

DOT 0180

OCCUPANT RESPONSE
AND
VEHICLE ACCELERATION
IN A
30-MPH FRONTAL CRASH TEST

GENERAL MOTORS CORPORATION
1978 BUICK LESABRE TWO-DOOR SEDAN
NHTSA 780109

E. Enserink
R. Pirtle

Contract DOT-HS-6-01478



June 1978

FINAL REPORT

Copies of this report are available from Technical Reference
Division, National Highway Traffic Safety Administration,
Room 5108; Nassif Building, 400 7th Street, S.W.,
Washington, D.C. 20590

PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

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16. Abstract A 1978 Buick LeSabre Two-Door Sedan (NHTSA 780109, VIN 4N37ABC120135) was crash tested for compliance with FMVSS 301 (Fuel System Integrity) and FMVSS 219 (Windshield Zone Intrusion). As a parallel, non-conflicting effort, the anthropomorphic dummies and the vehicle were instrumented with accelerometers to measure occupant response and vehicle acceleration. The results of this effort are documented herein. The vehicle impacted the fixed collision barrier in a zero-degree frontal mode at a speed of 29.65 mph. The occupant response is summarized below: <table border="0"> <thead> <tr> <th></th> <th><u>DRIVER</u></th> <th><u>PASSENGER</u></th> </tr> </thead> <tbody> <tr> <td>Head Injury Criterion:</td> <td>574.4</td> <td>395.9</td> </tr> <tr> <td>Chest Severity Index:</td> <td>240.39</td> <td>180.04</td> </tr> </tbody> </table> Peak vehicle accelerations were as follows: Occupant Compartment - Front: -36.11 @ 23 msec Occupant Compartment - Rear: -36.4 @ 23 msec					<u>DRIVER</u>	<u>PASSENGER</u>	Head Injury Criterion:	574.4	395.9	Chest Severity Index:	240.39	180.04
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons	0.9	metric ton	t
	(2000 lb)			
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
in ³	cubic inches	16	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	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Celsius	°C

Approximate Conversions From Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares	2.5	acres	ac
	(10 000 m ²)			
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton	1.1	short tons	
	(1000 kg)			
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
ml	milliliters	0.06	cubic inches	in ³
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	degrees Celsius	9/5 (then add 32)	degrees Fahrenheit	°F

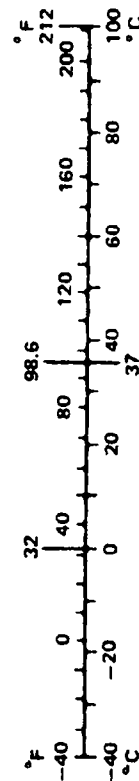


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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the effort documented herein was to acquire occupant response and vehicle acceleration data in a 1978 Buick LeSabre Two-door Sedan (NHTSA 780109) during a 30-mph fixed-barrier (zero-degree, frontal mode) crash test. The test was performed by Dynamic Science, Inc., a subsidiary of Talley Industries, for the National Highway Traffic Safety Administration under Contract No. DOT-HS-6-01478.

The test was conducted in conjunction with Federal Motor Vehicle Safety Standard (FMVSS) 301-75 (Fuel System Integrity) and FMVSS 219 (Windshield Zone Intrusion) compliance test. The occupant response and vehicle acceleration aspects of the test are covered in this report.

1.2 PROCEDURE

The test was conducted in accordance with the Dynamic Science Test Procedure for FMVSS 301-75 and FMVSS 219 submitted to and approved by the NHTSA FMVSS 301-75/219 Contract Technical Manager.

The scope of the above test procedure was expanded to accommodate the acquisition of occupant response and vehicle acceleration data. This was accomplished without creating any conflict with the FMVSS 301-75/219 Procedure or the NHTSA Laboratory Procedure issued by the Office of Standards Enforcement. Specific procedures issued to obtain the additional data are detailed in Section 4.0.

2.0 TEST SUMMARY

2.1 VEHICLE GENERAL INFORMATION

Manufacturer: General Motors Corporation

Make/Model: Buick LeSabre

Body Style: Two-Door Sedan Year: 1978

VIN: 4N37ABC120135 Build Date: 1/78

NHTSA No.: 780109 Color: White

Engine: 6 Cylinders, 231 C.I.D.

Transmission: - speeds, Manual Automatic X

Major Options: Power Brakes, Tinted Glass, Radio, Power Steering,
Air Conditioning, Tilting Steering Wheel

Seating Capacity: Front 3 Rear 3 Total 6

Capacity Weight (lb): 1100

GVWR (lb): Front 2304 Rear 2632 Total 4936

Recommended Cold Tire Pressure (psi): Front 26 Rear 30

Tire Size: FR 78-15

Load Range: B

Tires on Vehicle: FR 78-15

Delivered-Vehicle Values (fluids to capacity)

Weights (lb)

Wheel: RF 1039 LF 976 RR 847 LR 855

Axle : F 2015 (54.2%) R 1702 (45.8%)

Total: 3717

Attitude (in.)

RF 31.0 LF 31.0 RR 31.0 LR 31.0

Target Vehicle Test Weight (lb): 4245

2.2 TEST CONDITIONS

Date: May 17, 1978

Time: 1337

Temperature: 84 °F

Test Speed (mph): 29.65

Vehicle Weights (lb)

Wheel: RF 1097 LF 1086 RR 1025 LR 1041

Axle : F 2183 (51.4 %) R 2066 (48.6%)

Total: 4249

Vehicle Attitude (in.)

RF 30.1 LF 30.0 RR 29.3 LR 29.1

Pre-test Dummy Positions

<u>Measurement</u>	<u>Driver (in.)</u>	<u>Passenger (in.)</u>
Dummy Centerline to Vehicle Centerline	14.9	15.1
Nose to Upper Rim Steering Wheel	13.6	
Nose to Windshield (Horizontal Distance)		19.3
Left Knee to Closest Point on Lower Panel	7.3	5.8
Right Knee to Closest Point on Lower Panel	5.4	5.6
Ankle Distance $\bar{C}$ to $\bar{C}$	10.9	11.5
Knee Distance $\bar{C}$ to $\bar{C}$	8.8	10.5

Additional dummy positioning information is presented in the
PART 512 DUMMY IN-VEHICLE POSITION RECORDING SHEET which follows.

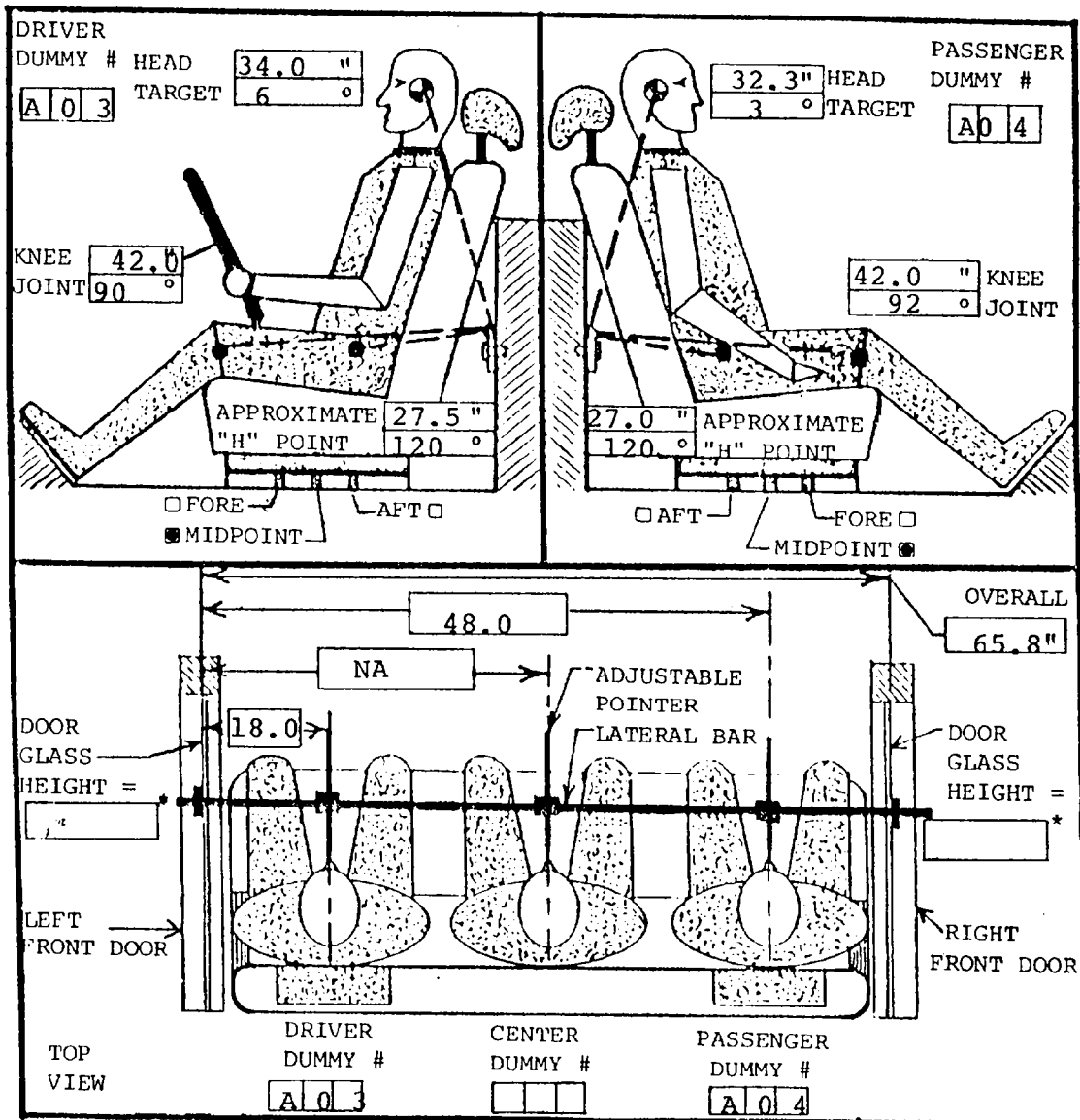
PART 572 DUMMY IN-VEHICLE POSITION
RECORDING SHEET

VEH. NHTSA NO.: 780109 MFR./MAKE/MODEL GM Buick LeSabre
SEAT TYPE: ☒ Bench ADJUSTER TYPE: ☒ Manual BUCKET SEAT BACK TYPE:
☐ Bucket ☐ Power ☐ Fixed
☐ Split Bench ☐ Adjustable Reclining

POSITIONING DATE: May 17, 1978; TECHNICIANS: 1. Enserink

AMBIENT TEMP.: 84 °F TIME: 1300 2.

All front seat dummies shall be positioned according to the procedure "OSE RECOMMENDED PROCEDURE FOR POSITIONING PART 572 DUMMIES IN TEST VEHICLE".



*Door glass height is equal on the right and left side of vehicle

2.3 SUMMARY OF TEST RESULTS

The following data sheets summarize:

1. The occupant response data (PART 572 DUMMY DATA SHEET)
2. The vehicle acceleration data (VEHICLE STRUCTURAL DATA SHEET)

More comprehensive data is presented in the appendix in the form of computer-generated plots.

PART 572 DUMMY DATA SHEET

	Driver				Passenger							
	Positive* Direction		Negative* Direction		Positive* Direction		Negative* Direction					
	Peak G	Time (msec)	Peak G	Time (msec)	Peak G	Time (msec)	Peak G	Time (msec)				
Head Acceleration												
Longitudinal	9	24	124	120	27	192	31	113				
Lateral	39	24	31	120	20	83	22	113				
Vertical	35	123	18	131	37	82	7	19				
Resultant	129	120			43	113						
HIC	574.4 (117-123 msec)				395.9 (65-193 msec)							
Chest Acceleration												
Longitudinal	1	177	31	126	2	198	24	116				
Lateral	11	74	22	126	5	89	3	156				
Vertical	2	25	9	128	8	74	17	139				
Resultant	39	126			26	116						
SEVERITY INDEX	240.39				180.04							
Belt Loads	(lb)	Time (msec)			(lb)	Time (msec)						
Lap	963	76			914	72						
Torso	1067	117			1174	111						
Vehicle Impact Speed (mph): 29.65												
*Positive Direction - Longitudinal: Forward Lateral: Rightward Vertical: Downward Negative Direction - Longitudinal: Rearward Lateral: Leftward Vertical: Upward												

VEHICLE STRUCTURAL DATA

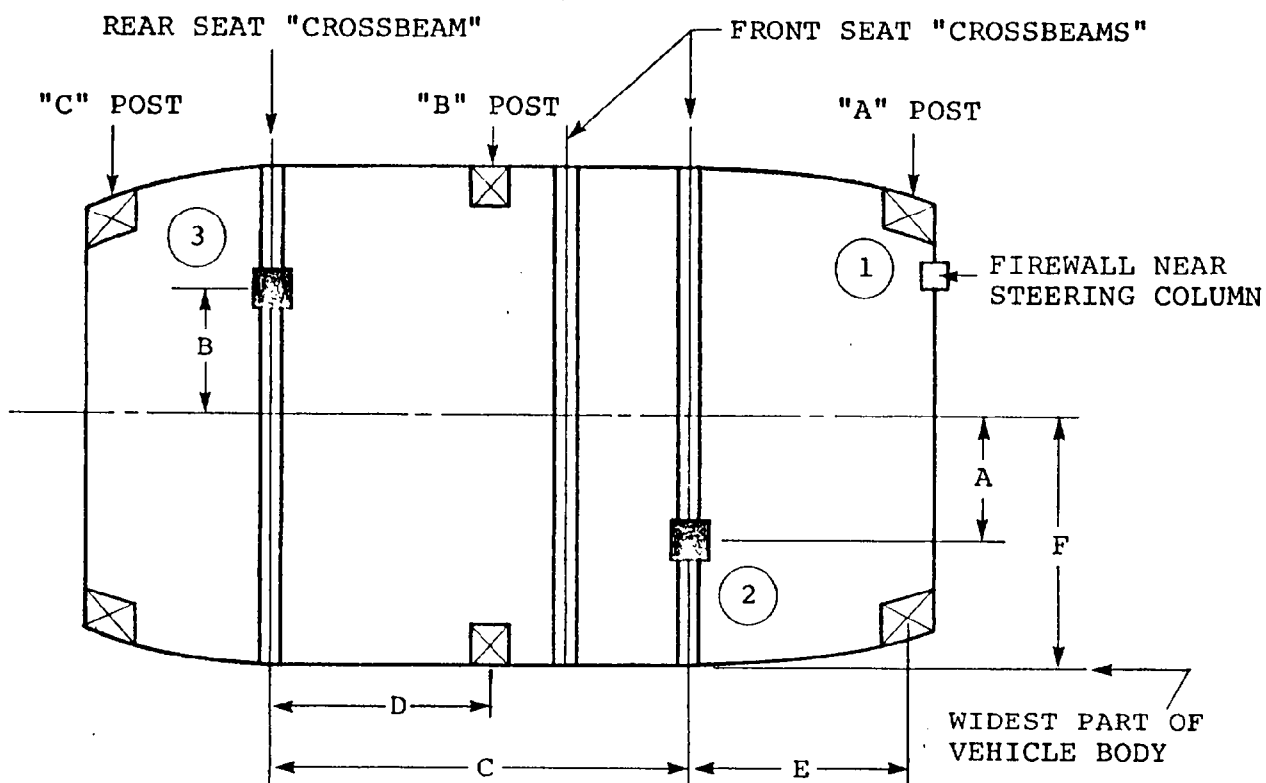
VEHICLE 1978 Buick LeSabre

NHTSA NO. 780109

TEST SPEED 29.65 mph

TEST DATE May 17, 1978

00087608



DIMENSIONS							
Location	Measurement (in.)		Location	Measurement (in.)			
A	9.0		D	5.0			
B	13.5		E	24.0			
C			F				
Steering Column Movement (in.) 1.5 rearward, .5 right, .4 downward							
Vehicle Overall Crush (in.) 25.45							
Test Weight (lb) 4245							
ACCELERATION PEAKS (CLASS 60 FILTER)							
Location	Positive* Direction		Negative* Direction		Average Longitudinal (G)	Dynamic Crush	
	Peak G	Time (msec)	Peak G	Time (msec)		Amount (ft)	Time (msec)
No. 1 Longitudinal							
No. 1 Vertical							
No. 2 Longitudinal	11.00	18	36.11	23	-10.0	2.73	113
No. 3 Longitudinal	13.40	18	36.34	23	10.95	3.01	123
No. 3 Vertical	30.84	43	25.32	38			
*Positive Direction - Longitudinal: Forward, Vertical: Downward							
Negative Direction - Longitudinal: Rearward, Vertical: Upward							

3.0 DISCUSSION OF TEST RESULTS

3.1 VEHICLE GUIDANCE AND IMPACT

A steel follower shoe riding on the monorail guided the vehicle to the fixed collision barrier. The follower shoe is detached from the vehicle just prior to the barrier impact. The vehicle impact speed was 29.65 mph, based on the breakwire speed traps which are located within 5 feet of the impact point. The required speed range at impact is 29.4 ± 0.5 mph. The test vehicle longitudinal centerline contacted the barrier within 1 inch of the barrier centerline.

