

DOT 0104

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

GENERAL MOTORS CORPORATION
1978 OLDSMOBILE CUTLASS TWO-DOOR SEDAN
NHTSA 780115

E. Enserink
R. Pirtle

Contract DOT-HS-6-01478



June 1978

FINAL REPORT

Copies of this report are available from Technical Reference
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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 Oldsmobile Cutlass Two-Door Sedan (NHTSA 780115 - VIN 3J87A8R402834) was crash tested for compliance with FMVSS 301-75 (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 29.84 mph. The occupant response is summarized below: <table border="1"> <thead> <tr> <th></th> <th>DRIVER</th> <th>PASSENGER</th> </tr> </thead> <tbody> <tr> <td>Head Injury Criterion</td> <td>607.30</td> <td>824.30</td> </tr> <tr> <td>Chest Severity Index</td> <td>295.83</td> <td>266.20</td> </tr> </tbody> </table> Peak vehicle accelerations were as follows: Occupant Compartment - Front: -30.07 G Occupant Compartment - Rear: -29.3 G							DRIVER	PASSENGER	Head Injury Criterion	607.30	824.30	Chest Severity Index	295.83	266.20
	DRIVER	PASSENGER												
Head Injury Criterion	607.30	824.30												
Chest Severity Index	295.83	266.20												
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METRIC CONVERSION FACTORS

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

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
ac	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

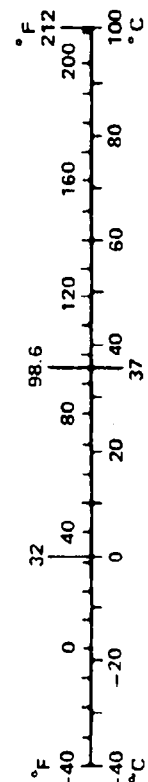


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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the effort documented herein was to acquire occupant response and vehicle acceleration data in a 1978 Oldsmobile Cutlass Two-Door Sedan (NHTSA 780115) 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: Oldsmobile Cutlass

Body Style: Two-Door Sedan Year: 1978

VIN: 3J87A8R402834 Build Date: 9/77

NHTSA NO.: 780115 Color: Tan

Engine: 6 Cylinders, 231 c.i.d.

Transmission: -- speeds, Manual Automatic x

Major Options: Power Brakes, Power Steering, Tinted Glass,

Radio, Air Conditioning

Seating Capacity: Front 3 Rear 3 Total 6

Capacity Weight (lb): 1060

GVWR (lb): Front 2190 Rear 2300 Total 4490

Recommended Cold Tire Pressure (psi): Front 32 Rear 32

Tire Size: P195/75R14

Load Range: B

Tires on Vehicle: P195/ 75R14

Delivered-Vehicle Values (fluids to capacity)

Weights (lb)

Wheel: RF 955 LF 931 RR 733 LR 736

Axle : F 1886 (56.2%) R 1467 (43.8%)

Total: 3355

Attitude (in.)

RF 30.0 LF 30.0 RR 30.0 LR 30.0

Target Vehicle Test Weight (lb): 3843

2.2 TEST CONDITIONS

Date: May 4, 1978

Time: 1441

Temperature: 90 °F

Test Speed (mph): 29.84

Vehicle Weights (lb)

Wheel: RF 1011 LF 1067 RR 883 LR 885

Axle : F 2078 (54.0%) R 1768 (46.0%)

Total: 3846

Vehicle Attitude (in.)

RF 29.5 LF 29.1 RR 29.0 LR 28.6

Pre-test Dummy Positions

<u>Measurement</u>	<u>Driver (in.)</u>	<u>Passenger (in.)</u>
Dummy Centerline to Vehicle Centerline	20.0	20.0
Nose to Upper Rim Steering Wheel	18.0	--
Nose to Windshield (Horizontal Distance)	--	20.0
Left Knee to Closest Point on Lower Panel	7.0	8.0
Right Knee to Closest Point on Lower Panel	7.0	8.0
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.

PART 572 DUMMY IN-VEHICLE POSITION

RECORDING SHEET

General Motors Corporation
Oldsmobile Cutlass Two-Door

VEH. NHTSA NO.: 7 8 0 1 1 5

MFR./MAKE/MODEL Sedan

SEAT TYPE:

☐ Bench
☐ Bucket
☒ Split Bench

ADJUSTER TYPE:

☒ Manual
☐ Power

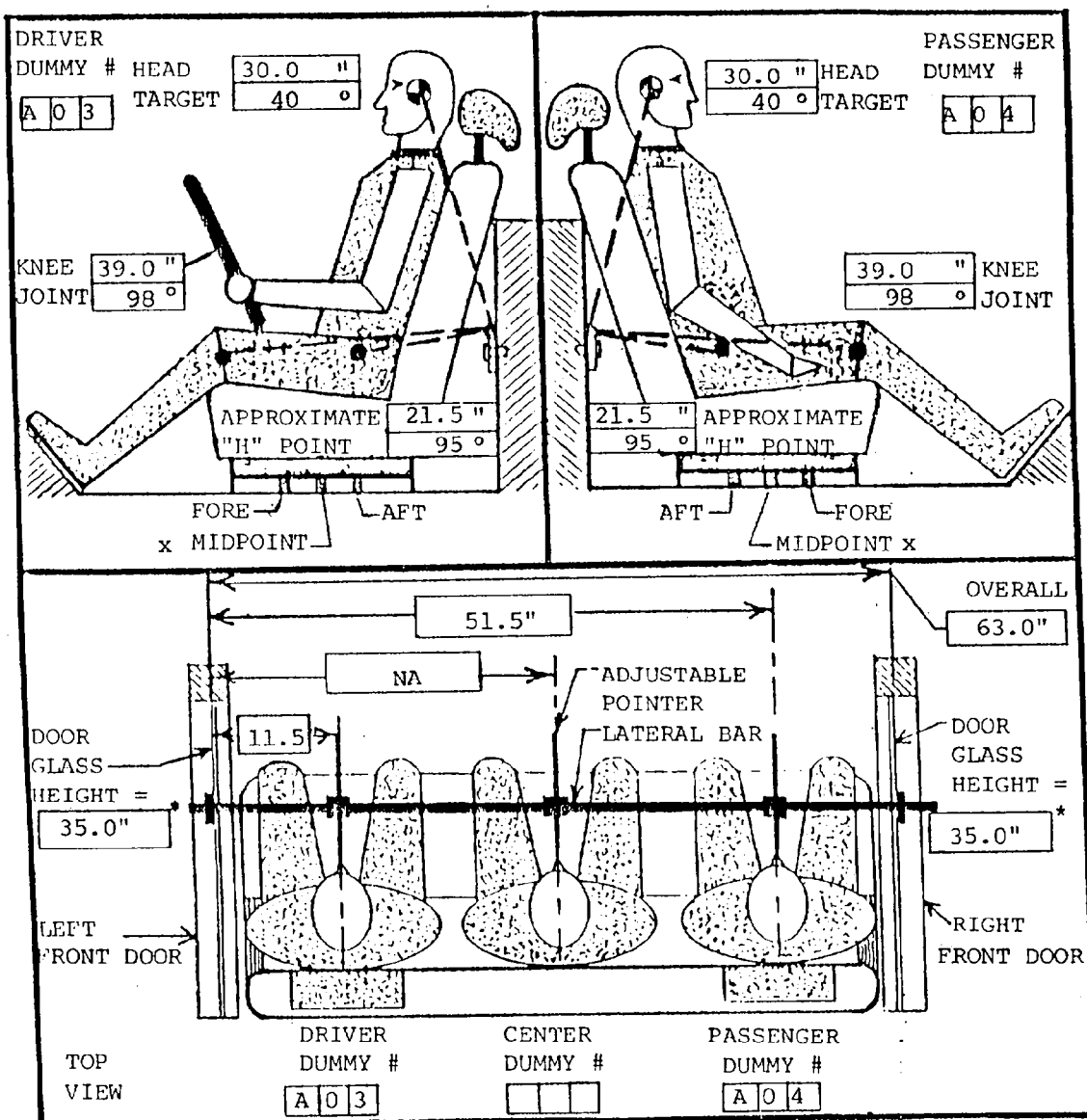
BUCKET SEAT BACK TYPE:

☐ Fixed
☐ Adjustable Reclining

POSITIONING DATE: , 1978; TECHNICIANS: 1. R. Pirtle

AMBIENT TEMP.: 90 °F TIME: 1400 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

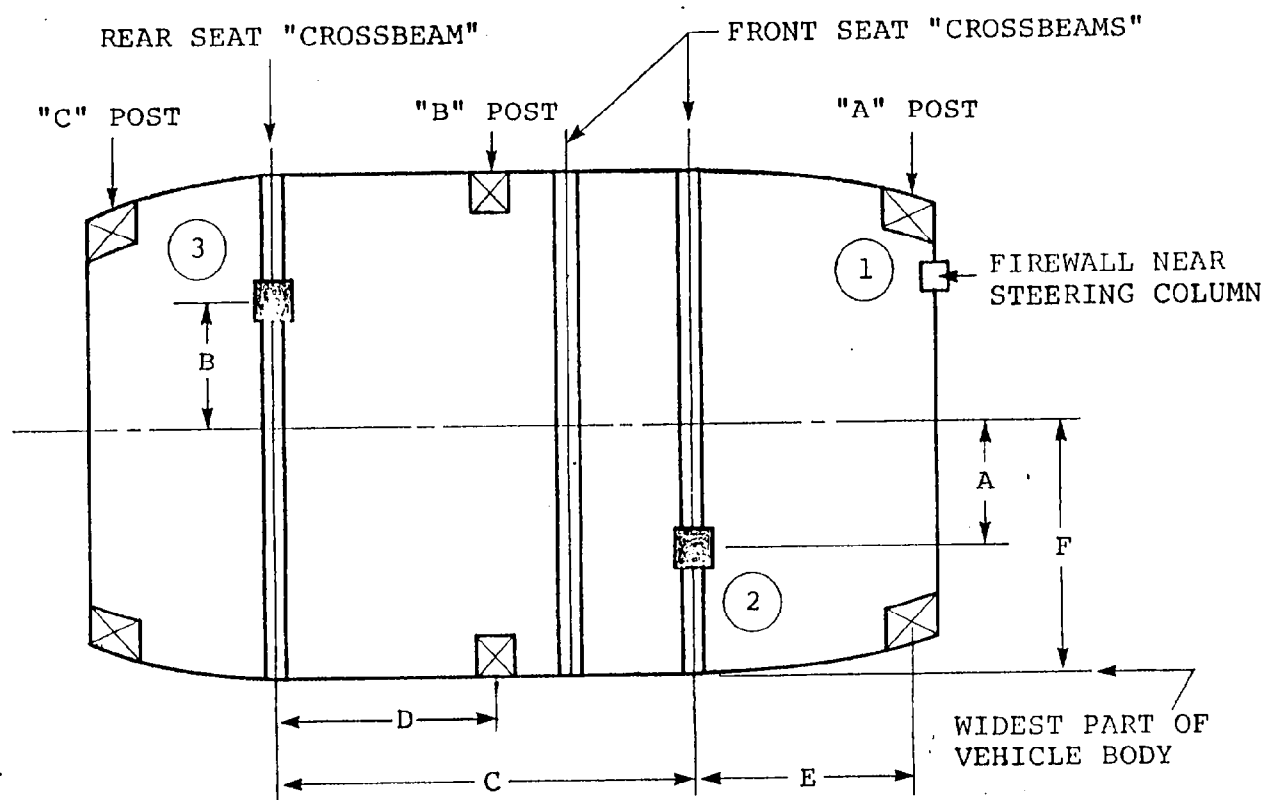
	Driver				Passenger							
	Positive* Direction		Negative* Direction		Positive* Direction		Negative* Direction					
	Peak G	Time (msec)	Peak G	Time (msec)	Peak G	Time (msec)	Peak G	Time (msec)				
Head Acceleration												
Longitudinal	3.73	31	65.68	116	26.90	193	71.46	147				
Lateral	10.54	152	13.89	120	61.28	108	79.49	93				
Vertical	35.60	94	10.58	132	52.07	109	10.96	10				
Resultant	66.65	116			86.86	93						
HIC	607.3 (70-134msec)				744 (74- 200msec)**							
Chest Acceleration												
Longitudinal	.86	195	37.28	88	5.64	183	33.96	102				
Lateral	5.48	102	5.07	77	3.85	200	10.30	128				
Vertical	15.58	69	23.56	124	11.50	76	17.13	138				
Resultant	37.40	88			35.13	102						
SEVERITY INDEX	295.83				266.20							
Belt Loads	(lb)	Time (msec)			(lb)	Time (msec)						
Lap	1238	84			1004	77						
Torso	1091	78			1259	90						
Vehicle Impact Speed (mph): 29.84												
*Positive Direction - Longitudinal: Forward Lateral: Rightward Vertical: Downward Negative Direction - Longitudinal: Rearward Lateral: Leftward Vertical: Upward												

**Anomalous electrical spikes show up in the passenger head acceleration data. These spikes were smoothed to the level of the surrounding data in order to compute the HIC shown here.

VEHICLE STRUCTURAL DATA

VEHICLE Oldsmobile Cutlass NHTSA NO. 780115
 TEST SPEED 29.84 mph TEST DATE May 4, 1978

00087608



DIMENSIONS								
Location		Measurement (in.)		Location		Measurement (in.)		
A		14.0		D		2.5		
B		28.5		E		10.5		
C				F		.		
Steering Column Movement (in.) .2 Forward, .4 Down								
Vehicle Overall Crush (in.) 24.15								
Test Weight (lb) 3846								
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		6.29	111	30.07	79	12.1 G	2.57	98
No. 3 Longitudinal		3.69	163	29.30	84	11.3 G	2.67	100
No. 3 Vertical		6.74	28	8.67	117			
*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 29.84 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 45.5 inches. The average overall static crush of the vehicle was 24.15 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:

- The front fenders impacted both front wheels
- The steering wheel deformed at the top
- Roof damage was noted to the "B" pillar



Figure 3-1. Pre-test View of Driver Dummy - 1978 Oldsmobile Cutlass Two-Door Sedan -
NHTSA 780115.



