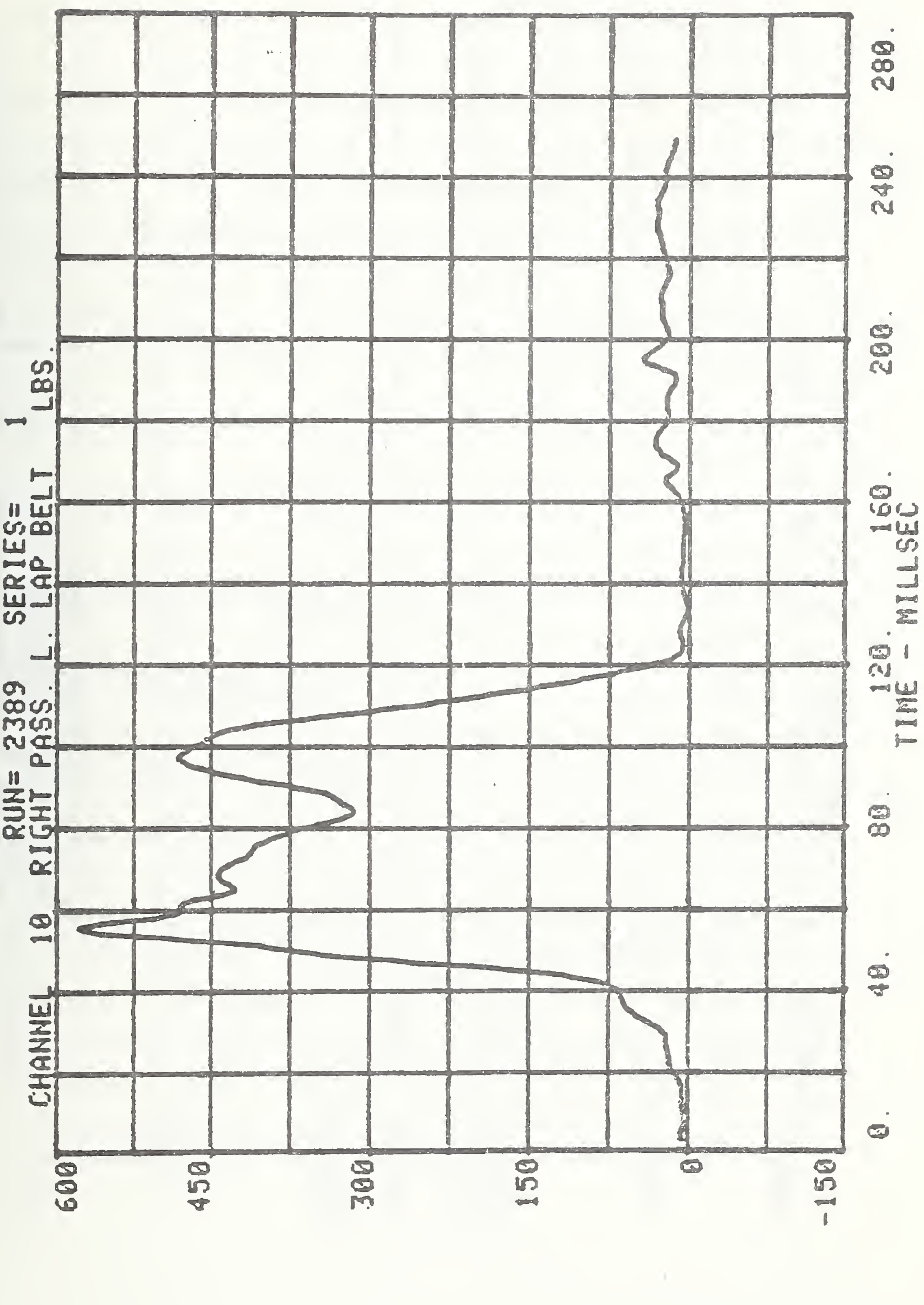

RUN= 2389 SERIES= 1
CHANNEL 3 RIGHT PASS. HEAD RESULT. G'S
400.
320.
240.
160.
80.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

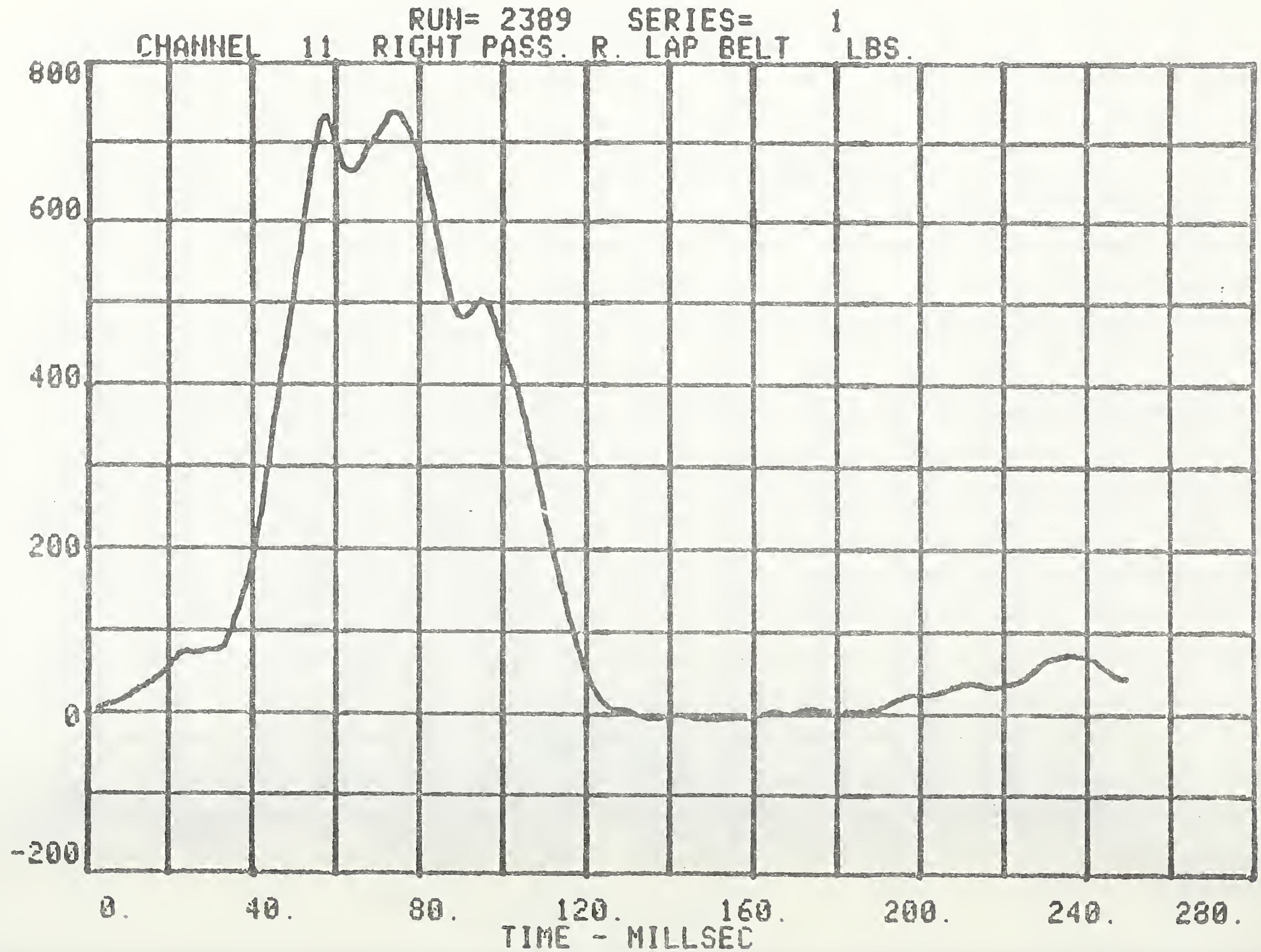

CHANNEL 4 RUN= 2389 SERIES= 1
RIGHT PASS. CHEST X G'S
30
15
0
-15
-30
-45
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 5 RUN= 2389 SERIES= 1
RIGHT PASS. CHEST Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
20 10 0 -10 -20 -30


CHANNEL 6 RUN= 2389 SERIES= 1
RIGHT PASS. CHEST Z G'S
60
45
30
15
0
-15
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 4 RUN= 2389 SERIES= 1
RIGHT PASS. CHEST RESULT G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100.


CHANNEL 10 RUN= 2389 SERIES= 1
RIGHT PASS. L. LAP BELT LBS.
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



RUN= 2389 SERIES= 1
CHANNEL 11 RIGHT PASS. R. LAP BELT LBS.
800
600
400
200
0
-200
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #1

RUN=2389

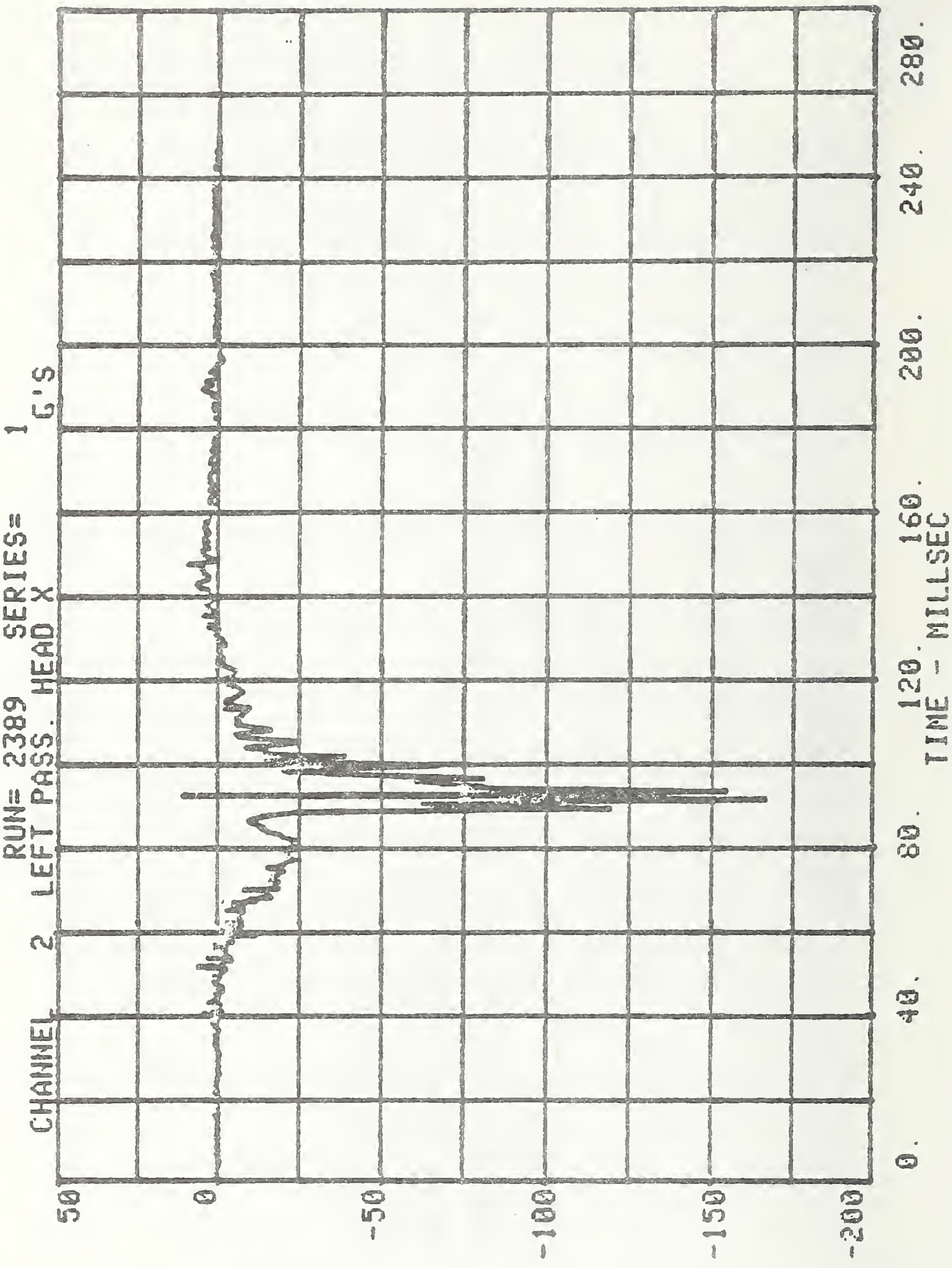
LEFT PASS. HEAD RESULT.

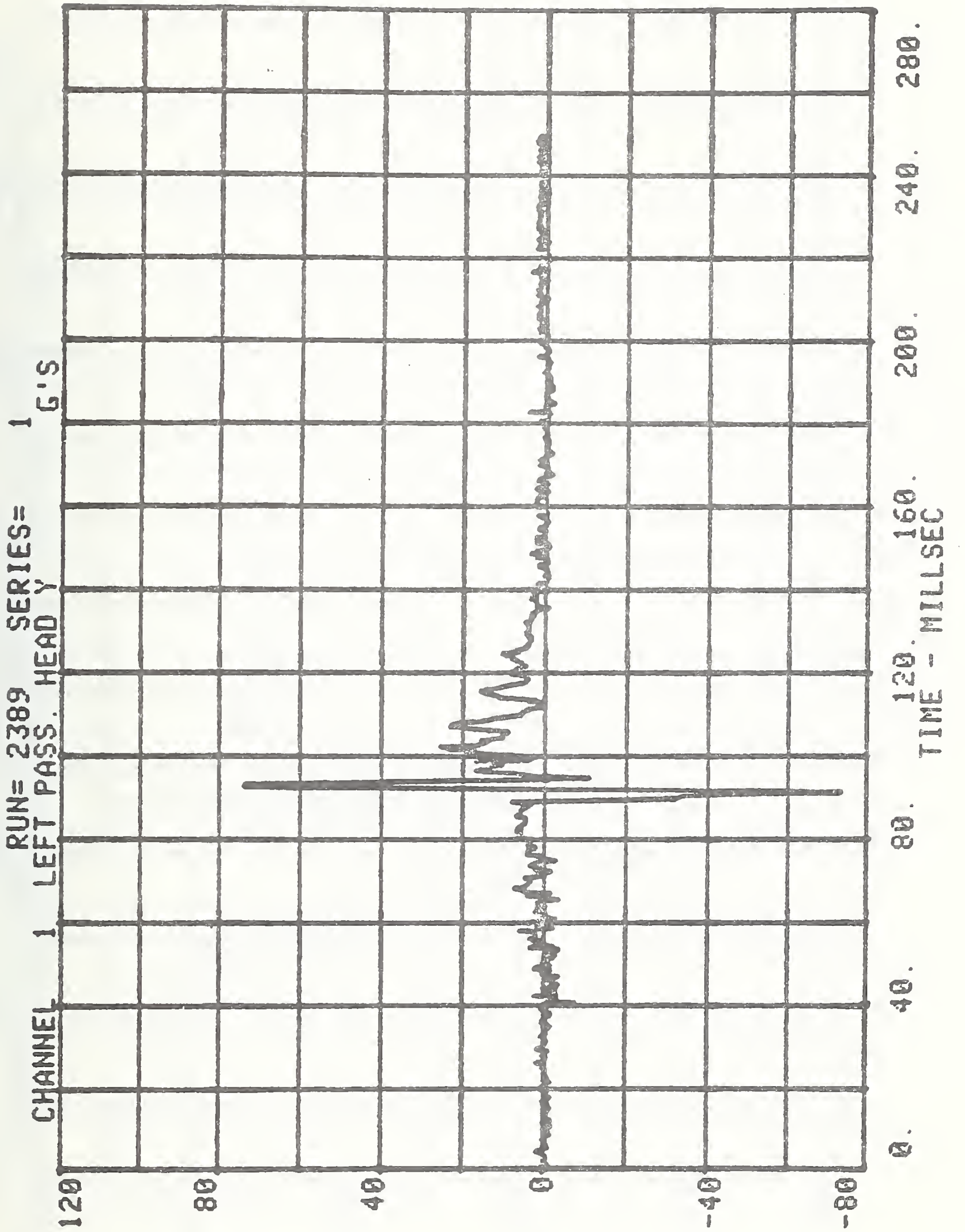
HIC=1865.5   FROM T1= .06990   TO T2= .10200

AVERAGE ACCELERATION BETWEEN T1 AND T2= 80.5G'S

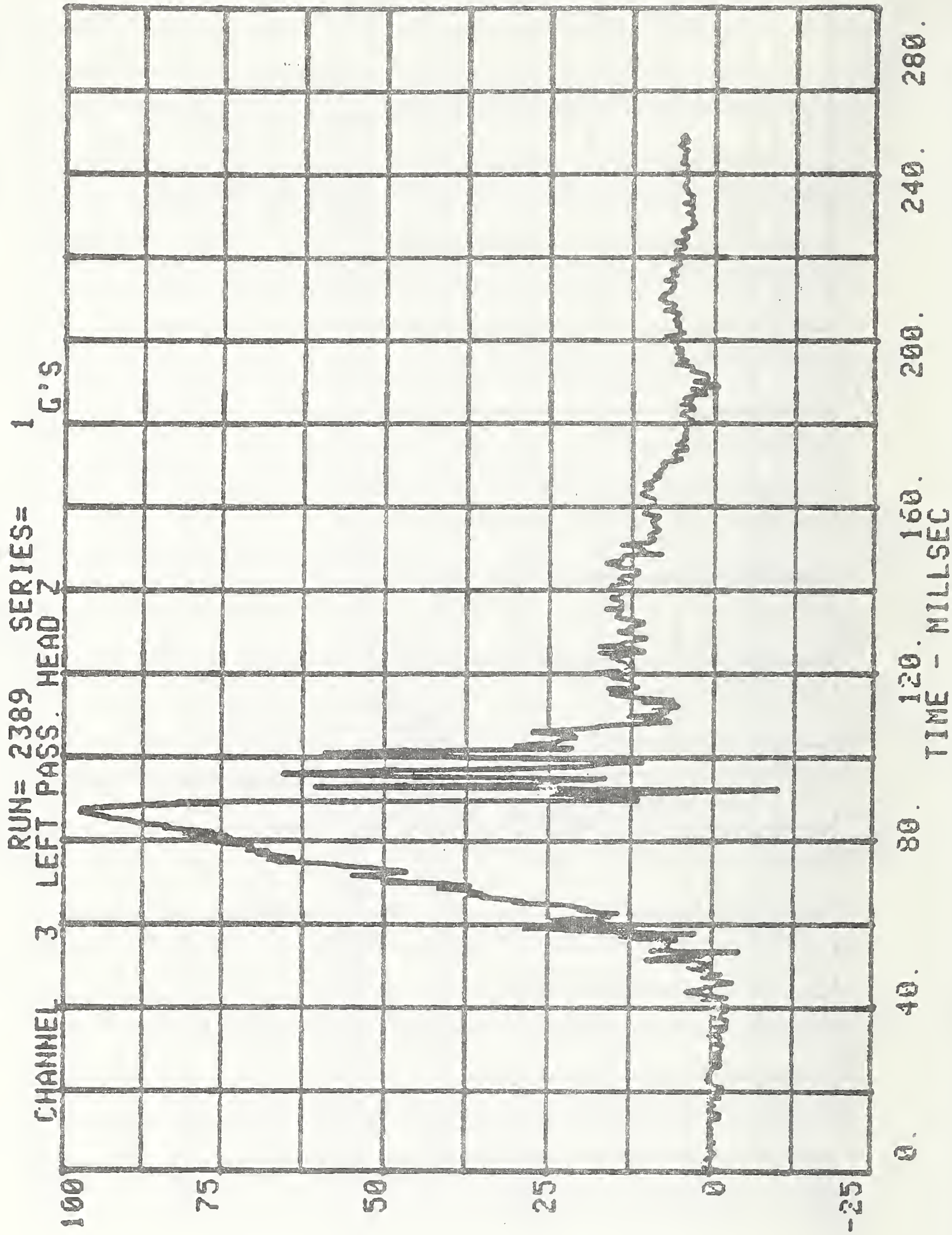
EVENT TIME= 250.0 MSEC

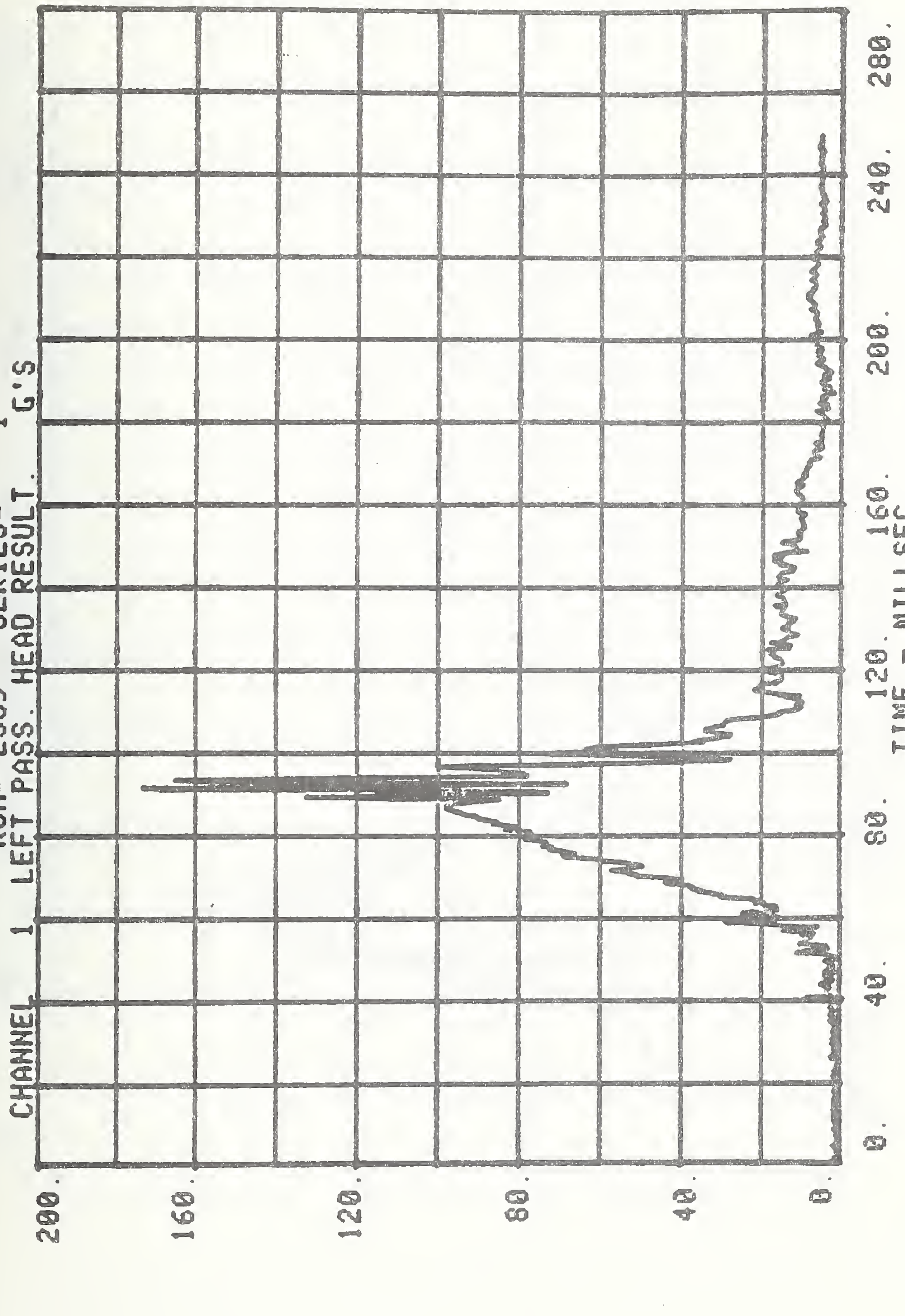
SEVERITY INDEX=2450.4

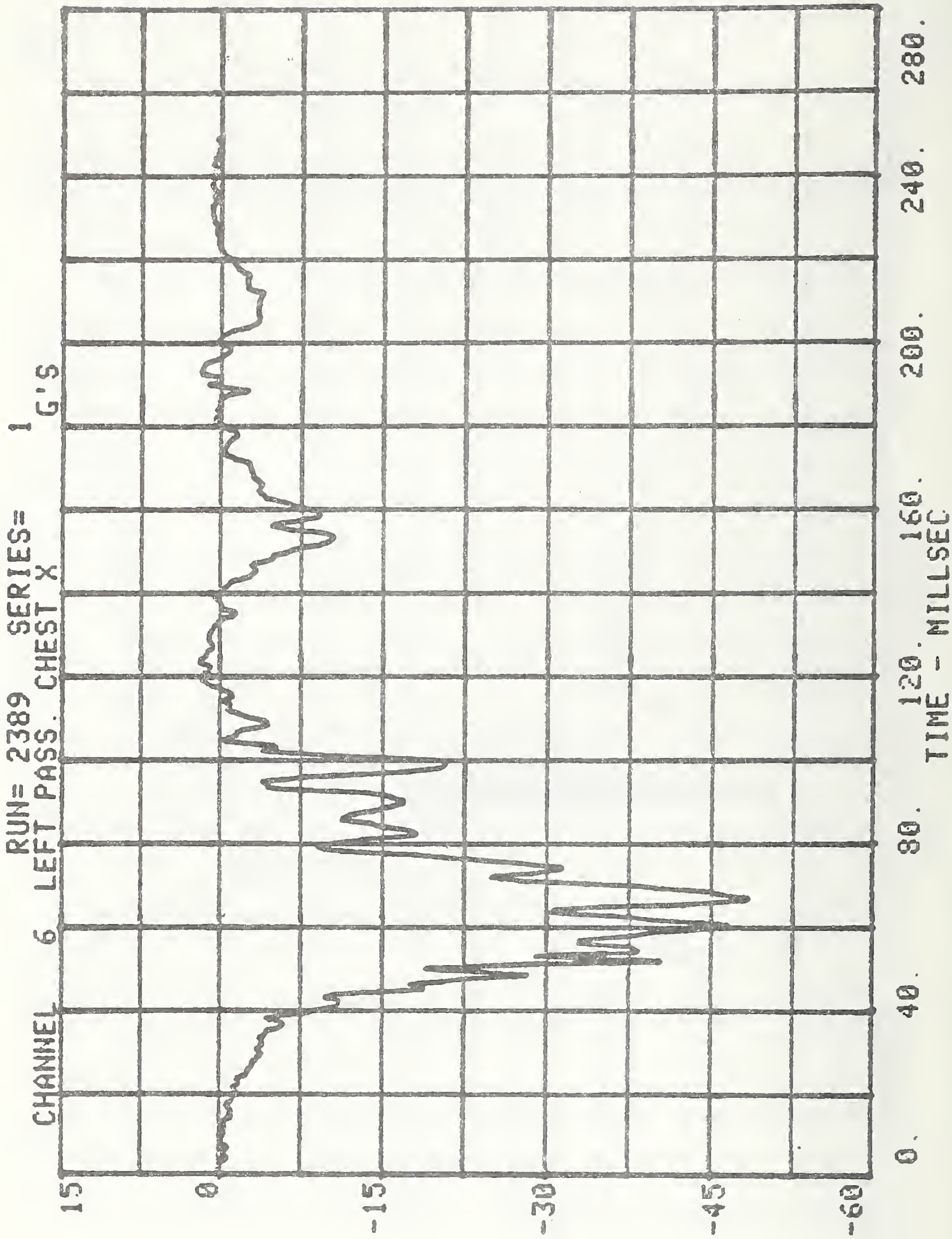

CHANNEL 2 RUN= 2389 SERIES= 1
LEFT PASS. HEAD X G'S
50
0
-50
-100
-150
-200
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



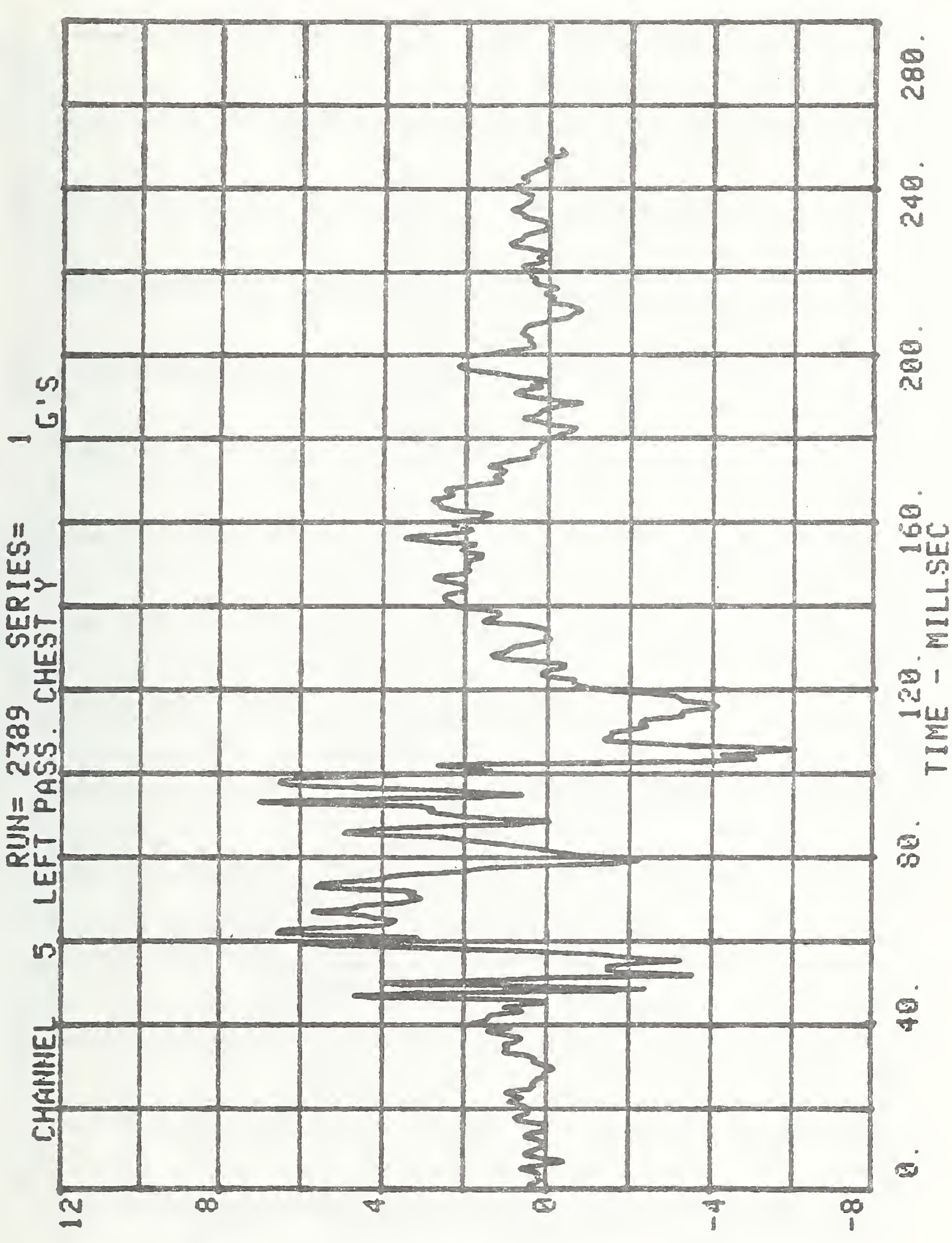
CHANNEL 1 RUN= 2389 SERIES= 1
LEFT PASS. HEAD Y G'S
120
80
40
0
-40
-80
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 3 RUN= 2389 SERIES= 1
LEFT PASS. HEAD Z G'S
100
75
50
25
0
-25
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

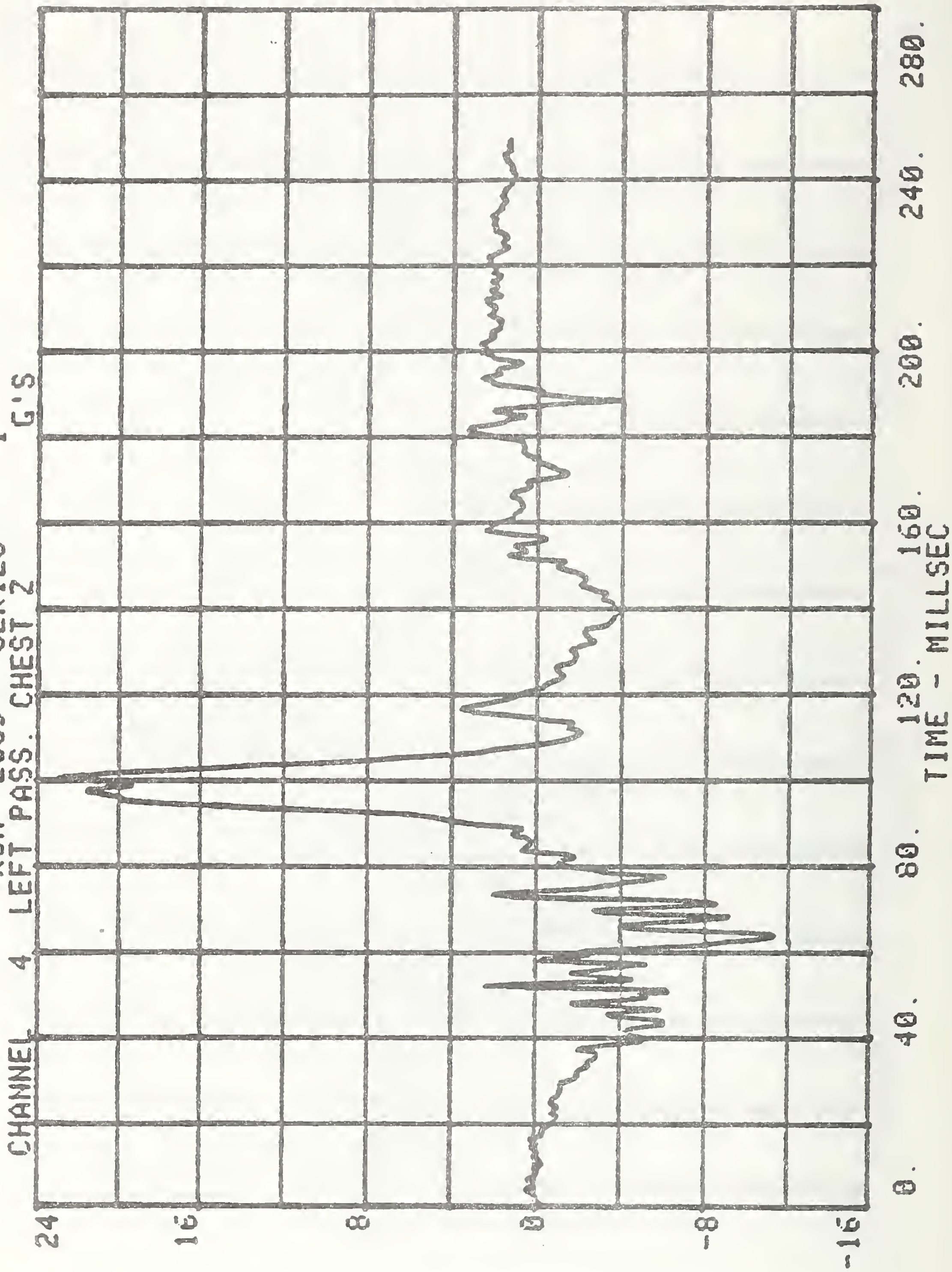

CHANNEL 1 RUN= 2389 SERIES= 1
LEFT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 40. 80. 120. 160. 200.

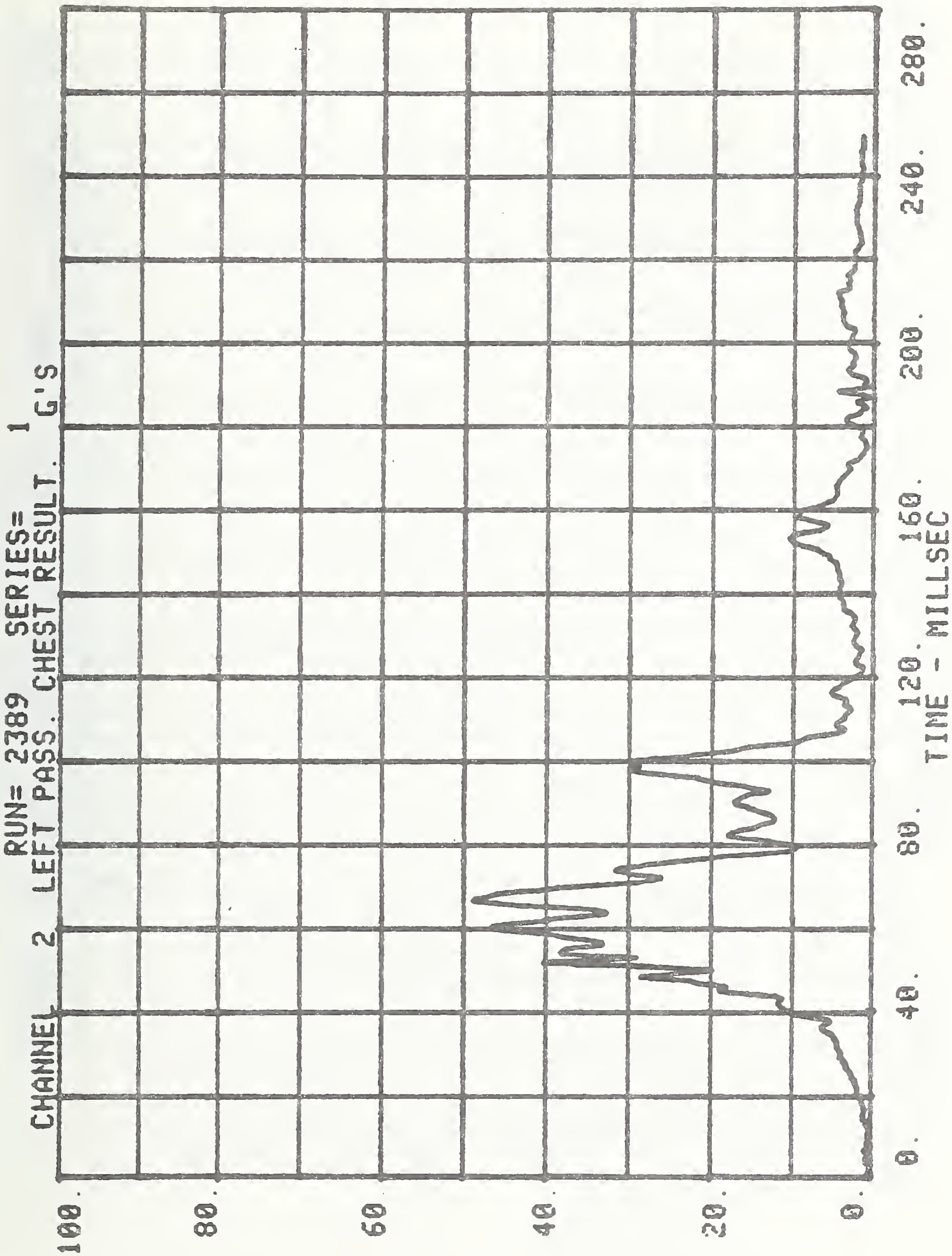


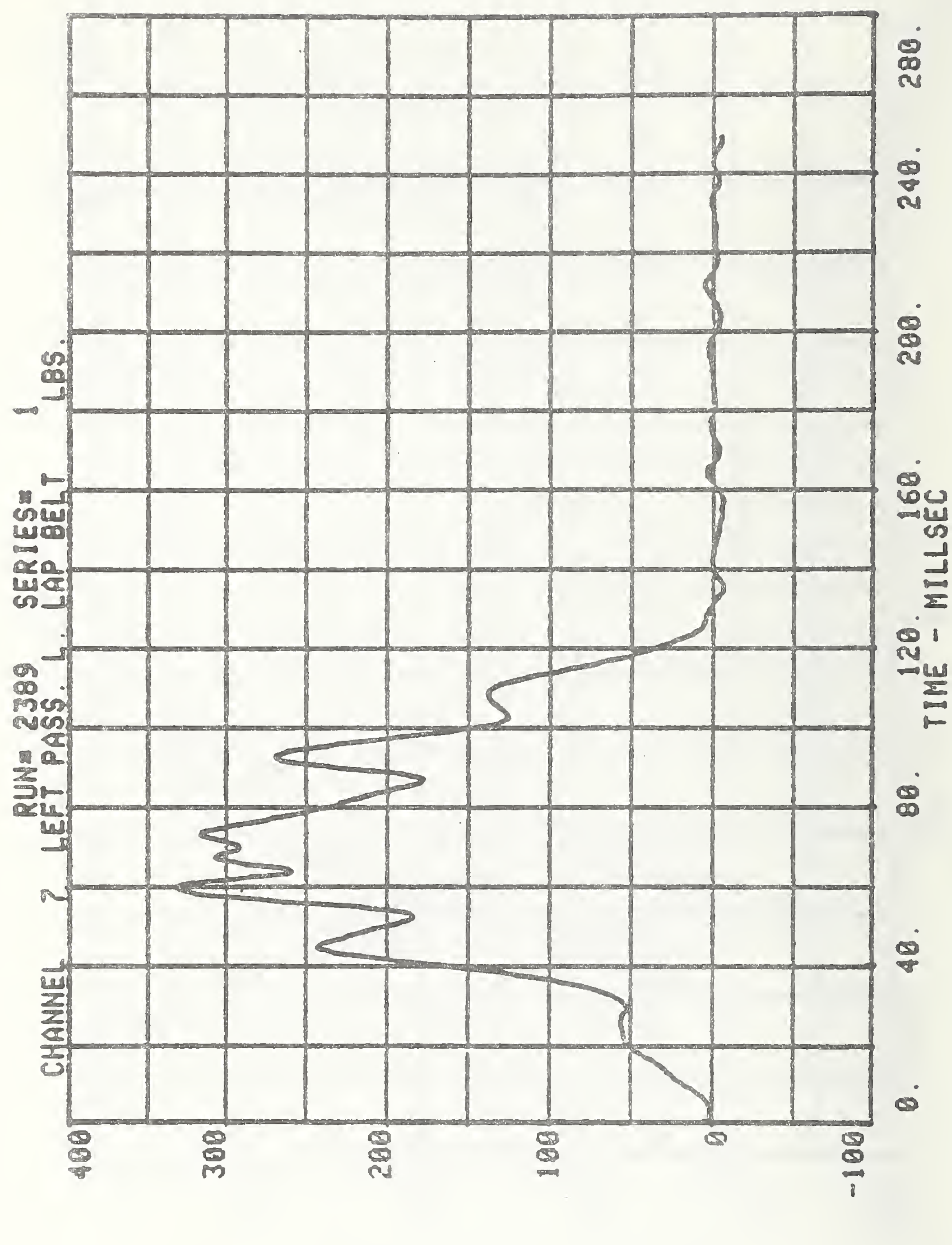
CHANNEL 6 RUN= 2389 SERIES= 1
LEFT PASS. CHEST X G'S
15
0
-15
-30
-45
-60
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

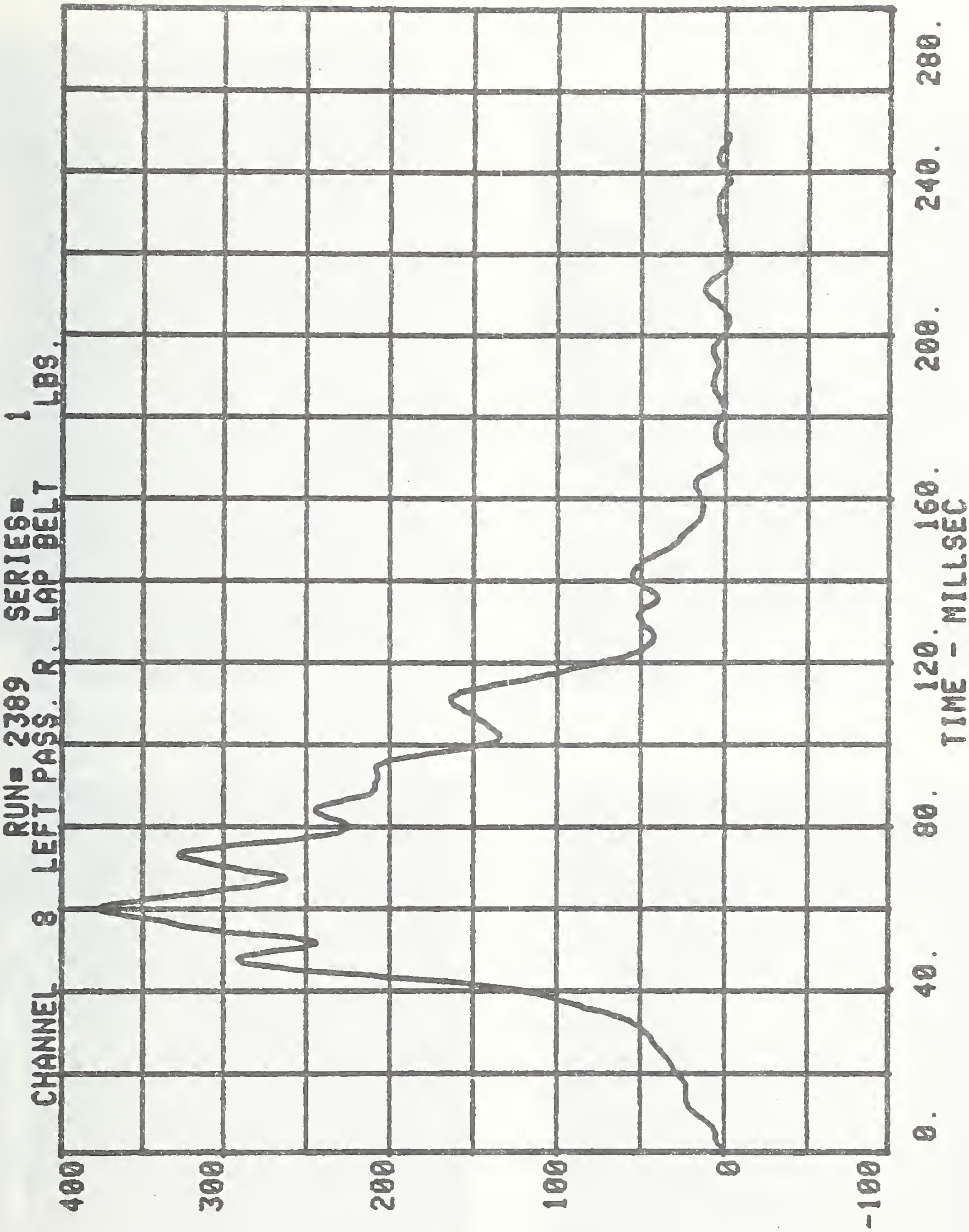


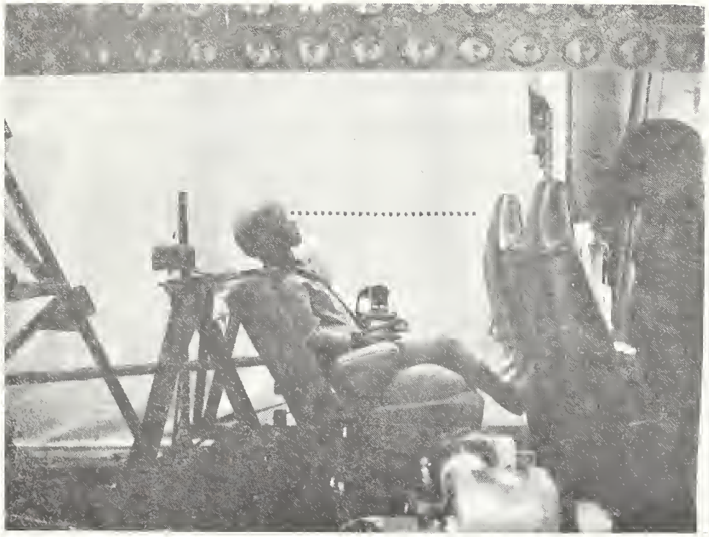
CHANNEL 5 RUN= 2389 SERIES= 1
LEFT PASS. CHEST Y G'S
12
8
4
0
-4
-8
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

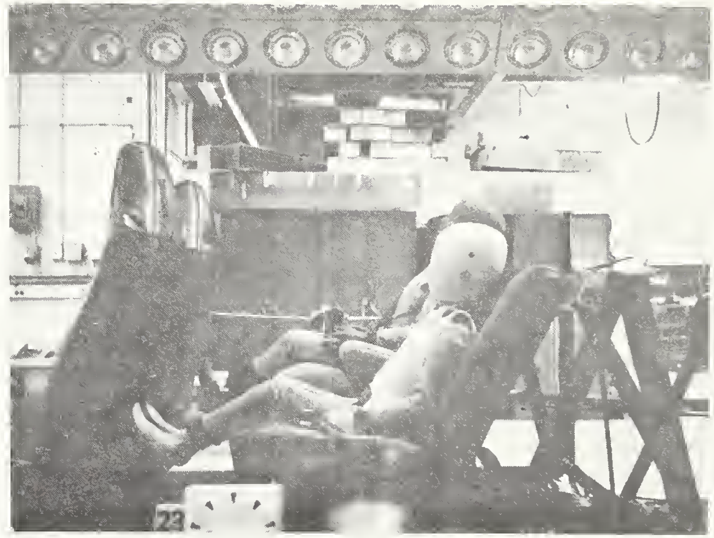

CHANNEL 4 RUN= 2389 SERIES= 1
LEFT PASS. CHEST 2 G'S
24
16
8
0
-8
-16
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 2 RUN= 2389 SERIES= 1
LEFT PASS. CHEST RESULT. G'S
100.
80.
60.
40.
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 7 RUN= 2389 SERIES= 1 LBS.
LEFT PASS. L. LAP BELT
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
400 300 200 100 0 -100


CHANNEL 8 RUN= 2389 SERIES= 1
LEFT PASS. R. LAP BELT LBS.
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
400
300
200
100
0
-100





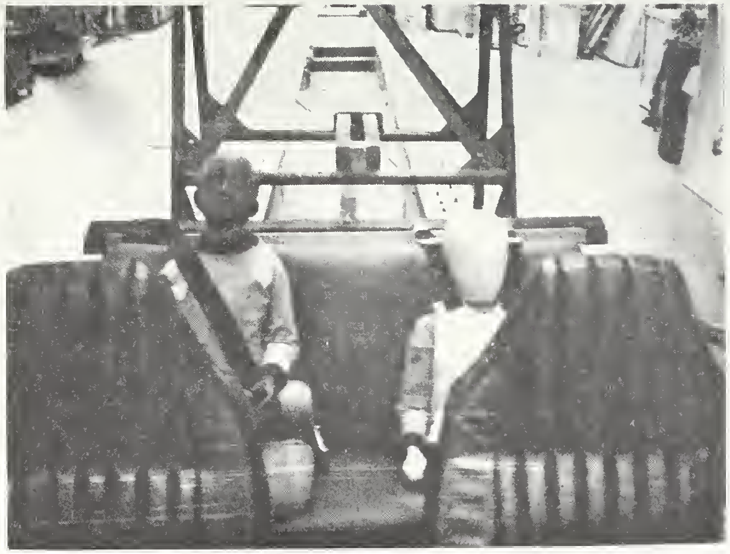
PRE-TEST

ALDERSON S/N 49

TNO

POST-TEST

RUN 2390



ALDERSON S/N 49 TNO

PRE-TEST

ALDERSON S/N 49 TNO

POST-TEST

RUN 2390

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #2

RUN=2390

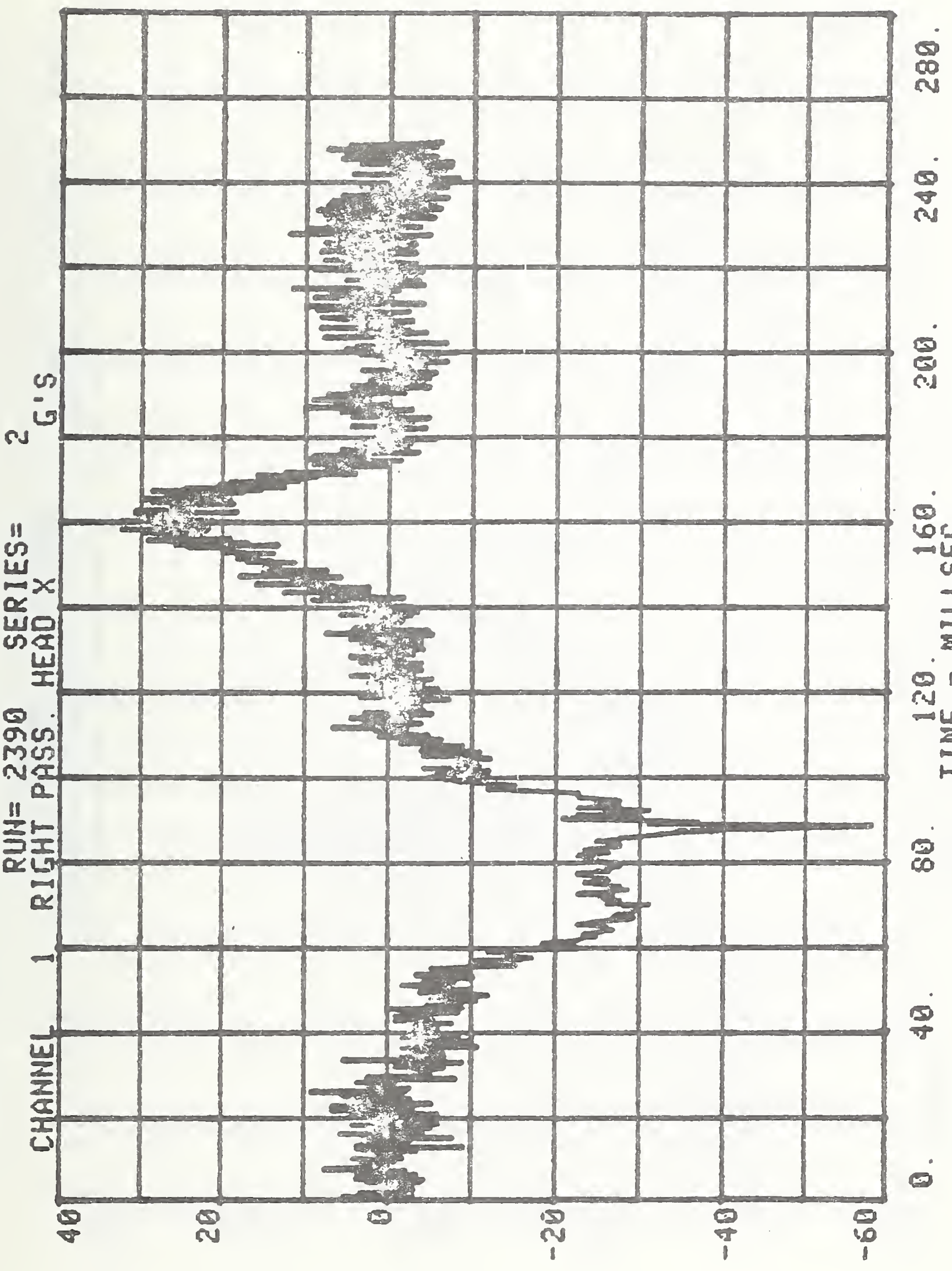
RIGHT PASS. HEAD RESULT.