3.2 VEHICLE REBOUND AND CRUSH

The distance from the front of the vehicle to the barrier after impact was 51.3 inches. The average overall static crush of the vehicle was 25.45 inches.

3.3 PHOTOGRAPHS

Figures 3-1 through 3-3 are pre-test and post-test views of the occupant compartment, restraint systems, and dummies.

3.4 POST-TEST DAMAGE OBSERVATIONS

A post-test inspection of the vehicle revealed the following:

- Front sheet metal pushed rearward against doors.
- Battery became loose.

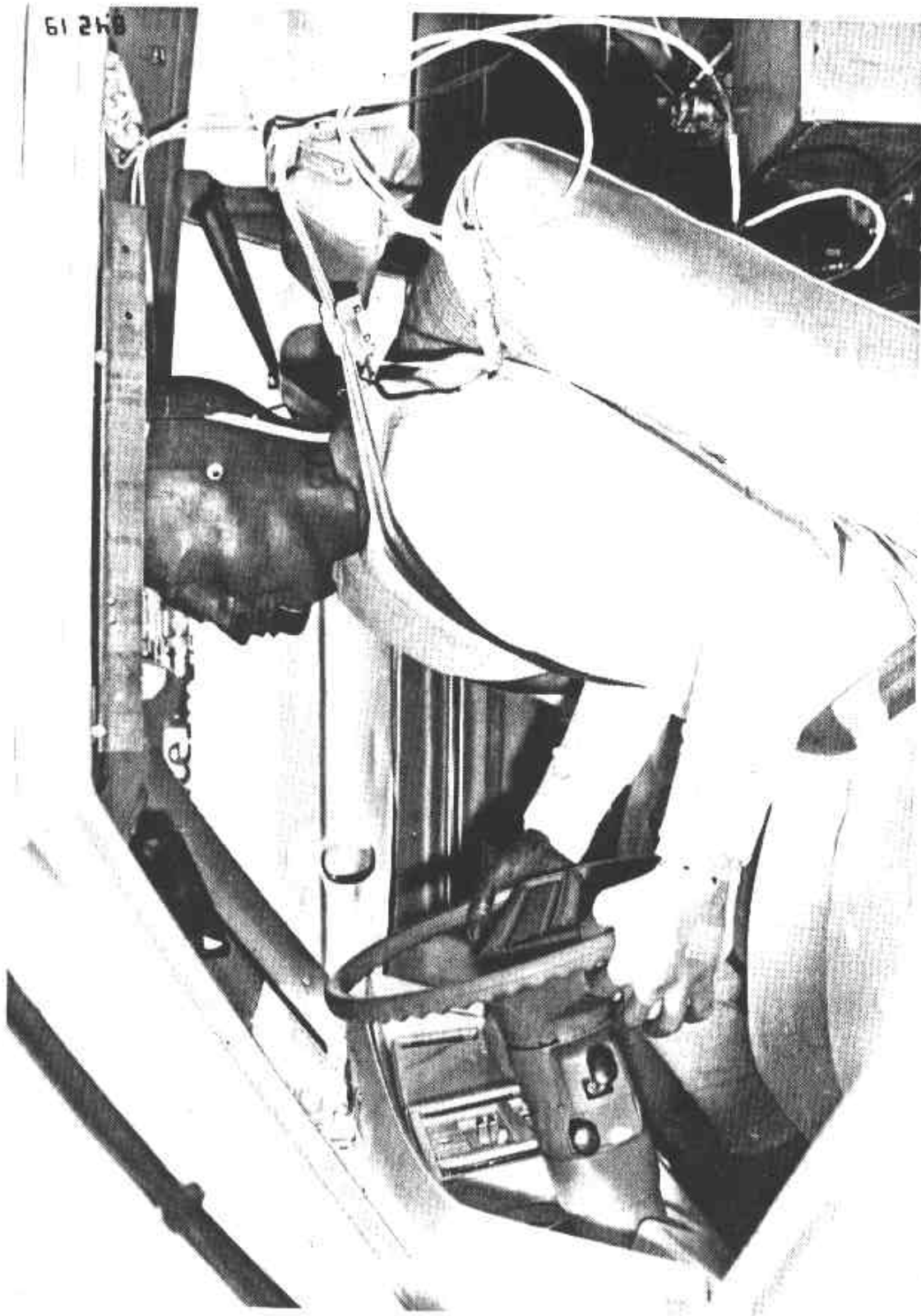


Figure 3-1. Pre-test View of Driver Dummy - 1978 Buick LeSabre Two-Door Sedan -
NHTSA 780109.



Figure 3-2. Pre-test View of Passenger Dummy - 1978 Buick LeSabre Two-Door Sedan -
NHTSA 780109.

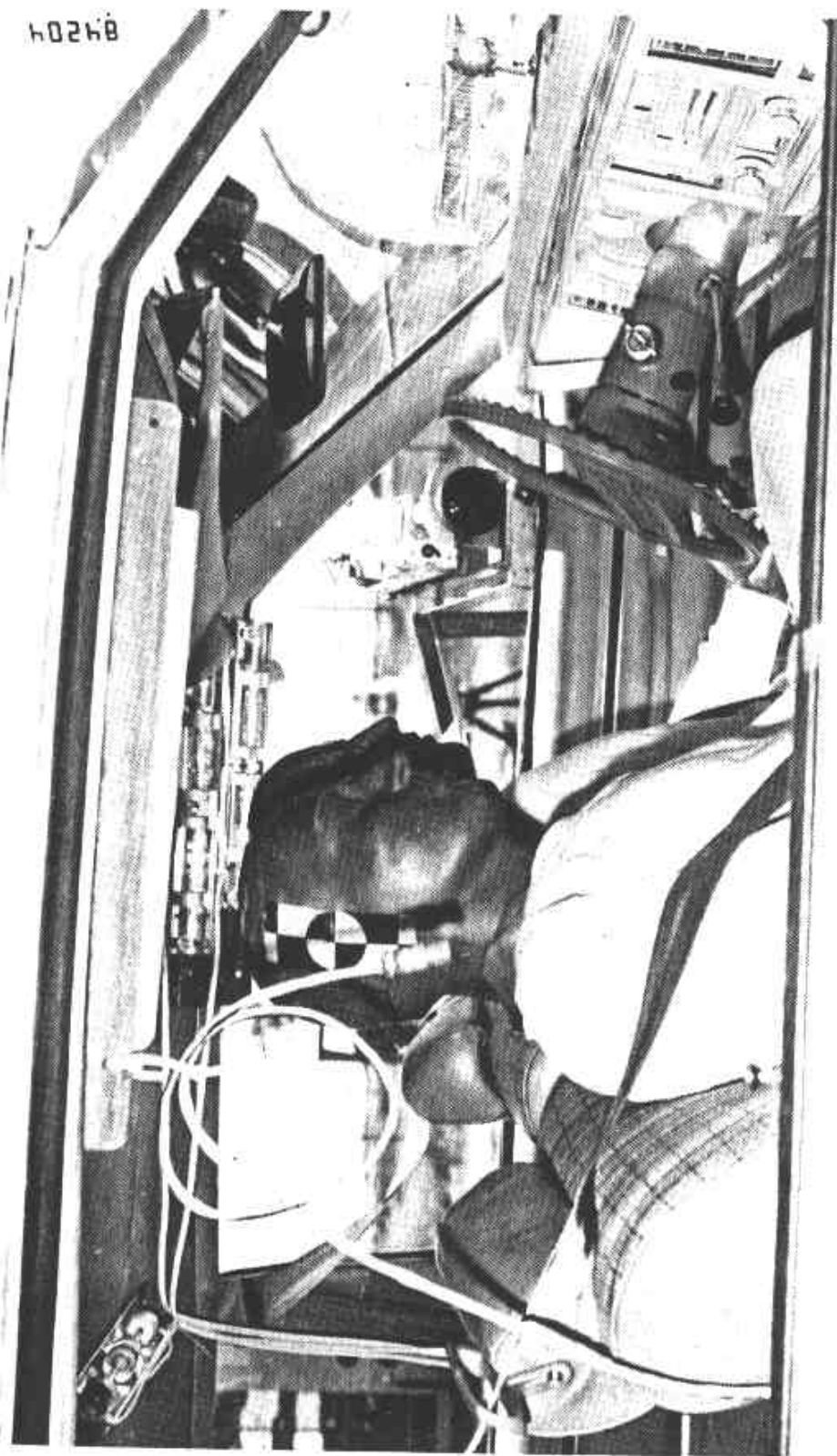


Figure 3-3. Post-test View of Dummies - 1978 Buick LeSabre Two-Door Sedan -
NHTSA 780109.

4.0 TEST PROCEDURES

4.1 CRASH TEST

The procedures for conducting the barrier crash test are presented in detail in the FMVSS 301 (Fuel System Integrity) report previously submitted to the NHTSA Office of Standards Enforcement.

4.2 DUMMY POSITIONING

The driver and right front passenger were placed in the center of the seat cushion and pushed into the seat back. The shoulders were pushed back against the seat back and the dummy head was centered on the head restraint. The thighs were pushed down on the seat cushion and the heels placed on the floor. The upper portion of the arms of the passenger was pushed against the seat back and the hands placed to the side of the thighs. The thumbs and index fingers of the driver dummy were positioned around the steering wheel rim at the 3 and 9 o'clock positions.

The front seat was placed at the mid fore-aft position. The seat back was positioned at its mid angle.

4.3 DATA ACQUISITION AND REDUCTION

The acceleration and belt load signals from the two dummies were converted to FM signals along with the signal from the impact (event) switch and transmitted to an analog tape recorder. The electrical signal was transmitted through an umbilical cable trailing the vehicle to the test control center. A redundant telemetry system was installed in the vehicle in case of umbilical cable failure or inadvertent separation of the cable from the vehicle.

Instruments used in this test are listed in Table 4-1.

The flow of the data during reduction phase is shown in Figure 4-1. Test data stored in a frequency format on analog tape serves as the input to the data reduction effort. These data are played back and the signal from the tape is passed through the appropriate demodulators which convert the data back to its original voltage form. These data are then passed through a presample filter, digitally sampled, and stored on a magnetic tape for subsequent processing on the digital computer by the Dynamic Science computer program "Crash". The procedure used for handling each data channel will first be discussed, followed by a discussion of the operations the computer program performs on each type of data from the crash tests.

Figure 4-2 illustrates the manner in which each data channel is handled from analog playback to digital processing. Following the discrimination process, the raw data in its original analog form is prefiltered through a linear phase low pass filter. The presampled filtered data are then digitized and stored on magnetic tape for subsequent computer processing. Digitizing rate (sampling rate) is dependent upon the presample filter as shown in Table 4-2. Also given in this table are the J211a data classes, the presample filters which Dynamic Science uses, and the data sampling rates for each J211a data class. The presample filters were chosen from those which Dynamic Science has in its playback systems to give a satisfactory data representation for each data class. Sample rates were selected to ensure that no aliasing of the presample filtered data would occur and yet provide sufficient sample rates to give adequate definition of the wave form of the original data.

Following the digitizing process, the data is then processed via the digital computer where it undergoes further filtering by means of a digital filter.

TABLE 4-1. INSTRUMENTATION SUMMARY FOR COLLISION TESTS

Measurand	Type of Transducer	Manufacturer and Model No.	Full-Scale Capacity	Output	Transducer Accuracy	Frequency Response (maximum)
<u>I. Test Vehicle</u>						
Vehicle impact	Contact switch	Tapeswitch	On-Off	0 - 2.5V	-	350 μ sec rise time
Acceleration	Unbonded strain gauge accelerometer	Statham Model No. A69Tc-200-350	200 G	4 MV/V	$\pm 0.75\%$	2300 Hz
<u>II. Occupant</u>						
Head and chest accelerations (triaxial)	Piezoresistive strain gauge accelerometer	Endevco Model No. 7332C-750	± 750 G (2500 G overload)	.1 MV/G @ 5V DC excitation	$\pm 1\%$ of reading	2000 Hz
<u>III. Facility</u>						
Approach velocity	Pulse generator/digital counter	Dynamic Science	>100 mph	600 Hz @ 100 mph	$\pm 0.5\%$ @ 30 mph	NA (1)
Impact velocity	Breakwire speed trap	Dynamic Science	>100 mph	10^4 counts	.01%	NA (1)
Barrier impact	Contact switch	Tapeswitch	On-Off	2.5V	-	350 μ sec rise time

(1) NA - Not applicable.

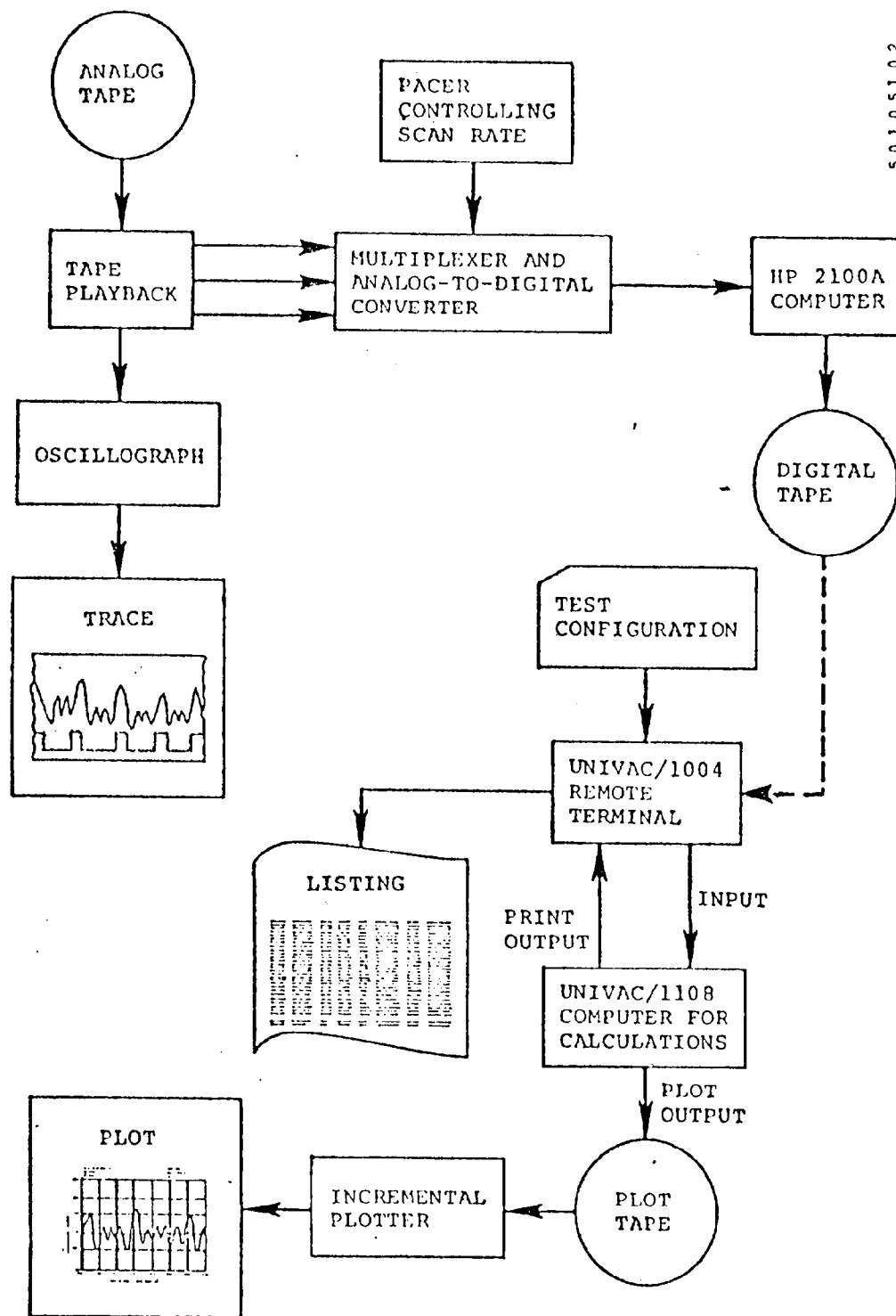


Figure 4-1. Data Reduction Flow Diagram.

