

DOT 422

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

GENERAL MOTORS CORPORATION
1978 CHEVROLET MONTE CARLO TWO-DOOR SEDAN
NHTSA 780113

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.,
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PREPARED FOR

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

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16. Abstract A 1978 Chevrolet Monte Carlo Two-Door Sedan (NHTSA 780113, VIN 1237U8R427232) 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 29.45 mph. The occupant response is summarized below: <table style="margin-left: auto; margin-right: auto; border: none;"> <thead> <tr> <th style="text-align: left;"></th> <th style="text-align: center;"><u>DRIVER</u></th> <th style="text-align: center;"><u>PASSENGER</u></th> </tr> </thead> <tbody> <tr> <td>Head Injury Criterion</td> <td style="text-align: center;">481.2</td> <td style="text-align: center;">883.5</td> </tr> <tr> <td>Chest Severity Index</td> <td style="text-align: center;">242.63</td> <td style="text-align: center;">245.73</td> </tr> </tbody> </table> Peak vehicle accelerations were as follows: Occupant Compartment - Front: -27.32 G Occupant Compartment - Rear: -27.56 G					<u>DRIVER</u>	<u>PASSENGER</u>	Head Injury Criterion	481.2	883.5	Chest Severity Index	242.63	245.73
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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

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
km	kilometers	1.1	yards	yd
		0.6	miles	mi
	AREA			
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	

Symbol	When You Know	Multiply by	To Find	Symbol
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	

Symbol	When You Know	Multiply by	To Find	Symbol
	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

°C	°F
9.5 (when add 32)	Fahrenheit temperature

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

Symbol	When You Know	Multiply by	To Find	Symbol
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t

Symbol	When You Know	Multiply by	To Find	Symbol
	VOLUME			
tblsp	tablespoons	5	milliliters	ml
tspo	teaspoons	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

°F	°C
5.9 (after subtracting 32)	Celsius temperature

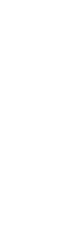
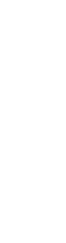
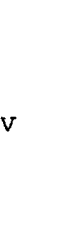
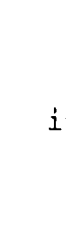
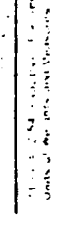
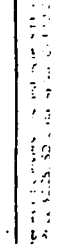
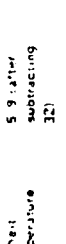
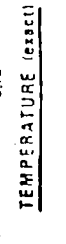
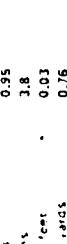
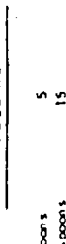
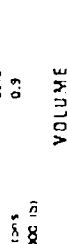
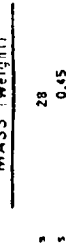
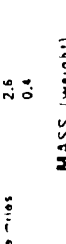
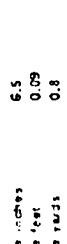
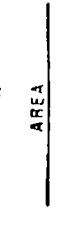
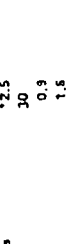
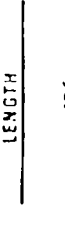
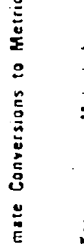
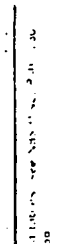
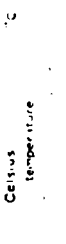
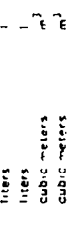
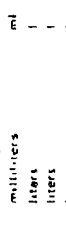
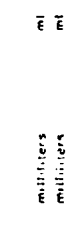
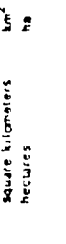
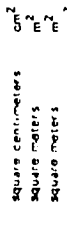
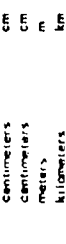
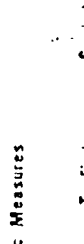


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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the effort documented herein was to acquire occupant response and vehicle acceleration data in a 1978 Chevrolet Monte Carlo Two-Door Sedan (NHTSA 780113) 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: Chevrolet Monte Carlo
Body Style: Two-Door Sedan Year: 1978
VIN: 1Z37U8R427232 Build Date: 1/78
NHTSA No.: 780113 Color: White
Engine: 8 Cylinders, 305 c.i.d.
Transmission: -- speeds, Manual Automatic X
Major Options: Power Brakes, Power Steering, Tinted Glass, Clock,
Air Conditioning, Tilting Steering Wheel, Automatic Speed Control
Seating Capacity: Front 3 Rear 3 Total 6
Capacity Weight (lb): 1060
GVWR (lb): Front 2309 Rear 2233 Total 4542
Recommended Cold Tire Pressure (psi): Front 29 Rear 32
Tire Size: P205/70R14
Load Range: B
Tires on Vehicle: P205/70 S/B14

Delivered-Vehicle Values (fluids to capacity)

Weights (lb)

Wheel: RF 994 LF 1002 RR 702 LR 689
Axle : F 1996 (58.9%) R 1391 (41.1%)
Total: 3387

Attitude (in.)

RF 30.0 LF 30.0 RR 30.0 LR 30.0

Target Vehicle Test Weight (lb): 3875

2.2 TEST CONDITIONS

Date: May 12, 1978

Time: 1148

Temperature: 88 °F

Test Speed (mph): 29.45

Vehicle Weights (lb)

Wheel: RF 1056 LF 1107 RR 855 LR 861

Axle : F 2163 (55.8%) R 1716 (44.2%)

Total: 3879

Vehicle Attitude (in.)

RF 29.5 LF 29.3 RR 28.8 LR 28.5

Pre-test Dummy Positions

<u>Measurement</u>	<u>Driver (in.)</u>	<u>Passenger (in.)</u>
Dummy Centerline to Vehicle Centerline	15.6	13.9
Nose to Upper Rim Steering Wheel	14.0	--
Nose to Windshield (Horizontal Distance)	--	22.0
Left Knee to Closest Point on Lower Panel	6.5	4.5
Right Knee to Closest Point on Lower Panel	7.0	7.5
Ankle Distance	9.0	9.0
Knee Distance	10.0	10.0

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

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.

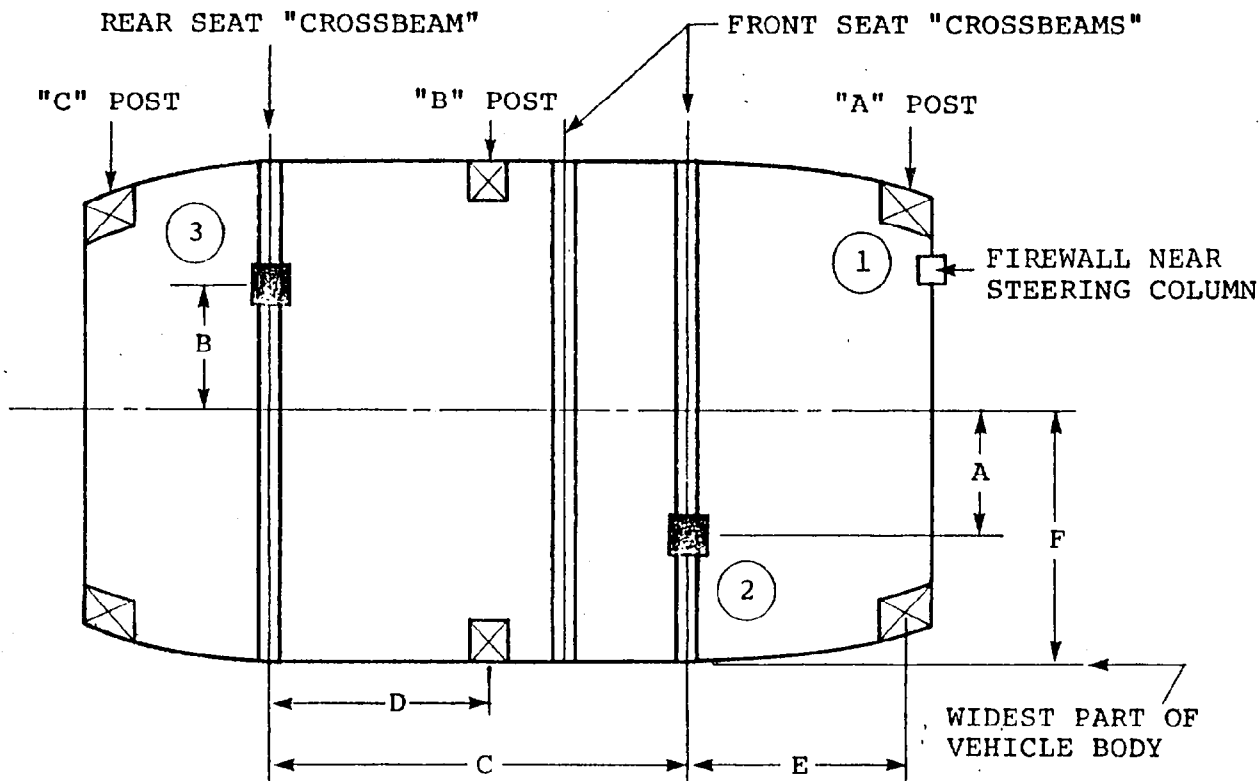
PART 572 DUMMY DATA SHEET

	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	4.43	169	48.83	96	62.93	94	42.71	136
Lateral	14.54	95	8.38	200	137.50	94	11.04	113
Vertical	35.06	86	12.80	146	50.58	114	5.84	17
Resultant	54.34	96			152.26	94		
HIC	481.2 (64-134msec)				809.0 (80-155msec)			
Chest Acceleration								
Longitudinal	1.07	190	31.11	93	3.27	180	35.22	88
Lateral	7.89	111	6.08	164	5.90	86	7.67	112
Vertical	11.59	71	19.86	125	13.74	77	18.68	101
Resultant	31.65	93			35.88	88		
SEVERITY INDEX	242.63				245.73			
Belt Loads	(lb)	Time (msec)			(lb)	Time (msec)		
Lap	1432	82			1304	78		
Torso	1223	78			1286	93		
Vehicle Impact Speed (mph): <u>29.45 mph</u>								
<p>*Positive Direction - Longitudinal: Forward Lateral: Rightward Vertical: Downward</p> <p>Negative Direction - Longitudinal: Rearward Lateral: Leftward Vertical: Upward</p>								

VEHICLE STRUCTURAL DATA

VEHICLE 1978 Chevrolet Monte Carlo Two-Door NHTSA NO. 780113
 TEST SPEED 29.45 mph Sedan TEST DATE May 12, 1978

00087608



DIMENSIONS							
Location	Measurement (in.)		Location	Measurement (in.)			
A	18.0		D	10.0			
B	14.5		E	28.0			
C			F				
Steering Column Movement (in.) _____							
Vehicle Overall Crush (in.) _____ 20.1							
Test Weight (lb) _____ 3879							
ACCELERATION PEAKS (CLASS 60 FILTER)							
Location	Positive* Direction		Negative* Direction		Average Longi- tudinal (G)	Dynamic Crush	
	Peak G	Time (msec)	Peak G	Time (msec)		Amount (ft)	Time (msec)
No. 1 Longitudinal							
No. 1 Vertical							
No. 2 Longitudinal	1.49	179	27.32	61	13.05 G	2.49	97
No. 3 Longitudinal	12.24	86	27.56	93	8.0 G	4.74	200
No. 3 Vertical	34.50	63	31.57	67			
*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 29.45 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 60.0 inches. The average overall static crush of the vehicle was 20.1 inches.

3.3 PHOTOGRAPHS

Figures 3-1 through 3-4 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:

- No seat movement along track
- Front bumper rotated downward and did not crush flatly with remainder of front structure
- Steering wheel deformed at top of rim
- Minor floor deformation
- Roof deformation to rear of "B" pillar
- Steering wheel rotated downward



Figure 3-1. Pre-test View of Driver Dummy - 1978 Chevrolet Monte Carlo Two-Door Sedan -
NHTSA 780113.

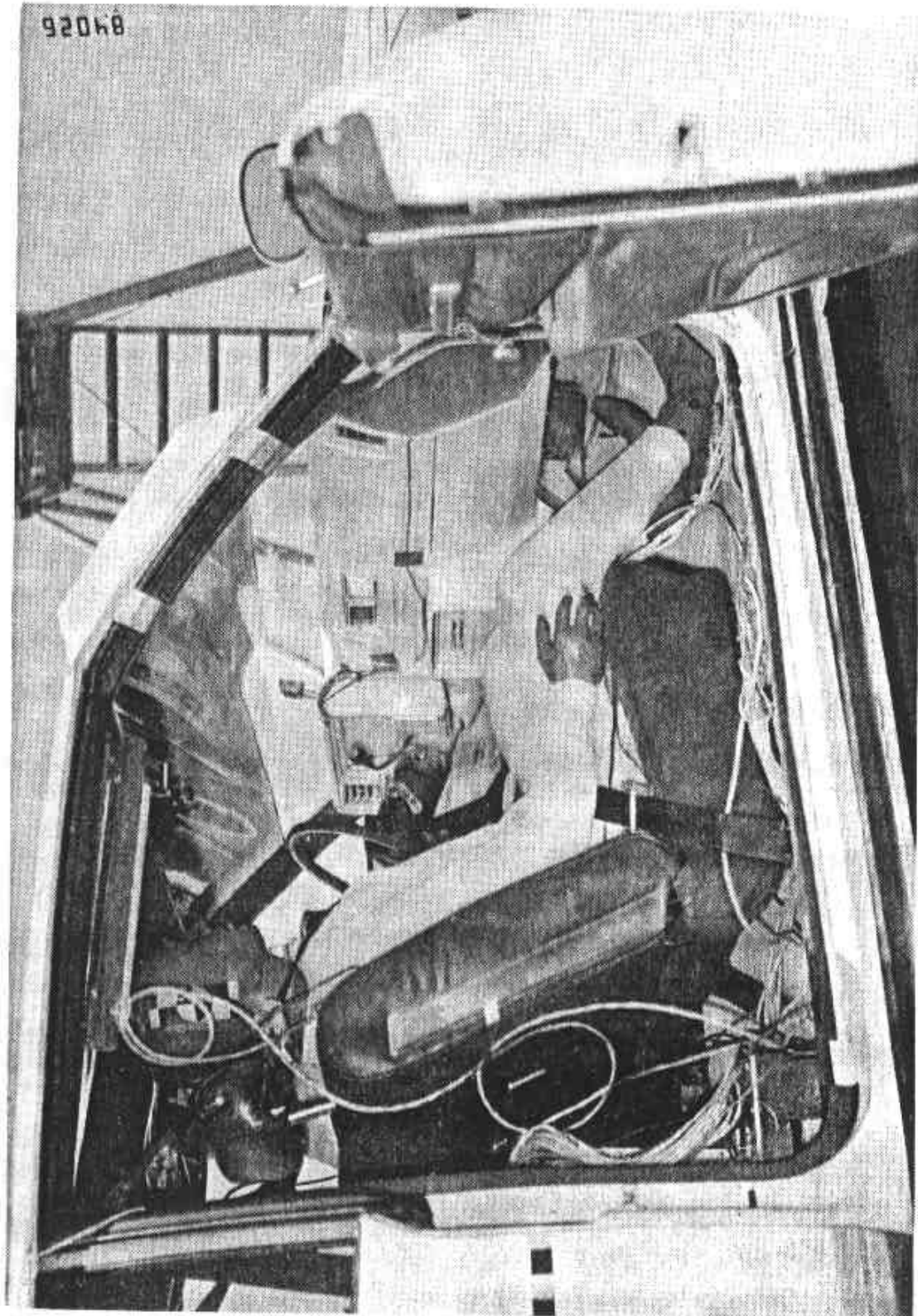


Figure 3-2. Pre-test View of Passenger Dummy - 1978 Chevrolet Monte Carlo Two-Door Sedan - NHTSA 780113.