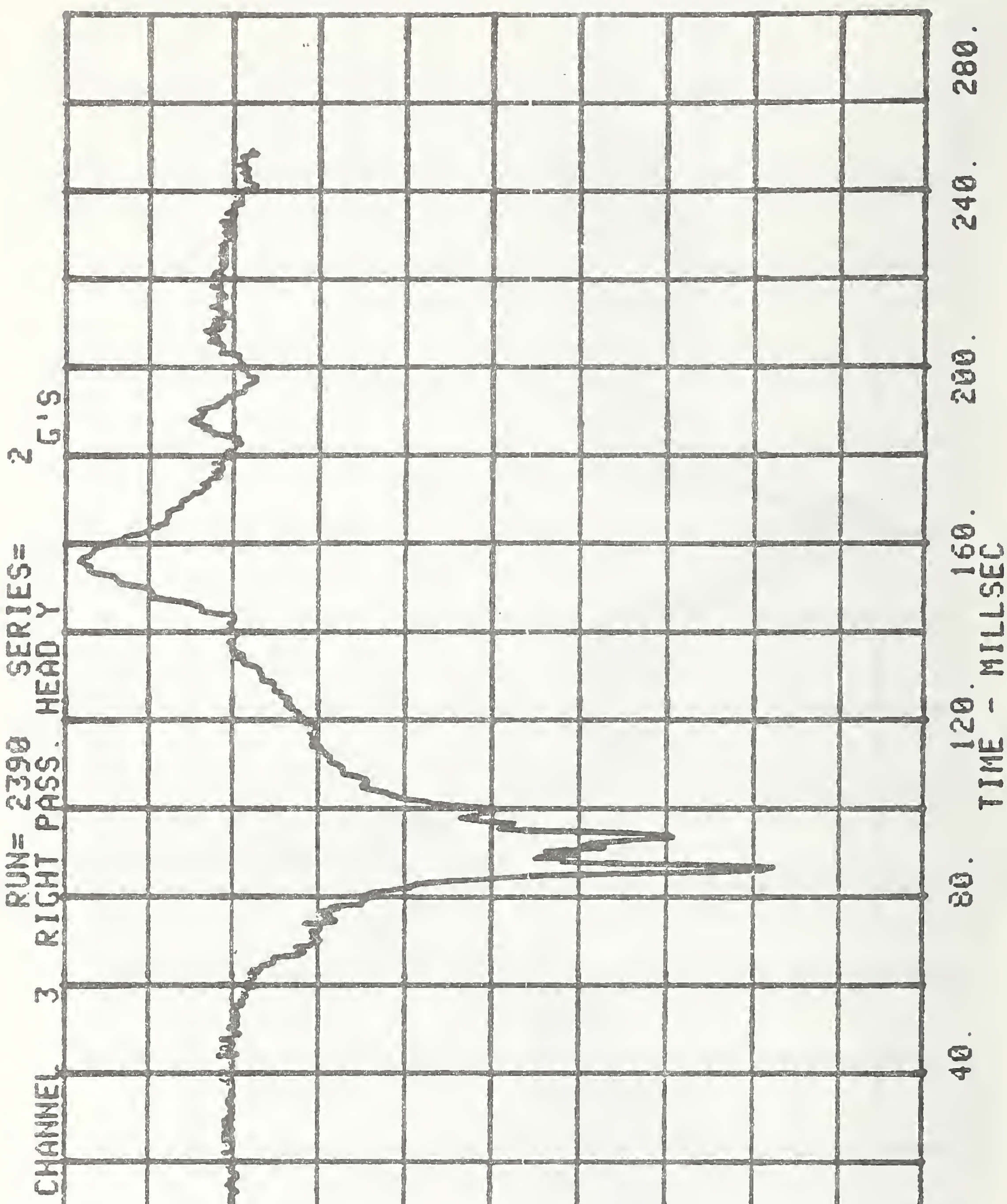
HIC= 964.8   FROM T1= .06180   TO T2= .17070

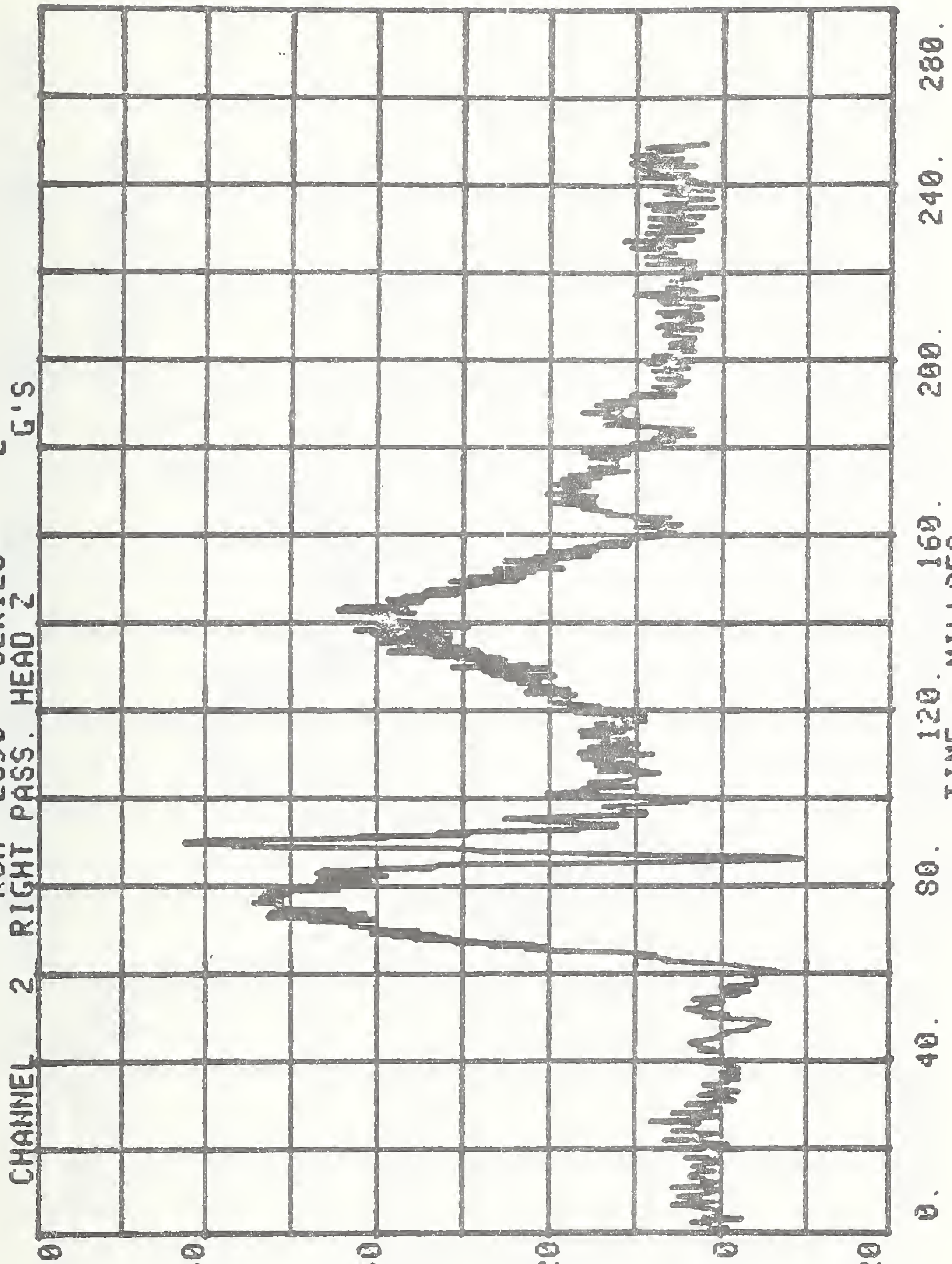
AVERAGE ACCELERATION BETWEEN T1 AND T2= 37.9G'S

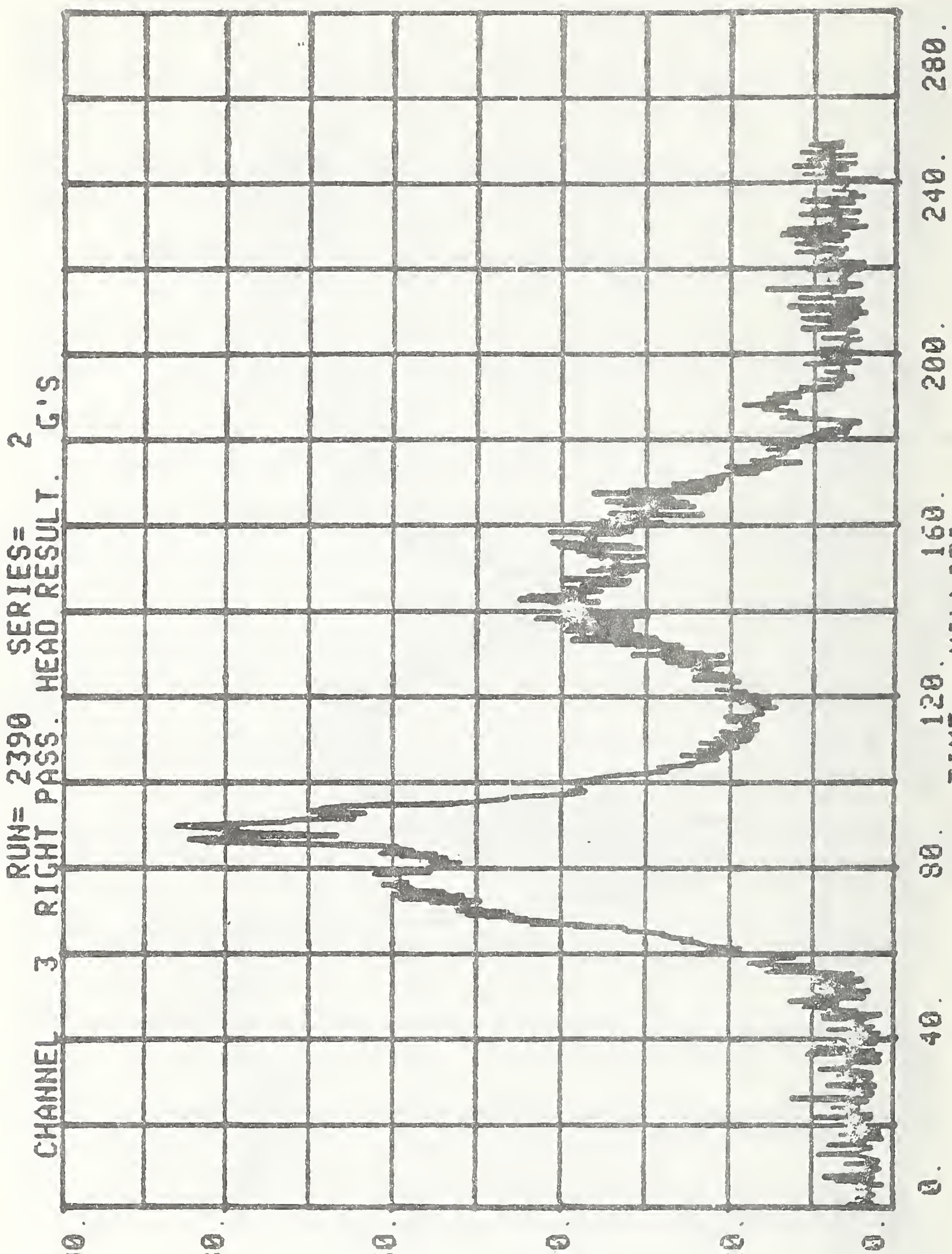
EVENT TIME= 250.0 MSEC

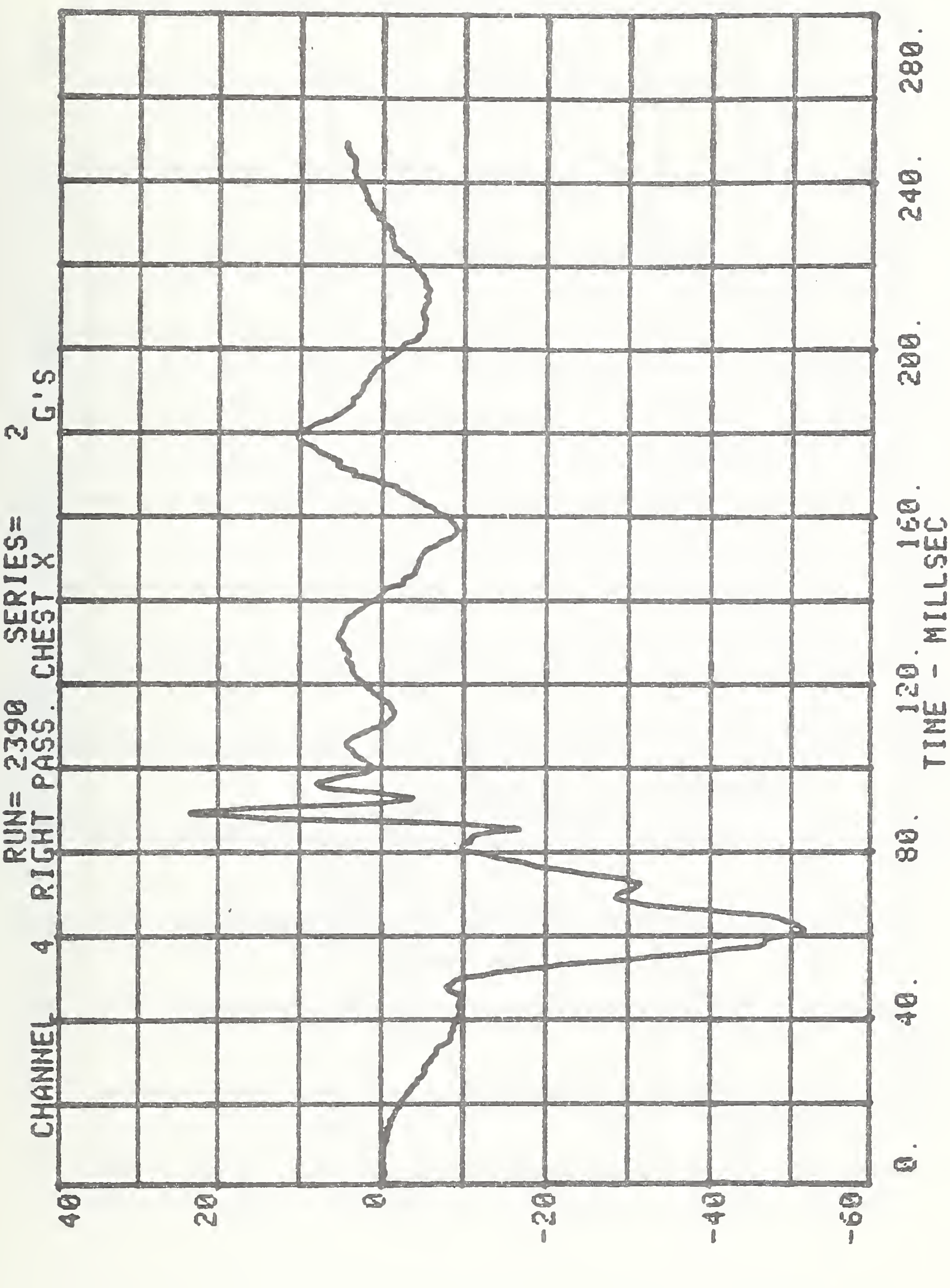
SEVERITY INDEX=1359.7

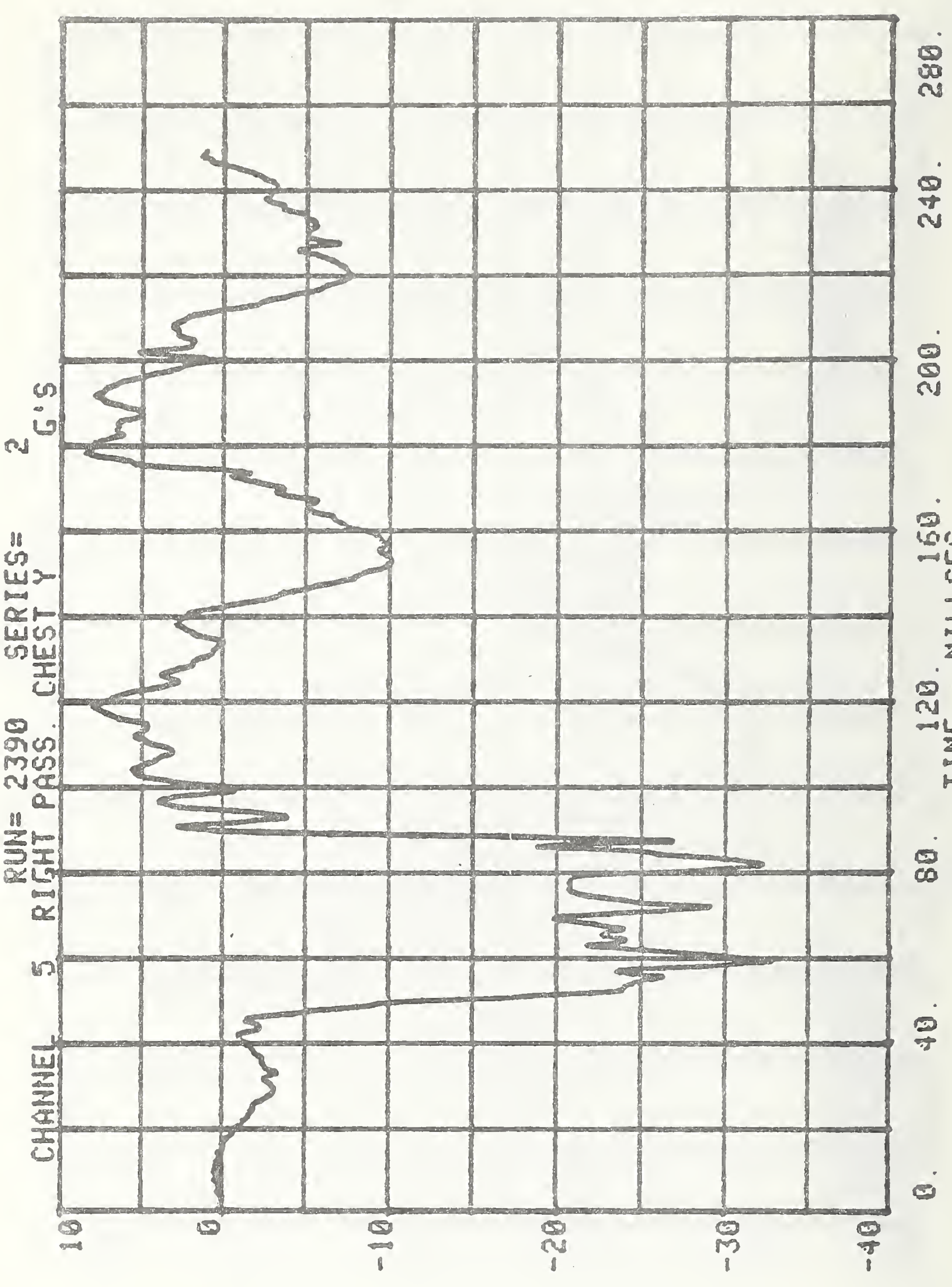

CHANNEL 1 RUN= 2390 SERIES= 2
RIGHT PASS. HEAD X G'S
40
20
0
-20
-40
-60
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 3 RUN= 2390 SERIES= 2
RIGHT PASS. HEAD Y G'S
25
0
-25
-50
-75
-100
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

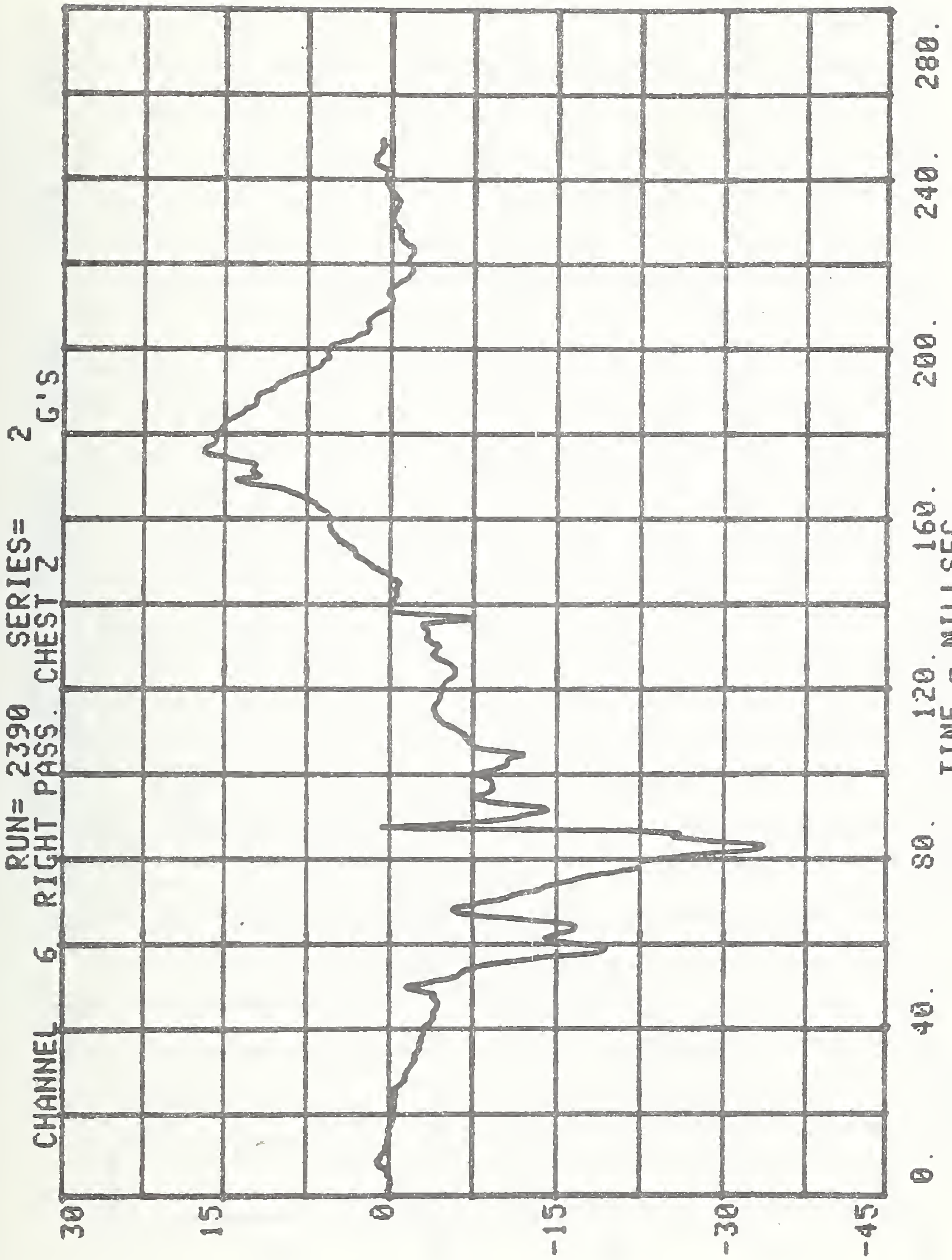

CHANNEL 2 RUN= 2390 SERIES= 2
RIGHT PASS. HEAD Z G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
80 60 40 20 0 -20

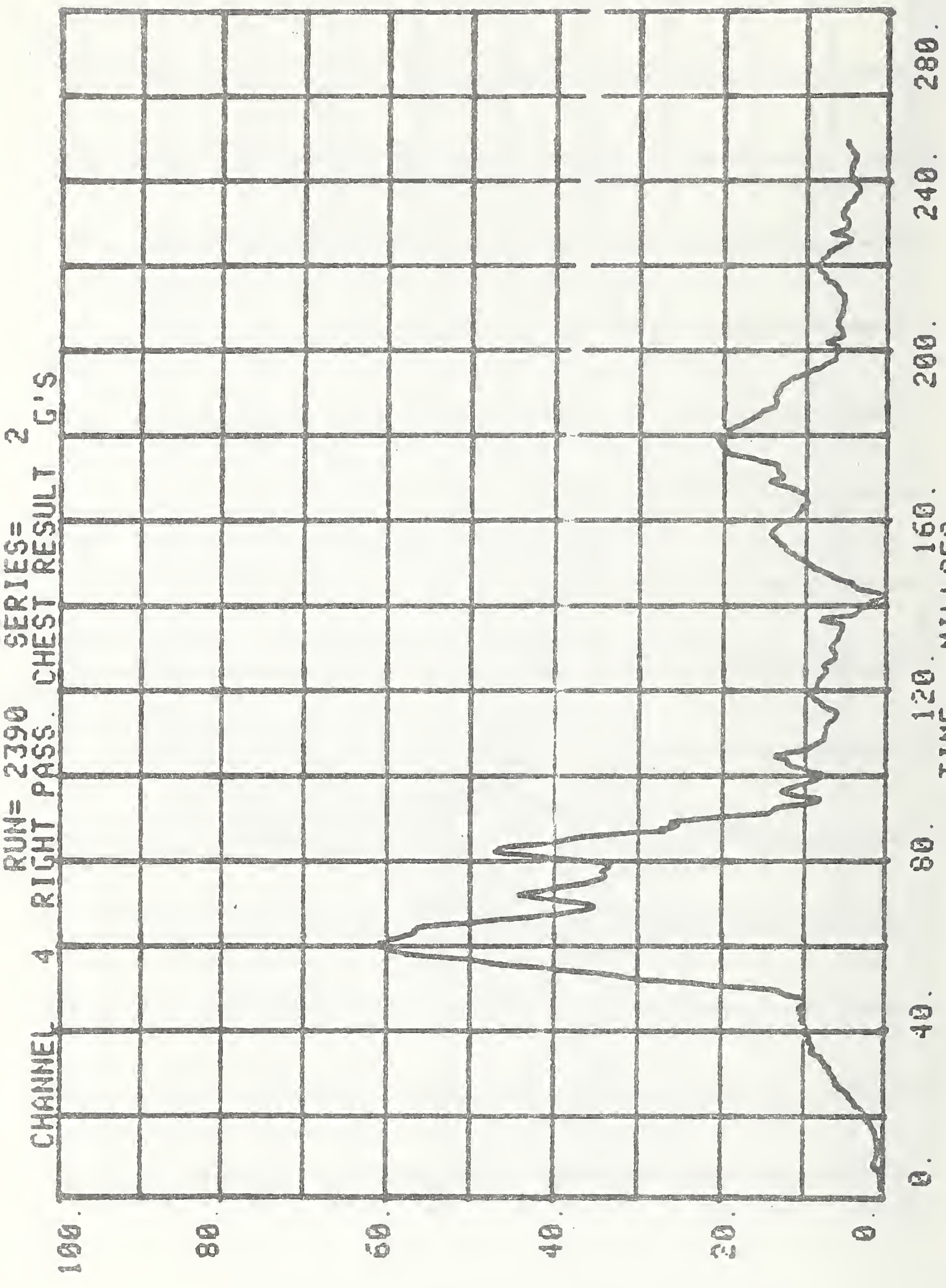

CHANNEL 3 RUN= 2390 SERIES= 2
RIGHT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
100.
80.
60.
40.
20.
0.

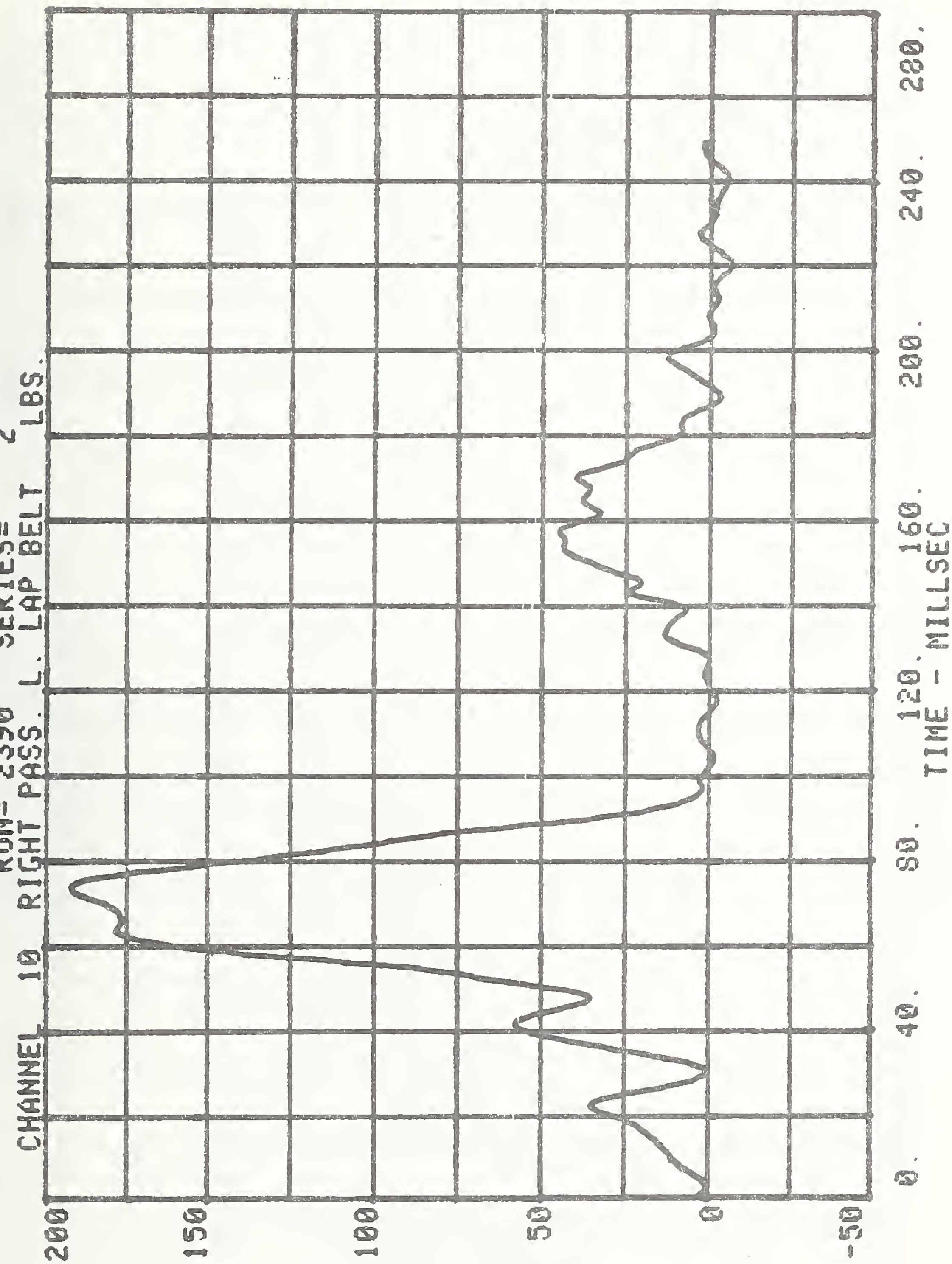

CHANNEL 4 RUN= 2390 SERIES= 2
RIGHT PASS. CHEST X G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
40
20
0
-20
-40
-60



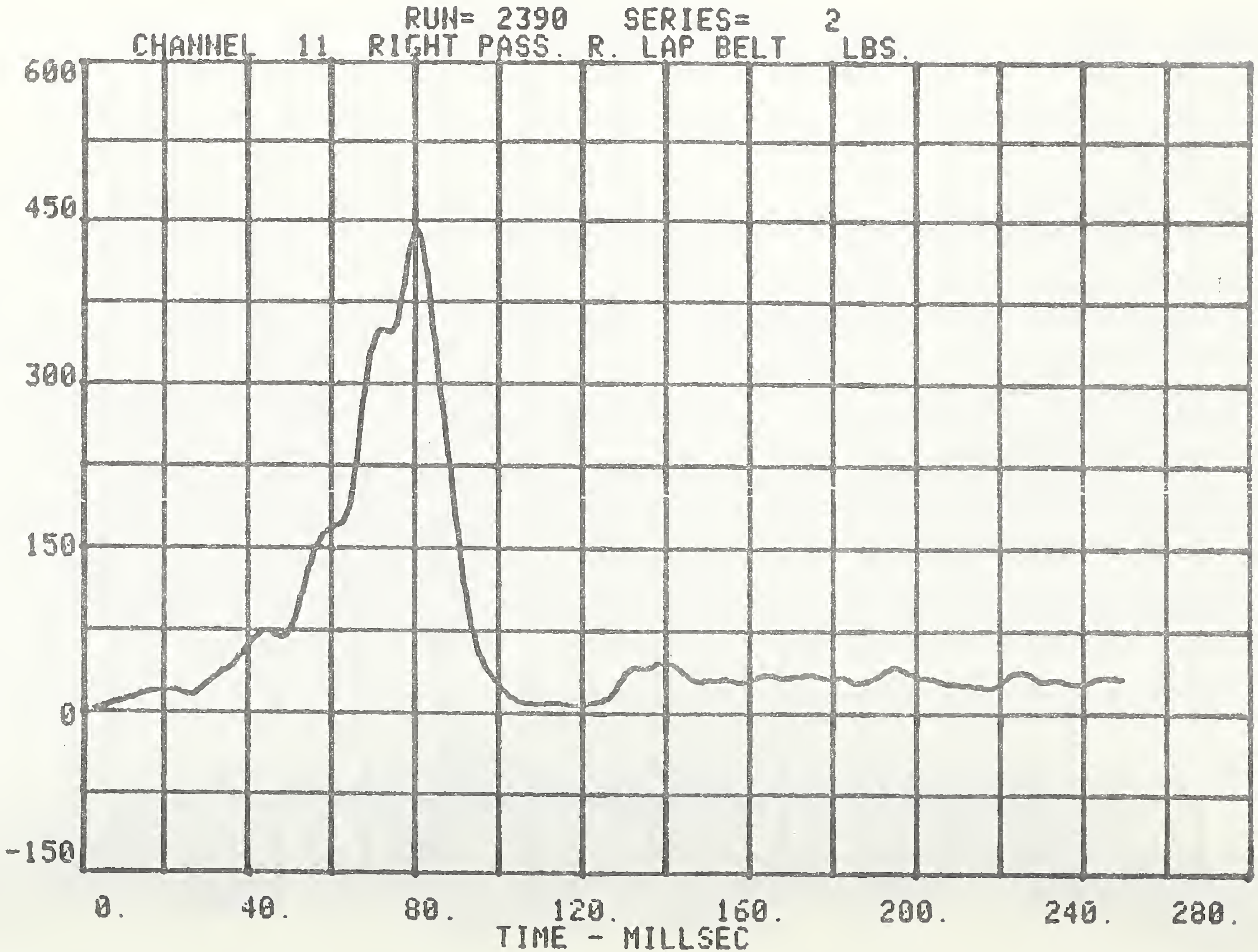
CHANNEL 5 RUN= 2390 SERIES= 2
RIGHT PASS. CHEST Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
10 0 -10 -20 -30 -40


CHANNEL 6 RUN= 2390 SERIES= 2
RIGHT PASS. CHEST Z G'S
30
15
0
-15
-30
-45
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 4 RUN= 2390 SERIES= 2
RIGHT PASS. CHEST RESULT G'S
100.
80.
60.
40.
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 10 RUN= 2390 SERIES= 2
RIGHT PASS. L. LAP BELT LBS.
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
200
150
100
50
0
-50



RUN= 2390 SERIES= 2
CHANNEL 11 RIGHT PASS. R. LAP BELT LBS.
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #2

RUN=2390

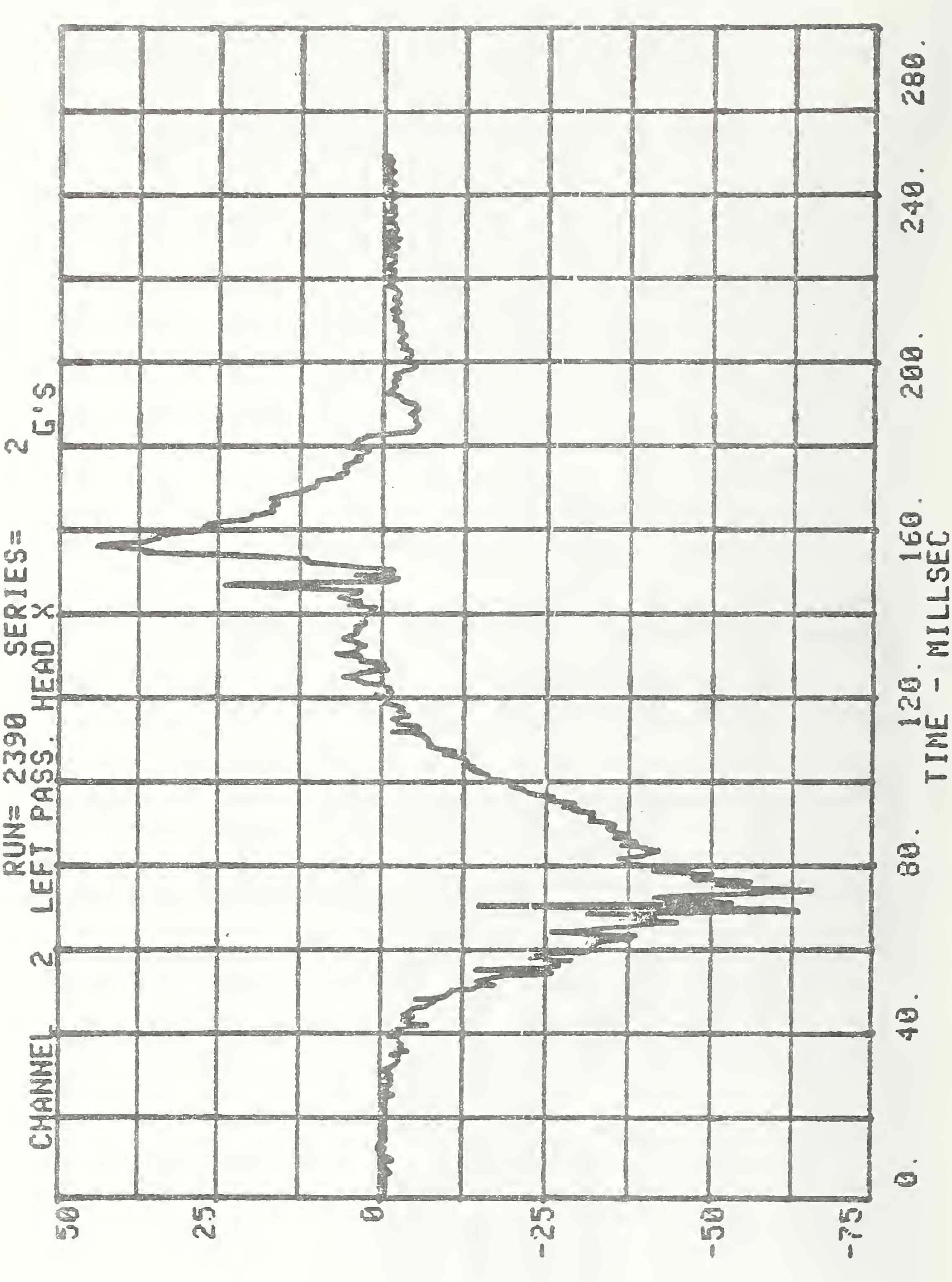
LEFT PASS. HEAD RESULT.

