TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	58.65	53.97	56.75	55.91	50.86
C5 - 420 F	41.35	46.03	43.25	44.09	49.14
420-700 F	0.00	0.00	0.00	0.00	0.00
700- END PT	0.00	0.00	0.00	0.00	0.00
C5+-END PT	41.35	46.03	43.25	44.09	49.14
ISO/NORMAL MOLE RATIO					
C4	0.3069	0.2000	0.0000	0.0000	0.1196
C5	0.4231	0.2576	0.0000	0.0000	0.2000
C6	0.9667	0.6000	0.4364	0.3673	0.3500
C4=	0.0634	0.0558	0.0000	0.0000	0.0000
PARAFFIN/OLEFIN RATIO					
C3	0.5061	0.4877	0.5000	0.4708	0.5047
C4	0.4371	0.4758	0.3947	0.4135	0.5347
C5	0.7303	0.6803	0.5718	0.6044	0.5366
GIQ HC COLLECTION					
PHYS. APPEARANCE					
DENSITY					
N, REFRACTIVE INDEX					
SIMULT'D DISTILATN					
10 WT % @ DEG F					
16					
50					
84					
90					
RANGE(16-84 %)					
WT % @ 420 F					
WT % @ 700 F					

TABLE 146 RESULT OF SYNGAS OPERATION

RUN NO 10112 02
CATALYST CO SIO2-AL2O3 #10042 1% 800C 40 196 148.42G AFTER RUN,18.26G
FEED H2:CO:ARGON OF 50:50: 0 @ 400 CC/MN OR 900 GHSV

RUN & SAMPLE NO	10112 02 06	012 02 07	012 02 08	012 02 09	012 02 10
FEED H2:CO AR	50:50: 0	50:50: 0	50:50: 0	50.50. 0	50.50. 0
HRS ON STREAM	78.66	97.11	103 66	119 58	127 25
PRESSURE,PSIG	285	291	285	290	291
TEMP. C	270	251	252	252	252
FEED CC/MIN	400	400	400	400	400
BOOKE FEEDING	6 25	14 67	6 11	22 25	7 67
EFFLNT GAS LITER	150 18	152 57	106 11	167 81	119 82
GM AQUEOUS LAYER	0 84	2 62	1 50	60 62	14 26
GM OIL	0 98	1 71	1 93	10 29	4 72
MATERIAL BALANCE					
GM ATOM CARBON %	102 6%	101 6%	96 16	99 30	96 41
GM ATOM HYDROGEN %	107 76	99 4%	102 64	98 07	96 46
GM ATOM OXYGEN %	103 53	101 27	102 2%	102 74	96 7o
RATIO CH4/CH2+/CO2+	0 6726	0 9074	0 8288	0 8551	0 90%
RATIO X IN CH4	2 5141	2 6104	2 6688	2 5016	2 4424
USAGE H2/CO PROD	2 0611	2 1557	2 1047	2 1229	2 1122
RATIO CO2+/H2O+CO2+	0 0261	0 0477	0 0318	0 0321	0 0380
% SHIFT IN EFFLNT	0 03	0 04	0 02	0 02	0 02
CONVERSION					
ON CO %	4 78	11 59	20 96	21 27	21 57
ON H2 %	10 07	17 47	46 56	49 45	51 63
ON CO+H2 %	7 49	26 81	33 97	35 27	37 56
PROT SELECTIVITY,WT %					
CH4	15 11	27 57	21 21	22 64	20 05
C2 HC'S	1 88	2 95	2 10	2 43	2 15
C3H8	1 67	4 40	3 50	3 75	3 30
C3H6-	1 19	3.58	2.74	2 70	2 39
C4H10	1.76	3.55	2.88	3 06	2.71
C4H8 -	3.21	4.80	3 66	3.68	3 26
C5H12	1.09	4.22	3.40	3.67	3.25
C5H10	2.70	4.41	3.51	3.52	3 12
C6H14	2.39	4.78	4.02	4.13	3.66
C6H12- & CYCLO'S	3.07	3.28	2.54	2.65	2.35
C7+ IN GAS	17.60	19.08	17.78	16.11	14.28
LIQ HC'S	46.33	17.37	32.66	31.66	19.48

TOTAL	100.00	100.00	100.00	100.00	100.00
SUB GROUPING:					
C1 - C4	26.82	26.84	36.10	38.24	41.87
C5 - 220 F	34.26	43.00	49.21	44.44	48.12
220 700 F	33.87	9.67	11.04	10.17	13.82
700 END PT	5.05	0.49	1.27	2.22	1.95
C5+ END PT	73.18	53.16	63.90	61.76	66.13
C5: NORMAL MOLE RATIO					
C5	0.2481	0.0413	0.0176	0.0205	0.0205
C6	0.4817	0.0650	0.0606	0.0455	0.0455
C8	0.7594	0.1498	0.1524	0.1087	0.1087
C9	0.0000	0.0209	0.0302	0.0295	0.0295
PARAFFIN/OLEFIN RATIO					
C5	0.5000	1.1727	1.2185	1.1190	1.1190
C6	0.5406	0.1427	0.7611	0.8015	0.8015
C9	0.9949	0.9264	0.9427	1.0147	1.0147
LIQ HC COLLECTION					
PHYS APPEARANCE	GREEN OIL	YLW OIL		GREEN OIL	
DENSITY		0.733		0.757	
N, REFRACTIVE INDEX		1.4284		1.4265	
SIMULTD DISTILATN					
IP WT % @ 150 F	0.04	3.21		0.07	
10	0.20	3.65		3.41	
30	7.31	9.52		9.60	
50	8.66	9.96		8.75	
90	7.06	8.11		8.75	
RANGE(10 - 90 %)	7.46	4.61		5.34	
WT % @ 220 F	10.00	21.50		21.10	
WT % @ 700 F	89.10	97.50		91.00	

TABLE 14C RESULT OF SYNGAS OPERATION

RUN NO. 10112-02
CATALYST CO-SIO2+AL2O3 #10042-15 80CC 4.19G (48.42G AFTER RUN,+8.23G)
FEED H2:CO:ARGON OF 50:50: 0 @ 240 CC/MN OR 300 GHSV

RUN & SAMPLE NO.	10112-02-11	112-02-12	012-02-13	012-02-14	012-02-15
FEED H2:CO:AR	88:12: 0	50:50: 0	50:50: 0	50:50: 0	50:50: 0
HRS ON STREAM	143.58	151.41	168.91	171.66	192.08
PRESSURE,PSIG	295	300	299	299	297
TEMP. C	251	252	252	252	252
FEED CC/MIN	341	400	400	400	400
HOURS FEEDING	24.00	7.83	17.50	20.25	20.42
EFFLNT GAS LITER	339.90	104.75	274.52	318.22	329.65
GM AQUEOUS LAYER	44.61	15.82	35.47	41.04	40.13
GM OIL	14.77	4.81	9.50	10.99	11.92
MATERIAL BALANCE					
GM ATOM CARBON %	64.23	84.73	94.96	95.32	97.39
GM ATOM HYDROGEN %	101.47	89.47	98.93	99.14	101.05
GM ATOM OXYGEN %	110.82	89.62	99.94	100.14	101.00
RATIO CHX/(H2O+CO2)	0.5791	0.8080	0.8075	0.8137	0.8571
RATIO X IN CHX	2.1653	2.4278	2.4682	2.4721	2.4609
USAGE H2/CO PRODT	2.0606	2.1028	2.1302	2.1311	2.1376
RATIO CO2/(H2O+CO2)	0.0000	0.0257	0.0228	0.0234	0.0222
K SHIFT IN EFFLNT	0.00	0.02	0.02	0.02	0.02
CONVERSION					
ON CO %	99.82	25.08	22.61	22.72	22.76
ON H2 %	24.80	55.69	51.59	51.74	50.70
ON CO+H2 %	30.89	40.80	37.40	37.52	36.99
PRDT SELECTIVITY,WT %					
CH4	7.19	18.33	20.46	20.50	20.09
C2 HC'S	0.56	2.39	2.34	2.39	2.39
C3H8	0.85	4.08	4.19	4.32	4.11
C3H6=	0.00	2.18	2.30	2.33	2.18
C4H10	1.19	3.48	3.41	3.58	3.39
C4H8=	0.00	2.89	3.05	3.31	3.01
C5H12	2.42	3.96	4.10	4.25	4.03
C5H10=	0.27	2.47	2.74	2.85	2.65
C6H14	3.40	4.54	4.60	4.66	4.47
C6H12= & CYCLO'S	0.70	1.88	2.07	2.06	2.03
C7+ IN GAS	17.89	12.02	14.42	13.76	13.88
LIQ HC'S	65.53	41.78	36.31	35.99	37.76

TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1 -C4	9.79	33.36	35.76	36.44	35.18
C5 -420 F	52.72	40.57	47.90	42.62	47.83
420-700 F	32.96	22.56	12.71	17.74	13.21
700-END PT	4.52	3.51	3.63	3.20	3.78
C5+-END PT	90.21	66.64	64.24	63.56	64.82
ISO/NORMAL MOLE RATIO					
C4	0.0469	0.0220	0.0179	0.0255	0.0225
C5	0.1199	0.0177	0.0319	0.0336	0.0299
C6	0.2063	0.0931	0.0864	0.0977	0.0958
C4=	0.0000	0.0347	0.0284	0.0290	0.0329
PARAFFIN/OLEFIN RATIO					
C3	0.0000	1.7892	1.7416	1.7704	1.8010
C4	1000.0000	1.1611	1.0789	1.0440	1.0843
C5	8.7460	1.5552	1.4571	1.4482	1.4796
LIQ HC COLLECTION					
PHYS. APPEARANCE	GREEN OIL	GREEN OIL	---	GREEN OIL	---
DENSITY	0.750	0.760	---	0.751	---
N, REFRACTIVE INDEX	1.4261	1.4279	---	1.4261	---
SIMULT'D DISTILATN					
10 WT % @ DEG F	304	306	---	305	---
16	341	343	---	341	---
50	449	480	---	453	---
84	626	652	---	652	---
90	674	692	---	696	---
RANGE(16-84 %)	285	309	---	311	---
WT % @ 420 F	42.80	37.60	---	41.80	---
WT % @ 700 F	93.10	91.60	---	91.10	---

