APPENDIX 11 FROM WCR
GEOCHEMICAL ANALYSIS
BOGGY CREEK - 1
W1053

APPENDIX－11

Geochemical Analysis

3 November 1992

Gas and Fuel Exploration N L
GPO Box 1841Q
MELBOURNE VIC 3001

Attention: John Foster

<u>**REPORT: HH/1971**</u>

CLIENT REFERENCE:	O/N 1648
MATERIAL:	Condensate Sample
LOCALITY:	Boggy Creek-1
WORK REQUIRED:	Geochemical Analyses

Please direct technical enquiries regarding this work to the signatory below under whose supervision the work was carried out.

Brian Watson.

BRIAN L WATSON
Laboratory Supervisor
on behalf of Amdel Core Services Pty Ltd

1. INTRODUCTION

A condensate sample from Boggy Creek-1 was received for geochemical analyses with the aim of determining its source affinity and maturity. This report is a formal presentation of data which was reported by facsimile as this work progressed.

2. ANALYTICAL PROCEDURES

Analytical procedures used in this report are presented in Appendix 1.

3. RESULTS

Analytical data is presented in this report in the following Tables and Figures.

Analysis	Tables	Figures
Gasoline Range (C_3 - C_7)	1 - 2	1 - 3
GC of Saturated Hydrocarbons	3	4
C_{12}+ Bulk Composition	3	-
C_{12}+ Alkane Ratios	3	5
GC-MS of Aromatic Hydrocarbons/ Aromatic Maturity Ratios	4	6 - 8
GC-MS of Branched/Cyclic Hydrocarbons	-	9 - 11 Appendix 2

The API gravity of the sample was determined to be 42.36°.

4. INTERPRETATION

4.1 Source Affinity and Biodegradation

The terrestrial source affinity of the Boggy Creek-1 condensate is indicated by various aspects of its molecular composition (C_3 - C_7 composition (ie.high aromatics and cycloalkane contents), Table 1, Figure 3; pristane/phytane ratio, Table 3, Figure 4; pristane/n-heptadecane and phytane/n-octadecane ratio, Table 3, Figures 4 - 5 and the presence of diterpanes, Figure 11). The pristane/phytane ratio (Table 3) is 6.39 for this sample. This value is indicative of generation from source rocks deposited in highly oxic conditions, which typically occur in terrestrial environments of deposition.

The presence of diterpanes is evidence of generation from a source containing resinite.

Figure 8 is a plot used to differentiate between Permian/Triassic and Jurassic/Cretaceous source intervals on the basis of their relative concentrations of 1,2,5-trimethylnaphthalene and 1-methylphenanthrene. These two aromatic biomarkers are derived from araucariacean flora (trees of the kauri pine group) which were abundant during Jurassic time. The low 1-methylphenanthrene abundance in this sample relative to the 1,2,5-trimethylnaphthalene, suggests that these biomarkers were derived from a source other than araucariacean flora. Thus no conclusion can be made about the age of this sample though the relative abundance of 1,2,5-trimethylnaphthalene is consistent with generation from a resin rich source.

The presence of C_{15} and C_{16} drimanes and rearranged drimanes in the branched/cyclic fraction of the sample (Figure 9 & 10) indicates possible bacterial reworking of the precursor higher plant derived organic matter into bituminite during deposition. This reworking commonly occurs at the sediment/water interface.

The extent of post pooling biodegradation of an oil may be gauged from both the gasoline range hydrocarbon data (C_3 - C_7, Tables 1 and 2, Figure 2) and the C_{12}+ chromatograms (Table 3, Figure 4). This data indicates that this condensate has undergone minimal alteration by post pooling biodegradation. The low heptane and isoheptane values are likely to be due to the sample's low maturity.

As the Boggy Creek-1 condensate appears to have undergone little biodegradation its high aromatics content (Tables 1 and 3) is likely to be source related.

4.2 Maturity

Aromatic maturity ratios (Table 4, Figures 6 - 8) calculated from GC-MS data indicate that the Boggy Creek-1 condensate was generated and expulsed from its source rock at a low maturity (VR ≈ 0.62%, Boreham et al calculation). This maturity is supported by the gasoline range data (Figure 2).

The low maturity for the generation of the Boggy Creek-1 condensate indicates that it was generated from thermally labile exinites, such as resinite, suberinite and bituminite.

4.3 Oil-Oil Correlation

The maturity of the Boggy Creek-1 condensate is similar to that of the nearby Katnook-1 and North Paaratte-2 condensates. The alkane ratios calculated from these condensates along with those from the more mature Katnook-2, Katnook-3, Ladbroke Grove-1 and Iona-1 condensates suggest that they were all generated from similar terrestrial source intervals. However, distinct variations in pristane/phytane ratios indicate that the source of the Boggy Creek-1 condensate was deposited in a significantly more oxidising environment than that of all of the other condensates mentioned above.

The Boggy Creek-1 condensate is unusual in that it has a very high aromatics content relative to other Otway Basin condensates previously studied.

Well	Aromatics Content (C_5-C_7 Hydrocarbons)
Katnook-1	3.22
Katnook-2	3.16-4.13
Katnook-3	3.79
Iona-1	1.41
Nth. Paaratte-2	1.60
Boggy Creek-1	33.81

This high aromatics content would suggest that the Boggy Creek-1 condensate has not been significantly affected by water-washing. The percentage of aromatics is an order of magnitude higher than similar condensates from nearby Otway Basin wells suggesting that the source of this oil may be different to that of the Iona and North Paaratte condensates.

The alkane distribution of the sample is indicative of a condensate and is similar to that of the Katnook condensates however these analyses cannot determine whether the sample is gaseous at reservoir temperature and pressure.

TABLE 1

AMDEL CORE SERVICES
GASOLINE-RANGE ANALYSIS

CLIENT: GAS AND FUEL EXPLORATION

WELL: BOGGY CREEK-1 LIQUID

COMPOUND	NORMAL %	BRANCHED %	CYCLIC %	AROMATIC %
2-METHYLBUTANE		1.59		
N-PENTANE	2.00			
2,2-DIMETHYLBUTANE		0.27		
CYCLOPENTANE			0.36	
2,3-DIMETHYLBUTANE		0.55		
2-METHYLPENTANE		2.14		
3-METHYLPENTANE		1.37		
N-HEXANE	4.13			
2,2-DIMETHYLPENTANE		0.00		
METHYLCYCLOPENTANE			4.22	
2,4-DIMETHYLPENTANE		0.42		
2,2,3-TRIMETHYLBUTANE		0.13		
BENZENE				8.37
3,3-DIMETHYLPENTANE		0.19		
CYCLOHEXANE			9.01	
2-METHYLHEXANE		1.99		
2,3-DIMETHYLPENTANE		0.84		
1,1-DIMETHYLCYCLOPENTANE			0.67	
3-METHYLHEXANE		2.02		
TRANS-1,3-DIMETHYLCYCLOPENTANE			0.89	
CIS-1,3-DIMETHYLCYCLOPENTANE			0.99	
3-ETHYLPENTANE		0.00		
TRANS-1,2-DIMETHYLCYCLOPENTANE			1.61	
N-HEPTANE	6.56			
METHYLCYCLOHEXANE			23.73	
ETHYLCYCLOPENTANE			0.51	
TOLUENE				25.43
TOTAL PERCENTAGES	12.69	11.51	41.99	33.81

TABLE 2

AMDEL CORE SERVICES
GASOLINE-RANGE PARAMETERS

CLIENT: GAS AND FUEL EXPLORATION

WELL: BOGGY CREEK-1 LIQUID

PARAMETER	
1	0.98
2	0.28
3	0.16
4	1.08
5	0.93
6	0.79
7	0.33
8	1.15
9	13.58

KEY TO PARAMETERS

Parameter	Derivation	Specificity
1	n-hexane/methylcyclopentane	mat/biodeg
2	n-heptane/methylcyclohexane	mat/biodeg
3	3-methylpentane/benzene	water washing
4	cyclohexane/benzene	water washing
5	methylcyclohexane/toluene	water washing
6	isopentane/normal pentane	mat/biodeg
7	3-methylpentane/n-hexane	biodegradation
8	isoheptane value *	maturity
9	heptane value *	maturity

(* from Thompson, 1983)

TABLE 3

C_{12+} BULK COMPOSITION AND ALKANE RATIOS OF BOGGY CREEK-1 CONDENSATE

Well	Composition			Alkane Ratios				
	Sats	Arom	Res + Asph	Np/Pr	Pr/Ph	Pr/n-C_{17}	Ph/n-C_{18}	TMTD/Pr
Boggy Creek-1	50.7	9.3	40.0	0.41	6.39	0.63	0.12	0.58

Sats = saturated hydrocarbons
Arom = aromatic hydrocarbons
Asph = asphaltenes
TMTD = trimethyltridecane

Np = norpristane
Pr = pristane
Ph = phytane
n-C_{17} = n-heptadecane
n-C_{18} = n-octadecane

