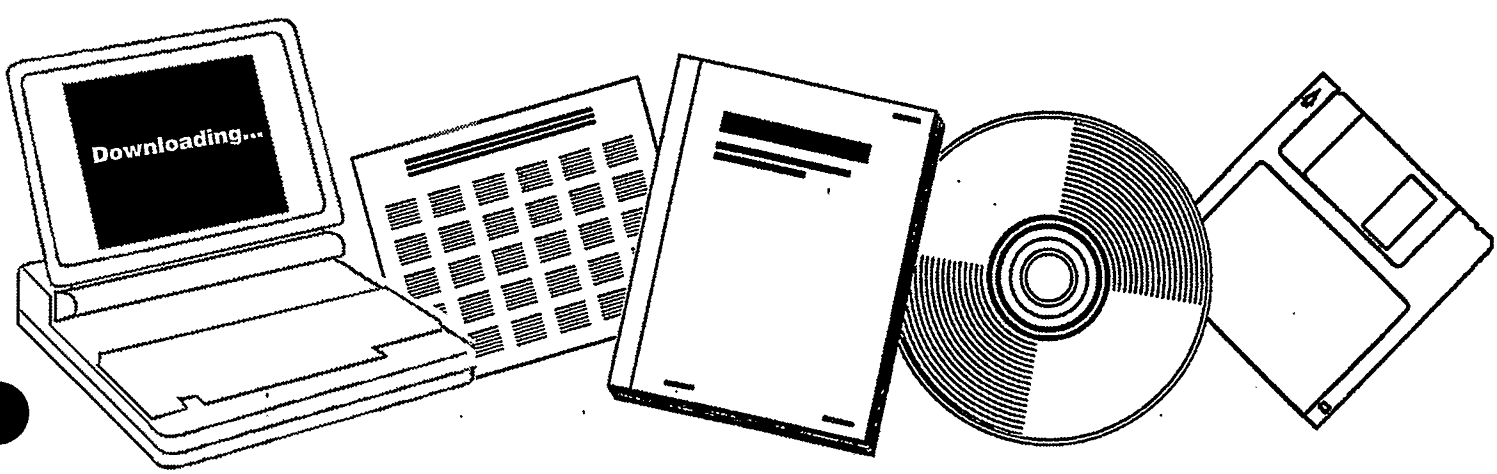
IMPROVED CATALYSTS FOR LIQUID HYDROCARBON FUELS FROM SYNGAS. FOURTH QUARTERLY TECHNICAL PROGRESS REPORT, JULY-SEPTEMBER 1985

UNION CARBIDE CORP., TARRYTOWN, NY.
TARRYTOWN TECHNICAL CENTER

1985



DOE/PC/70028--T5

RECEIVED BY OSTI NOV 07 1985

TECHNICAL PROGRESS REPORT
DE-AC22-84PC70028

Fourth Quarterly Report
July - September 1985

IMPROVED CATALYSTS FOR LIQUID HYDROCARBON FUELS FROM SYNGAS

Molecular Sieve Department
Catalysts and Process Systems Division

Union Carbide Corporation
Tarrytown Technical Center
Tarrytown, New York 10591

DOE/PC/70028--T5

DE86 002262

TECHNICAL PROGRESS REPORT
DE-AC22-84PC70028

Fourth Quarterly Report
July - September 1985

IMPROVED CATALYSTS FOR LIQUID HYDROCARBON FUELS FROM SYNGAS

Molecular Sieve Department
Catalysts and Process Systems Division

Union Carbide Corporation
Tarrytown Technical Center
Tarrytown, New York 10591

Contents

Appendixes

I. CONTRACT OBJECTIVE

The objective of the contract is to consolidate the advances made during the previous contract in the conversion of syngas to motor fuels using Molecular Sieve-containing catalysts and to demonstrate the practical utility and economic value of the new catalyst/process systems with appropriate laboratory runs.

II. SCHEDULE

The contract work was planned for the twenty-eight month period beginning September 18, 1984.

Work on the program is divided into six tasks.

Task 1 consists of the preparation of a detailed, non-proprietary work plan covering the entire performance of the contract. This work plan was completed in November, 1984.

Task 2 consists of a preliminary techno-economic assessment of the UCC catalyst/process system. This assessment, as well as the final techno-economic evaluation planned for Task 6, will be based on a sensitivity analysis that MITRE will conduct on their recently completed economic evaluation of the Union Carbide Corporation (UCC) system.

Task 3 consists of the optimization of the most promising catalysts developed under prior contract DE-AC22-81PC40077 towards goals defined by the MITRE and Task 2 studies. This work will run through the first 24 months of the contract.

Task 4 consists of the optimization of the UCC catalyst system in a manner that will give it the longest possible service life. This work will run through the first 24 months of the contract.

Task 5 consists of the optimization of a UCC process/catalyst system based upon a tubular reactor with a recycle loop (i.e., the Arge reactor) containing the most promising catalysts developed under the Tasks 3 and 4 studies. This optimal performance will be estimated from a mathematical model of the tubular reactor which incorporates reaction rate constants determined from appropriate Berty reactor runs. This effort will run through the first 24 months of the contract.

Task 6 consists of an economic evaluation of the optimal performance found under Task 5 for the UCC process/catalyst system. This effort will be based on the MITRE sensitivity analysis referred to in the description of Task 2.

The final four months of the contract will be devoted exclusively to the writing of the Eighth Quarterly Report and the Final Technical Report.

III. ORGANIZATION

This contract is being carried out by the Catalyst Research and Development Group of the Molecular Sieve Technology Department, Catalysts and Process Systems Division, Union Carbide Corporation, in Tarrytown, New York.

The principal investigator is Dr. Jule A. Rabo.

The program manager is Dr. Albert C. Frost.

IV. SUMMARY OF PROGRESS

A. Task 1

Task 1, a detailing of the work planned for the other tasks in the contract, has been completed.

B. Task 2

Task 2, a preliminary techno-economic assessment of the UCC catalyst/process system, will be based on a sensitivity analysis that MITRE will conduct on their recently completed economic evaluation of the UCC system.

This sensitivity study is expected to graphically show the differential cost (around the base case cost), expressed as differential cents per gallon of motor fuels, for changes in each of the operating parameters of space velocity, catalyst life, methane make, alpha, C_{25}-C_{30} carbon cutoff, overall conversion, feed H_2:CO ratio, reactor temperature, and reactor pressure.

These differential cost-operating parameter curves will not only strikingly illuminate which of those operating parameters have the greatest effect on product cost (for Task 2), but they will also be used with catalyst performance data and the existing tubular reactor design curves to readily obtain an economic worth for each tested catalyst for any set of envisioned process conditions (for Task 6).

C. Tasks 3 and 4

The major focus of the catalysts tested this Quarter revolved around further improving the X_{11} promoted catalyst of Run 32 (12200-19) which demonstrated improved product selectivity and quality.

Two of the catalysts (Runs 34 and 35) looked at the replacement of the UCC-103 support with UCC-114 and UCC-115 respectively. Both catalysts showed poor activity.

The use of the two additives X_3 and X_{12} were tested in Runs 40 and 39 respectively, for improving catalyst activity. The additive X_3 showed little or no improvement. The catalyst containing X_{12} demonstrated improved activity and selectivity while demonstrating excellent stability when tested at 240C. Stability was, however, less favorable at 260C.

The remainder of the catalysts tested looked at the effects of metal loading, synthesis procedure, and the variation in X_{11} concentration without attaining any major gains in performance.

D. Task 5

The comments of Mr. F. Kunreuther of F. Kunreuther Associates. from his review of the MITRE report, were passed along to MITRE. Although he suggested changes for some of the auxiliary units and for the method used for costing parallel reactors, he agreed with MITRE's overall conclusions.

The activities of almost all of the iron catalysts tested under this and the preceding contract were recalculated in terms of their "specific activity," a ratio that has as its numerator the CO conversion rate for the catalyst in question and has as its denominator the CO conversion rate calculated for an early cobalt-based catalyst operating under the same conditions. The best specific activity found for the iron catalysts was 1.02 at 250C and after 300 hours on stream, a value that is approximately one-half that for the current cobalt catalysts operating at 250C and for the same period of time. A listing of the iron catalysts and their specific activities is given in Appendix C.

The methane make correlation for some of the $Co/X_{11}/U3$ catalysts showed that these catalysts produced six percentage points less methane than did the earlier cobalt catalyst systems over a wide range of comparable H_2/CO ratios. This characteristic may allow the economical use of a higher H_2/CO feed ratio to gain a higher space velocity at a reasonable methane make. This trade-off can be costed when the MITRE sensitivity study is completed.

Work has started on the conversion of all of the DTSS (Dartmouth Time Sharing System, an outside system) computer programs over to CAPS (Catalyst and Process Systems, an inside system) before the planned January 1st phase-out of DTSS.

E. Task 6

Since this final techno-economic evaluation is scheduled to begin in Fiscal Year 1986, no work was done on it this quarter.

Additionally, the sequential sensitivity studies coming from MITRE will substantially aid in satisfying the objectives of this task in addition to completing those of Task 2 (see B. Task 2).

V. CHANGES

There were no contract changes during the Fourth Quarter.

VI. FUTURE WORK

Tasks 3 and 4 will continue to be devoted to developing new, stable catalyst formulations that will have higher specific activities and lower methane makes than do our present catalysts.

Task 5 will be devoted to continuing the changeover from the DTSS to the CAPS computer systems, and to examining the space velocity-methane make trade-off with correlated data for the $Co/X_{11}/UCC\text{-}103$ catalyst systems.

Albert C. Frost

APPENDIX A. CATALYST TESTING: SUMMARY OF RUNS REPORTED DURING THIS QUARTER

APPENDIX A. CATALYST TESTING: SUMMARY OF RUNS REPORTED DURING THIS QUARTER

J. G. Miller, L. F. Elek, C-L Yang and K. N. Beale

This report is organized around the ten catalytic tests conducted from July through September 1985, the fourth quarter of this contract.

A list of the catalysts tested, a description of their preparation, and a brief statement of each test's objective are shown in Table A1. All of the catalysts tested involved cobalt oxide intimately contacted with UCC-103, except for Runs 34 and 35, in which UCC-114 and UCC-115, respectively, were substituted for UCC-103 as the catalyst support. The catalysts tested look extensively at the use of the additive X_{11}, shown to be successful in Run 32 (12200-19) in Appendix B of this Report. Catalysts in Runs 40 and 41 were prepared by the intimately mixed method developed in the previous three year contract (DE-AC22-81PC40077) and the remainder were prepared by the intimately mixed method used for the catalyst tested in Run 11 (Third Quarterly Report) of the present contract.

An abbreviated table of results for these catalyst runs is shown in Table A2. The conversion, weight percent CH_4, weight percent C_5^+, specific activity, the methane factor and a qualitative estimate of stability are listed for each catalyst. A more complete report of results and analyses for these runs will be presented in the Fifth Quarterly Report.

Table A1. Description of most of the catalysts tested during the fourth quarter.

Run	Catalyst	Catalyst preparation	Objective of test
34	Co/X_{11}/UCC-114 (12200-20)	The X_{11} promoted cobalt oxide catalyst was formulated similarly to Run 32, except that UCC-114 was substituted for UCC-103. Theoretical pct Co=8.2, pct X_{11}=1.6.	Tested the use of UCC-114 as a replacement for UCC-103.
35	Co/X_{11}/UCC-115 (12185-20)	The X_{11} promoted cobalt oxide catalyst was formulated similarly to Run 32, except that UCC-115 was substituted for UCC-103. Theoretical pct Co=4.1, pct X_{11}=0.8.	Tested the use of UCC-115 as a replacement for UCC-103.
36	Co/X_{11}/UCC-103 (12200-21)	The X_{11} promoted cobalt oxide catalyst was formulated similarly to Run 32, but was exposed to different catalyst pretreatment. Theoretical pct Co=12.3, pct X_{11}=2.4.	Tested effects of both catalyst pretreatment and increasing cobalt concentration.
37	Co/X_{11}/UCC-103 (12185-21)	The X_{11} promoted cobalt oxide catalyst was formulated similarly to Run 32, except that the catalyst was exposed to the preatment used for Run 20. Theoretical pct Co=8.2, pct X_{11}=1.6.	Looked at the effects of catalyst pretreatment.
38	Co/X_{11}/UCC-103 (12200-22)	The X_{11} promoted cobalt oxide catalyst was formulated similarly to Run 37, except that it contained a higher concentration of cobalt. Theoretical pct Co=12.3, pct X_{11}=2.4.	Tested the effects of increasing the cobalt concentration.
39	$Co/X_{11}/X_{12}$/UCC-103 (11617-04)	The X_{11} and X_{12} promoted cobalt oxide catalyst was formulated similarly to Run 37. Theoretical pct Co=7.6, pct X_{11}=1.4, pct X_{12}=5.0.	Tested the new promoter X_{12} in improving catalyst performance.
40	$Co/X_{11}/X_3$/UCC-103) (12185-19)	The X_{11} and X_3 promoted cobalt oxide catalyst was formed in close contact with UCC-103 by the method used in Run 15 (3rd Qt Rept). The resulting powder was bonded with 15% silica and extruded to 1/8" pellets. Theoretical pct Co=8.2, pct X_{11}=1.6, pct X_3=0.06.	Tested the use of the additive X_3 on improving the performance of a catalyst formulated by the method used in Run 15.

continued

Table A1, continued.

Run	Catalyst	Catalyst preparation	Objective of test
41	Co/X_{11}/UCC-103 (11617-03)	The X_{11} promoted cobalt oxide catalyst was formed in close contact with UCC-103 by the method used in Run 15 (3rd Qt Rept). Theoretical pct Co=12.3, pct X_{11}=2.4.	Tested the effect of X_{11} on a catalyst formulated by the method used in Run 15.
42	Co/X_{11}/UCC-103 (11617-05)	The X_{11} promoted cobalt oxide catalyst was formulated similar to Run 36. Theoretical pct Co=8.1, pct X_{11}=2.6.	Tested the effect of increasing the X_{11} additive.
43	Co/X_{11}/UCC-103 (12570-01)	The X_{11} promoted cobalt oxide catalyst was formulated identical to Run 32. Theoretical pct Co=8.2, pct X_{11}=1.6.	Attempted to reproduce the results obtained with the catalyst used in Run 32.

Table A2. Preliminary catalyst test results for most of the runs made during the fourth quarter.

Run	Catalyst	Hours on stream	Total conversion ($CO+H_2$)	CH_4 wt %	C_5^+ wt %	Specific activity	Methane factor(1)	Stability
34	Co/X_{11}/UCC-114 (12200-20)	19.5	8.9	15.8	63.3	0.18	13.8	— (2)
35	Co/X_{11}/UCC-115 (12185-20)	19.0	12.6	30.8	48.8	0.21	3.77	— (2)
		43.5	13.1	29.5	51.9	0.22	3.85	
36	Co/X_{11}/UCC-103 (12200-21)	24.5	54.7	3.9	88.6	6.43	1.11	— (2)
		50.0	52.2	3.4	88.6	6.08	0.64	
		(run terminated due to power failure)						
37	Co/X_{11}/UCC-103 (12185-21)	43.8	49.2	6.7	83.1	3.53	0.78	Fair (2)
		114.0	46.7	6.2	82.3	3.36	0.95	
		138.0	62.4	10.7	77.4	2.75	2.25	Fair (3)
		401.7	58.2	10.8	76.6	2.05	4.01	
38	Co/X_{11}/UCC-103 (12200-22)	48.5	50.4	3.3	89.9	4.60	1.38	Poor (2)
		148.0	44.0	4.3	85.8	3.30	0.82	
		167.5	54.0	6.5	82.8	2.57	1.80	Fair (3)
		311.5	52.2	6.3	82.6	2.09	1.99	
		359.5	91.5	36.4	41.5	2.28	3.09	— (4)
		407.5	68.1	17.7	68.8	1.76	6.31	— (5)
39	$Co/X_{11}/X_{12}$/UCC-103 (11617-4)	44.0	50.8	4.8	87.2	4.12	1.18	Excellent (2)
		333.0	50.9	4.1	88.1	4.16	1.10	
		357.0	60.4	9.0	80.1	2.70	2.93	Fair (3)
		505.0	57.4	9.4	79.2	2.06	4.03	
40	$Co/X_{11}/X_3$/UCC-103 (12185-19)	43.0	62.3	12.1	75.7	1.97	2.61	Fair (3)
		187.0	56.6	10.0	79.7	1.81	1.91	

(1) The ratio of the amount of CH_4 actually produced to the amount of CH_4 predicted from the Schulz-Flory equation, $[CH_4/(1-\alpha)^2]$.
(2) Conditions: 240C, 300 psig, 300 GHSV, 1:1 H_2:CO.
(3) " 260C " " " " " "
(4) " 260C " " " " 2:1 H_2:CO.
(5) " 260C " " " " 1.5:1 H_2:CO.

continued

Table A2, continued.

Run	Catalyst	Hours on stream	Total conversion $(CO+H_2)$	CH_4 wt %	C_5^+ wt %	Specific activity	Methane factor(1)	Stability
41	Co/X_{11}/UCC-103 (11617-03)	48.0	41.7	4.3	90.9	1.81	1.11	—— (2)
		68.0	47.6	7.7	84.4	1.00	1.61	Good (3)
		91.5	49.1	7.9	84.3	0.99	2.20	
42	Co/X_{11}/UCC-103 (11617-05)	42.5	46.1	6.9	83.5	3.25	1.57	Fair (2)
		186.5	41.4	6.1	82.4	2.63	0.88	
		210.5	56.8	12.4	73.8	1.88	2.60	Fair (3)
		405.5	52.7	10.1	77.5	1.67	2.75	
43	Co/X_{11}/UCC-103 (12570-01)	45.0	49.1	4.7	87.0	3.64	0.75	Good (2)
		211.0	42.3	5.9	84.0	2.48	1.32	
		235.0	56.5	10.9	76.4	1.97	3.02	Good (3)
		405.5	52.7	10.1	77.5	1.67	2.75	

(1) The ratio of the amount of CH_4 actually produced to the amount of CH_4 predicted from the Schulz-Flory equation, $[CH_4/(1-\alpha)^2]$.
(2) Conditions: 240C, 300 psig, 300 GHSV, 1:1 H_2:CO.
(3) " 260C " " " " " "
(4) " 260C " " " " 2:1 H_2:CO.
(5) " 260C " " " " 1.5:1 H_2:CO.

APPENDIX B. CATALYST TESTING: DETAILS OF RUNS REPORTED DURING THIRD QUARTER

APPENDIX B. CATALYST TESTING: DETAILS OF RUNS REPORTED DURING THIRD QUARTER

J. G. Miller, L. F. Elek, C-L Yang and P. K. Coughlin

Contents

I. INTRODUCTION

This report presents detailed analyses of the eight catalyst test runs summarized in Appendix A of the Third Quarterly Report, which constituted the major thrust of the work during that Quarter.

All eight catalysts contained cobalt oxide intimately contacted with a Molecular Sieve--UCC-113 in one catalyst, UCC-103 in the seven others.

Catalyst 33 was formulated by methods developed in the previous contract (DE-AC22-81PC40077). All others were formulated by the method developed for Catalyst 11 of the Third Quarterly Report.

In Runs 26, 27 and 32, three of the newly formulated catalysts, which had shown very high initial activity at 260C, were tested at other reaction temperatures. The object was to explore the possibility of increasing their stability.

The properties of the Molecular Sieve UCC-113 were investigated by comparing its performance with that of a similar catalyst containing UCC-103.

Two new additives, X_3 and X_{11}, were tested for their effectiveness in a cobalt/UCC-103 catalyst. An additional test of the additive X_4, a proven stabilizer, was also run.

Pretreatment of the catalyst during synthesis was investigated, and correlated to some potentially interesting selectivity properties.

II. Run 26 (12185-14) with Catalyst 26 ($Co/X_9/X_{10}$/UCC-103

This run was a first attempt to test the effects of different reaction temperatures on the stability of catalysts formulated by the method developed for Catalyst 11 (Run 12200-06) of the Third Quarterly Report.

The composition and preparation of the catalyst were identical to those of Catalyst 20 (Run 12185-11) of the Third Quarterly Report except that this catalyst was calcined before bonding with silica. As in Catalyst 20, the theoretical concentrations of cobalt, X_9, and X_{10} were, respectively, 11.9, 0.5 and 0.7 percent.

Conversion, product selectivity, isomerization of the pentane, and percent olefins of the C_4's are plotted against time on stream in Figs. B1-4. Simulated distillations of the C_5^+ product are plotted in Figs. B5-25. Carbon number product distributions are plotted in Figs. B26-46. Chromatograms from simulated distillations are reproduced in Figs. B47-67. Detailed material balances appear in Tables B1-5.

The run was started at 200C, following which the temperature was systematically raised in increments of 10 and 20 degrees.

The initial activity at 200C was low, with a syngas conversion of 13.55 percent. The calculated specific activity, which should be independent of temperature, was only 2.95--much lower than the value of more than 7 for Catalyst 7 at 260C.

When the temperature was raised to 220C the conversion increased to 30.0 percent. The specific activity, however, remained at about 2.9.

The temperature was raised again to 240C, where it was held for 119.5 hours. The stability during this period was fairly good. A linear least squares analysis predicted a loss of conversion of one percentage point every 91 hours; based on specific activity, in contrast, the estimated loss was only one specific activity unit every 1600 hours.

At 250C the pattern was similar: by linear least squares calculation, a loss of conversion of one percentage point every 370 hours and a loss of specific activity of one specific activity unit every 512 hours.

The stability fell off considerably at 260C, with a loss of conversion of one percentage point every 33 hours and a loss of specific activity of one specific activity unit every 225 hours. The level of specific activity at this temperature was comparable to that of Catalyst 20 at 115.5 hours on stream--2.6 and 2.3 respectively.

The selectivity at 260C was similar to that of Catalyst 20 at comparable conversion levels. The high initial water gas shift activity of Catalyst 20, however, was not equalled by this catalyst at any time during the test.

The Schulz-Flory plots of product distribution are linear except for the usual high methane. Unlike those of Catalyst 20, they show no potential carbon number cut-off; this is now believed to be linked to the catalyst pre-treatment, for which further evidence will be presented in the analysis of Run 31.

This test has demonstrated a temperature-dependent property of the X_9, X_{10} promoted catalyst, with stability good to excellent at temperatures of 250C and lower. The high initial syngas conversion and water gas shift activity of Catalyst 20 at 260C were not obtained with this catalyst when the run was started at 200C.

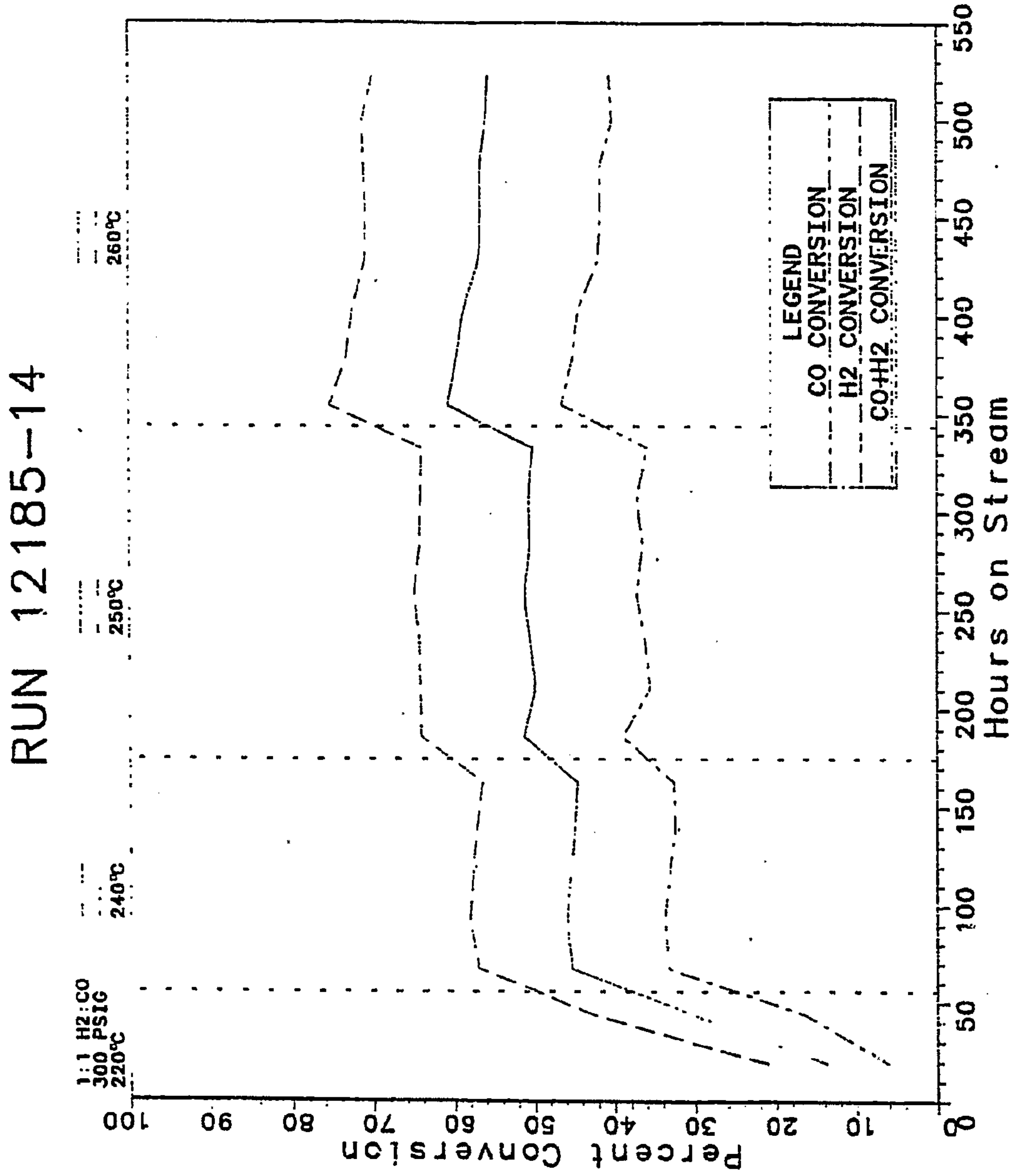

RUN 12185-14
1:1 H2:CO
300 PSIG
220°C
240°C
250°C
260°C
LEGEND
CO CONVERSION
H2 CONVERSION
CO+H2 CONVERSION
Percent Conversion
Hours on Stream

Fig. B1

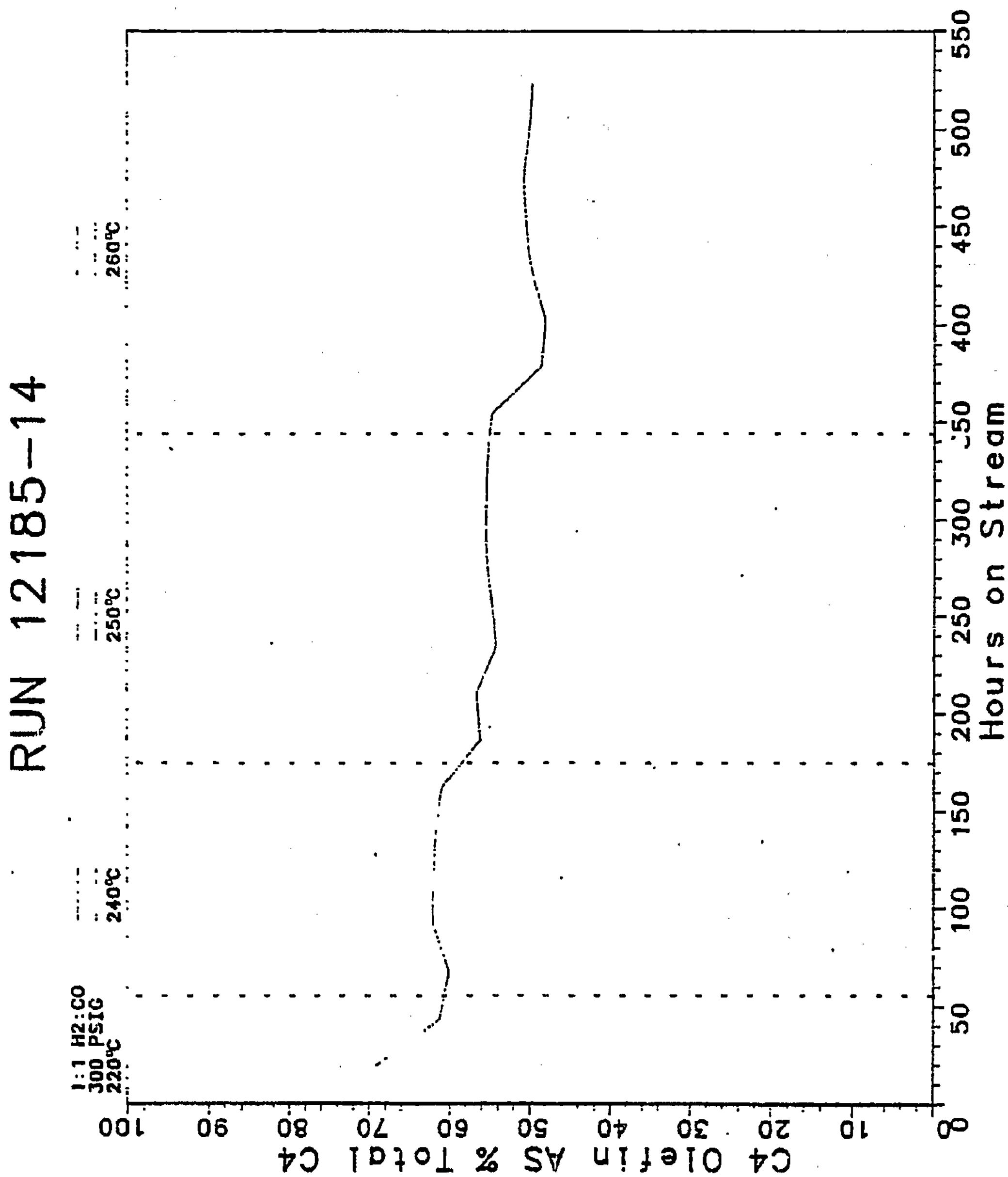

RUN 12185-14
1:1 H2:CO
300 PSIG
220°C
240°C
250°C
260°C
Hours on Stream
C4 Olefin AS % Total C4

Fig. B2

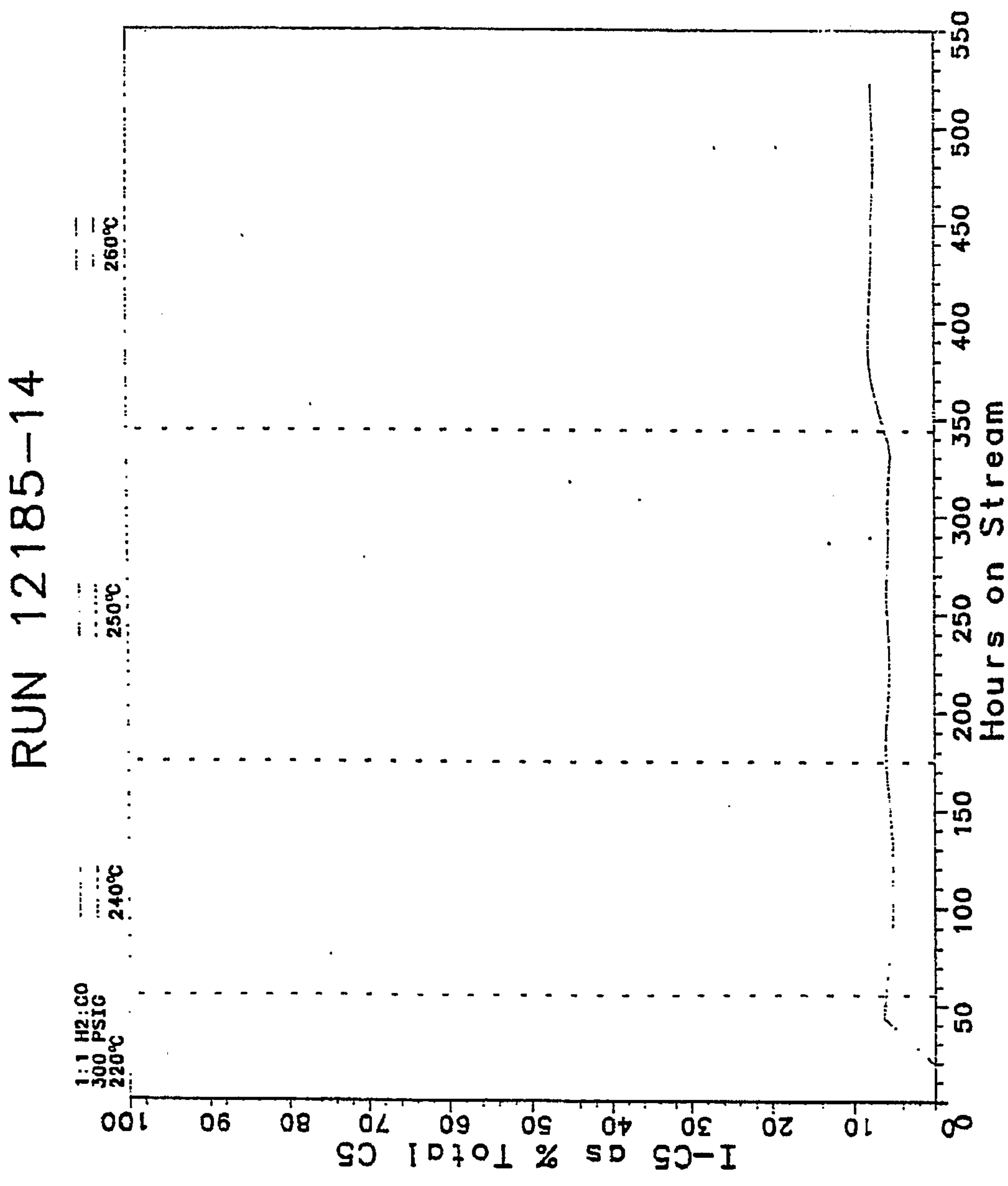

RUN 12185-14
1:1 H2:CO
300 PSIG
220°C
240°C
250°C
260°C
0
50
100
150
200
250
300
350
400
450
500
550
Hours on Stream
0
10
20
30
40
50
60
70
80
90
100
I-C5 as % Total C5

Fig. B3

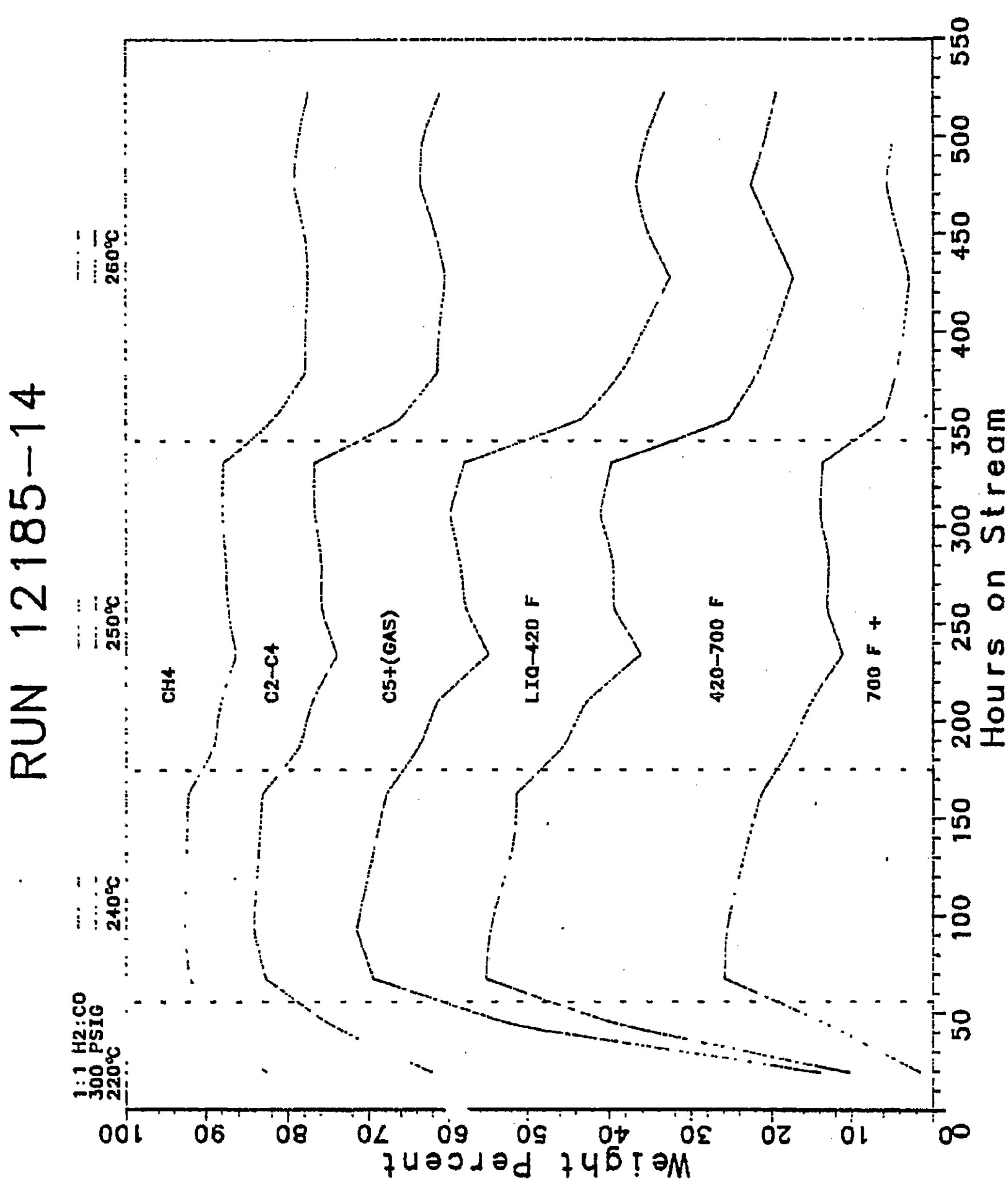

RUN 12185-14
Hours on Stream
Weight Percent
1:1 H2:CO
300 PSIG
220°C
240°C
250°C
260°C
CH4
C2-C4
C5+(GAS)
LIQ-420 F
420-700 F
700 F +
0
50
100
150
200
250
300
350
400
450
500
550
10
20
30
40
50
60
70
80
90
100

Fig. B4

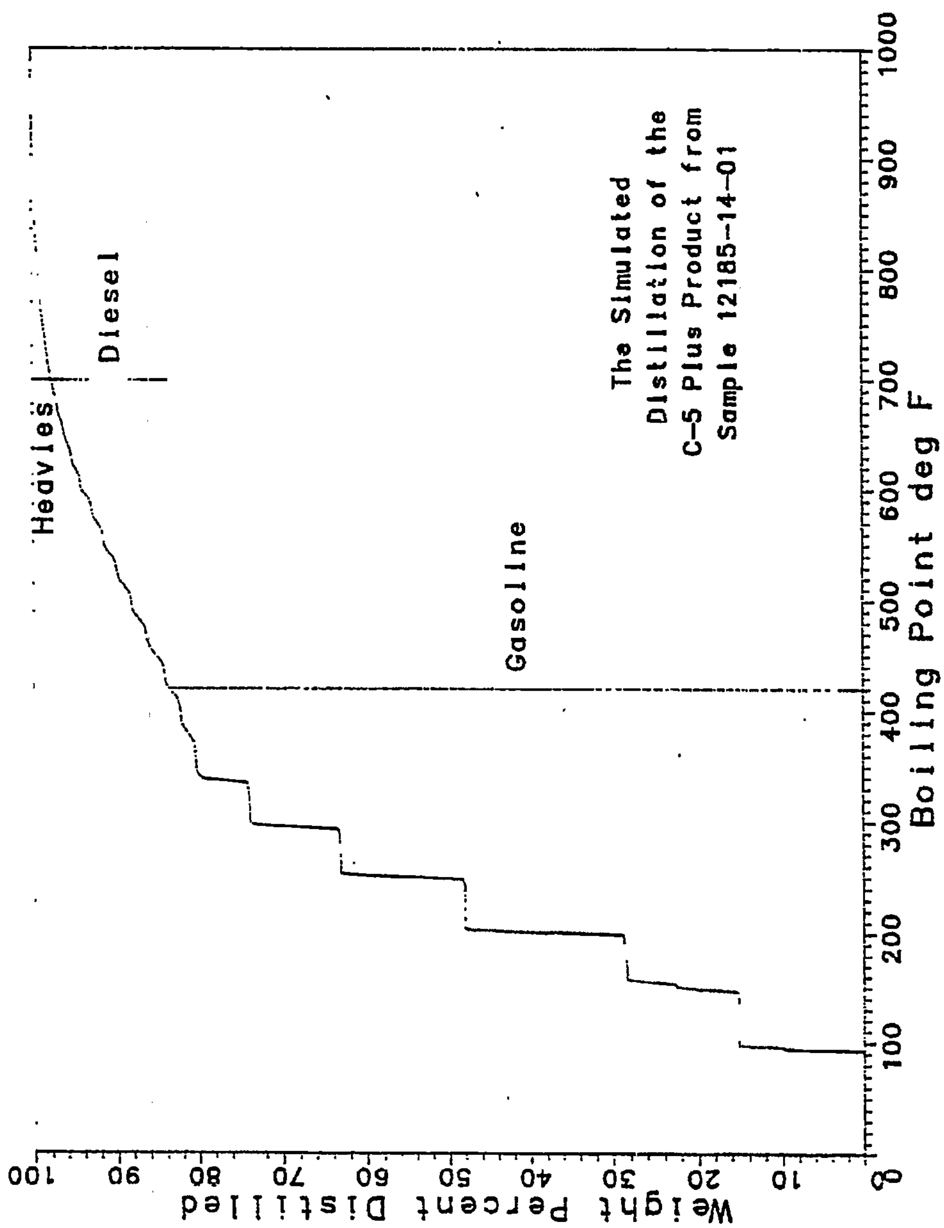

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-01
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
100 200 300 400 500 600 700 800 900 1000
0 10 20 30 40 50 60 70 80 90 100

Fig. B5

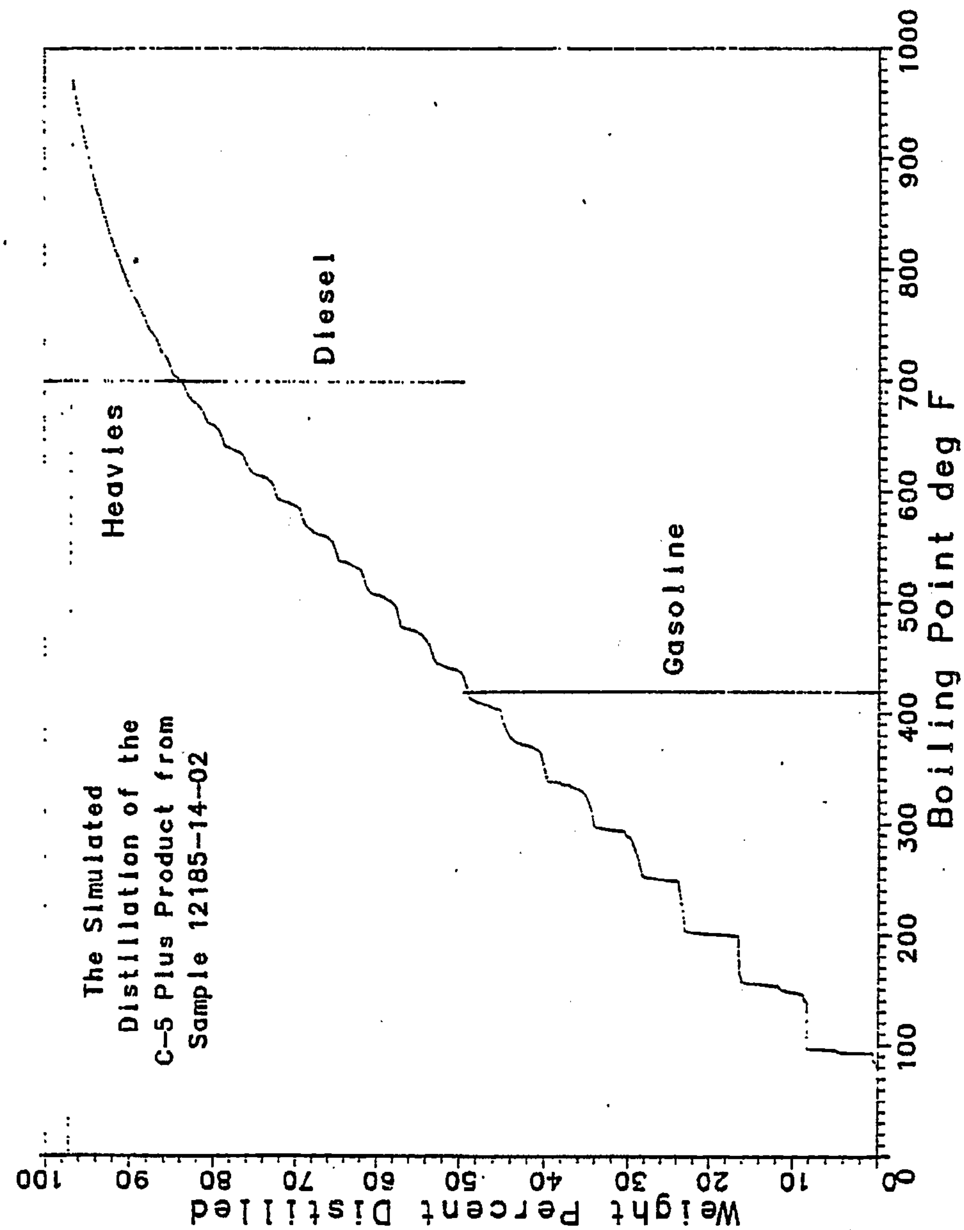

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-02
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled

Fig. B6

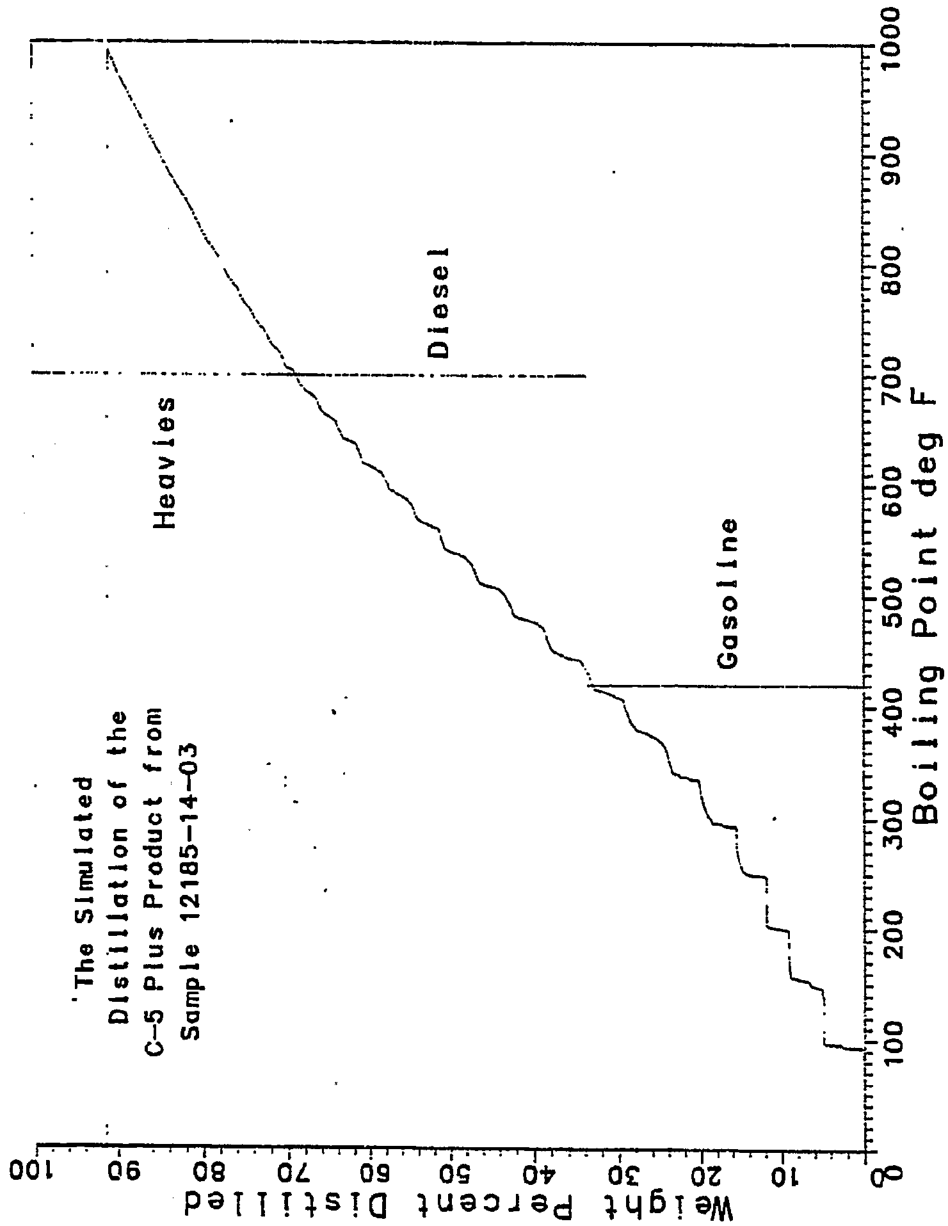
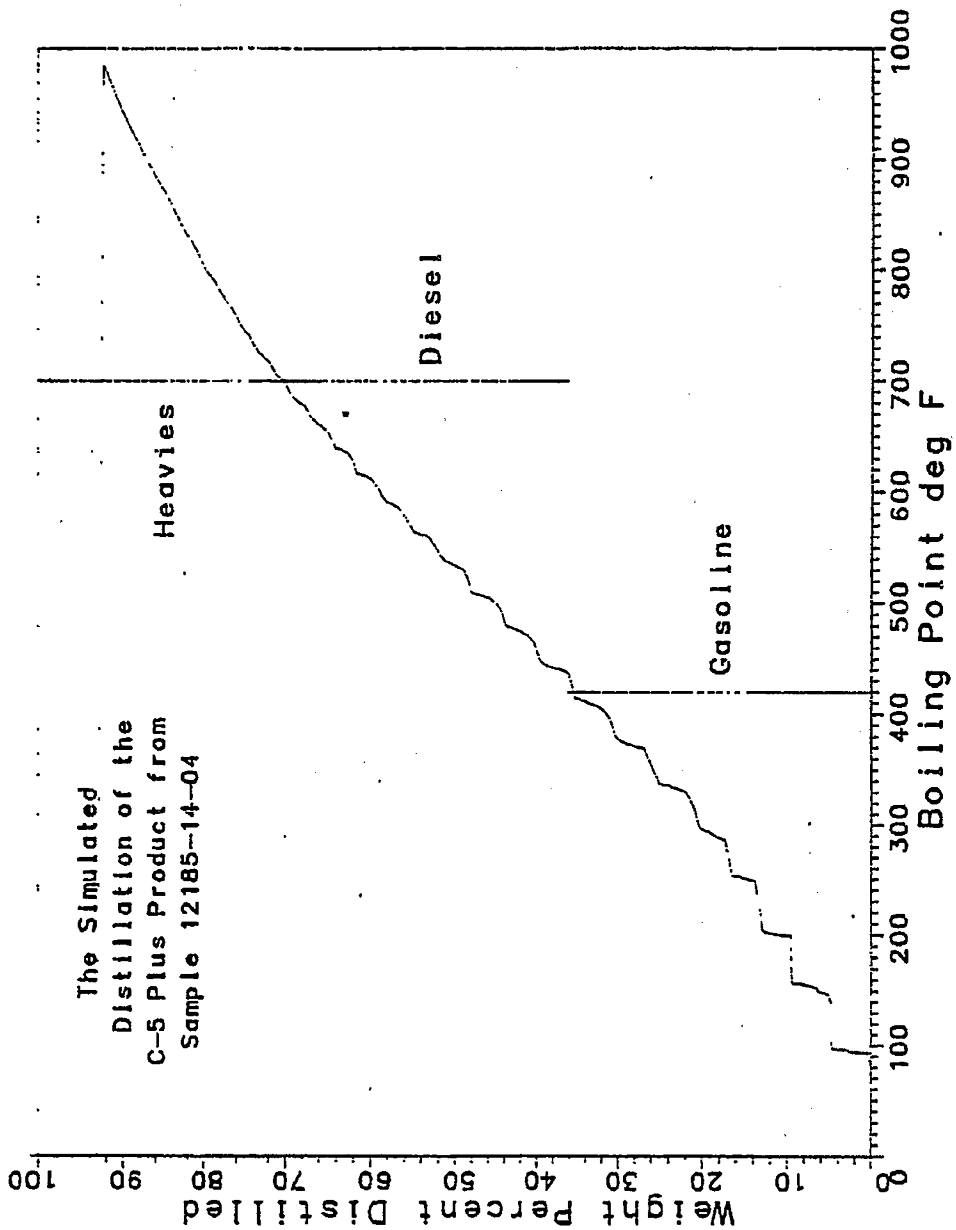

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-03
Heavies
Diesel
Gasoline
Weight Percent Distilled
Boiling Point deg F
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000

Fig. B7



The Simulated Distillation of the C-5 Plus Product from Sample 12185-14-04
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0 100 200 300 400 500 600 700 800 900 1000
0 10 20 30 40 50 60 70 80 90 100

Fig. B8

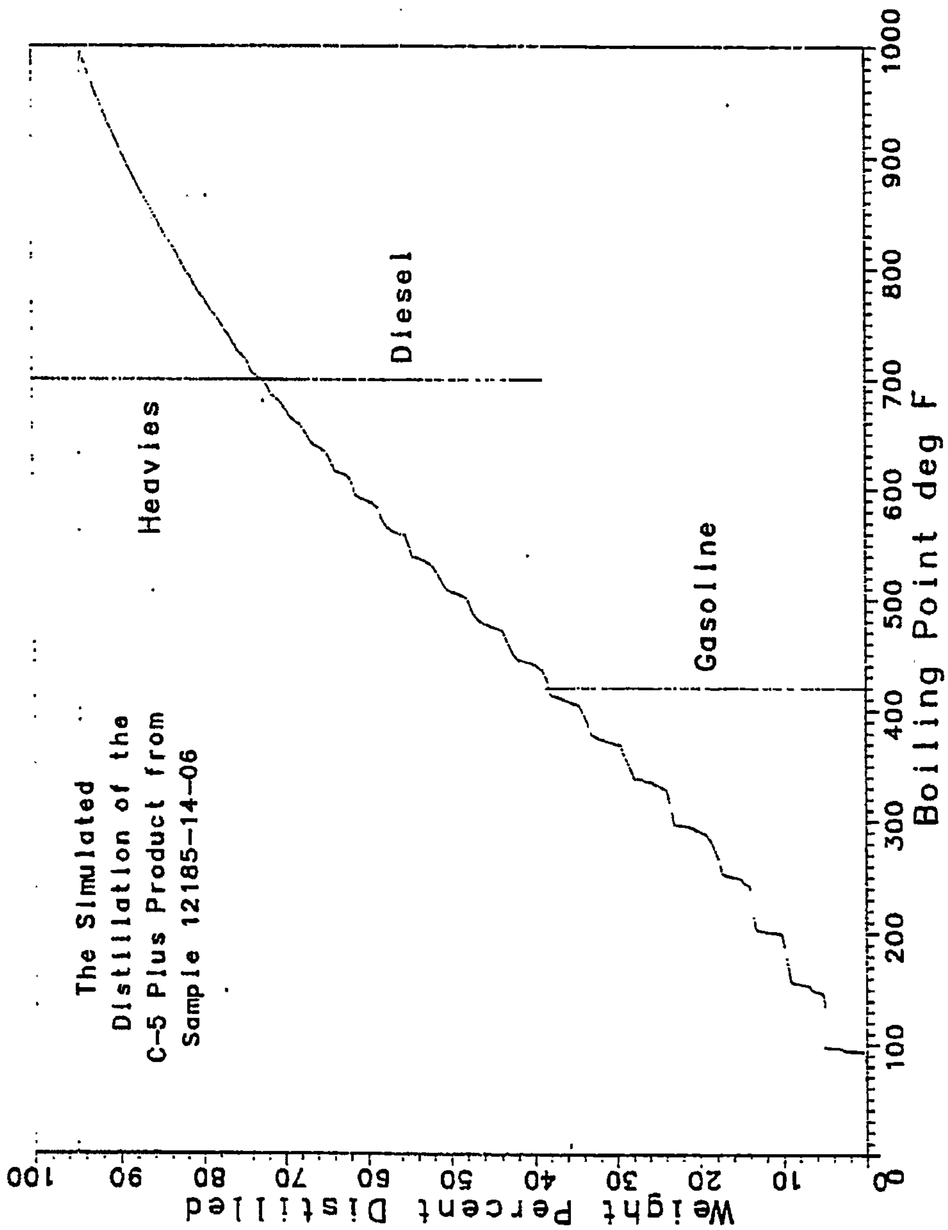

The Simulated Distillation of the C-5 Plus Product from Sample 12185-14-06
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000

Fig. B9

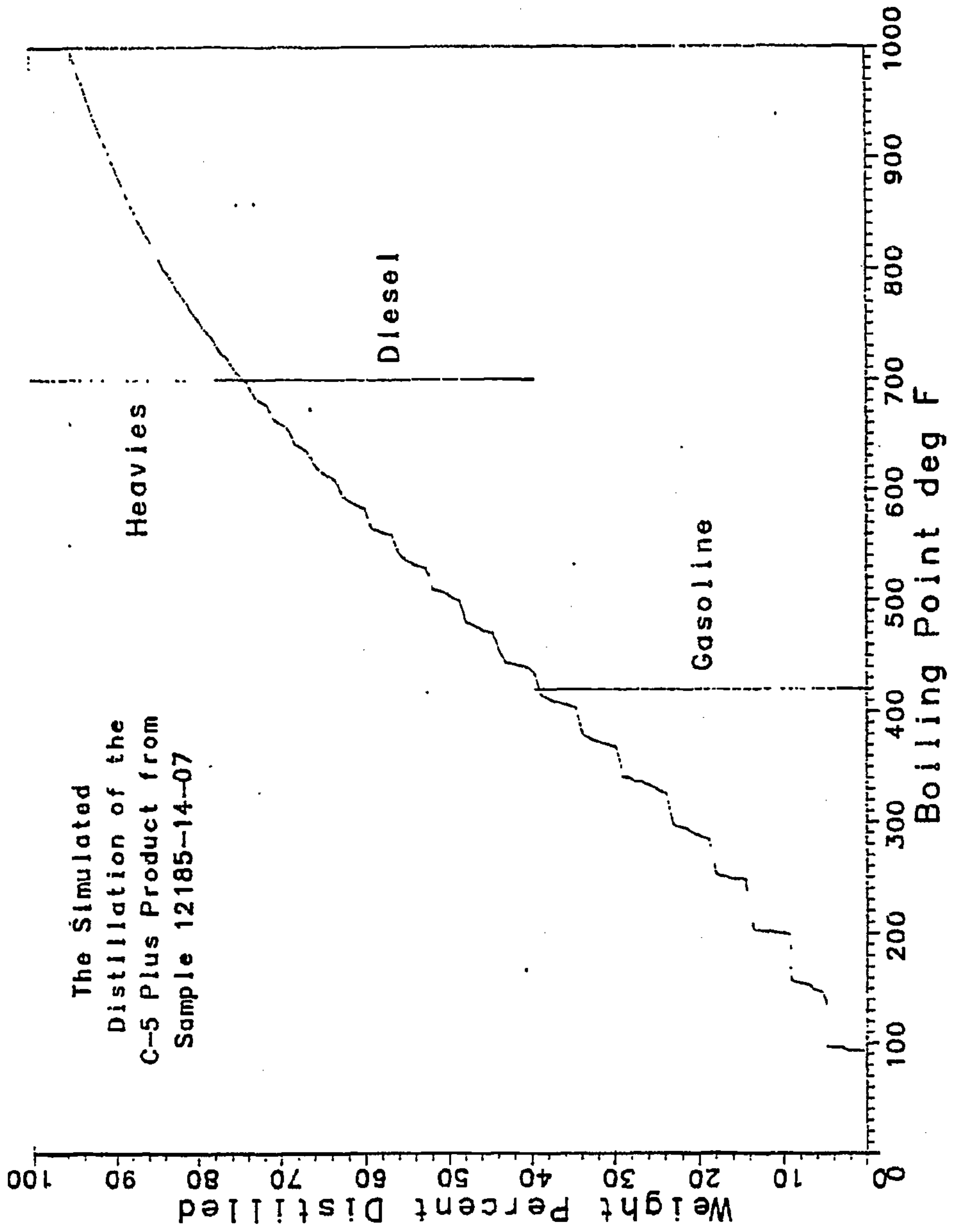

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-07
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
100 200 300 400 500 600 700 800 900 1000
0 10 20 30 40 50 60 70 80 90 100

Fig. B10

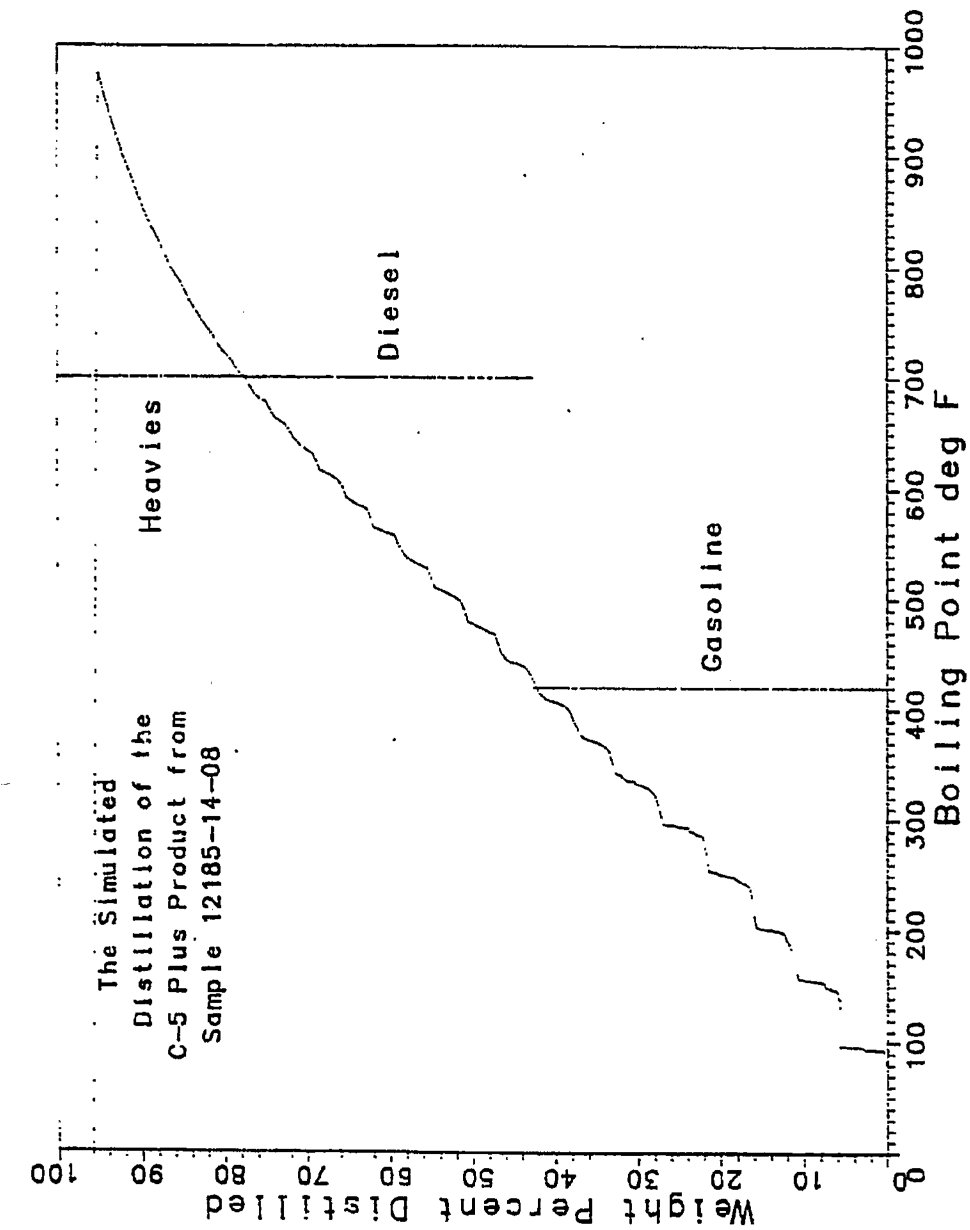

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-08
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000