Figure 3-2. Pre-test View of Passenger Dummy - 1978 Oldsmobile Cutlass Two-Door Sedan - NHTSA 780115.

E9LE8



Figure 3-3. Post-test View of Driver Dummy - 1978 Oldsmobile Cutlass Two-Door Sedan - NHTSA 780115.



Figure 3-4. Post-test View of Passenger Dummy - 1978 Oldsmobile Cutlass Two-Door Sedan - NHTSA 780115.

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)
<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	$\pm 7.5\%$	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	$\pm .5\%$ @ 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.

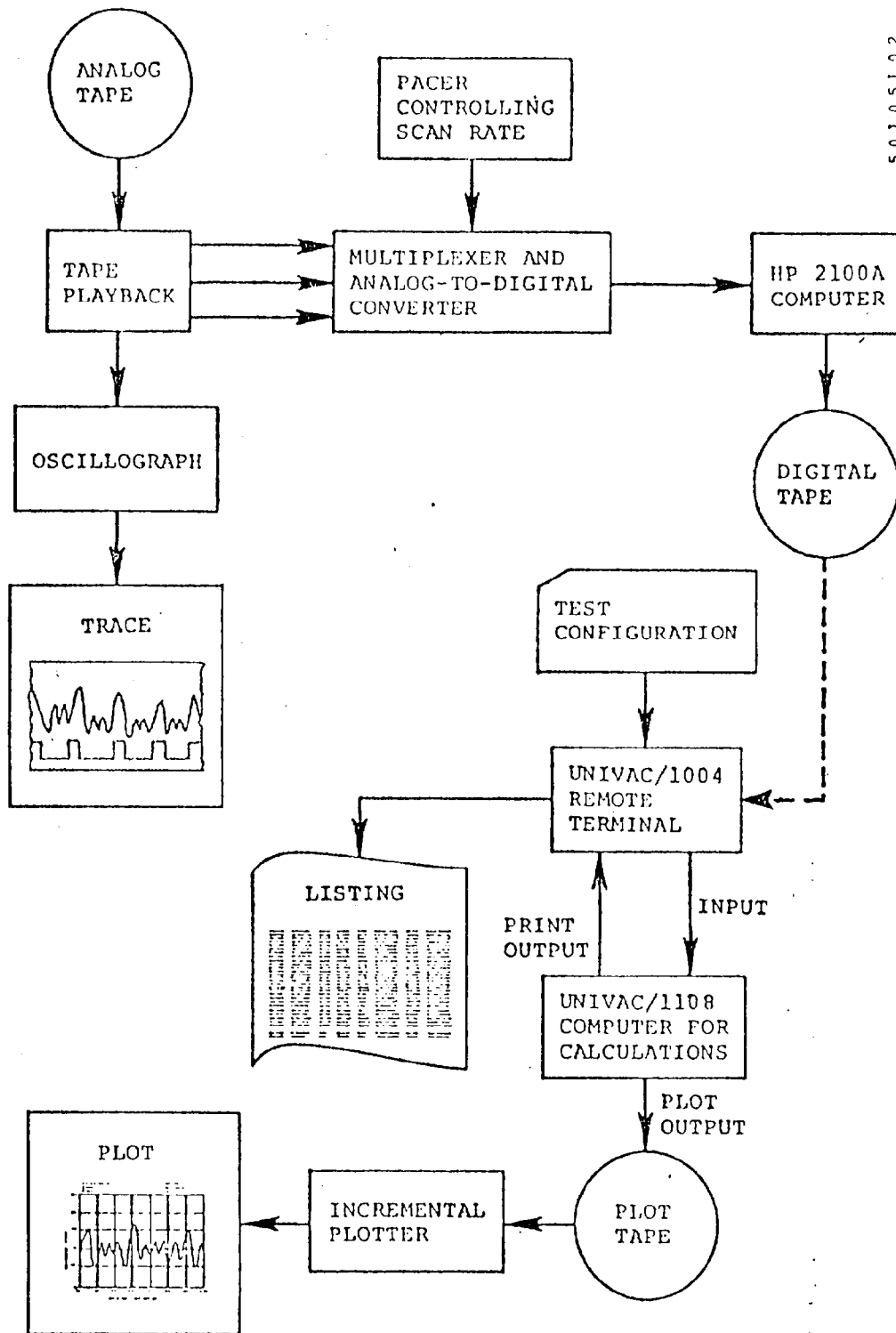


Figure 4-1. Data Reduction Flow Diagram.

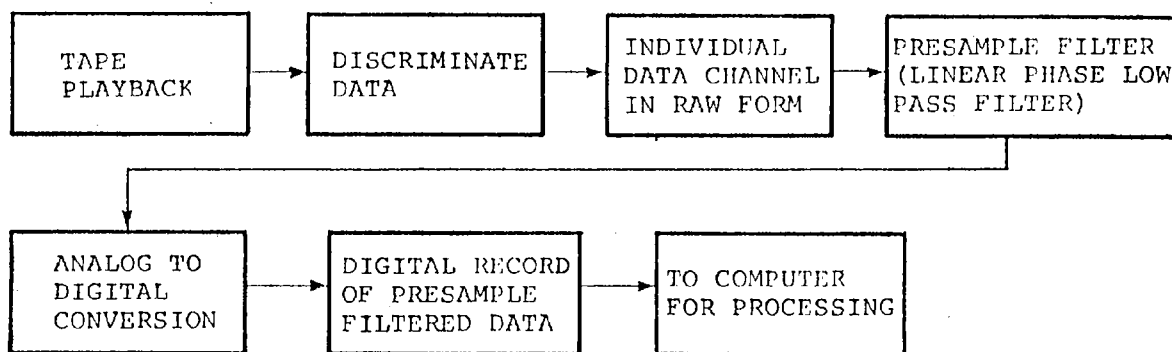


Figure 4-2. Flow of Individual Data Channel.

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

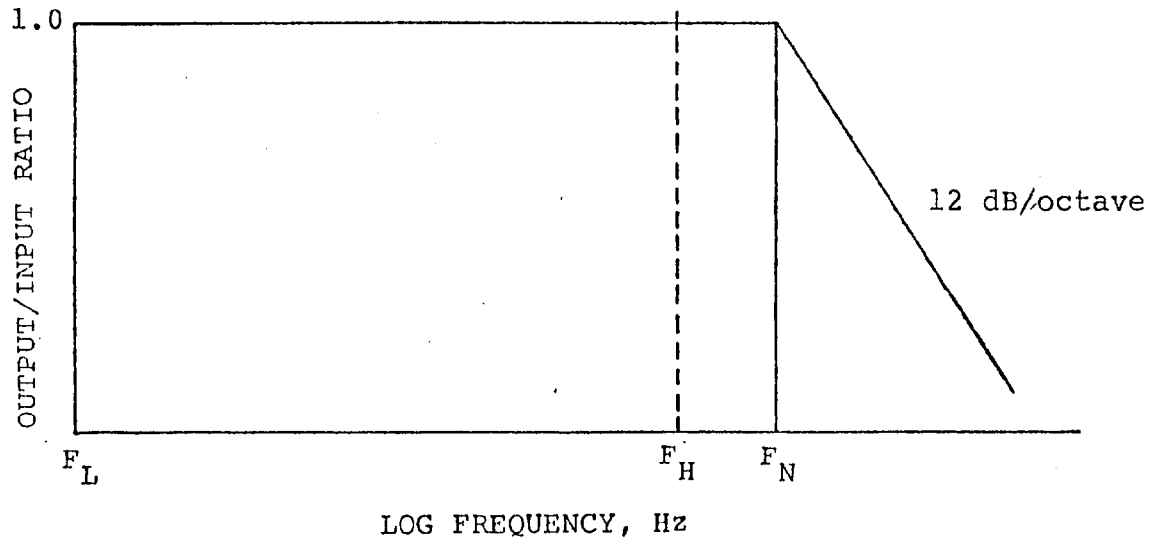
Item	Data Class	Presample Filter (3dB Frequency)	Sampling Rate	Digital Filter Cutoff Frequency
Chest Accelerations	180	250	1000	Not Filtered
Head Accelerations	1000	2000 Hz	8000	1650

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



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.

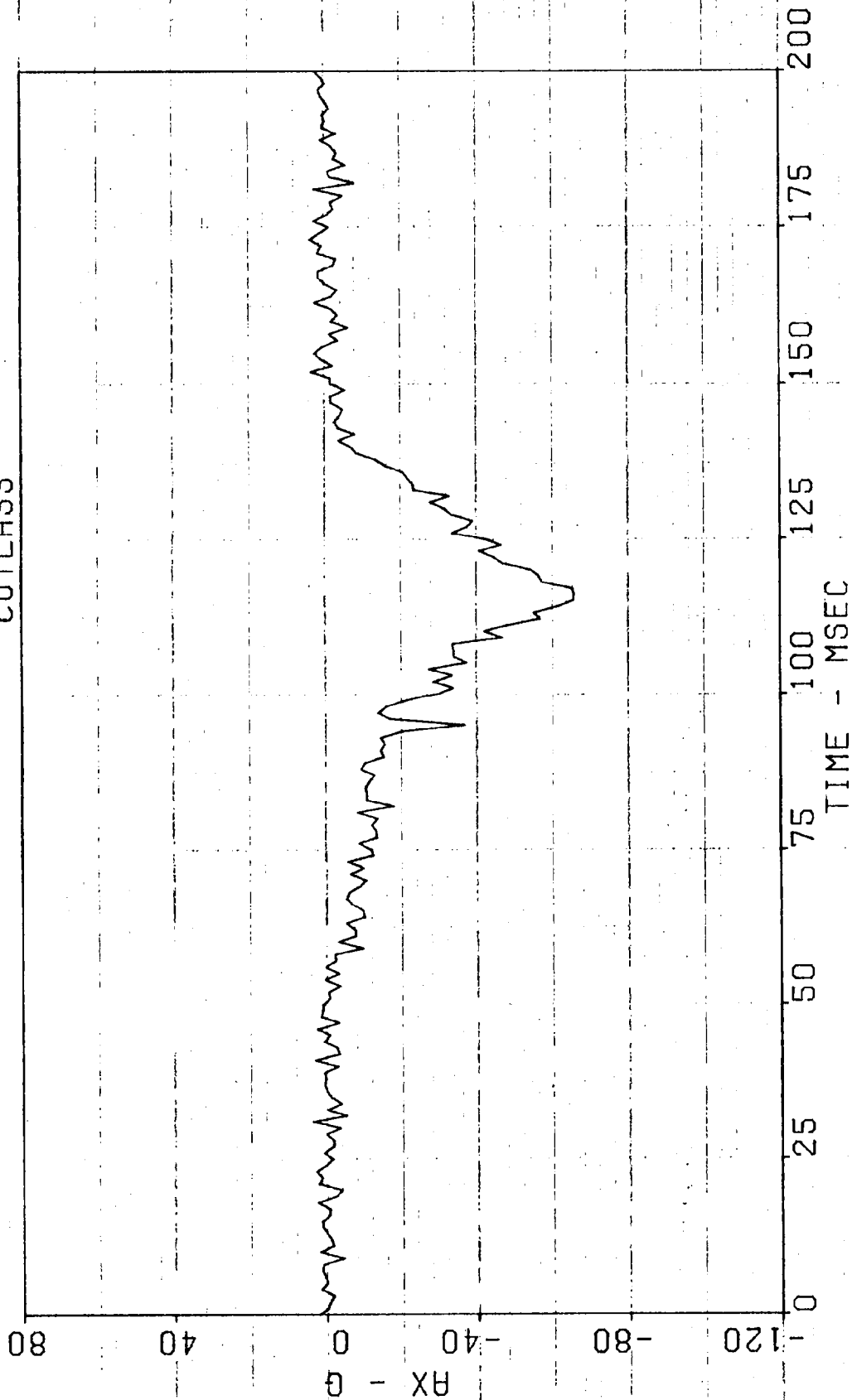
APPENDIX

CALCOMP PLOTS

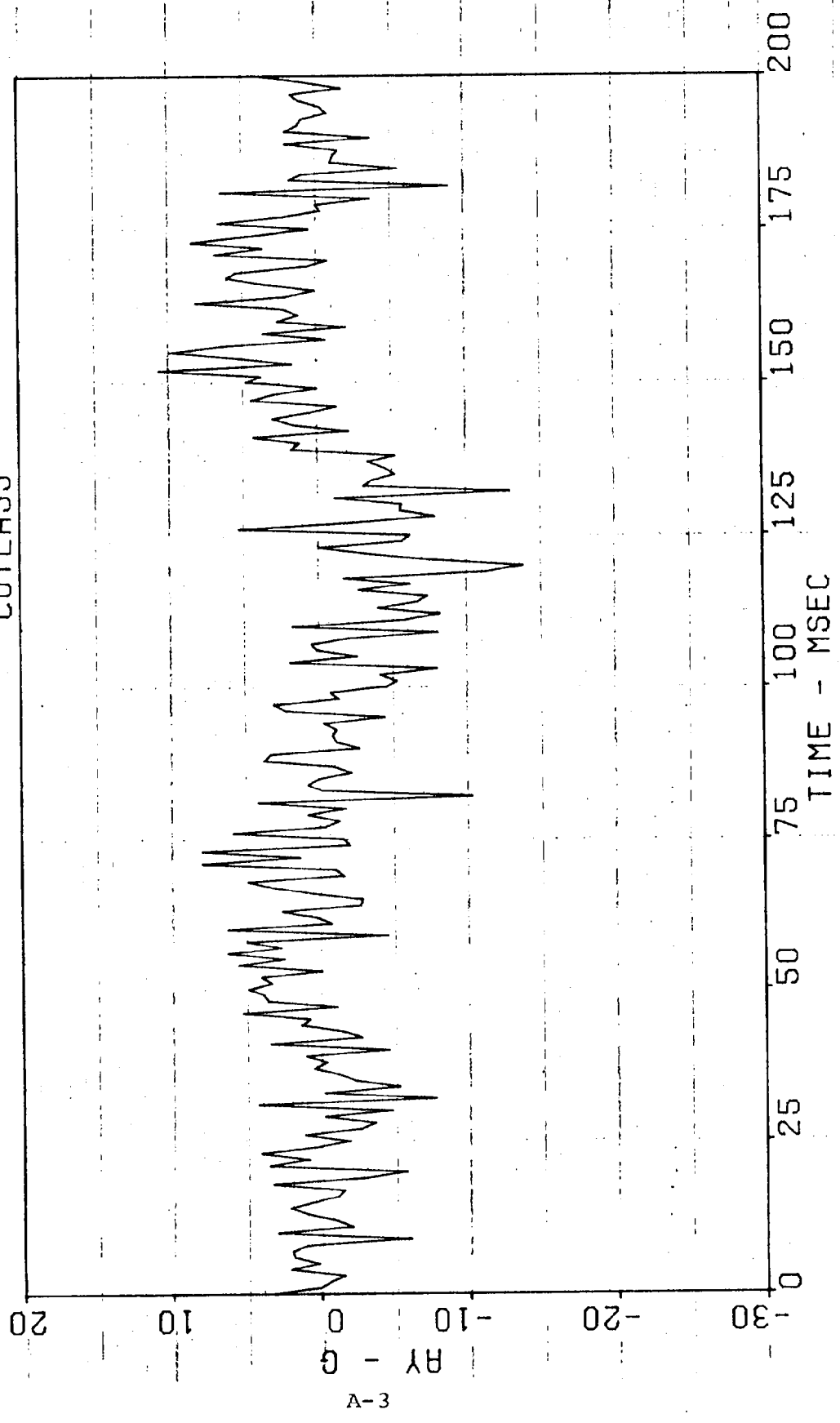
The following location numbers are used in the CalComp plot titles to identify transducer locations:

<u>Location</u>	<u>Number</u>
Driver Head Accelerometer	501
Driver Chest Accelerometer	1101
Driver Lap Belt Load Cell	4101
Driver Torso Belt Load Cell	4111
Passenger Head Accelerometer	503
Passenger Chest Accelerometer	1103
Passenger Lap Belt Load Cell	4103
Passenger Torso Belt Load Cell	4133
Occupant Compartment Front Accelerometer	102
Occupant Compartment Rear Accelerometer	104

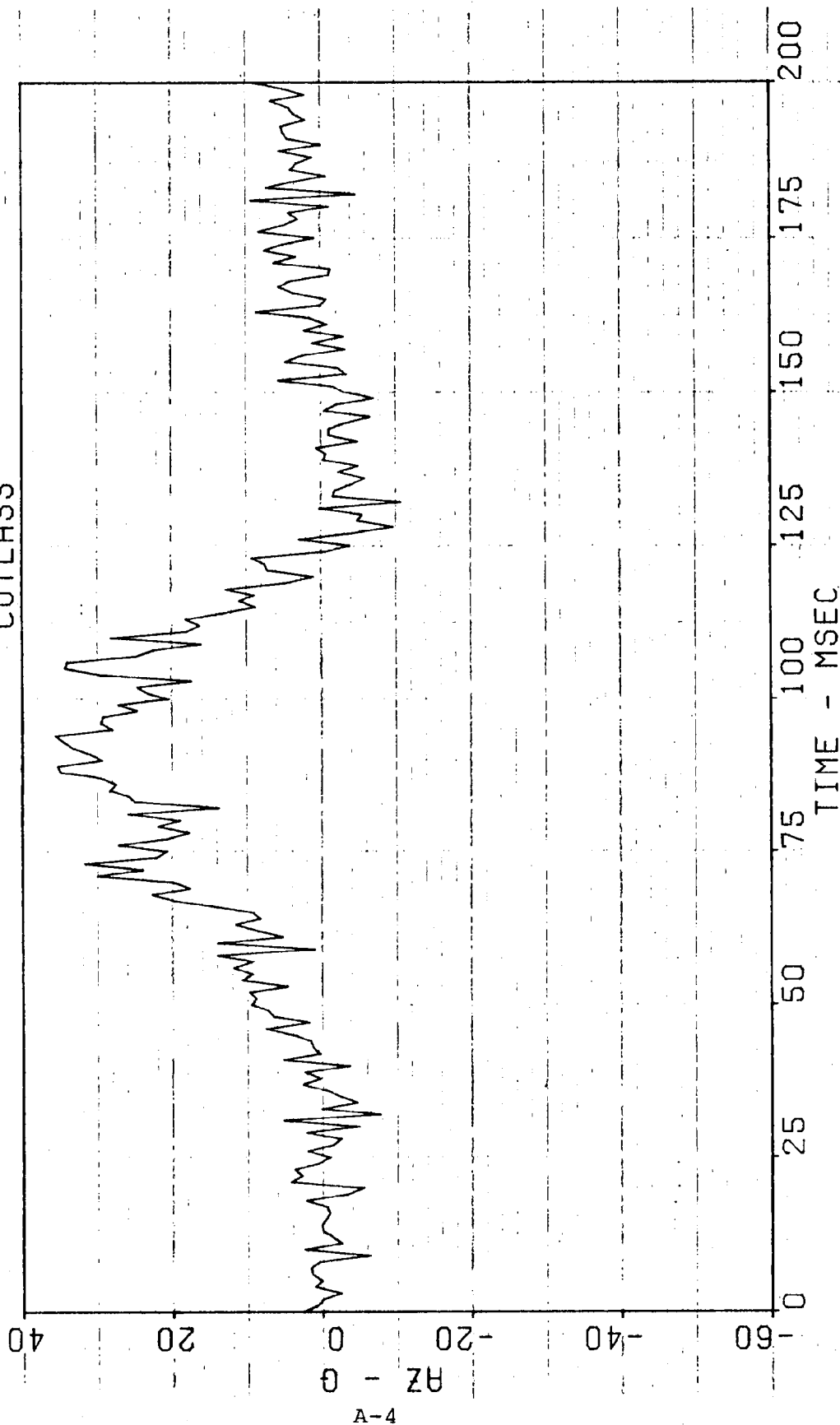
DATE 5-4-78 FILTER 1600 LOCATION 501 TEST NO 051678
FRONT/BARR CUTLASS