TABLE 4

TABLE 1: AROMATIC MATURITY DATA

SAMPLE	MPI	MPR	MPDF	VR CALC (%)				
				A	B	C	E	F
BOGGY CREEK-1	0.569	0.930	0.434	0.74	1.96	0.91	0.62	0.81

FIGURE 1

BOGGY CREEK-1 CONDENSATE

HIGH RESOLUTION GC OF C_1-C_7 HYDROCARBONS

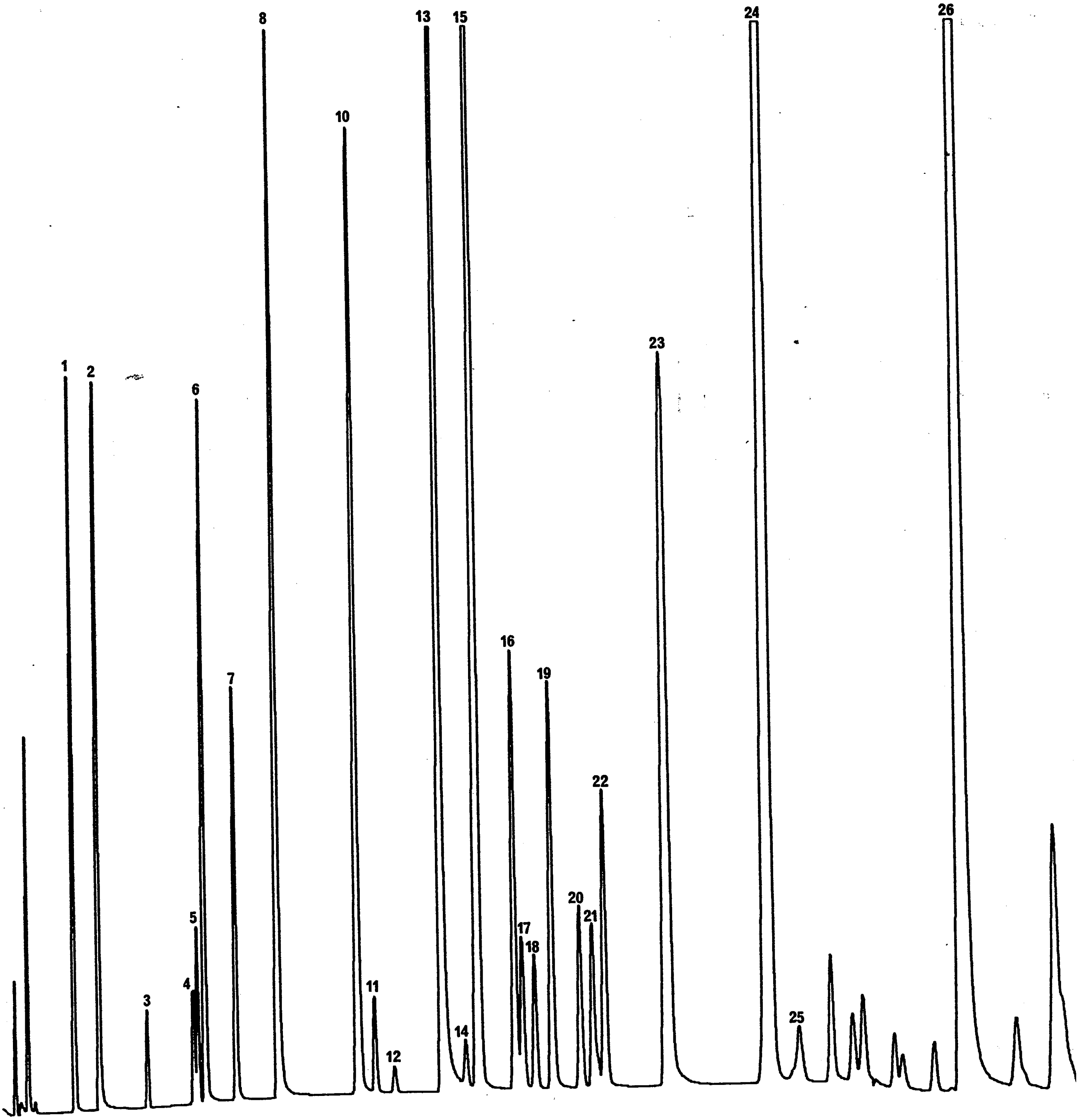


FIGURE 2

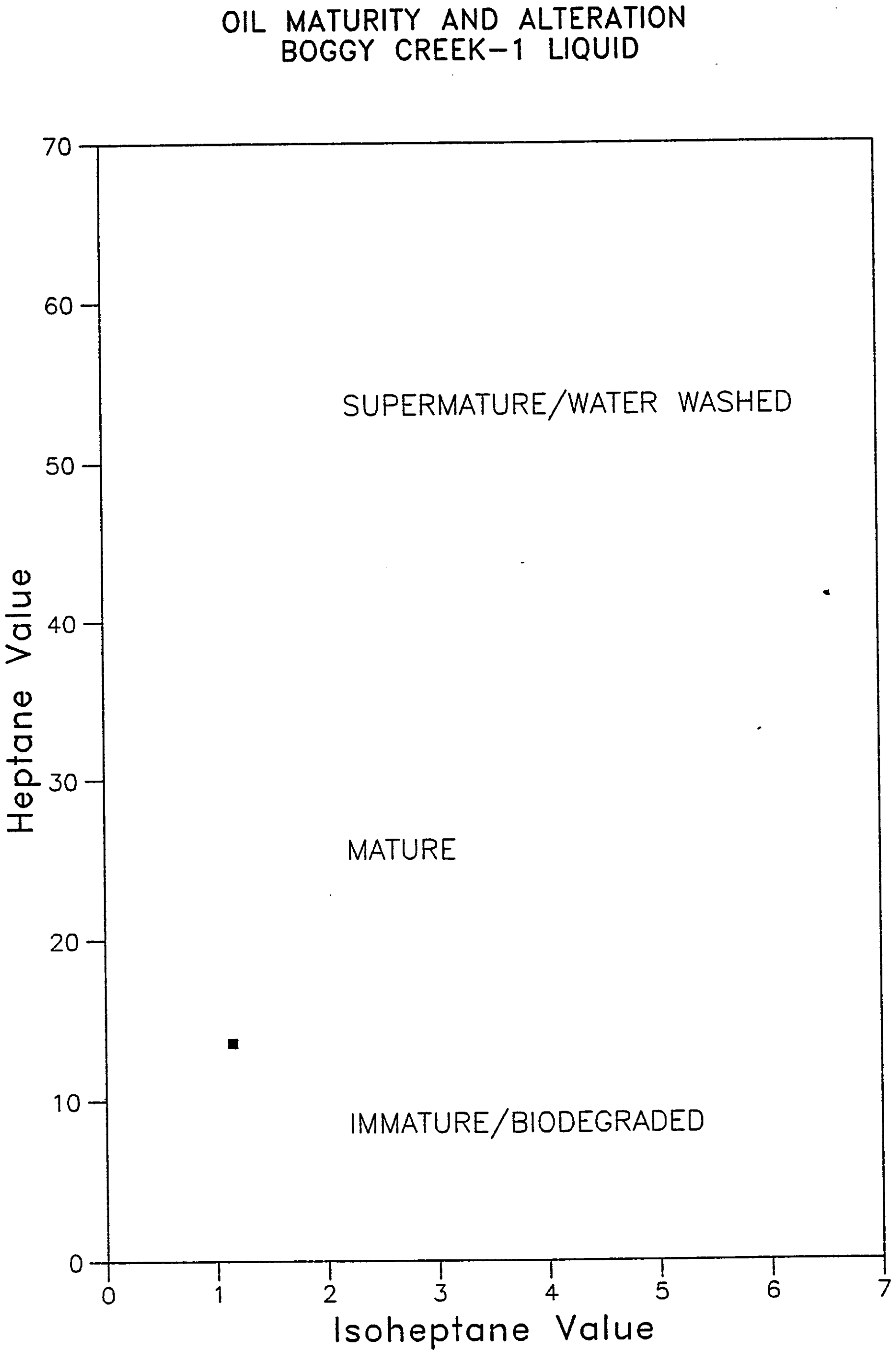
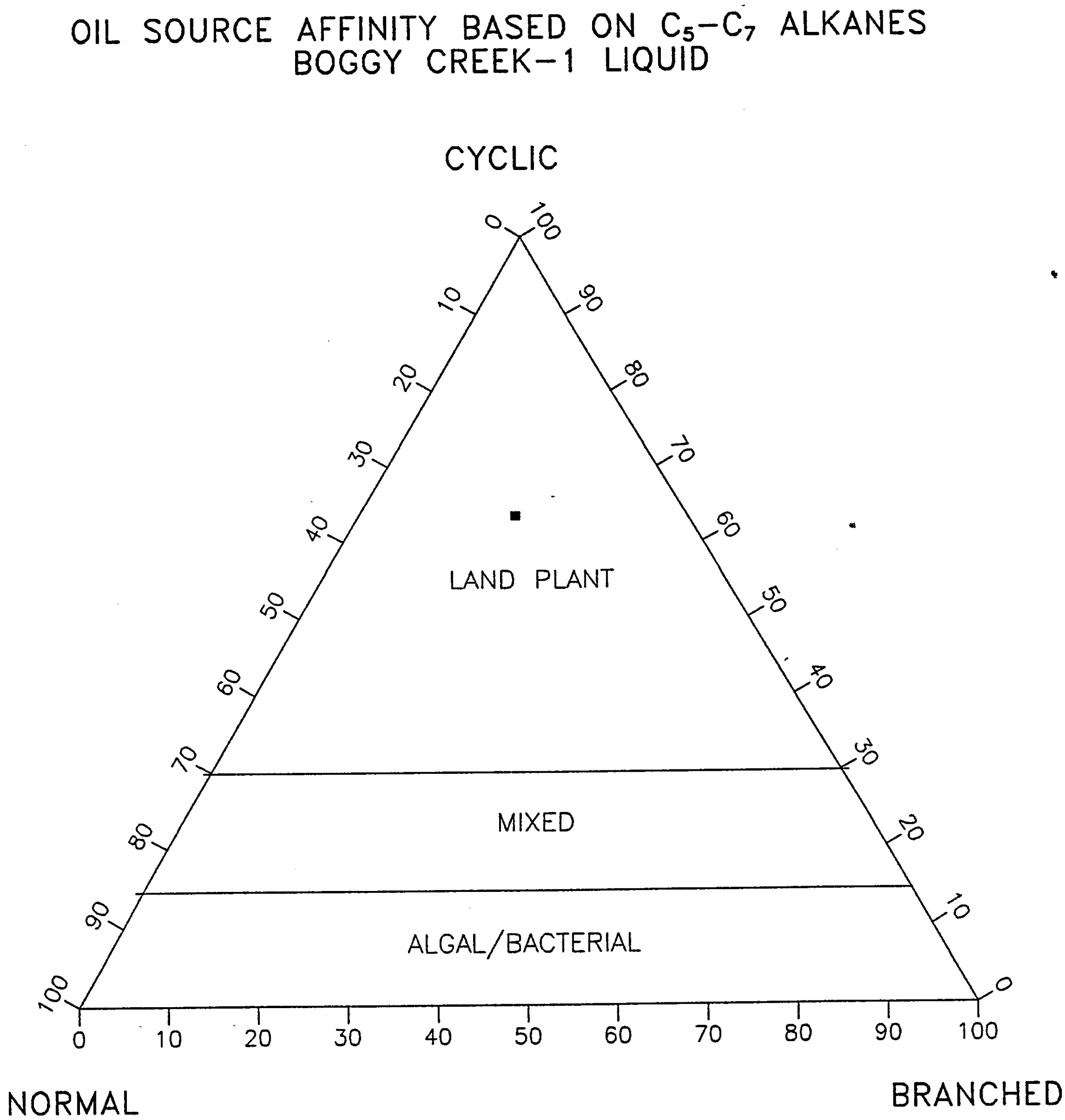

OIL MATURITY AND ALTERATION
BOGGY CREEK-1 LIQUID
70
60
50
40
30
20
10
0
Heptane Value
SUPERMATURE/WATER WASHED
MATURE
IMMATURE/BIODEGRADED
0
1
2
3
4
5
6
7
Isoheptane Value

FIGURE 3



OIL SOURCE AFFINITY BASED ON C_5-C_7 ALKANES
BOGGY CREEK-1 LIQUID
CYCLIC
LAND PLANT
MIXED
ALGAL/BACTERIAL
0
10
20
30
40
50
60
70
80
90
100
NORMAL
BRANCHED