TABLE 14D RESULT OF SYNGAS OPERATION

RUN NO. 10112-02
CATALYST CO-SIO2+AL2O3 #10042-15 80CC 40.19G (48.42G AFTER RUN,+8.23G)
FEED H2:CO:ARGON OF 50:50: 0 @ 400 CC/MN OR 300 GHSV

RUN & SAMPLE NO.	10112-02-16
FEED H2:CO:AR	50:50: 0
HRS ON STREAM	195.91
PRESSURE,PSIG	296
TEMP. C	252
FEED CC/MIN	400
HOURS FEEDING	24.25
EFFLNT GAS LITER	391.60
GM AQUEOUS LAYER	47.66
GM OIL	14.16
MATERIAL BALANCE	
GM ATOM CARBON %	97.72
GM ATOM HYDROGEN %	101.24
GM ATOM OXYGEN %	101.08
RATIO CHX/(H2O+CO2)	0.8664
RATIO X IN CHX	2.4634
USAGE H2/CO PRODT	2.1392
RATIO CO2/(H2O+CO2)	0.0226
K SHIFT IN EFFLNT	0.02
CONVERSION	
ON CO %	22.94
ON H2 %	50.93
ON CO+H2 %	37.19
PRDT SELECTIVITY,WT %	
CH4	20.15
C2 HC'S	2.34
C3H8	4.20
C3H6=	2.29
C4H10	3.57
C4H8=	3.24
C5H12	4.08
C5H10=	2.82
C6H14	4.54
C6H12= & CYCLO'S	2.00
C7+ IN GAS	13.43
LIQ HC'S	37.34

TOTAL	100.00
SUB-GROUPING	
C1 -C4	35.79
C5 -420 F	41.44
420-700 F	18.82
700-END PT	3.96
C5+-END PT	64.21
ISO/NORMAL MOLE RATIO	
C4	0.0239
C5	0.0323
C6	0.0983
C4=	0.0379
PARAFFIN/OLEFIN RATIO	
C3	1.7512
C4	1.0642
C5	1.4057
LIQ HC COLLECTION	
PHYS. APPEARANCE	GREEN OIL
DENSITY	0.750
N, REFRACTIVE INDEX	1.4264
SIMULT'D DISTILATN	
10 WT % @ DEG F	307
16	343
50	480
84	659
90	703
RANGE(16-84 %)	316
WT % @ 420 F	39.00
WT % @ 700 F	89.40

Cobalt Pore-Filled on UCC-101, Run 10011-14

This catalyst was prepared in the same manner as the previously discussed cobalt catalyst except UCC-101 extrudate replaced the silica-alumina extrudate. Again the cobalt loading was 10%.

The conversion, product selectivity, percent iso- of the pentanes, and the percent olefins of the C_4's are shown in Figures 96 to 99. Figures 100 to 116 contain the carbon number product distributions. The detailed material balances are presented in Tables 15A to 15E.

As can be seen in Figure 96, this catalyst has activity at 220°C. The conversion is low but steady. The conversion is quite good at 250°C especially considering the low metal loading of this catalyst. The high H_2/CO usage ratio shows that this catalyst also lacks WGS activity and can not use the 1:1 syngas efficiently. The catalyst later used 2:1 syngas very efficiently. The drop in conversion at 150 hours on stream was caused by a doubling of the space velocity. After the initial sample the catalyst shows no signs of deactivation.

On a carbon number basis, the product selectivity is excellent, although the methane yield is again quite high. As can be seen in the carbon number product distribution, the methane yield is again out of line with the yields of the other hydrocarbons. This again implies a separate methanation mechanism. The C_5^+ yield is excellent, accounting for over 75% of the hydrocarbon product. Almost 70% of the hydrocarbons boil in the desired motor fuel range, C_5-700°F. This kind of selectivity was not achieved with the iron catalysts. A hypothetical catalyst with an exact Schultz-Flory product distribution could produce almost 72% of the product in the motor fuel range. Such a catalyst would produce less than 3% methane and almost 9% material boiling above 700°F. This catalyst, except for the excess methane production, is exceeding this best possible S-F catalyst for the production of motor fuel. This can be seen in the carbon number distribution plots, Figures 100 to 116. The catalyst had the most favorable product distribution at 250°C with the lower space velocity. Samples 7 to 11 particularly show a distinct carbon number cut off above C_{20}. If the methanation reaction could be avoided, such a catalyst would be unmatched for production of motor fuel range products. Doubling the space velocity at 250°C lowered the yield of gasoline and diesel oil to 64%, which is still better than the iron catalysts.

There is still a question of the quality of the motor fuels produced. The C_4's are approximately 70% olefins. The refractive index of the liquid is consistent with this but with such heavy liquids such an estimate is unreliable. Very little of the pentane is isomerized. The isomerization activity showed deactivation at 250°C. The catalyst began producing a waxy condensed product just prior to the space velocity change. The chromatograms from the simulated distillations, Figures 117 to 123, show the same trend in isomerization as did pentane. By Sample 12, the liquid is clearly dominated by the normals.

The product quality of the gasoline produced by this catalyst is clearly inferior to that produced by iron + UCC-108 but the quantity of motor fuels produced is good. This catalyst has proven the usefulness of cobalt, even unpromoted cobalt, for use in this kind of molecular sieve containing catalyst.