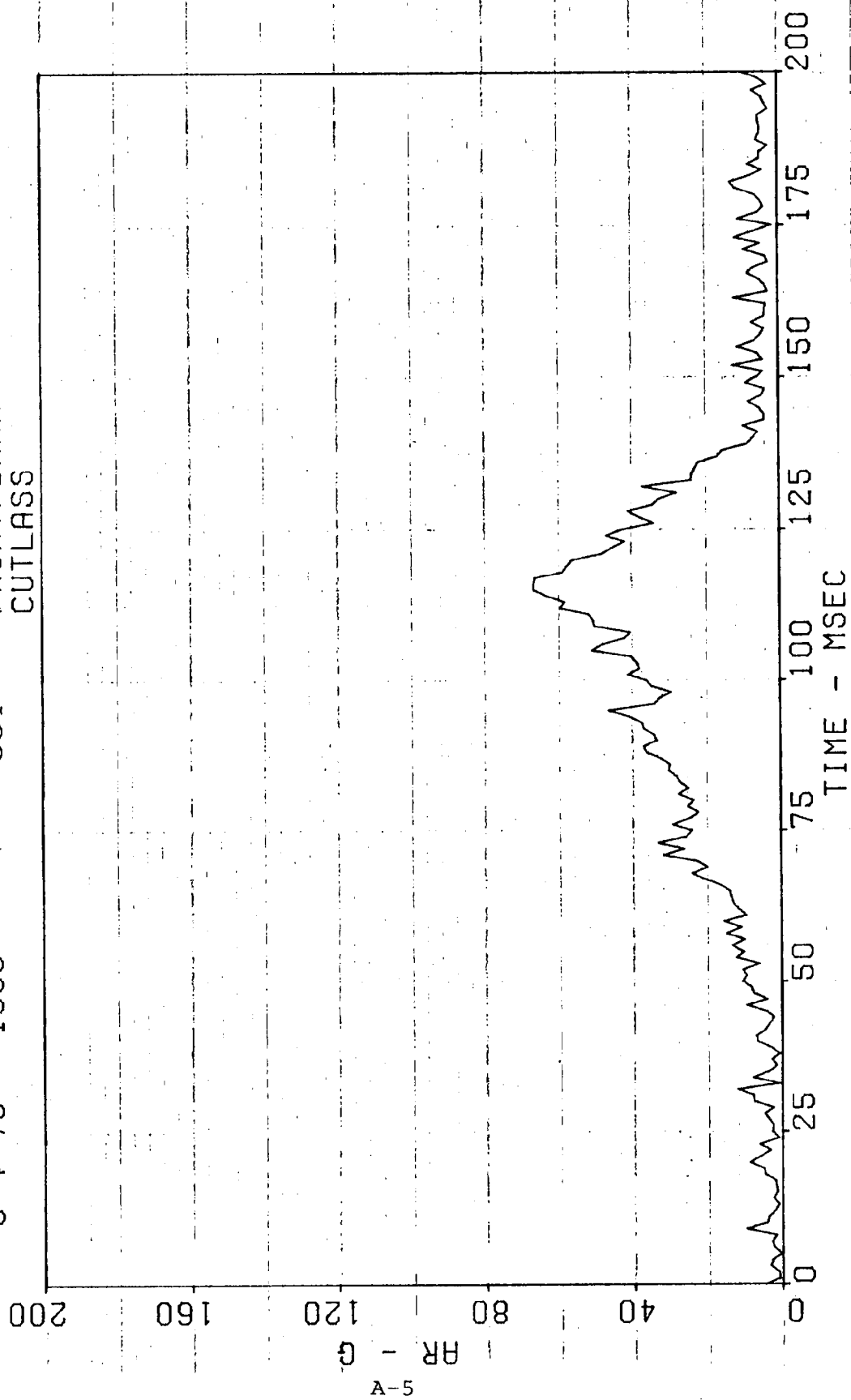
DATE 5-4-78 FILTER 1600 LOCATION 501 TEST NO 051678
FRONT/BARR CUTLASS



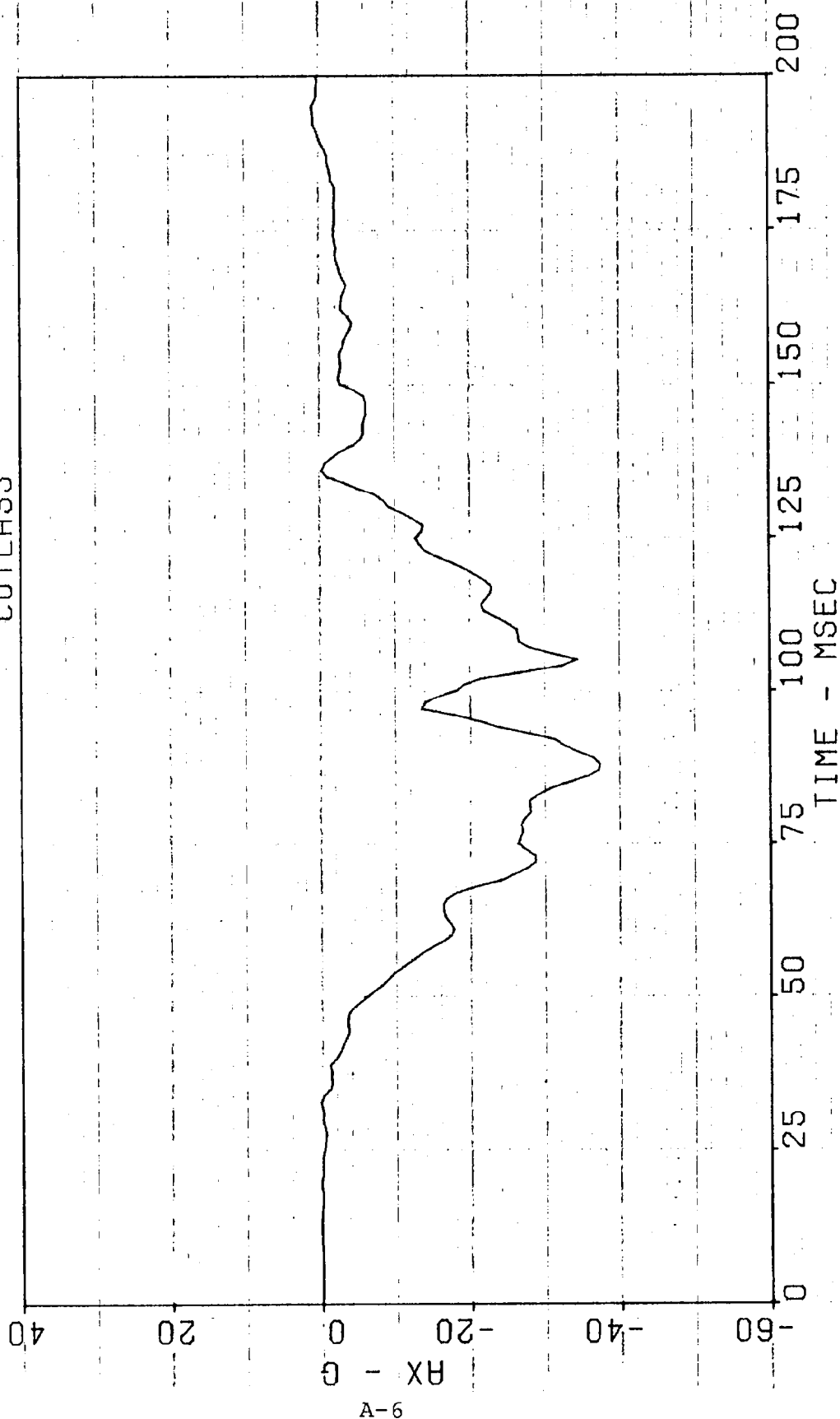
DATE 5-4-78 FILTER 1600 LOCATION 501 TEST NO 051678
FRONT/BARR CUTLASS



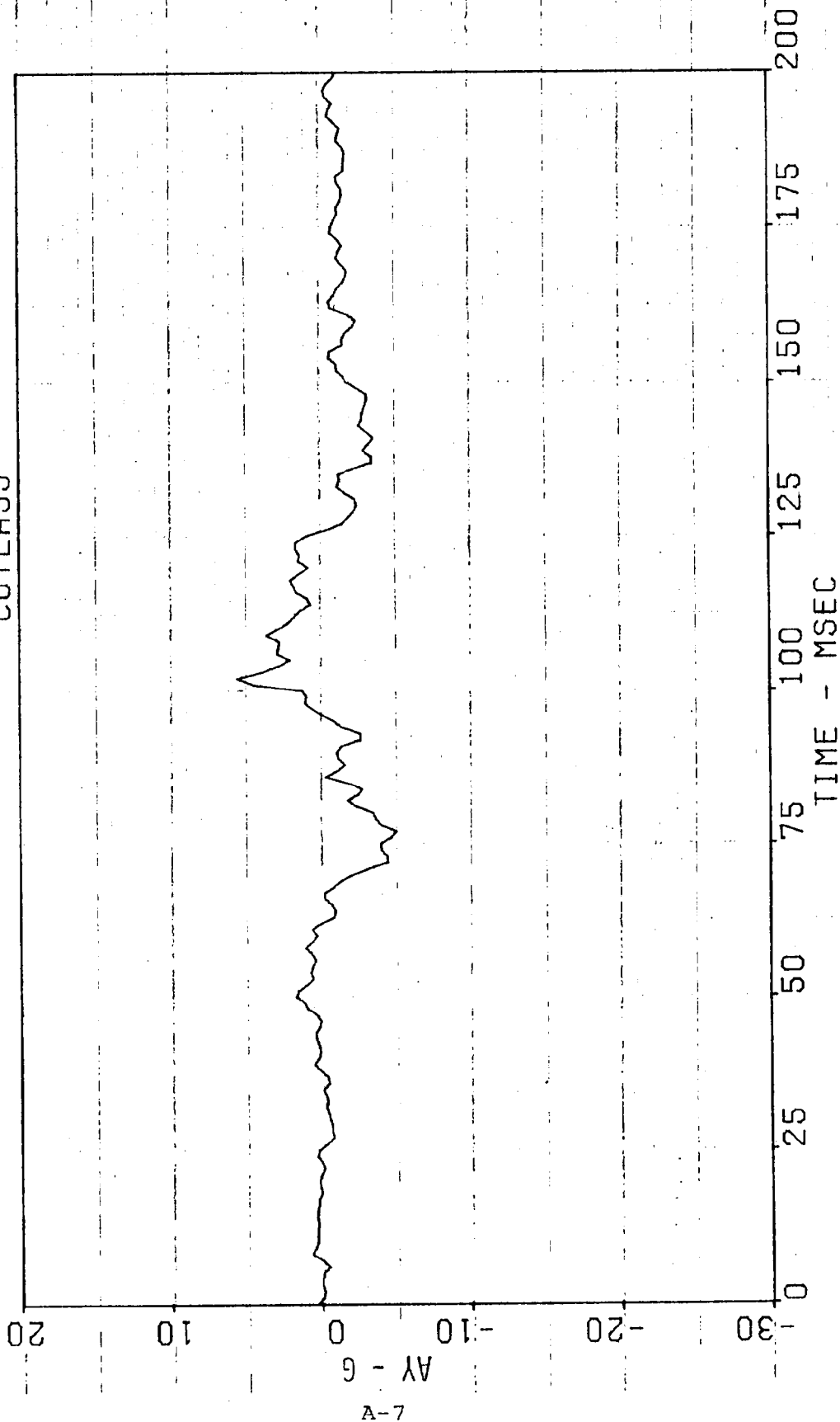
DATE 5-4-78 FILTER 1600 LOCATION 501 TEST NO 051678
FRONT/BARR CUTLASS



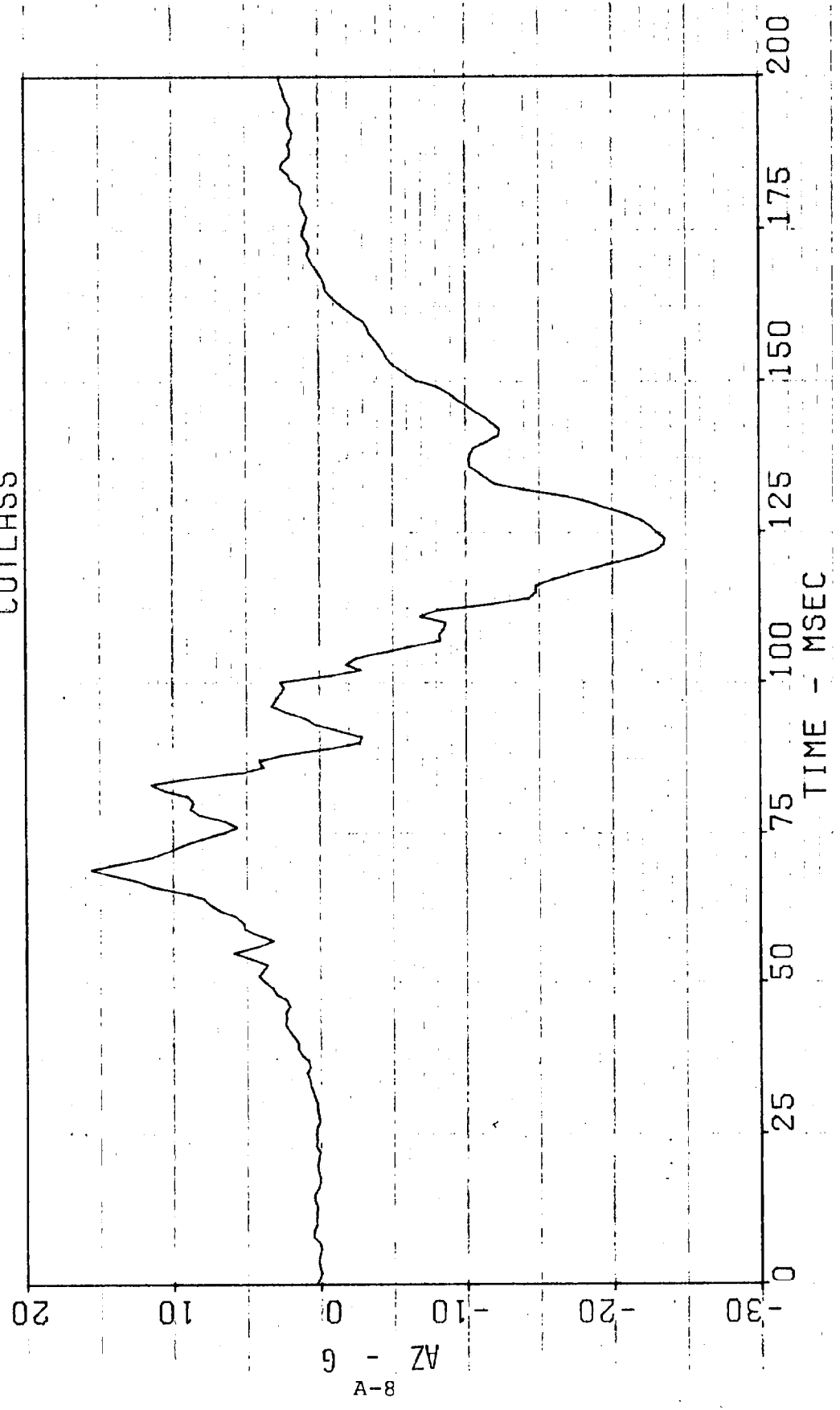
DATE 5-4-78 FILTER 315 LOCATION 1101 TEST NO 051678
FRONT/BARR CUTLASS