FIGURE 4

BOGGY CREEK-1 CONDENSATE

GC OF SATURATES FRACTION

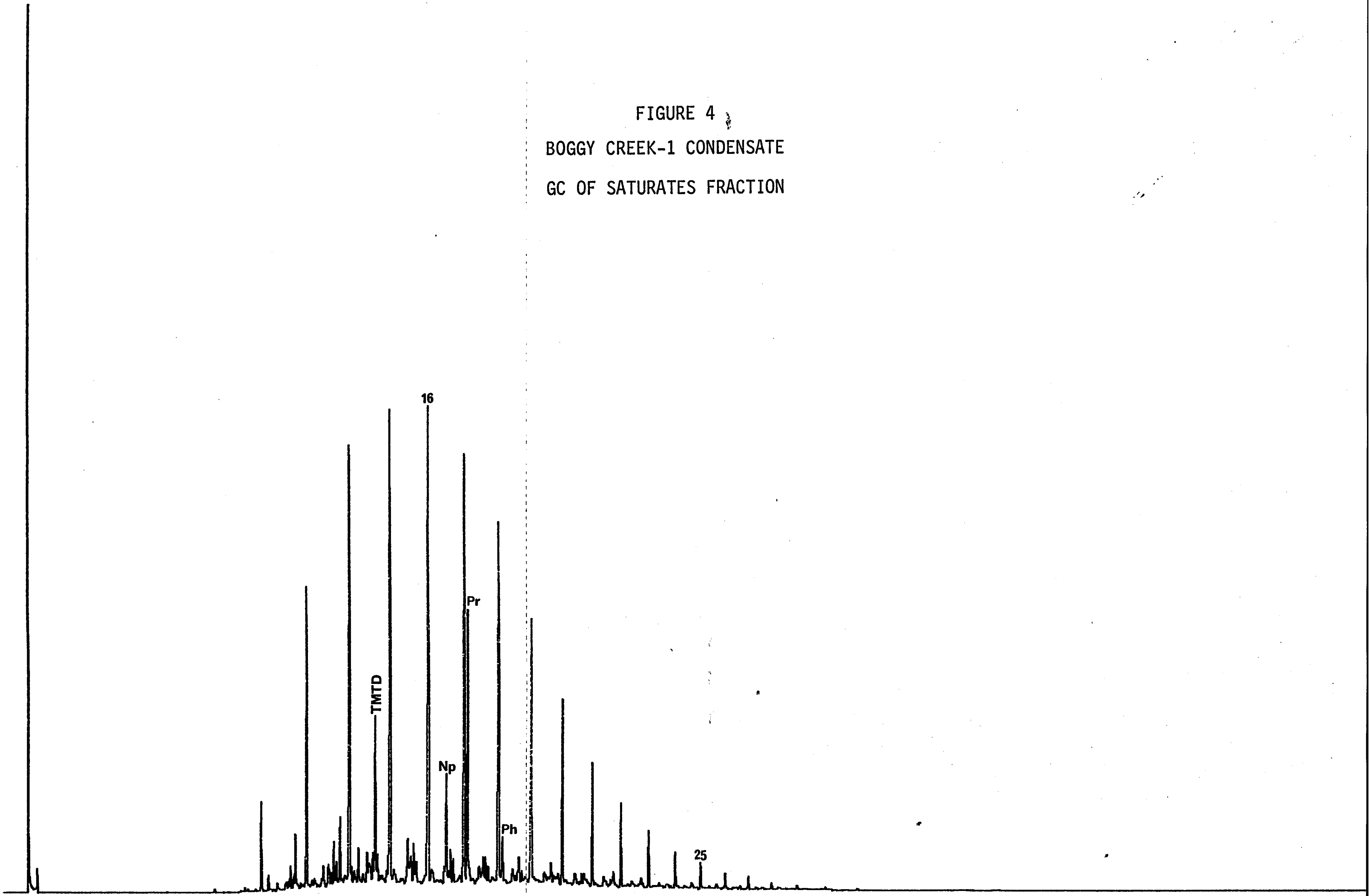


FIGURE 5

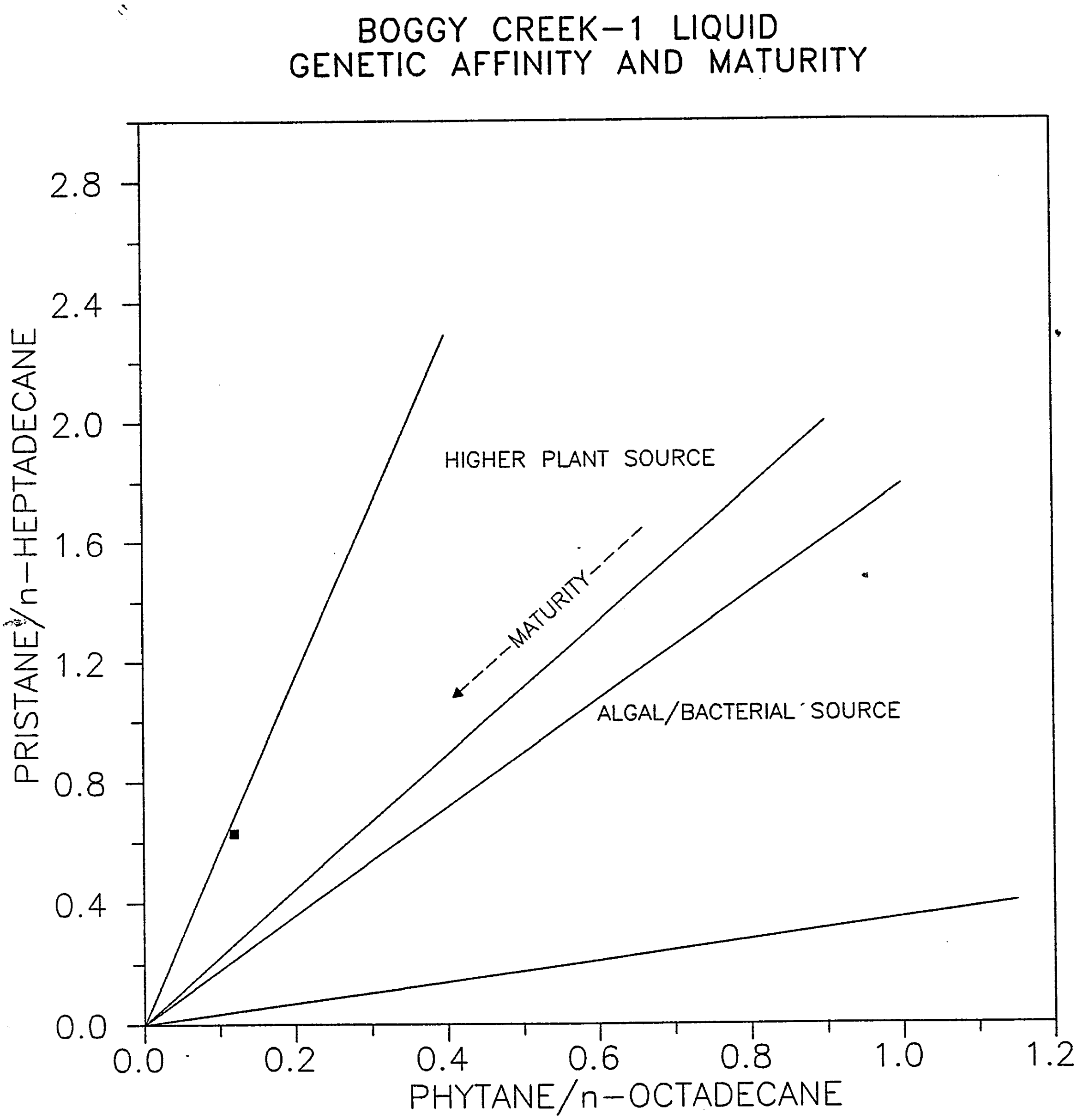

BOGGY CREEK-1 LIQUID
GENETIC AFFINITY AND MATURITY
HIGHER PLANT SOURCE
MATURITY
ALGAL/BACTERIAL SOURCE
PRISTANE/n-HEPTADECANE
PHYTANE/n-OCTADECANE
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
0.0
0.2
0.4
0.6
0.8
1.0
1.2

FIGURE 6

Chromatogram A:ACS459 Acquired: Sep-10-1992 15:06:53
Comment: MPI GAS AND FUEL BOGGY CREEK-1 AMDEL CORE SERVICES
Scan Range: 2080 - 2580 Scan: 2080 Int = 1795 @ 34:41 100% = 421092

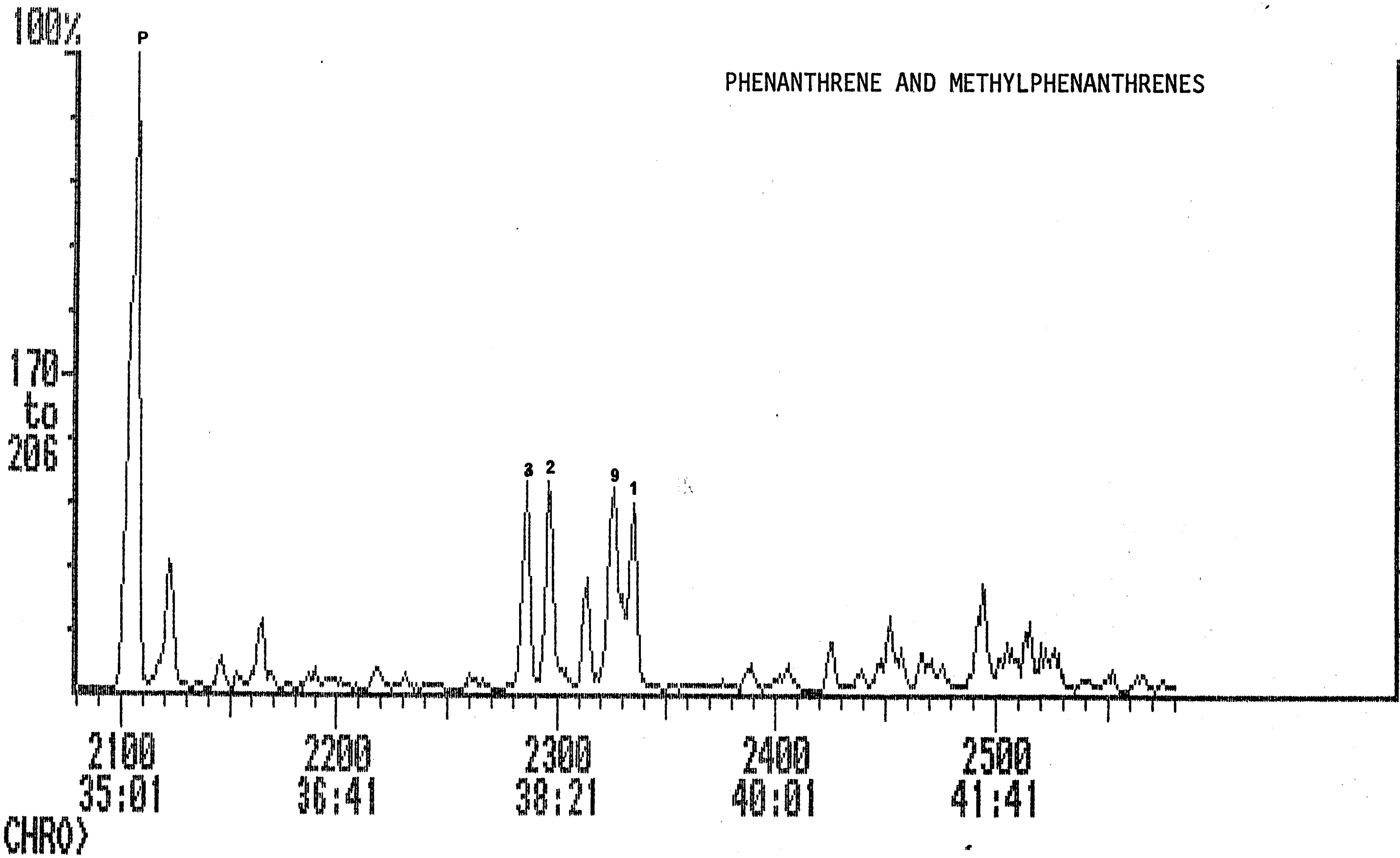


FIGURE 7

Chromatogram A:ACS459 Acquired: Sep-10-1992 15:06:53
Comment: MPI GAS AND FUEL BOGGY CREEK-1 AMDEL CORE SERVICES
Scan Range: 1300 - 1800 Scan: 1300 Int = 53 @ 21:41 100% = 48853

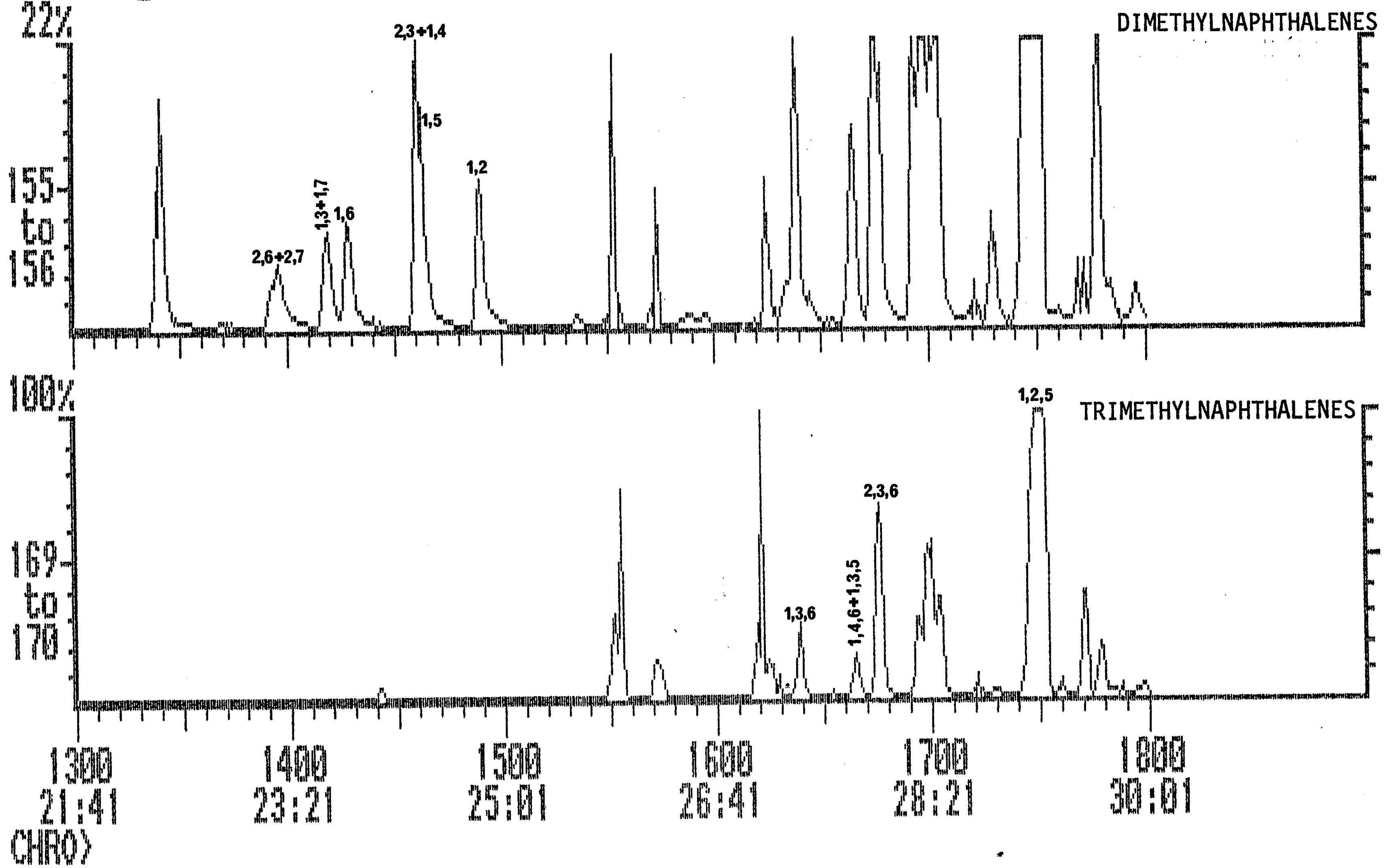
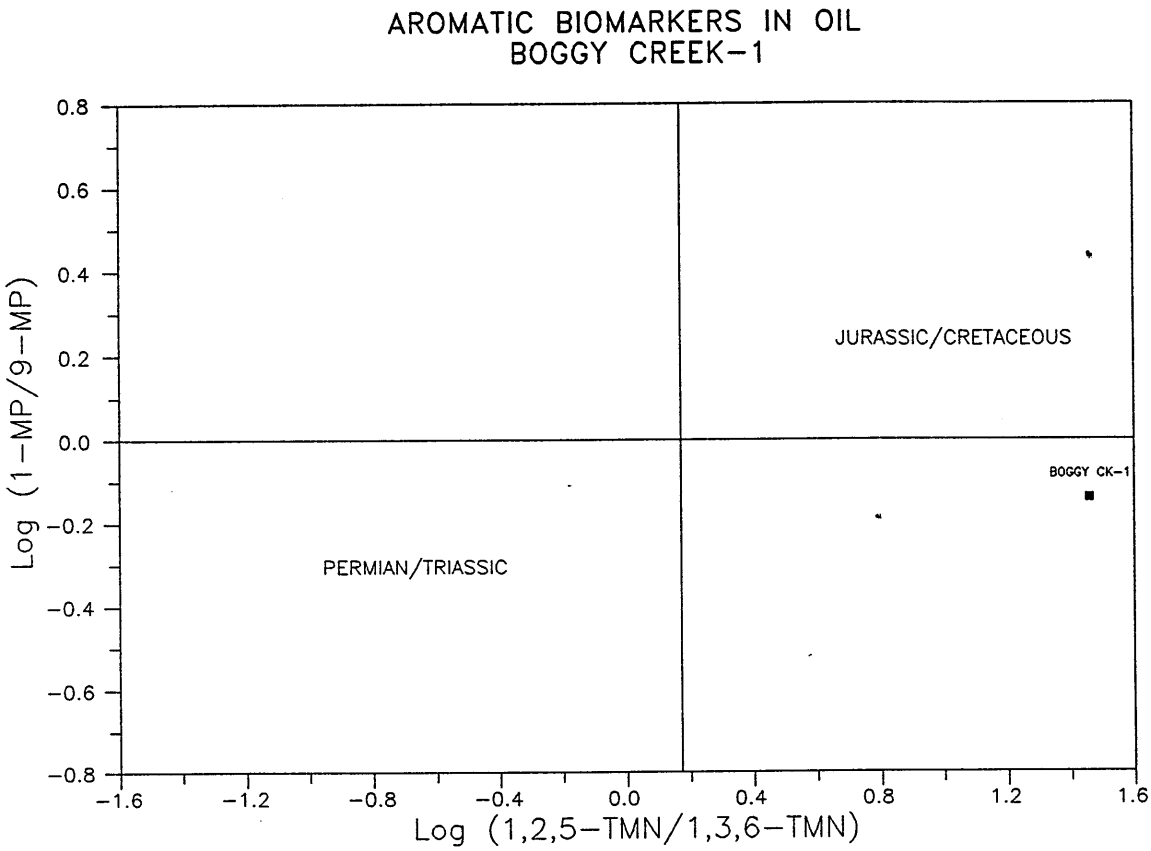