FIGURE 96

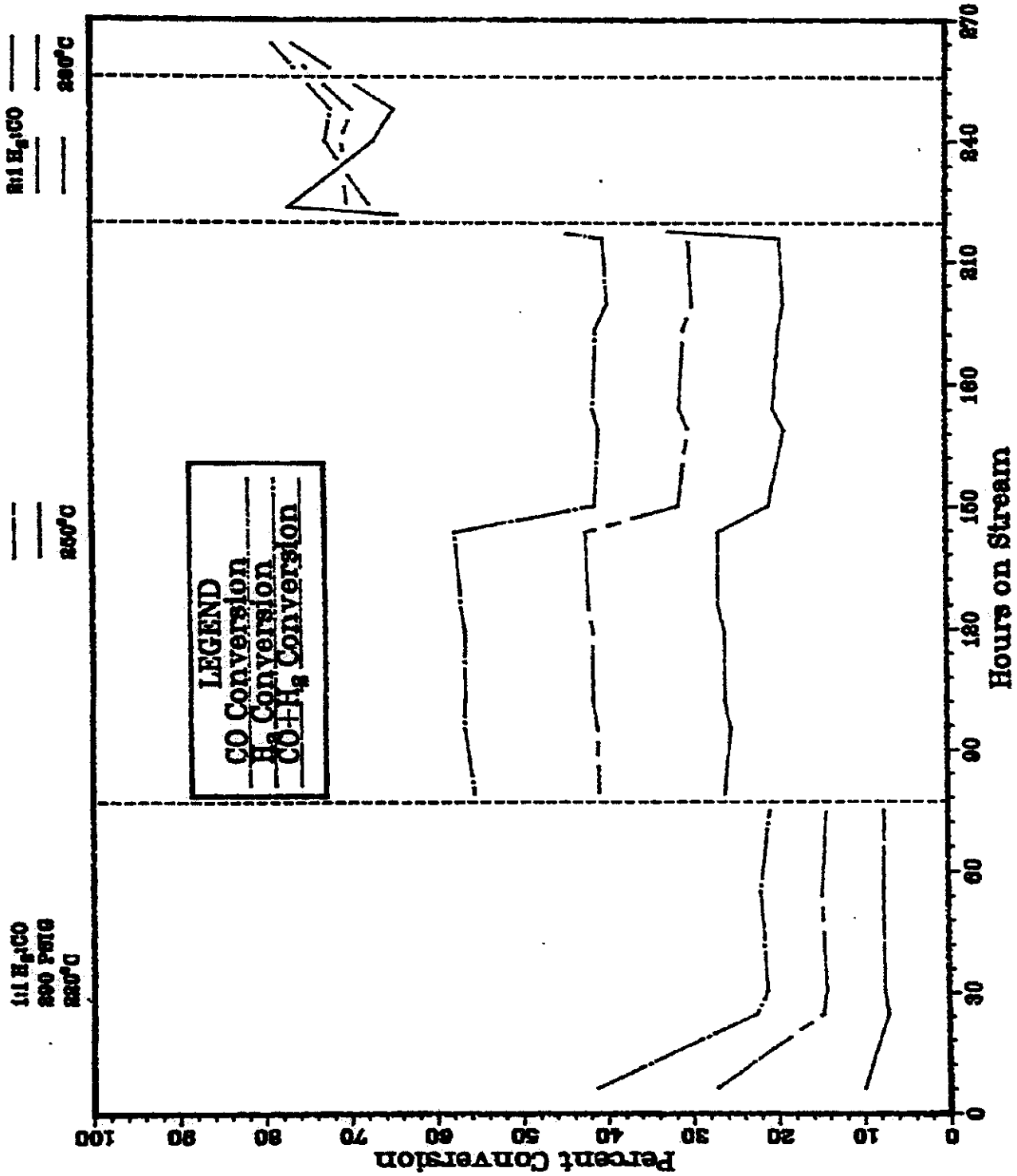


FIGURE 97

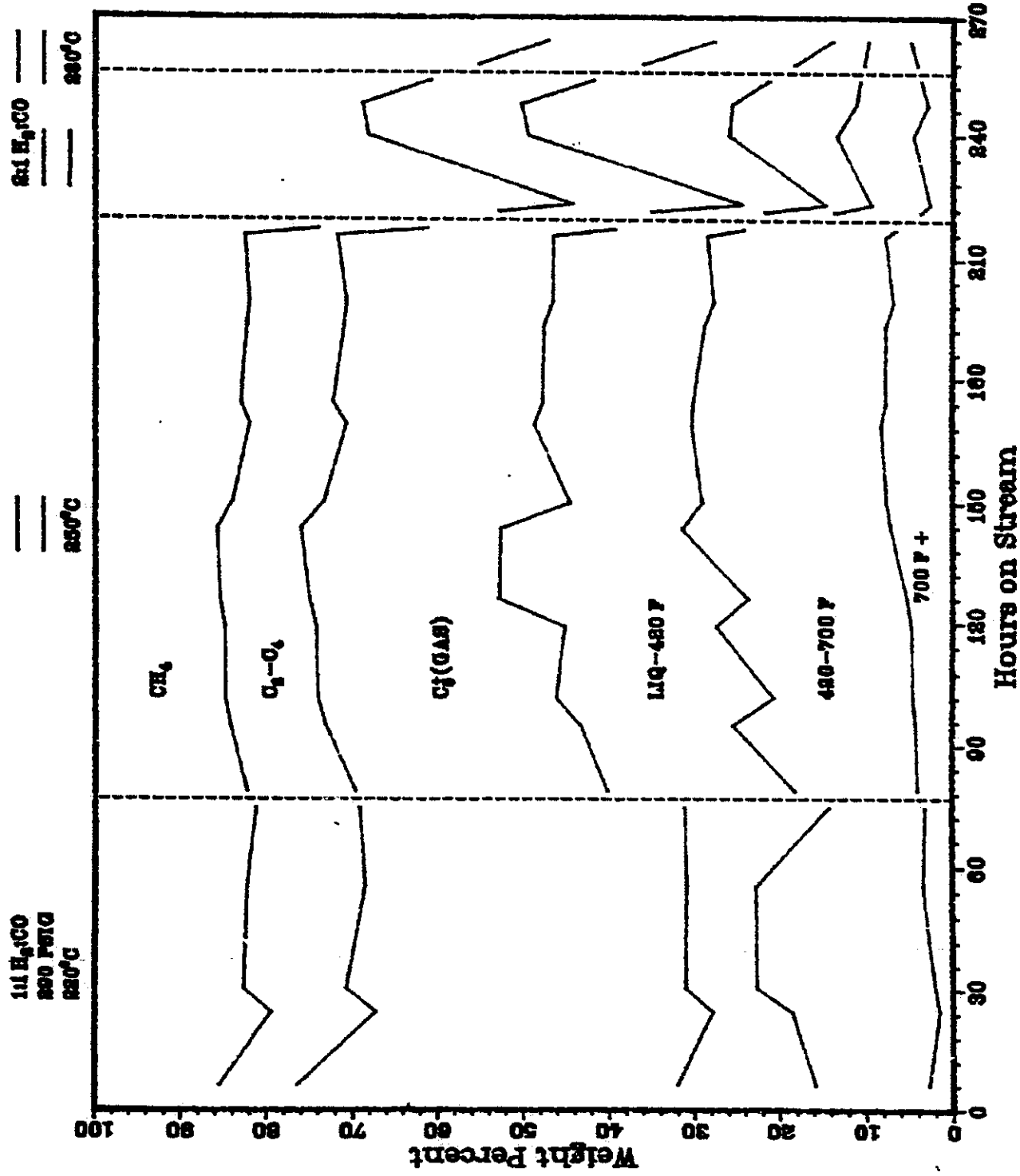


FIGURE 98

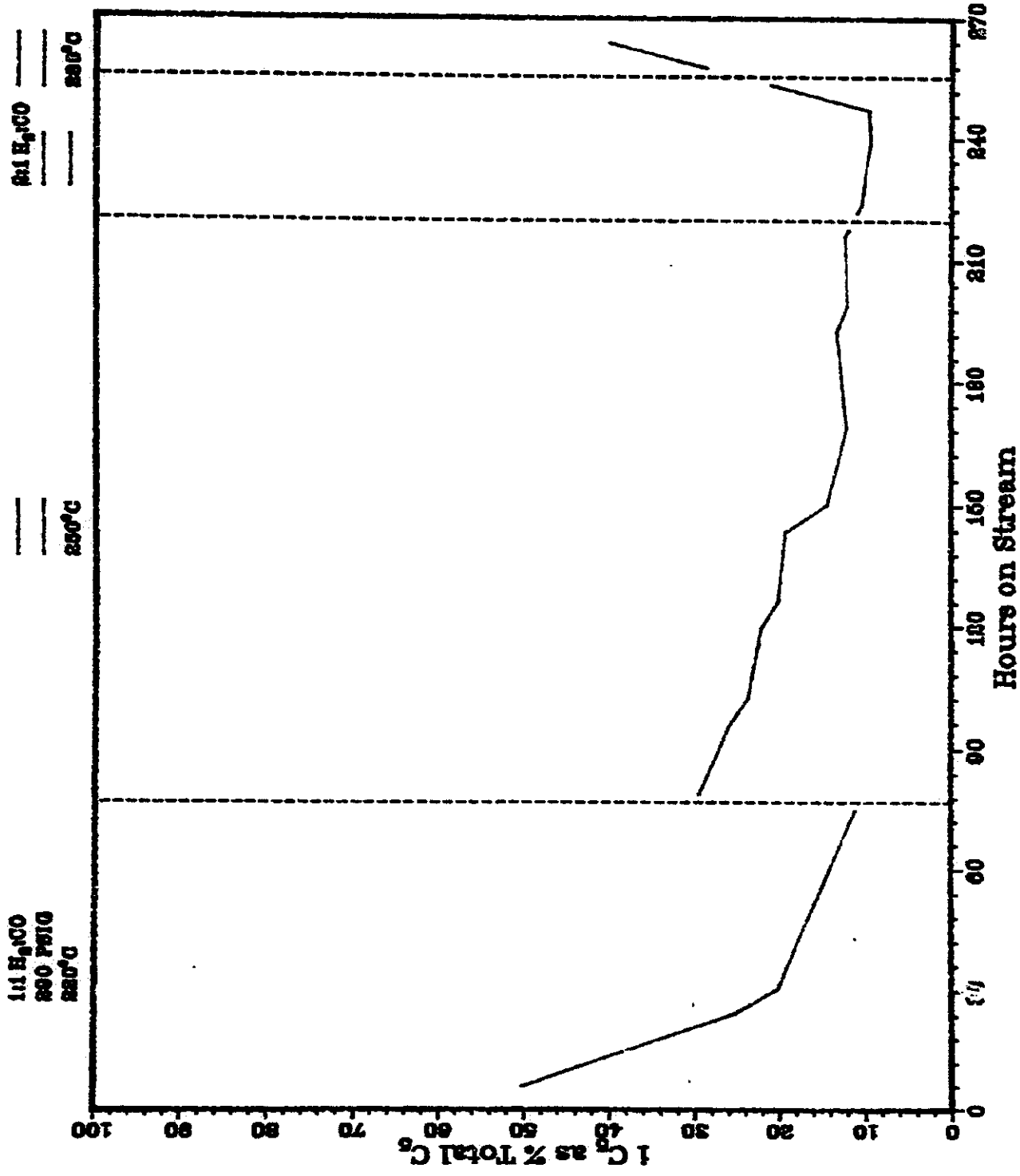
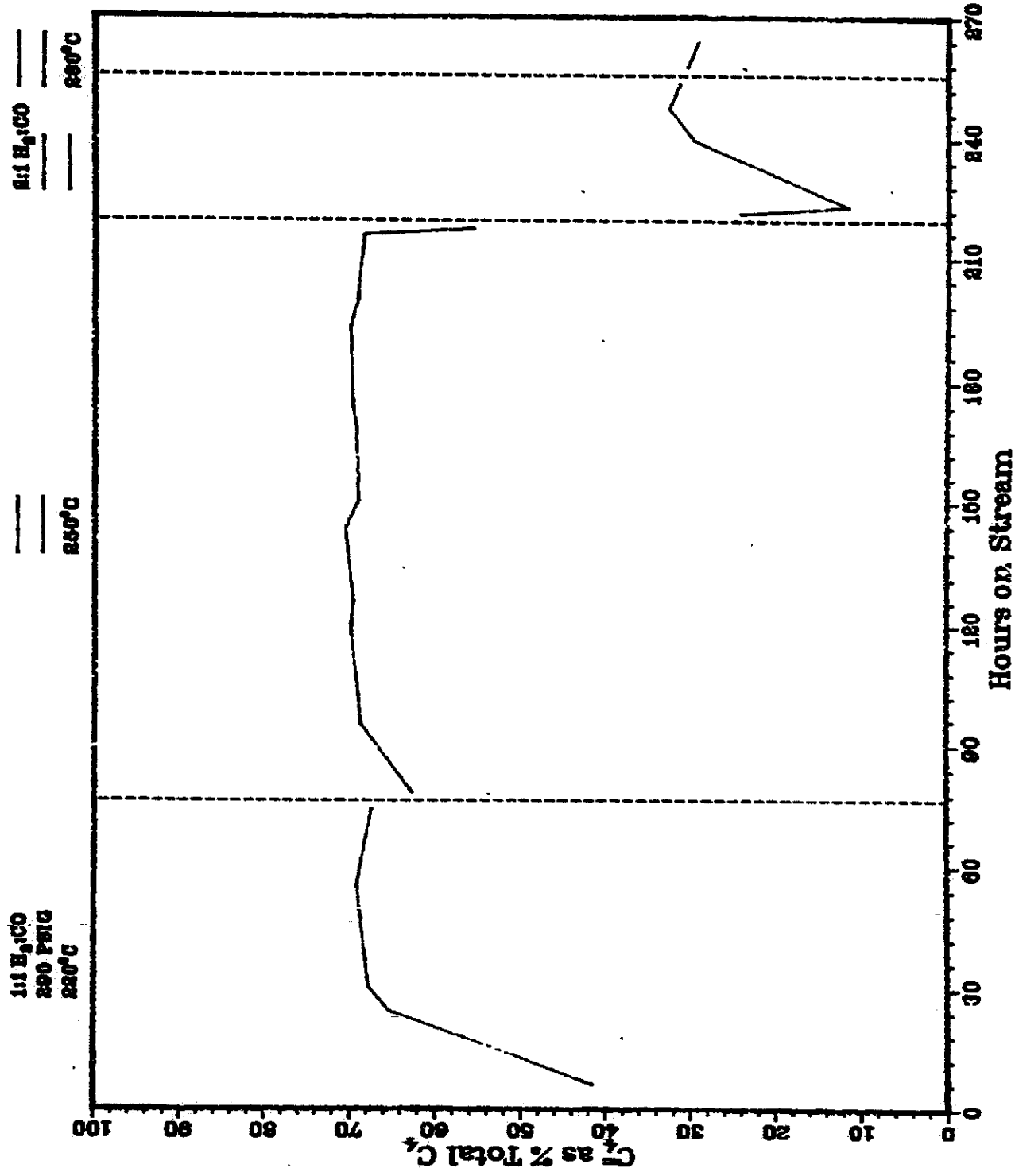