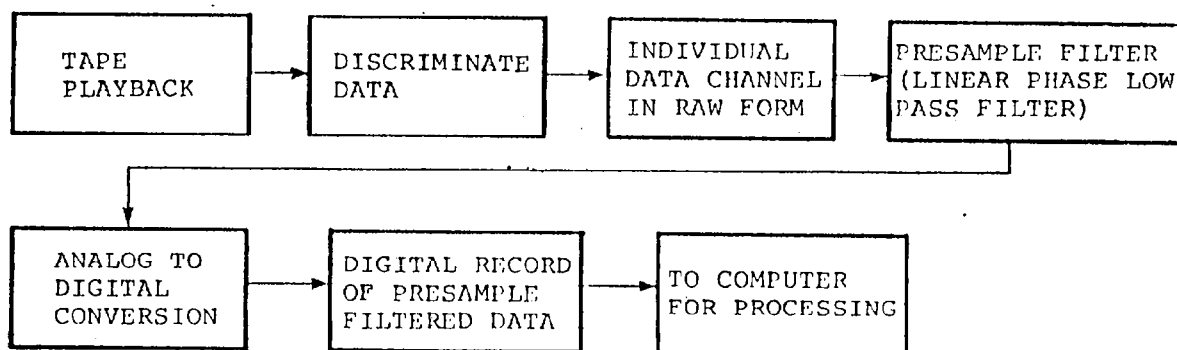


Figure 4-2. Flow of Individual Data Channel.

TABLE 4-2. DIGITAL SAMPLING RATES FOR J211a DATA CLASSES

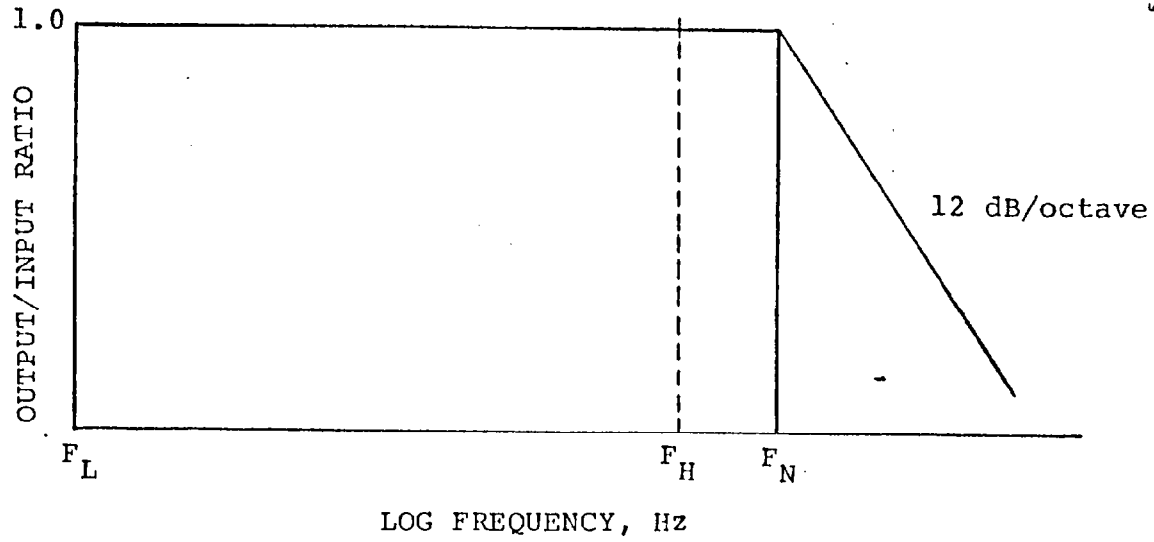
Item	Data Class	Presample Filter (3dB Frequency)	Sampling Rate	Digital Filter Cutoff Frequency
Chest Accelerations	180	250	1000	Not Filtered
Head Accelerations	1000	2000 Hz	8000	1650

The digital filter used a fast Fourier transformation to transfer the data to the frequency domain where the filtering occurs. Filtering is achieved by multiplying the Fourier transformed data by the filter transfer characteristics shown in Figure 4-3. The data from the product are transferred back to the time domain where the analysis is then performed.

The data are then processed in more detail by means of the computer.

The output from the computer is basically in two forms:
 (1) a listing of the basic data and the resulting calculations derived from the data and (2) selected incremental plots of these data.

TRANSFER FUNCTION



50105104

DATA CLASSES

<u>DATA CLASS</u>	<u>F_H-Hz</u>	<u>F_H-Hz</u>	<u>ROLL OFF - dB/oct</u>
1000	1000	1650	12
600	600	1000	12
180	180	300	12
60	60	100	12

Figure 4-3. Digital Filter Transfer Function for SAE J211a Data Classes.

Data from each type of test are discussed below.

4.4 CRASH DATA

4.4.1 Dummy Head Data

The dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to five velocities and displacements. The HIC is computed as well as the Severity Index. The HIC is maximized over the event interval on the basis of every 5th time point (≈ 0.001 second) to establish the maximum HIC value and the interval over which it occurred.

Data output is in the form of a computer printout at one (1) millisecond intervals, as well as incremental computer plots (shown in the Appendix plotted at one millisecond intervals).

4.4.2 Dummy Chest Accelerations

The dummy chest accelerations are processed as class 180 data, combined to get resultants, and integrated to get velocities and displacements. The resultant accelerations, velocities, displacements, and severity index are listed on the digital printout at one (1) millisecond intervals. These outputs can also be plotted on an incremental plotter. Also outputted is the time duration above 60G.

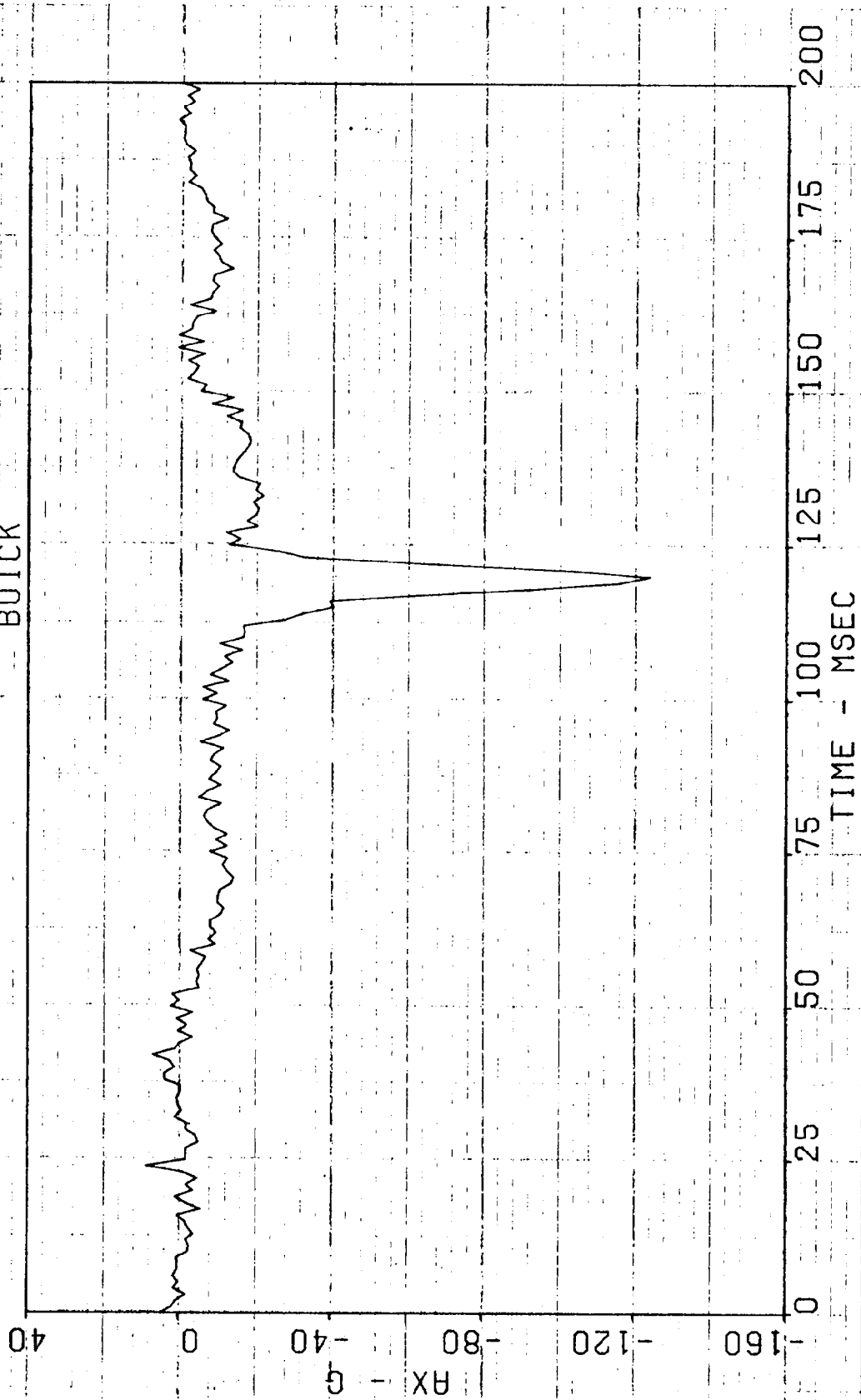
APPENDIX

CALCOMP PLOTS

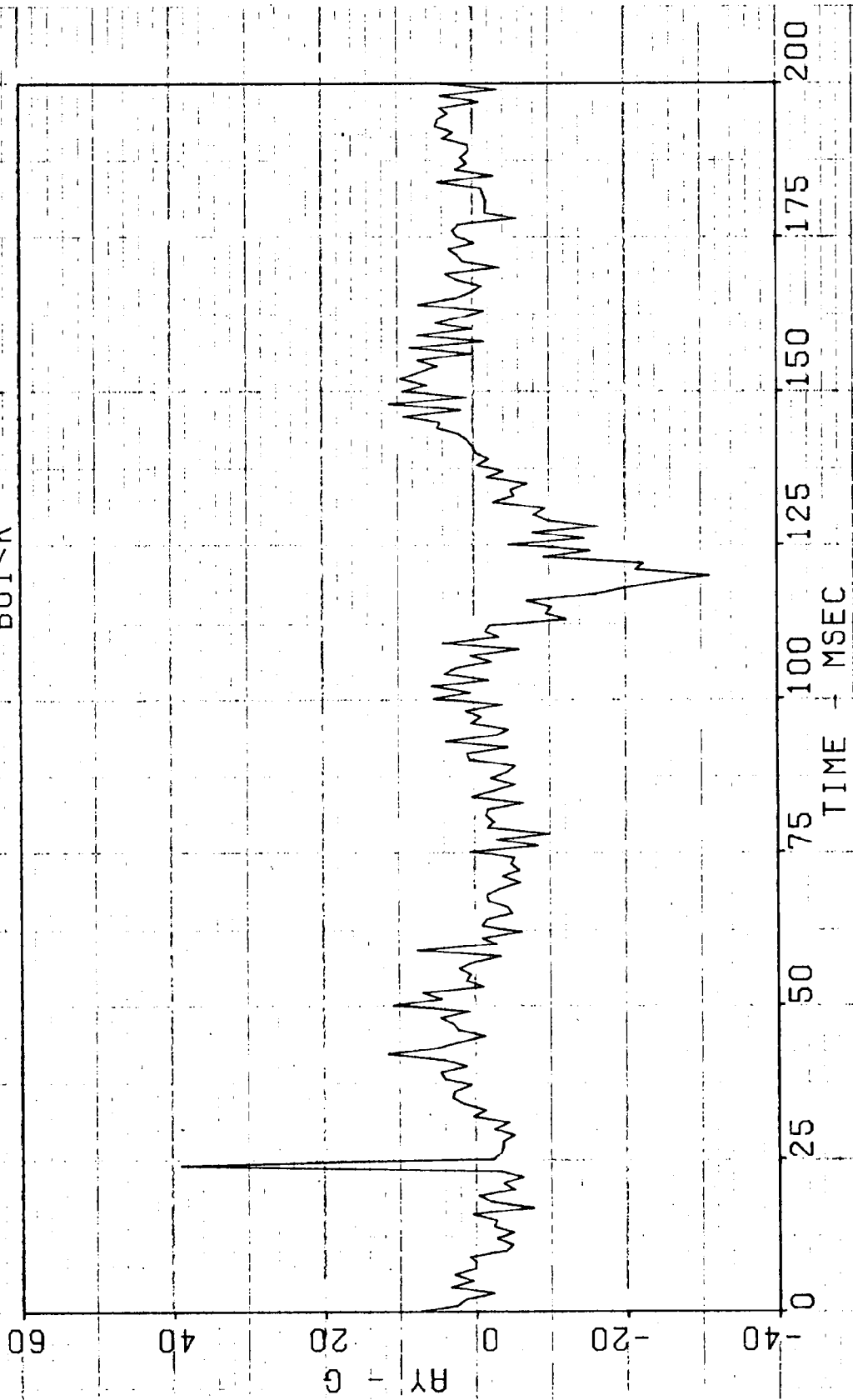
The following location numbers are used in the CalComp plot titles to identify transducer locations:

<u>Location</u>	<u>Number</u>
Driver Head Accelerometer	501
Driver Chest Accelerometer	1101
Driver Lap Belt Load Cell	4001L
Driver Torso Belt Load Cell	4001T
Passenger Head Accelerometer	503
Passenger Chest Accelerometer	1103
Passenger Lap Belt Load Cell	4003L
Passenger Torso Belt Load Cell	4003T
Occupant Compartment Front Accelerometer	102
Occupant Compartment Rear Accelerometer	104