Fig. B11

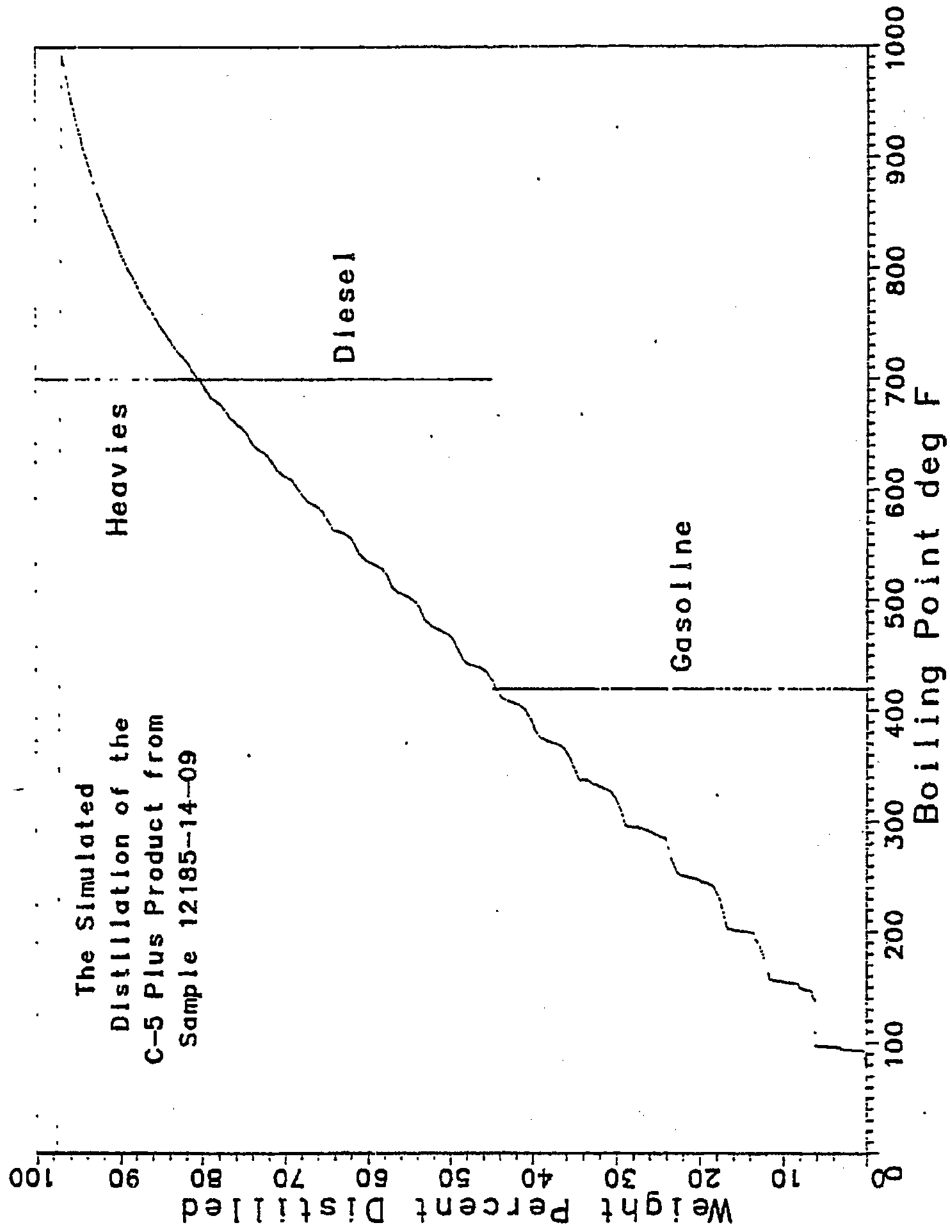

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-09
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0 100 200 300 400 500 600 700 800 900 1000
0 10 20 30 40 50 60 70 80 90 100

Fig. B12

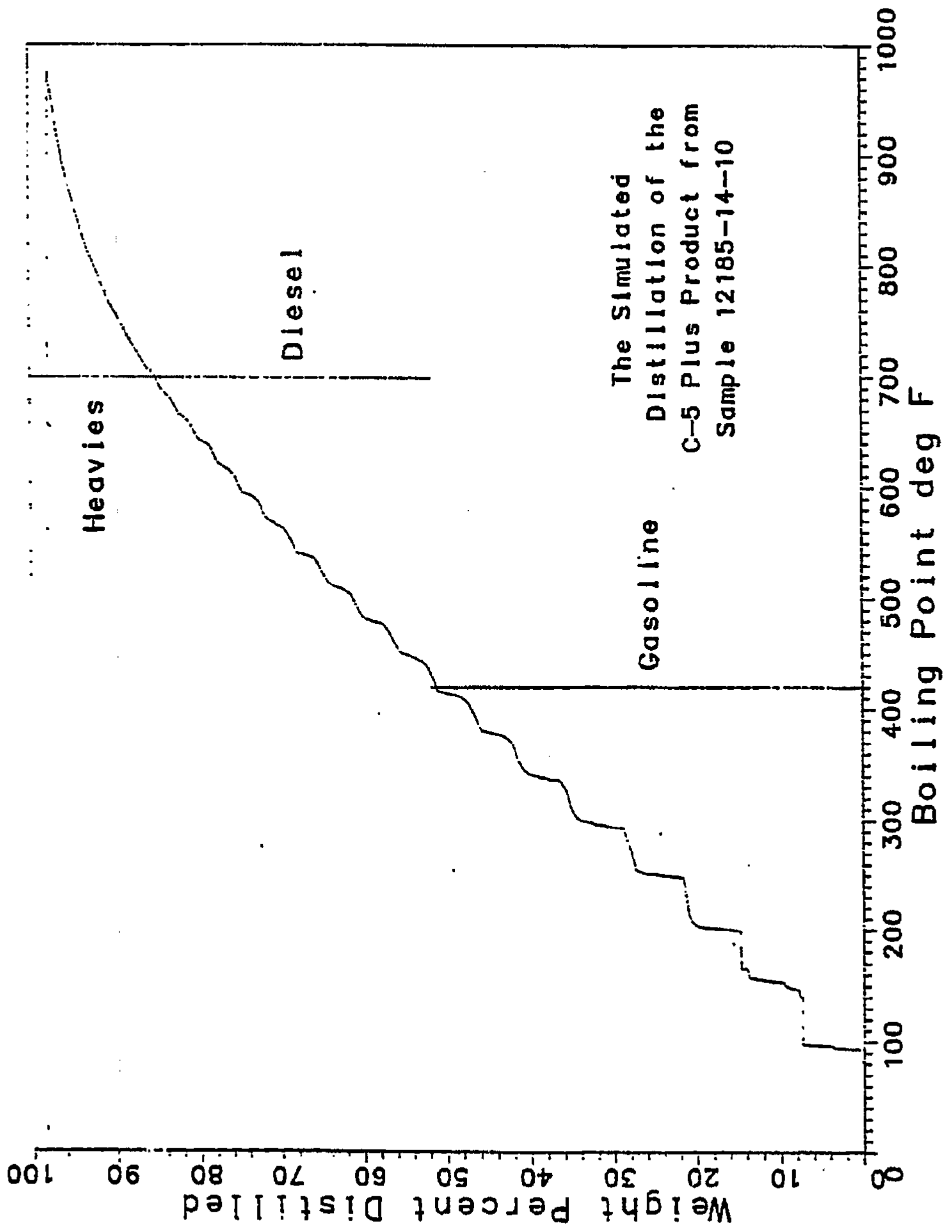
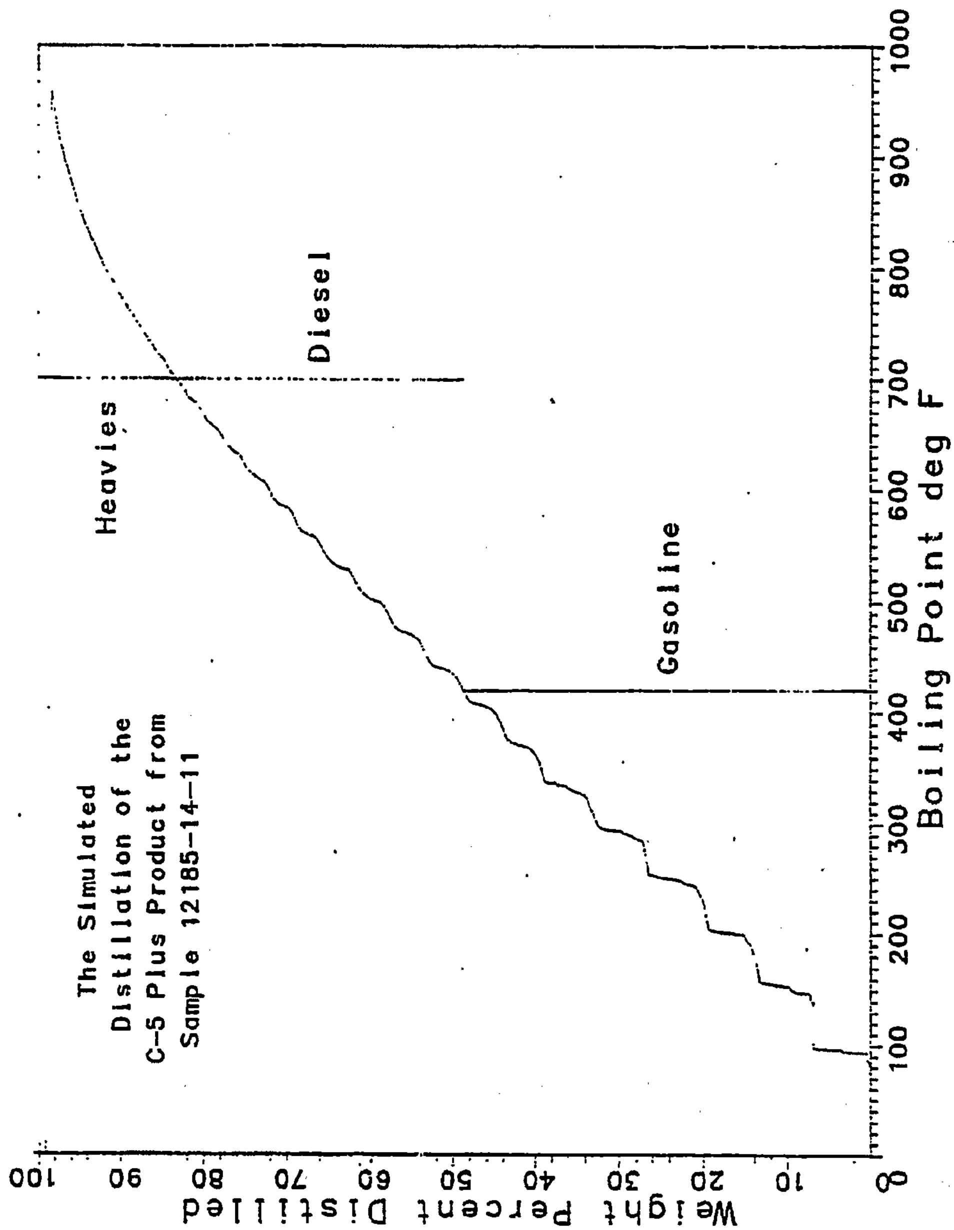

Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-10
Boiling Point deg F
Weight Percent Distilled

Fig. B13



The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-11
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000

Fig. B14

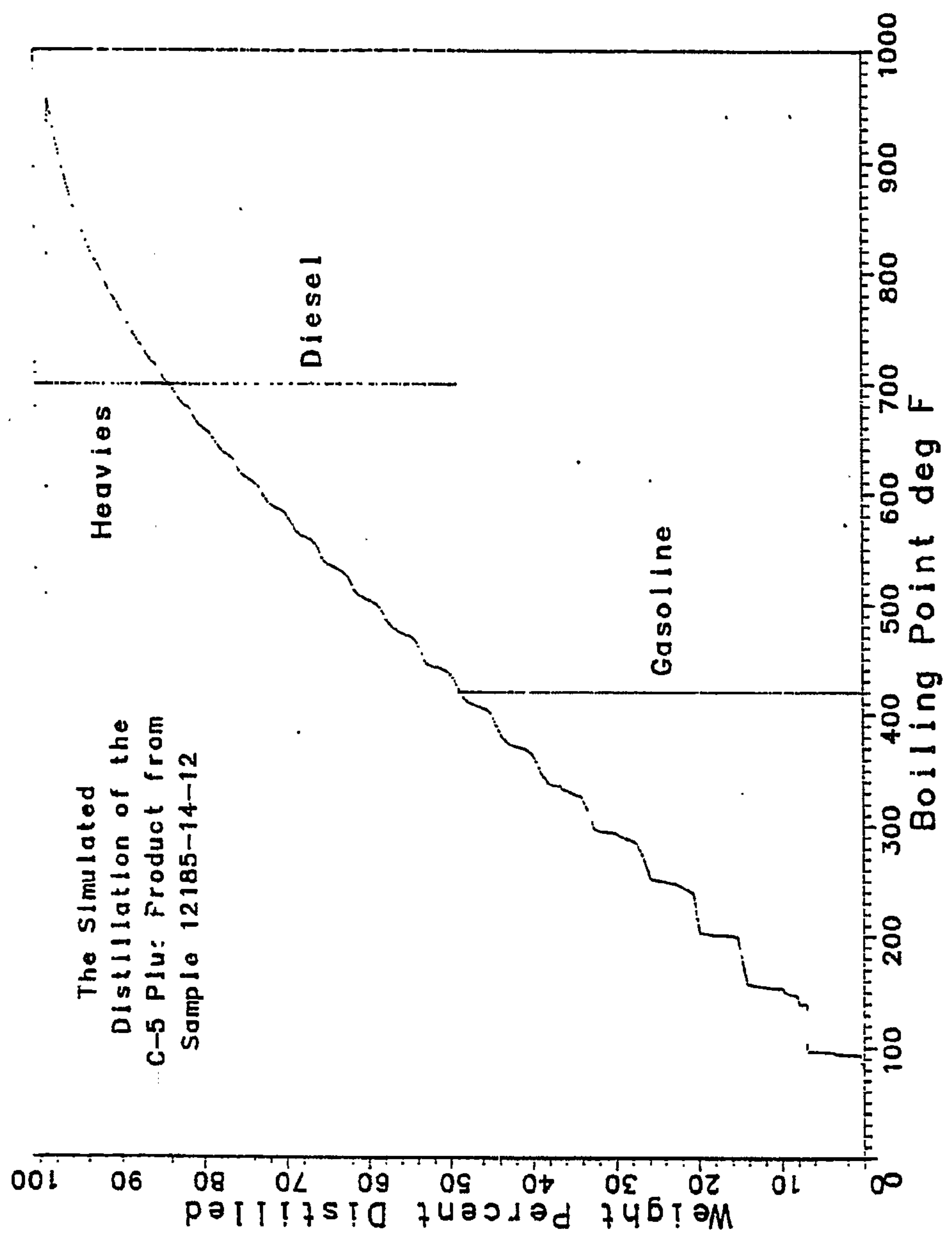

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-12
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000

Fig. B15

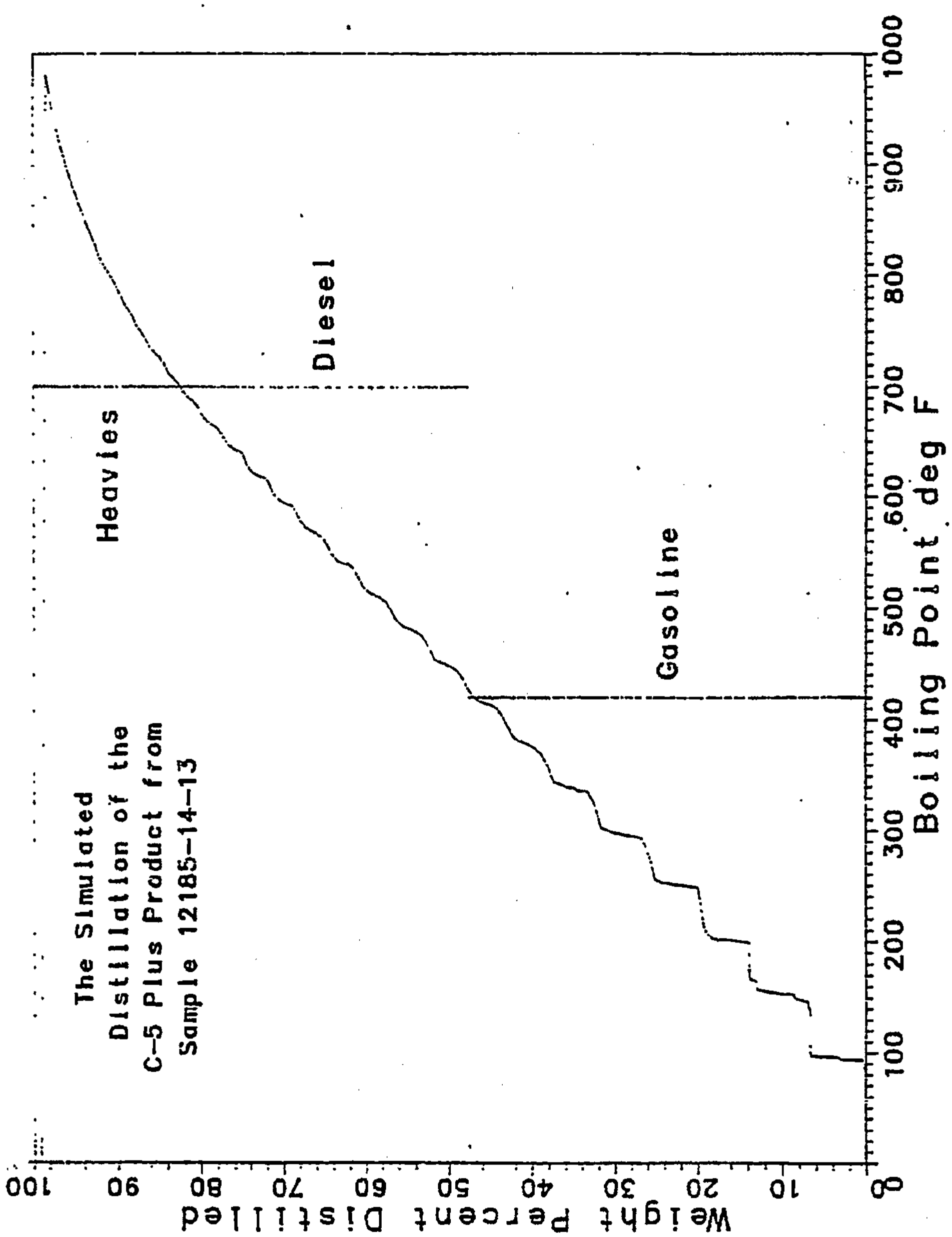

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-13
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000

Fig. B16

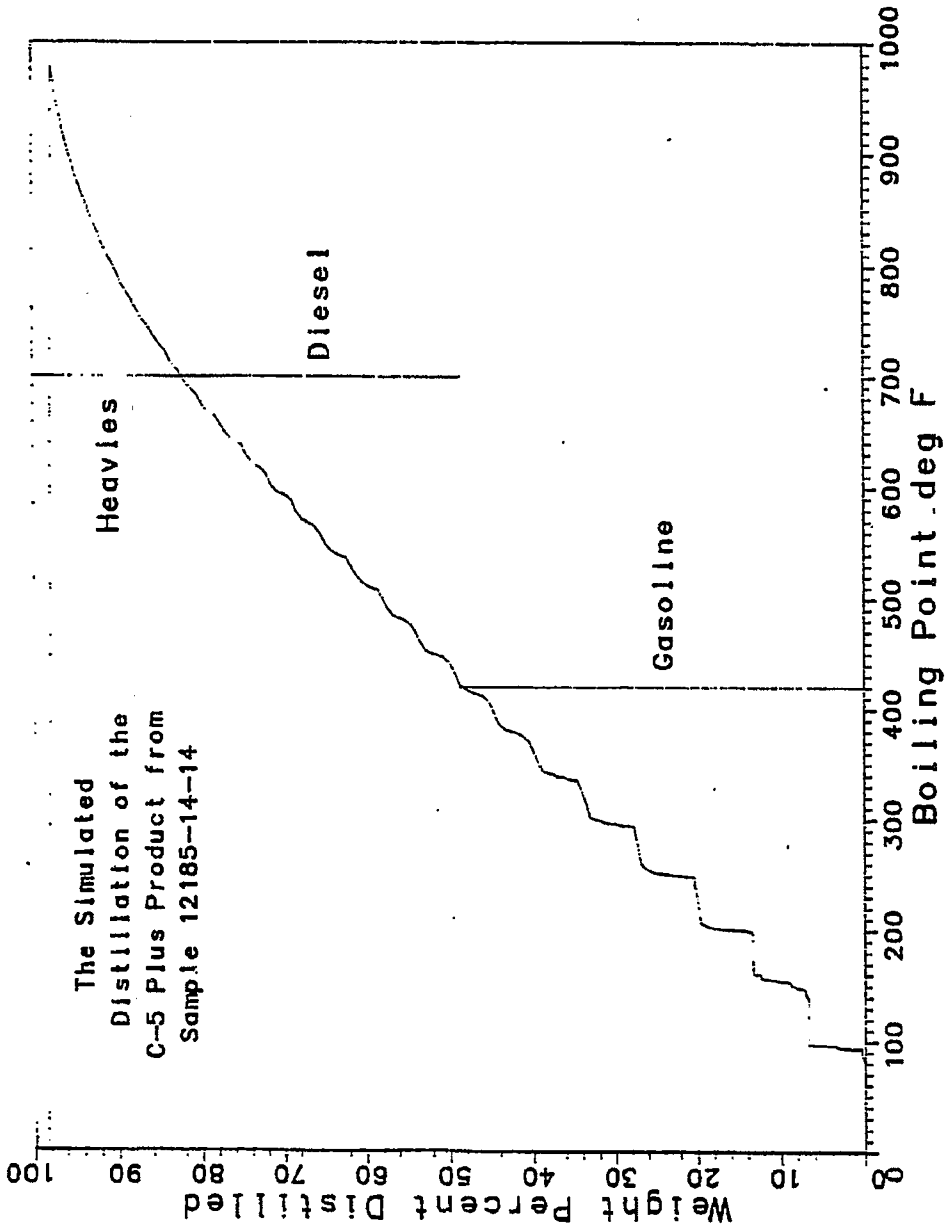
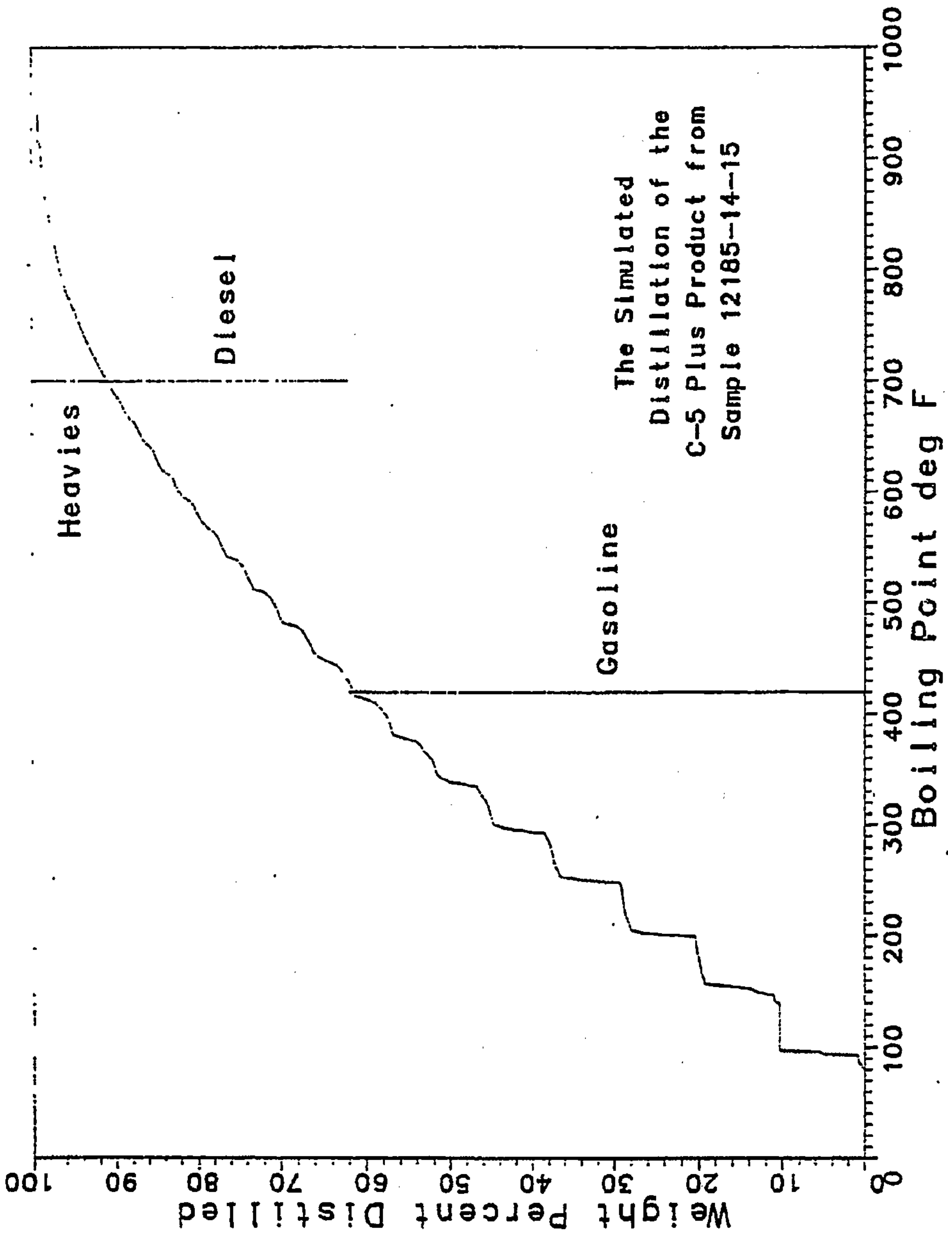
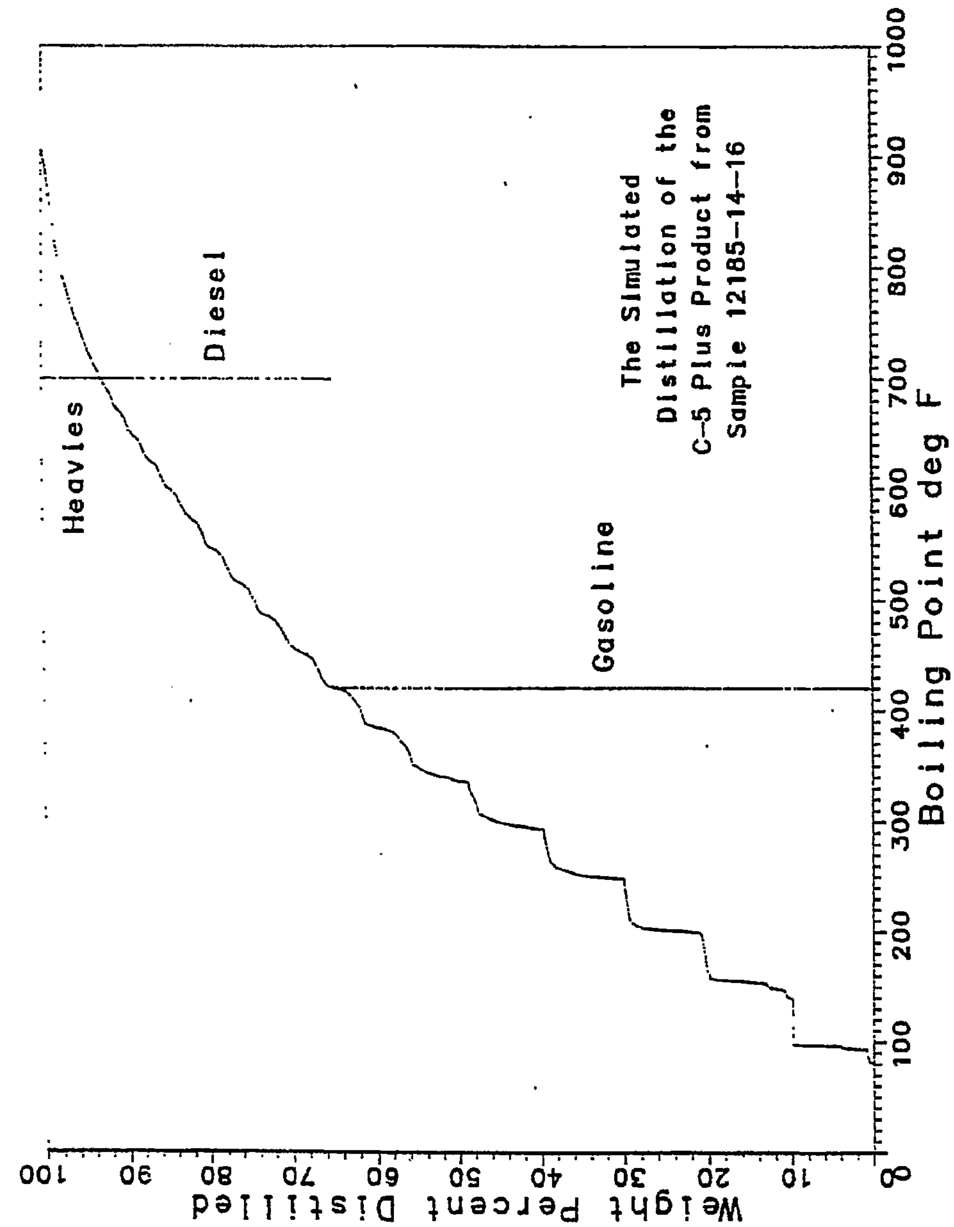

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-14
Heavies
Diesel
Gasoline
Boiling Point.deg F
Weight Percent Distilled
0
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100

Fig. B17



Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-15
Boiling Point deg F
Weight Percent Distilled
0
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100

Fig. B18



The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-16
Heavies
Diesel
Gasoline
Weight Percent Distilled
Boiling Point deg F
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000

Fig. B19

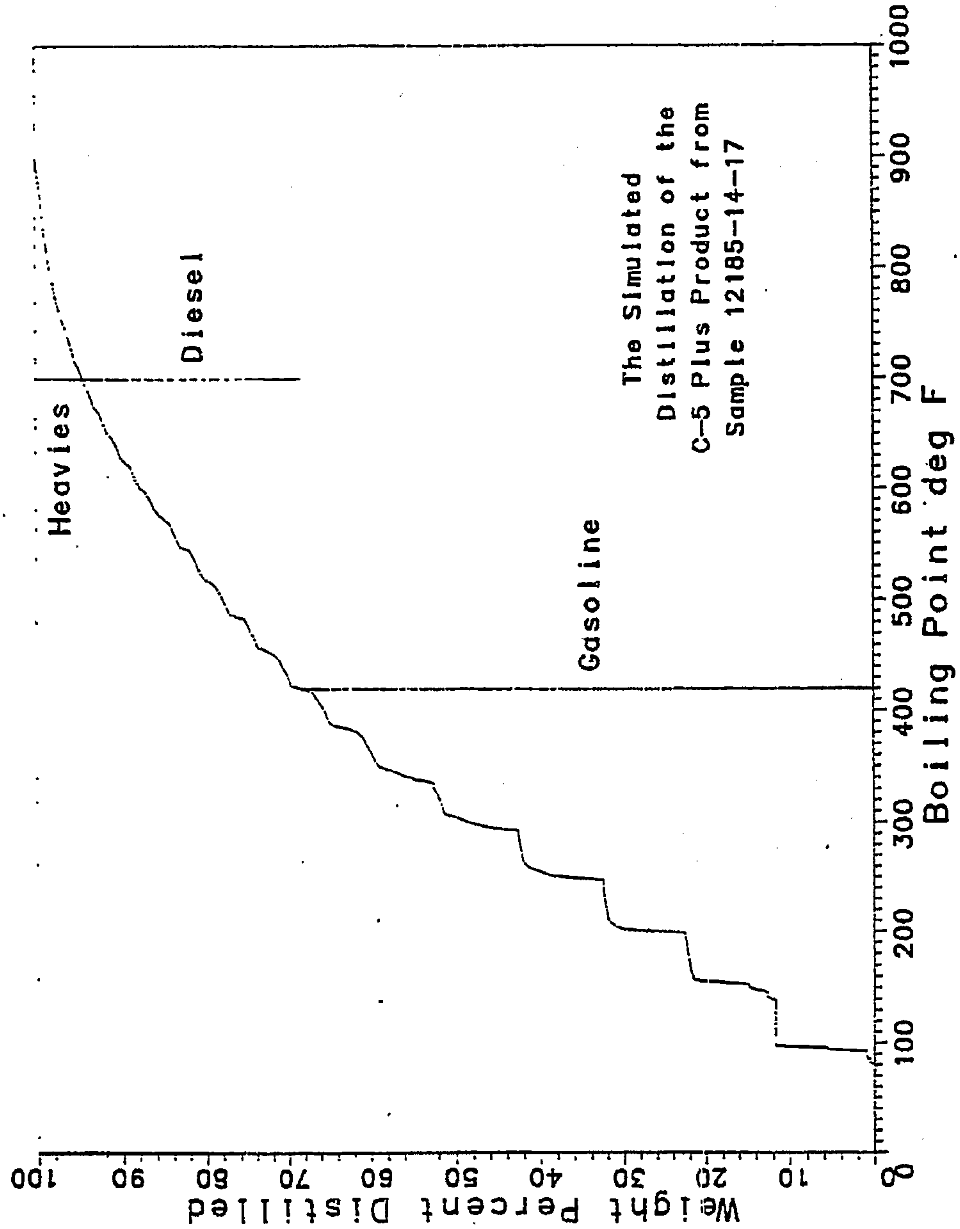

Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-17
Boiling Point deg F
Weight Percent Distilled
0 100 200 300 400 500 600 700 800 900 1000
0 10 20 30 40 50 60 70 80 90 100

Fig. B20

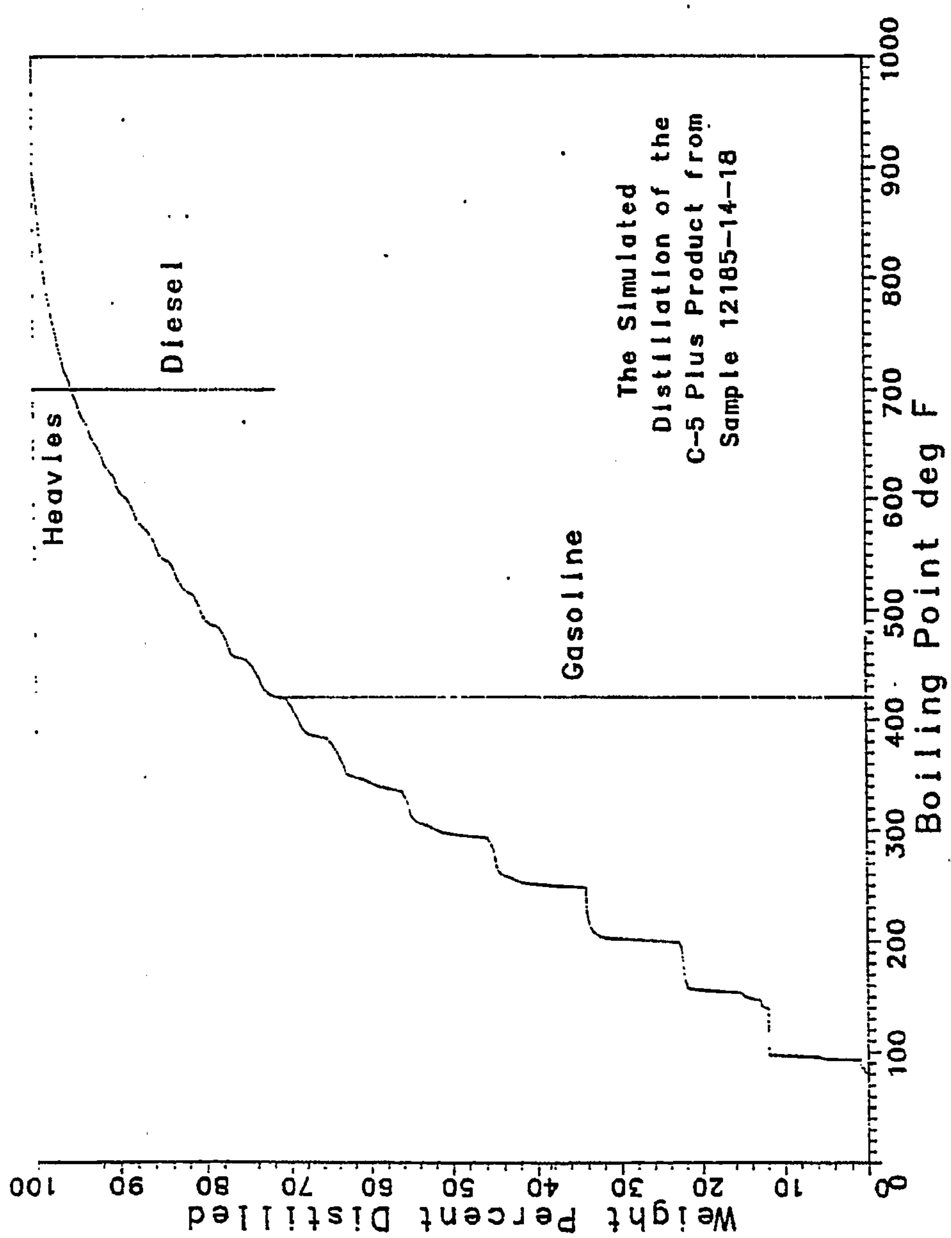

Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-18
Boiling Point deg F
0 100 200 300 400 500 600 700 800 900 1000
Weight Percent Distilled
0 10 20 30 40 50 60 70 80 90 100

Fig. B21

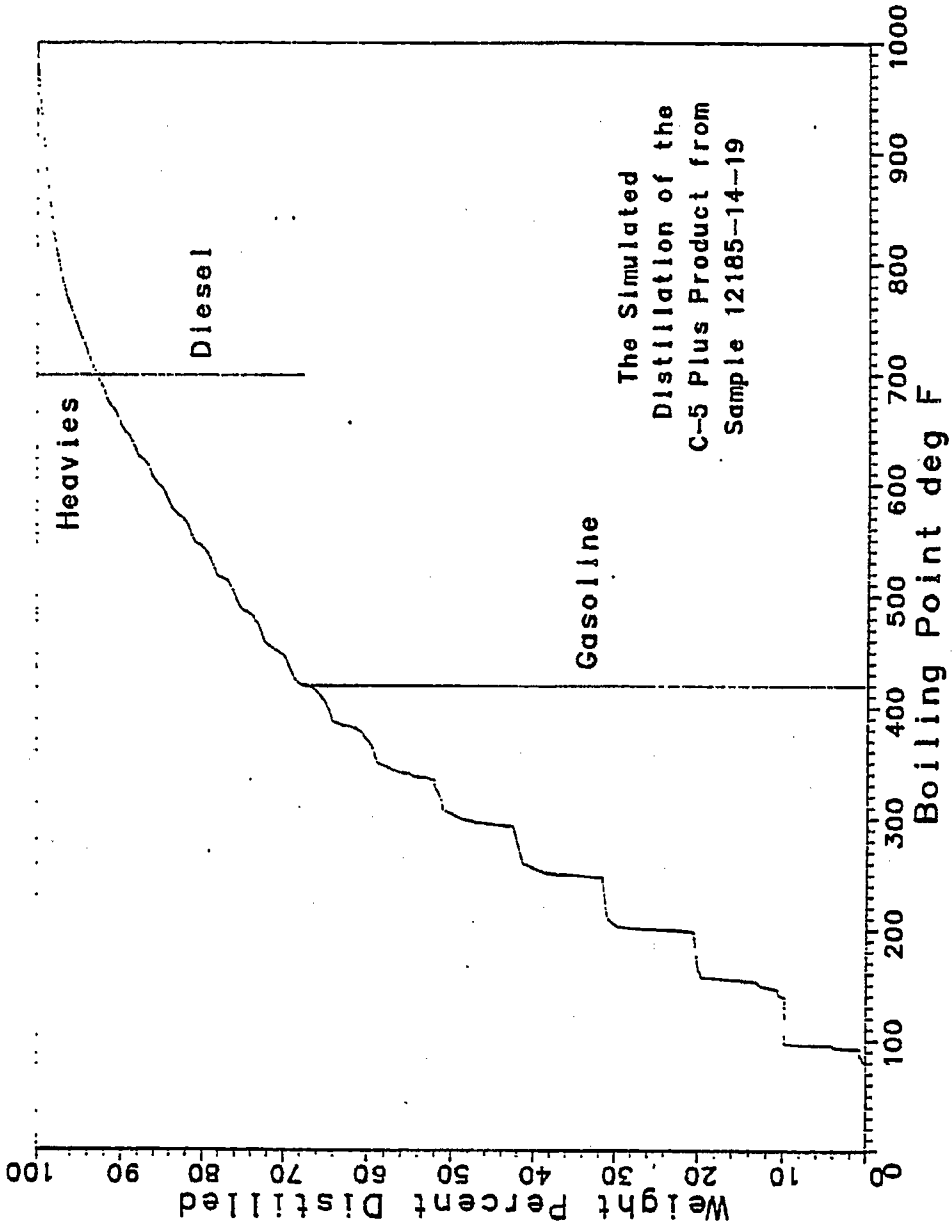
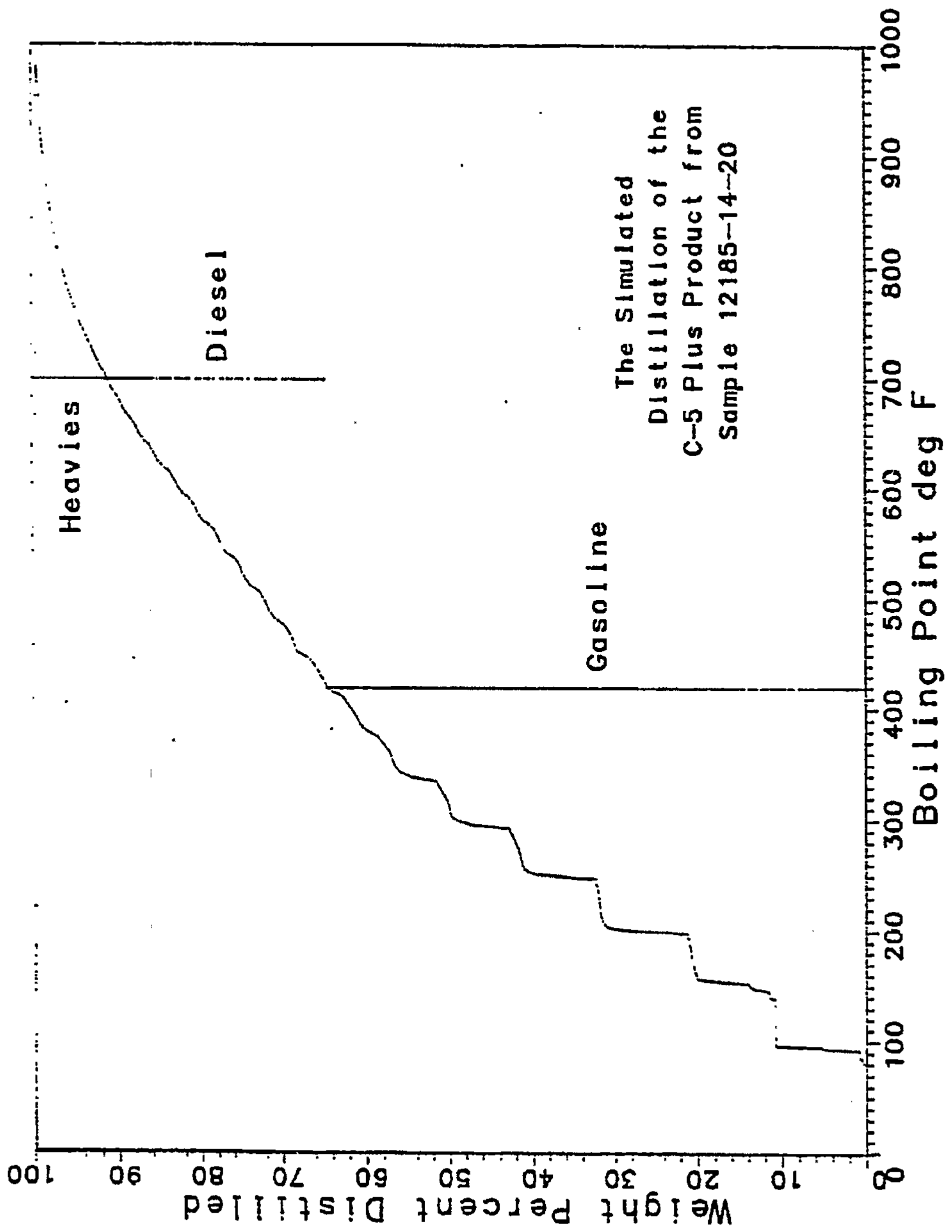
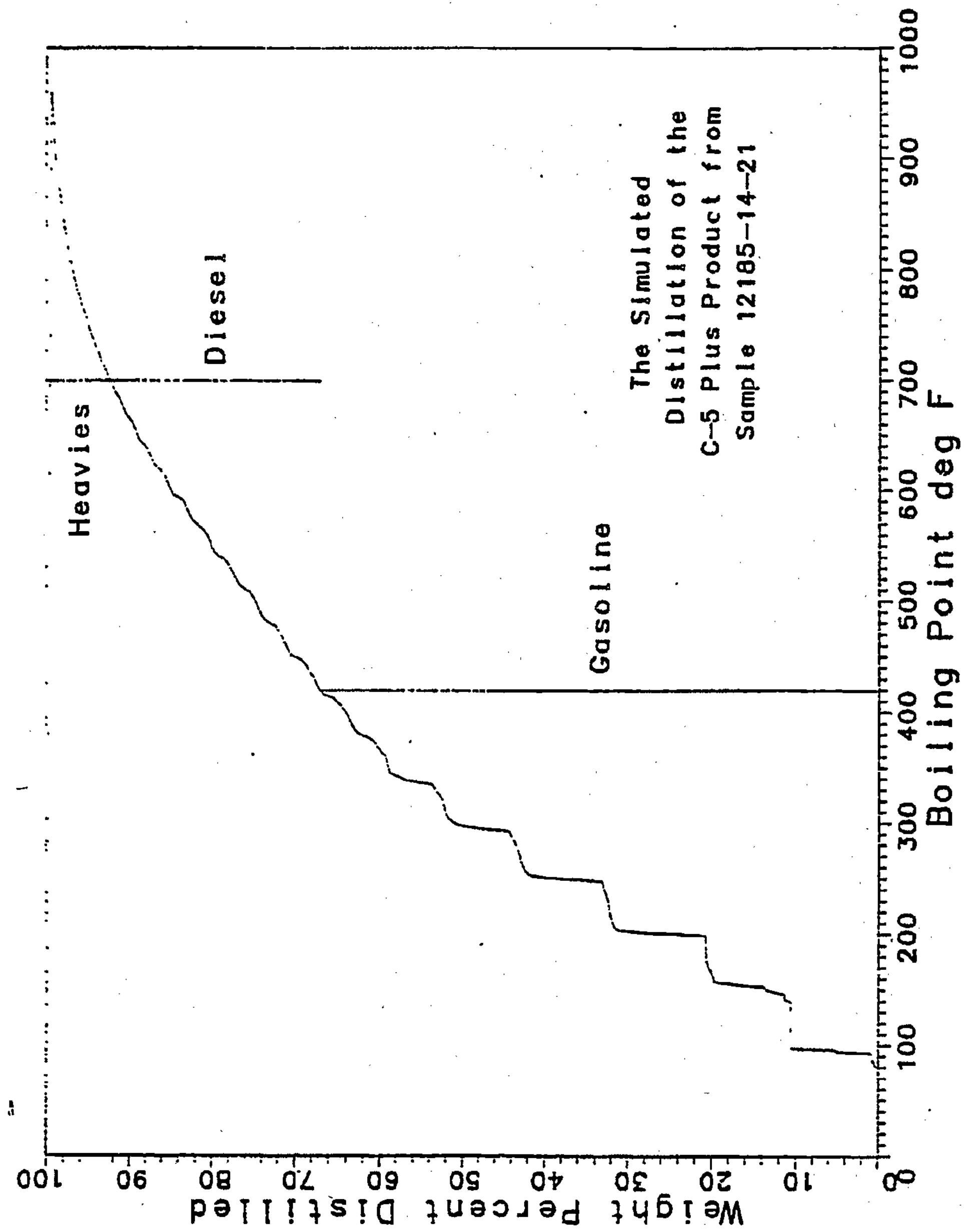

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-19
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled

Fig. B22



The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-20
Heavies
Diesel
Gasoline
Boiling Point deg F
0
100
200
300
400
500
600
700
800
900
1000
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100

Fig. B23



The Simulated
Distillation of the
C-5 Plus Product from
Sample 12185-14-21
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100

Fig. B24

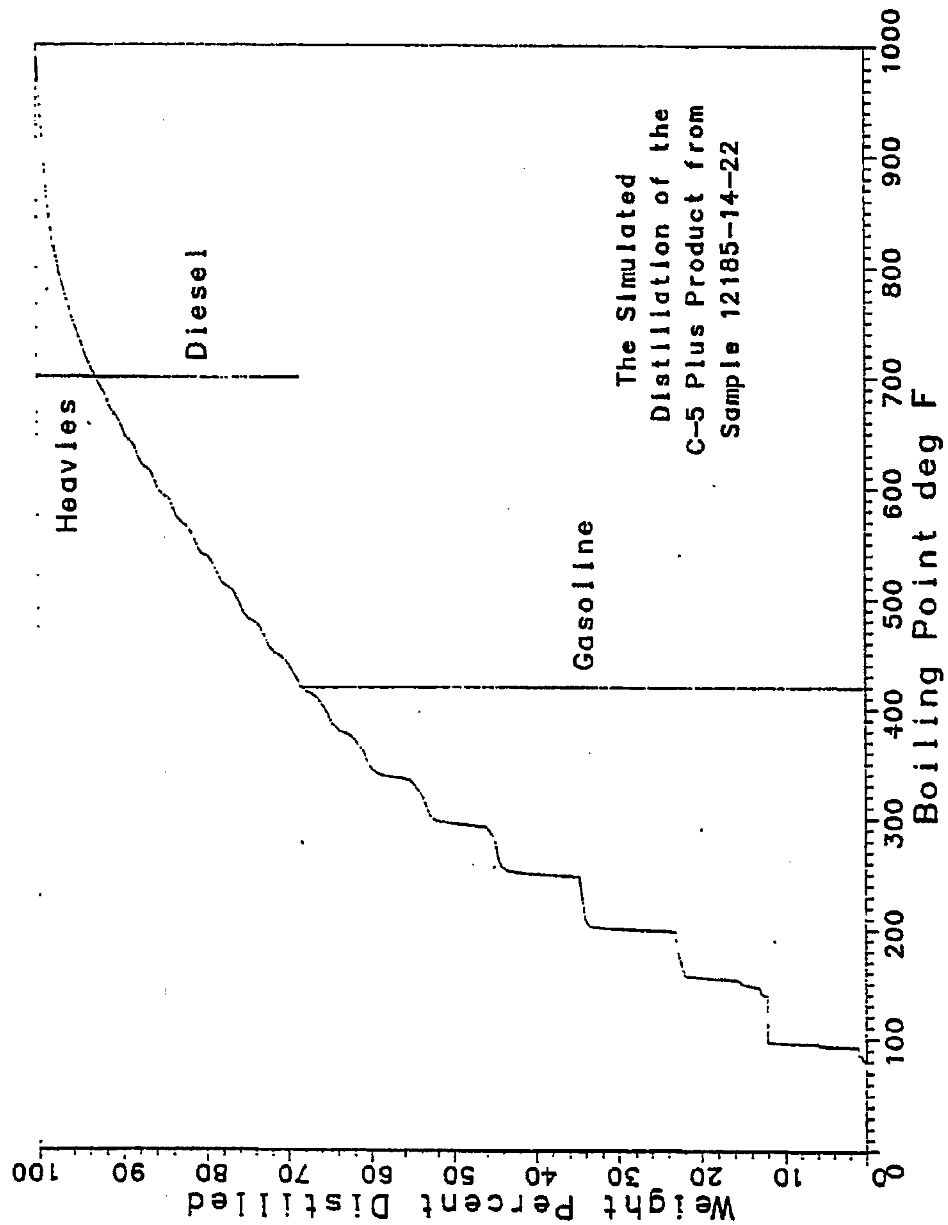

The Simulated Distillation of the C-5 Plus Product from Sample 12185-14-22
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100

Fig. B25

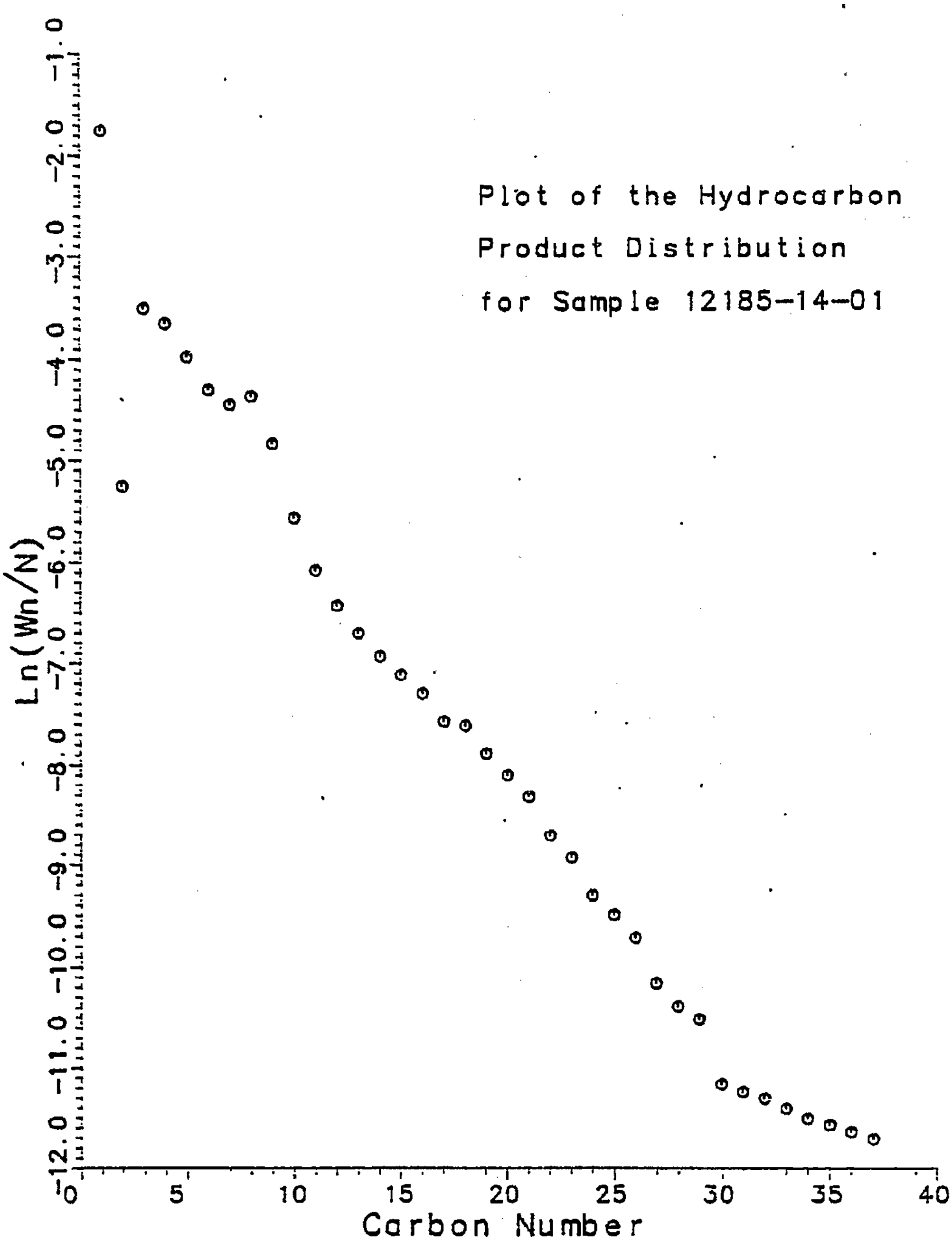

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-01
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
-12.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B26

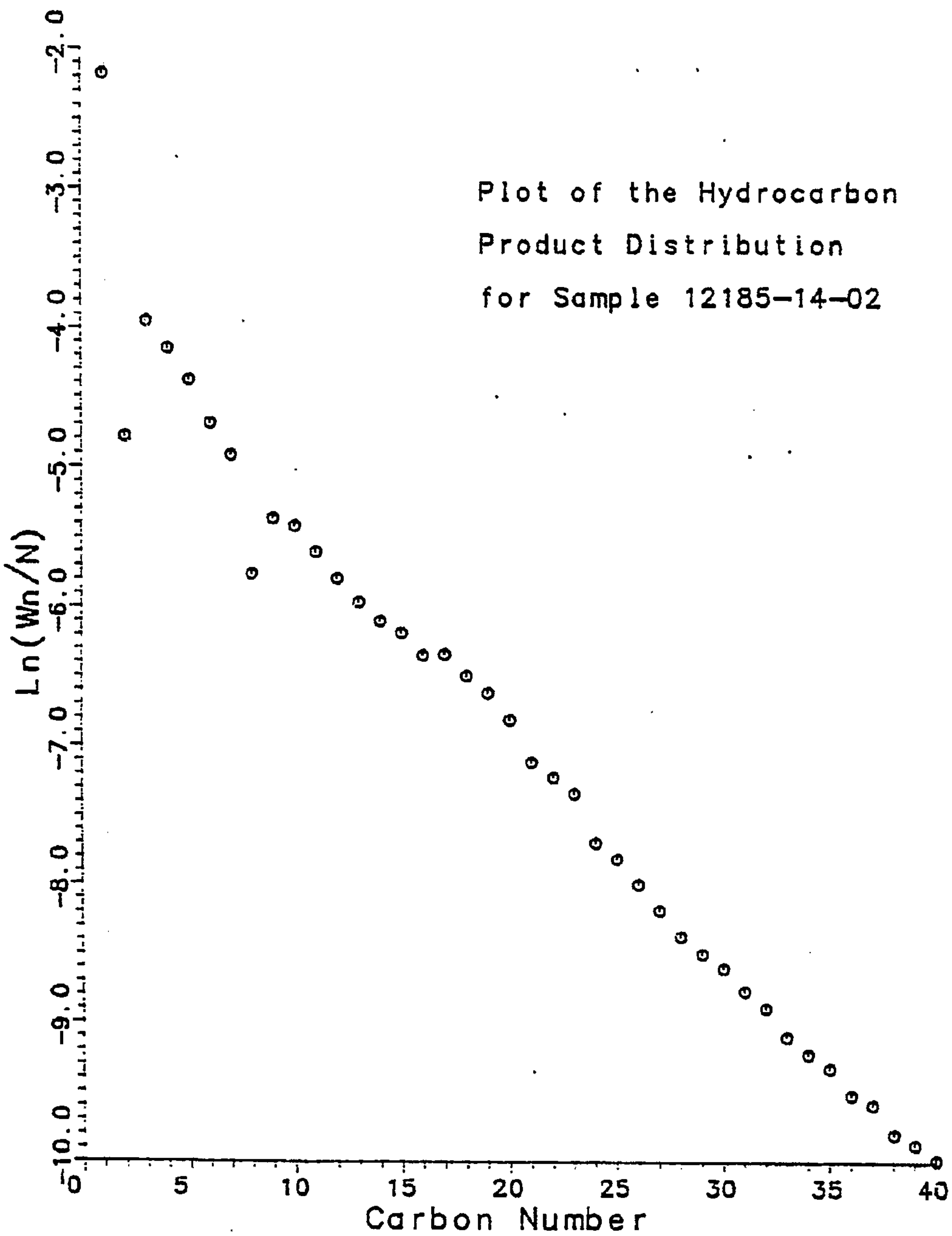
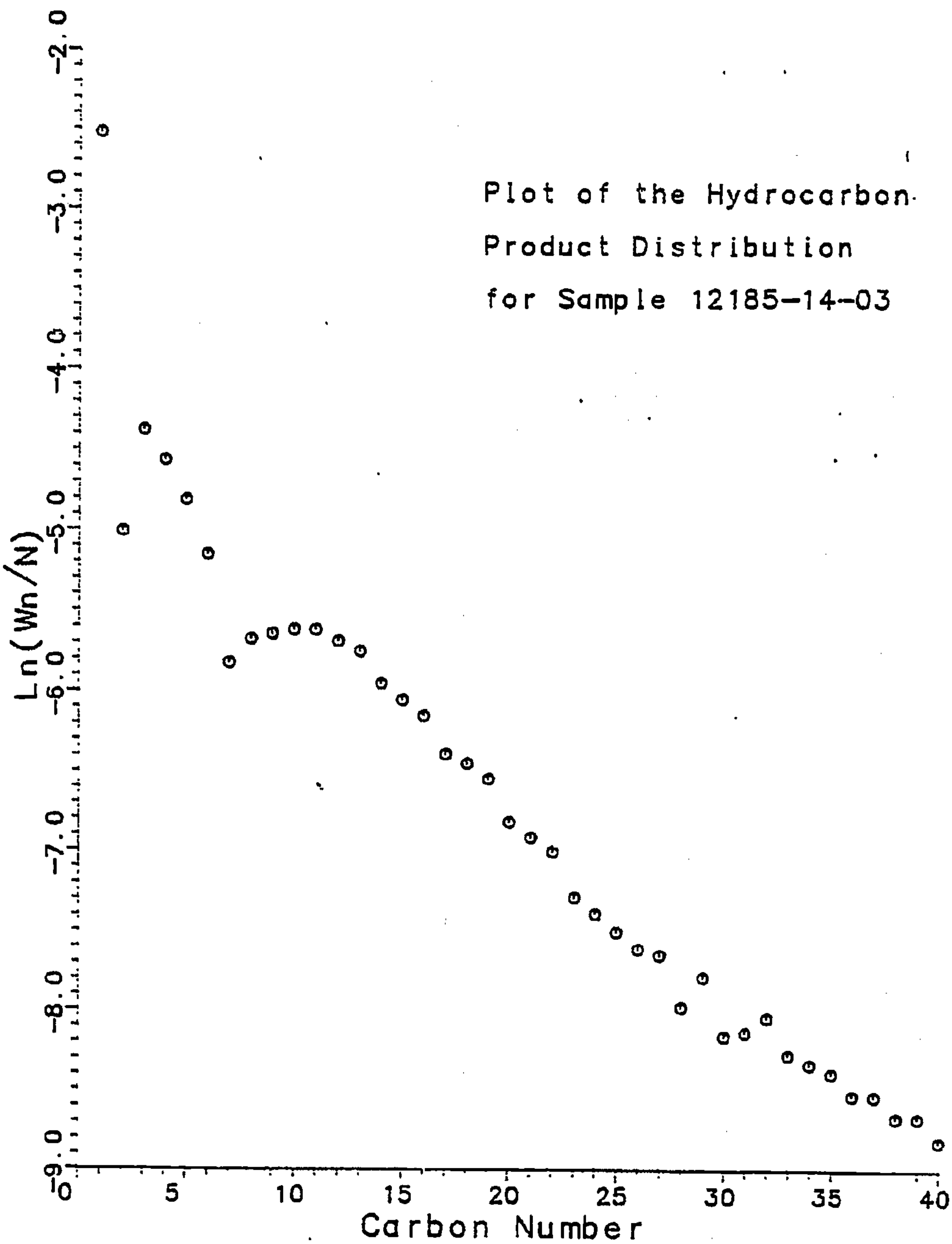