HIC=1104.3   FROM T1= .05100   TO T2= .09390

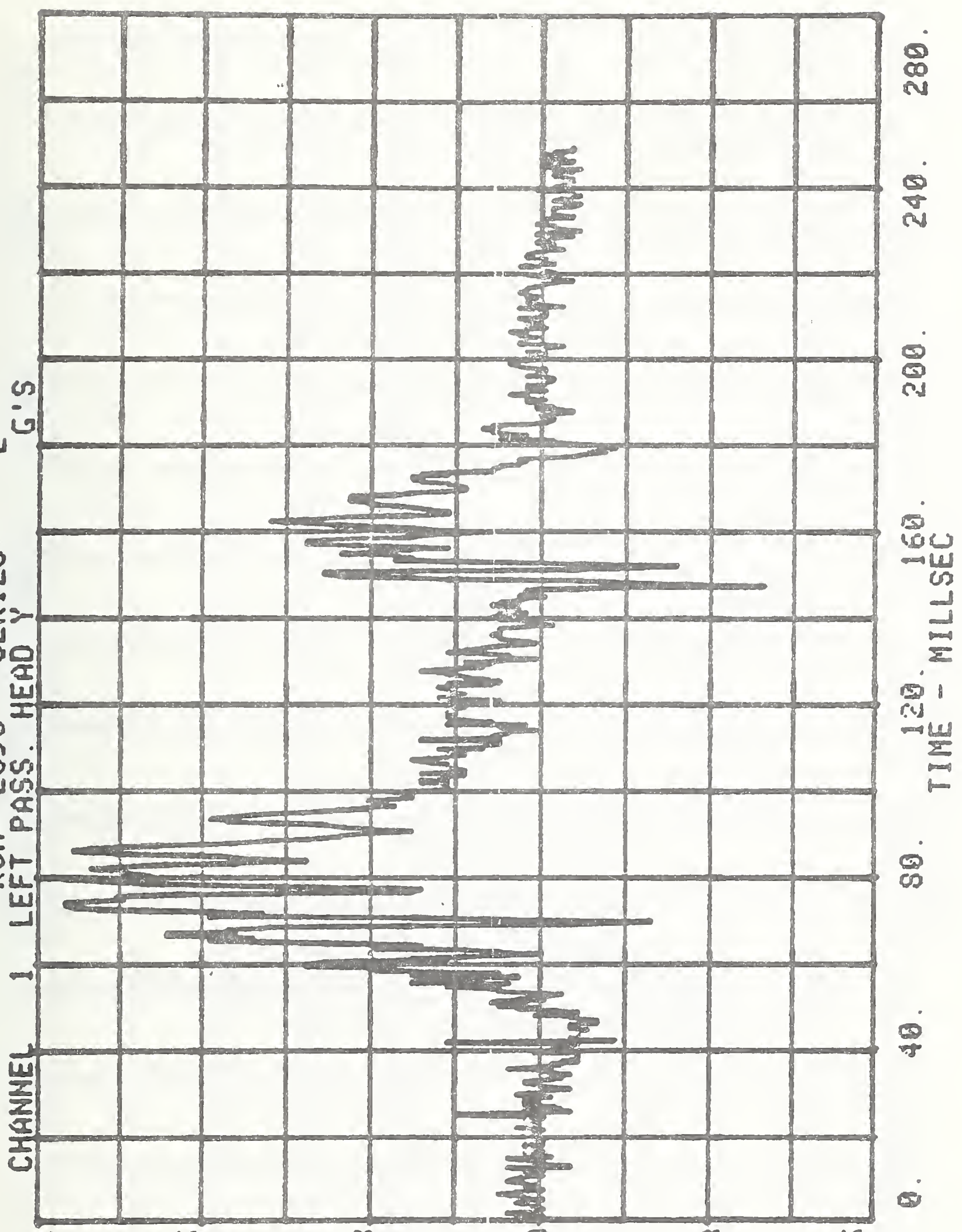
AVERAGE ACCELERATION BETWEEN T1 AND T2= 58.1G'S

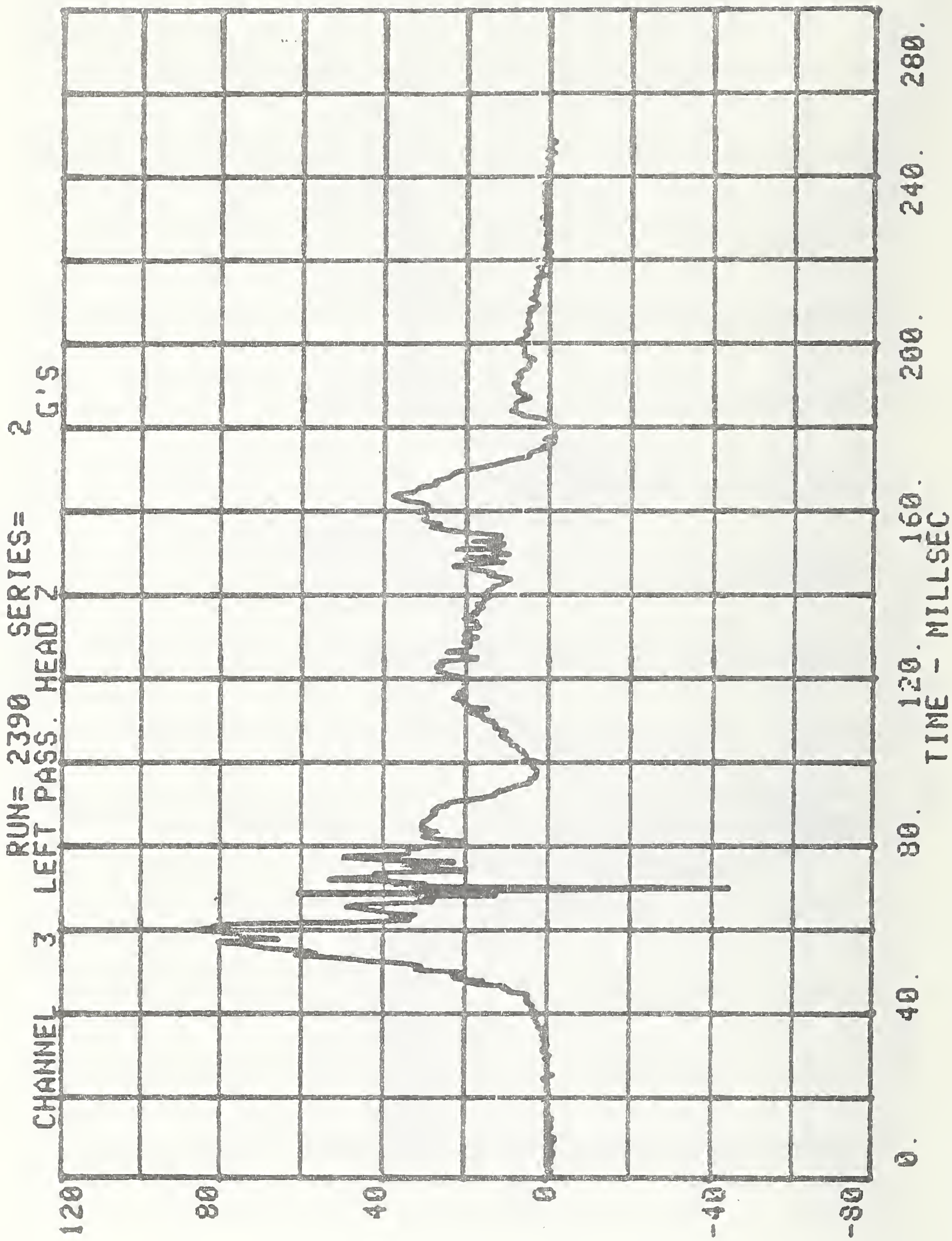
EVENT TIME= 250.0 MSEC

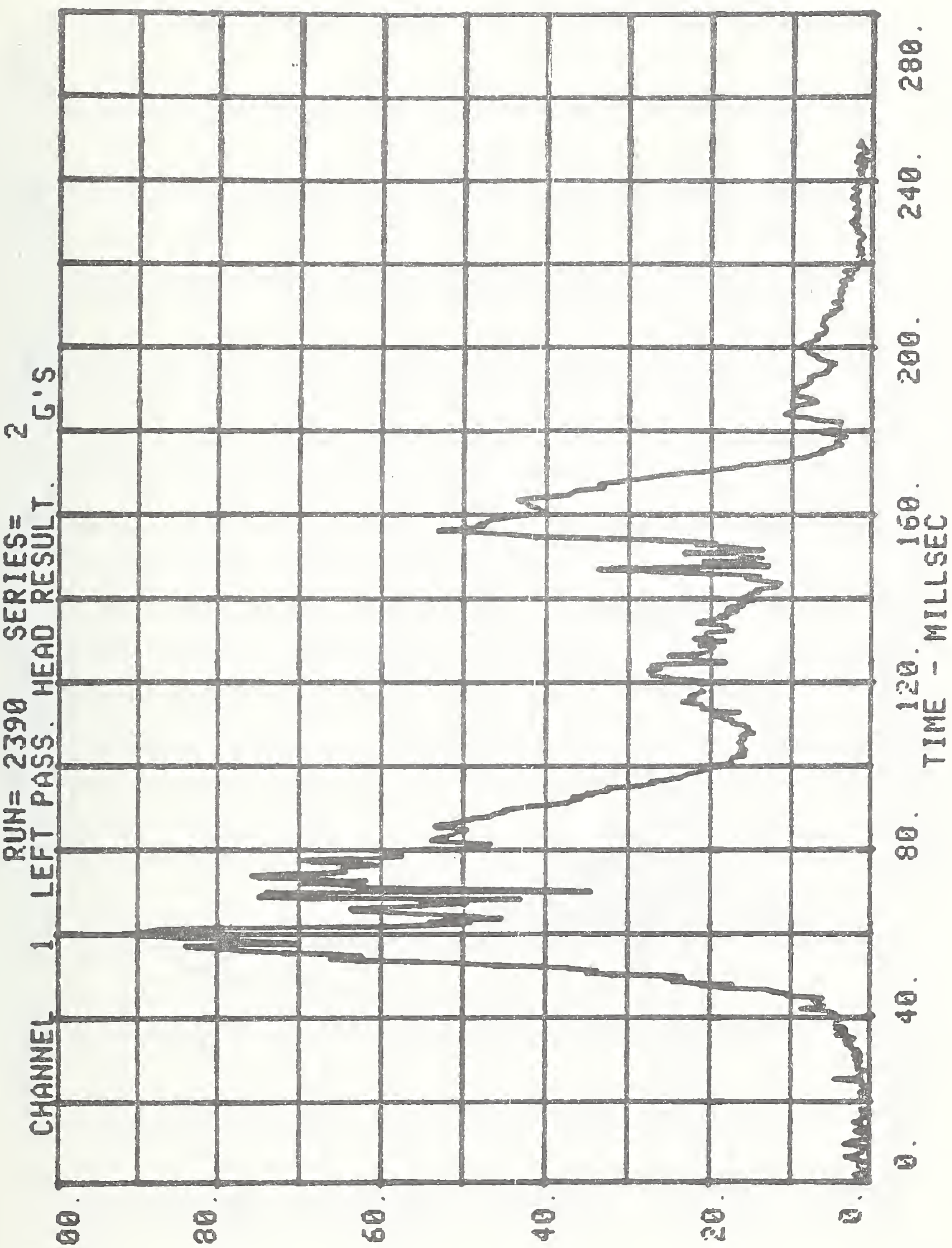
SEVERITY INDEX=1540.9

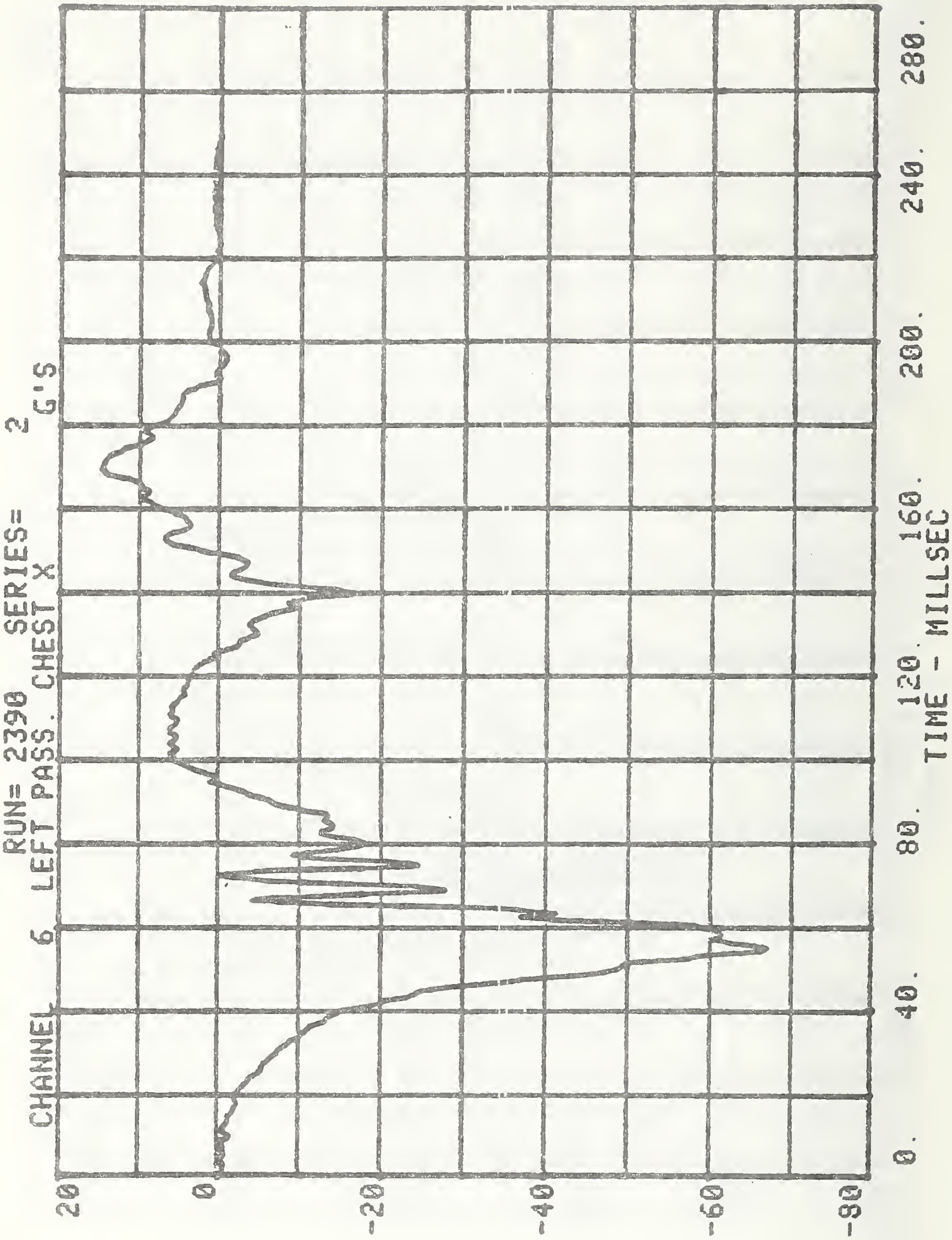


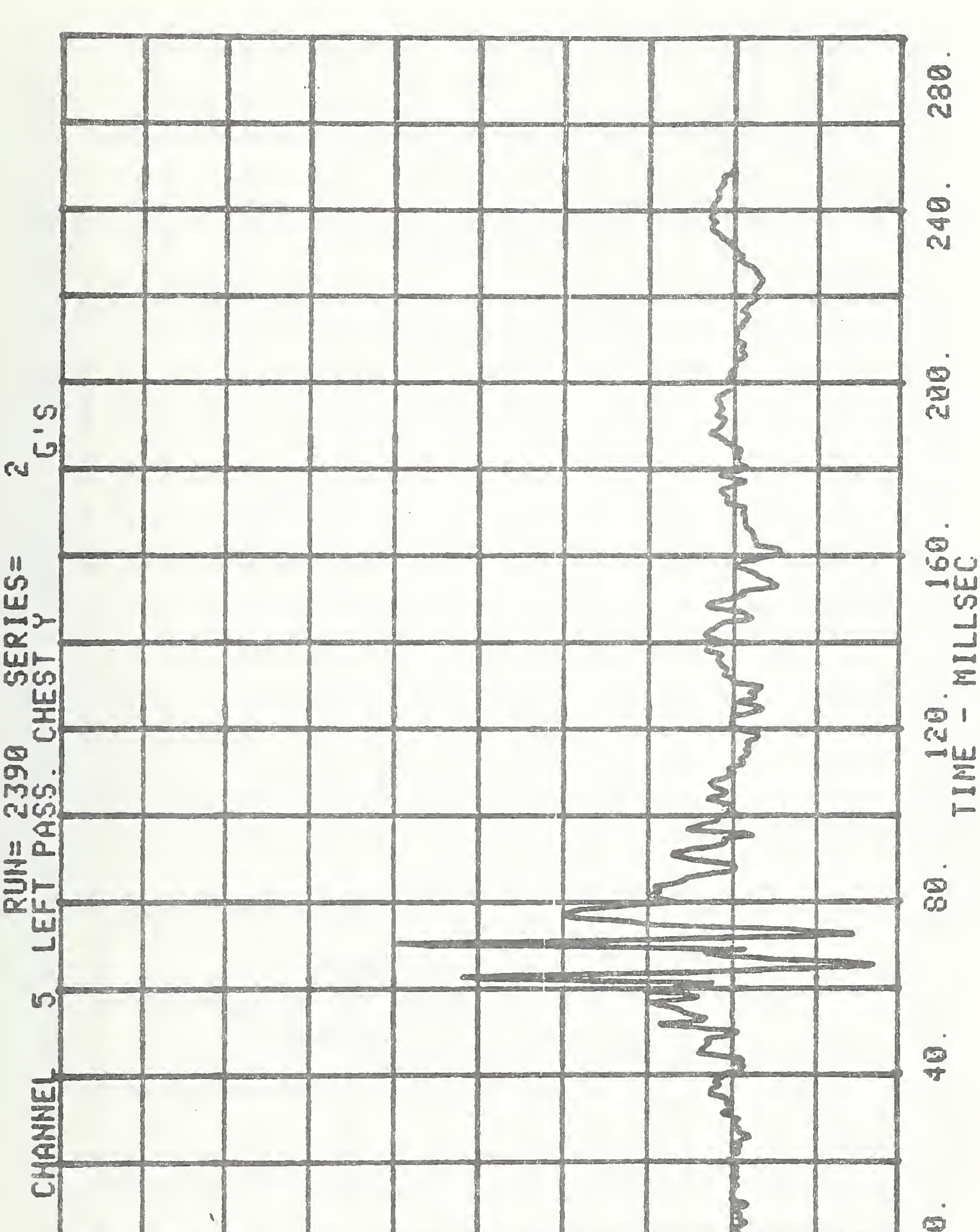
CHANNEL 2 RUN= 2390 SERIES= 2
LEFT PASS. HEAD X G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
50
25
0
-25
-50
-75

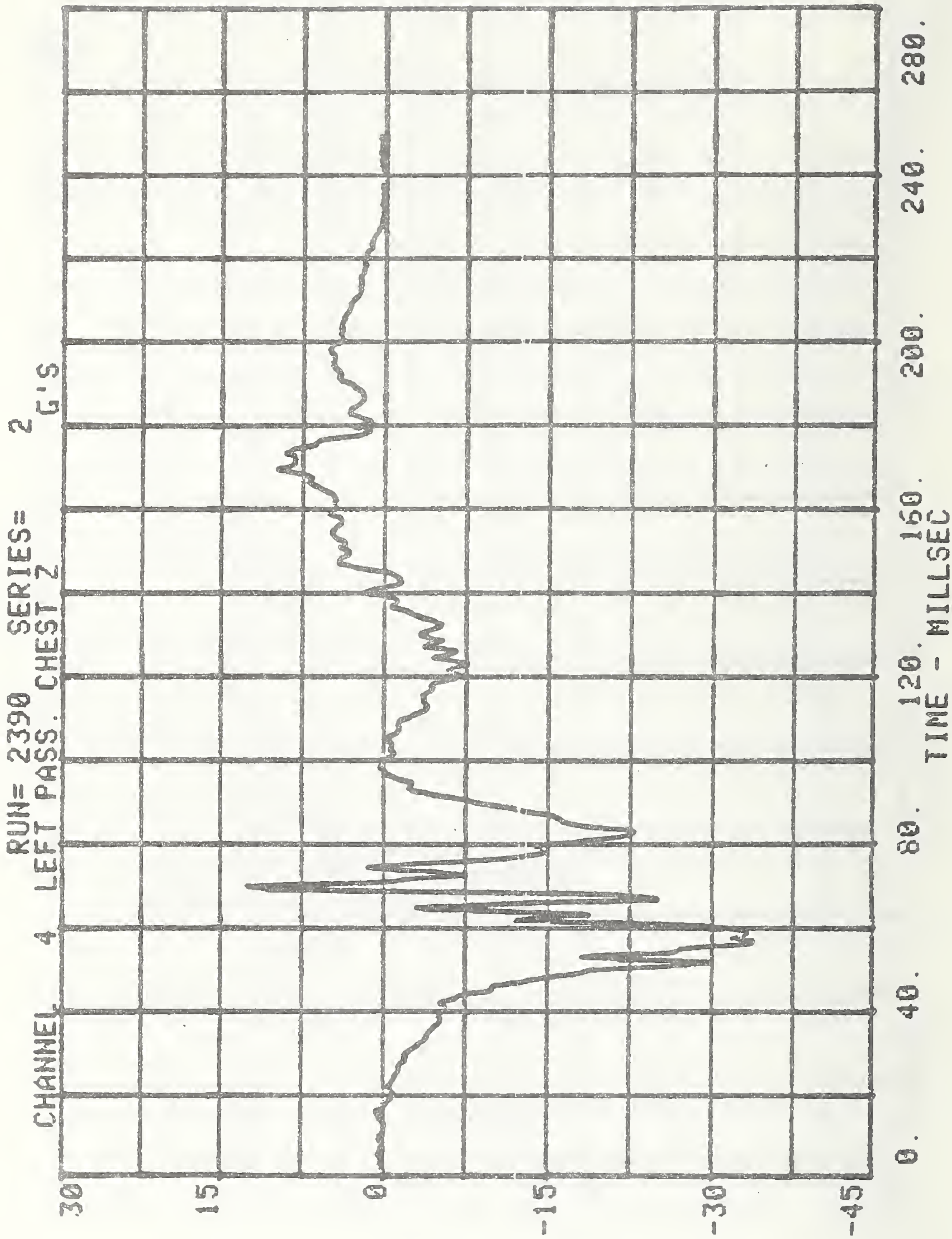

CHANNEL 1 RUN= 2390 SERIES= 2
LEFT PASS. HEAD Y G'S
24
16
8
0
-8
-16
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

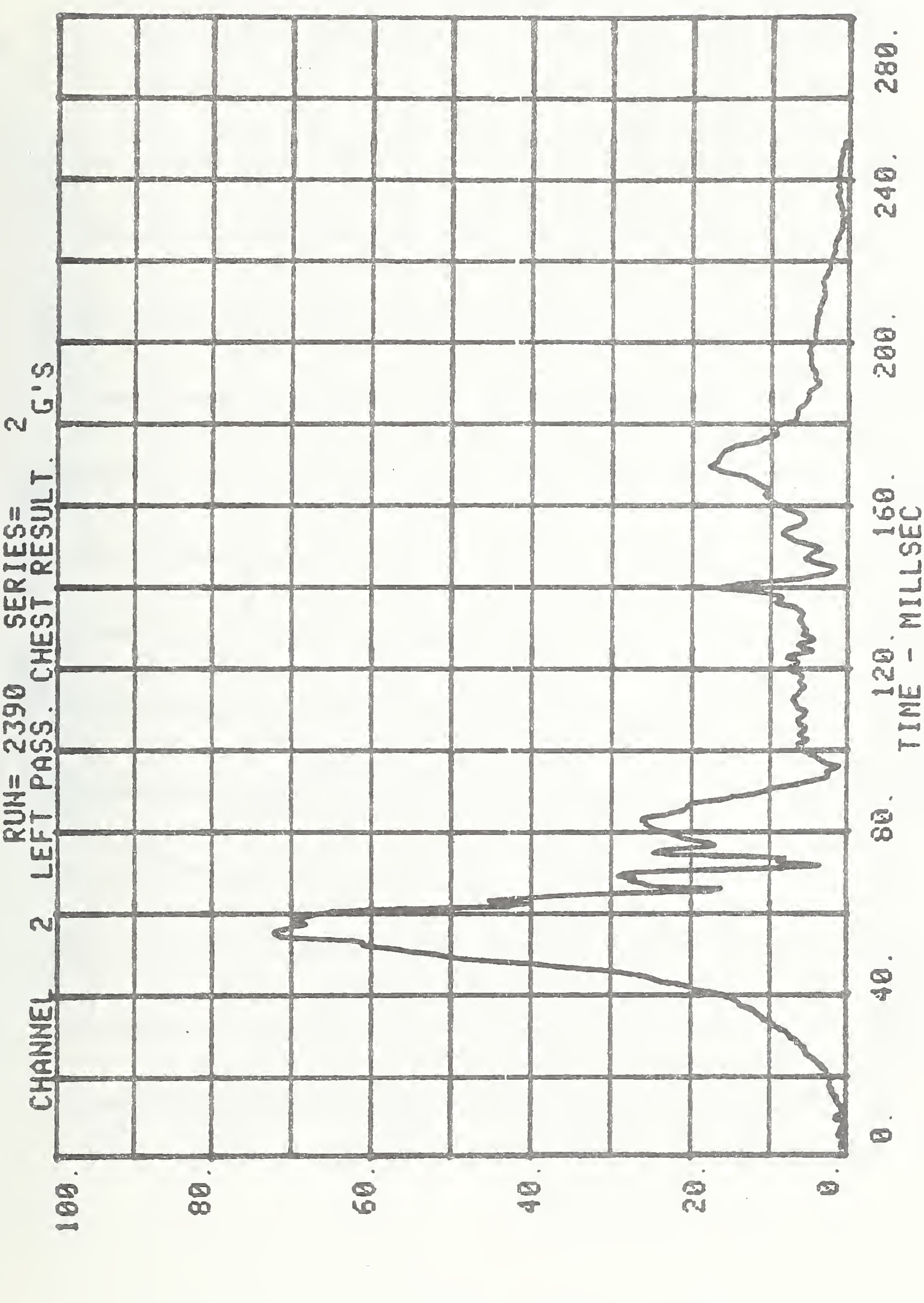

CHANNEL 3 RUN= 2390 SERIES= 2
LEFT PASS. HEAD Z
G'S
120
80
40
0
-40
-80
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

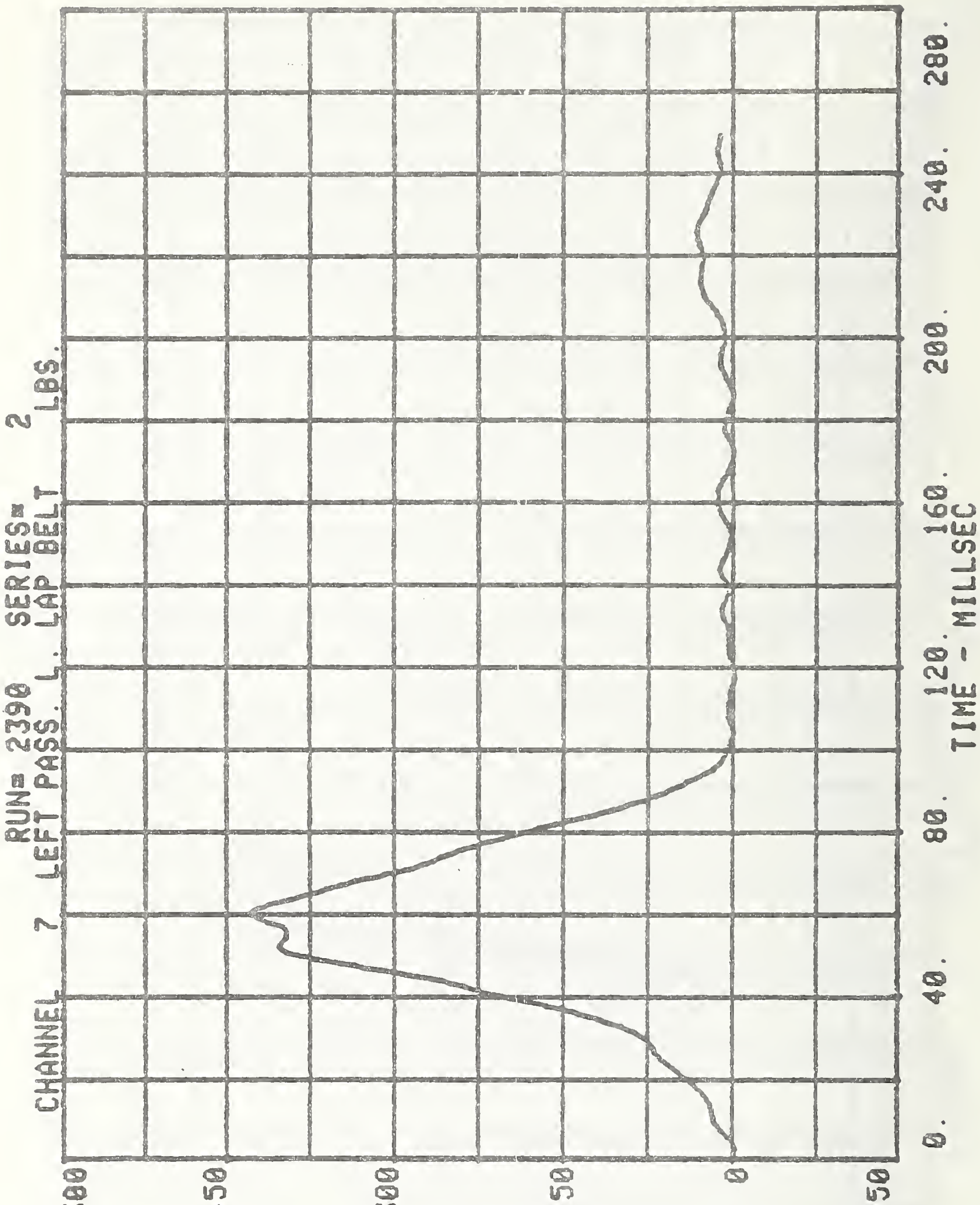

CHANNEL 1 RUN= 2390 SERIES= 2
LEFT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 20. 40. 60. 80. 100.

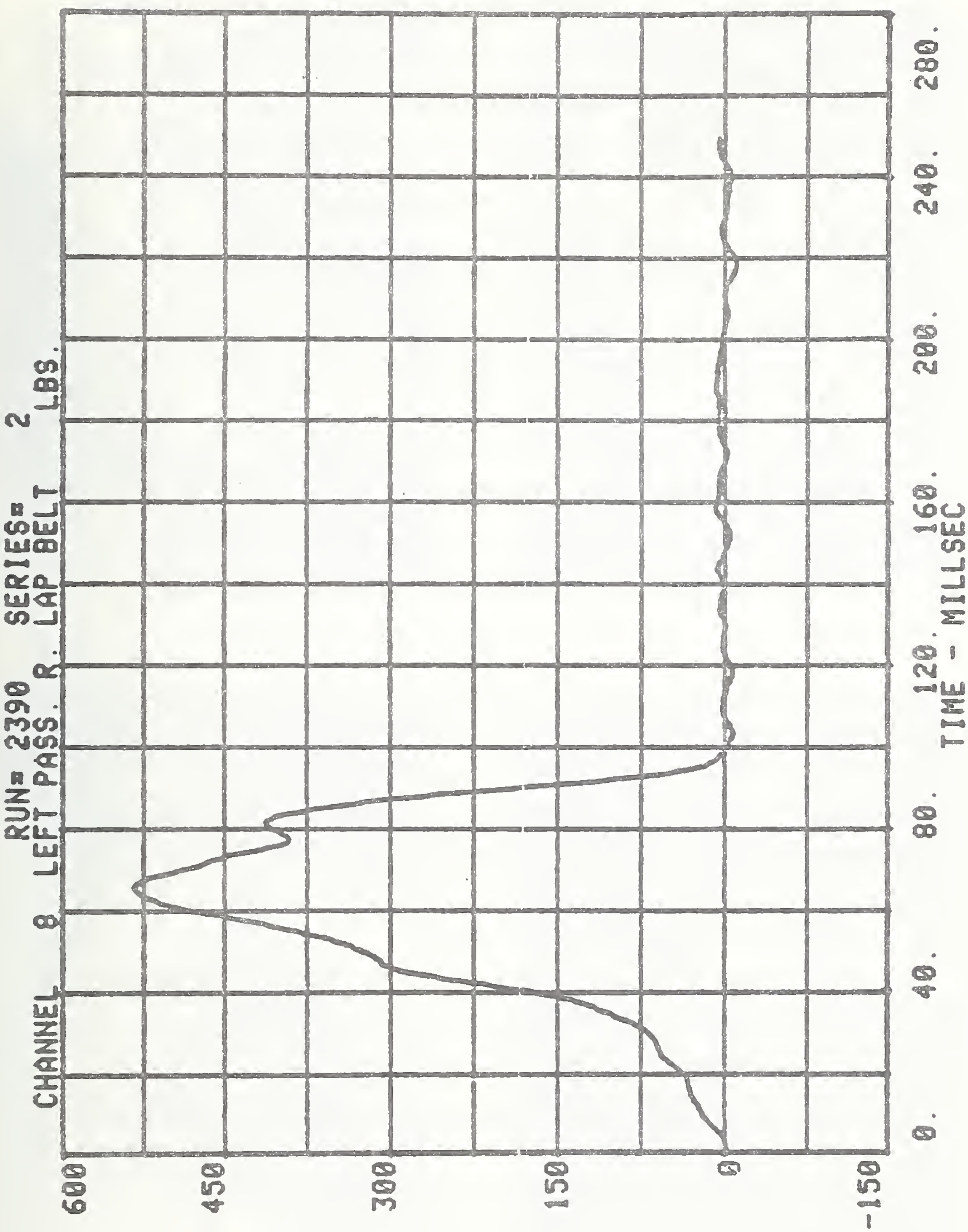

CHANNEL 6 RUN= 2390 SERIES= 2
LEFT PASS. CHEST X G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
20 0 -20 -40 -60 -80

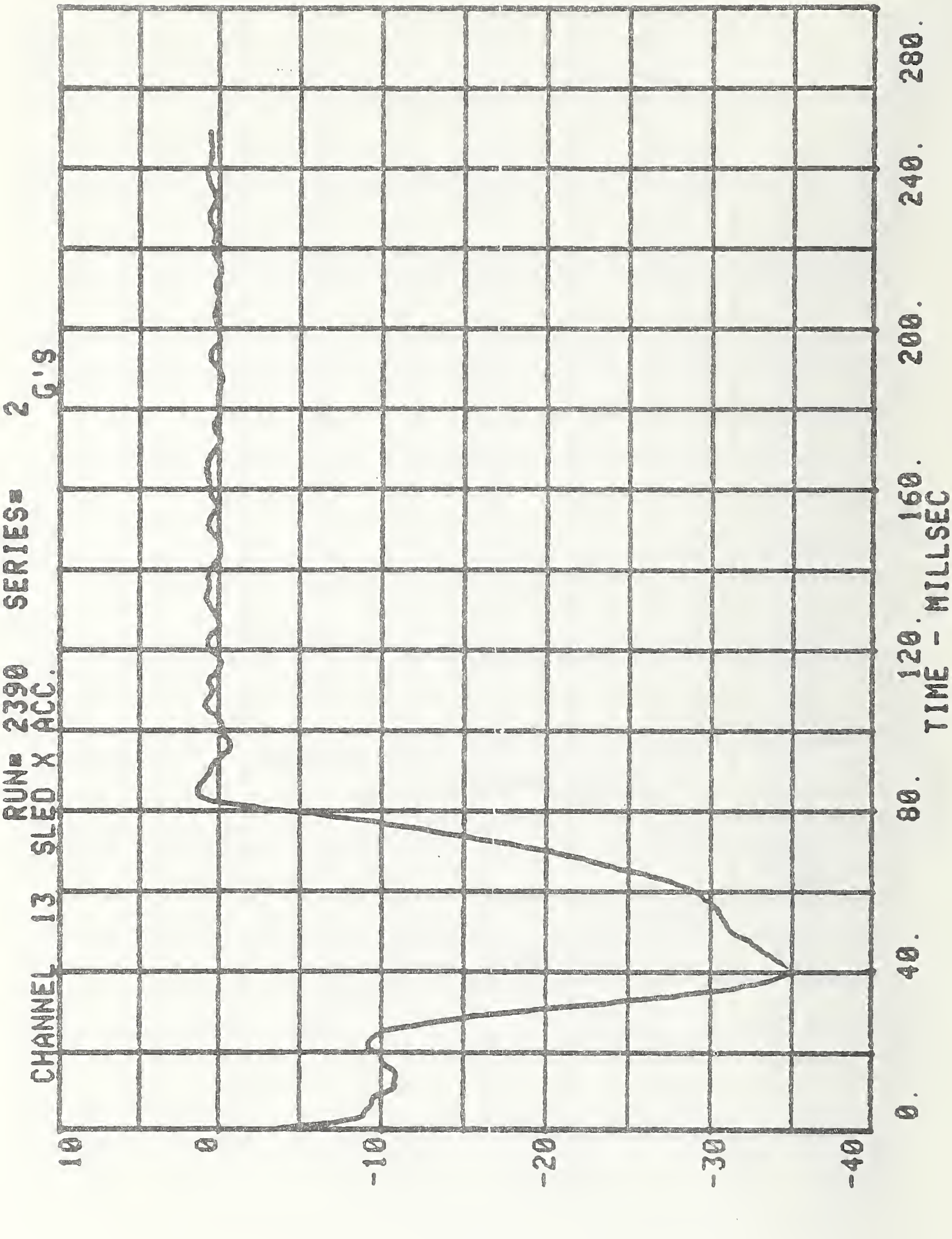

RUN= 2390 SERIES= 2
CHANNEL 5 LEFT PASS. CHEST Y
G'S
32
24
16
8
0
-8
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

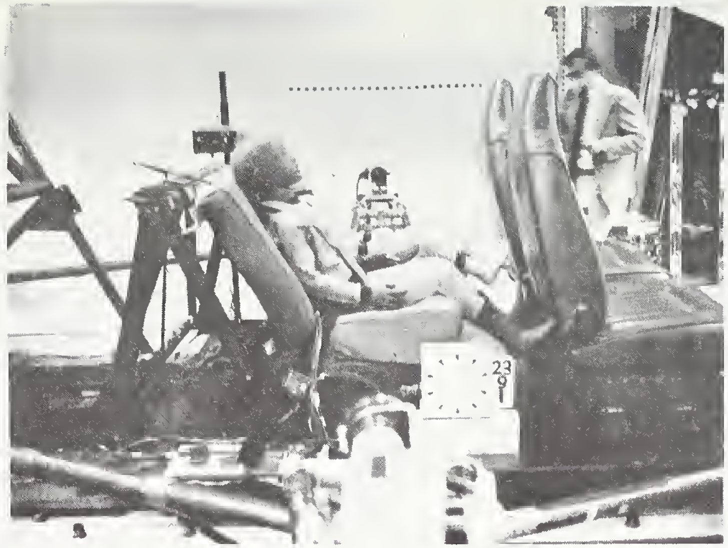

CHANNEL 4 RUN= 2390 SERIES= 2
LEFT PASS. CHEST Z G'S
30
15
0
-15
-30
-45
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

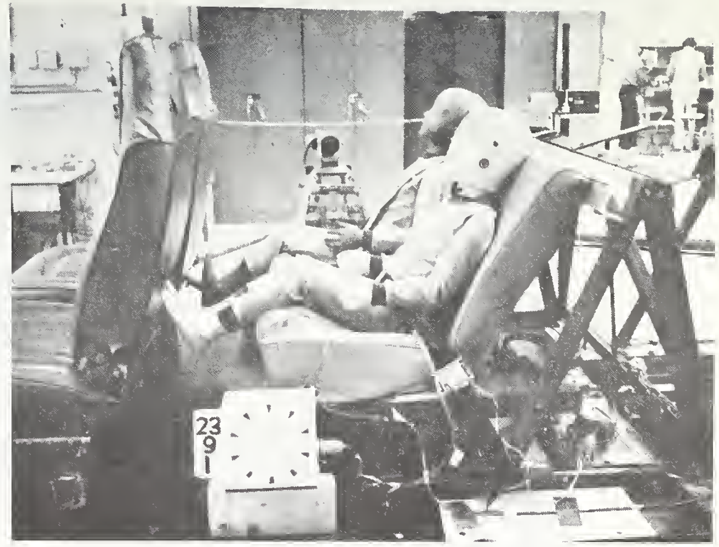

CHANNEL 2 RUN= 2390 SERIES= 2
LEFT PASS. CHEST RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
100.
80.
60.
40.
20.
0.


CHANNEL 7 RUN= 2390 SERIES= 2 LBS.
LEFT PASS. L. LAP BELT
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

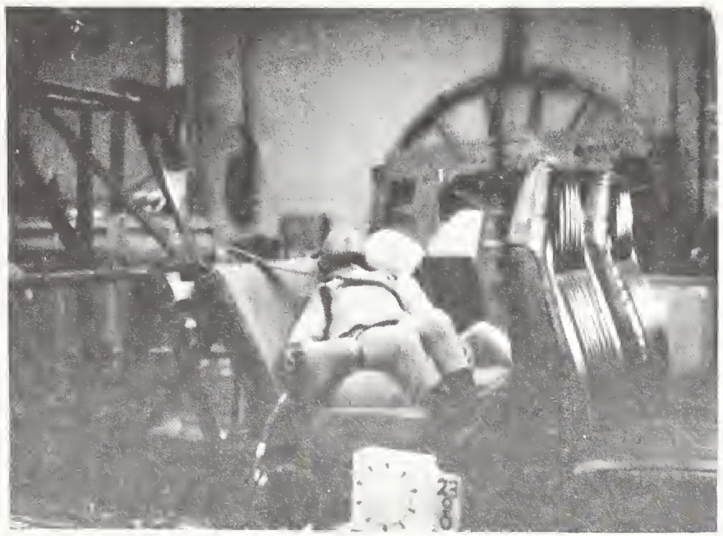

CHANNEL 8 RUN= 2390 SERIES= 2
LEFT PASS. R. LAP BELT LBS.
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

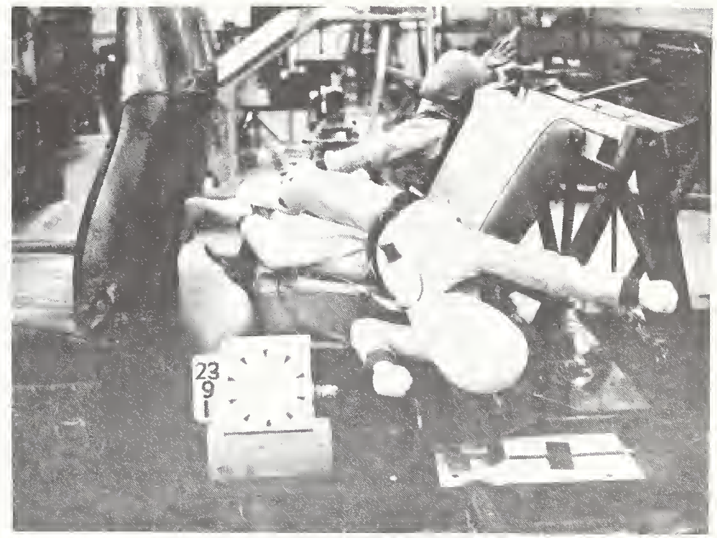

CHANNEL 13 RUN= 2390 SERIES= 2
SLED X ACC. G'S
10
0
-10
-20
-30
-40
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC





PRE-TEST



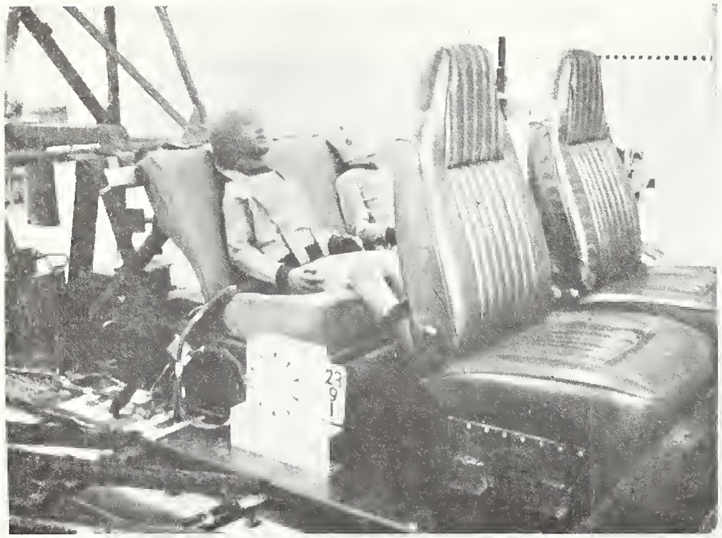


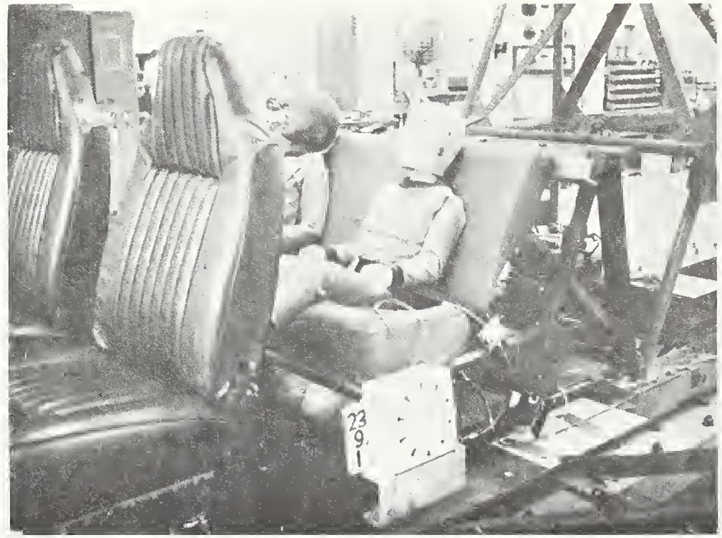
ALDERSON S/N 49

TNO

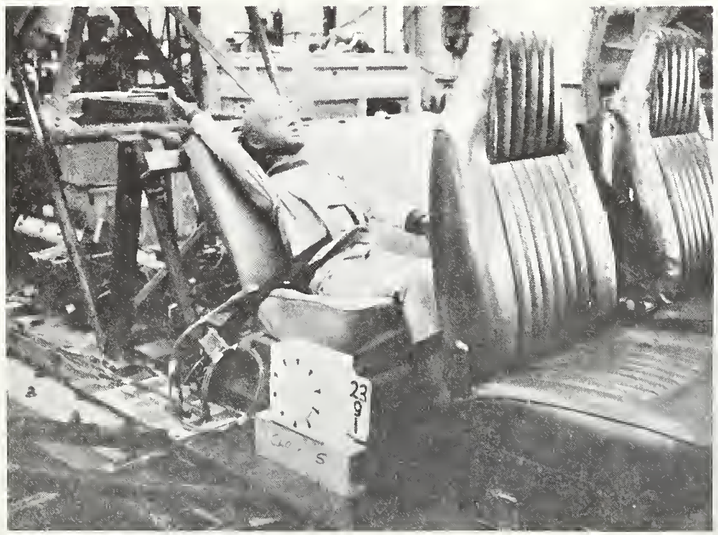
POST-TEST

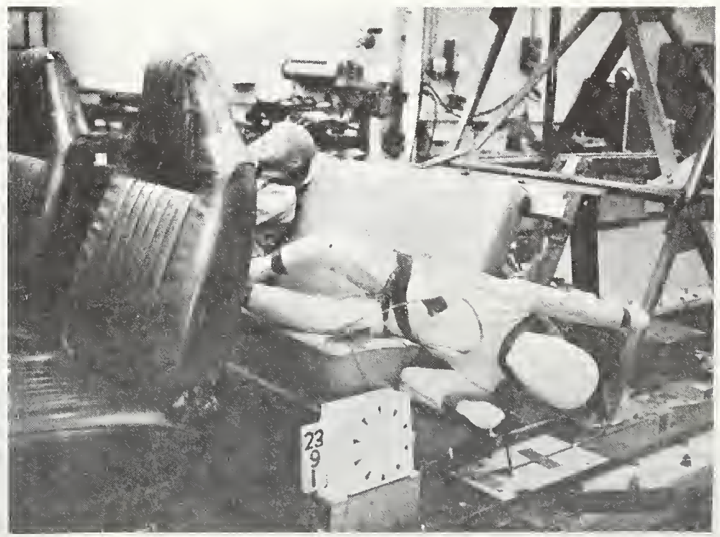
RUN 2391





PRE-TEST





ALDERSON S/N 49

TNO

POST-TEST

RUN 2391

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #3

RUN=2391

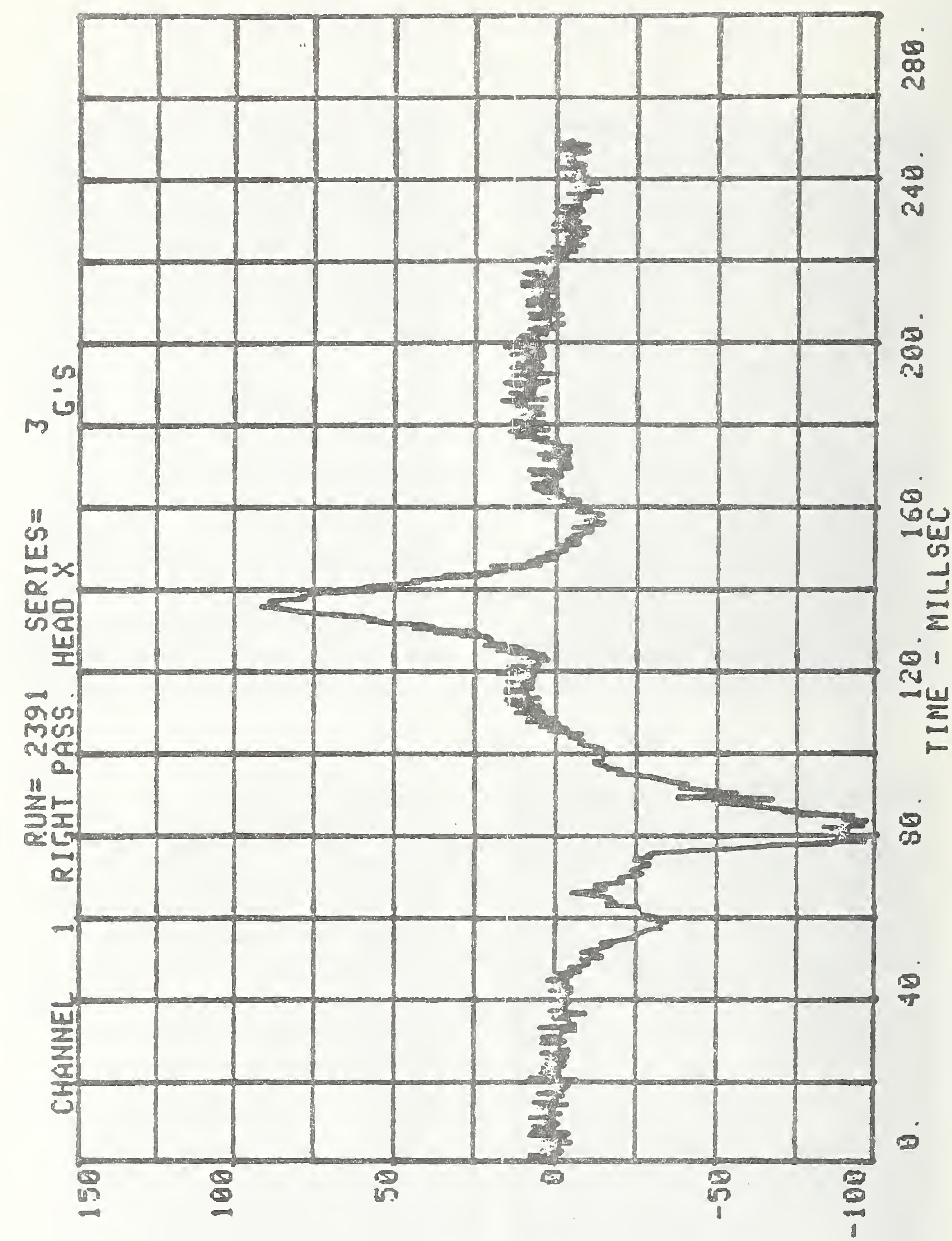
RIGHT PASS. HEAD RESULT.