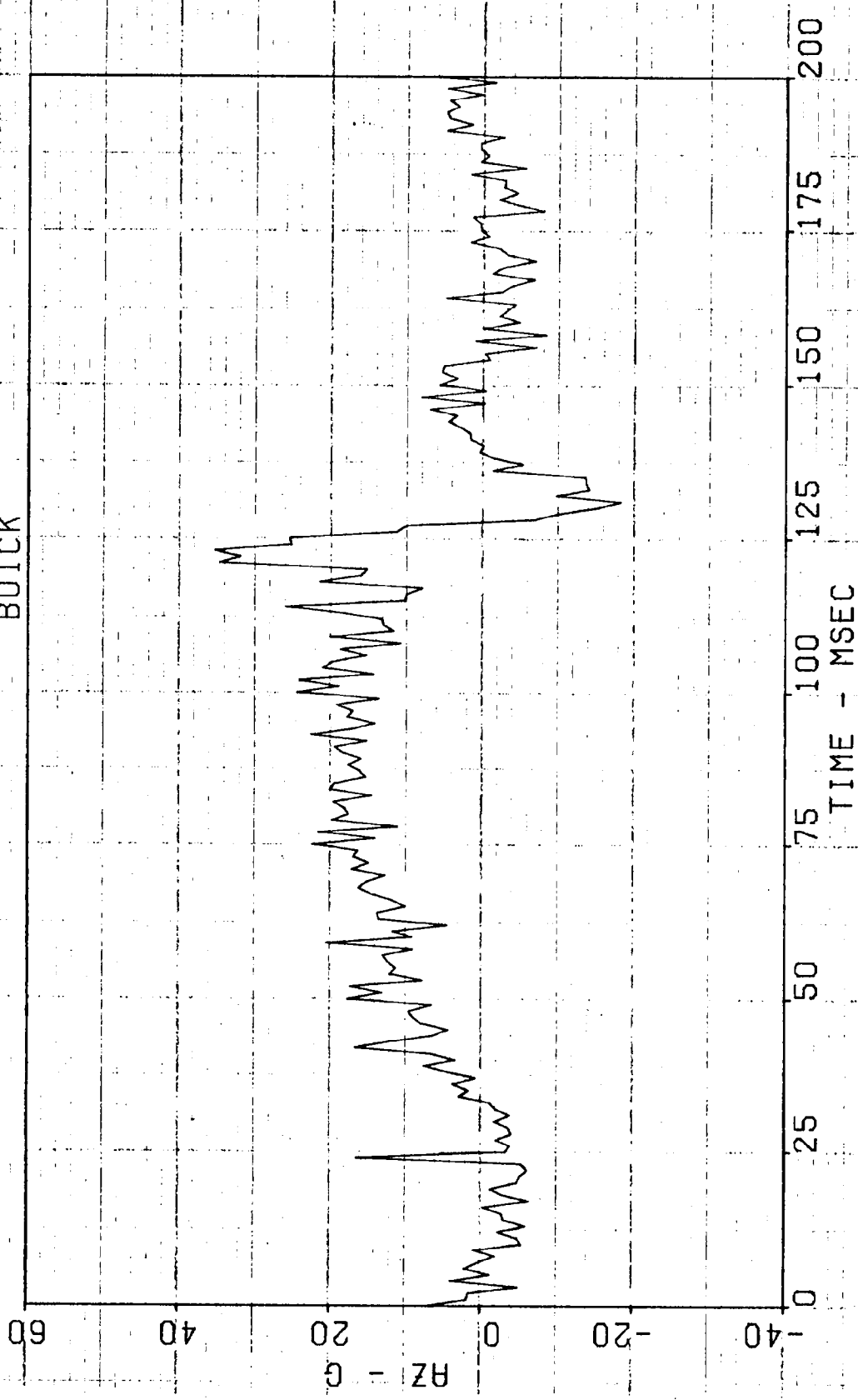
DATE 5-17-78 FILTER 1600 LOCATION 501 TEST NO 062378
FRONT/BARR BUICK



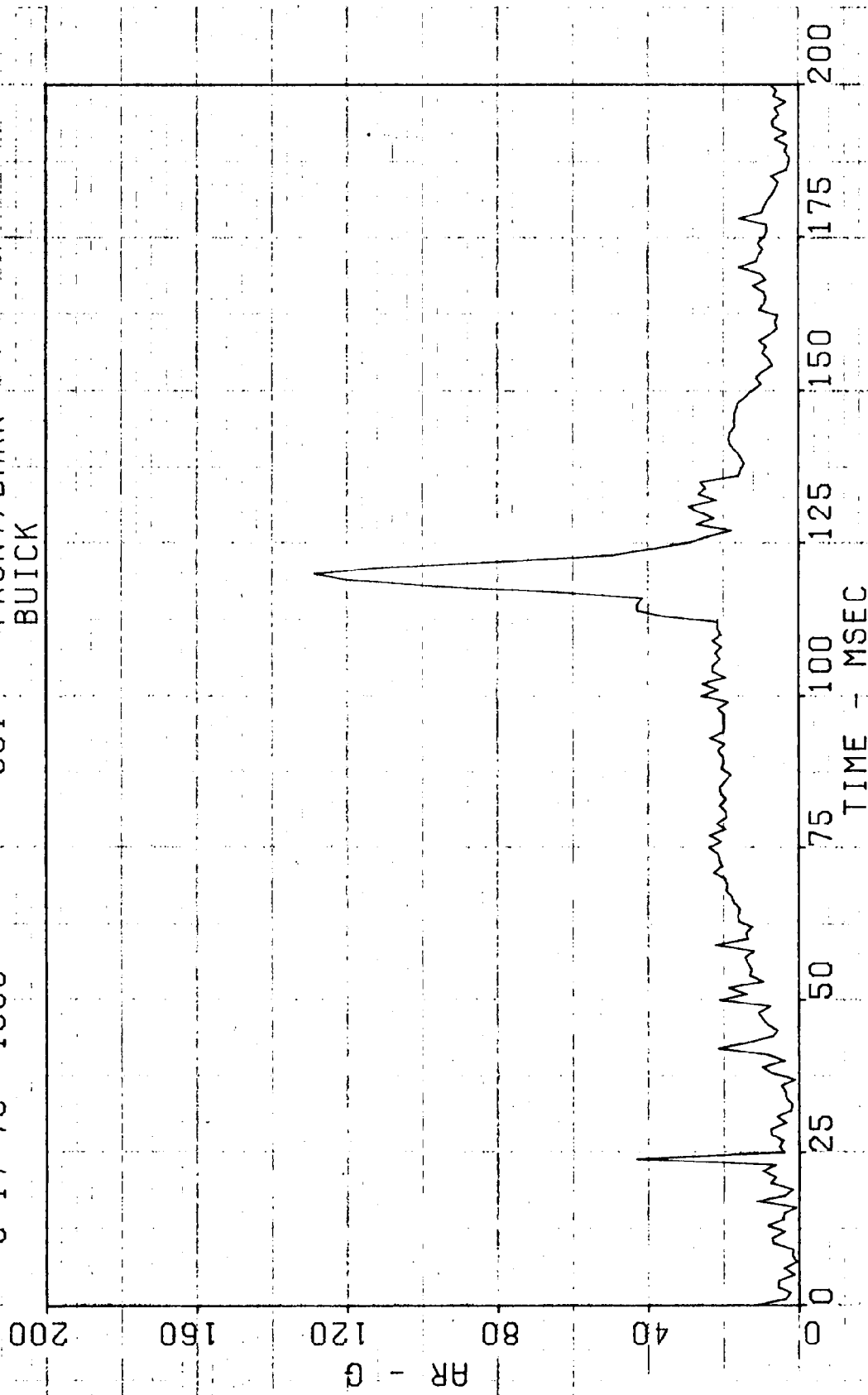
DATE 5-17-78 FILTER 1600 LOCATION 501 TEST NO 062778
FRONT/BARR BUI<K



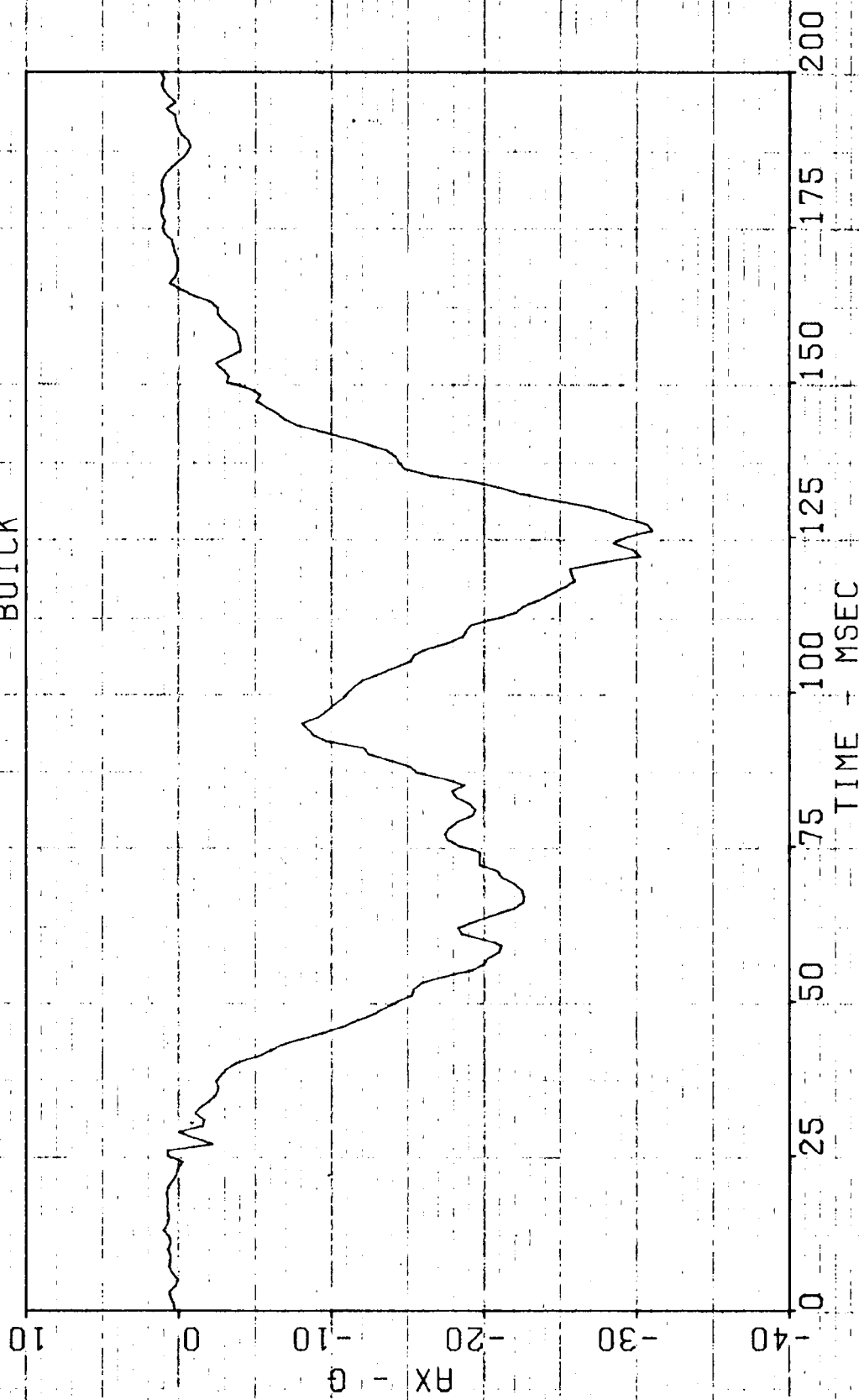
DATE 5-17-78 FILTER 1600 LOCATION 501 TEST NO 062378 FRONT/BARR BUICK



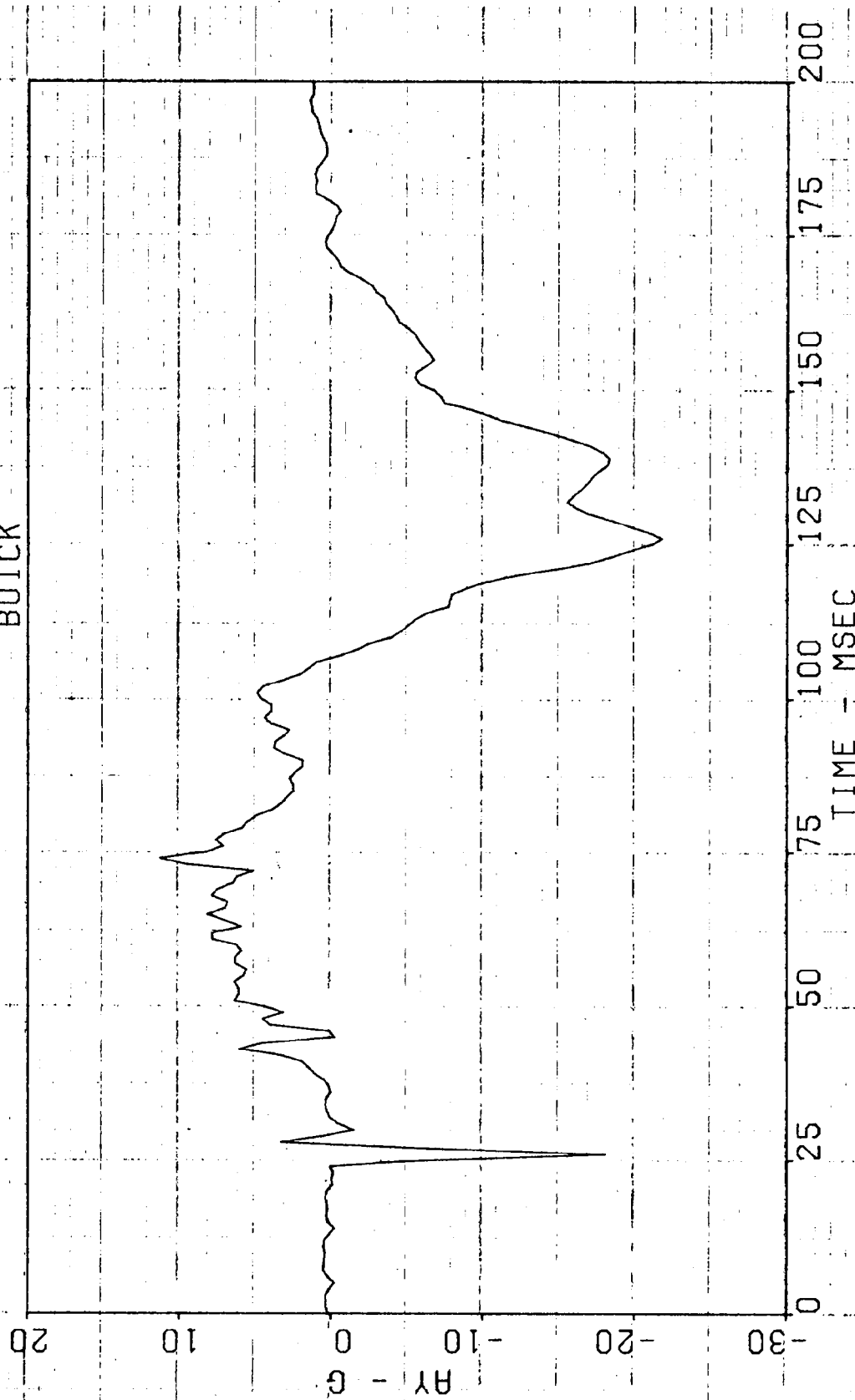
DATE 5-17-78 FILTER 1600 LOCATION 501 TEST NO 062378
FRONT/BARR
BUICK



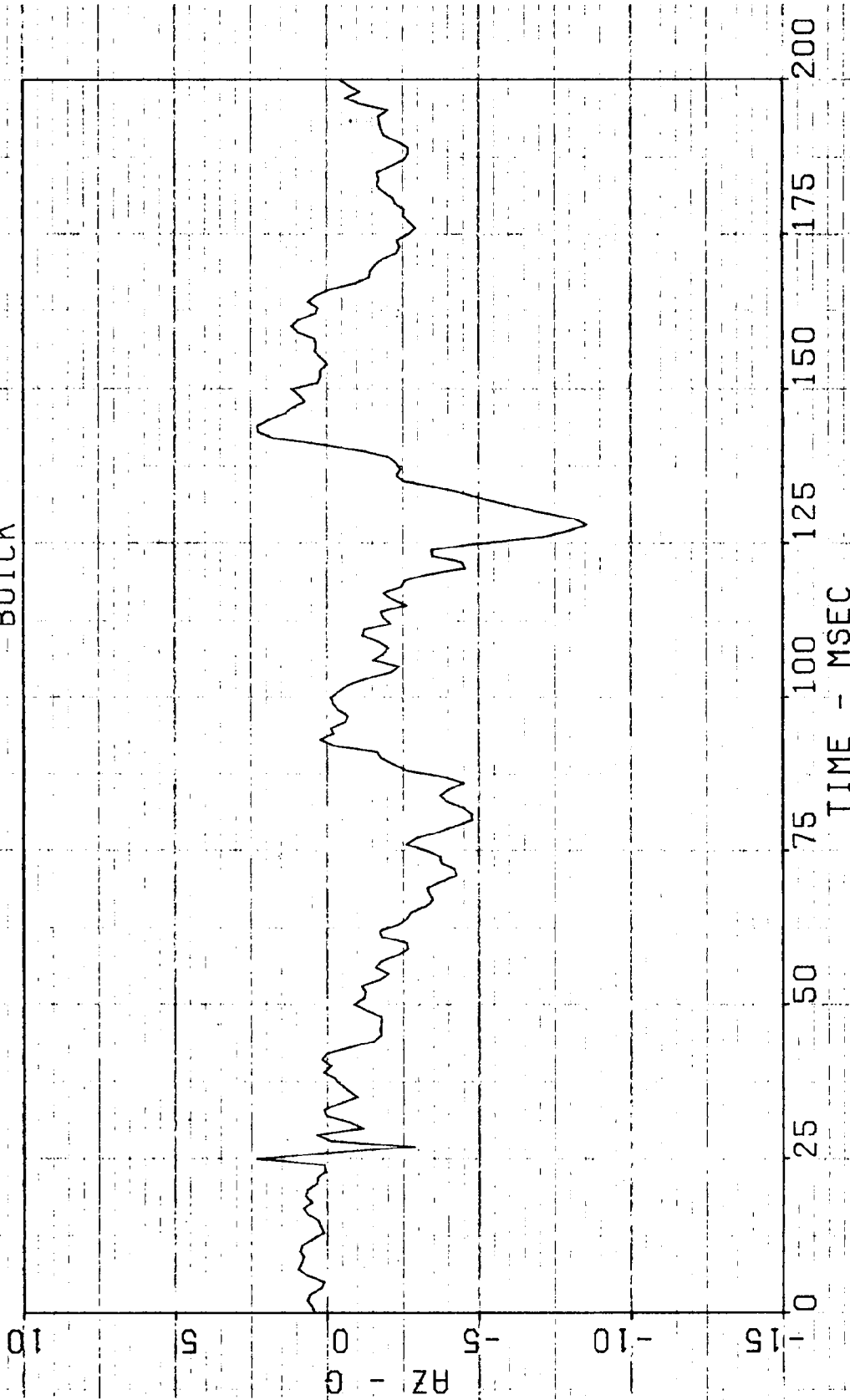