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-02
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B27



Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-03
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B28

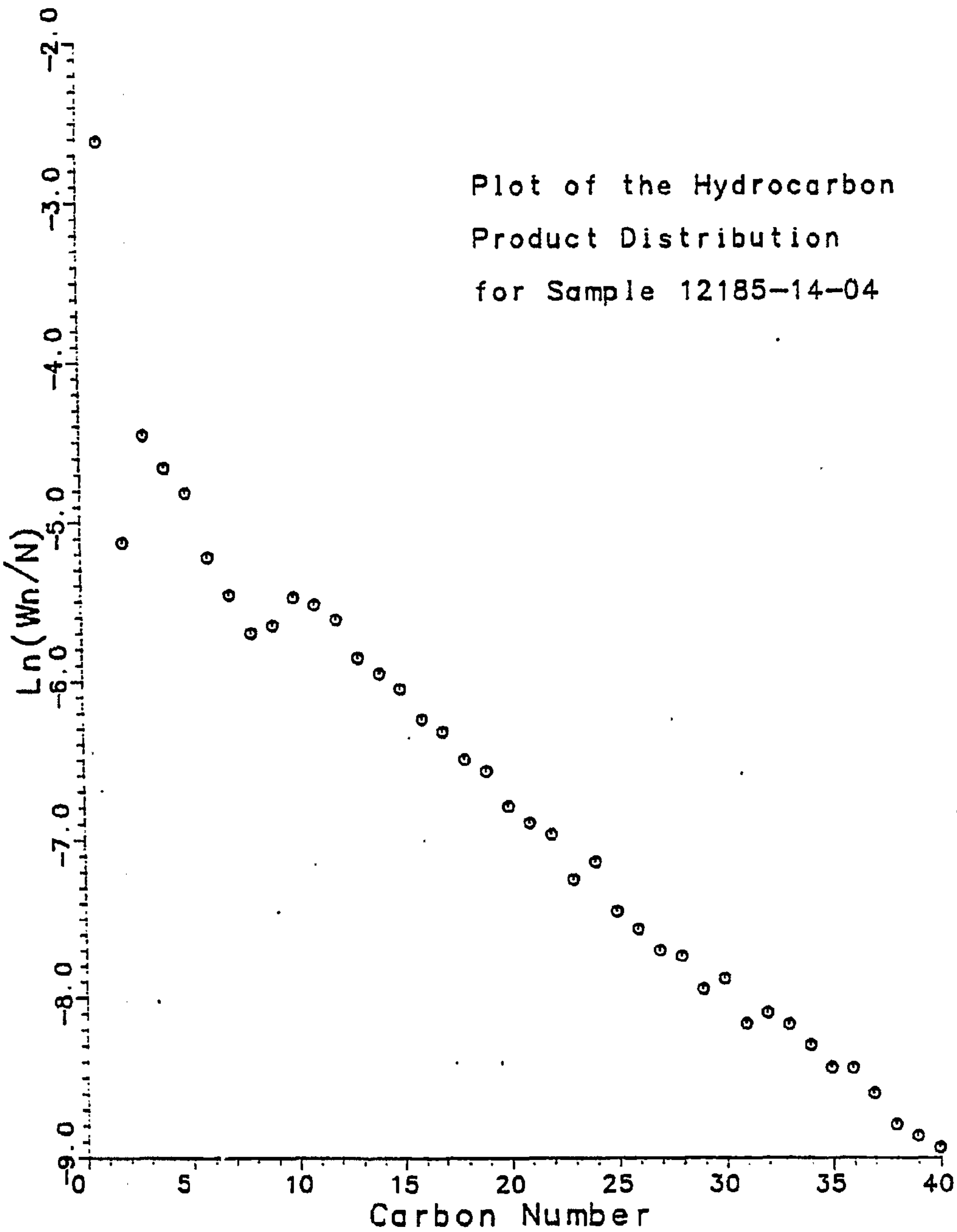
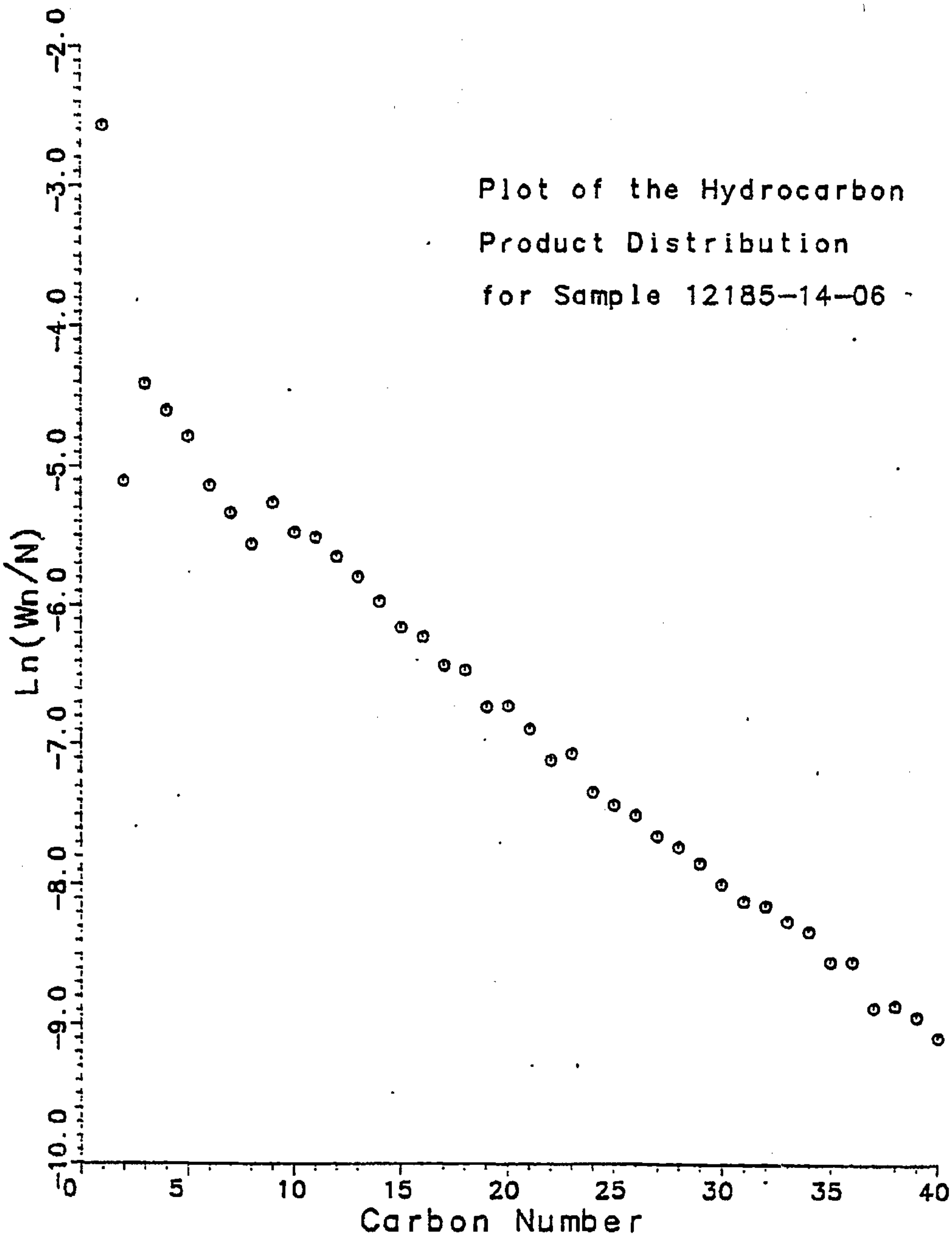
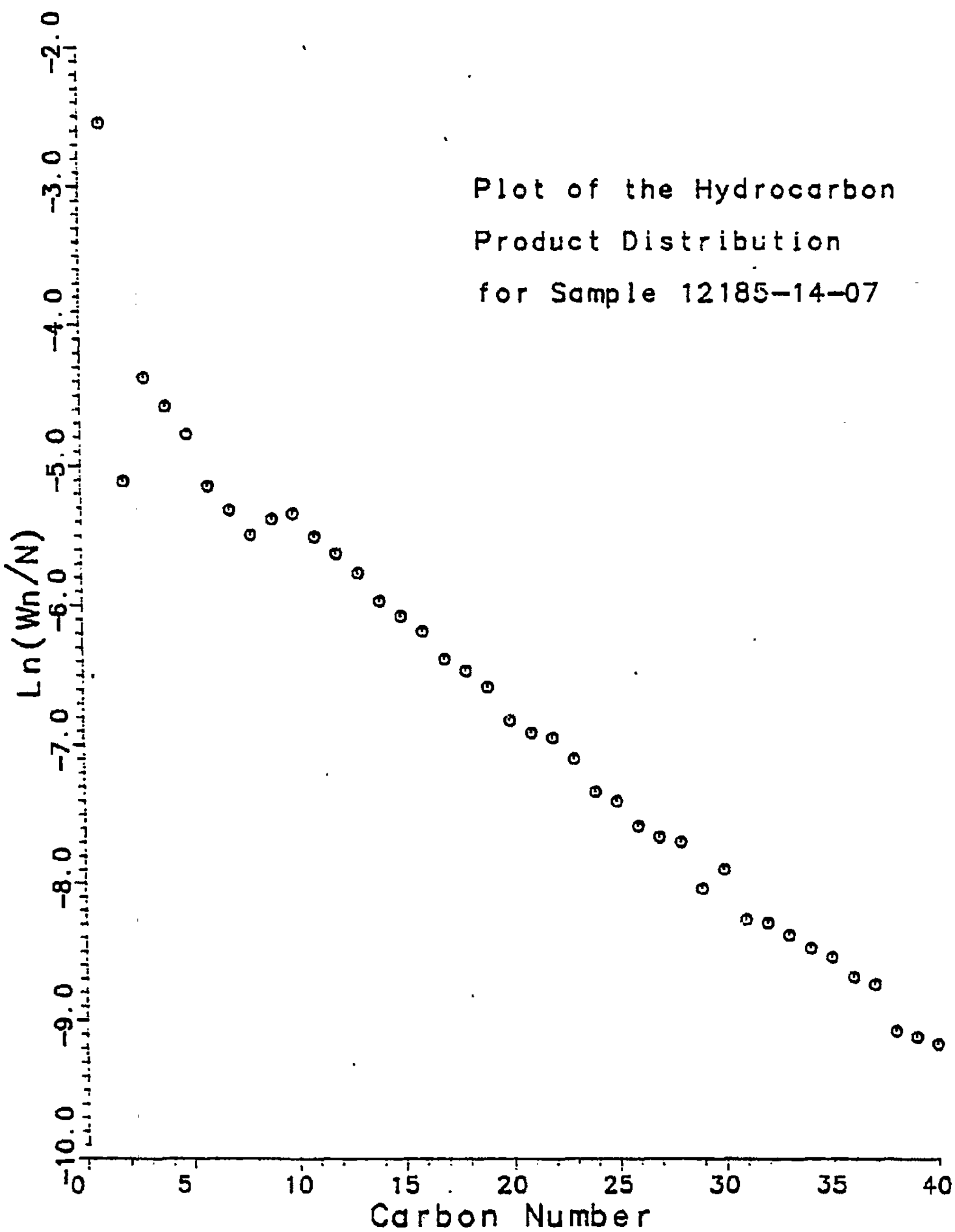

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-04
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B29



Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-06
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B30


Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-07
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number
Fig. B31

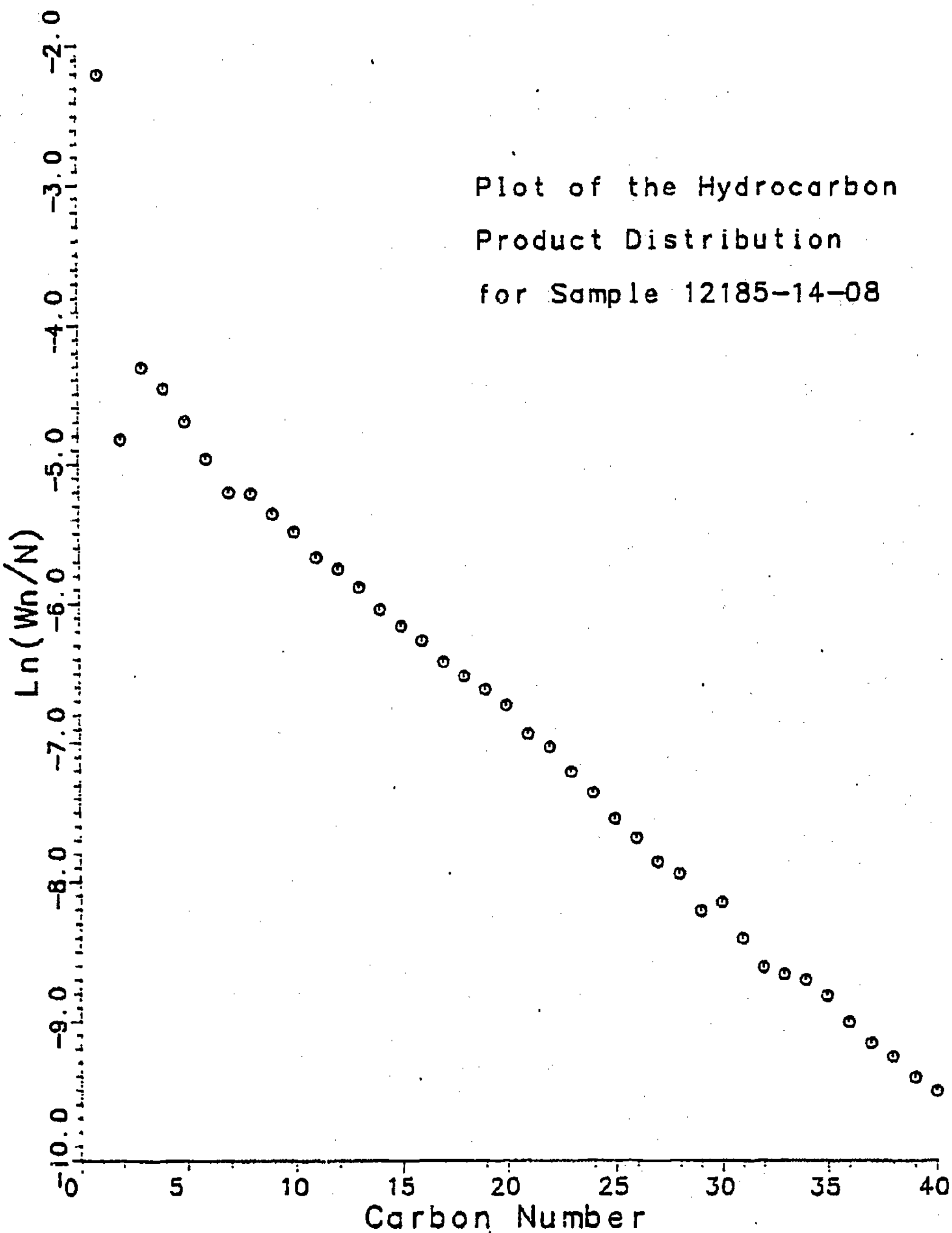

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-08
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B32

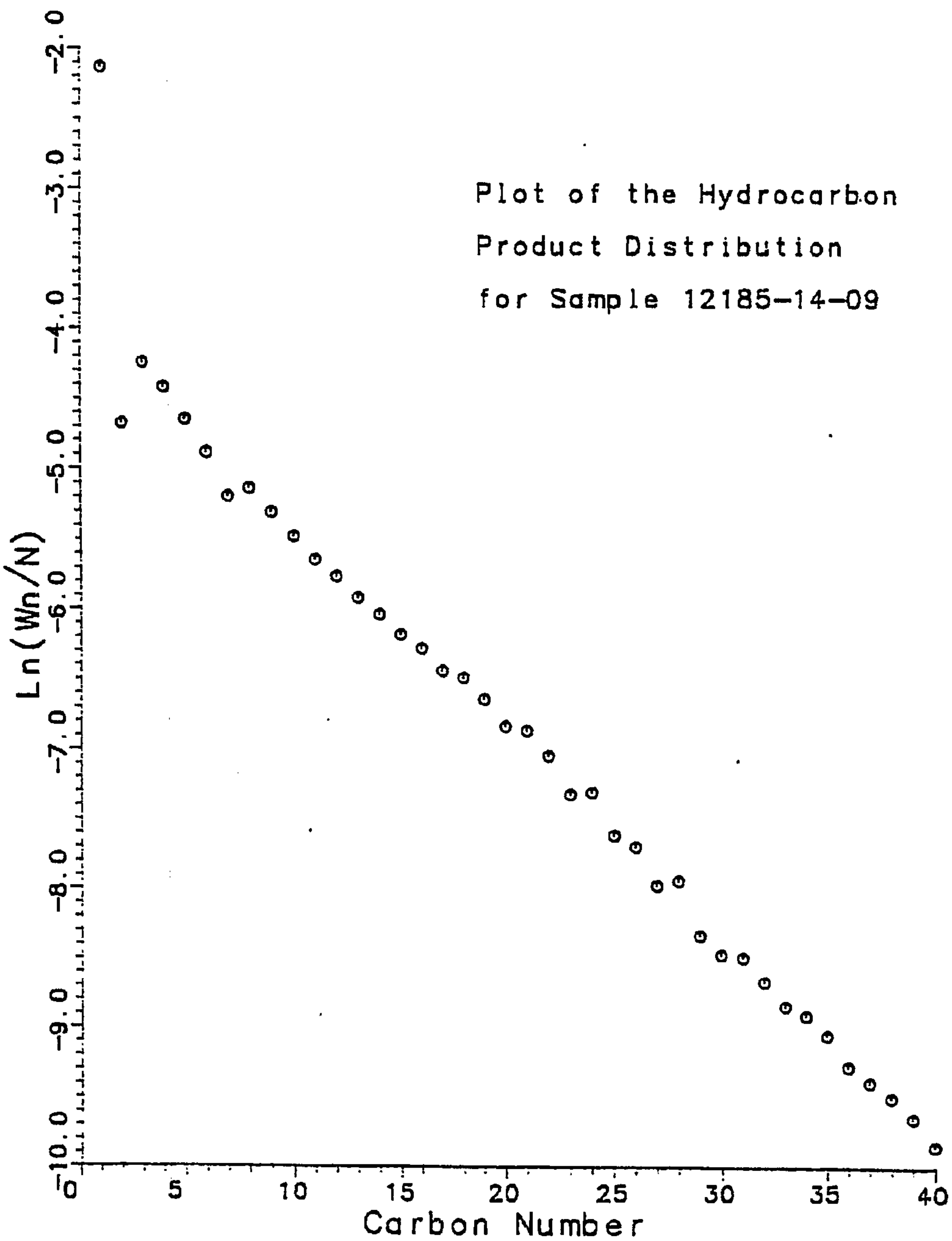

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-09
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B33

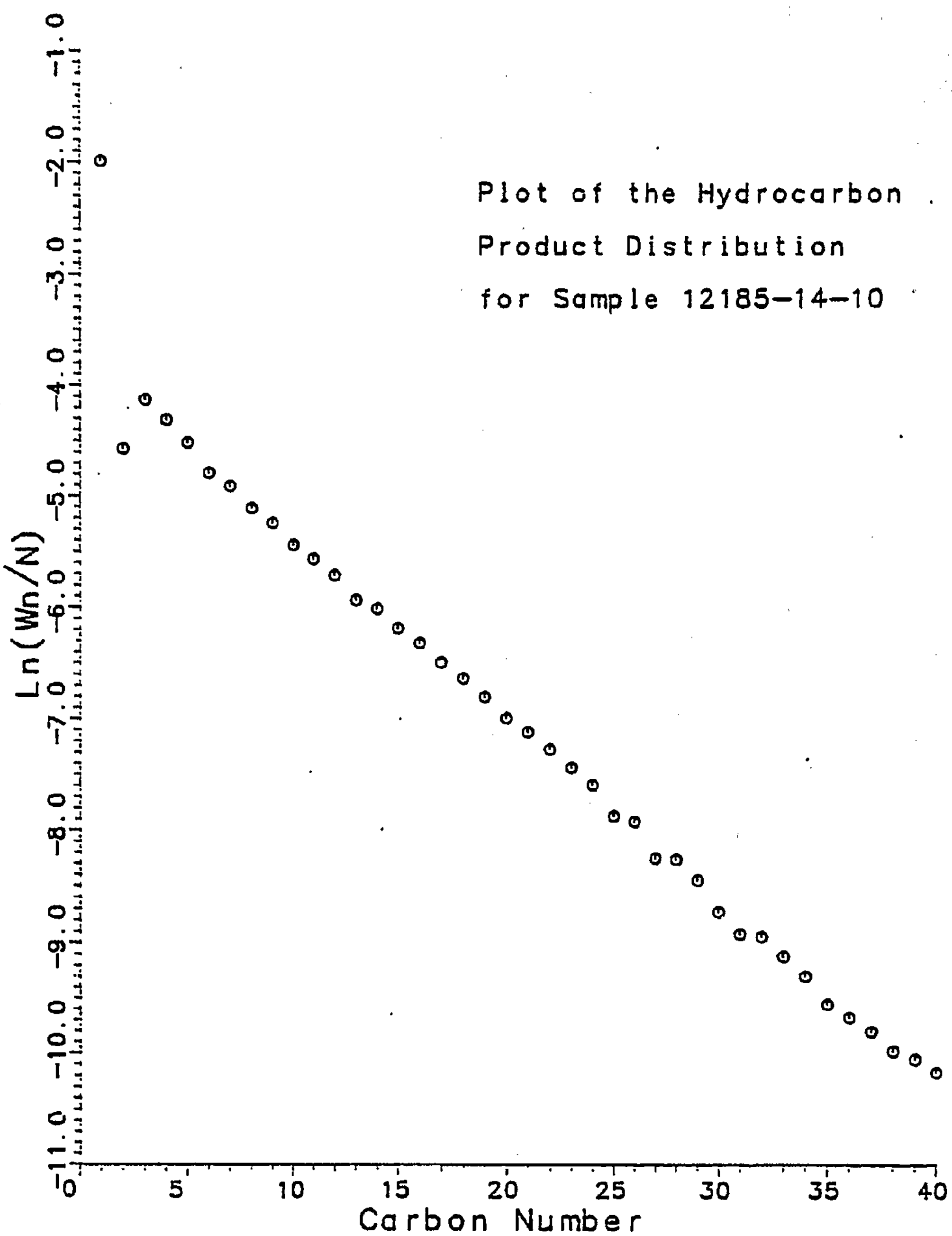

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-10
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B34

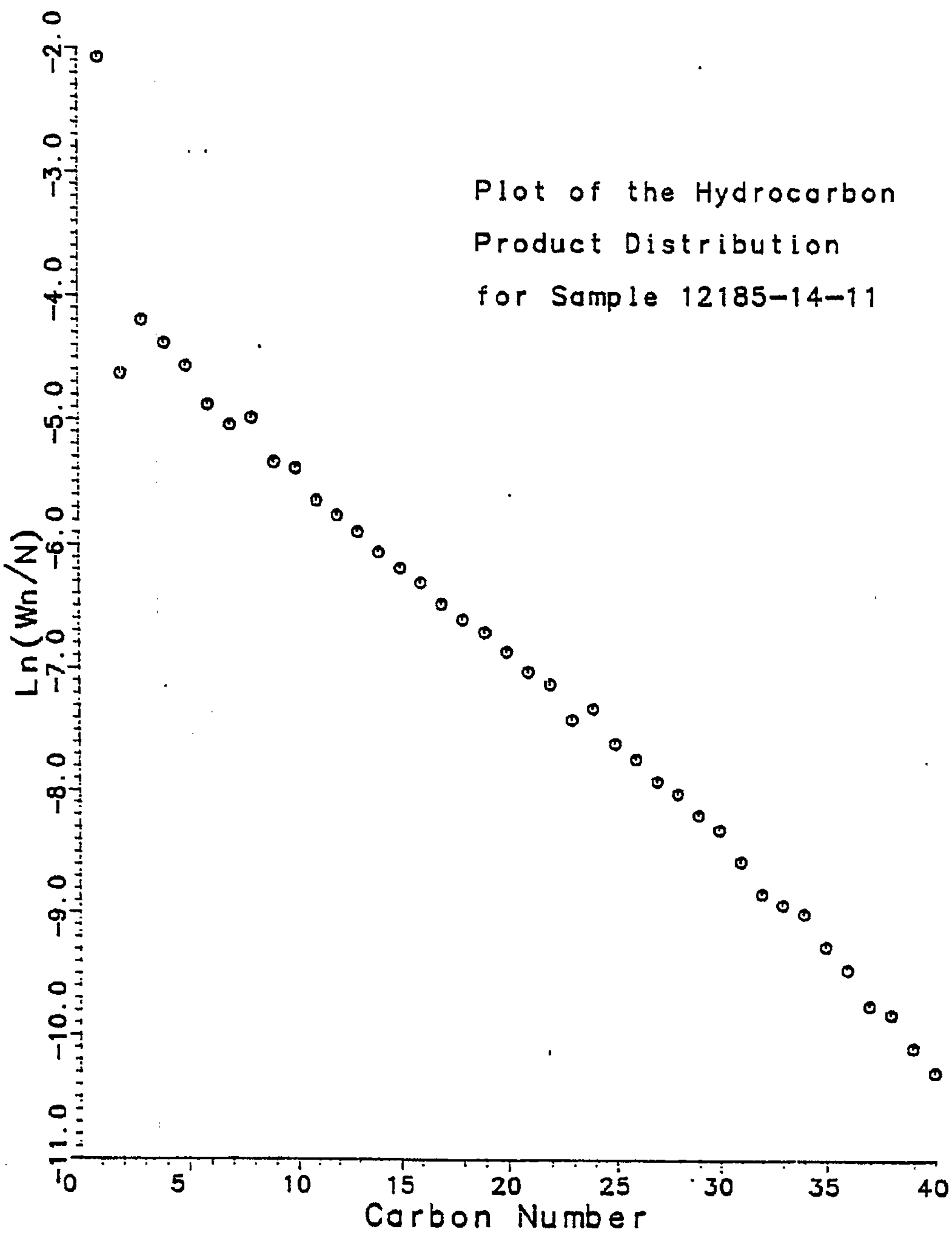
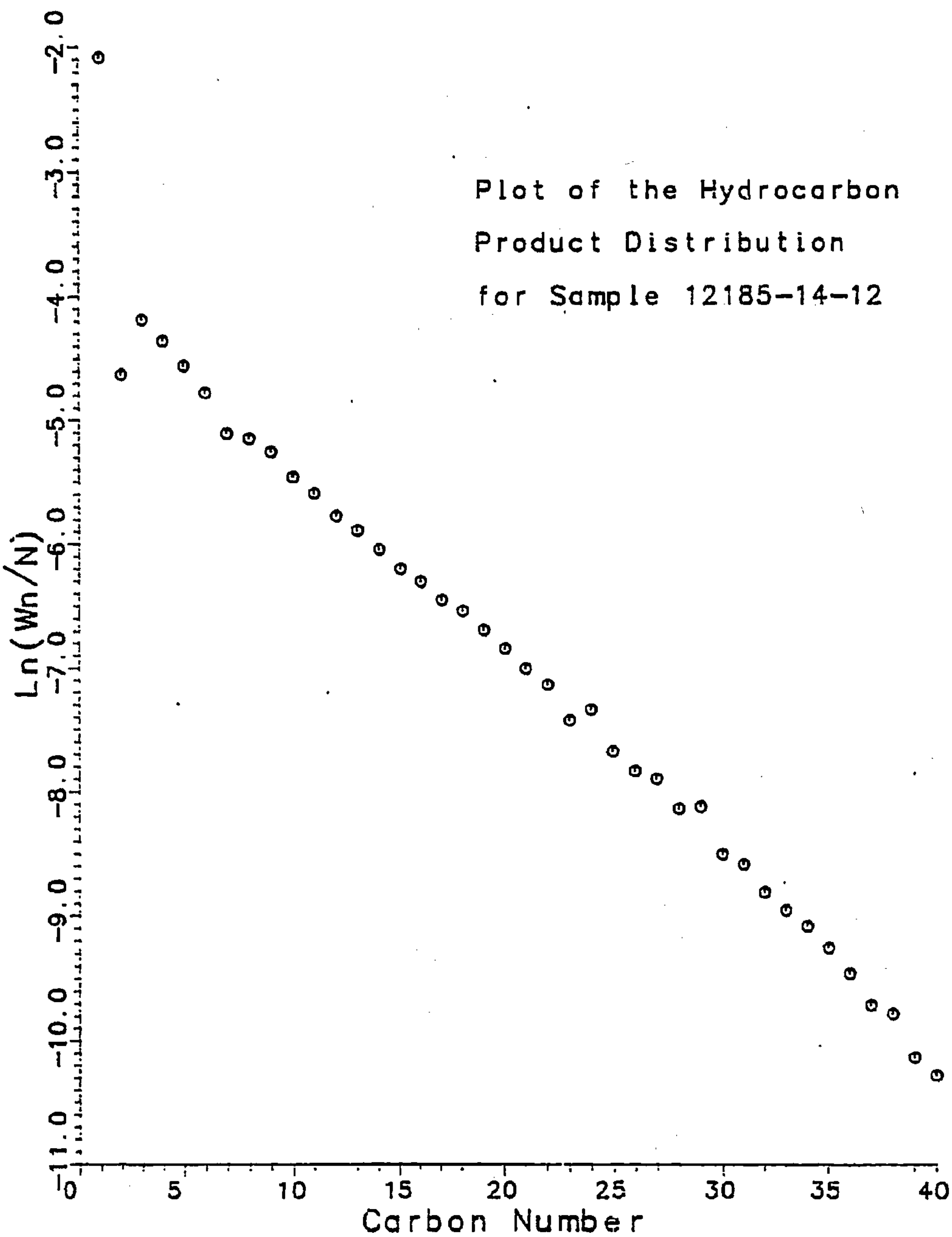
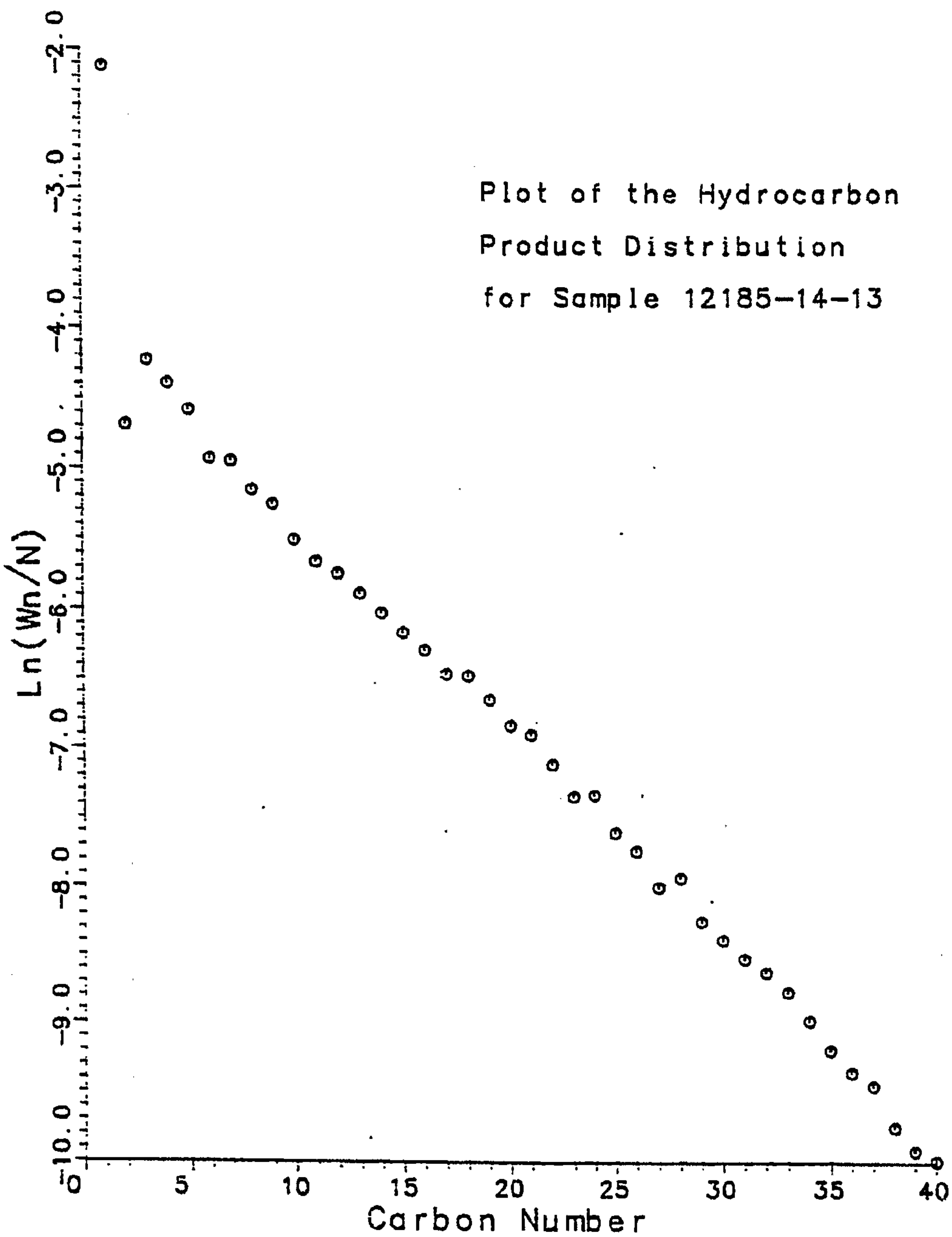

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-11
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B35



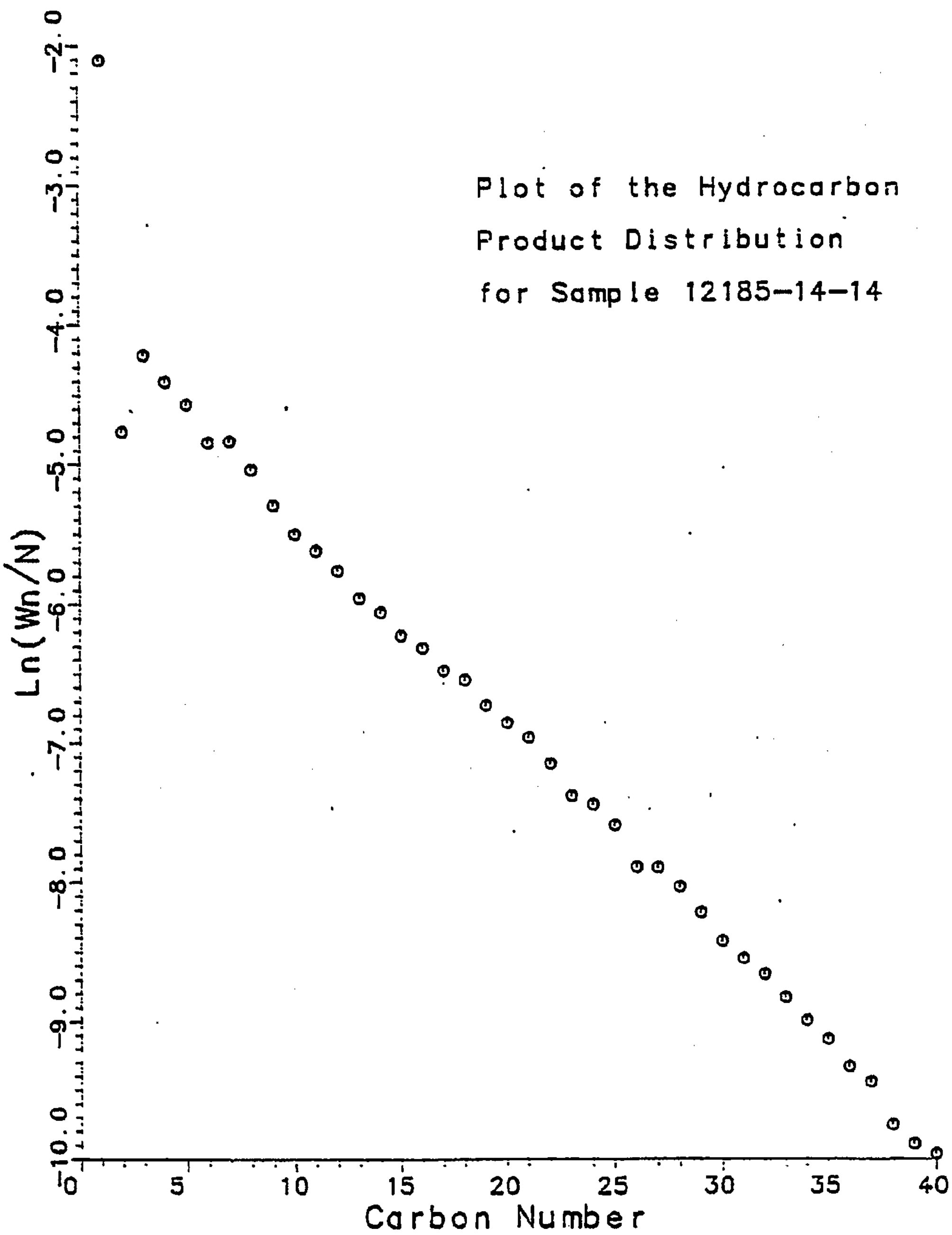
Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-12
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B36



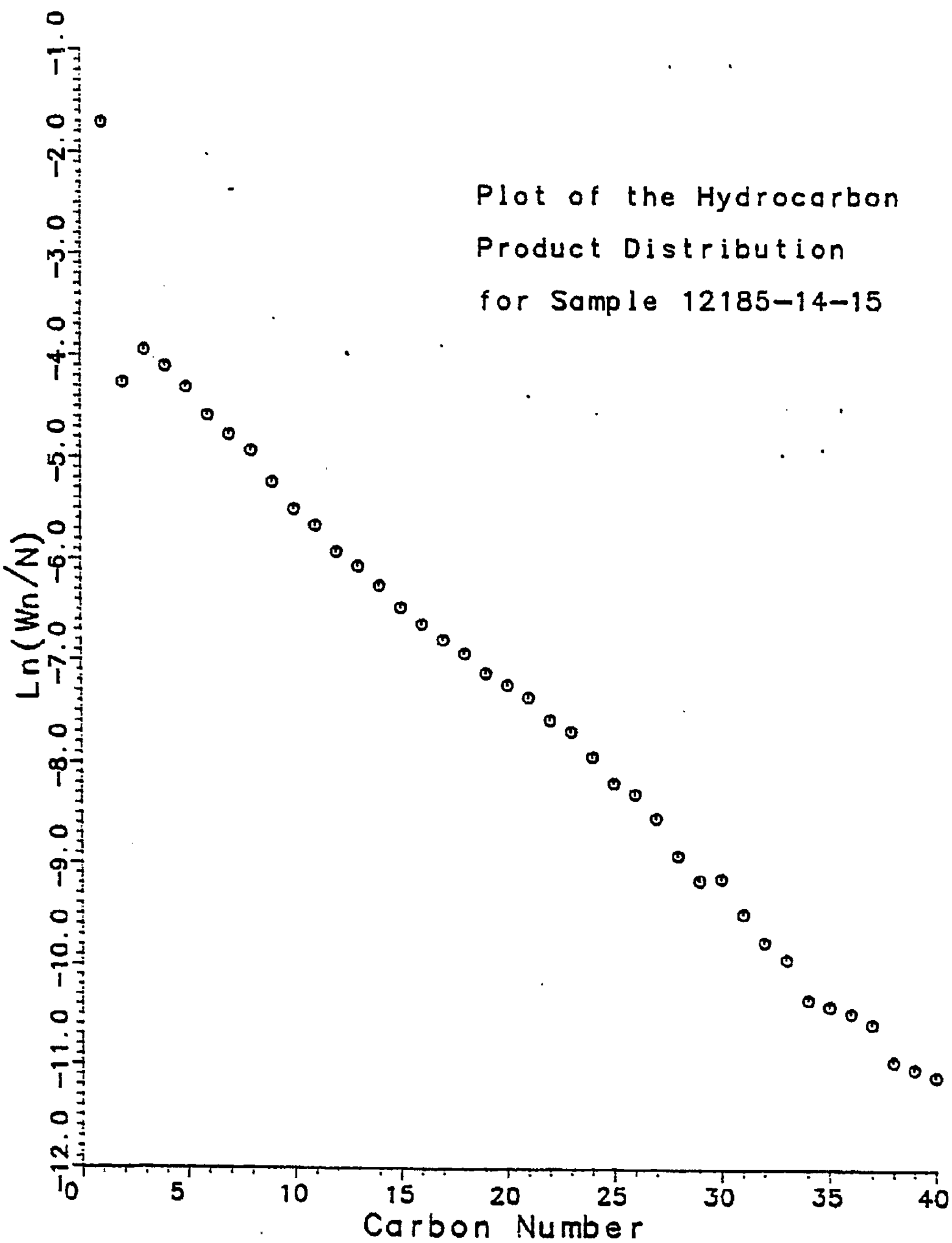
Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-13
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B37



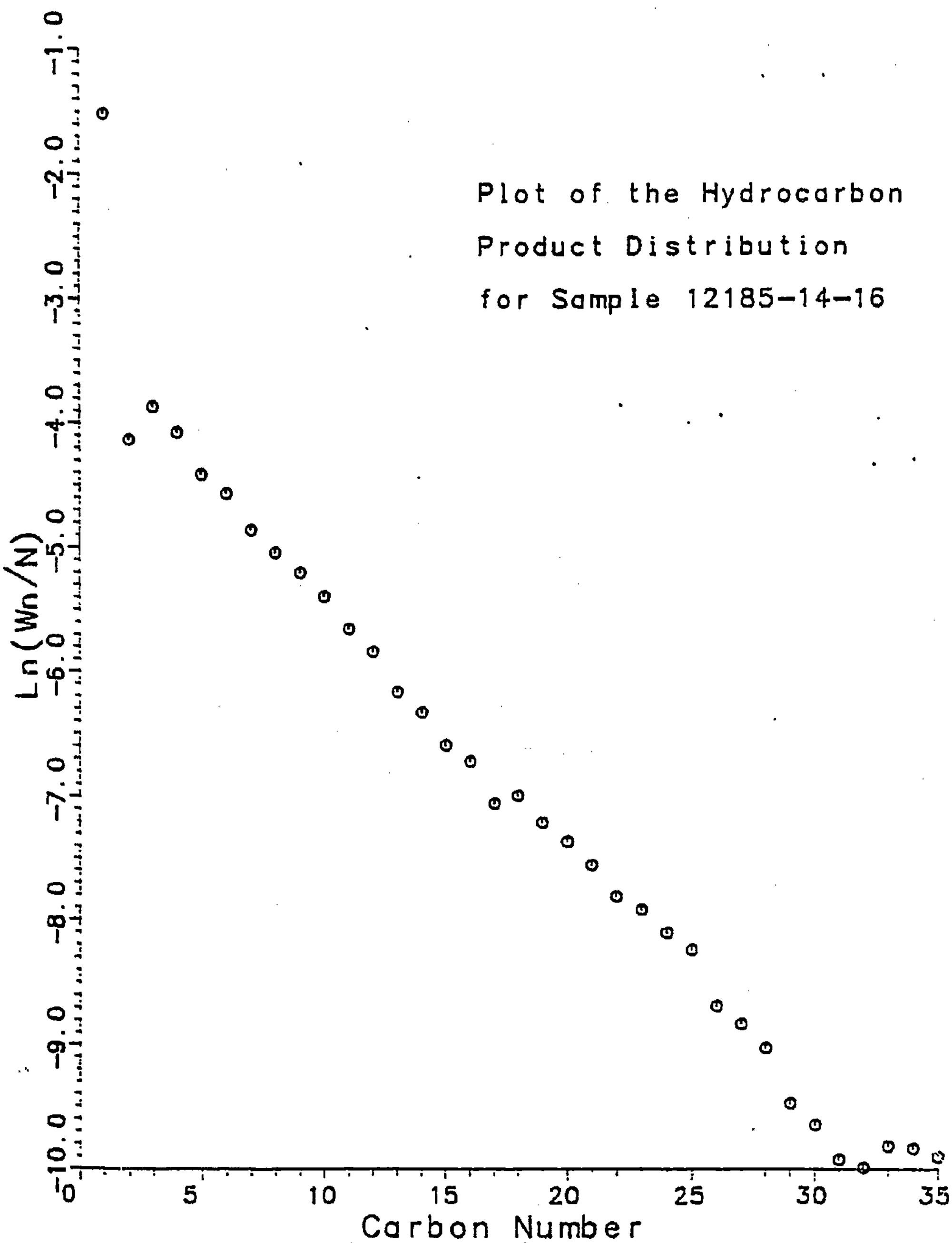
Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-14
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B38



Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-15
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
-12.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B39



Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-16
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
Carbon Number

Fig. B40

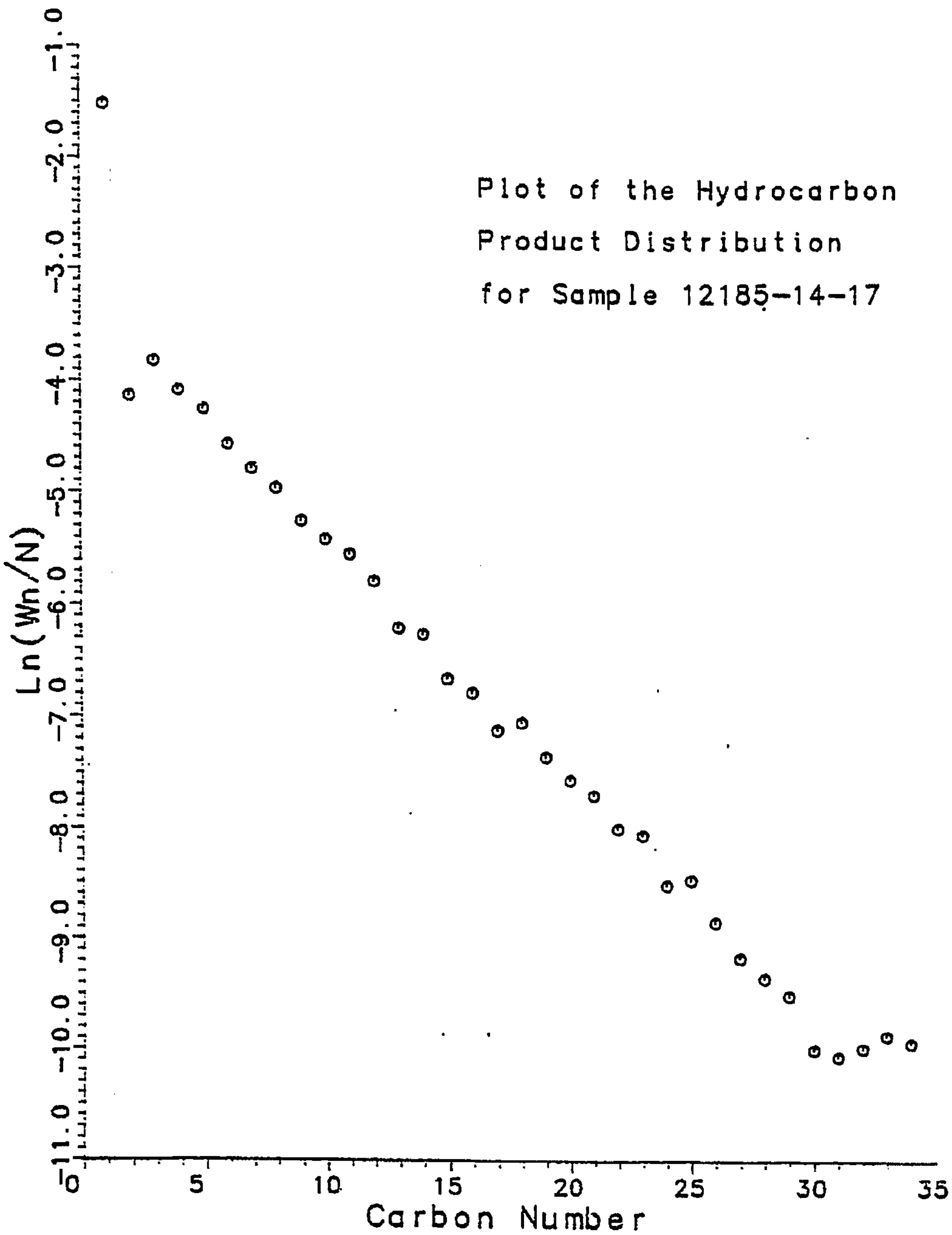
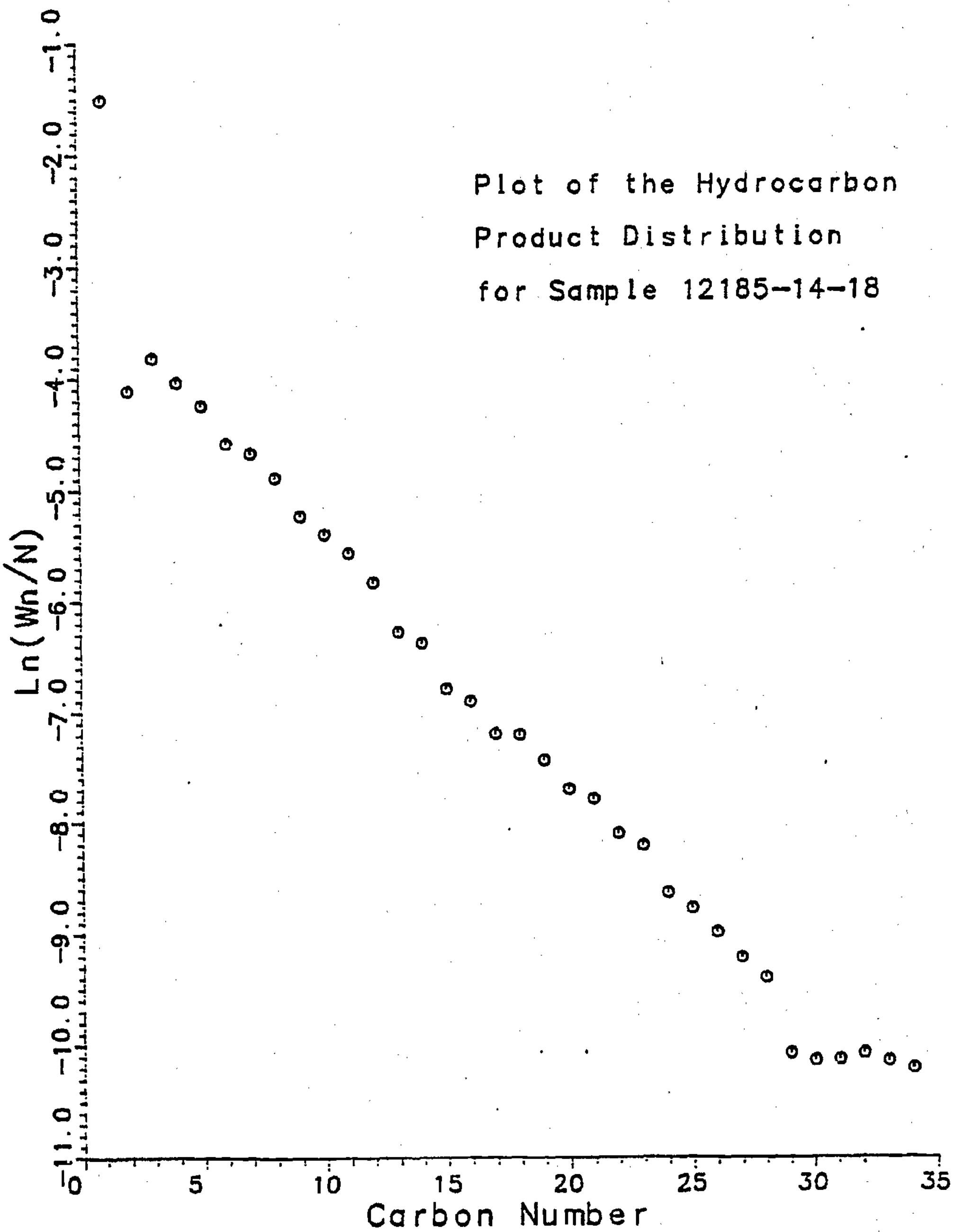
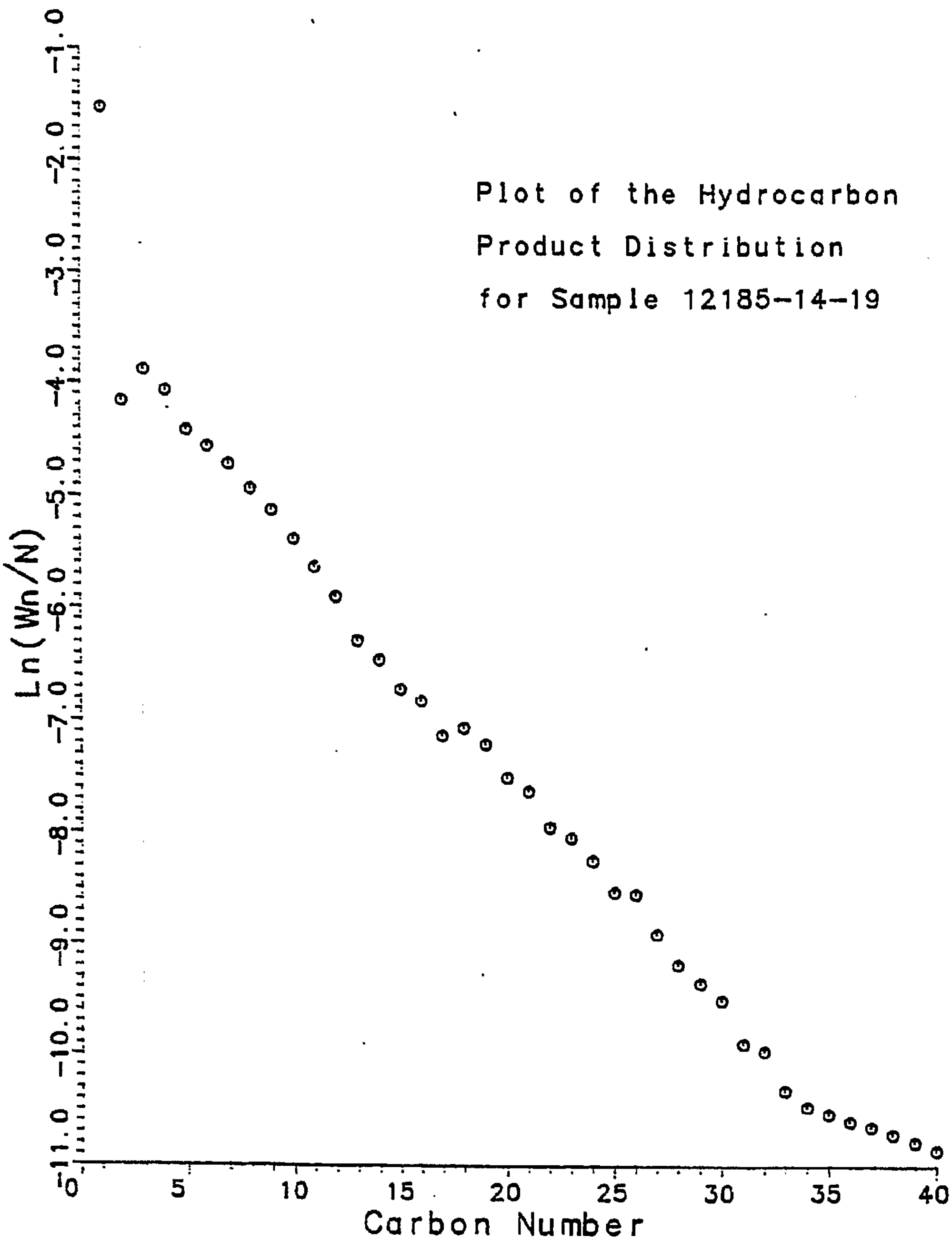

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-17
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
Carbon Number

Fig. B41



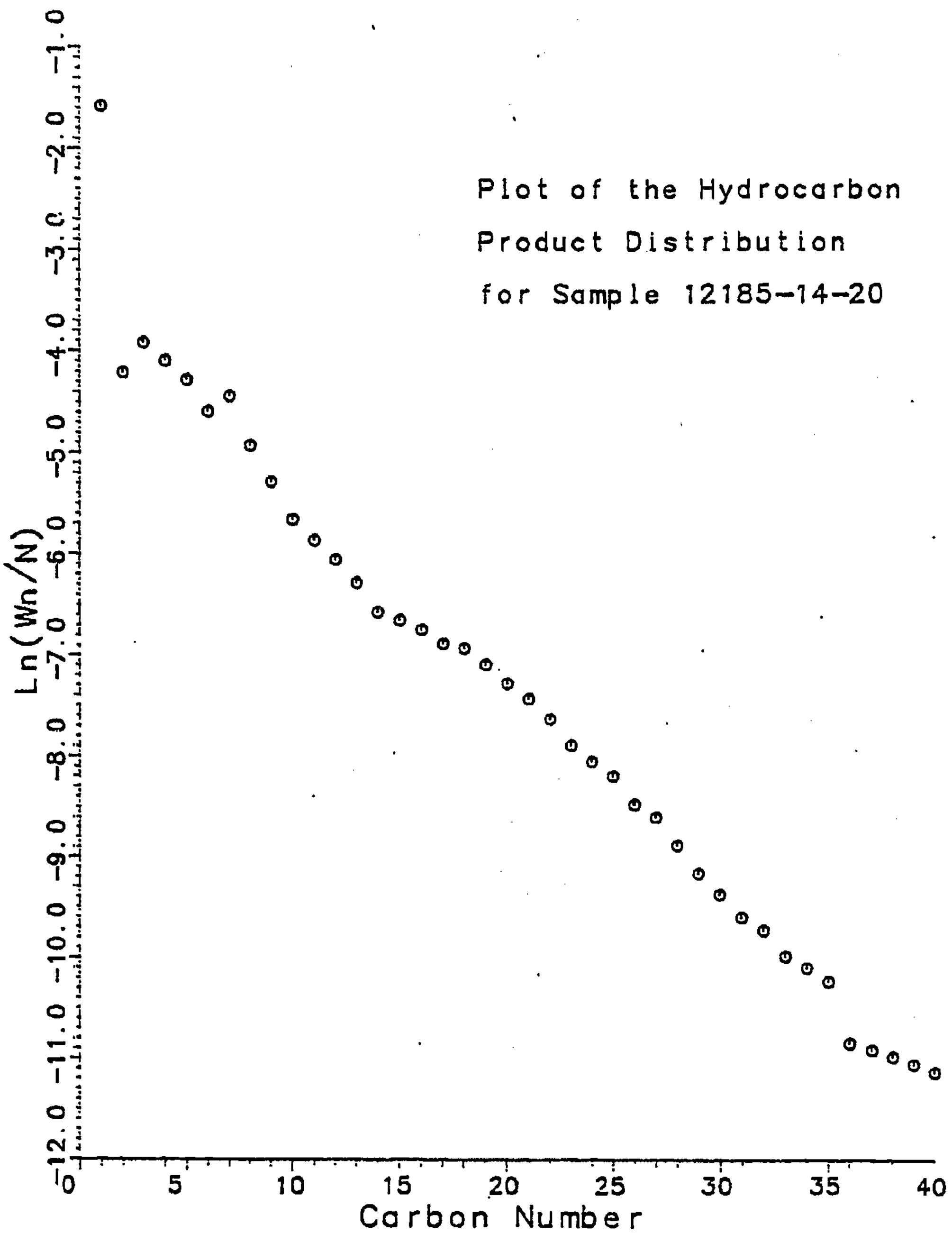
Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-18
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
Carbon Number

Fig. B42



Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-19
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B43



Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-20
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
-12.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B44