1:1 H_2CO
880 PSIG
280°C
1:1 H_2CO
280°C
280°C
% C_5 as % Total C_5
Hours on Stream
0
10
20
30
40
50
60
70
80
90
100
0
30
60
90
120
150
180
210
240
270

FIGURE 99



1001114

FIGURE 100

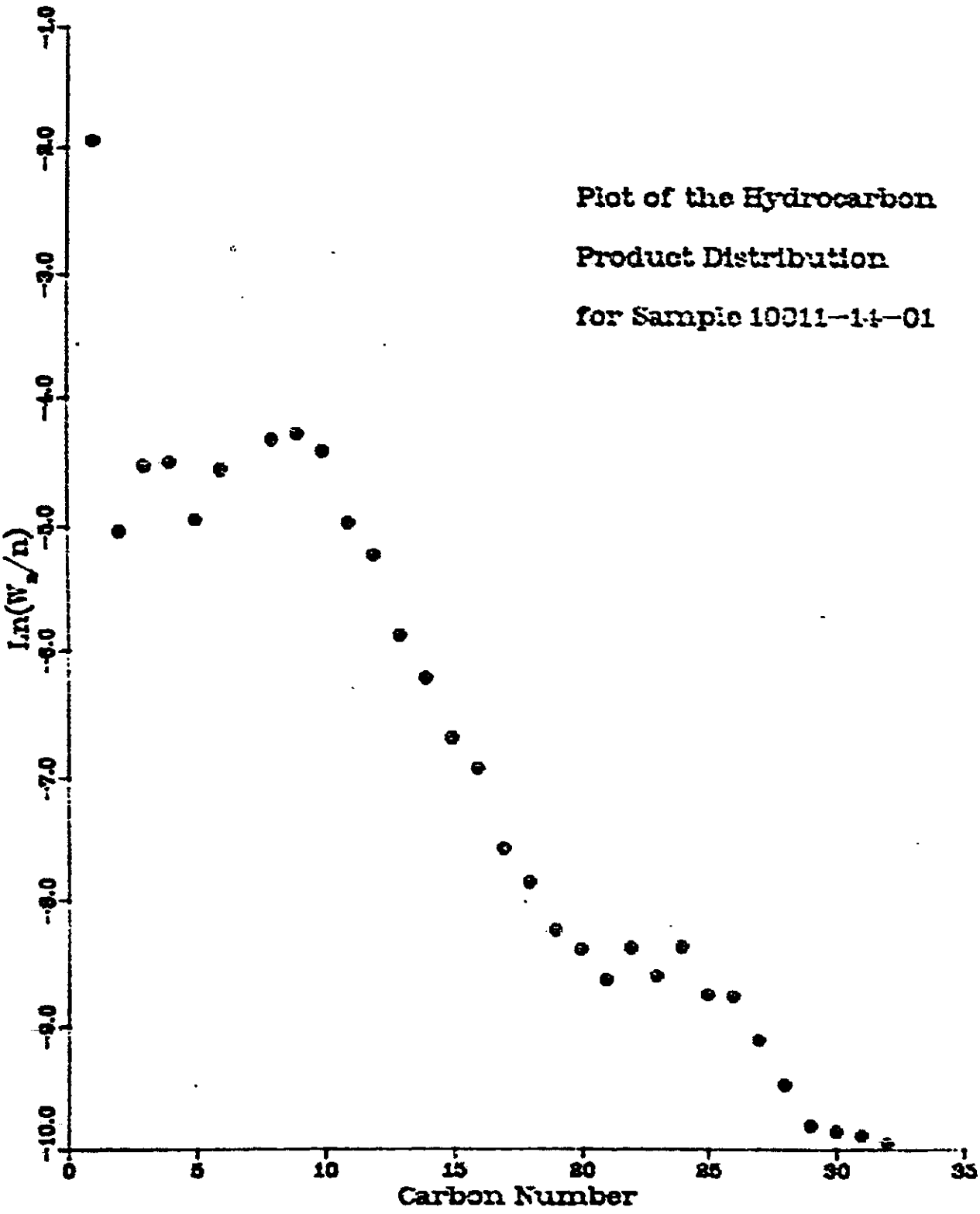

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-01
Ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
Carbon Number

FIGURE 101

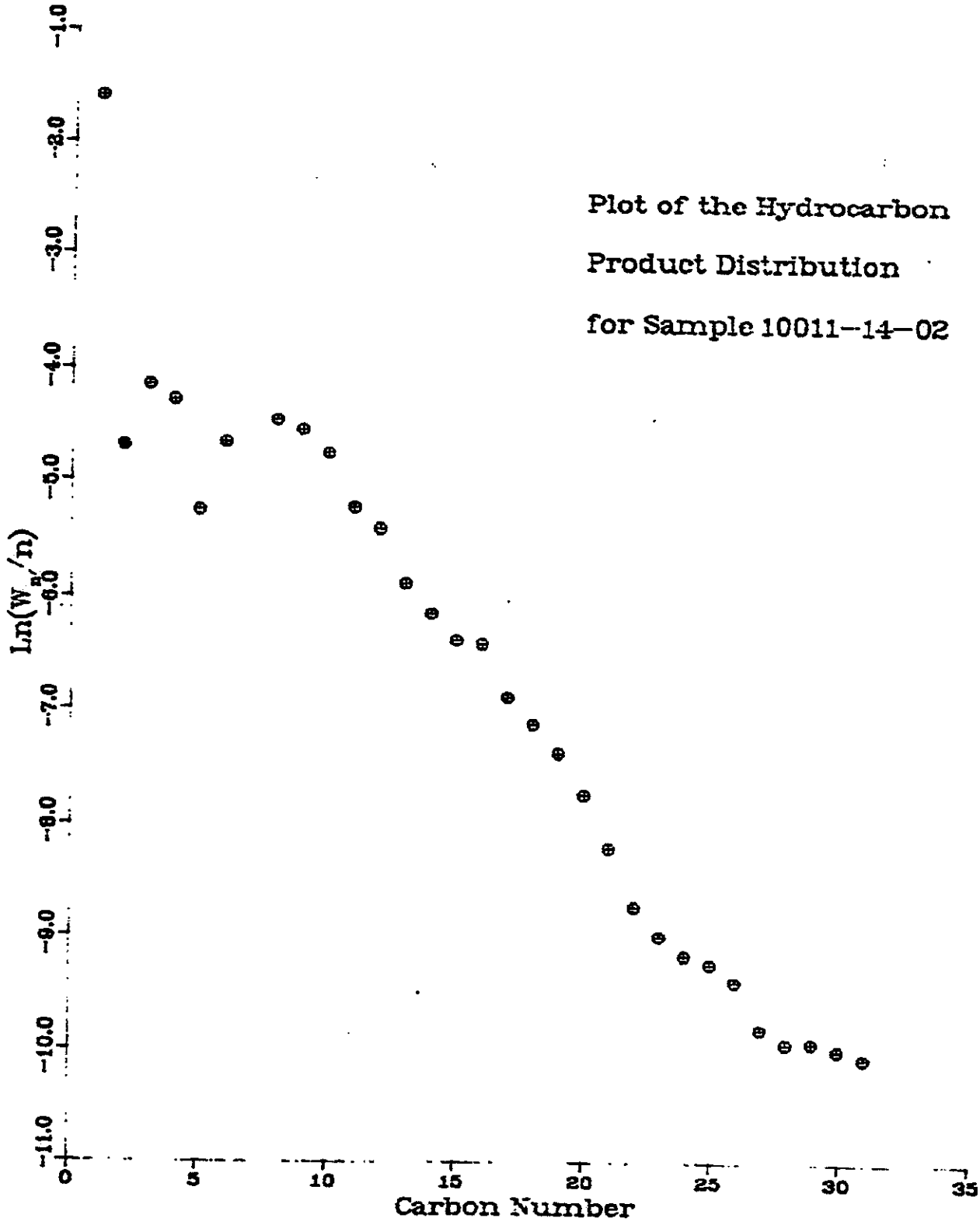

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-02
Ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
Carbon Number