FIGURE 8



AROMATIC BIOMARKERS IN OIL
BOGGY CREEK-1
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
Log (1-MP/9-MP)
JURASSIC/CRETACEOUS
BOGGY CK-1
PERMIAN/TRIASSIC
-1.6
-1.2
-0.8
-0.4
0.0
0.4
0.8
1.2
1.6
Log (1,2,5-TMN/1,3,6-TMN)

FIGURE 9

Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
Comment: NAPTH GAS & FUEL BOGGY CK-1 AMDEL CORE SERVICES
Scan Range: 601 - 1100 Scan: 601 Int = 9865 @ 10:02 100% = 22821

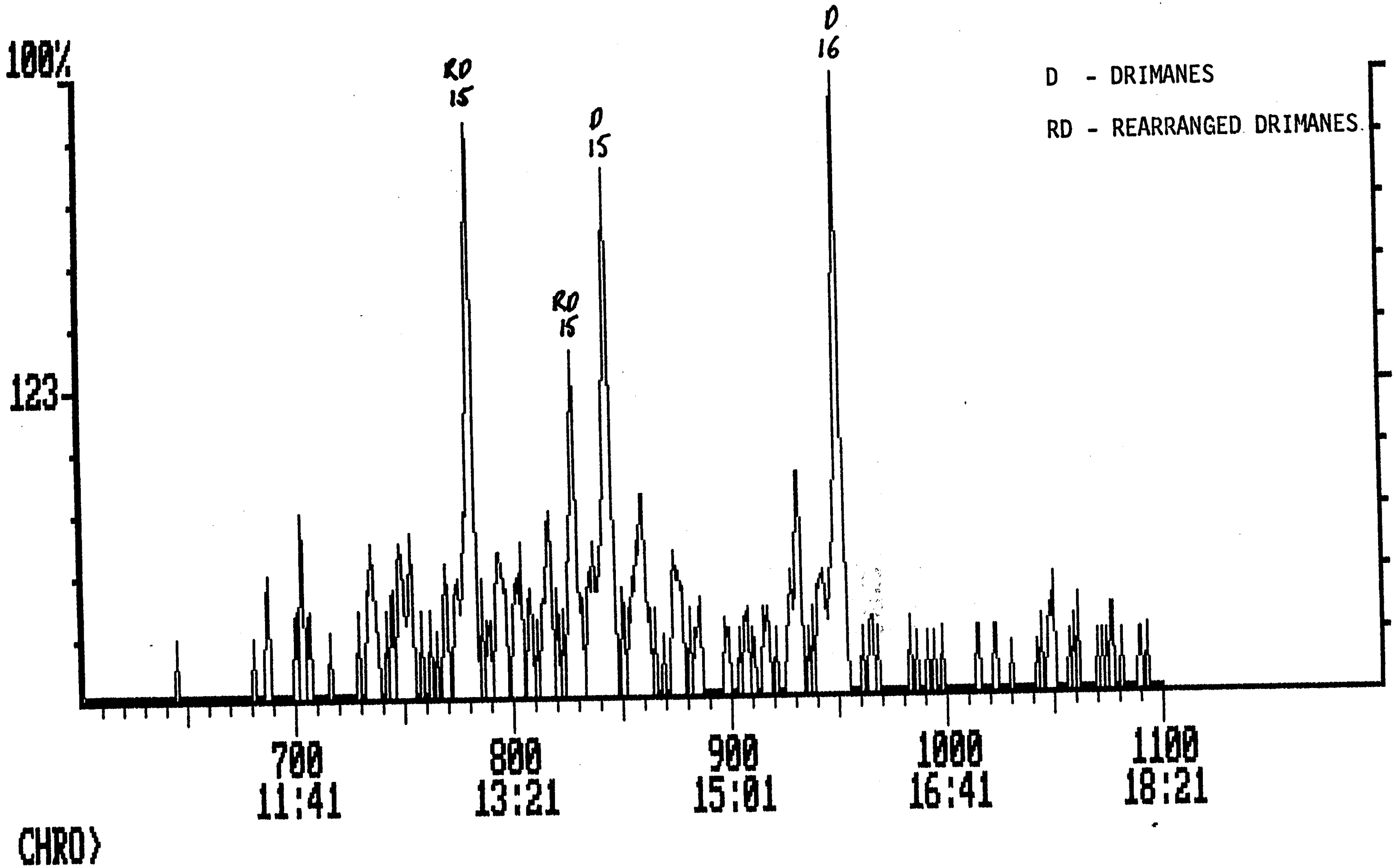


FIGURE 10

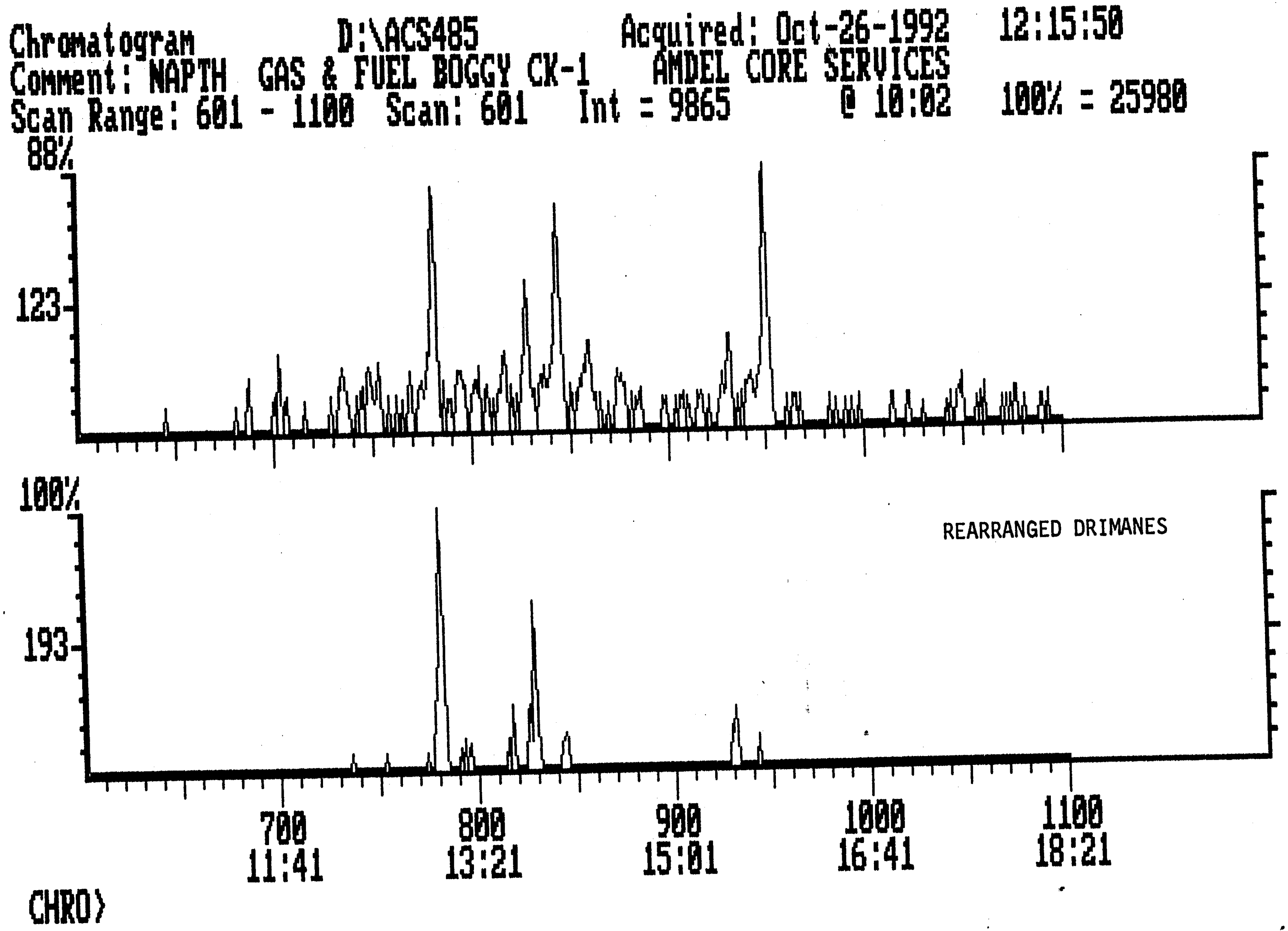
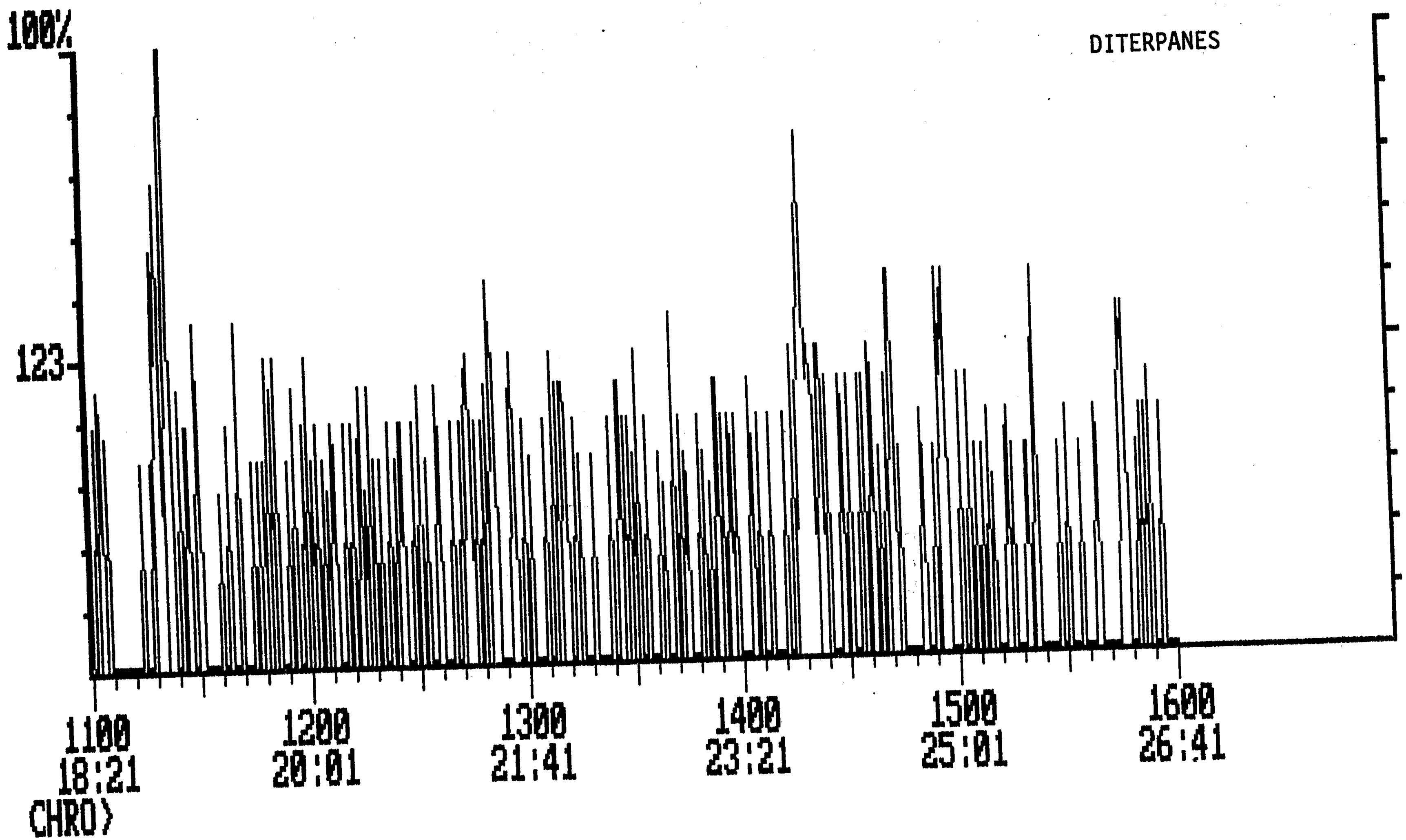

Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
Comment: NAPTH GAS & FUEL BOGGY CK-1 AMDEL CORE SERVICES
Scan Range: 601 - 1100 Scan: 601 Int = 9865 @ 10:02 100% = 25980
88%
123
100%
193
REARRANGED DRIMANES
700
11:41
800
13:21
900
15:01
1000
16:41
1100
18:21
CHRO>

FIGURE 11

Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
Comment: NAPTH GAS & FUEL BOGGY CK-1 AMDEL CORE SERVICES
Scan Range: 1100 - 1600 Scan: 1100 Int = 45291 @ 18:21 100% = 6319



APPENDIX 1

APPENDIX 1

ANALYTICAL PROCEDURES

1. GASOLINE-RANGE HYDROCARBONS

The condensate samples were analysed on a Perkin-Elmer 8500 Gas Chromatograph equipped with a 50 m, 0.2 mm i.d. HP PONA column. Concentrations of C_3 - C_8 hydrocarbons were calculated from the peak areas for each compound.

2. LIQUID CHROMATOGRAPHY

Asphaltenes were not precipitated from the condensate prior to liquid chromatography. The condensate was separated into hydrocarbons (saturates and aromatics) and polar compounds (resins) by liquid chromatography on activated alumina (sample: adsorbent ratio = 1:100). Hydrocarbons were eluted with petroleum ether/dichloromethane (50:50) and resins with methanol/dichloromethane (65:35). The saturated and aromatic hydrocarbons were then separated by liquid chromatography on activated silica gel (sample: adsorbent ratio = 1:100) eluting in turn with petroleum ether and petroleum ether/dichloromethane (91:9).

3. GAS CHROMATOGRAPHY

Whole oils and saturated hydrocarbons (alkanes) were examined by gas chromatography using the following instrumental parameters:

Gas chromatograph:	Carlo Erba Mega Series operated in the split injection mode
Column:	25 m x 0.3 mm fused silica, SGE QC3/BP1
Detector temperature:	300°C
Oven temperature:	40°C for 1 minute, then 8° per min. to 300°C and held isothermal at 300°C until all peaks eluted
Quantification:	Relative concentrations of individual hydrocarbons were obtained by measurement of peak areas with a Perkin Elmer LCI 100 integrator. The areas of peaks corresponding to aromatic hydrocarbons were multiplied by appropriate response factors.

Appendix 1 (continued)

4. THIN LAYER CHROMATOGRAPHY (TLC)

Aromatic hydrocarbons were isolated from the extracted oil by preparative TLC using Merck GF_{254} silica plates and distilled AR grade n-pentane as eluent. Naphthalene and anthracene were employed as reference standards for the diaromatic and triaromatic hydrocarbons, respectively. These two bands, visualised under UV light, were scraped from the plate and the aromatic hydrocarbons redissolved in dichloromethane.

5. GAS CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS)

The di- and triaromatic hydrocarbons isolated from the extracted oil by thin layer chromatography were analysed by GC-MS.

GC-MS analysis of the aromatic hydrocarbons was undertaken in the selected ion detection (SID) mode. The instrument and its operating parameters were as follows:

System:	Perkin-Elmer 8420 GC coupled with an Ion Trap mass selective detector and data system
Column:	50 mm x 0.2 mm i.d. HP PONA cross-linked methylsilicone phase fused silica, interfaced directly to source of mass spectrometer
Injector:	Split injection (40:1)
Carrier gas:	He at 1.2 kg/cm^2 head pressure
Column temperature:	50-260°C @ 4°/min.
Mass spectrometer conditions:	70 eV EI; 9-ion selected ion monitoring, 70 millisec dwell time for each ion

The following mass fragmentograms were recorded:

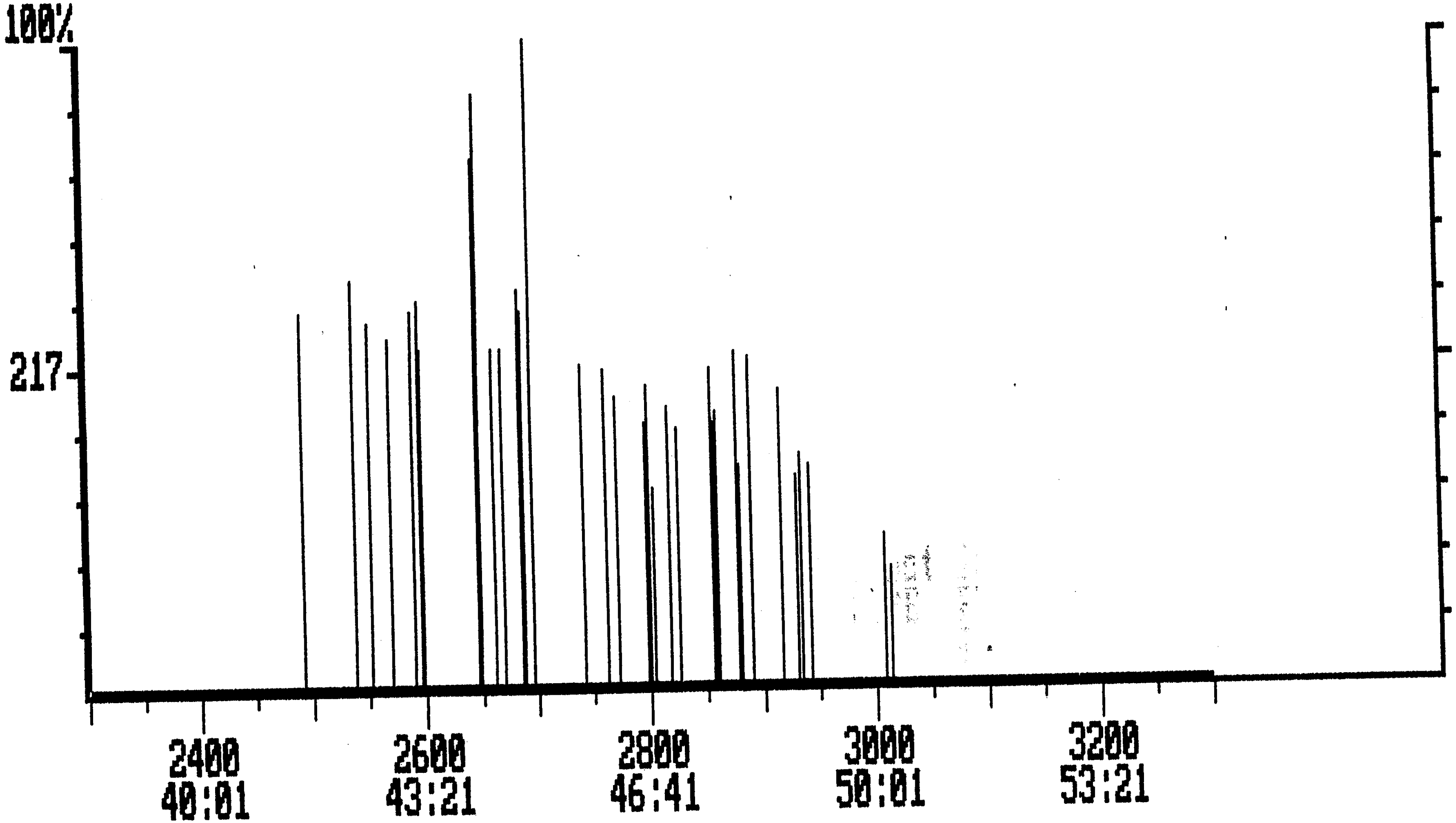
m/z	Compound Type
155 + 156	dimethylnaphthalenes
169 + 170	trimethylnaphthalenes
178	phenanthrene
191 + 192	methylphenanthrene

The area of the phenanthrene peak was multiplied by a response factor of 0.667 when calculating the methylphenanthrene index (MPI).