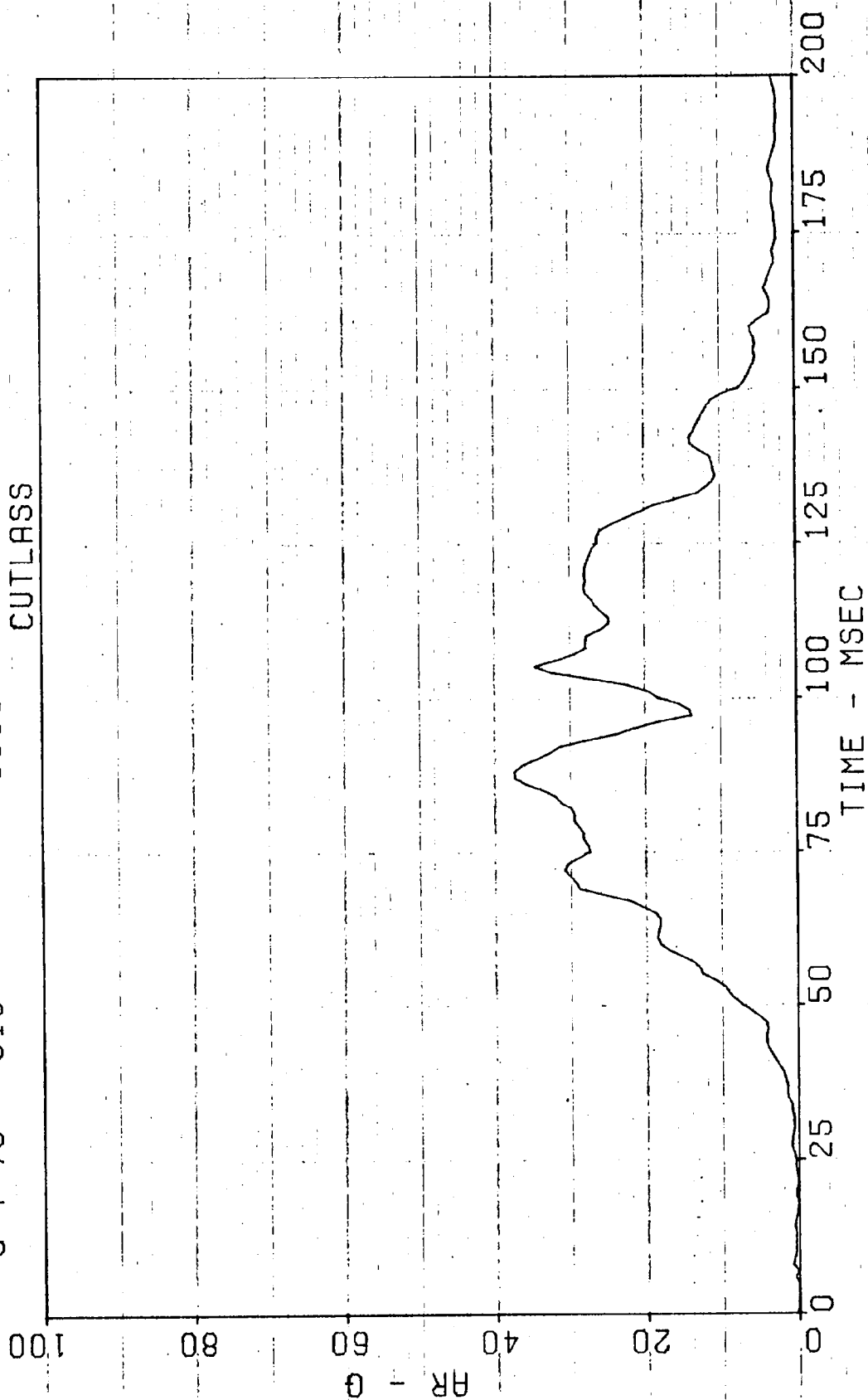
DATE 5-4-78 FILTER 315 LOCATION 1101 TEST NO 051678
FRONT/BARR CUTLASS



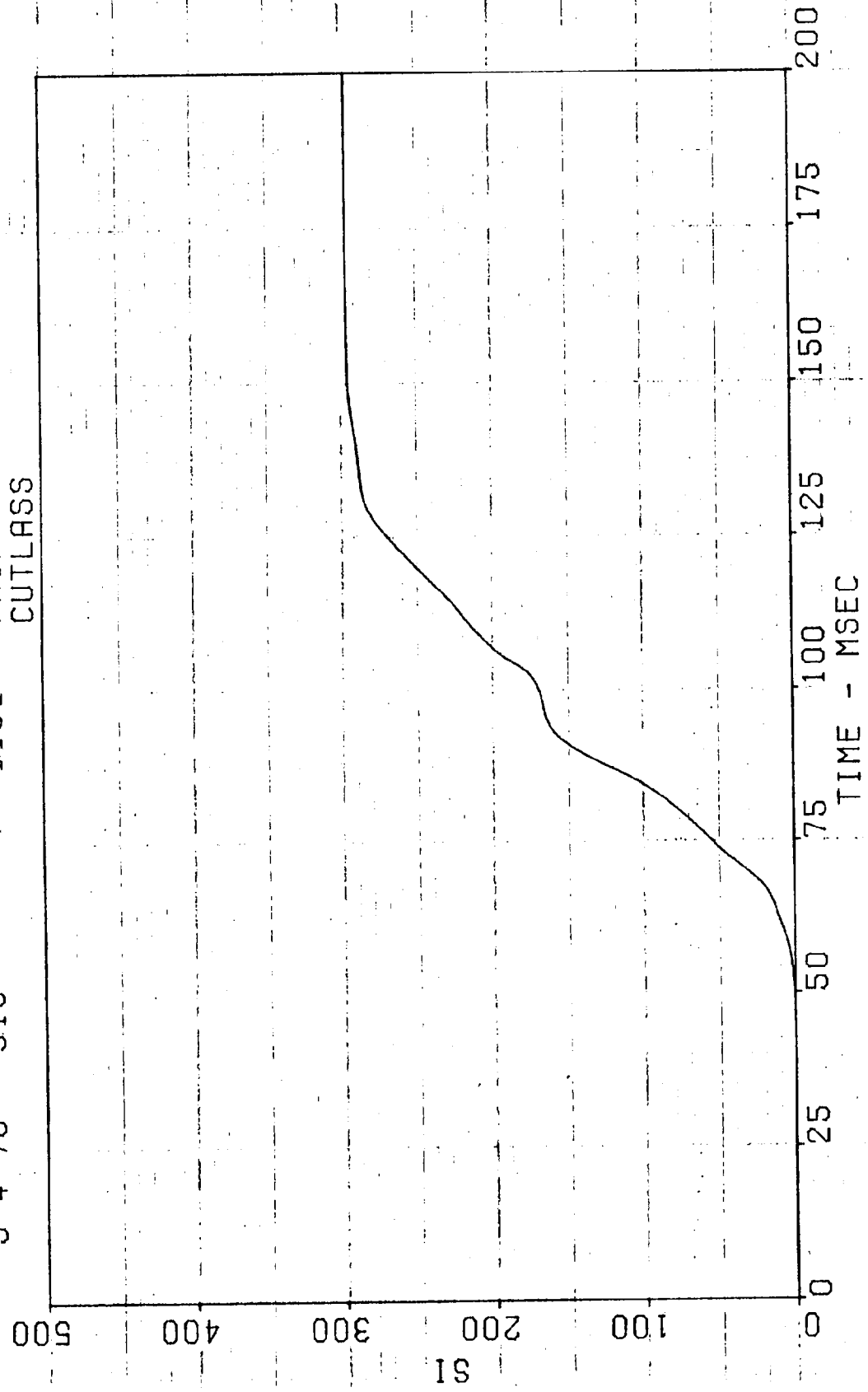
DATE 5-4-78 FILTER 315 LOCATION 1101 TEST NO 051678
FRONT/BARR CUTLASS



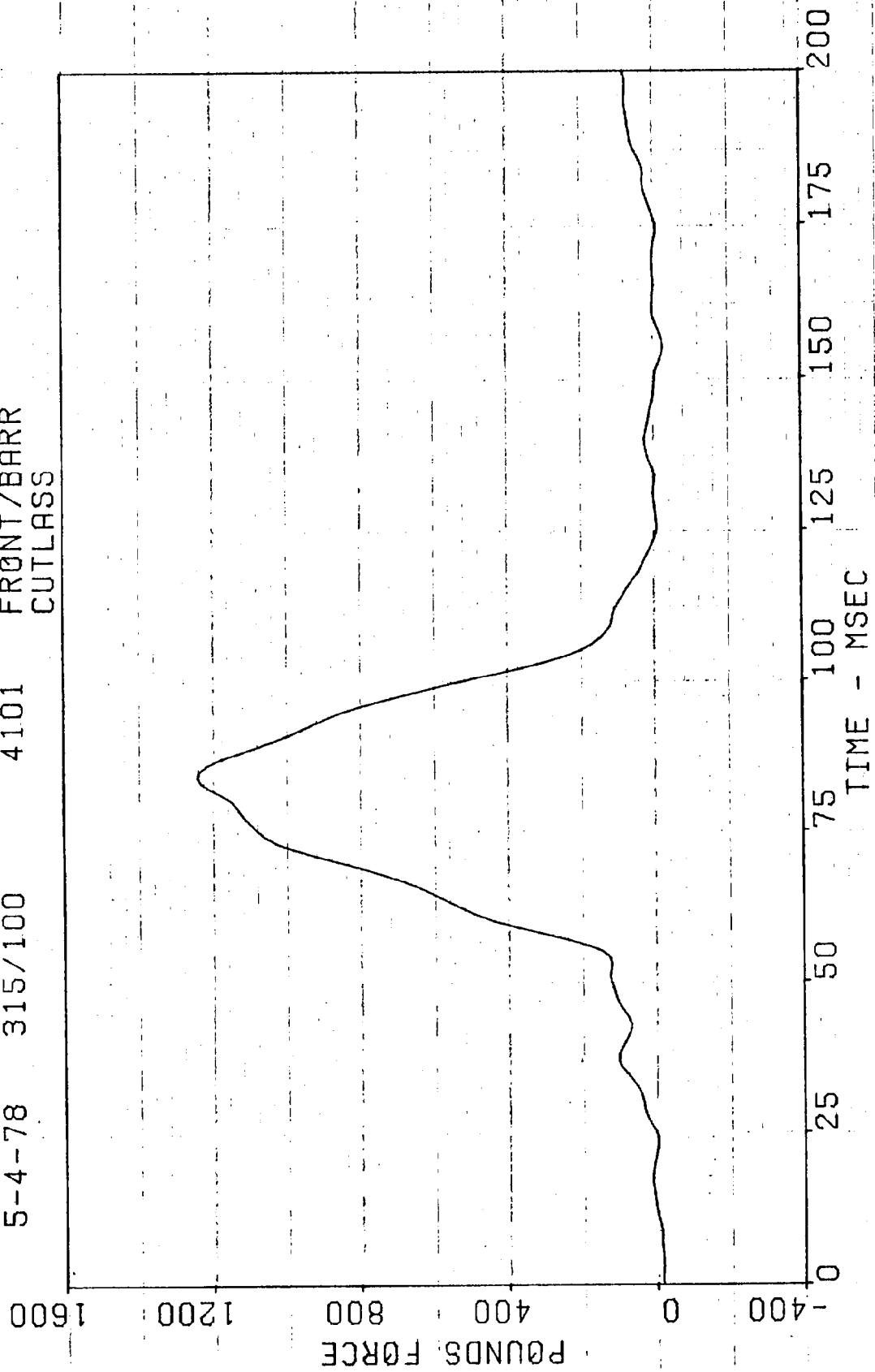
DATE 5-4-78 FILTER 315 LOCATION 1101 TEST NO 051678
FRONT/BARR CUTLASS



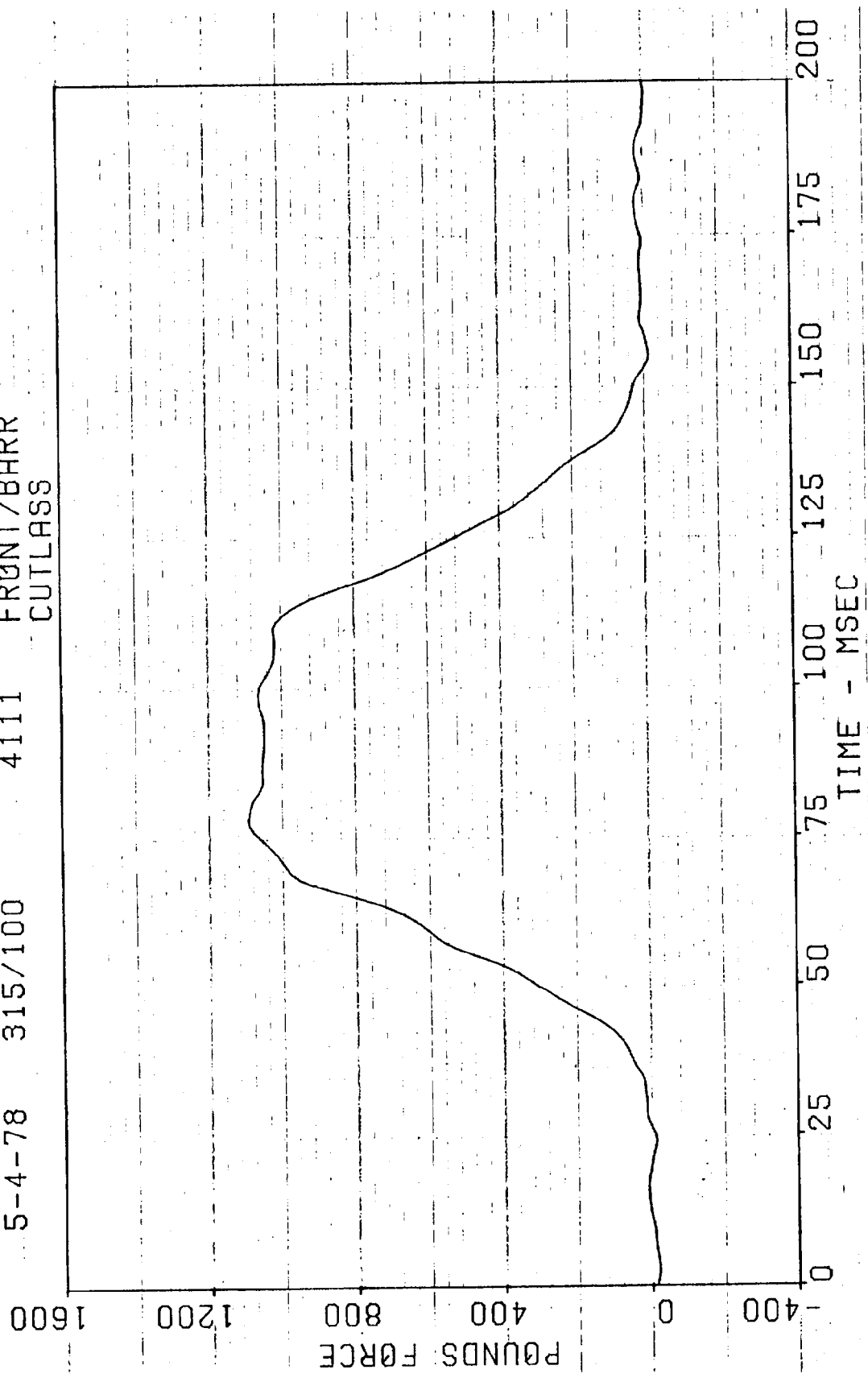
DATE - 5-4-78 FILTER - 315 LOCATION - 1101 TEST NO - 051678
FRONT/BARR
CUTLASS



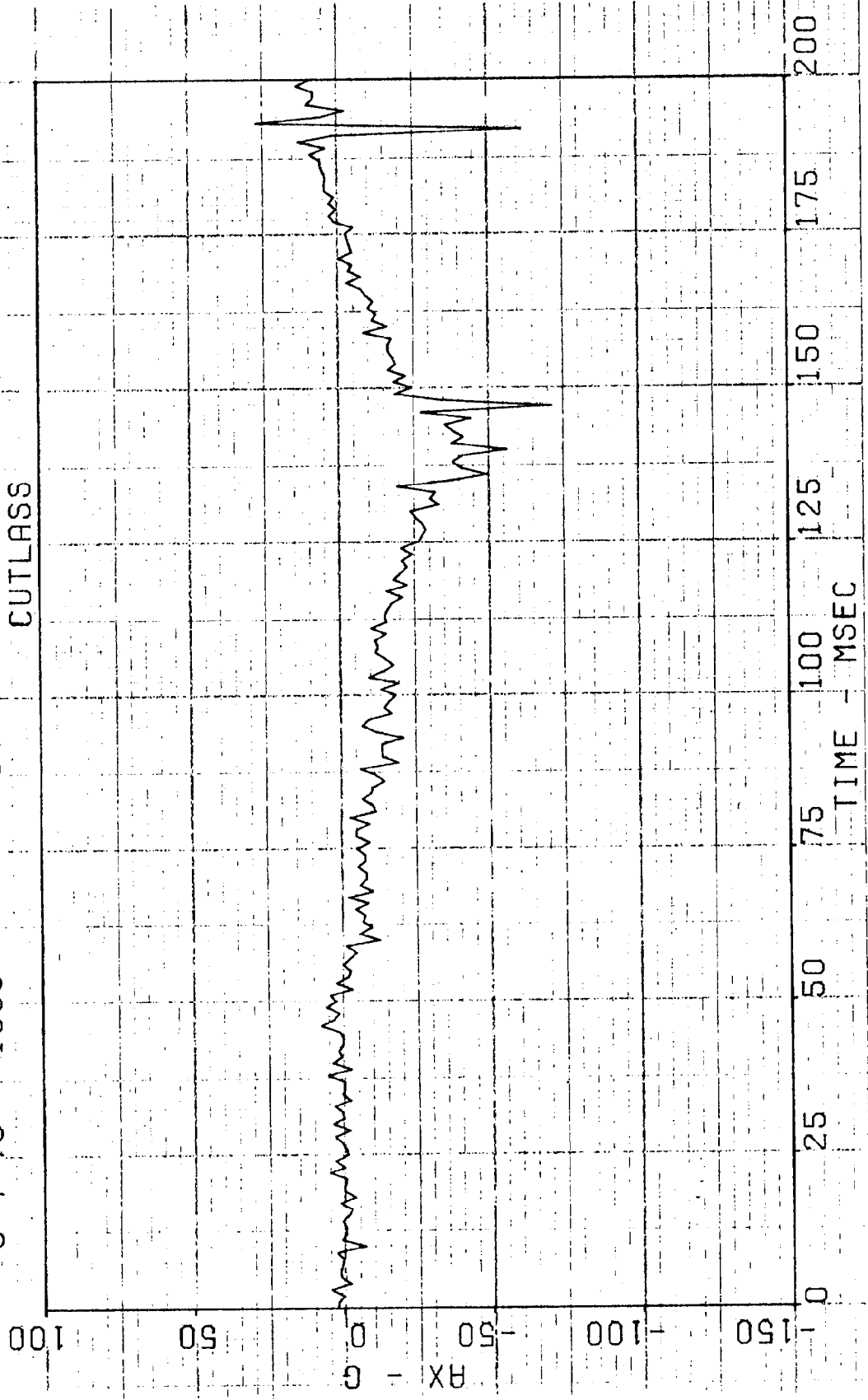