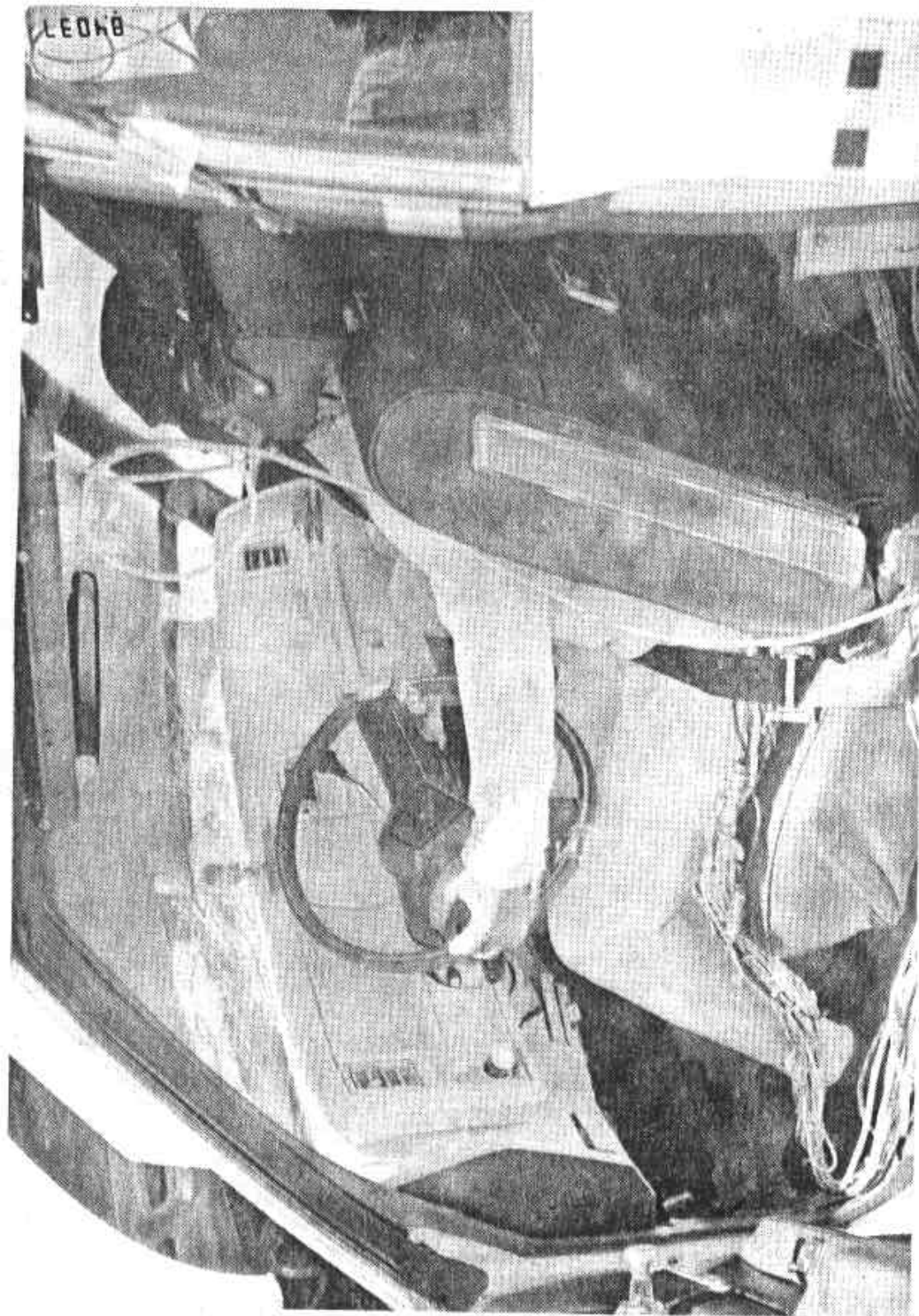


Figure 3-3. Post-test View of Driver Dummy - 1978 Chevrolet Monte Carlo Two-Door Sedan - NHTSA 780113.

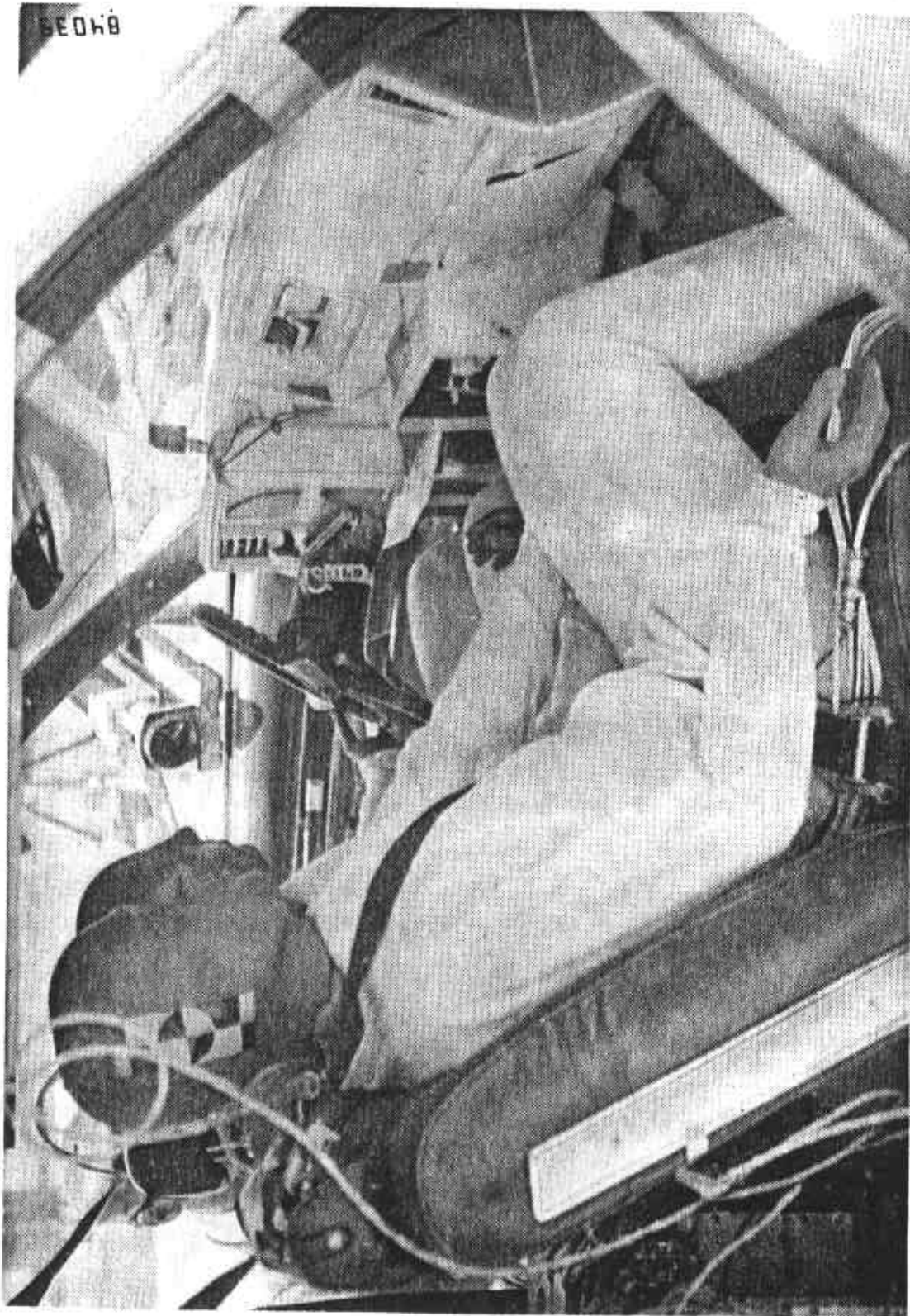


Figure 3-4. Post-test View of Passenger Dummy - 1978 Chevrolet Monte Carlo Two-Door Sedan - NHTSA 780113.

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 head centered on the head restraint (the head restraint is integral with the seat back and not adjustable). 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.

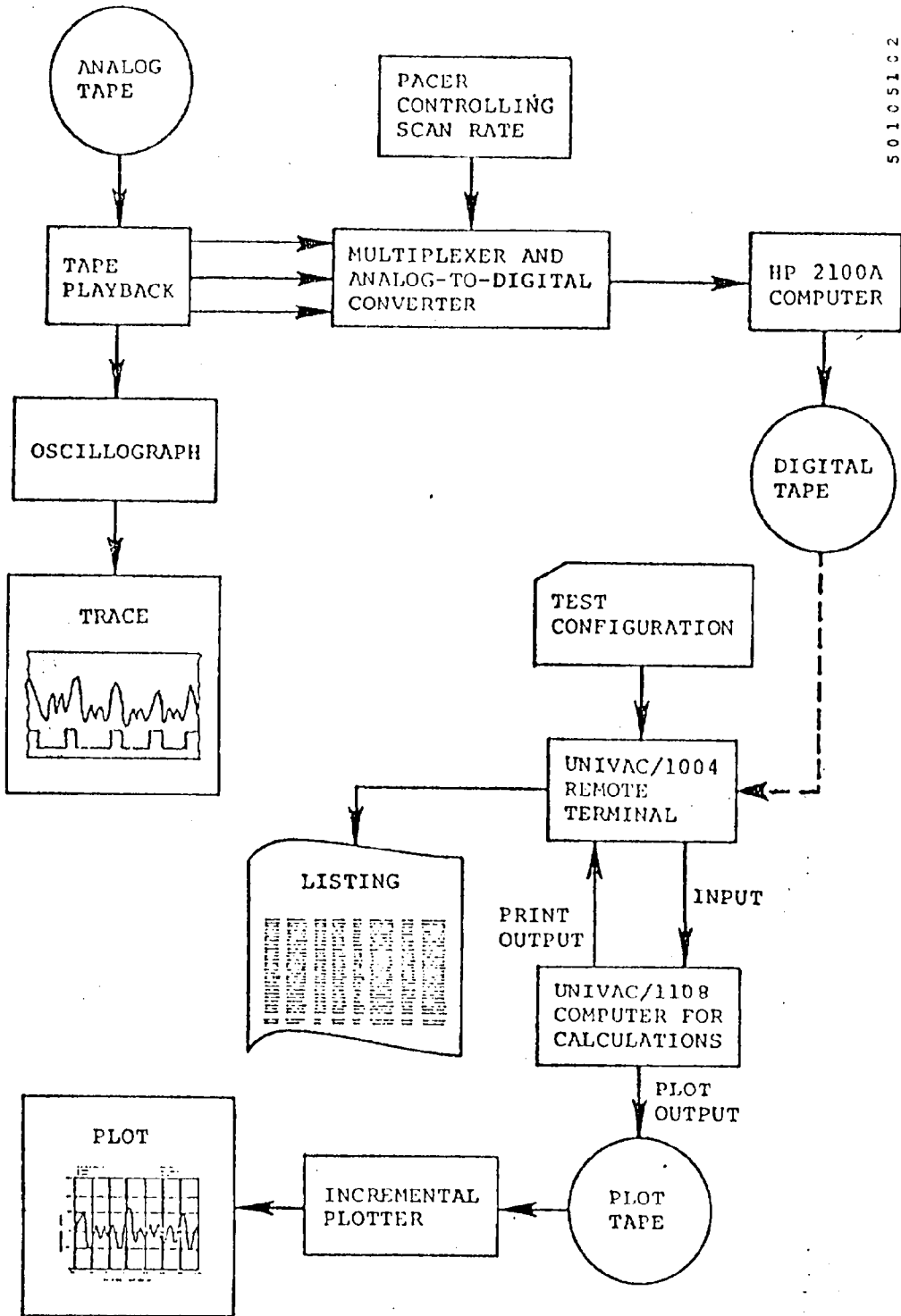
Figure 4-2 illustrates the manner in which each data channel is handled from analog playback to digital processing. Following the discrimination process, the raw data in its original analog form is prefiltered through a linear phase low pass filter. The presampled filtered data are then digitized and 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	Full-Scale Output	Transducer Accuracy	Frequency Response (maximum)
I. <u>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
II. <u>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
III. <u>Facility</u>						
Approach velocity	Pulse generator/digital counter	Dynamic Science	>100 mph	600 Hz @ 100 mph	$\pm 0.5\%$ @ 30 mph	NA (L)
Impact velocity	Breakwire speed trap	Dynamic Science	>100 mph	10^4 counts	.01%	NA (L)
Barrier impact	Contact switch	Tapeswitch	On-Off	2.5V	-	350 μ sec rise time

(L) NA - Not applicable.



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Figure 4-1. Data Reduction Flow Diagram.

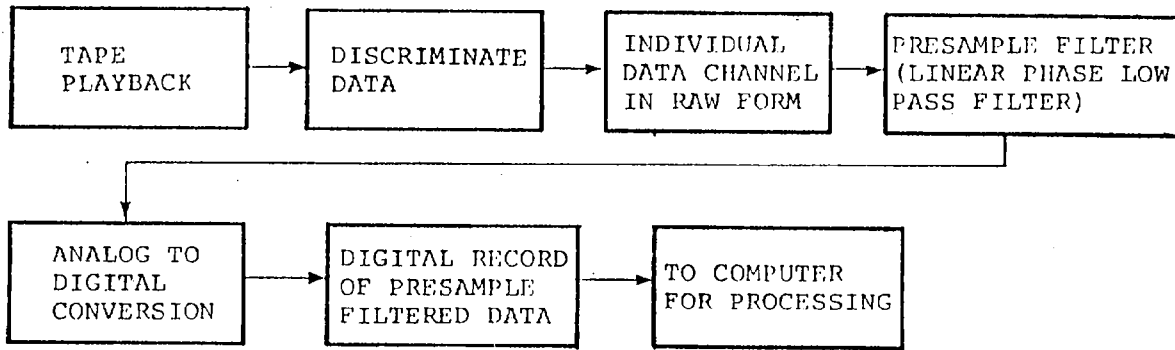


Figure 4-2. Flow of Individual Data Channel.