FIGURE 102

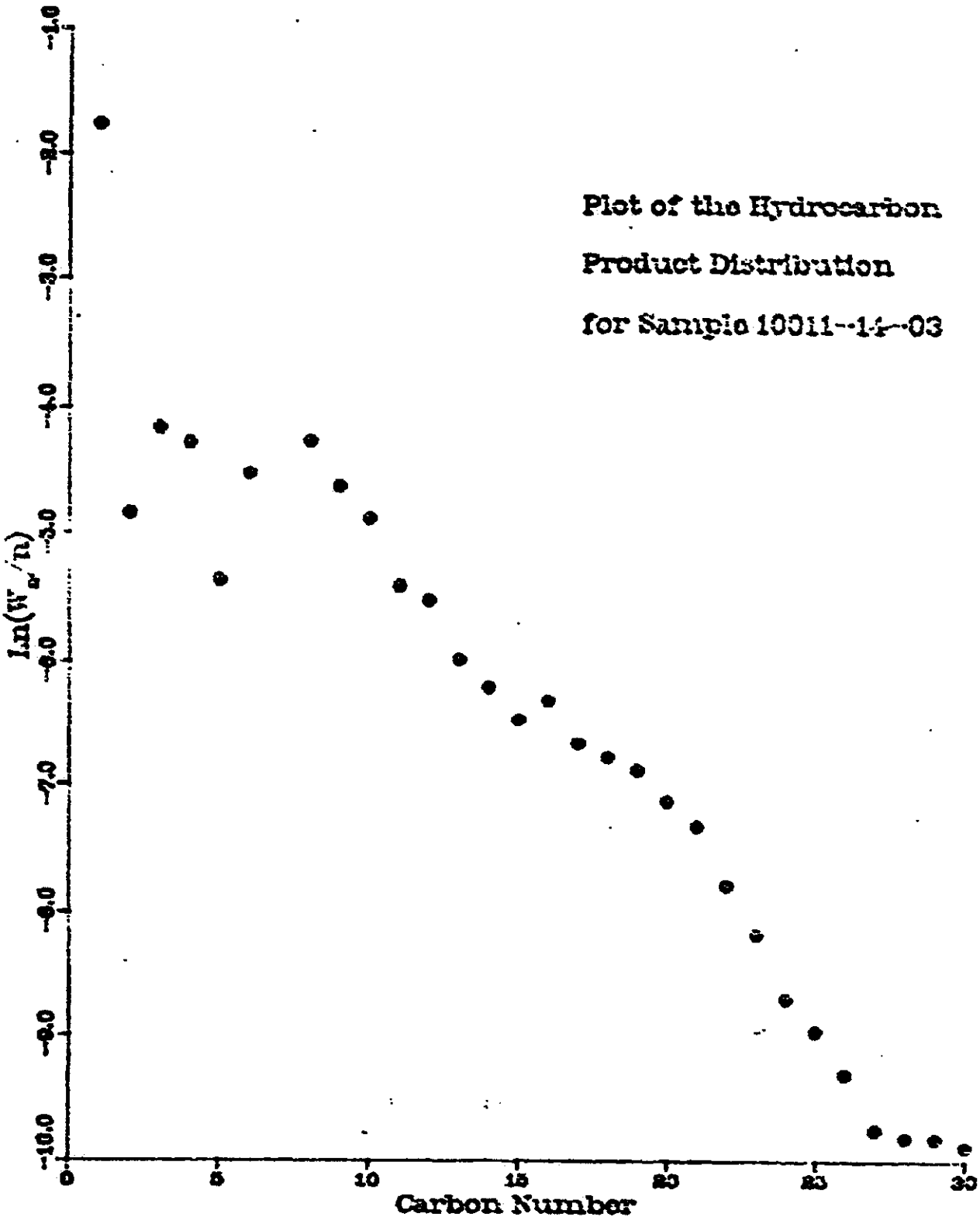

Plot of the Hydrocarbon
Product Distribution
for Sample 10011--14--03
ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
Carbon Number

FIGURE 103

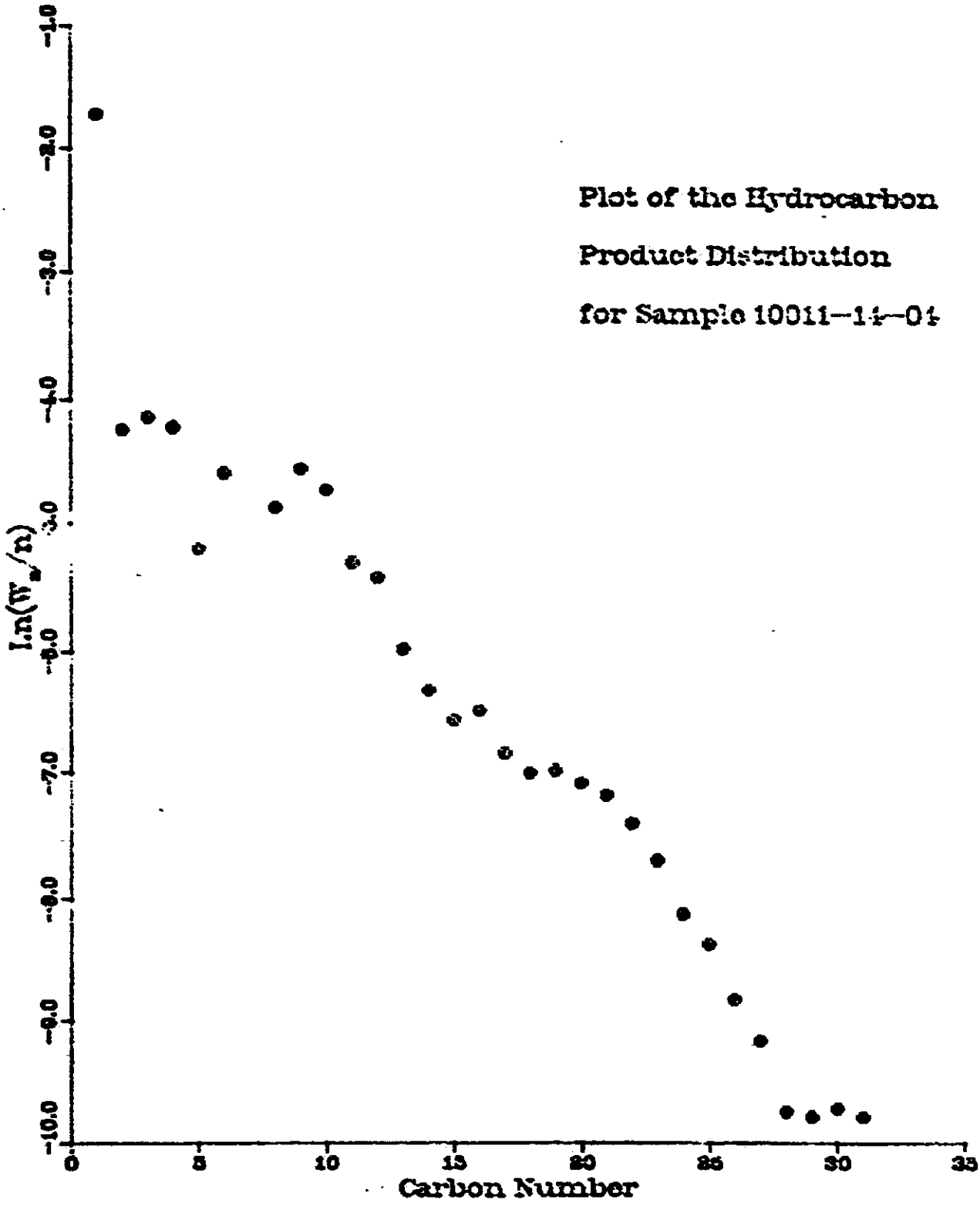

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-01
ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
Carbon Number