DATE 5-4-78 FILTER 315/100 LOCATION 4101 TEST NO 051678
FRONT/BARR CUTLASS



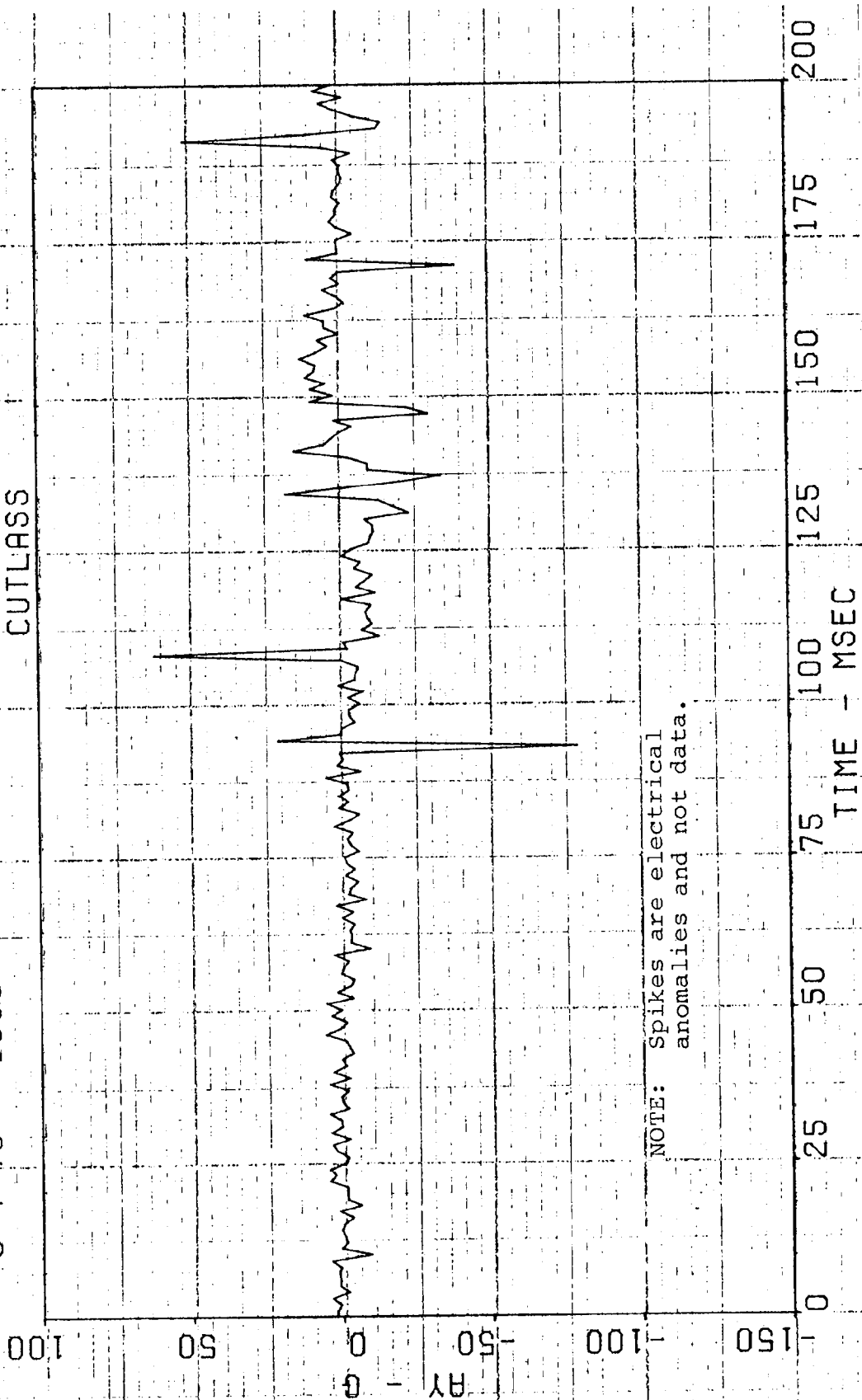
DATE 5-4-78 FILTER 315/100 LOCATION 4111 TEST NO 051678
FRONT/BARR CUTLASS



DATE 5-4-78 FILTER 1600 LOCATION 503 TEST NO 060278
 FRONT/BARR CUTLASS

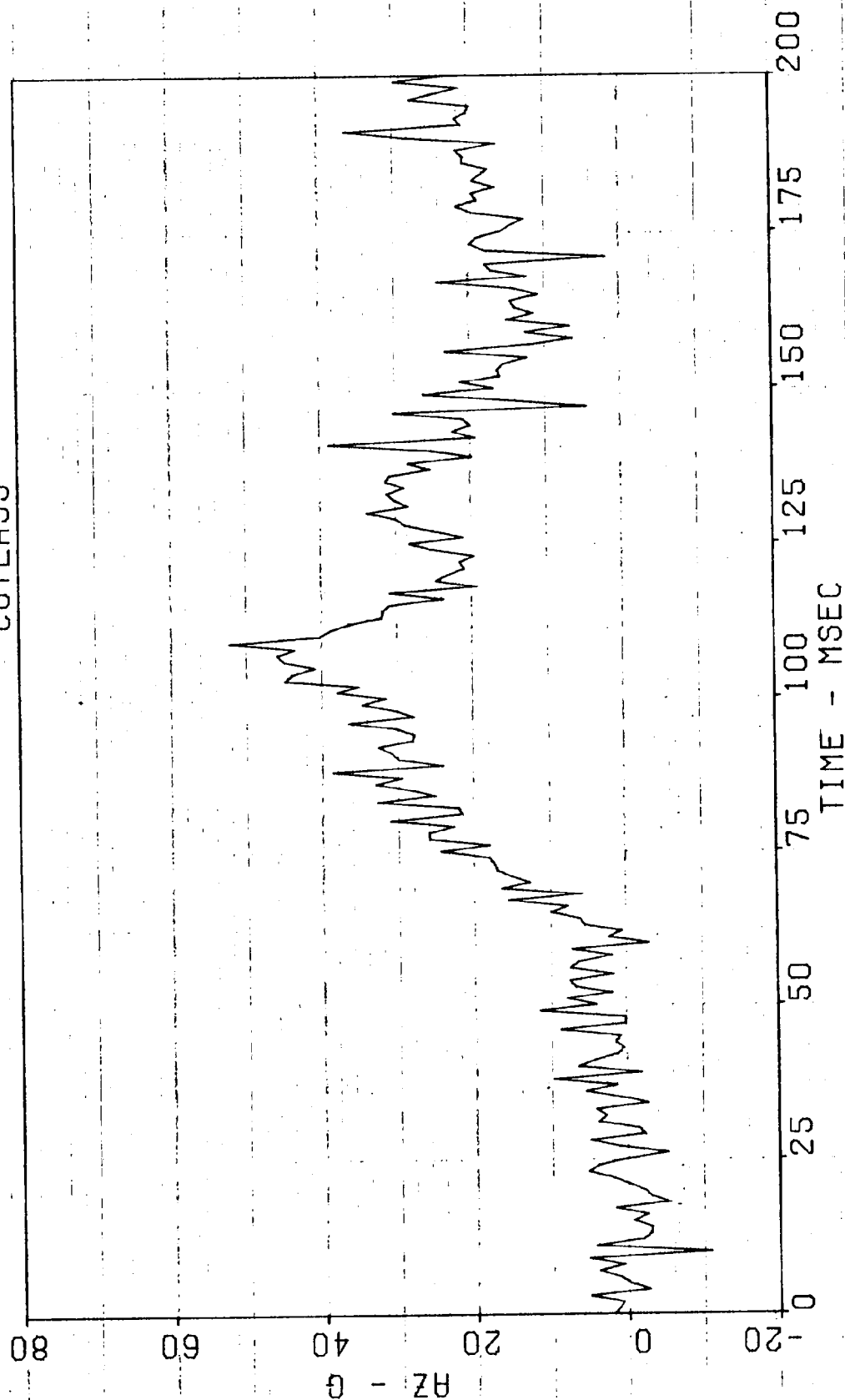


DATE 5-4-78
 FILTER 1600
 LOCATION 503
 TEST NO 060278
 FRONT/BARR
 CUTLASS

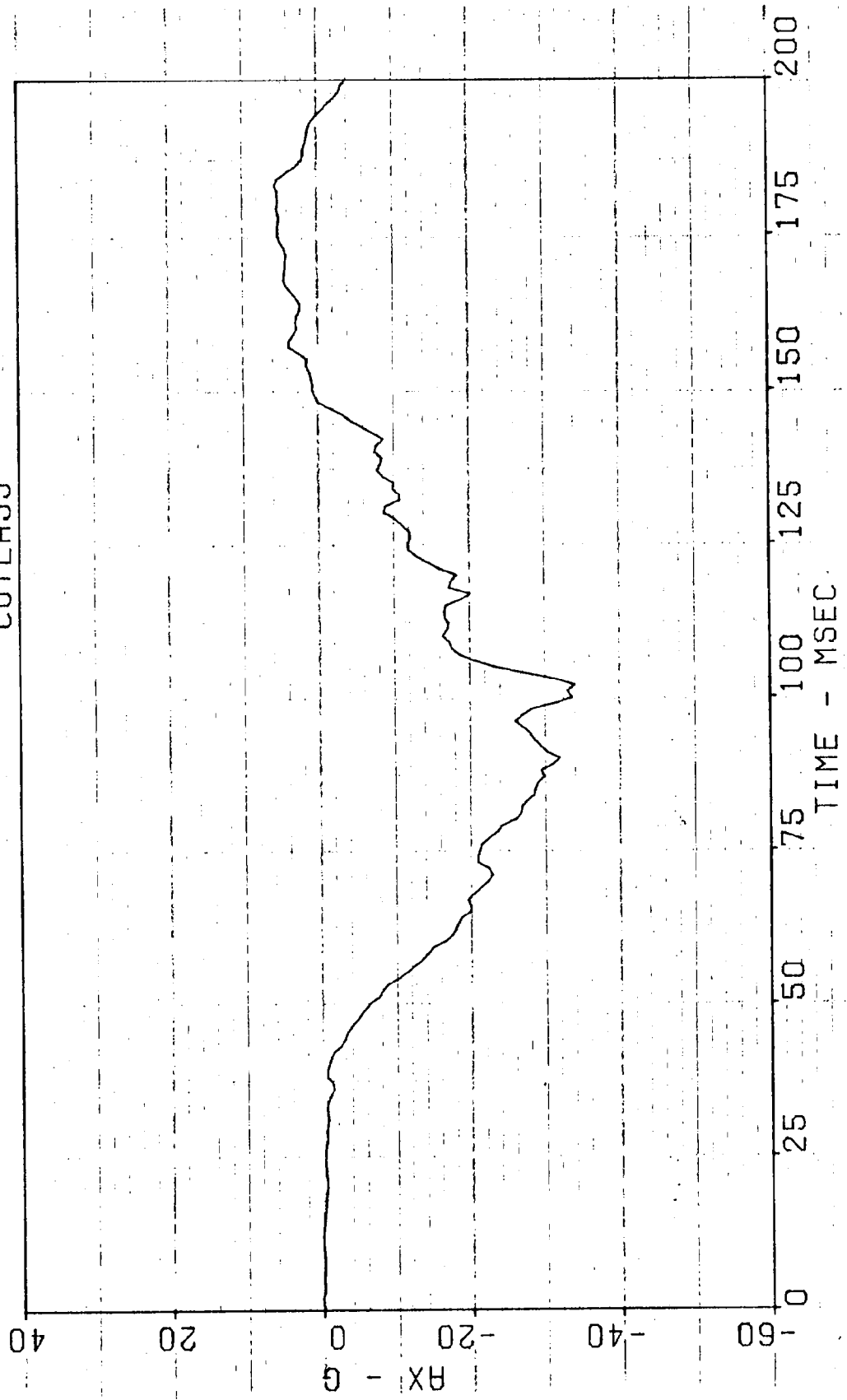


NOTE: Spikes are electrical
 anomalies and not data.