HIC=2892.5   FROM T1= .05700   TO T2= .14310

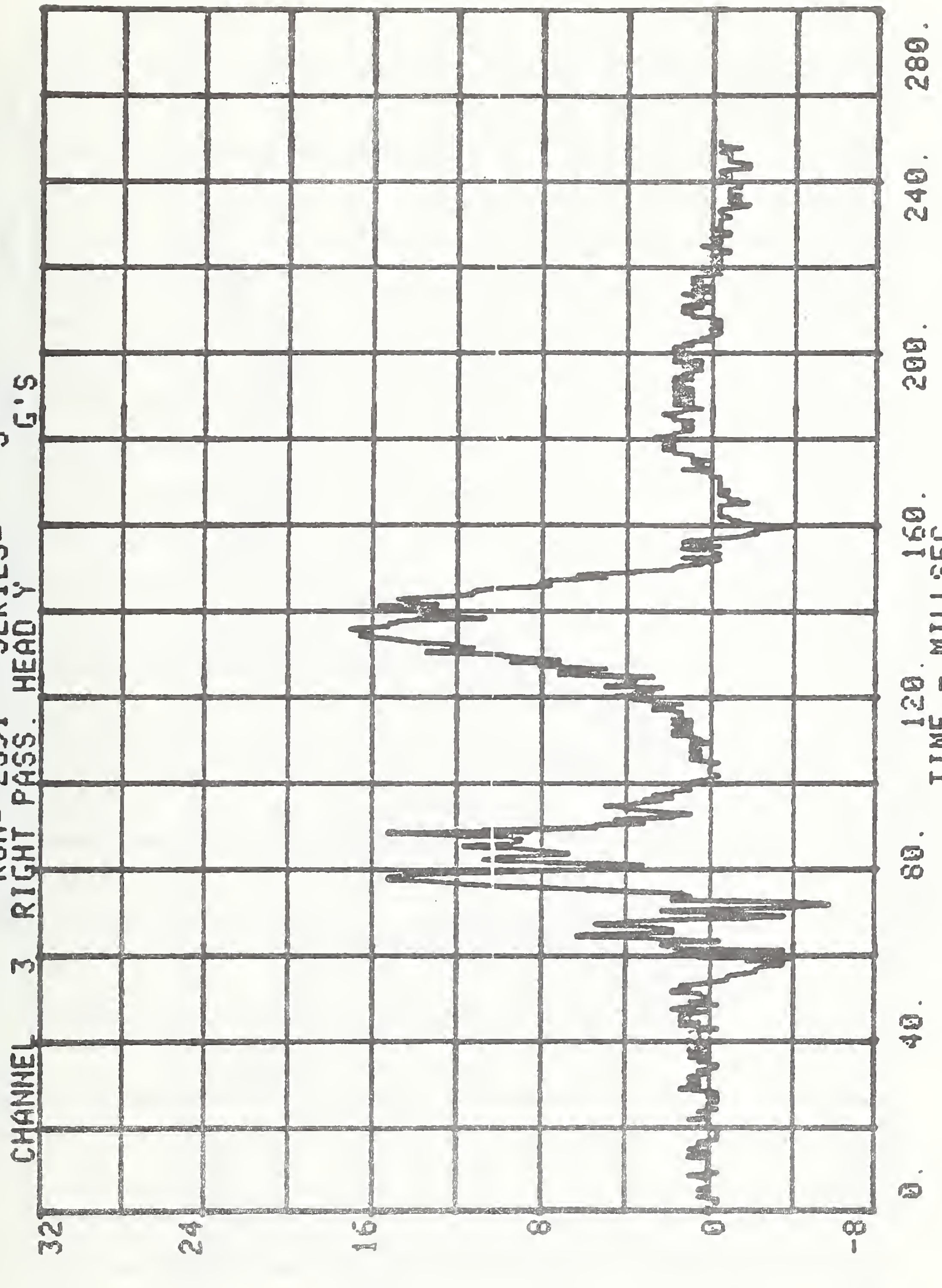
AVERAGE ACCELERATION BETWEEN T1 AND T2= 64.6G'S

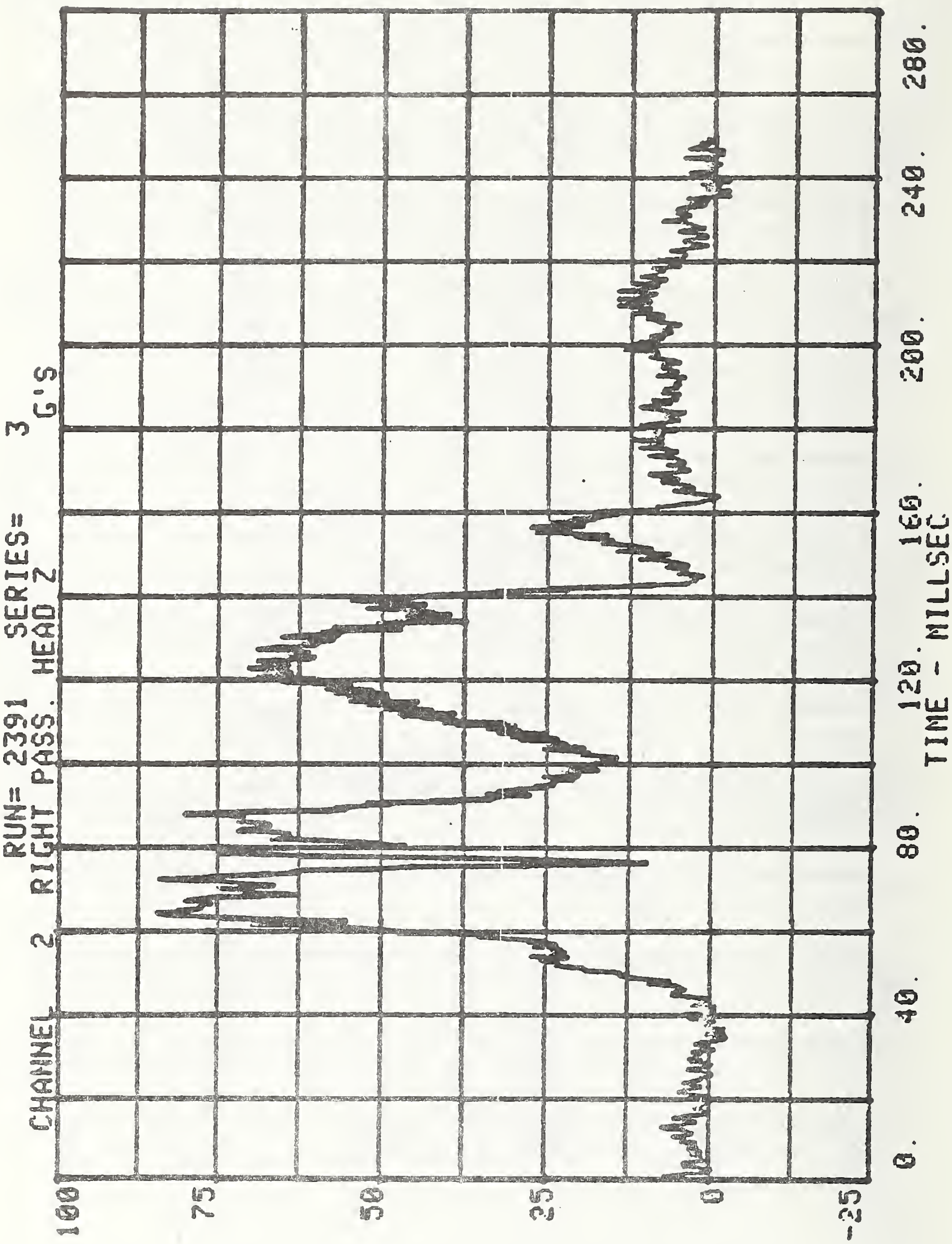
EVENT TIME= 250.0 MSEC

SEVERITY INDEX=3862.2

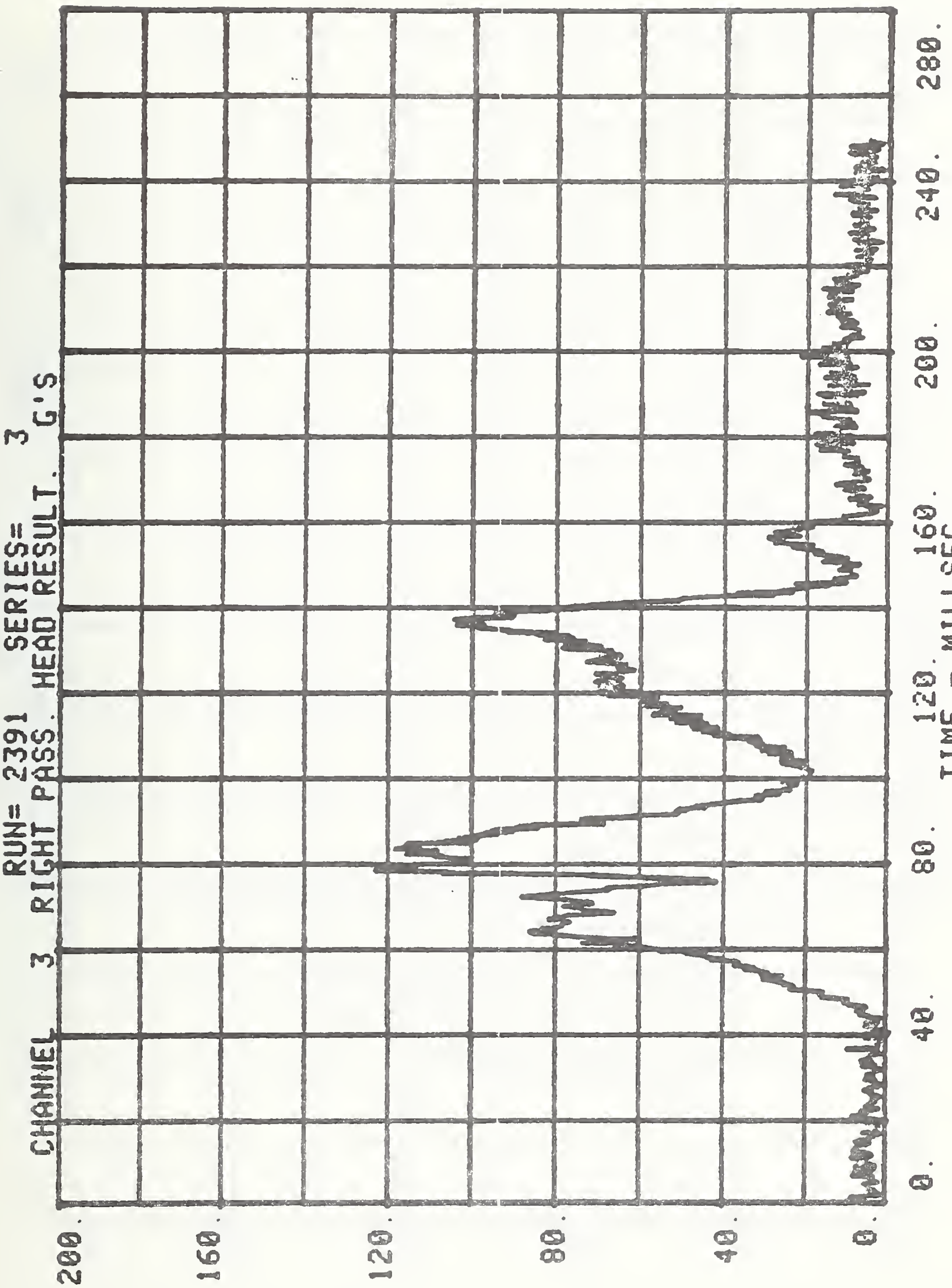


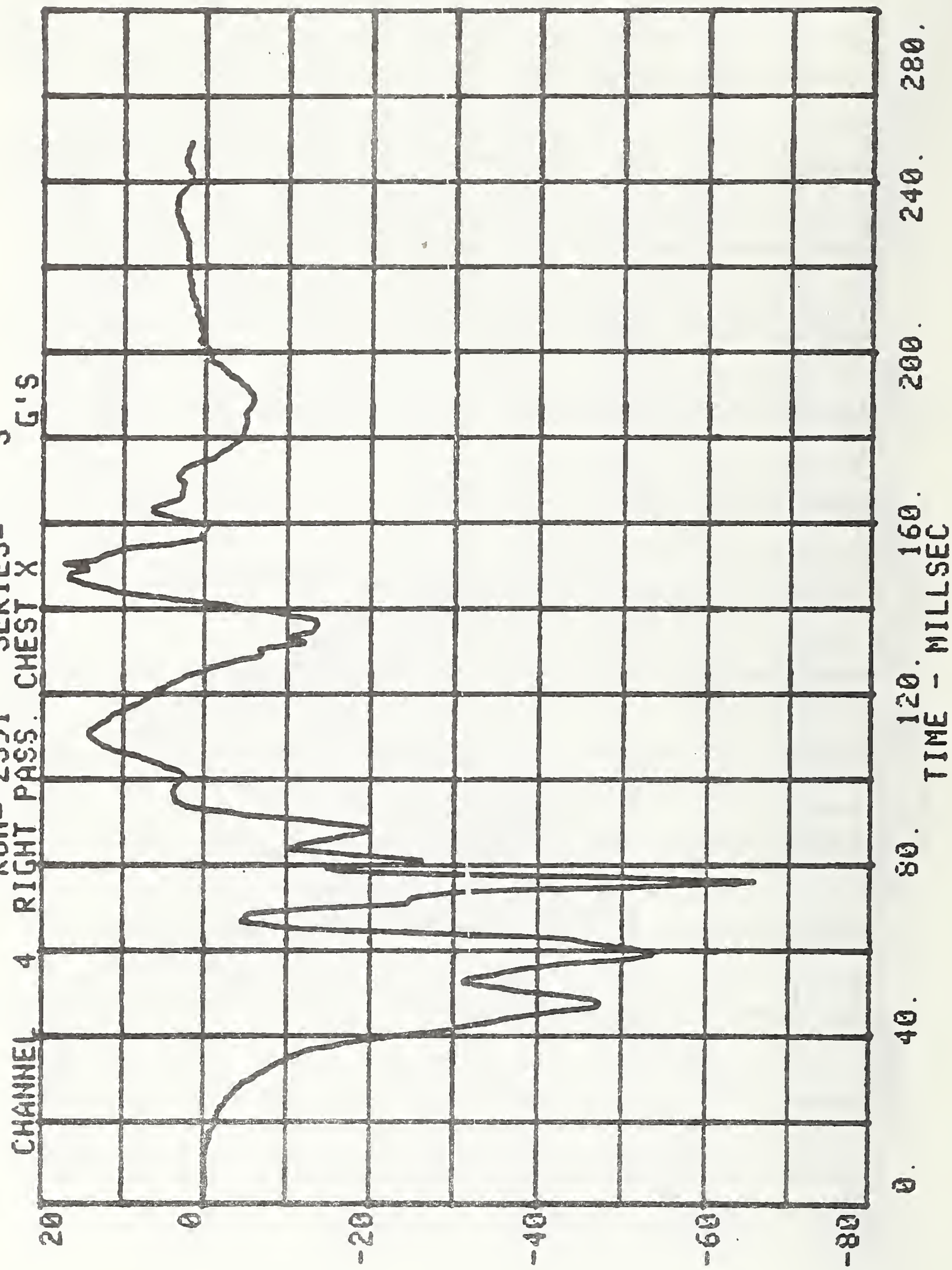
CHANNEL 1 RUN= 2391 SERIES= 3
RIGHT PASS. HEAD X G'S
150
100
50
0
-50
-100
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

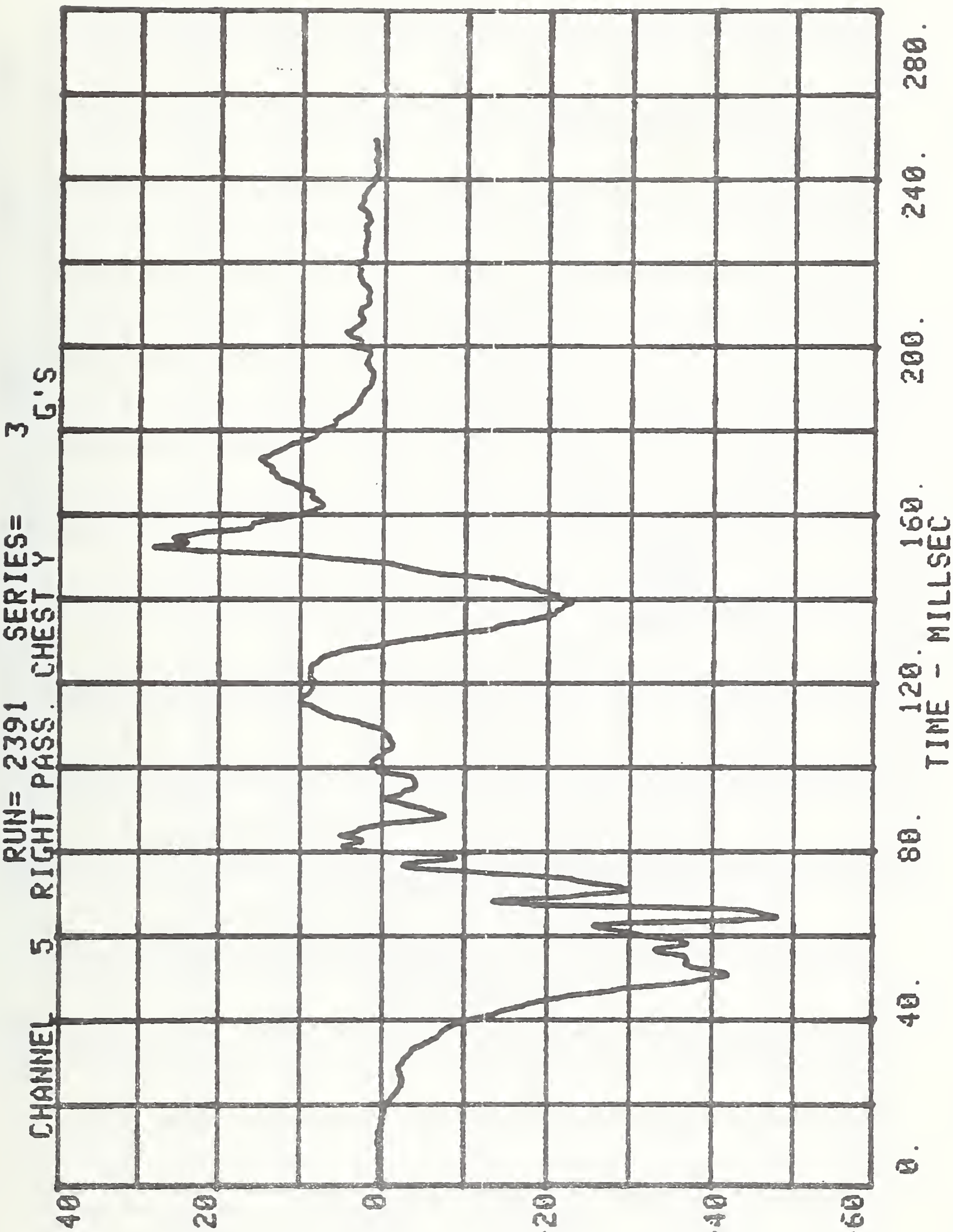

CHANNEL 3 RUN= 2391 SERIES= 3
RIGHT PASS. HEAD Y G'S
32
24
16
8
0
-8
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



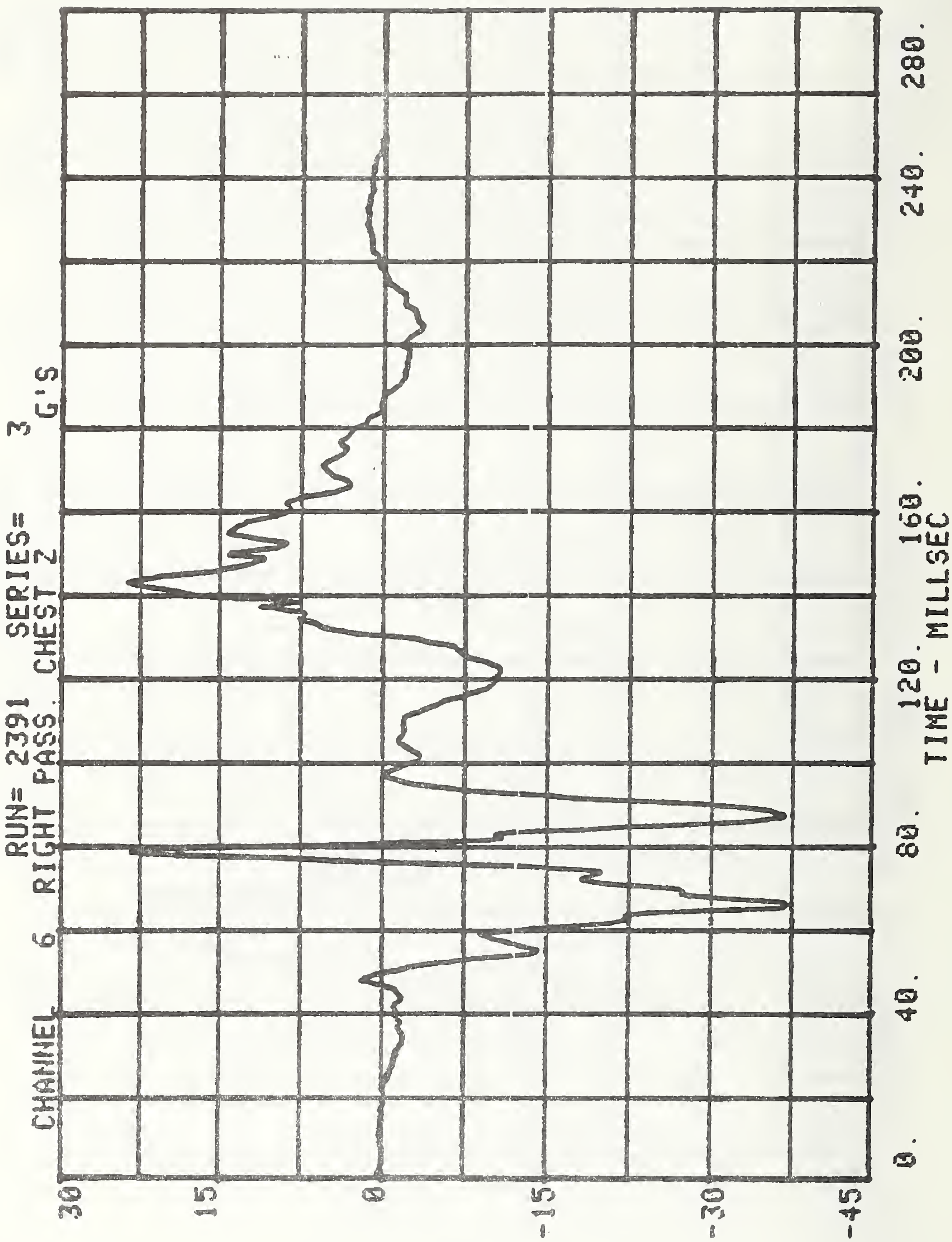
CHANNEL 2 RUN= 2391 SERIES= 3
RIGHT PASS. HEAD 2 G'S
100
75
50
25
0
-25
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

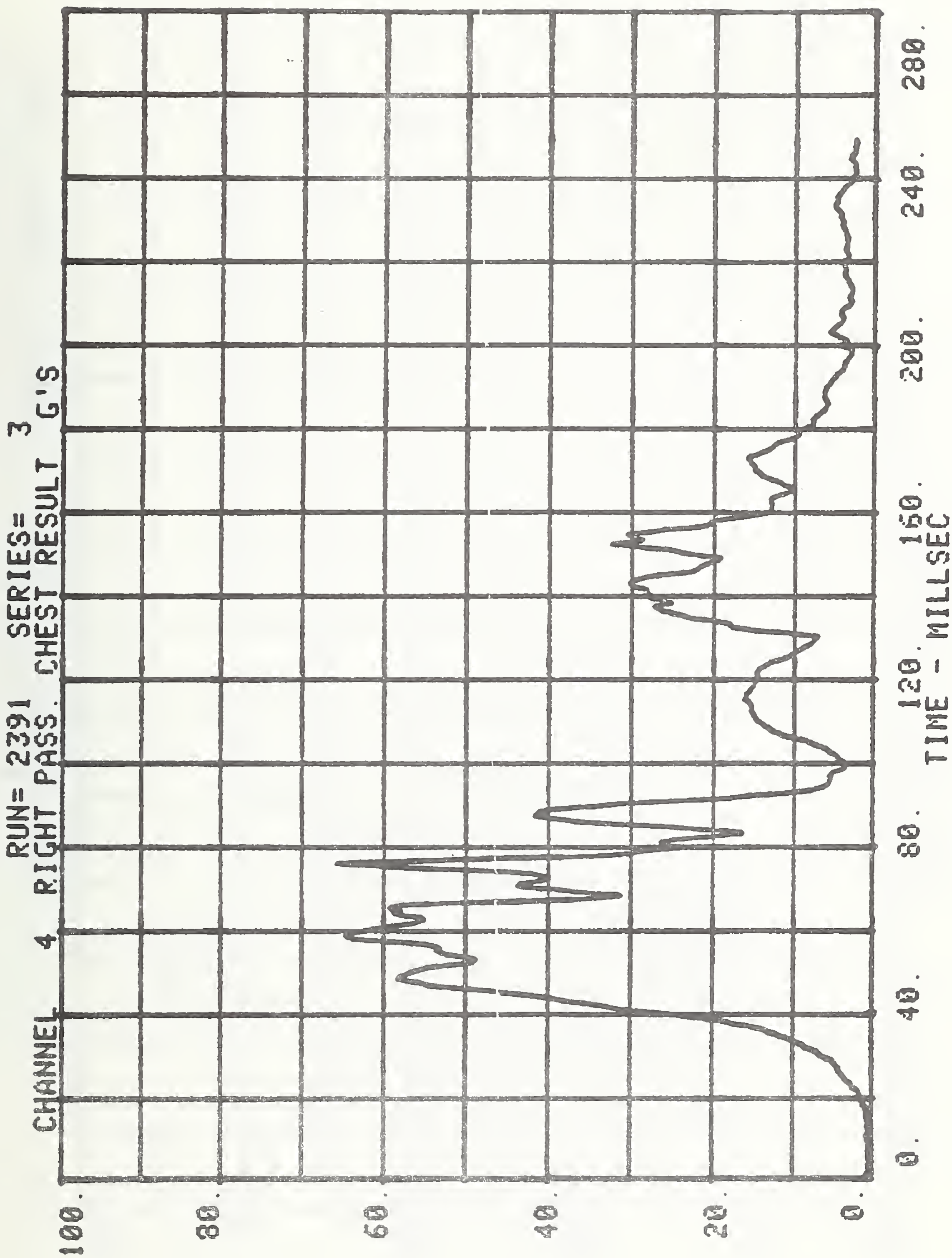

CHANNEL 3 RUN= 2391 SERIES= 3
RIGHT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 40. 80. 120. 160. 200.

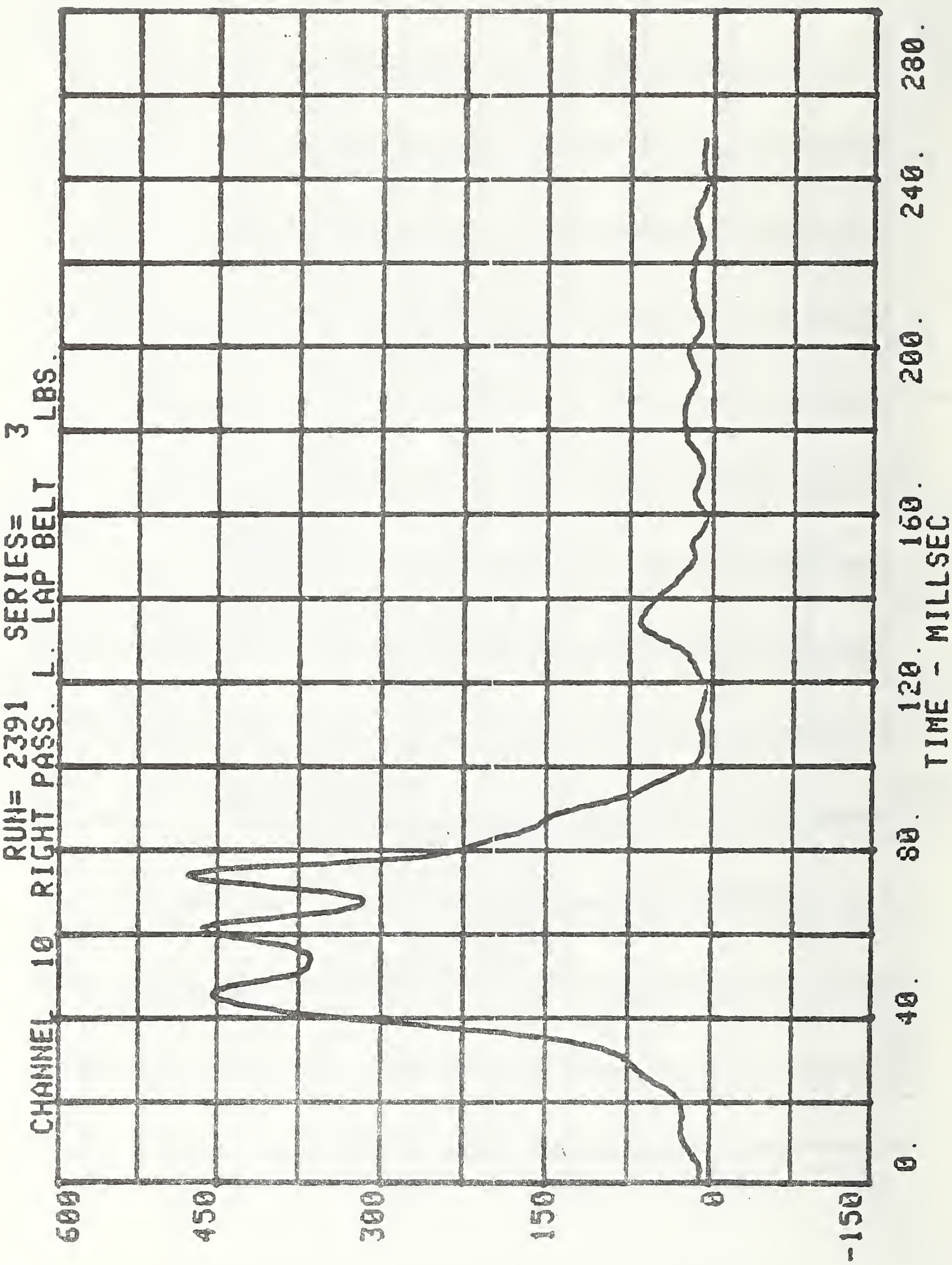

CHANNEL 4 RUN= 2391 SERIES= 3
RIGHT PASS. CHEST X G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
20 0 -20 -40 -60 -80



CHANNEL 5 RUN= 2391 SERIES= 3
RIGHT PASS. CHEST Y G'S
40
20
0
-20
-40
-60
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

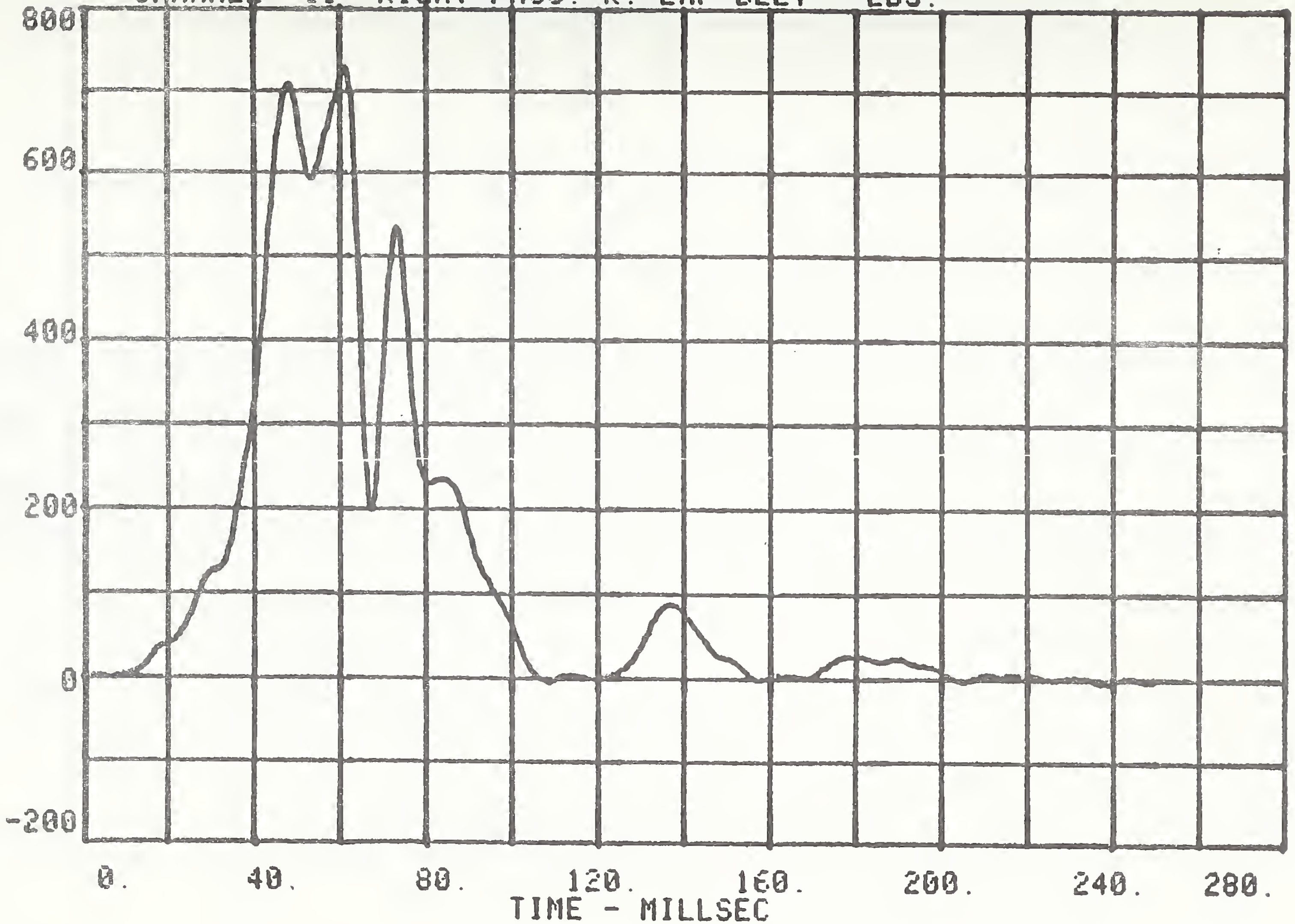

CHANNEL 6 RUN= 2391 SERIES= 3
RIGHT PASS. CHEST Z G'S
30
15
0
-15
-30
-45
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 4 RUN= 2391 SERIES= 3
RIGHT PASS. CHEST RESULT G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
100.
80.
60.
40.
20.
0.



CHANNEL 10 RUN= 2391 SERIES= 3
RIGHT PASS. L. LAP BELT LBS.
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

RUN= 2391 SERIES= 3
CHANNEL 11 RIGHT PASS. R. LAP BELT LBS.



HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #3

RUN=2391

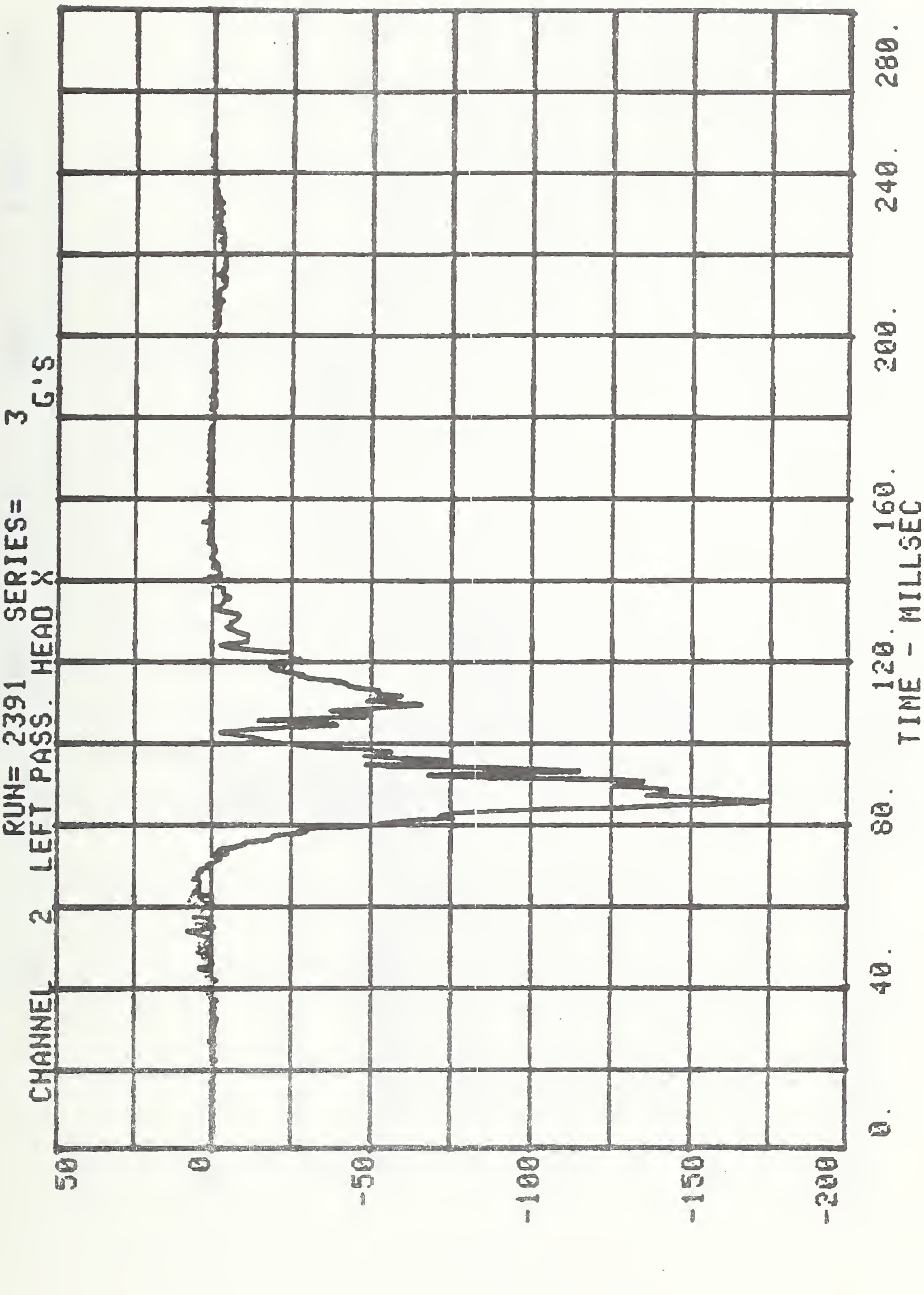
LEFT PASS. HEAD RESULT.

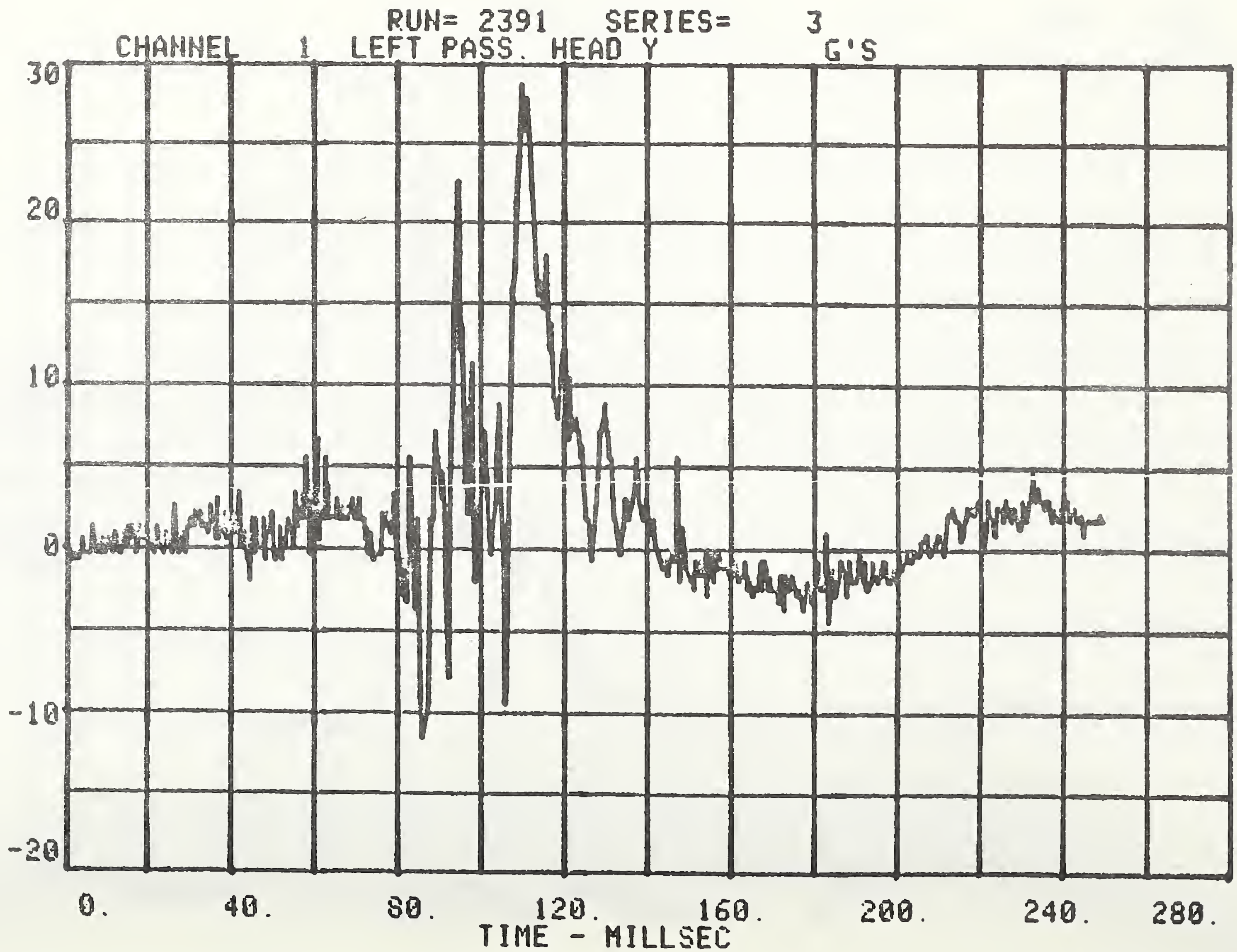
HIC=3347.8 FROM T1= .07920 TO T2= .10260