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

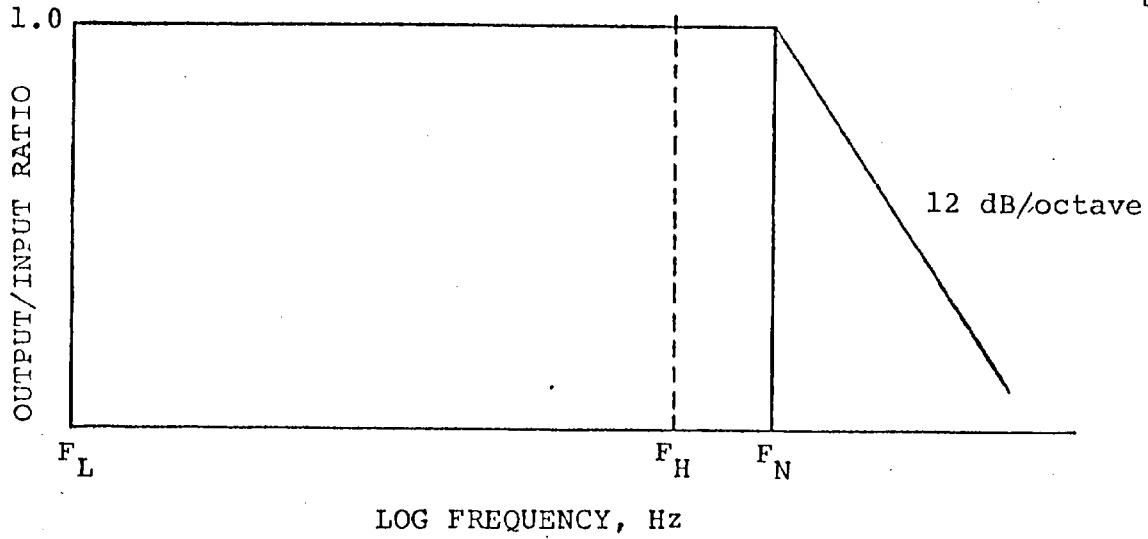
The digital filter used a fast Fourier transformation to transfer the data to the frequency domain where the filtering occurs. Filtering is achieved by multiplying the Fourier transformed data by the filter transfer characteristics shown in Figure 4-3. The data from the product are transferred back to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

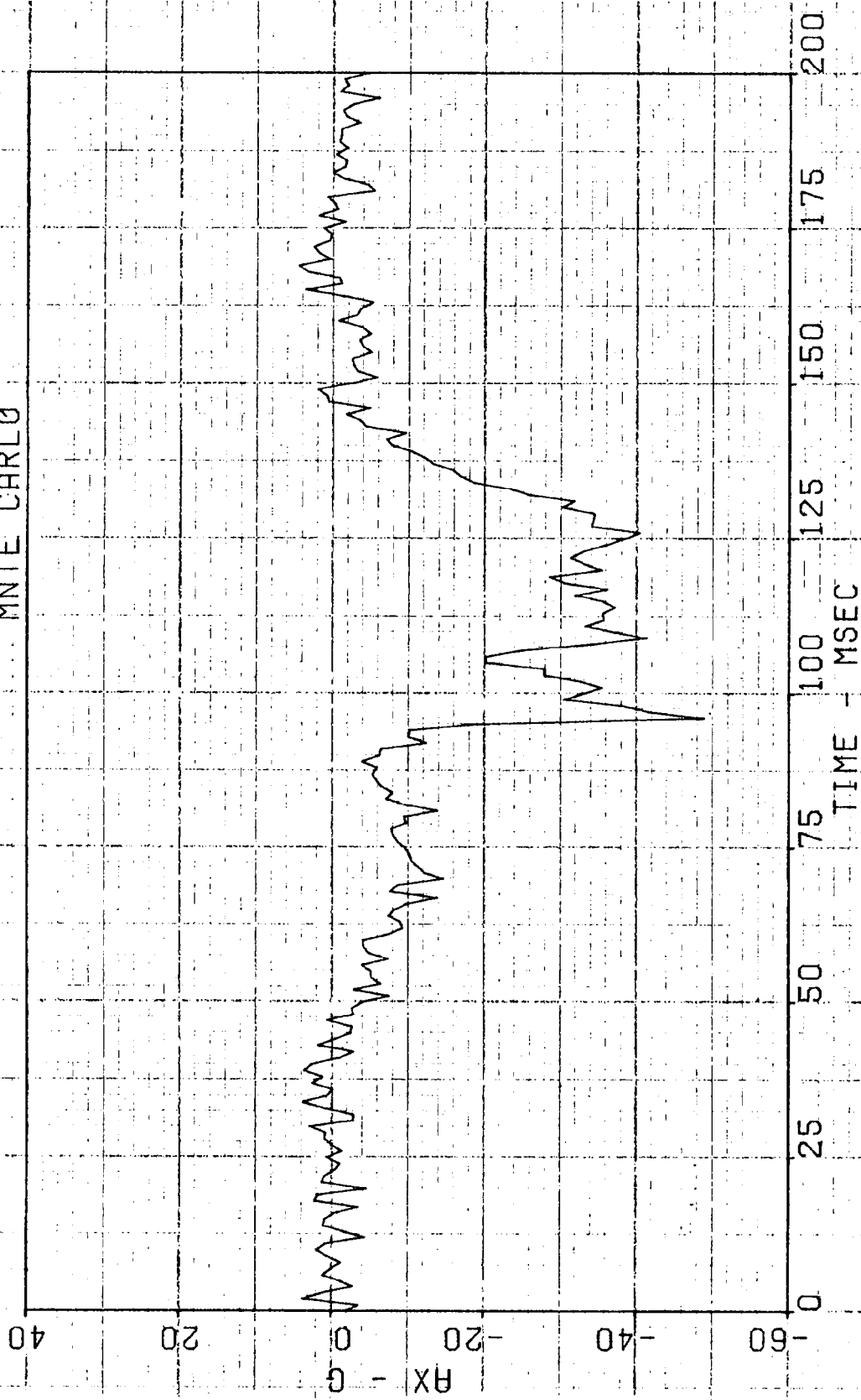
The dummy chest accelerations are processed as class 180 data, combined to get resultants, and integrated to get velocities and displacements. The resultant accelerations, velocities, displacements, and severity index are listed on the digital printout at one (1) millisecond intervals. These outputs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

APPENDIX
CALCOMP PLOTS

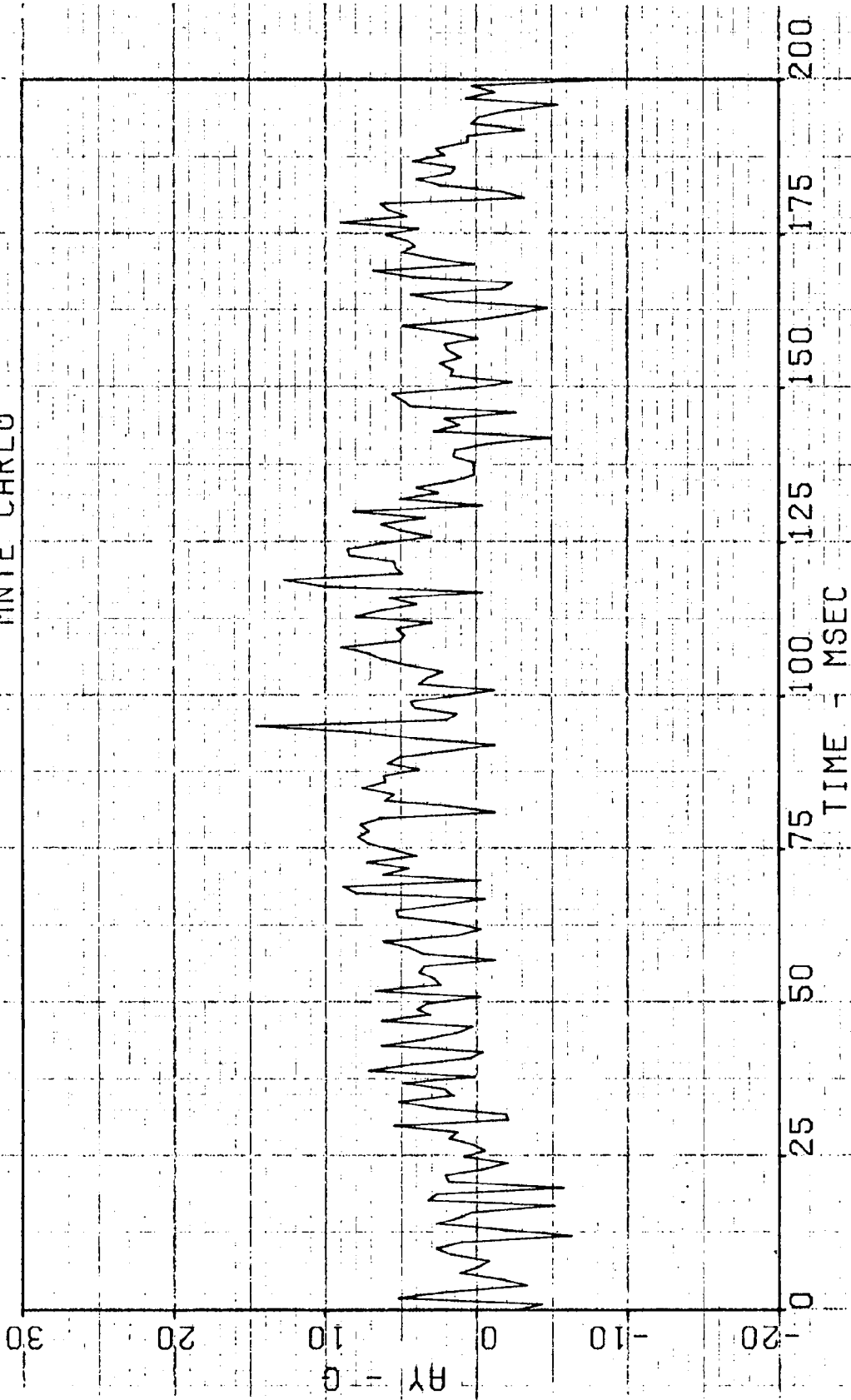
The following location numbers are used in the CalComp plot titles to identify transducer locations:

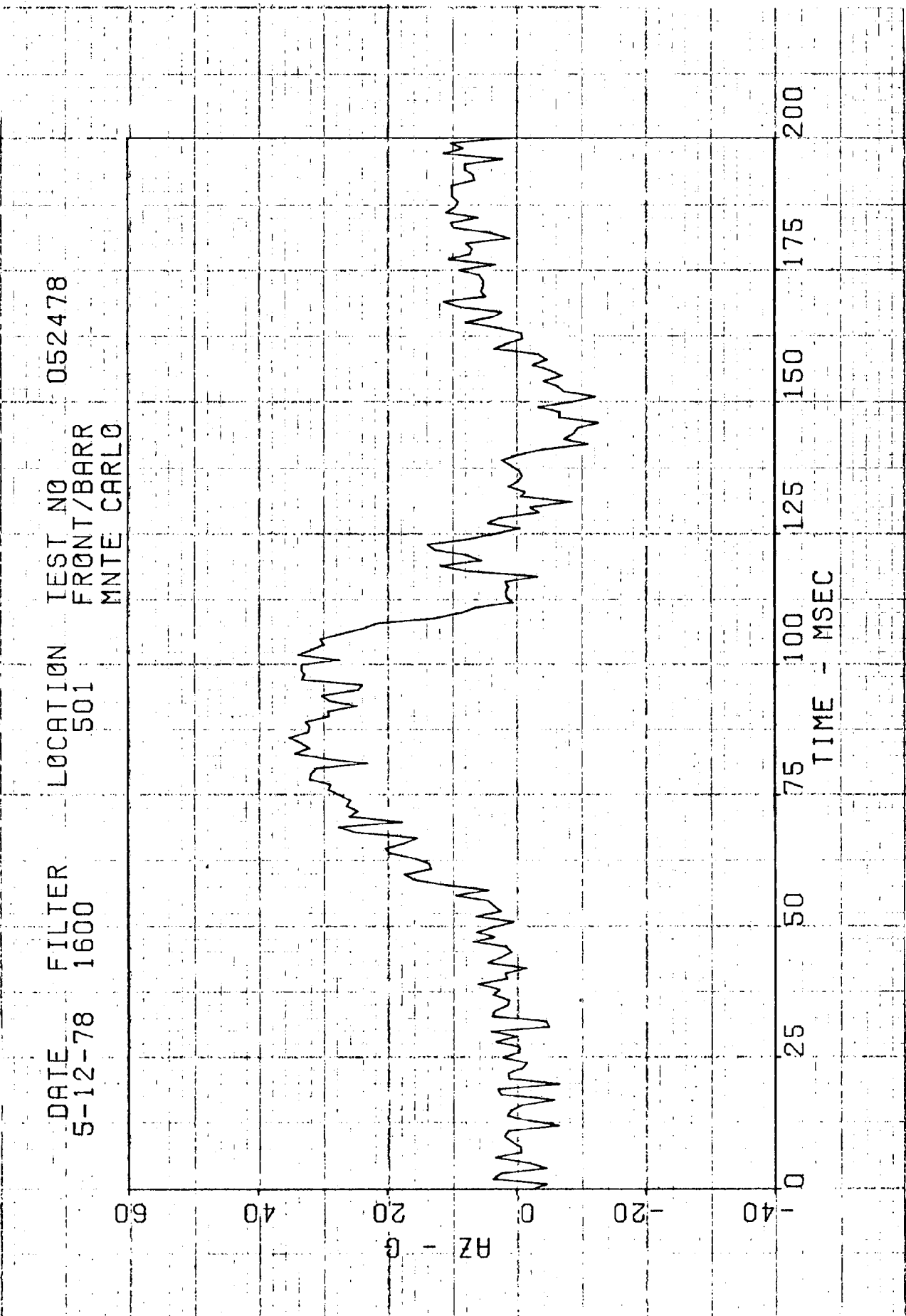
<u>Location</u>	<u>Number</u>
Driver Head Accelerometer	501
Driver Chest Accelerometer	1101
Driver Lap Belt Load Cell	4101L
Driver Torso Belt Load Cell	4101T
Passenger Head Accelerometer	503
Passenger Chest Accelerometer	1103
Passenger Lap Belt Load Cell	4103L
Passenger Torso Belt Load Cell	4103T
Occupant Compartment Front Accelerometer	102
Occupant Compartment Rear Accelerometer	104