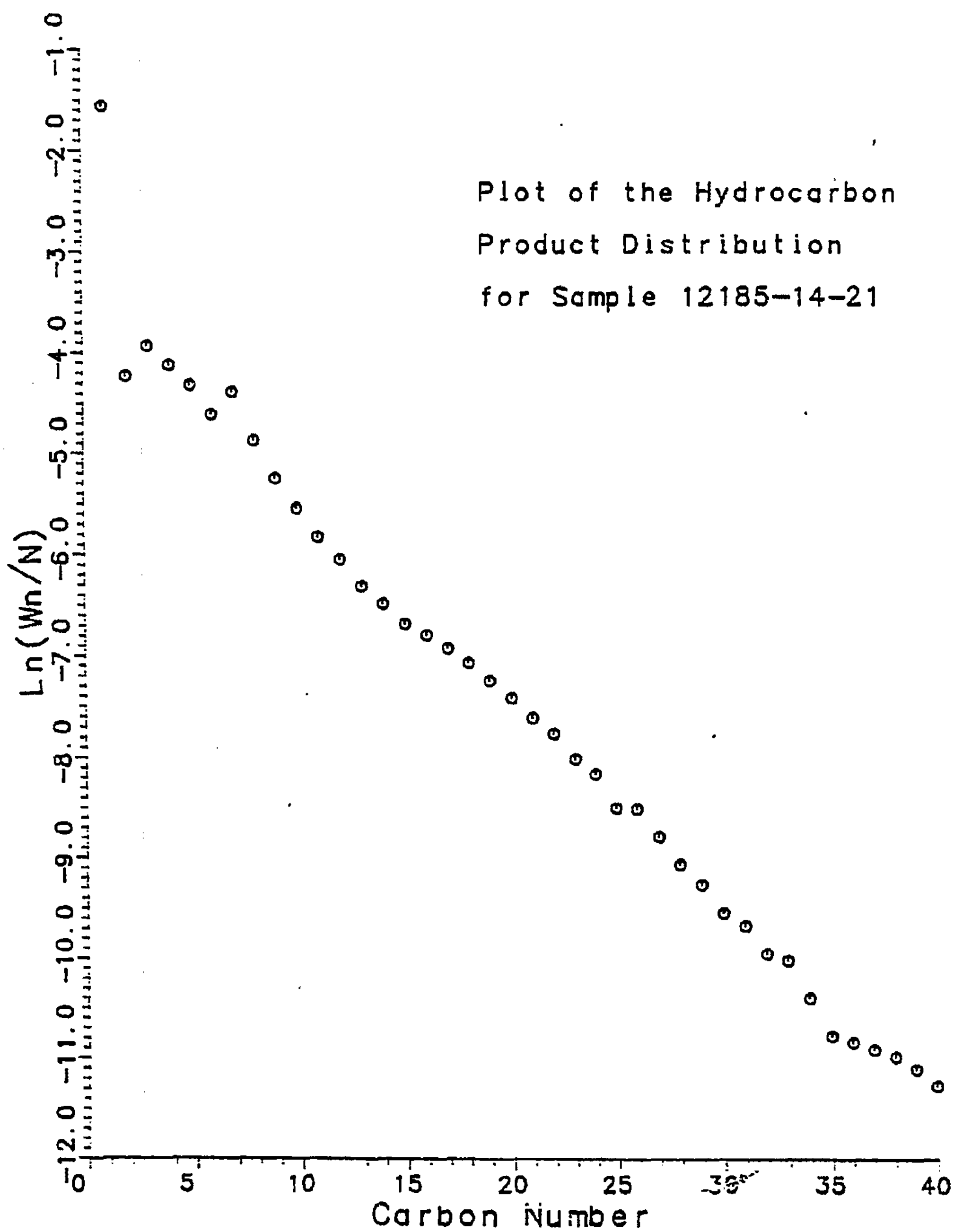
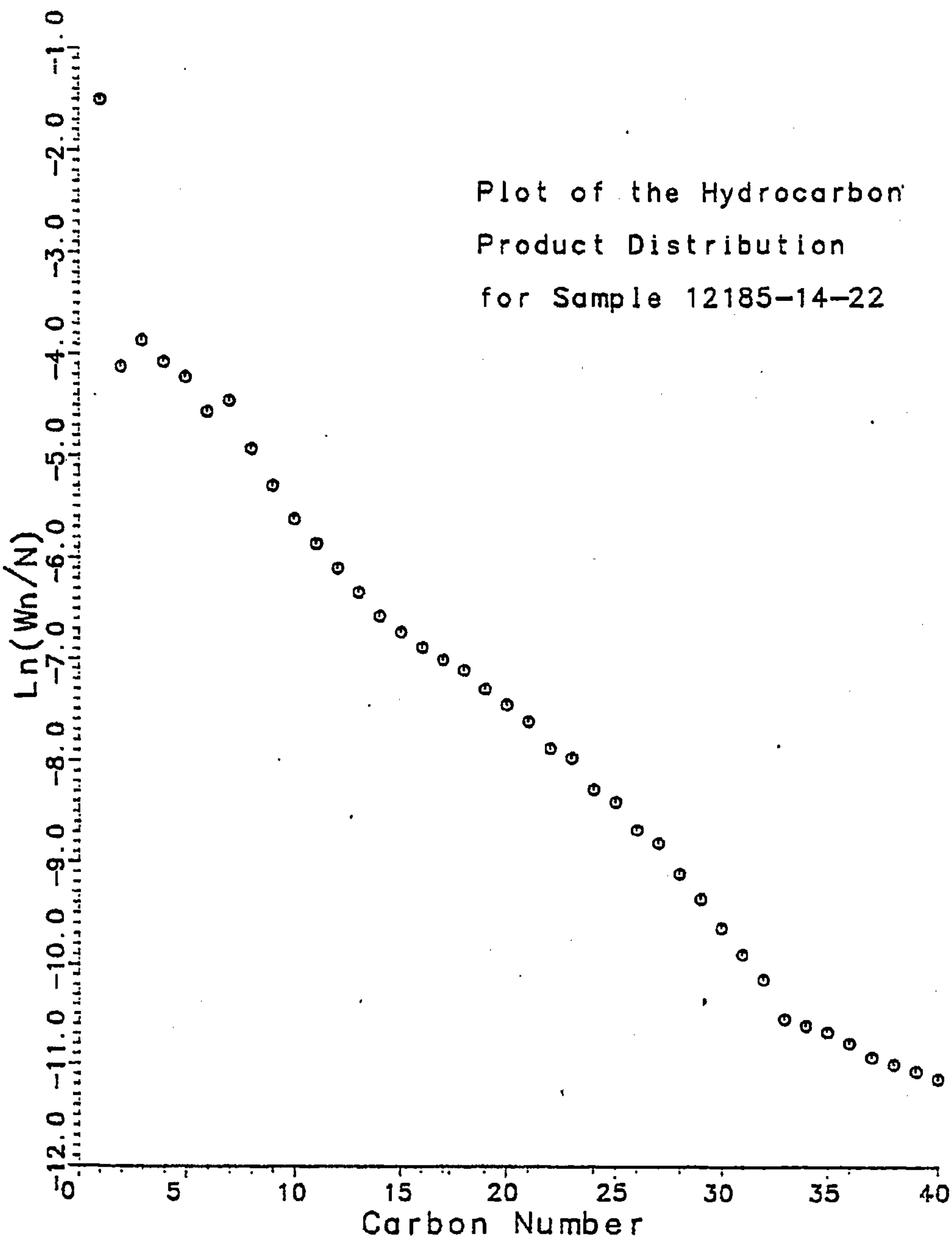

Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-21
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
-12.0
0
5
10
15
20
25
30
35
40
Carbon Number

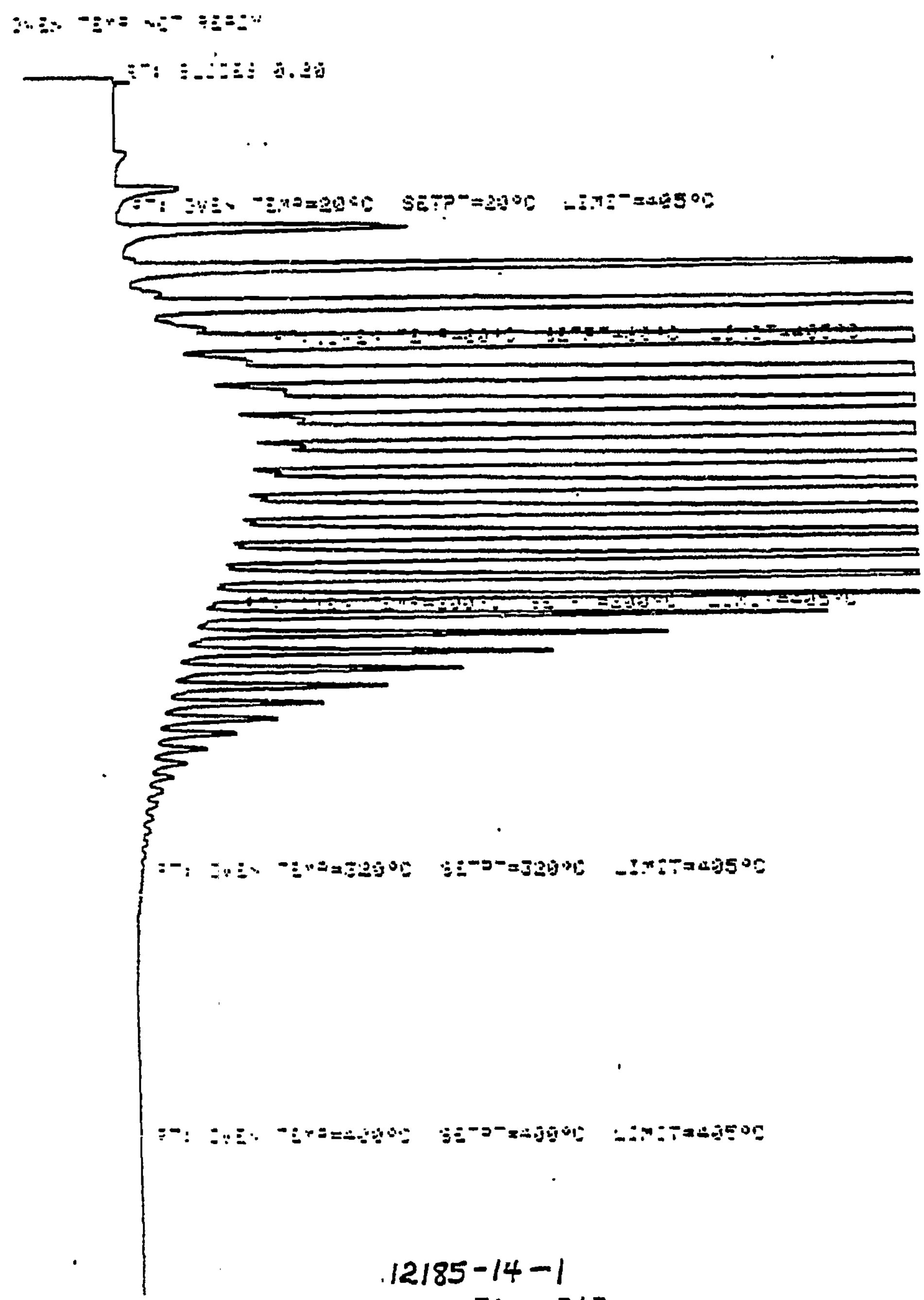
Fig. B45



Plot of the Hydrocarbon
Product Distribution
for Sample 12185-14-22
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
-12.0
0
5
10
15
20
25
30
35
40
Carbon Number

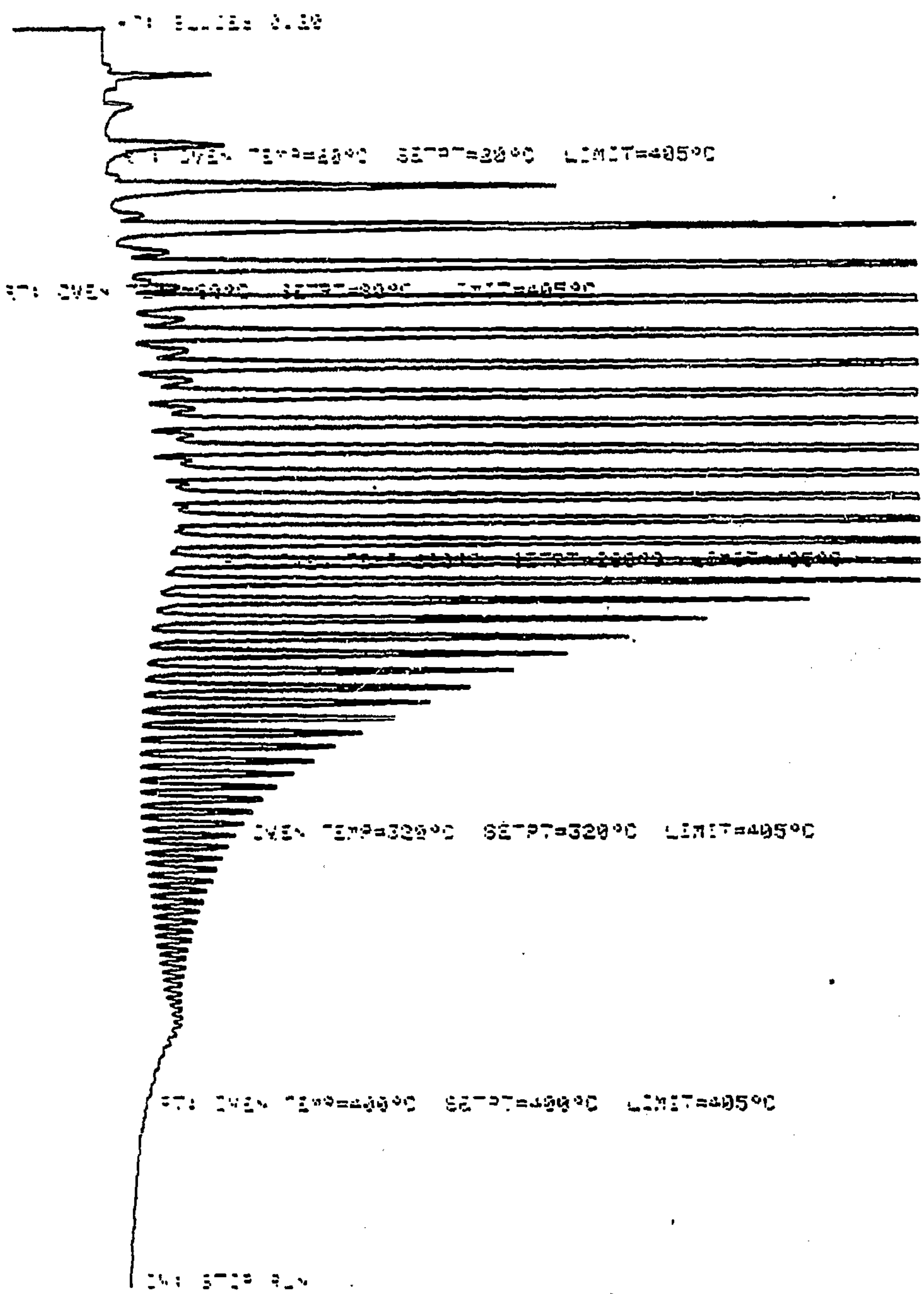
Fig. B46

133



12185-14-1

Fig. B47



12185-14-2

Fig. B48

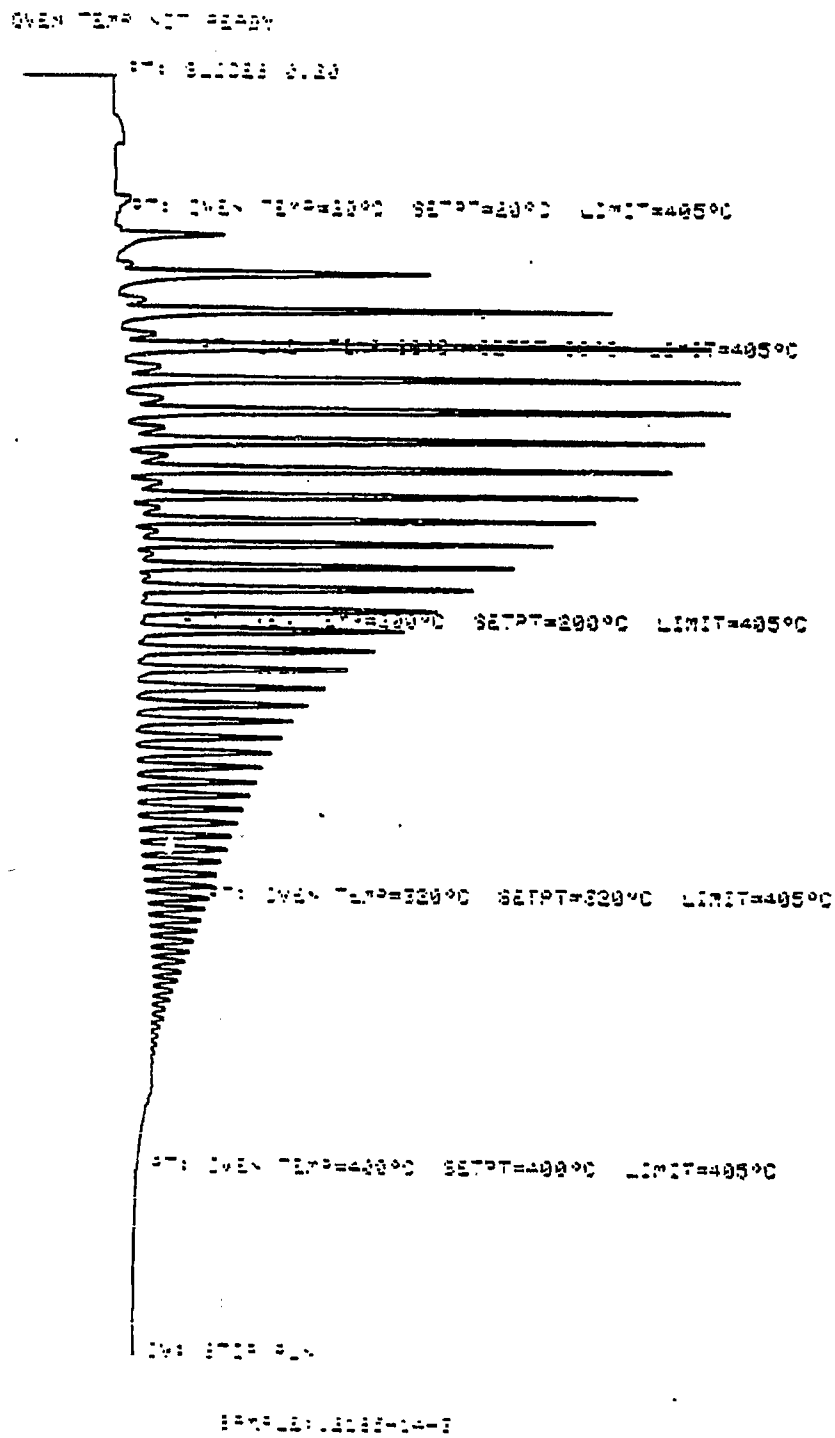
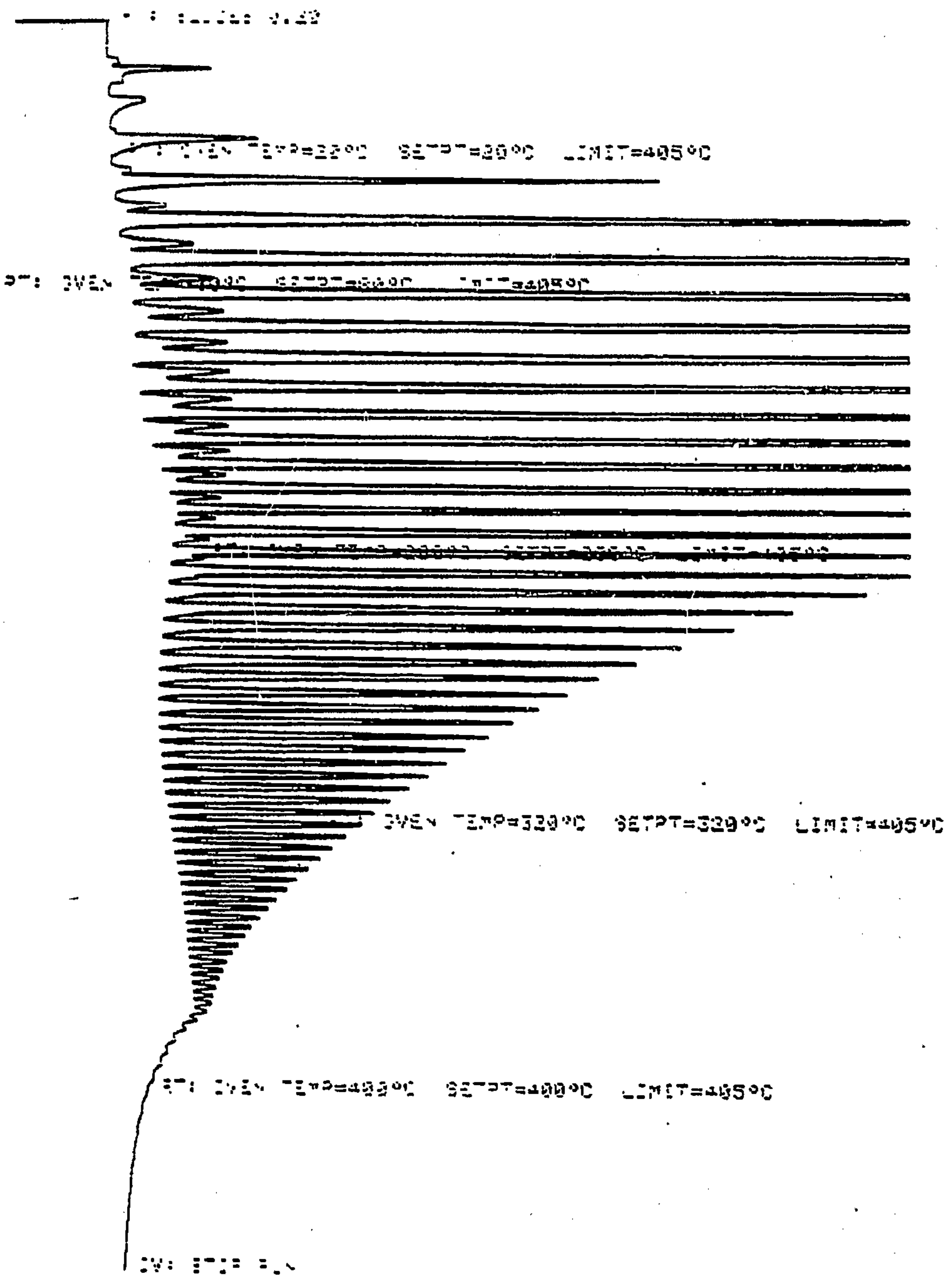
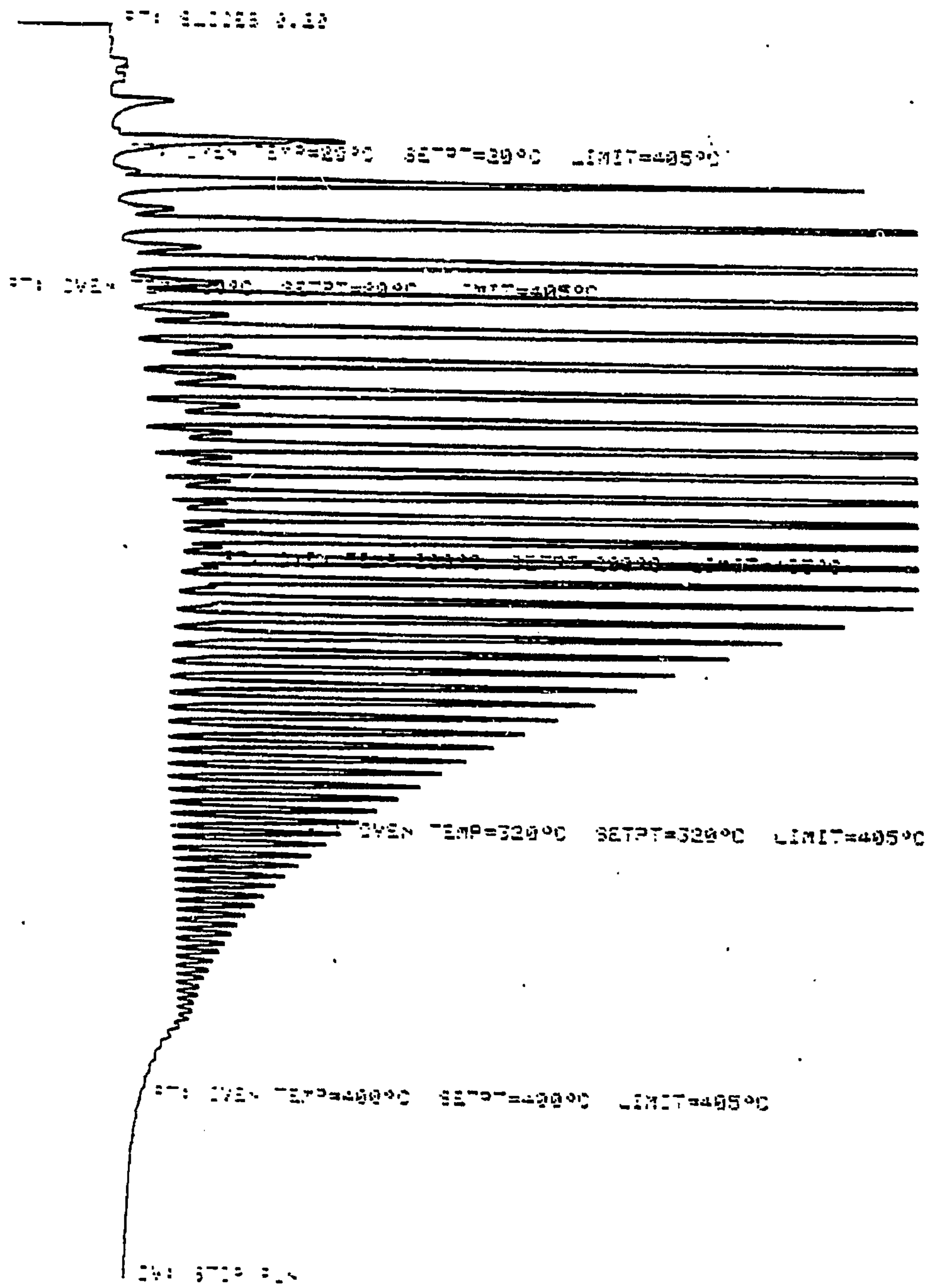

LIMIT=405°C
SETPT=200°C LIMIT=405°C
SETPT=320°C LIMIT=405°C
SETPT=400°C LIMIT=405°C

Fig. B49



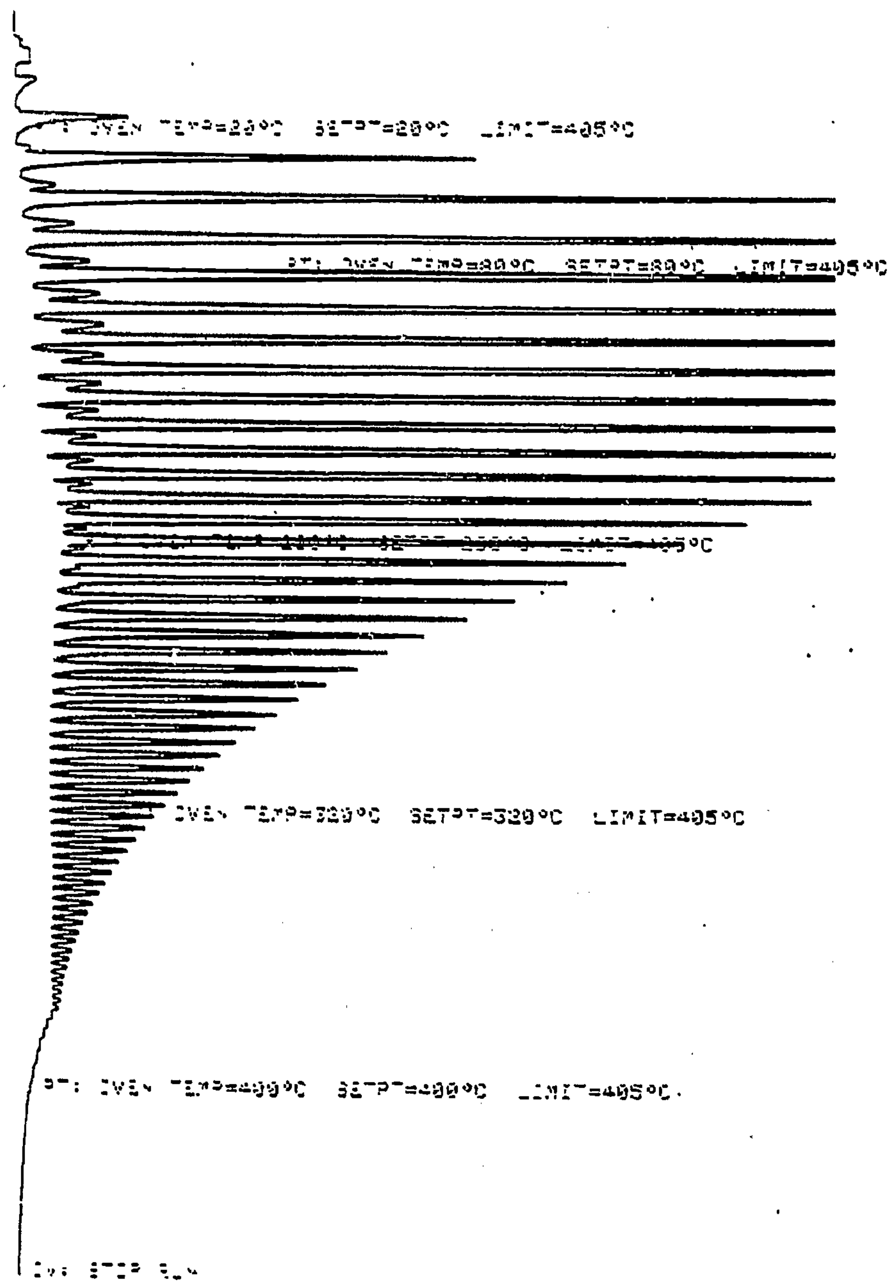
12185-14-4

Fig. B50



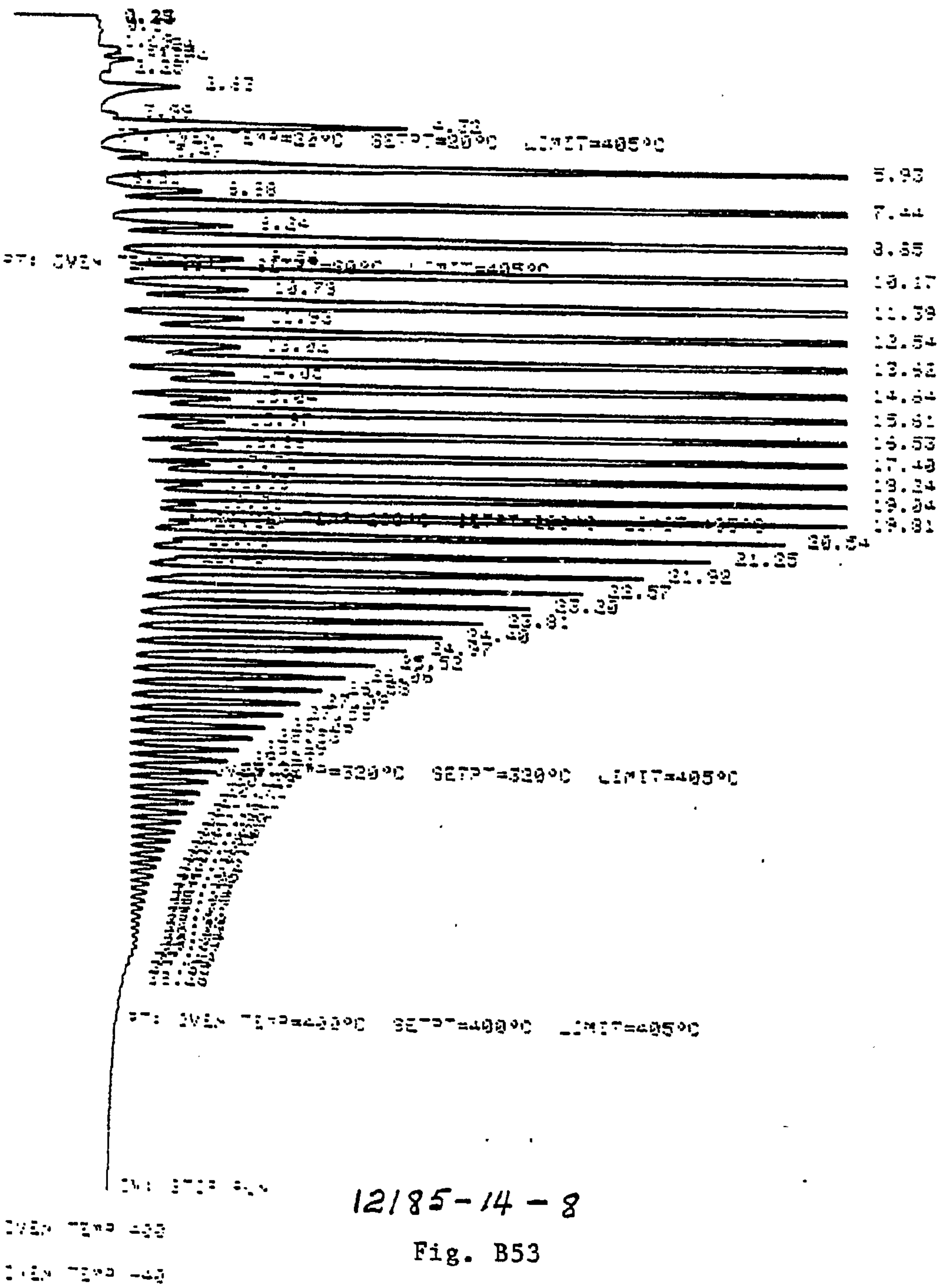
12185-14-6

Fig. B51



12185-14-7

Fig. B52



12185-14-8

Fig. B53

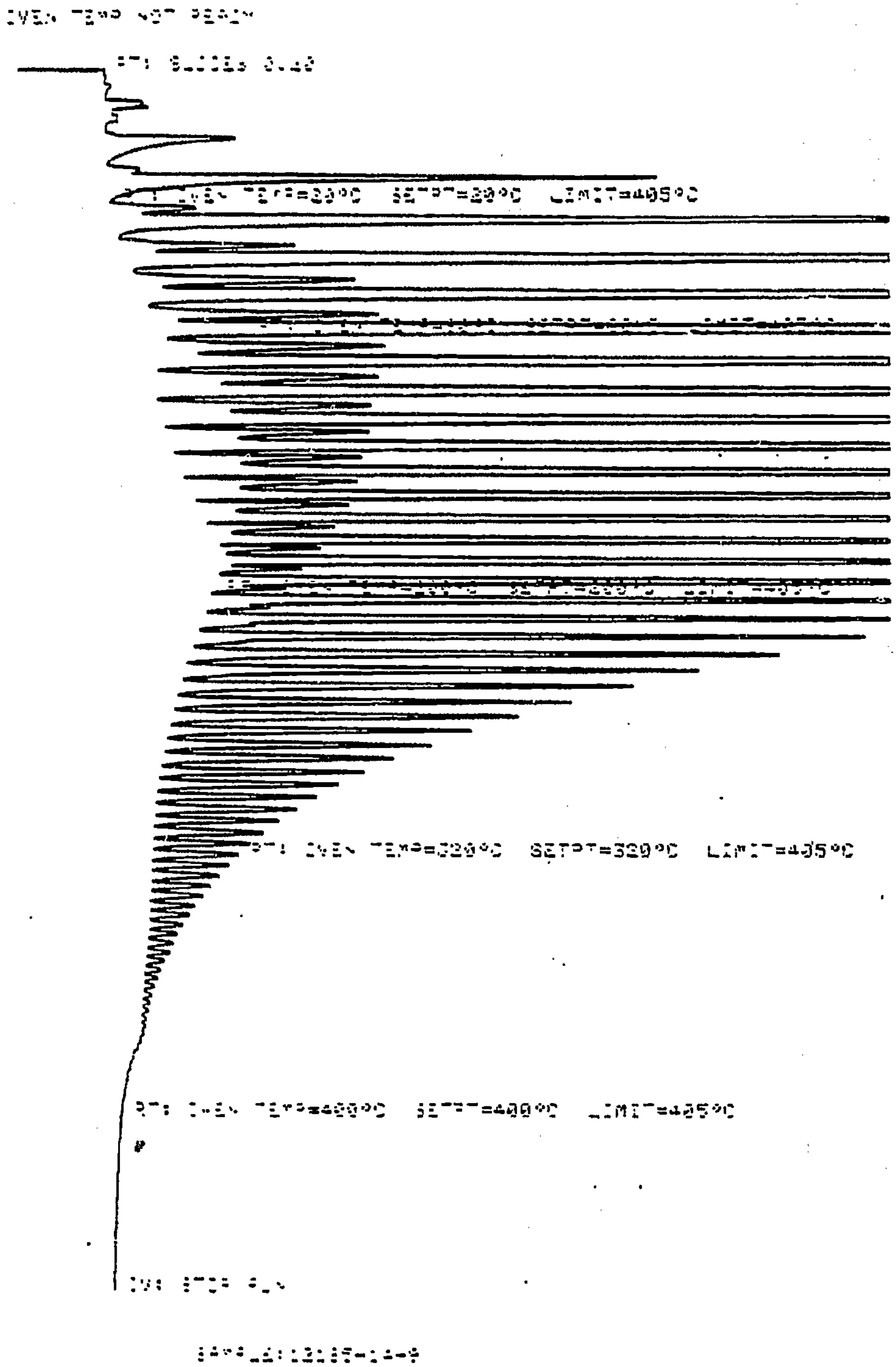


Fig. B54

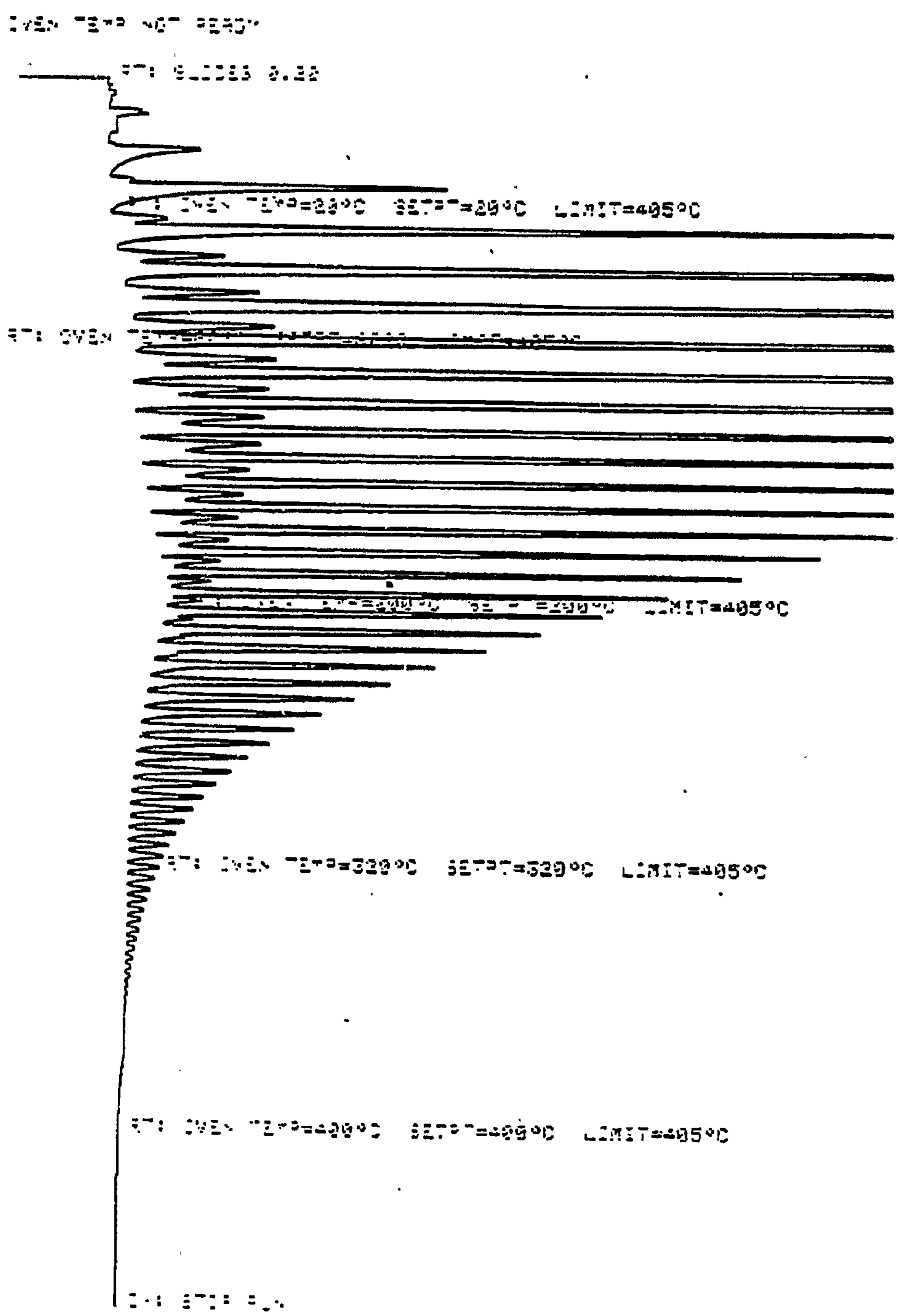
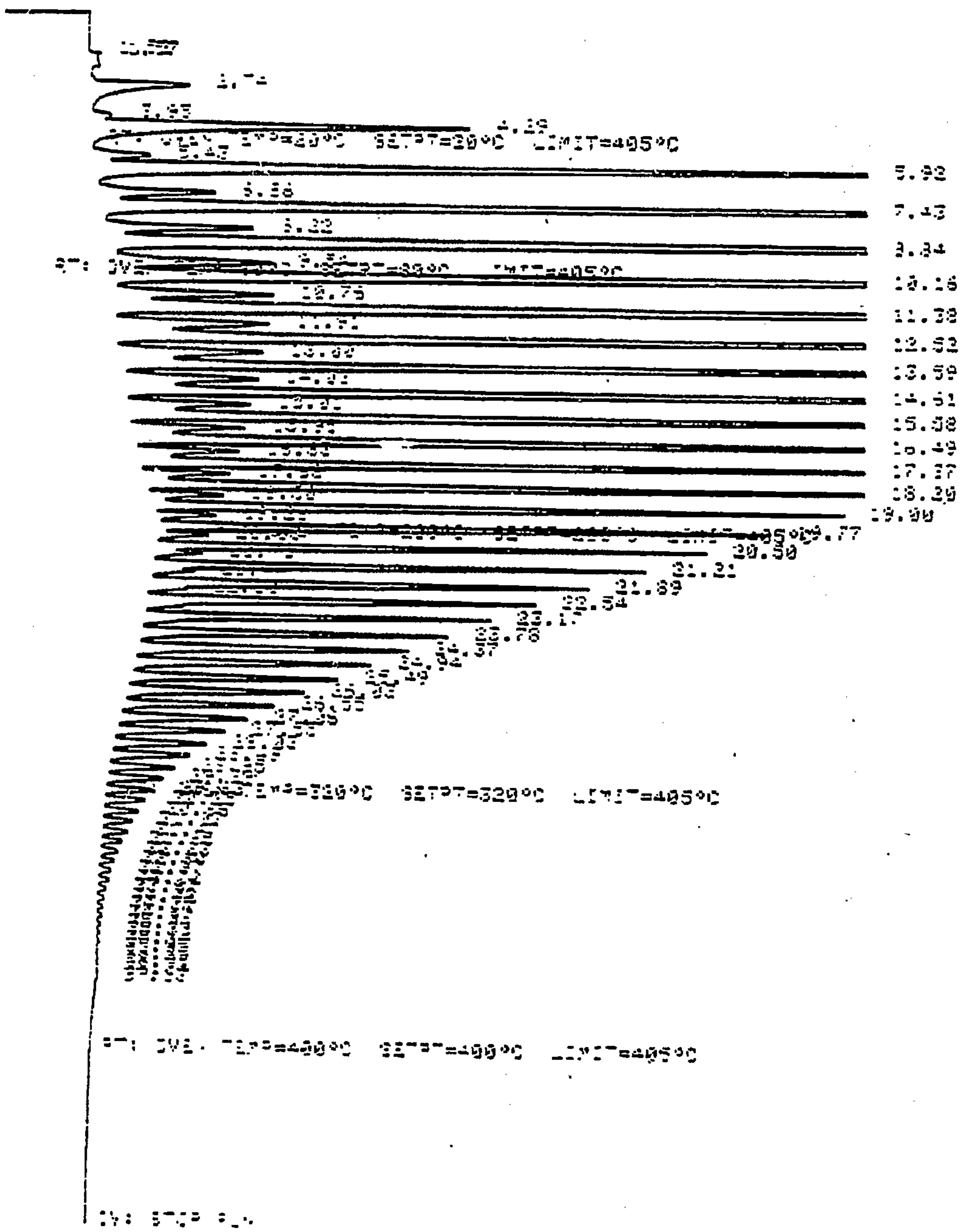
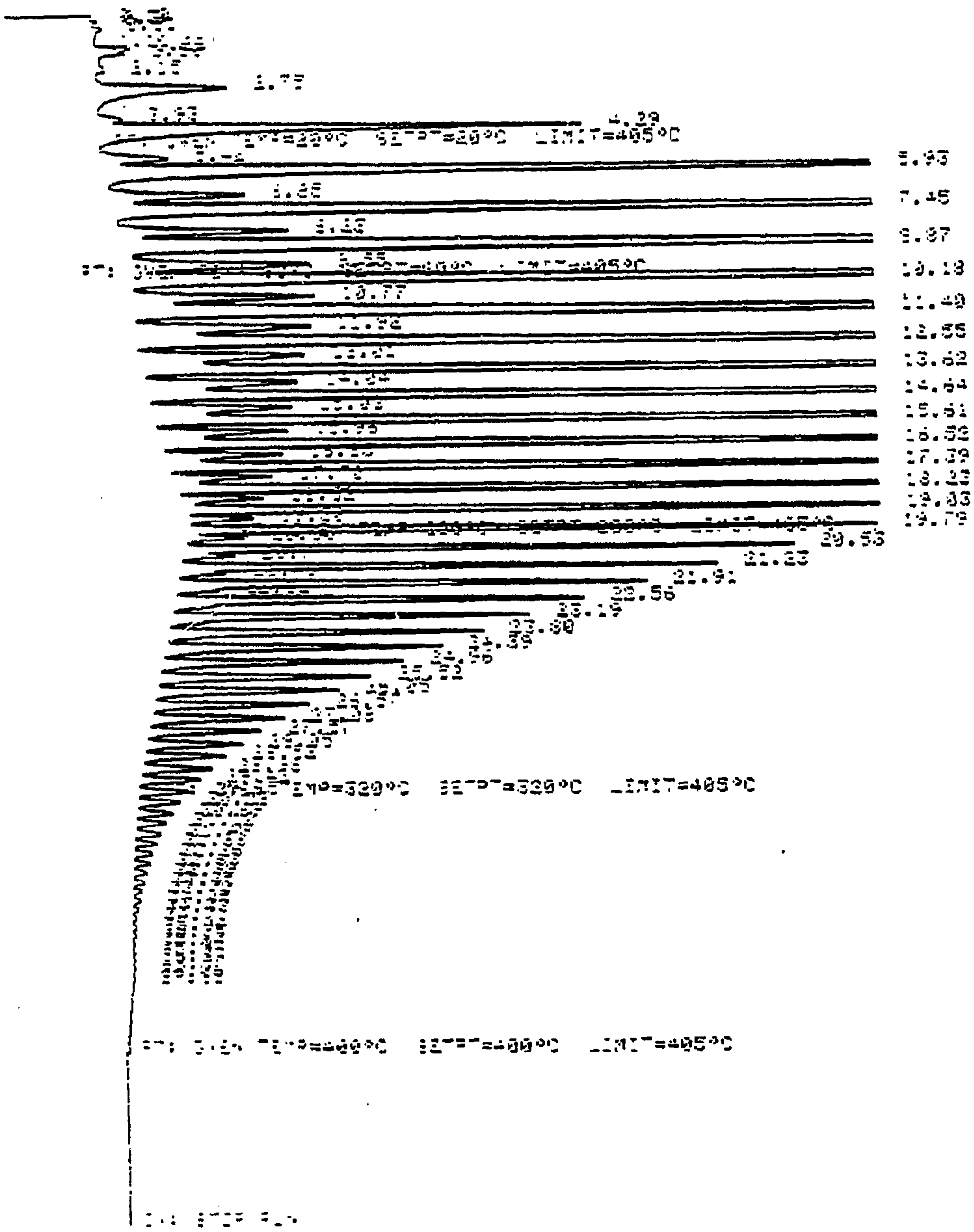