FIGURE 104

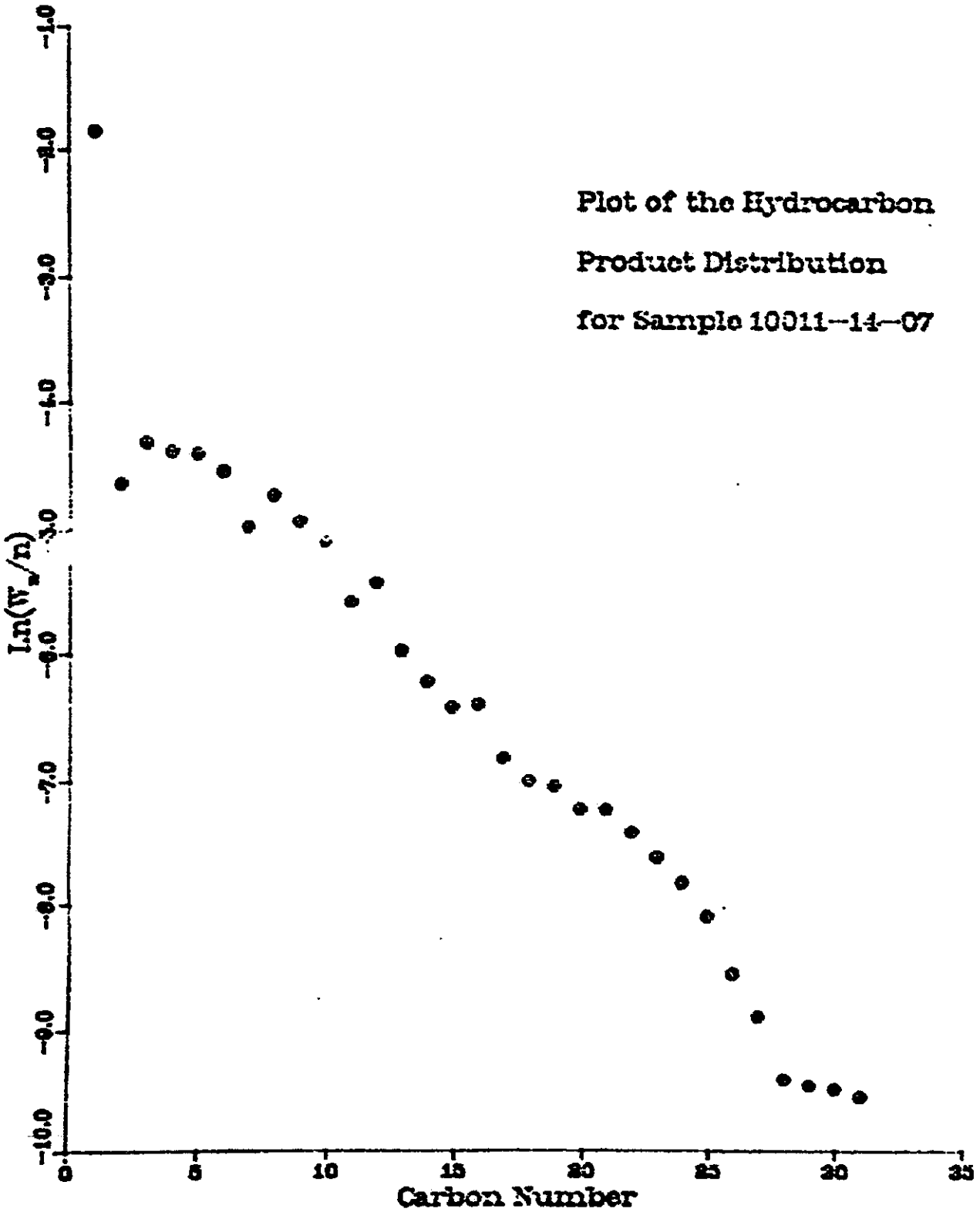

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-07
Ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
Carbon Number

FIGURE 105

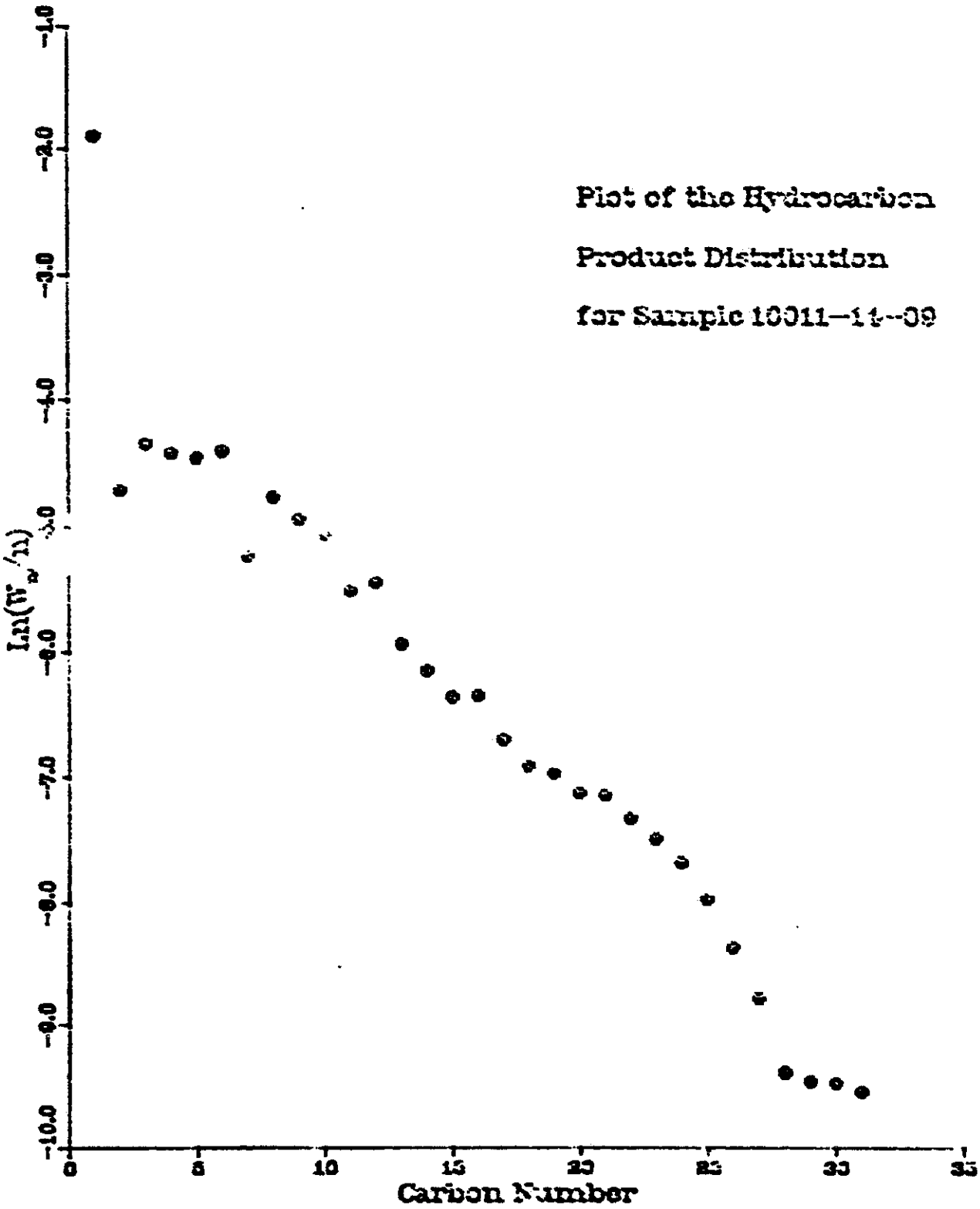

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-11-09
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
Ln(W_n/n)
0
5
10
15
20
25
30
35
Carbon Number

FIGURE 106

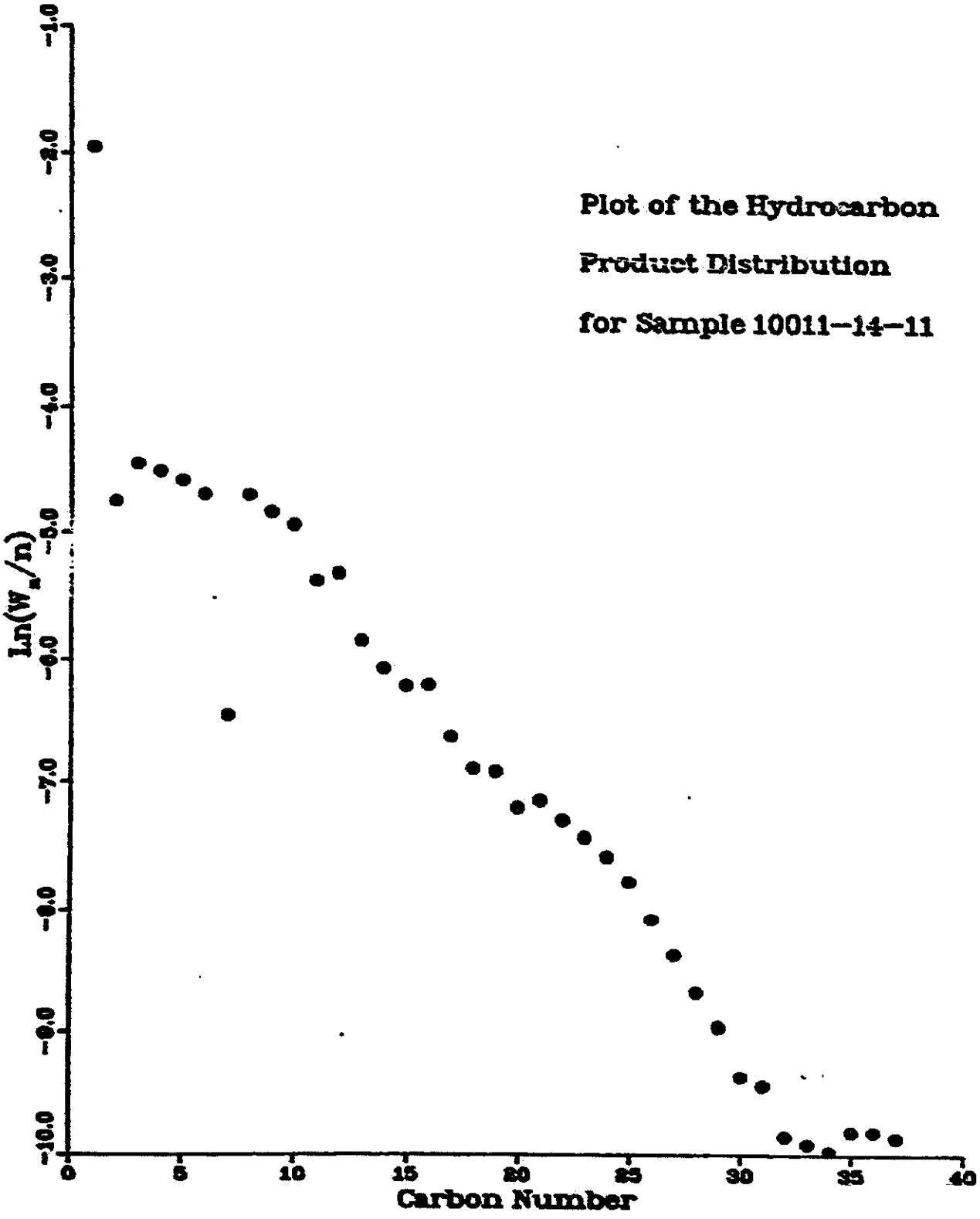

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-11
Ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0
5
10
15
20
25
30
35
40
Carbon Number