APPENDIX 2

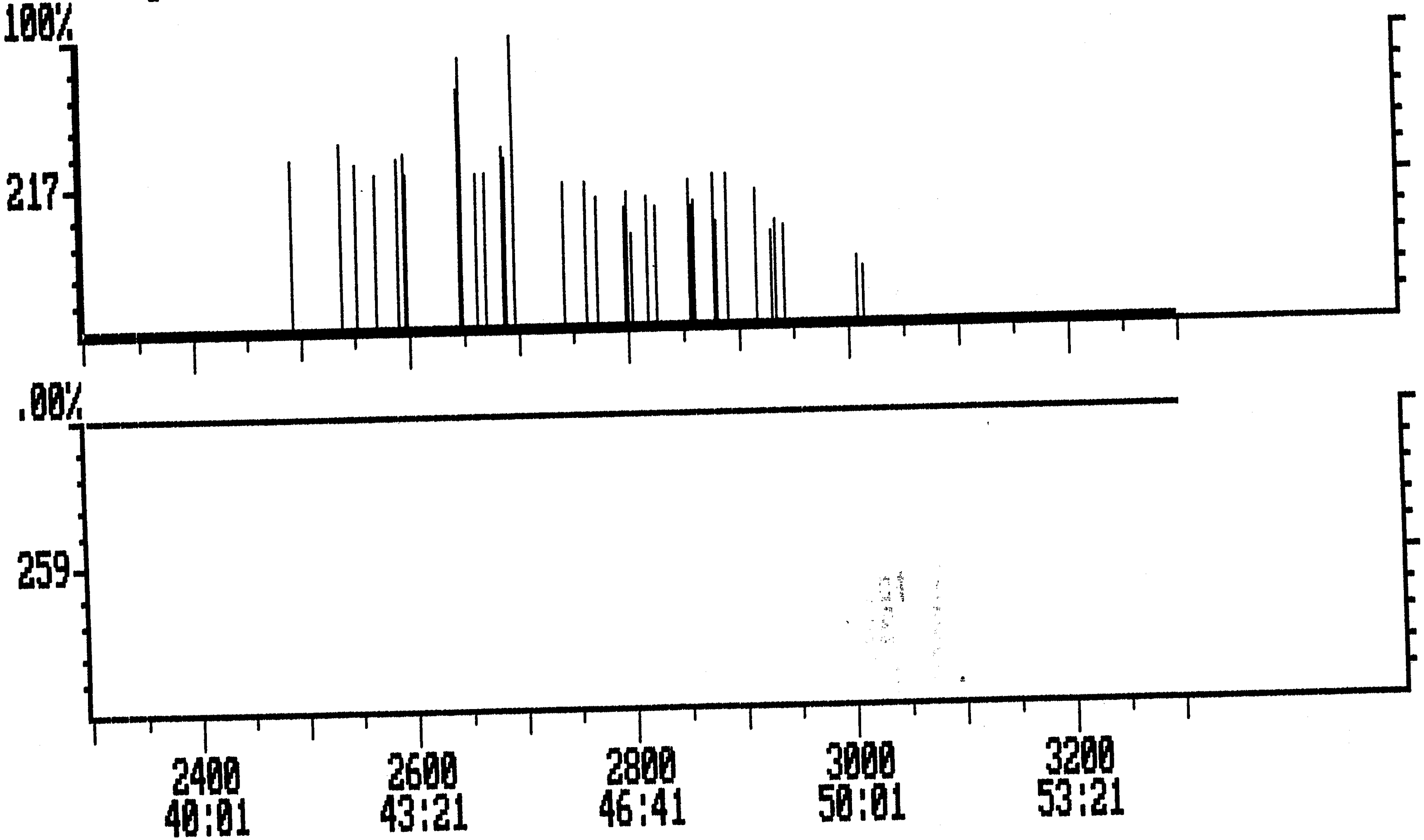
GC-MS OF BRANCHED/CYCLIC HYDROCARBONS

Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
Comment: NAPTH GAS & FUEL BOGGY CK-1 AMDEL CORE SERVICES
Scan Range: 2300 - 3300 Scan: 2300 Int = 15799 @ 38:21 100% = 1685



CHRO>

Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
Comment: NAPTH GAS & FUEL BOGGY CK-1 AMDEL CORE SERVICES
Scan Range: 2300 - 3300 Scan: 2300 Int = 15799 @ 38:21 100% = 1685



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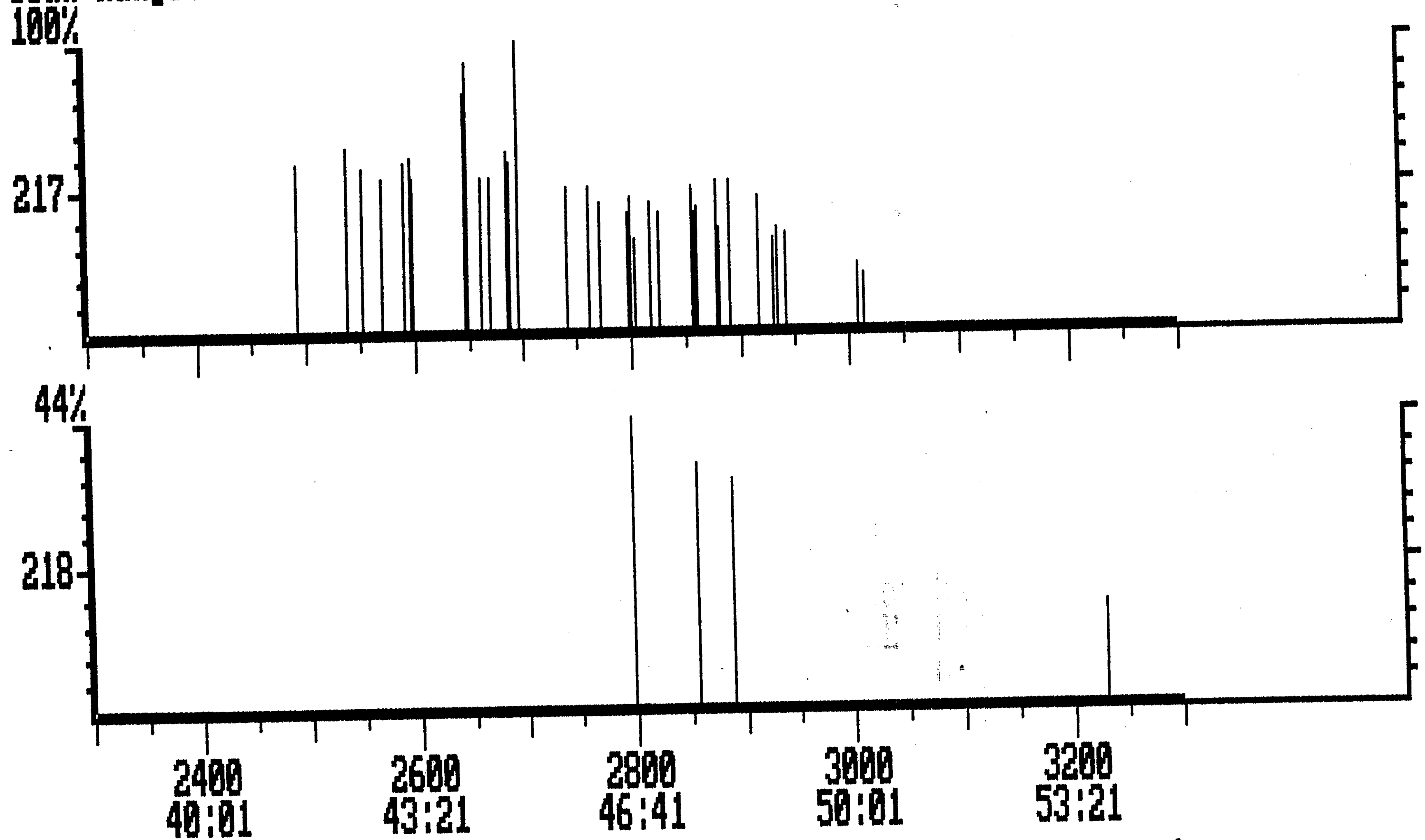
Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
Comment: NAPTH GAS & FUEL BOGGY CK-1 AMDEL CORE SERVICES
Scan Range: 2300 - 3300 Scan: 2300 Int = 15799 @ 38:21 100% = 1685



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Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
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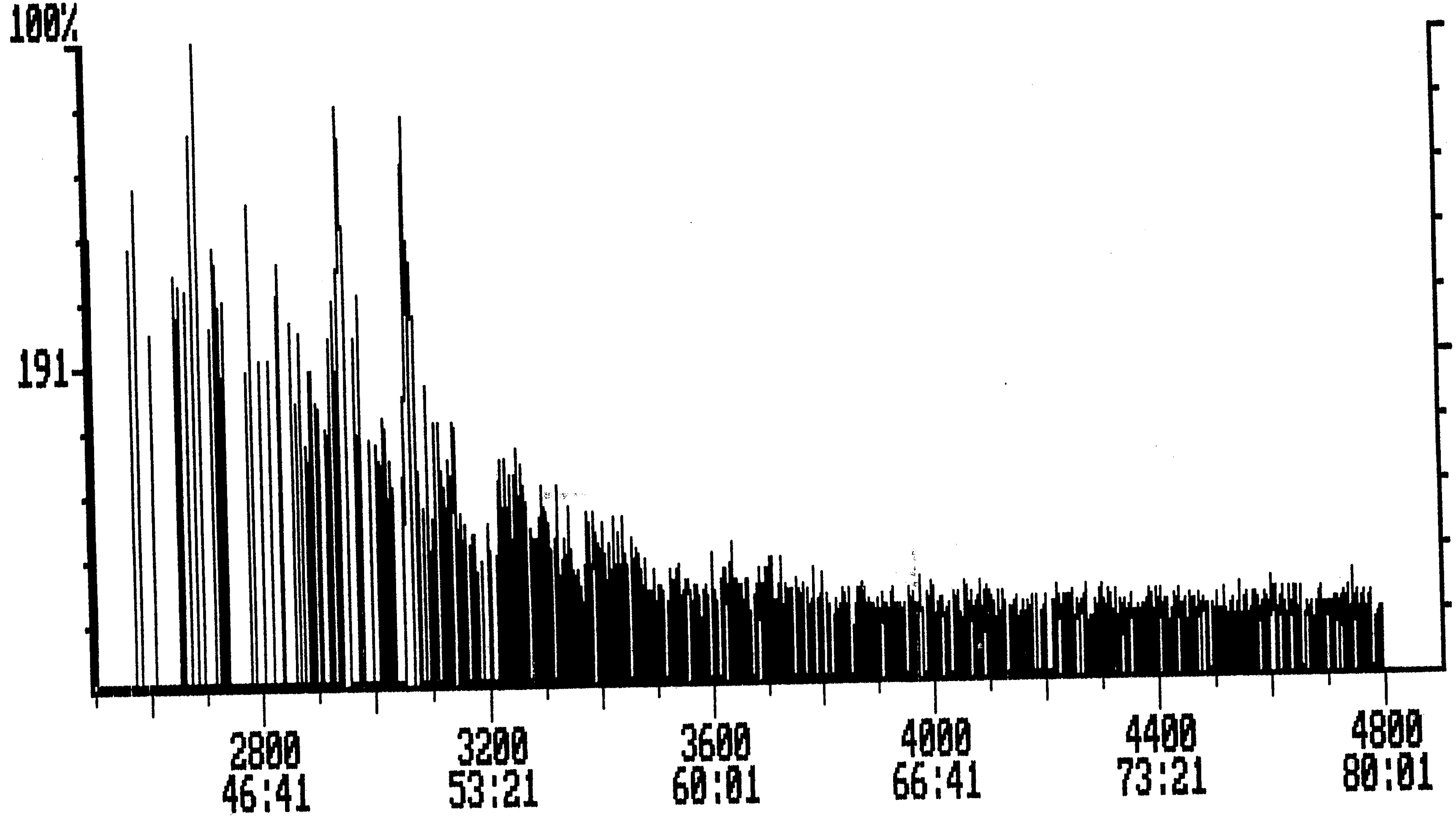
Scan Range: 2500 - 4800 Scan: 2500 Int = 17655 @ 41:41 100% = 1404



CHRO>

Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
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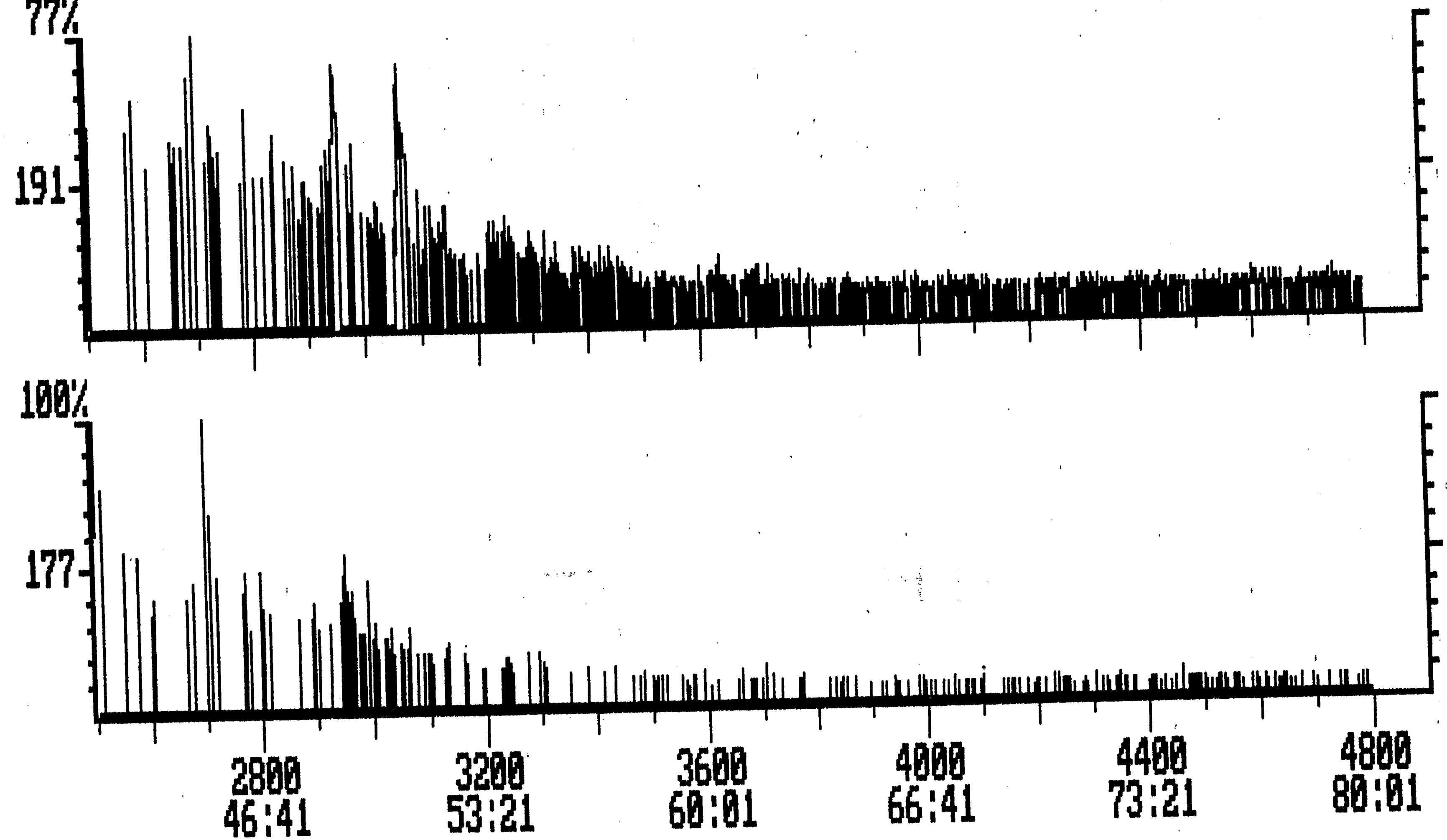