SETPT=20°C LIMIT=405°C
LIMIT=405°C
OVEN TEMP=320°C SETPT=320°C LIMIT=405°C
OVEN TEMP=400°C SETPT=400°C LIMIT=405°C

Fig. B55



12185-14-11

Fig. B56



12185-14-12

Fig. B57

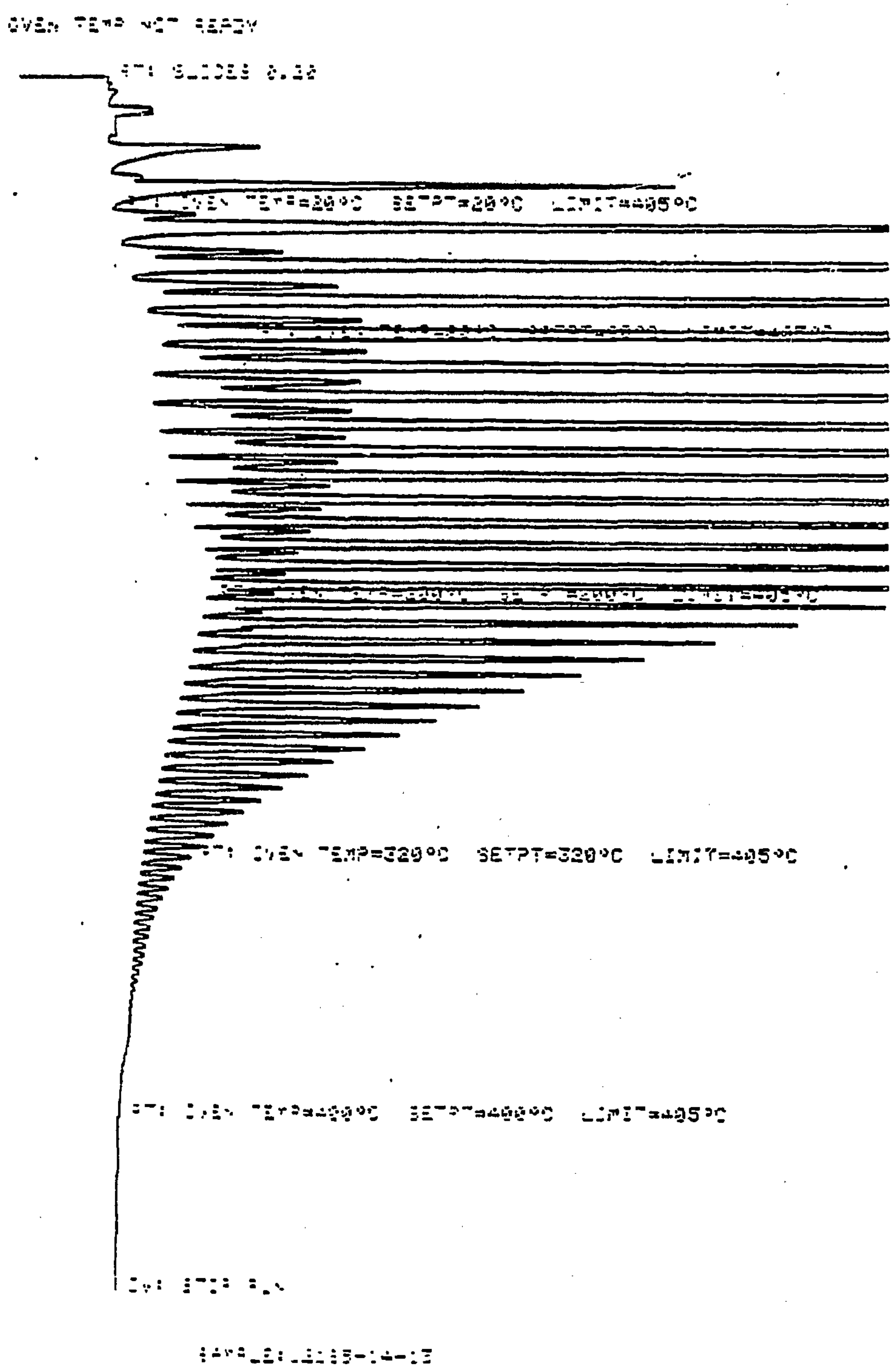


Fig. B58

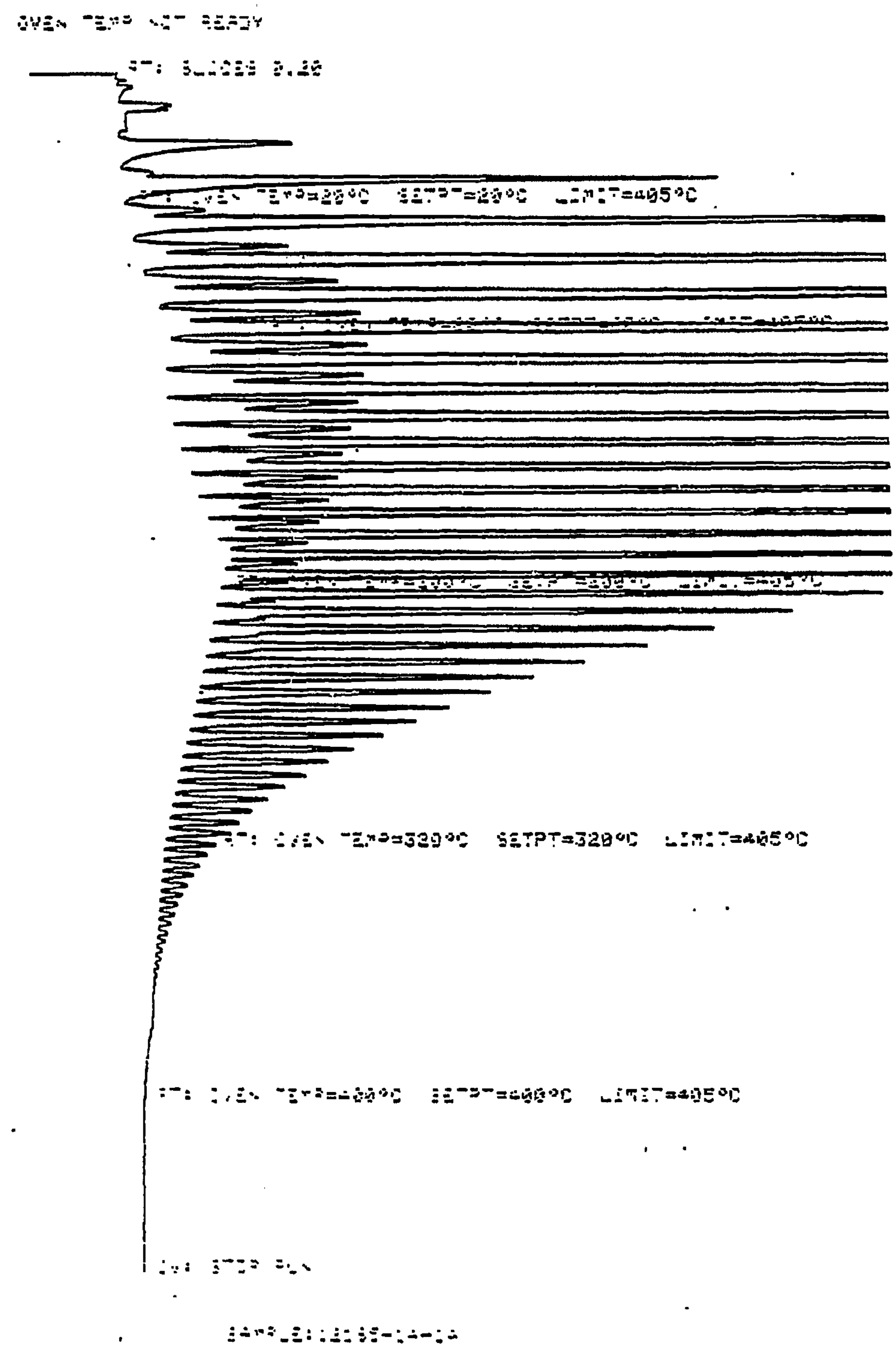

OVEN TEMP NOT READY
OVEN TEMP=320°C SETPT=320°C LIMIT=405°C
OVEN TEMP=400°C SETPT=400°C LIMIT=405°C

Fig. B59

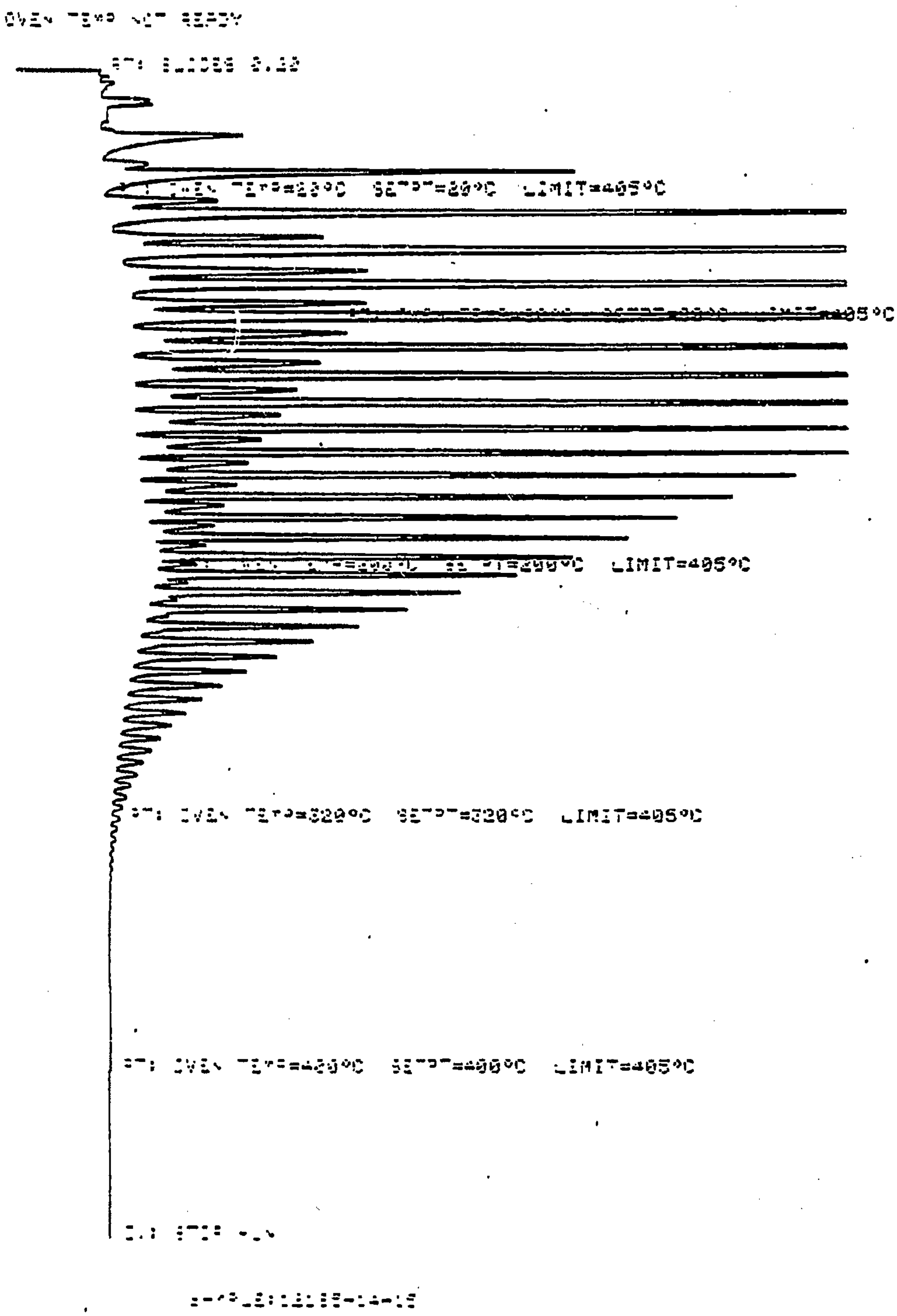


Fig. B60

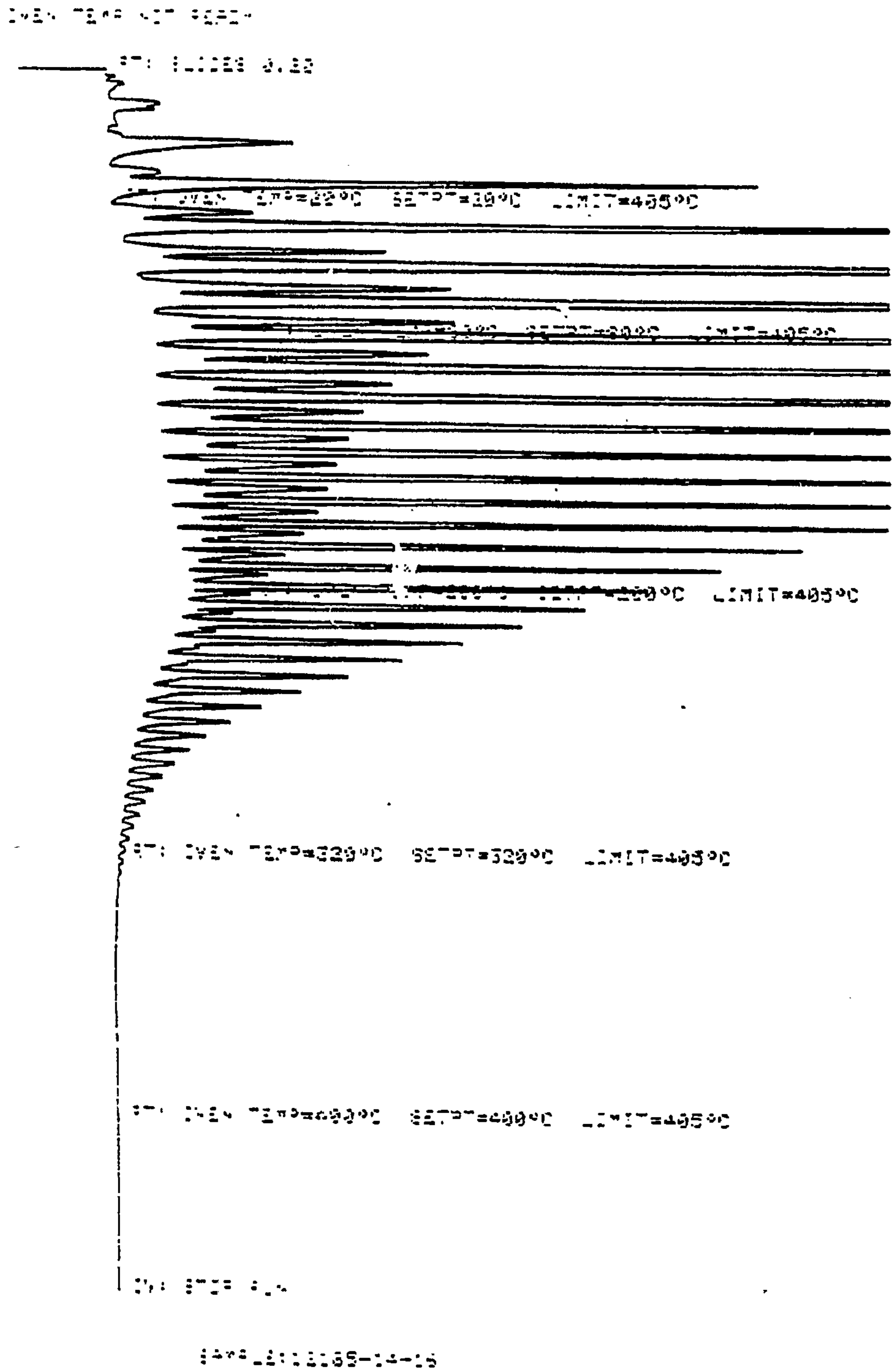


Fig. B61

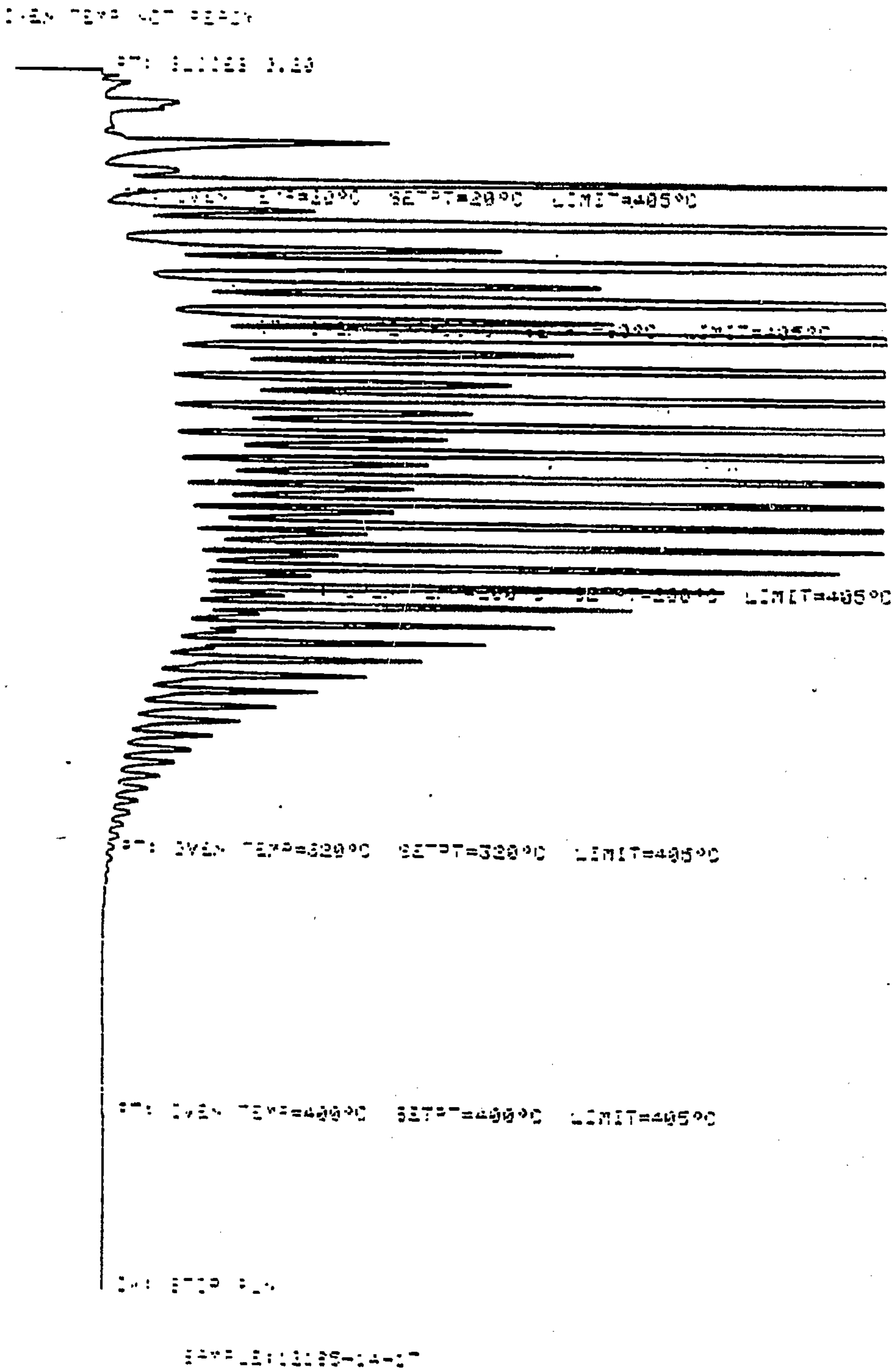


Fig. B62

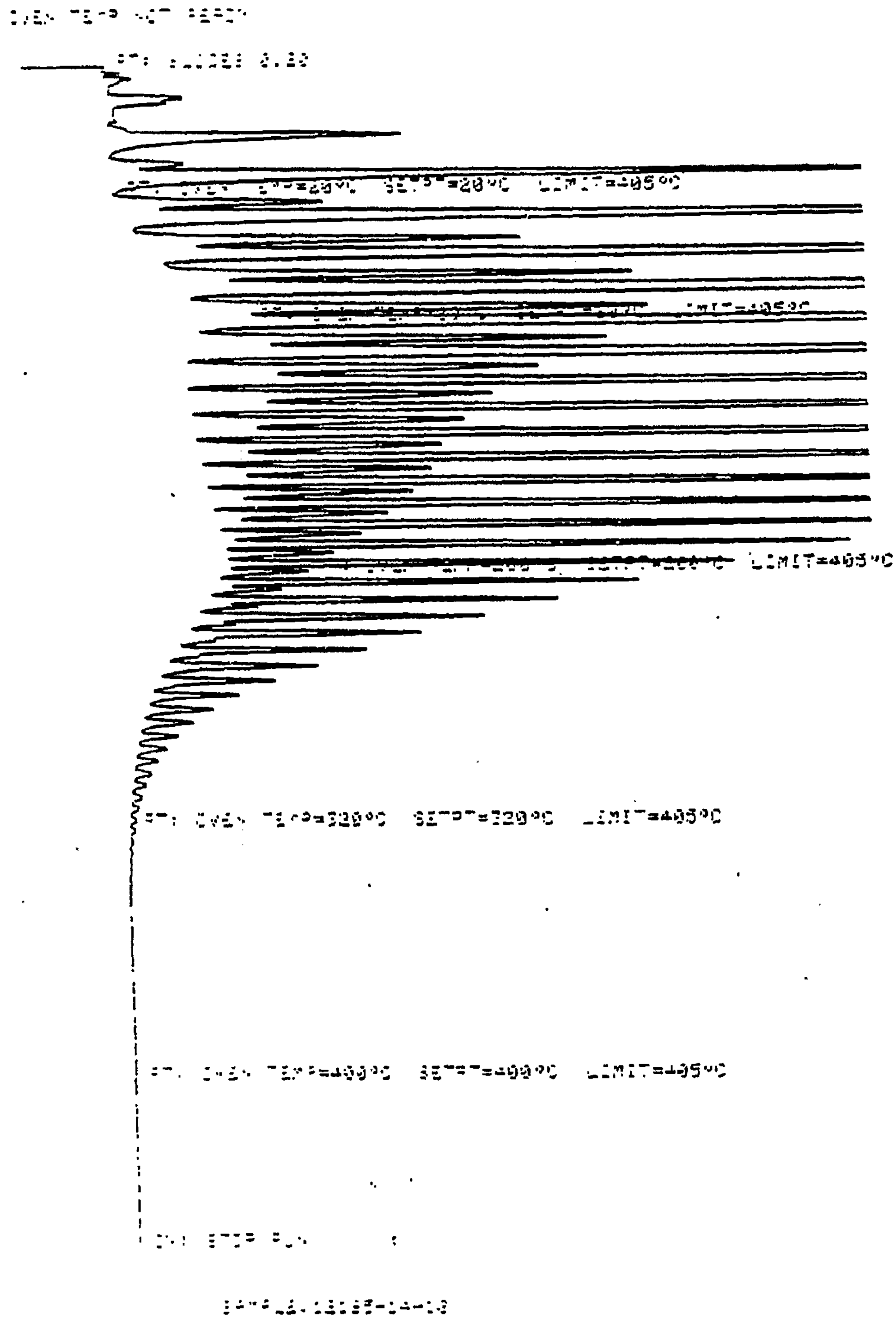


Fig. B63

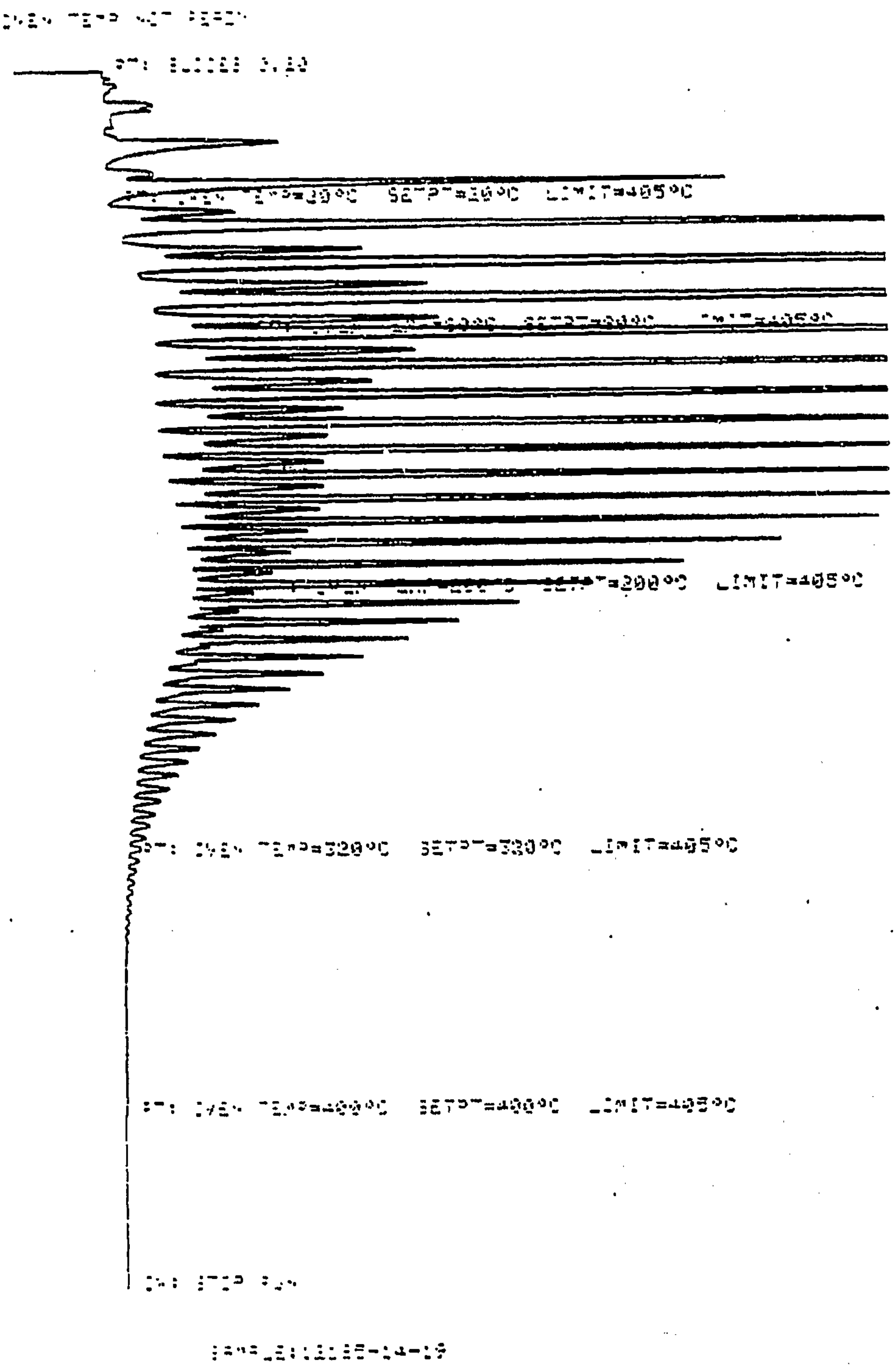


Fig. B64

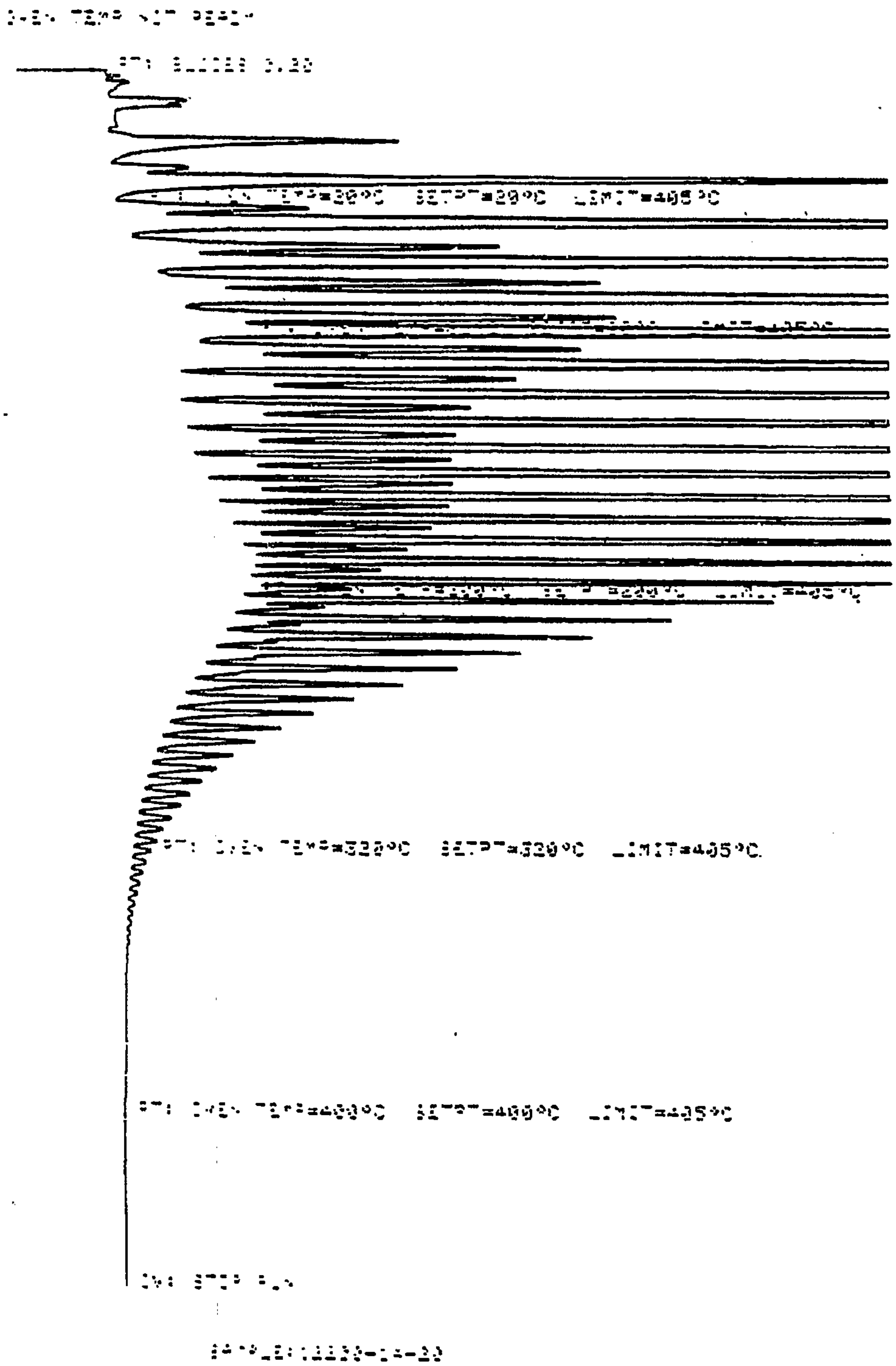


Fig. B65

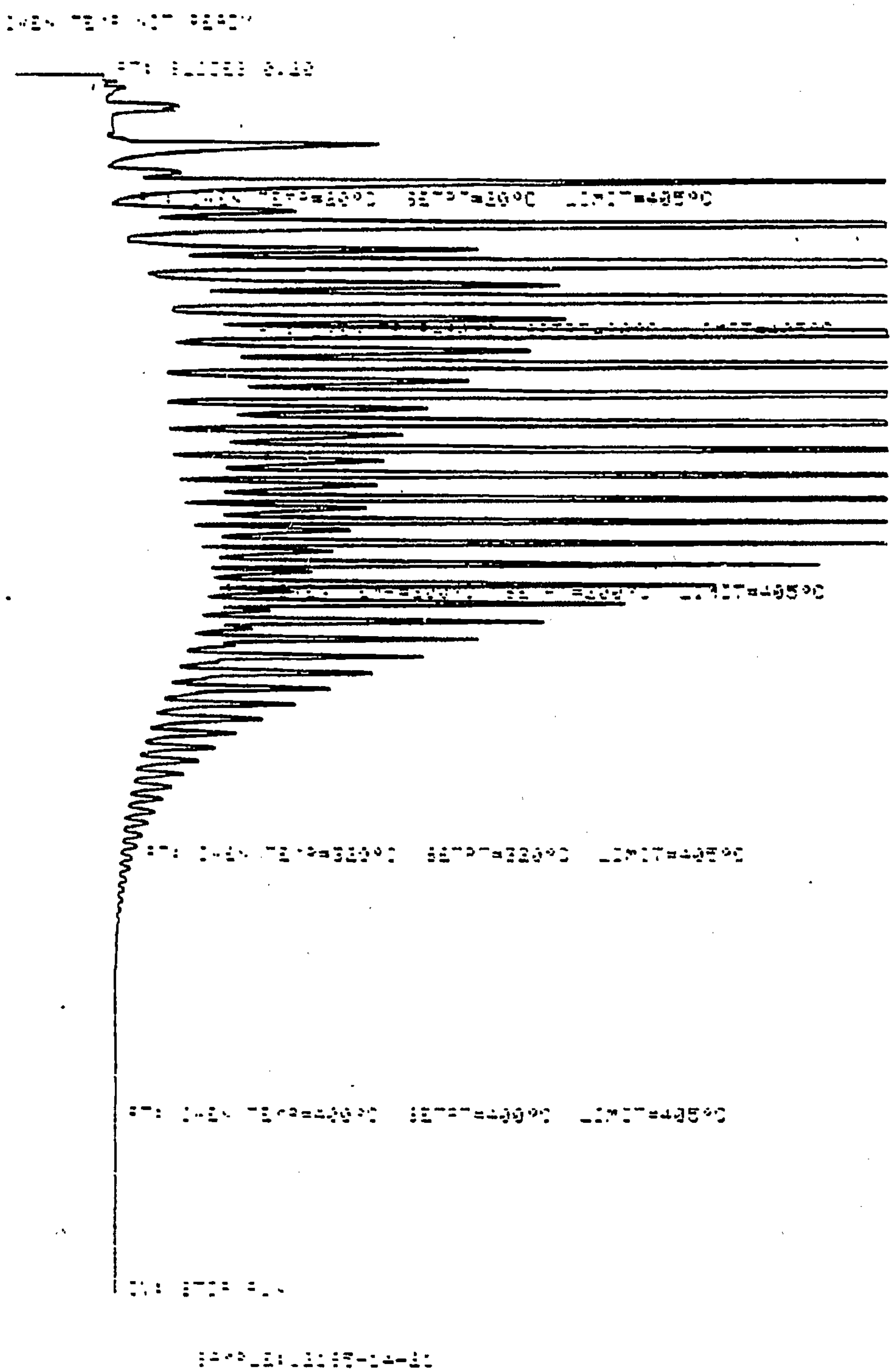


Fig. B66

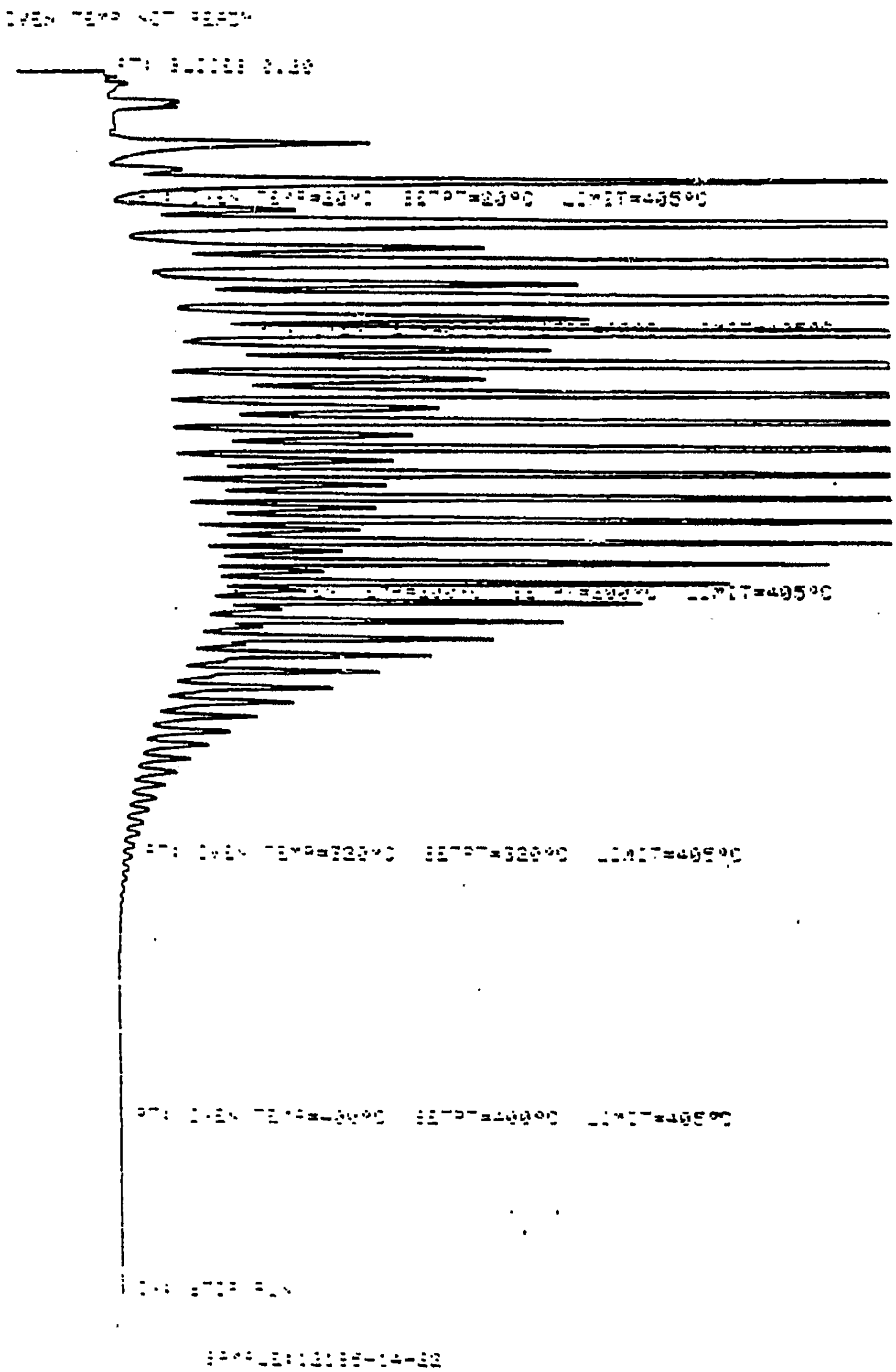


Fig. B67

Table B1

FILE: 1218514A TSS3Q1   A1

RESULT OF SYNGAS OPERATION

RUN NO.   12185-14
CATALYST   CO/X9/X10-U103 250 CC 108.2 G AFTER USE:155.3 G (+47.1 G)
FEED   H2:CO OF 50:50 @ 1260 CC/MN OR 300 GHSV   (CAT#12251-38-32)

RUN & SAMPLE NO.	12185-14-01	185-14-02	185-14-03	185-14-04	185-14-06
FEED H2:CO:AR	50:50: 0	50:50: 0	50:50: 0	50:50: 0	50:50: 0
HRS ON STREAM	19.0	43.5	67.5	92.5	138.5
PRESSURE,PSIG	300	300	300	300	300
TEMP. C	204	222	239	239	239
FEED CC/MIN	1260	1260	1260	1260	1260
HOURS FEEDING	19.00	24.50	24.00	25.00	22.00
EFFLNT GAS LITER	1169.50	1194.50	1071.75	1111.00	1002.81
GM AQUEOUS LAYER	50.77	151.39	140.01	143.11	127.61
GM OIL	3.24	35.70	112.03	126.65	105.22
MATERIAL BALANCE					
GM ATOM CARBON %	90.70	83.11	98.44	100.66	101.53
GM ATOM HYDROGEN %	91.59	92.39	100.93	101.20	102.03
GM ATOM OXYGEN %	97.89	96.04	93.88	93.57	95.20
RATIO CHX/(H2O+CO2)	0.4323	0.4927	1.1778	1.2860	1.2551
RATIO X IN CHX	2.3937	2.3335	2.2769	2.2622	2.2677
USAGE H2/CO PRODT	3.4783	2.8942	1.7528	1.7269	1.7692
FEED H2/CO FRM EFFLNT	1.0098	1.1115	1.0253	1.0053	1.0049
RESIDUAL H2/CO RATIO	0.8500	0.7650	0.6623	0.6373	0.6378
RATIO CO2/(H2O+CO2)	0.0031	0.0382	0.1004	0.0857	0.0731
K SHIFT IN EFFLNT	0.0026	0.0304	0.0739	0.0597	0.0503
SPECIFIC ACTIVITY SA	2.9534	2.9348	3.0458	3.2876	3.1223
CONVERSION					
ON CO %	6.08	16.27	33.29	33.78	32.45
ON H2 %	20.95	42.37	56.91	58.02	57.13
ON CO+H2 %	13.55	30.01	45.25	45.93	44.82
PRDT SELECTIVITY,WT %					
CH4	17.54	11.41	8.06	7.37	7.72
C2 HC'S	1.05	1.67	1.34	1.20	1.22
C3H8	2.32	2.36	1.71	1.42	1.47
C3H6=	6.76	3.44	2.05	2.08	2.20
C4H10	3.30	2.51	1.70	1.48	1.58
C4H8=	7.16	3.82	2.47	2.34	2.45
C5H12	3.25	2.93	1.95	1.87	1.92
C5H10=	6.15	3.34	2.12	2.21	2.27
C6H14	3.63	3.22	2.09	1.98	2.17
C6H12= & CYCLO'S	4.52	2.29	1.38	1.28	1.35
C7+ IN GAS	30.44	11.05	5.65	5.28	6.57
LIQ HC'S	13.88	51.96	69.47	71.49	69.08
TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	38.13	25.21	17.34	15.89	16.63
C5 -420 F	51.74	35.97	27.29	29.28	31.76
420-700 F	8.79	26.19	29.39	29.10	28.60
700-END PT	1.35	12.63	25.98	25.74	23.00

Table B1 (continued)

FILE: 1218514A TSS3Q1 A1

C5+-END PT	61.87	74.79	82.66	84.11	83.37
ISO/NORMAL MOLE RATIO					
C4	0.0000	0.0000	0.0218	0.0256	0.0142
C5	0.0000	0.0677	0.0614	0.0538	0.0550
C6	0.0000	0.0825	0.0775	0.0828	0.0790
C4=	0.0000	0.0000	0.0000	0.0000	0.0000
PARAFFIN/OLEFIN RATIO					
C3	0.3272	0.6567	0.7928	0.6530	0.6394
C4	0.4443	0.6341	0.6669	0.6110	0.6217
C5	0.5135	0.8545	0.8917	0.8205	0.8206
SCHULZ-FLORY DISTRBTN					
ALPHA (EXP(SLOPE))	0.7598	0.8476	0.8780	0.8828	0.8775
RATIO CH4/(1-A)**2	3.0391	4.9095	5.4142	5.3633	5.1425
ALPHA FRM CORRELATION	0.8222	0.8261	0.8321	0.8340	0.8339
ALPHA (EXPTL/CORR)	0.9241	1.0260	1.0552	1.0585	1.0523
W%CH4 FRM CORRELATION	9.8198	13.1548	15.3106	14.7275	14.7396
W%CH4 (EXPTL/CORR)	1.7861	0.8671	0.5266	0.5005	0.5235
LIQ HC COLLECTION					
PHYS. APPEARANCE	CLR OIL	OIL WAX	OIL WAX	OIL WAX	OIL WAX
DENSITY (* 40 C)	0.7651	N/A	N/A	N/A	N/A
N, REFRACTIVE INDEX	1.4231*	N/A	N/A	N/A	N/A
SIMULT'D DISTILATN					
10 WT % @ DEG F	341	334	365	335	332
16	378	372	407	375	371
50	510	560	609	592	584
84	654	779	928	902	866
90	697	872	1007	985	946
RANGE(16-84 %)	276	407	521	527	495
WT % @ 420 F	27.00	25.30	20.30	23.30	25.30
WT % @ 700 F	90.30	75.70	62.60	64.00	66.70

Table B2

FILE: 1218514B TSS3Q1 A1

RESULT OF SYNGAS OPERATION

RUN NO. 12185-14
CATALYST CO/X9/X10-U103 250 CC 108.2 G AFTER USE 155.3 G (+47.1 G)
FEED H2:CO OF 50:50 @ 1260 CC/MN OR 300 GHSV (CAT#12251-38-32)

RUN & SAMPLE NO.	12185-14-07	185-14-08	185-14-09	185-14-10	185-14-11
FEED H2:CO:AR	50:50: 0	50:50: 0	50:50: 0	50:50: 0	50:50: 0
HRS ON STREAM	163.0	186.5	210.5	234.5	257.8
PRESSURE,PSIG	300	300	300	300	300
TEMP. C	239	249	249	250	249
FEED CC/MIN	1260	1260	1260	1260	1260
HOURS FEEDING	24.50	23.50	24.00	24.00	23.22
EFFLNT GAS LITER	1134.24	1008.90	1000.00	990.40	968.20
GM AQUEOUS LAYER	134.83	131.77	163.47	171.50	163.32
GM OIL	117.09	121.50	102.07	89.59	98.58
MATERIAL BALANCE					
GM ATOM CARBON %	102.54	105.39	98.36	95.61	98.85
GM ATOM HYDROGEN %	102.87	100.94	97.98	99.23	101.79
GM ATOM OXYGEN %	94.62	95.90	97.72	97.20	97.29
RATIO CHX/(H2O+CO2)	1.3336	1.3530	1.0209	0.9503	1.0500
RATIO X IN CHX	2.2705	2.3388	2.3540	2.3898	2.3676
USAGE H2/CO PRODT	1.7308	1.5752	1.8009	1.8438	1.7942
FEED H2/CO FRM EFFLNT	1.0032	0.9578	0.9962	1.0379	1.0298
RESIDUAL H2/CO RATIO	0.6506	0.5636	0.5536	0.5811	0.5768
RATIO CO2/(H2O+CO2)	0.0754	0.1751	0.1296	0.1348	0.1285
K SHIFT IN EFFLNT	0.0530	0.1196	0.0824	0.0906	0.0851
SPECIFIC ACTIVITY SA	3.0611	2.7045	2.4198	2.1759	2.4152
CONVERSION					
ON CO %	32.64	38.97	35.48	36.17	37.21
ON H2 %	56.32	64.09	64.15	64.26	64.83
ON CO+H2 %	44.50	51.25	49.79	50.48	51.22
PRDT SELECTIVITY,WT %					
CH4	7.89	11.14	11.91	13.75	12.66
C2 HC'S	1.21	1.62	1.87	2.09	1.97
C3H8	1.55	2.20	2.23	2.64	2.42
C3H6=	2.26	1.86	2.10	2.20	2.12
C4H10	1.64	2.08	2.15	2.52	2.32
C4H8=	2.47	2.56	2.70	2.87	2.71
C5H12	2.05	2.46	2.54	2.98	2.82
C5H10=	2.18	2.12	2.27	2.52	2.38
C6H14	2.24	2.80	2.95	3.45	3.17
C6H12= & CYCLO'S	1.27	1.27	1.40	1.41	1.30
C7+ IN GAS	7.41	6.26	6.49	8.62	8.29
LIQ HC'S	67.82	63.62	61.38	54.95	57.86
TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	17.03	21.47	22.96	26.07	24.18
C5 -420 F	31.63	33.04	34.31	37.77	36.42
420-700 F	29.98	27.93	27.56	25.06	26.27
700-END PT	21.36	17.56	15.16	11.10	13.13

Table B2 (continued)

FILE: 1218514B TSS3Q1 A1

C5+-END PT	82.97	78.53	77.04	73.93	75.82
ISO/NORMAL MOLE RATIO					
C4	0.0236	0.0164	0.0160	0.0190	0.0123
C5	0.0620	0.0654	0.0592	0.0590	0.0644
C6	0.0742	0.0920	0.0853	0.0935	0.0862
C4=	0.0000	0.0000	0.0000	0.0000	0.0000
PARAFFIN/OLEFIN RATIO					
C3	0.6537	1.1277	1.0151	1.1451	1.0915
C4	0.6426	0.7827	0.7684	0.8463	0.8259
C5	0.9151	1.1262	1.0878	1.1485	1.1539
SCHULZ-FLORY DISTRBTN					
ALPHA (EXP(SLOPE))	0.8778	0.8699	0.8662	0.8500	0.8626
RATIO CH4/(1-A)**2	5.2873	6.5789	6.6539	6.1087	6.7032
ALPHA FRM CORRELATION	0.8329	0.8394	0.8402	0.8378	0.8382
ALPHA (EXPTL/CORR)	1.0539	1.0364	1.0309	1.0145	1.0291
W%CH4 FRM CORRELATION	15.0411	15.2875	15.0180	15.9885	15.6393
W%CH4 (EXPTL/CORR)	0.5248	0.7287	0.7933	0.8602	0.8093
LIQ HC COLLECTION					
PHYS. APPEARANCE	.OIL WAX	OIL WAX	OIL WAX	OIL WAX	OIL WAX
DENSITY	N/A	N/A	0.794	0.788	0.810
N, REFRACTIVE INDEX	N/A	N/A	N/A	N/A	N/A
SIMULT'D DISTILATN					
10 WT % @ DEG F	333	294	291	294	290
16	372	336	333	335	331
50	566	558	536	510	529
84	844	809	776	735	756
90	926	896	856	807	820
RANGE(16-84 %)	472	473	443	400	425
WT % @ 420 F	24.30	28.50	30.40	34.20	31.90
WT % @ 700 F	68.50	72.40	75.30	79.80	77.30

Table B3

FILE: 1218514C TSS3Q1 A1

RESULT OF SYNGAS OPERATION

RUN NO. 12185-14
CATALYST CO/X9/X10-U103 250 CC 108.2 G AFTER USE:155.3 G (+47.1 G)
FEED H2:CO OF 50:50 @ 1260 CC/MN OR 300 GHSV (CAT#12251-38-32)

RUN & SAMPLE NO.	12185-14-12	185-14-13	185-14-14	185-14-15	185-14-16
FEED H2:CO:AR	50:50: 0	50:50: 0	50:50: 0	50:50: 0	50:50: 0
HRS ON STREAM	282.7	306.7	333.0	355.0	379.0
PRESSURE,PSIG	300	300	300	300	300
TEMP. C	249	249	249	260	261
FEED CC/MIN	1260	1260	1260	1260	1260
HOURS FEEDING	24.22	23.98	26.25	22.00	24.00
EFFLNT GAS LITER	1030.83	1000.67	1087.20	815.45	875.05
GM AQUEOUS LAYER	169.13	157.25	183.44	157.43	181.96
GM OIL	103.58	107.01	106.67	77.66	68.22
MATERIAL BALANCE					
GM ATOM CARBON %	100.08	99.04	96.71	98.84	91.18
GM ATOM HYDROGEN %	102.33	101.12	100.02	95.90	96.57
GM ATOM OXYGEN %	98.39	94.76	95.78	100.01	95.97
RATIO CHX/(H2O+CO2)	1.0547	1.1474	1.0306	0.9687	0.8717
RATIO X IN CHX	2.3663	2.3553	2.3558	2.4794	2.5587
USAGE H2/CO PRODT	1.8010	1.7578	1.8447	1.5716	1.7196
FEED H2/CO FRM EFFLNT	1.0225	1.0210	1.0342	0.9702	1.0592
RESIDUAL H2/CO RATIO	0.5768	0.5852	0.5822	0.4494	0.5190
RATIO CO2/(H2O+CO2)	0.1244	0.1212	0.1100	0.2639	0.2266
K SHIFT IN EFFLNT	0.0819	0.0807	0.0719	0.1611	0.1520
SPECIFIC ACTIVITY SA	2.3518	2.3700	2.2641	2.6348	1.8939
CONVERSION					
ON CO %	36.41	37.17	35.80	46.42	44.99
ON H2 %	64.13	63.99	63.86	75.18	73.04
ON CO+H2 %	50.42	50.72	50.07	60.58	59.42
PRDT SELECTIVITY,WT %					
CH4	12.57	12.06	12.23	18.35	22.10
C2 HC'S	1.98	1.85	1.71	2.85	3.23
C3H8	2.38	2.26	2.28	3.38	4.14
C3H6=	2.21	2.12	2.18	2.49	2.18
C4H10	2.34	2.25	2.24	3.09	3.59
C4H8=	2.82	2.70	2.67	3.60	3.27
C5H12	2.78	2.77	2.77	3.65	4.11
C5H10=	2.51	2.37	2.43	3.14	1.99
C6H14	3.12	2.96	3.08	3.96	4.33
C6H12= & CYCLO'S	1.35	1.31	1.41	1.75	1.55
C7+ IN GAS	7.35	7.44	8.96	10.37	11.01
LIQ HC'S	58.60	59.90	58.05	43.38	38.47
TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	24.29	23.25	23.31	33.76	38.53
C5 -420 F	36.16	35.54	36.93	40.78	39.73
420-700 F	26.78	27.14	26.12	19.48	17.39
700-END PT	12.77	14.08	13.64	5.99	4.35

Table B3 (continued)

FILE: 1218514C TSS3Q1 A1

C5+-END PT	75.71	76.75	76.69	66.24	61.47
ISO/NORMAL MOLE RATIO					
C4	0.0137	0.0173	0.0143	0.0146	0.0168
C5	0.0603	0.0622	0.0566	0.0750	0.0900
C6	0.0863	0.0853	0.0800	0.1159	0.1345
C4=	0.0000	0.0000	0.0000	0.0000	0.0000
PARAFFIN/OLEFIN RATIO					
C3	1.0251	1.0198	0.9995	1.2979	1.8119
C4	0.8014	0.8046	0.8085	0.8292	1.0599
C5	1.0771	1.1350	1.1069	1.1289	2.0064
SCHULZ-FLORY DISTRBTN					
ALPHA (EXP(SLOPE))	0.8590	0.8643	0.8617	0.8279	0.8178
RATIO CH4/(1-A)**2	6.3216	6.5444	6.3893	6.1970	6.6616
ALPHA FRM CORRELATION	0.8382	0.8375	0.8378	0.8498	0.8427
ALPHA (EXPTL/CORR)	1.0248	1.0319	1.0285	0.9743	0.9705
W%CH4 FRM CORRELATION	15.6385	15.8560	15.7794	14.4207	16.8255
W%CH4 (EXPTL/CORR)	0.8038	0.7603	0.7748	1.2723	1.3137
LIQ HC COLLECTION					
PHYS. APPEARANCE	OIL WAX	OIL WAX	OIL WAX	OIL WAX	OIL WAX
DENSITY (* 40 C)	0.780	0.775	0.790	0.757	0.7585
N, REFRACTIVE INDEX	N/A	N/A	N/A	N/A	1.4186*
SIMULT'D DISTILATN					
10 WT % @ DEG F	288	296	294	254	260
16	329	337	336	298	302
50	524	538	537	472	453
84	750	764	764	683	662
90	814	832	833	735	712
RANGE(16-84 %)	421	427	428	385	360
WT % @ 420 F	32.50	31.20	31.50	41.30	43.50
WT % @ 700 F	78.20	76.50	76.50	86.20	88.70

Table B4

FILE: 1218S14D TSS3Q1 A1

RESULT OF SYNGAS OPERATION

RUN NO. 12185-14
CATALYST CO/X9/X10-U103 250 CC 108.2 G AFTER USE:155.3 G (+47.1 G)
FEED H2:CO OF 50:50 @ 126C CC/MN OR 300 GHSV (CAT#12251-38-32)

RUN & SAMPLE NO.	12185-14-17	185-14-18	185-14-19	185-14-20	185-14-21
FEED H2:CO:AR	50:50: 0	50:50: 0	50:50: 0	50:50: 0	50:50: 0
HRS ON STREAM	403.0	428.0	452.0	475.0	499.0
PRESSURE,PSIG	300	300	300	300	300
TEMP. C	261	261	261	261	261
FEED CC/MIN	1260	1260	1260	1260	1260
HOURS FEEDING	24.00	25.00	24.00	23.00	24.00
EFFLNT GAS LITER	900.30	952.90	918.85	840.95	917.75
GM AQUEOUS LAYER	181.68	186.90	179.33	165.79	181.01
GM OIL	64.08	57.28	60.75	58.91	60.56
MATERIAL BALANCE					
GM ATOM CARBON %	92.82	91.71	92.48	89.31	93.35
GM ATOM HYDROGEN %	98.22	96.31	96.93	93.32	95.78
GM ATOM OXYGEN %	96.96	96.91	96.93	92.81	97.43
RATIO CHX/(H2O+CO2)	0.8885	0.8558	0.8753	0.8975	0.8842
RATIO X IN CHX	2.5561	2.5600	2.5496	2.5215	2.5289
USAGE H2/CO PRODT	1.7258	1.7745	1.7812	1.7779	1.8189
FEED H2/CO FRM EFFLNT	1.0581	1.0502	1.0482	1.0449	1.0260
RESIDUAL H2/CO RATIO	0.5263	0.5285	0.5267	0.5207	0.4938
RATIO CO2/(H2O+CO2)	0.2209	0.2079	0.2002	0.1929	0.1808
K SHIFT IN EFFLNT	0.1493	0.1387	0.1318	0.1244	0.1090
SPECIFIC ACTIVITY SA	1.8213	1.6680	1.6567	1.6911	1.7363
CONVERSION					
ON CO %	44.34	41.88	41.57	41.69	40.16
ON H2 %	72.31	70.75	70.64	70.94	71.20
ON CO+H2 %	58.72	56.67	56.45	56.64	55.88
PRDT SELECTIVITY,WT %					
CH4	22.14	22.52	21.98	20.72	21.20
C2 HC'S	3.23	3.31	3.15	2.98	2.95
C3H8	4.21	4.24	3.92	3.68	3.70
C3H6=	2.45	2.43	2.32	2.31	2.26
C4H10	3.60	3.63	3.47	3.33	3.33
C4H8=	3.21	3.50	3.42	3.34	3.22
C5H12	4.19	4.17	3.94	3.91	3.85
C5H10=	2.96	3.06	2.13	3.00	2.90
C6H14	4.34	4.36	4.34	4.05	3.99
C6H12= & CYCLO'S	1.53	1.47	1.64	1.65	1.63
C7+ IN GAS	12.45	14.65	14.02	14.12	15.17
LIQ HC'S	35.70	32.67	35.67	36.92	35.80
TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	38.84	39.63	38.25	36.36	36.66
C5 -420 F	41.70	43.05	41.60	40.90	42.47
420-700 F	16.07	14.51	15.77	17.06	16.04
700-END PT	3.39	2.81	4.39	5.69	4.83

Table B4 (continued)

FILE: 1218514D TSS3Q1   A1

C5+-END PT	61.16	60.37	61.75	63.64	63.34
ISO/NORMAL MOLE RATIO					
C4	0.0184	0.0147	0.0145	0.0163	0.0159
C5	0.0889	0.0846	0.0852	0.0804	0.0827
C6	0.1475	0.1270	0.1245	0.1235	0.1262
C4=	0.0000	0.0000	0.0000	0.0000	0.0000
PARAFFIN/OLEFIN RATIO					
C3	1.6395	1.6668	1.6086	1.5173	1.5625
C4	1.0810	1.0025	0.9802	0.9645	0.9989
C5	1.3763	1.3241	1.8016	1.2675	1.2927
SCHULZ-FLORY DISTRBTN					
ALPHA (EXP(SLOPE))	0.8055	0.8000	0.8128	0.8265	0.8190
RATIO CH4/(1-A)**2	5.8496	5.6296	6.2736	6.8855	6.4694
ALPHA FRM CORRELATION	0.8420	0.8418	0.8420	0.8425	0.8451
ALPHA (EXPTL/CORR)	0.9566	0.9503	0.9654	0.9810	0.9691
W%CH4 FRM CORRELATION	17.0364	17.0984	17.0476	16.8754	16.0740
W%CH4 (EXPTL/CORR)	1.2994	1.3171	1.2895	1.2278	1.3190
LIQ HC COLLECTION					
PHYS. APPEARANCE	OIL WAX	OIL WAX	OIL WAX	OIL WAX	OIL WAX
DENSITY (* 40 C)	0.7632	0.7589	0.7652	0.7619	0.7608
N, REFRACTIVE INDEX	1.4186*	1.4186*	1.4191*	1.4196*	1.4195*
SIMULT'D DISTILATN					
10 WT % @ DEG F	260	260	260	258	255
16	302	302	302	301	298
50	441	428	453	485	468
84	642	629	669	692	679
90	694	686	725	748	734
RANGE(16-84 %)	340	327	367	391	381
WT % @ 420 F	45.50	47.00	43.50	38.40	41.70
WT % @ 700 F	90.50	91.40	87.70	84.60	86.50

Table B5

FILE: 1218514E TSS3Q1 A1

RESULT OF SYNGAS OPERATION

RUN NO. 12185-14
CATALYST CO/X9/X10-U103 250 CC 108.2 G AFTER USE:155.3 G (+47.1 G)
FEED H2:CO OF 50:50 @ 1260 CC/MN OR 300 GHSV (CAT#12251-38-32)

RUN & SAMPLE NO.	12185-14-22
FEED H2:CO:AR	50:50:0
HRS ON STREAM	523.0
PRESSURE,PSIG	300
TEMP. C	261
FEED CC/MIN	1260
HOURS FEEDING	24.00
EFFLNT GAS LITER	932.50
GM AQUEOUS LAYER	178.99
GM OIL	56.32
MATERIAL BALANCE	
GM ATOM CARBON %	92.42
GM ATOM HYDROGEN %	97.62
GM ATOM OXYGEN %	96.56
RATIO CHX/(H2O+CO2)	0.8821
RATIO X IN CHX	2.5562
USAGE H2/CO PRODT	1.8181
FEED H2/CO FRM EFFLNT	1.0563
RESIDUAL H2/CO RATIO	0.5368
RATIO CO2/(H2O+CO2)	0.1858
K SHIFT IN EFFLNT	0.1225
SPECIFIC ACTIVITY SA	1.5517
CONVERSION	
ON CO %	40.54
ON H2 %	69.79
ON CO+H2 %	55.57
PRDT SELECTIVITY,WT %	
CH4	22.44
C2 HC'S	3.25
C3H8	3.92
C3H6=	2.39
C4H10	3.49
C4H8=	3.34
C5H12	4.11
C5H10=	3.24
C6H14	4.27
C6H12= & CYCLO'S	1.68
C7+ IN GAS	14.46
LIQ HC'S	33.42
TOTAL	100.00
SUB-GROUPING	
C1 -C4	38.82
C5 -420 F	41.70
420-700 F	15.94
700-END PT	3.54

Table B5 (continued)

FILE: 1218514E TSS3Q1 A1

C5+-END PT	61.18
ISO/NORMAL MOLE RATIO	
C4	0.0171
C5	0.0866
C6	0.1383
C4=	0.0000
PARAFFIN/OLEFIN RATIO	
C3	1.5692
C4	1.0094
C5	1.2333
SCHULZ-FLORY DISTRBTN	
ALPHA (EXP(SLOPE))	0.8161
RATIO CH4/(1-A)**2	6.6356
ALPHA FRM CORRELATION	0.8410
ALPHA (EXPTL/CORR)	0.9704
W%CH4 FRM CORRELATION	17.3335
W%CH4 (EXPTL/CORR)	1.2944
LIQ HC COLLECTION	
PHYS. APPEARANCE	OIL WAX
DENSITY (* 40 C)	0.7598
N, REFRACTIVE INDEX	1.4191*
SIMULT'D DISTILATN	
10 WT % @ DEG F	256
16	298
50	467
84	672
90	727
RANGE(16-84 %)	374
WT % @ 420 F	41.70
WT % @ 700 F	89.40

III. Run 27 (12200-15) with Catalyst 27 ($Co/X_9/X_{10}$/UCC-113

This catalyst is identical in composition and preparation to Catalyst 24 (Run 12185-13) of the Third Quarterly Report, with theoretical cobalt, X_9 and X_{10} content of 7.9, 0.37 and 0.50 percent respectively. The purpose of the run, as in Run 26, was to test the effect of temperature on stability. Results are to be compared with those from both Runs 24 and 26.

Conversion, product selectivity, isomerization of the pentane, and percent olefins of the C_4's are plotted against time on stream in Figs. B68-71. Simulated distillations of the C_5^+ product are plotted in Figs. B72-86. Carbon number product distributions are plotted in Figs. B87-101. Chromatograms from simulated distillations are reproduced in Figs. B102-116. Detailed material balances appear in Tables B6-8.

The run was started at 220C, and as in Run 26 both the initial syngas conversion and the initial water gas shift activity were significantly lower than when the same formulation was tested at 260C in Run 24.

At 240C the activity was significantly lower than that of Catalyst 26, which contained UCC-103 in place of UCC-113--the syngas conversion about 5 percentage points lower, the specific activity about 2.6 as against 3.1. On a percent cobalt basis, however, the specific activity of this catalyst was substantially higher, indicating a more efficient use of the cobalt:

	SA/pct Co (240C)
Catalyst 27 ($Co/X_9/X_{10}$/UCC-113)	0.33
Catalyst 26 ($Co/X_9/X_{10}$/UCC-103)	0.26

The stability at 240C--disregarding the first data point at 240C, when the material balance was poor--was only fair, with a loss of conversion, as estimated by linear least squares, of one percentage point every 27 hours and a loss of specific activity of one specific activity unit every 178 hours. The stability of this catalyst, at least during the short period at 240C in this run, was not as good as that of Catalyst 26.

The stability improved substantially at 250C, with a loss of conversion of one percentage point every 240 hours. But at 260C it deteriorated drastically to a loss of one percentage point every 14 hours.

The selectivity was comparable to that of Catalyst 26 but with both methane production, and olefin content of the C_4's, slightly higher. Following are the ratios of weight percent methane experimentally observed to weight percent predicted by the mathematical model:

Catalyst 27 ($Co/X_9/X_{10}$/UCC-113)	0.58:1
Catalyst 26 ($Co/X_9/X_{10}$/UCC-103)	0.52:1

These differences may be due either to the different Molecular Sieves or to the different concentrations of cobalt. The Schulz-Flory plots are linear except for the excess methane.

This test has demonstrated once again that the initial activity of this type of catalyst depends markedly on the initial test temperature. In addition, at the reaction temperatures studied, the UCC-113 catalyst has been generally less stable than the catalyst with UCC-103.

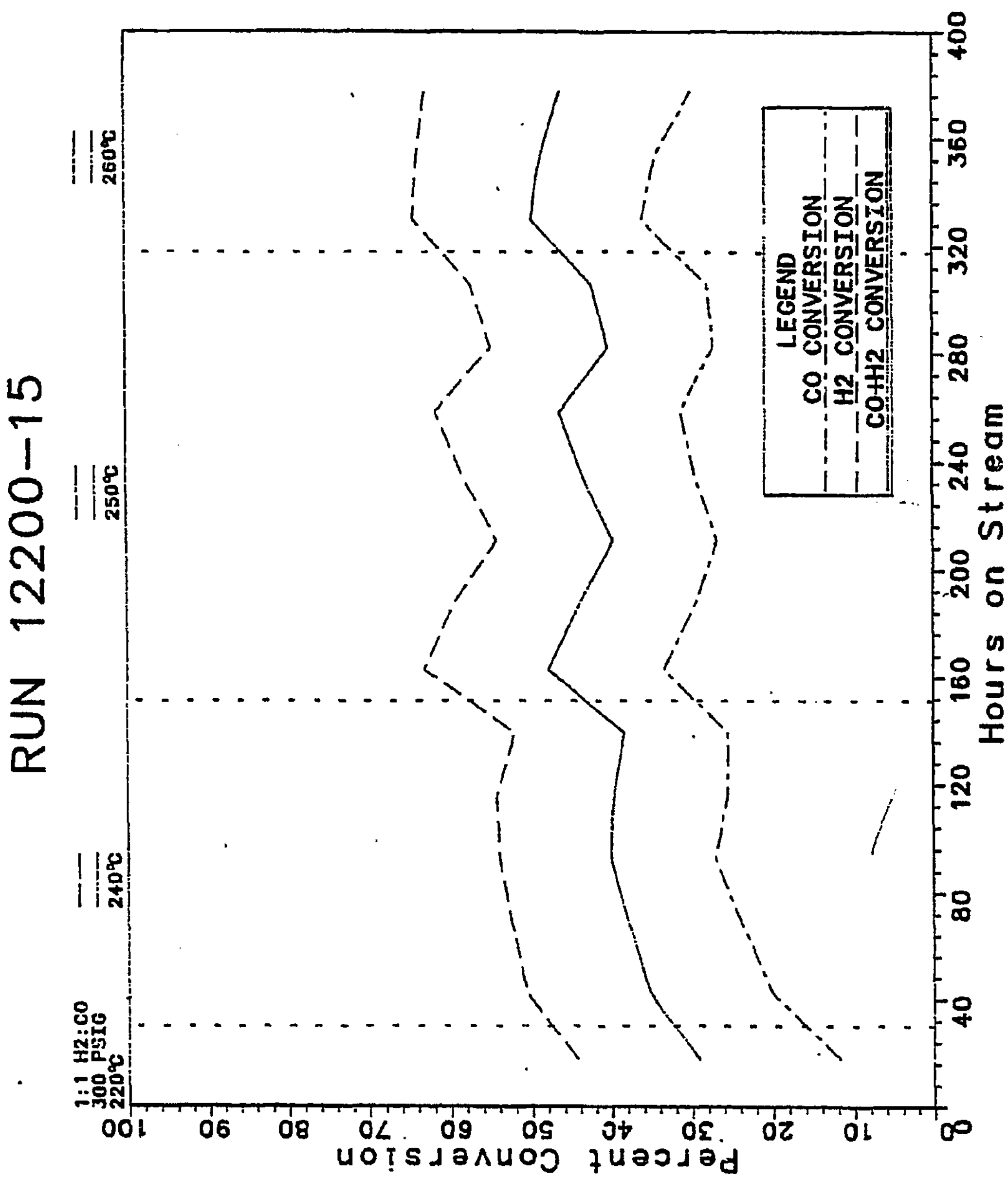

RUN 12200-15
1:1 H2:CO
300 PSIG
220°C
240°C
250°C
260°C
LEGEND
CO CONVERSION
H2 CONVERSION
CO+H2 CONVERSION
Hours on Stream
Percent Conversion
0
40
80
120
160
200
240
280
320
360
400
10
20
30
40
50
60
70
80
90
100

Fig. B68

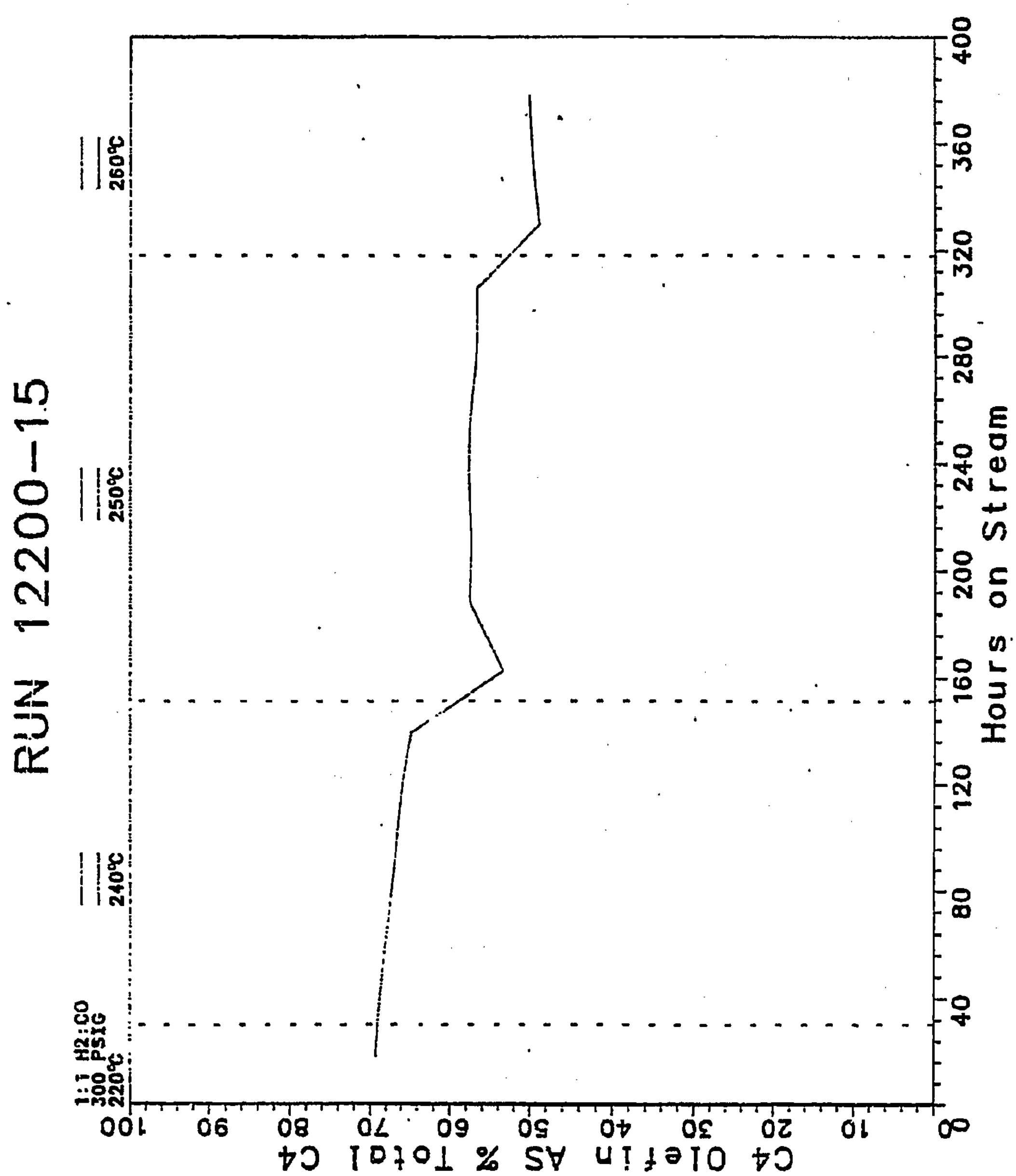

RUN 12200-15
1:1 H2:CO
300 PSIG
220°C
240°C
250°C
260°C
C4 Olefin AS % Total C4
Hours on Stream

Fig. B69

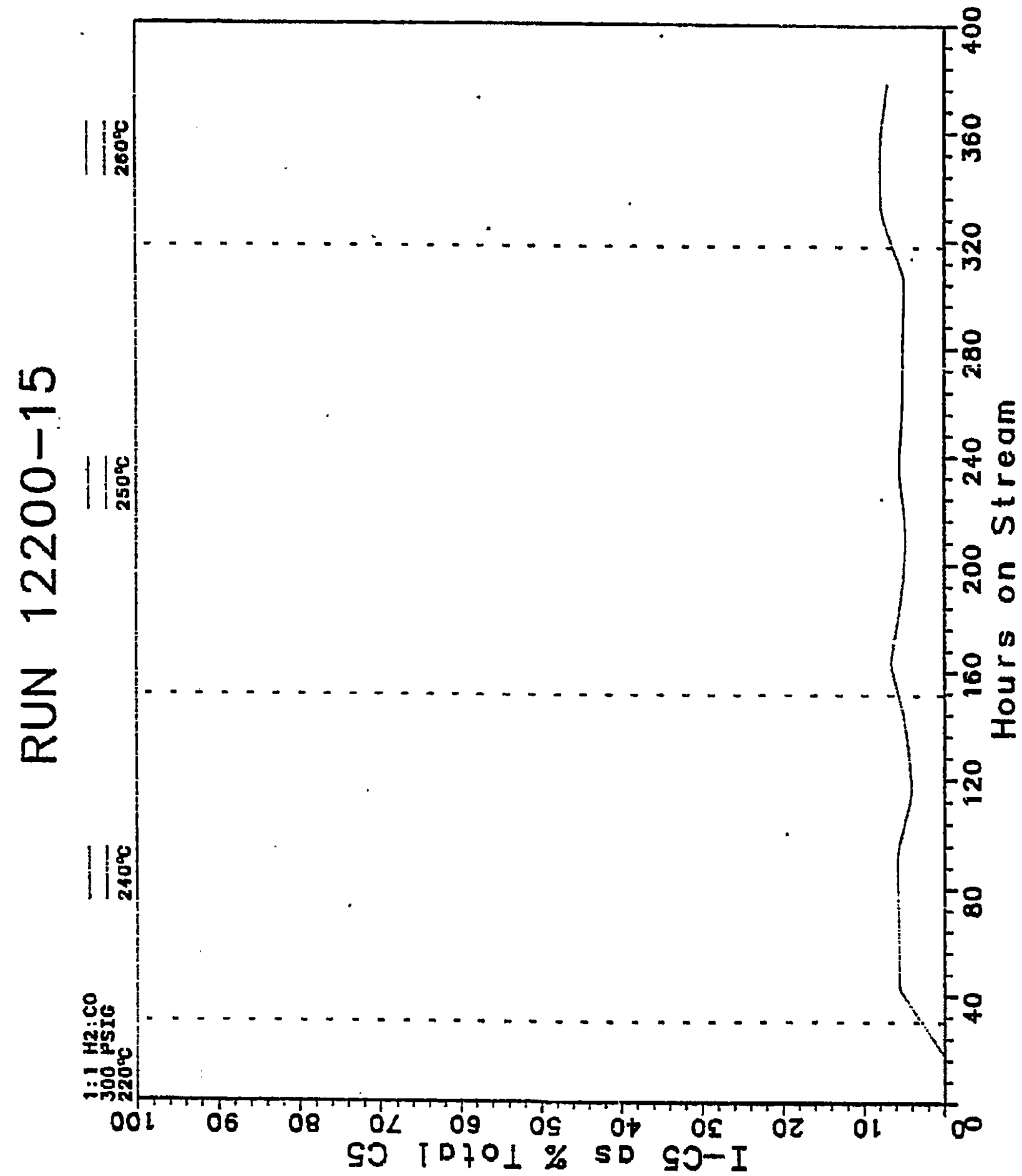

RUN 12200-15
1:1 H2:CO
300 PSIG
220°C
240°C
250°C
260°C
Hours on Stream
I-C5 as % Total C5
0
40
80
120
160
200
240
280
320
360
400
10
20
30
40
50
60
70
80
90
100

Fig. B70

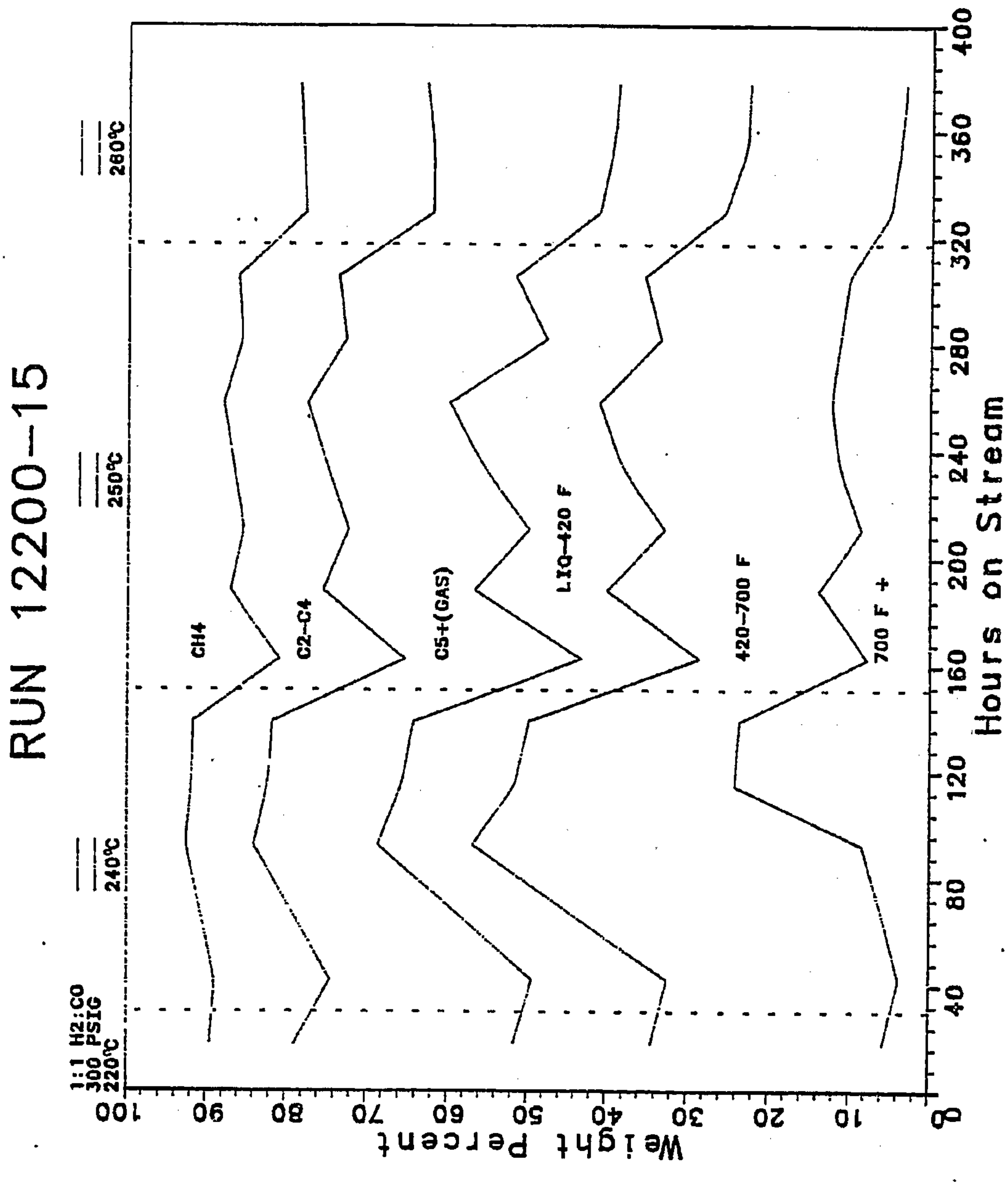

RUN 12200—15
Weight Percent
Hours on Stream
1:1 H2:CO
300 PSIG
220°C
240°C
250°C
260°C
CH4
C2—C4
C5+(GAS)
LIQ—420 F
420—700 F
700 F +
0
10
20
30
40
50
60
70
80
90
100
40
80
120
160
200
240
280
320
360
400