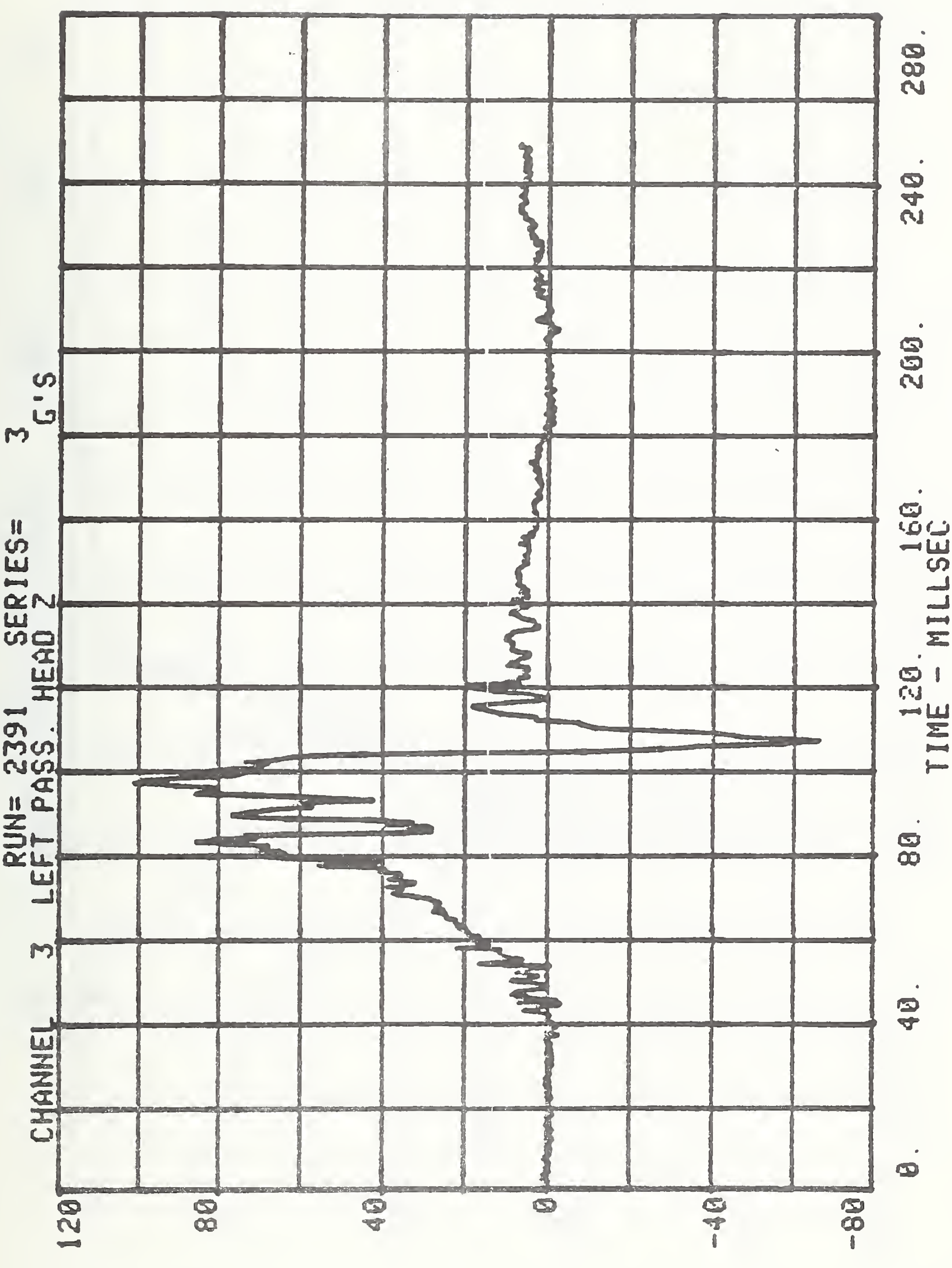
AVERAGE ACCELERATION BETWEEN T1 AND T2= 115.4G'S

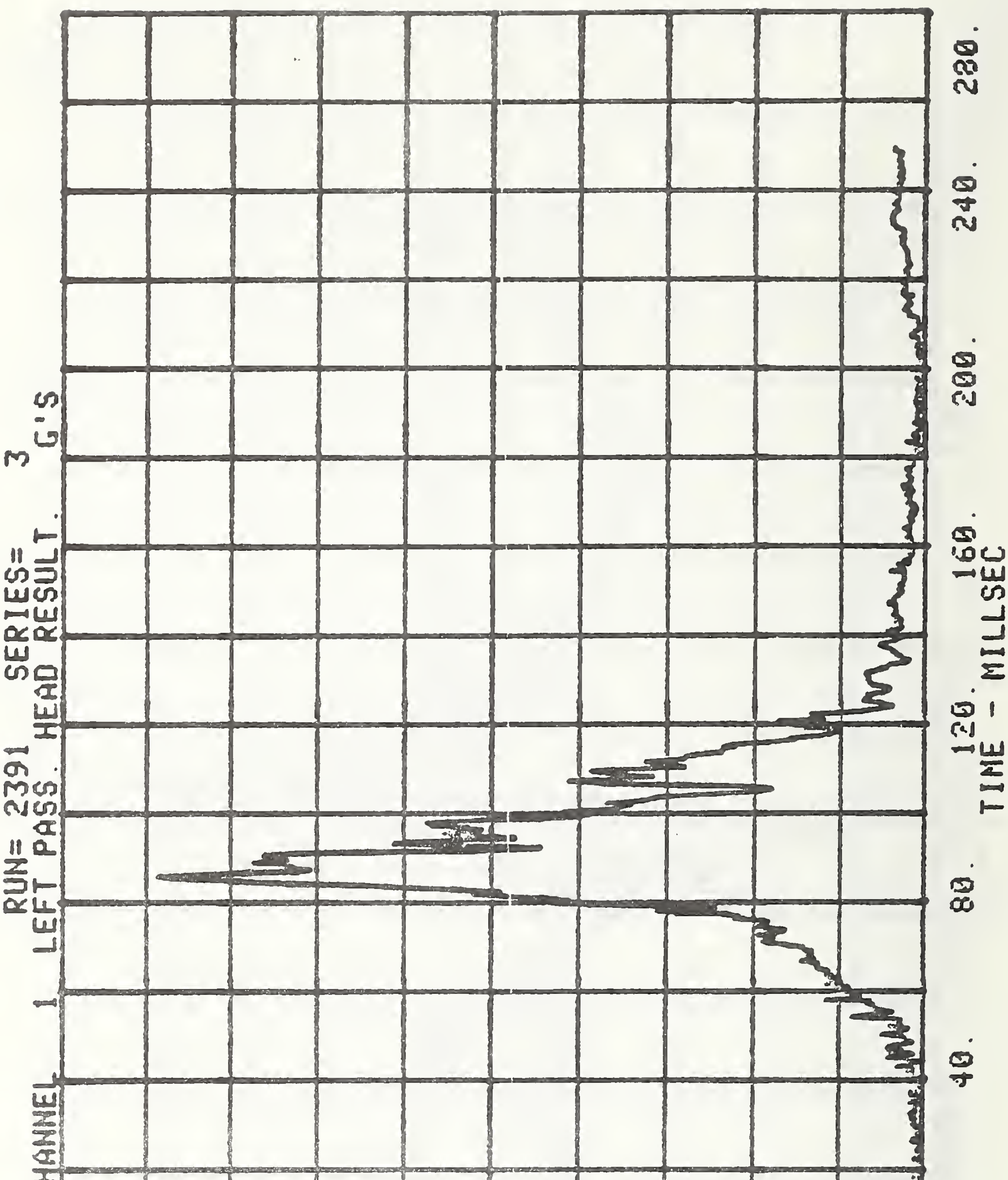
EVENT TIME= 250.0 MSEC

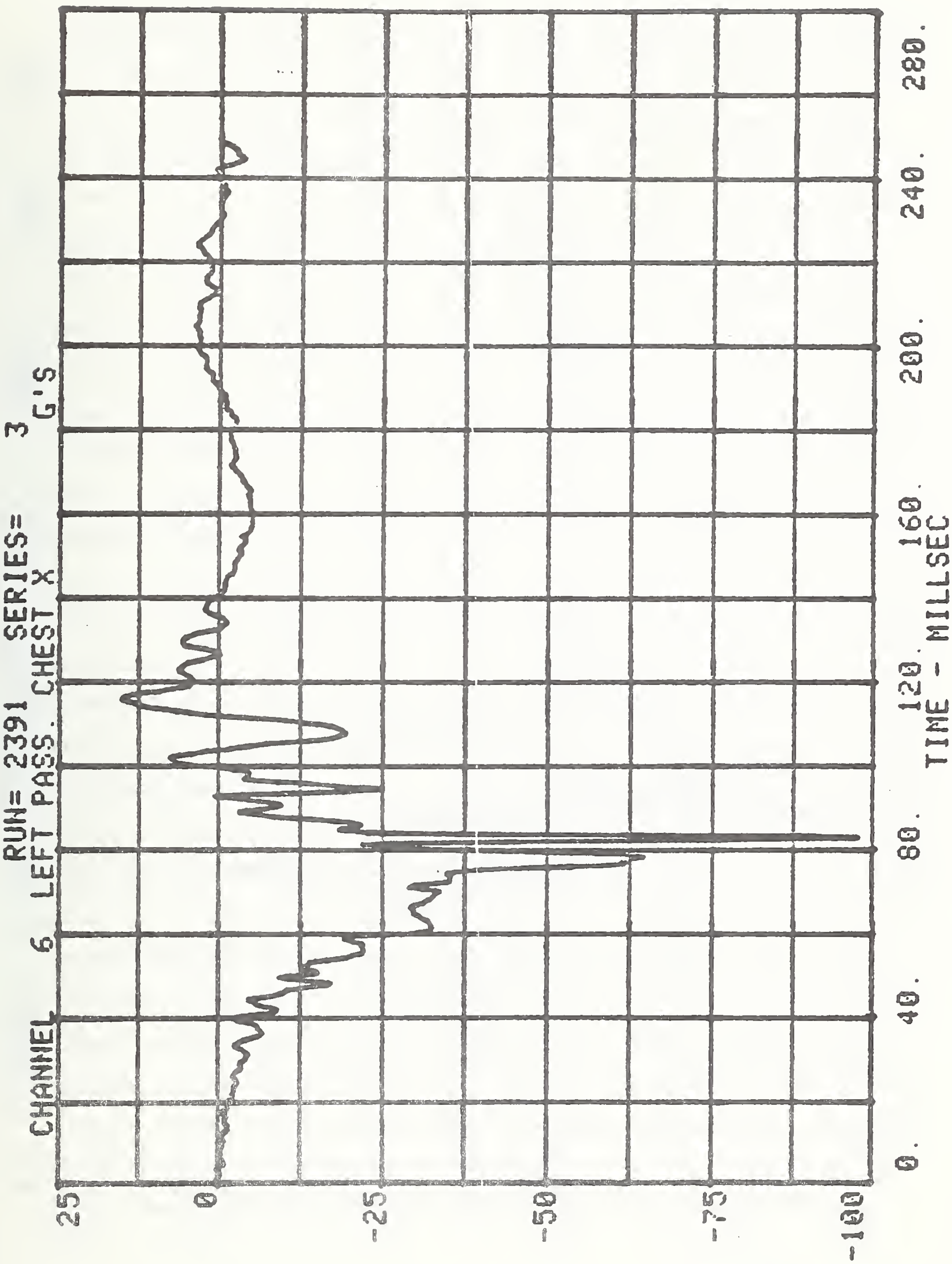
SEVERITY INDEX=4338.1


CHANNEL 2 RUN= 2391 SERIES= 3
LEFT PASS. HEAD X G'S
50
0
-50
-100
-150
-200
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

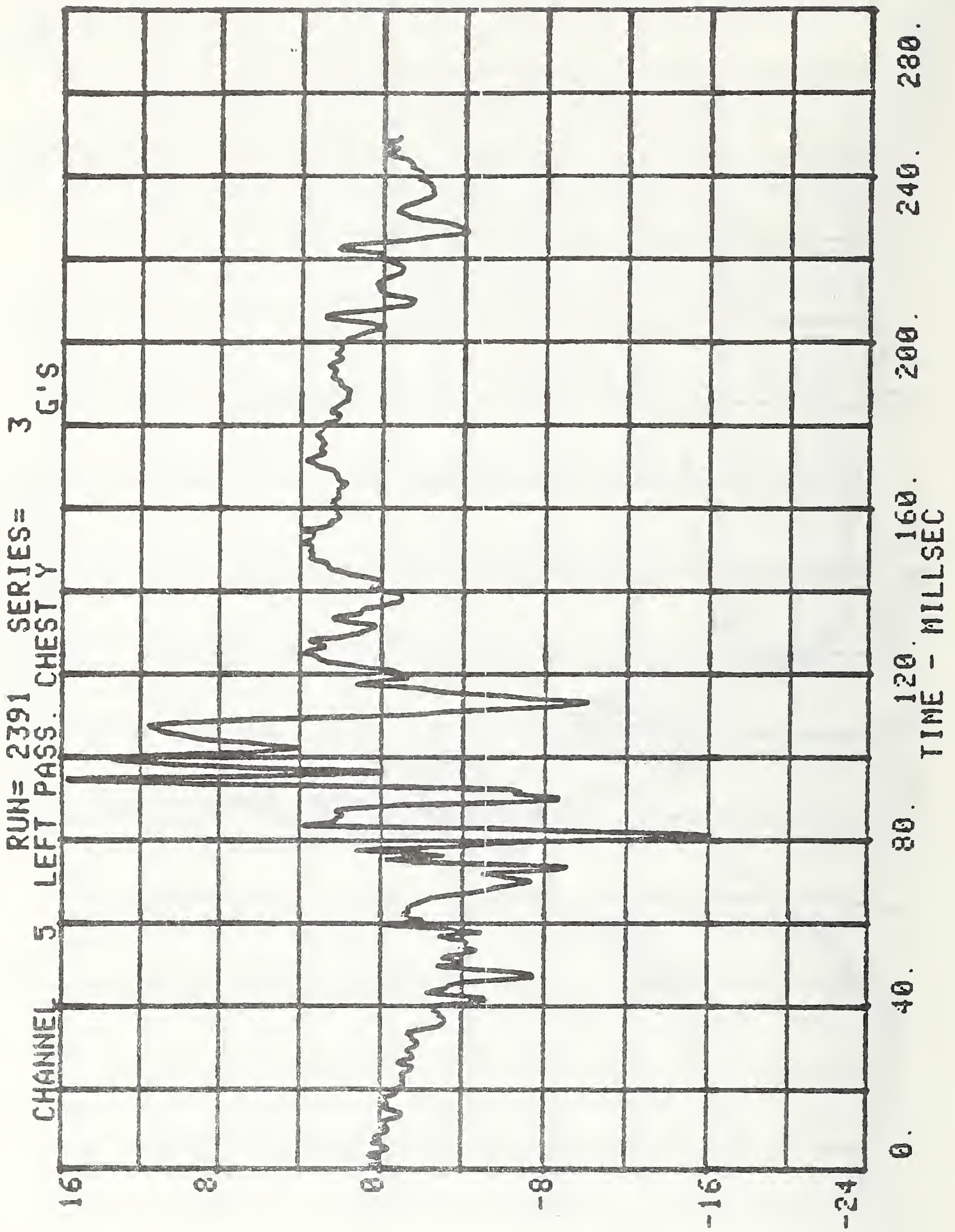

RUN= 2391 SERIES= 3
CHANNEL 1 LEFT PASS. HEAD Y G'S
30
20
10
0
-10
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 3 RUN= 2391 SERIES= 3
LEFT PASS. HEAD Z G'S
120
80
40
0
-40
-80
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

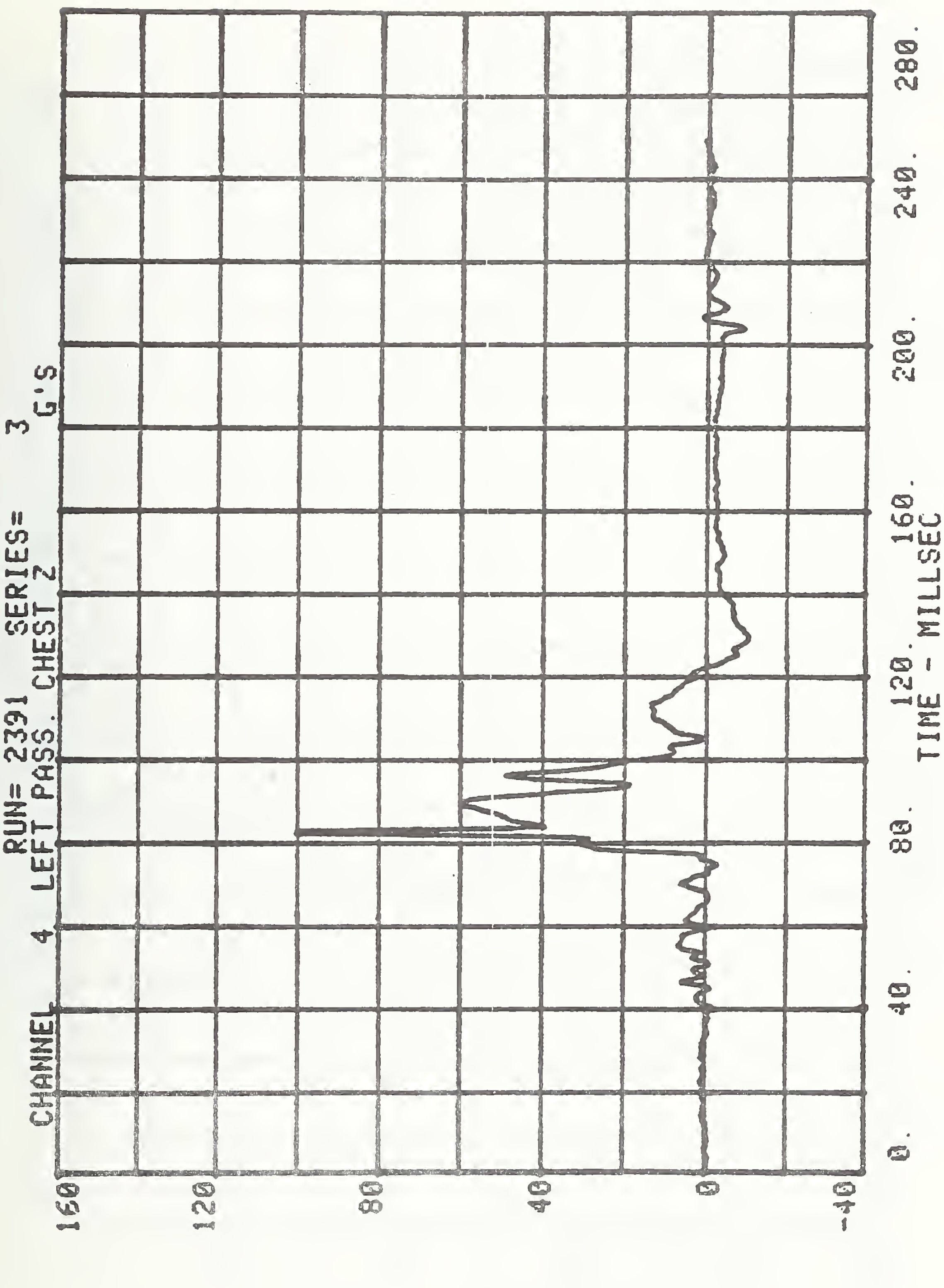

CHANNEL 1 RUN= 2391 SERIES= 3
LEFT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
0. 40. 80. 120. 160. 200.

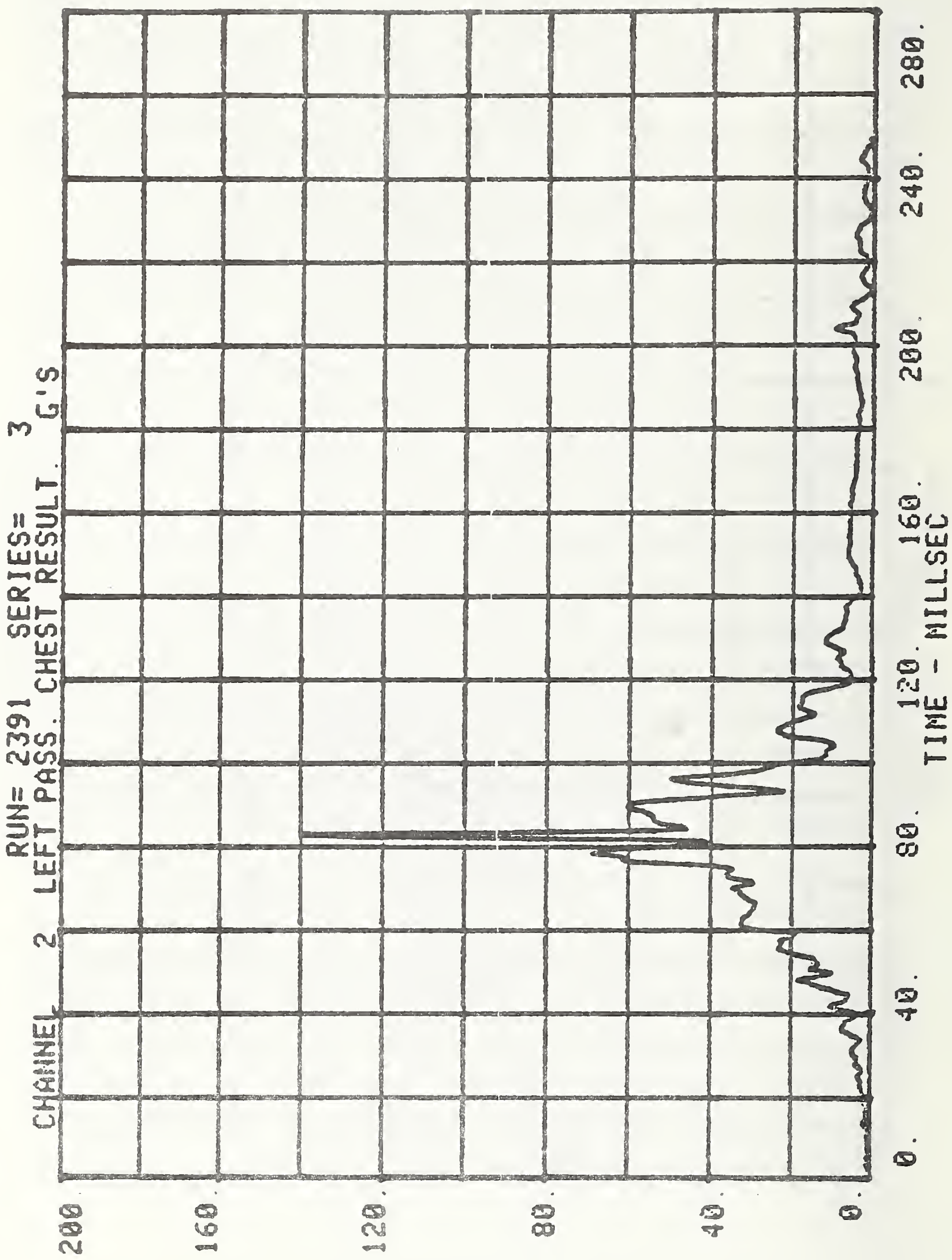


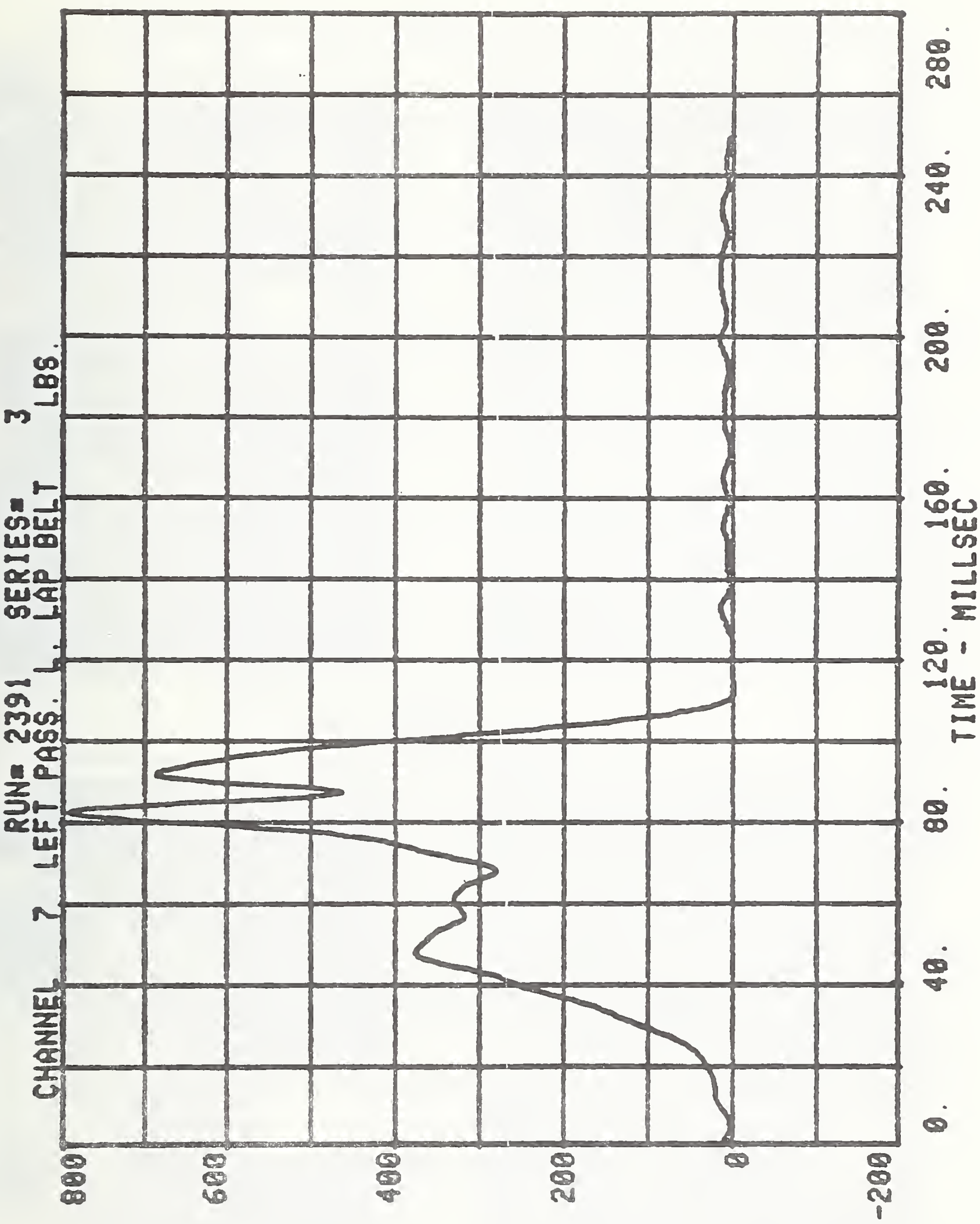
CHANNEL 6 RUN= 2391 SERIES= 3
LEFT PASS. CHEST X G'S
25
0
-25
-50
-75
-100
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

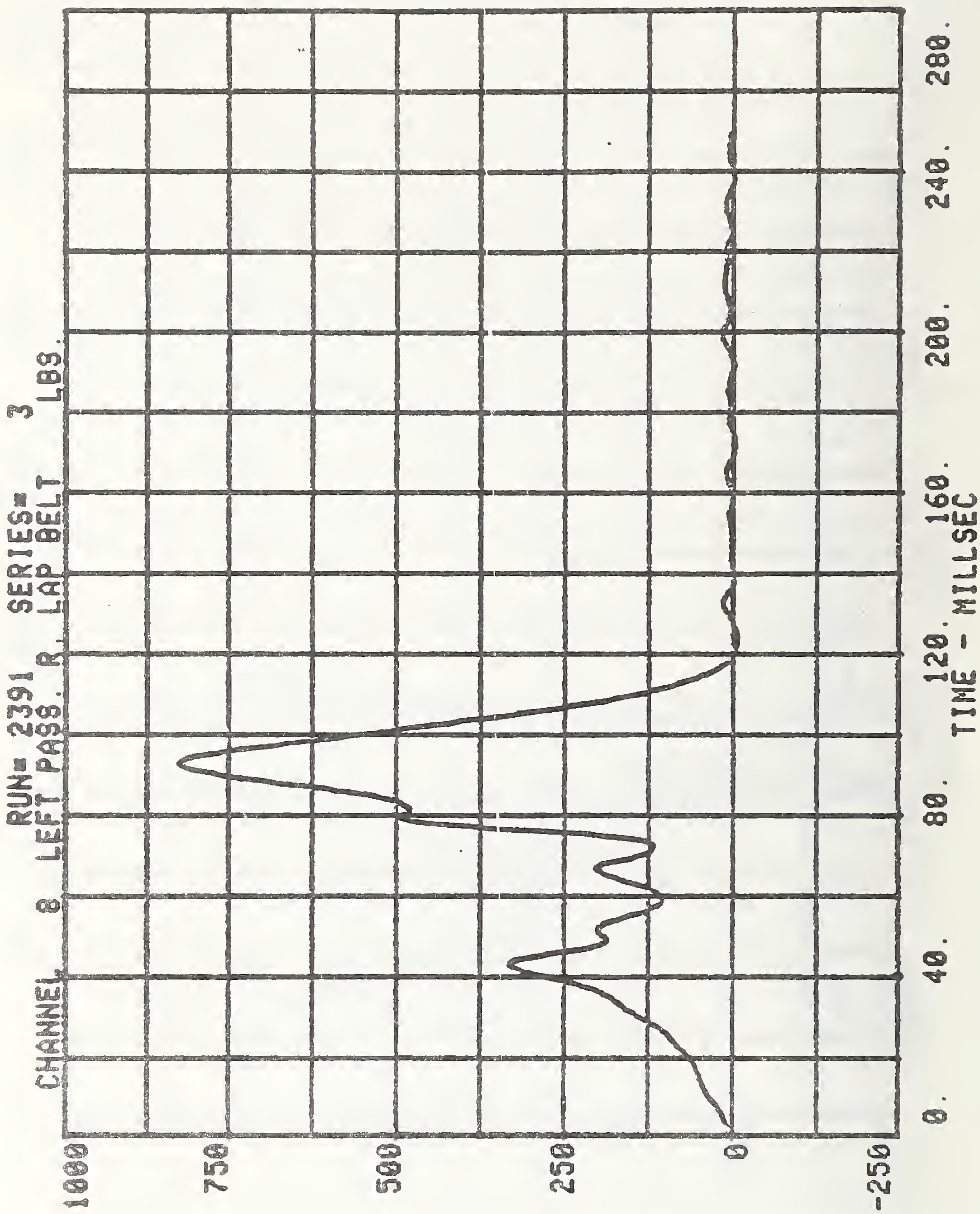


RUN= 2391 SERIES= 3
CHANNEL 5 LEFT PASS. CHEST Y G'S
16
8
0
-8
-16
-24
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

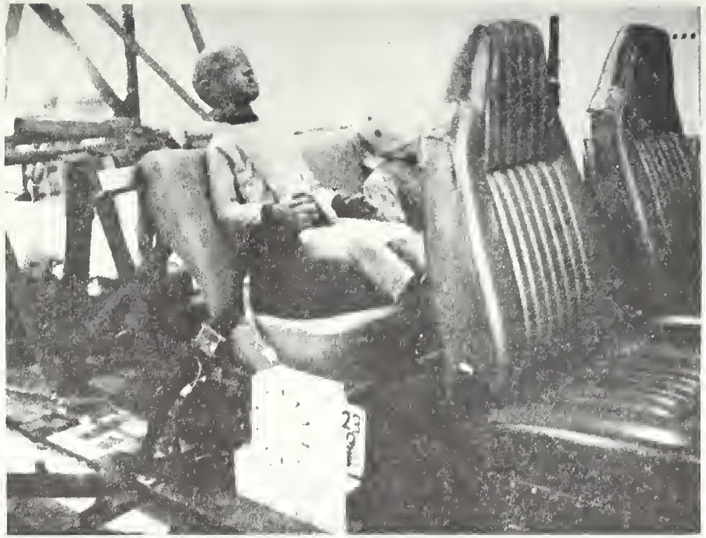

CHANNEL 4 RUN= 2391 SERIES= 3
LEFT PASS. CHEST Z G'S
160
120
80
40
0
-40
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


RUN= 2391 SERIES= 3
CHANNEL 2 LEFT PASS. CHEST RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
0.
40.
80.
120.
160.
200.

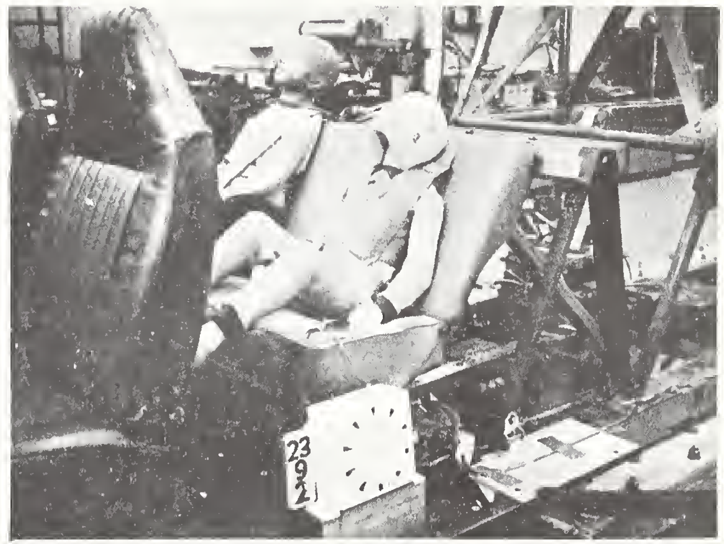

CHANNEL 7 RUN= 2391 SERIES= 3
LEFT PASS. L. LAP BELT LBS.
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
800
600
400
200
0
-200



CHANNEL 8 RUN= 2391 SERIES= 3
LEFT PASS. R. LAP BELT LBS.
1000
750
500
250
0
-250
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



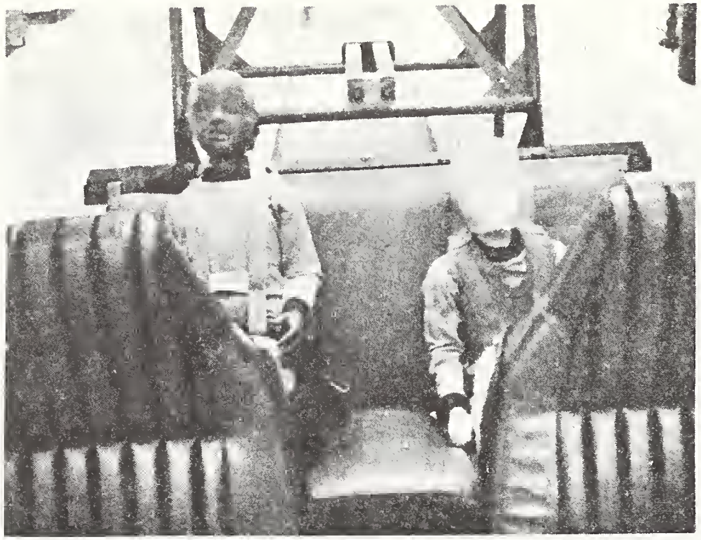
PRE-TEST



ALDERSON S/N 49

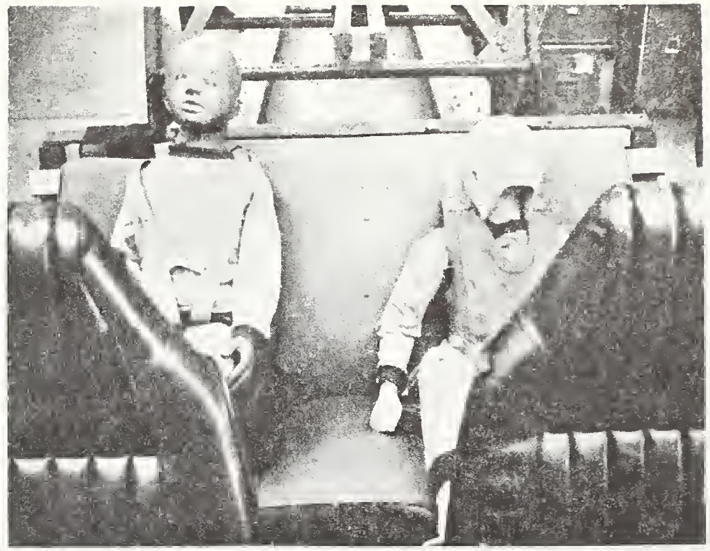
TNO

POST-TEST



ALDERSON S/N 49 TNO

PRE-TEST



ALDERSON S/N 49 TNO

POST-TEST

RUN 2392

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #4

RUN=2392

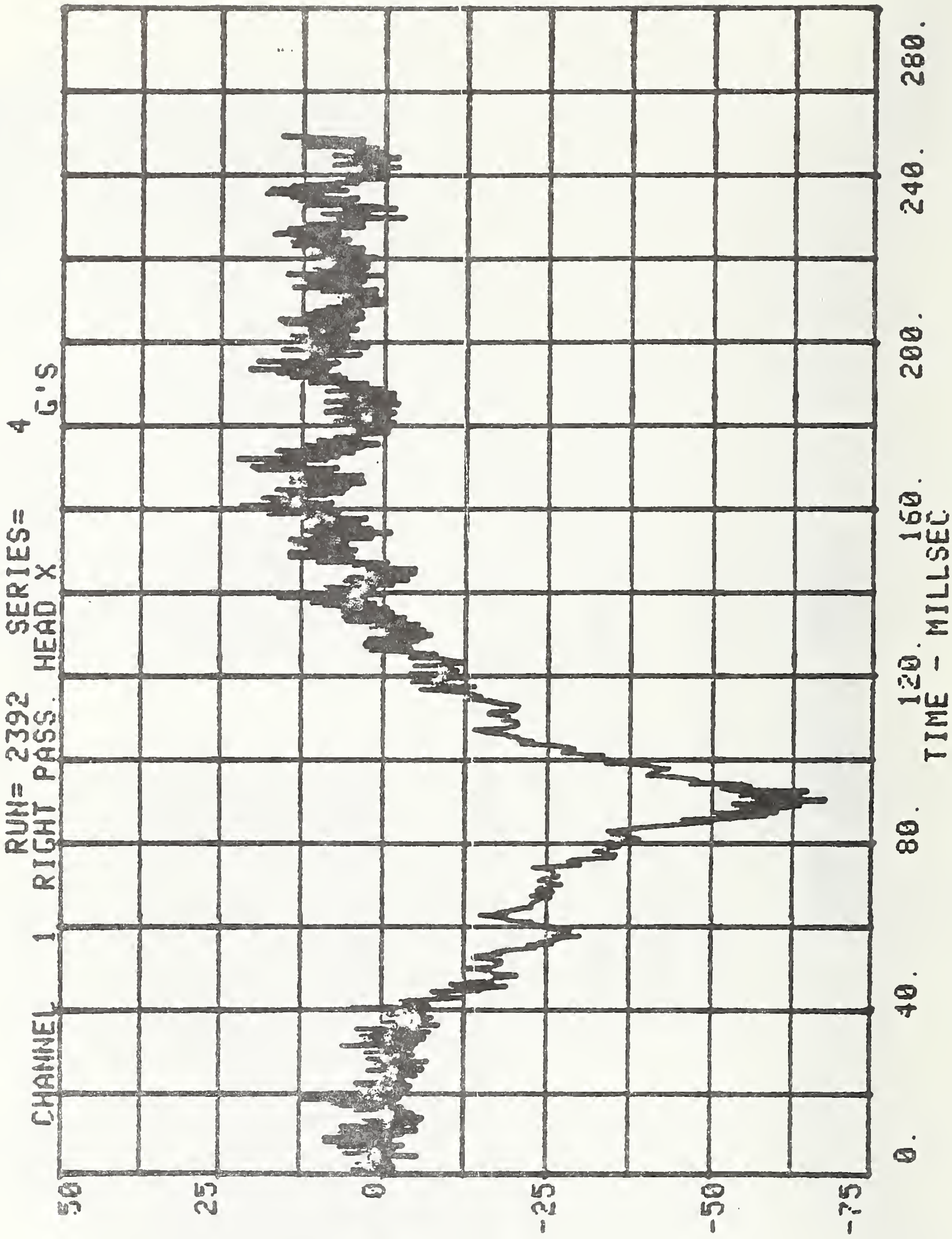
RIGHT PASS. HEAD RESULT.

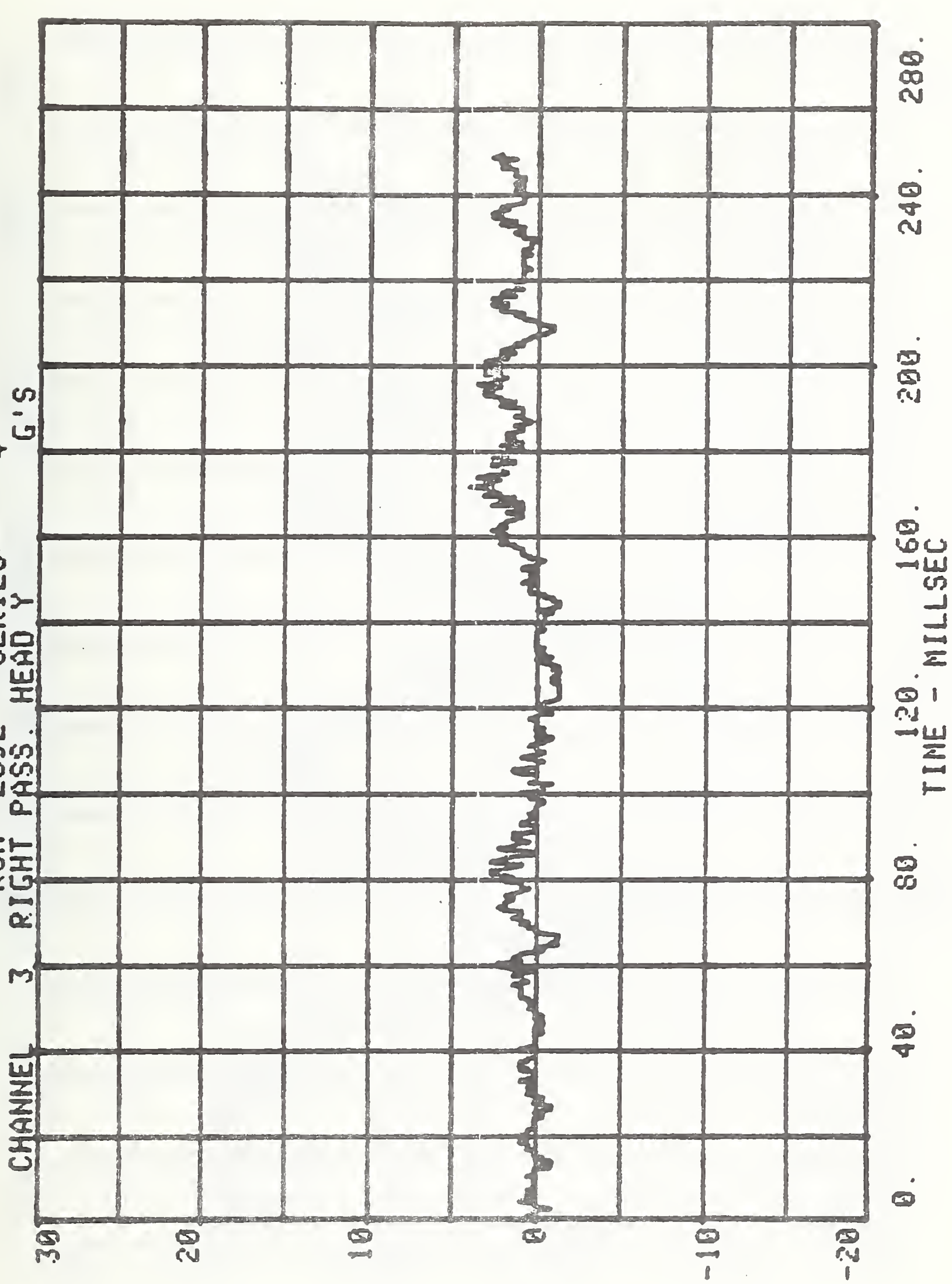
HIC= 697.4   FROM T1= .05010   TO T2= .16230

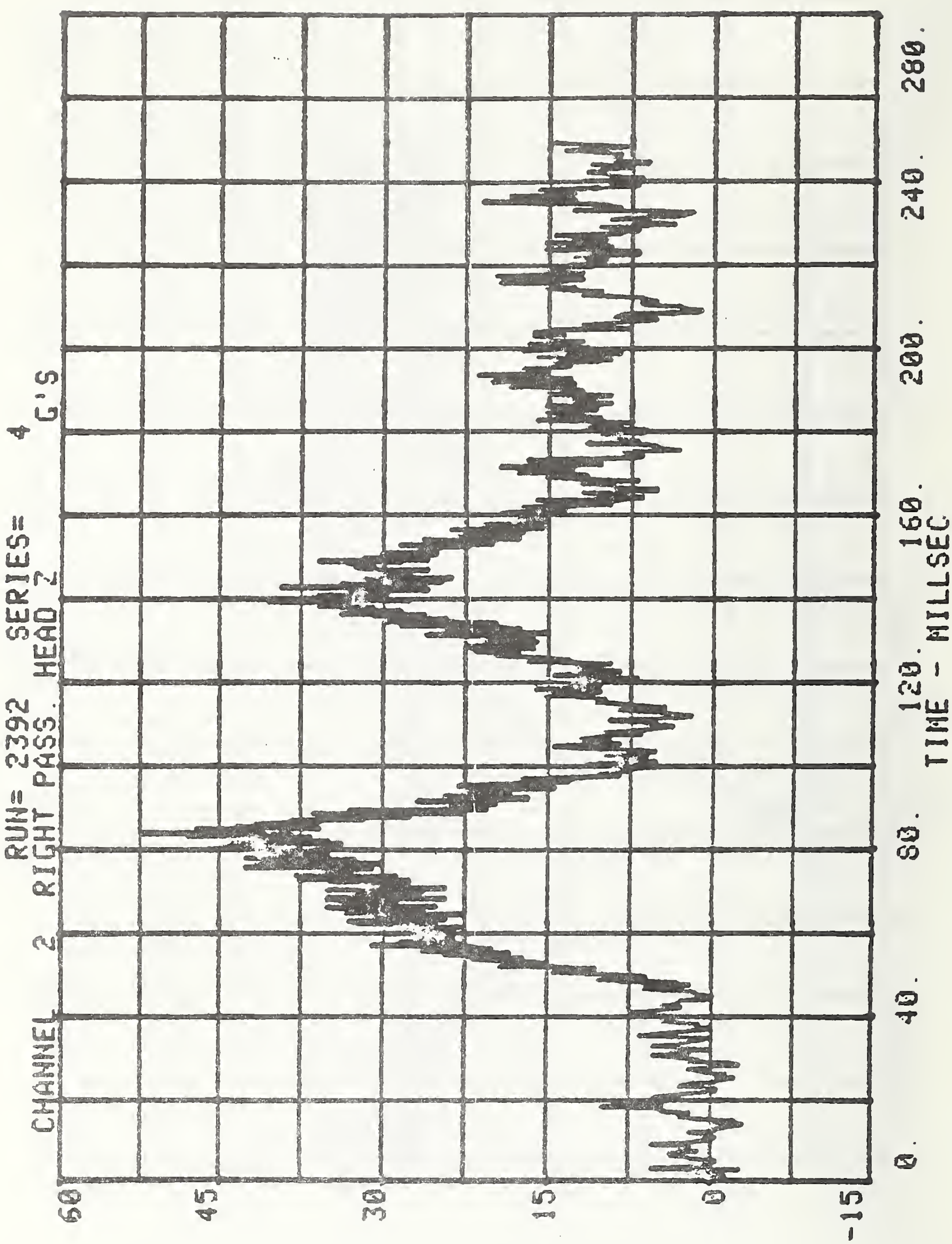
AVERAGE ACCELERATION BETWEEN T1 AND T2= 32.9G'S

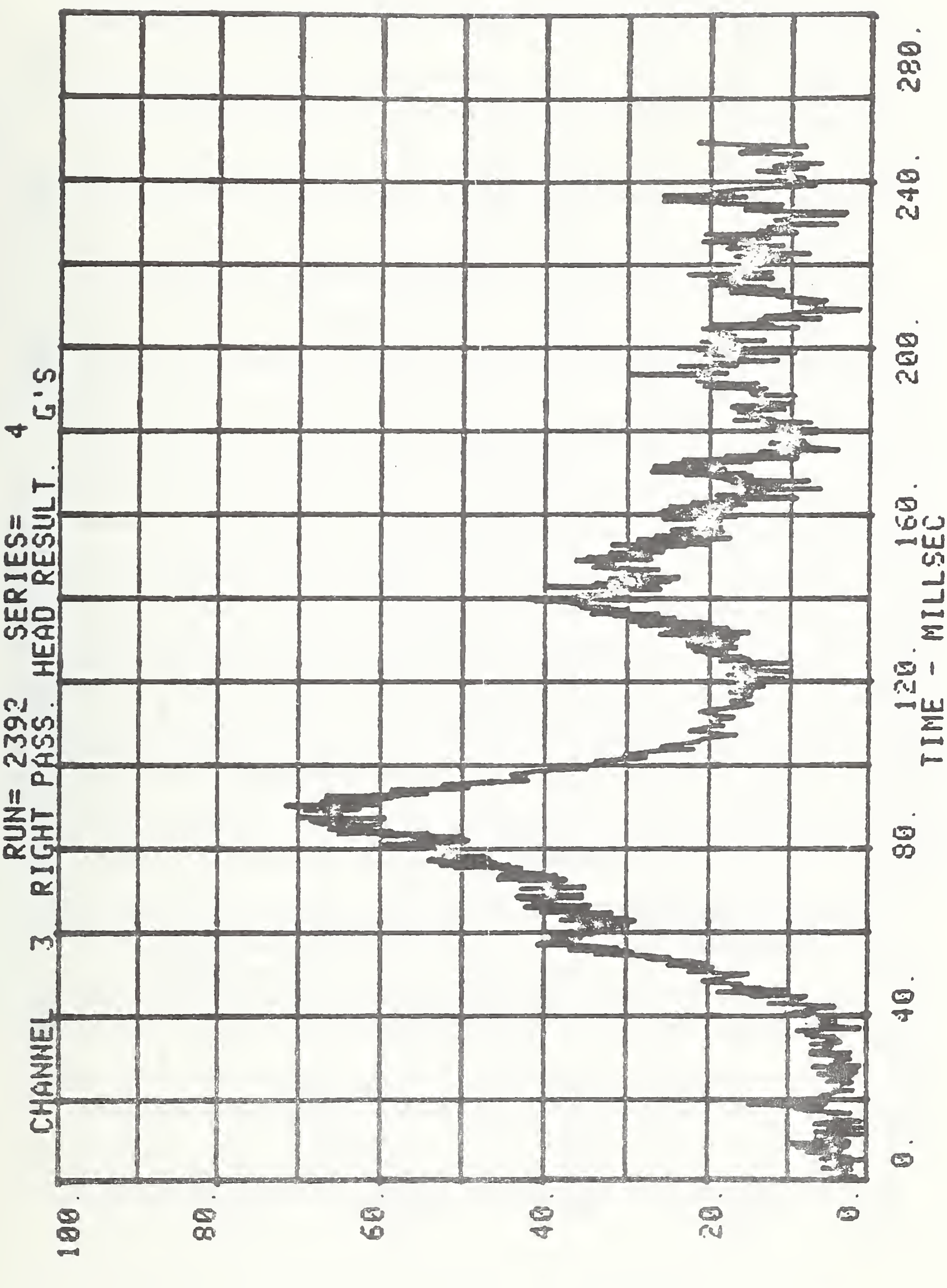
EVENT TIME= 250.0 MSEC

SEVERITY INDEX=1061.8

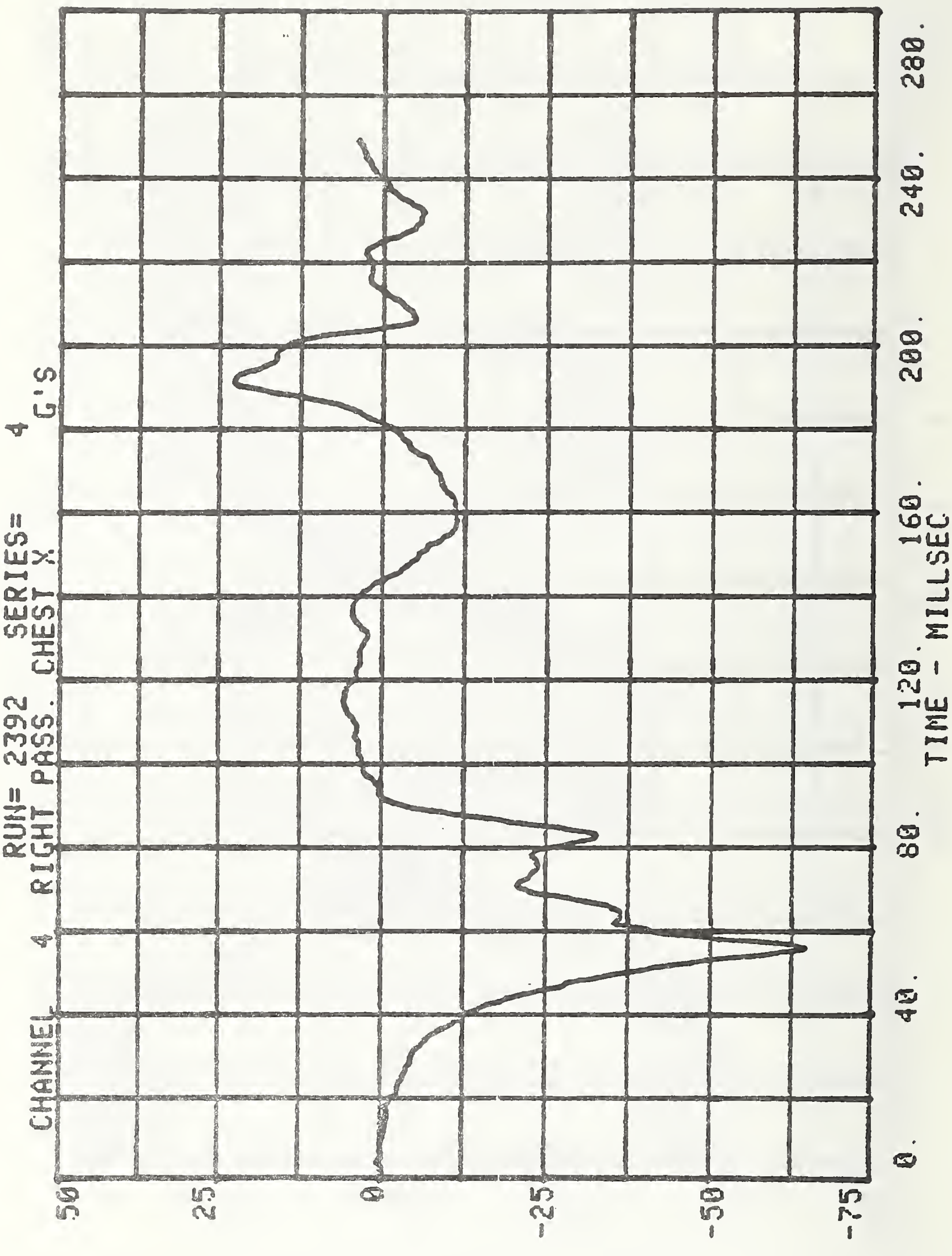

CHANNEL 1 RUN= 2392 SERIES= 4
RIGHT PASS HEAD X G'S
50
25
0
-25
-50
-75
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