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Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
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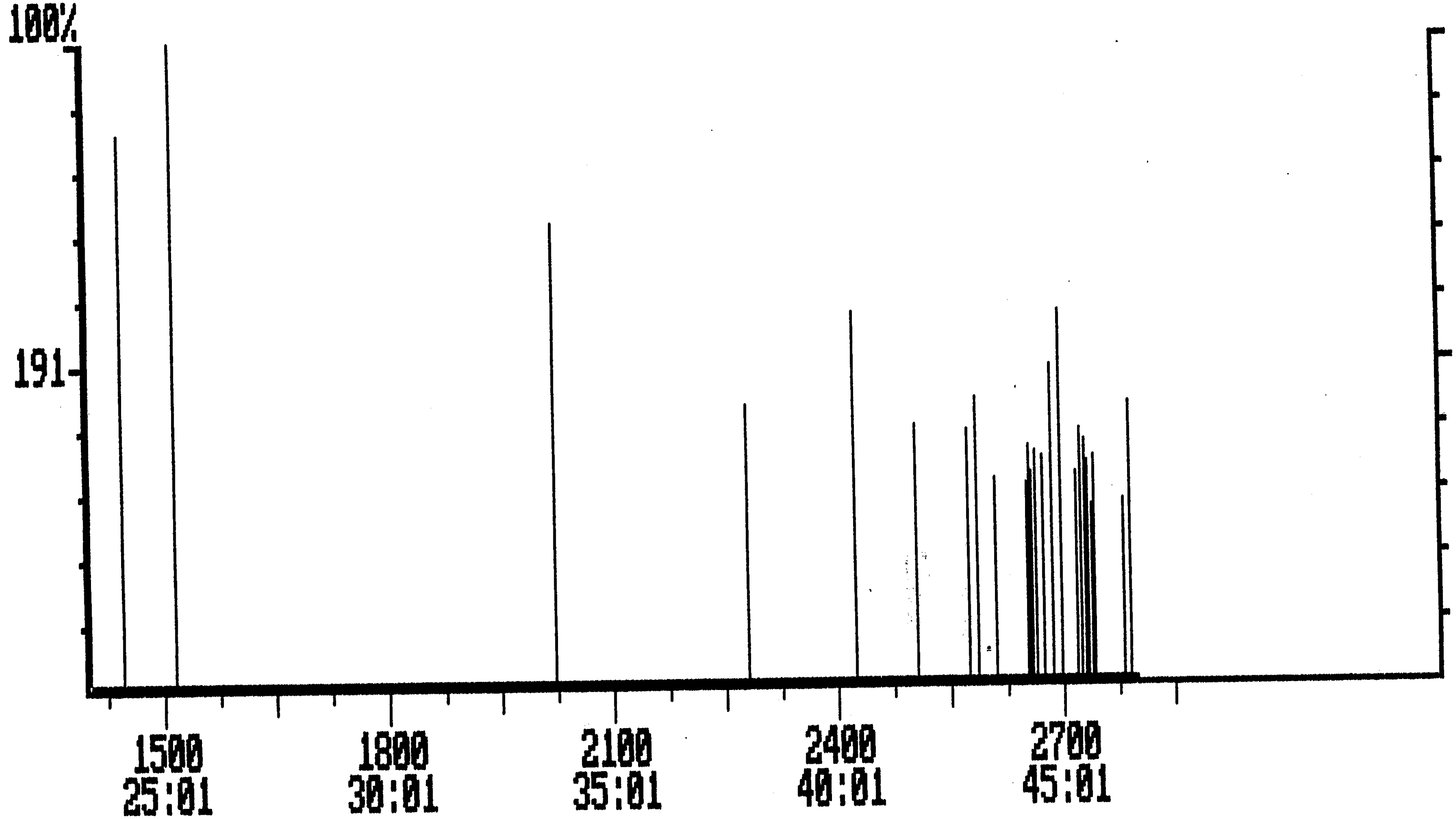

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Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
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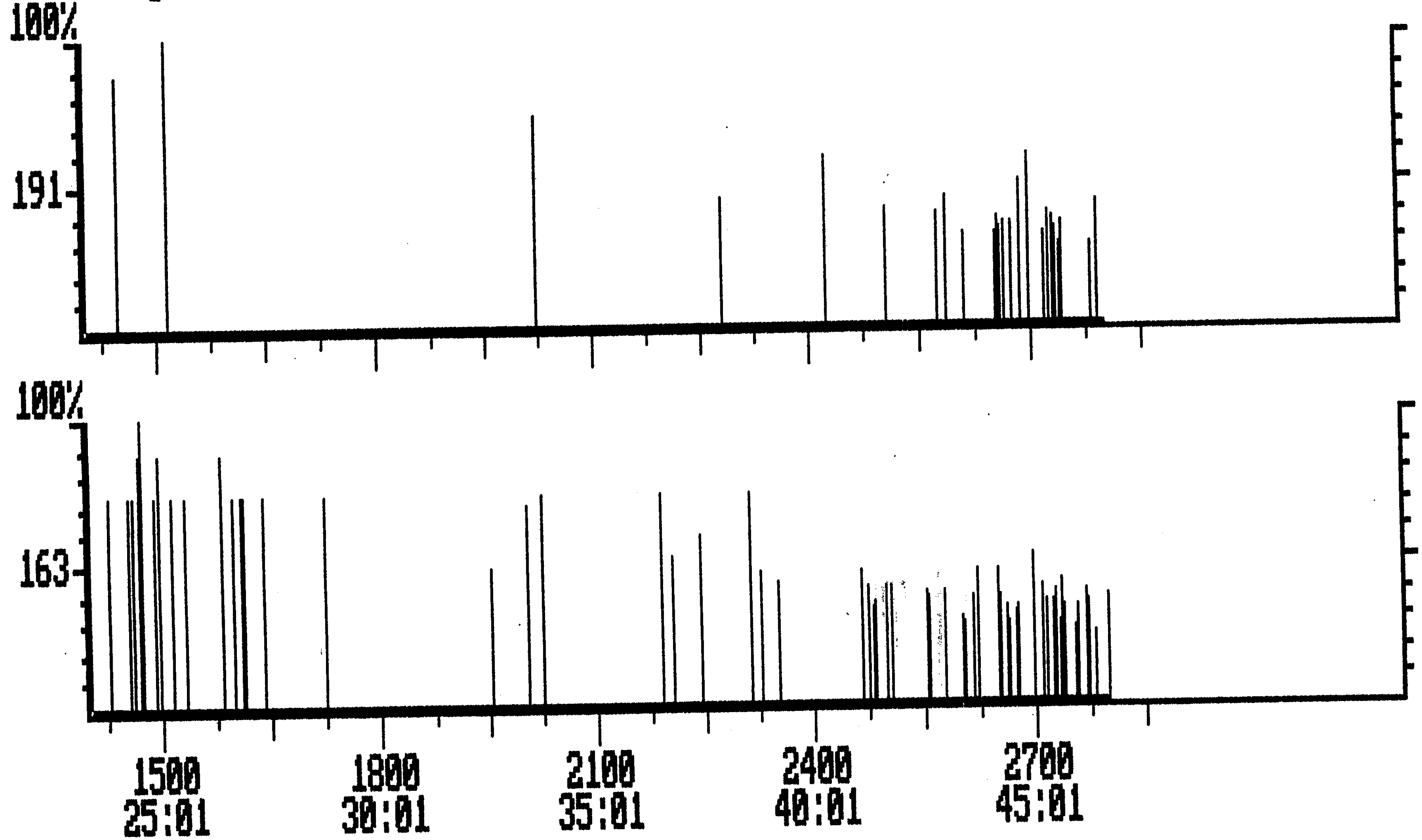
Scan Range: 1400 - 2800 Scan: 1400 Int = 36513 @ 23:21 100% = 2457



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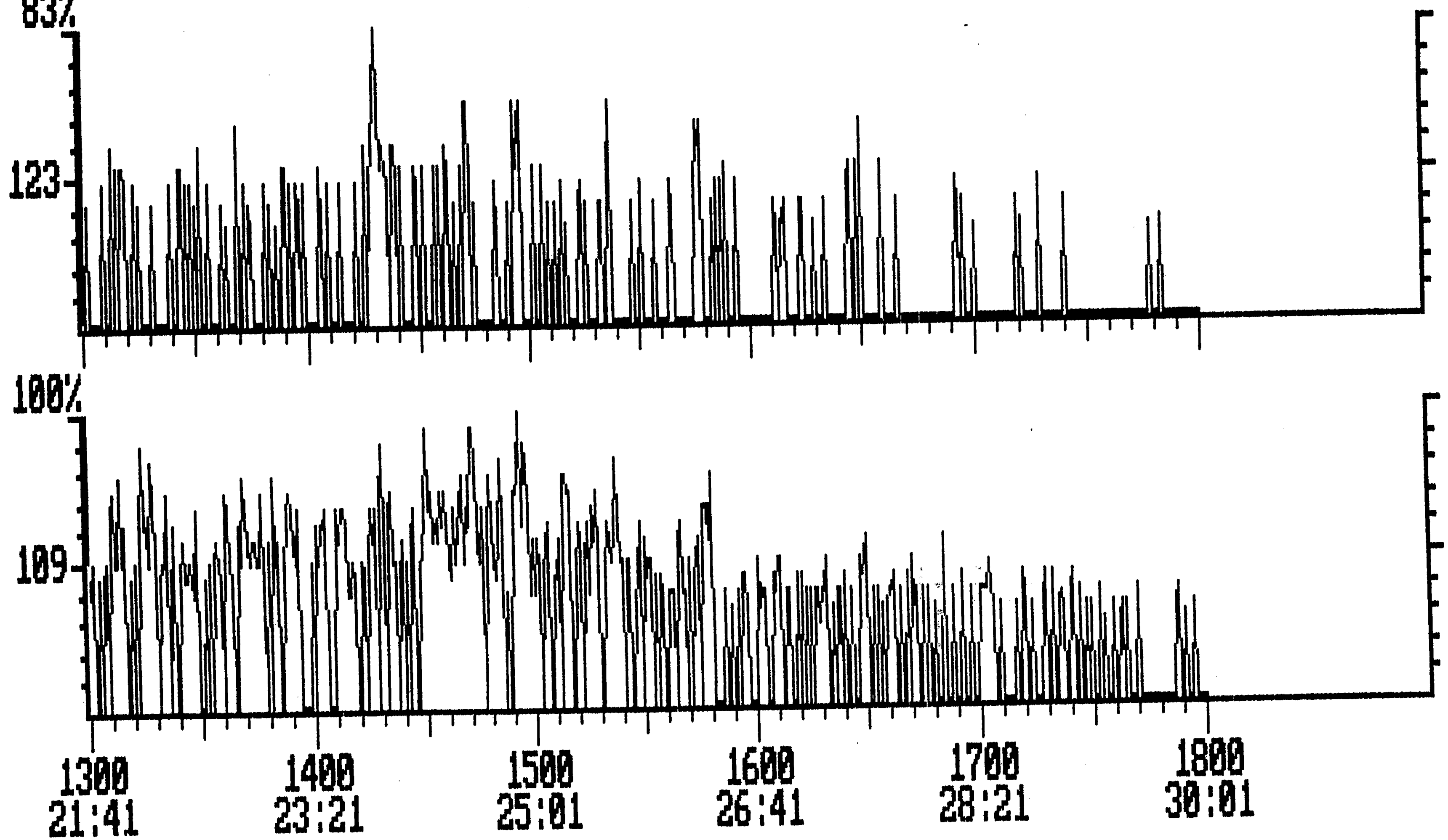
Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
Comment: NAPTH GAS & FUEL BOGGY CK-1 AMDEL CORE SERVICES
Scan Range: 1300 - 1800 Scan: 1300 Int = 28087 @ 21:41 100% = 6319