DATE 5-12-78 FILTER 1600 LOCATION 501 TEST NO. 052478
FRONT/BARR MNTTE CARLO

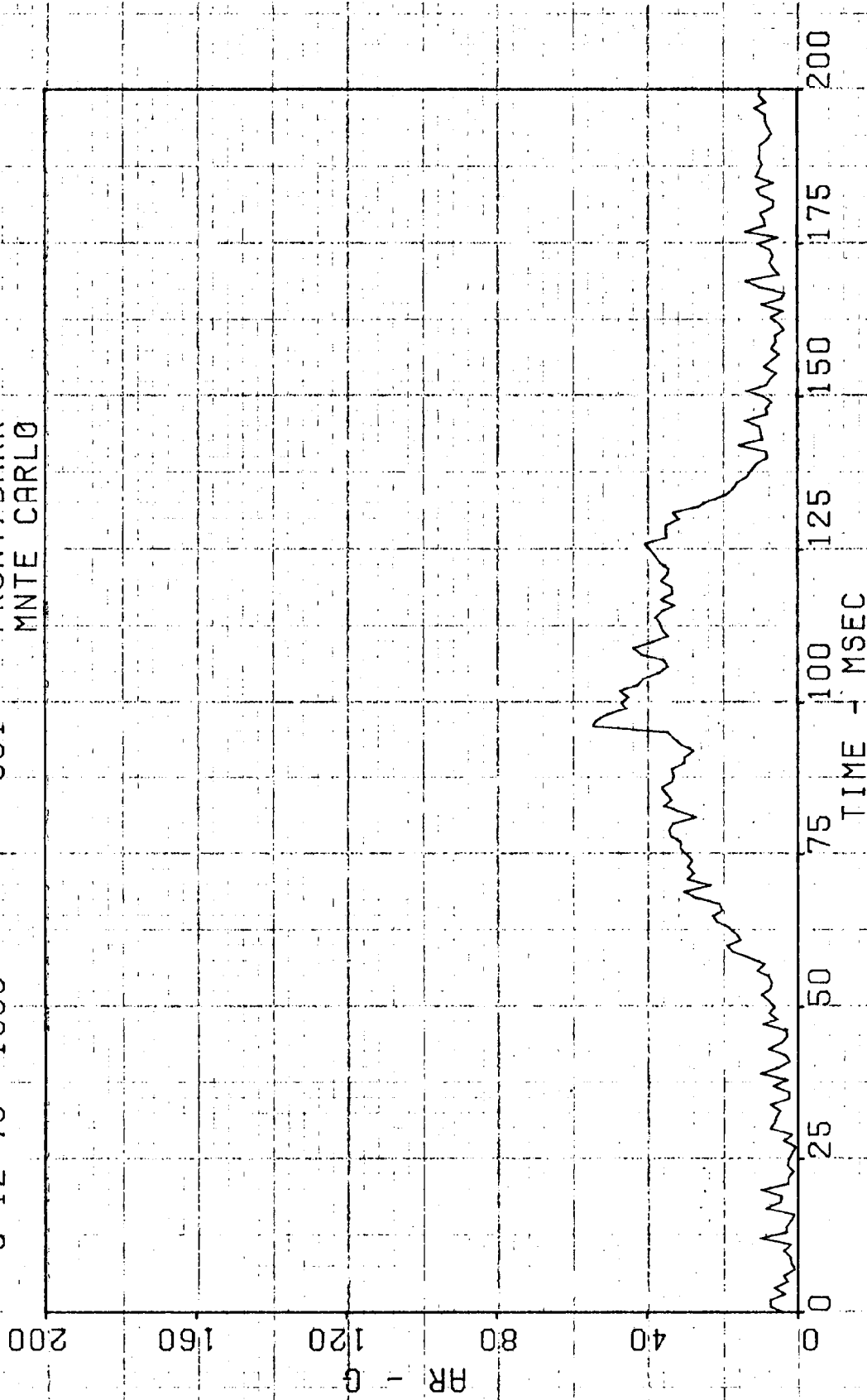


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FRONT/BARR MNTA CARLO

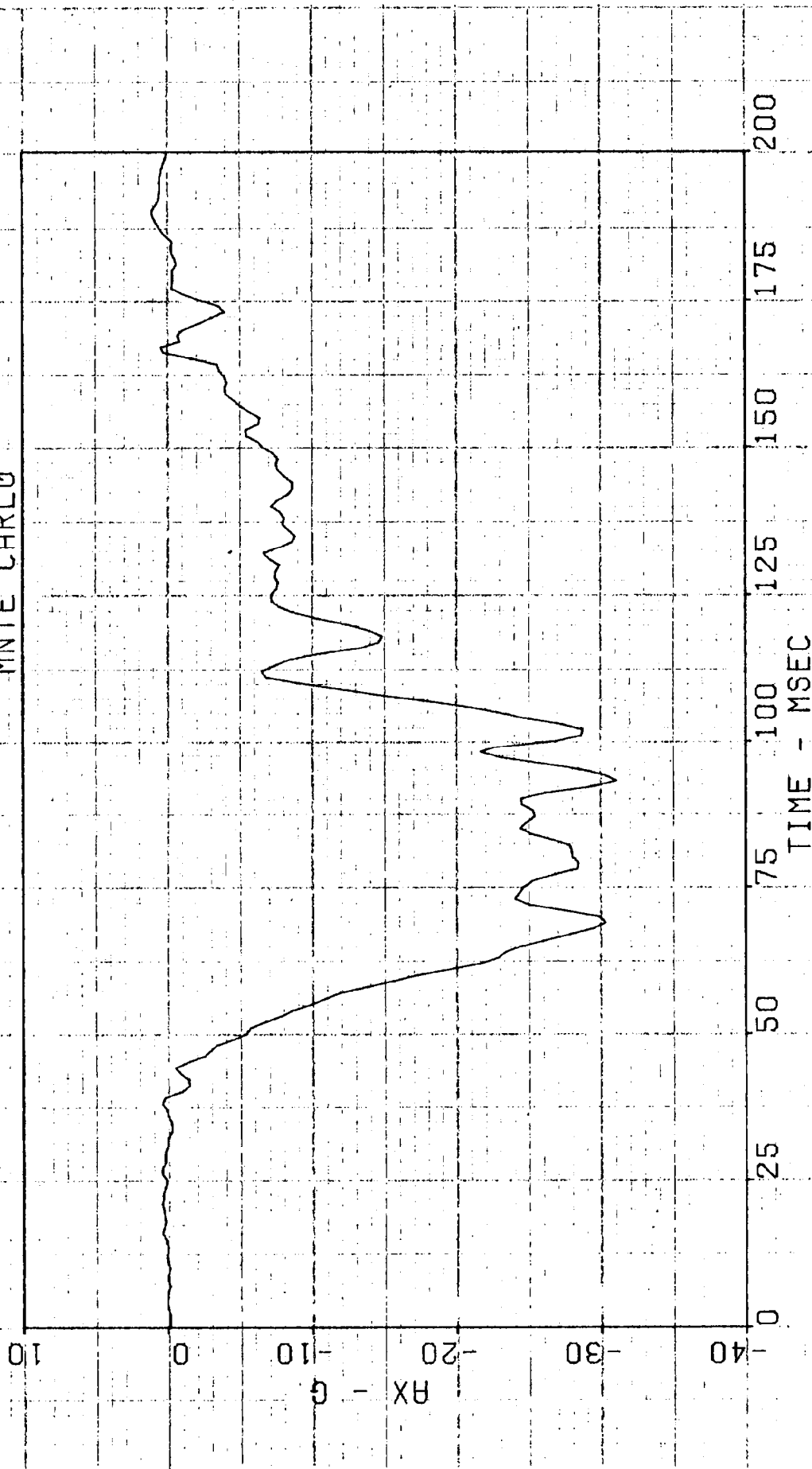




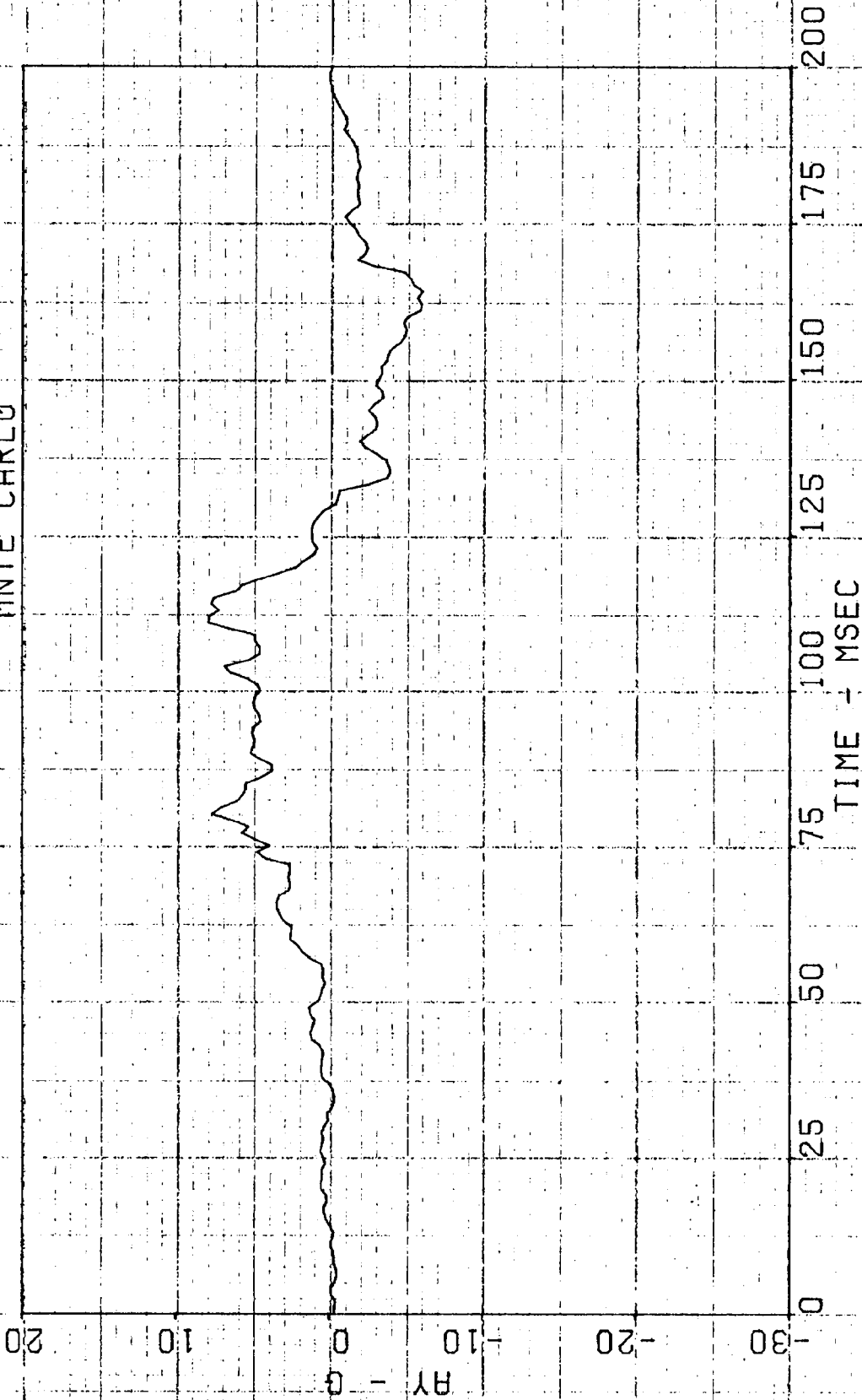
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FRONT/BARR MNTTE CARLO

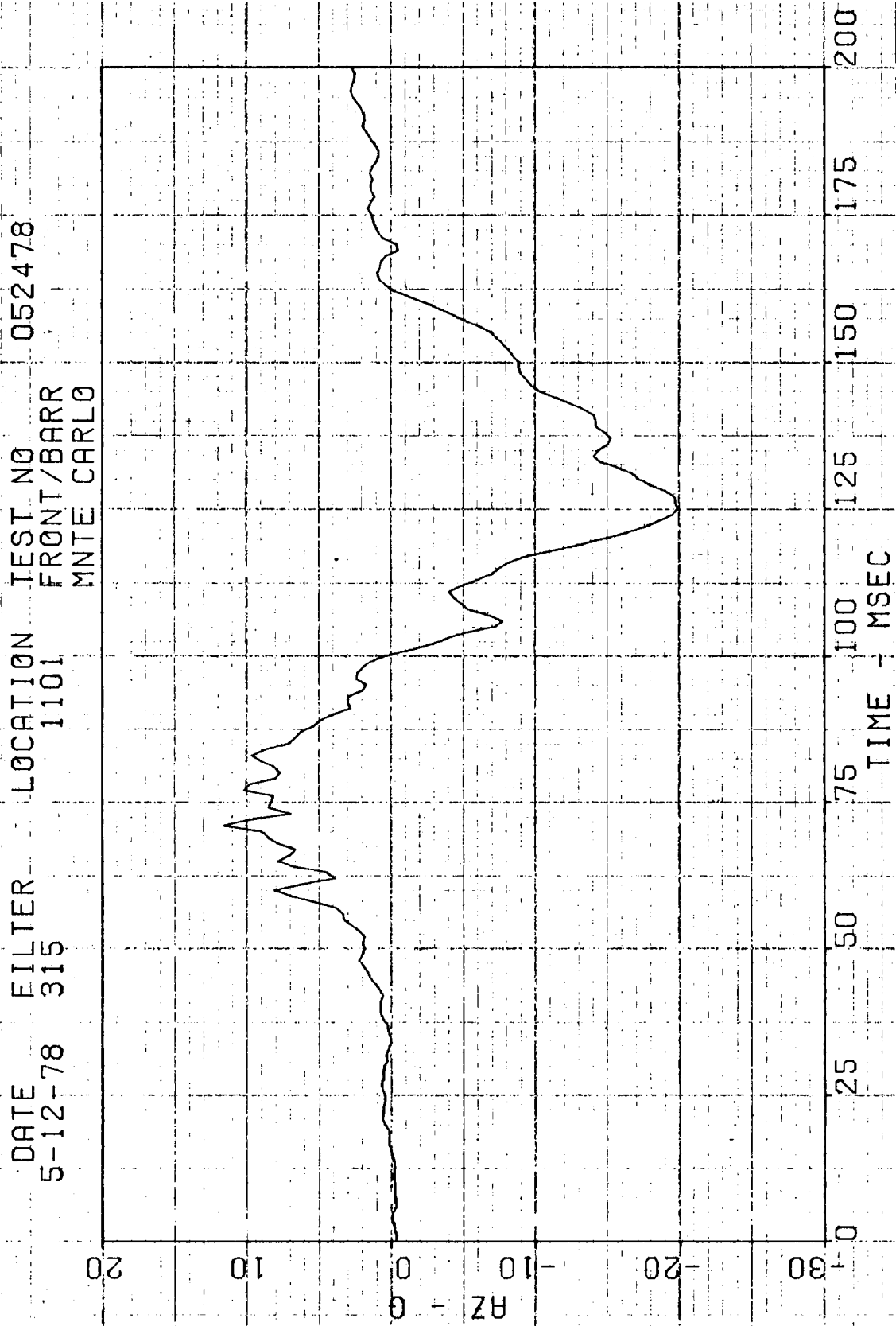


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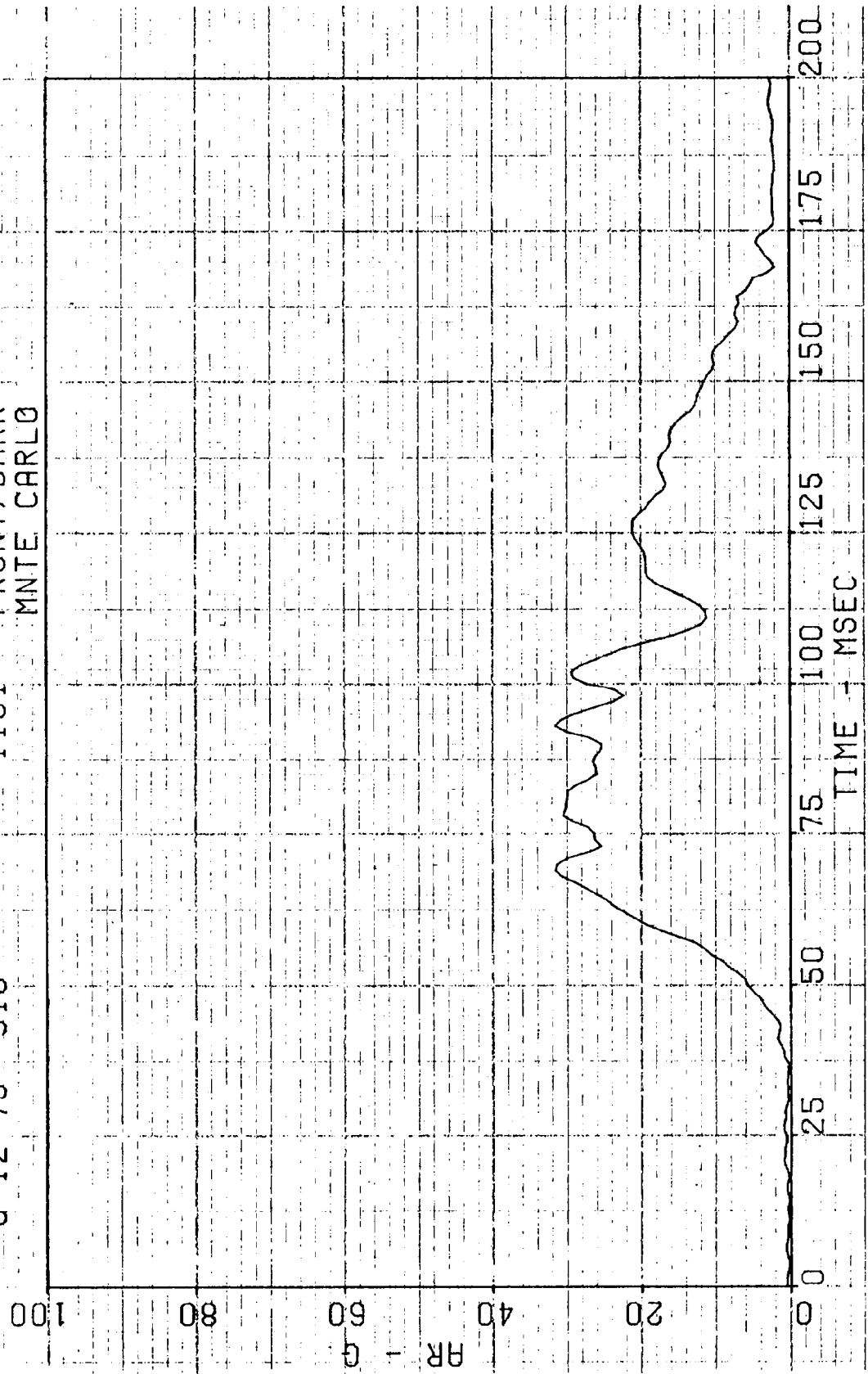