Fig. B71

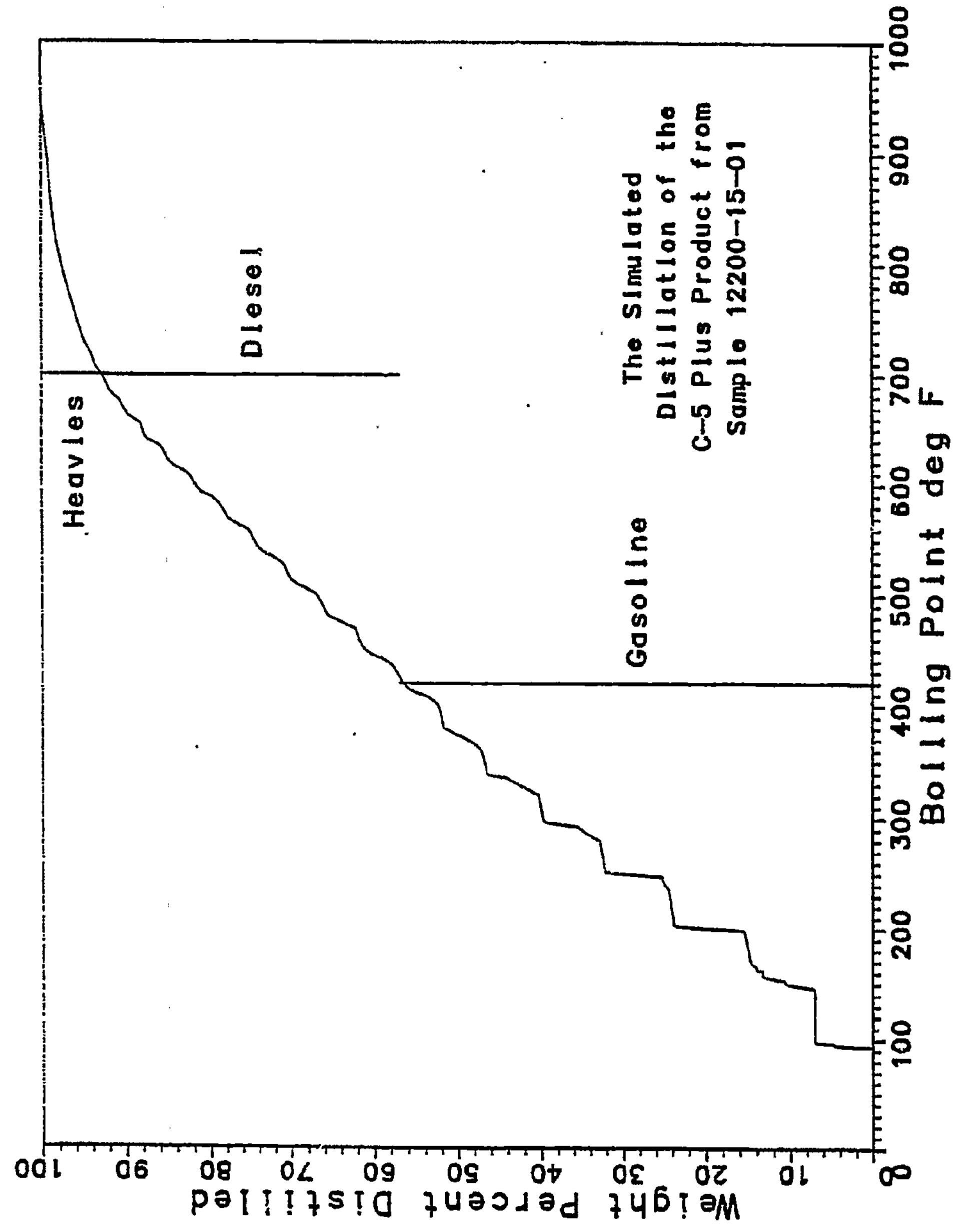
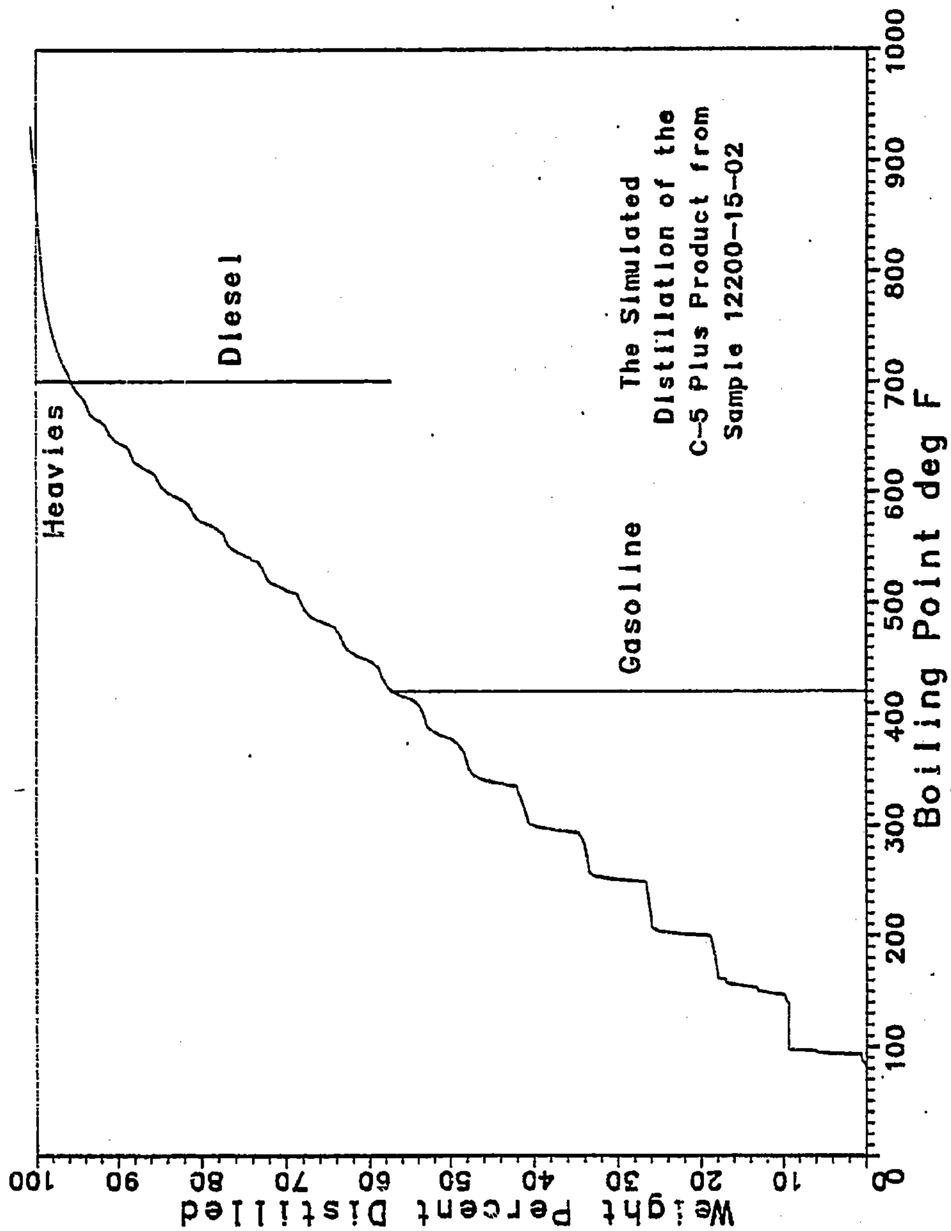

Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-01
100 200 300 400 500 600 700 800 900 1000
Boiling Point deg F
0 10 20 30 40 50 60 70 80 90 100
Weight Percent Distilled

Fig. B72



Heavies
Diesel
Gasoline
The Simulated Distillation of the C-5 Plus Product from Sample 12200-15-02
Boiling Point deg F
0 100 200 300 400 500 600 700 800 900 1000
Weight Percent Distilled
0 10 20 30 40 50 60 70 80 90 100

Fig. B73

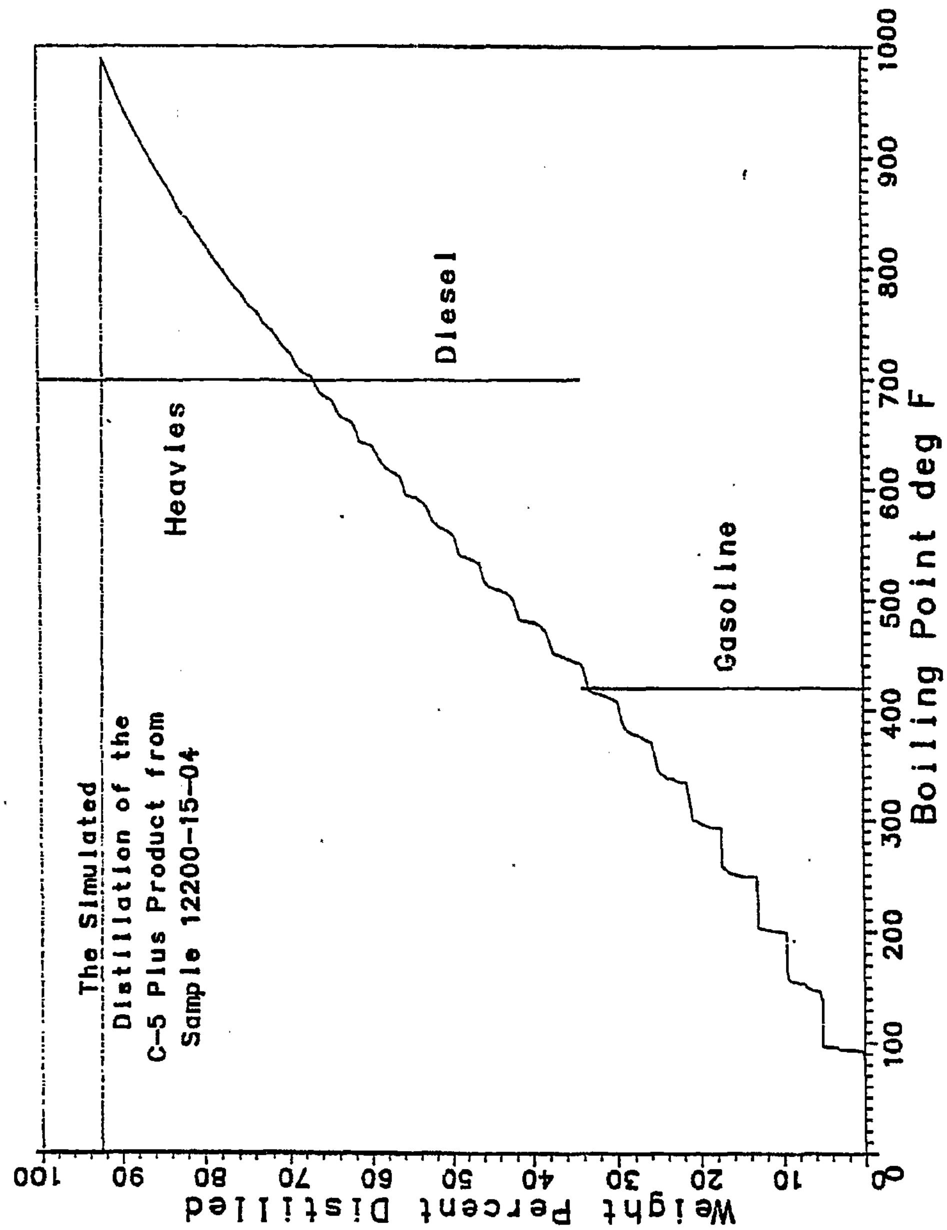
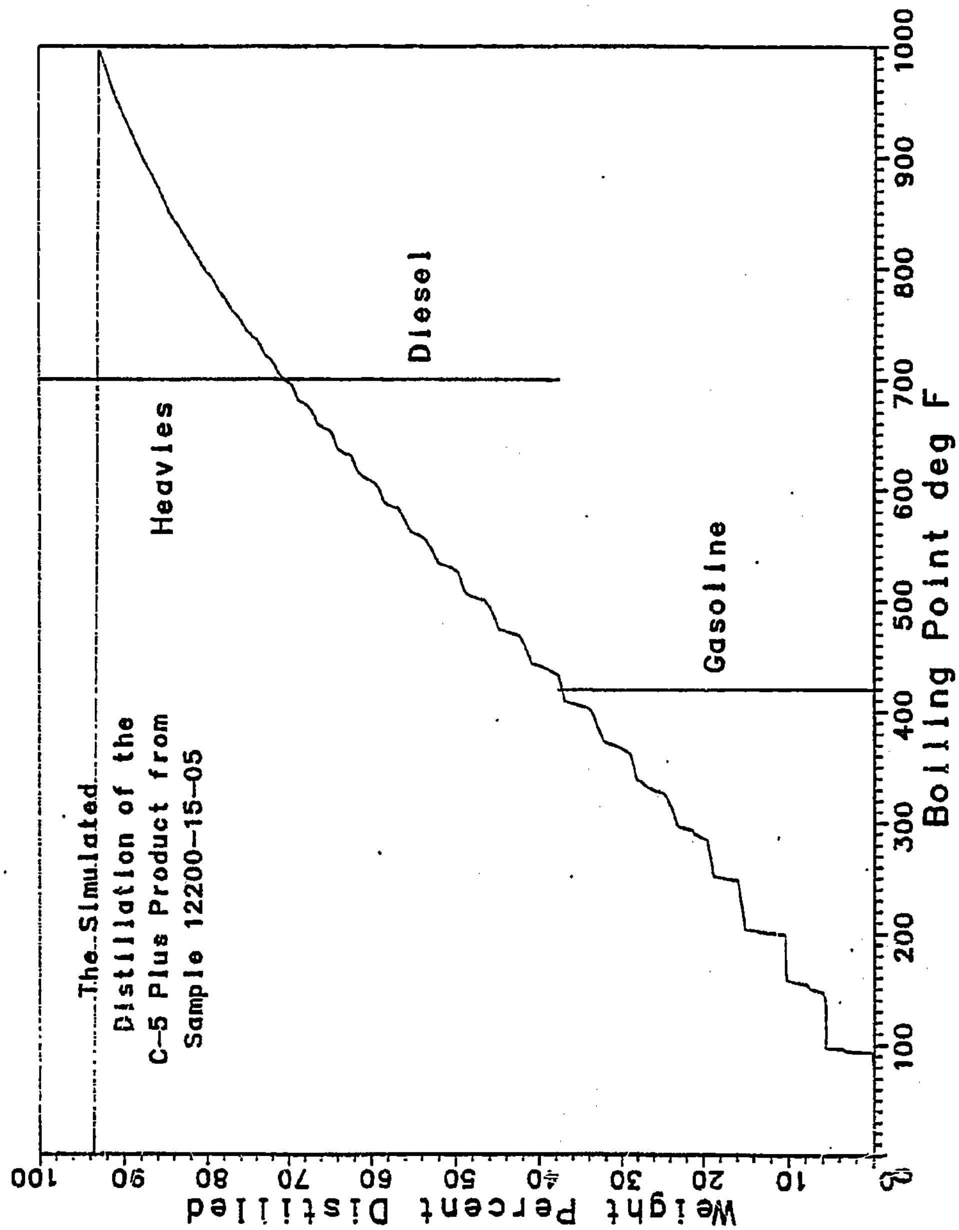

The Simulated Distillation of the C-5 Plus Product from Sample 12200-15-04
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100

Fig. B74



The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-05
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100

Fig. B75

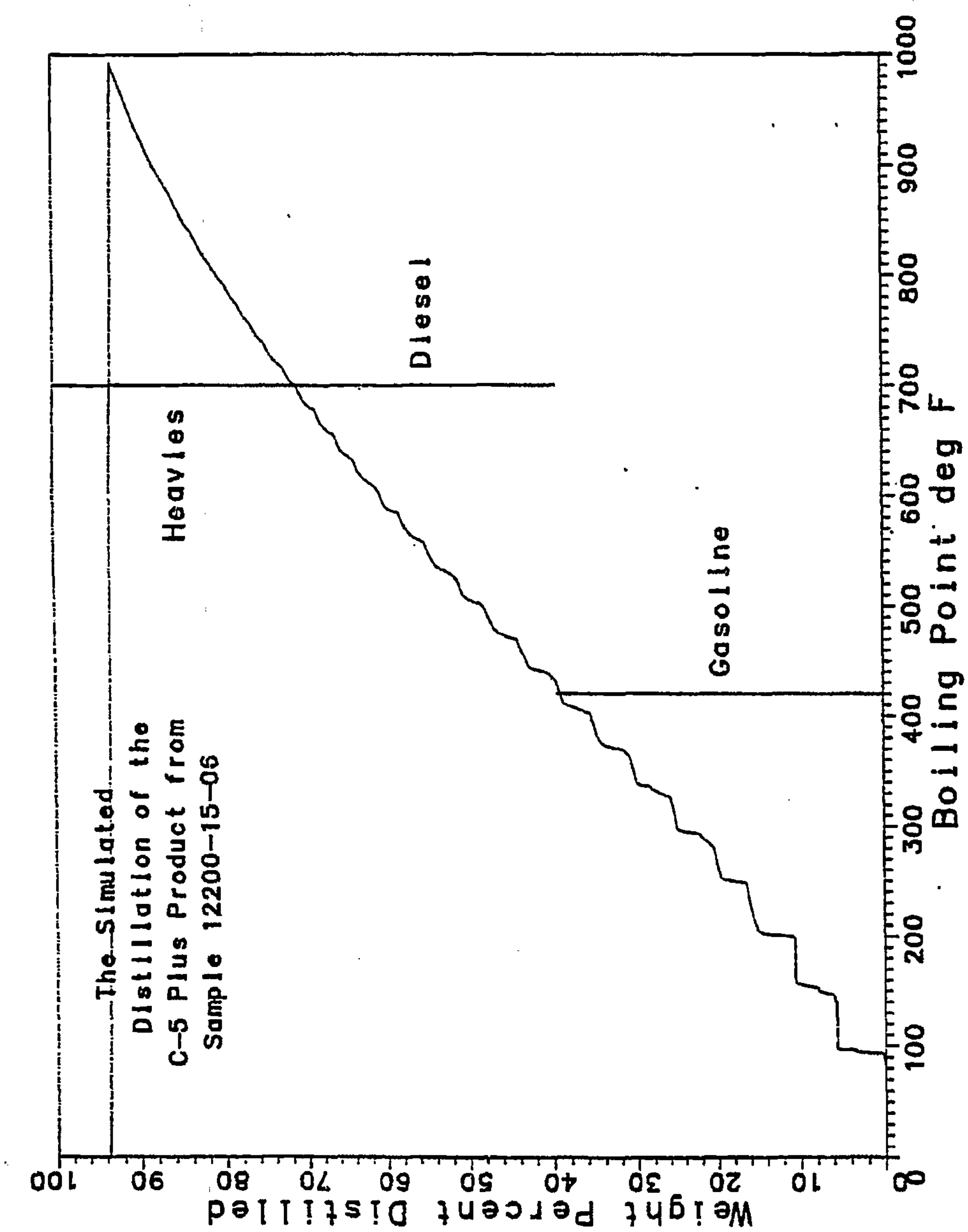

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-06
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100

Fig. B76

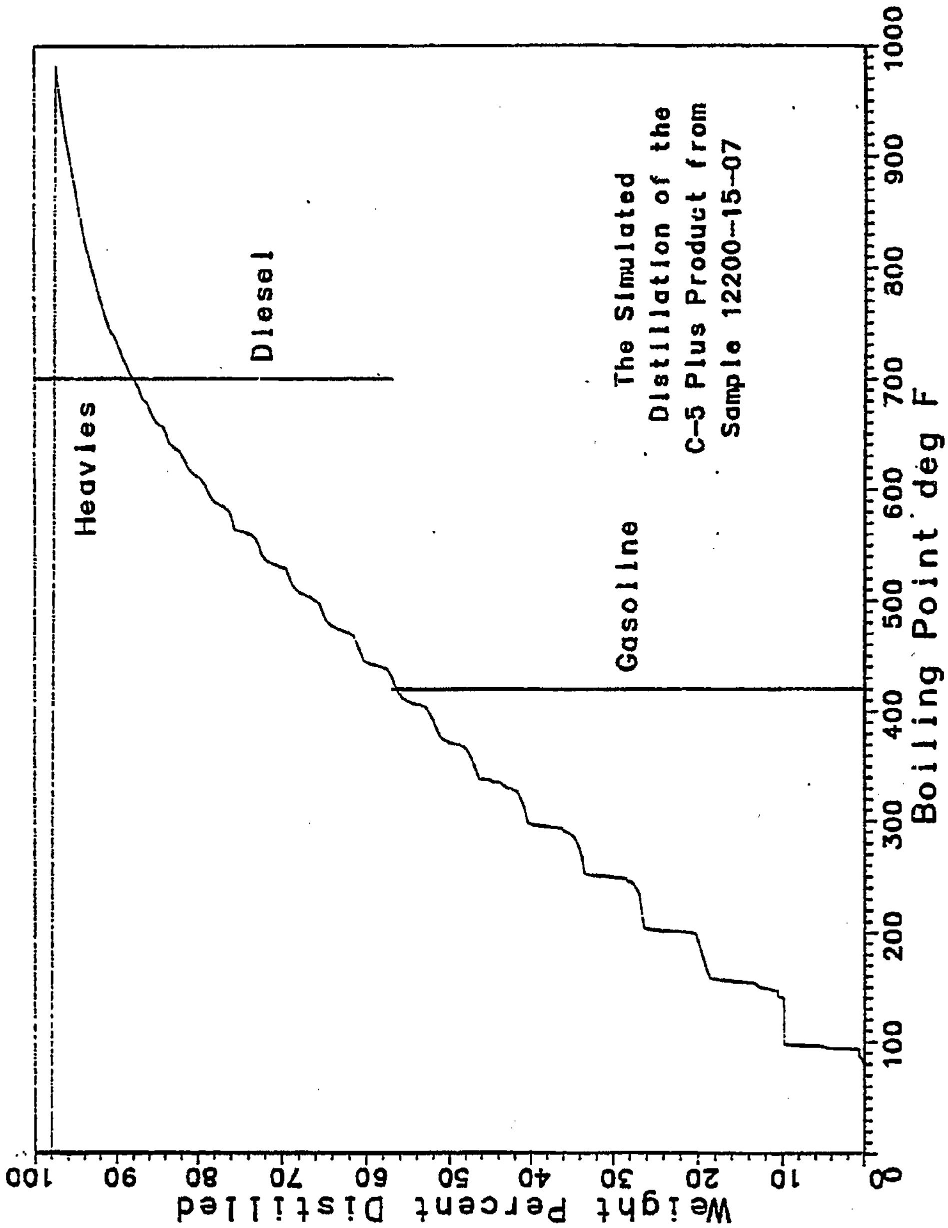

The Simulated Distillation of the C-5 Plus Product from Sample 12200-15-07
Heavies
Diesel
Gasoline
Boiling Point deg F
0
100
200
300
400
500
600
700
800
900
1000
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100

Fig. B77

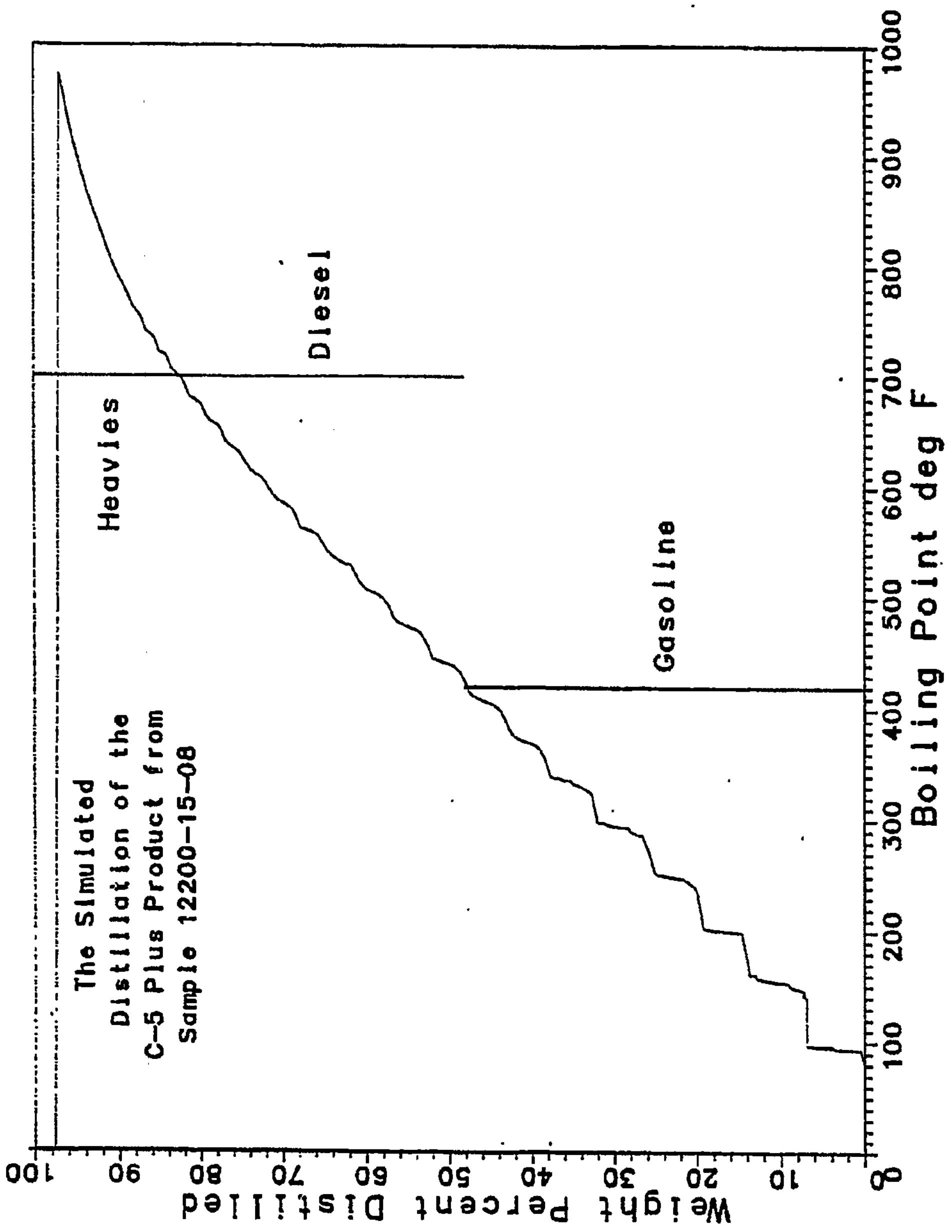

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-08
Heavies
Diesel
Gasoline
Boiling Point deg F
100 200 300 400 500 600 700 800 900 1000
Weight Percent Distilled
0 10 20 30 40 50 60 70 80 90 100

Fig. B78

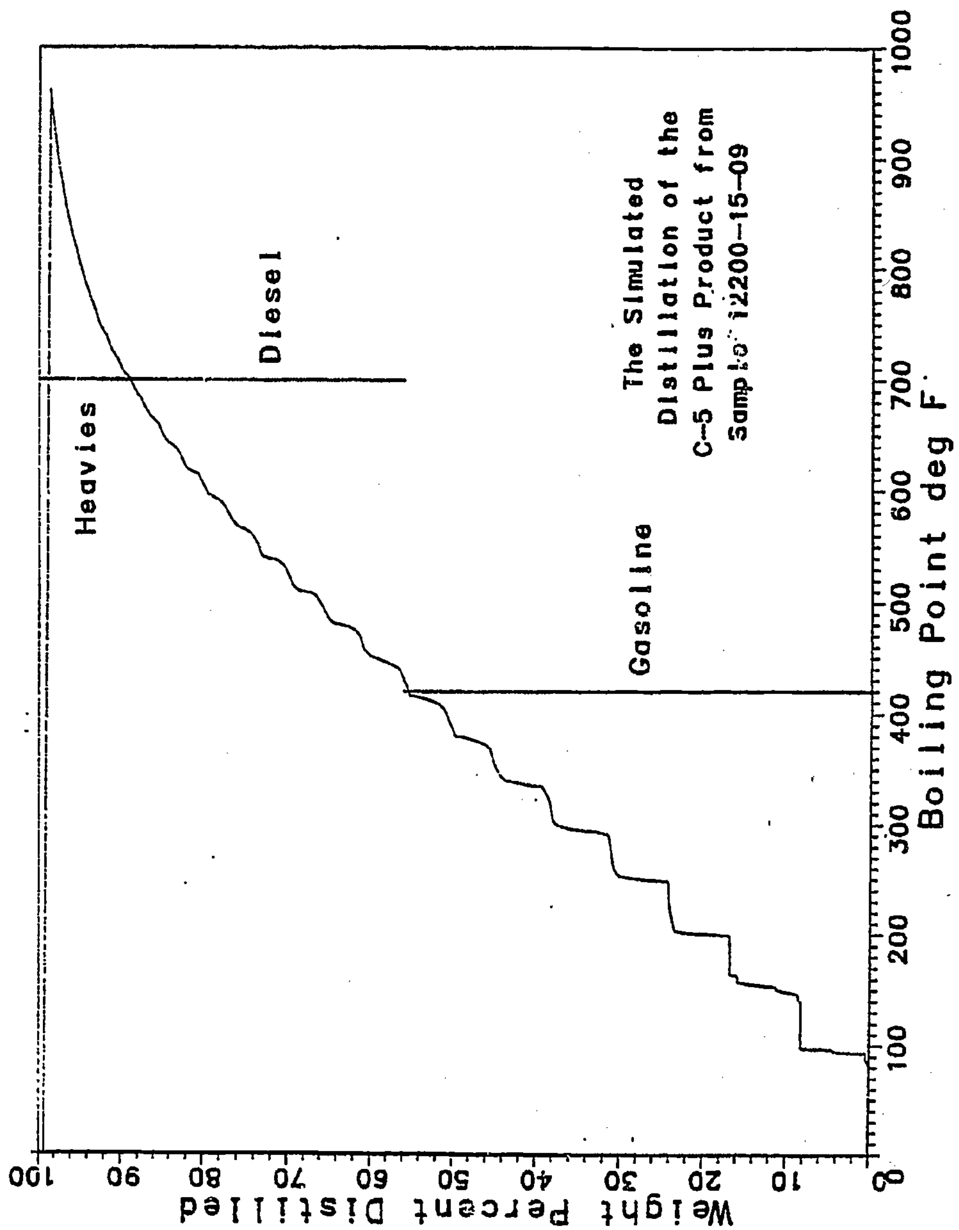

Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
12200-15-09
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000

Fig. B79

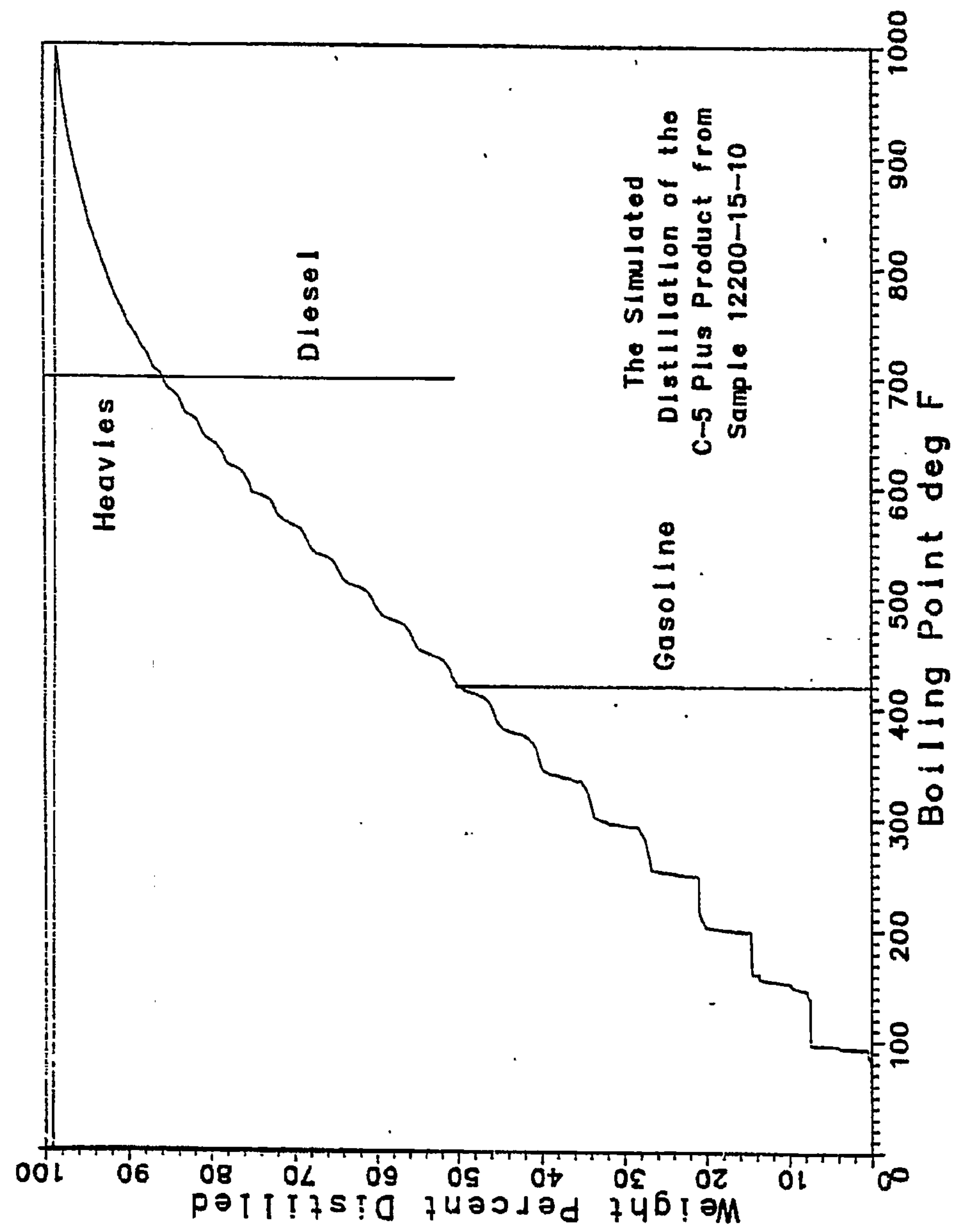

Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-10
Boiling Point deg F
0
100
200
300
400
500
600
700
800
900
1000
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100

Fig. B80

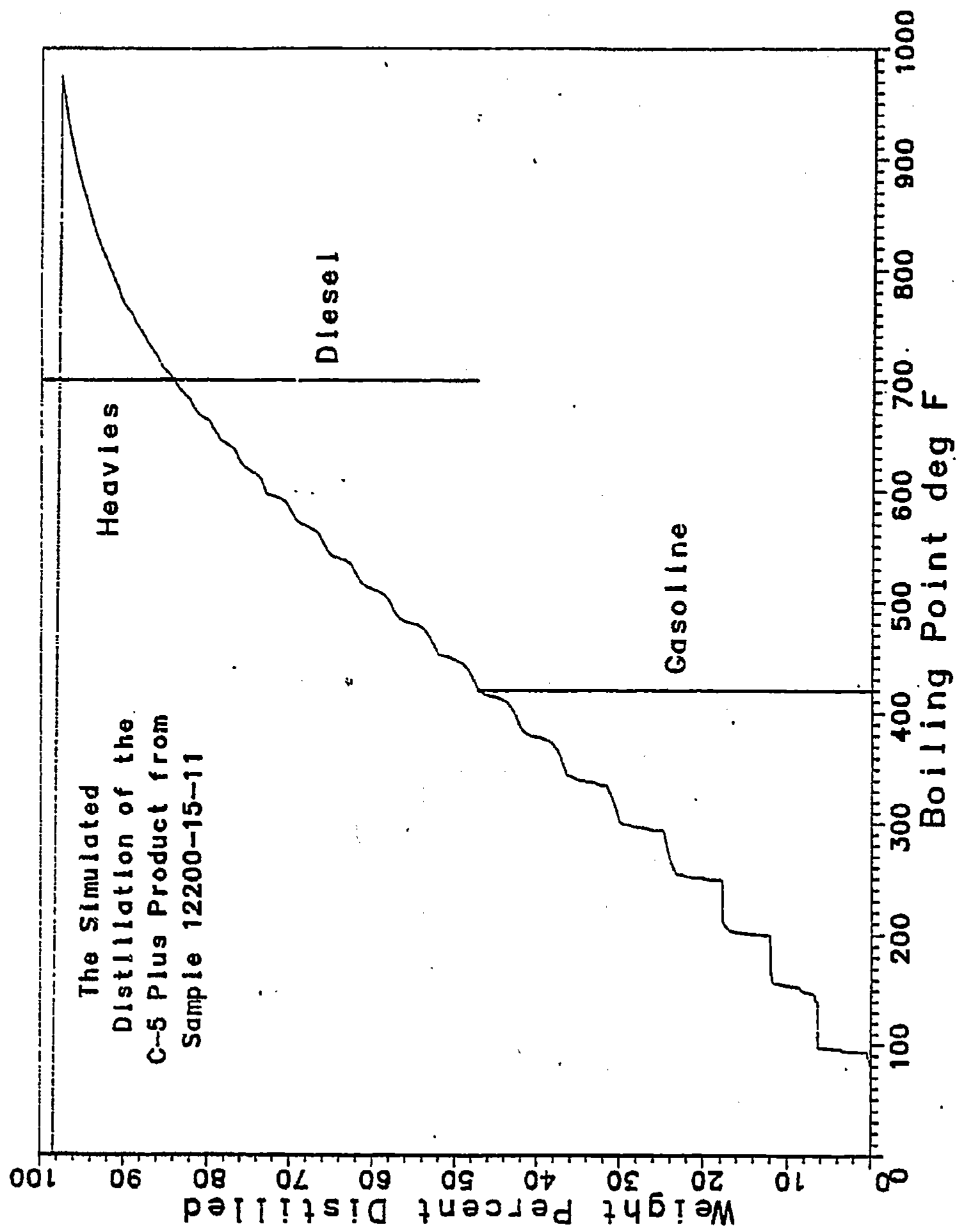

The Simulated Distillation of the C-5 Plus Product from Sample 12200-15-11
Heavies
Diesel
Gasoline
Boiling Point deg F
100 200 300 400 500 600 700 800 900 1000
Weight Percent Distilled
0 10 20 30 40 50 60 70 80 90 100

Fig. B81

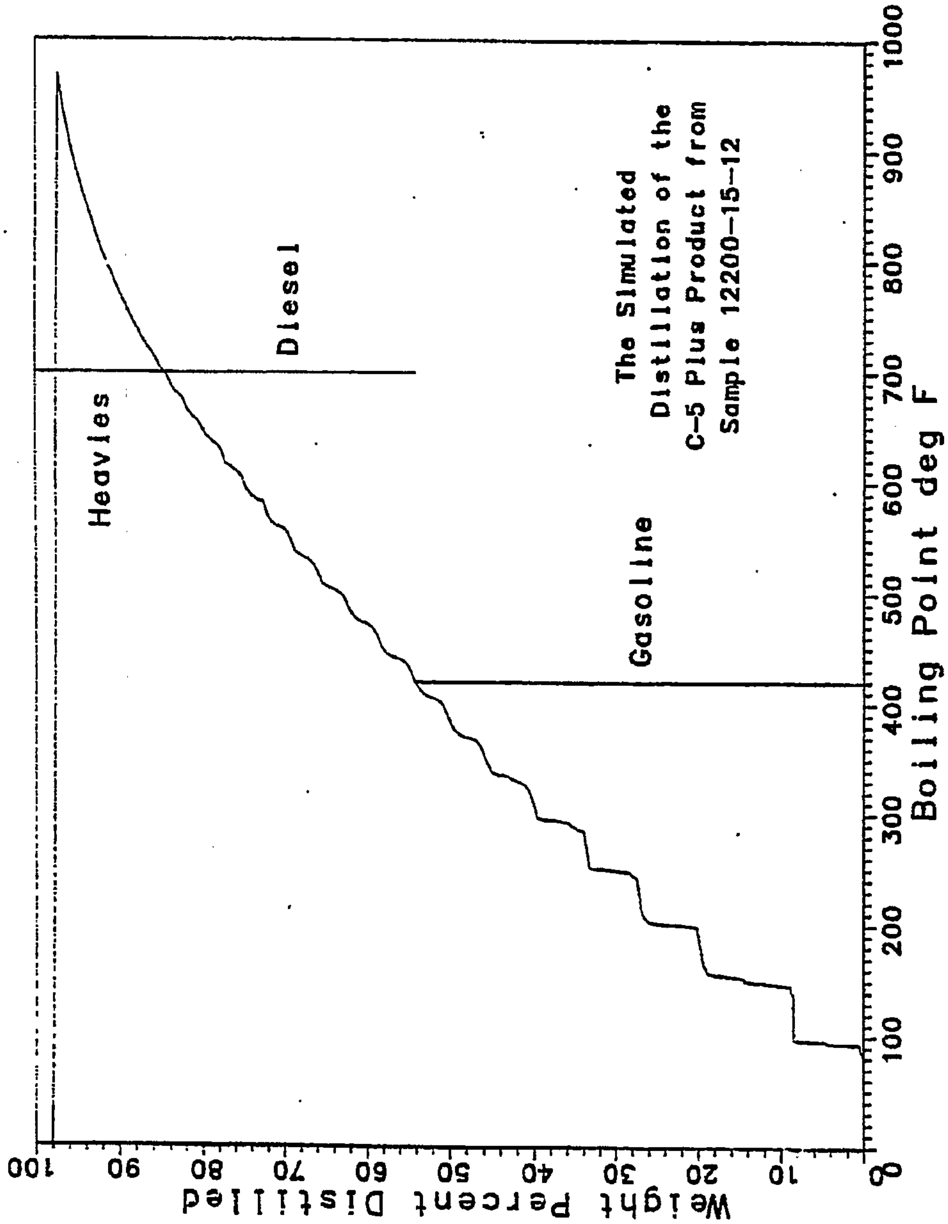
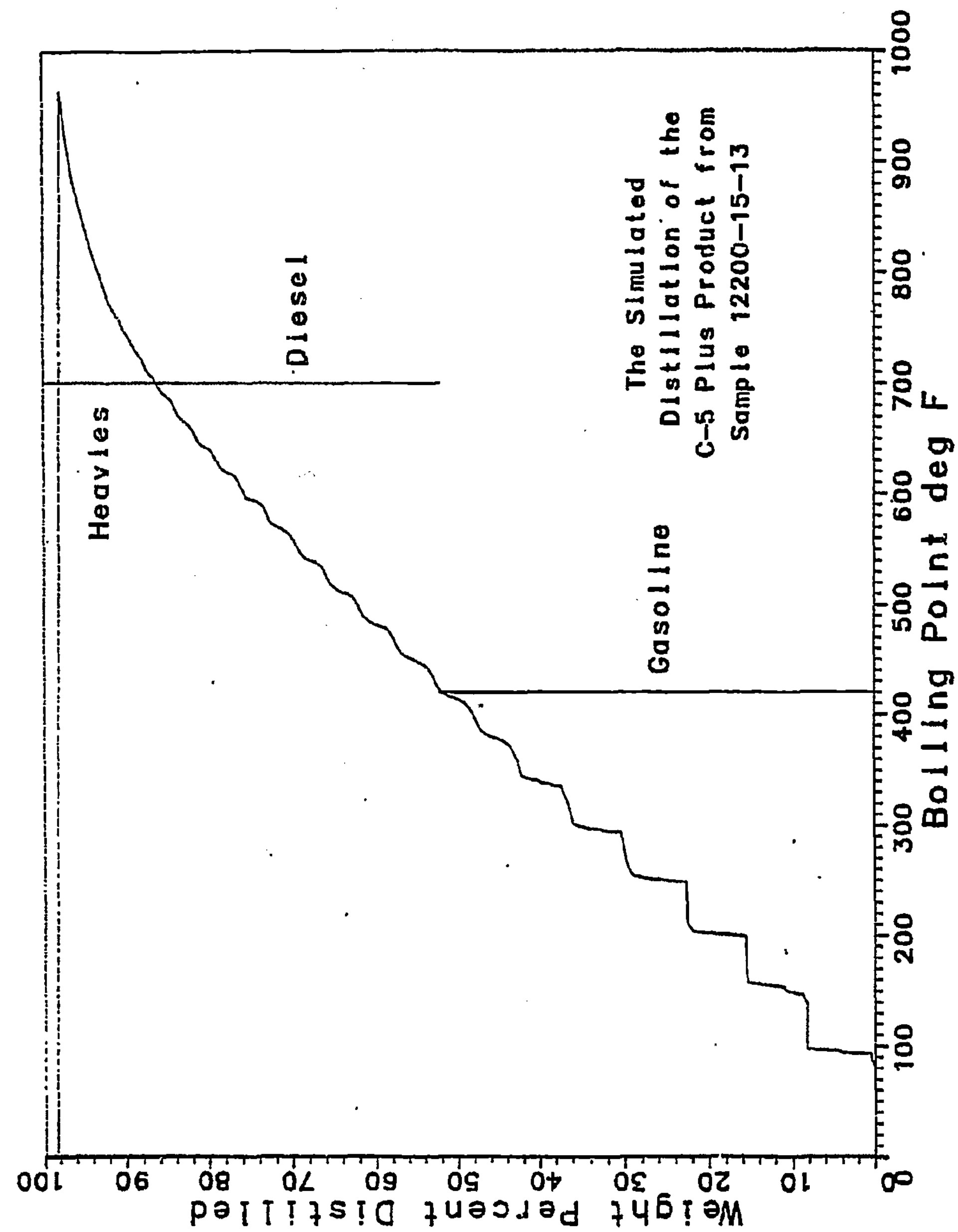

The Simulated Distillation of the C-5 Plus Product from Sample 12200-15-12
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000

Fig. B82



Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-13
Boiling Point deg F
Weight Percent Distilled

Fig. B83

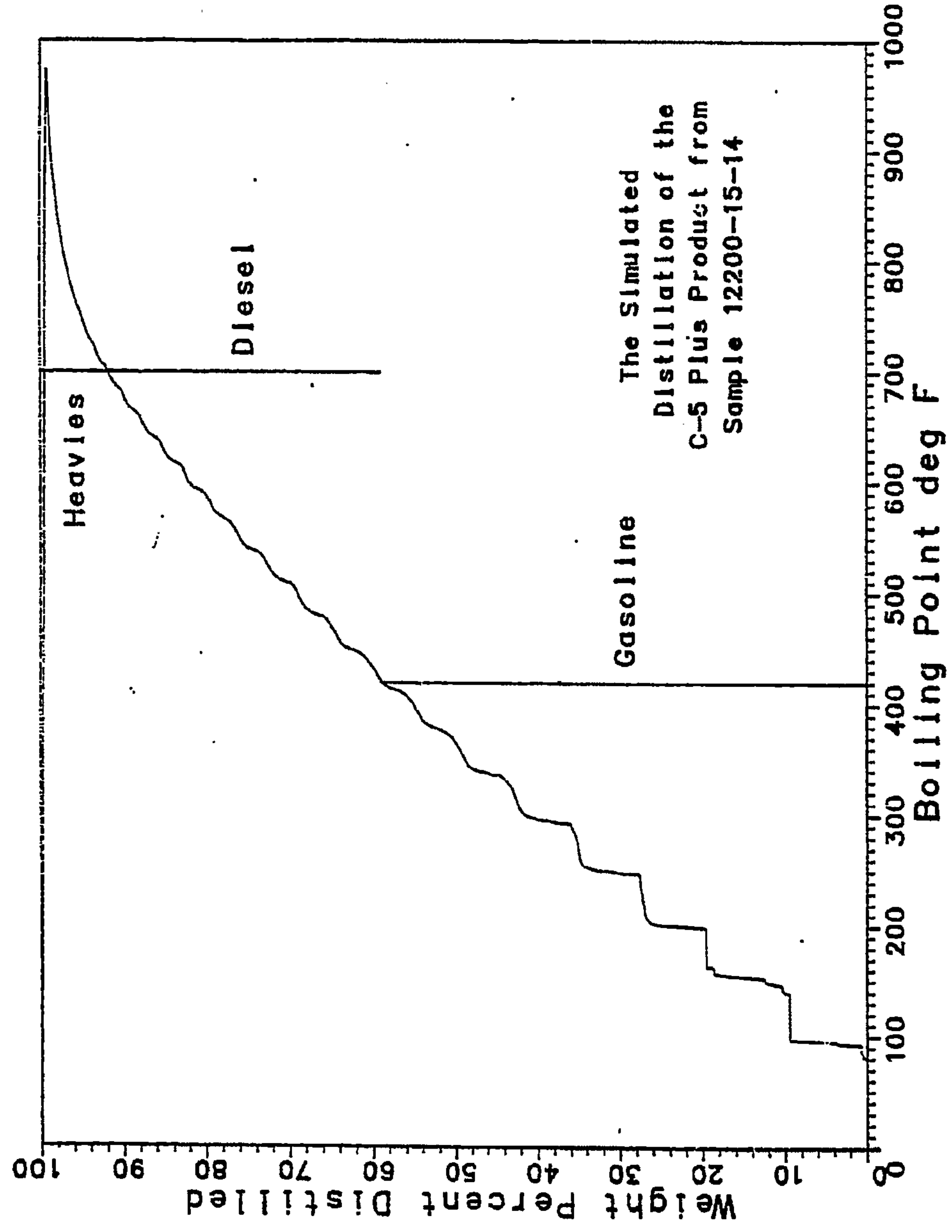

Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-14
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000

Fig. B84

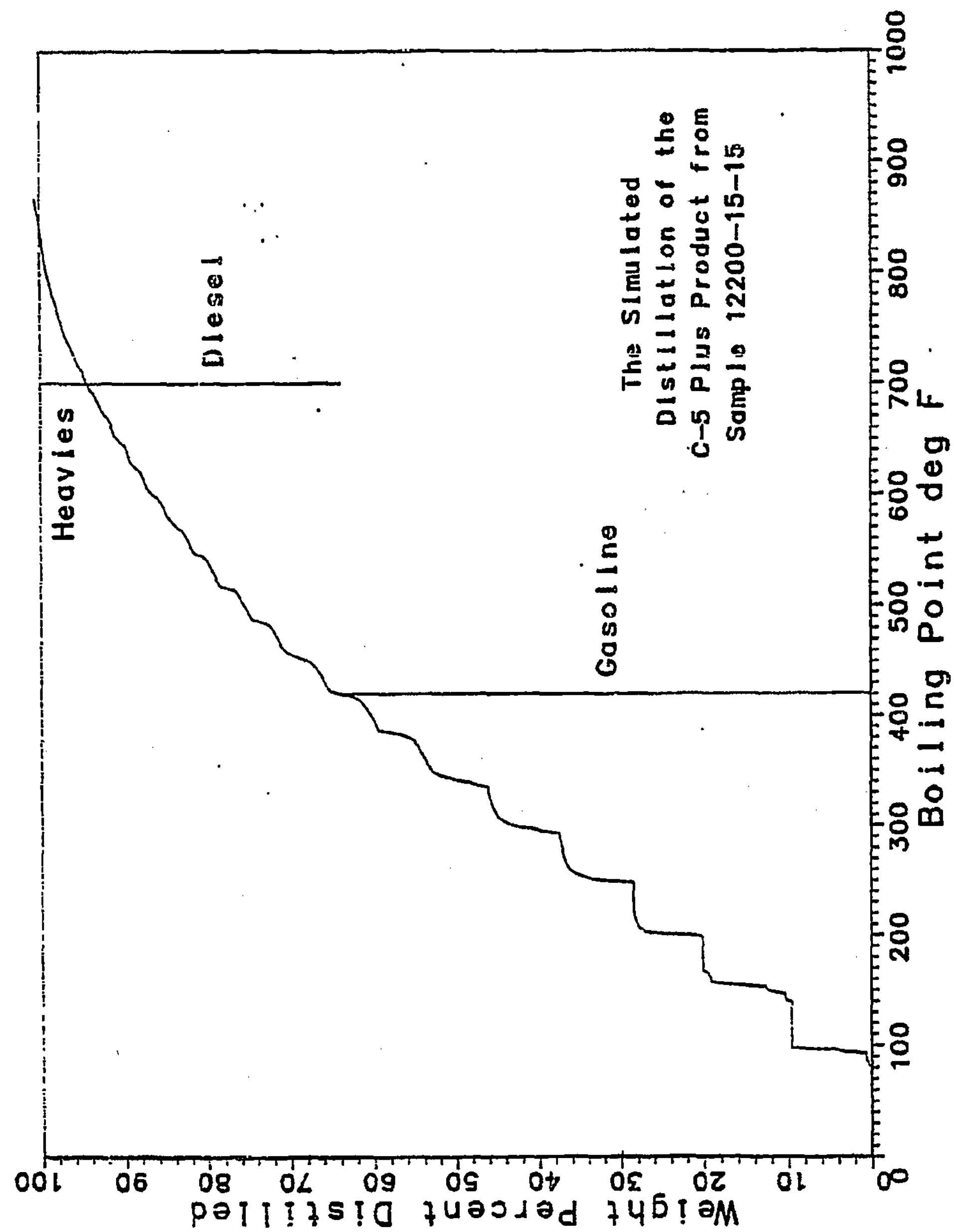

The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-15
Heavies
Diesel
Gasoline
Boiling Point deg F
Weight Percent Distilled
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000

Fig. B85

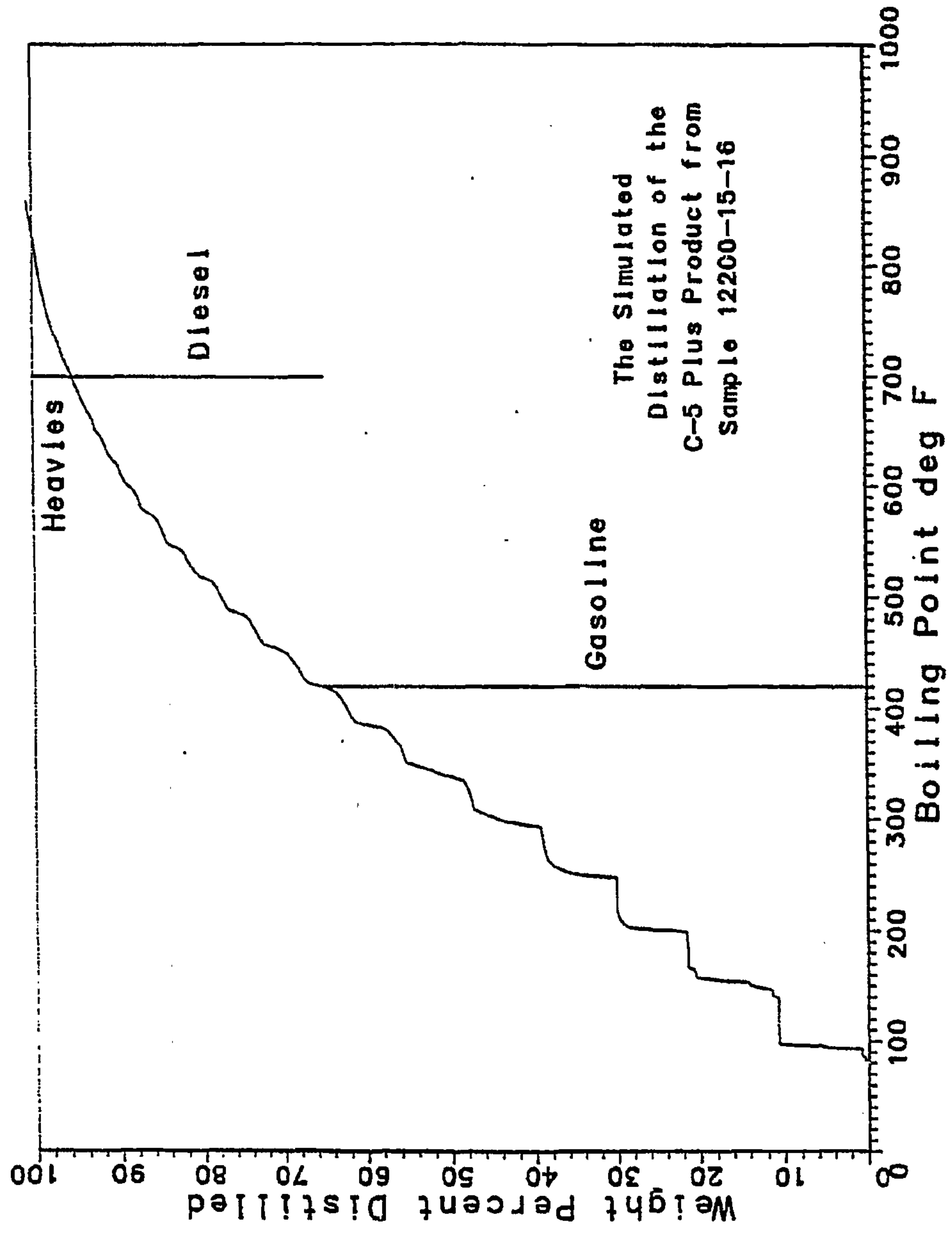
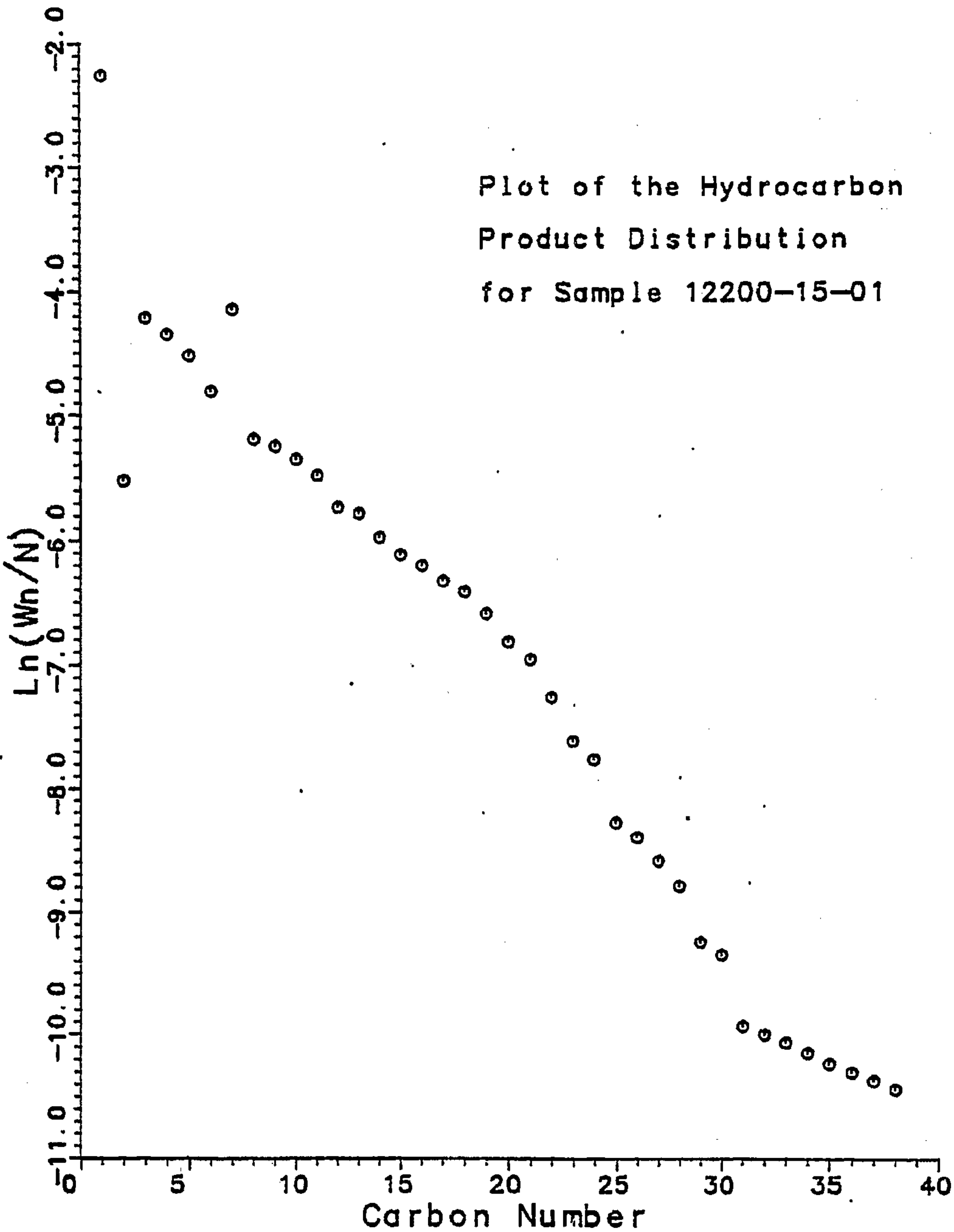
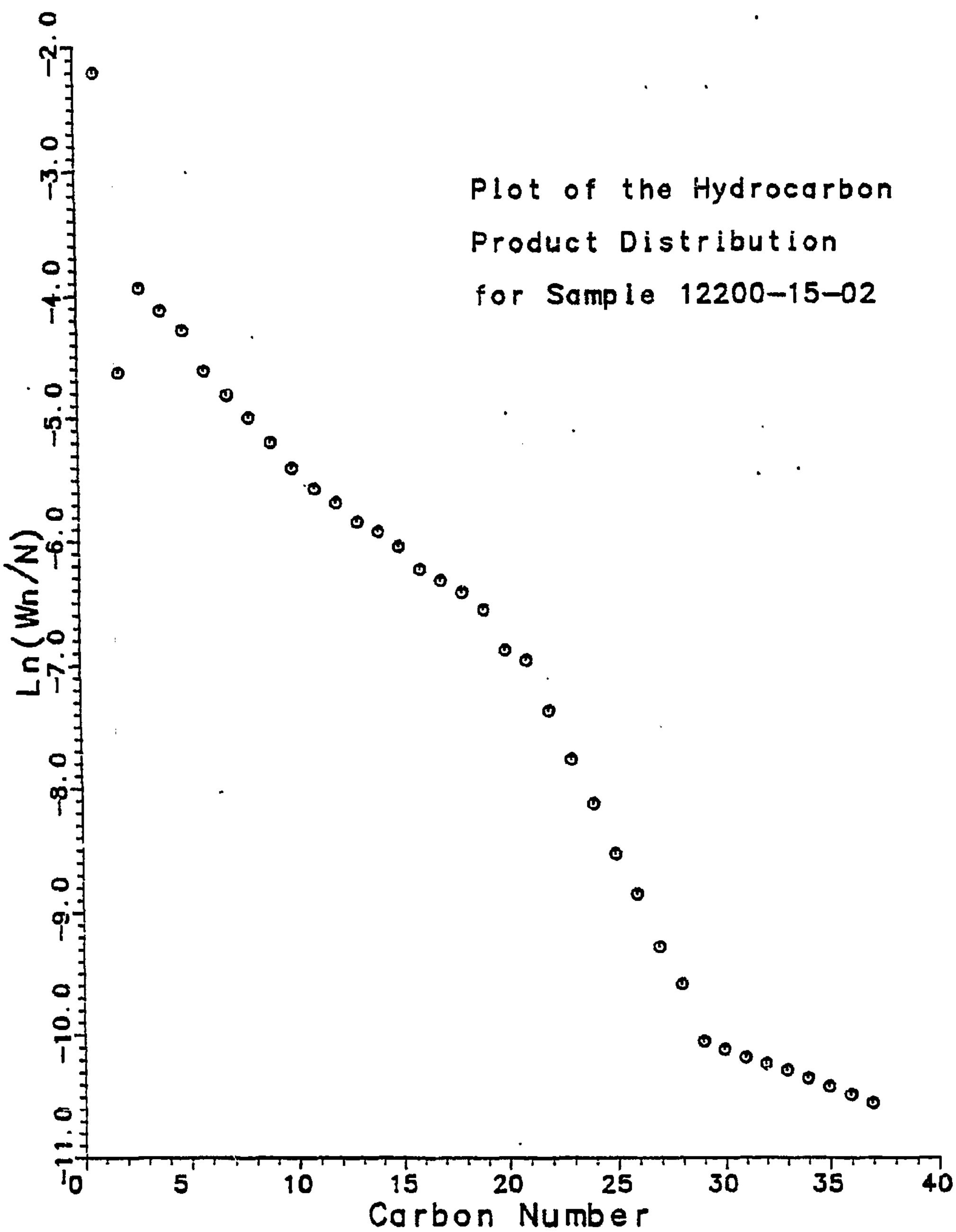