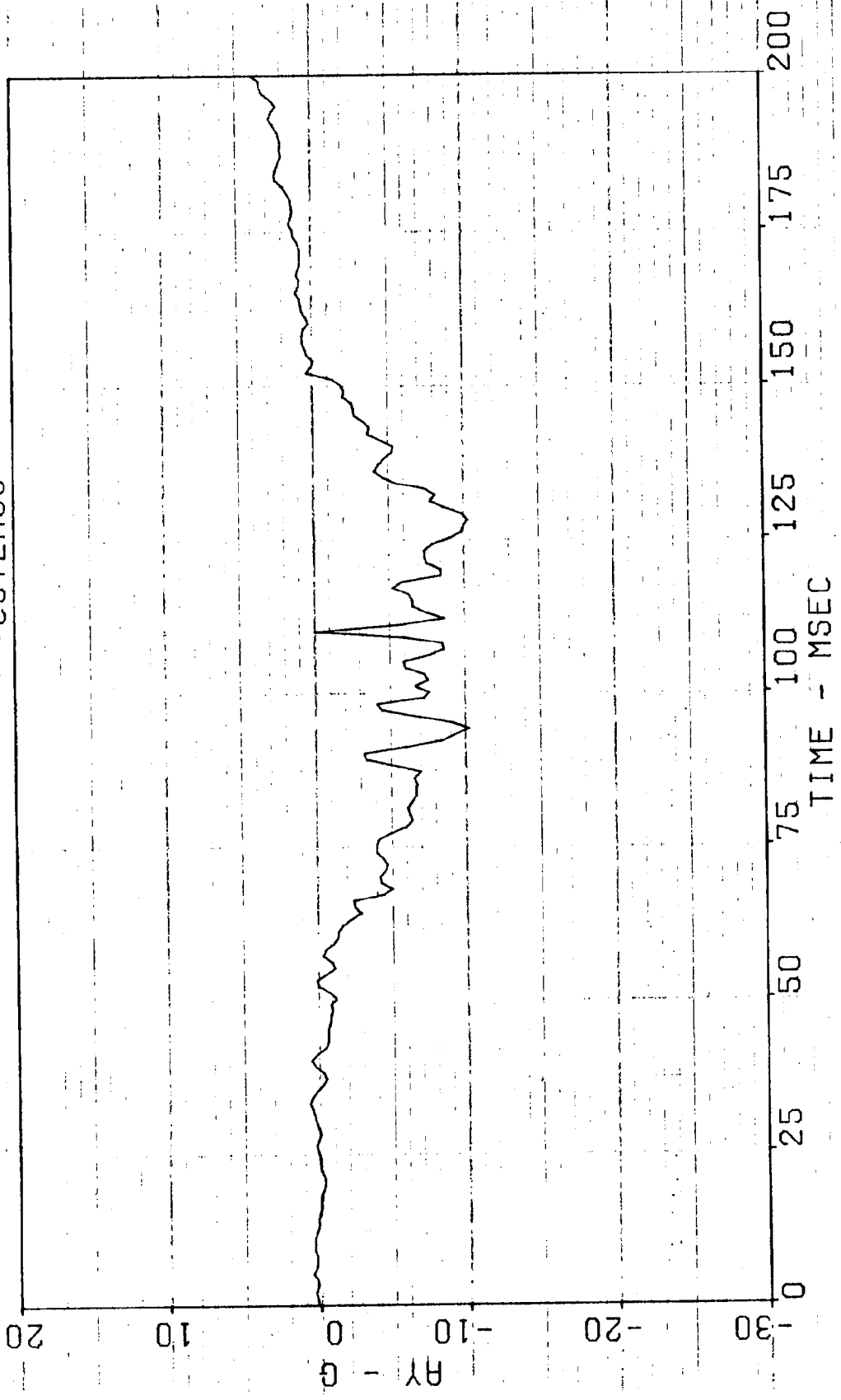
DATE 5-4-78 FILTER 1600 LOCATION 503 TEST NO 051678
FRONT/BARR CUTLASS



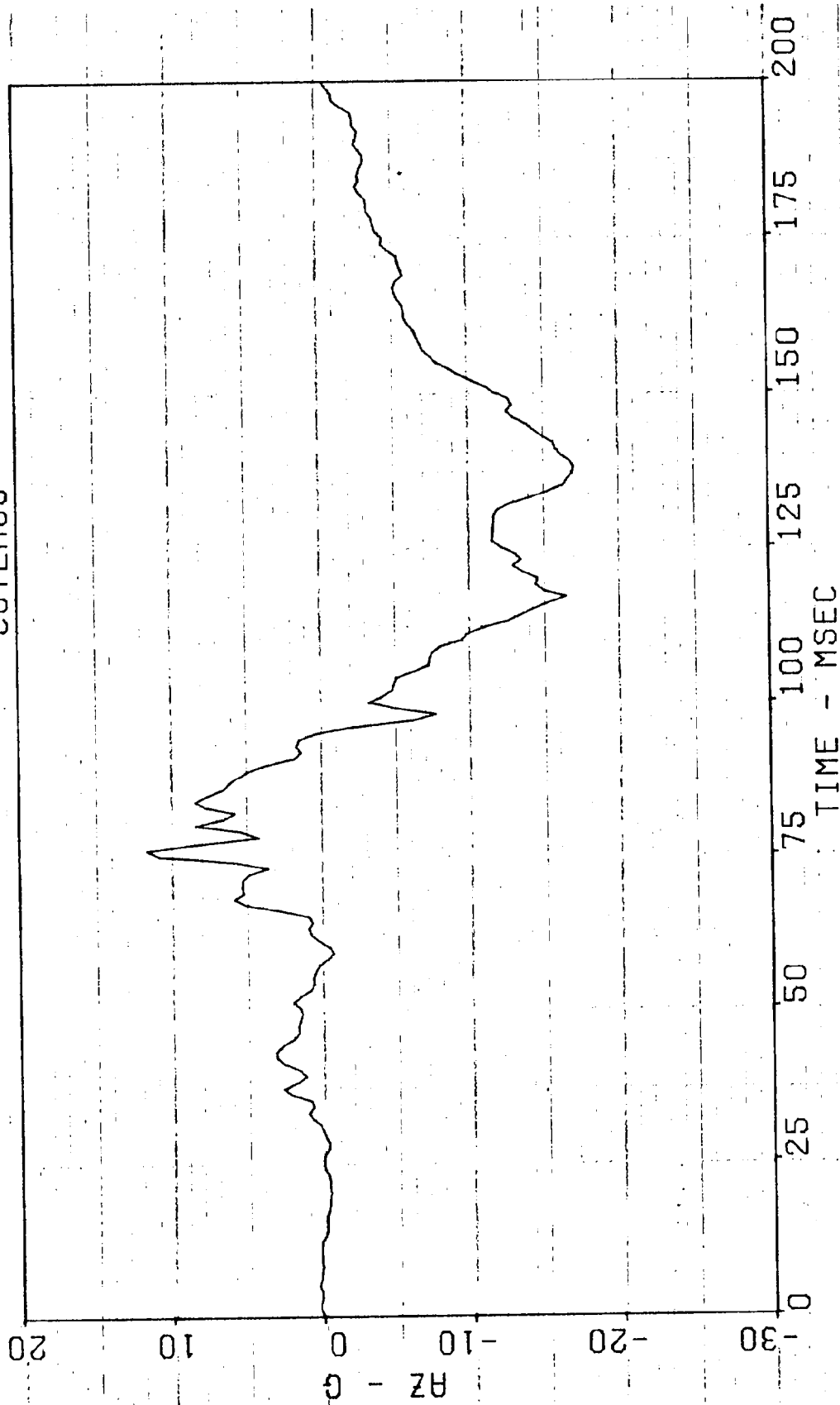
DATE 5-4-78 FILTER 315 LOCATION 1103 TEST NO 051678
FRONT/BARR CUTLASS



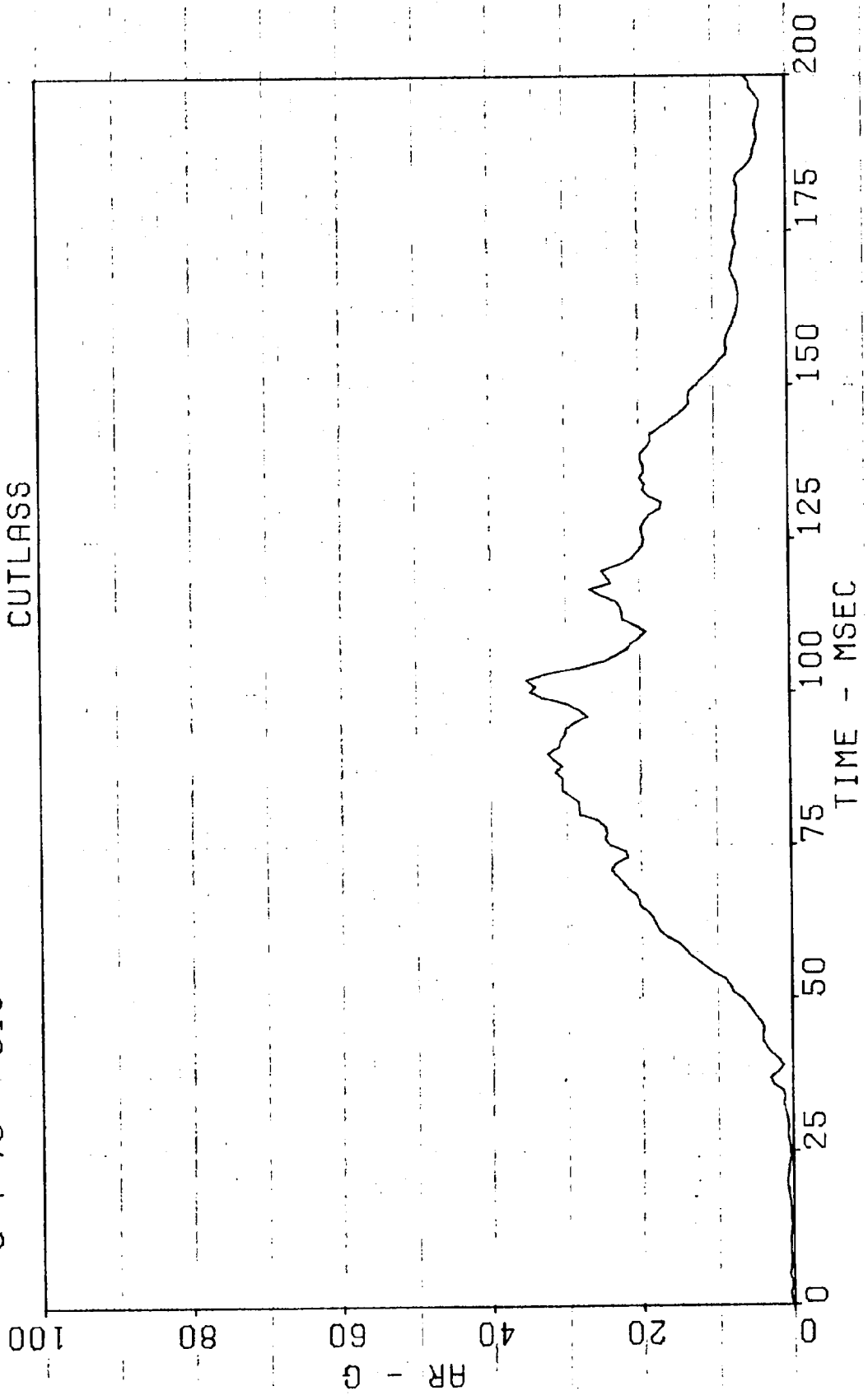
DATE 5-4-78 FILTER 315 LOCATION 1103 TEST NO 051678
FRONT/BARR CUTLASS



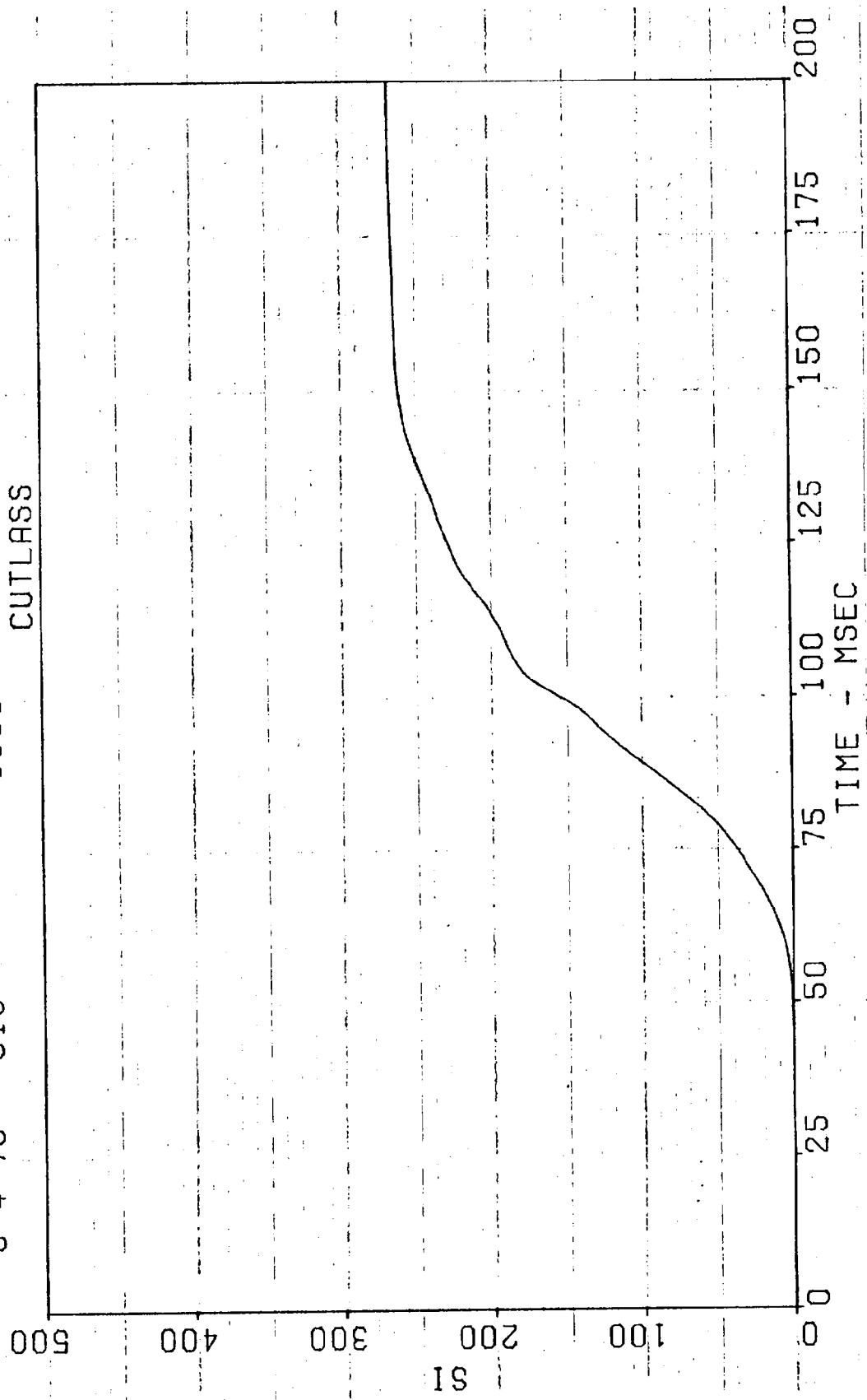
DATE 5-4-78 FILTER 315 LOCATION 1103 TEST NO 051678
FRONT/BARR CUTLASS



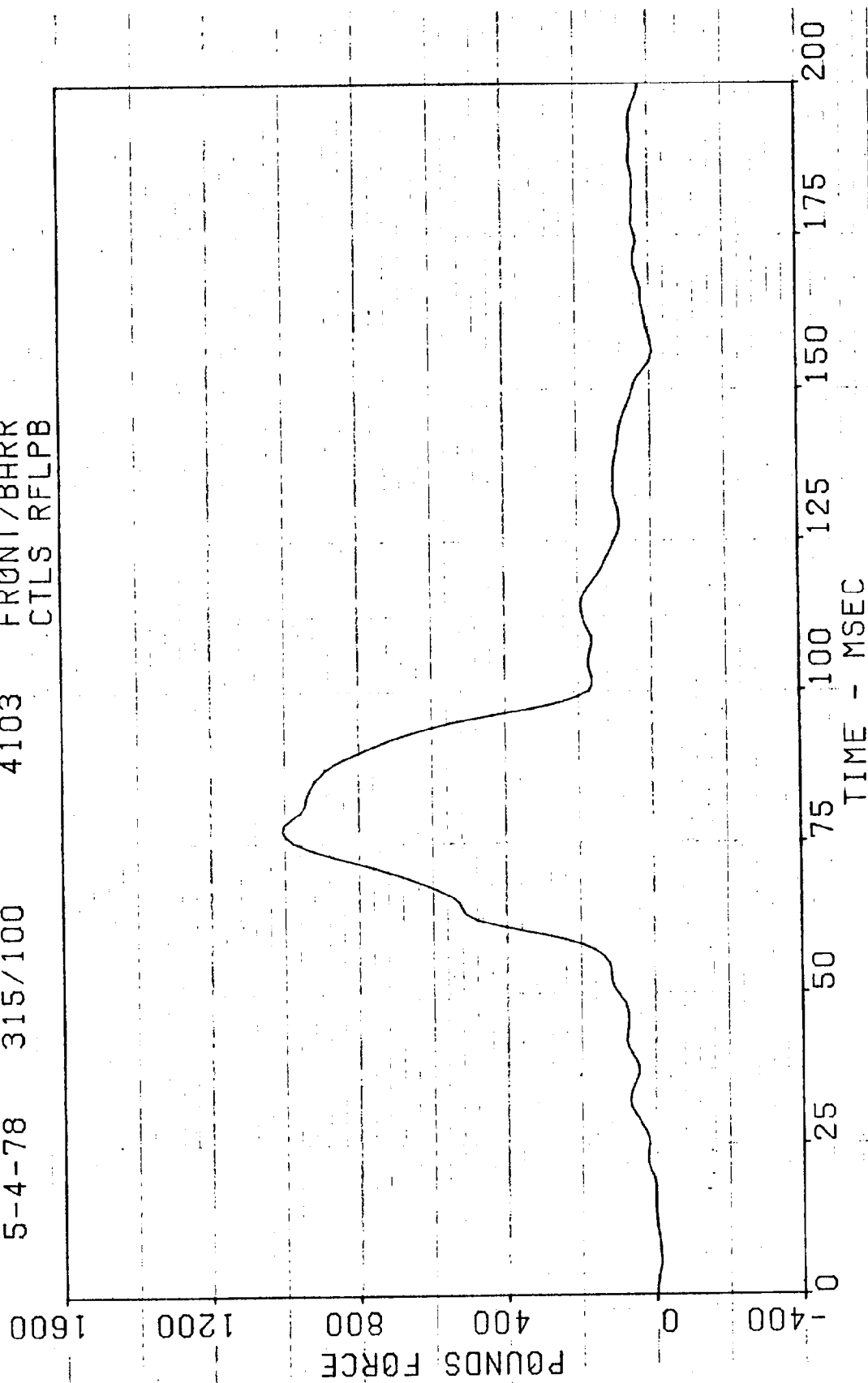
DATE 5-4-78 EILTER 315 LOCATION 1103 TEST NO 051678
FRONT/BARR CUTLASS