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FRONT/BARR MNTTE CARLO

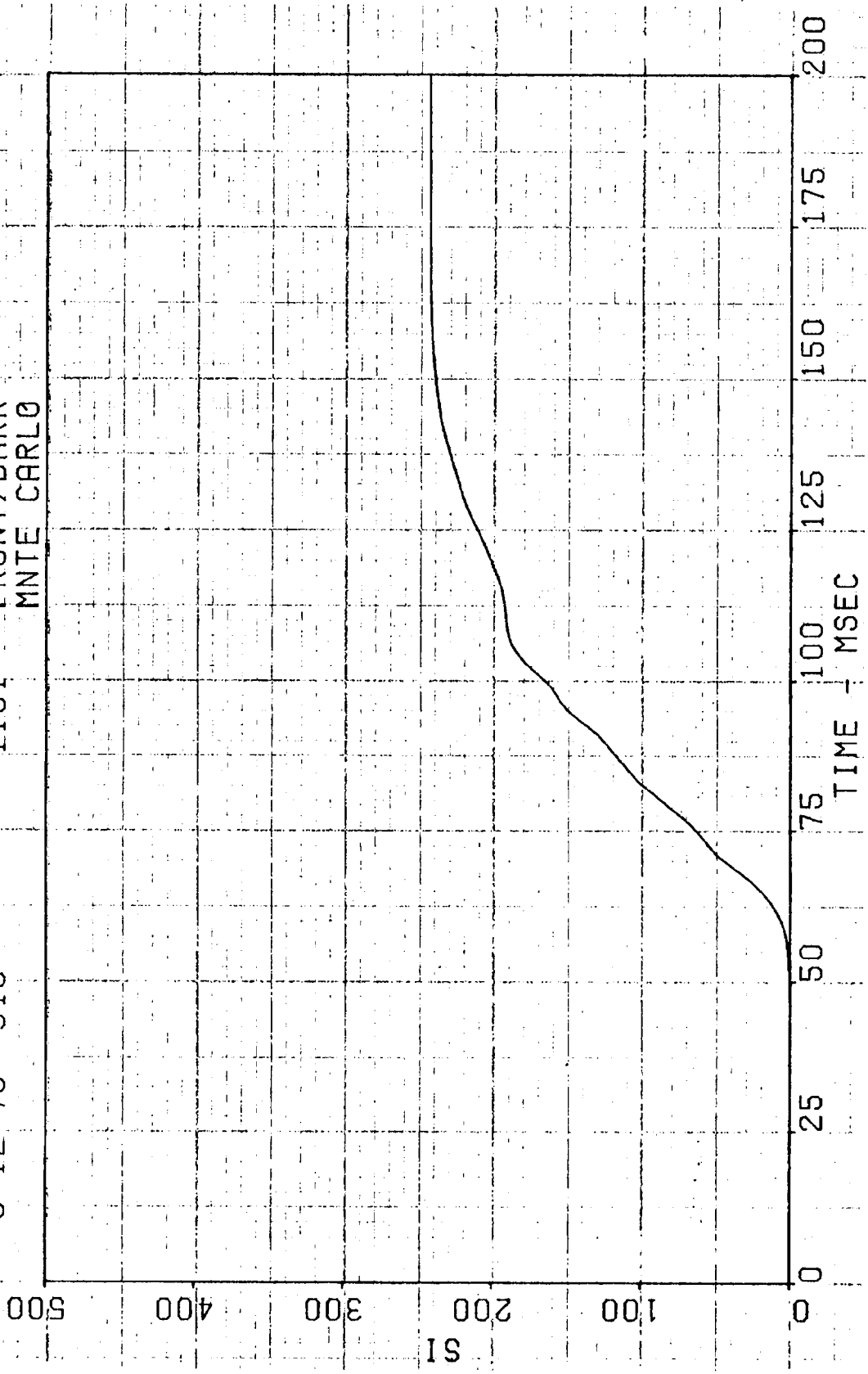




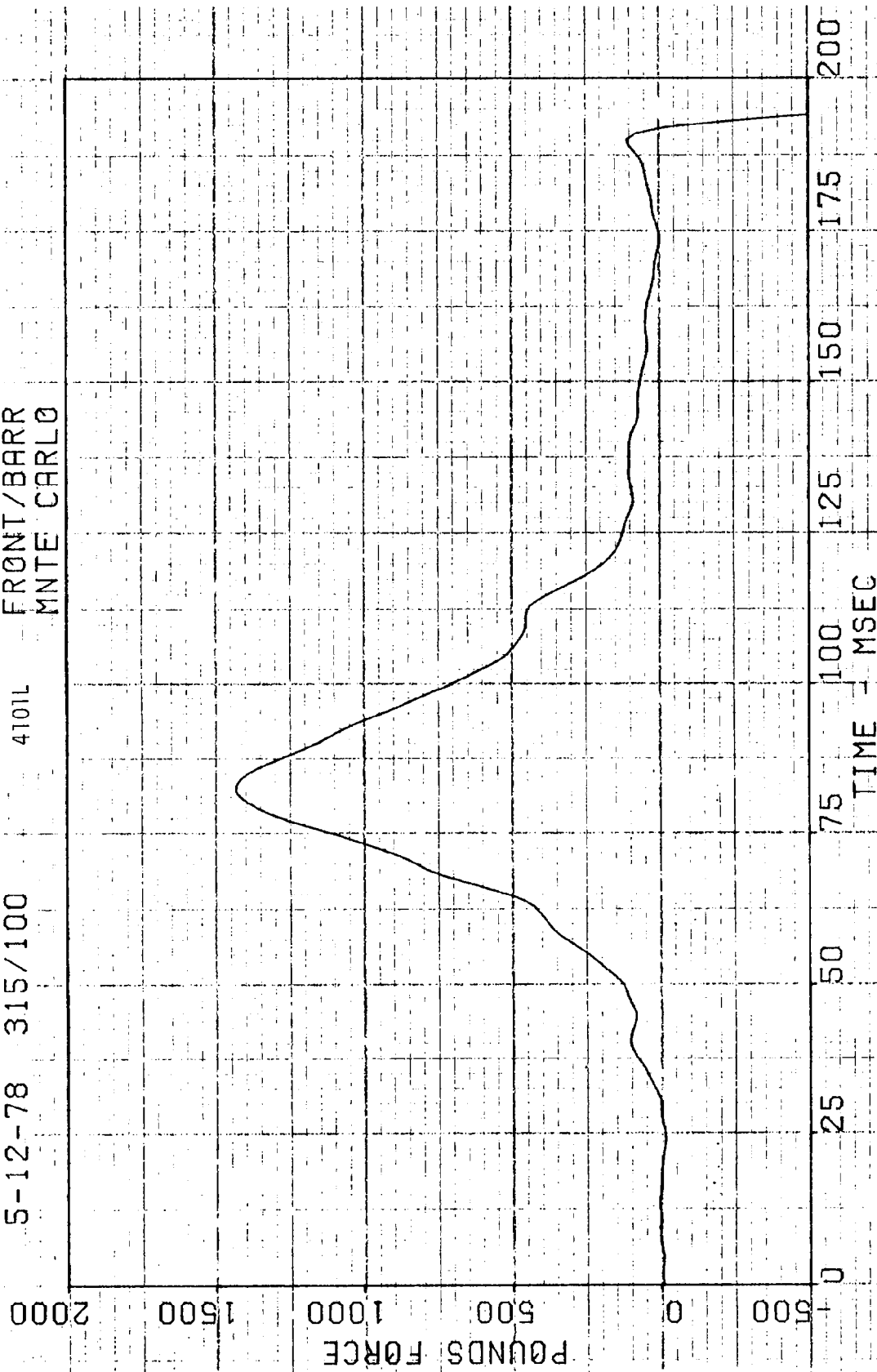
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 FRONT/BARR MNTE CARLO