DATE 5-17-78 FILTER 315 LOCATION 1101 TEST NO 062378
FRONT/BARR
BUICK



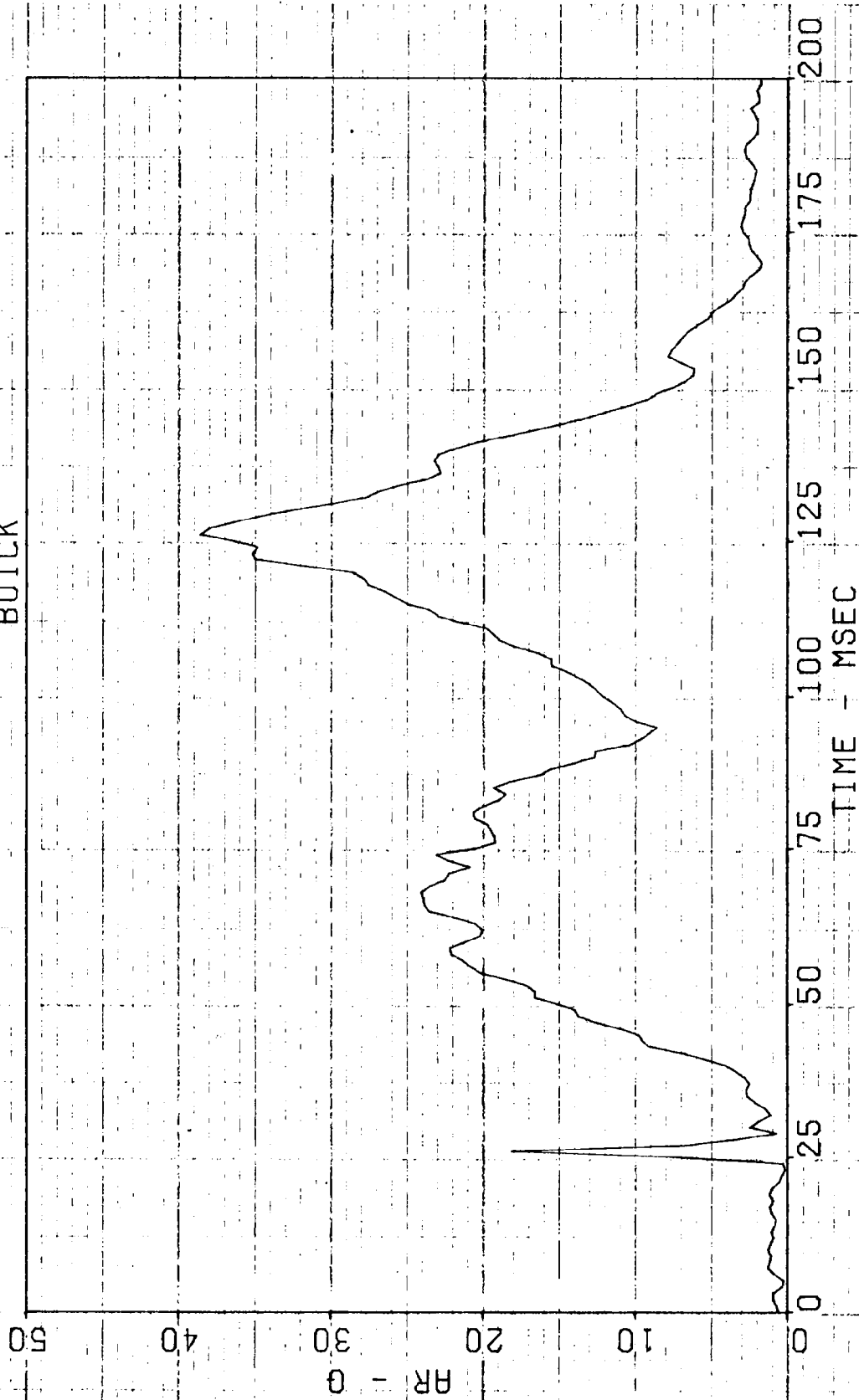
DATE 5-17-78 FILTER 315 LOCATION 1101 TEST NO 062778
FRONT/BARR BUICK



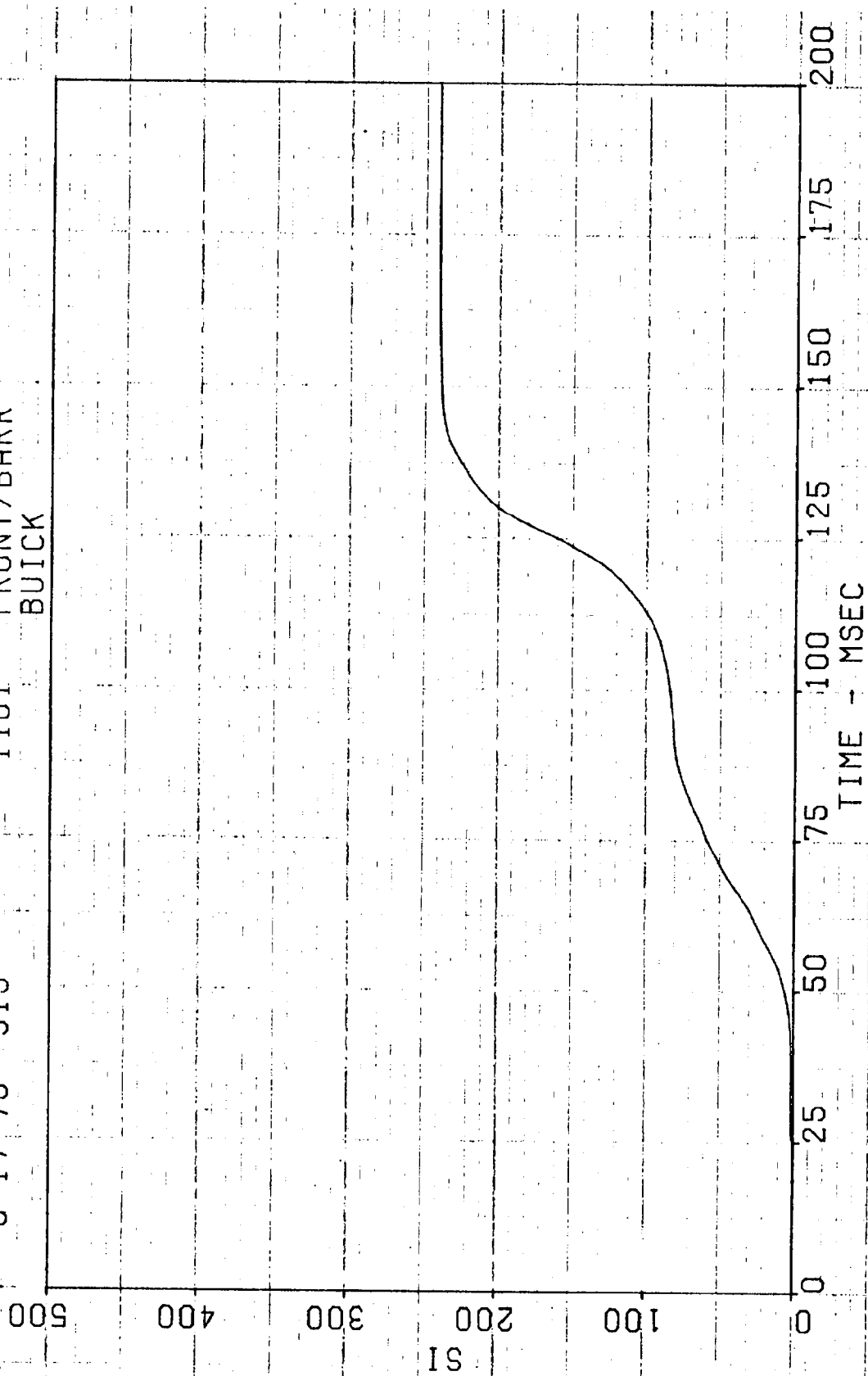
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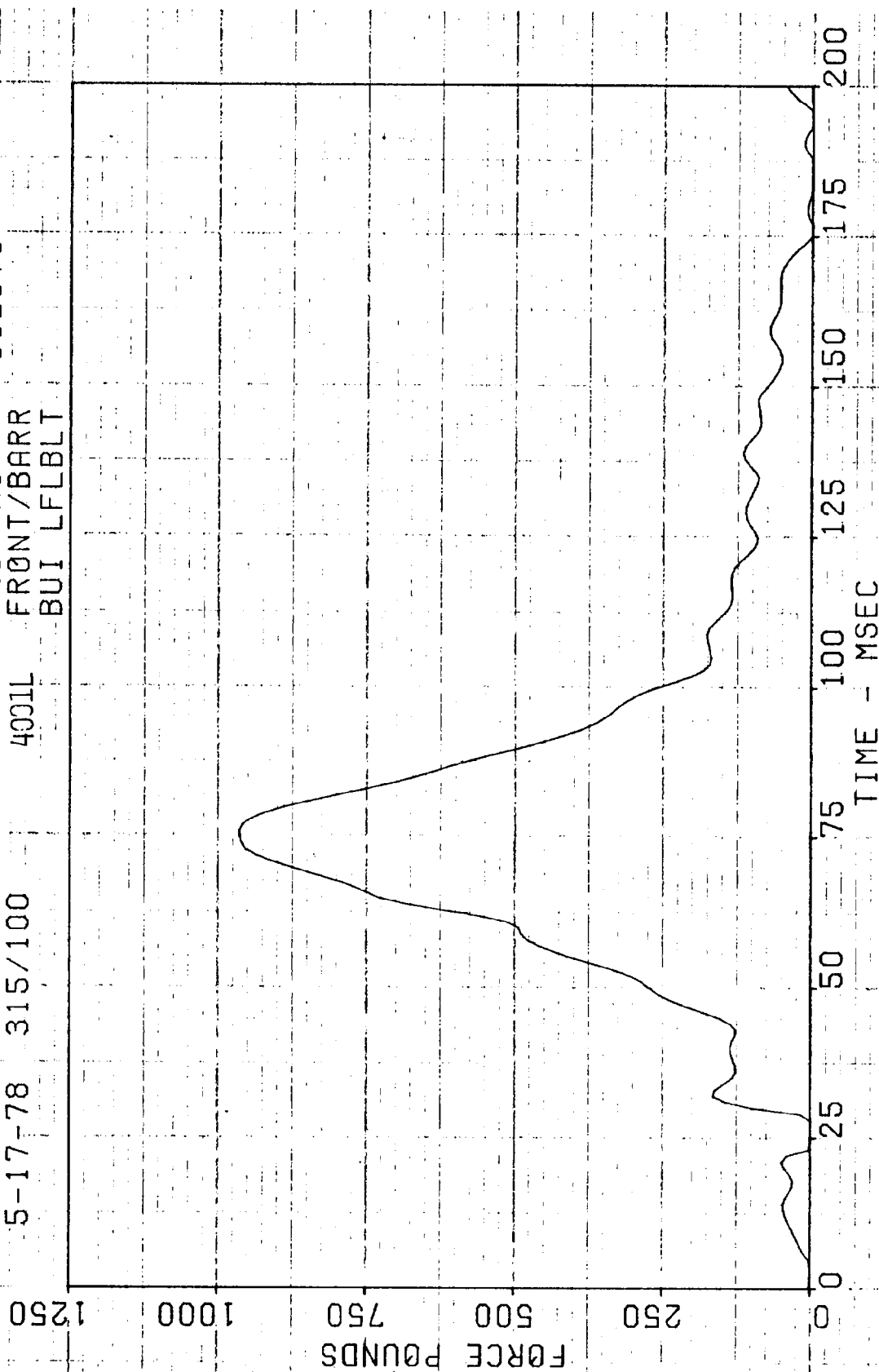
DATE 5-17-78 FILTER LOCATION TEST NO 062378
1101 FRONT/BARR
BUICK



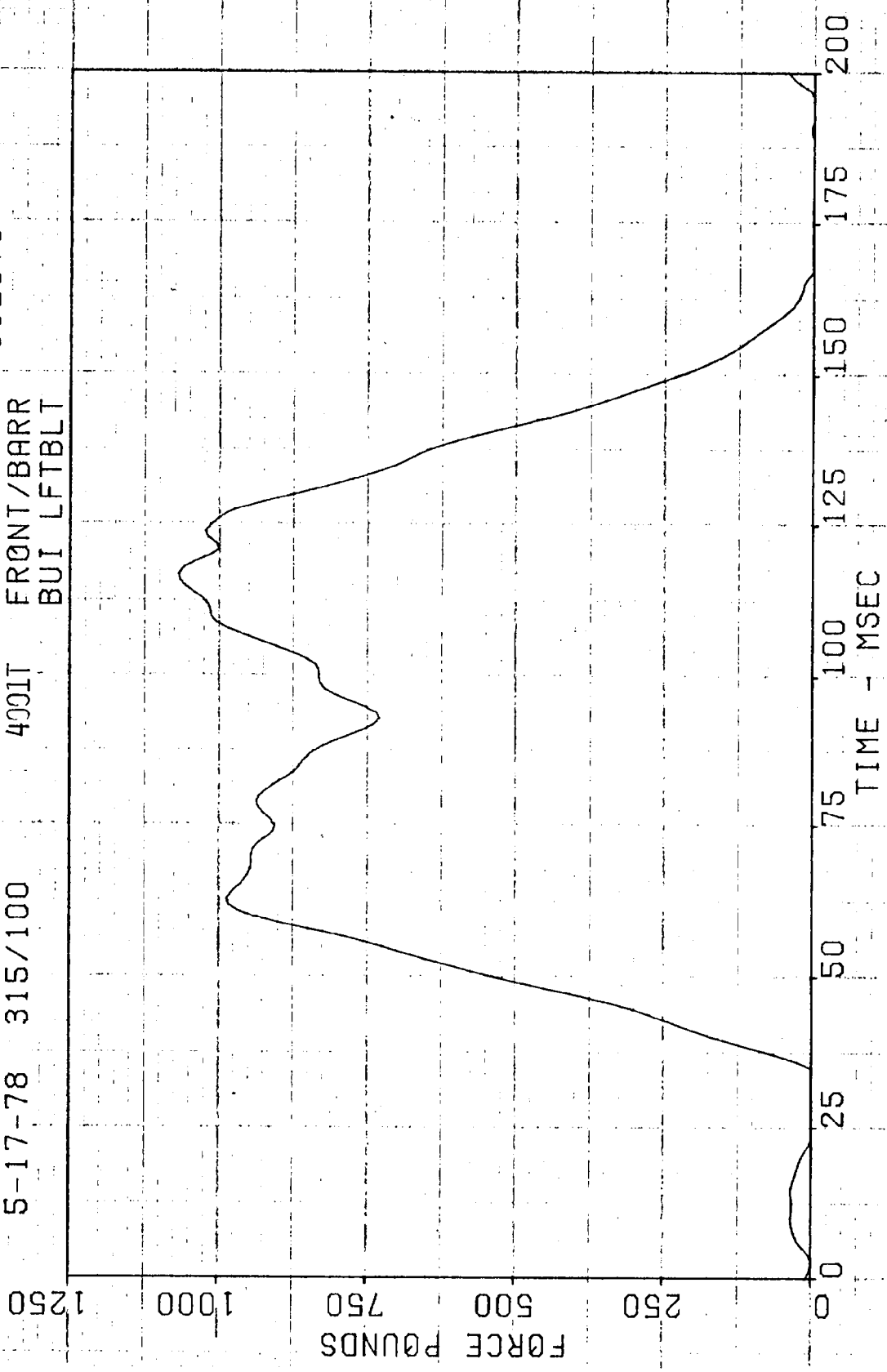
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FRONT/BARR BUICK