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Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
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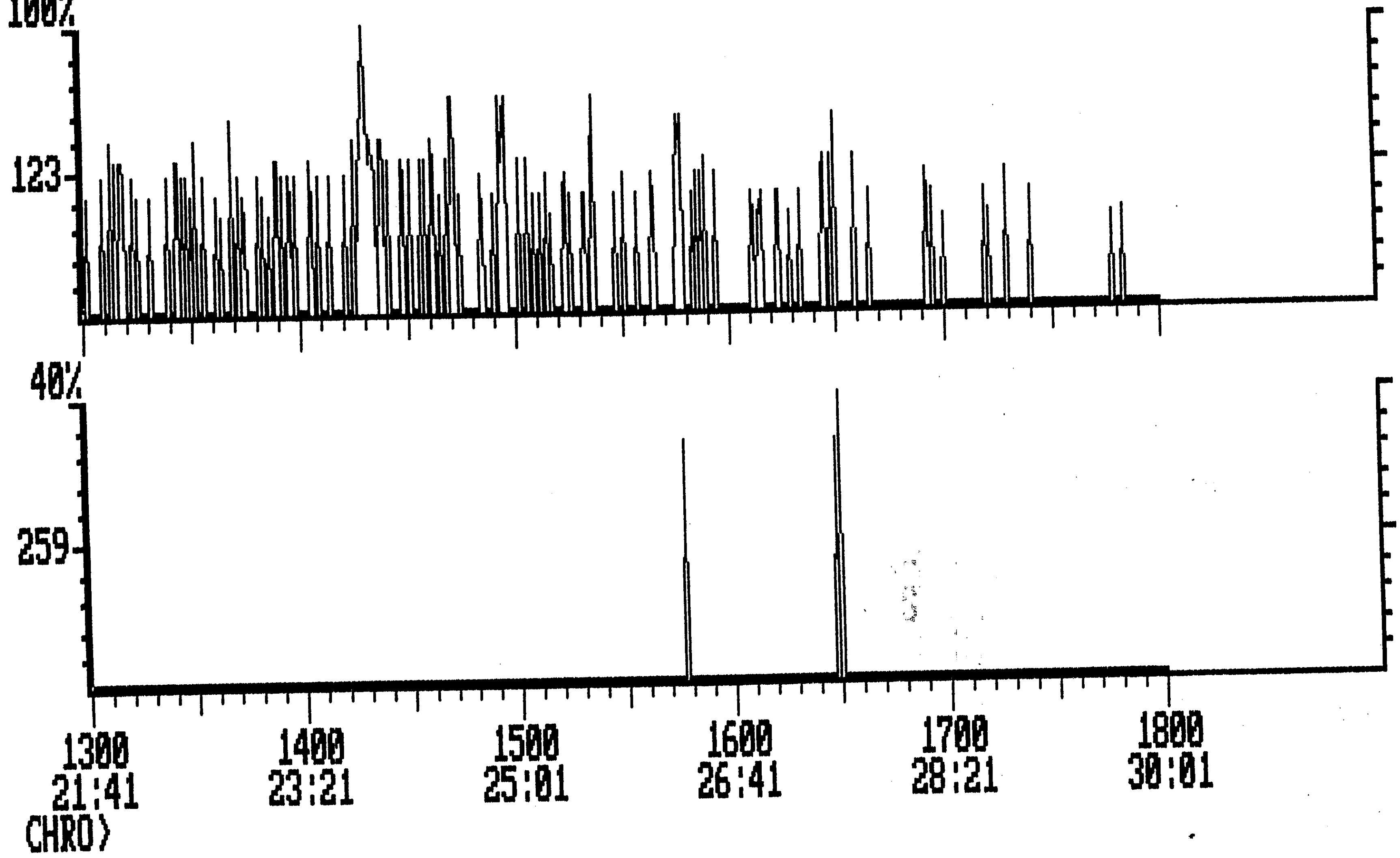

Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
Comment: NAPTH GAS & FUEL BOGGY CK-1 AMDEL CORE SERVICES
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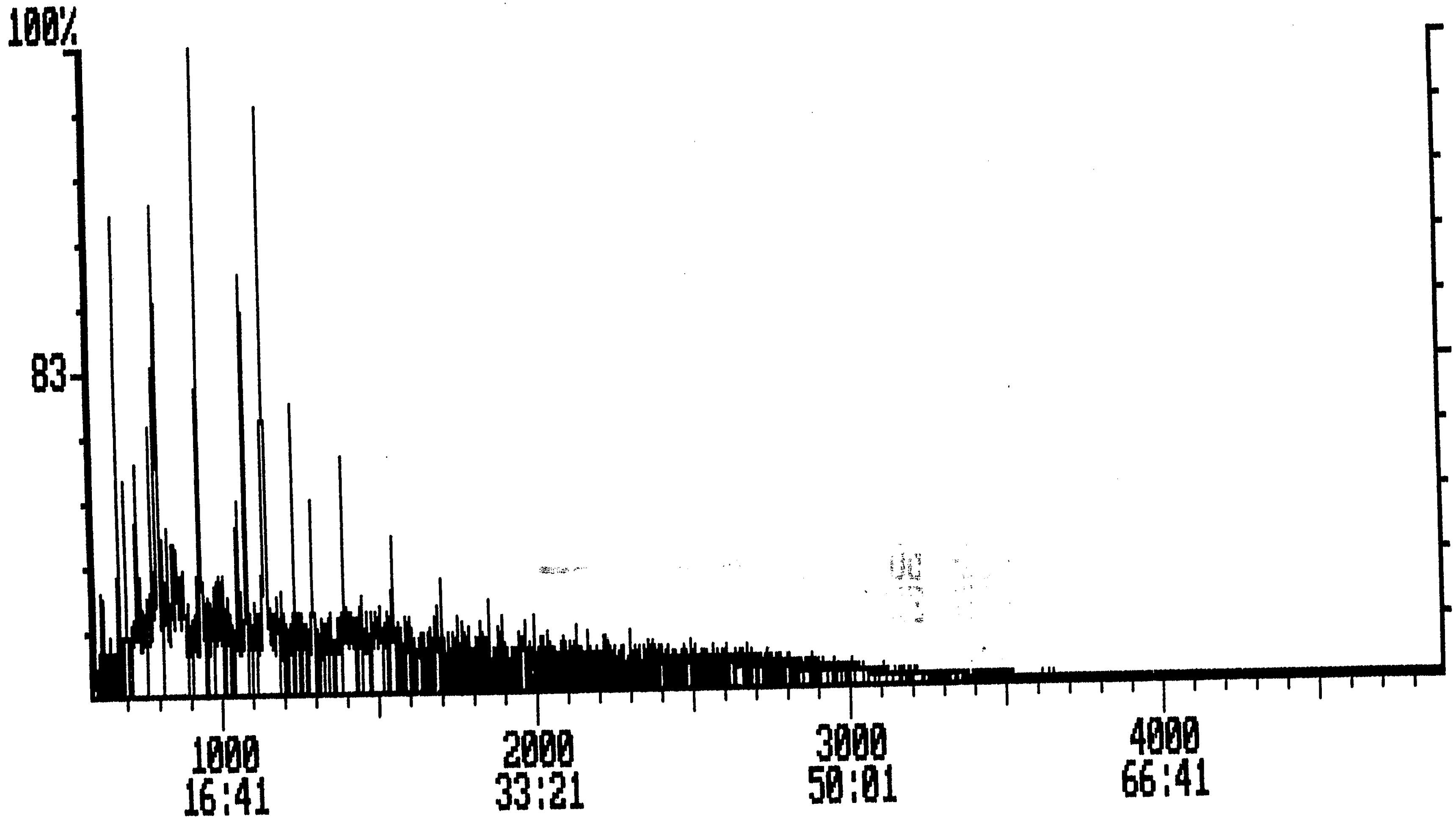

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Chromatogram D:\ACS485 Acquired: Oct-26-1992 12:15:50
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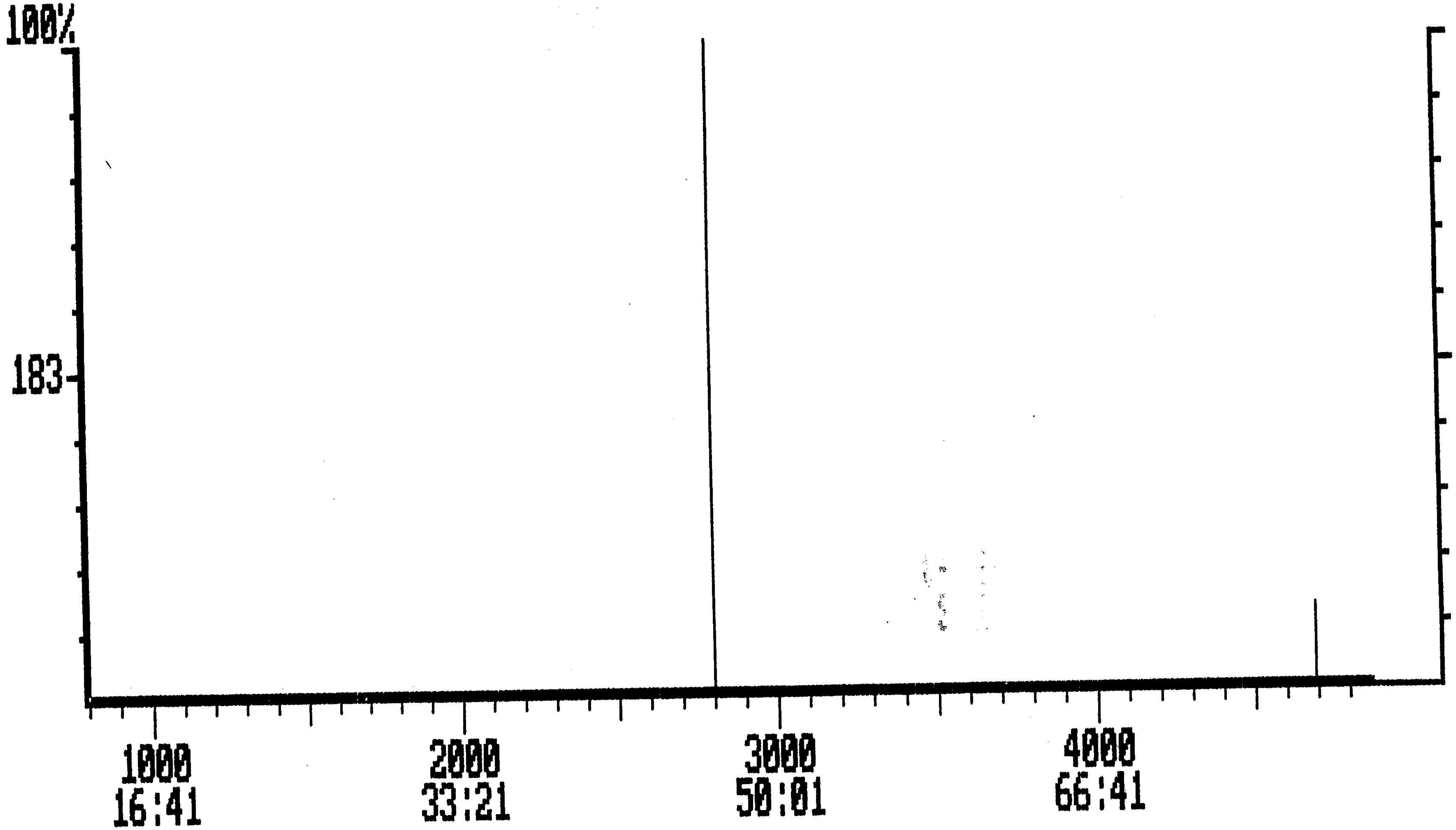
Scan Range: 800 - 4800 Scan: 800 Int = 277364 @ 13:21 100% = 856



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