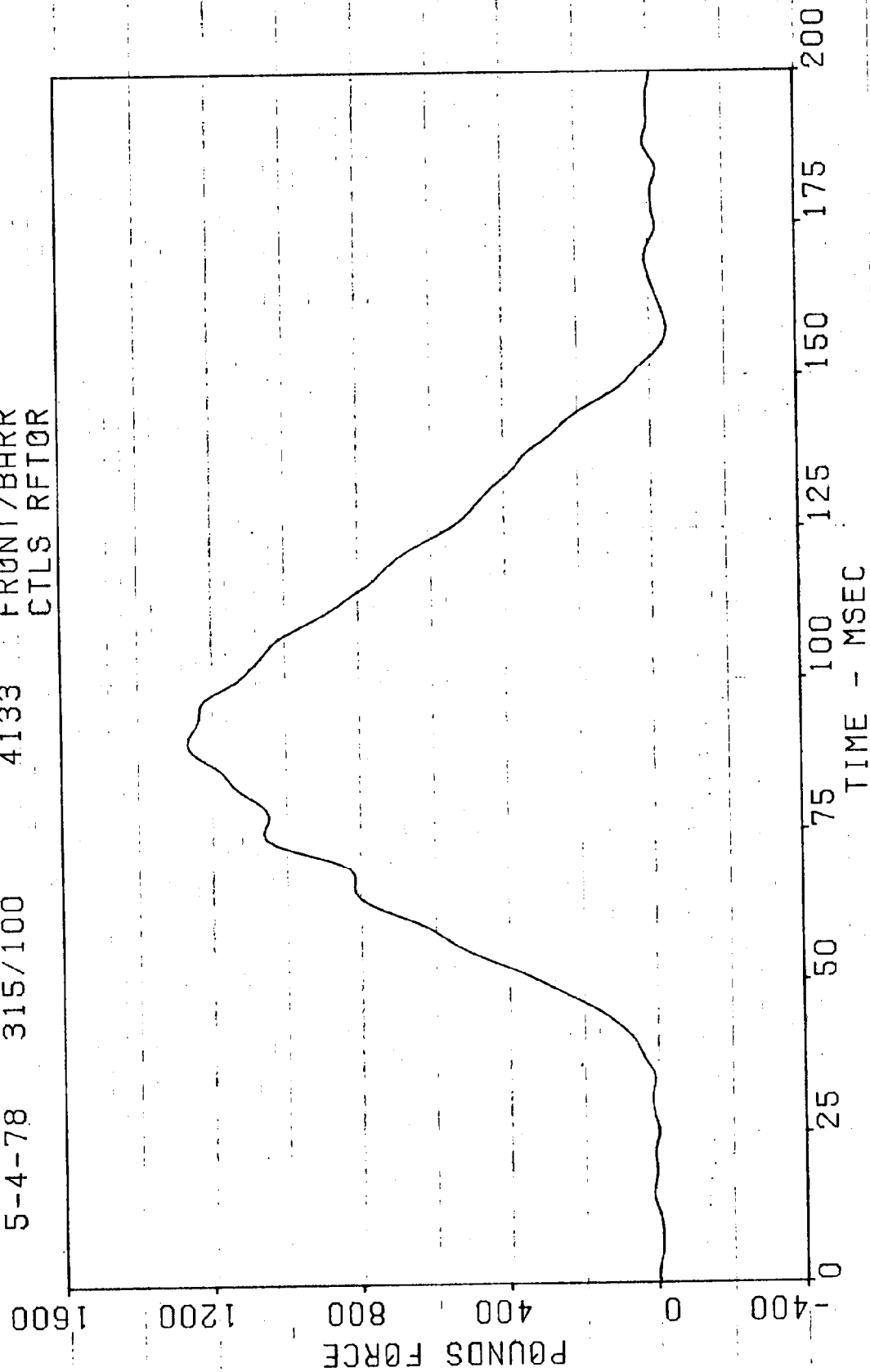
DATE 5-4-78 FILTER 315 LOCATION 1103 TEST NO 051678 FRONT/BARR CUTLASS



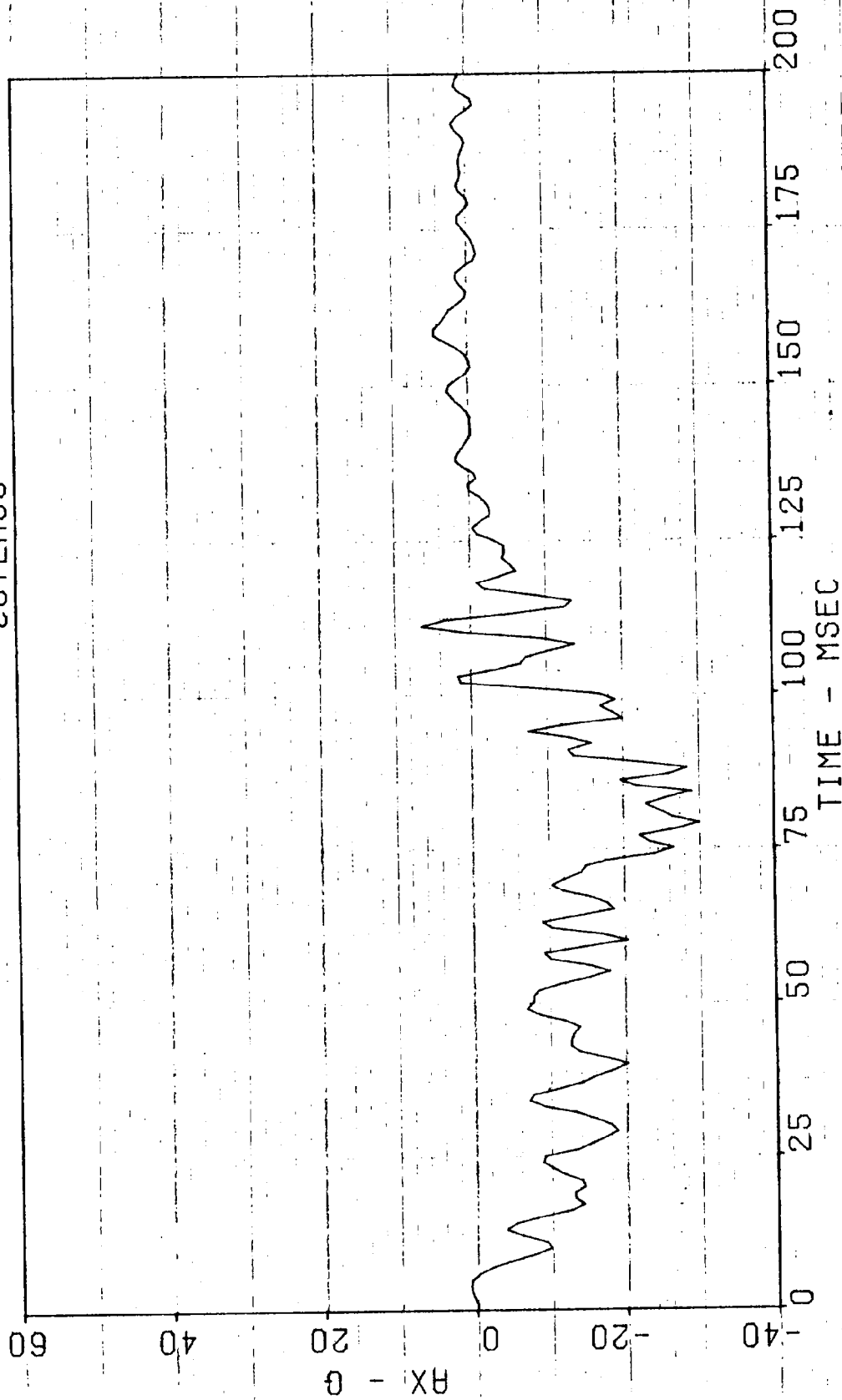
DATE 5-4-78 FILTER 315/100 LOCATION 4103 TEST NO 051678
FRONT/BARR CTLS RFLPB



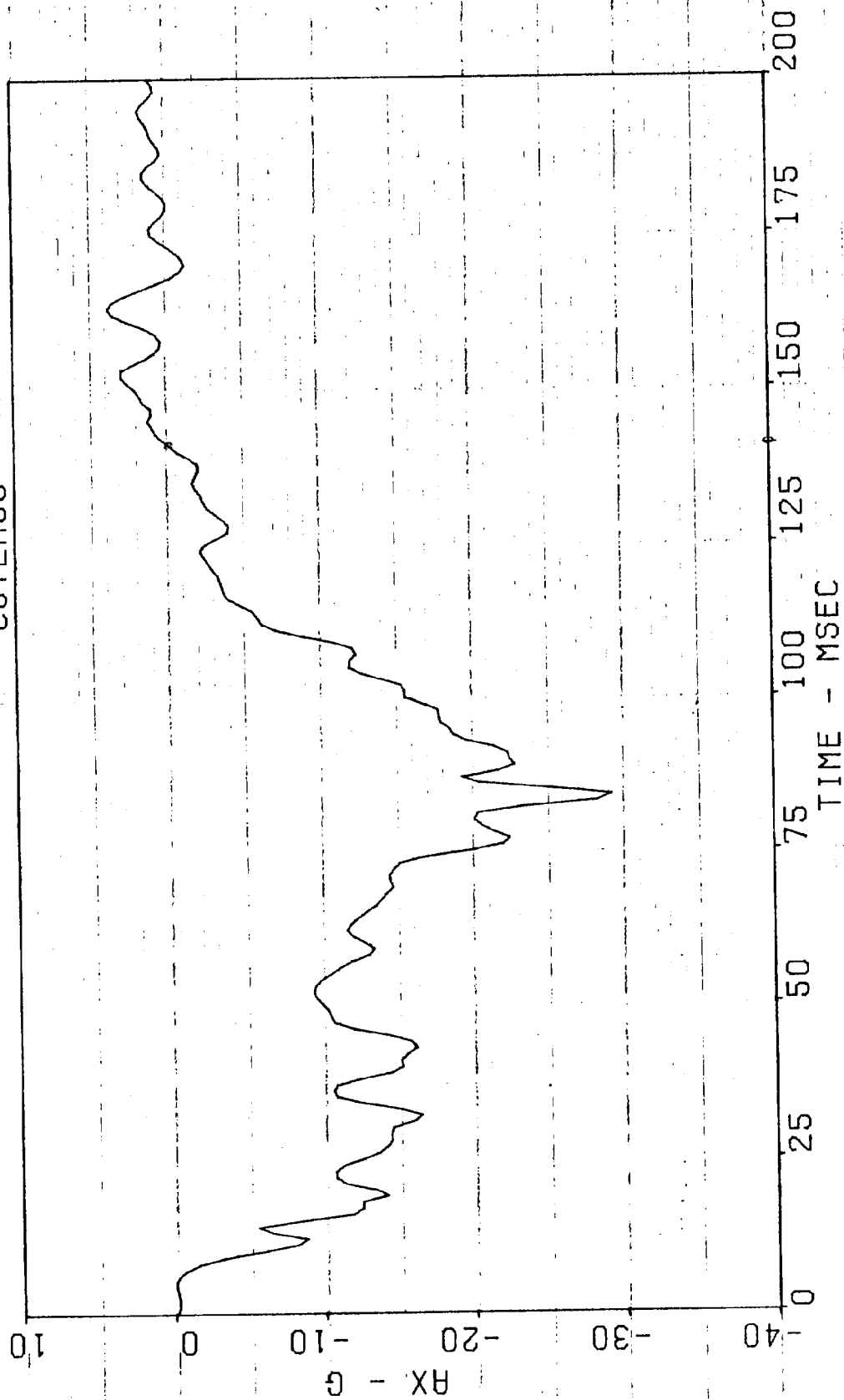
DATE 5-4-78 FILTER 315/100 LOCATION 4133 TEST NO 051678
FRONT/BARR
CTLS RFTOR



DATE 5-4-78 FILTER 315/100 LOCATION 102 TEST NO 051678
FRONT/BARR
CUTLASS



DATE 5-4-78 FILTER 315/100 LOCATION 104 TEST NO 051678 FRONT/BARR CUTLASS



DATE 5-4-78 FILTER 315/100 LOCATION 104 TEST NO 051678 FRONT/BARR CUTLASS