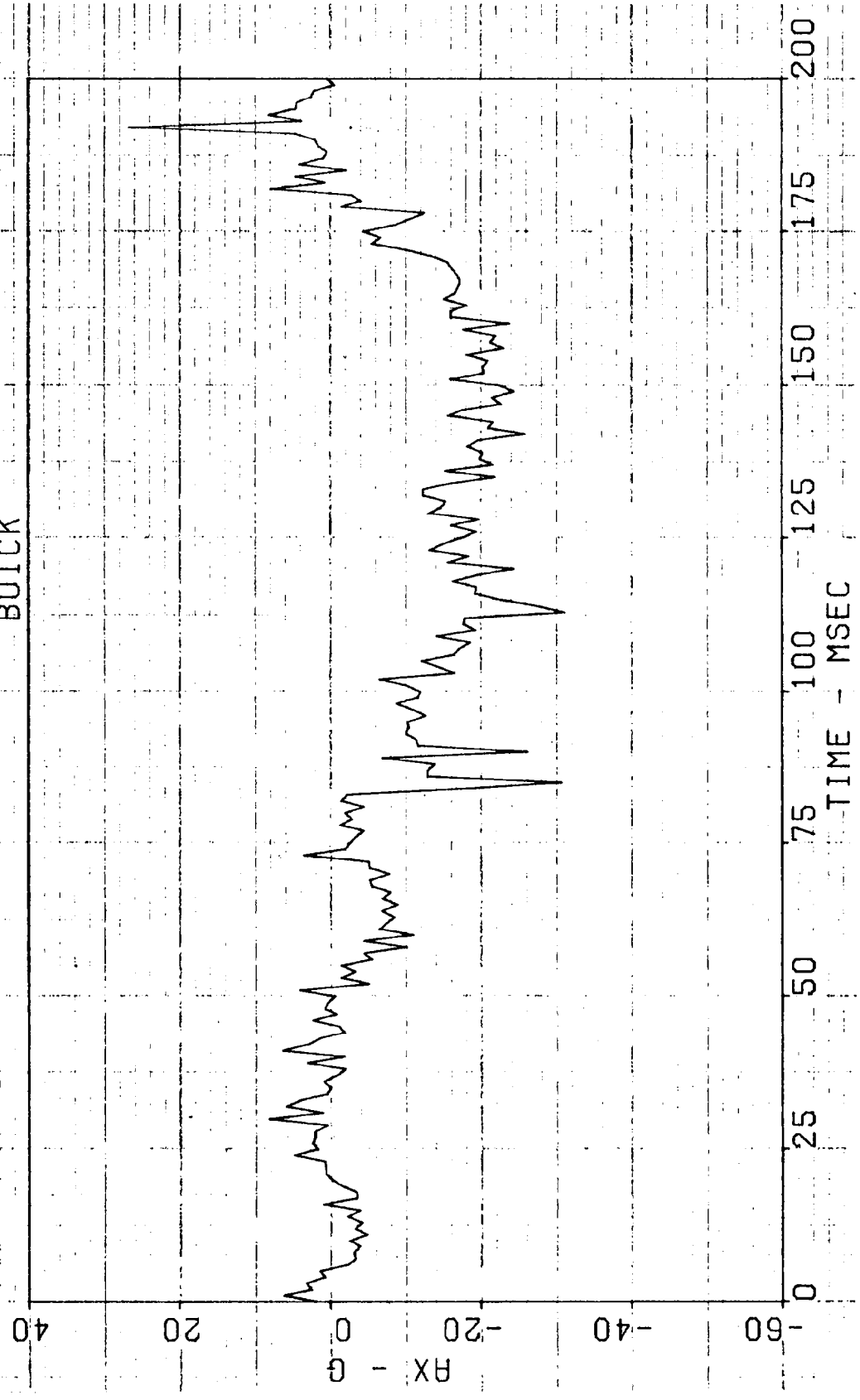
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FRONT/BARR BUI LFLBLT



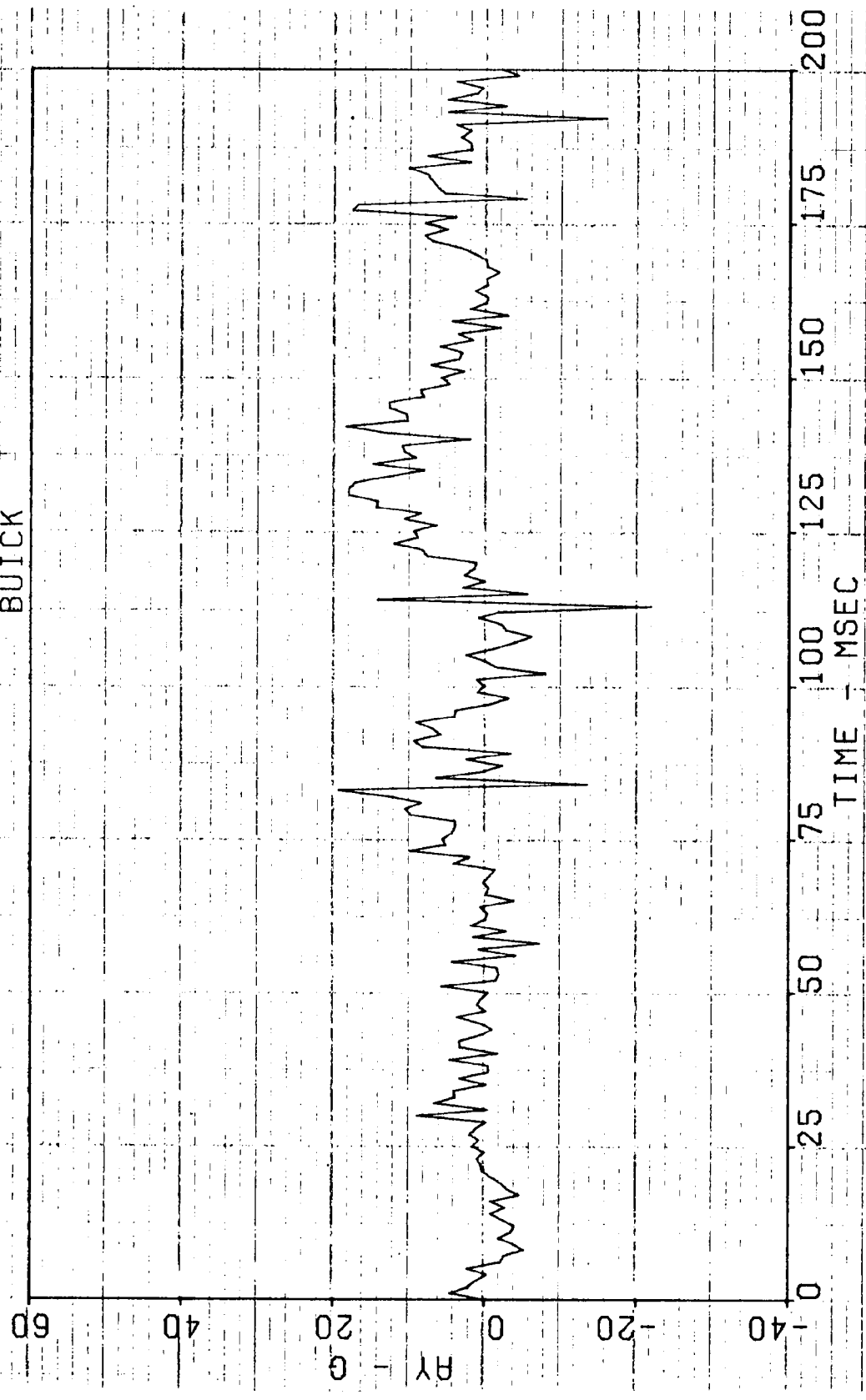
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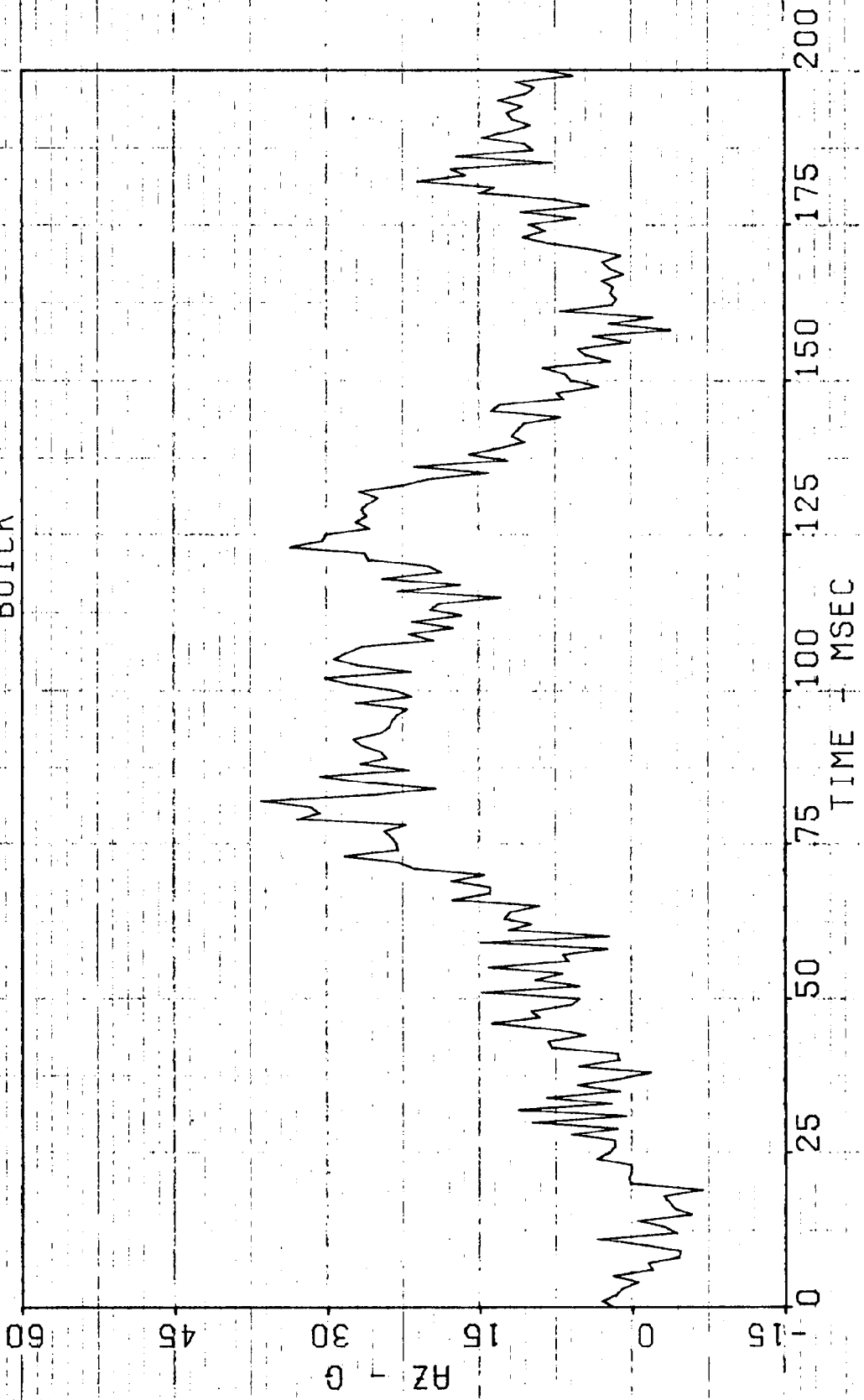
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FRONT/BARR
BUICK