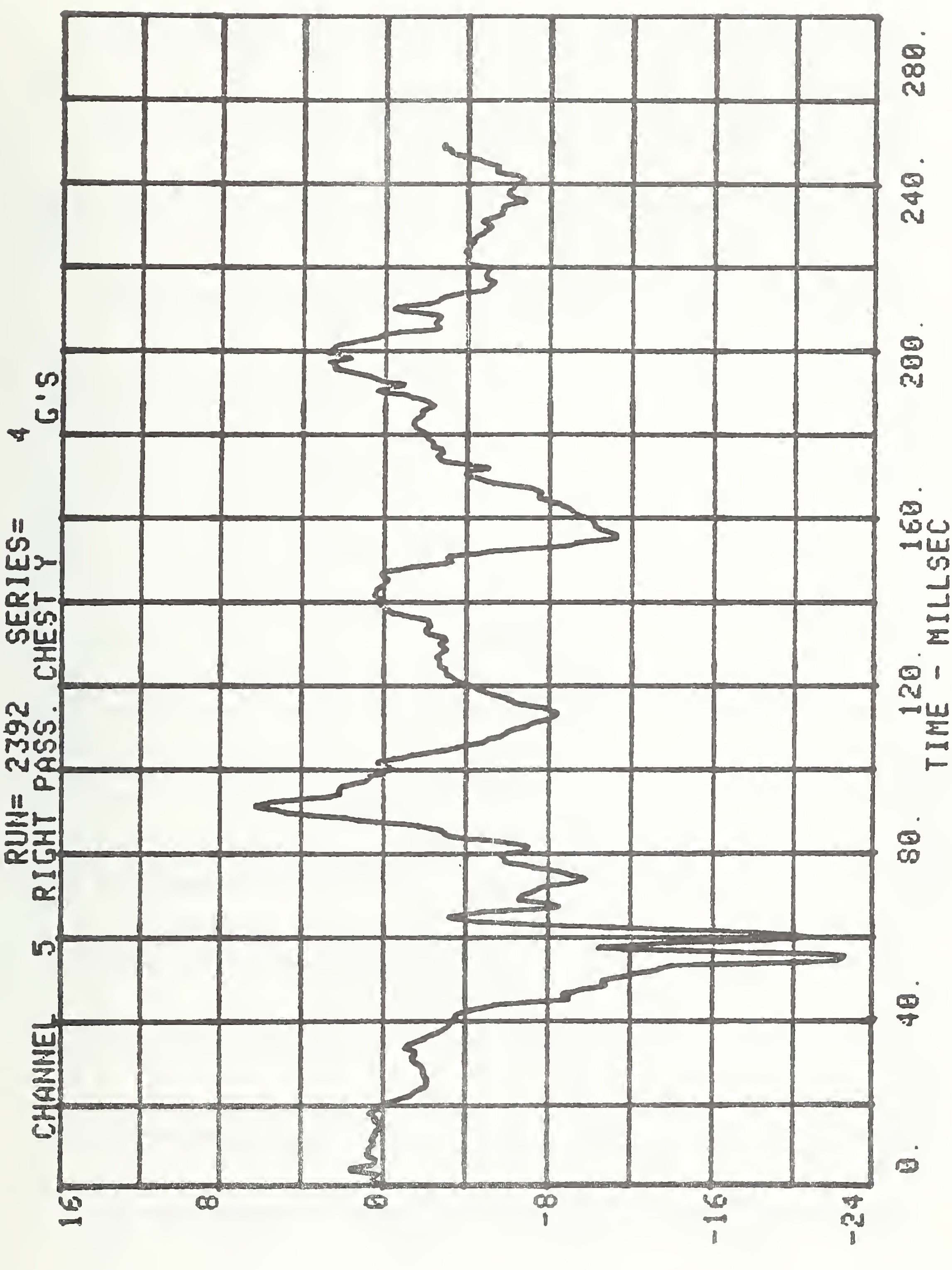

CHANNEL 3 RUN= 2392 SERIES= 4
RIGHT PASS. HEAD Y G'S
30
20
10
0
-10
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

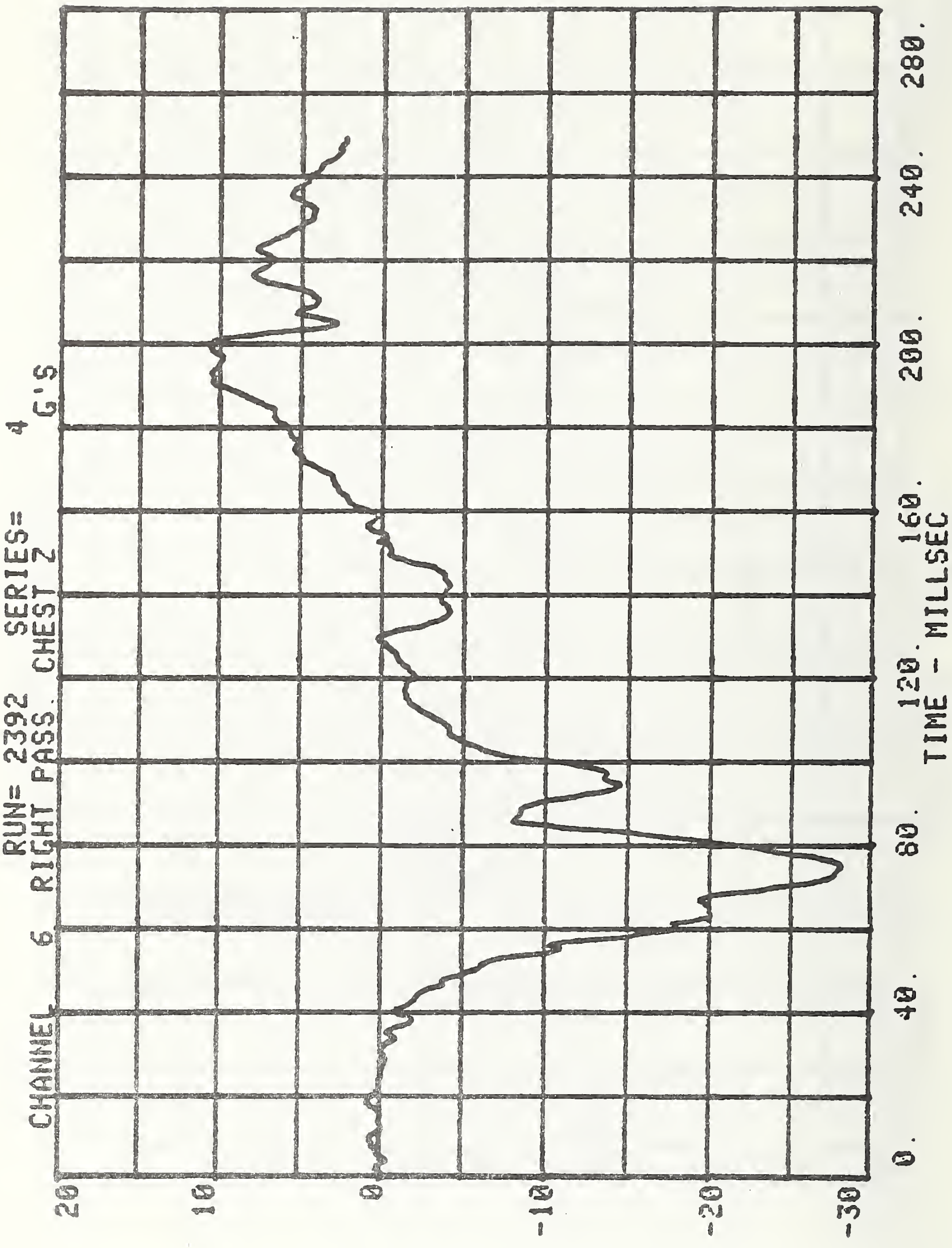

CHANNEL 2 RUN= 2392 SERIES= 4
RIGHT PASS. HEAD Z G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
60 45 30 15 0 -15



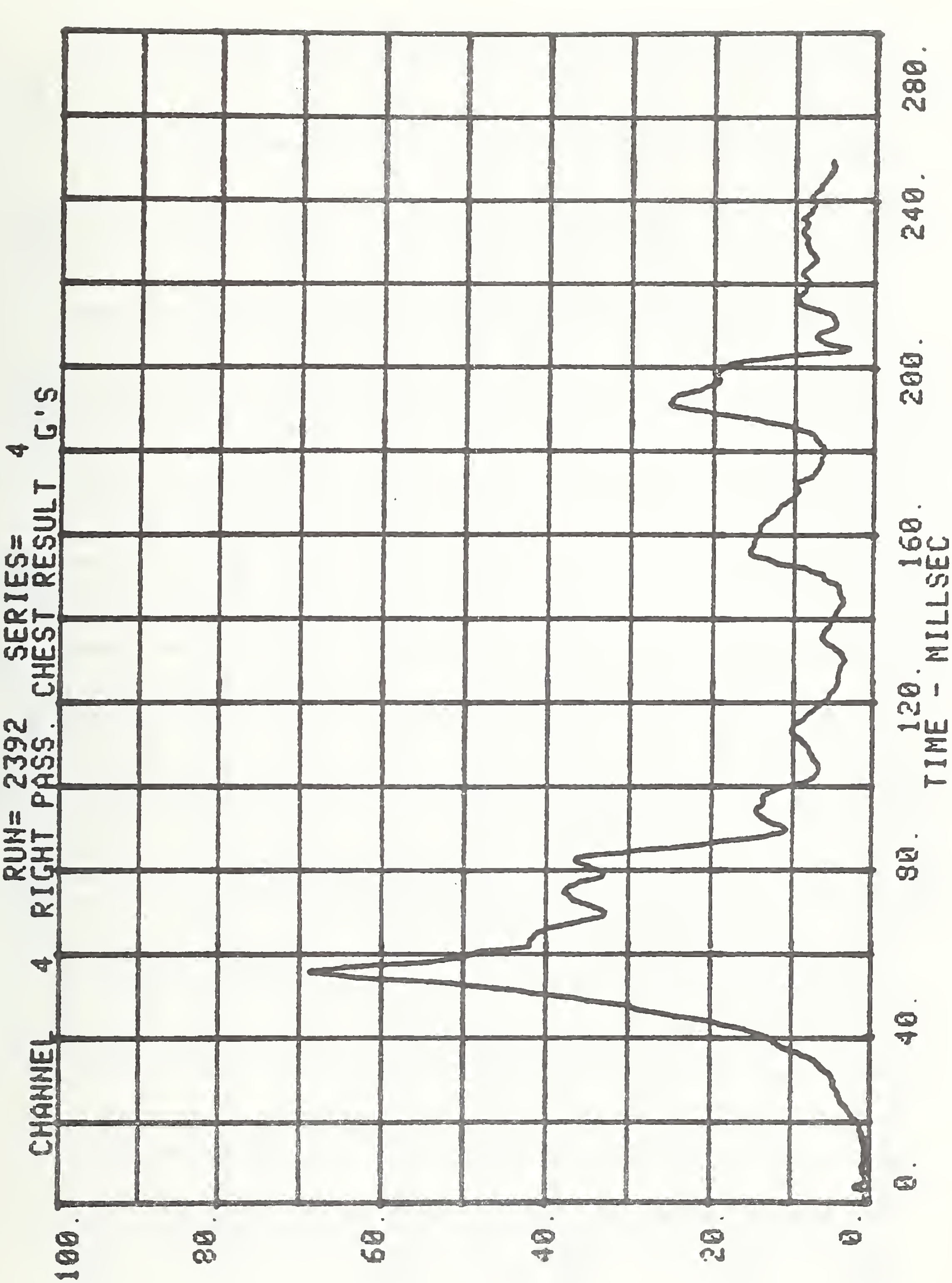
CHANNEL 3 RUN= 2392 SERIES= 4
RIGHT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
0.
20.
40.
60.
80.
100.

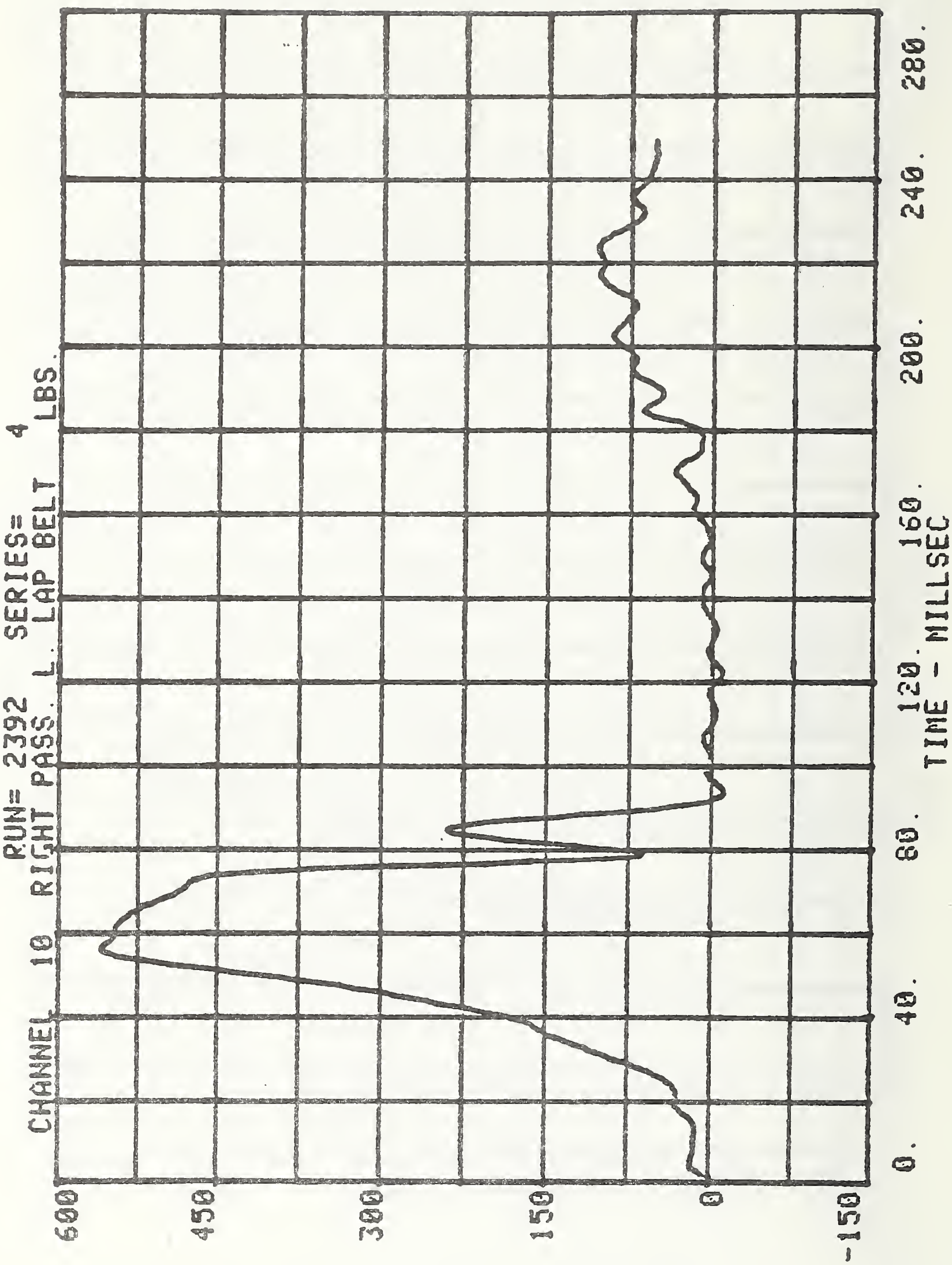

CHANNEL 4 RUN= 2392 SERIES= 4
RIGHT PASS. CHEST X G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
50 25 0 -25 -50 -75

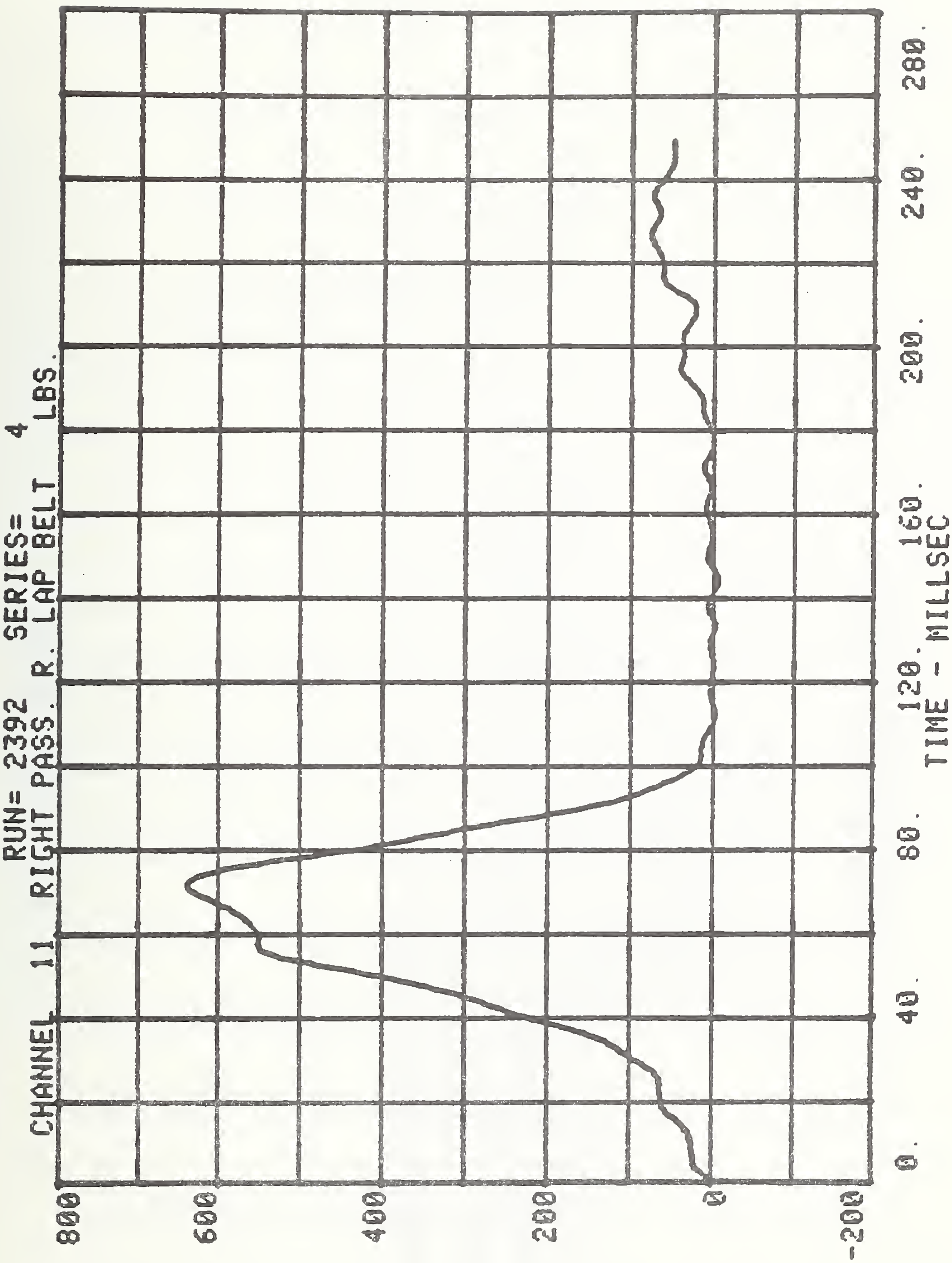

CHANNEL 5 RUN= 2392 SERIES= 4
RIGHT PASS. CHEST Y G'S
16
8
0
-8
-16
-24
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 6 RUN= 2392 SERIES= 4
RIGHT PASS. CHEST Z G'S
20
10
0
-10
-20
-30
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 4 RUN= 2392 SERIES= 4
RIGHT PASS. CHEST RESULT G'S
0. 40. 80. 120. 160. 200. 240. 280.
TIME - MILLSEC
100. 80. 60. 40. 20. 0.


CHANNEL 10 RUN= 2392 SERIES= 4
RIGHT PASS. L. LAP BELT LBS.
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 11 RUN= 2392 SERIES= 4
RIGHT PASS. R. LAP BELT LBS.
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
800 600 400 200 0 -200

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #4

RUN=2392

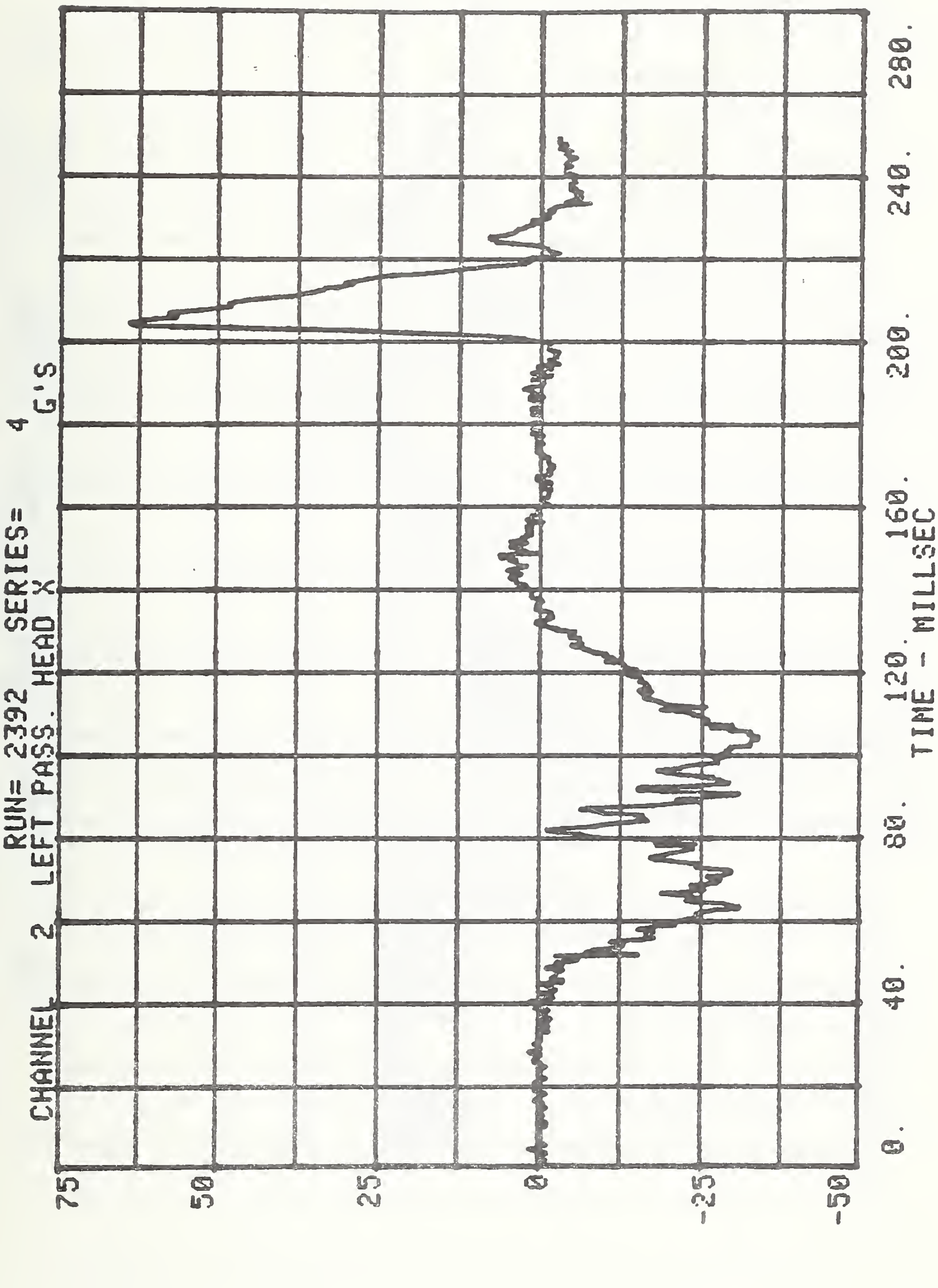
LEFT PASS. HEAD RESULT.

HIC= 819.5   FROM T1= .05850   TO T2= .09600

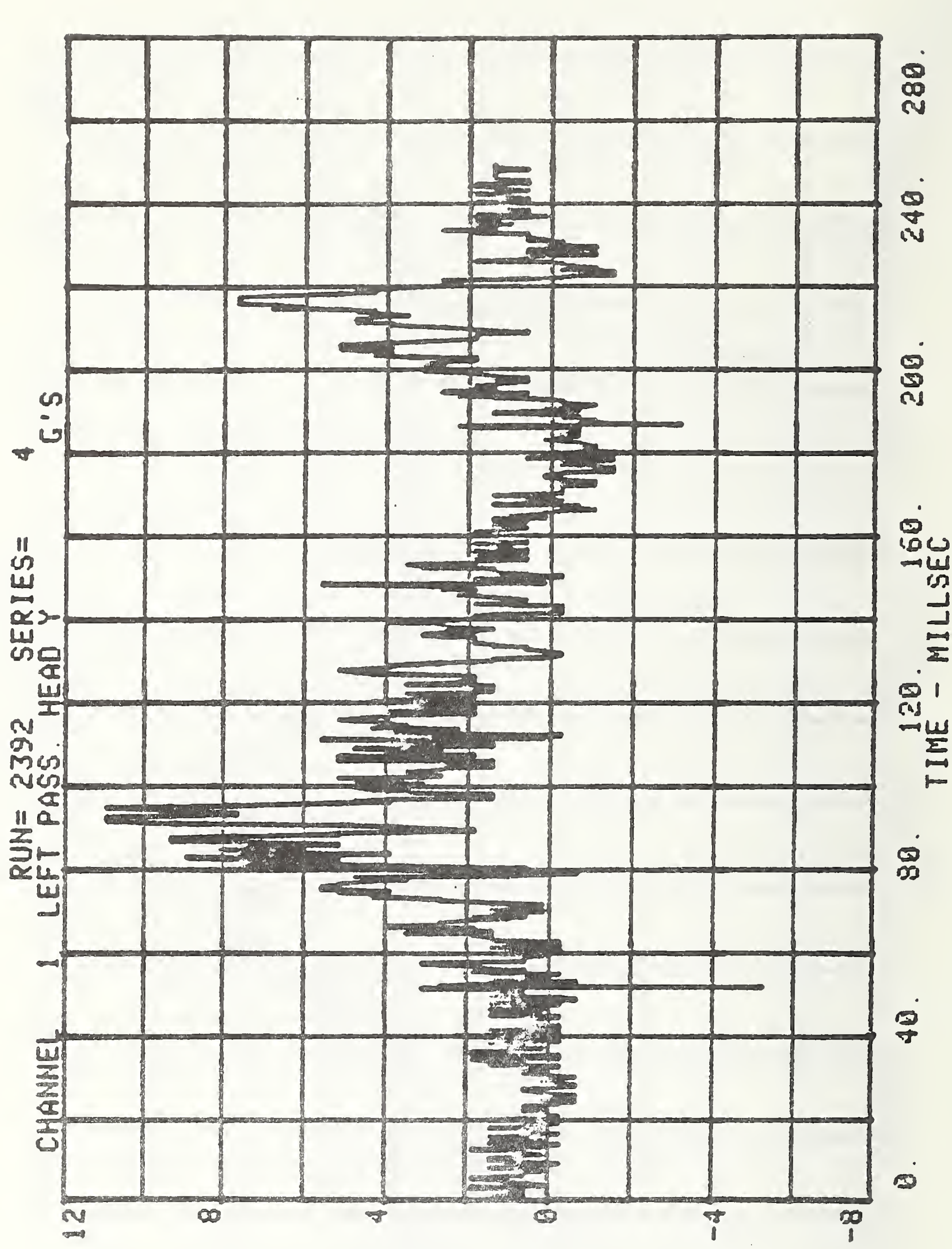
AVERAGE ACCELERATION BETWEEN T1 AND T2= 54.4G'S

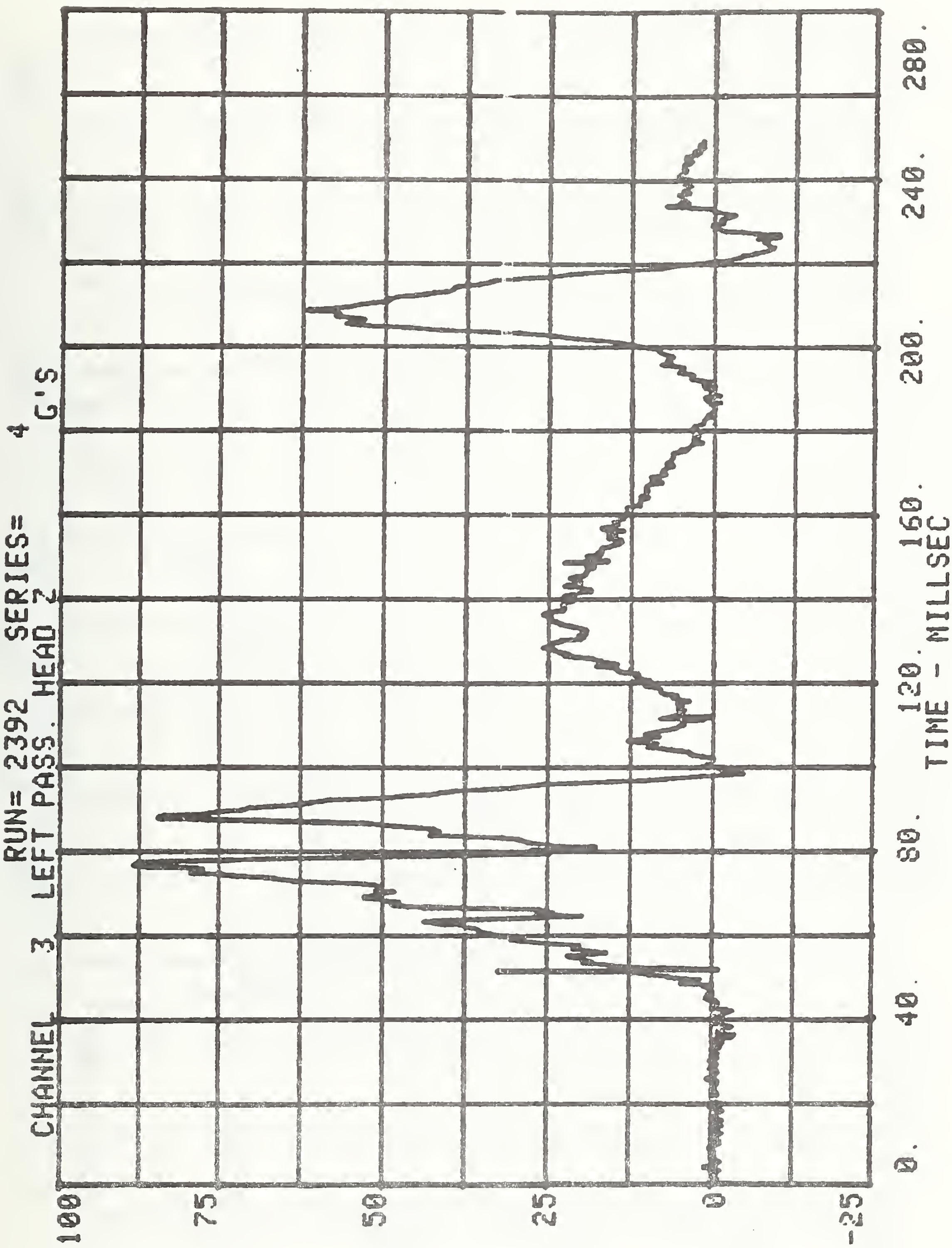
EVENT TIME= 250.0 MSEC

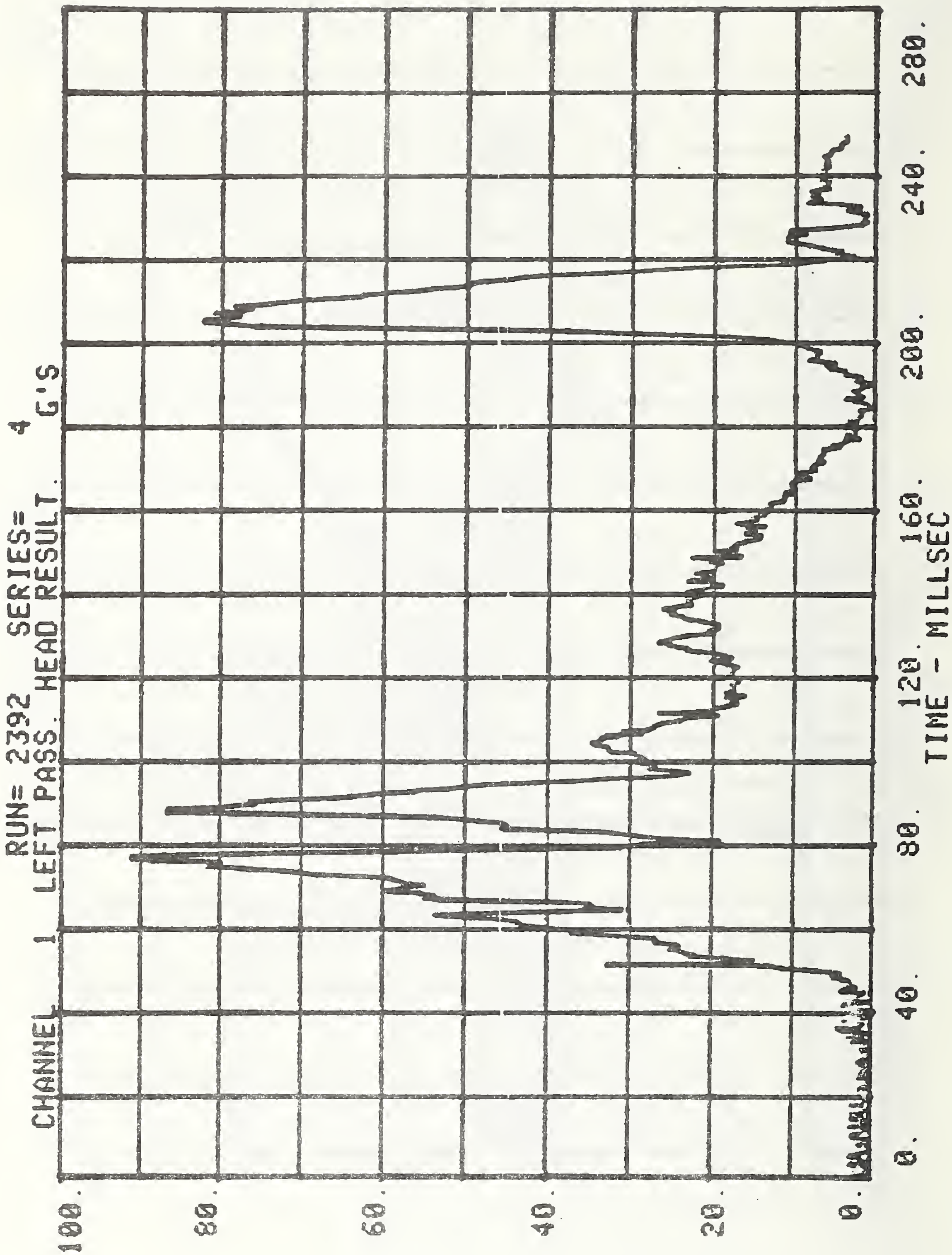
SEVERITY INDEX=1700.4

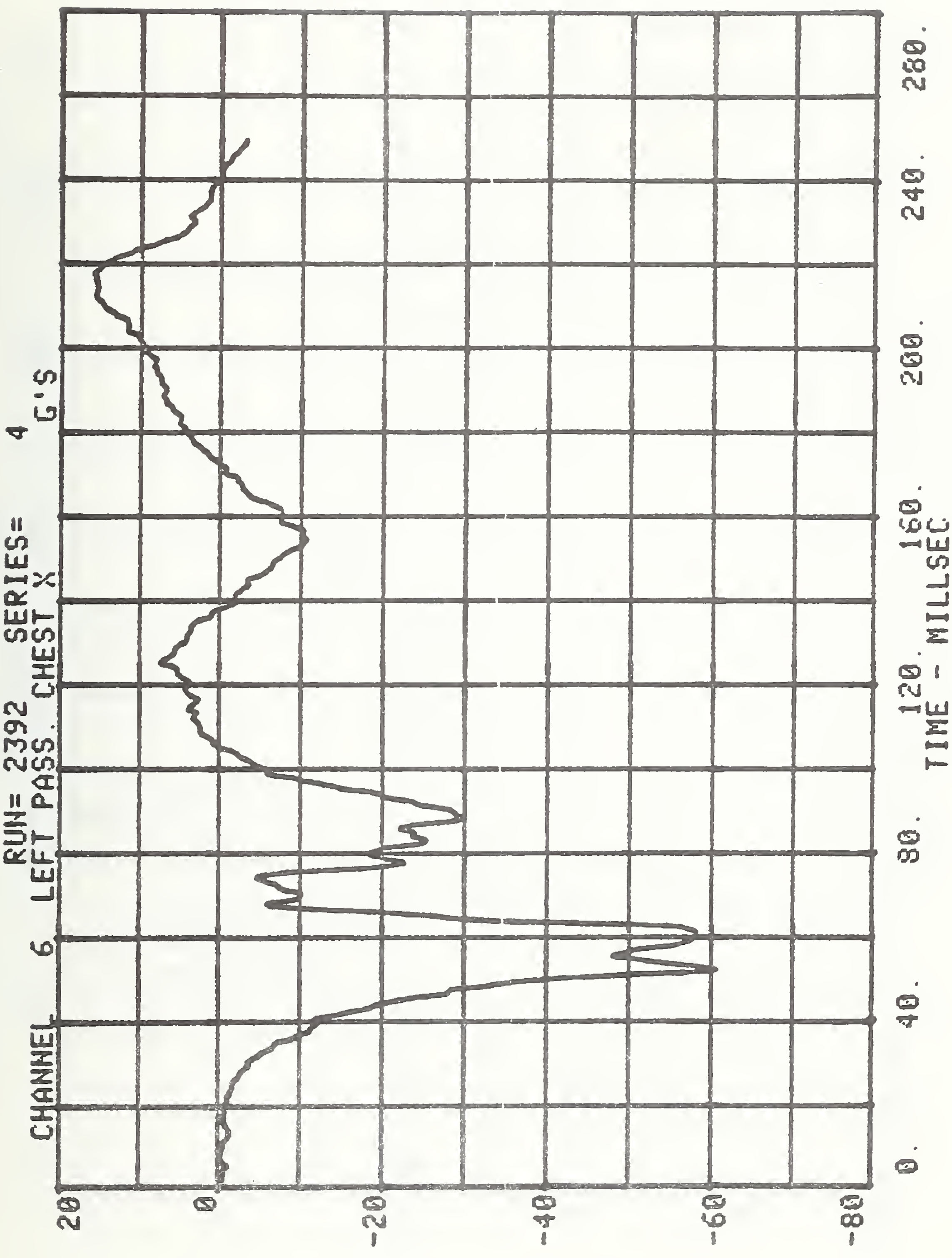


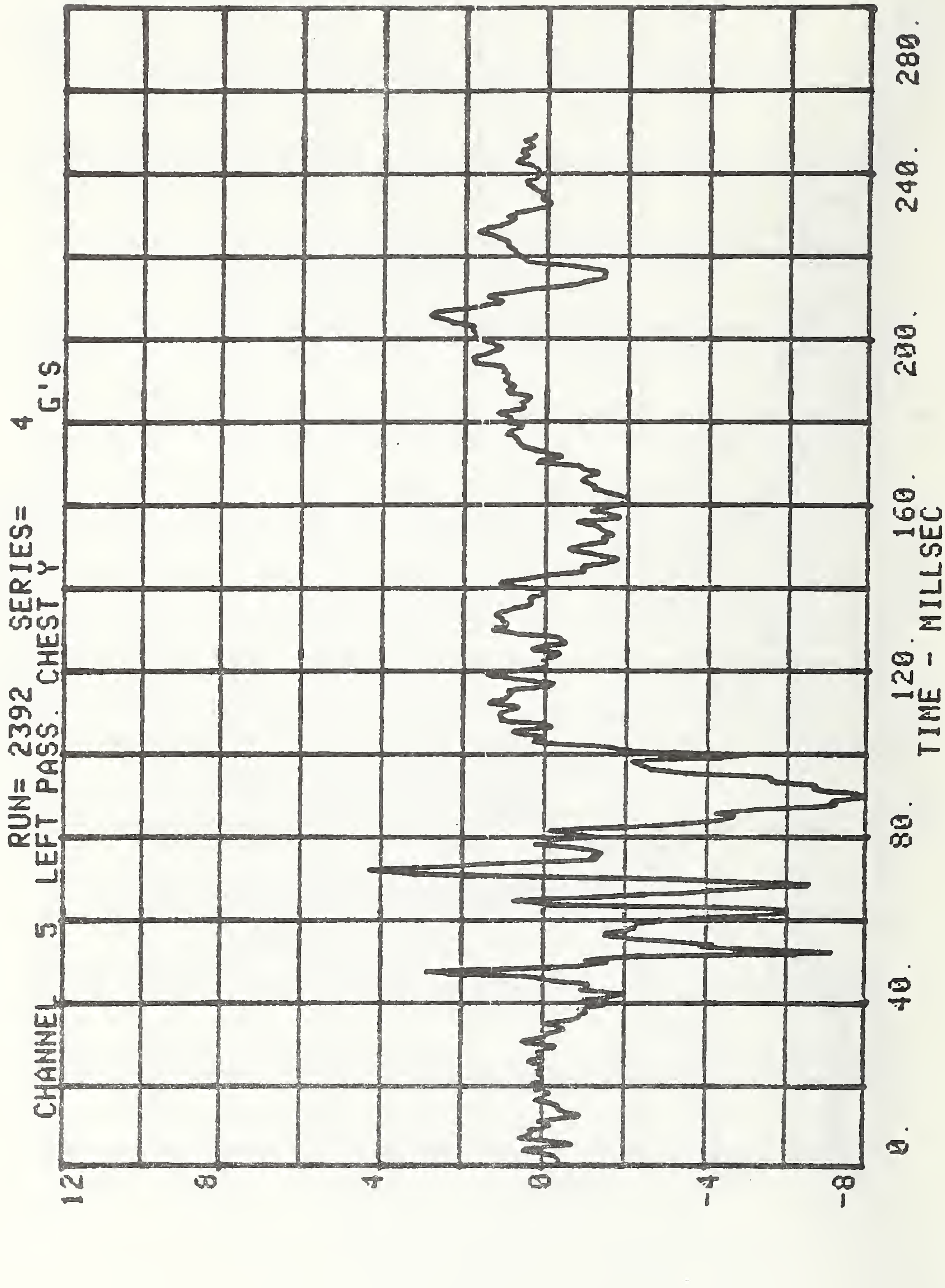
CHANNEL 2 RUN= 2392 SERIES= 4
LEFT PASS. HEAD X G'S
75
50
25
0
-25
-50
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

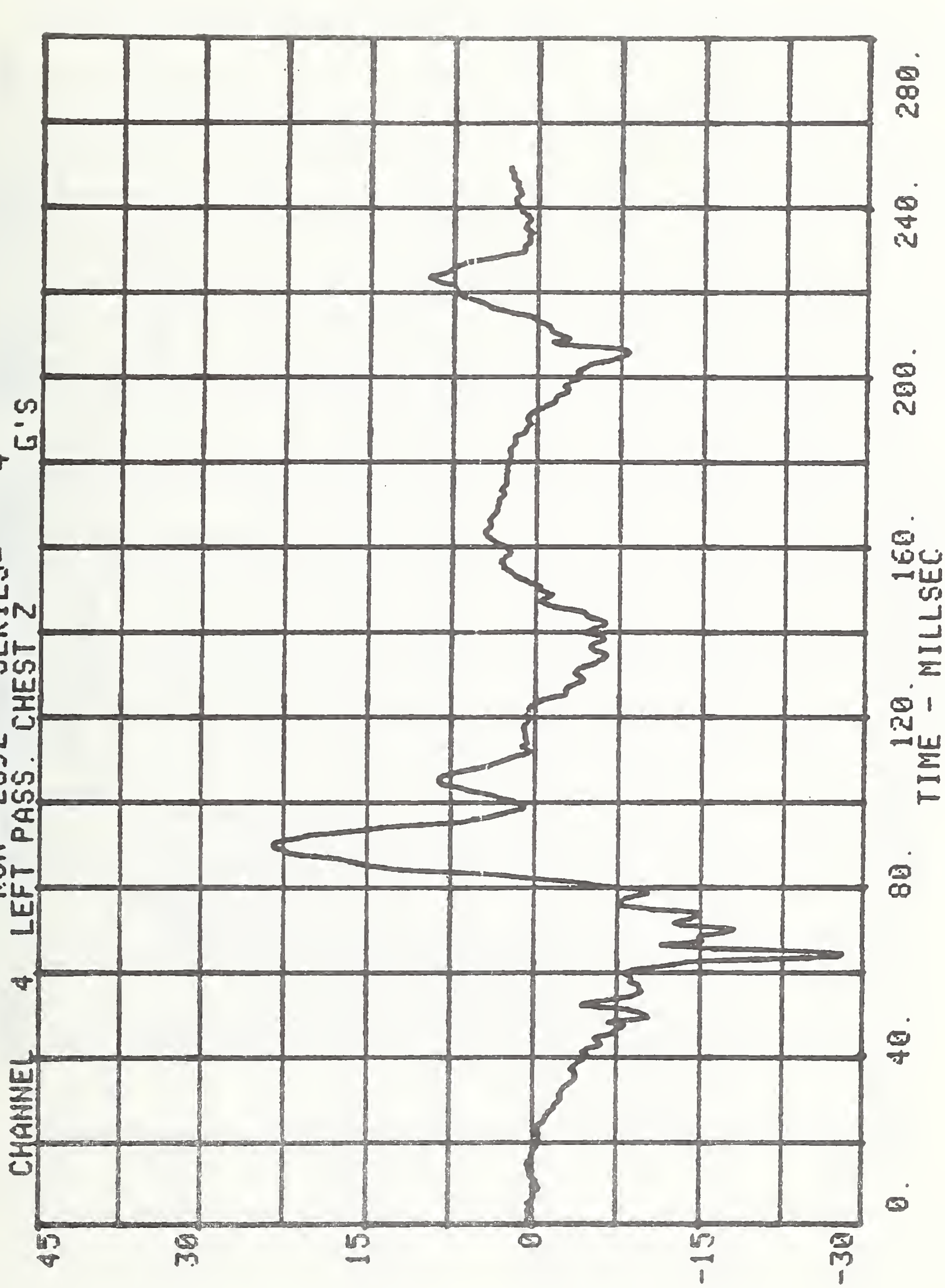

CHANNEL 1 RUN= 2392 SERIES= 4
LEFT PASS. HEAD Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
12 8 4 0 -4 -8


CHANNEL 3 RUN= 2392 SERIES= 4
LEFT PASS. HEAD Z G'S
100
75
50
25
0
-25
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

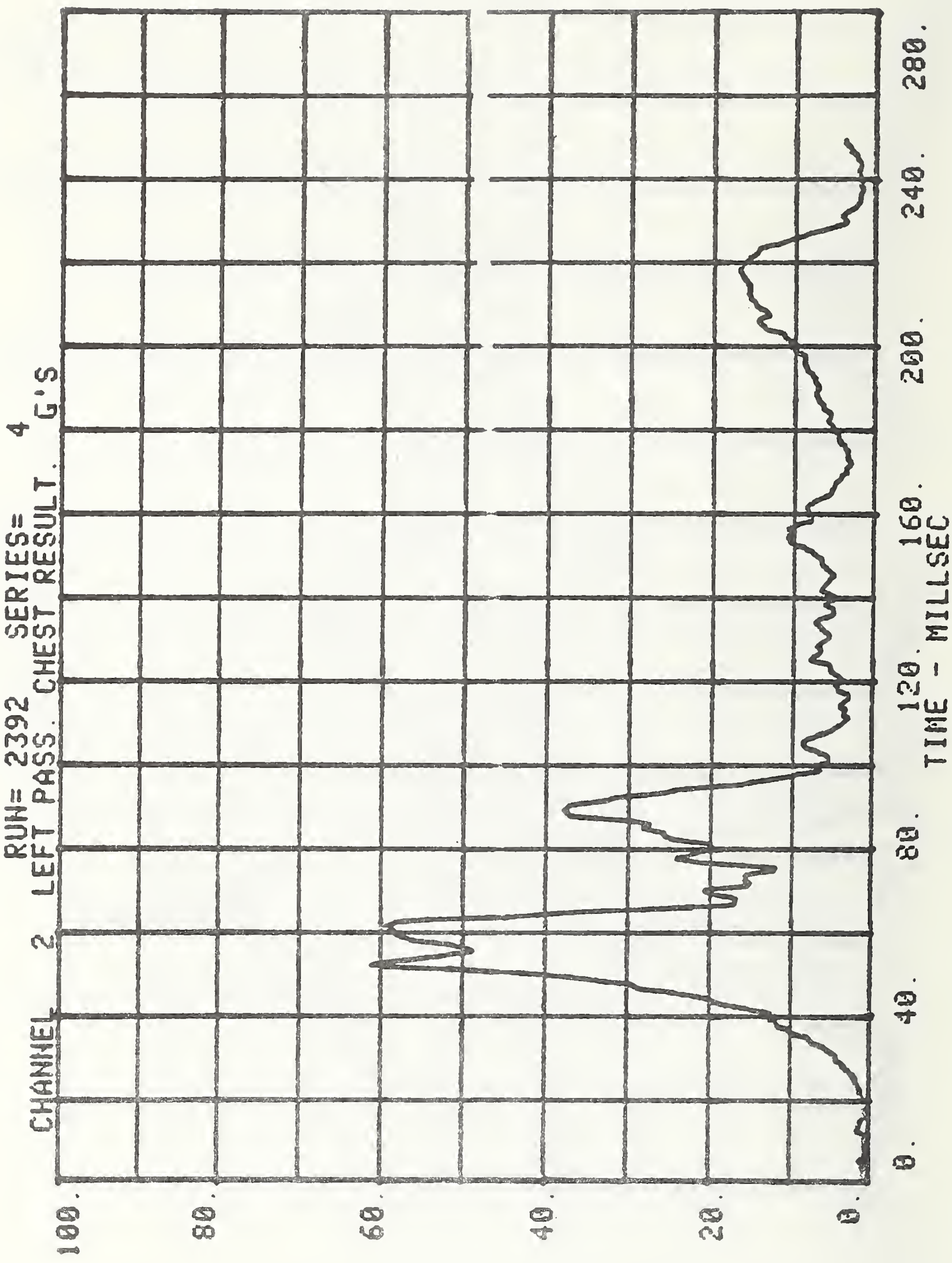

CHANNEL 1 RUN= 2392 SERIES= 4
LEFT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
0.
20.
40.
60.
80.
100.