Heavies
Diesel
Gasoline
The Simulated
Distillation of the
C-5 Plus Product from
Sample 12200-15-16
Boiling Point deg F
Weight Percent Distilled
0
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100

Fig. B86



Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-01
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B87



Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-02
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B88

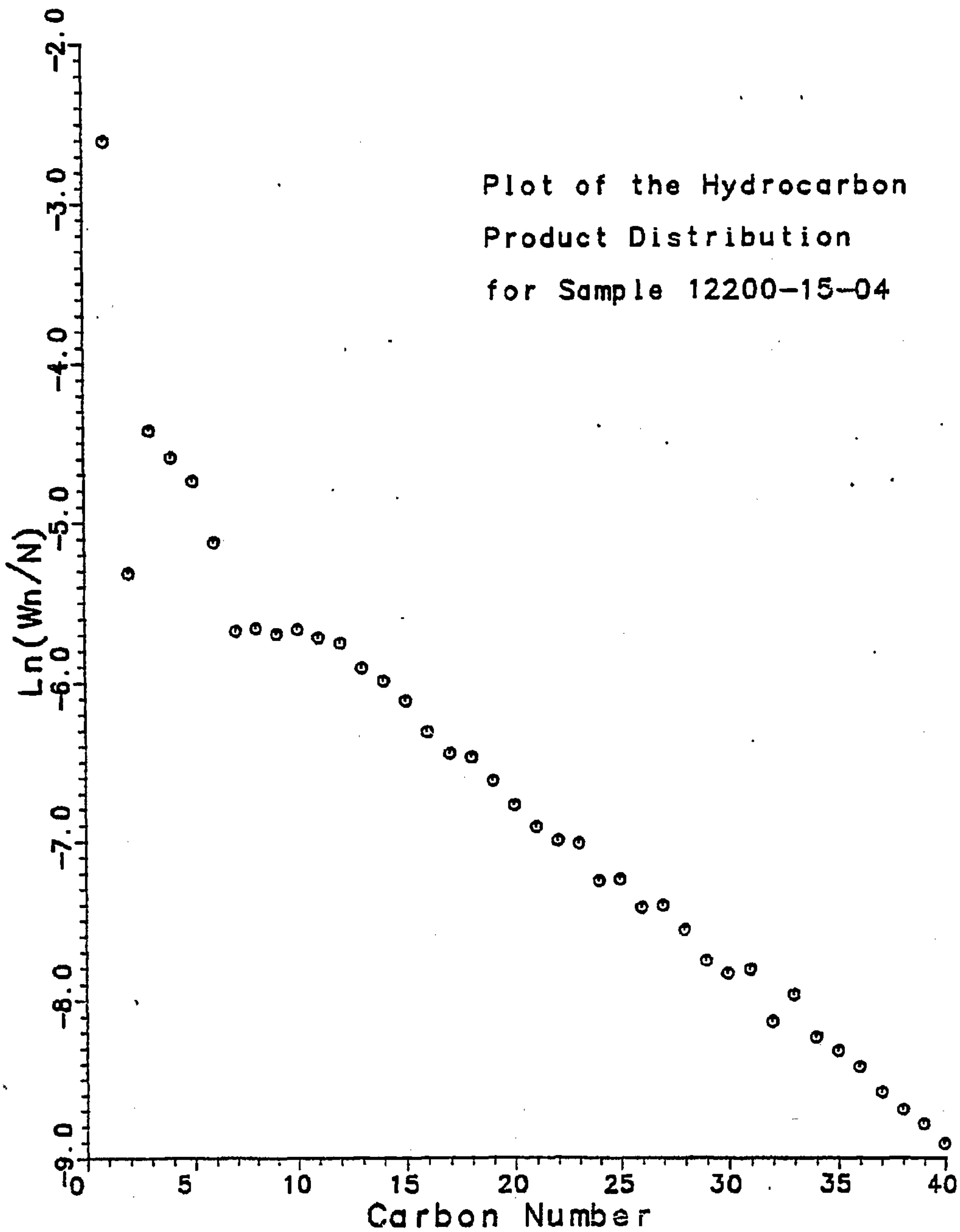
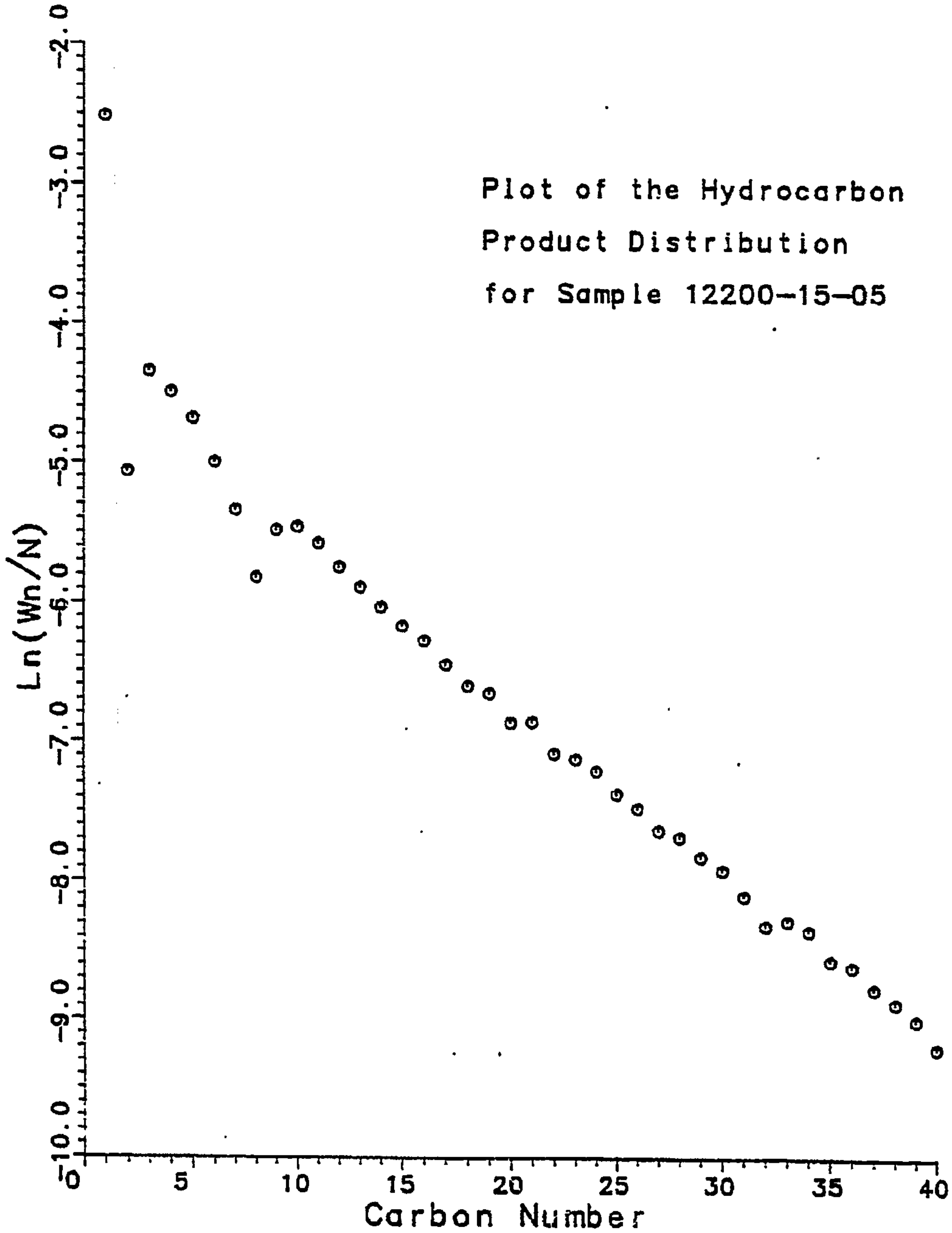
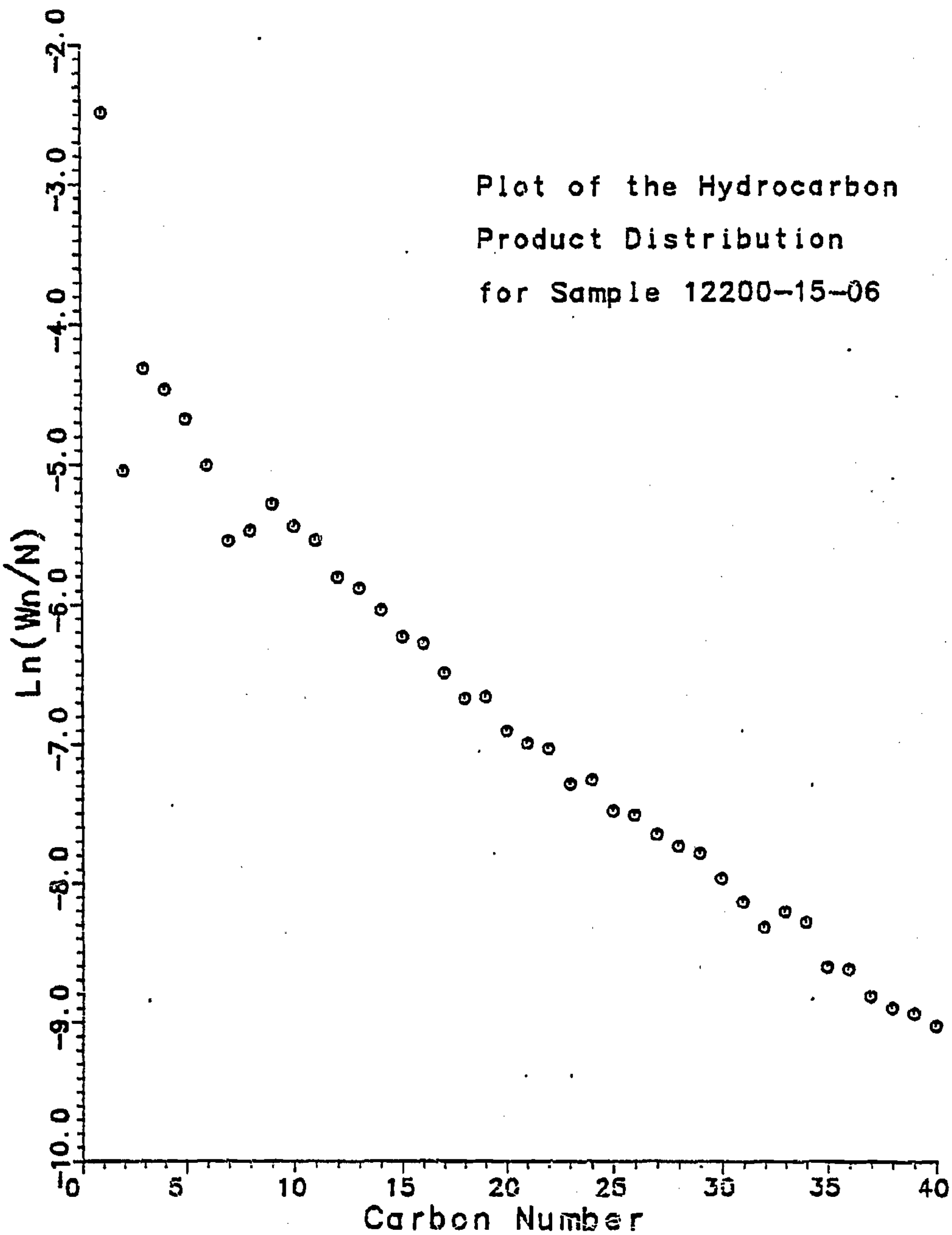

Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-04
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B89



Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-05
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B90



Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-06
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B91

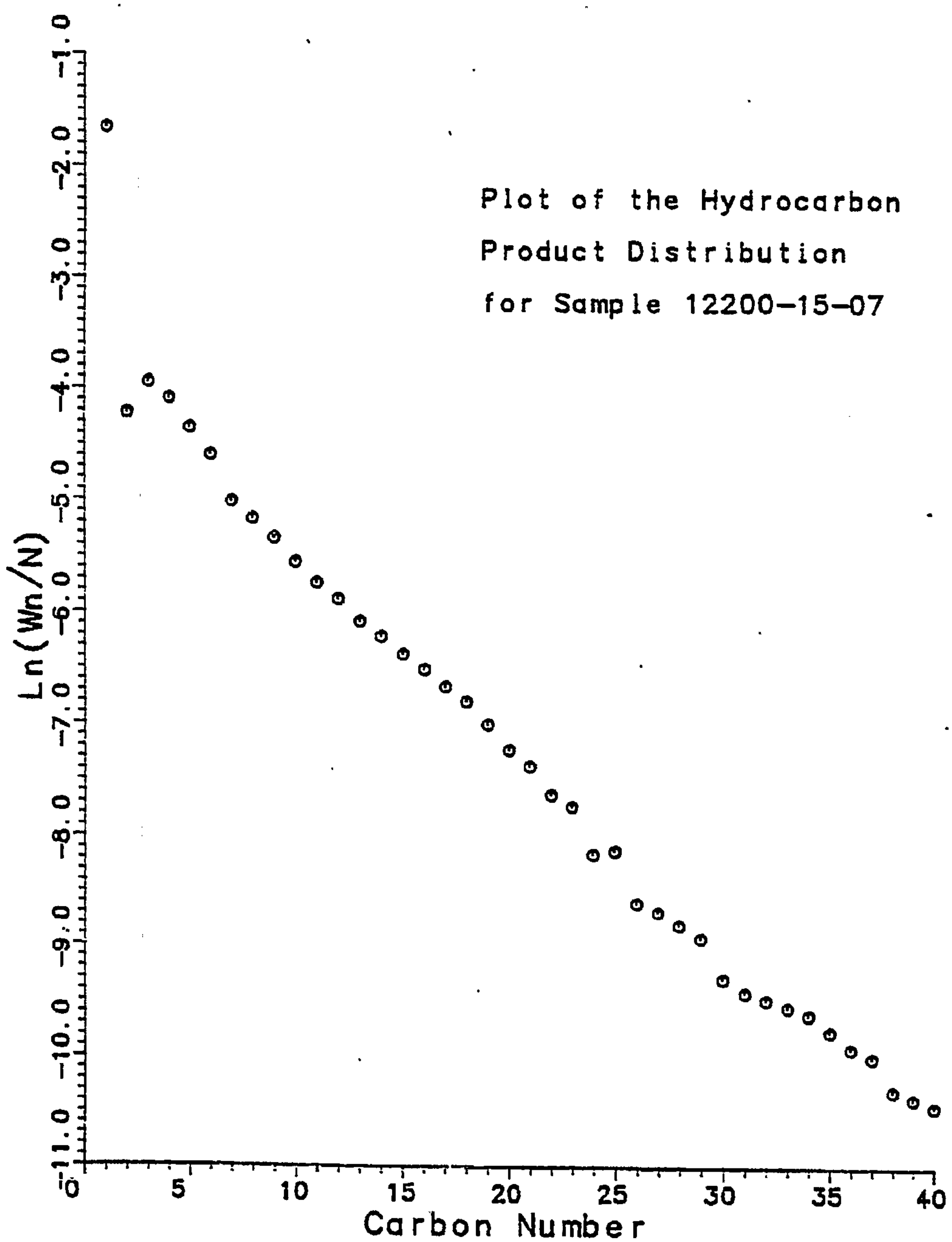
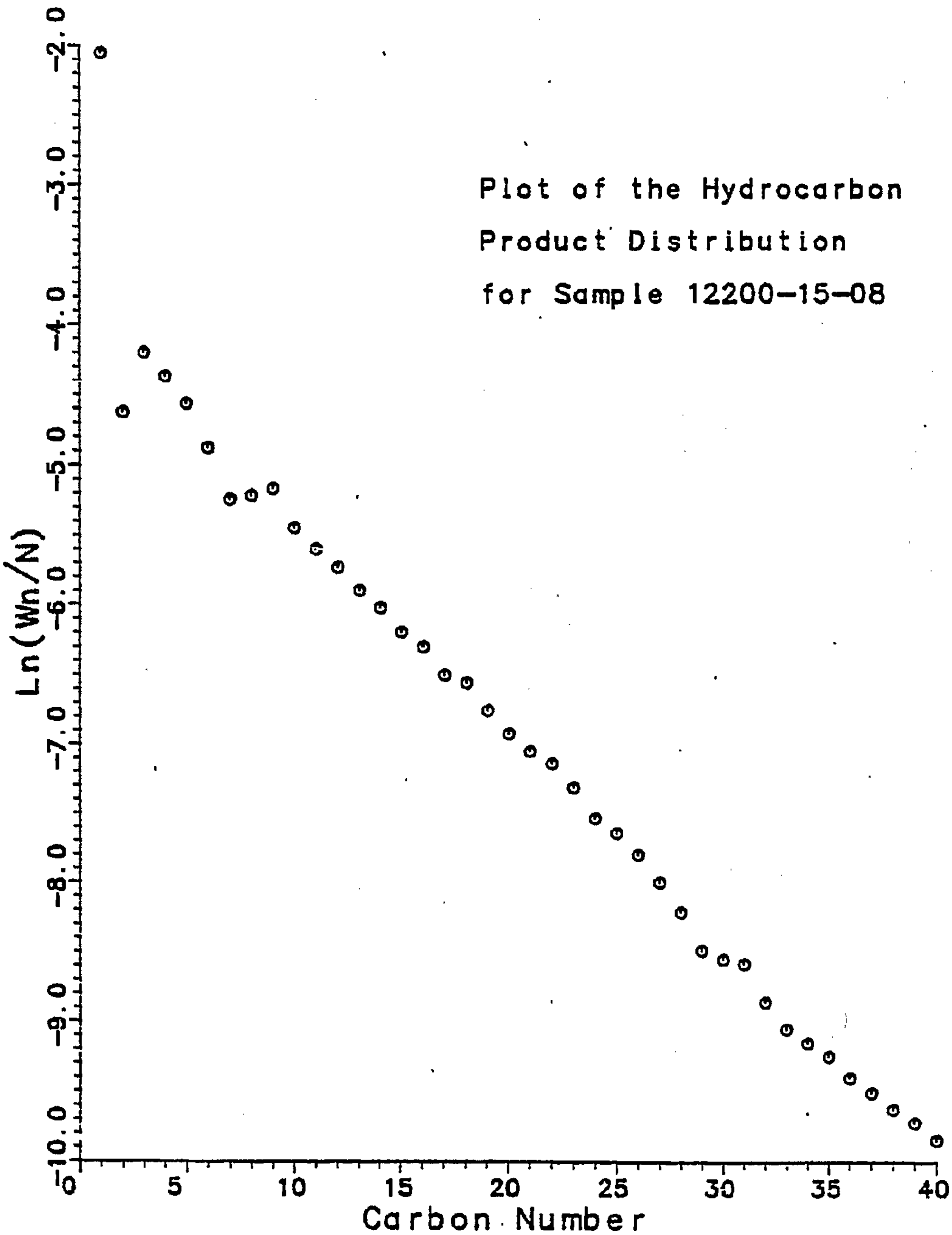
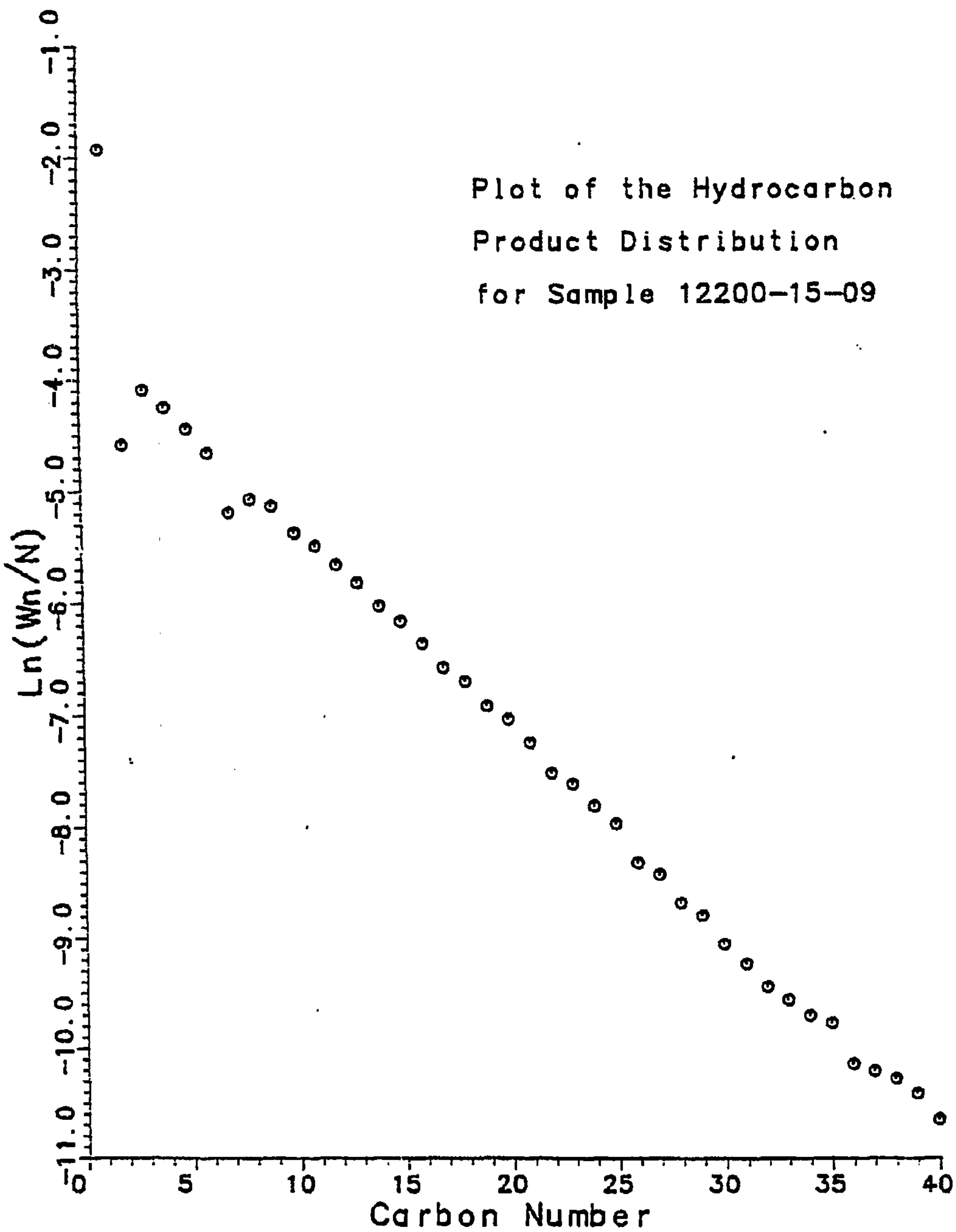

Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-07
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

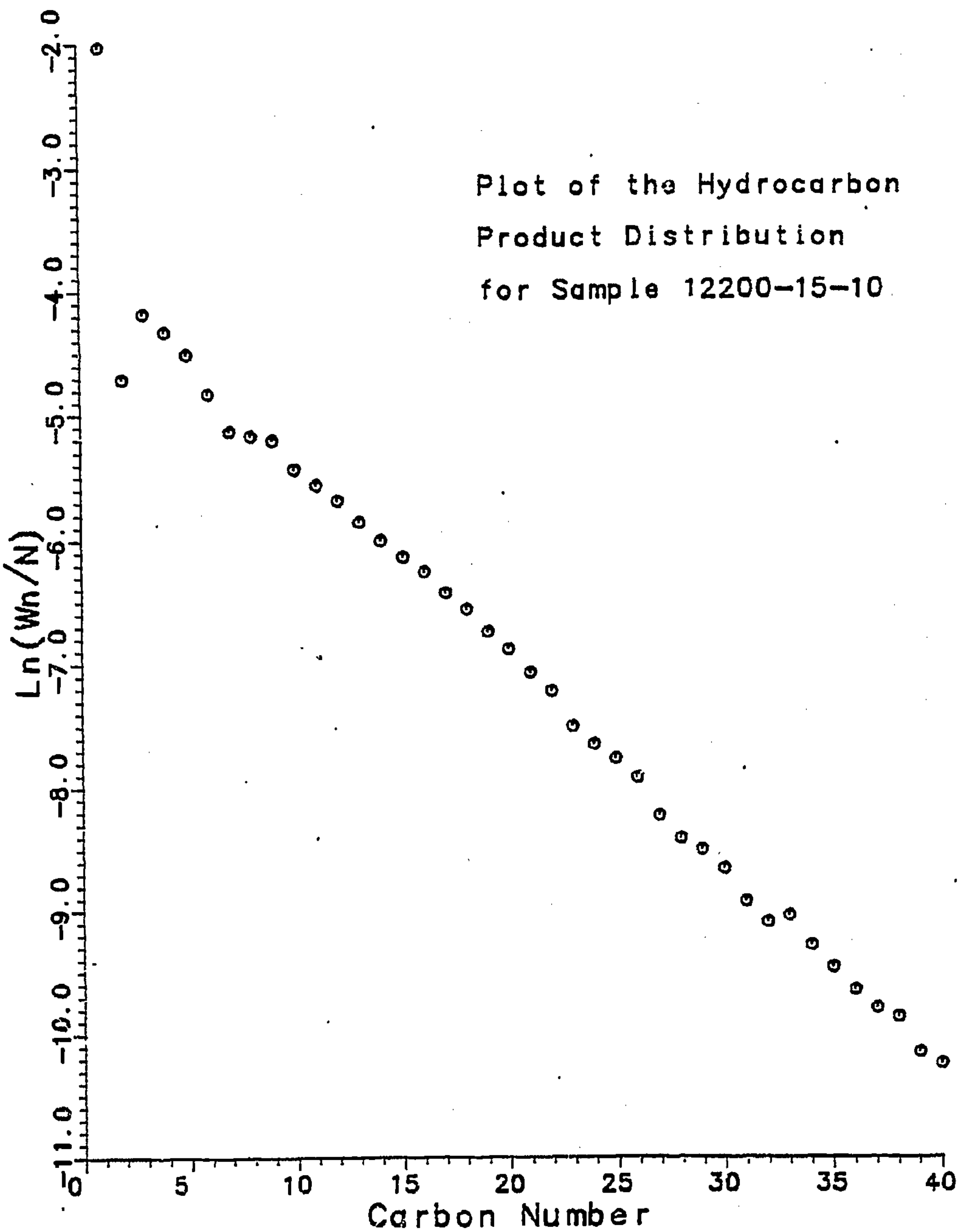
Fig. B92


Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-08
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number
Fig. B93



Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-09
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B94



Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-10
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B95

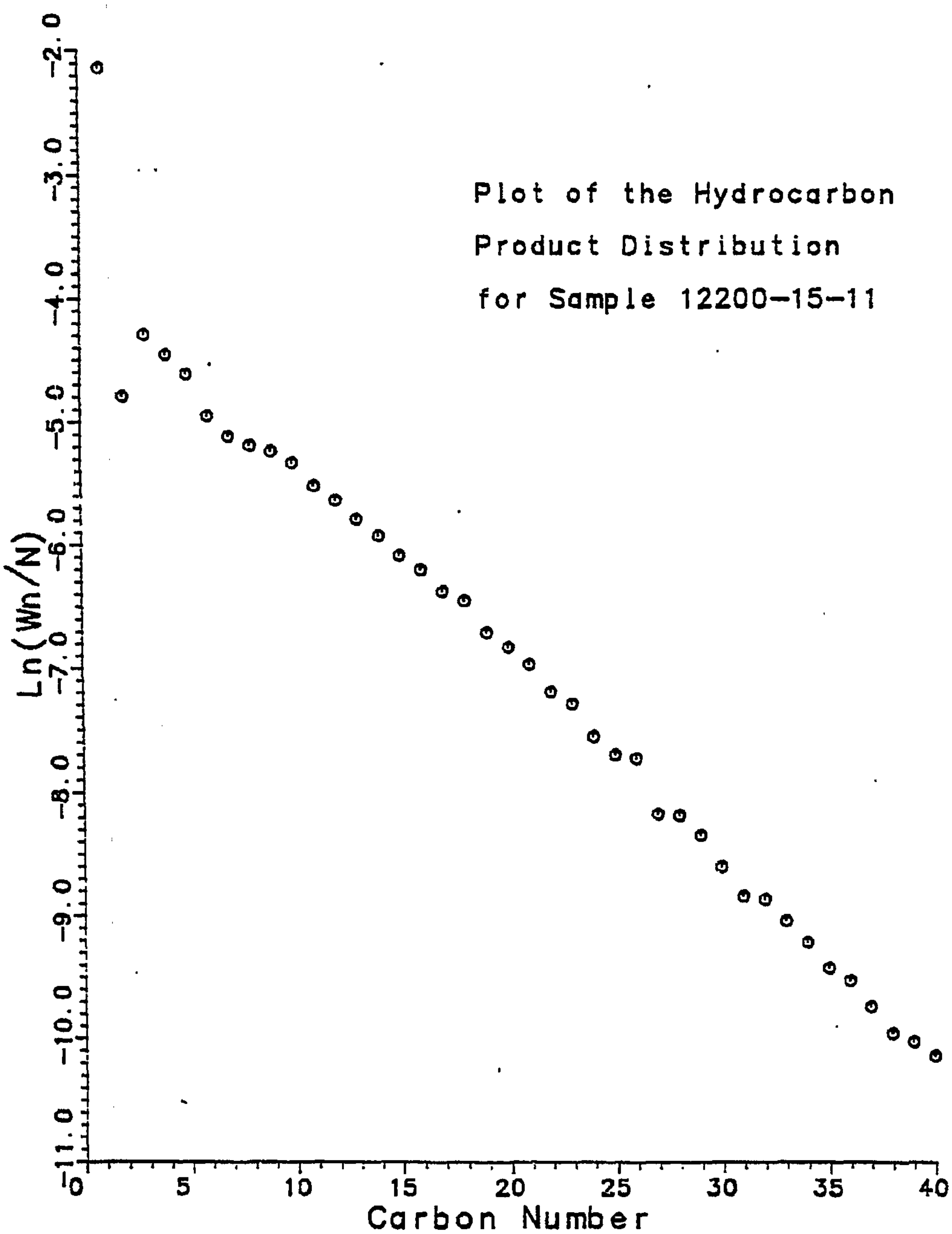

Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-11
Ln(Wn/N)
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B96

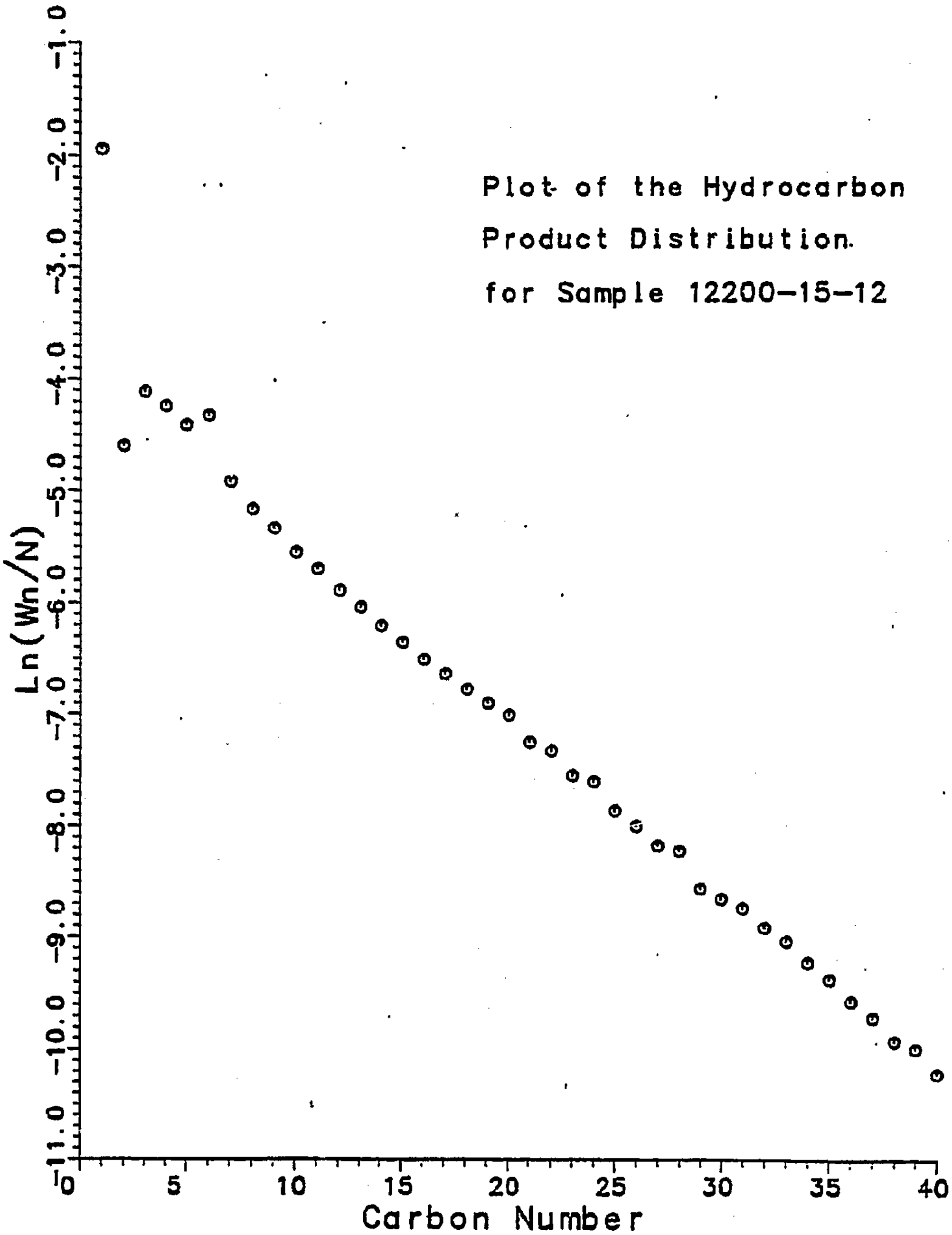

Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-12
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B97

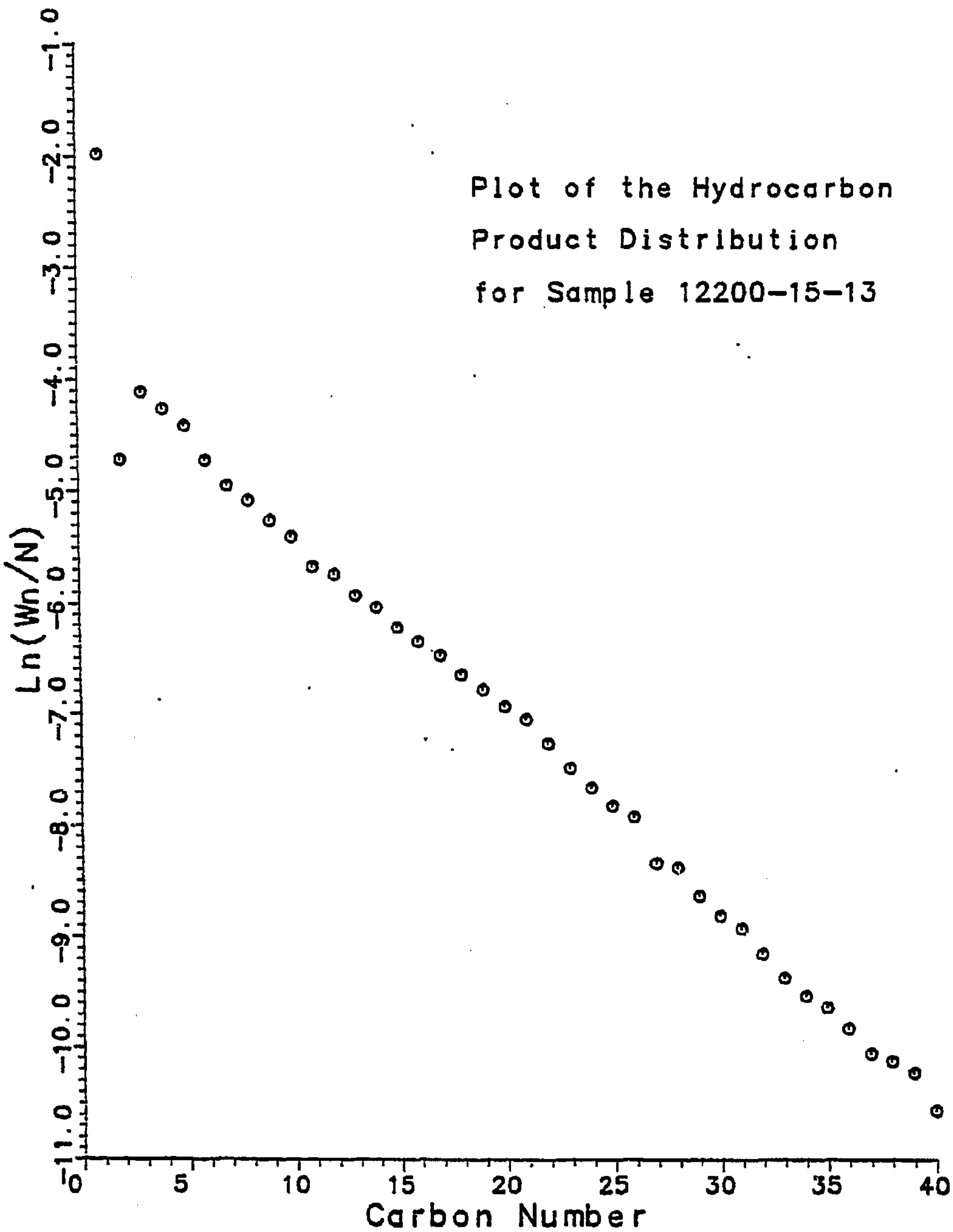
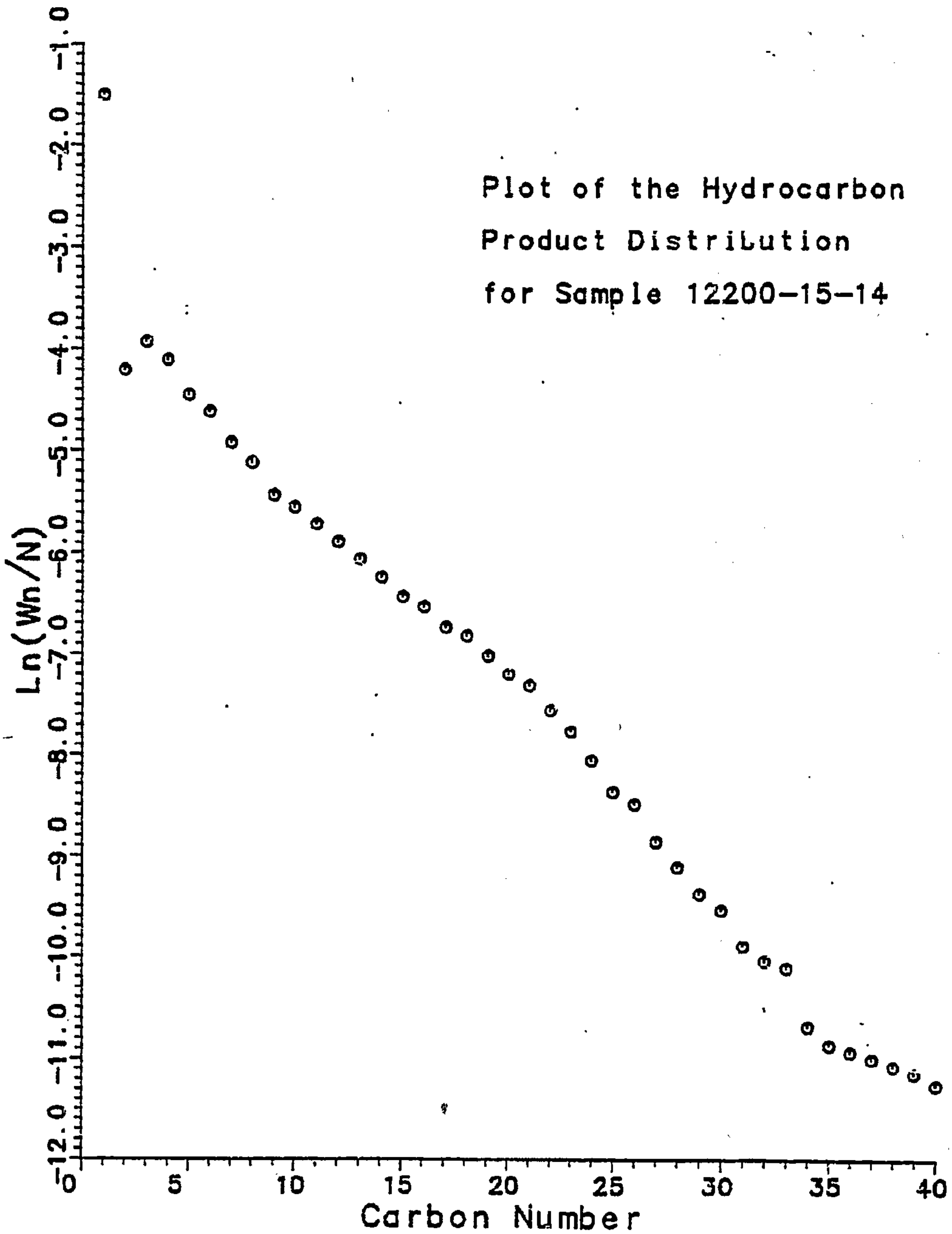

Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-13
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B98



Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-14
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
-12.0
0
5
10
15
20
25
30
35
40
Carbon Number

Fig. B99

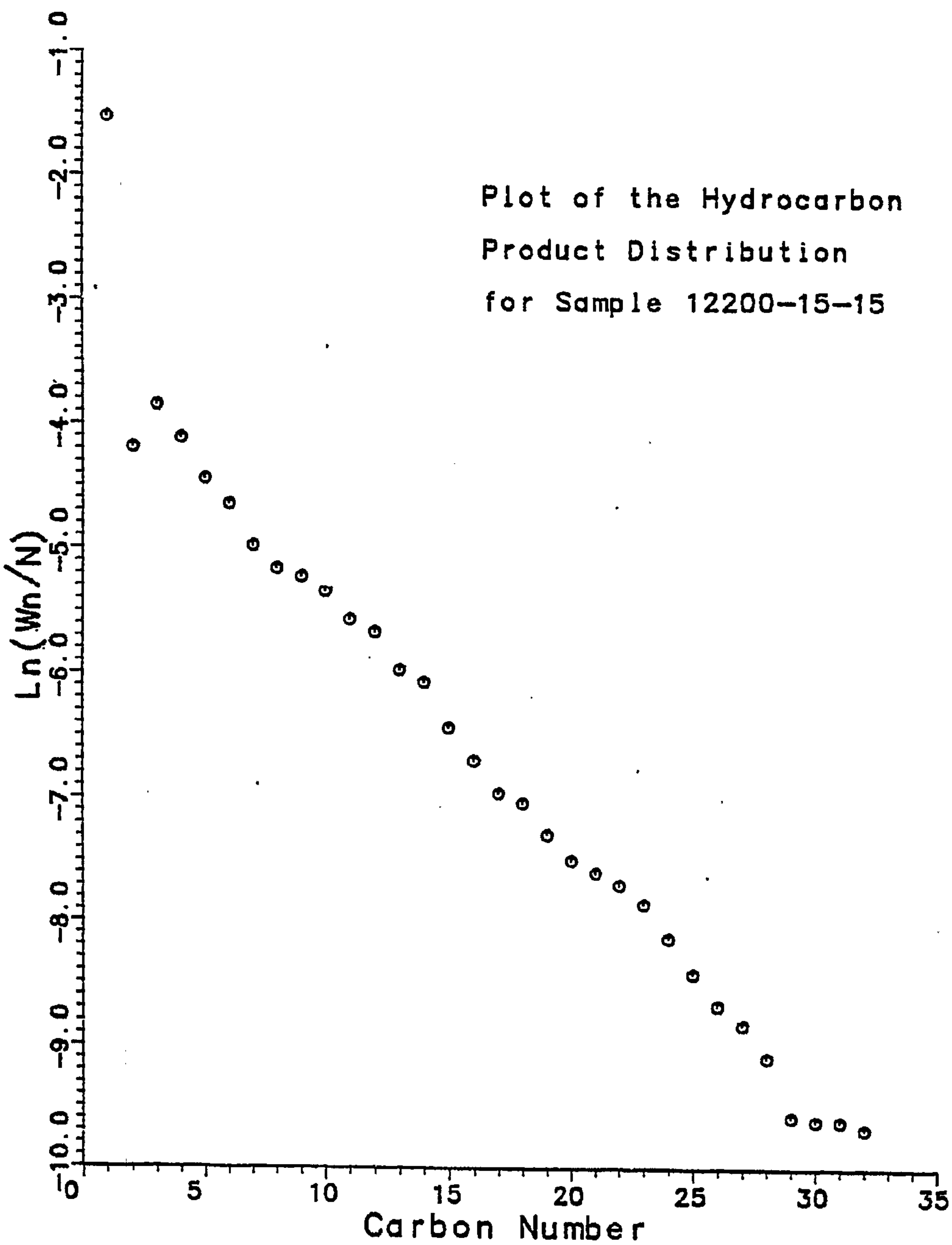
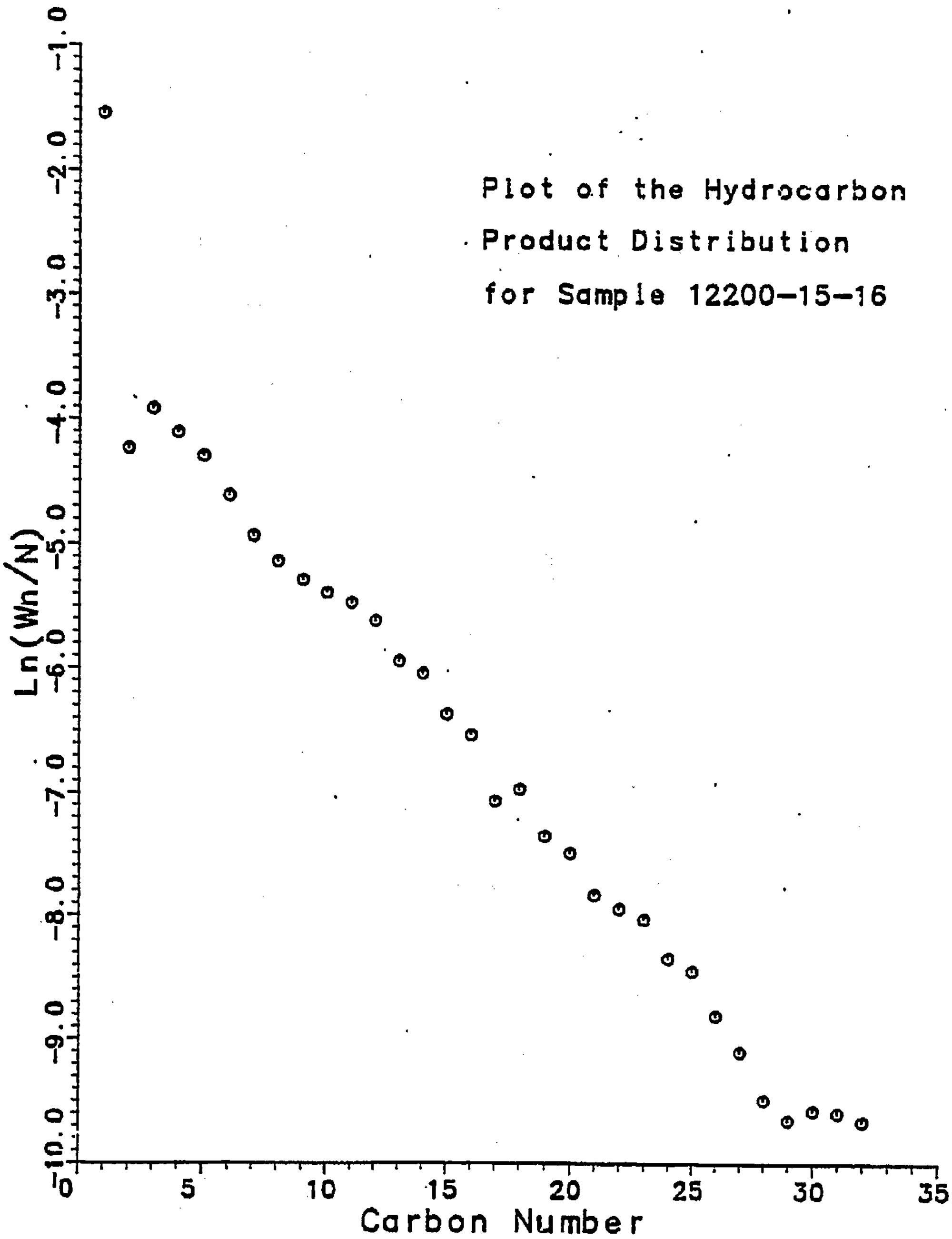
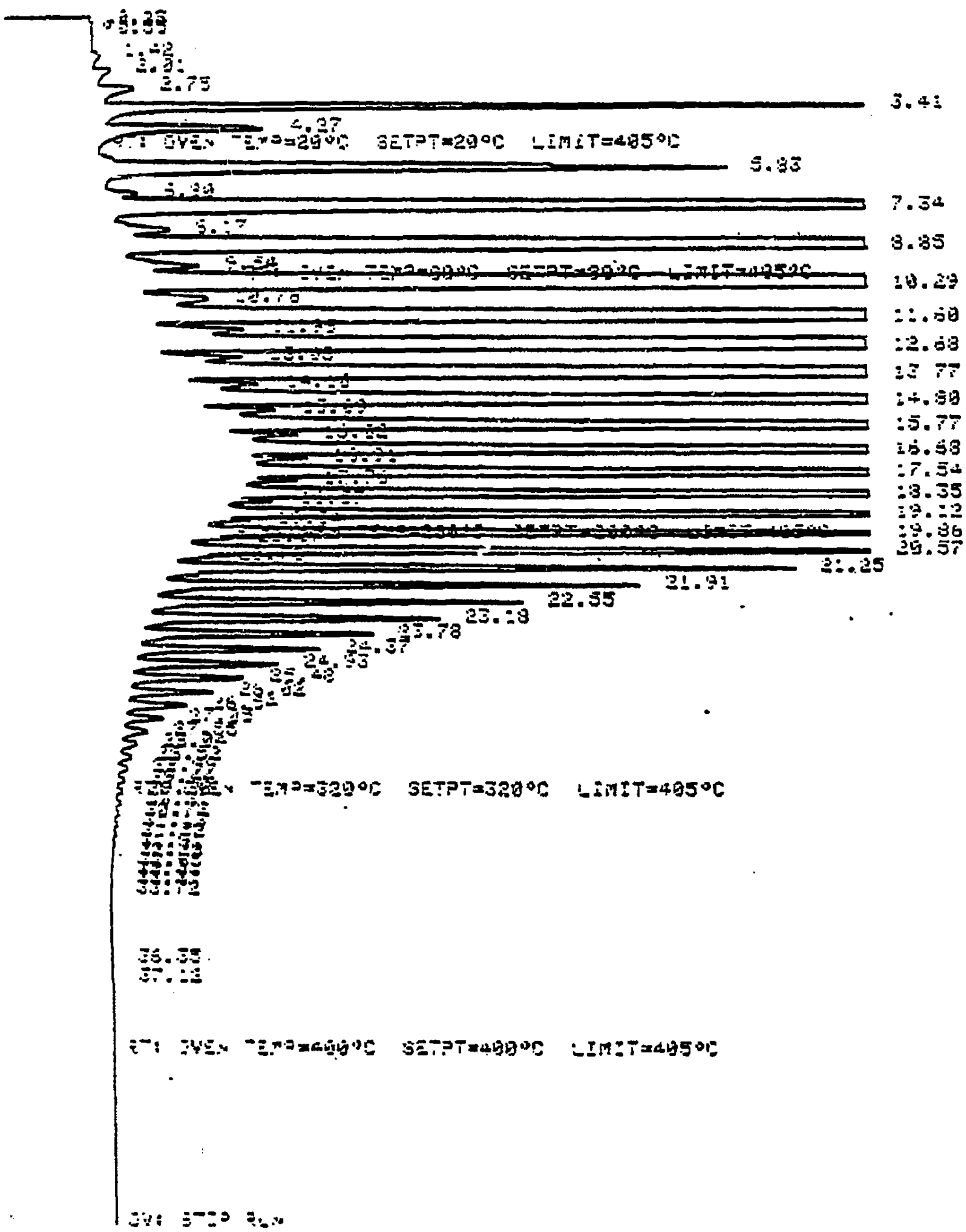

Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-15
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
Carbon Number

Fig. B100



Plot of the Hydrocarbon
Product Distribution
for Sample 12200-15-16
Ln(Wn/N)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
Carbon Number

Fig. B101



12200-15-1

Fig. B102

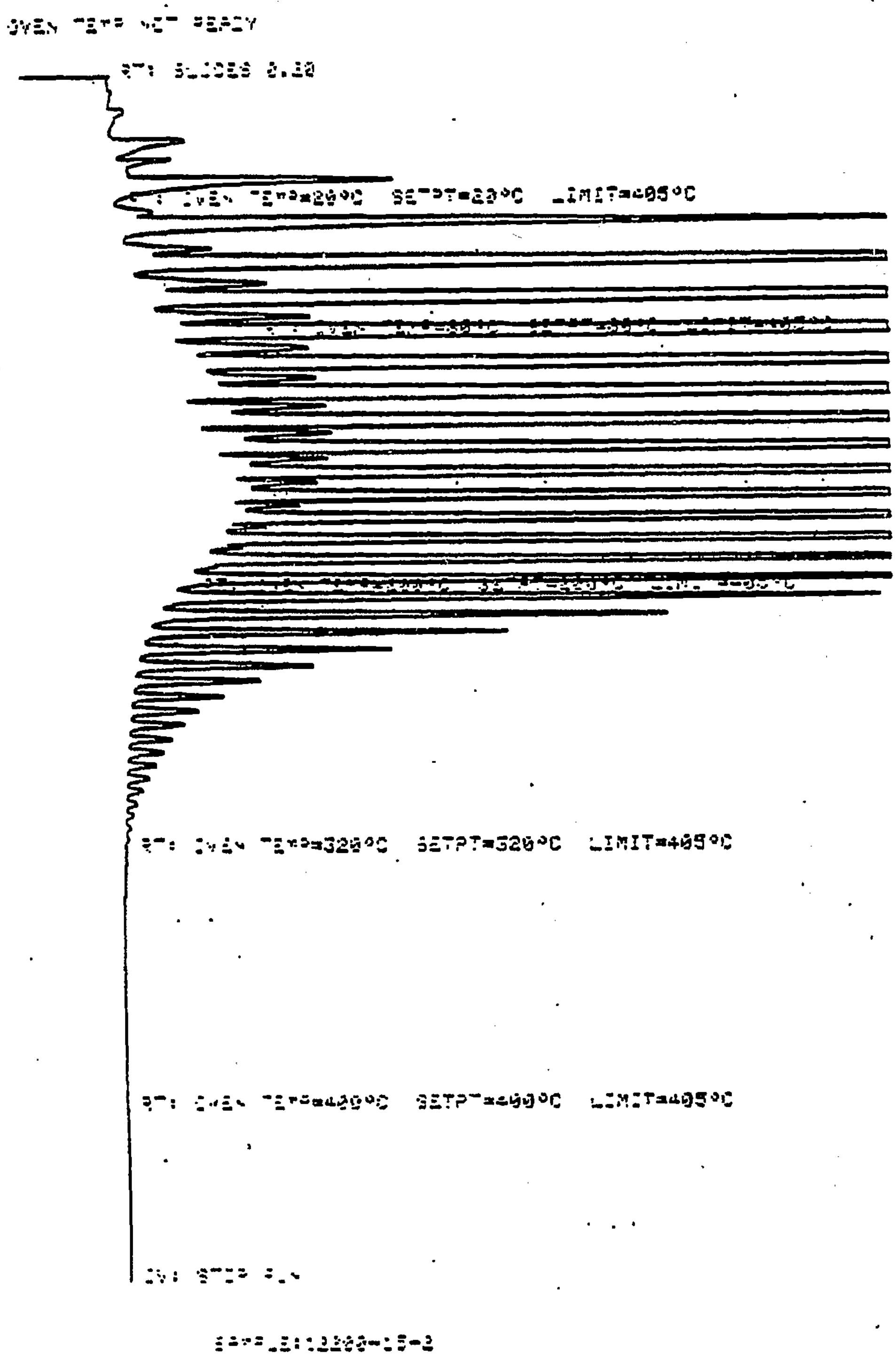

RT: OVEN TEMP=320°C SETPT=320°C LIMIT=405°C
RT: OVEN TEMP=400°C SETPT=400°C LIMIT=405°C

Fig. B103

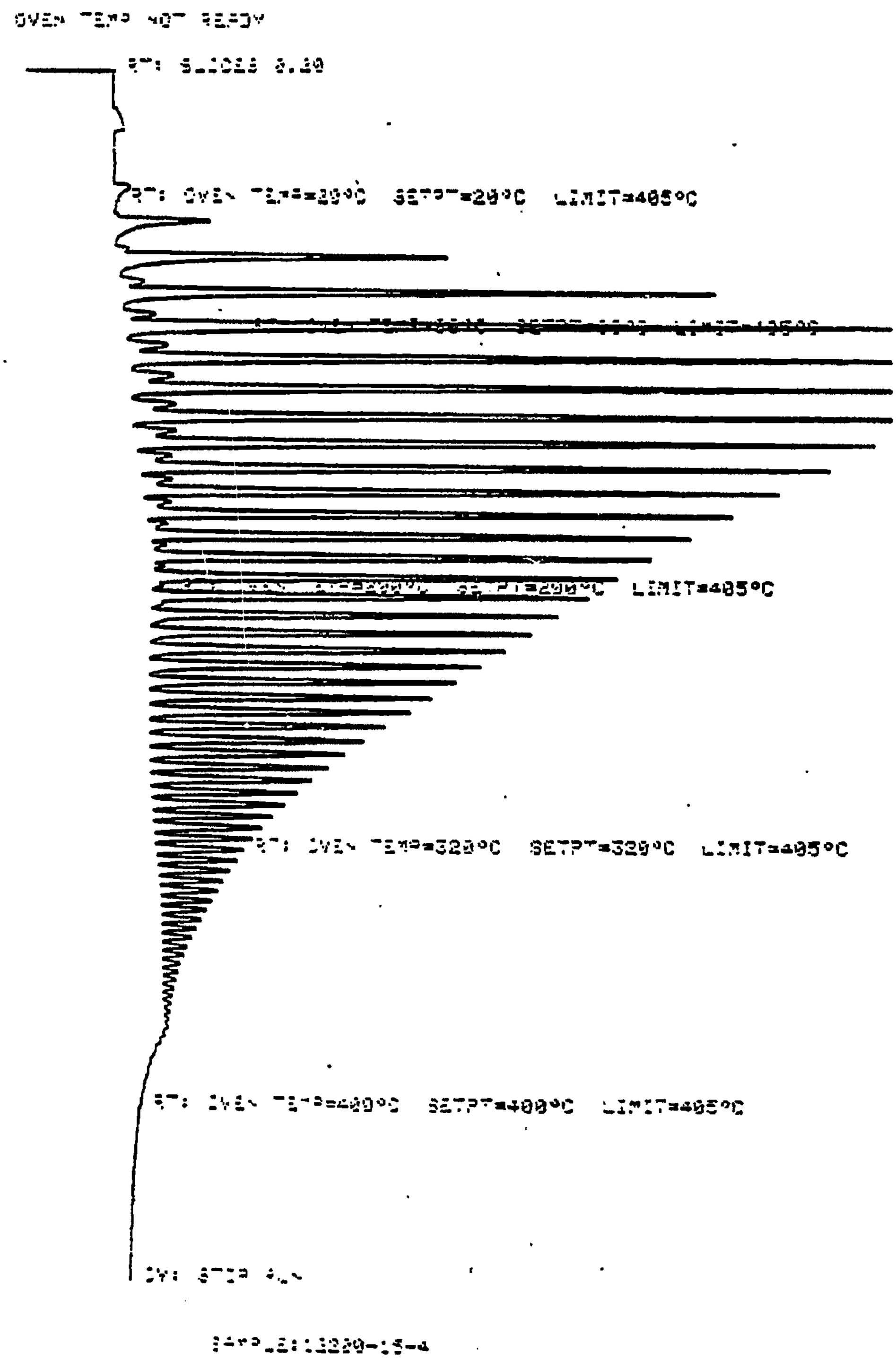
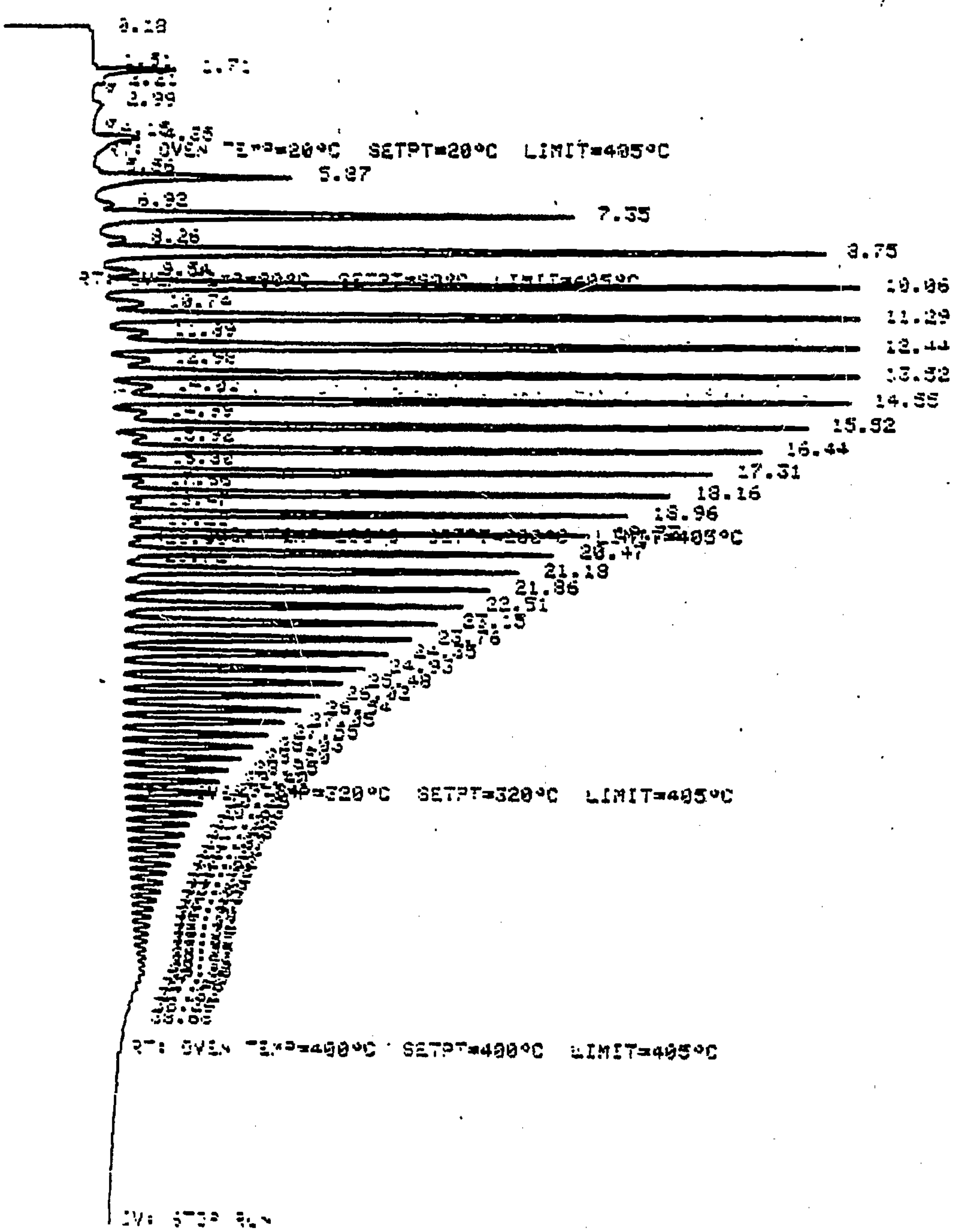
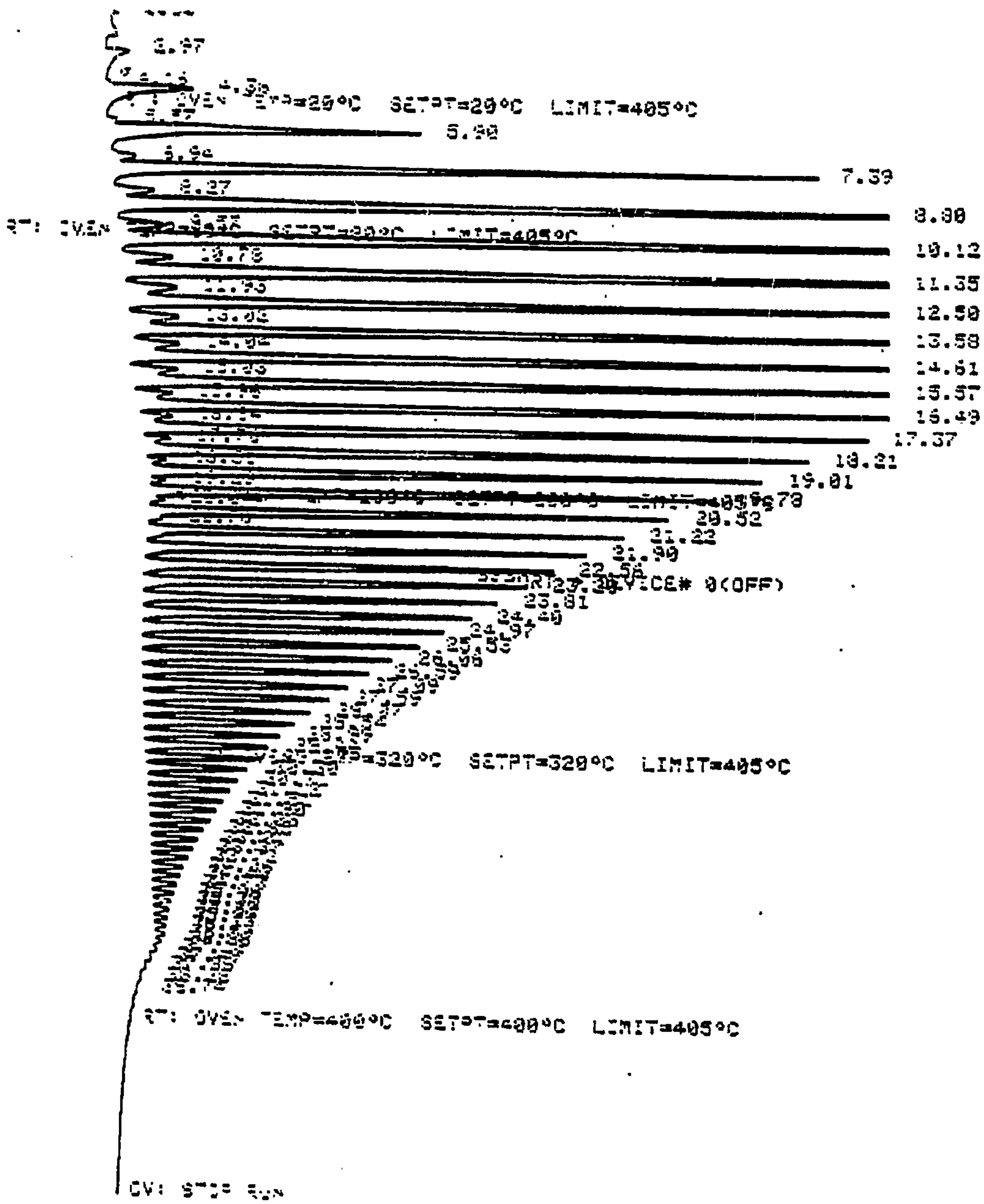