FIGURE 107

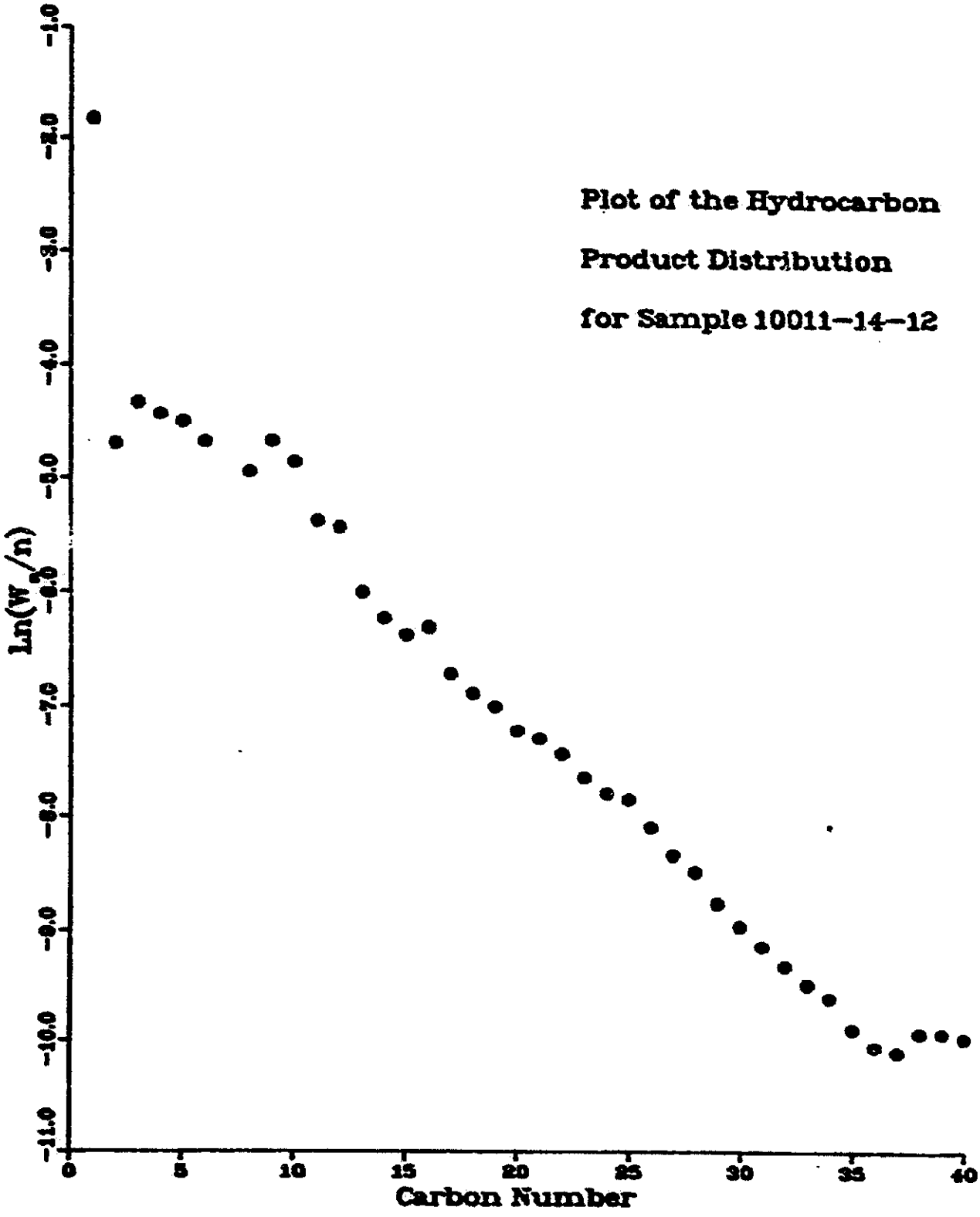

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-12
Ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

FIGURE 108

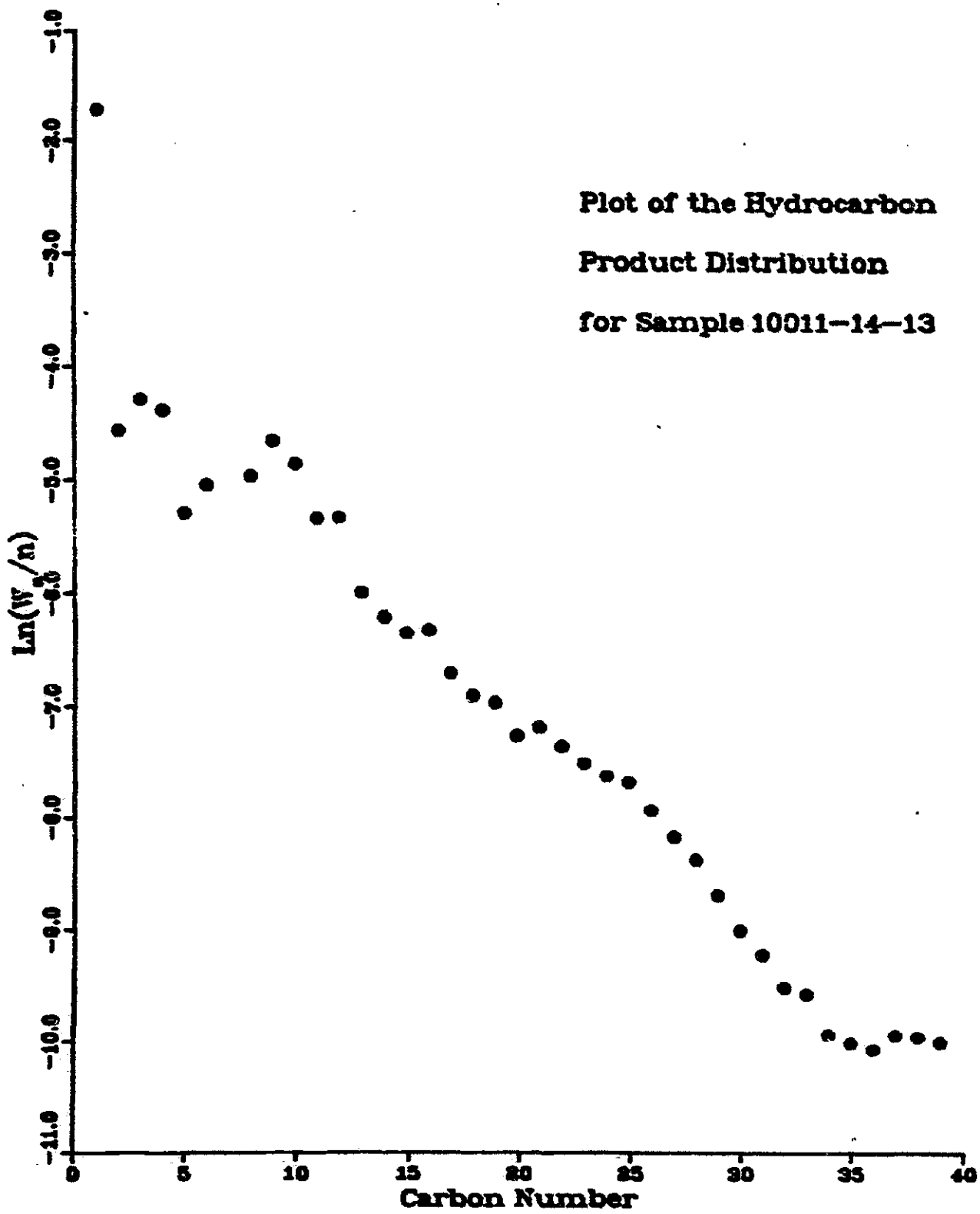

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-13
Ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