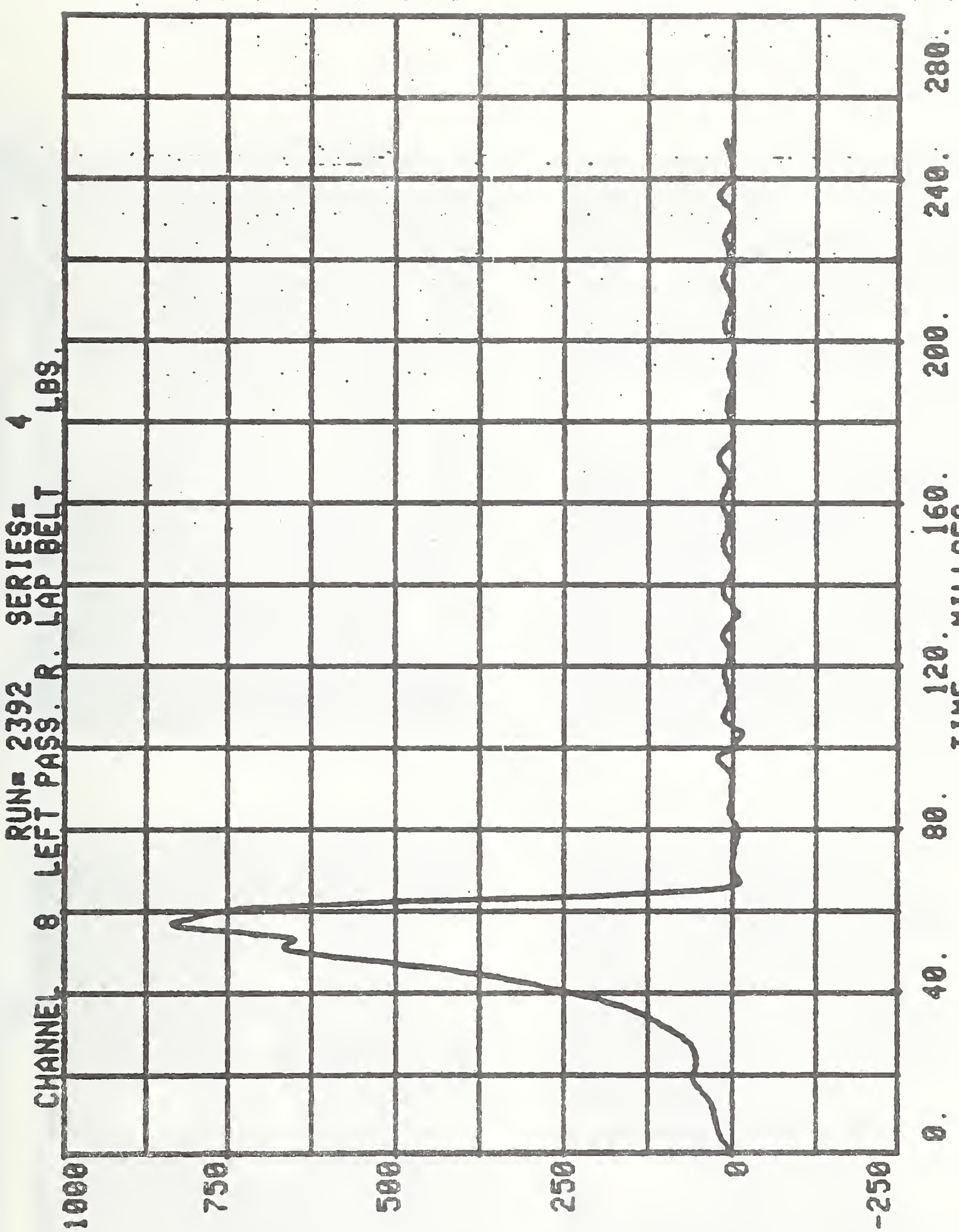

CHANNEL 6 RUN= 2392 SERIES= 4
LEFT PASS. CHEST X G'S
20
0
-20
-40
-60
-80
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


RUN= 2392 SERIES= 4
LEFT PASS. CHEST Y
CHANNEL 5
G'S
12
8
4
0
-4
-8
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

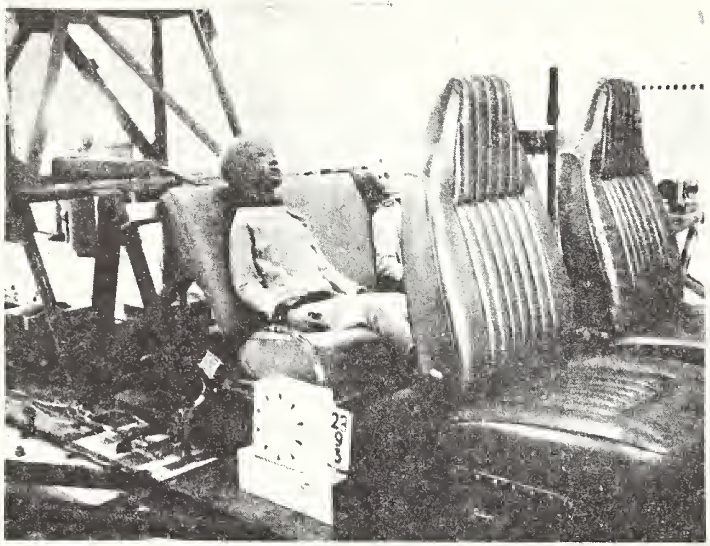


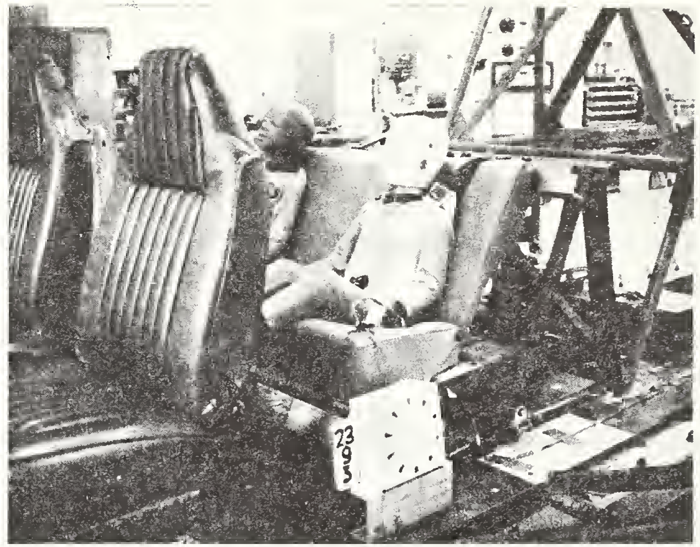
CHANNEL 4 RUN= 2392 SERIES= 4
LEFT PASS. CHEST Z
G'S
45
30
15
0
-15
-30
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 2 RUN= 2392 SERIES= 4
LEFT PASS. CHEST RESULT. G'S
100.
80.
60.
40.
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

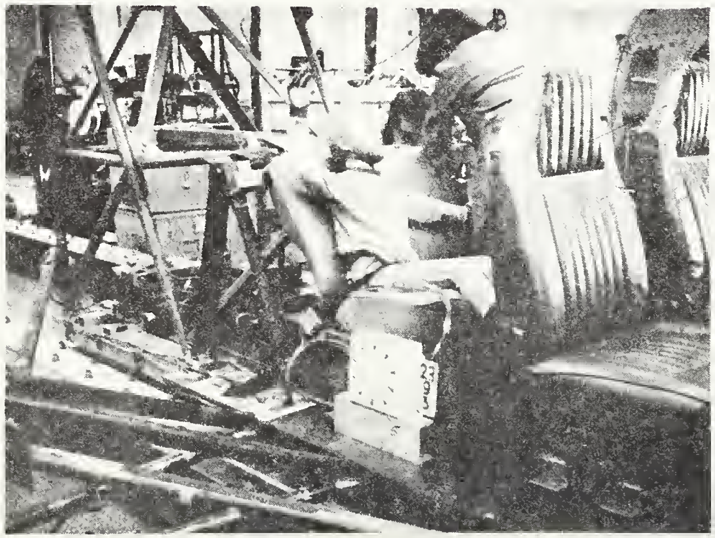


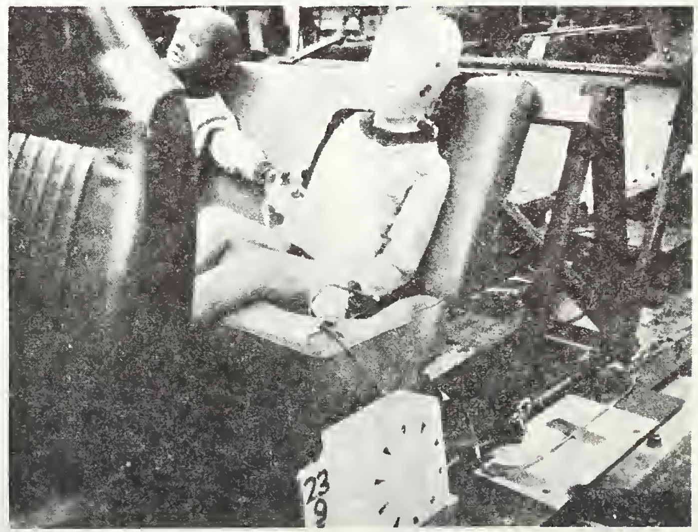
CHANNEL 8 RUN= 2392 SERIES= 4
LEFT PASS. R. LAP BELT LBS.
1000
750
500
250
0
-250
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC





PRE-TEST



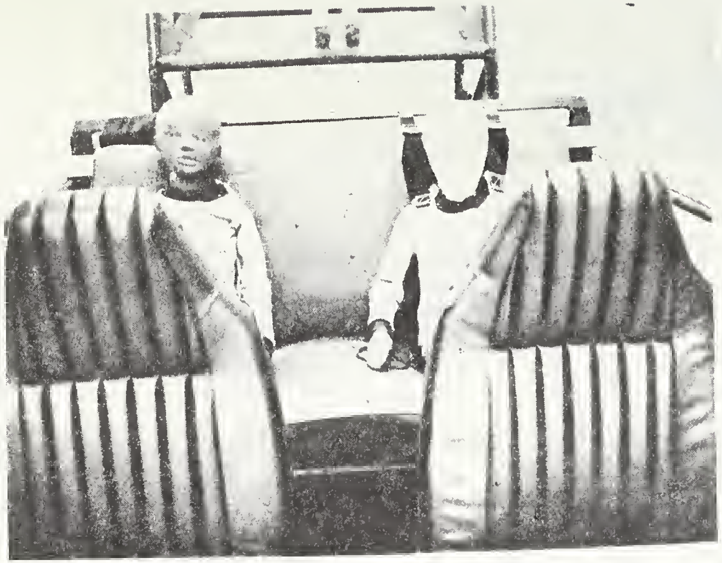


ALDERSON S/N 49

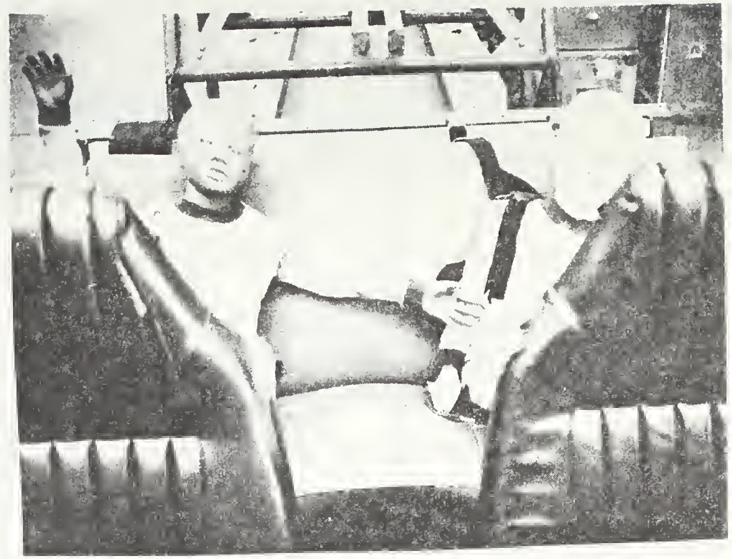
TNO

POST-TEST

RUN 2393



ALDERSON S/N 49 TNO



ALDERSON S/N 49 TNO

RUN 2393

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #5

RUN=2393

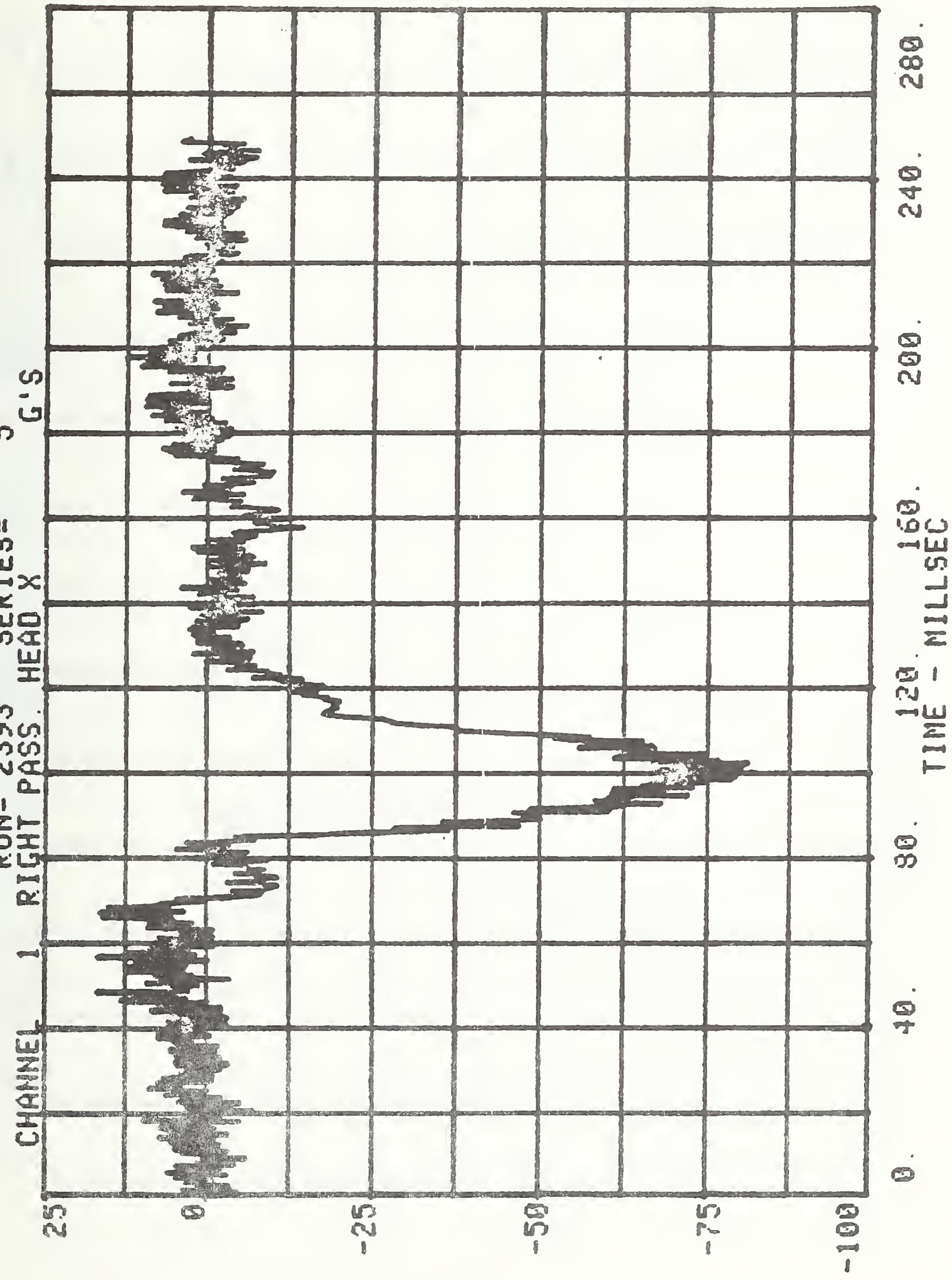
RIGHT PASS. HEAD RESULT.

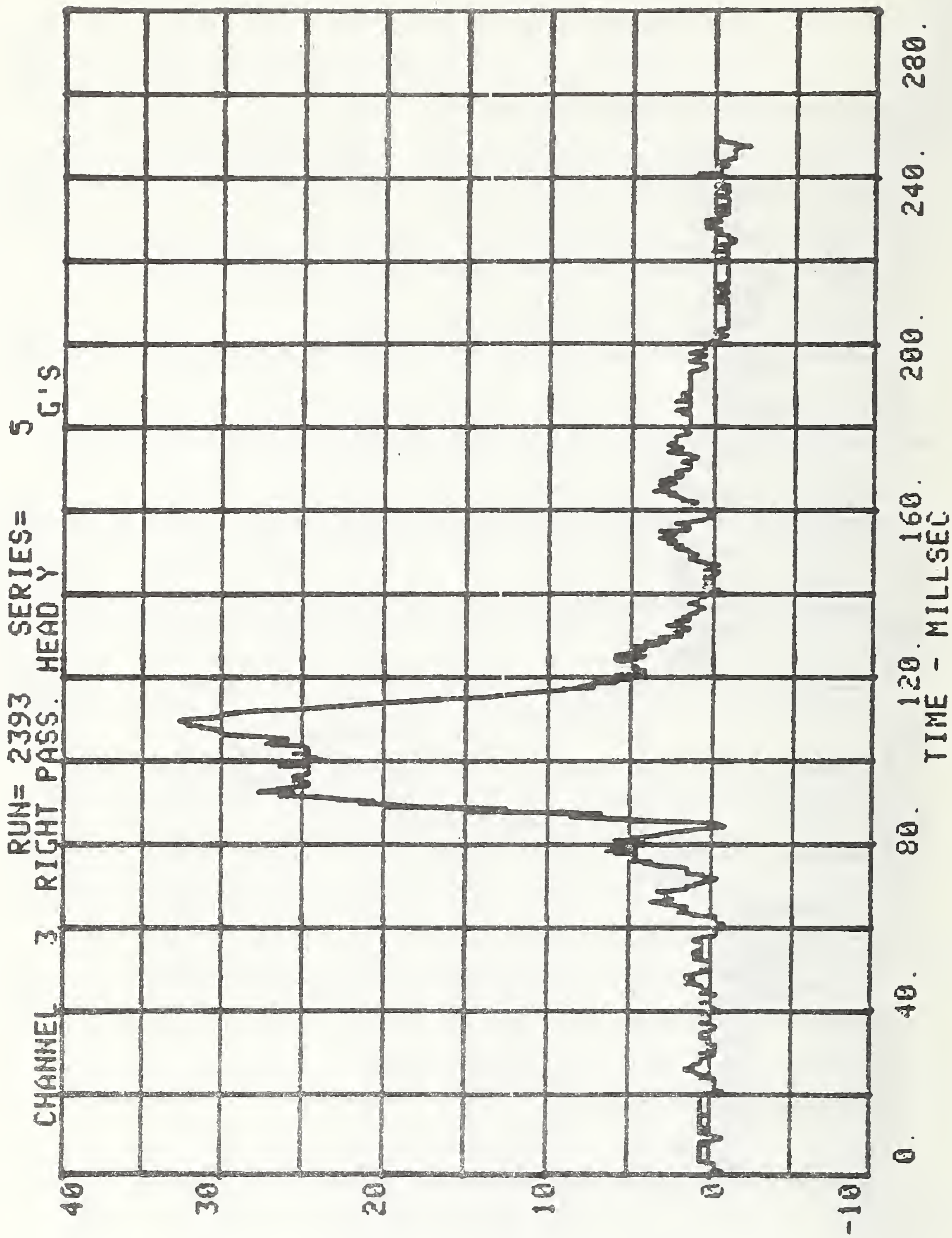
HIC=2681.4 FROM T1= .07350 TO T2= .10980

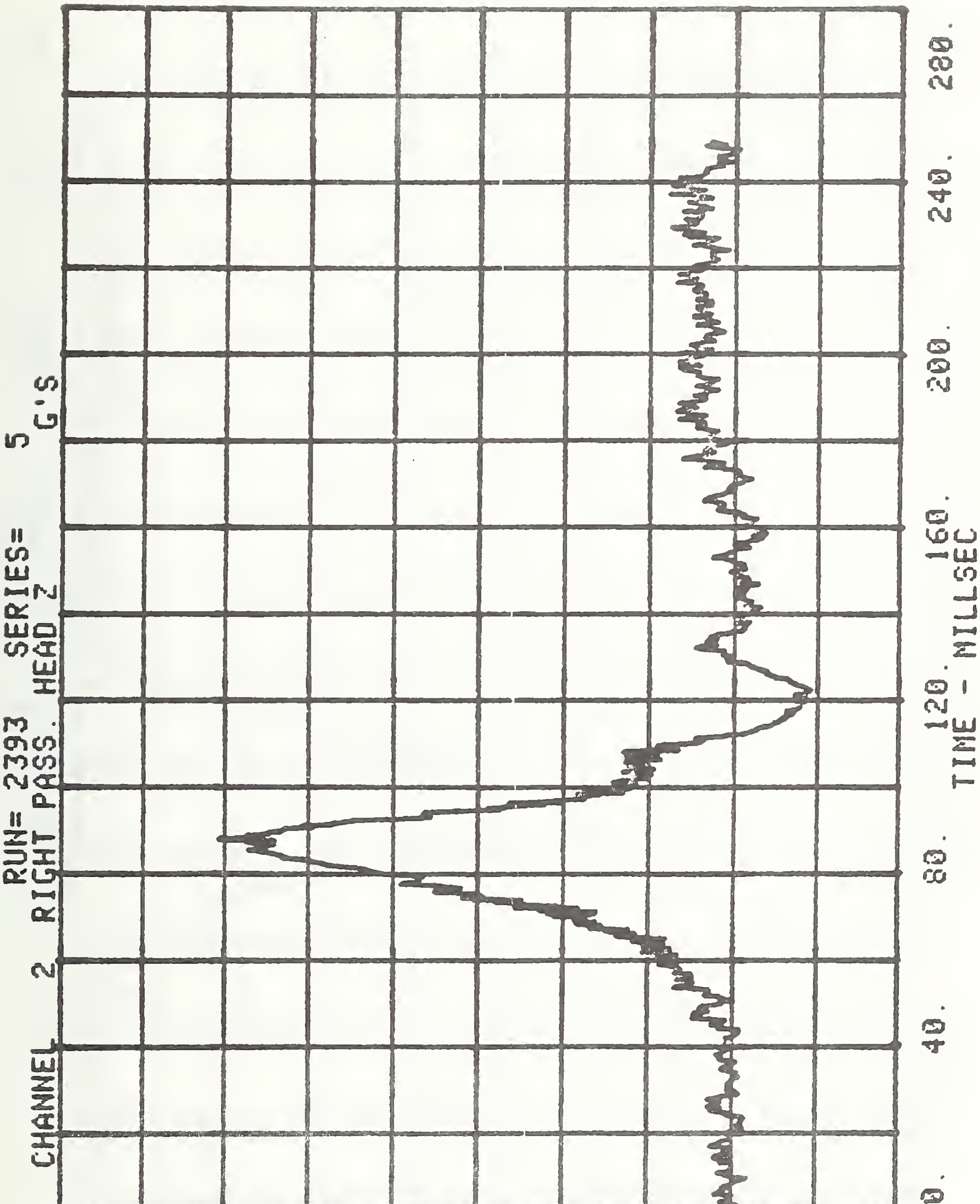
AVERAGE ACCELERATION BETWEEN T1 AND T2= 88.6G'S

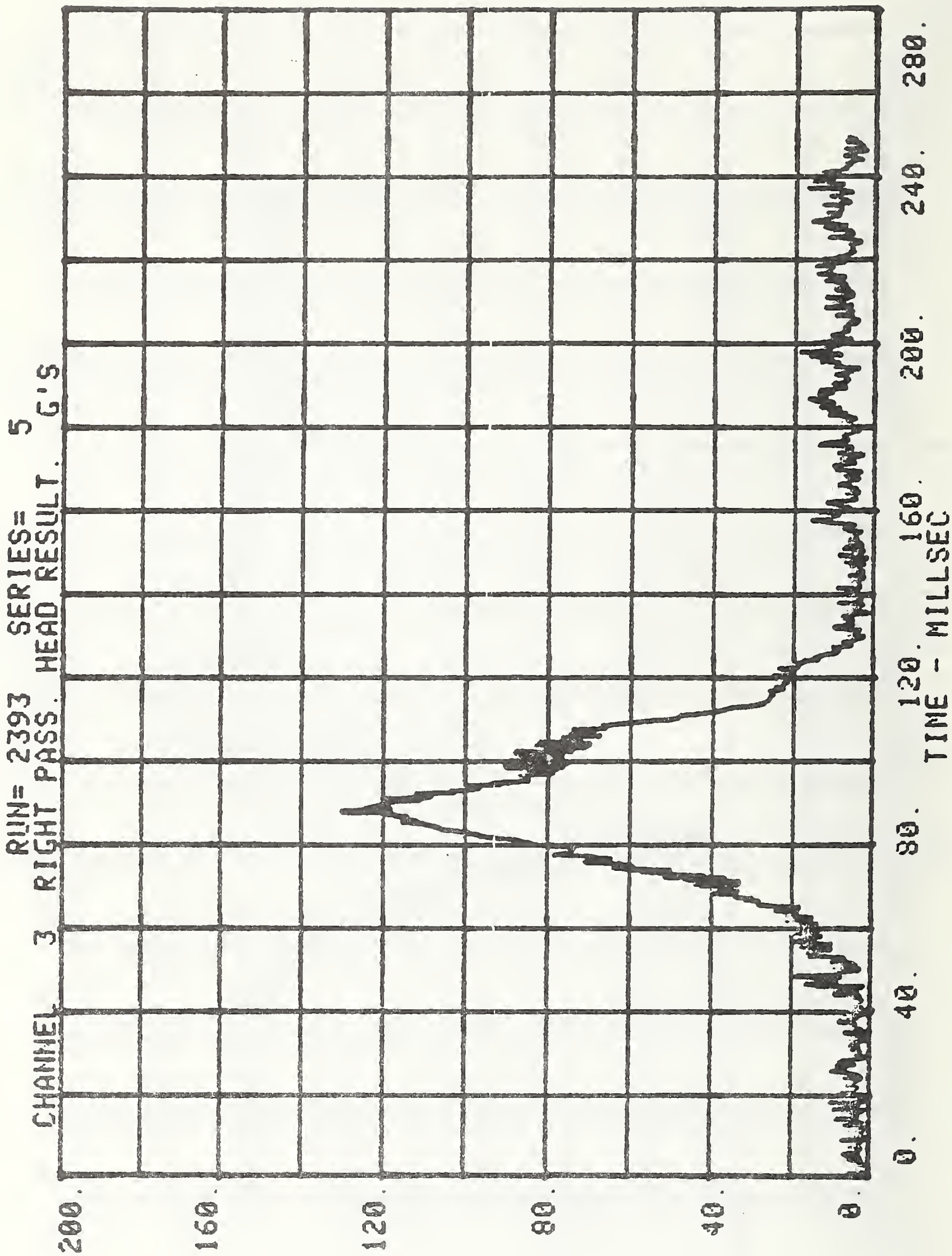
EVENT TIME= 250.0 MSEC

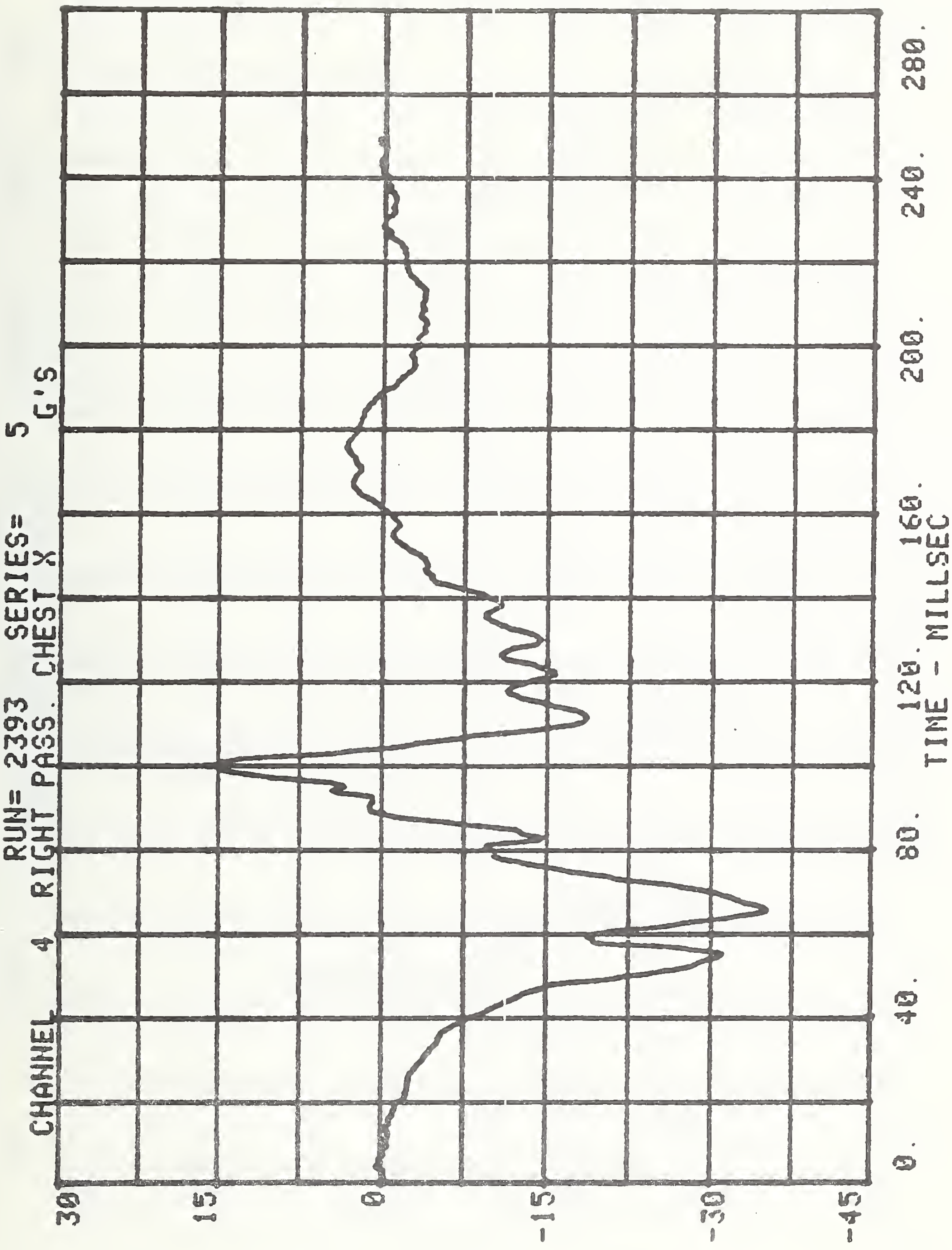
SEVERITY INDEX=3119.6


CHANNEL 1 RUN= 2393 SERIES= 5
RIGHT PASS. HEAD X G'S
25
0
-25
-50
-75
-100
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

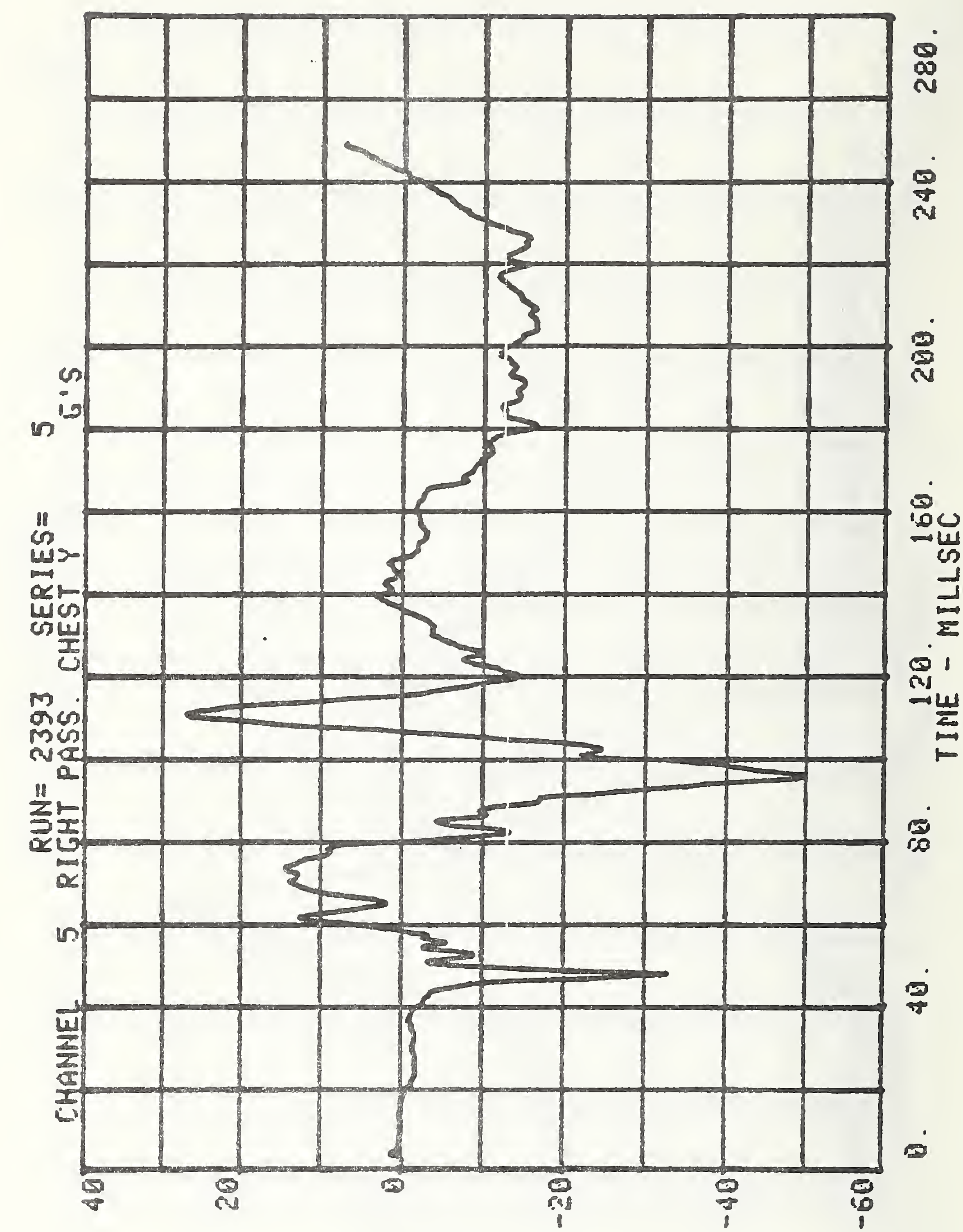

CHANNEL 3 RUN= 2393 SERIES= 5
RIGHT PASS. HEAD Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
40 30 20 10 0 -10

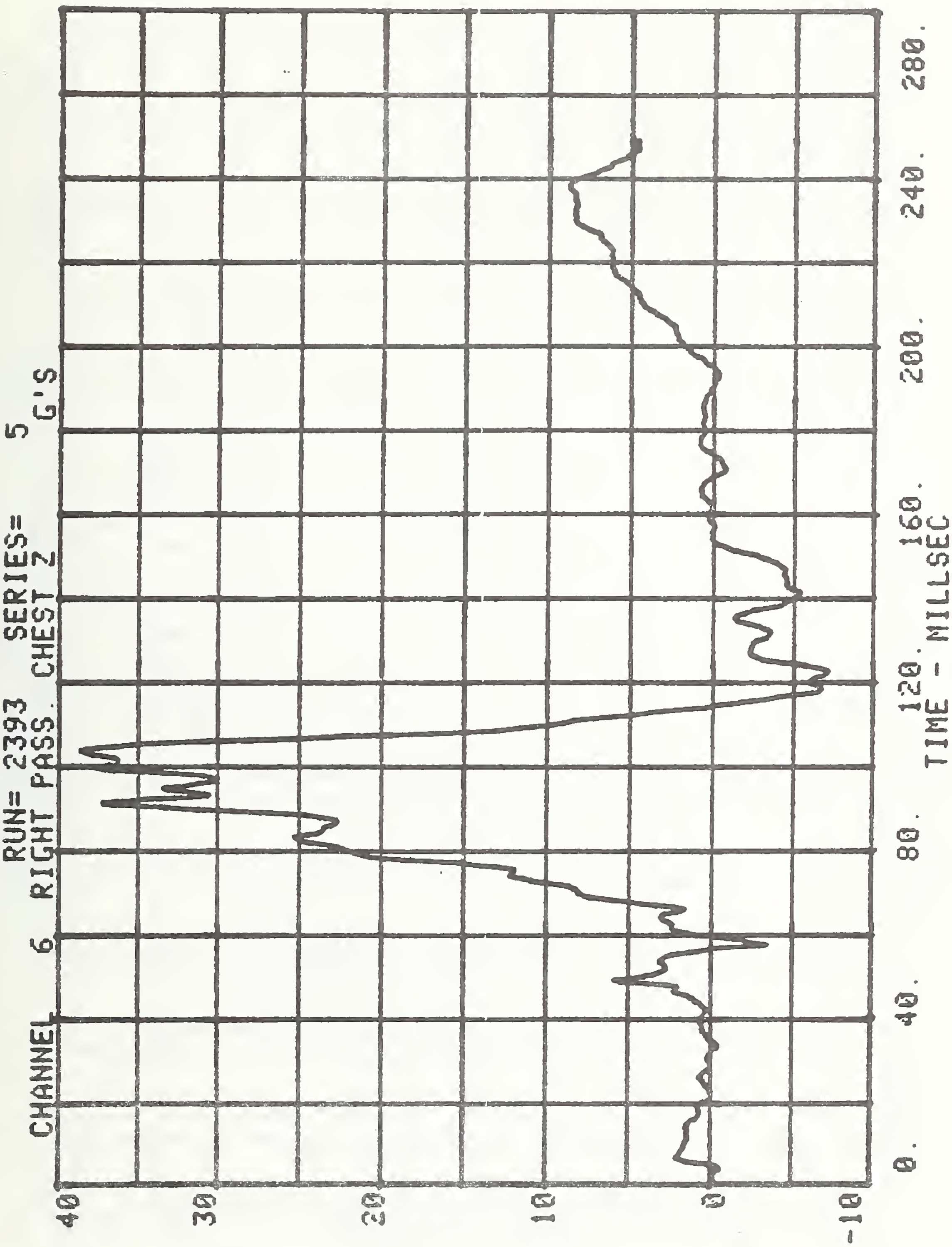

CHANNEL 2 RUN= 2393 SERIES= 5
RIGHT PASS. HEAD Z G'S
160
120
80
40
0
-40
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

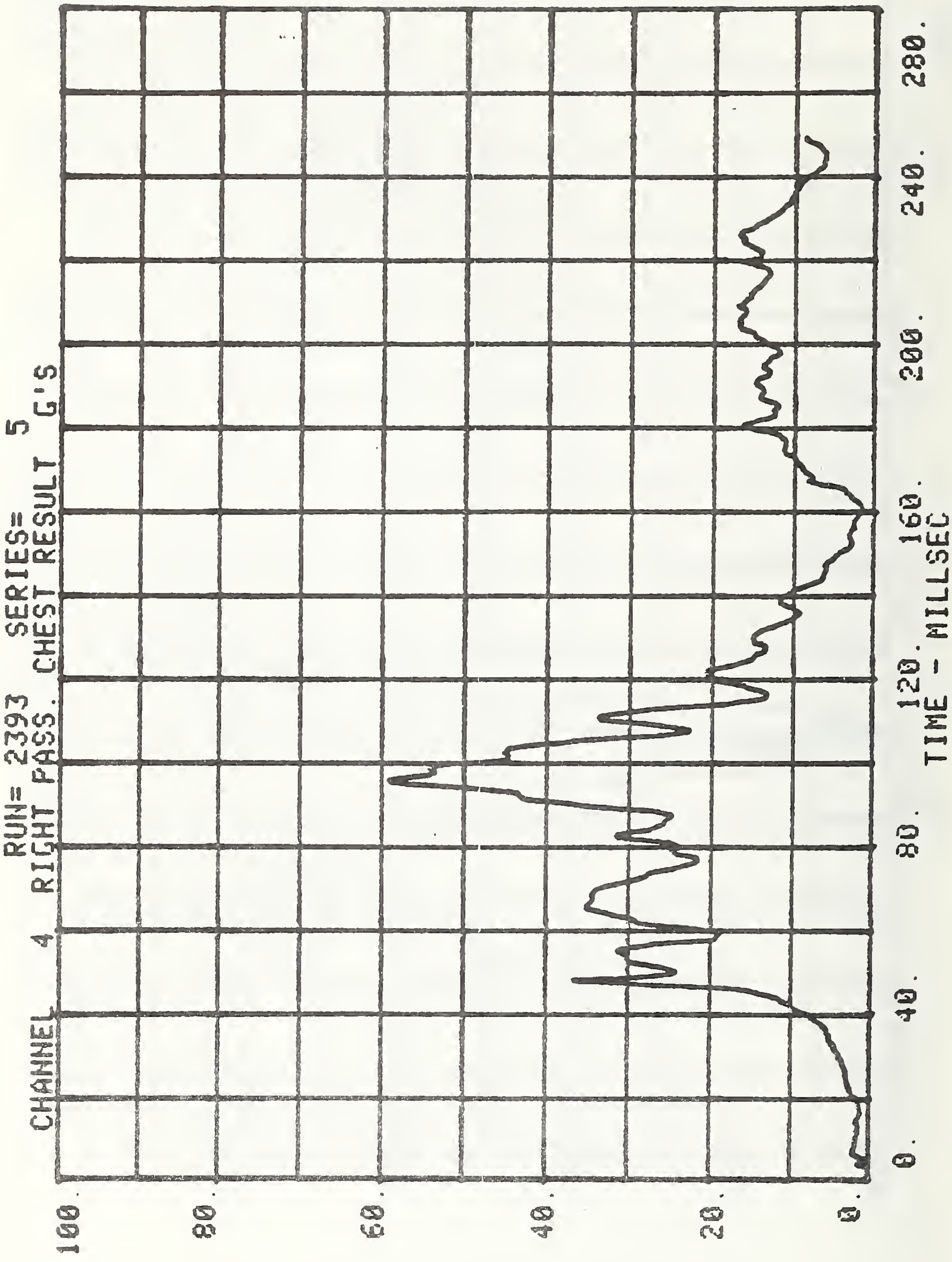

CHANNEL 3 RUN= 2393 SERIES= 5
RIGHT PASS. HEAD RESULT. G'S
TIME - MILLSEC
0.
40.
80.
120.
160.
200.
240.
280.
0.
40.
80.
120.
160.
200.