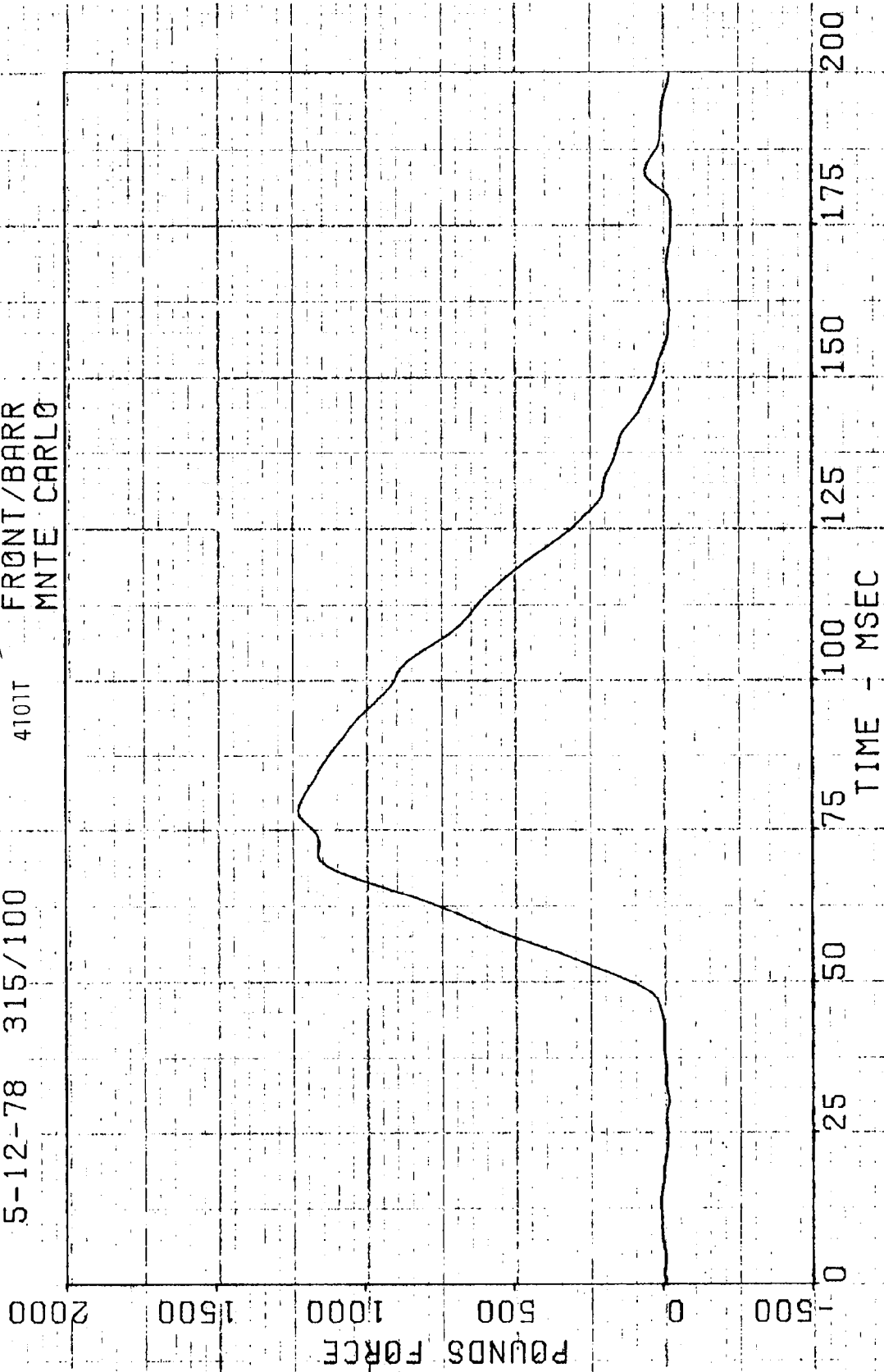
DATE 5-12-78 FILTER 315 LOCATION 1101 TEST NO 052478
FRONT/BARR MNTTE CARLO



DATE 5-12-78
FILTER 315/100
LOCATION 4101L
TEST NO 052478
FRONT/BARR
MNTE CARLO

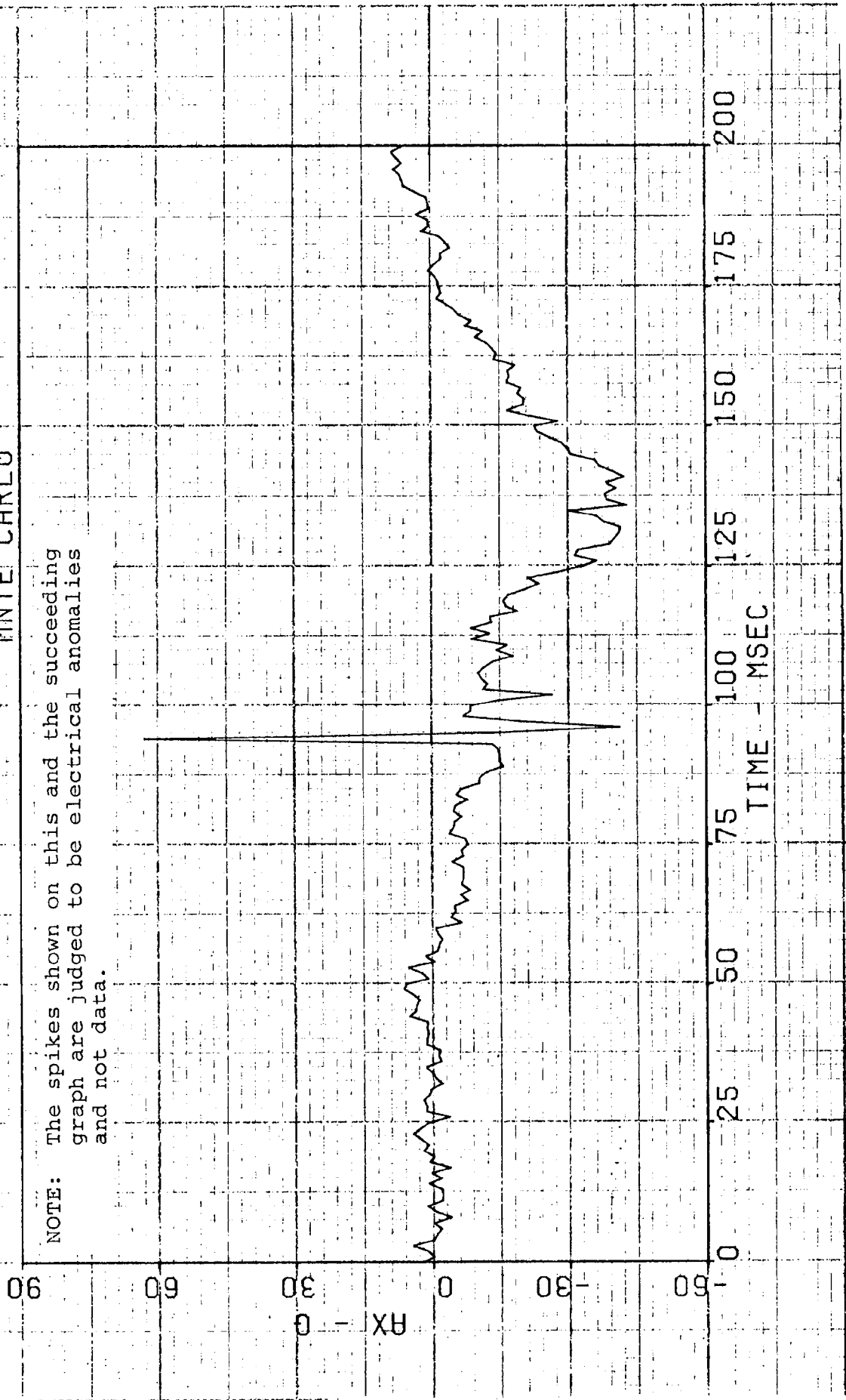


DATE 5-12-78 FILTER 315/100 LOCATION 4101T TEST NO 052478
FRONT/BARR MNTN CARLO

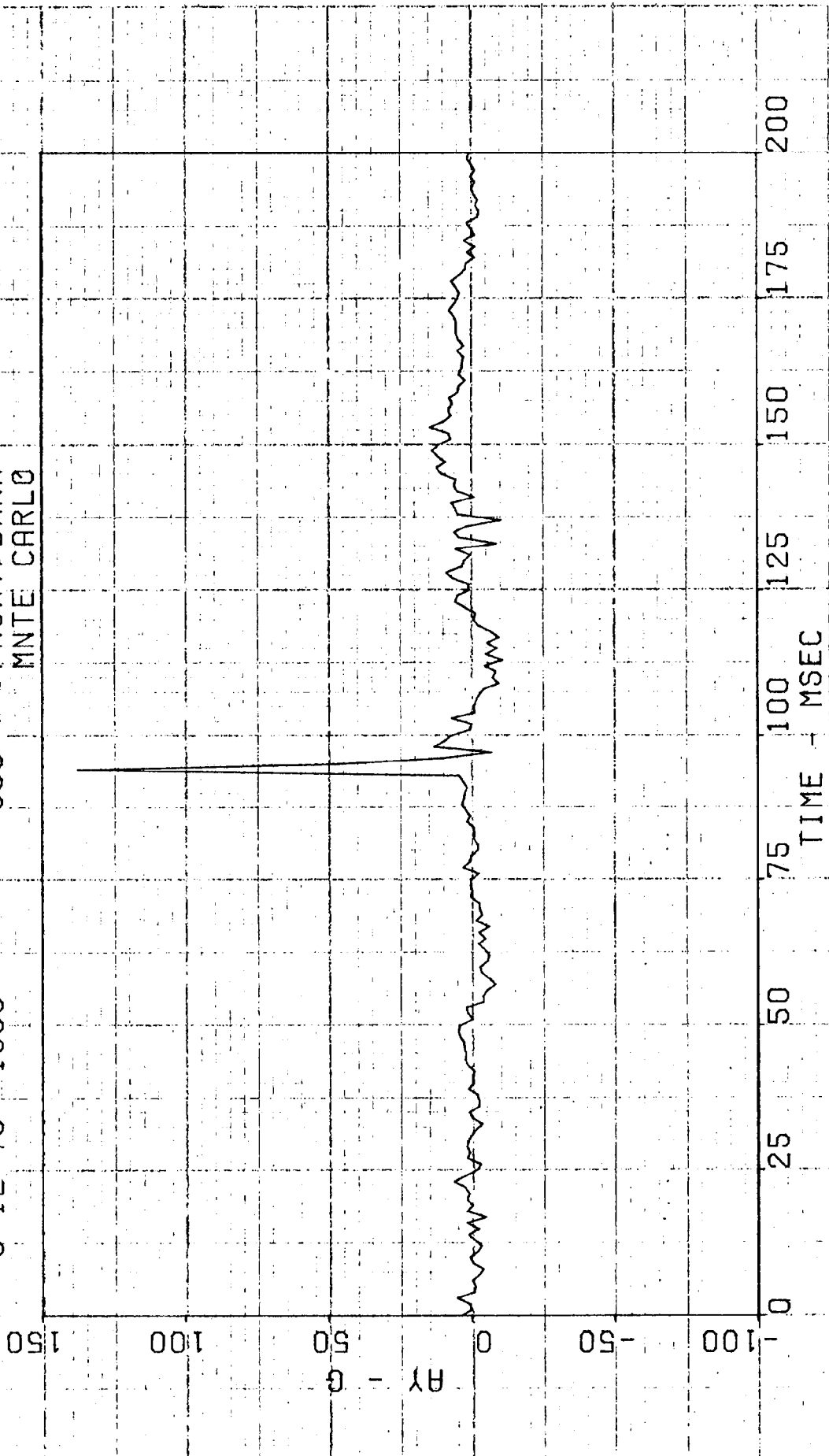


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FRONT/BARR MNTI CARLO

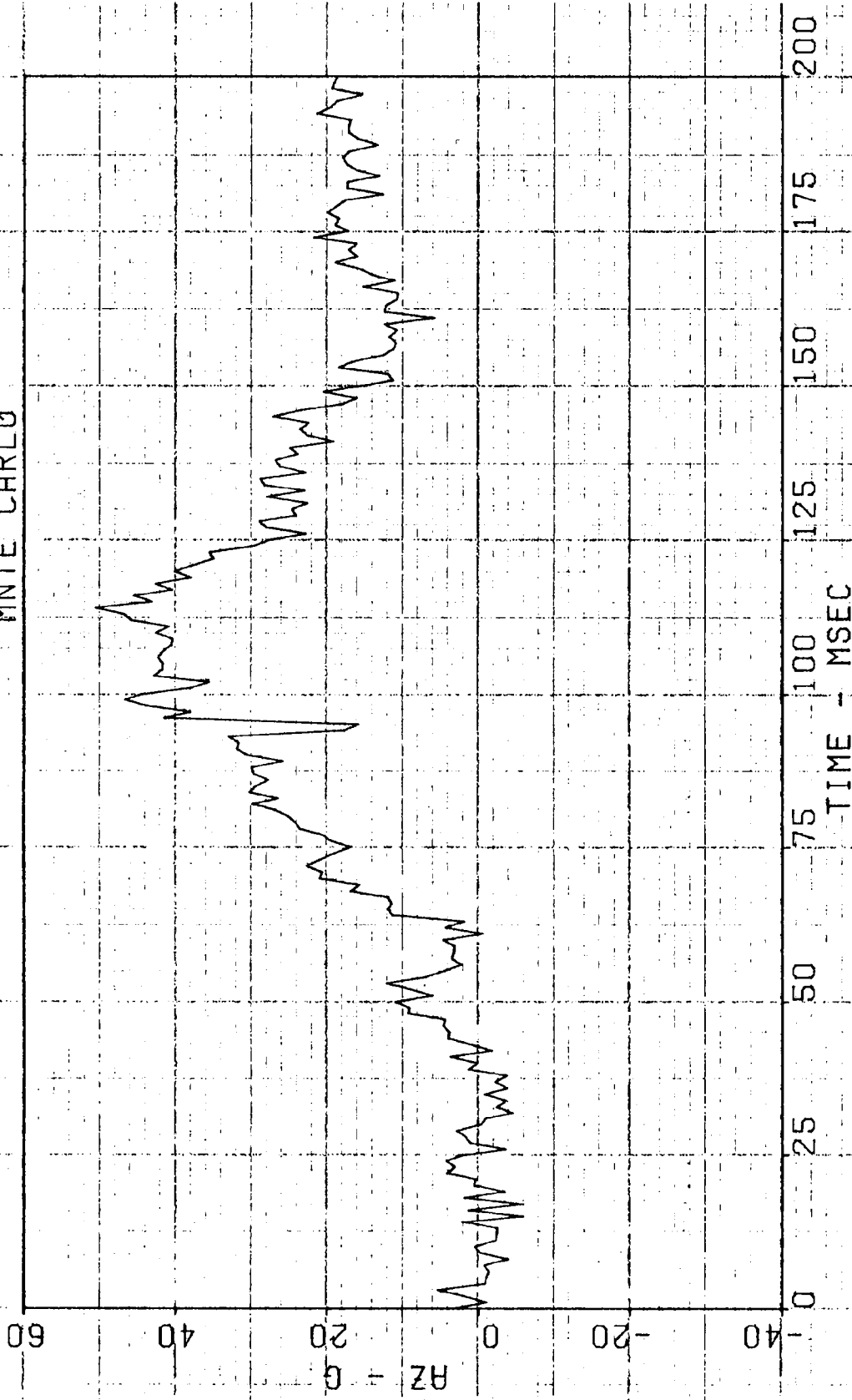
NOTE: The spikes shown on this and the succeeding graph are judged to be electrical anomalies and not data.