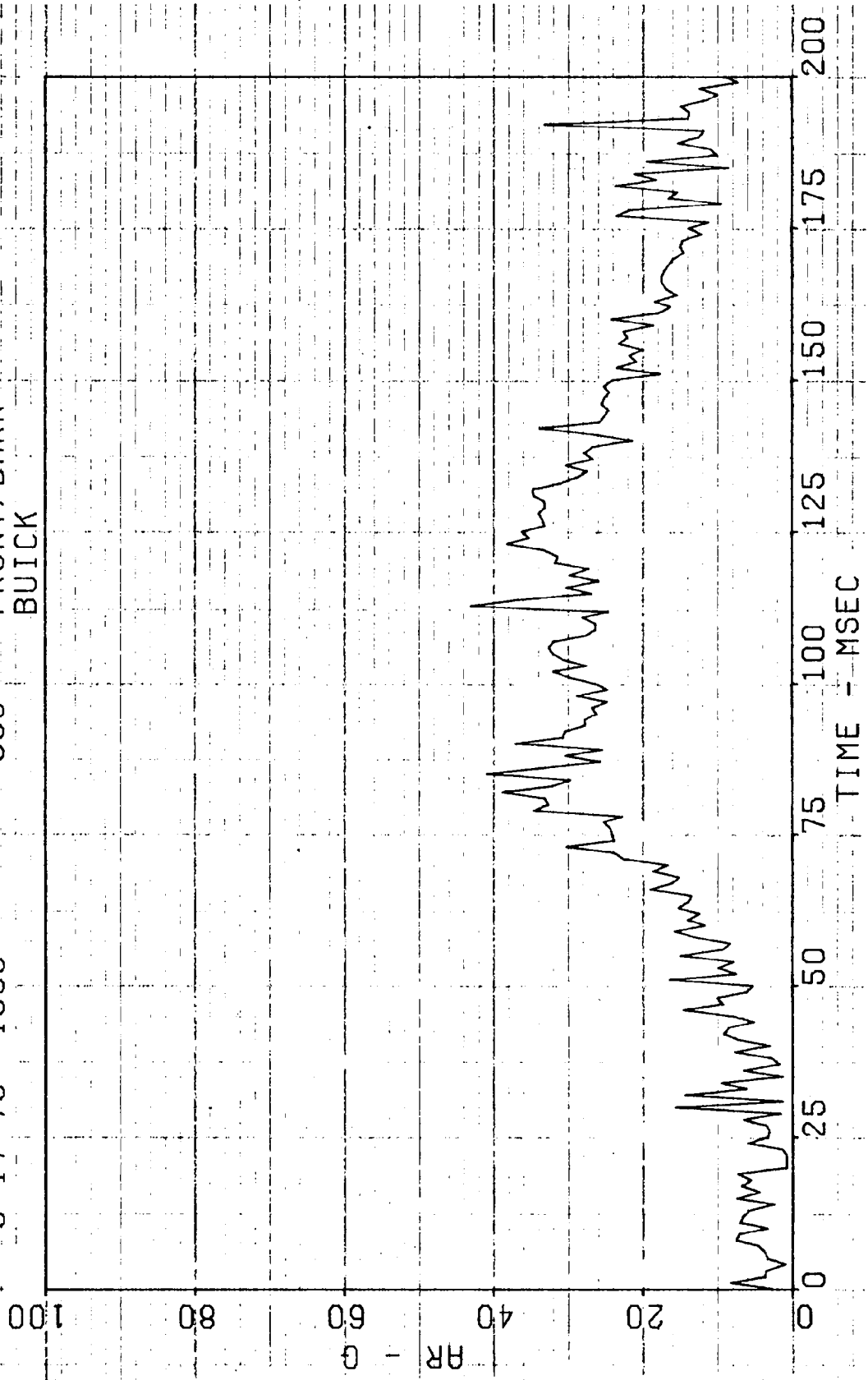
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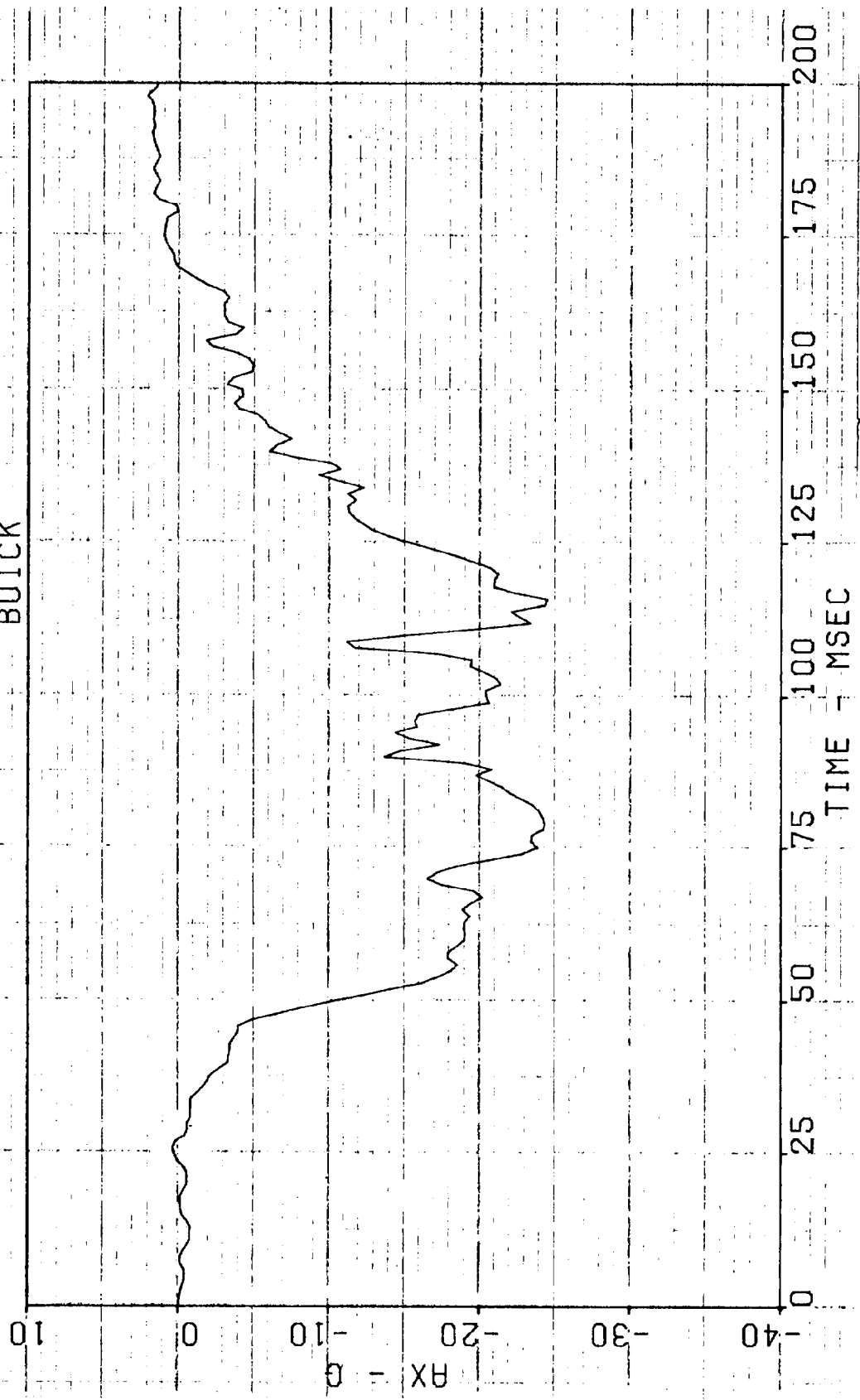
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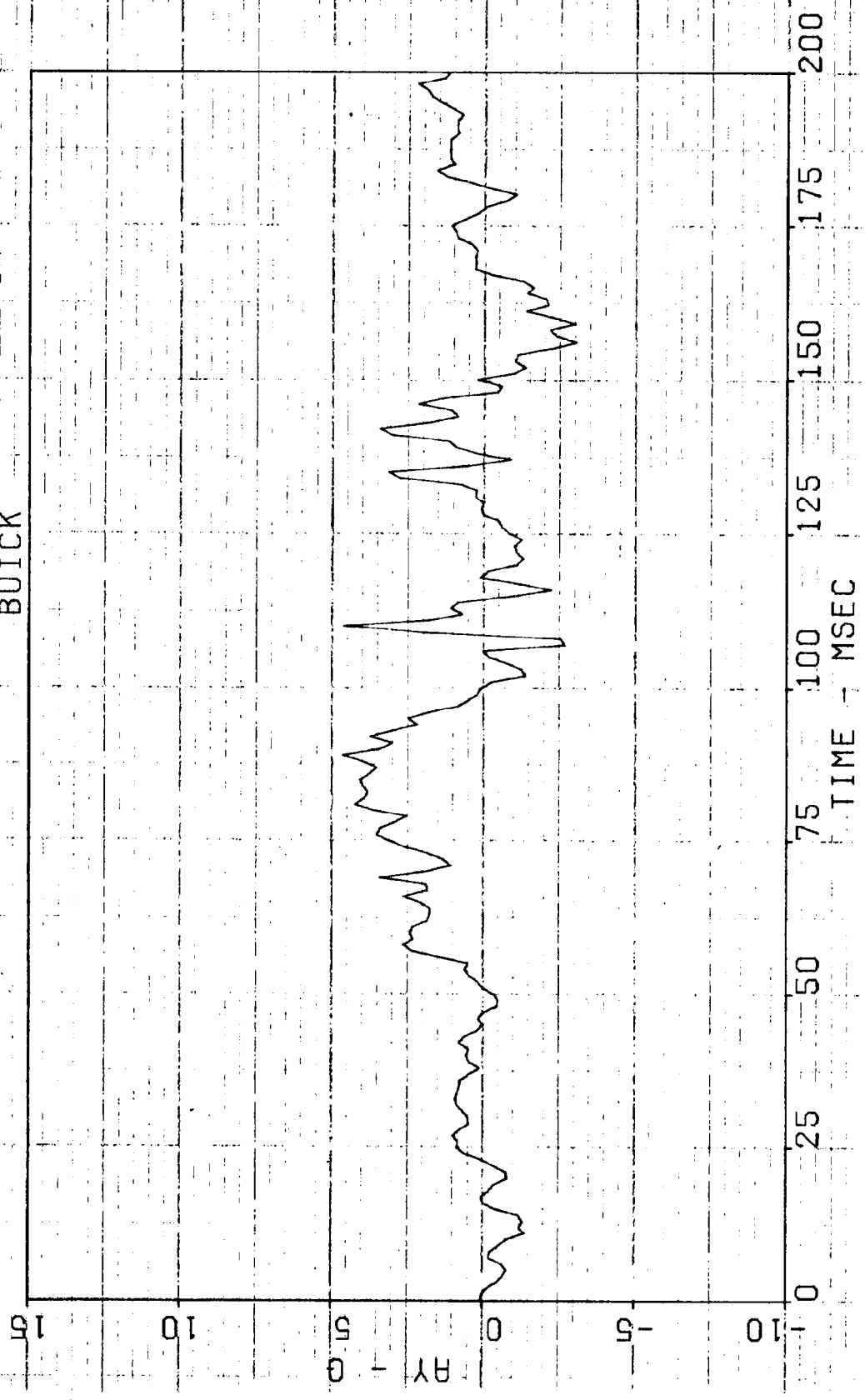
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FRONT/BARR BUICK



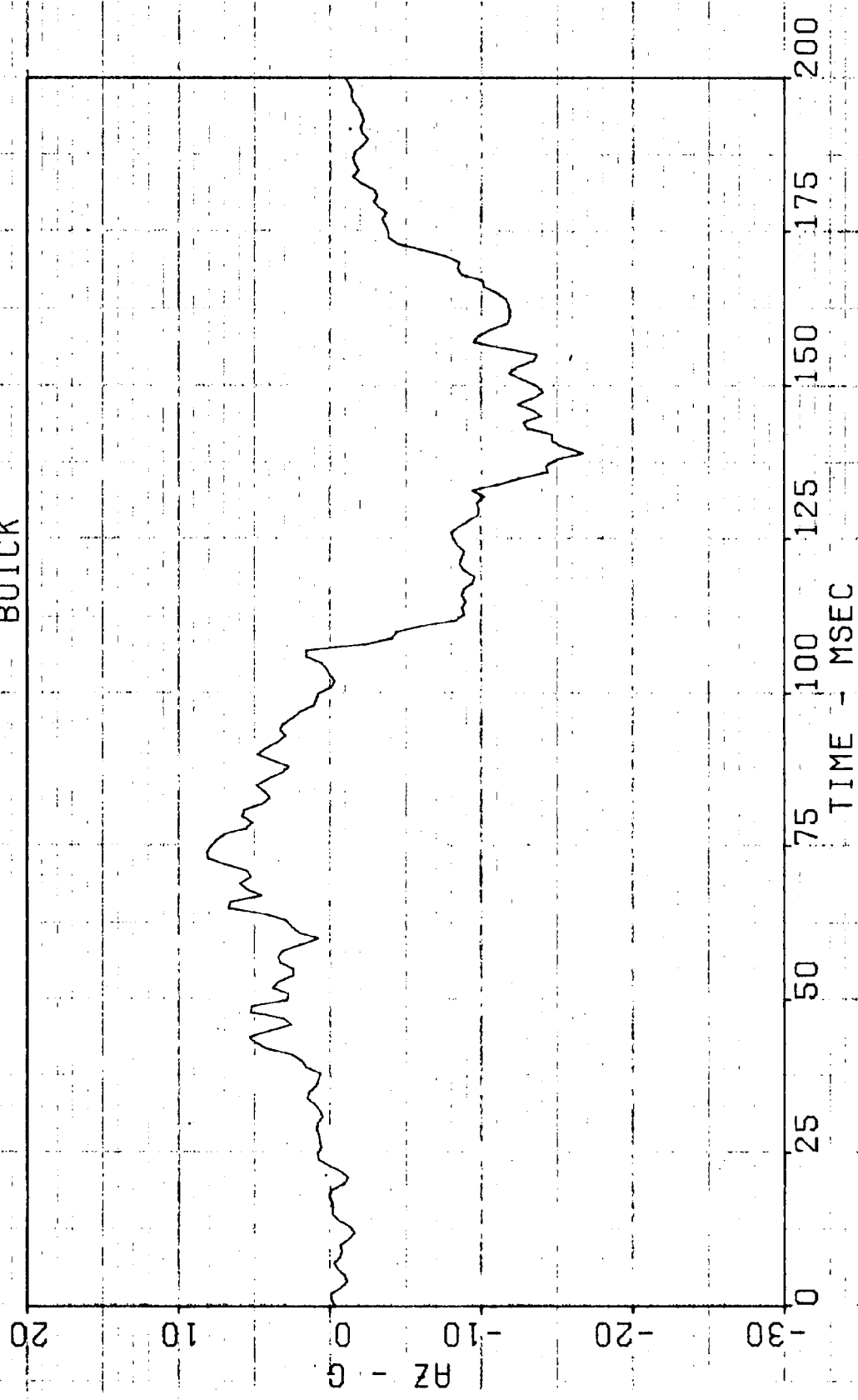
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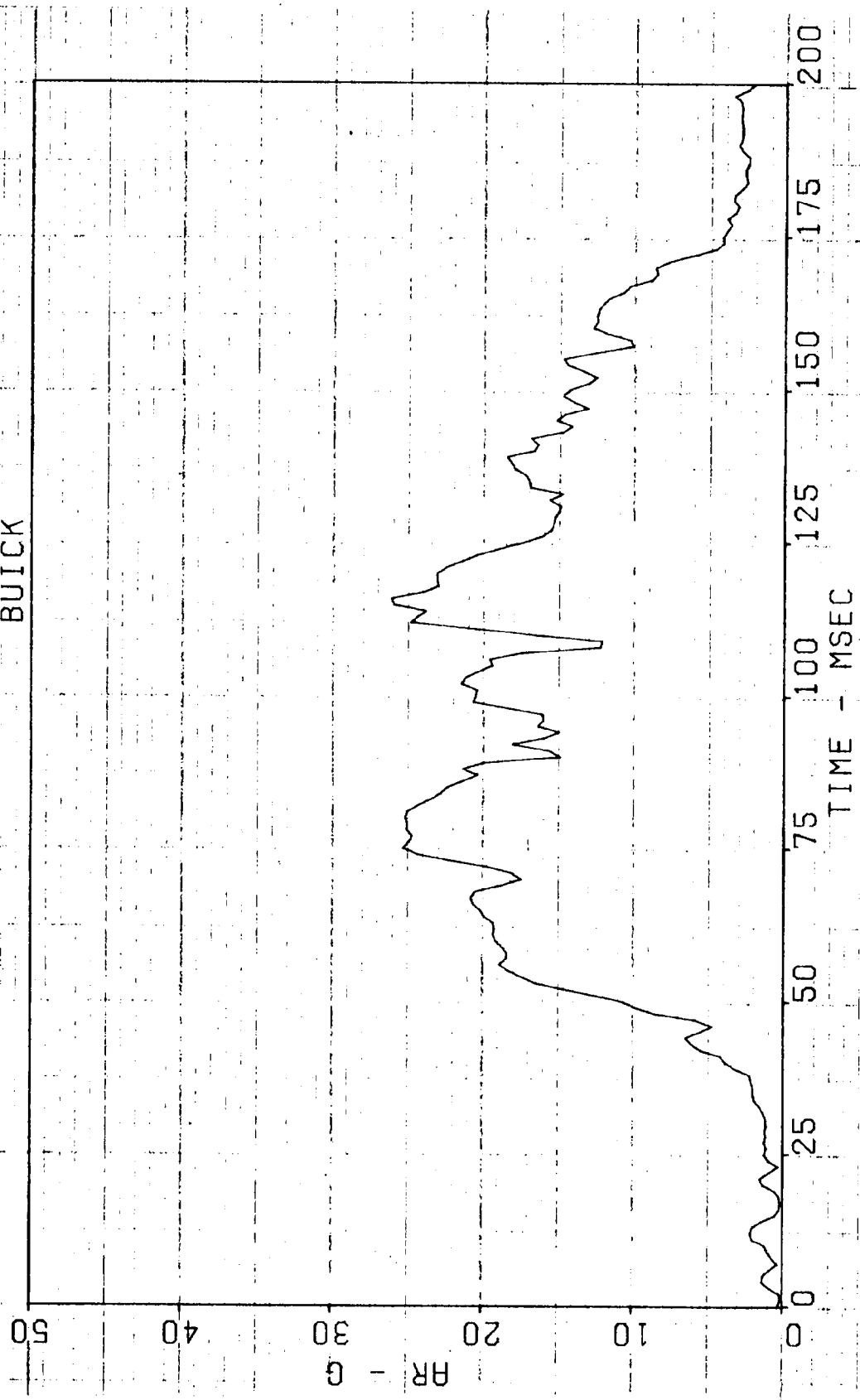
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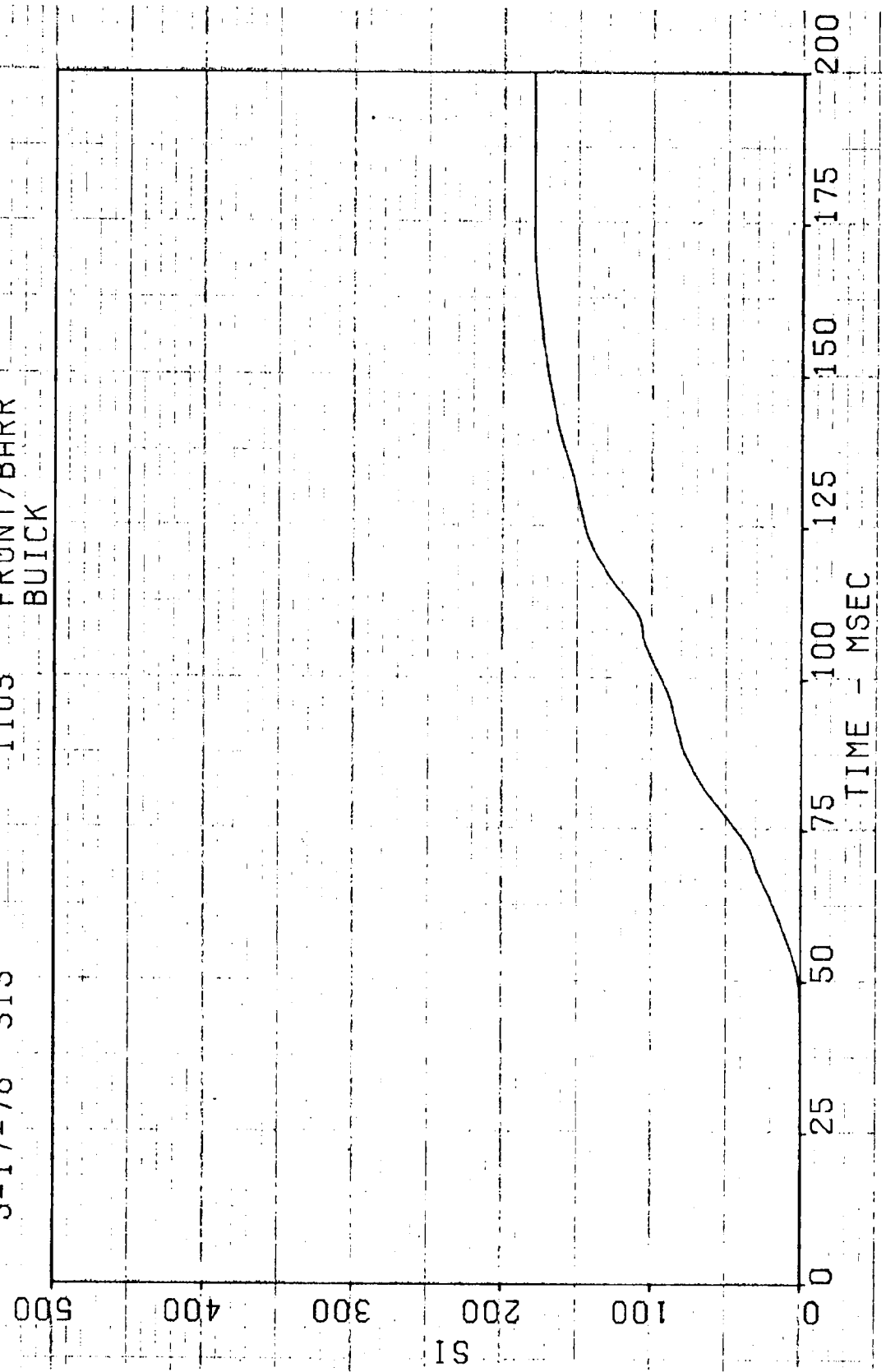
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FRONT/BARR BUICK