Fig. B104



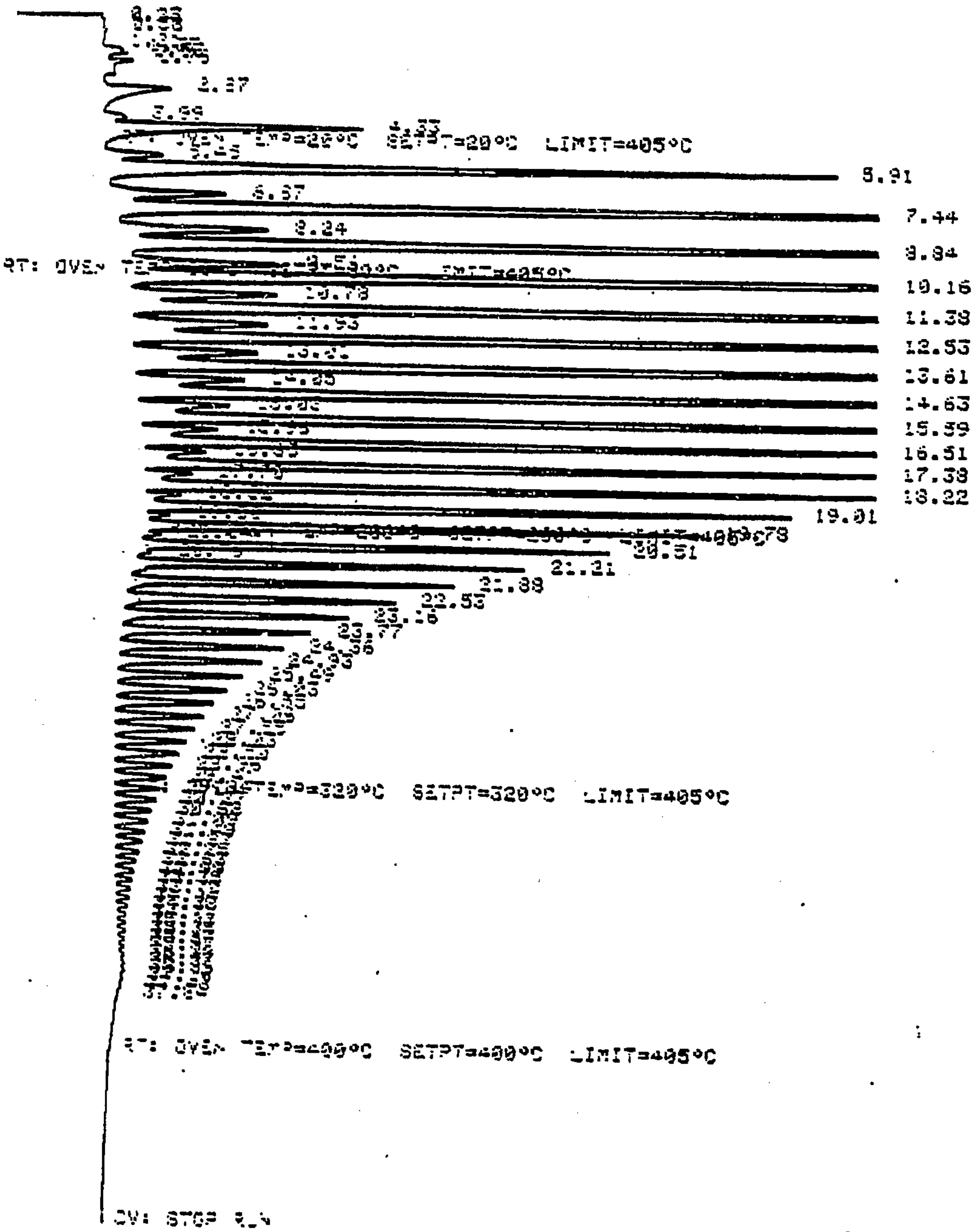
12200-15-5

Fig. B105



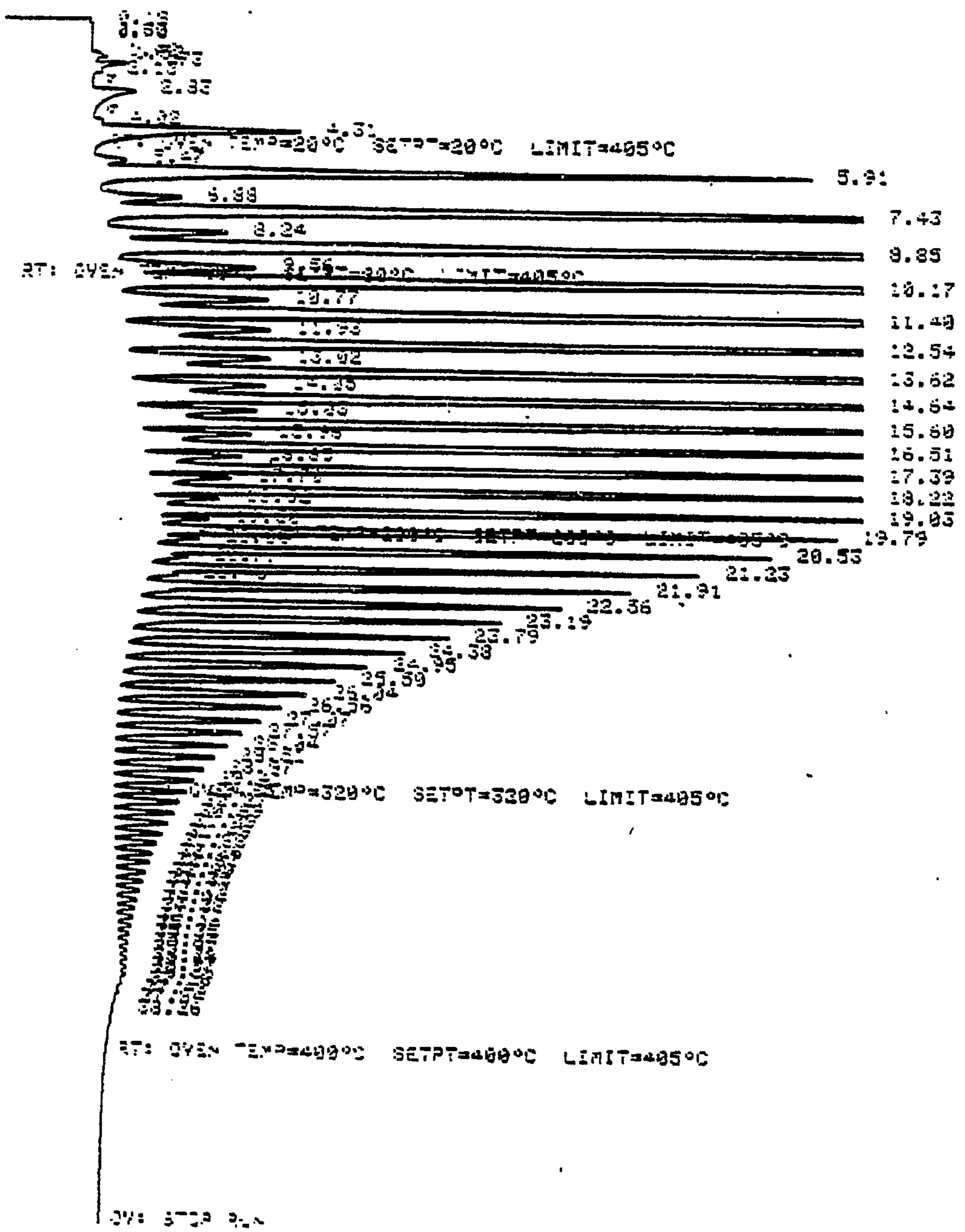
12200-15-6

Fig. B106



12200-15-7

Fig. B107



12200-15-8

Fig. B108

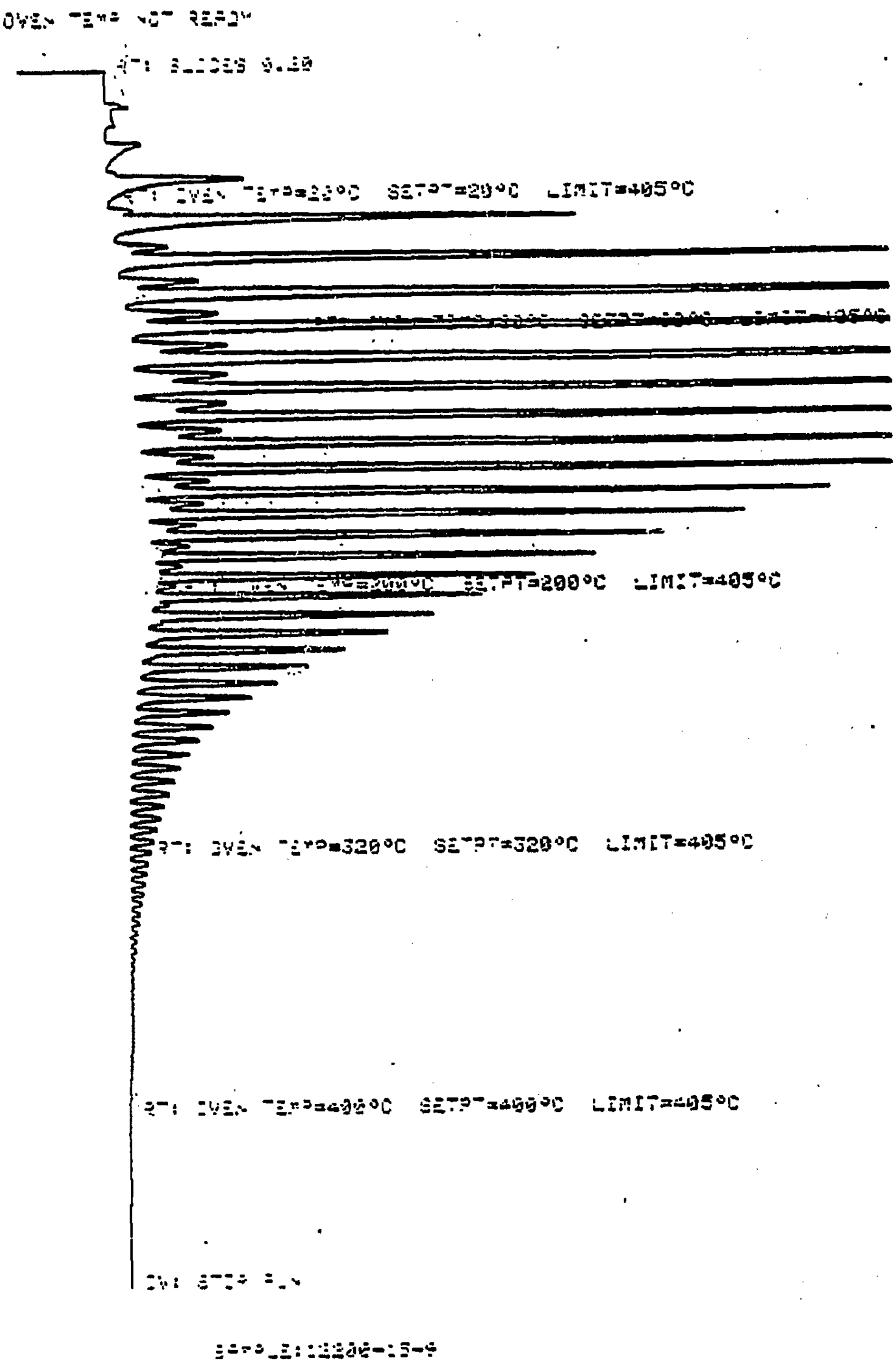


Fig. B109

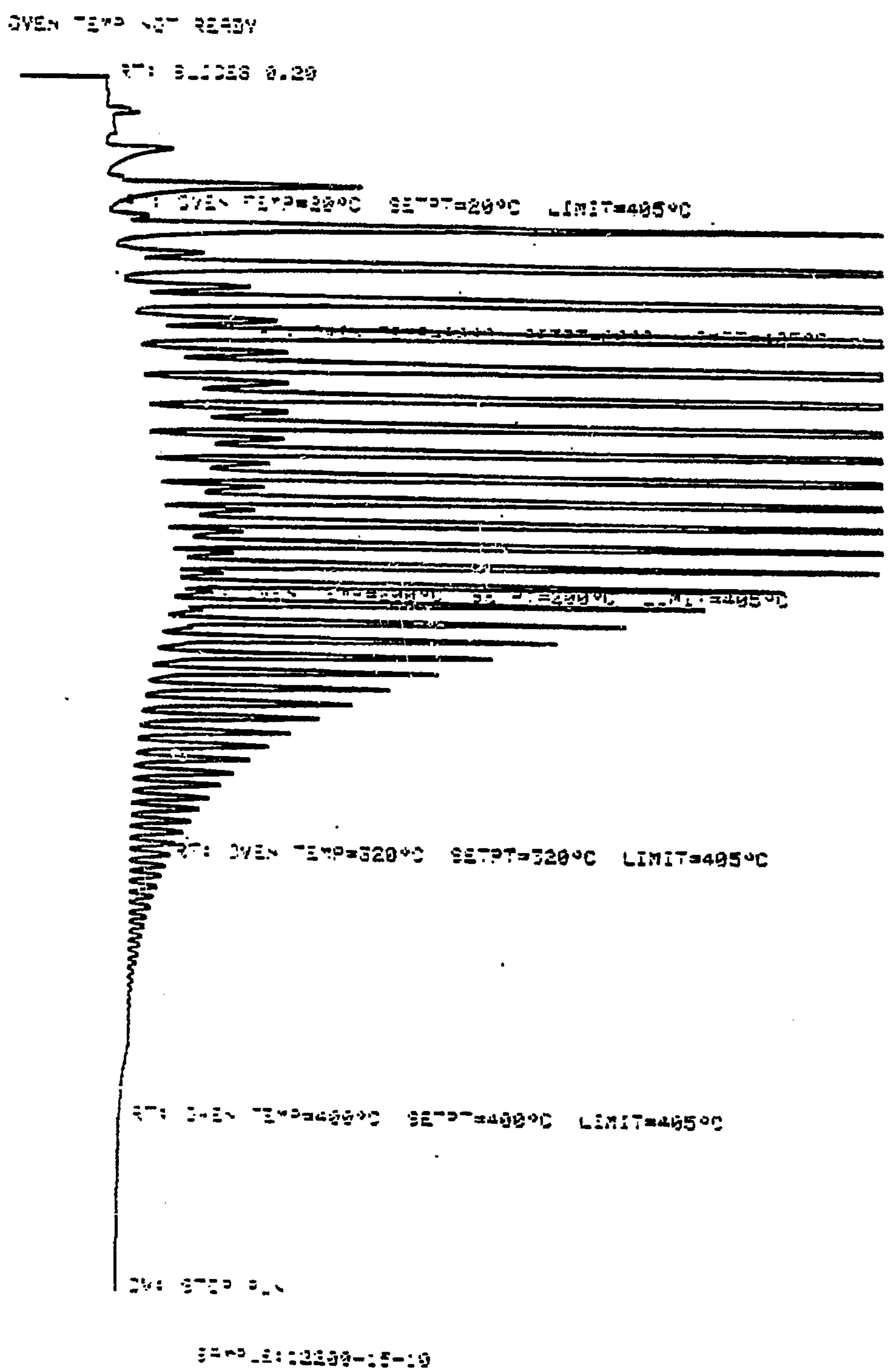


Fig. B110

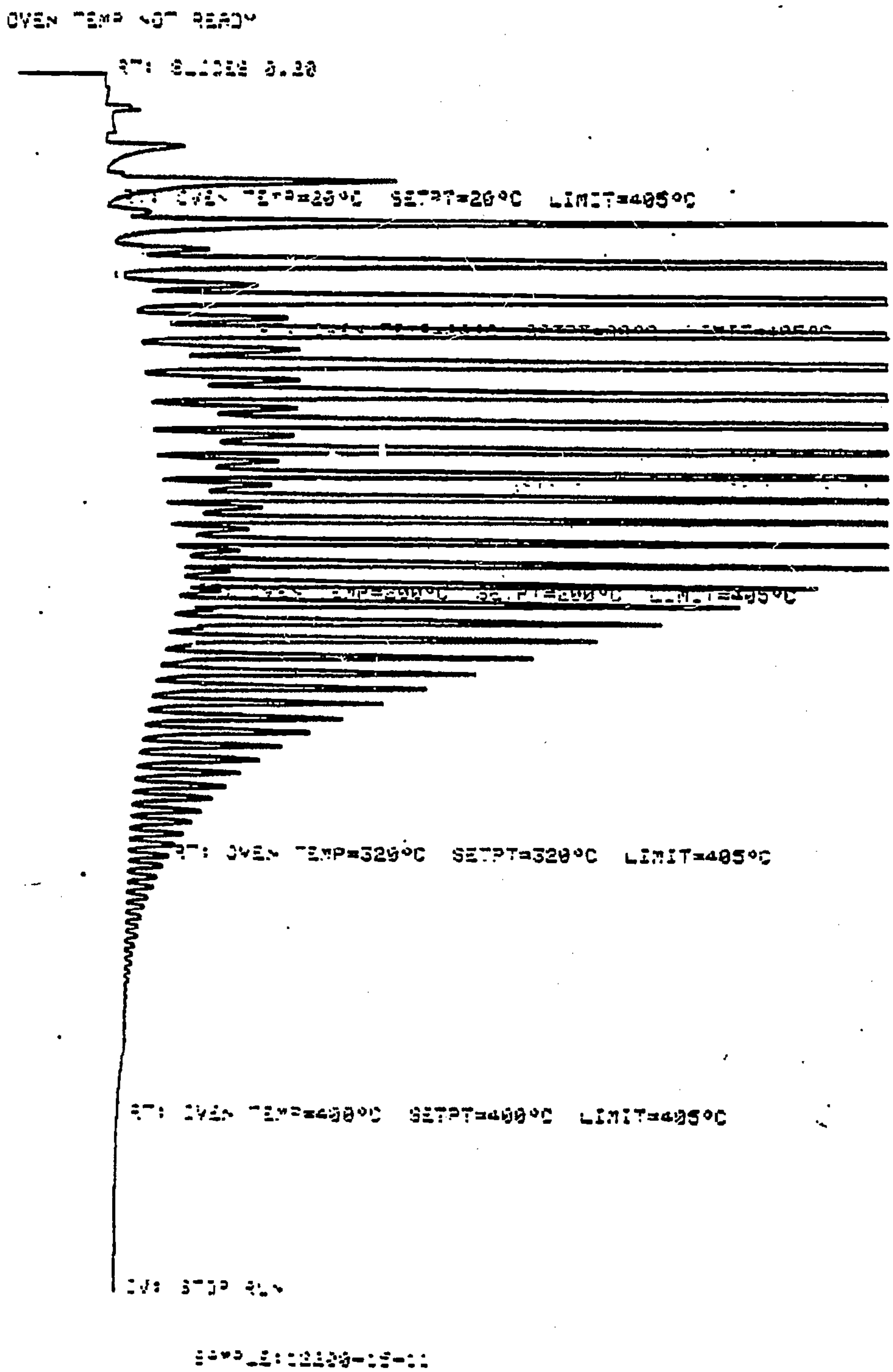
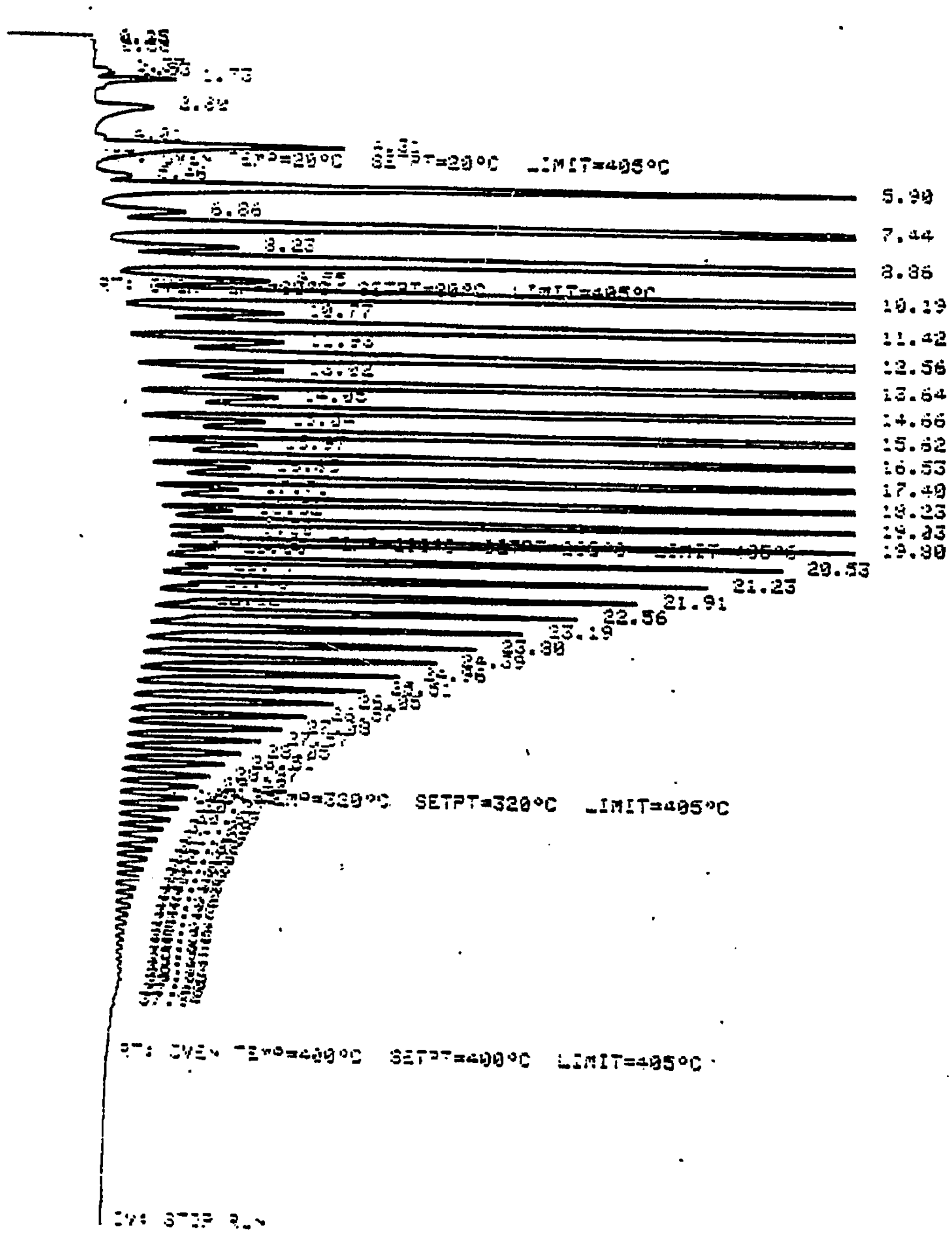

SETPT=20°C LIMIT=405°C
TEMP=320°C SETPT=320°C LIMIT=405°C
SETPT=400°C LIMIT=405°C

Fig. B111



12200-15-12
Fig. B112

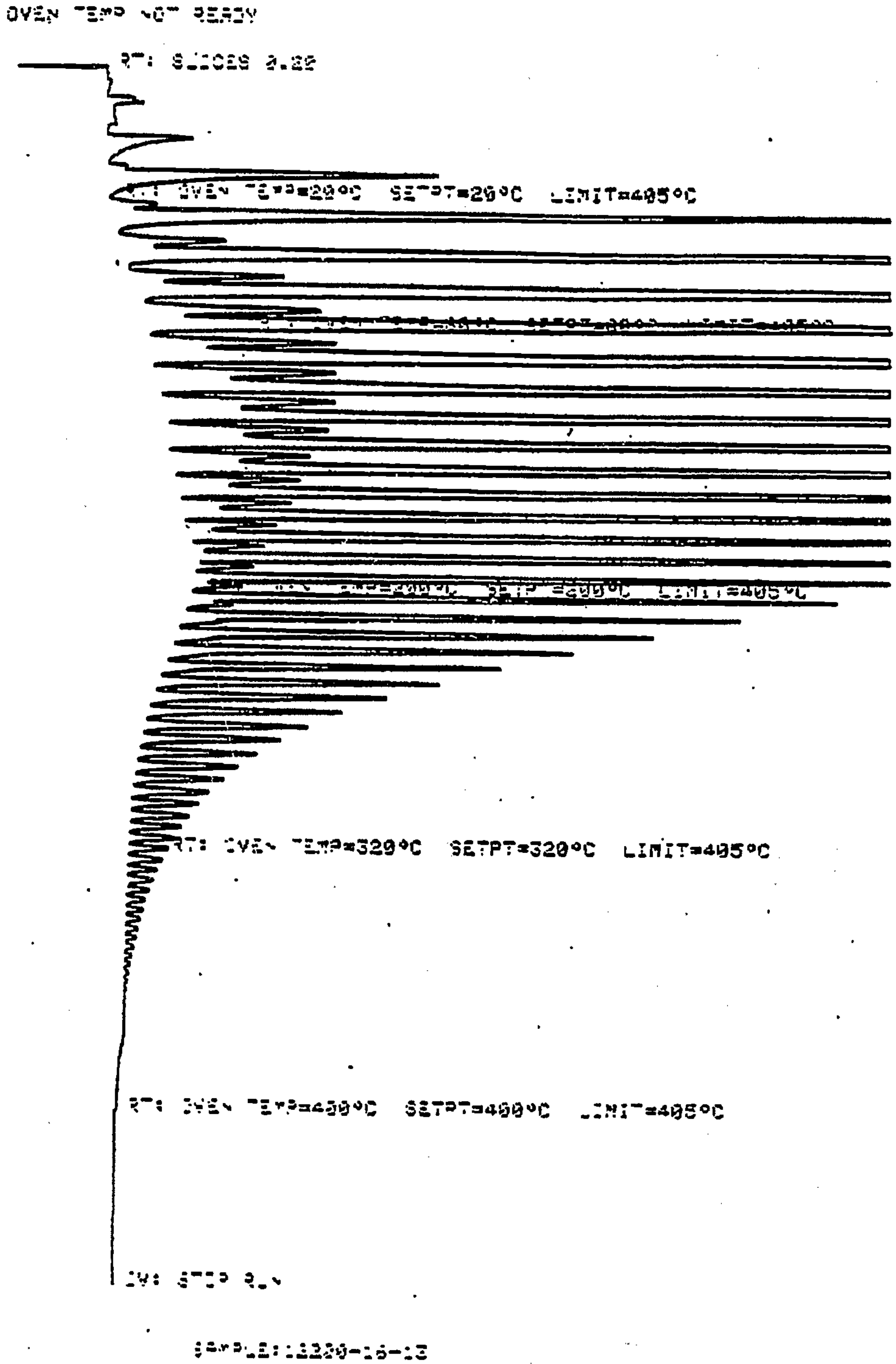


Fig. B113

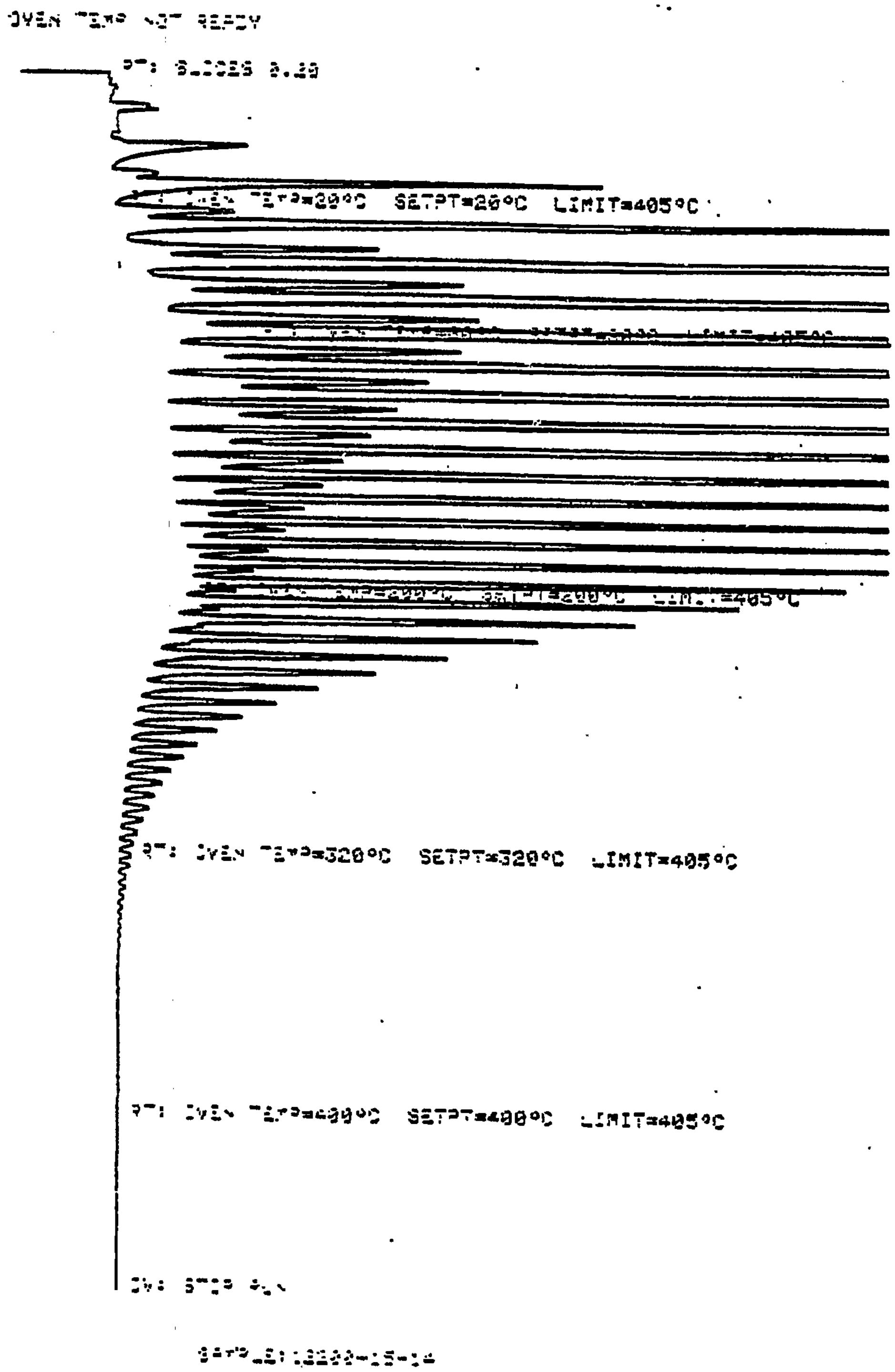

RT: OVEN TEMP=320°C SETPT=320°C LIMIT=405°C
SETPT=400°C LIMIT=405°C

Fig. B114

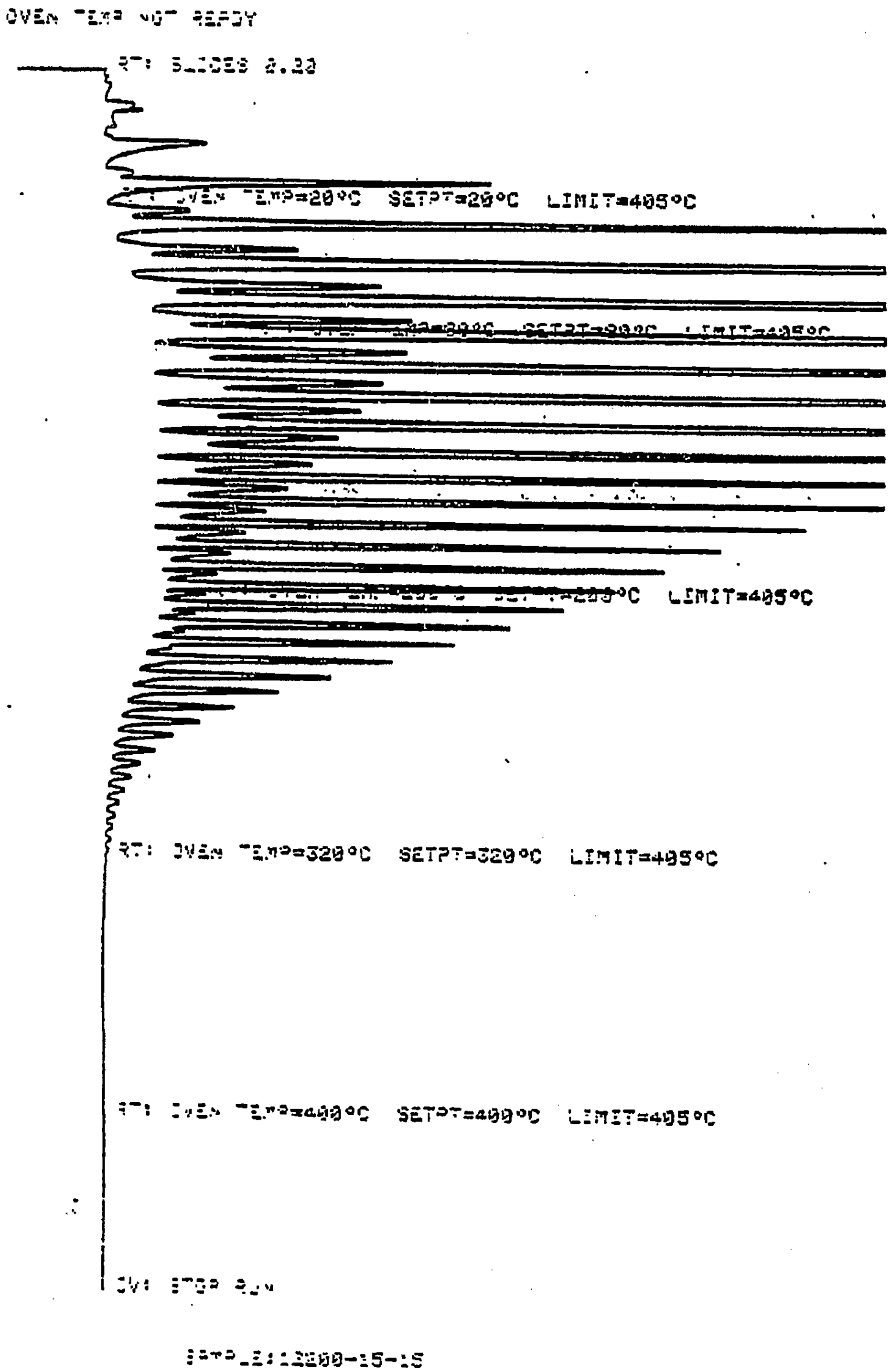
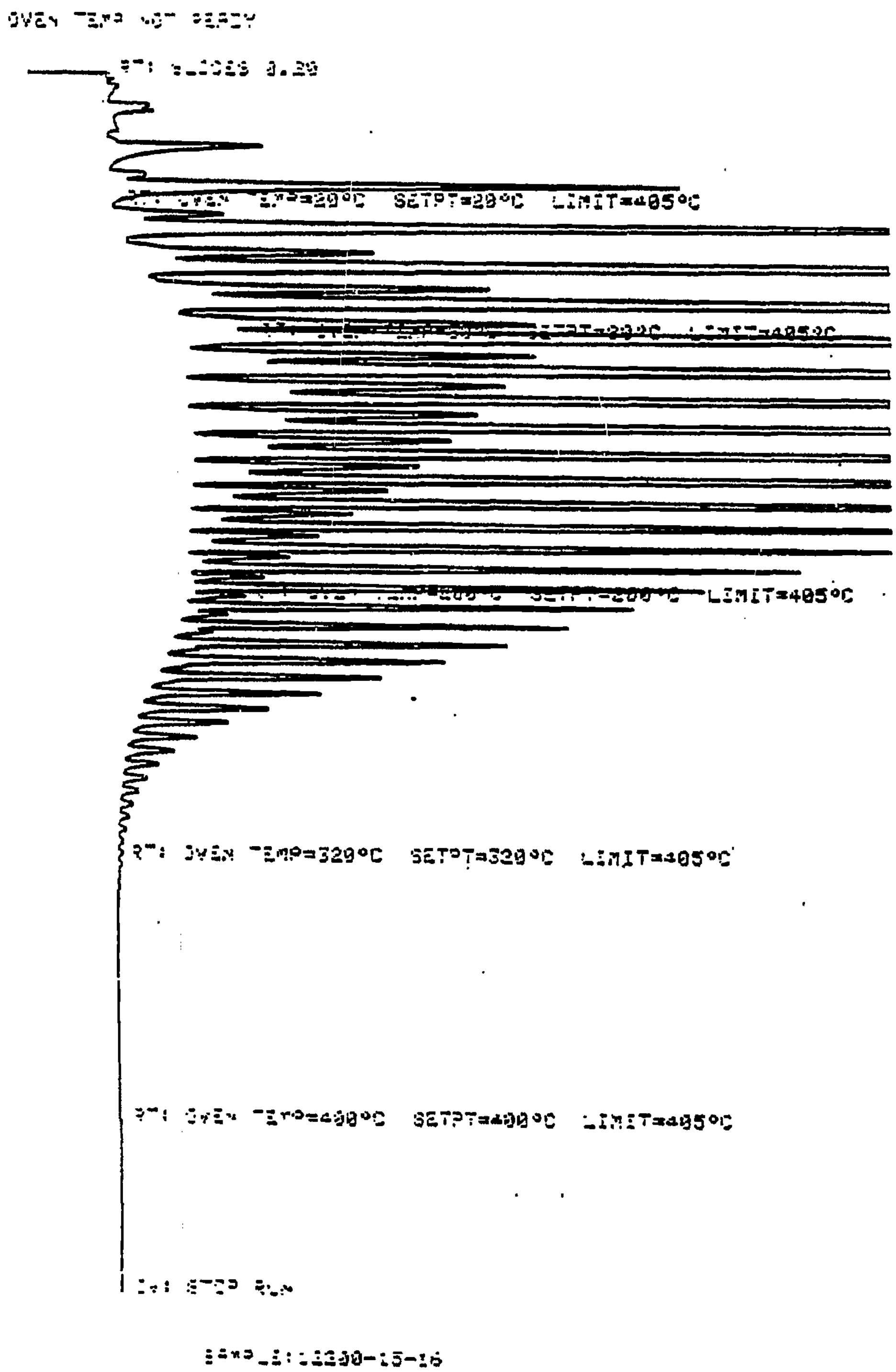

SETPT=20°C LIMIT=405°C
LIMIT=405°C
SETPT=320°C LIMIT=405°C
SETPT=400°C LIMIT=405°C

Fig. B115



OVEN TEMP=20°C SETPT=20°C LIMIT=405°C
LIMIT=405°C
RT: OVEN TEMP=320°C SETPT=320°C LIMIT=405°C
SETPT=400°C LIMIT=405°C

Fig. B116

Table B6

FILE: 1220015A TSS3Q1 A1

RESULT OF SYNGAS OPERATION

RUN NO. 12200-15
CATALYST CO/X9/X10-U113 80 CC 34.2 G AFTER RUN:51.4 G (+17.2 G)
FEED H2:CO OF 50:50 @ 400 CC/MN OR 300 GHSV (CAT # 12251-52-32)

RUN & SAMPLE NO.	12200-15-01	200-15-02	200-15-04	200-15-05	200-15-06
FEED H2:CO:AR	50:50: 0	50:50: 0	50:50: 0	50:50: 0	50:50: 0
HRS ON STREAM	18.0	42.0	93.0	115.0	139.5
PRESSURE,PSIG	300	300	300	300	300
TEMP. C	221	239	239	239	239
FEED CC/MIN	400	400	400	400	400
HOURS FEEDING	18.00	24.00	26.00	22.00	24.50
EFFLNT GAS LITER	247.00	336.20	377.65	325.80	369.50
GM AQUEOUS LAYER	39.83	48.24	44.60	44.80	41.32
GM OIL	5.45	12.81	31.54	23.82	26.22
MATERIAL BALANCE					
GM ATOM CARBON %	73.02	85.13	97.91	97.26	98.67
GM ATOM HYDROGEN %	82.22	83.95	92.51	95.51	92.85
GM ATOM OXYGEN %	92.03	96.40	95.66	100.40	97.69
RATIO CHX/(H2O+CO2)	0.3039	0.5754	1.0982	0.8816	1.0431
RATIO X IN CHX	2.2923	2.3239	2.2557	2.2698	2.2756
USAGE H2/CO PRODT	4.2659	2.5011	1.8890	2.0986	1.9363
FEED H2/CO FRM EFFLNT	1.1261	0.9862	0.9448	0.9819	0.9410
RESIDUAL H2/CO RATIO	0.7085	0.6077	0.5957	0.6024	0.6051
RATIO CO2/(H2O+CO2)	0.0099	0.0655	0.0568	0.0485	0.0569
K SHIFT IN EFFLNT	0.0071	0.0426	0.0359	0.0307	0.0365
SPECIFIC ACTIVITY SA	2.4359	1.9015	2.7822	2.5220	2.5199
CONVERSION					
ON CO %	11.74	19.99	26.99	25.37	25.24
ON H2 %	44.47	50.70	53.97	54.21	51.92
ON CO+H2 %	29.07	35.24	40.10	39.66	38.17
PRDT SELECTIVITY,WT %					
CH4	10.61	11.19	7.43	8.15	8.39
C2 HC'S	0.81	1.98	0.99	1.27	1.30
C3H8	1.18	1.97	1.27	1.42	1.50
C3H6=	3.32	3.94	2.32	2.50	2.55
C4H10	1.65	2.11	1.38	1.56	1.67
C4H8=	3.59	4.49	2.68	2.94	2.97
C5H12	1.88	2.77	1.77	1.94	2.01
C5H10=	3.63	4.23	2.61	2.70	2.70
C6H14	2.19	3.19	1.96	2.21	2.33
C6H12= & CYCLO'S	2.78	2.80	1.63	1.64	1.71
C7+ IN GAS	16.79	12.05	7.53	8.08	8.70
LIQ HC'S	51.57	49.29	68.44	65.58	64.17
TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	21.16	25.67	16.07	17.84	18.38
C5 -420 F	44.49	41.94	27.20	30.62	31.83
420-700 F	28.68	28.69	48.32	27.41	26.31
700-END PT	5.67	3.70	8.42	24.13	23.49

Table B6 (continued)

FILE: 1220015A TSS3Q1 A1

C5+-END PT	78.84	74.33	83.93	82.16	81.62
ISO/NORMAL MOLE RATIO					
C4	0.0000	0.0230	0.0000	0.0212	0.0242
C5	0.0000	0.0592	0.0629	0.0417	0.0499
C6	0.0000	0.0968	0.0835	0.0713	0.0670
C4=	0.0000	0.0000	0.0000	0.0000	0.0000
PARAFFIN/OLEFIN RATIO					
C3	0.3403	0.4779	0.5229	0.5423	0.5595
C4	0.4427	0.4547	0.4982	0.5124	0.5439
C5	0.5027	0.6362	0.6585	0.6975	0.7209
SCHULZ-FLORY DISTRBTN					
ALPHA (EXP(SLOPE))	0.8393	0.8154	0.8883	0.8778	0.8726
RATIO CH4/(1-A)**2	4.1063	3.2831	5.9478	5.4542	5.1701
ALPHA FRM CORRELATION	0.8299	0.8363	0.8372	0.8367	0.8365
ALPHA (EXPTL/CORR)	1.0113	0.9751	1.0609	1.0491	1.0432
W%CH4 FRM CORRELATION	11.7299	14.0084	13.7081	13.8779	13.9452
W%CH4 (EXPTL/CORR)	0.9042	0.7986	0.5417	0.5873	0.6019
LIQ HC COLLECTION					
PHYS. APPEARANCE	CLD OIL	CLD OIL	OIL WAX	OIL WAX	OIL WAX
DENSITY (* 40 C)	0.7768	0.7664	N/A	N/A	N/A
N, REFRACTIVE INDEX	1.4227*	1.4227*	N/A	N/A	N/A
SIMULT'D DISTILATN					
10 WT % @ DEG F	289	298	378	335	334
16	332	338	416	385	373
50	503	489	642	608	604
84	662	645	924	893	892
90	705	683	1006	980	974
RANGE(16-84 %)	330	307	508	508	519
WT % @ 420 F	33.40	34.30	17.10	21.40	22.40
WT % @ 700 F	89.00	92.50	87.70	63.20	63.40

Table B7

FILE: 1220015B TSS3Q1   A1

RESULT OF SYNGAS OPERATION

RUN NO.   12200-15
CATALYST   CO/X9/X10-U113   80 CC 34.2 G AFTER RUN:51.4 G (+17.2 G)
FEED   H2:CO OF 50:50 @ 400 CC/MN OR 300 GHSV   (CAT #12251-52-32)

RUN & SAMPLE NO.	12200-15-07	200-15-08	200-15-09	200-15-10	200-15-11
FEED H2:CO:AR	50:50: 0	50:50: 0	50:50: 0	50:50: 0	50:50: 0
HRS ON STREAM	163.0	188.5	211.0	234.0	258.2
PRESSURE,PSIG	300	300	300	300	300
TEMP. C	255	250	250	250	250
FEED CC/MIN	400	400	400	400	400
HOURS FEEDING	23.50	25.50	22.50	23.00	24.25
EFFLNT GAS LITER	324.55	354.85	408.50	339.05	293.35
GM AQUEOUS LAYER	48.76	49.19	42.47	43.86	46.65
GM OIL	19.37	25.97	22.82	24.41	25.21
MATERIAL BALANCE					
GM ATOM CARBON %	97.67	96.73	120.63	101.59	86.12
GM ATOM HYDROGEN %	93.19	91.05	108.01	95.90	85.20
GM ATOM OXYGEN %	102.47	98.21	119.72	101.39	87.37
RATIO CHX/(H2O+CO2)	0.8470	0.9447	1.0331	1.0073	0.9515
RATIO X IN CHX	2.4976	2.3682	2.4002	2.3743	2.3481
USAGE H2/CO PRODT	1.8067	1.9121	1.8213	1.8718	1.9510
FEED H2/CO FRM EFFLNT	0.9541	0.9413	0.8954	0.9440	0.9893
RESIDUAL H2/CO RATIO	0.5287	0.5428	0.5609	0.5603	0.5536
RATIO CO2/(H2O+CO2)	0.1879	0.1073	0.1270	0.1081	0.0884
K SHIFT IN EFFLNT	0.1223	0.0652	0.0816	0.0679	0.0537
SPECIFIC ACTIVITY SA	1.7302	1.8626	1.6145	1.7951	1.9529
CONVERSION					
ON CO %	33.29	29.10	26.54	29.26	31.18
ON H2 %	63.03	59.11	53.99	58.02	61.49
ON CO+H2 %	47.81	43.65	39.51	43.22	46.25
PRDT SELECTIVITY,WT %					
CH4	19.20	12.95	14.71	13.29	11.96
C2 HC'S	2.96	1.97	2.07	1.82	1.67
C3H8	3.55	2.24	2.53	2.31	2.08
C3H6=	2.27	2.29	2.52	2.32	2.07
C4H10	3.19	2.20	2.52	2.29	2.04
C4H8=	3.53	2.89	3.26	3.03	2.68
C5H12	3.52	2.57	2.96	2.76	2.49
C5H10=	2.94	2.67	2.97	2.78	2.53
C6H14	4.14	3.21	3.74	3.18	2.82
C6H12= & CYCLO'S	1.80	1.38	1.98	1.66	1.48
C7+ IN GAS	9.73	8.96	10.82	8.98	8.27
LIQ HC'S	43.18	56.67	49.92	55.58	59.90
TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	34.69	24.55	27.61	25.05	22.50
C5 -420 F	36.94	35.50	39.54	36.87	36.52
420-700 F	20.60	26.24	24.36	26.79	28.69
700-END PT	7.77	13.71	8.49	11.28	12.28

Table B7 (continued)

FILE: 1220015B TSS3Q1 A1

C5+-END PT	65.31	75.45	72.39	74.95	77.50
ISO/NORMAL MOLE RATIO					
C4	0.0207	0.0212	0.0161	0.0163	0.0140
C5	0.0713	0.0551	0.0489	0.0603	0.0541
C6	0.1321	0.0785	0.0841	0.0773	0.0768
C4=	0.0000	0.0000	0.0000	0.0000	0.0000
PARAFFIN/OLEFIN RATIO					
C3	1.4908	0.9341	0.9601	0.9530	0.9572
C4	0.8731	0.7362	0.7444	0.7291	0.7360
C5	1.1608	0.9354	0.9701	0.9658	0.9542
SCHULZ-FLORY DISTRBTN					
ALPHA (EXP(SLOPE))	0.8269	0.8576	0.8354	0.8501	0.8591
RATIO CH4/(1-A)**2	6.4051	6.3909	5.4305	5.9192	6.0274
ALPHA FRM CORRELATION	0.8421	0.8411	0.8395	0.8396	0.840[illegible]
ALPHA (EXPTL/CORR)	0.9819	1.0196	0.9951	1.0126	1.0226
W%CH4 FRM CORRELATION	15.7291	14.9584	15.4522	15.4360	15.2543
W%CH4 (EXPTL/CORR)	1.2207	0.8658	0.9520	0.8611	0.7841
LIQ HC COLLECTION					
PHYS. APPEARANCE	OIL WAX	OIL WAX	OIL WAX	OIL WAX	OIL WAX
DENSITY	N/A	0.773	0.769	0.777	0.765
N, REFRACTIVE INDEX	N/A	N/A	N/A	N/A	N/A
SIMULT'D DISTILATN					
10 WT % @ DEG F	292	298.	299	300	299
16	331	338	338	341	340
50	504	534	502	516	516
84	720	773	706	740	740
90	809	856	776	814	808
RANGE(16-84 %)	389	435	368	399	400
WT % @ 420 F	34.30	29.50	34.20	31.50	31.60
WT % @ 700 F	82.00	75.80	83.00	79.70	79.50

Table B8

FILE: 1220015C TSS3Q1 A1

RESULT OF SYNGAS OPERATION

RUN NO. 12200-15
CATALYST CO/X9/X10-U113 80 CC 34.2 G AFTER RUN:51.4 G (+17.2 G)
FEED H2:CO OF 50:50 @ 400 CC/MN OR 300 GHSV (CAT#12251-52-32)

RUN & SAMPLE NO.	12200-15-12	200-15-13	200-15-14	200-15-15	200-15-16
FEED H2:CO:AR	50:50: 0	50:50: 0	50:50: 0	50:50: 0	50:50: 0
HRS ON STREAM	282.2	306.0	330.0	354.0	378.0
PRESSURE,PSIG	300	300	300	300	300
TEMP. C	250	250	260	259	259
FEED CC/MIN	400	400	400	400	400
HOURS FEEDING	24.00	23.75	24.00	24.00	24.00
EFFLNT GAS LITER	418.02	333.88	325.85	321.50	328.50
GM AQUEOUS LAYER	44.27	43.80	43.66	46.87	47.05
GM OIL	23.14	20.90	20.36	18.08	18.67
MATERIAL BALANCE					
GM ATOM CARBON %	116.48	94.85	97.71	94.71	95.72
GM ATOM HYDROGEN %	105.15	90.19	92.53	91.26	95.27
GM ATOM OXYGEN %	114.69	96.34	98.13	97.77	92.57
RATIO CHX/(H2O+CO2)	1.0677	0.9413	0.9853	0.8968	1.1268
RATIO X IN CHX	2.3932	2.3852	2.5605	2.5491	2.5390
USAGE H2/CO PRODT	1.8272	1.9552	1.6871	1.8009	2.0941
FEED H2/CO FRM EFFLNT	0.9027	0.9508	0.9470	0.9637	0.9954
RESIDUAL H2/CO RATIO	0.5610	0.5652	0.5313	0.5324	0.5300
RATIO CO2/(H2O+CO2)	0.1155	0.0955	0.2230	0.1885	0.0229
K SHIFT IN EFFLNT	0.0733	0.0597	0.1525	0.1237	0.0124
SPECIFIC ACTIVITY SA	1.6411	1.6583	1.4498	1.4132	1.1940
CONVERSION					
ON CO %	26.98	27.74	35.97	34.00	29.75
ON H2 %	54.62	57.05	64.08	63.53	62.60
ON CO+H2 %	40.09	42.03	49.64	48.49	46.14
PRDT SELECTIVITY,WT %					
CH4	14.47	13.91	22.25	21.87	21.55
C2 HC'S	2.03	1.80	3.02	3.06	2.90
C3H8	2.48	2.47	3.96	3.98	3.77
C3H6=	2.47	2.45	2.01	2.46	2.24
C4H10	2.56	2.49	3.44	3.37	3.33
C4H8=	3.24	3.16	3.19	3.24	3.26
C5H12	3.06	3.04	3.94	3.90	3.78
C5H10=	3.07	3.04	1.92	2.04	3.05
C6H14	3.57	3.60	4.30	4.18	4.10
C6H12= & CYCLO'S	4.31	1.75	1.54	1.56	1.80
C7+ IN GAS	10.99	10.53	9.35	11.01	11.47
LIQ HC'S	47.74	51.75	41.08	39.33	38.74
TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	27.27	26.28	37.87	37.98	37.06
C5 -420 F	39.27	38.27	36.53	39.20	40.47
420-700 F	22.20	25.36	20.46	18.96	19.25
700-END PT	11.27	10.09	5.14	3.85	3.22

Table B8 (continued)

FILE: 1220015C TSS3Q1 A1

C5+-END PT	72.73	73.72	62.13	62.02	62.94
ISO/NORMAL MOLE RATIO					
C4	0.0155	0.0159	0.0220	0.0197	0.0177
C5	0.0546	0.0516	0.0849	0.0878	0.0758
C6	0.0723	0.0785	0.1368	0.1259	0.1200
C4=	0.0000	0.0000	0.0000	0.0000	0.0000
PARAFFIN/OLEFIN RATIO					
C3	0.9591	0.9639	1.8826	1.5424	1.6103
C4	0.7636	0.7596	1.0415	1.0030	0.9869
C5	0.9677	0.9713	1.9971	1.8562	1.2057
SCHULZ-FLORY DISTRBTN					
ALPHA (EXP(SLOPE))	0.8447	0.8474	0.8253	0.8165	0.8071
RATIO CH4/(1-A)**2	6.0015	5.9750	7.2917	6.4974	5.7941
ALPHA FRM CORRELATION	0.8395	0.8392	0.8416	0.8416	0.8418
ALPHA (EXPTL/CORR)	1.0062	1.0099	0.9807	0.9703	0.9588
W%CH4 FRM CORRELATION	15.4566	15.5692	16.9521	16.7554	16.6856
W%CH4 (EXPTL/CORR)	0.9364	0.8934	1.3125	1.3053	1.2918
LIQ HC COLLECTION					
PHYS. APPEARANCE	OIL WAX	OIL WAX	OIL WAX	OIL WAX	OIL WAX
DENSITY (* 40 C)	0.789	0.769	0.727	0.760	0.761
N, REFRACTIVE INDEX	N/A	N/A	N/A	1.4192*	1.4186*
SIMULT'D DISTILATN					
10 WT % @ DEG F	296	299	291	298	298
16	337	341	323	315	309
50	533	516	482	454	452
84	767	728	670	648	625
90	841	795	723	697	681
RANGE(16-84 %)	430	387	347	333	316
WT % @ 420 F	29.90	31.50	37.70	42.00	42.00
WT % @ 700 F	76.40	80.50	87.50	90.20	91.70

IV. Run 28 (12200-17) with Catalyst 28 ($Co/X_9/X_{10}/X_4$/UCC-113)

This run continues the search for a way to incorporate the excellent stabilizing properties of additive X_4 into a cobalt/X_9/X_{10} catalyst formulated by the method developed for Catalyst 11. The X_4 was obtained from the same source as that used in Catalyst 25, which produced higher syngas conversion activity than did the X_4 from any of the other sources tested. The order of introducing the additives, however, was different than for Catalyst 25, the X_4 not having been added until after the cobalt had been promoted with X_9 and X_{10} and intimately contacted with UCC-103. Also, the theoretical concentrations of cobalt, X_9 and X_{10} (4.1, 0.19 and 0.25 percent respectively) were lower than in Catalyst 25 (7.2, 0.32 and 0.43 percent respectively), while the concentration of X_4 was higher (0.58 vs. 0.33 percent).

Conversion, product selectivity, isomerization of the pentane, and percent olefins of the C_4's are plotted against time on stream in Figs. B117-120. Simulated distillations of the C_5^+ product are plotted in Figs. B121-122. Carbon number product distributions are plotted in Figs. B123-124. Chromatograms from simulated distillations are reproduced in Figs. B125-126. Detailed material balances appear in Table B9.

The syngas conversion activity was fairly low, with initial conversion of 27.0 percent at 240C and calculated specific activ-