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FRONT/BARR MNTE CARLO

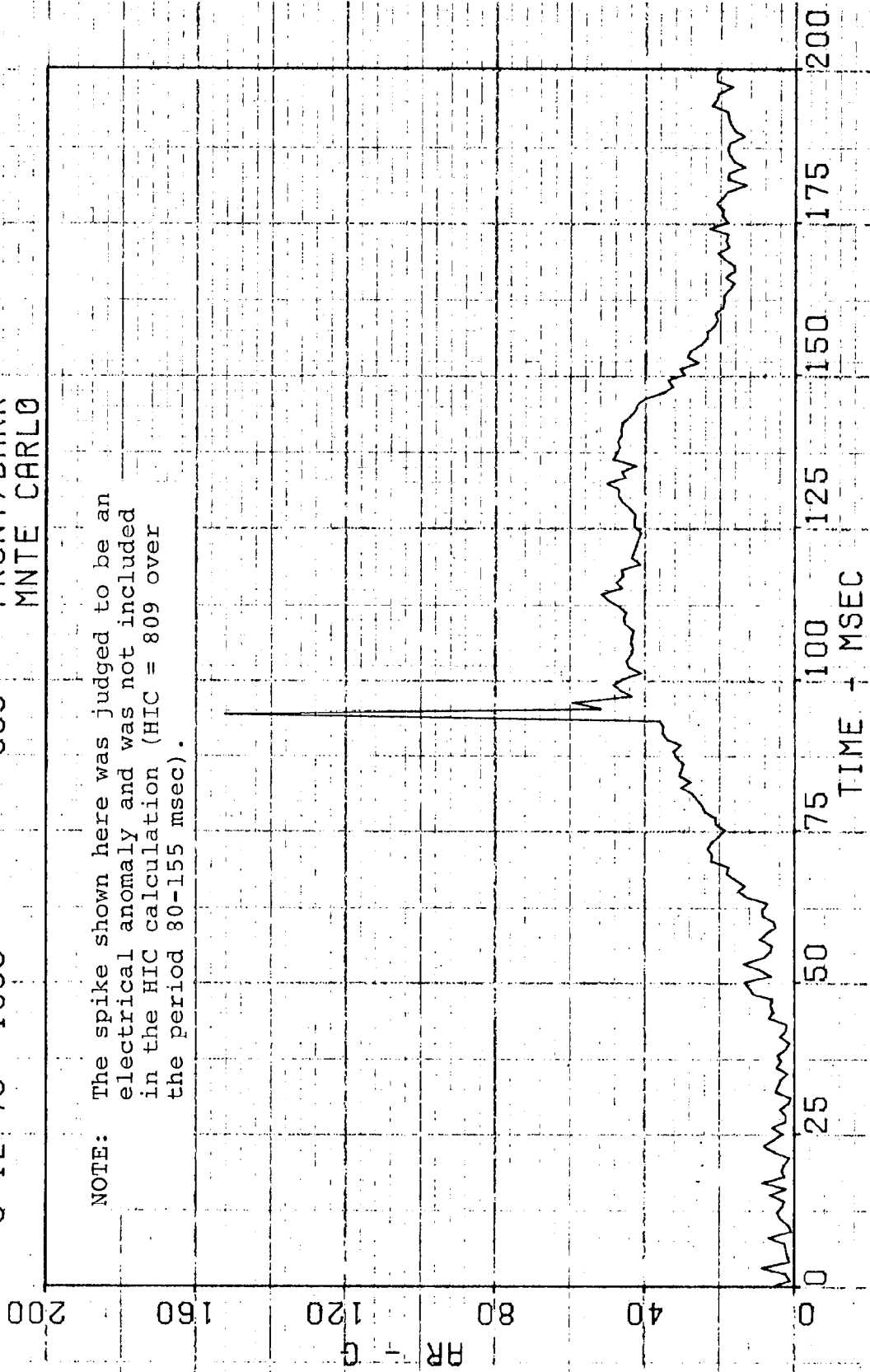


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FRONT/BARR MNTE CARLO

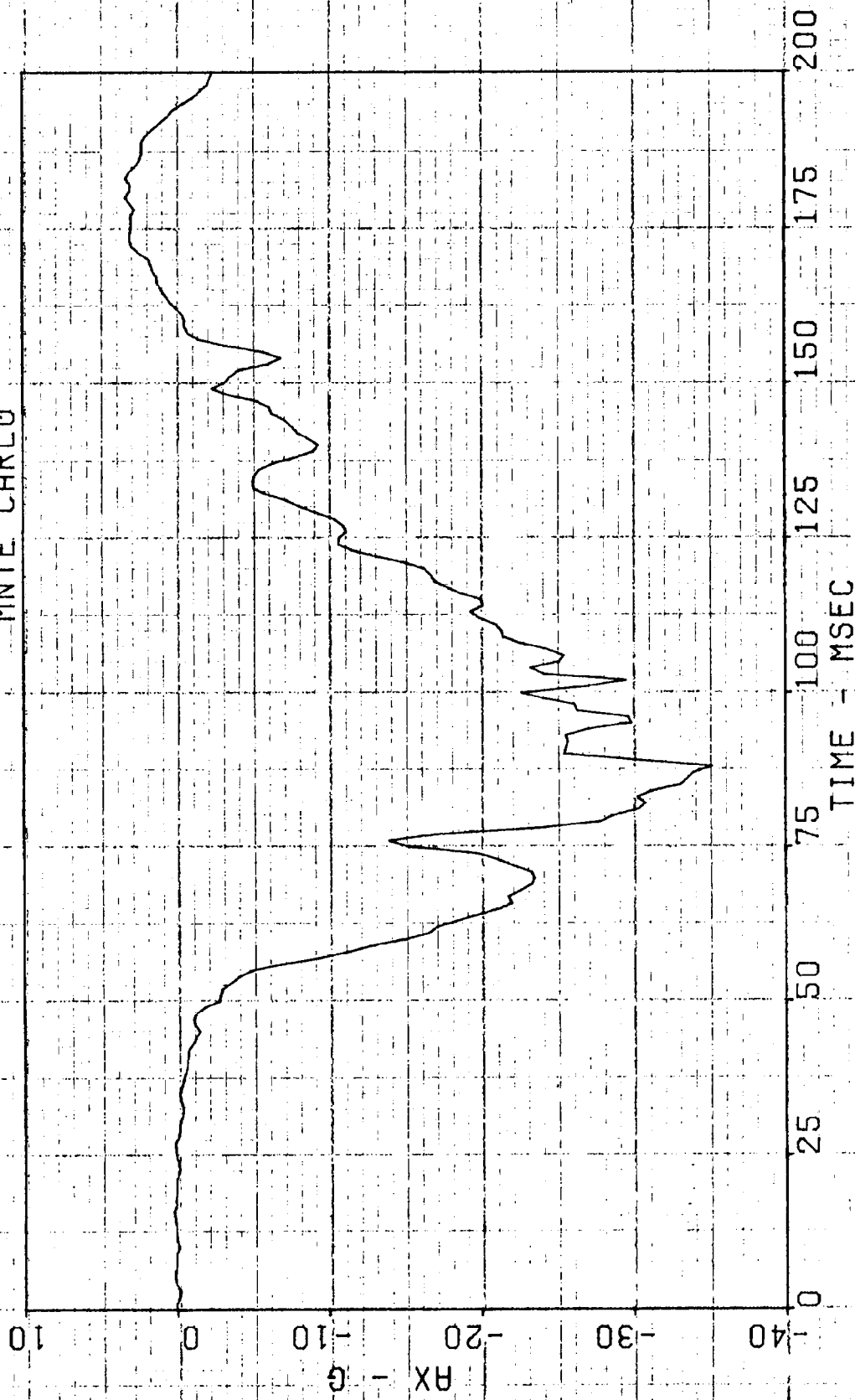


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FRONT/BARR MNTE CARLO

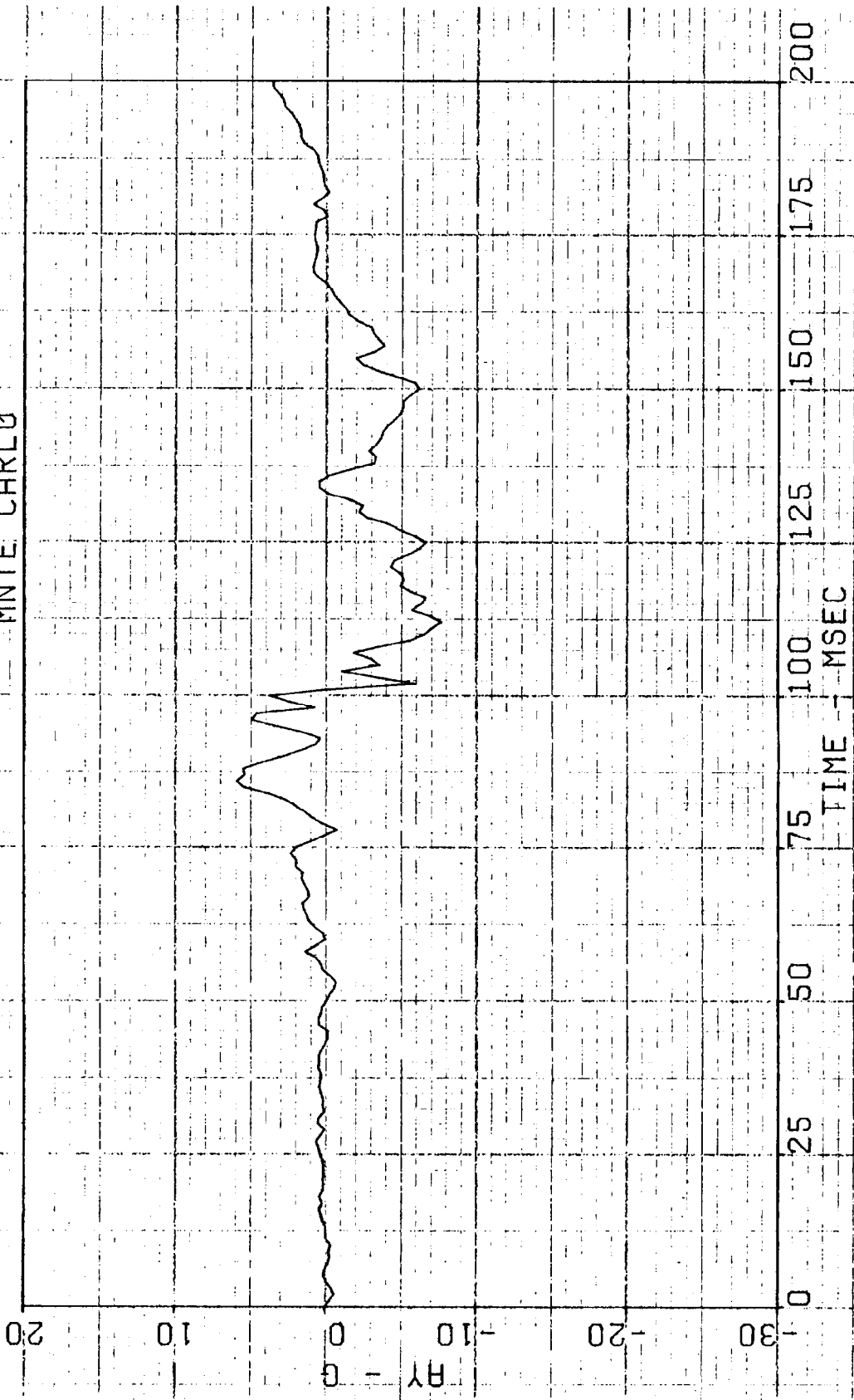
NOTE: The spike shown here was judged to be an electrical anomaly and was not included in the HIC calculation (HIC = 809 over the period 80-155 msec).



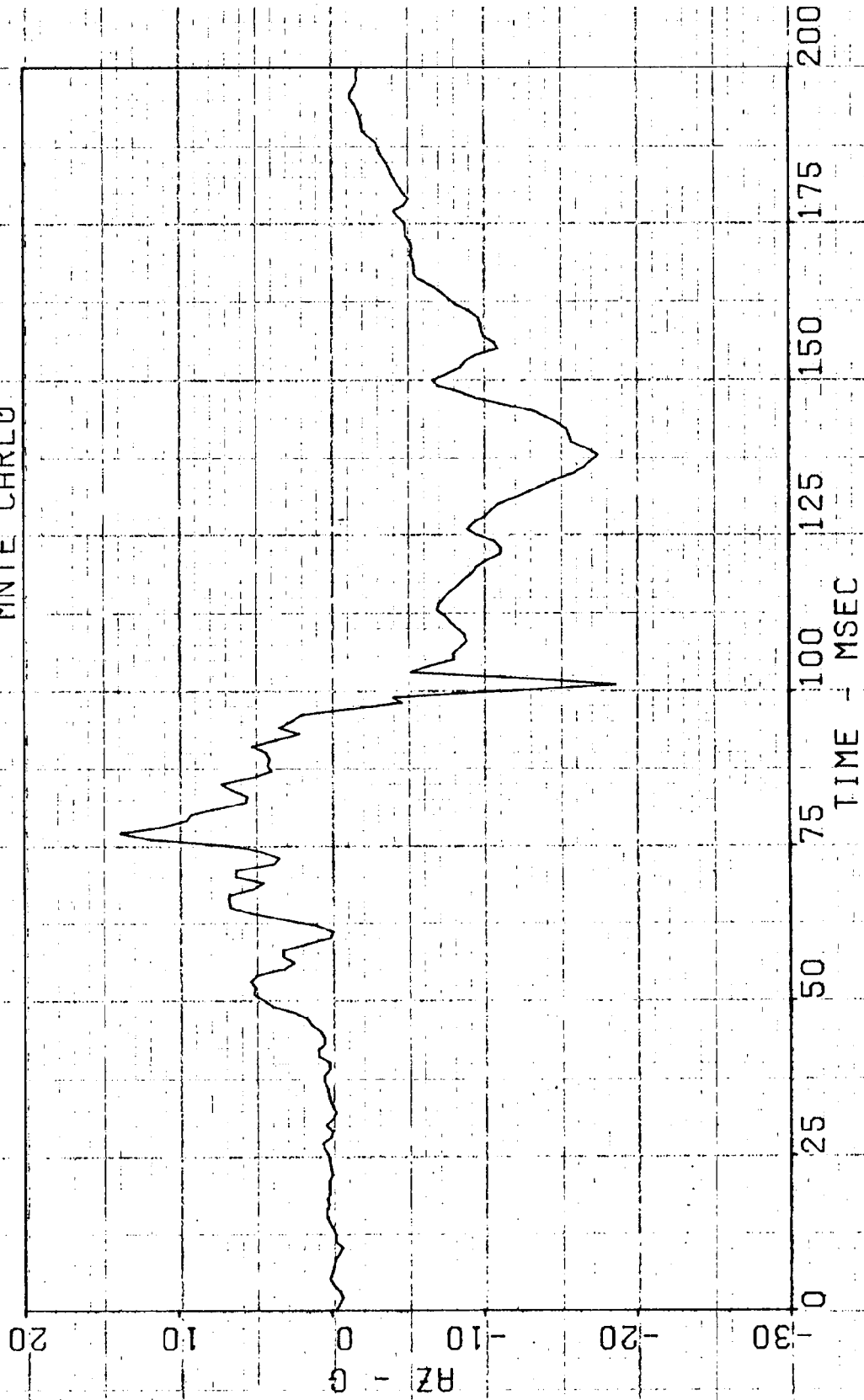
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FRONT/BARR MNTTE CARLO



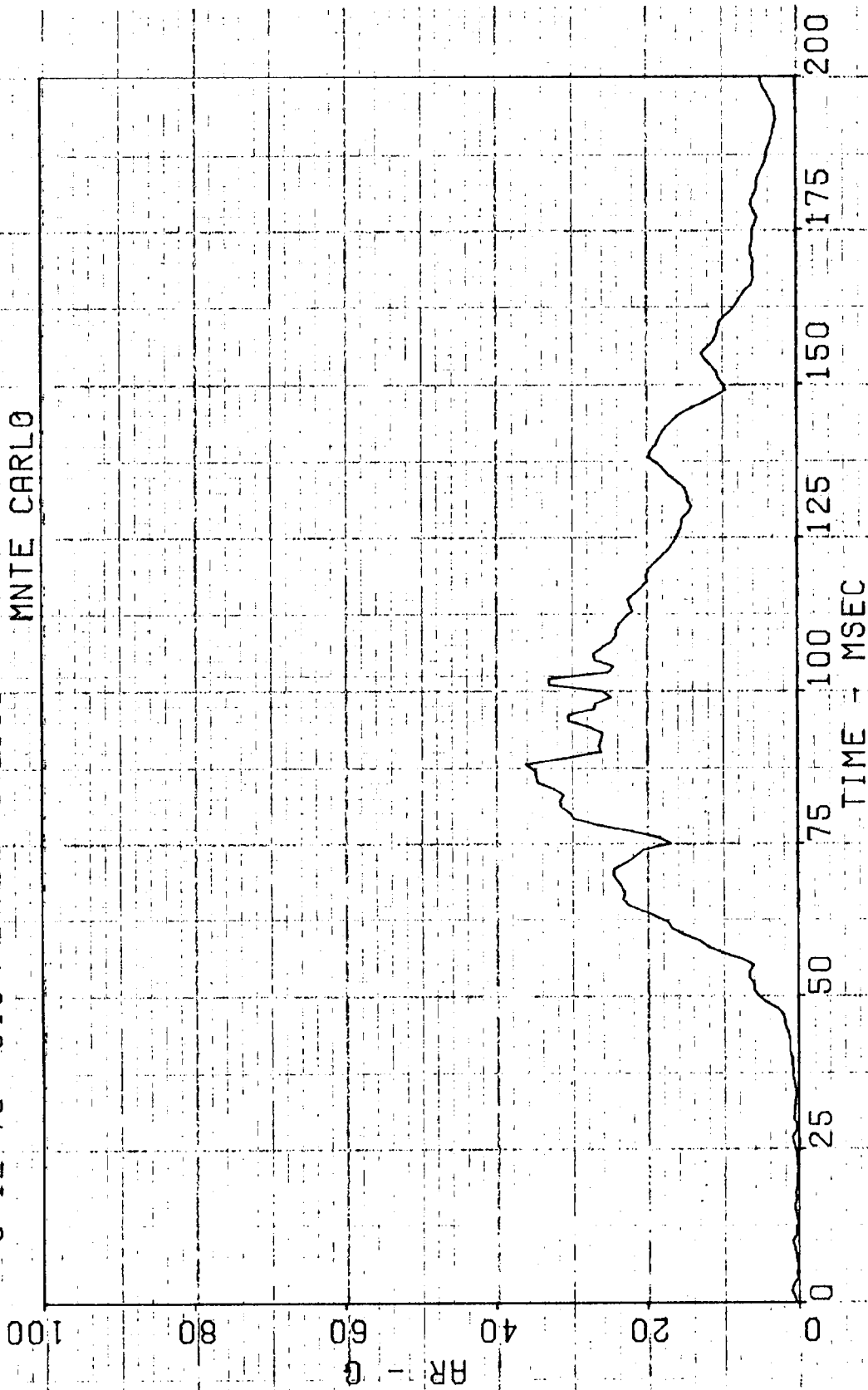
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FRONT/BARR MNTN CARLO



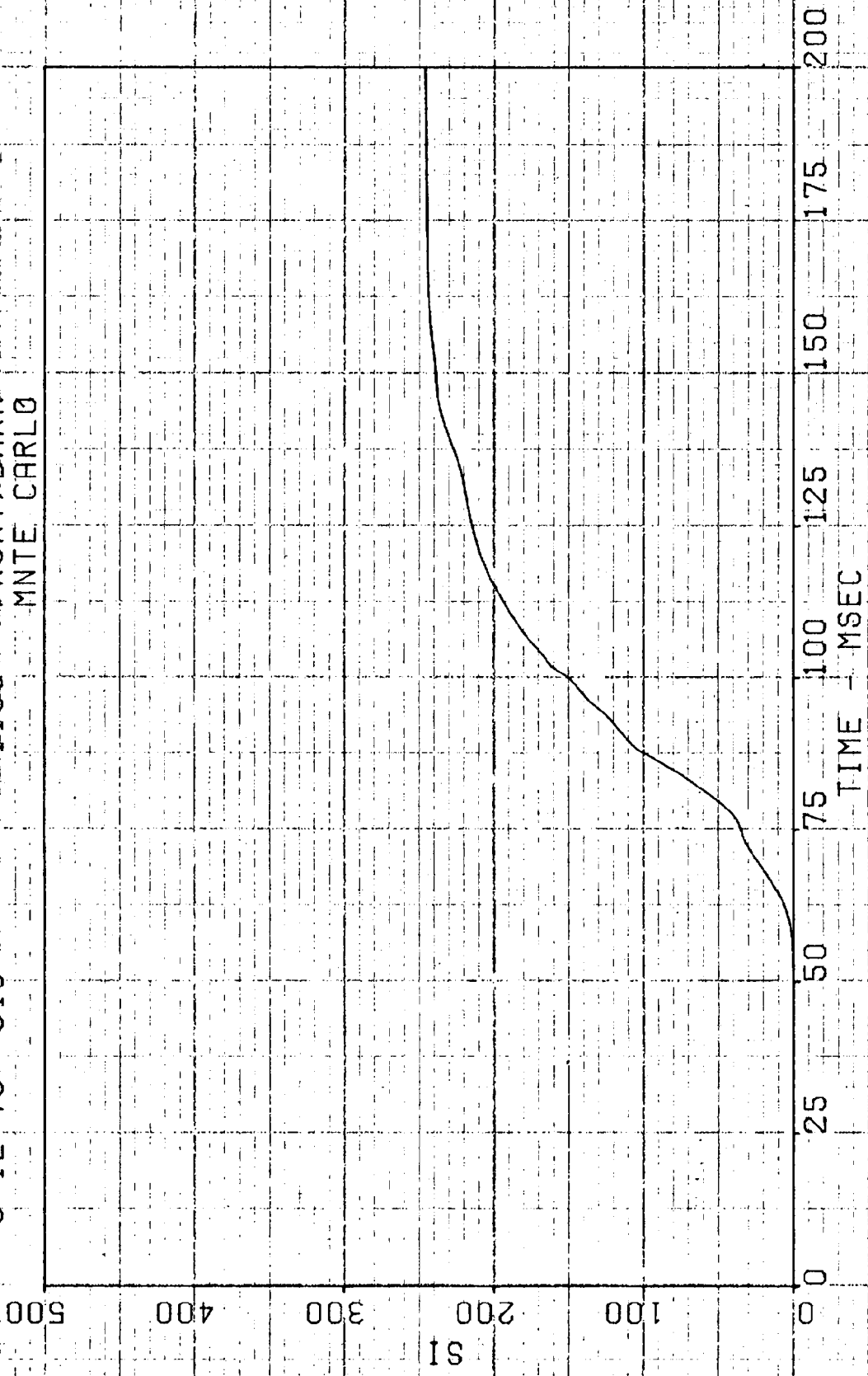
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FRONT/BARR MNTTE CARLO