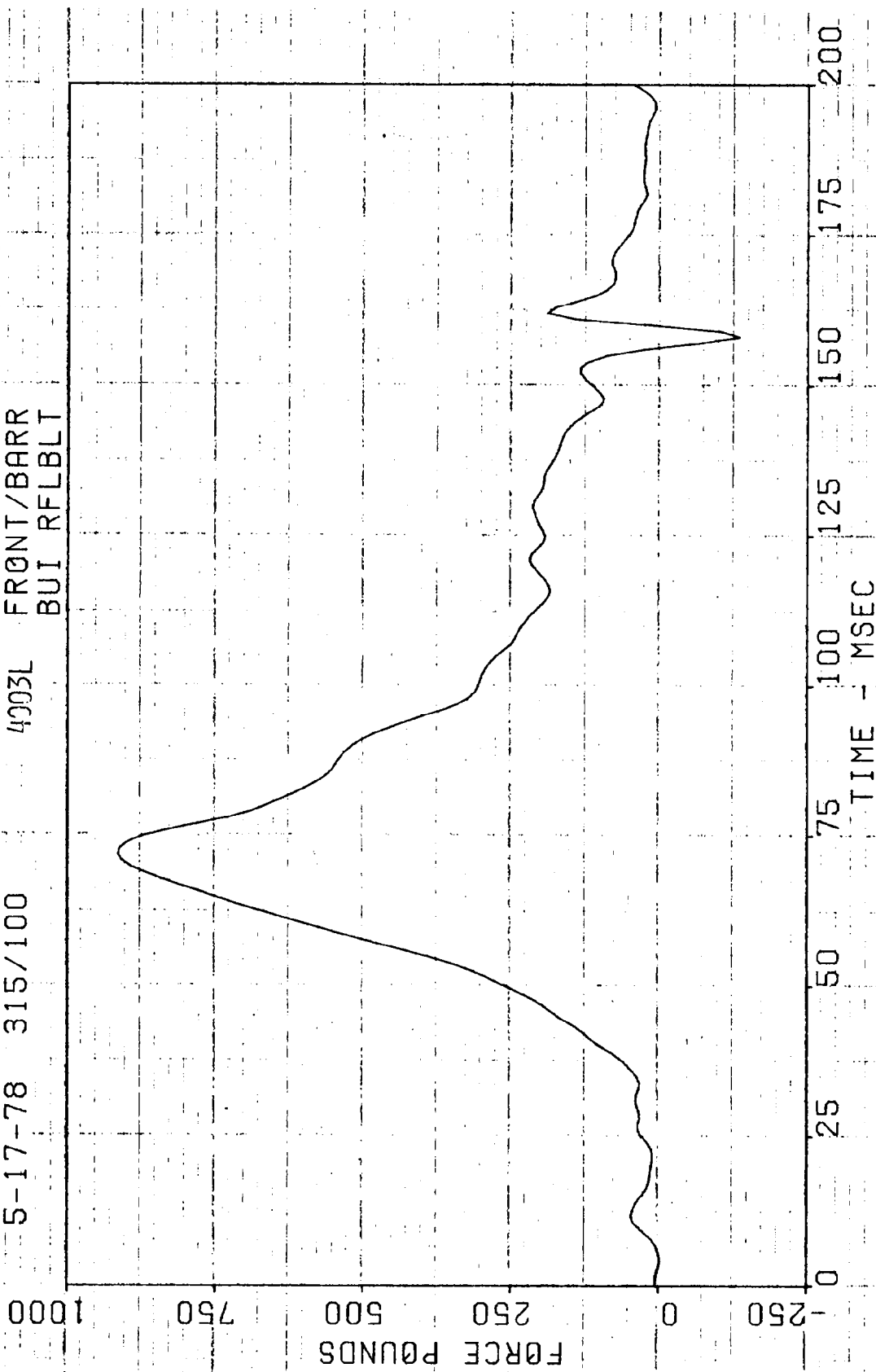
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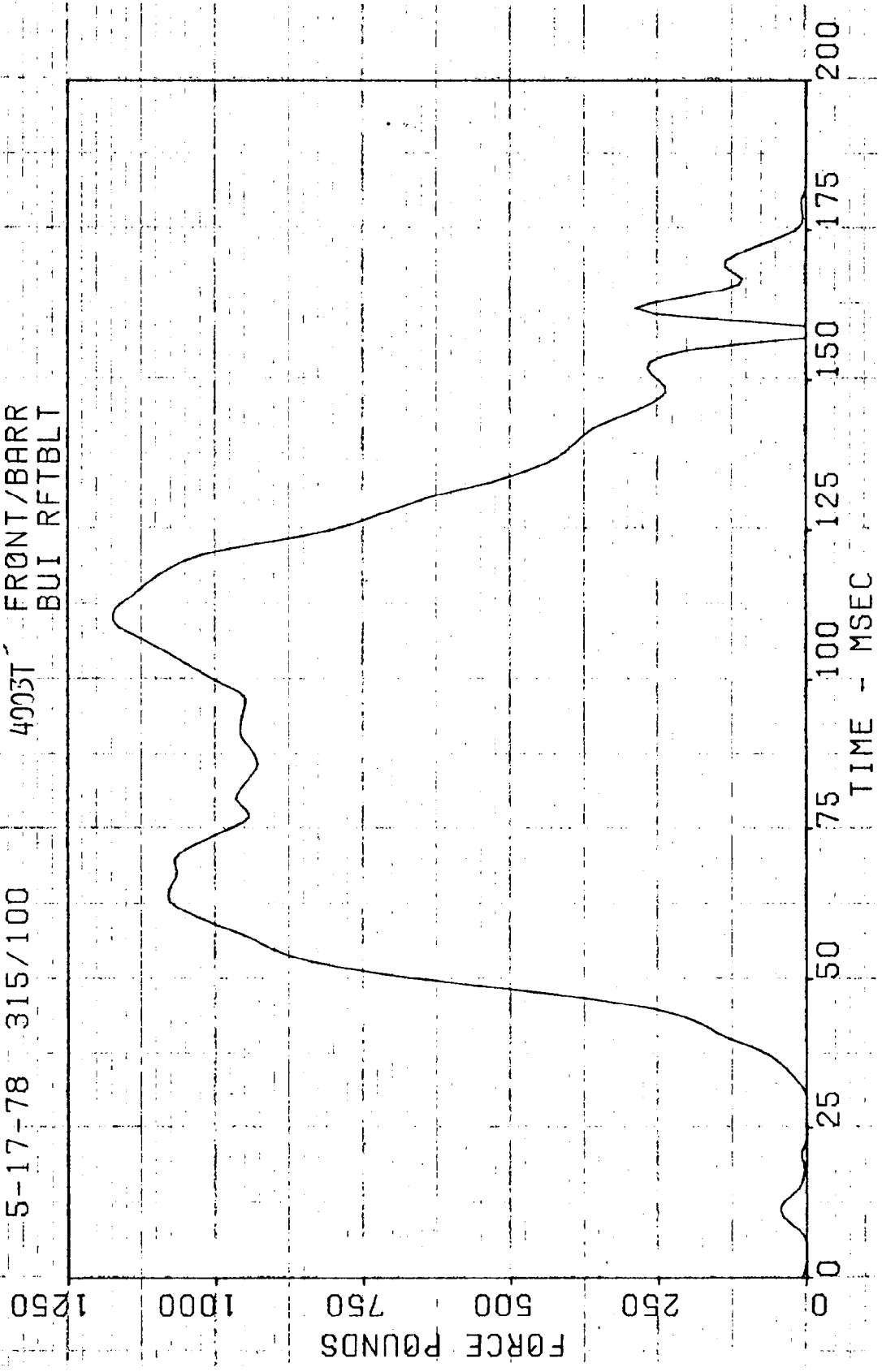
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FRONT/BARR
BUICK



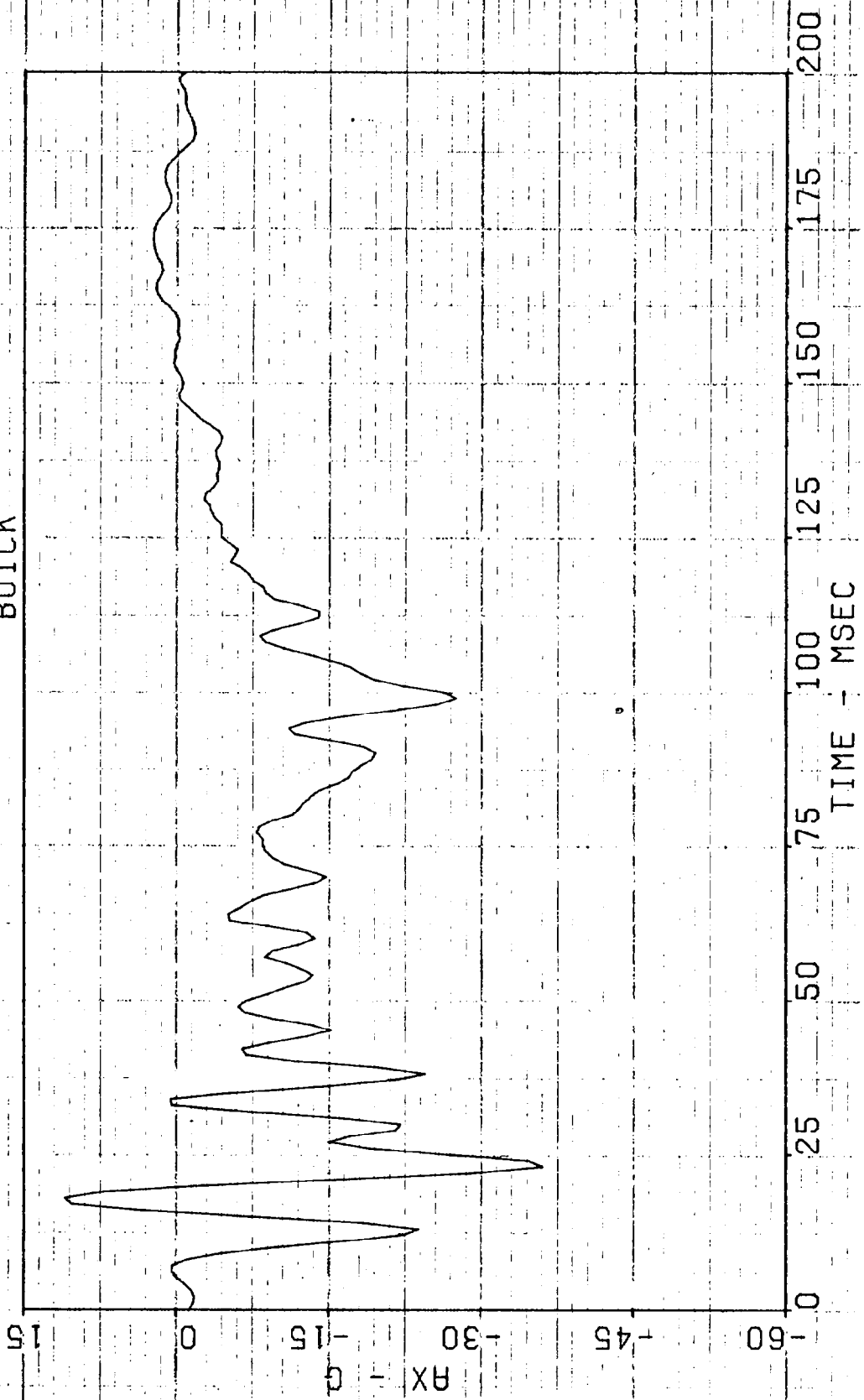
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FRONT/BARR BUI RFLBLT



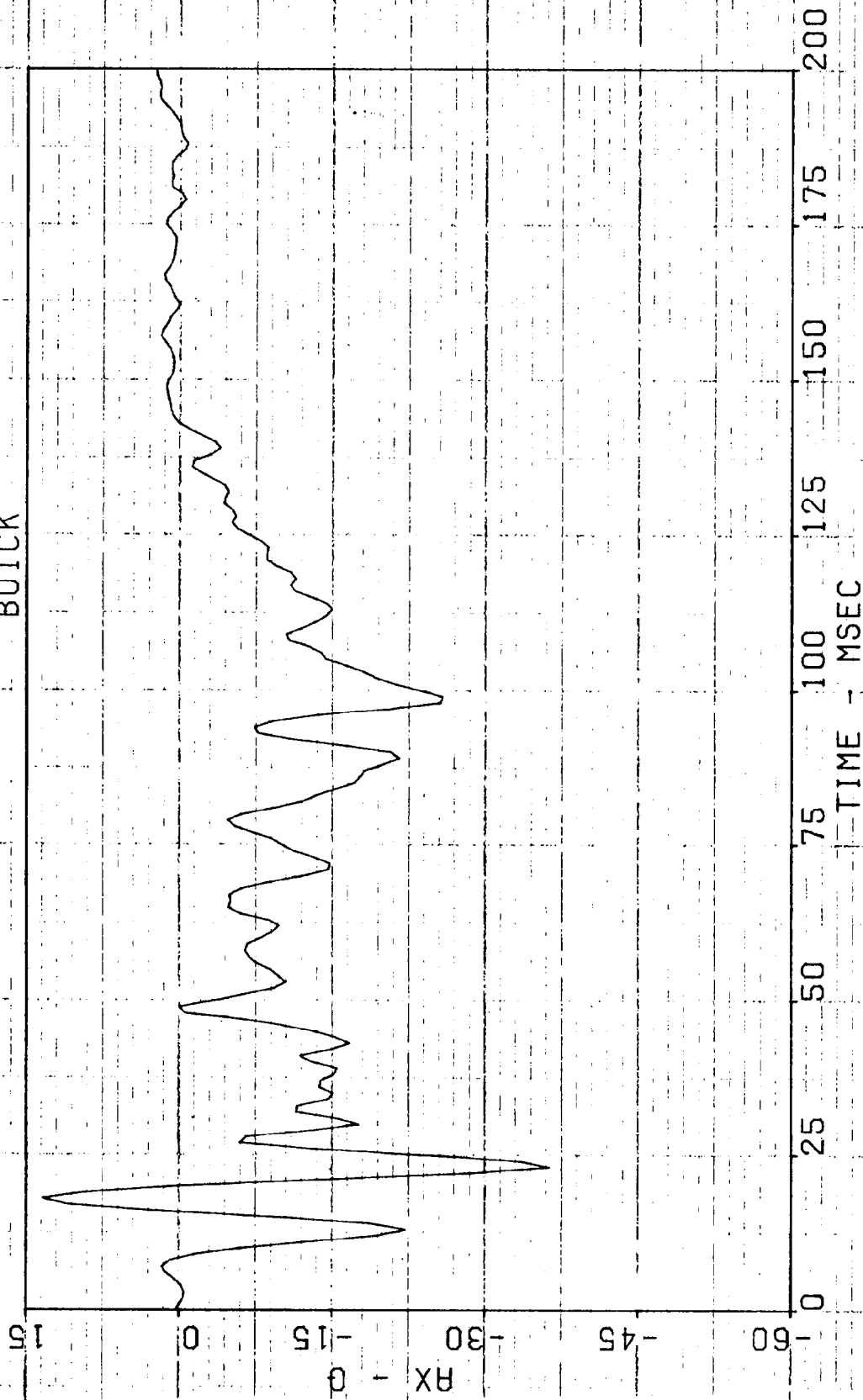
DATE 5-17-78 FILTER 315/100 LOCATION 4903T TEST NO 062378 FRONT/BARR BUI RFTBLT



DATE 5-17-78 FILTER 315/100 LOCATION 102 TEST NO 062778 FRONT/BARR BUICK



DATE 5-17-78 FILTER 315/100 LOCATION 104 TEST NO 062378
FRONT/BARR
BUICK



DATE 5-17-78 FILTER 315/100 LOCATION 104 TEST NO 062378
FRONT/BARR BUICK