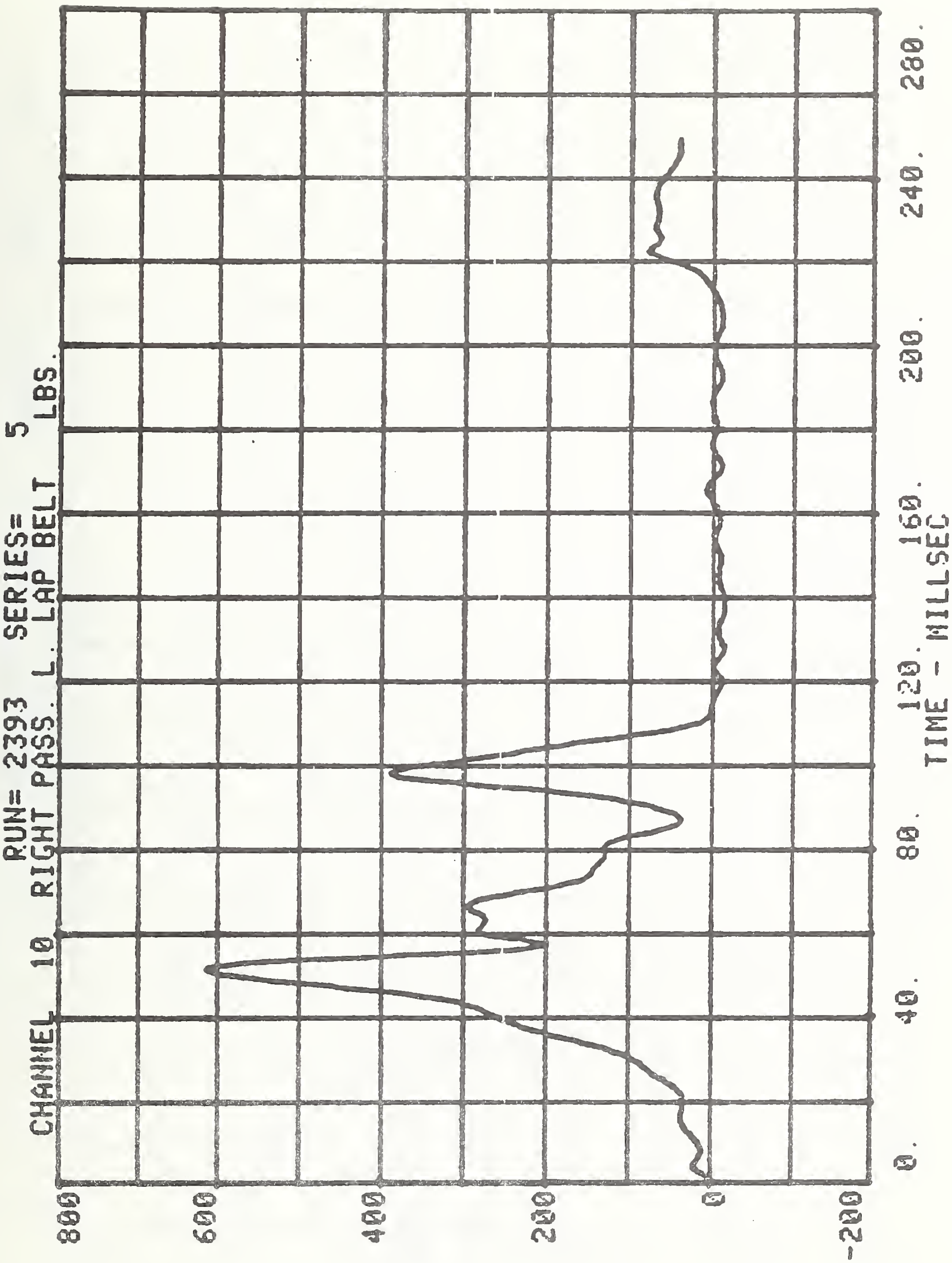


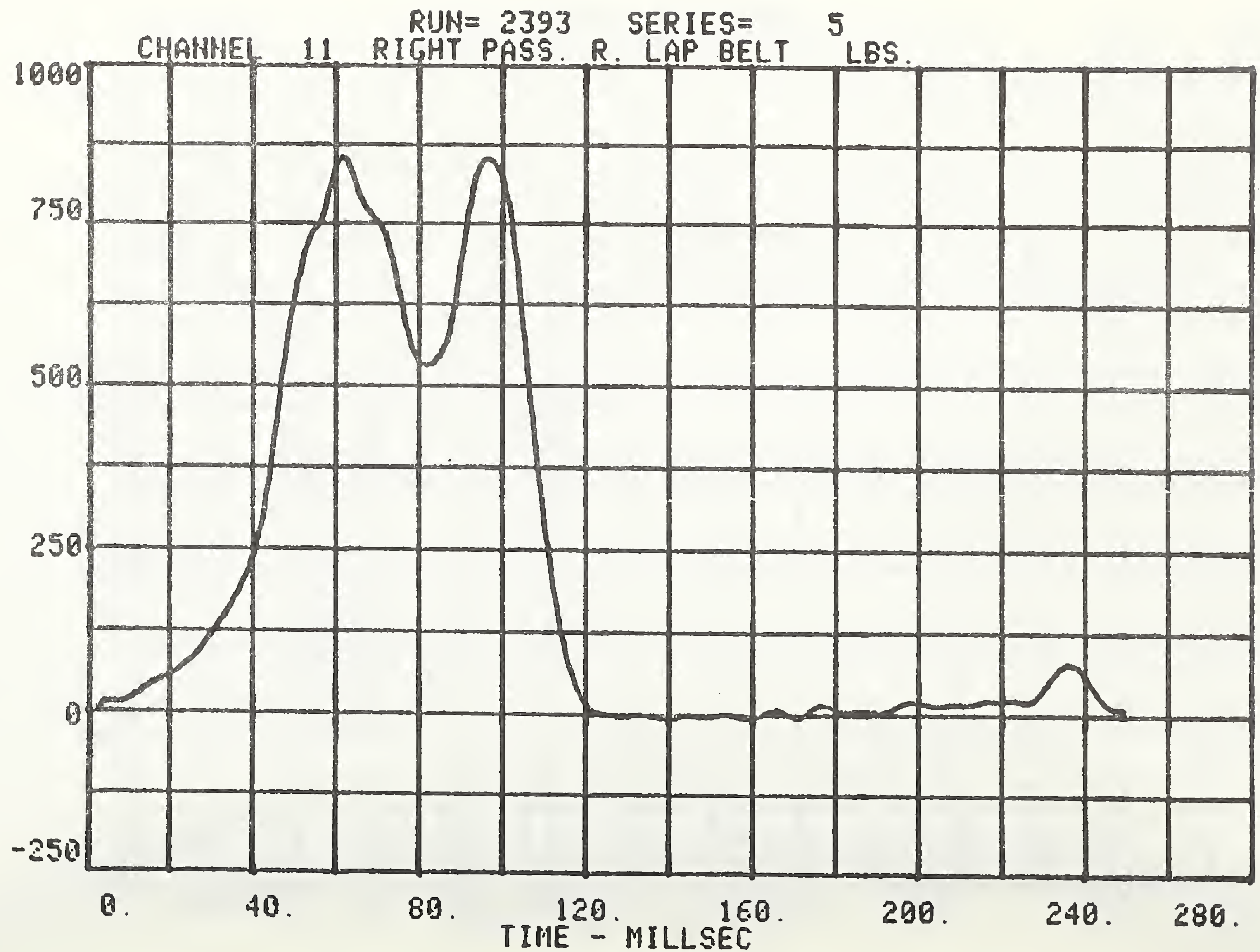
CHANNEL 4 RUN= 2393 SERIES= 5
RIGHT PASS. CHEST X G'S
30
15
0
-15
-30
-45
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 5 RUN= 2393 SERIES= 5
RIGHT PASS. CHEST Y G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
40 20 0 -20 -40 -60


CHANNEL 6 RUN= 2393 SERIES= 5
RIGHT PASS. CHEST Z G'S
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
-10 0 10 20 30 40


CHANNEL 4 RUN= 2393 SERIES= 5
RIGHT PASS. CHEST RESULT G'S
100.
80.
60.
40.
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 10 RUN= 2393 SERIES= 5
RIGHT PASS. L. LAP BELT LBS.
TIME - MILLSEC
0. 40. 80. 120. 160. 200. 240. 280.
800
600
400
200
0
-200


RUN= 2393 SERIES= 5
CHANNEL 11 RIGHT PASS. R. LAP BELT LBS.
1000
750
500
250
0
-250
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

HEAD INJURY CRITERION
HEAD SEVERITY INDEX

FORCE LIMITER VII TEST #5

RUN=2393

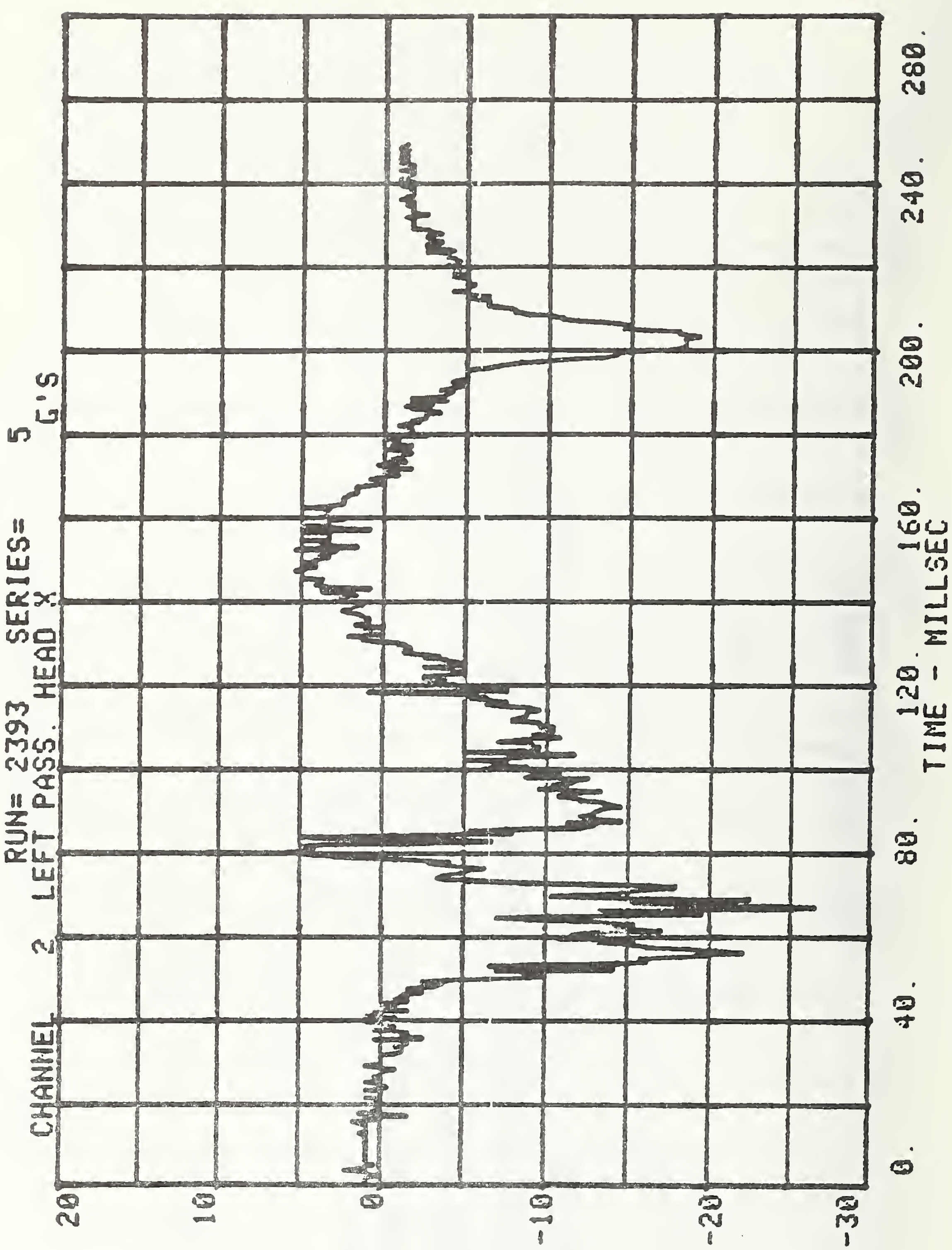
LEFT PASS. HEAD RESULT.

HIC= 582.7   FROM T1= .06570   TO T2= .08560

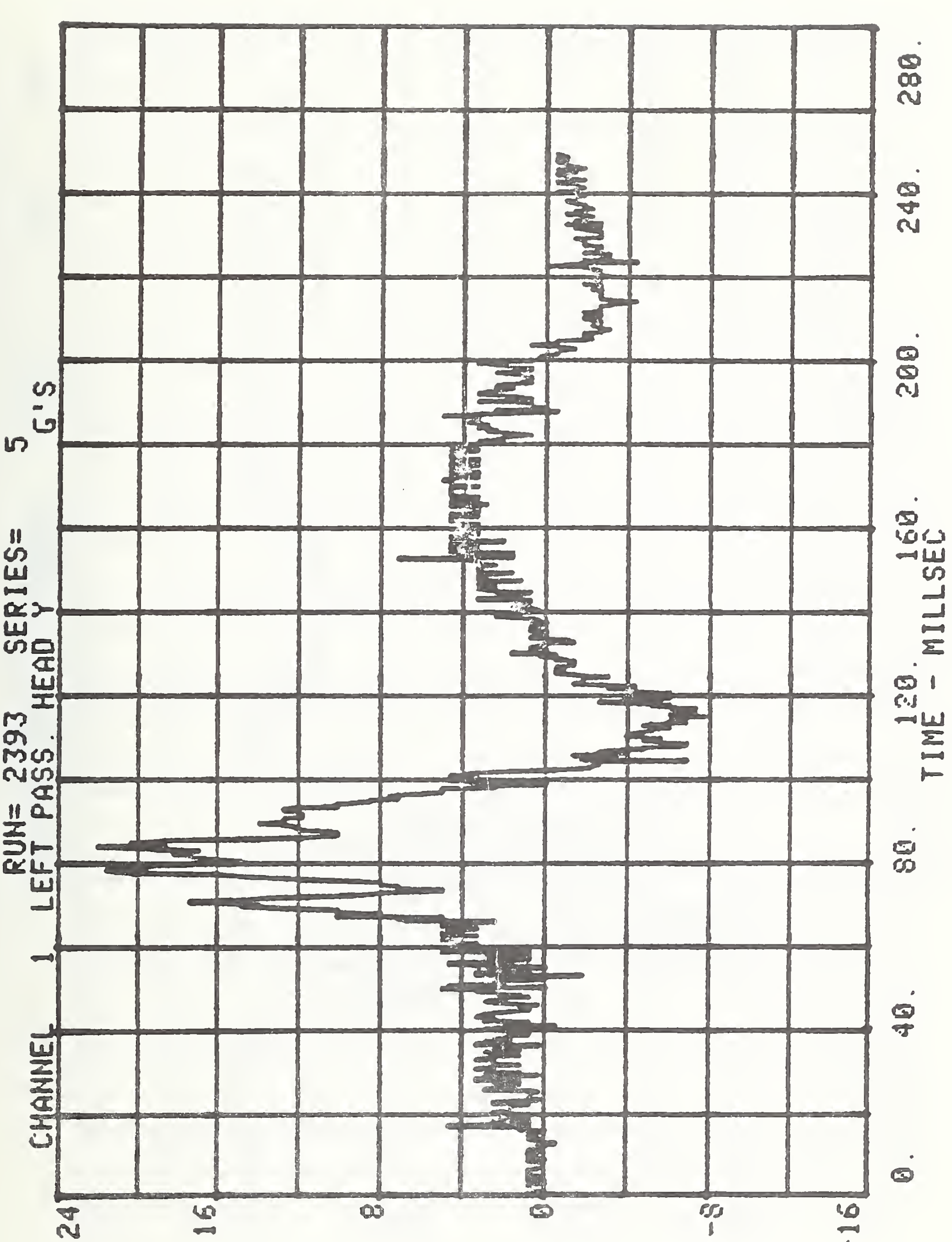
AVERAGE ACCELERATION BETWEEN T1 AND T2= 60.9G'S

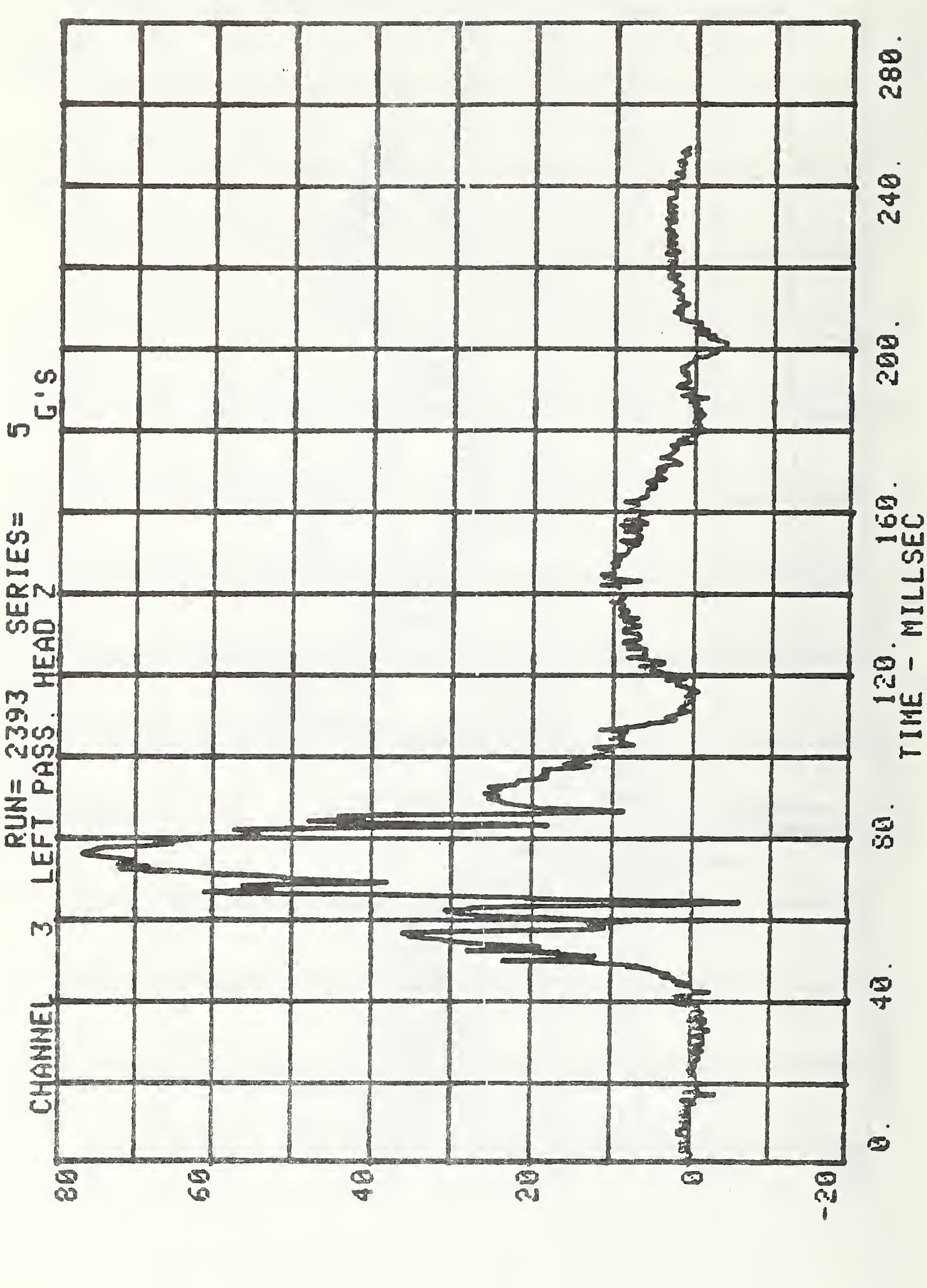
EVENT TIME= 250.0 MSEC

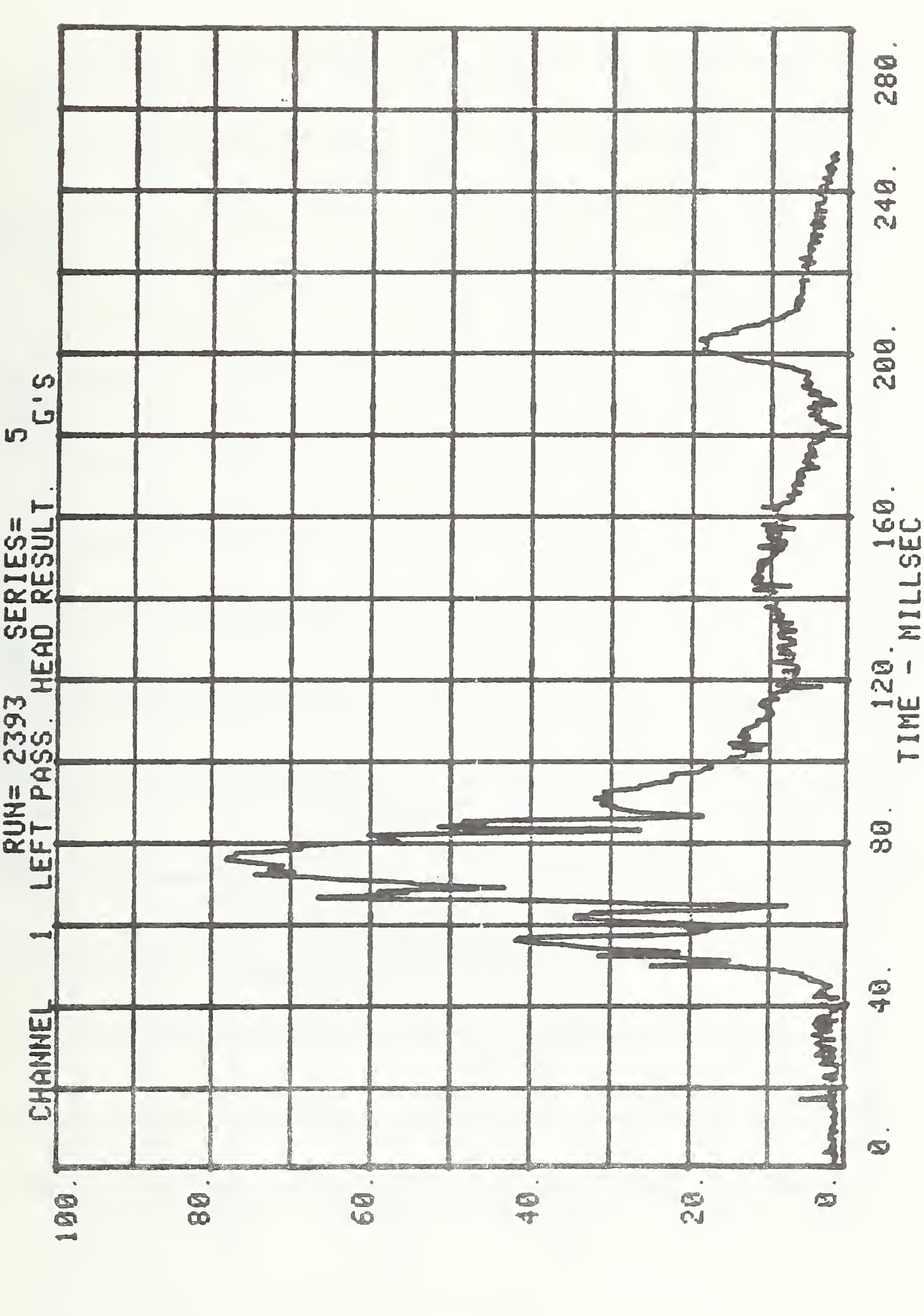
SEVERITY INDEX= 780.2

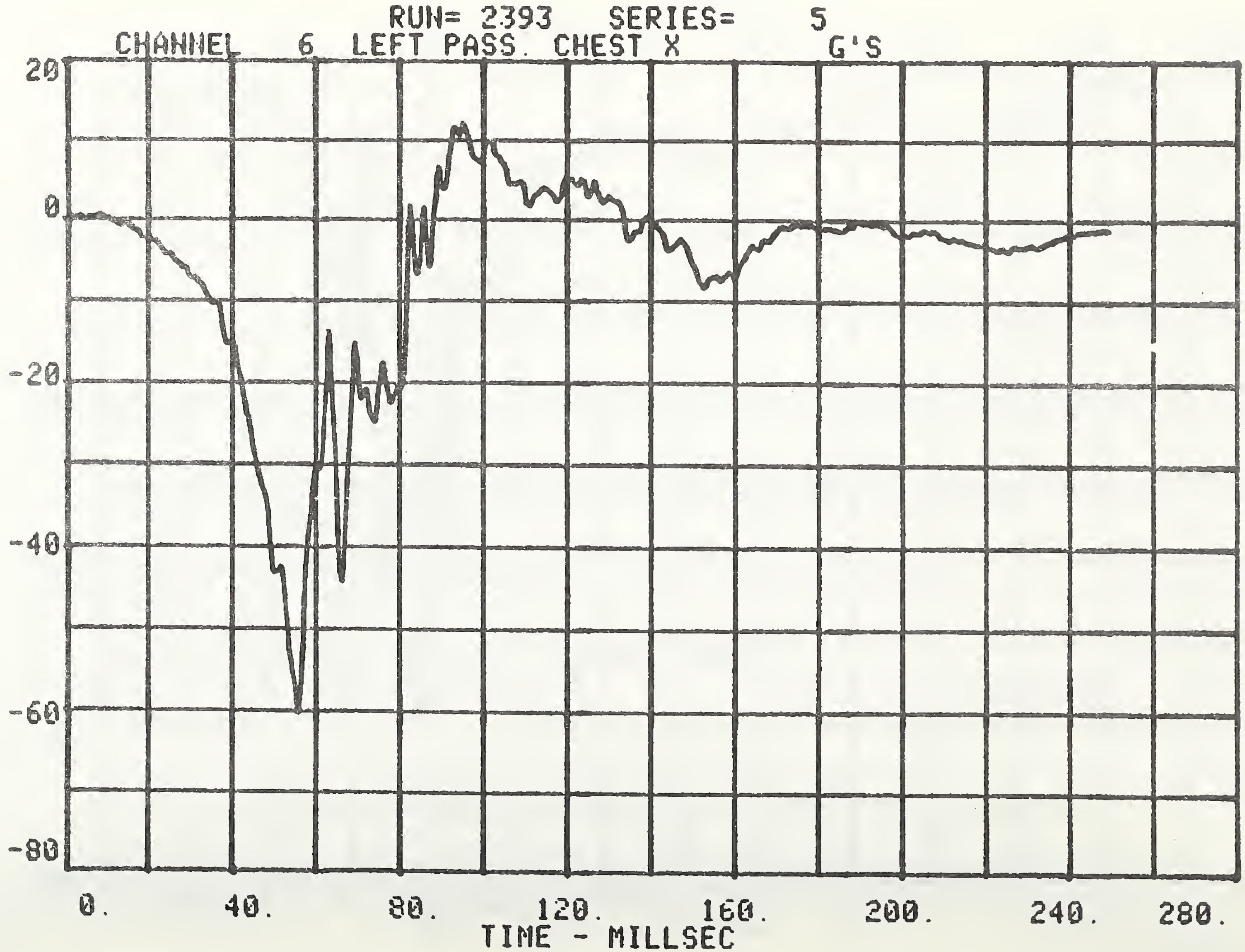


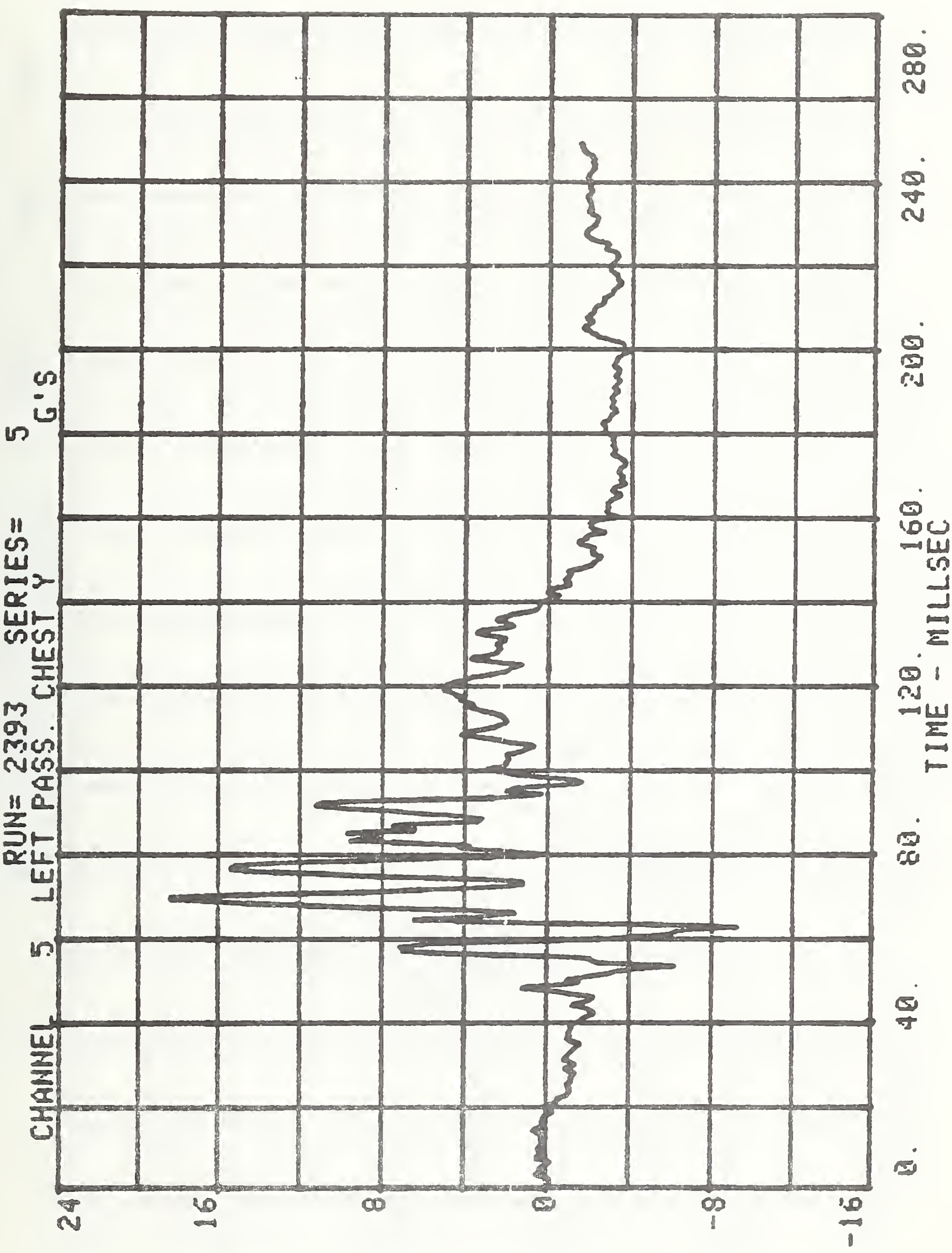
CHANNEL 2 RUN= 2393 SERIES= 5
LEFT PASS. HEAD X G'S
20
10
0
-10
-20
-30
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

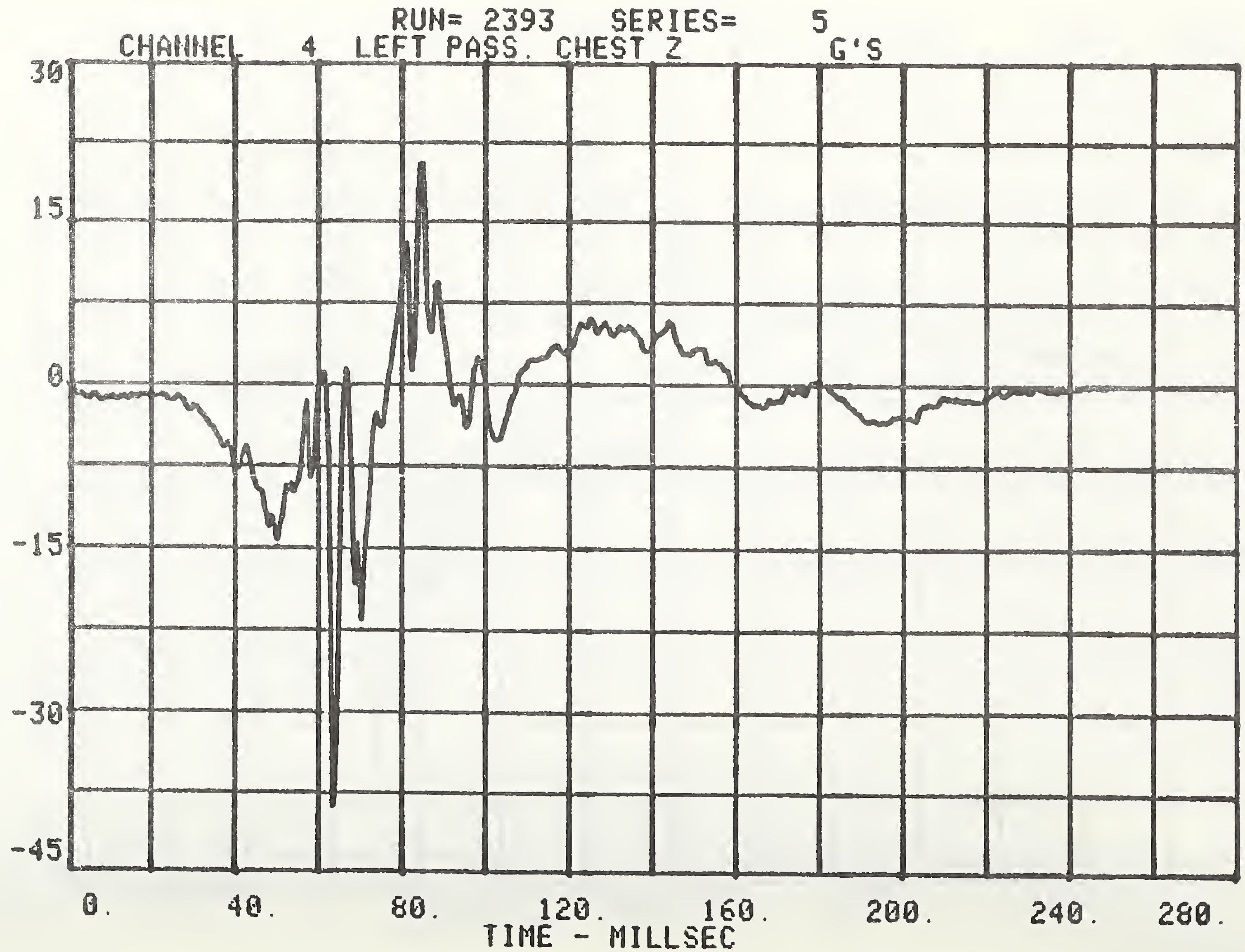

CHANNEL 1 RUN= 2393 SERIES= 5
LEFT PASS. HEAD Y G'S
24
16
8
0
-8
-16
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

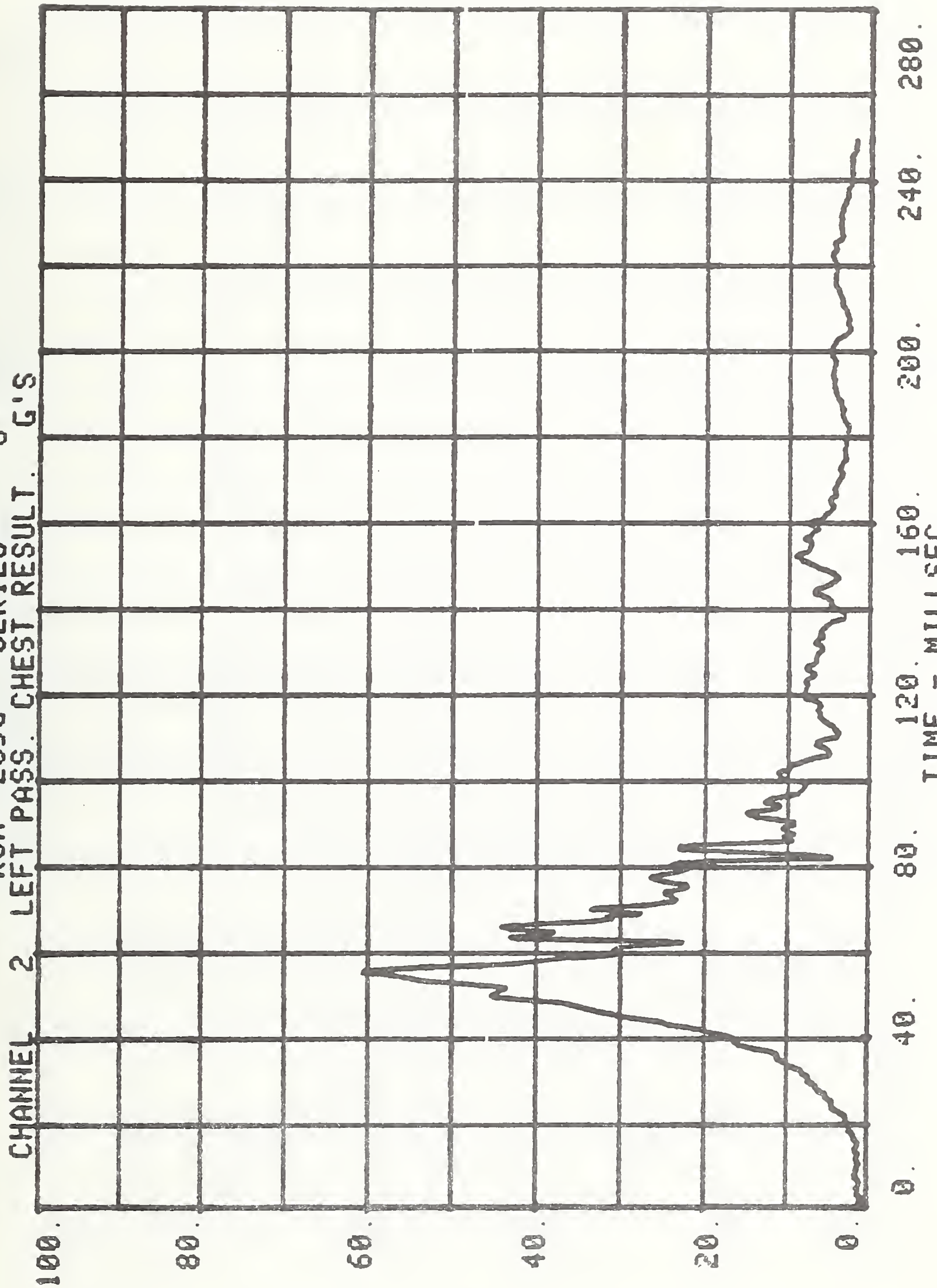

CHANNEL 3 RUN= 2393 SERIES= 5
LEFT PASS. HEAD Z
G'S
80
60
40
20
0
-20
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

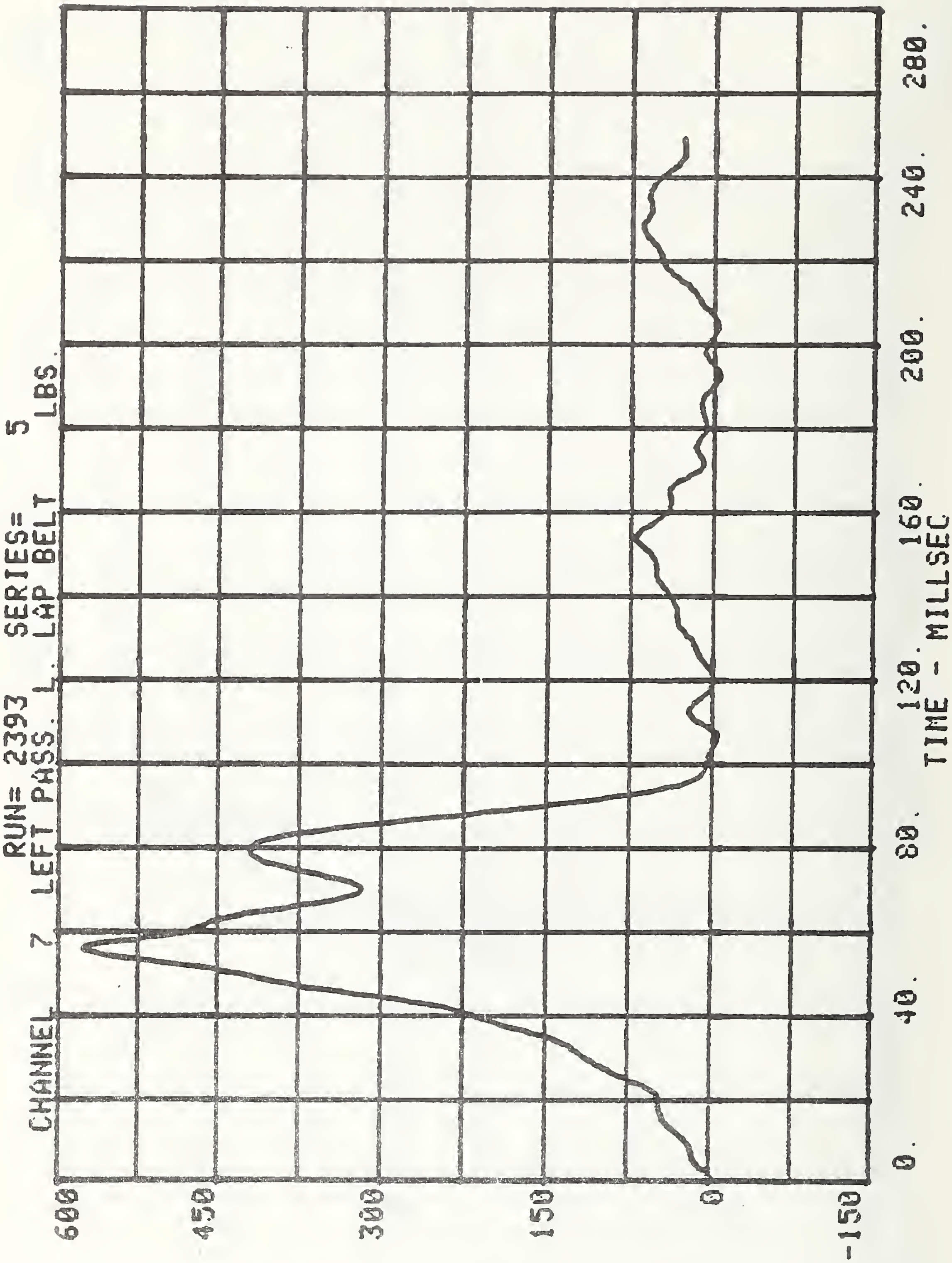

RUN= 2393 SERIES= 5
CHANNEL 1 LEFT PASS. HEAD RESULT. G'S
100.
80.
60.
40.
20.
0.
0. 40. 80. 120. 160. 200. 240. 280.
TIME - MILLSEC


RUN= 2393 SERIES= 5
CHANNEL 6 LEFT PASS. CHEST X G'S
20
0
-20
-40
-60
-80
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC

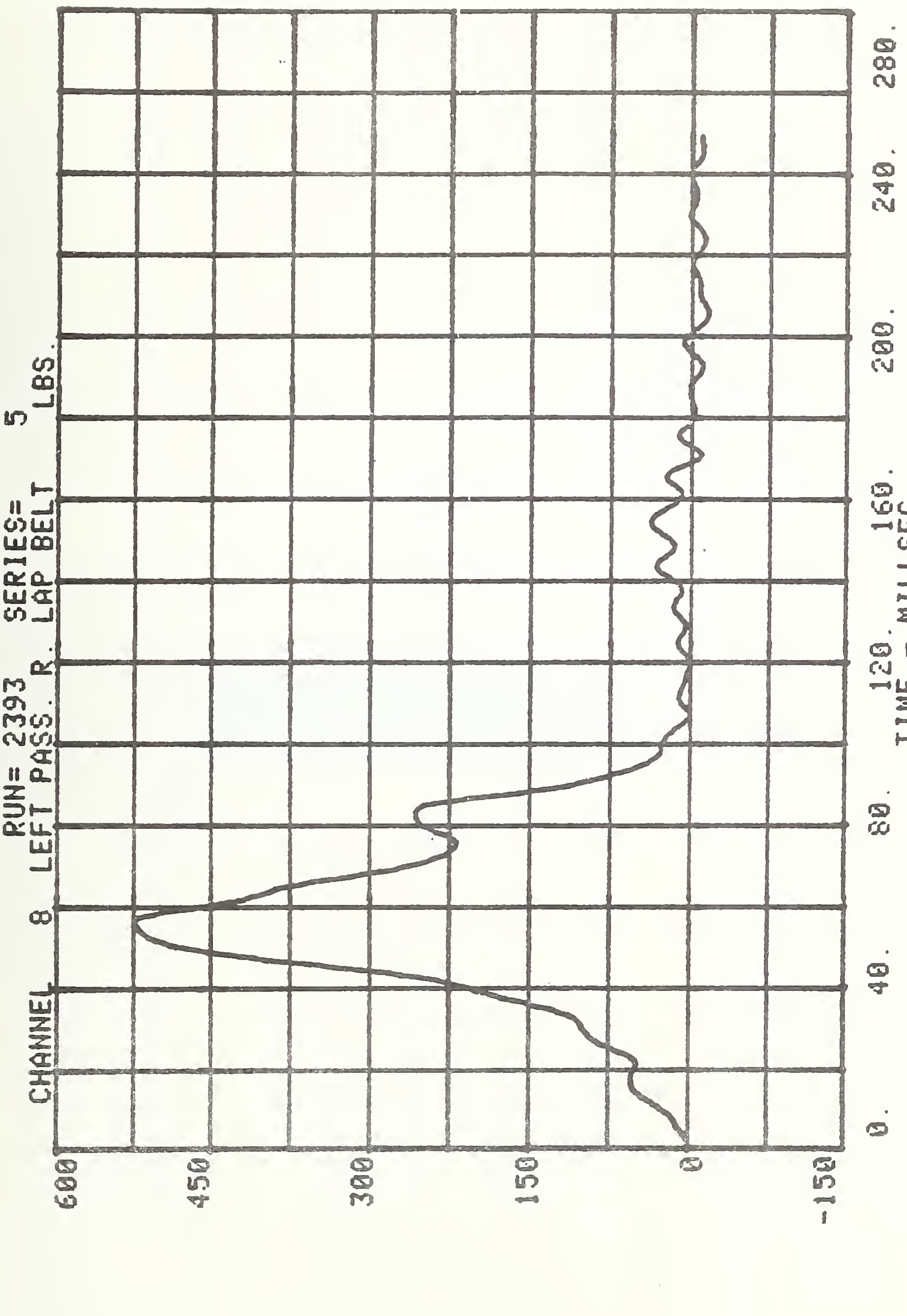

CHANNEL 5 RUN= 2393 SERIES= 5
LEFT PASS. CHEST Y G'S
24
16
8
0
-8
-16
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


RUN= 2393 SERIES= 5
CHANNEL 4 LEFT PASS. CHEST Z G'S
30
15
0
-15
-30
-45
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC


CHANNEL 2 RUN= 2393 SERIES= 5
LEFT PASS. CHEST RESULT. G'S
100.
80.
60.
40.
20.
0.
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 7 RUN= 2393 SERIES= 5
LEFT PASS. L. LAP BELT LBS.
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC



CHANNEL 8 RUN= 2393 SERIES= 5
LEFT PASS. R. LAP BELT LBS.
600
450
300
150
0
-150
0.
40.
80.
120.
160.
200.
240.
280.
TIME - MILLSEC