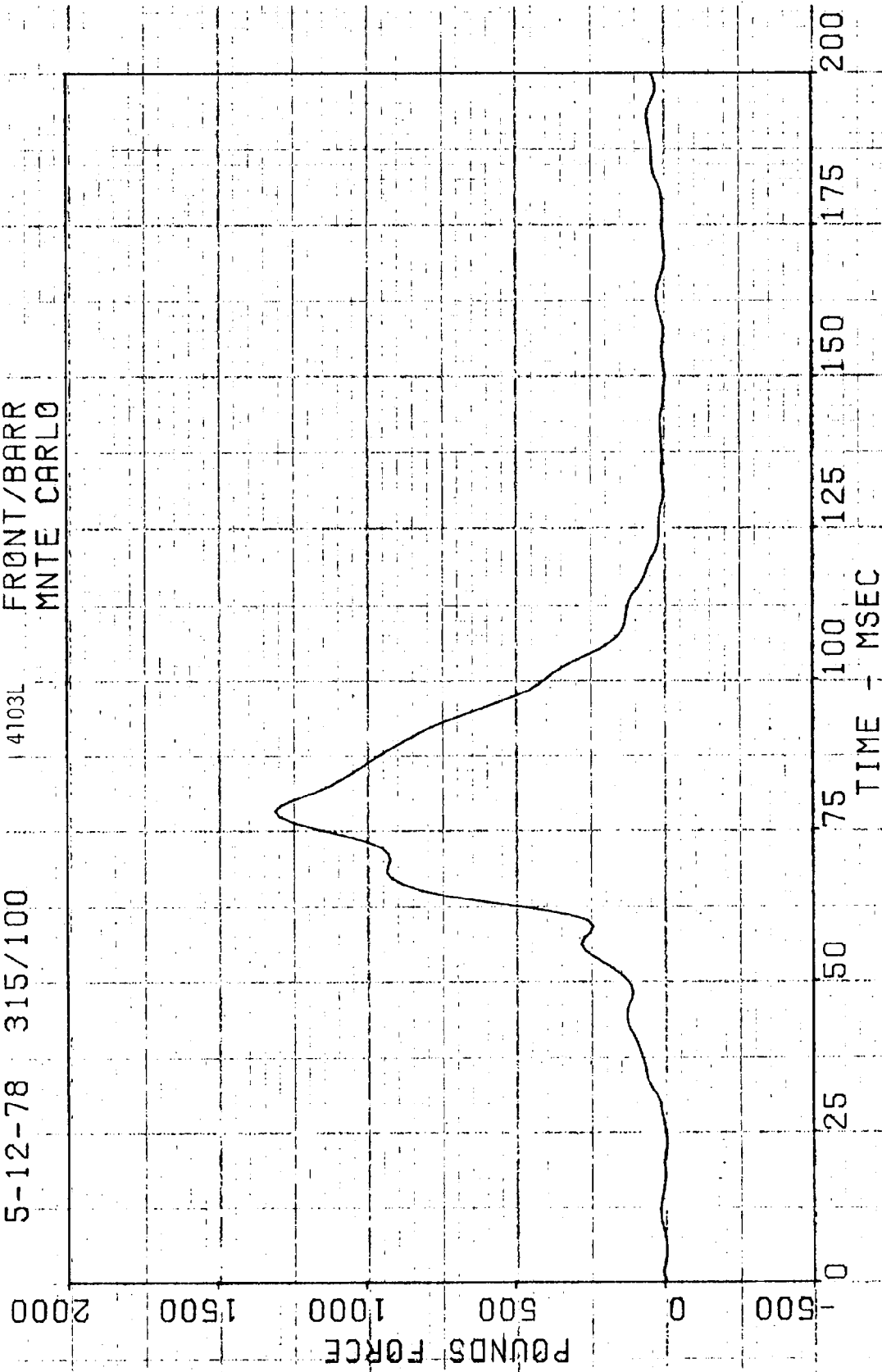
DATE 5-12-78 EILTER LOCATION TEST NO 052478
FRONT/BARR 1103 MNTTE CARLO

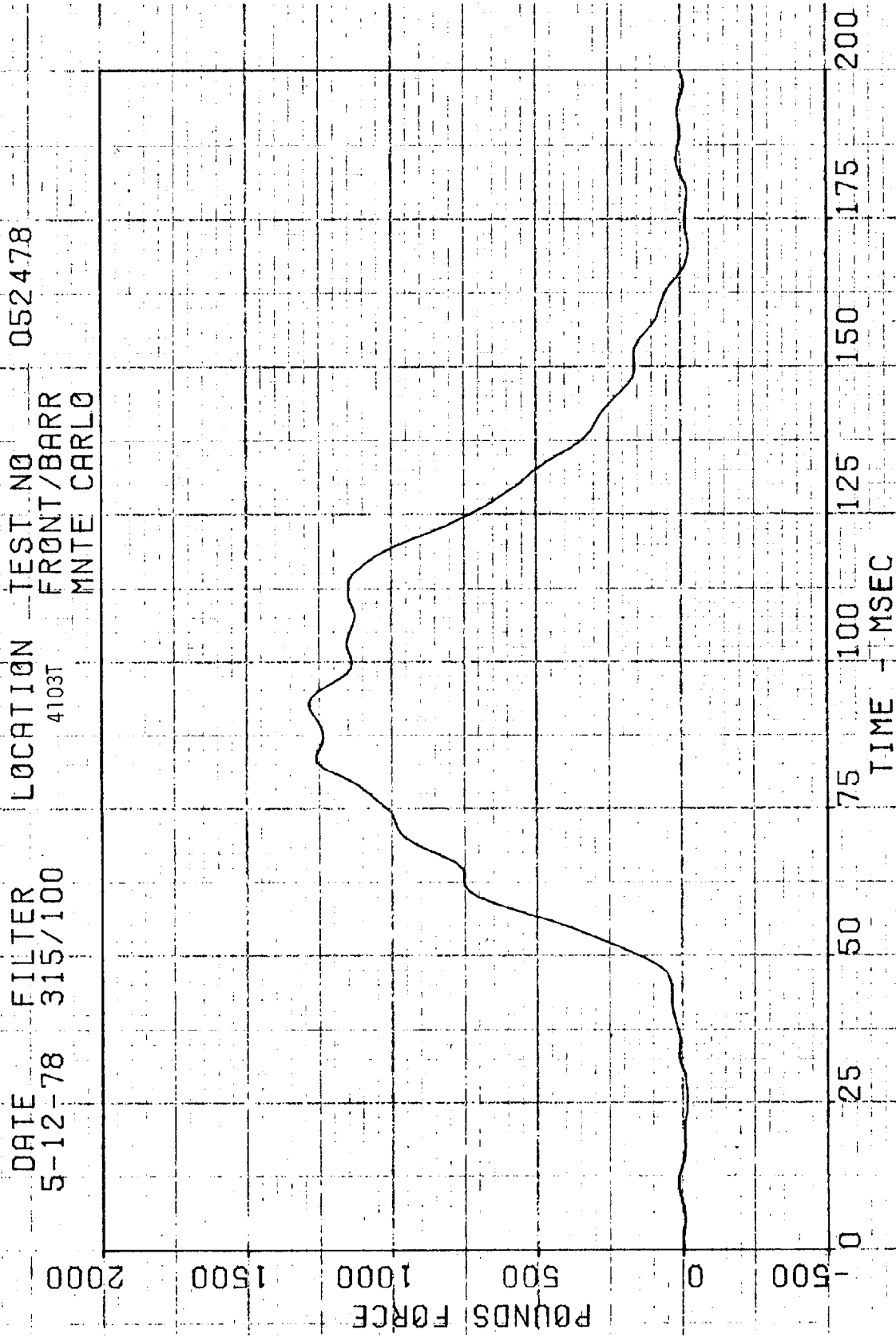


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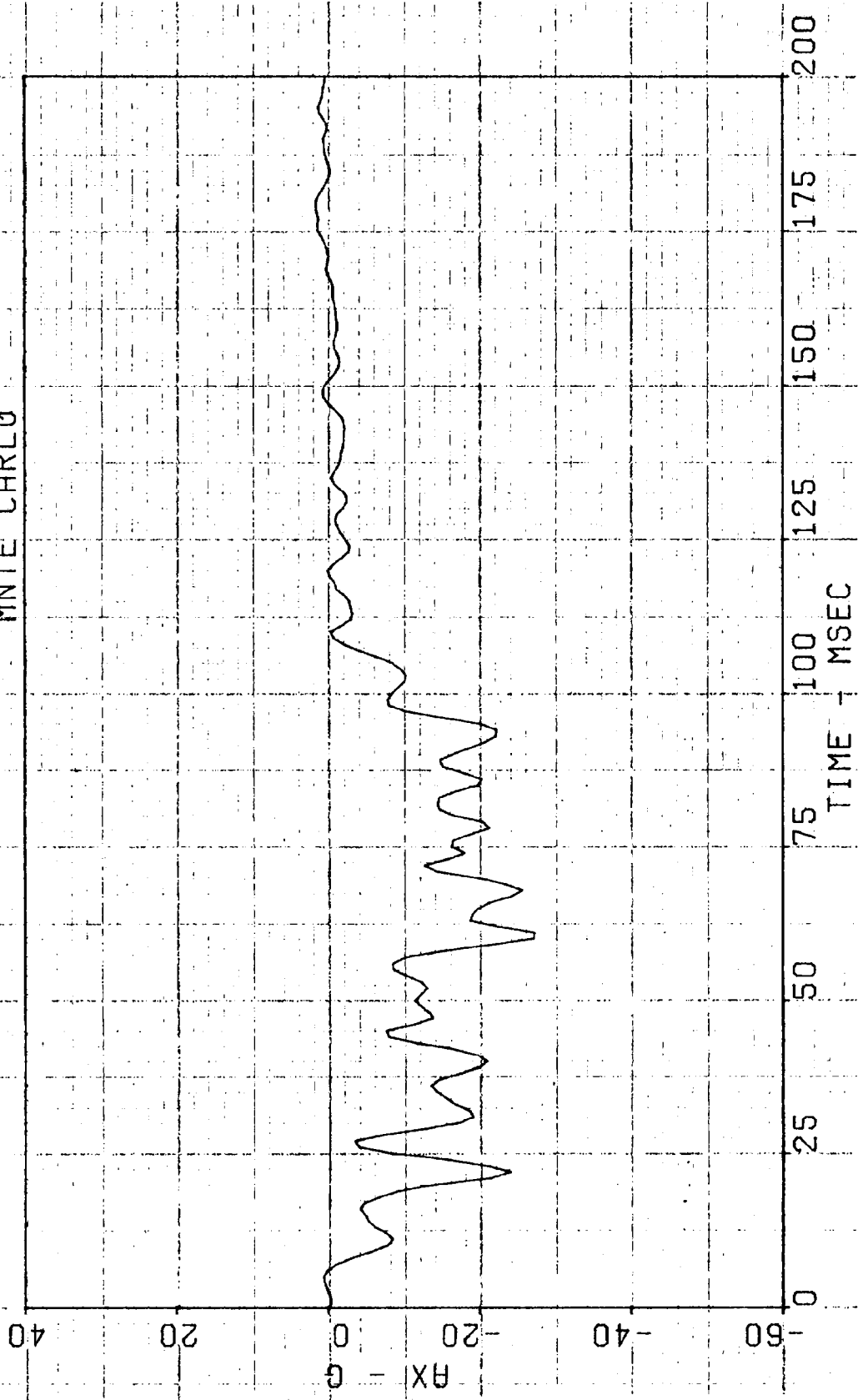


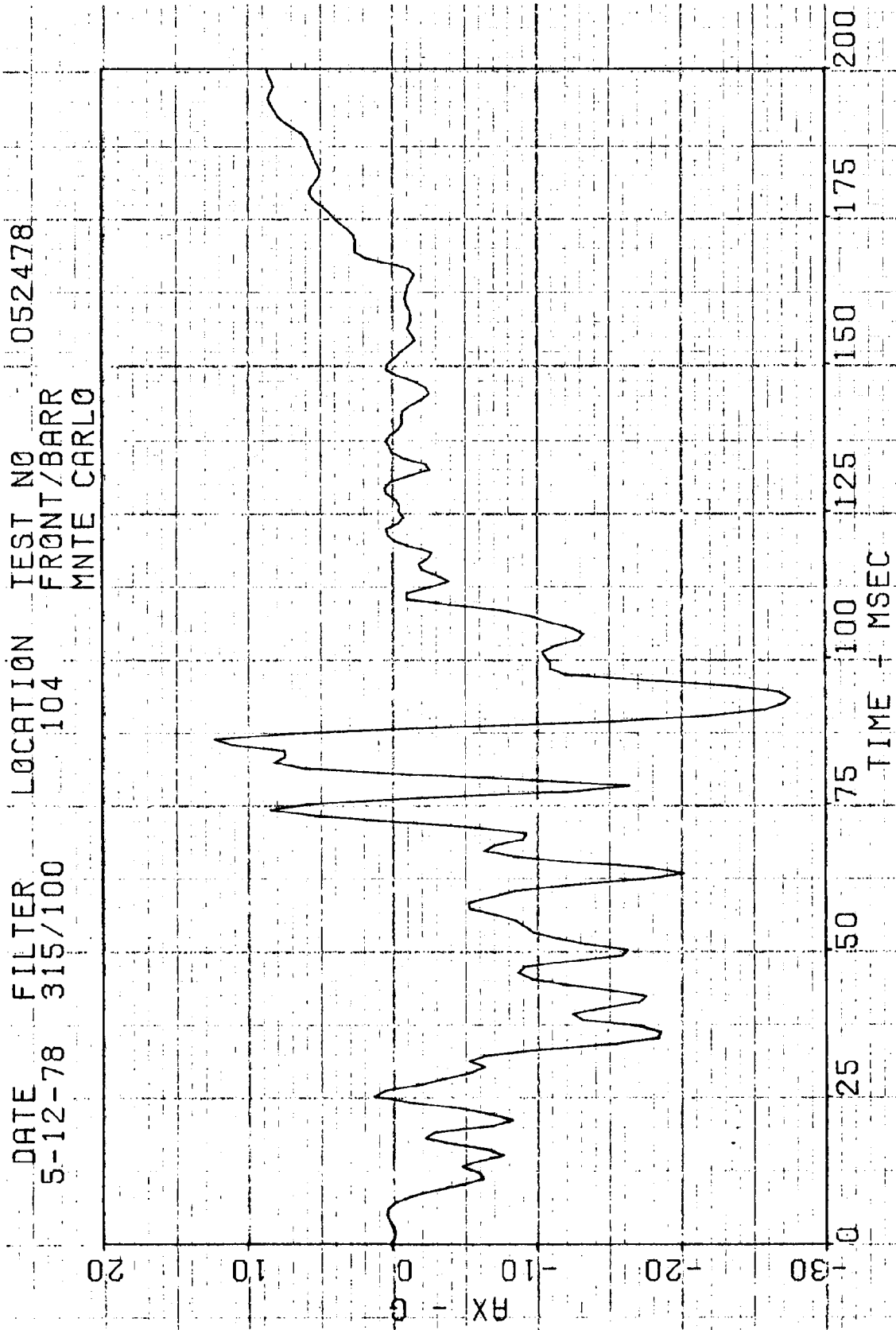
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FRONT/BARR MNTTE CARLO





DATE 5-12-78
EILTER 315/100
LOCATION 102
TEST NO 052478
FRONT/BARR
MNTE CARLO





DATE 5-12-78 FILTER 315/100 LOCATION 104 TEST NO 060278
FRONT/BARR MNTN CARLO