FIGURE 109

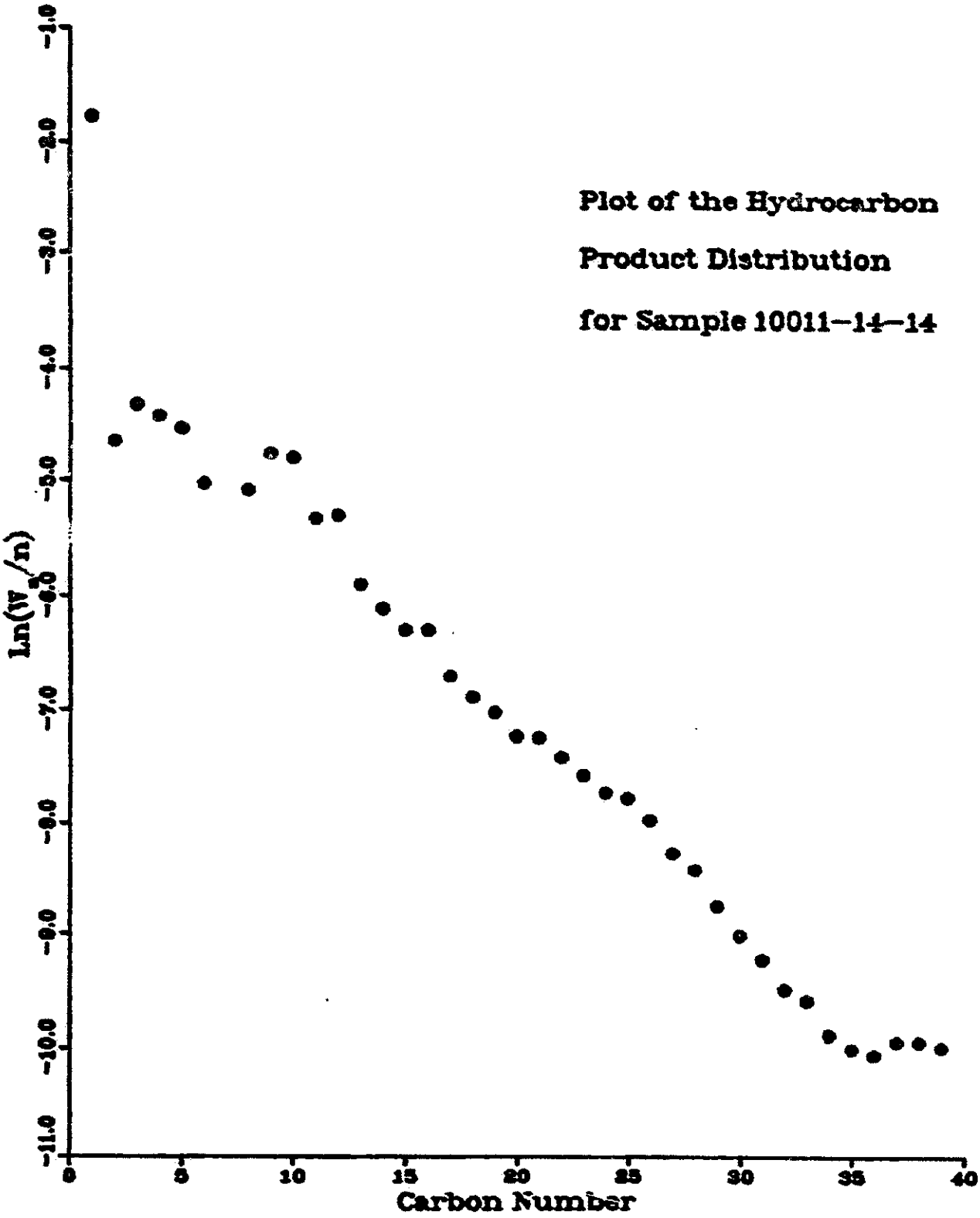

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-14
Ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

FIGURE 110

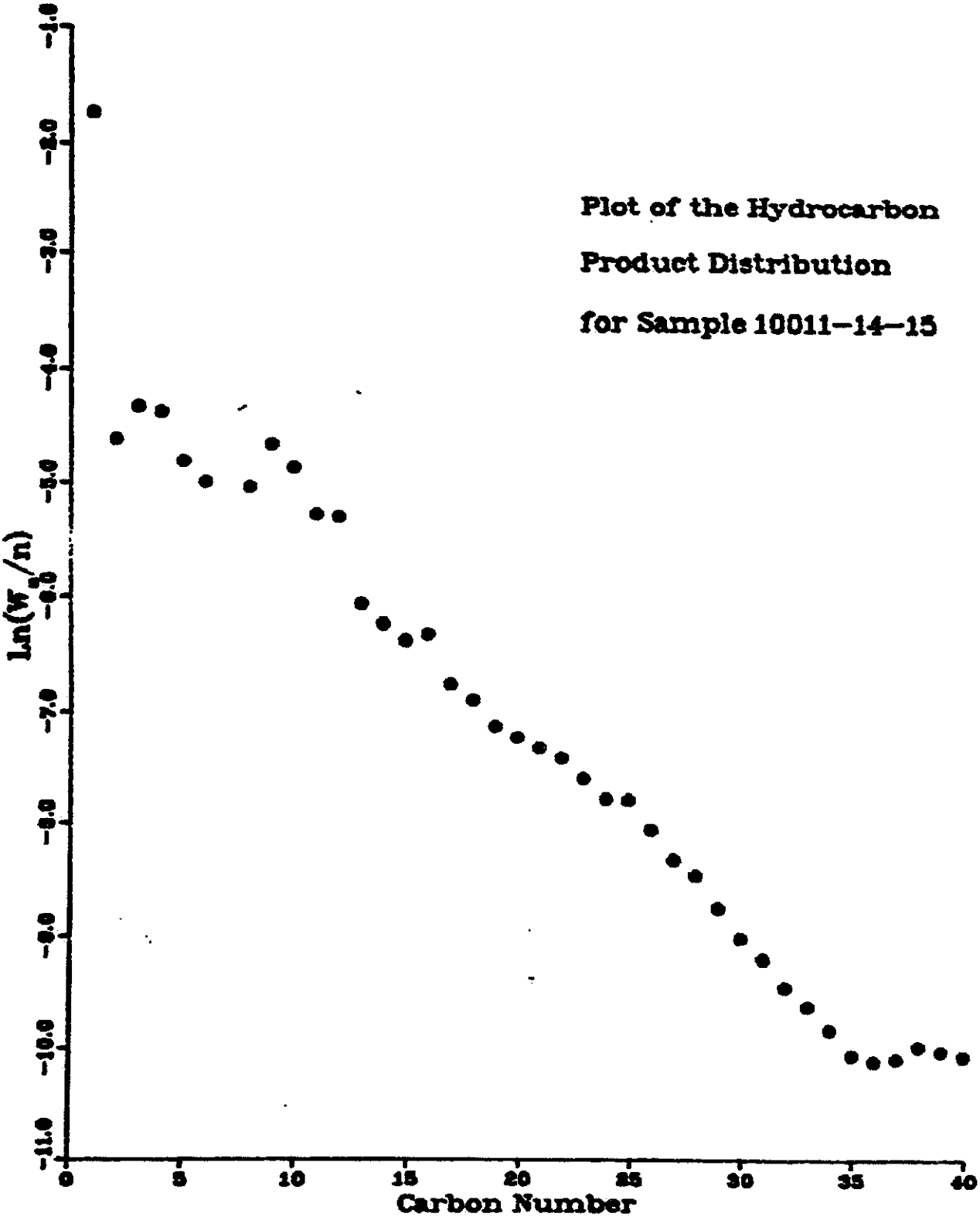
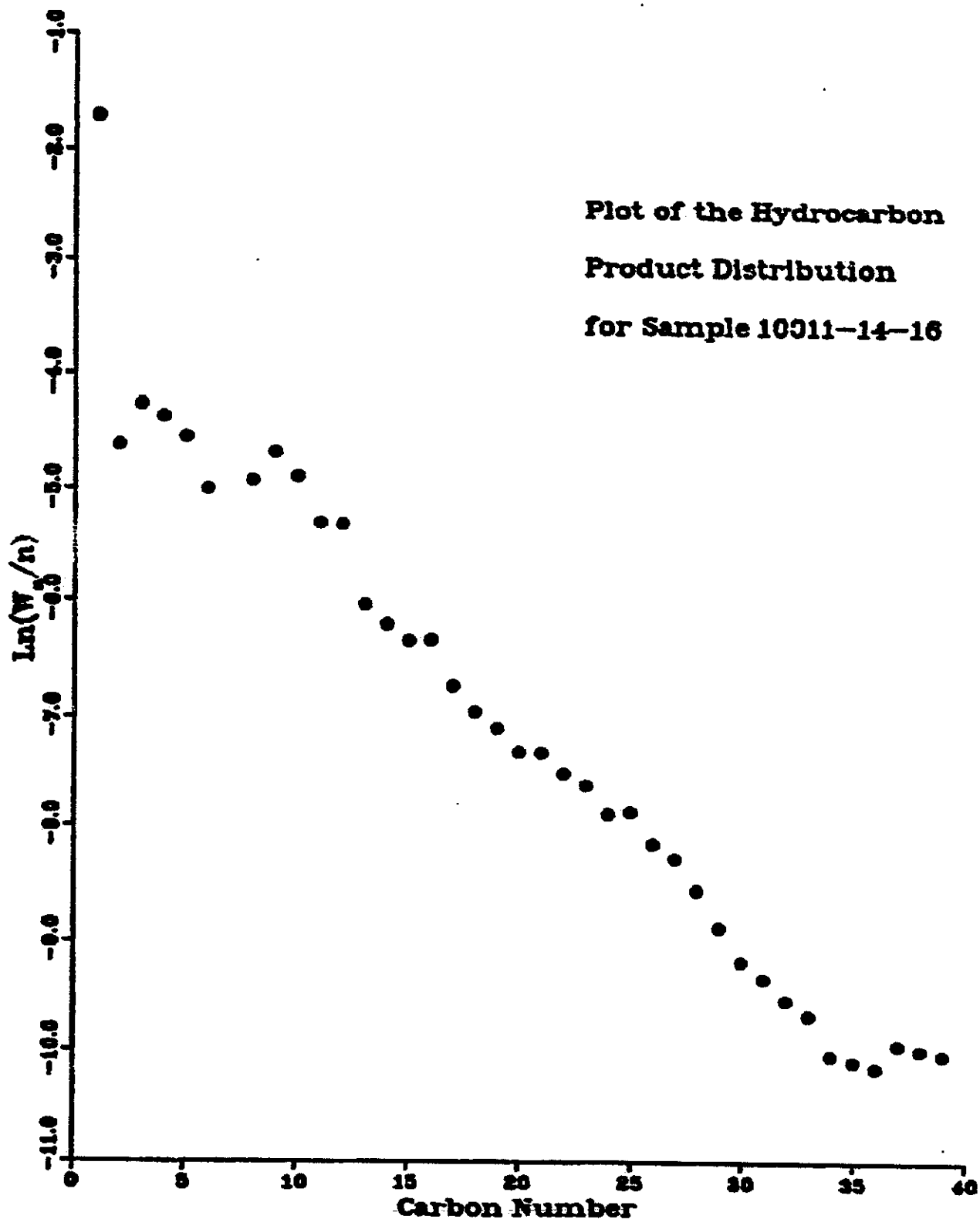

Plot of the Hydrocarbon
Product Distribution
for Sample 10011-14-15
Ln(W_n/n)
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
0
5
10
15
20
25
30
35
40
Carbon Number

FIGURE 111


Plot of the Hydrocarbon
Product Distribution
for Sample 10311-14-16
Ln(W_n/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